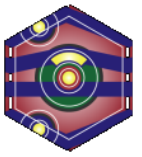



Synchrotron Radiation Background

Status

Yuri Soloviev DESY

Outline

1. SR Background from beam halo for LER – 2D magnetic field
   Lattice version – sler_1427.

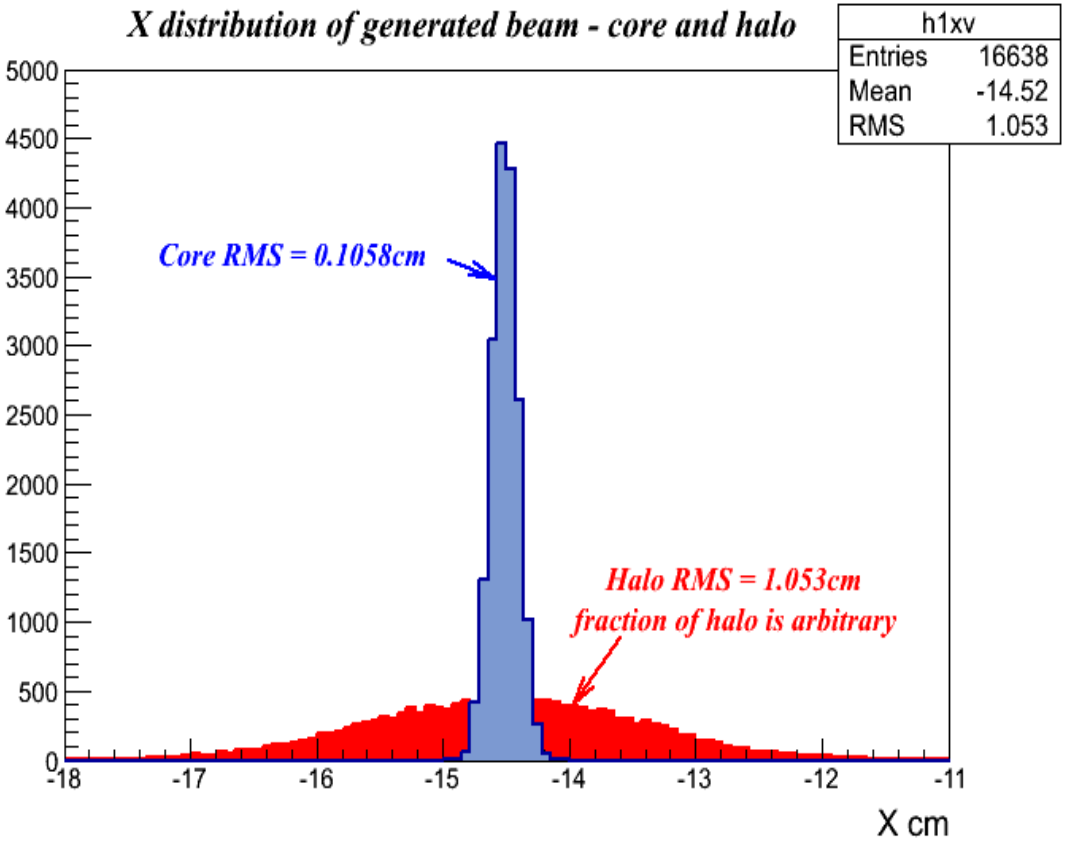
2. SR Background for LER with 3D magnetic field.
   Lattice version - sler_1682

SR background from beam halo 2D magnetic field
Lattice version - sler_1427

Assumptions:

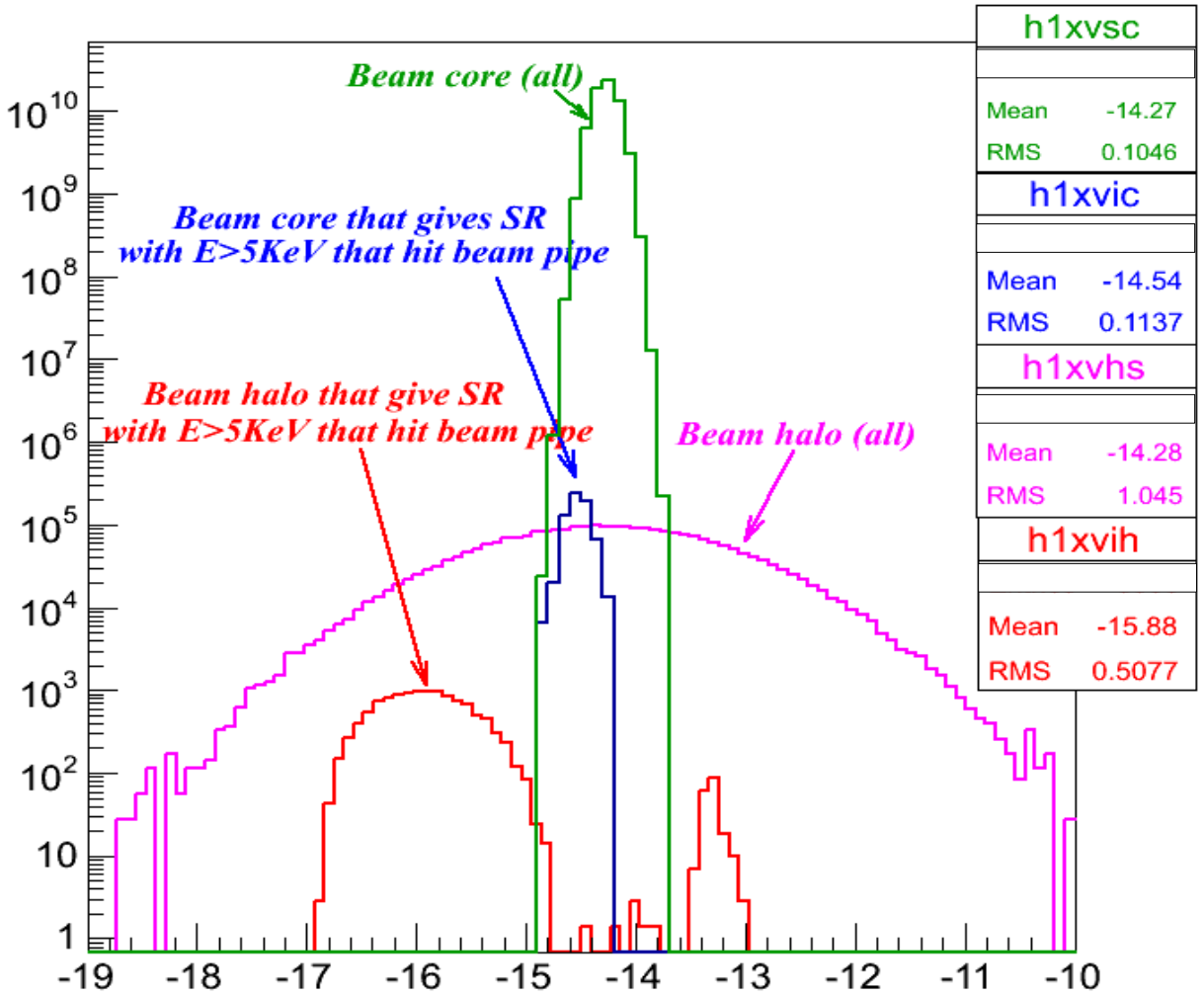
➔Beam halo is gaussian with sigma much larger than core – 10 sigma of the core.

➔Beam particles in the halo have emittance much larger than in the core and for 10 sigma
• it will make emittance of halo factor 100 larger.



What's fraction of Halo ?
From KEKB TDR : *... if the fractional particle population beyond 10σx and 30σy is kept below **e-5**, the SR background should have no significant harmful effects.. .Simulations of bunch tail development indicate that this condition will be met.*
This estimation is more conservative for gaussian shape of beam halo compare to one taking into account beam life time (10mins), that gives fraction of the halo beyond 10σx as **~e-8**.

Normalized X distribution of beam core/halo in front of QC2 (2D Field)



The fraction of the halo is taken assuming that the population of the fraction of the tails beyond $10\sigma_x$ *is equal to* 10^{-5}

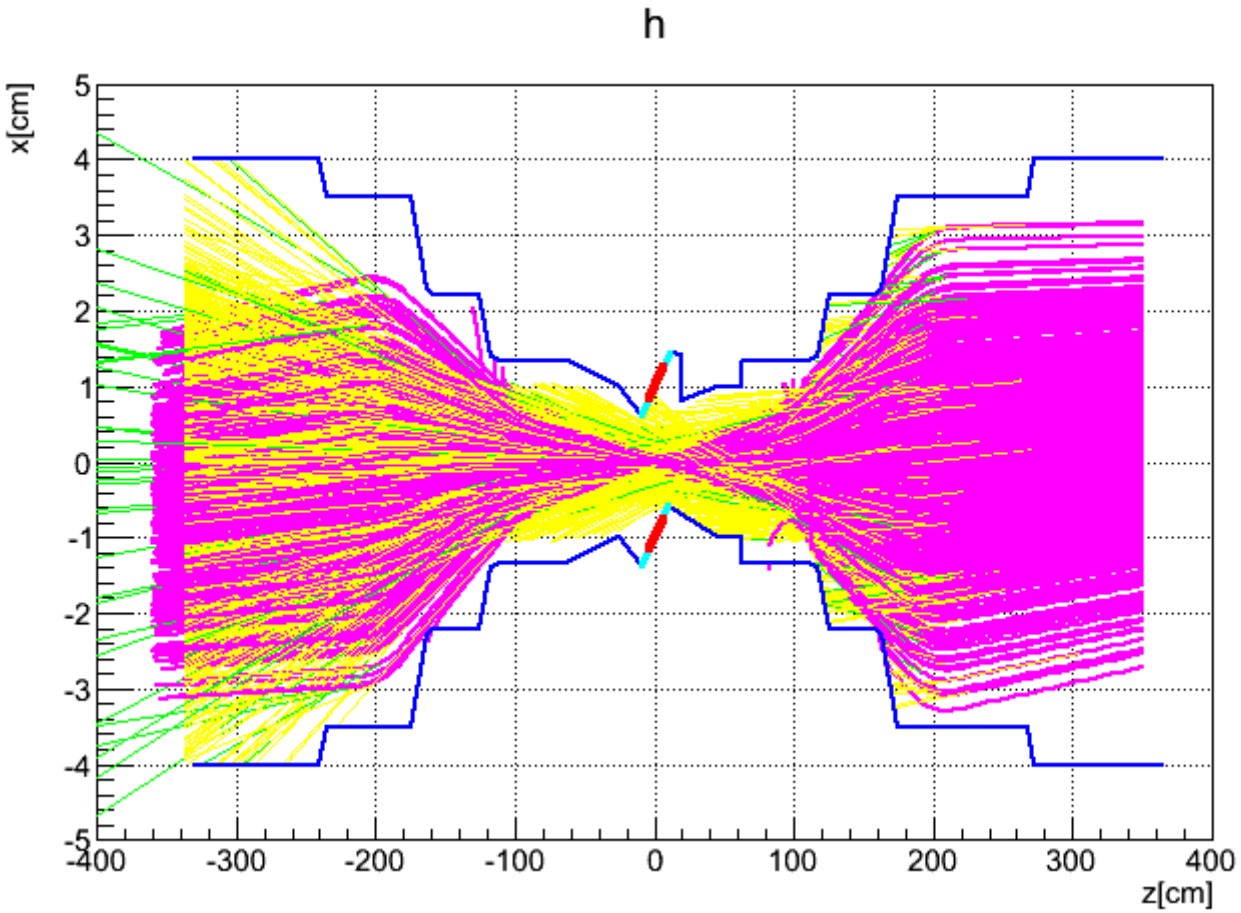
$$\frac{N_{core(hits)}}{N_{core(all)}} \approx 10^{-5}$$

$$\frac{N_{halo(hits)}}{N_{halo(all)}} \approx 4 * 10^{-3}$$

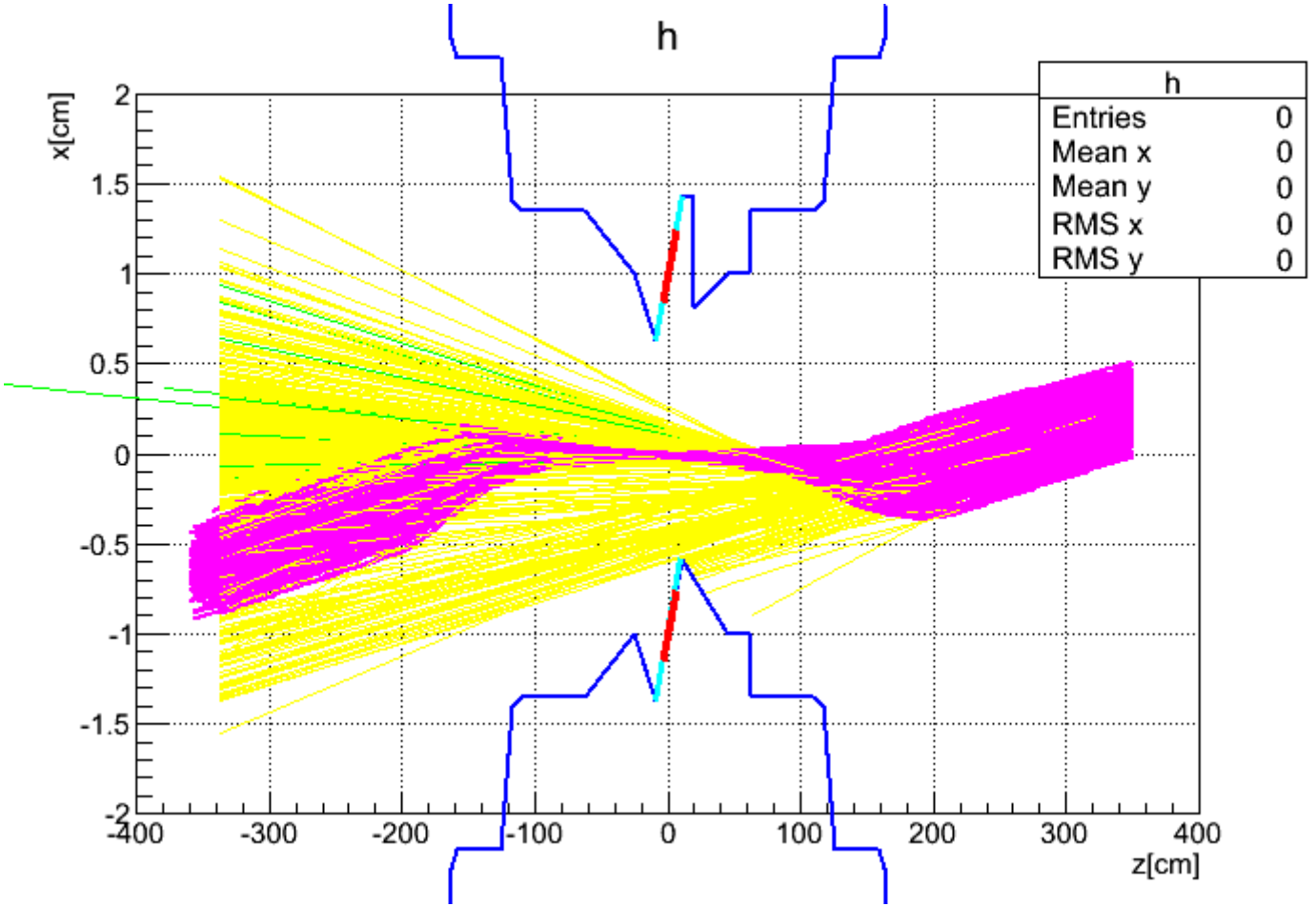
$$N_{core(all)} = 9 * 10^{10}$$

2 dimensional distributions (x,x') (y,y') can give more information → to be done

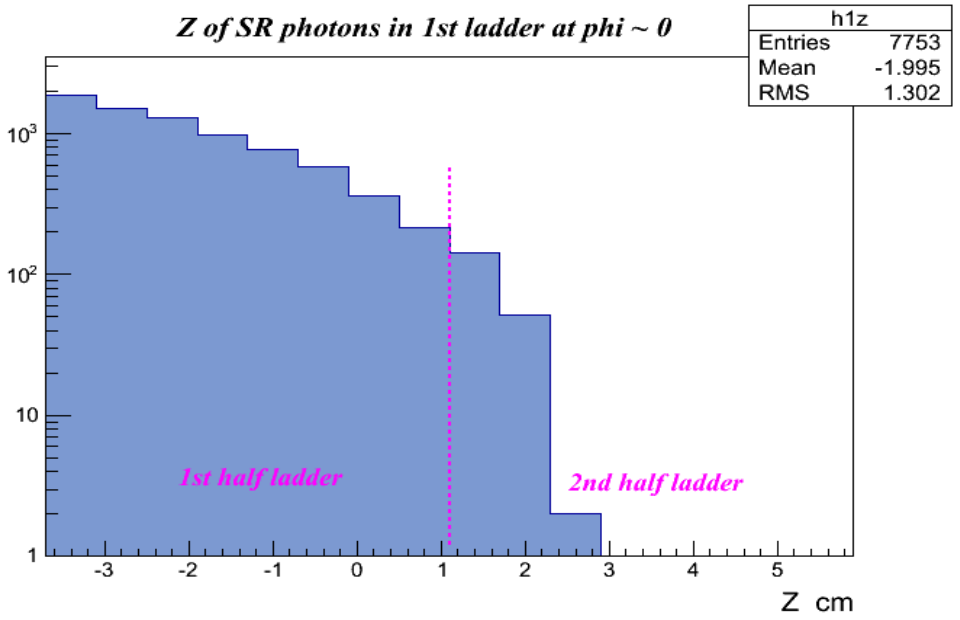
Beam Halo 10σx

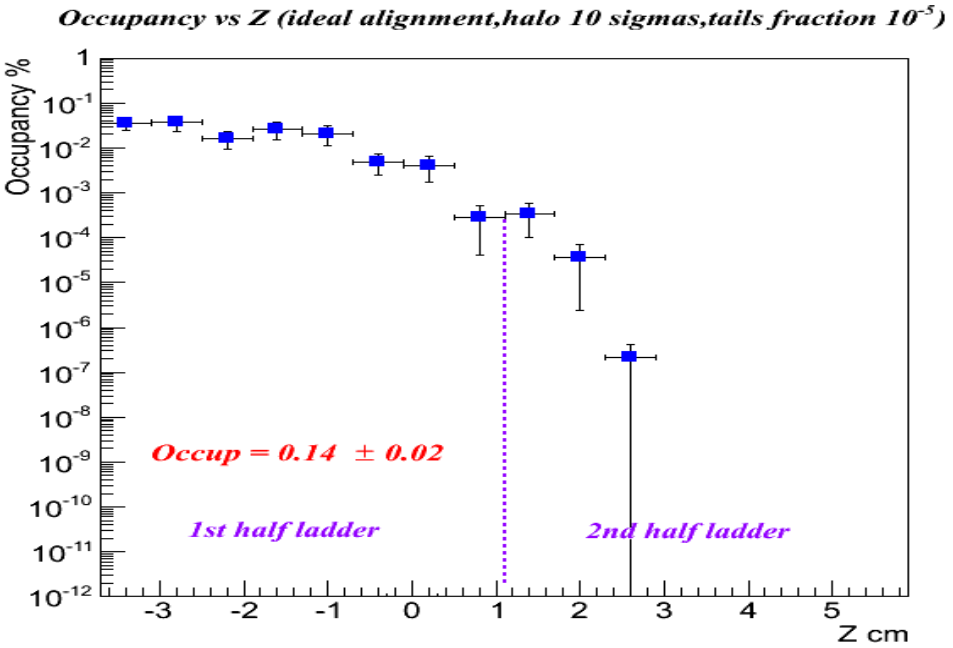


Beam core


h
h
Entries 0
Mean x 0
Mean y 0
RMS x 0
RMS y 0
x[cm]
z[cm]
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-400
-300
-200
-100
0
100
200
300
400

SR background from beam halo – ideal alignment





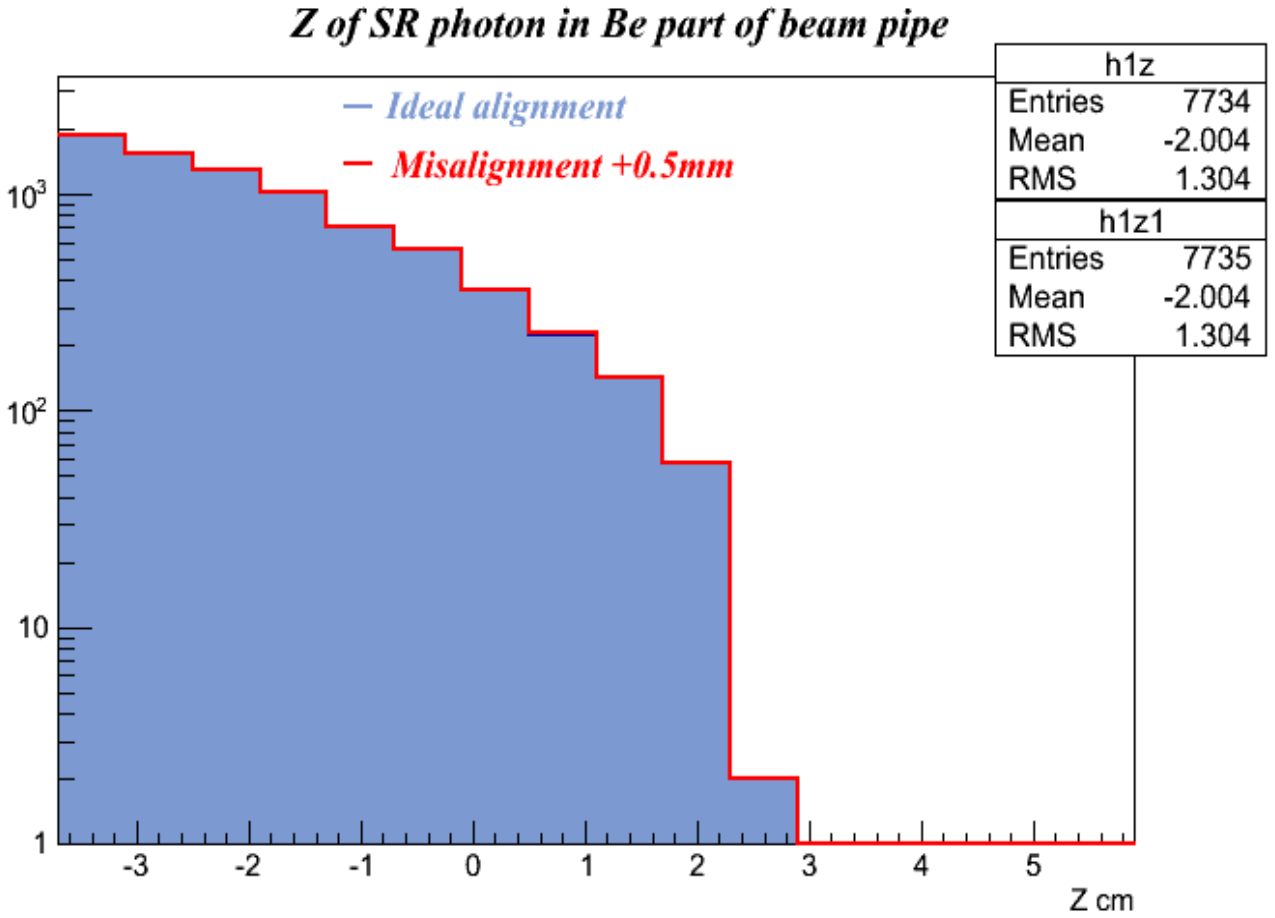
The occupancy estimation was done only for the 1st ladder at phi ~0 due to the shape of phi distribution for SR photons.
If population of the tails beyond 10σx is **e-5** , the occupancy of 1st half ladder (maximum occupancy) estimated as

(0.14 ± 0.02)%

which is negligible compare to the expected values from the beam core.

Horizontal misalignment +0.5mm

Due to the large width (10sigmas = 10.05mm) one wouldn't expect significant increasing of background from halo due to misalignment +0.5mm. Nevertheless the check was done and confirmed the assumption.



The number of hits in Be part of beam pipe is almost the same both for ideal alignment and misalignment.

Conclusions

1. For the largest possible aperture of LER of 5.827mm radius, using the energy/theta dependence of stopping power the estimation of the contribution to the occupancy for PXD (the ladder at phi = 0) from gaussian beam halo with the sigma = 10 sigmas of the beam core (~10mm) is estimated as

$$(0.14 \pm 0.02)\%$$

under assumption that the fractional population of particles beyond 10σx will be lower than **1*e-5.**

Misalignment +0.5mm doesn't give significant increase of SR background from beam halo.

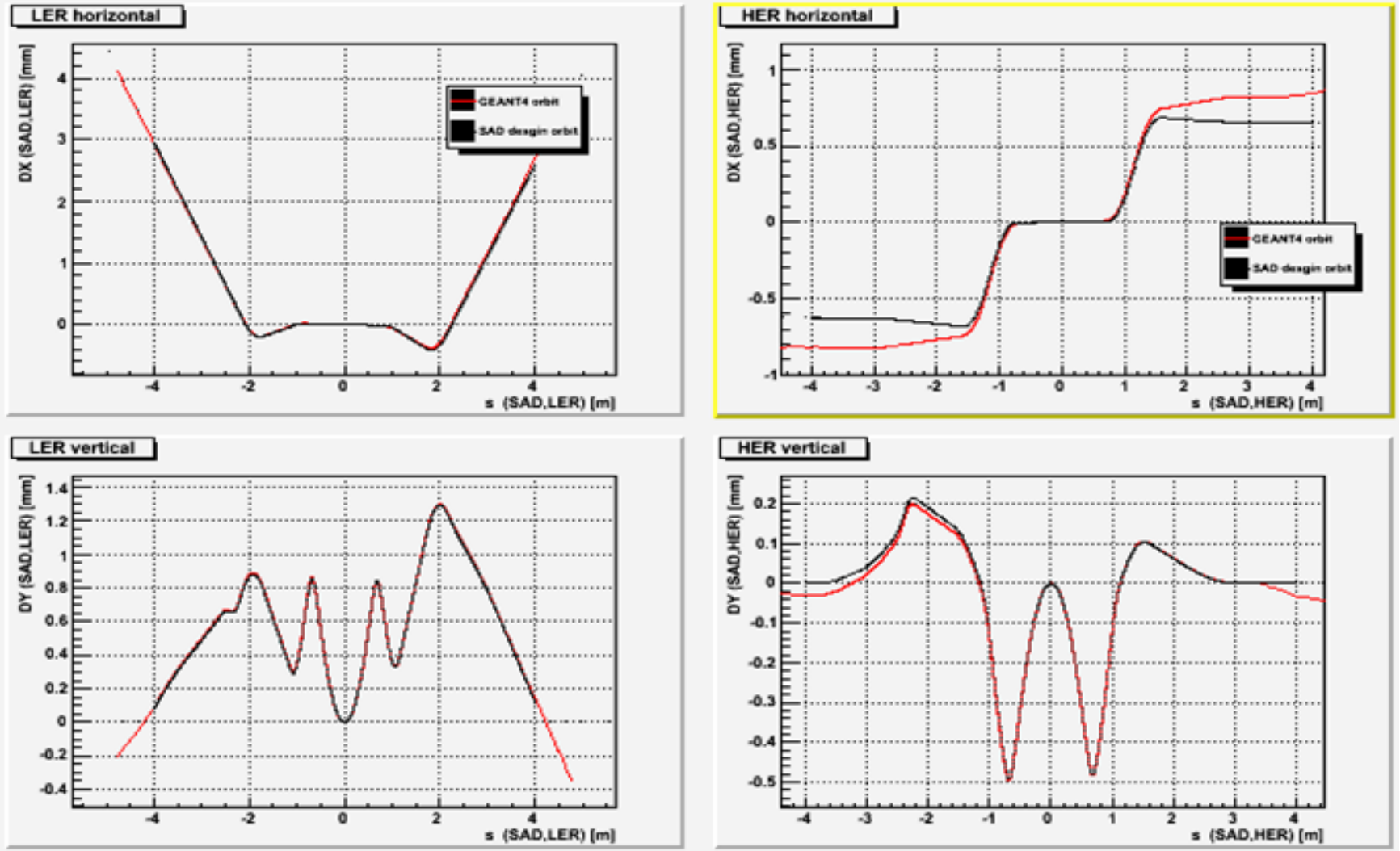
If the fraction of the tails beyond 10σx will be kept lower than **1*e-5,** contribution of SR background should not have significant effect.

SR Background with 3D magnetic field.
Lattice version - sler_1682

What is the difference in the orbit with 2D and 3D magnetic field mapping ?

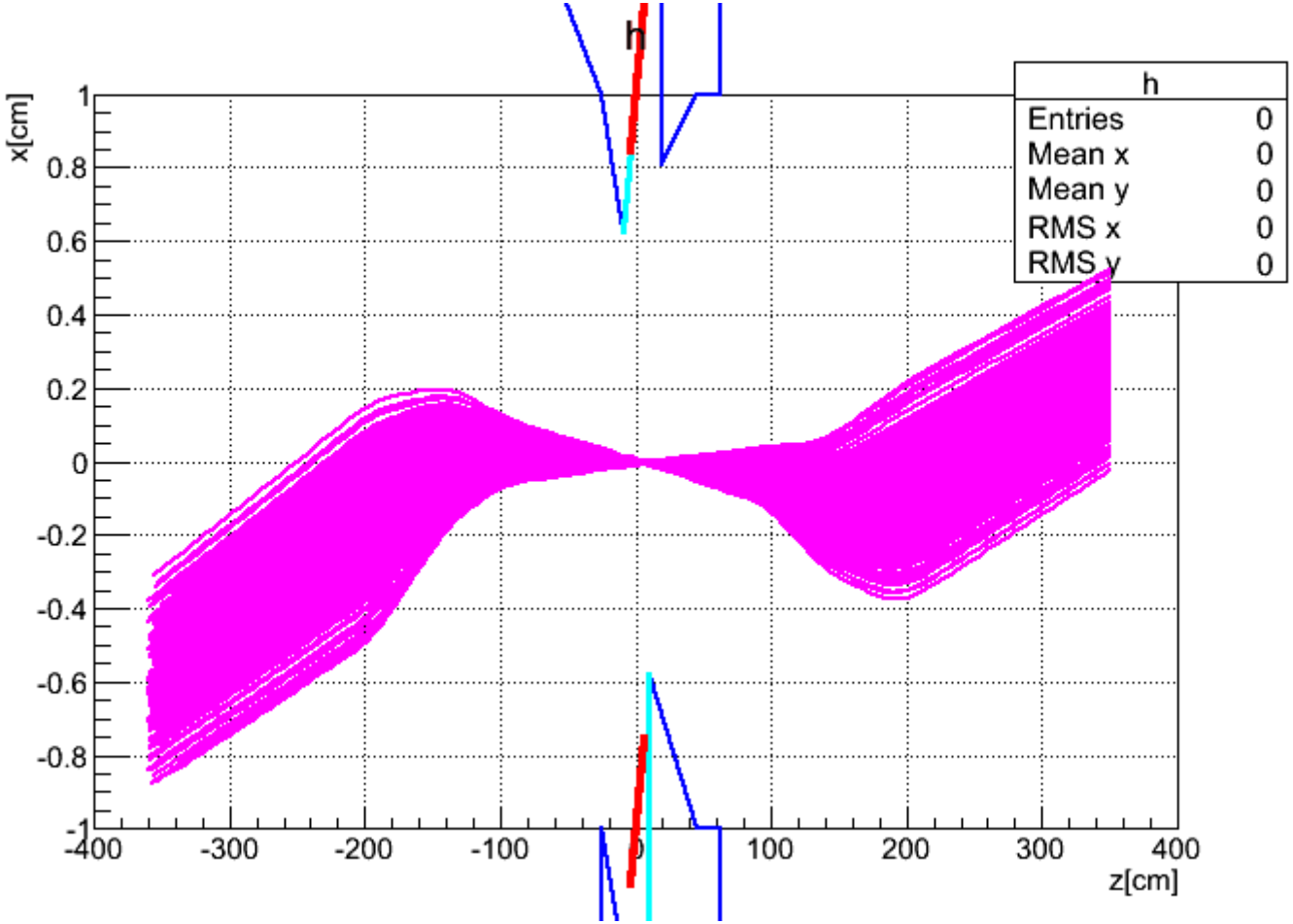
All tuning of the orbit in Geant was done by Nakayama-san

Geant versus SAD looks perfect for LER.



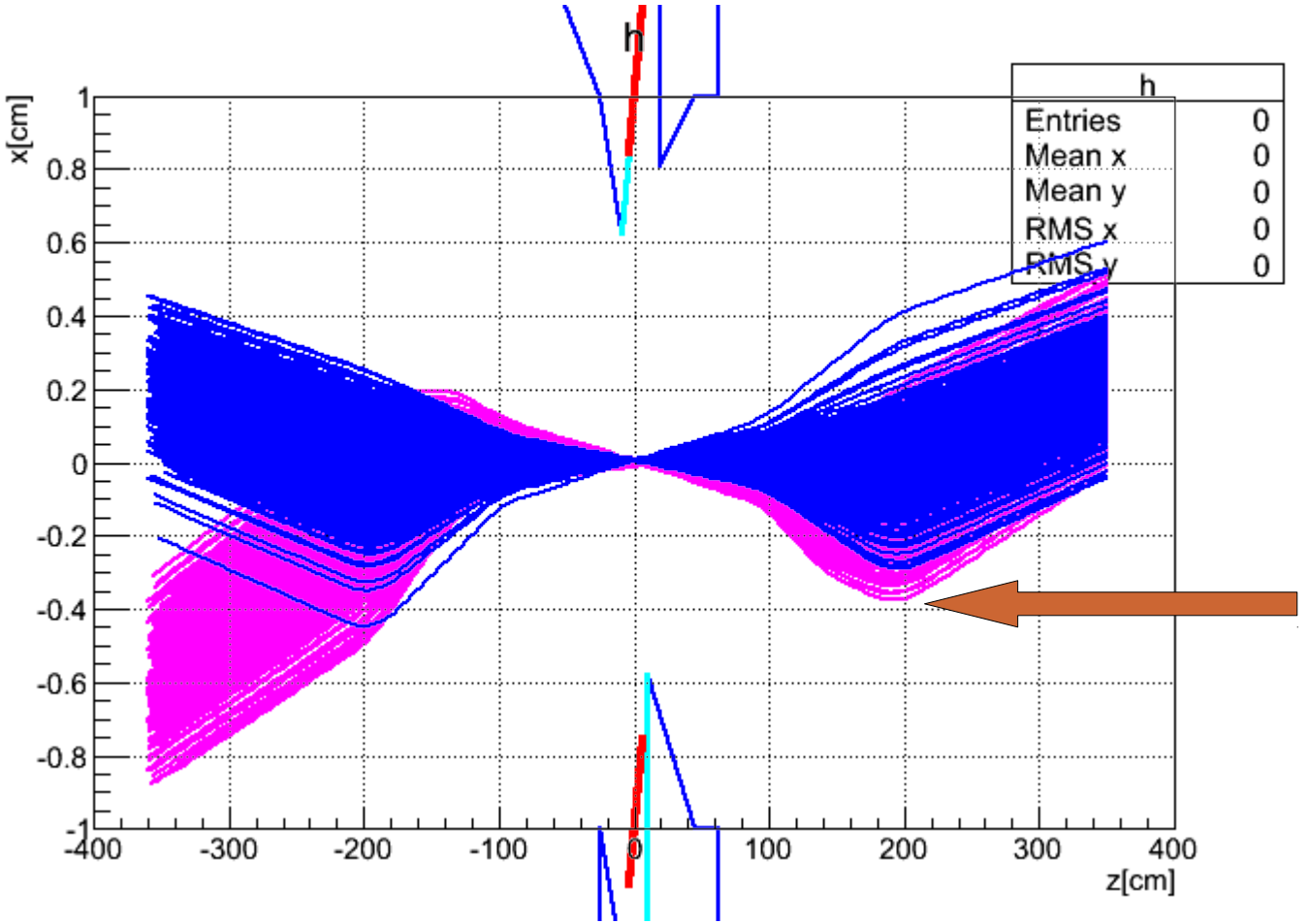
What is the difference in the orbit with 2D and 3D magnetic field mapping ?

2D magnetic Field



What is the difference in the orbit with 2D and 3D magnetic field mapping ?

2D magnetic Field



QC2RP

3D magnetic Field

CPU time consuming issues

After implementing release with 3D field mapping it was found that it consumes factor ~7 more CPU time (~10ms/event for 2D mapping and ~70ms/event for 3D).

After replacing the QUAD part of data of 2D mapping to 3D one and leaving the beam line mapping as of 2Dmapping the difference in speed went down to factor ~2.3 (23ms/event) and the difference in orbit is negligible.

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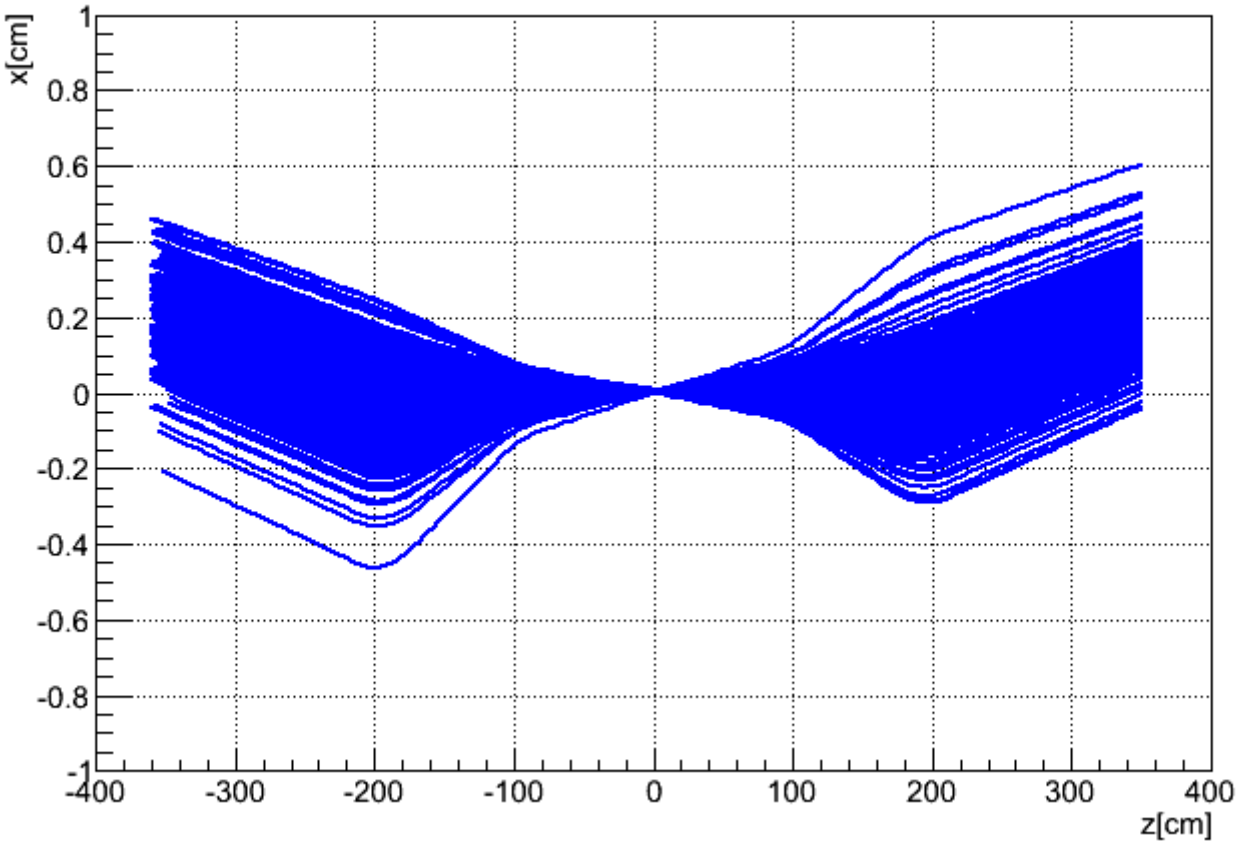
3D Field mapping original



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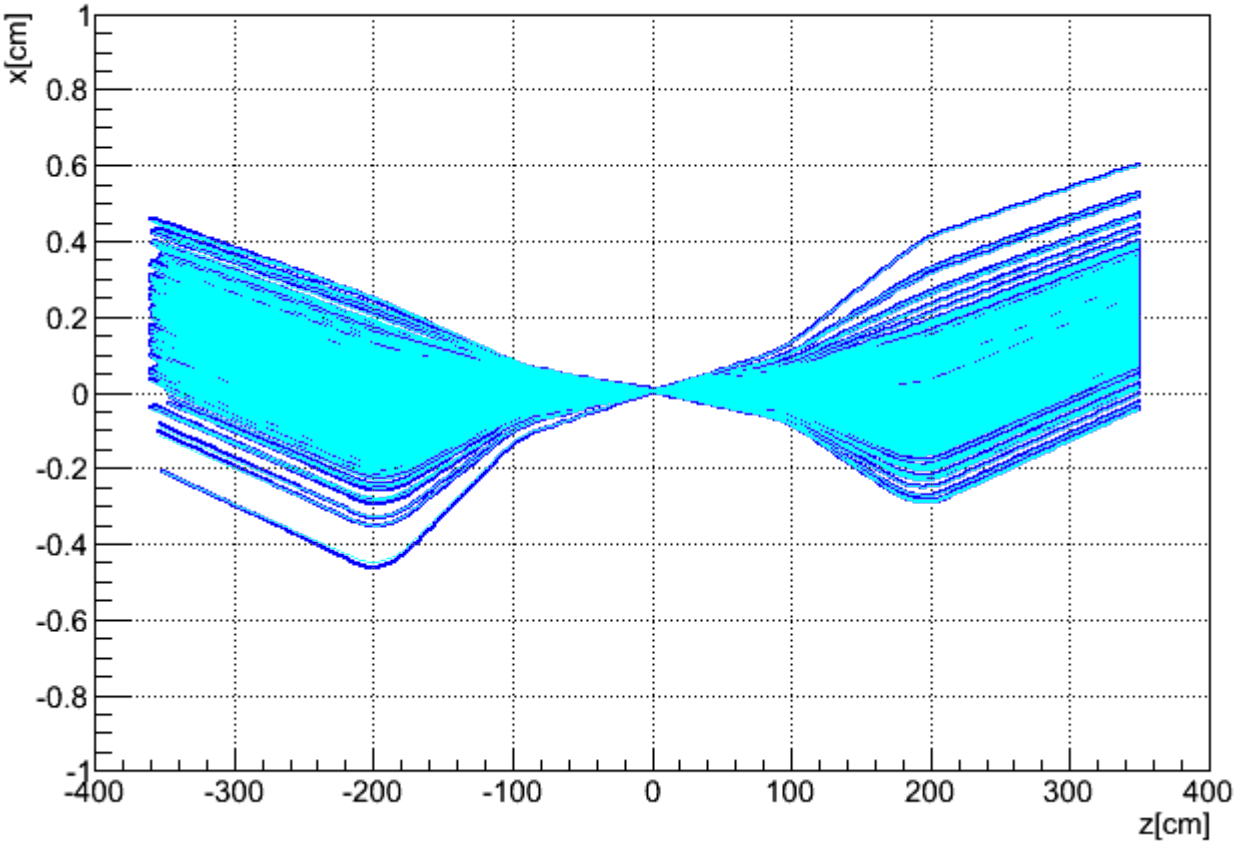


2D mapping with QUAD mapping from 3D

Such a CPU consumption considered as acceptable (taking into account that the number of CPU on DESY GRID cluster increased by factor ~3 :-)). It was decided not to spend time now to find the reason of increased CPU and start simulation for 3D mapping.

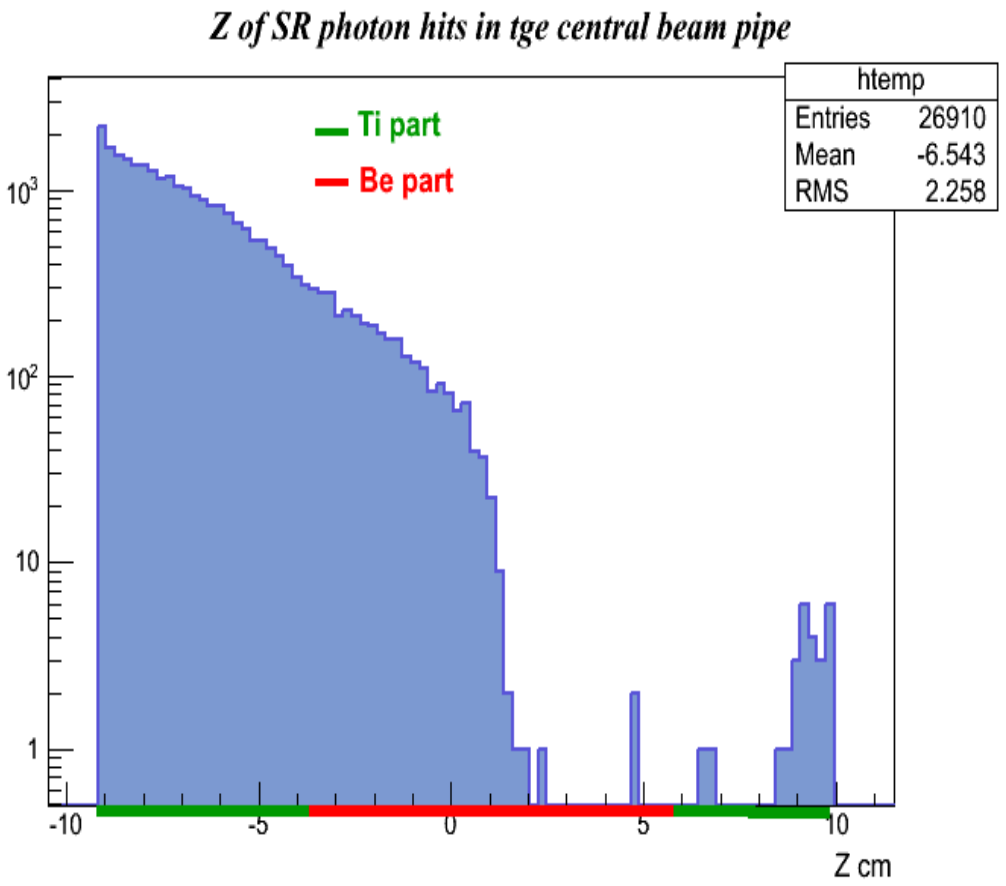
Data and results

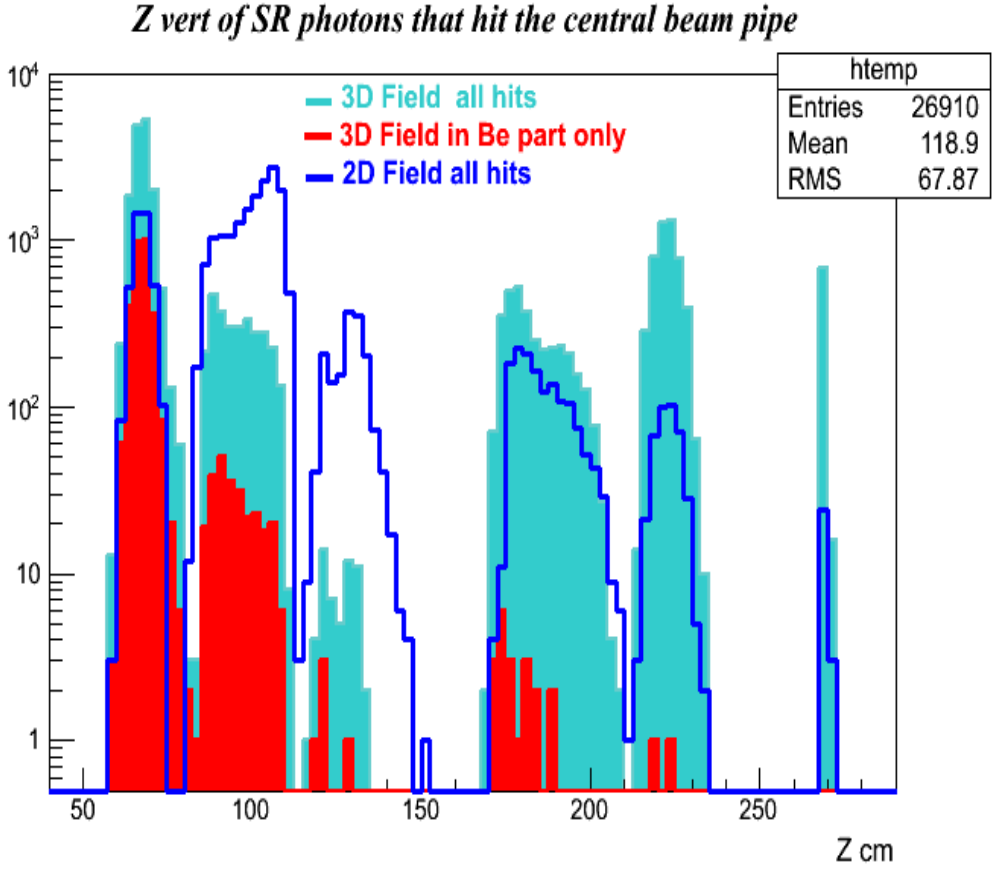
The data sample contains 9e+9 initial positrons generated that makes ~ 10% of LER bunch charge,ideal orbit alignment assumed, E > 5KeV.LER with 5.82mm aperture.

New beam pipe geometry (Kanazawa-san) not implemented yet.

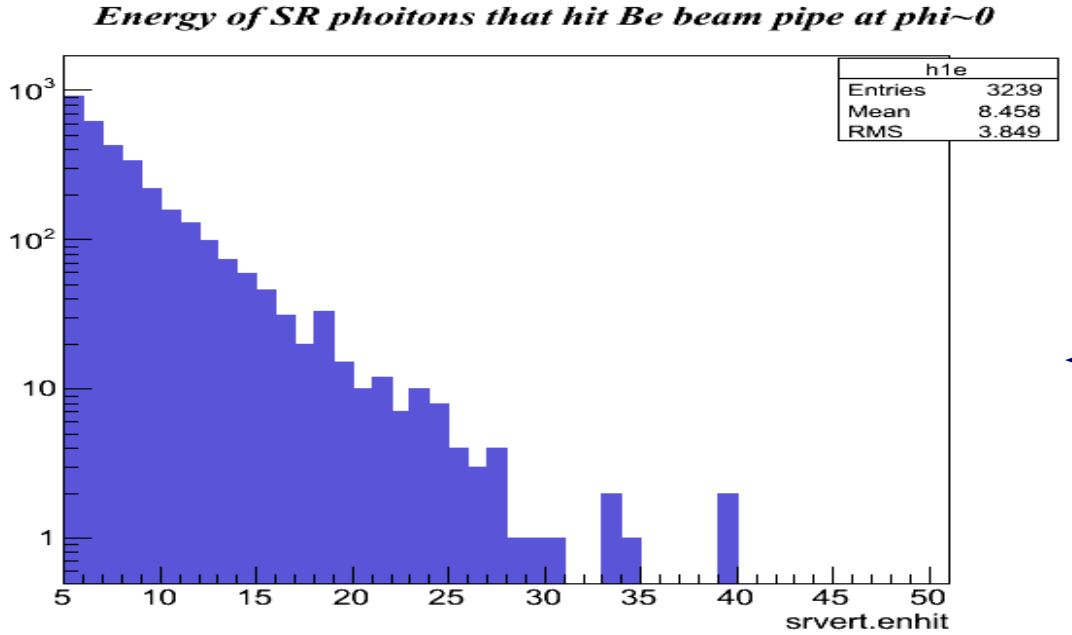
Estimation of PXD occupancy :

Evaluate the penetration rate of SR photons using dependence of stopping power on energy and theta (thickness of material)..

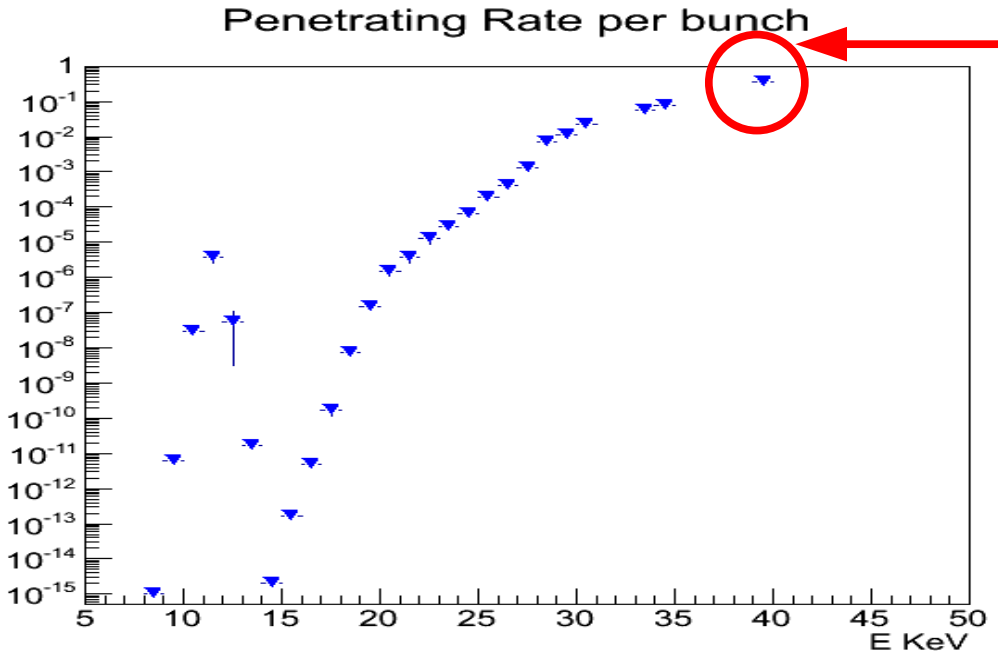




Energy Spectrum of Synchrotron Radiation photons – LER (3D)



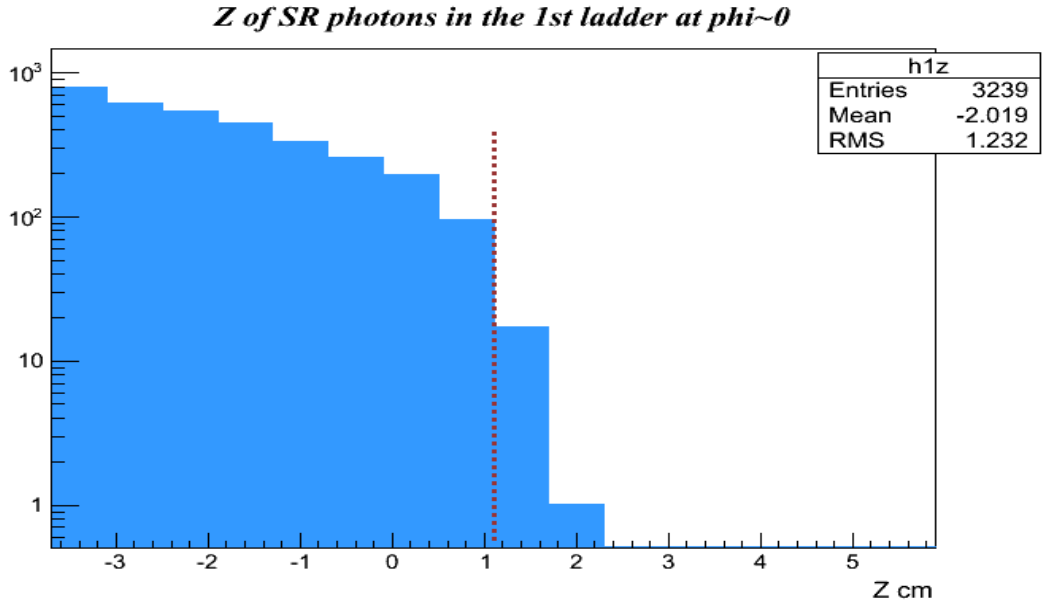
Energy spectrum of SR photons that hit Be part of beam pipe at Φ ~ 0 i.e. one ladder (98% of all hits). Number of hits corresponds to about 10% of bunch charge of LER.

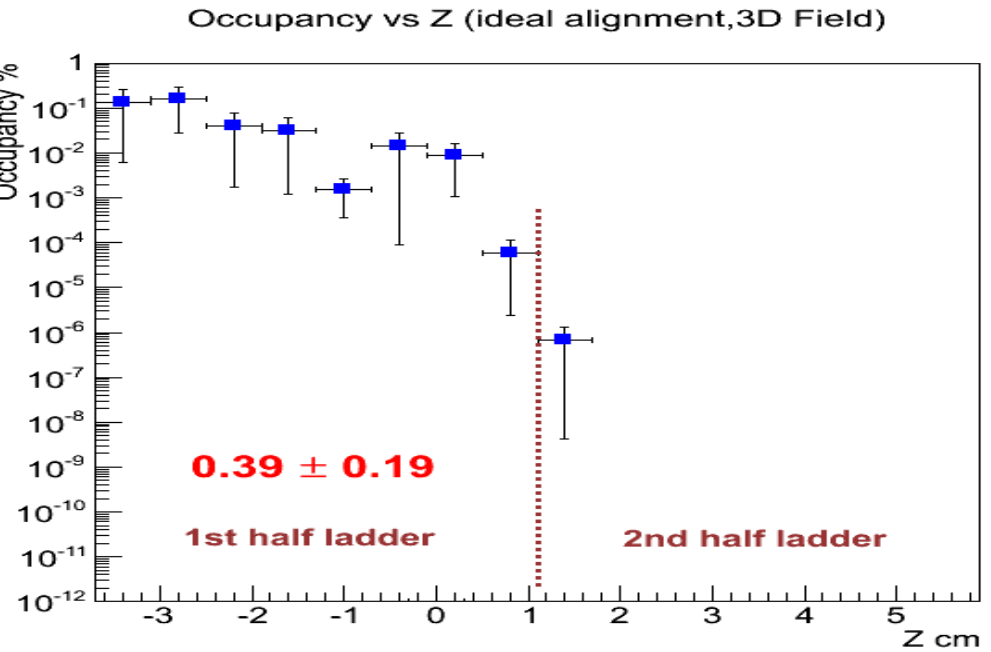


2 outliers give largest contribution

Energy spectrum weighted with probability to pass through 10μ of gold and 1mm of Be (folded with theta) - hits per bunch.

Occupancy estimation





Occupancy for:

1st half ladder with 3D Field

(0.4 ± 0.2)%

in comparison with 2D Field

(0.6 ± 0.15)%

2nd half ladder

< e-6

(0.05 ± 0.05)% for 2D Field

Preliminary conclusions and next steps

The latest Lattice version sler_1682 gives less fraction of SynRad photon hits in the central beam pipe and lower occupancy in PXD. Needs more statistics to get better estimation of occupancy in PXD.

1. Produce 2D distributions of (x.x') , (y,y') to obtain cuts on initial phase space of the beam for possible speedup of simulation.

2.Estimate misalignment effect for 3D magnetic field mapping.

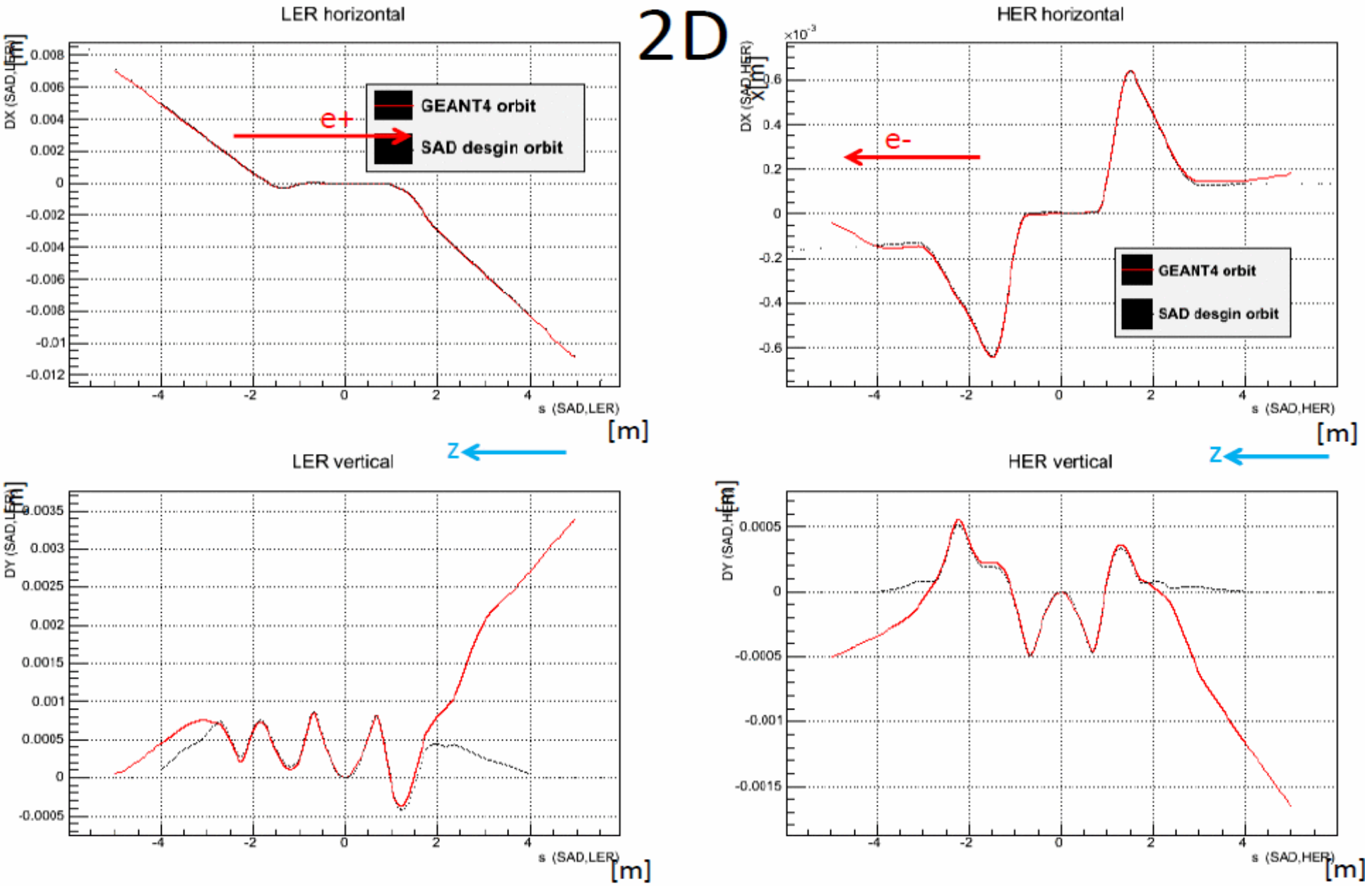
3. Vertical plane – non gaussian shape → to check.

4. SynRad for HER 3D Field – ideal alignment and misalignment. (SR background expected to be lower than for 2D Field.

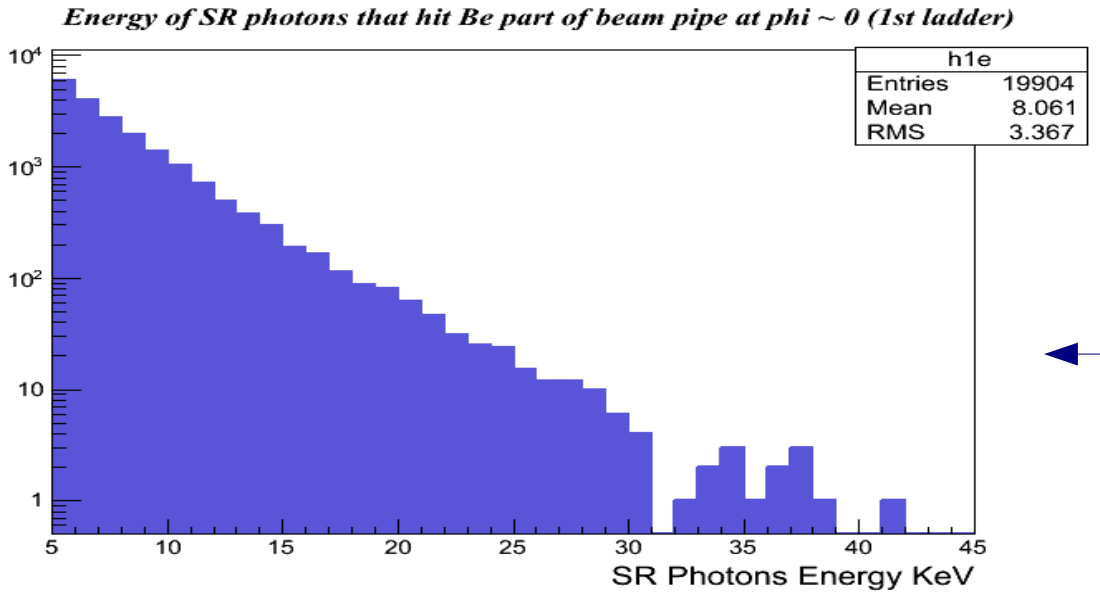
5. ….

…..

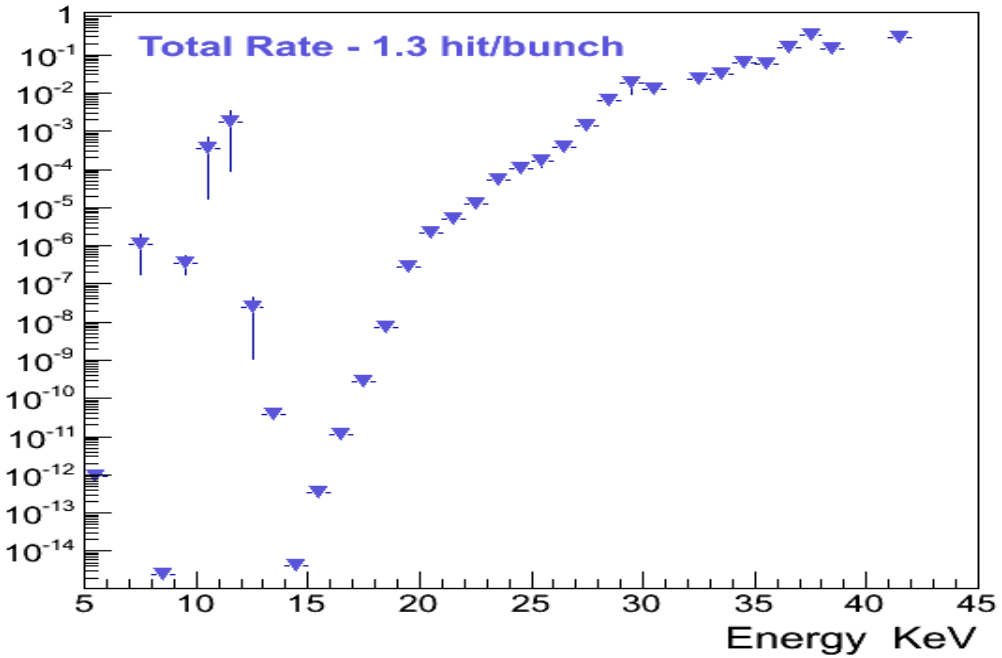
Backup


2D
LER horizontal
DX (SAD,LER) [m]
s (SAD,LER) [m]
e+
GEANT4 orbit
SAD desgin orbit
HER horizontal
DX (SAD,HER) [m]
s (SAD,HER) [m]
e-
GEANT4 orbit
SAD desgin orbit
z
LER vertical
DY (SAD,LER) [m]
s (SAD,LER) [m]
z
HER vertical
DY (SAD,HER) [m]
s (SAD,HER) [m]

Energy Spectrum of Synchrotron Radiation photons – LER (2D)

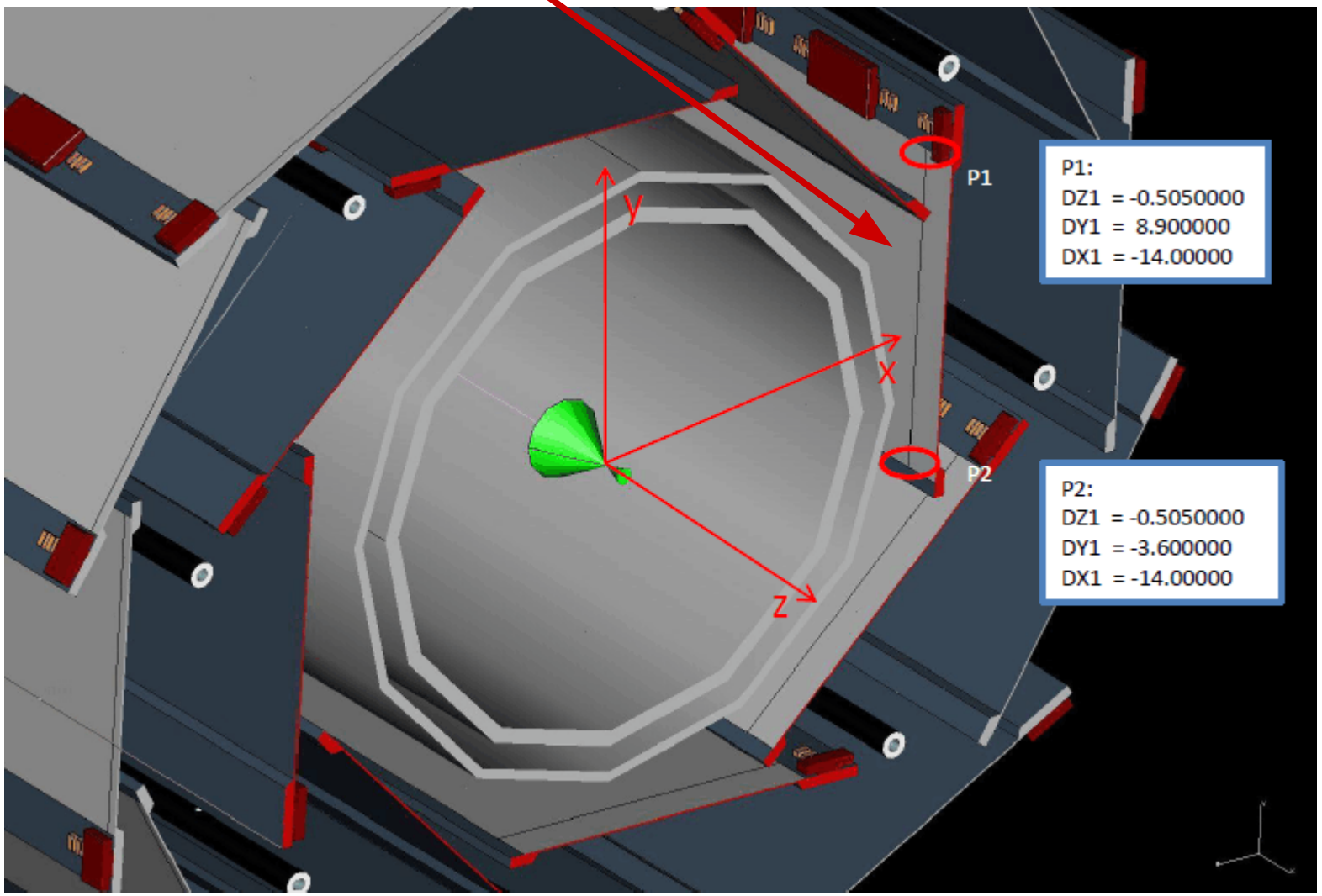


Energy spectrum of SR photons that hit Be part of beam pipe at Φ ~ 0 i.e. one ladder (98% of all hits). Number of hits corresponds to about 20% of bunch charge of LER.

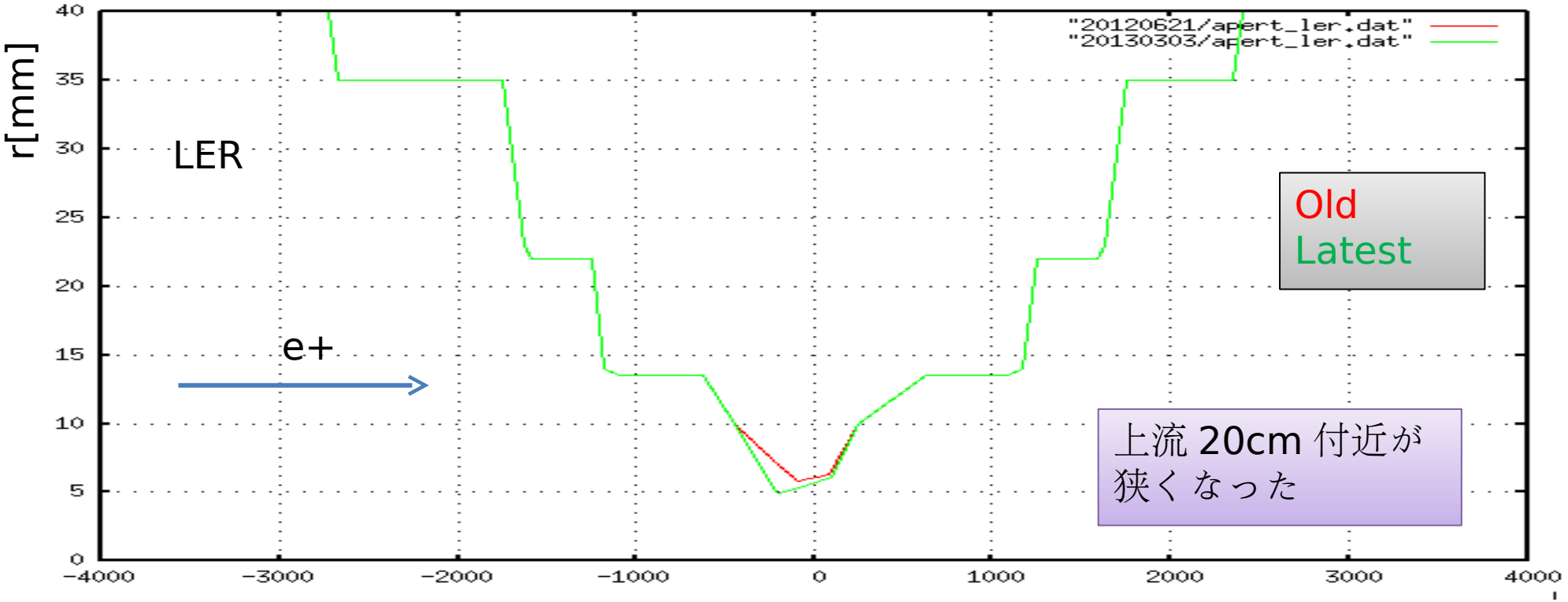


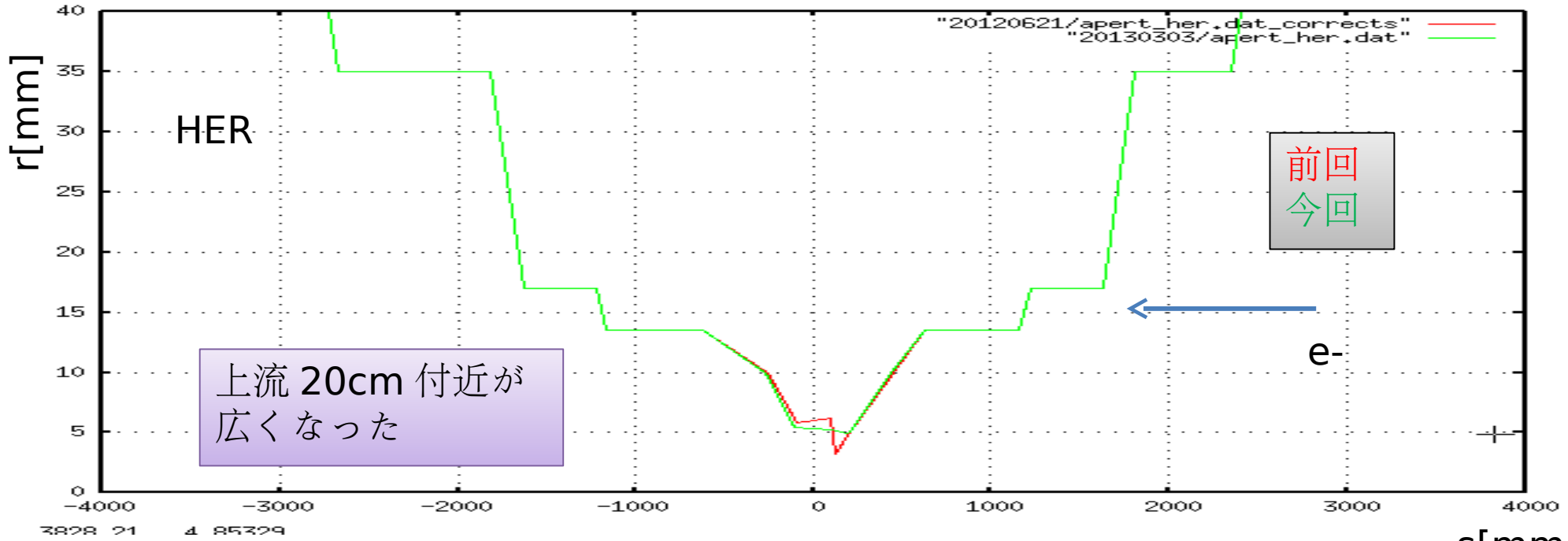
Energy spectrum weighted with probability to pass through 10μ of gold and 1mm of Be (hits per bunch).

Ladder with highest occupancy



Courtesy of K.Gadow


r[mm]
LER
e+
"20120621/apert_ler.dat"
"20130303/apert_ler.dat"
Old
Latest
上流 20cm 付近が
狭くなった


r[mm]
HER
"20120621/apert_her.dat_corrects"
"20130303/apert_her.dat"
前回
今回
e-
上流 20cm 付近が
広くなった
s[mm]

Resume for Ideal alignment

1. Using the energy/theta dependence of stopping power the estimation of the maximal occupancy for PXD (the 1st half ladder at phi = 0) is obtained as

   (0.6 ± 0.15)%

   for the largest possible aperture of LER of 5.827mm radius.

   The occupancy in the other ladders can be neglected.

2. Available data shows that the SR radiation background from HER is distributed roughly uniform over all PXD ladders (mostly scattered photons).

   → The estimation of PXD1 occupancy from HER for all ladders

   (0.5 ± 0.3)%.

   Therefore the highest occupancy is expected in one half ladder near phi ~0 :

   (1.1 ± 0.3)% (Only SynRad)

3. Adding the value of occupancy for ladder at Phi~0 (PXD1) from other sources (see next slide) gives the total occupancy of **2%** for the 1st half ladder and **1.5%** for the 2nd half ladder. 2% - relatively already high value.

   The occupancy in all other ladders - 0.5%(mainly HER) + 0.9% = **1.4%.**