Lumical @ future ee collider beamstrahlung and other studies

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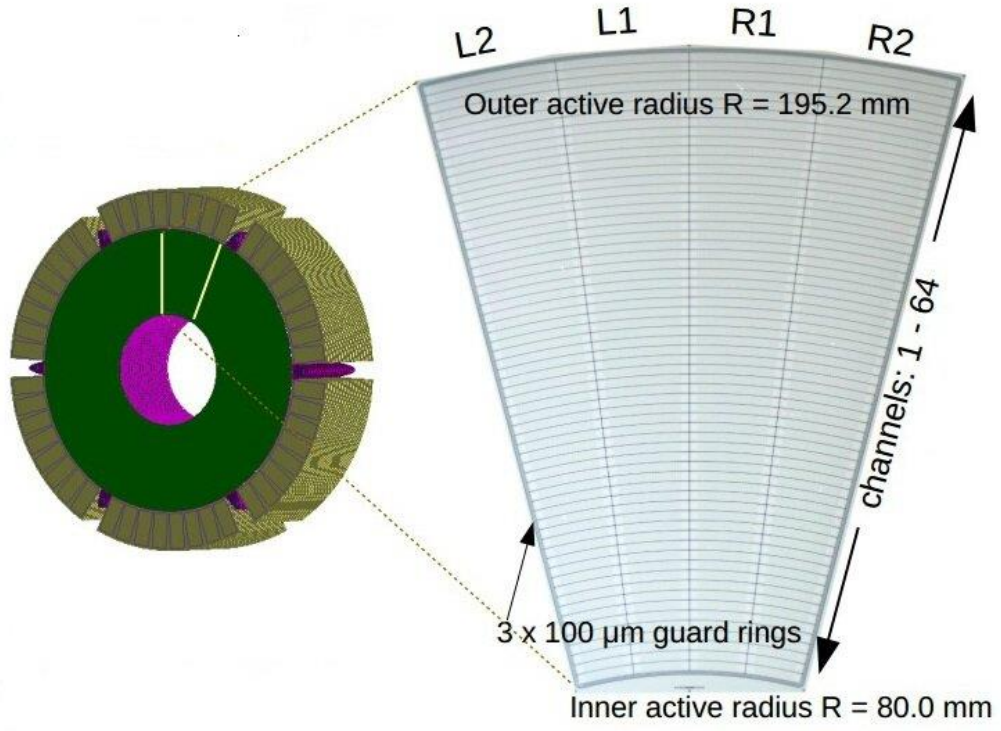
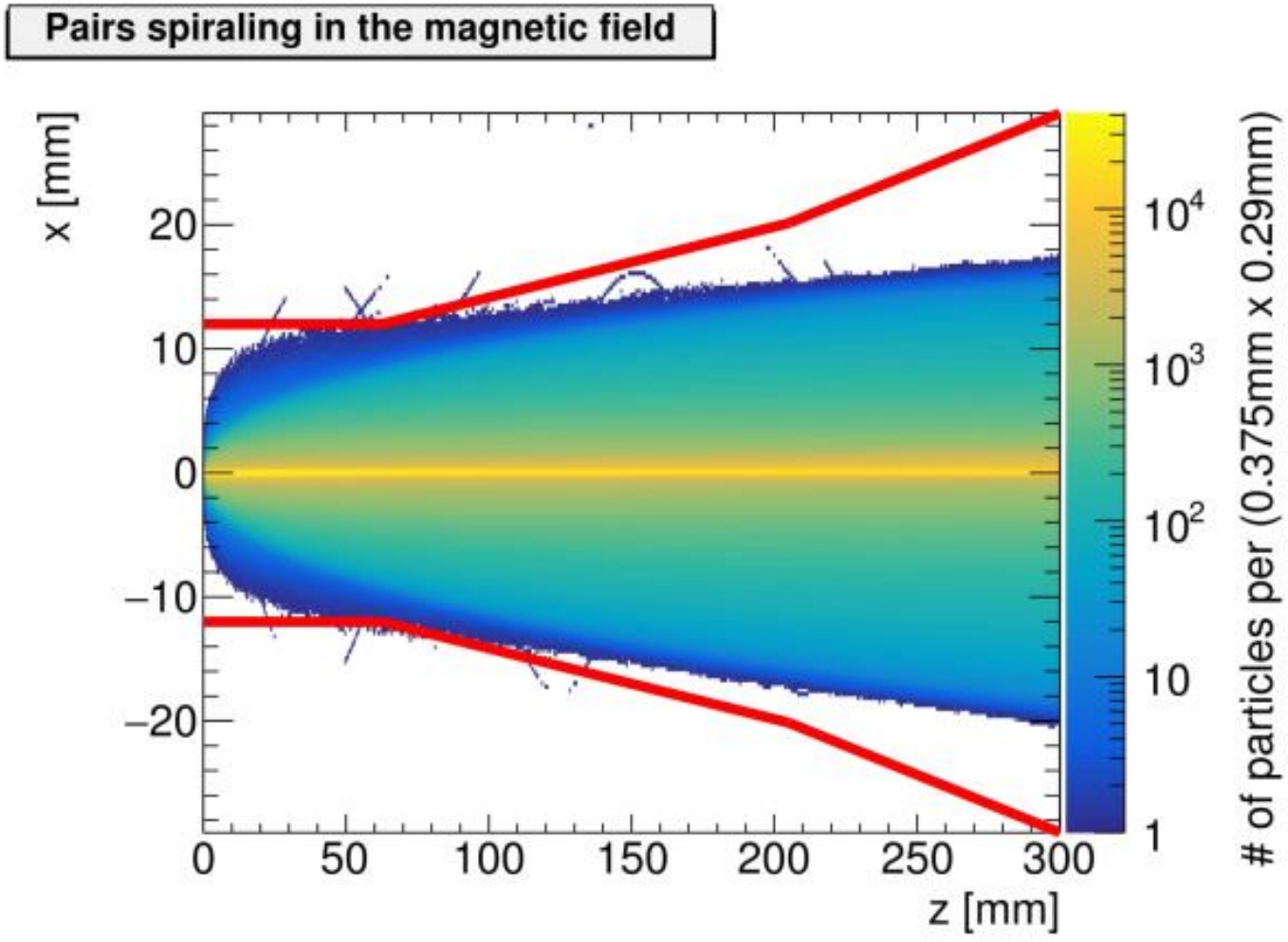
Motivations

- Part of the FCal collaboration:
  - Study and design of the forward detectors for ILC : luminosity detector (LumiCal), beam calorimeter (BeamCal)
  - my focus : LumiCal. In the last 10 years, important developments to reach an ultra thin electromagnetic calorimeter (silicon, readout, mechanics) tested in many beam tests.
- Present and future : study the luminosity calorimeter at ILD/FCC with complete simulation
  - Study of background (beamstrahlung, beam background, ….)
  - Study of signal (e^+e^- -> e^+e^-, e^+e^- -> $\gamma\,\gamma$)



Beamstrahlung : many low pT e+ e- pairs produced in each bunch crossing



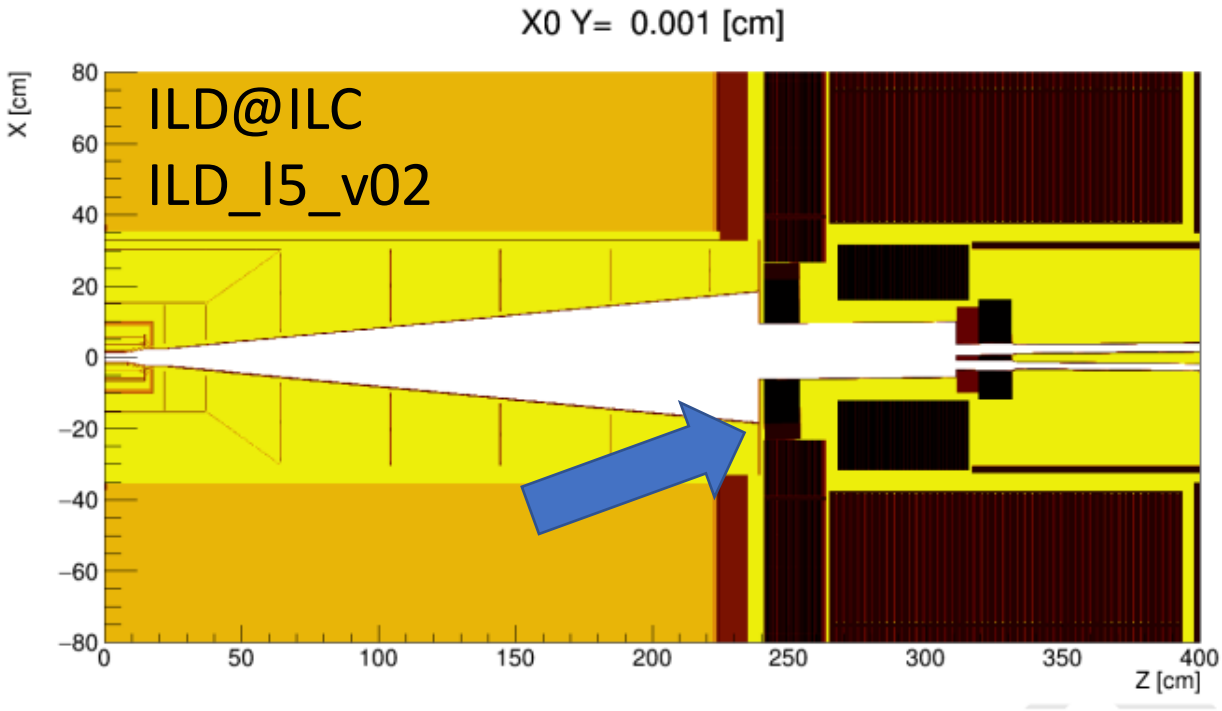
(b) *ILC250 set (A)*

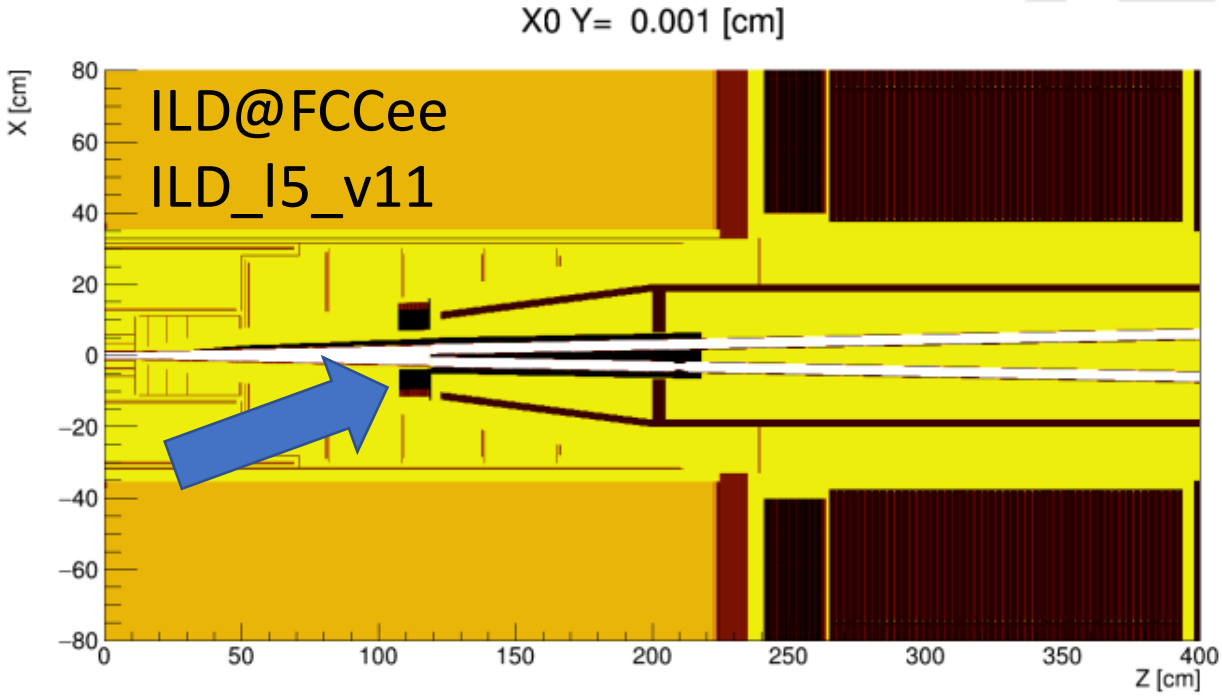
Pair background density for a full bunch train (1312 bunch crossings)

A. Schuetz arXiv:1801.04156

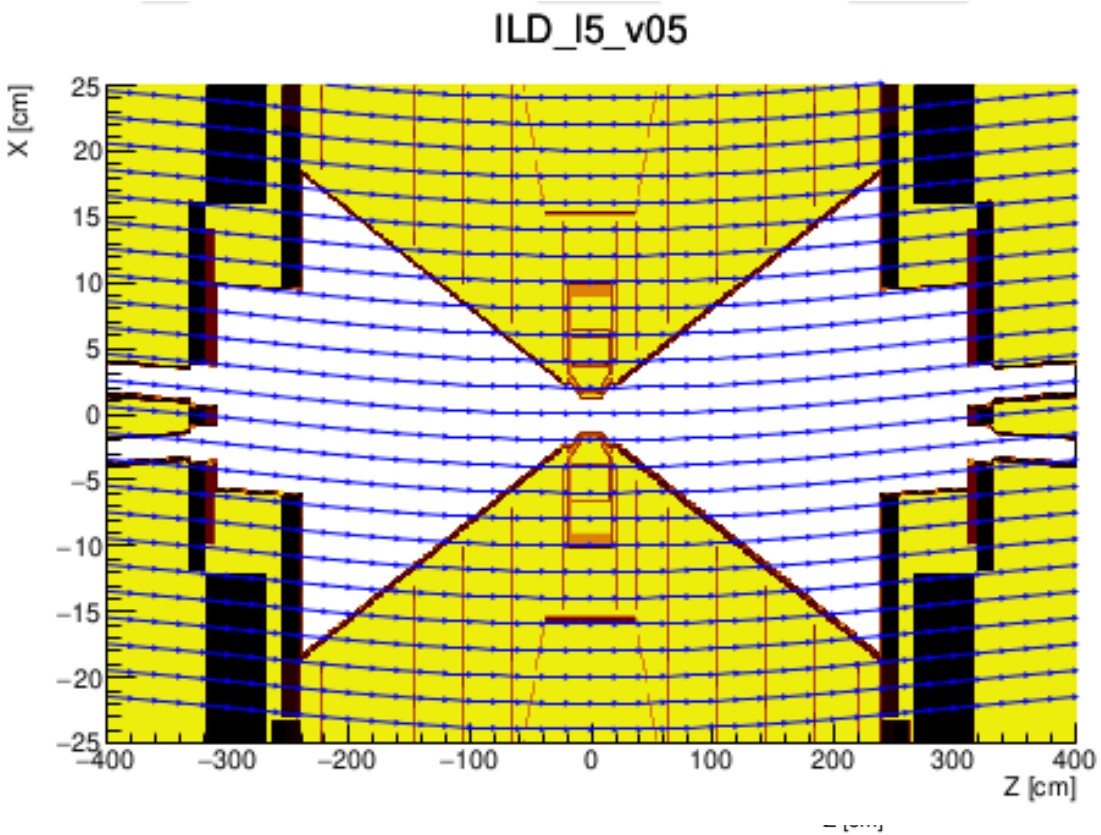
Machine-detector interface

	ILC	FCCee
Crossing angle	14 mrad	30 mrad
L* (distance from IP to last accel focusing quad. Magnet)	4.1m	2.0m
Detector solenoid	3.5T	2.0T
Additional B-fields	Anti-DID (?)	-compensating -screening

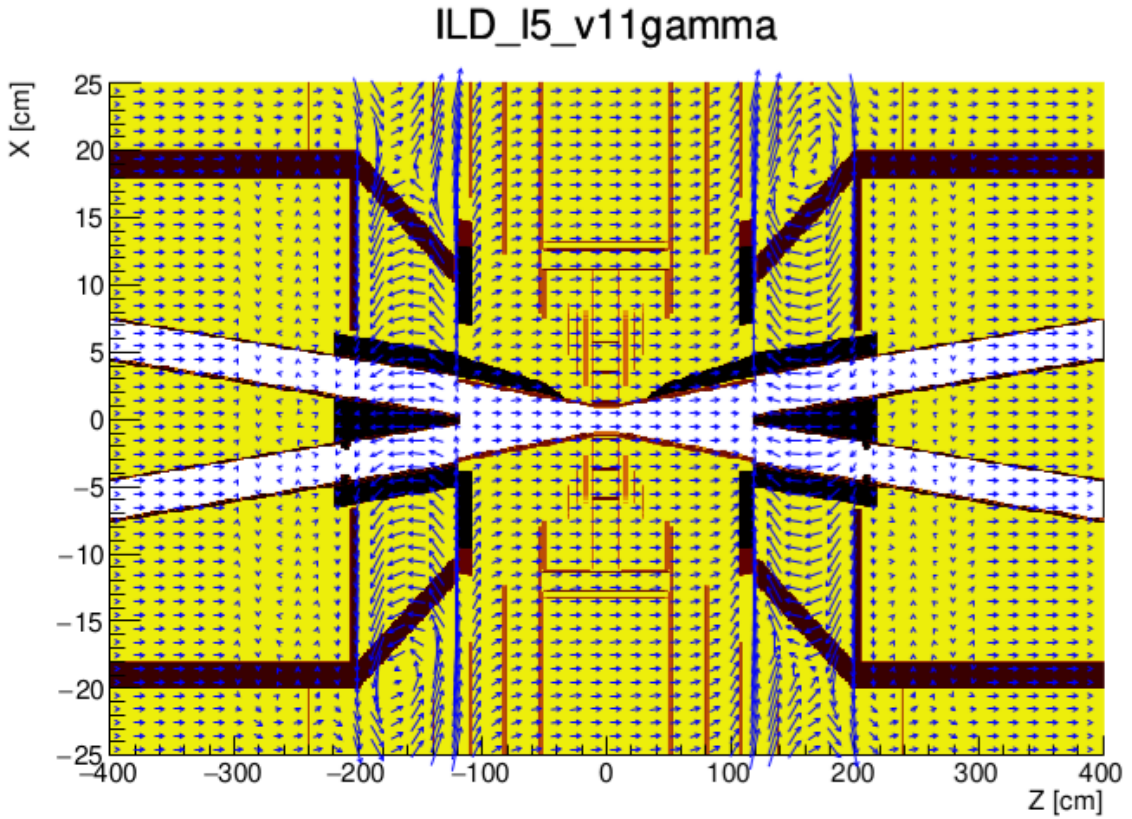




Field map



ILC with anti DID



FCCee : screening and compensation coil

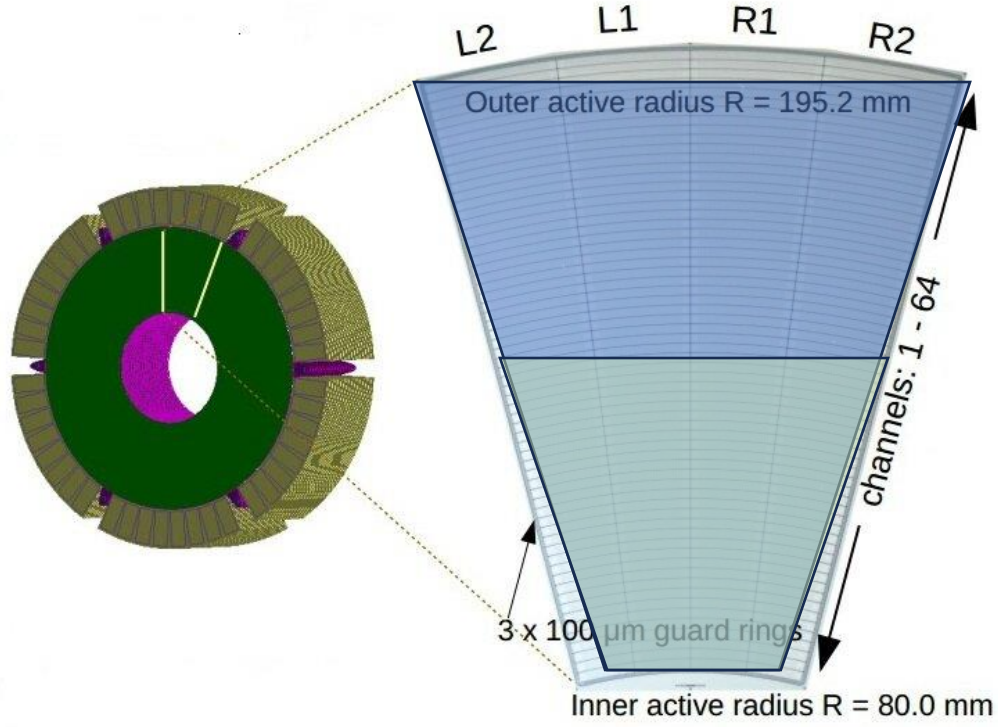
beamstrahlung: many very low p_T e+e- created in bunch collisions
very different bunch structure, materials and fields in the forward region → major effect on beamstrahlung backgrounds ?

Simulation : 100 BX

- GuineaPig : beamstrahlung generator
  - ILC-250 (from ILD/Mikael Berggren
  - FCCee-91, FCCee-240 (from FCCee/Andrea Ciarma)
- Using DD4HEP ILD detector models
- ILD@ILC:
  - Uniform 3.5 T (V02)
  - Uniform 2T (v02_2T)
  - Field map with and without anti DID (v03 and v05)
- ILD@FCCee:
  - Uniform 2T (v11beta)
  - Detailed magnetic field (v11gamma)

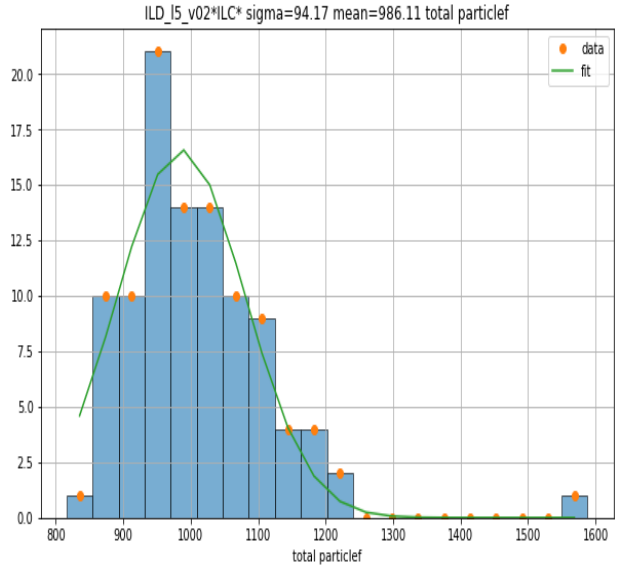
LumiCal @ ILD / FCC

	ILD	FCC
Sensitive region (mm)	80-195	55-115
Pad number in theta	64	32
z position (m)	~2.5	~1.1
Acceptance (mrad)	41-67	62-88 (wide)

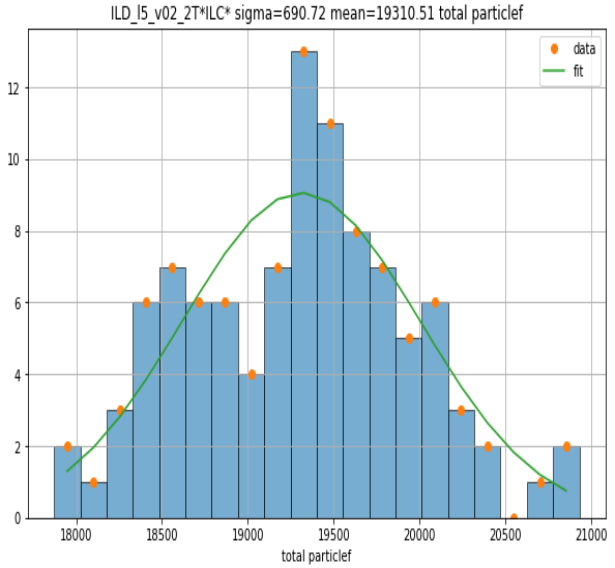


Number of hit pads in LumiCal

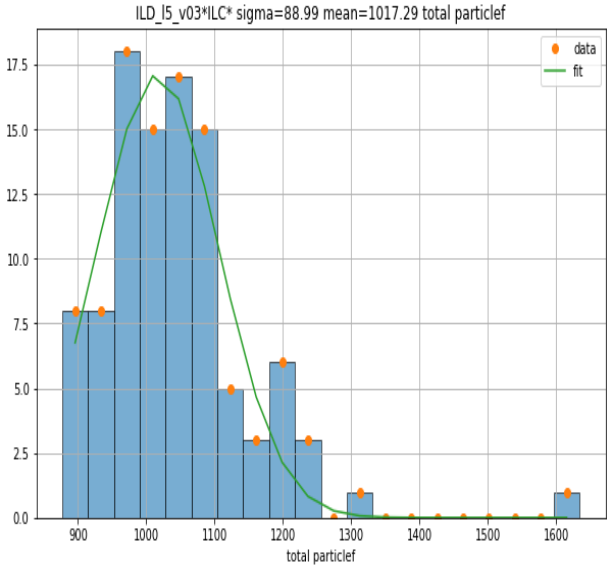
v02



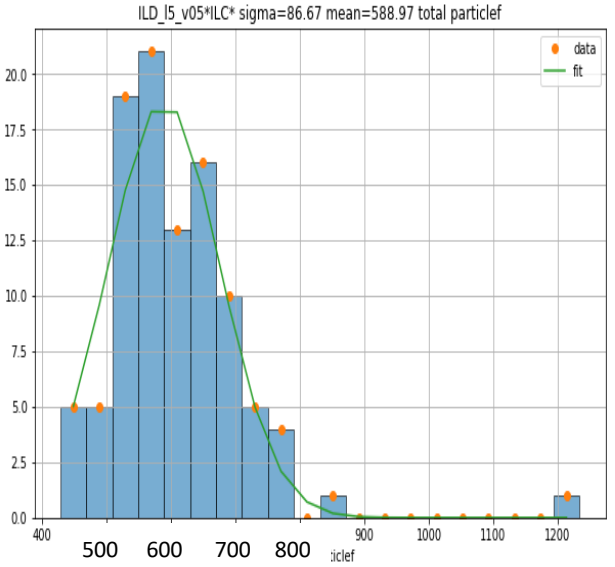
V02_2T



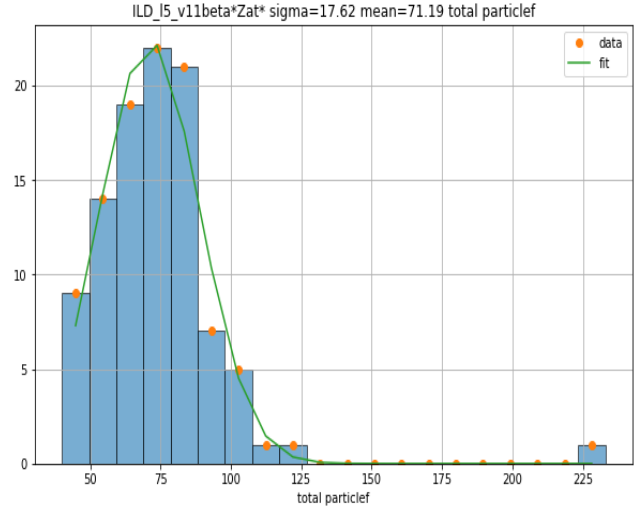
V03



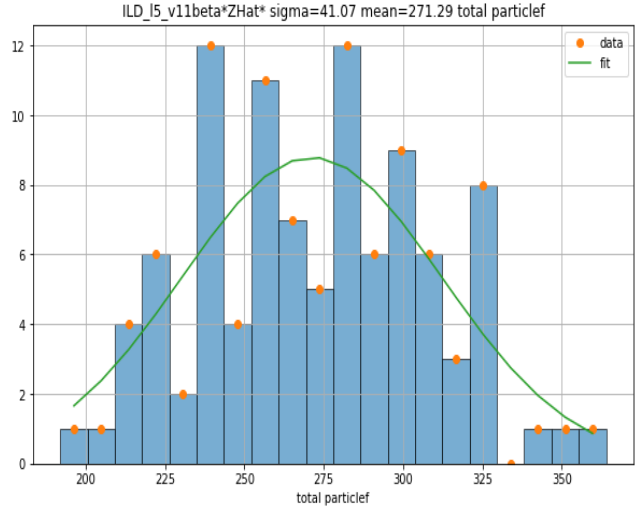
V05



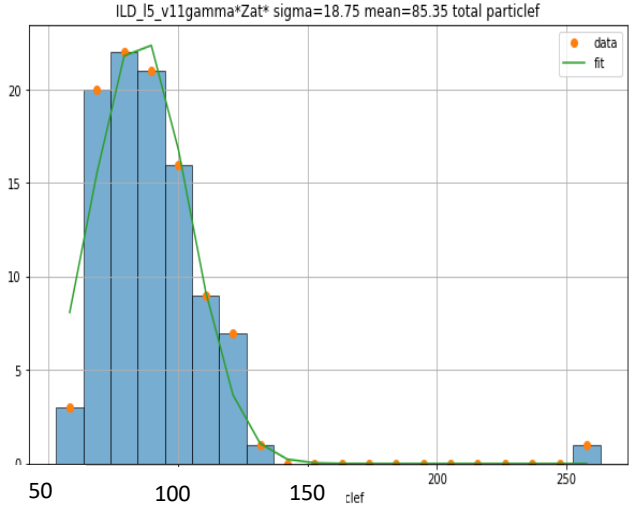
V11 beta @Z



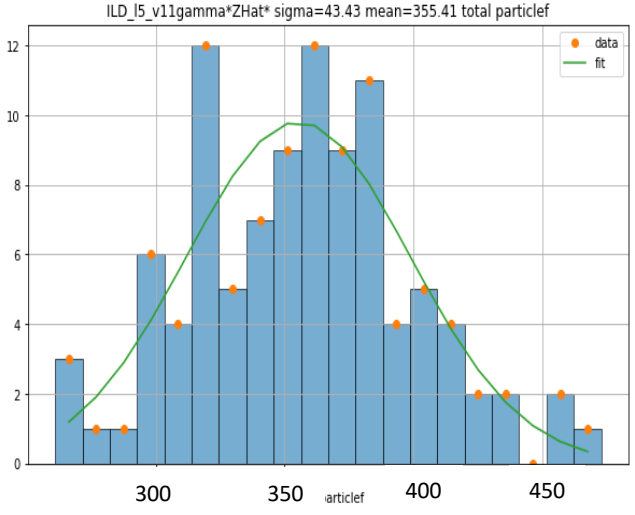
V11 beta @ZH



V11 gamma @Z

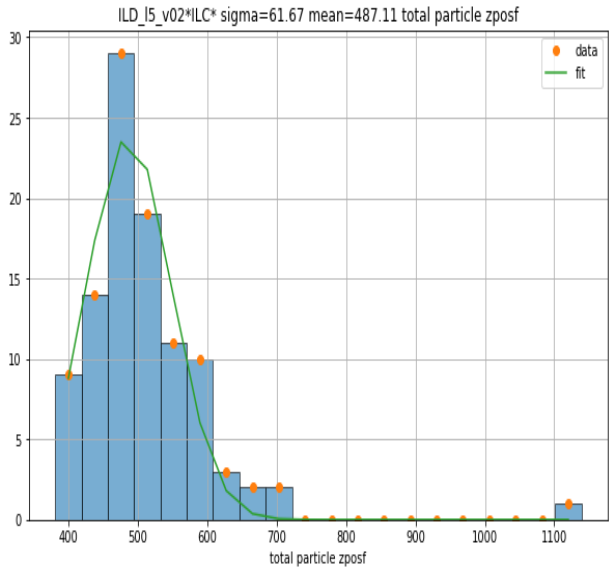


V11 gamma@ZH

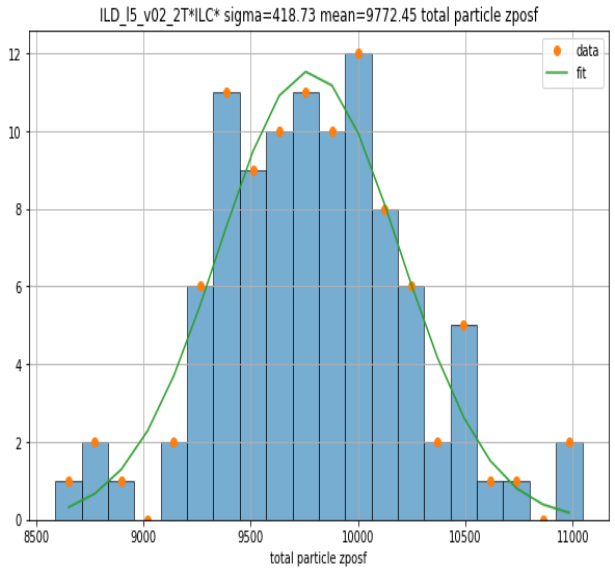


Number of hit pads in lumical z>0

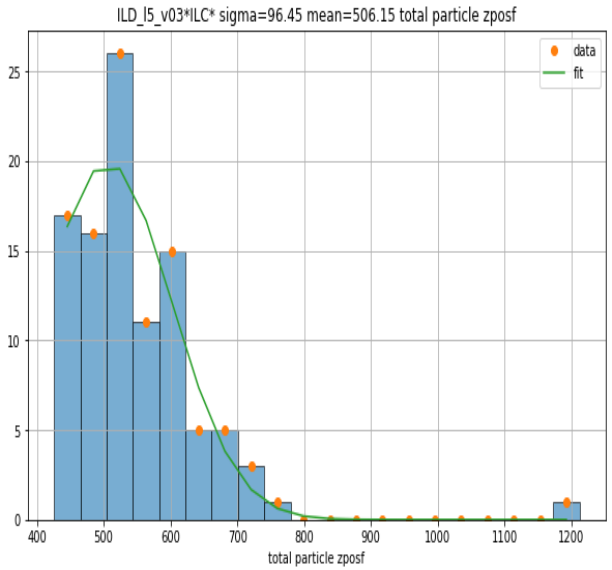
v02



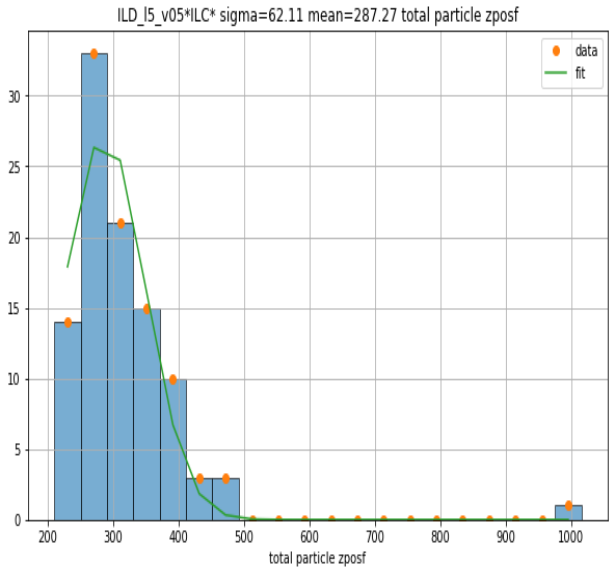
V02_2T



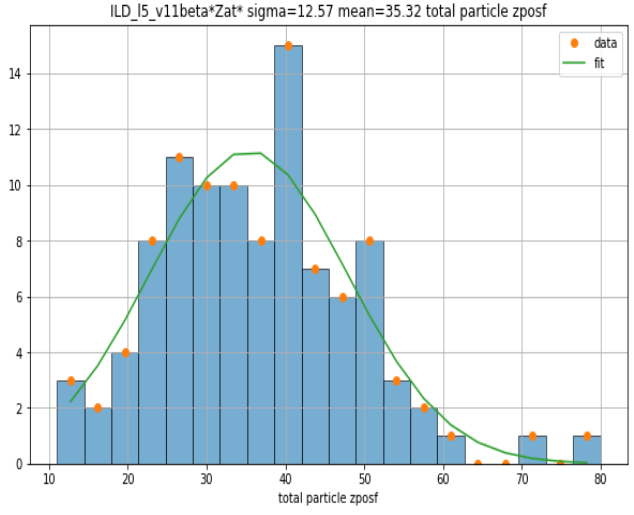
V03



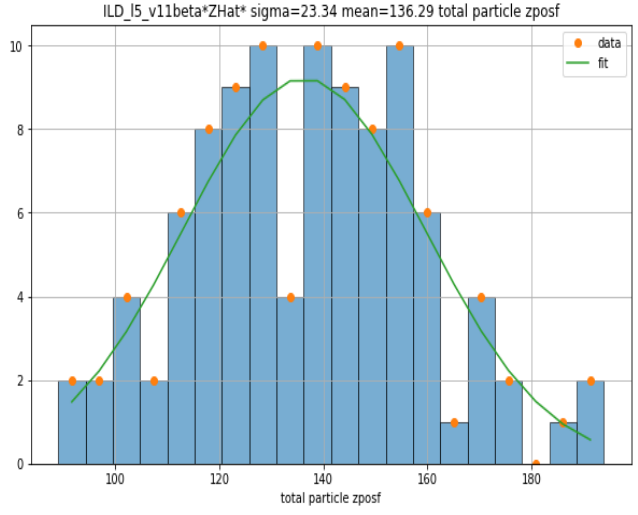
V05



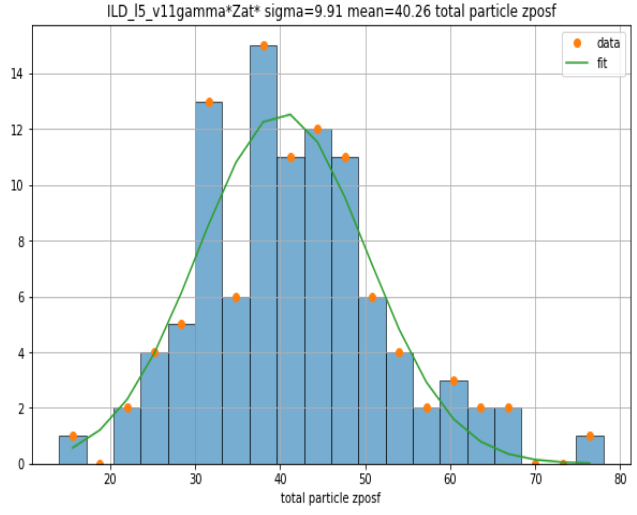
V11 beta @Z



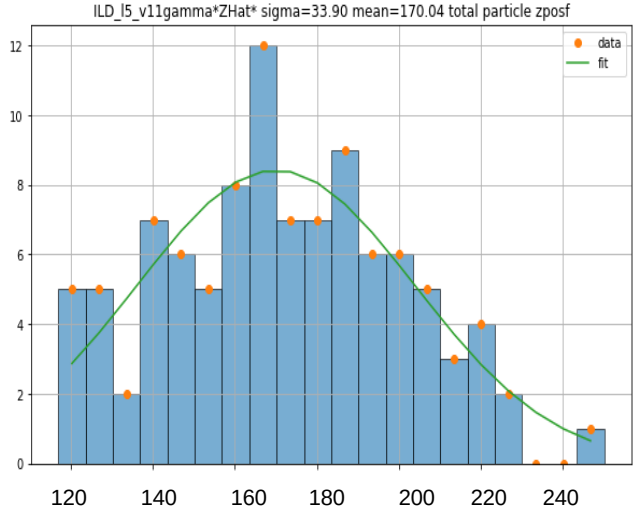
V11 beta @ZH



V11 gamma @Z

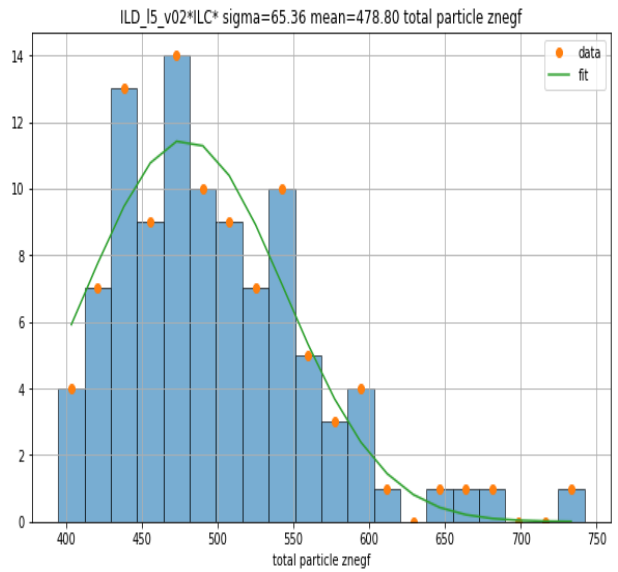


V11 gamma@ZH

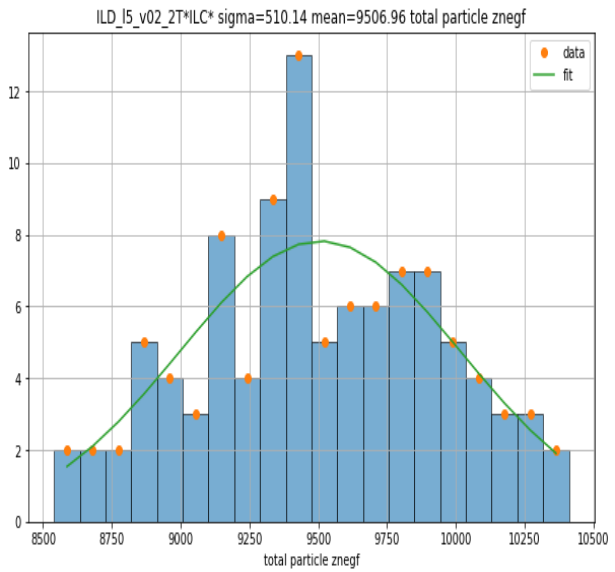


Number of hit pads in lumical z<0

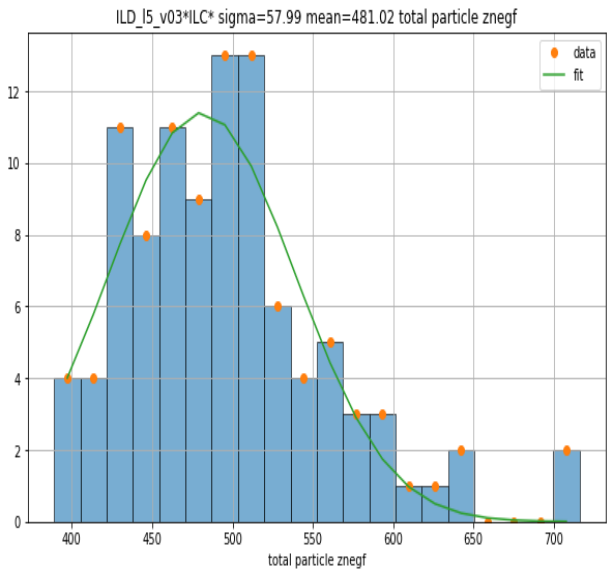
v02



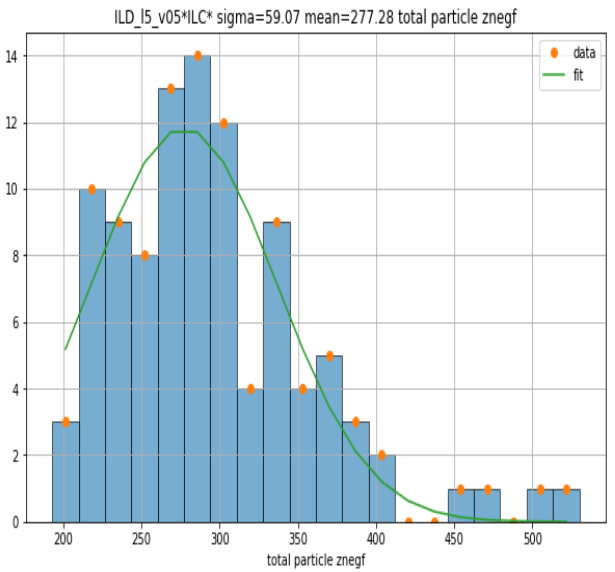
V02_2T



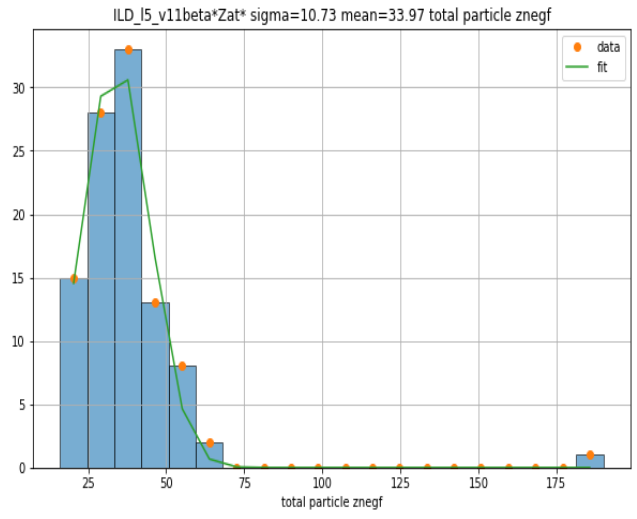
V03



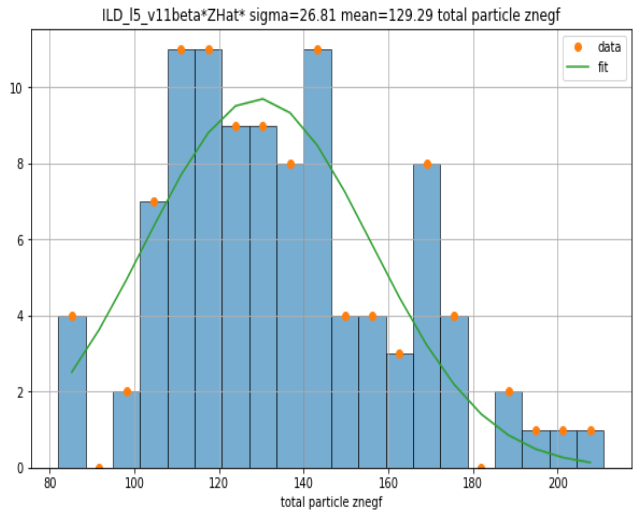
V05



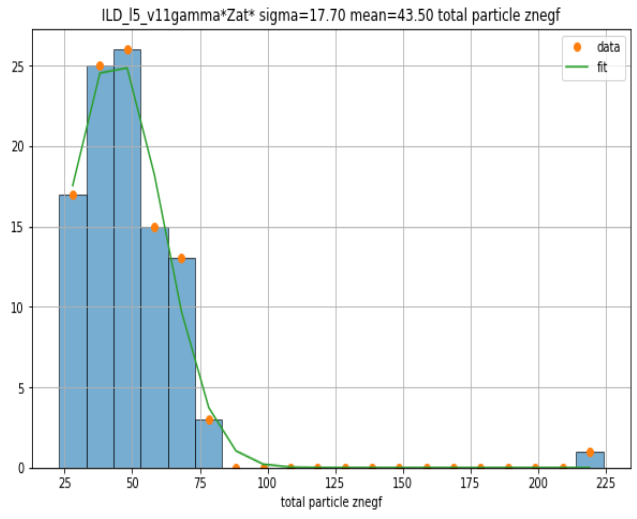
V11 beta @Z



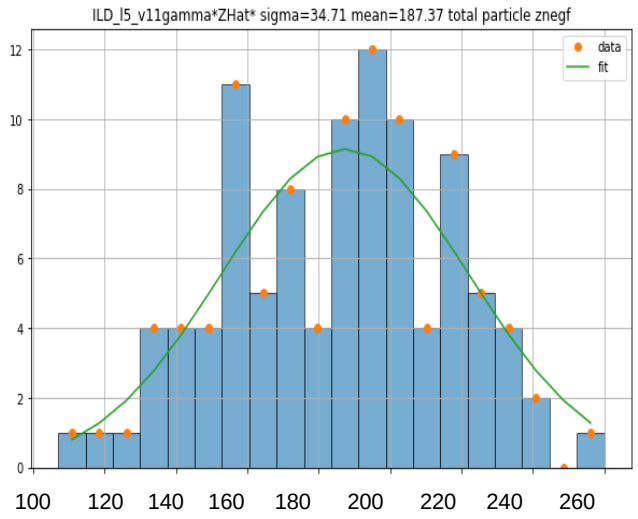
V11 beta @ZH



V11 gamma @Z

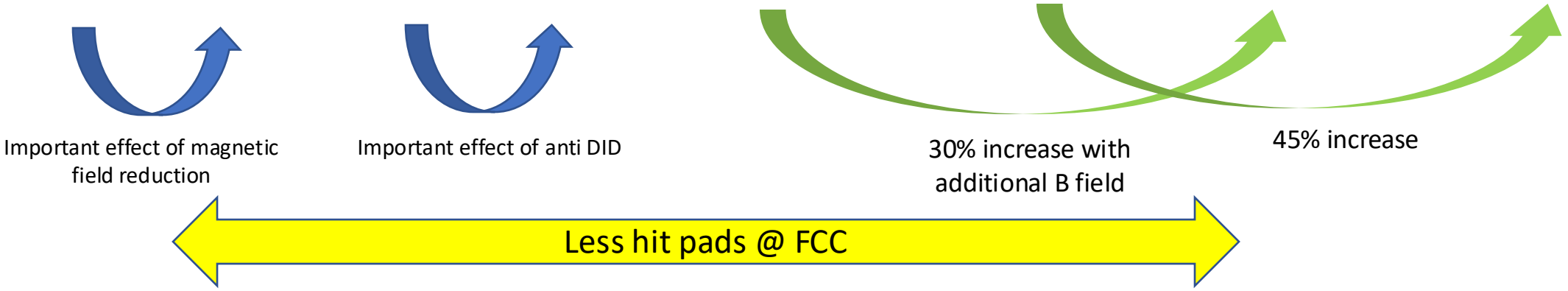


V11 gamma@ZH



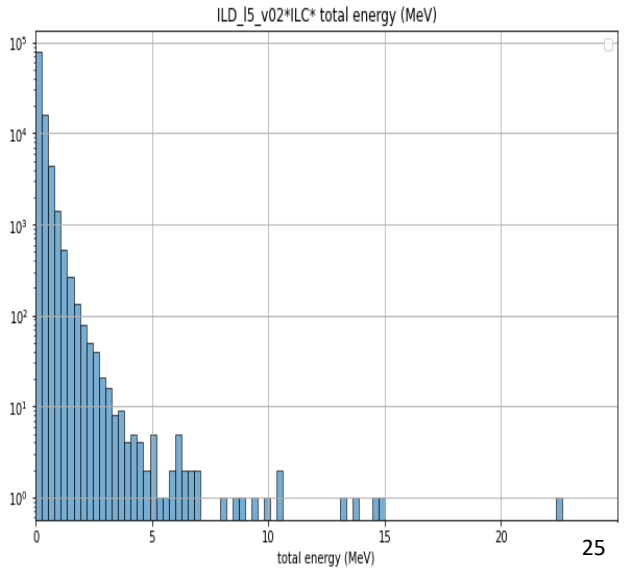
Number of hit pads (mean value) in LumiCal

	ILC				FCC			
	v02	V02_2T	V03	V05	V11 beta @Z	V11 beta @ZH	V11 gamma @Z	V11 gamma@ZH
total	986+/-8	19310+/-74	1017+/-8	589+/-7	71+/- 1	271+/- 7	85+/-1	355+/- 5
Z>0	487+/-5	9772+/-33	506+/-13	287+/-6	35+/- 1	136+/- 3	40+/-1	170+/- 3
Z<0	479+/-6	9507+/-60	481+/-5	277+/-6	33+/- 1	129+/- 4	43+/- 1	187+/-4

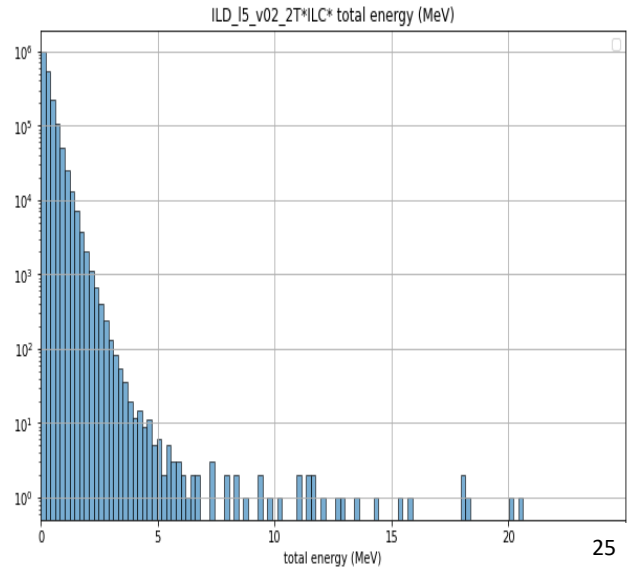


Energy deposited per pad (MeV)

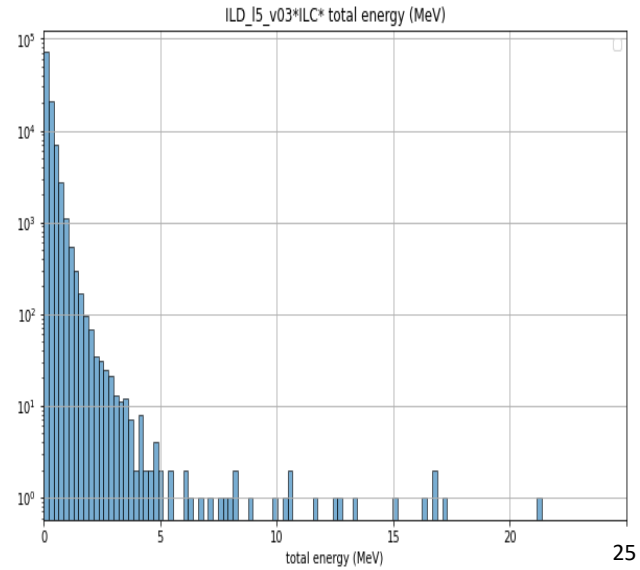
v02



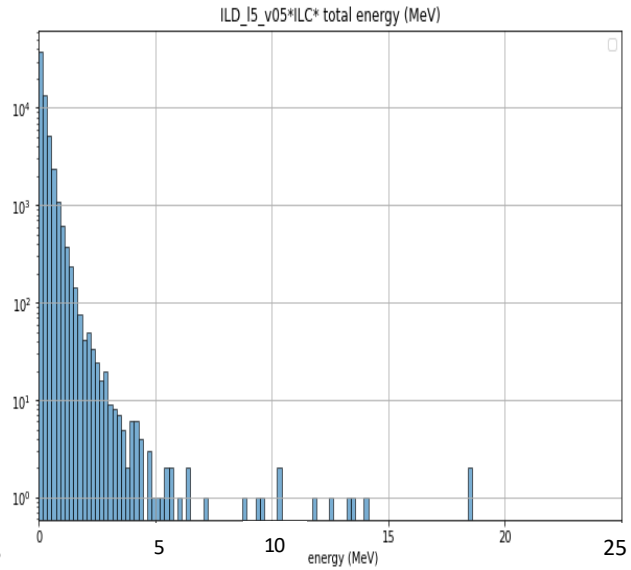
V02_2T



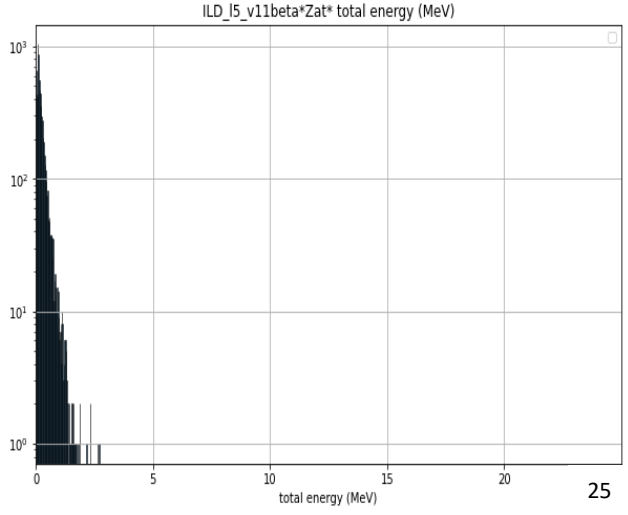
V03



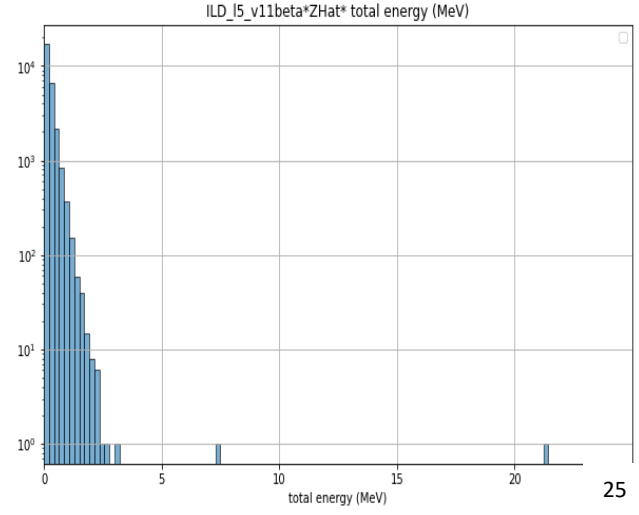
V05



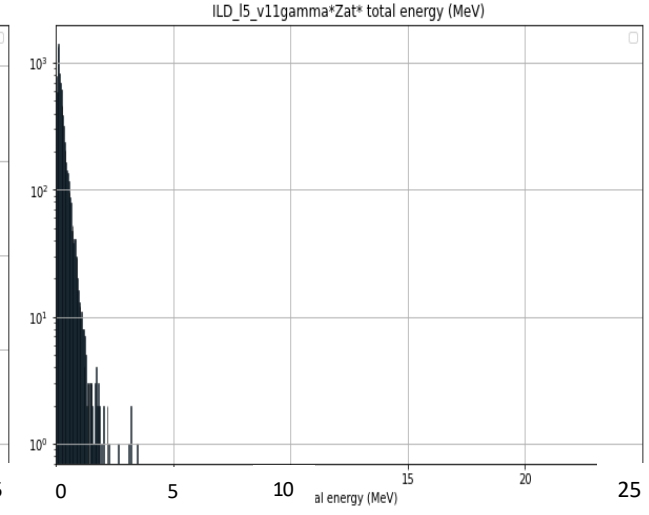
V11 beta @Z



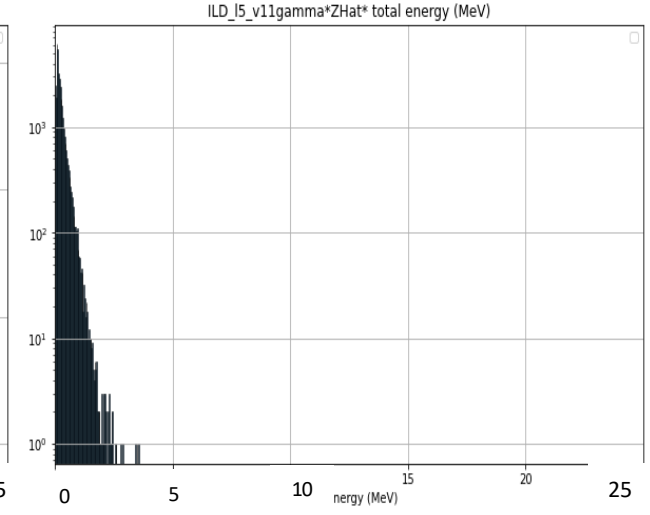
V11 beta @ZH



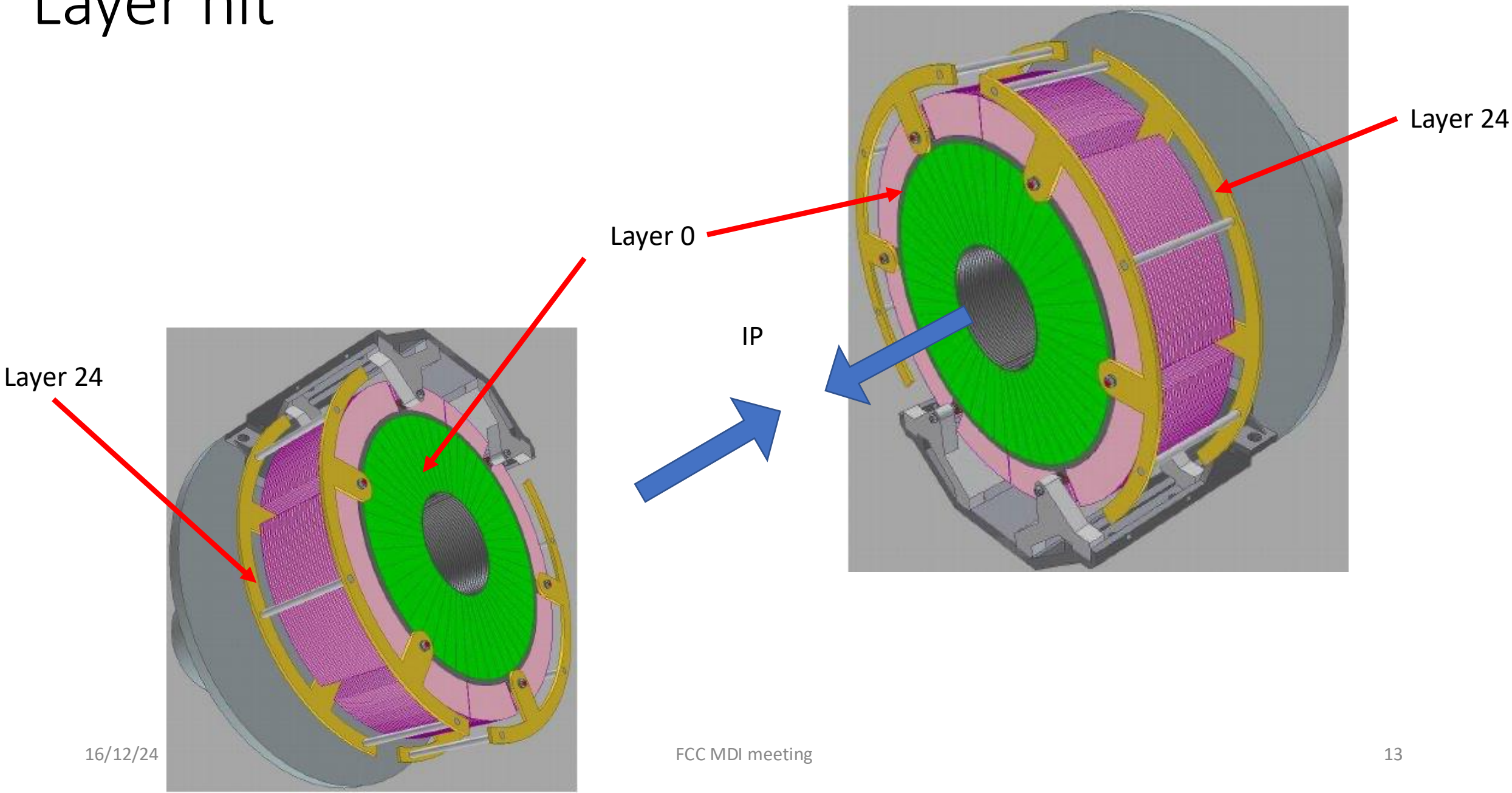
V11 gamma @Z



V11 gamma@ZH

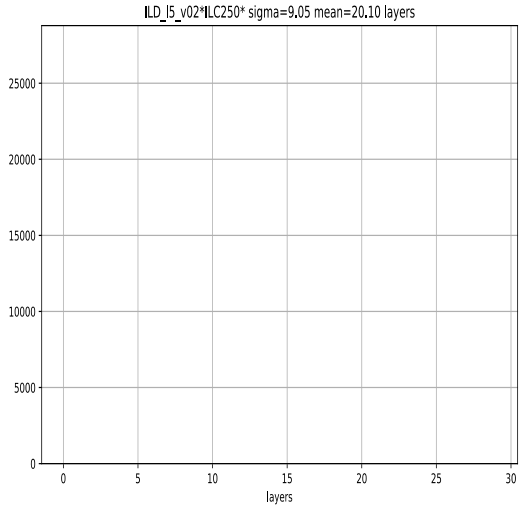


Layer hit

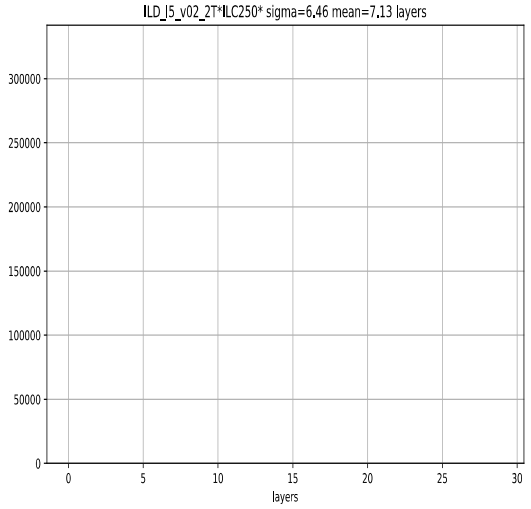


Layer hit for 100 BX

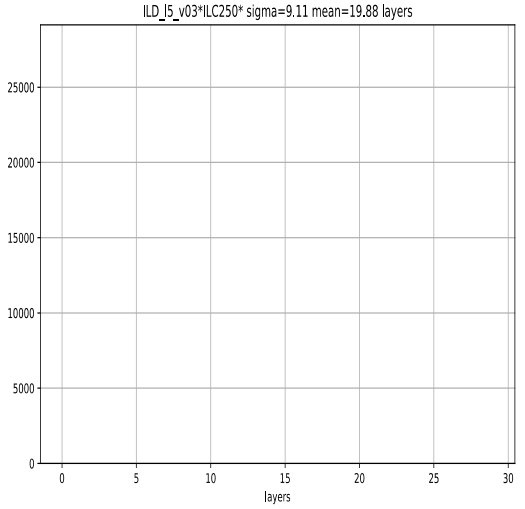
v02



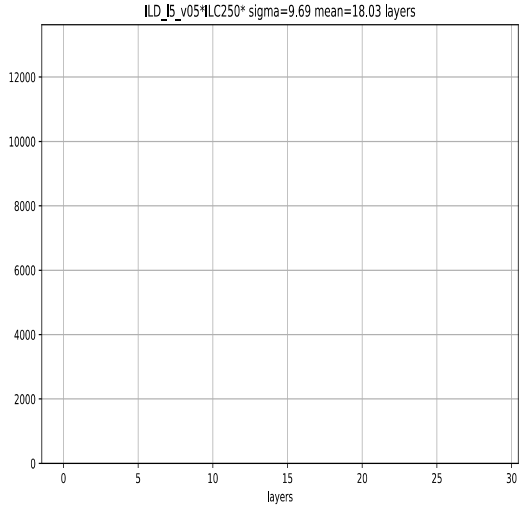
V02_2T



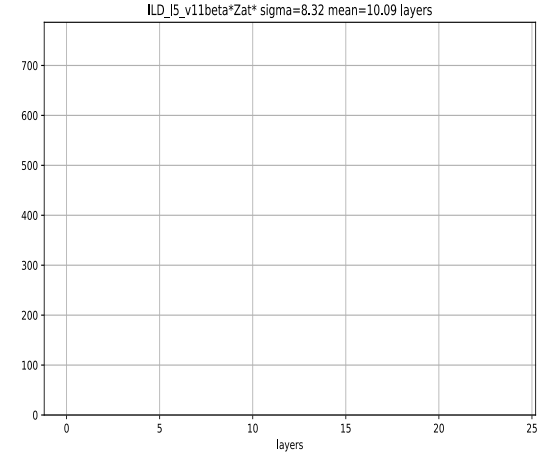
V03



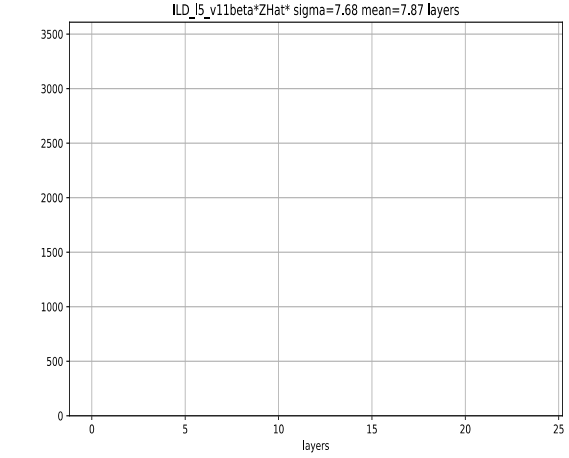
V05



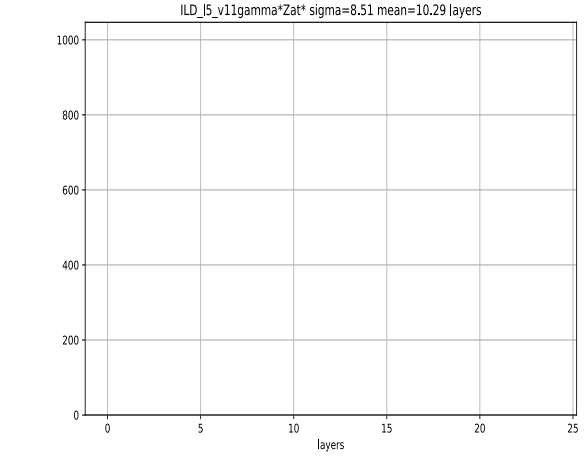
V11 beta @Z



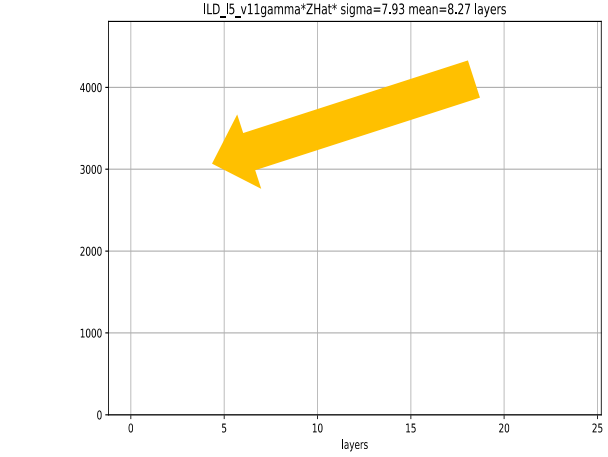
V11 beta @ZH



V11 gamma @Z

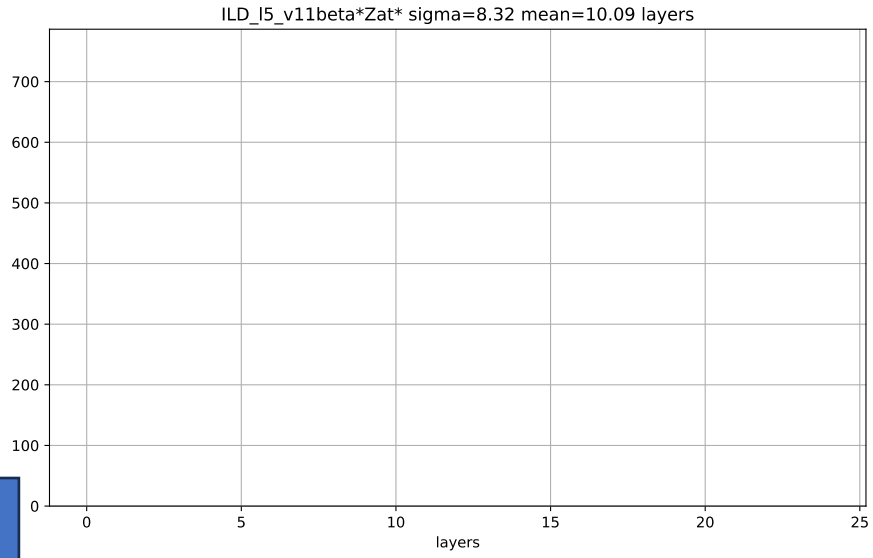


V11 gamma@ZH

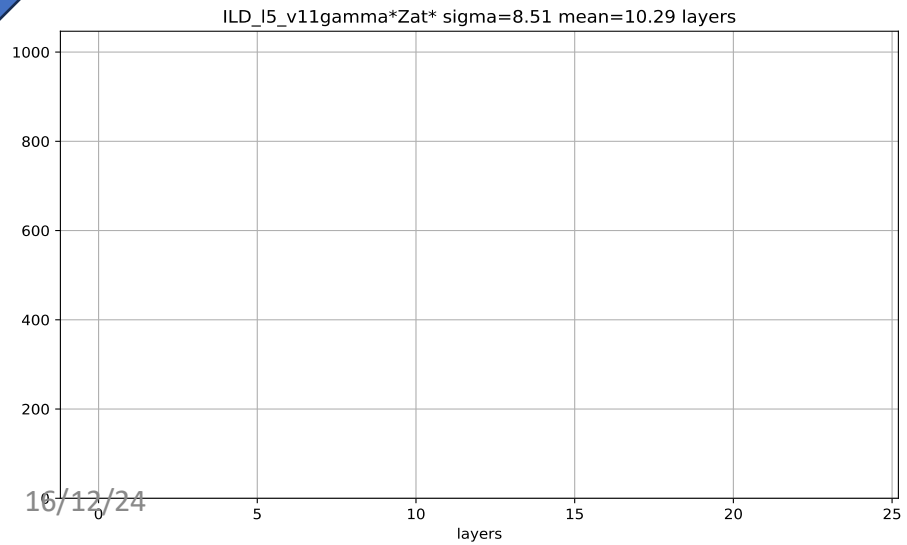


Layer hit for 100BX

Z peak

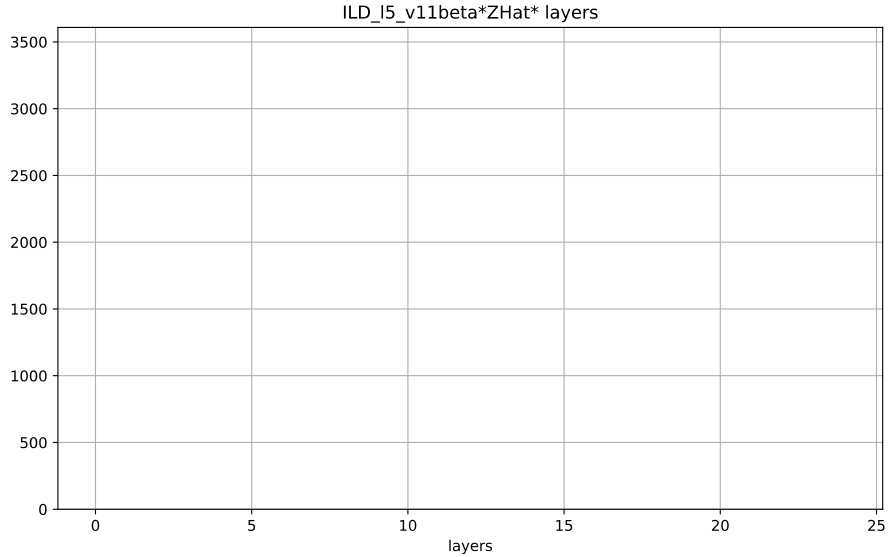


+17%



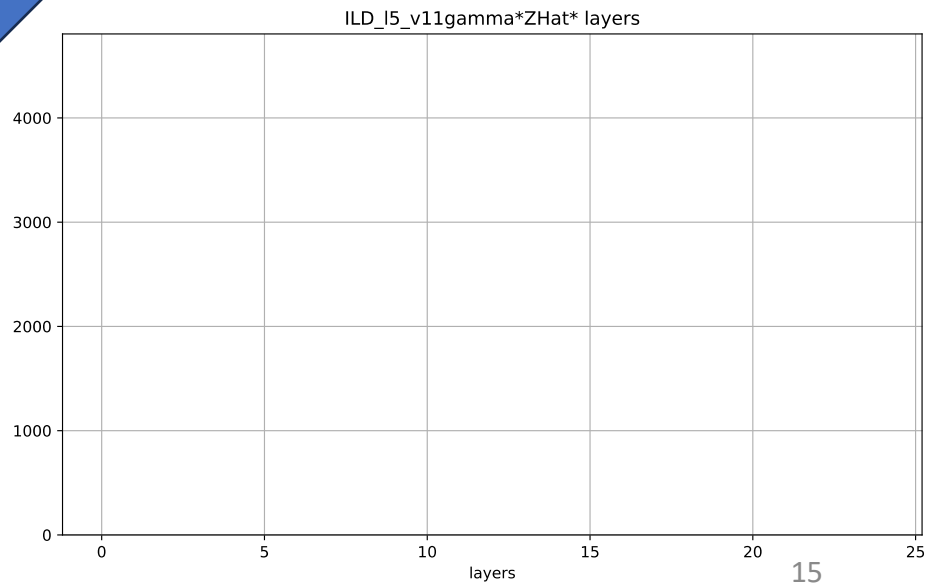
Uniform 2T

ZH



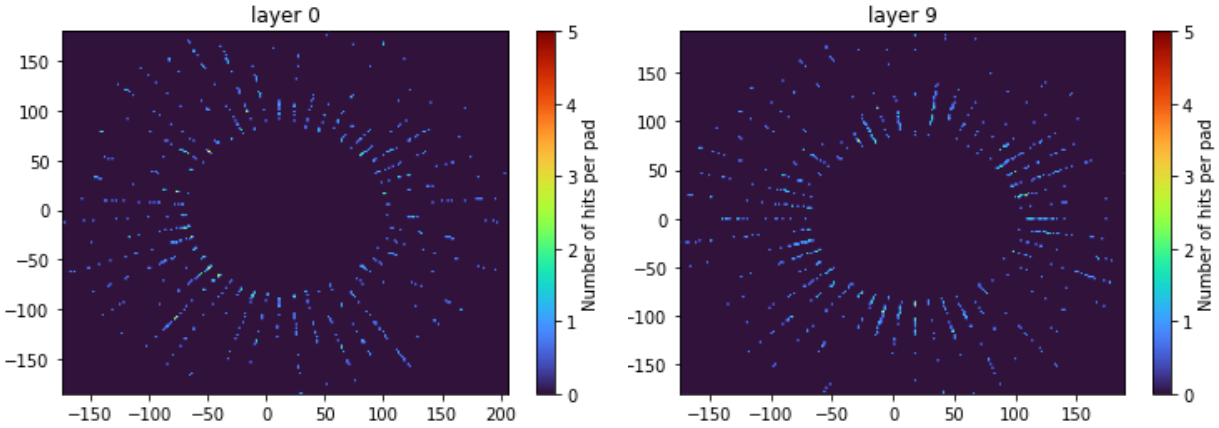
+30%

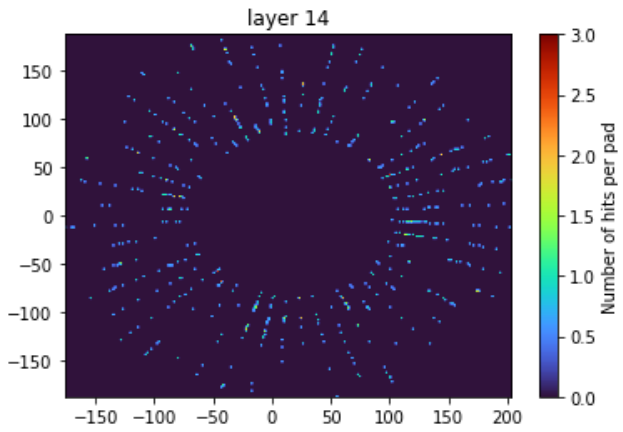
Detailed magnetic field

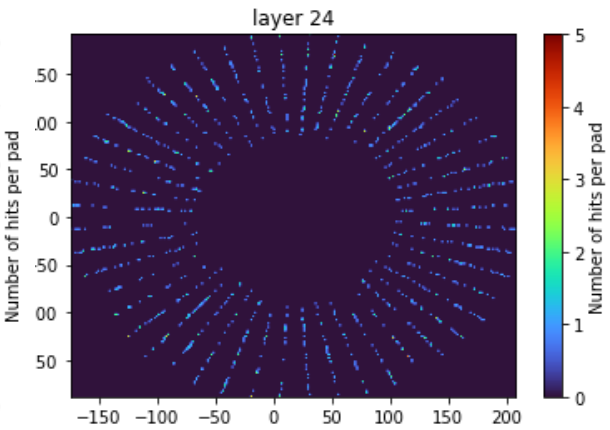


ILD_l5_v05 (ILC with anti DID)

z>0







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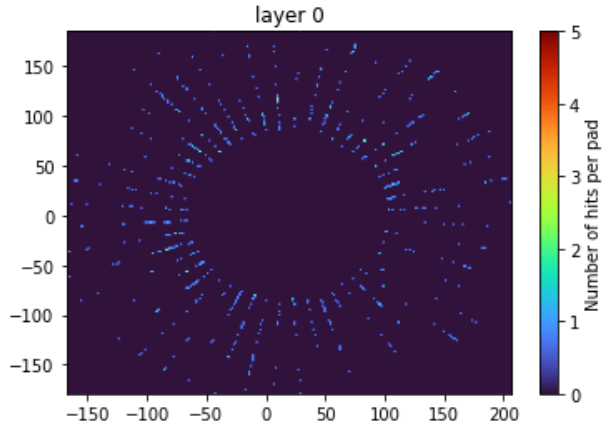
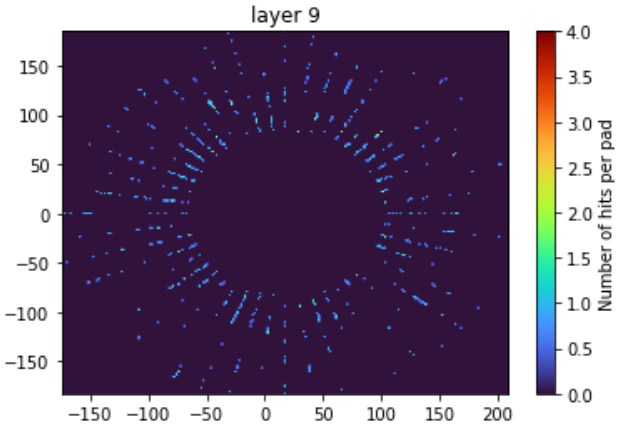
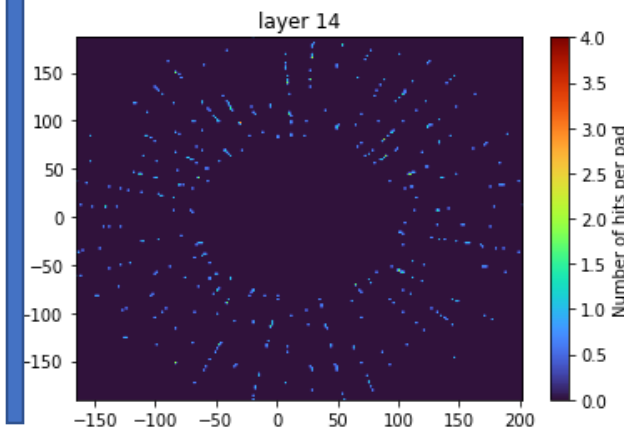
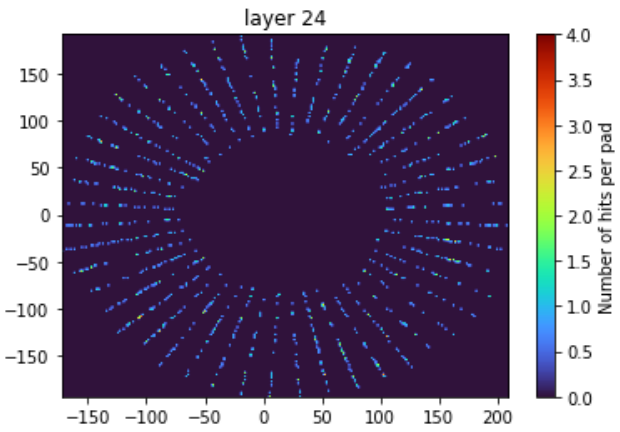


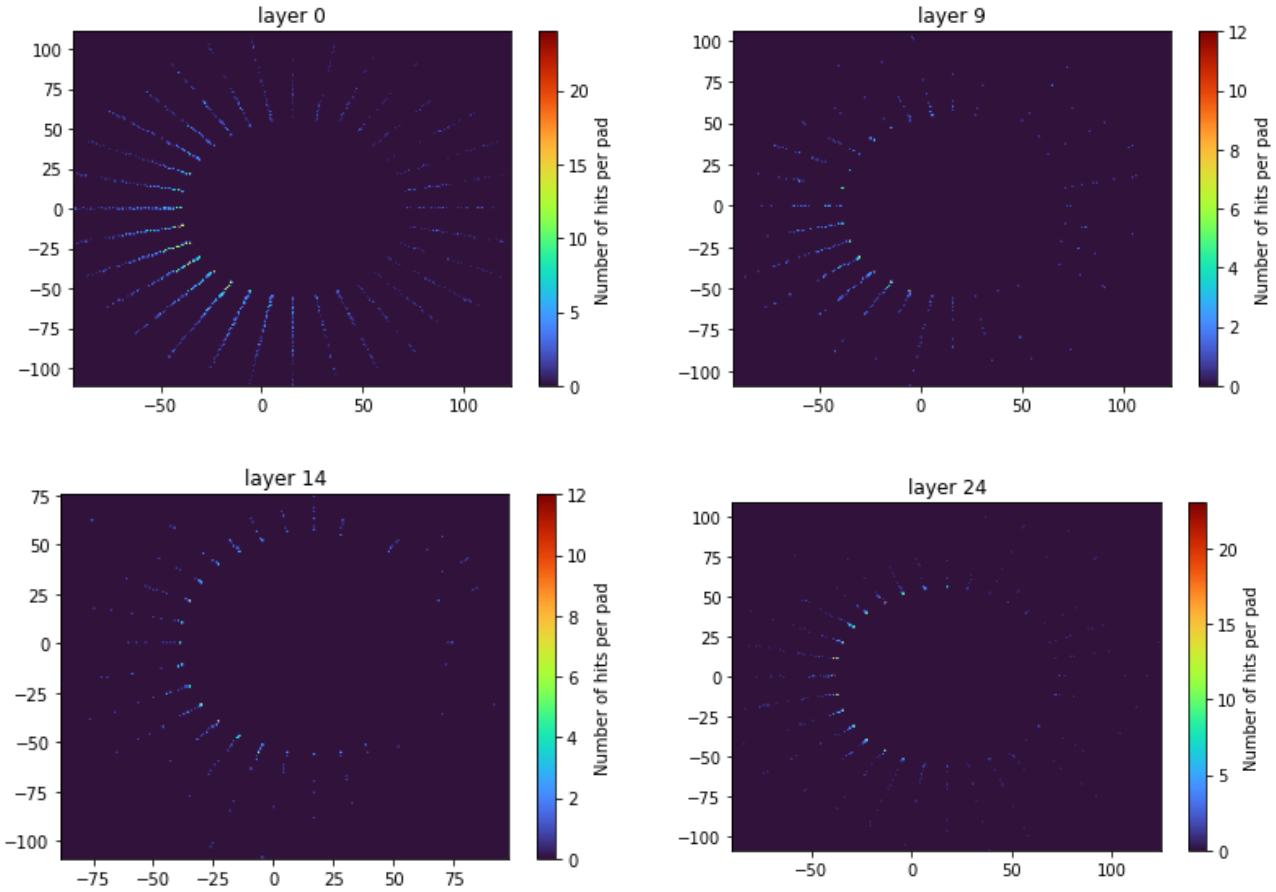






ILD_l5_v11gamma (FCC @ ZH peak)

z>0



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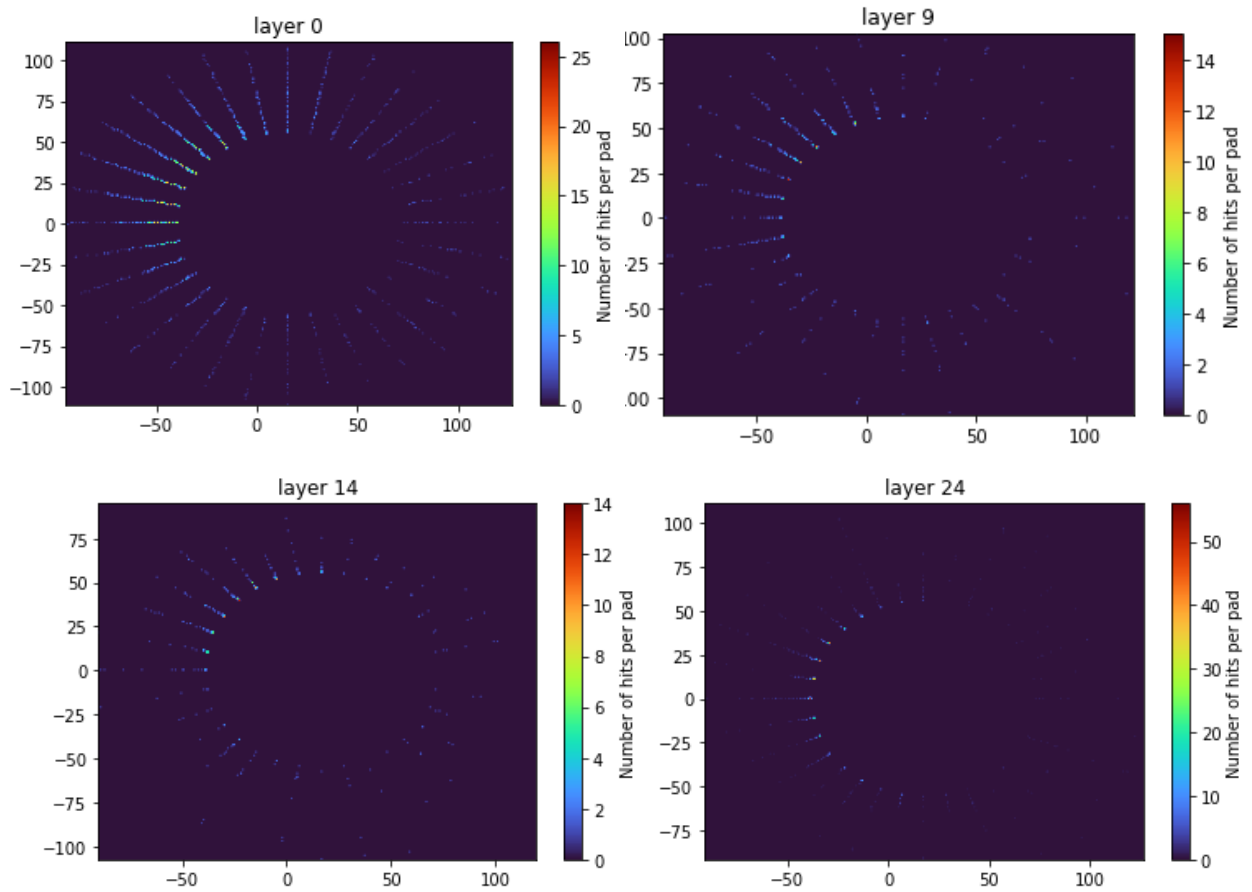


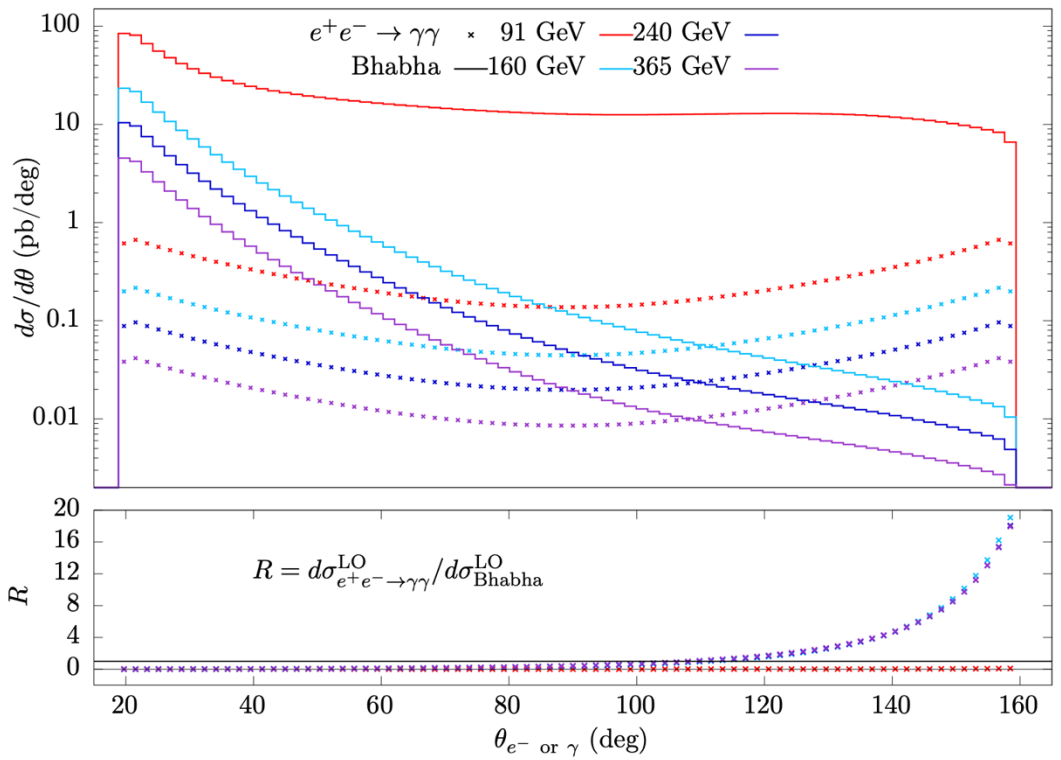
New study

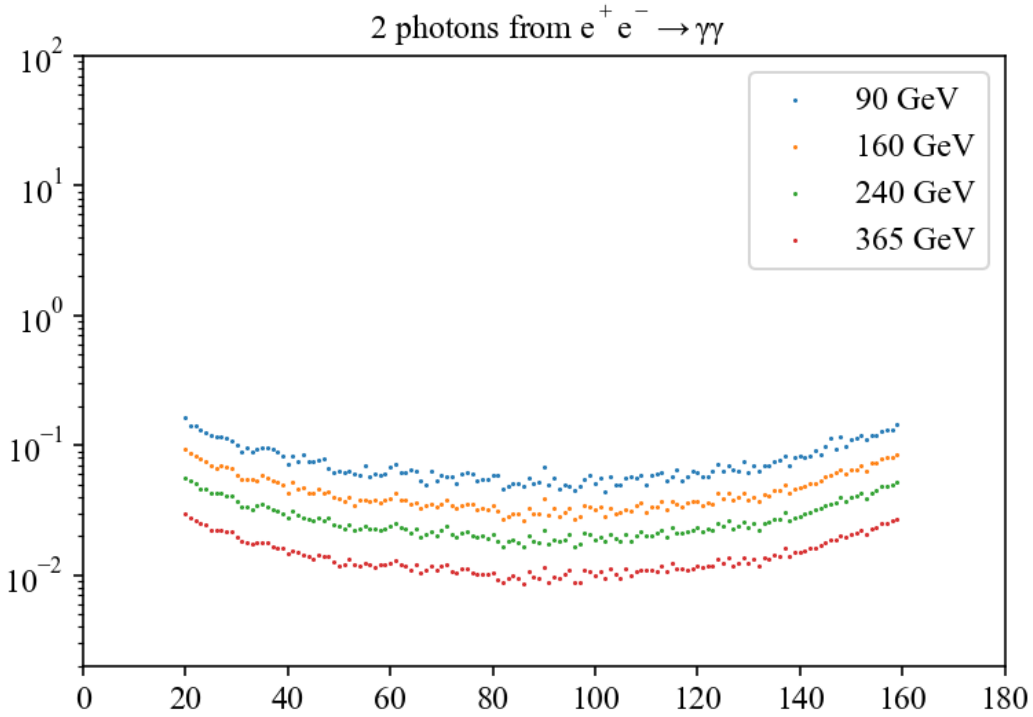
- possibility to use the signal e^+e^- -> $\gamma\,\gamma$
- Generation with BabaYaga@NLO for different energies (91, 160,240,365)
- Try to reproduce the study from Carlo Calame and al. (https://arxiv.org/pdf/1906.08056) production of di-photon pair at large angle (>20°)

$\sqrt{s}$ (GeV)	LO (pb)	NLO (pb)	w h.o. (pb)
91	364.68	447.27 [+23%]	445.6(9) [−0.46%]
160	123.71	154.37 [+25%]	153.2(2) [−0.95%]
240	56.816	71.809 [+26%]	71.07(6) [−1.30%]
365	25.385	32.515 [+28%]	32.09(2) [−1.67%]

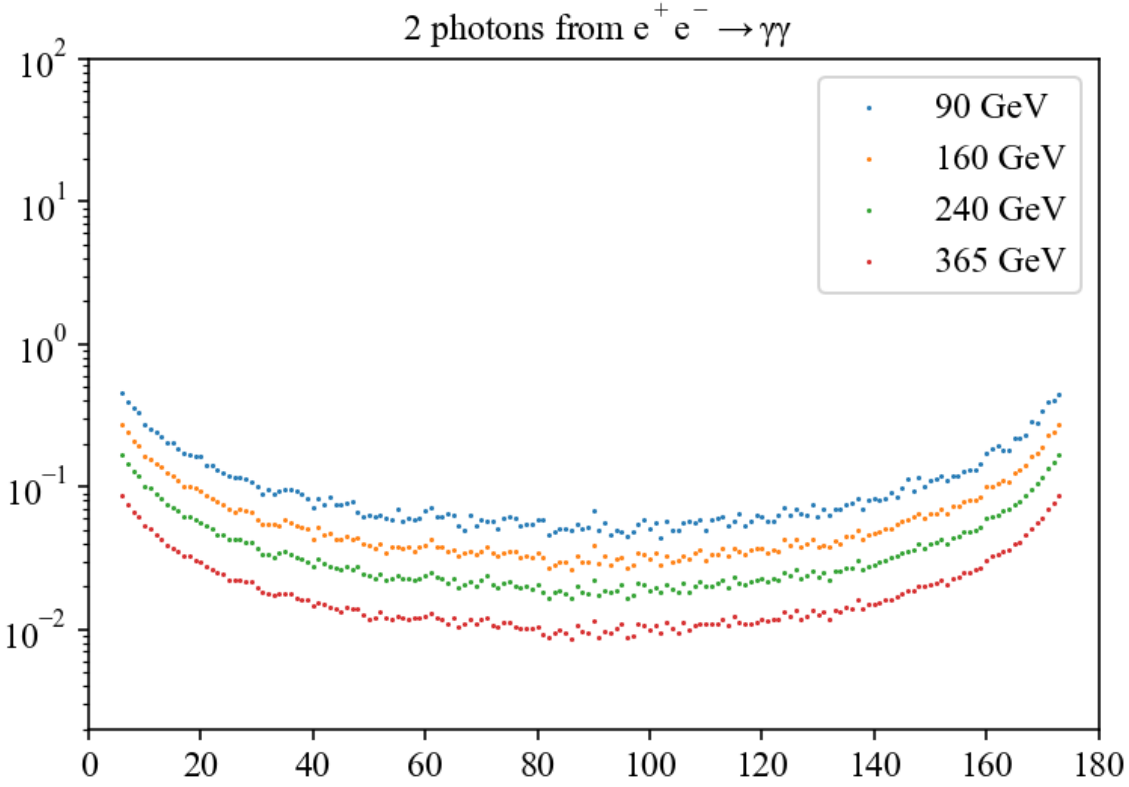
Sqrt(s) (GeV)	NLO (pb)
91	447.54
160	154.54
240	71.80
365	32.51

Sqrt(s) (GeV)	2 photons (%)	3 photons(%)
91	29.6	70.7
160	27.6	72.4
240	26.0	74.0
365	24.5	75.5





Extension to the LumiCal (2 photons).



	2-178	6-174	2-6 (pb)
91	24.44	17.80	6.64 (27%)
160	14.55	10.59	3.96 (27%)
240	8.86	6.44	2.42 (27%)
365	4.63	3.71	0.92 (25%)

Need to be simulated

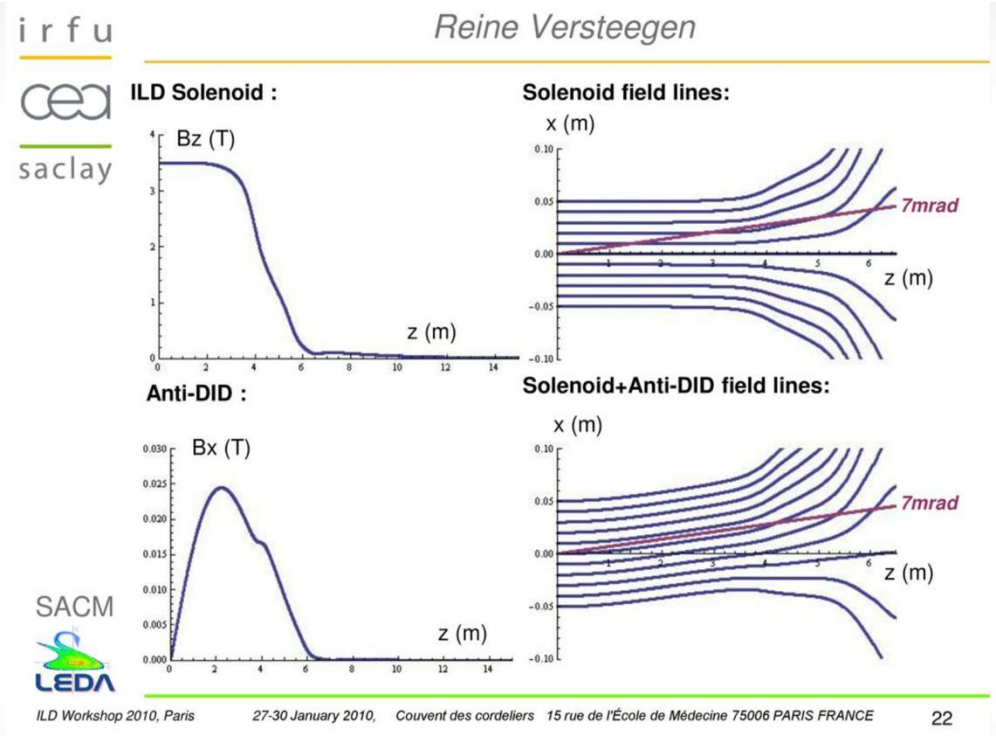
conclusion

- Study of beamstrahlung signal in LumiCal for FCCee started with full simulation (and comparison with ILC). Preliminary analysis shows:
  - Less hits in the LumiCal @ FCC than at ILC
  - Same energy deposited shape
  - Position of hits in LumiCal is different at FCC and ILC (front-end/right-left)
  - @ FCC with screening and compensation coil, number of pads hit per layer is between 2 and 10 at Z peak per BX
- future:
  - Maybe need more statistics (more BX to generate and simulate)
  - Continue the background study
  - Study the ee-> e^+e^- -> $\gamma\,\gamma$ signal
  - Bhabha generation and simulation with all the configurations

Thanks

DID and anti-DID

- DID : Detector Integrated Dipole. Pair of coils wound around the deetector solenoid which create a sine-like transverse field
- Anti DID : allows to zero the crossing angle for the outgoing beam



- Radius : FCC: 54<r<145
- Sensitive region : FCC 55<r<115 mm (32 pads) . ILD : 80<r<195mm (64 pads)
- Acceptance FCC: 62-88 mrad (wide). ILD : 41-67 mrad
- Services FCC : 115<r<145
- z position : ~2.5m/~1.1m
- Acceptance :