Belle II SVD-PXD Meeting

2012/02/08

Martin Ritter
on behalf of Andreas Moll

Max-Planck-Institut für Physik

Update on Background Simulation in the PXD

- Introduction and News
- Occupancies
- Neutron levels
- Summary and Outlook

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

MAX-PLANCK-GESELLSCHAFT

Belle II

Excellence Cluster
Universe

Background in the PXD is two-fold:

Neutrons traversing the ASICs and the sensors

➡ **causes radiation damage**

Occupancy

➡ **Impact on DAQ, tracking, data reduction etc.**

Background processes:

• Touschek LER	(SAD)	**Updated**
• Touschek HER	(SAD)	**New**
• Radiative Bhabha scattering LER	(BBBrems + SAD)	**New**
• Radiative Bhabha scattering HER	(BBBrems + SAD)	**New**
• Beam-Gas Coulomb LER	(“Calculation”)	**New**
• Beam-Gas Coulomb HER	(“Calculation”)	**New**
• 4-fermion final state QED	(KoralW – no ISR)	**Updated**

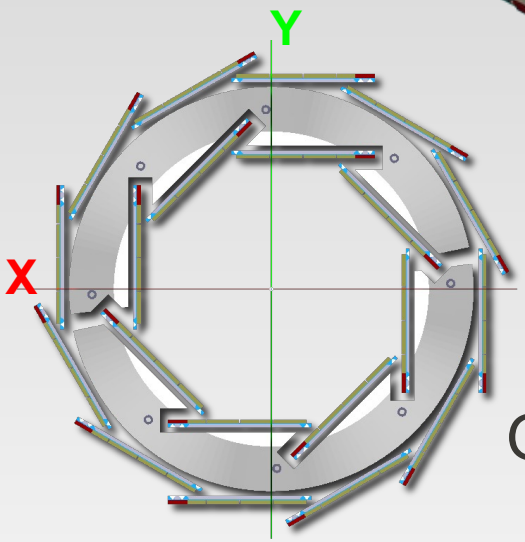
Software used for the simulation

- Belle II software framework BASF2
- Geant4 Belle II detector simulation
- Latest version of the official PXD digitizer
- Full detector geometry
- 2D Magnetic field map

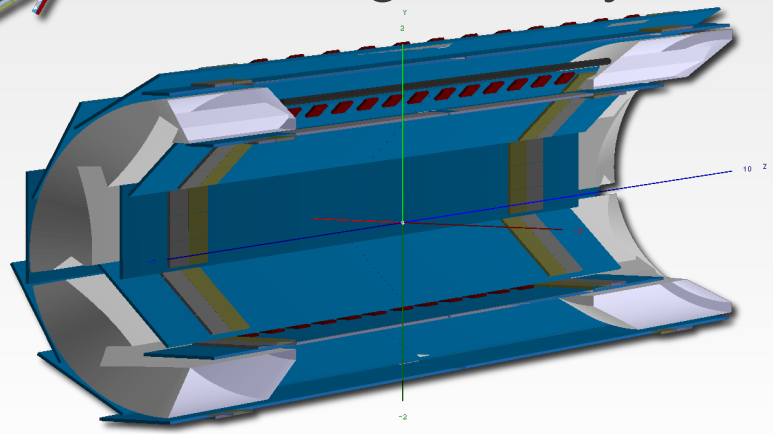
Specs and results

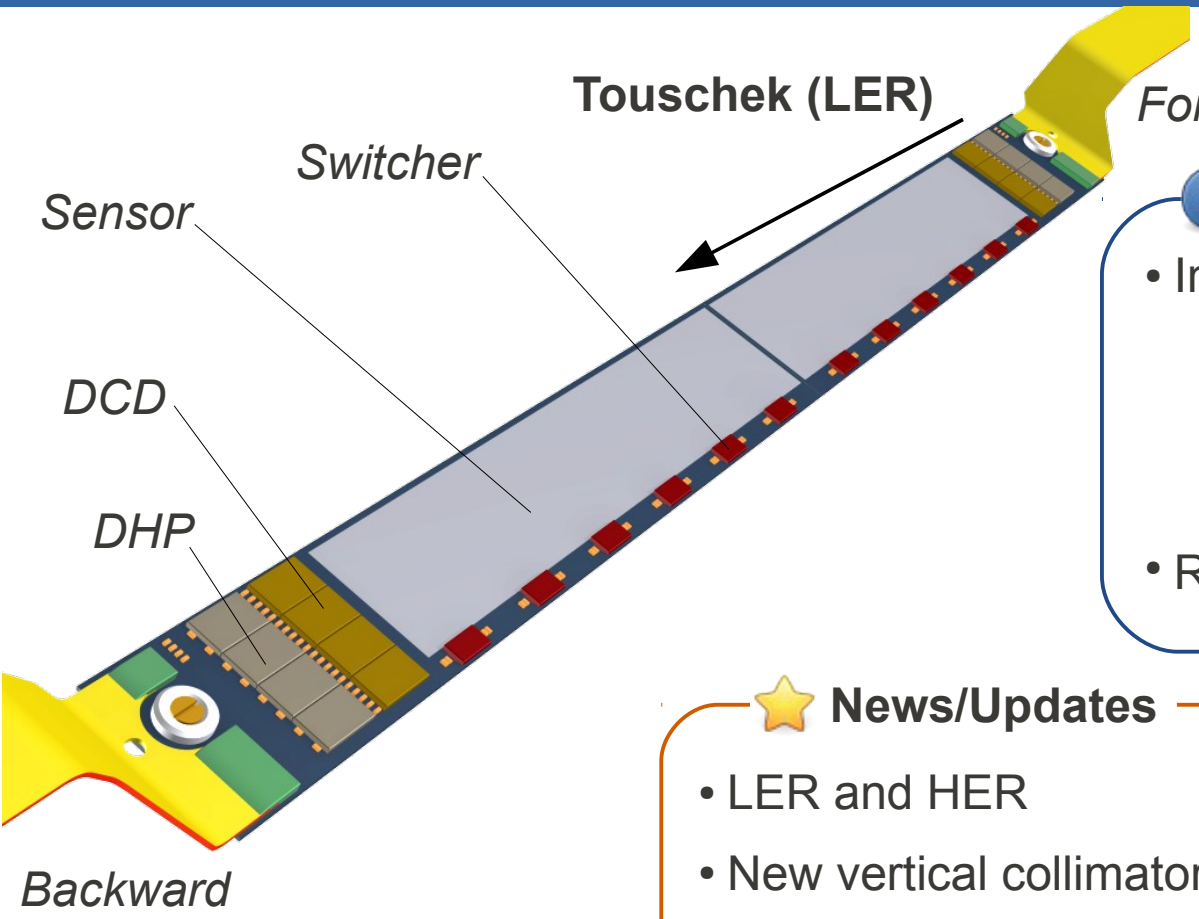
- The number of background events is estimated for the nominal luminosity of SuperKEKB: **$8 \cdot 10^{35}$ $cm^2 \cdot s^{-1}$**
- The occupancies are given for one readout frame (**ROF**) of the PXD (20 μs)

Mechanical design (CAD)



Geant4 geometry





Touschek

- Intra-beam scattering
  - Betatron oscillation
  - Particles from “outside”
- Rate goes like E^{-4} ➡ LER dominates

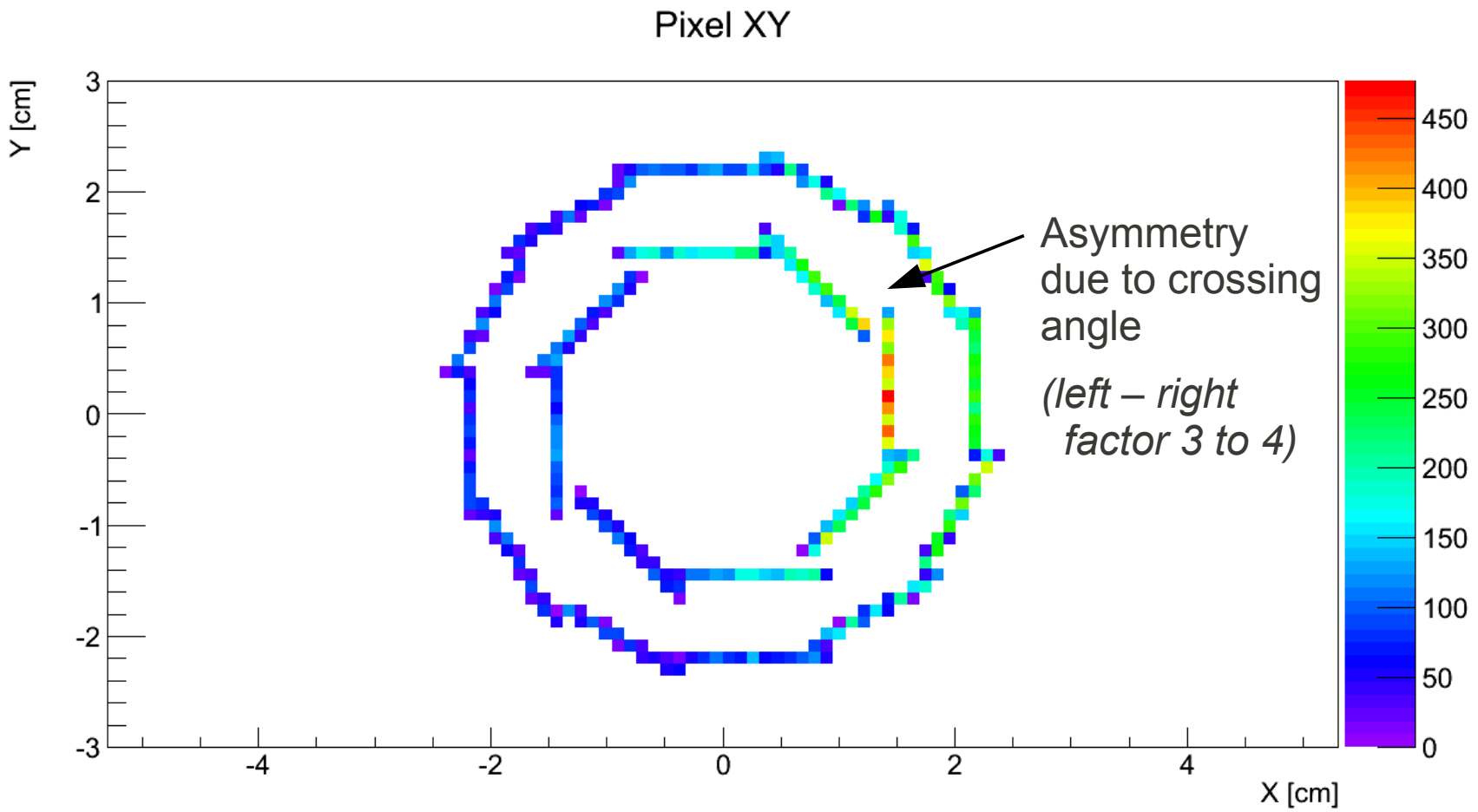
News/Updates

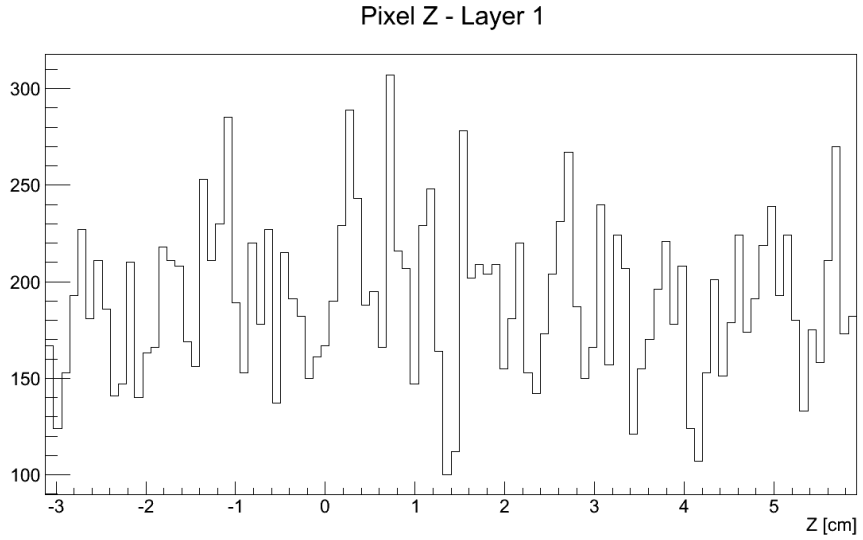
- LER and HER
- New vertical collimator reduced Touschek loss rate

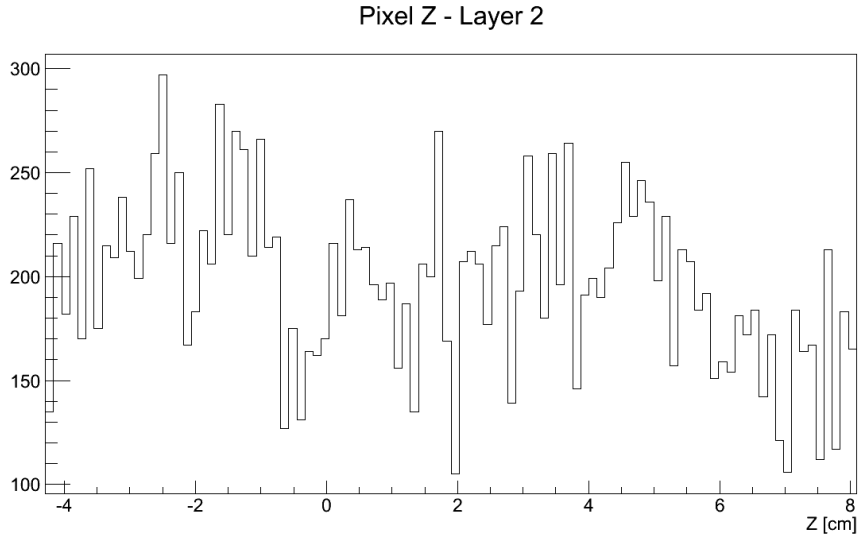
  0.89GHz ➡ 0.16GHz

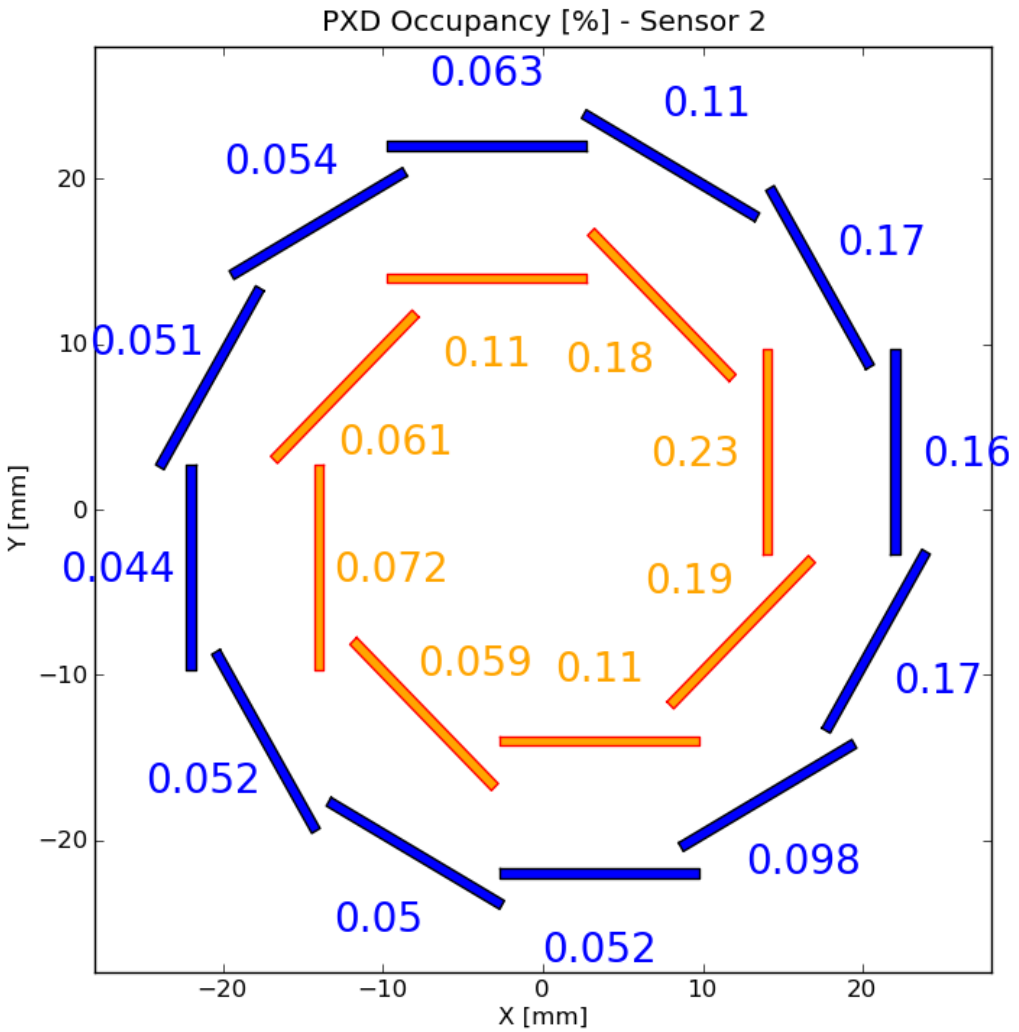
Simulation/Digitization

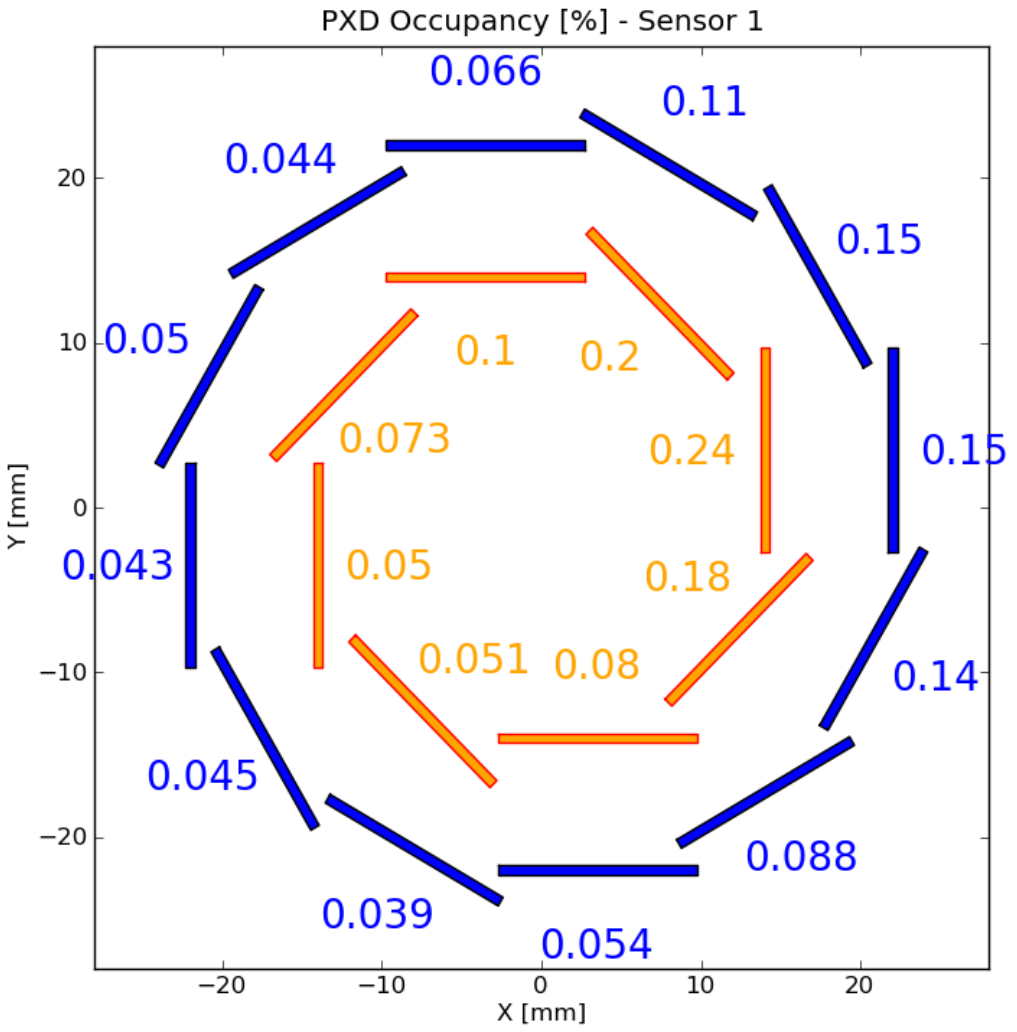
- Input data from SAD: one input file, Geant4 random seed
- **5** PXD readout frames
- official data (provided by Nakayama-san)


Pixel XY
Y [cm]
X [cm]
Asymmetry due to crossing angle
(left – right factor 3 to 4)


Pixel Z - Layer 1
Z [cm]


Pixel Z - Layer 2
Z [cm]

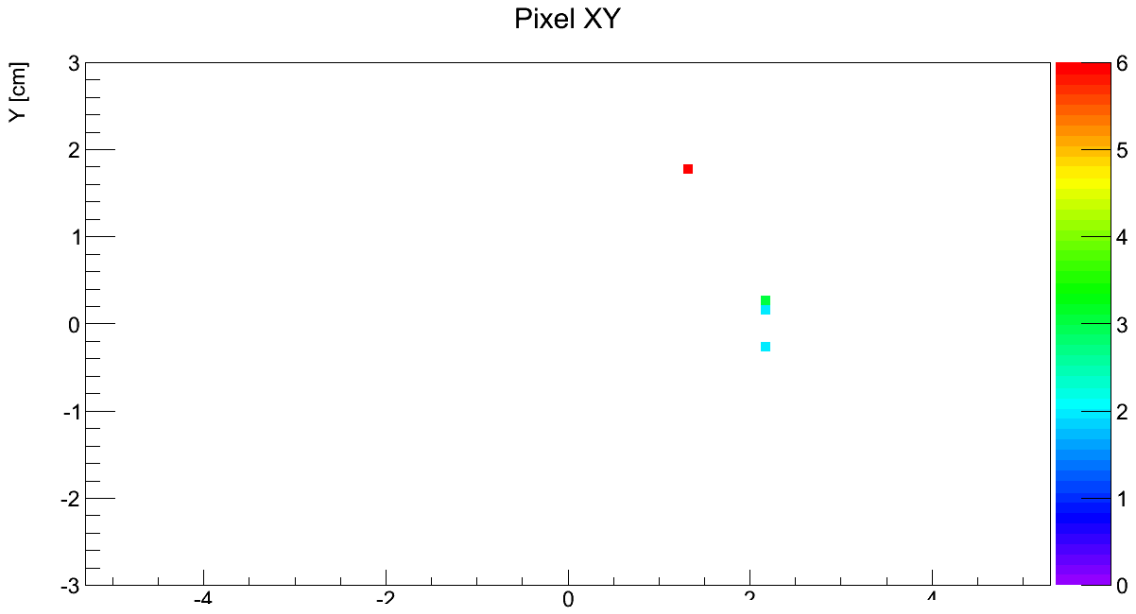

PXD Occupancy [%] - Sensor 2
0.063
0.11
0.054
0.17
0.051
0.11
0.18
0.061
0.23
0.16
0.044
0.072
0.19
0.059
0.11
0.17
0.052
0.098
0.05
0.052
Y [mm]
X [mm]

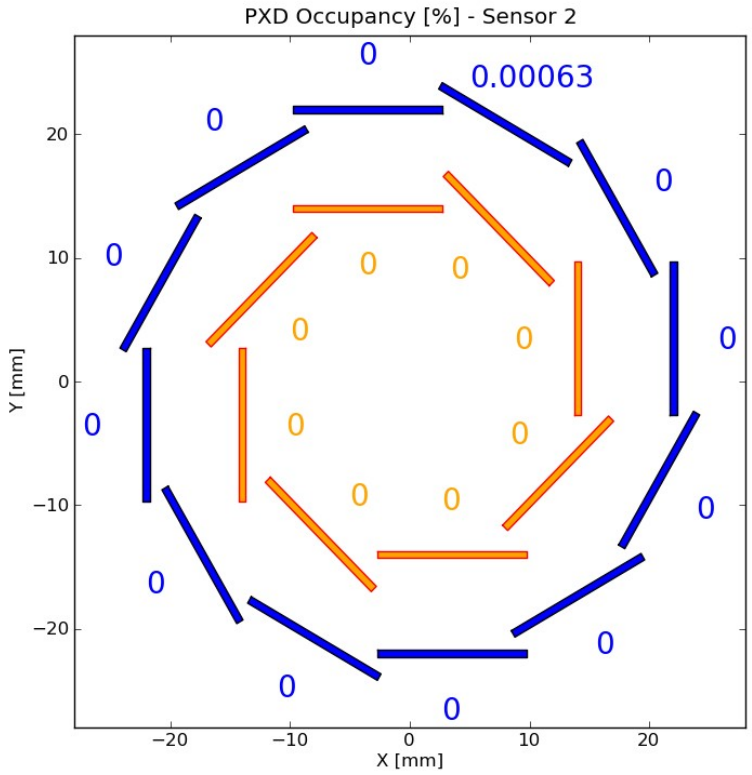

PXD Occupancy [%] - Sensor 1
0.066
0.11
0.044
0.15
0.05
0.1
0.2
0.073
0.24
0.15
0.043
0.05
0.18
0.051
0.08
0.14
0.045
0.088
0.039
0.054
Y [mm]
X [mm]

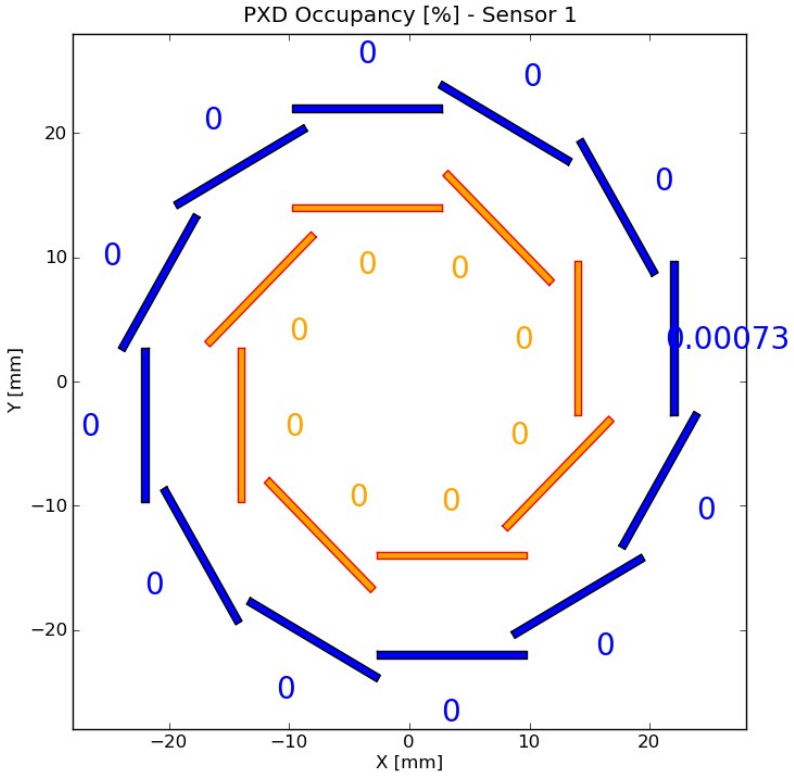

2. *. 2
2. *. 1
1 *. 2
1 *. 1
bwd
fwd

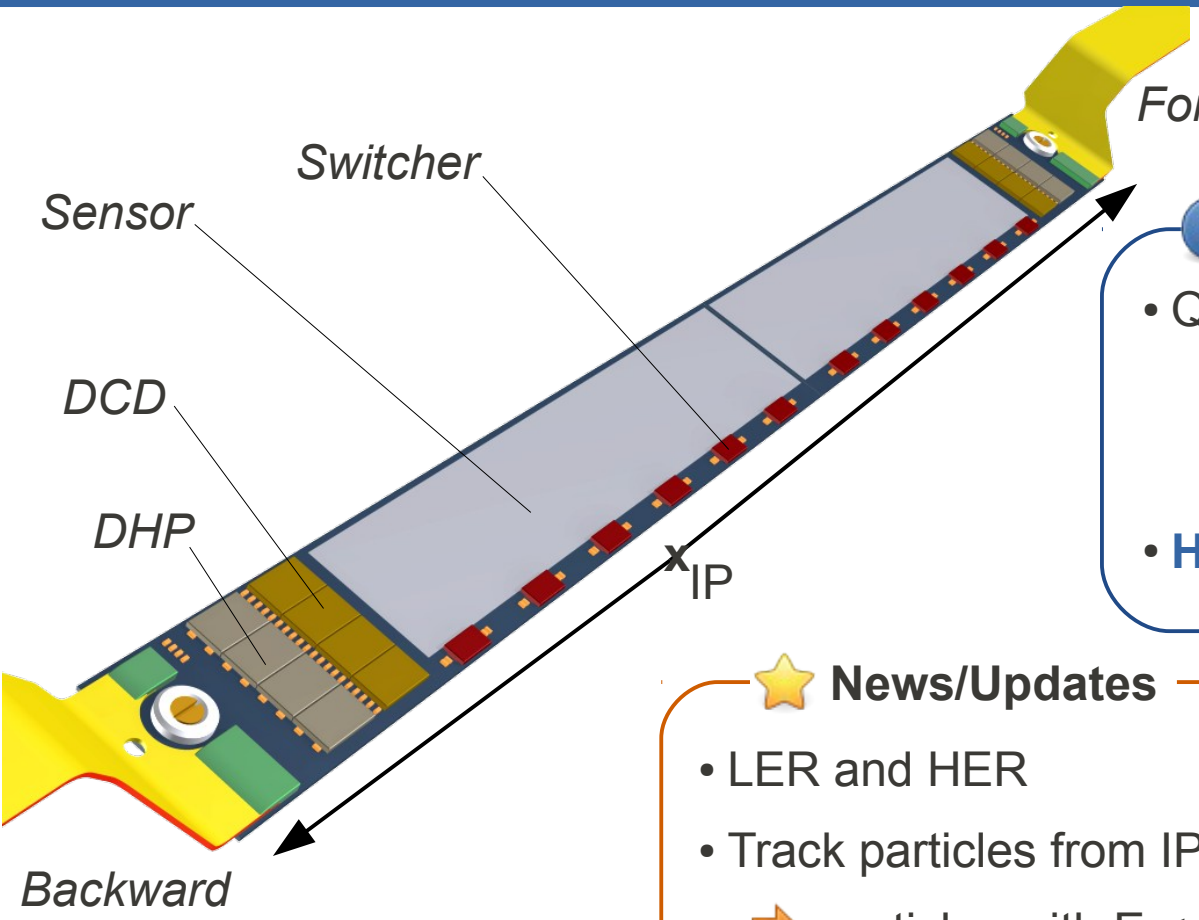
Touschek HER

Occupancy ≈ 0 %









Radiative Bhabha

- QED process
  - Back scattered particles hit PXD
  - Particles from “outside”
- **Highest background at SuperKEKB**

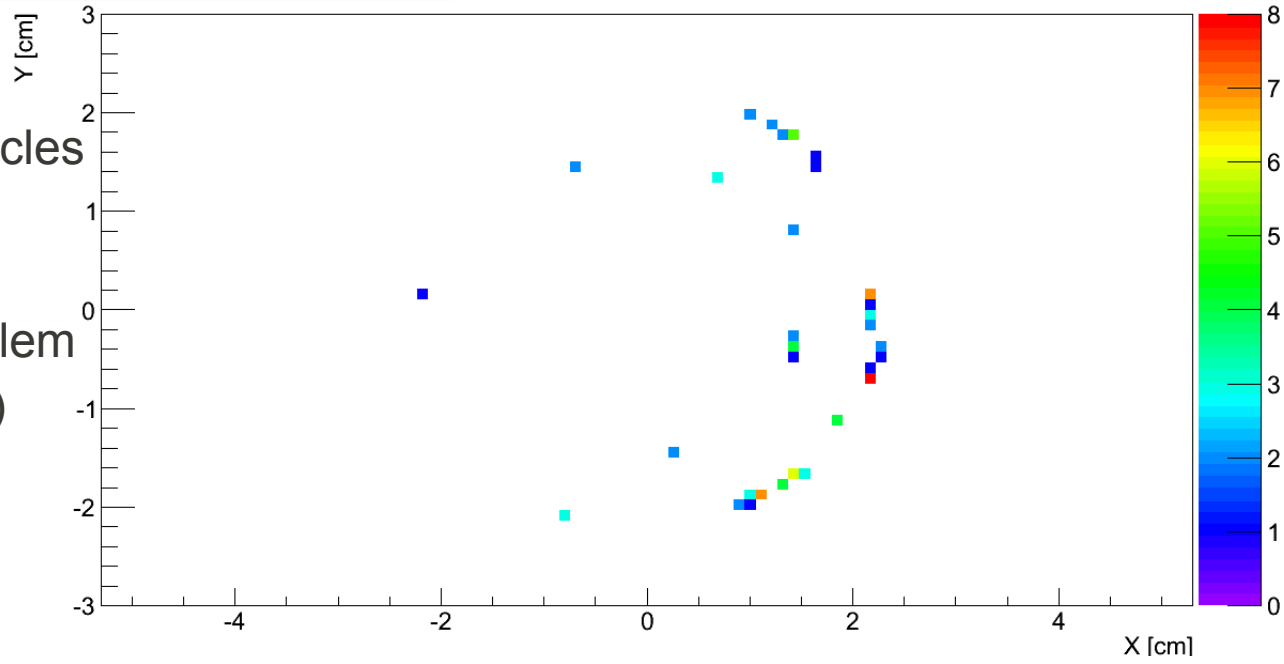
News/Updates

- LER and HER
- Track particles from IP with SAD until they are lost
  - particles with E < 2 GeV are lost within 4 m from IP

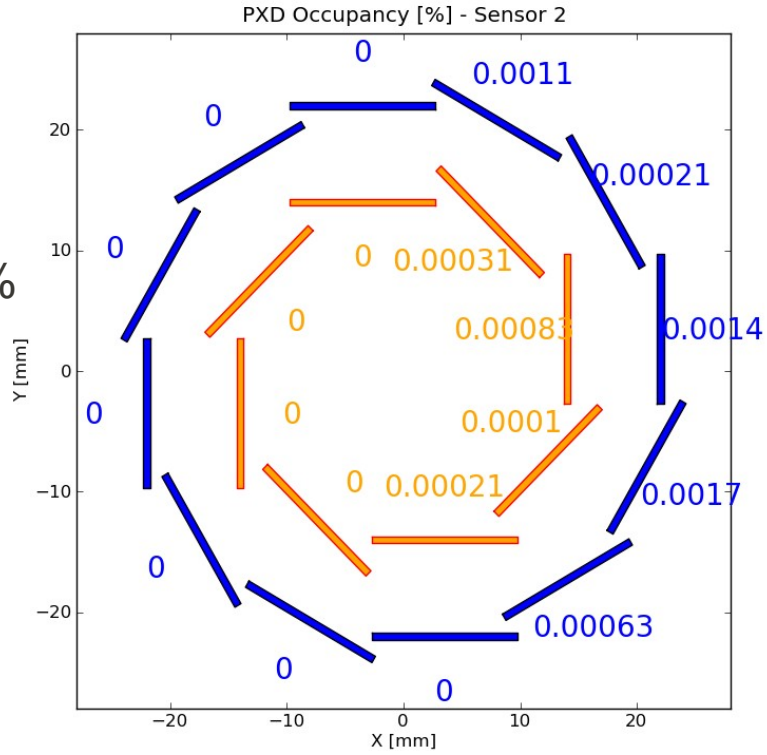
Simulation/Digitization

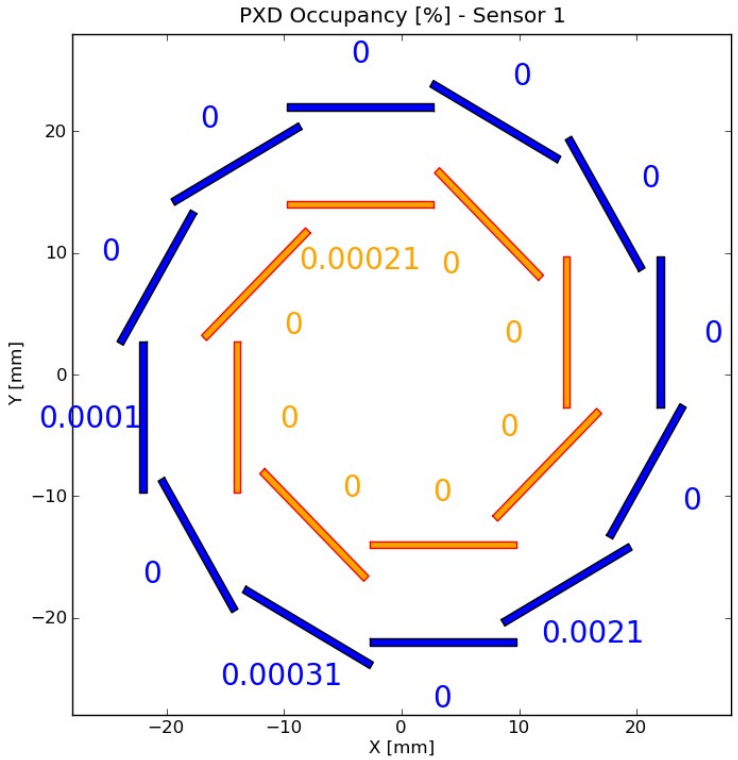
- Input data from SAD: one input file, Geant4 random seed
- **5** PXD readout frames
- official data (provided by Nakayama-san)

- Hits only from **back-scattered** particles
- **Good:** most particles **miss PXD**
  - Radiative Bhabha serious problem for other detectors (CDC, TOP)
- **Asymmetry** from crossing angle



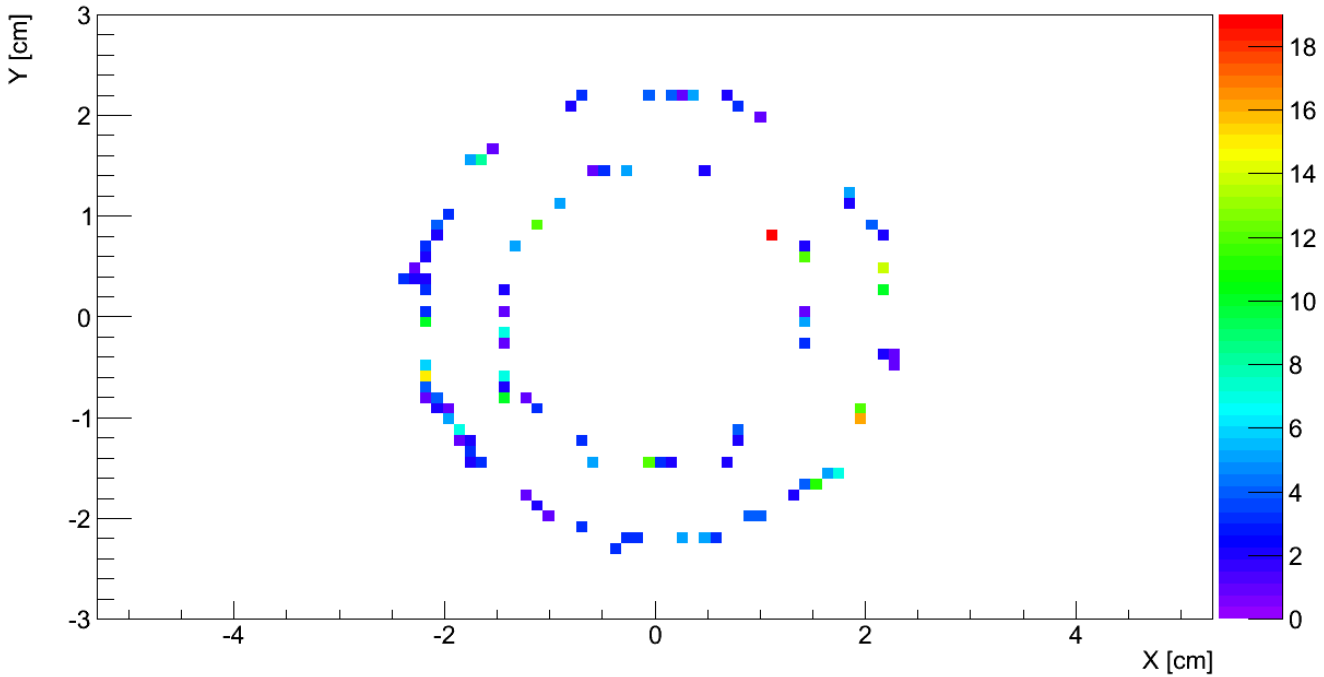
Occupancy < 10^{-3} %

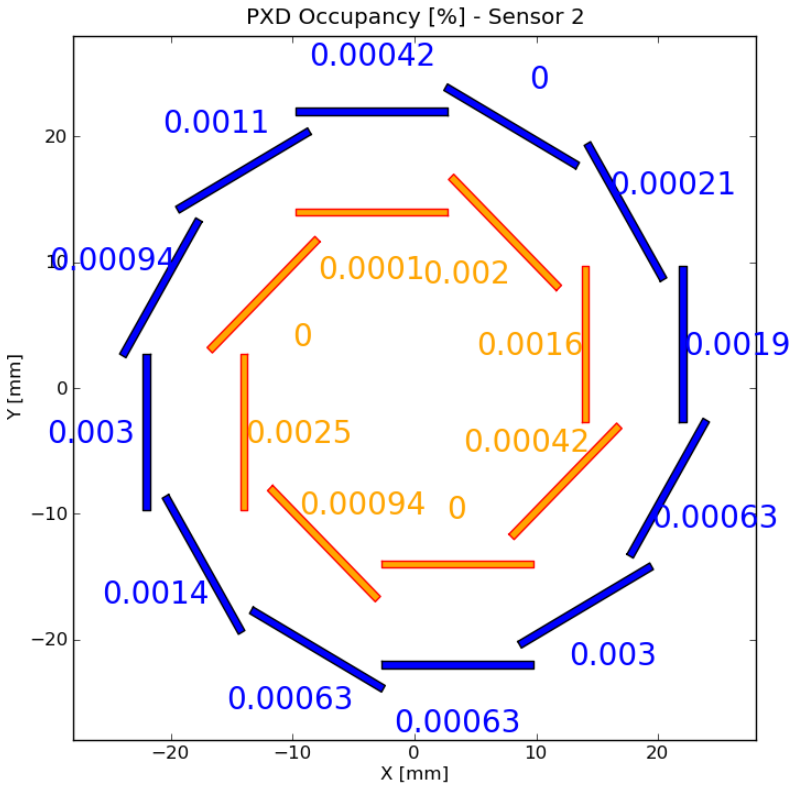


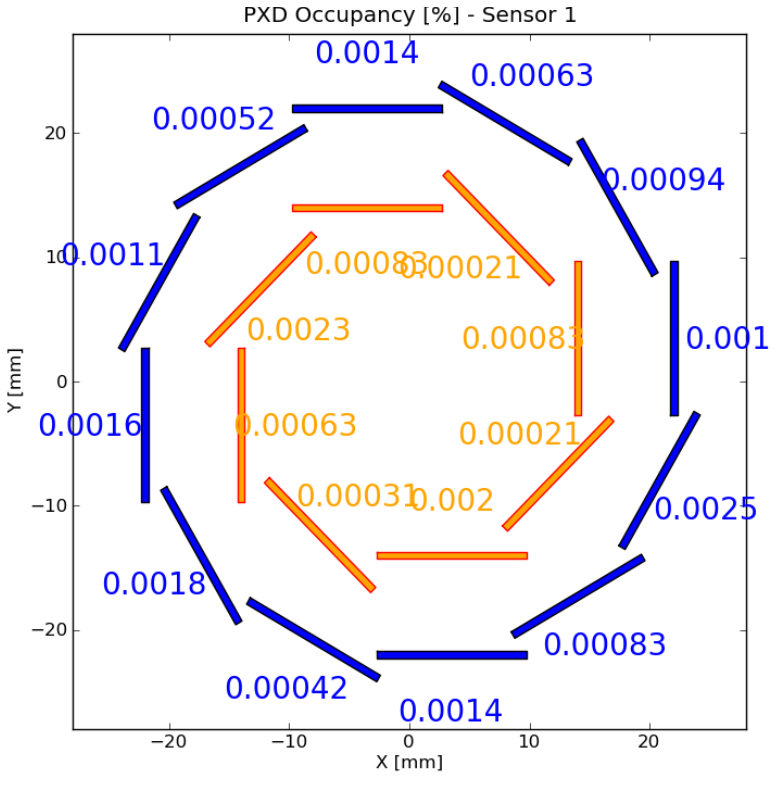


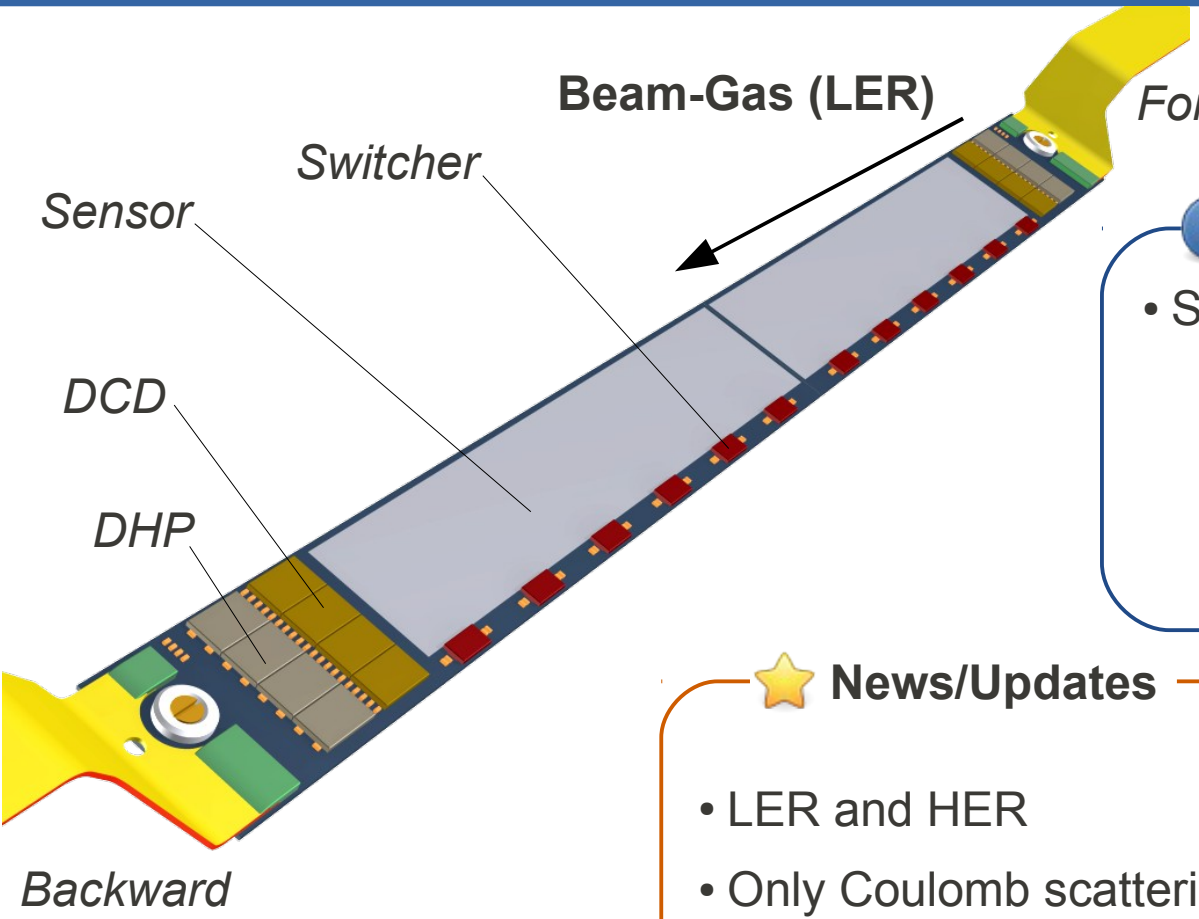
Radiative Bhabha HER

Occupancy < 10^{-3} %









Beam-Gas scattering

- Scattering on the residual gas nuclei
  - 1st order: Coulomb (elastic)
  - 2nd order: Bremsstrahlung (inelastic)
  - Particles from “outside”

News/Updates

- LER and HER
- Only Coulomb scattering at the moment

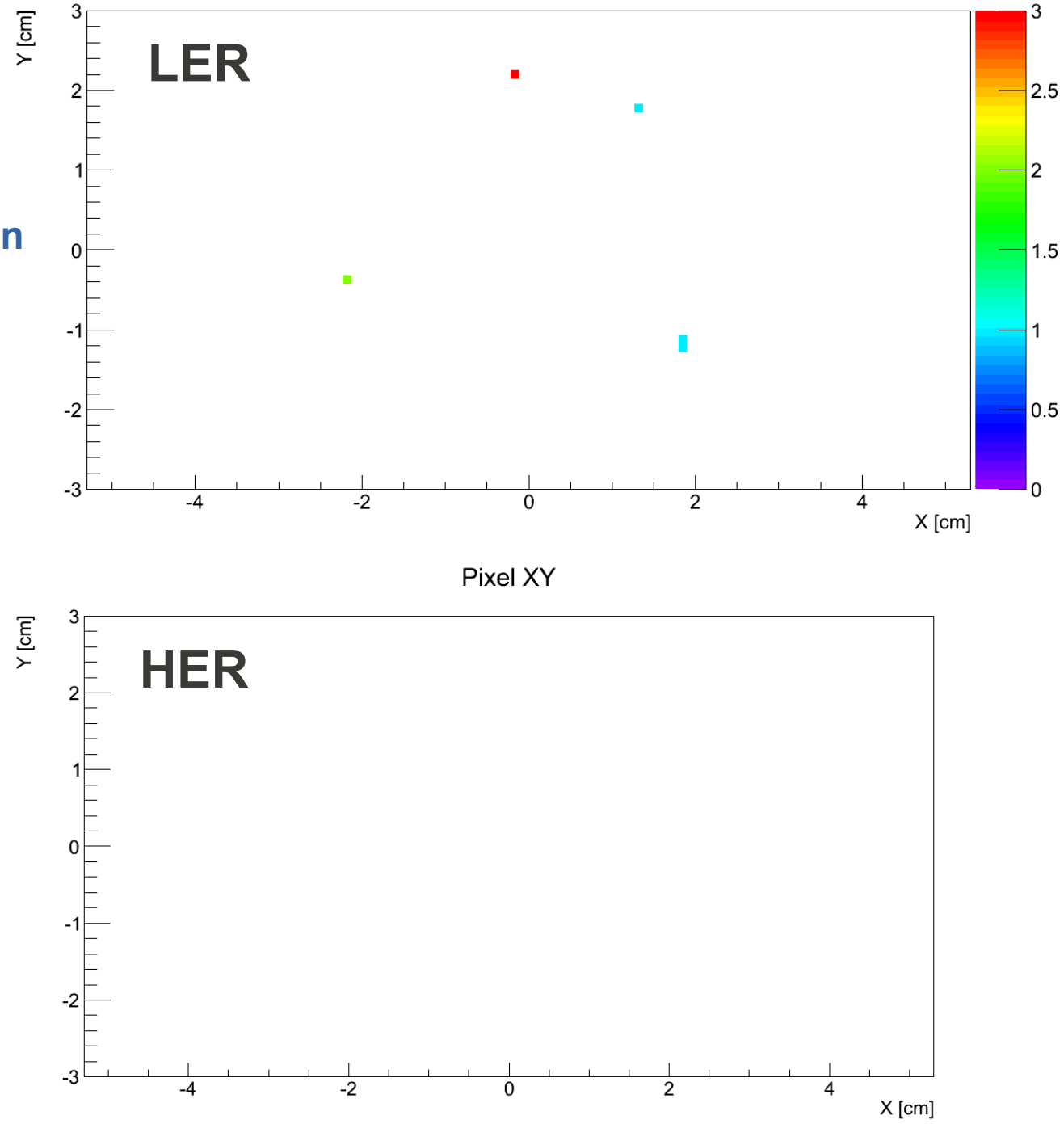
Simulation/Digitization

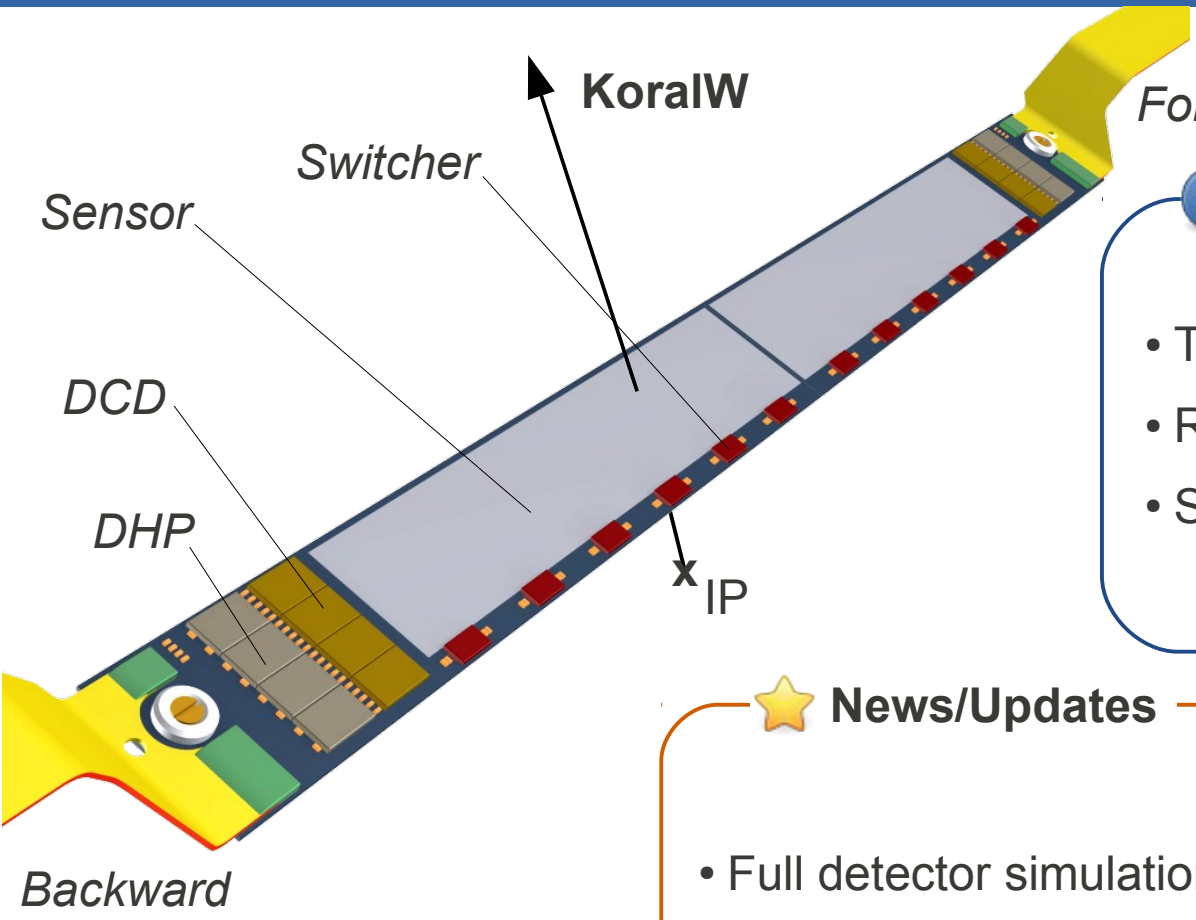
- Input: 2 space-points calculated, shoot particles according to loss-rate from there
- **realistic SAD input not yet available**
- **5** PXD readout frames
- official data (provided by Nakayama-san)

Beam-Gas Coulomb

- Very, very **rough approximation**
  - ➡ not very realistic
- Realistic input available **soon**

Occupancy ≈ 0 %





4-fermion final state QED

- Two photon QED process
- Rate increases with the luminosity
- Signal-like event topology

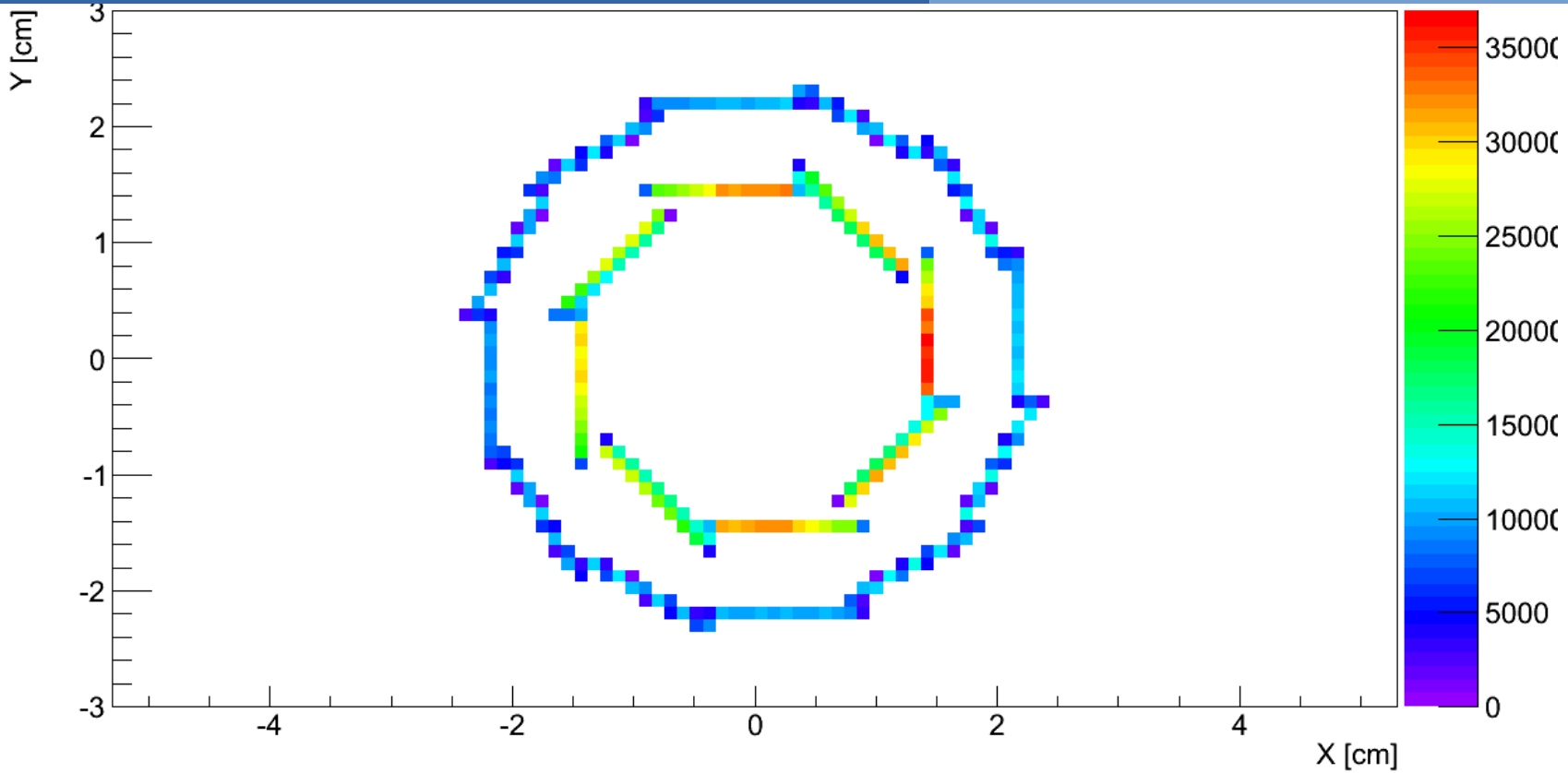
News/Updates

- Full detector simulation (not only PXD)

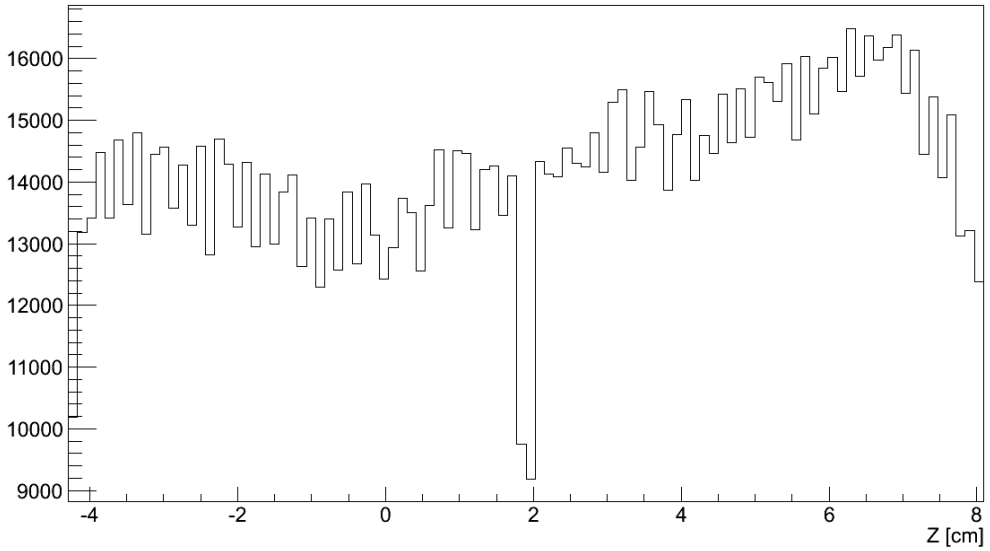
Simulation/Digitization

- KoralW generator, no ISR
- **139** PXD readout frames

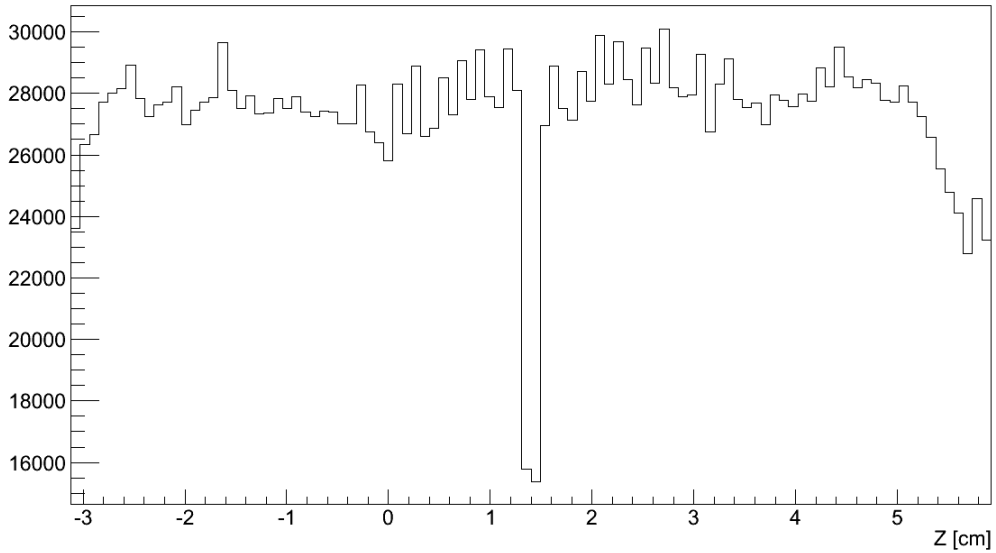
Occupancy – 4-fermion final state QED

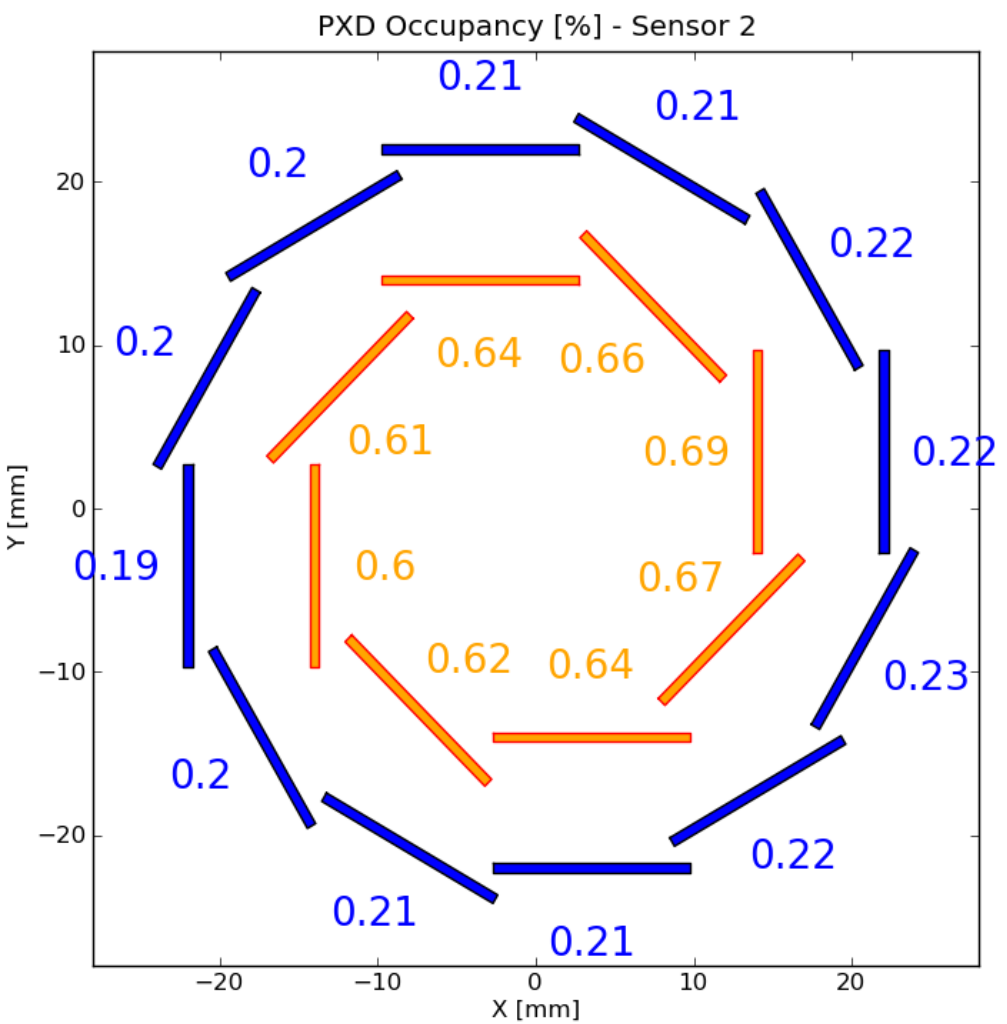


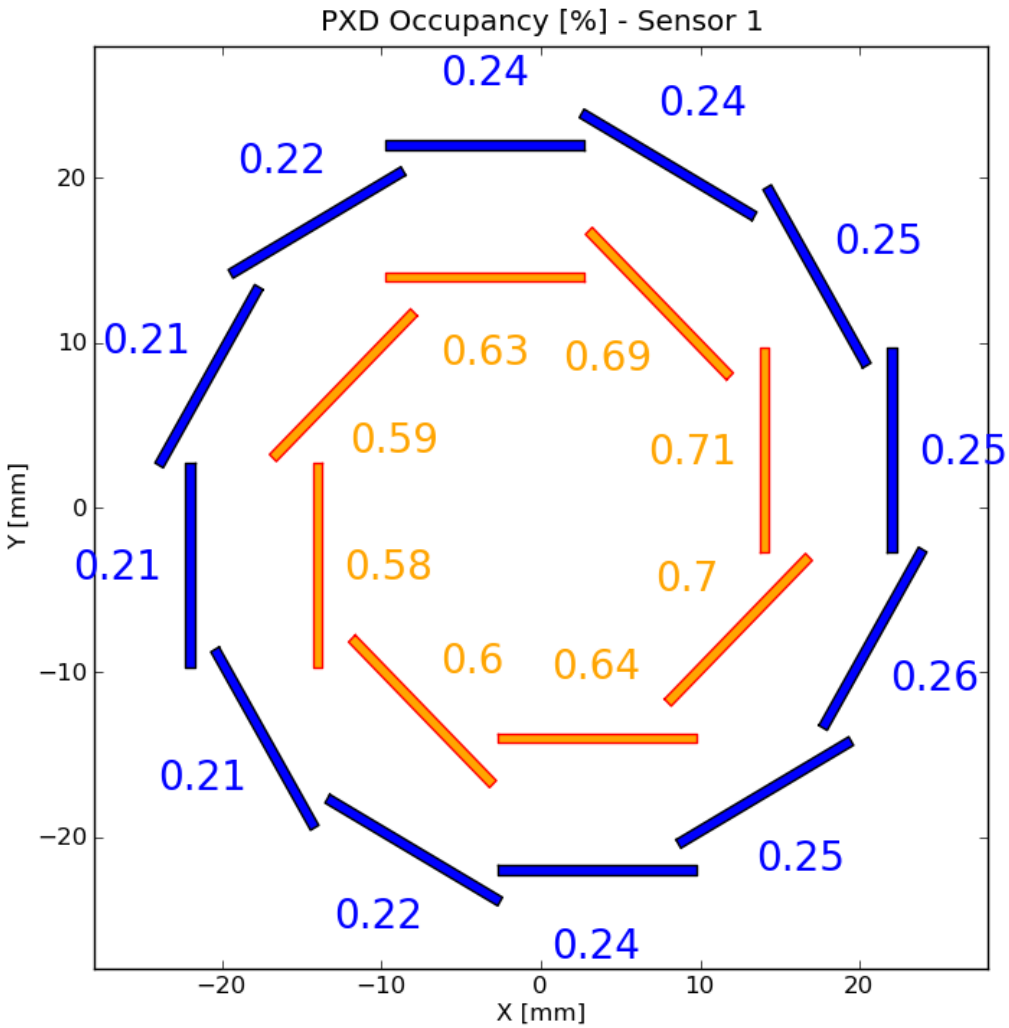
Pixel Z - Layer 2



Pixel Z - Layer 1




PXD Occupancy [%] - Sensor 2
0.21
0.21
0.2
0.22
0.2
0.64
0.66
0.61
0.69
0.22
0.19
0.6
0.67
0.62
0.64
0.23
0.2
0.22
0.21
0.21
Y [mm]
X [mm]
20
10
0
−10
−20
−20
−10
0
10
20


PXD Occupancy [%] - Sensor 1
0.24
0.24
0.22
0.25
0.21
0.63
0.69
0.59
0.71
0.25
0.21
0.58
0.7
0.6
0.64
0.26
0.21
0.25
0.22
0.24
Y [mm]
X [mm]
20
10
0
−10
−20
−20
−10
0
10
20


2. *. 2
2. *. 1
1 *. 2
1 *. 1
bwd
fwd

		Layer 1	Layer 2
Touschek	LER	**0.12 %**	**0.09%**
Touschek	HER	0.0 %	0.0 %
Beam-Gas Coulomb	LER	0.0 %	0.0 %
Beam-Gas Coulomb	HER	0.0 %	0.0 %
Radiative Bhabha	LER	10^{-4} %	10^{-4} %
Radiative Bhabha	HER	10^{-3} %	10^{-3} %
4-fermion final state QED		**0.64 %**	**0.23 %**
Total		**0.76 %**	**0.32 %**

Number of Neutrons **per second per cm^2**
Unfortunately, **low statistics**

		Switcher		DCD		DHP	
		-Z	+Z	-Z	+Z	-Z	+Z
Touschek	LER	829	2724	2232	2009	2605	2158
Touschek	HER	473	473	744	371	0	148
Beam-Gas Coulomb	LER	2133	473	744	0	1786	297
Beam-Gas Coulomb	HER	0	0	0	0	0	0
Radiative Bhabha	LER	473	711	297	1488	1488	1786
Radiative Bhabha	HER	947	5687	3572	1334	3572	4019
KoralW		1049	1023	1543	1730	1859	2100
Total (Neutrons per s per cm^2)		**5904**	**10068**	**9132**	**6932**	**11310**	**10508**

About 10^4 Neutrons per second per cm^2 from background

- ✓ Updated Background for Touschek and KoralW
- ✓ New Backgrounds for Beam-Gas and Radiative Bhabha
- ✓ Full detector simulation (not only PXD)
- ✓ Total occupancy is 0.8 % for inner layer and 0.3 % for outer layer
- ✓ Neutron flux is estimated to be 10^4 Neutrons per second per cm^2

Outlook

- Simulate more statistics as soon as numbers from accelerator group start converging
- Add synchrotron radiation background
- Add 3D magnetic field