Testing modules for Backscattering calorimeter

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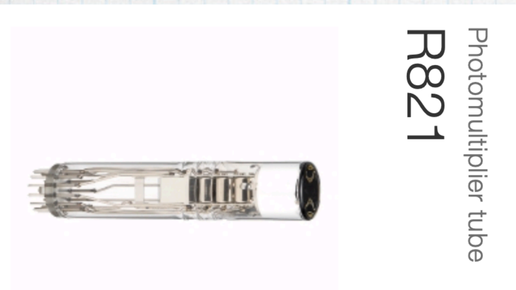
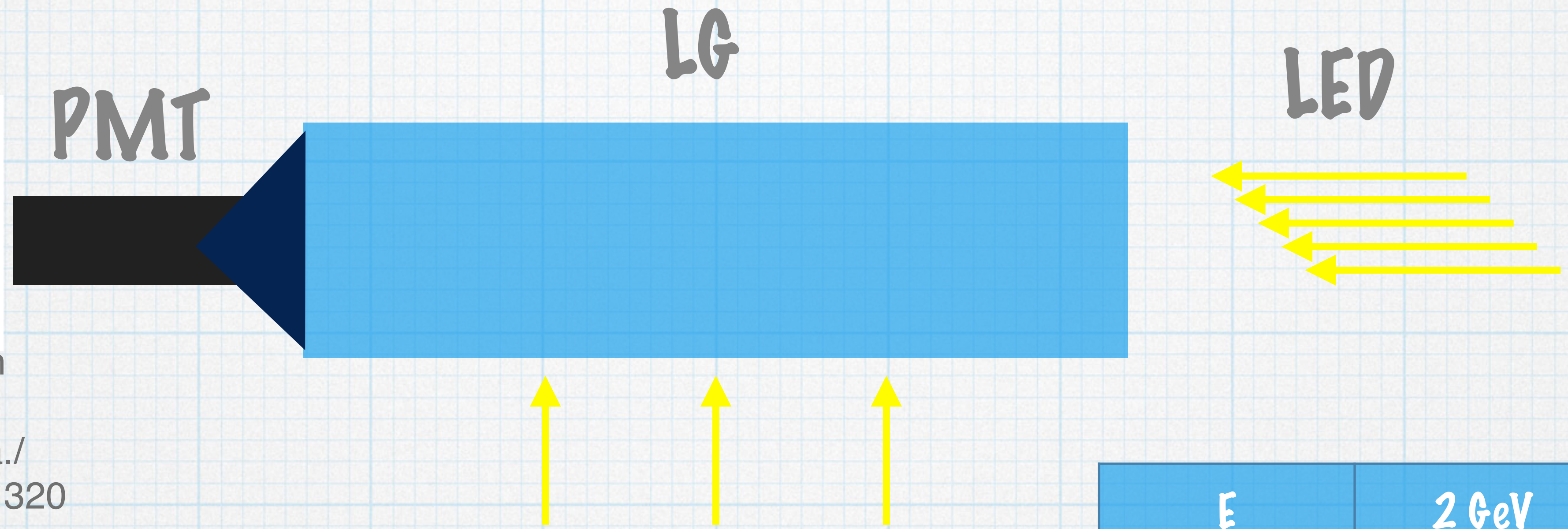
12/05/21
LUXE weekly technical meeting

LUXE

Testing at TBF DESY



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



E	2 GeV	5 GeV
f	8000HZ	15 HZ

To test radiation hardness (TF101 type?).

- Test light transmittance in LG block with LED before and after irradiation

- To irradiate at DESY TB 8 kHz at 2 GeV

To irradiate the crystal with 1.6e4 GeV/c

To convert it to Gy, convert it to J: 1 GeV=1.6e-10J and then divide it to the mass of crystals in kg (2.5 kg). Gy= J/kg

2.56e-6 J/2.5kg = 1e-6 Gy

We need 1e8 sec to irradiate it

Testing at DESY

the high particle count area at DESY is under commissioning now and will be available since the spring.
12 Hz of 10e10 electrons at 6.5 GeV

- Length is 45 cm corresponds to 18X0

To irradiate the crystal with 6.5*10e10 *12 =7.8 GeV/c

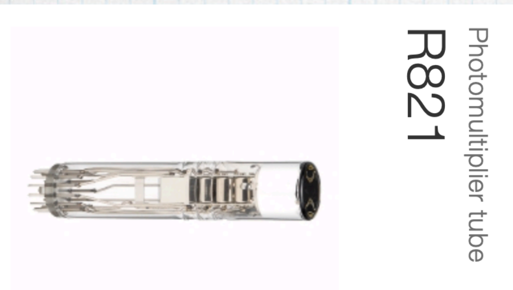
To convert it to Gy, convert it to J: 1 GeV=1.6e-10J and then divide it to the mass of crystals in kg (2.5 kg). Gy= J/kg

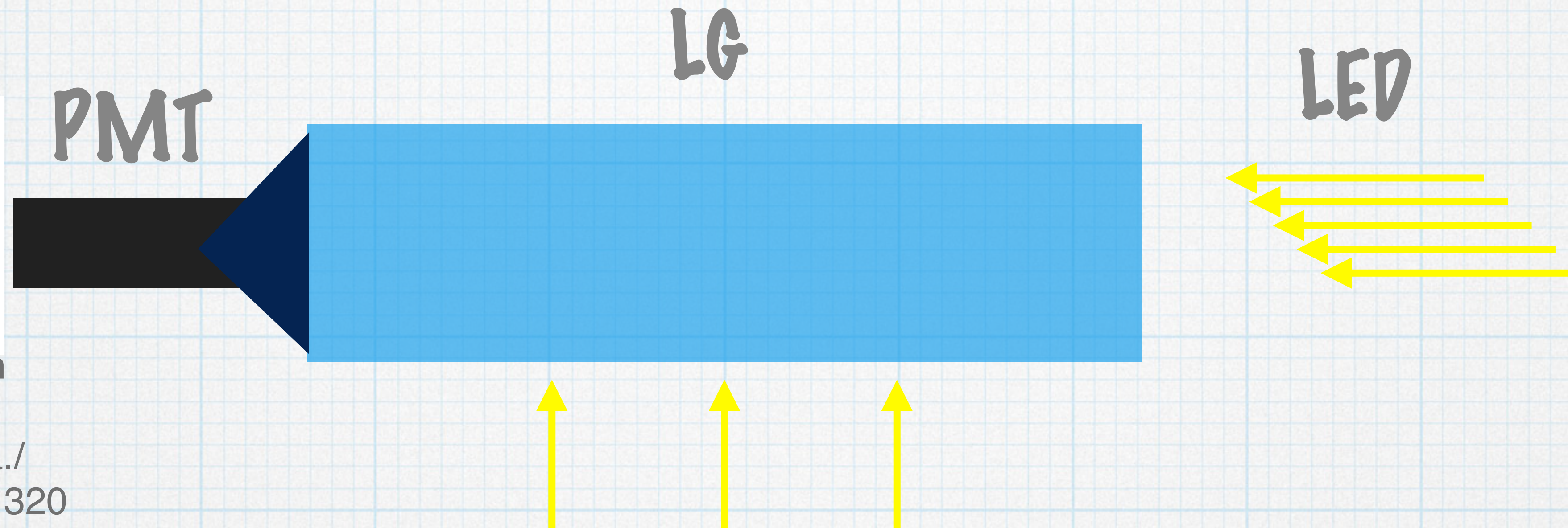
125J/2.5kg = 50 Gy

We need 2 sec to irradiate it

Back up

calibrate the light output





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

- 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 the crystal
- To couple the block with photo- multiplier (R821)

Lead glass blocks in Hera West @DESY

- ✳New TF-1 (or TF-101) LG blocks! Not irradiated, w/ measures 3.8 × 3.8 cm^2, 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

Cherenkov calorimeters

Detectable Cherenkov light is produced whenever a particle traverses a transparent medium with a speed v> c/n, where c/n is the speed of light in that medium and n is the refractive index of the medium.

The maximum photon intensity is obtained for short wavelengths (typically ~ 300-350 nm), whereas most photocathodes are sensitive to the region 300-600 nm.

As an example, about 1000 photoelectrons are produced in lead glass per deposited GeV, which alone (i.e. without taking into account possible inefficiencies in the signal collection and other effects like shower containment) gives an energy resolution of 3%/sqrt(E, GeV)

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

Spectrophotometers could be used to measure transmittance

SCILOGEX spectrophotometers are an indispensable instrument routinely used in colleges, universities and research institutes for quantitative analysis in fields including biotechnology and quality control of new material developed

Model	SP-V1000	SP-UV1000
Optical System	Single Beam	Single Beam
Light Source	Tungsten lamp	Tungsten lamp & Deuterium lamp
Spectral Bandwidth	4.0nm	4.0nm
Wavelength Range	325-1000nm	200-1000nm
Wavelength Accuracy	±2nm	±2nm

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 nm)

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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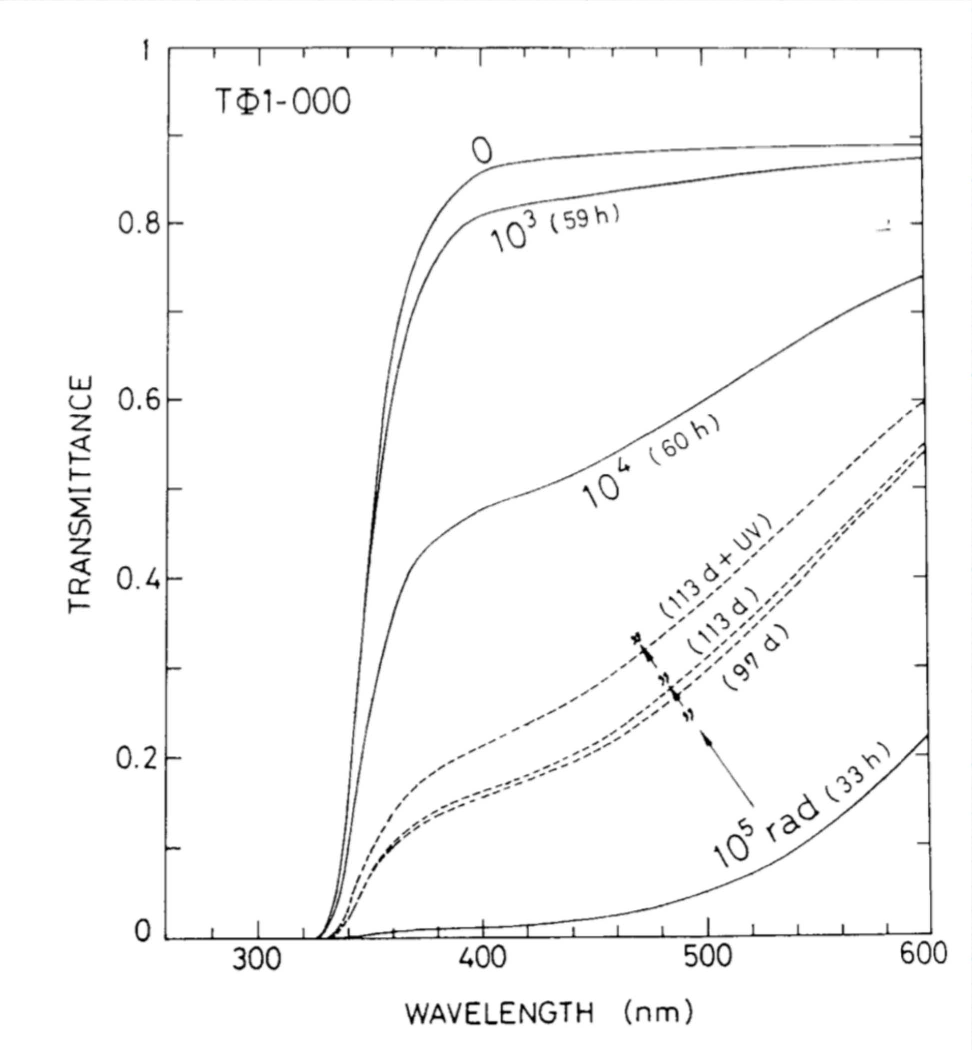
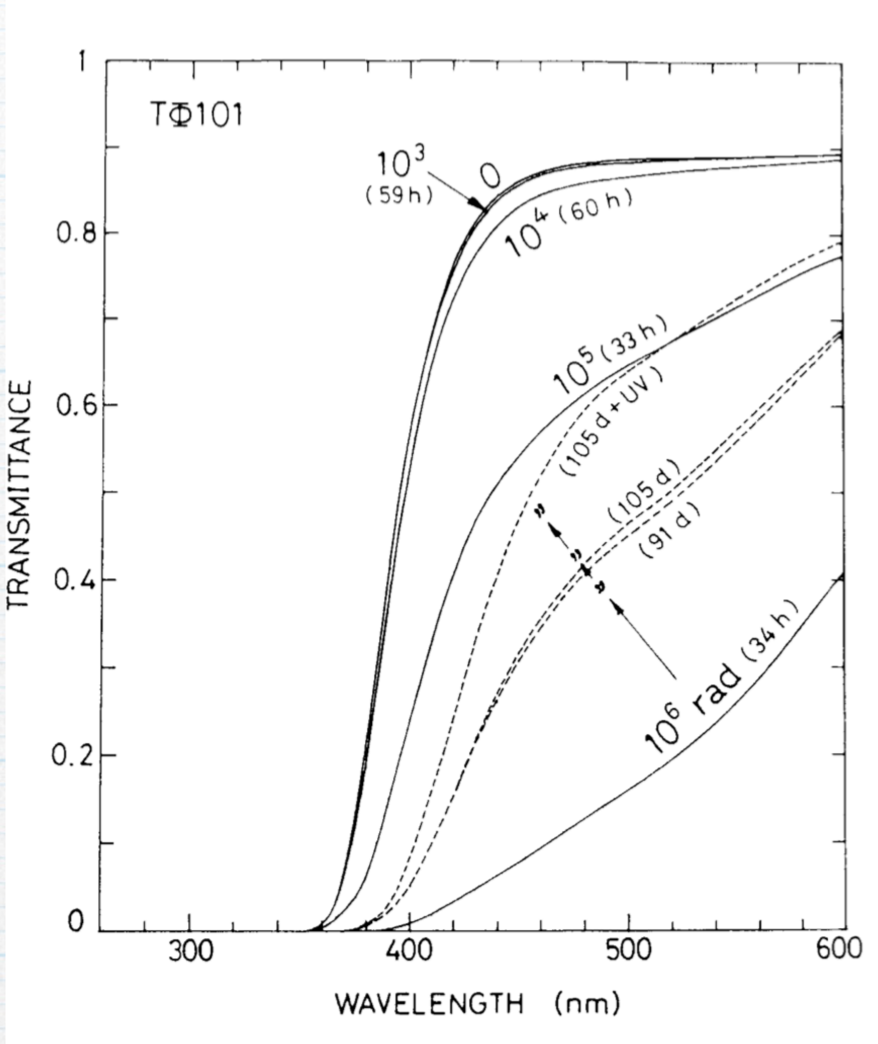
Sehr geehrte(r) Frau Maryna Borysova,

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

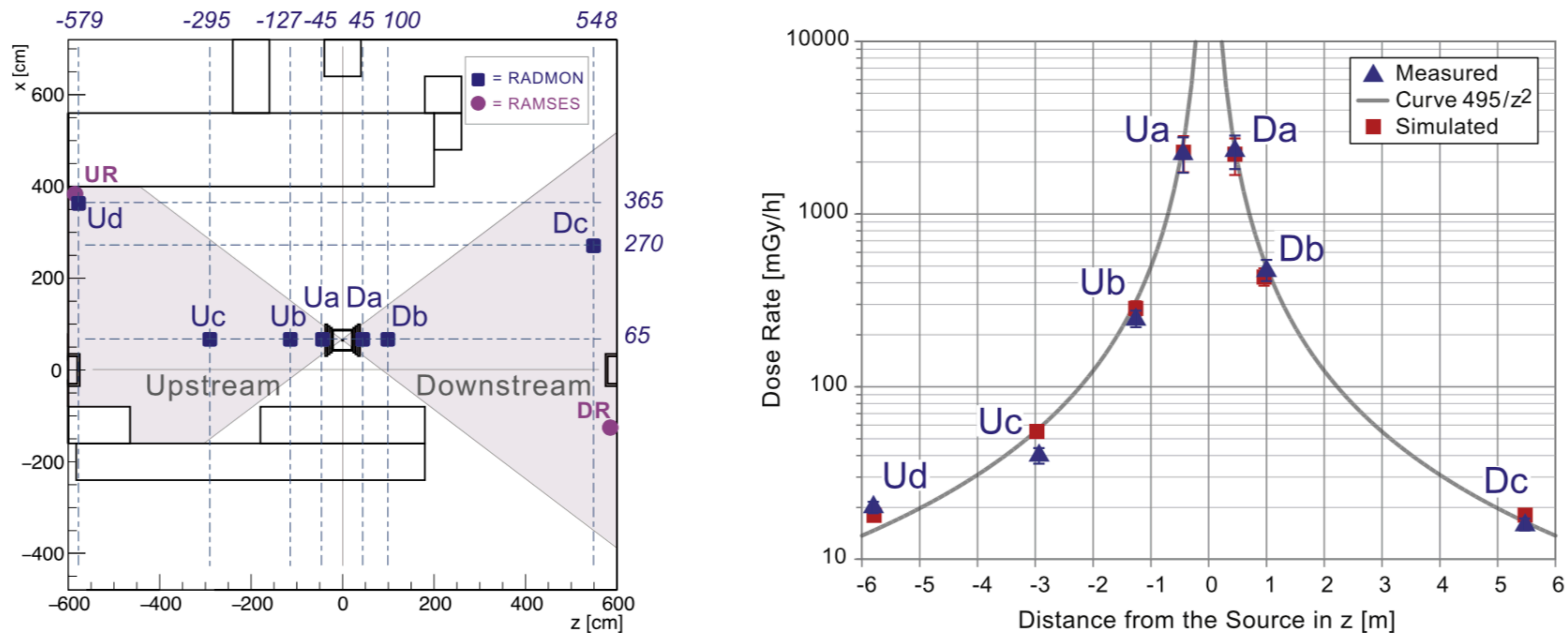
TF101 - radiation hardened with addition of 0.2% cerium

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)

GIF++ radiation doses



(a) RADMON measurement positions.

(b) Measured and simulated data.

Table 3
Measured and simulated dose rate at the measurement locations in March 2015 (I1 to UR), December 2015 (Da to Dc) and March 2016 (Ua to Ud). Values in parentheses are the estimated uncertainties.

Position	*x* [m]	*y* [m]	*z* [m]	Detector	Downstream open, Upstream open		
					Measured dose rate mGy/h	Simulated dose rate mGy/h	Measured dose rate / Simulated dose rate [%]
March 2016							
Ua	0.65	0.0	−0.45	RADMON	2251(557)	2274(536)	99
Ub	0.65	0.0	−1.27	RADMON	249(30)	283(25)	88
Uc	0.65	0.07	−2.95	RADMON	40(4)	55(2)	73
Ud	3.65	0.13	−5.79	RADMON	20(2)	18(1)	111

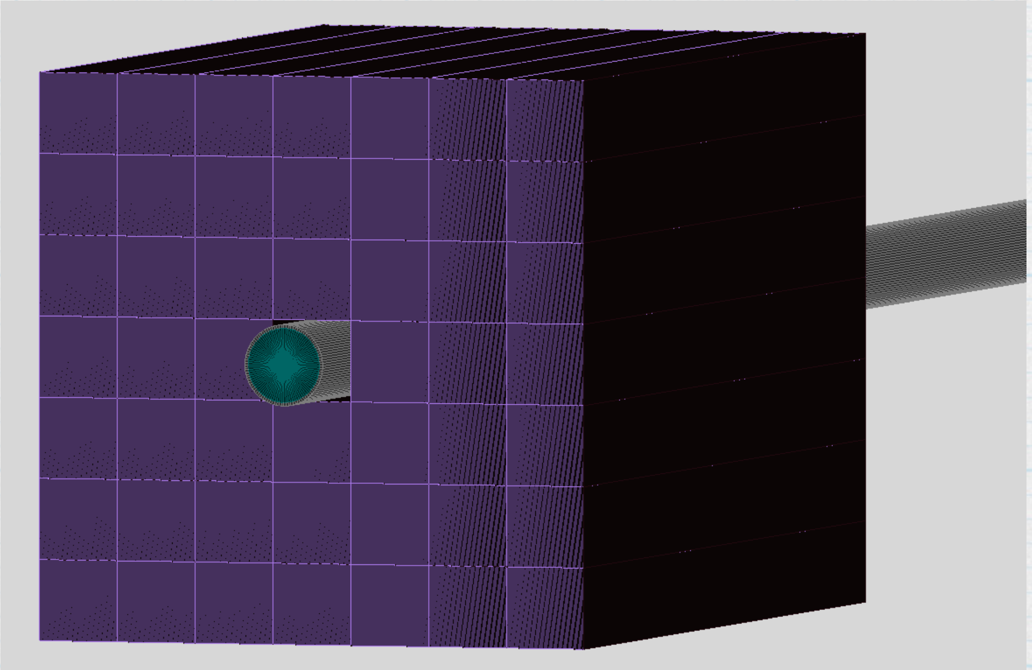
To measure transparency before and after irradiation

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

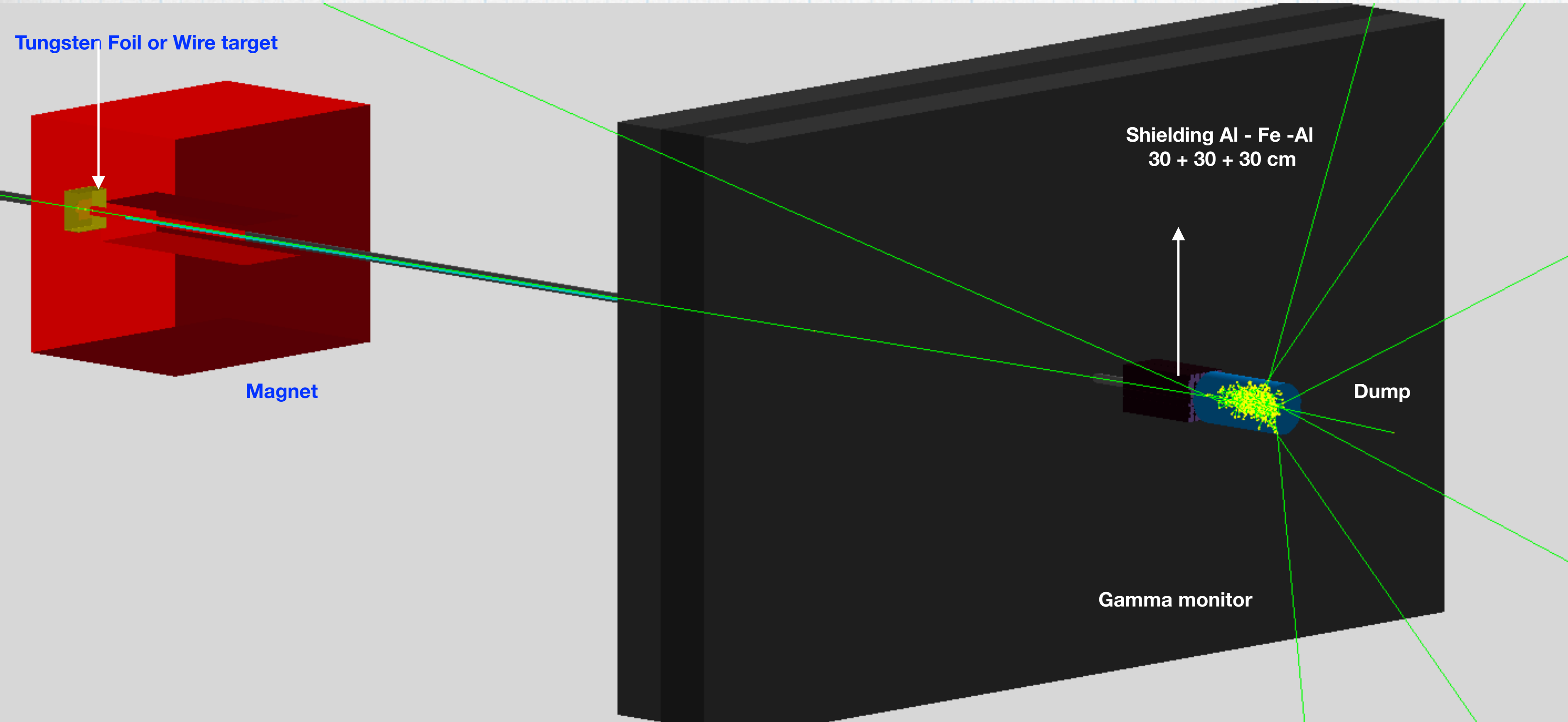


- to test one crystal in the realistic conditions: measure transparency before and after irradiation
- To estimate exposure time for radiation damage studies in simulations (considering DESY beam test facility or source)

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})	$8.5 * 10^6$	

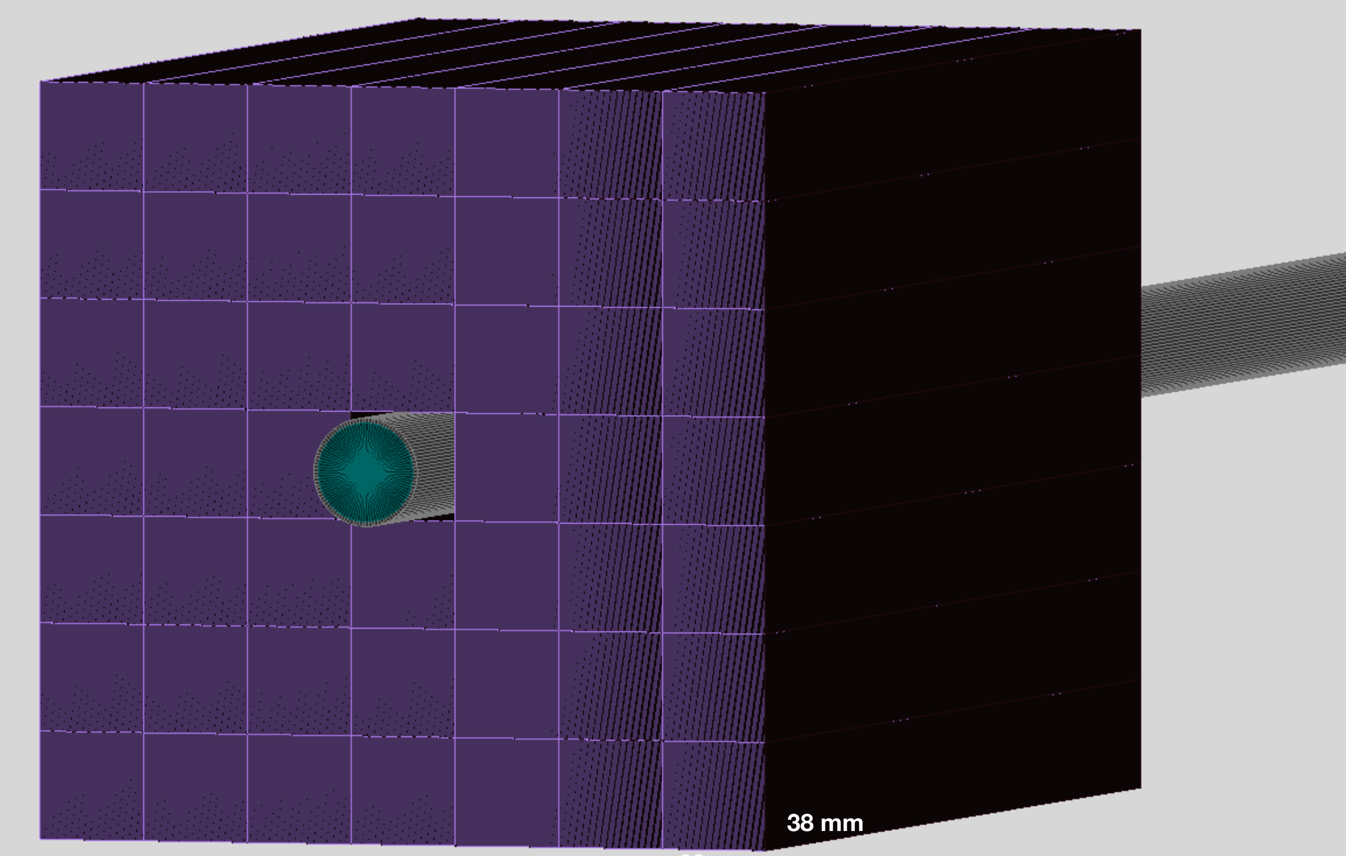
Table 7. Chemical composition and physical properties of the lead-glass TF-101.

Gamma Monitor

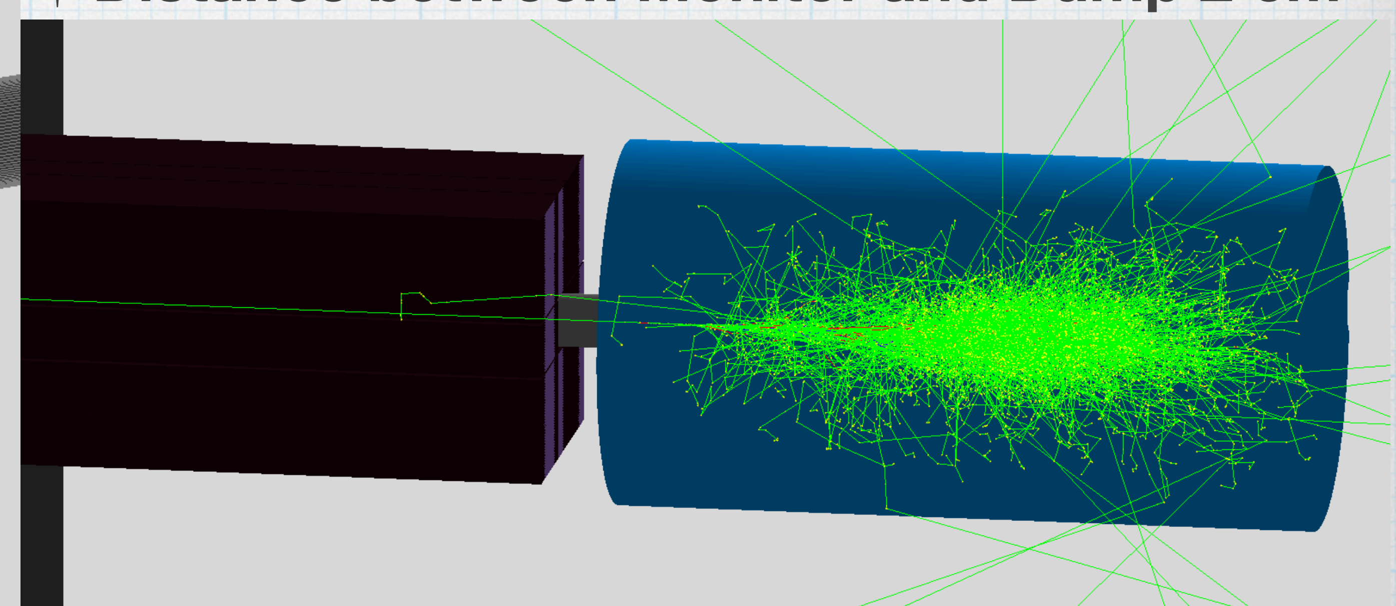


- The implementation of FDS in Luxe geometry with the LG Gamma Monitor made of new LG blocks in front of Al-Cu Dump,
- LG w/ measures 3.8 × 3.8 cm², length is 45 cm
- Wrapped with Aluminium foil of 0.016 mm (typical household foil; no account for air)

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

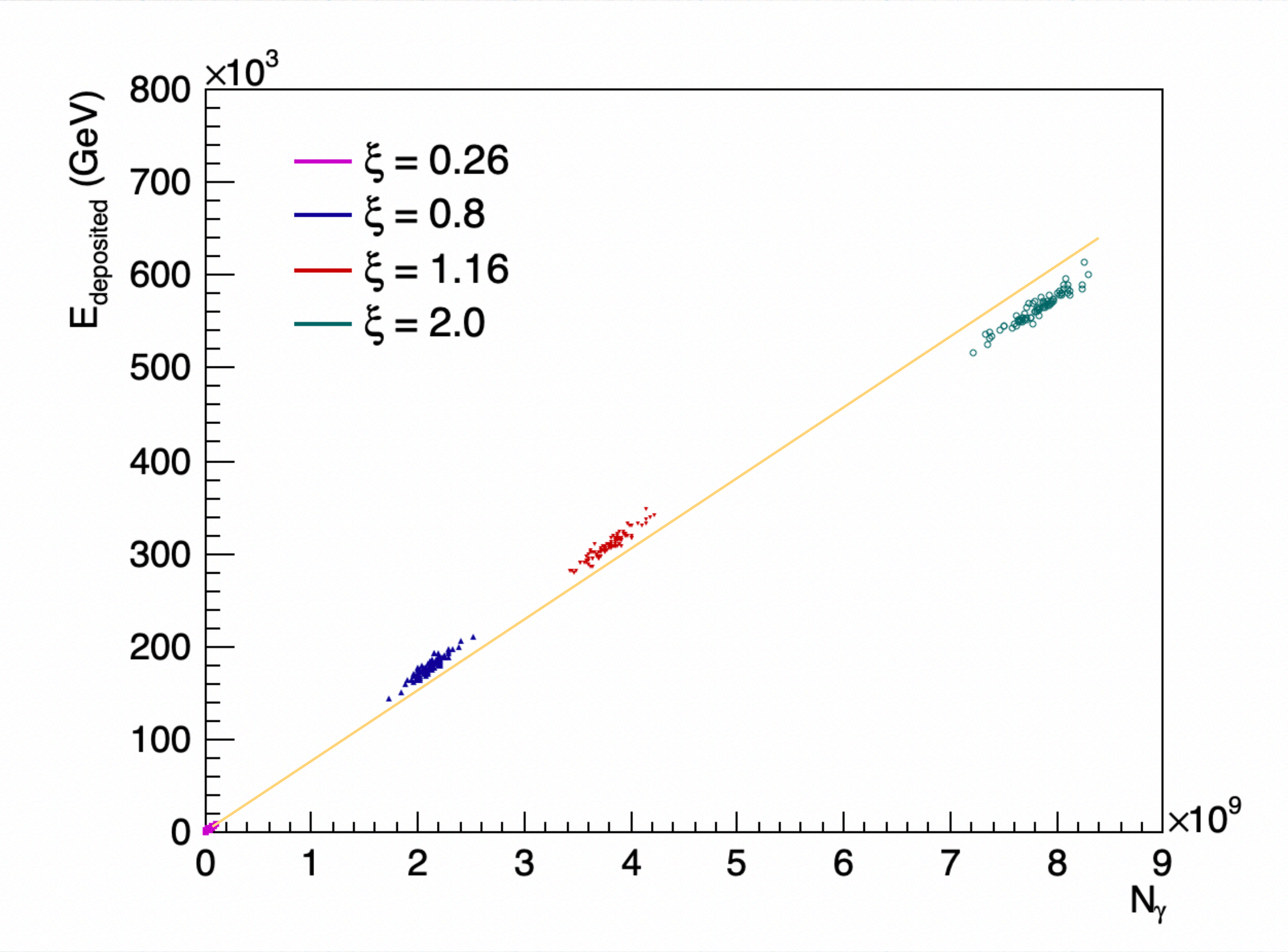


- Distance between Monitor and Dump 2 cm

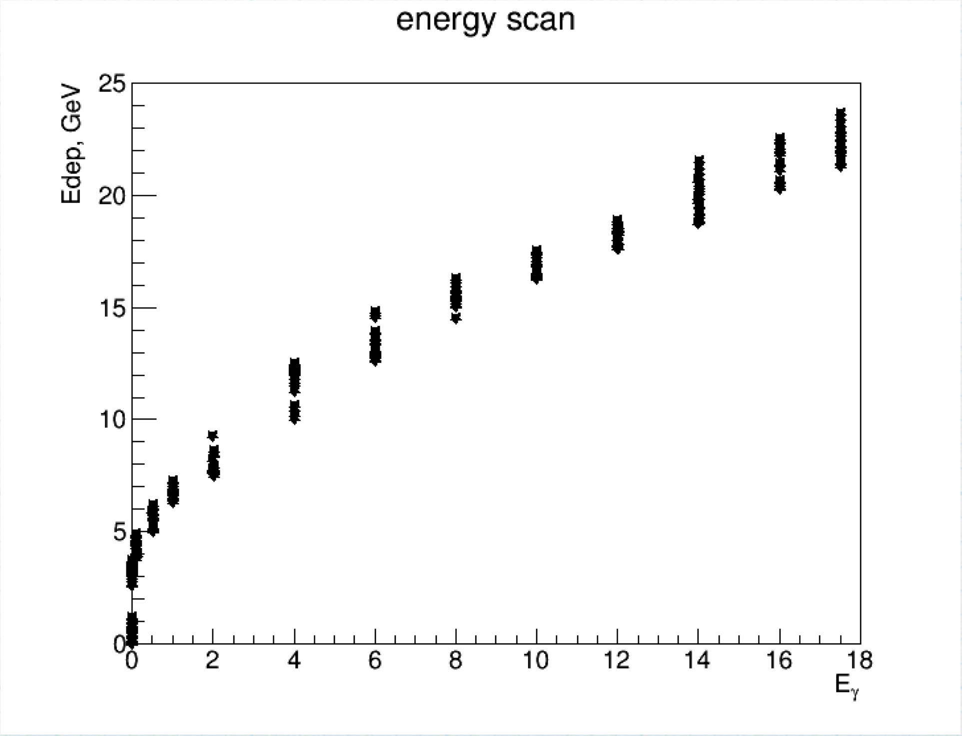


Simulation and Performance

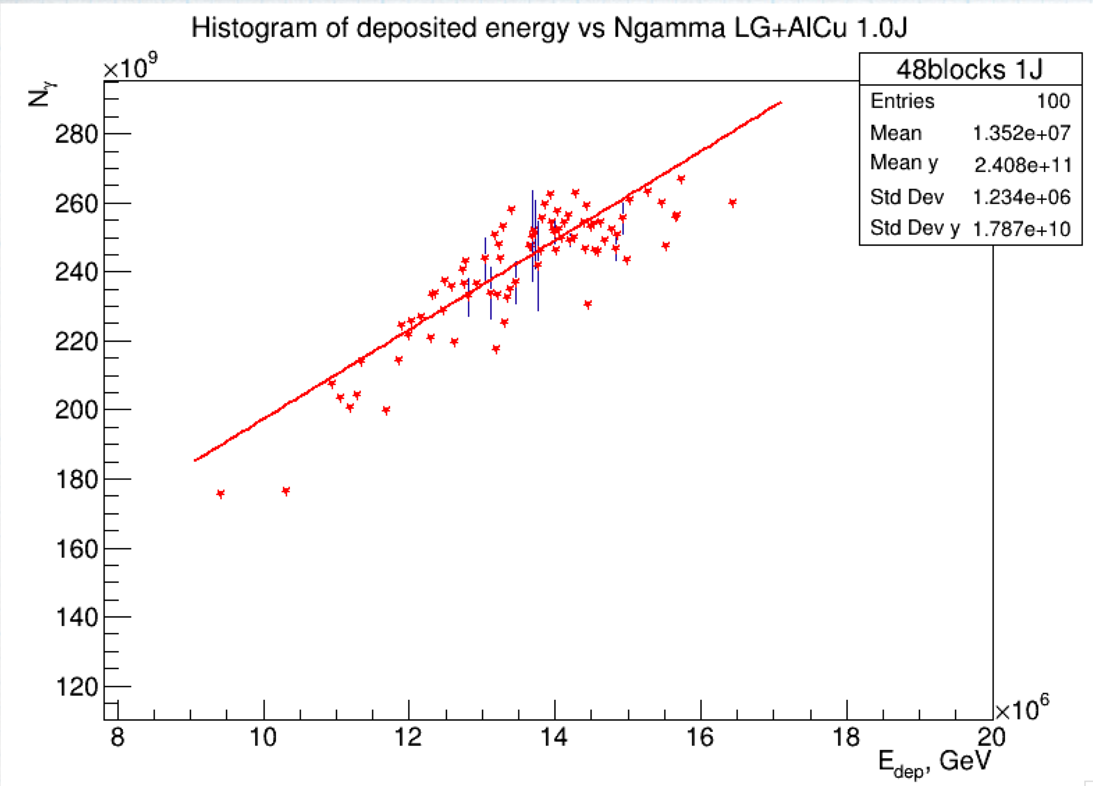
Deposited energy versus true number of photons. Each point is one BX



- 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

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

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

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

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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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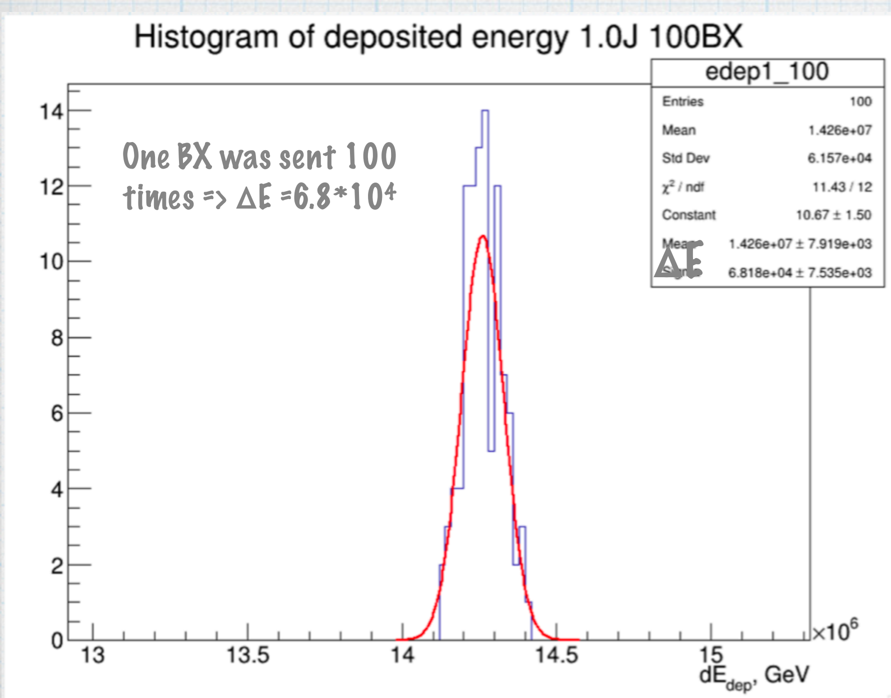
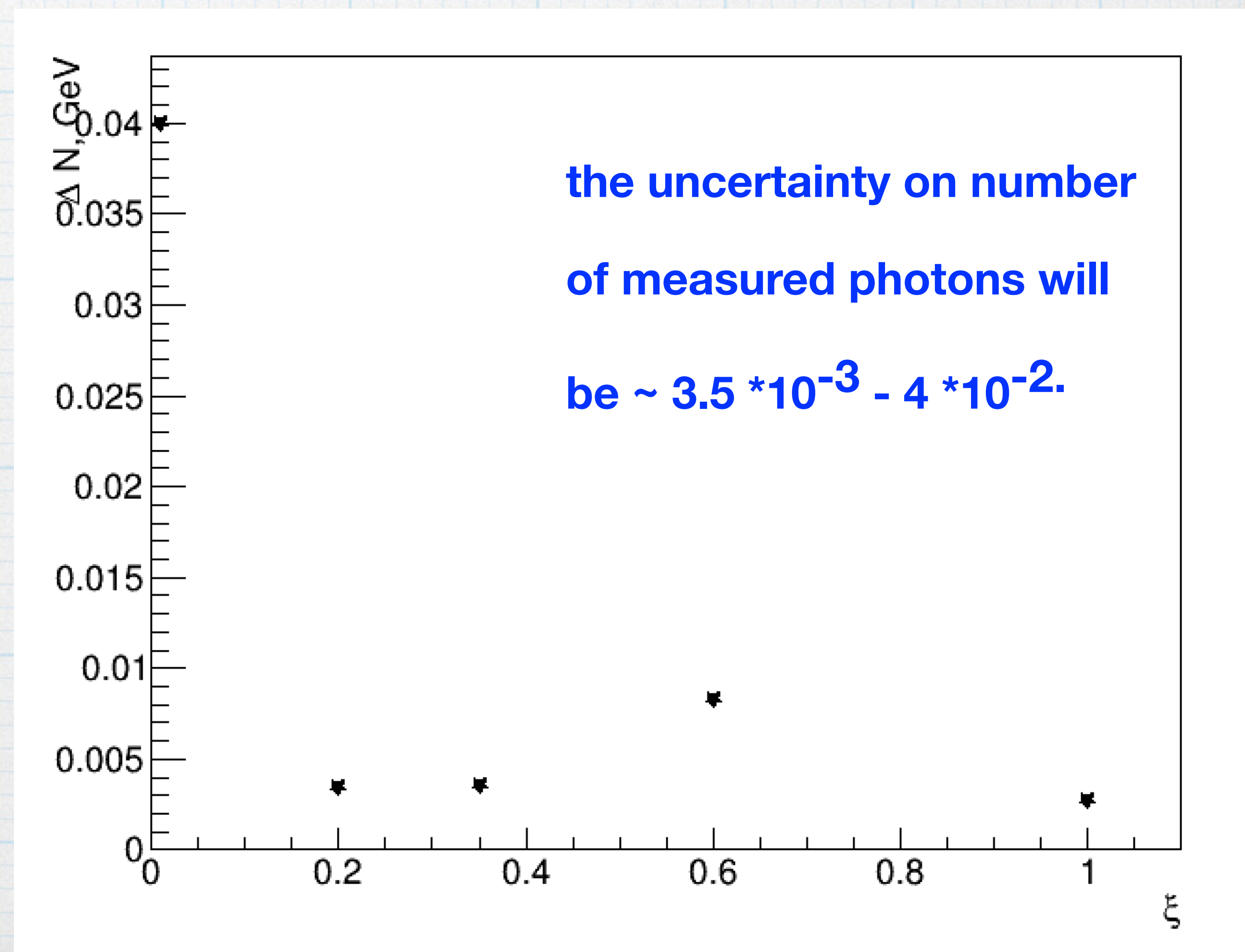
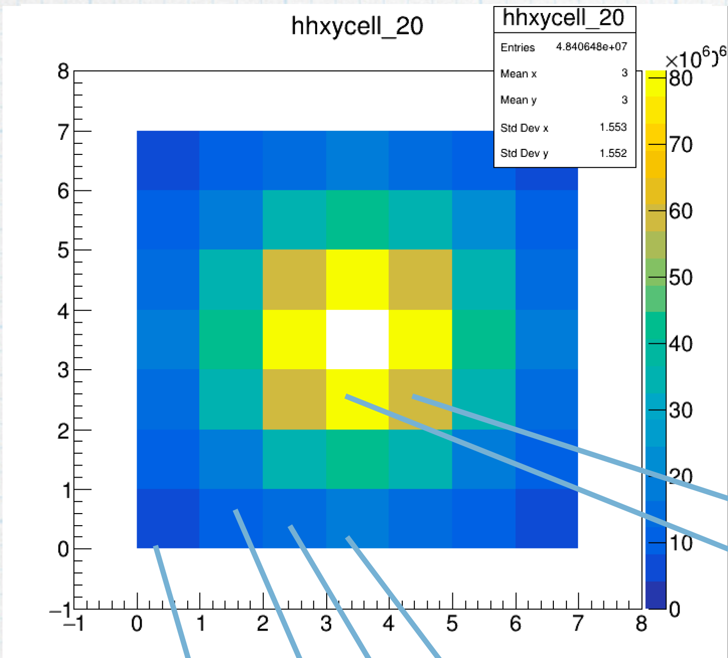


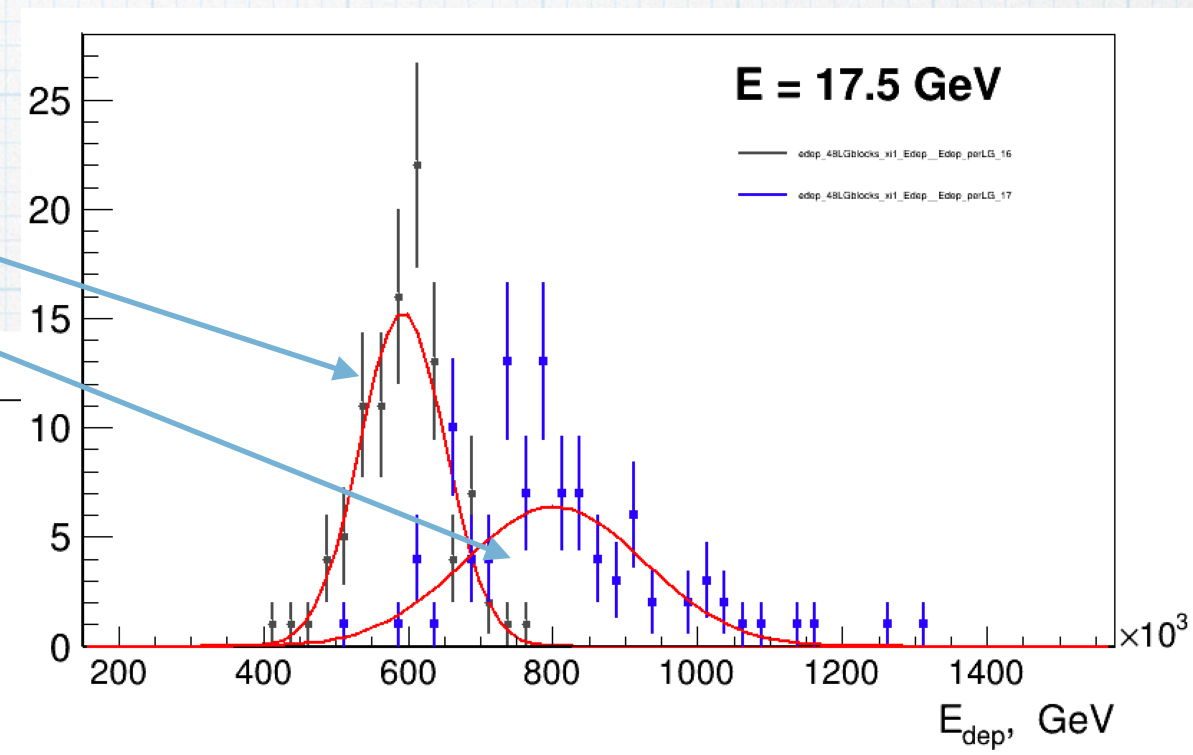


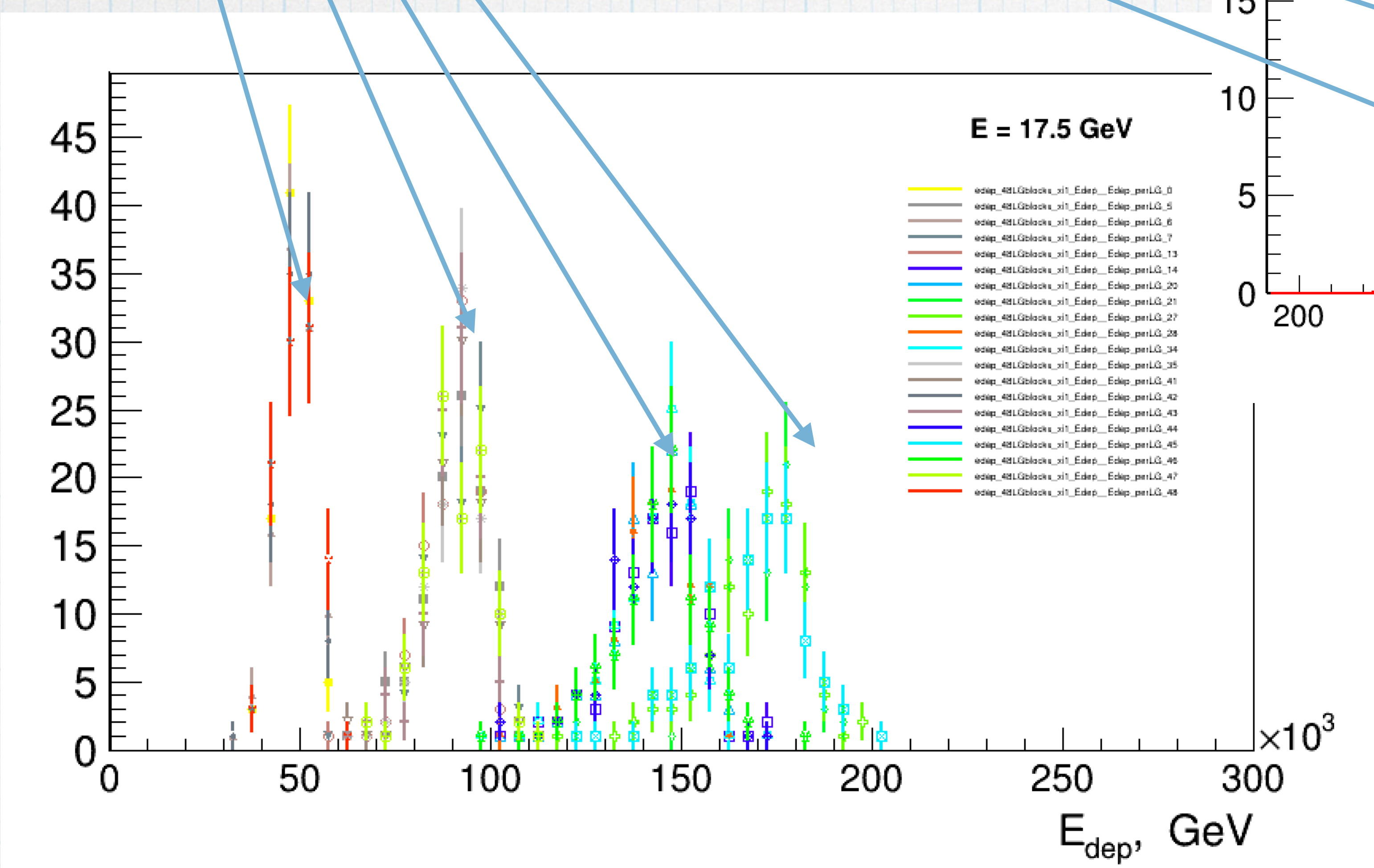
tolerable accumulated doses in the individual blocks



✷ **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

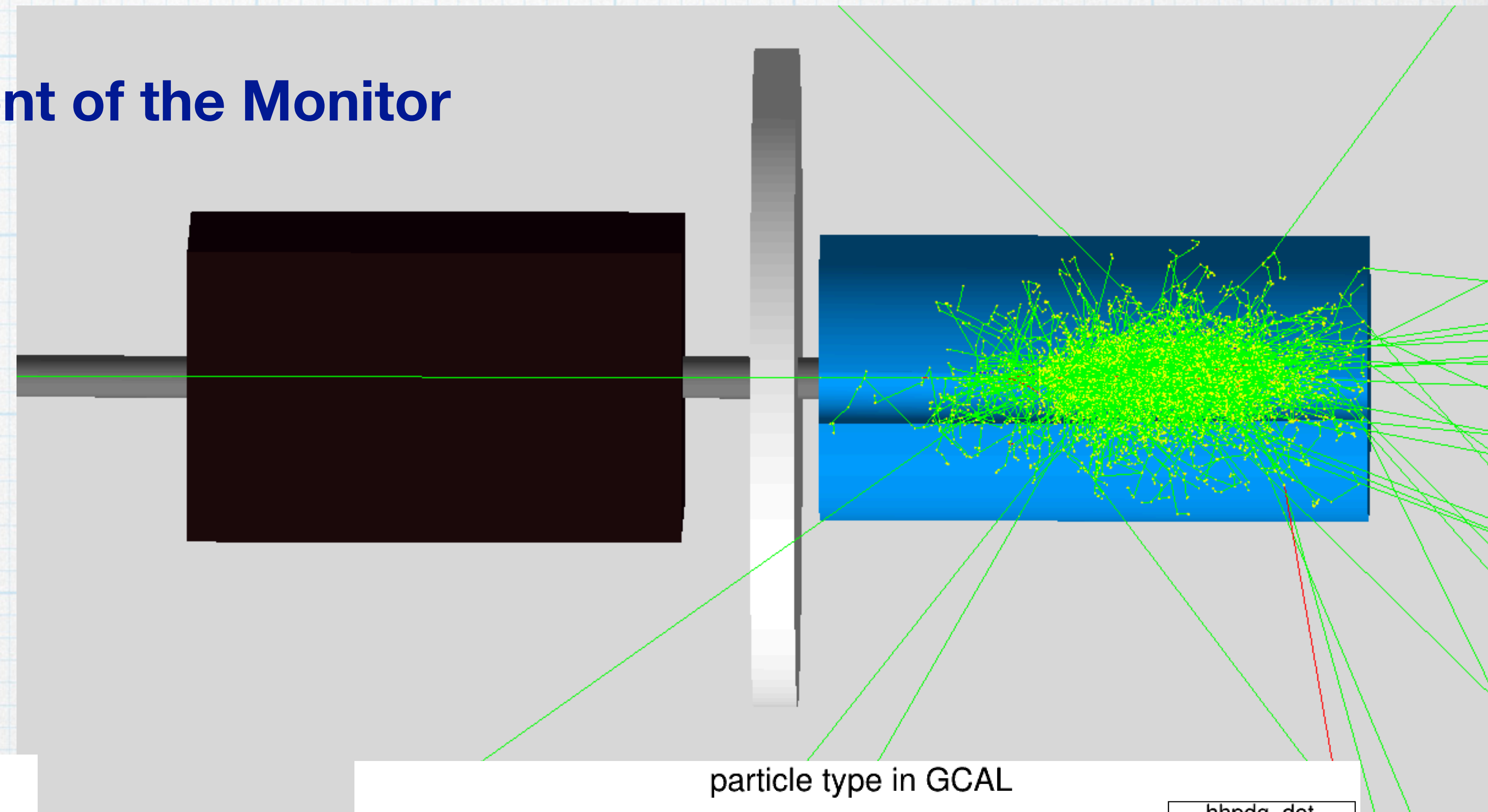


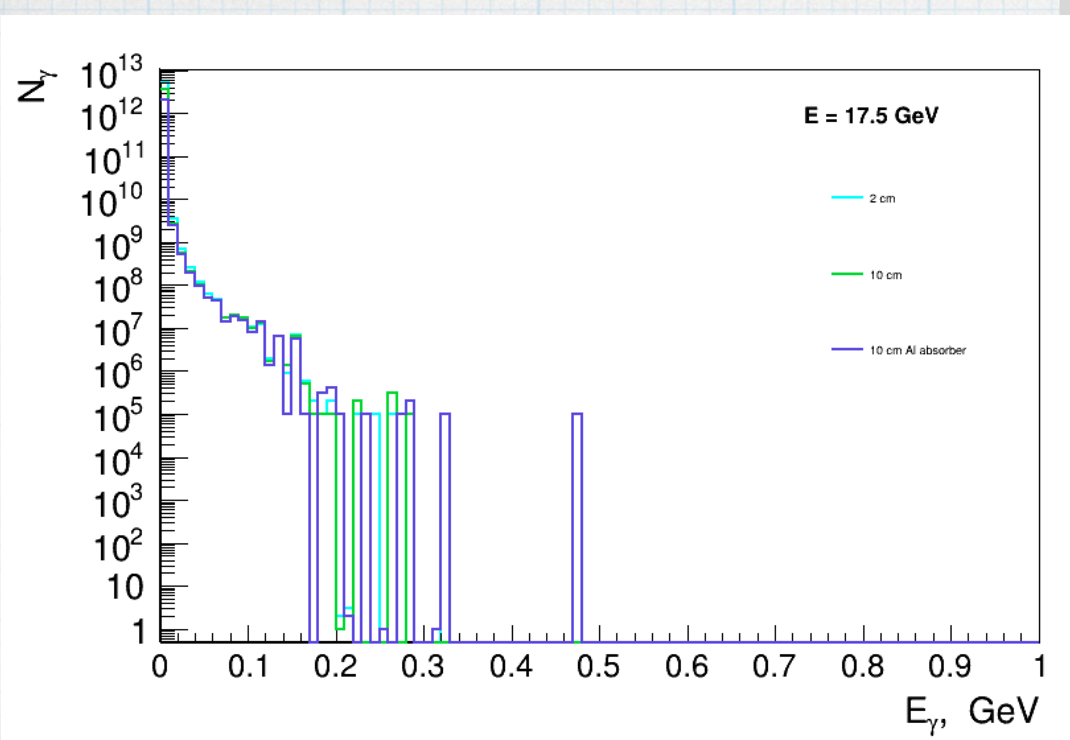


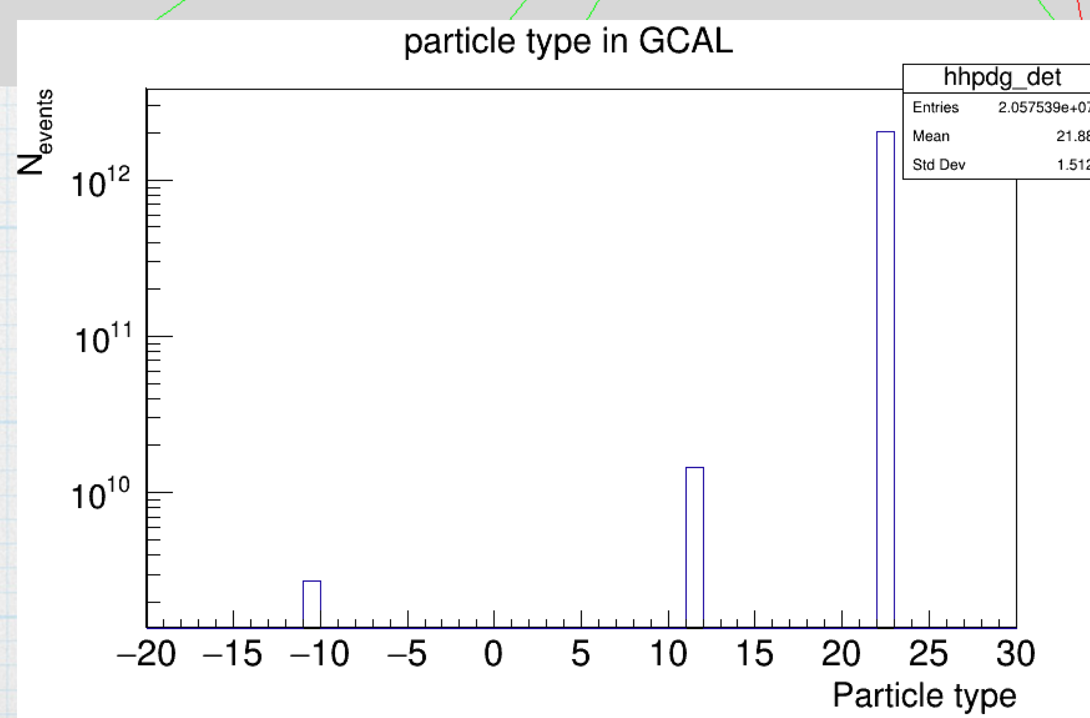
At 10 Hz rate the energy deposition accumulates the dose of 5 Gy in the whole TF1 block which ranges from 3 hours up to 45 hours

Adding absorber

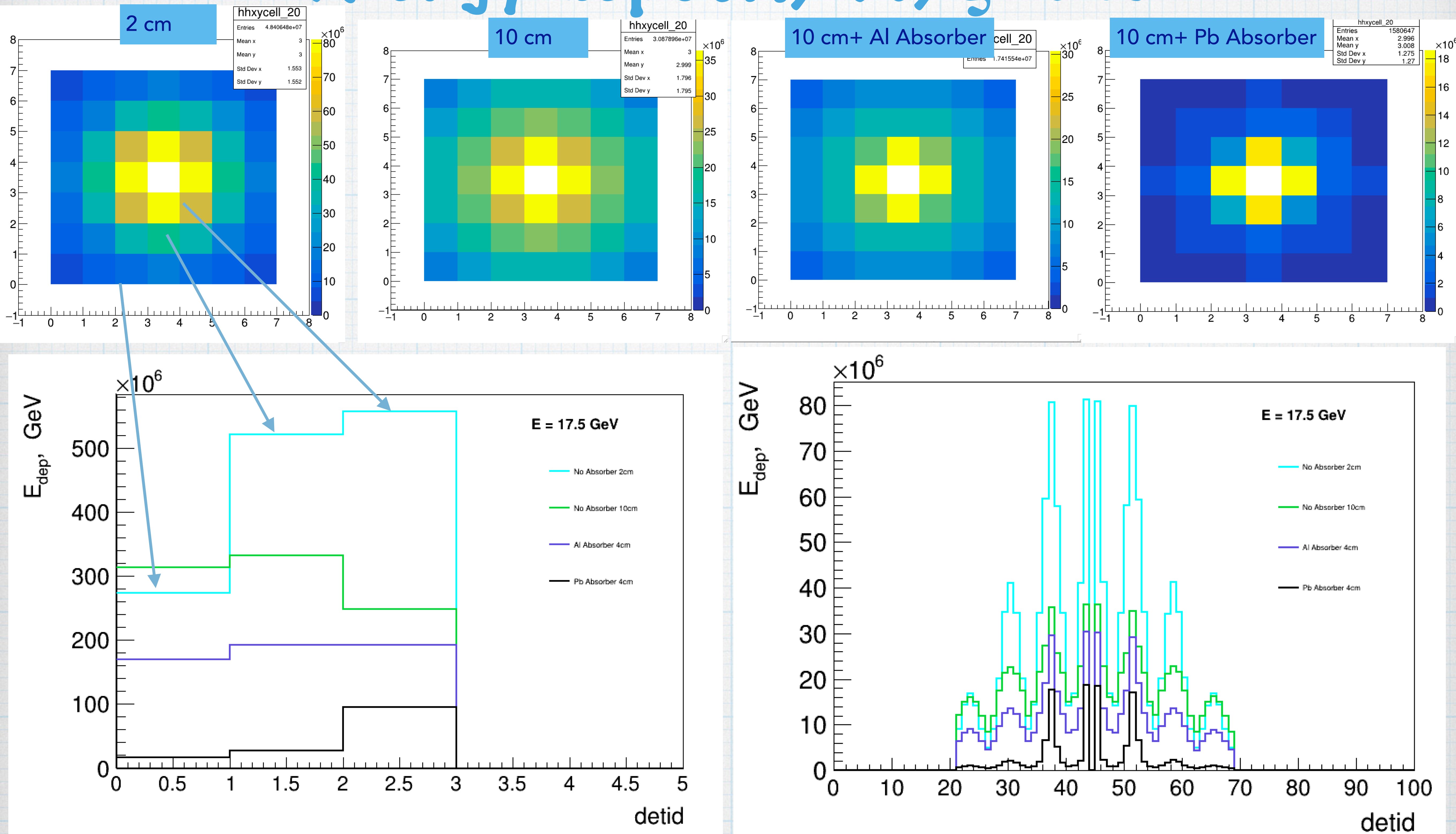
- 2Months ~1460 hours
- To try:
  - ✓ absorber (Al or Pb, 4 cm) in front of the Monitor







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**