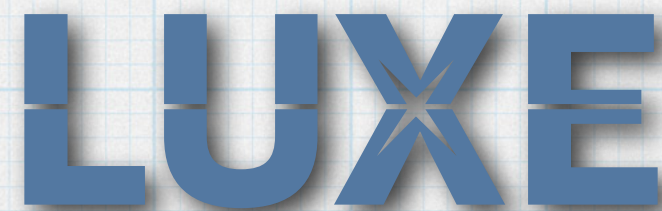


Radiation load

Borysova Maryna (KINR)

30/11/21

LUXE simulation meeting

The logo for the LUXE experiment, featuring the word "LUXE" in a bold, blue, sans-serif font. The letter "X" is stylized with a grey, multi-pointed starburst or spark-like graphic in the center, suggesting high-energy particle collisions.

Absorbed dose estimation

Absorbed dose is a dose quantity which is the measure of the energy deposited in **matter** by **ionizing radiation** per unit mass.

Absorbed dose of ionizing radiation

Common symbols	D
SI unit	Gray
Other units	Rad, Erg
In SI base units	$\text{J} \cdot \text{kg}^{-1}$

- * Energy deposited in sensitive volumes from Hits tree
- * $D = E_{\text{dep}} / M$ $\text{Gy} = [\text{J/kg}]$
- * M is the mass of sensitive volume (pad, pixel...)
- * To convert it to Gray, convert E_{dep} in GeV to Joule: 1 GeV is equal to $\sim 1.6 \times 10^{-10}$ J.
- * Samples used for estimations:

Signal MC

Oleksandr Borysov posted on 11. Feb. 2021 10:58h – last edited by Oleksandr Borysov on 05. Oct. 2022

PTarmigan_V0.8.1

JETI40 (Phase 0, circularly polarized laser)

e_laser 16.5 GeV

MC	# MC out (BX)	Processed (BX)	Location	Notes
e0gpc_0.5_g4{0-9}	10	10	/nfs/dust/luxe/group/MCProduction/Signal/g4/ptarmigan-v0.8.1/e-laser/phase0/gpc/e0gpc_0.5	IP magnet 0.95T, MC: e0gpc_0.5{0-9}
e0gpc_1.0_g4{0-9}	10	10	/nfs/dust/luxe/group/MCProduction/Signal/g4/ptarmigan-v0.8.1/e-laser/phase0/gpc/e0gpc_1.0	IP magnet 0.95T, MC: e0gpc_1.0{0-9}
e0gpc_3.0_g4{0-9}	10	9	/nfs/dust/luxe/group/MCProduction/Signal/g4/ptarmigan-v0.8.1/e-laser/phase0/gpc/e0gpc_3.0	IP magnet 0.95T, MC: e0gpc_3.0{0-9}

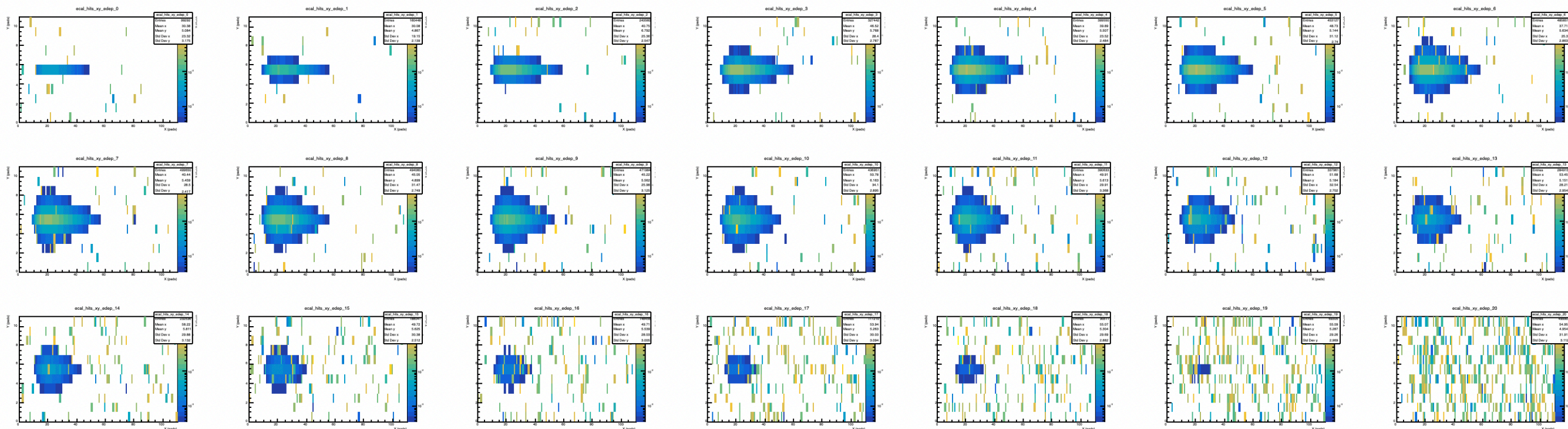
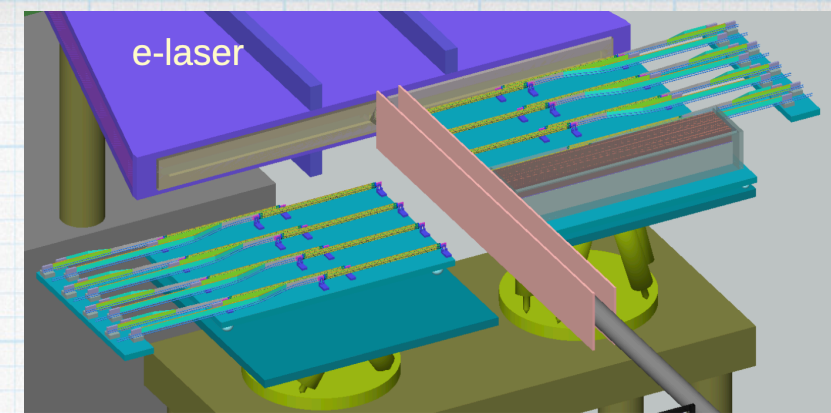
Electron-laser 16.5 GeV Background

Simulation	ID	# particles	Processed (BX)	Location	Notes
Background for electron-laser setup	tdr_el_01	3.2e9	2.13	/nfs/dust/luxe/group/MCProduction/Background/elaser/31082021_7671ee4c/list_root_7671ee4c.txt	Setup corresponds to commit 7671ee4c305 (hics branch) elaer_tdr_v0.1
Background for electron-laser setup	tdr_el_f_01	1.12e10	7.45	/nfs/dust/luxe/group/MCProduction/Background/elaser/10102021_7671ee4c_fast	Setup corresponds to commit 7671ee4c305 (hics branch) elaer_tdr_v0.1 with the option to stop tracking particles which hit beam dumps or shielding
Background for electron-laser setup	tdr_el_n_01	2.09e8	0.14	/nfs/dust/luxe/group/MCProduction/Background/elaser/03112021_b7acaa6e/ob	Setup corresponds to commit b7acaa6e (hics branch) with additional neutron absorber attached to the electron beam dump. It is made of borated polyethylene concrete.

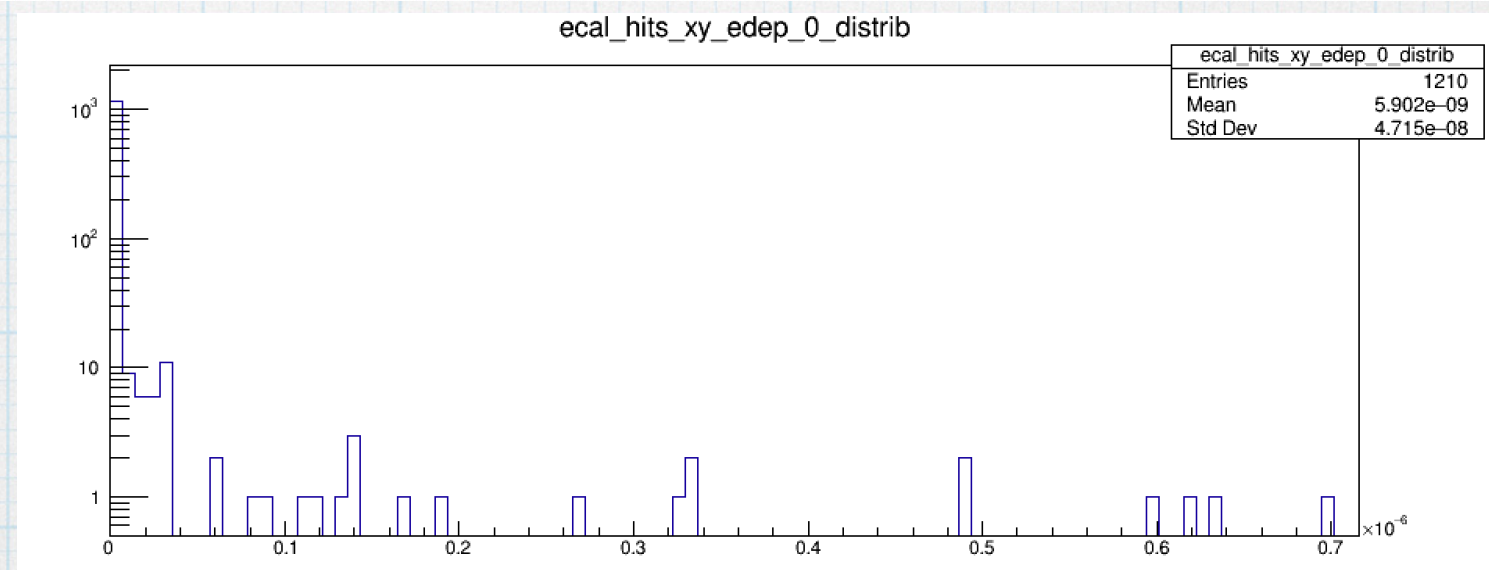
The estimations are done using
1x signal + 9x background

ECAL Signal

- JET140, 16.5 GeV, 3 um, 9 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan



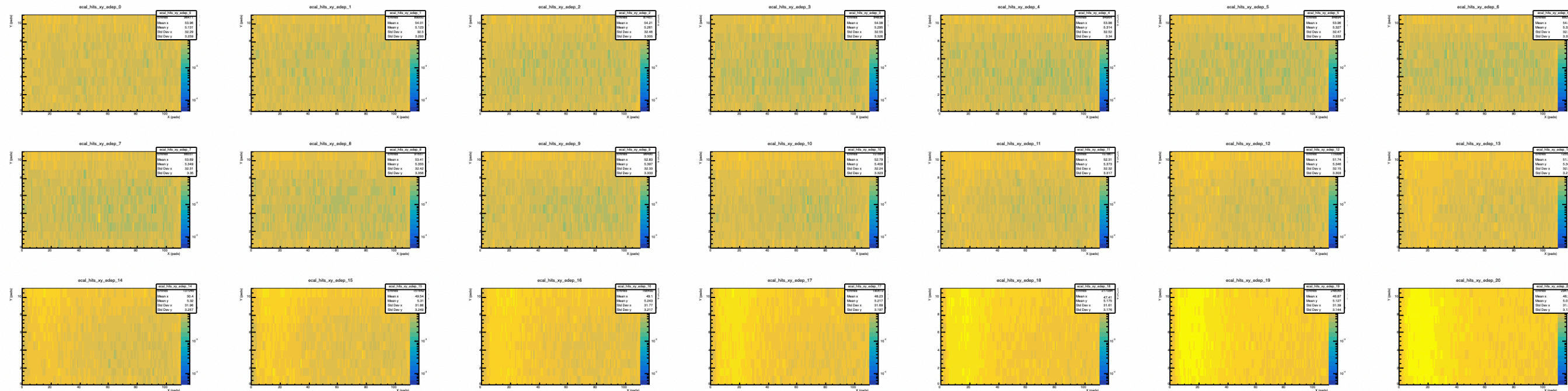
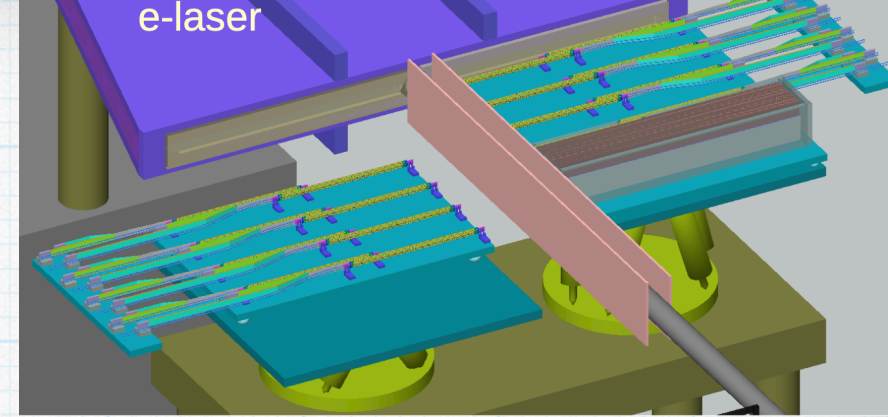
Layer	D, Gy
0	7.19E-09
1	5.50E-09
2	1.11E-08
3	1.17E-08
4	1.27E-08
5	1.54E-08
6	2.05E-08
7	1.50E-08
8	1.47E-08
9	1.58E-08
10	1.64E-08
11	1.83E-08
12	1.55E-08
13	2.19E-08
14	2.63E-08
15	2.81E-08
16	3.48E-08
17	4.77E-08
18	4.61E-08
19	6.74E-08
20	9.14E-08



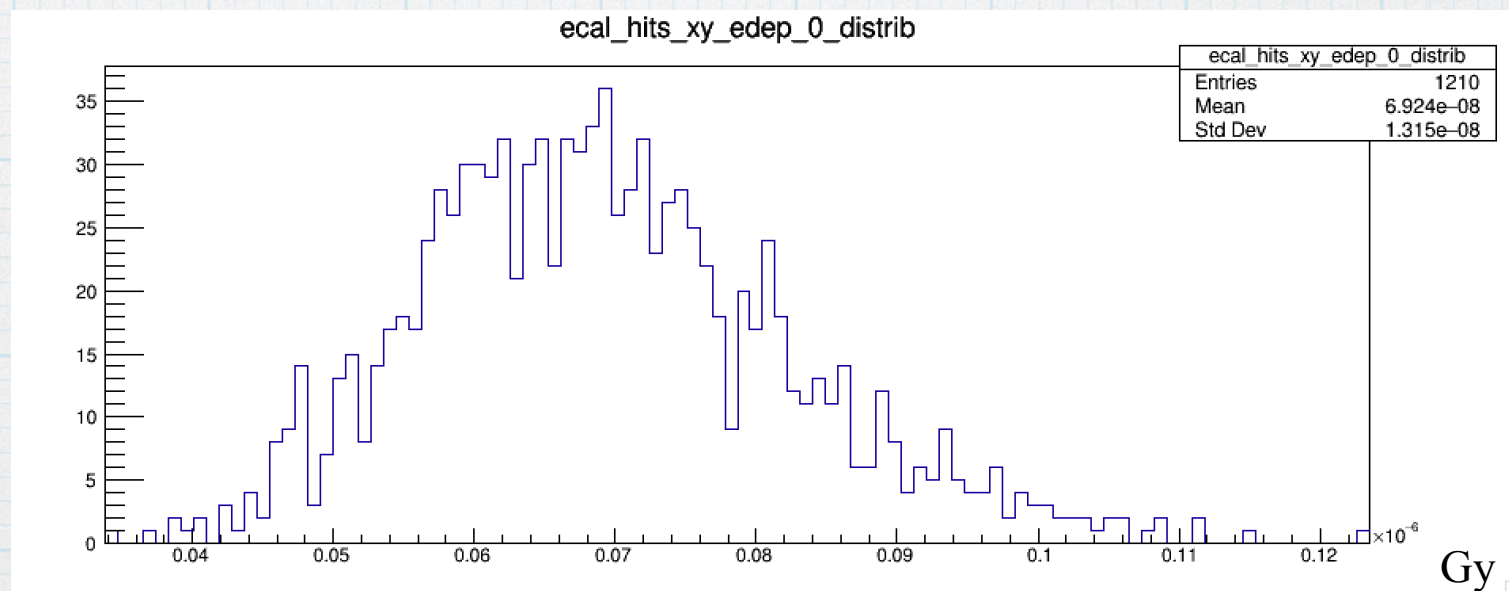
detid	det_name	Averaged Dose, Gy	Max Dose, Gy
2000	Ecal	7.19e-09	7.0e-06
2019	Ecal	6.74e-08	

ECAL Bkg

- JET140, 16.5 GeV, BKG, 2 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings,

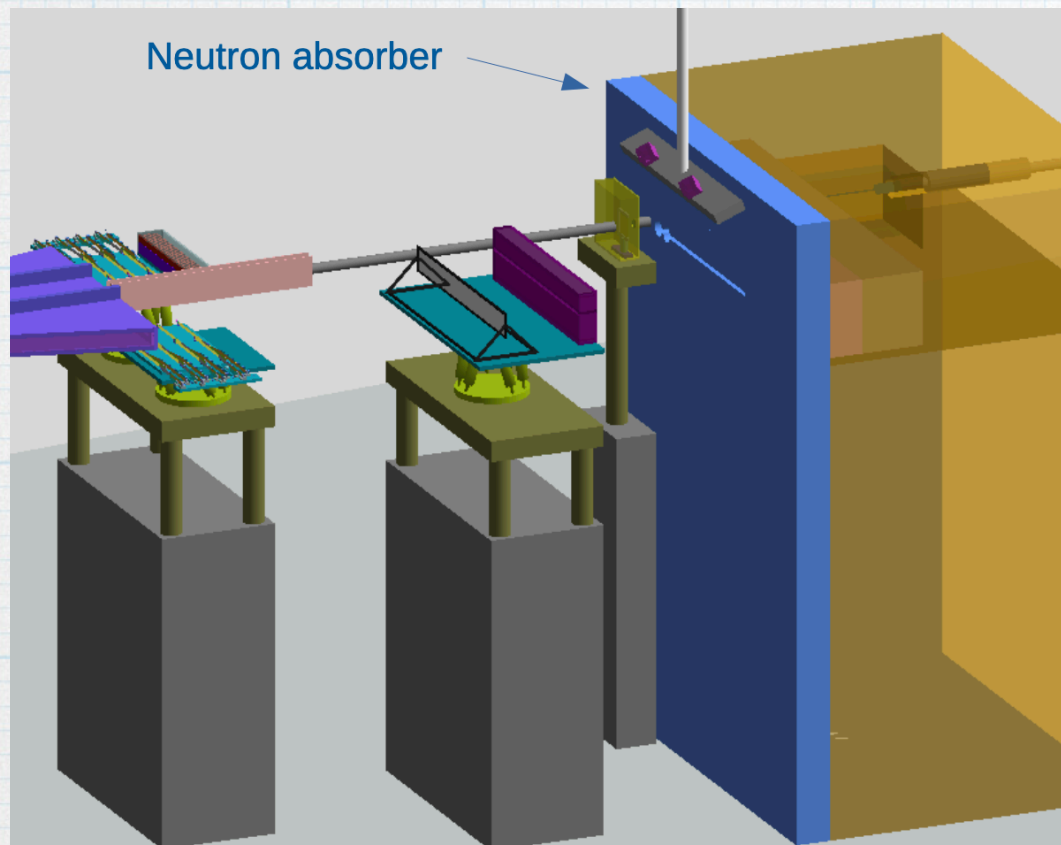


	Sig	Bkg	S+9*B
0	7.19E-09	7.07E-08	6.44E-07
1	5.50E-09	6.52E-08	5.93E-07
2	1.11E-08	6.30E-08	5.78E-07
3	1.17E-08	6.08E-08	5.59E-07
4	1.27E-08	6.08E-08	5.60E-07
5	1.54E-08	6.04E-08	5.59E-07
6	2.05E-08	6.12E-08	5.72E-07
7	1.50E-08	6.30E-08	5.82E-07
8	1.47E-08	6.49E-08	5.98E-07
9	1.58E-08	6.77E-08	6.25E-07
10	1.64E-08	7.18E-08	6.62E-07
11	1.83E-08	7.62E-08	7.04E-07
12	1.55E-08	8.15E-08	7.49E-07
13	2.19E-08	8.83E-08	8.17E-07
14	2.63E-08	9.61E-08	8.91E-07
15	2.81E-08	1.07E-07	9.94E-07
16	3.48E-08	1.20E-07	1.11E-06
17	4.77E-08	1.36E-07	1.27E-06
18	4.61E-08	1.57E-07	1.46E-06
19	6.74E-08	1.81E-07	1.70E-06
20	9.14E-08	1.87E-07	1.78E-06

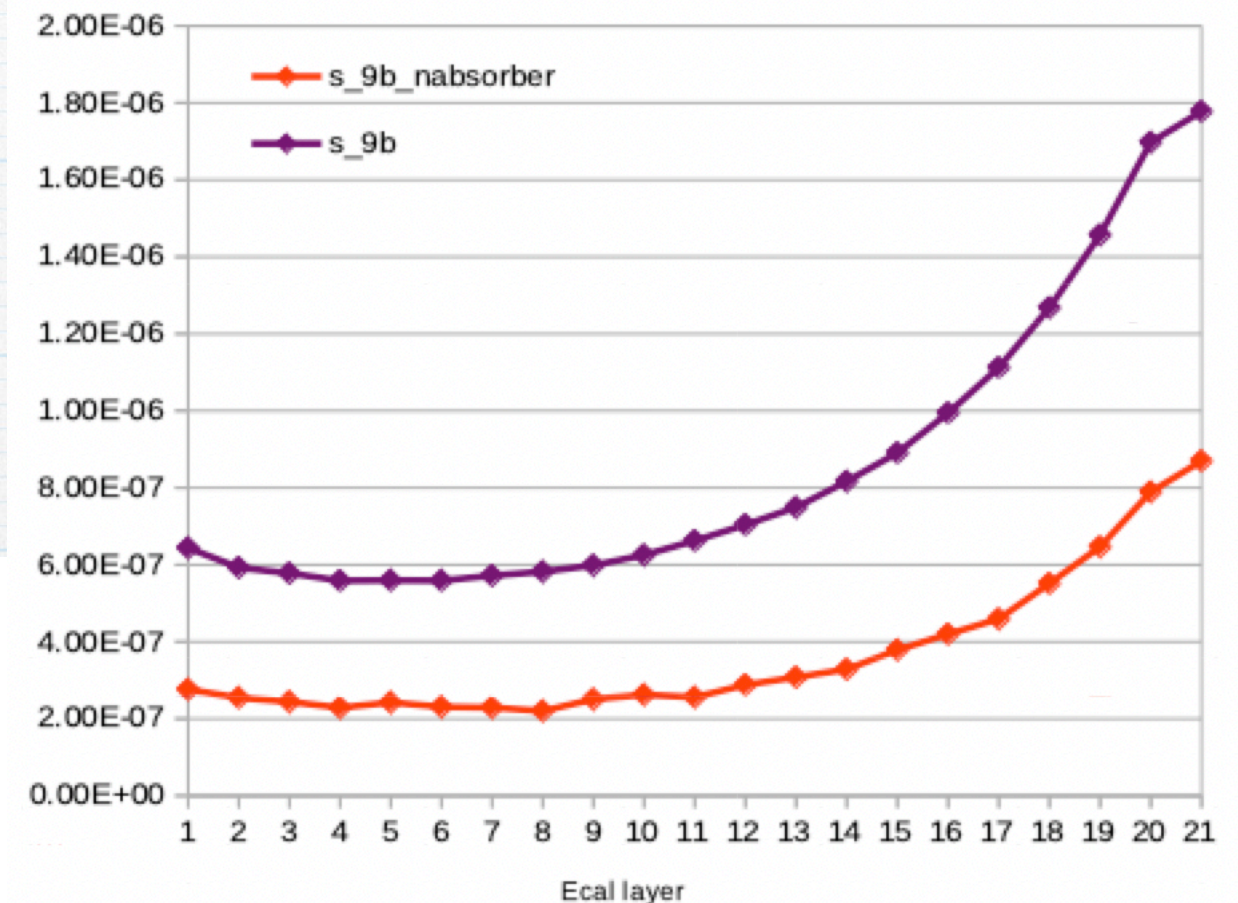
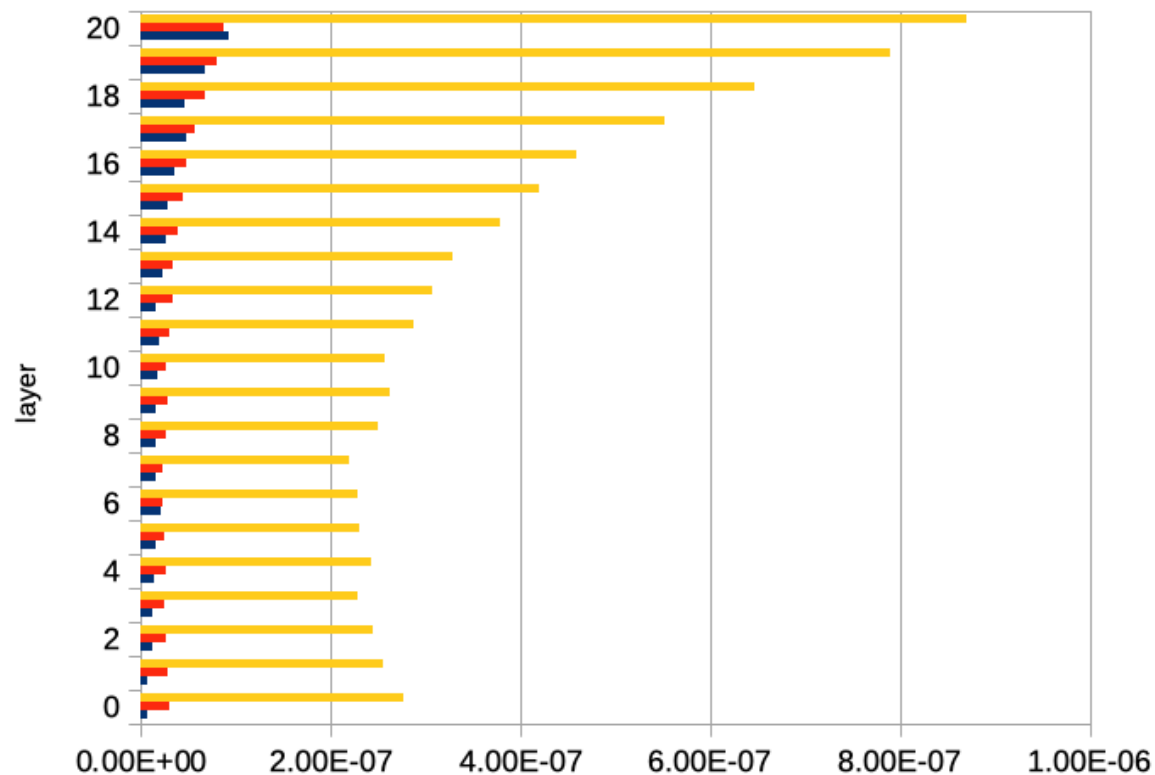


detid	det_name	Averaged Dose, Gy	Max Dose, Gy
2000	Ecal	7.19e-09 +9*7.07e-08 = 6.4349E-07	1.3e-07

Neutron absorber

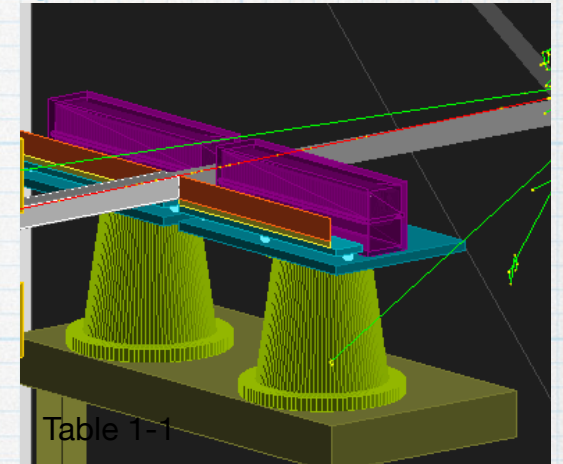


Borated concrete with polyethylene aggregate:
 .Boron 1%
 .PE 50%
 .170 mm layer thickness

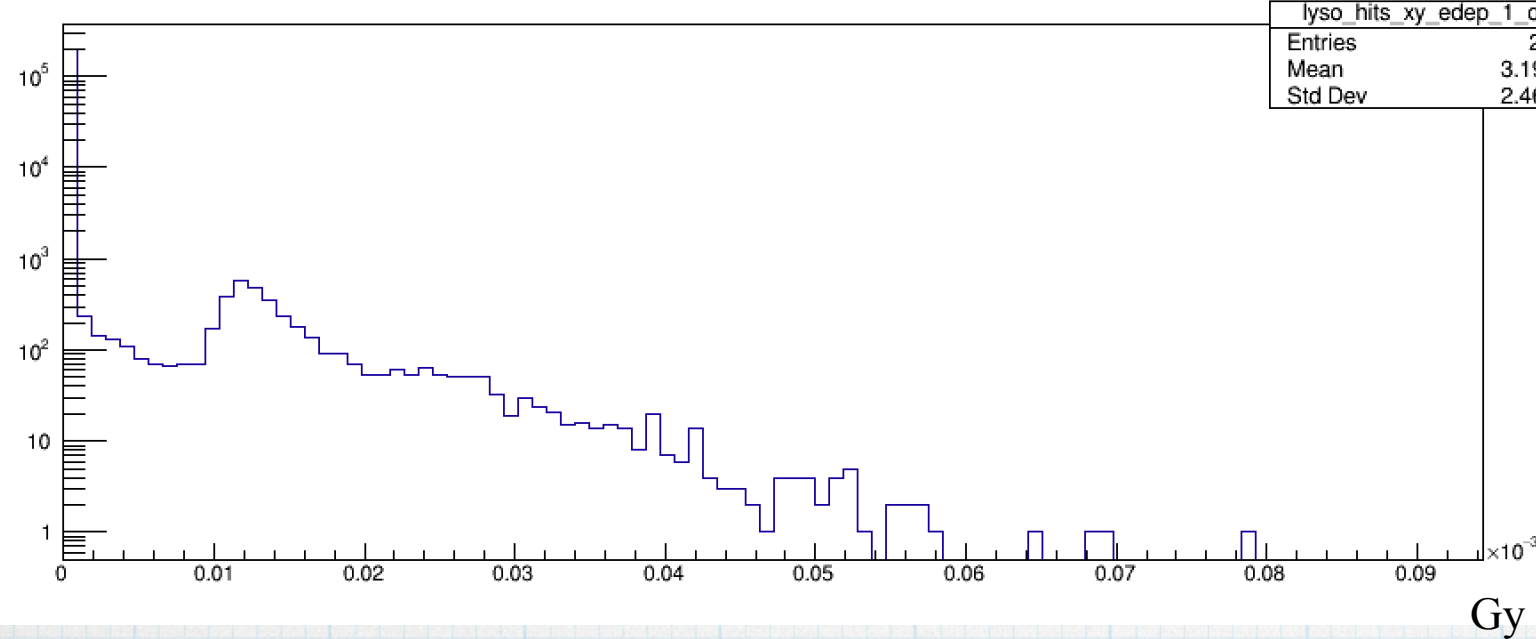


FDS Lanex Spectrometer

- JET140, 16.5 GeV, 3 μm , Signal, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan

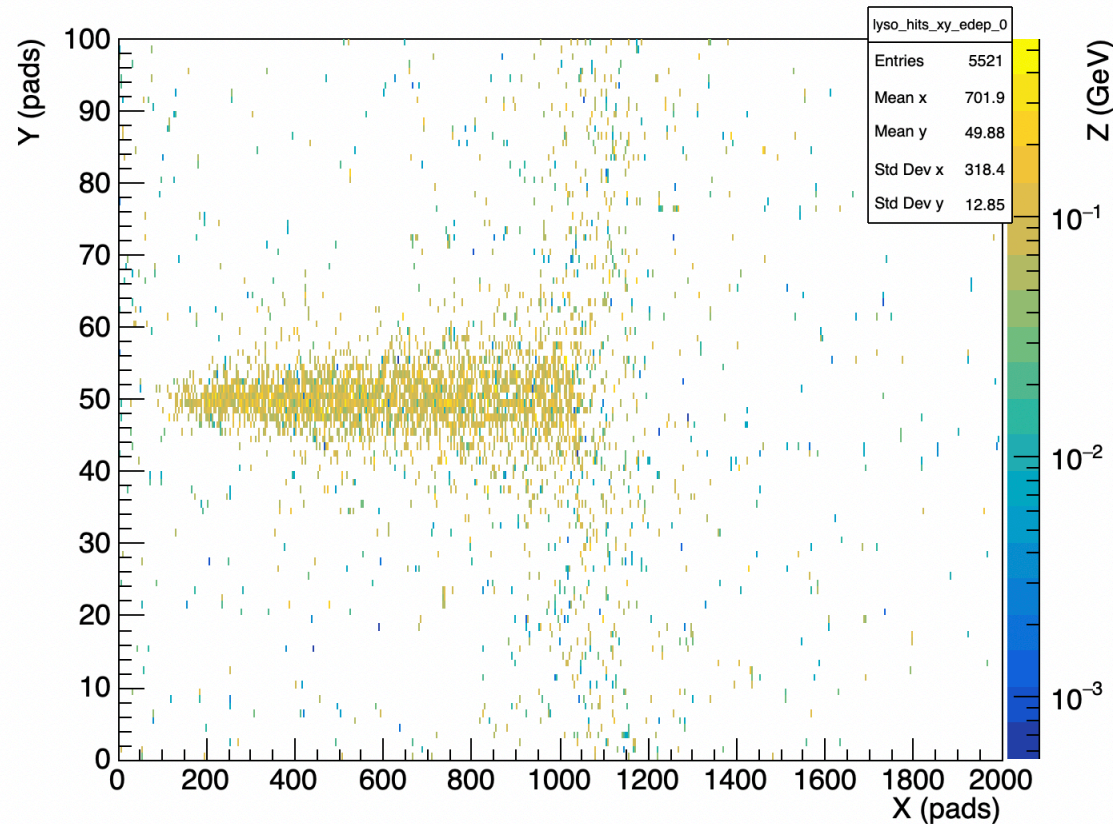


lyso_hits_xy_edep_1_distrib

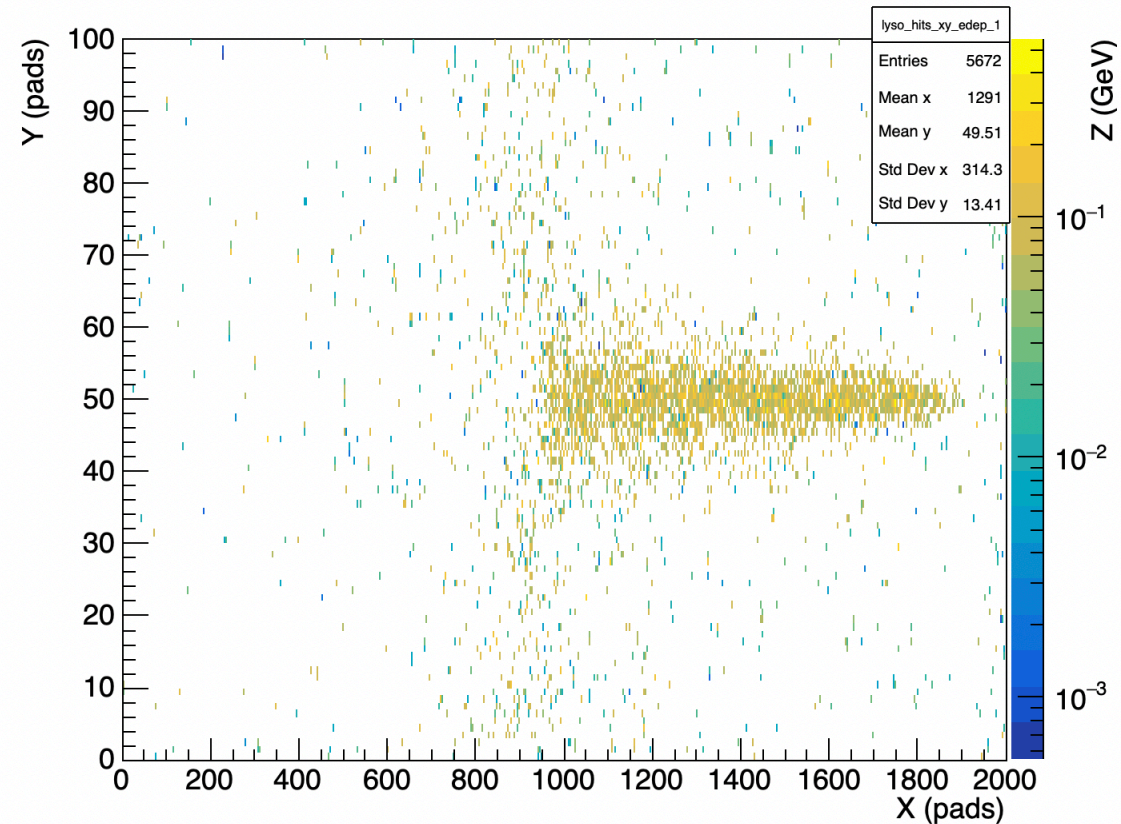


detid	det_name	Averaged Dose, Gy	Max Dose, Gy
3001	LysoCal	3.15e-07	7.9e-5
3000	LysoCal	3.20e-07	

lyso_hits_xy_edep_0

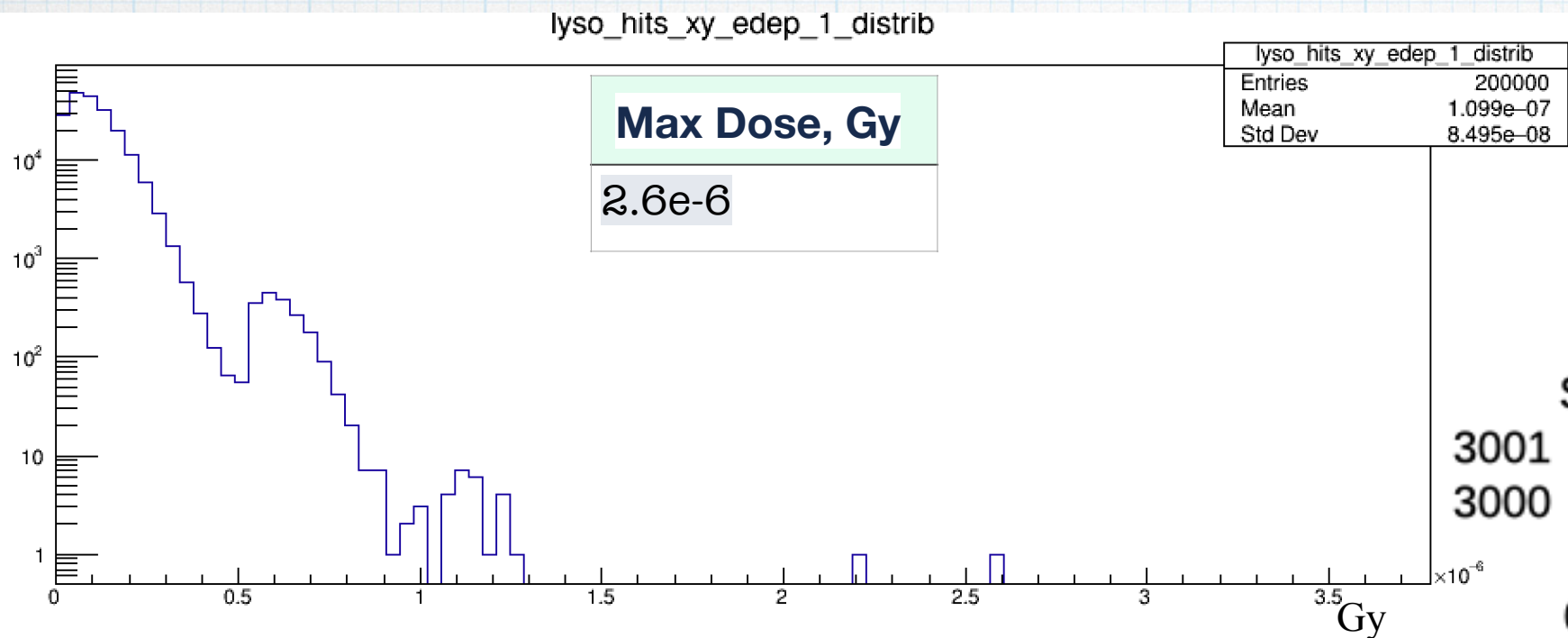
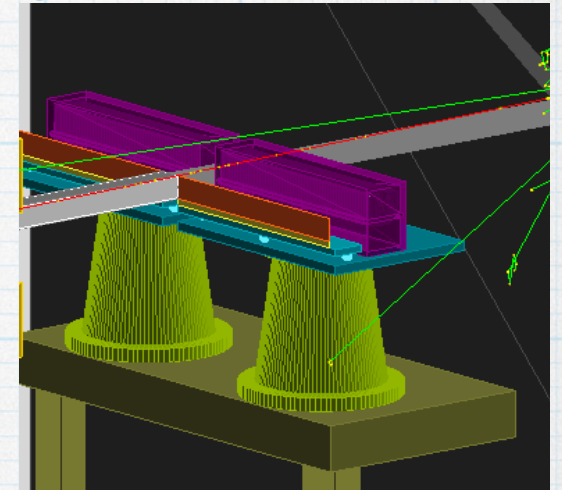


lyso_hits_xy_edep_1



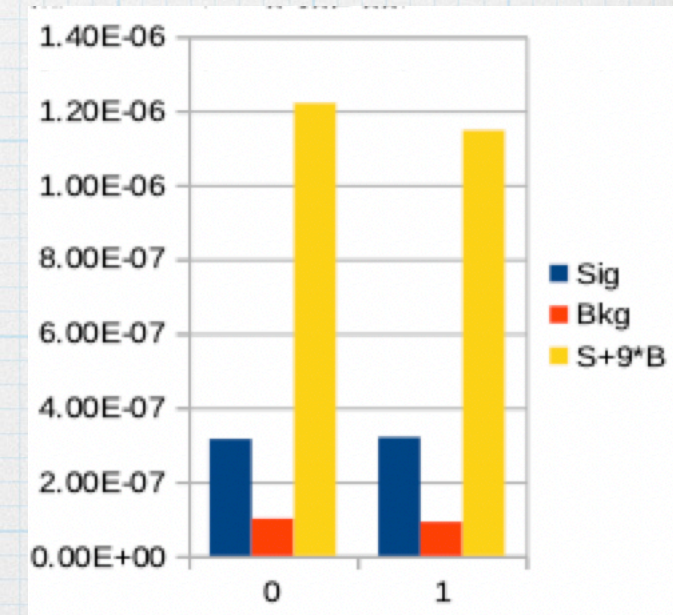
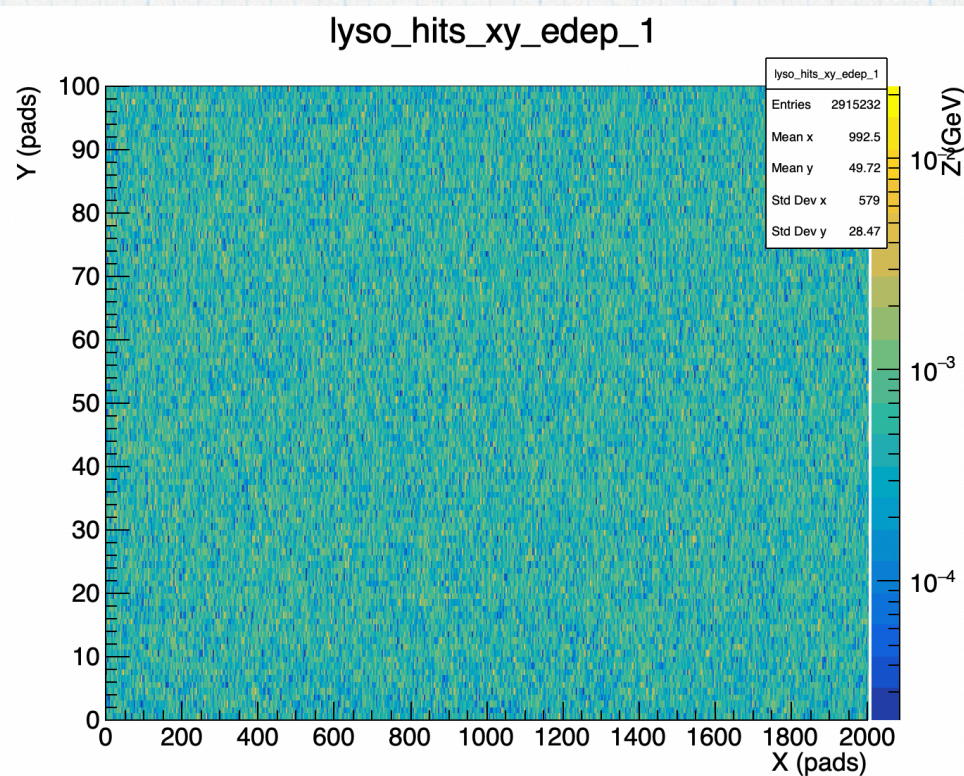
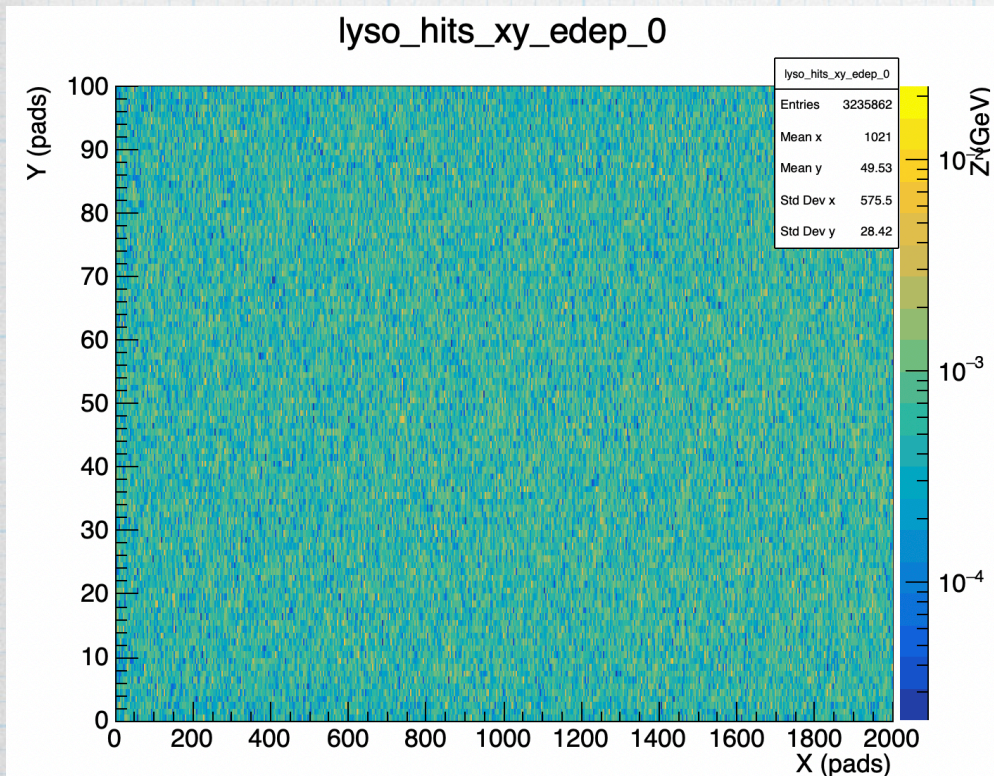
FDS Lanex Spectrometer

- JET140, 16.5 GeV, e^- , BKG, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings



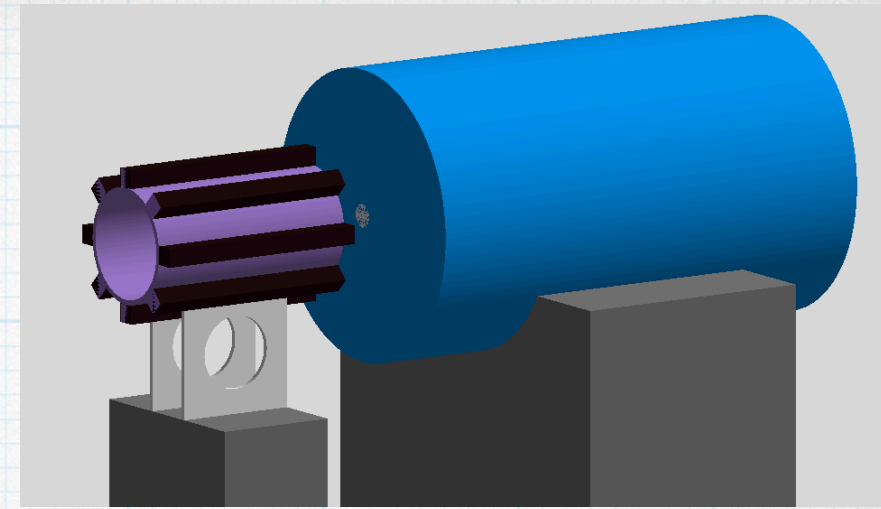
	Sig	Bkg	S+9*B
3001	3.15E-07	1.10E-07	1.31E-06
3000	3.20E-07	1.20E-07	1.40E-06

	Sig	Bkg w/ nAbsorber	S+9*B
0	3.15E-07	1.01E-07	1.22E-06
1	3.20E-07	9.19E-08	1.15E-06

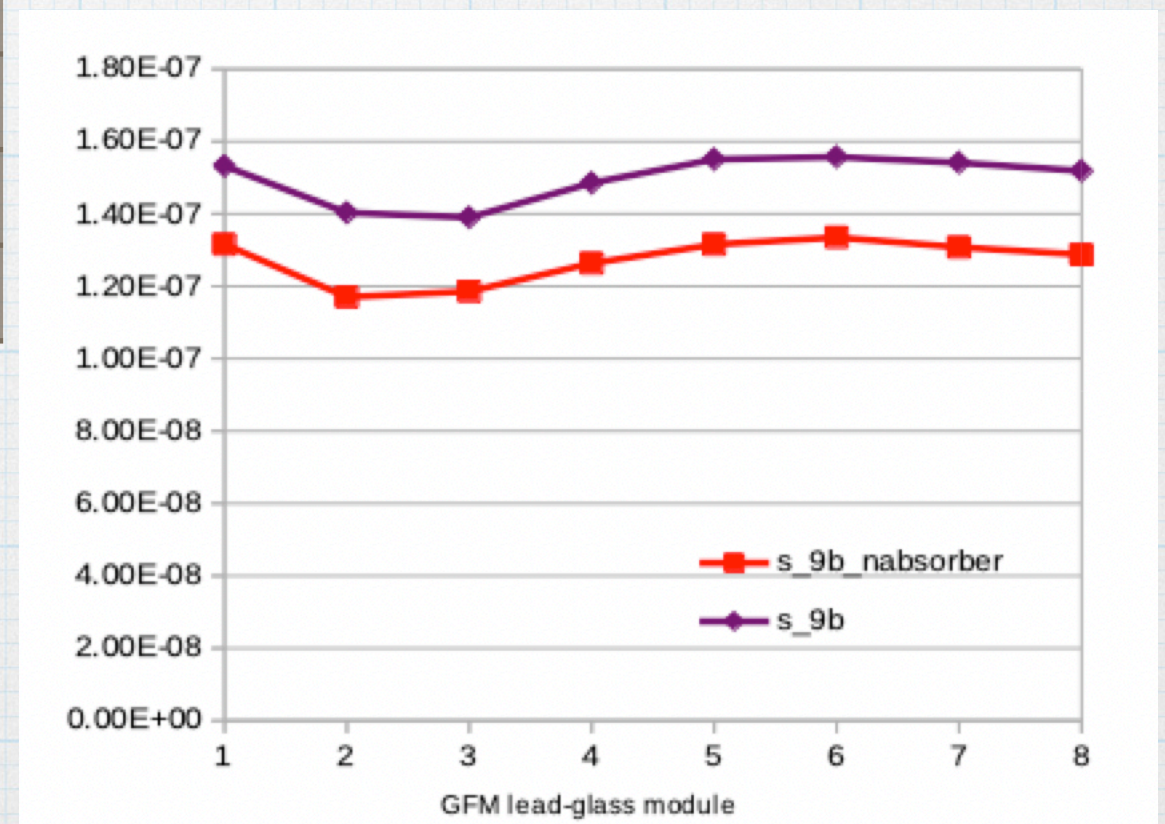
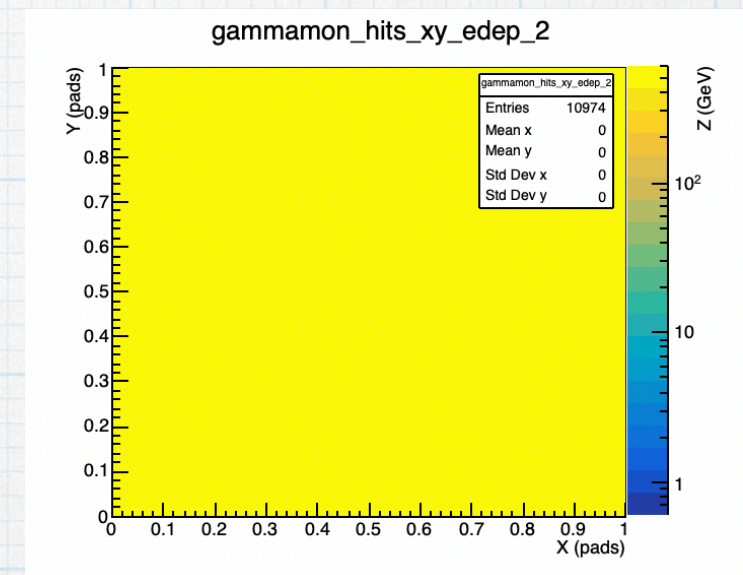


Gamma Monitor

- JETI40, 16.5 GeV, 3 um, Signal, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan
- JETI40, 16.5 GeV, e-, BKG, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings

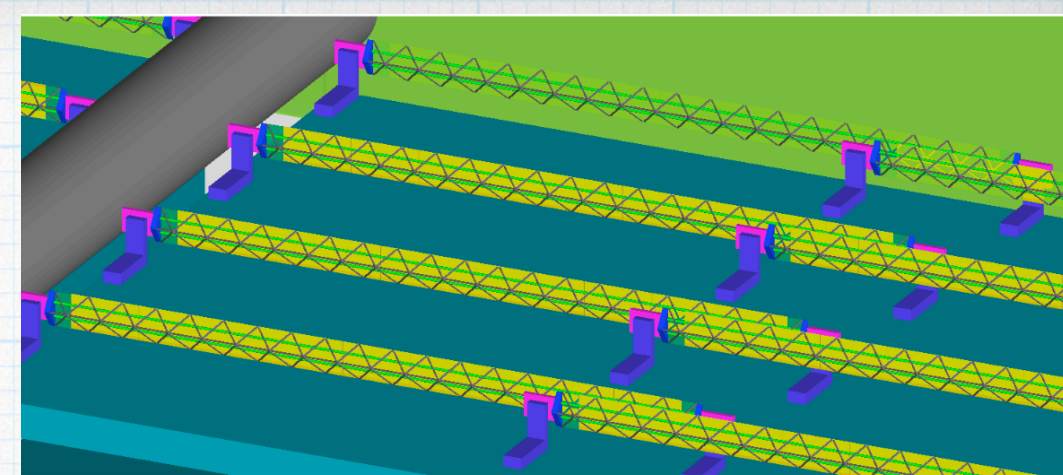


GFM	Sig	Bkg	S+9*B	Bkg w/ nAbsorber	S+9*B
0	3.77E-08	1.28E-08	1.53E-07	1.04E-08	1.32E-07
1	3.28E-08	1.19E-08	1.40E-07	9.36E-09	1.17E-07
2	3.31E-08	1.18E-08	1.39E-07	9.50E-09	1.19E-07
3	3.26E-08	1.29E-08	1.49E-07	1.04E-08	1.26E-07
4	3.17E-08	1.37E-08	1.55E-07	1.11E-08	1.32E-07
5	3.41E-08	1.35E-08	1.56E-07	1.10E-08	1.34E-07
6	3.86E-08	1.28E-08	1.54E-07	1.02E-08	1.31E-07
7	3.66E-08	1.28E-08	1.52E-07	1.02E-08	1.29E-07

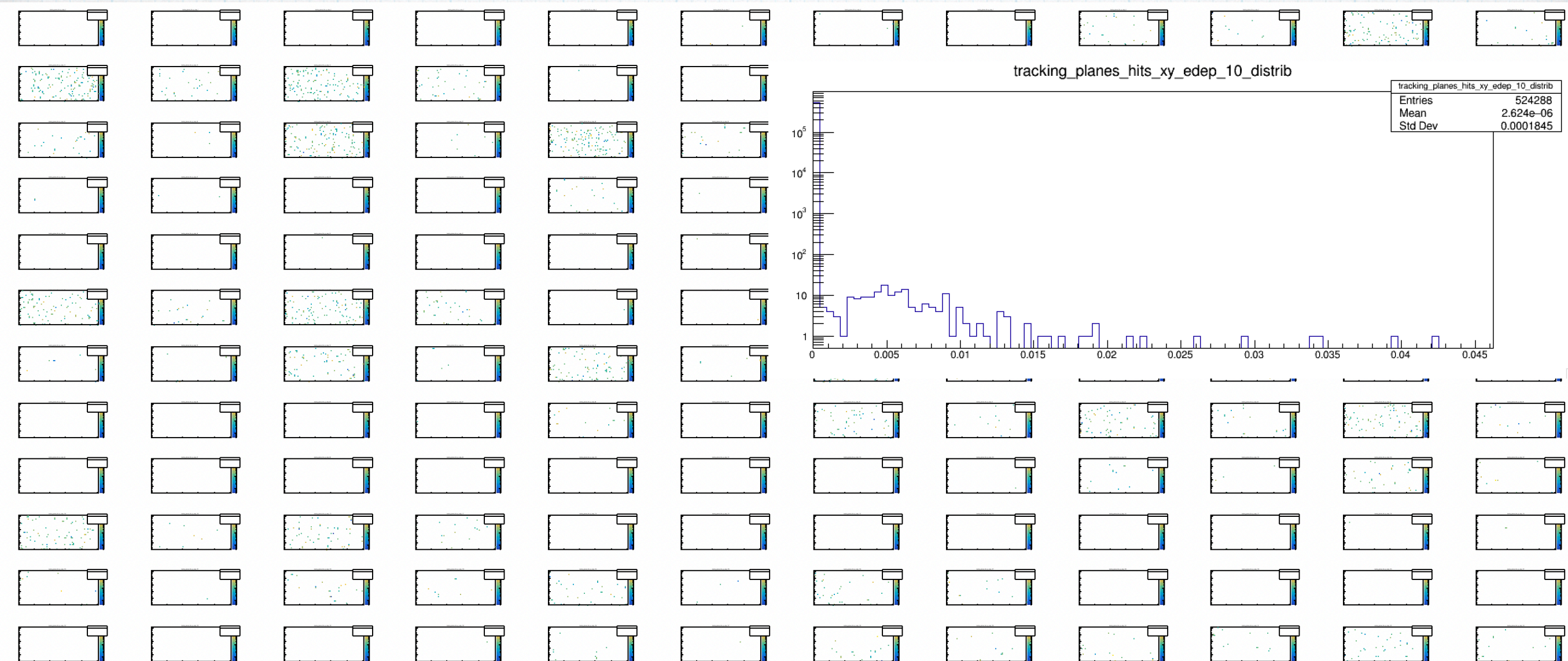


Tracker

- JET140, 16.5 GeV, 3 um, 9 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan

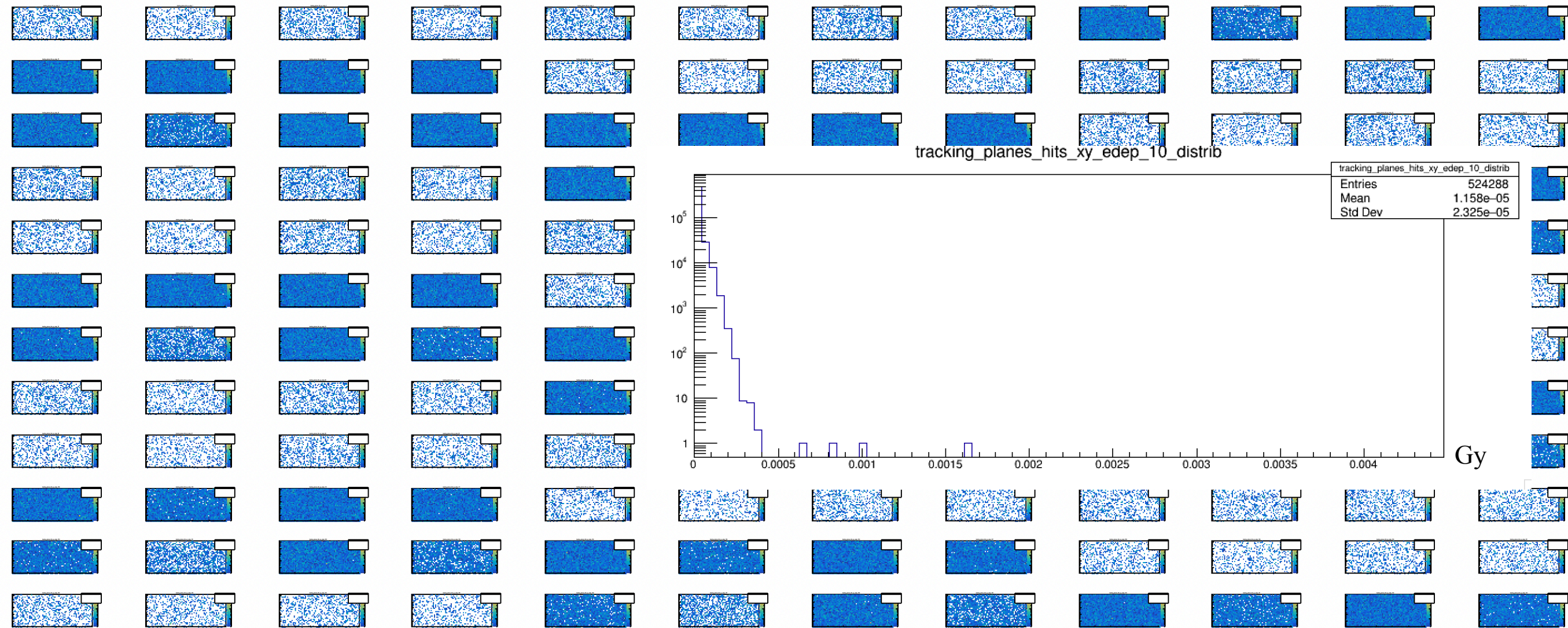
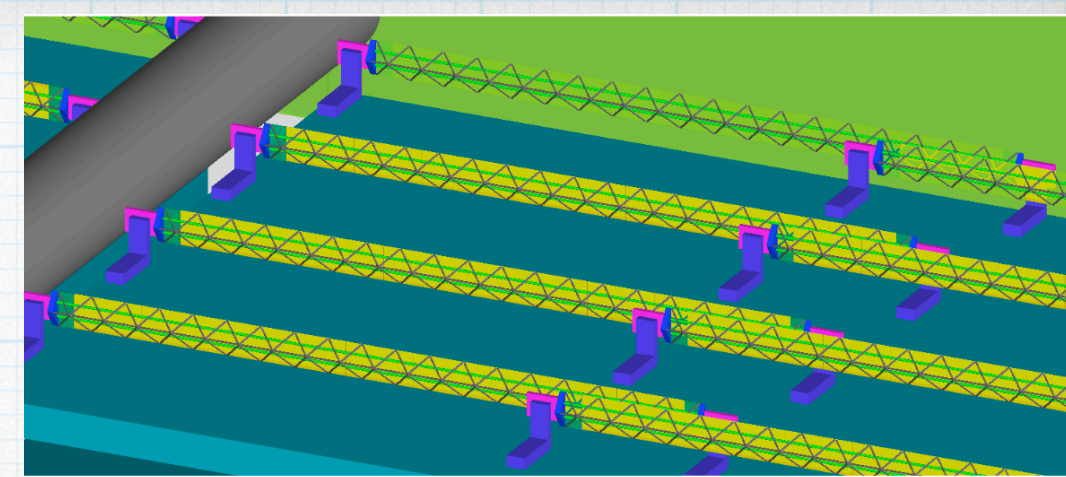


0	1	2	3	4	5	6	7	8	9	10	11
1.23E-10	5.07E-11	6.59E-11	7.55E-11	8.51E-09	1.17E-07	5.14E-08	1.49E-10	5.02E-07	1.92E-07	2.72E-06	5.37E-07



Tracker

- JET140, 16.5 GeV, BKG BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings

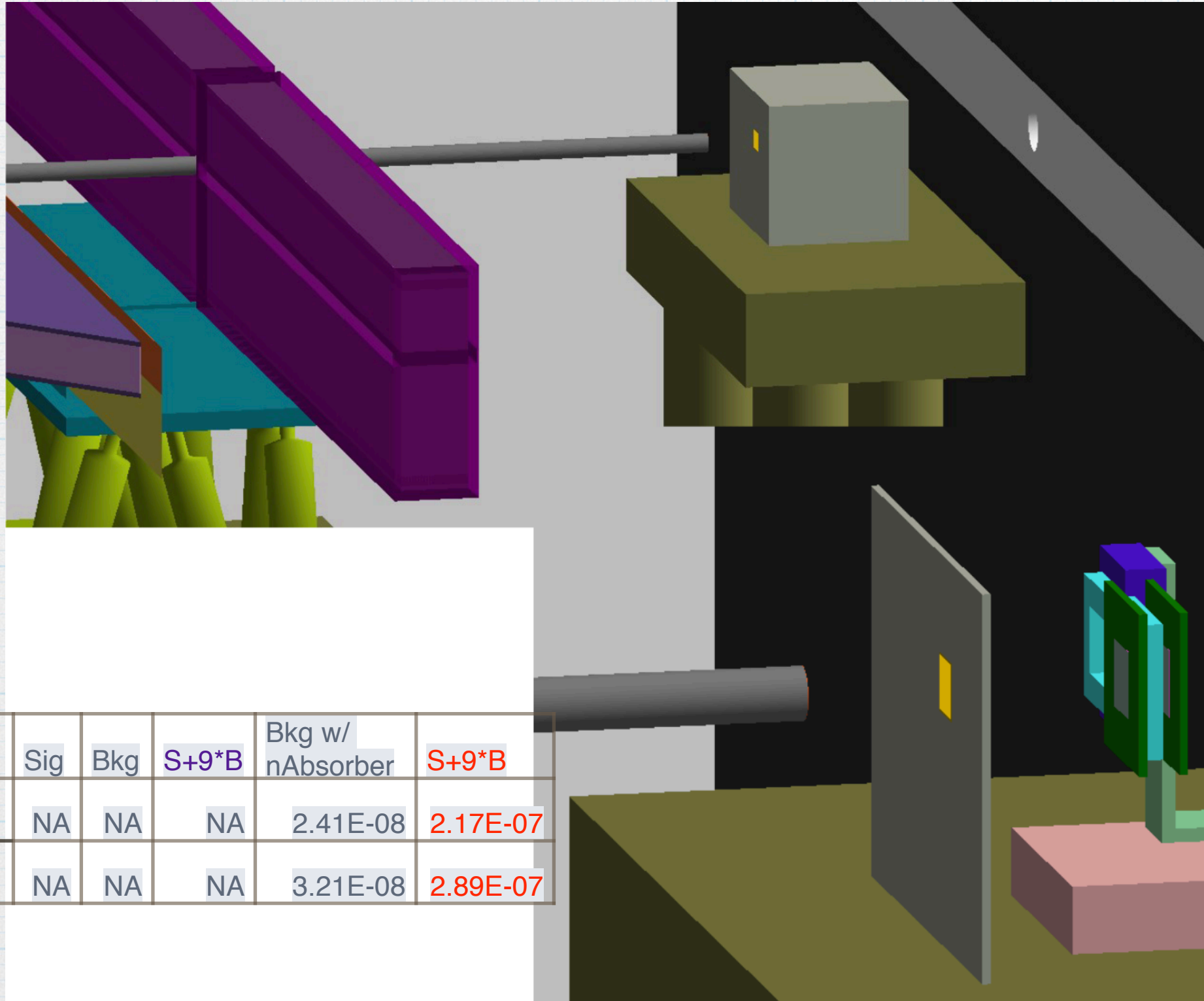


Tracker	min	max	Average
bkg, Gy	3.57E-08	1.16E-05	1.66E-06
sig, Gy	1.06E-13	3.91E-06	5.54E-07
sig+9*bkg	3.22E-07	1.07E-04	1.57E-05

Bkg w/ nAbsorber

Tracker	min	max	av
bkg	8.43E-09	1.07E-05	1.54E-06
sig	1.06E-13	3.91E-06	5.54E-07
sig+9*bkg	7.58E-08	9.87E-05	1.46E-05

Profiler



Background only:
JETI40, 16.5 GeV,
QGSP_BERT_HP list,
updated g4 setup with
no leaking dump,
shielding with neutron
Absorber

results on absorbed dose

per BX, per sensitise detector

JET140, 16.5 GeV, 3 um, Signal 1 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan

+

JET140, 16.5 GeV, e-, BKG 9 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings

det_name	Averaged Dose (BERT), Gy	Per year, 10 ⁷ sec, Gy	Tolerable dose, Gy
PDS GadOx Scintillator	1.4e-06	14	1e8
PDS Backscatter Calorimeter	1.5e-07	1.5	300
IP Calorimeter	6.4e-07 / 1.8e-06	6-18	1e6
IP Pixel tracker	3.22E-07 / 1.07E-04	3-1000	2.7E+04

det_name	Averaged Dose (BERT), Gy	Per year, 10 ⁷ sec, Gy
PDS GadOx Scintillator	1.2e-06	12
PDS Backscatter Calorimeter	1.3e-07	1.3
IP Calorimeter	2.2e-07 / 8.7e-07	2-9
IP Pixel tracker	7.6e-07 / 9.9e-05	7-990

} shielding with neutron Absorber

Summary

- The estimations were done using 1x signal + 9x background
- the signal simulation: JETI40, 16.5 GeV, 3 um, 9 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan.
- for background: 2 BX, JETI40, 16.5 GeV, e-, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shielding
 - With the updated simulation it seems that the radiation levels are higher for the detectors before the dump due to the neutrons from the dump.
- Sasha produced 0.14 BX simulation with an additional shielding to reduce the neutron flux. the radiation analysis with and w/o that extra shielding for the detectors
 - Situation improved for ECal
- The dose is tolerable for the detector types for which estimation were done

Back up

Detector	avg. annual dose [Gy]	tolerable dose [Gy]
IP Pixel tracker	10	$27 \cdot 10^3$
IP Calorimeter	1	10^6
IP Scintillator	2×10^4	10^8
PDS GadOx Scintillator	10	10^8
PDS LYSO Scintillator	10^4	$10^4 - 10^7$
PDS Gamma Profiler	$< 10^7$	10^7
PDS Backscatter Calorimeter	0.5	300

results on absorbed dose

per BX, per sensitise detector

- JET140, 16.5 GeV, 8 um, 9479 BX, standart EM physics list, IPStrong
- JET140, 16.5 GeV, 5 um, 976 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, the most recent MC IPStrong
- JET140, 16.5 GeV, 3 um, 9 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, shieldings, the most recent MC ptarmigan

detid	det_name	Averaged Dose (BERT), Gy, TDR	Averaged Dose, (BERT) Gy, CDR	Averaged Dose, (EM) Gy
5000	ComptonEl	---	4.88e-05 / 0.002	6.23e-05 / 0.003
3000-1	LysoCal	3.20e-07	7.15e-07	4.17e-07
4000-7	LeadGlass	3.77e-08	4.49e-08	7.08e-08
2000-20	EcalSensor	5.50e-09 / 9.14e-08	4.65e-08 / 1.13e-07	2.75e-08 / 2.56e-07
1000-143	TrackerSensor	1.06e-13 / 3.91e-06	7.5e-14 / 1.06e-06	8.5e-08 / 1.44e-06

results on absorbed dose

per BX, per sensitise detector

JET140, 16.5 GeV, 8 um, 9479 BX, standart EM physics list

detid	det_name	Averaged Dose, Gy	Per year, 10 ⁷ sec, Gy	Radiation Hardness, kGy
5000	ComptonEI	6.23e-05 /0.003	6e2 - 3e4	~10 ⁵ (Lanex)
3000-1	LysoCal	4.17e-07	4.2	~10 ⁵ (Lanex)
4000-7	LeadGlass	7.08e-08	0.7	1 (TF101)
2000-20	EcalSensor	2.75e-08 /2.56e-07	0.3-3	~1000 (Si)
1000-143	TrackerSensor	8.5e-08 /1.44e-06	1-15	27 (Alpide)

JET140, 16.5 GeV, 5 um, 976 BX, QGSP_BERT_HP list, updated g4 setup with no leaking dump, the most recent MC IPStrong

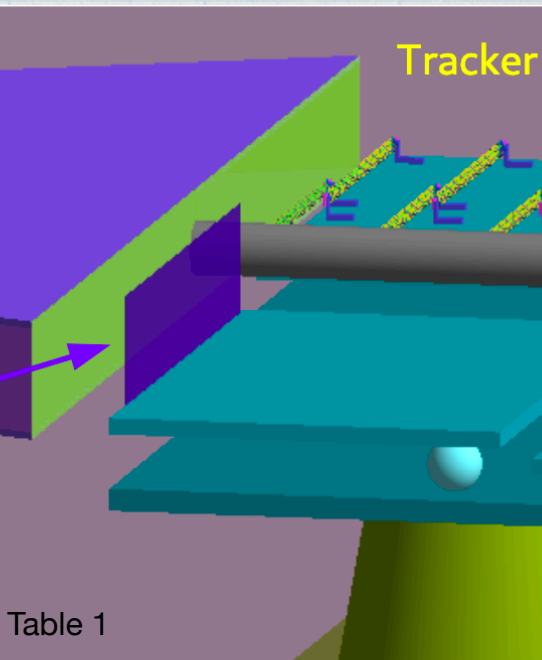
det_name	Averaged Dose (BERT), Gy	Per year, 10 ⁷ sec, Gy
IP Scintillator	4.88e-05 /0.002	5e2 - 2e4
PDS GadOx Scintillator	7.15e-07	7.2
PDS Backscatter Calorimeter	4.49e-08	0.5
IP Calorimeter	4.65e-08 / 1.13e-07	0.5-1
IP Pixel tracker	7.5e-14 /1.06e-06	7e-7 - 10

det_name	Averaged Dose (BERT), Gy	Per year, 10 ⁷ sec, Gy
IP Scintillator	4.88e-05 / 0.002	5e2 - 2e4
PDS GadOx Scintillator	7.15e-07	7.2
PDS Backscatter Calorimeter	4.49e-08	0.5
IP Calorimeter	4.65e-08 / 1.13e-07	0.5-1
IP Pixel tracker	7.5e-14 / 1.06e-06	7e-7 — 10

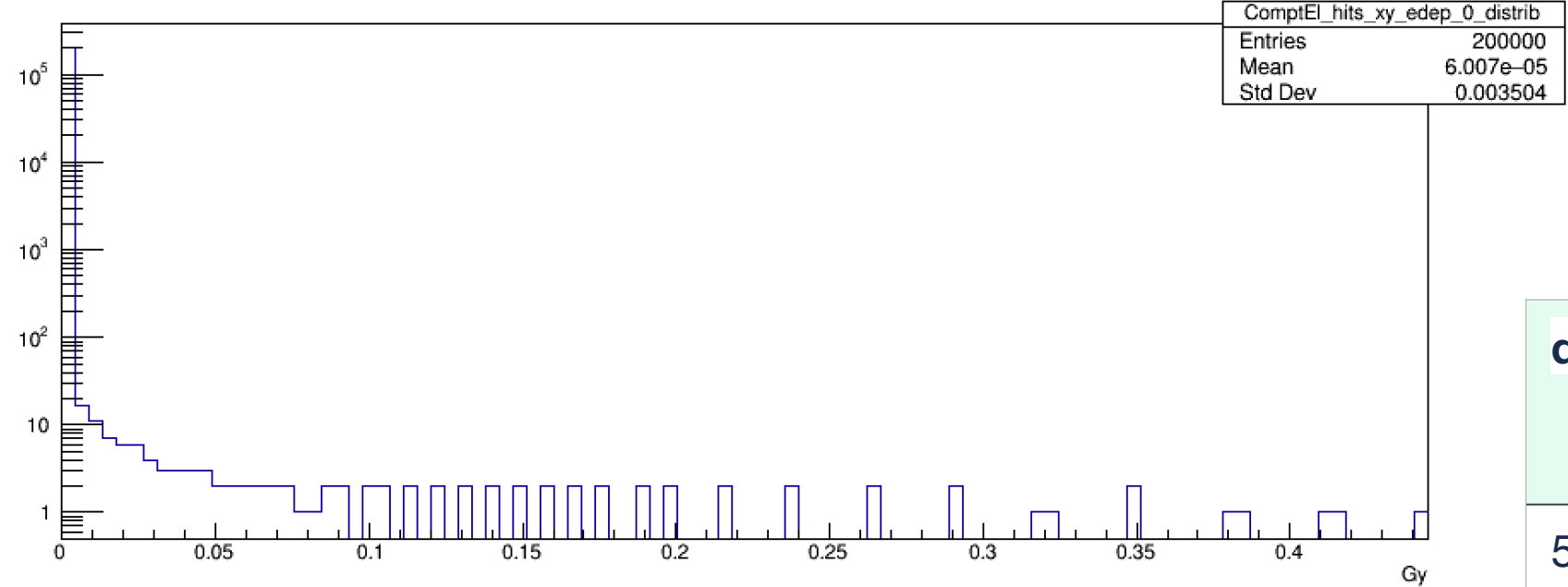
detid	det_name	Averaged Dose (BERT), Gy	Averaged Dose, Gy
5000	ComptonEI	4.88e-05 / 0.002	6.23e-05 / 0.003
3000-1	LysoCal	7.15e-07	4.17e-07
4000-7	LeadGlass	4.49e-08	7.08e-08
2000-20	EcalSensor	4.65e-08 / 1.13e-07	2.75e-08 / 2.56e-07
1000-143	TrackerSensor	7.5e-14 / 1.06e-06	8.5e-08 / 1.44e-06

Compton Electron Lanex

JETI40, 16.5 GeV, 8 μm , 9479 BX

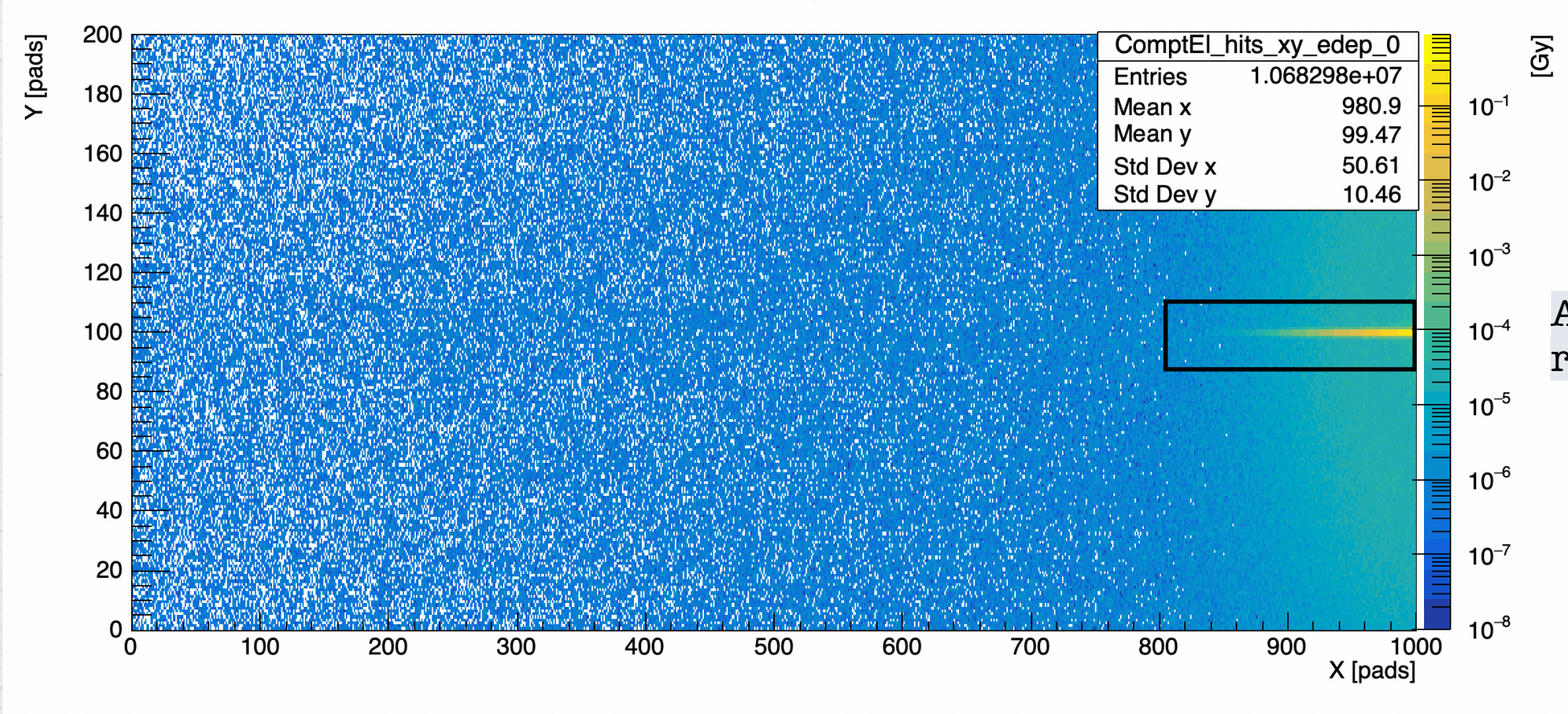


ComptEI_hits_xy_edep_0_distrib



detid	det_name	Average d Dose, Gy	Max Dose, Gy
5000	ComptonEI	6.23e-05	0.42

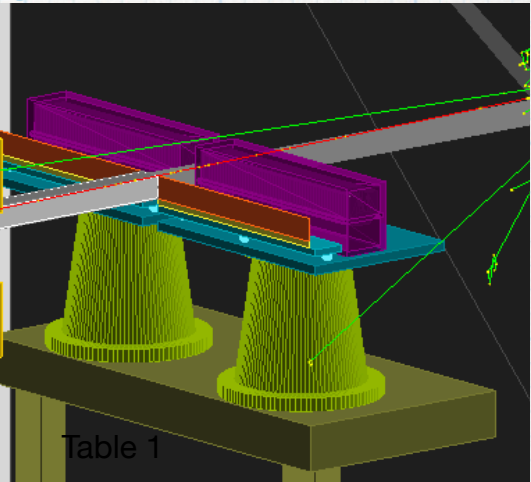
ComptEI_hits_xy_edep_0



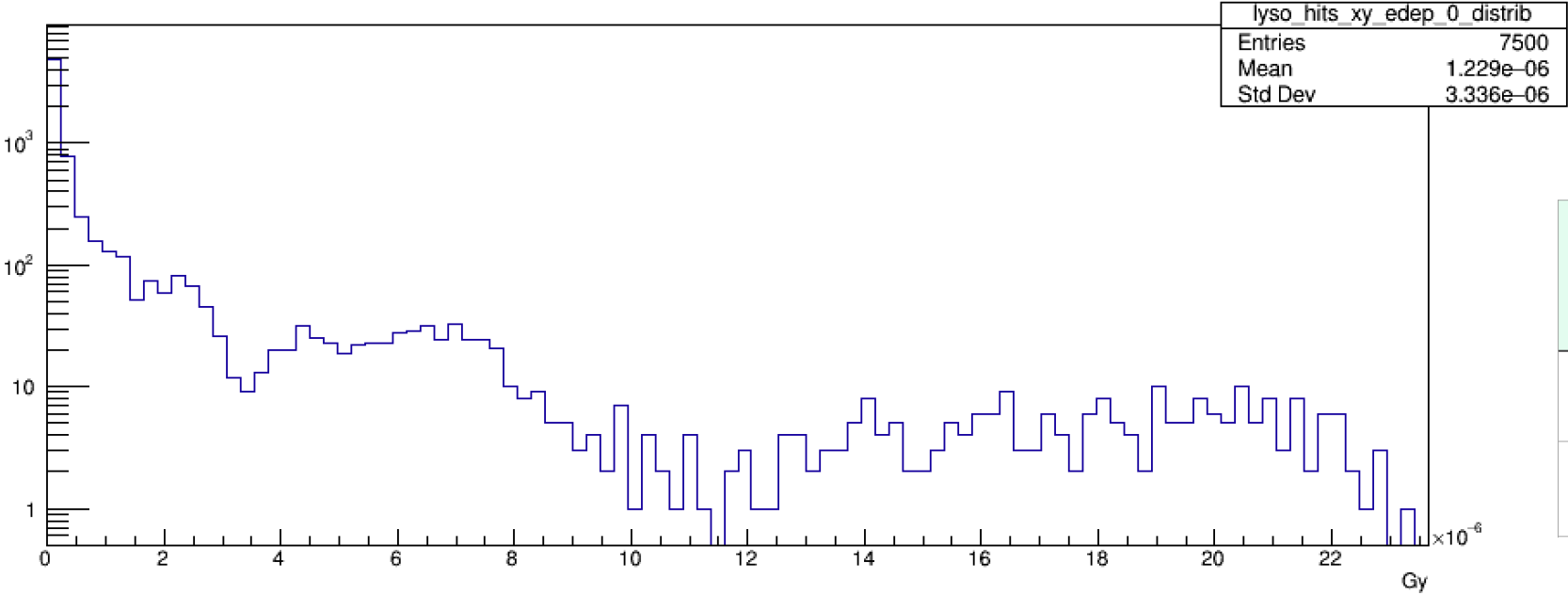
Averaged dose per selected region ~ 0.003 Gy

FDS Lanex Spectrometer

JET140, 16.5 GeV, 8 μm , 9479 BX

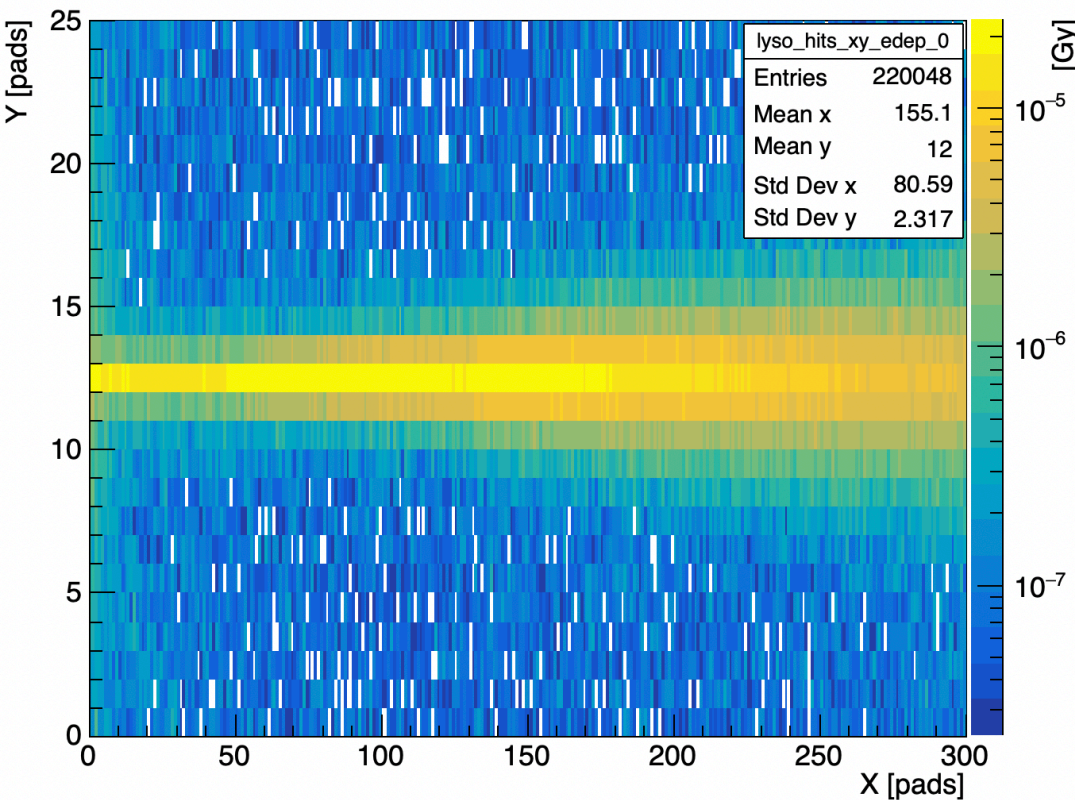


lyso_hits_xy_edep_0_distrib

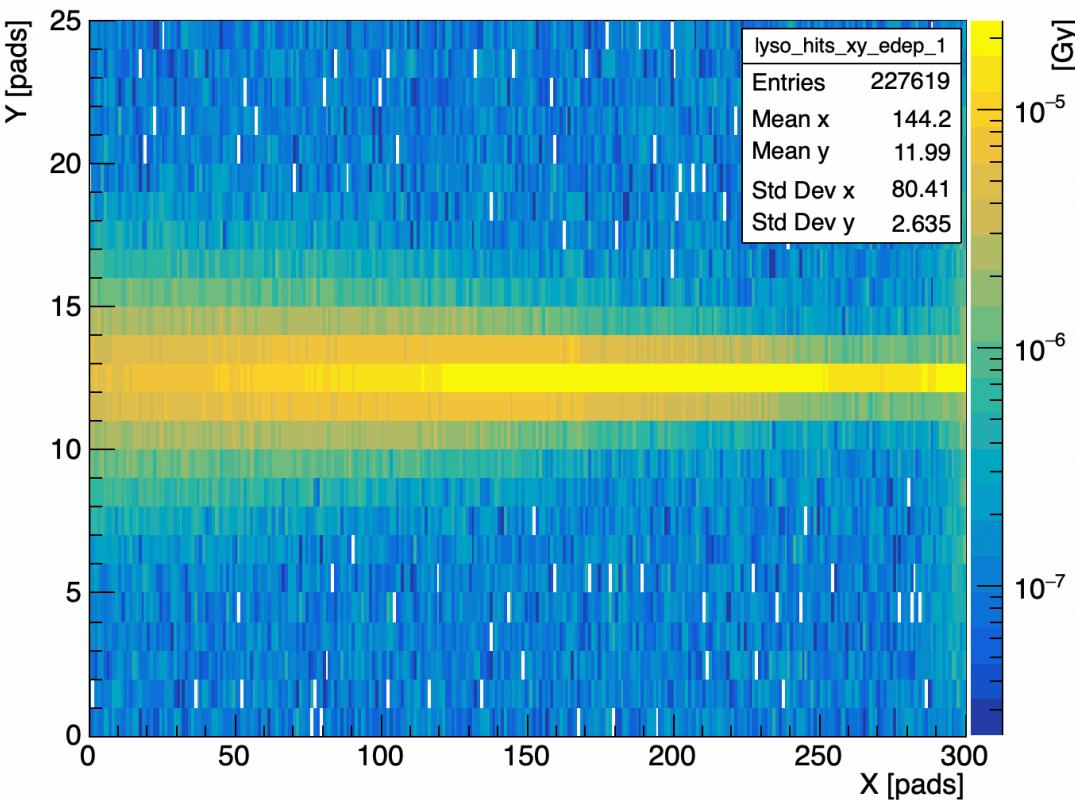


detid	det_name	Averaged Dose, Gy	Max Dose, Gy
3001	LysoCal	1.24e-6	2.4e-5
3000	LysoCal	1.26e-6	4.1e-5

lyso_hits_xy_edep_0



lyso_hits_xy_edep_1



BSM

