

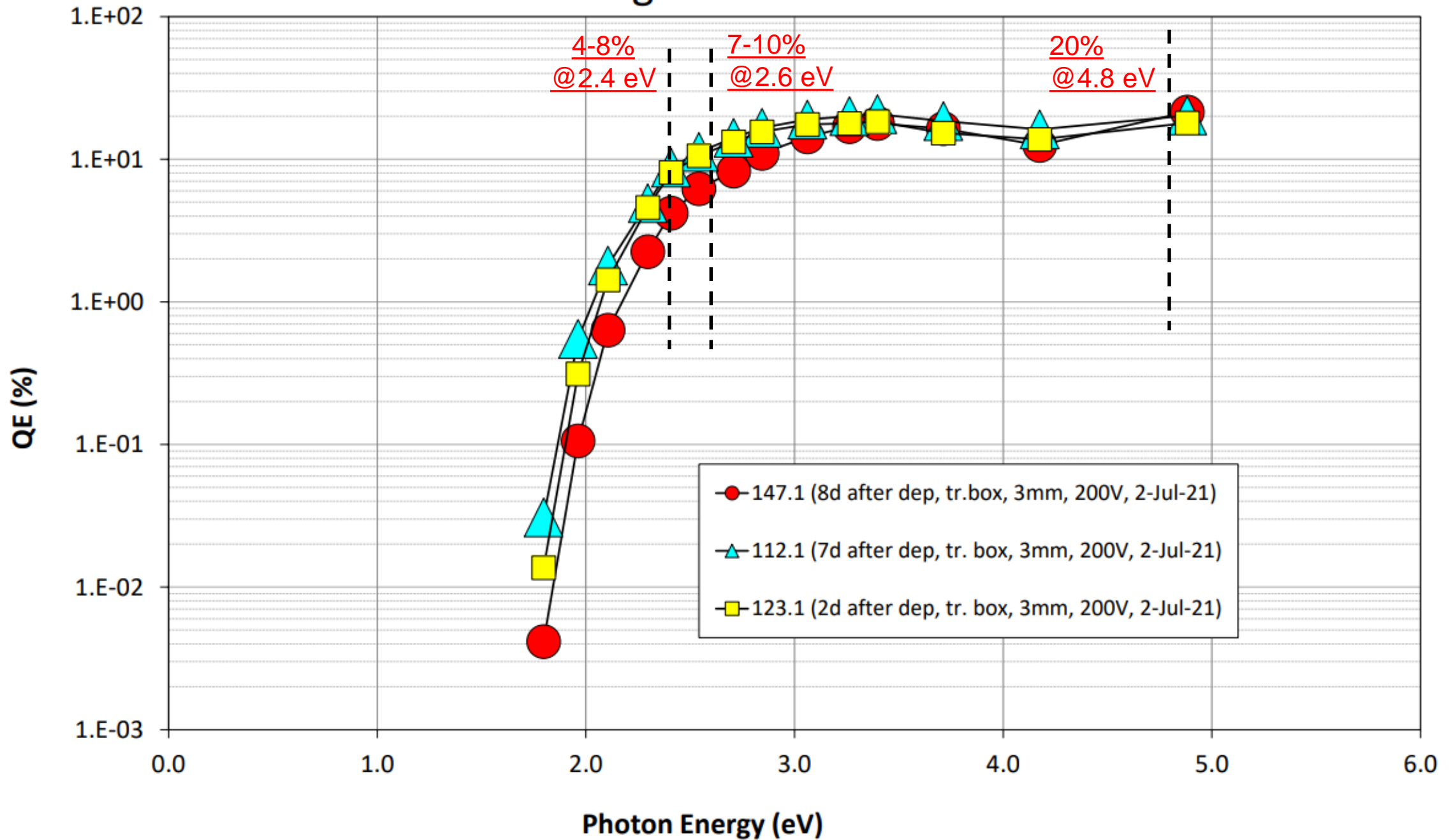
Summary of green cathode testing

2021-Run-9 (Weeks 28/29)

Gun 4.2

Houjun Qian
27.07.2021

Before closing the suitcase UHV valve

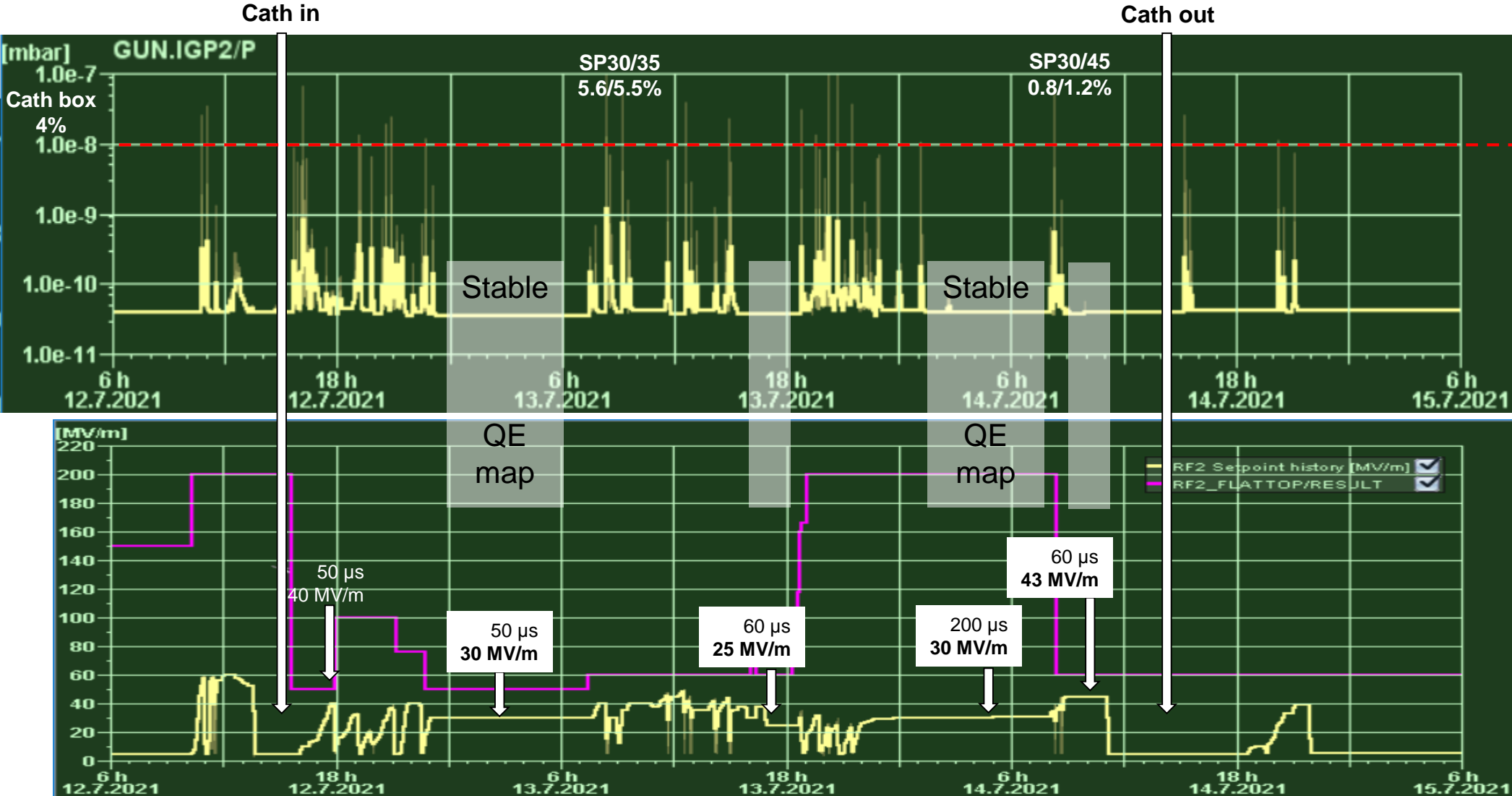


RUN-9 (week 28/29)

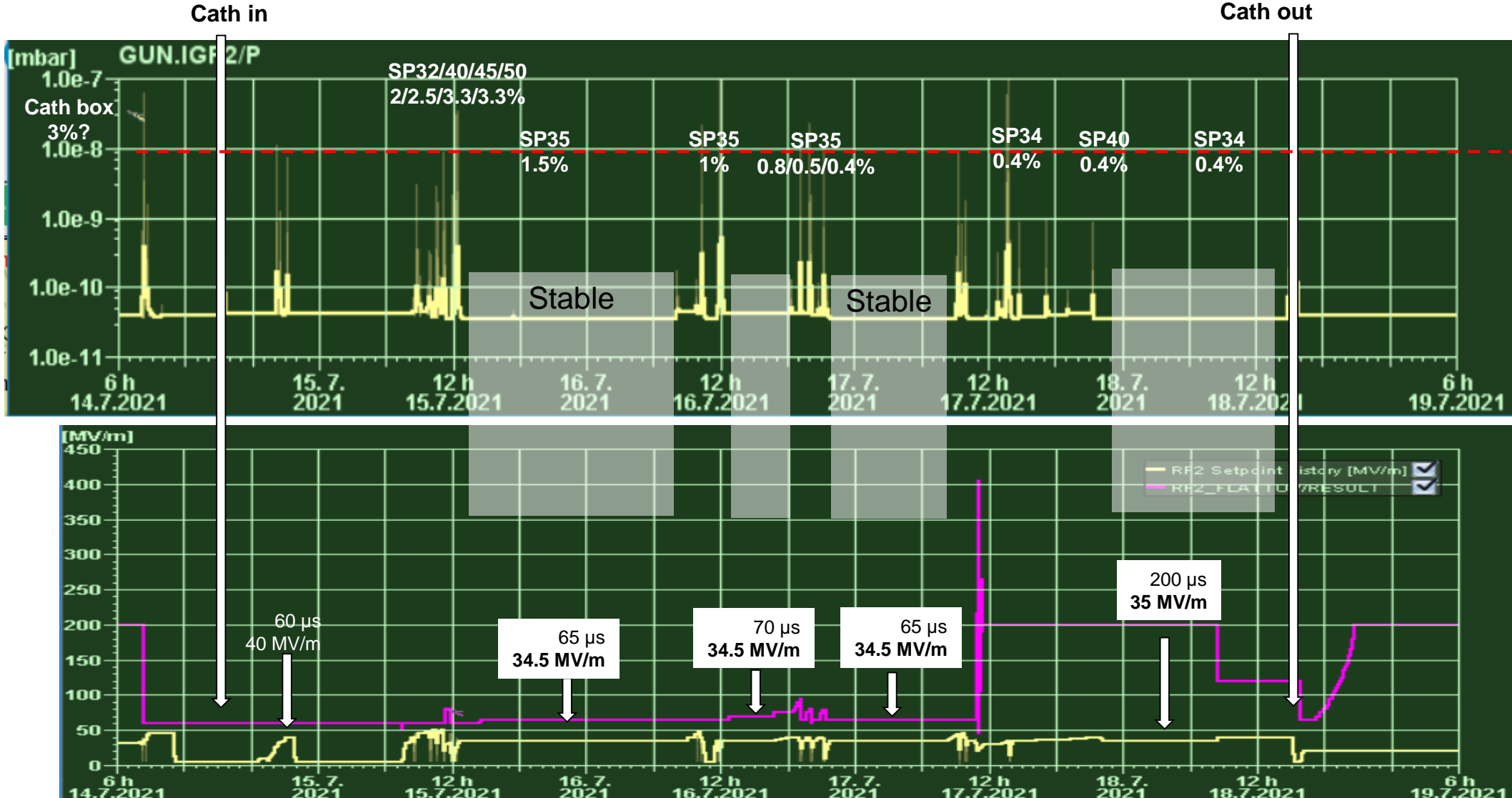
	70 C water		50 C water		70 C water		UV							
	Mon Jul-12	Tue Jul-13	Wed Jul-14	Thu Jul-15	Fri Jul-16	Sat Jul-17	Sun Jul-18	Mon Jul-19	Tue Jul-20	Wed Jul-21	Thu Jul-22	Fri Jul-23	Sat Jul-24	Sun Jul-25
Morn. 07:00 to 15:30	Green 123.1 Weilbach Startup Cs2Te, DC/DC imaging	conditioning Weilbach Abo QE DC vs SP	DC vs SP QE Laser pulse length	conditioning Qian conditioning	conditioning QE DC vs SP Thermal emittance	Conditioning Aftab Gun quad script test	QE recovery Script test Aftab Emittance	conditioning Qian QE DC vs SP Thermal emittance	Boonpornpras Adhikari Conditioning	Boonpornpras Adhikari Conditioning	Change Water back to 70 C Put TDS back to work Slice emit for best 100 pC case Response time		Check 112.1 QE in UV Field emitter location Thermal emit	Krasilnikov Insert Mo plug, check dark current VS SP
Late 15:00 to 23:30	Cath cond Rough QE map(mirror)	Thermal emittance Koschitzki conditioning	Good Cath Conditioning	QE DC vs SP Thermal emittance	conditioning Weilbach Conditioning	Conditioning Weilbach Conditioning 200 us	Weilbach Cath Conditioning	Thermal emittance Peak power conditioning	100 pC @SP40 BSA0.8/0.9/1.0	100 pC @SP40 BSA0.8/0.9/1.0	E		Boonpornpras Adhikari Thermal emit	Boonpornpras Adhikari Insert Cs2Te, check QE, QE map, dark current VS SP
Night 23:00 to 07:30	Automatic Conditioning	Automatic Conditioning		Life time test	Automatic Conditioning	Automatic Conditioning QE map	Automatic Conditioning	Automatic Conditioning	Qian Aftab	Qian Aftab	Hoffmann Pharos UV		Qian Aftab QE map Hoffmann	Hoffmann
Resp. Phys	Good	Good	Good	Weilbach	Weilbach	Weilbach	Weilbach	Phys	Gross					
Laser	Koschitzki	Koschitzki	Koschitzki	Koschitzki	Gross	Gross	Gross		Gross	Gross	Gross	Gross	Gross	Gross

- **Cathode conditioning**
- QE, QE map, **QE life time**, vs cathode temperature
- **Dark current vs gradient**, Dark current imaging
- Thermal emittance vs gradient, **vs wavelength**
- **Response time**
- 100 pC emittance @40 MV/m
- Green cathode impact on gun

CsK2Sb #123.1 (2-day operation, 70 C water)



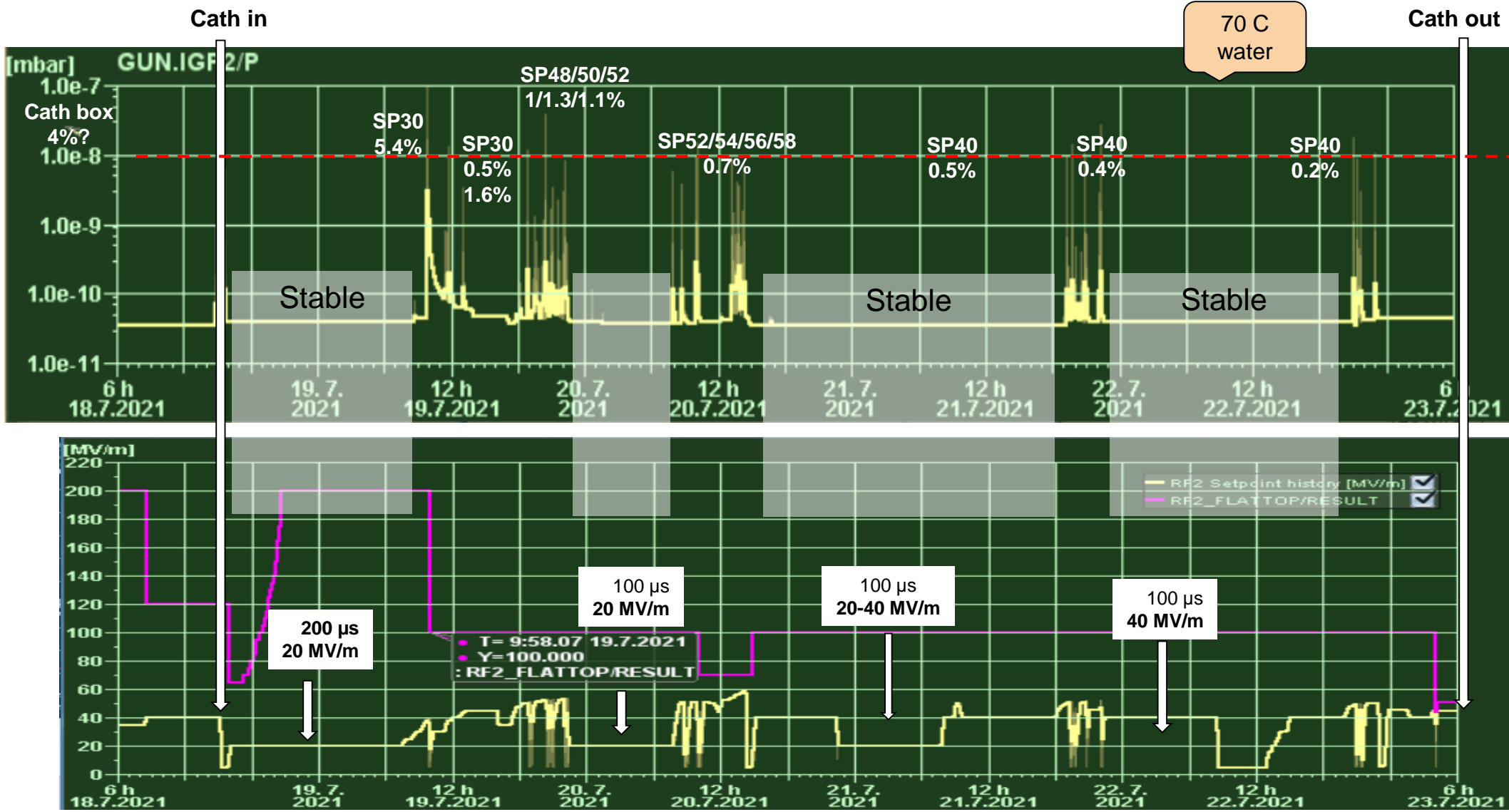
CsK2Sb #147.1 (4-day operation, 50 C water)



70 C water

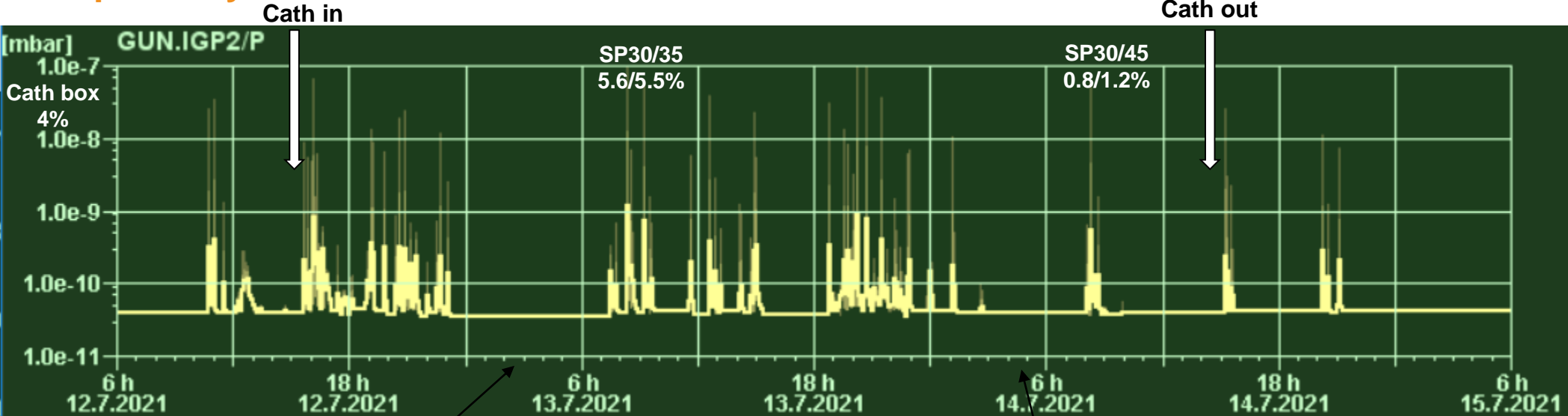
SP40
0.4%
0.7%
7 days later

CsK2Sb #112.1 (4-day operation, 50 C water)

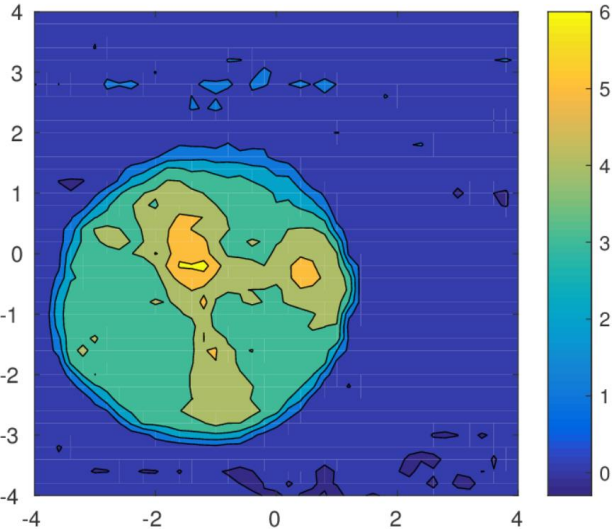
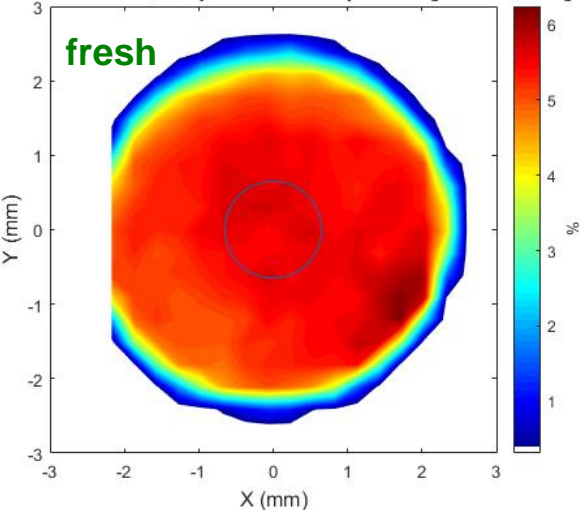


CsK2Sb #123.1

QE map history

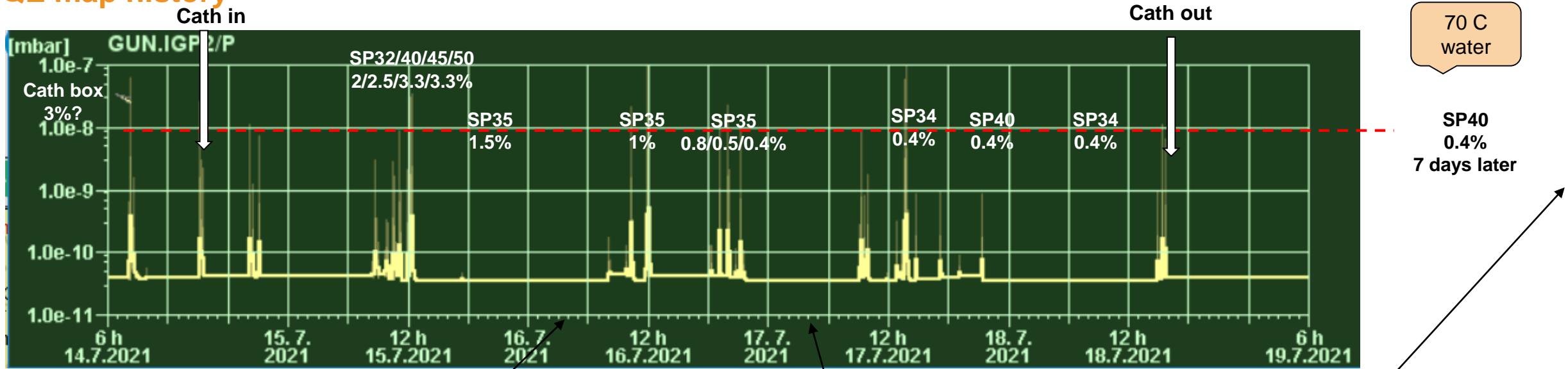


Cathode#123.1; QE(BSA=1.3mm)=5.6% [20210712A]

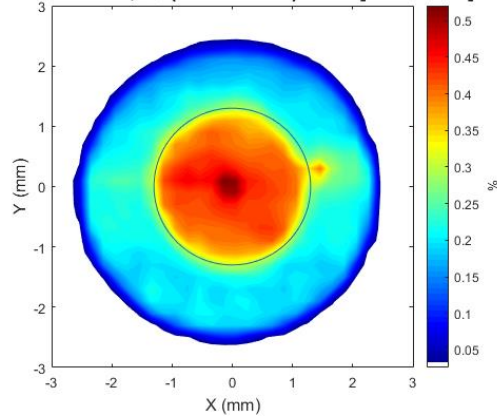


CsK2Sb #147.1

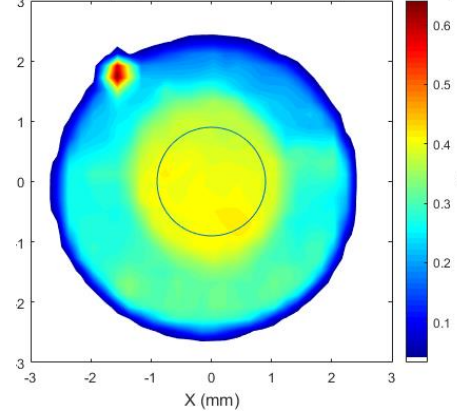
QE map history



Cathode#147.1; QE(BSA=2.6mm)=0.4% [20210716N]

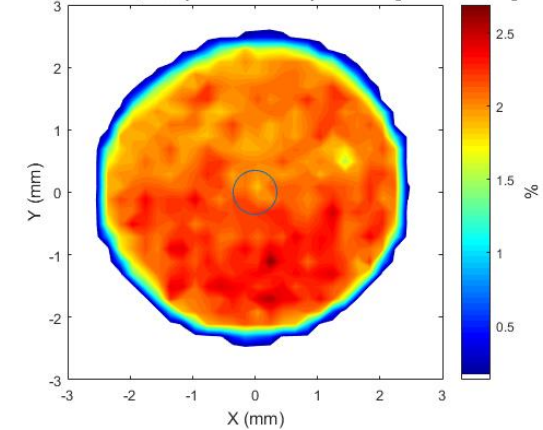


Cathode#147.1; QE(BSA=1.8mm)=0.4% [20210717N]



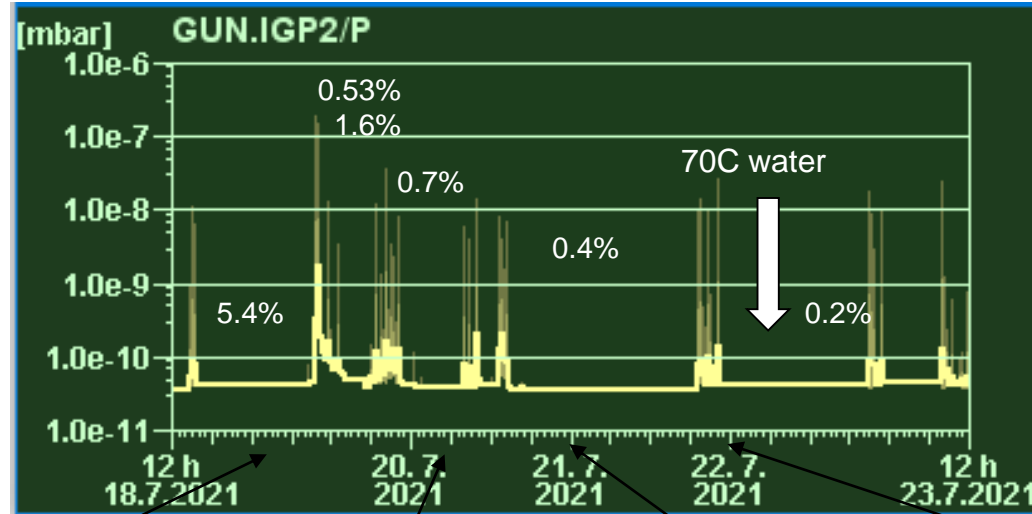
UV QE-map

Cathode#147.1; QE(BSA=0.7mm)=2.07% [20210725M]

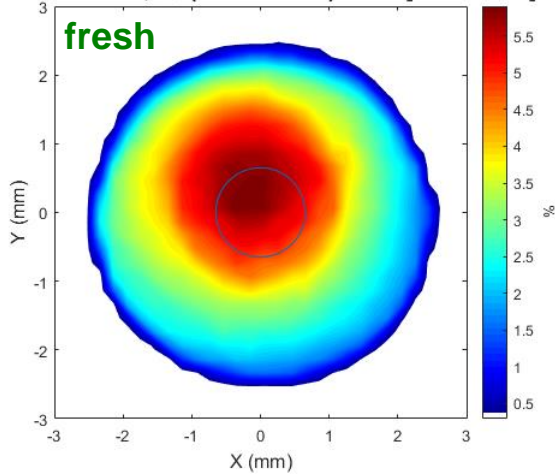


CsK2Sb #112.1

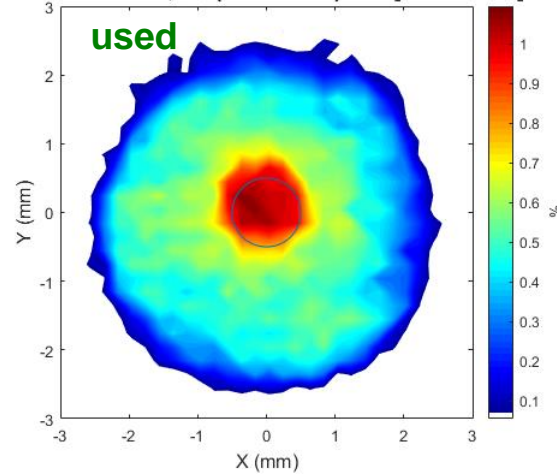
QE map history



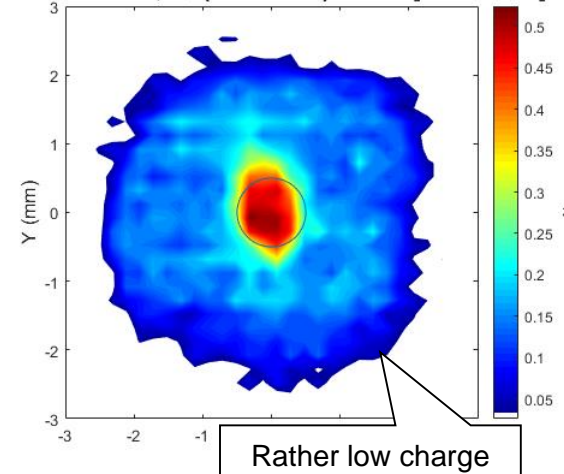
Cathode#112.1; QE(BSA=1.3mm)=5.5% [20210718N]



Cathode#112.1; QE(BSA=1mm)=1% [20210719N]

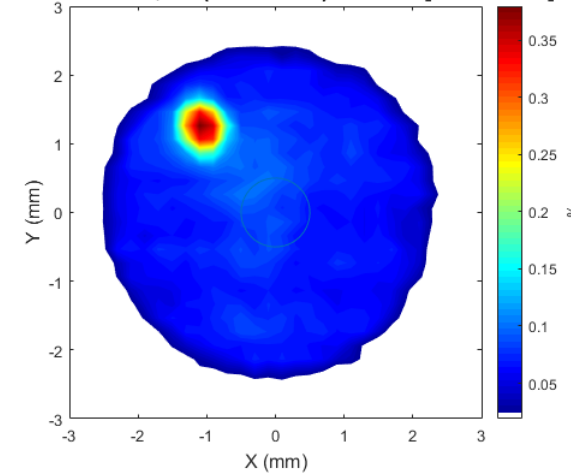


Cathode#112.1; QE(BSA=1mm)=0.44% [20210721M]



Rather low charge used (noisy measurements)

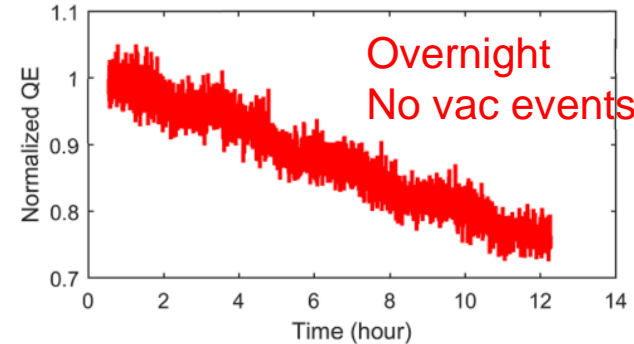
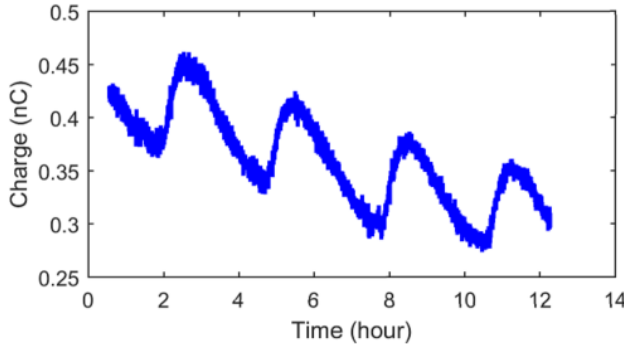
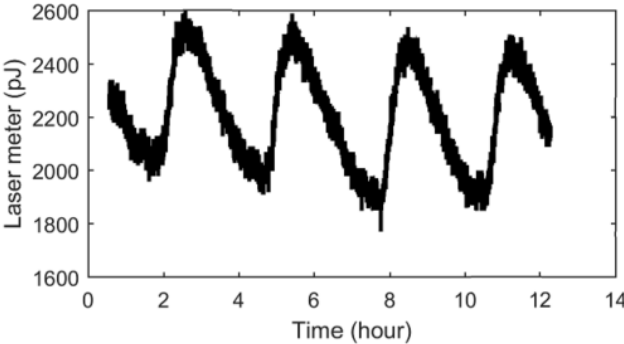
Cathode#112.1; QE(BSA=1mm)=0.085% [20210721N]



QE evolution without vac events

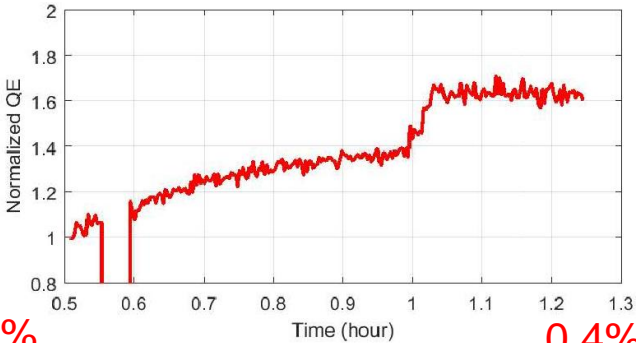
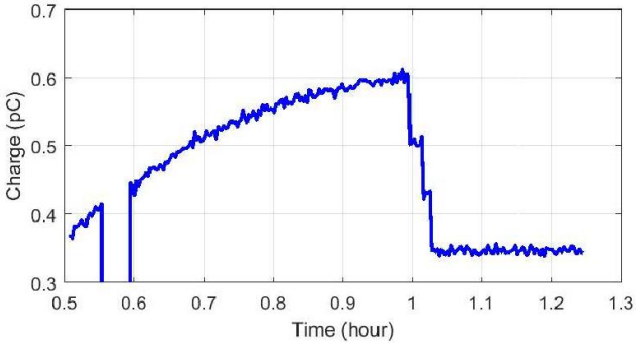
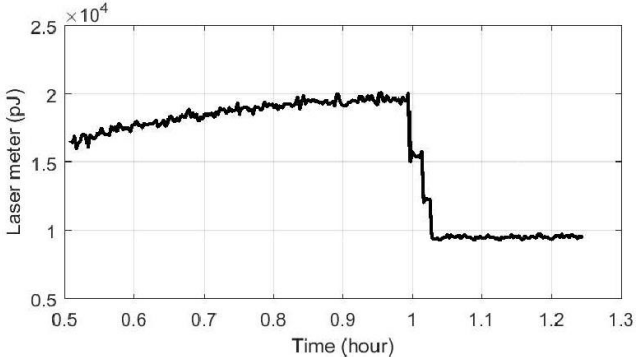
CsK2Sb #147.1

- QE drop over 12 hours
- QE recovery every morning by laser
 - ~1 hour



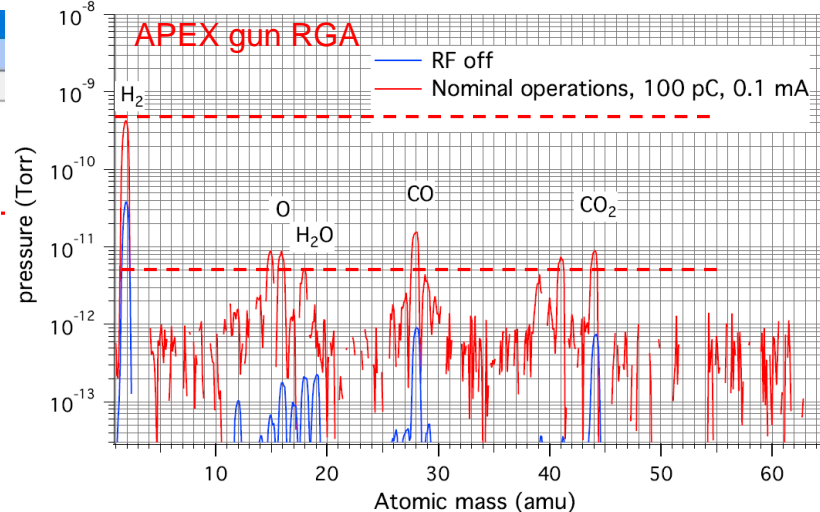
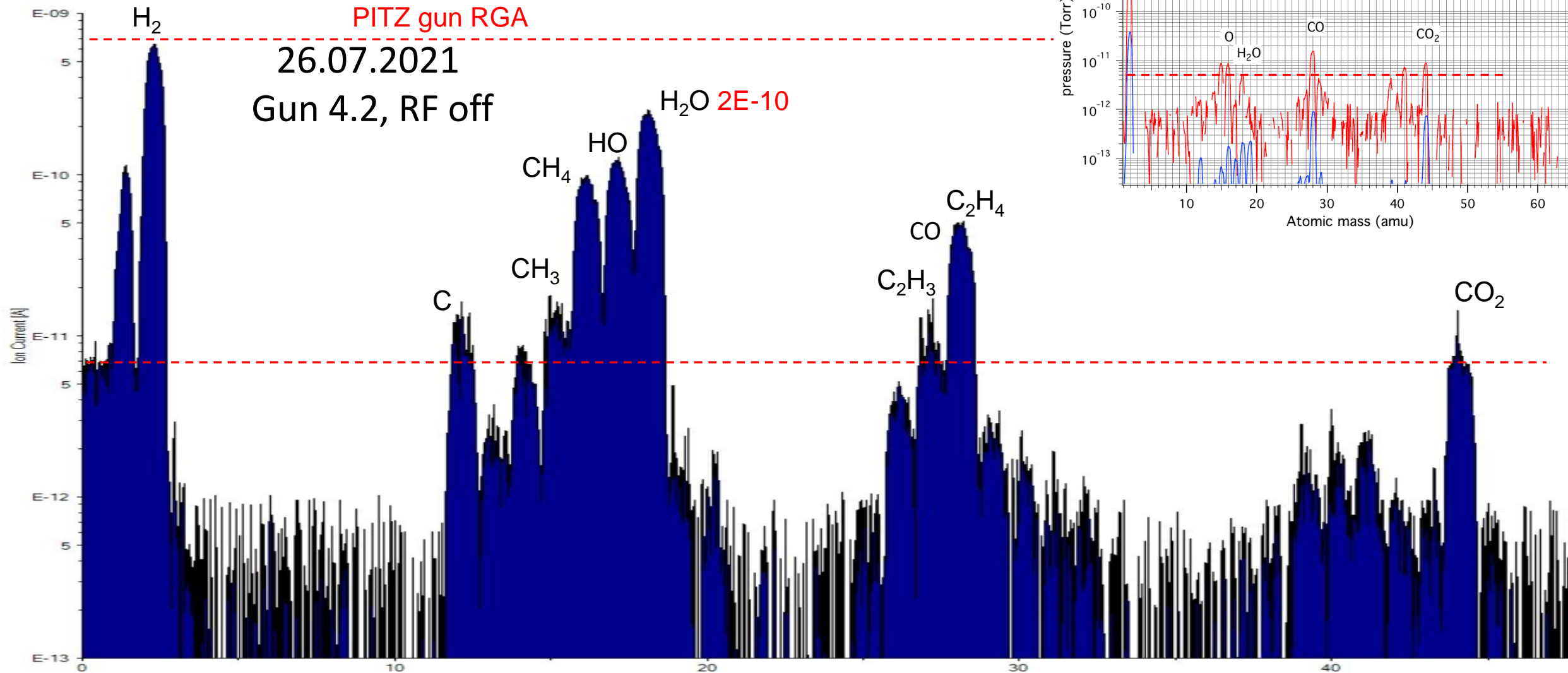
1.5%

1.2%

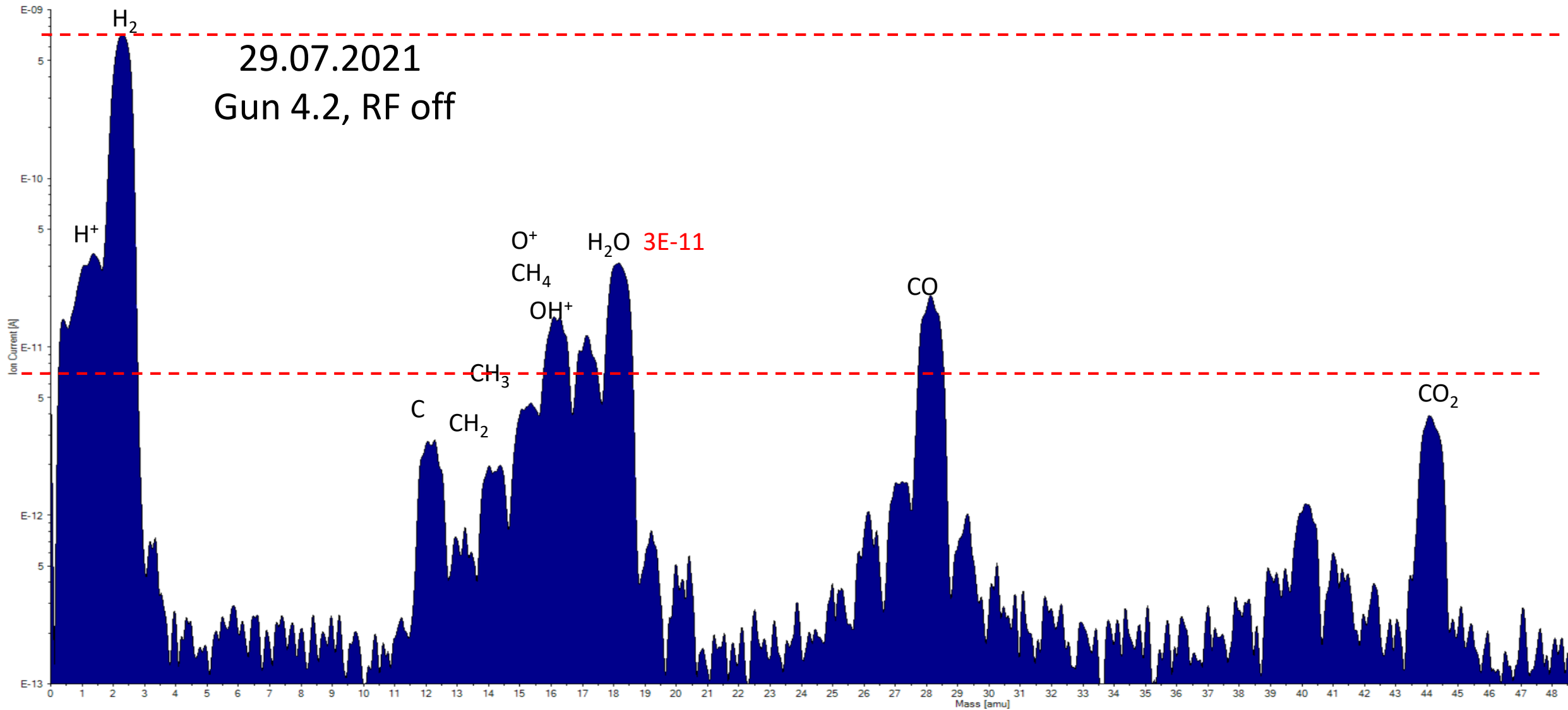


0.2%

0.4%



Scan



29.07.2021
Gun 4.2, RF off

O⁺ H₂O 3E-11

CH₄

OH⁺

CH₃

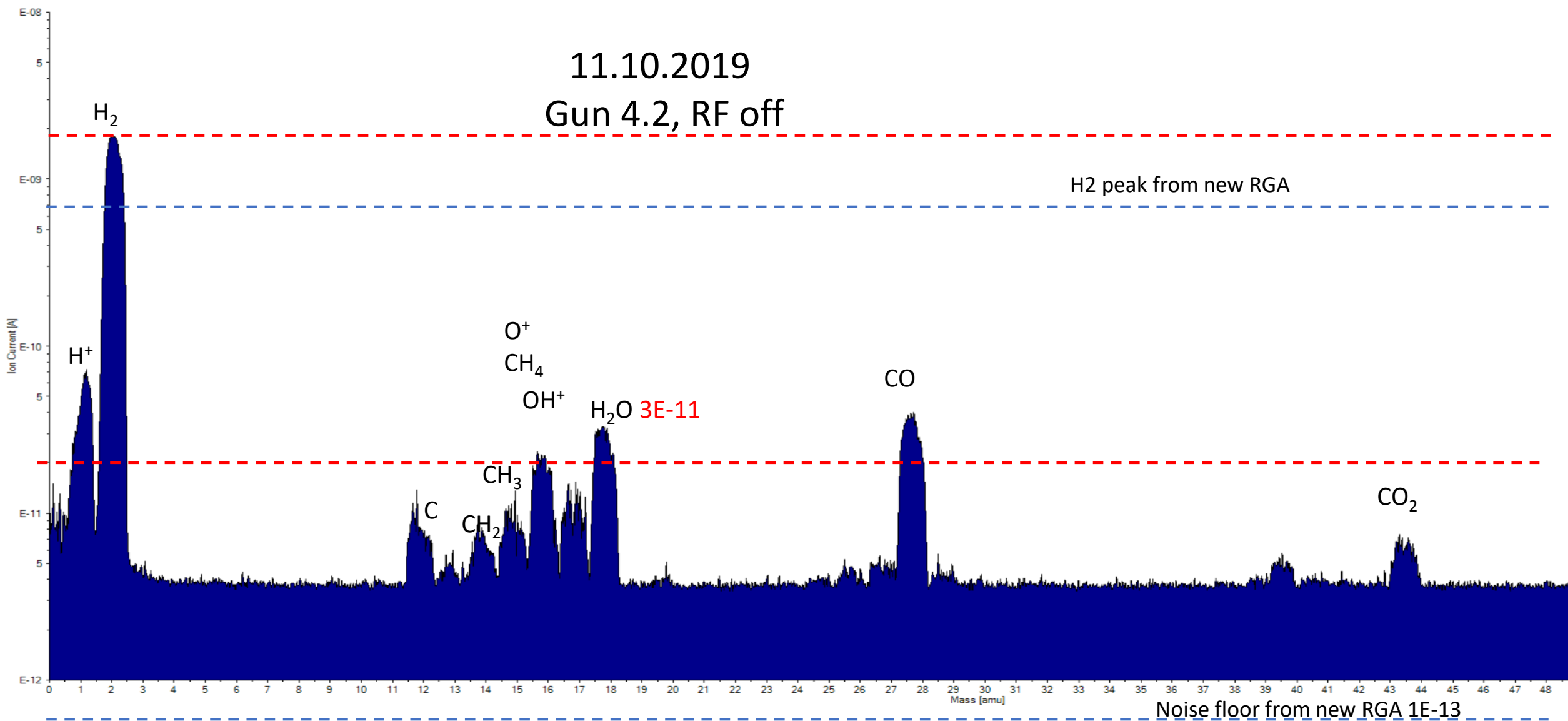
C

CH₂

CO

CO₂





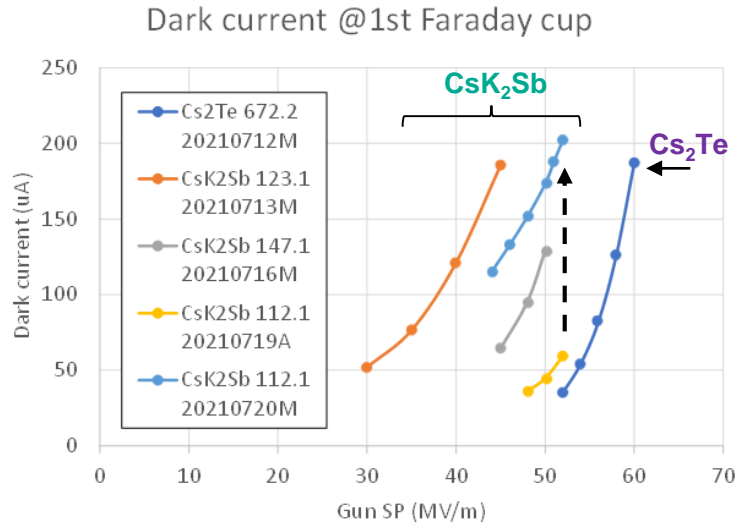
11.10.2019 08:58:00.793

11.10.2019 08:58:00.793



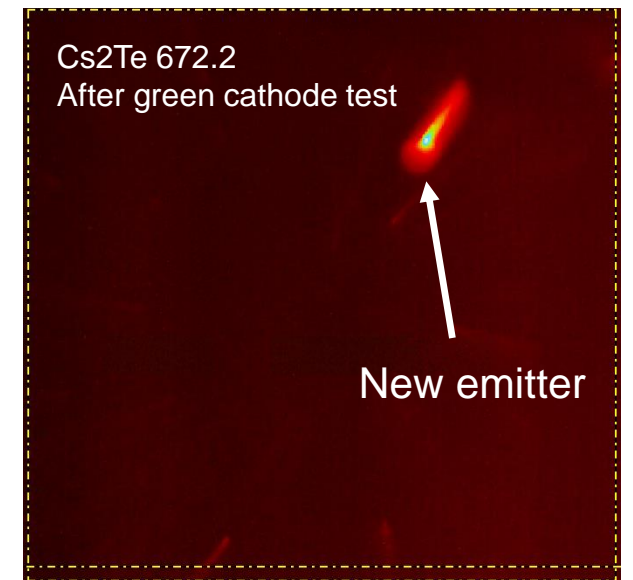
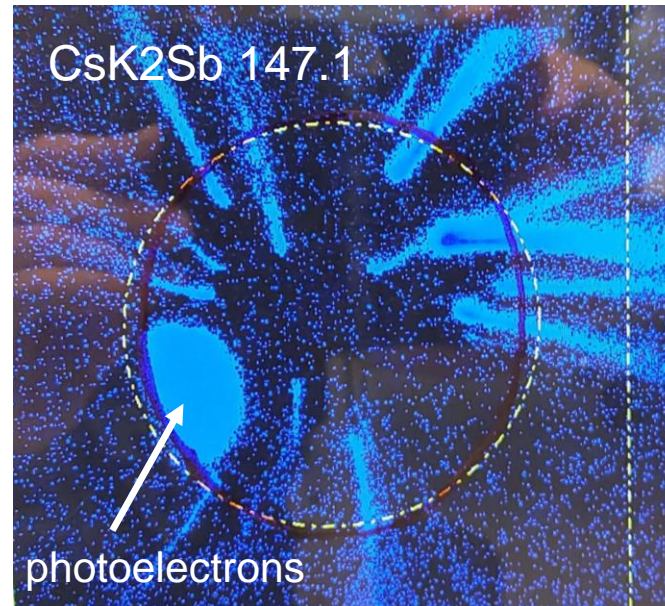
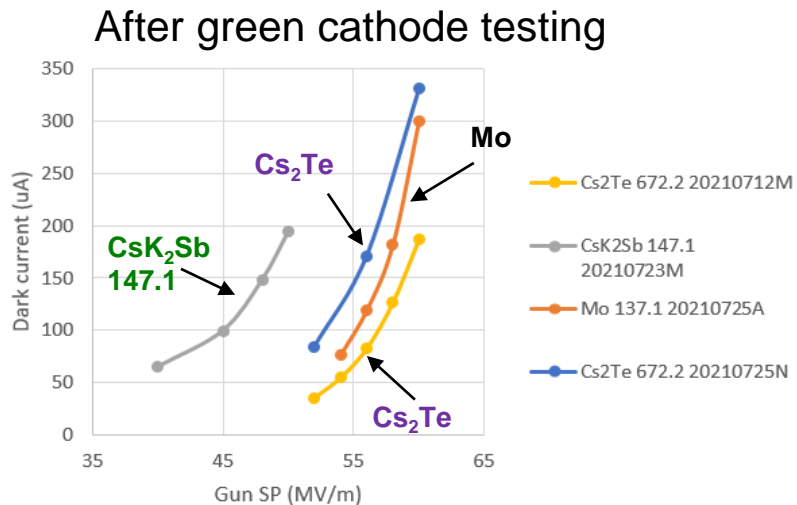
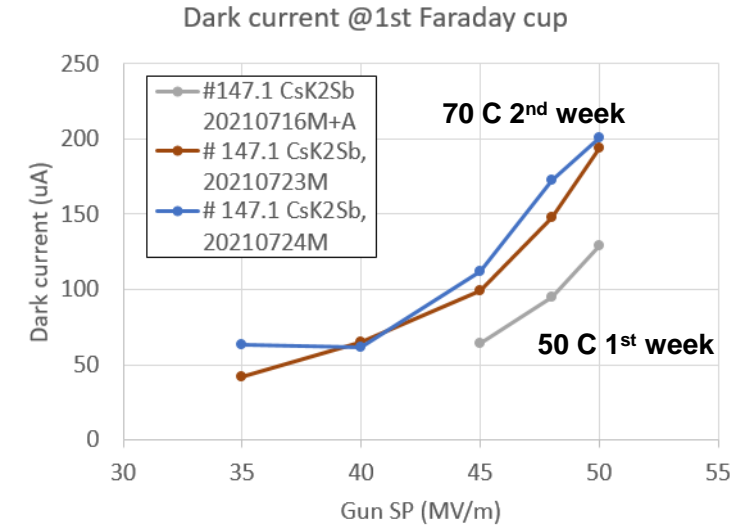
Dark current

Vs gradient, and imaging



- FN fitting (just to have a feeling)

	beta	A (nm ²)
Cs₂Te 672.2	126	15212
123.1	462	0.002
147.1	97	0.98
147.1	102	1.1
112.1	99	0.3
112.1	246	0.013
Mo	109	126581
Cs ₂ Te 672.2	163	1968

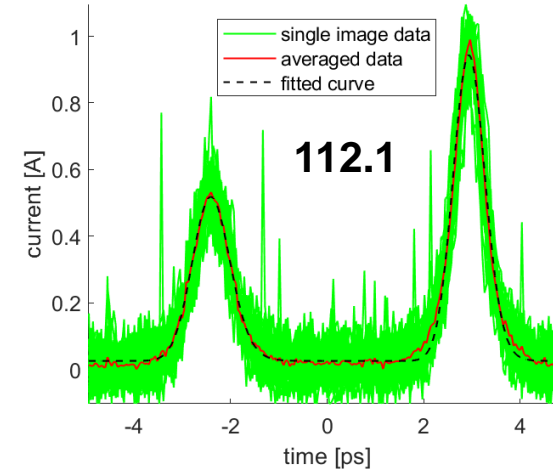


CsKSb cathode response times

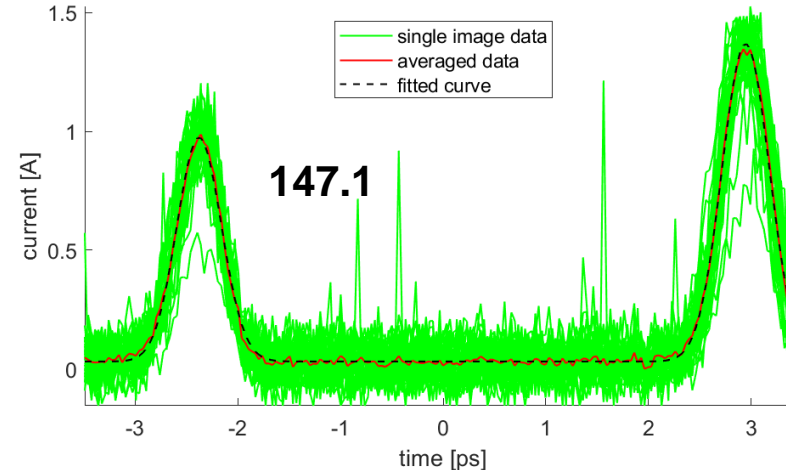
First response time measurements with green cathodes

- ▶ #112.1, thin CsKSb
 - ▶ Complex bunch shapes → difficult analysis
 - ▶ Transverse bunchsize ~big
→ measurement of short resp. time difficult
 - ▶ Preliminary result:
#112.1 (thin) response time seems <200 fs !!??
- ▶ #147.1, thick CsKSb
 - ▶ Much cleaner bunch focus
 - ▶ **Response time ~50fs !!! (!!!)**
- ▶ *Conclusion: measurements with 112.1 probably not reliable, 147.1 to be checked but seems ok → 50fs response of CsKSb*

centered single and averaged bunch profiles, phase: -89



centered single and averaged bunch profiles, phase: -86



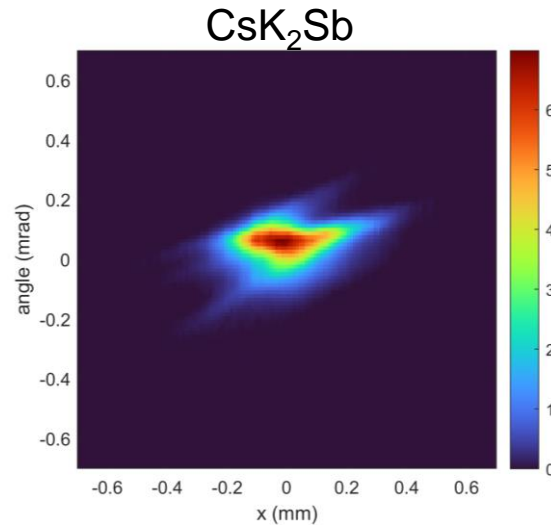
100 pC emittance @40MV/m

- 100 pC Proj. emit @40 MV/m

	Cs ₂ Te	CsK ₂ Sb
BSA0.8	15.05	20.07
Scaled	0.43	0.4
Unscaled	0.36	0.28
Core	0.33	0.25
4D Peak	760	1209

- Thermal emittance

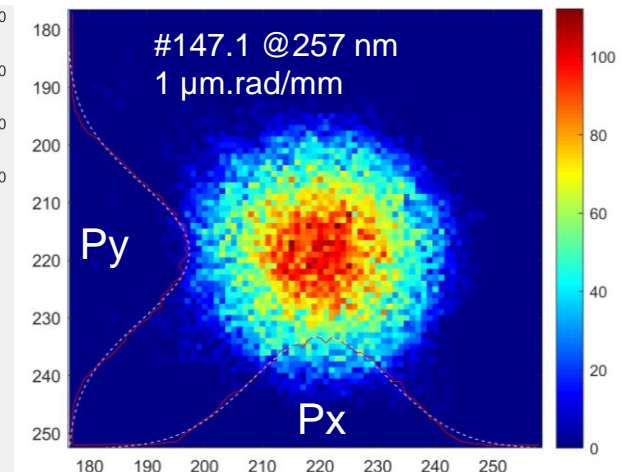
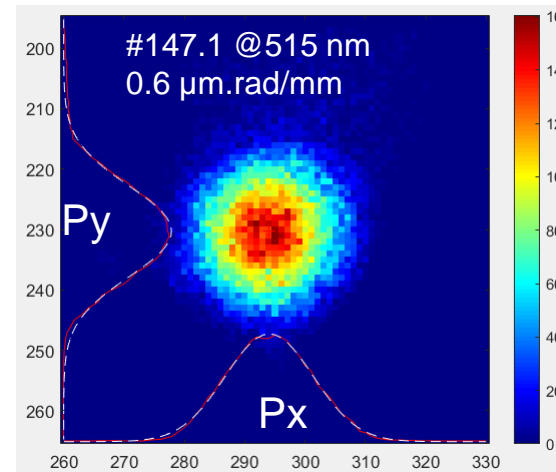
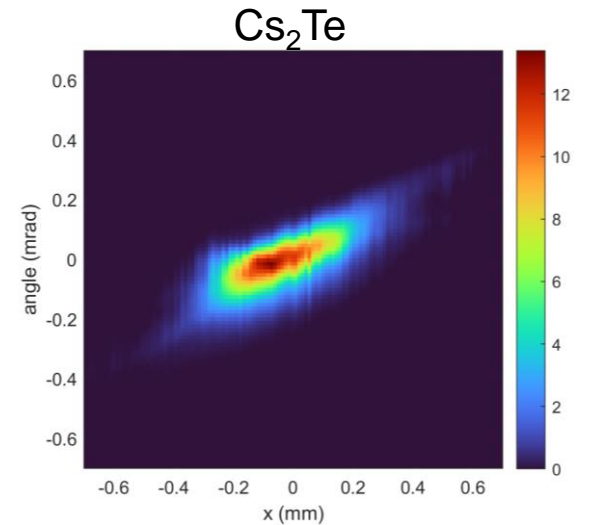
- 515 nm
- 19 MV/m, 0.6 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (2% & 0.8%, 1.5%)
 - Same as APEX results (515 nm, 19 MV/m), higher than Cornell 0.56 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (532 nm, 2.33 eV, 5 MV/m)
- 29 MV/m, 0.7 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (1.5%)
- 257 nm
- 19 MV/m, 1 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (2.5%)
- Same as Cs₂Te



BSA0.8mm

ϵ_{core} 24% ↓

B_{4D} 59% ↑

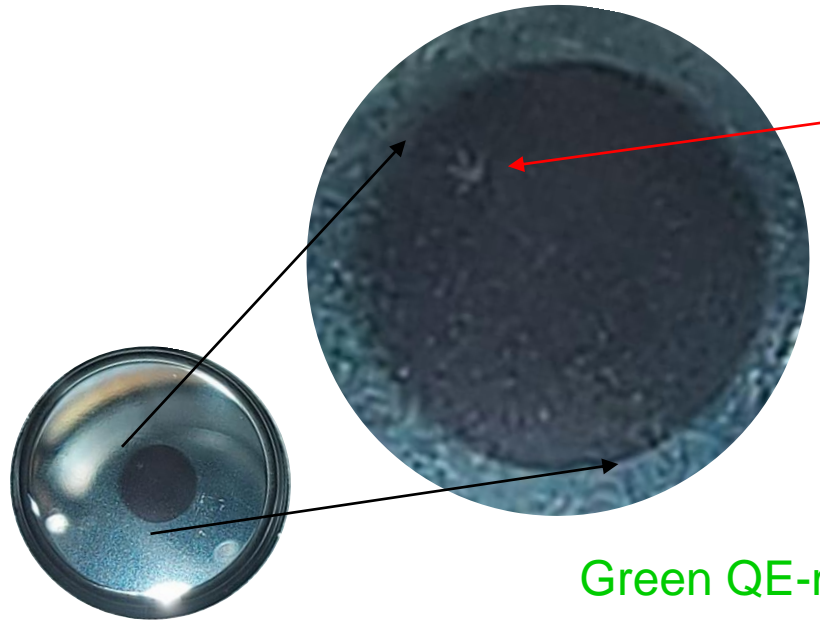


Cathodes #112.1 (CsK₂Sb, thin) and #147.1 1 (CsK₂Sb, thick)

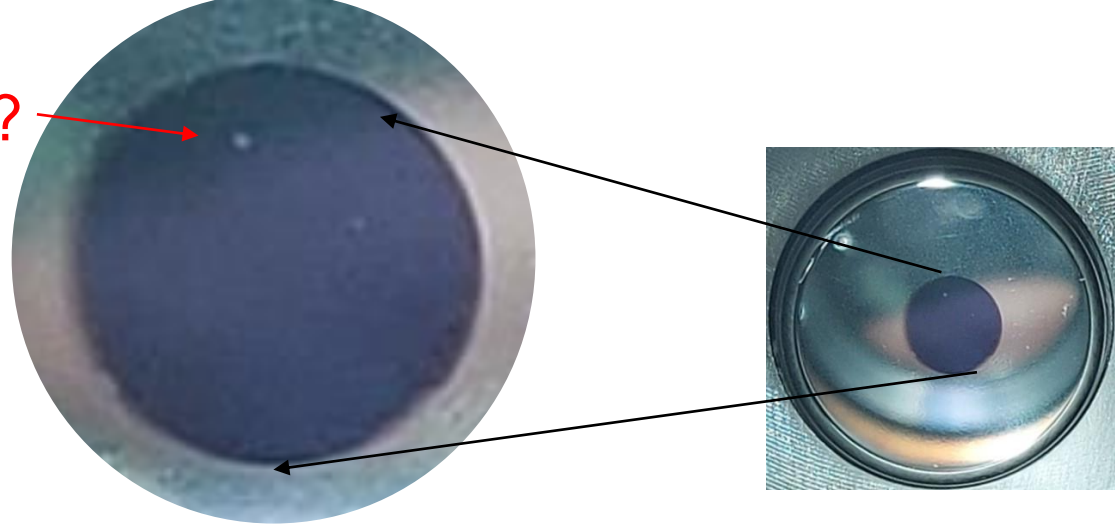
Some observations

cathode #112.1 after extraction from the gun (vertically flipped)

cathode #147.1 after extraction from the gun (vertically flipped)



Mask defect?



Green QE-map

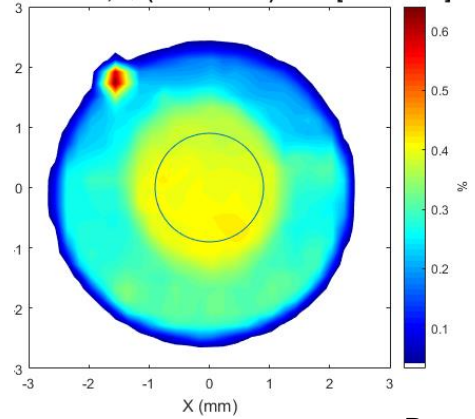
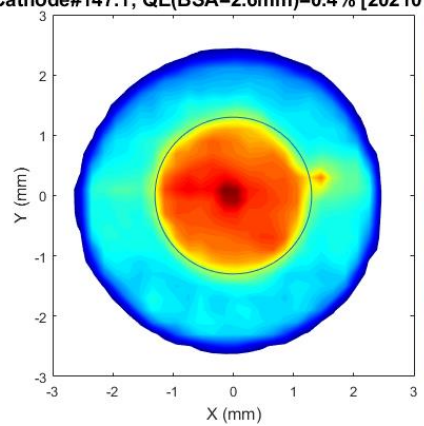
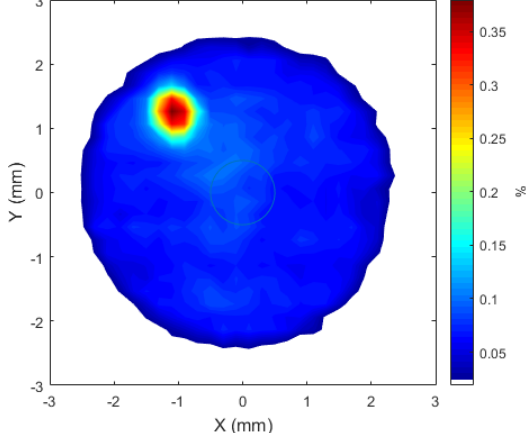
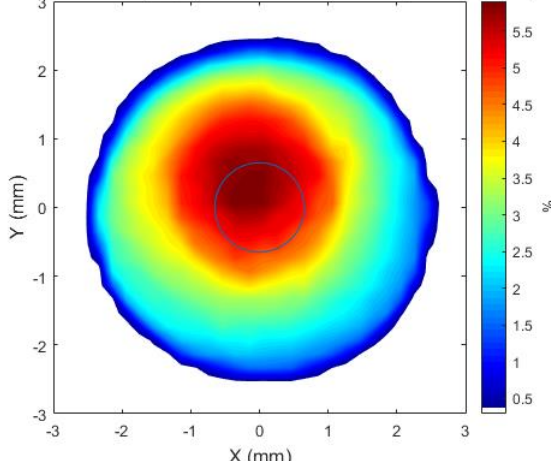
Green QE-maps

Cathode#112.1; QE(BSA=1.3mm)=5.5% [20210718N]

athode#112.1; QE(BSA=1mm)=0.085% [20210721N]

Cathode#147.1; QE(BSA=2.6mm)=0.4% [20210716N]

ode#147.1; QE(BSA=1.8mm)=0.4% [20210717N]



Summary

- Green cathode survived the cathode box transportation, installation and cathode insertion
- Cathode conditioning
 - Below 30 MV/m, almost not necessary, up to 400 us was tested without vac events
 - Above 30-40 MV/m, much more vac events than Cs₂Te conditioning, degrades QE significantly
- QE
 - Fresh QE in gun is consistent with lab measurements
 - QE drop within 2 days from 3-6% to below 1%, dominated by vac events during cathode conditioning, but there is also a slower QE decrease even without vac events
 - QE map uniformity is not repeatable between different cathodes, degrades during QE decay
- Thermal emittance consistent with APEX results for different cathodes and different QEs
 - 515 nm, 19 MV/m, 0.6 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (2% & 0.8%, 1.5%)
 - 515 nm, 29 MV/m, 0.7 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (1.5%), Schottky effect, or surface roughness?
 - 257 nm, 19 MV/m, 1 $\mu\text{m}\cdot\text{rad}/\text{mm}$ (2.5%)
- Response time
 - One good dataset for #147.1, preliminary analysis shows ~50 fs, compared to ~200 fs of Cs₂Te
- Cathode temperature effect
 - Both QE drop and QE rise has been observed from 50 C to 70 C change
 - Higher dark current is observed for 147.1 in 2nd week when changed to 70 C water, for 112.1 also observed, but 112.1 DC changes very day to day even with 50 C water.
 - Not conclusive
- Mask defect?