Shielding Design of the SPring-8 XFEL Facility

Yoshihiro Asano[1], and Toshiro Itoga[1]
[1] *XFEL Project Riken, SPring-8 1-1 Sayo Hyogo 679-5148, Japan*

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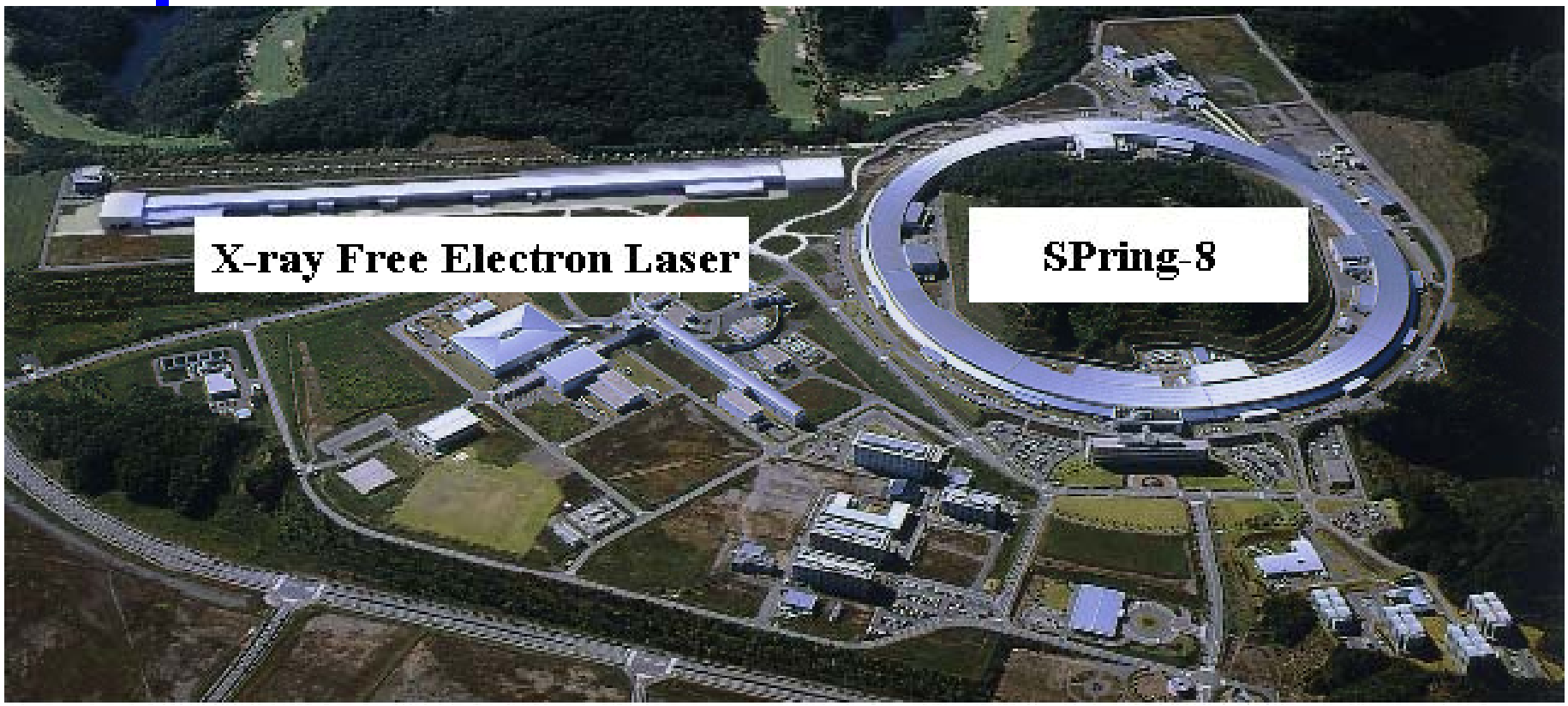
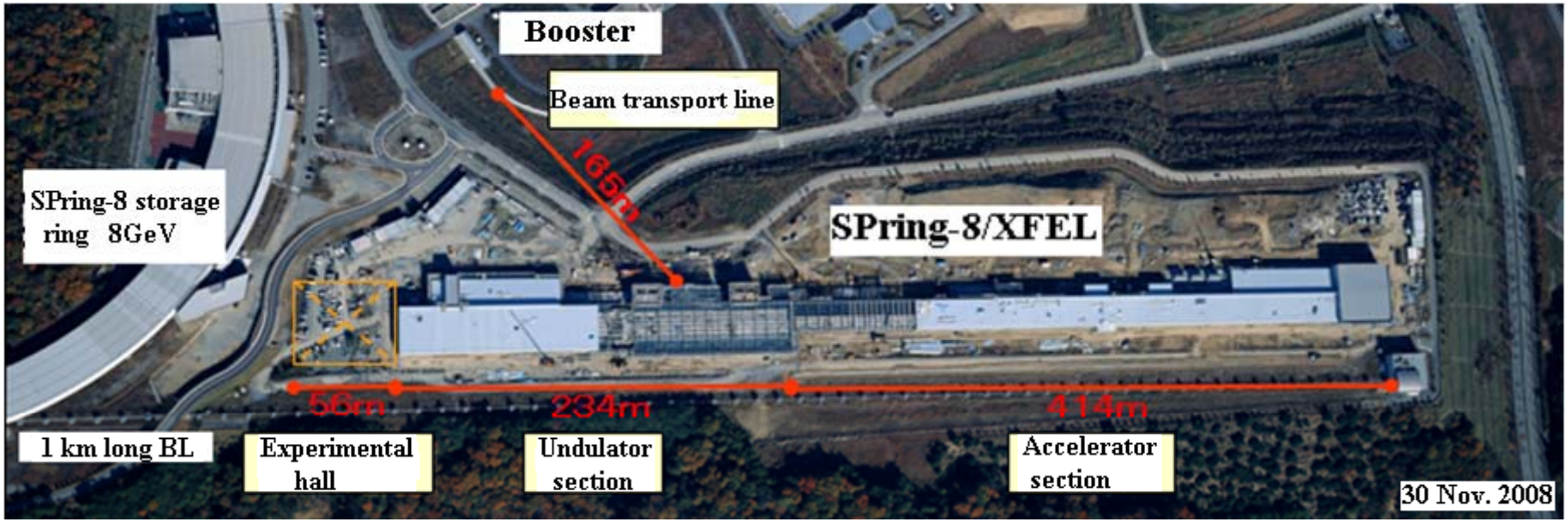
Shielding Design of the SPring-8 XFEL Facility



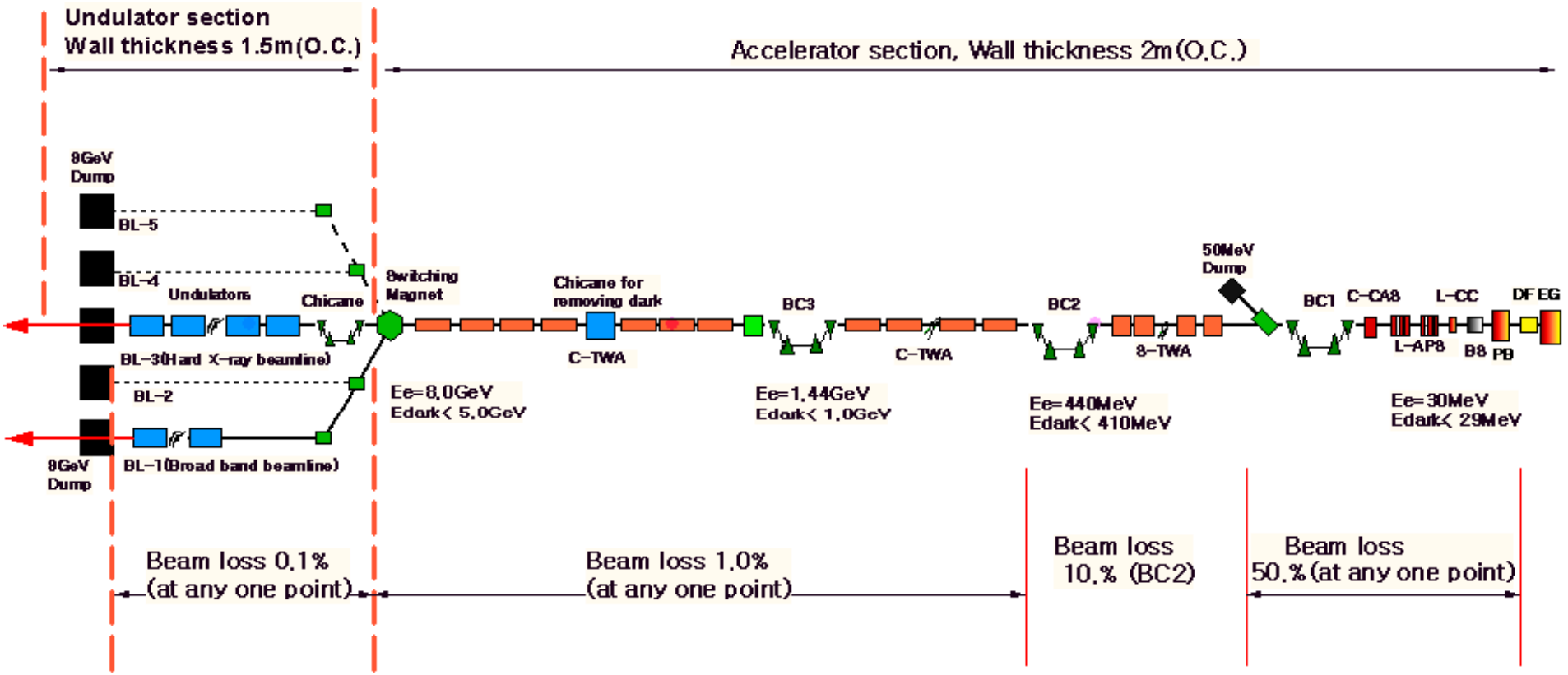
SPring-8/XFEL

- X-ray Free Electron Laser　wave length < 0.1nm
- Three new techniques　Thermionic gun（CeB6）
  C-band accelerators
  In-vacuum type undulator
- 1nC　60pps　8GeV

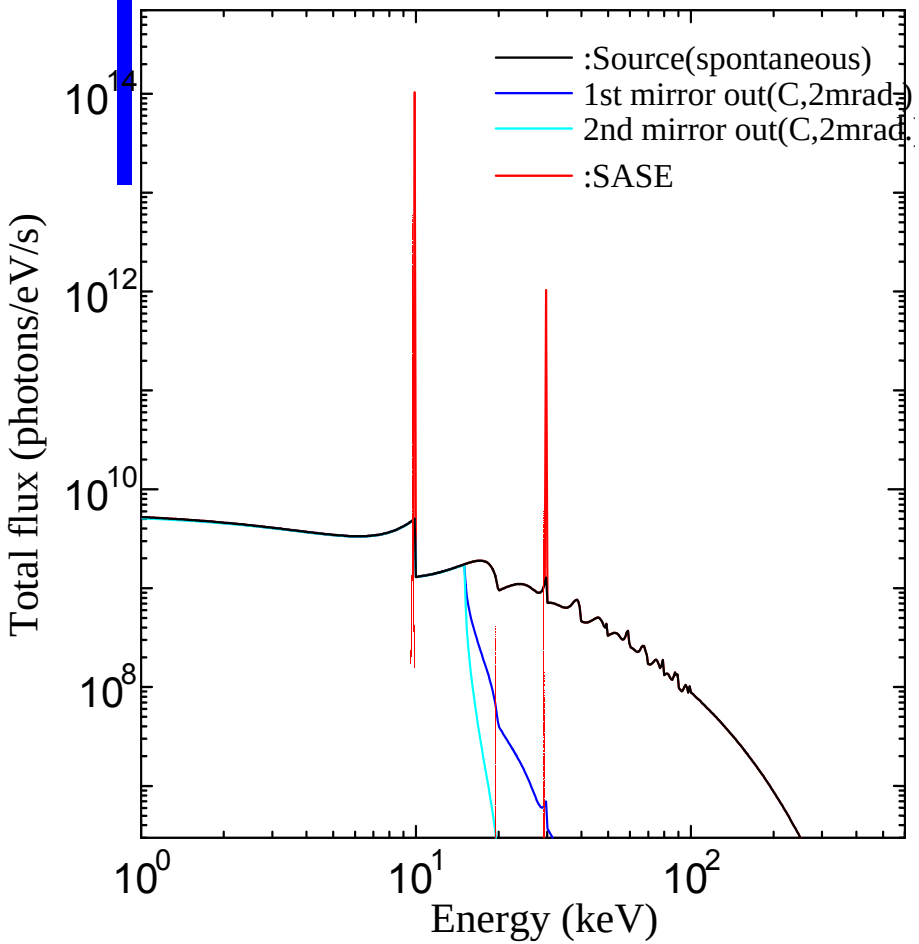


SPring-8/XFEL

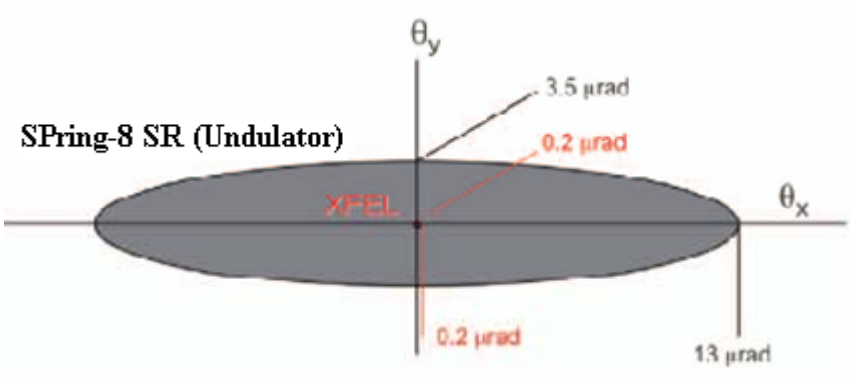
Illustration of accelerator components



SPring-8/XFEL



XFEL and undulator spectra at SPring8/XFEL



Beam spreads of XFEL and Undulators at SPring-8

Brightness : more than 10^9

SPring-8/XFEL

Shielding Design criteria

- Based on the ALARA principles
- Controlled area　　Max 25μSv/h (Law)
- 　　Design criteria 8μSv/h
- Boundary of controlled area
- 　Design criteria (Law)　 2.5 μSv/h
- Site boundary
- 　　Max　250 μSv/3M
- 　　Design criteria 100 μSv/y

Electron Accelerator Bulk Shielding
(Comparison between Jenkins formula, SHIELD１１, and FLUKA)

- SHIELD11(SLAC)
  → Improvements of Jenkins ‘ formula
- SHIELD11
  (1) Capability of wide application
  (2) Self shielding of Target,
  (3) Local shielding

- Comparison with SHIELD11,
- FLUKA, and Jenkins Formula

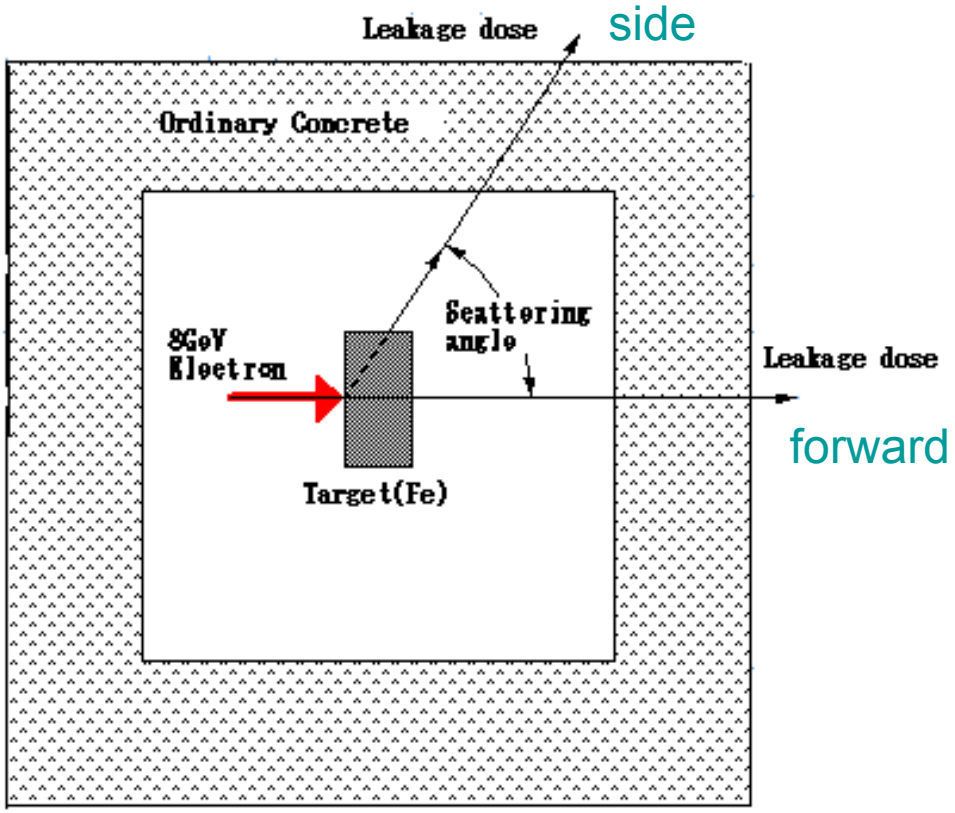
Electron Accelerator Shielding (Attenuation length)

Comparison between the attenuation lengths which we used for SPring-8 and SHIELD11

(cm)

Material		Neutron			Photon
		High Energy (λ_1)	Intermediate (λ_3)	Giant resonance (λ_2)	(λ)
Ord. Concrete	SPring-8	54.6	25.0	13.7	18.9
	SHIELD11	54.55	25.0	13.64	19.1
Iron	SPring-8	21.3	12.4	6.8	4.3
	SHIELD11	18.6	18.6	6.0	4.3
Lead	SPring-8	22.7	18.3	10.0	2.1
	SHIELD11	17.6	17.6	8.54	2.1

Intercomparison between SHIELD11, Jenkins, and FLUKA at 8GeV



Calculation model

Cylindrical target 20 cm thick

20cm radius

O.C wall 1m－2．5m thick

Jenkins : side

Swanson :forward

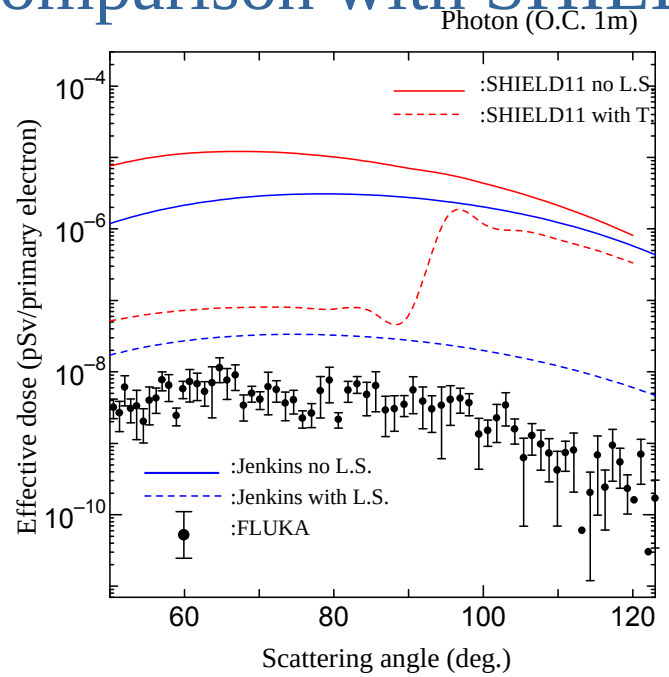
SHIELD11 :with and without considering self shield of target

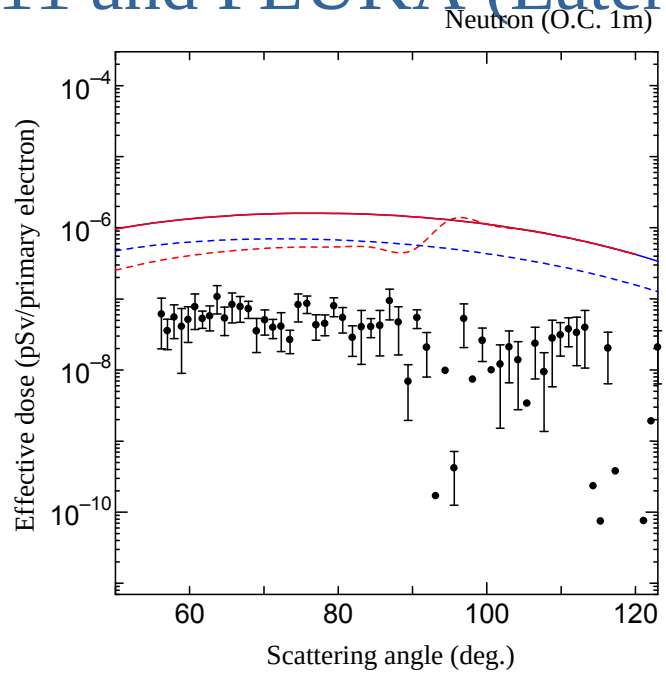
FLUKA :Effective Dose

（worst geometry)

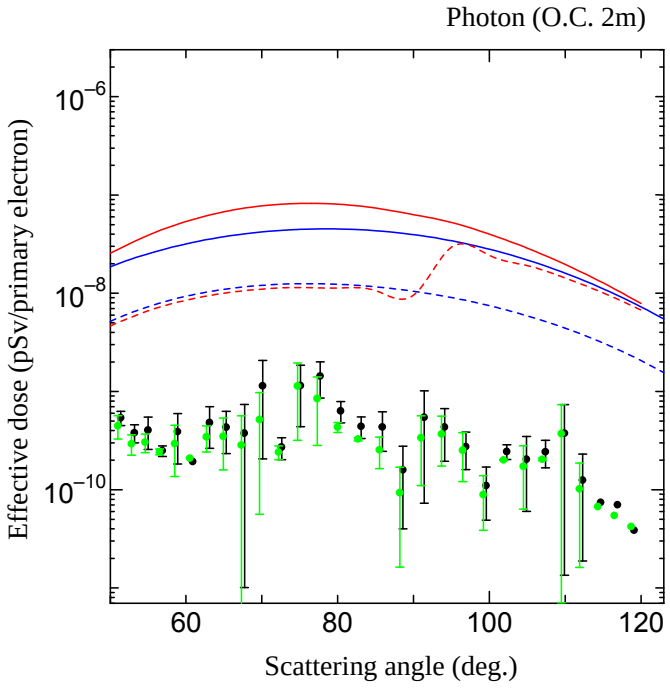
:Ambient Dose

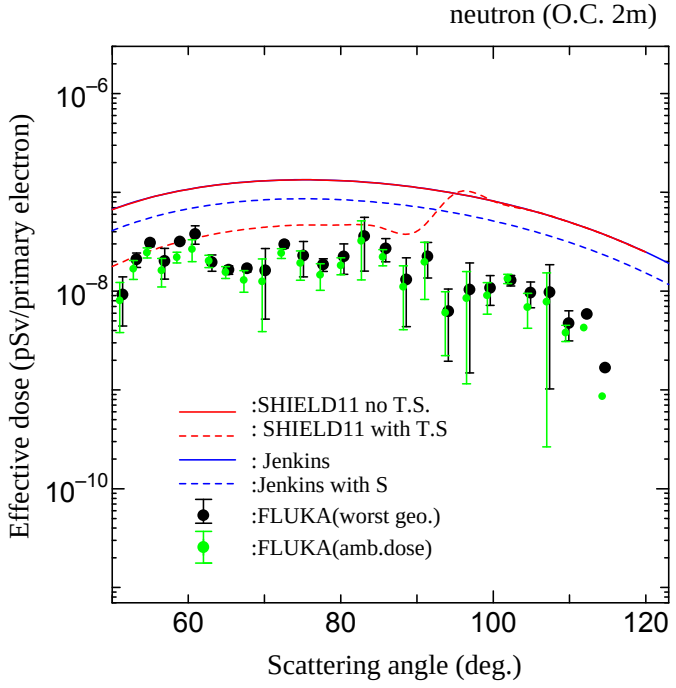
Comparison with SHILD11 and FLUKA (Lateral)





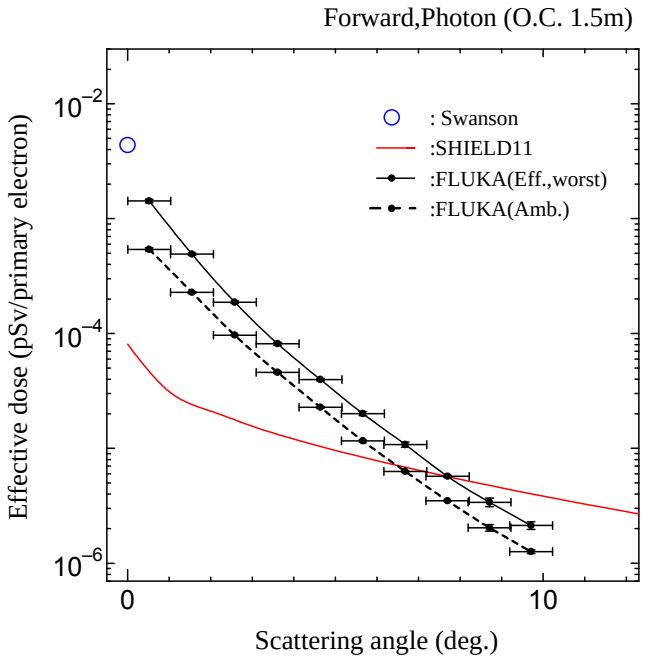
O.C. 1 m

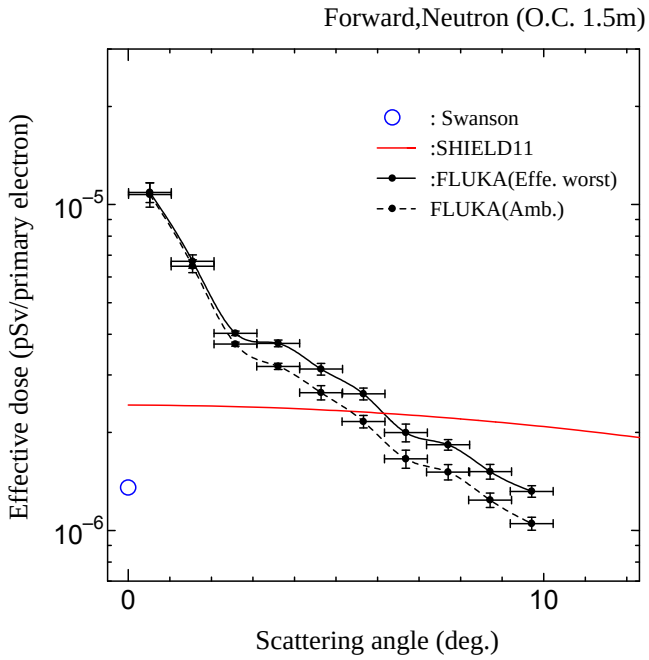




O.C. 2m

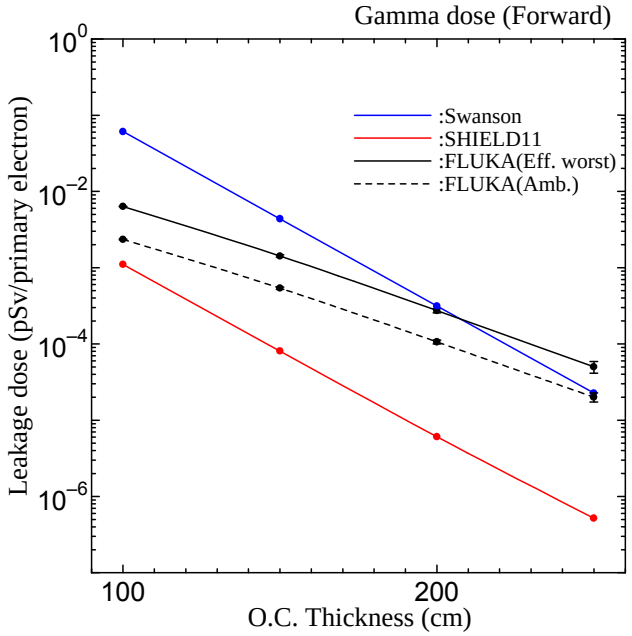
Comparison between SHILD11and FLUKA (forward)

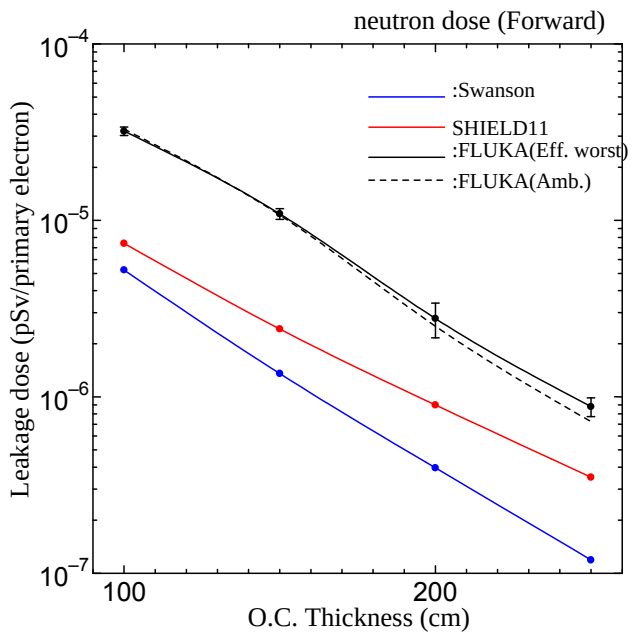




O.C. 1.5m

scattering angle

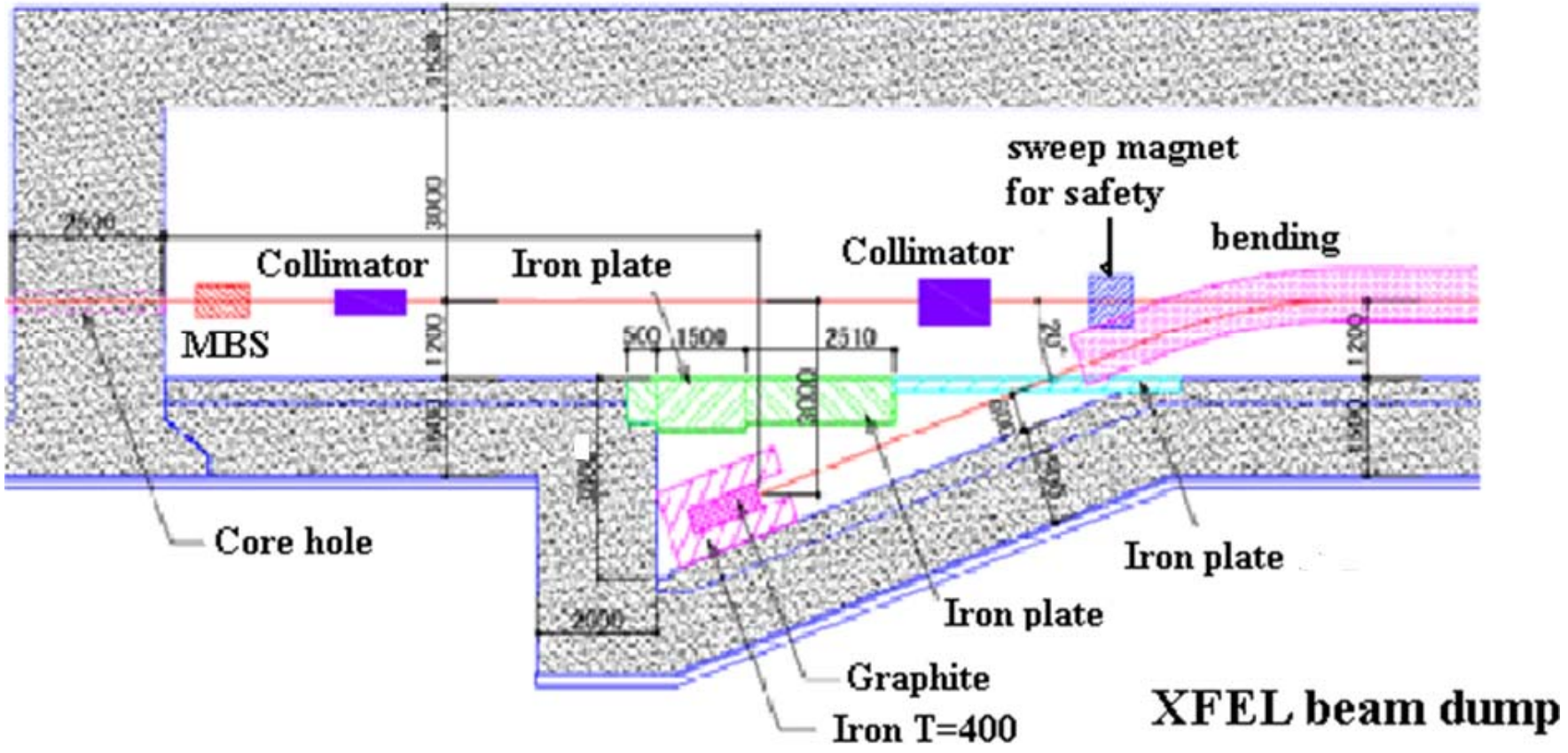




O.C. thickness

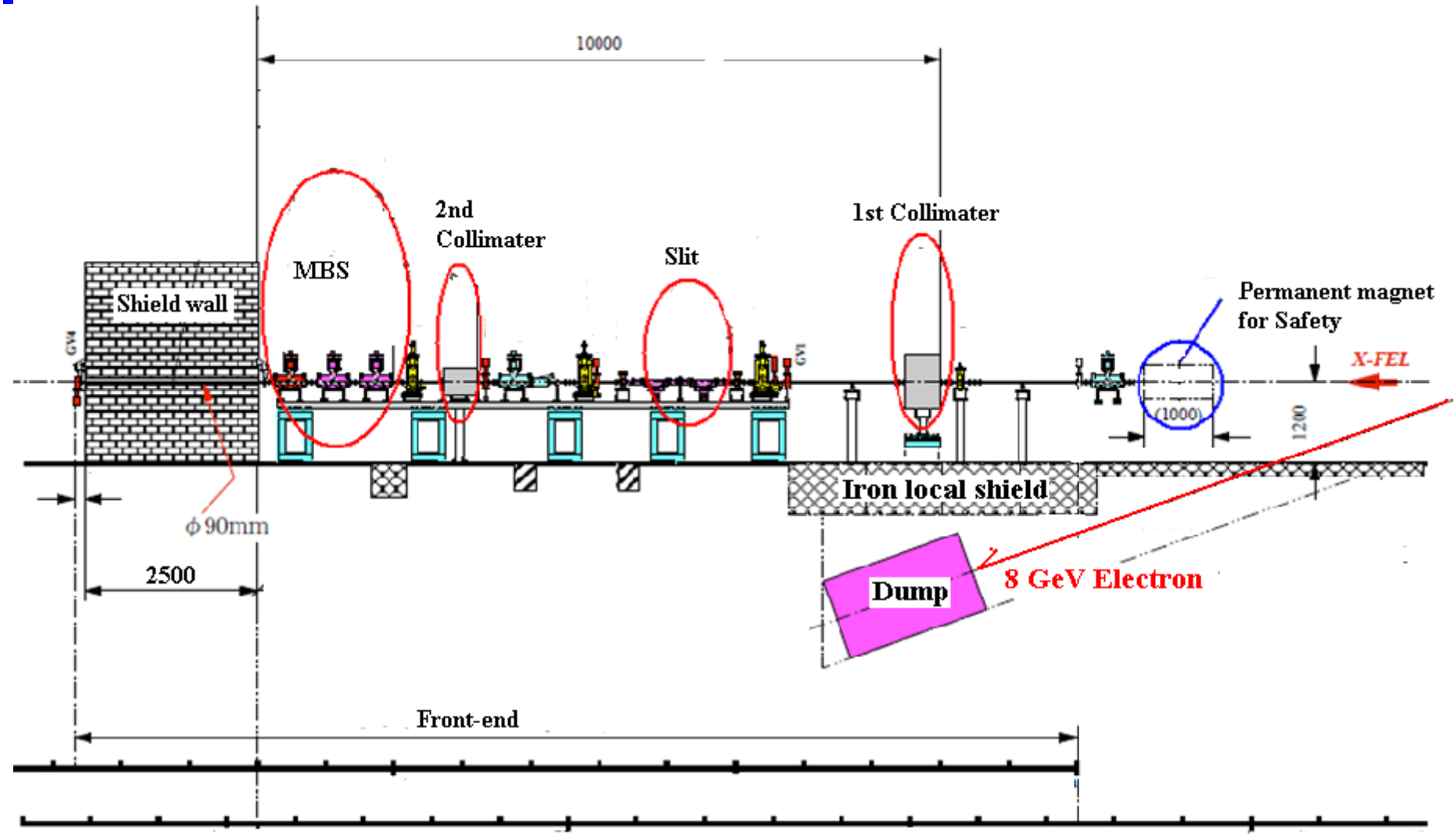
Scattering angle
0 deg.

Beam dump

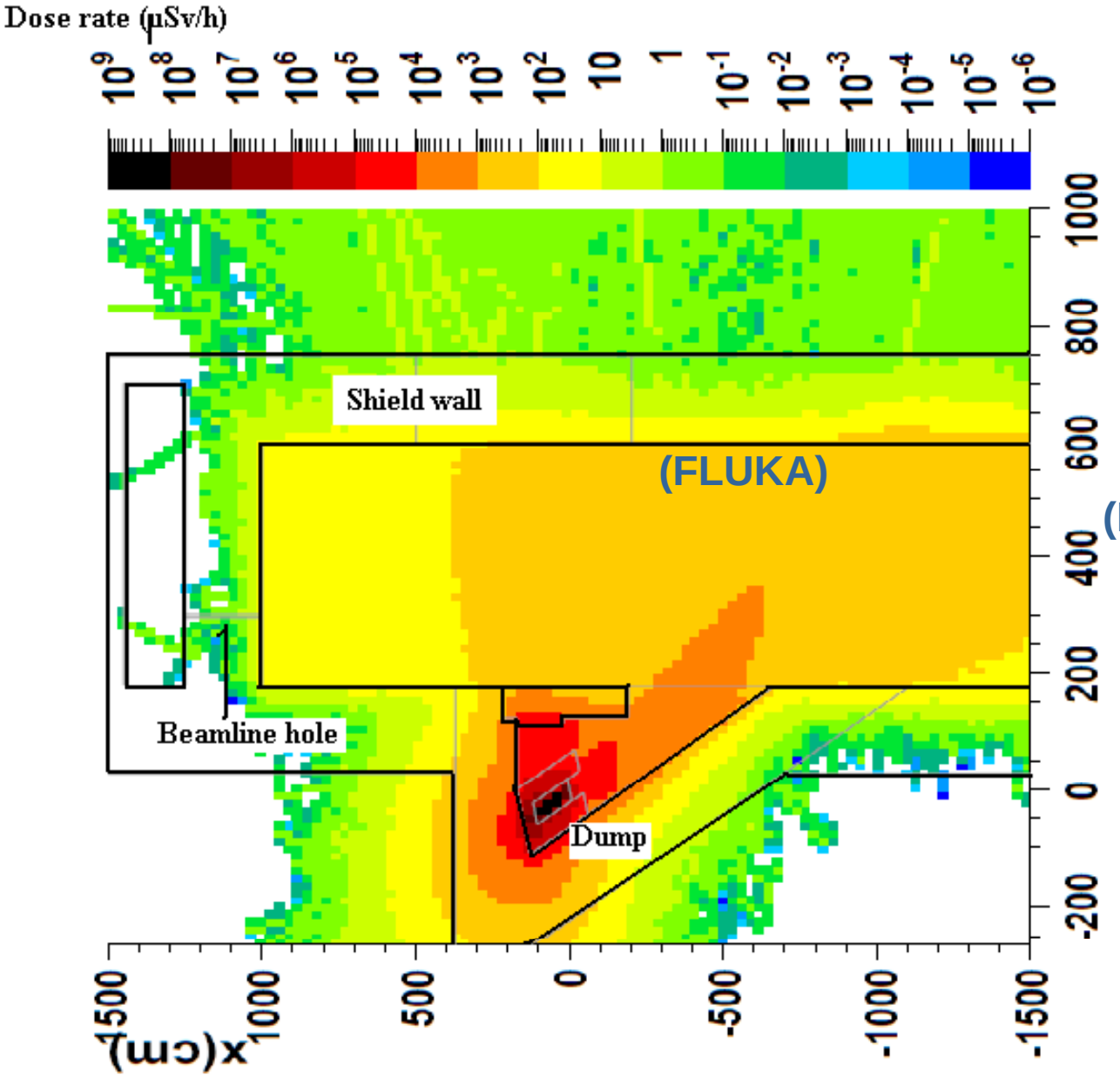


XFEL beam dump

Beamline components(Front-end)



Dose distribution during the beam injection to the dump(FLUKA)



Source; 1nC 60pps

(FLUKA)

Leakage dose outside the roof at the beam dump area

Cal. condition

8 GeV electron ;

１ｎC、６０ｐｐｓ、

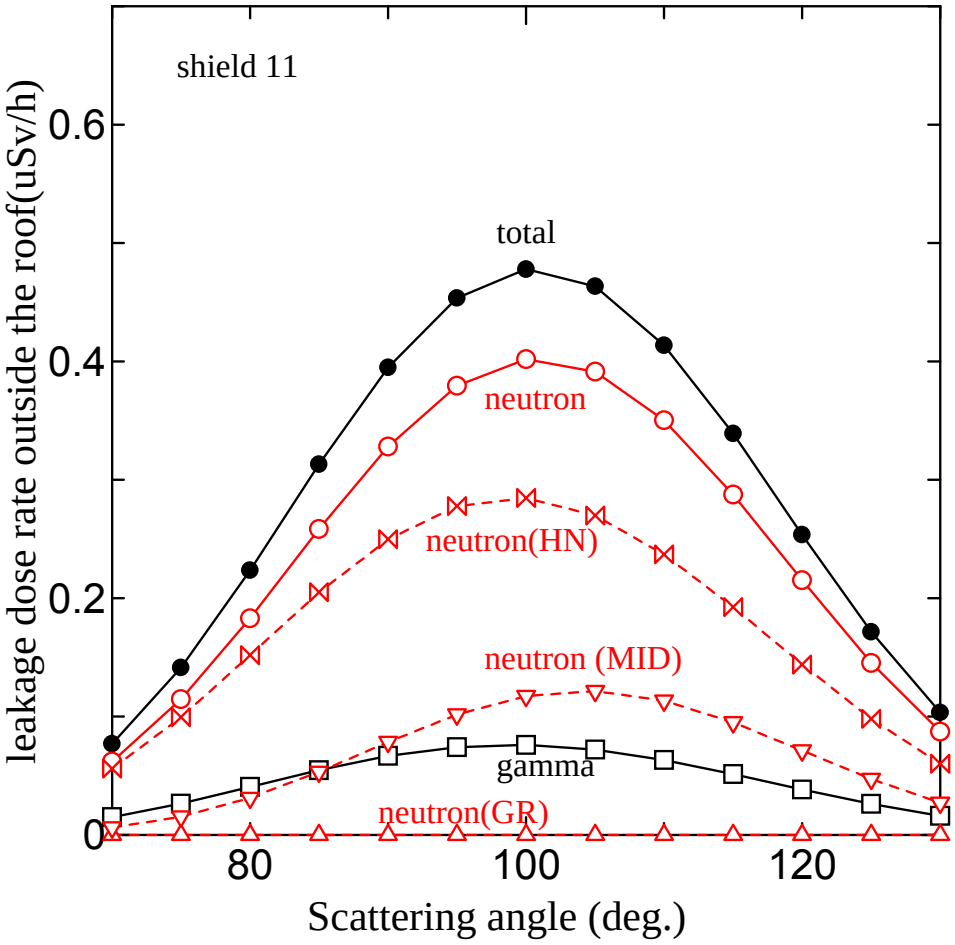
20 deg. inclined dump

Dump（double cylindrical structure）
Graphite +40cm Fe

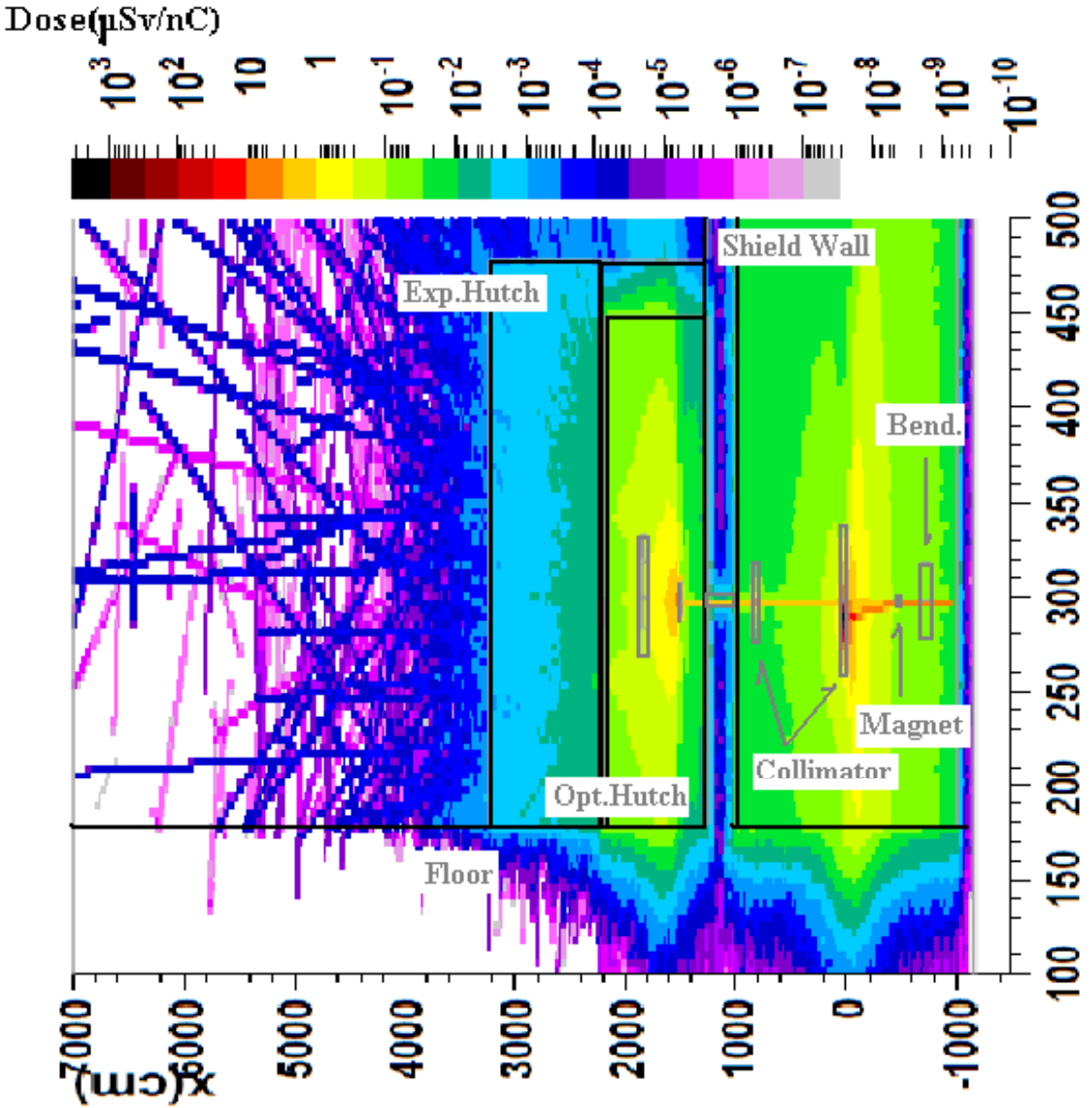
Shield

Iron65cm（portion:55cm）

＋O.C. １．５m



Electron beam loss (power lost of B.M.)



Permanent Magnet

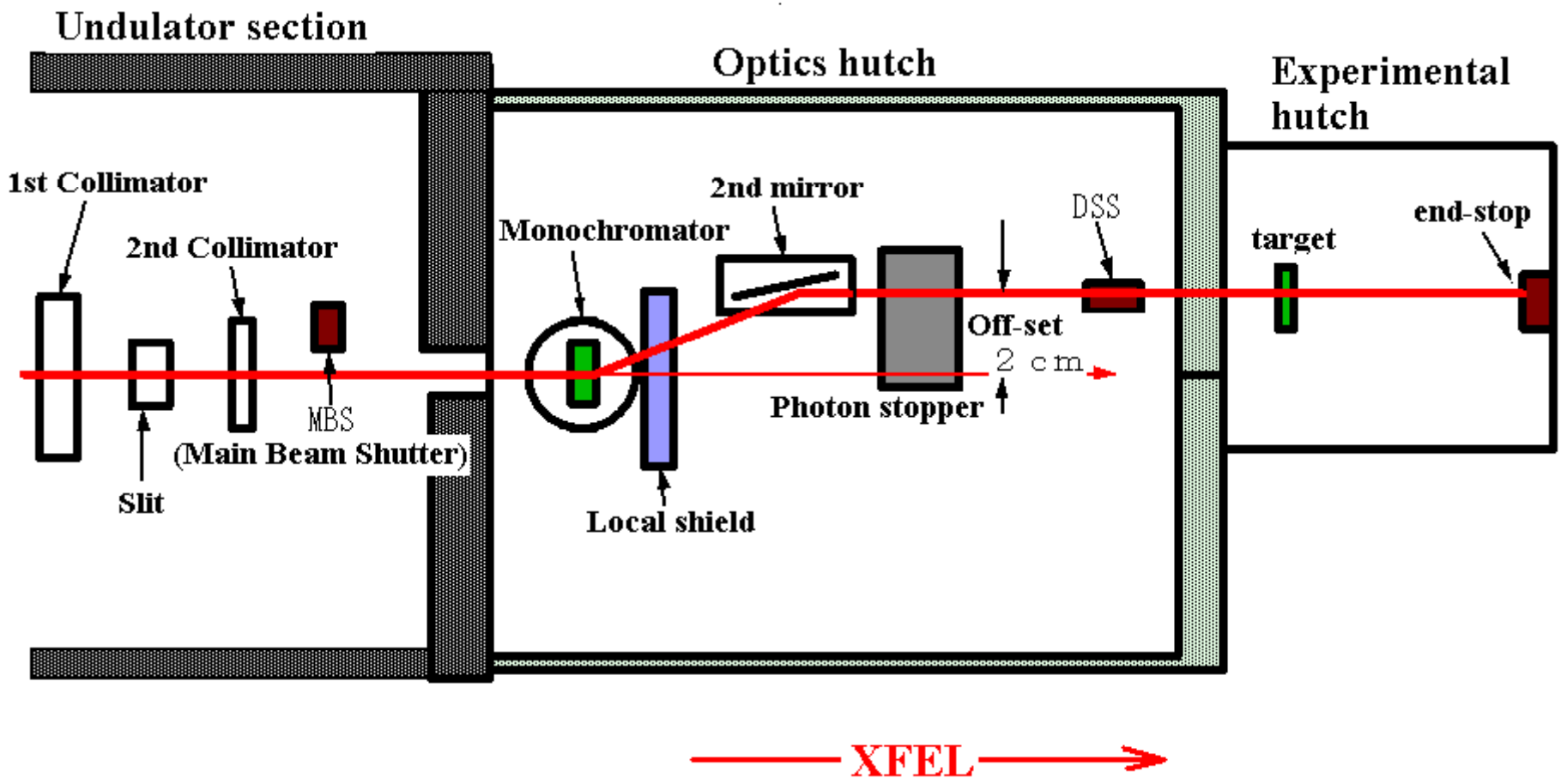
０．９T、５７ｃｍ

Aperture size of collimator 13mmφ

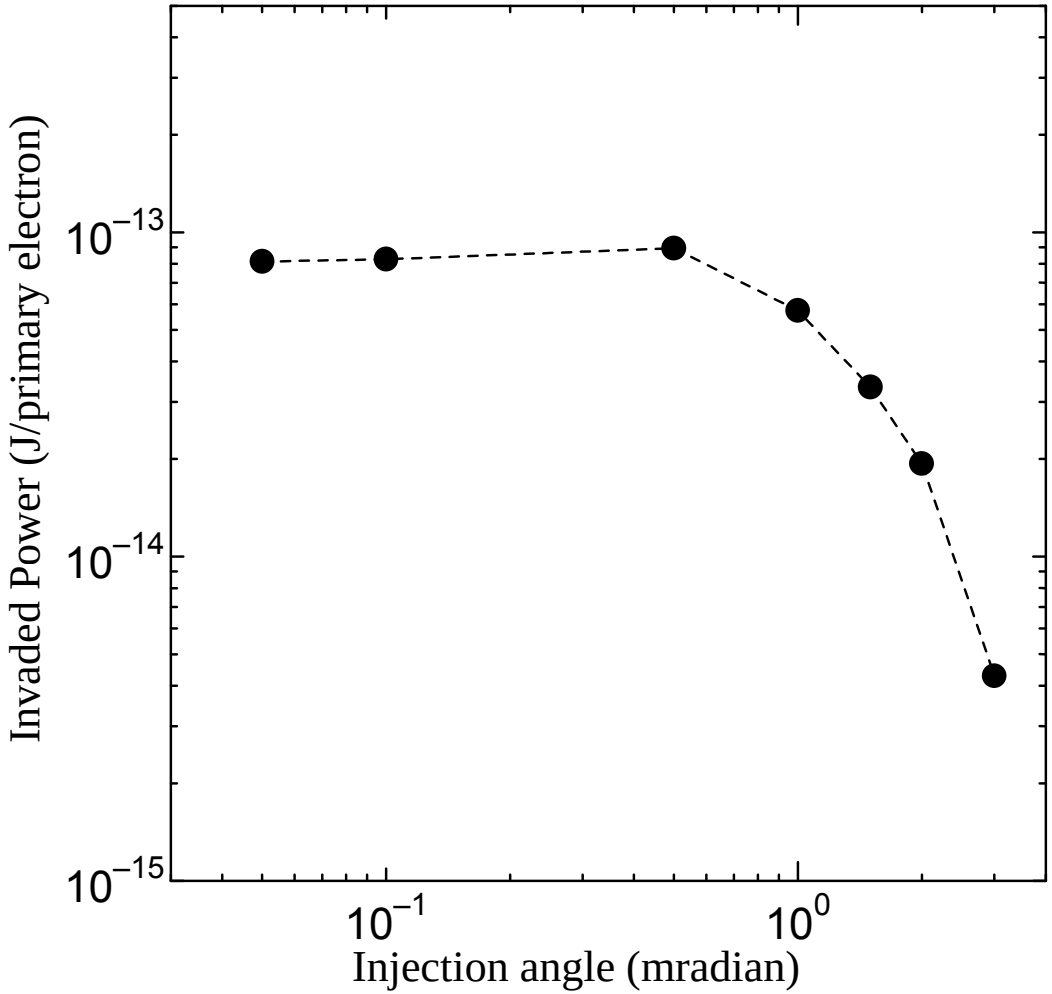
Distance from the magnet to the collimator 5m

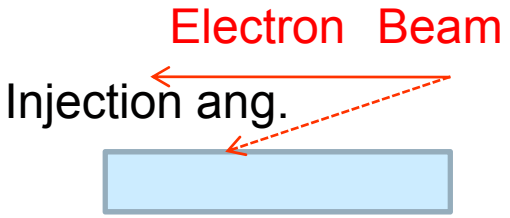
8GeV electrons never inject into optics hutch

Conceptual design of the optical elements at the XFEL beamline



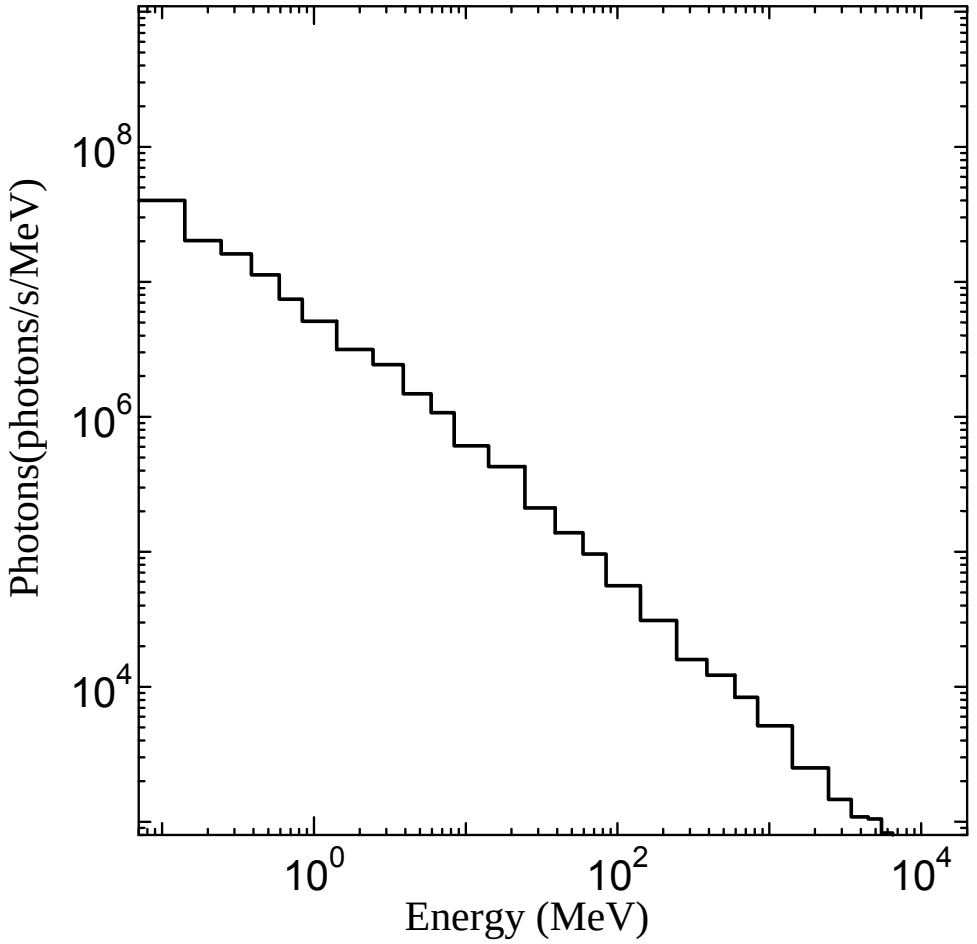
Injection angle dependence of the invaded photon power（EGS4）





Aperture size of the collimators 13mm Φ

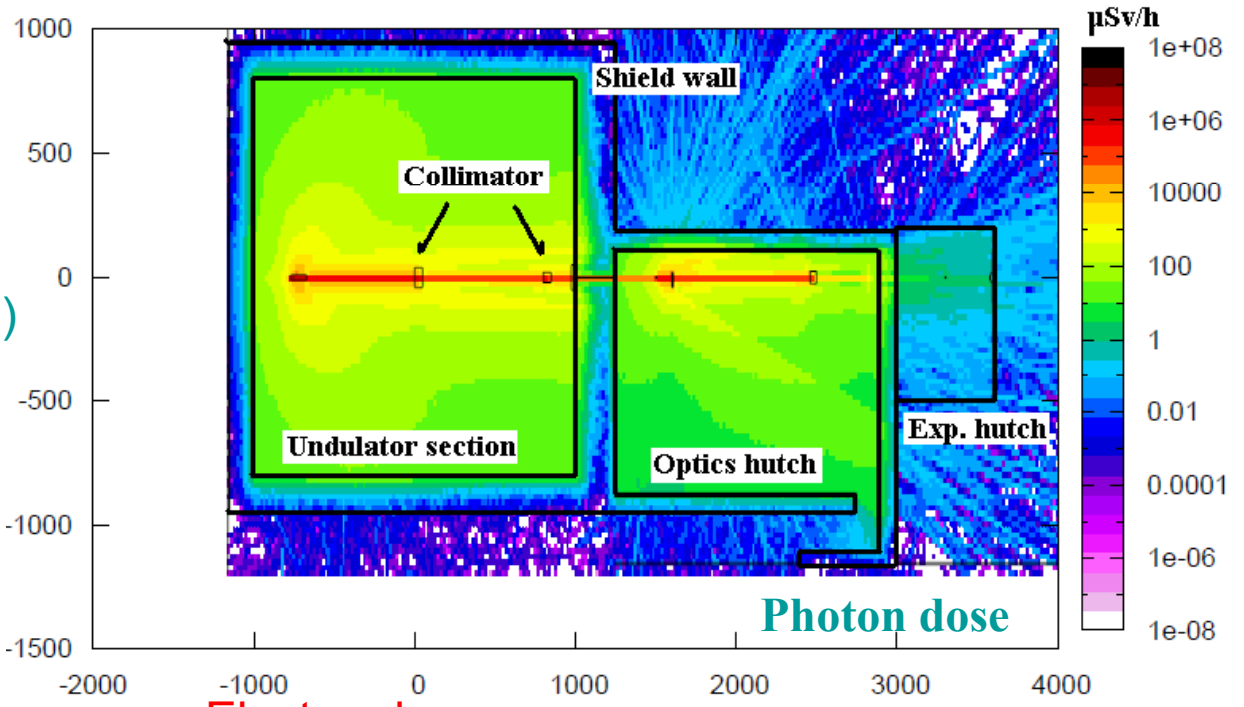
Photon spectrum due to electron beam loss at the optics hutch（EGS4）



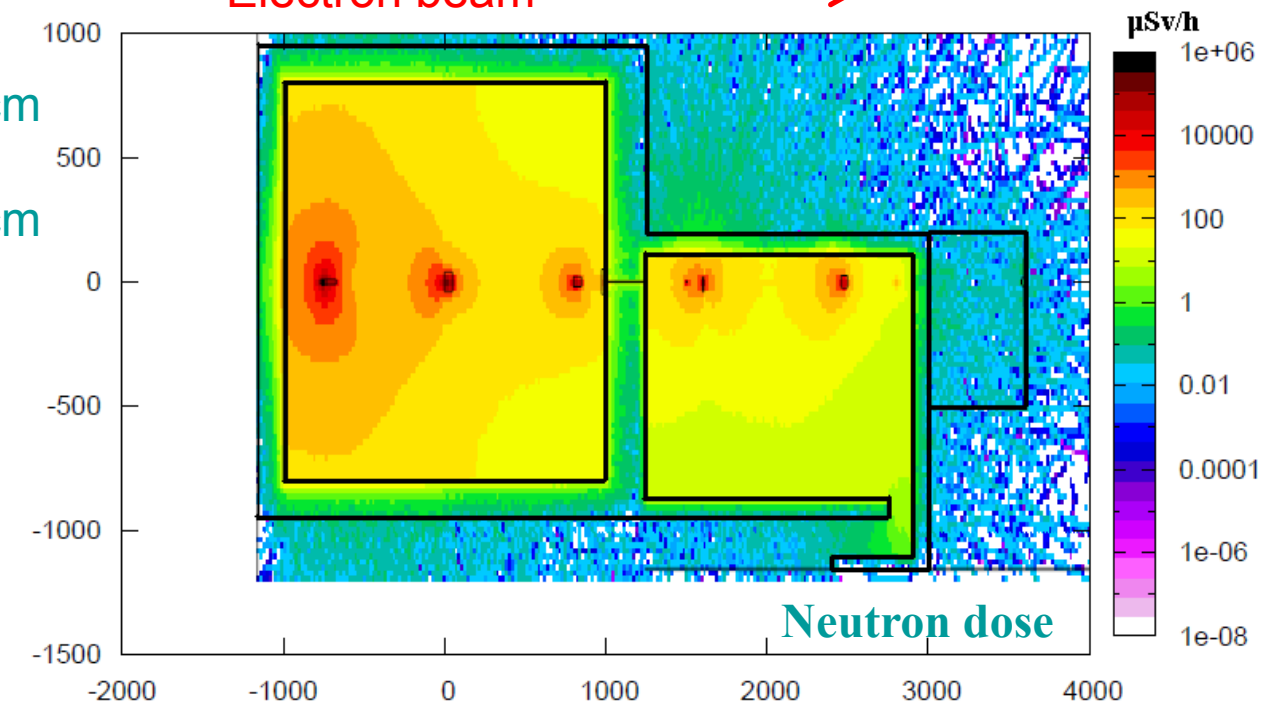
Dose distribution around
the optics hutch

Beam loss 0.1% (1nC,60pps)
Injection angle 0.1mradian

optics hutch
side wall 80cm O.C.
back wall 100cm O.C.
Scatterer
Cu 5cm
Local shield (Pb)
60cmWx60cmHx10cm
Photon stopper
50cmWx50cmHx40cm
DSS (W)
4cmWx3cmHx10cm



Electron beam



Shielding Design of the SPring-8 XFEL Facility

- **Summary**
- **For the design of the bulk shield of XFEL, we employed the SHIELD11 code, Jenkins' formula, Swanson's method, and Monte Carlo code FLUKA, and compared each other.**
- **As the results of the leakage dose at the lateral direction , we found the calculation results by using the Jenkins underestimate in comparison with the SHIELD 11 for gamma dose, and neutron doses are almost the same. Both gamma and neutron doses calculated by SHIELD11 show the conservative values in comparison with that of FLUKA(effective dose).**
- **For the doses at the forward direction, SHIELD 11 underestimates both the gamma and neutron doses in comparison with that of FLUKA so that we must care the calculations in the forward direction.**
- **For the XFEL beamline shielding, we employed the FLUKA code because the bremsstrahlung photons and photoneutrons are dominant for the radiation protection.**
- **The shield tunnel and the building of the SPring-8/XFEL have been constructed, and the accelerators are now under construction.**
- **The commissioning will be started in next year.**