

Field emission issue and strategy to improve

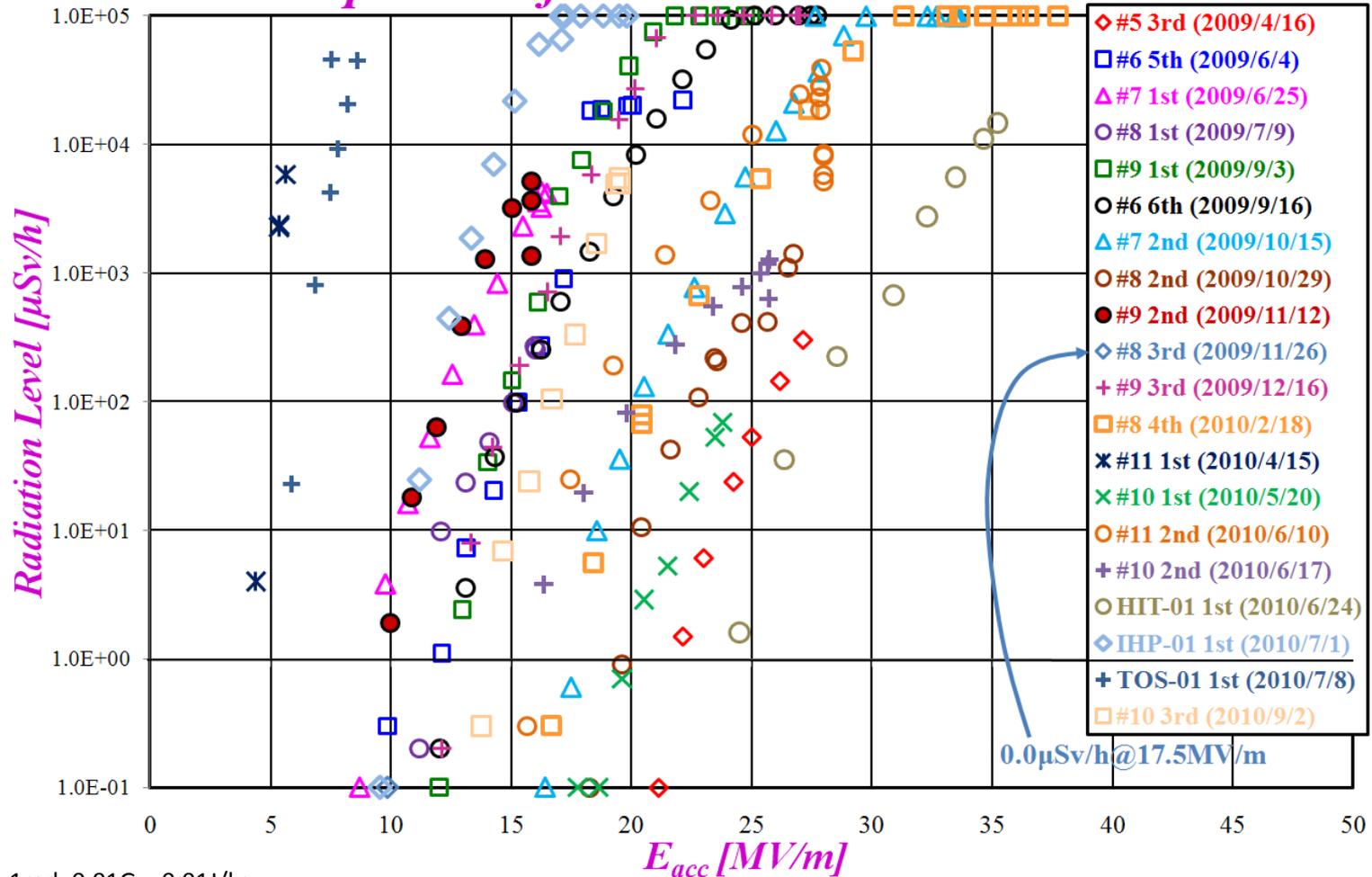
H. Hayano

Field emission Issue in STF

Radiation level of Recent STF cavities in VT

Radiation monitor is placed at Top outside of VT cryostat end-plate, inside of radiation shield.

Comparison of Radiation Level in recent V.T.s



1 Sv=100rem
For X-ray, 1rem=1rad=0.01Gy=0.01J/kg

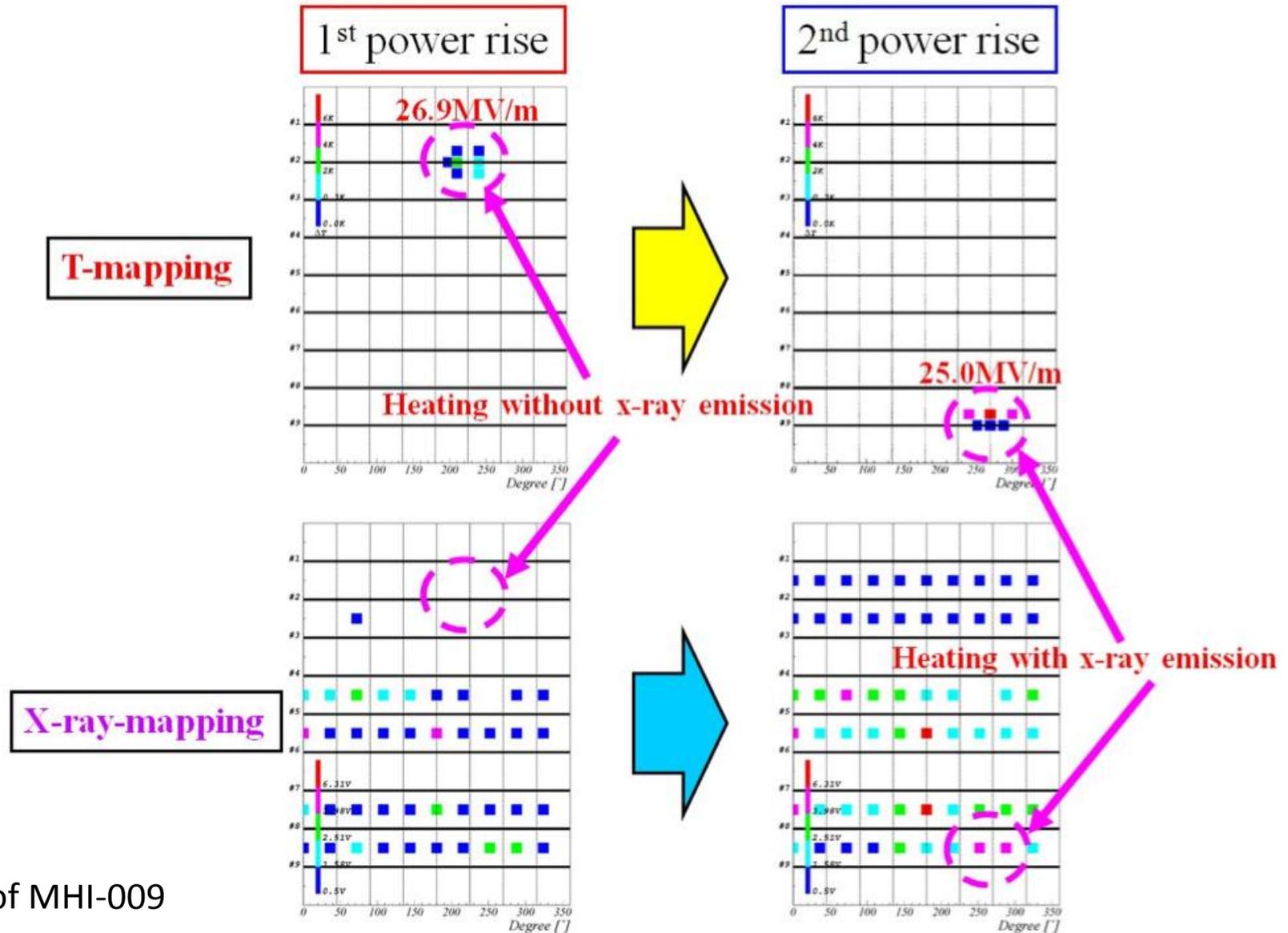
Cf. KEK Radiation worker area: <20 $\mu\text{Sv/h}$

KEK cavities in VT have strong radiation, every time.

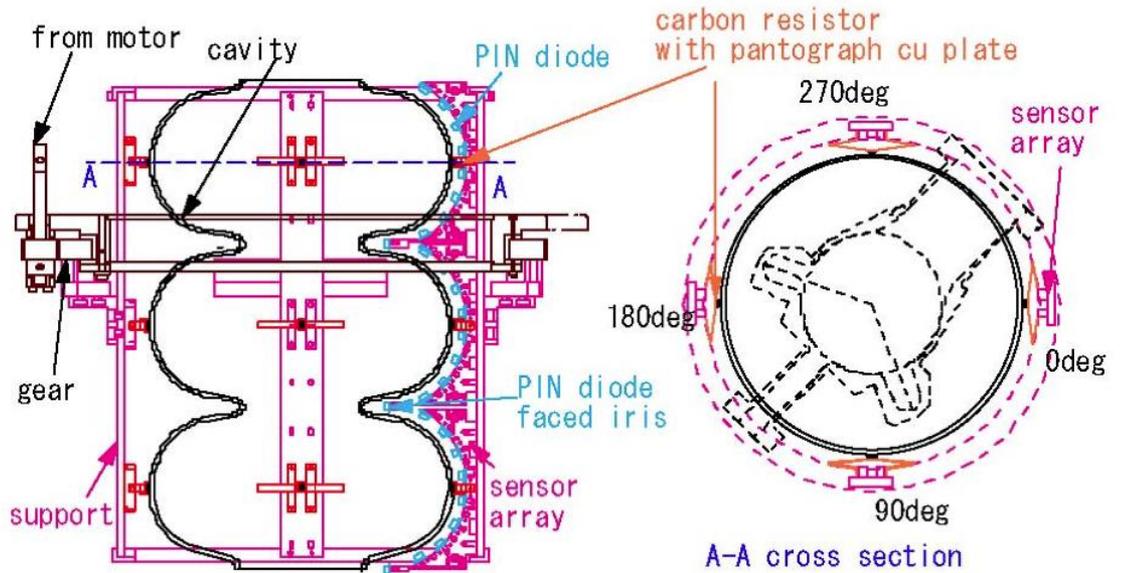
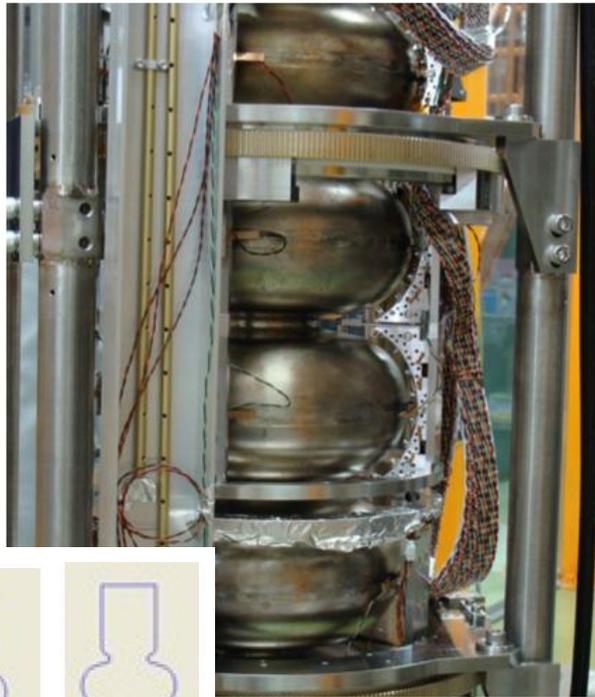
T-map & X-ray-map example in MHI-009 9-cell cavity

Some correlation was observed on T-map and X-ray-map.

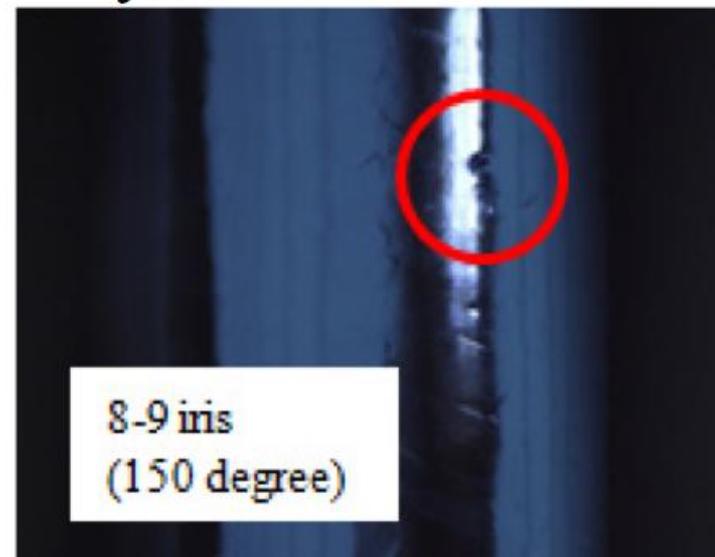
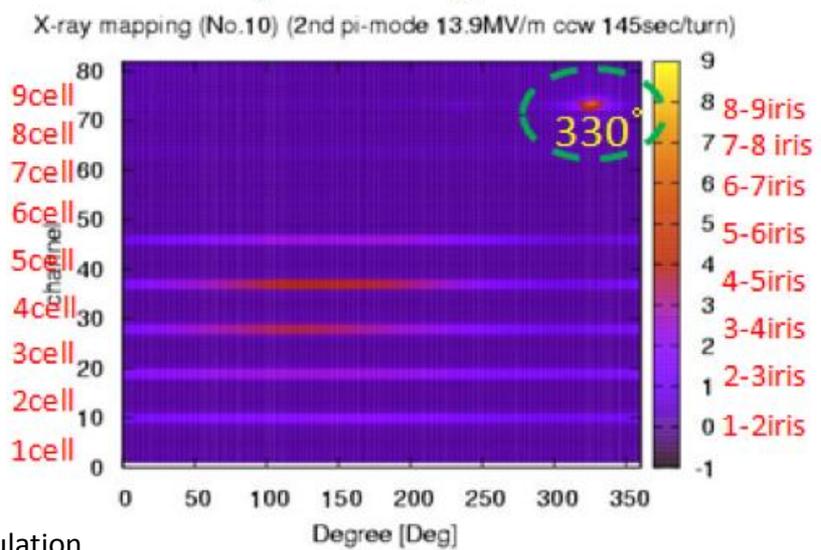
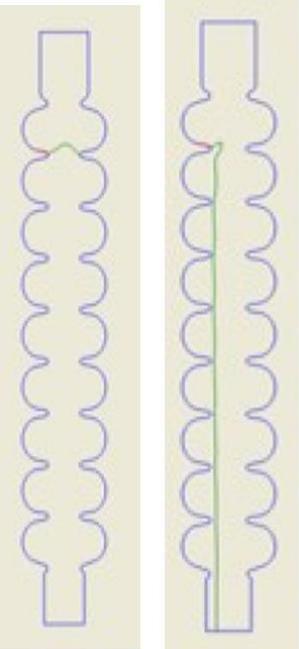
We could not observe the source defect by Kyoto-camera. Not enough resolution?



Field emission by defect on iris, happened in KEK ERL 9-cell cavity



ERL X-ray map: Total 82 PIN diode array rotates around cavity



Electron trajectory calculation

Top & bottom PIN-diodes on beam-pipe flange of 9-cell cavity

X-ray signal intensity

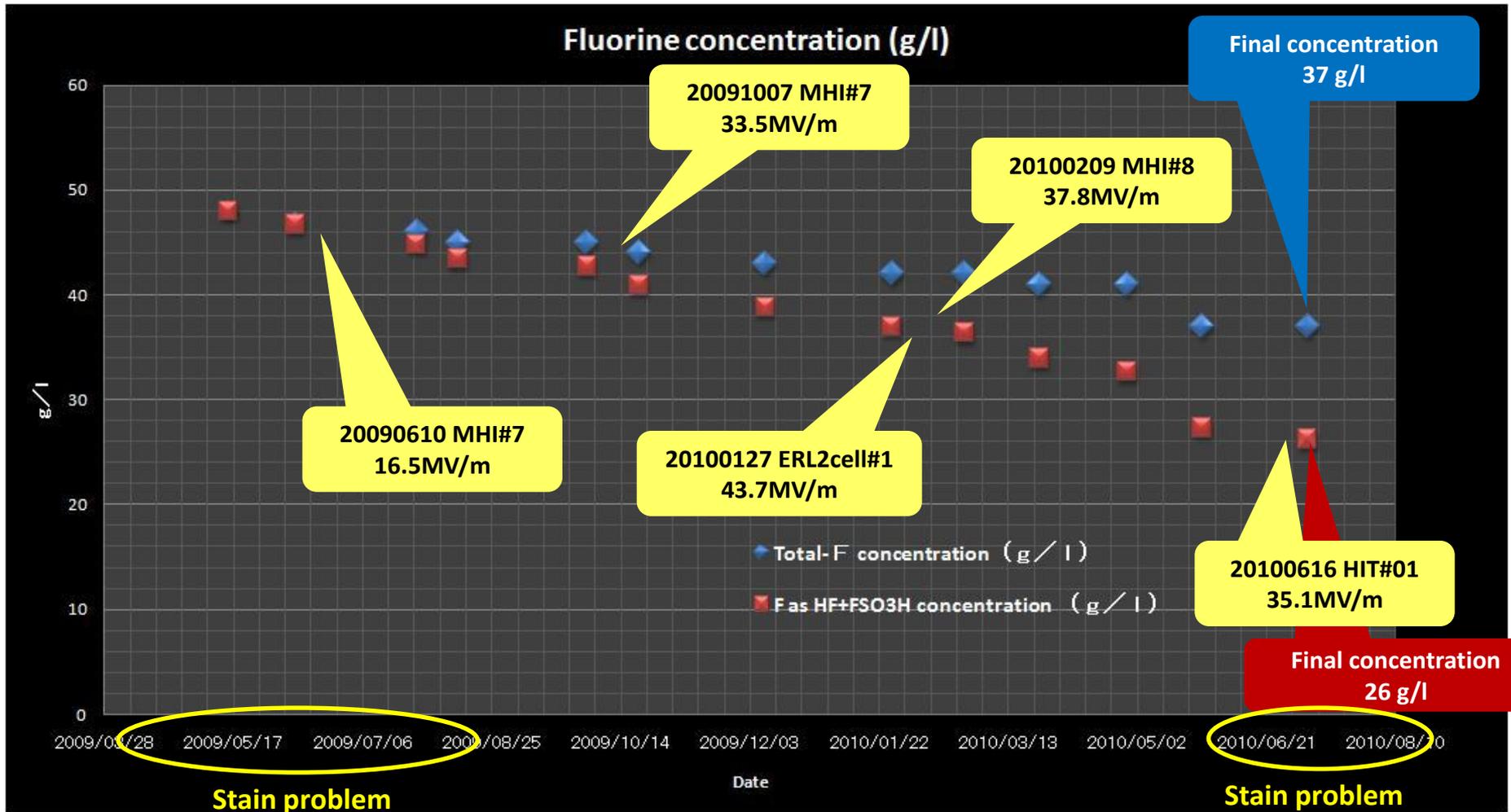
cavity	# of V.T.	Gradient [MV/m]	Radiation level [$\mu\text{Sv/h}$]	P.D. (Top) [V]	P.D. (Bottom) [V]	larger direction
MHI#5	1 st	27.3	>999	>>10	>10	top
MHI#5	2 nd	19.7	134	5	1	top
MHI#5	3 rd	27.1	303	0	0	–
MHI#6	1 st	25.7	>999	>10	8	top
MHI#6	4 th	19.6	0	0	0	–
MHI#6	6 th	27.7	>99900	13	0	top
MHI#7	1 st	16.5	4120	4	10	bottom
MHI#7	2 nd	33.6	>99900	>14	1	top
MHI#8	1 st	16.0	256	0	0.5	bottom
MHI#8	2 nd	26.8	1410	0	5	bottom
MHI#8	3 rd	17.5	0	0	0	–
MHI#8	4 th	37.8	>99900	>14	3	top
MHI#9	1 st	25.0	>99900	>10	10	top
MHI#9	2 nd	15.9	1360	0.5	0	top
MHI#9	3 rd	27.0	>99900	>14	0	top

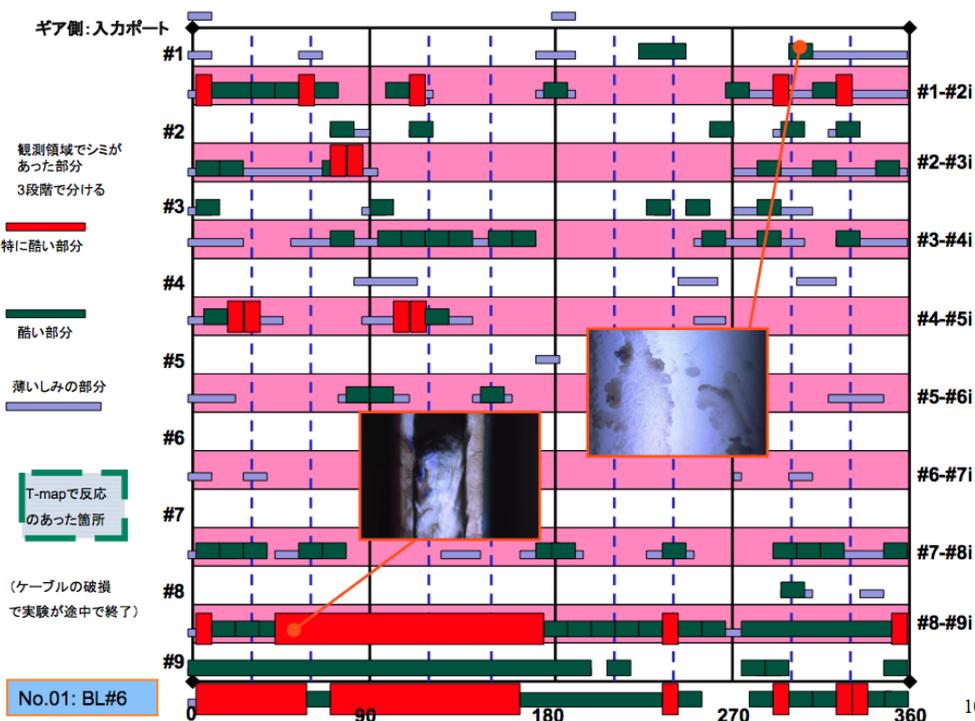
MHI cavity favors to emit radiation on top side

(input coupler port on top, VT power from bottom beam pipe end plate).

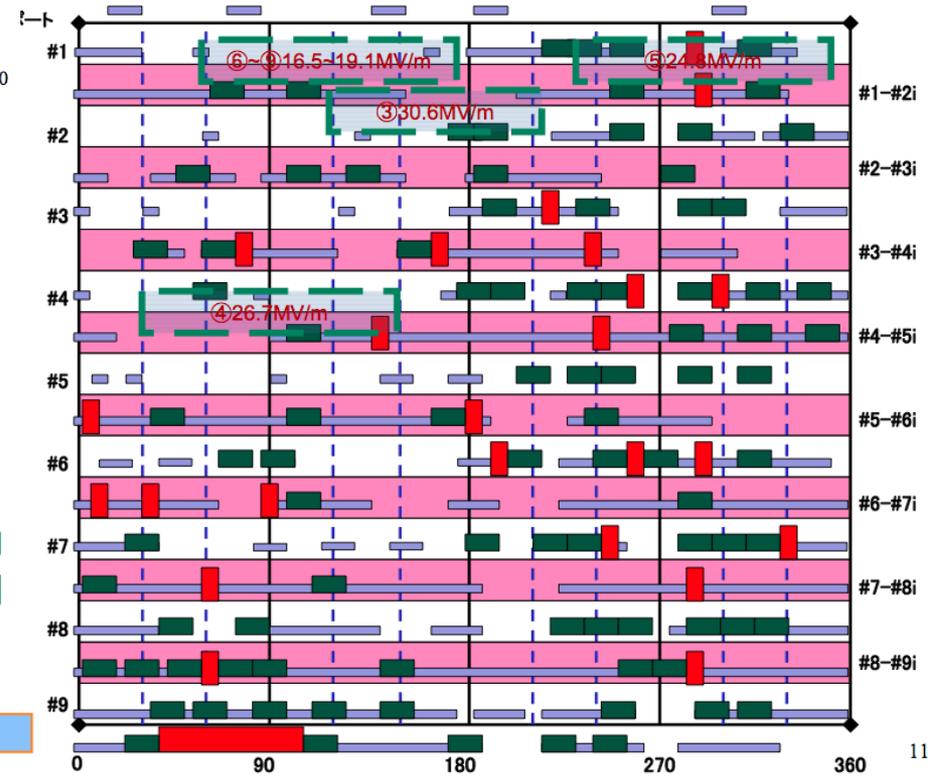
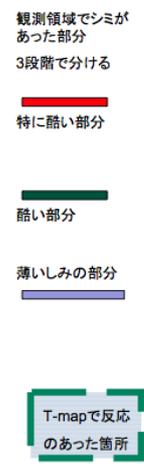
Stain problem in STF

Fluorine concentration change in 2000 litter EP acid for 1 year

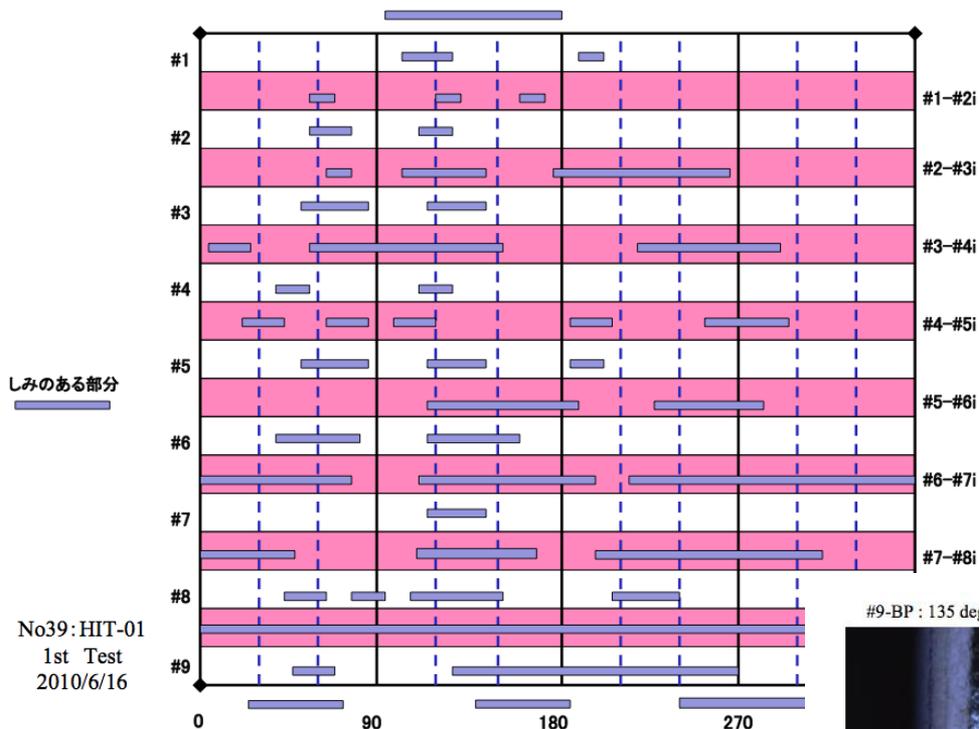




A lot of stains were found in MHI-006,
However, field was limited by RF cable trouble
at 20MV/m. (2009.06.04)



MHI-007 cavity limited at 8~16MV/m,
with stains in right figure.(2009.06.25)



HIT-01 cavity without HOM reached 35MV/m,
with stains below.

#9-BP : 135 deg.



#5-#6 iris : 123 deg.



#9 : 143 deg.



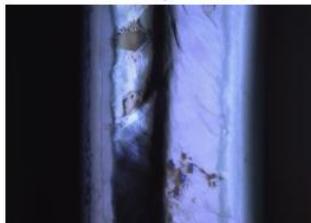
#8-#9 iris : 136 deg.



#1 : 106 deg.



#8-#9 iris : 238 deg.



#2 : 118 deg.

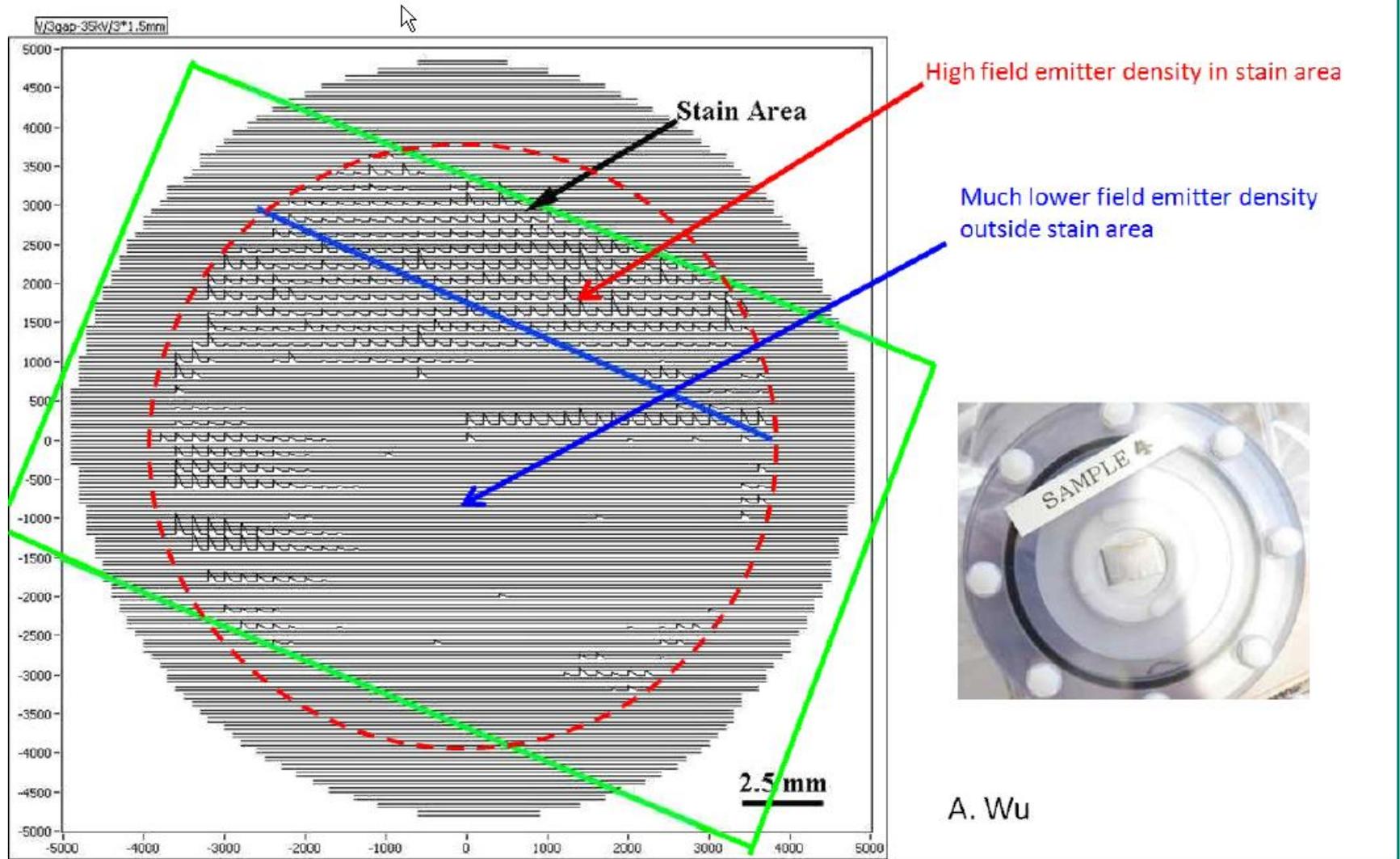


**Relation with field emission and stains
is not clear !**

Field emitter scan on stain sample : JLAB-KEK collaboration

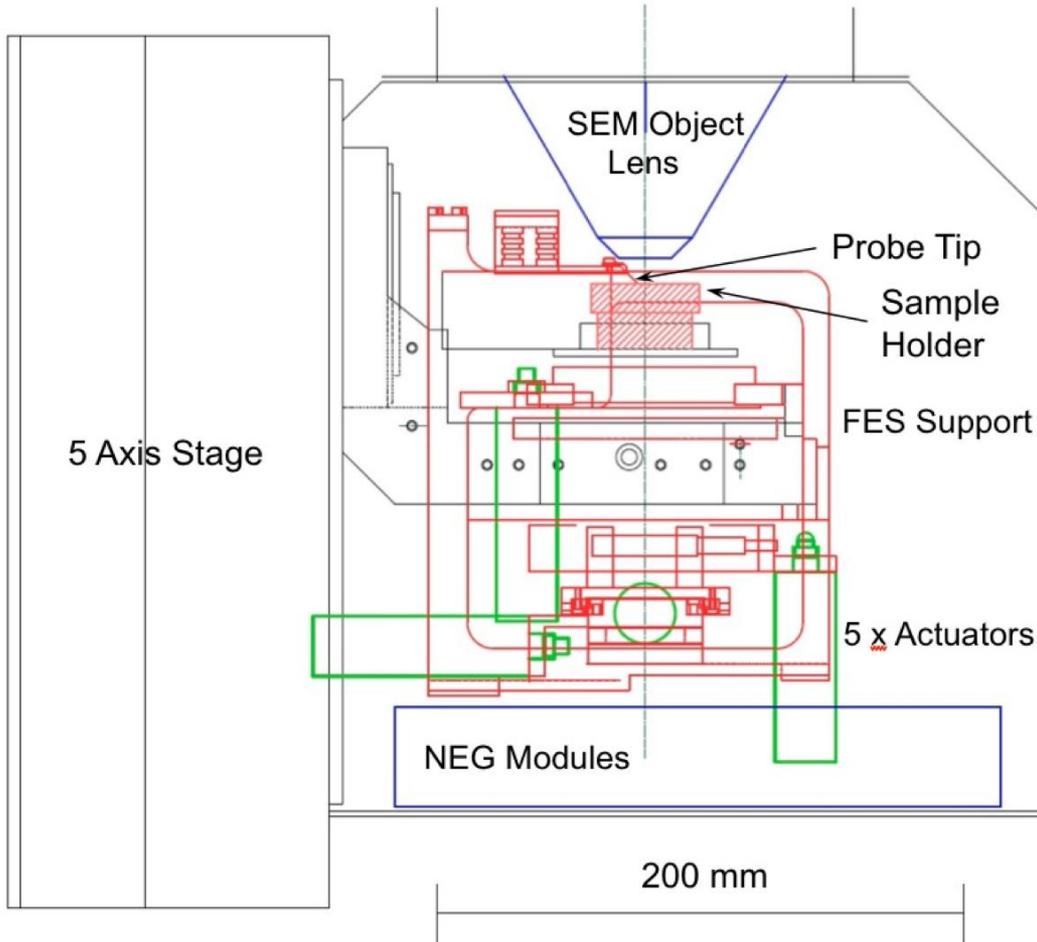
JLab SFSEM analysis of KEK rectangular shape EP'ed Nb coupon with stain

First data of DC field scan up to 140 MV/m. It seems to confirm stain being source of FE.

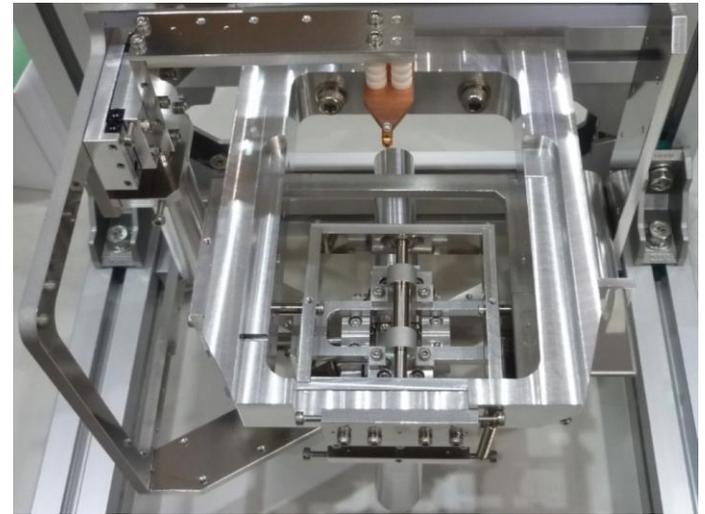


For more systematic study of field emission and stain correlation,
SEM-FES combination device is under development in KEK

Scanning Electron Microscope – Field Emission Scanner



Schematic view of SEM-FES



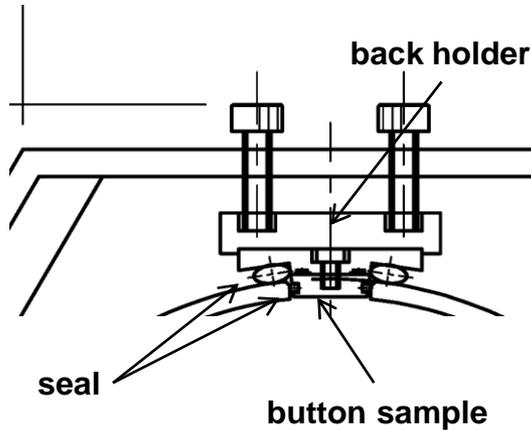
Picture of SEM-FES movable table under developing

EP'd surface analysis (monitoring) using button samples

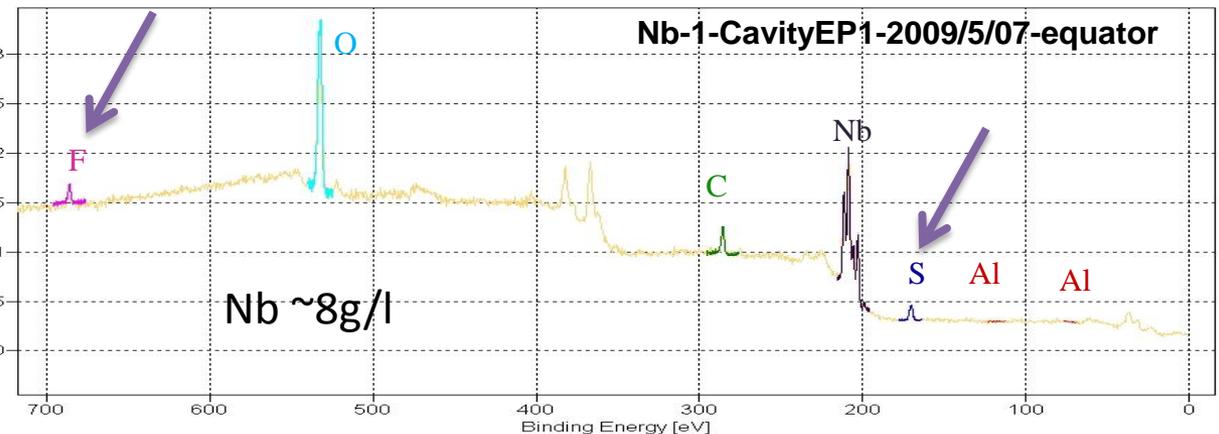
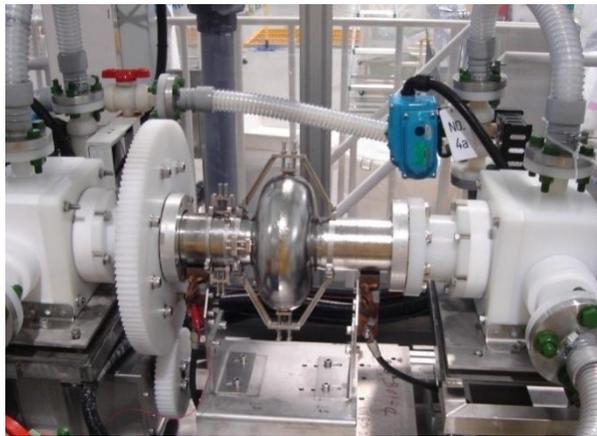
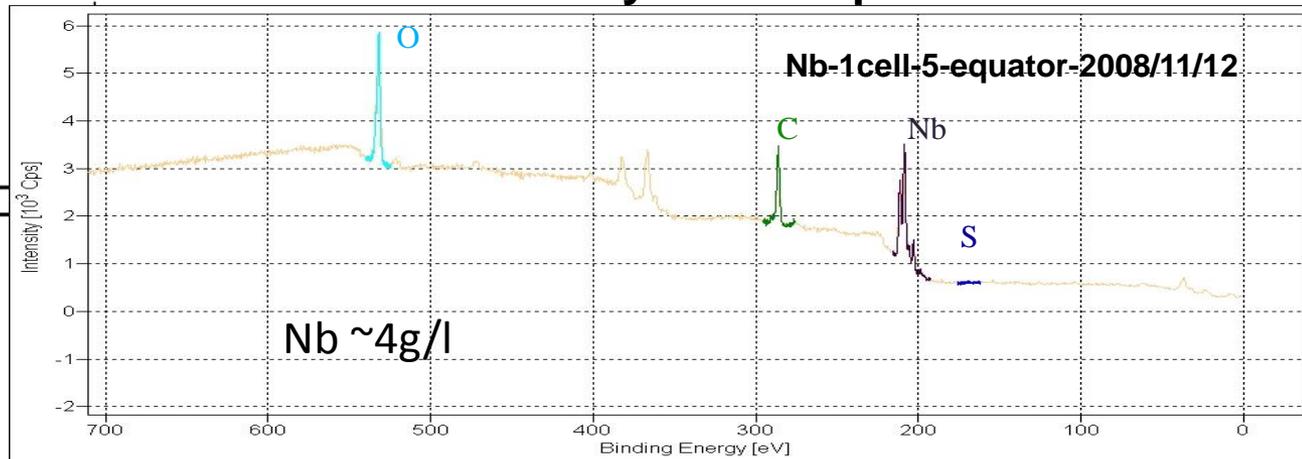


For understanding of Residuals after treatment,
SEM-EDX, XPS, AES, SIMS are the tool of analysis.

Nb button samples: 8mm dia.



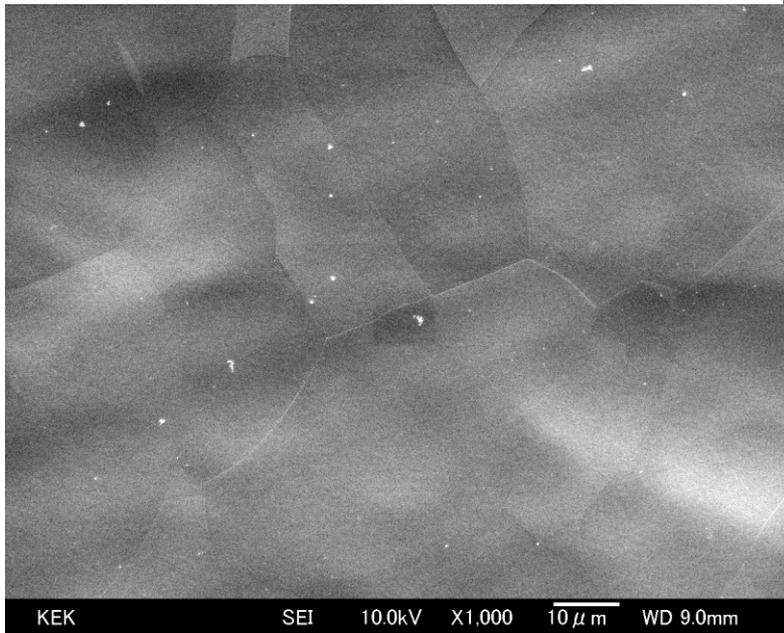
XPS analysis example



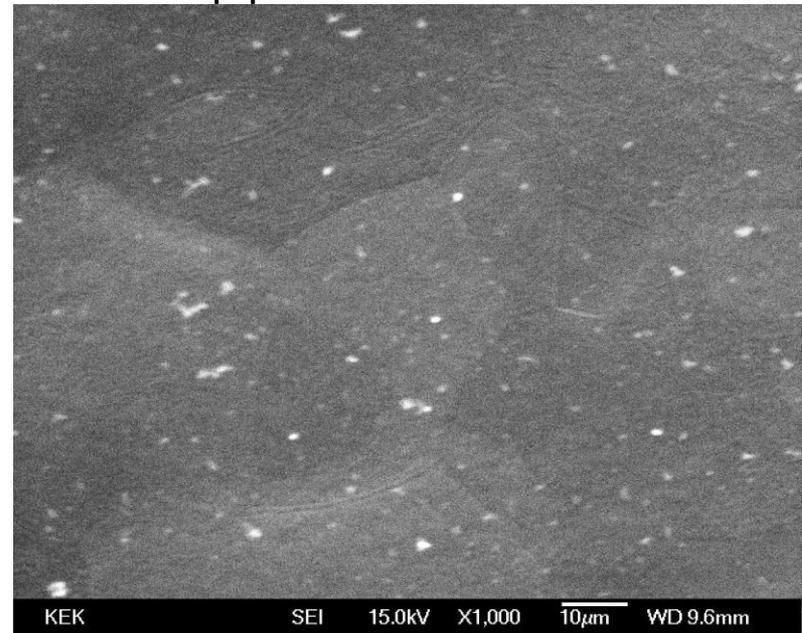
EP'd surface analysis (monitoring) using button samples

SEM analysis example

button sample on beam-pipe



new EP acid

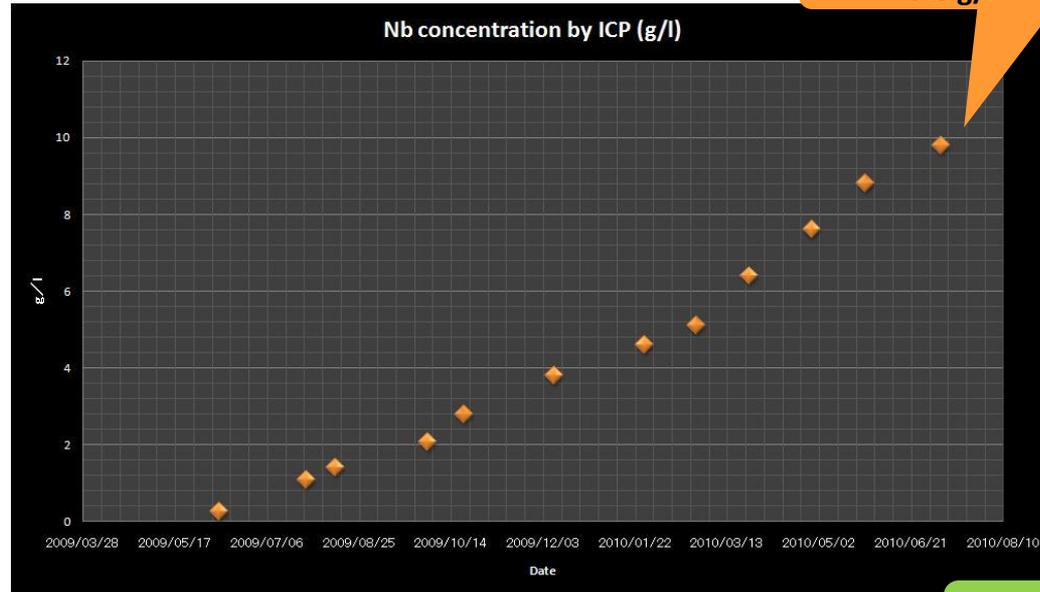


aged EP acid (Nb = 7.9g/l)

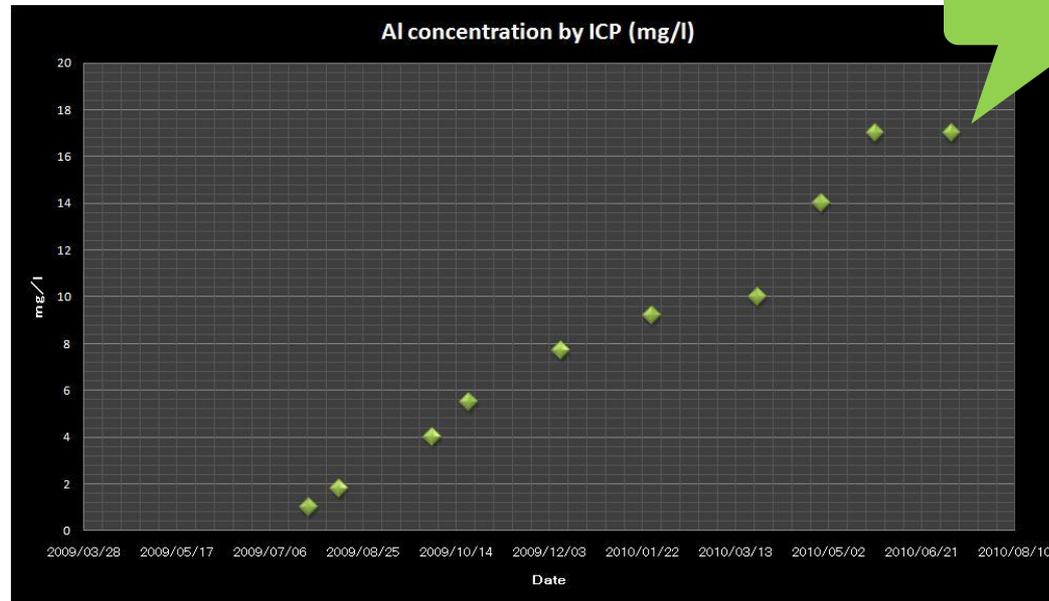
(Our EDX could not analyze the white spot.)

Monitoring dissolved metal in EP acid

Nb



Al



How to suppress Field emission

Jlab succeeded field emission reduction

Strategy to reduce field emission,

- (1) Analyze Jlab process and learn from them
 - STF will send people to Jlab with STF cavities
 - fair comparison of radiation level, EP process, rinse, clean-room work
- (2) Identify the source location by upgrading
 - T-map, X-ray-map, inspection camera
- (3) Q.C. of cavity handle (clean room work)
 - Review of cavity handling work
 - Training of people, establish procedure
- (3) EP process optimization and monitoring
- (4) rinsing optimization and monitoring
- (5) research on EP'd surface