Synchrotron Radiation Background Simulation

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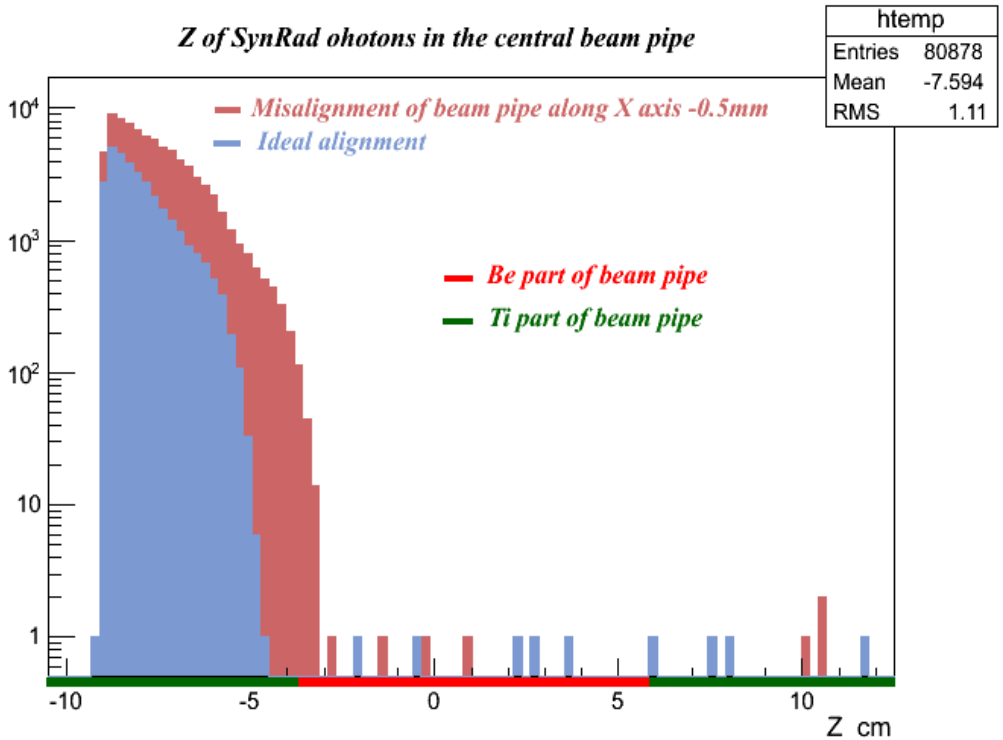
DESY

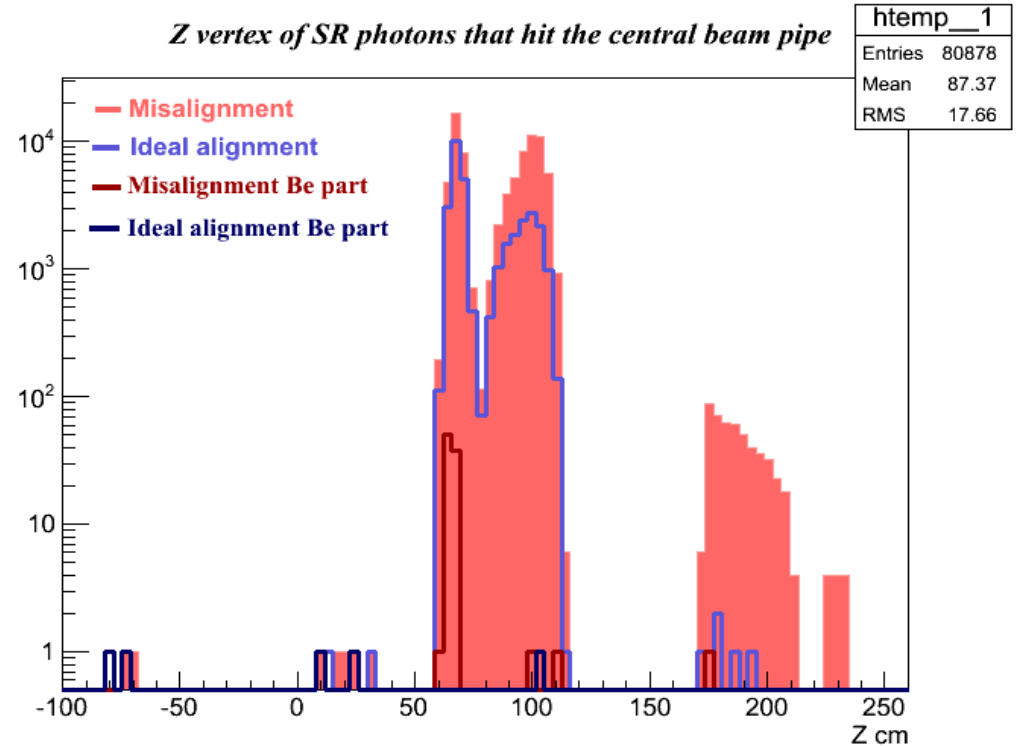
Misalignment

Beam Halo

Misalignment - LER

The displacement of the beam pipe on -0.5mm along X axis is considered as misalignment.
The data sample contains ~3.5e+10 initial positrons generated that makes ~39% of LER bunch charge, cut on SR photon energy E > 5KeV. Lattice version – sler_1682. Latest IR geometry version.





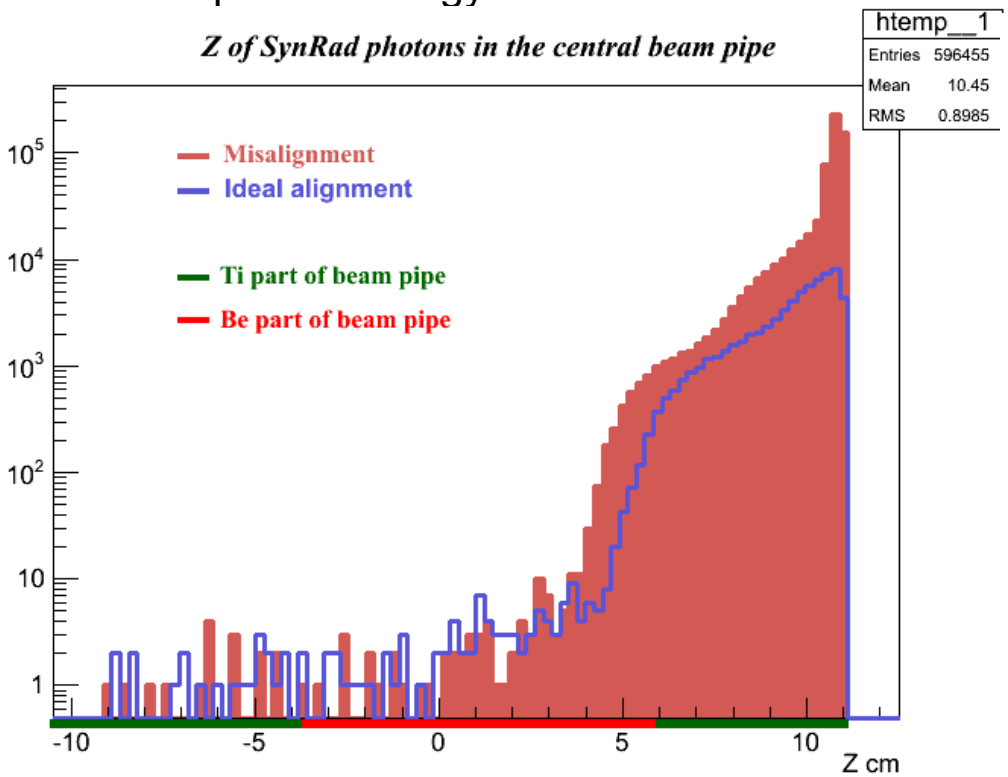
Number of hits per bunch crossing:

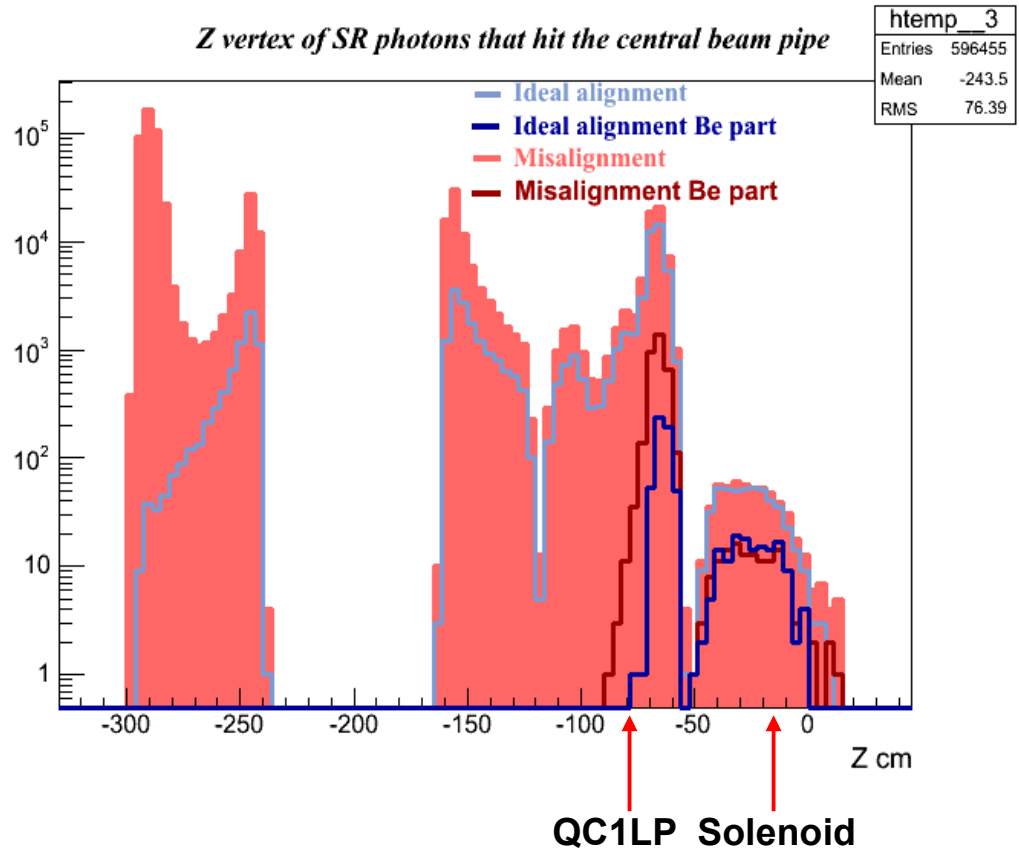
	Misalignment	Ideal alignment
Be part	250 ± 25	15 ± 6
Ti part	2.1e+5 ± 700	8.3e+4 ± 500

Extrapolating hit rates in Be part yields in occupancy for PXD1 from LER in case of misalignment : **~2e-3%** , occupancy for ideal alignment is **~1e-4%**.

Misalignment - HER

The displacement of the beam pipe on -0.5mm along X axis is considered as misalignment.
The data sample contains ~3.11e+10 initial positrons generated that makes ~48% of HER bunch charge, cut on SR photon energy E > 5KeV. Lattice version – sher_5753. Latest IR geometry version.





Number of hits per bunch crossing:

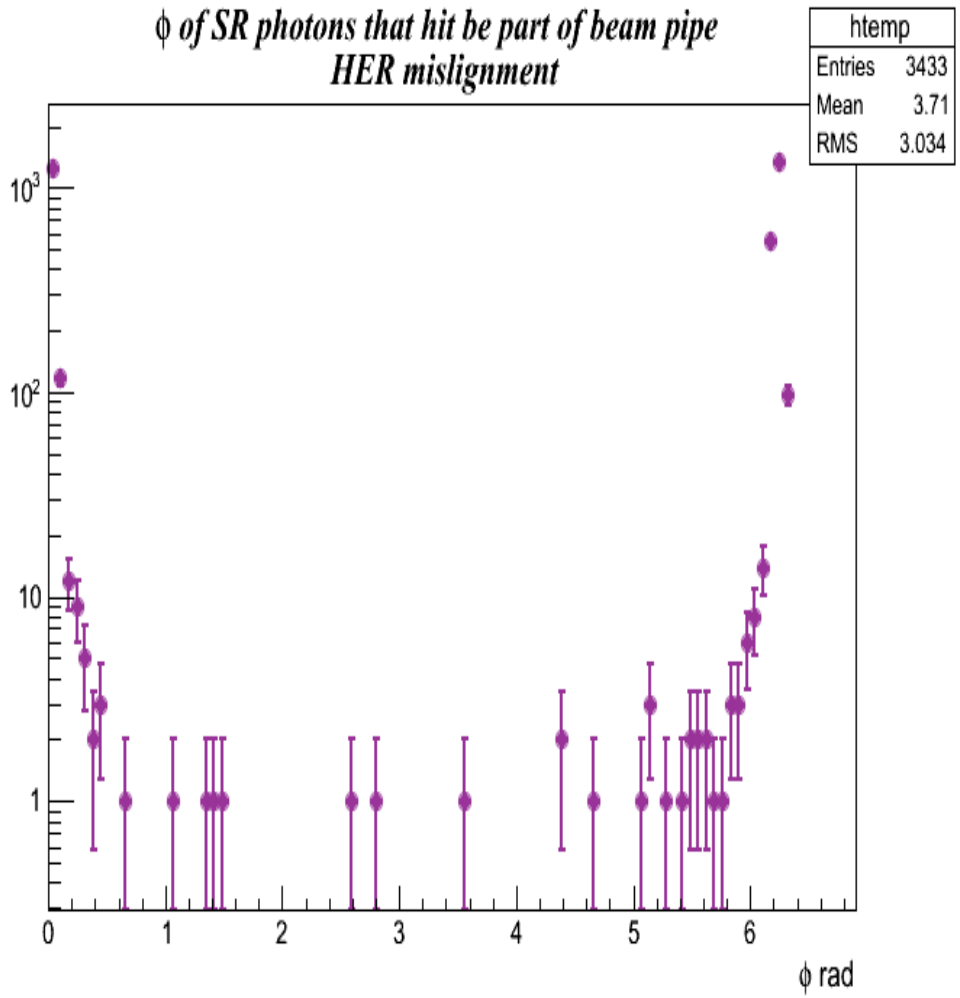
	Misalignment	Ideal alignment
Be part	7.2e+3 ± 200	1.4e+3 ± 100
Ti part	1.2e+6 ± 1.6e+3	1.3e+5 ± 600

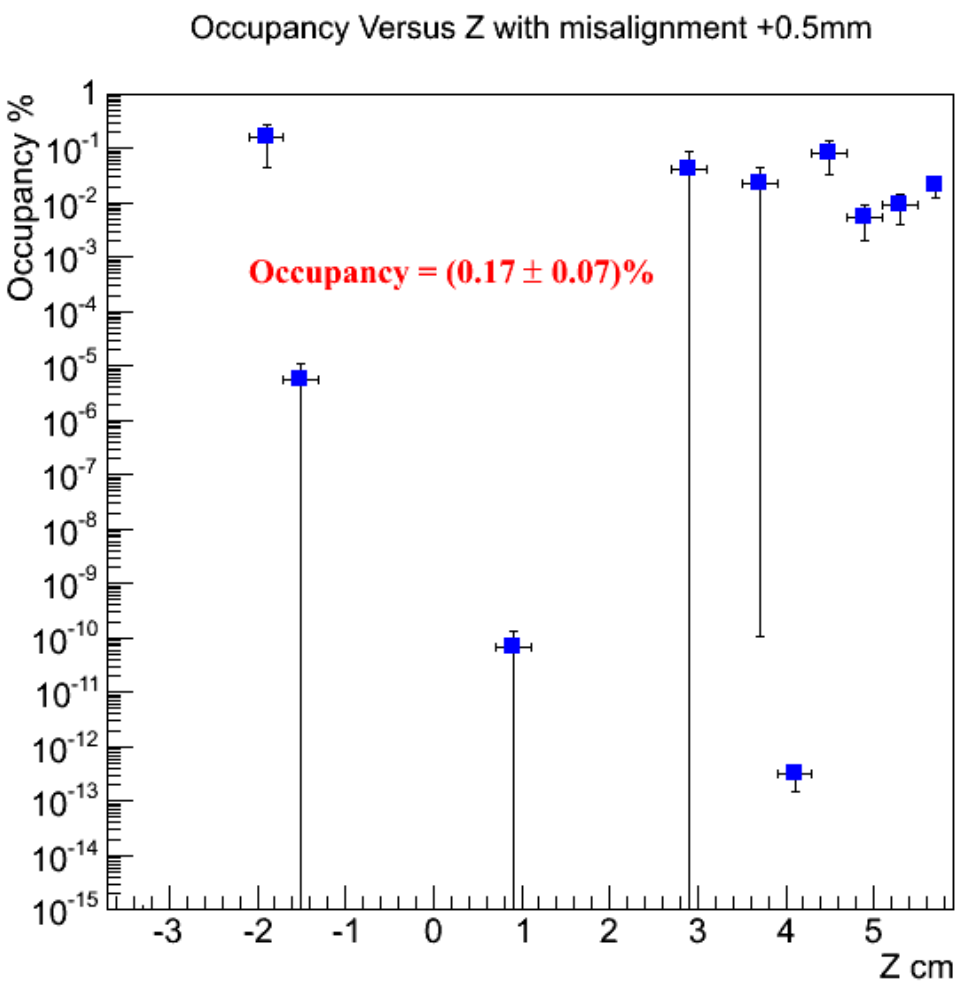
Extrapolating hit rates in Be part yields in occupancy for PXD1 from HER in case of misalignment : .

(0.15 ± 0.07%

Misalignment - HER

Occupancy estimation with stopping power method:

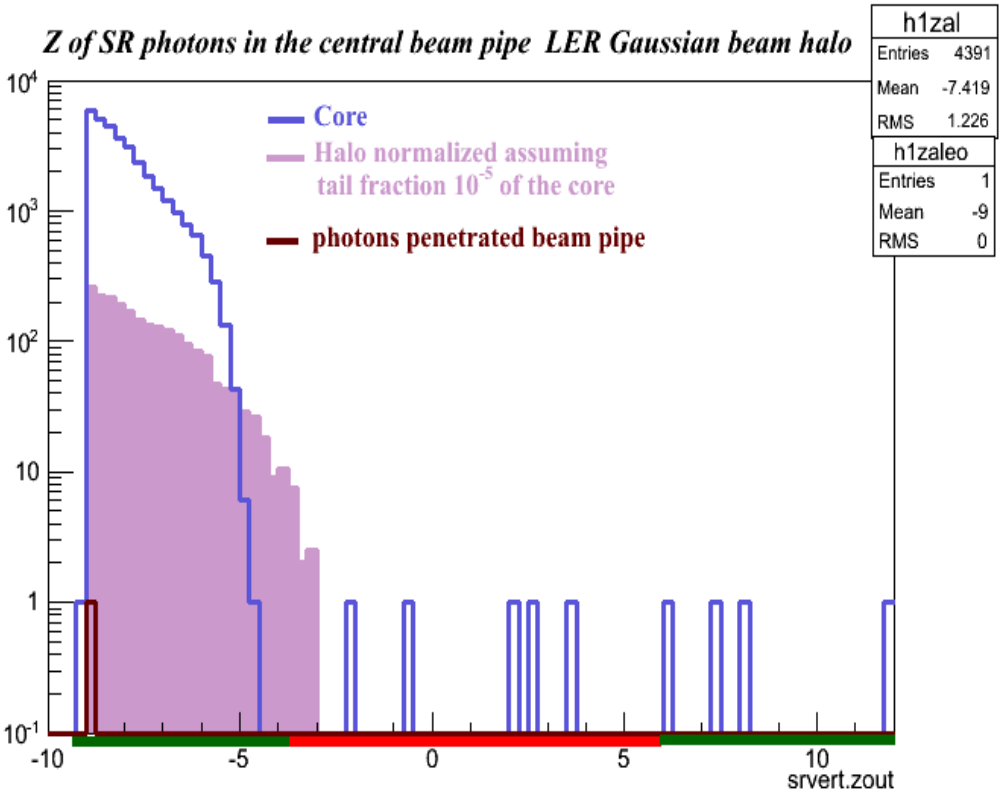


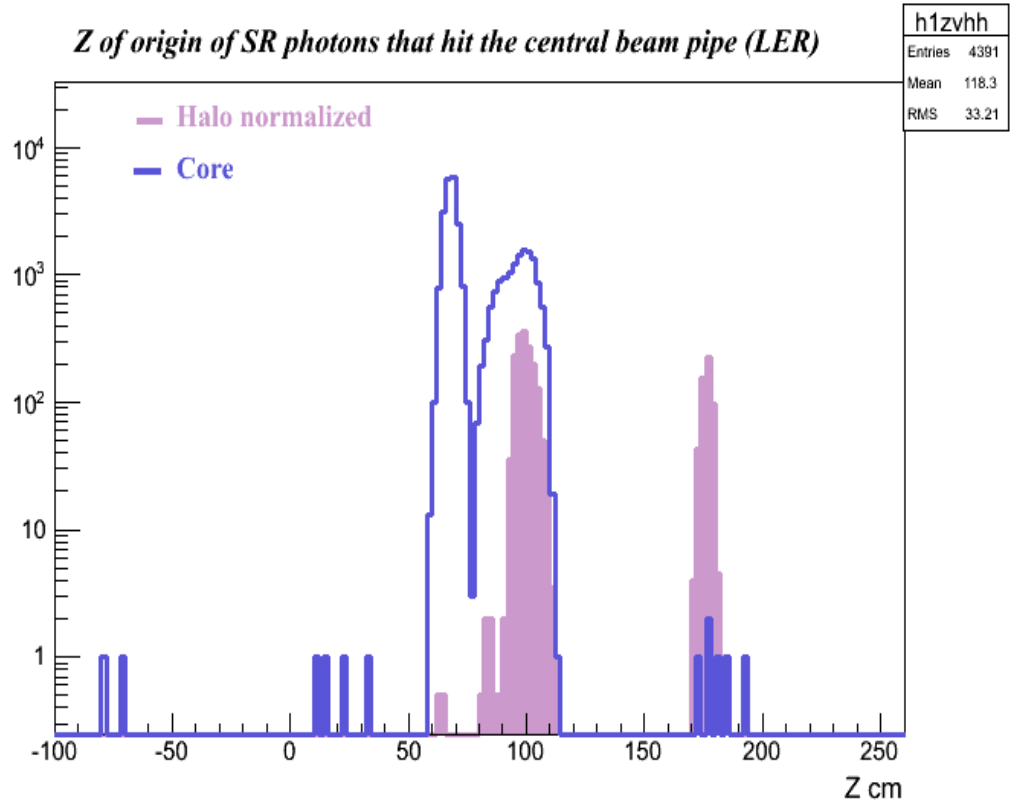


Most of the hits assumes to be in sensors 1.1.1 and 1.1.2 (φ and z – distributions).
The result is compatible with estimation using hit rates – (0.15 ± 0.07)%
Occupancy for ideal alignment (**0.06 ± 0.04)%**.

Beam halo - LER (*gaussian halo*)

The data sample contains ~5.68e+6 initial electrons generated that corresponds to ~2*LER bunch charge, assuming that fraction of the tails outside 10σx of the core is equal **1e-5** of the core,cut on SR photon energy E > 5KeV. Lattice version – sler_1682. Gaussian shape of the halo with σ = 10σ of the core.



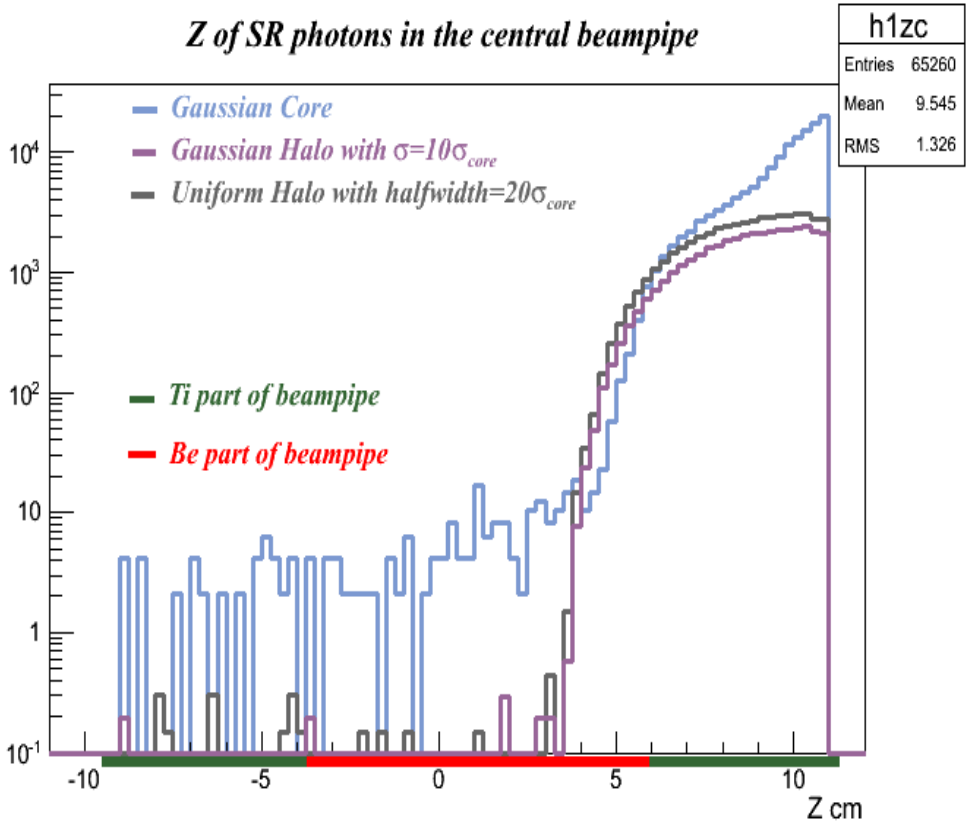


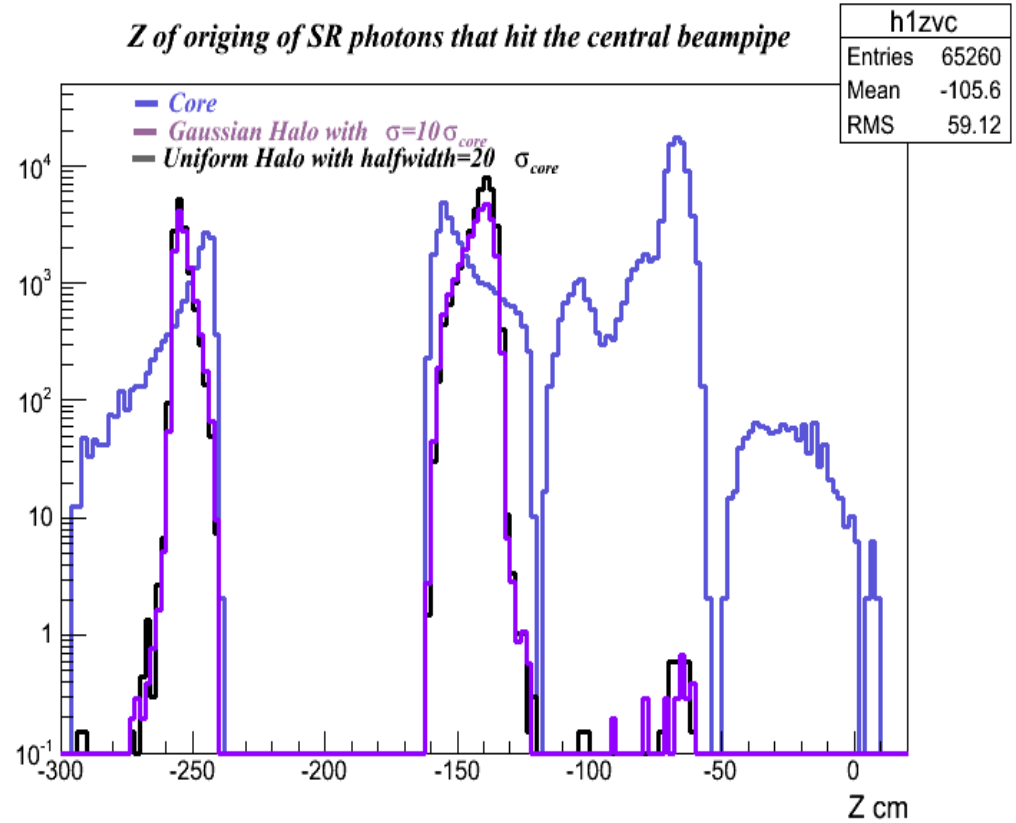
Number of hits per bunch crossing:

	Halo	Core		Halo	Core
Be part	9 ± 2	15 ± 6	Ti part	2.2e+3 ± 40	8.3e+4 ± 500

Extrapolating hit rates in Be part yields in the occupancy for PXD1 from beam halo in LER ~ **1e-4%** .
Normalization is done assuming that fraction of tails beyond 10σx = **1e-5 of the core** (KEKB TDR)

Beam halo - HER (gaussian and uniform)





Uniform halo – 2D circular flat distribution of (X,X')/(Y,Y') in normalized coordinates with radius ***20*√εx/εy*** (half width = 20σ of the core) instead of gaussian with **σ = 10σ of the core**.

Number of hits per bunch crossing:

	GausHalo	UnifHalo	Core		GausHalo	UnHalo	Core
Be part	1.8e+3 ± 20	2.6e+3 ± 20	1.4e+3 ± 100	Ti part	3.7e+4 ± 100	4.7e+4 ± 100	1.3e+5 ± 600

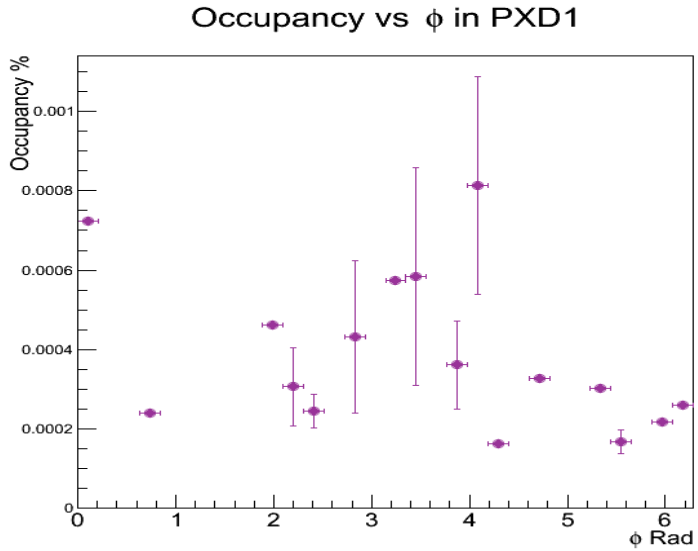
Gaussian halo - 349 SR photons penetrated beam pipe and 29 of them hit the PXD1.
Uniform halo - 393 SR photons penetrated beam pipe and 41 of them hit the PXD1.

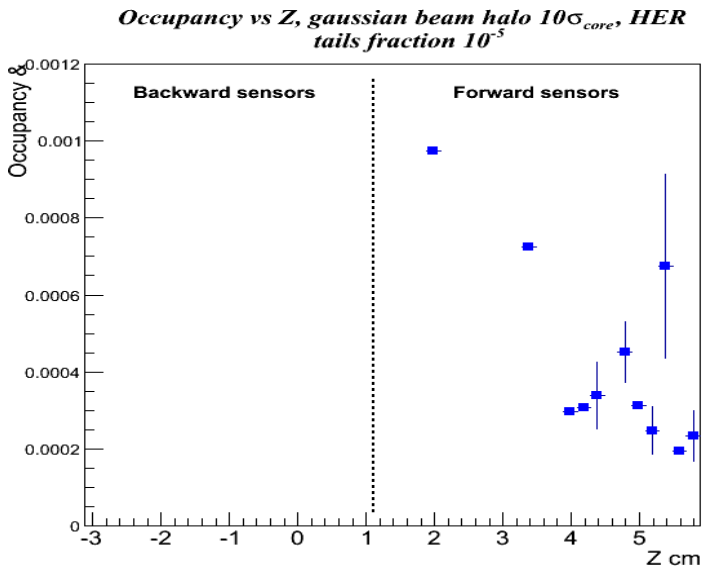
Occupancy estimation under assumption that fraction of tails beyond 10σx = 1e-5 of the core

Beam halo HER

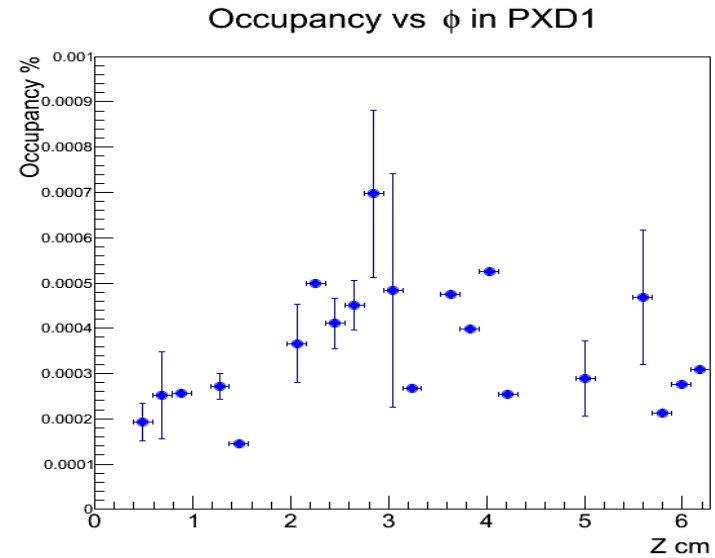
Occupancy in PXD1

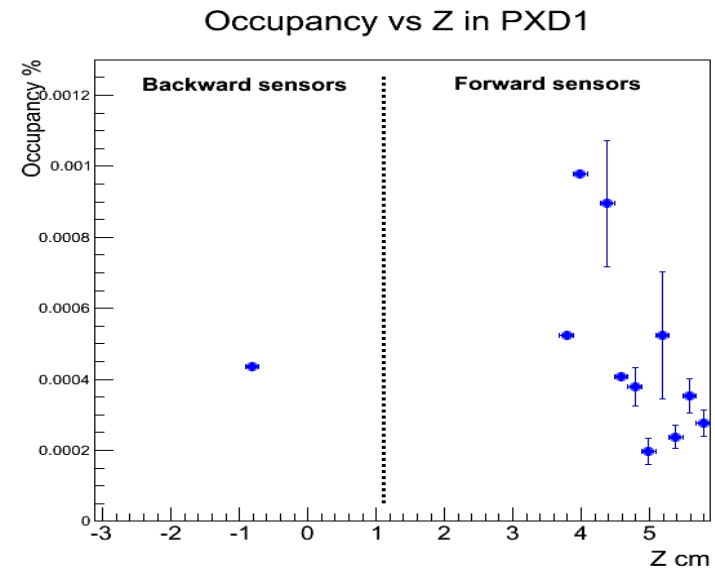
Occupancy calculated assuming uniform phi distribution and that hits are only in the forward sensors.
Total occupancy – ~0.001% (for both type of halo) - negligible.





Gaus Halo

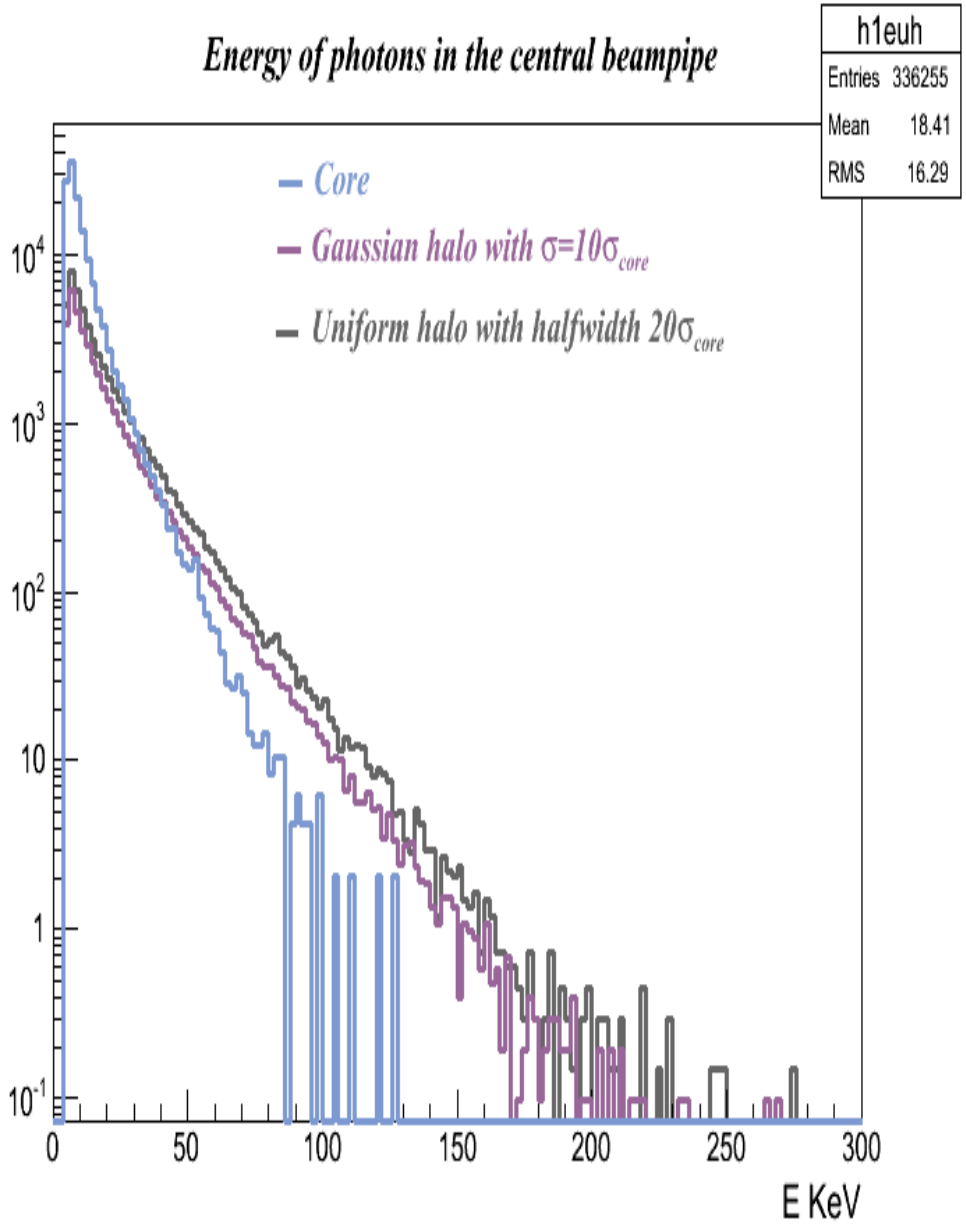


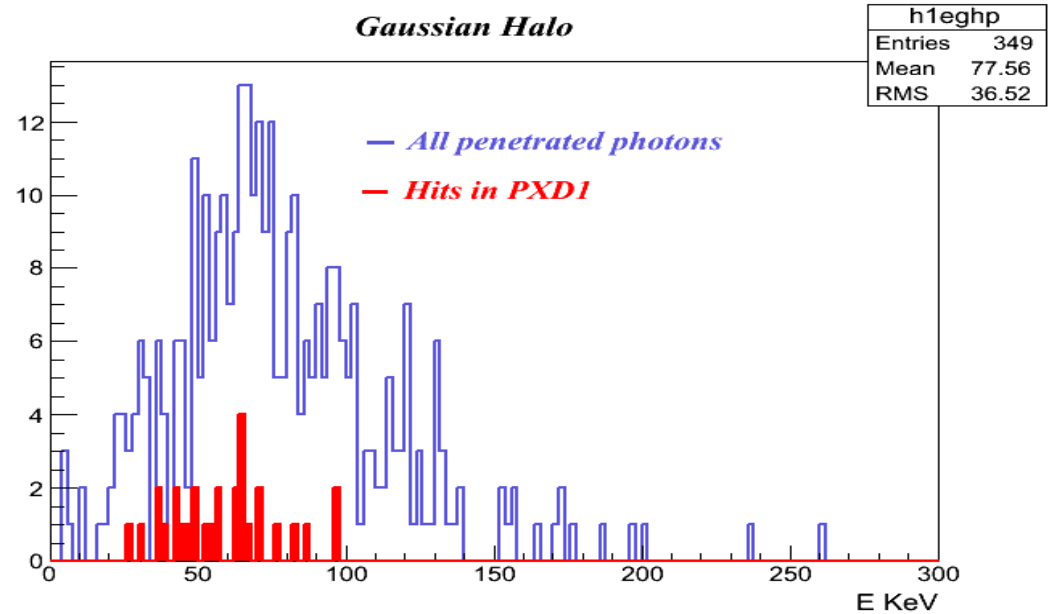


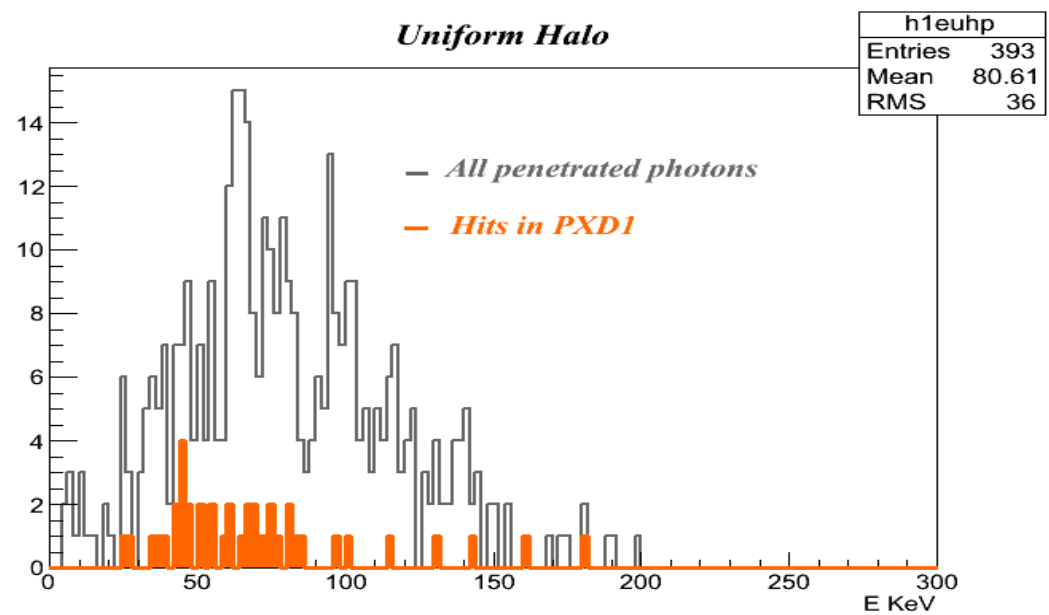
Uniform Halo

Beam halo HER

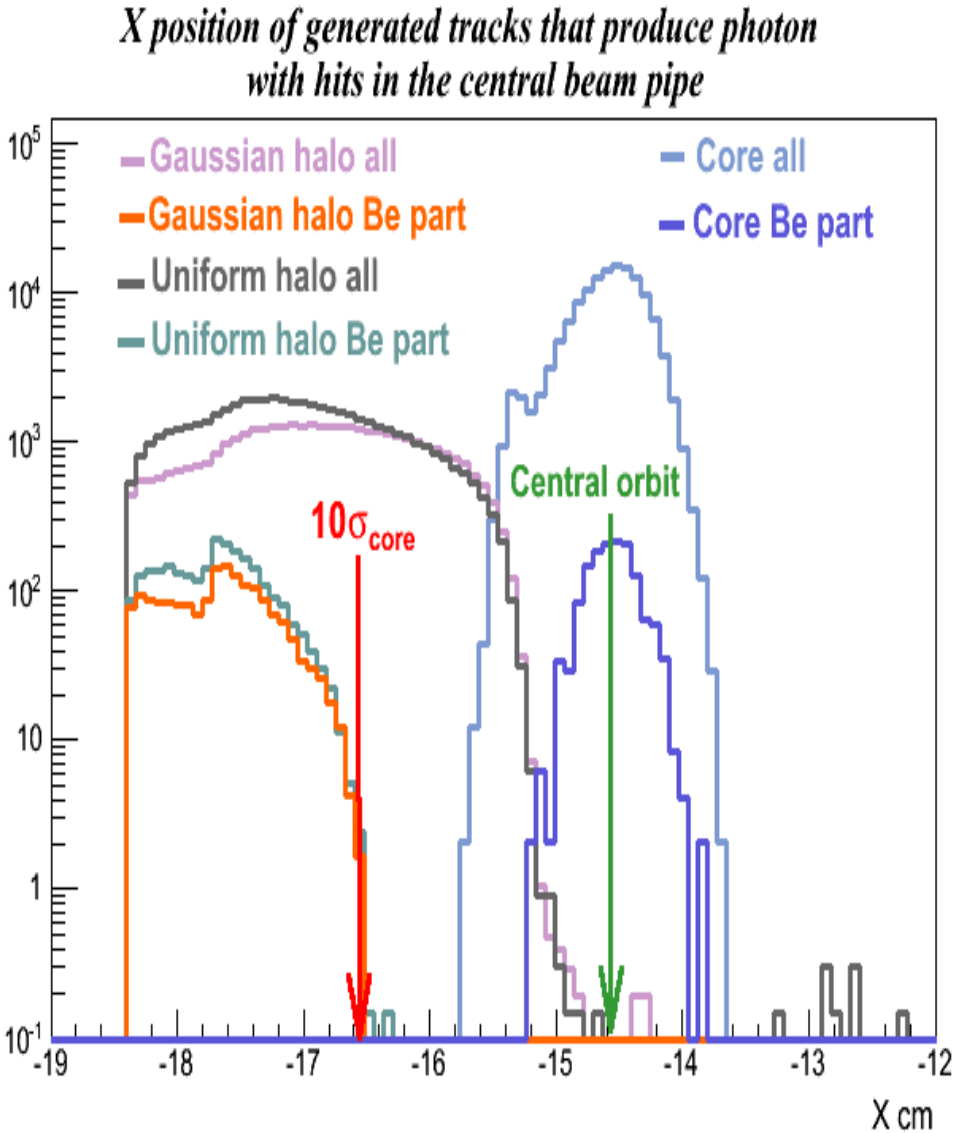
Energy spectrum

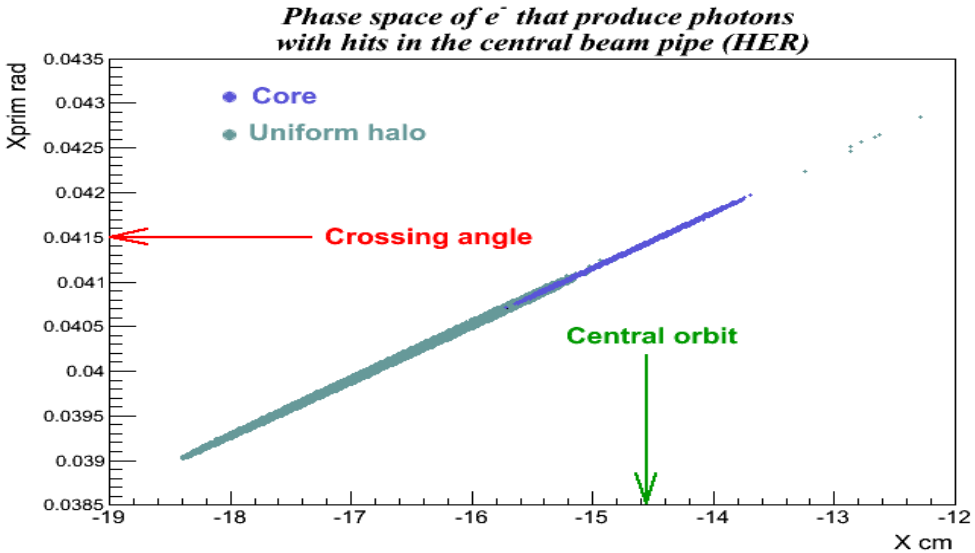


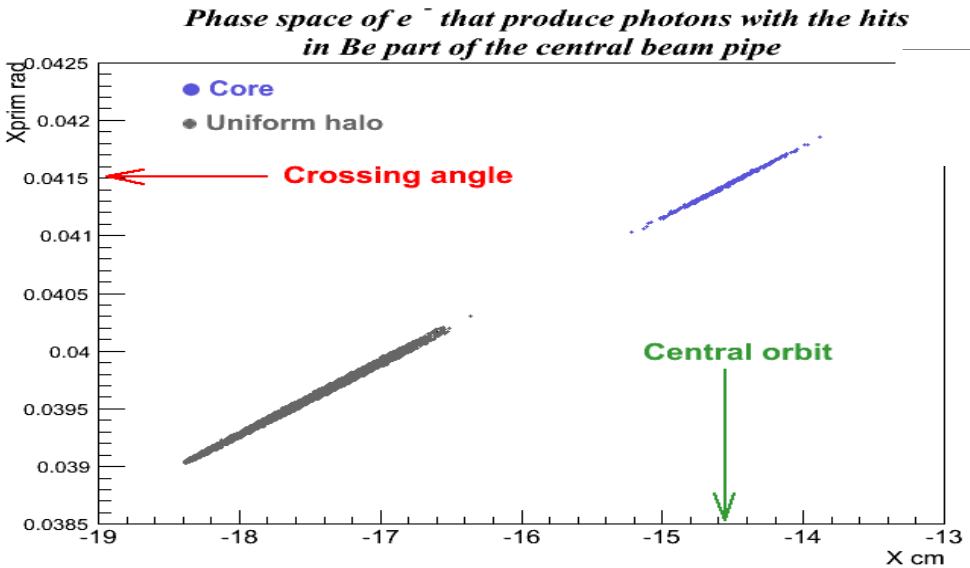




Beam halo HER



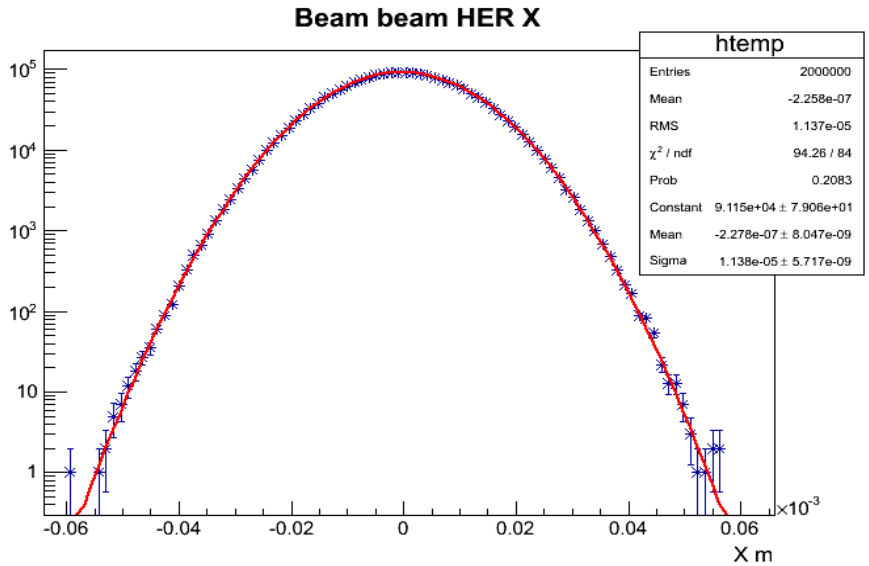


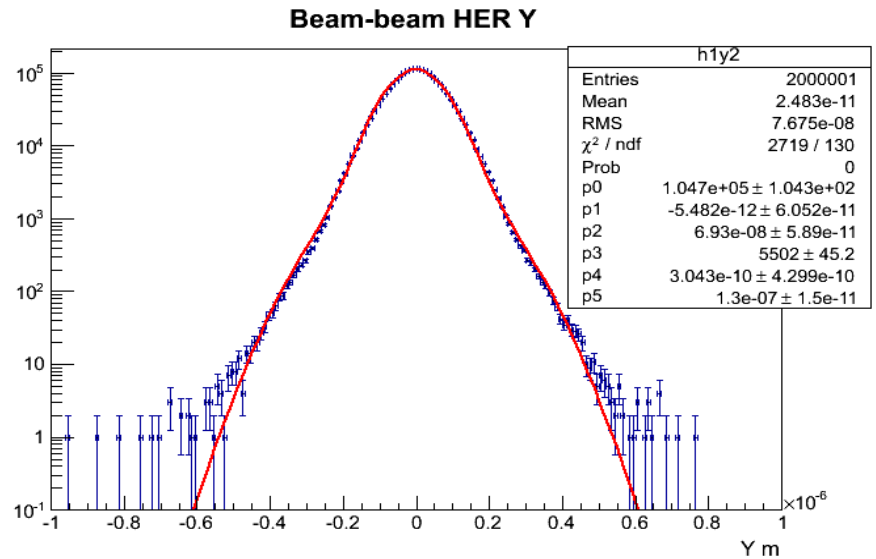


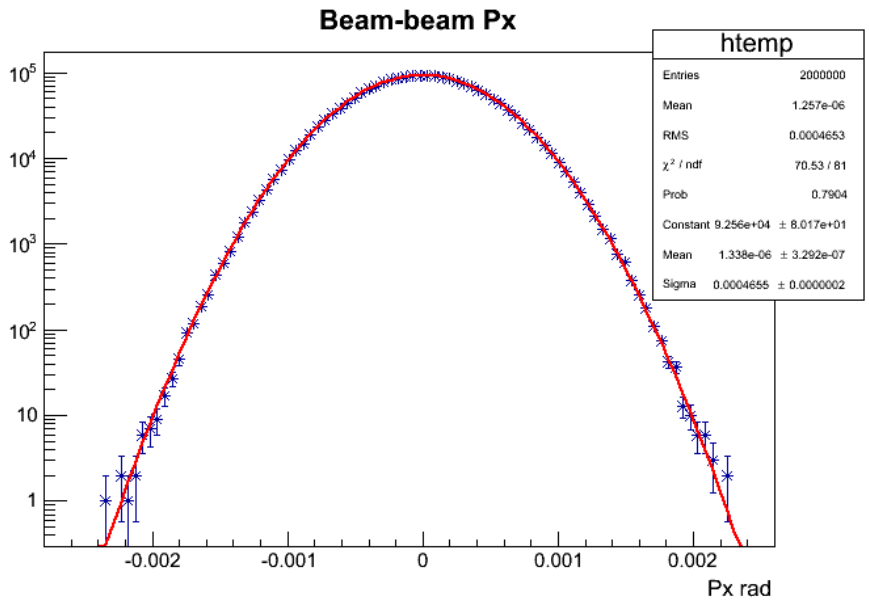
All distributions are normalized to HER bunch charge

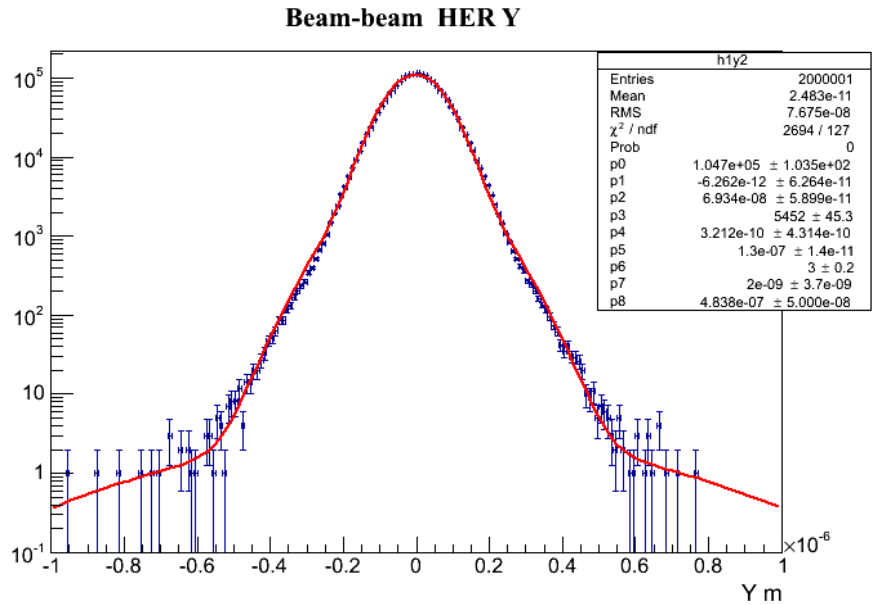
Most of SR photons of beam halo that hit the Be part of beam pipe are produced by the tails far from the central beam orbit (beyond 10σ of the core) inwards HER.

Halo shape from beam-beam simulation









No entries beyond 10σ(X/Px) and beyond 30σ(Y/Py). → The fraction of tails < 5e-07.
Negligible contribution to PXD occupancy for beam halo for both HER and LER.

Atomic Deexcitation processes.

Fluorescence and Particle Induced X-ray Emission (PIXE).

Test run (1.1e+10, ~ 17% of bunch charge) with FLUO and PIXE for HER.
The hit rates withing statistical uncertainties are the same as without Atomic deexitation.

The very first Test was done my standalone GEANT4 simulation for 20KeV photons (**1e+6 events**) with activated deexcitation processes (FLUO, PIXE) and then with deactivated deexcitation processes without energy cut with the layers structure like central beam pipe wall.
The difference in the energy spectra is on the level of ~ **1e-4** (number of entries) **.**
With the estimated hit rate in Ti+Be part of beam pipe as **2.2e+5 hit/bunch** (both rings) its unlikely to expect significant contribution of the atomic deexcitation processes to PXD occupancy.

Test run for LER was done with **1e+7** initial positrons and no deexcitation processes observed.

Conclusions

With the latest version of central beam pipe geometry the contribution of:

1. Misalignment to PXD occupancy is much less than the limit for HER (0.17% - dominating) and negligible for LER (~2e-3%).

2. Beam halo to PXD occupancy is negligible for both HER and LER (≤ 0.001%).

3. The halo shape from beam-beam simulation gives much lower (≤ 5e-7) fraction of tails beyond 10σx (30σy) than taken in simulation (1e-5) and therefore even smaller contribution to PXD occupancy.

4. Atomic deexitation processes do not contribute to occupancy significantly.

Occupancy in PXD1 from SynRad background:

LER{2e-3%(misalignment) + 1e-4%(halo)}
+ HER{0.17%(misalignment) + 1e-3%(halo)}
= 0.17%

Thank you for your attention

Additional material

The latest estimation of occupancy in PXD with previous version of geometry:

Occupancy in one half ladder at $\varphi \sim 0$:
0.5%(SR HER ideal alignment only!) + 0.15%(SR LER incl. misalignment and halo with 10σ of the beam core) $\rightarrow$ 0.65%.

Occupancy in all other ladders : 0.5%(SR HER)
Occupancy could be larger taking into account misalignment for HER.

HER - 5μm of gold plating,ideal alignment

About 34% of bunch charge of HER simulated with the energy cut 3.7KeV that corresponds about the same stopping power for 5μm of gold as 5KeV for 10μm.

Number of hits per bunch crossing:

	5μm && 3.7KeV	10μm && 5KeV
Be part	2.3e+3 ± 100	1.4e+3 ± 100
Ti part	1.9e+5 ± 800	1.3e+5 ± 600

Occupancy – the same value as for 10μm within statistical uncertainties.

10μm → (0.06 ± 0.04)% 5μm → (0.05 ± 0.035)%

Detector misalignment.

Two kind of misalignment:

1. Misalignment of the detector (i.e. central beam pipe) with respect to the orbit.
2. Misalignment of the magnets.

Only first type of misalignment is considered here.

Experts : Maximal expected misalignment = ±0.5mm.

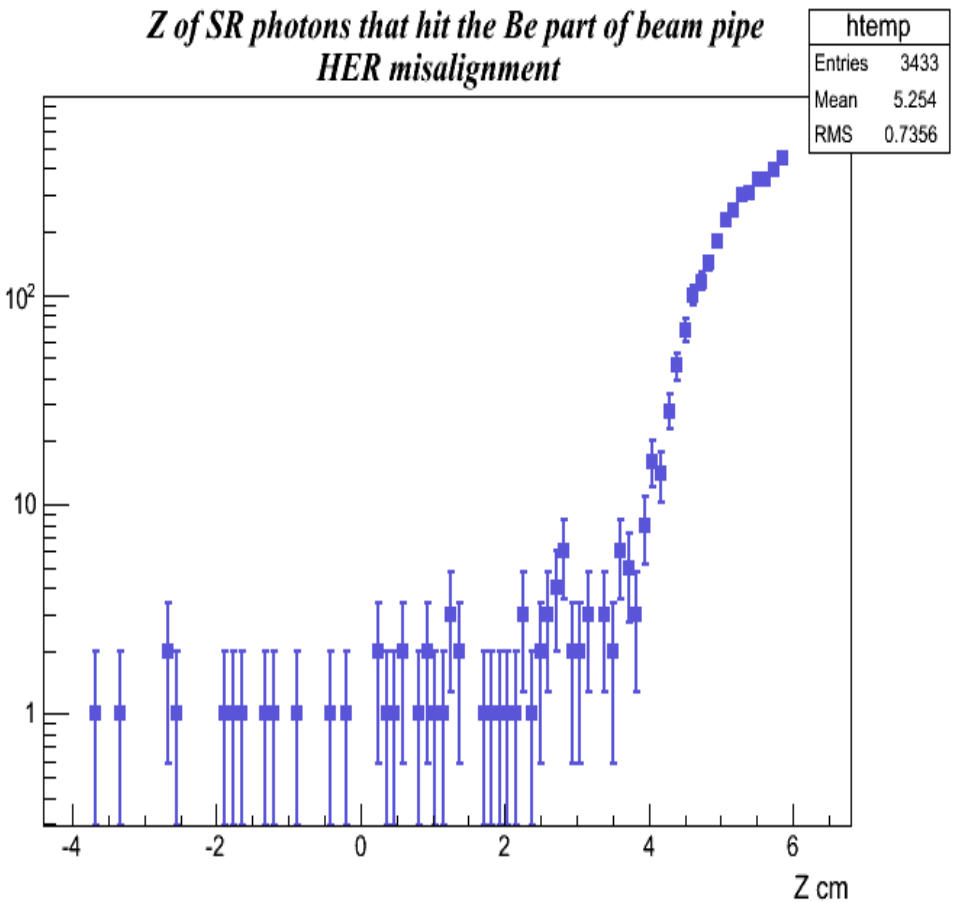
In the first case the misalignment may occur at the position of the bellows at ±482mm from IP.

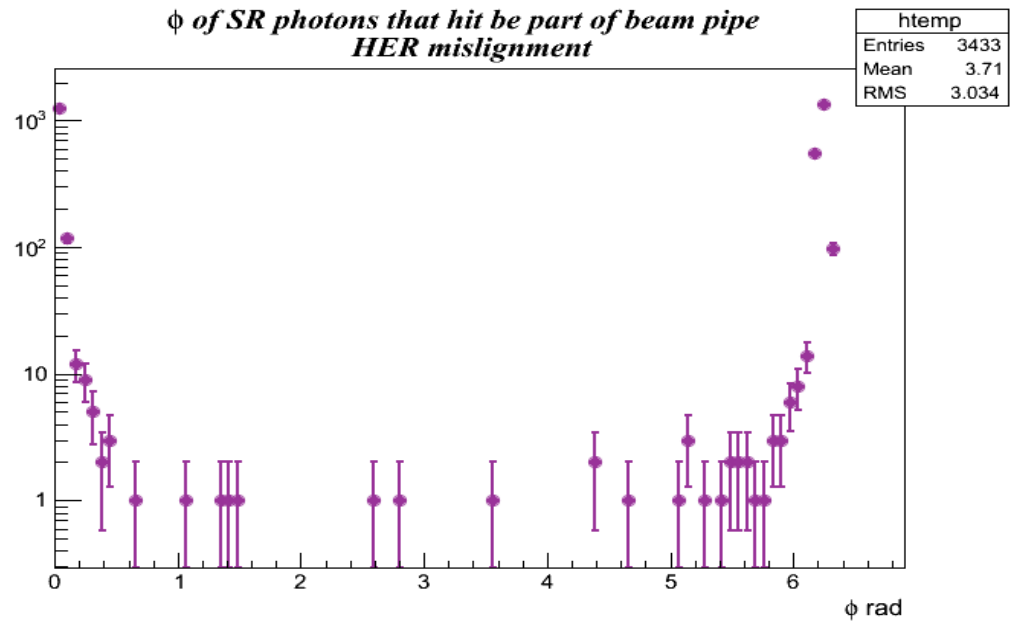
Two possible extreme cases : Rotation and Displacement.
In case of rotation the shift of 0.5mm at bellow positions would propagate to 0.1mm at the “dangerous” part of central beam pipe (at -Z), the maximal angle of rotation = 0.06º.
In case of displacement the shift on 0.5mm at bellow positions would give the same value of shift on 0.5mm for the whole central beam pipe.
The displacement of the beam pipe on -0.5mm (towards center of the accelerator ring) along X-axis is considered as most dangerous misalignment .

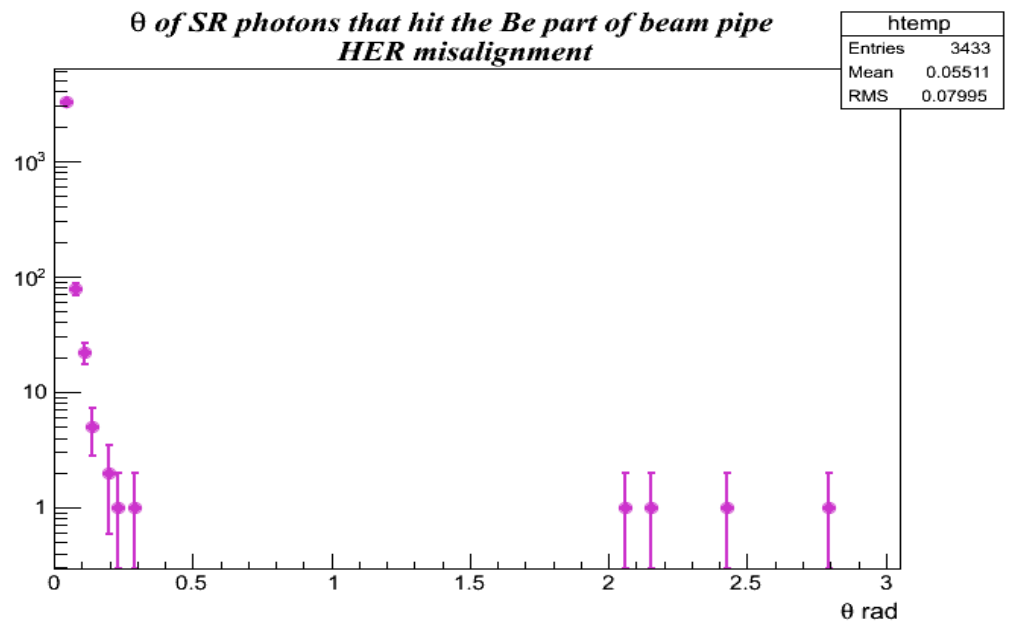
Changes in SynRad background due to misalignment of the detector can be estimated using available MC files.
Photon's tracks parameters → extrapolating tracks in the geometry with misalignment →
→ changes in number of hits and occupancy.

Misalignment - HER

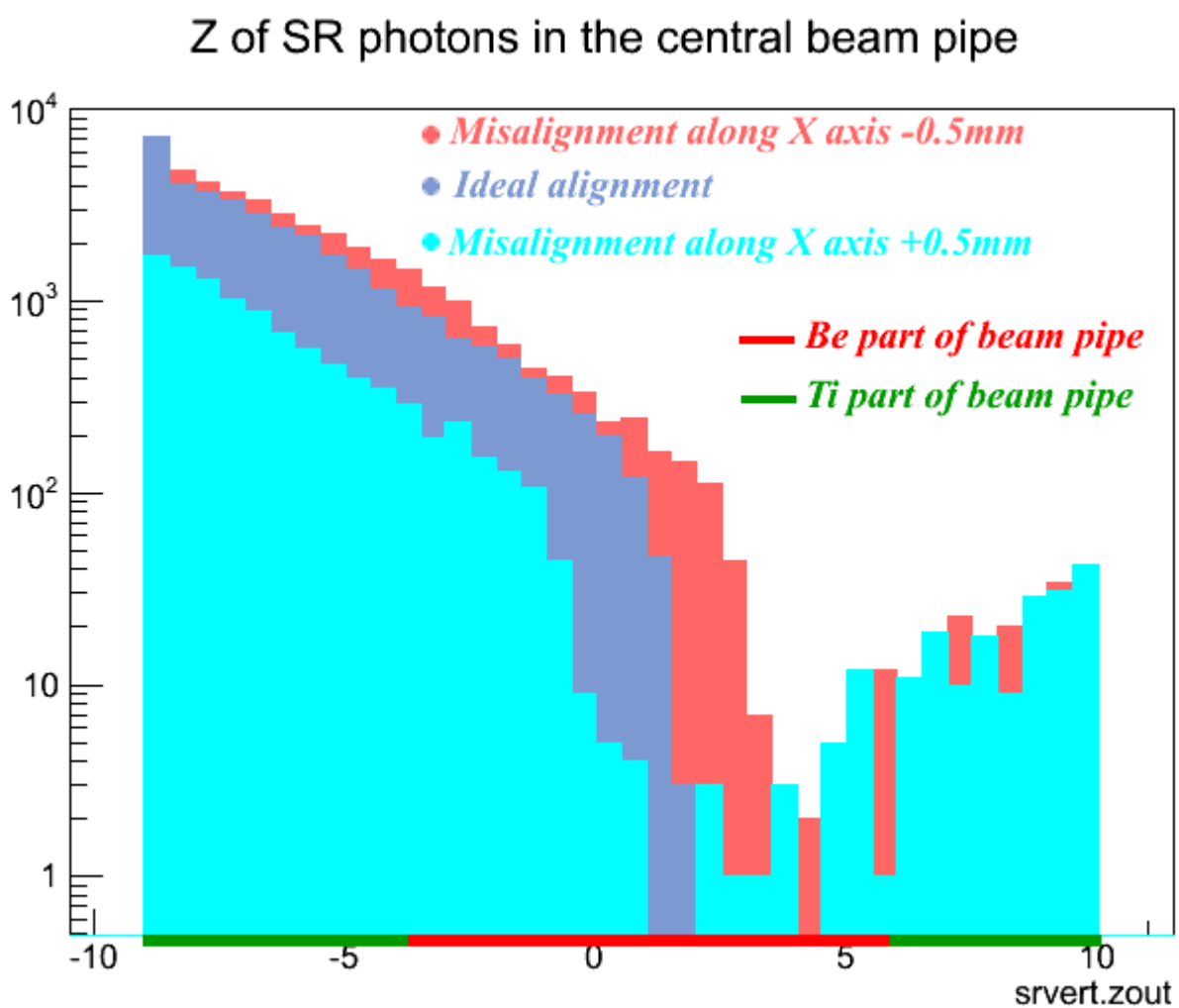
Z, θ and φ of photons in Be part of beam pipe





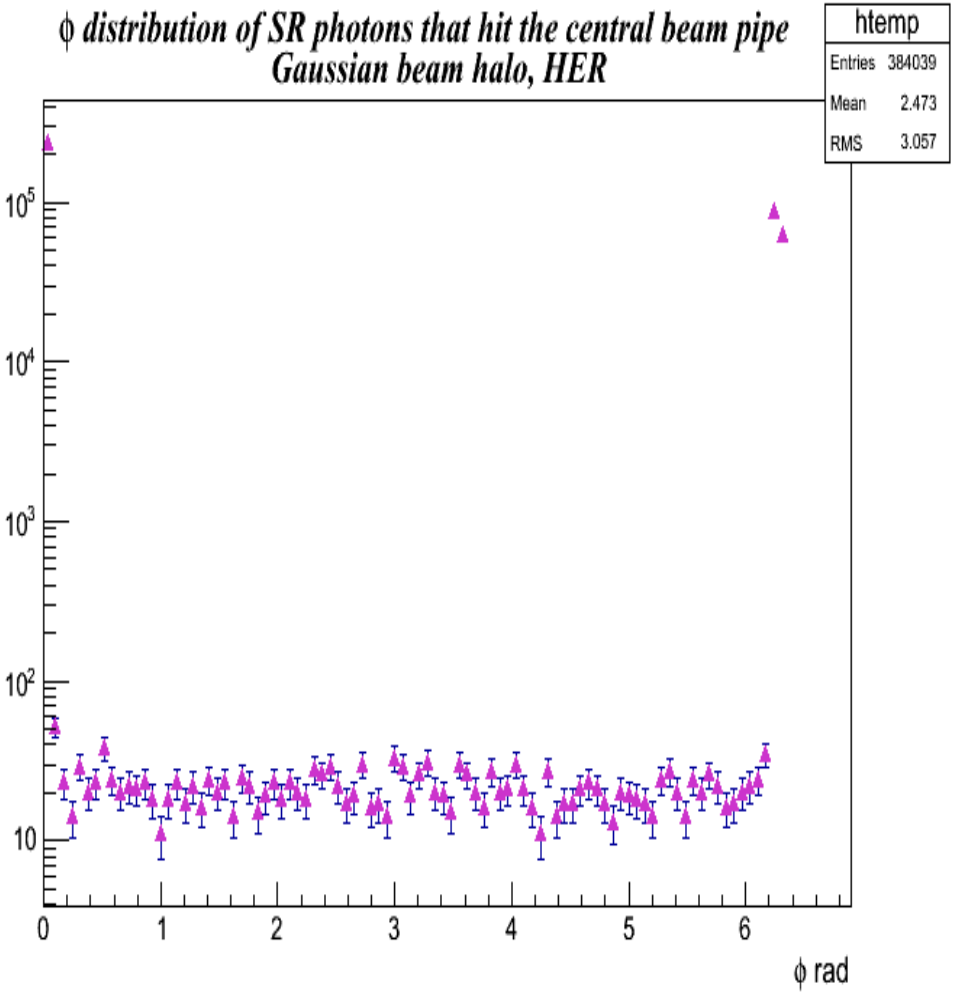


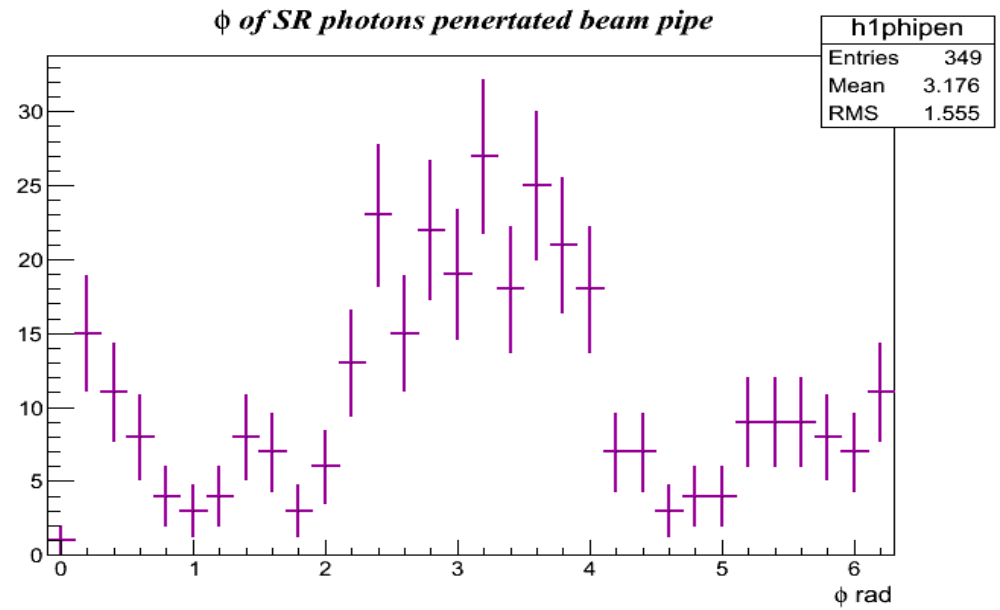
Comparison of misalignment in different directions.
Lattice version sler_1682, previous beam pipe design.

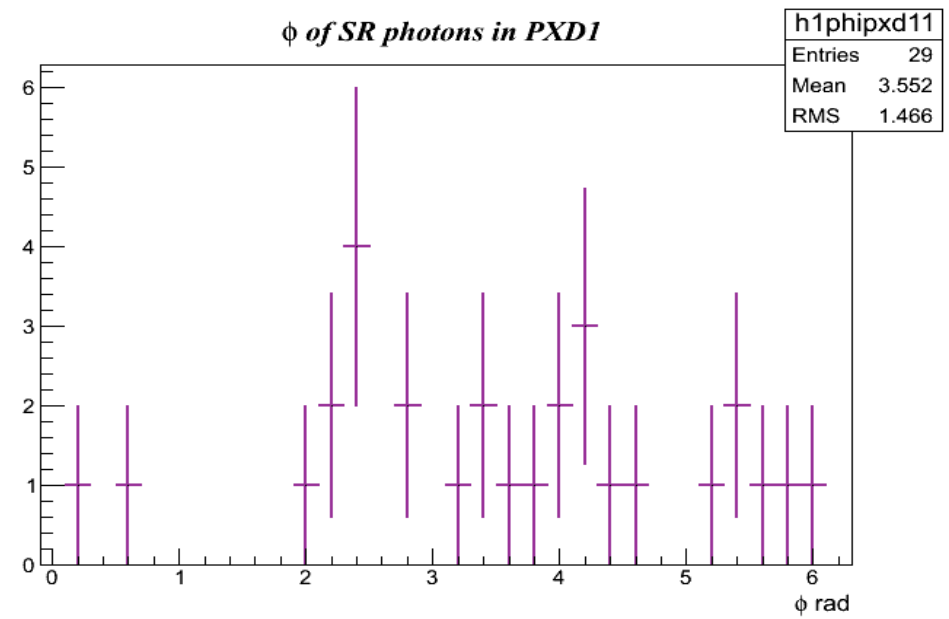


Beam halo HER (*gaussian halo*)

φ distribution



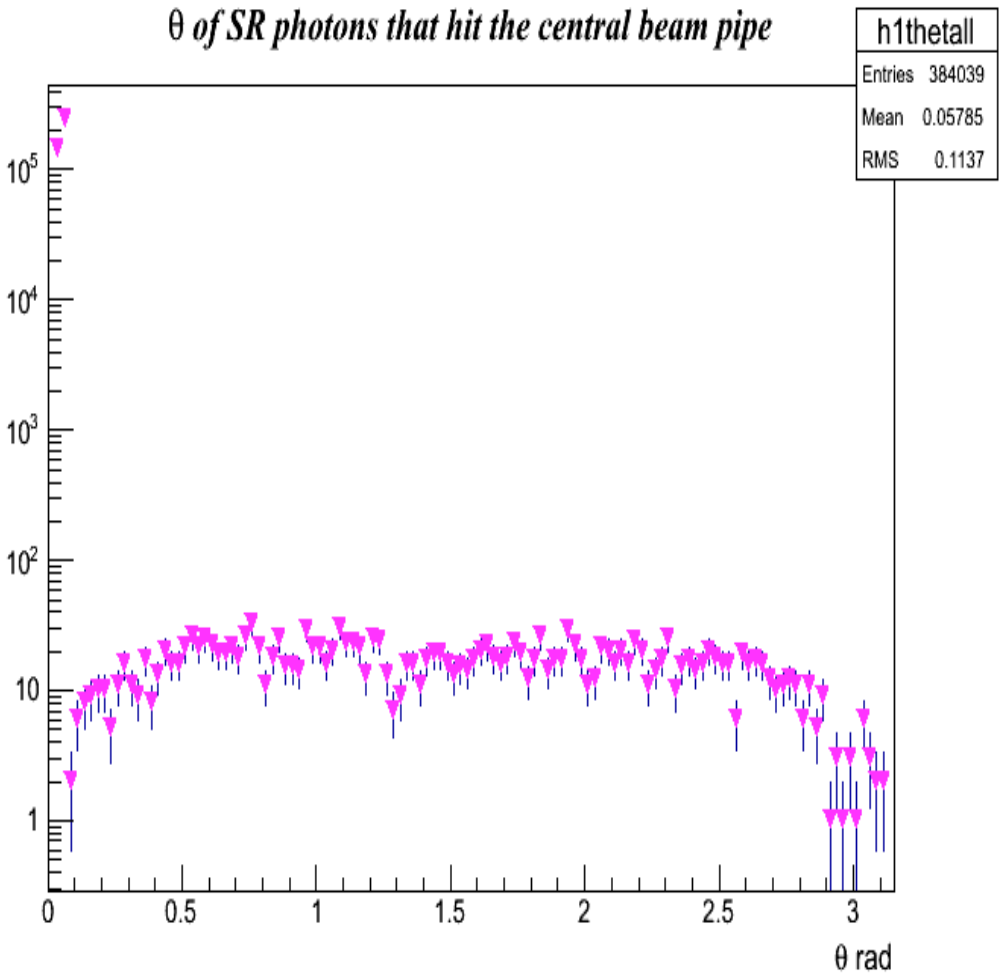


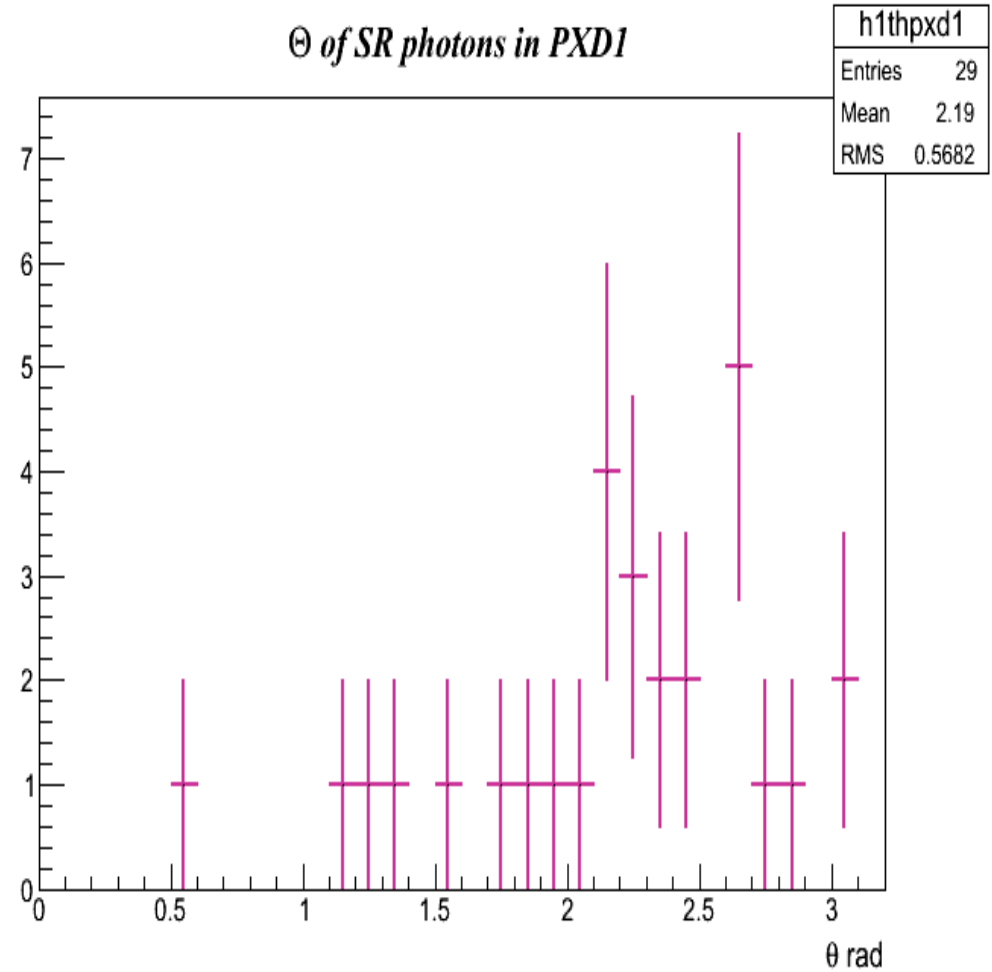


φ distribution of SR photons in PXD1 is rather uniform

Beam halo HER (*gaussian halo*)

θ distribution

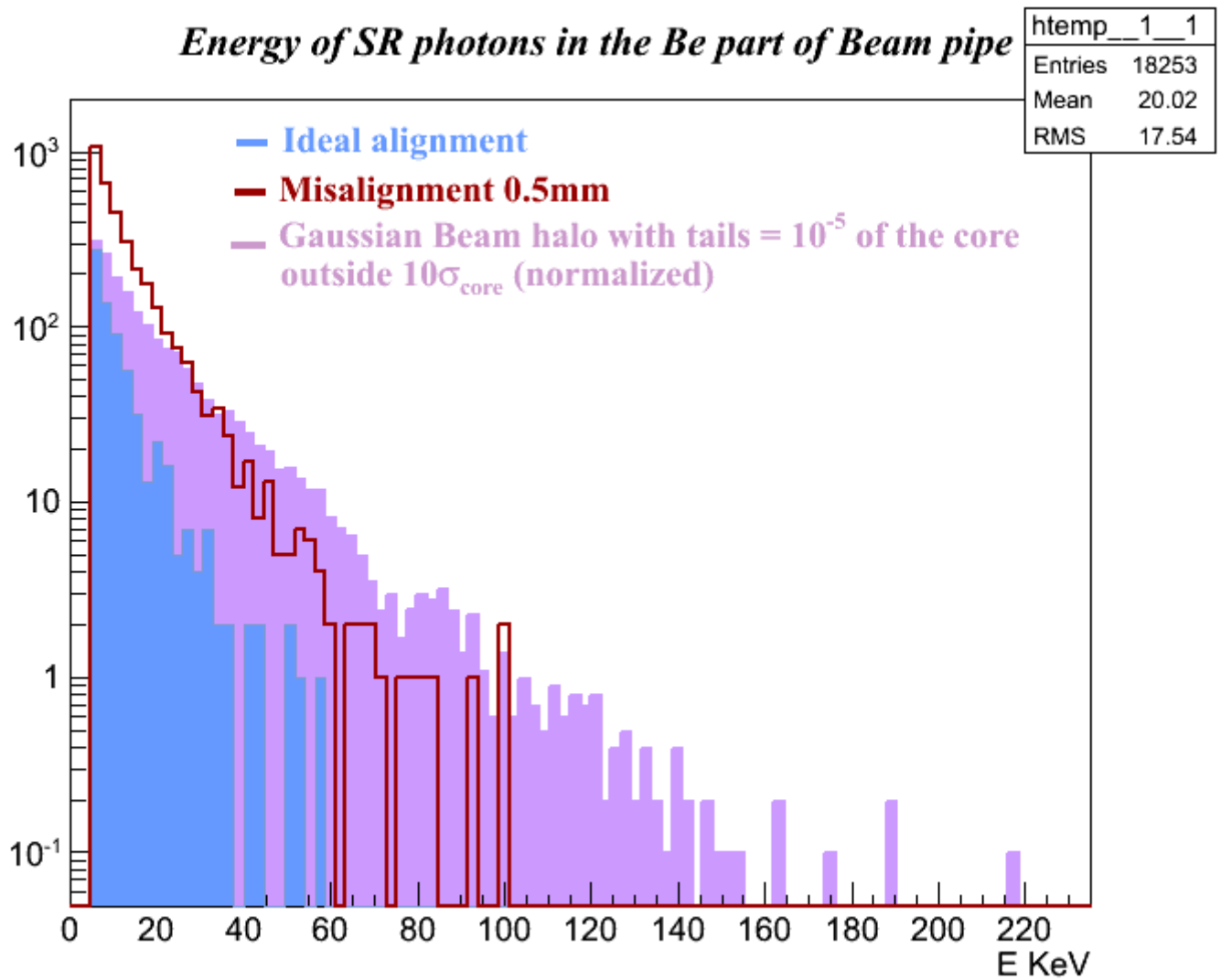




All SR photons that hit PXD1 are back scattered.

Beam halo HER (*gaussian halo*)

Energy spectrum



Beam halo HER (*gaussian halo*)