1
00:00:06,110 --> 00:00:03,350
hello everyone and welcome to this

2
00:00:08,150 --> 00:00:06,120
evening's edition of the 2023 Von Carmen

3
00:00:10,250 --> 00:00:08,160
series my name is Nikki Wyrick from

4
00:00:12,470 --> 00:00:10,260
jpl's Office of communications and

5
00:00:14,330 --> 00:00:12,480
education and thank you all so much for

6
00:00:17,210 --> 00:00:14,340
joining us for our wonderful discussion

7
00:00:19,790 --> 00:00:17,220
tonight the universe of very cold the

8
00:00:22,130 --> 00:00:19,800
James Webb Space Telescope Miri and the

9
00:00:25,070 --> 00:00:22,140
cryo cooler the James Webb Space

10
00:00:27,109 --> 00:00:25,080
Telescope or jwst launched about a year

11
00:00:29,150 --> 00:00:27,119
and a half ago and has taken some

12
00:00:32,269 --> 00:00:29,160
incredible images using infrared light

13
00:00:35,650 --> 00:00:32,279

the Optics and science instruments must

14
00:00:38,750 --> 00:00:35,660
be incredibly cold especially jwst's

15
00:00:41,750 --> 00:00:38,760
mid-infrared instrument or Miri this is

16
00:00:43,910 --> 00:00:41,760
not possible without the cryo cooler

17
00:00:46,910 --> 00:00:43,920
joining us as co-host for this evening

18
00:00:49,790 --> 00:00:46,920
discussion is Caitlin soars the public

19
00:00:52,130 --> 00:00:49,800
Outreach lead for astrophysics at NASA's

20
00:00:53,930 --> 00:00:52,140
jet propulsion laboratory presenting

21
00:00:55,810 --> 00:00:53,940
data through a creative lens and making

22
00:00:59,150 --> 00:00:55,820
complex scientific information

23
00:01:00,650 --> 00:00:59,160
accessible to wide audiences Caitlyn is

24
00:01:03,170 --> 00:01:00,660
passionate about exploring how the

25
00:01:04,969 --> 00:01:03,180
convergence of Art and Science can serve

26
00:01:06,230 --> 00:01:04,979
the public hiya Caitlin thanks for being

27
00:01:08,570 --> 00:01:06,240
here tonight

28
00:01:10,570 --> 00:01:08,580
thanks Nikki and thank you to everyone

29
00:01:13,250 --> 00:01:10,580
online for viewing our program tonight

30
00:01:14,870 --> 00:01:13,260
NASA is your space program and we wanted

31
00:01:17,270 --> 00:01:14,880
you to be involved in the conversation

32
00:01:18,890 --> 00:01:17,280
this evening so please ask questions in

33
00:01:21,230 --> 00:01:18,900
the chat and our social media team we'll

34
00:01:23,090 --> 00:01:21,240
pass them along to us if for some reason

35
00:01:25,310 --> 00:01:23,100
you don't see the chat please refresh

36
00:01:26,690 --> 00:01:25,320
your browser and it should be there we

37
00:01:28,429 --> 00:01:26,700
will try to ask as many of your

38
00:01:30,289 --> 00:01:28,439

questions as possible for our discussion

39
00:01:32,030 --> 00:01:30,299
discussion tonight

40
00:01:34,490 --> 00:01:32,040
um and yeah we're really excited to get

41
00:01:36,710 --> 00:01:34,500
into it so back to you Nikki awesome

42
00:01:38,810 --> 00:01:36,720
thank you so much Caitlin uh as always

43
00:01:40,609 --> 00:01:38,820
folks if we do run into any technical

44
00:01:42,590 --> 00:01:40,619
difficulties or small failures tonight

45
00:01:44,390 --> 00:01:42,600
we do ask for your patience and please

46
00:01:47,630 --> 00:01:44,400
do stick with us we will get them sorted

47
00:01:49,429 --> 00:01:47,640
out as soon as we can and now let's

48
00:01:53,210 --> 00:01:49,439
introduce our speaker for this evening

49
00:01:55,130 --> 00:01:53,220
Dr Constantine peninen who led miri's

50
00:01:58,670 --> 00:01:55,140
crowd cooler development team through

51
00:02:02,330 --> 00:01:58,680
its design build test and delivery to

52
00:02:04,550 --> 00:02:02,340
jwst system integration he then led the

53
00:02:08,210 --> 00:02:04,560
Miri project as it supported the larger

54
00:02:11,029 --> 00:02:08,220
jwst spacecraft element and Observatory

55
00:02:12,650 --> 00:02:11,039
integration and testing now currently he

56
00:02:15,290 --> 00:02:12,660
is leading payload system development

57
00:02:17,869 --> 00:02:15,300
for spherex and all Sky infrared

58
00:02:19,610 --> 00:02:17,879
spectral survey medium Explorer Mission

59
00:02:23,990 --> 00:02:19,620
with a background in low temperature

60
00:02:25,670 --> 00:02:24,000
physics he joined JPL in 2002 wow and

61
00:02:27,589 --> 00:02:25,680
worked out a variety of fundamental

62
00:02:29,869 --> 00:02:27,599
research instrumentation and flight

63
00:02:33,410 --> 00:02:29,879

projects you might even say he has the

64
00:02:35,030 --> 00:02:33,420
coolest job at JPL hiya Constantine how

65
00:02:38,089 --> 00:02:35,040
are you this evening I'm pretty good

66
00:02:40,070 --> 00:02:38,099
thank you awesome we're so thankful to

67
00:02:42,290 --> 00:02:40,080
have you with us today so let's jump in

68
00:02:43,910 --> 00:02:42,300
right off the bat what is the James Webb

69
00:02:45,110 --> 00:02:43,920
Space Telescope and what is its main

70
00:02:49,729 --> 00:02:45,120
mission

71
00:02:51,410 --> 00:02:49,739
well um James frappa telescope is a is

72
00:02:55,190 --> 00:02:51,420
the most recent Flagship mission that

73
00:02:58,729 --> 00:02:55,200
NASA launched uh and uh it's uh

74
00:03:01,250 --> 00:02:58,739
um it's a iconic image you can see there

75
00:03:02,570 --> 00:03:01,260
on your screen right now

76
00:03:05,089 --> 00:03:02,580
um this is something that has been in

77
00:03:10,250 --> 00:03:05,099
development uh I for

78
00:03:12,410 --> 00:03:10,260
um over a decade uh and it's uh um

79
00:03:14,990 --> 00:03:12,420
it's going to produce results for many

80
00:03:16,610 --> 00:03:15,000
many years to come it is an infrared

81
00:03:18,410 --> 00:03:16,620
Mission overall

82
00:03:22,070 --> 00:03:18,420
um what you can see there

83
00:03:24,770 --> 00:03:22,080
um is a an iconic primary mirror

84
00:03:29,449 --> 00:03:24,780
um uh where you you can see a reflection

85
00:03:31,850 --> 00:03:29,459
of uh um of cosmic structure behind uh

86
00:03:34,550 --> 00:03:31,860
you can also see the uh very large

87
00:03:37,430 --> 00:03:34,560
diamond-like a feature which is the the

88
00:03:39,530 --> 00:03:37,440

sun shield uh that blocks the light from

89
00:03:42,649 --> 00:03:39,540
the sun and from from the earth

90
00:03:45,050 --> 00:03:42,659
um exposing the telescope to to heat and

91
00:03:50,089 --> 00:03:45,060
that is really key uh to producing

92
00:03:53,449 --> 00:03:50,099
infrared images there was jwst uh will

93
00:03:56,570 --> 00:03:53,459
be obtaining data in the range of

94
00:03:58,610 --> 00:03:56,580
infrared uh wavelengths we will go into

95
00:04:02,210 --> 00:03:58,620
that a little bit uh more in just a

96
00:04:03,830 --> 00:04:02,220
little bit uh but uh um the main goals

97
00:04:05,930 --> 00:04:03,840
of for glbst

98
00:04:08,630 --> 00:04:05,940
um as a user facility as a flagship

99
00:04:10,309 --> 00:04:08,640
Mission uh is uh it's a surf scientist

100
00:04:12,770 --> 00:04:10,319
in in uh

101
00:04:16,969 --> 00:04:12,780
for Sciences to reach their their goals

102
00:04:18,710 --> 00:04:16,979
uh and the main capabilities that James

103
00:04:21,770 --> 00:04:18,720
Phelps provide is a really high

104
00:04:23,390 --> 00:04:21,780
resolution uh images uh uh in the

105
00:04:26,510 --> 00:04:23,400
infrared in the in the science goals

106
00:04:27,650 --> 00:04:26,520
that come with that are looking at at

107
00:04:30,350 --> 00:04:27,660
stars

108
00:04:33,110 --> 00:04:30,360
uh as they are born at galaxies as they

109
00:04:37,430 --> 00:04:33,120
were born as well as

110
00:04:40,070 --> 00:04:37,440
um at uh um planets uh around Stars if

111
00:04:41,150 --> 00:04:40,080
we uh if we get to see them

112
00:04:43,790 --> 00:04:41,160
um

113
00:04:46,129 --> 00:04:43,800

and so let's uh let's go for a second uh

114
00:04:49,550 --> 00:04:46,139
to image three

115
00:04:53,689 --> 00:04:49,560
um this one shows the uh history of the

116
00:04:56,870 --> 00:04:53,699
universe uh uh in a very uh compact way

117
00:04:59,390 --> 00:04:56,880
um it shows the uh going from left to

118
00:05:01,490 --> 00:04:59,400
right it shows uh time spanning from the

119
00:05:05,150 --> 00:05:01,500
uh from The Big Bang from the time that

120
00:05:08,629 --> 00:05:05,160
the uh Universe came into existence uh

121
00:05:12,170 --> 00:05:08,639
up to the present time uh and uh uh over

122
00:05:15,830 --> 00:05:12,180
the initial period of time uh when uh

123
00:05:18,370 --> 00:05:15,840
this really uh hot product material

124
00:05:21,530 --> 00:05:18,380
um radiation coalesced into

125
00:05:25,430 --> 00:05:21,540
intellimetary particles then then atoms

126
00:05:27,290 --> 00:05:25,440
then molecules and eventually particles

127
00:05:30,110 --> 00:05:27,300
of dust and then eventually started

128
00:05:31,790 --> 00:05:30,120
forming dust uh started forming stars

129
00:05:35,510 --> 00:05:31,800
and and then galaxies

130
00:05:38,090 --> 00:05:35,520
um and uh jwst will be looking uh um

131
00:05:41,150 --> 00:05:38,100
back in time in a way uh because it will

132
00:05:43,490 --> 00:05:41,160
be able to see uh some of the first

133
00:05:45,469 --> 00:05:43,500
stars that uh that got uh created the

134
00:05:48,290 --> 00:05:45,479
first galaxies that got created it will

135
00:05:52,670 --> 00:05:48,300
also uh observe stars that are getting

136
00:05:56,689 --> 00:05:52,680
created uh um now uh in in spaces uh

137
00:05:59,150 --> 00:05:56,699
where there are a large uh congregations

138
00:06:02,810 --> 00:05:59,160

of dust and space

139
00:06:04,490 --> 00:06:02,820
um it's it's an exciting facility and it

140
00:06:05,990 --> 00:06:04,500
will serve the humanity for for many

141
00:06:06,650 --> 00:06:06,000
many years

142
00:06:09,770 --> 00:06:06,660
um

143
00:06:10,490 --> 00:06:09,780
let's go uh to slide four for a second

144
00:06:13,189 --> 00:06:10,500
um

145
00:06:16,550 --> 00:06:13,199
and and this is uh to address the uh

146
00:06:17,450 --> 00:06:16,560
question of what what exactly uh how GWT

147
00:06:21,050 --> 00:06:17,460
is different

148
00:06:22,370 --> 00:06:21,060
um uh here's a electronic Spectrum

149
00:06:25,610 --> 00:06:22,380
um you're familiar with the visible

150
00:06:26,990 --> 00:06:25,620
light uh lights ranging from red to

151
00:06:27,590 --> 00:06:27,000
Violet

152
00:06:30,290 --> 00:06:27,600
um

153
00:06:32,210 --> 00:06:30,300
as I I just wanted to note something

154
00:06:33,950 --> 00:06:32,220
um if you look in the sky at night uh

155
00:06:37,010 --> 00:06:33,960
and and if you like it to see that if

156
00:06:38,330 --> 00:06:37,020
you're if the light pollution uh allows

157
00:06:40,969 --> 00:06:38,340
you to

158
00:06:43,189 --> 00:06:40,979
um you will generally not see any green

159
00:06:44,570 --> 00:06:43,199
stars um even though it's it's right

160
00:06:46,790 --> 00:06:44,580
there in the Spectrum but what you will

161
00:06:51,170 --> 00:06:46,800
see there either ready stars or bluish

162
00:06:53,210 --> 00:06:51,180
Stars uh or white stars um red stars uh

163
00:06:55,550 --> 00:06:53,220

are the ones that are tilted towards the

164
00:06:57,230 --> 00:06:55,560
uh uh infrared or red part of the

165
00:06:59,870 --> 00:06:57,240
spectrum blue are on the shorter

166
00:07:02,330 --> 00:06:59,880
wavelengths on the on the blue side uh

167
00:07:05,749 --> 00:07:02,340
but uh mostly that's because the light

168
00:07:08,029 --> 00:07:05,759
from Stars uh is is a mix of of various

169
00:07:10,010 --> 00:07:08,039
colors uh and of course our sun uh

170
00:07:13,249 --> 00:07:10,020
shines nice and white which is a

171
00:07:16,730 --> 00:07:13,259
combination of all of these colors

172
00:07:19,129 --> 00:07:16,740
um jwst is looking at light uh to the

173
00:07:21,050 --> 00:07:19,139
right of what is shown here

174
00:07:23,689 --> 00:07:21,060
um in the invisible Spectrum it's it's

175
00:07:26,990 --> 00:07:23,699
in the infrared and it's spinning uh

176
00:07:30,110 --> 00:07:27,000
wavelengths from about one micron to

177
00:07:32,330 --> 00:07:30,120
about 25 microns for various instruments

178
00:07:34,490 --> 00:07:32,340
yeah so let's hit on that you mentioned

179
00:07:37,010 --> 00:07:34,500
various instruments jwst actually has

180
00:07:39,350 --> 00:07:37,020
four main instruments but one of those

181
00:07:41,749 --> 00:07:39,360
JPL is responsible for called the mid

182
00:07:43,550 --> 00:07:41,759
infrared instrument or Miri so can you

183
00:07:44,689 --> 00:07:43,560
tell us a little bit more about how does

184
00:07:48,309 --> 00:07:44,699
Mary work

185
00:07:51,409 --> 00:07:48,319
right so me in the infrared instrument

186
00:07:52,850 --> 00:07:51,419
is the longest wavelength instrument on

187
00:07:55,070 --> 00:07:52,860
jlbst

188
00:07:57,469 --> 00:07:55,080

um it spans the wavelength from roughly

189
00:07:58,909 --> 00:07:57,479
five microns to 25 microns just just

190
00:08:01,850 --> 00:07:58,919
over

191
00:08:04,749 --> 00:08:01,860
um and uh it has uh several functions uh

192
00:08:07,249 --> 00:08:04,759
it has uh um an imager which is

193
00:08:09,110 --> 00:08:07,259
essentially a camera with which you can

194
00:08:10,249 --> 00:08:09,120
you can take pictures and we've also

195
00:08:12,350 --> 00:08:10,259
really spent most of the time today

196
00:08:14,629 --> 00:08:12,360
talking about that it can also take

197
00:08:16,689 --> 00:08:14,639
Spectra um what that means is that it

198
00:08:20,749 --> 00:08:16,699
can look at a specific object in the sky

199
00:08:23,689 --> 00:08:20,759
and then figure out what uh what

200
00:08:27,790 --> 00:08:23,699
compositions of that Spectrum uh show up

201
00:08:31,610 --> 00:08:27,800
uh in in uh for that particular image

202
00:08:35,029 --> 00:08:31,620
and for the imager for that object for

203
00:08:38,029 --> 00:08:35,039
the imager uh

204
00:08:40,370 --> 00:08:38,039
um Miri also has a number of uh filters

205
00:08:43,010 --> 00:08:40,380
that filter out light of a particular

206
00:08:45,410 --> 00:08:43,020
set of wavelengths and uh by switching

207
00:08:48,949 --> 00:08:45,420
between those it is also keep of taking

208
00:08:51,650 --> 00:08:48,959
images in in different uh bands of of

209
00:08:54,829 --> 00:08:51,660
wavelengths

210
00:08:56,210 --> 00:08:54,839
yeah so it's great to hear that

211
00:08:57,530 --> 00:08:56,220
um it you've talked about how it's a

212
00:08:59,570 --> 00:08:57,540
little distinct because it uses this

213
00:09:01,190 --> 00:08:59,580

longer wavelength I'd love for you to

214
00:09:02,269 --> 00:09:01,200
talk to us a little about image five if

215
00:09:03,410 --> 00:09:02,279
we could pull that up can you tell us

216
00:09:04,610 --> 00:09:03,420
what we're seeing here in image five

217
00:09:08,269 --> 00:09:04,620
Constantine

218
00:09:10,130 --> 00:09:08,279
yes uh this is an uh a great image uh

219
00:09:13,370 --> 00:09:10,140
and this is coming as a recommendation

220
00:09:15,949 --> 00:09:13,380
of uh a project scientist uh Mike

221
00:09:17,870 --> 00:09:15,959
wrestler and what you see on the on the

222
00:09:19,850 --> 00:09:17,880
right side is an image taken by another

223
00:09:22,850 --> 00:09:19,860
instrument on James Webb that's uh

224
00:09:25,430 --> 00:09:22,860
that's near cam you can see it's a lot

225
00:09:27,470 --> 00:09:25,440
of uh stars and galaxies there actually

226
00:09:30,110 --> 00:09:27,480
galaxies mostly

227
00:09:32,449 --> 00:09:30,120
um there's a there's a number of them uh

228
00:09:35,810 --> 00:09:32,459
but you can see that the common feature

229
00:09:39,170 --> 00:09:35,820
for them is that you see

230
00:09:41,030 --> 00:09:39,180
um that reddish tint uh uh and bluish

231
00:09:43,250 --> 00:09:41,040
tint and white uh but you don't really

232
00:09:45,769 --> 00:09:43,260
see uh anything really in between and

233
00:09:49,670 --> 00:09:45,779
what that really indicates is that uh

234
00:09:51,949 --> 00:09:49,680
near cam uh it's uh taking essentially a

235
00:09:54,530 --> 00:09:51,959
thermal spectrum of of various objects

236
00:09:58,130 --> 00:09:54,540
various galaxies what you see on the

237
00:09:59,150 --> 00:09:58,140
left is a Miri image of of the same

238
00:10:00,889 --> 00:09:59,160

field

239
00:10:03,889 --> 00:10:00,899
um and what uh what I'd like to

240
00:10:06,290 --> 00:10:03,899
highlight is is this is that uh on

241
00:10:08,389 --> 00:10:06,300
you can see a very Stark colors

242
00:10:12,110 --> 00:10:08,399
including greens

243
00:10:14,630 --> 00:10:12,120
um a Microsoft would like to call it

244
00:10:16,370 --> 00:10:14,640
Skittles uh in the sky it's a very very

245
00:10:18,350 --> 00:10:16,380
apt analogy

246
00:10:21,110 --> 00:10:18,360
um the reason why the colors are so so

247
00:10:24,889 --> 00:10:21,120
distinct there is that uh on

248
00:10:30,410 --> 00:10:24,899
there are some uh chemicals uh in the

249
00:10:33,889 --> 00:10:30,420
dust that that produced in in galaxies

250
00:10:36,590 --> 00:10:33,899
um it's those chemicals are akin to

251
00:10:39,590 --> 00:10:36,600
um car exhaust and barbecue smoke uh in

252
00:10:41,630 --> 00:10:39,600
not very pleasant stuff uh but uh um

253
00:10:44,509 --> 00:10:41,640
those are

254
00:10:47,030 --> 00:10:44,519
um aromatic hydrocarbons uh

255
00:10:51,170 --> 00:10:47,040
those uh light up with particular

256
00:10:54,110 --> 00:10:51,180
wavelengths um and uh if you take an

257
00:10:55,850 --> 00:10:54,120
image with uh with Miri uh that

258
00:10:58,310 --> 00:10:55,860
particular wavelength is highlighted and

259
00:11:01,069 --> 00:10:58,320
some of these objects are moving from us

260
00:11:05,150 --> 00:11:01,079
uh uh at at various speeds at various

261
00:11:07,850 --> 00:11:05,160
velocities and as they uh as they move

262
00:11:10,190 --> 00:11:07,860
away from us the light from from this

263
00:11:12,710 --> 00:11:10,200

galaxies is redshifted so it's it's

264
00:11:14,750 --> 00:11:12,720
getting longer in wavelength but the

265
00:11:18,050 --> 00:11:14,760
combination of that is that you can see

266
00:11:20,389 --> 00:11:18,060
uh galaxies that are closer to us are

267
00:11:22,430 --> 00:11:20,399
looking more more bluish uh galaxies

268
00:11:24,769 --> 00:11:22,440
that a further away are looking more red

269
00:11:26,810 --> 00:11:24,779
but they they also have very very

270
00:11:28,970 --> 00:11:26,820
distinct colors

271
00:11:30,590 --> 00:11:28,980
yeah I mean so we've talked a little bit

272
00:11:31,970 --> 00:11:30,600
about this longest wavelength and that

273
00:11:33,829 --> 00:11:31,980
we can see these more interesting things

274
00:11:37,490 --> 00:11:33,839
and you mentioned very briefly just then

275
00:11:39,110 --> 00:11:37,500
we can see through this dust what why do

276
00:11:40,310 --> 00:11:39,120
we want to look through the dust why why

277
00:11:41,150 --> 00:11:40,320
is that something we want to be looking

278
00:11:42,829 --> 00:11:41,160
through

279
00:11:46,009 --> 00:11:42,839
so um

280
00:11:49,250 --> 00:11:46,019
so let's uh let's uh actually move uh uh

281
00:11:51,470 --> 00:11:49,260
to Image six for a sec um and I'll I'll

282
00:11:52,190 --> 00:11:51,480
speak to your question as well

283
00:11:55,970 --> 00:11:52,200
um

284
00:11:59,750 --> 00:11:55,980
so uh does the obscures uh uh light uh

285
00:12:03,590 --> 00:11:59,760
as as it comes uh from from galaxies uh

286
00:12:05,810 --> 00:12:03,600
and particularly uh in nebulae uh when

287
00:12:07,430 --> 00:12:05,820
you have a dust you can you cannot

288
00:12:10,370 --> 00:12:07,440

really seem uh

289
00:12:12,829 --> 00:12:10,380
material light from behind there and so

290
00:12:15,829 --> 00:12:12,839
if you take an image invisible or in

291
00:12:18,829 --> 00:12:15,839
your infrared uh you would uh able to

292
00:12:20,569 --> 00:12:18,839
see only the light from objects uh that

293
00:12:23,930 --> 00:12:20,579
doesn't pass through that dust and and

294
00:12:26,930 --> 00:12:23,940
then in the in the infrared uh you in

295
00:12:29,990 --> 00:12:26,940
the uh mid infrared you get more of the

296
00:12:33,110 --> 00:12:30,000
light uh coming through uh the the dust

297
00:12:35,630 --> 00:12:33,120
and you can see uh objects on

298
00:12:38,090 --> 00:12:35,640
uh that you otherwise wouldn't uh stars

299
00:12:40,250 --> 00:12:38,100
that are hidden otherwise uh uh in

300
00:12:41,750 --> 00:12:40,260
places that they are born uh in those

301
00:12:44,090 --> 00:12:41,760
nebula

302
00:12:47,930 --> 00:12:44,100
um and uh and then on this image what

303
00:12:48,889 --> 00:12:47,940
you what you see uh is a a debris disc

304
00:12:52,310 --> 00:12:48,899
um

305
00:12:55,550 --> 00:12:52,320
uh what what you can see here is

306
00:12:57,530 --> 00:12:55,560
effectively a a solar system that is uh

307
00:13:00,889 --> 00:12:57,540
in the in the process of getting born

308
00:13:03,170 --> 00:13:00,899
this is really probably how our solar

309
00:13:05,090 --> 00:13:03,180
system looked uh uh four or four and a

310
00:13:07,250 --> 00:13:05,100
half billion years ago

311
00:13:09,110 --> 00:13:07,260
um the you can see there are two

312
00:13:11,150 --> 00:13:09,120
distinct rings

313
00:13:14,509 --> 00:13:11,160

um the outer ring was something that

314
00:13:17,810 --> 00:13:14,519
that was uh uh seen before before JW

315
00:13:20,990 --> 00:13:17,820
steel launched uh for for decades the

316
00:13:24,230 --> 00:13:21,000
inner ring is something that was uh uh

317
00:13:26,930 --> 00:13:24,240
possible to see only with Steve and Miri

318
00:13:29,150 --> 00:13:26,940
uh uh basically in the last year and

319
00:13:31,250 --> 00:13:29,160
what what you can see there uh really

320
00:13:33,530 --> 00:13:31,260
what that what the really uh corresponds

321
00:13:36,769 --> 00:13:33,540
to in our solar system the outer ring is

322
00:13:40,730 --> 00:13:36,779
uh uh looking like a Oort cloud it's

323
00:13:44,449 --> 00:13:40,740
similar to our on Old Cloud that's uh uh

324
00:13:46,850 --> 00:13:44,459
Pluto orbit and Beyond uh and uh the

325
00:13:49,730 --> 00:13:46,860
inner ring here corresponds to what we

326
00:13:51,290 --> 00:13:49,740
have for the asteroid belt and and the

327
00:13:54,230 --> 00:13:51,300
fact that these are really well defined

328
00:13:55,610 --> 00:13:54,240
that really means that uh that those uh

329
00:13:58,009 --> 00:13:55,620
dust particles are interacting with

330
00:14:00,050 --> 00:13:58,019
gravity centers so there is flop uh uh

331
00:14:03,290 --> 00:14:00,060
probably something that uh that looks

332
00:14:04,910 --> 00:14:03,300
like a planetary system uh in there it's

333
00:14:07,430 --> 00:14:04,920
a it's again I mean it's it's one of the

334
00:14:10,069 --> 00:14:07,440
things that that we see with the uh with

335
00:14:12,230 --> 00:14:10,079
the infrared and the fact that uh the uh

336
00:14:14,870 --> 00:14:12,240
rings are so bright that indicates that

337
00:14:16,129 --> 00:14:14,880
there is some heat dissipating uh uh in

338
00:14:18,170 --> 00:14:16,139

there that means that those particles

339
00:14:20,930 --> 00:14:18,180
are colliding with each other uh all the

340
00:14:23,090 --> 00:14:20,940
time producing a little bit of that heat

341
00:14:25,069 --> 00:14:23,100
wow that's incredible to think that just

342
00:14:26,930 --> 00:14:25,079
looking at this image like when we talk

343
00:14:28,970 --> 00:14:26,940
about our own solar system we can only

344
00:14:30,650 --> 00:14:28,980
see what is essentially as far out as

345
00:14:33,350 --> 00:14:30,660
Pluto in the Oort cloud but now with

346
00:14:34,970 --> 00:14:33,360
Miri we can see so much more detail in

347
00:14:35,930 --> 00:14:34,980
this image that's I just think that's

348
00:14:37,310 --> 00:14:35,940
amazing

349
00:14:38,389 --> 00:14:37,320
um so we talked a little bit about the

350
00:14:41,509 --> 00:14:38,399
dust and we talked a little bit about

351
00:14:43,370 --> 00:14:41,519
Miri but this instrument it does great

352
00:14:45,530 --> 00:14:43,380
things but it needs to be incredibly

353
00:14:47,990 --> 00:14:45,540
cold in order to work right Constantine

354
00:14:50,150 --> 00:14:48,000
that's correct and uh let me tell you

355
00:14:51,769 --> 00:14:50,160
first why

356
00:14:52,370 --> 00:14:51,779
um so so

357
00:14:54,650 --> 00:14:52,380
um

358
00:14:57,170 --> 00:14:54,660
the the infrared what we really see with

359
00:15:00,230 --> 00:14:57,180
infrared is is heat

360
00:15:01,129 --> 00:15:00,240
um if you uh I mentioned wavelengths of

361
00:15:04,430 --> 00:15:01,139
light

362
00:15:07,250 --> 00:15:04,440
um between uh uh 5 and 25 microns per

363
00:15:10,009 --> 00:15:07,260

metering uh right in the middle of that

364
00:15:11,750 --> 00:15:10,019
is roughly 10 microns and that is uh the

365
00:15:14,110 --> 00:15:11,760
wavelength at which all of us are

366
00:15:17,210 --> 00:15:14,120
radiating heat uh so as we walk around

367
00:15:19,430 --> 00:15:17,220
uh most of the uh most of the spectrum

368
00:15:22,730 --> 00:15:19,440
that's emitted from from human bodies at

369
00:15:25,129 --> 00:15:22,740
roughly 300 Kelvin uh is at about 10

370
00:15:27,290 --> 00:15:25,139
Micron wavelength what that really means

371
00:15:30,050 --> 00:15:27,300
is that uh if we launch the telescope at

372
00:15:32,210 --> 00:15:30,060
300 Kelvin uh we would be blinded by the

373
00:15:34,310 --> 00:15:32,220
telescope itself we wouldn't really see

374
00:15:37,790 --> 00:15:34,320
anything so the telescope needs to cool

375
00:15:39,350 --> 00:15:37,800
off uh that's one uh and then uh in

376
00:15:42,110 --> 00:15:39,360
order to detect the light at this

377
00:15:43,670 --> 00:15:42,120
wavelength uh it all has to come down to

378
00:15:46,370 --> 00:15:43,680
a detector

379
00:15:48,290 --> 00:15:46,380
um let me uh share an image image 12

380
00:15:51,769 --> 00:15:48,300
please

381
00:15:53,810 --> 00:15:51,779
um that's an image of uh one of uh three

382
00:15:56,449 --> 00:15:53,820
Miri detectors

383
00:15:58,009 --> 00:15:56,459
uh it really is very similar uh if you

384
00:16:01,250 --> 00:15:58,019
open up your camera if you have an

385
00:16:02,689 --> 00:16:01,260
ability to do so to remove your lens uh

386
00:16:04,310 --> 00:16:02,699
you will see something looking kind of

387
00:16:07,670 --> 00:16:04,320
similar to that it's a it's about an

388
00:16:10,250 --> 00:16:07,680

inch by an inch uh a size uh uh is

389
00:16:13,250 --> 00:16:10,260
square and uh it's it senses in this

390
00:16:15,410 --> 00:16:13,260
case uh infrared uh the technology in

391
00:16:18,050 --> 00:16:15,420
order to see uh infrared of this

392
00:16:20,569 --> 00:16:18,060
wavelength is such that uh the detectors

393
00:16:23,030 --> 00:16:20,579
need to run really really cold and for

394
00:16:26,210 --> 00:16:23,040
us uh the the temperature at which the

395
00:16:29,509 --> 00:16:26,220
detector run uh need to be a below 7

396
00:16:32,629 --> 00:16:29,519
Kelvin and Mary runs uh uh each

397
00:16:35,090 --> 00:16:32,639
detectors uh uh at the temperature of

398
00:16:37,610 --> 00:16:35,100
roughly 6 Kelvin

399
00:16:39,949 --> 00:16:37,620
um so uh so for both reasons uh for

400
00:16:41,749 --> 00:16:39,959
detector technology reasons and not to

401
00:16:43,910 --> 00:16:41,759
be swamped by the light from the

402
00:16:46,129 --> 00:16:43,920
instrument itself everything needs to be

403
00:16:50,930 --> 00:16:48,590
I get that it needs to be cold but it's

404
00:16:52,610 --> 00:16:50,940
kind of cold in parts of space this

405
00:16:54,530 --> 00:16:52,620
needs to be even colder than that right

406
00:16:56,569 --> 00:16:54,540
what's the difference between passive

407
00:16:59,449 --> 00:16:56,579
cooling which is used by a lot of the

408
00:17:02,810 --> 00:16:59,459
other instruments on board uh jwst and

409
00:17:04,970 --> 00:17:02,820
the active cooling used for Mary that's

410
00:17:06,710 --> 00:17:04,980
that's right so uh for the longer

411
00:17:10,370 --> 00:17:06,720
wavelength between one and five microns

412
00:17:13,850 --> 00:17:10,380
a combination of uh more tolerance uh to

413
00:17:18,230 --> 00:17:13,860

this background and uh uh more tolerance

414
00:17:20,329 --> 00:17:18,240
to or or different detective technology

415
00:17:23,630 --> 00:17:20,339
um those detectors can run at a

416
00:17:26,510 --> 00:17:23,640
temperature of 30 Kelvin even even above

417
00:17:29,210 --> 00:17:26,520
that and that temperature is possible uh

418
00:17:30,770 --> 00:17:29,220
to meaningfully achieve uh with passive

419
00:17:32,390 --> 00:17:30,780
Cooling and what that really means is

420
00:17:34,970 --> 00:17:32,400
that uh

421
00:17:37,130 --> 00:17:34,980
um if you if you look into the deep of

422
00:17:40,029 --> 00:17:37,140
of space and and you don't have any heat

423
00:17:43,789 --> 00:17:40,039
sources nearby and you Shield yourself

424
00:17:45,770 --> 00:17:43,799
from the light and heat of the Sun and

425
00:17:46,610 --> 00:17:45,780
and Earth and Moon

426
00:17:48,289 --> 00:17:46,620
um

427
00:17:50,630 --> 00:17:48,299
you will eventually reach the

428
00:17:52,570 --> 00:17:50,640
temperature of the micro background

429
00:17:55,610 --> 00:17:52,580
radiation which is a

430
00:17:58,490 --> 00:17:55,620
3.3 3.7 Kelvin

431
00:18:00,049 --> 00:17:58,500
um so you can passively cool uh you can

432
00:18:04,909 --> 00:18:00,059
pull to 30

433
00:18:07,669 --> 00:18:04,919
um to get to a temperature of 5.9 or 6

434
00:18:09,950 --> 00:18:07,679
Kelvin uh that is not really

435
00:18:11,570 --> 00:18:09,960
meaningfully uh possible just very tiny

436
00:18:14,150 --> 00:18:11,580
amounts of heat dissipation that we need

437
00:18:16,190 --> 00:18:14,160
to have in the detectors uh and and

438
00:18:18,590 --> 00:18:16,200

attempts at passive cooling with just uh

439
00:18:21,049 --> 00:18:18,600
take it over the edge and uh and

440
00:18:23,450 --> 00:18:21,059
therefore we need to do active active

441
00:18:25,669 --> 00:18:23,460
Cooling

442
00:18:27,890 --> 00:18:25,679
so Constantine just to clarify the

443
00:18:29,150 --> 00:18:27,900
passive cooling is very similar to what

444
00:18:30,590 --> 00:18:29,160
you were talking about with the sun

445
00:18:33,289 --> 00:18:30,600
shade earlier when we looked at that

446
00:18:35,270 --> 00:18:33,299
first image right that is correct yes so

447
00:18:37,669 --> 00:18:35,280
you put the sun shade uh to block

448
00:18:41,450 --> 00:18:37,679
yourself from from the Sun uh and then

449
00:18:43,970 --> 00:18:41,460
you put something that's painted a black

450
00:18:46,850 --> 00:18:43,980
dark that that does really good job of

451
00:18:50,330 --> 00:18:46,860
emitting in the infrared uh uh you point

452
00:18:52,850 --> 00:18:50,340
it uh to the uh a deep of space uh and

453
00:18:55,190 --> 00:18:52,860
uh and that's how you get uh to to those

454
00:18:58,430 --> 00:18:55,200
temperature of 30 Kelvin and and uh

455
00:19:00,830 --> 00:18:58,440
other missions uh uh rely on on just

456
00:19:03,890 --> 00:19:00,840
that method of of cooling uh many

457
00:19:06,169 --> 00:19:03,900
missions do uh including CRX that that

458
00:19:09,289 --> 00:19:06,179
you heard a little bit earlier uh but

459
00:19:11,930 --> 00:19:09,299
for for me that's not enough uh for uh

460
00:19:15,169 --> 00:19:11,940
Miri we need to do active Cooling and

461
00:19:15,770 --> 00:19:15,179
let me uh jump into into what that is

462
00:19:19,669 --> 00:19:15,780
um

463
00:19:21,529 --> 00:19:19,679

uh for in order for us to uh cool nearly

464
00:19:24,409 --> 00:19:21,539
we use a cryo cooler

465
00:19:26,090 --> 00:19:24,419
and crackler is a fancy name for a uh

466
00:19:27,970 --> 00:19:26,100
for a refrigerator that works really

467
00:19:32,090 --> 00:19:27,980
really cold uh cryo stands for cold

468
00:19:33,890 --> 00:19:32,100
cooler means for cooler uh uh if you uh

469
00:19:34,549 --> 00:19:33,900
I'll show a picture

470
00:19:45,470 --> 00:19:34,559
um

471
00:19:48,529 --> 00:19:45,480
what you have here is uh is sort of the

472
00:19:51,350 --> 00:19:48,539
heart of the of the miracle cooler uh

473
00:19:54,230 --> 00:19:51,360
it's a several compressors what you see

474
00:19:56,810 --> 00:19:54,240
there in those cylinders uh is Pistons

475
00:19:57,590 --> 00:19:56,820
uh that move back and forth

476
00:20:01,490 --> 00:19:57,600
um

477
00:20:03,529 --> 00:20:01,500
and some uh if some of them at one of

478
00:20:06,350 --> 00:20:03,539
them at 30 times a second another one at

479
00:20:10,490 --> 00:20:06,360
90 times a second uh and it it

480
00:20:14,630 --> 00:20:10,500
compresses gas uh and then expands it

481
00:20:18,409 --> 00:20:14,640
um so as a gas is compressed uh it gets

482
00:20:22,610 --> 00:20:18,419
heated up uh um you take away that heat

483
00:20:25,730 --> 00:20:22,620
and uh radiated the way uh into space uh

484
00:20:27,890 --> 00:20:25,740
and after that uh you expand the gas and

485
00:20:29,330 --> 00:20:27,900
then that cools that gas off a little

486
00:20:31,070 --> 00:20:29,340
bit more

487
00:20:33,529 --> 00:20:31,080
um and then you repeat that a minute

488
00:20:35,690 --> 00:20:33,539

times a second uh and you do that in

489
00:20:38,390 --> 00:20:35,700
several stages uh you take the first

490
00:20:41,210 --> 00:20:38,400
stage uh you cool that to something like

491
00:20:44,750 --> 00:20:41,220
150 Kelvin next stage to 50 next stage

492
00:20:47,930 --> 00:20:44,760
to 18. uh and and the final stage you

493
00:20:49,850 --> 00:20:47,940
get to something uh like like six gallon

494
00:20:52,310 --> 00:20:49,860
it's a little bit more complex than that

495
00:20:55,070 --> 00:20:52,320
and if you want to look for more detail

496
00:20:57,409 --> 00:20:55,080
uh just uh use your web browser and

497
00:21:00,710 --> 00:20:57,419
search for miracle you'll find a lot

498
00:21:03,289 --> 00:21:00,720
more more uh but uh generally that's

499
00:21:05,390 --> 00:21:03,299
what this is it's a it's the the most

500
00:21:09,710 --> 00:21:05,400
awesome refrigerator in space

501
00:21:11,270 --> 00:21:09,720
um it's uh it consumes power uh uh if

502
00:21:13,070 --> 00:21:11,280
you're familiar with incandescent light

503
00:21:16,130 --> 00:21:13,080
bulbs we used to have those

504
00:21:19,070 --> 00:21:16,140
um it uses the roughly light of uh of

505
00:21:22,669 --> 00:21:19,080
power of of two light bulbs it's a just

506
00:21:26,570 --> 00:21:22,679
over a hundred Watts uh and it achieves

507
00:21:28,730 --> 00:21:26,580
the temperature uh of uh of six Kelvin

508
00:21:31,789 --> 00:21:28,740
Constantine this is the most awesome

509
00:21:33,649 --> 00:21:31,799
cooler in space that is for sure but how

510
00:21:35,029 --> 00:21:33,659
does something like this get designed

511
00:21:39,470 --> 00:21:35,039
and built

512
00:21:41,630 --> 00:21:39,480
well that's a an enormously uh a complex

513
00:21:44,810 --> 00:21:41,640

process and long process and something

514
00:21:46,549 --> 00:21:44,820
that involved a very large number of of

515
00:21:47,570 --> 00:21:46,559
folks

516
00:21:51,830 --> 00:21:47,580
um

517
00:21:55,970 --> 00:21:51,840
the the concept for this guy cooler uh

518
00:21:57,950 --> 00:21:55,980
predated uh hwc concept uh and and has

519
00:21:59,390 --> 00:21:57,960
been in development for a while uh it's

520
00:22:02,149 --> 00:21:59,400
a team effort

521
00:22:04,850 --> 00:22:02,159
um a decry cooler uh was developed at

522
00:22:08,270 --> 00:22:04,860
Northrop Grumman uh the effort is led by

523
00:22:08,930 --> 00:22:08,280
uh by JPL

524
00:22:11,690 --> 00:22:08,940
um

525
00:22:12,890 --> 00:22:11,700
uh what is what is happening is that uh

526
00:22:15,049 --> 00:22:12,900
if we start with the design we

527
00:22:18,110 --> 00:22:15,059
demonstrate that uh the design works on

528
00:22:19,490 --> 00:22:18,120
the Prototype uh then we start designing

529
00:22:22,250 --> 00:22:19,500
flight Hardware

530
00:22:25,430 --> 00:22:22,260
um and then uh then piece by piece build

531
00:22:28,430 --> 00:22:25,440
it up uh and then then test it uh test

532
00:22:29,990 --> 00:22:28,440
it thoroughly uh we go through uh

533
00:22:32,690 --> 00:22:30,000
Environmental Testing which means that

534
00:22:35,810 --> 00:22:32,700
uh we expose the the hardware that we

535
00:22:39,529 --> 00:22:35,820
built uh to equivalence of a rocket

536
00:22:42,950 --> 00:22:39,539
launch uh and the uh deep of space for

537
00:22:46,610 --> 00:22:42,960
uh thermal reasons uh um it's a it's a

538
00:22:48,890 --> 00:22:46,620

rigorous uh and uh rigorous process

539
00:22:51,230 --> 00:22:48,900
that's uh common to many announce

540
00:22:52,909 --> 00:22:51,240
emissions uh and and cry cooler had to

541
00:22:54,830 --> 00:22:52,919
experience that

542
00:22:55,850 --> 00:22:54,840
so Constantine why don't you tell us a

543
00:22:58,610 --> 00:22:55,860
little bit more about the development

544
00:23:00,950 --> 00:22:58,620
and let's pull up image 15 and can you

545
00:23:04,310 --> 00:23:00,960
tell us what you see on that image

546
00:23:07,669 --> 00:23:04,320
right so um this is the uh last stage

547
00:23:09,049 --> 00:23:07,679
this is the heat uh this is the golf

548
00:23:12,289 --> 00:23:09,059
head assembly this is something that is

549
00:23:15,350 --> 00:23:12,299
mounted uh right next to the uh um to

550
00:23:19,909 --> 00:23:15,360
the instrument uh to the uh

551
00:23:22,010 --> 00:23:19,919
Optical bench of Miri uh you you saw

552
00:23:24,049 --> 00:23:22,020
that detector uh so that that detector

553
00:23:26,930 --> 00:23:24,059
would be within a couple of feet from uh

554
00:23:30,289 --> 00:23:26,940
from this uh coffee can

555
00:23:33,649 --> 00:23:30,299
um so uh the this portion of the kayak

556
00:23:35,570 --> 00:23:33,659
cooler is uh is right next to the uh to

557
00:23:38,149 --> 00:23:35,580
the instrument which also means that uh

558
00:23:39,950 --> 00:23:38,159
it's uh if you remember the from from

559
00:23:44,630 --> 00:23:39,960
image

560
00:23:45,590 --> 00:23:44,640
two for a sec

561
00:23:48,049 --> 00:23:45,600
um

562
00:23:50,090 --> 00:23:48,059
you can see here the the primary mirror

563
00:23:52,010 --> 00:23:50,100

uh what we are talking about is what's

564
00:23:54,529 --> 00:23:52,020
behind the primary emulator but what's

565
00:23:56,630 --> 00:23:54,539
happening really for GWT is uh light

566
00:23:57,830 --> 00:23:56,640
bounces off of the primary hits the

567
00:24:00,590 --> 00:23:57,840
secondary that's the thing that is

568
00:24:03,529 --> 00:24:00,600
sticking out supported by uh by uh those

569
00:24:07,130 --> 00:24:03,539
uh three struts and then the uh it's a

570
00:24:10,130 --> 00:24:07,140
tertiary that is uh in that uh extended

571
00:24:11,930 --> 00:24:10,140
uh knob there and then it is the light

572
00:24:14,450 --> 00:24:11,940
is distributed to a number of

573
00:24:16,250 --> 00:24:14,460
instruments uh all of those Left Behind

574
00:24:18,890 --> 00:24:16,260
uh behind the mirror

575
00:24:21,110 --> 00:24:18,900
um and and that's where where Miri is

576
00:24:23,810 --> 00:24:21,120
one of those instruments so of what you

577
00:24:26,029 --> 00:24:23,820
saw and let's go back to image 15 uh

578
00:24:28,010 --> 00:24:26,039
what you saw is uh the cold head

579
00:24:30,950 --> 00:24:28,020
assembly that eventually got integrated

580
00:24:33,470 --> 00:24:30,960
uh into the Integrated Science

581
00:24:36,710 --> 00:24:33,480
instrument module let's go to uh image

582
00:24:41,210 --> 00:24:39,770
what you see here uh and uh you just saw

583
00:24:44,930 --> 00:24:41,220
that coffee can

584
00:24:48,110 --> 00:24:44,940
um by itself and and now uh this is uh

585
00:24:50,870 --> 00:24:48,120
that same uh cold head assembly uh that

586
00:24:52,850 --> 00:24:50,880
is sitting next to a mere Optical bench

587
00:24:55,610 --> 00:24:52,860
Mary was the first instrument integrated

588
00:24:56,330 --> 00:24:55,620

uh I we're very proud of that

589
00:24:59,450 --> 00:24:56,340
um

590
00:25:03,289 --> 00:24:59,460
uh and uh and here you can see uh uh

591
00:25:06,230 --> 00:25:03,299
just uh moments after after the uh this

592
00:25:08,810 --> 00:25:06,240
uh cold head assembly uh gold uh got

593
00:25:10,190 --> 00:25:08,820
installed uh onto

594
00:25:11,750 --> 00:25:10,200
um onto Isom Integrated Science

595
00:25:13,730 --> 00:25:11,760
instrument module

596
00:25:17,690 --> 00:25:13,740
there's a a little bit clearer picture

597
00:25:22,850 --> 00:25:20,210
yeah what you can see here is is just

598
00:25:24,470 --> 00:25:22,860
before uh

599
00:25:26,810 --> 00:25:24,480
um well you you can see here the same

600
00:25:29,930 --> 00:25:26,820
condition stage assembly uh cold head

601
00:25:33,710 --> 00:25:29,940
assembly uh as well as uh somewhat

602
00:25:36,470 --> 00:25:33,720
opened up uh image of uh uh Miri Optical

603
00:25:39,590 --> 00:25:36,480
bench I do want to mention uh uh one

604
00:25:43,070 --> 00:25:39,600
thing I I had mentioned that uh um GPL

605
00:25:45,409 --> 00:25:43,080
was uh uh responsible for uh for Miri

606
00:25:48,289 --> 00:25:45,419
JPL was responsible for Familia uh from

607
00:25:51,529 --> 00:25:48,299
uh NASA perspective for the uh us

608
00:25:54,289 --> 00:25:51,539
segment of uh of this work but Miri is

609
00:25:56,990 --> 00:25:54,299
an international collaboration uh with

610
00:26:00,230 --> 00:25:57,000
uh Issa and Miri uh European Consortium

611
00:26:03,470 --> 00:26:00,240
it's a 50 50 partnership uh European

612
00:26:05,710 --> 00:26:03,480
Partners uh built up the optical bench

613
00:26:08,870 --> 00:26:05,720

um and then they included GPL build

614
00:26:12,710 --> 00:26:08,880
detectors in that Optical bench

615
00:26:14,930 --> 00:26:12,720
um and then uh GPL was responsible for

616
00:26:16,610 --> 00:26:14,940
for the detectors as well as the kayak

617
00:26:19,130 --> 00:26:16,620
cooler and and the and the car cooler

618
00:26:21,289 --> 00:26:19,140
work is what I'm describing here

619
00:26:23,690 --> 00:26:21,299
so Constantine since you brought it up

620
00:26:25,549 --> 00:26:23,700
uh it takes a whole bunch of people to

621
00:26:27,169 --> 00:26:25,559
do something like this so what was it

622
00:26:29,269 --> 00:26:27,179
like the team behind the scenes that was

623
00:26:31,909 --> 00:26:29,279
able to build both Mary and the cryo

624
00:26:35,390 --> 00:26:31,919
cooler I think this is the the most

625
00:26:38,090 --> 00:26:35,400
amazing uh uh really uh multi-year

626
00:26:39,769 --> 00:26:38,100
multi-institution development

627
00:26:41,029 --> 00:26:39,779
um it's uh it spanned of course many

628
00:26:44,149 --> 00:26:41,039
many years

629
00:26:47,450 --> 00:26:44,159
um was uh trying at some point uh uh to

630
00:26:50,049 --> 00:26:47,460
count number of people who touched uh a

631
00:26:53,330 --> 00:26:50,059
Miri flight hardware and the the number

632
00:26:56,029 --> 00:26:53,340
uh eventually goes into thousands

633
00:26:58,430 --> 00:26:56,039
um if uh if you if you count all the

634
00:27:00,890 --> 00:26:58,440
components that had to come together uh

635
00:27:02,210 --> 00:27:00,900
and uh and the mirror car cooler I

636
00:27:05,149 --> 00:27:02,220
already mentioned north of grahaman we

637
00:27:07,970 --> 00:27:05,159
also had uh our contributions uh into

638
00:27:10,549 --> 00:27:07,980

the hardware both from JPL uh and from

639
00:27:11,390 --> 00:27:10,559
uh gored space flight center

640
00:27:14,149 --> 00:27:11,400
um

641
00:27:17,210 --> 00:27:14,159
but uh but the the team is is is large

642
00:27:20,090 --> 00:27:17,220
and uh and uh they had to uh follow the

643
00:27:22,669 --> 00:27:20,100
hardware uh from the design stage uh all

644
00:27:24,769 --> 00:27:22,679
the way into the in integration

645
00:27:26,510 --> 00:27:24,779
um and uh there are a number of

646
00:27:28,190 --> 00:27:26,520
interfaces between different pieces of

647
00:27:29,510 --> 00:27:28,200
Hardware what that what that means is

648
00:27:30,950 --> 00:27:29,520
that uh when you build something like

649
00:27:32,810 --> 00:27:30,960
that you need to know that it's going to

650
00:27:34,610 --> 00:27:32,820
fit when you put it into into the next

651
00:27:36,590 --> 00:27:34,620
thing which means that you need to have

652
00:27:38,870 --> 00:27:36,600
people talking to each other uh all

653
00:27:42,230 --> 00:27:38,880
along making sure that that's that goes

654
00:27:44,570 --> 00:27:42,240
uh smoothly uh and that goes not just to

655
00:27:46,430 --> 00:27:44,580
uh mechanical integration it also means

656
00:27:48,409 --> 00:27:46,440
that you have to agree on how the power

657
00:27:50,210 --> 00:27:48,419
is going to be used how the data is

658
00:27:53,090 --> 00:27:50,220
going to be transmitted all of those

659
00:27:55,669 --> 00:27:53,100
details are quite complex and uh it's uh

660
00:27:57,890 --> 00:27:55,679
it's amazing how this came together uh

661
00:28:00,350 --> 00:27:57,900
as a system at the end

662
00:28:02,450 --> 00:28:00,360
absolutely and if we could pull up image

663
00:28:04,610 --> 00:28:02,460

23 real quick this is only a small

664
00:28:07,190 --> 00:28:04,620
fraction of the team that you worked

665
00:28:11,269 --> 00:28:07,200
with right Constantine that's correct so

666
00:28:14,090 --> 00:28:11,279
this is the uh uh a part of miracula

667
00:28:17,570 --> 00:28:14,100
this is the compressor assembly uh just

668
00:28:20,930 --> 00:28:17,580
before it got a shipped from Northrop

669
00:28:22,549 --> 00:28:20,940
Grumman uh to JPL and and the team that

670
00:28:25,310 --> 00:28:22,559
is displayed there is a combination of

671
00:28:27,169 --> 00:28:25,320
uh of JPL folks and Northrop folks as as

672
00:28:31,190 --> 00:28:27,179
we worked together

673
00:28:33,110 --> 00:28:31,200
um I think this this was uh uh an a

674
00:28:35,690 --> 00:28:33,120
significant development for uh for both

675
00:28:38,269 --> 00:28:35,700
entities and uh and uh and the team was

676
00:28:42,830 --> 00:28:38,279
extremely dedicated and and very skilled

677
00:28:45,049 --> 00:28:42,840
uh it's uh for many of us uh um it's it

678
00:28:47,870 --> 00:28:45,059
really is a accomplishment of a lifetime

679
00:28:50,090 --> 00:28:47,880
it's uh it's it's it's quite amazing

680
00:28:51,590 --> 00:28:50,100
so Constantine I want to leave plenty of

681
00:28:52,909 --> 00:28:51,600
time for the audience questions but I've

682
00:28:54,950 --> 00:28:52,919
got one last question for you before we

683
00:28:56,630 --> 00:28:54,960
open it up to them what do we expect to

684
00:28:57,830 --> 00:28:56,640
see from the cryo cooler in the coming

685
00:29:01,490 --> 00:28:57,840
years

686
00:29:04,310 --> 00:29:01,500
well um uh we expect the current cooler

687
00:29:06,950 --> 00:29:04,320
to uh continue checking along uh there

688
00:29:09,490 --> 00:29:06,960

is nothing in the car cooler that is is

689
00:29:12,250 --> 00:29:09,500
limiting its life uh um eventually

690
00:29:15,230 --> 00:29:12,260
Electronics in space uh tends to

691
00:29:17,029 --> 00:29:15,240
deteriorate and die uh just because it's

692
00:29:19,070 --> 00:29:17,039
exposed to radiation so at some point

693
00:29:21,769 --> 00:29:19,080
that will start happening

694
00:29:22,730 --> 00:29:21,779
um so far uh things are becoming really

695
00:29:26,750 --> 00:29:22,740
well

696
00:29:28,909 --> 00:29:26,760
um and and for jobst in general uh uh

697
00:29:31,730 --> 00:29:28,919
the life really is limited by the

698
00:29:34,610 --> 00:29:31,740
station keeping Maneuvers uh uh that the

699
00:29:36,710 --> 00:29:34,620
amount of fuel on board is is going to

700
00:29:38,450 --> 00:29:36,720
eventually limit uh but it's not going

701
00:29:39,830 --> 00:29:38,460
to happen for for years and years to

702
00:29:43,010 --> 00:29:39,840
come

703
00:29:45,590 --> 00:29:43,020
um I did want to show uh how this all

704
00:29:49,130 --> 00:29:45,600
comes together can we go to image 25 for

705
00:29:51,230 --> 00:29:49,140
just a sec yeah absolutely uh so this is

706
00:29:54,289 --> 00:29:51,240
the integration of the observatory

707
00:29:56,810 --> 00:29:54,299
overall uh and uh in the middle of that

708
00:29:59,990 --> 00:29:56,820
image you can see a little harmonica

709
00:30:03,649 --> 00:30:00,000
looking like shiny object and that's

710
00:30:06,049 --> 00:30:03,659
just a little portion of the of the cryo

711
00:30:08,870 --> 00:30:06,059
cooler that that that is sticking out

712
00:30:10,490 --> 00:30:08,880
through there if we go to image 26 for a

713
00:30:13,789 --> 00:30:10,500

sec

714
00:30:16,730 --> 00:30:13,799
you can see that a cry cooler getting

715
00:30:22,190 --> 00:30:16,740
moved from below the observerter to be

716
00:30:25,610 --> 00:30:22,200
integrated and uh and uh eventually uh

717
00:30:28,310 --> 00:30:25,620
this Hardware had to be connected uh the

718
00:30:30,230 --> 00:30:28,320
two different pieces of of cry cooler uh

719
00:30:31,789 --> 00:30:30,240
the one that's close to the instrument

720
00:30:34,610 --> 00:30:31,799
and the one that is running in the in

721
00:30:36,590 --> 00:30:34,620
the spacecraft bus they needed to be uh

722
00:30:38,389 --> 00:30:36,600
tied together and that was happening at

723
00:30:42,169 --> 00:30:38,399
the at the very end of the integration

724
00:30:44,090 --> 00:30:42,179
without I do want to show uh when the

725
00:30:46,190 --> 00:30:44,100
work was complete uh can we go to image

726
00:30:50,029 --> 00:30:46,200
27 for a sec

727
00:30:53,029 --> 00:30:50,039
and so this is uh this is the team uh uh

728
00:30:56,029 --> 00:30:53,039
after the cry cooler got integrated uh

729
00:30:57,529 --> 00:30:56,039
and uh we just happened to be uh at

730
00:30:59,029 --> 00:30:57,539
Northrop Grumman when they were also

731
00:31:03,470 --> 00:30:59,039
doing the test deployments of the

732
00:31:07,010 --> 00:31:03,480
mirrors uh and uh this is just a a a

733
00:31:09,230 --> 00:31:07,020
wonderful picture uh but I I my my

734
00:31:11,630 --> 00:31:09,240
favorite picture and let's go to image

735
00:31:13,610 --> 00:31:11,640
28 for a sec

736
00:31:16,070 --> 00:31:13,620
uh is this or not because of the face

737
00:31:17,930 --> 00:31:16,080
there uh but I asked for this image to

738
00:31:20,090 --> 00:31:17,940

be taken because what you see there is

739
00:31:22,789 --> 00:31:20,100
what's behind the behind the curtain

740
00:31:25,370 --> 00:31:22,799
behind the mirror uh this was the time

741
00:31:29,090 --> 00:31:25,380
uh after the cry cooler got in uh

742
00:31:31,310 --> 00:31:29,100
installed uh into gwc uh we needed to

743
00:31:33,289 --> 00:31:31,320
make sure that uh

744
00:31:35,149 --> 00:31:33,299
all of the connections all the pneumatic

745
00:31:37,370 --> 00:31:35,159
connections I I mentioned that the gas

746
00:31:40,010 --> 00:31:37,380
that's getting compressed and uh and

747
00:31:42,710 --> 00:31:40,020
expanded uh that none of that gas is

748
00:31:44,630 --> 00:31:42,720
leaking out uh and so this is after we

749
00:31:47,330 --> 00:31:44,640
made final integration of the car cooler

750
00:31:49,370 --> 00:31:47,340
we needed to do that leak check uh and

751
00:31:51,590 --> 00:31:49,380
uh and that work is happening on the

752
00:31:52,850 --> 00:31:51,600
background right here this is this was

753
00:31:54,710 --> 00:31:52,860
uh

754
00:31:56,750 --> 00:31:54,720
um I think we were the last to be at the

755
00:31:58,789 --> 00:31:56,760
heart of the observatory uh to to

756
00:32:00,590 --> 00:31:58,799
perform that measurement uh and when we

757
00:32:03,110 --> 00:32:00,600
were done we were uh we were very very

758
00:32:04,970 --> 00:32:03,120
happy Constantine I have to say that is

759
00:32:07,310 --> 00:32:04,980
also my favorite image that you can

760
00:32:08,690 --> 00:32:07,320
build up so far this evening uh they

761
00:32:10,370 --> 00:32:08,700
have been asking a lot of great

762
00:32:12,230 --> 00:32:10,380
questions online so folks thank you for

763
00:32:14,210 --> 00:32:12,240

those questions Caitlyn what are they

764
00:32:16,070 --> 00:32:14,220
asking

765
00:32:17,450 --> 00:32:16,080
they have a lot of questions here

766
00:32:18,950 --> 00:32:17,460
Constantine

767
00:32:20,990 --> 00:32:18,960
um I'm going to start with kind of an

768
00:32:23,750 --> 00:32:21,000
umbrella question but can you speak a

769
00:32:25,970 --> 00:32:23,760
little bit to um what the key science

770
00:32:28,370 --> 00:32:25,980
objectives are of the James Webb Space

771
00:32:30,649 --> 00:32:28,380
Telescope and to add on to that how is

772
00:32:33,289 --> 00:32:30,659
Miri supporting those objectives right

773
00:32:38,990 --> 00:32:33,299
so so the key objectives uh

774
00:32:42,470 --> 00:32:39,000
um uh would be uh to uh look at at the

775
00:32:44,510 --> 00:32:42,480
first light uh from from the Universe

776
00:32:46,730 --> 00:32:44,520
um this will be the creation the light

777
00:32:48,769 --> 00:32:46,740
from the first uh

778
00:32:50,690 --> 00:32:48,779
from the first galaxies the formation of

779
00:32:53,389 --> 00:32:50,700
first galaxies we're beginning to see

780
00:32:58,370 --> 00:32:53,399
some of that those results already

781
00:33:02,149 --> 00:32:58,380
um there's an uh objective uh um for

782
00:33:04,430 --> 00:33:02,159
um HBC is to be able to observe uh birth

783
00:33:06,830 --> 00:33:04,440
of stars and planets

784
00:33:08,389 --> 00:33:06,840
um that is also something that already

785
00:33:09,710 --> 00:33:08,399
has been happening in the in the last

786
00:33:13,970 --> 00:33:09,720
year

787
00:33:16,490 --> 00:33:13,980
um and uh um a lot more and and more

788
00:33:19,190 --> 00:33:16,500

recent uh addition to the set of goals

789
00:33:20,509 --> 00:33:19,200
uh uh for glbc was looking at the

790
00:33:24,909 --> 00:33:20,519
exoplanets

791
00:33:28,430 --> 00:33:24,919
um uh sort of the uh the variety of of

792
00:33:30,470 --> 00:33:28,440
solar systems uh where you would have uh

793
00:33:33,529 --> 00:33:30,480
exoplans uh

794
00:33:34,389 --> 00:33:33,539
um that uh that our understanding of

795
00:33:37,370 --> 00:33:34,399
that

796
00:33:40,909 --> 00:33:37,380
grew in size quite a bit uh in the last

797
00:33:47,389 --> 00:33:40,919
few years and gwc certainly is uh is is

798
00:33:51,710 --> 00:33:49,430
great

799
00:33:54,889 --> 00:33:51,720
um we have another question here

800
00:33:56,509 --> 00:33:54,899
um Cyril on LinkedIn asks what are some

801
00:33:58,730 --> 00:33:56,519
of the surprising results from Mary

802
00:34:01,070 --> 00:33:58,740
observation so far could you speak to

803
00:34:03,430 --> 00:34:01,080
one or two of those

804
00:34:05,690 --> 00:34:03,440
well I I I

805
00:34:07,009 --> 00:34:05,700
so I I do want to say a couple of things

806
00:34:12,829 --> 00:34:07,019
I I

807
00:34:14,930 --> 00:34:12,839
very very curious about the science that

808
00:34:17,030 --> 00:34:14,940
Miriam is going to achieve uh but I do

809
00:34:19,550 --> 00:34:17,040
want to say that uh you know one one one

810
00:34:23,629 --> 00:34:19,560
image that that I showed about that uh

811
00:34:26,089 --> 00:34:23,639
in a ring uh that was a surprise uh uh

812
00:34:28,010 --> 00:34:26,099
the Skittles uh that was uh that was a

813
00:34:31,490 --> 00:34:28,020

bit of a surprise uh it's just looking

814
00:34:33,290 --> 00:34:31,500
at a variety of that uh of of that that

815
00:34:35,690 --> 00:34:33,300
was that was really good I do want to

816
00:34:44,930 --> 00:34:35,700
show uh something can we go to image

817
00:34:49,909 --> 00:34:47,210
so uh in the image that you're just

818
00:34:52,609 --> 00:34:49,919
about to look at image nine uh what you

819
00:34:55,669 --> 00:34:52,619
can see uh it was one of the first

820
00:34:58,310 --> 00:34:55,679
things that uh uh that folks uh very

821
00:35:00,109 --> 00:34:58,320
quickly uh found even during the the

822
00:35:02,450 --> 00:35:00,119
commissioning of the of the crikola that

823
00:35:06,410 --> 00:35:02,460
uh sorry a commissioning of the of glbsd

824
00:35:09,109 --> 00:35:06,420
this was looking uh with uh with Miri uh

825
00:35:13,250 --> 00:35:09,119
at the same uh part of the sky uh as

826
00:35:14,170 --> 00:35:13,260
another mission uh Spitzer uh looked at

827
00:35:18,050 --> 00:35:14,180
before

828
00:35:20,870 --> 00:35:18,060
this this is around 8 Micron wavelength

829
00:35:24,530 --> 00:35:20,880
this is basically the difference uh you

830
00:35:28,670 --> 00:35:24,540
can see uh what what Miri can do it look

831
00:35:32,390 --> 00:35:28,680
it it looks uh uh at uh ad details and

832
00:35:35,210 --> 00:35:32,400
Miriam jwbst overall it looks at uh at

833
00:35:37,370 --> 00:35:35,220
objects with far more detail and and and

834
00:35:39,829 --> 00:35:37,380
that's where where the focus really is

835
00:35:43,010 --> 00:35:39,839
uh is is uh

836
00:35:44,810 --> 00:35:43,020
um to to find places uh to to observe

837
00:35:55,390 --> 00:35:44,820
things uh with much more clarity than

838
00:35:59,089 --> 00:35:58,370

a lot of questions coming in

839
00:36:00,410 --> 00:35:59,099
um

840
00:36:01,970 --> 00:36:00,420
I don't know if you want to answer this

841
00:36:03,890 --> 00:36:01,980
Constantine but I'm going to throw it at

842
00:36:06,109 --> 00:36:03,900
you what would happen if for any reason

843
00:36:09,050 --> 00:36:06,119
the cryo cooler got damaged or was in

844
00:36:14,030 --> 00:36:11,030
um yeah so

845
00:36:15,470 --> 00:36:14,040
um I I unlike Hubble

846
00:36:16,430 --> 00:36:15,480
um there is not a plan for a service

847
00:36:18,829 --> 00:36:16,440
Mission

848
00:36:22,790 --> 00:36:21,290
um so uh what really needed to happen is

849
00:36:24,890 --> 00:36:22,800
is for us to build it in the way that

850
00:36:25,870 --> 00:36:24,900
it's uh it's robust and reliable

851
00:36:28,250 --> 00:36:25,880
um

852
00:36:31,670 --> 00:36:28,260
I mentioned electronics that uh

853
00:36:33,109 --> 00:36:31,680
potentially uh will get damaged uh uh by

854
00:36:34,849 --> 00:36:33,119
radiation

855
00:36:37,370 --> 00:36:34,859
um we actually have two of everything

856
00:36:41,089 --> 00:36:37,380
there for electronics so if uh if we

857
00:36:43,970 --> 00:36:41,099
have a a particular component uh that

858
00:36:47,329 --> 00:36:43,980
failed on us uh if we have an ability to

859
00:36:50,810 --> 00:36:47,339
uh swap out I mean to switch out to to a

860
00:36:51,470 --> 00:36:50,820
second uh one of the same

861
00:36:54,890 --> 00:36:51,480
um

862
00:36:57,290 --> 00:36:54,900
of course uh there are uh

863
00:36:59,270 --> 00:36:57,300

other possibilities so uh you know

864
00:37:02,630 --> 00:36:59,280
nightmares are built of those things uh

865
00:37:04,490 --> 00:37:02,640
we can have a micrometer or it hit just

866
00:37:07,130 --> 00:37:04,500
in the wrong spot and we can have a

867
00:37:09,770 --> 00:37:07,140
helium leaking out or you know or or

868
00:37:13,150 --> 00:37:09,780
some some other type of damage

869
00:37:16,190 --> 00:37:13,160
um we uh were careful to calculate uh

870
00:37:18,290 --> 00:37:16,200
what those effects might be and build

871
00:37:21,829 --> 00:37:18,300
some design features that protect from

872
00:37:26,990 --> 00:37:21,839
most of that so we should be good

873
00:37:31,609 --> 00:37:27,000
um but uh but sorry no no plan to to uh

874
00:37:35,510 --> 00:37:34,010
all right and um speaking of design

875
00:37:37,670 --> 00:37:35,520
features

876
00:37:39,650 --> 00:37:37,680
um what types of metals lubricants Etc

877
00:37:41,569 --> 00:37:39,660
are used for the cryo cooler components

878
00:37:44,089 --> 00:37:41,579
to function at such a low temperature

879
00:37:45,530 --> 00:37:44,099
uh well that's that's a that's really

880
00:37:46,370 --> 00:37:45,540
interesting so

881
00:37:48,770 --> 00:37:46,380
um

882
00:37:50,390 --> 00:37:48,780
uh because we have to design for very

883
00:37:53,870 --> 00:37:50,400
long life

884
00:37:56,690 --> 00:37:53,880
um uh cry cooler said this very reliable

885
00:37:59,390 --> 00:37:56,700
cry coolers um they're now built without

886
00:38:01,730 --> 00:37:59,400
lubricants uh they're built uh with very

887
00:38:04,550 --> 00:38:01,740
very tight tolerances mechanically

888
00:38:06,770 --> 00:38:04,560

um so that you would end up uh with uh

889
00:38:08,390 --> 00:38:06,780
with not something that uh erups against

890
00:38:11,990 --> 00:38:08,400
each other

891
00:38:14,990 --> 00:38:12,000
um it's uh it's a a uh it's a difficult

892
00:38:19,250 --> 00:38:15,000
problem uh but it has been for the most

893
00:38:19,910 --> 00:38:19,260
part solved um so so no lubricants

894
00:38:22,790 --> 00:38:19,920
um

895
00:38:25,250 --> 00:38:22,800
uh again I there are no features here

896
00:38:26,569 --> 00:38:25,260
that are really life limiting uh I think

897
00:38:30,349 --> 00:38:26,579
everything that we thought uh

898
00:38:34,430 --> 00:38:30,359
mechanically through uh uh makes us

899
00:38:38,510 --> 00:38:36,950
great thank you

900
00:38:40,550 --> 00:38:38,520
um that question came from Johnny on

901
00:38:42,589 --> 00:38:40,560
YouTube this one comes from Jorge on

902
00:38:44,329 --> 00:38:42,599
Facebook who's asking actually a few

903
00:38:46,670 --> 00:38:44,339
folks have asked this where does the

904
00:38:48,349 --> 00:38:46,680
heat from Mary go like what what happens

905
00:38:50,270 --> 00:38:48,359
to the heat does the cryo cooler is

906
00:38:53,270 --> 00:38:50,280
bringing the temperature down oh that's

907
00:38:55,490 --> 00:38:53,280
a really excellent question so um uh the

908
00:38:57,890 --> 00:38:55,500
chronicola takes away heat from one spot

909
00:38:59,810 --> 00:38:57,900
and and has to dump it elsewhere uh so

910
00:39:02,270 --> 00:38:59,820
it takes away the heat from the

911
00:39:03,770 --> 00:39:02,280
instrument uh and and through these

912
00:39:06,170 --> 00:39:03,780
stages of cooling

913
00:39:08,329 --> 00:39:06,180

um it pumps it out eventually to

914
00:39:10,550 --> 00:39:08,339
radiators that are on the warm side of

915
00:39:13,250 --> 00:39:10,560
the spacecraft it's actually on this sun

916
00:39:14,930 --> 00:39:13,260
facing side uh and so the heat is

917
00:39:19,370 --> 00:39:14,940
getting rejected at roughly room

918
00:39:21,950 --> 00:39:19,380
temperature this is uh for convenience

919
00:39:23,930 --> 00:39:21,960
of of testing but also it's something

920
00:39:26,710 --> 00:39:23,940
that we know how to reliably work with

921
00:39:30,770 --> 00:39:26,720
so yes uh the heat is getting

922
00:39:33,349 --> 00:39:30,780
getting pumped from uh from the cold

923
00:39:34,370 --> 00:39:33,359
region into warm region and that takes

924
00:39:37,370 --> 00:39:34,380
energy

925
00:39:42,230 --> 00:39:37,380
um that's that's what those uh 100 Watts

926
00:39:45,890 --> 00:39:44,390
sounds like a lot of work for that cryo

927
00:39:47,810 --> 00:39:45,900
core

928
00:39:49,190 --> 00:39:47,820
um we have we unfortunately we only have

929
00:39:51,109 --> 00:39:49,200
time for one more question we have a lot

930
00:39:52,730 --> 00:39:51,119
of great questions in here um we have

931
00:39:53,990 --> 00:39:52,740
time for one more Ronald on Facebook

932
00:39:55,310 --> 00:39:54,000
asks

933
00:39:57,349 --> 00:39:55,320
um I am an eight-year-old and I'm

934
00:39:58,910 --> 00:39:57,359
wanting to be a scientist My ultimate

935
00:40:01,609 --> 00:39:58,920
goal is to work for NASA when I'm grown

936
00:40:03,290 --> 00:40:01,619
up uh could you share any advice uh to

937
00:40:05,690 --> 00:40:03,300
help me achieve my goal for working at

938
00:40:06,829 --> 00:40:05,700

Nasa as a scientist oh what a great

939
00:40:07,609 --> 00:40:06,839
question

940
00:40:10,609 --> 00:40:07,619
um

941
00:40:13,790 --> 00:40:10,619
what I would say is that

942
00:40:16,910 --> 00:40:13,800
um follow your heart I'd be curious

943
00:40:19,430 --> 00:40:16,920
um find what uh what appeals to you

944
00:40:22,130 --> 00:40:19,440
um and it it can be a lot of things it

945
00:40:26,089 --> 00:40:22,140
can be it can be various areas of

946
00:40:26,990 --> 00:40:26,099
science uh physics chemistry

947
00:40:31,310 --> 00:40:27,000
um

948
00:40:34,010 --> 00:40:31,320
uh it can be I is something that uh is

949
00:40:35,690 --> 00:40:34,020
uh engineering field of some sort so you

950
00:40:38,150 --> 00:40:35,700
can you can go and do mechanical

951
00:40:41,569 --> 00:40:38,160
engineering electrical engineering uh

952
00:40:46,310 --> 00:40:41,579
thermal engineering uh many many fields

953
00:40:48,470 --> 00:40:46,320
uh lead to a a path at Nasa and at a

954
00:40:51,890 --> 00:40:48,480
mission like that again out of those uh

955
00:40:54,589 --> 00:40:51,900
10 000 people uh the the variety of

956
00:40:57,829 --> 00:40:54,599
fields that uh that folks game came in

957
00:41:02,089 --> 00:40:57,839
with uh and I I don't want to

958
00:41:07,010 --> 00:41:02,099
um uh amid people who do the mechanical

959
00:41:09,890 --> 00:41:07,020
work of of Machining Parts uh um putting

960
00:41:13,190 --> 00:41:09,900
things together uh basically technicians

961
00:41:16,130 --> 00:41:13,200
uh that that solder Parts in place uh

962
00:41:19,910 --> 00:41:16,140
those are callings that uh that also uh

963
00:41:24,050 --> 00:41:22,010

uh thank you for that wonderful advice

964
00:41:25,550 --> 00:41:24,060
and uh as Caitlyn said unfortunately

965
00:41:27,410 --> 00:41:25,560
that is all the time we have today for

966
00:41:29,210 --> 00:41:27,420
those wonderful questions you all have

967
00:41:30,589 --> 00:41:29,220
been asking out there I want to take a

968
00:41:32,870 --> 00:41:30,599
moment to thank our speaker one of the

969
00:41:35,450 --> 00:41:32,880
coolest guys at JPL Dr Constantine

970
00:41:38,270 --> 00:41:35,460
pennin for joining us to discuss the

971
00:41:40,250 --> 00:41:38,280
cryo cooler and Miri also thank you to

972
00:41:42,650 --> 00:41:40,260
our wonderful questions co-host Caitlin

973
00:41:45,170 --> 00:41:42,660
Soares and everyone working behind the

974
00:41:47,329 --> 00:41:45,180
scenes to make this possible to all of

975
00:41:49,010 --> 00:41:47,339
you watching at home uh thank you so

976
00:41:51,170 --> 00:41:49,020
much for taking the time to join us each

977
00:41:53,030 --> 00:41:51,180
and every month and by the way if you

978
00:41:54,950 --> 00:41:53,040
did miss one or would like to revisit

979
00:41:57,349 --> 00:41:54,960
any of our Von Carmen talks from the

980
00:42:00,050 --> 00:41:57,359
past five years they're all available on

981
00:42:01,730 --> 00:42:00,060
jpl's YouTube page please do also join

982
00:42:05,329 --> 00:42:01,740
us next month for our discussion with Dr

983
00:42:07,849 --> 00:42:05,339
Stacy Boland vital work to benefit all