

Detector backgrounds in Central Tracking Detectors

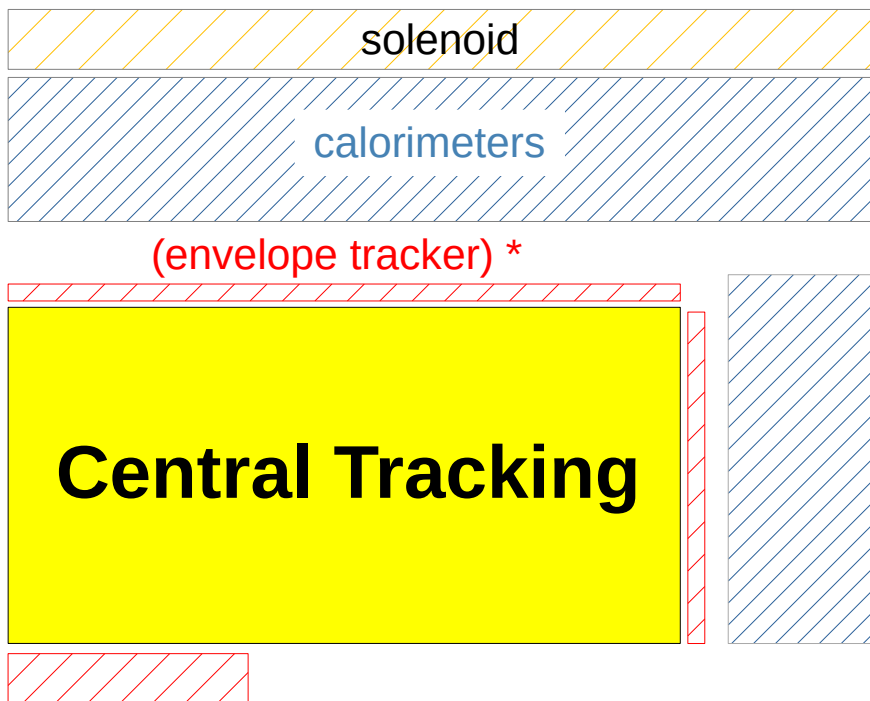
Daniel Jeans, KEK/IPNS

inputs from many in the MDI, detector, software groups



FCC week 2026 @ Helsinki





Central tracking system provides

- charged particle reconstruction
- momentum measurement
in tandem with **vertex (& envelope)**
- (particle identification)
via dE/dx or dN/dx

* see Armin Ilg's talk

Central tracker: technologies

gas

time projection chamber
drift chamber
straw tubes

optical

fibre tracker

silicon

pixels, strips, MAPS

Key aspects

single measurement precision

measurements / track

pattern recognition

particle ID : dE/dx , dN/dx

material budget & distribution

operational stability

calibration & alignment

construction complexity

...

In this talk, survey expected
background levels in the central trackers

Considered background sources:

Incoherent Pair Creation (IPC)

Synchrotron Radiation (SR) from particles in beam **core** and **halo**
[assuming perfect orbit]

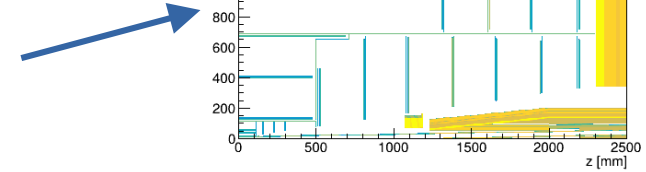
Beam Gas interactions – “worst case” before full vacuum conditioning
expect 100x less after conditioning

all for recent machine optics LCC v106.2 @ 91 GeV
fresh results → preliminary !

results for several tracker technologies

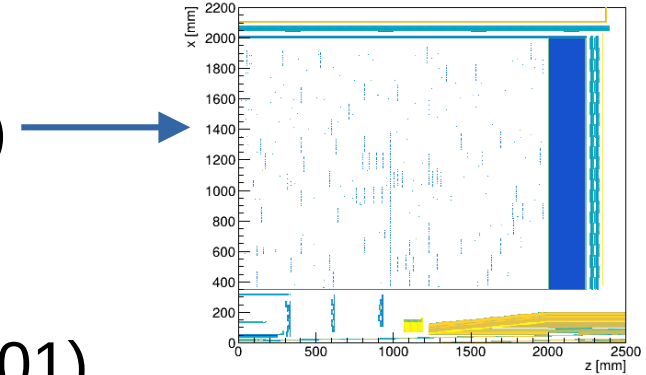
Silicon tracker

(in CLD_o2_v08)

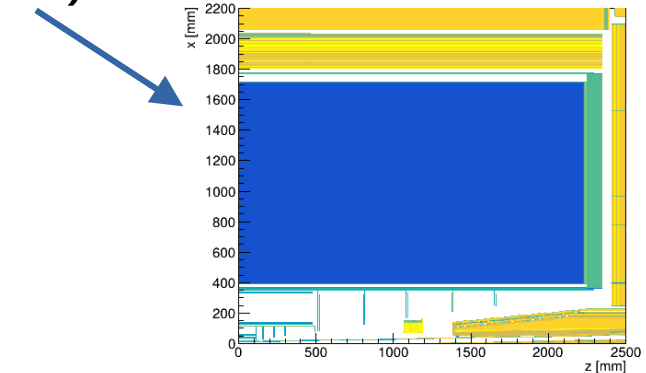


Drift Chamber

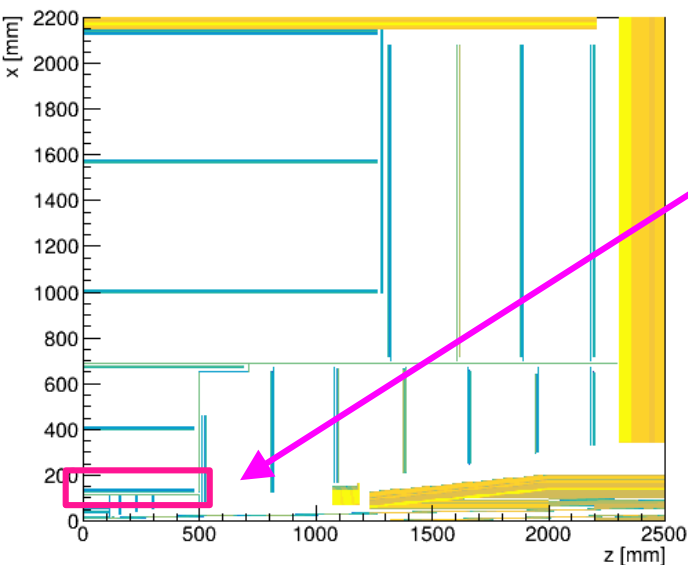
(in IDEA_o1_v03)



Time Projection Chamber (in ILD_FCCee_v01)



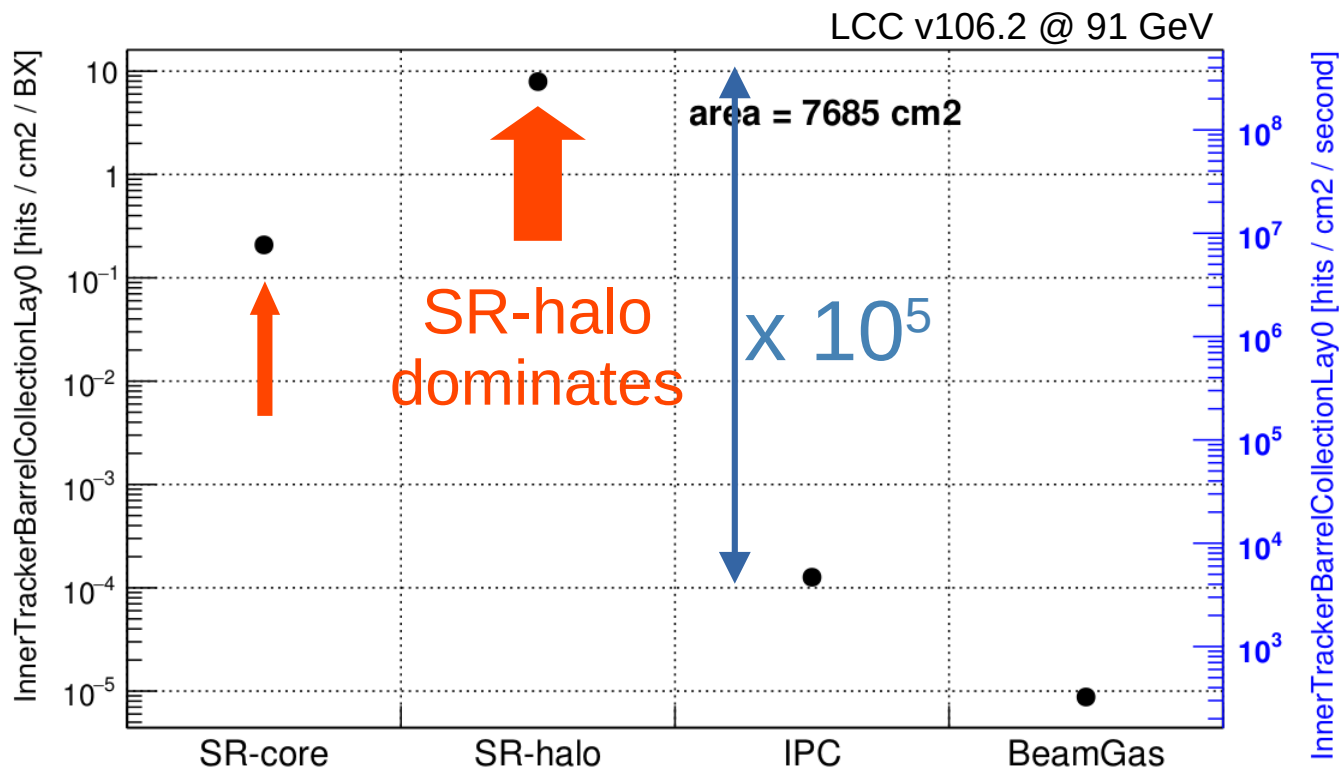
other technologies not yet available
in full detector simulation models

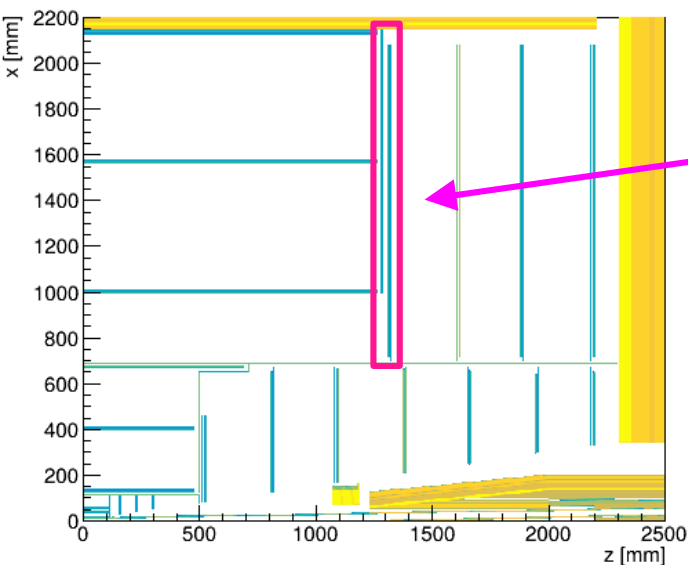


average hit density
energy > MIP/5
pixel multiplicity=1
no safety factor

Silicon tracker (CLD): number of hits

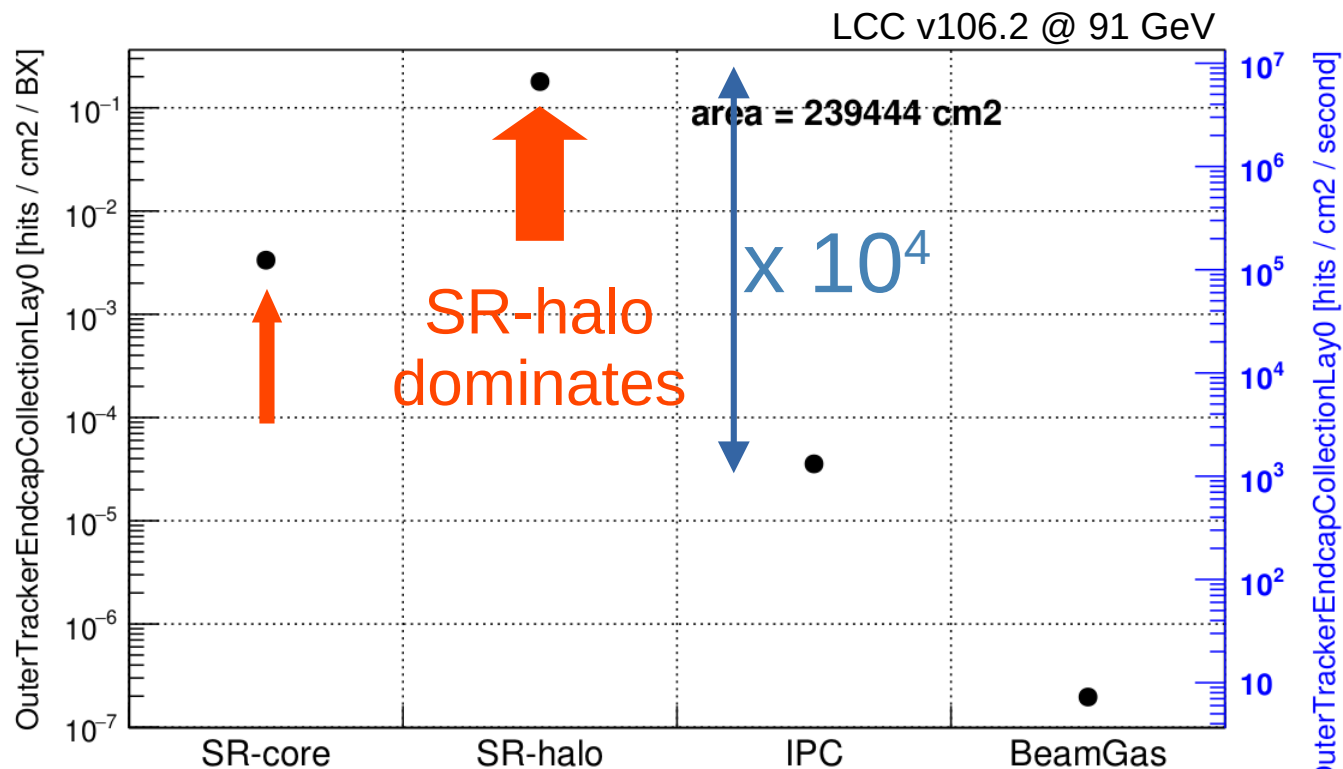
1st layer, Inner Tracker Barrel

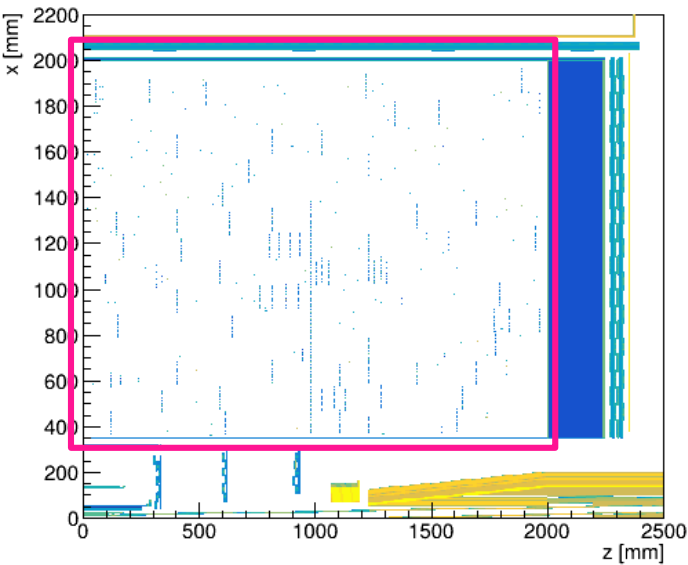




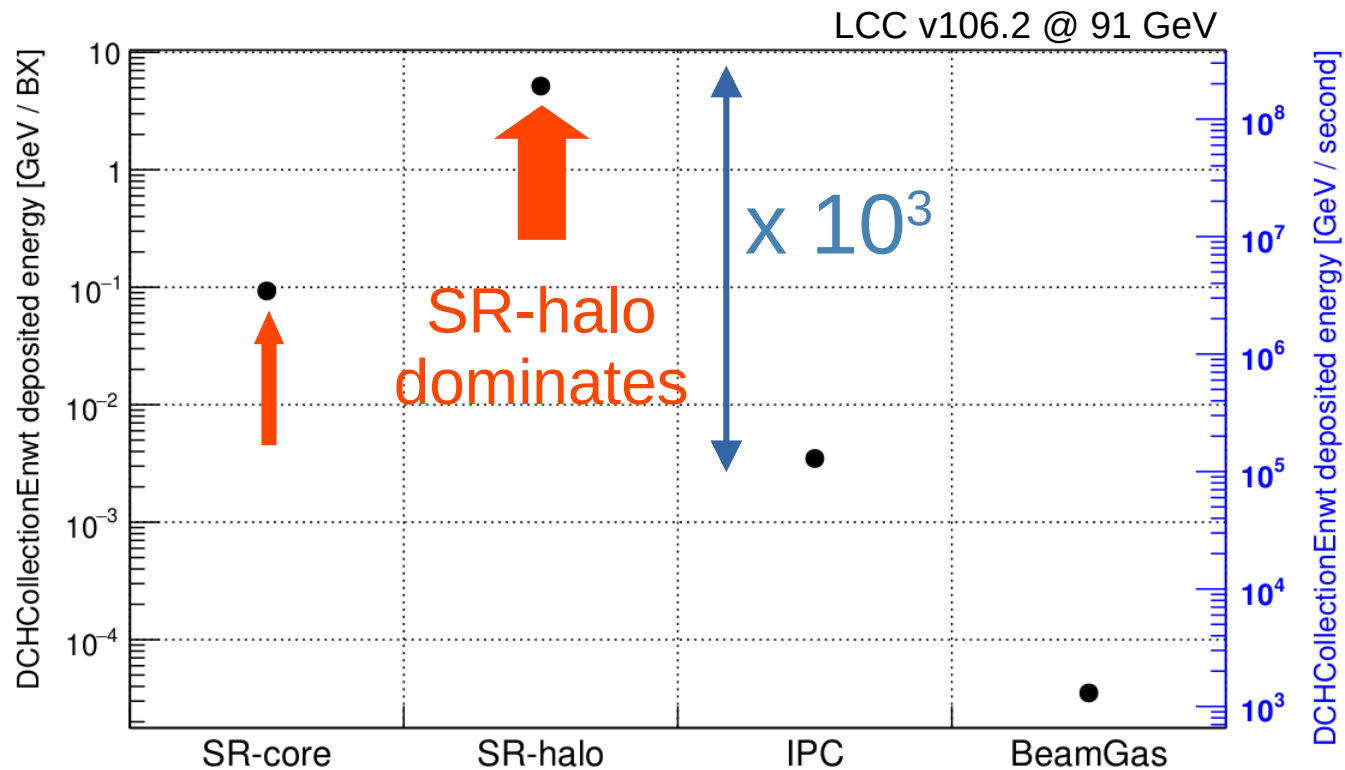
average hit density
energy > MIP/5
pixel multiplicity=1
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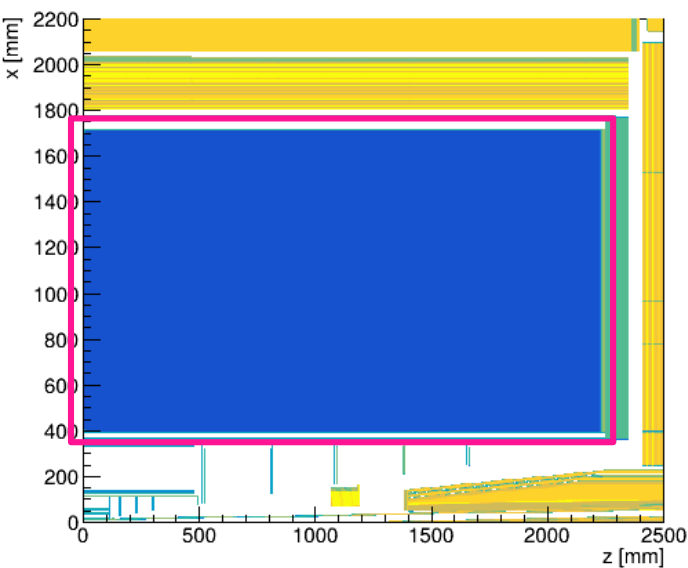
Silicon tracker (CLD): number of hits
1st layer, Outer Tracker Endcap





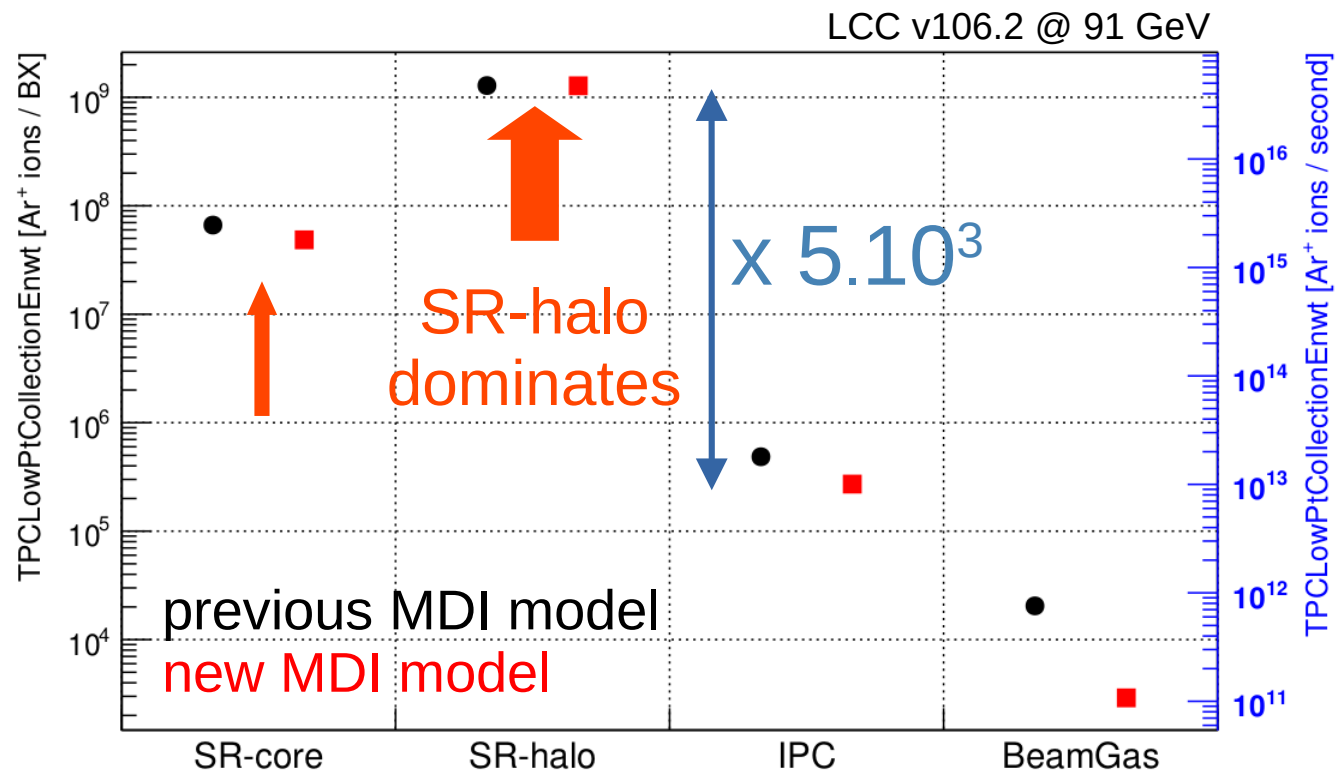
Drift Chamber (IDEA): total energy deposited in DCH





New MDI description
modest improvement for
some sources,
no change for dominant SR

Time Projection Chamber (ILD): ion production



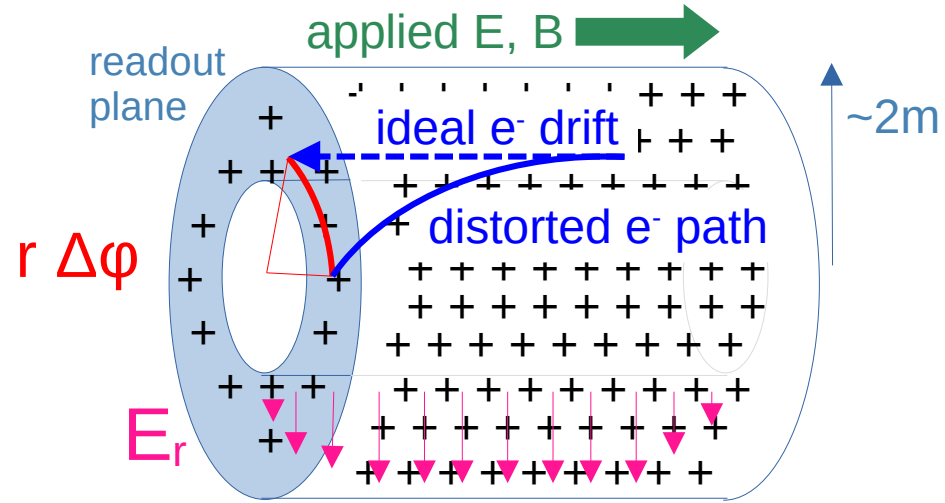
Space-charge in TPC

slow ion drift (~ 5 m/s) $\rightarrow$
ion cloud in tracking volume

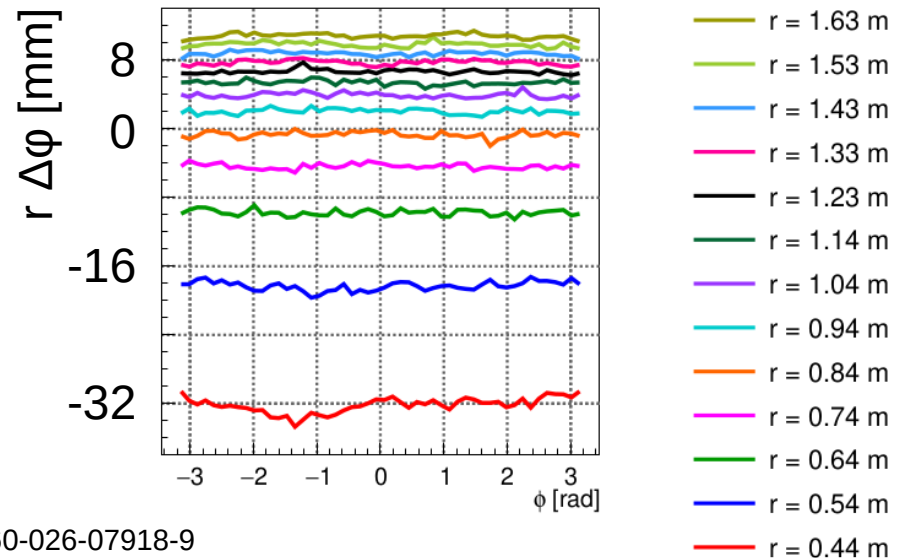
additional **E-field** $\rightarrow$
distorted electron trajectories
radial field E_r (r, ϕ, z) $\rightarrow$ affects track sagitta

for **IPC background** @ FCCee-91,
distortion typically several mm
can reach few cm
(with optimistic ion backflow assumption)
distortions seem stable @ μm

concern about much larger **SR-induced bg.**

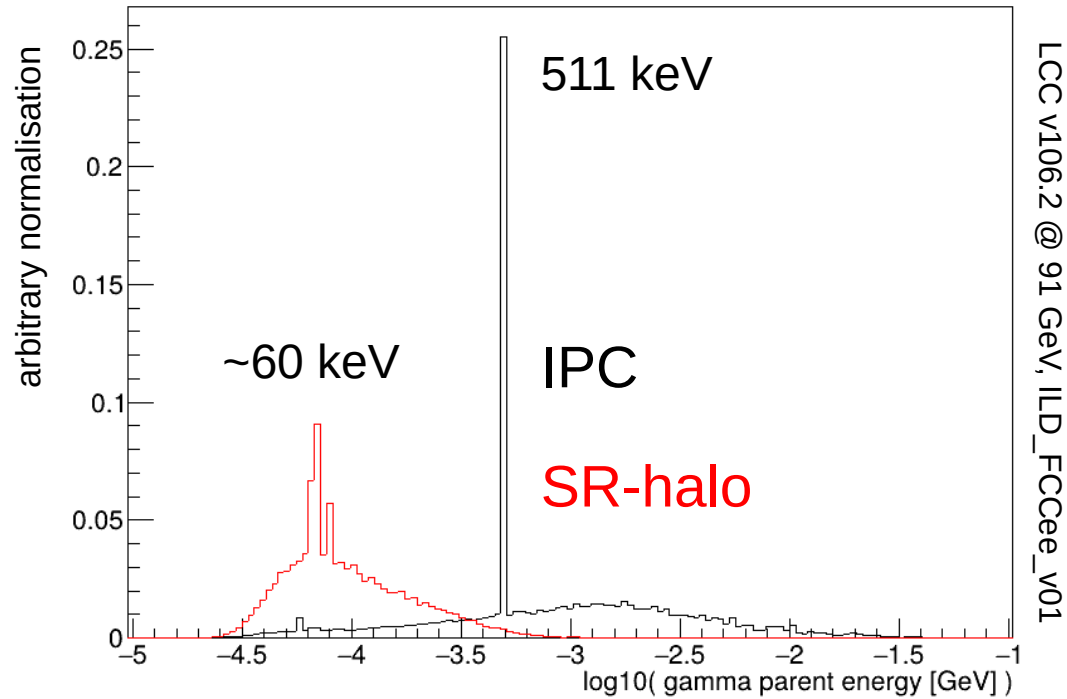


FCCee91: distortion in ϕ direction: $r \Delta\phi$



only photons can get from IP region to tracker
(low p_T , B-field)

only photons can get from IP region to tracker
(low p_T , B-field)



(energy of each TPC hit's
youngest photon ancestor)

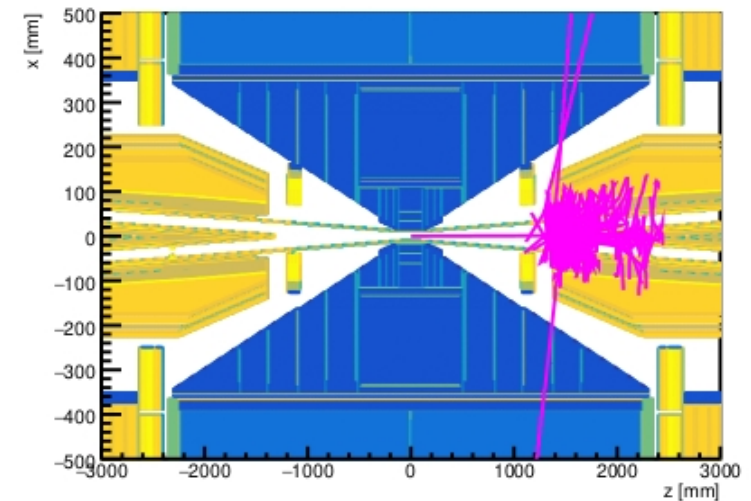
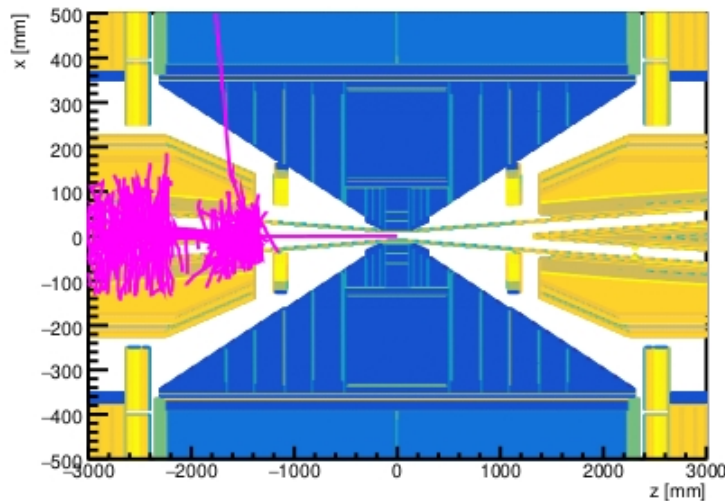
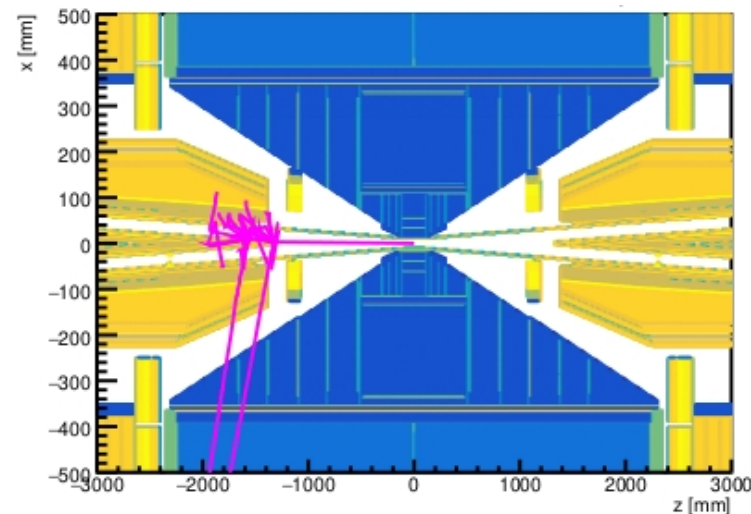
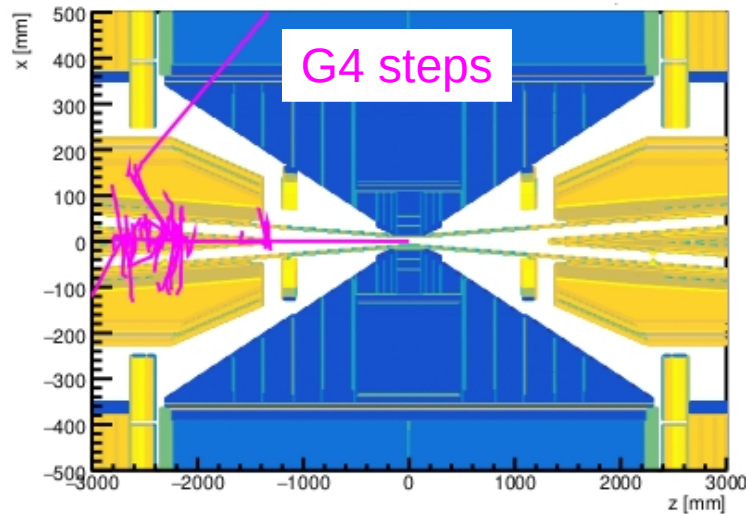
energy of photons which induce TPC hits

IPC

shower @
beampipe crotch

photons traverse
MDI material

→ increase W
component ?

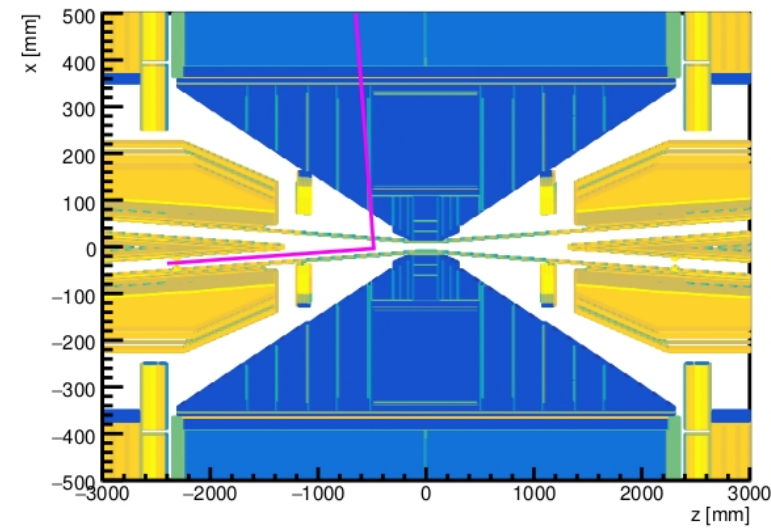
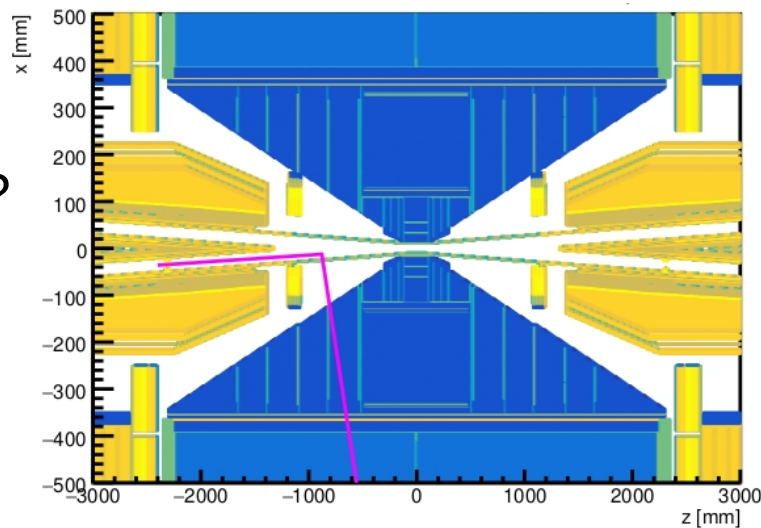
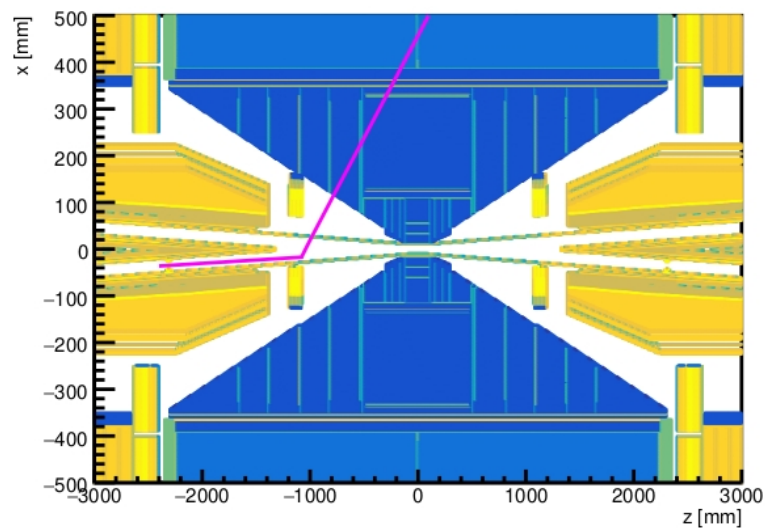
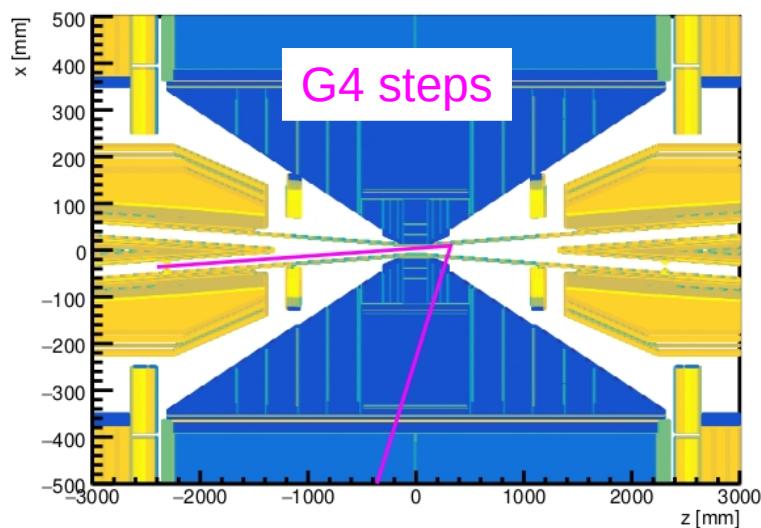


SR

photons scatter off
beampipe into
tracker

beampipe coating?

reduce incoming
flux $\rightarrow$ collimation ?



take-home message

@ 91 GeV	Silicon Tracker pixel rate @ 3 pix/hit	Drift Chamber occupancy	TPC typical distortion
IPC	10 kHz / cm ²	~7%*	few mm
SR my back-of-envelope	~GHz / cm ²	>1000%	few m

IPC [comfortable → challenging]
SR [extremely challenging → impossible]

Summary

several contrasting central tracker technologies considered for FCCee

new central tracker background estimates for FCCee-91 (preliminary)
using recent beam parameters & MDI description

Synchrotron Radiation dominates

~100 keV SR photons scatter off central beampipe into tracker

current background estimates are

extremely challenging → **impossible** for current technologies

must strongly reduce SR contribution...

tighter upstream collimation ? beampipe design/coating ?

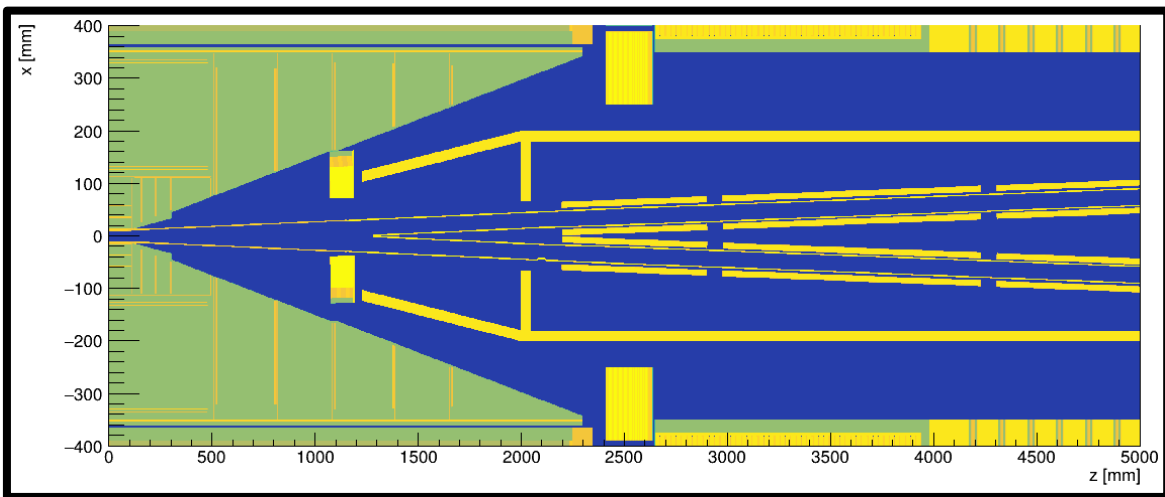
... else suitable tracking technology options will be severely constrained

should also look at WW, ZH, tt runs with latest parameters & designs,
& effects of backgrounds on track reconstruction

backup

Common MDI implemented in detector simulation models

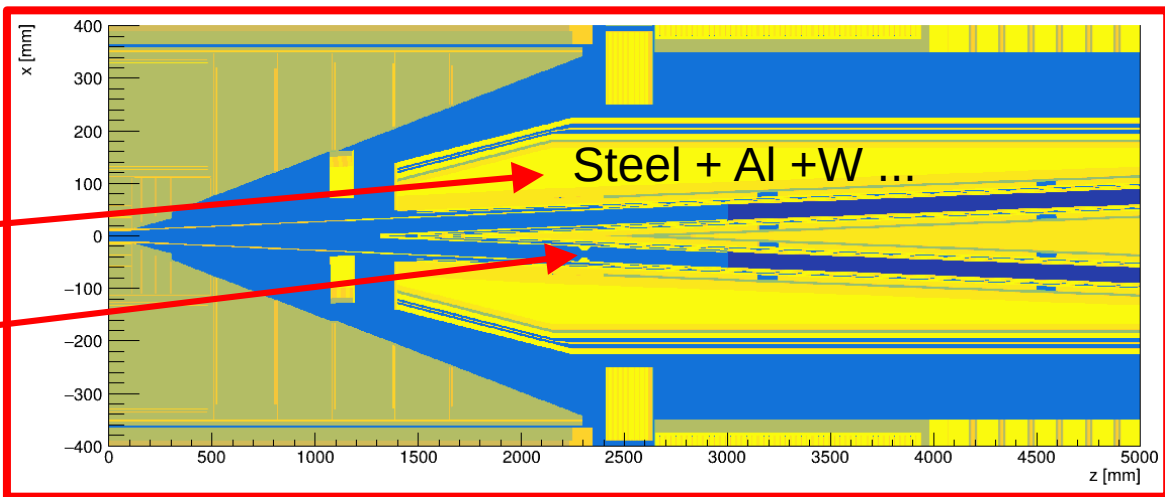
previous CAD-based model
MDI_o1_CADBased_v01



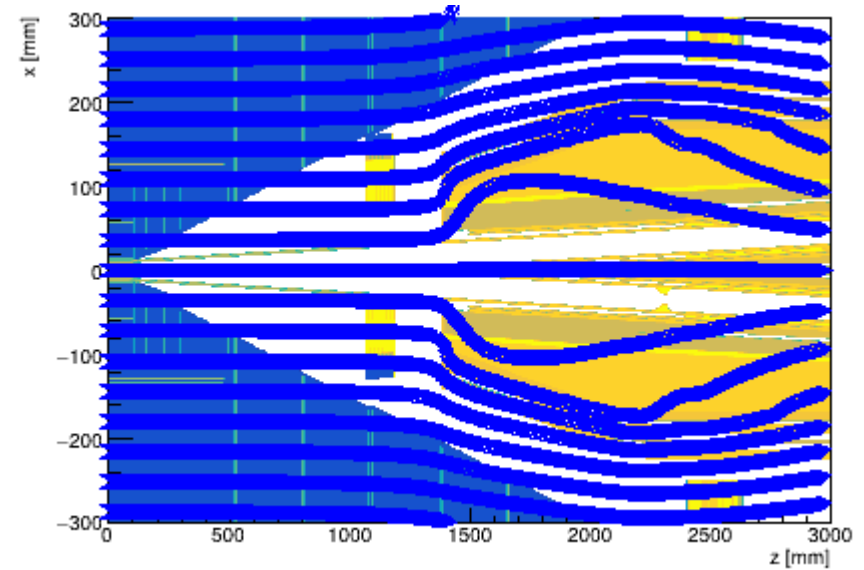
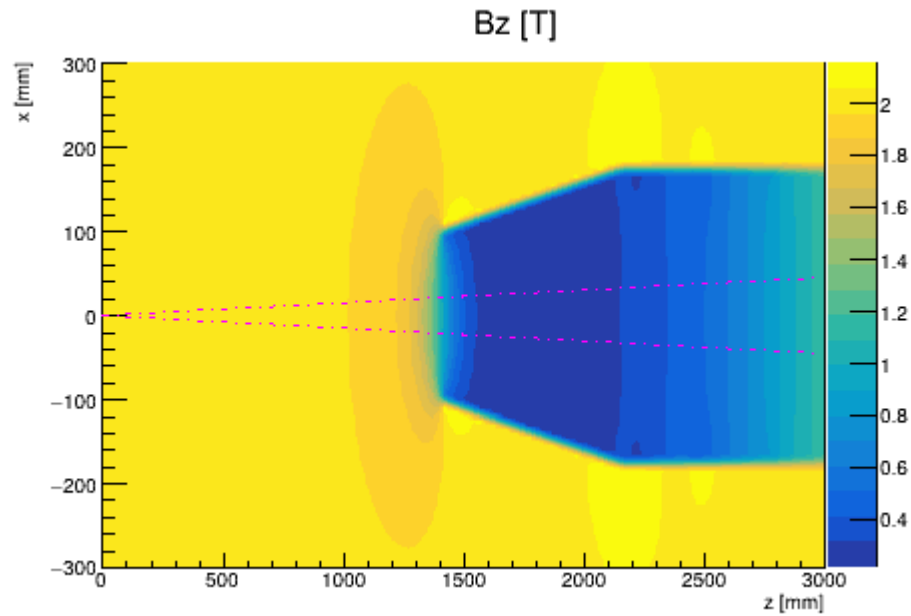
new CAD-based model
MDI_o1_CADBased_v02

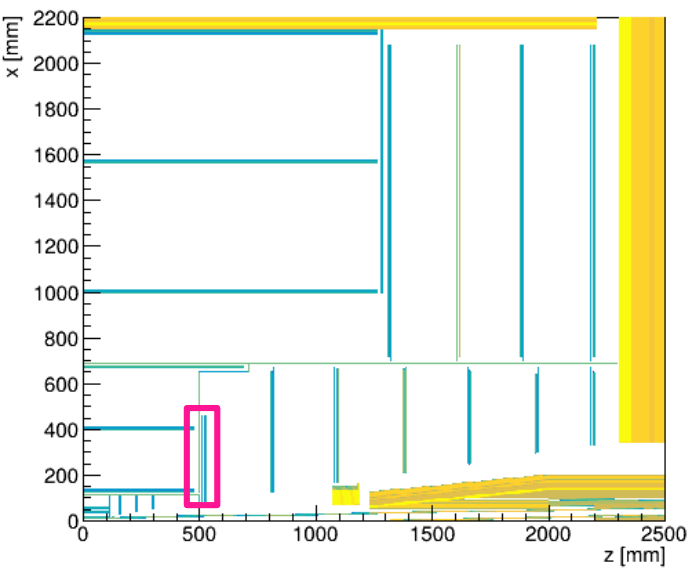
Cryostat full of material

SR masks

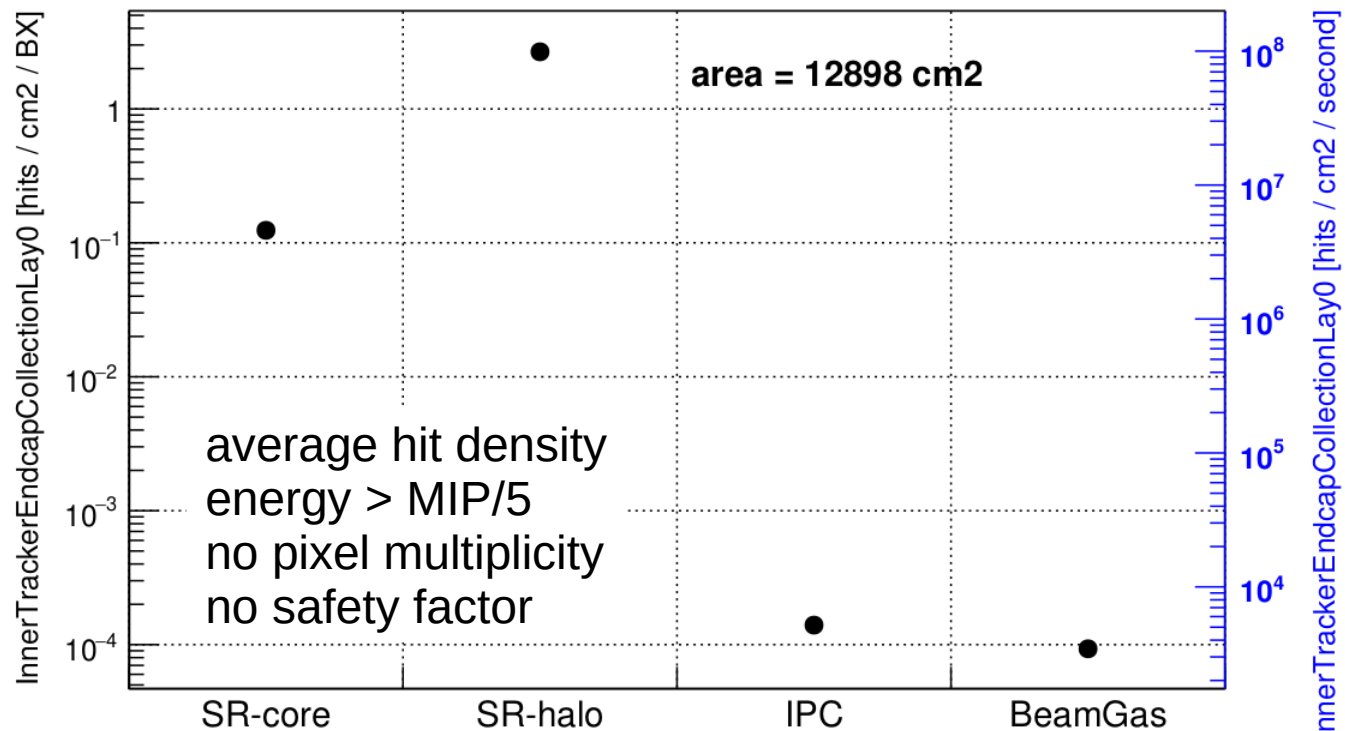


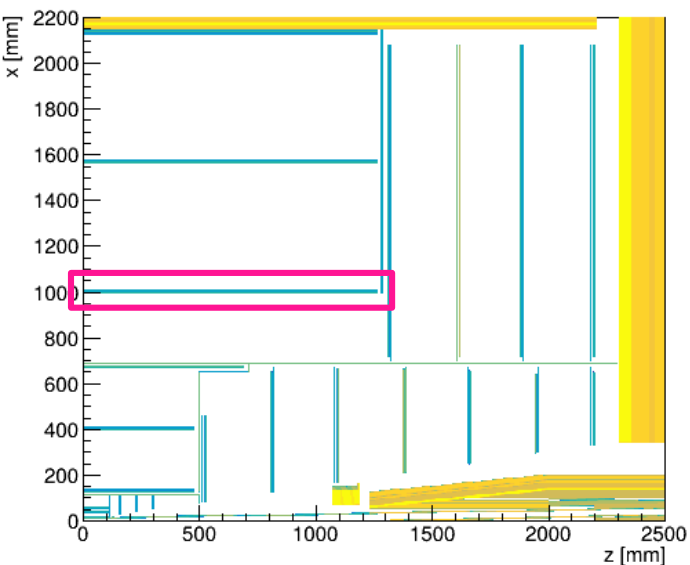
Magnetic field in detector models



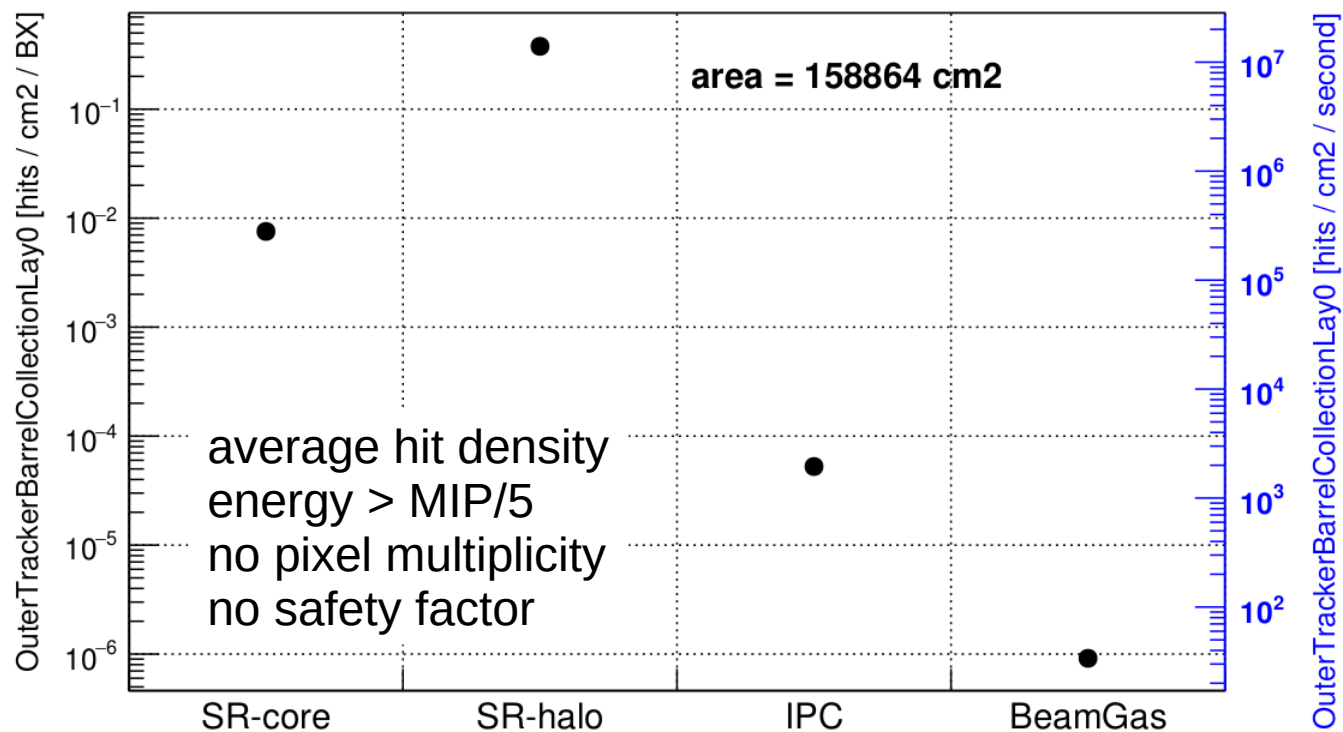


Silicon tracker (CLD): number of hits

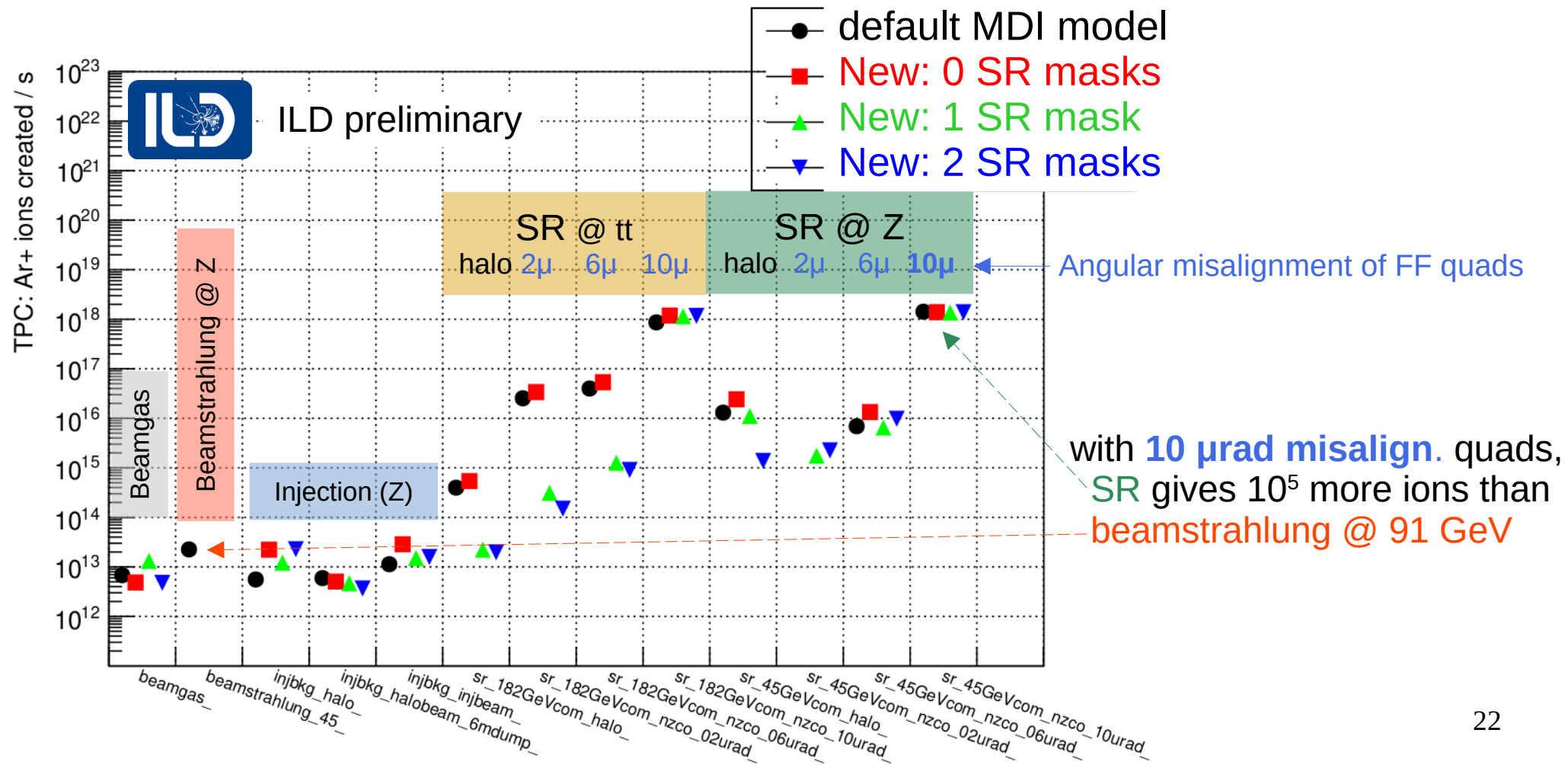




Silicon tracker (CLD): number of hits



Old results (Munich meeting)



Time Projection Chamber (ILD): ion production

Comparison with previous results

GHC optics
different MDI description
small statistics samples
...

