Beam monitor for LAPPD testbeam

at CERN PS T10 beamline

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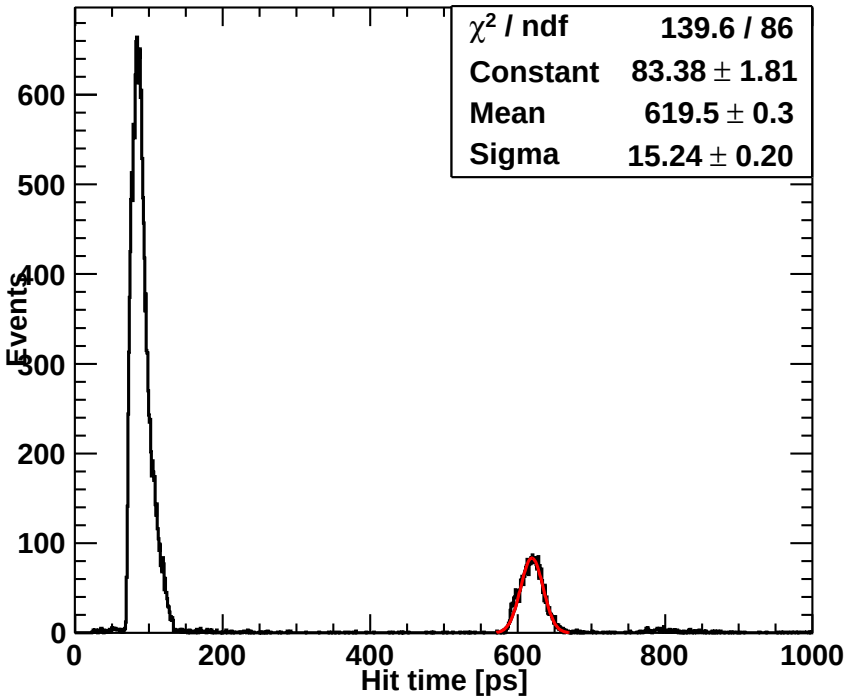
remote

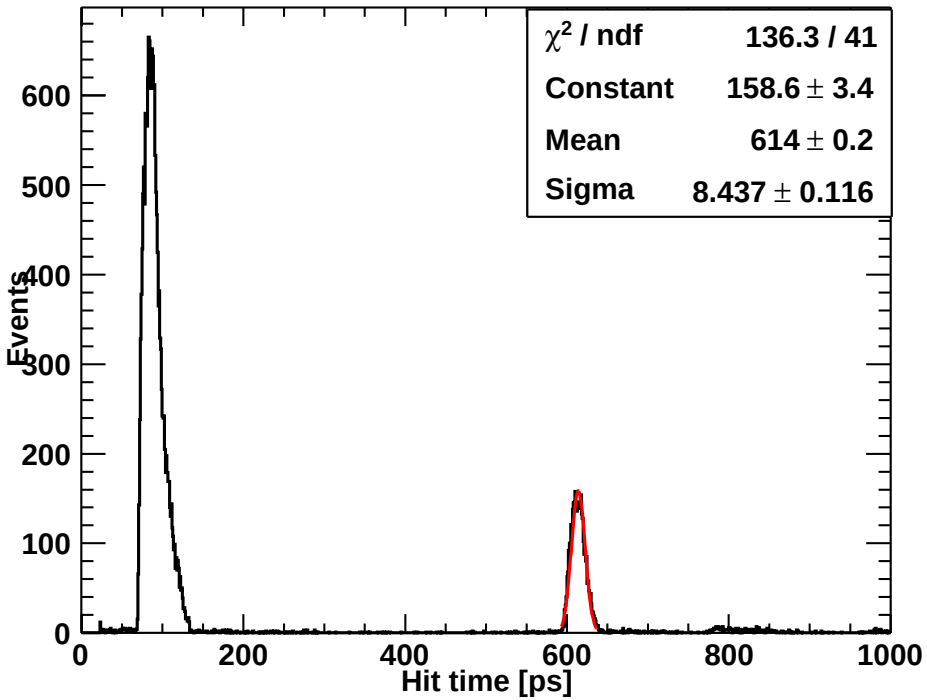
Beam spot size affects timing resolution

- ideal beam spot 0×0: timing RMS of 5 ps,
- (MCP-triggered) beam spot 10×10 mm^2: timing RMS of 15 ps,
- (monitor-selected) beam spot 5×5 mm^2: timing RMS of 8 ps (efficiency 17% of triggers).

beam spot 1 cm^2

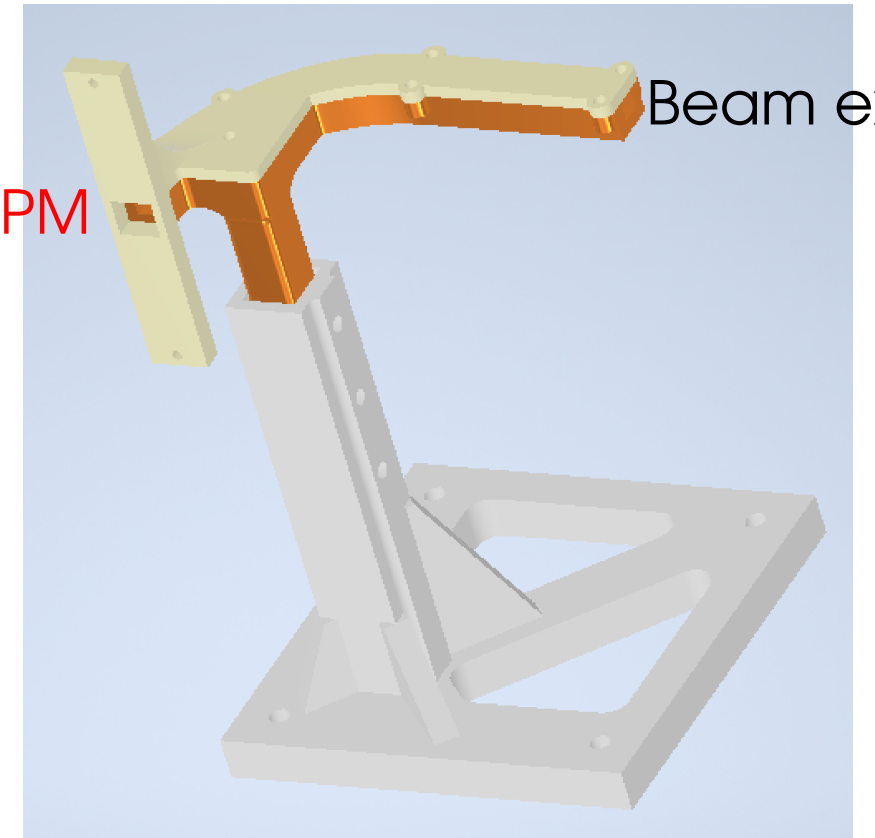


beam spot 0.25 cm^2



Beam monitor

- scintillating fibers: Kuraray 3HF(1500)MJ 0.5 mm Multi-cladding,
- 6×6 mm^2 SiPM readout: Hamamatsu MPPC S13360-6025CS,
- amplifier: INFN,
- support for fibers and SiPM in ABC: 5 cm straight, 5 cm radius.



Number of photo-electrons

- Assuming MIP energy loss 2.2 MeV/cm in the fiber (1.05 g/cm^3) and nominal scintillation photon yield of 8000 ph/MeV the number of produced photons is:

$$\frac{dN_\gamma}{dx} = 1.05 \times 2.2 \frac{MeV}{cm} \times 8000 \frac{ph}{MeV} = 1.85 \times 10^4 \frac{ph}{cm},$$

- assuming 5 cm track length, light collection efficiency 2.5% (nominal 5.4%) and the nominal SiPM PDE 25% we obtain:

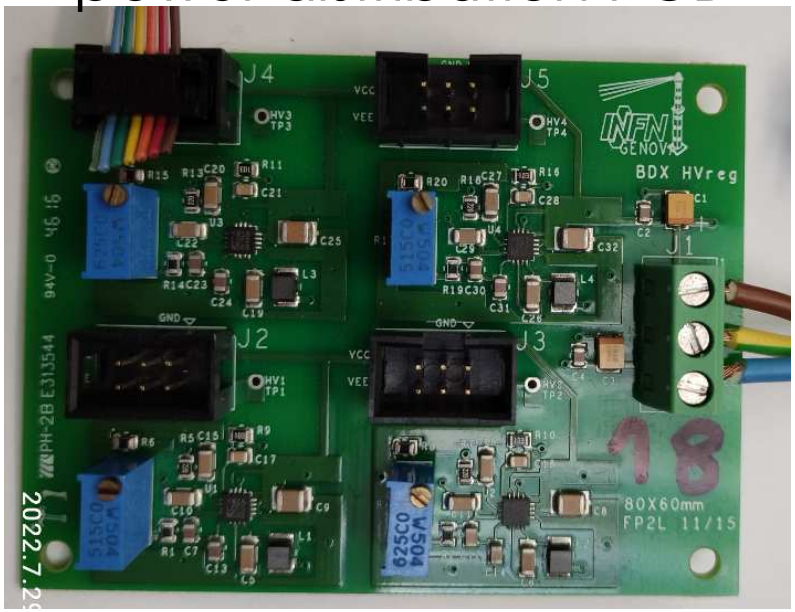
$$N_{p.e.} = 5\ cm \times 1.85 \times 10^4 \frac{ph}{cm} \times 0.025 \times 0.25 = 575\ p.e.,$$

- using S12572-100C SiPM we measured 10 mVpp/p.e. signals, with 20 ns risetime and 150 ns pulse duration. With larger S13360-6025CS SiPM featuring 4 times lower gain and 4 times larger capacitance we expect 2.5 $mVpp/p.e. \times 575 = 1.4$ V signals (amplifier saturation 1.5 V).

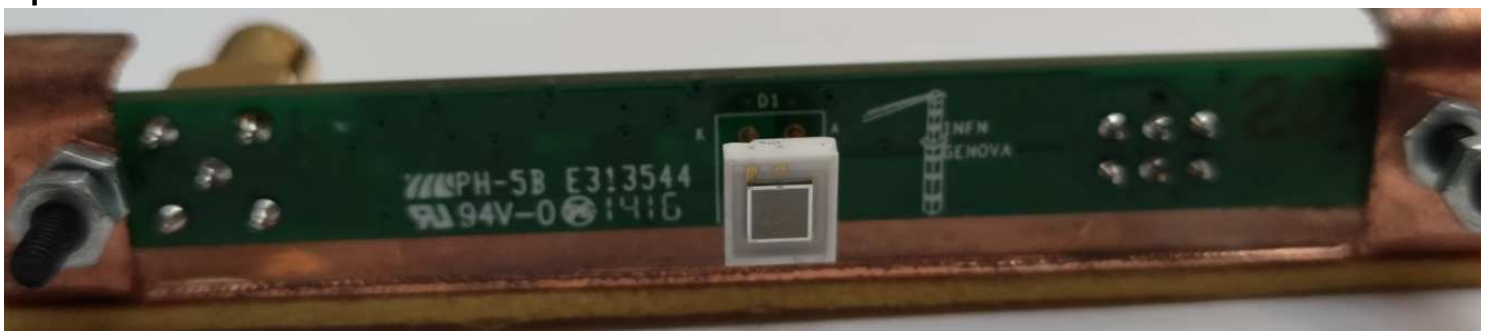
Transimpedance amplifier

1. power supply: +5 V and -5 V,
2. SiPM mounted on amplifier,
3. Lemo output connector.

power distribution PCB

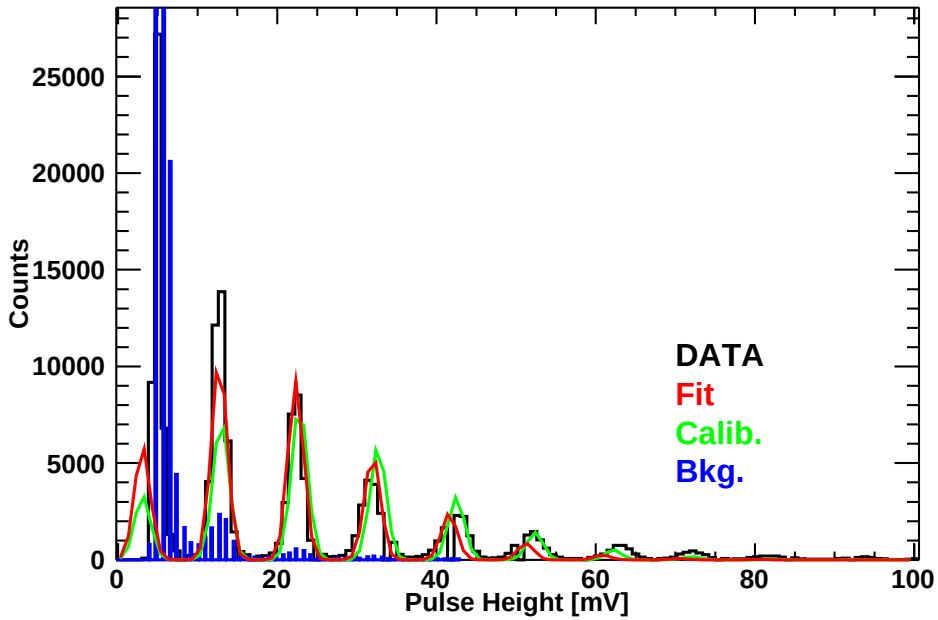


amplifier

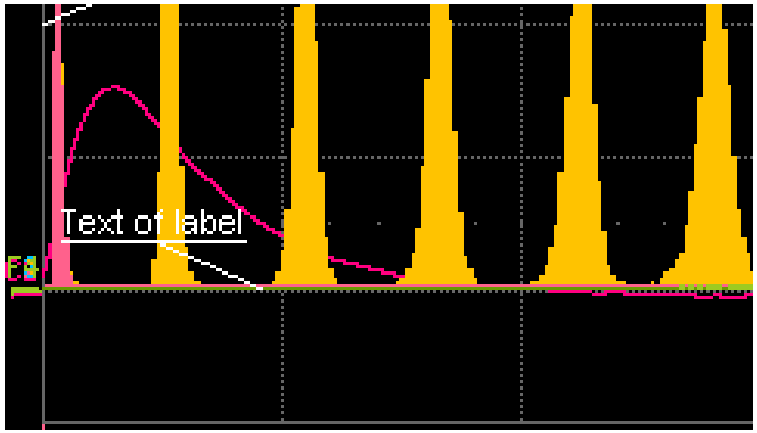


Previous measurements

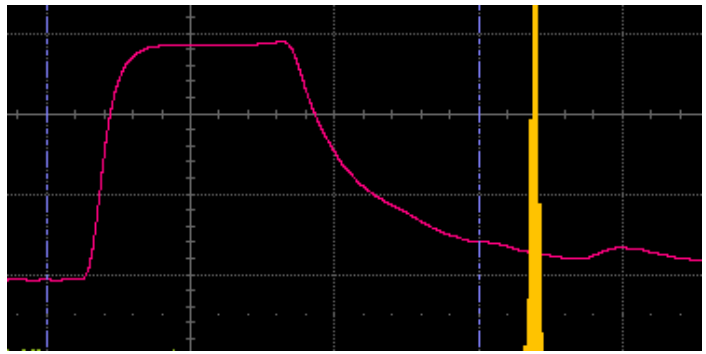
1. gain 10 mV/p.e.,
2. risetime 20 ns,
3. falltime 100 ns,
4. saturation at 1.5 V,
5. for S13360-6025CS SiPM expect 2.5 mV/p.e..



50 mV/100 ns



500 mV/100 ns



Summary

- we must put beam profile monitor 5x5 mm^2 in front of trigger MCP,
- prototype using 10×10 0.5 mm scintillating fiber bundle is designed;
- expected 575 photo-electrons/proton;
- this signal must be acquired in TR2 channel of V1742 digitizer for off-line event selection;
- although risetime is slow: 20-30 ns, but S/N is perhaps of the order of 10^3, thus its timing resolution is about 30 ps,
- plan to reduce risetime by gain reduction,
- can be used along with MCP as the time reference.

References

1. M. Amarian *et al.*, "The CLAS forward electromagnetic calorimeter", *Nucl. Instr. and Meth.* **A460**, 239 (2001).
2. M. Guillo, "EC Time Calibration Procedure for photon runs in CLAS", CLAS-Note-2001-014, 2001.
3. M. Osipenko, "Geometrical alignment of CLAS DCs using tracks with constrained vertex", CLAS-Note-2019-001, 2019.

Backup slides

Lateral hits

- about 30% of selected protons (12.5% of all), passing at curved side of the monitor will give a reduced signal,
- curvature radius 50 mm (100 fiber diameters),
- for these events average traversed thickness is about 17.5 mm, or 35% of 50 mm.
- thus we expect lateral hits to give $< 1/3$ of nominal signal,
- because of high number of p.e. (4% uncertainty) nominal signal and lateral should be separated by 16 RMS.