

Study on He processing and HPR for recovery from field emission

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TTC topical meeting on SRF cryomodule
clean room assembly

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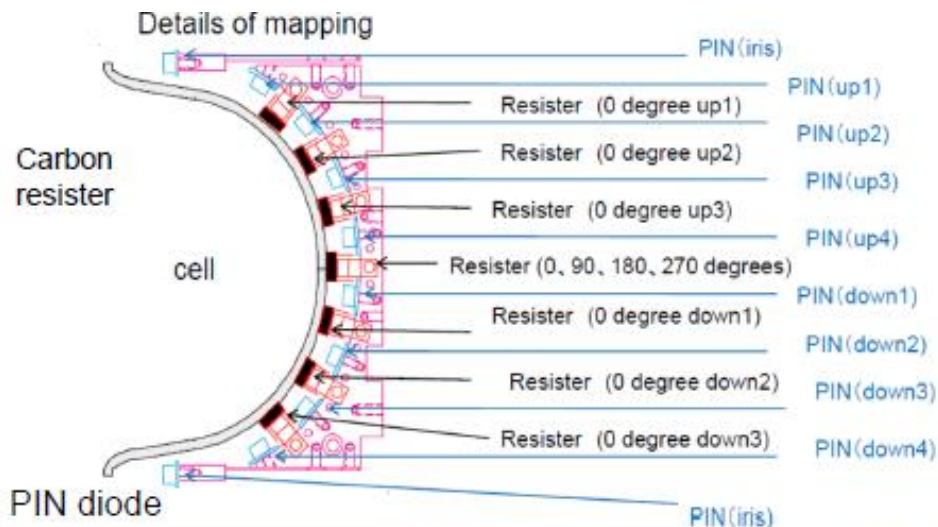
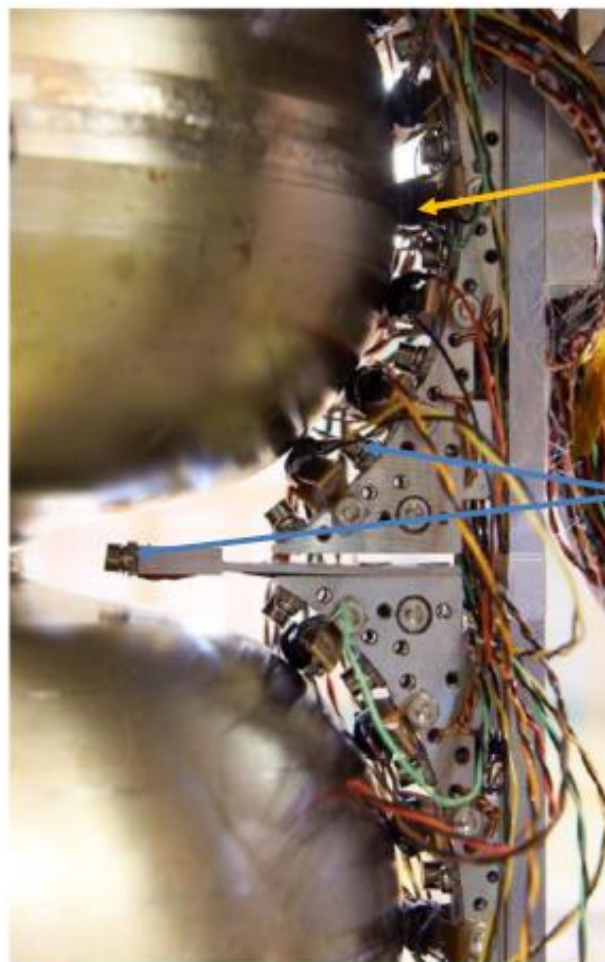
Motivation of study

- For recovering from bad performance of cavities, there are several ways;
 - in situ: He processing, RF processing
 - not in situ: HPR, EP, CP
- It is reported that He processing is effective. But it also could be risky. We want to know
 - what is happening during He processing?
 - how is it effective or risky?
 - what is safe/stable procedure of He processing?
- HPR is also effective to recover from field emission.
 - How is HPR effective?
 - Don't we need EP or CP to perfectly remove F.E. source?

History of KEK-ERL #2 cavity

VT	date	Surface treatment etc.	Aim of VT
1st VT	2010/Sep	EP(100um), Annealing,EP2(20um), HPR, Baking	Performance check
2nd VT	2010/Dec	EP(20um), HPR, Baking	Performance check
3rd VT	2011/Jan	Warm-up	Check Q-value after warm-up
4th VT	2012/Jul	HPR (assembly input and bottom flanges)	HPR study
5th VT	2013/Jul	Keep with vacuum condition	Check reproducibility
6th VT	2014/Aug	Ar purge (No flange assembly)	Check Ar purge procedure
7th VT	2014/May	(Warm-up)	System check of He processing (0)
8th VT	2014/Jun	(Warm-up)	Study on He processing (1)
9th VT	2014/Sep	Flange disassembly/assembly	Check flange disassembly/assembly procedure
10th VT	2014/Oct	(Warm-up)	Study on He processing (2)
11th VT	2014/Nov	HPR (assembly all flanges)	HPR study

X-ray mapping system



PIN diodes
(HAMAMATSU S1231)
for X-ray mapping with
current Amplifier



Carbon resistors for
Temperature map

82 PIN diodes and 93 Carbon resistors are mounted on the mapping system along a meridian to detect 9cell radiation and temperature mapping precisely

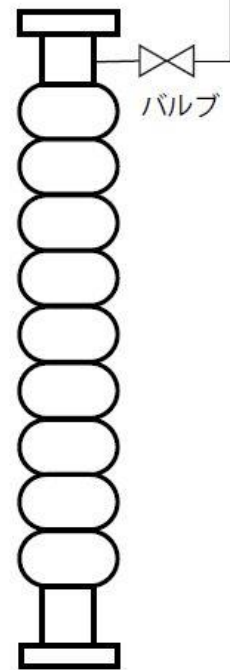
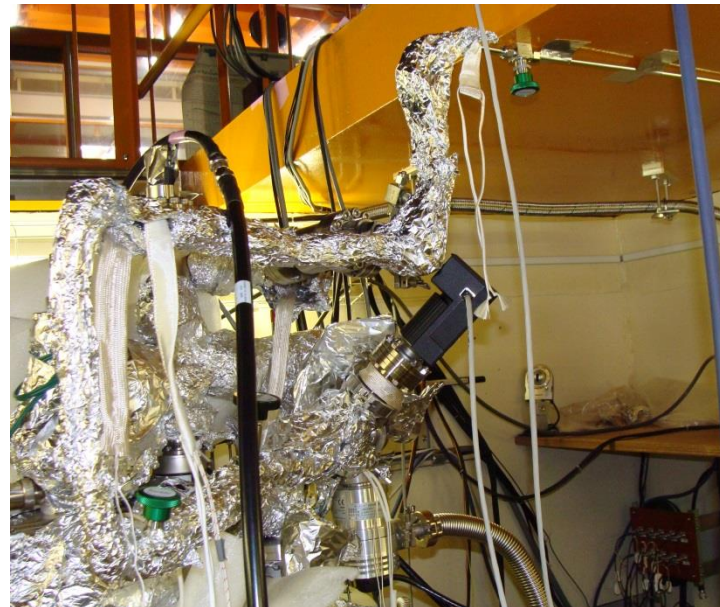
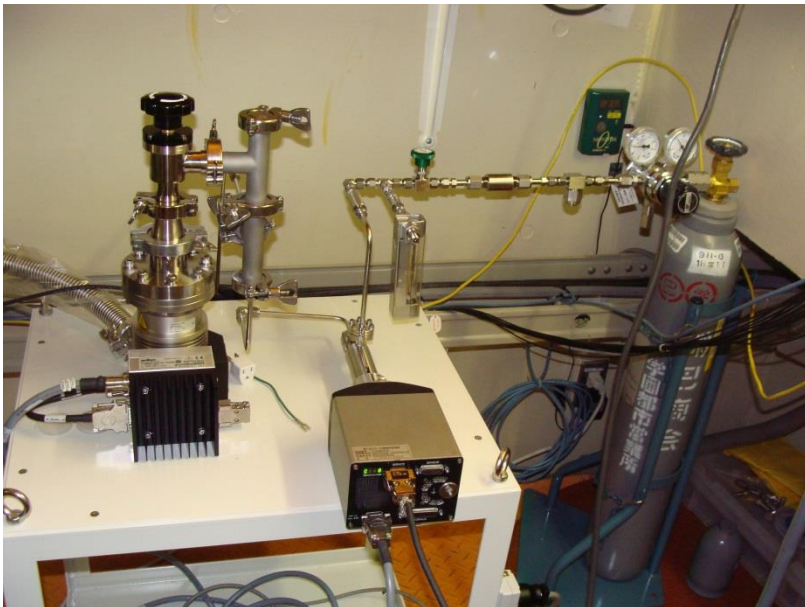
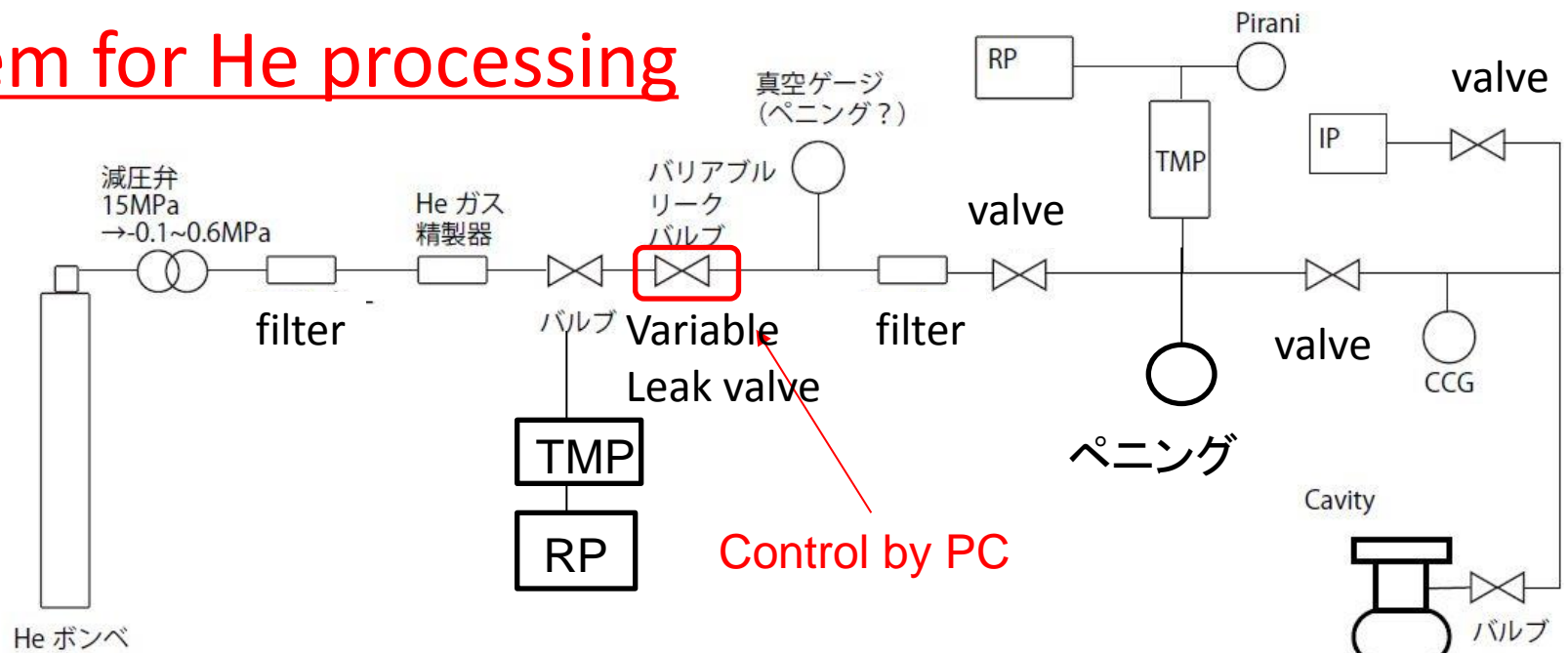
The sensor array can turn around the cavity surface using stepping motors via gear and data taking every 0.5s by logger

Figures of merit
(compared with fix mapping)

- Resolution 0.5°
- Small number of sensors



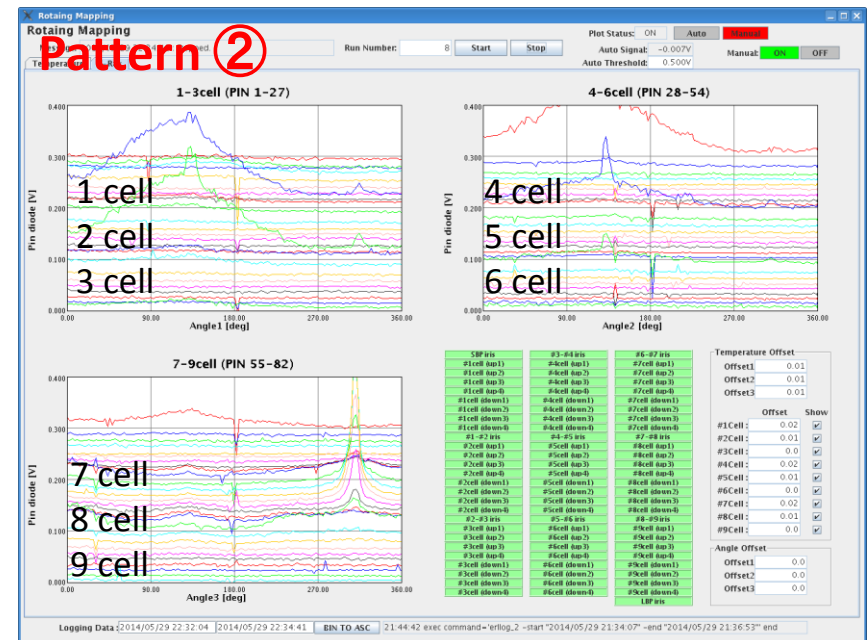
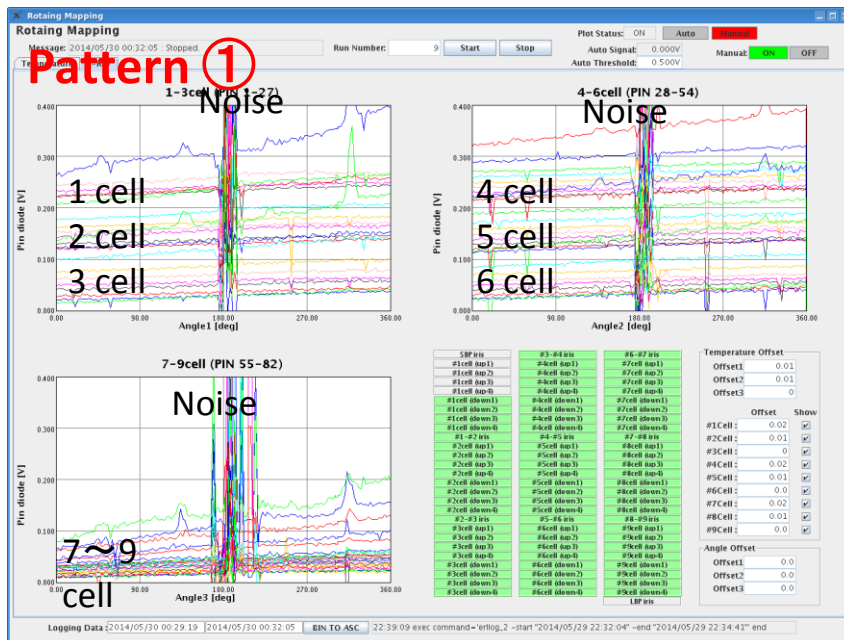
System for He processing



Two status during He processing

Two status appear during He processing

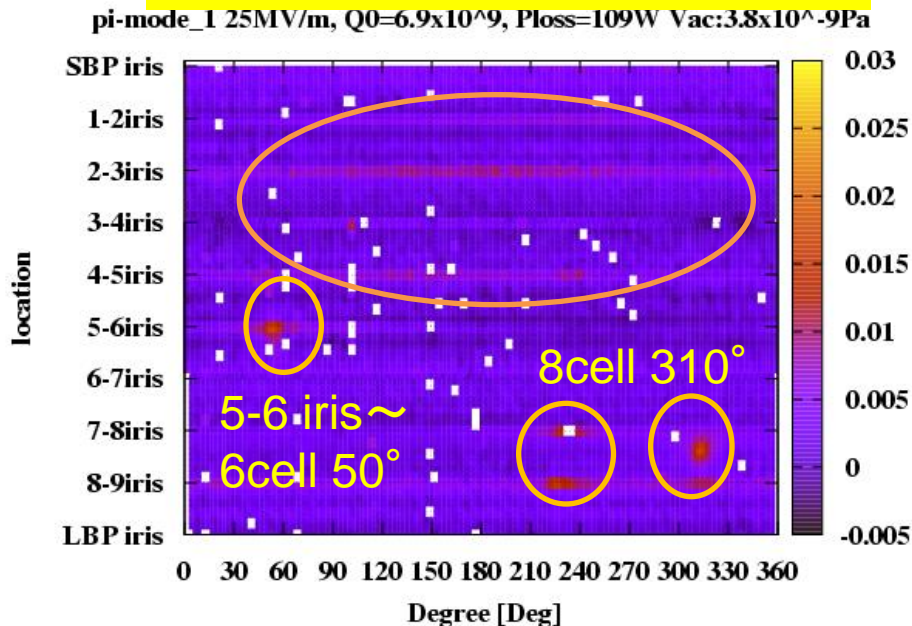
- ① **Radiation all over cavities. ~All surface mode~**
 - Like discharge? Plasma?
 - It occurs at vacuum level around 10^{-2} Pa.
- ② **Radiation are strongly activated. ~Enhanced mode~**
 - Some emitters can be activated. But some can not.
 - It occurs at vacuum level of $10^{-3} \sim 10^{-4}$ Pa.



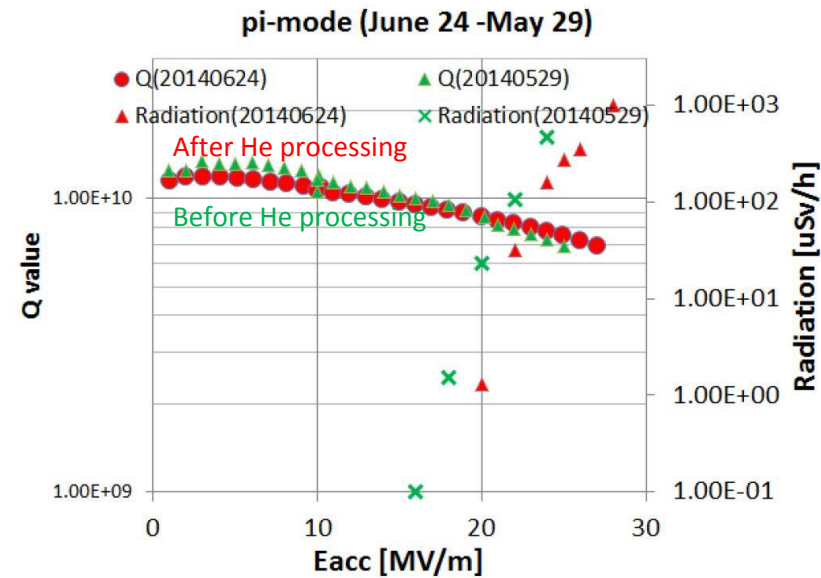
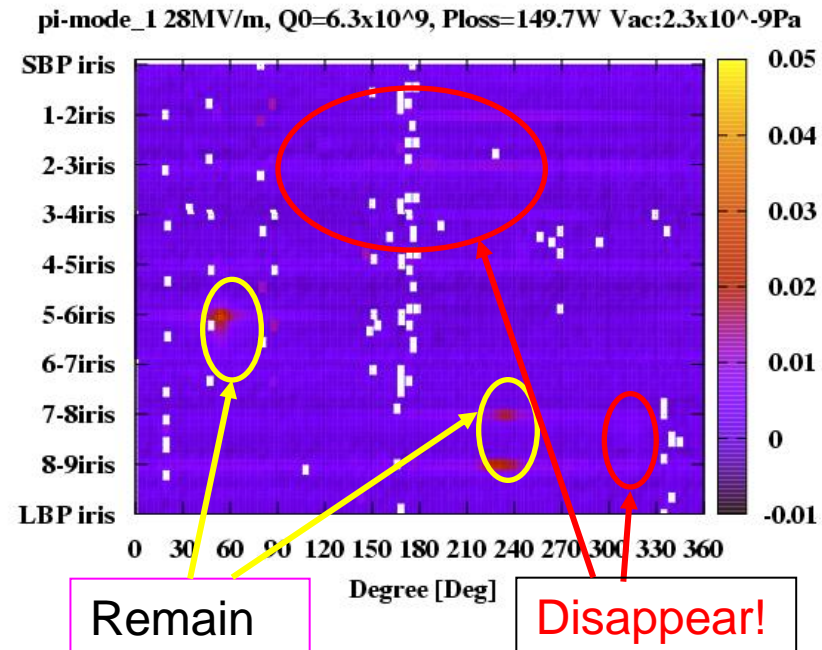
He processing trial (0&1)

- 3 emitters could be observed before He processing.
- 2 emitters remained and 1 emitter disappeared after He processing.
- emitter seems to disappear after several ten minutes of “enhanced mode”
- Q-value recover little bit and radiation on-set increased.

Before He processing : 10^{-8} Pa

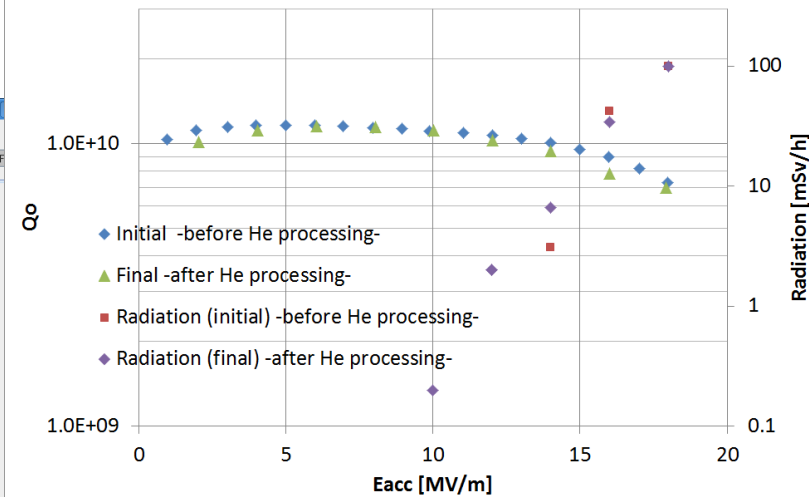
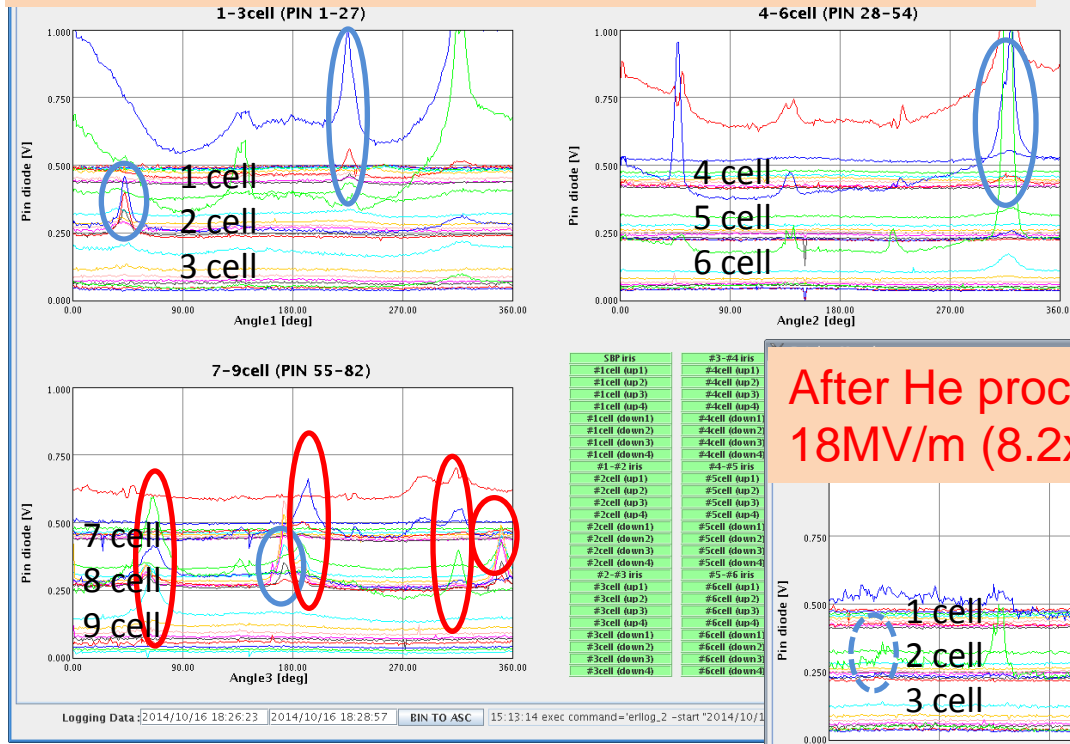


After He processing: 10^{-8} Pa

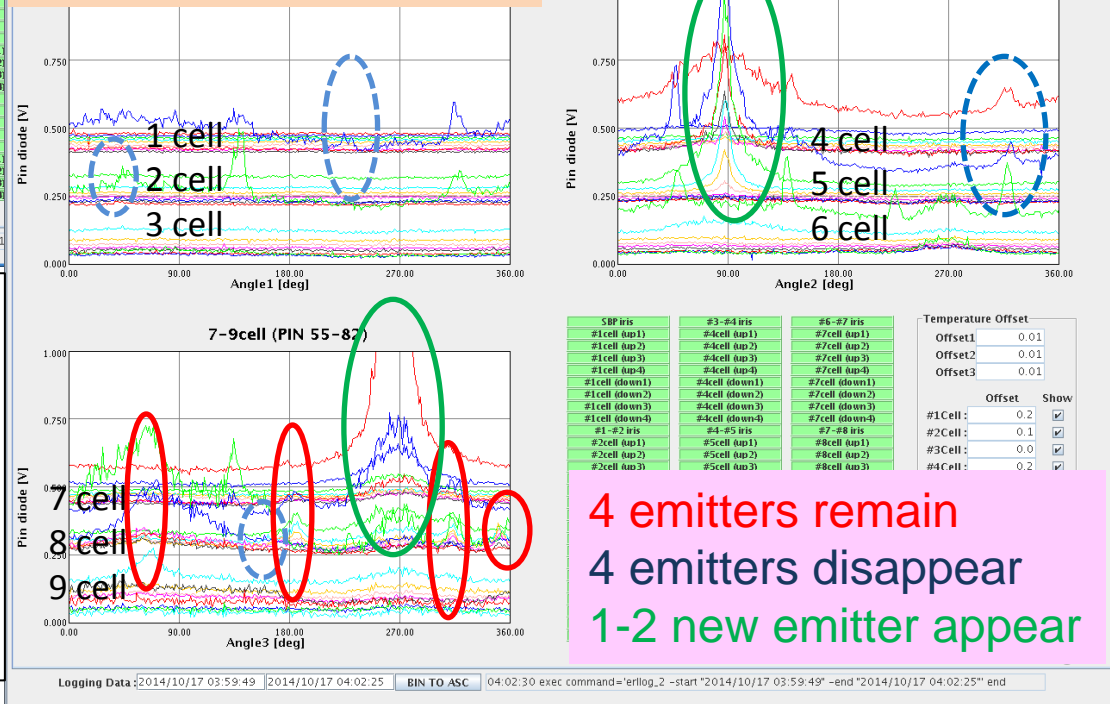


He processing trial (2)

Before He processing ~after flange exchange study~ 18MV/m (1.3×10^{-8} Pa)



After He processing
18MV/m (8.2×10^{-5} Pa)



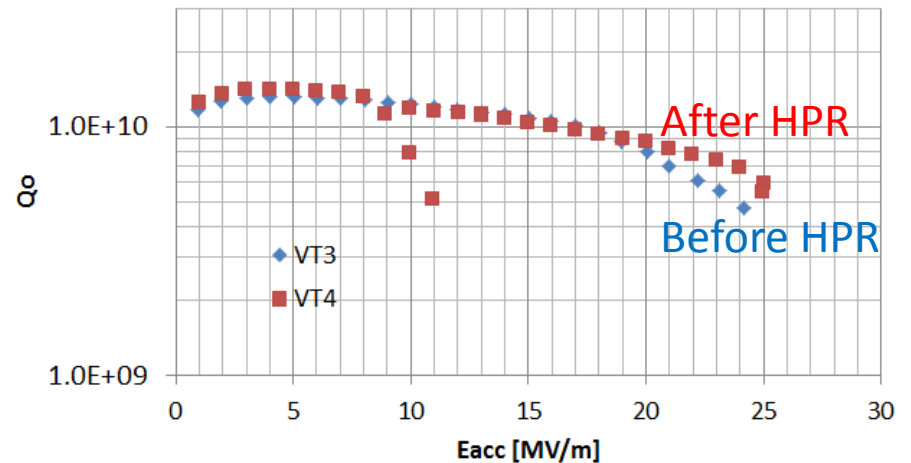
- 4 emitters remained, other 4 emitters disappeared and new 1 emitter appeared after “enhanced mode” of He processing.
- Q-value and radiation on-set did not change.

4 emitters remain
4 emitters disappear
1-2 new emitter appear

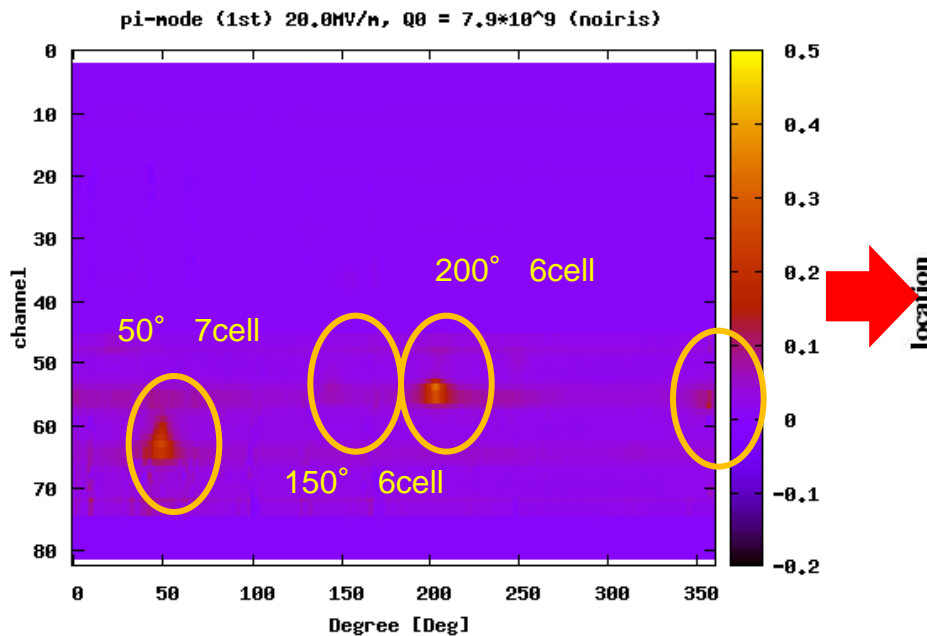
Study on HPR (1)

Comparison between 3rd & 4th VT

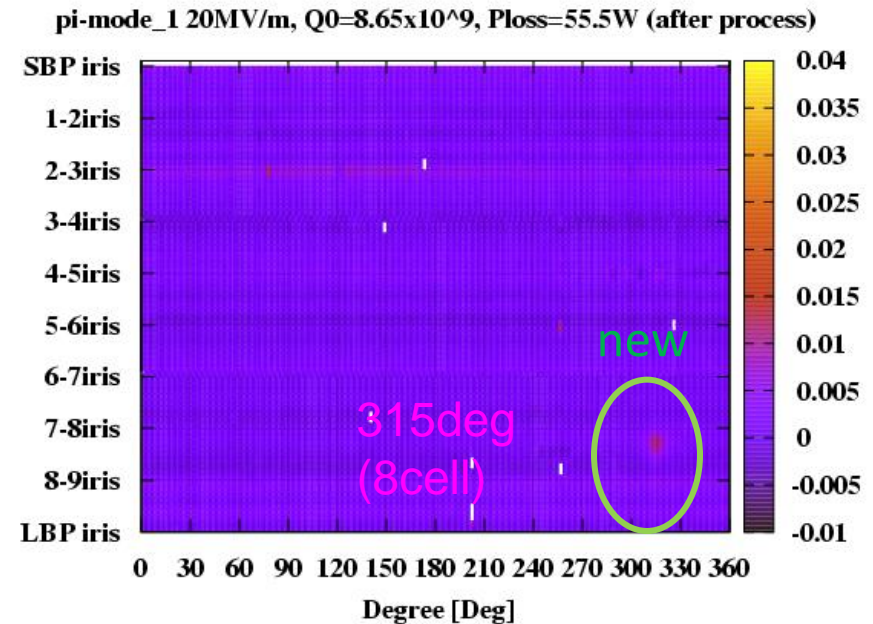
- HPR was applied.
- Emitter observed at 3rd VT were disappeared.
- Q-value, $E_{acc} > 20\text{MV/m}$, recovered



3rd Vertical test pi-mode (20MV/m)



4th vertical test (this) pi-mode (20MV/m)

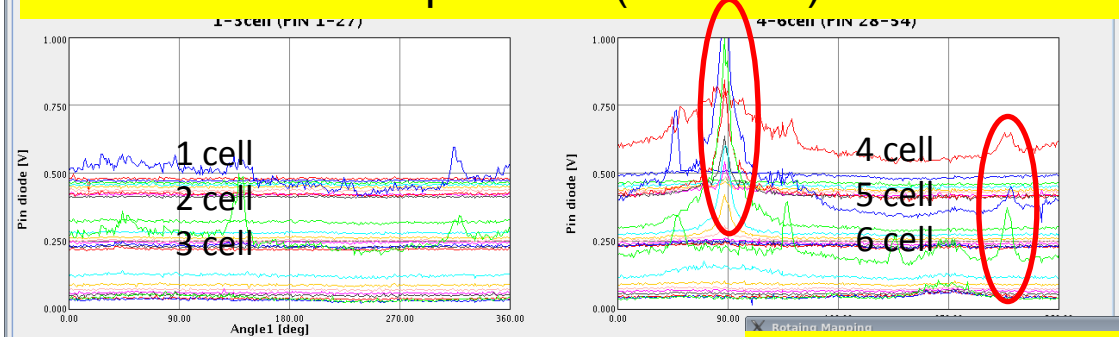


Every traces(emitters) disappear and one new emitter appears

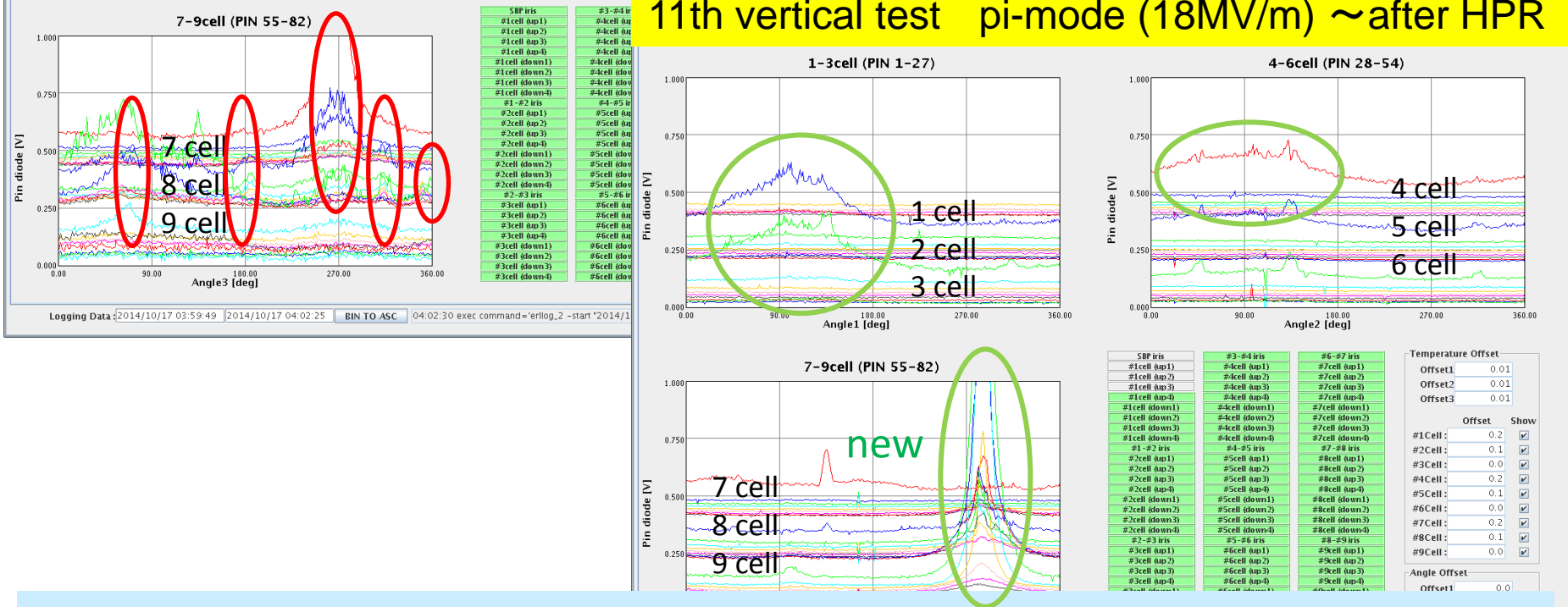
Study on HPR (2)

Comparison between 10th & 11th VT

10th Vertical test pi-mode (18MV/m) ~before HPR



11th vertical test pi-mode (18MV/m) ~after HPR

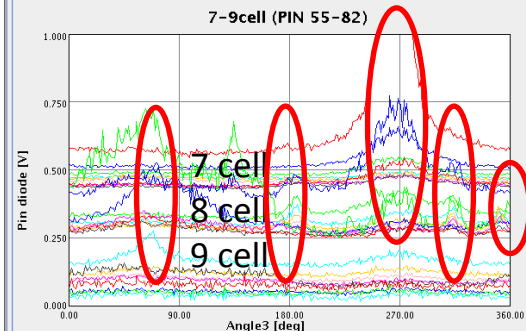
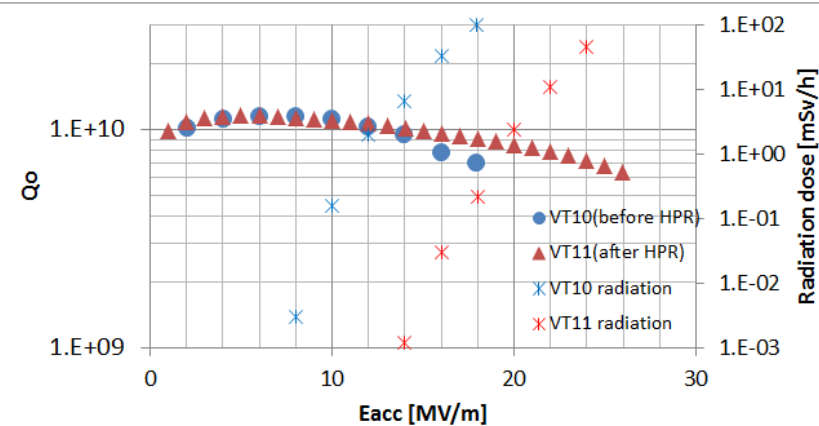
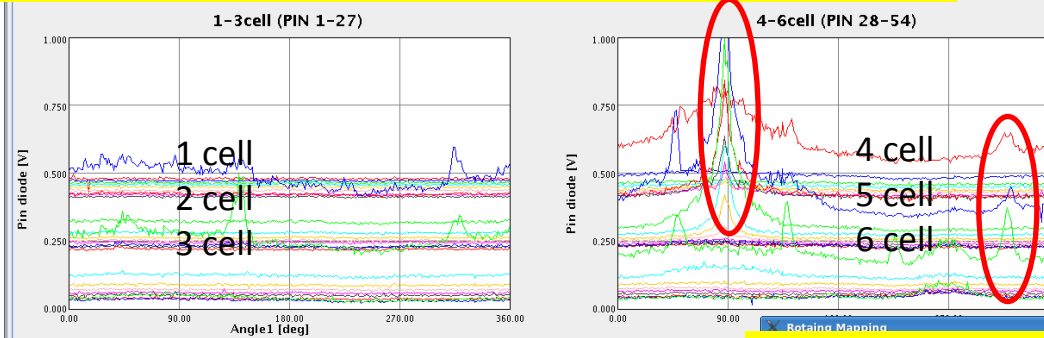


Every traces(emitters) disappear and one new emitter appears

Study on HPR (2) ~continue~

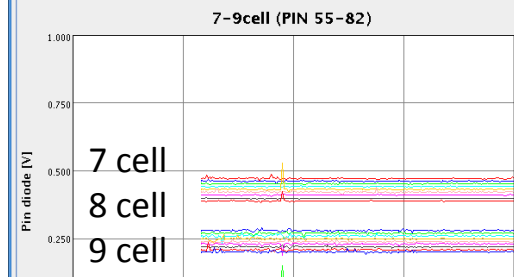
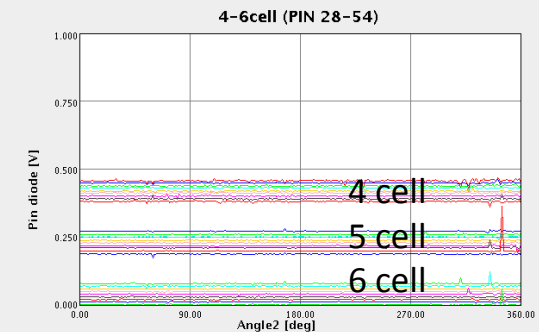
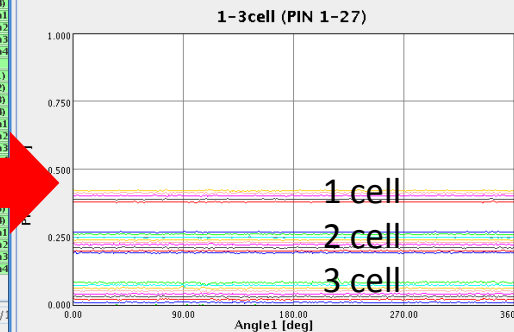
Comparison between 10th & 11th VT

10th Vertical test (18MV/m) ~before HPR



SRP iris	#3-#4 iris
#1cell up1	#4cell up1
#1cell up2	#4cell up2
#1cell up3	#4cell up3
#1cell up4	#4cell up4
#1cell down1	#4cell down1
#1cell down2	#4cell down2
#1cell down3	#4cell down3
#1cell down4	#4cell down4
#2-#3 iris	#4-#5 iris
#2cell up1	#5cell up1
#2cell up2	#5cell up2
#2cell up3	#5cell up3
#2cell up4	#5cell up4
#2cell down1	#5cell down1
#2cell down2	#5cell down2
#2cell down3	#5cell down3
#2cell down4	#5cell down4
#2-#3 iris	#5-#6 iris
#3cell up1	#6cell up1
#3cell up2	#6cell up2
#3cell up3	#6cell up3
#3cell up4	#6cell up4
#3cell down1	#6cell down1
#3cell down2	#6cell down2
#3cell down3	#6cell down3
#3cell down4	#6cell down4

11th vertical test pi-mode (18MV/m) ~after HPR



SRP iris	#3-#4 iris	#6-#7 iris
#1cell up1	#4cell up1	#7cell up1
#1cell up2	#4cell up2	#7cell up2
#1cell up3	#4cell up3	#7cell up3
#1cell up4	#4cell up4	#7cell up4
#1cell down1	#4cell down1	#7cell down1
#1cell down2	#4cell down2	#7cell down2
#1cell down3	#4cell down3	#7cell down3
#1cell down4	#4cell down4	#7cell down4
#1-#2 iris	#5-#6 iris	#8-#9 iris
#2cell up1	#5cell up1	#8cell up1
#2cell up2	#5cell up2	#8cell up2
#2cell up3	#5cell up3	#8cell up3
#2cell up4	#5cell up4	#8cell up4
#2cell down1	#5cell down1	#8cell down1
#2cell down2	#5cell down2	#8cell down2
#2cell down3	#5cell down3	#8cell down3
#2cell down4	#5cell down4	#8cell down4
#2-#3 iris	#6-#7 iris	#9-#10 iris
#3cell up1	#6cell up1	#9cell up1
#3cell up2	#6cell up2	#9cell up2
#3cell up3	#6cell up3	#9cell up3
#3cell up4	#6cell up4	#9cell up4
#3cell down1	#6cell down1	#9cell down1
#3cell down2	#6cell down2	#9cell down2
#3cell down3	#6cell down3	#9cell down3
#3cell down4	#6cell down4	#9cell down4

Temperature Offset	
Offset1	0.01
Offset2	0.01
Offset3	0.01
Offset	
#1Cell:	0.2
#2Cell:	0.1
#3Cell:	0.0
#4Cell:	0.2
#5Cell:	0.1
#6Cell:	0.0
#7Cell:	0.2
#8Cell:	0.1
#9Cell:	0.0
Angle Offset	
Offset1	0.0
Offset2	0.0
Offset3	0.0

- HPR was applied.
- Emitter observed at 10th VT were disappeared.
- Q-value recovered.

One new emitter is RF processed and disappeared.

Summary

[He processing]

- We tried He processing at vertical test.
 - Conditioning time is limited by radiation safety and He consumption.
- Two states of enhanced radiation status were observed. → Which is “so called” He processing at other labs?
- At moment , our statistics are too small to make conclusion. However, it indicates;
 - “enhanced mode” seems to be effective,
 - about half of emitter could be processed,
 - sometimes new emitter appear.
- Anyway we will collect more data.

[HPR]

- Tried twice. Both cases, observed emitters were removed after HPR.
- It indicates HPR is effective to remove field emission sources. → But also need more statistics.