MDI works for Super KEKB

2008/7/4

M. Iwasaki (Univ. of Tokyo)

MDI works for Super-KEKB

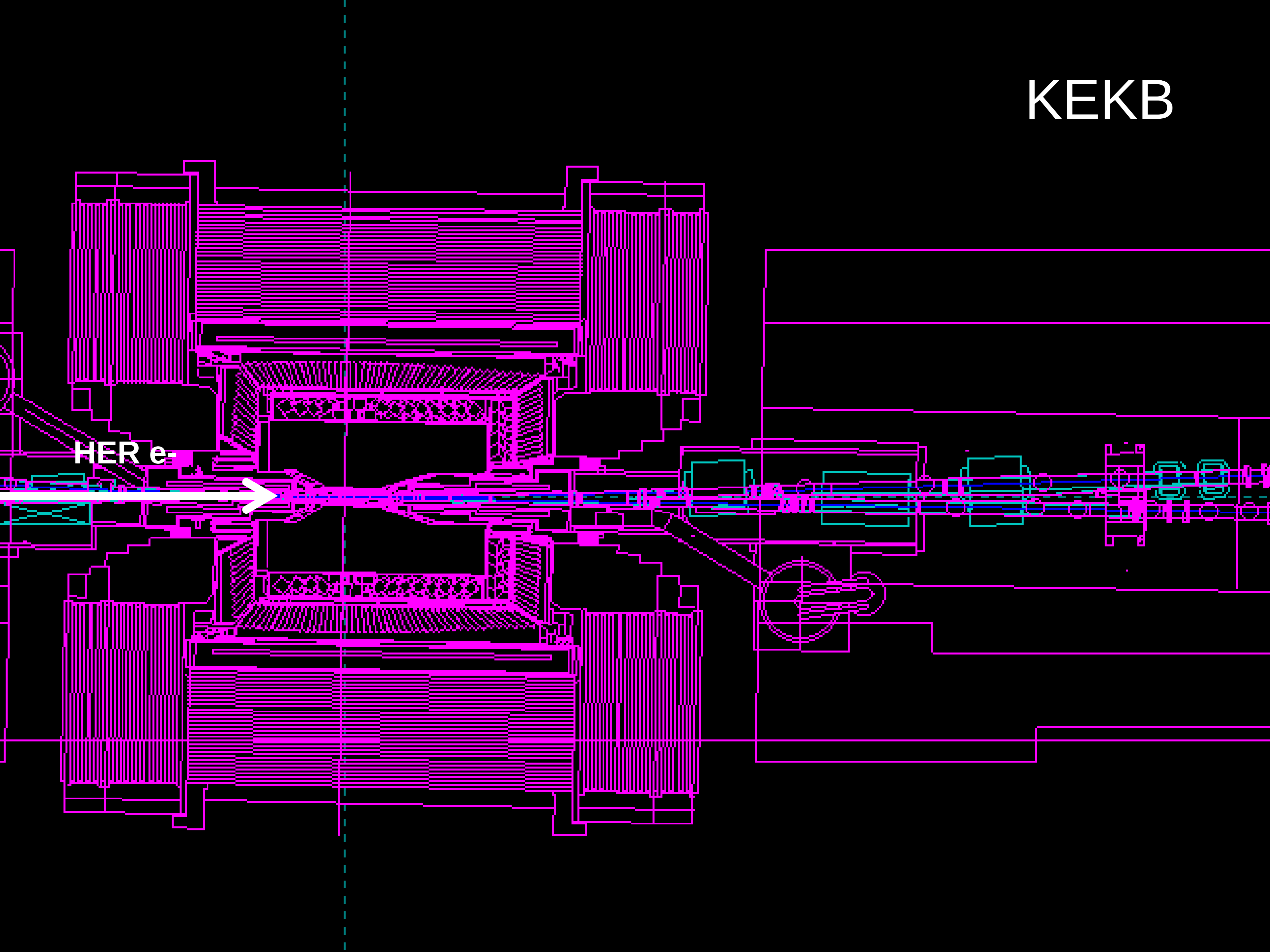
Super-KEKB → High luminosity experiment

- It is important to protect and assure the stable detector operation under the high current beam BG
- Beam BG study is important to design the IR region (Machine-Detector-Interface region)

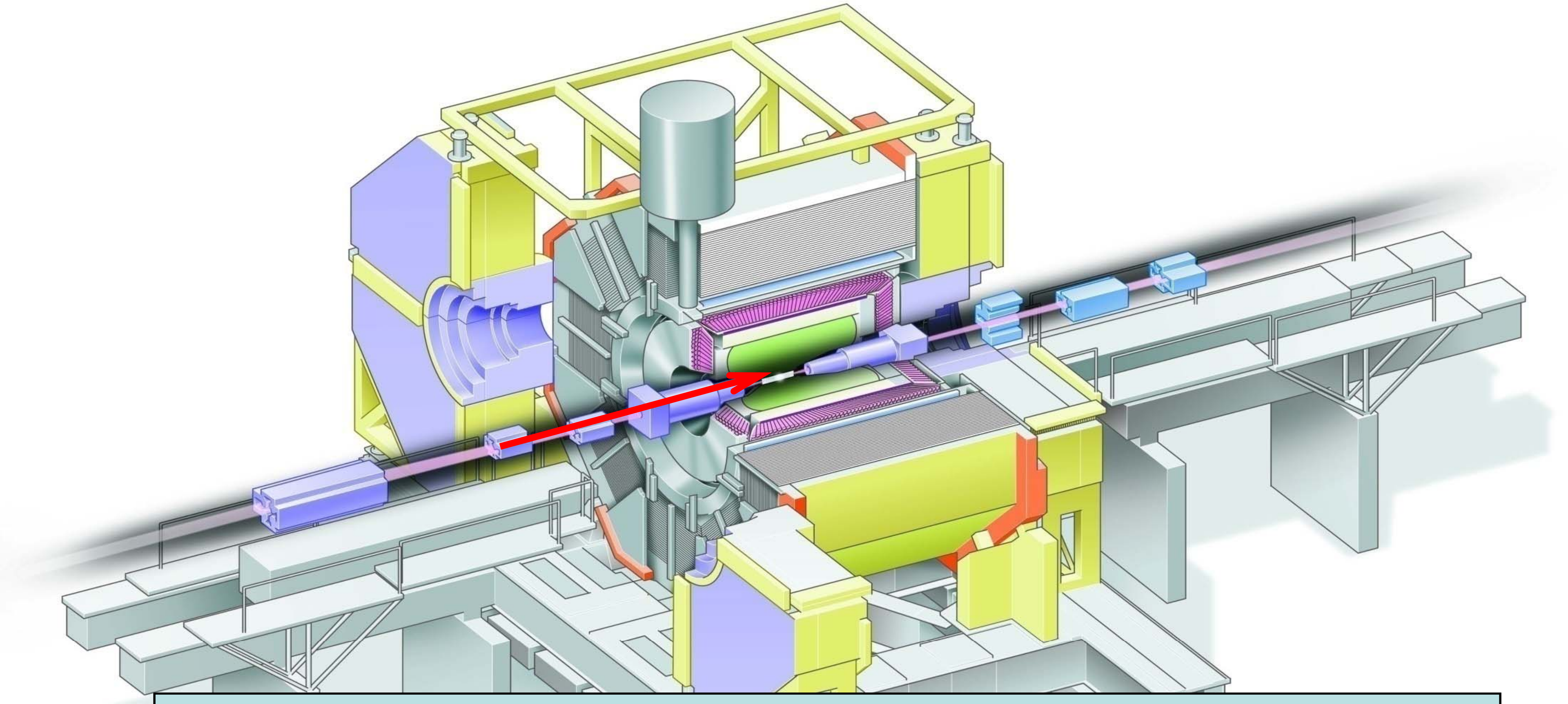
Beam BG simulation study for Super-KEKB

- To take care of the dynamic-beam effect, Super-KEKB IR design has been changed
- We must re-estimate the beam BG effect ASAP
  → important feed back to both KEKB and SVD groups

KEKB

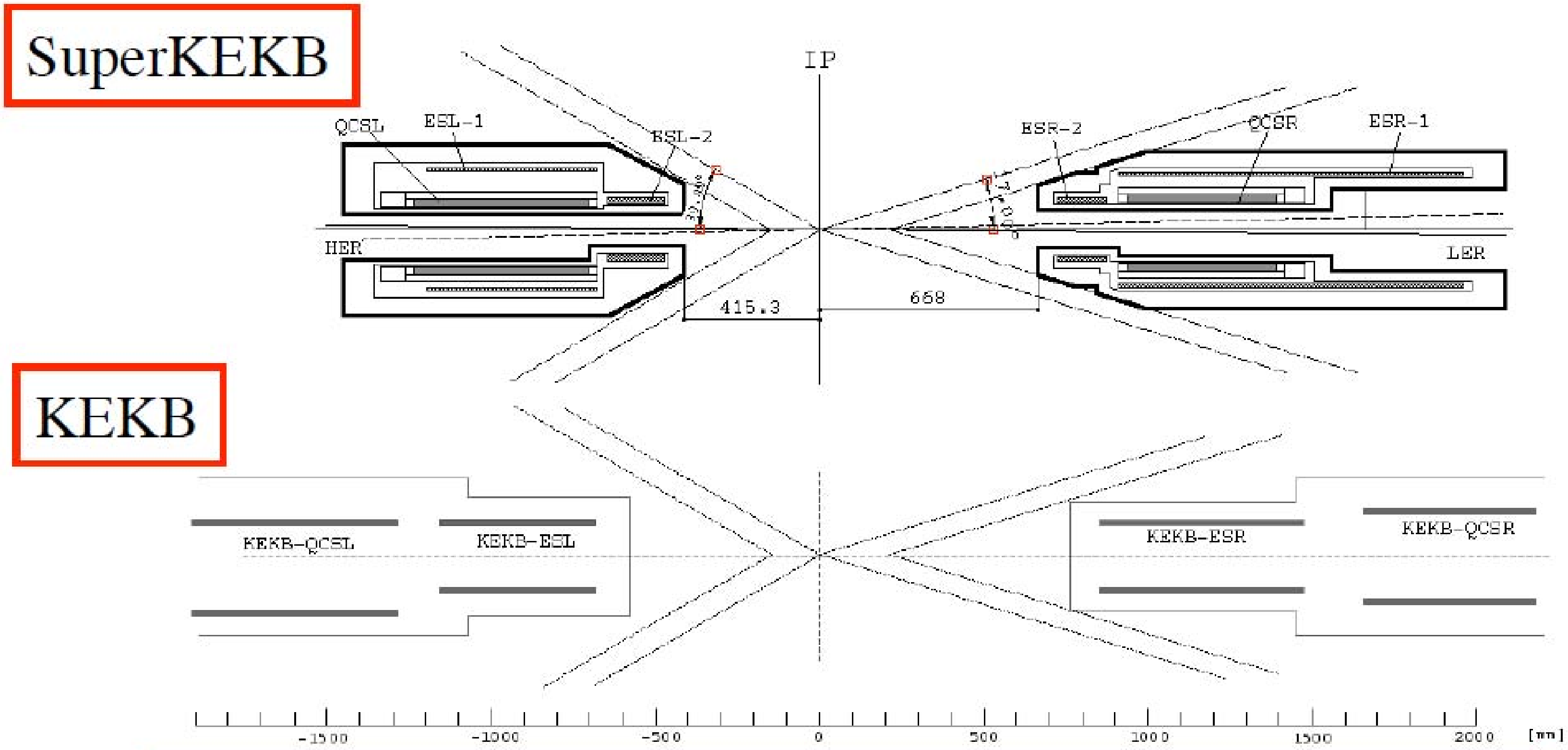


SR from upstream magnets



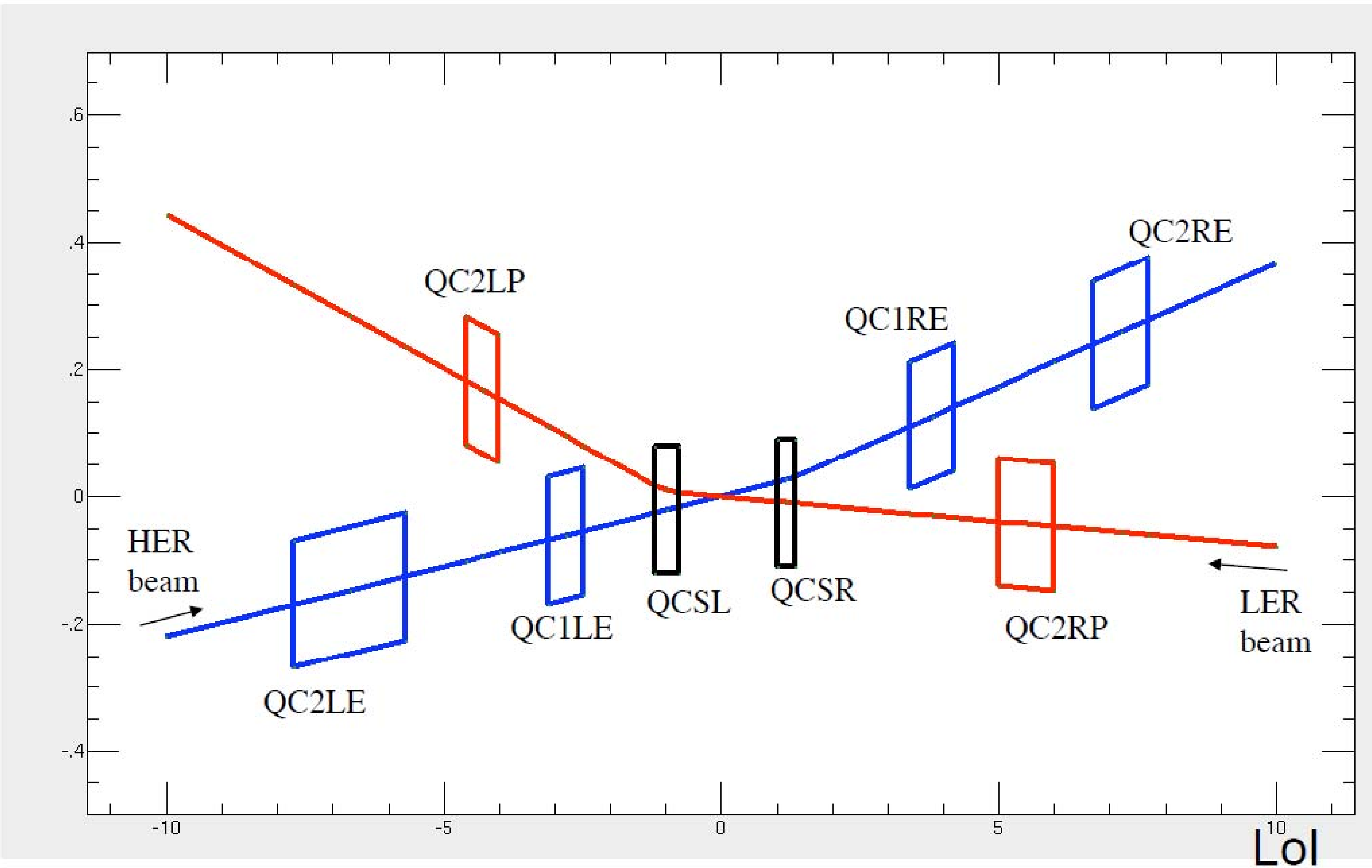
SVD1.0 killer source (1999)

Place QCS magnets closer to IP



The boundary between KEKB and Belle is the same.
ESL and ESR will be divided into two parts (to reduce E.M. force).
QCSL (QCSR) will be overlaid with (the one part of) ESL(ESR).

IR magnet layout



Beam BG study strategy

Possible beam BG sources

SR, beam-gas, radiative BhaBha, Touschek

With the current design, much higher SR BG is expected

Critical energy is 14keV (KEKB → less than 2keV)

SR size at IR is 3-7mm（for 5σ size beam）

(KEKB → <5mm for 10σ size beam)

Then, we'll start SR BG simulation study first

No detailed QCS structure. No detector . Beam-pipe only

For the other source BG, we need realistic magnet structure.

We use SC magnets for FF system (design → not fixed yet)

Will study later

To study the SR BG, we need simulation tools.

→ Use the simulation tools developed at Univ. Tokyo

Beam line simulation at UT

Based on the following programs, we construct
the Super-KEKB beam-line simulation at Univ. of Tokyo.

- SAD

To get the geometry / element definition / Twiss parameters.
SAD file with dynamic beam-beam effect from Funakoshi-san
(Dynamic effect → 5 times higher ε, 10 times smaller β in x)

- LCBDS

Beam line simulation <u>based on GEANT4</u>
developed by K.Tanabe and T.Abe (for ILC/T2K)

At first, we just align the beam line components and beam pipe
in the simulation

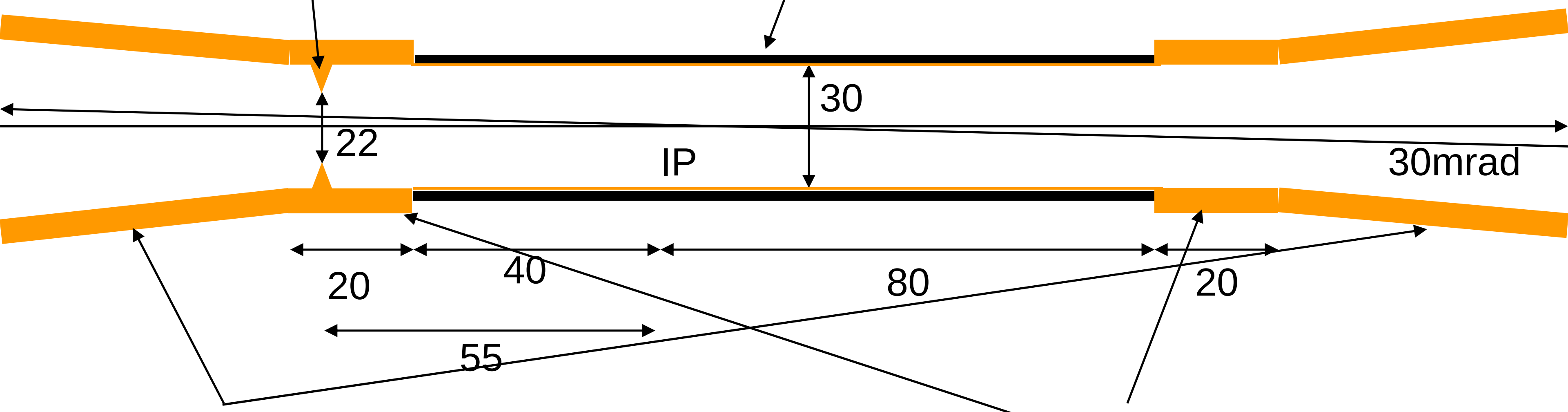
Beam pipe

S.Uno

We put the beam pipe in our simulation

Mask
Au
Base length 4mm
Height 4mm
Inner diameter 22mm

Be part
Au 10μm^t
Be 2mm^t
Inner diameter 30mm

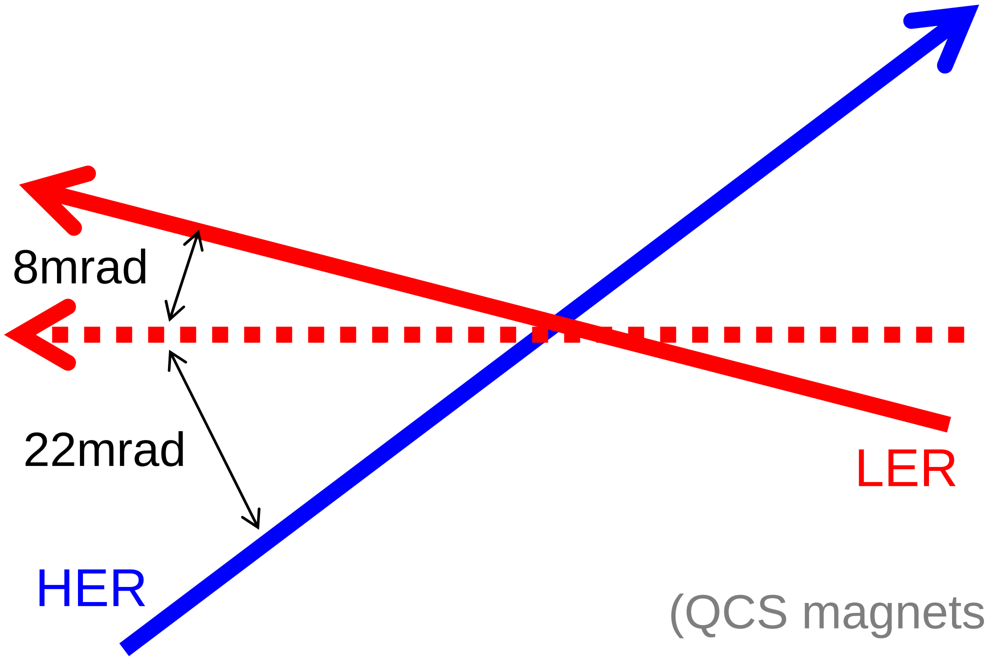


Au Taper part
Au 5mmt
30mrad taper
Length 500mm

Au straight part
Au 5mm^t
Inner diameter 30mm
Length 20mm

Relationship between s-Belle and Super-KEKB

In Super-KEKB, crossing angle will be increased : 22mrad → 30mrad



e^- KEKB / Super-KEKB
HER(e^-) axis will not change

e^+ KEKB, Belle solenoid
Belle solenoid will not change

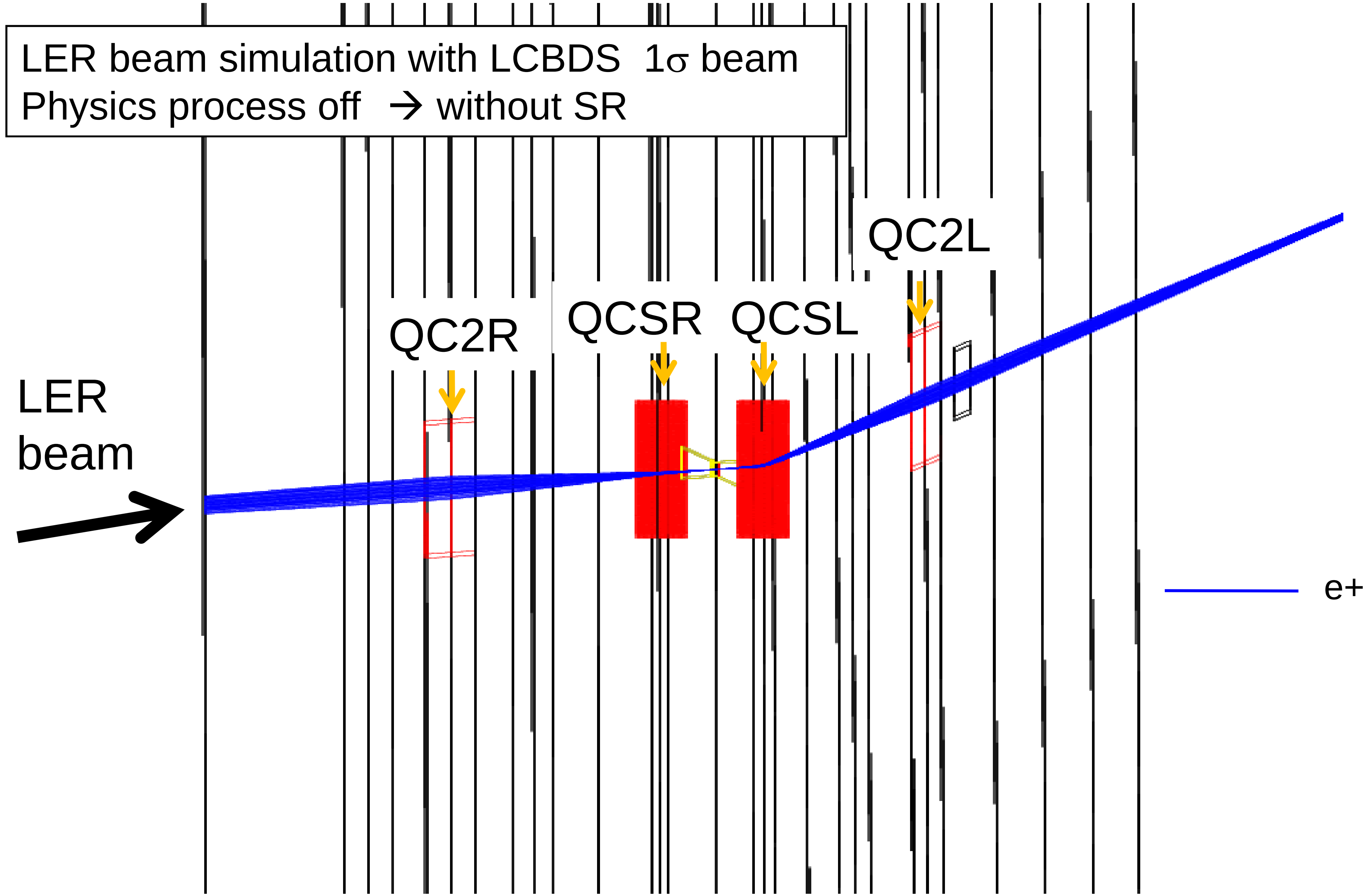
e^+ Super KEKB
LER(e^+) axis will rotate by 8mrad

(QCS magnets will be set parallel to Belle solenoid)

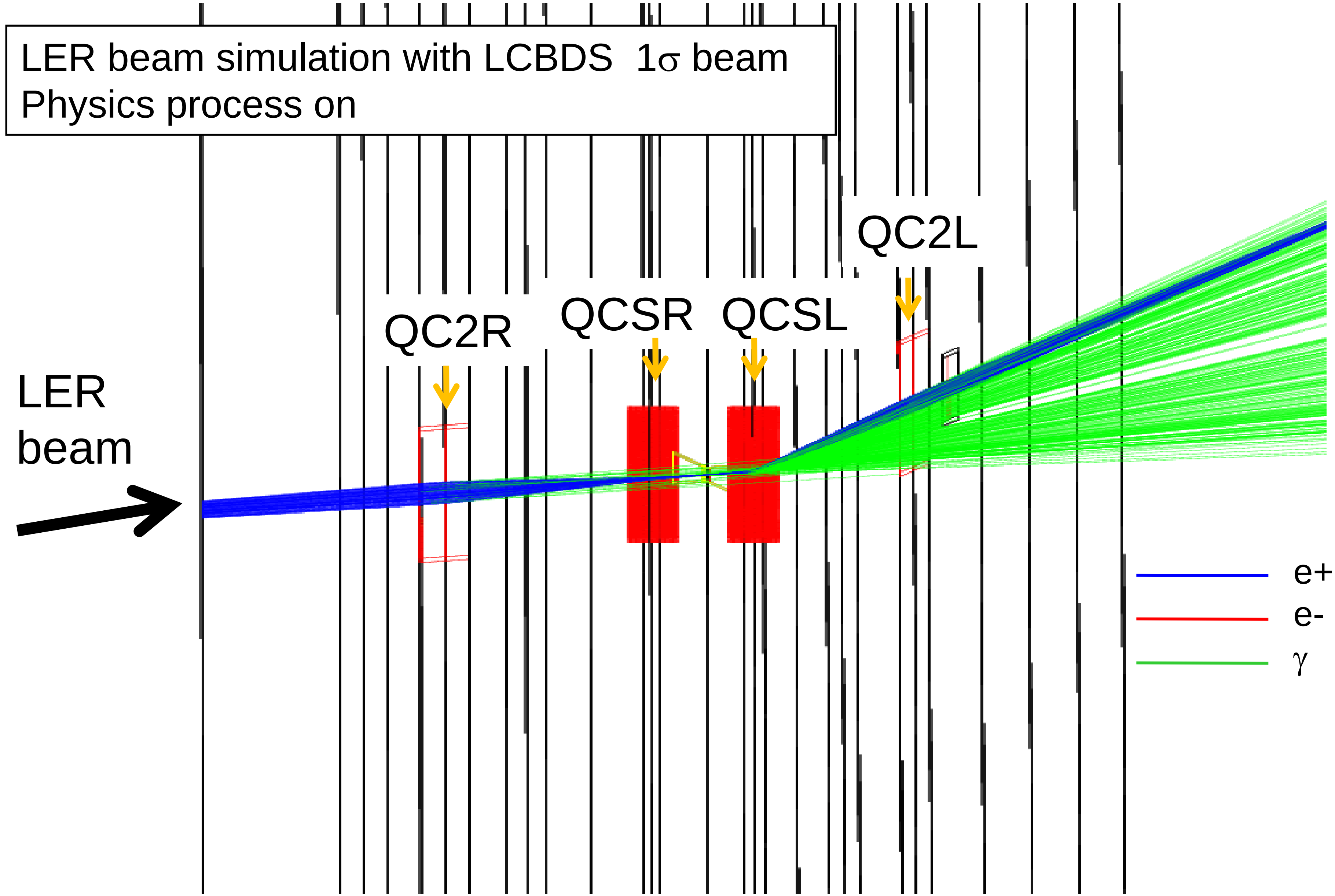
Belle beam pipe (and SVD??) axis at Super-KEKB
- Belle solenoid
- Center of the LER and HER (7mrad from Belle solenoid)
- <u>HER axis (22mrad from Belle solenoid)</u>

We put the beam pipe on HER axis in our simulation (to avoid SR from HER)

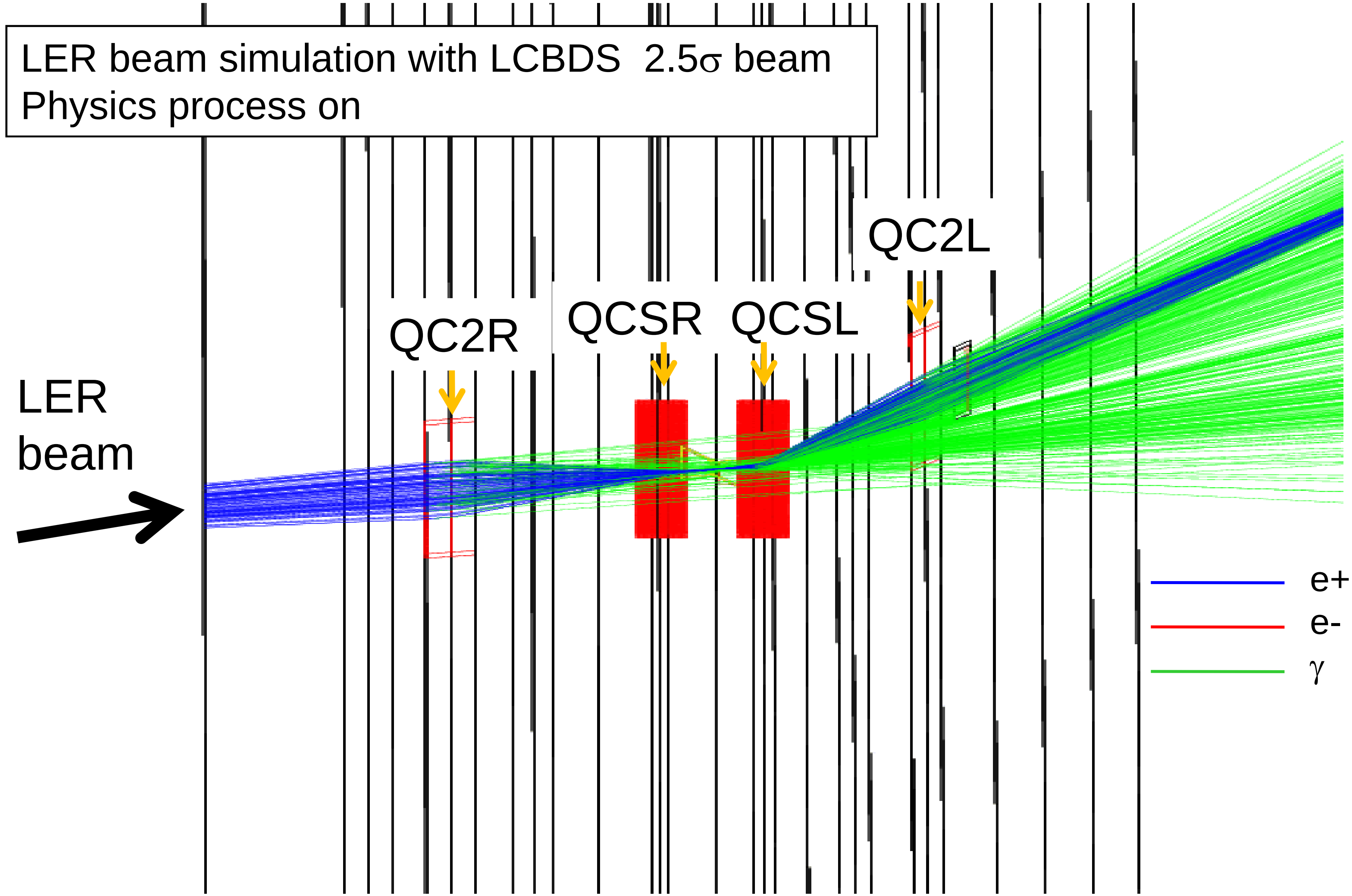
Current status of the beam-line simulation



LER beam-line simulation

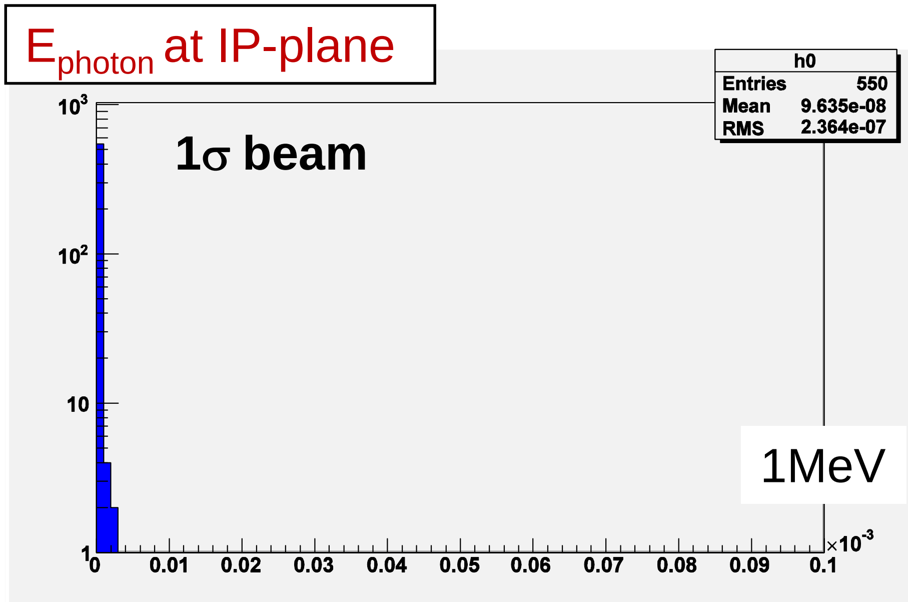


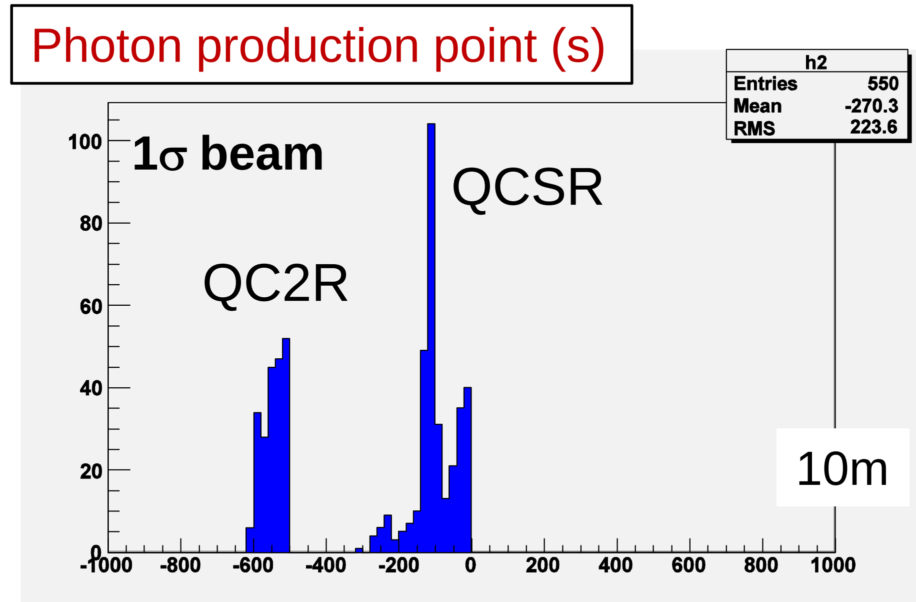
LER beam-line simulation

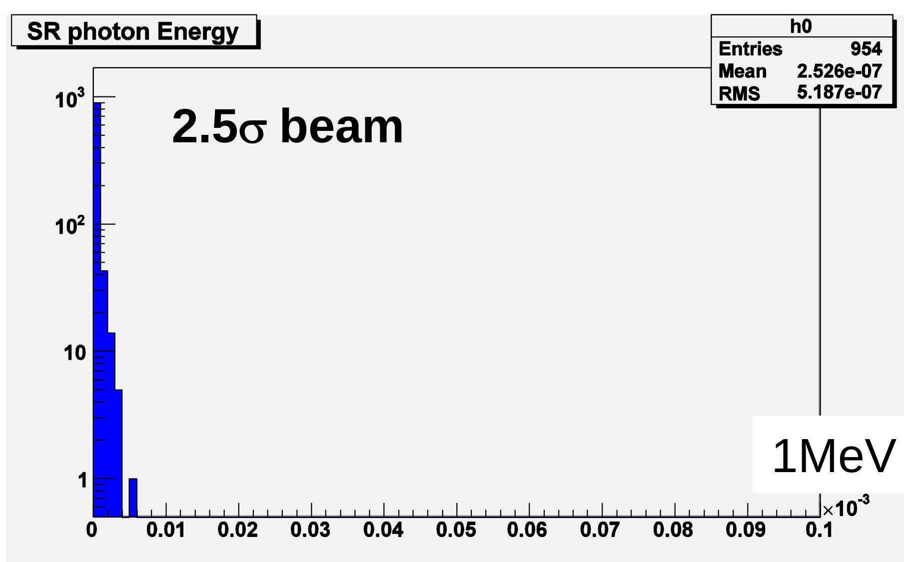


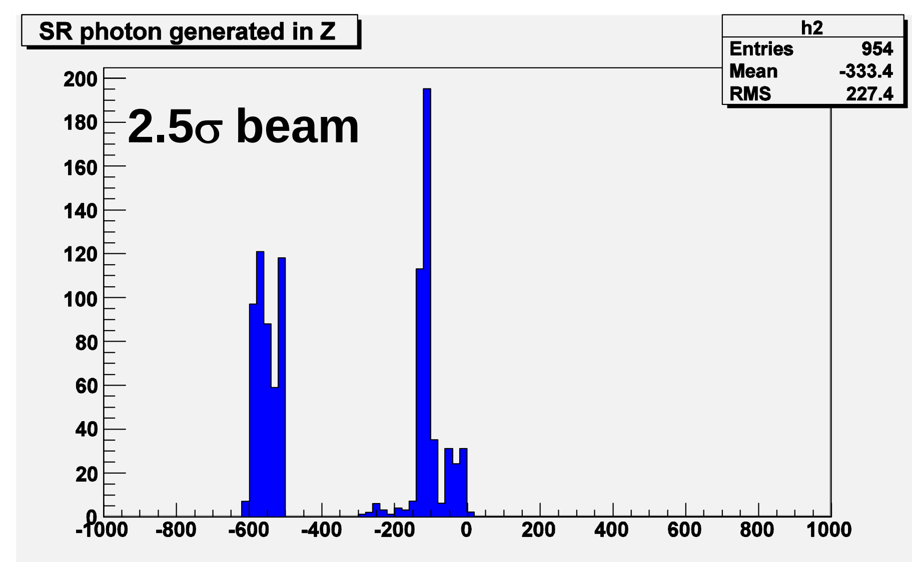
LER beam line simulation

1σ / 2.5σ beam physics process on, 2000 event each









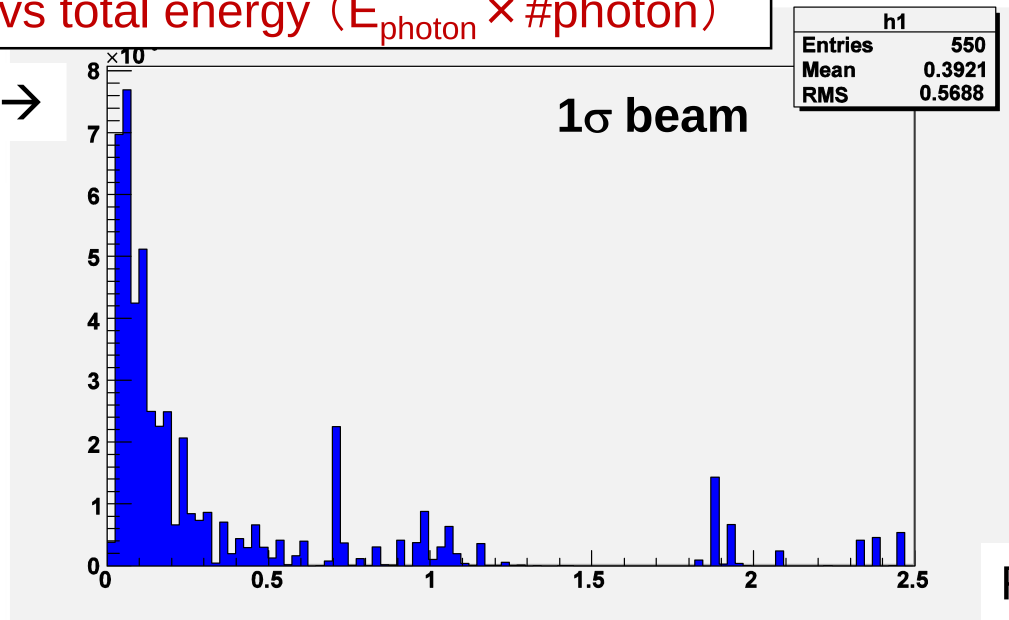
LER beamline simulation

R vs total energy（E_{photon} × #photon）

1σ/ 2.5σ beam
Q-magnet r =15cm
2000 event each

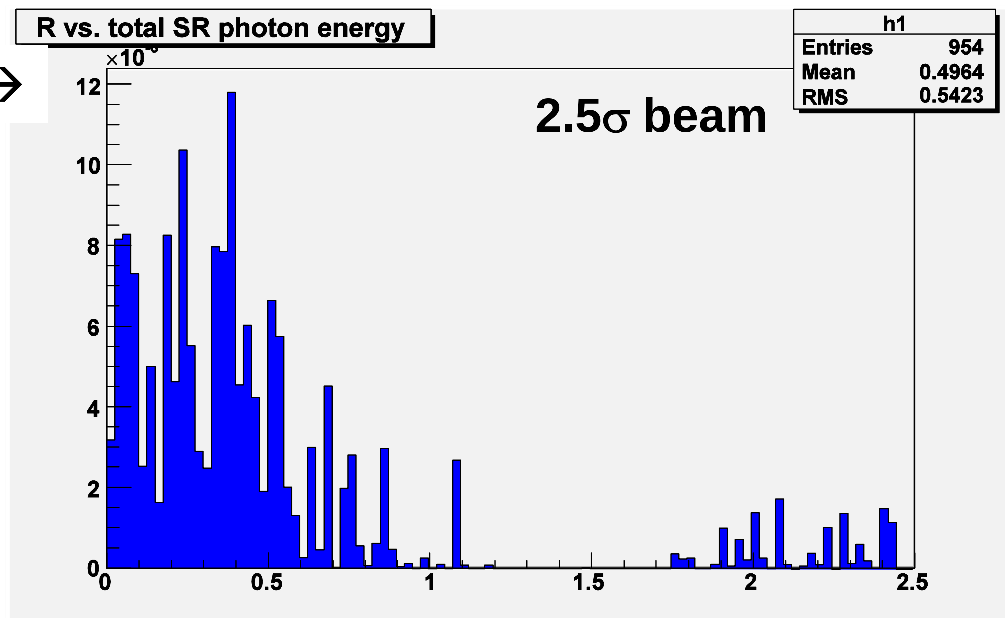
8keV →

Total energy

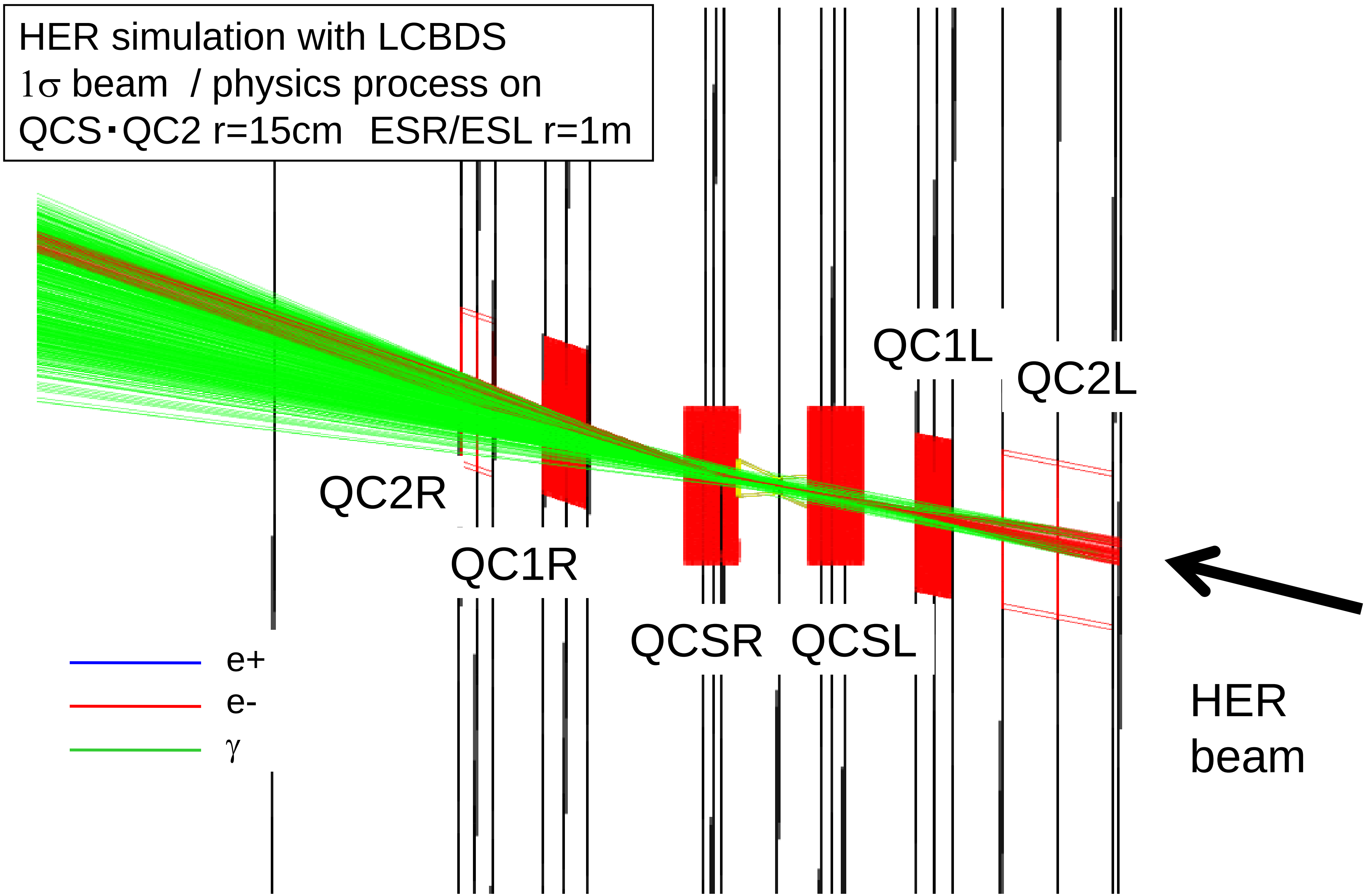


R (cm)

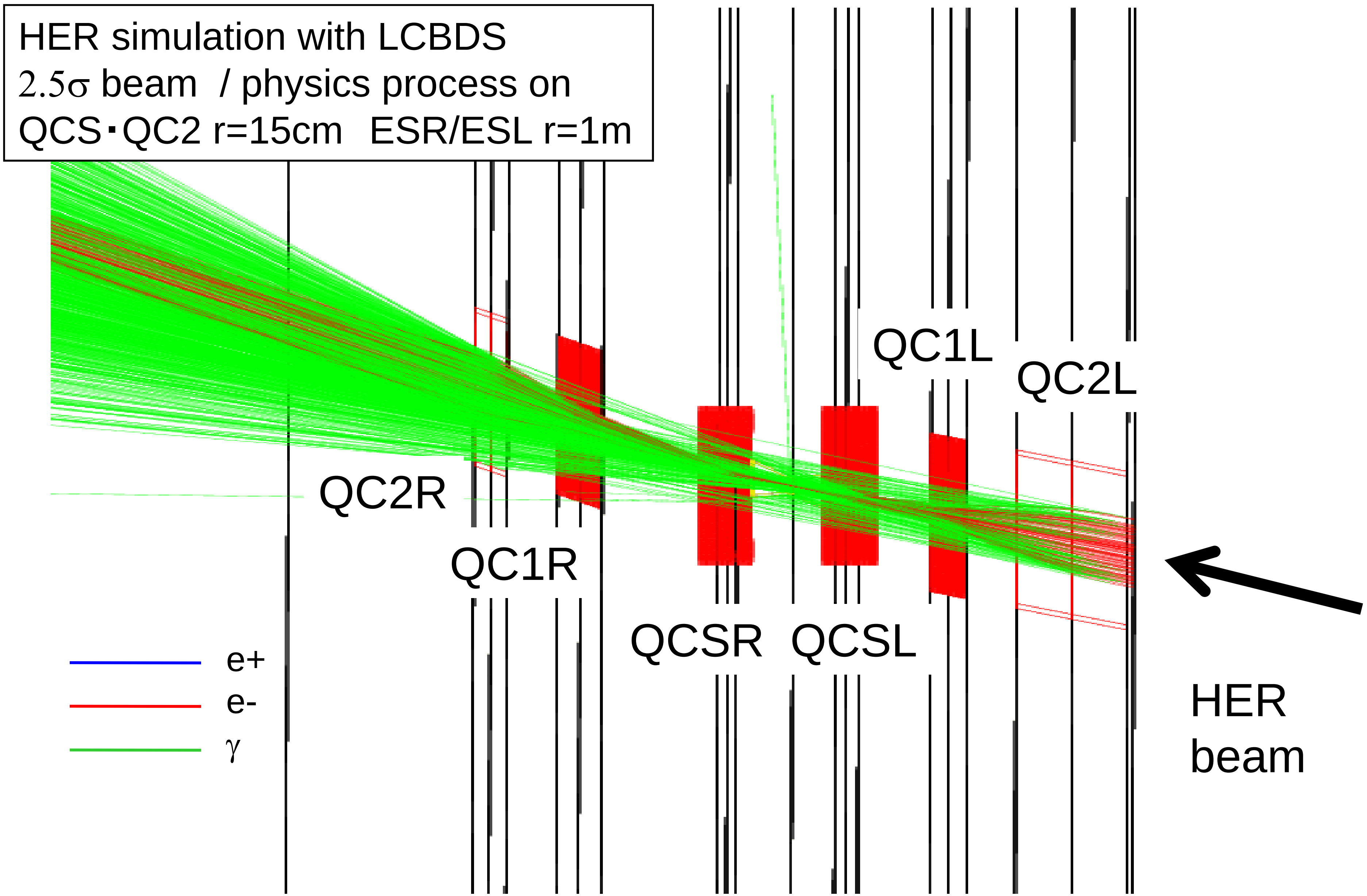
12keV →



HER simulation

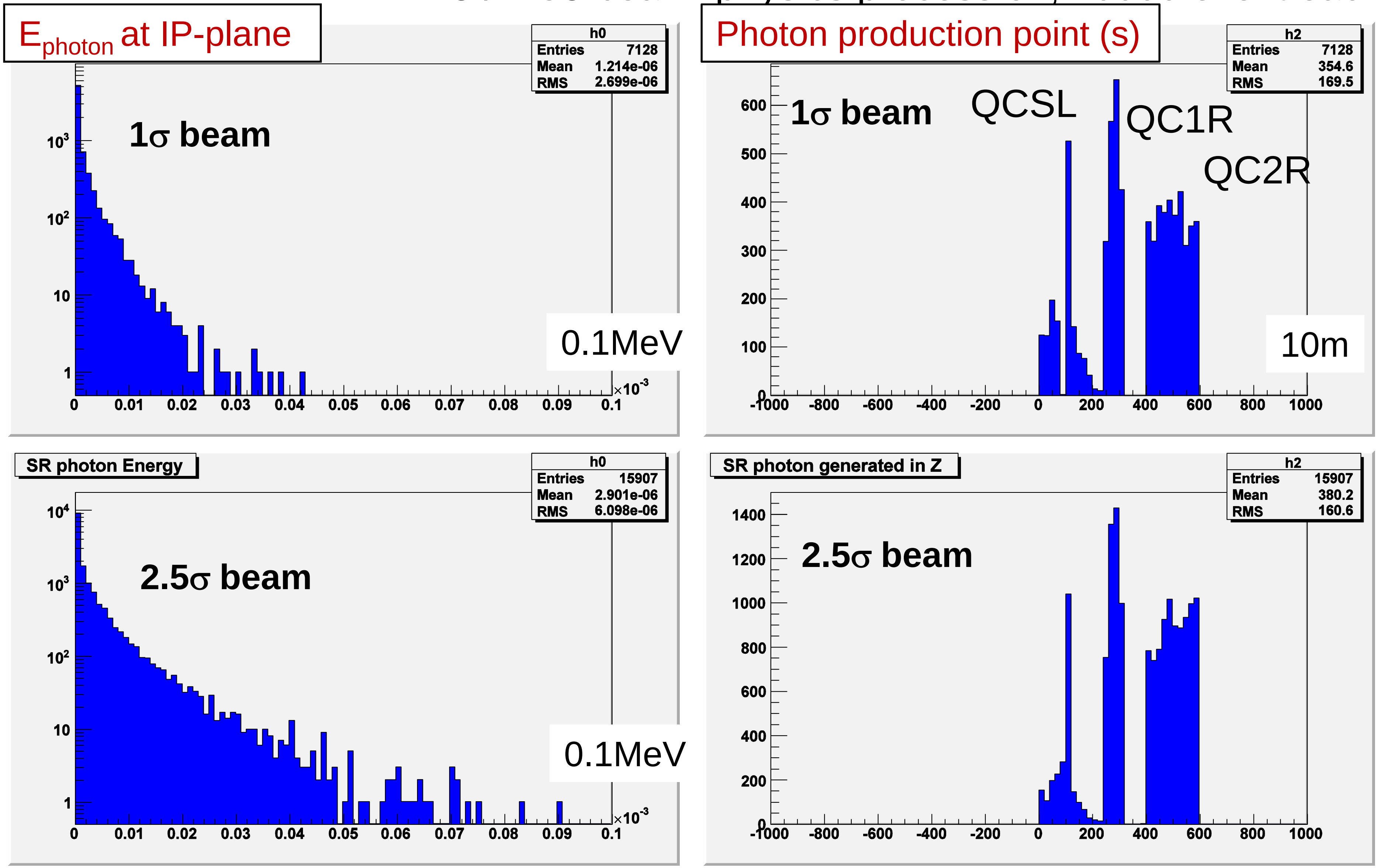


HER simulation



HER beam line simulation

1σ / 2.5σ beam physics process on, 10000 event each



Many SR from QC1/QC2 → because QCS aperture in our simulation is too large…

HER beamline simulation

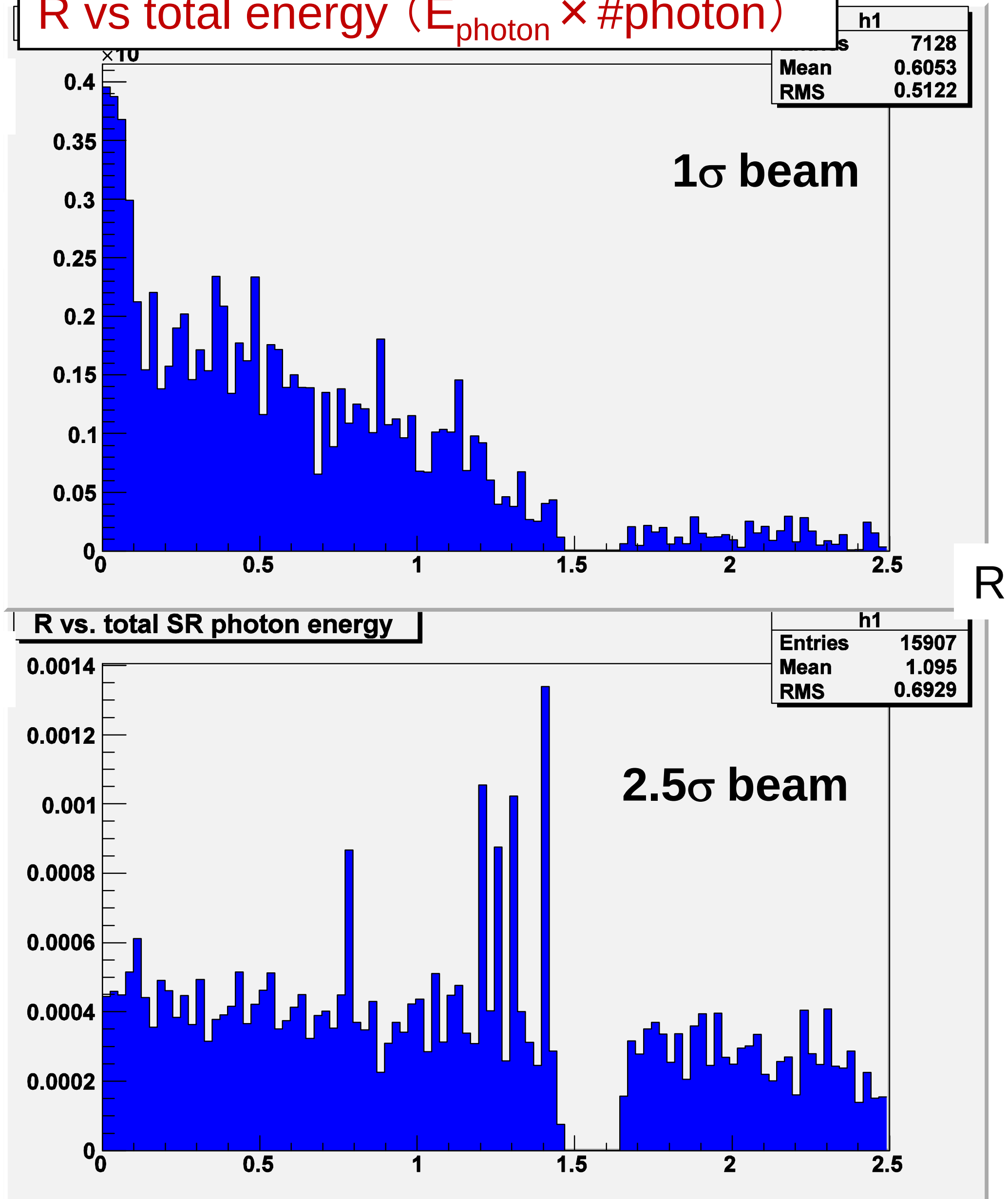
R vs total energy (E$_{photon}$ × #photon)

1σ/ 2.5σ beam
Q-magnet r =15cm
10000 event each

0.4MeV →

Total energy

1.4MeV →



R (cm)

Same problem: Many SR from QC1/QC2 → QCS aperture in our simulation is too large

Summary

Beam-BG study for Super-KEKB is very important

We have just started the BG simulation study

We start SR study with the new Super-KEKB IR design

→ feed back to KEKB and SVD group ASAP

Develop the beam line simulation tools

Estimate SVD occupancy

Comparison btw current KEKB

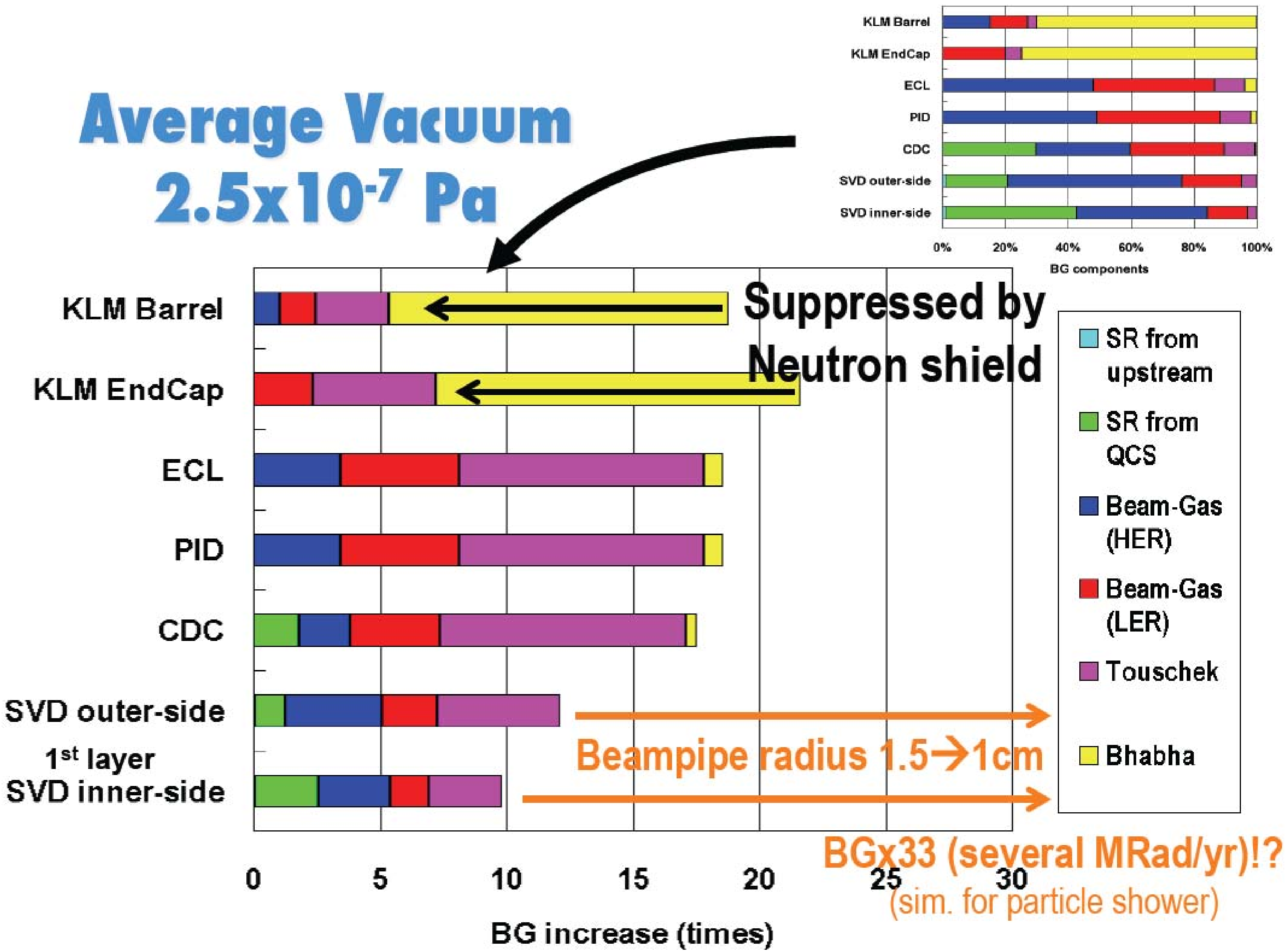
We also need to re-estimate the other BG sources

Set up the simulation tools

New contributions to the super-KEKB IR works would be highly welcomed!!

Back up

2005 O.Tajima



2005 O.Tajima

Summary on detector background

- Backscattering of QCS-SR is not serious, but strongly depends on IR chamber configuration
- Vacuum level is very important
  - Original design ($5x10^{-7}$ Pa) is serious → BGx25
  - w/ further effort ($2.5x10^{-7}$ Pa) → BGx18 ← -30%
- Increasing of Touschek origin BG
  - Smaller bunch size & higher bunch currents are reason
  - Might be reduced by further study
- Radiative Bhabha origin BG can be suppressed
- **Beampipe radius 1.5cm → 1cm**
  - Further simulation study of shower particles into SVD is important

Dynamic beam-beam effect at Super-KEKB

The focusing force of the beam-beam interaction
- squeezes the beam at IR
- increases the emittance drastically

→ affects all around the ring … "dynamic beam-beam effect"

Dynamic effects at Super-KEKB is very strong

Beam optics is re-considered, and there is a big change in the IR magnet layout

We must re-estimate the beam BG with the new IR design

Dynamic beam-beam effect

Parameter search for smaller beam size

Y.Funakoshi

	no b-b	nominal			higher emittance			higher βx*			even higher βx*		
ν_{x0}		.503	.505	.510	.503	.505	.510	.503	.505	.510	.503	.505	.510
ε_{x0} [nm]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	12	12	12	12	12
β_{x0}^* [cm]	20	20	20	20	20	20	20	40	40	40	[illegible]	[illegible]	[illegible]
ξ_{x0}	0	.270	.270	.270	.135	.135	.135	.272	.272	.272	.273	.273	.273
ε_x [nm]		81.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	82[illegible]	64.3	46.7	82.3	64.4	46.8
β_x^* [cm]		1.50	1.93	2.77	2.1	2.7	3.8	2.99	3.87	[illegible].53	[illegible]	[illegible]	[illegible]
σ_x@QC2RE [mm]	4.0	39.5	30.9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
No[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Emittance ε (wo dynamic effect)

ε (with dynamic effect)

β (wo dynamic effect)

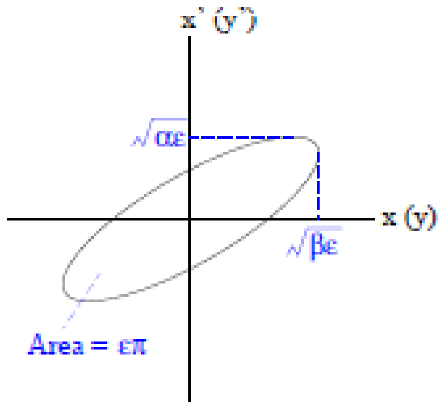
β (with dynamic effect)

5 times higher ε, 10 times smaller β in x

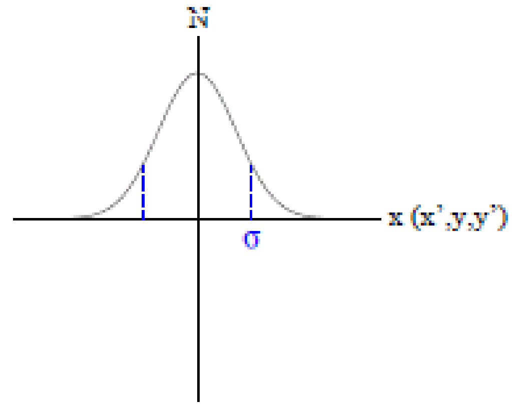
Dynamic effect at Super-KEKB is very strong

Shape of the input beam

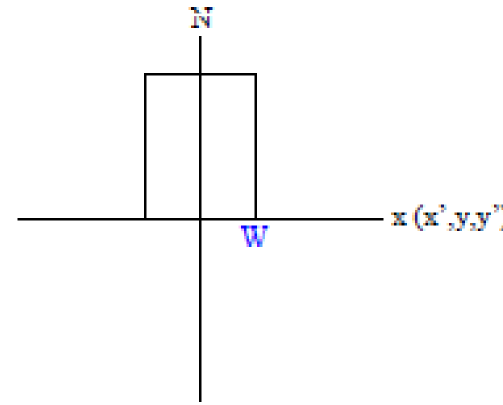
LCBDS supports following 3 kind of the beam shapes



$\mathrm{BeamShapeFlag} = 0$

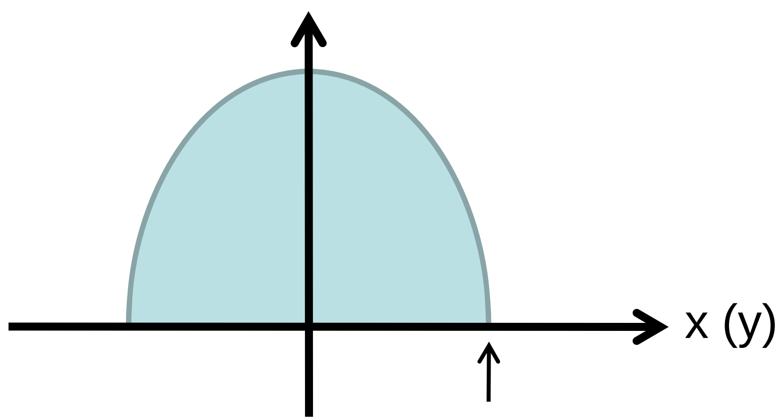


$\mathrm{BeamShapeFlag} = 1$



$\mathrm{BeamShapeFlag} = 2$

This time, we use BeamShapeFlag=0



We define the beam with the edge of x = sqrt($\beta\varepsilon$) × 2 as 1σ size beam

Beam size @ IR Q-magnets

ν_x =.505
(): 5 σ_x

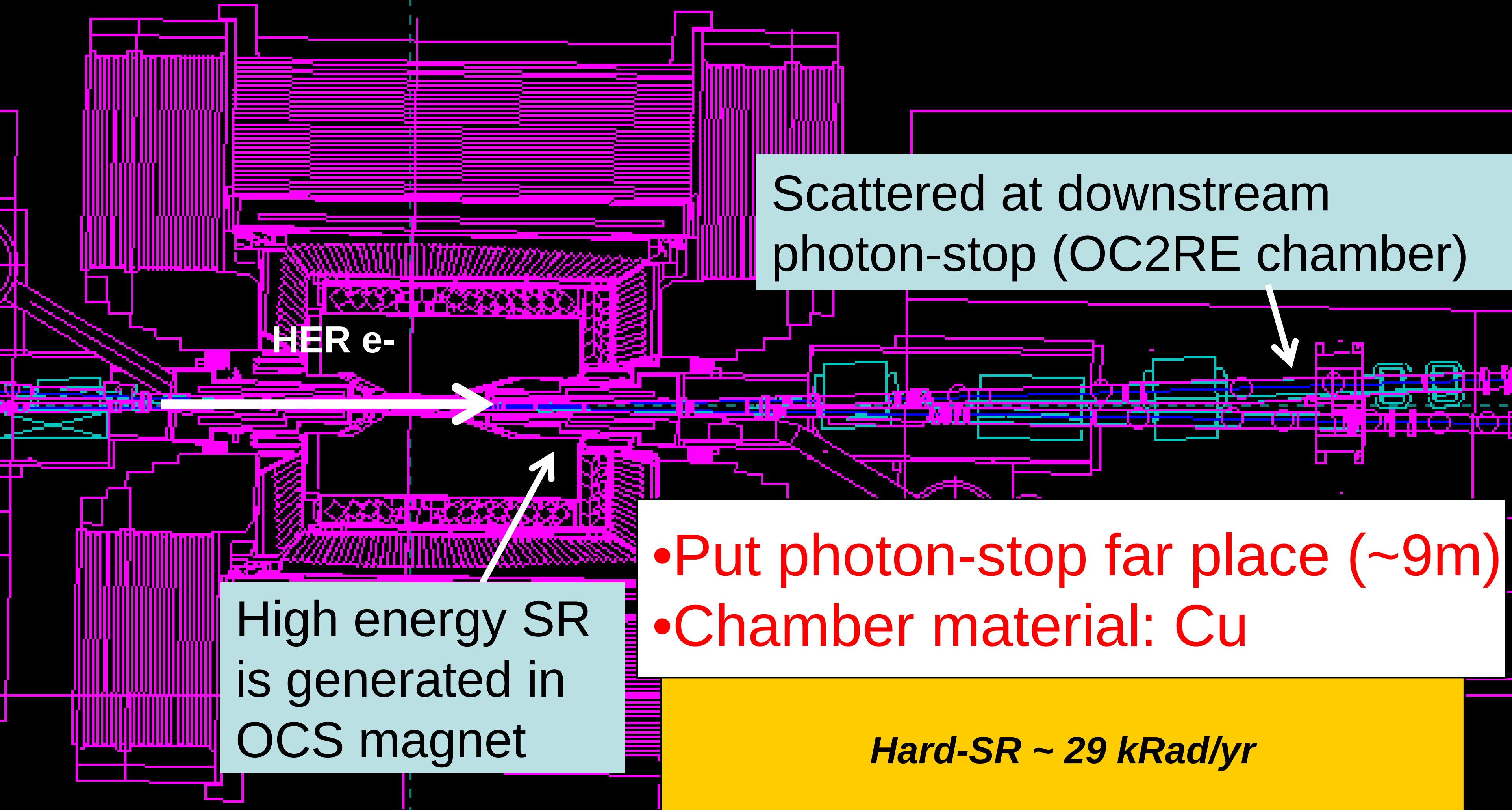
	QC1LE	QC2LE	QC1RE	QC2RE	QC2LP	QC2RP
β_x^*=20cm QC2RE:元	8.2 (41)	26.9 (134.5)	11.6 (58)	28.8 (144)	14.7 (73.5)	18.6 (93)
β_x^*=20cm QC2RE->IP	8.4 (42)	19.0 (95)	12.0 (60)	20.7 (103.5)		
β_x^*=40cm QC2RE-	5.9	13.4	8.5	14.6	9.8	12.3

		QC1LE	QC2LE	QC1RE	QC2RE	QC2LP	QC2RP
Field gradient	T/m	15.5	3.4	12.0	8.8	6.7	3.4
Pole length	m	0.64	2.0	0.75	0.8	0.6	1.0
b bore radius	mm	25	50	48	90	80	40
Current	AT	3920	3400	11050	28400	17100	1980
coil turns	/pole	3	8	3	16	15	3
Current density of Septum conductor	A/mm^2	30	10	70	24	31	15
Field in the area for couter-circulating beam	Gauss	0∼-0.65	0∼-0.4	0∼-1.1	0∼-0.35	0∼-0.85	0∼-0.35

Table 3.3: Parameters of special quadrupole magnets

We set the aperture of QC1, QC2 and QCS to be 15cm

Reduction of Hard-SR



- Put photon-stop far place (~9m)
- Chamber material: Cu

Hard-SR ~ 29 kRad/yr