Compton simulation preliminary results

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https://arxiv.org/pdf/hep-ph/9711447.pdf

Simulation setup

- Using our default Compton generator
  - https://gitlab.com/eic/mceg/comptonRad
- The generator gives out the 4-momentum for both the photon and electron together with 4 weight factors: unpolarized and polarized tree level cross sections (eq 26,27 of paper) and the order alpha corrections (not used for the following analysis)
- To obtain the average analyzing power for a particular configuration (or average over any number of bins) we need to weight by cross section
- An average FOM can also be calculated weighting by sqrt(N)

$$W_1 = \frac{1}{2\rho^{(n)}(x)}\left[\frac{d^n\sigma^{(0)}}{dx^n}(s,-) + \frac{d^n\sigma^{(0)}}{dx^n}(s,+)\right] \quad \text{unpolarized xsection} \quad (26)$$

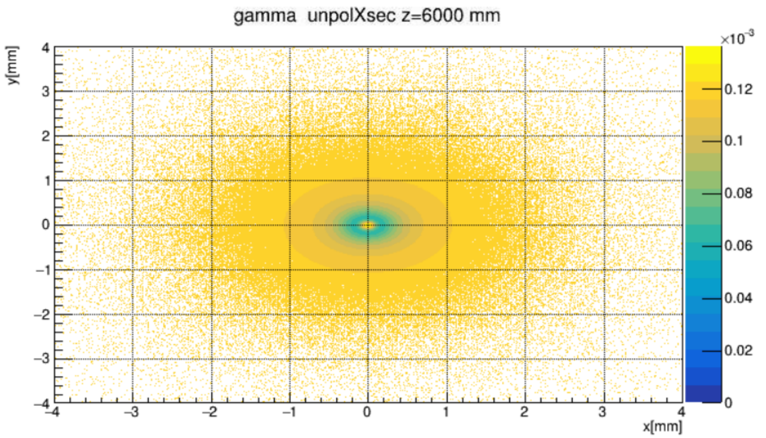
$$W_2 = \frac{1}{2\rho^{(n)}(x)}\left[\frac{d^n\sigma^{(0)}}{dx^n}(s,-) - \frac{d^n\sigma^{(0)}}{dx^n}(s,+)\right] \quad \text{polarized xsection} \quad (27)$$

$$A_N = \frac{\sigma^- - \sigma^+}{\sigma^- + \sigma^+} = \frac{\sigma^p}{\sigma^u} \equiv \frac{W_1}{W_2}$$

$$\langle A_N\rangle = \frac{\sum_i A_{N,i}\cdot\sigma_i^u}{\sum_i \sigma_i^u} = \frac{\sum_i \sigma_i^p}{\sum_i \sigma_i^u}$$

$$\langle FOM\rangle = \frac{\sum_i A_{N,i}\cdot\sqrt{\sigma_i^u}\cdot\sigma_i^u}{\sum_i \sigma_i^u} = \frac{\sum_i \sigma_i^p\cdot\sqrt{\sigma_i^u}}{\sum_i \sigma_i^u}$$

$$\langle E\cdot A_N\rangle = \frac{\sum_i E_i\cdot\sigma_i^p}{\sum_i E_i\cdot\sigma_i^u}$$



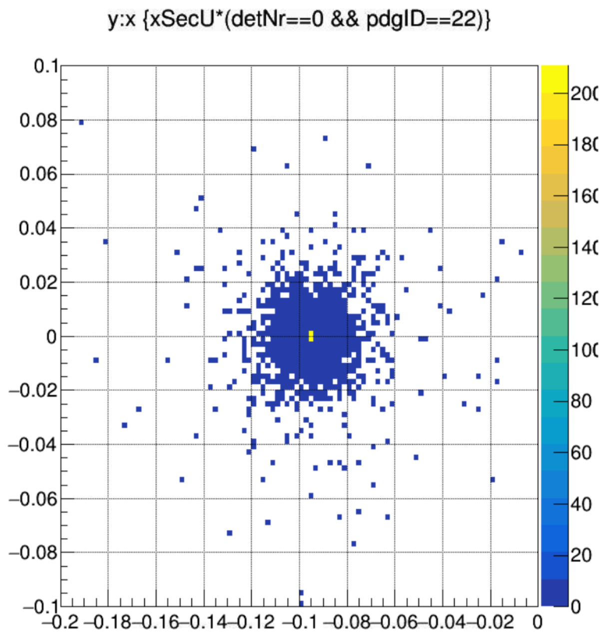
Simulation setup

- Implemented IP12 magnet configuration
  - https://github.com/cipriangal/fun4all_Compton
  - Particles going in –z direction with the origin at the exit of QD12
  - The lunch angle is the same as the QD12 angle for both the electron and photon
    - Confirmed that with this lunch angle an 18GeV electron goes through the middle of all magnet apertures
  - Look at the “truth” information at different planes before and after magnetic elements

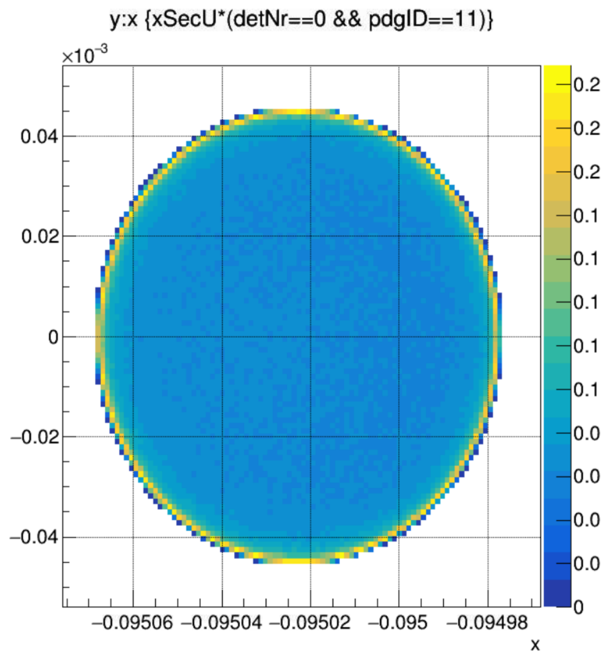
	X [m]	Y [m]	Z [m]	theta
QF13	0.17	0.00	6.19	38.40
DB23	0.07	0.00	3.25	28.80
QD12	0.00	0.00	0.30	19.20
DB23	-0.05	0.00	-2.65	9.60
QF11	-0.06	0.00	-5.59	0.00
QD10	-0.06	0.00	-16.32	0.00
QF9	-0.06	0.00	-27.04	0.00

Particle envelopes

photon

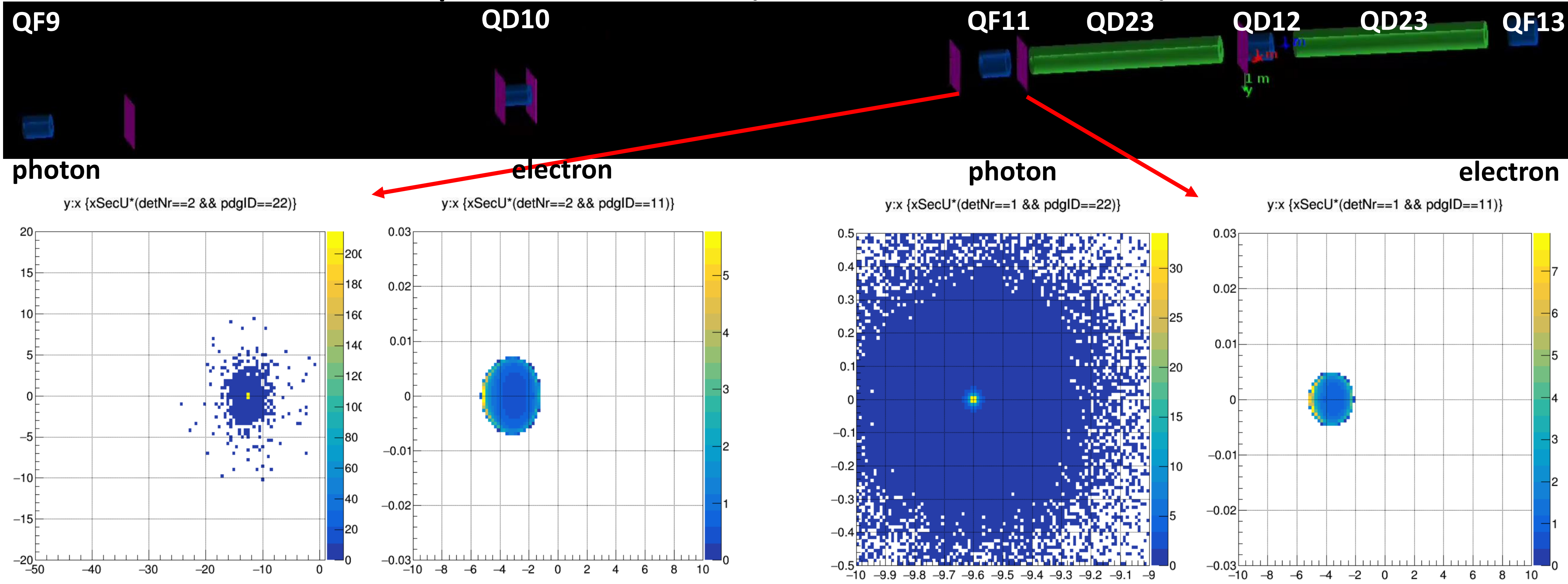


electron



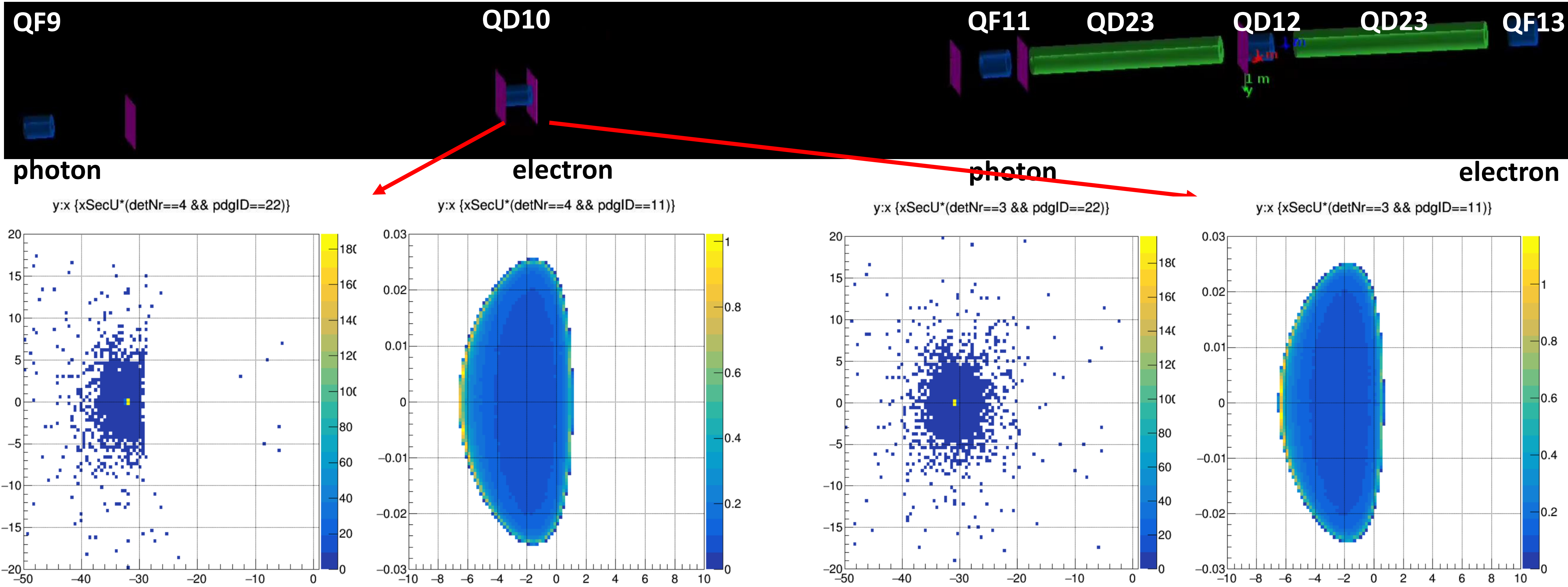
- All the axes are in cm
- The first "truth" plane is 6 cm downstream of the vertex point

Particle envelopes: QF11 (Rmin = 20 cm)



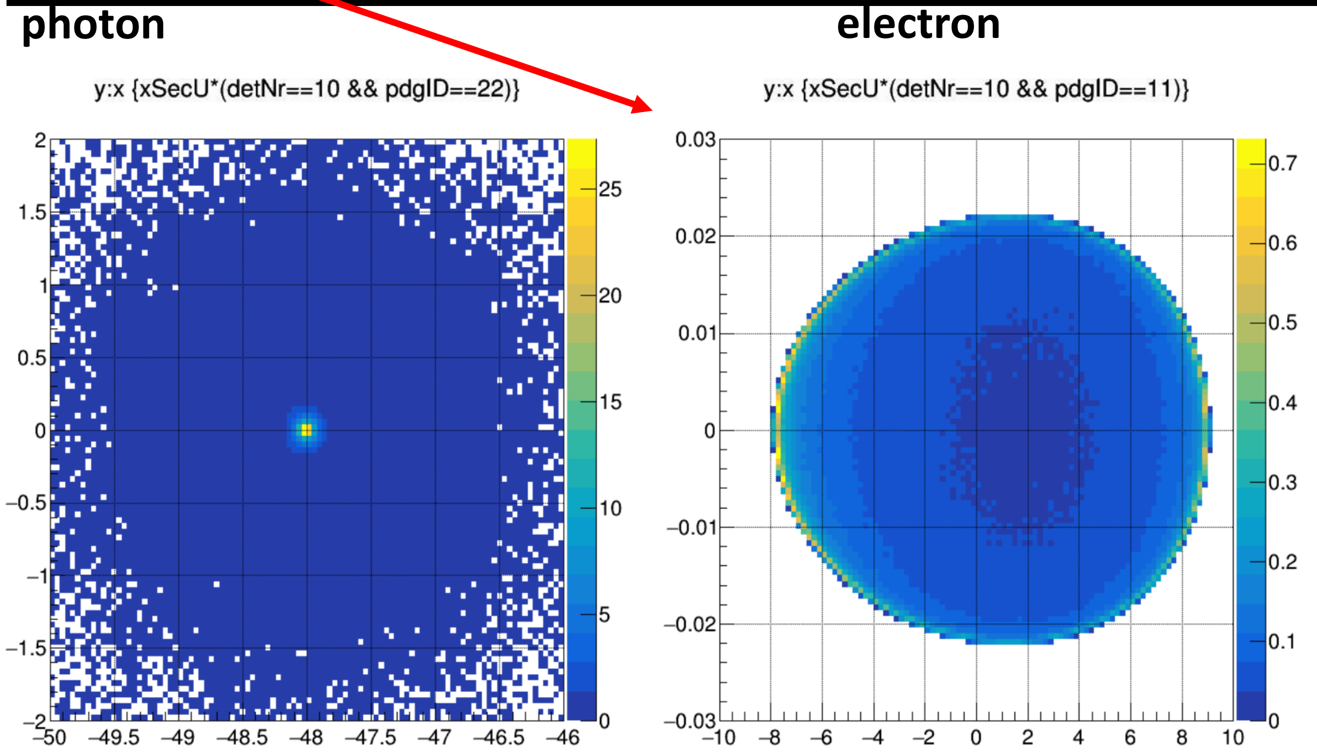
- I increased the bore of the quad to look downstream, but we can see we would start cutting into the photon envelope if Rmin<10cm (quad center is x=-6cm)

Particle envelopes: QD10 (Rmin=8.5cm Rmax=22.5cm)



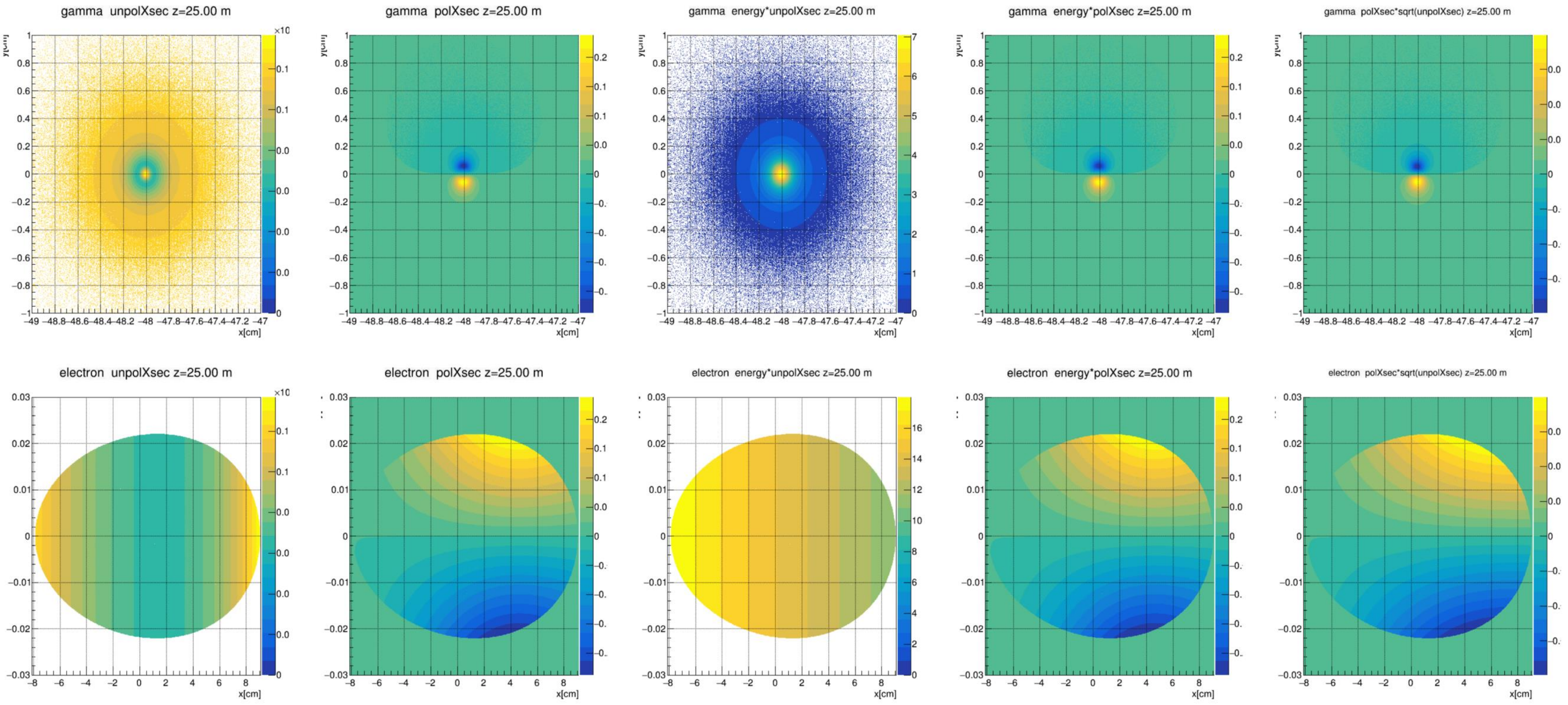
- Even with the restrictive magnet sizes we cut into the photon envelope with the QD10 outer size

Particle envelopes: “detector plane”



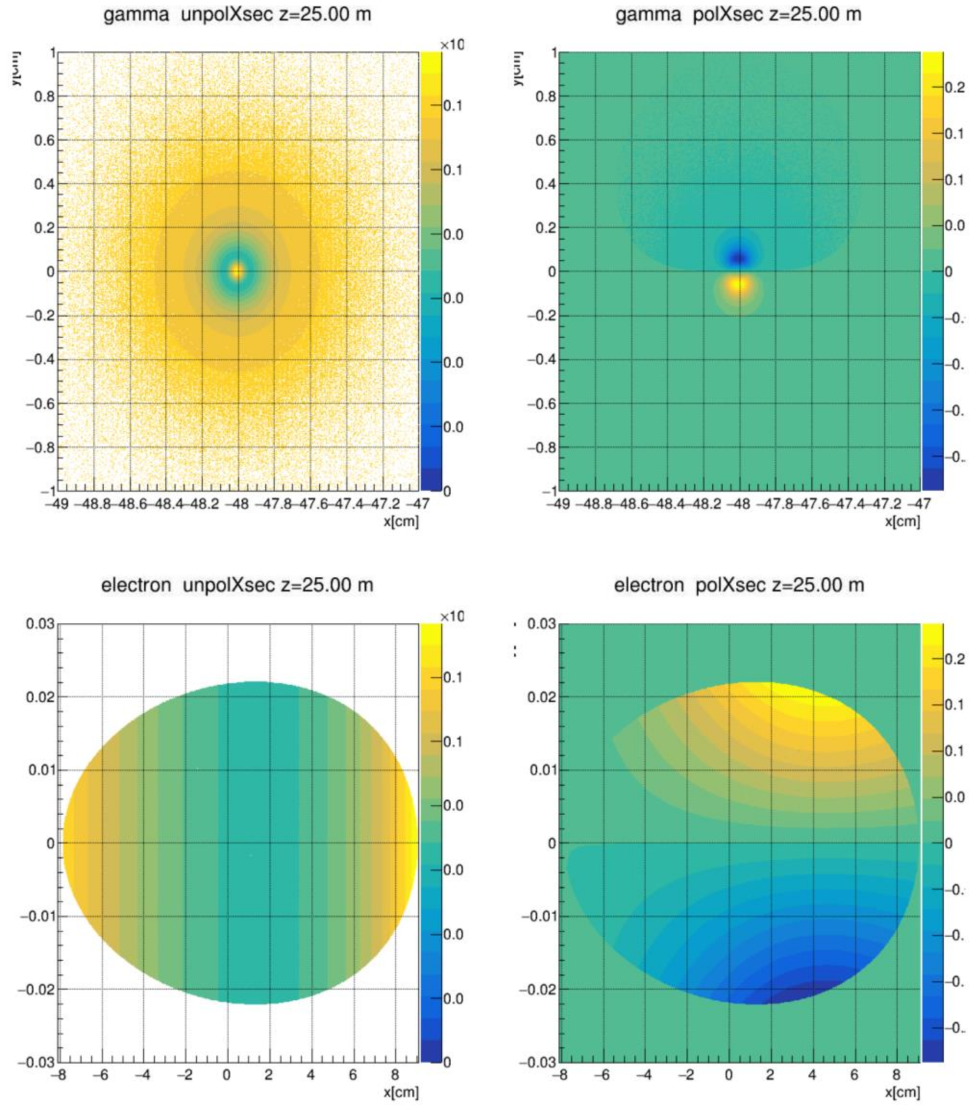
- For QF9 with Rmin=10cm and Rmax=25cm we will have significant showering from the electron envelope
- This will produce a significant charged background for the electron detector tracker
- To place a calorimeter for the photon detector we only have about 42cm clearance from the center of the beamline

Detector plane: nominal configuration

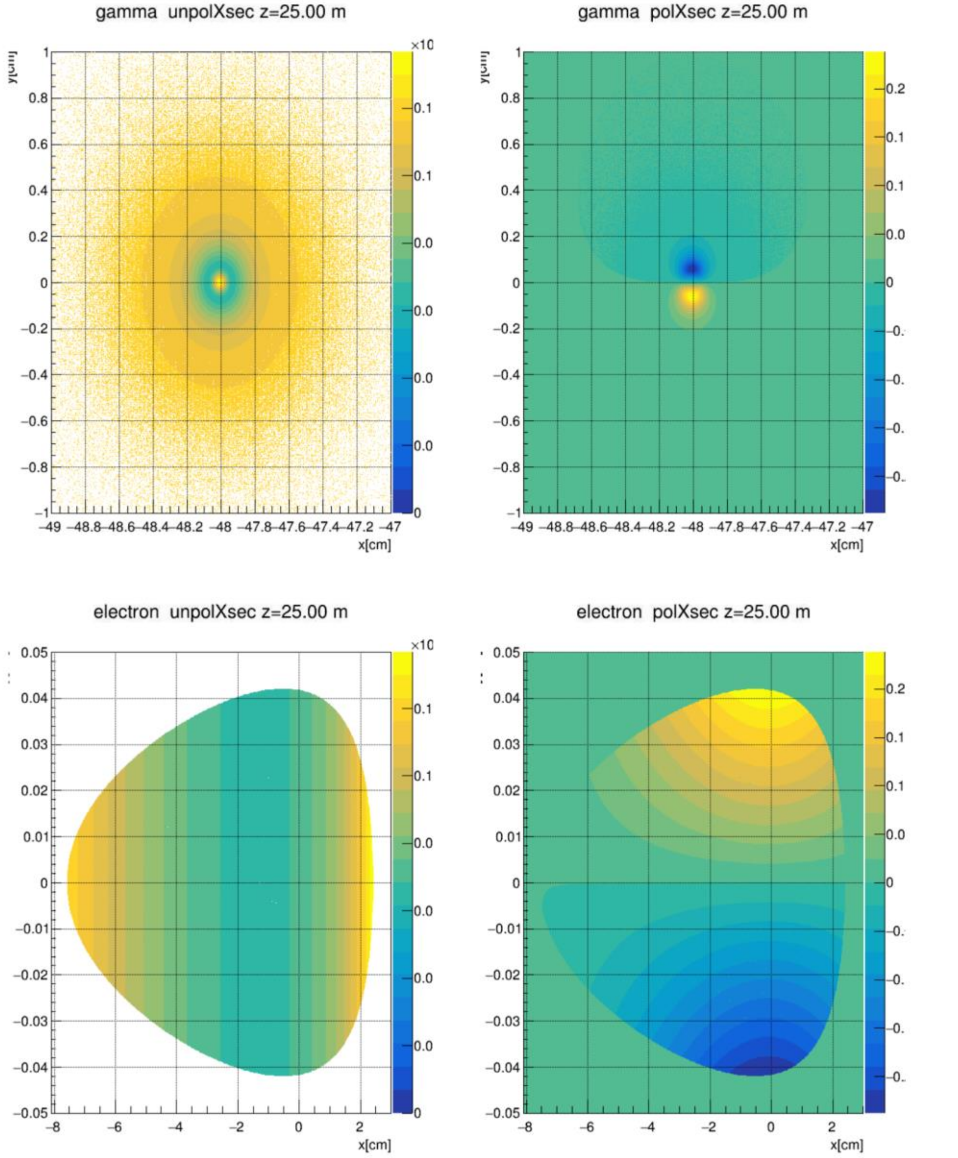


Without QD10

Nominal config



- Without the vertical focusing the scattered electron envelope would almost double by the time it gets to the detector plane



Vertex smearing

```
eicfile->set_vertex_distribution_mean(0,0,0,0);//cm, ns
eicfile->set_vertex_distribution_width(4.3e-3,3.3e-3,0.9,0);//cm, ns
```

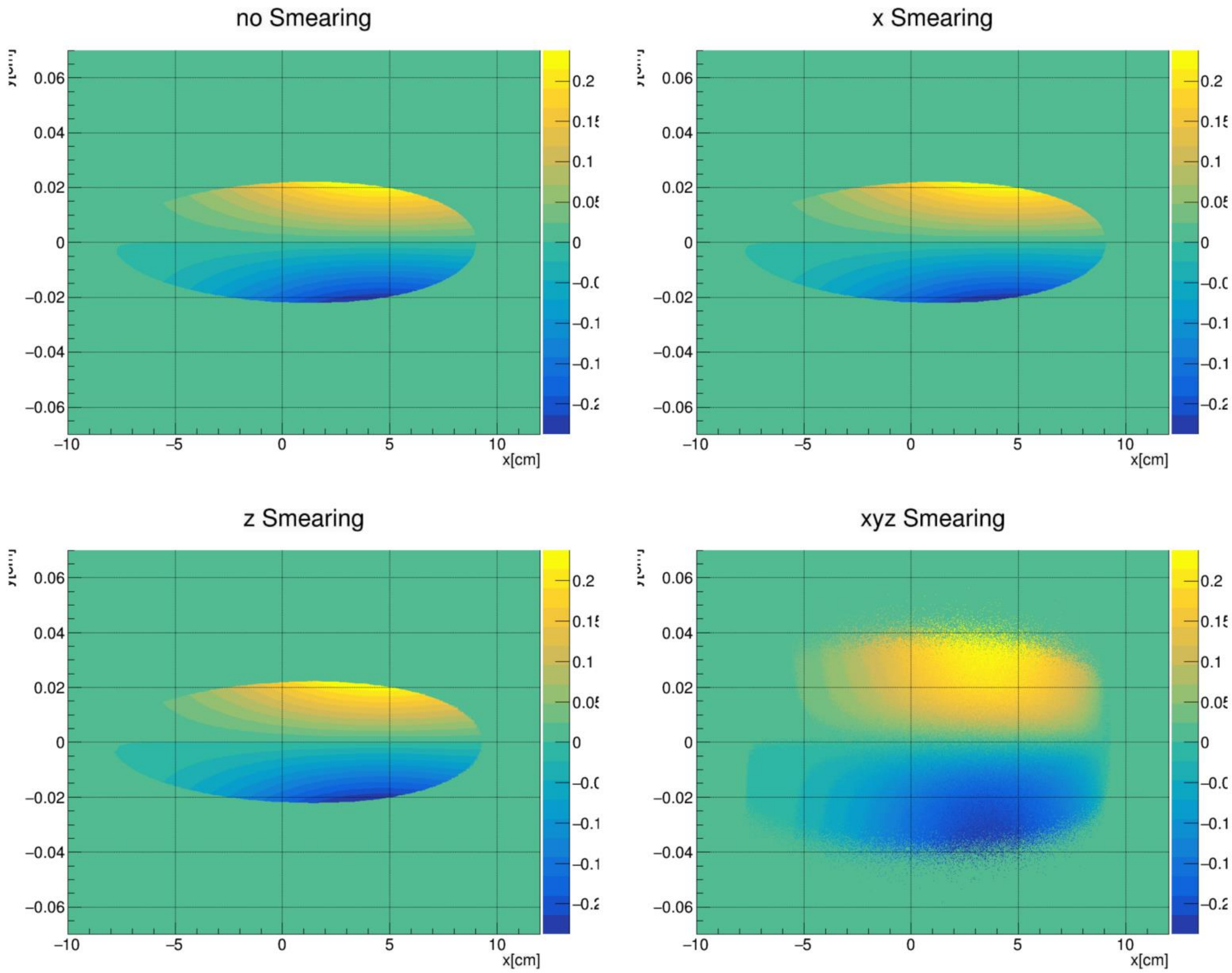
Here is the twiss parameters for IR12. "BETX", "BETY" is the beta function. "ALFX", "ALFY" is the slope of the beta function.

* NAME	S	L	BETX	ALFX	BETY	ALFY
"QF13"	1823.294259	0.6	4.669745436	0.310750451	23.49304068	-0.7668571524
"DB23"	1826.241095	4.223670697	3.777088439	-0.2494192314	37.53084031	-2.797041129
"QD12"	1829.18793	0.6	7.833576927	-1.577181773	54.98601912	0.06492603105
********* IP of the Compton polarimeter here *********						
"DB23"	1832.134765	4.223670697	25.91330713	-4.11259067	36.90923362	2.876766807
"QF11"	1835.0816	0.6	54.98959915	-2.21962997	22.61170074	0.5441235163
"QD10"	1845.805117	0.6	27.78894174	0.01007799586	54.99548409	-0.1719185813
"QF9"	1856.528634	0.6	54.99503024	0.2700717205	27.09541968	0.004988464914

$$\sigma_i = \sqrt{\epsilon_i * \beta_i}$$

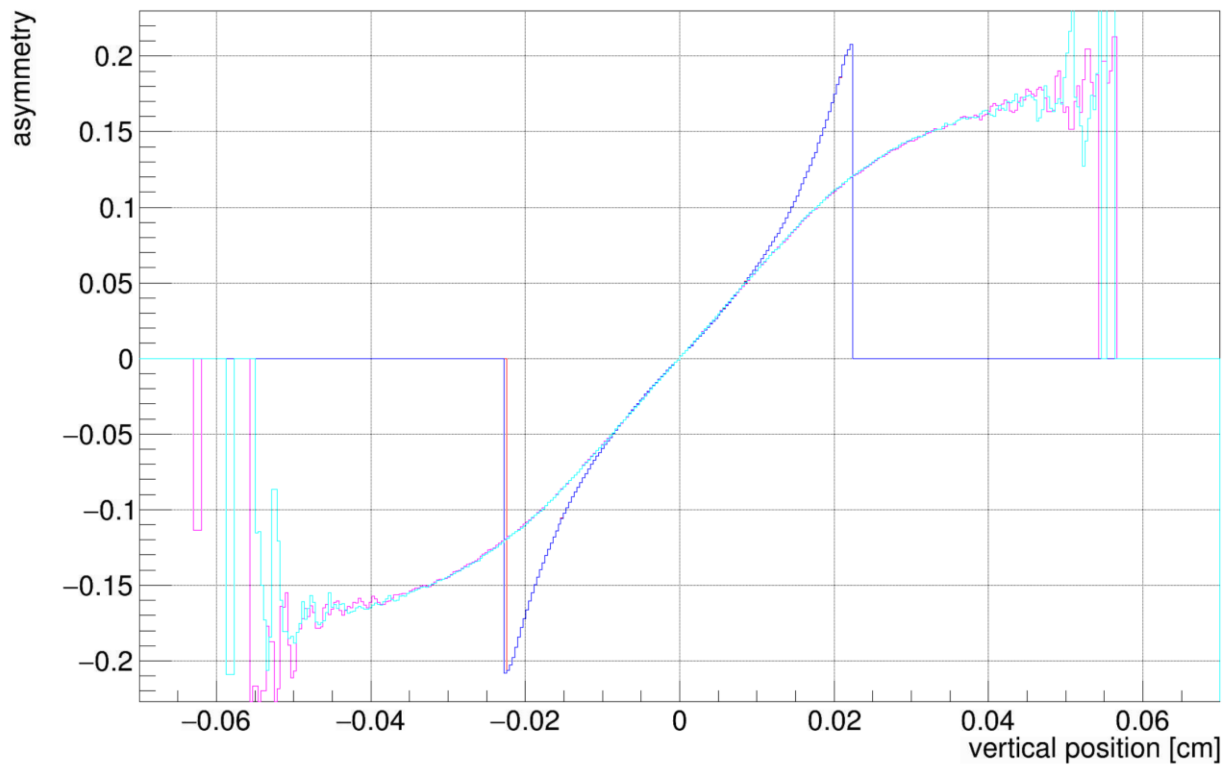
Species	proton	electron
Energy [GeV]	275	18
CM energy [GeV]	140.7	
Bunch intensity [10^{10}]	20.5	6.2
No. of bunches	290	
Beam current [A]	0.74	0.227
RMS norm. emit., h/v [μm]	4.6/0.75	845/72
RMS emittance, h/v [nm]	16/2.6	24/2.0
β^*, h/v [cm]]	90/4.0	59/5.0
IP RMS beam size, h/v [μm]	119/10	
K_x	11.8	
RMS $\Delta\theta$, h/v [μrad]	132/253	202/202
BB parameter, h/v [10^{-3}]	3/2	100/100
RMS long. emittance [10^{-3}, eV·sec]	36	
RMS bunch length [cm]	6	0.9
RMS $\Delta p/p$ [10^{-4}]	6.8	10.9
Max. space charge	0.006	neglig.
Piwinski angle [rad]	5.6	0.8
Long. IBS time [h]	2.1	
Transv. IBS time [h]	2	
Hourglass factor H	0.86	
Luminosity [10^{33}cm^{-2}sec^{-1}]	1.65	

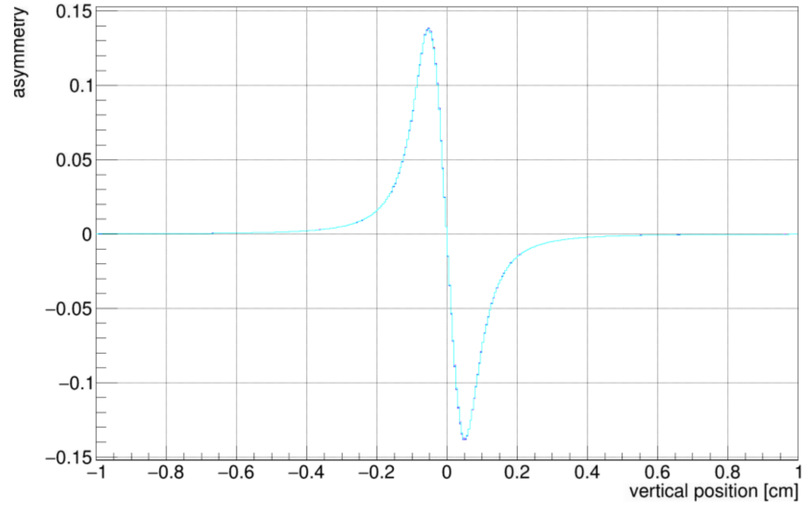
Vertex smearing

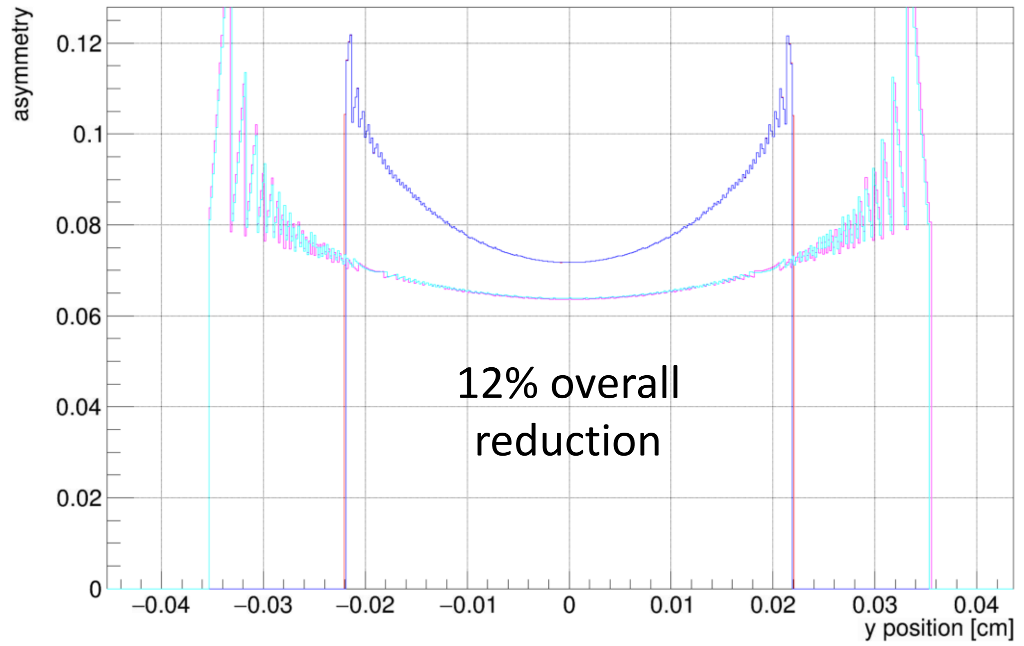


- We can see that x and z smearing is relatively benign to for the electron detector
- The Y smearing will push the electron envelope

Vertex smearing: vertical asymmetry

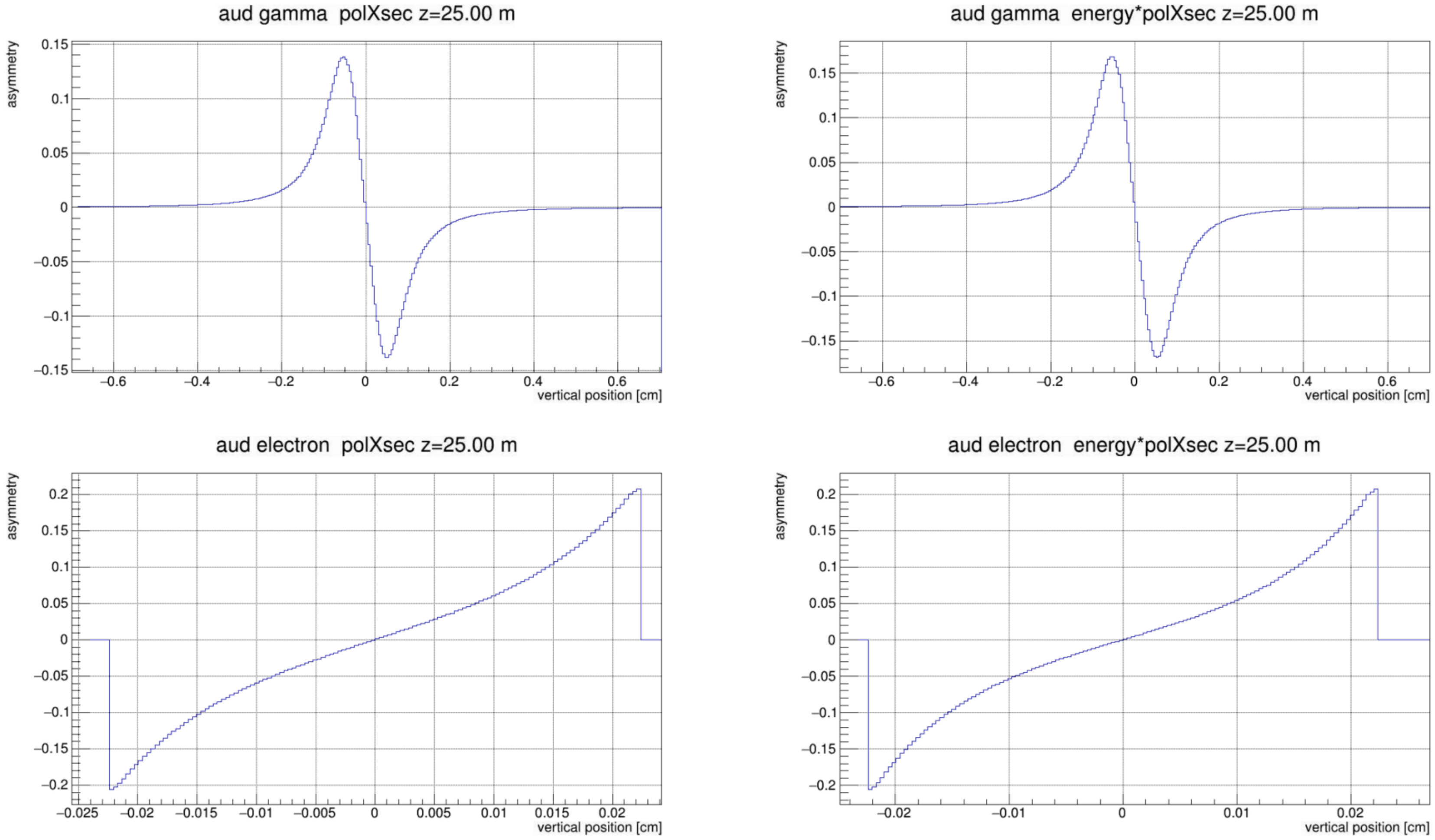






- The smearing will decrease the average measured asymmetry
- Plots in the following slides will be without any smearing

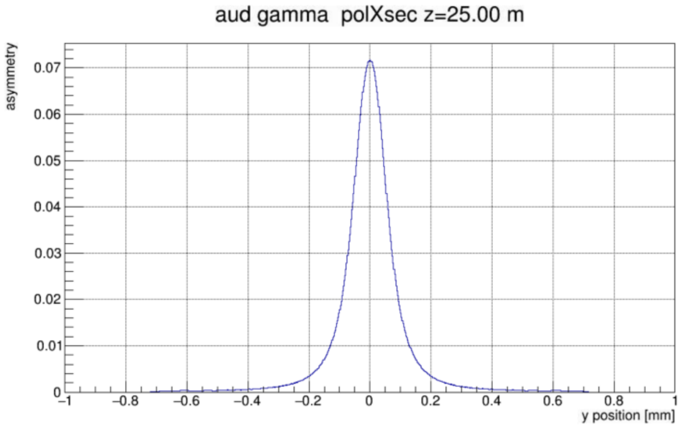
Vertical asymmetry: detector plane

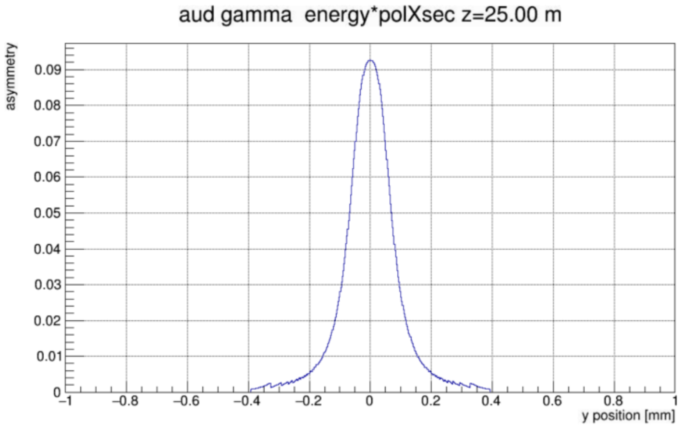


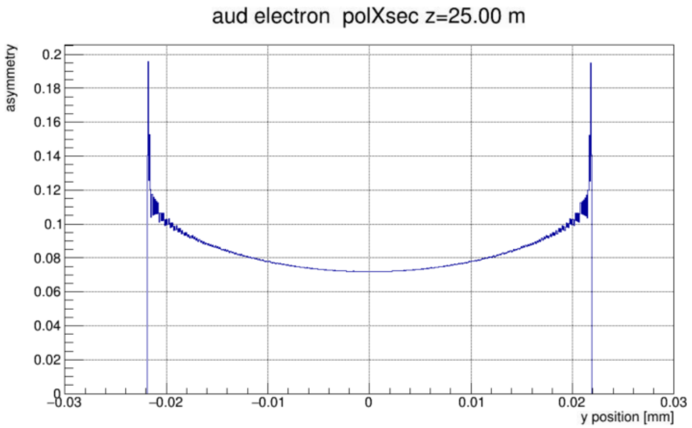
- We can see that the analyzing power goes up to ~14% for the photon and ~20% for the eletron

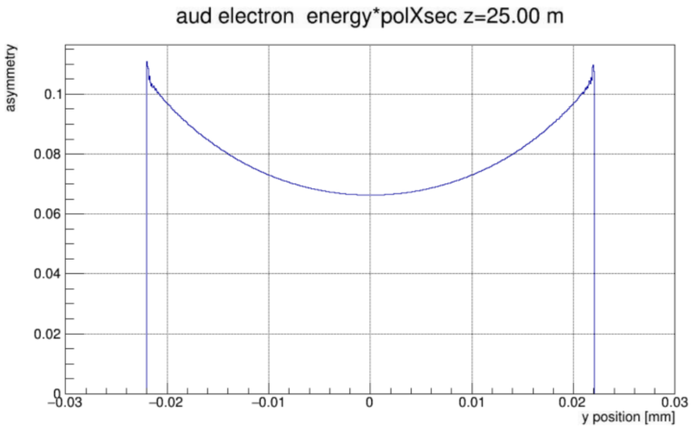
AUD and position offsets (detector plane)

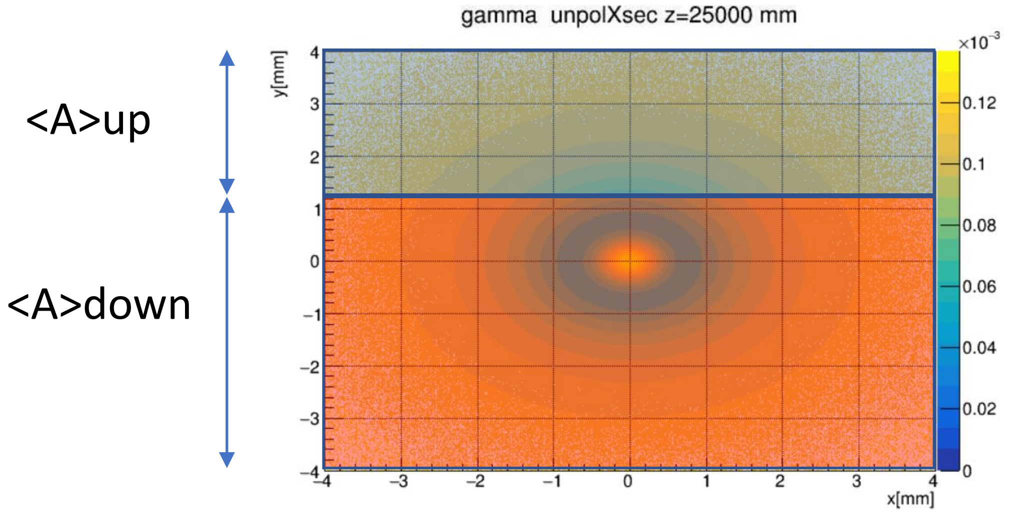
Vertical axis: (<A>up - <A>down)/2





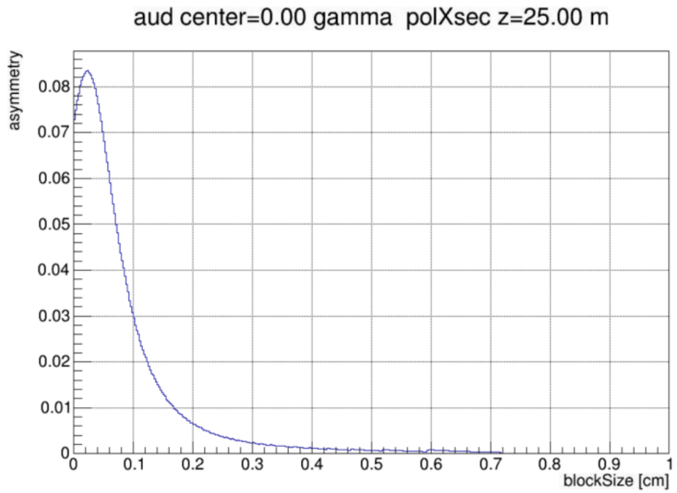


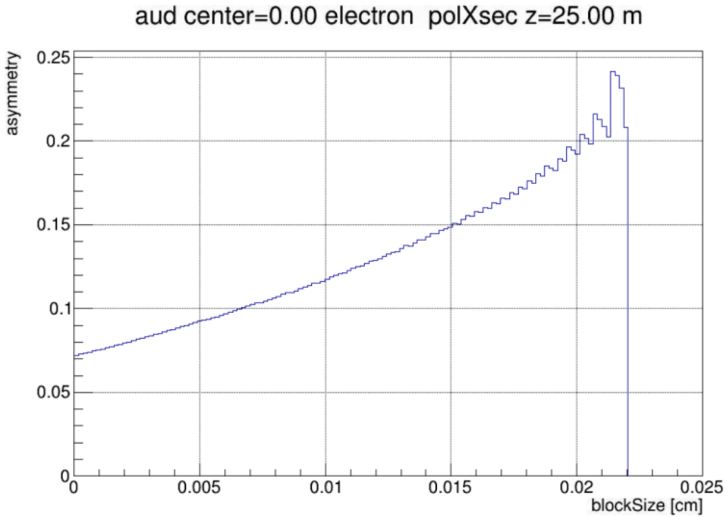


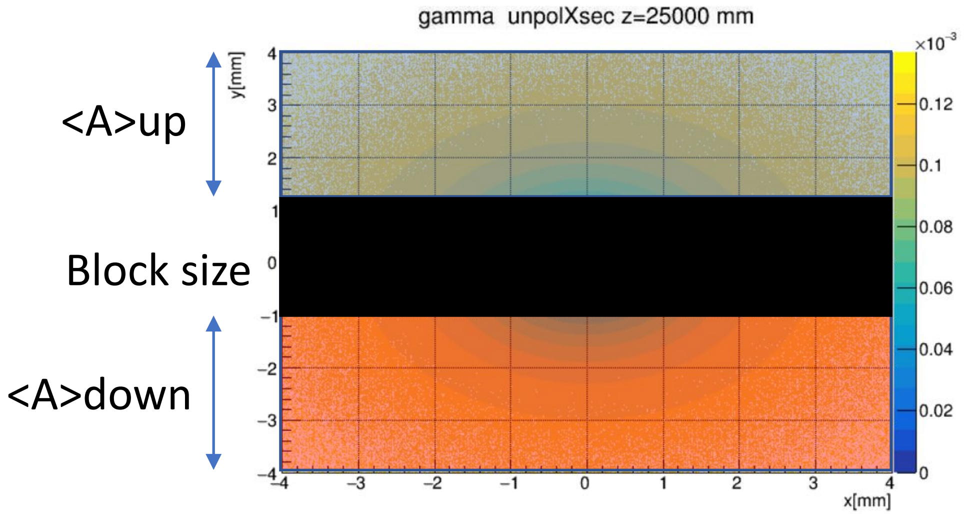


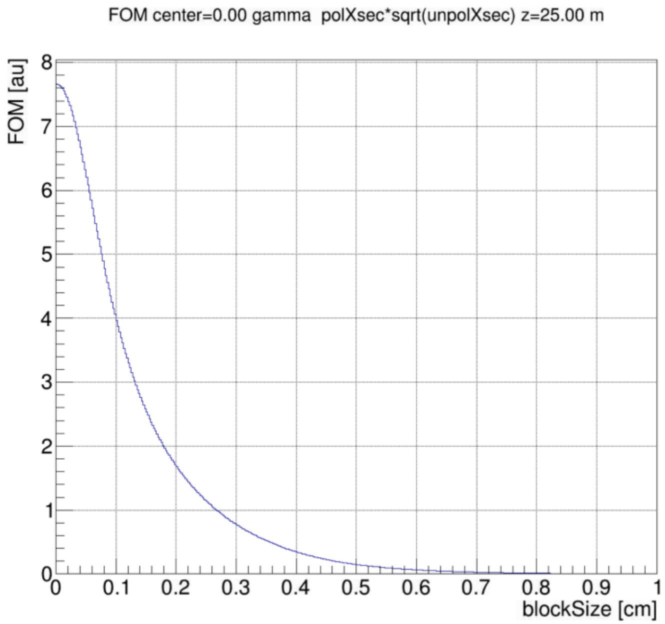
- For a simple "2-side" analysis both the photon and electron effective analyzing power is a ~7% for the counting analysis
  - An energy weighted analysis would increase the analyzing power for the photon by about 2% and decrease the electron analyzing power by about 1%

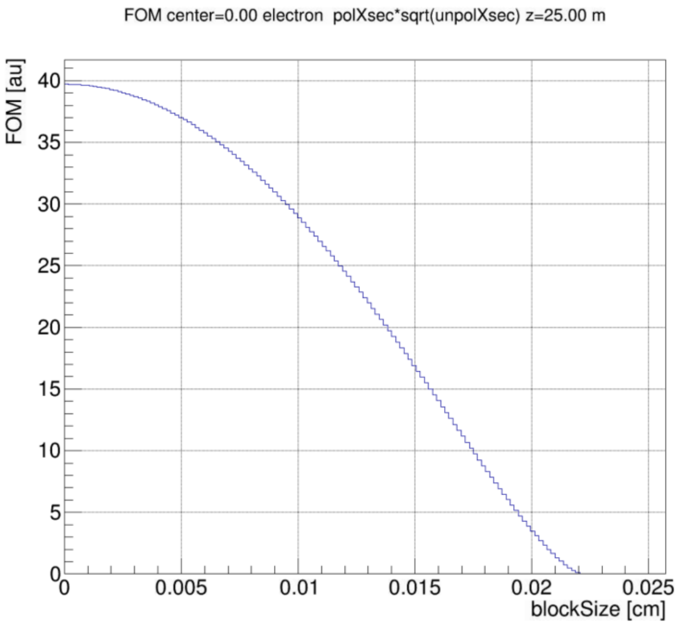
AUD block measurements – with Bfields





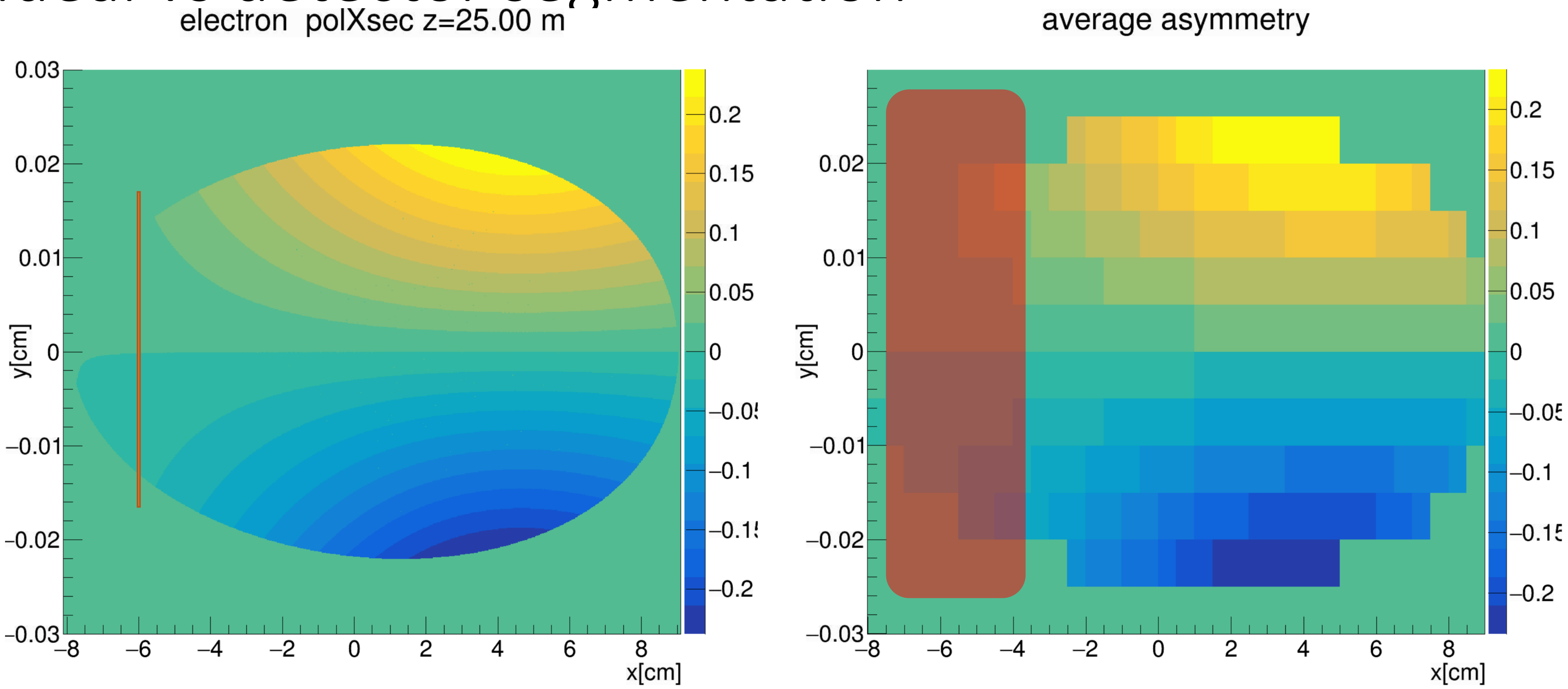






- While I made the claim last time there could be some gain from using two detector halves if we look at the FOM we see that is not really the case

Ideal vs detector segmentation

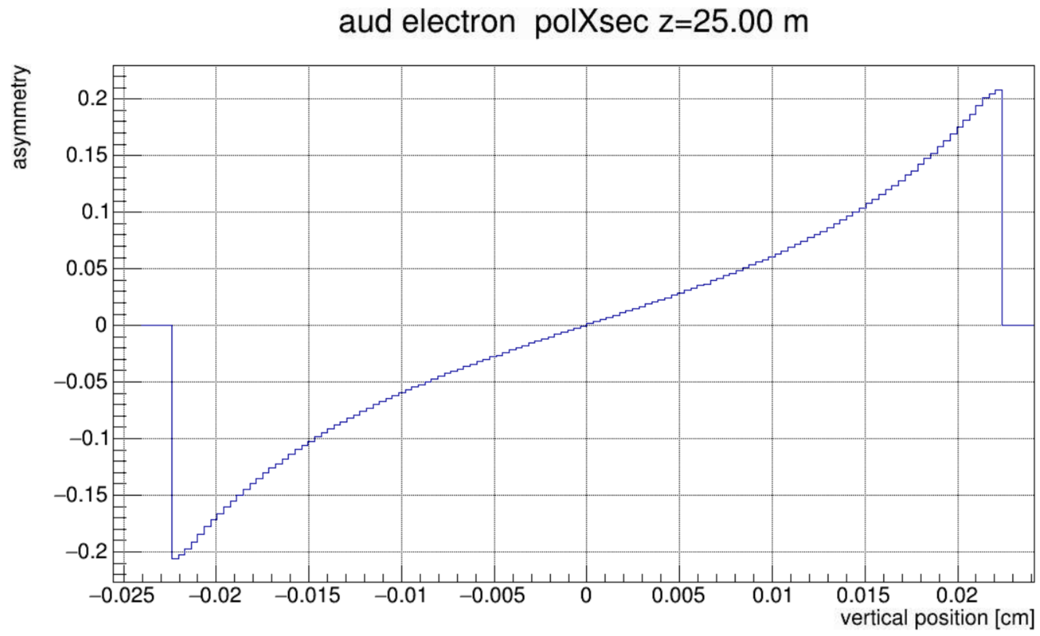


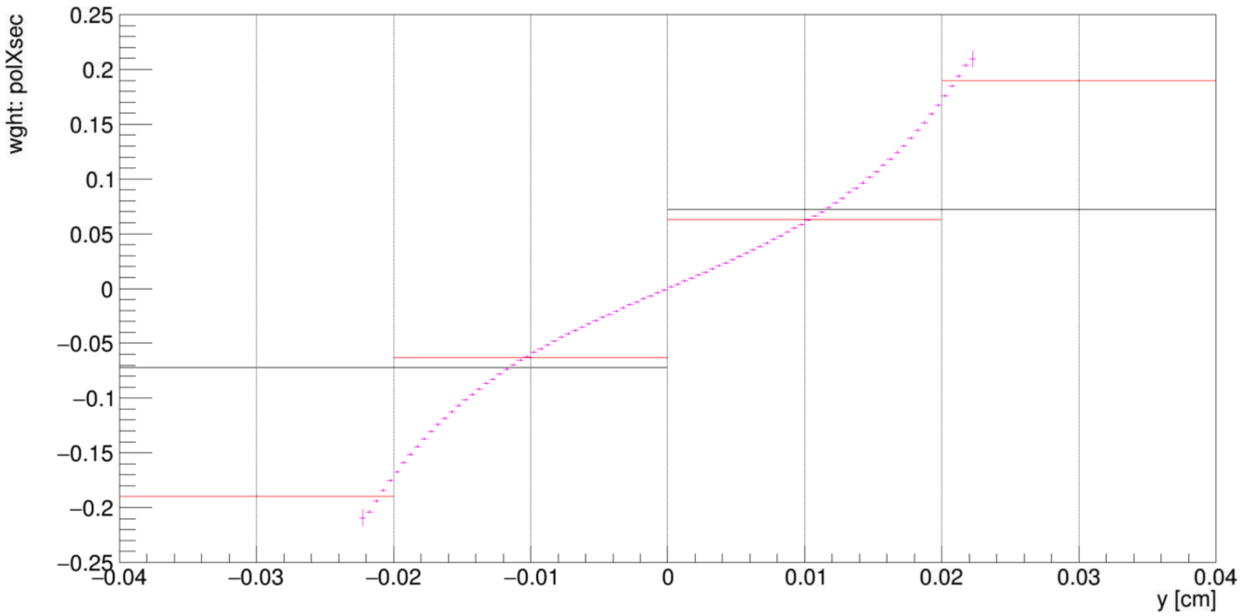
- For the "detector" analysis the left side should be removed (not done in the following)

Electron detector segmentation

segmentation [um]	norm	uncertainty
400	30.53	0.06
200	75.71	0.16
100	73.74	0.14
50	73.43	0.13
10	73.01	0.11
5	73.00	0.11

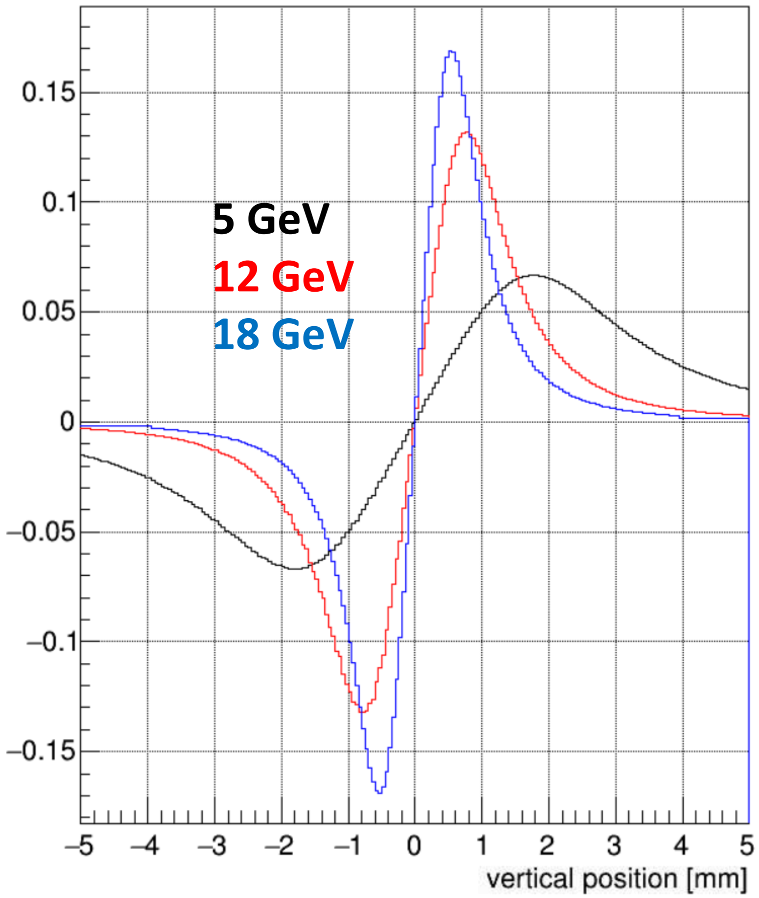
- Similar to the analysis Dave showed I vertically "segmented" and normalized (0.73) the asymmetry and fit it to the expected simulation asymmetry
- We can see that event at 50um we have a shift in the "extracted" polarization





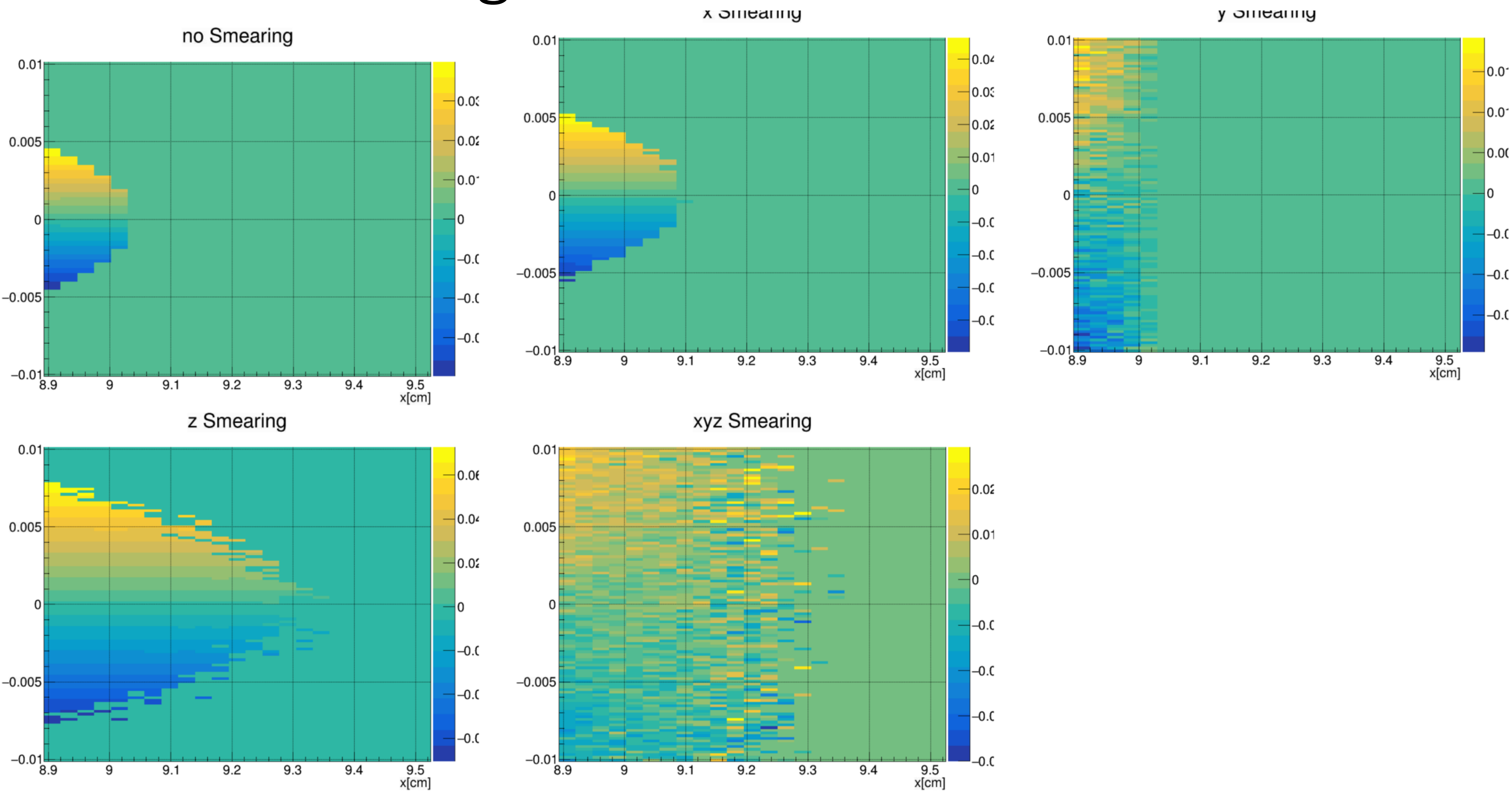
To do

- Redo analysis with smeared distributions and potential detector area
- Fold in luminosity and get a time estimate for 1% measurements
- Repeat for other energies
- Look at IP6

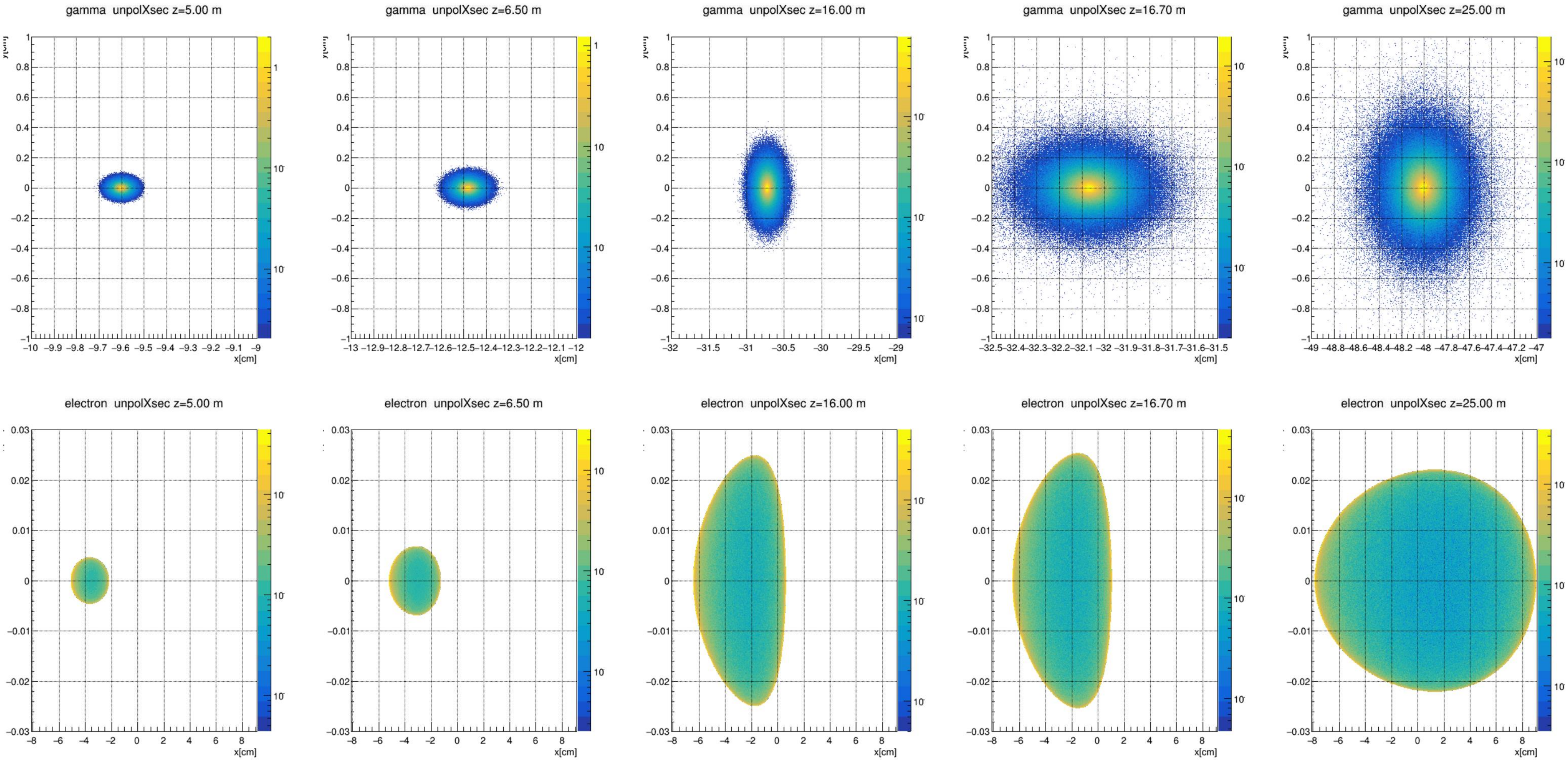


Backup

Vertex smearing



Xsection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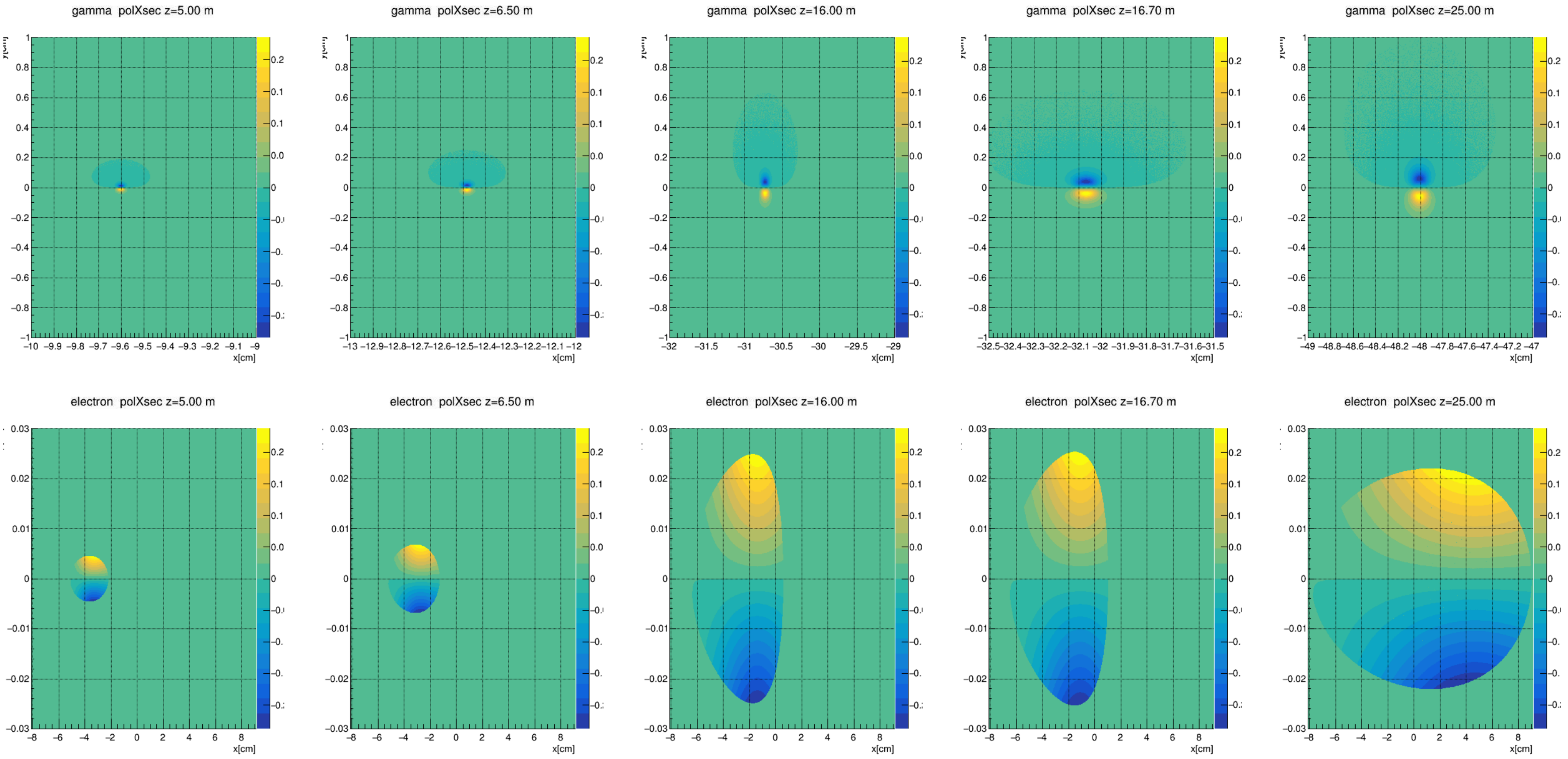
gamma unpolXsec z=6.50 m
gamma unpolXsec z=16.00 m
gamma unpolXsec z=16.70 m
gamma unpolXsec z=25.00 m
electron unpolXsec z=5.00 m
electron unpolXsec z=6.50 m
electron unpolXsec z=16.00 m
electron unpolXsec z=16.70 m
electron unpolXsec z=25.00 m
x[cm]

Asym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gamma polXsec z=6.50 m
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gamma polXsec z=16.70 m
gamma polXsec z=25.00 m
electron polXsec z=5.00 m
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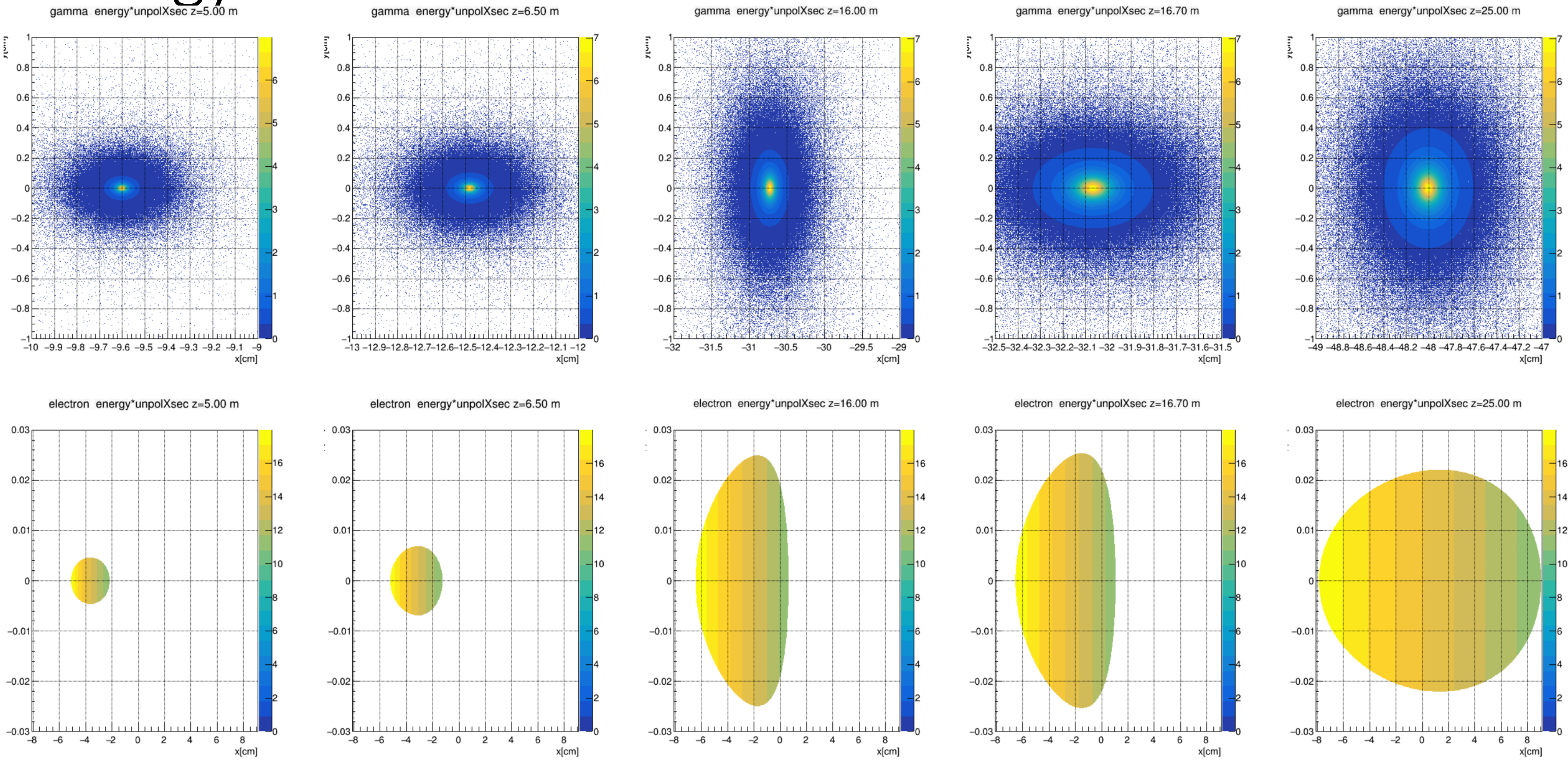
electron polXsec z=16.00 m
electron polXsec z=16.70 m
electron polXsec z=25.00 m
x[cm]

<Energy>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gamma energy*unpolXsec z=6.50 m
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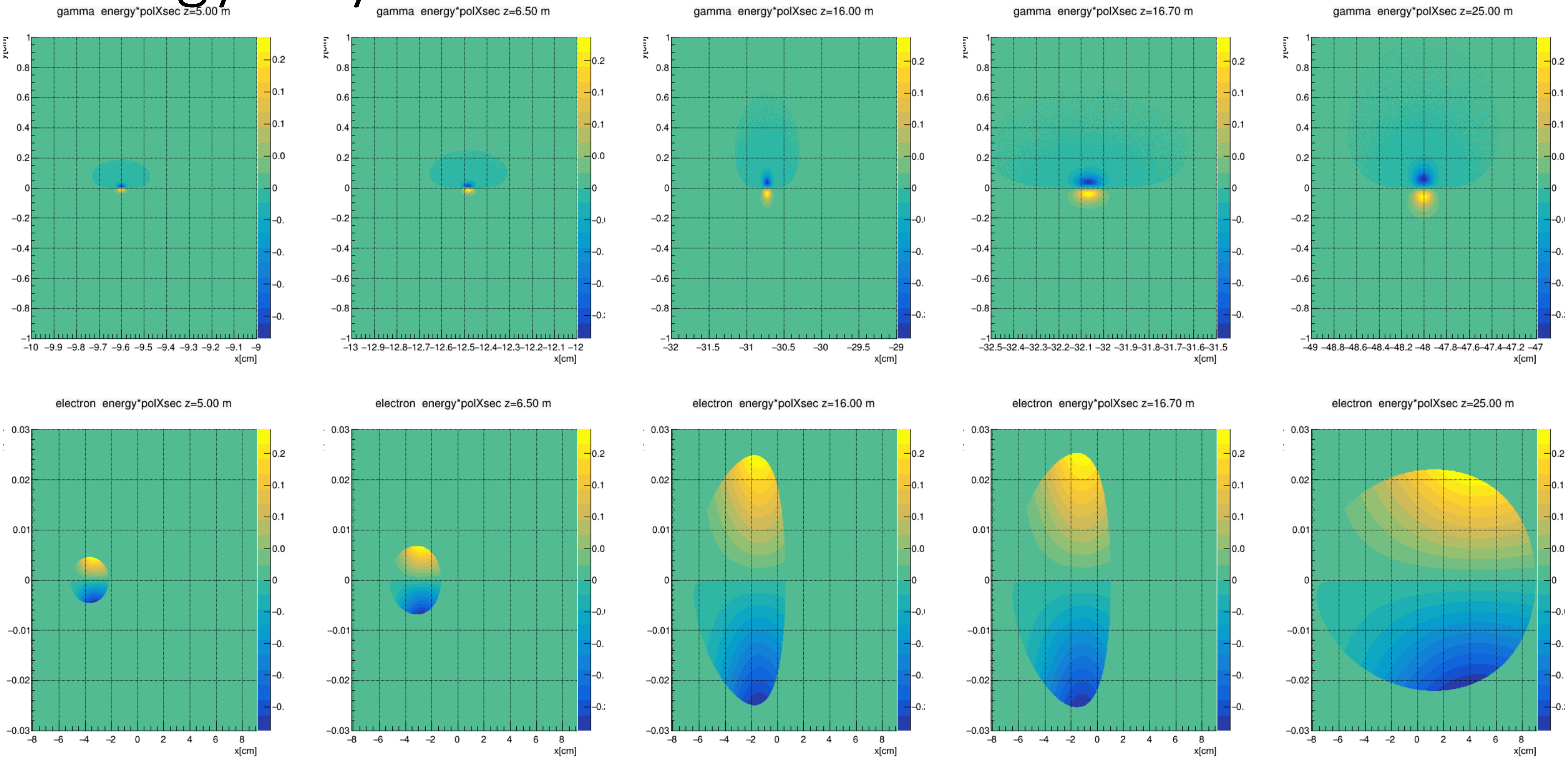
gamma energy*unpolXsec z=16.70 m
gamma energy*unpolXsec z=25.00 m
electron energy*unpolXsec z=5.00 m
electron energy*unpolXsec z=6.50 m
electron energy*unpolXsec z=16.00 m
electron energy*unpolXsec z=16.70 m
electron energy*unpolXsec z=25.00 m
x[cm]

<Energy*Asym>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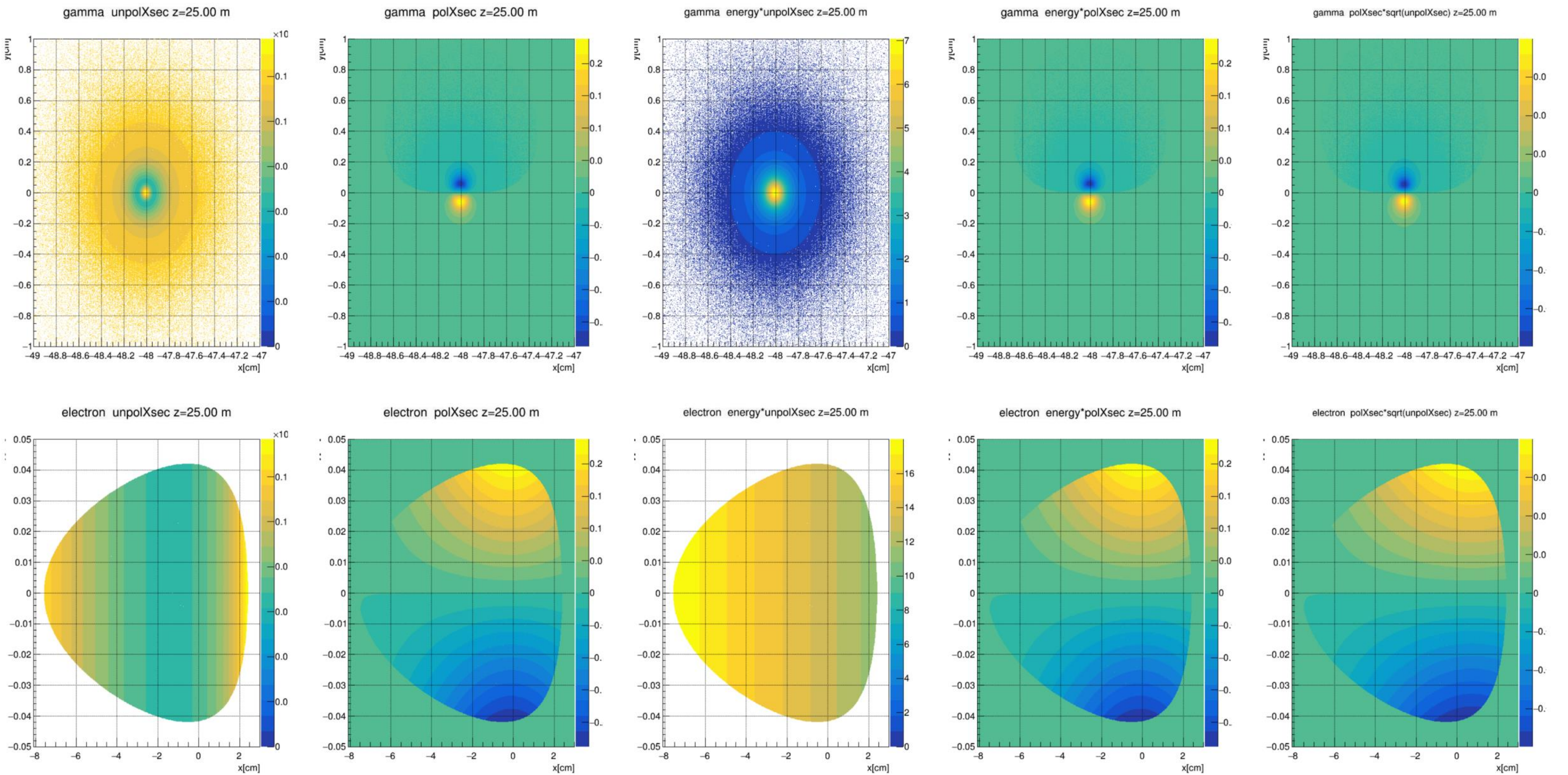
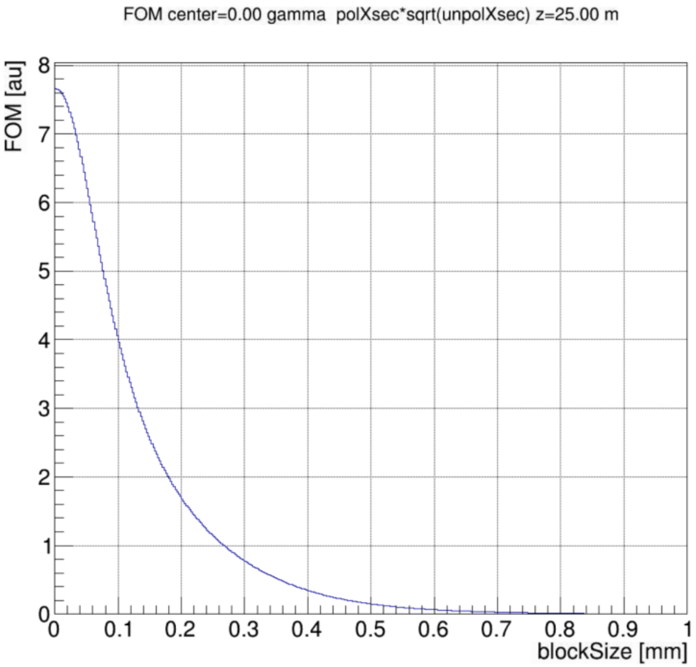
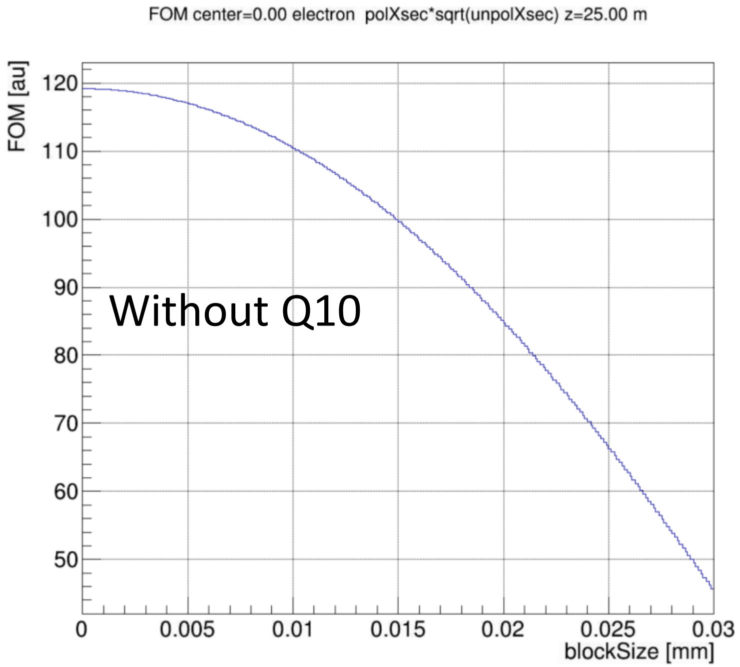
gamma energy*polXsec z=6.50 m
gamma energy*polXsec z=16.00 m
gamma energy*polXsec z=16.70 m
gamma energy*polXsec z=25.00 m
electron energy*polXsec z=5.00 m
electron energy*polXsec z=6.50 m
electron energy*polXsec z=16.00 m
electron energy*polXsec z=16.70 m
electron energy*polXsec z=25.00 m
x[cm]

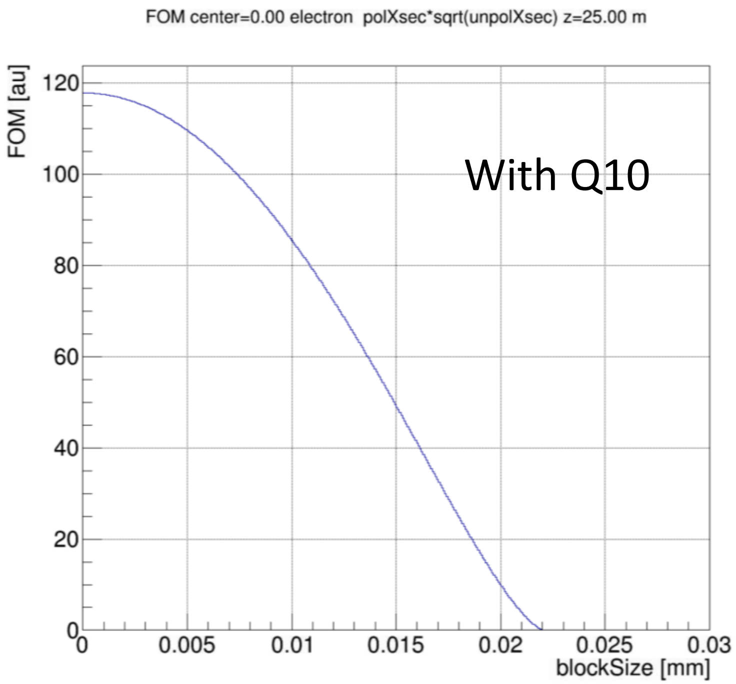
25m (det plane): noQD10



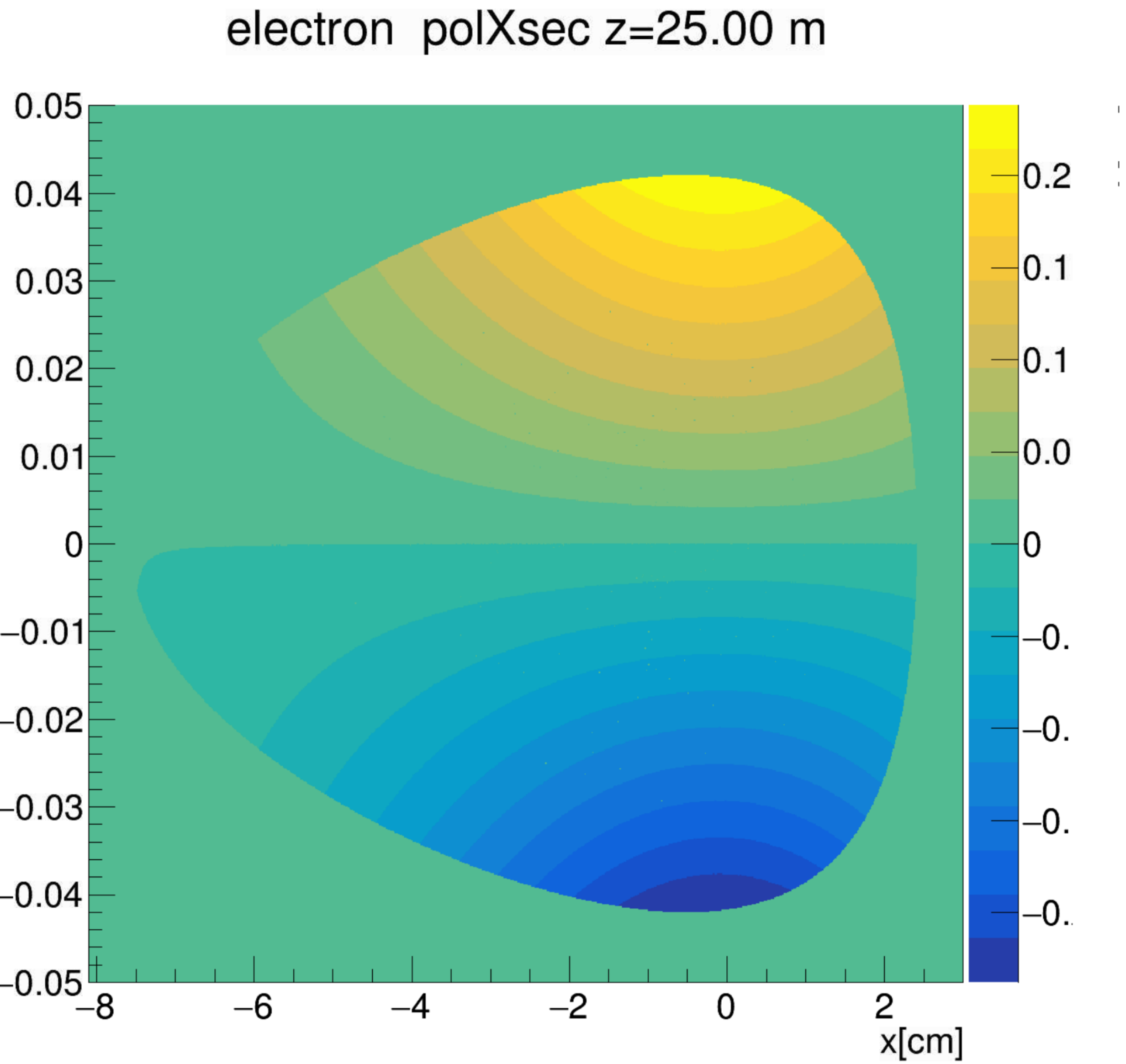
AUD block measurements – with Bfields

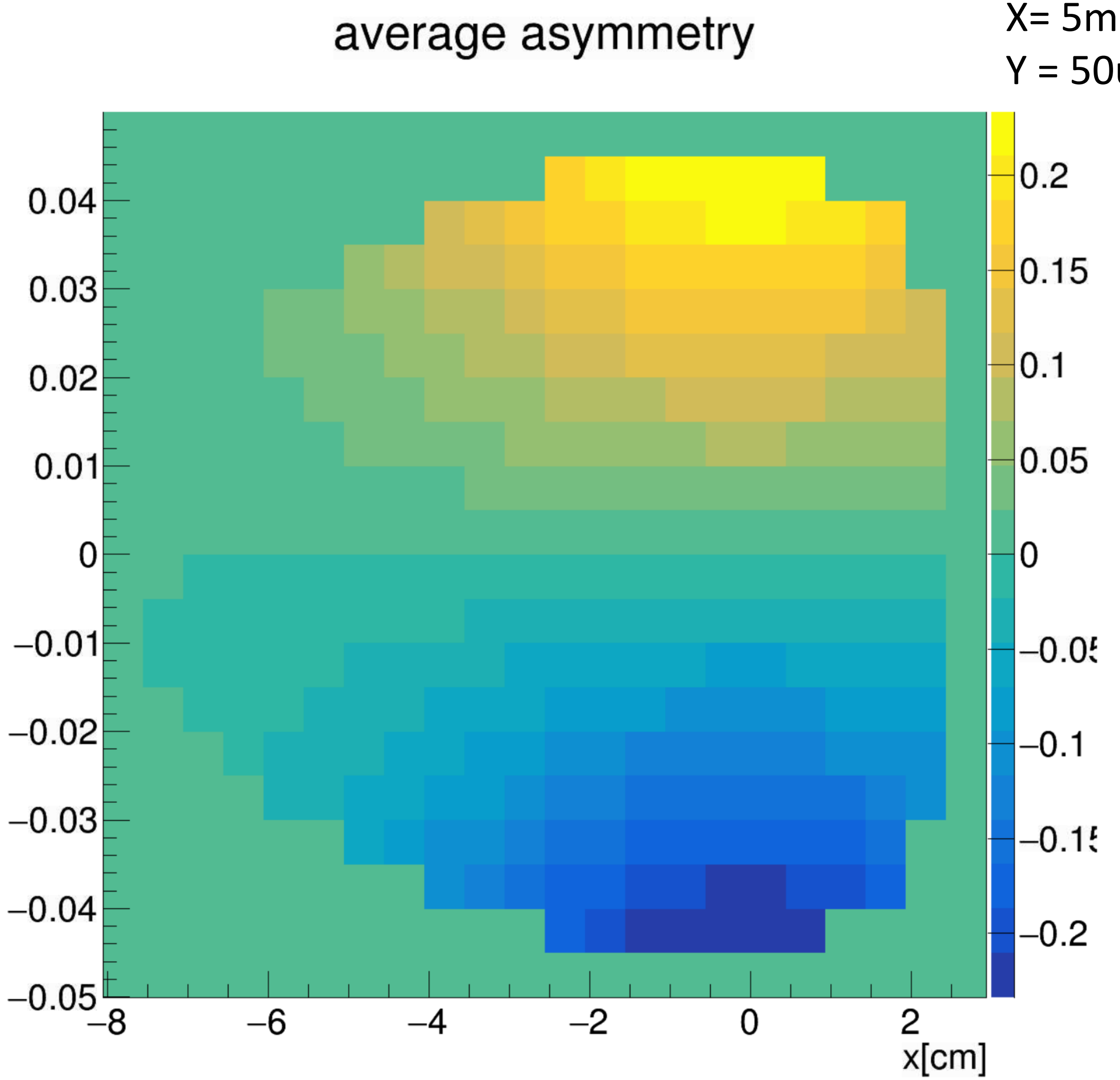






Ideal vs detector segmentation





X= 5mm
Y = 50um