



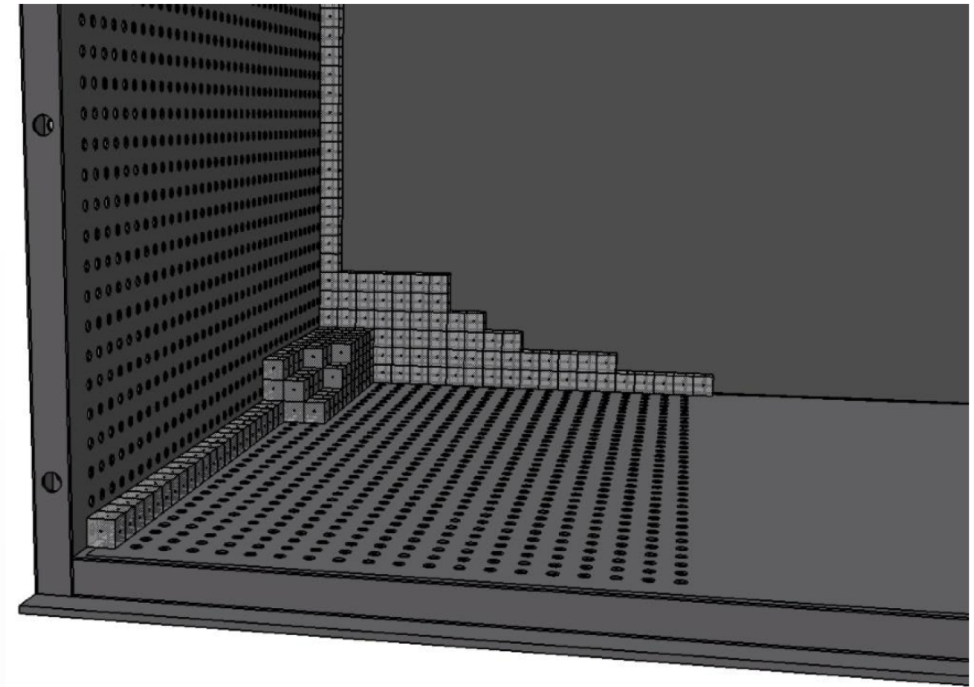
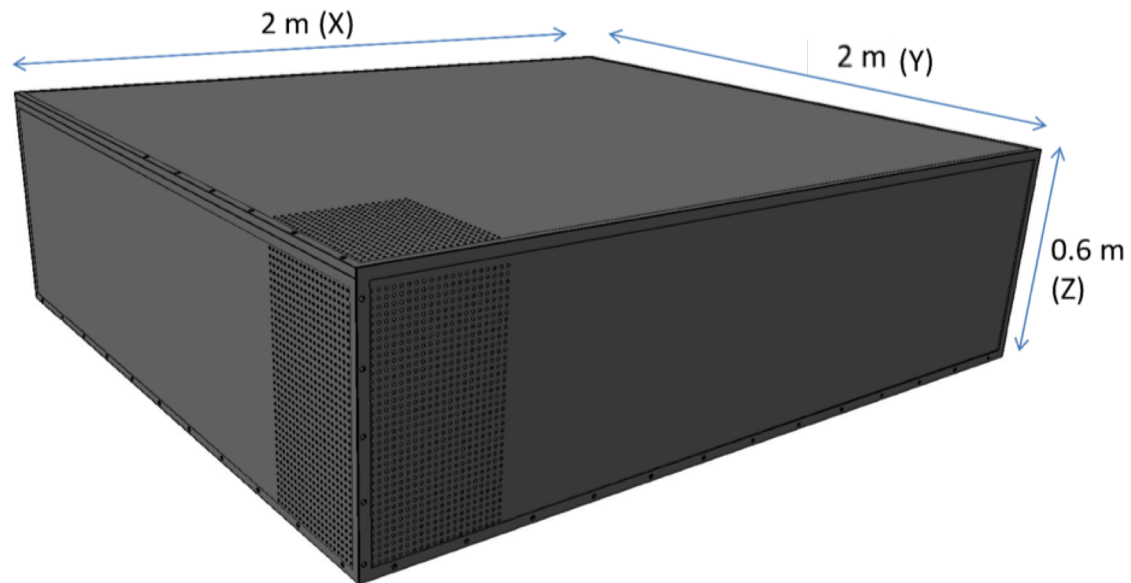
Development of a novel 3D SuperFGD neutrino detector

Aleksandr Mefodev for SFGD

INR RAS

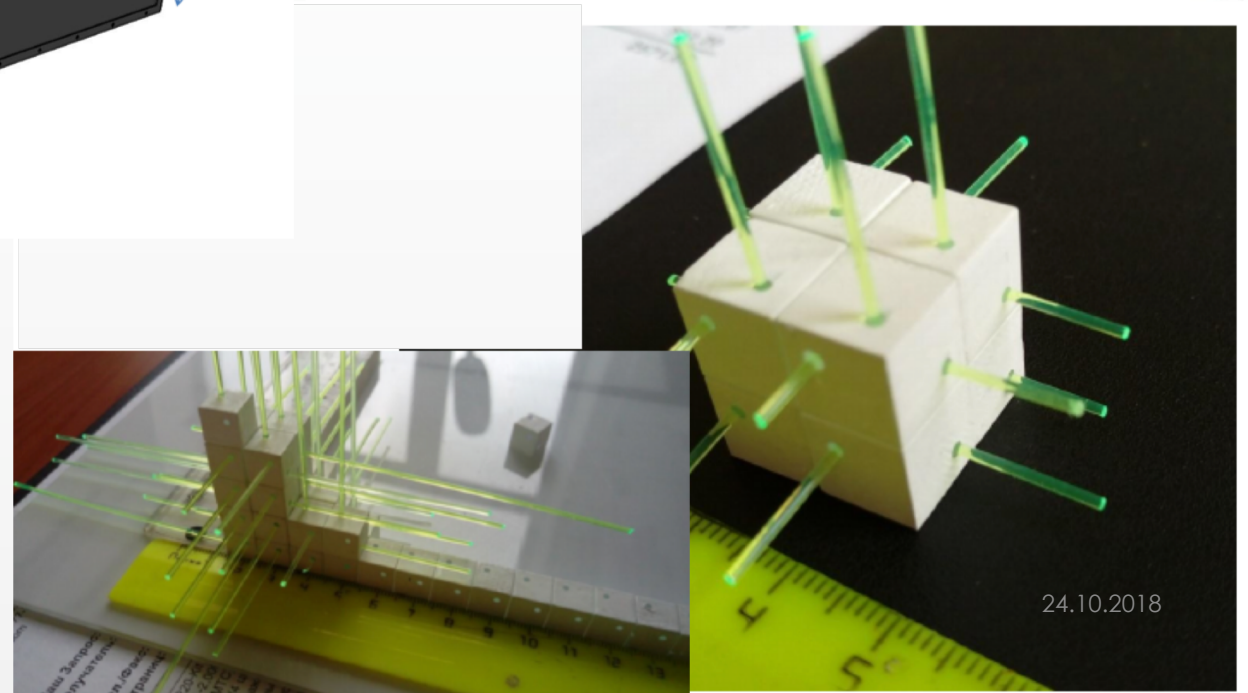
IV International Conference on Particle Physics and Astrophysics, Moscow
22-26 October 2018

Super FGD design



Super FGD

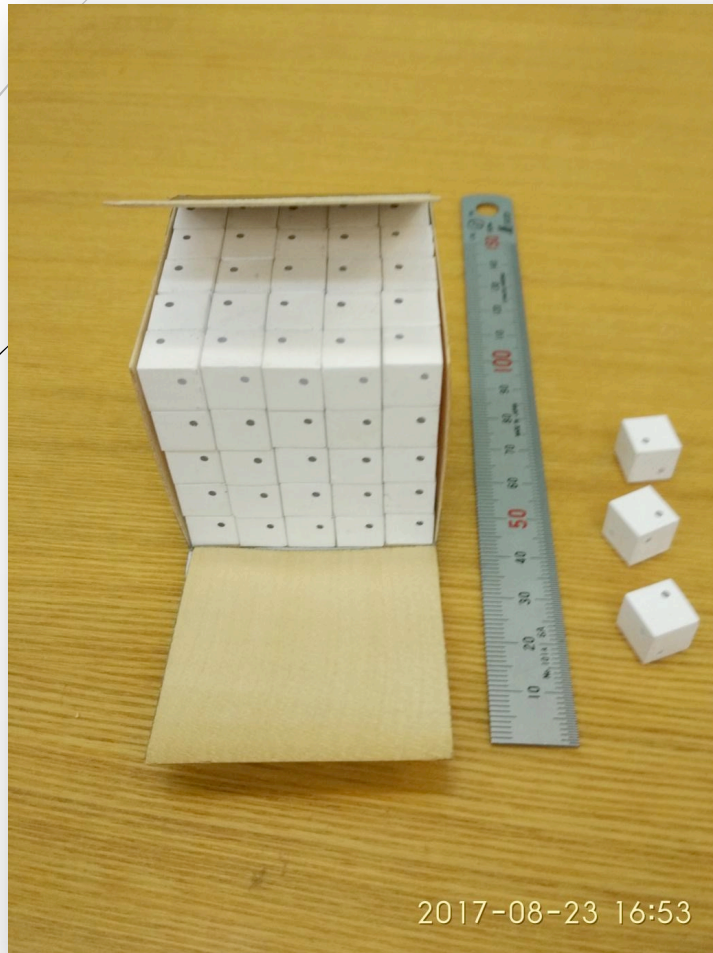
- 2000 x 2000 x 600 mm³
- $\sim 2 \times 10^6$ cubes (1 x 1 x 1 cm³)
- $\sim 6 \times 10^4$ channels



Motivation

- Capability for full investigation of neutrino interaction models
 - Full 4π coverage
 - Common shortcomings of the current experiments
- T2K-II, ND Upgrade: innovative R&D and detectors for precision flux and cross-section measurements
- Systematics Error 5.8 \Rightarrow 4% (<3% HyperK/Dune)
 - Near Detectors measurements is a key!

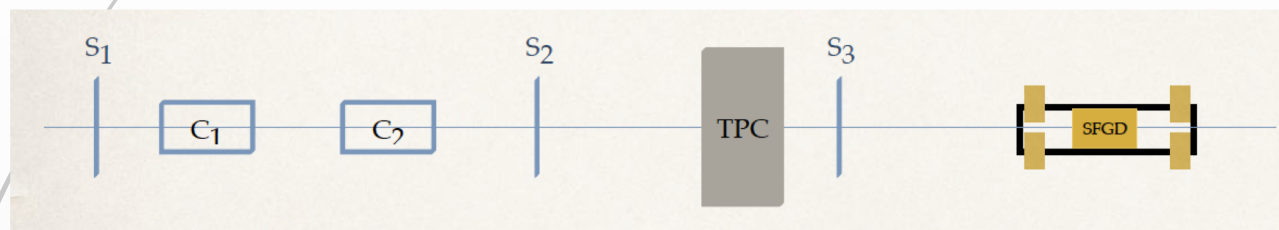
Cubes



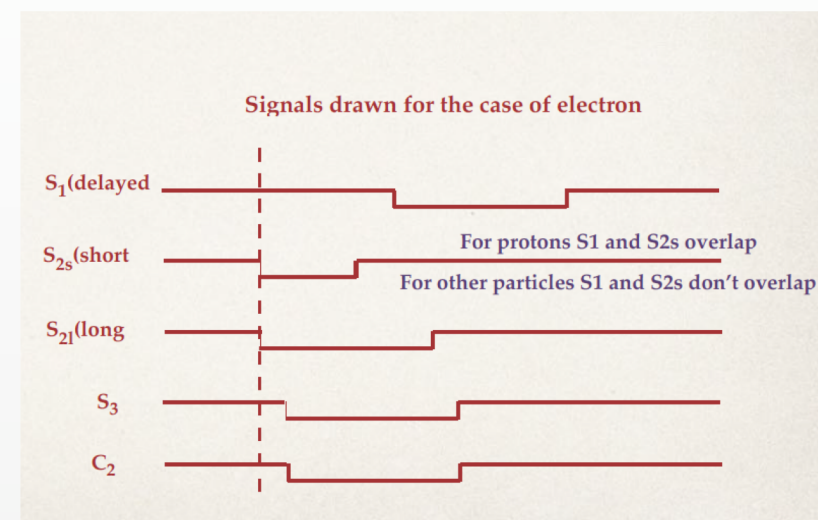
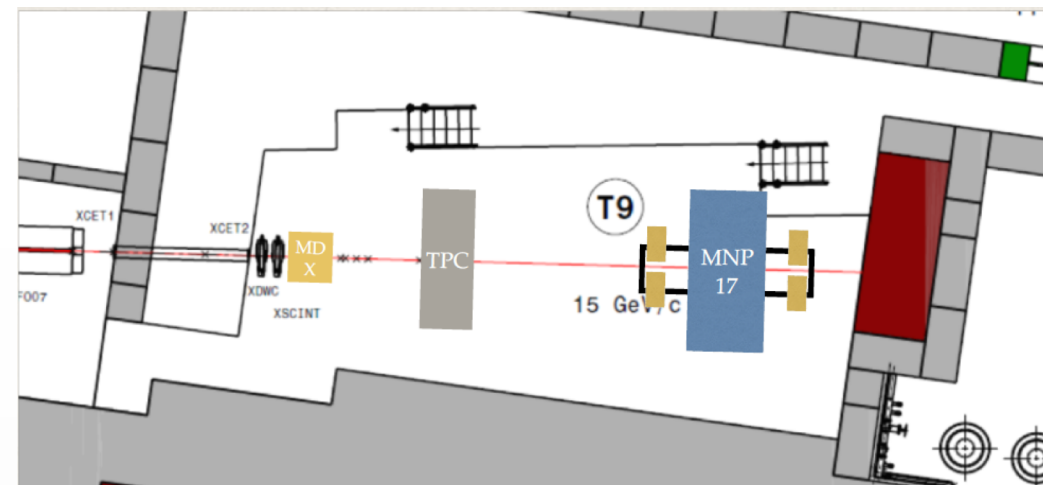
- Manufactured in Vladimir (Uniplast Co.)
- Cube size: $10 \times 10 \times 10 \text{ mm}^3$
- Material: polystyrene doped with 1.5% of paraterphenyl (PTP) and 0.01% of POPOP
- White chemical reflector: thickness is about $50 \text{ }\mu\text{m}$
- Holes for WLS fibers: three of 1.5 mm diameter

Setup at T9 Aug/Sep beam test
 Super FGD prototype took beam
 parasitically with TPC group from
 August 24th to September 5th 2018.

Trigger system



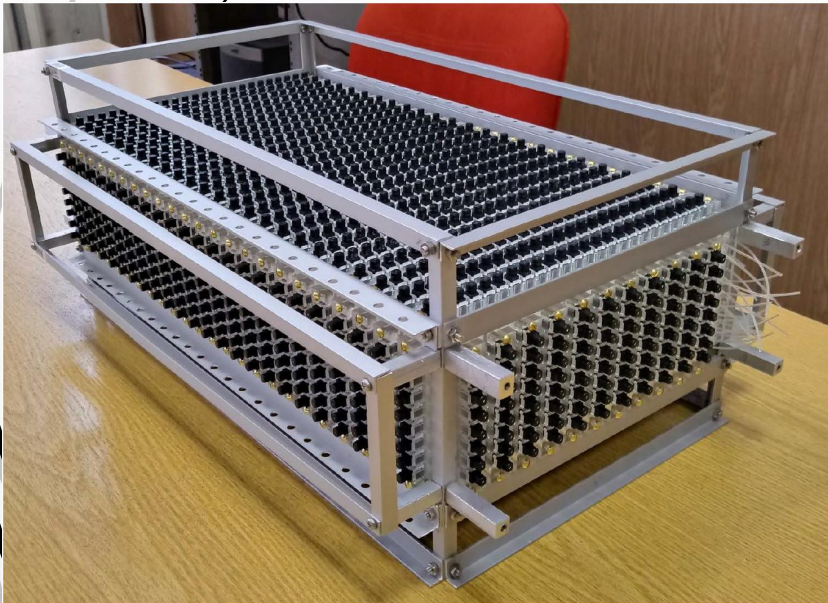
$$\begin{aligned}
 \text{All} &: S_{2l} \times S_3 \times S_1 \\
 e &: S_{2l} \times S_3 \times C_2 \\
 p &: S_{2s} \times S_3 \times S_1 \\
 \pi/\mu &: \text{all} \times \bar{p} \times \bar{e}
 \end{aligned}$$



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August – September beam test at CERN:

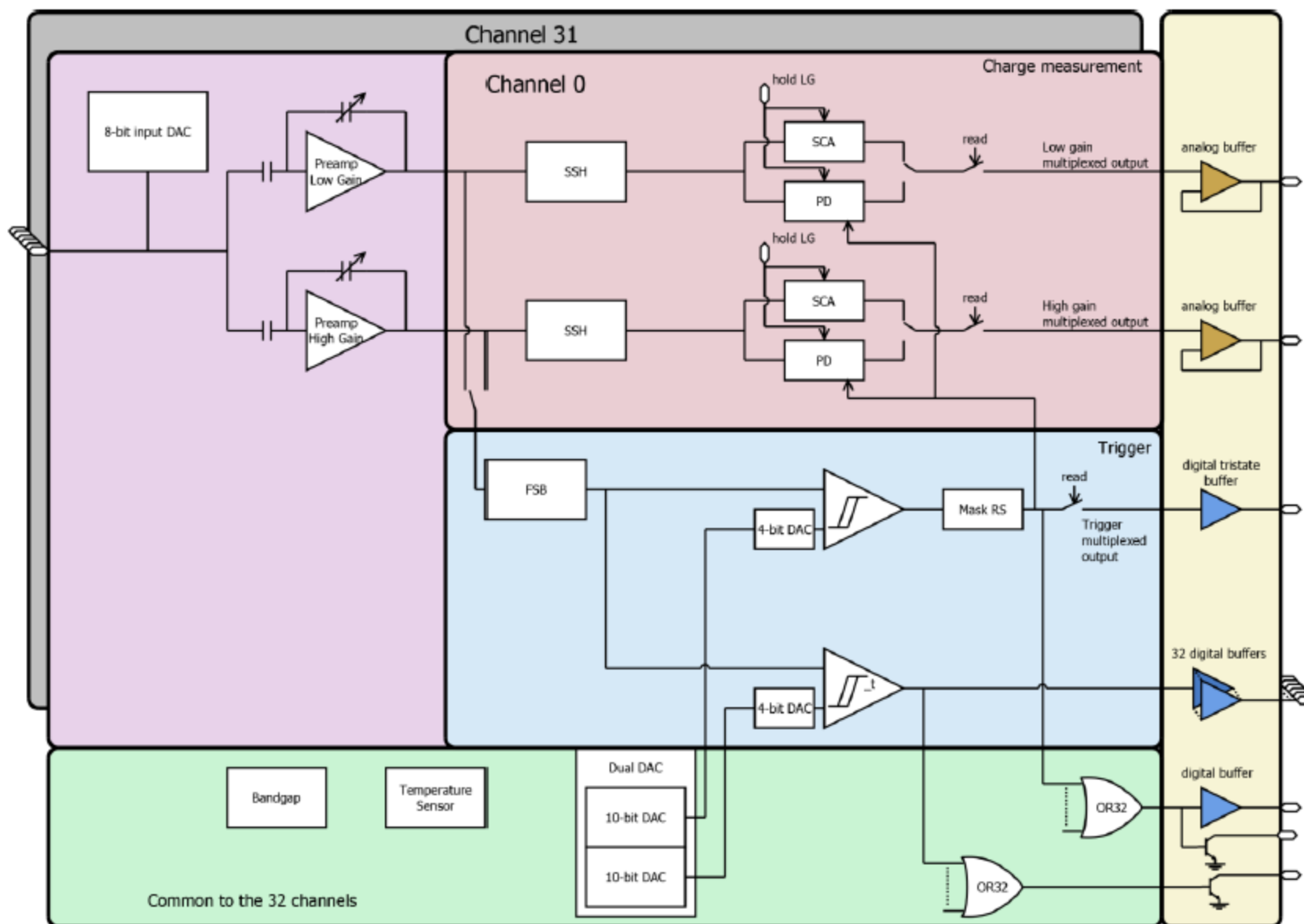
- 9216 cubes – 1728 channels;
- Baby MIND FEBs
- Time of flight;



24.10.2018

CITIROC BLOC DIAGRAM

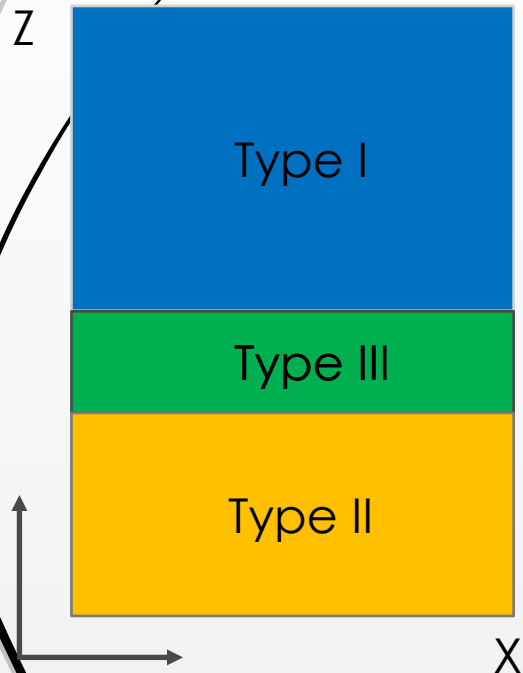
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SiPMs

Three different types of MPPCs:

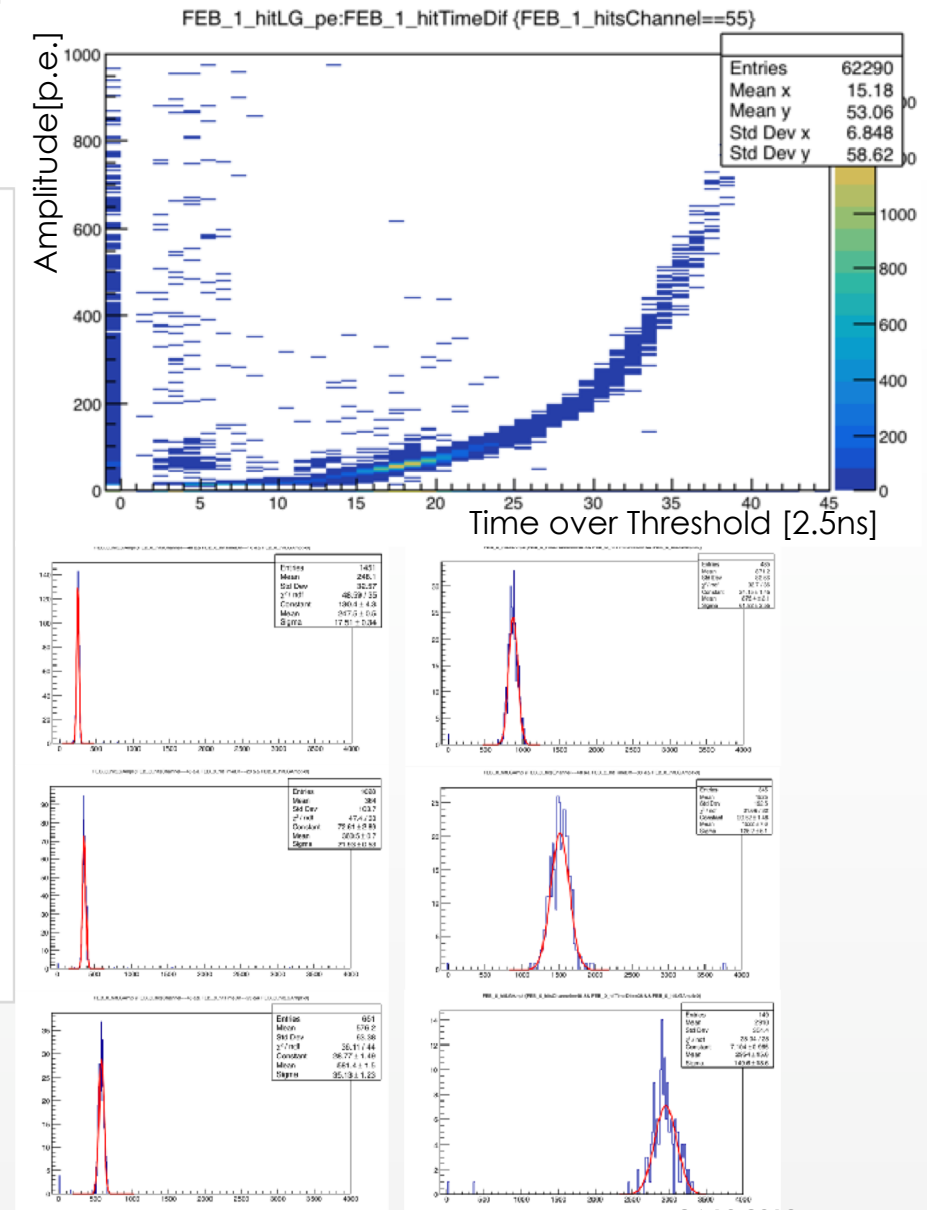
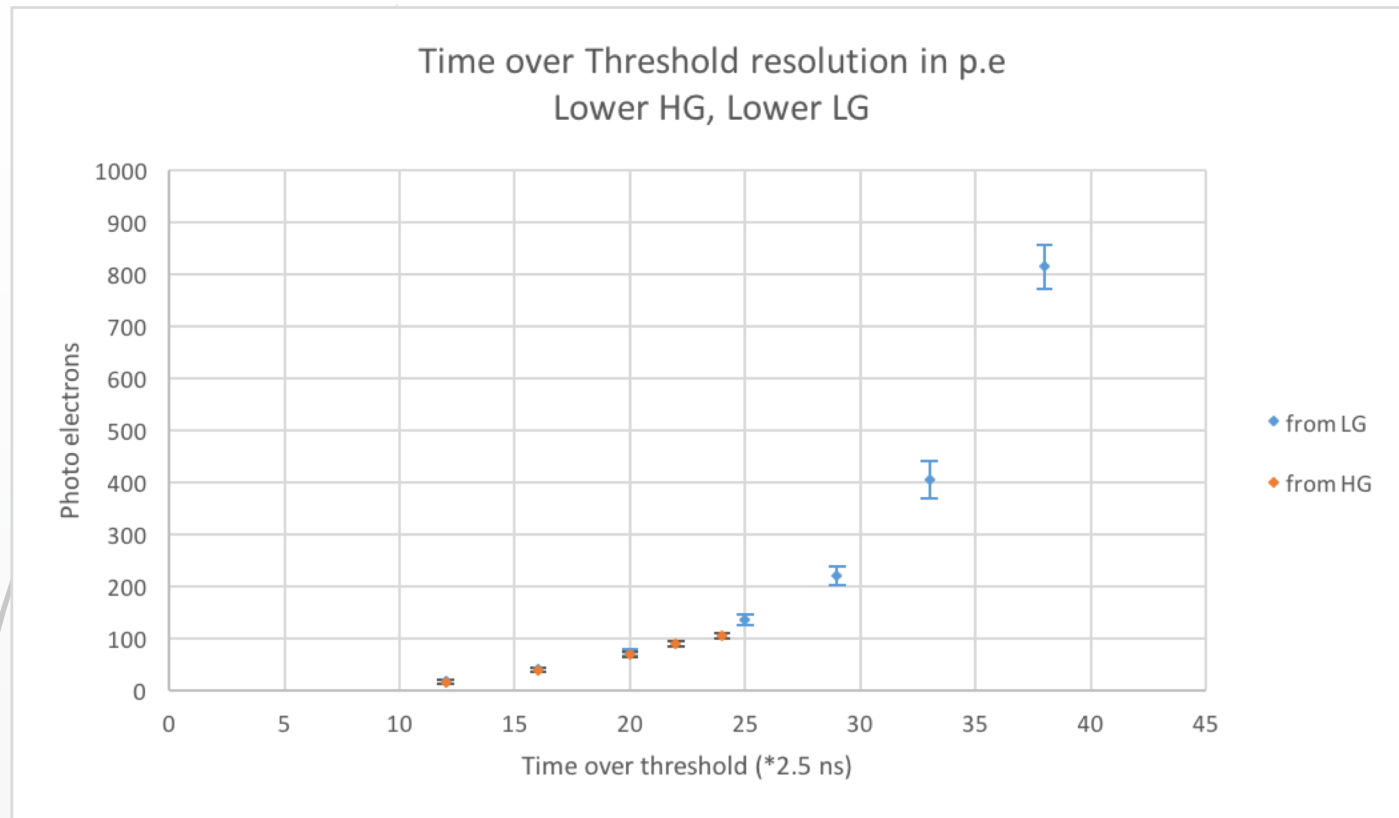
- ▶ Type I – S13360-025CS (1.3 x 1.3 mm², 2668 px, gain $7 \cdot 10^5$, PDE 25, voltage range 56.3- 57 V);
- ▶ Type II – S13081-050CS (1.3 x 1.3 mm², 667 px, gain $1.1 \cdot 10^6$, PDE 35 , voltage range 53.2- 54.8 V);
- ▶ Type III – S12571-025C (1 x 1 mm², 1600 px, gain $5.15 \cdot 10^5$, PDE 35 , voltage range 67- 68 V).



The MPPCs was sorted in groups (x32) according to V_{op} in 100 mV ranges
 V_{op} was individually preset for each group by Baby MIND FEBs.

Dynamic range and resolution

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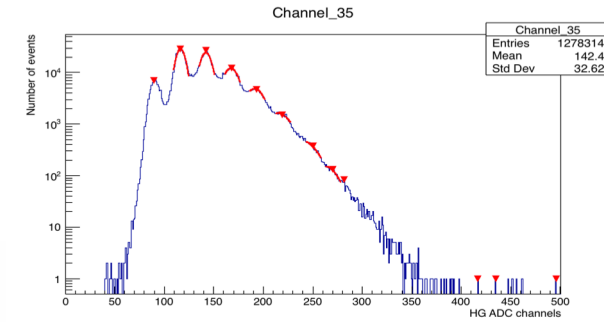
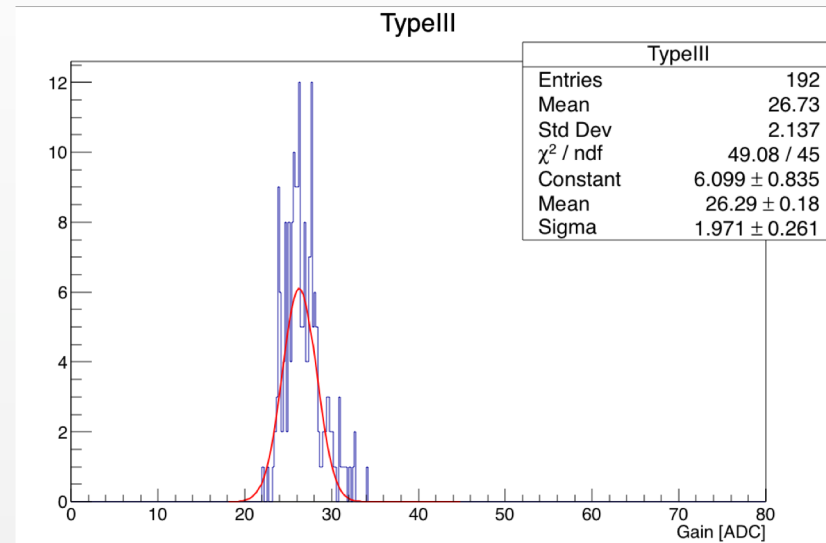
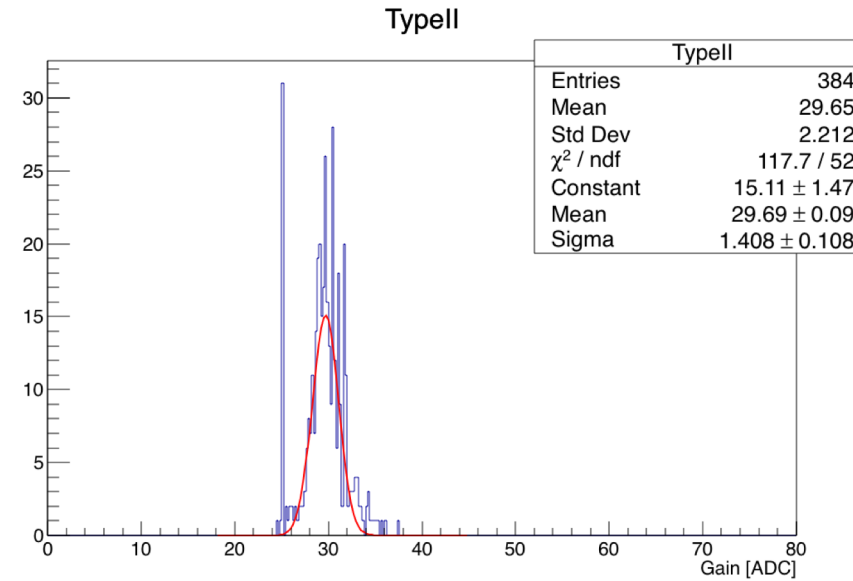
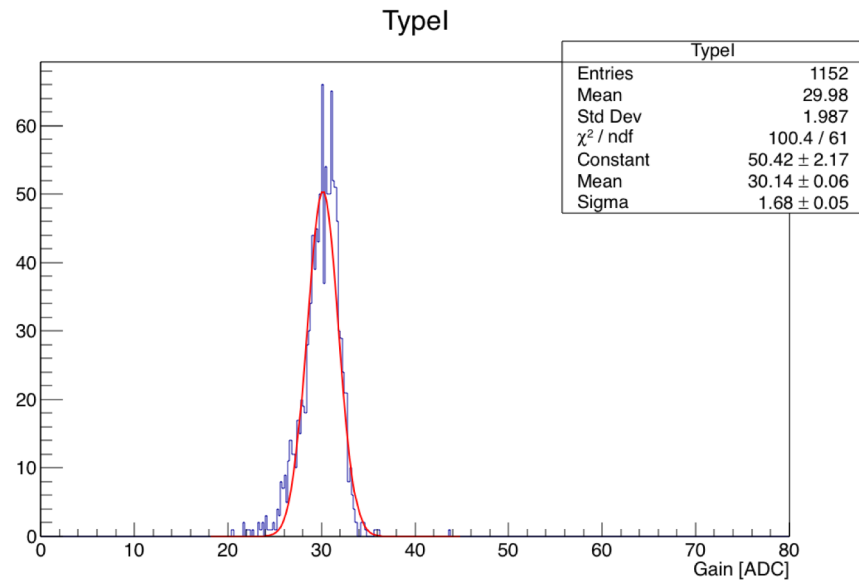


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Calibration

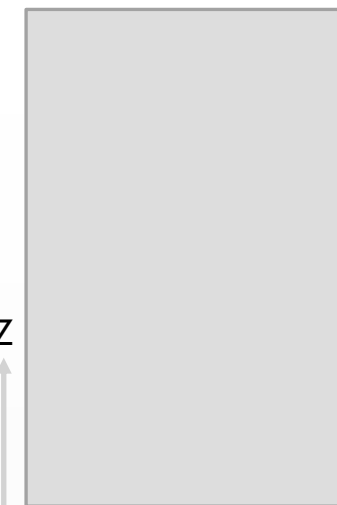
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➤ Calibration was done with LED system



Light Yield for fibers results

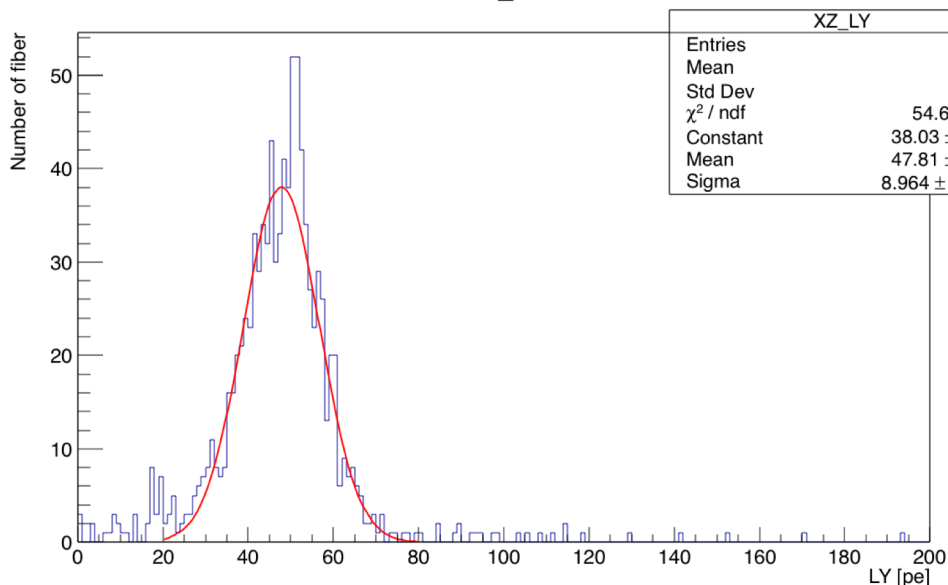
0° rotation



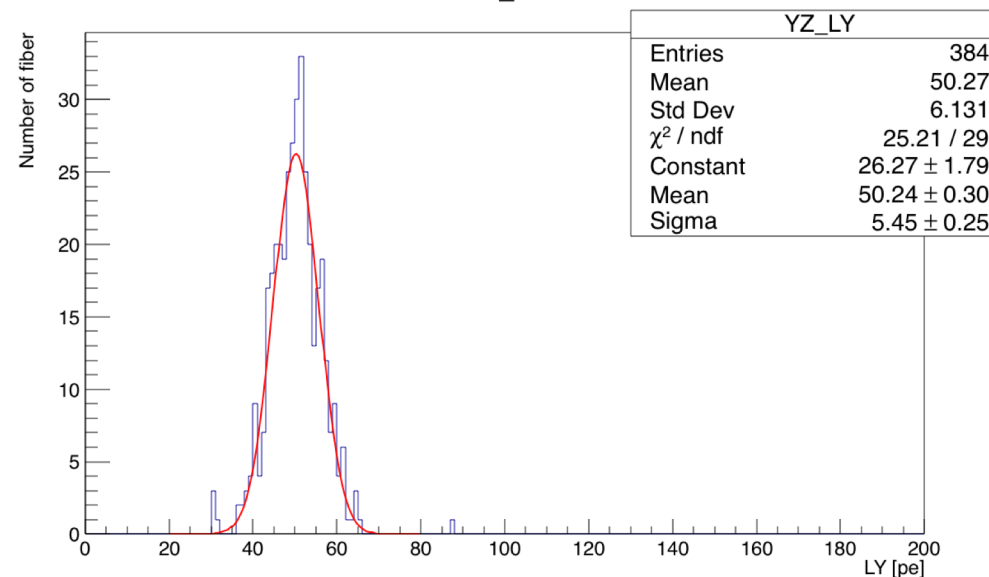
2GeV muons

All events
synchronized with
ToF

XZ_LY



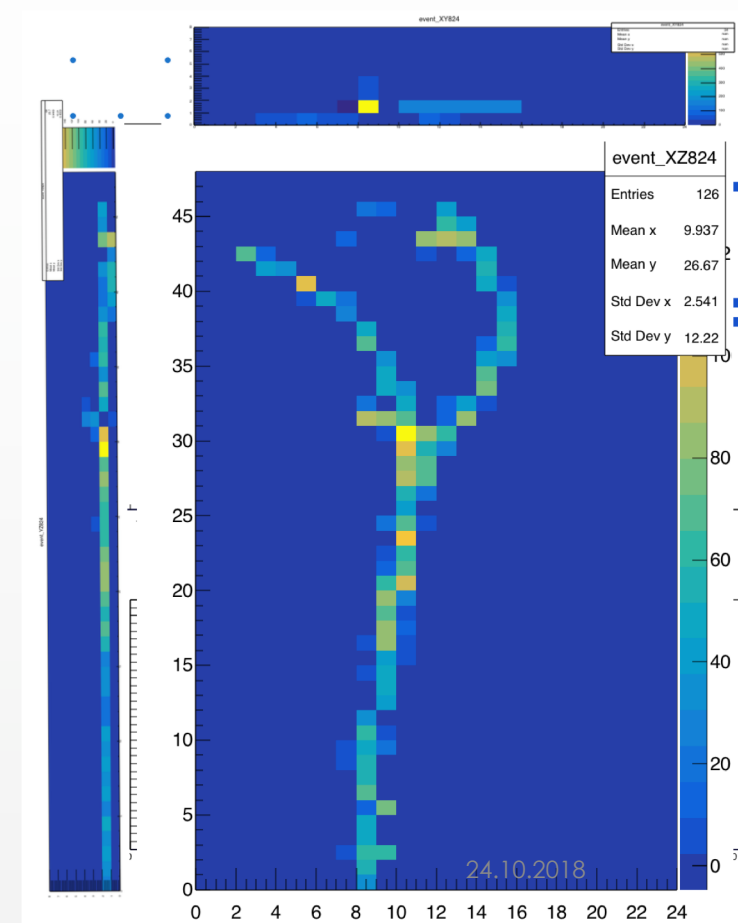
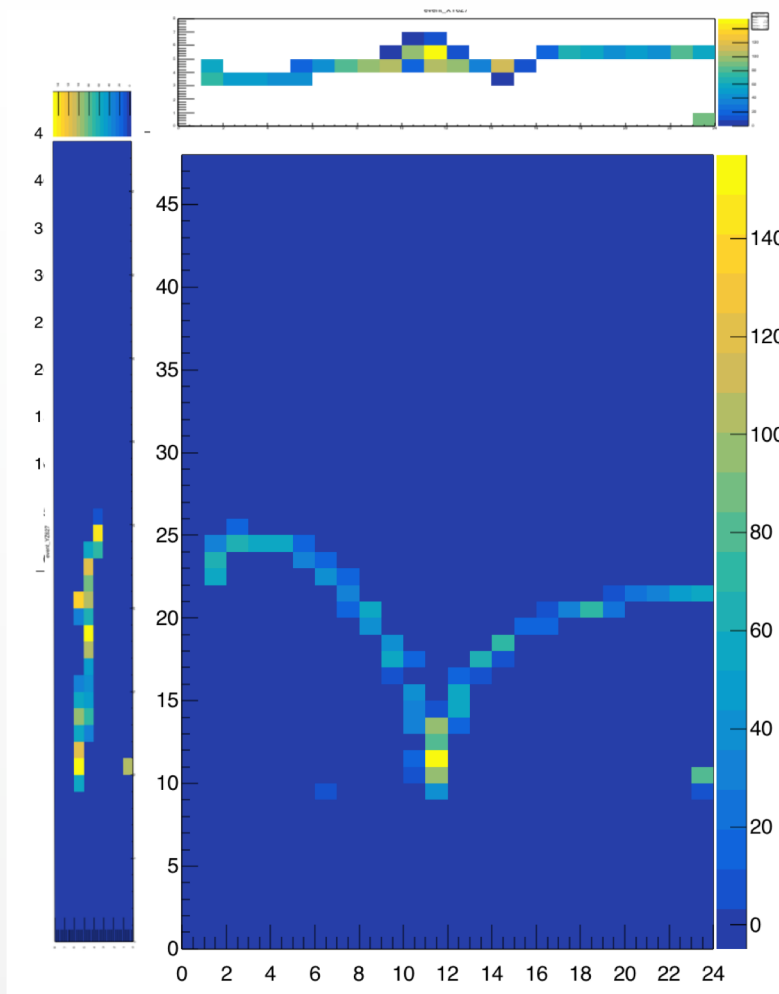
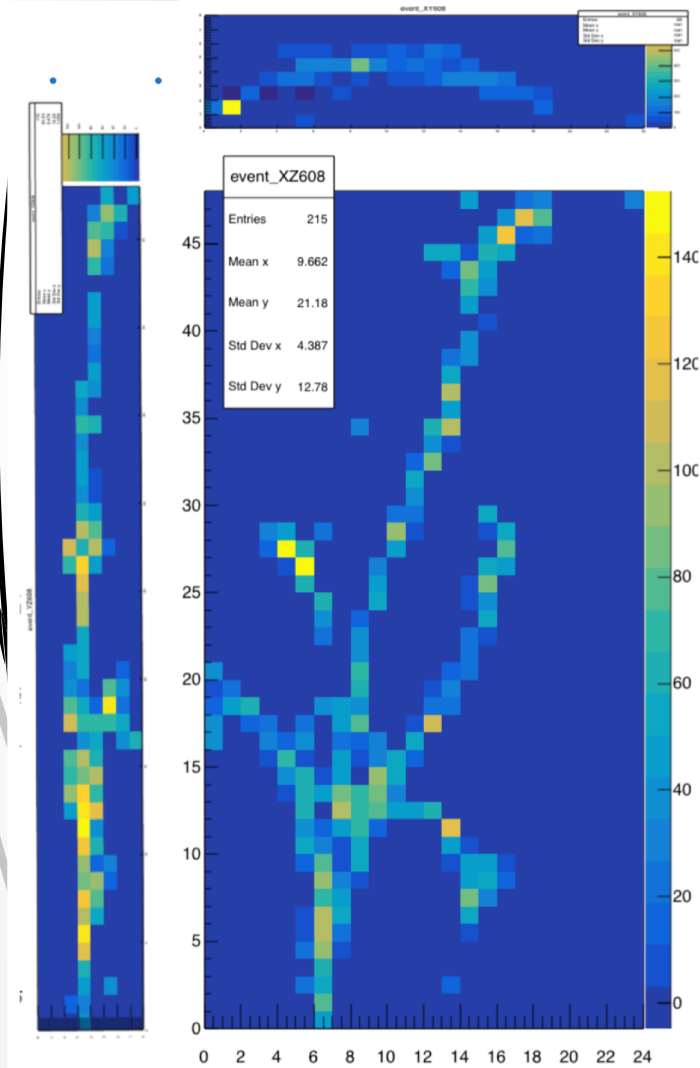
YZ_LY



Each entry is fiber's LY in p.e.

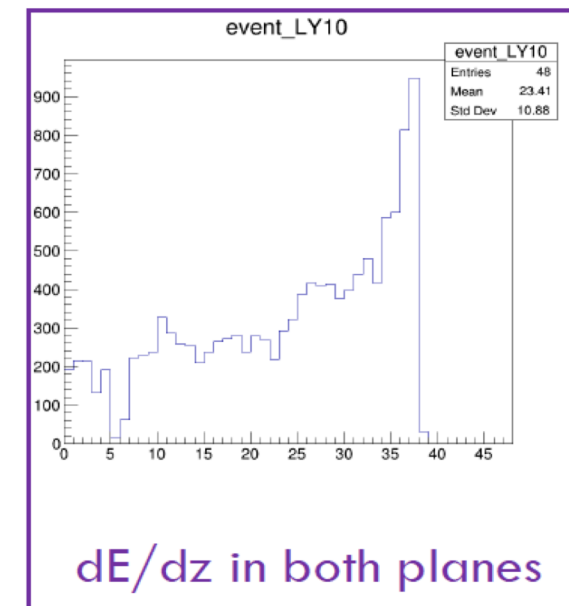
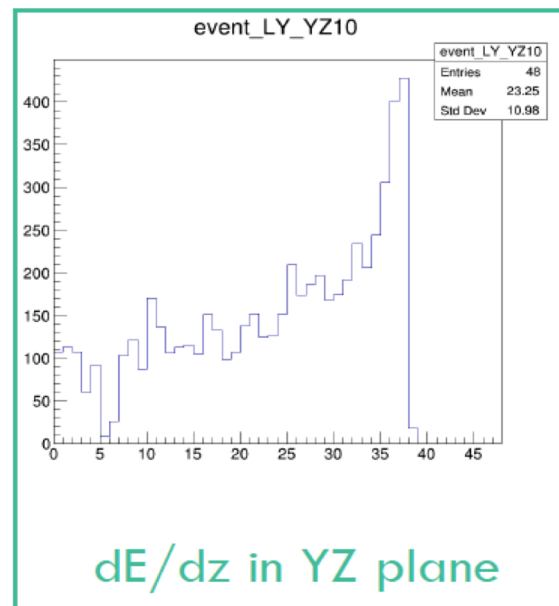
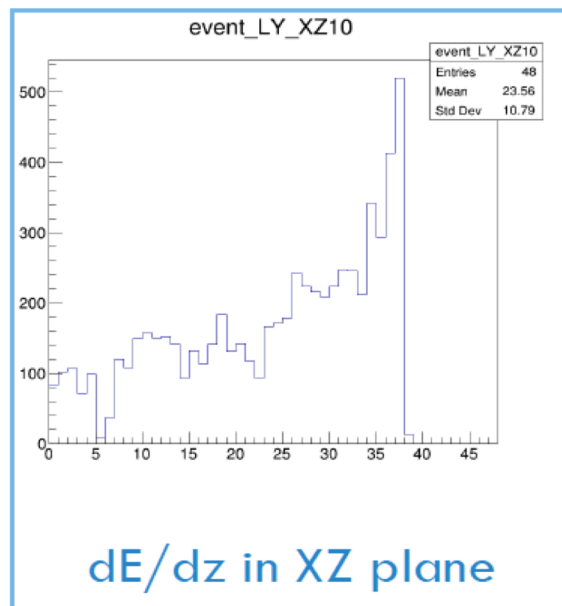
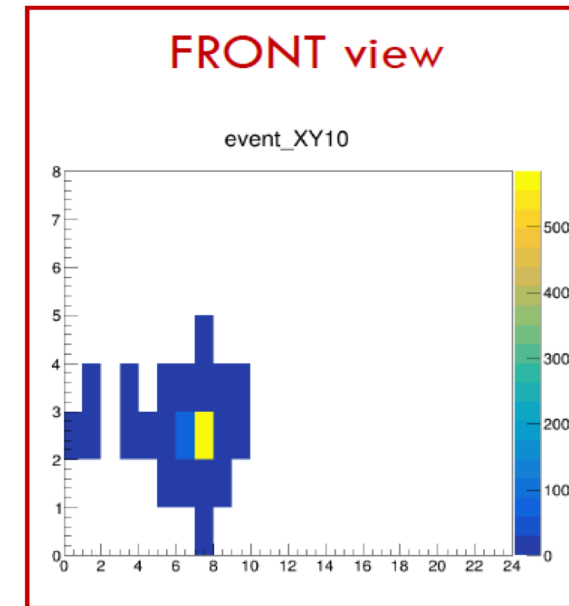
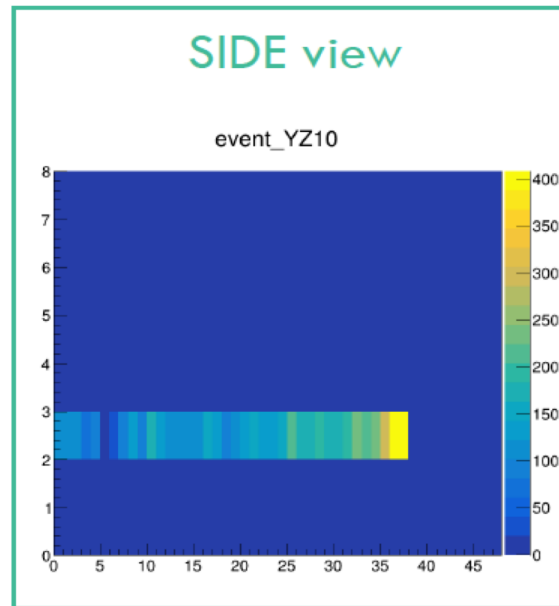
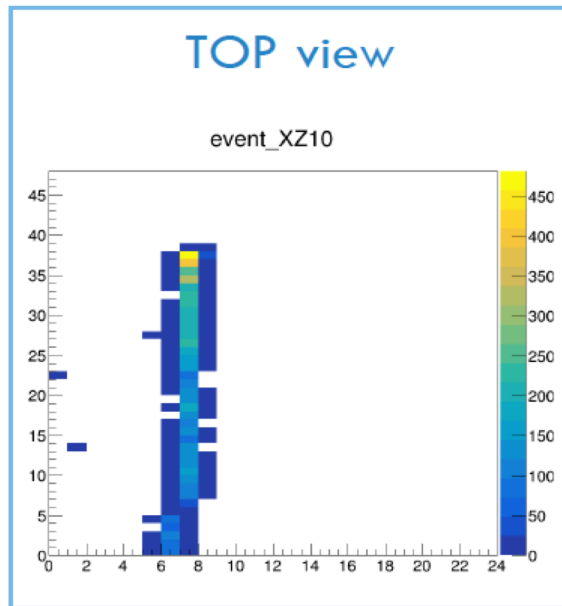
Using LED
calibration
results

What did we done in 4 weeks?

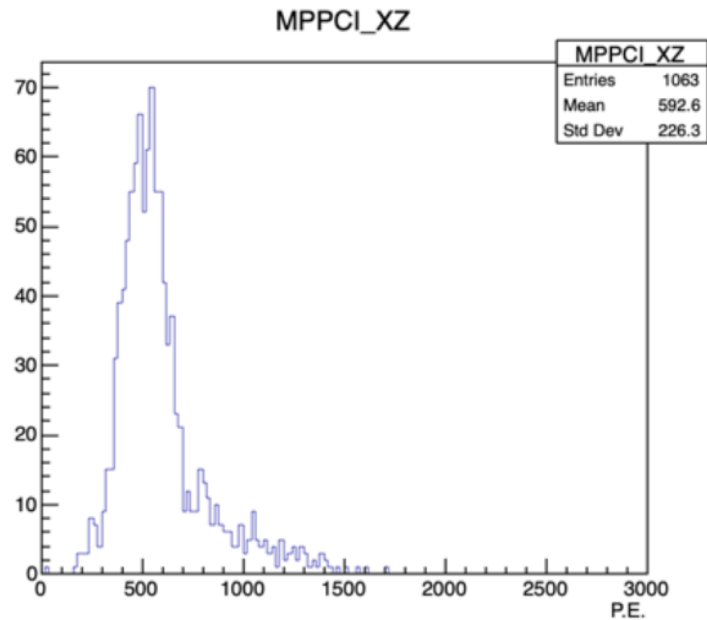


Stopping proton

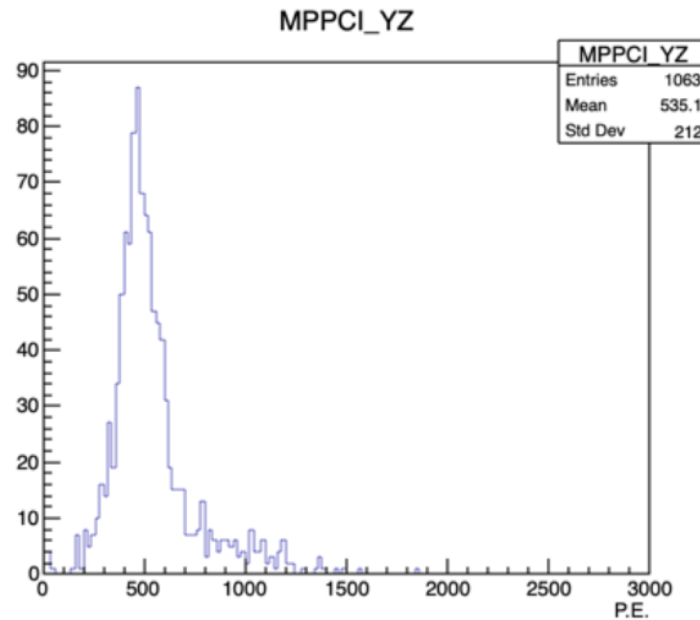
13



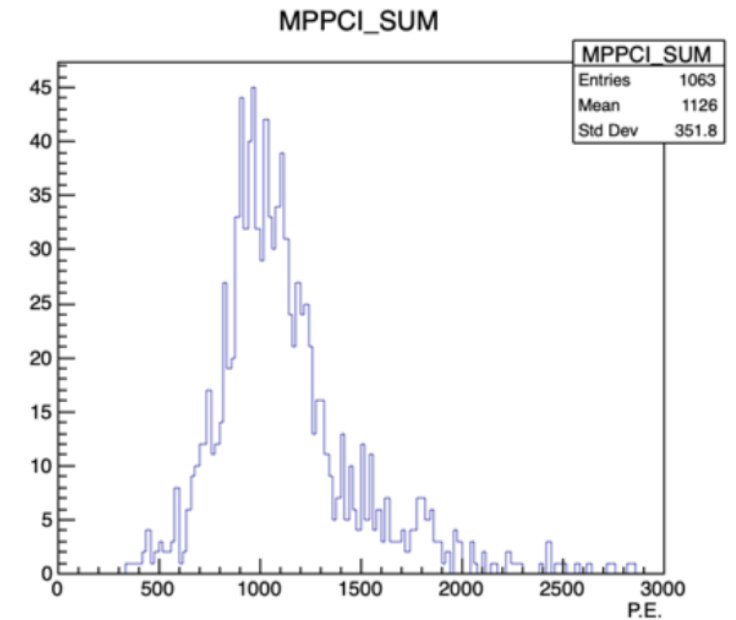
Energy deposit in the last sell



Energy taken by fibers along the
Y axis only (vertical)

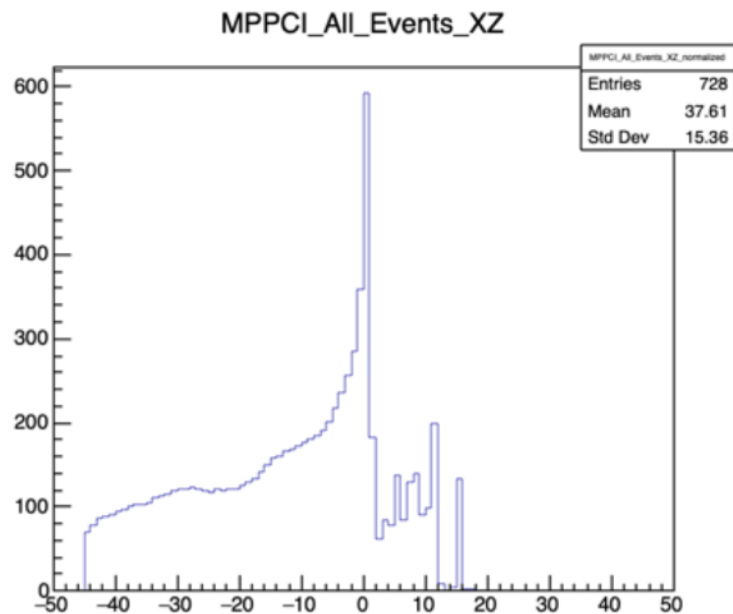


Energy taken by fibers along the
X axis only (horizontal and
perpendicular to the beam)

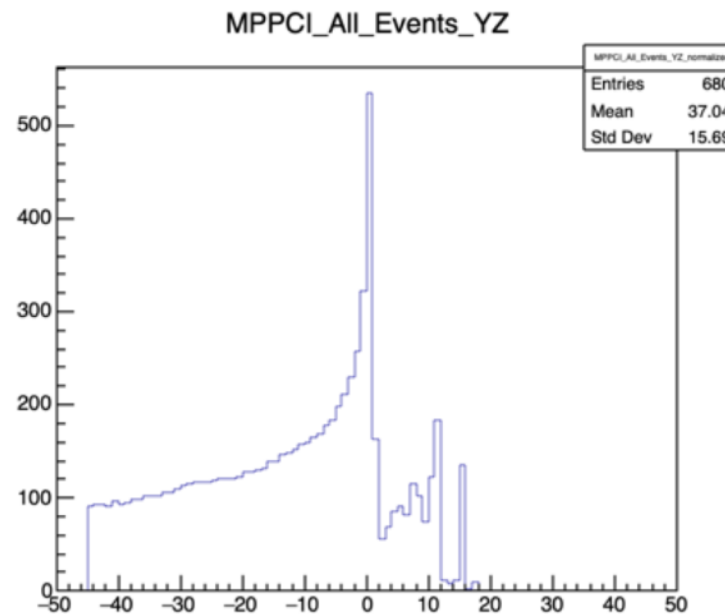


Sum of energy taken by both
sets of fibers.

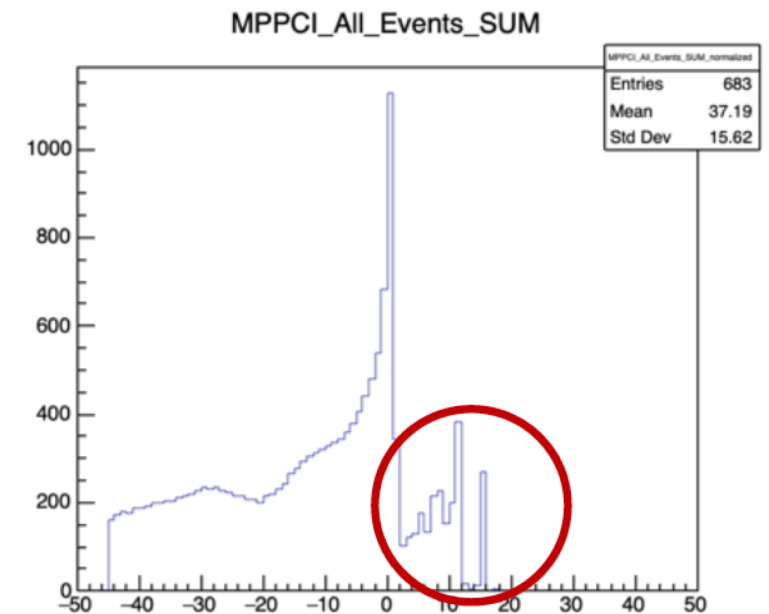
Relative energy deposit from end point of each event



Energy taken by fibers along the Y axis only (vertical)



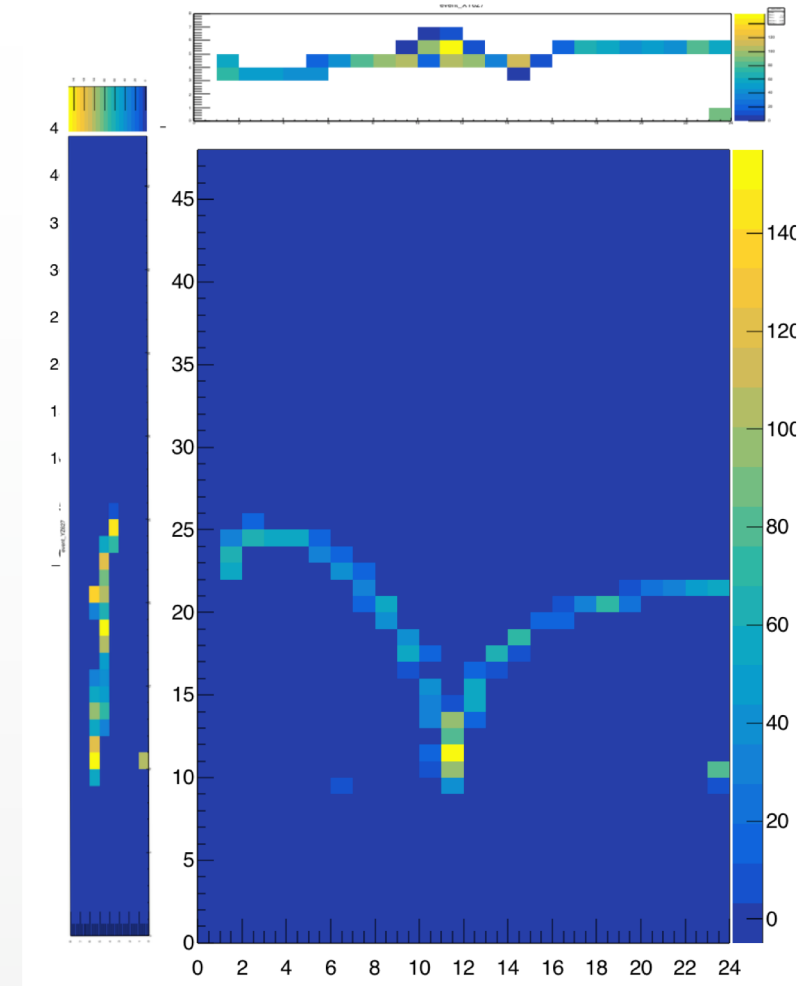
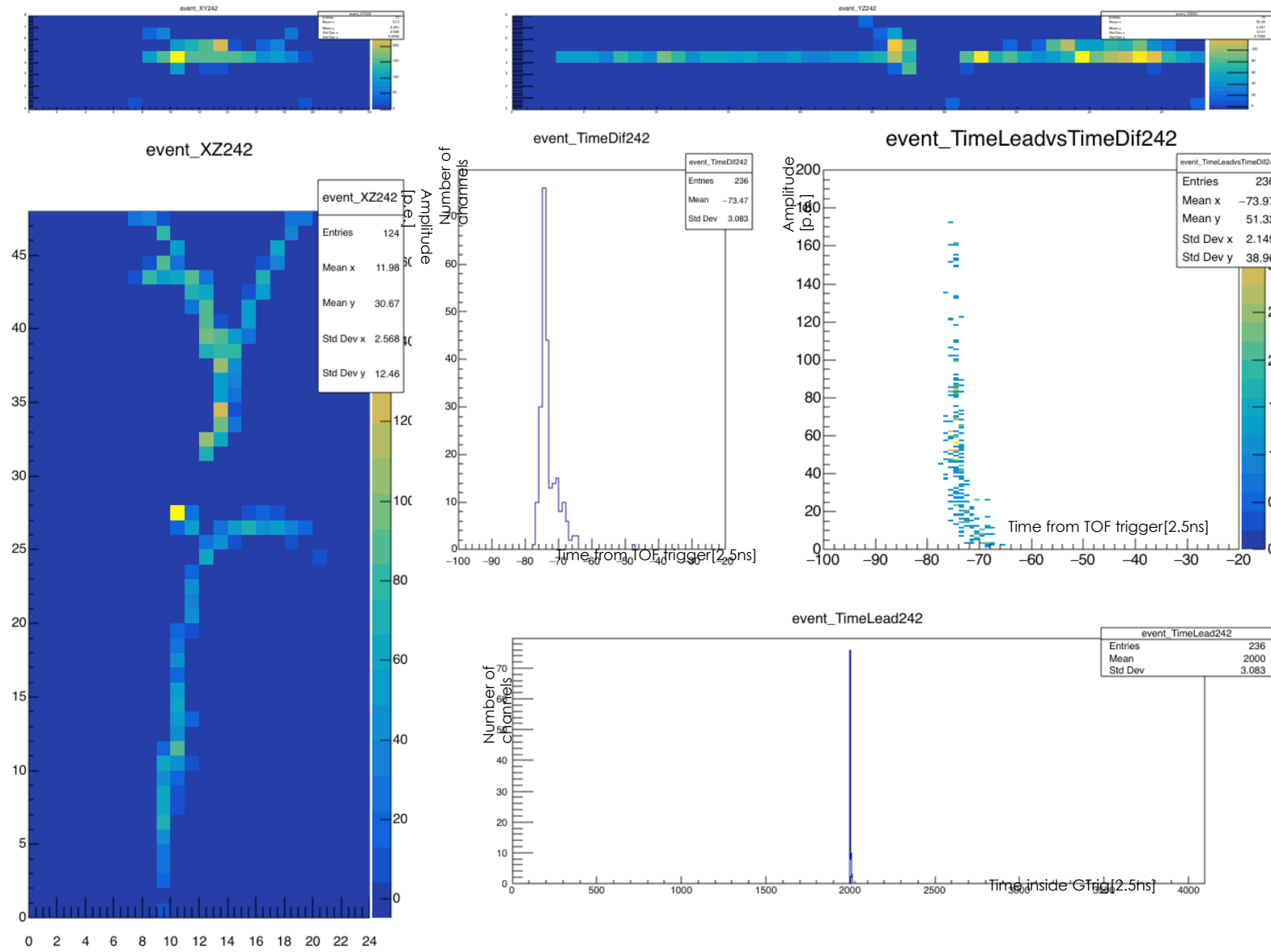
Energy taken by fibers along the X axis only (horizontal and perpendicular to the beam)



Sum of energy taken by both sets of fibers.

Photon beam

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Summary:

- ▶ Beam test results presented;
- ▶ Prototype: 9216 cubes (1x1x1 cm³) – 1728 channels;
- ▶ Collected data:
 - ▶ π , μ , p, e;
 - ▶ 0,3; 0.5; 0.8; 1; 2 GeV.
- ▶ Average L.Y. \approx **50 p.e.** per a fiber;
- ▶ Dynamic range for electronics is up to 1000p.e.
- ▶ Stopping proton energy deposit at the end point is 1000p.e.

project was supported by RFBR Grant 18-32-00070

June – July 2018 beam test at T9 CERN

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Prototype
80 x 240 x 500 mm³
8 x 24 x 48 cubes
1792 channels

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