Status of the magnetized neutrino detector Baby-MIND

A.BLONDEL, C. FRANK, Y. FAVRE, A.KHOTJANTSEV, Yu.KUDENKO, O.MINEEV, A.MEFODIEV*, E.NOAH.

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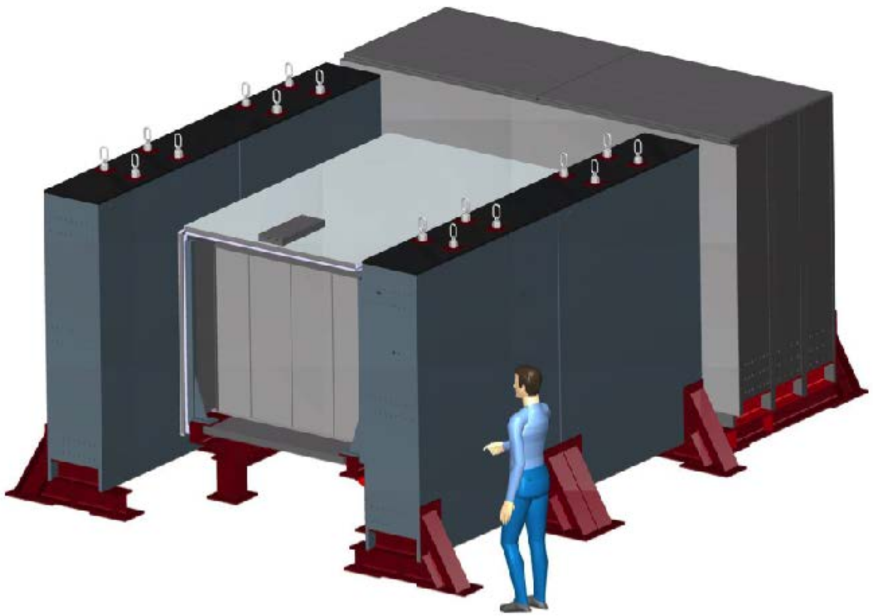
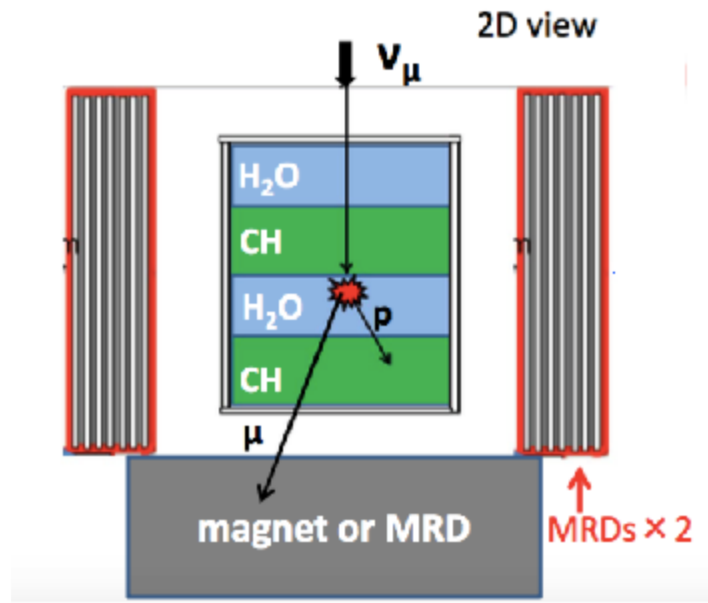
Purpose:

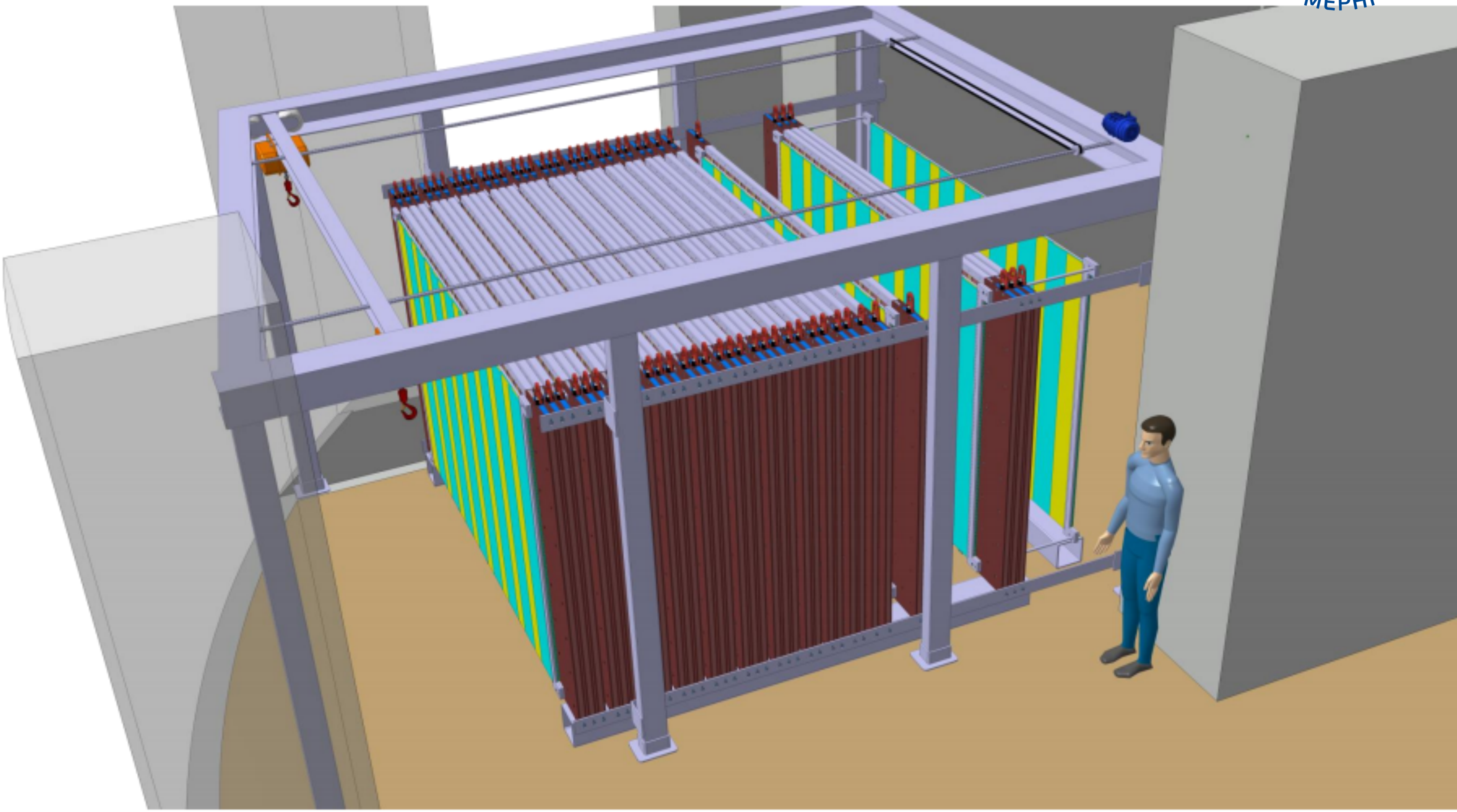
- Magnetized Iron Neutrino Detector (MIND) Design;
- Creation and study of detector modules;
- Beam tests result (T9 CERN);
- Determination of the time resolution.
- Baby-Mind SiPM Front End Electronics Design

WAGASCI Design

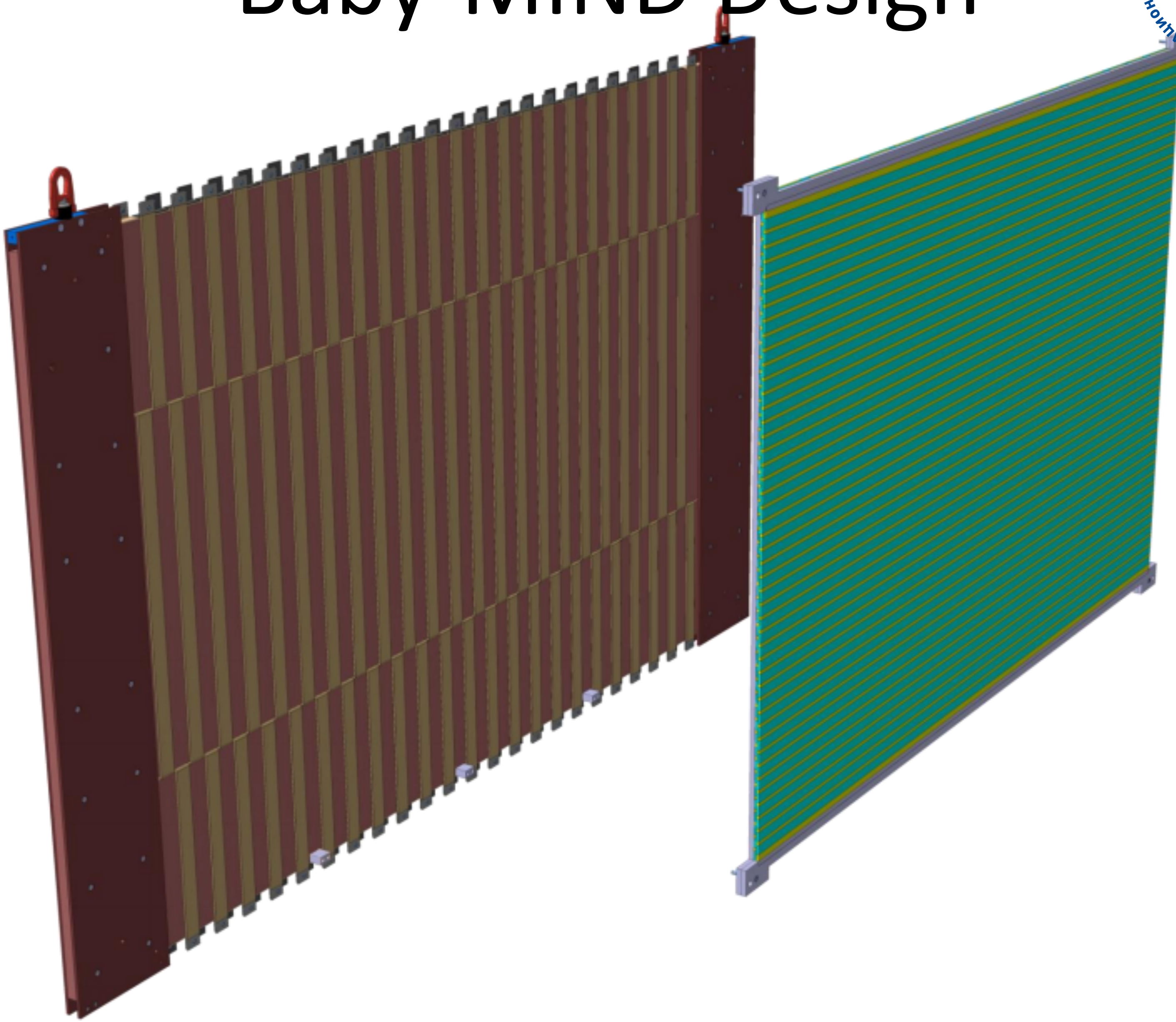




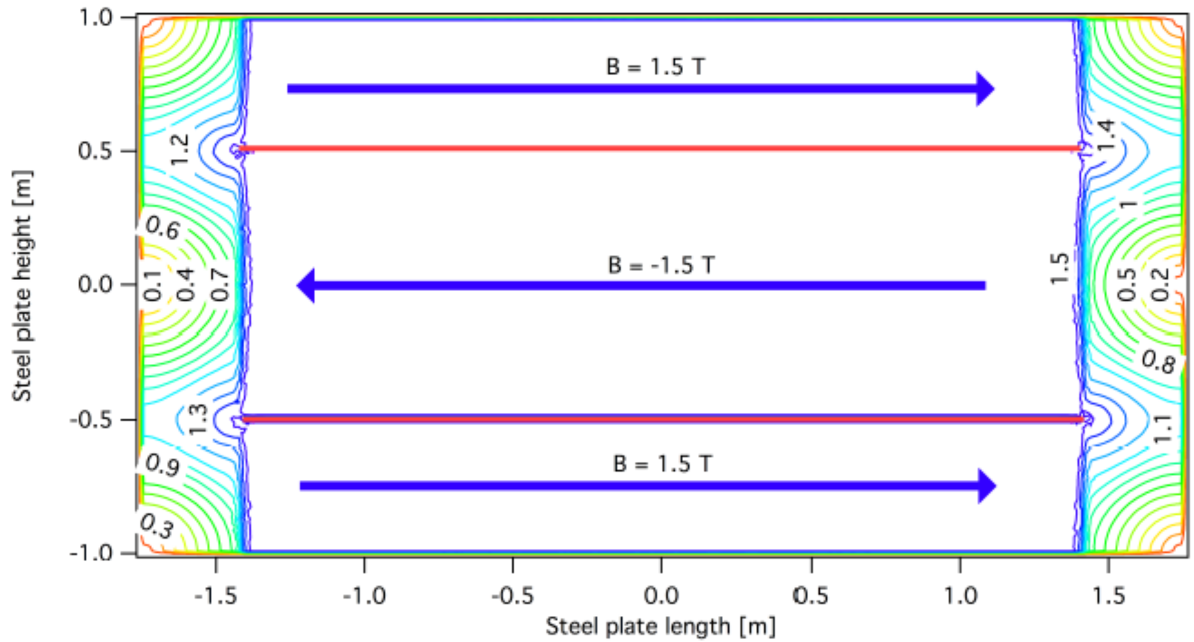
Baby-MIND Design



Baby-MIND Design



Magnetic field map

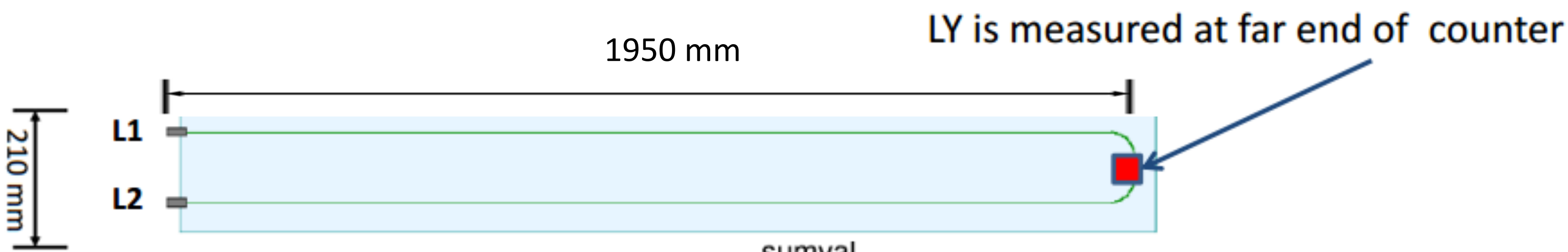


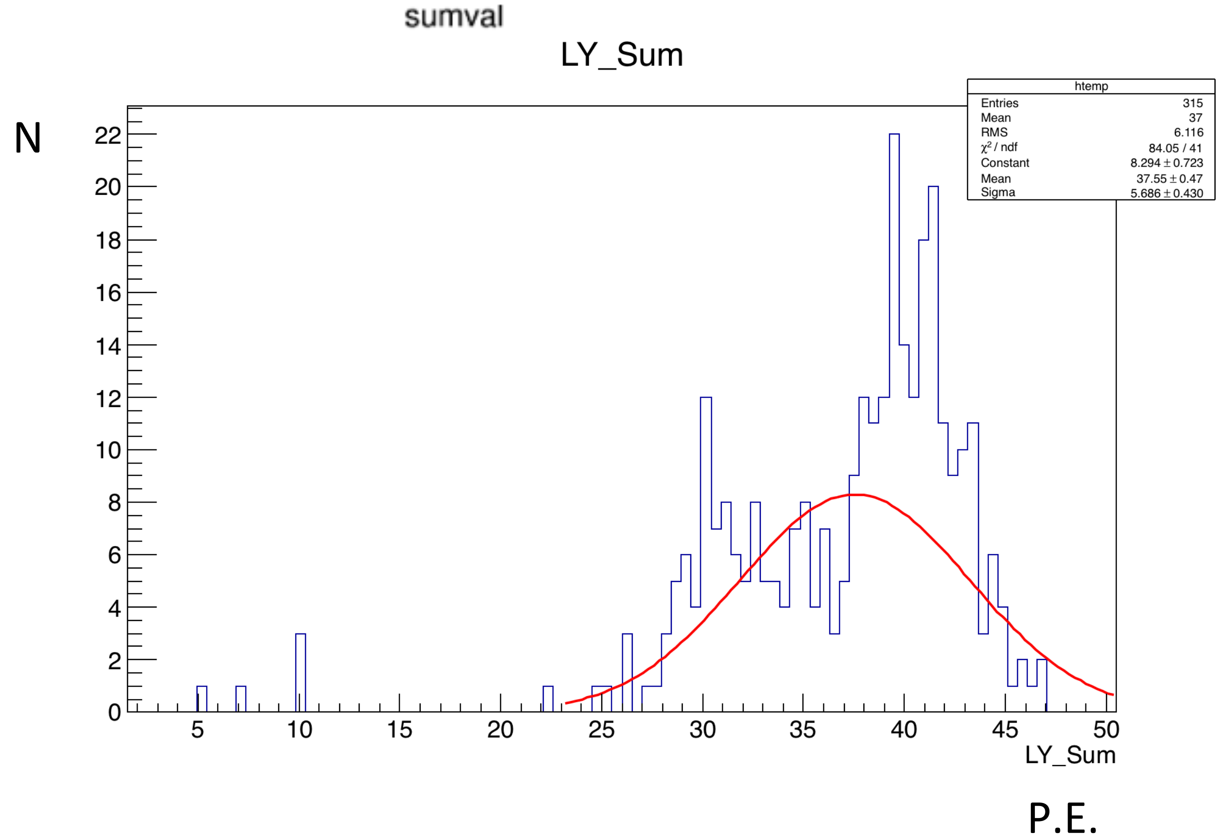
Baby-MIND scintillator counters

- Extruded polystyrene plates supplemented with 1.5% paraterphenyl (PTP) and POPOP 0.01%;
- 30-100 micron layer Uniplast acting as a diffusive reflector;
- WLS Y11 KURARAY $\varnothing 1 мм$;
- Hamamatsu SiPM with active area 1x1 mm^2, 25 micron pixel size (MPPC S12571-025C) ;
- Optic glue EJ-500.

Vertical scintillator counters for Baby-MIND

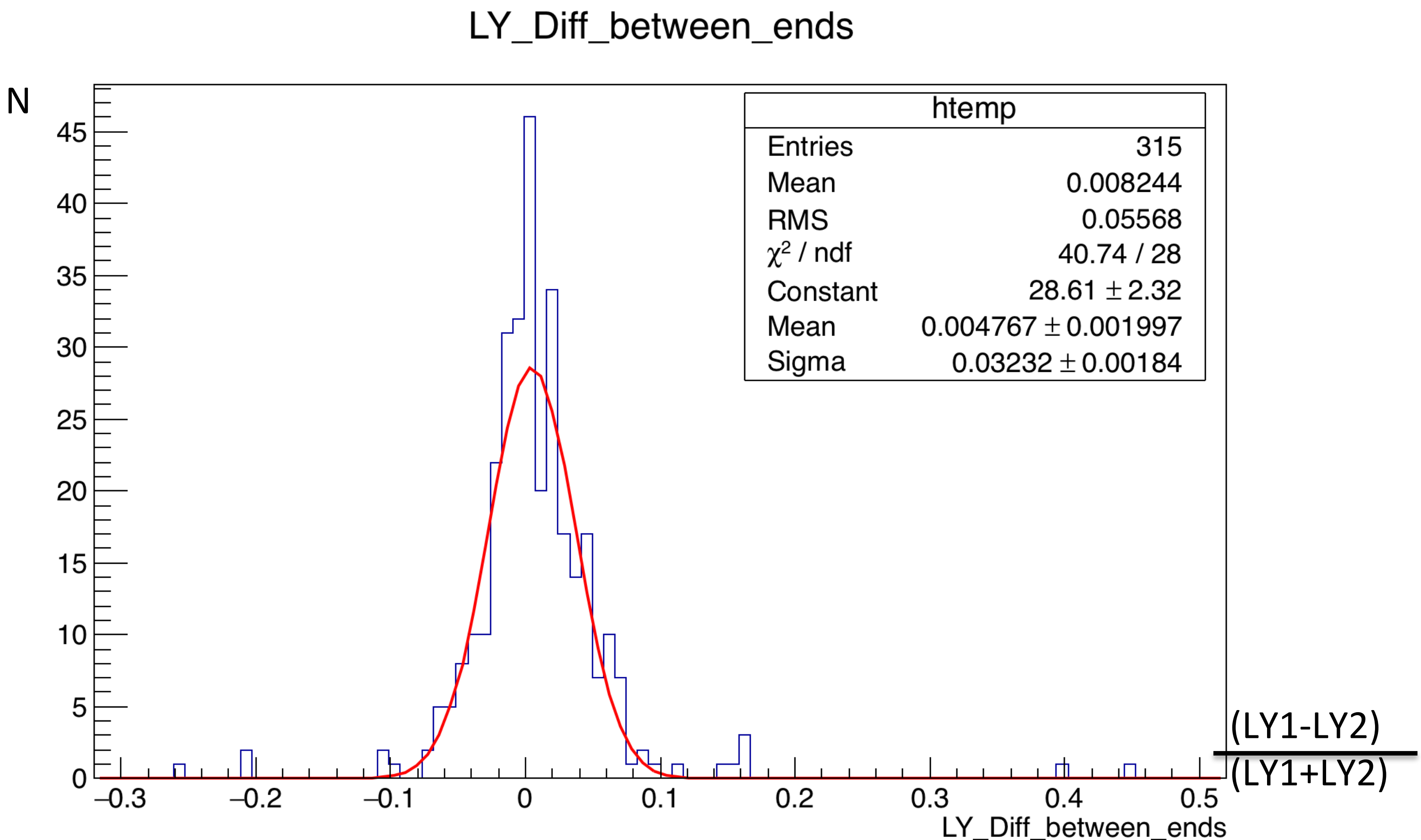
Light Yield = Sum of 2 signals (L1+L2) from both ends





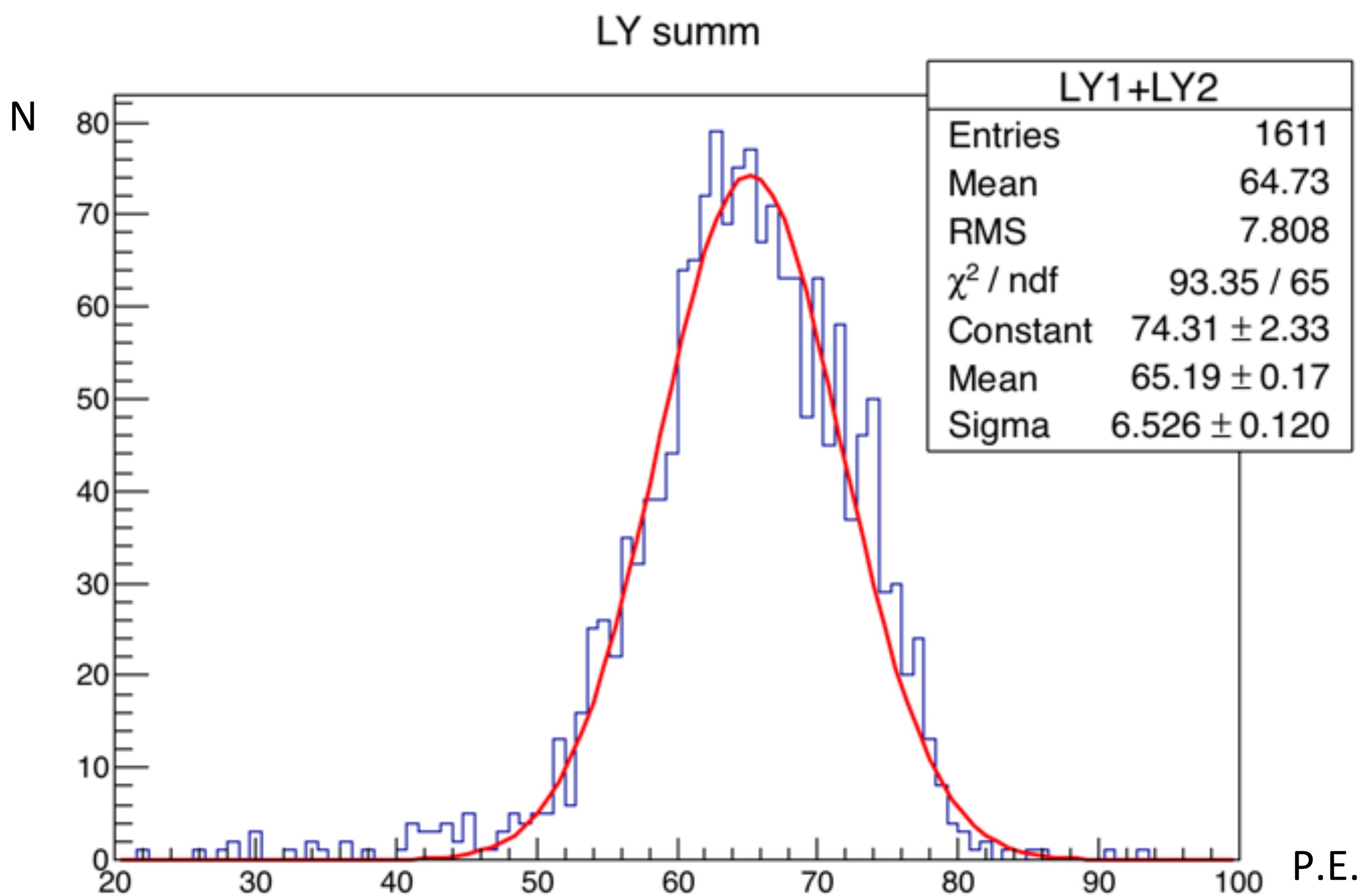
Vertical scintillator counters for Baby-MIND

Asymmetry of LY: A = (L1-L2)/L1+L2)



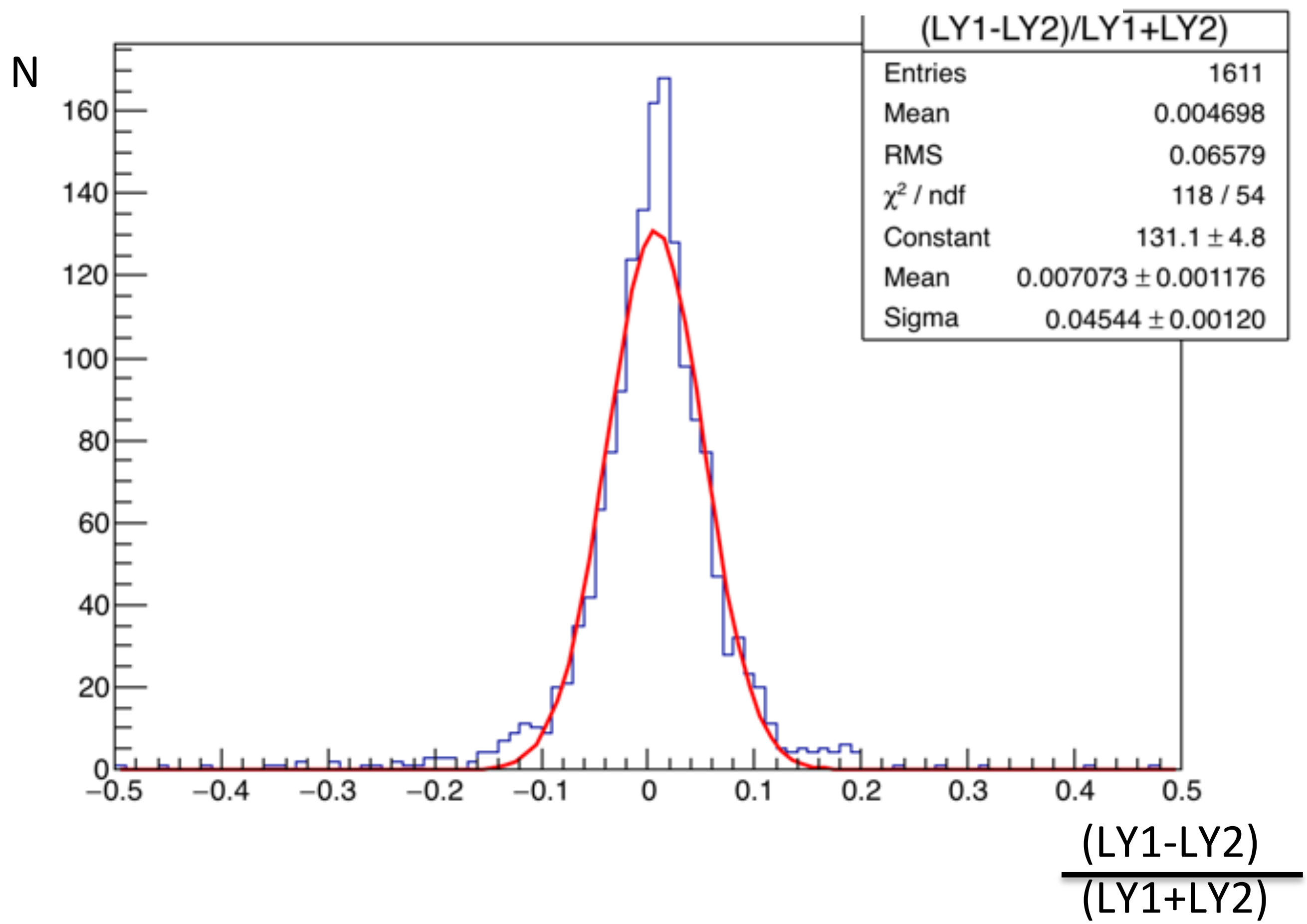
Horizontal scintillator counters for Baby-MIND

Light Yield = Sum of 2 signals (L1+L2) from both ends

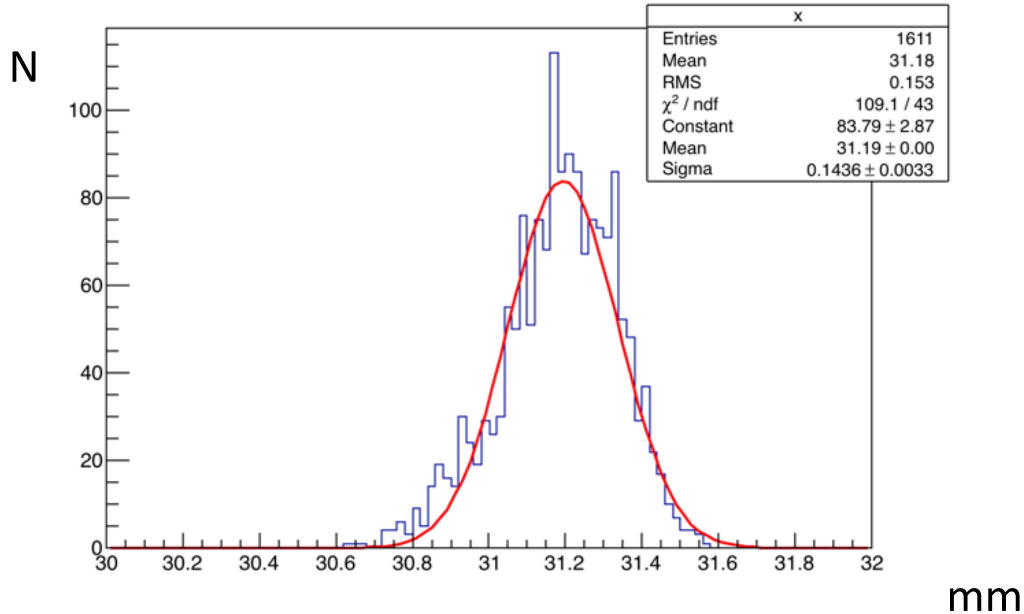


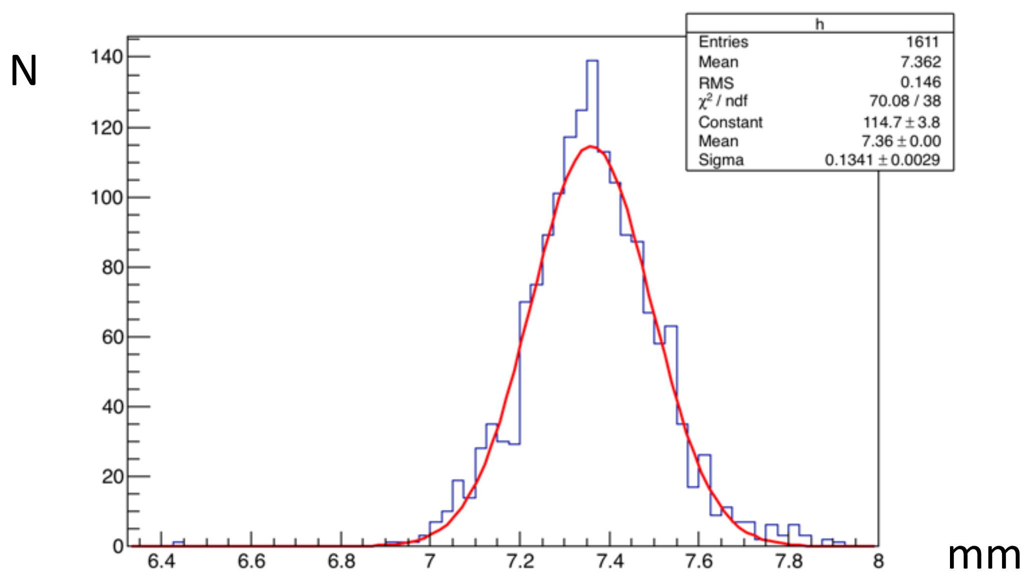
Horizontal scintillator counters for Baby-MIND

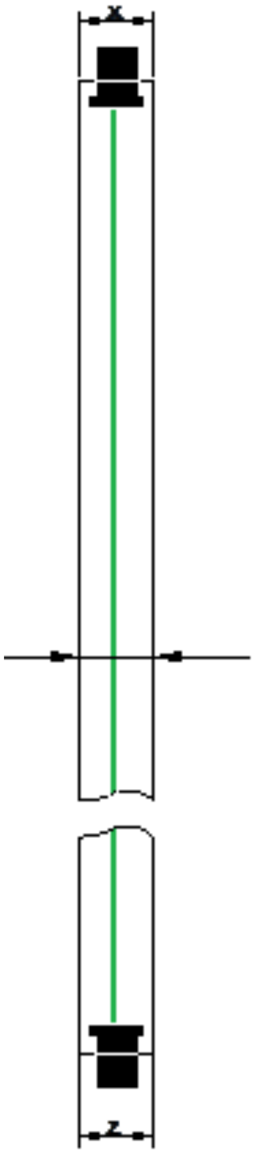
Asymmetry of LY: **A** = (L1-L2)/L1+L2)



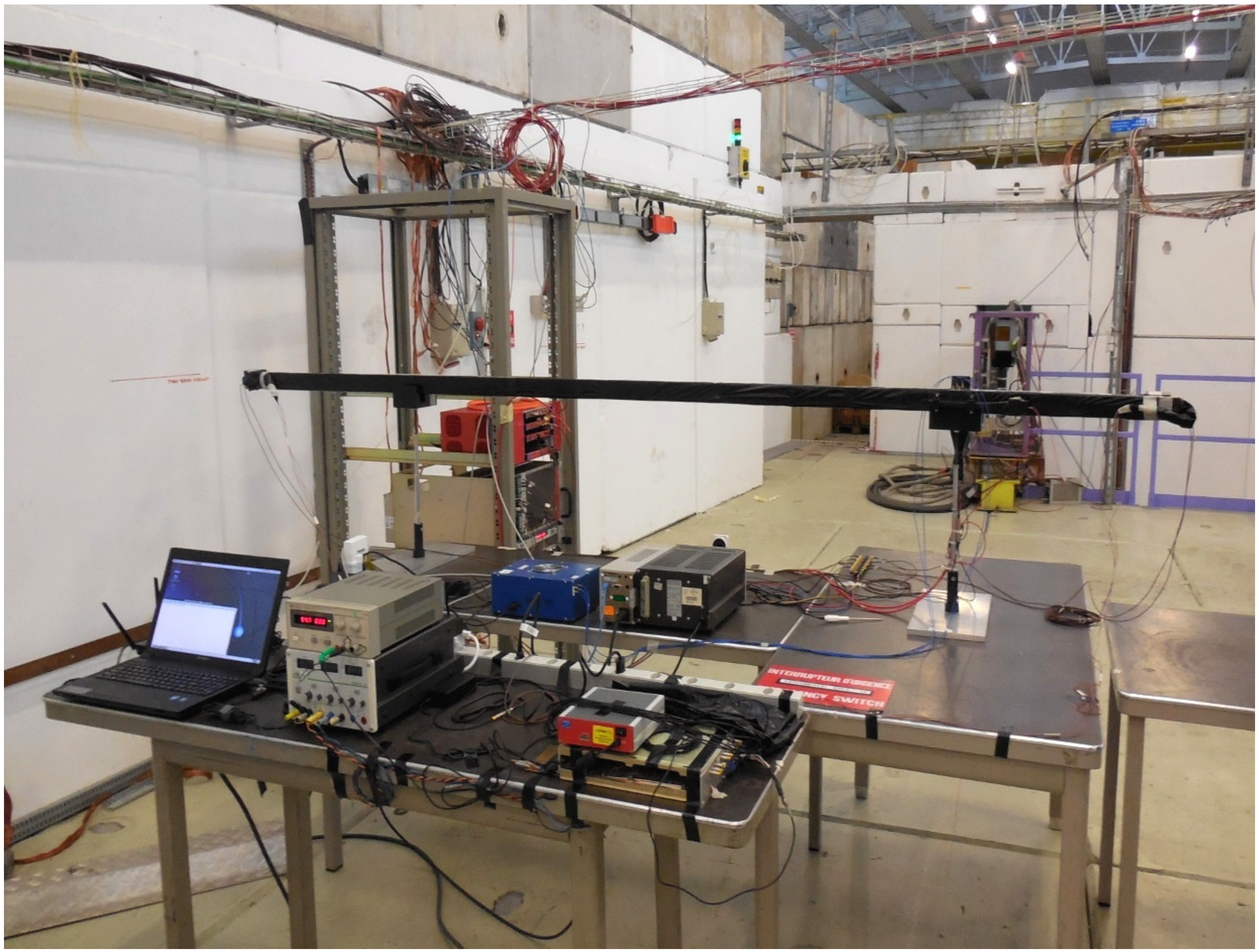
Horizontal scintillator counters for Baby-MIND







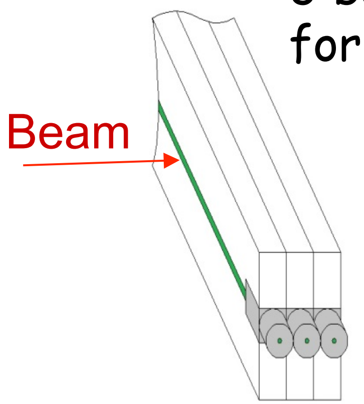
Test of bar scintillators at PS T9 beam line in CERN



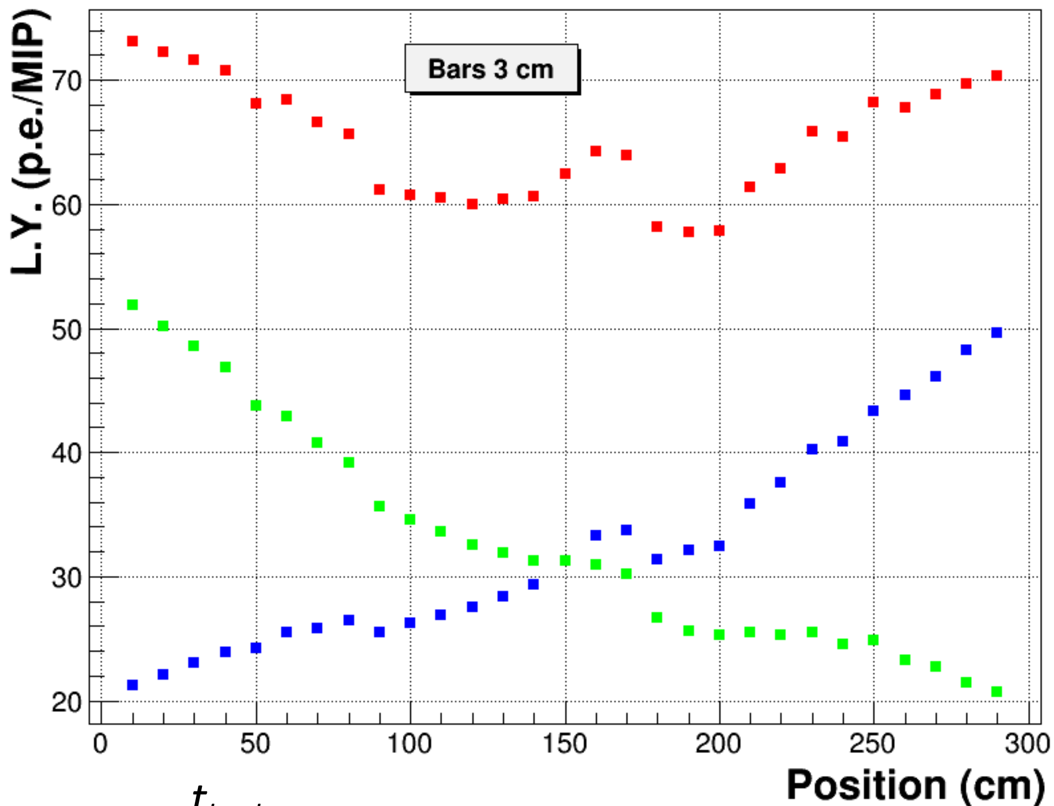
Beam: **10 GeV/c**

Beam size:
Trigger counters cut the beam spot $1 \times 5\ cm^2$

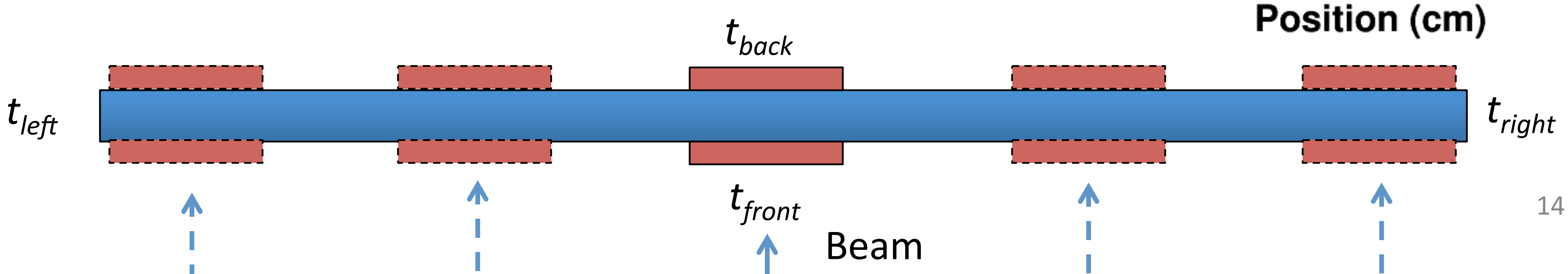
Light yield in 3-cm bars



3 bars were irradiated in the beam. The plot shows the average result for all 3 tested bars. Red points are the sum from both ends.



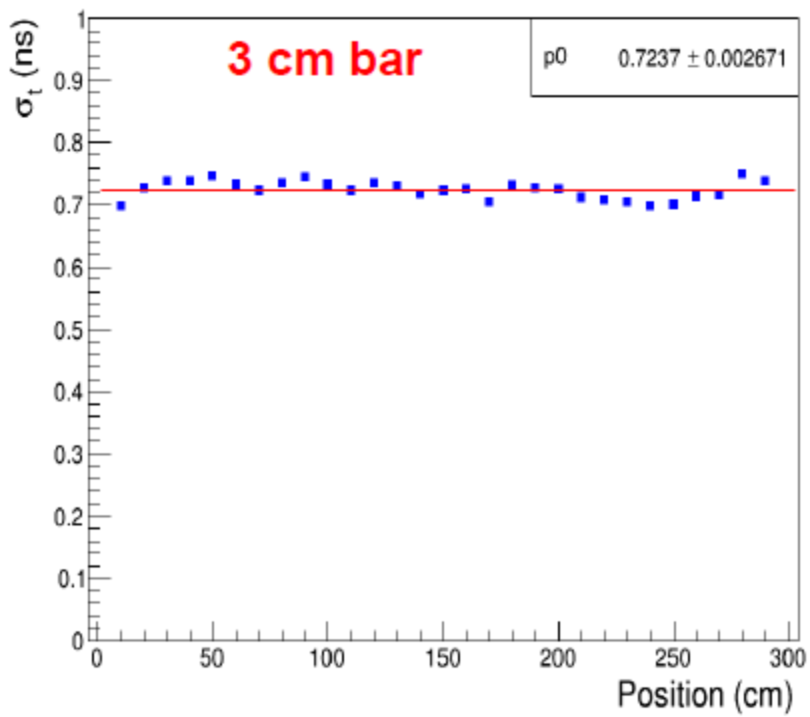
No correction was made for temperature fluctuations (+/- 2 C).



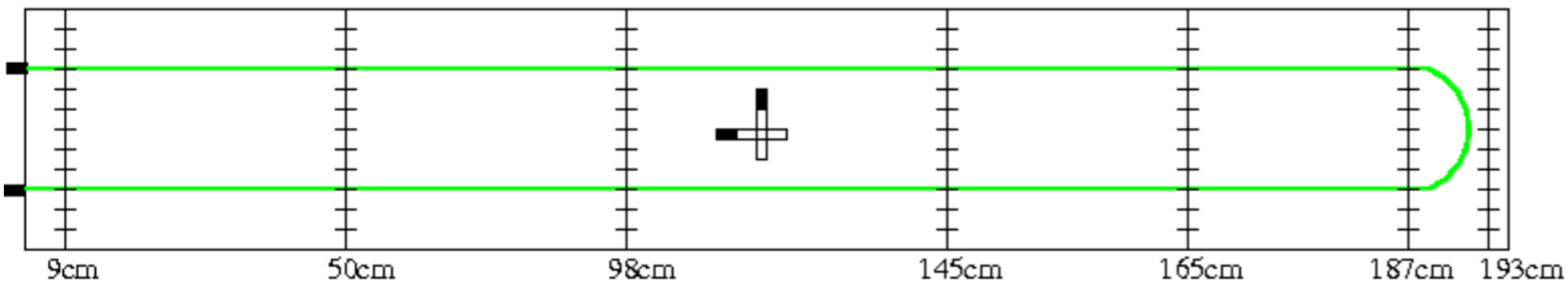
Timing for 3 -cm bars vs position along the bars

Time resolution σ_t was calculated for distribution $(T_{left}+T_{right})/2$, where T is the signal time minus trigger time. Trigger jitter contributes in σ_t. Each point is the average for 3 bars.

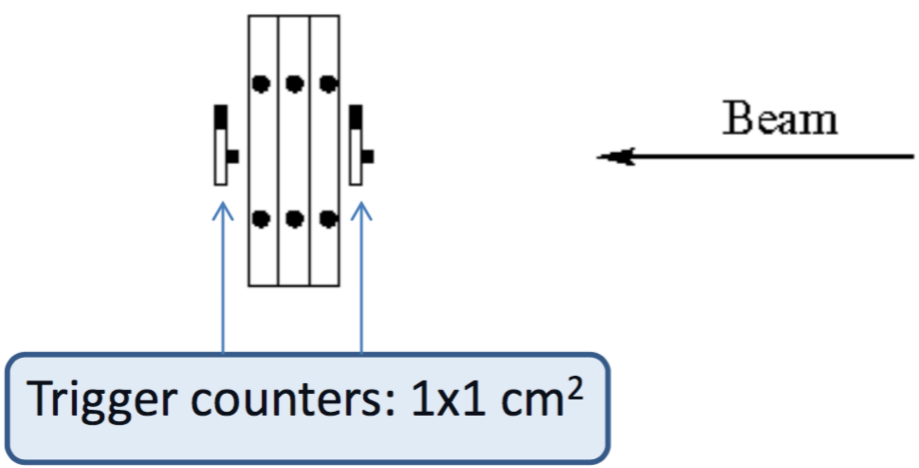
Average σ_t = 724 ps



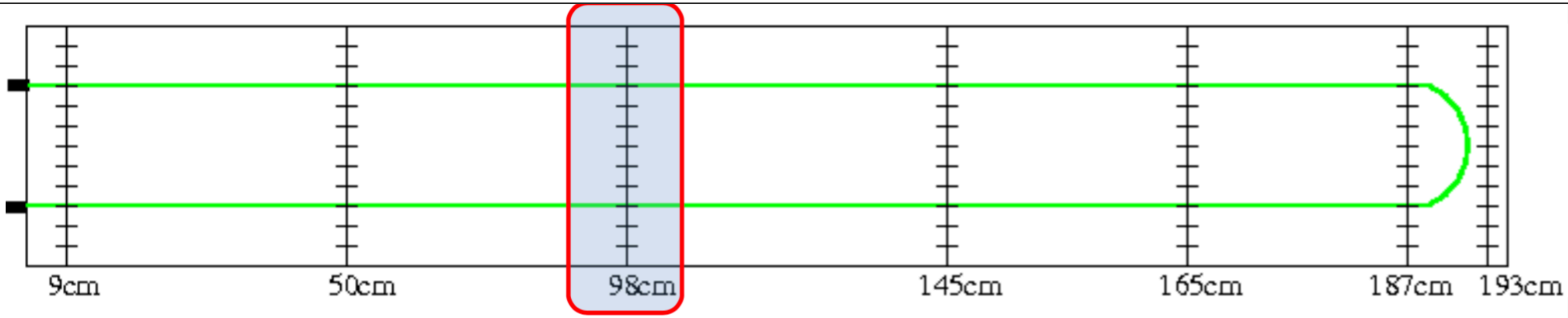
Test of BabyMIND vertical bars

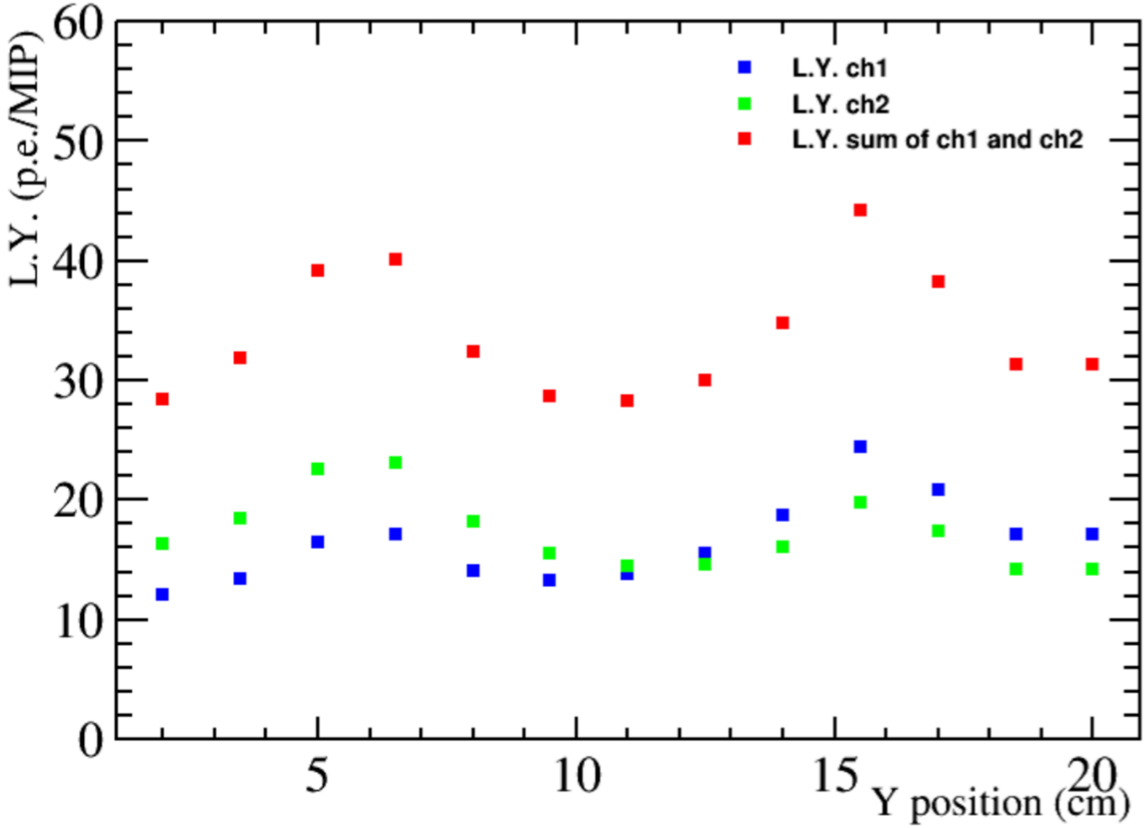


The bars were individually isolated and assembled into a single module.

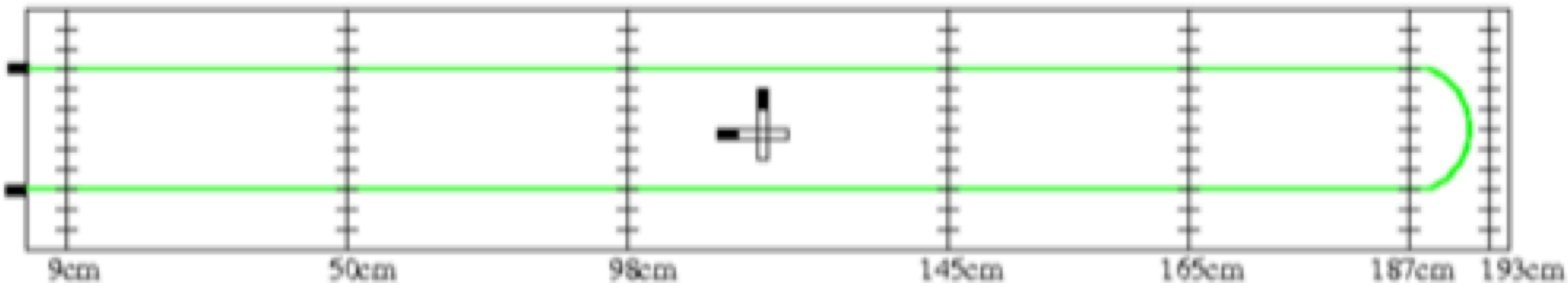


Trigger is made up of four cut TASD bars crosswise in coincidence

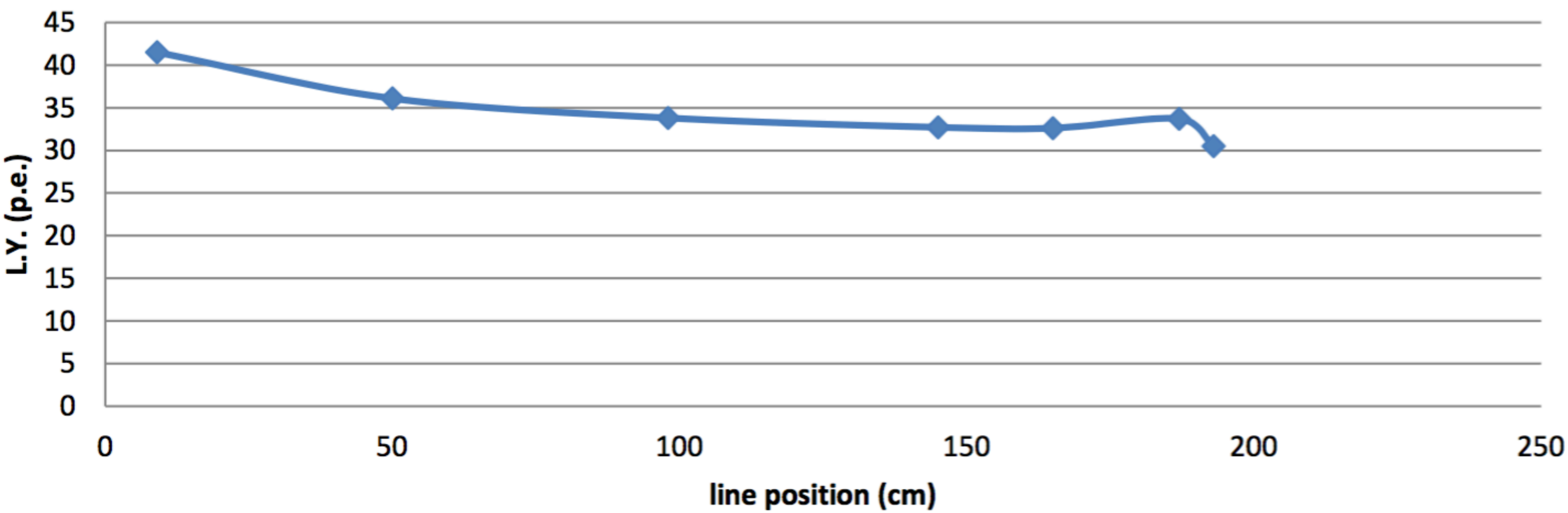




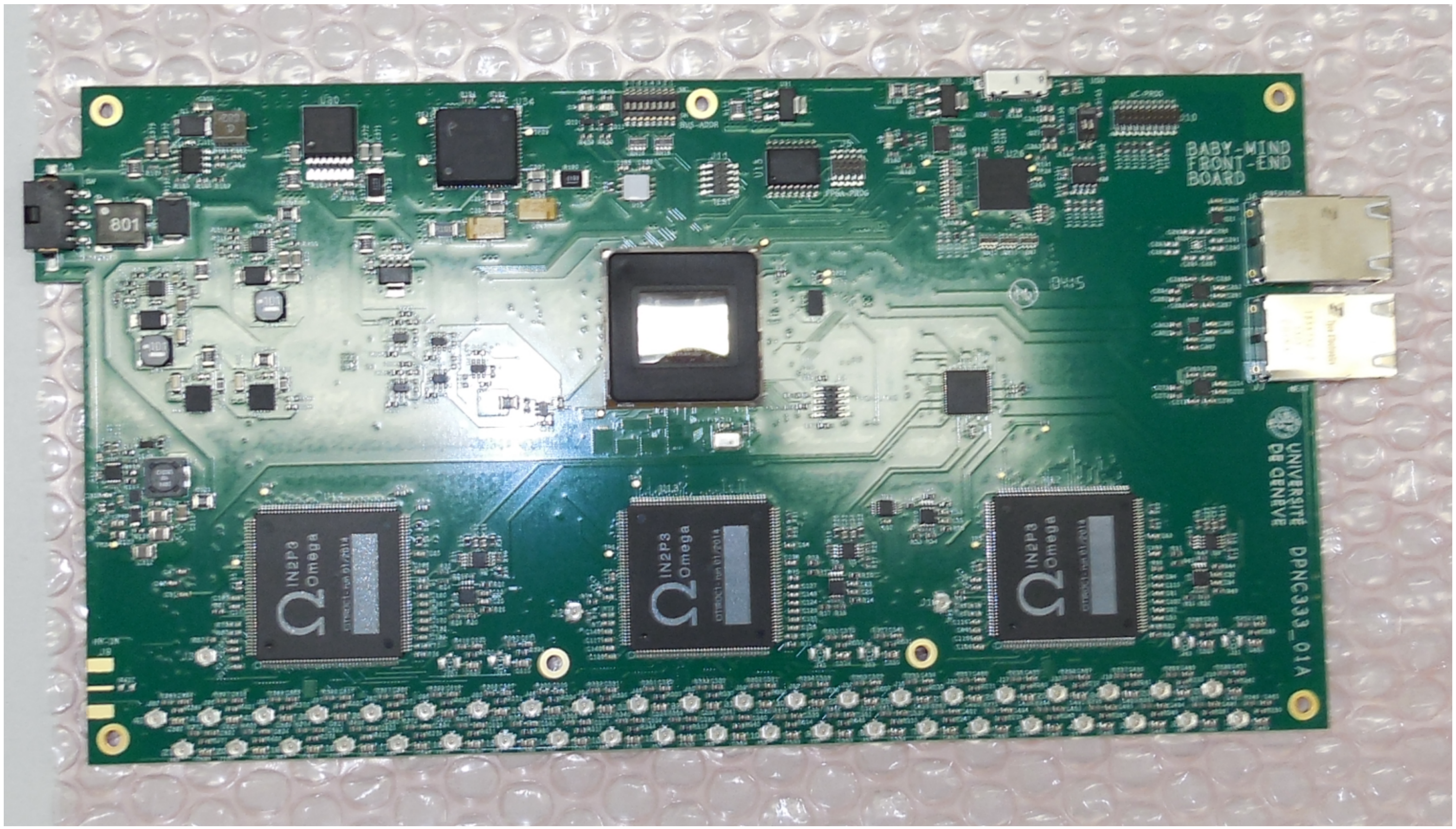
Average L.Y. is 33.8 p.e.



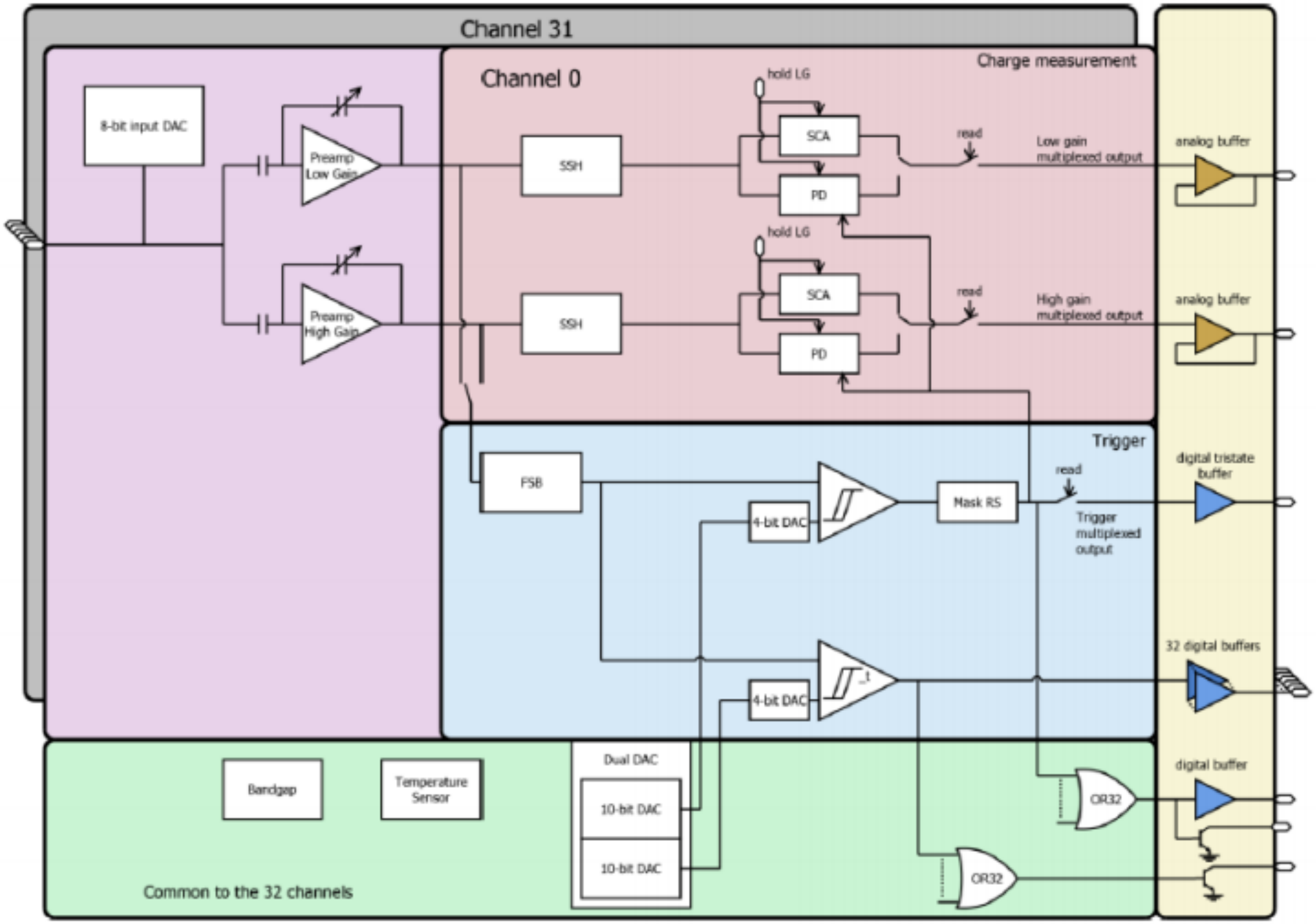
Dependence the average L.Y. from the line positions



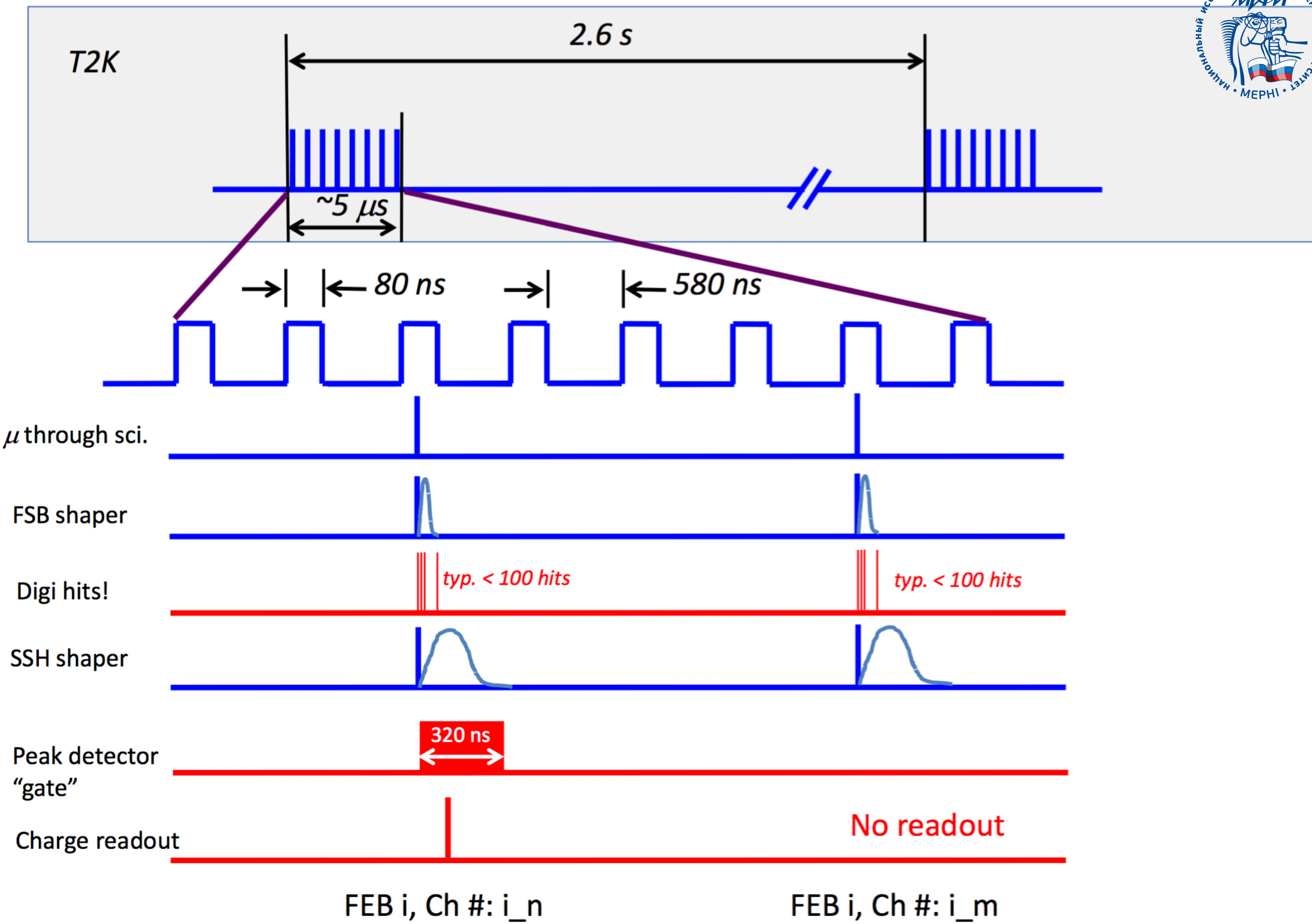
Citiroc SiPM Front End Electronics



CITIROC BLOC DIAGRAM

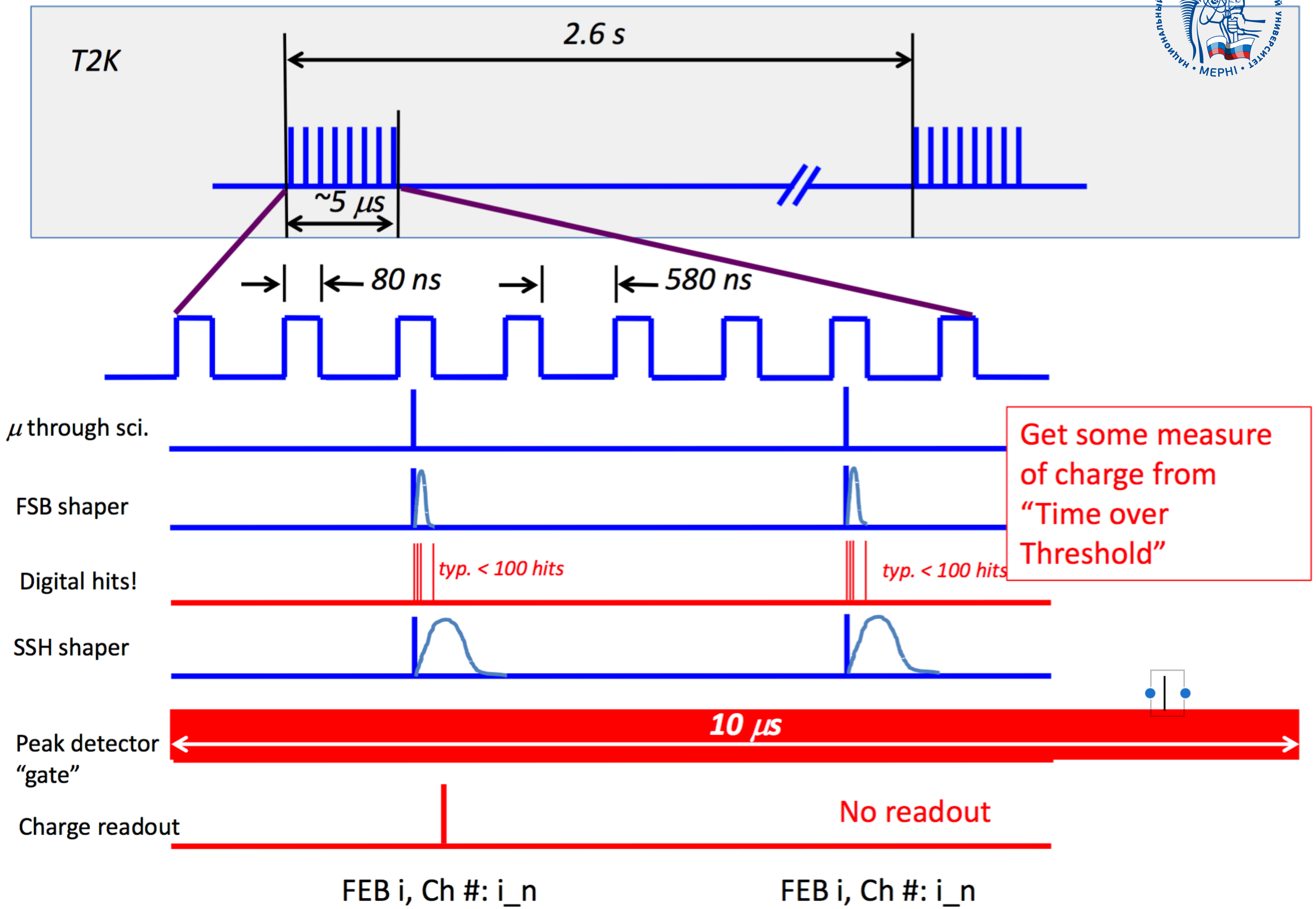


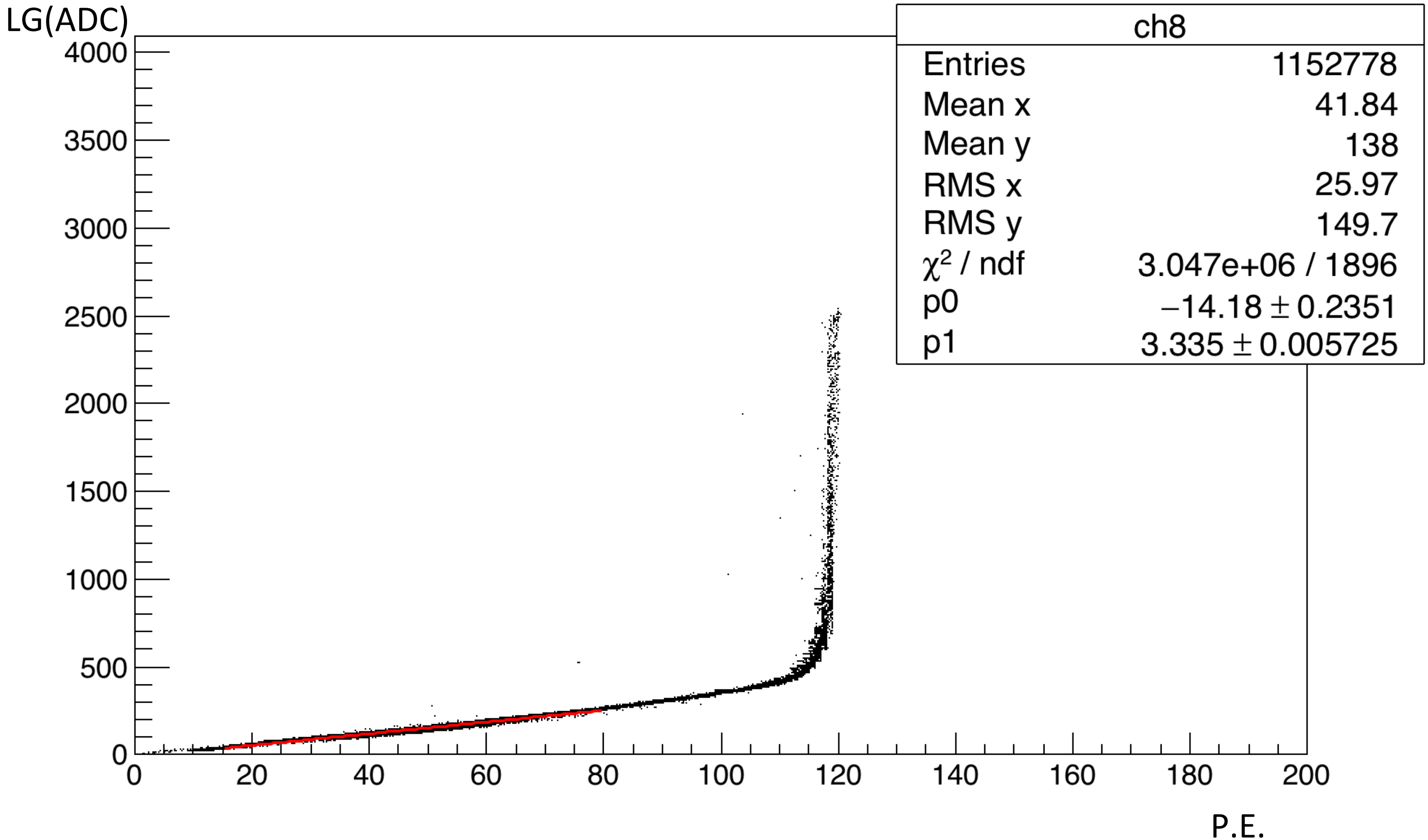
Readout with peak detector window set to 320 ns



Single channel occupancy issue

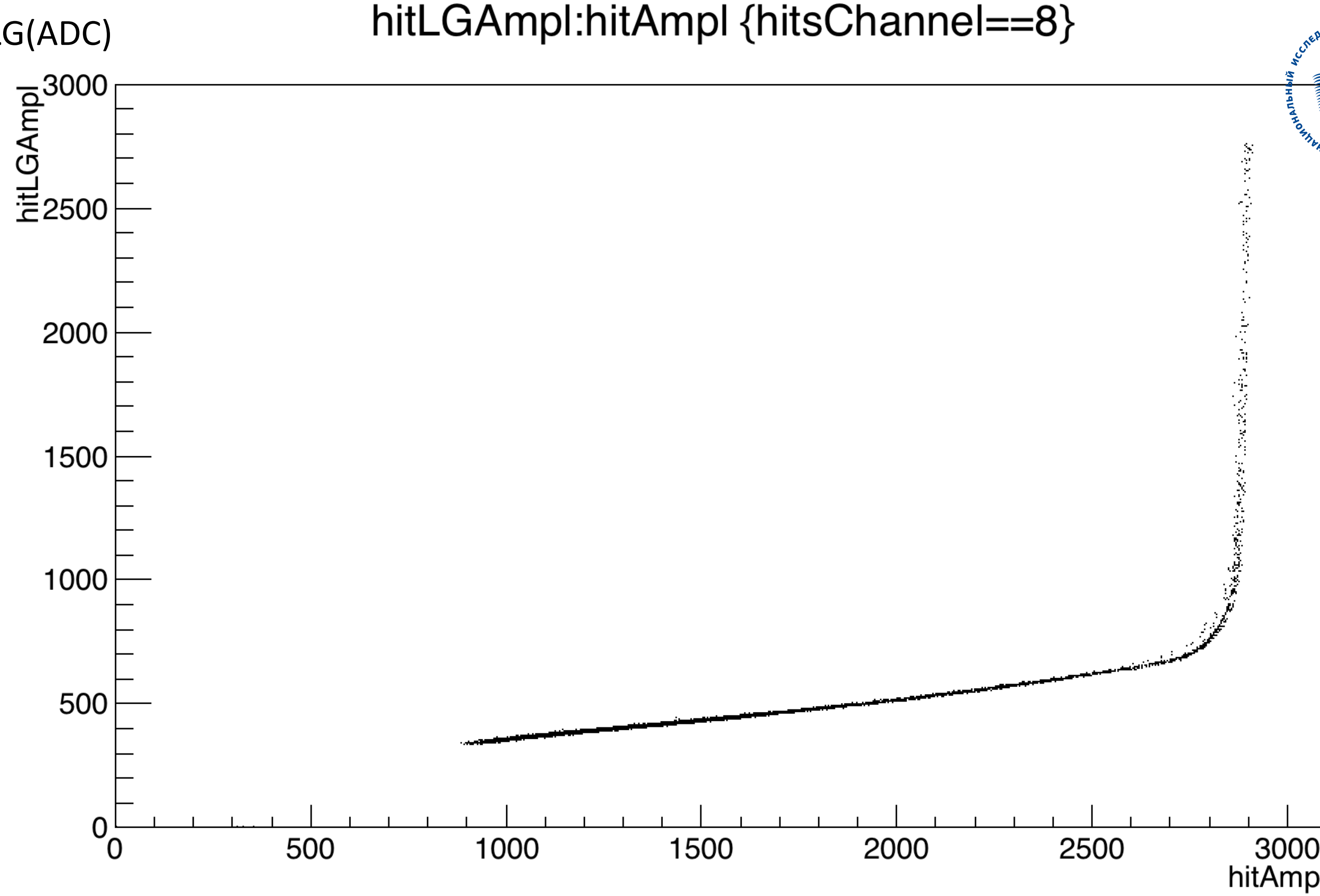
For a given channel "Peak detector" will only retain highest amplitude hit occuring in its 10 μs window




LG(ADC)
ch8
Entries 1152778
Mean x 41.84
Mean y 138
RMS x 25.97
RMS y 149.7
χ² / ndf 3.047e+06 / 1896
p0 −14.18 ± 0.2351
p1 3.335 ± 0.005725
4000
3500
3000
2500
2000
1500
1000
500
0
0 20 40 60 80 100 120 140 160 180 200
P.E.

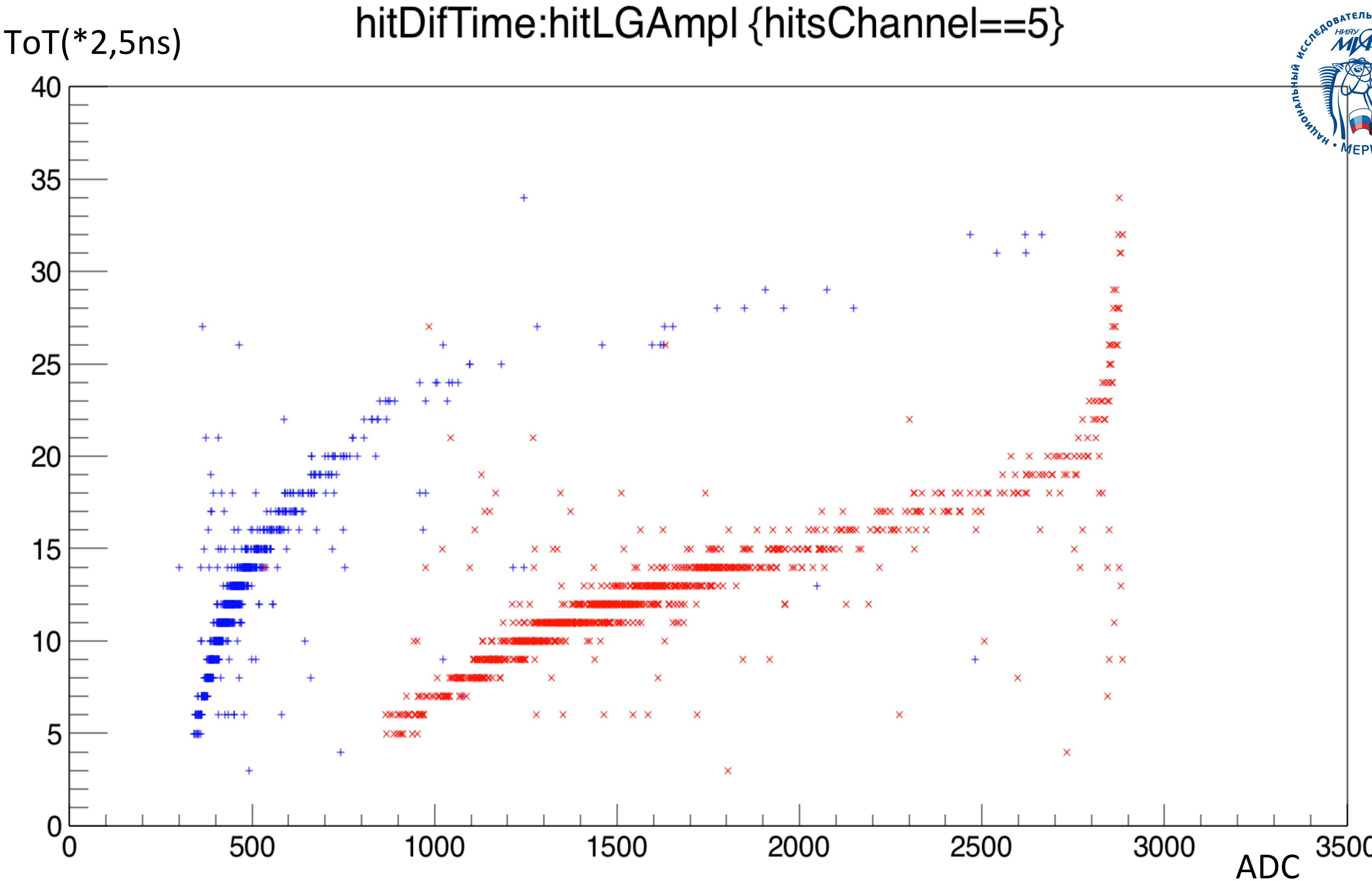
LG vs P.E.

LG(ADC)

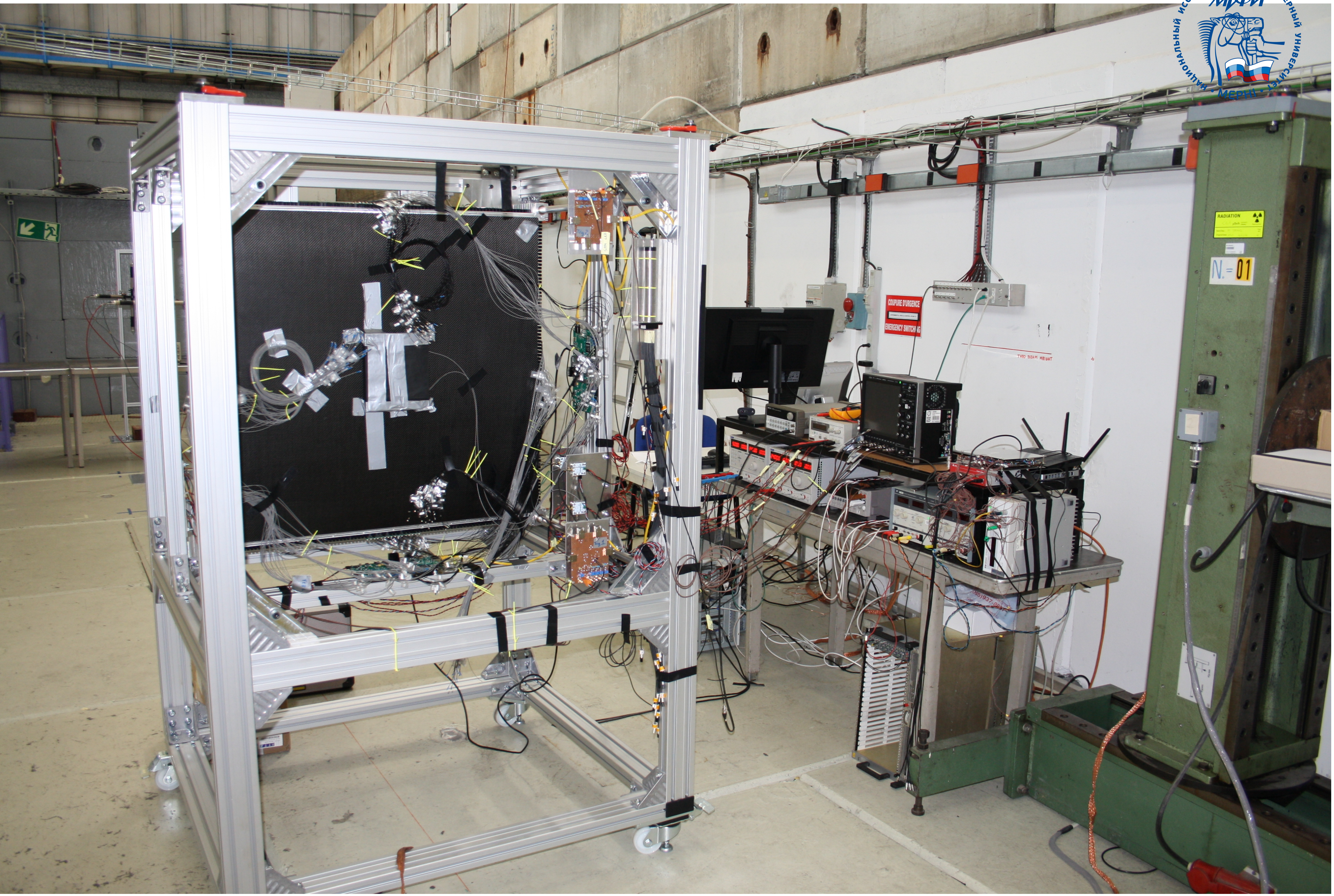


HG(ADC)

There is linear correlation between LG and HG.



Correlation between ToT (Vertical scale units of 2.5ns) and:
LG55 (Horizontal scale ADC units) in BLUE.
HG50 (Horizontal scale ADC units) in RED.



Summary

	Horizontal bars	Vertical bars	Total (hor. + vert.)
Plastic scintillators			
# bars per layer	48/47	8	56
# bars per module	95	16	111
# bars total	**1710**	**288**	**1998**
Readout per module			
# SiPMs per module	190	32	222
# CITIROC per module	6	1	7
# Front End Boards per module	TBC	TBC	TBC
Readout total (18 modules)			
# SiPMs total	**3420**	**576**	**3996**
# CITIROC total	108	18	126
# Front End Boards total	TBC	TBC	TBC

Summary:

- 700 scintillation counters for Baby-MIND are created and tested;
- Light yield for horizontal bars is 67 P.E./MIP;
- Light yield for vertical bars is 37 P.E./MIP;
- Scintillation bars sizes in range of 0.14mm;

Planned to test Baby-MIND on T9 CERN beam area by the end of 2016

background slides

Layout standard momentum measurement

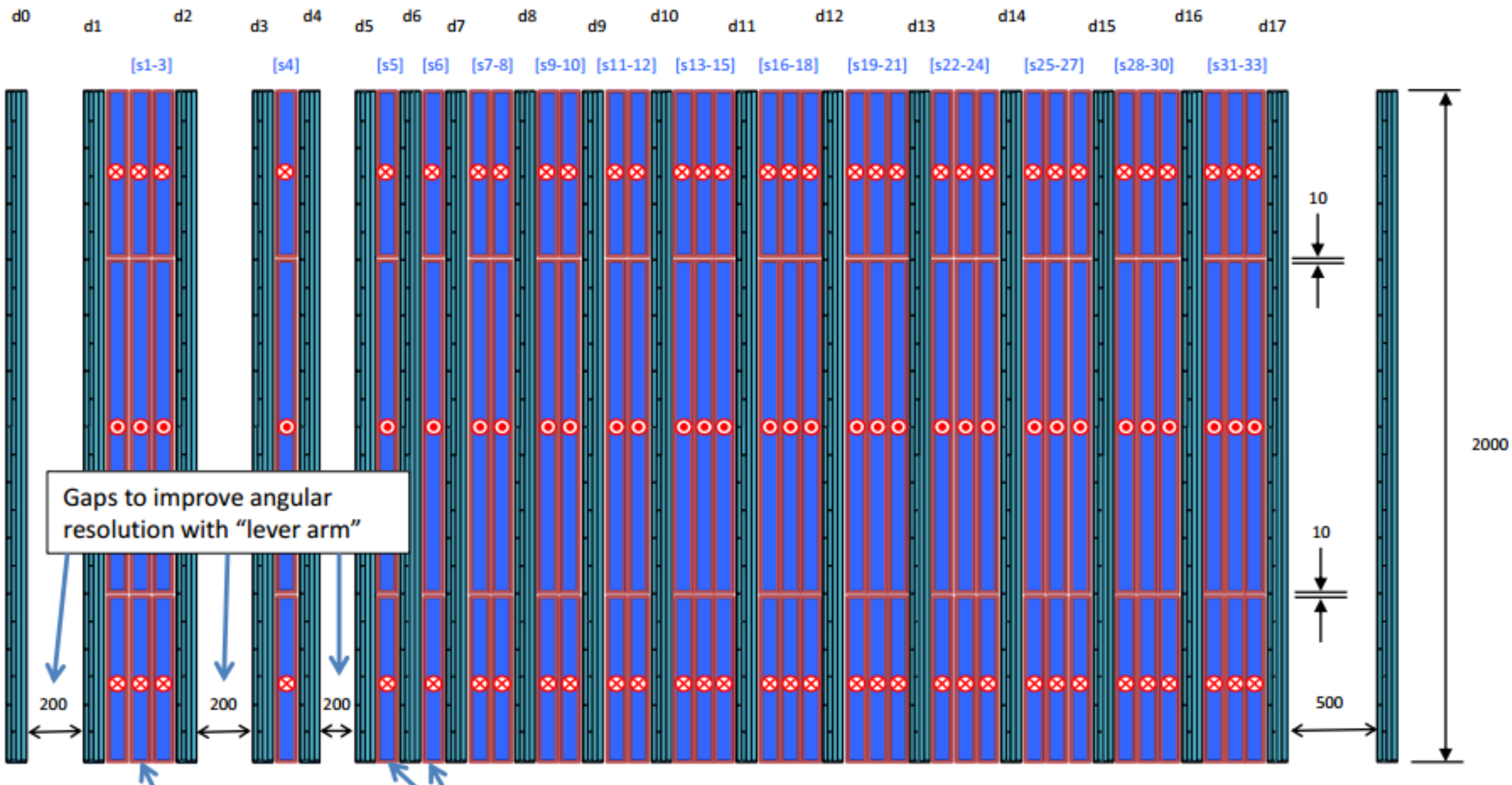
d: detector module

s: steel module

Note 1: d0 is smaller since it has to fit closeto (right up against) WAGASCI neutrino targets

Note 2: this layout will definitely evolve!!

Note 3: ... must integrate all WAGASCI sub-detectors!



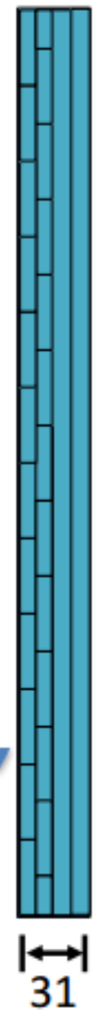
Thicker steel to better resolve angular deflection by B-field from angular deflection by M.S.

Thinner steel here to improve cross-calibration of detector:
i.e. momentum resolution by **range** vs **B-field**
(E_{loss} **=** 35 MeV in 30 mm of steel for MIP μ)

Distribution of detector modules amongst magnetized steel plates

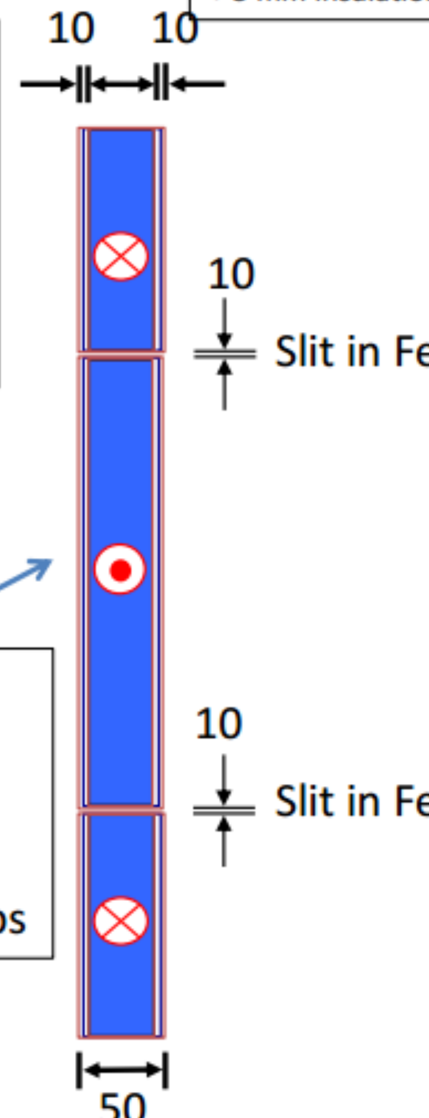
- 18 detector modules
- 33 steel plates
  - ➢ not all steel plates can be instrumented

detector module:
31 mm thick: mostly plastic scintillator
4 layers x 7.5 mm
2 envelopes x 0.5 mm (carbon fiber)



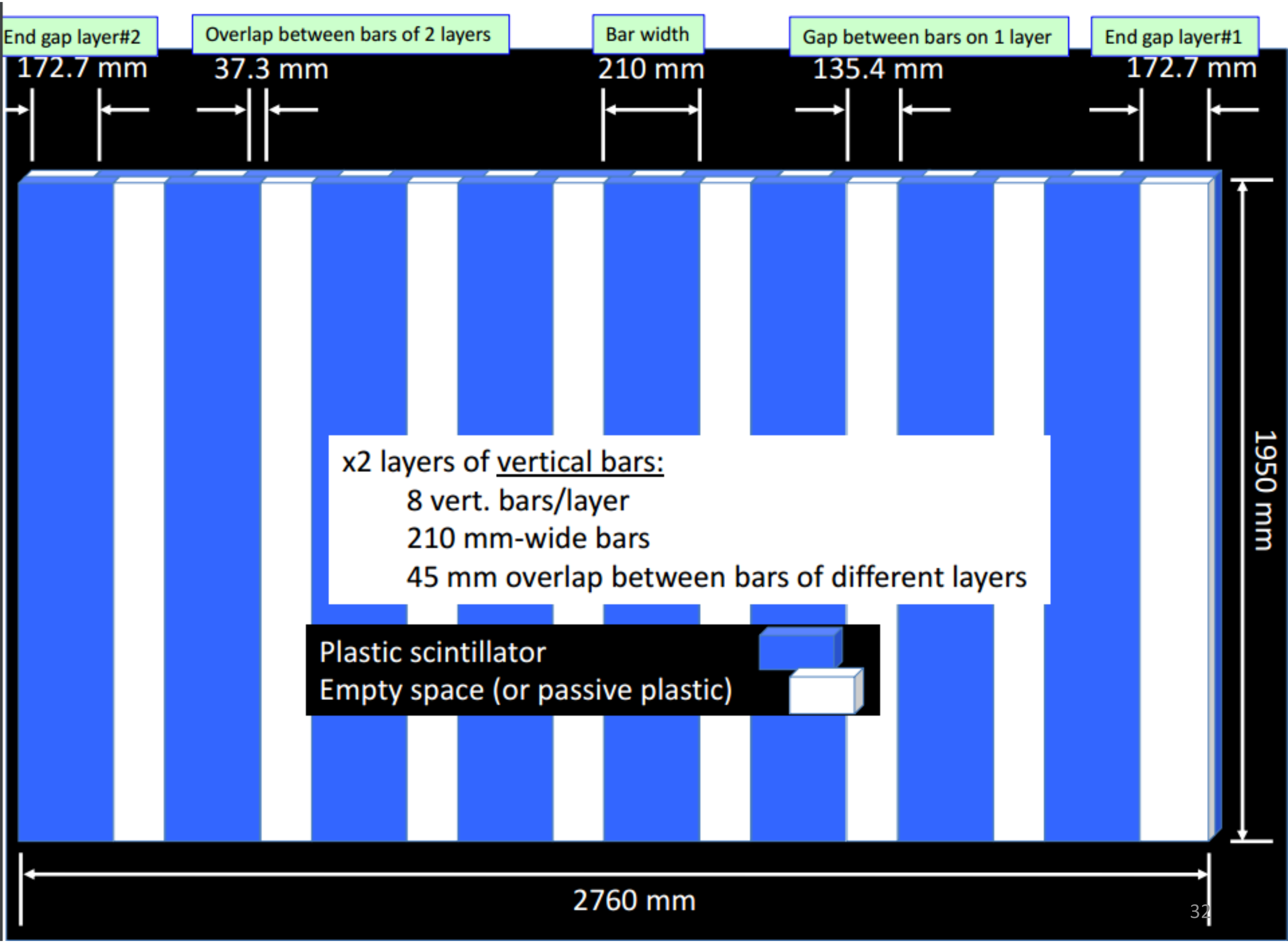
For illustration only!
In practice, there are gaps between adjacent bars on one plane!

Alu. coil
= 5 mm thick
+ 5 mm insulation



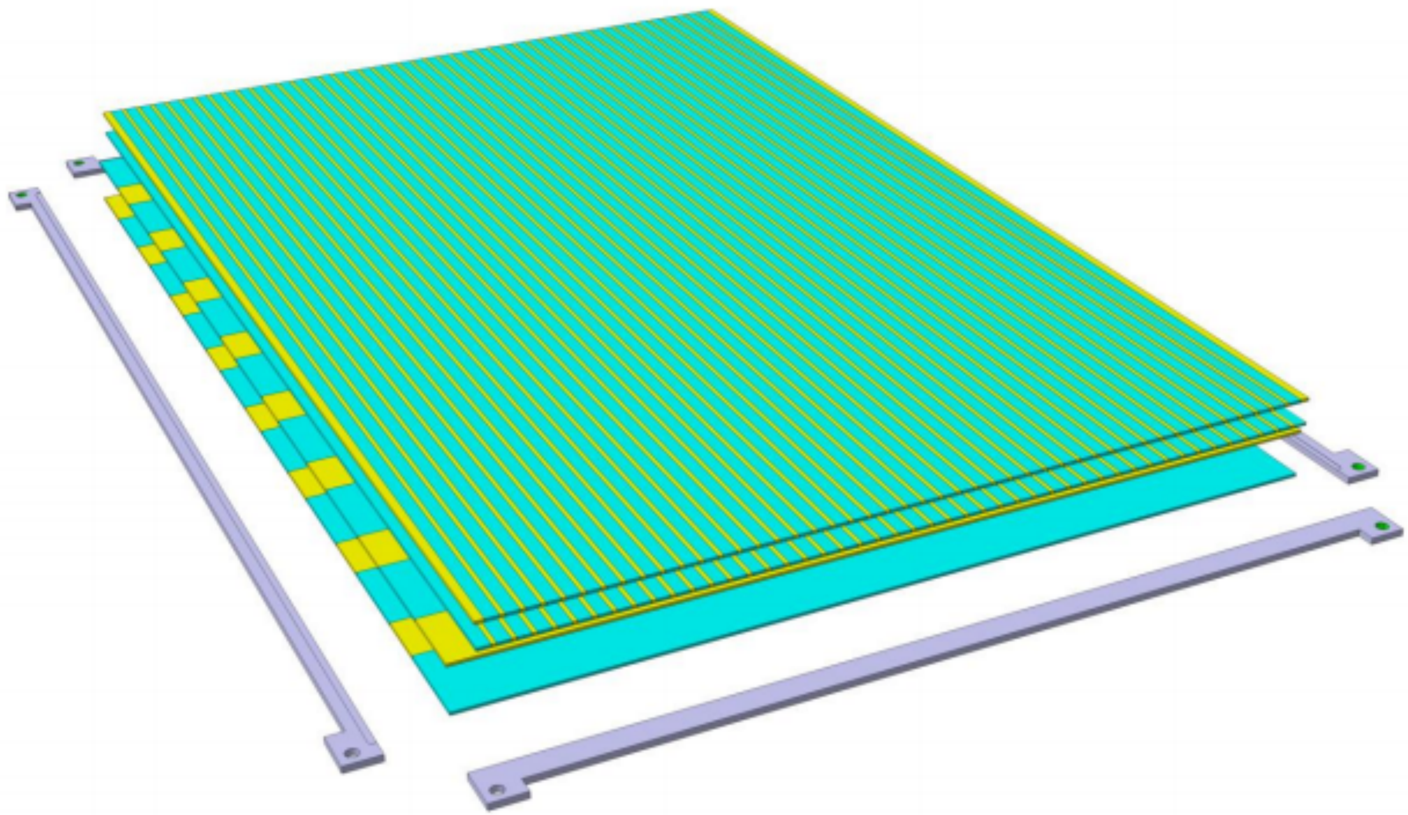
steel module:
50 mm thick:
30 mm Fe
10 mm Al
10 mm insulator + gaps

= 60 mm including tolerances!

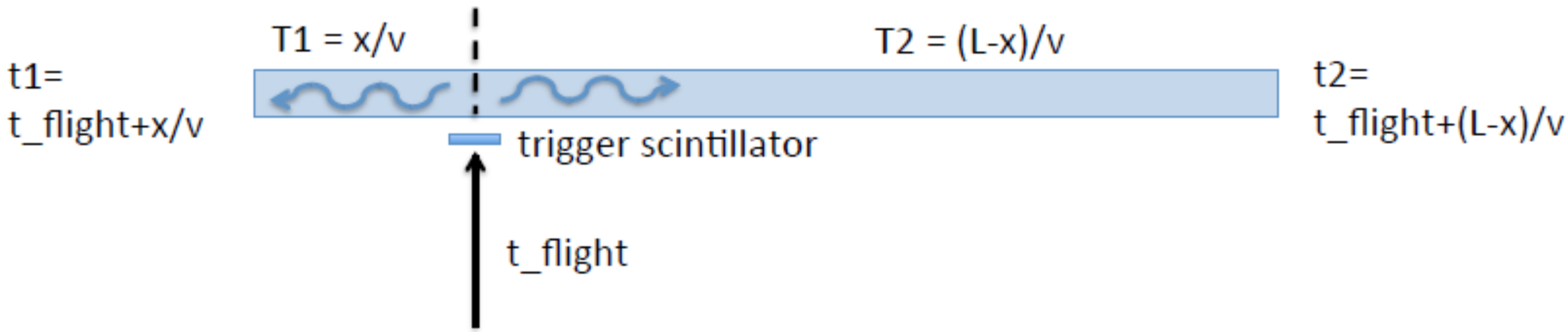


End gap layer#2
Overlap between bars of 2 layers
Bar width
Gap between bars on 1 layer
End gap layer#1
172.7 mm
37.3 mm
210 mm
135.4 mm
172.7 mm
x2 layers of vertical bars:
8 vert. bars/layer
210 mm-wide bars
45 mm overlap between bars of different layers
Plastic scintillator
Empty space (or passive plastic)
1950 mm
2760 mm

View showing horizontal bars



Timing with bars

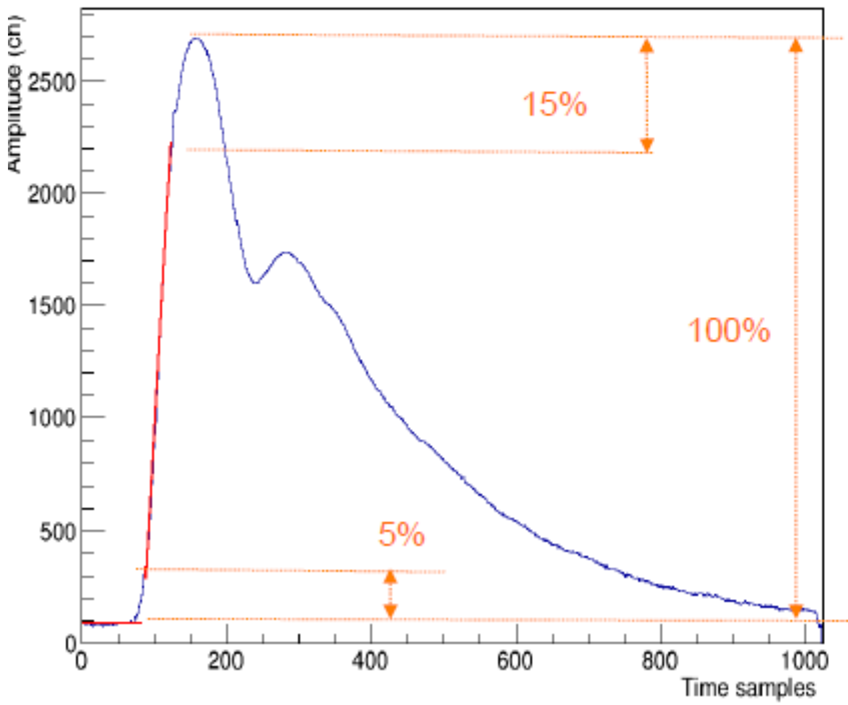


t_flight = (t1+t2)/2 - L/2v

x = ((t1-t2)/2)v + L/2

Calculation of time coordinate

For timing we fit with the straight lines the baseline before a signal pulse and the front of this pulse. Crossing of the lines gives relative time coordinate of the pulse.



Fit area on pulse front is determined in the following way:

1. Pulse height is taken as 100%.
2. First time stamp is at the level of 5% from the baseline.
3. Last time stamp is at the level of 85% from the baseline.
4. All points between first and last time stamps are fitted with the straight line. Typical number of fitted points are 40-50.

The baseline is fitted with horizontal straight line.