Beam Background in the Interaction Region

Hiroyuki Nakayama (KEK)

My talk covers overview of SuperKEKB background. Next talk by Nakano will cover Touschek simulation, and the final talk in this session by A. Moll shows latest background simulation results on PXD.

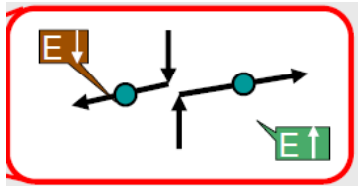
Background sources at SuperKEKB

- Background from scattered beam particles
- Background from physics processes
- Background from synchrotron radiation
- etc..

Background sources
~1. **Scattered beam particles~**

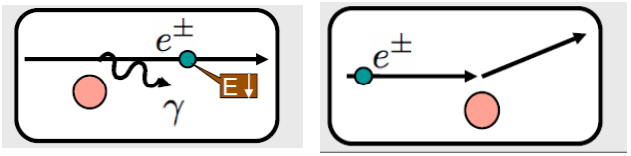
Touschek scattering

- Intra-bunch scattering, Rate $\propto$ (beam size)$^{-1}$,(E_{beam})$^{-3}$
- Most dangerous background at SuperKEKB,
  since the beam size is ~x20 smaller ("Nano-beam scheme")
- Details are shown in the following talk by Nakano

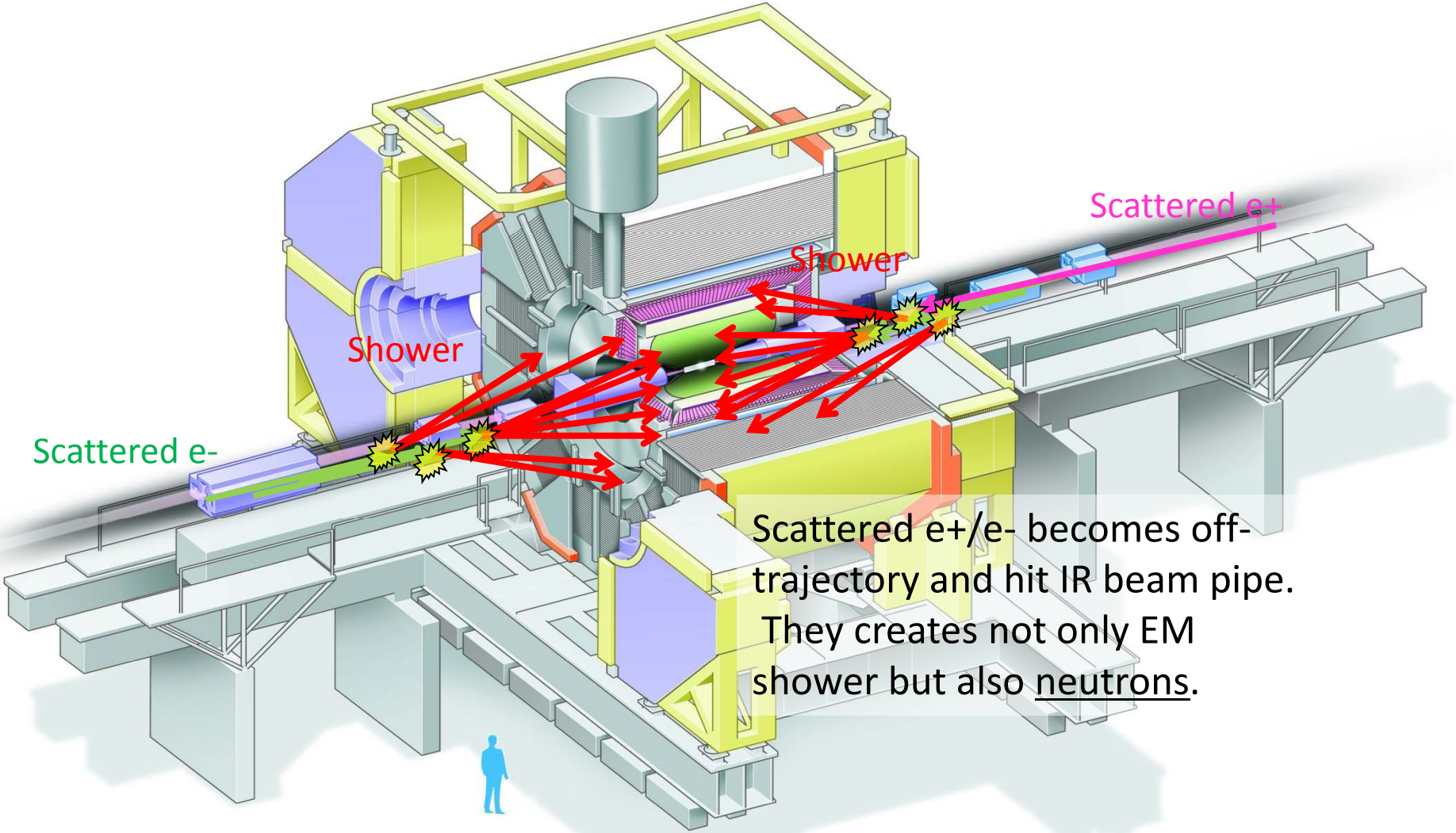


Beam-gas scattering

- Scattering by remaining gas, Rate $\propto$ IxP
- Vacuum level at SuperKEKB will be similar to KEKB,
  so less dangerous compared to Touschek scattering
- Vacuum level in IR region could be worse than KEKB, but particles scattered in IR region will be lost far downstream IP and will not be dangerous for the detector



Touschek/Beam-gas background

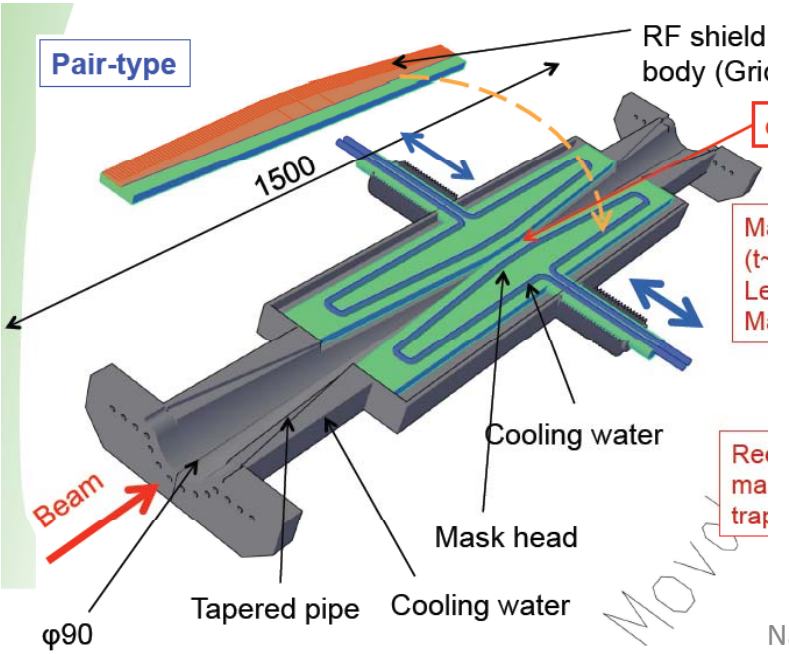


Scattered e+/e- becomes off-trajectory and hit IR beam pipe. They creates not only EM shower but also neutrons.

Countermeasures

Collimators in the ring

- Horizontal collimation from both inner/outer sides
- Stop off-momentum e+/e- before reaching interaction region



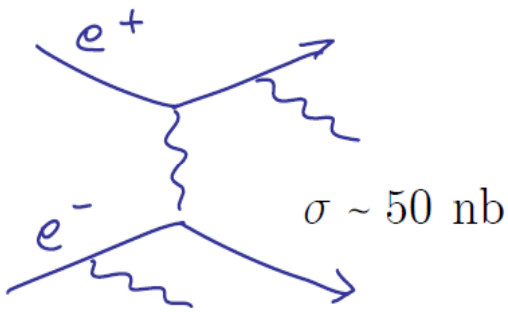
Heavy-metal shield

- Placed outside IR beam pipe
- Protect inner detector from EM shower created by loss particle

Background sources (cntd.)
~2. Luminosity dependent~

Radiative Bhabha

- Rate∝Luminosity (KEKBx40)
- e+/e- lose energy and hit downstream beam pipe, hit position is very far (~10m) from IP, so it's OK
- γ hit magnet(@IP+10m) and create neutrons. Need to increase neutron shields in the tunnel

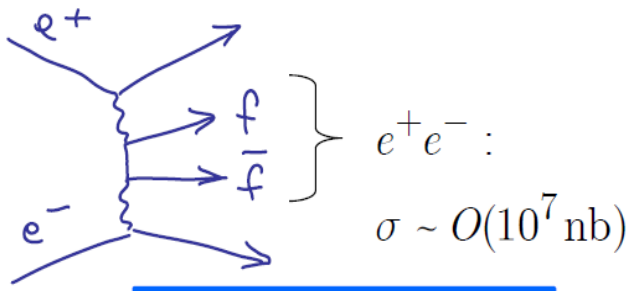


Bhabha scattering

2-photon process

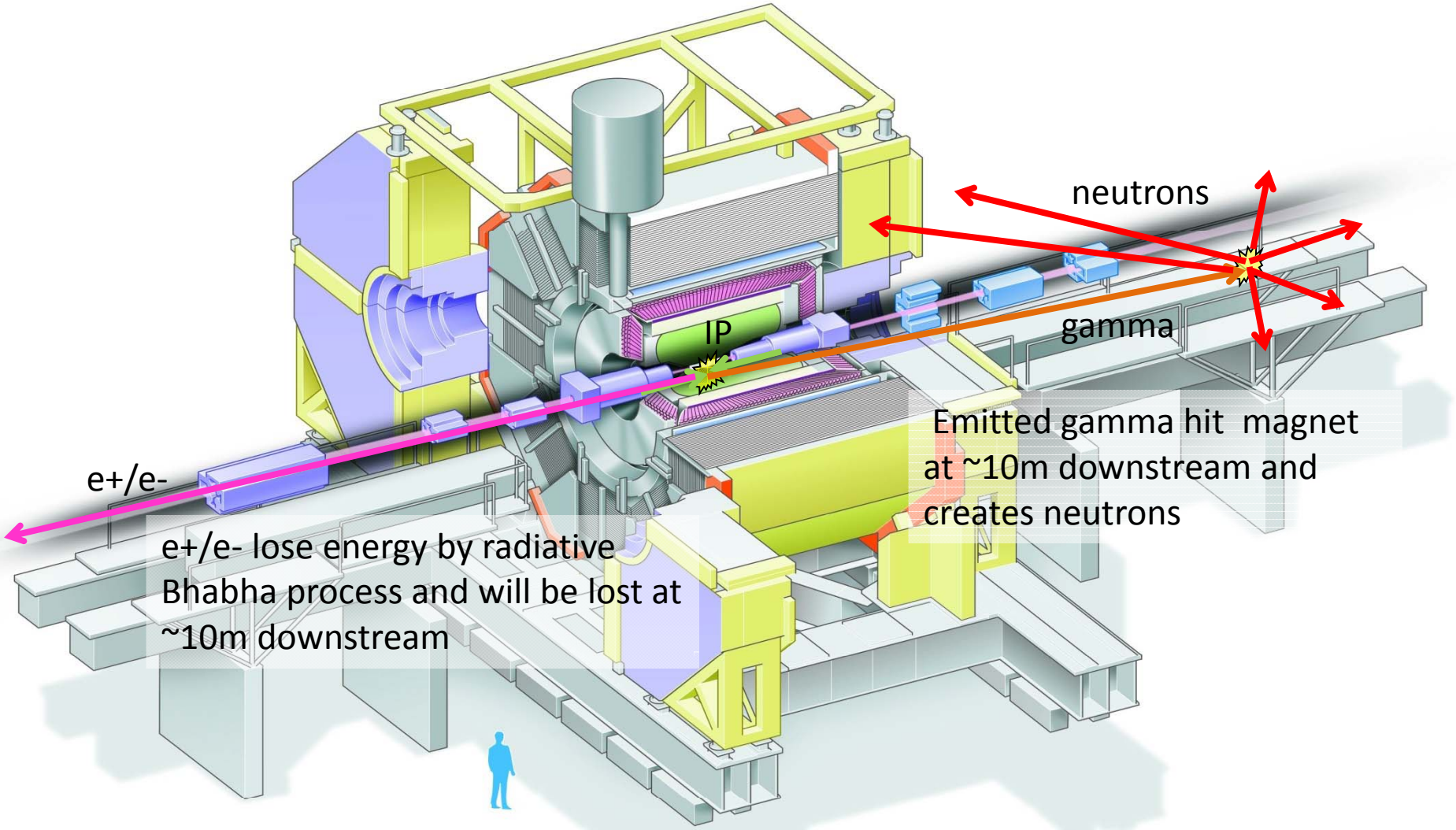
- Generated e+e- pair might hit PXD
- Confirms to be OK, according to simulation and KEKB machine study

"0.2%(<<2%) occupancy on PXD"



2-photon-processes

Radiative Bhabha

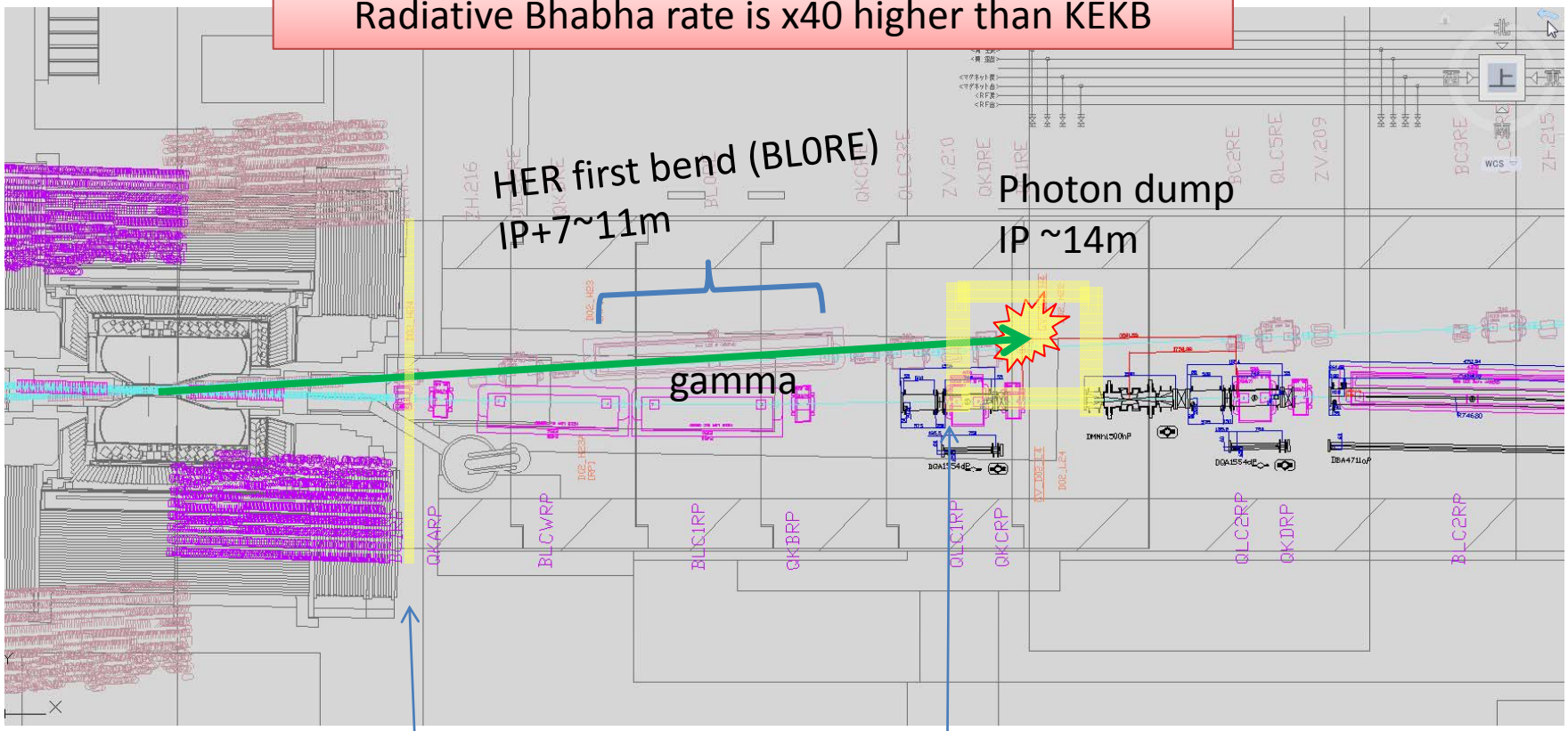


Emitted gamma hit magnet at ~10m downstream and creates neutrons

e+/e- lose energy by radiative Bhabha process and will be lost at ~10m downstream

Additional neutron shield around radiative Bhabha photon dump

Radiative Bhabha rate is x40 higher than KEKB

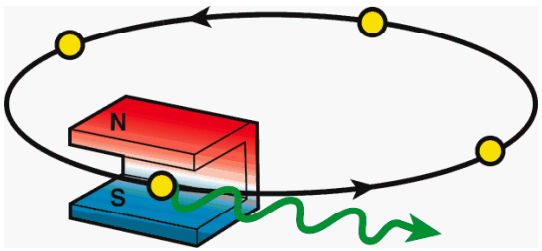


Polyethylene shield (10cm) at KEKB

Additional neutron shield around photon dump?

Background sources (cntd.)
~3. Synchrotron radiation~

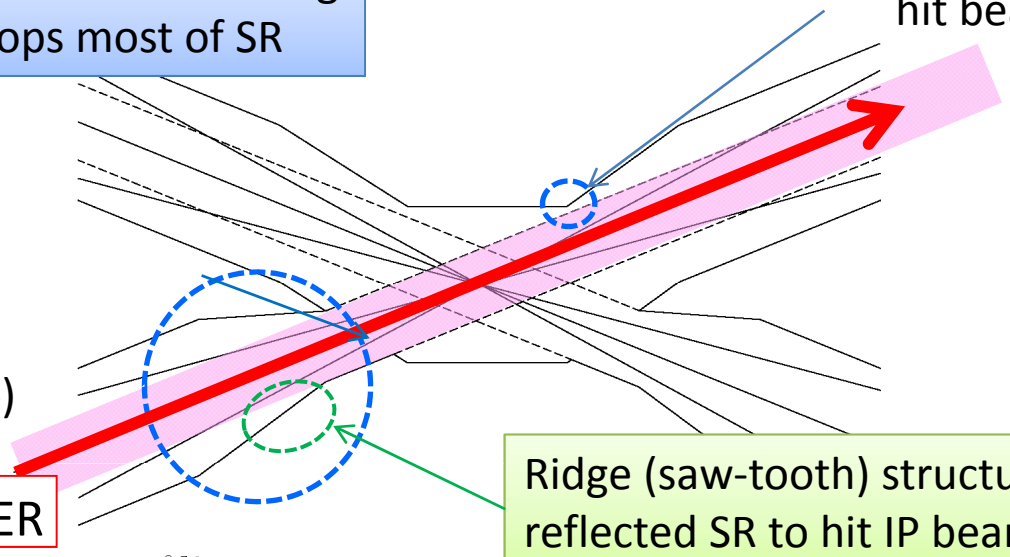
Synchrotron radiation



- Rate ∝ E^2B^2: mainly from HER
- Photons are emitted inside final focusing magnet
  →hit IP beam pipe (Be) and penetrate → reach PXD/SVD

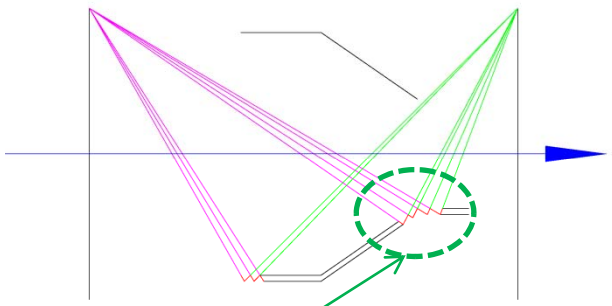
Collimation on incoming pipe stops most of SR

~2×10^2/bunch (>5keV) photons hit beam pipe here
→ PXD occp. <<1%



(20mmϕ
→9mmϕ)

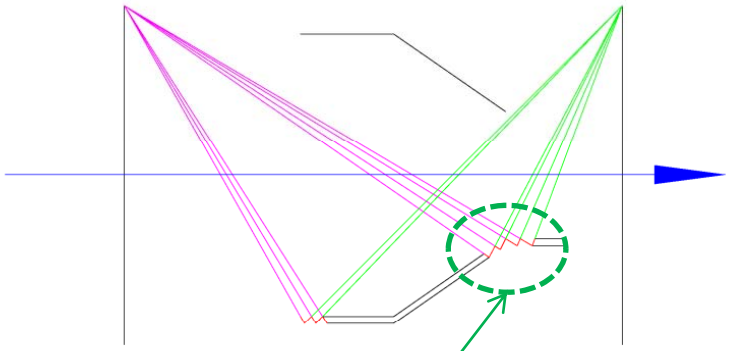
HER



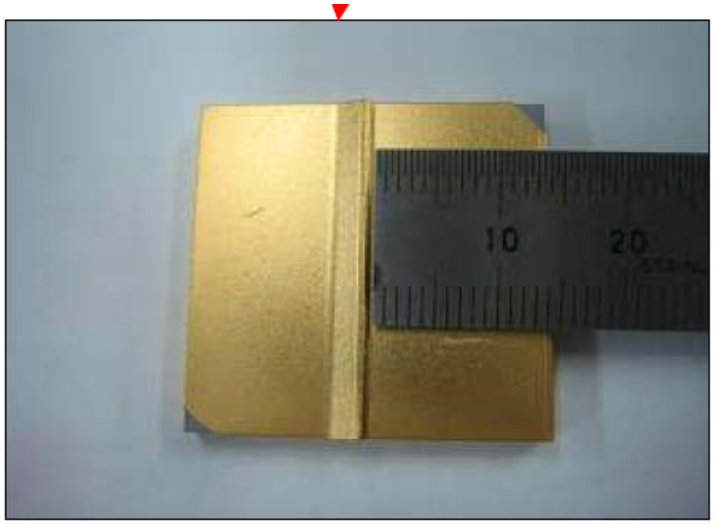
Ridge (saw-tooth) structure avoid reflected SR to hit IP beam pipe

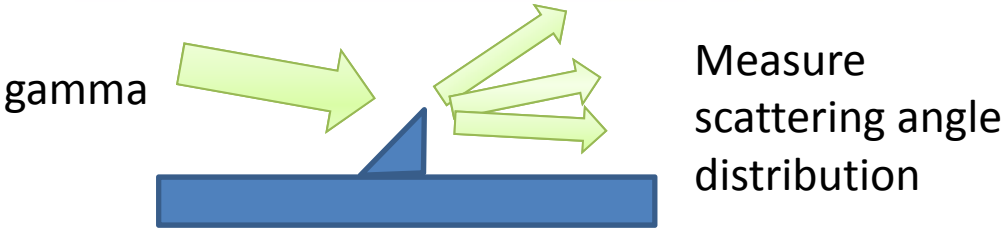
Beam test for tip-scattering

Ridge (saw-tooth) structure avoid reflected X-ray to hit the straight part of beam pipe, but “tip-scattered” X-rays might create additional hits.



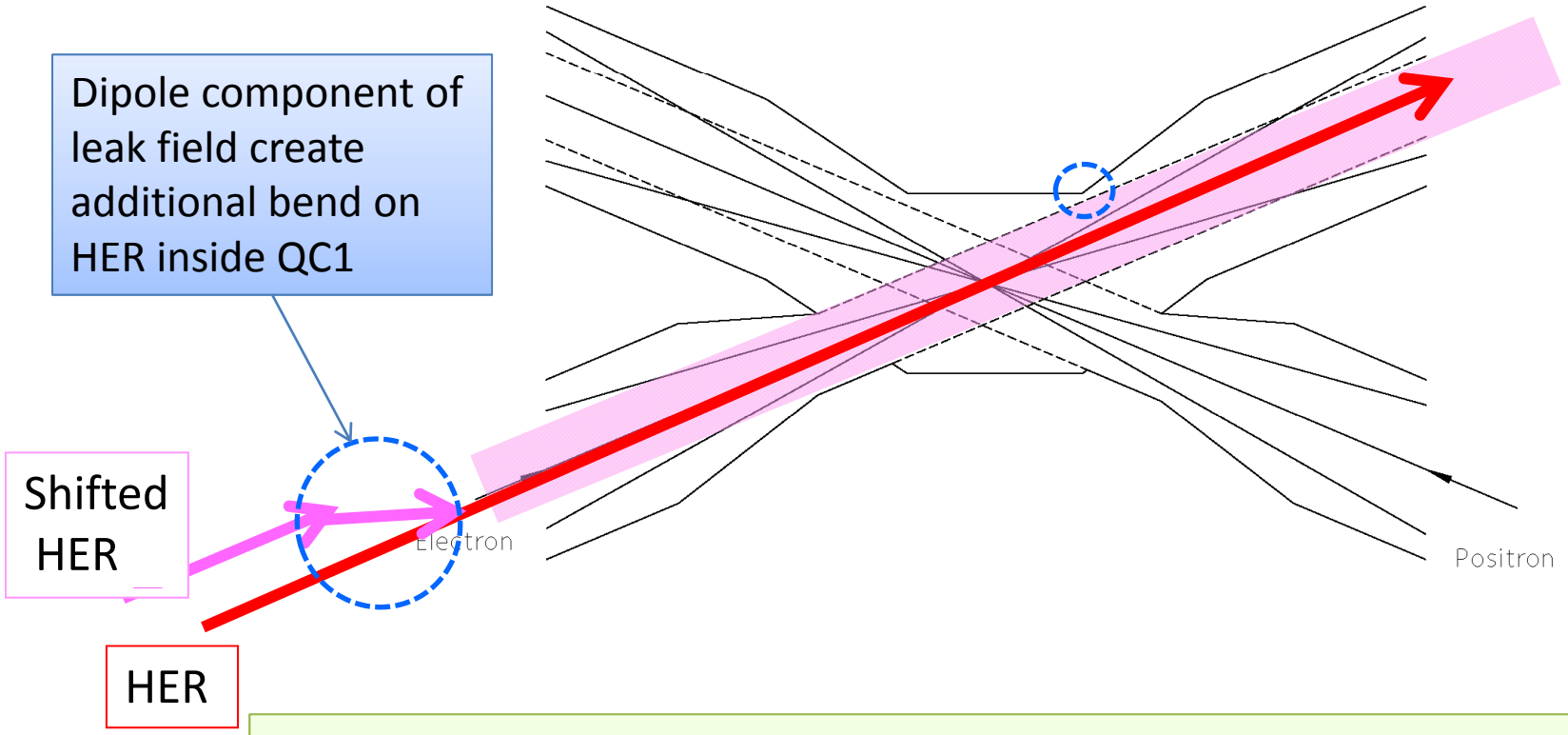
Ridge (saw-tooth) structure avoid reflected SR to hit IP beam pipe





Beam test scheduled in 2011 summer

Shifted HER trajectory with leak field

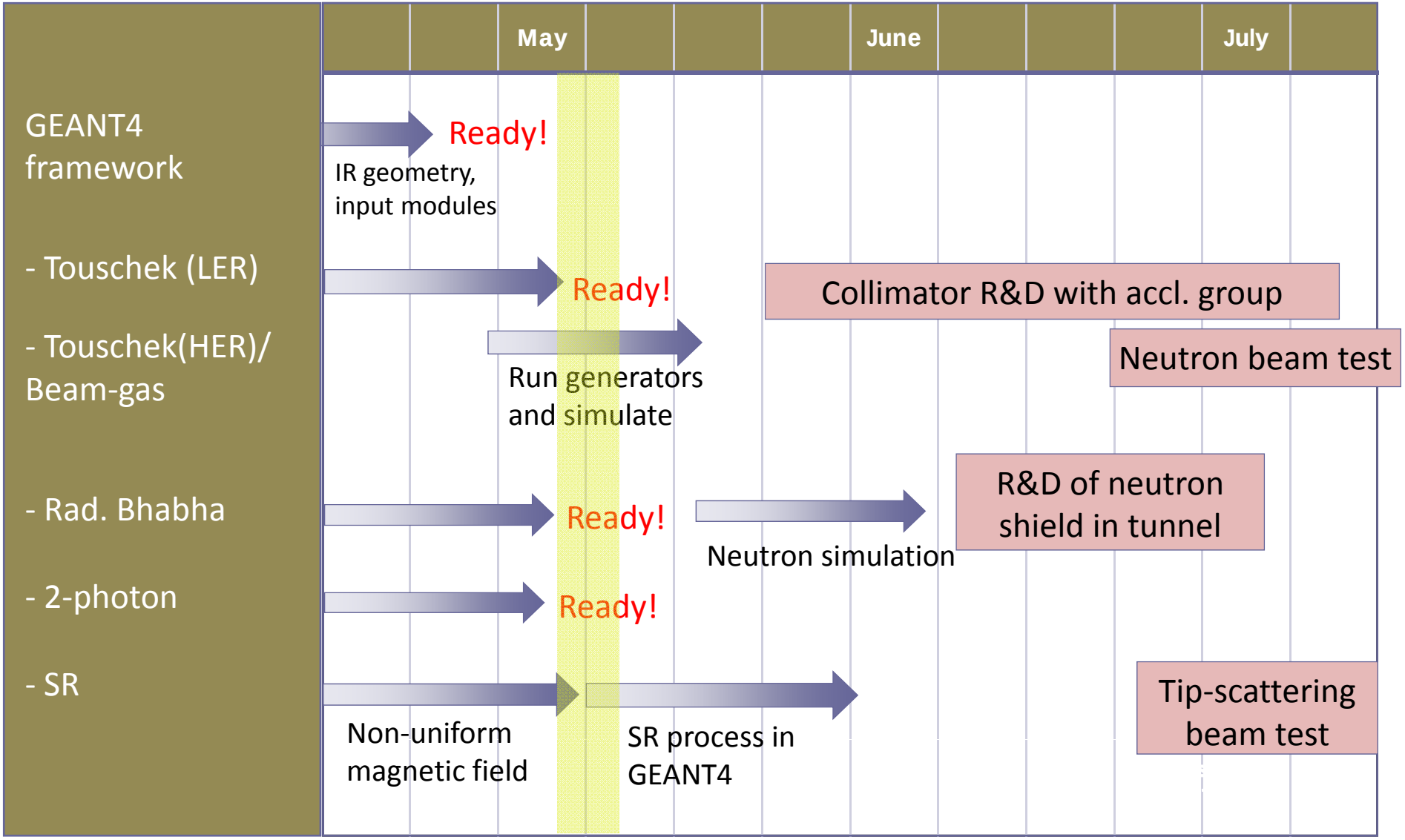


It seems the direction of the trajectory shift is in a “less worse” direction. (additional SR will not hit the beam-pipe at the position circled in blue) Anyway, we will confirm it with our full-detector simulation.

Summary

- Touschek scattering is most dangerous background source at SuperKEKB
- Both EM shower/neutrons from by Touschek loss particle should be carefully estimated
- SR estimation should be updated, taken into account the leak field and tip-scattering
- Other background sources might not be a big problem. We simulate them anyway.

Status & Schedule

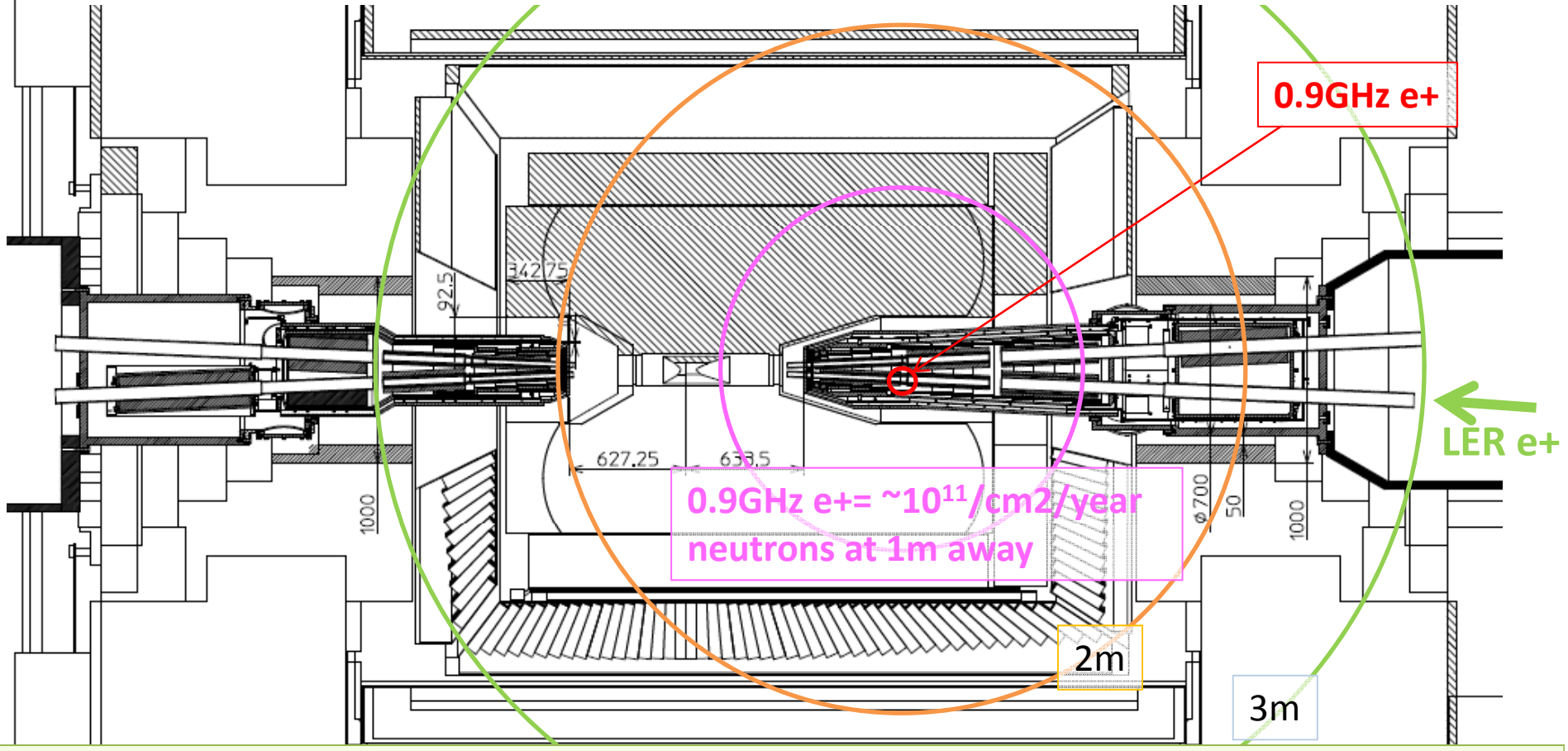


backup

Simulation status summary

Source	Generator	Simulation	Comment
Touschek	LER: Ready HER: Yet (SAD, TURTLE)	LER: Finished HER: Yet	LER is OK for now, but we should check the impact coming from collimator imperfectness. HER will be ready in few weeks.
Neutrons from Touschek loss	LER: Ready HER: Yet	LER: Finished HER: Yet	Dangerous. Need to be checked by each detector group.
Beam-gas	Ready (TURTLE)	Running	Should be OK (KEKBx2),
e+/e- from rad. Bhabha	Ready (BHWIDE, BBbrem)	Running	Should be OK (e+/e- are lost ~10m downstream), thanks to no QCS off-center bend
Neutrons from rad. Bhabha	Ready (BHWIDE, BBbrem)	Running	KEKBx40, generated at ~10m downstream should increase shields in beam tunnel.
2-photon process	Ready (KoralW)	Running	Should be OK (confirmed by stand-alone simulation and machine study)
SR	Ready	Yet	Will be ready in a month, but simple simulation has already shown it's OK. Leak field impact should be updated. Tip-scattering beam test is planned.
Beam-beam	Yet	Yet	Accelerator group are now investigating.

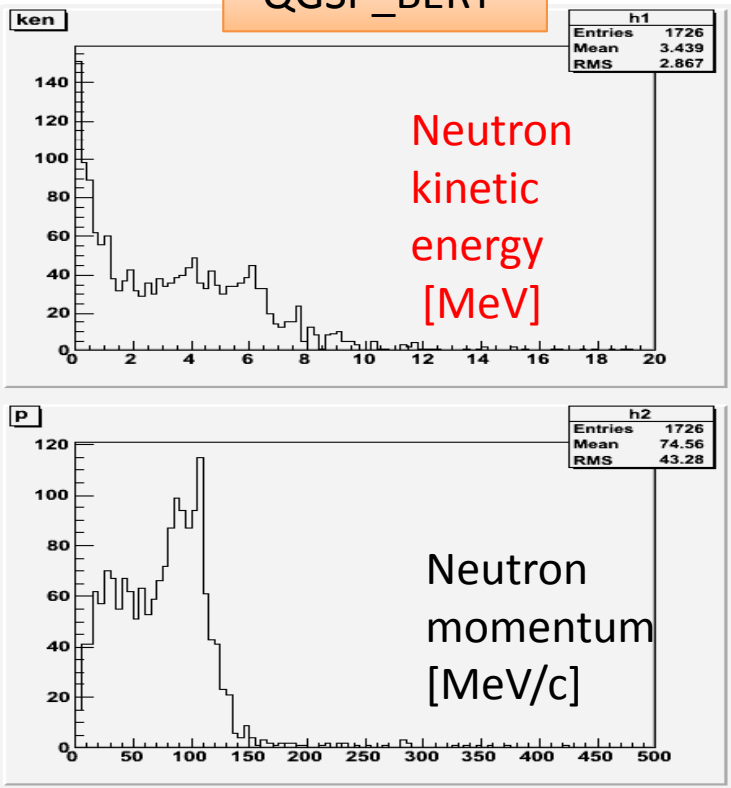
Neutron flux from LER Touschek



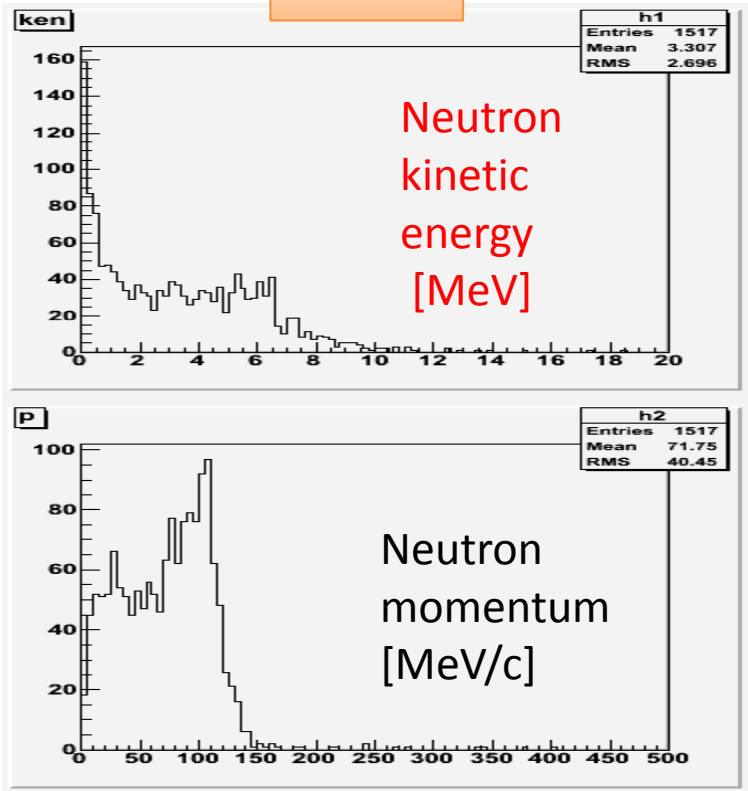
- γs in showers hit nuclei and generate 1~2 neutrons (few MeV) per 4GeV/c e+ (Giant Dipole Resonance)
- e+ hitting point is quite close to detector(IP-1.2m). almost no space to put neutron shield.
- 0.9GHz e+ = few*10^{11}/cm2/year neutrons (1MeV equiv.): in the same order with detector assumption
- Other sources are being simulated: from HER Touschek, beam-gas, showers created at the last collimator

Neutron energy spectrum
(at generated point)

"QGSP_BERT"

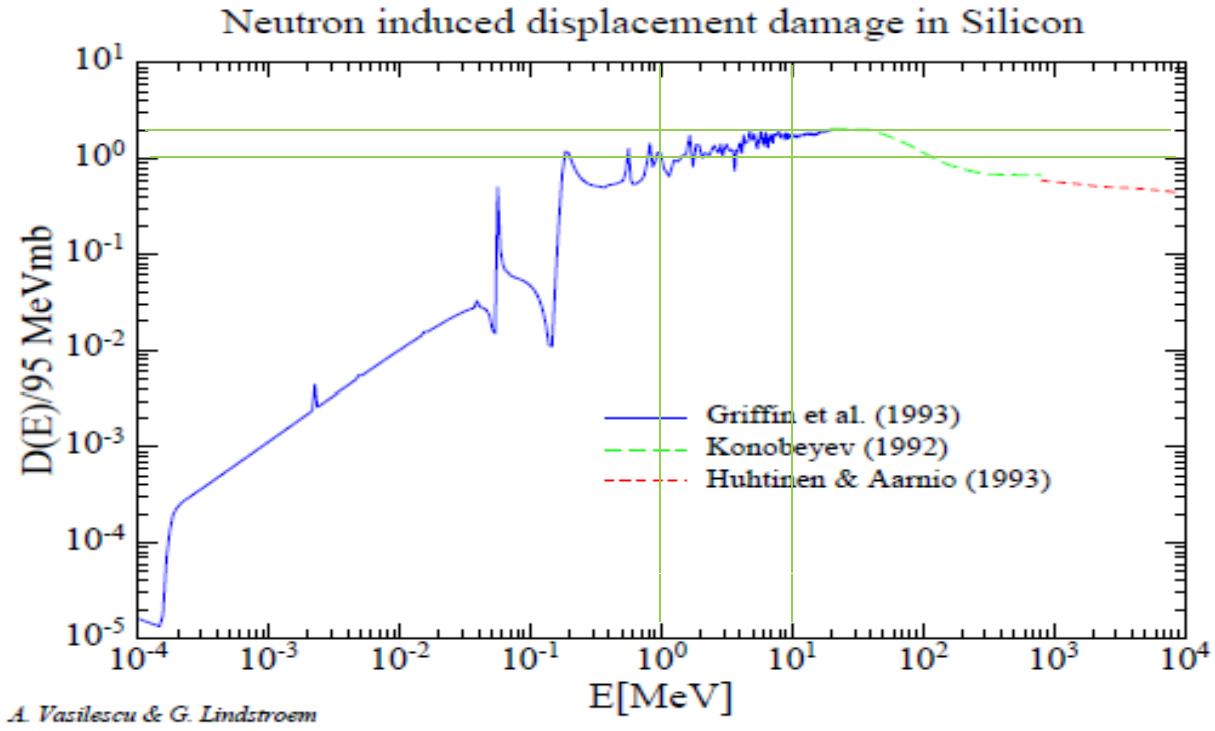


"HLEP"



Neutron kinematic energy is **~5MeV.**
(Neutron momentum is ~100MeV/c)

Neutron displacement damage on Si

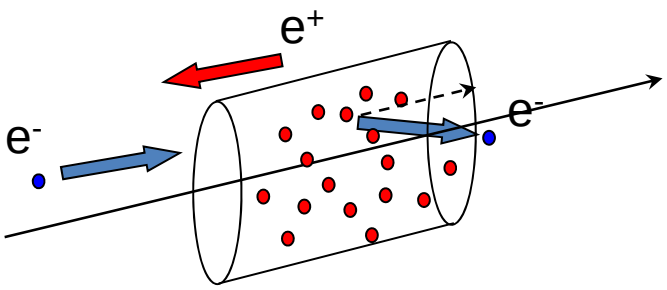


Displacement damage on Silicon by few MeV neutron is about **twice larger** than the damage by 1MeV neutron

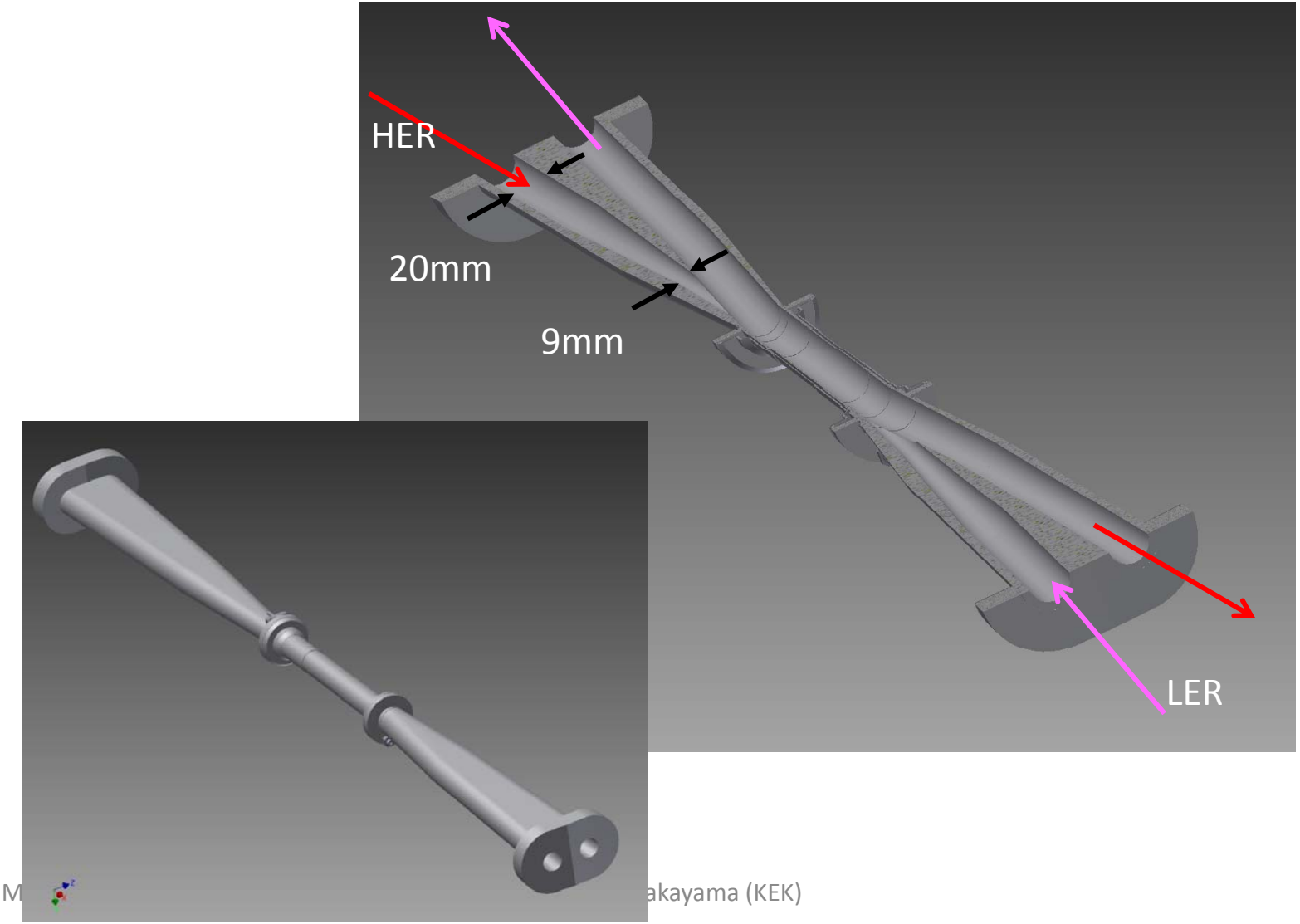
Background sources (cntd.)
~4. beam-beam interaction~

Beam-beam interaction

- Scattered at IP, by field of the other beam
- Beam shape has non-Gaussian tail → might increase SR background
- Multi-body effect, not easy to calculate analytically
- Being simulated by accelerator group



Beam pipe design to stop SR



Gamma from radiative Bhabha

Measured at KEKB. At SuperKEKB, 40 times severer.

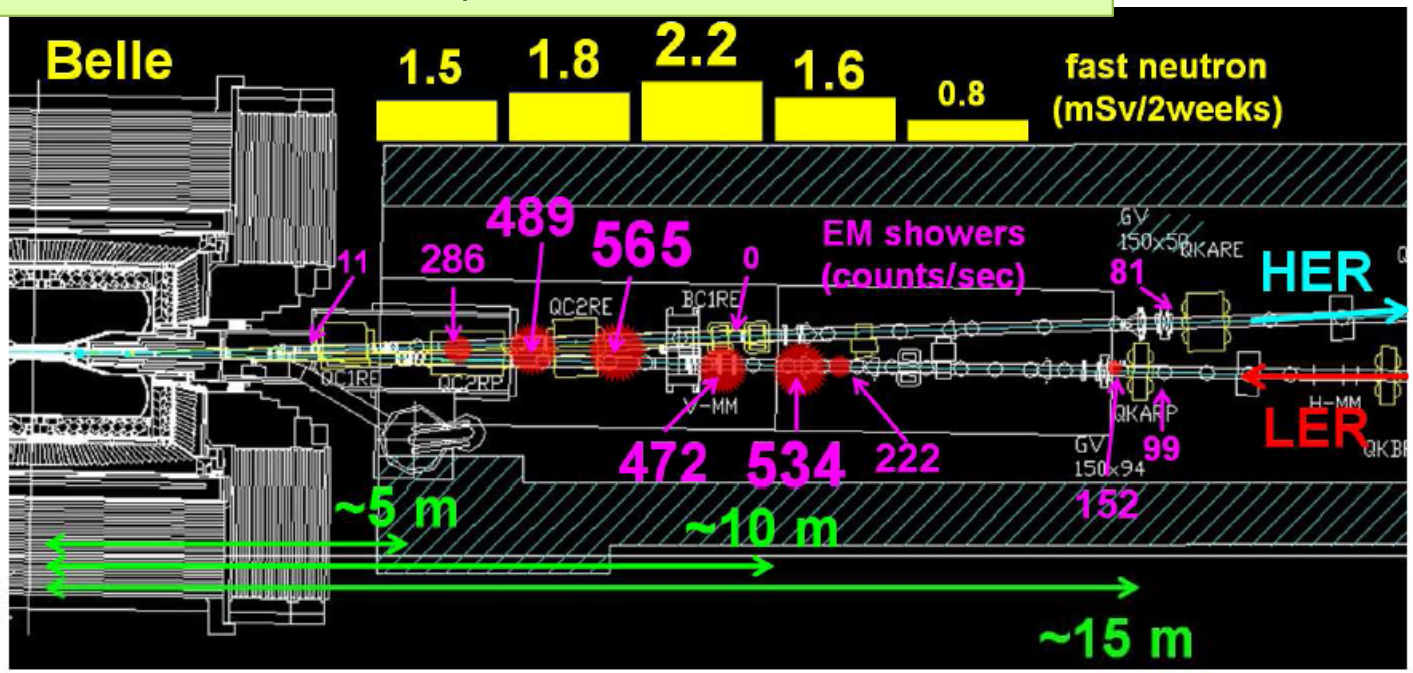


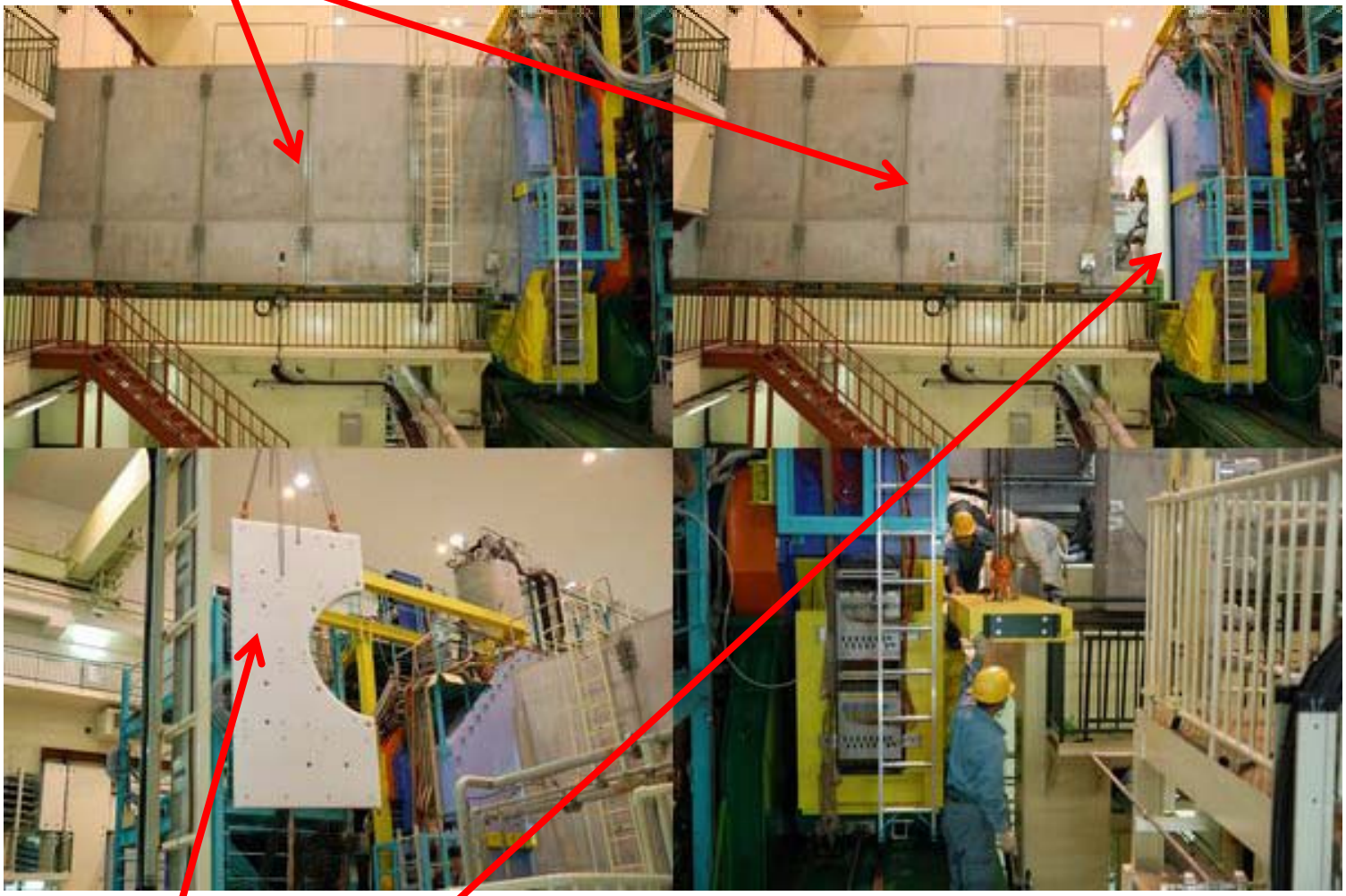
FIG. 1: Measured radiation levels around the beam lines in the HER downstream of the Belle detector. Neutron dose rates were measured outside of the concrete shield in 2003. The electromagnetic (EM) shower rates were measured with a scintillation counter in the same year. The position resolution of a movable EM shower counter is a 150 mm diameter circle along the beam lines; the counter is surrounded by a 200 mm thick lead shield and has a window diameter of 20 mm.

1Gy=1J/kg

1Sv=1Gv x 5x0.1

Neutron shield @ KEKB

Concrete wall



Polyethylene shield