

Radiation Safety Issues for Progress of KEK Photon Factory

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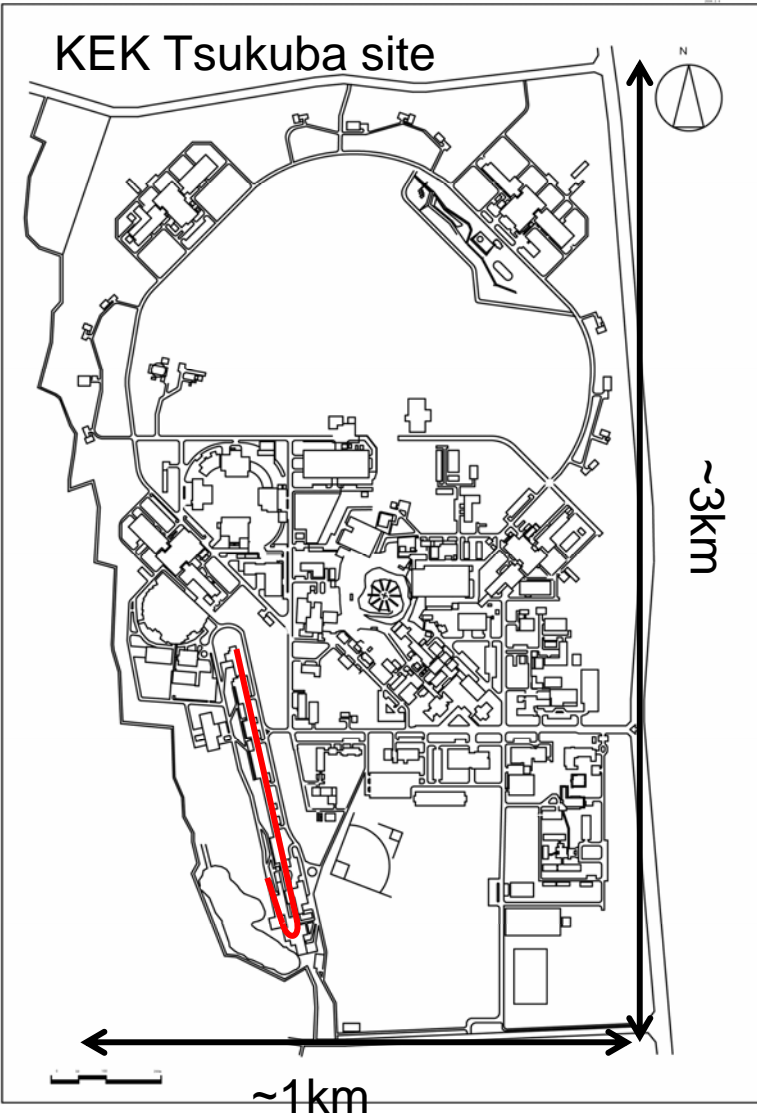
**RadSynch'07 @ Canadian Light Source
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Introduction

Current state of KEK

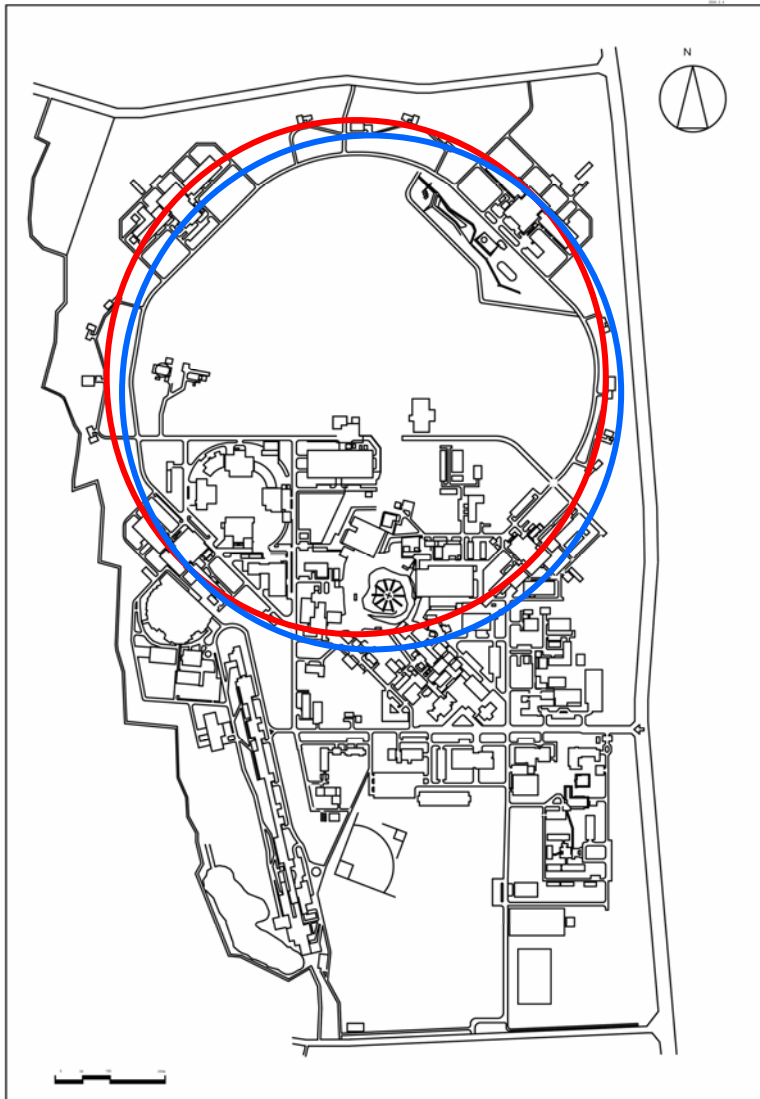
- Shut down proton synchrotron complex → J-PARC
- Various program for accelerator development
- 4 e-/e+ storage rings, driven by single injector → see next slide
 - B-factory operated by continues injection.
 - Switch over time have considerable effect for the operation
- Injector upgrade project (on going)
 - Fast switch injection for 4 ring
 - Reduce switch over time
 - Top-up operation of PF ring
- Radiation safety design for this operation

KEK electron accelerators

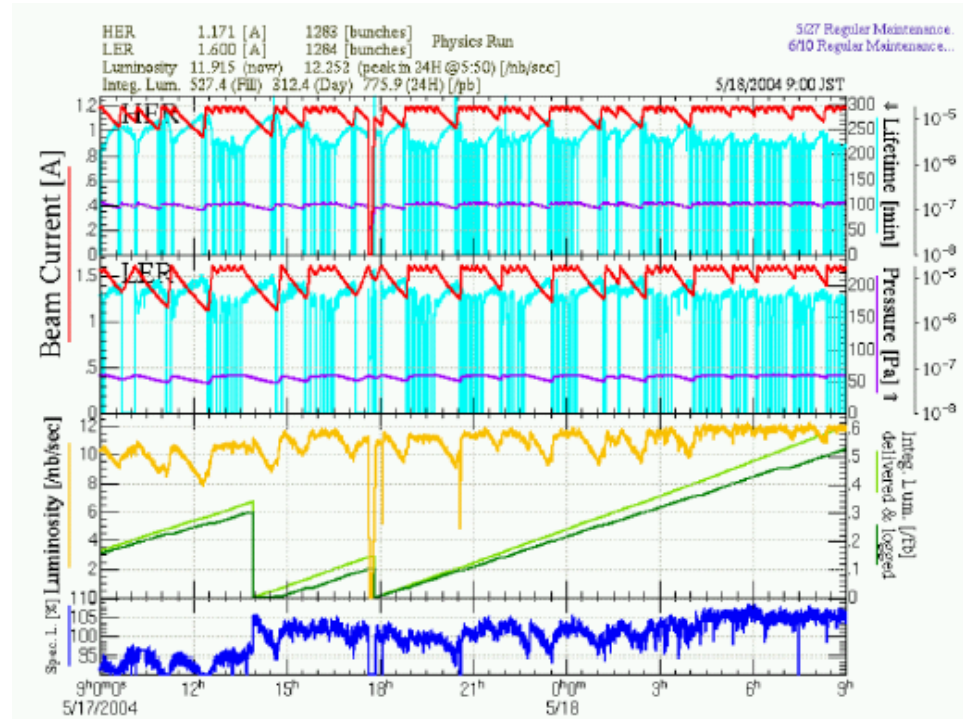


- **Electron and positron LINAC**
 - **8 GeV/2.5 GeV e⁻, 3.5 GeV e⁺ typical**
 - Maximum allowable
10GeV (e⁻), 12.5 GeV·μA
5GeV (e⁺), 6.25GeV·μA
 - **Provide electron 3 rings**
 - **Provide positron 1 ring**
 - **0.05 GeV linac for slow e⁺ production,**
 - **0.04 GeV linac for telescope array calibration**

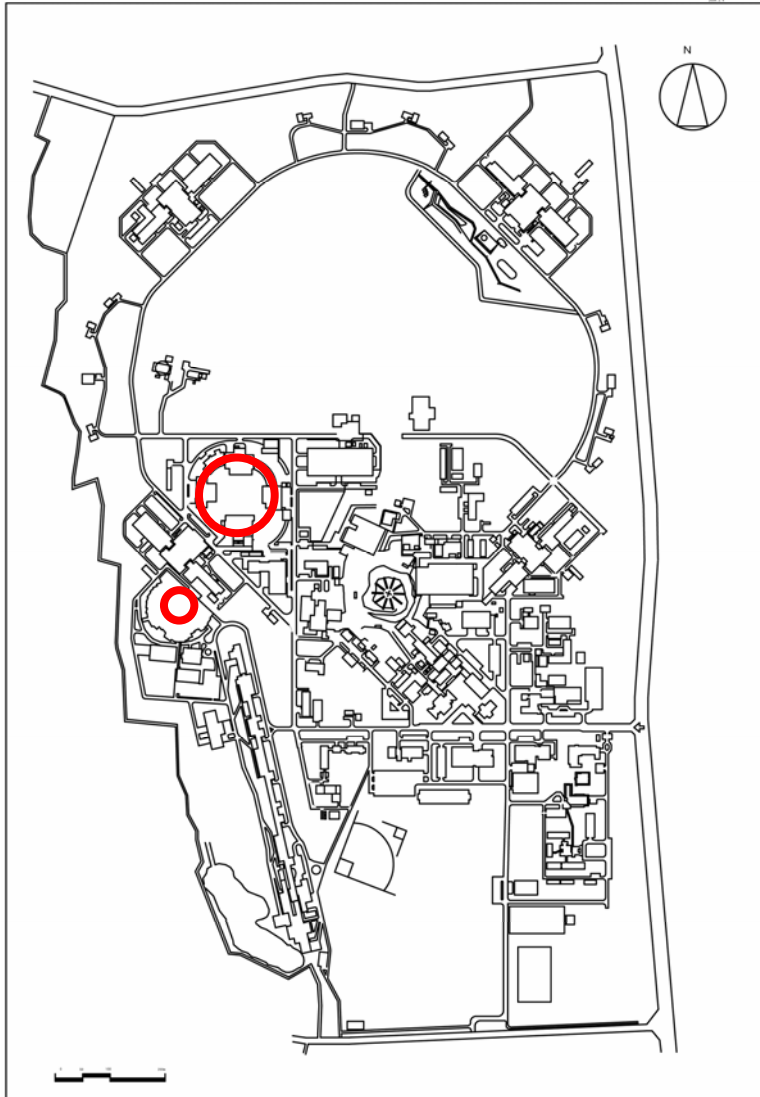
KEK electron accelerators (cont)



- B-Factory (KEKB)
 - To investigate b-meson symmetry
- 8 GeV electron in HER
- 3.5 GeV positron in LER
- Continues injection



KEK electron accelerators



- Synchrotron light sources
 - **Photon Factory (PF)**
 - 2.5 GeV electron.
 - PF-AR (PF Advanced Ring for pulse X ray)
 - 6.5 GeV electron for pulse X ray



Parameters of Photon Factory

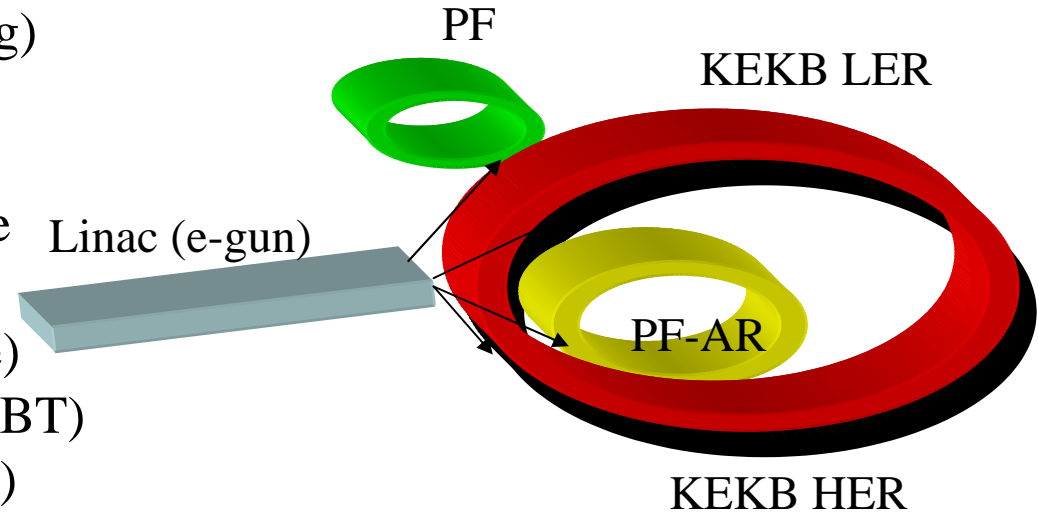
Beam energy	2.5 GeV (0.75 - 3.0 GeV)
Initial beam current	450 mA (achieved 770 mA)
Beam emittance (design value)	36 nm*rad (105 deg./cell optics)
Number of bending magnets	28
Number of rf accelerating cavities	4
rf frequency	500.1 MHz
Circumference	187 m
Number of insertion devices	8
Beam lifetime	50 h (at I=400mA)
Average ring pressure	6×10^{-8} Pa (at 400 mA)
Radiation loss per turn	400 keV
Stability of SR beam position	beam drift is less than 20 micro m during the whole day (at 20 m from SR source point)

4(3) rings fast switch injection

- LINAC: Fast switch injection operation to share 50Hz pulse
 - KEKB HER 8 GeV e- (1 nC e-)
 - KEKB LER 3.5 GeV e+ (10nC e- with e+TGT)
 - **PF 2.5 GeV e- (0.1 nC e-) [New!]**
 - (PF-AR 2.5 GeV e-, planning)

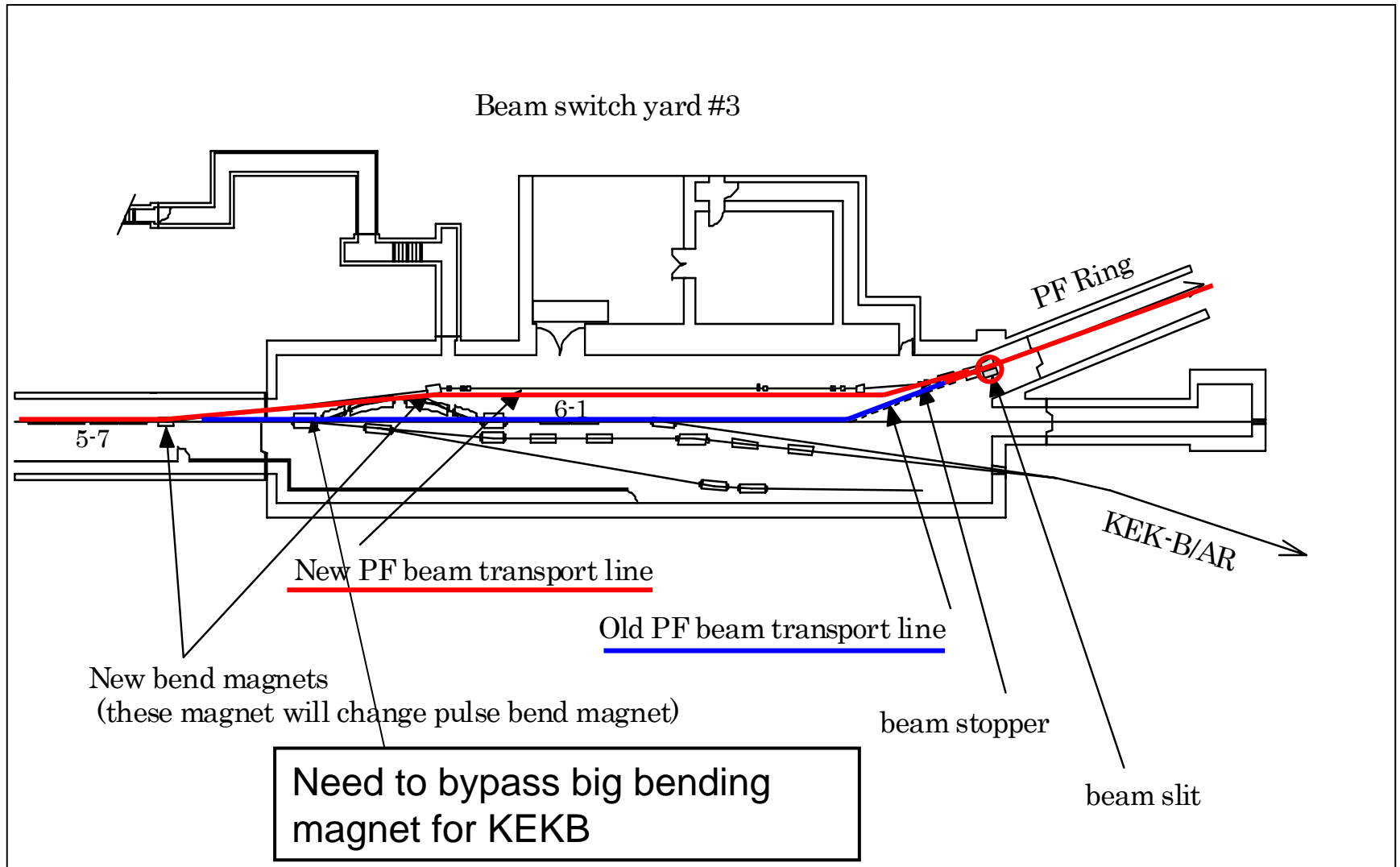
- Requirement of the operation

- Redesign beam transport line
 - Fast switch
- Acceleration field (RF phase)
- Magnet (choose appropriate BT)
- Electron gun (charge control)



- Radiation safety issues coming up
 - Beam loss points
 - Power (charge and energy) control
 - The way to injection interlock for each ring

New beam line & slit



Radiation safety design

Radiation safety design for top-up of PF

- beam loss point

1. Energy tail cut slit

Designed to accept 65W beam loss

2. Charge control slit

Designed to accept 6.5W beam loss

Control injection power less than 0.65W

3. Beam transport line dump

Designed to accept 65W beam loss

Beam goes to the dump in case of exceeding 6.5W

Utilize future extension for short pulse light source

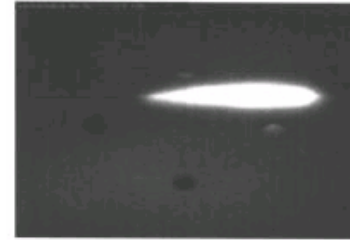
4. Small aperture place on ring

- Beam power control

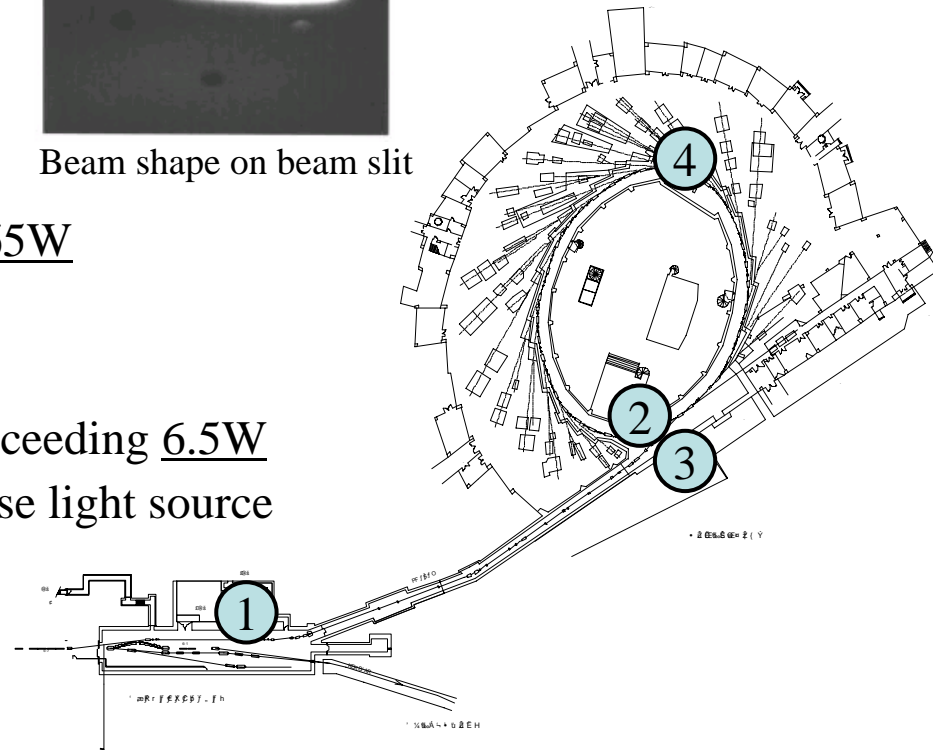
- Charge integration in each beam transport line

- Independent grid pulser to drive e-gun

- Develop original module to perform hardware limit

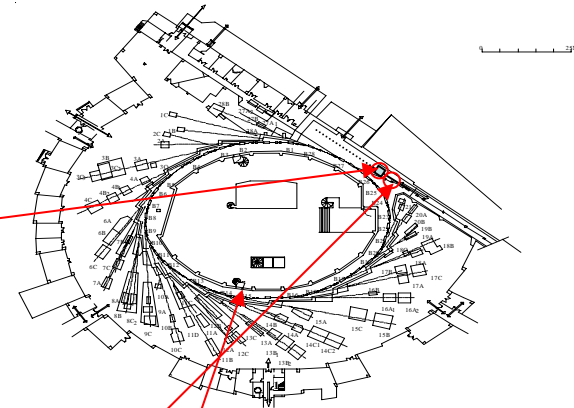


Beam shape on beam slit



Radiation safety design (cont)

- Shielding design for beam loss point
 1. Energy tail cut slit
Increase slit thickness to stop forward photon
 2. Charge control slit
Already designed 6.5W loss 2times/day
0.65W continuous loss is less than this value
 3. Beam transport line dump
Newly constructed
New control access area
 4. Shield small aperture point
Put lead based on measured dose rate



Radiation safety design (cont.)

- Shielding and dose rate

1. Contribution to the ground surface

$< 0.2\mu\text{Sv/h}$, because of road

Radiation monitor (Interlock)

2. 3. Contribution to underground, exp hall

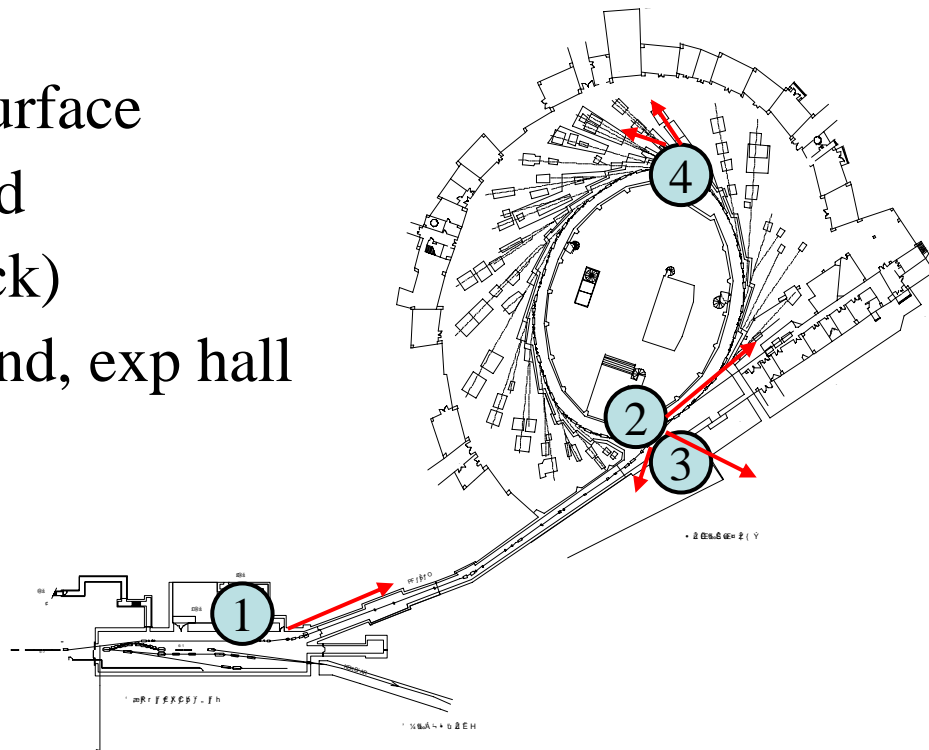
$< 20\mu\text{Sv/h}$

Shield and access control

4. Contribution to exp hall

$< 20\mu\text{Sv/h}$

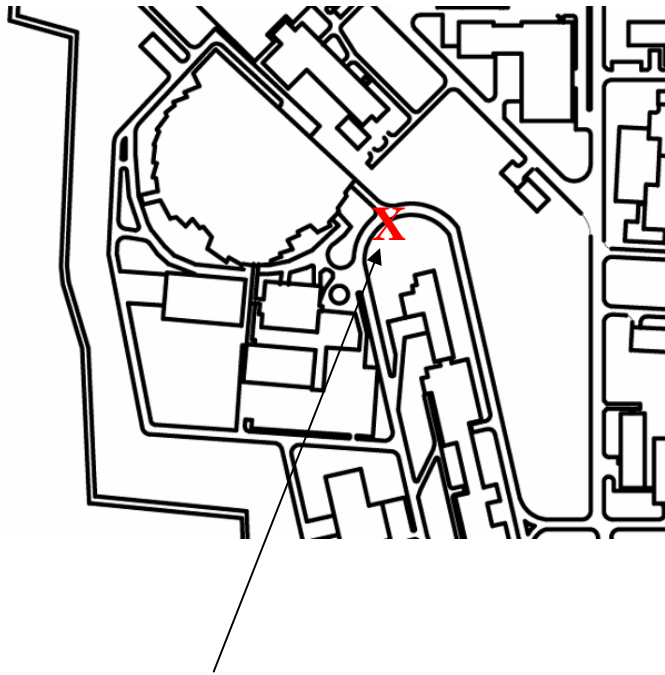
Radiation monitor (Alarm) and access control



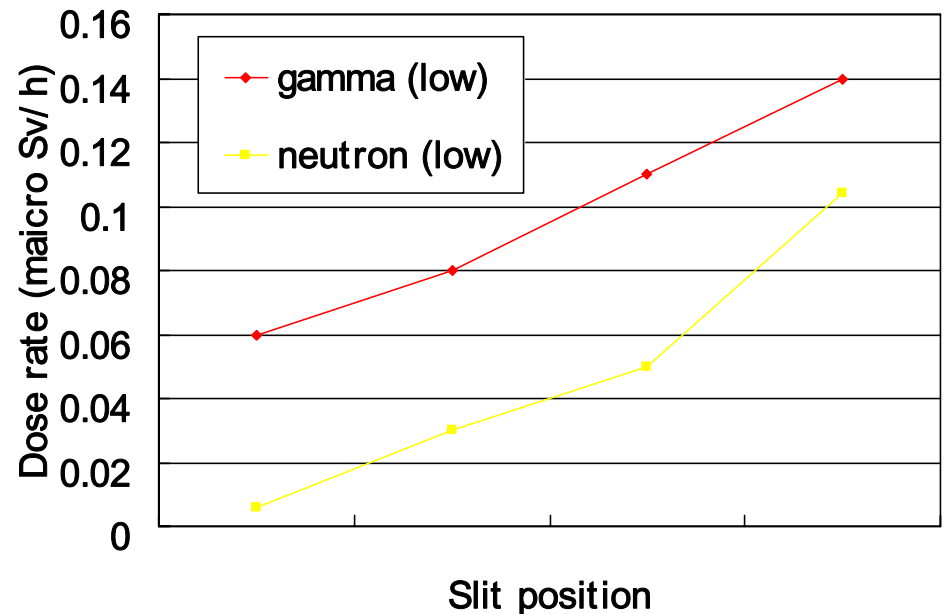
- Radiation survey during the operation

Result of dose rate

Dose rate around energy tail cut slit

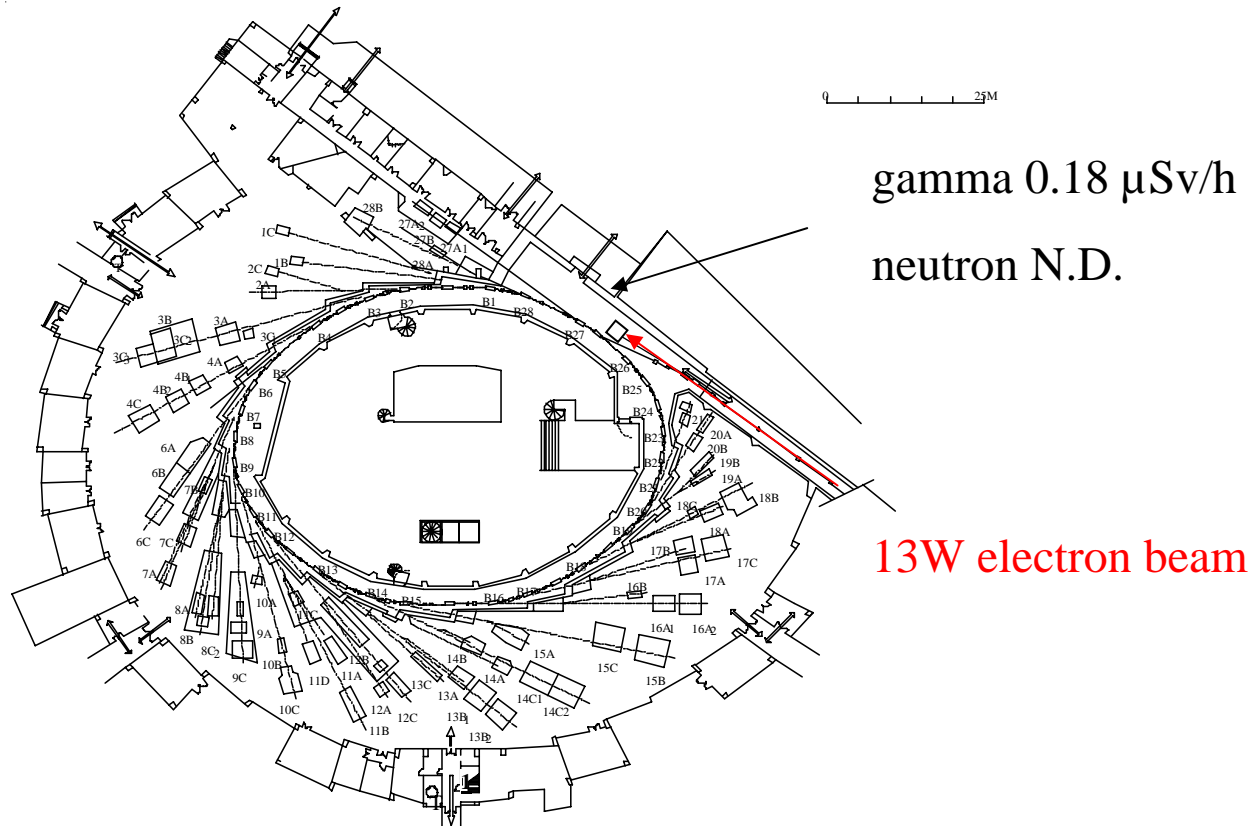


ground surface (uncontrolled area)



full beam stop on slit
gamma $0.7 \mu\text{Sv/h}$
neutron $0.8 \mu\text{Sv/h}$

Dose rate around injection point



Dose rate of around W#14&MPW#16

RAD-S-2006/02 (KEK)

Measurement of MBS Open Injection

Date 2006/6/12 13:30-14:30
 Measurer Kawara, Takahashi (RC)
 Instrument Ion chamber (Aika ICS-311) B.G 0.0 μ Sv/h
 @@@@ counter (Aika TGS-501)
 @@@@ scientific instrumentation counter (Aika ICS 161)

3mV/s 5Hz

VW#14 : Beam loss point (Neck of horizontal width)

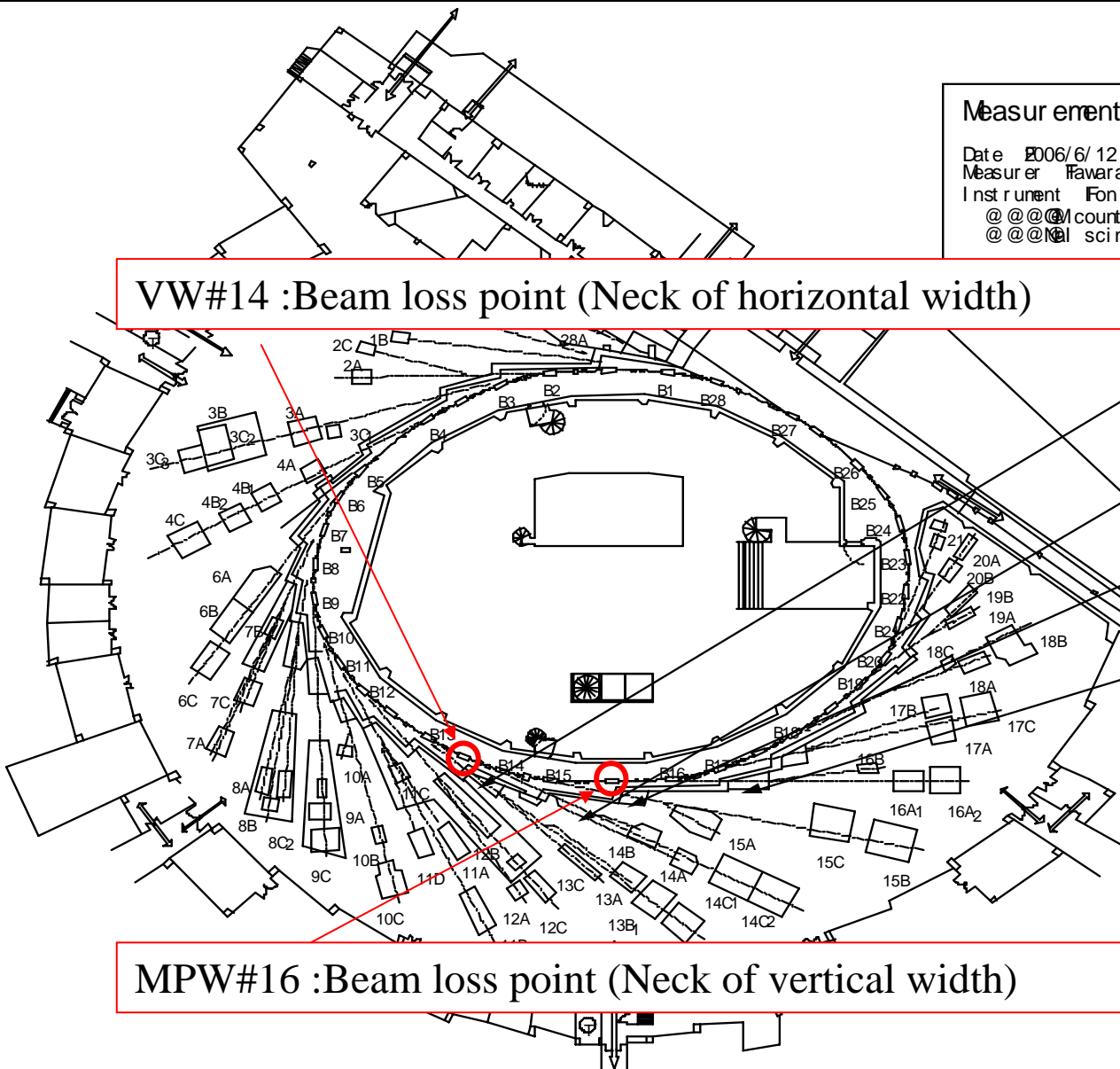
- BL13 @de of BBS
 MBS close 1 μ Sv/h
 MBS open 0.8 μ Sv/h
- BL14 @de of BBS
 MBS close 5 μ Sv/h
MBS open 5 μ Sv/h
- BL15 @de of main hatch
 MBS close 0.5 μ Sv/h
 MBS open 0.5 μ Sv/h
- BL16 @de of BBS
 MBS close 0.3 μ Sv/h
MBS open 14 μ Sv/h
 (with 3mm lead shield)

MPW#16 : Beam loss point (Neck of vertical width)

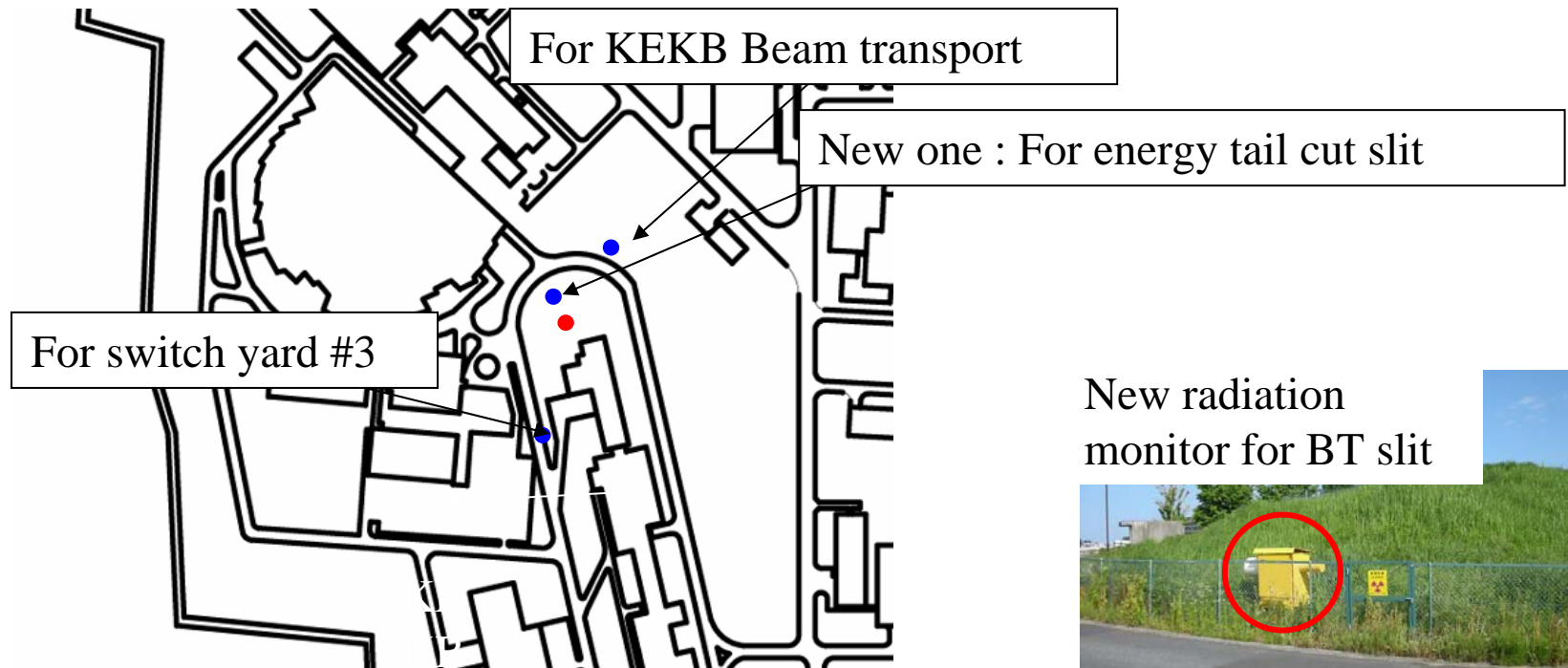
ID card reader

↔ door way

Frequency 5Hz



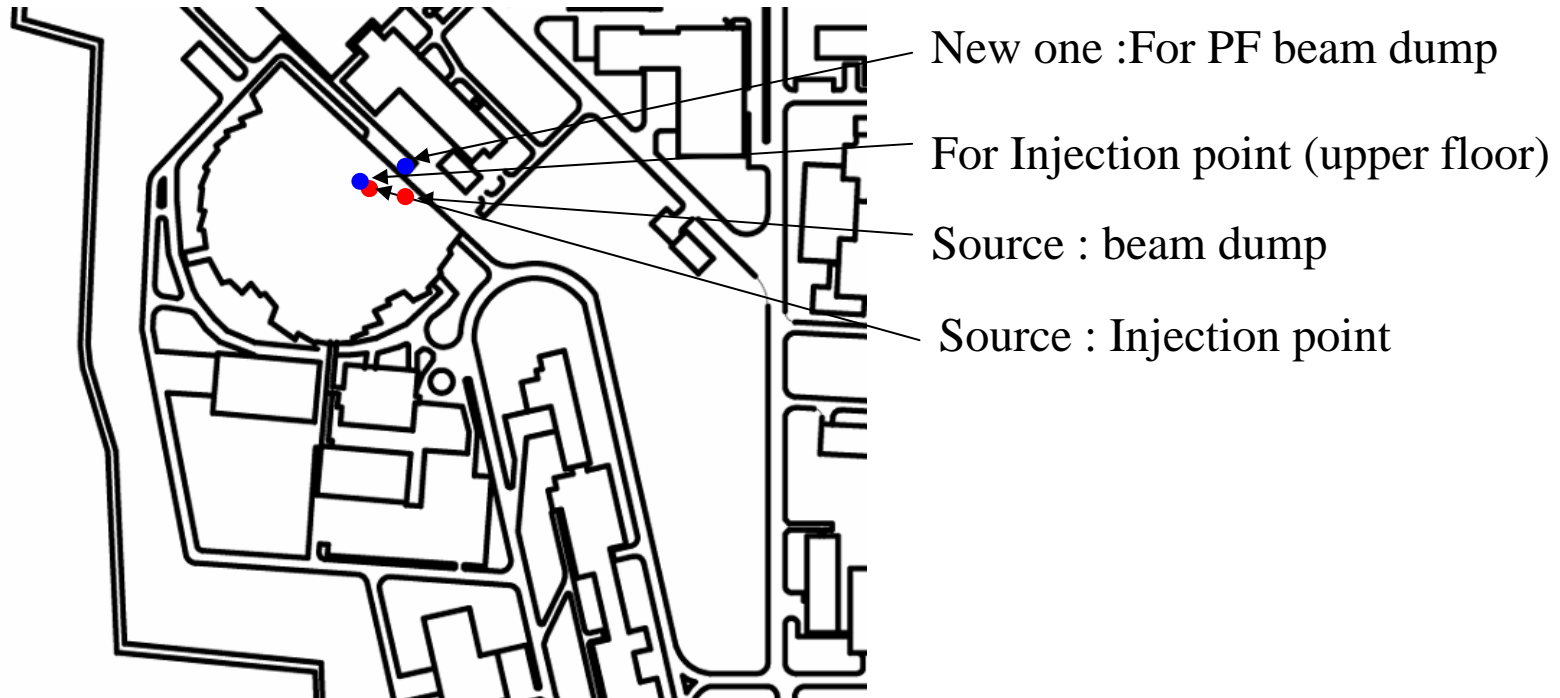
Radiation monitors around the energy tail beam slit



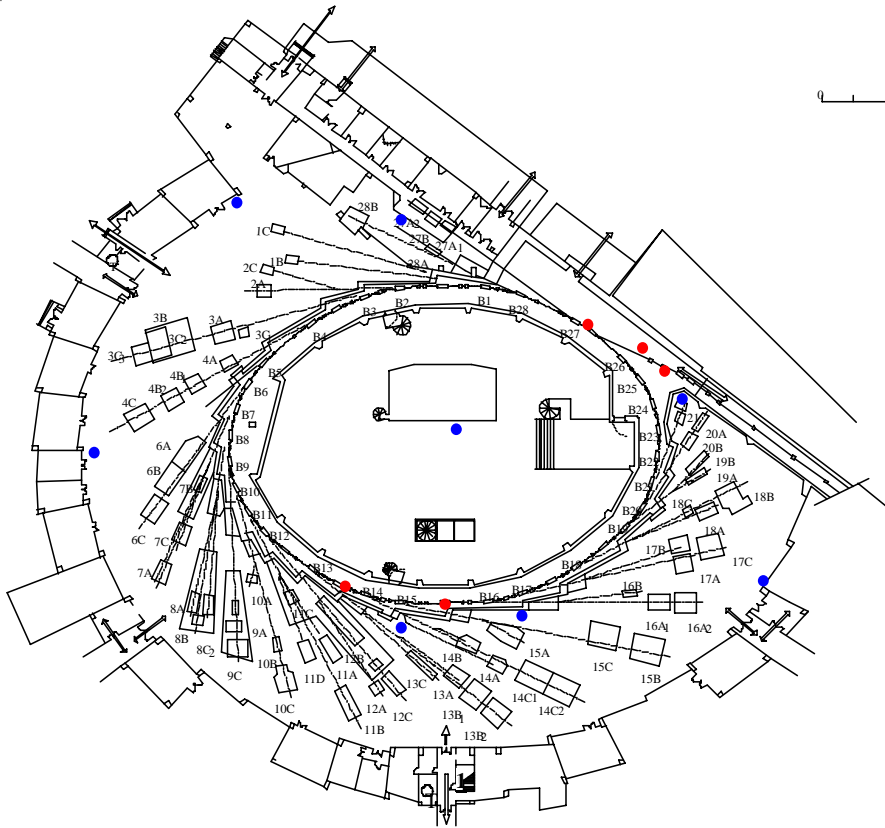
New radiation monitor for BT slit



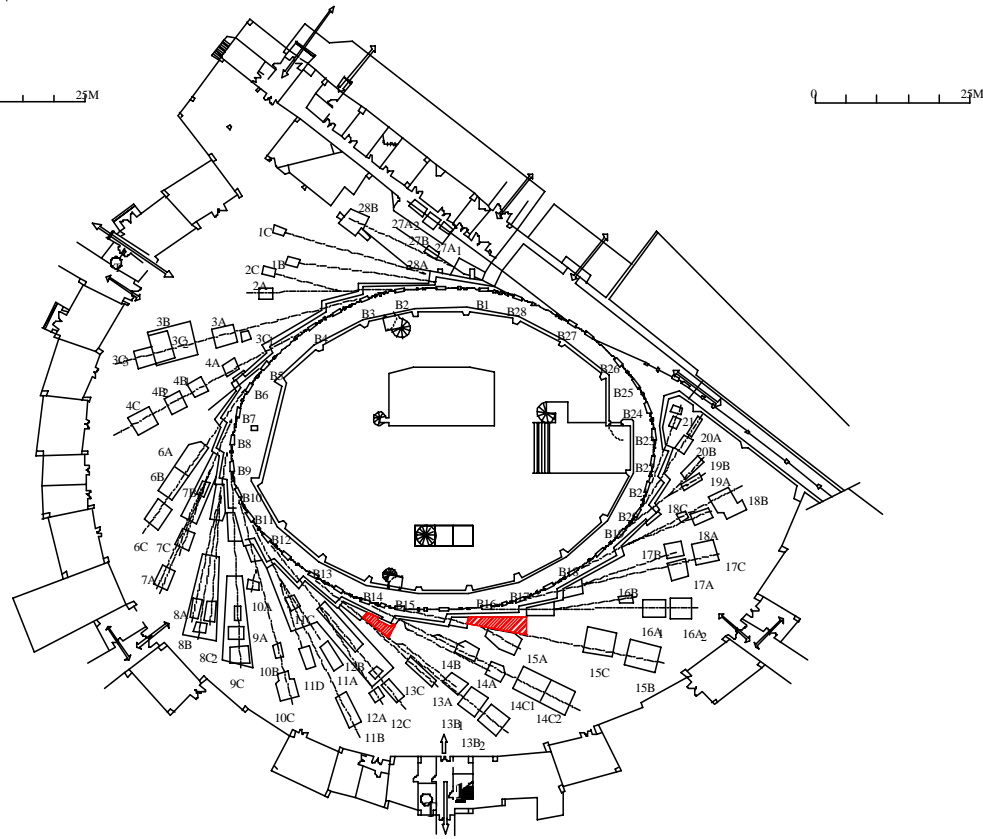
Radiation monitors around the injection point



Radiation monitors and restricted area in experimental hall



Reallocate monitors close to the wall



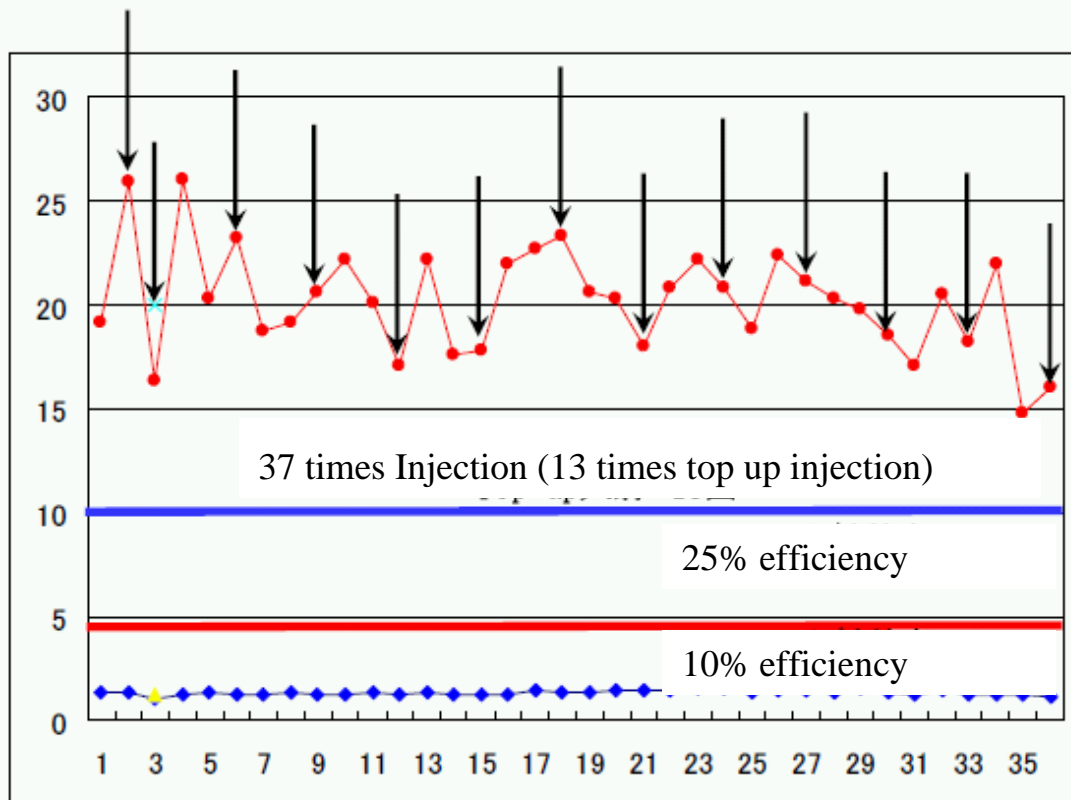
Define restricted area

PF top-up operation

- Boundary condition for Top-up injection (Injection with MBS open)
 1. $> 5\text{mA}$ stored beam current
 2. $> 12.5\%$ injection efficiency

Injection efficiency mA/sec/nC (40mA/sec/nC = 100%)

Injection rate mA/sec

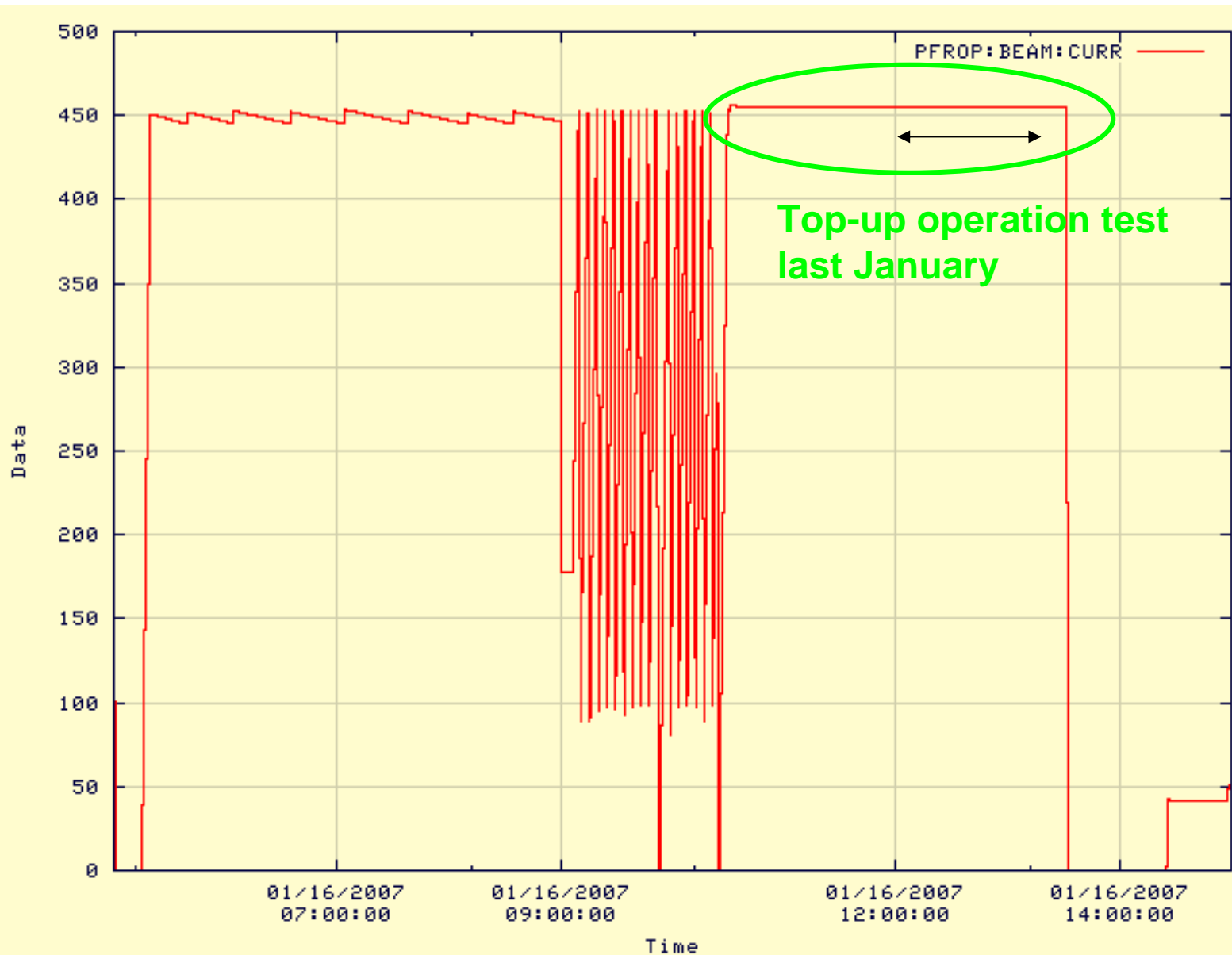


Normal injection efficiency

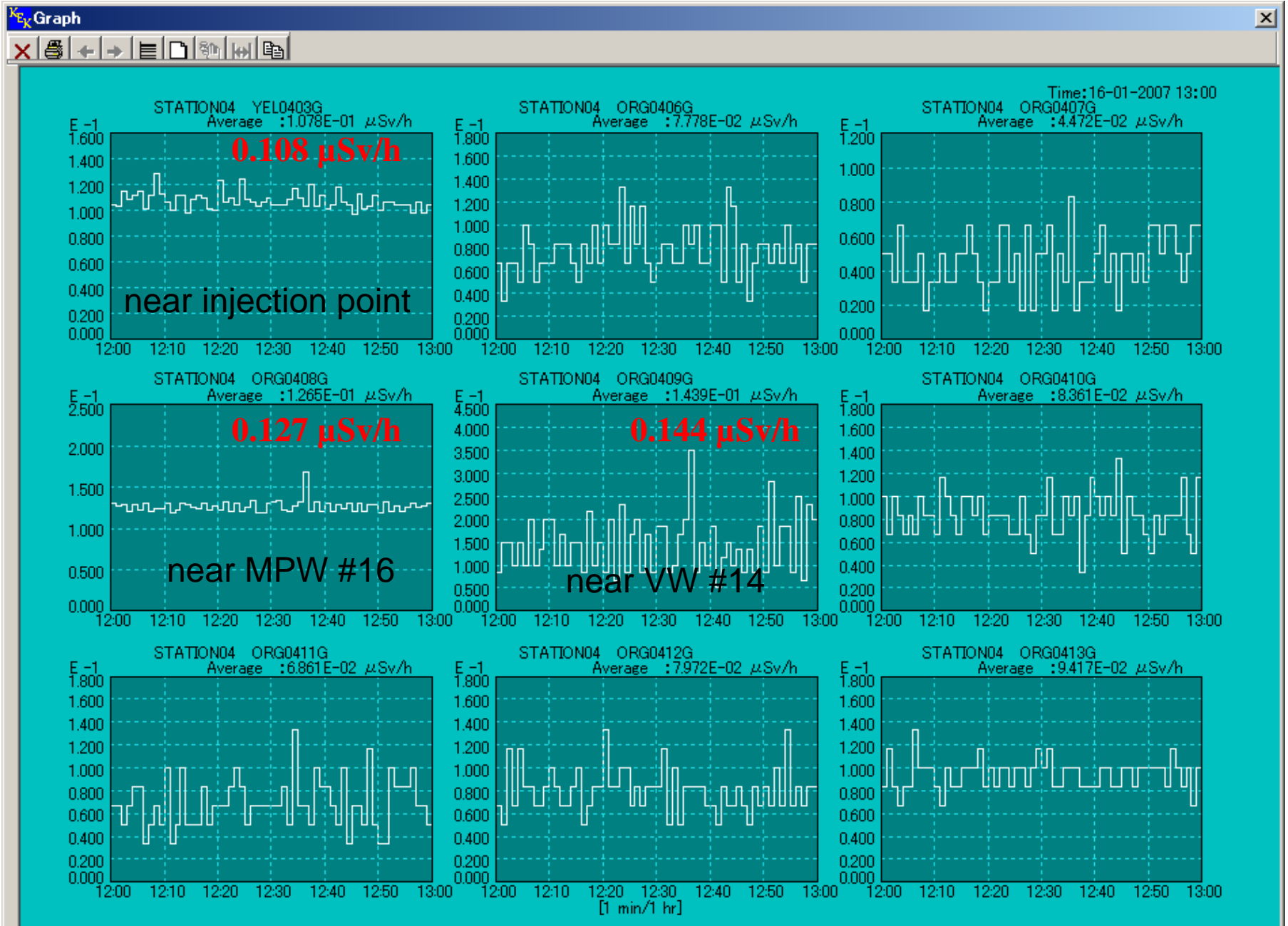
60%

← 50%

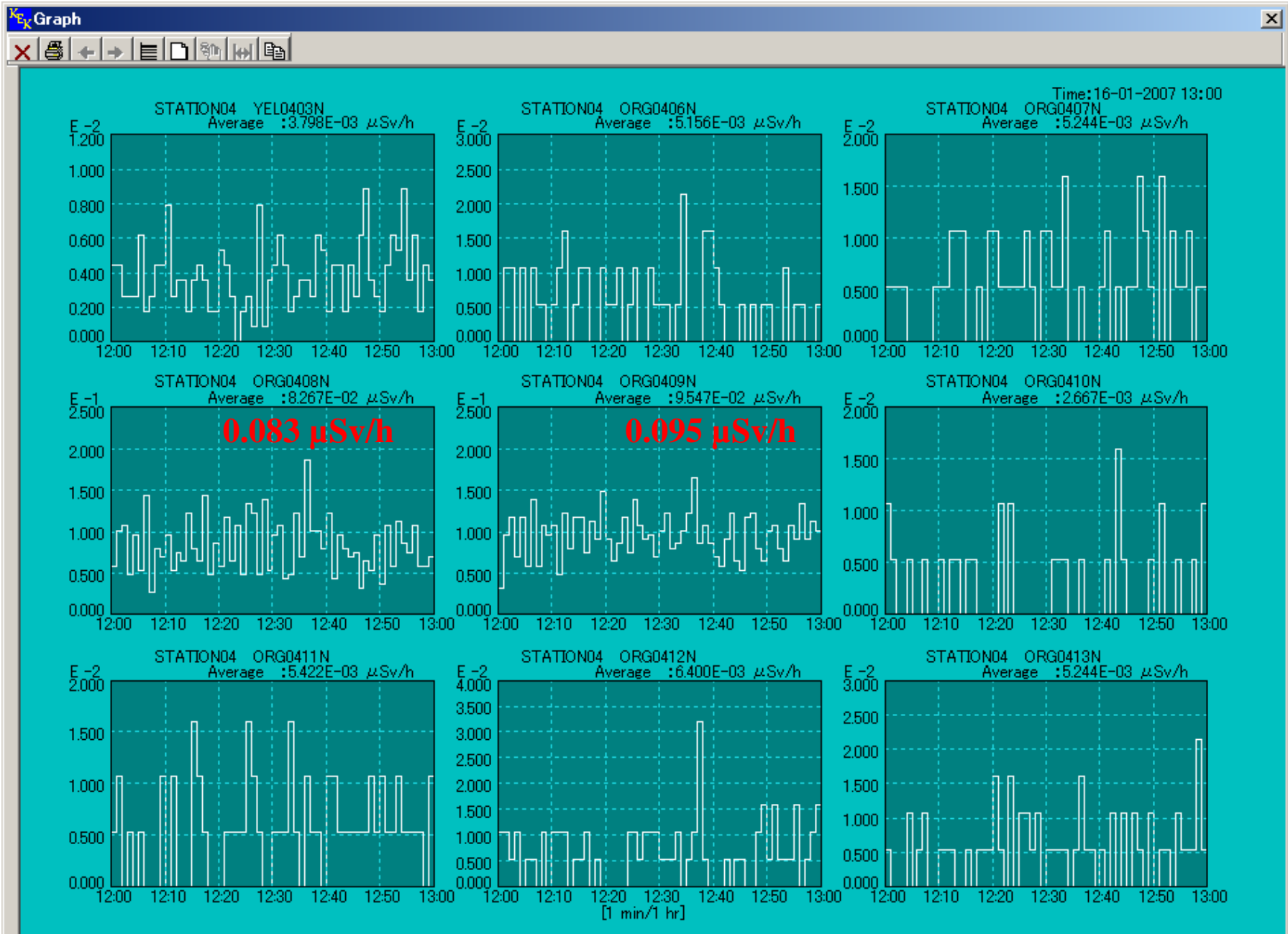
Top-up operation test



Dose rate during top-up mode (gamma)



Dose rate during top-up mode (neutron)



Summary

- KEK Radiation science center permits KEK PF Top-up mode because...
 - Dose rate satisfy limitation during top-up injection at almost all beam line.
 - BL14,16: near beam loss point, we define new restricted area.
 - We limit number of electrons to keep safety around accelerators.