Testing modules for Backscattering calorimeter

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17/12/20
LUXE weekly technical meeting

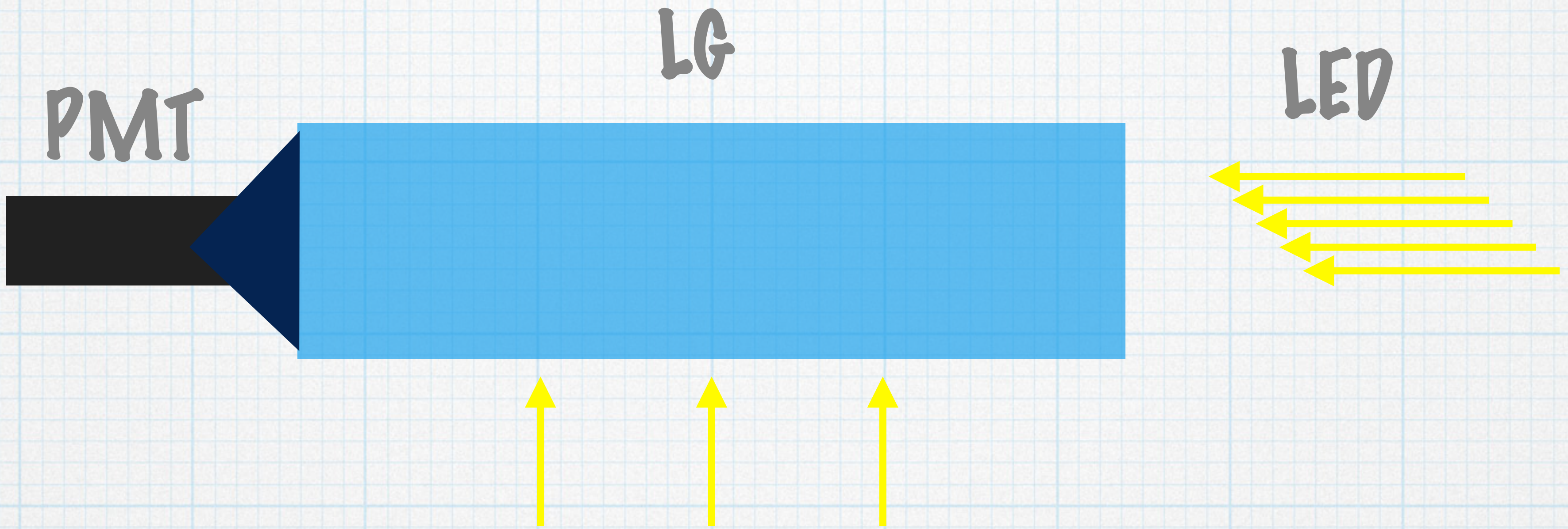
LUXE

Lead glass blocks in Hera West @DESY

- New TF-1 (or TF-101) LG blocks! Not irradiated, w/ measures 3.8 × 3.8 cm², length is 45 cm , ~50
- Will give the possibility to determine precisely coordinates and energies

- Spare modules found in Hera West thanks to Sergey Schuwalow
- There is a preliminary agreement to move it to the LUXE Lab

calibrate the light output



- Test light transmittance in LG block with LED
- Test response on light injected in different positions
- Wrap design (50um thick aluminized mylar foil and covered with 125um thick tedlar foil to provide light isolation) with LED interface in different positions t crystal
- To couple the block with photo- multiplier (R972 or R821)

PMTs

Photomultiplier tube

R972

Photomultiplier tube

R821

R972: 19mm dia., Head-on type, Cs-I photocathode (Effective area : 13 mm dia./Spectral response : 115 to 200

R821: 19mm dia., Head-on type, Cs-Te photocathode (Effective area : 13 mm dia./Spectral response : 160 to 320 nm)

GERMANY

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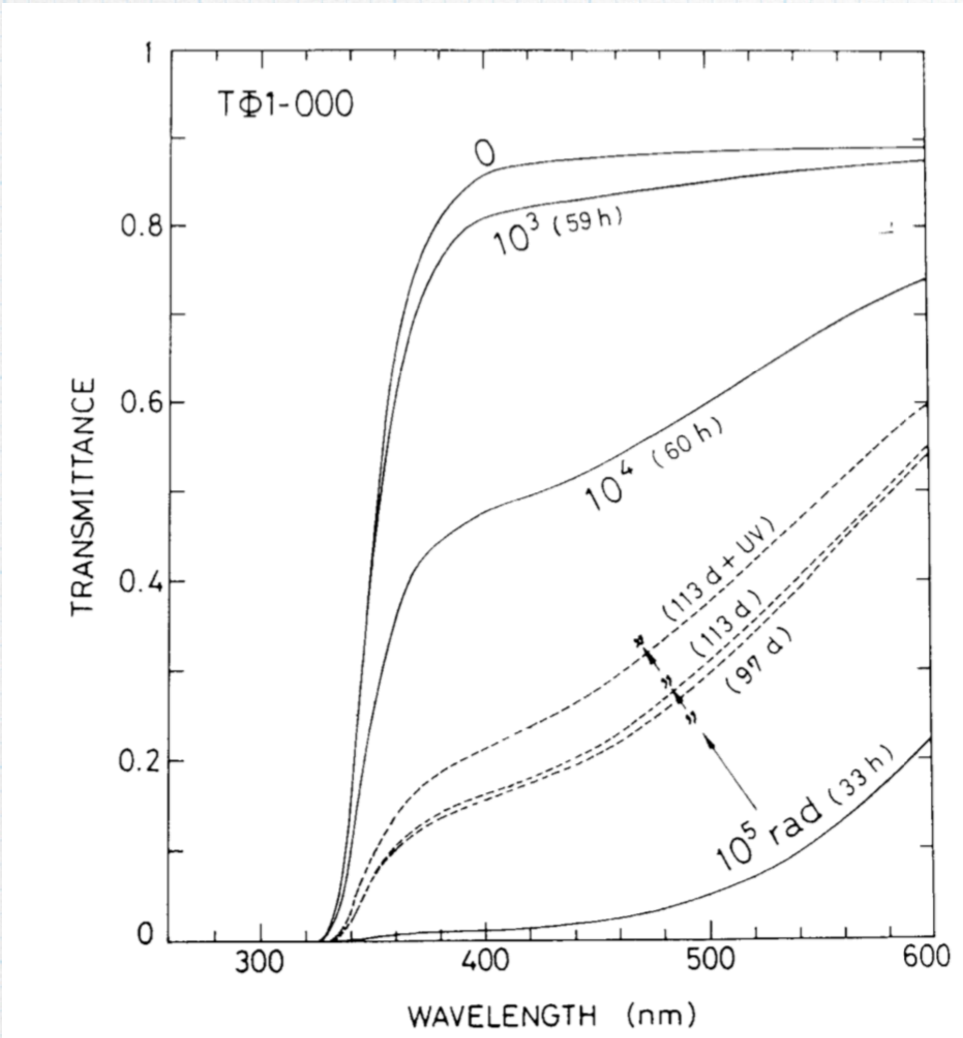
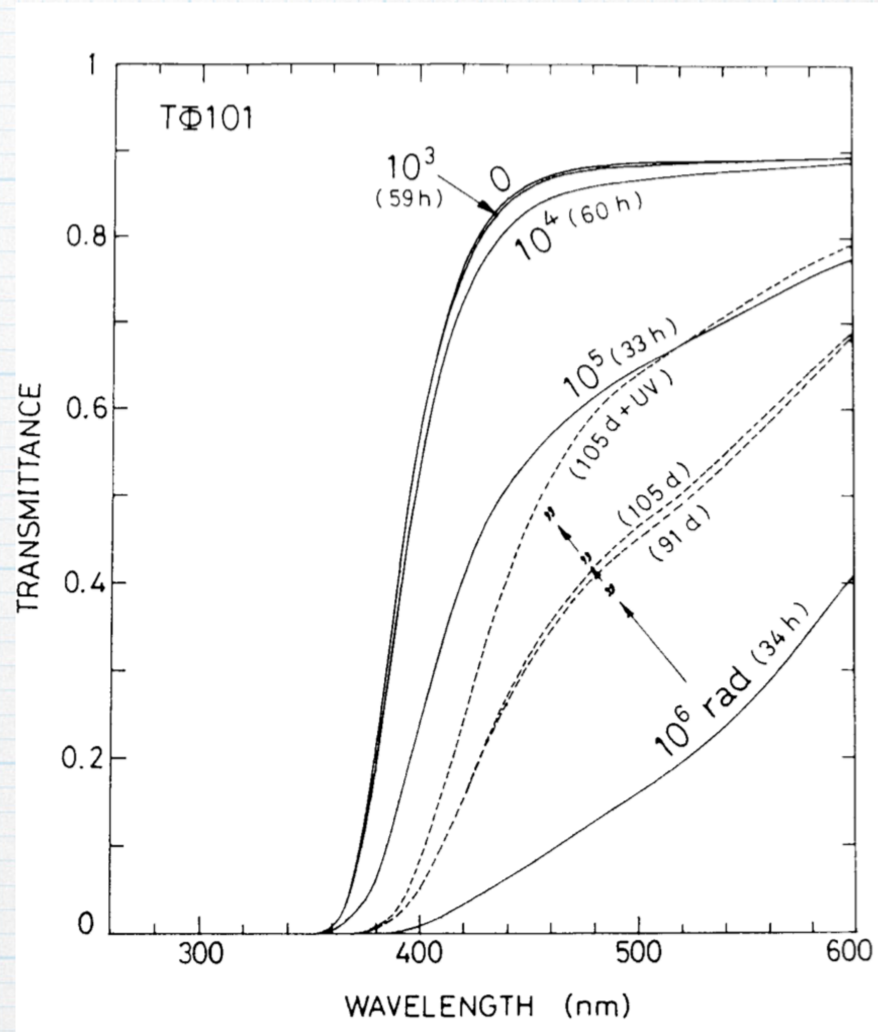
Sehr geehrte(r) Frau Maryna Borysova,

Pos.	Artikel-Nr. Beschreibung	Menge (Stk)	Einzelpreis EUR	Gesamtpreis EUR
1.1	R972 Photomultiplier RoHS konform	1	2.159,09	2.159,09
2.1	R821 Photomultiplier RoHS konform	1	1.129,09	1.129,09
		Gesamtbetrag Netto		3.288,18

LIEFERZEITEN:
Pos. 1: ca. 6 Wochen
Pos. 2: noch zu bestimmen

Degradation of the optical properties of the lead glass (TF1& TF101) by radiation





1rad= 0.01 Gy

TF101 - radiation hardened with addition of 0.2% cerium

https://doi.org/10.1016/0168-9002(94)90990-3

If, we require the decrease of transmission over the detector depth of 45 cm LG block to be less than 1/e, the tolerable accumulated dose in TF101 should be about 10^4 rad = 100 Gy or a little higher.

(=> 5* 10^2 rad = 5Gy In TF1)

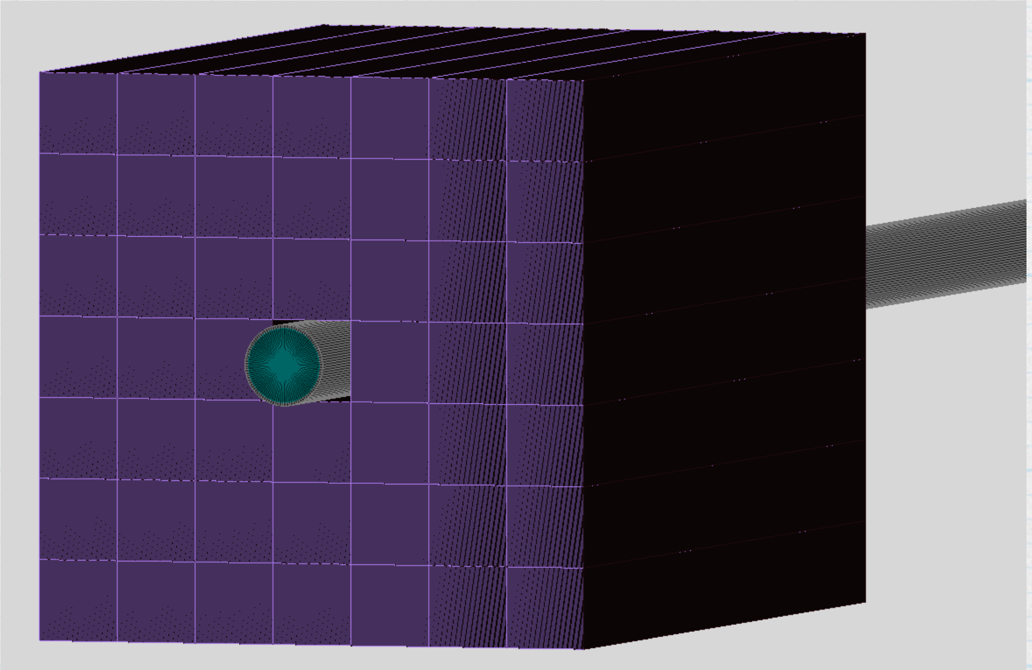
To measure transparency before and after irradiation

the type of the lead glass crystals: are they of the best radiation hardness TF101 crystals?
It was a plan to test them in HERA-B conditions, where they also had radiation hardness problem.

the radiation tolerance for 7X7 geometry was studied in G4:

After 1 kGy full recovery is possible (with UV exposure); for 10 kGy - substantial damage.

Gamma Monitor 48		
	Accumulated 1 kGy, (days)	10 kGy, (days)
TF101	20% degradation	turns brown
Inner layer	226.0	2260.4
	305.9	3059.1
Middle layer	411.8	4118.0
	517.7	5177.0
	906.0	9059.7
Outer layer	1068.0	10680.2
	1261.2	12611.7
	1985.4	19853.7
	3730.6	37306.0



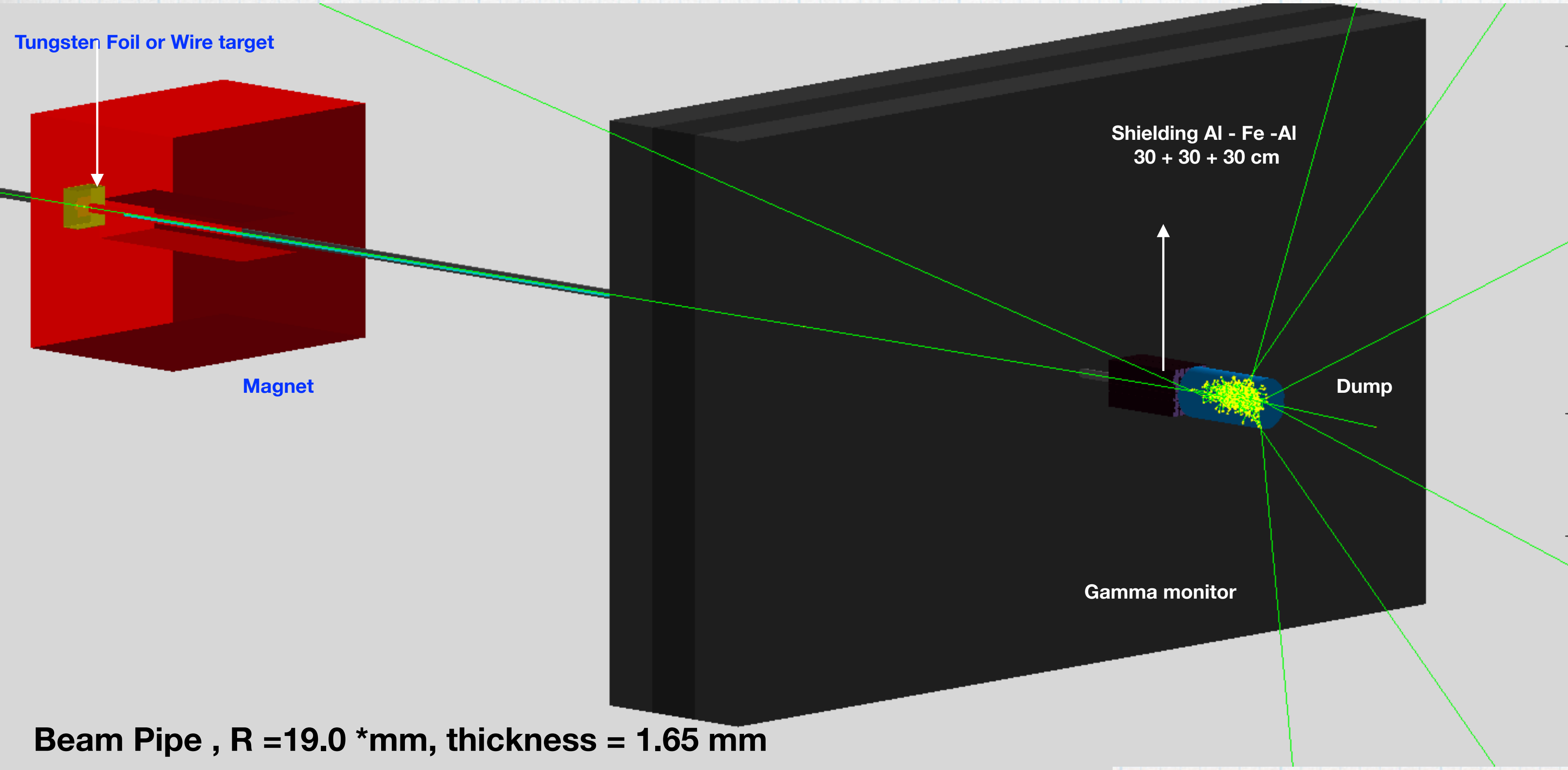
- **to test one crystal in the realistic conditions: measure transparency before and after irradiation**
- **To estimate exposure time for radiation damage studies in simulations (considering DESY beam test facility or source)**

Back up

Chemical composition	weight	Fractions atomic units
Pb_3O_4	51.23	Pb - 0.0795
SiO_2	41.53	0 - 0.6223
K_2O	7.0	Si - 0.2450
Ce	0.2.	K - 0.0527
		Ce - 0.0005
Radiation length (cm)	2.78	
Density (g/cm^3)	3.86	
Critical energy (MeV)	17.97	
Refraction index	1.65	
Moliere radius (cm)	3.28	
Thermal expansion coefficient (C^{-1})	$8.5 * 10^6$	

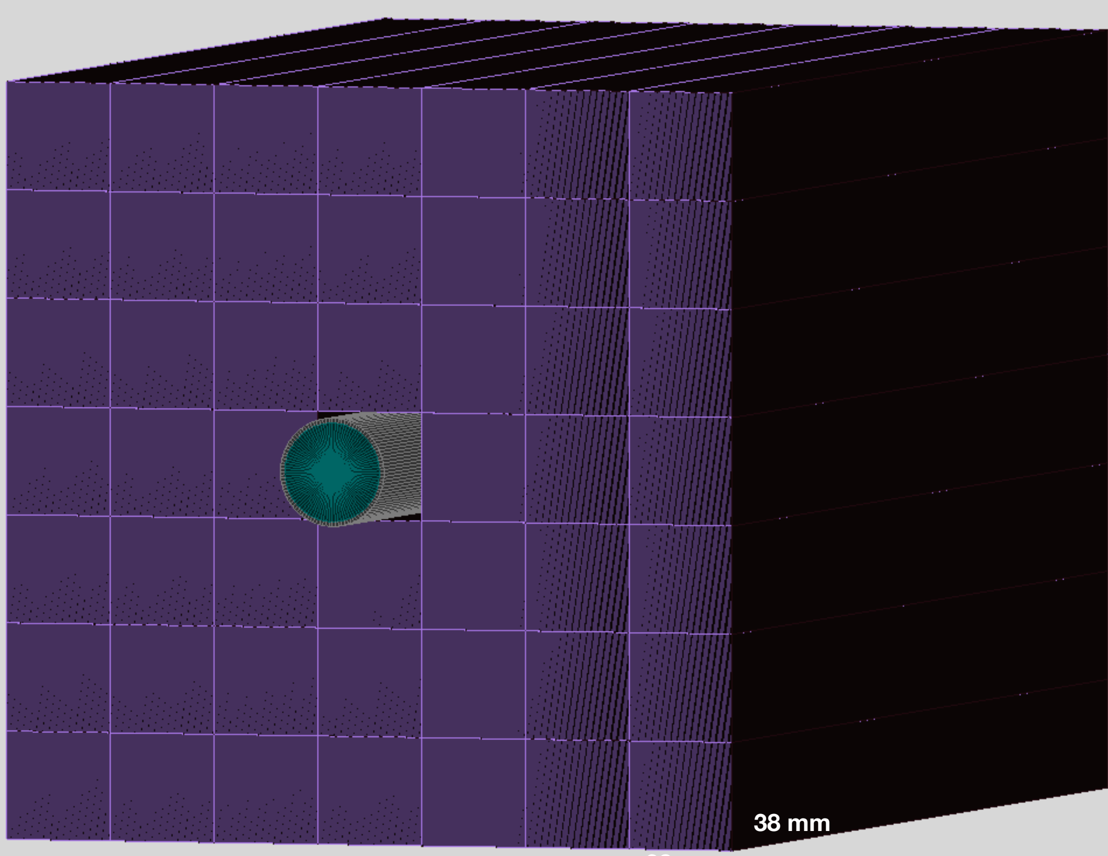
Table 7. Chemical composition and physical properties of the lead-glass TF-101.

Gamma Monitor

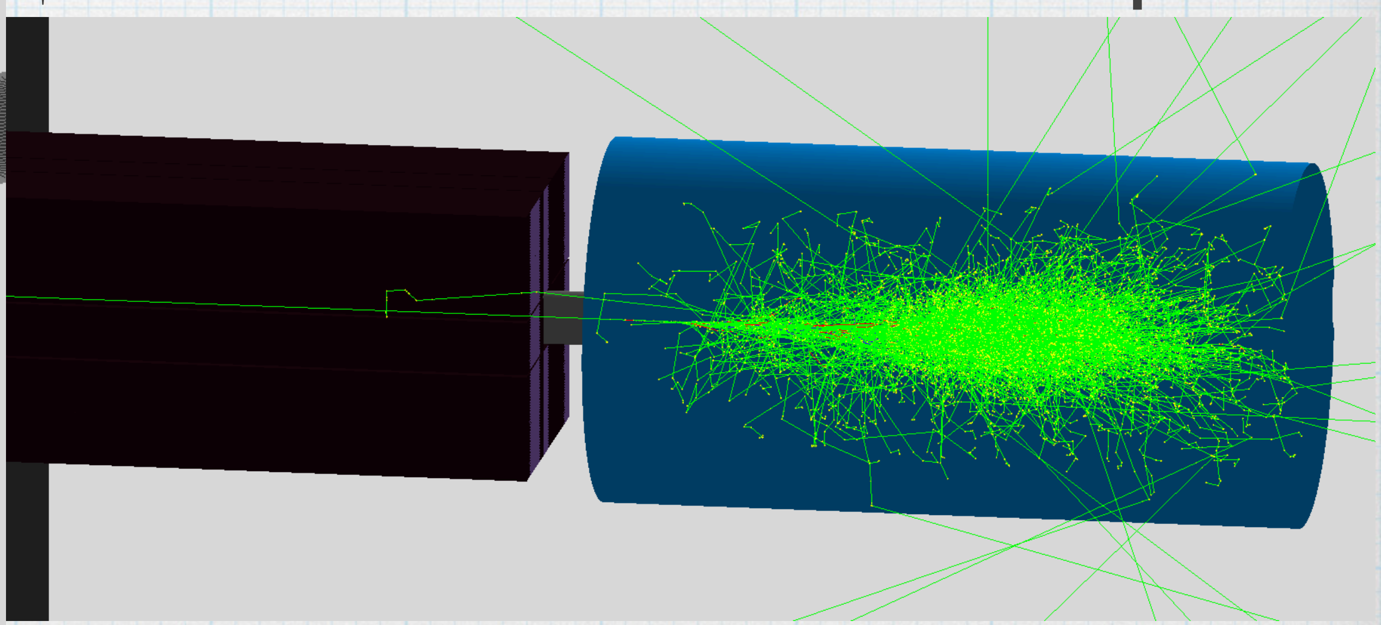


- The implementation of FDS in Luxe geometry with the LG Gamma Monitor made of new LG blocks in front of Al-Cu Dump,
- LG w/ measures 3.8 × 3.8 cm^2, length is 45 cm
- Wrapped with Aluminium foil of 0.016 mm (typical household foil; no account for air)

Beam Pipe , R =19.0 *mm, thickness = 1.65 mm

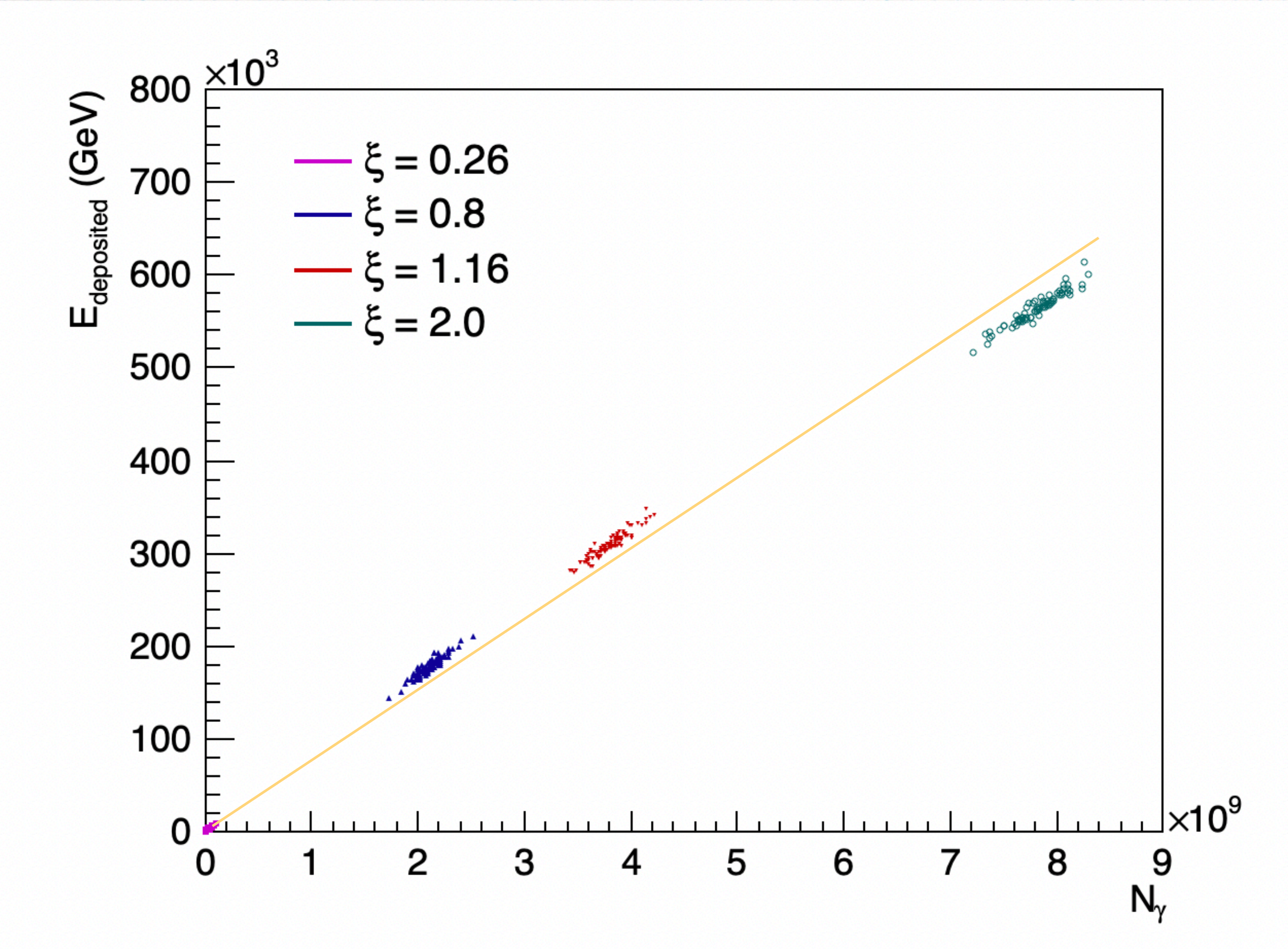


- Distance between Monitor and Dump 2 cm

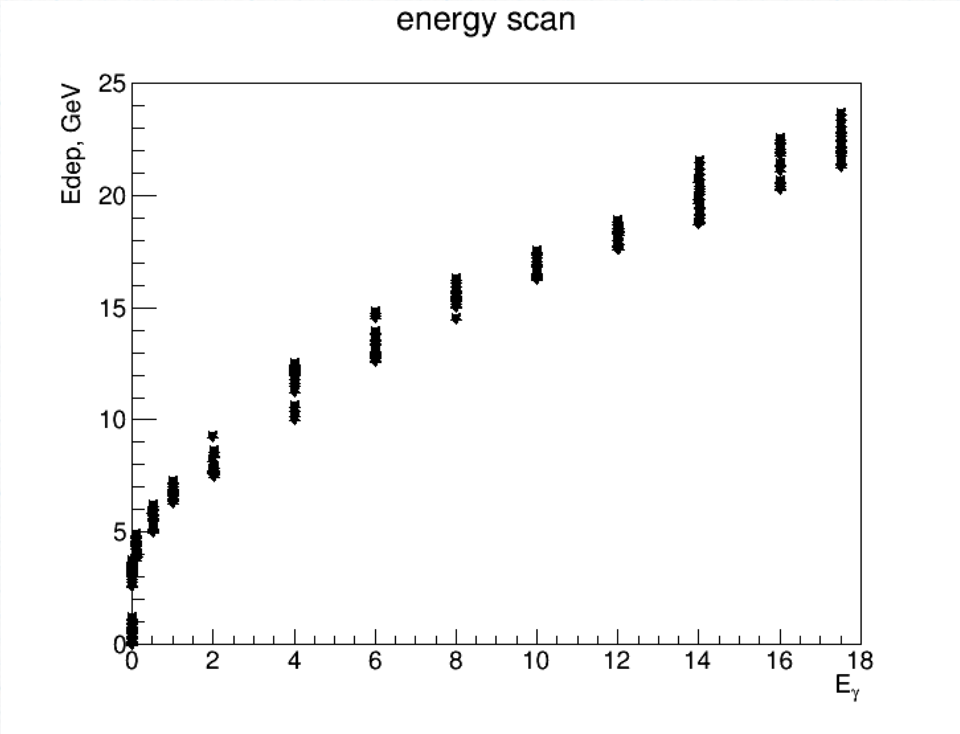


Simulation and Performance

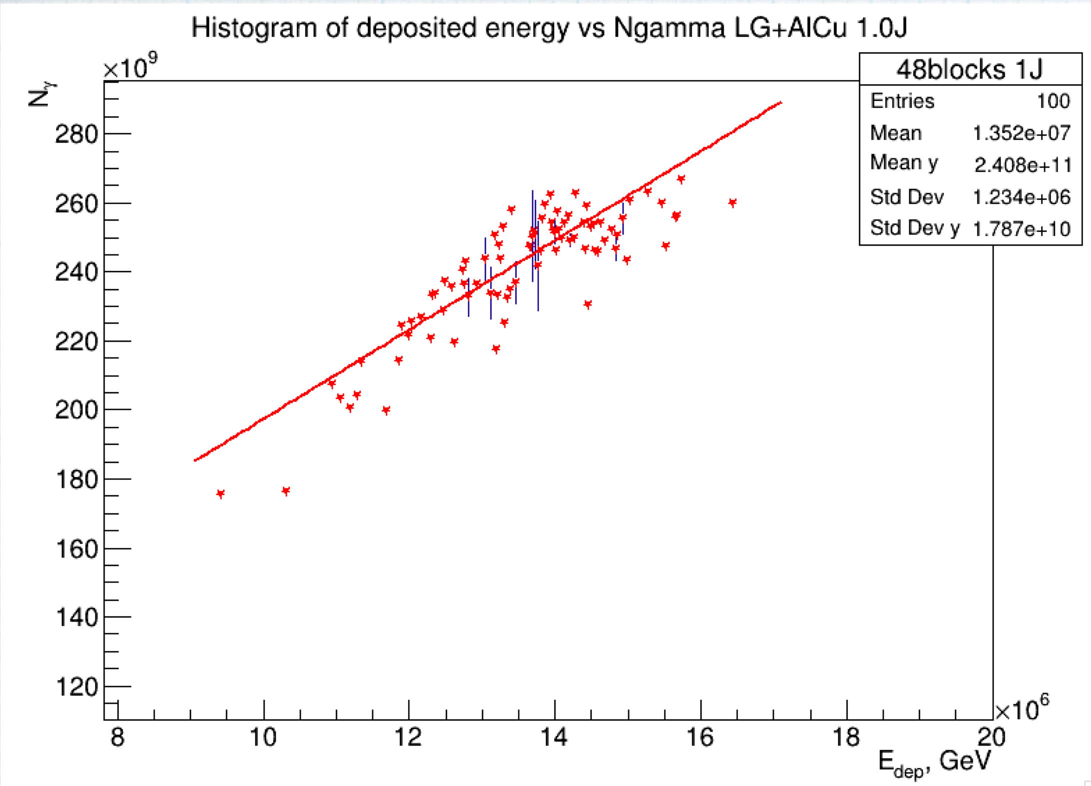
Deposited energy versus true number of photons. Each point is one BX



- The (almost) linear dependence of deposited energy on number of incoming photons in GM allows the usage of backscatters for monitoring the photon flux
- For small ξ the HICS spectrum is softer and soft photons produce less back-scatters. This is the reason of small deviation from linearity in Edep on Eγ dependence



Uncertainties estimation



N(E) number of photons

$$\Delta N = \frac{\partial N}{\partial E}\Delta E \quad \Rightarrow \quad \frac{\Delta N}{N} = \frac{1}{N}\frac{\partial N}{\partial E}\Delta E$$

$N = 2.5 * 10^{11}$ $\partial N/\partial E = 12940$

$$\frac{\Delta N}{N} = \frac{1}{N}\frac{\partial N}{\partial E}\Delta E = 6.8*10^4 * 1.3 * 10^4 / 2.5 * 10^{11} = 3.5 * 10^{-3}$$

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****************************************
Minimizer is Linear
Chi2                      =      49.2879
NDf                       =           13
p0                        =  6.79976e+10    +/-    3.97264e+09
p1              ∂N/∂E     =      12940.5    +/-    282.483
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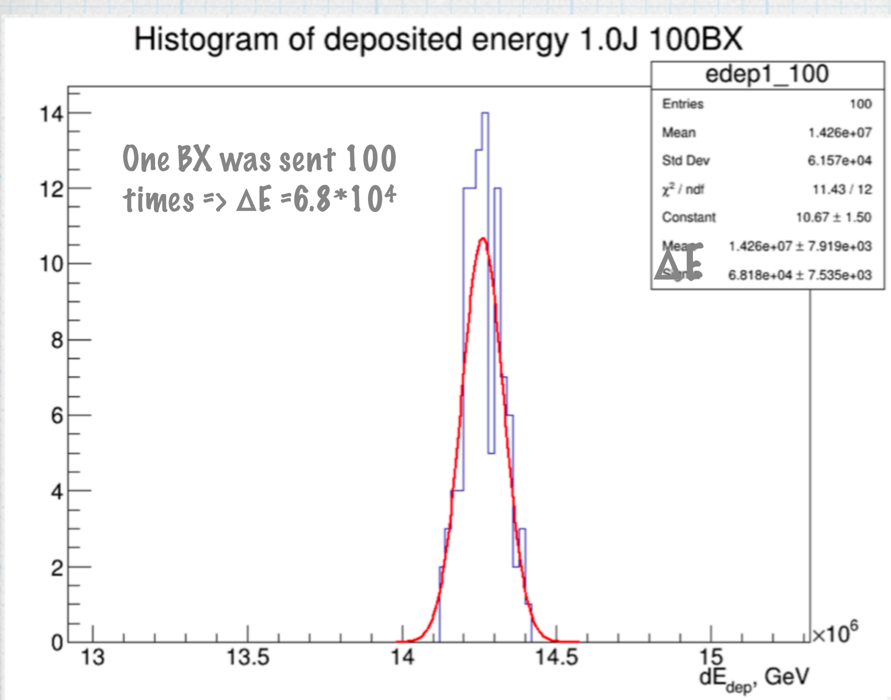
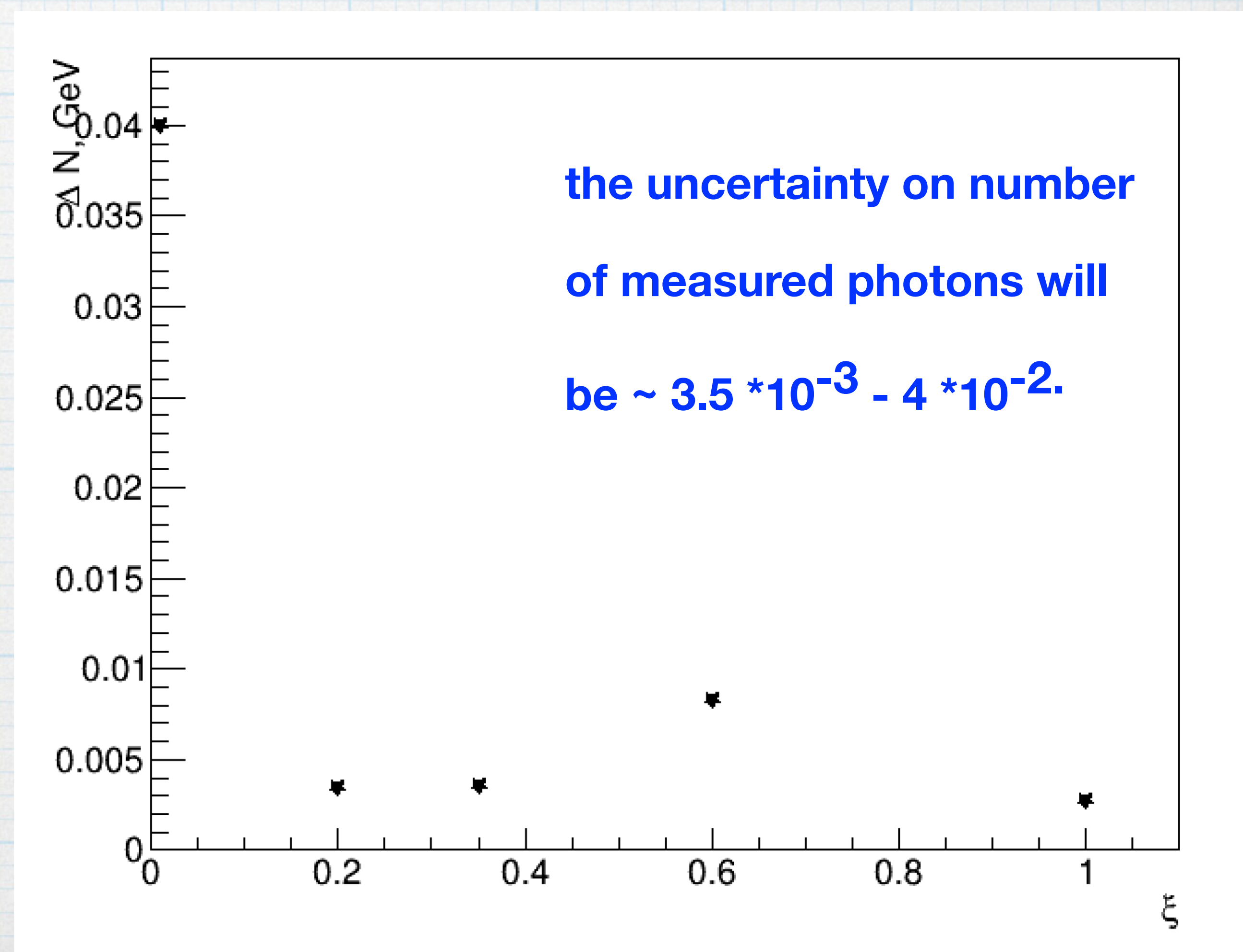
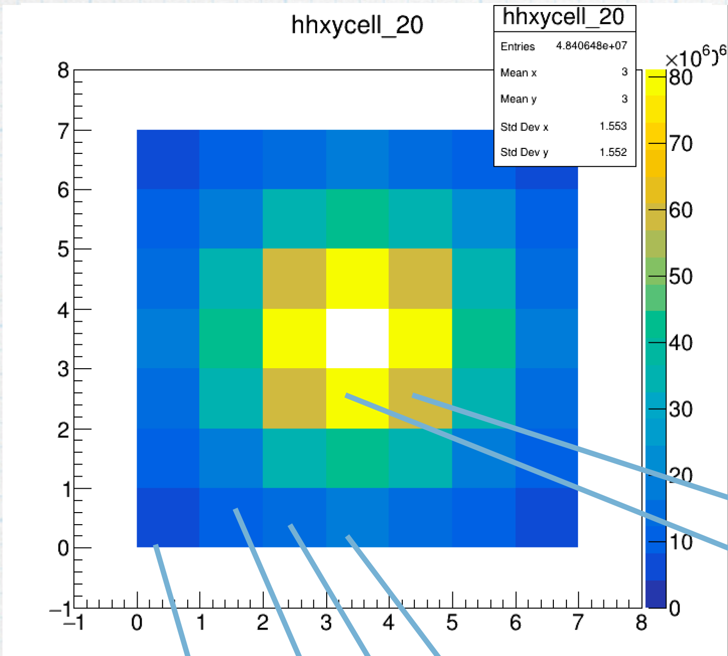


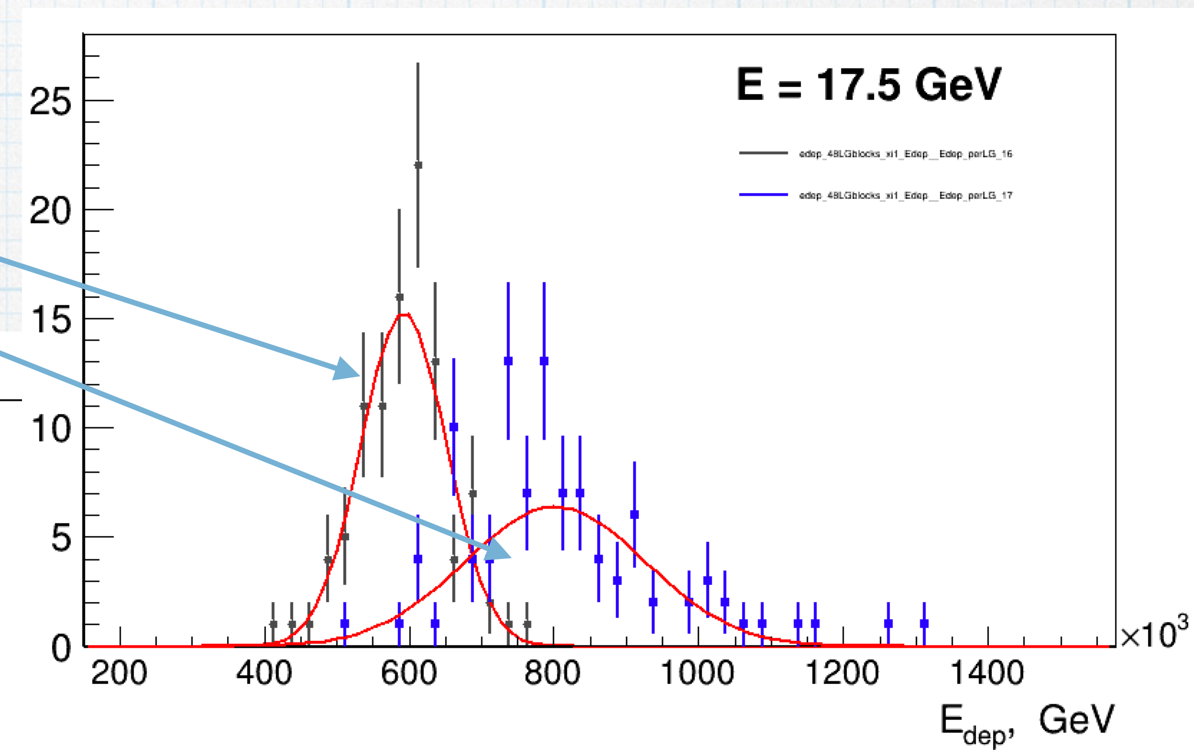


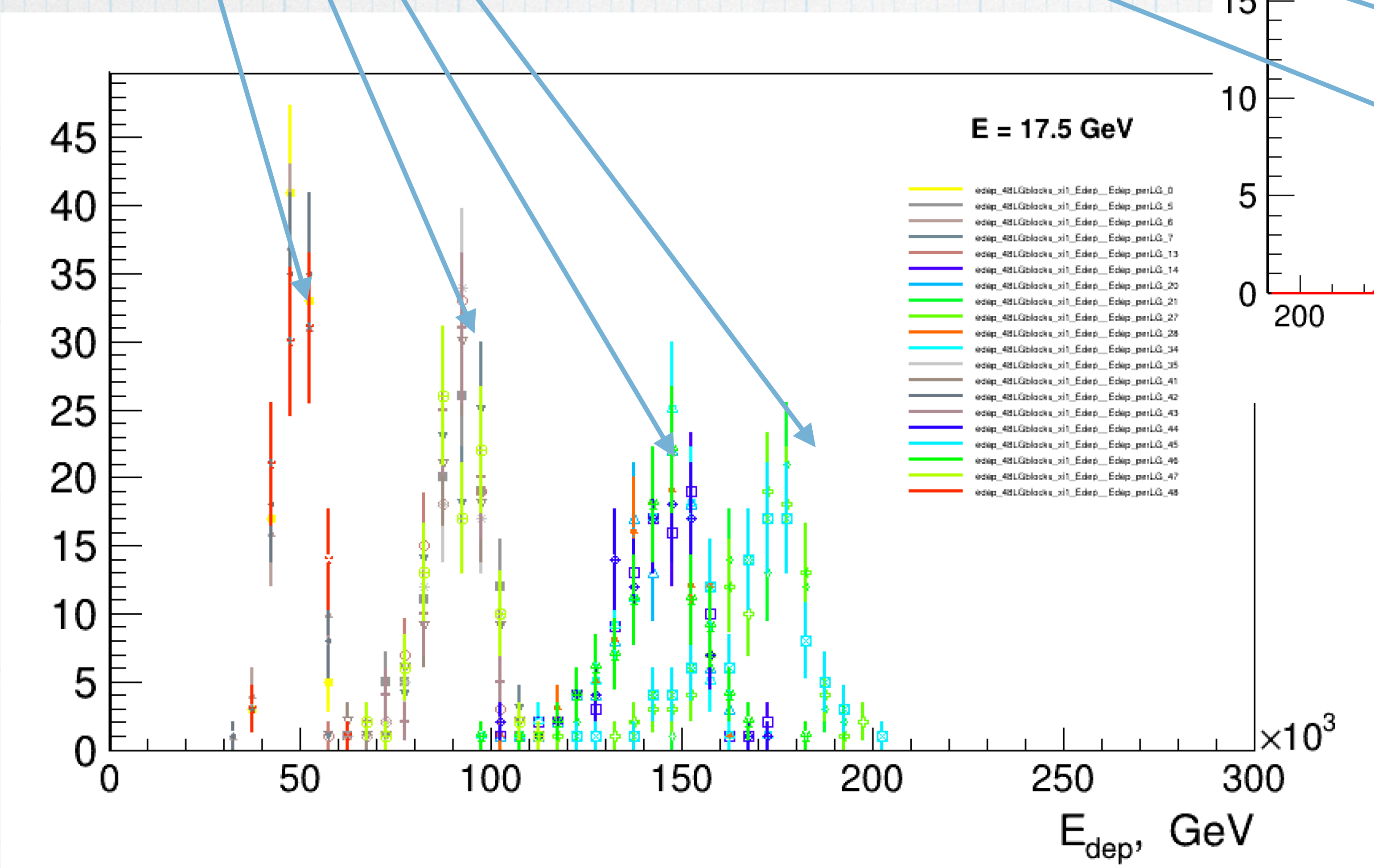
tolerable accumulated doses in the individual blocks



✴ At high laser intensities ξ =2.6 (1J)

	Edep(100BX),GeV	Edep(1BX),GeV	Edep(1BX), J	Edep(1BX), J/kg (x0)=Gy	Edep(1BX), J/(2.5kg block)=Gy	Edep(1BX), Gy/sec(2.5kg block)	sec	hours
Inner layer	8.02E+07	8.02E+05	1.28E-04	9.22E-04	5.12E-05	5.12E-04	9.76E+03	2.71
	5.92E+07	5.92E+05	9.49E-05	6.81E-04	3.78E-05	3.78E-04	1.32E+04	3.67
Middle layer	4.40E+07	4.40E+05	7.05E-05	5.06E-04	2.81E-05	2.81E-04	1.78E+04	4.94
	3.50E+07	3.50E+05	5.61E-05	4.03E-04	2.24E-05	2.24E-04	2.24E+04	6.21
	2.00E+07	2.00E+05	3.21E-05	2.30E-04	1.28E-05	1.28E-04	3.91E+04	10.87
Outer layer		1.70E+05	2.72E-05	1.95E-04	1.08E-05	1.08E-04	4.61E+04	12.81
		1.44E+05	2.30E-05	1.65E-04	9.18E-06	9.18E-05	5.45E+04	15.13
		9.13E+04	1.46E-05	1.05E-04	5.83E-06	5.83E-05	8.57E+04	23.82
		4.86E+04	7.78E-06	5.59E-05	3.10E-06	3.10E-05	1.61E+05	44.76

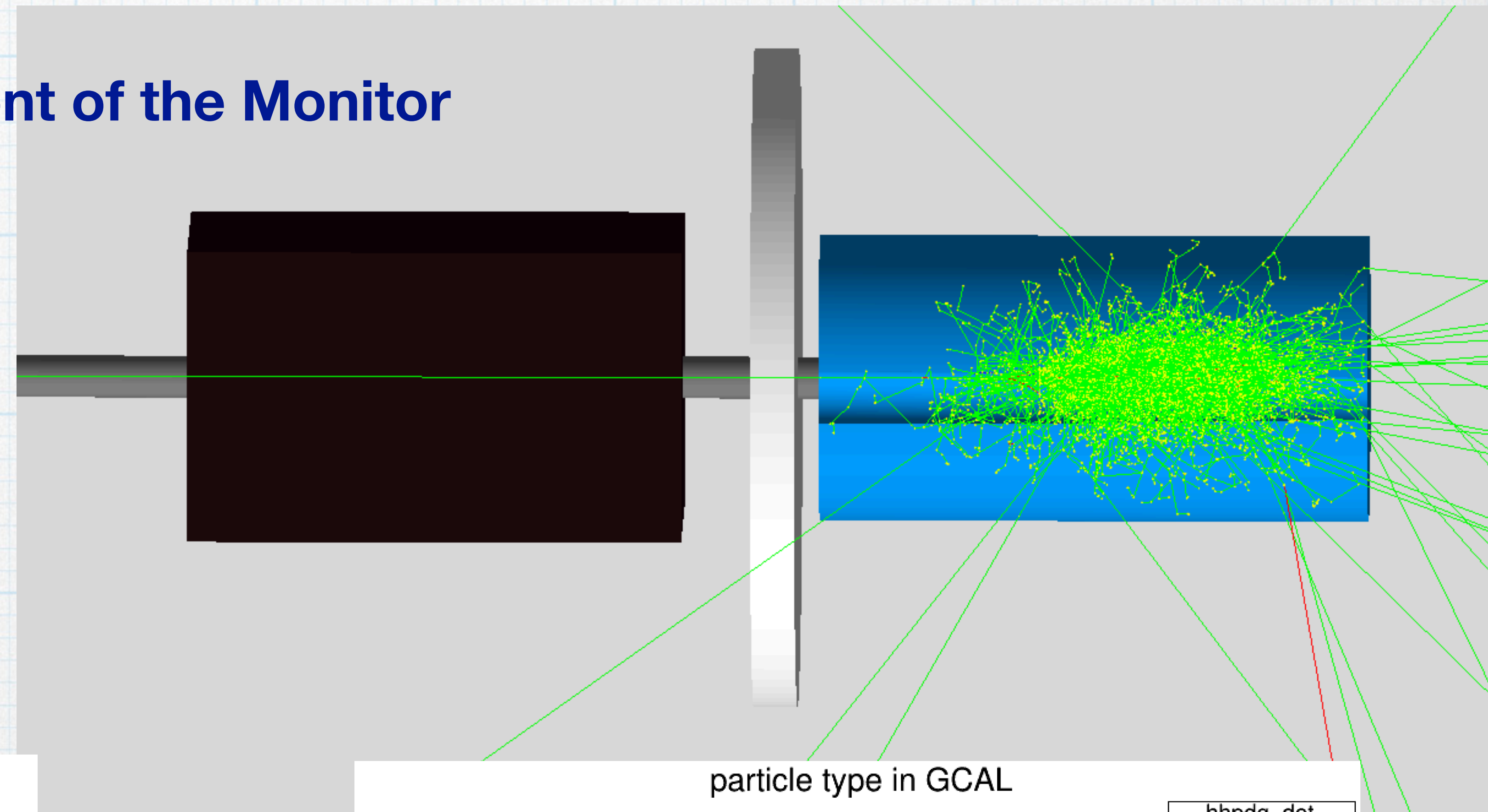


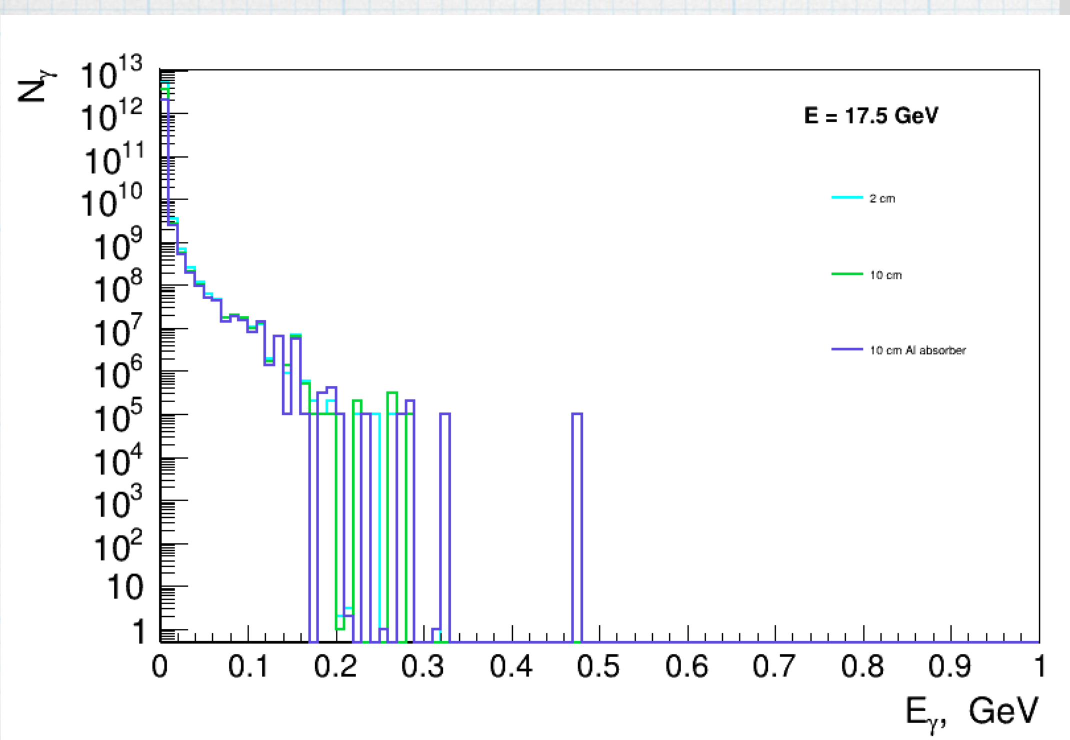


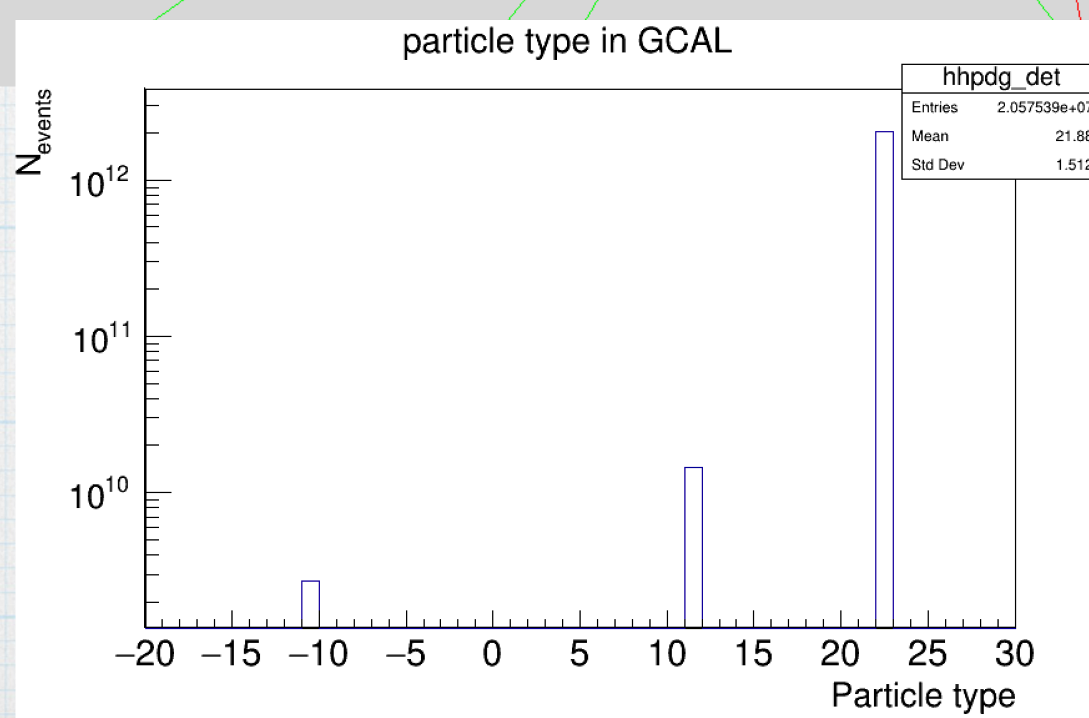
At 10 Hz rate the energy deposition accumulates the dose of 5 Gy in the whole TF1 block which ranges from 3 hours up to 45 hours

Adding absorber

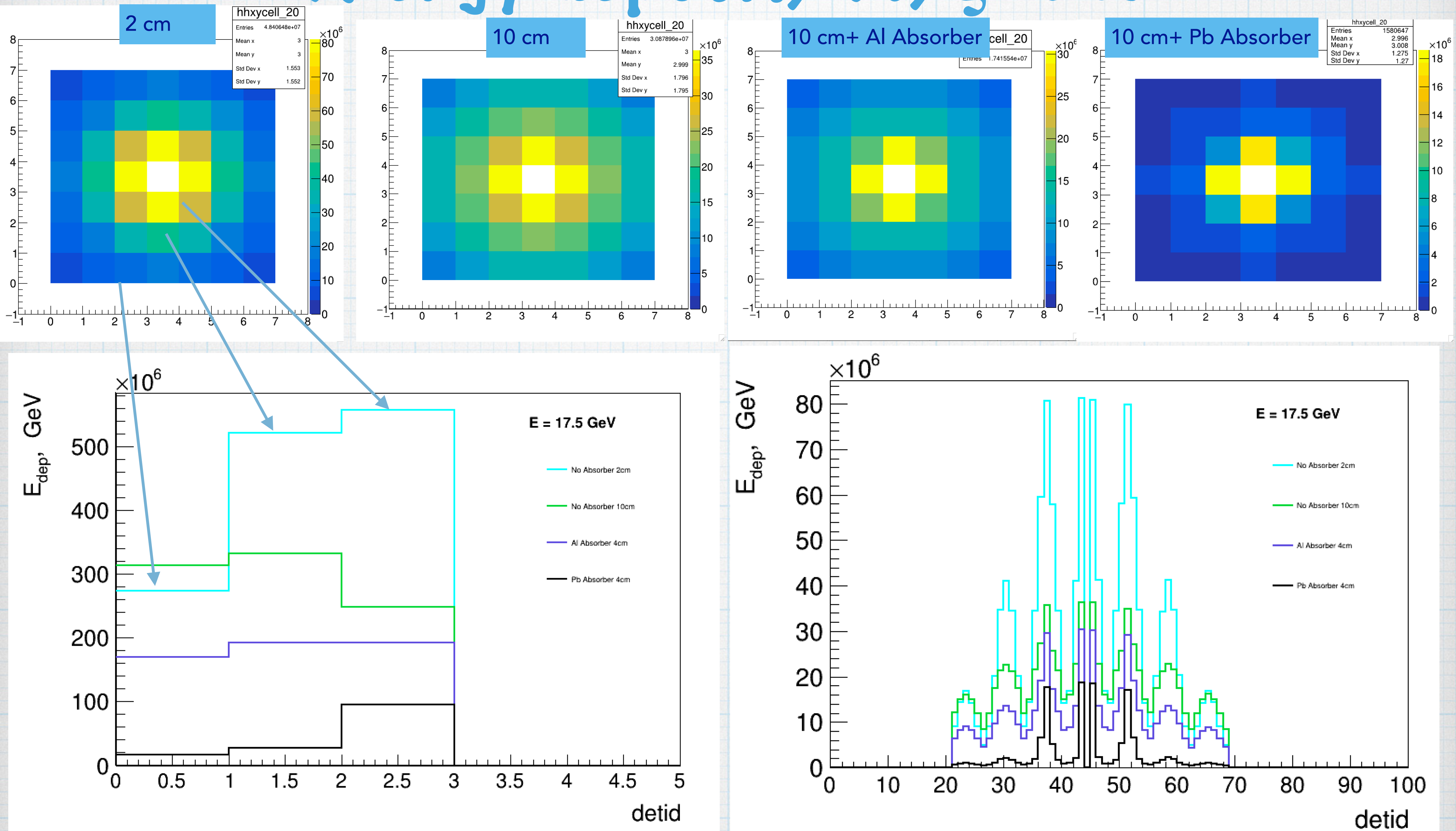
- ✳ **2Months ~1460 hours**
- ✳ **To try:**
  - ✓ **absorber (Al or Pb, 4 cm) in front of the Monitor**







Energy deposit, 48, ξ =2.6



* Moving further from the dump the deposit in inner layer twice less, which prolonged the usage of inner layer up to 7 hours
* Adding 4 cm Al absorber between dump and monitor prolongs up to 10 hours for the inner layer