SR BG simulation status
(E deposit to the beam pipe)

2009/03/18
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Upstream SR simulation studies

SR power is much higher than current KEKB,
then we start from SR BG estimation

1. Design the IP beam-pipe to avoid
HER SR direct hits to the detector

2. Study of the energy deposit to the IP beam-pipe

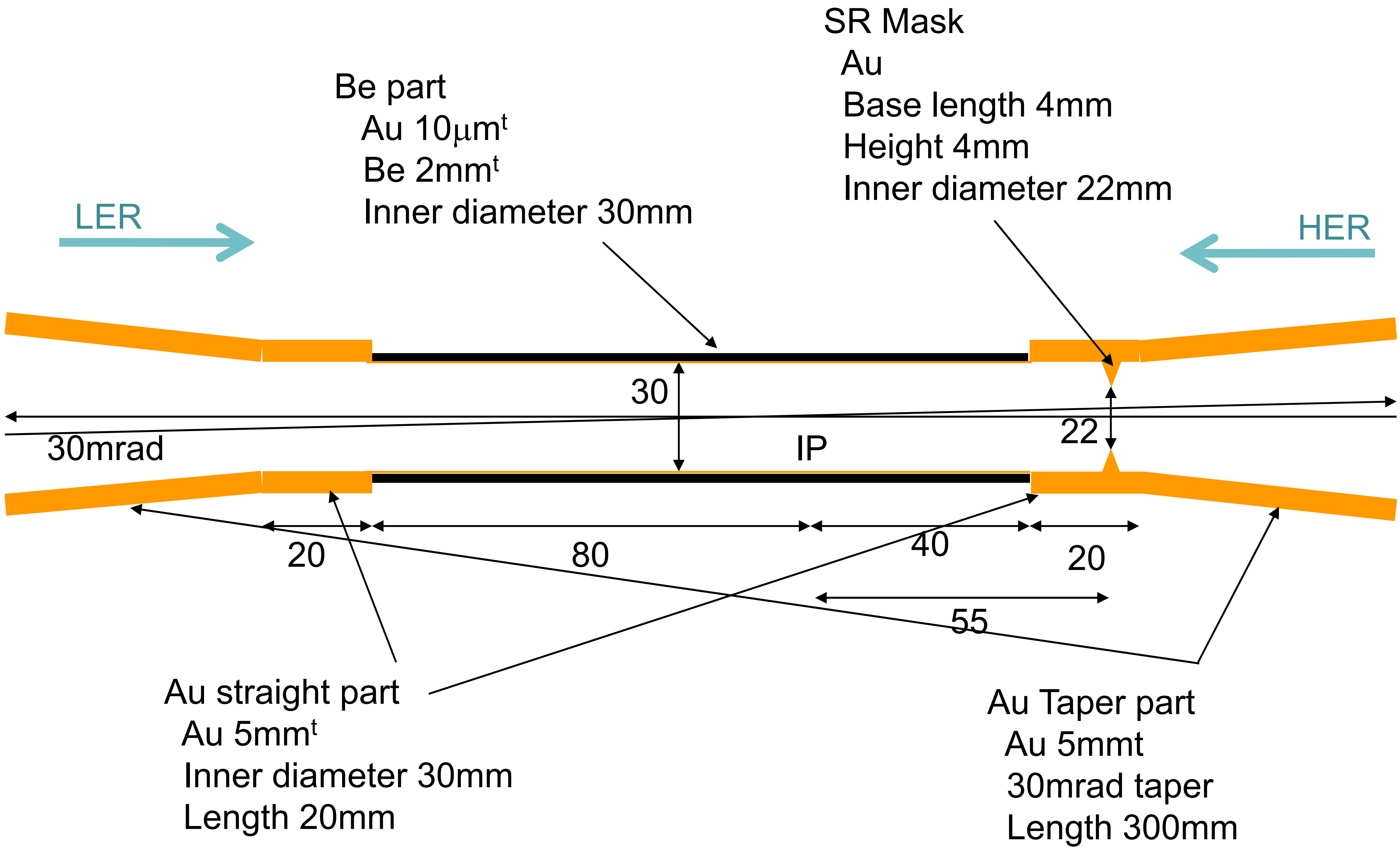
For the SR BG study,
we construct the beam line simulation based on GEANT4.

Simple beam pipe + 1st layer SVD + B-field of Q-magnets

Beam pipe design

S.Uno

We put the beam pipe in our simulation



Conclusion

@ MAC Feb.10, 2009

Based on the GEANT4 simulation, SR BG has been studied

1. Upstream SR

- Design of the IP beam-pipe to avoid SR from HER

To avoid the SR direct hit, we should

Locate the beam pipe parallel to HER (22mrad from Belle solenoid), and

Put a 4mm height SR mask

- Study of the energy deposit to the IP beam-pipe

The energy deposit from HER SR will be ~1kW (SR mask) ~1kW (taper)

1kW deposit to the 4mm mask makes ~500 degree temperature rise

→ It is very hard to cool the beam pipe…

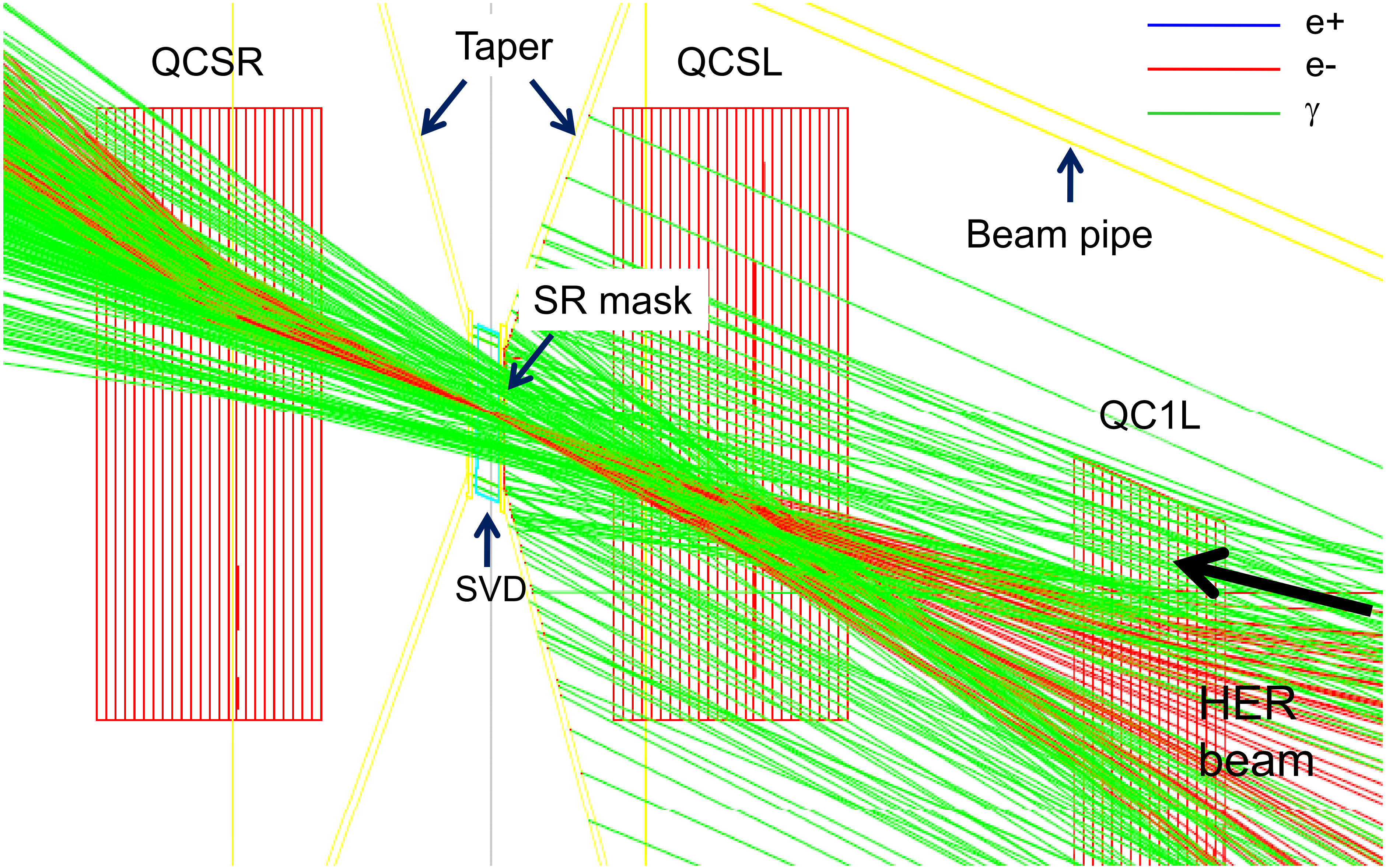
2. Backscattered SR

We need more MC statistics to study in detail.

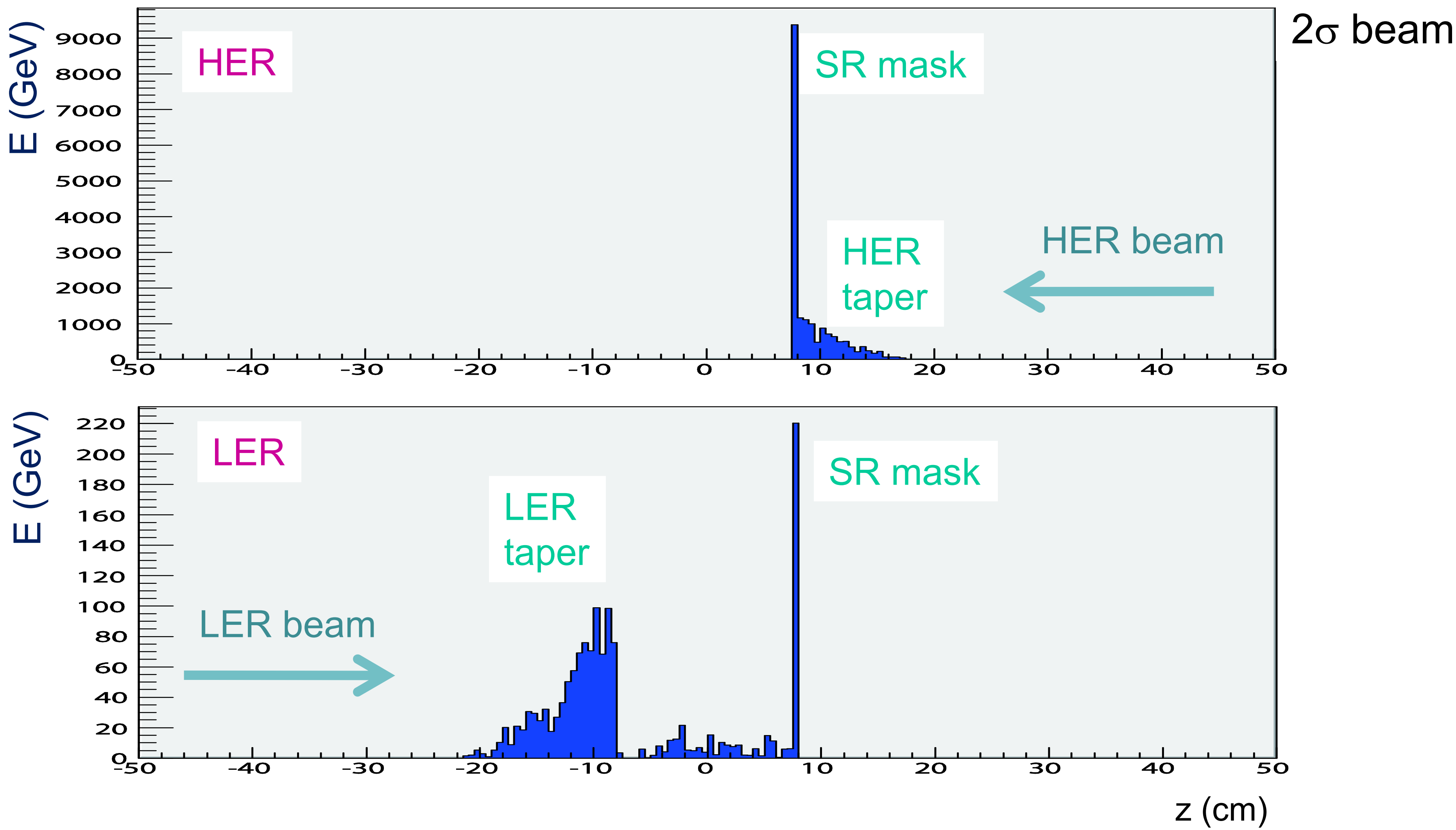
We try to minimize the BG effect in our beam-pipe design, but SR power is so high that we cannot cool the beam-pipe

New super-KEKB machine parameters with lower SR power are highly appreciated

HER simulation



Energy deposit from upstream SR



Total E deposit to the IP beam pipe

HER ~18000GeV/bunch → 1.4kW

LER ~1400GeV/bunch → 110W

Energy deposit from SR

2σ beam

HER

SR Mask 0.73kW HER taper 0.69kW

LER

SR Mask 20W LER taper 75W IP beam-pipe 15W

We have ~1kW Energy deposit at 4mm height SR mask...

New super-KEKB optics(1012a)

New super-KEKB optics has just been delivered

- **Beam size at the Q-magnet**

  QC1L / QC2L : ½ of the current one

- **B-field of the Q-magnet**

  QC1L : x1.6 of the current one

  QC2L : same

- **Same magnet length**

In total, SR power is reduced to

80% (QC1L) or 25% (QC2L) of the current one

We'll re-estimate the SR BG based on the new optics

Beam size @ IR Q-magnets

IP

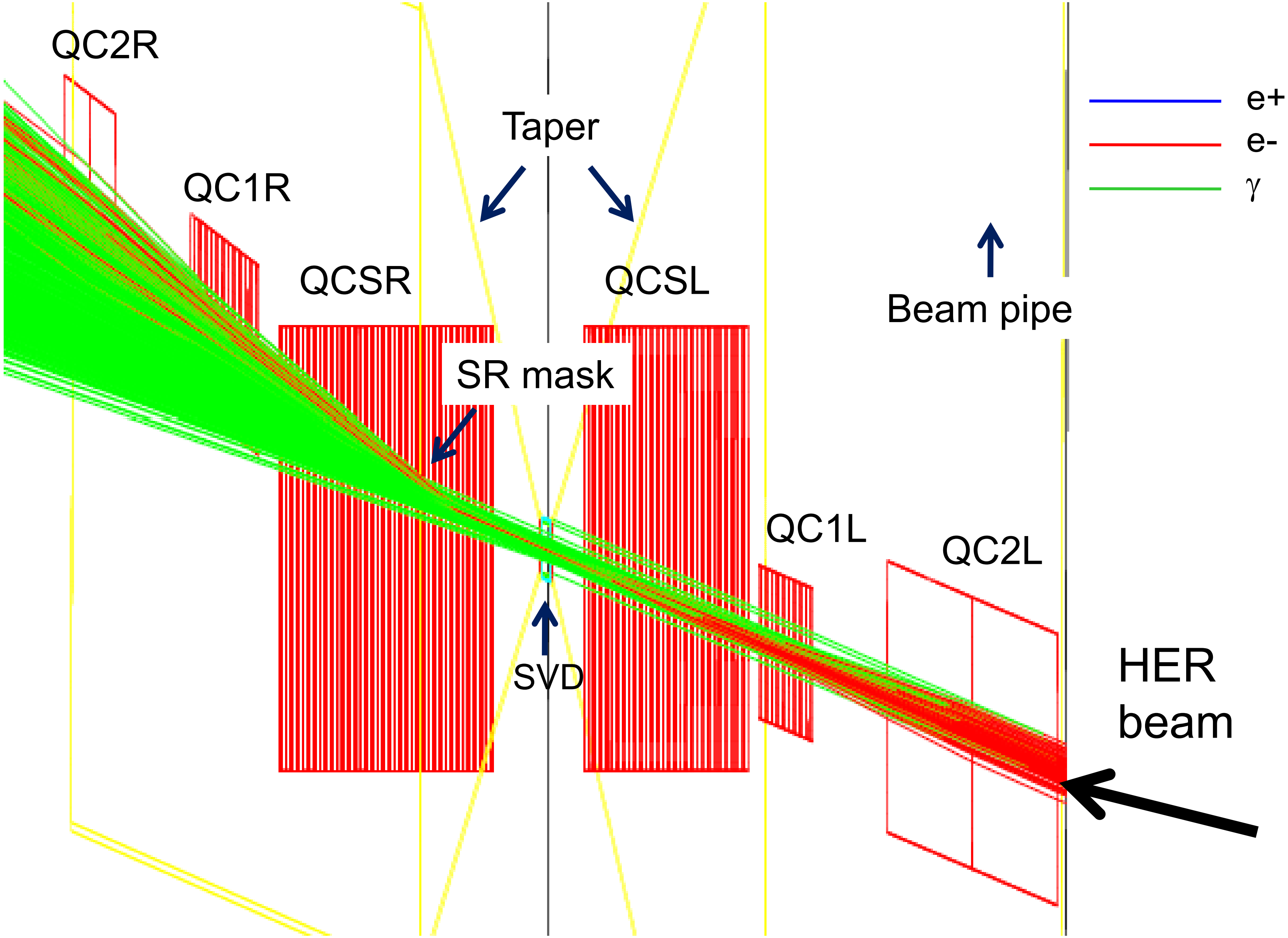
HER Beam

HER	QC2R	QC1R	QCSR	QCSL	QC1L	QC2L
OLD optics	74.5mm ($5\sigma_x$)	30.3	4.4	11.0	31.1	75.2
New optics	69.0 ($5\sigma_x$)	30.1	6.3	14.4	16.5	35.4

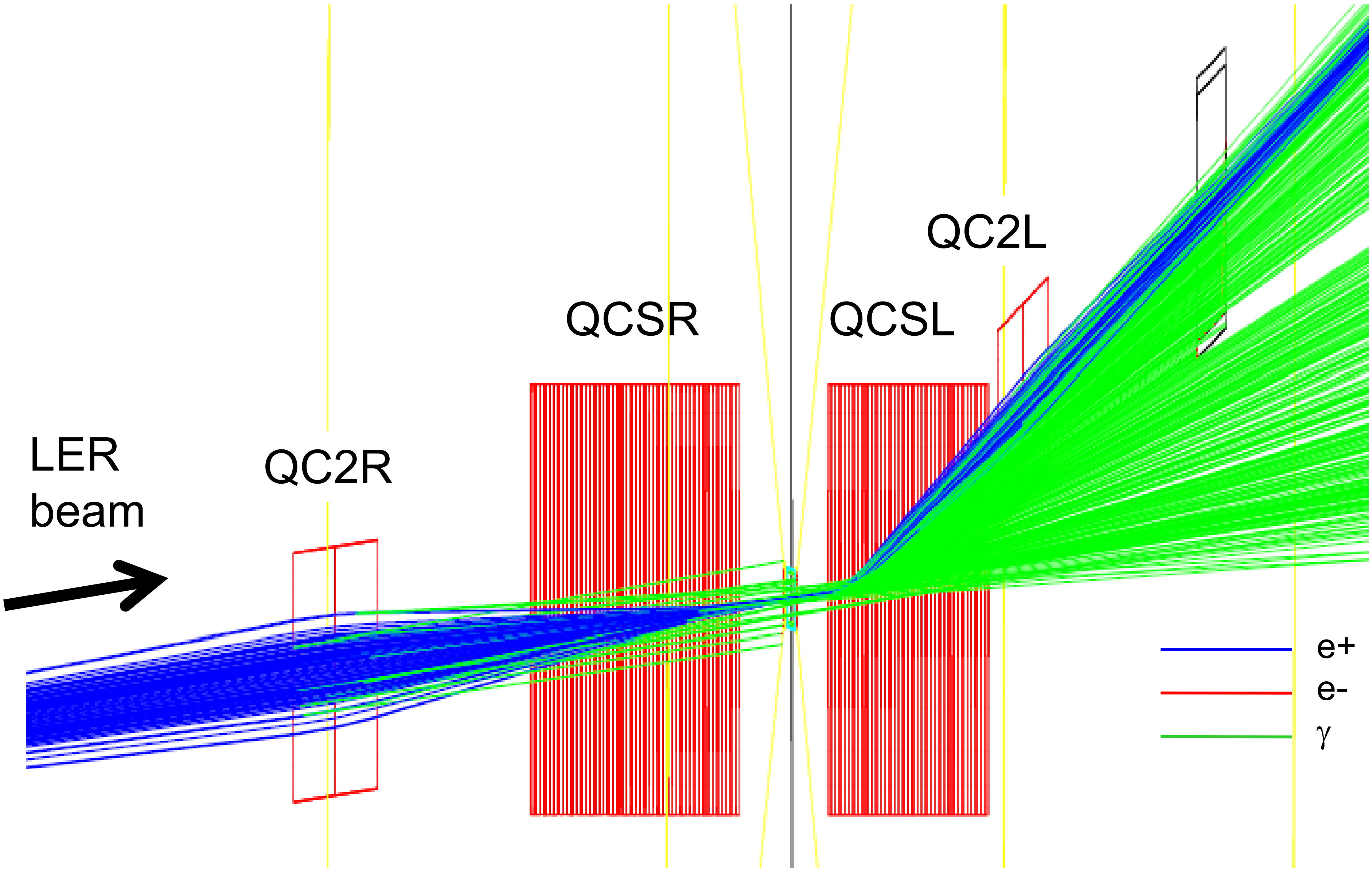
LER Beam

LER	QC2R	QC1R	QCSR	QCSL	QC1L	QC2L
OLD	63.9 ($5\sigma_x$)	52.2	15.1	2.9	29.0	52.1mm
New	66.3 ($5\sigma_x$)	---	10.7	2.9	---	34.4

HER beam-line simulation

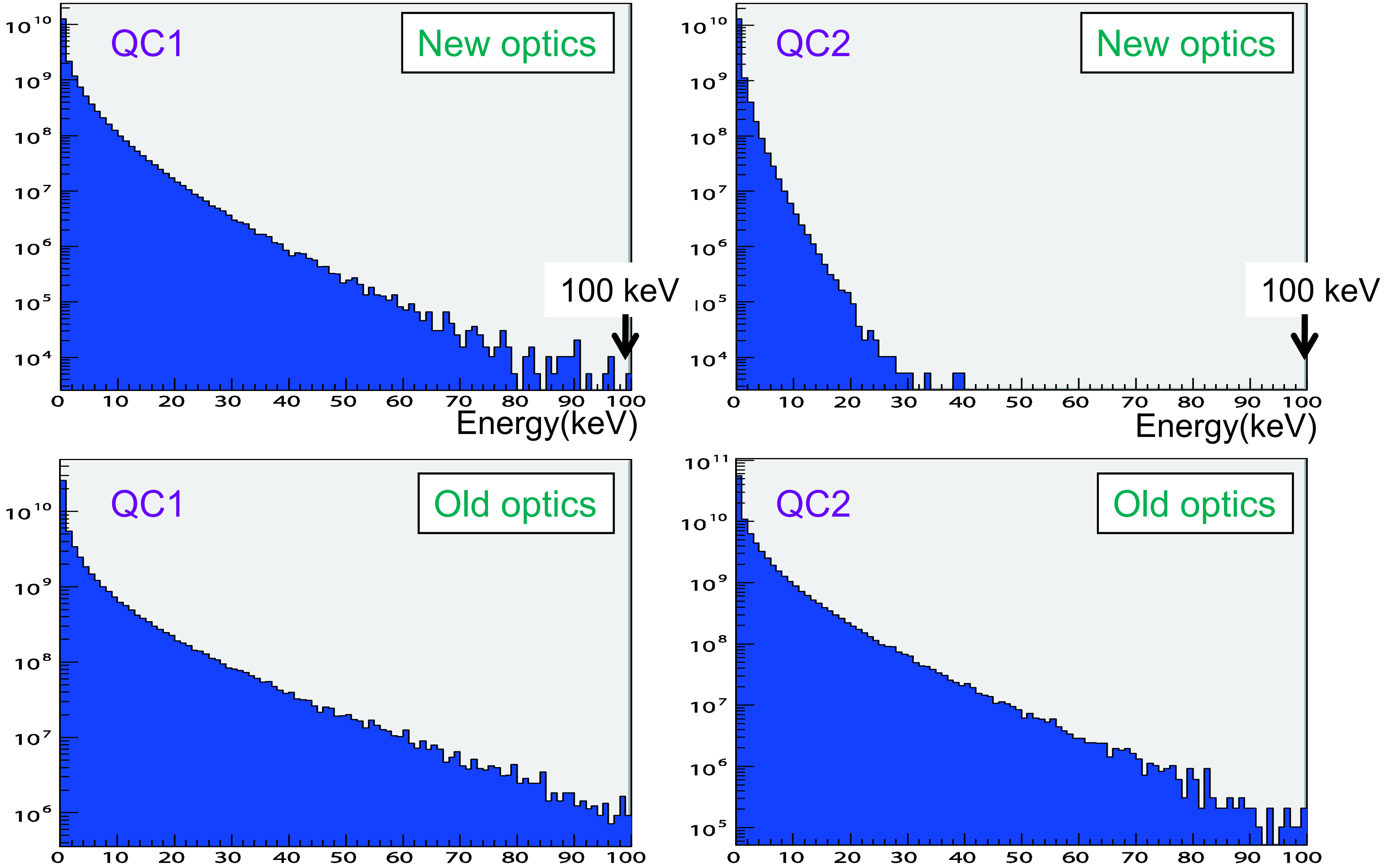


LER beam-line simulation



HER upstream SR energy

5σ beam

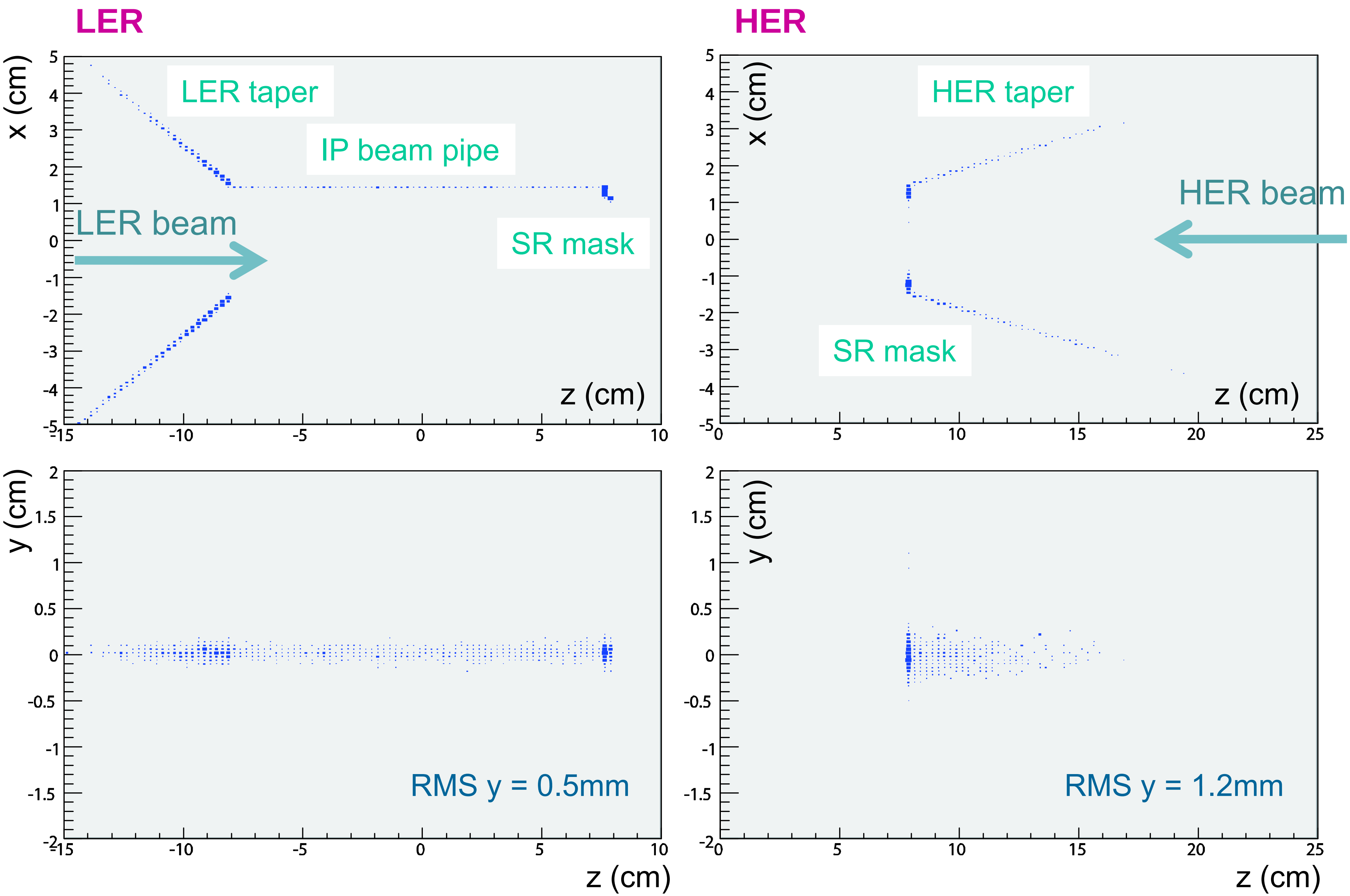


The SR energy from HER is still high

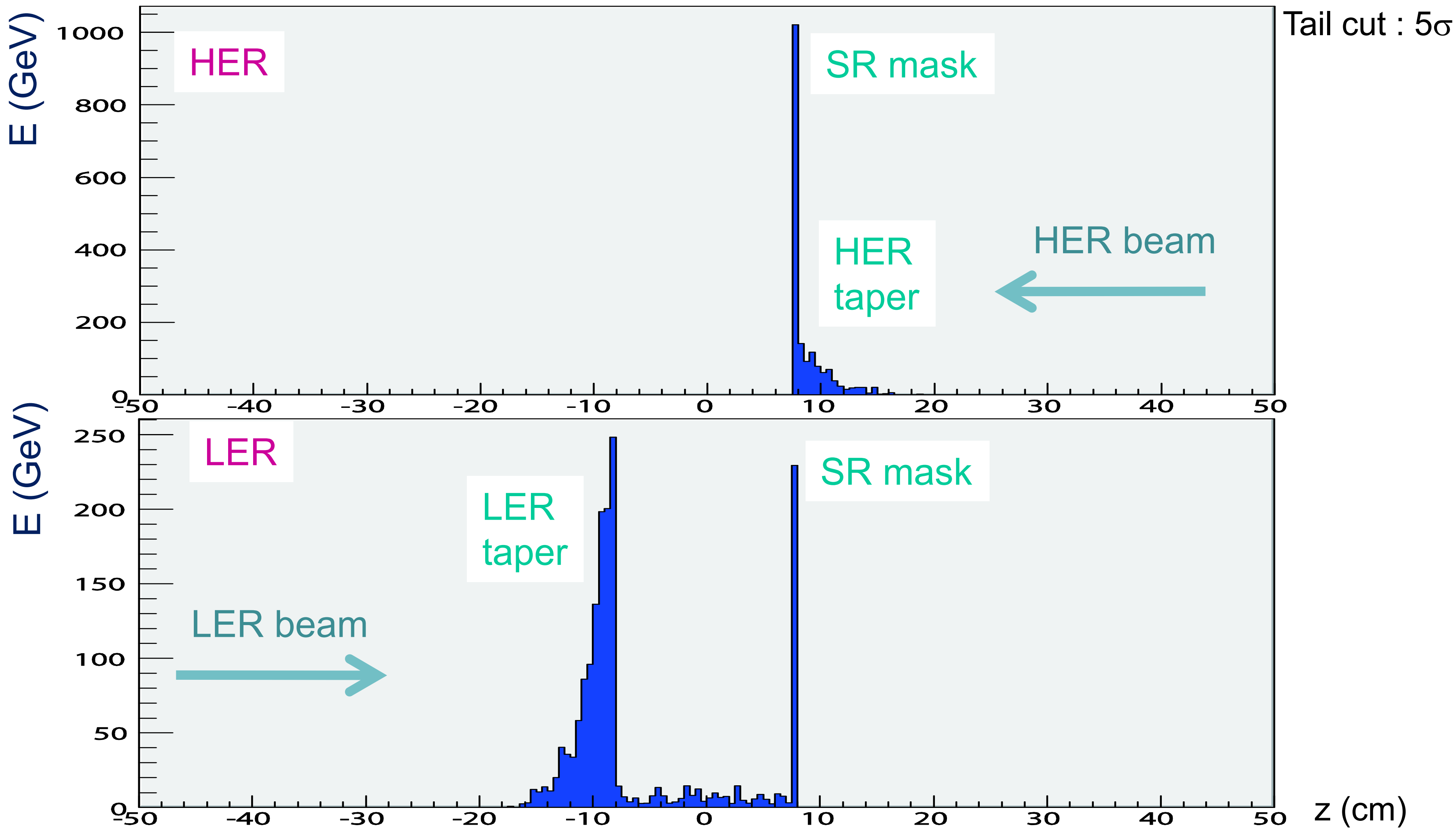
→ We don't want the direct hits from HER SR

(Vertical scale: Scaled for 1-bunch beam)

SR hit to the IP beam pipe



Energy deposit from upstream SR



Total E deposit to the IP beam pipe

HER ~1750GeV/bunch → 140W (old: 1.4kW)

LER ~1650GeV/bunch → 130W (old: 110W)

Energy deposit from SR

New optics (1012a) Gaussian beam 5σ tail cut

HER

SR Mask 82W HER taper 60W

LER

SR Mask 18W LER taper 97W IP beam-pipe 17W

- We still have 100W Energy deposit at SR mask.

→ See heating calculation by Yamaoka-san

OLD optics (sqrt 2σ beam)

HER: SR Mask 0.73kW HER taper 0.69kW

LER : SR Mask 20W LER taper 75W IP beam-pipe 15W

Summary

1. Simulation studies for the Super-KEKB high-current option
   - There expected huge energy deposit of ~1kW
     from HER SR in the old version Super-KEKB design
   - With the current new optics, it is decreased to ~100W
     (which is x10 of the current KEKB)
   - Detailed heating calculation / simulation is needed
     to design the cooling system (see Yamaoka-san's talk)
   - We need to start the other BG source studies

2. We will start the Super-KEKB nano-beam option studies

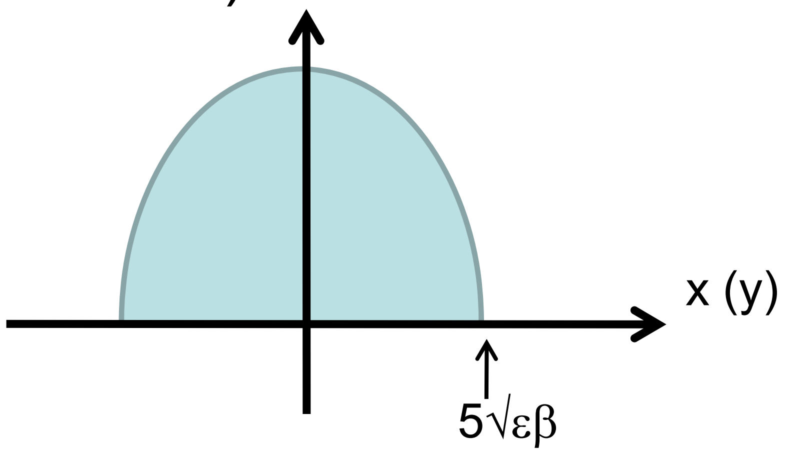
   Lower SR BG and HOM power are expected

   → Is it possible to use the smaller radius beam-pipe?

Back up

Beam line simulation setup

- Aperture of the Q-magnets ~ 5σ (= 5√εβ)
- Beam size 5σ (max = 5σ) or 2σ (max = 2σ)
- Beam shape : sqrt(x) shape



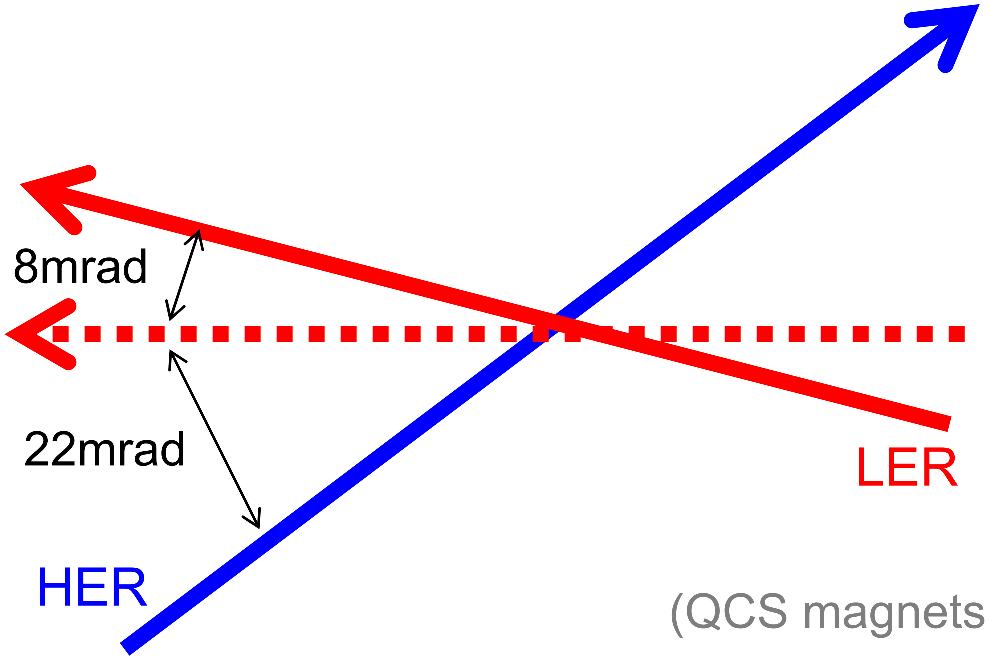
- The number of particles in a bunch

HER : 4.1A / (1.6*10^-19)/(100kHz)/5000 = 0.5 *10^{11}

LER : 9.4A / (1.6*10^-19)/(100kHz)/5000 = 1.2 *10^{11}

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

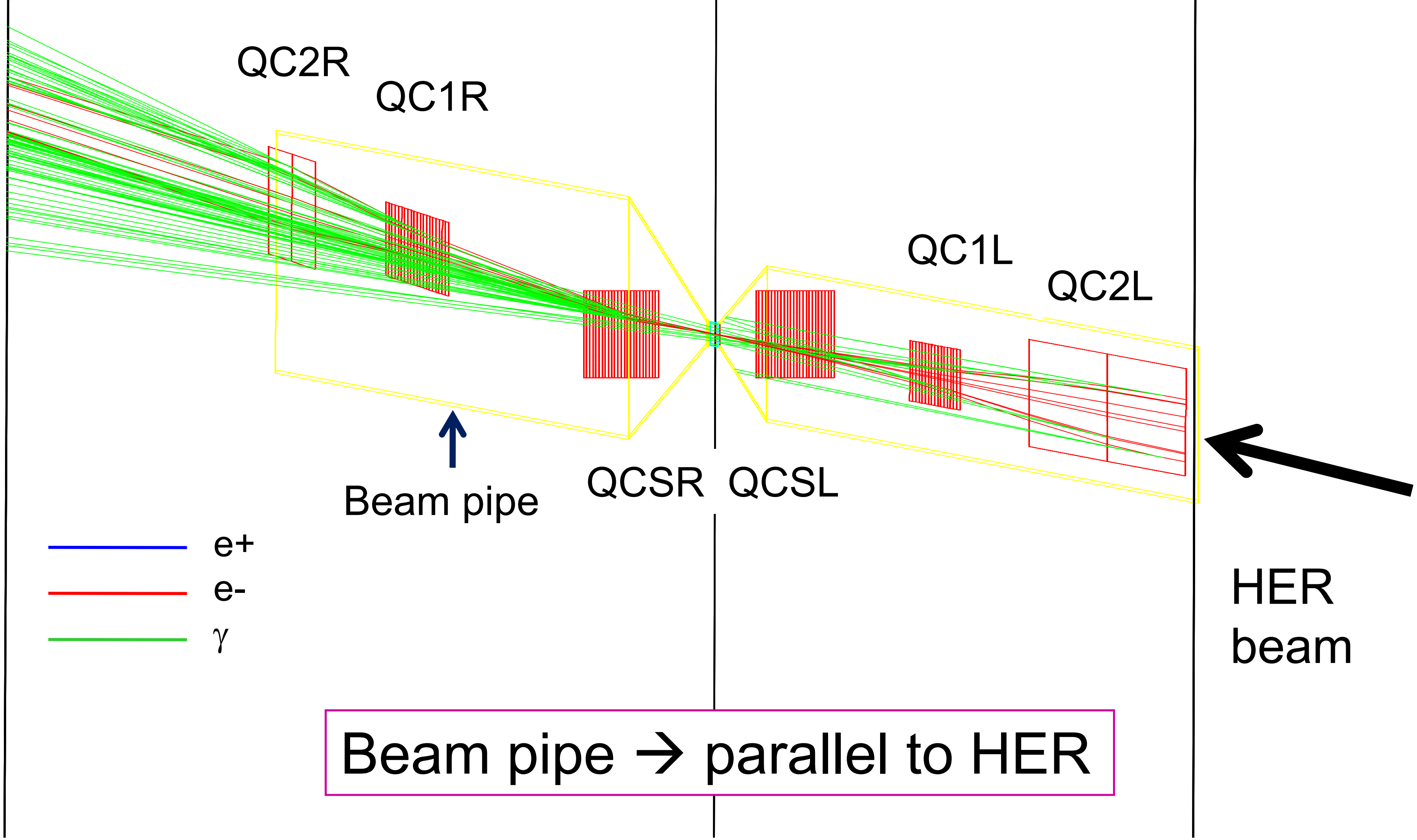
(QCS magnets will be set parallel to Belle solenoid)

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>

HER beam line simulation

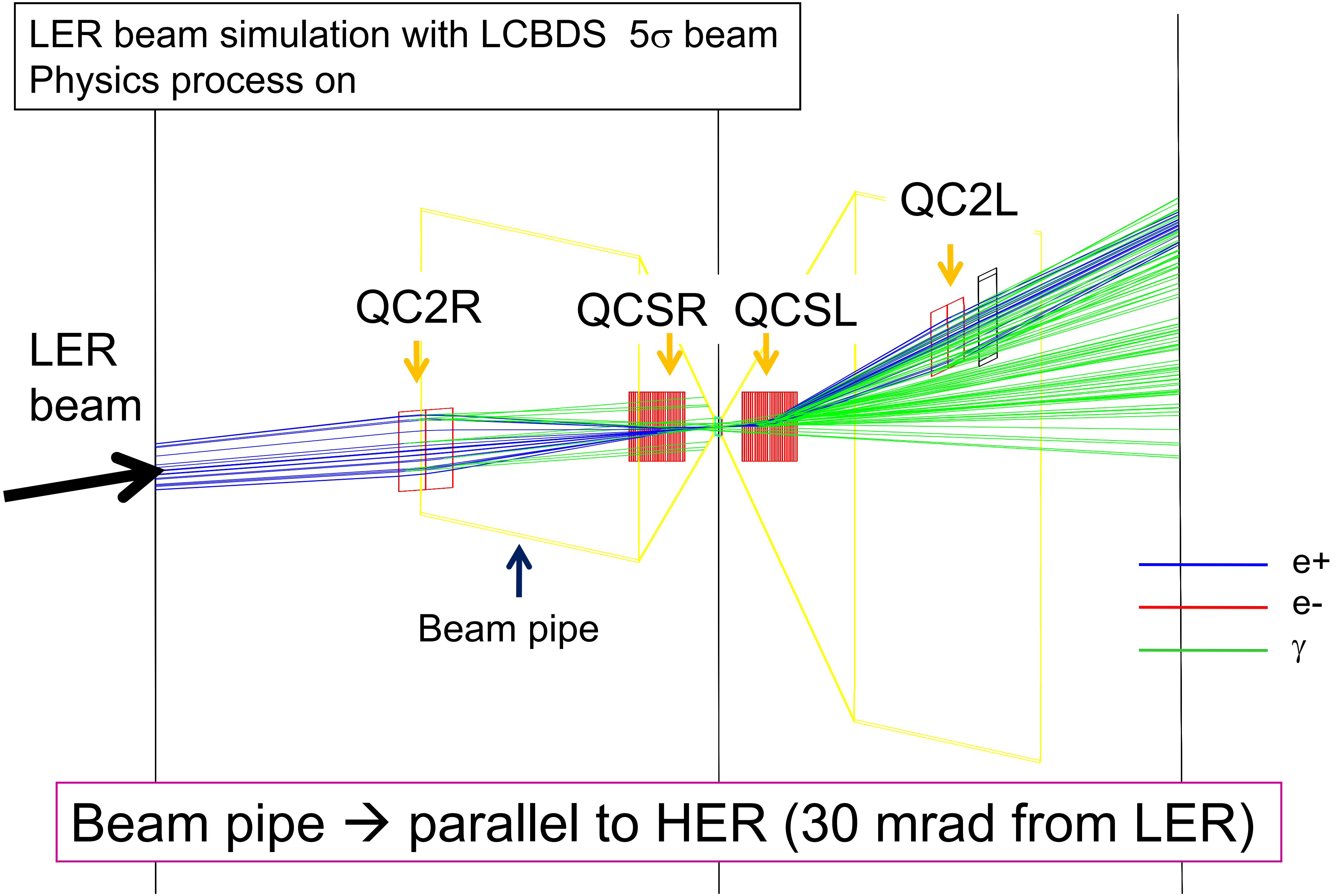
HER simulation with LCBDS
5σ beam / physics process on



Beam pipe → parallel to HER

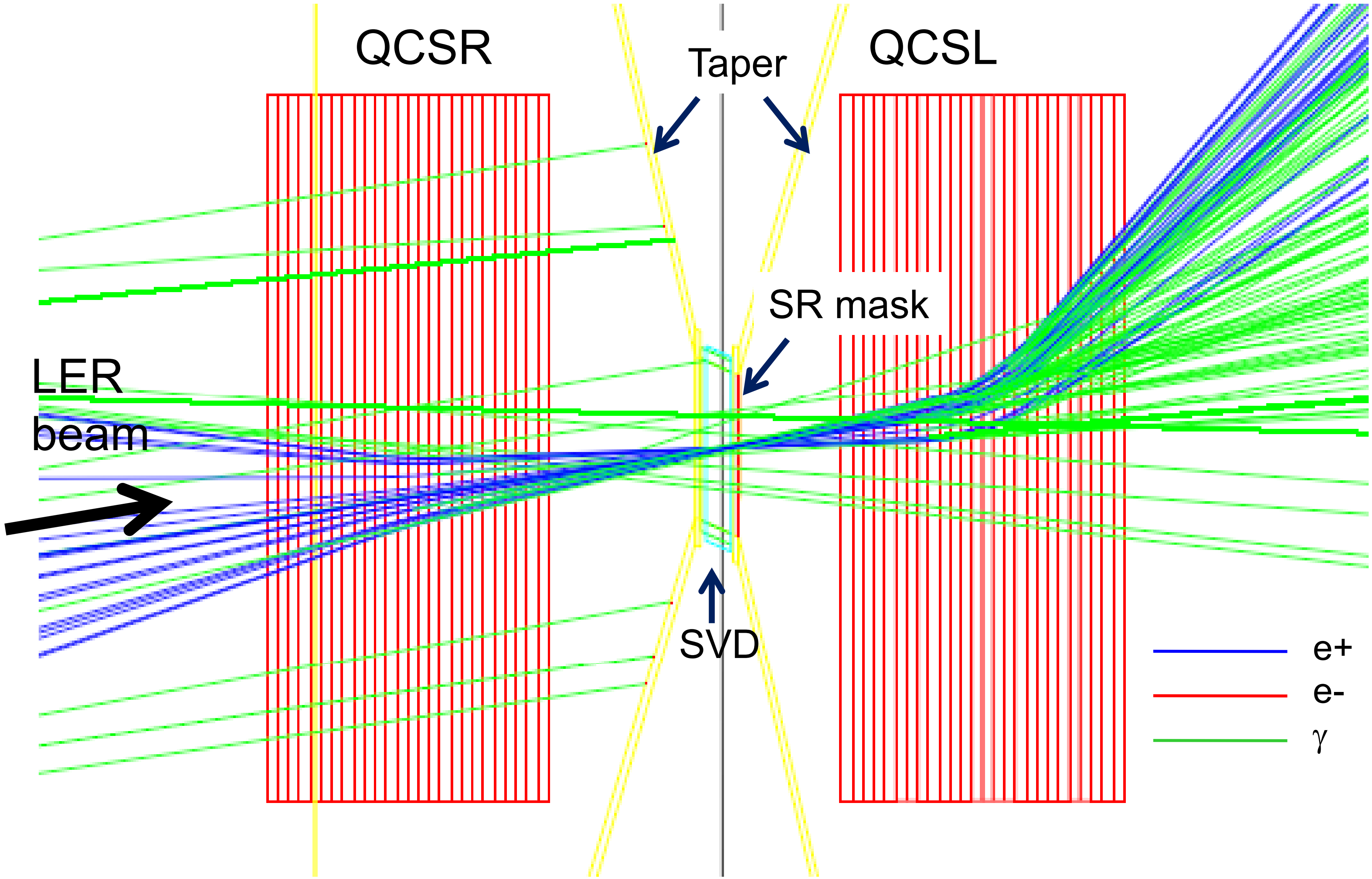
LER beam-line simulation

LER beam simulation with LCBDS 5σ beam
Physics process on



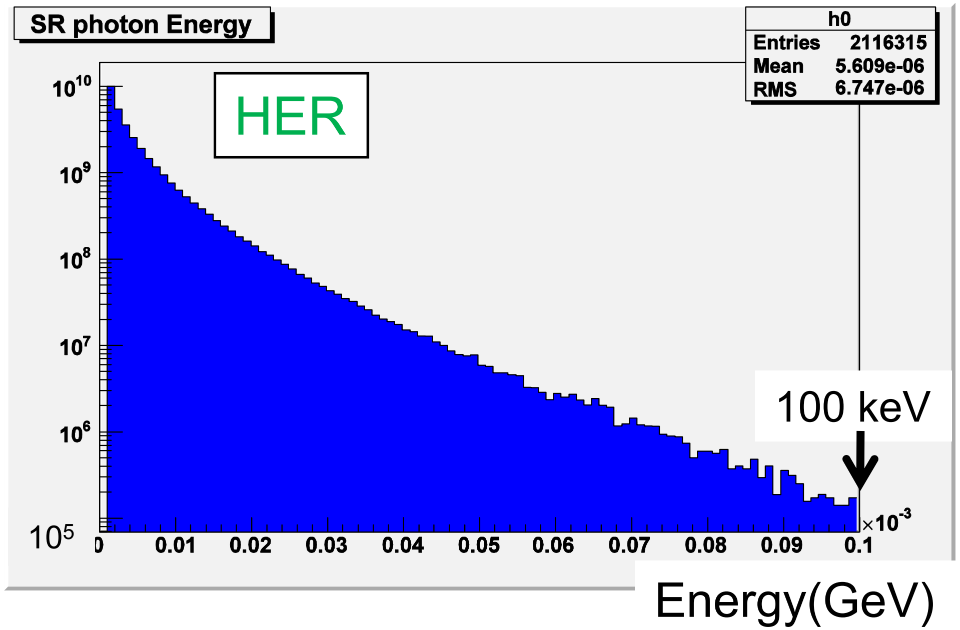
Beam pipe → parallel to HER (30 mrad from LER)

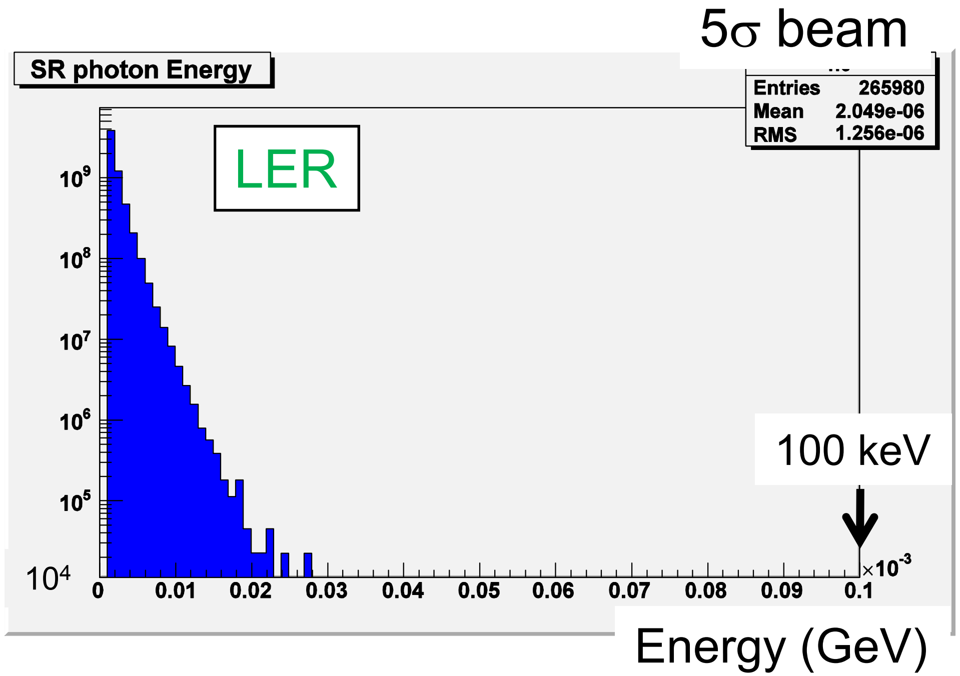
LER simulation



Upstream SR energy

SR energy (at IP)





(Vertical scale: Scaled for 1-bunch beam)

The SR energy from HER is very high (< ~100keV)

→ We don't want the direct hits from HER SR at first

Energy deposit from HER SR

Why do we have so high energy deposit?

1. Increase the beam current — effect : x3

2. Change beam optics (QC2L)
   - x3 Beam size at the Q-magnet ↑
   - x7 B-field of the Q-magnet ↑
   - Same magnet length
   - No-bending component ↓

Critical Energy @ QC2L : 2keV for 10σ beam (KEKB)

56keV for 10σ beam (super-KEKB) — effect : x28

→ We have 3x28 ~ 100 times higher E deposit at super-KEKB

Current super-KEKB beam optics produces huge power SR

Total SR power produced at Q-magnet

- To check our simulation results,
  we compare the total SR power at the QC2 magnet

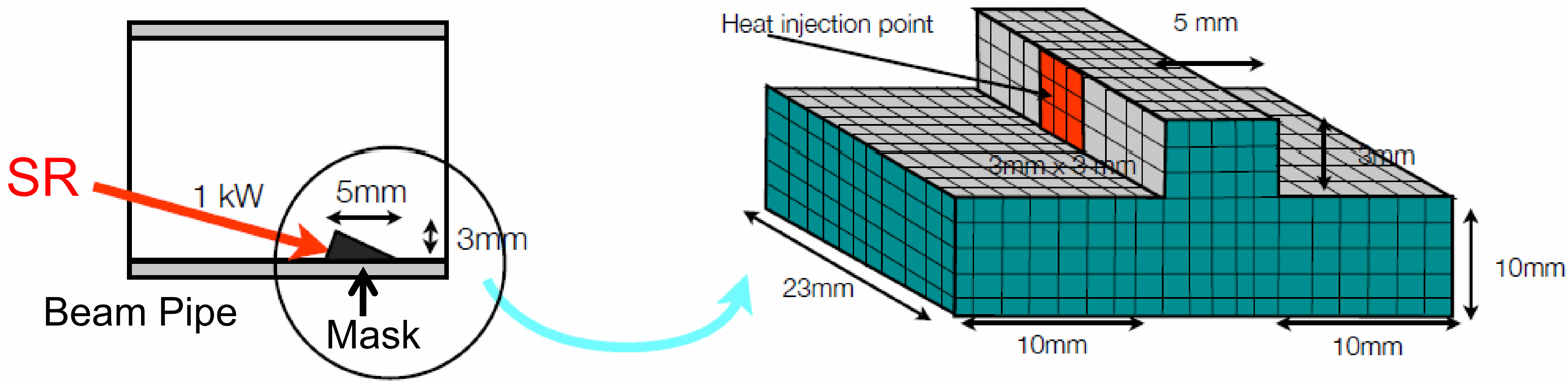
1. GEANT4 simulation
   (For 2σ beam :corresponds to nominal Gaussian beam core)
   Total power = 3.3kW
2. Hand calculation (by Y.Funakoshi-san)
   Total power = 2.9kW

- We also check that SR power produced at QC2 in our current KEKB is about 1/100 of super-KEKB, in GEANT4 simulation

Heat at the synchrotron light mask

T.Tsuboyama (KEK)

- The heat differential equation is solved by a 3D discrete finite difference method.
- The following model was made and calculated.
- The bottom surfaces are connected to a heat sink (0 °C)
- The other surfaces are heat insulated.
- Calculation was done with equal mesh size: 1 mm in x,y,z direction.

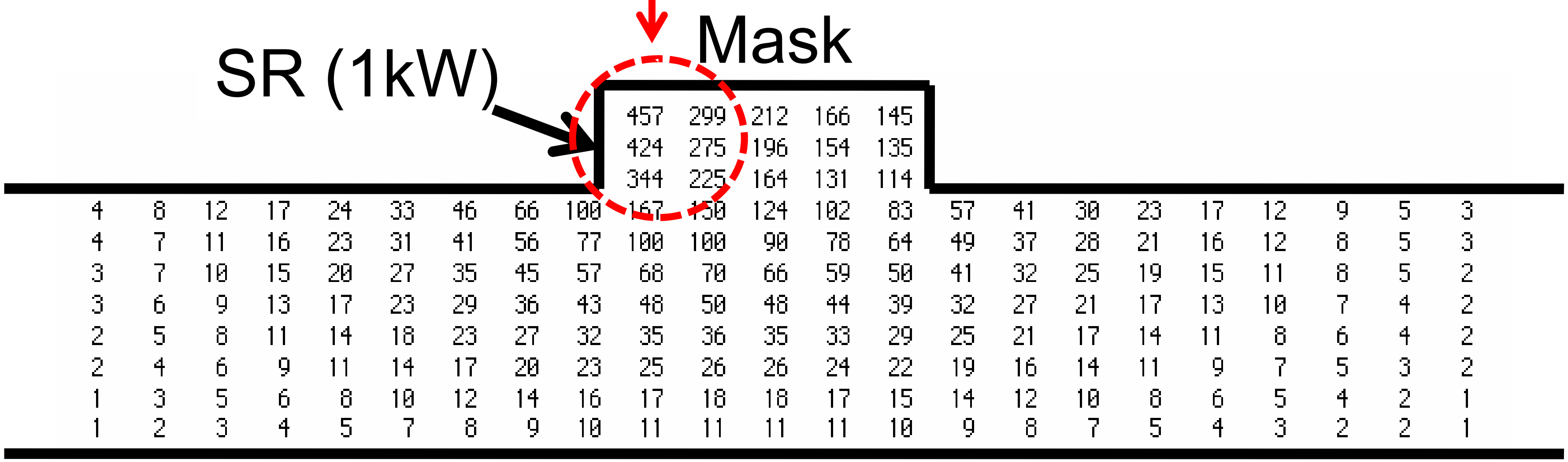


Material : copper is assumed (because of its good thermal conductivity)

Heat at the synchrotron light mask

T.Tsuboyama (KEK)

- The temperature distribution Δt for the center slice after equilibration (in one second) is shown below.
- The temperature goes up to Δt = ~450 degree.
- The heat dissipation to the mask should be of order 100W.
- Next step: reliable calculation by ANSYS or a similar tool.

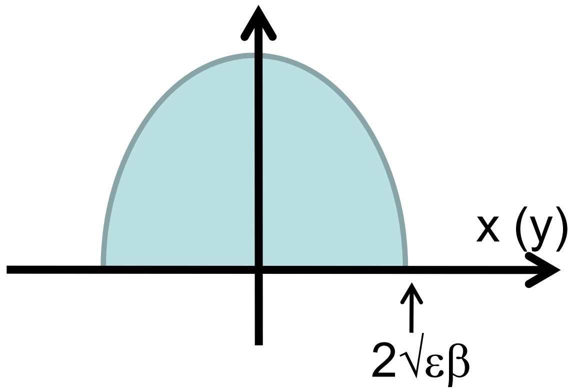


									457	299	212	166	145									
									424	275	196	154	135									
									344	225	164	131	114									
4	8	12	17	24	33	46	66	100	167	150	124	102	83	57	41	30	23	17	12	9	5	3
4	7	11	16	23	31	41	56	77	100	100	90	78	64	49	37	28	21	16	12	8	5	3
3	7	10	15	20	27	35	45	57	68	70	66	59	50	41	32	25	19	15	11	8	5	2
3	6	9	13	17	23	29	36	43	48	50	48	44	39	32	27	21	17	13	10	7	4	2
2	5	8	11	14	18	23	27	32	35	36	35	33	29	25	21	17	14	11	8	6	4	2
2	4	6	9	11	14	17	20	23	25	26	26	24	22	19	16	14	11	9	7	5	3	2
1	3	5	6	8	10	12	14	16	17	18	18	17	15	14	12	10	8	6	5	4	2	1
1	2	3	4	5	7	8	9	10	11	11	11	11	10	9	8	7	5	4	3	2	2	1

Change beam shape in MC

Old optics

- 2σ sqrt-shape beam



HER: SR Mask 0.73kW HER taper 0.69kW

QC1 0.30kW QC1 0.02kW

QC2 0.44kW QC2 0.67kW

LER: SR Mask 20W LER taper 75W IP beam-pipe 15W

- Gaussian beam (2σ tail cut)

HER: SR Mask 0.52kW HER taper 0.43kW

QC1 0.15kW QC1 0.01kW

QC2 0.37kW QC2 0.42kW

- Gaussian beam (5σ tail cut)

HER: SR Mask 0.68kW HER taper 1.18kW

QC1 0.32kW QC1 0.17kW

QC2 0.36kW QC2 1.01kW

Energy deposit from SR

New optics (1012a) Gaussian beam

HER

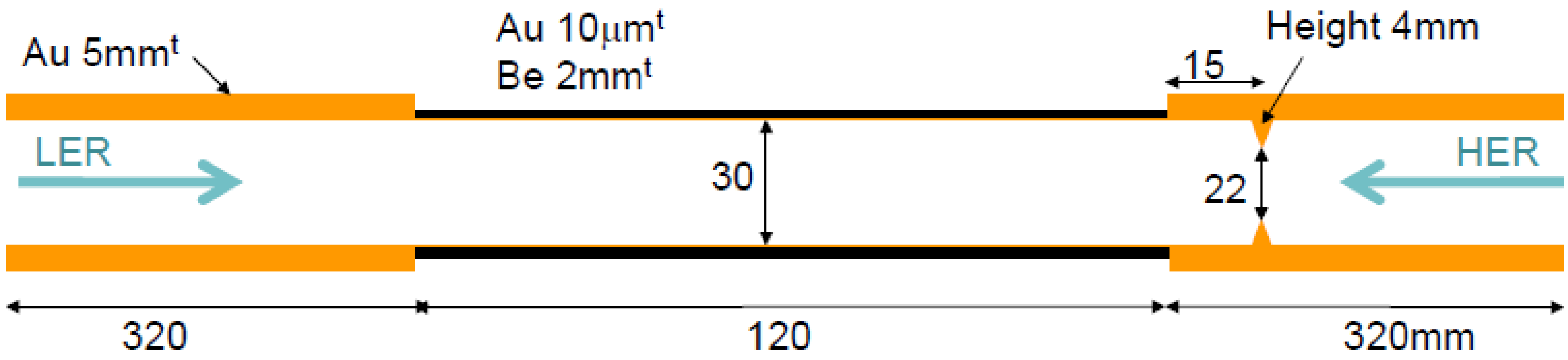
SR Mask	82W	HER taper	60W	(5σ tail cut)
	46W		10W	(2σ tail cut)

E deposit to the SR mask → SR from beam core

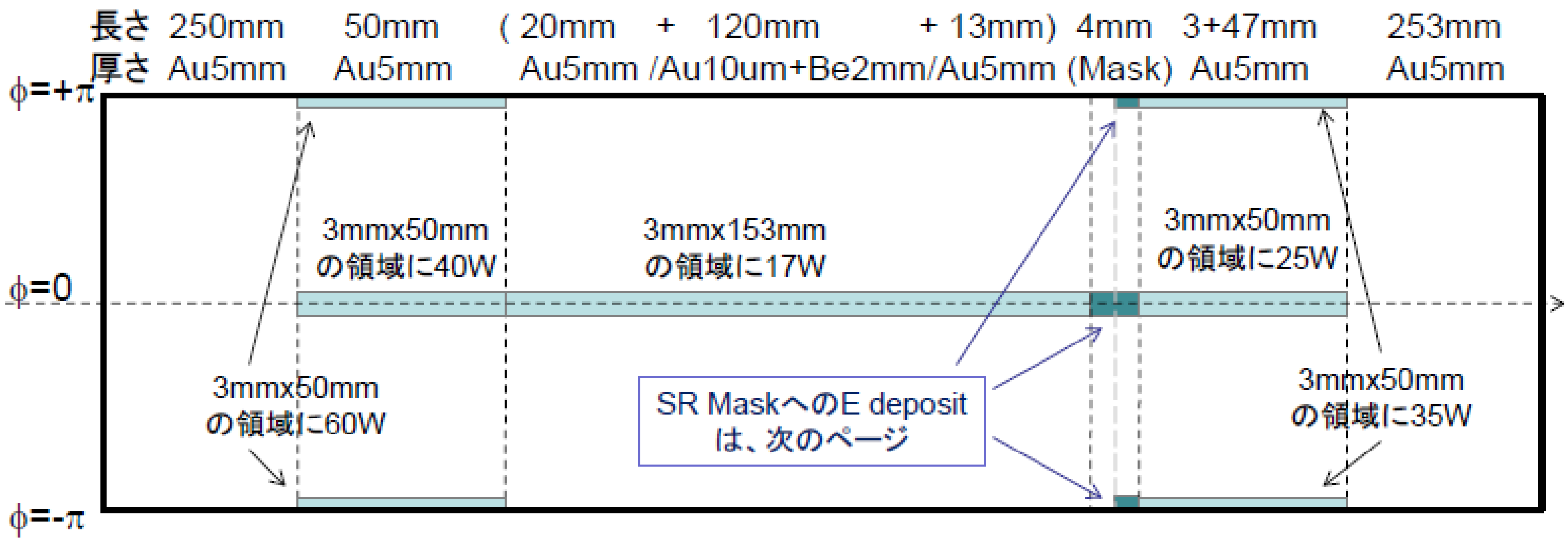
Her taper → SR from beam tail part

E deposit to the Beam pipe

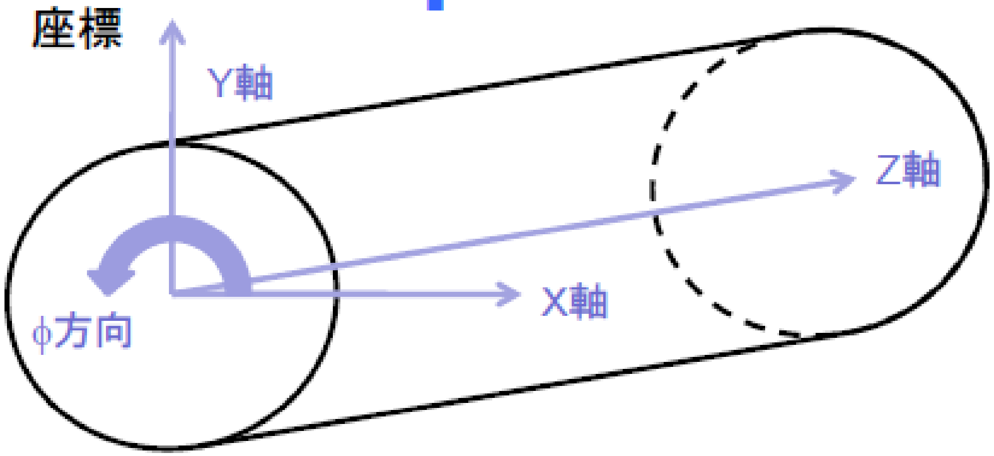
簡単のため、テーパー部の傾きはなし。筒状のものを考える。

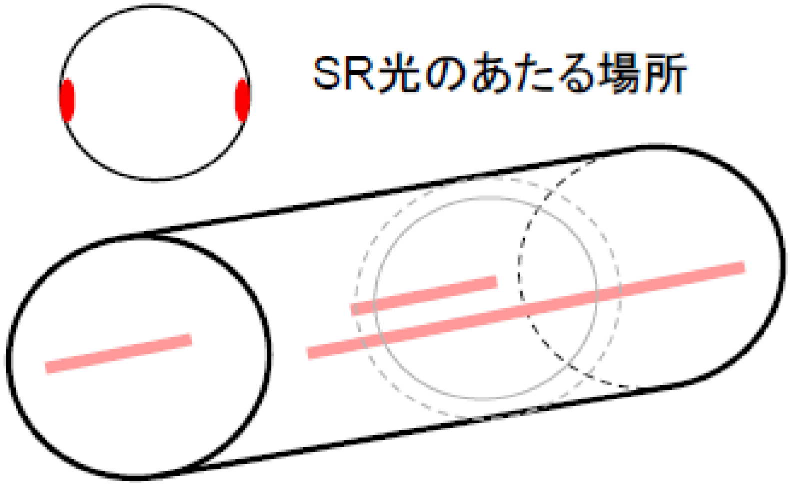


ビームパイプへのE deposit（筒を開いたもの。内側表面から、SR光が当たる。）

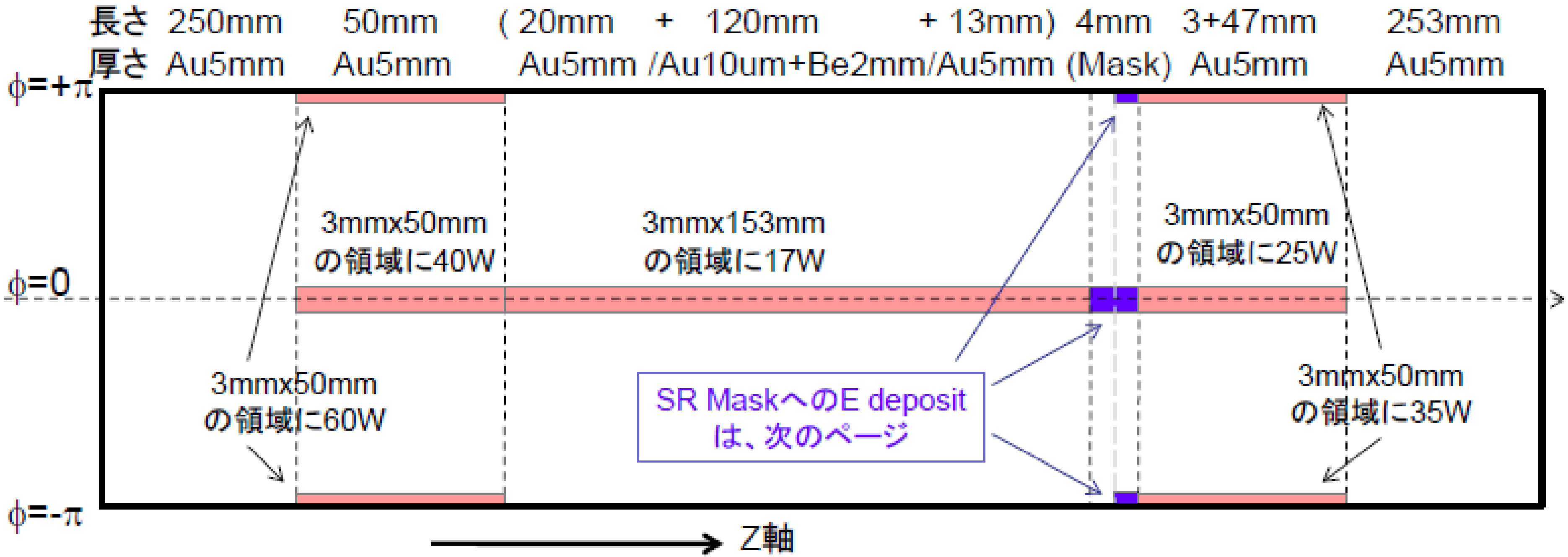


E deposit to the Beam pipe





ビームパイプへのE deposit（筒を開いたもの。内側表面から、SR光が当たる。）



E deposit to the SR mask

SR maskへのE deposit（内側表面から、SR光が当たる。）