AbSciCon 2019

1
00:00:00,790 --> 00:00:07,320
[Music]

2
00:00:13,060 --> 00:00:09,900
[Applause]

3
00:00:15,220 --> 00:00:13,070
today I'm going to talk about the

4
00:00:16,269 --> 00:00:15,230
compact integrated Raman spectrometer

5
00:00:20,890 --> 00:00:16,279
thank you

6
00:00:22,720 --> 00:00:20,900
and basically this is a picture if we

7
00:00:26,439 --> 00:00:22,730
all know about the Euro Philander and

8
00:00:28,210 --> 00:00:26,449
the configuration that we were given so

9
00:00:31,210 --> 00:00:28,220
we're going to be taking a sample cup

10
00:00:34,600 --> 00:00:31,220
that we are going to be hand handed

11
00:00:37,479 --> 00:00:34,610
taking it into a sample chamber here

12
00:00:40,210 --> 00:00:37,489
where we will analyze this in its

13
00:00:42,970 --> 00:00:40,220

original state we may actually have this

14
00:00:44,229 --> 00:00:42,980
sitting outside in the cold so it had we

15
00:00:47,709 --> 00:00:44,239
get as low as temperature as possible

16
00:00:51,190 --> 00:00:47,719
but we like to look at the structure of

17
00:00:54,340 --> 00:00:51,200
the ice in its native form and we like

18
00:00:56,889 --> 00:00:54,350
to melt that sample and do chemometrics

19
00:00:59,560 --> 00:00:56,899
to look at quantitatively what the salts

20
00:01:01,560 --> 00:00:59,570
and things that are in the sample and

21
00:01:04,180 --> 00:01:01,570
finally we want to desiccate the sample

22
00:01:07,420 --> 00:01:04,190
so that we dry down all the solid

23
00:01:09,910 --> 00:01:07,430
material to the bottom of this clear

24
00:01:13,060 --> 00:01:09,920
bottom sample holder so that we can look

25
00:01:14,820 --> 00:01:13,070
at it with our raman spectrograph over

26
00:01:17,350 --> 00:01:14,830
here's a picture of our spectrograph and

27
00:01:20,560 --> 00:01:17,360
I'll talk a little bit more about this

28
00:01:23,770 --> 00:01:20,570
this is really based upon here a design

29
00:01:26,200 --> 00:01:23,780
we already have that I'll show you later

30
00:01:29,499 --> 00:01:26,210
and basically it's the same sized optics

31
00:01:32,230 --> 00:01:29,509
in this incarnation but this all fits in

32
00:01:34,270 --> 00:01:32,240
Box B but likely to make this a little

33
00:01:38,260 --> 00:01:34,280
smaller as we mature the architecture of

34
00:01:40,870 --> 00:01:38,270
the next two years so so any as I said

35
00:01:43,060 --> 00:01:40,880
the idea is to bring things in in its

36
00:01:45,010 --> 00:01:43,070
native form look things in a solid state

37
00:01:50,710 --> 00:01:45,020
this allows us to look at things like

38
00:01:53,020 --> 00:01:50,720

inclusions in the ice when when ice

39
00:01:56,080 --> 00:01:53,030
crystallizes oftentimes things that are

40
00:01:58,179 --> 00:01:56,090
not ice are excluded from and put in

41
00:02:00,609 --> 00:01:58,189
little grains that you can look at and

42
00:02:03,280 --> 00:02:00,619
identify so you get a benefit of some

43
00:02:05,800 --> 00:02:03,290
concentration by doing that we're

44
00:02:07,450 --> 00:02:05,810
interested in getting some quantitative

45
00:02:09,460 --> 00:02:07,460
idea of what's going on

46
00:02:12,100 --> 00:02:09,470
so by liquefying the sample we're able

47
00:02:14,830 --> 00:02:12,110
to do that and finally by desiccating

48
00:02:17,440 --> 00:02:14,840
the sample by book essentially letting

49
00:02:21,150 --> 00:02:17,450
thaw all the water boil off essentially

50
00:02:23,310 --> 00:02:21,160
at the bottom we'll collect all the same

51
00:02:26,580 --> 00:02:23,320
and hopefully get some concentration in

52
00:02:29,190 --> 00:02:26,590
that mechanism as well we have a 2d

53
00:02:32,090 --> 00:02:29,200
scanner in this architecture which allow

54
00:02:36,150 --> 00:02:32,100
us to scan and target any of the points

55
00:02:39,480 --> 00:02:36,160
throughout that volume so this is the

56
00:02:41,550 --> 00:02:39,490
specs on the instrument it's a 532 green

57
00:02:43,820 --> 00:02:41,560
Rama an instrument that it's been under

58
00:02:46,080 --> 00:02:43,830
development for I think 25 years and

59
00:02:48,180 --> 00:02:46,090
it's we're using a single frequency

60
00:02:52,680 --> 00:02:48,190
laser that has a really good spatial

61
00:02:55,950 --> 00:02:52,690
mode focal spot is 20 microns or smaller

62
00:03:00,060 --> 00:02:55,960
actually and we can vary the power from

63
00:03:02,250 --> 00:03:00,070

3 to 50 millivolts to avoid burning the

64
00:03:05,190 --> 00:03:02,260
sample so we can start low and move high

65
00:03:08,250 --> 00:03:05,200
and do that adaptively with the laser

66
00:03:10,260 --> 00:03:08,260
that we have we use a high F number

67
00:03:12,330 --> 00:03:10,270
laser and I'll talk a little bit about

68
00:03:15,660 --> 00:03:12,340
the fact that this allows us to do a

69
00:03:17,880 --> 00:03:15,670
pencil beam and we use f/2 collection

70
00:03:20,370 --> 00:03:17,890
optics which is I think one of the

71
00:03:22,500 --> 00:03:20,380
lowest F numbers of any Raman instrument

72
00:03:26,040 --> 00:03:22,510
out there to give us the optimal

73
00:03:28,080 --> 00:03:26,050
sensitivity working distance currently

74
00:03:31,350 --> 00:03:28,090
is 25 millimeters we're going to try to

75
00:03:33,480 --> 00:03:31,360
scale that down as we since what the

76
00:03:34,830 --> 00:03:33,490
samples being handled handed to us as

77
00:03:36,990 --> 00:03:34,840
opposed to having the instrument on the

78
00:03:39,900 --> 00:03:37,000
end of a rover arm like it was

79
00:03:42,030 --> 00:03:39,910
originally designed since we have a cup

80
00:03:44,100 --> 00:03:42,040
we don't have to have an inch of working

81
00:03:48,090 --> 00:03:44,110
distance and this will allow us to scale

82
00:03:51,120 --> 00:03:48,100
the architecture proportionally we can

83
00:03:53,160 --> 00:03:51,130
cover from 150 to 4000 wave numbers so

84
00:03:56,190 --> 00:03:53,170
this allows us to cover really low

85
00:03:59,760 --> 00:03:56,200
vibrational modes cover the entire

86
00:04:02,130 --> 00:03:59,770
mineral fingerprint region as well as

87
00:04:05,160 --> 00:04:02,140
the O h and CH stretches that occur

88
00:04:07,800 --> 00:04:05,170

beyond 3000 wave numbers spectral

89
00:04:11,340 --> 00:04:07,810
resolution is just six wave numbers and

90
00:04:13,800 --> 00:04:11,350
we have a signal noise ratio of five or

91
00:04:15,630 --> 00:04:13,810
greater when we're one centimeter away

92
00:04:17,789 --> 00:04:15,640
from best focus so one of the other

93
00:04:20,880 --> 00:04:17,799
features of the architecture is that it

94
00:04:24,600 --> 00:04:20,890
doesn't require you to to autofocus in

95
00:04:26,580 --> 00:04:24,610
any way and we as I said we have we're

96
00:04:29,790 --> 00:04:26,590
looking in one centimeter we're going to

97
00:04:32,400 --> 00:04:29,800
have a spatial resolution with native

98
00:04:33,340 --> 00:04:32,410
spatial resolution with our context

99
00:04:38,770 --> 00:04:33,350
imager

100
00:04:40,360 --> 00:04:38,780
15:04 by 2 mm so one of the reasons to

101
00:04:42,550 --> 00:04:40,370
use green light is if you look at the

102
00:04:45,760 --> 00:04:42,560
absorption of ice and water

103
00:04:48,040 --> 00:04:45,770
5:32 is at the very minimum and other

104
00:04:51,520 --> 00:04:48,050
wavelengths you my choice choose or

105
00:04:56,230 --> 00:04:51,530
something like 7 to 10 times worse

106
00:04:59,430 --> 00:04:56,240
so actually more than that so so Green

107
00:05:03,490 --> 00:04:59,440
is an excellent wavelength to use it is

108
00:05:04,990 --> 00:05:03,500
giving you a lot of people use 785 if

109
00:05:07,630 --> 00:05:05,000
you looked at the number of Raman

110
00:05:09,550 --> 00:05:07,640
spectrometer sold 785 is the wavelength

111
00:05:13,060 --> 00:05:09,560
that people use but rocks don't have

112
00:05:14,680 --> 00:05:13,070
very good run on cross sections so sort

113
00:05:17,290 --> 00:05:14,690

of the runner-up in terms of the pie

114
00:05:19,120 --> 00:05:17,300
chart of Raman instruments sold is green

115
00:05:21,820 --> 00:05:19,130
and those allow you to interrogate

116
00:05:25,360 --> 00:05:21,830
things like minerals with good with good

117
00:05:30,490 --> 00:05:25,370
response so because silicon detectors

118
00:05:33,190 --> 00:05:30,500
cut off at 1100 nanometers by using 532

119
00:05:36,400 --> 00:05:33,200
are able to catch that higher beyond

120
00:05:40,180 --> 00:05:36,410
3000 wave numbers it's very important

121
00:05:42,640 --> 00:05:40,190
for astrobiology applications let's see

122
00:05:45,460 --> 00:05:42,650
we also avoid photo and thermal

123
00:05:48,310 --> 00:05:45,470
degradation by avoiding UV light by

124
00:05:52,810 --> 00:05:48,320
keeping the power low as low as possible

125
00:05:55,300 --> 00:05:52,820
to actually acquire signal and we do

126
00:05:58,300 --> 00:05:55,310
have this issue I'm sure everybody knows

127
00:06:00,160 --> 00:05:58,310
that there's concern over intrinsic

128
00:06:01,930 --> 00:06:00,170
fluorescence laser induced fluorescence

129
00:06:04,690 --> 00:06:01,940
with green light so we're going to talk

130
00:06:06,730 --> 00:06:04,700
about a new technique that we have Carl

131
00:06:12,130 --> 00:06:06,740
Terry shifted excitation to deal with

132
00:06:15,100 --> 00:06:12,140
that problem and so so anyhow this is a

133
00:06:17,920 --> 00:06:15,110
graph of the integration time as a

134
00:06:19,420 --> 00:06:17,930
function of focuses focal distance and

135
00:06:22,030 --> 00:06:19,430
you can imagine this going into your

136
00:06:25,090 --> 00:06:22,040
sample cup which is about a centimeter

137
00:06:27,610 --> 00:06:25,100
deep and what we know is that with dark

138
00:06:29,950 --> 00:06:27,620

pyroxene we're able to maintain a signal

139
00:06:31,600 --> 00:06:29,960
noise ratio of five and that's one of

140
00:06:34,530 --> 00:06:31,610
the weaker Raman scatterers that are

141
00:06:36,880 --> 00:06:34,540
around so we use that as a benchmark

142
00:06:39,220 --> 00:06:36,890
pencil beam we have going into the

143
00:06:41,650 --> 00:06:39,230
sample has f15 which allows us

144
00:06:44,920 --> 00:06:41,660
essentially to be out of focus yet still

145
00:06:46,959 --> 00:06:44,930
be on a small area relatively small spot

146
00:06:49,059 --> 00:06:46,969
somewhere between 15 and

147
00:06:52,359 --> 00:06:49,069
30 microns all the way through the

148
00:06:54,969 --> 00:06:52,369
sample but we use f2 to collect even

149
00:06:56,799 --> 00:06:54,979
though we're out of focus you know when

150
00:06:58,959 --> 00:06:56,809
we're not at best focus over a

151
00:07:04,059 --> 00:06:58,969
centimeter we're still able to see dark

152
00:07:06,069 --> 00:07:04,069
pyroxene so this is the this is an older

153
00:07:11,079 --> 00:07:06,079
incarnation of the instrument called mm

154
00:07:13,479 --> 00:07:11,089
RS mm RS uses this kind of spectrometer

155
00:07:15,789 --> 00:07:13,489
based upon a holographic rating and a

156
00:07:19,329 --> 00:07:15,799
fiber input and this is the probe head

157
00:07:21,459 --> 00:07:19,339
which uses a laser that is contact

158
00:07:23,529 --> 00:07:21,469
bonded and actually doesn't work real

159
00:07:25,959 --> 00:07:23,539
well it doesn't have any temperature

160
00:07:28,449 --> 00:07:25,969
control so as it got colder in the Attic

161
00:07:30,879 --> 00:07:28,459
hammer things things didn't work out so

162
00:07:33,039 --> 00:07:30,889
well as the temperature change turn a

163
00:07:35,769 --> 00:07:33,049

laser on it gets hot the response

164
00:07:38,109 --> 00:07:35,779
changes so we wanted to change the laser

165
00:07:42,489 --> 00:07:38,119
and work on this this was a category 1

166
00:07:45,579 --> 00:07:42,499
instrument for MSL but fibers caused a

167
00:07:47,769 --> 00:07:45,589
lot of concern so that is I think

168
00:07:52,089 --> 00:07:47,779
fundamentally why this instrument was

169
00:07:54,459 --> 00:07:52,099
not selected for MSL even though it was

170
00:07:56,949 --> 00:07:54,469
looked at in the early stages of the

171
00:07:58,779 --> 00:07:56,959
puzzle development so this is the

172
00:08:00,639 --> 00:07:58,789
current picture of the instrument so I

173
00:08:03,699 --> 00:08:00,649
got rid of two fibers and that about

174
00:08:05,589 --> 00:08:03,709
thousand wires know only about 100 so

175
00:08:07,269 --> 00:08:05,599
these are these are the wires between a

176
00:08:09,579 --> 00:08:07,279
controller which is a cots base

177
00:08:11,799 --> 00:08:09,589
instrument and this is the Rahman head

178
00:08:14,350 --> 00:08:11,809
here's the architecture we start with a

179
00:08:17,619 --> 00:08:14,360
laser going through like coming back

180
00:08:19,359 --> 00:08:17,629
that is longer than 532 is dispersed

181
00:08:22,239 --> 00:08:19,369
through the spectrometer and focuses on

182
00:08:27,569 --> 00:08:22,249
the back through CCD light is a shorter

183
00:08:30,879 --> 00:08:27,579
it's illuminated by 467 nanometer LEDs

184
00:08:32,679 --> 00:08:30,889
we also have UV LEDs but primarily these

185
00:08:35,259 --> 00:08:32,689
are the ones that are used this gives us

186
00:08:38,649 --> 00:08:35,269
a context imager we implement light

187
00:08:41,259 --> 00:08:38,659
field imaging like Chris does similar to

188
00:08:43,869 --> 00:08:41,269

what Chris does so that we don't need to

189
00:08:47,110 --> 00:08:43,879
implement an autofocus either for the

190
00:08:48,999 --> 00:08:47,120
context imager so here's a picture of

191
00:08:52,449 --> 00:08:49,009
some radiation testing we did with our

192
00:08:54,100 --> 00:08:52,459
JD su laser and so we ran it at two

193
00:08:56,049 --> 00:08:54,110
different currents that's kind of hard

194
00:08:57,850 --> 00:08:56,059
to see but the we're seeing hardly any

195
00:08:59,780 --> 00:08:57,860
change there's like a black shadow

196
00:09:03,770 --> 00:08:59,790
around this versus the blue

197
00:09:07,220 --> 00:09:03,780
for the 600 and the ends it's sorry for

198
00:09:09,230 --> 00:09:07,230
red and then for and and so essentially

199
00:09:11,360 --> 00:09:09,240
you can see very little change and you

200
00:09:14,360 --> 00:09:11,370
see the step like behavior that occurs

201
00:09:16,970 --> 00:09:14,370
as you switch across modes of this laser

202
00:09:20,360 --> 00:09:16,980
so it maintains single mode behavior

203
00:09:24,890 --> 00:09:20,370
over a wide distance and consists of a

204
00:09:26,540 --> 00:09:24,900
pump laser a KTP doubling crystal and a

205
00:09:29,930 --> 00:09:26,550
host crystal the vanadate laser that

206
00:09:33,170 --> 00:09:29,940
leaves us between these two places so

207
00:09:35,480 --> 00:09:33,180
anyhow this is the art this is the

208
00:09:37,730 --> 00:09:35,490
architecture of that laser we because we

209
00:09:41,680 --> 00:09:37,740
have a birefringence crystal did student

210
00:09:43,730 --> 00:09:41,690
and doubling it also causes

211
00:09:47,720 --> 00:09:43,740
implementation of something called Ali

212
00:09:49,970 --> 00:09:47,730
Leo filter which basically will vary its

213
00:09:52,160 --> 00:09:49,980

face as you teint change the temperature

214
00:09:54,140 --> 00:09:52,170
as you change the temperature the laser

215
00:09:57,050 --> 00:09:54,150
slightly what'll happen is this will

216
00:09:59,570 --> 00:09:57,060
start allowing this this mode or this

217
00:10:01,370 --> 00:09:59,580
mode of this motor this mode to lase and

218
00:10:03,800 --> 00:10:01,380
that's what's giving you the behavior

219
00:10:05,720 --> 00:10:03,810
here that we're seeing so what we do is

220
00:10:08,300 --> 00:10:05,730
we use this because we know that the

221
00:10:10,790 --> 00:10:08,310
Raman spectrum will shift with weight

222
00:10:13,820 --> 00:10:10,800
rady with wavelength shifts but the

223
00:10:16,370 --> 00:10:13,830
fluorescence things for s the lowest

224
00:10:18,350 --> 00:10:16,380
excited state and this will so this

225
00:10:21,080 --> 00:10:18,360
allows to separate these two things so

226
00:10:24,170 --> 00:10:21,090
we observe the raw spectra set for let's

227
00:10:27,410 --> 00:10:24,180
say 10 different samples we look at that

228
00:10:30,320 --> 00:10:27,420
and we mathematically solve for the

229
00:10:32,030 --> 00:10:30,330
fluorescence component separately from

230
00:10:34,640 --> 00:10:32,040
the Raman component and we can show

231
00:10:37,100 --> 00:10:34,650
here's some examples here of enstatite

232
00:10:39,610 --> 00:10:37,110
and here we have Dena caucus radiate

233
00:10:43,010 --> 00:10:39,620
Duran's which happens to have a

234
00:10:45,440 --> 00:10:43,020
carotenoid in it that is made without

235
00:10:47,300 --> 00:10:45,450
the use of light by the way and so this

236
00:10:51,080 --> 00:10:47,310
is a reasonable biomarker and we can do

237
00:10:53,570 --> 00:10:51,090
because green is a longer wavelength

238
00:10:55,040 --> 00:10:53,580

than UV you see longer molecules like

239
00:10:59,180 --> 00:10:55,050
carotenoids and you can get resin

240
00:11:02,990 --> 00:10:59,190
enhancement down to symptom - well or

241
00:11:04,760 --> 00:11:03,000
low picomolar type concentrations so

242
00:11:07,400 --> 00:11:04,770
we're also using light field imaging and

243
00:11:09,140 --> 00:11:07,410
I'll try to skim past this but since

244
00:11:11,490 --> 00:11:09,150
Chris talked about this but we're able

245
00:11:13,470 --> 00:11:11,500
to essentially do it

246
00:11:16,650 --> 00:11:13,480
we can look at various planes all in one

247
00:11:19,850 --> 00:11:16,660
shot and do this without any moving

248
00:11:22,650 --> 00:11:19,860
parts just wanted to show an example of

249
00:11:24,600 --> 00:11:22,660
sort of what happens in the in terms of

250
00:11:27,270 --> 00:11:24,610
RAW images as you put the images

251
00:11:29,610 --> 00:11:27,280
together you essentially can tell by

252
00:11:31,320 --> 00:11:29,620
looking at you cross-correlate these

253
00:11:34,170 --> 00:11:31,330
little sub regions and this allows you

254
00:11:35,970 --> 00:11:34,180
to get range information and allow you

255
00:11:39,270 --> 00:11:35,980
to all of them lace stitch the image

256
00:11:41,910 --> 00:11:39,280
back together and finally this is our

257
00:11:43,530 --> 00:11:41,920
cameras so so we have two different

258
00:11:46,410 --> 00:11:43,540
cameras now we have to mitigate issues

259
00:11:49,260 --> 00:11:46,420
of radiation so replacing what we're

260
00:11:53,460 --> 00:11:49,270
currently using the 47 - 20 tip with a

261
00:11:56,190 --> 00:11:53,470
much rad heart hard 347 - 20 chip same

262
00:11:59,400 --> 00:11:56,200
amount same electronics lower voltages

263
00:12:02,670 --> 00:11:59,410

bias voltages to make it operate and and

264
00:12:04,830 --> 00:12:02,680
so this has been developed by E - V and

265
00:12:06,480 --> 00:12:04,840
so our currently just essentially taking

266
00:12:07,980 --> 00:12:06,490
that chip in implementing electronics

267
00:12:10,350 --> 00:12:07,990
for it it's very similar to what we

268
00:12:12,720 --> 00:12:10,360
already have and we can't use the ki

269
00:12:14,220 --> 00:12:12,730
2020 which is what we which is in Mali

270
00:12:16,560 --> 00:12:14,230
but it's just not going to work with

271
00:12:19,950 --> 00:12:16,570
radiation we're replacing that with a

272
00:12:22,110 --> 00:12:19,960
CMOS CIS 115 which is used in Juneau and

273
00:12:23,730 --> 00:12:22,120
as they said where we love this

274
00:12:27,210 --> 00:12:23,740
architecture but we're gonna have to

275
00:12:28,860 --> 00:12:27,220
shift to special optics to make sure

276
00:12:32,130 --> 00:12:28,870
that they don't turn dark with radiation

277
00:12:34,320 --> 00:12:32,140
either here's two examples of the lasers

278
00:12:36,030 --> 00:12:34,330
I talked about this one this little tiny

279
00:12:38,130 --> 00:12:36,040
one we're also looking at that we just

280
00:12:41,970 --> 00:12:38,140
exposed to 10 times the radiation dose

281
00:12:44,250 --> 00:12:41,980
it's on Europa and it's working great so

282
00:12:46,110 --> 00:12:44,260
I think that's it this is a summary that

283
00:12:47,640 --> 00:12:46,120
I'll let you guys read but if I can

284
00:12:48,630 --> 00:12:47,650
answer any questions that would be great

285
00:12:53,120 --> 00:12:48,640
thanks

286
00:13:01,050 --> 00:12:58,170
any questions good I particularly like

287
00:13:03,000 --> 00:13:01,060
the use of the shifted laser wavelength

288
00:13:07,140 --> 00:13:03,010

to address the fluorescence background

289
00:13:08,880 --> 00:13:07,150
and amusingly in another life I spent

290
00:13:12,030 --> 00:13:08,890
about 30 or 40 years doing Raman

291
00:13:15,060 --> 00:13:12,040
spectroscopy and way back about 1992 and

292
00:13:16,980 --> 00:13:15,070
II Shrieve was working on looking at

293
00:13:18,570 --> 00:13:16,990
photosynthetic reaction Center residents

294
00:13:21,150 --> 00:13:18,580
Raman where the fluorescence is a real

295
00:13:22,800 --> 00:13:21,160
killer and we invented a technique which

296
00:13:24,090 --> 00:13:22,810
we called shifted excitation ROM on

297
00:13:26,610 --> 00:13:24,100
different spectroscopy

298
00:13:28,620 --> 00:13:26,620
so the acronym serdes never really

299
00:13:29,880 --> 00:13:28,630
caught on because it's kind of ugly but

300
00:13:31,290 --> 00:13:29,890
if you don't know about the reference

301
00:13:34,500 --> 00:13:31,300
I'll give it to you oh I certainly know

302
00:13:36,060 --> 00:13:34,510
about sir thank you very much so that's

303
00:13:38,880 --> 00:13:36,070
sort of what started the whole thing

304
00:13:43,140 --> 00:13:38,890
going this is search you bet

305
00:13:45,450 --> 00:13:43,150
well by the way I want to also just just

306
00:13:47,370 --> 00:13:45,460
offer up that we are looking for MPP

307
00:13:50,160 --> 00:13:47,380
postdoc applications which are coming

308
00:13:51,300 --> 00:13:50,170
due so if any of your students or any

309
00:13:53,640 --> 00:13:51,310
students in this room won't be