Shielding Design of Test Facility for Superconducting RF Cavity of PLS II and Commissioning Results

Hee-Seock Lee*, Nam-Suk Jung, Sukmo Hong,
Radiation Protection Team
Young-Uk Sohn
1st Engineering Team
Pohang Accelerator Laboratory, POSTECH

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PLSII - Upgrade Project of PLS

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Commissioning of the PLS-II[1]

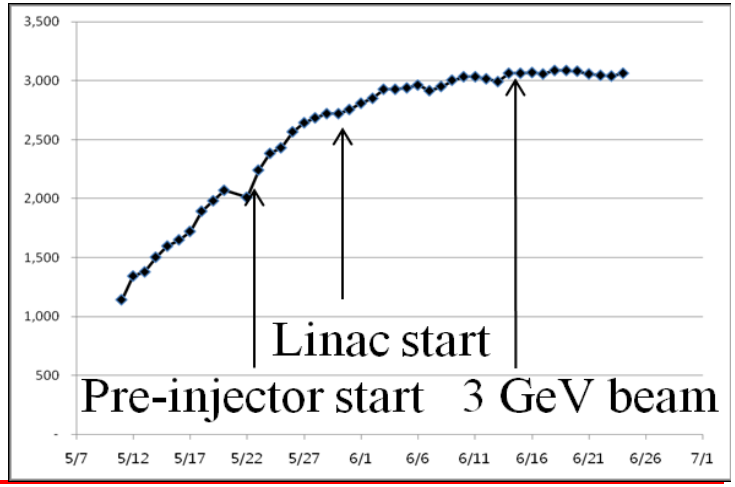
S. Shin,[2] S. Kwon, D-T. Kim, D-E. Kim, M. Kim, S-H. Kim, S-C. Kim, J. Kim, C. Kim, B. Park, S-S. Park, S-J. Park, E. Park, Y. Son, J. Yoon, B. Lee, E. Lee, J-W. Lee, H-S. Lee, Y. Joo, J. Choi, T. Ha, W. Hwang, I. Hwang, J-Y. Lee, B. Oh, C-H. Lee, H-S. Lee, J-Y. Kim, J.Y. Hwang, S.H. Nam and M. Cho

Pohang Accelerator Laboratory,
Pohang, Kyungbuk 790-784, Korea

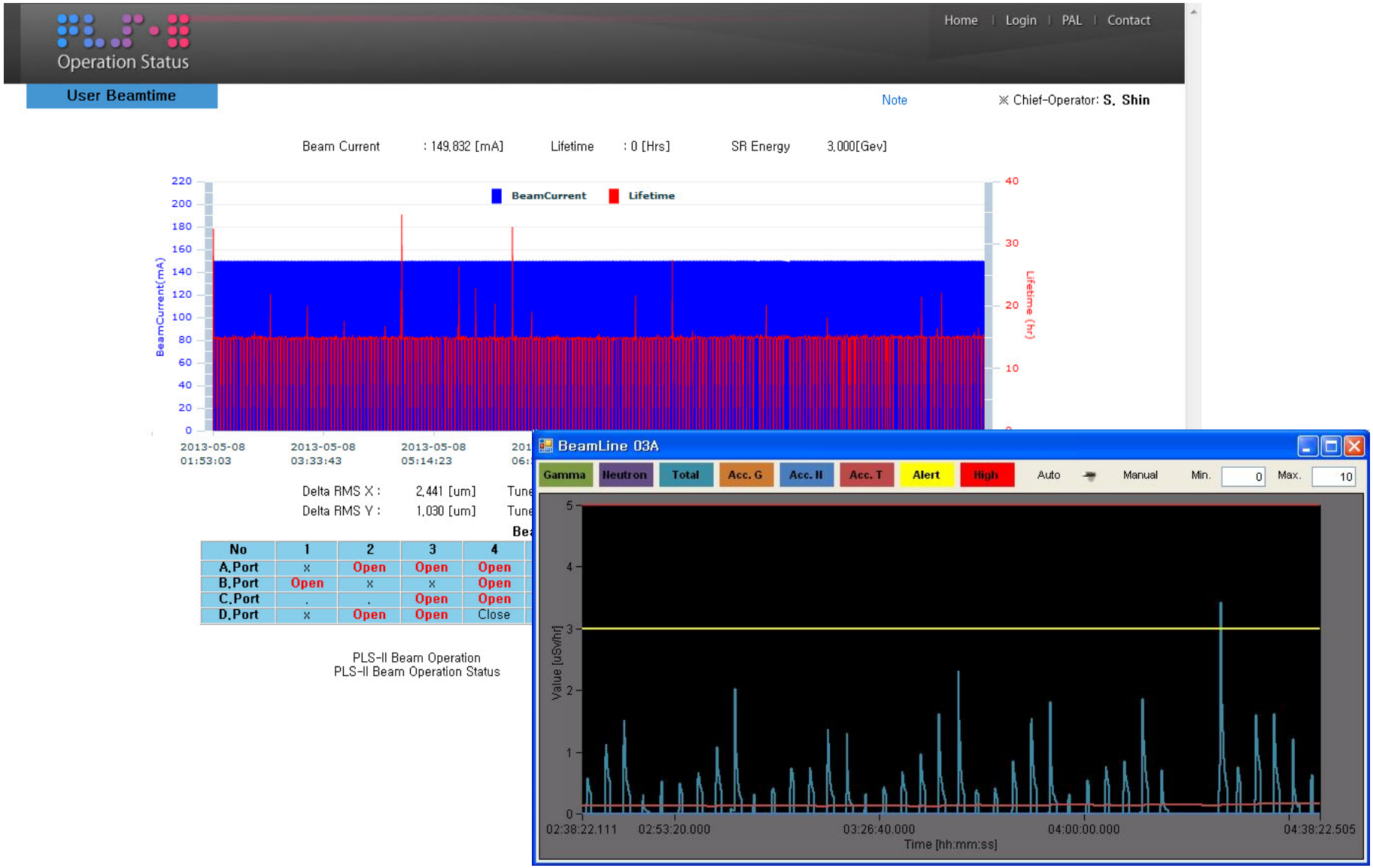
2013 JINS

PLSII - its beginning history

- Operation of PLS stopped on 10 AM at Dec. 10th, 2010
- Dismantling started on 9 AM at Dec. 9th, 2010.
- PLSII installation started at Jan. 23rd, 2011
- 23 May 2011, Linac commissioning begins after Radsynch2011
- 13th June, first linac beam at 3 GeV
- 1 July, first beam to SR
- **7 October, 100mA stored at SR**
- 24 October, First photons to beam lines
- 14 February 2012, Commissioning with users
- **21 March 2012, Start of user operations**



PLSII - Its Presents



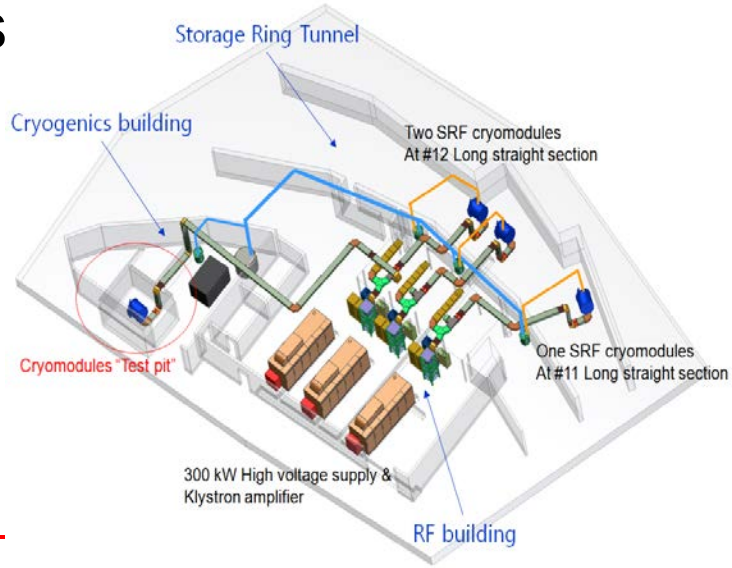
Superconducting RF Cavity at PLSII

- Operation Goal
  - 3 GeV, 400 mA, Top-up Mode
  - 20 Insertion Devices including 14 undulators
  - Beam loss power for each turn : > 500 kW

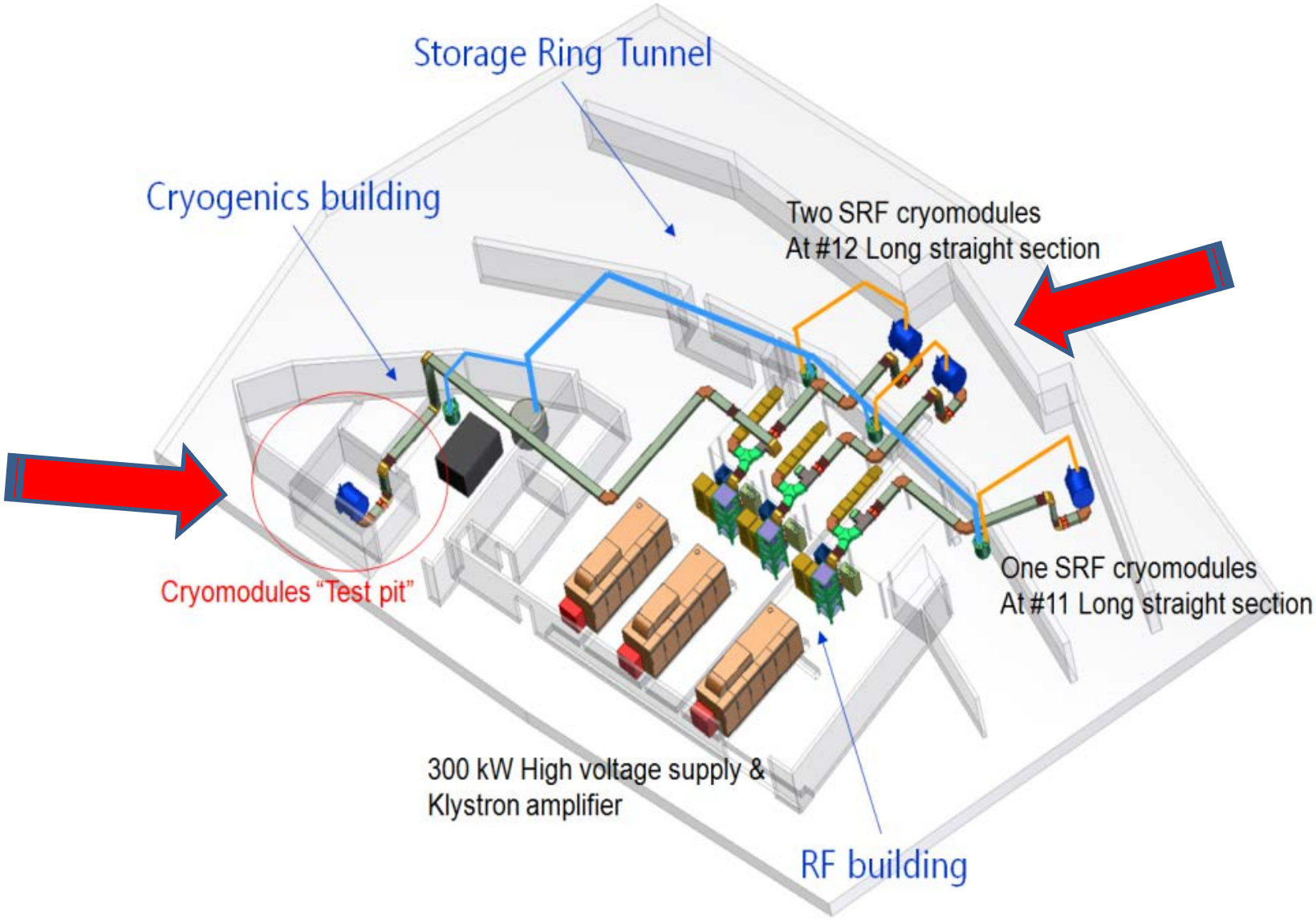
- High Power Cavity is required : Superconducting

  Fundamentally, Two SRF cavities

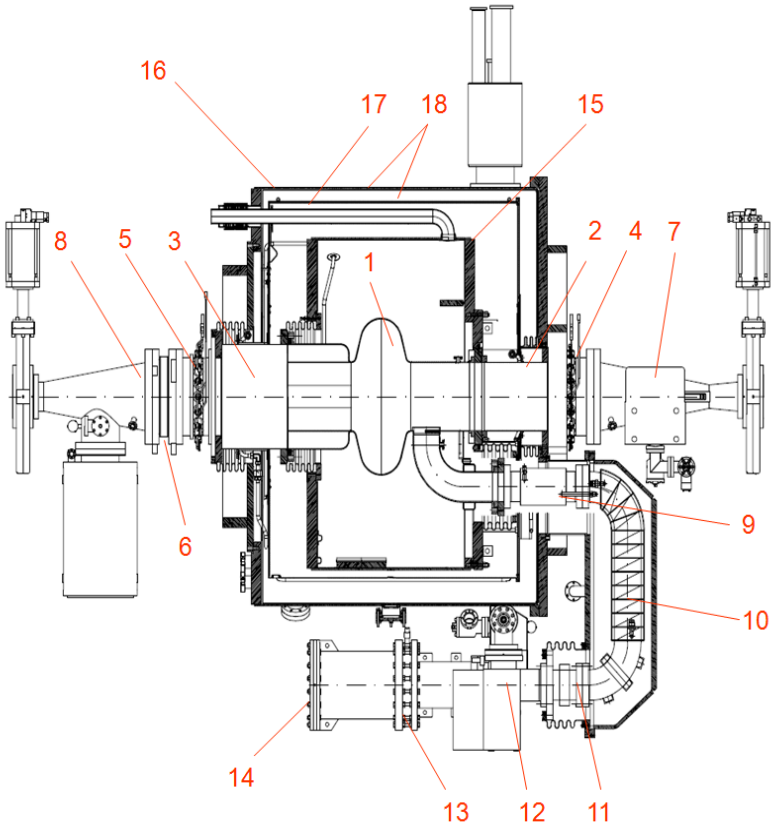
  Finally, Three cavities

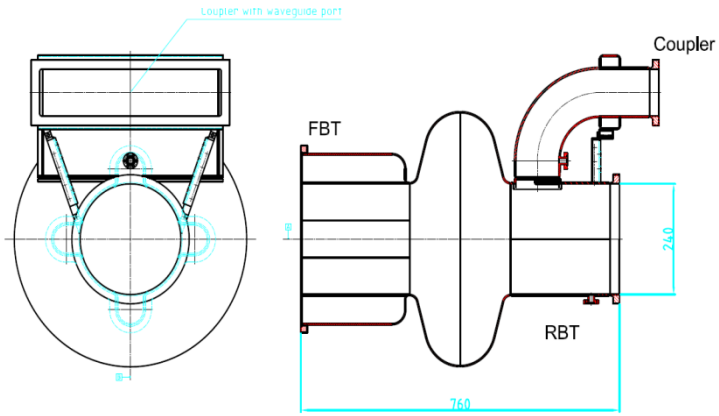


Superconducting RF Cavity at PLSII



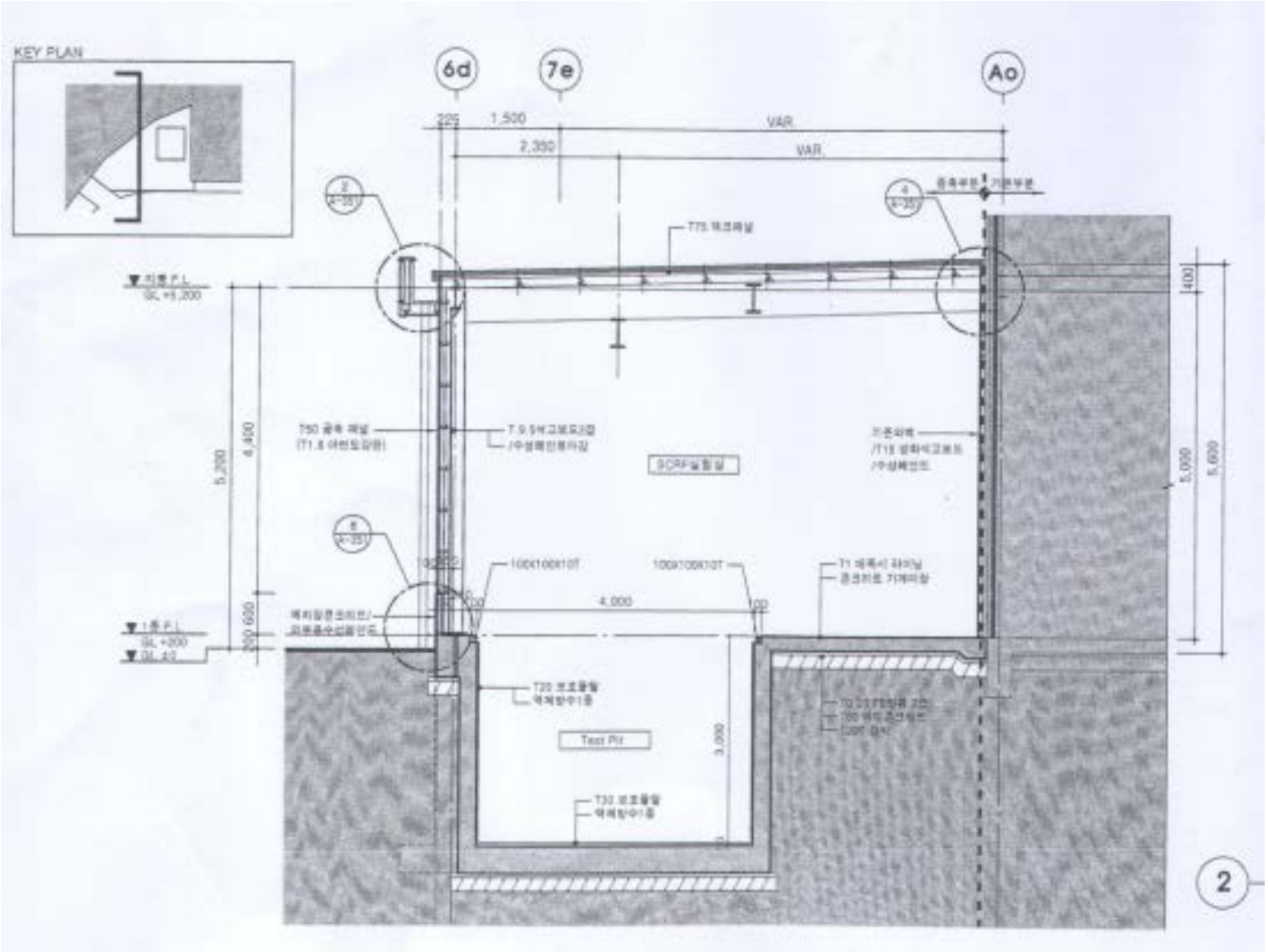
SRF Cavity Specifications





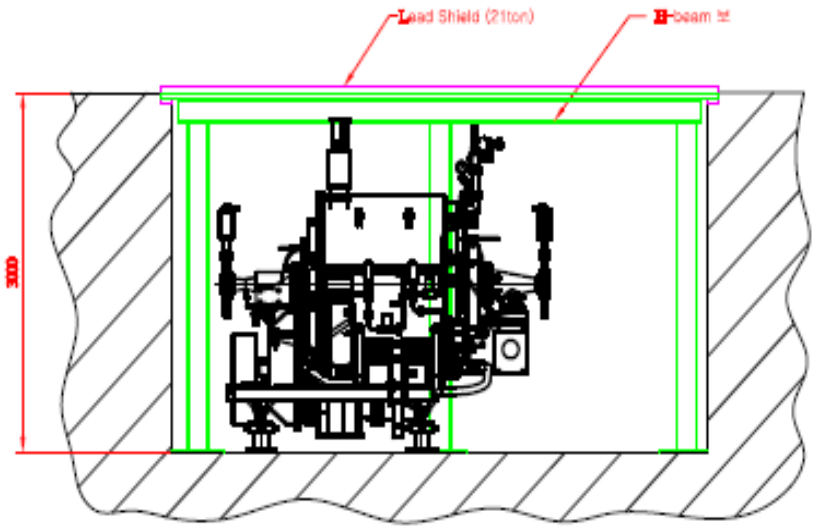
- CESR B-factory type SRF cavity (500 MHz)
- He tank : 3 mm SUS + 3 mm Cu + 1mm Mu-metal + 3 mm SUS
- **Cavity : 3 mm Nb**
- V_{acc} > 2.8 MV **(Nominal Voltage = 2 MV)**
- $E_{acc,max}$: 8.33 MV/m

Test Fit for SRF cavity conditioning

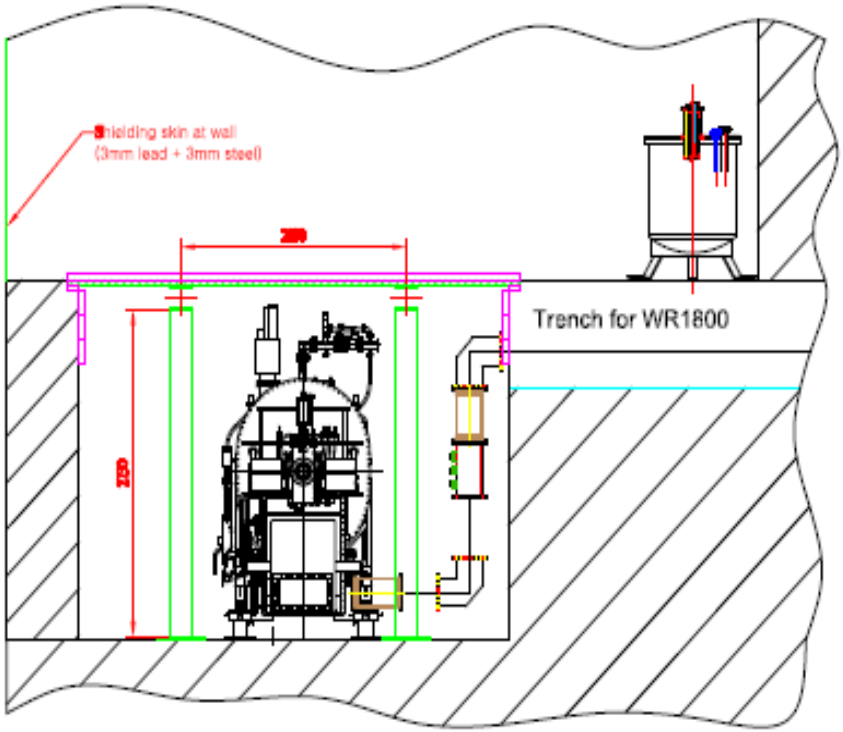


Test Fit for SRF cavity conditioning

- Concrete Fit (3 m in depth, 5 m in length, 4 m in width)
- Outer wall of building at NE side – restricted area (0.25 < D < 1 mSv/year)

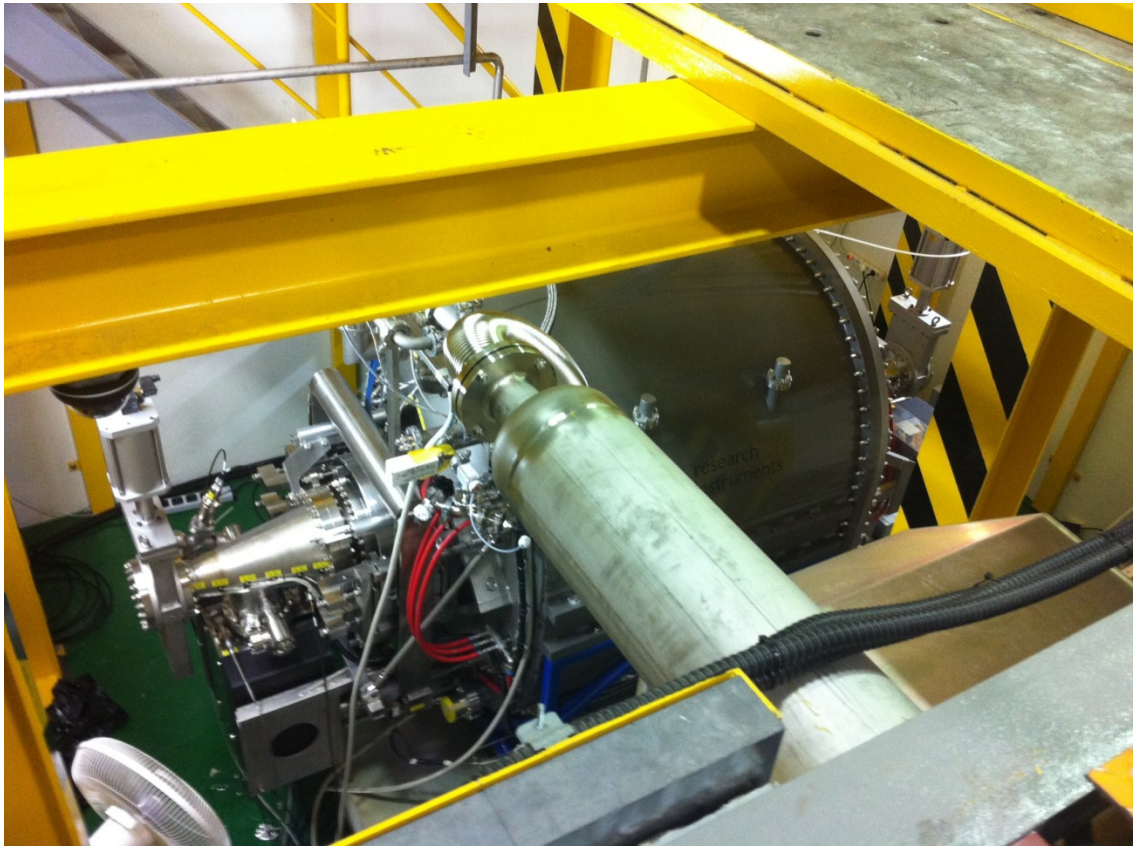


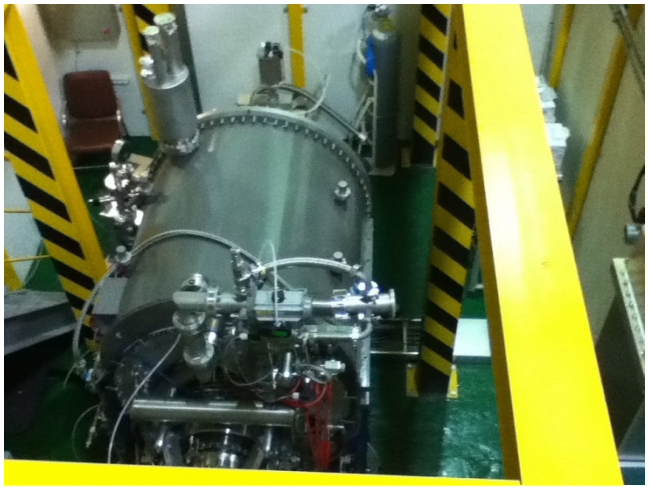
Front View in the Test-pit



Side View

Test Fit & SRF cavity

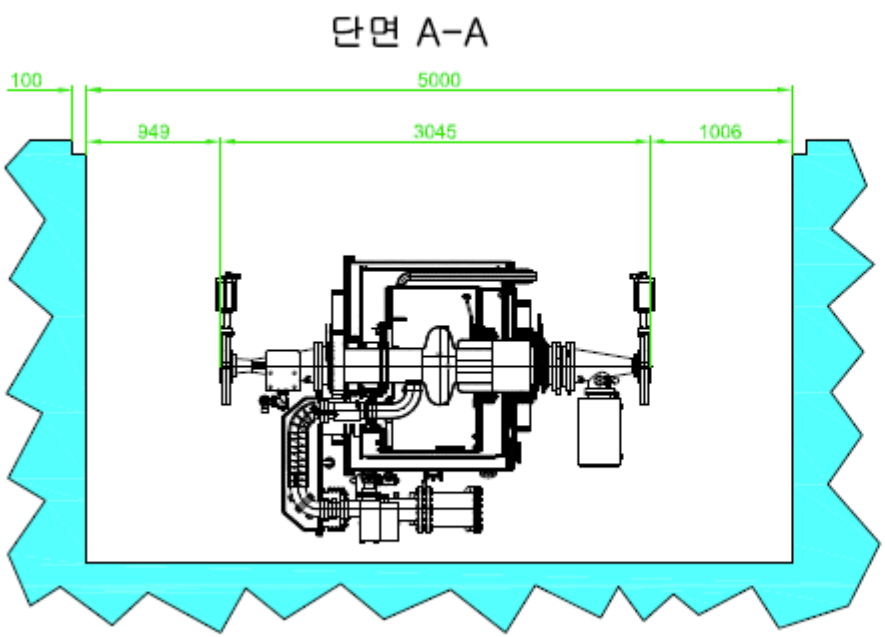


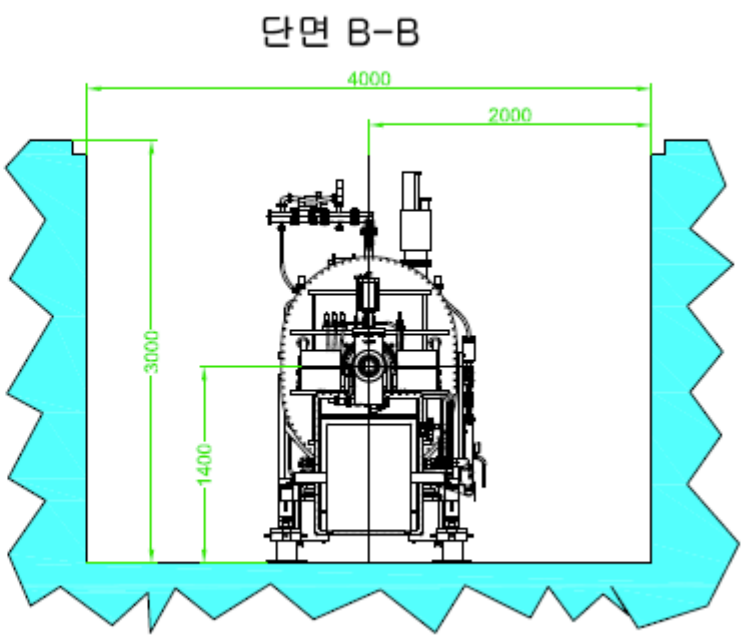


Parameters for Shielding Analysis

- 2.0 MeV (Nominal condition)
- Dark Current due to field emission:
  RF power coupled into field emission (Cornell Univ.) = 80 W
  80/0.72= 110 uA = 1.8 E+15 electrons/sec
- Target: 3 mm thick Nb sphere (for cavity)

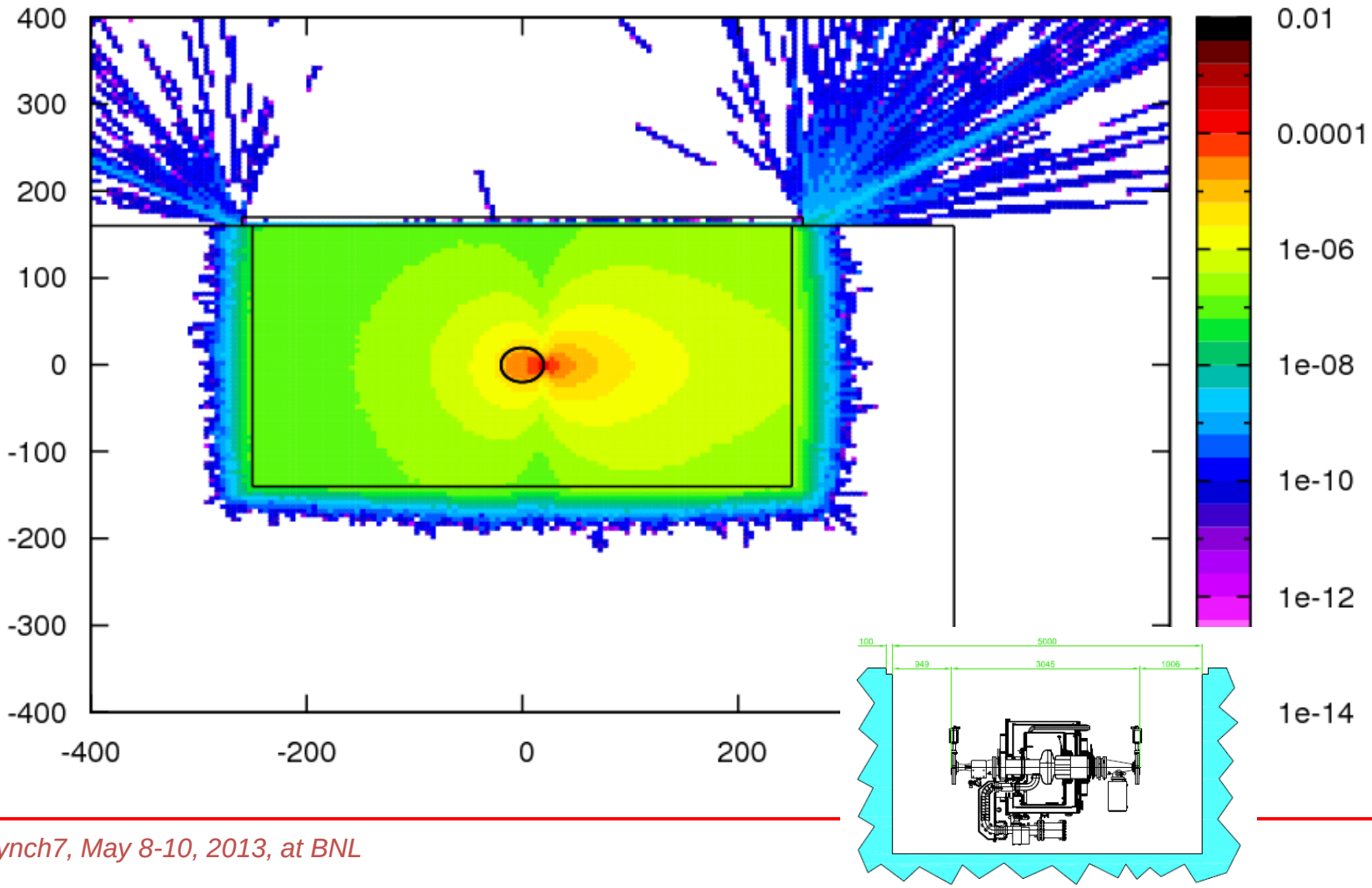
Too High !





Stray Radiation at boundary edge

10 cm(T) Pb cover panel & 10 cm overlap at boundary
Dose rate unit : pSv/electron



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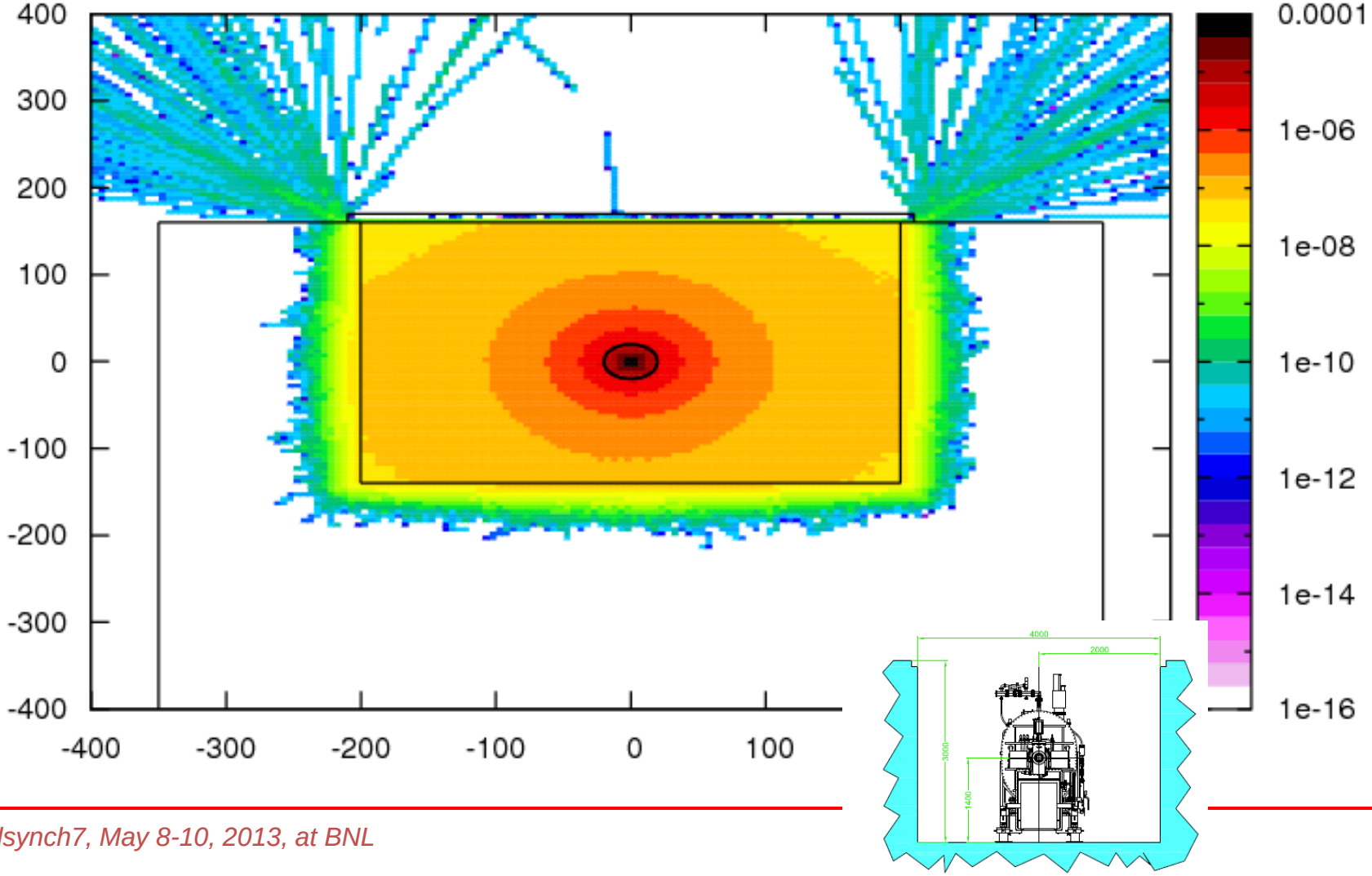
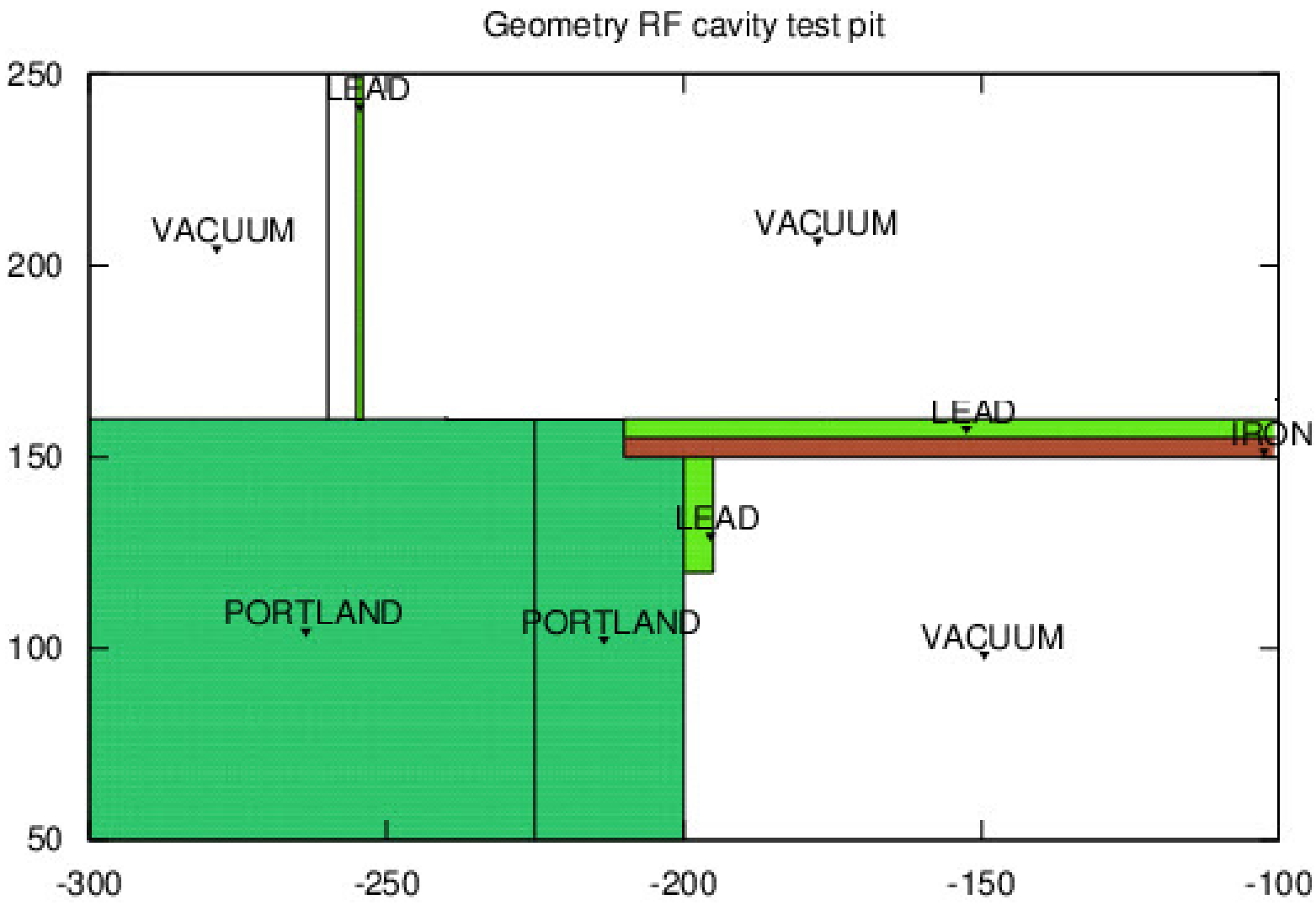
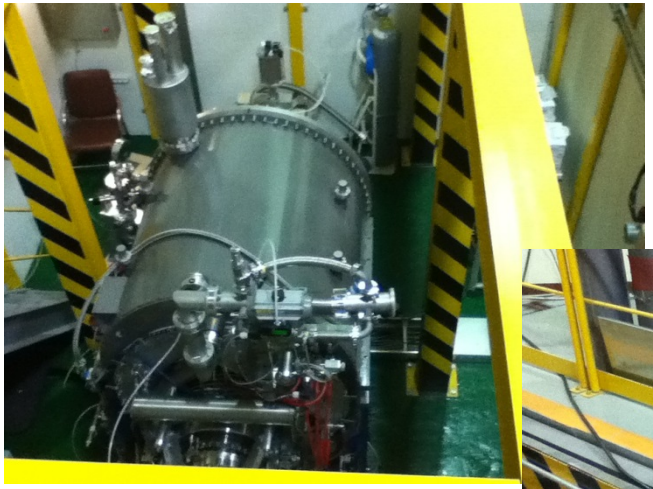


Shielding structure proposed finally

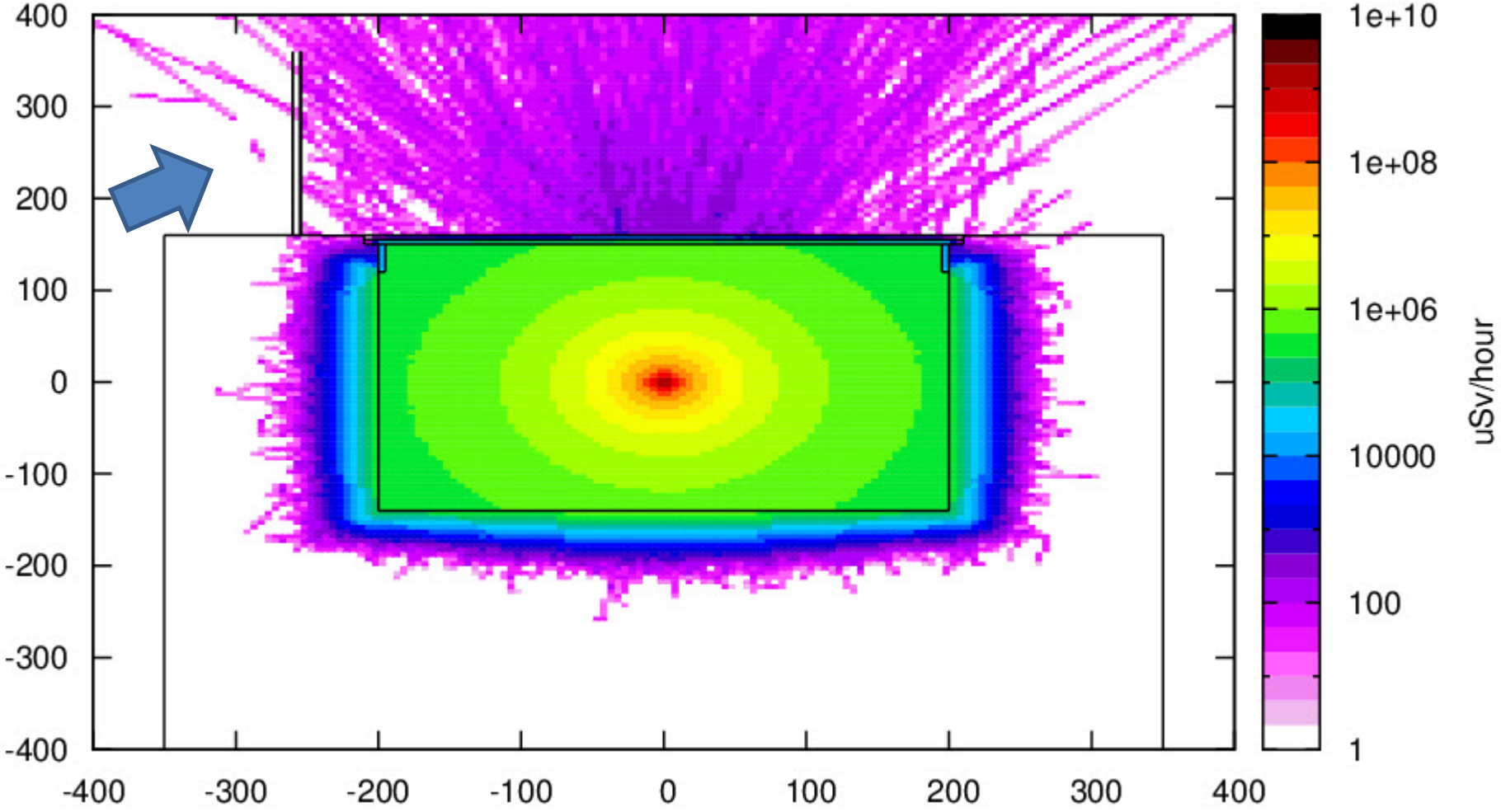


Shielding structure proposed finally

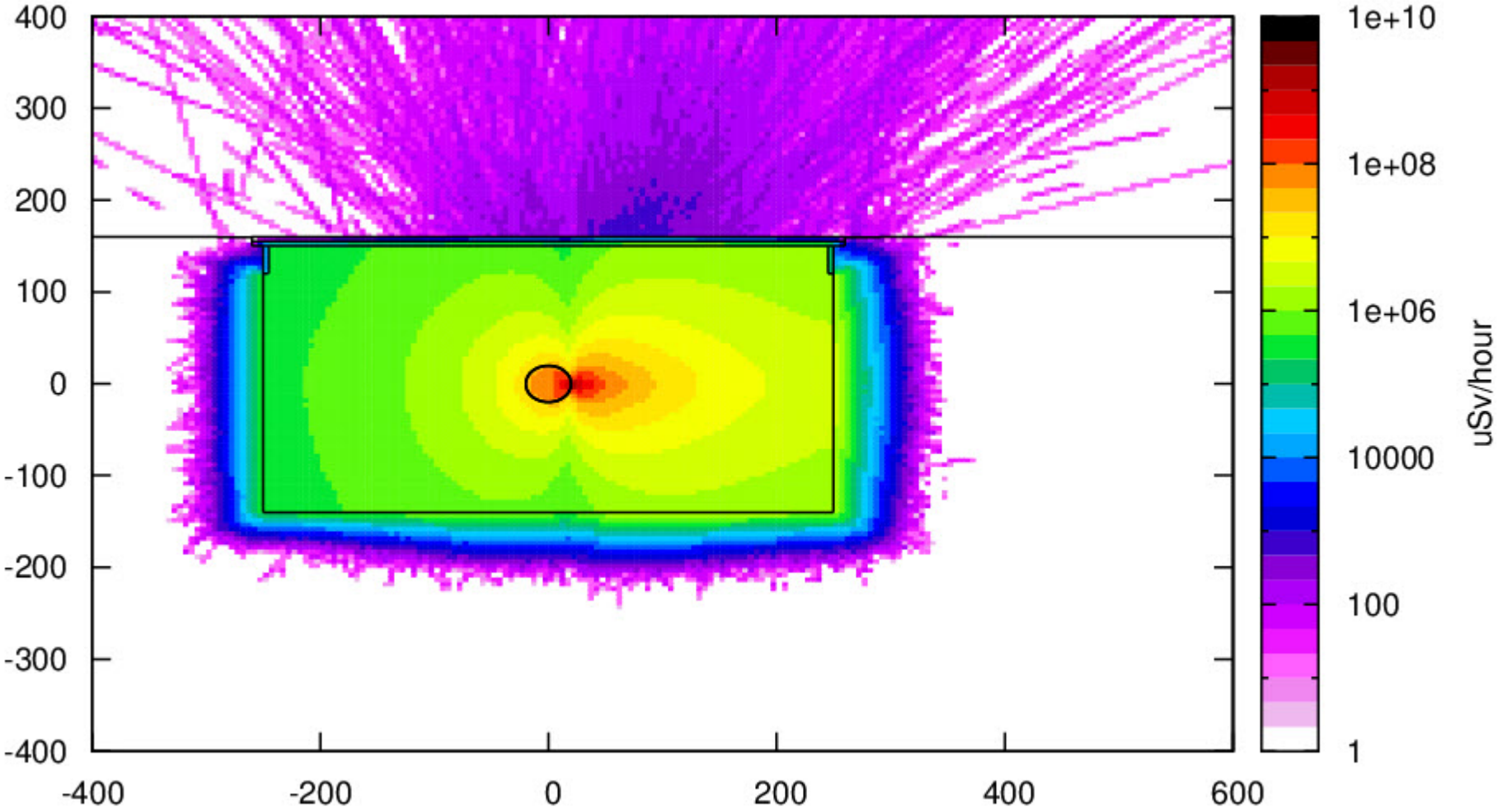
- Boundary Edge: 5 cm (T), 30 cm (H) Lead Belt
- Cover Panel: 5 cm (T) Lead + 5 cm (T) Steel (lower)
- Overlap by panel: 20 cm
- Additional wall for uncontrolled area: 1 cm (T) Lead
- Additional cover for waveguide channel: 5 cm (T) Lead



Dose Distribution at lateral cross-section

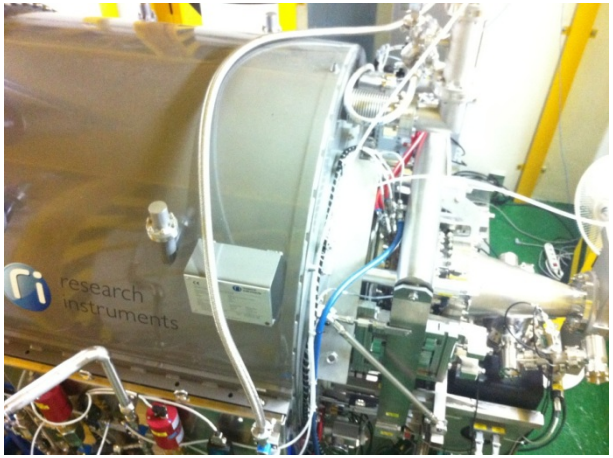


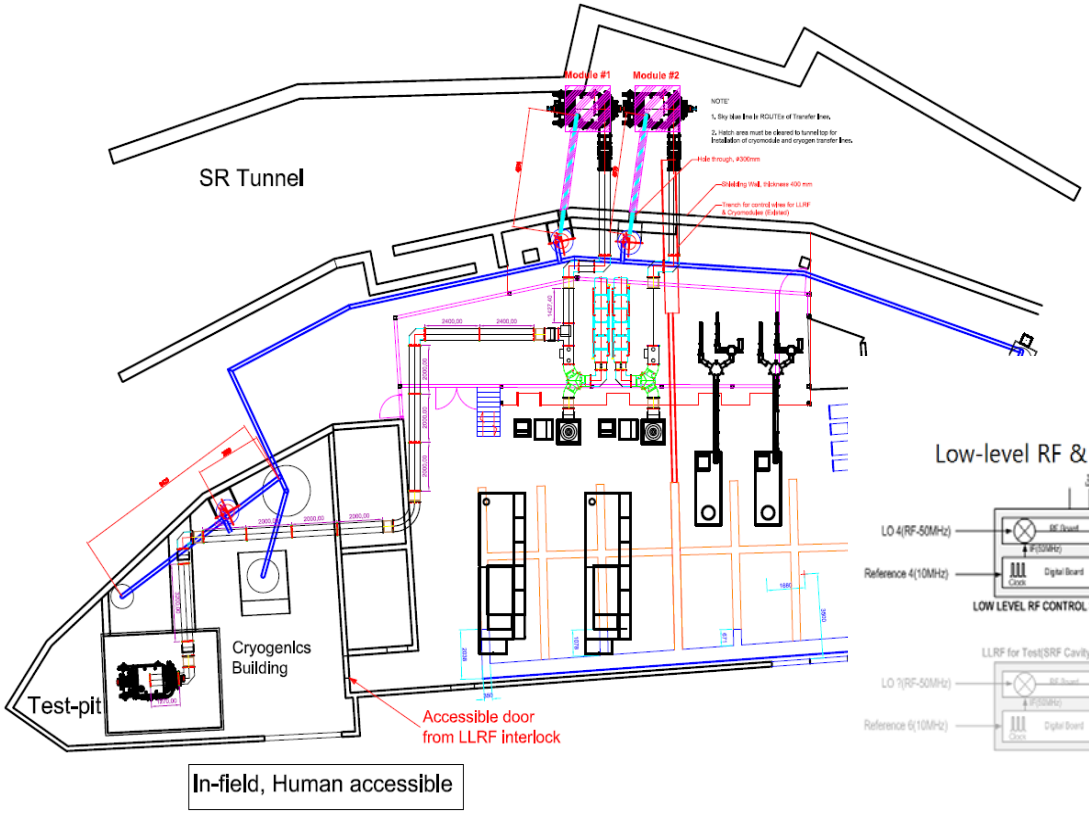
Dose Distribution at longitudinal cross-section

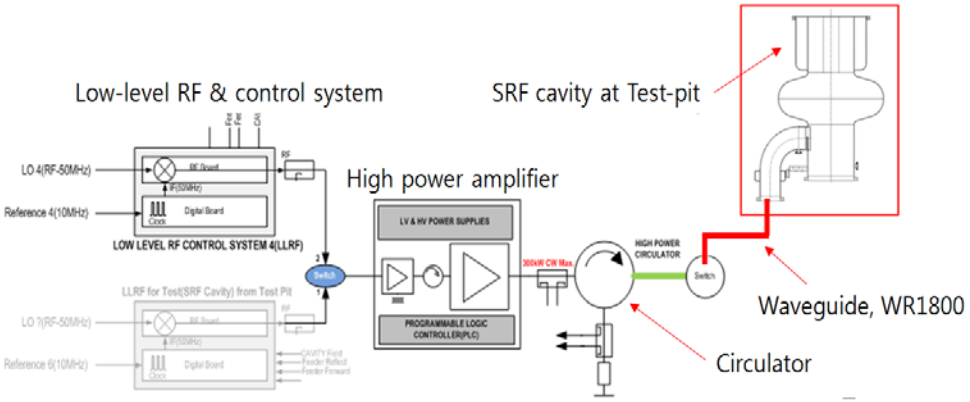


Conditioning at Test Fit

- Conditioning of 1st SRF cavity was performed at Teat Fit.
- Conditioning of 2nd SRF cavity was done in the SR tunnel (in-situ)







Planning Radiation Measurement

❑ Dose Measurement

- Real Time: **4 ICs**
- Accumulated: **37 OSNLs**

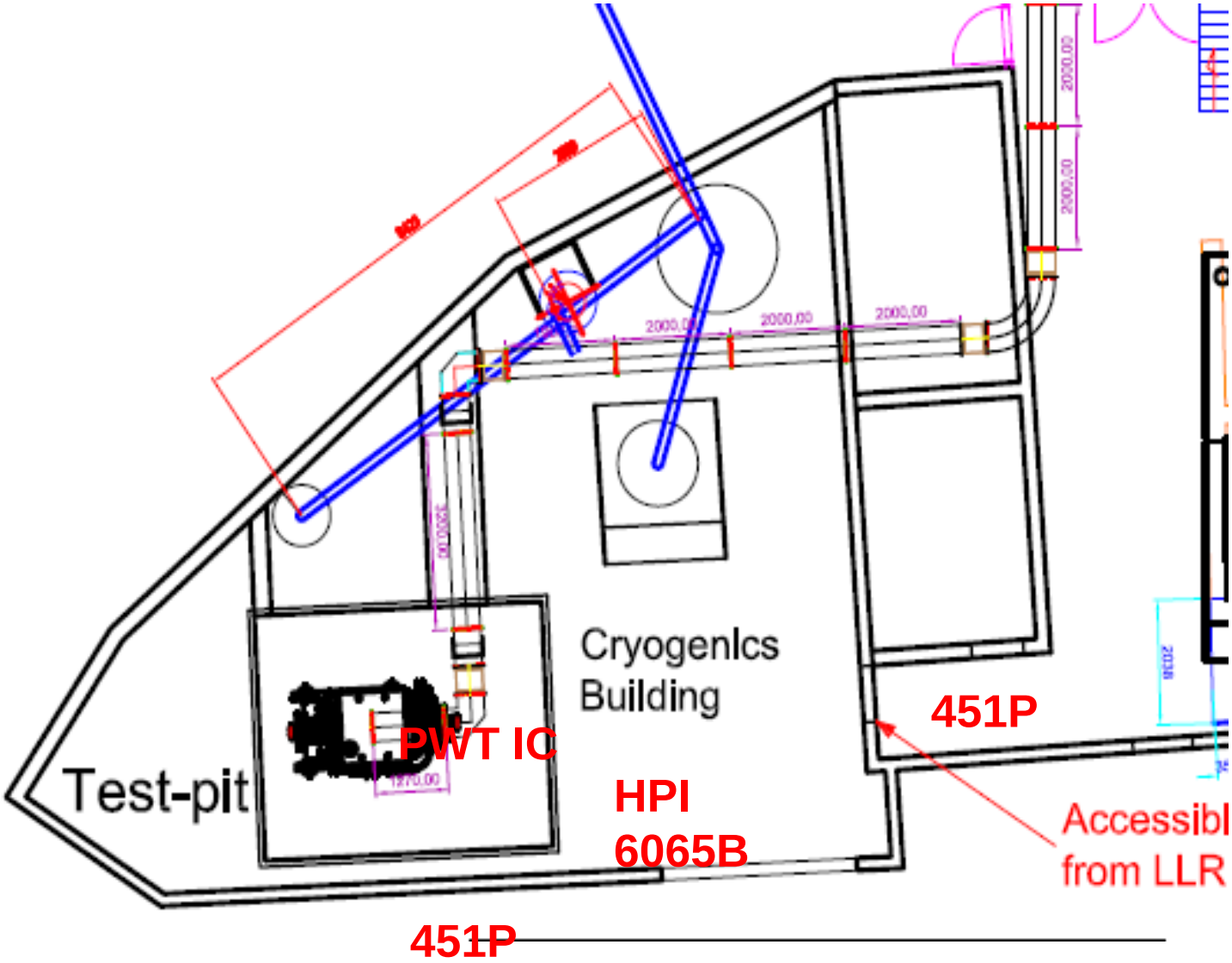
❑ Type of ICs and locations

PTW-freiburg 23361 (In a PIT)

PTW-freiburg 7262 (on a PIT cover)

Victoreen 451 (two, Out of Room)

HPI 6065B (in a Room)


Cryogenics
Building
Test-pit
PWT IC
HPI
6065B
451P
Accessibl
from LLR
451P

Real Time Measurement

- Applied RF power **: $P_{forward}$ [kW]**
- Probe signal of cavity : V_{trans} [mV]

vs. **Dose of ICs**

- Operation Records : Aug 14, 11am – 17th, 11am, 2012
- Hot periods ($P_{forward}$ > 20 kW)

  1) 8/14, 6pm ~ 8/15 4am (10 hours)

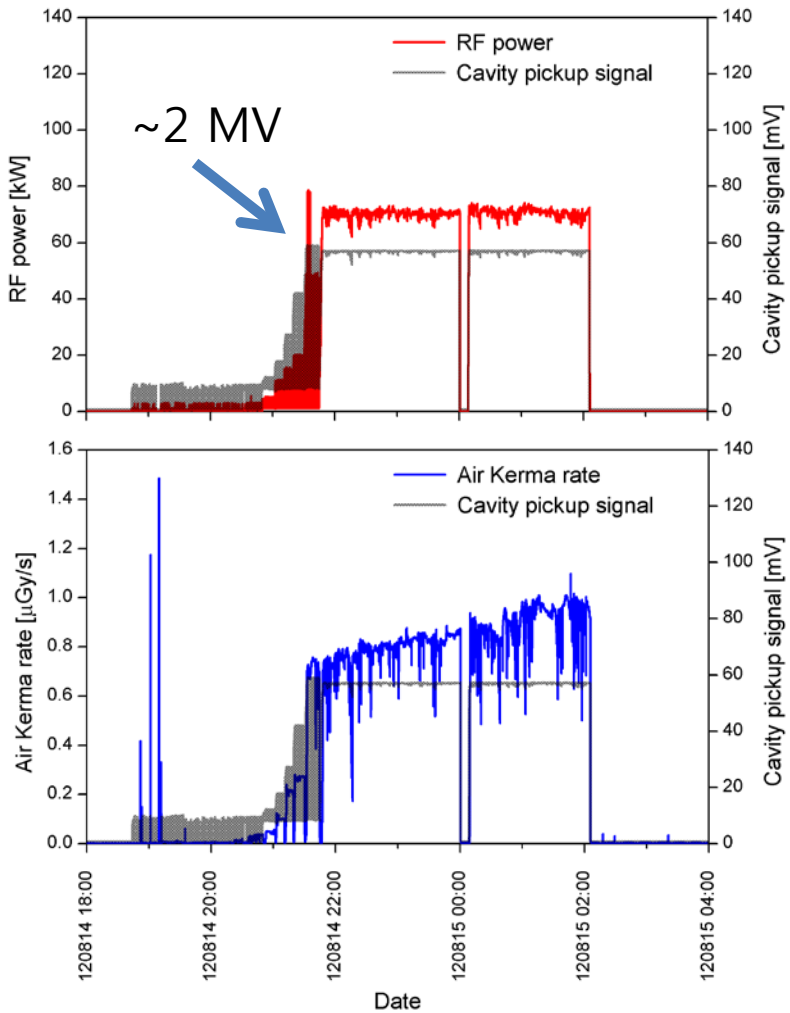
  2) 8/15, 2pm ~ 12am (10 hours)

  3) 8/16, 10am ~ 4pm (6 hours)
- Record Fail for PTW-freiburg 7262 (on the pit cover)

  - Operator mistake

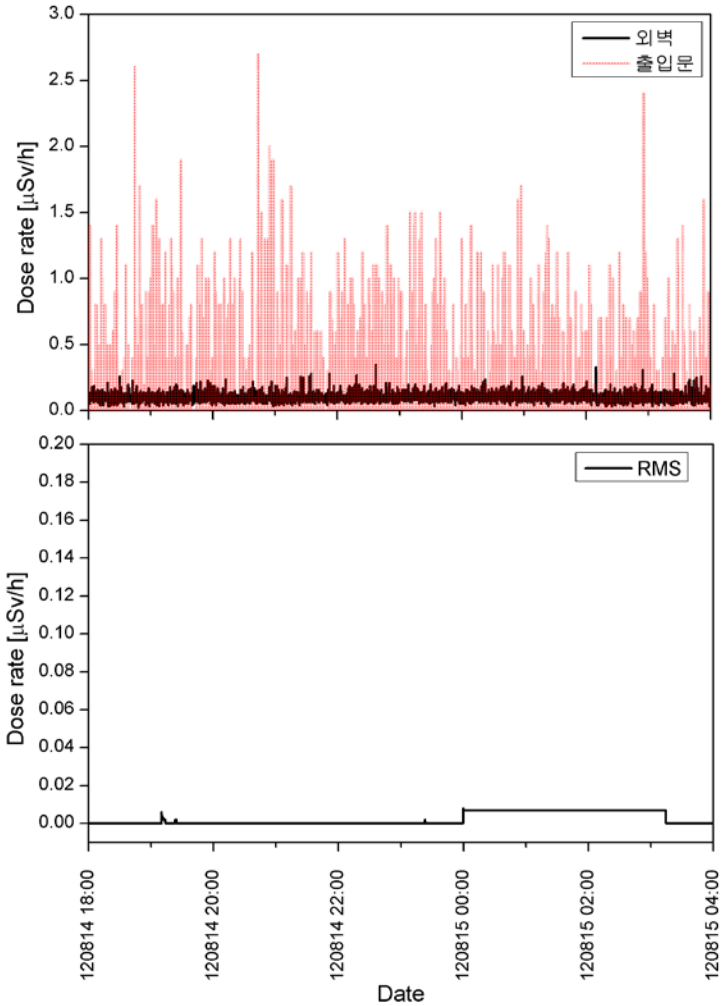
  - Facility background : ~ 20 pGy/s

Real Time Dose Profile (Period 1)



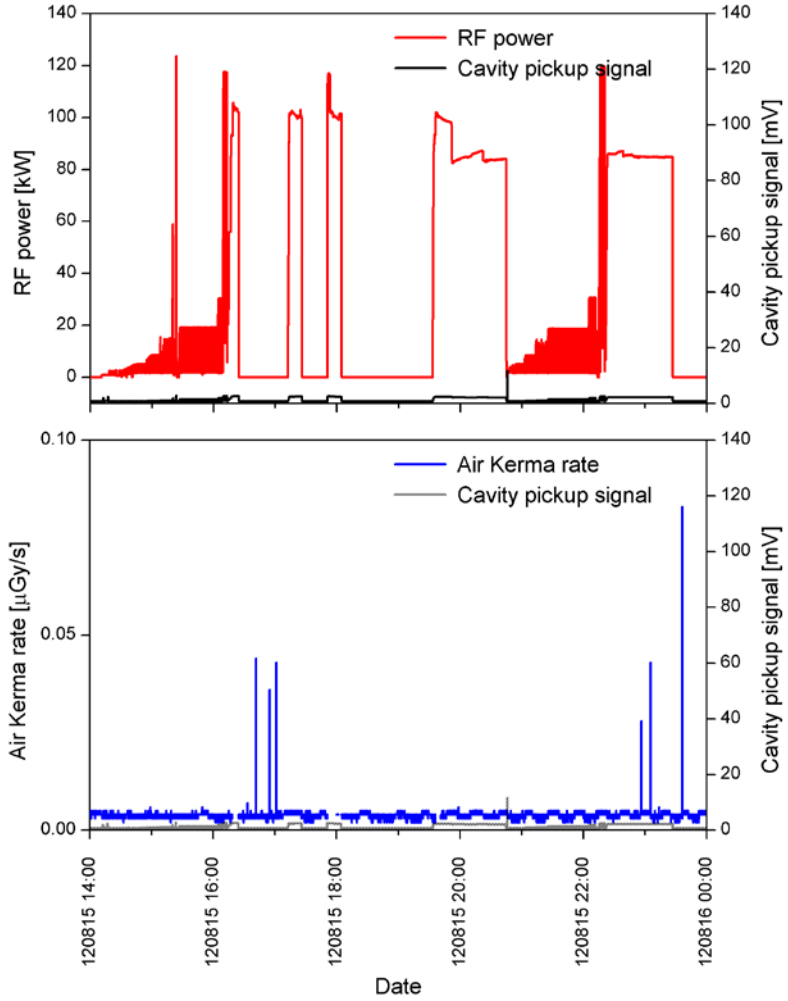
PTW-freiburg 23361 (In a PIT)

Victoreen 451P (Out of Room)



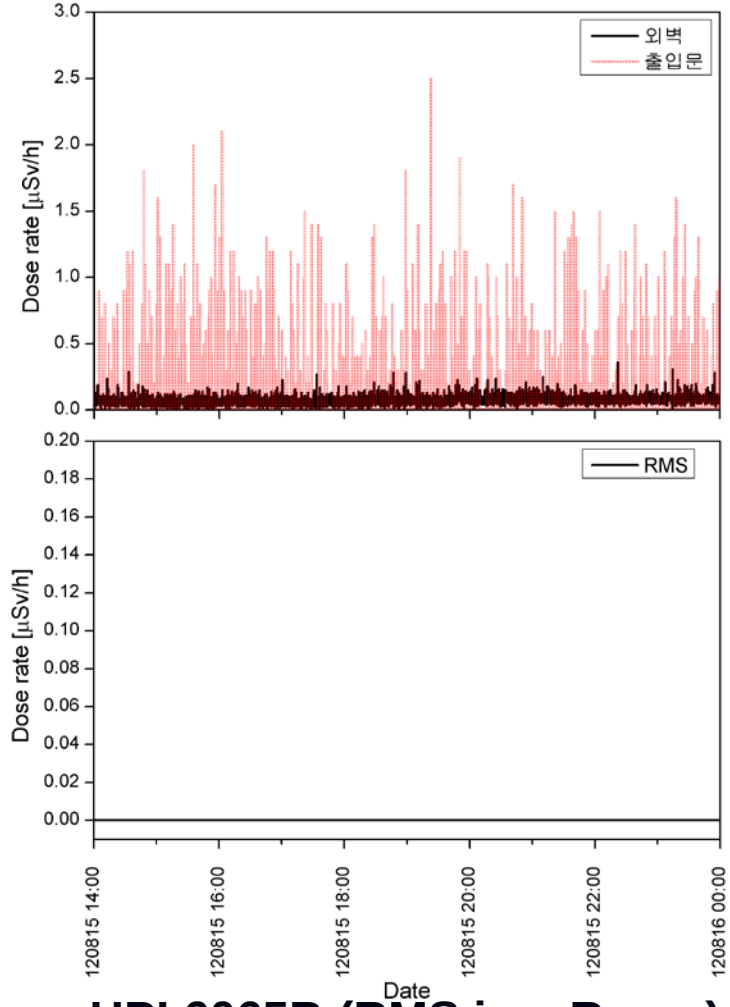
HPI 6065B (RMS in a Room)

Real Time Dose Profile (Period 2)



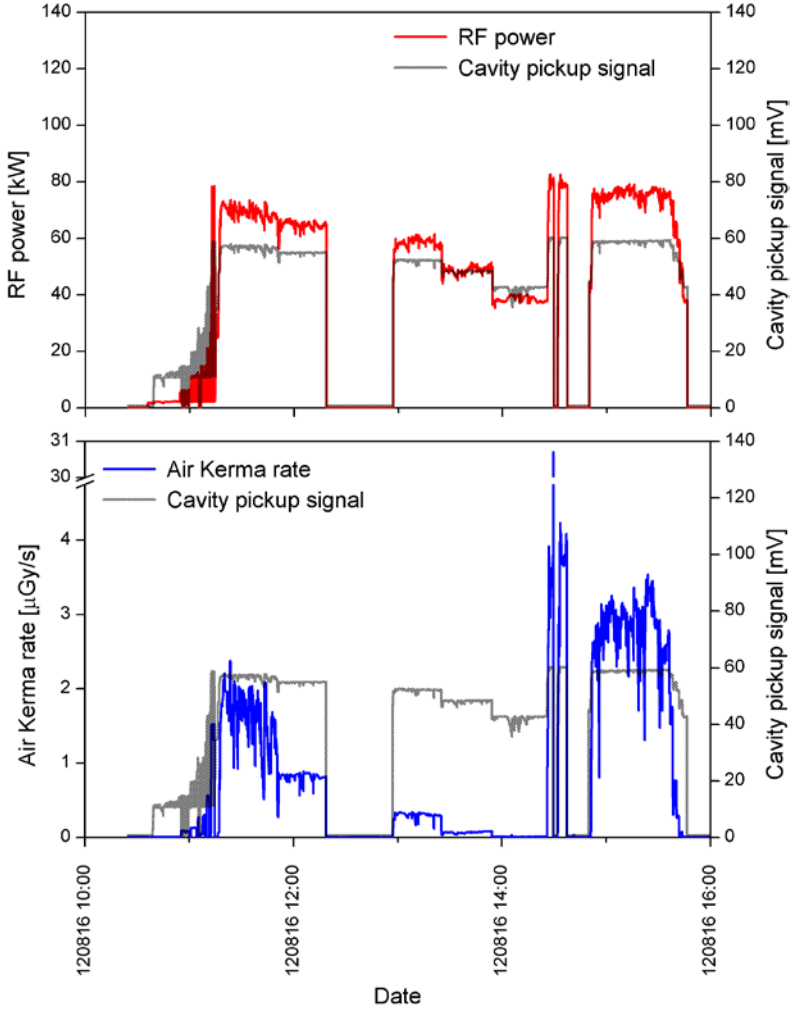
PTW-freiburg 23361 (In a PIT)

Victoreen 451P (Out of Room)



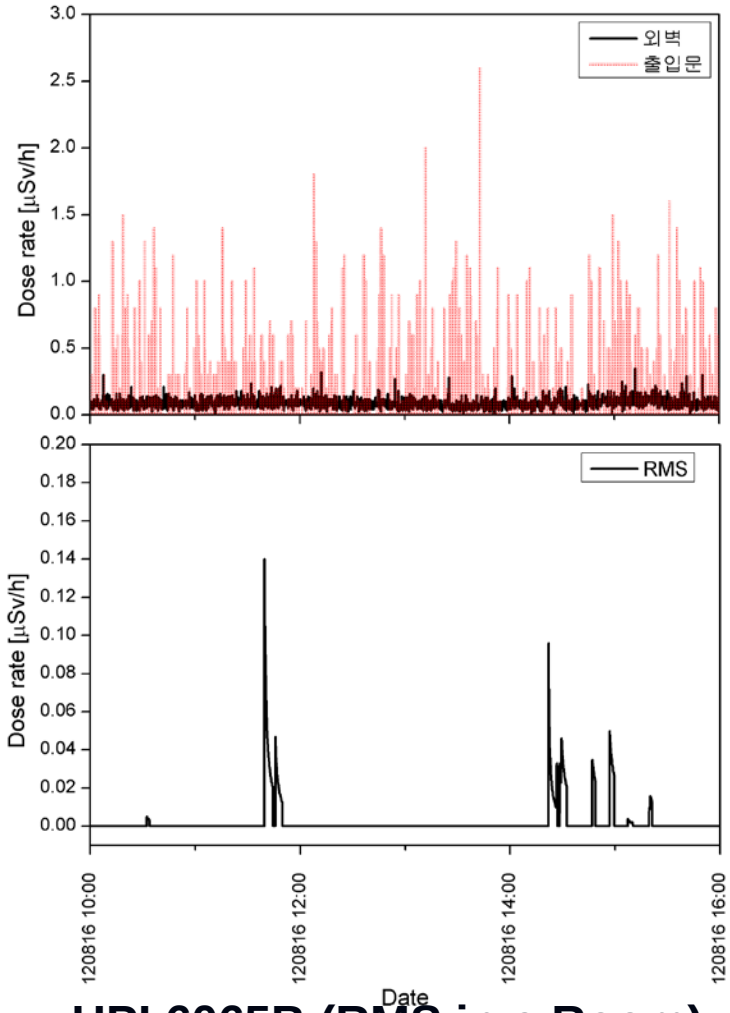
HPI 6065B (RMS in a Room)

Real Time Dose Profile (Period 3)



PTW-freiburg 23361 (In a PIT)

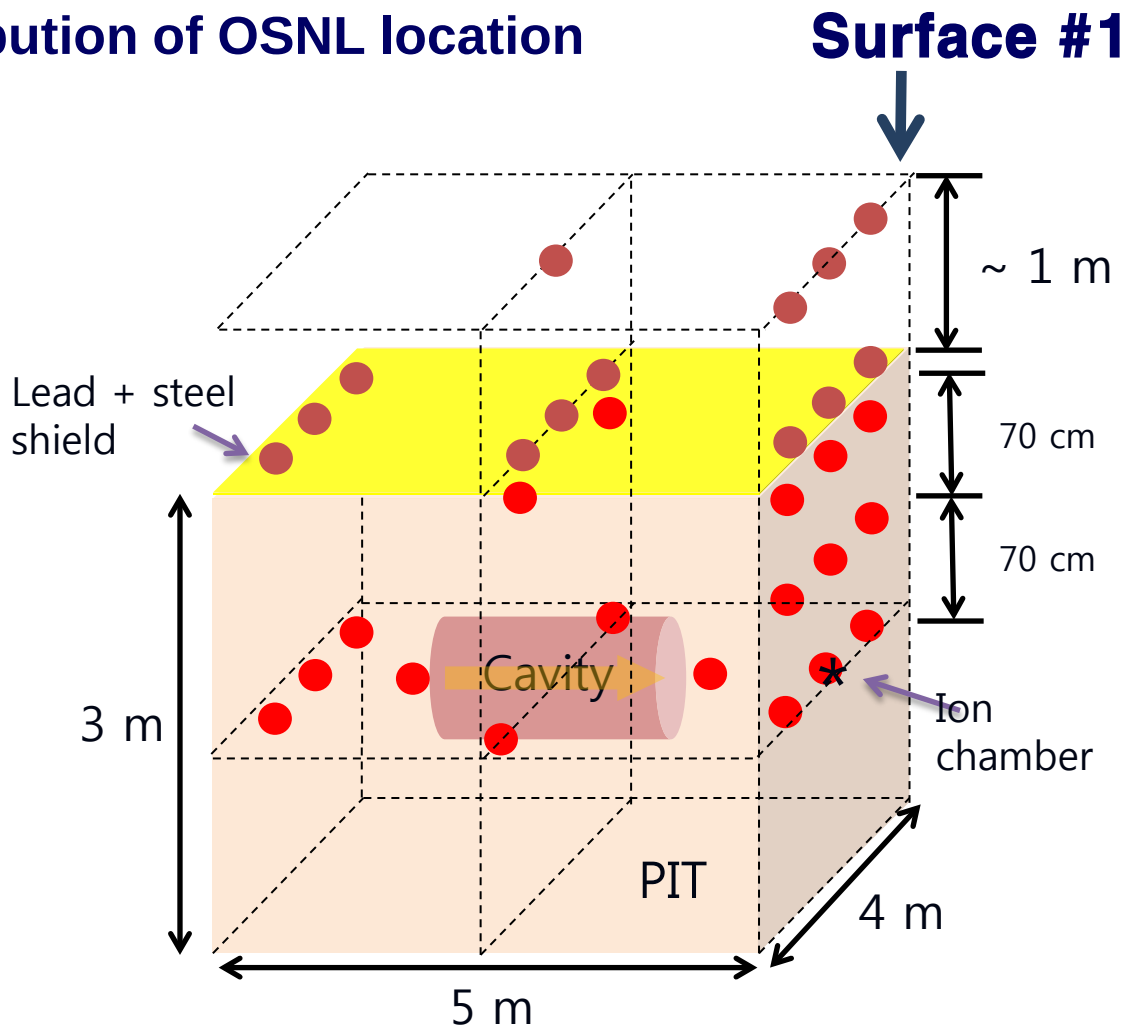
Victoreen 451P (Out of Room)



HPI 6065B (RMS in a Room)

Accumulated Dose Measurements

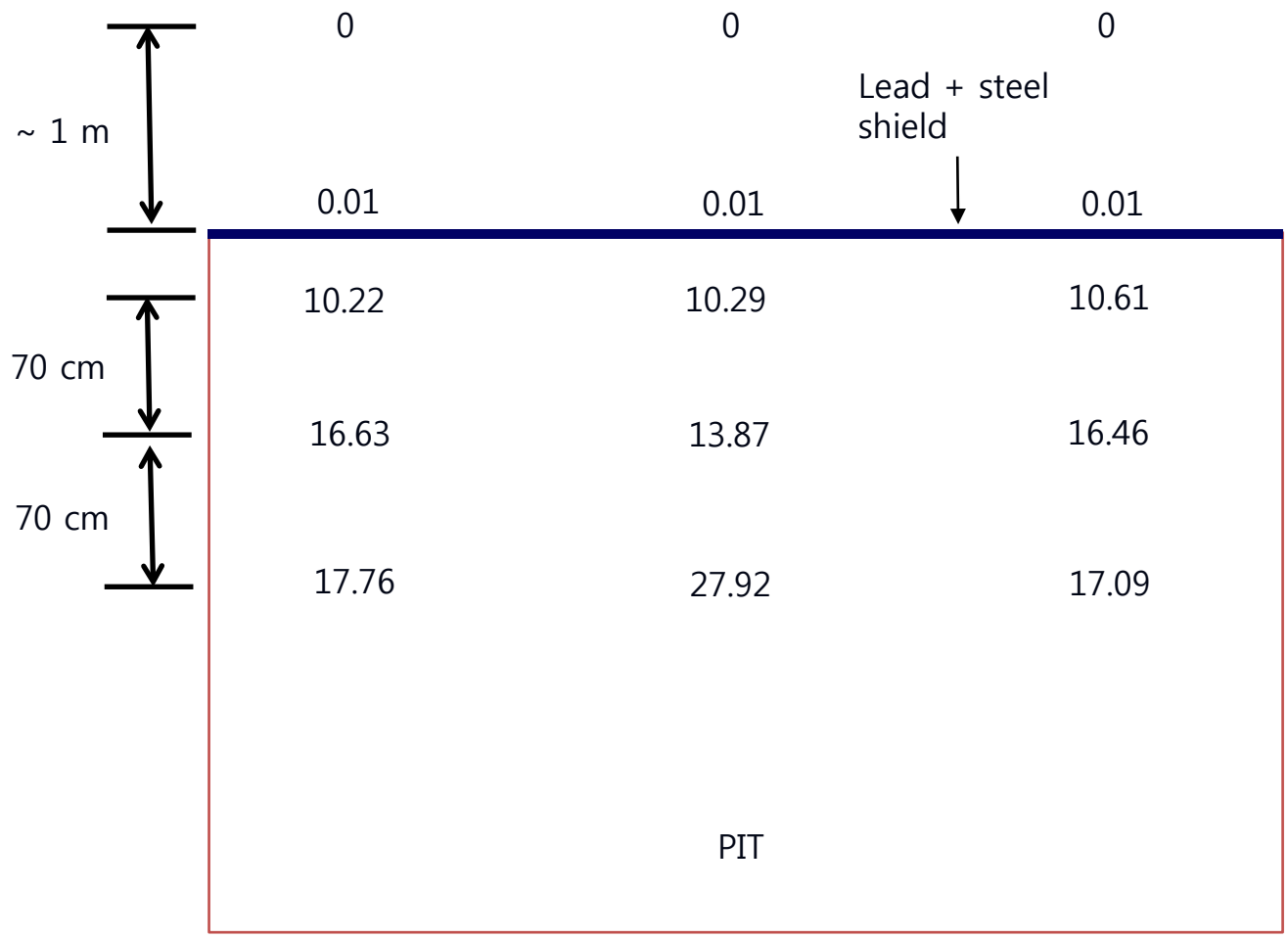
❑ Distribution of OSNL location



- PIT size : 5 m (W) x 4 (D) x 3 m (H)

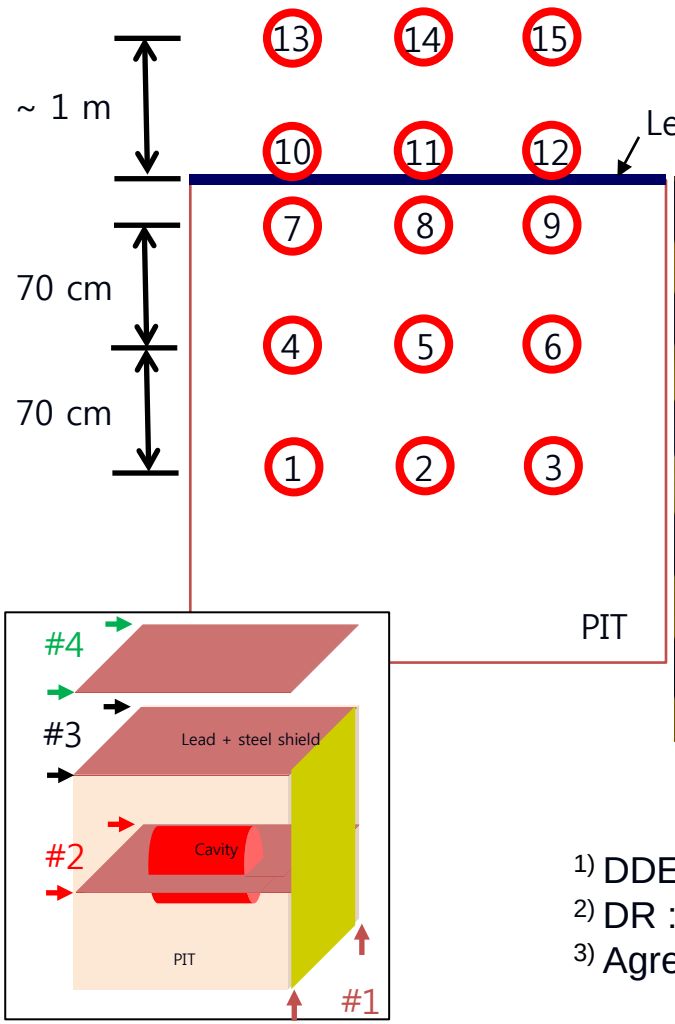
Accumulated Dose - Results

❑ Surface #1(Vertical)



Accumulated Dose - Results

❑ Surface #1 (Vertical)



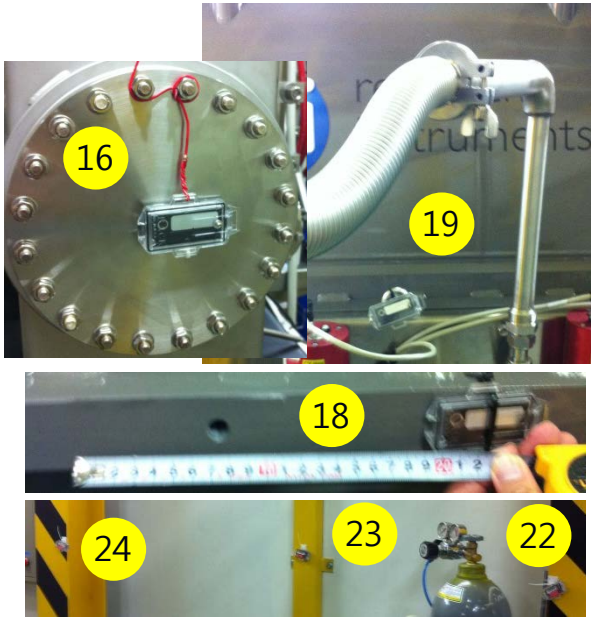
- H-beam size : 20 x 20 cm

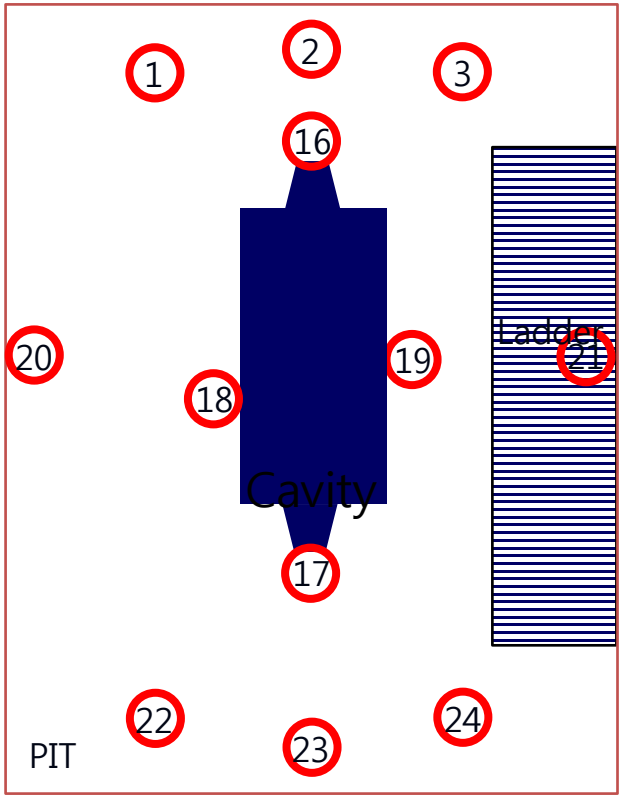
OSLN no.	DDE [1] [mSv]	DR [2] [uSv/h]
1	17.76	1973.33
2	27.92 [3]	3102.22
3	17.09	1898.89
4	16.63	1847.78
5	13.87	1541.11
6	16.46	1828.89
7	10.22	1135.56
8	10.29	1143.33
9	10.61	1178.89
10	0.01	1.11
11	0.01	1.11
12	0.01	1.11
13	0	0.00
14	0	0.00
15	0	0.00

[1] DDE : Deep Dose Equivalent
[2] DR : Dose Rate (time : 9 hr)
[3] Agree with IC Dose (29.3 mSv) within 5%, 27.92 mSv → 0.86 uSv/s

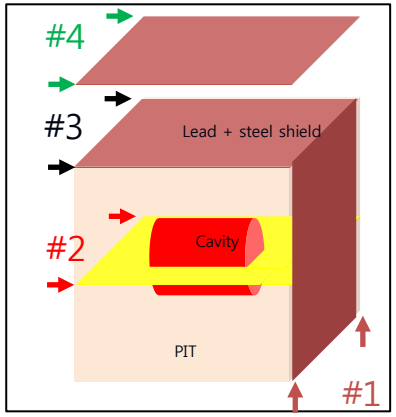
Accumulated Dose - Results

❑ Surface #2 (Horizontal)





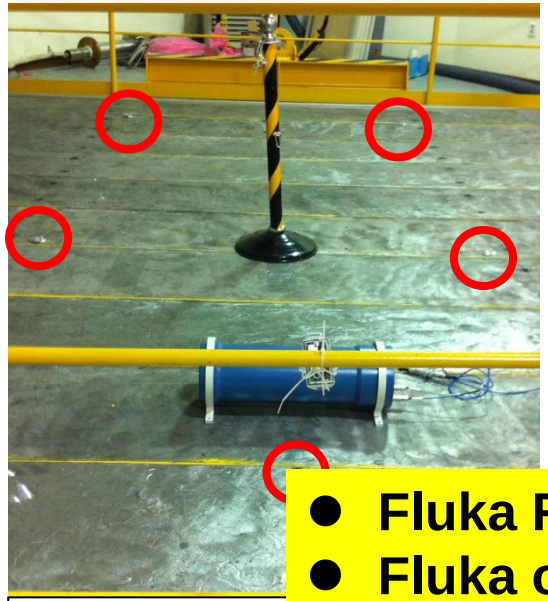
OSLN no.	DDE [mSv]	DR [uSv/h]
1	17.76	1973.33
2	27.92	3102.22
3	17.09	1898.89
16	489.65	54405.56
17	264.51	29390.00
18	11.96	1328.89
19	31.73	3525.56
20	10.05	1116.67
21	7.71	856.67
22	8.33	925.56
23	3.35	372.22
24	9.01	1001.11

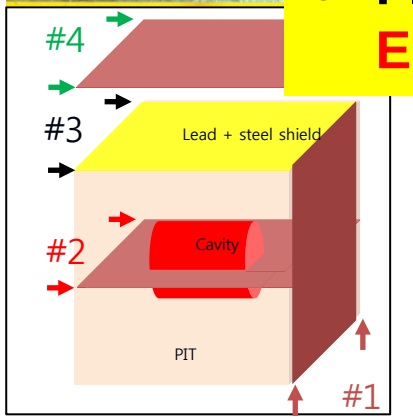


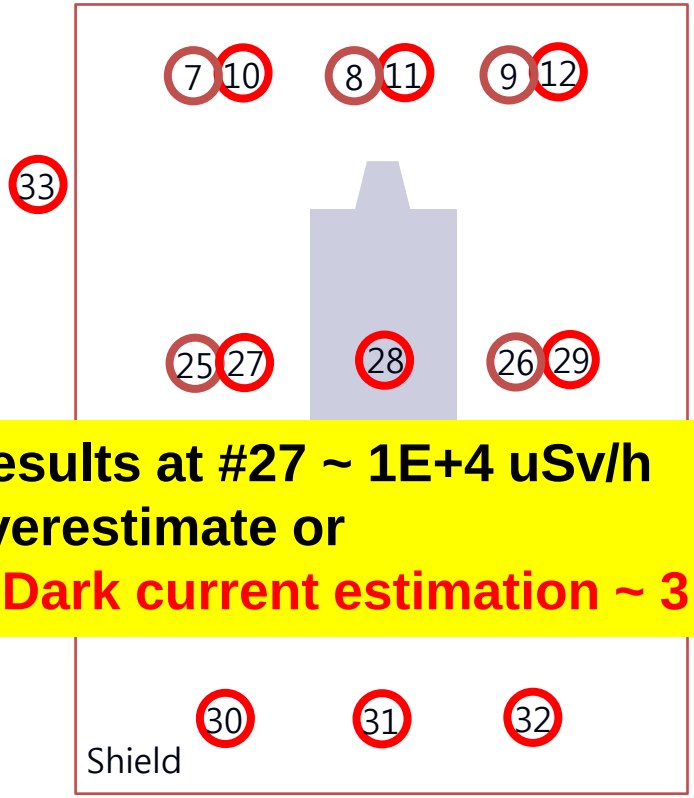
- **Fluka Results at #19 ~ 5E+6 uSv/h**
- **Fluka overestimate or**
  Error in Dark current estimation ~ 3 orders

Accumulated Dose - Results

❑ Surface #3 (Horizontal) – Comparison before and after a shield cover







: below the lead + steel shield

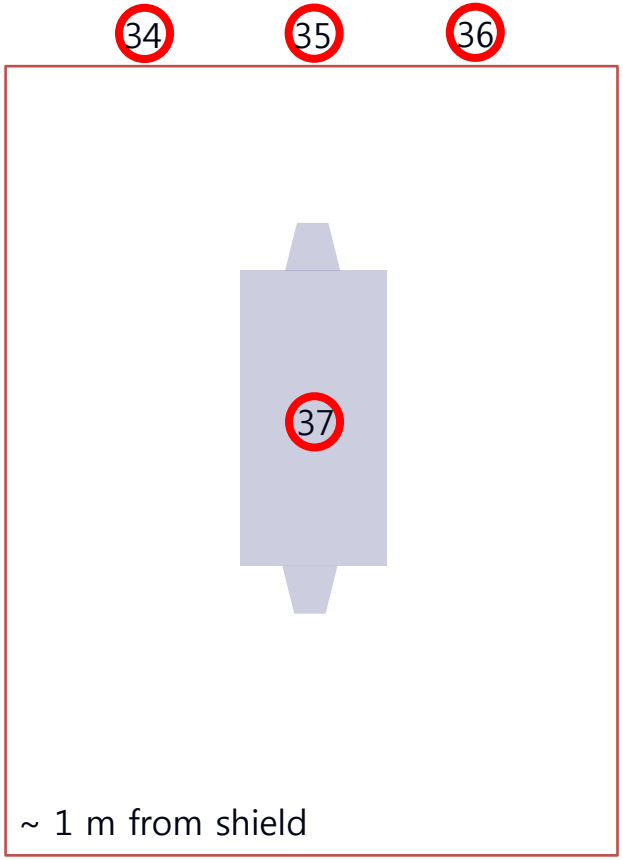
: on the lead + steel shield

- **Fluka Results at #27 ~ 1E+4 uSv/h**
- **Fluka overestimate or**
  Error in Dark current estimation ~ 3 orders

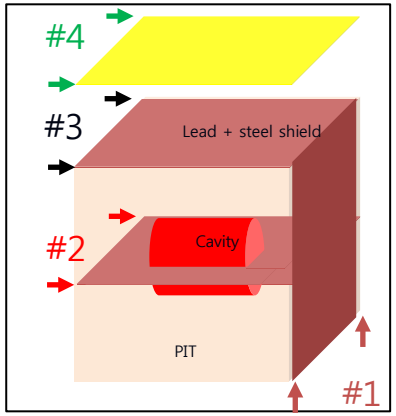
OSLN no.	DDE [mSv]	DR [uSv/h]
7	10.22	1135.56
8	10.29	1143.33
9	10.61	1178.89
25	21.59	2398.89
26	20.18	2242.22
10	0.01	1.11
	0.01	1.11
	0.01	1.11
	0.09	10.00
28	0.07	7.78
29	0.02	2.22
30	0	0.00
31	0	0.00
32	0.05	5.56
33	0.01	1.11

Accumulated Dose - Results

❑ Surface #4 (Horisontal)



OSLN no.	DDE [mSv]	DR [uSv/h]
34	0	0.00
35	0	0.00
36	0	0.00
37	0.03	3.33



Summary of Conditioning at Test Fit

- Shielding Design is proper to protech operator of SRF cavity.
  - On the cover, D < 10 uSv/h
  - Out of room, D < 2.5 uSv/h

  The room can be considered to radiologically-controlled area where worker can access during testing.

- Fluka results show acceptable accuracy.
- At least, dark current or its energy is overestimated.

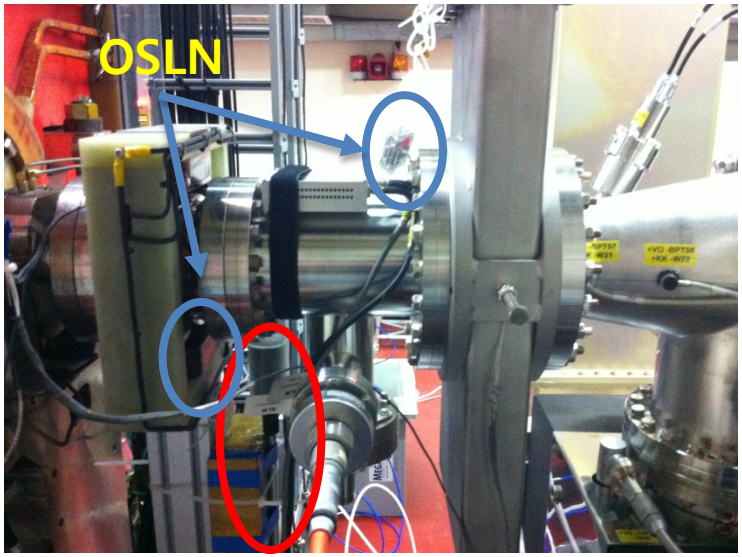
Conditioning in SR tunnel (In-situ)

❑ Dose Measurements

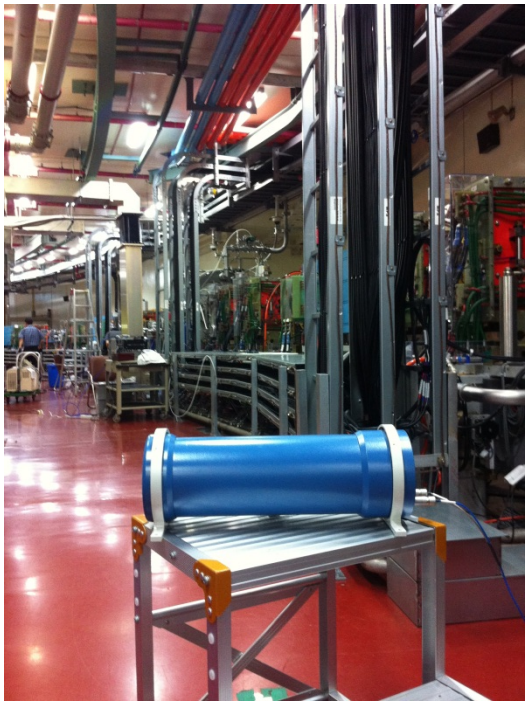
- Real Time: 2 ICs
- Accumulated : OSLN

* SRF cavity which conditioning was done at Test Fit

❑ Locations of ICs

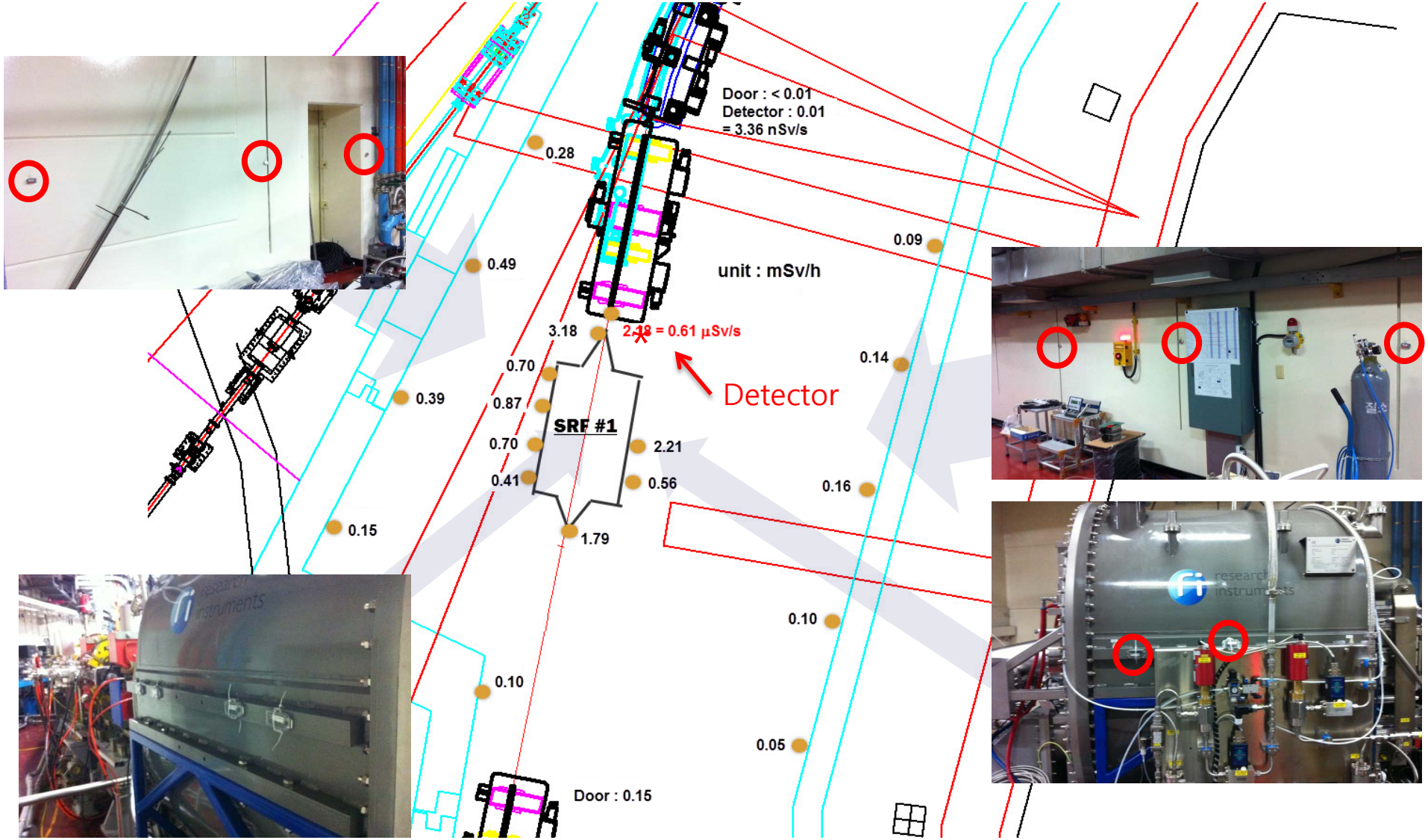


PTW-freiburg 23361

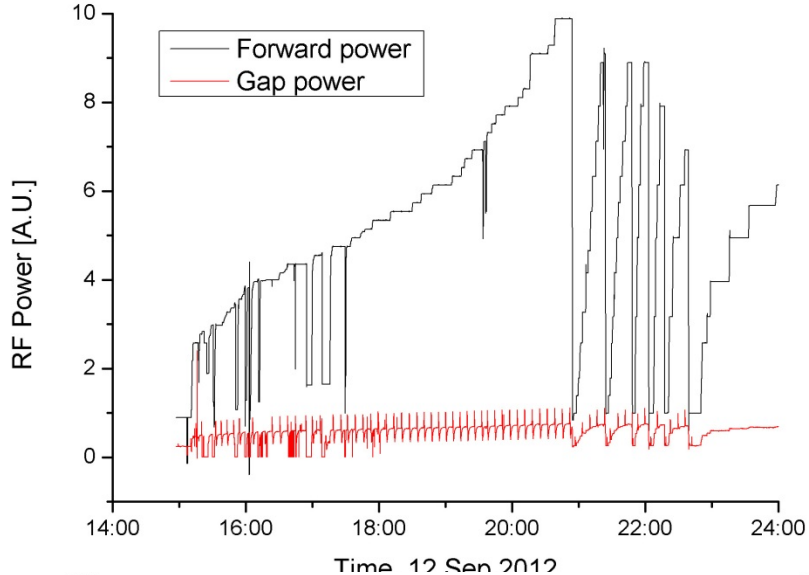


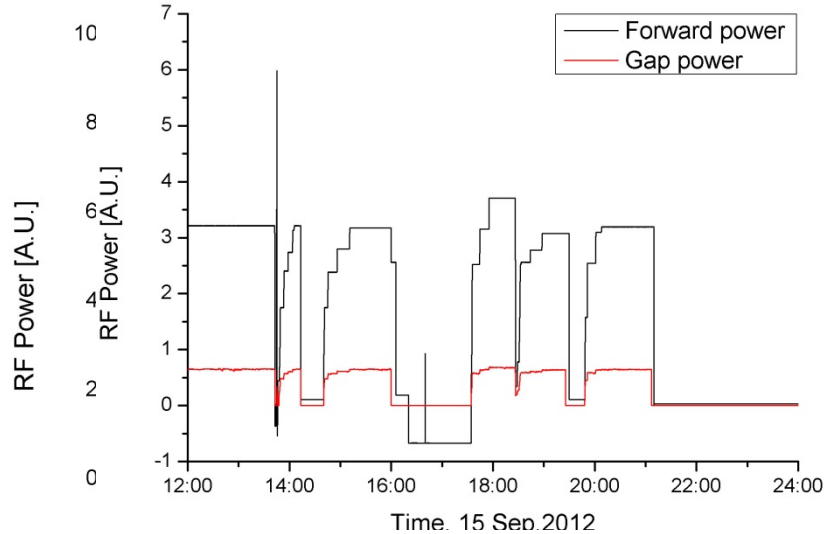
PTW-freiburg 7262

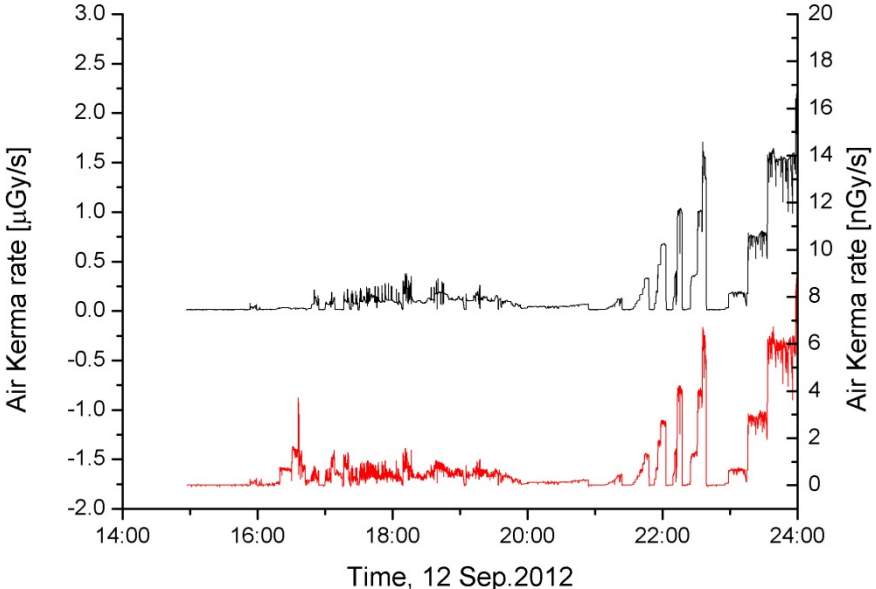
Accumulated Dose - Results

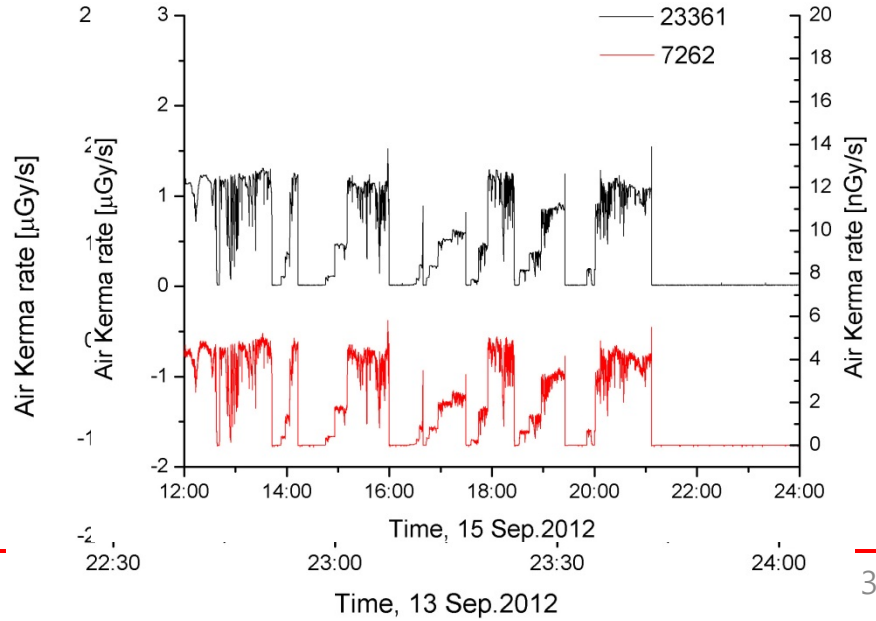


Relationship between RF (forward) power and Radiation Dose

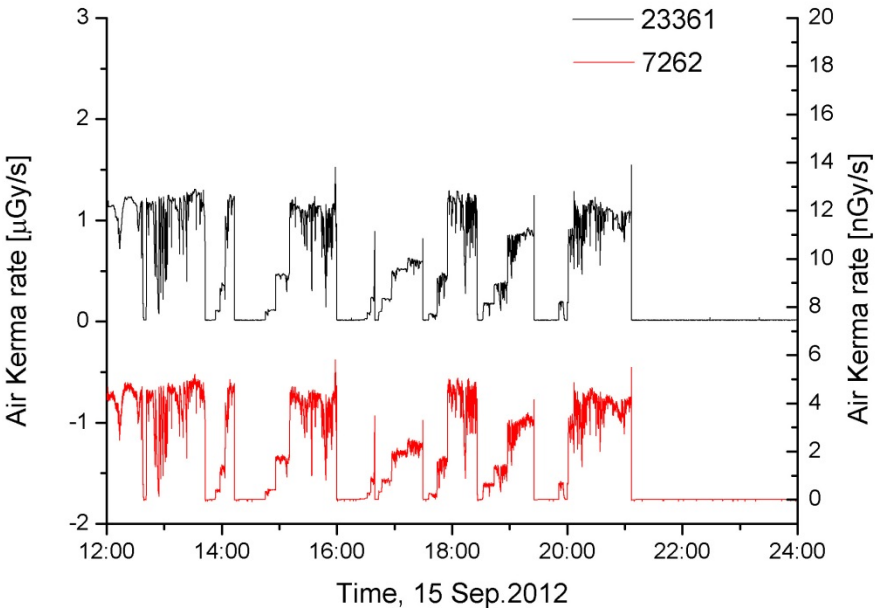


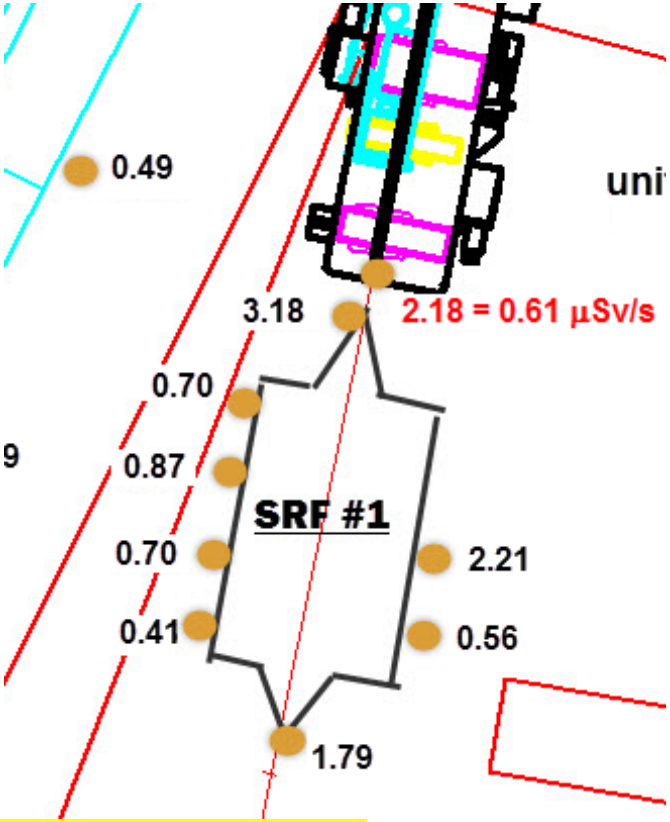






Real Time Dose & Accumulated Dose





- **At PTW23361, ~1.0 uGy/s - 0.75 uSv/s (2.68 mSv)**
- **At PTW7262, ~ 4 nGy/s - < 2.7 nSv/s (0.01 mSv)**

Summary

- PLSII Project was carried out successfully and it's proved by records including Top-up operation.
- Dose characteristics for 500 MHz CESR B-factory type SRF cavity was investigated
- Fluka results shows good accuracy and performance of shielding design of Test Fit of SRF cavity was verified.
- The dark current information based on Cornell Univ. study may make us overestimate the radiation level around SRF cavity
- This will be one more data set for dark current study which have still many unknown things.

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April 23-24, 2001 APS Conference Center
Argonne National Laboratory Argonne, Illinois USA

Thank you for your attention!