

1  
00:00:00,030 --> 00:00:03,688  
hello everybody and welcome to our

2  
00:00:01,409 --> 00:00:05,640  
latest Hubble hangout this is a place

3  
00:00:03,689 --> 00:00:07,679  
where you can come each week and learn

4  
00:00:05,639 --> 00:00:10,050  
about the latest science and discoveries

5  
00:00:07,679 --> 00:00:11,580  
of the Hubble Space Telescope my name is

6  
00:00:10,050 --> 00:00:12,929  
Tony Darnell I work in space telescope

7  
00:00:11,580 --> 00:00:14,309  
science institute and today we've got a

8  
00:00:12,929 --> 00:00:16,199  
really great hangout planned for you I

9  
00:00:14,308 --> 00:00:17,669  
am very excited about this particular

10  
00:00:16,199 --> 00:00:18,990  
one because there's people on it that I

11  
00:00:17,670 --> 00:00:20,760  
haven't seen in a long time and I'm

12  
00:00:18,989 --> 00:00:22,889  
looking forward to catching up we're

13  
00:00:20,760 --> 00:00:25,140  
gonna be discussing ground-based surveys

14  
00:00:22,890 --> 00:00:26,939  
today in particular the pan star survey

15  
00:00:25,140 --> 00:00:29,160  
because we're having a workshop here at

16  
00:00:26,939 --> 00:00:31,649  
the Institute all week long on on the

17  
00:00:29,160 --> 00:00:33,480  
science of this particular survey so

18  
00:00:31,649 --> 00:00:35,280  
we'll talk about what the survey is what

19  
00:00:33,479 --> 00:00:37,578  
it's up to and as a bonus we're also

20  
00:00:35,280 --> 00:00:40,379  
gonna talk about a future ground-based

21  
00:00:37,579 --> 00:00:43,890  
survey that's going to be even larger

22  
00:00:40,378 --> 00:00:47,099  
and out in the is being built right now

23  
00:00:43,890 --> 00:00:49,289  
the large synoptic survey or LSST so

24  
00:00:47,100 --> 00:00:50,789  
before I get to my introductions let me

25  
00:00:49,289 --> 00:00:55,140  
just say that we are hoping you will

26  
00:00:50,789 --> 00:00:56,910  
comment and tweet at us let us know any

27  
00:00:55,140 --> 00:00:59,370  
questions or comments while we're here

28  
00:00:56,909 --> 00:01:01,349  
you can I'm looking at the Google Plus

29

00:00:59,369 --> 00:01:04,588  
hangout page you can also tweet using

30  
00:01:01,350 --> 00:01:06,960  
the hubble hangouts and you can also do

31  
00:01:04,588 --> 00:01:10,079  
they are using the Hubble hangout hashtag

32  
00:01:06,959 --> 00:01:12,719  
too many H's in that and you can also

33  
00:01:10,079 --> 00:01:14,099  
use the Q&A app that the Hangout is

34  
00:01:12,719 --> 00:01:15,478  
being broadcast from we're monitoring

35  
00:01:14,099 --> 00:01:16,679  
all of that and we'll take some time out

36  
00:01:15,478 --> 00:01:19,679  
toward the end here and take some

37  
00:01:16,680 --> 00:01:21,090  
comments and questions so let's get

38  
00:01:19,680 --> 00:01:25,560  
started pan-starrs

39  
00:01:21,090 --> 00:01:27,780  
is a panoramic survey telescope and

40  
00:01:25,560 --> 00:01:30,060  
rapid response system every time I say

41  
00:01:27,780 --> 00:01:31,978  
that I feel like I'm talking about some

42  
00:01:30,060 --> 00:01:33,719  
kind of anti-terrorist organization or a

43  
00:01:31,978 --> 00:01:38,039

first response team or something like

44

00:01:33,719 --> 00:01:39,989  
that but here to discuss some of these

45

00:01:38,040 --> 00:01:41,759  
things with me as always is dr. Carol

46

00:01:39,989 --> 00:01:44,009  
Christian she is the Hubble Space

47

00:01:41,759 --> 00:01:45,868  
Telescope outreach astronomer hi Carol

48

00:01:44,009 --> 00:01:47,790  
thanks for coming along to help me with

49

00:01:45,868 --> 00:01:50,938  
this discussion hopefully Wrangell these

50

00:01:47,790 --> 00:01:53,700  
guys because with me are and I'll go

51

00:01:50,938 --> 00:01:56,339  
from my left to right as I see you on

52

00:01:53,700 --> 00:01:58,200  
the screen dr. Armond rest he is an

53

00:01:56,340 --> 00:01:59,909  
astronomer here the Space Telescope

54

00:01:58,200 --> 00:02:01,859  
Science Institute and I guess you're

55

00:01:59,909 --> 00:02:03,960  
pretty heavily involved in pan star so

56

00:02:01,859 --> 00:02:07,140  
you're so I'm told

57

00:02:03,959 --> 00:02:08,159  
I mean I'm excited to finally have you

58  
00:02:07,140 --> 00:02:09,479  
in one of these hangouts I've been

59  
00:02:08,159 --> 00:02:12,598  
trying to do this for a while because I

60  
00:02:09,479 --> 00:02:14,010  
first heard about you in my dark energy

61  
00:02:12,598 --> 00:02:16,229  
survey days when I was working

62  
00:02:14,009 --> 00:02:17,759  
in Illinois and I learned about that you

63  
00:02:16,229 --> 00:02:19,378  
were also a South Pole telescope and

64  
00:02:17,759 --> 00:02:20,848  
doing a lot of great work in cosmology

65  
00:02:19,378 --> 00:02:24,688  
and black holes and all kinds of stuff

66  
00:02:20,848 --> 00:02:27,658  
so that is awesome and also with me is

67  
00:02:24,688 --> 00:02:29,128  
Eddie and I forgot to write down your

68  
00:02:27,658 --> 00:02:31,169  
last name can you speak your name for me

69  
00:02:29,128 --> 00:02:32,489  
yeah I'm Eddie Schlafly I'm a postdoc

70  
00:02:31,169 --> 00:02:34,828  
working at the Max Planck Institute for

71  
00:02:32,489 --> 00:02:36,420  
astronomy in Germany thank you I was

72  
00:02:34,829 --> 00:02:38,700  
remiss in not writing that down and I

73  
00:02:36,419 --> 00:02:41,039  
also have with me dr. Robert Lupton from

74  
00:02:38,699 --> 00:02:43,259  
Princeton he is I haven't seen him since

75  
00:02:41,039 --> 00:02:46,048  
my dark energy survey days either and

76  
00:02:43,259 --> 00:02:47,669  
I'm very excited to talk to him again

77  
00:02:46,049 --> 00:02:49,739  
and get caught up with some of the

78  
00:02:47,669 --> 00:02:53,219  
latest news he gave talk yesterday on

79  
00:02:49,739 --> 00:02:56,389  
the LSST so Wow welcome guys and let's

80  
00:02:53,219 --> 00:02:59,729  
get started so Armen pan-starrs

81  
00:02:56,389 --> 00:03:02,159  
this is the Hubble hangout what are we

82  
00:02:59,729 --> 00:03:06,268  
doing talking about a ground survey in a

83  
00:03:02,158 --> 00:03:08,878  
PSD hangout well you know HST has a very

84  
00:03:06,269 --> 00:03:12,599  
small area but it observes on the sky it

85  
00:03:08,878 --> 00:03:15,209  
only observes a very small area and so

86

00:03:12,598 --> 00:03:17,039  
if you want to follow up or if you want

87  
00:03:15,209 --> 00:03:19,620  
to observe interesting objects they are

88  
00:03:17,039 --> 00:03:21,750  
normally very rare and in order to find

89  
00:03:19,620 --> 00:03:25,289  
them you have to cover and observe a

90  
00:03:21,750 --> 00:03:27,329  
huge area of the sky so this HST we

91  
00:03:25,289 --> 00:03:28,888  
cannot do that and that's a video I have

92  
00:03:27,329 --> 00:03:32,819  
let me just interrupt you real quick I

93  
00:03:28,889 --> 00:03:34,290  
have up now on my screen a graphic

94  
00:03:32,818 --> 00:03:35,818  
that's gonna illustrate what Armen is

95  
00:03:34,289 --> 00:03:39,150  
talking about we have the pan-starrs

96  
00:03:35,818 --> 00:03:40,530  
field of view and go ahead arm and you

97  
00:03:39,150 --> 00:03:42,870  
can need to continue I just wanted to

98  
00:03:40,530 --> 00:03:48,209  
let people know I have that up so if you

99  
00:03:42,870 --> 00:03:50,609  
click on Japan stars area so this is a

100  
00:03:48,209 --> 00:03:53,699

field of view of pencils this is the

101

00:03:50,609 --> 00:03:56,519

area that pencils can observe this one

102

00:03:53,699 --> 00:03:59,639

single image and if you now click on the

103

00:03:56,519 --> 00:04:01,500

Hubble Space Telescope one that is

104

00:03:59,639 --> 00:04:02,760

Hubble Space Telescope I don't know if

105

00:04:01,500 --> 00:04:06,120

you guys can see it but there's a little

106

00:04:02,759 --> 00:04:09,810

tiny yellow square in the center of this

107

00:04:06,120 --> 00:04:12,269

yep yeah so it also uses like looking at

108

00:04:09,810 --> 00:04:14,310

the universe through a not even a straw

109

00:04:12,269 --> 00:04:18,750

one of those cocktail straws it's really

110

00:04:14,310 --> 00:04:19,978

really narrow and also by comparison

111

00:04:18,750 --> 00:04:22,408

there are some other telescopes here

112

00:04:19,978 --> 00:04:24,360

this is the this is on the Subaru this

113

00:04:22,408 --> 00:04:26,939

is a I'm told by Robert and older camera

114

00:04:24,360 --> 00:04:27,660

the sub the su prime cam only looks at a



115  
00:04:26,939 --> 00:04:29,579  
half a degree

116  
00:04:27,660 --> 00:04:32,460  
in this image which as you can see is

117  
00:04:29,579 --> 00:04:34,680  
equal to roughly the full moon Robert

118  
00:04:32,459 --> 00:04:40,199  
how about the new one it's 1.8 square

119  
00:04:34,680 --> 00:04:41,939  
degrees 3 x 3 x value and finally the

120  
00:04:40,199 --> 00:04:44,939  
Palomar Sky Survey and this particular

121  
00:04:41,939 --> 00:04:47,250  
thing is the entire square a very very

122  
00:04:44,939 --> 00:04:48,810  
wild feet wide field so pan-starrs can

123  
00:04:47,250 --> 00:04:50,399  
see a pretty good section of sky what's

124  
00:04:48,810 --> 00:04:52,230  
that good for arm and what's the what's

125  
00:04:50,399 --> 00:04:54,359  
that useful for well you can cover a

126  
00:04:52,230 --> 00:04:57,210  
huge amount of sky and so you can look

127  
00:04:54,360 --> 00:05:00,540  
for where objects and for clusters for

128  
00:04:57,209 --> 00:05:03,000  
supernovae for asteroids for all

129  
00:05:00,540 --> 00:05:05,340  
different kinds of things and one of the

130  
00:05:03,000 --> 00:05:08,250  
big advantages of pencils is it not only

131  
00:05:05,339 --> 00:05:10,799  
has this very big field of view this big

132  
00:05:08,250 --> 00:05:13,350  
area it also has it's a relatively big

133  
00:05:10,800 --> 00:05:16,560  
telescope for for that field of view and

134  
00:05:13,350 --> 00:05:19,980  
so not only can we cover a very big area

135  
00:05:16,560 --> 00:05:22,350  
or 30,000 square degrees or so sky but

136  
00:05:19,980 --> 00:05:25,980  
we can also call crudité deeper than any

137  
00:05:22,350 --> 00:05:28,050  
other survey of death scale and that

138  
00:05:25,980 --> 00:05:30,800  
means we can really push into new areas

139  
00:05:28,050 --> 00:05:33,509  
of science by covering this big areas to

140  
00:05:30,800 --> 00:05:38,189  
understand the depths so one very rare

141  
00:05:33,509 --> 00:05:39,959  
thing would be the moon in Orion yeah I

142  
00:05:38,189 --> 00:05:51,629  
should have started by saying you know

143

00:05:39,959 --> 00:05:54,899  
this is a yeah that was a little bit of

144  
00:05:51,629 --> 00:05:57,930  
a Photoshop I just wanted to jump in

145  
00:05:54,899 --> 00:05:59,909  
here and say that that it when we have

146  
00:05:57,930 --> 00:06:01,439  
big surveys like this and people work

147  
00:05:59,910 --> 00:06:04,680  
hard on finding all different kinds of

148  
00:06:01,439 --> 00:06:07,500  
objects it's very helpful because there

149  
00:06:04,680 --> 00:06:10,350  
are big catalogs that are built and also

150  
00:06:07,500 --> 00:06:12,810  
the data is archived so the entire

151  
00:06:10,350 --> 00:06:15,450  
community as well as the public can can

152  
00:06:12,810 --> 00:06:17,370  
use that archival data and that's what

153  
00:06:15,449 --> 00:06:19,979  
we're working on here we are going to

154  
00:06:17,370 --> 00:06:22,230  
help hosts of pan-starrs data and then

155  
00:06:19,980 --> 00:06:23,520  
once the science begins scientists then

156  
00:06:22,230 --> 00:06:26,310  
go out and they use different

157  
00:06:23,519 --> 00:06:28,289

observatories to then investigate the

158

00:06:26,310 --> 00:06:30,720

particular objects they're interested in

159

00:06:28,290 --> 00:06:33,240

and very often they will used

160

00:06:30,720 --> 00:06:35,970

ground-based observatories as well as

161

00:06:33,240 --> 00:06:39,060

the space observatories Hubble Spitzer

162

00:06:35,970 --> 00:06:41,520

Chandra etc because they're looking at a

163

00:06:39,060 --> 00:06:44,699

specific kind of object

164

00:06:41,519 --> 00:06:47,219

like galaxies tidal tails who knows what

165

00:06:44,699 --> 00:06:48,840

and so they need all of those kinds of

166

00:06:47,220 --> 00:06:51,300

observations to understand that

167

00:06:48,839 --> 00:06:53,429

Astrophysical phenomena yeah so there's

168

00:06:51,300 --> 00:06:55,079

the relevance there that that that's not

169

00:06:53,430 --> 00:06:56,610

that's nicely summed up because in

170

00:06:55,079 --> 00:06:59,818

addition to operating the Hubble Space

171

00:06:56,610 --> 00:07:01,800

Telescope the the Institute also has the

172  
00:06:59,819 --> 00:07:03,360  
Mikulski archive for Space Telescope

173  
00:07:01,800 --> 00:07:04,919  
which as Carol said has a lot of you

174  
00:07:03,360 --> 00:07:06,629  
know it has a lot of different data sets

175  
00:07:04,918 --> 00:07:08,250  
in it for example all of the Kepler data

176  
00:07:06,629 --> 00:07:10,500  
are stored there and we're going to be

177  
00:07:08,250 --> 00:07:12,629  
doing the Panthers day I guess we're not

178  
00:07:10,500 --> 00:07:15,389  
doing it yet that's still at Hawaii is

179  
00:07:12,629 --> 00:07:16,590  
that correct yeah sadena is currently

180  
00:07:15,389 --> 00:07:17,550  
still at Hawaii

181  
00:07:16,589 --> 00:07:20,250  
we're still working on getting

182  
00:07:17,550 --> 00:07:23,370  
everything into a database getting the

183  
00:07:20,250 --> 00:07:26,639  
data already making sure that the data

184  
00:07:23,370 --> 00:07:31,228  
is correct and so dates that we will mix

185  
00:07:26,639 --> 00:07:35,069  
a data public is April of next year 2050

186  
00:07:31,228 --> 00:07:37,889  
so in one year okay so as I said it was

187  
00:07:35,069 --> 00:07:41,580  
it was started by the University of

188  
00:07:37,889 --> 00:07:45,569  
Hawaii and it was I guess they started

189  
00:07:41,579 --> 00:07:47,718  
doing all of this back in May of 2010 is

190  
00:07:45,569 --> 00:07:51,090  
that right

191  
00:07:47,718 --> 00:07:53,579  
so first observation we had in actually

192  
00:07:51,089 --> 00:07:56,000  
in the summer of 2009 we were operating

193  
00:07:53,579 --> 00:07:59,008  
it for about I think it was two months

194  
00:07:56,000 --> 00:08:03,300  
and then we shut it down for a while we

195  
00:07:59,009 --> 00:08:06,330  
worked on a telescope and then we really

196  
00:08:03,300 --> 00:08:09,778  
started to lose a real survey in spring

197  
00:08:06,329 --> 00:08:11,068  
of 2010 yes okay okay and it's like I

198  
00:08:09,778 --> 00:08:13,408  
says it was developed at University of

199  
00:08:11,069 --> 00:08:16,348  
Hawaii it's got a 1.8 mirror or one

200

00:08:13,408 --> 00:08:18,750  
point 8 meter mirror which is pretty

201  
00:08:16,348 --> 00:08:21,500  
amazing I mean here let me let me just

202  
00:08:18,750 --> 00:08:27,240  
show you a quick picture that I have of

203  
00:08:21,500 --> 00:08:29,269  
this of the of the observatory itself so

204  
00:08:27,240 --> 00:08:33,000  
here's here's what it looks like and

205  
00:08:29,269 --> 00:08:34,500  
I've got it up now and it's a pretty

206  
00:08:33,000 --> 00:08:36,620  
night that's a beautiful place up there

207  
00:08:34,500 --> 00:08:41,250  
I've been up there a couple of times and

208  
00:08:36,620 --> 00:08:42,599  
it's is-is-is Haleakala dedicated to

209  
00:08:41,250 --> 00:08:45,028  
pan-starrs right now or do they do other

210  
00:08:42,599 --> 00:08:46,860  
things I think they also do other things

211  
00:08:45,028 --> 00:08:50,100  
but uh pencils is definitely one of the

212  
00:08:46,860 --> 00:08:52,139  
main things well STS is just good yes

213  
00:08:50,100 --> 00:08:53,790  
yes it's just going that all the

214  
00:08:52,139 --> 00:08:54,990

advanced technology solar telescopes

215

00:08:53,789 --> 00:08:57,958

that's right don't try that

216

00:08:54,990 --> 00:09:01,320

being built there what is that well

217

00:08:57,958 --> 00:09:03,088

that's a different topic so you got me

218

00:09:01,320 --> 00:09:06,000

you got me distracted with shiny objects

219

00:09:03,089 --> 00:09:07,770

now so I was reading the website and

220

00:09:06,000 --> 00:09:09,509

following along on the talks and

221

00:09:07,769 --> 00:09:12,449

everything and it turns out that

222

00:09:09,509 --> 00:09:14,929

pan-starrs has the world's largest

223

00:09:12,450 --> 00:09:19,709

digital camera I think you're boasting

224

00:09:14,929 --> 00:09:22,889

1.4 billion pixels or 1400 megapixels if

225

00:09:19,708 --> 00:09:25,199

you want to go with the with the usual

226

00:09:22,889 --> 00:09:30,330

unit that digital cameras are measured

227

00:09:25,200 --> 00:09:32,129

by is it really the largest one I think

228

00:09:30,330 --> 00:09:34,350

it is X is a largest worldwide



229  
00:09:32,129 --> 00:09:35,450  
I mean it's 1.4 gigapixel actually don't

230  
00:09:34,350 --> 00:09:38,940  
make a pixel it's the largest

231  
00:09:35,450 --> 00:09:43,800  
unclassified one yeah at this I said one

232  
00:09:38,940 --> 00:09:46,080  
point 100 megapixels oh okay yeah so for

233  
00:09:43,799 --> 00:09:49,949  
gigapixels that's correct 1.4 billion

234  
00:09:46,080 --> 00:09:53,278  
pixels and we had a I believe that's up

235  
00:09:49,950 --> 00:09:56,310  
now oh you got the slide up there was

236  
00:09:53,278 --> 00:09:58,889  
one with the big with with the the focal

237  
00:09:56,309 --> 00:10:07,289  
or the CCD array can you put that one up

238  
00:09:58,889 --> 00:10:10,278  
ah it is back one more one back there it

239  
00:10:07,289 --> 00:10:12,569  
is so here's a slide of a guy holding

240  
00:10:10,278 --> 00:10:16,379  
it's actually tauntaun to me he actually

241  
00:10:12,570 --> 00:10:18,180  
builds disc em over hold it yes he's no

242  
00:10:16,379 --> 00:10:20,429  
one else how much money is in his hands

243

00:10:18,179 --> 00:10:21,899  
right there I wonder if ee i oh i don't

244

00:10:20,429 --> 00:10:25,409  
know by that you don't want it that's

245

00:10:21,899 --> 00:10:30,389  
for sure that would be a disaster the

246

00:10:25,409 --> 00:10:33,000  
chips if you did yeah not gonna see the

247

00:10:30,389 --> 00:10:35,100  
the the webcam version of this anytime

248

00:10:33,000 --> 00:10:37,259  
soon that's pretty big

249

00:10:35,100 --> 00:10:38,550  
that's what 1.4 billion pixels looks

250

00:10:37,259 --> 00:10:41,429  
like folks and right now it's the

251

00:10:38,549 --> 00:10:43,439  
biggest camera in existence DCAM which

252

00:10:41,429 --> 00:10:44,699  
was another large when is a 500

253

00:10:43,440 --> 00:10:45,149  
megapixels I believe is that right

254

00:10:44,700 --> 00:10:47,370  
Robert

255

00:10:45,149 --> 00:10:49,559  
I don't remember hyper supreme cameras

256

00:10:47,370 --> 00:10:52,200  
800 megapixels oh okay so that one's

257

00:10:49,559 --> 00:10:54,599  
even better okay so so that was the one

258  
00:10:52,200 --> 00:10:56,550  
that's brand new on Subaru telescope as

259  
00:10:54,600 --> 00:10:58,019  
well so okay so what are we doing with

260  
00:10:56,549 --> 00:11:02,159  
this stuff so we've got cool cameras

261  
00:10:58,019 --> 00:11:04,319  
we've got we've got you know wide fields

262  
00:11:02,159 --> 00:11:06,639  
of view we're looking at the sky how

263  
00:11:04,320 --> 00:11:09,790  
often does this thing observe

264  
00:11:06,639 --> 00:11:13,028  
it observes everyday that severa is good

265  
00:11:09,789 --> 00:11:21,069  
enough and nights as well and most

266  
00:11:13,028 --> 00:11:22,778  
nights as well yeah you know we were

267  
00:11:21,070 --> 00:11:24,850  
doing the email like just back and forth

268  
00:11:22,778 --> 00:11:28,659  
with this hangout Roberts email showed

269  
00:11:24,850 --> 00:11:37,659  
up as Robert Lupton the good that's

270  
00:11:28,659 --> 00:11:39,069  
historic that's a lie and astronomy

271  
00:11:37,659 --> 00:11:40,838

that's been perpetrated this is what it

272

00:11:39,070 --> 00:11:43,660

can save and you have a non-existing

273

00:11:40,839 --> 00:11:45,910

telescope you know in the bad or decent

274

00:11:43,659 --> 00:11:50,969

bad black hole it was Hawking radiation

275

00:11:45,909 --> 00:11:54,219

only the good survive anyway

276

00:11:50,970 --> 00:11:57,720

apologies hang out observers these guys

277

00:11:54,220 --> 00:11:57,720

have been sitting in a meeting for

278

00:12:00,958 --> 00:12:09,549

talking about the football as well

279

00:12:04,169 --> 00:12:13,899

soccer tomorrow's a big day we digress

280

00:12:09,549 --> 00:12:15,490

big big cameras yes let's get to the

281

00:12:13,899 --> 00:12:18,129

science of pants star so this thing's

282

00:12:15,490 --> 00:12:20,110

wide field-of-view three degrees and it

283

00:12:18,129 --> 00:12:23,980

and it can it's got a huge camera can

284

00:12:20,110 --> 00:12:27,190

see down to twenty fourth magnitude very

285

00:12:23,980 --> 00:12:29,139

very faint things so what's that good

286  
00:12:27,190 --> 00:12:30,100  
for Eddie let's get you in on this let's

287  
00:12:29,139 --> 00:12:31,750  
talk a little bit about some of the

288  
00:12:30,100 --> 00:12:32,649  
science that's being done with

289  
00:12:31,750 --> 00:12:35,470  
pan-starrs

290  
00:12:32,649 --> 00:12:36,820  
well so they're so the pens and stars as

291  
00:12:35,470 --> 00:12:38,290  
we've discussed is just a survey

292  
00:12:36,820 --> 00:12:39,850  
telescope that it observes

293  
00:12:38,289 --> 00:12:42,039  
the entire sky basically or

294  
00:12:39,850 --> 00:12:43,570  
three-quarters of the sky four times

295  
00:12:42,039 --> 00:12:45,429  
each year so they're actually a huge

296  
00:12:43,570 --> 00:12:46,260  
range of projects that are underway in

297  
00:12:45,429 --> 00:12:48,669  
pan-starrs

298  
00:12:46,259 --> 00:12:51,129  
they've divided it up into like twelve

299  
00:12:48,669 --> 00:12:53,019  
nominal projects ranging from everything

300  
00:12:51,129 --> 00:12:55,448  
to the inner solar system trying to find

301  
00:12:53,019 --> 00:12:58,209  
asteroids that might hit the earth to

302  
00:12:55,448 --> 00:13:00,370  
the very most distant things and sort of

303  
00:12:58,208 --> 00:13:04,000  
the observable universe the large-scale

304  
00:13:00,370 --> 00:13:07,089  
structure the imprint of the Cosmic

305  
00:13:04,000 --> 00:13:08,980  
Microwave Background on the structure

306  
00:13:07,089 --> 00:13:10,480  
aware where we find galaxies in the

307  
00:13:08,980 --> 00:13:12,009  
universe today so there's a tremendous

308  
00:13:10,480 --> 00:13:13,990  
range of projects actually that are

309  
00:13:12,009 --> 00:13:18,309  
being worked on in the pan-starrs

310  
00:13:13,990 --> 00:13:19,690  
project as for highlights I can you know

311  
00:13:18,309 --> 00:13:21,339  
I can talk about my own person

312  
00:13:19,690 --> 00:13:22,960  
research which is you know the tiniest

313  
00:13:21,340 --> 00:13:25,060  
drop in the bucket of what pan-starrs

314

00:13:22,960 --> 00:13:27,420  
does well Elena has a picture up here

315  
00:13:25,059 --> 00:13:30,549  
what do we what are we looking at there

316  
00:13:27,419 --> 00:13:32,979  
right so this is this is a project that

317  
00:13:30,549 --> 00:13:35,319  
I've been doing with collaborators at

318  
00:13:32,980 --> 00:13:38,200  
Harvard and in Germany where we're

319  
00:13:35,320 --> 00:13:40,420  
trying to map the structure of the

320  
00:13:38,200 --> 00:13:42,520  
galaxy in three dimensions and so this

321  
00:13:40,419 --> 00:13:44,740  
in particular here is a map of the dust

322  
00:13:42,519 --> 00:13:47,340  
in the galaxy and so if I can tell a

323  
00:13:44,740 --> 00:13:51,639  
little story to explain what dust is so

324  
00:13:47,340 --> 00:13:53,139  
I like to say so the galaxy is a giant

325  
00:13:51,639 --> 00:13:55,600  
pile of stars and each one of these

326  
00:13:53,139 --> 00:13:57,759  
stars is in some sense of fire or a

327  
00:13:55,600 --> 00:14:00,100  
nuclear fire that's burning hydrogen and

328  
00:13:57,759 --> 00:14:02,559

helium into heavier elements and when it

329

00:14:00,100 --> 00:14:04,750

when these stars burn hydrogen helium to

330

00:14:02,559 --> 00:14:06,699

have your elements they make dust and so

331

00:14:04,750 --> 00:14:08,470

each each star is some kind of little

332

00:14:06,700 --> 00:14:10,840

fire that's giving off the smoke and the

333

00:14:08,470 --> 00:14:13,899

smoke is this dust that that's filling

334

00:14:10,840 --> 00:14:16,269

our galaxy up and so this map that we're

335

00:14:13,899 --> 00:14:19,750

showing here is a sort of map of the

336

00:14:16,269 --> 00:14:21,720

galaxy which is really a sphere but it's

337

00:14:19,750 --> 00:14:25,029

been unfolded here in this image and

338

00:14:21,720 --> 00:14:27,279

each pixel on this map is trying to show

339

00:14:25,029 --> 00:14:28,689

how much dust how much of the smoke

340

00:14:27,279 --> 00:14:32,439

produced by the stars is in each

341

00:14:28,690 --> 00:14:34,450

direction on the sky and until reason so

342

00:14:32,440 --> 00:14:36,430

these maps these maps are crucial every



343  
00:14:34,450 --> 00:14:39,910  
almost everyone in astronomy cares about

344  
00:14:36,429 --> 00:14:41,409  
dust because when when you look at any

345  
00:14:39,909 --> 00:14:44,019  
star in the sky even even when you look

346  
00:14:41,409 --> 00:14:46,659  
at the Sun from the earth the color of

347  
00:14:44,019 --> 00:14:48,909  
the Sun depends on how much dust there

348  
00:14:46,659 --> 00:14:50,709  
is between you and the Sun which is why

349  
00:14:48,909 --> 00:14:52,240  
when you look at the Sun at sunset the

350  
00:14:50,710 --> 00:14:53,769  
Sun appears red and that's because all

351  
00:14:52,240 --> 00:14:56,860  
the blue light from the Sun has been

352  
00:14:53,769 --> 00:14:58,720  
scattered away by dust or stuff in the

353  
00:14:56,860 --> 00:15:00,669  
atmosphere so you only see the red light

354  
00:14:58,720 --> 00:15:02,440  
that gets through and in exactly the

355  
00:15:00,669 --> 00:15:04,329  
same way when you look at a star in the

356  
00:15:02,440 --> 00:15:06,370  
sky if there's a lot of dust between you

357  
00:15:04,330 --> 00:15:07,180  
and it it appears redder than it

358  
00:15:06,370 --> 00:15:09,339  
actually is

359  
00:15:07,179 --> 00:15:11,169  
and astronomers care about what the

360  
00:15:09,339 --> 00:15:13,690  
Stars really look like not just what

361  
00:15:11,169 --> 00:15:15,819  
they appear to look to us because of the

362  
00:15:13,690 --> 00:15:17,410  
dust between us and the stars and so

363  
00:15:15,820 --> 00:15:18,940  
whenever they want to try to figure out

364  
00:15:17,409 --> 00:15:20,588  
what the real colors of the stars are

365  
00:15:18,940 --> 00:15:23,050  
not just the colors that they appear to

366  
00:15:20,589 --> 00:15:25,180  
be they need to use maps of dust to

367  
00:15:23,049 --> 00:15:28,240  
figure out what the dust is doing to

368  
00:15:25,179 --> 00:15:29,649  
their observations and until recent so

369  
00:15:28,240 --> 00:15:31,570  
people have always used NASA dust for a

370  
00:15:29,649 --> 00:15:33,189  
long time but until recently they don't

371

00:15:31,570 --> 00:15:35,020  
they haven't been able to look at where

372  
00:15:33,190 --> 00:15:37,600  
the dust is in three dimensions they

373  
00:15:35,019 --> 00:15:39,610  
only look at dust the total column of

374  
00:15:37,600 --> 00:15:41,920  
dust going out in any direction and so

375  
00:15:39,610 --> 00:15:44,259  
what I'm showing in this panel is nearby

376  
00:15:41,919 --> 00:15:46,599  
dust which is in blue in this picture

377  
00:15:44,259 --> 00:15:48,549  
and then further away dust which is in

378  
00:15:46,600 --> 00:15:50,680  
green and the farthest away dust which

379  
00:15:48,549 --> 00:15:52,509  
is in red and we have more fidelity than

380  
00:15:50,679 --> 00:15:54,039  
this but I only have three colors to

381  
00:15:52,509 --> 00:15:57,189  
work with and still make something that

382  
00:15:54,039 --> 00:15:59,019  
looks plausible and so this one picture

383  
00:15:57,190 --> 00:16:01,990  
of how where the dust in the galaxy

384  
00:15:59,019 --> 00:16:03,490  
resides okay wait I'm confused what is

385  
00:16:01,990 --> 00:16:05,139

the weight we never asked what's the

386

00:16:03,490 --> 00:16:07,090

wavelength range of pan-starrs what

387

00:16:05,139 --> 00:16:09,610

wavelengths are we looking at here yes

388

00:16:07,090 --> 00:16:13,269

Penrose observes everything between four

389

00:16:09,610 --> 00:16:17,139

hundred nanometers and about 1,000 maybe

390

00:16:13,269 --> 00:16:21,779

1,100 I forgotten on the red handle yeah

391

00:16:17,139 --> 00:16:24,580

visible to give you a little bit of yeah

392

00:16:21,779 --> 00:16:26,169

so how are you able to get dust in those

393

00:16:24,580 --> 00:16:28,930

wavelengths how are you able to see dust

394

00:16:26,169 --> 00:16:30,549

well right so in exactly the same way

395

00:16:28,929 --> 00:16:32,799

that when you when you look at the star

396

00:16:30,549 --> 00:16:35,049

at sorry at the Sun sometimes it's red

397

00:16:32,799 --> 00:16:36,459

and when you look at sunset and when you

398

00:16:35,049 --> 00:16:38,769

look at other times it's more yellow in

399

00:16:36,460 --> 00:16:40,269

the same way and stars has observed

400  
00:16:38,769 --> 00:16:43,600  
hundreds and hundreds of millions of

401  
00:16:40,269 --> 00:16:46,179  
stars so we use 600 million observations

402  
00:16:43,600 --> 00:16:47,920  
of stars and we compare their colors and

403  
00:16:46,179 --> 00:16:50,529  
so many of these stars are very blue

404  
00:16:47,919 --> 00:16:51,909  
many of these stars are very red and

405  
00:16:50,529 --> 00:16:53,589  
there are definitely certain places on

406  
00:16:51,909 --> 00:16:55,269  
this guy where all the stars you look at

407  
00:16:53,590 --> 00:16:57,399  
practically are very red that's because

408  
00:16:55,269 --> 00:16:58,899  
there's a giant cloud of dust between us

409  
00:16:57,399 --> 00:17:01,179  
and those stars that's making all of

410  
00:16:58,899 --> 00:17:03,639  
those stars look to red and we do some

411  
00:17:01,179 --> 00:17:05,409  
statistical modeling of the colors of

412  
00:17:03,639 --> 00:17:09,068  
all of those stars to try to locate

413  
00:17:05,410 --> 00:17:10,420  
where the dust clouds have to be to make

414  
00:17:09,068 --> 00:17:13,769  
the Stars have the colors that we

415  
00:17:10,420 --> 00:17:16,509  
observe and so then and plots like these

416  
00:17:13,769 --> 00:17:18,609  
when you see that there's a bunch of red

417  
00:17:16,509 --> 00:17:19,900  
dust in this plot so towards the center

418  
00:17:18,609 --> 00:17:21,399  
of this image we see a bunch of red

419  
00:17:19,900 --> 00:17:23,680  
that's saying that all the stars that

420  
00:17:21,400 --> 00:17:25,360  
are very far away are much redder than

421  
00:17:23,680 --> 00:17:27,279  
we expect and so there's probably a big

422  
00:17:25,359 --> 00:17:29,679  
cloud of dust that's far away that's

423  
00:17:27,279 --> 00:17:31,029  
making those stars redder than they

424  
00:17:29,680 --> 00:17:33,430  
might otherwise have appeared if there

425  
00:17:31,029 --> 00:17:36,700  
weren't any dust so you're looking at

426  
00:17:33,430 --> 00:17:38,590  
these stars as they appear to us in

427  
00:17:36,700 --> 00:17:42,759  
pan-starrs at the wavelengths that the

428

00:17:38,589 --> 00:17:44,619  
cameras operate exactly had we but we

429  
00:17:42,759 --> 00:17:46,390  
don't trust that they don't really look

430  
00:17:44,619 --> 00:17:47,119  
that way we know this because there must

431  
00:17:46,390 --> 00:17:50,180  
be

432  
00:17:47,119 --> 00:17:51,889  
how do we go from what we see and you

433  
00:17:50,180 --> 00:17:53,650  
said you did a model I understand that

434  
00:17:51,890 --> 00:17:57,890  
but how do you know what they should be

435  
00:17:53,650 --> 00:18:00,920  
right yes that's a good question

436  
00:17:57,890 --> 00:18:03,830  
so when you look so the galaxy is sort

437  
00:18:00,920 --> 00:18:05,990  
of a disk and as we can see sort of from

438  
00:18:03,829 --> 00:18:07,730  
that image almost all of the dust and

439  
00:18:05,990 --> 00:18:09,890  
the galaxy is in the plane of the galaxy

440  
00:18:07,730 --> 00:18:12,890  
so it's all confined to sort of a thin

441  
00:18:09,890 --> 00:18:14,840  
layer in the main plane of the galaxy

442  
00:18:12,890 --> 00:18:17,240

and when you look up out of that plane

443

00:18:14,839 --> 00:18:19,250

so when you look straight up in some

444

00:18:17,240 --> 00:18:20,299

sense of the galaxy some disk when you

445

00:18:19,250 --> 00:18:22,940

look straight up out of it there's

446

00:18:20,299 --> 00:18:24,950

practically no dust and so from areas

447

00:18:22,940 --> 00:18:27,490

like that you can see what color stars

448

00:18:24,950 --> 00:18:30,590

normally have and then when you compare

449

00:18:27,490 --> 00:18:31,940

what the colors that stars normally have

450

00:18:30,589 --> 00:18:33,740

with the colors that they have when

451

00:18:31,940 --> 00:18:36,920

they're at different locations in the

452

00:18:33,740 --> 00:18:39,019

galaxy you can infer what they really

453

00:18:36,920 --> 00:18:41,390

look like okay so you look outside the

454

00:18:39,019 --> 00:18:44,389

plane of the galaxy you look up as far

455

00:18:41,390 --> 00:18:46,340

as Galactic up and try to see what stars

456

00:18:44,390 --> 00:18:47,270

really look like without all that dust



457  
00:18:46,339 --> 00:18:48,559  
you go aha

458  
00:18:47,269 --> 00:18:50,869  
here's what they really look like now

459  
00:18:48,559 --> 00:18:52,879  
how do I go from here to what I'm seeing

460  
00:18:50,869 --> 00:18:55,639  
and that's where the model comes in and

461  
00:18:52,880 --> 00:18:58,160  
you're able to model that that dust this

462  
00:18:55,640 --> 00:18:59,540  
way now I should point out that what

463  
00:18:58,160 --> 00:19:01,550  
people are looking at there that long

464  
00:18:59,539 --> 00:19:03,230  
line is actually the galaxies is what we

465  
00:19:01,549 --> 00:19:05,329  
see when we look up at the sky so well

466  
00:19:03,230 --> 00:19:06,769  
not in those colors but that's the Milky

467  
00:19:05,329 --> 00:19:09,230  
Way and what's also cool about this

468  
00:19:06,769 --> 00:19:12,470  
image is that it gives us a good sense

469  
00:19:09,230 --> 00:19:16,700  
of where pan-starrs cannot see right

470  
00:19:12,470 --> 00:19:20,350  
right so that's a good point so yes

471  
00:19:16,700 --> 00:19:23,480  
there's a big region of this math around

472  
00:19:20,349 --> 00:19:25,099  
galactic longitude of minus 50 where

473  
00:19:23,480 --> 00:19:28,130  
there's no data it's just giant black

474  
00:19:25,099 --> 00:19:30,500  
blob and that's a region where so that

475  
00:19:28,130 --> 00:19:32,090  
the telescope is on the earth and if we

476  
00:19:30,500 --> 00:19:34,279  
imagine that the telescope were on the

477  
00:19:32,089 --> 00:19:36,049  
North Pole then it would be impossible

478  
00:19:34,279 --> 00:19:37,609  
for the telescope to observe half the

479  
00:19:36,049 --> 00:19:40,789  
sky because half the sky would always be

480  
00:19:37,609 --> 00:19:42,469  
blocked by the earth the telescope isn't

481  
00:19:40,789 --> 00:19:44,029  
quite on the North Pole it's and but

482  
00:19:42,470 --> 00:19:45,380  
it's not on the equator either and so

483  
00:19:44,029 --> 00:19:47,509  
there's a region of the sky that's

484  
00:19:45,380 --> 00:19:50,480  
challenging to observe and so and stars

485

00:19:47,509 --> 00:19:52,309  
never observes south of that line and so

486  
00:19:50,480 --> 00:19:54,589  
that's what leads to a region of no

487  
00:19:52,309 --> 00:19:56,480  
observations in the data this says a lot

488  
00:19:54,589 --> 00:19:58,429  
about where we locate these telescopes

489  
00:19:56,480 --> 00:20:00,889  
foreground surfer sky surveys - and

490  
00:19:58,430 --> 00:20:03,830  
we'll talk about with LSST in a minute

491  
00:20:00,888 --> 00:20:06,079  
but so there's just some places you

492  
00:20:03,829 --> 00:20:08,058  
cannot see from Hawaii and that in these

493  
00:20:06,079 --> 00:20:10,548  
are those places there what what about

494  
00:20:08,058 --> 00:20:12,829  
the gaps around the the parts we can see

495  
00:20:10,548 --> 00:20:14,929  
there's just these islands of black yeah

496  
00:20:12,829 --> 00:20:17,509  
so there so this this particular figure

497  
00:20:14,929 --> 00:20:19,820  
was taken from the data that the

498  
00:20:17,509 --> 00:20:22,669  
telescope had produced within one and a

499  
00:20:19,819 --> 00:20:24,710

half years of the survey we now have

500

00:20:22,669 --> 00:20:25,970

three years of the survey and hopefully

501

00:20:24,710 --> 00:20:28,340

all these little holes should fill in

502

00:20:25,970 --> 00:20:30,620

but I mean these are just things like on

503

00:20:28,339 --> 00:20:32,629

one day the telescope went down because

504

00:20:30,619 --> 00:20:36,048

the shutter was broken for one week we

505

00:20:32,630 --> 00:20:37,639

had bad storms and so there was it was

506

00:20:36,048 --> 00:20:40,609

impossible to take observations so a

507

00:20:37,638 --> 00:20:42,048

variety of complicated factors ends up

508

00:20:40,609 --> 00:20:43,908

making you know determining where

509

00:20:42,048 --> 00:20:46,849

particular holes and the data are in

510

00:20:43,909 --> 00:20:47,960

this plot okay so Armen let's move on to

511

00:20:46,849 --> 00:20:49,428

you what are you doing what are you

512

00:20:47,960 --> 00:20:50,470

doing with pan-starrs besides running at

513

00:20:49,429 --> 00:20:54,200

workshops

514  
00:20:50,470 --> 00:20:57,500  
well I'm mostly interested in things

515  
00:20:54,200 --> 00:21:00,798  
that go boom like supernovae and other

516  
00:20:57,500 --> 00:21:02,210  
things and so supernovae are really

517  
00:21:00,798 --> 00:21:05,179  
important the end stage of stellar

518  
00:21:02,210 --> 00:21:07,730  
evolution all the massive stars end up

519  
00:21:05,179 --> 00:21:10,309  
as core collapse supernovae so they burn

520  
00:21:07,730 --> 00:21:12,919  
also fueled in at some point see one out

521  
00:21:10,308 --> 00:21:16,519  
of fuel and the core collapses and then

522  
00:21:12,919 --> 00:21:17,990  
it explodes and so that this type of

523  
00:21:16,519 --> 00:21:19,700  
supernovae and there was another type of

524  
00:21:17,990 --> 00:21:22,759  
supernovae that are thermonuclear

525  
00:21:19,700 --> 00:21:25,548  
explosions where you have kind of like a

526  
00:21:22,759 --> 00:21:27,408  
corpse of a office star it's called a

527  
00:21:25,548 --> 00:21:29,658  
white dwarf it's a left over and

528  
00:21:27,409 --> 00:21:32,210  
normally if I'd Worf was just like float

529  
00:21:29,659 --> 00:21:34,010  
in space and cool down but it has if it

530  
00:21:32,210 --> 00:21:36,440  
has a companion star that dumps more

531  
00:21:34,009 --> 00:21:39,079  
material on top of it at some point then

532  
00:21:36,440 --> 00:21:41,840  
it goes over certain mass gravity wins

533  
00:21:39,079 --> 00:21:44,869  
and then that white dwarf also explodes

534  
00:21:41,839 --> 00:21:47,418  
and so they important and stages of

535  
00:21:44,869 --> 00:21:50,268  
evolution and also what's really

536  
00:21:47,419 --> 00:21:52,759  
important all of the elements that you

537  
00:21:50,269 --> 00:21:53,329  
see on earth like eros or carbon and

538  
00:21:52,759 --> 00:21:56,629  
oxygen

539  
00:21:53,329 --> 00:21:59,210  
all of these everything's but hydrogen

540  
00:21:56,630 --> 00:22:02,210  
and helium and lithium was actually

541  
00:21:59,210 --> 00:22:04,669  
produced in stars and was a supernova

542

00:22:02,210 --> 00:22:06,769  
and then this supernova basically blast

543  
00:22:04,669 --> 00:22:09,470  
out and distribute all of these things

544  
00:22:06,769 --> 00:22:11,089  
in the interstellar medium and I mean

545  
00:22:09,470 --> 00:22:13,069  
the next stars form out of this

546  
00:22:11,089 --> 00:22:15,109  
interstellar medium then you have

547  
00:22:13,069 --> 00:22:19,009  
it's that form from this material that

548  
00:22:15,109 --> 00:22:21,859  
was produced before and so this you know

549  
00:22:19,009 --> 00:22:24,399  
Whitefield survey like pan-starrs we can

550  
00:22:21,859 --> 00:22:26,750  
detect hundreds or even thousands of

551  
00:22:24,398 --> 00:22:29,058  
supernovae and then we can observe them

552  
00:22:26,750 --> 00:22:31,190  
and learn about them and that's uh one

553  
00:22:29,058 --> 00:22:33,200  
of my main interests so is it kind of

554  
00:22:31,190 --> 00:22:35,058  
like is it a statistical thing where

555  
00:22:33,200 --> 00:22:36,500  
you're looking at large areas of the sky

556  
00:22:35,058 --> 00:22:39,200

and you're seeing more stars your

557

00:22:36,500 --> 00:22:41,778

chances of finding a supernova go up yes

558

00:22:39,200 --> 00:22:45,048

is it like that okay it's like that

559

00:22:41,778 --> 00:22:48,589

how many have so you said thousands have

560

00:22:45,048 --> 00:22:51,980

been seen in pan-starrs yeah so I'm

561

00:22:48,589 --> 00:22:54,678

mainly looking at the data where we get

562

00:22:51,980 --> 00:22:58,548

daily observations of the same field and

563

00:22:54,679 --> 00:23:01,850

so we get very nice light curves and in

564

00:22:58,548 --> 00:23:03,980

these fields we have found about 4000

565

00:23:01,849 --> 00:23:06,589

supernovae and from these 4,000

566

00:23:03,980 --> 00:23:09,079

supernovae we have confirmed this

567

00:23:06,589 --> 00:23:10,699

spectroscopy about five minutes

568

00:23:09,079 --> 00:23:12,288

supernova so wait a minute we've been

569

00:23:10,700 --> 00:23:14,629

pantsed ours has been observing for

570

00:23:12,288 --> 00:23:16,460

three years and has found thousands of



571  
00:23:14,628 --> 00:23:19,668  
supernovae that means there's a lot of

572  
00:23:16,460 --> 00:23:21,798  
stars blowing up oh yeah what's the

573  
00:23:19,669 --> 00:23:23,059  
supernovae rate in this galaxy these are

574  
00:23:21,798 --> 00:23:24,888  
all within our galaxy right

575  
00:23:23,058 --> 00:23:27,558  
no no they are outside our galaxy so

576  
00:23:24,888 --> 00:23:29,089  
they're all in other galaxies then in a

577  
00:23:27,558 --> 00:23:32,359  
given galaxy you have an ever watch

578  
00:23:29,089 --> 00:23:36,220  
about one supernova for 100 years

579  
00:23:32,359 --> 00:23:36,219  
good I was hoping to hear somebody say

580  
00:23:36,940 --> 00:23:42,288  
the last blows one supernova was a

581  
00:23:39,769 --> 00:23:44,509  
supernova 87a in the Large Magellanic

582  
00:23:42,288 --> 00:23:47,558  
Cloud which is this satellite galaxy

583  
00:23:44,509 --> 00:23:59,480  
that goes around the Milky Way galaxy

584  
00:23:47,558 --> 00:24:00,918  
it happened in 1987 yeah so it's

585  
00:23:59,480 --> 00:24:02,450  
actually you know it's very difficult to

586  
00:24:00,919 --> 00:24:04,639  
find supernovae that are close by

587  
00:24:02,450 --> 00:24:06,950  
because they're so rare and so when you

588  
00:24:04,638 --> 00:24:08,628  
have this team of surveys you can find

589  
00:24:06,950 --> 00:24:12,889  
lots of these supernovae in other

590  
00:24:08,628 --> 00:24:16,369  
galaxies so I'm I'm pretty old and as

591  
00:24:12,888 --> 00:24:19,729  
people go and I remember when I first

592  
00:24:16,369 --> 00:24:21,678  
started studying astronomy it was it was

593  
00:24:19,730 --> 00:24:23,569  
still very common to think about the sky

594  
00:24:21,679 --> 00:24:25,610  
as a pretty static place not a whole lot

595  
00:24:23,569 --> 00:24:26,369  
happened except planets moved and they I

596  
00:24:25,609 --> 00:24:28,169  
mean I'm not as all

597  
00:24:26,369 --> 00:24:31,739  
to say the Babylonians are coming I feel

598  
00:24:28,170 --> 00:24:33,120  
that way the but what's what's been

599

00:24:31,740 --> 00:24:35,549  
amazing to me over those over the

600  
00:24:33,119 --> 00:24:37,379  
decades has been this talk of transient

601  
00:24:35,549 --> 00:24:40,079  
astronomy where you're actually looking

602  
00:24:37,380 --> 00:24:42,480  
for things the change in the night sky

603  
00:24:40,079 --> 00:24:44,189  
we're looking at supernovae expanding

604  
00:24:42,480 --> 00:24:46,620  
we're looking at stars moving we're

605  
00:24:44,190 --> 00:24:48,930  
looking at them exploding and and things

606  
00:24:46,619 --> 00:24:51,659  
that weren't there last week are there

607  
00:24:48,930 --> 00:24:53,940  
now and and we have detectors and

608  
00:24:51,660 --> 00:24:56,070  
telescopes that let us get all of this

609  
00:24:53,940 --> 00:24:59,360  
stuff and pan-starrs is is of course one

610  
00:24:56,069 --> 00:25:01,500  
of them and another area of transient

611  
00:24:59,359 --> 00:25:03,058  
astronomy I guess you could call it is a

612  
00:25:01,500 --> 00:25:06,150  
little bit closer to home these wide

613  
00:25:03,058 --> 00:25:07,410

field surveys do a pretty good job at

614

00:25:06,150 --> 00:25:11,130

helping us find things that are gonna

615

00:25:07,410 --> 00:25:13,950

hit us right near-earth objects and how

616

00:25:11,130 --> 00:25:17,970

how does pan-starrs help us do that who

617

00:25:13,950 --> 00:25:20,850

wants to take that one well I could take

618

00:25:17,970 --> 00:25:23,460

that one okay yeah I mean pencil is

619

00:25:20,849 --> 00:25:26,819

really it's one of the one of the best

620

00:25:23,460 --> 00:25:28,950

machines so let's say to find these

621

00:25:26,819 --> 00:25:31,409

near-earth asteroids asteroids comets

622

00:25:28,950 --> 00:25:34,590

all different all these different types

623

00:25:31,410 --> 00:25:40,170

of objects that we have in our solar

624

00:25:34,589 --> 00:25:43,379

system and the the way to find these is

625

00:25:40,170 --> 00:25:45,990

again you have to cover a big area and

626

00:25:43,380 --> 00:25:46,860

just like you know look for this needle

627

00:25:45,990 --> 00:25:50,910

in a haystack

628  
00:25:46,859 --> 00:25:52,799  
and so it's just like hips tremendously

629  
00:25:50,910 --> 00:25:56,850  
do have these huge cameras with a

630  
00:25:52,799 --> 00:26:00,599  
reasonably big telescopes and you know

631  
00:25:56,849 --> 00:26:04,199  
we we have had a couple of events in in

632  
00:26:00,599 --> 00:26:07,259  
recent years one in Russia where are we

633  
00:26:04,200 --> 00:26:11,100  
there was a seeing a 20 meter meteor

634  
00:26:07,259 --> 00:26:14,058  
coming down and what Billy a gigantic

635  
00:26:11,099 --> 00:26:17,339  
fireball in the sky it was amazing and

636  
00:26:14,058 --> 00:26:20,490  
this is a pressure wave I think like

637  
00:26:17,339 --> 00:26:22,799  
about a thousand people got in short so

638  
00:26:20,490 --> 00:26:24,900  
if you want a guard against things like

639  
00:26:22,799 --> 00:26:27,659  
that and that was a very benign one in a

640  
00:26:24,900 --> 00:26:30,450  
way if a big Earth object comes like a

641  
00:26:27,660 --> 00:26:33,360  
50 meter object or even a hundred or two

642  
00:26:30,450 --> 00:26:36,179  
not either object in that moment you

643  
00:26:33,359 --> 00:26:39,178  
really have an issue if it hits a city I

644  
00:26:36,179 --> 00:26:39,820  
mean it really could wipe out a city but

645  
00:26:39,179 --> 00:26:42,620  
Chaplin

646  
00:26:39,819 --> 00:26:43,939  
500 kilotons yeah something like that

647  
00:26:42,619 --> 00:26:45,949  
there was a trainee mirror once oh it

648  
00:26:43,940 --> 00:26:50,120  
was you know it was a pretty good one

649  
00:26:45,950 --> 00:26:52,100  
but half a maggot yeah but it it could

650  
00:26:50,119 --> 00:26:54,889  
be much bigger and so there are you know

651  
00:26:52,099 --> 00:26:57,799  
objects out there that get close to us

652  
00:26:54,890 --> 00:27:00,230  
and you know in the past these big

653  
00:26:57,799 --> 00:27:03,379  
things have hit us and had a major

654  
00:27:00,230 --> 00:27:06,230  
impact on the environment and so one of

655  
00:27:03,380 --> 00:27:09,350  
the goals is from us and some of these

656

00:27:06,230 --> 00:27:11,900  
other service is to basically catalog

657  
00:27:09,349 --> 00:27:15,699  
all possible near-earth asteroids that

658  
00:27:11,900 --> 00:27:19,970  
are potentially hazardous so that if one

659  
00:27:15,700 --> 00:27:21,890  
gets close or it's likely to hit earth

660  
00:27:19,970 --> 00:27:24,110  
that we can do something at least that

661  
00:27:21,890 --> 00:27:27,530  
we can move the people out of the way so

662  
00:27:24,109 --> 00:27:29,178  
it's a very important part so here's an

663  
00:27:27,529 --> 00:27:31,428  
animation that I got from the pan-starrs

664  
00:27:29,179 --> 00:27:34,009  
website this is on their pan-starrs in

665  
00:27:31,429 --> 00:27:37,250  
any of threat and in here you get an

666  
00:27:34,009 --> 00:27:39,410  
idea of just how little animation of how

667  
00:27:37,250 --> 00:27:41,230  
these are the I guess the asteroids that

668  
00:27:39,410 --> 00:27:43,820  
we know about these are the ones that

669  
00:27:41,230 --> 00:27:45,890  
whose orbits we've figured out and

670  
00:27:43,819 --> 00:27:48,879

there's a lot of them and you you can of

671

00:27:45,890 --> 00:27:51,860  
course see that most of them are

672

00:27:48,880 --> 00:27:54,350  
situated in certain in a certain area in

673

00:27:51,859 --> 00:27:56,119  
our solar system but it's the ones we

674

00:27:54,349 --> 00:27:58,428  
don't see the ones that are not in this

675

00:27:56,119 --> 00:27:59,839  
animation that are the most worrying and

676

00:27:58,429 --> 00:28:02,179  
that's the ones that come from us from

677

00:27:59,839 --> 00:28:03,740  
though like the the Russian meteor last

678

00:28:02,179 --> 00:28:05,720  
year and things like that so pan-starrs

679

00:28:03,740 --> 00:28:07,069  
does pan-starrs have the kind of time

680

00:28:05,720 --> 00:28:10,730  
frequency and does it have an alert

681

00:28:07,069 --> 00:28:13,609  
system I mean it part of its acronym is

682

00:28:10,730 --> 00:28:15,620  
Rapid Response so I'm assuming there's

683

00:28:13,609 --> 00:28:17,928  
some way of letting people know when

684

00:28:15,619 --> 00:28:20,599  
something is upon the way yeah of course



685  
00:28:17,929 --> 00:28:22,790  
I mean as soon we we have observations

686  
00:28:20,599 --> 00:28:26,839  
that get reduced and if you find any

687  
00:28:22,789 --> 00:28:31,490  
asteroid they are getting sent to the to

688  
00:28:26,839 --> 00:28:34,189  
the MPC Minor Planet Center and so it's

689  
00:28:31,490 --> 00:28:36,230  
a Minor Planet Center now okay so you

690  
00:28:34,190 --> 00:28:37,910  
basically submit all of your intentions

691  
00:28:36,230 --> 00:28:39,650  
that you find all of your asteroid

692  
00:28:37,910 --> 00:28:42,980  
detection to this Minor Planet Center

693  
00:28:39,650 --> 00:28:45,530  
and it collects all all asteroids all

694  
00:28:42,980 --> 00:28:47,420  
solar system objects from all these

695  
00:28:45,529 --> 00:28:49,369  
different surveys because lots of time

696  
00:28:47,420 --> 00:28:52,850  
it's really advantageous to actually

697  
00:28:49,369 --> 00:28:53,209  
connect the detections from one survey

698  
00:28:52,849 --> 00:28:55,879  
to the

699  
00:28:53,210 --> 00:28:59,419  
detection of another survey so you have

700  
00:28:55,880 --> 00:29:01,309  
found and your earth asteroids in one

701  
00:28:59,419 --> 00:29:03,860  
survey then we observe it with another

702  
00:29:01,308 --> 00:29:05,928  
survey a year later or two years later

703  
00:29:03,859 --> 00:29:08,648  
you have a much better orbit because you

704  
00:29:05,929 --> 00:29:11,090  
have a much longer time baseline so

705  
00:29:08,648 --> 00:29:15,349  
collecting all of this data in one place

706  
00:29:11,089 --> 00:29:16,339  
really makes sense and so yeah I mean of

707  
00:29:15,349 --> 00:29:17,359  
course if there would be anything

708  
00:29:16,339 --> 00:29:19,339  
dangerous

709  
00:29:17,359 --> 00:29:22,639  
it would be you know people would be

710  
00:29:19,339 --> 00:29:25,428  
immediately notified great okay so um

711  
00:29:22,640 --> 00:29:27,288  
what's also when I was at the workshop I

712  
00:29:25,429 --> 00:29:30,890  
was listening to talks I'm hearing about

713

00:29:27,288 --> 00:29:32,480  
pan-starrs one and pan-starrs two what's

714  
00:29:30,890 --> 00:29:35,090  
what's all that about are there two of

715  
00:29:32,480 --> 00:29:37,009  
them now or is there another one that's

716  
00:29:35,089 --> 00:29:40,009  
a the second one is basically under

717  
00:29:37,009 --> 00:29:41,869  
construction right now so Sikkema ha

718  
00:29:40,009 --> 00:29:43,849  
already exists or it's getting put

719  
00:29:41,869 --> 00:29:47,178  
together right now it's the same as a

720  
00:29:43,849 --> 00:29:50,480  
telescope so schedule is that pencils

721  
00:29:47,179 --> 00:29:52,429  
too will be finished and commissioned

722  
00:29:50,480 --> 00:29:55,460  
beginning of next year so that's a

723  
00:29:52,429 --> 00:29:57,528  
schedule so it is anime not an exact

724  
00:29:55,460 --> 00:30:00,860  
clone of pens last one but it's very

725  
00:29:57,528 --> 00:30:03,019  
similar and then you have you know twice

726  
00:30:00,859 --> 00:30:05,778  
it's a fire power in a way and you can

727  
00:30:03,019 --> 00:30:08,329

do twice as many things okay

728

00:30:05,778 --> 00:30:10,700

so the website says first light for ps2

729

00:30:08,329 --> 00:30:13,099

is supposed to be in 2013 and did that

730

00:30:10,700 --> 00:30:13,640

does not happen there no that hasn't

731

00:30:13,099 --> 00:30:16,298

happened yet

732

00:30:13,640 --> 00:30:18,950

that is a I think with a lot of

733

00:30:16,298 --> 00:30:22,278

astronomical projects you you do have a

734

00:30:18,950 --> 00:30:24,169

couple of years delay actually I think

735

00:30:22,278 --> 00:30:26,359

the telescope might be finished and they

736

00:30:24,169 --> 00:30:28,309

have a dumb little camera on they might

737

00:30:26,359 --> 00:30:30,408

have actually cio tons but not with the

738

00:30:28,308 --> 00:30:34,908

final set up yes yes there's a finally

739

00:30:30,409 --> 00:30:36,919

comma because I thought I saw a press

740

00:30:34,909 --> 00:30:42,919

release that you know some light hand

741

00:30:36,919 --> 00:30:44,120

comes and the field of view for ps2 is

742  
00:30:42,919 --> 00:30:46,460  
I'm sorry did you say it was twice as

743  
00:30:44,119 --> 00:30:48,709  
bigger is that just a detector size no

744  
00:30:46,460 --> 00:30:51,679  
no I mean it spaces the same size than

745  
00:30:48,710 --> 00:30:53,808  
ps1 but now we have two telescopes and

746  
00:30:51,679 --> 00:30:57,380  
these two telescopes you can of course

747  
00:30:53,808 --> 00:31:00,648  
oh I see twice as much I understand now

748  
00:30:57,380 --> 00:31:02,539  
okay good so so we're using it to find

749  
00:31:00,648 --> 00:31:04,308  
any O's we're using it for supernova

750  
00:31:02,538 --> 00:31:06,890  
search wide field wide field studies

751  
00:31:04,308 --> 00:31:09,048  
coming up and it is

752  
00:31:06,890 --> 00:31:11,390  
so this there is there a mission

753  
00:31:09,048 --> 00:31:13,009  
timeline when this will all end or is it

754  
00:31:11,390 --> 00:31:15,770  
just ongoing as the University of Hawaii

755  
00:31:13,009 --> 00:31:19,490  
and everybody else just funding this for

756  
00:31:15,769 --> 00:31:22,700  
so long people use it so the ps1 Japan

757  
00:31:19,490 --> 00:31:26,509  
sus one science collaboration basically

758  
00:31:22,700 --> 00:31:28,670  
finished this year so it was a video

759  
00:31:26,509 --> 00:31:30,379  
survey where we had you know several

760  
00:31:28,670 --> 00:31:33,798  
institutions from all over the world

761  
00:31:30,380 --> 00:31:36,049  
coming together and doing this for

762  
00:31:33,798 --> 00:31:38,480  
science but that collaboration is right

763  
00:31:36,048 --> 00:31:44,058  
now finished and for the next year

764  
00:31:38,480 --> 00:31:47,120  
ps1 will be focusing I think over 90% on

765  
00:31:44,058 --> 00:31:52,490  
finding your asteroids and other solar

766  
00:31:47,119 --> 00:31:54,048  
system so go ahead yes so this is a

767  
00:31:52,490 --> 00:31:55,970  
science collaboration meeting that we

768  
00:31:54,048 --> 00:32:00,650  
have right now is actually our last

769  
00:31:55,970 --> 00:32:03,500  
wheel science collaboration meeting so

770

00:32:00,650 --> 00:32:05,120  
the data it's not available yet to

771  
00:32:03,500 --> 00:32:07,339  
everyone we've got some time before

772  
00:32:05,119 --> 00:32:11,000  
people can get it is that right Carol or

773  
00:32:07,339 --> 00:32:12,769  
or I mean we're ultimately I think going

774  
00:32:11,000 --> 00:32:15,140  
to be serving the data here at the

775  
00:32:12,769 --> 00:32:17,058  
Institute right yeah and I want to

776  
00:32:15,140 --> 00:32:18,679  
wanted to point out I mean Harmon is

777  
00:32:17,058 --> 00:32:21,289  
kind of you know you're saying there's

778  
00:32:18,679 --> 00:32:24,230  
alert system and you know all these

779  
00:32:21,289 --> 00:32:26,269  
observations these surveys are not I

780  
00:32:24,230 --> 00:32:29,679  
mean they need to be calibrated there's

781  
00:32:26,269 --> 00:32:33,369  
a whole process of getting the data

782  
00:32:29,679 --> 00:32:38,080  
process the instrument signature removed

783  
00:32:33,369 --> 00:32:40,819  
and you know registered and

784  
00:32:38,079 --> 00:32:43,339

understanding what the data means and of

785

00:32:40,819 --> 00:32:45,889

course even though they look at the same

786

00:32:43,339 --> 00:32:47,720

part of the sky the observations might

787

00:32:45,890 --> 00:32:50,240

not look exactly the same and you have

788

00:32:47,720 --> 00:32:51,919

to make sure that it's not the

789

00:32:50,240 --> 00:32:53,630

instrument or the telescope or they

790

00:32:51,919 --> 00:32:56,390

atmosphere which is causing things to

791

00:32:53,630 --> 00:32:59,870

look different so the processing is very

792

00:32:56,390 --> 00:33:03,140

important for before you can let the

793

00:32:59,869 --> 00:33:06,349

archive open to everyone because you

794

00:33:03,140 --> 00:33:09,620

want to make sure that the data that the

795

00:33:06,349 --> 00:33:13,069

community is using is really robust data

796

00:33:09,619 --> 00:33:16,369

and so this data has been a challenge to

797

00:33:13,069 --> 00:33:19,099

get in that state any kind of survey

798

00:33:16,369 --> 00:33:20,750

data is like that HST data is a



799

00:33:19,099 --> 00:33:22,549

challenge you know the

800

00:33:20,750 --> 00:33:24,740

who are doing these large surveys with

801

00:33:22,549 --> 00:33:27,169

HST have a challenge as well to make

802

00:33:24,740 --> 00:33:29,329

sure that the data is calibrated as well

803

00:33:27,170 --> 00:33:31,970

as impossible possibly can

804

00:33:29,329 --> 00:33:33,710

there's always a possibility of

805

00:33:31,970 --> 00:33:36,110

reprocessing the data but when you

806

00:33:33,710 --> 00:33:38,059

release the archive you want people to

807

00:33:36,109 --> 00:33:40,009

kind of been able to be able to use it

808

00:33:38,059 --> 00:33:41,929

out of the box and that is a big

809

00:33:40,009 --> 00:33:46,759

challenge and it's a lot of data as well

810

00:33:41,930 --> 00:33:49,970

so just handing it over is is not that

811

00:33:46,759 --> 00:33:52,369

easy yeah it's actually 2 petabytes of

812

00:33:49,970 --> 00:33:57,380

data ah you read my mind

813  
00:33:52,369 --> 00:33:59,659  
ok 1.4 gigapixel camera that literally

814  
00:33:57,380 --> 00:34:02,090  
all night long every single night takes

815  
00:33:59,660 --> 00:34:05,000  
pictures as fast as it can yeah save all

816  
00:34:02,089 --> 00:34:12,199  
of that misil's camera yeah and if you

817  
00:34:05,000 --> 00:34:14,179  
think that's a lot of data well that let

818  
00:34:12,199 --> 00:34:17,480  
us now segue this is a good segue you

819  
00:34:14,179 --> 00:34:19,579  
think that is a lot of native then we

820  
00:34:17,480 --> 00:34:21,619  
have got a lot more in store in the

821  
00:34:19,579 --> 00:34:25,190  
coming years I'm very pleased to have

822  
00:34:21,619 --> 00:34:29,648  
here in my end his hangouts with me dr.

823  
00:34:25,190 --> 00:34:31,909  
Robert Lofton he working on the L SST

824  
00:34:29,648 --> 00:34:33,949  
Sky Survey which has been in the

825  
00:34:31,909 --> 00:34:35,809  
planning stages and the building stages

826  
00:34:33,949 --> 00:34:37,939  
I learned about it when I was at

827

00:34:35,809 --> 00:34:39,440  
Illinois with dark energy survey a lot

828  
00:34:37,940 --> 00:34:40,878  
of people around me and we're working on

829  
00:34:39,440 --> 00:34:44,418  
it the data management system things

830  
00:34:40,878 --> 00:34:46,940  
like that and now I watch Robert Lufton

831  
00:34:44,418 --> 00:34:49,429  
yesterday and I'm hearing that this is

832  
00:34:46,940 --> 00:34:51,110  
actually actually he was giving us a

833  
00:34:49,429 --> 00:34:53,599  
really funny slide about all the the top

834  
00:34:51,110 --> 00:34:56,329  
10 lessons he's learned and one of his

835  
00:34:53,599 --> 00:34:58,759  
lessons was don't join a project until

836  
00:34:56,329 --> 00:35:00,889  
it's been funded so I guess that's been

837  
00:34:58,760 --> 00:35:03,290  
that's changed now right LSST years ago

838  
00:35:00,889 --> 00:35:05,480  
is that right Robert I think that's true

839  
00:35:03,289 --> 00:35:07,219  
yeah I didn't think they were a funny

840  
00:35:05,480 --> 00:35:11,679  
slide I thought they were very deep and

841  
00:35:07,219 --> 00:35:11,679

insightful ten lessons actually well

842

00:35:12,579 --> 00:35:16,969

things have changed I started working

843

00:35:15,199 --> 00:35:18,679

with CCD cameras when the biggest one in

844

00:35:16,969 --> 00:35:21,230

the world was a quarter megapixel on the

845

00:35:18,679 --> 00:35:22,969

biggest telescope in the world LSST is

846

00:35:21,230 --> 00:35:25,699

going to have a 3 point 2 Giga pixel

847

00:35:22,969 --> 00:35:27,919

camera which is something like three

848

00:35:25,699 --> 00:35:33,559

times bigger than pan-starrs on a much

849

00:35:27,920 --> 00:35:34,579

bigger mirror you know my previous

850

00:35:33,559 --> 00:35:36,650

camera was 100

851

00:35:34,579 --> 00:35:37,579

40 megapixels on the Sloan's we're

852

00:35:36,650 --> 00:35:40,880

moving up in the system

853

00:35:37,579 --> 00:35:43,940

so yeah LSST is a project is about there

854

00:35:40,880 --> 00:35:46,630

is every expectation that we will get an

855

00:35:43,940 --> 00:35:49,460

official funding start in early July

856  
00:35:46,630 --> 00:35:52,670  
2014 in fact the National Science Board

857  
00:35:49,460 --> 00:35:54,650  
which is the sort of top-level governing

858  
00:35:52,670 --> 00:35:55,880  
body for science in the US has

859  
00:35:54,650 --> 00:35:58,820  
instructed the National Science

860  
00:35:55,880 --> 00:36:01,030  
Foundation to release the funding for

861  
00:35:58,820 --> 00:36:03,530  
the construction of this project

862  
00:36:01,030 --> 00:36:04,940  
nominally by July 1 we expect it will

863  
00:36:03,530 --> 00:36:07,610  
take a little longer due to technical

864  
00:36:04,940 --> 00:36:10,519  
details and crossing eyes and crossing

865  
00:36:07,610 --> 00:36:12,760  
dollar science really but sometime in

866  
00:36:10,519 --> 00:36:14,960  
July we expected to construction start

867  
00:36:12,760 --> 00:36:18,500  
the primary mirror is eight and a half

868  
00:36:14,960 --> 00:36:21,289  
meters across so that's what 25 26 feet

869  
00:36:18,500 --> 00:36:23,659  
I can't do it in my head so a 2.48 is

870  
00:36:21,289 --> 00:36:25,130  
the magic number I think there's some

871  
00:36:23,659 --> 00:36:26,690  
pictures actually of the mirrors which

872  
00:36:25,130 --> 00:36:29,059  
have already been made Elena

873  
00:36:26,690 --> 00:36:32,030  
can we pull I just wanted to comment

874  
00:36:29,059 --> 00:36:33,920  
Roberts had something he said it is a

875  
00:36:32,030 --> 00:36:36,560  
project and that wasn't a throwaway

876  
00:36:33,920 --> 00:36:39,769  
statement that is a significant thing

877  
00:36:36,559 --> 00:36:41,929  
it's one thing to have your concept on

878  
00:36:39,769 --> 00:36:43,730  
PowerPoint slides and convince everybody

879  
00:36:41,929 --> 00:36:45,829  
you have this great idea and you've got

880  
00:36:43,730 --> 00:36:48,650  
lots of Technology and engineers and all

881  
00:36:45,829 --> 00:36:51,500  
that but when you are a project that

882  
00:36:48,650 --> 00:36:53,260  
means you actually might be able to

883  
00:36:51,500 --> 00:36:56,539  
build the telescope and so it's a very

884

00:36:53,260 --> 00:36:58,970  
significant milestone for LSST to be a

885  
00:36:56,539 --> 00:37:02,239  
project it's been a long time coming and

886  
00:36:58,969 --> 00:37:04,730  
it's very exciting very exciting so

887  
00:37:02,239 --> 00:37:06,289  
somebody yeah was it you tony was the

888  
00:37:04,730 --> 00:37:07,909  
picture somebody had a picture with the

889  
00:37:06,289 --> 00:37:10,489  
Sun there we go I do

890  
00:37:07,909 --> 00:37:14,299  
I can you see my screen would I have

891  
00:37:10,489 --> 00:37:16,250  
right now the rendering of where they're

892  
00:37:14,300 --> 00:37:19,820  
going to build this you have that up

893  
00:37:16,250 --> 00:37:21,409  
this is chili Cerro Patong and they're

894  
00:37:19,820 --> 00:37:23,330  
gonna be building it right across the

895  
00:37:21,409 --> 00:37:26,629  
street or down the road from the Gemini

896  
00:37:23,329 --> 00:37:28,670  
telescope this will be as construction

897  
00:37:26,630 --> 00:37:31,130  
start will construction start on this

898  
00:37:28,670 --> 00:37:32,809

Robert do we know I don't remember we

899

00:37:31,130 --> 00:37:35,240

blew the top off the mountain the only

900

00:37:32,809 --> 00:37:38,000

the only truth in this picture is the

901

00:37:35,239 --> 00:37:42,109

flat top where it says LSST rendering on

902

00:37:38,000 --> 00:37:45,199

earth we actually it's actually just a

903

00:37:42,110 --> 00:37:47,000

flat thing now that the telescope isn't

904

00:37:45,199 --> 00:37:48,199

there we're about to start letting

905

00:37:47,000 --> 00:37:50,239

contracts for things like

906

00:37:48,199 --> 00:37:53,239

steal here's a picture of the telescope

907

00:37:50,239 --> 00:37:54,889

so it's a very squat not quite as ugly

908

00:37:53,239 --> 00:37:58,399

as the swollen telescope they're pretty

909

00:37:54,889 --> 00:38:00,618

bad so none of the steel has been

910

00:37:58,400 --> 00:38:03,380

ordered yet it's very very compact at

911

00:38:00,619 --> 00:38:05,150

one point to f-ratio primary if we can

912

00:38:03,380 --> 00:38:07,820

go to the pictures of the primary the



913  
00:38:05,150 --> 00:38:09,530  
photos Tony oh that's just an artist's

914  
00:38:07,820 --> 00:38:11,390  
impression there we go that's the actual

915  
00:38:09,530 --> 00:38:13,880  
mirror that's a big piece of glass

916  
00:38:11,389 --> 00:38:15,828  
sitting underneath the football stadium

917  
00:38:13,880 --> 00:38:16,460  
in Arizona you'll see it's really

918  
00:38:15,829 --> 00:38:18,769  
bizarre

919  
00:38:16,460 --> 00:38:20,838  
it's two mirrors in one the outer part

920  
00:38:18,769 --> 00:38:23,000  
has one curvature and the inner part

921  
00:38:20,838 --> 00:38:26,328  
that looks a little bit like a hand

922  
00:38:23,000 --> 00:38:28,010  
basin as another curvature so we

923  
00:38:26,329 --> 00:38:29,510  
actually have three mirror systems of a

924  
00:38:28,010 --> 00:38:31,760  
light comes in it bounces off the outer

925  
00:38:29,510 --> 00:38:33,500  
part it hits an enormous secondary

926  
00:38:31,760 --> 00:38:35,750  
mirror which isn't in this picture which

927  
00:38:33,500 --> 00:38:37,639  
is three and a half meters across it

928  
00:38:35,750 --> 00:38:39,199  
bounces down it hits the center part

929  
00:38:37,639 --> 00:38:41,960  
then goes back up into this enormous

930  
00:38:39,199 --> 00:38:43,460  
camera which will be the biggest

931  
00:38:41,960 --> 00:38:45,949  
certainly astronomical camera in the

932  
00:38:43,460 --> 00:38:47,240  
world at that point the data rate is 400

933  
00:38:45,949 --> 00:38:49,489  
megabytes per second

934  
00:38:47,239 --> 00:38:52,279  
sustained that's the average data rate

935  
00:38:49,489 --> 00:38:54,649  
so I think we end up with 60 petabytes

936  
00:38:52,280 --> 00:38:56,800  
of imaging data no not that much more

937  
00:38:54,650 --> 00:39:02,088  
than pen stylus but but bigger and worse

938  
00:38:56,800 --> 00:39:03,920  
right what do we get with this shape I

939  
00:39:02,088 --> 00:39:05,150  
mean okay so the outer the outer donate

940  
00:39:03,920 --> 00:39:07,760  
or Taurus or whatever you want to call

941

00:39:05,150 --> 00:39:10,130  
it do it has a certain via has a certain

942  
00:39:07,760 --> 00:39:12,050  
figure it goes up goes to the secondary

943  
00:39:10,130 --> 00:39:14,450  
like you said and bounces back and hits

944  
00:39:12,050 --> 00:39:17,810  
this ball this deeper Bowl which then

945  
00:39:14,449 --> 00:39:20,000  
goes straight to the camera what do you

946  
00:39:17,809 --> 00:39:22,549  
get with this what's the you've got a

947  
00:39:20,000 --> 00:39:24,559  
very large field so we we showed you the

948  
00:39:22,550 --> 00:39:27,170  
Hubble field which is about the zero and

949  
00:39:24,559 --> 00:39:28,730  
then the new supreme cam field which is

950  
00:39:27,170 --> 00:39:30,440  
one point eight square degrees and the

951  
00:39:28,730 --> 00:39:33,469  
pan-starrs which is three they're bigger

952  
00:39:30,440 --> 00:39:36,588  
and bigger this is a ten degree field so

953  
00:39:33,469 --> 00:39:38,389  
that the diameter of the field is six

954  
00:39:36,588 --> 00:39:40,578  
times larger than the full moon so you

955  
00:39:38,389 --> 00:39:43,368

see it in a very large area of the sky

956

00:39:40,579 --> 00:39:45,289

at once you're like this what is our

957

00:39:43,369 --> 00:39:47,720

name for it or is it like they're called

958

00:39:45,289 --> 00:39:50,239

TMA's which stands for three mirror and

959

00:39:47,719 --> 00:39:50,750

a stick mats that's what they call them

960

00:39:50,239 --> 00:39:52,549

in the business

961

00:39:50,750 --> 00:39:55,010

in fact the W first mirror is the

962

00:39:52,550 --> 00:39:57,500

similar it's done in different ways but

963

00:39:55,010 --> 00:39:59,060

it's also a three mirror design W first

964

00:39:57,500 --> 00:40:01,159

is a it's based another Space

965

00:39:59,059 --> 00:40:02,090

Telescope's I'm sure Kerry will be

966

00:40:01,159 --> 00:40:04,429

telling you all about

967

00:40:02,090 --> 00:40:07,010

yes hangouts planned on that one so yeah

968

00:40:04,429 --> 00:40:09,289

definitely W thirst is going to play

969

00:40:07,010 --> 00:40:12,230

very nicely with the LSS T data they're

970  
00:40:09,289 --> 00:40:13,880  
very well matched so you just get more

971  
00:40:12,230 --> 00:40:15,530  
degrees of freedom you can get a bigger

972  
00:40:13,880 --> 00:40:17,300  
field why do you want a bigger field

973  
00:40:15,530 --> 00:40:19,820  
because you can carry a cover more of

974  
00:40:17,300 --> 00:40:21,440  
the sky at one time why do you want to

975  
00:40:19,820 --> 00:40:23,720  
do that well you can cover the whole sky

976  
00:40:21,440 --> 00:40:26,450  
in less time and in fact with the LS s

977  
00:40:23,719 --> 00:40:28,519  
teak system we can cover the complete

978  
00:40:26,449 --> 00:40:31,879  
sky or hop that all we can see at one

979  
00:40:28,519 --> 00:40:35,030  
time in about three days so we can take

980  
00:40:31,880 --> 00:40:37,910  
a monochromatic picture of the entire

981  
00:40:35,030 --> 00:40:40,370  
sky twice a week we've got six filters

982  
00:40:37,909 --> 00:40:43,609  
so we can actually take a color picture

983  
00:40:40,369 --> 00:40:45,650  
of the sky every well basically every

984  
00:40:43,610 --> 00:40:47,780  
week and a half every 10 days so let's

985  
00:40:45,650 --> 00:40:50,240  
just I need to emphasize that because

986  
00:40:47,780 --> 00:40:53,930  
that is an amazing thing to say I mean

987  
00:40:50,239 --> 00:40:57,199  
here we have we are they're going to be

988  
00:40:53,929 --> 00:41:01,369  
taking 800 images a night and cover the

989  
00:40:57,199 --> 00:41:07,309  
entire sky in about a 1/2 no cover the

990  
00:41:01,369 --> 00:41:09,289  
whole sky in three days oh yeah in each

991  
00:41:07,309 --> 00:41:12,469  
color so we cover this so twice each

992  
00:41:09,289 --> 00:41:13,820  
week I I that just blows me away I mean

993  
00:41:12,469 --> 00:41:15,829  
that the amount of data and the fact

994  
00:41:13,820 --> 00:41:17,030  
that we can do that at all is and there

995  
00:41:15,829 --> 00:41:17,539  
will be no blind spots like in

996  
00:41:17,030 --> 00:41:19,910  
pan-starrs

997  
00:41:17,539 --> 00:41:21,500  
it'll be able to know we're in the south

998

00:41:19,909 --> 00:41:23,359  
so we'll see the southern part of the

999  
00:41:21,500 --> 00:41:26,179  
sky we can't see the north pole you

1000  
00:41:23,360 --> 00:41:28,340  
can't see Polaris from Chile and that

1001  
00:41:26,179 --> 00:41:30,679  
was Sarah lappa John which is in Chile

1002  
00:41:28,340 --> 00:41:33,380  
so we'll see the part of the sky

1003  
00:41:30,679 --> 00:41:35,210  
pan-starrs can't see it has various

1004  
00:41:33,380 --> 00:41:36,890  
advantages there's lots of big glass in

1005  
00:41:35,210 --> 00:41:39,710  
the south and the galactic center is in

1006  
00:41:36,889 --> 00:41:41,179  
the south so the compliment I mean

1007  
00:41:39,710 --> 00:41:43,820  
people like Eddie who really care about

1008  
00:41:41,179 --> 00:41:45,679  
dust and things like that we're really

1009  
00:41:43,820 --> 00:41:48,500  
excited because we'll get a great view

1010  
00:41:45,679 --> 00:41:49,940  
of the southern the sky on a on a queued

1011  
00:41:48,500 --> 00:41:52,639  
rather a bigger telescope will go a lot

1012  
00:41:49,940 --> 00:41:54,320

deeper than pen stars but you'll still

1013

00:41:52,639 --> 00:41:56,059

get the complete coverage from the north

1014

00:41:54,320 --> 00:41:58,970

from telescopes that pants dad's so

1015

00:41:56,059 --> 00:42:01,340

we'll see the whole sky well as you

1016

00:41:58,969 --> 00:42:02,929

mentioned a while ago you came from the

1017

00:42:01,340 --> 00:42:05,329

Sloan Digital Sky Survey which was run

1018

00:42:02,929 --> 00:42:08,449

from New Mexico and was we an amazingly

1019

00:42:05,329 --> 00:42:11,179

detailed rendering of a lot of just you

1020

00:42:08,449 --> 00:42:13,219

know millions of galaxies and you guys

1021

00:42:11,179 --> 00:42:15,619

made a 3d map of the universe that you

1022

00:42:13,219 --> 00:42:17,659

could see with Sloan

1023

00:42:15,619 --> 00:42:20,599

which was you know it had slices in it

1024

00:42:17,659 --> 00:42:22,429

and it basically amounted to the areas

1025

00:42:20,599 --> 00:42:24,650

that Sloane could see are you going to

1026

00:42:22,429 --> 00:42:26,659

make something like that with LSST well



1027  
00:42:24,650 --> 00:42:28,309  
the trouble is that Sloane did two

1028  
00:42:26,659 --> 00:42:30,049  
things when the conditions were really

1029  
00:42:28,309 --> 00:42:31,789  
good we took pictures of the sky with

1030  
00:42:30,050 --> 00:42:34,700  
what was then the biggest camera in the

1031  
00:42:31,789 --> 00:42:37,429  
world is now in the Smithsonian and the

1032  
00:42:34,699 --> 00:42:39,259  
rest of the time we took spectra so we

1033  
00:42:37,429 --> 00:42:41,539  
could measure the distances to galaxies

1034  
00:42:39,260 --> 00:42:43,820  
by using a spectrograph which is still

1035  
00:42:41,539 --> 00:42:45,980  
there takes a thousand spectra at a time

1036  
00:42:43,820 --> 00:42:47,690  
the a necessity is just an imaging

1037  
00:42:45,980 --> 00:42:49,670  
camera it'll be taking pictures all the

1038  
00:42:47,690 --> 00:42:52,159  
time and in fact one of the really

1039  
00:42:49,670 --> 00:42:53,900  
difficult things for the next generation

1040  
00:42:52,159 --> 00:42:56,480  
of big surveys is there is no big

1041  
00:42:53,900 --> 00:42:58,460  
imaging big spectrographic camera I mean

1042  
00:42:56,480 --> 00:43:00,139  
one of my many projects I have many is

1043  
00:42:58,460 --> 00:43:01,670  
to build an instrument called the prime

1044  
00:43:00,139 --> 00:43:03,949  
focus spectrograph that goes on the

1045  
00:43:01,670 --> 00:43:06,230  
Subaru amount of care so not that far

1046  
00:43:03,949 --> 00:43:08,809  
from the Panzers telescope which would

1047  
00:43:06,230 --> 00:43:11,420  
in fact take spectra for 2,400 objects

1048  
00:43:08,809 --> 00:43:13,820  
at a time twelve tons of spectrograph

1049  
00:43:11,420 --> 00:43:14,930  
but there's no equivalent some object in

1050  
00:43:13,820 --> 00:43:16,670  
this telescope

1051  
00:43:14,929 --> 00:43:19,129  
no equivalent instrument in the South

1052  
00:43:16,670 --> 00:43:21,260  
there are there an attempt to put such

1053  
00:43:19,130 --> 00:43:23,390  
instruments on Manor care but I'm not

1054  
00:43:21,260 --> 00:43:25,340  
sure where they're going looking well

1055

00:43:23,389 --> 00:43:28,039  
I'm confused in Robert because I have up

1056  
00:43:25,340 --> 00:43:30,920  
now the webpage of LSST and it says here

1057  
00:43:28,039 --> 00:43:32,719  
right on it data from LSST will be used

1058  
00:43:30,920 --> 00:43:34,730  
to create a 3d map of the universe with

1059  
00:43:32,719 --> 00:43:37,189  
unprecedented depth in detail this map

1060  
00:43:34,730 --> 00:43:38,449  
can be used to locate mysterious dark

1061  
00:43:37,190 --> 00:43:40,340  
matter and to characterize the

1062  
00:43:38,449 --> 00:43:42,439  
properties and even more mysterious dark

1063  
00:43:40,340 --> 00:43:46,250  
energy ok well I can tell you what that

1064  
00:43:42,440 --> 00:43:48,050  
means I can tell you why it's true the

1065  
00:43:46,250 --> 00:43:49,550  
easiest and best way to measure the

1066  
00:43:48,050 --> 00:43:51,289  
distance to something is to take its

1067  
00:43:49,550 --> 00:43:52,580  
spectrum and we did that for I can

1068  
00:43:51,289 --> 00:43:55,789  
remember many million objects in the

1069  
00:43:52,579 --> 00:43:58,309

sdss the stone now but there are various

1070

00:43:55,789 --> 00:44:00,199

surrogates for that one is to say well

1071

00:43:58,309 --> 00:44:02,179

if I could find out where the dust is

1072

00:44:00,199 --> 00:44:04,549

and I know this star is behind this

1073

00:44:02,179 --> 00:44:06,199

layer of dust I get some idea how far

1074

00:44:04,550 --> 00:44:08,810

away it is and that's what Eddie and his

1075

00:44:06,199 --> 00:44:12,319

friends are doing another way is to say

1076

00:44:08,809 --> 00:44:13,639

well as you move as you look at galaxies

1077

00:44:12,320 --> 00:44:15,890

which are further and further and

1078

00:44:13,639 --> 00:44:17,960

further away from us they get more and

1079

00:44:15,889 --> 00:44:19,579

more redshifted and that's by looking at

1080

00:44:17,960 --> 00:44:21,980

the colors of the galaxies you get a

1081

00:44:19,579 --> 00:44:23,719

pretty good guess as to how far away

1082

00:44:21,980 --> 00:44:25,400

they are so that's what's called a

1083

00:44:23,719 --> 00:44:28,369

photometric redshift or nuts

1084  
00:44:25,400 --> 00:44:29,570  
perhaps good to 3% if you work hard and

1085  
00:44:28,369 --> 00:44:31,190  
if you believe the

1086  
00:44:29,570 --> 00:44:32,960  
optimists it's better it's a little bit

1087  
00:44:31,190 --> 00:44:36,320  
better than that it depends on how many

1088  
00:44:32,960 --> 00:44:38,000  
different colors you measure so the LSST

1089  
00:44:36,320 --> 00:44:39,769  
project will be able to measure

1090  
00:44:38,000 --> 00:44:42,110  
photometric red shifts to a large number

1091  
00:44:39,769 --> 00:44:45,230  
of objects which enables you to do a

1092  
00:44:42,110 --> 00:44:46,700  
sort of poor-man's distance and in fact

1093  
00:44:45,230 --> 00:44:49,309  
one of the reasons why I'm excited about

1094  
00:44:46,699 --> 00:44:51,500  
W first is because it makes that work

1095  
00:44:49,309 --> 00:44:53,059  
very much better because at higher

1096  
00:44:51,500 --> 00:44:56,449  
redshift you need to go into the near

1097  
00:44:53,059 --> 00:44:58,880  
infrared so yeah we get sort of few

1098  
00:44:56,449 --> 00:45:00,559  
percent distances and then because you

1099  
00:44:58,880 --> 00:45:03,230  
could look at the distortion of images

1100  
00:45:00,559 --> 00:45:05,329  
of those far distant galaxies by

1101  
00:45:03,230 --> 00:45:07,130  
material between us you can measure

1102  
00:45:05,329 --> 00:45:09,259  
where the mass is between us and the

1103  
00:45:07,130 --> 00:45:12,280  
galaxies and that's what that propaganda

1104  
00:45:09,260 --> 00:45:14,540  
blurb on that page you pulled up

1105  
00:45:12,280 --> 00:45:16,130  
okay so good I know I'm glad you brought

1106  
00:45:14,539 --> 00:45:17,690  
out that's exactly what I wanted to hear

1107  
00:45:16,130 --> 00:45:19,130  
photometric redshift is something that

1108  
00:45:17,690 --> 00:45:20,750  
we hear a lot about in astronomy and

1109  
00:45:19,130 --> 00:45:23,119  
it's is it it's a good technique for

1110  
00:45:20,750 --> 00:45:24,559  
doing a rough a rougher estimate of how

1111  
00:45:23,119 --> 00:45:26,480  
far away things are then be able to then

1112

00:45:24,559 --> 00:45:27,739  
being able to get their spectra only

1113  
00:45:26,480 --> 00:45:30,260  
because they look different in different

1114  
00:45:27,739 --> 00:45:34,459  
filters and you can infer their

1115  
00:45:30,260 --> 00:45:37,190  
distance from those so the so I want to

1116  
00:45:34,460 --> 00:45:38,630  
get to a couple of a couple of questions

1117  
00:45:37,190 --> 00:45:40,309  
oh wait before I do that though your

1118  
00:45:38,630 --> 00:45:42,890  
talk Robert you said that there was the

1119  
00:45:40,309 --> 00:45:45,440  
challenges for hs4 LSST and one of them

1120  
00:45:42,889 --> 00:45:47,480  
was you had outlined that doing things

1121  
00:45:45,440 --> 00:45:48,800  
that you know some of them were you know

1122  
00:45:47,480 --> 00:45:50,329  
very technical that we don't have to get

1123  
00:45:48,800 --> 00:45:51,740  
into here like background subtraction of

1124  
00:45:50,329 --> 00:45:54,710  
things like that what do you see is the

1125  
00:45:51,739 --> 00:45:57,529  
biggest challenge and getting LSST built

1126  
00:45:54,710 --> 00:45:59,990

oh there are three things about the

1127

00:45:57,530 --> 00:46:01,460

other sisty many things about the other

1128

00:45:59,989 --> 00:46:04,099

sisty the first things we have to build

1129

00:46:01,460 --> 00:46:06,380

a CAD telescope that's not that I mean I

1130

00:46:04,099 --> 00:46:08,029

couldn't do it I'm gonna before it's

1131

00:46:06,380 --> 00:46:08,680

been done before I mean you've got to do

1132

00:46:08,030 --> 00:46:11,240

it really well

1133

00:46:08,679 --> 00:46:12,769

you know it'll be fine we've got to

1134

00:46:11,239 --> 00:46:14,389

build the biggest camera in the world I

1135

00:46:12,769 --> 00:46:16,280

couldn't do that either but that's also

1136

00:46:14,389 --> 00:46:19,309

been done before I mean it's somewhat

1137

00:46:16,280 --> 00:46:20,600

bigger than John toneri's camera it's

1138

00:46:19,309 --> 00:46:22,159

bigger than the Sloan camera that's

1139

00:46:20,599 --> 00:46:31,579

again something that I believe can be

1140

00:46:22,159 --> 00:46:35,420

done girls contributing but on the other



1141  
00:46:31,579 --> 00:46:38,659  
hand and I see so many okay in that case

1142  
00:46:35,420 --> 00:46:41,420  
if you want to figure out what orbit the

1143  
00:46:38,659 --> 00:46:43,838  
Hubble Space Telescope is it if you take

1144  
00:46:41,420 --> 00:46:46,700  
the cost of the hubble space

1145  
00:46:43,838 --> 00:46:49,338  
how many kilometres that comes to in

1146  
00:46:46,699 --> 00:46:52,009  
piled up dollar bills John you get quite

1147  
00:46:49,338 --> 00:46:59,239  
a good estimate anyway what I was

1148  
00:46:52,010 --> 00:47:05,750  
intending to come here to talk five

1149  
00:46:59,239 --> 00:47:07,250  
years yeah yeah five years yeah that's a

1150  
00:47:05,750 --> 00:47:08,539  
long time no these bridges what I was

1151  
00:47:07,250 --> 00:47:10,579  
going to say it's actually the software

1152  
00:47:08,539 --> 00:47:12,289  
is all the software is really hard so

1153  
00:47:10,579 --> 00:47:14,359  
the thing that scares me most is getting

1154  
00:47:12,289 --> 00:47:16,219  
the the good enough brilliant people

1155  
00:47:14,358 --> 00:47:17,179  
enough people and persuading them to

1156  
00:47:16,219 --> 00:47:19,608  
work for me

1157  
00:47:17,179 --> 00:47:20,960  
so as to get the software written yeah

1158  
00:47:19,608 --> 00:47:22,608  
but that are pretty far selves in your

1159  
00:47:20,960 --> 00:47:27,769  
talk about that yesterday oh yes

1160  
00:47:22,608 --> 00:47:35,690  
absolutely I'm desi Baker's not yet I'm

1161  
00:47:27,769 --> 00:47:37,460  
really nice I'm serious I mean the

1162  
00:47:35,690 --> 00:47:40,130  
software analysis is hard the sort of

1163  
00:47:37,460 --> 00:47:43,690  
things we have to do is measure the

1164  
00:47:40,130 --> 00:47:47,119  
distortions in the shapes of gases -

1165  
00:47:43,690 --> 00:47:49,159  
well less than 1% in the presence of the

1166  
00:47:47,119 --> 00:47:51,710  
atmosphere which smears all the stars

1167  
00:47:49,159 --> 00:47:54,170  
out in complicated ways and that's an

1168  
00:47:51,710 --> 00:47:56,150  
extremely hard measurement we have to be

1169

00:47:54,170 --> 00:47:57,980  
able to say what's the color of an

1170  
00:47:56,150 --> 00:48:00,440  
object so I can do these photometric red

1171  
00:47:57,980 --> 00:48:02,300  
chips but in fact galaxies don't have a

1172  
00:48:00,440 --> 00:48:04,909  
single color they have red bulges they

1173  
00:48:02,300 --> 00:48:07,369  
have blue disks they've got star forming

1174  
00:48:04,909 --> 00:48:10,190  
regions off to the side they overlap so

1175  
00:48:07,369 --> 00:48:11,869  
one galaxy here overlaps this galaxy you

1176  
00:48:10,190 --> 00:48:14,539  
have to sort of sort all of those things

1177  
00:48:11,869 --> 00:48:16,880  
out in reliable enough ways that as

1178  
00:48:14,539 --> 00:48:19,190  
Carol says you can make a database that

1179  
00:48:16,880 --> 00:48:22,250  
people could do science of what you

1180  
00:48:19,190 --> 00:48:24,079  
don't tell unfortunately we've promised

1181  
00:48:22,250 --> 00:48:26,650  
the world that all that data will be

1182  
00:48:24,079 --> 00:48:29,420  
public to everybody in the US and Chile

1183  
00:48:26,650 --> 00:48:31,010

immediately we will put out the alerts

1184

00:48:29,420 --> 00:48:33,019  
on everything that changes and moves

1185

00:48:31,010 --> 00:48:35,060  
within 60 seconds of closing the shutter

1186

00:48:33,019 --> 00:48:37,818  
so we don't have a lot of time to get an

1187

00:48:35,059 --> 00:48:39,170  
army of graduate students to look at all

1188

00:48:37,818 --> 00:48:42,469  
these images in fact we're not either

1189

00:48:39,170 --> 00:48:44,030  
planning to do that no where is is not

1190

00:48:42,469 --> 00:48:46,279  
trivial is there any brilliant people

1191

00:48:44,030 --> 00:48:48,800  
out there who would love a job there you

1192

00:48:46,280 --> 00:48:53,480  
go folks this is your chance since its

1193

00:48:48,800 --> 00:48:54,289  
Robert locked in the good at just Google

1194

00:48:53,480 --> 00:48:58,309  
for Rob

1195

00:48:54,289 --> 00:49:01,610  
goodnight thank you okay so I got a

1196

00:48:58,309 --> 00:49:04,219  
couple questions here from the from the

1197

00:49:01,610 --> 00:49:06,500  
Q&A app Hugo Hugo Burnham is going as

1198  
00:49:04,219 --> 00:49:08,419  
asking how big is a pixel and I guess we

1199  
00:49:06,500 --> 00:49:10,219  
could do it for either one LSST or

1200  
00:49:08,420 --> 00:49:12,860  
pan-starrs but let's do pan-starrs first

1201  
00:49:10,219 --> 00:49:15,919  
how piece of piss how BIG's a pixel one

1202  
00:49:12,860 --> 00:49:20,090  
pixel is point two seven like seconds

1203  
00:49:15,920 --> 00:49:22,970  
and so one seconds is one sixtieth of an

1204  
00:49:20,090 --> 00:49:25,789  
IKE minutes and one Eichmann is one

1205  
00:49:22,969 --> 00:49:30,049  
sixtieth of one degree so what I saying

1206  
00:49:25,789 --> 00:49:32,449  
there's a 1 over 3,600 degrees but more

1207  
00:49:30,050 --> 00:49:34,610  
interestingly stars on the and stars are

1208  
00:49:32,449 --> 00:49:36,199  
something like one arcsecond across so

1209  
00:49:34,610 --> 00:49:37,640  
the atmosphere blurring them out

1210  
00:49:36,199 --> 00:49:39,589  
that's not how big they really are how

1211  
00:49:37,639 --> 00:49:41,389  
big they look yes and so what you want

1212  
00:49:39,590 --> 00:49:44,600  
to do in a camera you want to be is

1213  
00:49:41,389 --> 00:49:46,519  
leave us all of the stars how it appears

1214  
00:49:44,599 --> 00:49:49,549  
to you and so you have basically four

1215  
00:49:46,519 --> 00:49:52,630  
pixels on each side to make a bomb and

1216  
00:49:49,550 --> 00:49:55,070  
for the hyper supreme cam the pixels of

1217  
00:49:52,630 --> 00:49:58,070  
0.168 arcseconds because the telescope

1218  
00:49:55,070 --> 00:49:59,450  
is in fact widely believed for the best

1219  
00:49:58,070 --> 00:50:02,180  
telescope in the world so you need

1220  
00:49:59,449 --> 00:50:05,049  
rather smaller pixels and LSST is less

1221  
00:50:02,179 --> 00:50:07,789  
ambitious there 0.2 arc second pixels

1222  
00:50:05,050 --> 00:50:13,460  
and there are about 15 microns if you

1223  
00:50:07,789 --> 00:50:15,590  
really want previously the amount of sky

1224  
00:50:13,460 --> 00:50:18,650  
that projects into each pixel again

1225  
00:50:15,590 --> 00:50:20,990  
Roberts was the actual physical size of

1226

00:50:18,650 --> 00:50:22,579  
each pixel on the camera yeah if you

1227  
00:50:20,989 --> 00:50:28,219  
took a micrometer and tried to measure

1228  
00:50:22,579 --> 00:50:31,789  
it that's what you get is an assist here

1229  
00:50:28,219 --> 00:50:35,899  
0.2 arc second pixels the same size as

1230  
00:50:31,789 --> 00:50:37,849  
pen stores yeah what is the limit for

1231  
00:50:35,900 --> 00:50:40,940  
seeing on earth the best place in the

1232  
00:50:37,849 --> 00:50:42,849  
world gives you what seeing the best it

1233  
00:50:40,940 --> 00:50:46,550  
partly depends on the wavelength

1234  
00:50:42,849 --> 00:50:48,469  
somewhere around 0.4 0.4 arc seconds and

1235  
00:50:46,550 --> 00:50:51,320  
in fact on hyper supreme cam we've

1236  
00:50:48,469 --> 00:50:53,329  
routinely seen point 4 2 arc second

1237  
00:50:51,320 --> 00:50:55,640  
point 4 5 across the whole focal plane

1238  
00:50:53,329 --> 00:50:58,579  
but most ground-based telescopes aren't

1239  
00:50:55,639 --> 00:51:00,500  
that good you can do what's called

1240  
00:50:58,579 --> 00:51:02,329

adaptive optics where you look at a star

1241  
00:51:00,500 --> 00:51:04,280  
and you adjust the mirror to take out

1242  
00:51:02,329 --> 00:51:06,170  
the effects of the atmosphere and that

1243  
00:51:04,280 --> 00:51:08,090  
works very well over very very small

1244  
00:51:06,170 --> 00:51:10,159  
fields of view they may get chesty

1245  
00:51:08,090 --> 00:51:12,289  
good put it that way yeah they but

1246  
00:51:10,159 --> 00:51:14,629  
neither pan-starrs nor LSST is doing a

1247  
00:51:12,289 --> 00:51:16,489  
adaptive optics right you can't is the

1248  
00:51:14,630 --> 00:51:18,650  
problem because you can correct this

1249  
00:51:16,489 --> 00:51:20,479  
teeny tiny part of the sky but we're

1250  
00:51:18,650 --> 00:51:22,039  
looking at a very large part of the sky

1251  
00:51:20,480 --> 00:51:23,420  
not the whole area that they're looking

1252  
00:51:22,039 --> 00:51:26,389  
at that's a fear that would be a big

1253  
00:51:23,420 --> 00:51:27,829  
challenge right there Canada France and

1254  
00:51:26,389 --> 00:51:30,589  
we got better seeing there that on a



1255  
00:51:27,829 --> 00:51:32,239  
routine basis but as they point out it's

1256  
00:51:30,590 --> 00:51:34,100  
in a very small field of view the

1257  
00:51:32,239 --> 00:51:36,079  
outside field of view wouldn't be as

1258  
00:51:34,099 --> 00:51:38,900  
good because the way the atmosphere

1259  
00:51:36,079 --> 00:51:41,900  
moves you can get little little snippets

1260  
00:51:38,900 --> 00:51:44,150  
of places where the image quality is

1261  
00:51:41,900 --> 00:51:48,110  
magnificent and other places it's not so

1262  
00:51:44,150 --> 00:51:54,260  
good so of course we're always going to

1263  
00:51:48,110 --> 00:51:56,240  
be limited by the sky it looks like and

1264  
00:51:54,260 --> 00:51:58,250  
the Riveria side iya is for doing better

1265  
00:51:56,239 --> 00:52:00,169  
from the ground so we may be able to get

1266  
00:51:58,250 --> 00:52:02,179  
somewhat bigger fields but that's okay

1267  
00:52:00,170 --> 00:52:04,670  
for a talk I think let me get to another

1268  
00:52:02,179 --> 00:52:07,730  
question is this is from Adams energy

1269  
00:52:04,670 --> 00:52:11,000  
also from the Q&A app is pan-starrs used

1270  
00:52:07,730 --> 00:52:13,010  
to hunt for Kuiper belt objects and is

1271  
00:52:11,000 --> 00:52:16,329  
it being used to help find a second

1272  
00:52:13,010 --> 00:52:18,440  
target for the new Horizons flyby

1273  
00:52:16,329 --> 00:52:19,699  
recently in case you don't know it was

1274  
00:52:18,440 --> 00:52:21,500  
recently announced that Hubble is gonna

1275  
00:52:19,699 --> 00:52:23,629  
look and try to give some targets for

1276  
00:52:21,500 --> 00:52:26,420  
New Horizons to go to I can take the

1277  
00:52:23,630 --> 00:52:28,610  
second half yeah so we definitely look

1278  
00:52:26,420 --> 00:52:30,530  
for for Kuiper belt objects yes that's

1279  
00:52:28,610 --> 00:52:32,750  
one of the science goals and we have

1280  
00:52:30,530 --> 00:52:35,000  
already put out a few papers I don't

1281  
00:52:32,750 --> 00:52:37,579  
know exactly the details but yes I mean

1282  
00:52:35,000 --> 00:52:40,159  
it's ideal to fight Kuiper belt objects

1283

00:52:37,579 --> 00:52:42,199  
as well okay so one of Penn Stars main

1284  
00:52:40,159 --> 00:52:44,179  
missions is finding objects that move in

1285  
00:52:42,199 --> 00:52:47,149  
the Kuiper belt objects move and so it's

1286  
00:52:44,179 --> 00:52:48,980  
ideally suited for pen stars and of

1287  
00:52:47,150 --> 00:52:51,250  
course LSST will do that too but it's

1288  
00:52:48,980 --> 00:52:54,079  
going to be on the sky around 2022

1289  
00:52:51,250 --> 00:52:55,730  
rather than now so pan-starrs gets a

1290  
00:52:54,079 --> 00:52:58,009  
good chance to take a first bite of the

1291  
00:52:55,730 --> 00:53:02,570  
cherry or Apple or everyone takes bites

1292  
00:52:58,010 --> 00:53:08,540  
off these days I think the answer is

1293  
00:53:02,570 --> 00:53:11,990  
which country is Ecuadorians so on the

1294  
00:53:08,539 --> 00:53:13,639  
new horizons so this is a Pluto mission

1295  
00:53:11,989 --> 00:53:16,039  
as you know and it's trying to find a

1296  
00:53:13,639 --> 00:53:18,230  
copper belt object behind Pluto the

1297  
00:53:16,039 --> 00:53:19,940

trouble is Pluto is currently in front

1298

00:53:18,230 --> 00:53:21,949

of a Sagittarius as the center of the

1299

00:53:19,940 --> 00:53:26,329

galaxy so it's a very very

1300

00:53:21,949 --> 00:53:28,098

crowded field the to find moving things

1301

00:53:26,329 --> 00:53:30,349

behind that you really need very good

1302

00:53:28,099 --> 00:53:32,030

image quality so it's not quite clear

1303

00:53:30,349 --> 00:53:32,809

that's going to be done but probably not

1304

00:53:32,030 --> 00:53:34,369

with pan-starrs

1305

00:53:32,809 --> 00:53:36,769

there's a chance you can do it with

1306

00:53:34,369 --> 00:53:38,660

hyper supreme cam as I mentioned the

1307

00:53:36,769 --> 00:53:40,820

Subaru telescope which was an incredibly

1308

00:53:38,659 --> 00:53:43,338

expensive Japanese telescope does

1309

00:53:40,820 --> 00:53:46,670

produce superb image quality and there

1310

00:53:43,338 --> 00:53:49,820

is an attempt to use HSC hyper supreme

1311

00:53:46,670 --> 00:53:53,930

can not HST to find Kuiper belt objects

1312  
00:53:49,820 --> 00:53:54,588  
behind behind Pluto and it's not clear

1313  
00:53:53,929 --> 00:53:56,210  
if that will work

1314  
00:53:54,588 --> 00:53:57,828  
there's also an attempt to use Hubble

1315  
00:53:56,210 --> 00:53:59,599  
Space Telescope to do it and I'm not

1316  
00:53:57,829 --> 00:54:03,260  
sure which is going to end up being the

1317  
00:53:59,599 --> 00:54:04,880  
correct answer yeah so yeah so it is but

1318  
00:54:03,260 --> 00:54:06,410  
they are gonna at least their budding to

1319  
00:54:04,880 --> 00:54:08,480  
working now on finding some targets or

1320  
00:54:06,409 --> 00:54:10,279  
at least looking to plan the observing

1321  
00:54:08,480 --> 00:54:12,349  
for Hubble to do the same thing so we'll

1322  
00:54:10,280 --> 00:54:14,300  
see how that plays out well guys I guess

1323  
00:54:12,349 --> 00:54:16,309  
that's I'll go ahead and stop here I

1324  
00:54:14,300 --> 00:54:17,690  
want to thank you guys very much for

1325  
00:54:16,309 --> 00:54:19,279  
taking time out of the workshop to speak

1326  
00:54:17,690 --> 00:54:20,869  
to us this has been a lot of fun Robert

1327  
00:54:19,280 --> 00:54:23,150  
and Armin it was wonderful to see you

1328  
00:54:20,869 --> 00:54:24,800  
guys again and I hope I can get you guys

1329  
00:54:23,150 --> 00:54:27,980  
back and Eddie welcome for the first

1330  
00:54:24,800 --> 00:54:29,240  
time was a pleasure to meet you it's

1331  
00:54:27,980 --> 00:54:35,568  
coming back for another one how about

1332  
00:54:29,239 --> 00:54:44,239  
some more LSST hangouts and he doesn't

1333  
00:54:35,568 --> 00:54:50,509  
quit his career after this in the future

1334  
00:54:44,239 --> 00:54:52,219  
is looking at these guys between JWST

1335  
00:54:50,510 --> 00:54:55,880  
and LSST the future is looking really a

1336  
00:54:52,219 --> 00:54:59,029  
job yeah you're in a good spot for

1337  
00:54:55,880 --> 00:55:00,890  
astronomy you are very exciting okay so

1338  
00:54:59,030 --> 00:55:02,480  
all I want to thank everybody for

1339  
00:55:00,889 --> 00:55:04,429  
watching on behalf of Karol Christian I

1340

00:55:02,480 --> 00:55:06,469  
want to thank you very much for watching

1341  
00:55:04,429 --> 00:55:08,059  
our Hubble hangout I hope we won't be

1342  
00:55:06,469 --> 00:55:10,129  
around next week we are going to be

1343  
00:55:08,059 --> 00:55:13,818  
doing we're because of the July 4th

1344  
00:55:10,130 --> 00:55:17,420  
holiday 101 fireworks

1345  
00:55:13,818 --> 00:55:19,009  
yeah yes and but we will we will be back

1346  
00:55:17,420 --> 00:55:20,599  
the following week July 9th we'll be

1347  
00:55:19,010 --> 00:55:22,250  
talking about some citizen science

1348  
00:55:20,599 --> 00:55:25,519  
initiatives that are coming out so we

1349  
00:55:22,250 --> 00:55:26,030  
hope you'll join us then the 10th but

1350  
00:55:25,519 --> 00:55:28,280  
yeah

1351  
00:55:26,030 --> 00:55:32,380  
is it the 10th thought I was a 9th ok

1352  
00:55:28,280 --> 00:55:32,380  
days the 4th if that helps

1353  
00:55:34,369 --> 00:55:40,469  
it's Thursday the 10th but far be it

1354  
00:55:37,528 --> 00:55:42,898

from me I think we're going back to our

1355

00:55:40,469 --> 00:55:44,699

Thursday schedule okay and I and I just

1356

00:55:42,898 --> 00:55:46,558

got a really brief comment from peda

1357

00:55:44,699 --> 00:55:49,168

flux on YouTube that says I think you

1358

00:55:46,559 --> 00:55:50,909

should build an IST an International

1359

00:55:49,168 --> 00:55:52,679

Space Telescope that gets bigger and

1360

00:55:50,909 --> 00:55:54,209

bigger over time unless you wouldn't

1361

00:55:52,679 --> 00:55:59,608

that would look like maybe it could have

1362

00:55:54,208 --> 00:56:01,469

years and a total diameter in the world

1363

00:55:59,608 --> 00:56:03,478

because there was a proposal to do

1364

00:56:01,469 --> 00:56:05,639

something like that is to you know have

1365

00:56:03,478 --> 00:56:07,678

you would have these segments and then

1366

00:56:05,639 --> 00:56:09,449

you would build a basic telescope and

1367

00:56:07,679 --> 00:56:11,849

then eventually you know you'd send up

1368

00:56:09,449 --> 00:56:13,588

robots with additional pieces that would



1369

00:56:11,849 --> 00:56:17,399

all fit together be quite challenging

1370

00:56:13,588 --> 00:56:20,699

but interesting nonetheless yeah thank

1371

00:56:17,398 --> 00:56:25,548

you for that ok guys that's it thank you

1372

00:56:20,699 --> 00:56:25,548

for watching and as always keep looking