
Kepler Discovery
NASA
On Phone
Question from Media

1
00:00:09,350 --> 00:00:07,990
hello i'm trent parado public affairs

2
00:00:11,270 --> 00:00:09,360
officer for nasa's science mission

3
00:00:13,110 --> 00:00:11,280
directorate in washington dc i'd like to

4
00:00:14,390 --> 00:00:13,120
welcome you all today to the news

5
00:00:17,349 --> 00:00:14,400
conference to discuss the latest

6
00:00:19,109 --> 00:00:17,359
findings from the nasa's kepler mission

7
00:00:20,790 --> 00:00:19,119
kepler is the first nasa mission capable

8
00:00:23,029 --> 00:00:20,800
of finding earth-sized planets in or

9
00:00:24,870 --> 00:00:23,039
near the habitable zone as the region in

10
00:00:26,150 --> 00:00:24,880
a planetary system where liquid water

11
00:00:27,429 --> 00:00:26,160
could exist on the surface of an

12
00:00:29,269 --> 00:00:27,439
orbiting planet

13
00:00:31,589 --> 00:00:29,279

additionally kepler is detecting planets

14
00:00:34,150 --> 00:00:31,599
and planet candidates with a wide range

15
00:00:35,590 --> 00:00:34,160
of sizes and orbital distances to help

16
00:00:38,069 --> 00:00:35,600
us better understand our place in the

17
00:00:39,270 --> 00:00:38,079
galaxy for those joining us online you

18
00:00:41,830 --> 00:00:39,280
can find out more information at

19
00:00:44,310 --> 00:00:41,840
www.nasa.gov

20
00:00:45,910 --> 00:00:44,320
forward slash kepler as for the order of

21
00:00:47,510 --> 00:00:45,920
events today we have four panelists

22
00:00:49,270 --> 00:00:47,520
joining us each will give a short

23
00:00:50,709 --> 00:00:49,280
briefing and then we'll open the floor

24
00:00:52,549 --> 00:00:50,719
and the phone lines for questions and

25
00:00:55,189 --> 00:00:52,559
answers i'd like to take a brief moment

26
00:00:58,229 --> 00:00:55,199
to welcome and introduce the panelists

27
00:01:00,310 --> 00:00:58,239
first we have douglas hudgins kepler

28
00:01:01,670 --> 00:01:00,320
program scientist nasa headquarters in

29
00:01:04,149 --> 00:01:01,680
washington

30
00:01:06,230 --> 00:01:04,159
next bill beruki kepler science

31
00:01:07,990 --> 00:01:06,240
principal investigator in nasa's ames

32
00:01:09,429 --> 00:01:08,000
research center at moffett field

33
00:01:12,070 --> 00:01:09,439
california

34
00:01:14,310 --> 00:01:12,080
jack lasauer kepler co-investigator and

35
00:01:16,469 --> 00:01:14,320
planetary scientist at ames

36
00:01:18,550 --> 00:01:16,479
and debra fisher professor of astronomy

37
00:01:19,910 --> 00:01:18,560
at yale university in new haven

38
00:01:21,030 --> 00:01:19,920

connecticut

39
00:01:23,030 --> 00:01:21,040
and with that i'll hand off the

40
00:01:24,390 --> 00:01:23,040
discussion to doug hudgins

41
00:01:27,109 --> 00:01:24,400
thank you trent

42
00:01:29,510 --> 00:01:27,119
hello there uh on behalf of the

43
00:01:30,950 --> 00:01:29,520
astrophysics division and the kepler

44
00:01:34,069 --> 00:01:30,960
mission i'd like to welcome everyone

45
00:01:36,310 --> 00:01:34,079
here as we mark the second major public

46
00:01:38,230 --> 00:01:36,320
release of data from the kepler mission

47
00:01:40,069 --> 00:01:38,240
and also announced the discovery of a

48
00:01:43,190 --> 00:01:40,079
fascinating new planetary system with

49
00:01:45,910 --> 00:01:43,200
more transiting exoplanets than any

50
00:01:48,310 --> 00:01:45,920
other system discovered before

51
00:01:49,990 --> 00:01:48,320
all clustered around their star in orbit

52
00:01:51,270 --> 00:01:50,000
smaller than the orbit of the planet

53
00:01:52,550 --> 00:01:51,280
venus

54
00:01:55,429 --> 00:01:52,560
as you know

55
00:01:57,030 --> 00:01:55,439
kepler is nasa's first space telescope

56
00:01:59,270 --> 00:01:57,040
dedicated to the search for planets

57
00:02:02,630 --> 00:01:59,280
around other stars also called

58
00:02:05,429 --> 00:02:02,640
extrasolar planets or simply exoplanets

59
00:02:07,350 --> 00:02:05,439
that means that the milestones that

60
00:02:08,949 --> 00:02:07,360
kepler achieves with each and every

61
00:02:10,790 --> 00:02:08,959
discovery

62
00:02:12,550 --> 00:02:10,800
shaped the course of all future

63
00:02:14,949 --> 00:02:12,560

exoplanet missions

64
00:02:16,949 --> 00:02:14,959
kepler has been in operation for a

65
00:02:18,790 --> 00:02:16,959
little over a year and a half now

66
00:02:21,510 --> 00:02:18,800
continuously monitoring the brightness

67
00:02:24,070 --> 00:02:21,520
of more than a hundred and fifty 000

68
00:02:26,710 --> 00:02:24,080
stars in a single patch of sky near the

69
00:02:29,589 --> 00:02:26,720
constellation of cygnus the swan

70
00:02:32,150 --> 00:02:29,599
now we all know that the holy grail of

71
00:02:34,070 --> 00:02:32,160
the kepler mission is the discovery of

72
00:02:36,309 --> 00:02:34,080
an earth-sized planet

73
00:02:39,190 --> 00:02:36,319
orbiting in the habitable zone of a star

74
00:02:41,509 --> 00:02:39,200
like our own sun and believe me

75
00:02:43,750 --> 00:02:41,519
no one is more eager to get to that

76
00:02:46,550 --> 00:02:43,760
point than the kepler team however

77
00:02:48,150 --> 00:02:46,560
that's going to take time as i've said

78
00:02:49,830 --> 00:02:48,160
kepler's only been in operation for

79
00:02:52,470 --> 00:02:49,840
about a year and a half and it'll

80
00:02:54,630 --> 00:02:52,480
require at least three years of kepler

81
00:02:55,430 --> 00:02:54,640
data as well as

82
00:02:57,830 --> 00:02:55,440
uh

83
00:02:59,350 --> 00:02:57,840
painstaking observations from some of

84
00:03:01,750 --> 00:02:59,360
the world's largest ground-based

85
00:03:03,350 --> 00:03:01,760
telescopes before those types of planets

86
00:03:06,390 --> 00:03:03,360
are going to begin to emerge from the

87
00:03:08,390 --> 00:03:06,400
data however in the meantime kepler is

88
00:03:10,710 --> 00:03:08,400

absolutely revolutionizing our

89
00:03:14,390 --> 00:03:10,720
understanding of exoplanetary systems

90
00:03:16,390 --> 00:03:14,400
and exoplanets of all sizes

91
00:03:19,830 --> 00:03:16,400
think about it

92
00:03:22,149 --> 00:03:19,840
the first 15 years of exoplanet searches

93
00:03:24,789 --> 00:03:22,159
from the ground turned up a little more

94
00:03:26,949 --> 00:03:24,799
than 500 extrasolar planets

95
00:03:29,990 --> 00:03:26,959
last june the kepler team announced the

96
00:03:31,910 --> 00:03:30,000
discovery of more than 700 extrasolar

97
00:03:34,710 --> 00:03:31,920
planet candidates in just the first

98
00:03:36,390 --> 00:03:34,720
month and a half of mission data

99
00:03:38,470 --> 00:03:36,400
today you're going to hear that when you

100
00:03:40,229 --> 00:03:38,480
add the next three months of data that

101
00:03:41,750 --> 00:03:40,239
were released earlier this morning the

102
00:03:44,070 --> 00:03:41,760
number of candidates jumps to more than

103
00:03:47,750 --> 00:03:44,080
1200.

104
00:03:49,270 --> 00:03:47,760
now you might imagine that uh with more

105
00:03:51,830 --> 00:03:49,280
than 1200

106
00:03:54,070 --> 00:03:51,840
uh candidates

107
00:03:55,429 --> 00:03:54,080
uh the uh well

108
00:03:57,429 --> 00:03:55,439
the uh

109
00:04:00,869 --> 00:03:57,439
uh the the key thing

110
00:04:02,630 --> 00:04:00,879
is to remember that uh i you'll you'll

111
00:04:06,309 --> 00:04:02,640
notice that i talk about exoplanet

112
00:04:08,630 --> 00:04:06,319
candidates rather than just exoplanets

113
00:04:10,630 --> 00:04:08,640

and the reason for that is every time we

114
00:04:12,550 --> 00:04:10,640
see in the data the evidence of some

115
00:04:14,550 --> 00:04:12,560
sort of a signal

116
00:04:16,710 --> 00:04:14,560
uh that requires

117
00:04:19,430 --> 00:04:16,720
analysis and follow-up observations to

118
00:04:21,189 --> 00:04:19,440
confirm that that signal is actually due

119
00:04:23,510 --> 00:04:21,199
to a planet and not just something

120
00:04:25,990 --> 00:04:23,520
masquerading as a planet now you might

121
00:04:28,629 --> 00:04:26,000
imagine with more than 1200 exoplanet

122
00:04:29,590 --> 00:04:28,639
candidates at this point

123
00:04:31,670 --> 00:04:29,600
the

124
00:04:33,270 --> 00:04:31,680
kepler science team has been basically

125
00:04:35,430 --> 00:04:33,280
trying to drink out of a fire hose to

126
00:04:37,670 --> 00:04:35,440
keep up with the violent observations

127
00:04:40,390 --> 00:04:37,680
that's why nasa is pleased to be

128
00:04:41,990 --> 00:04:40,400
releasing this data at this time

129
00:04:44,070 --> 00:04:42,000
and so that it can harness the

130
00:04:45,350 --> 00:04:44,080
horsepower of the entire astronomical

131
00:04:47,270 --> 00:04:45,360
community

132
00:04:50,150 --> 00:04:47,280
now you didn't come here to hear some

133
00:04:51,350 --> 00:04:50,160
nasa guy blah blah blah endlessly uh so

134
00:04:53,110 --> 00:04:51,360
i'm going to turn it over to the

135
00:04:55,830 --> 00:04:53,120
scientists here pretty soon but before i

136
00:04:57,270 --> 00:04:55,840
do i simply would like to acknowledge

137
00:04:58,950 --> 00:04:57,280
that the results that you're going to

138
00:05:02,230 --> 00:04:58,960

hear about today and in fact all the

139
00:05:05,909 --> 00:05:02,240
kepler results are the culmination of

140
00:05:08,950 --> 00:05:05,919
years of tireless work by scientists

141
00:05:11,270 --> 00:05:08,960
engineers chief cooks and bottle washers

142
00:05:13,749 --> 00:05:11,280
at nasa ames research center the jet

143
00:05:15,189 --> 00:05:13,759
propulsion laboratory ball aerospace

144
00:05:17,670 --> 00:05:15,199
corporation

145
00:05:19,029 --> 00:05:17,680
and institutions across the country and

146
00:05:21,510 --> 00:05:19,039
around the world

147
00:05:23,670 --> 00:05:21,520
the success of the kepler mission is a

148
00:05:26,469 --> 00:05:23,680
tribute to those people's efforts and i

149
00:05:28,550 --> 00:05:26,479
tip my hat to each and every one of them

150
00:05:30,070 --> 00:05:28,560
i'll turn it over to bill now

151
00:05:33,110 --> 00:05:30,080
thank you doug

152
00:05:35,909 --> 00:05:33,120
what i'd like to present today is the

153
00:05:38,550 --> 00:05:35,919
results of the first four months of

154
00:05:42,230 --> 00:05:38,560
science operations of the kepler mission

155
00:05:44,550 --> 00:05:42,240
uh doug has and and uh trent have i

156
00:05:46,870 --> 00:05:44,560
think well describe the mission

157
00:05:48,870 --> 00:05:46,880
as objective basically is defined

158
00:05:50,390 --> 00:05:48,880
earth's earth-sized planets particularly

159
00:05:53,270 --> 00:05:50,400
in the habitable zone

160
00:05:56,070 --> 00:05:53,280
of uh sun-like stars could have the

161
00:05:58,070 --> 00:05:56,080
first figure please

162
00:06:00,550 --> 00:05:58,080
this is a sketch of the

163
00:06:02,629 --> 00:06:00,560

spacecraft itself in orbit looking uh at

164
00:06:04,710 --> 00:06:02,639
a planet transiting a star and that's

165
00:06:06,710 --> 00:06:04,720
how we do our photometry we look for

166
00:06:08,870 --> 00:06:06,720
dimmings of a star

167
00:06:11,430 --> 00:06:08,880
the data that i'm going to talk about is

168
00:06:13,670 --> 00:06:11,440
of 155 000 stars that we've been

169
00:06:16,710 --> 00:06:13,680
monitoring for four months

170
00:06:18,790 --> 00:06:16,720
it's of the 1235

171
00:06:20,550 --> 00:06:18,800
candidates that we have found and i will

172
00:06:21,590 --> 00:06:20,560
describe those

173
00:06:23,670 --> 00:06:21,600
as well

174
00:06:25,990 --> 00:06:23,680
but i'd like to start out first with a a

175
00:06:29,670 --> 00:06:26,000
family portrait of what where we've come

176
00:06:32,230 --> 00:06:29,680
from could i have a next uh figure

177
00:06:34,150 --> 00:06:32,240
this uh basically shows you our

178
00:06:36,150 --> 00:06:34,160
confirmed planet discoveries these

179
00:06:38,469 --> 00:06:36,160
aren't candidates these are confirmed

180
00:06:40,629 --> 00:06:38,479
planets in the first season

181
00:06:43,990 --> 00:06:40,639
we were able to find the

182
00:06:45,510 --> 00:06:44,000
top row there four uh planets bigger

183
00:06:48,070 --> 00:06:45,520
than jupiter and they're compared to

184
00:06:49,670 --> 00:06:48,080
jupiter there plus a planet that was

185
00:06:52,469 --> 00:06:49,680
about the size of neptune that's the

186
00:06:54,950 --> 00:06:52,479
green object down in the bottom line

187
00:06:57,589 --> 00:06:54,960
uh the giant plants were a surprise we

188
00:07:00,469 --> 00:06:57,599

didn't think we would find that many uh

189
00:07:02,950 --> 00:07:00,479
certainly the the one on your far left

190
00:07:04,550 --> 00:07:02,960
uh was an even bigger surprise is a

191
00:07:05,749 --> 00:07:04,560
planet with one of the lowest densities

192
00:07:08,070 --> 00:07:05,759
ever found

193
00:07:10,710 --> 00:07:08,080
this enormous planet bigger than jupiter

194
00:07:11,830 --> 00:07:10,720
has a density of styrofoam just

195
00:07:14,629 --> 00:07:11,840
astounding

196
00:07:16,230 --> 00:07:14,639
the neptune was a surprise in that it's

197
00:07:17,909 --> 00:07:16,240
extremely close to its star it's very

198
00:07:19,749 --> 00:07:17,919
hot and you'd think that that would

199
00:07:22,550 --> 00:07:19,759
expand it and its density would fall

200
00:07:24,150 --> 00:07:22,560
that is not the case another surprise

201
00:07:26,550 --> 00:07:24,160
uh and this

202
00:07:28,790 --> 00:07:26,560
last year uh one of the things that we

203
00:07:30,790 --> 00:07:28,800
were able to confirm was a star with

204
00:07:32,469 --> 00:07:30,800
three transiting planets and that's

205
00:07:35,510 --> 00:07:32,479
shown in a bottom row two of these

206
00:07:38,070 --> 00:07:35,520
planets uh nine b and c are planets

207
00:07:39,589 --> 00:07:38,080
about the size of saturn and one of them

208
00:07:41,830 --> 00:07:39,599
that little blue

209
00:07:44,230 --> 00:07:41,840
object there is a planet one point six

210
00:07:46,550 --> 00:07:44,240
times the size of earth so we're down in

211
00:07:49,589 --> 00:07:46,560
the super earth size

212
00:07:51,909 --> 00:07:49,599
a few weeks ago since the start of 2011

213
00:07:55,189 --> 00:07:51,919

we had another announcement that is the

214
00:07:57,749 --> 00:07:55,199
fir kepler's first rocky planet a planet

215
00:07:59,670 --> 00:07:57,759
1.4 to the size of the earth and a

216
00:08:01,830 --> 00:07:59,680
density greater than that of the earth

217
00:08:03,749 --> 00:08:01,840
so it's obviously a rocky planet of some

218
00:08:05,909 --> 00:08:03,759
type so we're moving into the direction

219
00:08:08,710 --> 00:08:05,919
we want from the bigger easier planets

220
00:08:10,629 --> 00:08:08,720
to the smaller planets that

221
00:08:12,550 --> 00:08:10,639
might harbor life

222
00:08:14,629 --> 00:08:12,560
so let's go and talk about not what we

223
00:08:17,189 --> 00:08:14,639
had found up to today but look at the

224
00:08:18,230 --> 00:08:17,199
data itself that we released last night

225
00:08:19,670 --> 00:08:18,240
it's going to have the next figure

226
00:08:21,510 --> 00:08:19,680
please

227
00:08:22,390 --> 00:08:21,520
when we started out this was our field

228
00:08:24,550 --> 00:08:22,400
of view

229
00:08:26,790 --> 00:08:24,560
uh that covers 100 square degrees of sky

230
00:08:29,589 --> 00:08:26,800
you see three yellow points there these

231
00:08:31,589 --> 00:08:29,599
three were planets that were known uh

232
00:08:33,909 --> 00:08:31,599
before we launched they were in our

233
00:08:35,909 --> 00:08:33,919
field of view and of course made

234
00:08:38,149 --> 00:08:35,919
measurements of them but let's look at

235
00:08:40,389 --> 00:08:38,159
the same field of view

236
00:08:43,509 --> 00:08:40,399
after looking at four months of kepler

237
00:08:47,030 --> 00:08:43,519
data next figure please

238
00:08:49,190 --> 00:08:47,040

this are those 1200 candidates we cover

239
00:08:51,030 --> 00:08:49,200
the field of view with all sorts of

240
00:08:53,670 --> 00:08:51,040
candidates

241
00:08:54,389 --> 00:08:53,680
let's look at the next figure

242
00:08:58,470 --> 00:08:54,399
we

243
00:09:00,310 --> 00:08:58,480
tell you which are earth's size which

244
00:09:02,870 --> 00:09:00,320
are neptune size which is super earth

245
00:09:05,030 --> 00:09:02,880
size and you see that in color the

246
00:09:07,509 --> 00:09:05,040
yellow the blue dots are earth-sized

247
00:09:08,550 --> 00:09:07,519
planets earth-sized candidates not yet

248
00:09:10,949 --> 00:09:08,560
planets

249
00:09:12,550 --> 00:09:10,959
the green ones yellow ones are super

250
00:09:14,710 --> 00:09:12,560
earths up to twice the size of the earth

251
00:09:16,150 --> 00:09:14,720
but still plants that if they're

252
00:09:18,870 --> 00:09:16,160
confirmed might very well have a solid

253
00:09:21,190 --> 00:09:18,880
surface people could walk on

254
00:09:24,230 --> 00:09:21,200
then we have the neptunes the size and

255
00:09:25,750 --> 00:09:24,240
the giant planet sizes so a huge range

256
00:09:28,150 --> 00:09:25,760
of of planets

257
00:09:30,230 --> 00:09:28,160
throughout this field of view could have

258
00:09:32,389 --> 00:09:30,240
the next figure

259
00:09:33,509 --> 00:09:32,399
this gives you the numbers of what we

260
00:09:34,829 --> 00:09:33,519
have found

261
00:09:37,990 --> 00:09:34,839
68

262
00:09:40,949 --> 00:09:38,000
earth-sized candidates

263
00:09:43,269 --> 00:09:40,959

candidates up to 1.25 the size some of

264
00:09:44,949 --> 00:09:43,279
these candidates smaller

265
00:09:46,790 --> 00:09:44,959
considerably smaller than the earth

266
00:09:49,590 --> 00:09:46,800
close to mars size

267
00:09:51,870 --> 00:09:49,600
then we have the 288 candidates that are

268
00:09:55,590 --> 00:09:51,880
somewhat bigger than the earth

269
00:09:57,990 --> 00:09:55,600
662 662

270
00:09:59,750 --> 00:09:58,000
neptune-sized candidates

271
00:10:02,150 --> 00:09:59,760
as

272
00:10:04,870 --> 00:10:02,160
doug mentioned earlier in the 15 years

273
00:10:06,870 --> 00:10:04,880
of observations the total number of

274
00:10:08,389 --> 00:10:06,880
known planets that have been discovered

275
00:10:10,790 --> 00:10:08,399
is like 520

276
00:10:13,350 --> 00:10:10,800
just this group alone of candidates

277
00:10:15,550 --> 00:10:13,360
exceeds that so there's an enormous

278
00:10:18,550 --> 00:10:15,560
number of candidates that we're finding

279
00:10:19,990 --> 00:10:18,560
165 geophysical sized objects objects

280
00:10:22,069 --> 00:10:20,000
that are even bigger than jupiter and

281
00:10:26,310 --> 00:10:22,079
we're not quite sure what they are and

282
00:10:29,430 --> 00:10:27,430
go to the next let's go to the next

283
00:10:30,949 --> 00:10:29,440
figure please

284
00:10:32,870 --> 00:10:30,959
one of the things that we want to do

285
00:10:35,509 --> 00:10:32,880
when we find these candidates is find

286
00:10:37,509 --> 00:10:35,519
candidates in particular around stars

287
00:10:39,350 --> 00:10:37,519
like the sun because there's all sorts

288
00:10:41,670 --> 00:10:39,360

of stars out there giant stars that have

289
00:10:43,030 --> 00:10:41,680
engulfed there there there are planets

290
00:10:46,230 --> 00:10:43,040
various you know stars that are burned

291
00:10:48,389 --> 00:10:46,240
out we would like to find

292
00:10:51,910 --> 00:10:48,399
candidates around stars like our own and

293
00:10:54,310 --> 00:10:51,920
this figure shows that if you look at

294
00:10:56,949 --> 00:10:54,320
the earth-sized candidates and the

295
00:10:57,910 --> 00:10:56,959
supersize and the neptune size all of

296
00:10:59,750 --> 00:10:57,920
those

297
00:11:02,870 --> 00:10:59,760
are centered the maximum number is

298
00:11:05,030 --> 00:11:02,880
around the temperature of the star the

299
00:11:06,870 --> 00:11:05,040
temperature of our sun so these stars

300
00:11:09,190 --> 00:11:06,880
are very much lockers and there's a

301
00:11:11,269 --> 00:11:09,200
variety that you see there but most of

302
00:11:14,389 --> 00:11:11,279
them are around stars like the sun and

303
00:11:15,990 --> 00:11:14,399
of course that didn't happen by accident

304
00:11:19,190 --> 00:11:16,000
it happened because before we launched

305
00:11:20,630 --> 00:11:19,200
that mission our co-investigators

306
00:11:22,790 --> 00:11:20,640
led by dave

307
00:11:25,110 --> 00:11:22,800
latham at the smithsonian astrophysical

308
00:11:26,310 --> 00:11:25,120
observatory used ground-based telescopes

309
00:11:29,670 --> 00:11:26,320
to observe

310
00:11:32,150 --> 00:11:29,680
4.4 million stars in this field of view

311
00:11:34,310 --> 00:11:32,160
and classify them that allowed us to

312
00:11:36,069 --> 00:11:34,320
choose just the stars their most

313
00:11:38,150 --> 00:11:36,079

sun-like most

314
00:11:39,910 --> 00:11:38,160
and the brightest star so we could find

315
00:11:41,430 --> 00:11:39,920
really good targets to make these

316
00:11:44,310 --> 00:11:41,440
measurements with

317
00:11:46,230 --> 00:11:44,320
the next figure please

318
00:11:47,990 --> 00:11:46,240
when we look at these candidates again

319
00:11:50,150 --> 00:11:48,000
i've broken them into four groups the

320
00:11:52,710 --> 00:11:50,160
blue group their earth size and green

321
00:11:54,470 --> 00:11:52,720
groups super earth size and neptune size

322
00:11:57,190 --> 00:11:54,480
and jupiter size one of the things we

323
00:12:00,310 --> 00:11:57,200
see is this the number as a function of

324
00:12:02,389 --> 00:12:00,320
the orbital period in days and you see

325
00:12:04,870 --> 00:12:02,399
that each of these curves falls to the

326
00:12:07,590 --> 00:12:04,880
right it gets fewer and fewer as you get

327
00:12:08,949 --> 00:12:07,600
the larger and larger orbital periods

328
00:12:11,910 --> 00:12:08,959
this occurs

329
00:12:13,750 --> 00:12:11,920
because it's harder to see

330
00:12:15,829 --> 00:12:13,760
planets further out

331
00:12:17,430 --> 00:12:15,839
the chance of seeing them is diamond of

332
00:12:18,949 --> 00:12:17,440
the star over time of the orbit so as

333
00:12:21,269 --> 00:12:18,959
you move further and further out it gets

334
00:12:22,389 --> 00:12:21,279
more and more difficult so you see fewer

335
00:12:24,949 --> 00:12:22,399
and fewer

336
00:12:27,350 --> 00:12:24,959
of these candidates and these planets it

337
00:12:30,389 --> 00:12:27,360
gets more difficult as you look for

338
00:12:31,750 --> 00:12:30,399

planets toward the habitable zone

339
00:12:33,990 --> 00:12:31,760
the other thing to notice is there's a

340
00:12:35,350 --> 00:12:34,000
peak the peak here is between two and

341
00:12:36,829 --> 00:12:35,360
four days

342
00:12:39,030 --> 00:12:36,839
and that occurs for every one of the

343
00:12:40,710 --> 00:12:39,040
groups and

344
00:12:42,710 --> 00:12:40,720
the thought here is what's happening is

345
00:12:45,350 --> 00:12:42,720
that when planets form they form an

346
00:12:47,509 --> 00:12:45,360
accretion disk that accretion disk

347
00:12:50,550 --> 00:12:47,519
picks out takes momentum and energy from

348
00:12:52,389 --> 00:12:50,560
these uh planets and they spiral into

349
00:12:55,110 --> 00:12:52,399
toward their star

350
00:12:57,829 --> 00:12:55,120
and so if they come spiraling in and

351
00:13:00,150 --> 00:12:57,839
they that orbital period matches the

352
00:13:02,790 --> 00:13:00,160
rotation period of the star

353
00:13:04,389 --> 00:13:02,800
tides rise on the star and on a planet

354
00:13:06,870 --> 00:13:04,399
such that the star can transfer its

355
00:13:08,949 --> 00:13:06,880
rotational momentum to the planet and

356
00:13:11,430 --> 00:13:08,959
stop the planet from crashing into the

357
00:13:14,790 --> 00:13:11,440
star and so that's sort of a storage bin

358
00:13:17,030 --> 00:13:14,800
of these of these planets so we see that

359
00:13:19,030 --> 00:13:17,040
very very clearly in this data

360
00:13:22,870 --> 00:13:19,040
but then you see there's a big dip for

361
00:13:24,870 --> 00:13:22,880
periods shorter than three or four days

362
00:13:27,190 --> 00:13:24,880
and the and and clearly it's easy for us

363
00:13:28,710 --> 00:13:27,200

to see short periods uh planets because

364
00:13:30,310 --> 00:13:28,720
they give us so many transits more

365
00:13:33,670 --> 00:13:30,320
transits the easier

366
00:13:35,670 --> 00:13:33,680
uh to detect them so this is real

367
00:13:37,350 --> 00:13:35,680
and the implication here is that some of

368
00:13:40,230 --> 00:13:37,360
these planets when they came spiraling

369
00:13:42,629 --> 00:13:40,240
in didn't come in with synchronous as

370
00:13:44,389 --> 00:13:42,639
synchronized with the or the rotation of

371
00:13:46,710 --> 00:13:44,399
the star and so they continued on their

372
00:13:48,389 --> 00:13:46,720
wagon and did

373
00:13:50,069 --> 00:13:48,399
dissolve dissolving the star

374
00:13:51,910 --> 00:13:50,079
on the other hand we see some that are

375
00:13:53,189 --> 00:13:51,920
still there and that might mean they

376
00:13:55,189 --> 00:13:53,199
were lucky

377
00:13:57,350 --> 00:13:55,199
they simply came in toward the star and

378
00:13:59,910 --> 00:13:57,360
the accretion star lit up blew away the

379
00:14:01,670 --> 00:13:59,920
accretion disk and now they're safe or

380
00:14:03,350 --> 00:14:01,680
maybe they're not so safe

381
00:14:05,910 --> 00:14:03,360
they still have tides on those those

382
00:14:07,829 --> 00:14:05,920
planets and they may be on their way in

383
00:14:10,550 --> 00:14:07,839
to the star yet so areas of

384
00:14:12,389 --> 00:14:10,560
investigation that many scientists will

385
00:14:14,150 --> 00:14:12,399
be looking at in the coming months and

386
00:14:16,310 --> 00:14:14,160
years could i have the next figure

387
00:14:18,710 --> 00:14:16,320
please

388
00:14:20,870 --> 00:14:18,720

when we started out people had found

389
00:14:22,870 --> 00:14:20,880
planets around other stars and people

390
00:14:25,670 --> 00:14:22,880
had found them with a transit technique

391
00:14:28,230 --> 00:14:25,680
that we use and here's an example of the

392
00:14:30,310 --> 00:14:28,240
size of of the planets they found

393
00:14:32,389 --> 00:14:30,320
relative to the earth so one is earth

394
00:14:34,710 --> 00:14:32,399
size four is neptune size and you can

395
00:14:36,790 --> 00:14:34,720
see the little sketches of the planets

396
00:14:39,269 --> 00:14:36,800
along the edges there

397
00:14:41,269 --> 00:14:39,279
and you see the dots the dots basically

398
00:14:42,949 --> 00:14:41,279
show you that what was being found

399
00:14:44,870 --> 00:14:42,959
were planets quite a bit larger than

400
00:14:48,069 --> 00:14:44,880
jupiter and at very short orbital

401
00:14:49,910 --> 00:14:48,079
periods and so we really want to observe

402
00:14:51,590 --> 00:14:49,920
not in the upper left corner but the

403
00:14:54,310 --> 00:14:51,600
lower right corner where you've got

404
00:14:56,550 --> 00:14:54,320
small planets at cool temperatures so

405
00:15:00,069 --> 00:14:56,560
let's look at what kepler's contributed

406
00:15:02,310 --> 00:15:00,079
last june next figure please

407
00:15:04,470 --> 00:15:02,320
you can see all these purple dots and

408
00:15:06,629 --> 00:15:04,480
you can see that most of them are quite

409
00:15:09,350 --> 00:15:06,639
a bit smaller than jupiter most of them

410
00:15:12,310 --> 00:15:09,360
are the earth's between earth size and

411
00:15:14,069 --> 00:15:12,320
neptune size further they're not at the

412
00:15:16,710 --> 00:15:14,079
shortest periods they're much longer

413
00:15:18,790 --> 00:15:16,720

periods so again a movement toward the

414
00:15:20,310 --> 00:15:18,800
lower right hand corner next figure

415
00:15:22,389 --> 00:15:20,320
please

416
00:15:24,790 --> 00:15:22,399
this is what we released yesterday this

417
00:15:29,189 --> 00:15:24,800
is all the data from those

418
00:15:31,829 --> 00:15:29,199
1235 candidates those 15 150 000 stars

419
00:15:34,470 --> 00:15:31,839
shown here and now you see again

420
00:15:36,069 --> 00:15:34,480
many more uh planetary candidates closer

421
00:15:38,470 --> 00:15:36,079
to the size of the earth

422
00:15:40,949 --> 00:15:38,480
and in fact if you look a lot of them

423
00:15:43,749 --> 00:15:40,959
are below the size these objects are

424
00:15:46,470 --> 00:15:43,759
getting down toward mars size in fact so

425
00:15:48,310 --> 00:15:46,480
we are seeing smaller smaller candidates

426
00:15:50,870 --> 00:15:48,320
and they're moving to the right to

427
00:15:52,550 --> 00:15:50,880
longer orbital periods you can still see

428
00:15:54,470 --> 00:15:52,560
there's a little gap there

429
00:15:56,470 --> 00:15:54,480
that we want to go to in the lower right

430
00:15:57,749 --> 00:15:56,480
hand corner

431
00:16:00,069 --> 00:15:57,759
but we ought to talk about the

432
00:16:01,829 --> 00:16:00,079
temperatures of these these candidates

433
00:16:02,790 --> 00:16:01,839
if they're too hot for life we want to

434
00:16:05,110 --> 00:16:02,800
know that we want to know their

435
00:16:06,550 --> 00:16:05,120
temperatures are they cool enough

436
00:16:08,550 --> 00:16:06,560
so they could have liquid water on the

437
00:16:10,629 --> 00:16:08,560
surface could they have

438
00:16:12,150 --> 00:16:10,639

an ocean could they have an atmosphere

439
00:16:14,470 --> 00:16:12,160
so we're going to change the axis the

440
00:16:15,829 --> 00:16:14,480
horizontal axis is no longer going to be

441
00:16:17,509 --> 00:16:15,839
orbital period

442
00:16:19,829 --> 00:16:17,519
it's going to be the temperature that we

443
00:16:23,590 --> 00:16:19,839
calculate for the candidates

444
00:16:26,710 --> 00:16:25,189
the temperatures here now are in

445
00:16:28,550 --> 00:16:26,720
fahrenheit

446
00:16:30,310 --> 00:16:28,560
and what we see again the science the

447
00:16:32,790 --> 00:16:30,320
size relative to the earth

448
00:16:34,710 --> 00:16:32,800
we see what we saw before some smaller

449
00:16:37,590 --> 00:16:34,720
than that of the earth many between

450
00:16:40,470 --> 00:16:37,600
earth size and neptune size and a fair

451
00:16:43,189 --> 00:16:40,480
number that are bigger even than jupiter

452
00:16:44,790 --> 00:16:43,199
the temperature is 1000 degrees twice as

453
00:16:46,949 --> 00:16:44,800
hot as a pizza oven

454
00:16:49,509 --> 00:16:46,959
2000 degrees you've got those planets

455
00:16:50,790 --> 00:16:49,519
are molten lava 3000 degrees they're

456
00:16:53,430 --> 00:16:50,800
molten iron

457
00:16:55,829 --> 00:16:53,440
so very very hot the area of interest

458
00:16:58,310 --> 00:16:55,839
now is not in the lower right it's in

459
00:16:59,749 --> 00:16:58,320
the lower left so let's go and expand

460
00:17:01,350 --> 00:16:59,759
that lower left could i have the next

461
00:17:03,509 --> 00:17:01,360
figure please

462
00:17:06,630 --> 00:17:03,519
so we're going to take this portion

463
00:17:08,710 --> 00:17:06,640

of that that group of 1200 candidates

464
00:17:10,549 --> 00:17:08,720
and expand that out so that you can see

465
00:17:12,549 --> 00:17:10,559
in detail what the temperatures look

466
00:17:16,150 --> 00:17:12,559
like for those that are close or in the

467
00:17:18,949 --> 00:17:16,160
habitable zone next figure please

468
00:17:21,270 --> 00:17:18,959
this is that expanded area now you see

469
00:17:22,630 --> 00:17:21,280
the temperatures aren't in thousands

470
00:17:25,750 --> 00:17:22,640
but they're temperatures that many of us

471
00:17:29,350 --> 00:17:25,760
experience from zero fahrenheit up to

472
00:17:32,230 --> 00:17:29,360
200 i started to a 200 fahrenheit and

473
00:17:33,990 --> 00:17:32,240
some colder temperatures as well this is

474
00:17:36,390 --> 00:17:34,000
the the region where you could have

475
00:17:37,909 --> 00:17:36,400
liquid water now clearly minus 50

476
00:17:39,350 --> 00:17:37,919
fahrenheit you don't have liquid water

477
00:17:40,950 --> 00:17:39,360
you have ice but if you have an

478
00:17:43,430 --> 00:17:40,960
atmosphere those temperatures will come

479
00:17:46,230 --> 00:17:43,440
up as well and so now we're seeing in

480
00:17:47,990 --> 00:17:46,240
the habitable zone

481
00:17:50,150 --> 00:17:48,000
of these stars

482
00:17:52,150 --> 00:17:50,160
54 candidates

483
00:17:53,029 --> 00:17:52,160
one of which you can see is smaller than

484
00:17:54,789 --> 00:17:53,039
earth

485
00:17:56,950 --> 00:17:54,799
four of them are somewhat larger than

486
00:17:59,750 --> 00:17:56,960
earth they're super earth-sized we see

487
00:18:01,350 --> 00:17:59,760
many and the jupiter the

488
00:18:02,549 --> 00:18:01,360

the jupiter's and some greater than

489
00:18:04,150 --> 00:18:02,559
jupiter

490
00:18:06,150 --> 00:18:04,160
now that's very rather interesting

491
00:18:07,350 --> 00:18:06,160
jupiter's big enough mass enough so you

492
00:18:09,669 --> 00:18:07,360
could have

493
00:18:11,029 --> 00:18:09,679
earth-like moons orbiting jupiter if

494
00:18:13,350 --> 00:18:11,039
that jupiter that jupiter is in the

495
00:18:15,909 --> 00:18:13,360
habitable zone so those moons are also

496
00:18:18,070 --> 00:18:15,919
in hamilton all the moons

497
00:18:19,830 --> 00:18:18,080
of jupiter of that those jupiters are in

498
00:18:21,510 --> 00:18:19,840
the habitable zone and you can imagine

499
00:18:23,270 --> 00:18:21,520
some of them if they were assigned could

500
00:18:25,590 --> 00:18:23,280
have atmospheres they're close to one

501
00:18:27,909 --> 00:18:25,600
another so for your christmas vacation

502
00:18:29,990 --> 00:18:27,919
you could go from one moon to another

503
00:18:31,750 --> 00:18:30,000
and have a vacation on a different moon

504
00:18:34,950 --> 00:18:31,760
so i'm not saying that happens every day

505
00:18:37,270 --> 00:18:34,960
but it's it's a consi it's conceivable

506
00:18:39,190 --> 00:18:37,280
so habitable lots of habitable zone

507
00:18:41,590 --> 00:18:39,200
candidates here for us to follow up

508
00:18:43,909 --> 00:18:41,600
clearly some area that we will be uh

509
00:18:45,669 --> 00:18:43,919
working very hard in the next months and

510
00:18:48,870 --> 00:18:45,679
years to confirm

511
00:18:52,789 --> 00:18:50,710
one of the great things that happened

512
00:18:54,070 --> 00:18:52,799
earlier this year was the confirmation

513
00:18:57,029 --> 00:18:54,080

of earth

514
00:18:59,190 --> 00:18:57,039
kepler's first rocky planet this rocky

515
00:19:01,669 --> 00:18:59,200
planet is uh

516
00:19:03,430 --> 00:19:01,679
1.4 times the size of the earth

517
00:19:05,430 --> 00:19:03,440
we were able to confirm it we were able

518
00:19:07,669 --> 00:19:05,440
to photometrically detect it get the

519
00:19:09,669 --> 00:19:07,679
period get the epoch but you want to

520
00:19:12,310 --> 00:19:09,679
confirm it you want something some other

521
00:19:15,190 --> 00:19:12,320
method to prove this is indeed a planet

522
00:19:17,029 --> 00:19:15,200
and the radio velocity work here

523
00:19:18,789 --> 00:19:17,039
rather heroic work by a number of team

524
00:19:21,029 --> 00:19:18,799
members at keck and many other

525
00:19:23,750 --> 00:19:21,039
observatories agt nordic optical

526
00:19:26,150 --> 00:19:23,760
telescope the wind telescope

527
00:19:28,310 --> 00:19:26,160
allowed us to confirm this as a rocky

528
00:19:31,190 --> 00:19:28,320
planet get a density

529
00:19:33,110 --> 00:19:31,200
but as we talk about these small planets

530
00:19:36,630 --> 00:19:33,120
the plants we're most interested in the

531
00:19:39,990 --> 00:19:36,640
signal for radial velocity is very small

532
00:19:42,310 --> 00:19:40,000
it takes a lot of time and this is in a

533
00:19:43,590 --> 00:19:42,320
an orbital period of less than one day

534
00:19:45,510 --> 00:19:43,600
it's year

535
00:19:47,510 --> 00:19:45,520
it's less than one day and so that

536
00:19:49,110 --> 00:19:47,520
signal is still fairly large but as we

537
00:19:52,070 --> 00:19:49,120
move further out into larger orbital

538
00:19:53,990 --> 00:19:52,080

periods 30 days 50 days 300 days the

539
00:19:57,110 --> 00:19:54,000
signal gets so small we probably will

540
00:19:59,190 --> 00:19:57,120
not be able to do that for many if any

541
00:20:01,590 --> 00:19:59,200
of these small

542
00:20:03,350 --> 00:20:01,600
rocky plants instead we need a method

543
00:20:05,430 --> 00:20:03,360
that supplements it could i have the

544
00:20:07,909 --> 00:20:05,440
next figure

545
00:20:10,470 --> 00:20:07,919
the supplemental figure as a way of

546
00:20:13,830 --> 00:20:10,480
doing is a method that we have proved uh

547
00:20:15,990 --> 00:20:13,840
works that was released uh the discovery

548
00:20:18,830 --> 00:20:16,000
was released last year and what we have

549
00:20:21,270 --> 00:20:18,840
here is a planetary system with three

550
00:20:23,909 --> 00:20:21,280
planets they orbit the same star they

551
00:20:25,510 --> 00:20:23,919
transit and when these two inner planets

552
00:20:27,750 --> 00:20:25,520
which are fairly close together go by

553
00:20:29,990 --> 00:20:27,760
each other they cause changes in the

554
00:20:31,909 --> 00:20:30,000
orbital period and by seeing when the

555
00:20:35,590 --> 00:20:31,919
transit occurs and that's moving back

556
00:20:37,590 --> 00:20:35,600
and forth we can deduce from the transit

557
00:20:39,909 --> 00:20:37,600
timing changes

558
00:20:41,590 --> 00:20:39,919
the mass of these objects we don't need

559
00:20:43,430 --> 00:20:41,600
radial velocity for this measurement

560
00:20:45,909 --> 00:20:43,440
radium velocity is always helpful but

561
00:20:47,110 --> 00:20:45,919
this case we can get at the masses

562
00:20:50,390 --> 00:20:47,120
very well

563
00:20:52,310 --> 00:20:50,400

by simply watching these these changes

564
00:20:54,070 --> 00:20:52,320
and that means we ought to be able for

565
00:20:56,310 --> 00:20:54,080
at least for some of the earth-sized

566
00:20:57,990 --> 00:20:56,320
planets to get at their masses even if

567
00:20:59,950 --> 00:20:58,000
we can't get it get at them with radio

568
00:21:02,149 --> 00:20:59,960
velocity but what you need is

569
00:21:04,630 --> 00:21:02,159
multi-planet systems they're the most

570
00:21:06,710 --> 00:21:04,640
valuable thing that we we can find and

571
00:21:08,830 --> 00:21:06,720
in fact we now see in the data that we

572
00:21:10,549 --> 00:21:08,840
released

573
00:21:13,990 --> 00:21:10,559
170

574
00:21:16,390 --> 00:21:14,000
stars that have these multi-planet

575
00:21:18,070 --> 00:21:16,400
system candidate systems

576
00:21:20,710 --> 00:21:18,080
sometimes with two sometimes with three

577
00:21:22,149 --> 00:21:20,720
sometimes with four as many as six

578
00:21:23,909 --> 00:21:22,159
transiting

579
00:21:25,830 --> 00:21:23,919
candidates around these and that's going

580
00:21:28,310 --> 00:21:25,840
to be enormously helpful because not

581
00:21:30,630 --> 00:21:28,320
only can we get at masses

582
00:21:32,950 --> 00:21:30,640
we're studying systems of planets like

583
00:21:36,310 --> 00:21:32,960
the solar system not just individual

584
00:21:37,590 --> 00:21:36,320
planets so a great deal of progress and

585
00:21:39,909 --> 00:21:37,600
great deal of

586
00:21:41,590 --> 00:21:39,919
encouragement to detect so many of these

587
00:21:43,110 --> 00:21:41,600
next figure please

588
00:21:46,310 --> 00:21:43,120

this is a summary of course of what we

589
00:21:49,190 --> 00:21:46,320
have found to be explicit we do find we

590
00:21:51,029 --> 00:21:49,200
have released the data to the public at

591
00:21:52,710 --> 00:21:51,039
the space telescope science institute is

592
00:21:55,909 --> 00:21:52,720
to everyone who would like to use it

593
00:21:59,390 --> 00:21:55,919
i'll get at it 150 data for 155 000

594
00:22:02,149 --> 00:21:59,400
stars uh

595
00:22:03,990 --> 00:22:02,159
1035 candidates with each of the

596
00:22:05,590 --> 00:22:04,000
transits

597
00:22:08,310 --> 00:22:05,600
and their properties of this of each of

598
00:22:11,909 --> 00:22:08,320
the stars we

599
00:22:13,149 --> 00:22:11,919
see 68 earth size 288 super earth size

600
00:22:14,710 --> 00:22:13,159
we're seeing

601
00:22:17,909 --> 00:22:14,720
662

602
00:22:20,630 --> 00:22:17,919
neptune size 165 jupiter size

603
00:22:22,549 --> 00:22:20,640
54

604
00:22:25,590 --> 00:22:22,559
candidates in the habitable zones of

605
00:22:28,710 --> 00:22:25,600
their stars and then 170 stars with

606
00:22:30,789 --> 00:22:28,720
these multiple candidate systems

607
00:22:33,029 --> 00:22:30,799
so kepler is making good progress toward

608
00:22:36,789 --> 00:22:33,039
its goals could i have the animation

609
00:22:41,990 --> 00:22:38,870
this is the field of view of kepler on

610
00:22:43,590 --> 00:22:42,000
the sky the 50s represents about the 50

611
00:22:46,390 --> 00:22:43,600
candidates in the habitable zone there's

612
00:22:48,470 --> 00:22:46,400
cygnus the swan and you can imagine

613
00:22:50,789 --> 00:22:48,480

that we found

614
00:22:53,669 --> 00:22:50,799
1200 candidates

615
00:22:55,510 --> 00:22:53,679
in the single field view imagine

616
00:22:57,590 --> 00:22:55,520
that we had that field of view

617
00:23:00,870 --> 00:22:57,600
covering the sky

618
00:23:03,990 --> 00:23:00,880
kepler looks at a 400th the sky

619
00:23:06,830 --> 00:23:04,000
if we had 400 these fields of view we

620
00:23:11,350 --> 00:23:06,840
would see 400 times that number of

621
00:23:13,270 --> 00:23:11,360
candidates we would see 400 000

622
00:23:16,310 --> 00:23:13,280
candidates and what that's telling you

623
00:23:18,870 --> 00:23:16,320
is the stars around us that surround us

624
00:23:21,110 --> 00:23:18,880
have a huge number of planets and

625
00:23:23,270 --> 00:23:21,120
candidates for us to look at and if we

626
00:23:25,350 --> 00:23:23,280
find that earth

627
00:23:27,750 --> 00:23:25,360
are common or science plants are common

628
00:23:30,789 --> 00:23:27,760
inhabitable zone of stars

629
00:23:33,990 --> 00:23:30,799
very likely that means life is common

630
00:23:37,029 --> 00:23:34,000
around these stars and in fact kepler

631
00:23:39,669 --> 00:23:37,039
is the first step there's a step in that

632
00:23:42,789 --> 00:23:39,679
exploit mankind's exploration

633
00:23:44,630 --> 00:23:42,799
of the surrounding galaxy to find

634
00:23:45,990 --> 00:23:44,640
life and the extent of life in our

635
00:23:48,149 --> 00:23:46,000
galaxy

636
00:23:51,909 --> 00:23:48,159
and jack is going to tell us about these

637
00:23:53,590 --> 00:23:51,919
very valuable systems of stars and that

638
00:23:55,990 --> 00:23:53,600

help us understand

639
00:23:57,990 --> 00:23:56,000
where the earths are okay

640
00:24:00,390 --> 00:23:58,000
well thank you bill

641
00:24:01,510 --> 00:24:00,400
so bill mentioned towards the end of his

642
00:24:03,350 --> 00:24:01,520
talk

643
00:24:06,950 --> 00:24:03,360
kepler-9

644
00:24:10,070 --> 00:24:06,960
which is a system with three

645
00:24:12,630 --> 00:24:10,080
confirmed transiting planets

646
00:24:14,630 --> 00:24:12,640
it is the only star

647
00:24:17,430 --> 00:24:14,640
known to have

648
00:24:19,590 --> 00:24:17,440
more than one transiting planet

649
00:24:22,149 --> 00:24:19,600
before today

650
00:24:26,070 --> 00:24:22,159
and transiting planets

651
00:24:29,750 --> 00:24:26,080
are very very valuable because that's

652
00:24:33,350 --> 00:24:29,760
the way we can get the sizes of the

653
00:24:36,390 --> 00:24:33,360
planets and all the other 100 transiting

654
00:24:39,830 --> 00:24:36,400
confirmed planets prior to today

655
00:24:40,789 --> 00:24:39,840
were orbiting one per star kepler-9 had

656
00:24:46,149 --> 00:24:40,799
three

657
00:24:51,830 --> 00:24:48,230
this emphasizes

658
00:24:57,269 --> 00:24:53,430
candidate

659
00:24:58,630 --> 00:24:57,279
multiple planet systems that kepler has

660
00:25:00,549 --> 00:24:58,640
identified

661
00:25:01,669 --> 00:25:00,559
the small dots or the

662
00:25:05,590 --> 00:25:01,679
stars

663
00:25:09,830 --> 00:25:07,110

the

664
00:25:12,310 --> 00:25:09,840
small blue circles

665
00:25:13,830 --> 00:25:12,320
and there are over a hundred of them

666
00:25:15,909 --> 00:25:13,840
are the targets

667
00:25:19,750 --> 00:25:15,919
with two

668
00:25:33,830 --> 00:25:21,110
the

669
00:25:35,029 --> 00:25:33,840
135 red triangles represent

670
00:25:36,870 --> 00:25:35,039
the

671
00:25:37,669 --> 00:25:36,880
45 targets

672
00:25:39,430 --> 00:25:37,679
with

673
00:25:40,710 --> 00:25:39,440
three

674
00:25:43,590 --> 00:25:40,720
transiting

675
00:25:46,630 --> 00:25:43,600
candidates

676
00:25:49,350 --> 00:25:46,640
the 32

677
00:25:50,950 --> 00:25:49,360
pink squares

678
00:25:54,830 --> 00:25:50,960
represent

679
00:25:57,830 --> 00:25:54,840
the candidates around the eight

680
00:26:00,630 --> 00:25:57,840
targets that have four candidates so

681
00:26:03,190 --> 00:26:00,640
we've got a lot of stars with two three

682
00:26:06,149 --> 00:26:03,200
and even four candidates

683
00:26:08,830 --> 00:26:06,159
if you look over towards the lower left

684
00:26:12,950 --> 00:26:08,840
you'll see five

685
00:26:14,310 --> 00:26:12,960
pentagons they represent the five

686
00:26:16,149 --> 00:26:14,320
candidates

687
00:26:18,230 --> 00:26:16,159
around

688
00:26:19,590 --> 00:26:18,240

one star

689
00:26:23,830 --> 00:26:19,600
which has

690
00:26:24,950 --> 00:26:23,840
five transiting planet candidates

691
00:26:27,029 --> 00:26:24,960
but

692
00:26:29,269 --> 00:26:27,039
towards the center and a little off to

693
00:26:32,310 --> 00:26:29,279
the right in the figure representing

694
00:26:33,669 --> 00:26:32,320
mid-sized planets at medium to long

695
00:26:35,190 --> 00:26:33,679
periods

696
00:26:36,950 --> 00:26:35,200
among our sample

697
00:26:40,789 --> 00:26:36,960
that stand out

698
00:26:44,470 --> 00:26:40,799
those green hexagons

699
00:26:47,029 --> 00:26:44,480
the only target that we see

700
00:26:47,909 --> 00:26:47,039
six signals

701
00:26:50,789 --> 00:26:47,919
and

702
00:26:51,669 --> 00:26:50,799
those are no longer

703
00:26:53,430 --> 00:26:51,679
just

704
00:26:54,470 --> 00:26:53,440
candidates

705
00:26:59,190 --> 00:26:54,480
we

706
00:27:01,669 --> 00:26:59,200
have confirmed that all six of them

707
00:27:04,310 --> 00:27:01,679
are indeed planets

708
00:27:08,070 --> 00:27:04,320
orbiting the same star

709
00:27:11,190 --> 00:27:08,080
which we've named kepler-11

710
00:27:12,549 --> 00:27:11,200
now in the next slide this just shows

711
00:27:15,110 --> 00:27:12,559
the position

712
00:27:17,430 --> 00:27:15,120
of kepler-11

713
00:27:21,430 --> 00:27:17,440

this is a sun-like star

714
00:27:24,310 --> 00:27:21,440
it's in the constellation cygnus

715
00:27:25,909 --> 00:27:24,320
it's approximately two thousand light

716
00:27:29,590 --> 00:27:25,919
years from earth

717
00:27:31,590 --> 00:27:29,600
so the light that kepler is seeing

718
00:27:35,269 --> 00:27:31,600
from this star

719
00:27:39,269 --> 00:27:35,279
left the star around the time caesar was

720
00:27:43,909 --> 00:27:43,110
now if we can have the video

721
00:27:48,310 --> 00:27:43,919
this

722
00:27:50,710 --> 00:27:48,320
is a kepler view of the system to begin

723
00:27:52,950 --> 00:27:50,720
we see this target

724
00:27:55,750 --> 00:27:52,960
dimming like clockwork

725
00:27:58,070 --> 00:27:55,760
but like a very special clock

726
00:28:00,070 --> 00:27:58,080
one with six hands

727
00:28:04,230 --> 00:28:00,080
moving at six different rates

728
00:28:05,350 --> 00:28:04,240
and we interpret this as six planets

729
00:28:09,269 --> 00:28:05,360
orbiting

730
00:28:12,070 --> 00:28:09,279
very near the same plane

731
00:28:15,190 --> 00:28:12,080
now looking at it face on and these are

732
00:28:18,230 --> 00:28:15,200
very close in especially the inner five

733
00:28:20,630 --> 00:28:18,240
very close to one another the most

734
00:28:21,590 --> 00:28:20,640
compact

735
00:28:24,310 --> 00:28:21,600
system

736
00:28:27,269 --> 00:28:24,320
of planets ever discovered by any

737
00:28:31,029 --> 00:28:27,279
technique anywhere

738
00:28:33,350 --> 00:28:31,039

so if i can have next slide

739
00:28:35,750 --> 00:28:33,360
we see these planets

740
00:28:36,630 --> 00:28:35,760
on the occasions when they transit the

741
00:28:39,669 --> 00:28:36,640
star

742
00:28:42,950 --> 00:28:39,679
most of the time none are transiting

743
00:28:44,950 --> 00:28:42,960
sometimes one is transiting

744
00:28:47,830 --> 00:28:44,960
occasionally two

745
00:28:50,710 --> 00:28:47,840
and one time last summer

746
00:28:54,470 --> 00:28:50,720
we observed the signature of three

747
00:28:59,190 --> 00:28:54,480
planets transiting at the same time

748
00:29:01,669 --> 00:28:59,200
which is illustrated in this graphic

749
00:29:03,990 --> 00:29:01,679
now i've said that this is a very very

750
00:29:06,789 --> 00:29:04,000
flat planetary system

751
00:29:08,950 --> 00:29:06,799
and it doesn't look so flat

752
00:29:10,870 --> 00:29:08,960
in this graphic

753
00:29:13,029 --> 00:29:10,880
but that's because

754
00:29:15,430 --> 00:29:13,039
the planet orbits

755
00:29:17,510 --> 00:29:15,440
are much much bigger than the size of

756
00:29:20,870 --> 00:29:17,520
the star itself

757
00:29:23,110 --> 00:29:20,880
so although they're not exactly in the

758
00:29:24,470 --> 00:29:23,120
same plane when they go in front of the

759
00:29:27,269 --> 00:29:24,480
star they look

760
00:29:28,549 --> 00:29:27,279
very similar to in the same plane

761
00:29:30,870 --> 00:29:28,559
and in fact

762
00:29:34,149 --> 00:29:30,880
if we had a scale model

763
00:29:36,950 --> 00:29:34,159

of just the inner five closely spaced

764
00:29:39,669 --> 00:29:36,960
planets around this star

765
00:29:43,669 --> 00:29:39,679
it would be as flat

766
00:29:49,909 --> 00:29:46,389
now the sixth planet

767
00:29:52,630 --> 00:29:49,919
is orbiting significantly farther out

768
00:29:54,549 --> 00:29:52,640
so if we had a scale model that included

769
00:29:55,990 --> 00:29:54,559
the six planets

770
00:29:59,430 --> 00:29:56,000
had to go

771
00:30:00,710 --> 00:29:59,440
into the attic to find this

772
00:30:06,149 --> 00:30:00,720
it would be

773
00:30:09,830 --> 00:30:08,389
so let's move on to the next slide

774
00:30:12,070 --> 00:30:09,840
please

775
00:30:16,389 --> 00:30:12,080
and this shows

776
00:30:18,870 --> 00:30:16,399
the kepler-11 system at the same scale

777
00:30:20,310 --> 00:30:18,880
as the inner part of our own solar

778
00:30:23,029 --> 00:30:20,320
system

779
00:30:25,430 --> 00:30:23,039
so the five inner planets the ones that

780
00:30:27,909 --> 00:30:25,440
are closely spaced to one another are

781
00:30:30,870 --> 00:30:27,919
all closer to the star

782
00:30:35,430 --> 00:30:30,880
than any planet is to our sun

783
00:30:37,909 --> 00:30:35,440
this despite the fact that these planets

784
00:30:39,430 --> 00:30:37,919
are well they're not huge they're not

785
00:30:41,430 --> 00:30:39,440
jupiter size

786
00:30:42,710 --> 00:30:41,440
but they're not tiny either they range

787
00:30:46,230 --> 00:30:42,720
in size

788
00:30:48,549 --> 00:30:46,240

from about twice the radius of the earth

789
00:30:51,510 --> 00:30:48,559
to a bit over four times the radius of

790
00:30:53,909 --> 00:30:51,520
the earth and then that sixth planet

791
00:30:55,909 --> 00:30:53,919
it's a little farther out but if it were

792
00:30:57,509 --> 00:30:55,919
placed in our own solar system it would

793
00:31:01,750 --> 00:30:57,519
be between the orbits of the two

794
00:31:03,190 --> 00:31:01,760
innermost planets mercury and venus

795
00:31:05,750 --> 00:31:03,200
well i've been focusing i've been

796
00:31:07,669 --> 00:31:05,760
talking about this as a system and it is

797
00:31:10,310 --> 00:31:07,679
an amazing system

798
00:31:13,190 --> 00:31:10,320
these planets are close in we never

799
00:31:16,310 --> 00:31:13,200
thought we'd see this many planets that

800
00:31:19,590 --> 00:31:16,320
aren't real real tiny

801
00:31:21,029 --> 00:31:19,600
this close to one another

802
00:31:22,630 --> 00:31:21,039
and the fact that they're close to one

803
00:31:24,470 --> 00:31:22,640
another

804
00:31:26,710 --> 00:31:24,480
means that they're tugging on each

805
00:31:29,190 --> 00:31:26,720
other's orbits

806
00:31:31,110 --> 00:31:29,200
and we use the same technique that we

807
00:31:33,669 --> 00:31:31,120
use to measure the masses of two of the

808
00:31:34,950 --> 00:31:33,679
planets around kepler-9

809
00:31:37,190 --> 00:31:34,960
to measure

810
00:31:39,590 --> 00:31:37,200
the masses of five

811
00:31:42,389 --> 00:31:39,600
these five inner planets

812
00:31:45,590 --> 00:31:42,399
in the kepler-11 system and if i could

813
00:31:47,590 --> 00:31:45,600

have my next slide

814
00:31:51,110 --> 00:31:47,600
this diagram is a little more

815
00:31:53,509 --> 00:31:51,120
complicated but it's really important

816
00:31:56,710 --> 00:31:53,519
so what we have here

817
00:31:58,070 --> 00:31:56,720
on the vertical axis is the size of the

818
00:32:00,470 --> 00:31:58,080
planet

819
00:32:02,070 --> 00:32:00,480
and on the horizontal axis

820
00:32:03,029 --> 00:32:02,080
the mass

821
00:32:06,149 --> 00:32:03,039
we've

822
00:32:09,350 --> 00:32:06,159
observed the size by the amount

823
00:32:13,190 --> 00:32:09,360
of dimming that each planet causes when

824
00:32:16,389 --> 00:32:13,200
it transits in front of its star

825
00:32:19,830 --> 00:32:16,399
we measured the masses we've weighed in

826
00:32:21,990 --> 00:32:19,840
other words the inner five bodies by the

827
00:32:25,029 --> 00:32:22,000
amount that they

828
00:32:27,990 --> 00:32:25,039
tug on one another's orbit

829
00:32:30,950 --> 00:32:28,000
retarding or advancing the transit times

830
00:32:33,750 --> 00:32:30,960
of each other by 10 or 20 minutes

831
00:32:35,029 --> 00:32:33,760
relative to their orbital periods which

832
00:32:38,630 --> 00:32:35,039
are between

833
00:32:42,630 --> 00:32:38,640
10 and 47 days

834
00:32:43,669 --> 00:32:42,640
now we estimate the planetary radii

835
00:32:45,190 --> 00:32:43,679
and

836
00:32:50,870 --> 00:32:45,200
we're not exact

837
00:32:51,669 --> 00:32:50,880
the radius relative to the star very

838
00:32:53,430 --> 00:32:51,679

well

839
00:32:56,230 --> 00:32:53,440
but we have a little uncertainty in the

840
00:32:59,190 --> 00:32:56,240
radius of the star

841
00:33:01,029 --> 00:32:59,200
in terms of the masses of the planets

842
00:33:02,230 --> 00:33:01,039
we have an estimate by the amount they

843
00:33:05,350 --> 00:33:02,240
tug

844
00:33:07,909 --> 00:33:05,360
but these are very small variations

845
00:33:11,190 --> 00:33:07,919
so there's a bit of an uncertainty

846
00:33:13,830 --> 00:33:11,200
so these ellipses for the extrasolar

847
00:33:17,430 --> 00:33:13,840
planets both the five

848
00:33:18,310 --> 00:33:17,440
that around kepler-11

849
00:33:23,350 --> 00:33:18,320
that

850
00:33:25,269 --> 00:33:23,360
by the letters which designate the

851
00:33:28,230 --> 00:33:25,279
particular planets

852
00:33:30,470 --> 00:33:28,240
and the three around other stars

853
00:33:32,389 --> 00:33:30,480
which are ellipses of a different color

854
00:33:35,269 --> 00:33:32,399
have some uncertainty cover a different

855
00:33:39,430 --> 00:33:36,470
but

856
00:33:41,830 --> 00:33:39,440
they still constrain

857
00:33:44,789 --> 00:33:41,840
both the mass and the size of these

858
00:33:48,310 --> 00:33:44,799
stars and you as planets excuse me mass

859
00:33:50,950 --> 00:33:49,830
we compare them

860
00:33:53,750 --> 00:33:50,960
to

861
00:33:56,549 --> 00:33:53,760
four of the planets most like them

862
00:33:58,149 --> 00:33:56,559
in our solar system venus and earth on

863
00:34:00,870 --> 00:33:58,159

the small side

864
00:34:04,870 --> 00:34:00,880
and uranus neptune on the large side

865
00:34:07,110 --> 00:34:04,880
these are intermediate class of planets

866
00:34:09,990 --> 00:34:07,120
and of these

867
00:34:11,589 --> 00:34:10,000
eight that we have that we know in this

868
00:34:12,950 --> 00:34:11,599
range

869
00:34:16,310 --> 00:34:12,960
five

870
00:34:19,829 --> 00:34:17,510
the star

871
00:34:23,909 --> 00:34:19,839
that we call kepler-11 they're the ones

872
00:34:28,069 --> 00:34:24,869
and that

873
00:34:33,750 --> 00:34:29,030
is

874
00:34:36,710 --> 00:34:33,760
announced last month and bill mentioned

875
00:34:39,109 --> 00:34:36,720
as a rocky planet

876
00:34:41,510 --> 00:34:39,119
now the ones that we found

877
00:34:45,589 --> 00:34:41,520
in kepler-11 that we're announcing today

878
00:34:48,149 --> 00:34:45,599
they're all higher up on this graph

879
00:34:50,710 --> 00:34:48,159
than that rocky planet the rocky planet

880
00:34:53,510 --> 00:34:50,720
is really really really close to its

881
00:34:55,430 --> 00:34:53,520
star and really hot

882
00:34:58,069 --> 00:34:55,440
these planets are kind of close to their

883
00:35:00,630 --> 00:34:58,079
star and they're warm but not nearly as

884
00:35:03,829 --> 00:35:02,870
and we find that these are

885
00:35:05,910 --> 00:35:03,839
bigger

886
00:35:09,190 --> 00:35:05,920
for the same amount of mass

887
00:35:10,790 --> 00:35:09,200
which means they must be made of lighter

888
00:35:14,710 --> 00:35:10,800

material

889
00:35:18,550 --> 00:35:14,720
they're not super earths they're not big

890
00:35:22,310 --> 00:35:20,790
the innermost two

891
00:35:25,190 --> 00:35:22,320
c and b

892
00:35:26,710 --> 00:35:25,200
they might be mixtures

893
00:35:27,910 --> 00:35:26,720
of rock

894
00:35:30,550 --> 00:35:27,920
and water

895
00:35:31,750 --> 00:35:30,560
or they might be mixtures of rock water

896
00:35:37,510 --> 00:35:31,760
and gas

897
00:35:39,349 --> 00:35:37,520
but we know the three more distant of

898
00:35:42,790 --> 00:35:39,359
this fivesome

899
00:35:45,030 --> 00:35:42,800
called d e and f on this graph

900
00:35:46,470 --> 00:35:45,040
are so big

901
00:35:48,950 --> 00:35:46,480
for their mass

902
00:35:51,030 --> 00:35:48,960
this substantial fraction of their

903
00:35:52,710 --> 00:35:51,040
volume must be

904
00:35:54,390 --> 00:35:52,720
made of the two

905
00:35:57,510 --> 00:35:54,400
lightest elements

906
00:36:02,230 --> 00:35:57,520
hydrogen and helium gases

907
00:36:05,670 --> 00:36:02,240
so not only is kepler 11 telling us

908
00:36:09,510 --> 00:36:05,680
about planetary systems

909
00:36:11,829 --> 00:36:09,520
of a type that we had no idea existed

910
00:36:15,990 --> 00:36:11,839
but right now

911
00:36:17,030 --> 00:36:16,000
it's providing our best clues

912
00:36:22,950 --> 00:36:17,040
on

913
00:36:26,790 --> 00:36:22,960

individual worlds

914
00:36:27,750 --> 00:36:26,800
so if we can move on to my next slide

915
00:36:30,710 --> 00:36:27,760
this

916
00:36:34,069 --> 00:36:30,720
is the family portrait

917
00:36:36,470 --> 00:36:34,079
and we see the cousins that were found

918
00:36:40,870 --> 00:36:36,480
previously and bill showed you in his

919
00:36:44,069 --> 00:36:40,880
earlier slide on the top two row and the

920
00:36:46,630 --> 00:36:44,079
new set of six siblings in the family

921
00:36:48,790 --> 00:36:46,640
the long lost cousins that we found

922
00:36:52,310 --> 00:36:48,800
today and are announcing today

923
00:36:53,750 --> 00:36:52,320
around kepler 11 in the bottom row

924
00:36:56,069 --> 00:36:53,760
so if we can go

925
00:36:59,270 --> 00:36:56,079
to the next slide

926
00:37:01,829 --> 00:37:00,310
kepler

927
00:37:03,670 --> 00:37:01,839
11

928
00:37:04,710 --> 00:37:03,680
is a surprisingly

929
00:37:06,950 --> 00:37:04,720
flat

930
00:37:10,150 --> 00:37:06,960
and compact system

931
00:37:13,190 --> 00:37:10,160
of six transiting planets

932
00:37:16,870 --> 00:37:13,200
the five inner planets

933
00:37:18,069 --> 00:37:16,880
are especially close together

934
00:37:20,950 --> 00:37:18,079
something that

935
00:37:23,030 --> 00:37:20,960
we didn't think would happen for worlds

936
00:37:25,750 --> 00:37:23,040
of this size

937
00:37:29,430 --> 00:37:25,760
and really forces us

938
00:37:34,230 --> 00:37:29,440

to go back and look at formation models

939
00:37:40,230 --> 00:37:37,190
and it also means that the planets are

940
00:37:41,829 --> 00:37:40,240
perturbing one another

941
00:37:43,109 --> 00:37:41,839
significantly enough that we can weigh

942
00:37:44,710 --> 00:37:43,119
the planets

943
00:37:47,190 --> 00:37:44,720
we find out

944
00:37:49,030 --> 00:37:47,200
that they're low density

945
00:37:51,270 --> 00:37:49,040
they're fluffy

946
00:37:54,710 --> 00:37:51,280
they're sort of like

947
00:37:57,750 --> 00:37:54,720
marshmallows but they're not all gas

948
00:38:00,550 --> 00:37:57,760
they got to have something a little

949
00:38:06,470 --> 00:38:00,560
heavier there so maybe a marshmallow

950
00:38:09,670 --> 00:38:08,310
now

951
00:38:12,390 --> 00:38:09,680
we really

952
00:38:13,670 --> 00:38:12,400
were just amazed

953
00:38:14,870 --> 00:38:13,680
at this

954
00:38:18,069 --> 00:38:14,880
gift

955
00:38:20,790 --> 00:38:18,079
that nature not the magazine

956
00:38:23,109 --> 00:38:20,800
but with a capital n

957
00:38:25,030 --> 00:38:23,119
has given us

958
00:38:25,990 --> 00:38:25,040
and

959
00:38:27,030 --> 00:38:26,000
with

960
00:38:30,150 --> 00:38:27,040
six

961
00:38:31,589 --> 00:38:30,160
transiting planets five so close to

962
00:38:34,150 --> 00:38:31,599
their star

963
00:38:35,349 --> 00:38:34,160

and getting the size and masses of these

964
00:38:38,310 --> 00:38:35,359
five

965
00:38:39,990 --> 00:38:38,320
fairly small worlds

966
00:38:41,829 --> 00:38:40,000
there's only

967
00:38:44,470 --> 00:38:41,839
one word

968
00:38:47,910 --> 00:38:44,480
that i can think of

969
00:38:51,829 --> 00:38:47,920
that adequately describes the new

970
00:38:58,390 --> 00:38:55,510
the kepler 11 system

971
00:38:59,190 --> 00:38:58,400
of six transiting planets

972
00:39:03,910 --> 00:38:59,200
is

973
00:39:08,550 --> 00:39:05,990
and with that

974
00:39:12,069 --> 00:39:08,560
i'll hand things over to debra

975
00:39:14,150 --> 00:39:12,079
we'll give you the outside expert's view

976
00:39:16,069 --> 00:39:14,160
on what we've been announcing today

977
00:39:18,550 --> 00:39:16,079
thank you

978
00:39:21,670 --> 00:39:18,560
well uh folks this of course is an

979
00:39:24,710 --> 00:39:21,680
amazing era of discovery for astronomy

980
00:39:25,990 --> 00:39:24,720
but for exoplanets in particular

981
00:39:28,550 --> 00:39:26,000
and

982
00:39:30,710 --> 00:39:28,560
there's no doubt that the search for

983
00:39:33,109 --> 00:39:30,720
planets is motivated by a search for

984
00:39:35,510 --> 00:39:33,119
life humans are interested in whether or

985
00:39:37,589 --> 00:39:35,520
not life evolves on other planets we'd

986
00:39:39,990 --> 00:39:37,599
especially like to find communicating

987
00:39:42,230 --> 00:39:40,000
technological life and we look around

988
00:39:44,150 --> 00:39:42,240

our own solar system and we see that of

989
00:39:47,109 --> 00:39:44,160
all the planets there's only one that's

990
00:39:49,750 --> 00:39:47,119
inhabited and so naturally we think that

991
00:39:52,870 --> 00:39:49,760
finding another earth-like planet is you

992
00:39:55,990 --> 00:39:52,880
know find identifying a site that's at

993
00:39:57,430 --> 00:39:56,000
least friendly here for the evolution of

994
00:40:00,230 --> 00:39:57,440
life

995
00:40:02,550 --> 00:40:00,240
so the mission the primary goal of

996
00:40:05,910 --> 00:40:02,560
kepler mission was to statistically

997
00:40:07,829 --> 00:40:05,920
assess the occurrence of these small

998
00:40:10,790 --> 00:40:07,839
terrestrial worlds

999
00:40:13,030 --> 00:40:10,800
and i remember in march of 2009 when i

1000
00:40:15,109 --> 00:40:13,040
was here when uh right after the kepler

1001
00:40:17,910 --> 00:40:15,119
mission launched and i remember

1002
00:40:20,550 --> 00:40:17,920
commenting that uh the planets would

1003
00:40:23,270 --> 00:40:20,560
begin to roll out of the kepler mission

1004
00:40:25,910 --> 00:40:23,280
uh like an assembly line and then in the

1005
00:40:28,630 --> 00:40:25,920
first year we could expect to see jovian

1006
00:40:30,630 --> 00:40:28,640
mass planets or jovian sized planets and

1007
00:40:33,190 --> 00:40:30,640
after two or three years we'd see the

1008
00:40:35,109 --> 00:40:33,200
neptunes begin to roll out and then

1009
00:40:37,670 --> 00:40:35,119
finally the earth

1010
00:40:39,990 --> 00:40:37,680
so i'm amazed to sit here today and see

1011
00:40:42,069 --> 00:40:40,000
that kepler is actually reaching the

1012
00:40:45,589 --> 00:40:42,079
milestone discoveries

1013
00:40:47,190 --> 00:40:45,599

faster certainly than i anticipated

1014
00:40:49,030 --> 00:40:47,200
kepler has blown the lid off of

1015
00:40:51,589 --> 00:40:49,040
everything that we know about extrasolar

1016
00:40:53,589 --> 00:40:51,599
planets and this week to me feels very

1017
00:40:55,990 --> 00:40:53,599
different than last week did and i'll

1018
00:40:58,309 --> 00:40:56,000
tell you summarize actually the three

1019
00:41:00,470 --> 00:40:58,319
reasons that i say that

1020
00:41:01,750 --> 00:41:00,480
so first of all from the doppler planet

1021
00:41:04,390 --> 00:41:01,760
searches

1022
00:41:07,030 --> 00:41:04,400
we could see that the gas giant planets

1023
00:41:08,710 --> 00:41:07,040
like jupiter were less common than the

1024
00:41:11,510 --> 00:41:08,720
low mass planets we could see a

1025
00:41:13,589 --> 00:41:11,520
mountainous sort of rise towards smaller

1026
00:41:14,950 --> 00:41:13,599
and smaller or lower and lower mass

1027
00:41:17,030 --> 00:41:14,960
planets

1028
00:41:19,990 --> 00:41:17,040
but our detection technique was hitting

1029
00:41:22,150 --> 00:41:20,000
a wall just because of the precision of

1030
00:41:24,150 --> 00:41:22,160
our measurements and so we were at the

1031
00:41:26,710 --> 00:41:24,160
point we were pounding away right now on

1032
00:41:28,950 --> 00:41:26,720
this wall trying to shake out a few uh

1033
00:41:30,550 --> 00:41:28,960
planets that are you know two three four

1034
00:41:32,870 --> 00:41:30,560
five times the mass of the earth the

1035
00:41:34,470 --> 00:41:32,880
super earth regime but our statistics

1036
00:41:36,790 --> 00:41:34,480
there are not so good

1037
00:41:39,910 --> 00:41:36,800
and so what kepler has done is it's

1038
00:41:42,550 --> 00:41:39,920

extended a bridge that crosses this gap

1039
00:41:44,230 --> 00:41:42,560
in our knowledge of what kind of small

1040
00:41:46,710 --> 00:41:44,240
planets form

1041
00:41:48,870 --> 00:41:46,720
still the amazing thing to remember is

1042
00:41:50,710 --> 00:41:48,880
that the detection of large planets or

1043
00:41:52,870 --> 00:41:50,720
massive planets is always going to be

1044
00:41:55,270 --> 00:41:52,880
easier than the detection of the small

1045
00:41:57,910 --> 00:41:55,280
guys and so what that means is that the

1046
00:42:01,990 --> 00:41:57,920
statistics that kepler has gained even

1047
00:42:04,470 --> 00:42:02,000
on the exoplanet candidates okay maybe

1048
00:42:06,630 --> 00:42:04,480
20 percent of the candidates won't pan

1049
00:42:09,270 --> 00:42:06,640
out but statistically

1050
00:42:11,910 --> 00:42:09,280
we can see that the we understand the

1051
00:42:14,550 --> 00:42:11,920
fraction the rate of occurrence of the

1052
00:42:17,030 --> 00:42:14,560
mass of planets from jupiter i think all

1053
00:42:18,630 --> 00:42:17,040
the way down to neptune actually

1054
00:42:20,790 --> 00:42:18,640
those numbers are solid we can take

1055
00:42:23,670 --> 00:42:20,800
those numbers to the bank that's pretty

1056
00:42:26,870 --> 00:42:23,680
amazing uh it's impressive right that

1057
00:42:29,670 --> 00:42:26,880
the number of small planets is growing

1058
00:42:32,150 --> 00:42:29,680
in a region a parameter space that

1059
00:42:34,790 --> 00:42:32,160
theoreticians actually predicted uh

1060
00:42:37,270 --> 00:42:34,800
might be a planet desert

1061
00:42:40,630 --> 00:42:37,280
the second amazing thing is that it's

1062
00:42:43,589 --> 00:42:40,640
really difficult to untangle the signals

1063
00:42:46,309 --> 00:42:43,599

from multiple planet systems

1064
00:42:48,710 --> 00:42:46,319
so it's uh worth re-emphasizing that

1065
00:42:52,309 --> 00:42:48,720
kepler now shows that something like

1066
00:42:54,470 --> 00:42:52,319
almost one in five of their transiting

1067
00:42:57,589 --> 00:42:54,480
of their stars with transiting planets

1068
00:43:00,069 --> 00:42:57,599
hosts at least one other planet

1069
00:43:03,349 --> 00:43:00,079
and kepler 11 which was just presented

1070
00:43:06,470 --> 00:43:03,359
by jack lessauer today is an absolutely

1071
00:43:08,870 --> 00:43:06,480
uh staggering uh result with five

1072
00:43:11,510 --> 00:43:08,880
low-mass planets in the system

1073
00:43:14,390 --> 00:43:11,520
this discovery is as momentous as 51

1074
00:43:16,870 --> 00:43:14,400
pagues in in 1995.

1075
00:43:19,990 --> 00:43:16,880
it shows that planetary systems with

1076
00:43:22,390 --> 00:43:20,000
several small planets like our own

1077
00:43:23,910 --> 00:43:22,400
seem to be common

1078
00:43:25,910 --> 00:43:23,920
and then the third point is that

1079
00:43:28,470 --> 00:43:25,920
kepler's really reaching out into a

1080
00:43:30,150 --> 00:43:28,480
different part of the milky way galaxy

1081
00:43:33,109 --> 00:43:30,160
than we're observing with the doppler

1082
00:43:34,710 --> 00:43:33,119
technique our own nearby neighborhood

1083
00:43:37,349 --> 00:43:34,720
and i think it shows us that the

1084
00:43:39,990 --> 00:43:37,359
adjacent neighborhoods in the galaxy

1085
00:43:41,829 --> 00:43:40,000
looked a lot like our own neighborhood

1086
00:43:43,550 --> 00:43:41,839
and so i think that's encouraging and

1087
00:43:45,910 --> 00:43:43,560
important if we're trying to make

1088
00:43:48,390 --> 00:43:45,920

extrapolations about the formation of

1089
00:43:49,670 --> 00:43:48,400
planets elsewhere and perhaps

1090
00:43:52,069 --> 00:43:49,680
life

1091
00:43:53,109 --> 00:43:52,079
so i can also actually provide some

1092
00:43:55,349 --> 00:43:53,119
insight

1093
00:43:56,790 --> 00:43:55,359
about the enthusiasm of the public for

1094
00:43:59,109 --> 00:43:56,800
the kepler data

1095
00:44:01,349 --> 00:43:59,119
at yale university we were so excited

1096
00:44:03,589 --> 00:44:01,359
when we saw the kepler light curves that

1097
00:44:07,750 --> 00:44:03,599
we teamed up with the citizen science

1098
00:44:10,230 --> 00:44:07,760
alliance who host milky way galaxy zoo

1099
00:44:12,309 --> 00:44:10,240
among others universe projects

1100
00:44:16,790 --> 00:44:12,319
to let the public participate in

1101
00:44:19,030 --> 00:44:16,800
discovering planets at planethunters.org

1102
00:44:20,790 --> 00:44:19,040
when we started the project we discussed

1103
00:44:22,950 --> 00:44:20,800
it among ourselves and we really thought

1104
00:44:25,910 --> 00:44:22,960
there was about a 50 50 chance that this

1105
00:44:28,390 --> 00:44:25,920
project would completely flop because

1106
00:44:29,910 --> 00:44:28,400
uh you know galaxy zoo shows beautiful

1107
00:44:32,550 --> 00:44:29,920
pictures that people get to look at

1108
00:44:34,630 --> 00:44:32,560
we're showing time series brightness

1109
00:44:37,910 --> 00:44:34,640
measurements of stars

1110
00:44:41,510 --> 00:44:37,920
but in just a few uh short weeks we have

1111
00:44:43,589 --> 00:44:41,520
over 16 000 dedicated users and they

1112
00:44:46,630 --> 00:44:43,599
send their greetings to us from turkey

1113
00:44:49,750 --> 00:44:46,640

russia poland spain the canary islands

1114
00:44:52,710 --> 00:44:49,760
italy brazil argentina chile you know

1115
00:44:55,030 --> 00:44:52,720
one country after another it's amazing

1116
00:44:57,510 --> 00:44:55,040
the users have made more than 1.3

1117
00:45:00,390 --> 00:44:57,520
million classifications just using the

1118
00:45:02,950 --> 00:45:00,400
first release of 35 days of public

1119
00:45:05,829 --> 00:45:02,960
release data they've they've identified

1120
00:45:08,550 --> 00:45:05,839
hundreds of uh solid transiting planet

1121
00:45:10,710 --> 00:45:08,560
candidates and eclipsing binary systems

1122
00:45:12,309 --> 00:45:10,720
um that weren't published before so of

1123
00:45:14,550 --> 00:45:12,319
course they're very eager now to see the

1124
00:45:16,710 --> 00:45:14,560
list that will be coming out and see if

1125
00:45:19,589 --> 00:45:16,720
they have any matches

1126
00:45:22,150 --> 00:45:19,599
we're really excited and appreciative

1127
00:45:25,349 --> 00:45:22,160
that 12 hours ago nasa and the kepler

1128
00:45:27,990 --> 00:45:25,359
mission has poured um essentially

1129
00:45:28,950 --> 00:45:28,000
quadrupled the amount of public release

1130
00:45:30,950 --> 00:45:28,960
data

1131
00:45:33,430 --> 00:45:30,960
into the archive on an accelerated

1132
00:45:34,950 --> 00:45:33,440
schedule this is this is really

1133
00:45:37,109 --> 00:45:34,960
wonderful

1134
00:45:39,030 --> 00:45:37,119
at planethunters.org we hear from

1135
00:45:41,270 --> 00:45:39,040
teachers who are using

1136
00:45:43,270 --> 00:45:41,280
kepler data through the planet hunter

1137
00:45:44,870 --> 00:45:43,280
interface and their school curriculum

1138
00:45:47,190 --> 00:45:44,880

from students who are having fun

1139
00:45:48,790 --> 00:45:47,200
searching for this needle in a haystack

1140
00:45:51,750 --> 00:45:48,800
just because they know the payoff is

1141
00:45:54,630 --> 00:45:51,760
going to be so enormous i had one of the

1142
00:45:56,950 --> 00:45:54,640
planet hunters email me yesterday and he

1143
00:45:58,950 --> 00:45:56,960
or she said you know that they had found

1144
00:46:02,150 --> 00:45:58,960
four transiting planets and they felt so

1145
00:46:03,750 --> 00:46:02,160
proud and another person commented that

1146
00:46:05,190 --> 00:46:03,760
they were going back to school now that

1147
00:46:06,630 --> 00:46:05,200
they'd seen the data and they wanted to

1148
00:46:07,750 --> 00:46:06,640
learn more and they were returning to

1149
00:46:10,150 --> 00:46:07,760
school

1150
00:46:12,150 --> 00:46:10,160
but really the dominant recurring theme

1151
00:46:13,910 --> 00:46:12,160
that we hear from the public is that

1152
00:46:16,230 --> 00:46:13,920
they're excited because they get to

1153
00:46:18,230 --> 00:46:16,240
contribute to real research and they

1154
00:46:20,390 --> 00:46:18,240
have a sense that they're a part of

1155
00:46:23,910 --> 00:46:20,400
history they understand the importance

1156
00:46:26,630 --> 00:46:23,920
of the kepler data and i i want to just

1157
00:46:28,950 --> 00:46:26,640
uh echo that and say that also i feel

1158
00:46:31,270 --> 00:46:28,960
this is an incredible historic moment

1159
00:46:33,270 --> 00:46:31,280
and just want to thank the entire kepler

1160
00:46:35,030 --> 00:46:33,280
team for this treasure chest of data

1161
00:46:38,069 --> 00:46:35,040
that they provided

1162
00:46:39,589 --> 00:46:38,079
so back to trent thanks very much debra

1163
00:46:41,349 --> 00:46:39,599

okay let's jump into the question and

1164
00:46:42,870 --> 00:46:41,359
answer session uh just a reminder for

1165
00:46:44,069 --> 00:46:42,880
everyone in the audience to uh please

1166
00:46:45,270 --> 00:46:44,079
just wait until we get a microphone to

1167
00:46:47,109 --> 00:46:45,280
you there should be two running on

1168
00:46:49,190 --> 00:46:47,119
either side uh and please identify

1169
00:46:50,710 --> 00:46:49,200
yourself in your media affiliation uh

1170
00:46:52,870 --> 00:46:50,720
before you ask your question

1171
00:46:54,390 --> 00:46:52,880
um for everyone online please

1172
00:46:56,870 --> 00:46:54,400
try to direct your question at least to

1173
00:46:58,230 --> 00:46:56,880
a panelist to help avoid some confusion

1174
00:46:59,750 --> 00:46:58,240
and for those joining by phone you can

1175
00:47:02,069 --> 00:46:59,760
signal the operator you have a question

1176
00:47:03,589 --> 00:47:02,079
by pushing the star one keys on your

1177
00:47:05,190 --> 00:47:03,599
telephone and i understand we have one

1178
00:47:07,589 --> 00:47:05,200
question here in the audience

1179
00:47:09,109 --> 00:47:07,599
yes randy shostak reporter with eos the

1180
00:47:10,390 --> 00:47:09,119
newspaper of the american geophysical

1181
00:47:12,870 --> 00:47:10,400
union

1182
00:47:14,710 --> 00:47:12,880
fantastic results i wonder if

1183
00:47:17,190 --> 00:47:14,720
panelists can comment on how these

1184
00:47:19,190 --> 00:47:17,200
results might influence the emerging

1185
00:47:21,750 --> 00:47:19,200
research efforts

1186
00:47:26,950 --> 00:47:21,760
for instance change what researchers are

1187
00:47:32,390 --> 00:47:29,990
i'd be happy to answer that one

1188
00:47:34,790 --> 00:47:32,400

basically one of the things that we

1189
00:47:37,510 --> 00:47:34,800
are doing is determining these

1190
00:47:40,069 --> 00:47:37,520
frequencies how many around how many

1191
00:47:42,230 --> 00:47:40,079
stars what type of stars because there

1192
00:47:44,630 --> 00:47:42,240
will be follow-on missions

1193
00:47:46,790 --> 00:47:44,640
and follow-on missions need this kind of

1194
00:47:49,190 --> 00:47:46,800
information for their design there are a

1195
00:47:51,190 --> 00:47:49,200
couple of designs out there one is a is

1196
00:47:53,430 --> 00:47:51,200
a chronographic kind of approach another

1197
00:47:55,670 --> 00:47:53,440
one is a big interferometer and they

1198
00:47:58,069 --> 00:47:55,680
have different areas of

1199
00:47:59,670 --> 00:47:58,079
application and so one of the things

1200
00:48:01,349 --> 00:47:59,680
that we're doing in some sense is

1201
00:48:03,030 --> 00:48:01,359
providing information

1202
00:48:05,190 --> 00:48:03,040
required for the future missions that

1203
00:48:07,510 --> 00:48:05,200
will go out and find the planet's

1204
00:48:10,549 --> 00:48:07,520
nearest in the nearest stars as well as

1205
00:48:12,870 --> 00:48:10,559
going out and finding the composition of

1206
00:48:14,549 --> 00:48:12,880
the atmospheres of these planets and

1207
00:48:18,710 --> 00:48:14,559
that is another step toward our

1208
00:48:24,309 --> 00:48:20,549
let me just do a quick check for

1209
00:48:28,309 --> 00:48:26,230
hello i'm paul workman with canadian

1210
00:48:29,510 --> 00:48:28,319
television and a general question first

1211
00:48:30,950 --> 00:48:29,520
of all how much does this bring us

1212
00:48:32,710 --> 00:48:30,960
closer to um

1213
00:48:34,710 --> 00:48:32,720

discovering whether there's alien life

1214
00:48:37,109 --> 00:48:34,720
and second how do you now find out if

1215
00:48:41,349 --> 00:48:37,119
the five planets in the habitable zone

1216
00:48:43,910 --> 00:48:42,470
patience

1217
00:48:46,630 --> 00:48:43,920
that's how it's done

1218
00:48:48,950 --> 00:48:46,640
and lots of money

1219
00:48:51,670 --> 00:48:48,960
that's reality uh this mission is

1220
00:48:54,230 --> 00:48:51,680
designed to do something and do it as

1221
00:48:56,309 --> 00:48:54,240
well as can be for this first step it

1222
00:48:59,030 --> 00:48:56,319
finds the frequency of these objects

1223
00:49:01,910 --> 00:48:59,040
these planets and their distribution

1224
00:49:03,829 --> 00:49:01,920
but you must do the other steps you must

1225
00:49:05,270 --> 00:49:03,839
in some sense build the cathedral the

1226
00:49:06,950 --> 00:49:05,280
first generation is going to build a

1227
00:49:08,710 --> 00:49:06,960
foundation the next generation's going

1228
00:49:09,990 --> 00:49:08,720
to build the walls third generation can

1229
00:49:11,829 --> 00:49:10,000
put the ceiling and the fourth

1230
00:49:13,030 --> 00:49:11,839
generation is going to enjoy it and so

1231
00:49:15,109 --> 00:49:13,040
we are in some sense the first

1232
00:49:17,030 --> 00:49:15,119
generation we're finding them the second

1233
00:49:19,910 --> 00:49:17,040
generation is going to build instruments

1234
00:49:23,030 --> 00:49:19,920
of far more complexity than what we have

1235
00:49:24,870 --> 00:49:23,040
to go and find these nearby ones and

1236
00:49:27,430 --> 00:49:24,880
even greater demands are going to be

1237
00:49:29,910 --> 00:49:27,440
made to find the atmospheres on these

1238
00:49:31,510 --> 00:49:29,920

planets and then of course having done

1239
00:49:33,109 --> 00:49:31,520
that our grandchildren will have to

1240
00:49:35,349 --> 00:49:33,119
decide what's the next step do they want

1241
00:49:38,790 --> 00:49:35,359
to go there send a robot a robotic

1242
00:49:40,390 --> 00:49:38,800
system there so this is only one step

1243
00:49:43,750 --> 00:49:40,400
it's an important step but there are

1244
00:49:47,349 --> 00:49:45,510
great i'd like to go to the phones now

1245
00:49:48,870 --> 00:49:47,359
if we're ready um i believe seth

1246
00:49:52,470 --> 00:49:48,880
bornstein from the associated press is

1247
00:49:58,309 --> 00:49:54,870
yes thank you for doing this um this is

1248
00:50:00,470 --> 00:49:58,319
more for bill in of the 54 in the um

1249
00:50:02,470 --> 00:50:00,480
potent candidates in the habitable zone

1250
00:50:04,230 --> 00:50:02,480
i think you said one was earth size or

1251
00:50:05,670 --> 00:50:04,240
actually smaller than the earth and four

1252
00:50:07,670 --> 00:50:05,680
were super earths

1253
00:50:10,630 --> 00:50:07,680
uh does that mean essentially that the

1254
00:50:11,670 --> 00:50:10,640
other 49 are more candidates as you say

1255
00:50:12,790 --> 00:50:11,680
for

1256
00:50:15,589 --> 00:50:12,800
the

1257
00:50:18,309 --> 00:50:15,599
for for satellites for moons or are is

1258
00:50:19,670 --> 00:50:18,319
there a group that is sort of in the

1259
00:50:22,230 --> 00:50:19,680
range that could

1260
00:50:25,430 --> 00:50:22,240
that might have be rocky and the other

1261
00:50:27,910 --> 00:50:25,440
question is what i know definitions for

1262
00:50:30,069 --> 00:50:27,920
habitable zones vary what is your

1263
00:50:32,069 --> 00:50:30,079

temperature definition is it zero to 100

1264
00:50:33,589 --> 00:50:32,079
c or is it slightly bigger

1265
00:50:36,870 --> 00:50:33,599
thank you

1266
00:50:38,870 --> 00:50:36,880
yes seth uh the

1267
00:50:41,990 --> 00:50:38,880
the temperature range that we consider

1268
00:50:44,630 --> 00:50:42,000
part of the habitable zone is extended

1269
00:50:47,030 --> 00:50:44,640
in that clearly if you extend it down

1270
00:50:49,589 --> 00:50:47,040
below the freezing point of water

1271
00:50:51,589 --> 00:50:49,599
that's the cat what we calculate if the

1272
00:50:53,349 --> 00:50:51,599
planet has no atmosphere if the planet

1273
00:50:54,870 --> 00:50:53,359
does have an atmosphere the temperature

1274
00:50:57,270 --> 00:50:54,880
is certainly going to be warmer than

1275
00:50:58,230 --> 00:50:57,280
that and maybe very well to have have

1276
00:51:00,069 --> 00:50:58,240
liquid

1277
00:51:02,790 --> 00:51:00,079
on its surface

1278
00:51:03,910 --> 00:51:02,800
the the habitable zone is a very fuzzy

1279
00:51:06,150 --> 00:51:03,920
concept

1280
00:51:09,109 --> 00:51:06,160
certainly enceladus and other moons that

1281
00:51:12,069 --> 00:51:09,119
are very far art but are heated by the

1282
00:51:14,230 --> 00:51:12,079
internal energy of their moons

1283
00:51:15,829 --> 00:51:14,240
you know there's possible possibilities

1284
00:51:19,270 --> 00:51:15,839
life there as well we're just trying to

1285
00:51:20,630 --> 00:51:19,280
pick a region that uh has a higher

1286
00:51:23,670 --> 00:51:20,640
probability

1287
00:51:26,470 --> 00:51:23,680
of having life sort of a start uh

1288
00:51:29,349 --> 00:51:26,480

in in in the search

1289
00:51:30,950 --> 00:51:29,359
does that answer your question

1290
00:51:31,829 --> 00:51:30,960
and oh you asked about the other ones as

1291
00:51:33,829 --> 00:51:31,839
well

1292
00:51:35,750 --> 00:51:33,839
we we have these five that are that are

1293
00:51:37,510 --> 00:51:35,760
small nine tenths the size of the earth

1294
00:51:39,910 --> 00:51:37,520
up to twice the size of the earth a

1295
00:51:41,589 --> 00:51:39,920
group that a neptune size and a small

1296
00:51:44,069 --> 00:51:41,599
number of the order of half a thousand

1297
00:51:44,870 --> 00:51:44,079
or a dozen that are jupiter size

1298
00:51:46,150 --> 00:51:44,880
and

1299
00:51:47,910 --> 00:51:46,160
uh

1300
00:51:49,910 --> 00:51:47,920
clearly all of those are interesting to

1301
00:51:51,510 --> 00:51:49,920
us we will want to explore them further

1302
00:51:53,349 --> 00:51:51,520
but we don't know much more about them

1303
00:51:55,030 --> 00:51:53,359
than we've told you at this point we

1304
00:51:58,069 --> 00:51:55,040
have a lot of work to do to better

1305
00:51:59,990 --> 00:51:58,079
understand them and to confirm them

1306
00:52:01,510 --> 00:52:00,000
okay uh let's go back to the phones uh

1307
00:52:05,349 --> 00:52:01,520
this time with david perlman from the

1308
00:52:07,109 --> 00:52:05,359
san francisco chronicle go ahead david

1309
00:52:10,549 --> 00:52:07,119
yeah thank you very much i have a

1310
00:52:14,069 --> 00:52:10,559
question for bill i guess and that is

1311
00:52:16,230 --> 00:52:14,079
how do you define a candidate and when

1312
00:52:18,870 --> 00:52:16,240
does a candidate

1313
00:52:21,990 --> 00:52:18,880

not be a candidate anymore but be

1314
00:52:25,109 --> 00:52:24,230
that's a very

1315
00:52:26,790 --> 00:52:25,119
good

1316
00:52:28,870 --> 00:52:26,800
tough question

1317
00:52:30,390 --> 00:52:28,880
in that of course when we see a series

1318
00:52:32,790 --> 00:52:30,400
of transits the first thing you'd like

1319
00:52:34,230 --> 00:52:32,800
to say is oh that's a planet

1320
00:52:36,710 --> 00:52:34,240
more light more than likely it's got an

1321
00:52:39,430 --> 00:52:36,720
eclipsing binary or maybe some galactic

1322
00:52:41,829 --> 00:52:39,440
cosmic rays that hit your detector or a

1323
00:52:44,390 --> 00:52:41,839
lot of other phenomena one of the ones

1324
00:52:46,630 --> 00:52:44,400
that we are the most troublesome with

1325
00:52:48,390 --> 00:52:46,640
are the eclipsing binary stars

1326
00:52:50,950 --> 00:52:48,400
when we look out in the galaxy we see

1327
00:52:52,870 --> 00:52:50,960
not just our target but lots of stars in

1328
00:52:55,589 --> 00:52:52,880
the background lots of these little red

1329
00:52:57,510 --> 00:52:55,599
m dwarfs that are everywhere and if

1330
00:52:59,270 --> 00:52:57,520
they're an eclipsing binary

1331
00:53:01,510 --> 00:52:59,280
the instrument thinks it's seeing the

1332
00:53:03,829 --> 00:53:01,520
target star vary so we go through a

1333
00:53:05,510 --> 00:53:03,839
great deal of effort for each of these

1334
00:53:08,790 --> 00:53:05,520
objects that look interesting our

1335
00:53:13,109 --> 00:53:11,270
provides a beautiful example of all the

1336
00:53:14,549 --> 00:53:13,119
threshold crossing events events that

1337
00:53:17,030 --> 00:53:14,559
have a big enough signal to be

1338
00:53:19,030 --> 00:53:17,040

interesting it looks at these

1339
00:53:21,750 --> 00:53:19,040
and the pipeline looks at these and asks

1340
00:53:24,470 --> 00:53:21,760
is there a secondary eclipse that's a

1341
00:53:26,470 --> 00:53:24,480
warning right away that this is a star

1342
00:53:28,470 --> 00:53:26,480
that looks at the shape and if it's

1343
00:53:31,109 --> 00:53:28,480
v-shaped it's a warning right away this

1344
00:53:33,190 --> 00:53:31,119
is probably an eclipsing binary so the

1345
00:53:36,630 --> 00:53:33,200
analysis pipeline that our team has put

1346
00:53:39,430 --> 00:53:36,640
together has built a system that

1347
00:53:41,589 --> 00:53:39,440
eliminates most of these false positive

1348
00:53:44,230 --> 00:53:41,599
events and some of the tests some of the

1349
00:53:45,910 --> 00:53:44,240
work they've done is absolutely elegant

1350
00:53:47,829 --> 00:53:45,920
nevertheless after they've processed the

1351
00:53:50,950 --> 00:53:47,839
data for four months it comes to the

1352
00:53:53,190 --> 00:53:50,960
science team uh basically of observers

1353
00:53:54,069 --> 00:53:53,200
and and others and we look at these and

1354
00:53:55,990 --> 00:53:54,079
ask

1355
00:53:58,470 --> 00:53:56,000
which of these can we go to the

1356
00:54:01,589 --> 00:53:58,480
telescope with and have a chance of

1357
00:54:03,510 --> 00:54:01,599
proving their planet we look

1358
00:54:04,710 --> 00:54:03,520
with the ground-based telescopes and ask

1359
00:54:06,710 --> 00:54:04,720
are there

1360
00:54:08,150 --> 00:54:06,720
other stars really close in that could

1361
00:54:09,910 --> 00:54:08,160
explain this

1362
00:54:11,829 --> 00:54:09,920
we look at the other we do

1363
00:54:13,670 --> 00:54:11,839

reconnaissance spectra

1364
00:54:15,829 --> 00:54:13,680
with our observers to see what the

1365
00:54:17,670 --> 00:54:15,839
characteristics of the star are

1366
00:54:19,030 --> 00:54:17,680
if you don't know the size of the star

1367
00:54:21,270 --> 00:54:19,040
you don't know the size of the planet so

1368
00:54:23,270 --> 00:54:21,280
we make an effort to get at the size of

1369
00:54:25,190 --> 00:54:23,280
the star through reconnaissance spectre

1370
00:54:26,870 --> 00:54:25,200
and then if it still looks good we want

1371
00:54:28,790 --> 00:54:26,880
to confirm it we go to the biggest

1372
00:54:31,670 --> 00:54:28,800
telescopes in the world the kicks and

1373
00:54:33,910 --> 00:54:31,680
the hets and analytic optical telescopes

1374
00:54:36,630 --> 00:54:33,920
and go and measure the rate of velocity

1375
00:54:38,710 --> 00:54:36,640
fluctuations so it's a series of steps

1376
00:54:40,230 --> 00:54:38,720
that generally takes

1377
00:54:42,069 --> 00:54:40,240
from when the data comes down from the

1378
00:54:44,069 --> 00:54:42,079
spacecraft to when we have an

1379
00:54:46,470 --> 00:54:44,079
announcement generally of the order of a

1380
00:54:47,750 --> 00:54:46,480
year that's the kind of time that's

1381
00:54:49,829 --> 00:54:47,760
required

1382
00:54:51,270 --> 00:54:49,839
to be able to prove something as a

1383
00:54:53,030 --> 00:54:51,280
planet

1384
00:54:54,950 --> 00:54:53,040
you know i'd just like to i'd just like

1385
00:54:55,670 --> 00:54:54,960
to jump in and say you know you listen

1386
00:54:56,950 --> 00:54:55,680
to

1387
00:54:58,309 --> 00:54:56,960
uh

1388
00:54:59,670 --> 00:54:58,319

to bill's description there and it

1389
00:55:00,870 --> 00:54:59,680
should give you a better understanding

1390
00:55:03,430 --> 00:55:00,880
of the fact

1391
00:55:04,710 --> 00:55:03,440
of just how much work goes into dubbing

1392
00:55:06,789 --> 00:55:04,720
something up

1393
00:55:09,109 --> 00:55:06,799
taking something from planet exoplanet

1394
00:55:12,630 --> 00:55:09,119
candidate to exoplanet

1395
00:55:15,349 --> 00:55:12,640
uh i i everybody wants to be able to

1396
00:55:17,670 --> 00:55:15,359
you know just go through and and roll

1397
00:55:20,630 --> 00:55:17,680
out hundreds of planets but each and

1398
00:55:23,349 --> 00:55:20,640
every one of these require this sort of

1399
00:55:24,150 --> 00:55:23,359
uh this sort of uh

1400
00:55:24,870 --> 00:55:24,160
you know

1401
00:55:28,069 --> 00:55:24,880
uh

1402
00:55:30,309 --> 00:55:28,079
painstaking work to go through and

1403
00:55:31,910 --> 00:55:30,319
uh and confirm that they actually are

1404
00:55:33,349 --> 00:55:31,920
planets and not something out there

1405
00:55:35,990 --> 00:55:33,359
trying to trick us into thinking it's a

1406
00:55:37,589 --> 00:55:36,000
planet so i mean it's uh it bill gave a

1407
00:55:39,349 --> 00:55:37,599
good description there and as you kind

1408
00:55:41,109 --> 00:55:39,359
of think about that because it's it's an

1409
00:55:43,109 --> 00:55:41,119
amazing amount of work by a lot of

1410
00:55:45,750 --> 00:55:43,119
people that's going into this

1411
00:55:47,670 --> 00:55:45,760
and i just like to add bill did an

1412
00:55:50,630 --> 00:55:47,680
excellent description

1413
00:55:52,630 --> 00:55:50,640

and all the steps before the last

1414
00:55:55,270 --> 00:55:52,640
we're basically doing for every

1415
00:55:57,030 --> 00:55:55,280
candidate before we'd even consider

1416
00:56:00,829 --> 00:55:57,040
calling it a planet

1417
00:56:03,910 --> 00:56:00,839
but there are three different last steps

1418
00:56:06,630 --> 00:56:03,920
because those radial velocities bill

1419
00:56:08,710 --> 00:56:06,640
mentioned the doppler method

1420
00:56:10,549 --> 00:56:08,720
that works for big enough planets

1421
00:56:12,950 --> 00:56:10,559
orbiting close enough in

1422
00:56:15,270 --> 00:56:12,960
around bright enough stars

1423
00:56:17,670 --> 00:56:15,280
but for kepler 11

1424
00:56:18,870 --> 00:56:17,680
they're too small

1425
00:56:21,349 --> 00:56:18,880
they're not

1426
00:56:22,390 --> 00:56:21,359
super close in

1427
00:56:25,670 --> 00:56:22,400
and

1428
00:56:28,829 --> 00:56:25,680
they're around a fairly faint star

1429
00:56:32,150 --> 00:56:28,839
and so the second method

1430
00:56:35,990 --> 00:56:32,160
is one that's only been used twice

1431
00:56:38,950 --> 00:56:36,000
for kepler 9 and kepler 11.

1432
00:56:42,069 --> 00:56:38,960
and that's as bill mentioned in his talk

1433
00:56:44,150 --> 00:56:42,079
the transit timing variations to see

1434
00:56:46,870 --> 00:56:44,160
the tug that they're exerting on one

1435
00:56:49,190 --> 00:56:46,880
another and you can't have that

1436
00:56:50,870 --> 00:56:49,200
in triple star systems because they

1437
00:56:53,109 --> 00:56:50,880
would go unstable the stars are much

1438
00:56:55,270 --> 00:56:53,119

more massive

1439
00:56:56,630 --> 00:56:55,280
so that's the second way

1440
00:56:58,950 --> 00:56:56,640
which like

1441
00:57:01,109 --> 00:56:58,960
the radial velocity method also gives

1442
00:57:01,990 --> 00:57:01,119
you the mass

1443
00:57:03,109 --> 00:57:02,000
but

1444
00:57:05,750 --> 00:57:03,119
it's

1445
00:57:09,270 --> 00:57:05,760
only on systems where the planets are

1446
00:57:12,549 --> 00:57:10,150
that

1447
00:57:14,470 --> 00:57:12,559
it's possible

1448
00:57:16,710 --> 00:57:14,480
so the third method which we've just

1449
00:57:18,549 --> 00:57:16,720
used on a couple

1450
00:57:19,750 --> 00:57:18,559
of objects

1451
00:57:21,829 --> 00:57:19,760
one

1452
00:57:25,109 --> 00:57:21,839
the third pla the third planet around

1453
00:57:26,230 --> 00:57:25,119
kepler-9 and one the sixth planet around

1454
00:57:28,030 --> 00:57:26,240
11

1455
00:57:31,030 --> 00:57:28,040
is to look

1456
00:57:32,150 --> 00:57:31,040
painstakingly at the field right around

1457
00:57:37,030 --> 00:57:32,160
the star

1458
00:57:39,270 --> 00:57:37,040
much as we can and look at the details

1459
00:57:41,349 --> 00:57:39,280
of the shape of the planet

1460
00:57:46,069 --> 00:57:41,359
and show

1461
00:57:47,109 --> 00:57:46,079
that the shape and the details of it

1462
00:57:48,950 --> 00:57:47,119
just

1463
00:57:51,030 --> 00:57:48,960

don't make sense

1464
00:57:53,510 --> 00:57:51,040
for any

1465
00:57:55,589 --> 00:57:53,520
false positive model with any reasonable

1466
00:57:58,230 --> 00:57:55,599
chance of occurring

1467
00:58:00,630 --> 00:57:58,240
and therefore

1468
00:58:01,589 --> 00:58:00,640
we're more than 99

1469
00:58:03,030 --> 00:58:01,599
certain

1470
00:58:05,349 --> 00:58:03,040
it's a planet

1471
00:58:07,190 --> 00:58:05,359
and we call it a planet and that's

1472
00:58:08,710 --> 00:58:07,200
better than the rates of things that

1473
00:58:11,670 --> 00:58:08,720
have been called planets in the past so

1474
00:58:13,750 --> 00:58:11,680
we think that's pretty good

1475
00:58:14,870 --> 00:58:13,760
and if it's not at 99

1476
00:58:17,109 --> 00:58:14,880
at least

1477
00:58:19,190 --> 00:58:17,119
it's still just a candidate

1478
00:58:21,190 --> 00:58:19,200
anything else to add

1479
00:58:23,349 --> 00:58:21,200
okay i know we have one more question at

1480
00:58:24,870 --> 00:58:23,359
least on the phone let me take that and

1481
00:58:26,069 --> 00:58:24,880
we'll come back to the audience and just

1482
00:58:28,470 --> 00:58:26,079
do a quick check to see if you're any

1483
00:58:32,789 --> 00:58:28,480
further uh kelly beatty sky and

1484
00:58:36,470 --> 00:58:34,630
thank you very much um

1485
00:58:39,109 --> 00:58:36,480
jack in

1486
00:58:41,670 --> 00:58:39,119
assuming in in concluding that uh some

1487
00:58:44,390 --> 00:58:41,680
of these have atmospheres you as i

1488
00:58:46,870 --> 00:58:44,400

understand you've basically been working

1489
00:58:49,030 --> 00:58:46,880
on the model fit to their densities

1490
00:58:51,270 --> 00:58:49,040
when you measure these transits and the

1491
00:58:54,309 --> 00:58:51,280
transit times if there are atmospheres

1492
00:58:55,349 --> 00:58:54,319
around how do the atmospheres affect

1493
00:59:02,150 --> 00:58:55,359
the

1494
00:59:04,950 --> 00:59:02,160
with a diameter that's artificially

1495
00:59:05,990 --> 00:59:04,960
larger than the planet itself

1496
00:59:09,270 --> 00:59:06,000
well

1497
00:59:11,109 --> 00:59:09,280
you have a good question and what is

1498
00:59:13,910 --> 00:59:11,119
the size of the planet

1499
00:59:15,270 --> 00:59:13,920
for earth you generally consider

1500
00:59:17,670 --> 00:59:15,280
the size

1501
00:59:20,710 --> 00:59:17,680
of the solid surface because then the

1502
00:59:22,710 --> 00:59:20,720
atmosphere is just so much more tenuous

1503
00:59:23,910 --> 00:59:22,720
but for giant planets in our solar

1504
00:59:26,309 --> 00:59:23,920
system

1505
00:59:28,309 --> 00:59:26,319
we have to say what is the size where we

1506
00:59:30,230 --> 00:59:28,319
want to cut things off

1507
00:59:33,910 --> 00:59:30,240
and we have to say that for these

1508
00:59:35,349 --> 00:59:33,920
planets too and

1509
00:59:38,230 --> 00:59:35,359
it turns out

1510
00:59:41,270 --> 00:59:38,240
that the size at which a the the

1511
00:59:43,270 --> 00:59:41,280
altitude the density in the atmosphere

1512
00:59:45,510 --> 00:59:43,280
that causes a transit

1513
00:59:47,430 --> 00:59:45,520

is a little bit less dense so a little

1514
00:59:49,589 --> 00:59:47,440
bit higher

1515
00:59:52,309 --> 00:59:49,599
so get a little larger than what we

1516
00:59:55,829 --> 00:59:52,319
would call the measurements of the sizes

1517
00:59:57,670 --> 00:59:55,839
of say jupiter saturn uranus or neptune

1518
00:59:59,349 --> 00:59:57,680
but it's by less than one percent in

1519
01:00:01,430 --> 00:59:59,359
those cases it may be a little more in

1520
01:00:05,349 --> 01:00:01,440
these cases but it's a it's a pretty

1521
01:00:07,589 --> 01:00:06,549
great let me just do a quick check in

1522
01:00:09,109 --> 01:00:07,599
the audience see if there any further

1523
01:00:10,549 --> 01:00:09,119
questions

1524
01:00:25,430 --> 01:00:10,559
okay we'll go to the phone line we have

1525
01:00:25,440 --> 01:00:34,150
one more time do we have now on the line

1526
01:00:38,789 --> 01:00:36,390
okay uh i think let me just do one more

1527
01:00:40,069 --> 01:00:38,799
check see if there any further questions

1528
01:00:42,390 --> 01:00:40,079
all right so i know we have a question

1529
01:00:45,109 --> 01:00:42,400
from ames research center let's go there

1530
01:00:49,829 --> 01:00:47,510
okay hello uh jansarg on swedish

1531
01:00:52,069 --> 01:00:49,839
national television uh

1532
01:00:54,390 --> 01:00:52,079
could you please elaborate a bit more on

1533
01:00:56,309 --> 01:00:54,400
these five uh

1534
01:00:58,230 --> 01:00:56,319
almost earth-sized planet in the

1535
01:01:00,309 --> 01:00:58,240
habitable zone i mean what could you

1536
01:01:03,030 --> 01:01:00,319
tell i mean what kind of stars do we

1537
01:01:04,470 --> 01:01:03,040
circle how far away are they what might

1538
01:01:07,910 --> 01:01:04,480

they look like

1539
01:01:10,069 --> 01:01:07,920
and uh furthermore i mean if you

1540
01:01:12,230 --> 01:01:10,079
wouldn't characterize these like

1541
01:01:13,349 --> 01:01:12,240
earth-like planets

1542
01:01:15,829 --> 01:01:13,359
i mean

1543
01:01:18,309 --> 01:01:15,839
when what what is the definition for

1544
01:01:21,270 --> 01:01:18,319
earth-like planet then and when might

1545
01:01:27,589 --> 01:01:21,280
these earth-like planets pop up uh

1546
01:01:32,950 --> 01:01:30,789
that's a very very hard question we we

1547
01:01:34,870 --> 01:01:32,960
can we can measure these we can detect

1548
01:01:35,910 --> 01:01:34,880
them we have yet to prove they're our

1549
01:01:38,950 --> 01:01:35,920
planet

1550
01:01:43,750 --> 01:01:41,670
they are many of these are small so we

1551
01:01:44,789 --> 01:01:43,760
haven't confirmed any but it's certainly

1552
01:01:47,510 --> 01:01:44,799
going to be something we will

1553
01:01:49,349 --> 01:01:47,520
investigate in the coming uh months and

1554
01:01:51,750 --> 01:01:49,359
years but at this point i can't tell you

1555
01:01:54,309 --> 01:01:51,760
much about them other than

1556
01:01:56,710 --> 01:01:54,319
generally the stars they orbit

1557
01:01:57,589 --> 01:01:56,720
are stars quite a bit smaller than the

1558
01:01:59,109 --> 01:01:57,599
sun

1559
01:02:01,270 --> 01:01:59,119
the order is sometimes

1560
01:02:03,910 --> 01:02:01,280
half the size of the sun the

1561
01:02:06,789 --> 01:02:03,920
temperatures are very much lower

1562
01:02:09,029 --> 01:02:06,799
the sun is about 5 5800 kelvin these

1563
01:02:11,109 --> 01:02:09,039

stars are almost half that temperature

1564
01:02:13,750 --> 01:02:11,119
of the order of three thousand thirty

1565
01:02:16,069 --> 01:02:13,760
five hundred i think some of the

1566
01:02:17,750 --> 01:02:16,079
slightly bigger objects are around uh

1567
01:02:18,710 --> 01:02:17,760
stars again cooler than the earth than

1568
01:02:20,870 --> 01:02:18,720
the sun

1569
01:02:23,430 --> 01:02:20,880
but the temperatures i think run about

1570
01:02:25,270 --> 01:02:23,440
44 to 4 800 kelvin so they would be

1571
01:02:27,430 --> 01:02:25,280
considered k dwarfs

1572
01:02:30,309 --> 01:02:27,440
stars intermediate between these very

1573
01:02:32,549 --> 01:02:30,319
small cool stars and the hotter star

1574
01:02:33,430 --> 01:02:32,559
like the sun

1575
01:02:35,270 --> 01:02:33,440
but i

1576
01:02:37,670 --> 01:02:35,280
we don't know much more about them as

1577
01:02:40,069 --> 01:02:37,680
yet uh we have discovered them of course

1578
01:02:41,829 --> 01:02:40,079
only very very recently uh it takes a

1579
01:02:45,430 --> 01:02:41,839
great deal of work to

1580
01:02:47,190 --> 01:02:45,440
uh define them to make sure that we uh

1581
01:02:48,549 --> 01:02:47,200
understand a little bit about the star

1582
01:02:50,549 --> 01:02:48,559
themselves

1583
01:02:51,589 --> 01:02:50,559
it's not

1584
01:02:55,990 --> 01:02:51,599
it's

1585
01:02:58,150 --> 01:02:56,000
information on the star how big is it

1586
01:03:00,309 --> 01:02:58,160
what is this composition

1587
01:03:02,549 --> 01:03:00,319
so the reconnaissance spectra and the

1588
01:03:04,230 --> 01:03:02,559

interpretation of the reconnaissance

1589
01:03:06,710 --> 01:03:04,240
spectra the

1590
01:03:08,549 --> 01:03:06,720
understanding of how all the stars might

1591
01:03:11,510 --> 01:03:08,559
be which tells you a little bit about

1592
01:03:13,510 --> 01:03:11,520
how mass and and size vary for these

1593
01:03:15,430 --> 01:03:13,520
stars are things that we still have a

1594
01:03:17,349 --> 01:03:15,440
lot of work to do so i'm afraid i can't

1595
01:03:19,510 --> 01:03:17,359
give you much information other than

1596
01:03:22,150 --> 01:03:19,520
many of them around the cooler stars

1597
01:03:24,789 --> 01:03:22,160
stars smaller than the sun

1598
01:03:25,910 --> 01:03:24,799
just to add a couple things

1599
01:03:27,430 --> 01:03:25,920
uh

1600
01:03:29,430 --> 01:03:27,440
if they are planets

1601
01:03:31,349 --> 01:03:29,440
and they are in the habitable zone

1602
01:03:34,069 --> 01:03:31,359
then the star

1603
01:03:36,549 --> 01:03:34,079
that they see in the sky close up is a

1604
01:03:38,390 --> 01:03:36,559
lot redder than our sun

1605
01:03:40,789 --> 01:03:38,400
and as

1606
01:03:42,470 --> 01:03:40,799
doug and bill stated earlier

1607
01:03:43,430 --> 01:03:42,480
the reason

1608
01:03:45,750 --> 01:03:43,440
the

1609
01:03:48,470 --> 01:03:45,760
habitable planet small habitable planet

1610
01:03:51,270 --> 01:03:48,480
candidates we're seeing now are only

1611
01:03:55,029 --> 01:03:51,280
around these small faint stars

1612
01:03:56,630 --> 01:03:55,039
is we just haven't had enough time

1613
01:03:59,270 --> 01:03:56,640

we

1614
01:04:02,630 --> 01:03:59,280
are searching for planets

1615
01:04:05,510 --> 01:04:02,640
that are true earth analogs earth size

1616
01:04:09,109 --> 01:04:05,520
around stars like the sun

1617
01:04:11,109 --> 01:04:09,119
but that's going to take a few more

1618
01:04:13,589 --> 01:04:11,119
years of data

1619
01:04:22,230 --> 01:04:13,599
to

1620
01:04:27,910 --> 01:04:24,950
it's mike mitchell with aviation week

1621
01:04:29,829 --> 01:04:27,920
you've had four months of

1622
01:04:31,430 --> 01:04:29,839
recorded observations out of i think

1623
01:04:33,029 --> 01:04:31,440
it's a three-year mission so you're

1624
01:04:35,349 --> 01:04:33,039
really just getting started here i'm

1625
01:04:38,069 --> 01:04:35,359
trying to get an idea of

1626
01:04:40,230 --> 01:04:38,079
the results you expect will they be do

1627
01:04:43,670 --> 01:04:40,240
you expect that they could be linear in

1628
01:04:45,190 --> 01:04:43,680
the sense of you've got 1235 candidate

1629
01:04:46,870 --> 01:04:45,200
planets now

1630
01:04:49,670 --> 01:04:46,880
or

1631
01:04:51,109 --> 01:04:49,680
will your early observations have you

1632
01:04:52,710 --> 01:04:51,119
you started to

1633
01:04:54,549 --> 01:04:52,720
see enough of the candidates that now

1634
01:04:55,670 --> 01:04:54,559
you're getting into the fine grain

1635
01:04:57,109 --> 01:04:55,680
detail

1636
01:04:59,829 --> 01:04:57,119
and we'll

1637
01:05:02,309 --> 01:04:59,839
we won't see results uh

1638
01:05:04,309 --> 01:05:02,319

stepping forward as as great as these

1639
01:05:06,390 --> 01:05:04,319
have been

1640
01:05:07,910 --> 01:05:06,400
that's that's right i i mentioned in my

1641
01:05:10,309 --> 01:05:07,920
talk that as you go further and further

1642
01:05:12,710 --> 01:05:10,319
out to larger orbital

1643
01:05:14,870 --> 01:05:12,720
distances larger orbital periods the

1644
01:05:18,309 --> 01:05:14,880
chance of getting an alignment falls

1645
01:05:20,069 --> 01:05:18,319
dramatically so we see this huge

1646
01:05:22,390 --> 01:05:20,079
a number of candidates in the first four

1647
01:05:24,470 --> 01:05:22,400
months of data but if we look at the

1648
01:05:27,109 --> 01:05:24,480
following years we don't expect to see

1649
01:05:29,430 --> 01:05:27,119
anywhere near that kind of increase

1650
01:05:31,029 --> 01:05:29,440
what we will see is fewer but more

1651
01:05:32,470 --> 01:05:31,039
interesting

1652
01:05:34,390 --> 01:05:32,480
planets they'll be the ones that are

1653
01:05:36,390 --> 01:05:34,400
further out that are cooler

1654
01:05:37,270 --> 01:05:36,400
the other aspect that's happening here

1655
01:05:44,390 --> 01:05:37,280
that

1656
01:05:45,829 --> 01:05:44,400
uh to correct for the the stars are very

1657
01:05:48,150 --> 01:05:45,839
noisy the stars are noisy than we

1658
01:05:50,390 --> 01:05:48,160
expected so it's harder to find these

1659
01:05:51,510 --> 01:05:50,400
small signals and we have a group of

1660
01:05:53,670 --> 01:05:51,520
people

1661
01:05:55,190 --> 01:05:53,680
at nasa ames that work very hard to

1662
01:05:57,029 --> 01:05:55,200
correct out the noise and the glitches

1663
01:05:59,750 --> 01:05:57,039

and things like that the data and as

1664
01:06:02,549 --> 01:05:59,760
they do so the analysis pipeline becomes

1665
01:06:05,190 --> 01:06:02,559
more and more capable of finding these

1666
01:06:06,470 --> 01:06:05,200
smaller objects so we're going to find

1667
01:06:08,390 --> 01:06:06,480
in in the

1668
01:06:10,309 --> 01:06:08,400
years that are going on that we're able

1669
01:06:12,630 --> 01:06:10,319
to find even in the data that we're

1670
01:06:13,829 --> 01:06:12,640
releasing right now

1671
01:06:15,510 --> 01:06:13,839
more planets

1672
01:06:17,750 --> 01:06:15,520
but they'll be smaller planets to be

1673
01:06:20,710 --> 01:06:17,760
buried in the noise and so it's a

1674
01:06:22,150 --> 01:06:20,720
capability or a mathematical analysis

1675
01:06:24,789 --> 01:06:22,160
that allows us to find these small

1676
01:06:26,470 --> 01:06:24,799
objects but we do not expect to see the

1677
01:06:29,029 --> 01:06:26,480
kind of plethora

1678
01:06:33,109 --> 01:06:29,039
increase that we see now there will be

1679
01:06:37,109 --> 01:06:33,119
many fewer as the years go on so quality

1680
01:06:41,109 --> 01:06:38,789
okay let's go back to the phones uh

1681
01:06:44,150 --> 01:06:41,119
let's try now greenfield voice at npr

1682
01:06:50,309 --> 01:06:48,470
hi can you hear me this time yes we can

1683
01:06:51,430 --> 01:06:50,319
okay sorry about that glitch before

1684
01:06:53,990 --> 01:06:51,440
thanks for doing this and thanks for

1685
01:06:56,390 --> 01:06:54,000
taking my question do you all anticipate

1686
01:06:58,390 --> 01:06:56,400
that the first confirmed um

1687
01:07:00,710 --> 01:06:58,400
uh earth-sized planet in a habitable

1688
01:07:02,230 --> 01:07:00,720

zone will be one of these candidates i

1689
01:07:03,990 --> 01:07:02,240
mean do you feel that

1690
01:07:06,069 --> 01:07:04,000
the holy grail as we said before is

1691
01:07:08,069 --> 01:07:06,079
actually in these data waited waiting to

1692
01:07:09,589 --> 01:07:08,079
be confirmed and i know you talked about

1693
01:07:12,069 --> 01:07:09,599
some of the steps that are required for

1694
01:07:13,829 --> 01:07:12,079
confirmation but just to reiterate how

1695
01:07:15,270 --> 01:07:13,839
long do you think that confirmation will

1696
01:07:16,950 --> 01:07:15,280
take

1697
01:07:18,789 --> 01:07:16,960
well i guess

1698
01:07:21,589 --> 01:07:18,799
i guess i can

1699
01:07:25,589 --> 01:07:21,599
speak to that again

1700
01:07:28,309 --> 01:07:25,599
no i wouldn't expect the holy grail if

1701
01:07:29,270 --> 01:07:28,319
you know to use the the term that that i

1702
01:07:32,390 --> 01:07:29,280
used

1703
01:07:34,789 --> 01:07:32,400
um to be in this set because again the

1704
01:07:37,190 --> 01:07:34,799
the holy grail and earth-sized planet

1705
01:07:39,109 --> 01:07:37,200
are in the habitable zone around a

1706
01:07:41,829 --> 01:07:39,119
sun-like star

1707
01:07:43,670 --> 01:07:41,839
uh obviously the orbital period of that

1708
01:07:46,390 --> 01:07:43,680
would be about a year

1709
01:07:48,470 --> 01:07:46,400
so in fact you would only if you were

1710
01:07:50,950 --> 01:07:48,480
far away in the plane of the earth's

1711
01:07:53,109 --> 01:07:50,960
orbit looking at transits across the sun

1712
01:07:56,470 --> 01:07:53,119
you would only see a transit by that

1713
01:07:58,789 --> 01:07:56,480

planet once every year so in fact it

1714
01:08:00,390 --> 01:07:58,799
would take you three years you know well

1715
01:08:03,990 --> 01:08:00,400
first off it would take you two years

1716
01:08:05,349 --> 01:08:04,000
before you even saw a second blip that

1717
01:08:07,510 --> 01:08:05,359
you know sort of stood out in the middle

1718
01:08:10,069 --> 01:08:07,520
of nowhere a year after the first one

1719
01:08:11,510 --> 01:08:10,079
came along and it would be a third

1720
01:08:13,029 --> 01:08:11,520
before you came along and said wow you

1721
01:08:16,789 --> 01:08:13,039
know we seem to be getting this blip

1722
01:08:18,709 --> 01:08:16,799
every year in that period so in fact at

1723
01:08:20,630 --> 01:08:18,719
this point with only a year and a half

1724
01:08:21,910 --> 01:08:20,640
worth of data we wouldn't have enough

1725
01:08:25,030 --> 01:08:21,920
blips yet

1726
01:08:27,990 --> 01:08:25,040
to identify it as a recurring event

1727
01:08:30,470 --> 01:08:28,000
so in that in that instance no i would i

1728
01:08:33,030 --> 01:08:30,480
would say just on that standpoint

1729
01:08:36,789 --> 01:08:33,040
the the planet candidate that could be

1730
01:08:38,630 --> 01:08:36,799
our uh our earth-like planet uh if you

1731
01:08:41,030 --> 01:08:38,640
will or the earth-sized planet in the

1732
01:08:45,510 --> 01:08:41,040
habitable zone to be more precise

1733
01:08:52,470 --> 01:08:48,390
okay we have alan boyle from msnbc on

1734
01:08:56,630 --> 01:08:55,269
hi um with the earlier data release

1735
01:08:59,030 --> 01:08:56,640
there were some candidates that were

1736
01:09:01,189 --> 01:08:59,040
held back uh for confirmation by the

1737
01:09:03,110 --> 01:09:01,199
kepler team 400

1738
01:09:04,390 --> 01:09:03,120

i wondered if

1739
01:09:07,590 --> 01:09:04,400
there are

1740
01:09:09,189 --> 01:09:07,600
are being held back this time for

1741
01:09:10,390 --> 01:09:09,199
similar reasons

1742
01:09:15,430 --> 01:09:10,400
no

1743
01:09:17,110 --> 01:09:15,440
all the data in in addition to the the

1744
01:09:21,189 --> 01:09:17,120
400 targets

1745
01:09:22,870 --> 01:09:21,199
that uh the the team had x uh extended

1746
01:09:24,309 --> 01:09:22,880
exclusive use period so that they could

1747
01:09:25,590 --> 01:09:24,319
have a full season of follow-up

1748
01:09:28,309 --> 01:09:25,600
observations

1749
01:09:30,789 --> 01:09:28,319
uh were released uh

1750
01:09:34,550 --> 01:09:30,799
actually just a few hours before all of

1751
01:09:35,749 --> 01:09:34,560
the data on the 156 000 for the

1752
01:09:37,590 --> 01:09:35,759
for the second three months of the

1753
01:09:39,669 --> 01:09:37,600
mission so all the data is out there

1754
01:09:41,269 --> 01:09:39,679
there are no uh targets that have been

1755
01:09:43,030 --> 01:09:41,279
held back at this point and one of the

1756
01:09:44,870 --> 01:09:43,040
things i think that we had an

1757
01:09:46,789 --> 01:09:44,880
opportunity to do was to take a look at

1758
01:09:49,110 --> 01:09:46,799
those

1759
01:09:51,110 --> 01:09:49,120
candidates that were held back

1760
01:09:53,829 --> 01:09:51,120
uh during the summer and do

1761
01:09:57,830 --> 01:09:53,839
reconnaissance spectra of many of those

1762
01:09:59,750 --> 01:09:57,840
of the thousands the two thousand uh

1763
01:10:01,990 --> 01:09:59,760

i'm sorry the twelve hundred candidates

1764
01:10:03,590 --> 01:10:02,000
and we found that uh some of those that

1765
01:10:05,669 --> 01:10:03,600
we had released some of those that we

1766
01:10:08,310 --> 01:10:05,679
had reserved were in fact false

1767
01:10:10,950 --> 01:10:08,320
positives things that ultimately were

1768
01:10:12,870 --> 01:10:10,960
eclipsing binaries or whatever so

1769
01:10:14,709 --> 01:10:12,880
the groups that we have released that is

1770
01:10:17,189 --> 01:10:14,719
all that we have released now are much

1771
01:10:18,390 --> 01:10:17,199
more heavily vetted so we have a much

1772
01:10:20,229 --> 01:10:18,400
better

1773
01:10:22,229 --> 01:10:20,239
understanding that these are really good

1774
01:10:24,229 --> 01:10:22,239
candidates go out observe these and

1775
01:10:26,870 --> 01:10:24,239
you're going to find planets and we have

1776
01:10:28,950 --> 01:10:26,880
released all the data uh

1777
01:10:30,630 --> 01:10:28,960
for the for the for this four months we

1778
01:10:32,550 --> 01:10:30,640
of course have data after that period of

1779
01:10:35,669 --> 01:10:32,560
time but we don't have any candidates

1780
01:10:38,149 --> 01:10:35,679
that we can show you

1781
01:10:42,709 --> 01:10:38,159
okay let's move on to mike wall of

1782
01:10:48,229 --> 01:10:45,910
oh yeah um yeah that's what i saw in the

1783
01:10:50,149 --> 01:10:48,239
like like a little press

1784
01:10:52,550 --> 01:10:50,159
press release that that actually kepler

1785
01:10:54,390 --> 01:10:52,560
went into safe mode and and i was just

1786
01:10:56,310 --> 01:10:54,400
wondering if if you guys could just

1787
01:10:58,149 --> 01:10:56,320
speak to what the problem was and if

1788
01:11:00,310 --> 01:10:58,159

it's serious or if everything is going

1789
01:11:02,470 --> 01:11:00,320
to be okay going forward with the

1790
01:11:06,070 --> 01:11:02,480
telescope

1791
01:11:07,830 --> 01:11:06,080
uh yes in fact the the kepler spacecraft

1792
01:11:10,310 --> 01:11:07,840
did turn up in

1793
01:11:13,990 --> 01:11:10,320
safe mode at the normal contact

1794
01:11:17,270 --> 01:11:14,000
um and the the team is currently working

1795
01:11:18,790 --> 01:11:17,280
the issue uh it appears to be at this

1796
01:11:21,590 --> 01:11:18,800
point and this is preliminary

1797
01:11:23,189 --> 01:11:21,600
information uh it appears to be a fault

1798
01:11:24,830 --> 01:11:23,199
with one of the star trackers which is

1799
01:11:27,030 --> 01:11:24,840
something that we have experienced

1800
01:11:29,350 --> 01:11:27,040
before the data shows that the

1801
01:11:31,189 --> 01:11:29,360
spacecraft is in fine shape

1802
01:11:34,310 --> 01:11:31,199
in fact it's been brought out of safe

1803
01:11:35,990 --> 01:11:34,320
mode and is in standby mode and probably

1804
01:11:38,630 --> 01:11:36,000
even as we speak here they're doing a

1805
01:11:40,310 --> 01:11:38,640
full download download of the

1806
01:11:42,149 --> 01:11:40,320
mission data recorder so they can make

1807
01:11:44,470 --> 01:11:42,159
sure that they know what's going on and

1808
01:11:47,430 --> 01:11:44,480
and find a uh

1809
01:11:49,189 --> 01:11:47,440
see if we can design a way to avoid this

1810
01:11:50,470 --> 01:11:49,199
problem in the future but this does

1811
01:11:52,790 --> 01:11:50,480
appear to be

1812
01:11:54,870 --> 01:11:52,800
a fault that we have experienced before

1813
01:11:57,430 --> 01:11:54,880

and we do not believe it represents any

1814
01:11:58,229 --> 01:11:57,440
serious threat to the mission

1815
01:12:00,149 --> 01:11:58,239
thanks

1816
01:12:03,830 --> 01:12:00,159
uh let's go back to seth borenstein the

1817
01:12:05,990 --> 01:12:03,840
associated press go ahead seth

1818
01:12:08,790 --> 01:12:06,000
yes thanks i i want to if we can focus

1819
01:12:11,189 --> 01:12:08,800
in on the the smallest of planets first

1820
01:12:14,070 --> 01:12:11,199
what is the smallest size you saw and

1821
01:12:15,910 --> 01:12:14,080
looking at the one earth-sized one uh

1822
01:12:20,390 --> 01:12:15,920
candidate in the potentially habitable

1823
01:12:23,830 --> 01:12:20,400
zone i believe that's a 0.6 earth radii

1824
01:12:26,630 --> 01:12:23,840
and a radius and i'm wondering if uh one

1825
01:12:27,669 --> 01:12:26,640
how secure are you about that i mean and

1826
01:12:29,590 --> 01:12:27,679
and would

1827
01:12:32,550 --> 01:12:29,600
because it's so small

1828
01:12:34,630 --> 01:12:32,560
would that um eliminate using radial

1829
01:12:37,270 --> 01:12:34,640
velocity to to get it and and i'm

1830
01:12:39,110 --> 01:12:37,280
wondering overall how many planets have

1831
01:12:41,430 --> 01:12:39,120
you found that are actually smaller than

1832
01:12:45,669 --> 01:12:43,510
thank you maybe deborah can talk about

1833
01:12:47,669 --> 01:12:45,679
uh confirming these small objects with

1834
01:12:50,070 --> 01:12:47,679
rate of velocity she's been working on a

1835
01:12:52,550 --> 01:12:50,080
new system that may

1836
01:12:54,229 --> 01:12:52,560
represent a significant step forward in

1837
01:12:57,270 --> 01:12:54,239
their ability of rate of velocity

1838
01:12:59,030 --> 01:12:57,280

systems to look at the smaller objects

1839
01:13:01,590 --> 01:12:59,040
well i can certainly comment that this

1840
01:13:04,310 --> 01:13:01,600
is extraordinarily difficult

1841
01:13:06,630 --> 01:13:04,320
that the detection our our measurement

1842
01:13:07,750 --> 01:13:06,640
errors right now are about one meter per

1843
01:13:10,470 --> 01:13:07,760
second

1844
01:13:12,709 --> 01:13:10,480
and we're to find an earth analog we

1845
01:13:15,110 --> 01:13:12,719
would need to be able to measure

1846
01:13:18,470 --> 01:13:15,120
an amplitude of reflex velocity in the

1847
01:13:20,709 --> 01:13:18,480
star of 10 centimeters per second

1848
01:13:22,630 --> 01:13:20,719
so that means we've got to shrink our

1849
01:13:24,149 --> 01:13:22,640
one meter per second error bars by a

1850
01:13:26,950 --> 01:13:24,159
factor of 10.

1851
01:13:29,669 --> 01:13:26,960
and yeah we're investigating i mean we

1852
01:13:31,830 --> 01:13:29,679
have at yale a doppler diagnostic

1853
01:13:33,750 --> 01:13:31,840
facility where we're setting radial

1854
01:13:35,750 --> 01:13:33,760
velocity precision as the figure of

1855
01:13:37,830 --> 01:13:35,760
merit and really trying to hammer down

1856
01:13:39,270 --> 01:13:37,840
on all of the error sources that we can

1857
01:13:40,149 --> 01:13:39,280
think of

1858
01:13:42,870 --> 01:13:40,159
but

1859
01:13:44,709 --> 01:13:42,880
i you know i think we're ways away the

1860
01:13:45,590 --> 01:13:44,719
maybe the best strategy we have right

1861
01:13:48,310 --> 01:13:45,600
now

1862
01:13:51,270 --> 01:13:48,320
is if our uh errors are random that's a

1863
01:13:53,910 --> 01:13:51,280

big if and not systematic errors then

1864
01:13:56,870 --> 01:13:53,920
one way we can shrink the error bar is

1865
01:13:58,790 --> 01:13:56,880
by taking many observations so you take

1866
01:14:01,110 --> 01:13:58,800
one measurement you get you know one

1867
01:14:03,189 --> 01:14:01,120
meter per second you take a hundred

1868
01:14:05,030 --> 01:14:03,199
you reduce that precision or improve

1869
01:14:06,870 --> 01:14:05,040
that precision by the square root of the

1870
01:14:08,790 --> 01:14:06,880
number of observations so that's how you

1871
01:14:10,550 --> 01:14:08,800
can get from one down to ten

1872
01:14:12,390 --> 01:14:10,560
problem is that it doesn't really go

1873
01:14:14,550 --> 01:14:12,400
down uh that fast because our errors

1874
01:14:16,630 --> 01:14:14,560
really aren't uh completely

1875
01:14:18,229 --> 01:14:16,640
gaussian or completely uh

1876
01:14:20,790 --> 01:14:18,239
normally distributed

1877
01:14:22,470 --> 01:14:20,800
um so it's the focus of work it's and

1878
01:14:25,030 --> 01:14:22,480
and i i think like everything in this

1879
01:14:27,189 --> 01:14:25,040
field we have to go you know step wise

1880
01:14:29,189 --> 01:14:27,199
one step at a time and it's it's too bad

1881
01:14:31,110 --> 01:14:29,199
we can't just sort of leap to the end

1882
01:14:33,270 --> 01:14:31,120
and see the answers but we're all doing

1883
01:14:35,189 --> 01:14:33,280
the hard ground work right now to try

1884
01:14:37,430 --> 01:14:35,199
and make that happen

1885
01:14:40,070 --> 01:14:37,440
and i'd like to add

1886
01:14:42,950 --> 01:14:40,080
that if we get lucky

1887
01:14:44,790 --> 01:14:42,960
and we find some earth-sized candidates

1888
01:14:46,149 --> 01:14:44,800

in the habitable zone

1889
01:14:50,550 --> 01:14:46,159
of stars

1890
01:14:51,910 --> 01:14:50,560
with more than one candidate

1891
01:14:53,110 --> 01:14:51,920
and

1892
01:14:54,790 --> 01:14:53,120
if

1893
01:14:56,870 --> 01:14:54,800
the spacecraft

1894
01:14:58,790 --> 01:14:56,880
is healthy

1895
01:15:02,790 --> 01:14:58,800
stays healthy

1896
01:15:05,350 --> 01:15:02,800
extended mission

1897
01:15:09,189 --> 01:15:05,360
maybe we'll be able to observe long

1898
01:15:12,070 --> 01:15:09,199
enough that we'll be able to see

1899
01:15:13,189 --> 01:15:12,080
transit timing variations

1900
01:15:16,709 --> 01:15:13,199
that

1901
01:15:19,350 --> 01:15:16,719
one planet causes on the other

1902
01:15:22,790 --> 01:15:19,360
and confirm it that way even if radial

1903
01:15:26,630 --> 01:15:22,800
velocity confirmation is impossible for

1904
01:15:29,669 --> 01:15:27,750
okay we're going to take the last

1905
01:15:31,270 --> 01:15:29,679
question this is back to david perlman

1906
01:15:33,830 --> 01:15:31,280
with the san francisco chronicle go

1907
01:15:39,189 --> 01:15:36,390
yeah thanks very much

1908
01:15:40,149 --> 01:15:39,199
i have to try to follow up before

1909
01:15:42,390 --> 01:15:40,159
uh

1910
01:15:45,350 --> 01:15:42,400
bill i'm still not clear

1911
01:15:48,630 --> 01:15:45,360
as to how you define

1912
01:15:51,189 --> 01:15:48,640
what is the definition of a candidate i

1913
01:15:53,590 --> 01:15:51,199

understand how you confirm it and you

1914
01:15:56,630 --> 01:15:53,600
all were very helpful on that subject

1915
01:15:59,430 --> 01:15:56,640
but how do you actually define a

1916
01:16:02,229 --> 01:15:59,440
candidate that makes you then go

1917
01:16:03,910 --> 01:16:02,239
and attempt to confirm it

1918
01:16:05,750 --> 01:16:03,920
okay that's

1919
01:16:07,590 --> 01:16:05,760
let's talk about that for a moment we

1920
01:16:09,990 --> 01:16:07,600
have this analysis pipeline it goes

1921
01:16:13,189 --> 01:16:10,000
through the data in an automated fashion

1922
01:16:15,590 --> 01:16:13,199
and it finds any set of transits that

1923
01:16:17,430 --> 01:16:15,600
have a signal noise ratio like like

1924
01:16:19,110 --> 01:16:17,440
seven the probability of getting

1925
01:16:21,669 --> 01:16:19,120
something like that random and random

1926
01:16:23,990 --> 01:16:21,679
data is 100 billion so you see that you

1927
01:16:25,910 --> 01:16:24,000
say well here the pipeline produces it

1928
01:16:29,189 --> 01:16:25,920
it gives you a list of these things this

1929
01:16:31,270 --> 01:16:29,199
star has such and such events threshold

1930
01:16:33,910 --> 01:16:31,280
crossing events with this period this

1931
01:16:36,709 --> 01:16:33,920
amplitude and it makes some checks and

1932
01:16:38,390 --> 01:16:36,719
it then spits this out gives us a report

1933
01:16:39,990 --> 01:16:38,400
and the uh

1934
01:16:43,430 --> 01:16:40,000
the team that was called easter the

1935
01:16:46,790 --> 01:16:43,440
threshold crossing uh events team looks

1936
01:16:49,030 --> 01:16:46,800
at the results of this computer output

1937
01:16:51,590 --> 01:16:49,040
and then begins to think about it

1938
01:16:52,630 --> 01:16:51,600

themselves do they believe this which do

1939
01:16:57,030 --> 01:16:52,640
they

1940
01:16:58,790 --> 01:16:57,040
is the threshold crossing event a

1941
01:17:00,709 --> 01:16:58,800
candidate if

1942
01:17:02,550 --> 01:17:00,719
the team looks at it and says yes it

1943
01:17:05,430 --> 01:17:02,560
becomes a candidate because they say

1944
01:17:07,990 --> 01:17:05,440
it's a candidate they make that decision

1945
01:17:10,550 --> 01:17:08,000
a group of about eight or ten people

1946
01:17:14,709 --> 01:17:10,560
meet generally once a week to make that

1947
01:17:17,910 --> 01:17:14,719
decision and it's that group then that

1948
01:17:19,990 --> 01:17:17,920
puts a priority rank on these things and

1949
01:17:22,070 --> 01:17:20,000
sends it to the group of people what's

1950
01:17:23,590 --> 01:17:22,080
called a follow-on observing program

1951
01:17:25,030 --> 01:17:23,600
group

1952
01:17:27,270 --> 01:17:25,040
fob who

1953
01:17:30,390 --> 01:17:27,280
look at what's been given to them and

1954
01:17:32,229 --> 01:17:30,400
see here is what t-cert wants us to look

1955
01:17:34,790 --> 01:17:32,239
at and they look and they just they

1956
01:17:37,350 --> 01:17:34,800
decide from the available telescopes and

1957
01:17:39,990 --> 01:17:37,360
instruments and so on which of these is

1958
01:17:41,910 --> 01:17:40,000
the most practical to do and then that

1959
01:17:44,470 --> 01:17:41,920
again that's a that's still a candidate

1960
01:17:46,630 --> 01:17:44,480
and they go forward with the

1961
01:17:49,590 --> 01:17:46,640
the validation procedures that we talked

1962
01:17:51,030 --> 01:17:49,600
about but the conversion of a threshold

1963
01:17:53,990 --> 01:17:51,040

crossing event

1964
01:17:56,310 --> 01:17:54,000
to a candidate is done by a team by team

1965
01:17:58,950 --> 01:17:56,320
members meeting in a group once a week

1966
01:18:00,870 --> 01:17:58,960
who make that decision by observe by

1967
01:18:03,350 --> 01:18:00,880
looking at the data

1968
01:18:05,830 --> 01:18:03,360
and then so bill has described how

1969
01:18:09,669 --> 01:18:05,840
something becomes a candidate

1970
01:18:13,350 --> 01:18:09,679
and it stays a candidate until either

1971
01:18:17,110 --> 01:18:13,360
it's confirmed as a planet or

1972
01:18:19,910 --> 01:18:19,110
right

1973
01:18:21,750 --> 01:18:19,920
yes

1974
01:18:24,149 --> 01:18:21,760
okay with that

1975
01:18:25,750 --> 01:18:24,159
we'll end today's media conference

1976
01:18:27,910 --> 01:18:25,760
just as a reminder you can find out more

1977
01:18:29,350 --> 01:18:27,920
information about today's announcements

1978
01:18:32,950 --> 01:18:29,360
uh and keep up with the latest on the

1979
01:18:34,630 --> 01:18:32,960
hunt for planets at www.nasa.gov

1980
01:18:36,550 --> 01:18:34,640
forward slash kepler i'd like to thank

1981
01:18:38,229 --> 01:18:36,560
the panelists for their time today and