Meet the Hubble eXtreme Deep Field Observing Team

Recorded live Thursday, September 27, 2012

1
00:00:11,589 --> 00:00:10,070
greetings from the space telescope

2
00:00:13,350 --> 00:00:11,599
science institute to all of our

3
00:00:15,030 --> 00:00:13,360
astronomy enthusiasts joining us for

4
00:00:16,390 --> 00:00:15,040
today's webinar

5
00:00:17,910 --> 00:00:16,400
we're here today to tell you the story

6
00:00:19,750 --> 00:00:17,920
behind the headlines of this week's

7
00:00:21,590 --> 00:00:19,760
photo release of hubble space

8
00:00:22,870 --> 00:00:21,600
telescope's steepest view of the

9
00:00:24,870 --> 00:00:22,880
universe

10
00:00:27,029 --> 00:00:24,880
three members of the team of scientists

11
00:00:28,390 --> 00:00:27,039
who put together this image are here

12
00:00:29,589 --> 00:00:28,400
with us today

13
00:00:32,310 --> 00:00:29,599

each of them will give brief

14
00:00:33,510 --> 00:00:32,320
presentations followed by questions from

15
00:00:36,470 --> 00:00:33,520
our viewers

16
00:00:39,110 --> 00:00:36,480
you can send questions via you youtube

17
00:00:41,350 --> 00:00:39,120
or the google events page

18
00:00:44,069 --> 00:00:41,360
let me introduce our panelists

19
00:00:46,150 --> 00:00:44,079
we have dr garth illingworth

20
00:00:48,310 --> 00:00:46,160
mr dan mcgee

21
00:00:49,510 --> 00:00:48,320
and dr pascal osch

22
00:00:51,430 --> 00:00:49,520
they're all at the university of

23
00:00:58,389 --> 00:00:51,440
california santa cruz

24
00:01:03,110 --> 00:01:00,389
thank you very much ray

25
00:01:05,509 --> 00:01:03,120
and so i would like to uh

26
00:01:07,590 --> 00:01:05,519
walk through a presentation that we've

27
00:01:09,590 --> 00:01:07,600
put together the three of us will do

28
00:01:11,510 --> 00:01:09,600
that in sequence and to give you a

29
00:01:14,550 --> 00:01:11,520
little background about this remarkable

30
00:01:17,030 --> 00:01:14,560
new extreme deep field and so if i could

31
00:01:20,950 --> 00:01:17,040
have the next slide please

32
00:01:23,030 --> 00:01:20,960
so hubble's extraordinary xdf and it

33
00:01:25,830 --> 00:01:23,040
certainly is extraordinary

34
00:01:27,109 --> 00:01:25,840
this is the deepest ever image taken of

35
00:01:27,910 --> 00:01:27,119
the sky

36
00:01:29,910 --> 00:01:27,920
it

37
00:01:32,630 --> 00:01:29,920
involves an exposure of two million

38
00:01:34,870 --> 00:01:32,640

seconds if you think about your iphone

39
00:01:36,550 --> 00:01:34,880
or your camera you typically take

40
00:01:39,270 --> 00:01:36,560
exposures that are a hundredth of a

41
00:01:41,510 --> 00:01:39,280
second so this is quite a contrast what

42
00:01:44,149 --> 00:01:41,520
it involves is 10 years of images from

43
00:01:46,789 --> 00:01:44,159
hubble's cameras and hubble's cameras

44
00:01:49,190 --> 00:01:46,799
are really twofold in 2002 the

45
00:01:51,030 --> 00:01:49,200
astronauts took up the new advanced

46
00:01:54,069 --> 00:01:51,040
camera at that time

47
00:01:55,030 --> 00:01:54,079
and then in 2009 a new wide field camera

48
00:01:57,429 --> 00:01:55,040
3

49
00:01:58,230 --> 00:01:57,439
and these two cameras complement each

50
00:02:00,630 --> 00:01:58,240
other

51
00:02:02,550 --> 00:02:00,640
and can i have the next slide and we'll

52
00:02:05,749 --> 00:02:02,560
explain a little about this

53
00:02:07,350 --> 00:02:05,759
so making the xdf the xdf started with

54
00:02:09,990 --> 00:02:07,360
the hubble ultra deep field which was

55
00:02:12,150 --> 00:02:10,000
taken largely in 2003

56
00:02:14,470 --> 00:02:12,160
using the new advanced camera

57
00:02:15,670 --> 00:02:14,480
it takes optical images

58
00:02:16,710 --> 00:02:15,680
and

59
00:02:18,229 --> 00:02:16,720
went in

60
00:02:21,270 --> 00:02:18,239
incredibly deep

61
00:02:24,150 --> 00:02:21,280
then in 2009 and 10 when the new wide

62
00:02:27,350 --> 00:02:24,160
field camera 3 became available the

63
00:02:29,670 --> 00:02:27,360

hubble ultra deep field 09 was taken

64
00:02:31,830 --> 00:02:29,680
this extended the

65
00:02:34,390 --> 00:02:31,840
wave bands extended to the red the

66
00:02:36,390 --> 00:02:34,400
information available and opened up a

67
00:02:38,630 --> 00:02:36,400
whole new area

68
00:02:40,150 --> 00:02:38,640
in addition to these images there are

69
00:02:42,790 --> 00:02:40,160
numerous other images that have been

70
00:02:45,589 --> 00:02:42,800
taken over the decade with these cameras

71
00:02:47,830 --> 00:02:45,599
on the hubble ultra deep field area and

72
00:02:49,670 --> 00:02:47,840
so what we did was take took all this

73
00:02:52,470 --> 00:02:49,680
data all this remarkable number of

74
00:02:55,430 --> 00:02:52,480
images combined it to make the xdf

75
00:02:57,509 --> 00:02:55,440
and dr dan mcgee will later explain how

76
00:02:59,350 --> 00:02:57,519
this was all put together could i have

77
00:03:00,550 --> 00:02:59,360
the next slide please

78
00:03:03,350 --> 00:03:00,560
so why

79
00:03:05,350 --> 00:03:03,360
are we interested in the xdf

80
00:03:08,309 --> 00:03:05,360
these ultra deep images

81
00:03:10,149 --> 00:03:08,319
which the xcf is the prime example is

82
00:03:10,949 --> 00:03:10,159
the ultimate example as it were at this

83
00:03:12,949 --> 00:03:10,959
time

84
00:03:15,350 --> 00:03:12,959
is key to understanding the origins of

85
00:03:16,949 --> 00:03:15,360
galaxies if you look in the upper right

86
00:03:19,670 --> 00:03:16,959
there's an image of andromeda our

87
00:03:21,350 --> 00:03:19,680
nearest neighbor a huge spiral galaxy

88
00:03:24,149 --> 00:03:21,360

much like our own

89
00:03:27,110 --> 00:03:24,159
so how did these galaxies like the

90
00:03:29,350 --> 00:03:27,120
andromeda like the milky way come about

91
00:03:30,070 --> 00:03:29,360
so that's the question that

92
00:03:32,869 --> 00:03:30,080
we

93
00:03:34,630 --> 00:03:32,879
so astronomers many groups are doing is

94
00:03:36,630 --> 00:03:34,640
searching for the first galaxies the

95
00:03:39,990 --> 00:03:36,640
earliest galaxies and trying to

96
00:03:42,710 --> 00:03:40,000
understand when and how galaxies formed

97
00:03:44,149 --> 00:03:42,720
and how they grow over time ultimately

98
00:03:46,470 --> 00:03:44,159
we're under trying to understand the

99
00:03:48,789 --> 00:03:46,480
origins of galaxies

100
00:03:50,869 --> 00:03:48,799
next slide please

101
00:03:52,630 --> 00:03:50,879
so how do early galaxies compare to

102
00:03:55,350 --> 00:03:52,640
those of today

103
00:03:57,830 --> 00:03:55,360
so in the upper right again andromeda

104
00:04:00,550 --> 00:03:57,840
and then there's a representative early

105
00:04:03,270 --> 00:04:00,560
galaxy this is not exactly like an early

106
00:04:06,070 --> 00:04:03,280
galaxy we can't see that level of detail

107
00:04:07,990 --> 00:04:06,080
but this is one that is probably very

108
00:04:10,710 --> 00:04:08,000
much like those that we're looking at at

109
00:04:13,910 --> 00:04:10,720
the very limits of the ultra deep field

110
00:04:16,629 --> 00:04:13,920
and the xdf the early galaxies are full

111
00:04:18,390 --> 00:04:16,639
of bright young blue stars

112
00:04:20,710 --> 00:04:18,400
they're forming lots of new stars

113
00:04:22,790 --> 00:04:20,720

they're growing very rapidly but they

114
00:04:24,710 --> 00:04:22,800
are very small they're very different

115
00:04:26,230 --> 00:04:24,720
they're about a tenth the size one

116
00:04:27,670 --> 00:04:26,240
percent of the mass

117
00:04:30,310 --> 00:04:27,680
and with none of the beautiful

118
00:04:32,550 --> 00:04:30,320
regularity that we see in galaxies like

119
00:04:35,909 --> 00:04:32,560
andromeda or our milky way

120
00:04:39,189 --> 00:04:36,790
so

121
00:04:41,590 --> 00:04:39,199
how is it that uh we can learn about

122
00:04:42,710 --> 00:04:41,600
galaxies from these telescopes like

123
00:04:47,670 --> 00:04:42,720
hubble

124
00:04:49,909 --> 00:04:47,680
these galaxies these early galaxies are

125
00:04:52,469 --> 00:04:49,919
so distant that light takes so long to

126
00:04:54,550 --> 00:04:52,479
reach us that we are actually seeing the

127
00:04:57,110 --> 00:04:54,560
galaxy at a very much earlier time in

128
00:04:59,510 --> 00:04:57,120
their development and in fact it's like

129
00:05:00,469 --> 00:04:59,520
looking back to when we were younger as

130
00:05:03,110 --> 00:05:00,479
people

131
00:05:05,990 --> 00:05:03,120
so xdf allows us to look back in time

132
00:05:07,590 --> 00:05:06,000
through 96 of the life of the universe a

133
00:05:09,590 --> 00:05:07,600
remarkable

134
00:05:11,270 --> 00:05:09,600
achievement for humankind to think that

135
00:05:12,870 --> 00:05:11,280
we could actually do that with the

136
00:05:14,710 --> 00:05:12,880
hubble telescope

137
00:05:17,749 --> 00:05:14,720
so we actually see galaxies that are

138
00:05:20,469 --> 00:05:17,759

forming 13.2 billion years ago

139
00:05:22,870 --> 00:05:20,479
this is remarkable this is just 450

140
00:05:26,230 --> 00:05:22,880
million years after the big bang which

141
00:05:27,670 --> 00:05:26,240
itself was about 13.7 billion years ago

142
00:05:29,590 --> 00:05:27,680
in the upper right

143
00:05:32,390 --> 00:05:29,600
is a picture and image of the most

144
00:05:34,629 --> 00:05:32,400
distant galaxy we know today this is a

145
00:05:37,189 --> 00:05:34,639
great search going on for

146
00:05:39,029 --> 00:05:37,199
other examples like this and we'll talk

147
00:05:40,469 --> 00:05:39,039
more about these later on in the

148
00:05:44,550 --> 00:05:40,479
presentation

149
00:05:48,469 --> 00:05:45,909
so

150
00:05:49,670 --> 00:05:48,479
what we're trying to do here is really a

151
00:05:52,150 --> 00:05:49,680
path of

152
00:05:54,790 --> 00:05:52,160
exploration we're reaching out to

153
00:05:55,830 --> 00:05:54,800
explore the galaxies when the universe

154
00:05:59,029 --> 00:05:55,840
was young

155
00:06:01,670 --> 00:05:59,039
if xdf allows us to do that

156
00:06:03,830 --> 00:06:01,680
and to take steps beyond what we could

157
00:06:05,990 --> 00:06:03,840
do with the al the original hubble ultra

158
00:06:07,990 --> 00:06:06,000
deep field that could only take us back

159
00:06:09,350 --> 00:06:08,000
to within about one billion years after

160
00:06:11,189 --> 00:06:09,360
the big bang

161
00:06:13,110 --> 00:06:11,199
but the first galaxies the earliest

162
00:06:15,430 --> 00:06:13,120
galaxies and some of the most dramatic

163
00:06:17,270 --> 00:06:15,440

changes in the universe occurred even

164
00:06:19,029 --> 00:06:17,280
earlier than that time

165
00:06:21,029 --> 00:06:19,039
and so with xdf

166
00:06:22,870 --> 00:06:21,039
this allows us to explore to even

167
00:06:23,749 --> 00:06:22,880
earlier times in the hubble ultra deep

168
00:06:25,990 --> 00:06:23,759
field

169
00:06:28,150 --> 00:06:26,000
and dr irsh will explain a little about

170
00:06:30,390 --> 00:06:28,160
this in his presentation

171
00:06:32,710 --> 00:06:30,400
next slide please

172
00:06:34,390 --> 00:06:32,720
but before we get into the science i'd

173
00:06:36,150 --> 00:06:34,400
like to hand over to

174
00:06:40,629 --> 00:06:36,160
dan mcgee to tell you how this

175
00:06:42,950 --> 00:06:40,639
remarkable image was put together dan

176
00:06:44,230 --> 00:06:42,960
thanks garth

177
00:06:46,550 --> 00:06:44,240
so i just want to give you a little

178
00:06:49,670 --> 00:06:46,560
background about how we put all of this

179
00:06:52,469 --> 00:06:49,680
data together um and to start with uh

180
00:06:55,189 --> 00:06:52,479
this slide here shows um

181
00:06:57,189 --> 00:06:55,199
uh where the actually the the

182
00:06:59,189 --> 00:06:57,199
extreme deep field is located and it's

183
00:07:01,670 --> 00:06:59,199
in a southern constellation of fornax in

184
00:07:04,150 --> 00:07:01,680
the southern part of the sky

185
00:07:06,870 --> 00:07:04,160
next slide please

186
00:07:08,950 --> 00:07:06,880
and the xdf is actually just a teeny

187
00:07:11,749 --> 00:07:08,960
portion of the sky and to show an

188
00:07:13,510 --> 00:07:11,759

example of this uh in this slide we show

189
00:07:16,790 --> 00:07:13,520
the full moon and then the area covered

190
00:07:17,510 --> 00:07:16,800
by the xdf and you can see in this slide

191
00:07:19,830 --> 00:07:17,520
that

192
00:07:21,749 --> 00:07:19,840
the xdf is actually only about

193
00:07:23,510 --> 00:07:21,759
less than a tenth of the area that is

194
00:07:25,430 --> 00:07:23,520
covered by

195
00:07:28,390 --> 00:07:25,440
the full moon

196
00:07:34,790 --> 00:07:31,749
so um hubble has spent more time

197
00:07:36,870 --> 00:07:34,800
observing uh the xdf than any other

198
00:07:38,390 --> 00:07:36,880
place in the sky

199
00:07:39,830 --> 00:07:38,400
and the observations

200
00:07:43,189 --> 00:07:39,840
uh that were used

201
00:07:46,629 --> 00:07:43,199
to create the xdf were taken about over

202
00:07:49,110 --> 00:07:46,639
a 10-year period from july of 2002 to

203
00:07:51,029 --> 00:07:49,120
about march of this year

204
00:07:52,629 --> 00:07:51,039
and over that 10-year period

205
00:07:53,909 --> 00:07:52,639
hubble observed

206
00:07:56,469 --> 00:07:53,919
the xdf

207
00:07:59,189 --> 00:07:56,479
for about 50 days

208
00:08:00,629 --> 00:07:59,199
and during those 50 days of pointing

209
00:08:03,110 --> 00:08:00,639
at the xdf

210
00:08:05,430 --> 00:08:03,120
uh the hubble took over 2000 exposures

211
00:08:07,749 --> 00:08:05,440
in eight different filters

212
00:08:09,589 --> 00:08:07,759
on two different cameras the the

213
00:08:11,430 --> 00:08:09,599

advanced camera for surveys

214
00:08:12,629 --> 00:08:11,440
using the wide field channel

215
00:08:16,070 --> 00:08:12,639
and

216
00:08:18,230 --> 00:08:16,080
the whitefield camera 3 infrared channel

217
00:08:20,150 --> 00:08:18,240
and so adding all these exposure up we

218
00:08:22,070 --> 00:08:20,160
get about 2 million seconds of exposure

219
00:08:24,230 --> 00:08:22,080
time

220
00:08:25,110 --> 00:08:24,240
next slide

221
00:08:28,390 --> 00:08:25,120
so

222
00:08:31,029 --> 00:08:28,400
to create the xdf we had to gather uh a

223
00:08:32,310 --> 00:08:31,039
lot of data uh we

224
00:08:34,870 --> 00:08:32,320
we took

225
00:08:37,589 --> 00:08:34,880
all the data covering the hubble ultra

226
00:08:40,550 --> 00:08:37,599
deep field and uh

227
00:08:41,589 --> 00:08:40,560
in the surrounding area around it and it

228
00:08:43,190 --> 00:08:41,599
took

229
00:08:47,269 --> 00:08:43,200
actually quite a bit of time to download

230
00:08:51,030 --> 00:08:48,870
we had to ask for it in small little

231
00:08:52,550 --> 00:08:51,040
bits so we didn't you know so we could

232
00:08:53,750 --> 00:08:52,560
one could get them in a reasonable time

233
00:08:55,350 --> 00:08:53,760
and and

234
00:08:57,350 --> 00:08:55,360
not totally

235
00:08:59,350 --> 00:08:57,360
mess up the archive by asking for all of

236
00:09:02,150 --> 00:08:59,360
it at once um

237
00:09:05,110 --> 00:09:02,160
so after downloading all that data it uh

238
00:09:08,470 --> 00:09:05,120

we ended up with about 250 gigabytes of

239
00:09:10,790 --> 00:09:08,480
images that we needed to process

240
00:09:12,710 --> 00:09:10,800
next slide please

241
00:09:14,790 --> 00:09:12,720
so here in this slide here i want to

242
00:09:17,590 --> 00:09:14,800
show you so

243
00:09:20,630 --> 00:09:17,600
this is a an outline of the original

244
00:09:23,110 --> 00:09:20,640
hubble deep field that was taken in 2003

245
00:09:25,590 --> 00:09:23,120
and some in 2004

246
00:09:27,269 --> 00:09:25,600
so these blue outlines here show you uh

247
00:09:28,949 --> 00:09:27,279
the advanced cameras for survey

248
00:09:30,230 --> 00:09:28,959
observations that were taken during that

249
00:09:31,430 --> 00:09:30,240
time

250
00:09:33,350 --> 00:09:31,440
next slide

251
00:09:36,389 --> 00:09:33,360
and now uh

252
00:09:38,630 --> 00:09:36,399
adding on to that area this is so in the

253
00:09:40,389 --> 00:09:38,640
outlined and red here we show you

254
00:09:42,790 --> 00:09:40,399
the uh

255
00:09:44,710 --> 00:09:42,800
data that was taken with the

256
00:09:48,710 --> 00:09:44,720
whitefield camera three

257
00:09:49,590 --> 00:09:48,720
uh infrared channel in 2009 and 2010 as

258
00:09:51,110 --> 00:09:49,600
garth

259
00:09:52,230 --> 00:09:51,120
said

260
00:09:53,590 --> 00:09:52,240
next slide

261
00:09:55,910 --> 00:09:53,600
and so

262
00:09:58,070 --> 00:09:55,920
as garth said before uh a lot of other

263
00:10:00,389 --> 00:09:58,080

data has been taken over this field over

264
00:10:03,110 --> 00:10:00,399
the over the last decade and so this

265
00:10:04,630 --> 00:10:03,120
slide sort of shows you the outlines of

266
00:10:05,990 --> 00:10:04,640
all the other sort of exposures that

267
00:10:07,509 --> 00:10:06,000
have been taken

268
00:10:10,070 --> 00:10:07,519
and um

269
00:10:11,910 --> 00:10:10,080
and that we include in the xdf

270
00:10:14,550 --> 00:10:11,920
and next slide

271
00:10:16,790 --> 00:10:14,560
and so in generating the xdf we added

272
00:10:18,550 --> 00:10:16,800
all this data together and combined it

273
00:10:20,150 --> 00:10:18,560
and so the area in orange just shows you

274
00:10:21,030 --> 00:10:20,160
the area that's covered

275
00:10:22,470 --> 00:10:21,040
by the

276
00:10:25,030 --> 00:10:22,480
xdf

277
00:10:25,990 --> 00:10:25,040
next slide

278
00:10:27,110 --> 00:10:26,000
so

279
00:10:29,030 --> 00:10:27,120
uh

280
00:10:30,470 --> 00:10:29,040
before we started processing all this

281
00:10:32,150 --> 00:10:30,480
data we had to

282
00:10:34,069 --> 00:10:32,160
do some things we actually had to

283
00:10:37,030 --> 00:10:34,079
visually inspect

284
00:10:39,350 --> 00:10:37,040
all of the 2000 exposures

285
00:10:40,870 --> 00:10:39,360
that were taken up

286
00:10:43,509 --> 00:10:40,880
so

287
00:10:45,829 --> 00:10:43,519
looking

288
00:10:48,069 --> 00:10:45,839

for problems in in exposures and

289
00:10:50,470 --> 00:10:48,079
occasionally you get artifacts in image

290
00:10:52,630 --> 00:10:50,480
and as an example of that uh

291
00:10:55,750 --> 00:10:52,640
you know when you're taking an exposure

292
00:10:57,590 --> 00:10:55,760
with hubble uh occasionally a satellite

293
00:10:59,110 --> 00:10:57,600
that's orbiting above hubble's orbit

294
00:11:01,350 --> 00:10:59,120
will actually pass through the field of

295
00:11:03,190 --> 00:11:01,360
view while you're observing and taking

296
00:11:05,829 --> 00:11:03,200
exposure and what happens is you'll get

297
00:11:07,190 --> 00:11:05,839
a streak across the image and so

298
00:11:09,030 --> 00:11:07,200
that's sort of the things we look out

299
00:11:12,150 --> 00:11:09,040
for and we have to mask those things out

300
00:11:15,670 --> 00:11:12,160
so we don't include those artifacts

301
00:11:17,190 --> 00:11:15,680
in the final combined images

302
00:11:18,310 --> 00:11:17,200
and the next step in the processing is

303
00:11:19,990 --> 00:11:18,320
we actually

304
00:11:22,870 --> 00:11:20,000
uh have to

305
00:11:25,269 --> 00:11:22,880
align all these images together you know

306
00:11:27,110 --> 00:11:25,279
hubble is pretty good at at has pretty

307
00:11:29,750 --> 00:11:27,120
good accuracy when pointing

308
00:11:32,949 --> 00:11:29,760
at a piece of a certain part of the sky

309
00:11:34,310 --> 00:11:32,959
but we to actually combine all these

310
00:11:36,389 --> 00:11:34,320
images together and to make them

311
00:11:38,630 --> 00:11:36,399
scientifically useful you have to

312
00:11:40,710 --> 00:11:38,640
do it with a much higher accuracy than

313
00:11:43,190 --> 00:11:40,720

just the hubble pointings so we had

314
00:11:44,949 --> 00:11:43,200
software and computer programs that we

315
00:11:47,590 --> 00:11:44,959
have written that we actually go through

316
00:11:49,590 --> 00:11:47,600
each of the exposures and identify

317
00:11:53,269 --> 00:11:49,600
objects in those exposures and then we

318
00:11:55,829 --> 00:11:53,279
compare every other exposure

319
00:11:57,509 --> 00:11:55,839
with each exposure and we determine

320
00:11:59,750 --> 00:11:57,519
actually how much we need to either

321
00:12:01,590 --> 00:11:59,760
shift an exposure or

322
00:12:05,829 --> 00:12:01,600
we may have to actually shift and rotate

323
00:12:06,790 --> 00:12:05,839
it slightly so they align up perfectly

324
00:12:09,990 --> 00:12:06,800
and

325
00:12:13,190 --> 00:12:10,000
next slide please

326
00:12:14,230 --> 00:12:13,200
so after we've got that figured out how

327
00:12:16,150 --> 00:12:14,240
uh

328
00:12:18,069 --> 00:12:16,160
once we've got them all aligned we need

329
00:12:22,069 --> 00:12:18,079
to combine these images and and to do

330
00:12:23,670 --> 00:12:22,079
that uh we use a a computer program that

331
00:12:25,750 --> 00:12:23,680
was written by the space telescope into

332
00:12:27,990 --> 00:12:25,760
called multi-drizzle and all

333
00:12:29,670 --> 00:12:28,000
multi-drizzle does is it well we could

334
00:12:31,190 --> 00:12:29,680
feed it different exposures from

335
00:12:32,710 --> 00:12:31,200
different filters

336
00:12:34,069 --> 00:12:32,720
and we've gone through the stuff to make

337
00:12:35,590 --> 00:12:34,079
sure that they were all matched up with

338
00:12:38,310 --> 00:12:35,600

each other and then we can stack them

339
00:12:40,550 --> 00:12:38,320
and actually create a nice mosaic image

340
00:12:41,430 --> 00:12:40,560
from each filter

341
00:12:43,990 --> 00:12:41,440
um

342
00:12:46,150 --> 00:12:44,000
and then you know and this this is done

343
00:12:48,389 --> 00:12:46,160
in a a in an optimal way in a in a

344
00:12:49,750 --> 00:12:48,399
process that's called drizzling

345
00:12:50,790 --> 00:12:49,760
and then from there

346
00:12:53,750 --> 00:12:50,800
we have

347
00:12:56,069 --> 00:12:53,760
a final mosaic picture from each

348
00:12:57,829 --> 00:12:56,079
exposure and we can use those mosaic

349
00:12:59,430 --> 00:12:57,839
pictures to actually create a final

350
00:13:01,350 --> 00:12:59,440
color picture

351
00:13:02,790 --> 00:13:01,360
using the different filters images of

352
00:13:04,550 --> 00:13:02,800
the different filters

353
00:13:06,550 --> 00:13:04,560
so at that point that's where the image

354
00:13:08,710 --> 00:13:06,560
processing ends and we can actually

355
00:13:10,470 --> 00:13:08,720
start doing science on this image

356
00:13:12,230 --> 00:13:10,480
and i'd like to now turn it over to

357
00:13:13,910 --> 00:13:12,240
pascal

358
00:13:16,550 --> 00:13:13,920
okay thanks dan

359
00:13:18,470 --> 00:13:16,560
um yeah so garth already gave you a nice

360
00:13:20,790 --> 00:13:18,480
overview of the type of science that you

361
00:13:22,629 --> 00:13:20,800
can do with this new image and i just

362
00:13:25,350 --> 00:13:22,639
want to go a little more into the

363
00:13:27,670 --> 00:13:25,360

details and in particular of

364
00:13:30,150 --> 00:13:27,680
how we can actually find these first

365
00:13:32,550 --> 00:13:30,160
generations of galaxies with this image

366
00:13:35,190 --> 00:13:32,560
but of course this is only a small part

367
00:13:36,949 --> 00:13:35,200
of what astronomers are doing and what

368
00:13:39,829 --> 00:13:36,959
those german astronomers are using this

369
00:13:41,670 --> 00:13:39,839
image for and we cannot cover all these

370
00:13:44,150 --> 00:13:41,680
today

371
00:13:47,430 --> 00:13:44,160
and so as garth and denver pointing out

372
00:13:50,150 --> 00:13:47,440
the the new xdf image is actually built

373
00:13:52,629 --> 00:13:50,160
on the old hubble ultra deep field image

374
00:13:55,190 --> 00:13:52,639
that was taken with the acs camera and

375
00:13:57,430 --> 00:13:55,200
the acs camera is sensitive to light in

376
00:13:59,750 --> 00:13:57,440
the optical wavelength range where we

377
00:14:01,509 --> 00:13:59,760
can see also with our eyes

378
00:14:02,790 --> 00:14:01,519
and now with the xcf

379
00:14:05,269 --> 00:14:02,800
we are

380
00:14:07,110 --> 00:14:05,279
extending this to longer wavelengths

381
00:14:09,910 --> 00:14:07,120
and to the near infrared

382
00:14:11,910 --> 00:14:09,920
and because the new we cannot see there

383
00:14:14,389 --> 00:14:11,920
with our eyes but the new camera the v3

384
00:14:16,389 --> 00:14:14,399
camera is really efficient at studying

385
00:14:18,550 --> 00:14:16,399
that light and detecting it

386
00:14:20,710 --> 00:14:18,560
and so this is really important if you

387
00:14:23,590 --> 00:14:20,720
want to study galaxies in the very early

388
00:14:25,189 --> 00:14:23,600

universe more than 800 million years

389
00:14:28,710 --> 00:14:25,199
earlier than 800 million years after the

390
00:14:31,269 --> 00:14:28,720
big bang um and because these galaxies

391
00:14:34,230 --> 00:14:31,279
you can see there as the shaded gray

392
00:14:36,150 --> 00:14:34,240
area these galaxies are completely

393
00:14:38,150 --> 00:14:36,160
in the hubble ultra deep field and we

394
00:14:40,069 --> 00:14:38,160
really need these near-infrared images

395
00:14:42,069 --> 00:14:40,079
to detect them

396
00:14:44,550 --> 00:14:42,079
and so on the next slide i just have a

397
00:14:46,310 --> 00:14:44,560
little example of this on the left

398
00:14:48,389 --> 00:14:46,320
there's a previous image a hubble ultra

399
00:14:50,230 --> 00:14:48,399
deep field the optical image and you can

400
00:14:51,430 --> 00:14:50,240
see in this circle there's just nothing

401
00:14:53,430 --> 00:14:51,440
there

402
00:14:56,470 --> 00:14:53,440
while in the new image in the xdf on the

403
00:14:58,389 --> 00:14:56,480
right you can see this bright red dot

404
00:15:00,949 --> 00:14:58,399
which is one of the most distant uh

405
00:15:02,069 --> 00:15:00,959
galaxies that we have uh detected in

406
00:15:04,069 --> 00:15:02,079
this image

407
00:15:06,230 --> 00:15:04,079
and and if you have seen the fly through

408
00:15:08,870 --> 00:15:06,240
uh video that was released together with

409
00:15:11,110 --> 00:15:08,880
this image this is the one galaxy

410
00:15:13,670 --> 00:15:11,120
the image essentially and that the video

411
00:15:16,230 --> 00:15:13,680
essentially ends on

412
00:15:17,750 --> 00:15:16,240
um and so on the next slide essentially

413
00:15:20,629 --> 00:15:17,760

i just marked up

414
00:15:23,590 --> 00:15:20,639
the positions of all these very early

415
00:15:24,949 --> 00:15:23,600
sources more than 800 million years

416
00:15:27,350 --> 00:15:24,959
from the big bang

417
00:15:29,670 --> 00:15:27,360
um and so um

418
00:15:31,670 --> 00:15:29,680
you can see by studying uh there's a lot

419
00:15:33,829 --> 00:15:31,680
of these sources here there are 60

420
00:15:36,870 --> 00:15:33,839
sources essentially that we identified

421
00:15:38,470 --> 00:15:36,880
in this image alone um and so these are

422
00:15:40,389 --> 00:15:38,480
very important because these are the

423
00:15:42,550 --> 00:15:40,399
galaxies that really change the early

424
00:15:44,389 --> 00:15:42,560
universe they ionized all the hydrogen

425
00:15:45,910 --> 00:15:44,399
gas in this round that is filling up the

426
00:15:47,509 --> 00:15:45,920
universe

427
00:15:48,710 --> 00:15:47,519
and by studying the properties of these

428
00:15:51,030 --> 00:15:48,720
sources

429
00:15:53,670 --> 00:15:51,040
how big they are how they look like and

430
00:15:55,110 --> 00:15:53,680
so on we can get a lot of information

431
00:15:57,829 --> 00:15:55,120
about how

432
00:16:00,150 --> 00:15:57,839
today's galaxies like our old military

433
00:16:03,590 --> 00:16:00,160
have been building up over time starting

434
00:16:05,430 --> 00:16:03,600
from these very very early times

435
00:16:06,870 --> 00:16:05,440
and so on the next slide

436
00:16:10,629 --> 00:16:06,880
essentially

437
00:16:12,550 --> 00:16:10,639
out and look for these sources yourself

438
00:16:14,550 --> 00:16:12,560

in this new image you can do that and

439
00:16:17,749 --> 00:16:14,560
you just have to go and look for red

440
00:16:20,949 --> 00:16:17,759
galaxies uh red dots in this image

441
00:16:22,949 --> 00:16:20,959
um one problem there is that

442
00:16:25,269 --> 00:16:22,959
red galaxy colors can also be assigned

443
00:16:26,790 --> 00:16:25,279
for old stars or for a lot of dust and

444
00:16:29,910 --> 00:16:26,800
so you have to be a little bit careful

445
00:16:32,150 --> 00:16:29,920
there um and so on the left there are

446
00:16:35,030 --> 00:16:32,160
two examples of sources

447
00:16:36,470 --> 00:16:35,040
that are only about six billion years

448
00:16:39,030 --> 00:16:36,480
away from us

449
00:16:41,350 --> 00:16:39,040
while only the very source on the right

450
00:16:43,670 --> 00:16:41,360
very right is 13 billion light years

451
00:16:45,189 --> 00:16:43,680
away

452
00:16:46,629 --> 00:16:45,199
okay and so on the next

453
00:16:49,430 --> 00:16:46,639
slide

454
00:16:51,430 --> 00:16:49,440
um we see again the wavelength coverage

455
00:16:53,749 --> 00:16:51,440
of the xdf field

456
00:16:55,110 --> 00:16:53,759
of the xdf image and

457
00:16:57,670 --> 00:16:55,120
as you can see

458
00:17:00,790 --> 00:16:57,680
now hubble is really reaching its limit

459
00:17:02,949 --> 00:17:00,800
for finding even earlier galaxies than

460
00:17:05,270 --> 00:17:02,959
what we can see with the xcf and the

461
00:17:07,990 --> 00:17:05,280
problem here is you can see in the

462
00:17:11,029 --> 00:17:08,000
shaded gray area again

463
00:17:13,590 --> 00:17:11,039

um the further we go back in time uh the

464
00:17:16,630 --> 00:17:13,600
the farther to the red the galaxy light

465
00:17:18,630 --> 00:17:16,640
is shifted and this is just

466
00:17:21,510 --> 00:17:18,640
a consequence of the expansion of our

467
00:17:23,990 --> 00:17:21,520
universe um and so uh

468
00:17:26,390 --> 00:17:24,000
galaxies about more than uh earlier than

469
00:17:28,710 --> 00:17:26,400
400 million years from the big bang

470
00:17:30,150 --> 00:17:28,720
essentially they will remain invisible

471
00:17:33,190 --> 00:17:30,160
to hubble's cameras because they will

472
00:17:36,630 --> 00:17:33,200
shift out of the view of the xcf

473
00:17:39,430 --> 00:17:36,640
and and so we really need a jwst and

474
00:17:41,669 --> 00:17:39,440
jblc will do a great job to go to push

475
00:17:43,350 --> 00:17:41,679
even further to discover the first

476
00:17:45,669 --> 00:17:43,360
galaxies and

477
00:17:47,830 --> 00:17:45,679
because it's just 100 times more

478
00:17:50,310 --> 00:17:47,840
efficient than the hubble space

479
00:17:52,470 --> 00:17:50,320
telescope itself and so this is going to

480
00:17:54,710 --> 00:17:52,480
be a very very exciting time and we're

481
00:17:59,190 --> 00:17:54,720
all looking forward to that

482
00:18:03,750 --> 00:18:01,669
okay i want to thank our three experts

483
00:18:06,230 --> 00:18:03,760
for uh telling you how they put this

484
00:18:07,990 --> 00:18:06,240
wonderful observation together it's hard

485
00:18:09,909 --> 00:18:08,000
to imagine that 20 years ago before

486
00:18:11,350 --> 00:18:09,919
hubble went up we could only see

487
00:18:13,350 --> 00:18:11,360
i think roughly halfway across the

488
00:18:15,110 --> 00:18:13,360

universe and to be sitting here today

489
00:18:17,750 --> 00:18:15,120
talking about galaxies at such

490
00:18:19,830 --> 00:18:17,760
tremendous distances is amazing

491
00:18:21,669 --> 00:18:19,840
now it's your turn to ask these experts

492
00:18:23,750 --> 00:18:21,679
any questions you want and again let me

493
00:18:25,909 --> 00:18:23,760
remind our viewers you can send us

494
00:18:27,990 --> 00:18:25,919
questions via youtube or the google

495
00:18:29,510 --> 00:18:28,000
events page with that let me go to the

496
00:18:30,549 --> 00:18:29,520
first question from from one of our

497
00:18:32,870 --> 00:18:30,559
audience

498
00:18:35,430 --> 00:18:32,880
um you're calling this the extreme deep

499
00:18:37,909 --> 00:18:35,440
field but can hubble go deeper still are

500
00:18:39,430 --> 00:18:37,919
any astronomers or teams of astronomers

501
00:18:41,350 --> 00:18:39,440
now using hubble

502
00:18:43,669 --> 00:18:41,360
looking at hubble uh using a look at the

503
00:18:45,750 --> 00:18:43,679
deep field now and trying to push back

504
00:18:48,150 --> 00:18:45,760
that limit

505
00:18:50,870 --> 00:18:48,160
certainly ray this has uh

506
00:18:53,270 --> 00:18:50,880
been an ongoing process as we've noted

507
00:18:55,909 --> 00:18:53,280
that this is ten years of observations

508
00:18:57,990 --> 00:18:55,919
of hubble on this area have been built

509
00:18:59,669 --> 00:18:58,000
up into the altar into the

510
00:19:00,870 --> 00:18:59,679
extreme deep field

511
00:19:02,070 --> 00:19:00,880
and so

512
00:19:04,630 --> 00:19:02,080
what we are

513
00:19:06,390 --> 00:19:04,640

of course hoping for over the next

514
00:19:09,190 --> 00:19:06,400
many years of hubble's life that yet

515
00:19:11,669 --> 00:19:09,200
more data comes in and we add it to the

516
00:19:14,310 --> 00:19:11,679
field to make it even deeper still

517
00:19:16,549 --> 00:19:14,320
in fact there is some data coming in

518
00:19:17,750 --> 00:19:16,559
from the infrared camera in particular

519
00:19:20,070 --> 00:19:17,760
this fall

520
00:19:22,549 --> 00:19:20,080
that will become available to the public

521
00:19:25,430 --> 00:19:22,559
and to all astronomers late this year

522
00:19:27,830 --> 00:19:25,440
and early next and that can be added in

523
00:19:28,630 --> 00:19:27,840
and that will add new information

524
00:19:31,590 --> 00:19:28,640
so

525
00:19:33,270 --> 00:19:31,600
we continue to hope that more will be

526
00:19:35,430 --> 00:19:33,280
added that we'll be able to push a

527
00:19:37,430 --> 00:19:35,440
little fainter and deeper

528
00:19:39,909 --> 00:19:37,440
what we probably can't do is we can't

529
00:19:42,950 --> 00:19:39,919
push out much closer to the big bang

530
00:19:45,270 --> 00:19:42,960
that's a really a limiting aspect of the

531
00:19:47,350 --> 00:19:45,280
current cameras on hubble and to go

532
00:19:48,870 --> 00:19:47,360
closer to the big bang to earlier times

533
00:19:51,590 --> 00:19:48,880
we really need

534
00:19:53,909 --> 00:19:51,600
the james webb space telescope but the

535
00:19:55,830 --> 00:19:53,919
new data will give us the opportunity to

536
00:19:58,310 --> 00:19:55,840
explore the universe in the first

537
00:20:00,470 --> 00:19:58,320
billion years in more detail which will

538
00:20:03,830 --> 00:20:00,480

be great

539
00:20:06,390 --> 00:20:03,840
okay the next question i have is

540
00:20:08,390 --> 00:20:06,400
how much farther in terms of years what

541
00:20:11,110 --> 00:20:08,400
what will the web show you that you

542
00:20:12,950 --> 00:20:11,120
can't see in these hubble pictures so

543
00:20:15,909 --> 00:20:12,960
that's the fascinating question

544
00:20:17,750 --> 00:20:15,919
fascinating you know ultimately we would

545
00:20:19,590 --> 00:20:17,760
really like to see the first stars in

546
00:20:22,950 --> 00:20:19,600
galaxies with hubble

547
00:20:25,029 --> 00:20:22,960
with james webb very challenging

548
00:20:27,029 --> 00:20:25,039
we certainly expect that we'll be able

549
00:20:30,310 --> 00:20:27,039
to push back a few hundred million years

550
00:20:31,190 --> 00:20:30,320
earlier and see galaxies in formation

551
00:20:33,750 --> 00:20:31,200
but

552
00:20:35,590 --> 00:20:33,760
exactly what the universe holds for us

553
00:20:38,870 --> 00:20:35,600
in those early times is something that

554
00:20:41,430 --> 00:20:38,880
jwst will reveal and at the moment it's

555
00:20:43,270 --> 00:20:41,440
merely a matter of speculation and

556
00:20:45,110 --> 00:20:43,280
imagination

557
00:20:46,470 --> 00:20:45,120
so it's looking forward to fascinating

558
00:20:51,510 --> 00:20:46,480
things

559
00:20:58,149 --> 00:20:54,549
essentially as garth was saying um

560
00:21:00,549 --> 00:20:58,159
what we see now uh with with the xdf and

561
00:21:02,230 --> 00:21:00,559
with the hubble images we see that

562
00:21:04,710 --> 00:21:02,240
galaxies there's there are still

563
00:21:07,029 --> 00:21:04,720

galaxies even as we push out to these

564
00:21:09,350 --> 00:21:07,039
early times and and so there will

565
00:21:11,510 --> 00:21:09,360
and they you know they have uh

566
00:21:13,430 --> 00:21:11,520
they have stars in them that have formed

567
00:21:15,590 --> 00:21:13,440
earlier than that and so there will be

568
00:21:19,029 --> 00:21:15,600
more galaxies out there and that we can

569
00:21:19,830 --> 00:21:19,039
detect with jwst further back in time

570
00:21:21,590 --> 00:21:19,840
so

571
00:21:23,110 --> 00:21:21,600
yeah

572
00:21:25,270 --> 00:21:23,120
okay great here's an interesting

573
00:21:27,350 --> 00:21:25,280
question if you were to aim hubble in

574
00:21:29,110 --> 00:21:27,360
the opposite direction

575
00:21:30,950 --> 00:21:29,120
would the universe look the same would

576
00:21:32,230 --> 00:21:30,960
you see a different age

577
00:21:33,270 --> 00:21:32,240
do you expect anything would look

578
00:21:37,830 --> 00:21:33,280
different

579
00:21:39,350 --> 00:21:37,840
but the universe is basically the same

580
00:21:40,470 --> 00:21:39,360
in any direction

581
00:21:44,470 --> 00:21:40,480
and

582
00:21:46,470 --> 00:21:44,480
observations have shown that to be the

583
00:21:48,549 --> 00:21:46,480
case but of course not in detail we

584
00:21:51,350 --> 00:21:48,559
would see different galaxies

585
00:21:53,830 --> 00:21:51,360
different objects and we would love to

586
00:21:56,630 --> 00:21:53,840
explore some other very deep field

587
00:21:59,270 --> 00:21:56,640
because we need other areas to build up

588
00:22:01,750 --> 00:21:59,280

the numbers of galaxies and the samples

589
00:22:04,870 --> 00:22:01,760
so more deep fields like the xdf would

590
00:22:06,789 --> 00:22:04,880
be incredibly good to have but a

591
00:22:07,909 --> 00:22:06,799
challenge it takes a lot of time as

592
00:22:11,029 --> 00:22:07,919
you've seen

593
00:22:13,510 --> 00:22:11,039
2 000 exposures on hubble 2 million

594
00:22:16,230 --> 00:22:13,520
seconds that's a lot of time

595
00:22:17,830 --> 00:22:16,240
um could any of you talk a bit about how

596
00:22:20,950 --> 00:22:17,840
much time it would take with the james

597
00:22:21,830 --> 00:22:20,960
webb to do the same kind of observation

598
00:22:25,669 --> 00:22:21,840
ah

599
00:22:28,870 --> 00:22:25,679
it's we have typically try used about a

600
00:22:30,230 --> 00:22:28,880
factor of 100 gain with james webb for

601
00:22:33,350 --> 00:22:30,240
typical

602
00:22:35,750 --> 00:22:33,360
imaging capabilities so it's a lot less

603
00:22:38,710 --> 00:22:35,760
so thousands of seconds

604
00:22:41,190 --> 00:22:38,720
so in fact hours would achieve what

605
00:22:44,310 --> 00:22:41,200
we've done already which is really quite

606
00:22:46,870 --> 00:22:44,320
remarkable james webb is astonishingly

607
00:22:49,830 --> 00:22:46,880
powerful will be astonishingly powerful

608
00:22:51,510 --> 00:22:49,840
when it launches in 2018.

609
00:22:53,270 --> 00:22:51,520
so the next question from one of our

610
00:22:55,110 --> 00:22:53,280
viewers has

611
00:22:56,549 --> 00:22:55,120
the field is full of galaxies and you

612
00:22:58,870 --> 00:22:56,559
showed us it's a little tiny piece of

613
00:23:00,870 --> 00:22:58,880

the sky has to change your estimate for

614
00:23:02,950 --> 00:23:00,880
the number of galaxies in the entire

615
00:23:04,789 --> 00:23:02,960
universe

616
00:23:07,190 --> 00:23:04,799
pascal did you want to answer that and i

617
00:23:10,230 --> 00:23:07,200
could add to it afterwards

618
00:23:11,669 --> 00:23:10,240
yeah so essentially um as i was as i was

619
00:23:13,750 --> 00:23:11,679
showing

620
00:23:16,230 --> 00:23:13,760
now with this new image with the new

621
00:23:18,310 --> 00:23:16,240
camera we are able to push to earlier

622
00:23:20,310 --> 00:23:18,320
times and in particular these earlier

623
00:23:23,110 --> 00:23:20,320
times um

624
00:23:25,750 --> 00:23:23,120
we found that there might be uh many

625
00:23:29,510 --> 00:23:25,760
more fainter galaxies the galaxy that we

626
00:23:31,909 --> 00:23:29,520
cannot currently see with hubble um but

627
00:23:35,190 --> 00:23:31,919
so we are really at the limit of of our

628
00:23:37,110 --> 00:23:35,200
detection of this image that we have now

629
00:23:39,590 --> 00:23:37,120
it seems like there are more galaxies

630
00:23:42,230 --> 00:23:39,600
than what we expected before um at these

631
00:23:44,710 --> 00:23:42,240
early times and more fainter galaxies so

632
00:23:47,510 --> 00:23:44,720
the and again these uh we will be able

633
00:23:49,350 --> 00:23:47,520
to detect with uh james webb uh very

634
00:23:51,510 --> 00:23:49,360
easily and quickly and so that's going

635
00:23:52,870 --> 00:23:51,520
to be a great

636
00:23:54,710 --> 00:23:52,880
garth you're going to say something more

637
00:23:57,430 --> 00:23:54,720
yeah let me just add to that i think one

638
00:23:59,029 --> 00:23:57,440

of the things that xdf has really taught

639
00:24:00,149 --> 00:23:59,039
us over the last few years as we've

640
00:24:03,270 --> 00:24:00,159
taken the

641
00:24:05,430 --> 00:24:03,280
data that has become the basis for xcf

642
00:24:07,750 --> 00:24:05,440
is that the universe is just full of

643
00:24:09,990 --> 00:24:07,760
tiny little galaxies in the in early

644
00:24:12,310 --> 00:24:10,000
times and it's these tiny little

645
00:24:14,870 --> 00:24:12,320
galaxies where most of the masses where

646
00:24:16,950 --> 00:24:14,880
most of the light is so these are very

647
00:24:19,430 --> 00:24:16,960
important to study so these

648
00:24:20,950 --> 00:24:19,440
extremely deep fields are crucial to

649
00:24:23,269 --> 00:24:20,960
understanding what's happening in the

650
00:24:25,750 --> 00:24:23,279
early universe and how galaxies are

651
00:24:27,430 --> 00:24:25,760
building up

652
00:24:29,590 --> 00:24:27,440
okay great we've got an our next

653
00:24:31,590 --> 00:24:29,600
question

654
00:24:34,310 --> 00:24:31,600
in terms of redshift which is a measure

655
00:24:36,310 --> 00:24:34,320
of how far away the galaxies are

656
00:24:38,470 --> 00:24:36,320
at what redshift do you expect there to

657
00:24:41,830 --> 00:24:38,480
be a sudden drop off in the number of

658
00:24:44,310 --> 00:24:41,840
galaxies an epic were galaxies were just

659
00:24:46,390 --> 00:24:44,320
just beginning to start forming do you

660
00:24:49,430 --> 00:24:46,400
have any prediction for that

661
00:24:53,830 --> 00:24:49,440
this is an interesting question because

662
00:24:56,710 --> 00:24:53,840
we have recently started to look at

663
00:24:59,350 --> 00:24:56,720

galaxies around 450 million years ago

664
00:25:01,750 --> 00:24:59,360
where was just now just two objects that

665
00:25:04,870 --> 00:25:01,760
are really part of that sample and

666
00:25:06,630 --> 00:25:04,880
galaxies uh 600 700 million years ago

667
00:25:08,710 --> 00:25:06,640
and there appear to be fewer of those

668
00:25:11,750 --> 00:25:08,720
than we might expect but clearly the

669
00:25:13,909 --> 00:25:11,760
numbers are very small so there's a time

670
00:25:16,149 --> 00:25:13,919
in there around redshift 10 for the

671
00:25:17,990 --> 00:25:16,159
folks who asked about redshift where

672
00:25:20,549 --> 00:25:18,000
things may be changing

673
00:25:23,990 --> 00:25:20,559
but what we really expect is the big

674
00:25:25,110 --> 00:25:24,000
changes will occur around redshift 12 13

675
00:25:27,190 --> 00:25:25,120
15

676
00:25:29,830 --> 00:25:27,200
at the times when the very first

677
00:25:31,510 --> 00:25:29,840
galaxies are starting to build up so we

678
00:25:34,470 --> 00:25:31,520
may be getting a hint from hubble

679
00:25:37,190 --> 00:25:34,480
already of those changes but it's still

680
00:25:39,590 --> 00:25:37,200
a region that needs more explanation

681
00:25:41,350 --> 00:25:39,600
more exploration and in fact the new

682
00:25:43,830 --> 00:25:41,360
data that is coming in and will become

683
00:25:45,830 --> 00:25:43,840
available later this year to everybody

684
00:25:47,590 --> 00:25:45,840
should give us some clues about that as

685
00:25:50,310 --> 00:25:47,600
well should it maybe increase the number

686
00:25:53,269 --> 00:25:50,320
of those objects around redshift 10.

687
00:25:54,950 --> 00:25:53,279
pascal did you want to add to that

688
00:25:57,909 --> 00:25:54,960

oh no i think that's that's a very good

689
00:26:02,549 --> 00:25:59,590
okay this is a fascinating question this

690
00:26:04,310 --> 00:26:02,559
is very imaginative uh let me remind the

691
00:26:06,870 --> 00:26:04,320
viewers that that hubble and web will

692
00:26:09,029 --> 00:26:06,880
look out to a certain redshift beyond

693
00:26:11,430 --> 00:26:09,039
that is the is the background glow from

694
00:26:12,470 --> 00:26:11,440
the big bang itself called the microwave

695
00:26:15,510 --> 00:26:12,480
background

696
00:26:17,430 --> 00:26:15,520
so one viewer asks could you have a

697
00:26:18,630 --> 00:26:17,440
microwave telescope or some kind of

698
00:26:21,669 --> 00:26:18,640
telescope

699
00:26:37,029 --> 00:26:21,679
to look even farther than the big bang

700
00:26:43,909 --> 00:26:38,950
earlier times i think

701
00:26:47,350 --> 00:26:44,789
um

702
00:26:49,110 --> 00:26:47,360
company uh can you tell us how many feel

703
00:26:50,310 --> 00:26:49,120
for how many astronomers and teams of

704
00:26:52,630 --> 00:26:50,320
astronomers

705
00:26:54,230 --> 00:26:52,640
have been using this this data from the

706
00:26:56,950 --> 00:26:54,240
past 10 years and

707
00:26:59,110 --> 00:26:56,960
and uh and and how many papers and

708
00:27:01,510 --> 00:26:59,120
discoveries have come out from omaha and

709
00:27:02,549 --> 00:27:01,520
in total i'm not sure it's interesting i

710
00:27:03,350 --> 00:27:02,559
know that

711
00:27:05,990 --> 00:27:03,360
when

712
00:27:07,269 --> 00:27:06,000
the hubble ultra d field 09 data came

713
00:27:09,909 --> 00:27:07,279

out with

714
00:27:11,909 --> 00:27:09,919
white field camera 3 with the infrared

715
00:27:13,750 --> 00:27:11,919
that that was

716
00:27:15,430 --> 00:27:13,760
elicited a lot of interest was the

717
00:27:17,669 --> 00:27:15,440
public data set

718
00:27:19,590 --> 00:27:17,679
i think six or seven groups of people

719
00:27:21,750 --> 00:27:19,600
have been working on that and publishing

720
00:27:24,230 --> 00:27:21,760
papers and there's over 40 papers that

721
00:27:26,149 --> 00:27:24,240
have come out just in the last uh let me

722
00:27:28,710 --> 00:27:26,159
see two and a half years since that data

723
00:27:31,350 --> 00:27:28,720
set became completely available

724
00:27:33,750 --> 00:27:31,360
so these and of course there are a huge

725
00:27:37,029 --> 00:27:33,760
number more now when you add in all the

726
00:27:38,149 --> 00:27:37,039
hubble ultra deep field data from 2003

727
00:27:40,470 --> 00:27:38,159
and 4.

728
00:27:41,909 --> 00:27:40,480
so i would estimate hundreds of papers

729
00:27:44,230 --> 00:27:41,919
have come out but i actually don't have

730
00:27:48,710 --> 00:27:44,240
at my fingertips the number pascal do

731
00:27:53,269 --> 00:27:51,590
no sorry i yeah i also don't know

732
00:27:55,190 --> 00:27:53,279
there's a lot of people and and of

733
00:27:57,269 --> 00:27:55,200
course you can do it so much more than

734
00:28:00,389 --> 00:27:57,279
what we are just saying here that you

735
00:28:02,149 --> 00:28:00,399
can you can study galaxies at slightly

736
00:28:03,110 --> 00:28:02,159
later times as well and you can see

737
00:28:05,029 --> 00:28:03,120
those in

738
00:28:06,470 --> 00:28:05,039

in detail that you haven't been able to

739
00:28:09,510 --> 00:28:06,480
see before so

740
00:28:11,190 --> 00:28:09,520
um there's a lot that people are doing

741
00:28:14,470 --> 00:28:11,200
yeah that's actually a very good point

742
00:28:17,269 --> 00:28:14,480
these data sets have uh value from

743
00:28:19,990 --> 00:28:17,279
galaxies all very close to us to

744
00:28:22,230 --> 00:28:20,000
at the earliest reaches of the universe

745
00:28:24,470 --> 00:28:22,240
and so they've been studied by a very

746
00:28:27,990 --> 00:28:24,480
large number of people and used very

747
00:28:29,510 --> 00:28:28,000
extensively throughout in the community

748
00:28:31,110 --> 00:28:29,520
of astronomers and physicist

749
00:28:33,669 --> 00:28:31,120
astrophysicists who are studying

750
00:28:35,990 --> 00:28:33,679
galaxies

751
00:28:37,110 --> 00:28:36,000
okay great here's a very good question

752
00:28:40,630 --> 00:28:37,120
um

753
00:28:43,350 --> 00:28:40,640
we've we've put out pictures from hubble

754
00:28:45,830 --> 00:28:43,360
where space is warped and the light of

755
00:28:48,070 --> 00:28:45,840
galaxies is warped by the phenomenon

756
00:28:49,909 --> 00:28:48,080
called gravitational lensing do you see

757
00:28:52,230 --> 00:28:49,919
any evidence of gravitational lensing in

758
00:28:56,630 --> 00:28:52,240
the xtf

759
00:28:58,789 --> 00:28:56,640
no not that not as far as i can recall

760
00:29:01,430 --> 00:28:58,799
or as far as we've seen

761
00:29:04,230 --> 00:29:01,440
we're looking at a very tiny region of

762
00:29:05,990 --> 00:29:04,240
space and we particularly this field was

763
00:29:07,669 --> 00:29:06,000

chosen originally

764
00:29:11,029 --> 00:29:07,679
to

765
00:29:13,830 --> 00:29:11,039
minimize having particular condensations

766
00:29:15,830 --> 00:29:13,840
of galaxies called clusters of galaxies

767
00:29:18,149 --> 00:29:15,840
which is where we would most obviously

768
00:29:20,630 --> 00:29:18,159
see the gravitational lensing there will

769
00:29:23,669 --> 00:29:20,640
be some effect from lensing but it's a

770
00:29:25,430 --> 00:29:23,679
relatively small effect very minor on

771
00:29:28,149 --> 00:29:25,440
this scale it's something you would have

772
00:29:30,710 --> 00:29:28,159
to search extremely hard for it's what

773
00:29:32,630 --> 00:29:30,720
people might call weak lensing and its

774
00:29:34,389 --> 00:29:32,640
effects on the galaxies are really

775
00:29:37,029 --> 00:29:34,399
really tiny

776
00:29:38,950 --> 00:29:37,039
pascal do you want to add to that

777
00:29:41,590 --> 00:29:38,960
no essentially you in order to see

778
00:29:43,830 --> 00:29:41,600
gravitational lensing you need a very

779
00:29:46,549 --> 00:29:43,840
very massive structure in front of you

780
00:29:48,950 --> 00:29:46,559
either cluster or a very massive galaxy

781
00:29:50,070 --> 00:29:48,960
and and so um yeah as scarf was saying

782
00:29:52,549 --> 00:29:50,080
we don't see

783
00:29:54,389 --> 00:29:52,559
evidence at all for strong lensing

784
00:29:56,470 --> 00:29:54,399
because these are very particular

785
00:30:00,630 --> 00:29:56,480
uh locations in the sky where you can

786
00:30:01,990 --> 00:30:00,640
see that and not in the portraits here

787
00:30:04,070 --> 00:30:02,000
now this is a very good question too

788
00:30:05,990 --> 00:30:04,080

when we talk about the any of these deep

789
00:30:07,669 --> 00:30:06,000
fields where we always talk about

790
00:30:08,389 --> 00:30:07,679
distance in terms of billions of light

791
00:30:10,070 --> 00:30:08,399
years

792
00:30:11,430 --> 00:30:10,080
but we're also talking about looking

793
00:30:13,590 --> 00:30:11,440
back in time

794
00:30:16,310 --> 00:30:13,600
billions of years can any of you provide

795
00:30:19,830 --> 00:30:16,320
a simple explanation to our viewers how

796
00:30:21,029 --> 00:30:19,840
you can look so far back in time

797
00:30:22,630 --> 00:30:21,039
and are you really sure you're looking

798
00:30:25,590 --> 00:30:22,640
back in time

799
00:30:28,470 --> 00:30:25,600
yeah i mean i would say that the the way

800
00:30:30,870 --> 00:30:28,480
you phrase it there explains it that

801
00:30:33,350 --> 00:30:30,880
the distances are billions of light

802
00:30:35,590 --> 00:30:33,360
years that is light takes

803
00:30:37,750 --> 00:30:35,600
in a year takes a certain wall to travel

804
00:30:39,909 --> 00:30:37,760
a certain distance the billions of light

805
00:30:41,909 --> 00:30:39,919
years is a distance that corresponds to

806
00:30:42,950 --> 00:30:41,919
billions of years for the light to reach

807
00:30:44,230 --> 00:30:42,960
us

808
00:30:46,710 --> 00:30:44,240
and so

809
00:30:49,669 --> 00:30:46,720
it's something that we have calibrated

810
00:30:50,950 --> 00:30:49,679
by various means but

811
00:30:53,990 --> 00:30:50,960
it's a

812
00:30:56,310 --> 00:30:54,000
way of characterizing the scale and it

813
00:30:57,269 --> 00:30:56,320

is intrinsic to the nature of the

814
00:30:59,750 --> 00:30:57,279
physics

815
00:31:02,230 --> 00:30:59,760
that uh light doesn't travel at infinite

816
00:31:05,269 --> 00:31:02,240
velocity it does take time to cover a

817
00:31:06,710 --> 00:31:05,279
distance and that distance then turns

818
00:31:08,870 --> 00:31:06,720
into a

819
00:31:11,430 --> 00:31:08,880
a time that light takes so an example is

820
00:31:14,470 --> 00:31:11,440
the sun is eight light minutes away we

821
00:31:16,549 --> 00:31:14,480
see the sun as it was eight minutes ago

822
00:31:18,389 --> 00:31:16,559
so we're seeing these galaxies as they

823
00:31:21,269 --> 00:31:18,399
were billions of years ago it's a big

824
00:31:22,630 --> 00:31:21,279
difference but the principle is the same

825
00:31:24,549 --> 00:31:22,640
pascal do you have a nice little

826
00:31:25,590 --> 00:31:24,559
explanation that would be good to add

827
00:31:27,350 --> 00:31:25,600
here

828
00:31:29,510 --> 00:31:27,360
no i think that is good it is a constant

829
00:31:31,430 --> 00:31:29,520
of nature and and the light takes time

830
00:31:33,990 --> 00:31:31,440
to reach us and to reach the hubble

831
00:31:37,269 --> 00:31:34,000
space telescope and so

832
00:31:39,269 --> 00:31:37,279
that's how we look back in time

833
00:31:41,750 --> 00:31:39,279
great now a very common question and it

834
00:31:43,669 --> 00:31:41,760
came up here is

835
00:31:46,950 --> 00:31:43,679
we've seen estimates for the age of the

836
00:31:48,710 --> 00:31:46,960
universe and does the xdf

837
00:31:50,870 --> 00:31:48,720
agree with those estimates does it help

838
00:31:54,950 --> 00:31:50,880

us to refine the age of the universe the

839
00:31:59,269 --> 00:31:54,960
published age is 13.7 billion years but

840
00:32:01,830 --> 00:31:59,279
does the xdf support that that value

841
00:32:03,909 --> 00:32:01,840
yeah fortunately the age of the universe

842
00:32:05,590 --> 00:32:03,919
has been determined now very well

843
00:32:07,909 --> 00:32:05,600
through a variety of techniques and

844
00:32:10,950 --> 00:32:07,919
particularly using very powerful

845
00:32:12,950 --> 00:32:10,960
microwave telescopes and so

846
00:32:15,110 --> 00:32:12,960
this is something that

847
00:32:17,509 --> 00:32:15,120
we have we not we

848
00:32:19,669 --> 00:32:17,519
this group sitting here but astronomers

849
00:32:20,710 --> 00:32:19,679
have determined independently

850
00:32:23,509 --> 00:32:20,720
and so

851
00:32:26,149 --> 00:32:23,519
we are just using our estimates of the

852
00:32:28,149 --> 00:32:26,159
ages of the look back time and so on and

853
00:32:29,269 --> 00:32:28,159
it's based around that age of the

854
00:32:30,710 --> 00:32:29,279
universe

855
00:32:32,230 --> 00:32:30,720
we don't have to

856
00:32:33,909 --> 00:32:32,240
come up with an independent and we

857
00:32:35,990 --> 00:32:33,919
couldn't this is not the sort of data

858
00:32:38,230 --> 00:32:36,000
that you use to get the age of the

859
00:32:41,269 --> 00:32:38,240
universe

860
00:32:44,549 --> 00:32:41,279
okay how do you want to add to that

861
00:32:47,029 --> 00:32:44,559
no i think that's that's good

862
00:32:49,750 --> 00:32:47,039
now a question along those lines that

863
00:32:51,990 --> 00:32:49,760

probably the some of the two biggest

864
00:32:53,750 --> 00:32:52,000
among the biggest questions in modern

865
00:32:55,509 --> 00:32:53,760
astronomy what is dark matter and what

866
00:32:57,509 --> 00:32:55,519
is dark energy

867
00:32:58,630 --> 00:32:57,519
that that force that's pushing universe

868
00:33:00,470 --> 00:32:58,640
apart and

869
00:33:01,269 --> 00:33:00,480
whatever that dark matter is floating

870
00:33:03,830 --> 00:33:01,279
out

871
00:33:06,470 --> 00:33:03,840
there does xtf provide any insights into

872
00:33:12,149 --> 00:33:09,190
it's interesting that

873
00:33:15,029 --> 00:33:12,159
supernova searches which were used to

874
00:33:17,190 --> 00:33:15,039
initially demonstrate that the dark

875
00:33:19,669 --> 00:33:17,200
energy existed the universe was behaving

876
00:33:21,430 --> 00:33:19,679
in a very unexpected way

877
00:33:23,509 --> 00:33:21,440
were

878
00:33:26,149 --> 00:33:23,519
part of those searches occurred around

879
00:33:28,389 --> 00:33:26,159
this region and in fact so the xdf

880
00:33:30,710 --> 00:33:28,399
actually has some images that were taken

881
00:33:33,509 --> 00:33:30,720
by the supernova search groups looking

882
00:33:35,669 --> 00:33:33,519
for measuring supernovae and so we've

883
00:33:38,870 --> 00:33:35,679
all incorporated that data but it's very

884
00:33:41,110 --> 00:33:38,880
peripheral xdf doesn't isn't explicitly

885
00:33:43,990 --> 00:33:41,120
aimed at trying to understand or to

886
00:33:45,990 --> 00:33:44,000
measure dark energy but it certainly

887
00:33:47,269 --> 00:33:46,000
includes some of the data that was used

888
00:33:50,230 --> 00:33:47,279

for that

889
00:33:51,669 --> 00:33:50,240
and for dark matter again that's

890
00:33:54,230 --> 00:33:51,679
something that

891
00:33:55,990 --> 00:33:54,240
we explore best with

892
00:33:58,549 --> 00:33:56,000
clusters of galaxies as a way of

893
00:34:01,509 --> 00:33:58,559
measuring that directly

894
00:34:03,830 --> 00:34:01,519
with weak lensing on large scales

895
00:34:06,310 --> 00:34:03,840
something the xcf which is a very

896
00:34:08,470 --> 00:34:06,320
focused pencil beam doesn't look at

897
00:34:10,149 --> 00:34:08,480
directly or can't be effectively used

898
00:34:12,230 --> 00:34:10,159
for directly so there are other

899
00:34:13,990 --> 00:34:12,240
approaches that

900
00:34:17,510 --> 00:34:14,000
were being used for both of these

901
00:34:19,510 --> 00:34:17,520
questions so xdf uses what we understand

902
00:34:21,349 --> 00:34:19,520
about dark matter and dark energy to

903
00:34:23,909 --> 00:34:21,359
understand about how the galaxies build

904
00:34:27,190 --> 00:34:23,919
up and grow but not directly will it

905
00:34:29,510 --> 00:34:27,200
contribute to either of those questions

906
00:34:32,230 --> 00:34:29,520
okay great scale your chance as well

907
00:34:34,629 --> 00:34:32,240
anything you want to add there

908
00:34:36,869 --> 00:34:34,639
no i think that's a good question good

909
00:34:38,790 --> 00:34:36,879
answer

910
00:34:40,629 --> 00:34:38,800
so another question i mean

911
00:34:42,389 --> 00:34:40,639
i think looking at the xtf it's one of

912
00:34:44,710 --> 00:34:42,399
the most colorful pictures we put out

913
00:34:46,710 --> 00:34:44,720

you've got the roy g biv galaxies

914
00:34:48,389 --> 00:34:46,720
everywhere so somebody asked what are

915
00:34:50,790 --> 00:34:48,399
the green galaxies and why are they

916
00:34:54,230 --> 00:34:53,589
very interesting so most of the galaxies

917
00:34:57,349 --> 00:34:54,240
are

918
00:34:59,510 --> 00:34:57,359
blue intrinsically they appear red

919
00:35:02,470 --> 00:34:59,520
because the hydrogen in the universe

920
00:35:05,430 --> 00:35:02,480
absorbs the very bluest light and so

921
00:35:07,109 --> 00:35:05,440
makes them appear red so

922
00:35:09,430 --> 00:35:07,119
as you look at that you see some blue

923
00:35:11,510 --> 00:35:09,440
galaxies most of the others i would say

924
00:35:12,310 --> 00:35:11,520
are blue there's also red galaxies in

925
00:35:14,310 --> 00:35:12,320
there

926
00:35:16,870 --> 00:35:14,320
then some of those are just because of

927
00:35:19,190 --> 00:35:16,880
this artifact of the hydrogen absorbing

928
00:35:21,990 --> 00:35:19,200
light but some of that is also because

929
00:35:25,030 --> 00:35:22,000
there are galaxies as pascal explained

930
00:35:26,470 --> 00:35:25,040
that contain older stars and look red

931
00:35:29,270 --> 00:35:26,480
and so

932
00:35:31,349 --> 00:35:29,280
there's now a sort of middle ground

933
00:35:33,670 --> 00:35:31,359
where there are some galaxies where the

934
00:35:36,069 --> 00:35:33,680
stars are aging

935
00:35:39,030 --> 00:35:36,079
and they can look green so they're not

936
00:35:40,630 --> 00:35:39,040
necessarily old or extremely distant and

937
00:35:43,270 --> 00:35:40,640
they all look green because of the

938
00:35:45,829 --> 00:35:43,280

nature of the stars and the effect of

939
00:35:47,589 --> 00:35:45,839
dust in the galaxy

940
00:35:50,150 --> 00:35:47,599
pascal do you want to add to that yeah

941
00:35:52,069 --> 00:35:50,160
so some of these so as as i was showing

942
00:35:54,230 --> 00:35:52,079
the and that scarf was saying the

943
00:35:55,829 --> 00:35:54,240
hydrogen is absorbing uh

944
00:35:57,109 --> 00:35:55,839
some of these lights of these sources

945
00:35:58,790 --> 00:35:57,119
and so that's why

946
00:36:00,310 --> 00:35:58,800
if you go back uh

947
00:36:02,710 --> 00:36:00,320
800 million years

948
00:36:04,950 --> 00:36:02,720
to the close to the big bang essentially

949
00:36:07,270 --> 00:36:04,960
these these sources are all red because

950
00:36:09,190 --> 00:36:07,280
the the light is only emitted at

951
00:36:12,390 --> 00:36:09,200
near-infrared wavelengths as it just

952
00:36:14,790 --> 00:36:12,400
goes slightly lower and these galaxies

953
00:36:17,589 --> 00:36:14,800
the same kind of galaxies they just look

954
00:36:20,710 --> 00:36:17,599
very green because they are they're blue

955
00:36:22,950 --> 00:36:20,720
intrinsically um but the light

956
00:36:25,349 --> 00:36:22,960
the very blue light is absorbed

957
00:36:26,950 --> 00:36:25,359
that you don't see that and so

958
00:36:29,510 --> 00:36:26,960
so that's why they appear green they're

959
00:36:31,750 --> 00:36:29,520
typically about one billion year after

960
00:36:33,510 --> 00:36:31,760
the big bang uh one of the most the

961
00:36:36,390 --> 00:36:33,520
greenest the galaxies that look the most

962
00:36:38,870 --> 00:36:36,400
green are roughly one billion year from

963
00:36:40,950 --> 00:36:38,880

the big bang and they've already in the

964
00:36:42,790 --> 00:36:40,960
hubble the original hubble ultra deep

965
00:36:45,750 --> 00:36:42,800
field in the acs data we could see those

966
00:36:49,430 --> 00:36:45,760
sources already um and now and in there

967
00:36:53,349 --> 00:36:51,589
okay next question the theory of the big

968
00:36:54,550 --> 00:36:53,359
bang of course is that space is

969
00:36:56,550 --> 00:36:54,560
expanding

970
00:36:58,550 --> 00:36:56,560
so these very distant galaxies you're

971
00:37:00,630 --> 00:36:58,560
looking at must have been more crowded

972
00:37:02,790 --> 00:37:00,640
and how far apart from each other do you

973
00:37:05,270 --> 00:37:02,800
think they were was it was everything

974
00:37:07,910 --> 00:37:05,280
kind of compacted back then

975
00:37:11,109 --> 00:37:07,920
yeah that's very interesting if uh by

976
00:37:13,510 --> 00:37:11,119
any chance there was anybody

977
00:37:15,829 --> 00:37:13,520
anything alive in those days to look at

978
00:37:17,190 --> 00:37:15,839
galaxies galaxies would have looked a

979
00:37:19,510 --> 00:37:17,200
lot different

980
00:37:22,150 --> 00:37:19,520
none of these beautiful spiral galaxies

981
00:37:24,150 --> 00:37:22,160
as uh tried to indicate in early in my

982
00:37:25,510 --> 00:37:24,160
slides they would be blobby little

983
00:37:27,270 --> 00:37:25,520
things blue

984
00:37:28,150 --> 00:37:27,280
and they would be much closer to each

985
00:37:30,310 --> 00:37:28,160
other

986
00:37:32,550 --> 00:37:30,320
and so the universe would look really

987
00:37:34,790 --> 00:37:32,560
very different the sky at night if you

988
00:37:37,270 --> 00:37:34,800

went out with a telescope and looked

989
00:37:39,670 --> 00:37:37,280
around you would just see

990
00:37:42,710 --> 00:37:39,680
more of these very blue small bright

991
00:37:44,230 --> 00:37:42,720
very intense galaxies much closer to

992
00:37:46,790 --> 00:37:44,240
each other

993
00:37:49,030 --> 00:37:46,800
so it changes over time

994
00:37:51,990 --> 00:37:49,040
pascal do you have an image of what is

995
00:37:54,150 --> 00:37:52,000
you think it's like as you go back

996
00:37:57,030 --> 00:37:54,160
essentially um what we can say is that

997
00:37:59,270 --> 00:37:57,040
the universe was only a tenth or so of

998
00:38:02,150 --> 00:37:59,280
its size that it is today when we see

999
00:38:04,310 --> 00:38:02,160
those galaxies those early galaxies um

1000
00:38:06,630 --> 00:38:04,320
but as garth was saying the galaxies

1001
00:38:09,270 --> 00:38:06,640
wouldn't have looked the same as as our

1002
00:38:12,069 --> 00:38:09,280
milky way today here so so it is

1003
00:38:15,510 --> 00:38:12,079
uh tricky to say

1004
00:38:19,589 --> 00:38:17,670
so along those lines you see these the

1005
00:38:21,190 --> 00:38:19,599
galaxies that existed billions of years

1006
00:38:22,470 --> 00:38:21,200
ago how do we know what they're doing

1007
00:38:23,510 --> 00:38:22,480
today

1008
00:38:25,030 --> 00:38:23,520
can we

1009
00:38:27,270 --> 00:38:25,040
figure that out

1010
00:38:30,310 --> 00:38:27,280
wow interesting most of those are going

1011
00:38:33,030 --> 00:38:30,320
to have ended up in galaxies like

1012
00:38:36,550 --> 00:38:33,040
our milky way like andromeda

1013
00:38:39,829 --> 00:38:36,560

like uh of the big red galaxies like big

1014
00:38:42,790 --> 00:38:39,839
red galaxies around us so these galaxies

1015
00:38:45,589 --> 00:38:42,800
at that those early times the seeds that

1016
00:38:47,030 --> 00:38:45,599
from which today's galaxies are built

1017
00:38:49,589 --> 00:38:47,040
and so

1018
00:38:50,950 --> 00:38:49,599
one can't trace the history and you know

1019
00:38:52,870 --> 00:38:50,960
exactly where they're going to build out

1020
00:38:55,030 --> 00:38:52,880
and go to because one of these little

1021
00:38:57,030 --> 00:38:55,040
galaxies is probably going to grow

1022
00:38:58,710 --> 00:38:57,040
somewhat of its own accord as gas falls

1023
00:39:01,349 --> 00:38:58,720
in and stars form but then it's going to

1024
00:39:03,910 --> 00:39:01,359
collide with another galaxy and there's

1025
00:39:06,150 --> 00:39:03,920
now going to be a merged galaxy that's

1026
00:39:09,589 --> 00:39:06,160
going to build up and grow so they have

1027
00:39:12,870 --> 00:39:09,599
a long history of activity merging

1028
00:39:15,349 --> 00:39:12,880
growing coming together changing

1029
00:39:18,150 --> 00:39:15,359
gas falling in forming the discs so

1030
00:39:20,790 --> 00:39:18,160
galaxies are the growth of galaxies a

1031
00:39:23,109 --> 00:39:20,800
very dynamic and dramatic process over

1032
00:39:24,790 --> 00:39:23,119
the first few billion years until the

1033
00:39:30,790 --> 00:39:24,800
universe started to look like the

1034
00:39:35,190 --> 00:39:33,109
essentially we're we're using our

1035
00:39:38,230 --> 00:39:35,200
observations for galaxies at different

1036
00:39:40,069 --> 00:39:38,240
times so that's because of the

1037
00:39:42,069 --> 00:39:40,079
constant of speed of light we can look

1038
00:39:43,990 --> 00:39:42,079

back in time as we were saying before

1039
00:39:45,829 --> 00:39:44,000
and so we were trying with our

1040
00:39:48,790 --> 00:39:45,839
observations to connect these different

1041
00:39:50,310 --> 00:39:48,800
galaxies at different epochs um but of

1042
00:39:52,550 --> 00:39:50,320
course we cannot be sure there's not a

1043
00:39:54,870 --> 00:39:52,560
one-to-one connection and so we're using

1044
00:39:56,950 --> 00:39:54,880
computer simulations in the end of

1045
00:39:59,349 --> 00:39:56,960
galaxies and of the buildup of the

1046
00:40:02,470 --> 00:39:59,359
universe essentially to decipher these

1047
00:40:04,790 --> 00:40:02,480
things and there's a very uh

1048
00:40:06,790 --> 00:40:04,800
tight essentially interplay between us

1049
00:40:08,069 --> 00:40:06,800
us observers essentially and and the

1050
00:40:10,950 --> 00:40:08,079
theorists and

1051
00:40:13,750 --> 00:40:10,960
that astronomer theorists potentially to

1052
00:40:15,190 --> 00:40:13,760
to answer this question

1053
00:40:17,190 --> 00:40:15,200
yeah

1054
00:40:19,910 --> 00:40:17,200
okay i'm going to come back to the

1055
00:40:21,670 --> 00:40:19,920
microwave background

1056
00:40:23,990 --> 00:40:21,680
fascinating question i don't think you

1057
00:40:26,470 --> 00:40:24,000
can talk in terms of distance but but

1058
00:40:30,150 --> 00:40:26,480
the the difference i guess in time

1059
00:40:31,670 --> 00:40:30,160
between the farthest galaxy in the xudf

1060
00:40:33,270 --> 00:40:31,680
and the time of this microwave

1061
00:40:34,950 --> 00:40:33,280
background when it became

1062
00:40:36,630 --> 00:40:34,960
transparent

1063
00:40:40,069 --> 00:40:36,640

you can express that in years but not

1064
00:40:44,630 --> 00:40:42,310
yeah the background sorry the microwave

1065
00:40:46,790 --> 00:40:44,640
background was essentially 400

1066
00:40:49,829 --> 00:40:46,800
000 years after the big bang so that was

1067
00:40:52,230 --> 00:40:49,839
very soon after the big bang and so

1068
00:40:53,990 --> 00:40:52,240
and our galaxies are essentially 400

1069
00:40:55,750 --> 00:40:54,000
million years then

1070
00:40:57,510 --> 00:40:55,760
after the big bang so there's

1071
00:40:59,990 --> 00:40:57,520
you know it's a negligible distance

1072
00:41:02,470 --> 00:41:00,000
almost uh from the big bang to our

1073
00:41:05,190 --> 00:41:02,480
galaxy that we're observing than uh from

1074
00:41:07,109 --> 00:41:05,200
the micro background to our galaxies

1075
00:41:08,710 --> 00:41:07,119
sorry garth

1076
00:41:10,790 --> 00:41:08,720
yeah so

1077
00:41:12,550 --> 00:41:10,800
it's sort of a fascinating discussion

1078
00:41:13,750 --> 00:41:12,560
because between

1079
00:41:15,190 --> 00:41:13,760
when uh

1080
00:41:17,109 --> 00:41:15,200
the four hundred thousand years that

1081
00:41:19,109 --> 00:41:17,119
pascal mentioned and when the first

1082
00:41:21,349 --> 00:41:19,119
galaxies formed which we don't the first

1083
00:41:23,829 --> 00:41:21,359
stars in galaxies we don't know when

1084
00:41:26,390 --> 00:41:23,839
that is but maybe it was around 150

1085
00:41:28,150 --> 00:41:26,400
million years 200 million years the sort

1086
00:41:29,990 --> 00:41:28,160
of a period in the universe we called

1087
00:41:32,230 --> 00:41:30,000
the dark ages when nothing was really

1088
00:41:34,390 --> 00:41:32,240

happening there were no stars there was

1089
00:41:35,910 --> 00:41:34,400
no light there was just gas permeated

1090
00:41:36,950 --> 00:41:35,920
through the universe

1091
00:41:39,030 --> 00:41:36,960
and so

1092
00:41:41,589 --> 00:41:39,040
it was a very different time the

1093
00:41:43,990 --> 00:41:41,599
universe was very um

1094
00:41:46,390 --> 00:41:44,000
i could say boring almost in the sense

1095
00:41:49,349 --> 00:41:46,400
that there wasn't the

1096
00:41:51,910 --> 00:41:49,359
beauty of the galaxies and stars forming

1097
00:41:54,710 --> 00:41:51,920
and then finally after 100 million years

1098
00:41:57,349 --> 00:41:54,720
150 million years the first stars came

1099
00:41:59,349 --> 00:41:57,359
together and very dramatic

1100
00:42:01,589 --> 00:41:59,359
growth started to occur

1101
00:42:03,190 --> 00:42:01,599
in galaxy in the stars and then in the

1102
00:42:05,109 --> 00:42:03,200
galaxies

1103
00:42:07,829 --> 00:42:05,119
and so we refer to that period in there

1104
00:42:12,390 --> 00:42:07,839
as the dark ages so the first stars and

1105
00:42:12,400 --> 00:42:15,589
okay great now here's

1106
00:42:19,270 --> 00:42:16,790
something dealing again with the big

1107
00:42:20,710 --> 00:42:19,280
bang the all the galaxies you see in the

1108
00:42:22,870 --> 00:42:20,720
xdf

1109
00:42:26,870 --> 00:42:22,880
uh are they accelerating and is that

1110
00:42:32,390 --> 00:42:29,030
uh they're growing along with the

1111
00:42:35,349 --> 00:42:32,400
universe and so they are moving apart

1112
00:42:37,349 --> 00:42:35,359
from each other as the universe grows

1113
00:42:38,790 --> 00:42:37,359

none of these galaxies well there are

1114
00:42:41,190 --> 00:42:38,800
galaxies in there that are probably

1115
00:42:43,190 --> 00:42:41,200
close enough together that they will

1116
00:42:45,670 --> 00:42:43,200
ultimately come together and merge and

1117
00:42:47,750 --> 00:42:45,680
make one galaxy but most of those

1118
00:42:52,230 --> 00:42:47,760
galaxies are going to be moving apart as

1119
00:42:56,870 --> 00:42:54,790
okay next question um

1120
00:42:58,950 --> 00:42:56,880
and again this gets more in the basic

1121
00:43:01,349 --> 00:42:58,960
physics of the universe

1122
00:43:02,790 --> 00:43:01,359
can can if the galaxies the universe is

1123
00:43:05,829 --> 00:43:02,800
expanding can

1124
00:43:07,030 --> 00:43:05,839
galaxies overtake other galaxies as is

1125
00:43:11,430 --> 00:43:07,040
the

1126
00:43:13,589 --> 00:43:11,440
speed of light faster or slower or some

1127
00:43:16,069 --> 00:43:13,599
physical parameters changed

1128
00:43:19,109 --> 00:43:16,079
in that early expansion

1129
00:43:21,990 --> 00:43:19,119
i think the best analogy that i like to

1130
00:43:24,230 --> 00:43:22,000
carry around is to just think of the

1131
00:43:26,150 --> 00:43:24,240
universe as

1132
00:43:29,510 --> 00:43:26,160
you know maybe i think the one that we

1133
00:43:31,829 --> 00:43:29,520
often see in our old textbooks is uh an

1134
00:43:34,550 --> 00:43:31,839
expanding loaf of bread as you bake it

1135
00:43:37,349 --> 00:43:34,560
or a cake or something that all the

1136
00:43:39,589 --> 00:43:37,359
raisins in such a loaf of you had raisin

1137
00:43:43,510 --> 00:43:39,599
bread would be moving apart from each

1138
00:43:45,510 --> 00:43:43,520

other as the universe expands with time

1139
00:43:47,990 --> 00:43:45,520
essentially the galaxies are carried

1140
00:43:50,550 --> 00:43:48,000
through space by the universe and

1141
00:43:52,230 --> 00:43:50,560
increasingly separate from each other

1142
00:43:54,550 --> 00:43:52,240
the only reason for them to come

1143
00:43:56,870 --> 00:43:54,560
together was if they were close enough

1144
00:43:59,270 --> 00:43:56,880
that the gravitational full of the two

1145
00:44:01,670 --> 00:43:59,280
galaxies was strong enough to bring them

1146
00:44:04,069 --> 00:44:01,680
together that happens but that's a small

1147
00:44:06,550 --> 00:44:04,079
fraction of the time

1148
00:44:09,510 --> 00:44:06,560
pascal do you have another thing analogy

1149
00:44:11,349 --> 00:44:09,520
you'd like to use no i guess

1150
00:44:13,750 --> 00:44:11,359
the balloon is a good analogy that you

1151
00:44:15,910 --> 00:44:13,760
blow up a balloon and

1152
00:44:18,630 --> 00:44:15,920
and if you put point you know put some

1153
00:44:20,230 --> 00:44:18,640
points on the balloon they will all uh

1154
00:44:24,150 --> 00:44:20,240
go away from each other and that's how

1155
00:44:27,109 --> 00:44:25,910
okay this is a fascinating question and

1156
00:44:29,349 --> 00:44:27,119
this gets

1157
00:44:31,349 --> 00:44:29,359
i know you guys use the term variance i

1158
00:44:33,270 --> 00:44:31,359
think but

1159
00:44:35,430 --> 00:44:33,280
why aren't you looking in the opposite

1160
00:44:37,349 --> 00:44:35,440
direction just to make sure

1161
00:44:39,829 --> 00:44:37,359
we're doing an xudf in the opposite

1162
00:44:40,870 --> 00:44:39,839
direction just to make sure there's no

1163
00:44:42,390 --> 00:44:40,880

funny

1164
00:44:44,550 --> 00:44:42,400
asymmetry

1165
00:44:46,470 --> 00:44:44,560
you know and maybe the universe is

1166
00:44:47,990 --> 00:44:46,480
lopsided you know

1167
00:44:50,470 --> 00:44:48,000
tell everybody

1168
00:44:53,190 --> 00:44:50,480
yes very interesting question we keep

1169
00:44:58,710 --> 00:44:55,670
i think i mentioned this earlier that we

1170
00:45:00,950 --> 00:44:58,720
really only have one xdf and it would be

1171
00:45:03,109 --> 00:45:00,960
great to have more than one

1172
00:45:06,870 --> 00:45:03,119
and and to have several spread around

1173
00:45:09,589 --> 00:45:06,880
the sky but as you saw there was 50 days

1174
00:45:11,589 --> 00:45:09,599
of hubble pointing at this one field to

1175
00:45:14,870 --> 00:45:11,599
build up these data and that's a lot of

1176
00:45:17,190 --> 00:45:14,880
time and so we would love to take hubble

1177
00:45:19,349 --> 00:45:17,200
and point it in the opposite direction

1178
00:45:21,589 --> 00:45:19,359
or in several other directions in the

1179
00:45:23,910 --> 00:45:21,599
sky for 50 days each

1180
00:45:25,670 --> 00:45:23,920
but it's very competitive to get time on

1181
00:45:27,109 --> 00:45:25,680
hubble and so far we haven't been

1182
00:45:29,510 --> 00:45:27,119
successful

1183
00:45:30,790 --> 00:45:29,520
so we're hoping that

1184
00:45:32,950 --> 00:45:30,800
the

1185
00:45:35,670 --> 00:45:32,960
time assignment committee of astronomers

1186
00:45:38,150 --> 00:45:35,680
will look favorably on future proposals

1187
00:45:41,190 --> 00:45:38,160
and uh that we get some deeper data in

1188
00:45:44,470 --> 00:45:41,200

another region so we welcome any support

1189
00:45:47,990 --> 00:45:46,309
this is this is such a unique field is

1190
00:45:50,390 --> 00:45:48,000
there is there a competition to try to

1191
00:45:51,750 --> 00:45:50,400
get orbits in time among among

1192
00:45:53,109 --> 00:45:51,760
astronomers

1193
00:45:54,069 --> 00:45:53,119
very much so

1194
00:45:57,109 --> 00:45:54,079
hubble

1195
00:46:00,309 --> 00:45:57,119
whenever every year astronomers uh send

1196
00:46:02,870 --> 00:46:00,319
proposals in to ask for time for hubble

1197
00:46:05,670 --> 00:46:02,880
and there's a huge over subscription

1198
00:46:08,230 --> 00:46:05,680
five to ten to one ten to one typically

1199
00:46:10,470 --> 00:46:08,240
and so it's extremely hard to get time

1200
00:46:12,550 --> 00:46:10,480
on hubble there's so many different

1201
00:46:15,109 --> 00:46:12,560
fascinating scientific problems to be

1202
00:46:16,710 --> 00:46:15,119
done with a space telescope and this is

1203
00:46:18,950 --> 00:46:16,720
only one of them unfortunately even

1204
00:46:21,270 --> 00:46:18,960
though i love this area i have to say

1205
00:46:23,270 --> 00:46:21,280
you know there's so many different areas

1206
00:46:25,510 --> 00:46:23,280
that only so much time could be

1207
00:46:27,750 --> 00:46:25,520
dedicated to this particular one but we

1208
00:46:30,470 --> 00:46:27,760
really do hope that we've managed to get

1209
00:46:32,630 --> 00:46:30,480
another deep field or two particularly

1210
00:46:36,069 --> 00:46:32,640
in preparation for james webb space

1211
00:46:37,910 --> 00:46:36,079
telescope that is really going to look

1212
00:46:39,589 --> 00:46:37,920
at early times and it's crucially

1213
00:46:42,150 --> 00:46:39,599

important that we have a number of these

1214
00:46:44,550 --> 00:46:42,160
deep fields

1215
00:46:47,030 --> 00:46:44,560
actually my next question how many since

1216
00:46:49,430 --> 00:46:47,040
web is so much more efficient are

1217
00:46:51,829 --> 00:46:49,440
astronomers talking about looking in all

1218
00:46:53,510 --> 00:46:51,839
different directions and doing uh the

1219
00:46:56,309 --> 00:46:53,520
deep fields

1220
00:46:59,190 --> 00:46:56,319
it's interesting they certainly will do

1221
00:47:01,349 --> 00:46:59,200
more with hubble with james webb but

1222
00:47:03,190 --> 00:47:01,359
hubble has some unique characteristics

1223
00:47:05,270 --> 00:47:03,200
that james webb doesn't it can look

1224
00:47:07,990 --> 00:47:05,280
further into the blue than james webb

1225
00:47:10,790 --> 00:47:08,000
will be able to and so it would be very

1226
00:47:13,990 --> 00:47:10,800
nice to set up and not just nice

1227
00:47:16,069 --> 00:47:14,000
important to set up several fields where

1228
00:47:18,790 --> 00:47:16,079
the coupled unique data could be

1229
00:47:22,069 --> 00:47:18,800
obtained before james webb flies

1230
00:47:24,710 --> 00:47:22,079
and so we would like to set in place the

1231
00:47:25,750 --> 00:47:24,720
initial phases of those data and also to

1232
00:47:28,150 --> 00:47:25,760
provide

1233
00:47:30,309 --> 00:47:28,160
some initial deep fields even in the

1234
00:47:32,950 --> 00:47:30,319
infrared so that james webb can hit the

1235
00:47:35,589 --> 00:47:32,960
ground running as it were so that when

1236
00:47:37,990 --> 00:47:35,599
it launches it can immediately start

1237
00:47:40,230 --> 00:47:38,000
looking at interesting objects to

1238
00:47:41,910 --> 00:47:40,240

understand them in more detail than we

1239
00:47:45,190 --> 00:47:41,920
ever can with hubble or with their

1240
00:47:47,510 --> 00:47:45,200
ground-based telescopes

1241
00:47:49,910 --> 00:47:47,520
yeah one point sorry there is also that

1242
00:47:52,470 --> 00:47:49,920
um with with a chainswag we will be able

1243
00:47:54,550 --> 00:47:52,480
to take spectra actually of sources not

1244
00:47:56,550 --> 00:47:54,560
only we cannot only take images but we

1245
00:47:59,030 --> 00:47:56,560
can take spectra of the sources that we

1246
00:48:01,510 --> 00:47:59,040
are looking at now and we

1247
00:48:03,270 --> 00:48:01,520
with that we can really determine

1248
00:48:05,670 --> 00:48:03,280
you know for sure the distance of these

1249
00:48:08,309 --> 00:48:05,680
sources and well now we have quite a bit

1250
00:48:11,829 --> 00:48:08,319
of uncertainty actually on how far uh

1251
00:48:12,870 --> 00:48:11,839
these sources are from us um exactly um

1252
00:48:13,829 --> 00:48:12,880
and so

1253
00:48:16,790 --> 00:48:13,839
having

1254
00:48:19,750 --> 00:48:16,800
additional uh data and additional fields

1255
00:48:21,589 --> 00:48:19,760
where we can identify that such sources

1256
00:48:24,309 --> 00:48:21,599
will be really important

1257
00:48:25,190 --> 00:48:24,319
to to really start with jwst to go and

1258
00:48:26,230 --> 00:48:25,200
look

1259
00:48:27,990 --> 00:48:26,240
and take

1260
00:48:29,589 --> 00:48:28,000
measure exactly the distance for a lot

1261
00:48:32,870 --> 00:48:29,599
for a lot of these sources immediately

1262
00:48:35,750 --> 00:48:34,790
i'm really delighted with the questions

1263
00:48:37,589 --> 00:48:35,760

we're getting we've got a lot of

1264
00:48:39,109 --> 00:48:37,599
inquiring minds out there this one's

1265
00:48:41,030 --> 00:48:39,119
particularly good

1266
00:48:42,470 --> 00:48:41,040
um

1267
00:48:44,710 --> 00:48:42,480
they've said there were theories that

1268
00:48:46,390 --> 00:48:44,720
stars were much more massive

1269
00:48:49,430 --> 00:48:46,400
in the distance past

1270
00:48:52,309 --> 00:48:49,440
can the xdf show us individual stars or

1271
00:48:55,270 --> 00:48:52,319
for that matter could james webb in in

1272
00:48:58,309 --> 00:48:55,280
those very early times

1273
00:48:59,109 --> 00:48:58,319
yeah i think it's hard for xdf to do

1274
00:49:01,670 --> 00:48:59,119
that

1275
00:49:03,510 --> 00:49:01,680
even the very massive stars very

1276
00:49:05,990 --> 00:49:03,520
difficult to see

1277
00:49:08,309 --> 00:49:06,000
james webb could probably do will

1278
00:49:10,710 --> 00:49:08,319
certainly be able to do better but i'm

1279
00:49:12,710 --> 00:49:10,720
not sure that even it could isolate

1280
00:49:14,309 --> 00:49:12,720
anything but groups of these massive

1281
00:49:16,950 --> 00:49:14,319
stars

1282
00:49:18,870 --> 00:49:16,960
pascal what do you think yeah

1283
00:49:21,510 --> 00:49:18,880
i don't think with james webb we can see

1284
00:49:24,630 --> 00:49:21,520
individual uh first stars because these

1285
00:49:27,030 --> 00:49:24,640
first stars are forming out of of of gas

1286
00:49:29,109 --> 00:49:27,040
that is very different from today's gas

1287
00:49:31,670 --> 00:49:29,119
it has essentially just a hydrogen

1288
00:49:33,589 --> 00:49:31,680

helium and nothing else

1289
00:49:35,030 --> 00:49:33,599
and so that's why

1290
00:49:37,670 --> 00:49:35,040
people think that this would be very

1291
00:49:40,630 --> 00:49:37,680
massive but i think what james webb will

1292
00:49:42,230 --> 00:49:40,640
be able to do is only to see a supernova

1293
00:49:44,309 --> 00:49:42,240
of these circuits these very massive

1294
00:49:45,430 --> 00:49:44,319
stars so because there's a message they

1295
00:49:48,309 --> 00:49:45,440
will

1296
00:49:51,109 --> 00:49:48,319
explode very quickly actually um into a

1297
00:49:53,910 --> 00:49:51,119
supernova and and this is a very

1298
00:49:56,390 --> 00:49:53,920
uh very energetic event of course and

1299
00:49:57,829 --> 00:49:56,400
and so with james webb um i think we

1300
00:50:00,150 --> 00:49:57,839
will be able to see

1301
00:50:02,950 --> 00:50:00,160
those supernovae but not

1302
00:50:05,270 --> 00:50:02,960
individual first stars

1303
00:50:06,710 --> 00:50:05,280
okay that makes sense

1304
00:50:09,589 --> 00:50:06,720
okay let me um

1305
00:50:12,390 --> 00:50:09,599
this is a fascinating question um

1306
00:50:14,710 --> 00:50:12,400
if you're an astronaut up in space and

1307
00:50:17,430 --> 00:50:14,720
let's assume your eyes are as good as

1308
00:50:22,630 --> 00:50:17,440
hubble's would you see all those colors

1309
00:50:27,829 --> 00:50:25,030
yes that's right i mean i think you know

1310
00:50:30,470 --> 00:50:27,839
you need a little wider range of eyes

1311
00:50:32,470 --> 00:50:30,480
maybe if you had um

1312
00:50:35,030 --> 00:50:32,480
just our normal eyes and look out

1313
00:50:37,750 --> 00:50:35,040

galaxies do show different colors

1314
00:50:38,630 --> 00:50:37,760
and do show quite a bit of variation

1315
00:50:45,589 --> 00:50:38,640
um

1316
00:50:47,109 --> 00:50:45,599
well just that you know we're seeing

1317
00:50:48,870 --> 00:50:47,119
uh we're

1318
00:50:50,630 --> 00:50:48,880
we're looking outside the visual part of

1319
00:50:52,549 --> 00:50:50,640
the spectrum with the

1320
00:50:53,349 --> 00:50:52,559
in the near infrared so i mean this

1321
00:50:54,950 --> 00:50:53,359
color

1322
00:50:56,870 --> 00:50:54,960
image shows us

1323
00:50:59,270 --> 00:50:56,880
stuff that we actually can't see with

1324
00:51:00,470 --> 00:50:59,280
our own eyes but you know we would still

1325
00:51:04,630 --> 00:51:00,480
see colors

1326
00:51:08,790 --> 00:51:07,109
yeah i just i suppose to add to that

1327
00:51:11,670 --> 00:51:08,800
you know if we could

1328
00:51:13,190 --> 00:51:11,680
the astronauts had extremely good eyes

1329
00:51:15,829 --> 00:51:13,200
and they looked around and they could

1330
00:51:18,870 --> 00:51:15,839
see faint galaxies distant galaxies they

1331
00:51:20,230 --> 00:51:18,880
would show different colors very much so

1332
00:51:23,109 --> 00:51:20,240
that's interesting to demonstrate a

1333
00:51:24,790 --> 00:51:23,119
range of colors now the the actual

1334
00:51:27,030 --> 00:51:24,800
colors there are probably not in the

1335
00:51:28,549 --> 00:51:27,040
image in the xcf because it does go into

1336
00:51:30,790 --> 00:51:28,559
the infrared are not truly

1337
00:51:34,150 --> 00:51:30,800
representative of what our eyes would

1338
00:51:36,870 --> 00:51:34,160

see but the range of colors from very

1339
00:51:38,710 --> 00:51:36,880
blue to very red would certainly be

1340
00:51:40,549 --> 00:51:38,720
visible it would appear that way to the

1341
00:51:42,150 --> 00:51:40,559
astronaut

1342
00:51:44,309 --> 00:51:42,160
that's fascinating almost like stars i

1343
00:51:45,430 --> 00:51:44,319
guess except their color temperature

1344
00:51:46,870 --> 00:51:45,440
rather than

1345
00:51:49,190 --> 00:51:46,880
red shift

1346
00:51:51,589 --> 00:51:49,200
um this is a more a philosophical

1347
00:51:53,270 --> 00:51:51,599
question but we're building this james

1348
00:51:54,309 --> 00:51:53,280
webb telescope but we're going to push

1349
00:51:56,069 --> 00:51:54,319
farther

1350
00:51:58,790 --> 00:51:56,079
when would you say you reached your

1351
00:52:01,109 --> 00:51:58,800
ultimate goal all the

1352
00:52:03,030 --> 00:52:01,119
effort and energy to build these monster

1353
00:52:06,470 --> 00:52:03,040
telescopes what

1354
00:52:09,430 --> 00:52:06,480
is there an ultimate finish line for

1355
00:52:11,109 --> 00:52:09,440
saying you've gone out as far as yeah

1356
00:52:14,069 --> 00:52:11,119
interesting question

1357
00:52:16,950 --> 00:52:14,079
so for a scientist we're always trying

1358
00:52:19,190 --> 00:52:16,960
to understand more about what happened

1359
00:52:22,069 --> 00:52:19,200
in the universe i would say at the

1360
00:52:23,589 --> 00:52:22,079
broadest level that what james webb is

1361
00:52:26,150 --> 00:52:23,599
setting out to do

1362
00:52:27,430 --> 00:52:26,160
to understand the first galaxies and

1363
00:52:28,230 --> 00:52:27,440

stars

1364
00:52:33,589 --> 00:52:28,240
is

1365
00:52:36,309 --> 00:52:33,599
goal that we really would like to

1366
00:52:38,950 --> 00:52:36,319
see the first galaxy sea stars forming

1367
00:52:40,230 --> 00:52:38,960
in those james webb will go a long way

1368
00:52:42,390 --> 00:52:40,240
towards that

1369
00:52:43,990 --> 00:52:42,400
will it be able to see the first stars

1370
00:52:45,030 --> 00:52:44,000
probably not

1371
00:52:46,790 --> 00:52:45,040
and so

1372
00:52:48,630 --> 00:52:46,800
you know maybe one would like to see a

1373
00:52:50,630 --> 00:52:48,640
successor to james webb that's even

1374
00:52:51,990 --> 00:52:50,640
better bigger and better

1375
00:52:54,549 --> 00:52:52,000
but

1376
00:52:56,470 --> 00:52:54,559
it does depend a lot on the question

1377
00:52:58,549 --> 00:52:56,480
james webb is obviously going to play a

1378
00:53:00,390 --> 00:52:58,559
role in searching for planets and trying

1379
00:53:02,230 --> 00:53:00,400
to understand the nature of planets

1380
00:53:05,109 --> 00:53:02,240
around nearby stars

1381
00:53:07,030 --> 00:53:05,119
can it really do that extremely well

1382
00:53:09,270 --> 00:53:07,040
it will make a lot of advances but

1383
00:53:10,870 --> 00:53:09,280
that's an extraordinarily challenging

1384
00:53:12,390 --> 00:53:10,880
problem and to do that

1385
00:53:15,270 --> 00:53:12,400
properly will probably require a

1386
00:53:17,430 --> 00:53:15,280
telescope way beyond the capabilities of

1387
00:53:19,589 --> 00:53:17,440
james webb and beyond what we can

1388
00:53:21,990 --> 00:53:19,599

probably build even right now there's a

1389
00:53:23,829 --> 00:53:22,000
lot of development needed for that so it

1390
00:53:26,230 --> 00:53:23,839
does depend on the nature of the

1391
00:53:28,230 --> 00:53:26,240
question and the part of astronomy

1392
00:53:30,470 --> 00:53:28,240
but there's no doubt for distant

1393
00:53:32,630 --> 00:53:30,480
galaxies understanding what's going on

1394
00:53:34,950 --> 00:53:32,640
in the early universe james webb is

1395
00:53:37,270 --> 00:53:34,960
going to be an amazing leap forward

1396
00:53:39,670 --> 00:53:37,280
a hundred times hubble a thousand times

1397
00:53:44,230 --> 00:53:39,680
the spitzer space telescope these are

1398
00:53:47,349 --> 00:53:45,990
pascal did you want to add anything to

1399
00:53:48,549 --> 00:53:47,359
that one

1400
00:53:51,030 --> 00:53:48,559
no

1401
00:53:53,510 --> 00:53:51,040
james webb will be great but it won't be

1402
00:53:54,829 --> 00:53:53,520
won't be the end of course to understand

1403
00:53:58,950 --> 00:53:54,839
our whole

1404
00:54:00,710 --> 00:53:58,960
universe a lot more needed

1405
00:54:03,510 --> 00:54:00,720
yeah let me add just one other thought

1406
00:54:06,069 --> 00:54:03,520
which just came up on this too is that

1407
00:54:08,790 --> 00:54:06,079
we're embarking on a new generation of

1408
00:54:10,470 --> 00:54:08,800
major telescopes on the ground 30 40

1409
00:54:13,430 --> 00:54:10,480
meter telescopes

1410
00:54:16,069 --> 00:54:13,440
these will have capabilities for

1411
00:54:18,069 --> 00:54:16,079
spectroscopy for looking in detail in

1412
00:54:19,510 --> 00:54:18,079
individual objects that even james webb

1413
00:54:20,630 --> 00:54:19,520

will not have

1414
00:54:23,349 --> 00:54:20,640
and so

1415
00:54:25,349 --> 00:54:23,359
it they if they can come along in about

1416
00:54:28,150 --> 00:54:25,359
the same time frame as james webb

1417
00:54:29,990 --> 00:54:28,160
working together with james webb will

1418
00:54:32,150 --> 00:54:30,000
make a big difference in our

1419
00:54:34,390 --> 00:54:32,160
understanding of the distant galaxies

1420
00:54:35,510 --> 00:54:34,400
just as hubble has worked together with

1421
00:54:38,710 --> 00:54:35,520
the big

1422
00:54:40,470 --> 00:54:38,720
telescopes like keck and the vlt today

1423
00:54:43,910 --> 00:54:40,480
to try and help us understand what's

1424
00:54:46,150 --> 00:54:43,920
happening in the early universe

1425
00:54:48,390 --> 00:54:46,160
so what you're saying garth is that the

1426
00:54:49,430 --> 00:54:48,400
future of astronomy is the symbiosis

1427
00:54:52,309 --> 00:54:49,440
between

1428
00:54:53,990 --> 00:54:52,319
giant ground-based and bigger spaces

1429
00:54:55,990 --> 00:54:54,000
that's certainly a key part of it it's

1430
00:54:57,750 --> 00:54:56,000
something that we have seen very often

1431
00:55:00,230 --> 00:54:57,760
at times you need very specialized

1432
00:55:02,309 --> 00:55:00,240
telescopes but at other times it's

1433
00:55:05,190 --> 00:55:02,319
different capabilities working together

1434
00:55:06,950 --> 00:55:05,200
that really help us make advances as

1435
00:55:09,349 --> 00:55:06,960
having ground huge ground-based

1436
00:55:13,829 --> 00:55:09,359
telescopes of the next generation

1437
00:55:16,790 --> 00:55:13,839
the tmt the 30 meter telescope the eelt

1438
00:55:19,430 --> 00:55:16,800

the european 40 million telescope these

1439
00:55:21,510 --> 00:55:19,440
will be remarkably powerful especially

1440
00:55:24,069 --> 00:55:21,520
as we use them in conjunction with james

1441
00:55:27,589 --> 00:55:25,829
um this is a very good question what

1442
00:55:30,630 --> 00:55:27,599
what new things have we learned about

1443
00:55:43,030 --> 00:55:30,640
the formation of the universe

1444
00:55:45,589 --> 00:55:43,040
i think xdf is really about galaxies

1445
00:55:47,910 --> 00:55:45,599
xdf is really about

1446
00:55:49,589 --> 00:55:47,920
understanding how galaxies themselves

1447
00:55:52,390 --> 00:55:49,599
formed and built up

1448
00:55:53,990 --> 00:55:52,400
the seeds of today's galaxies

1449
00:55:59,109 --> 00:55:54,000
the

1450
00:56:01,430 --> 00:55:59,119
occurred about between a few hundred

1451
00:56:04,470 --> 00:56:01,440
million years and about 900 million

1452
00:56:05,990 --> 00:56:04,480
years after the big bang when as pascal

1453
00:56:08,950 --> 00:56:06,000
mentioned all the hydrogen in the

1454
00:56:11,510 --> 00:56:08,960
universe was reionized was ionized at

1455
00:56:13,349 --> 00:56:11,520
that point the

1456
00:56:15,670 --> 00:56:13,359
universe changed from

1457
00:56:19,589 --> 00:56:15,680
neutral hydrogen everywhere to ionize

1458
00:56:22,309 --> 00:56:19,599
hydrogen galaxies uh the most likely

1459
00:56:23,589 --> 00:56:22,319
culprit for that highly likely so when

1460
00:56:26,710 --> 00:56:23,599
we're studying

1461
00:56:28,789 --> 00:56:26,720
these early galaxies we're also studying

1462
00:56:30,710 --> 00:56:28,799
the effect of these galaxies on the

1463
00:56:32,150 --> 00:56:30,720

universe as a whole

1464
00:56:34,549 --> 00:56:32,160
but for

1465
00:56:36,230 --> 00:56:34,559
cosmology which is more an understanding

1466
00:56:37,589 --> 00:56:36,240
of the nature of the universe and how

1467
00:56:39,829 --> 00:56:37,599
it's changing

1468
00:56:41,990 --> 00:56:39,839
xdf will not add a great deal of

1469
00:56:44,069 --> 00:56:42,000
knowledge to that explicitly

1470
00:56:46,069 --> 00:56:44,079
those questions are much more to do with

1471
00:56:49,109 --> 00:56:46,079
the great questions now of the nature of

1472
00:56:52,710 --> 00:56:49,119
dark energy and the changes in the

1473
00:56:58,230 --> 00:56:55,510
pascal anything you want to add to that

1474
00:57:00,069 --> 00:56:58,240
yeah i think the the difficulty in in

1475
00:57:02,950 --> 00:57:00,079
understanding the

1476
00:57:05,270 --> 00:57:02,960
uh build up of the universe from galaxy

1477
00:57:08,630 --> 00:57:05,280
looking at galaxies alone is that it's

1478
00:57:10,390 --> 00:57:08,640
it's very very difficult to predict um

1479
00:57:13,109 --> 00:57:10,400
from for instance just starting from

1480
00:57:16,069 --> 00:57:13,119
dark matter and the atoms that are

1481
00:57:17,750 --> 00:57:16,079
coming with the dark matter uh how stars

1482
00:57:20,710 --> 00:57:17,760
are forming how galaxies are forming and

1483
00:57:22,630 --> 00:57:20,720
so that's a very very messy process

1484
00:57:23,510 --> 00:57:22,640
and and so

1485
00:57:25,589 --> 00:57:23,520
um

1486
00:57:27,270 --> 00:57:25,599
we are learning a lot about the build-up

1487
00:57:29,270 --> 00:57:27,280
and the formation of galaxies with this

1488
00:57:31,829 --> 00:57:29,280

new image but not yeah as garth was

1489
00:57:34,470 --> 00:57:31,839
saying about the universe and expansion

1490
00:57:38,230 --> 00:57:36,470
great well we're coming up on on the new

1491
00:57:40,549 --> 00:57:38,240
hour i think we're going to cut things

1492
00:57:42,069 --> 00:57:40,559
off here i want to thank each of our

1493
00:57:43,670 --> 00:57:42,079
guests this has been

1494
00:57:46,069 --> 00:57:43,680
i hope for our audience this has been

1495
00:57:47,589 --> 00:57:46,079
very mind expanding a lot of great

1496
00:57:49,990 --> 00:57:47,599
questions about the fundamental nature

1497
00:57:52,230 --> 00:57:50,000
of the universe the evolving universe

1498
00:57:54,069 --> 00:57:52,240
and and we live at such a special time

1499
00:57:56,230 --> 00:57:54,079
we can we can actually talk about these

1500
00:57:57,990 --> 00:57:56,240
things these things were philosophical

1501
00:57:59,349 --> 00:57:58,000
for thousands of years and we can look

1502
00:58:01,750 --> 00:57:59,359
at real data

1503
00:58:03,630 --> 00:58:01,760
so but the adventure continues so i

1504
00:58:05,430 --> 00:58:03,640
invite everybody to come and visit

1505
00:58:07,109 --> 00:58:05,440
hubblesite.org where

1506
00:58:09,349 --> 00:58:07,119
new discoveries are coming out from

1507
00:58:11,750 --> 00:58:09,359
hubble all the time and no doubt will

1508
00:58:15,109 --> 00:58:11,760
even have deeper pictures uh in the

1509
00:58:17,510 --> 00:58:15,119
coming months as garth said um with that

1510
00:58:19,910 --> 00:58:17,520
i want to thank everybody and

1511
00:58:21,349 --> 00:58:19,920
we'll we'll do this again sometime

1512
00:58:23,349 --> 00:58:21,359
okay thank

1513
00:58:25,030 --> 00:58:23,359

thank you thank you ryan thank you to