Timing studies for the TOP calibration system in Torino

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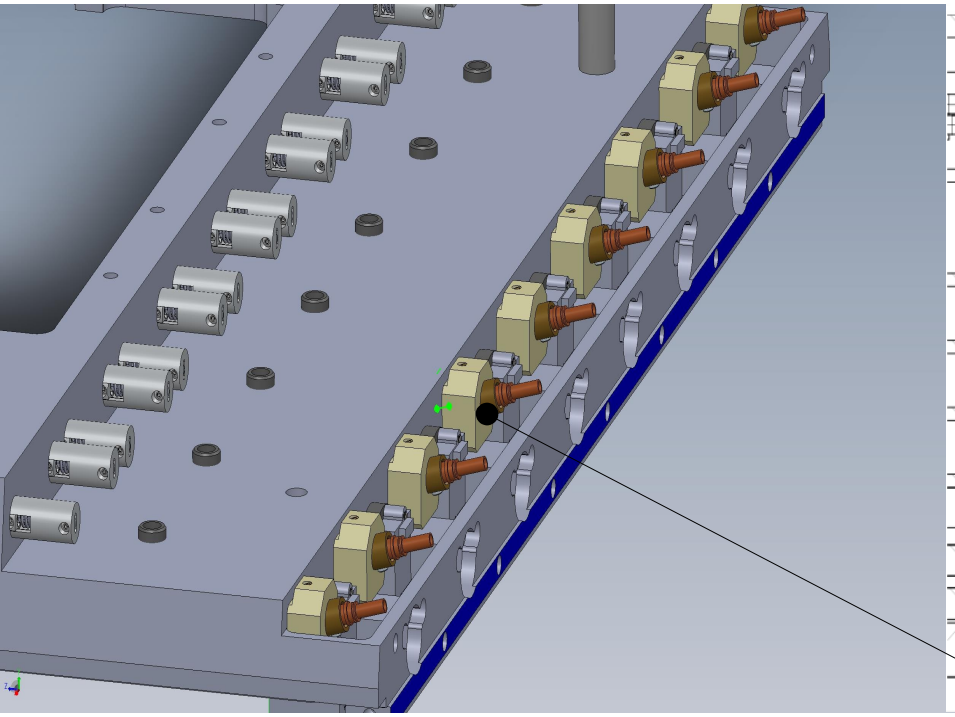
TOP laser calibration

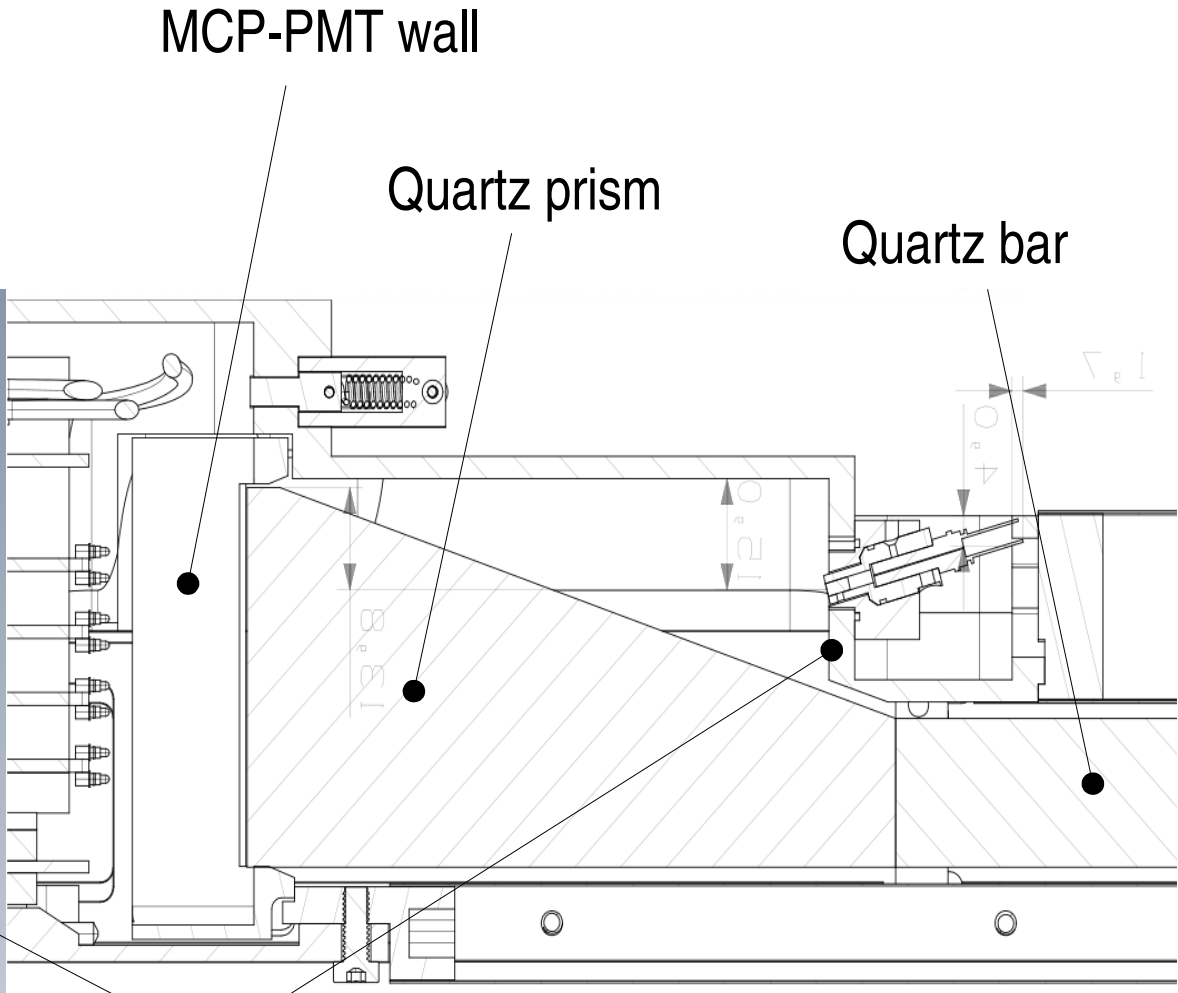
The TOP readout ASIC (IRS3X) needs to be constantly calibrated along time in order to assure the <100 ps resolution on single photons

Laser calibration system is needed

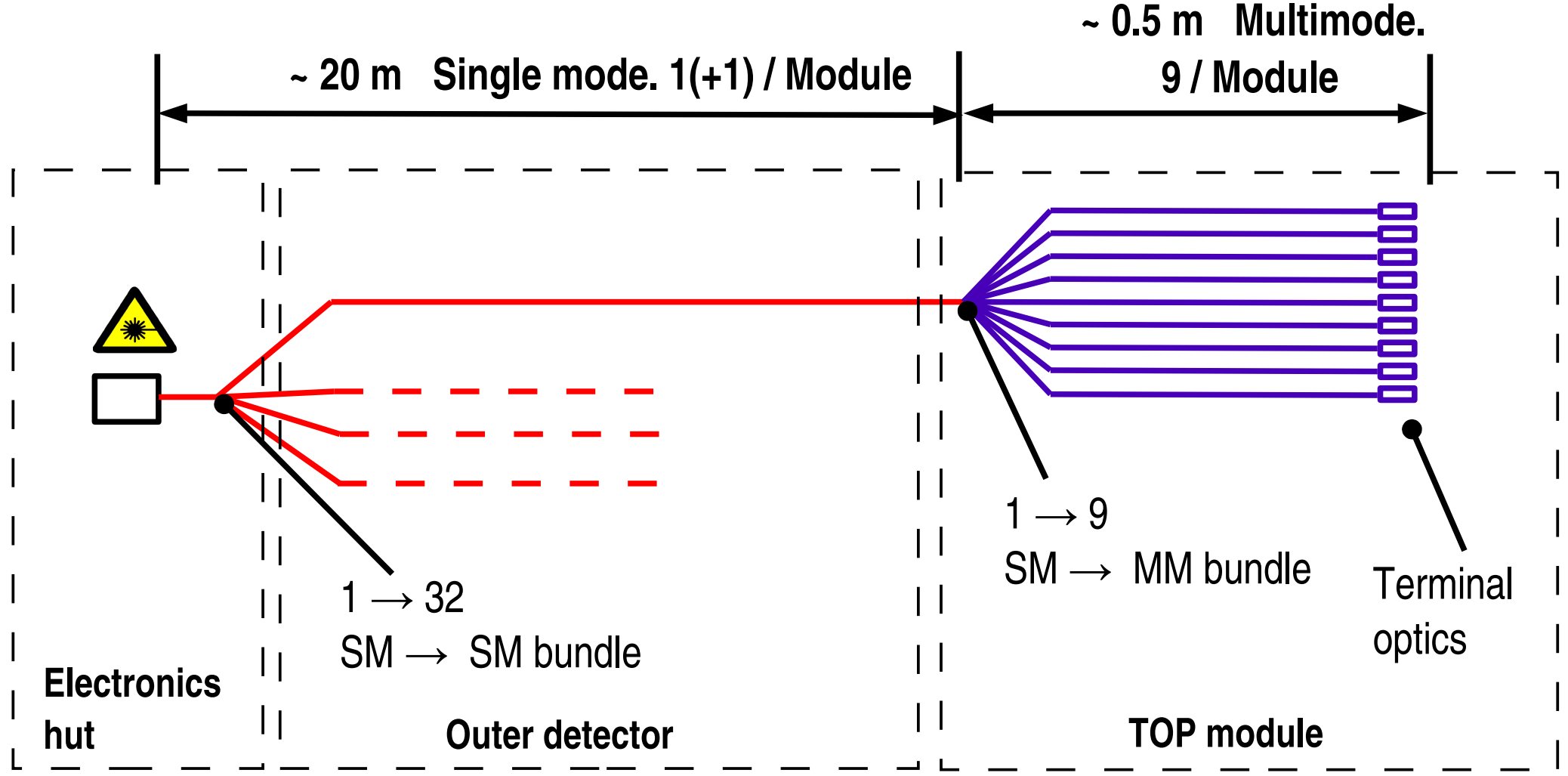
→ <<100 ps pulse stability

→ 9 sources each bar





Light distribution



Tasks in Torino

→ Time resolution of the calibration system
→ SM → SM bundle
→ MC simulation

Tasks in Padova

→ SM → MM bundle
→ Terminal optics
→ Light injection mechanics
→ Radiation tests

Equipment in Torino

Hamamatsu 16 ch MCP-PMT (same model used for the TOP)
Readout board with prototype of the custom amplifier (G. Visser, Indiana Univ.)
Black box (45 x 45 x 45 cm)
Black box with optical bench (90 x 70 x 50 cm)

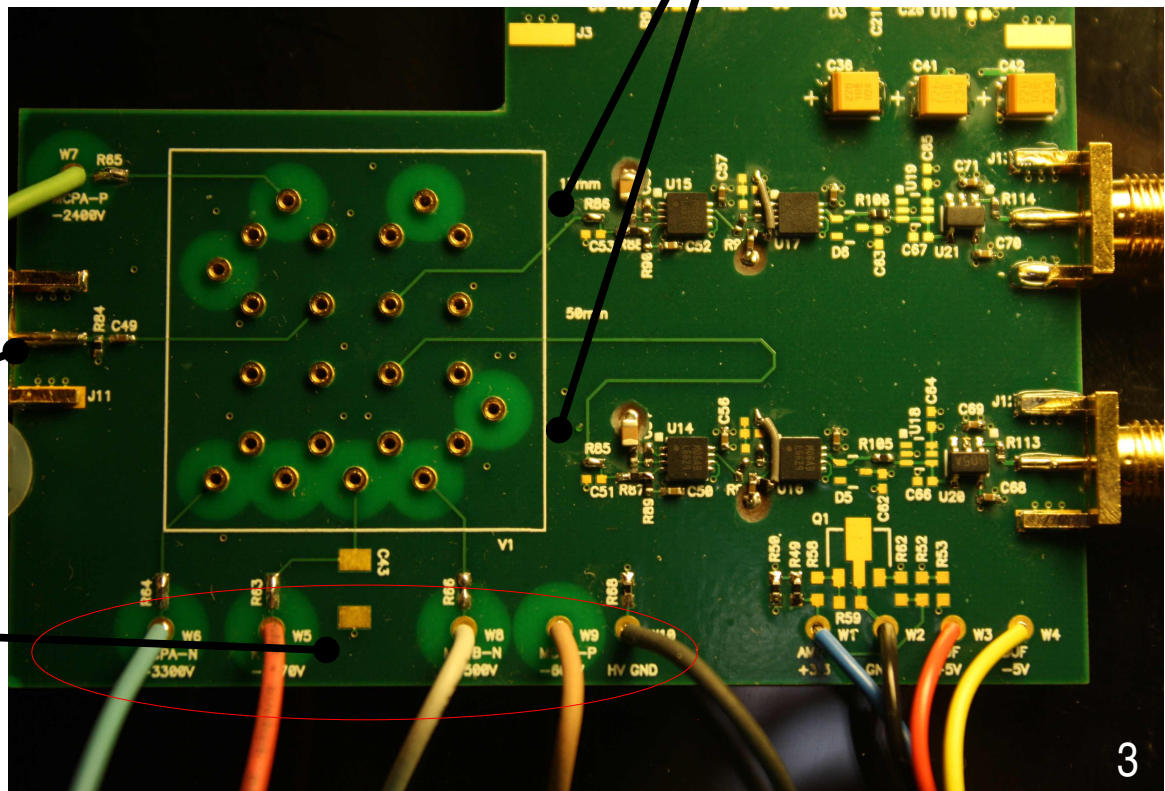
Picolaser
$\lambda = 405 \pm 2$ nm
Time Jitter < 20 ps with internal clock

LeCroy 4ch scope WaveRunner 625zi
BW = 2.5 GHz
Sampling rate = 0.2 – 40 GS/s

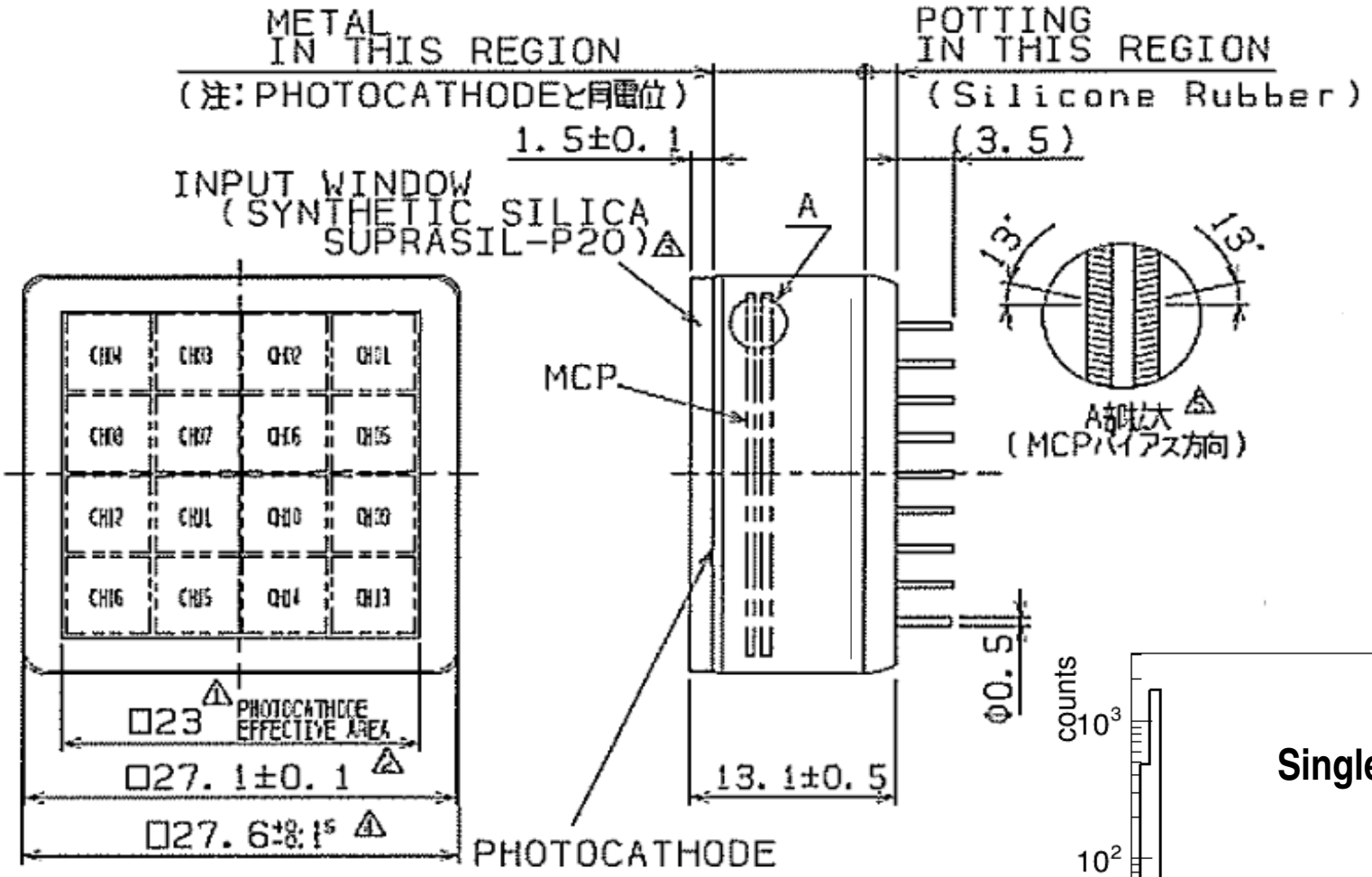
Amplified channels

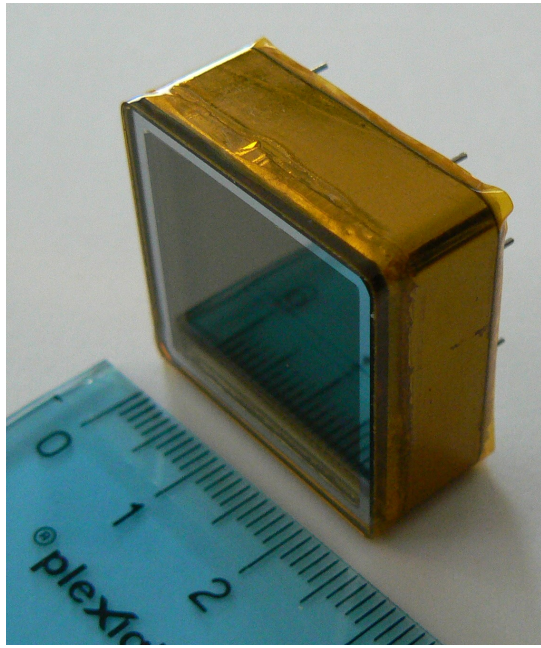
Bare channel

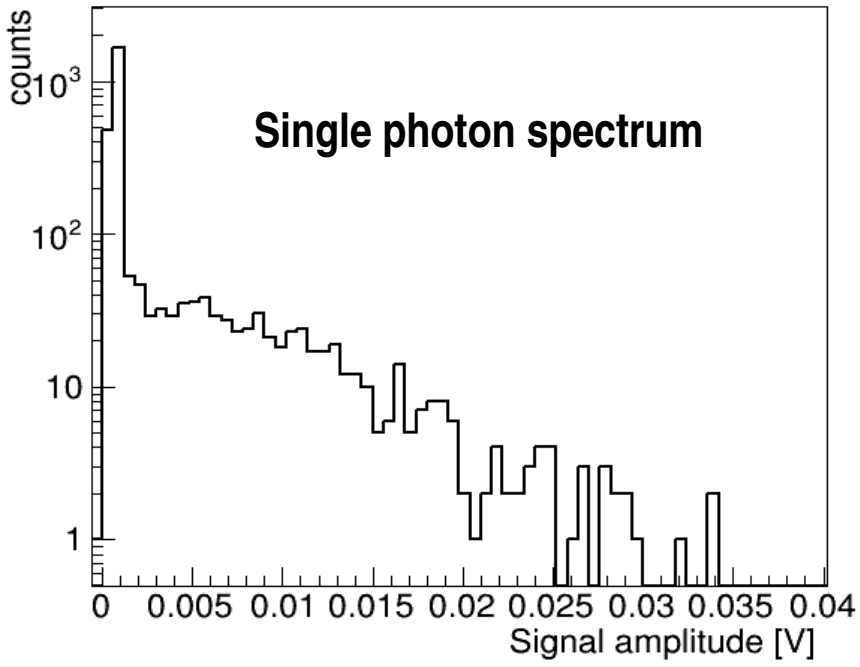
PMT HV supply



MCP-PMT in a nutshell





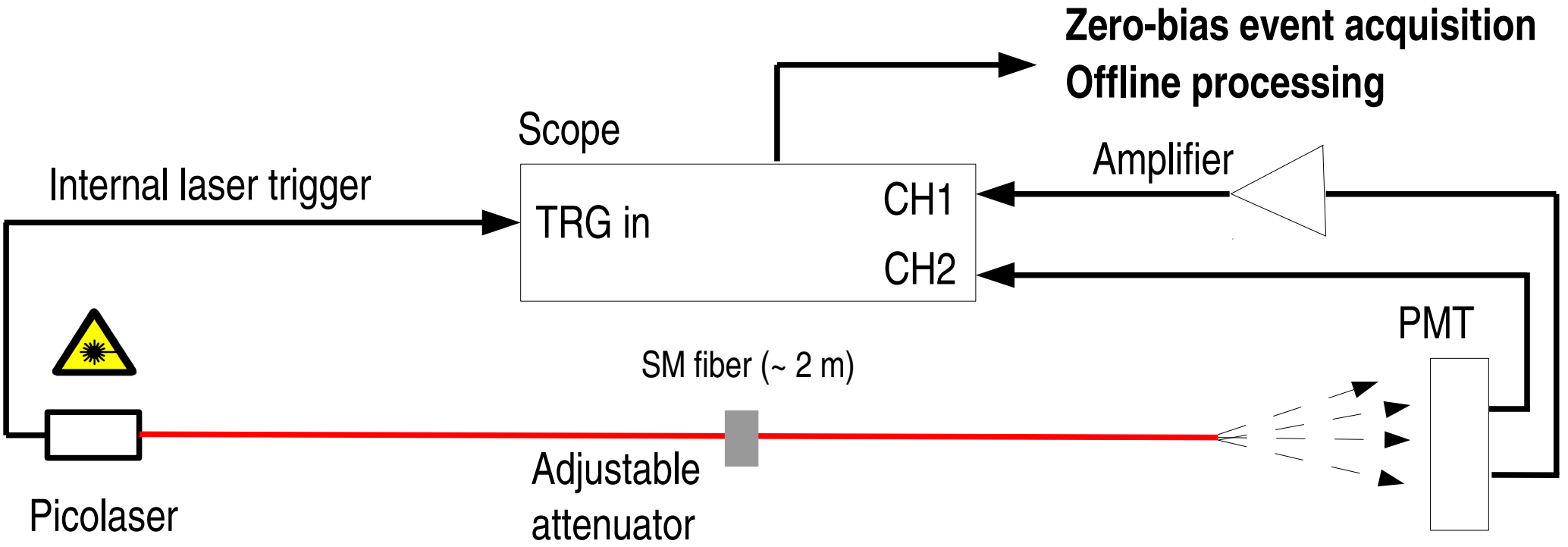


Fast response, high time resolution

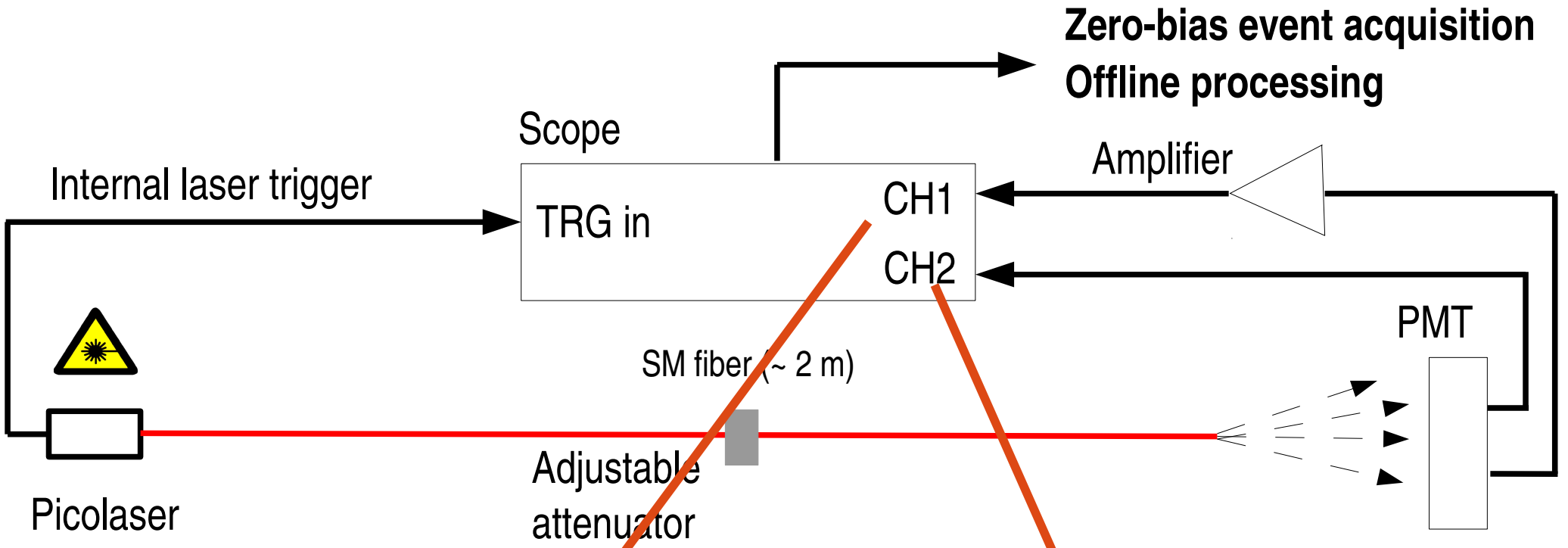
Gain 10^5 -10^6

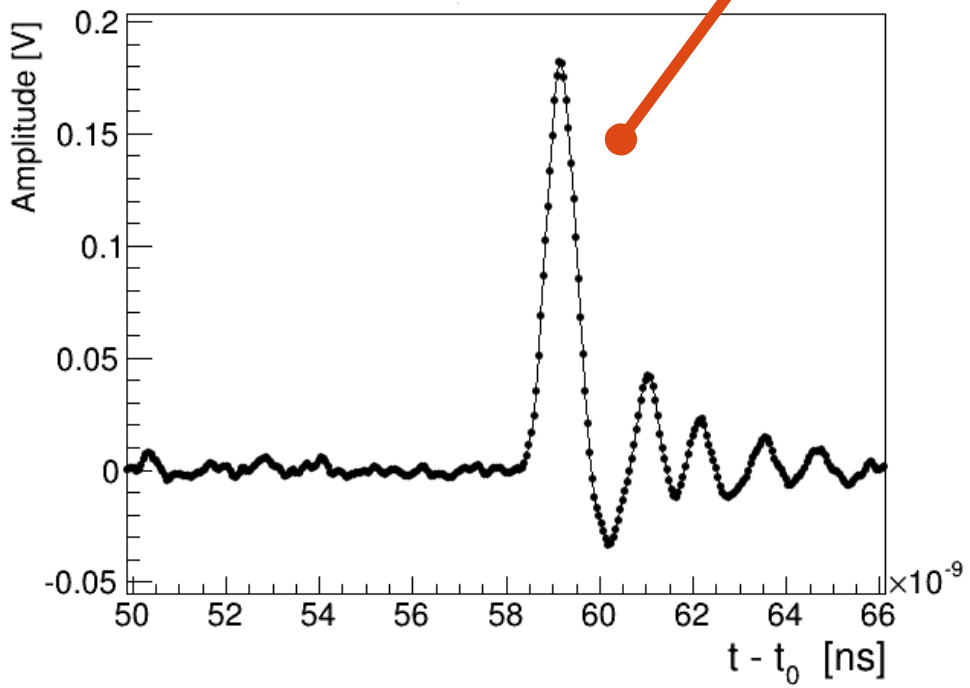
Bad energy resolution

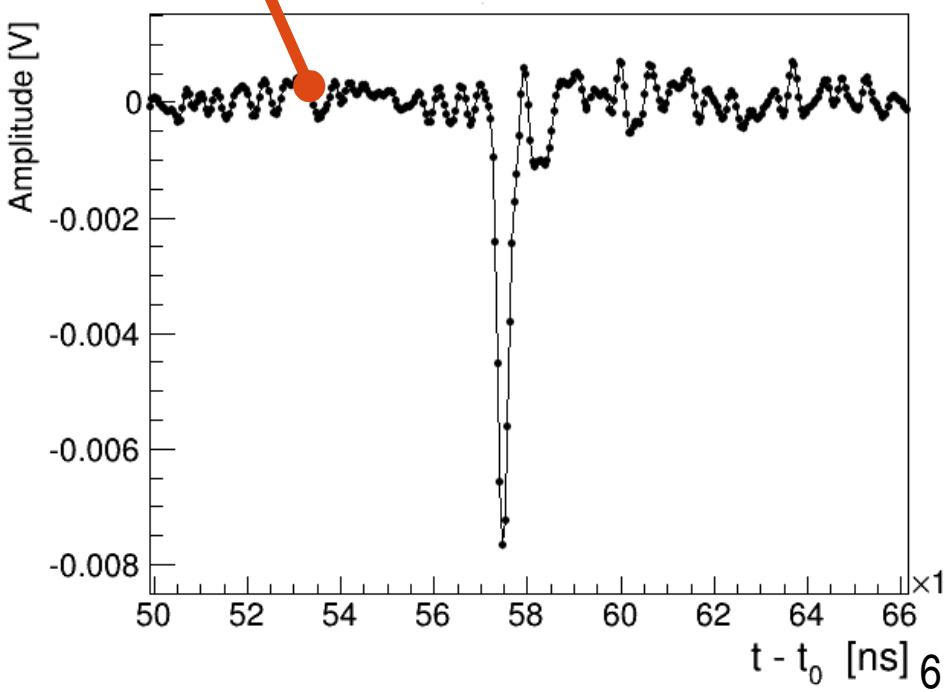
Experimental setup in Torino



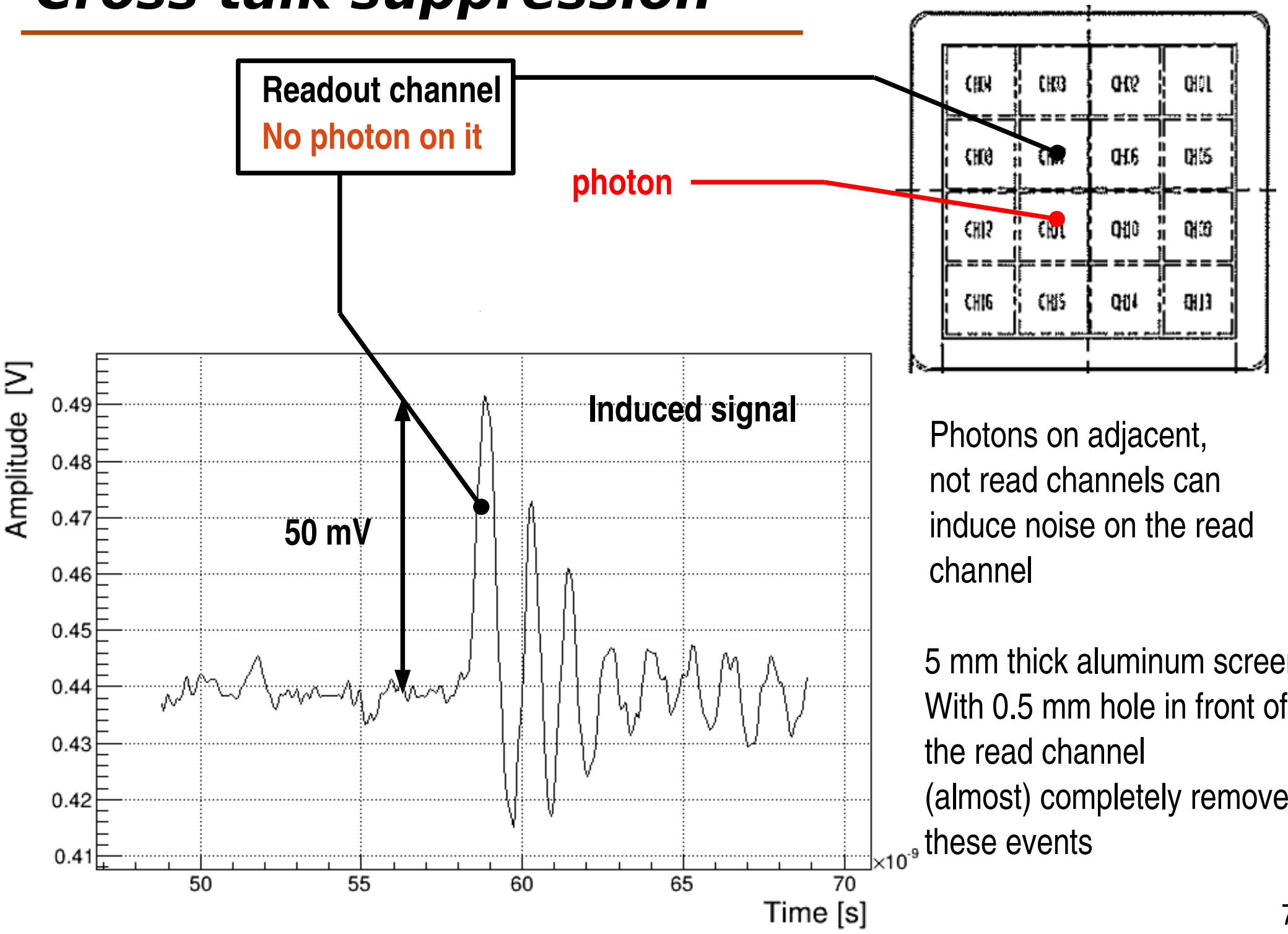
Experimental setup in Torino







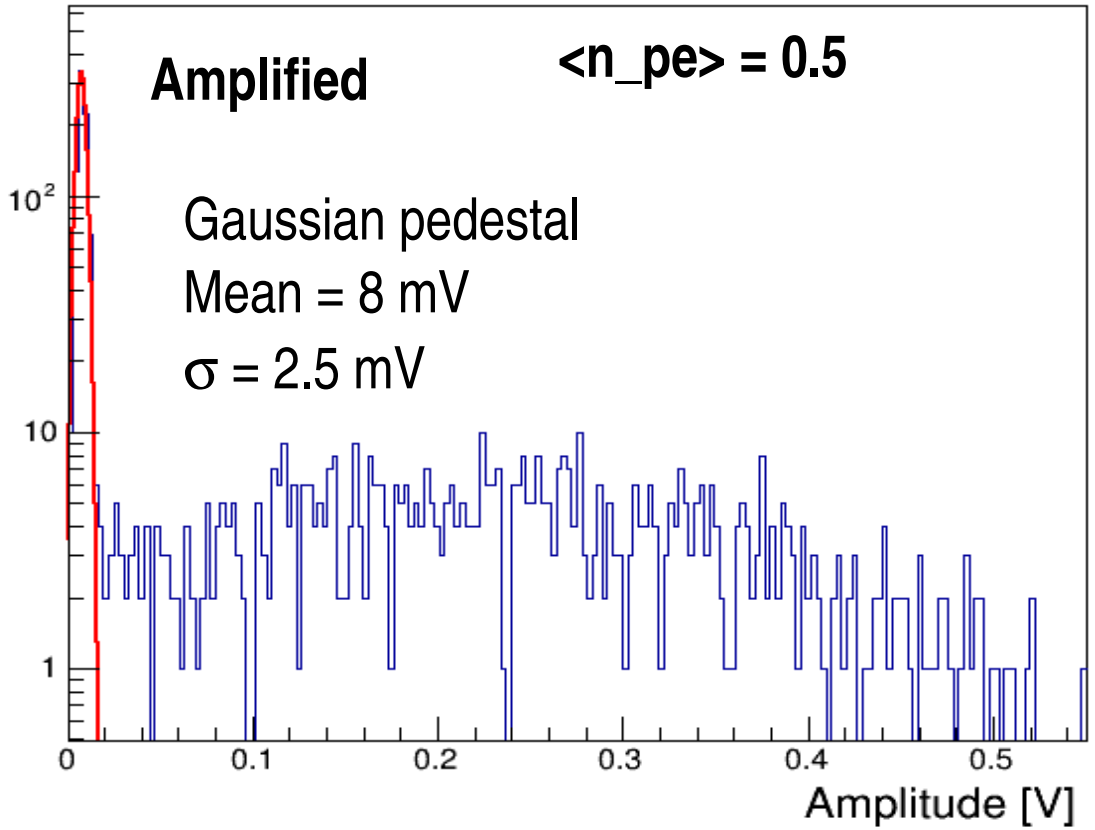
Cross talk suppression



Photons on adjacent, not read channels can induce noise on the read channel

5 mm thick aluminum screen With 0.5 mm hole in front of the read channel (almost) completely remove these events

Signal amplitude



Amplitude of the highest peak in the trigger

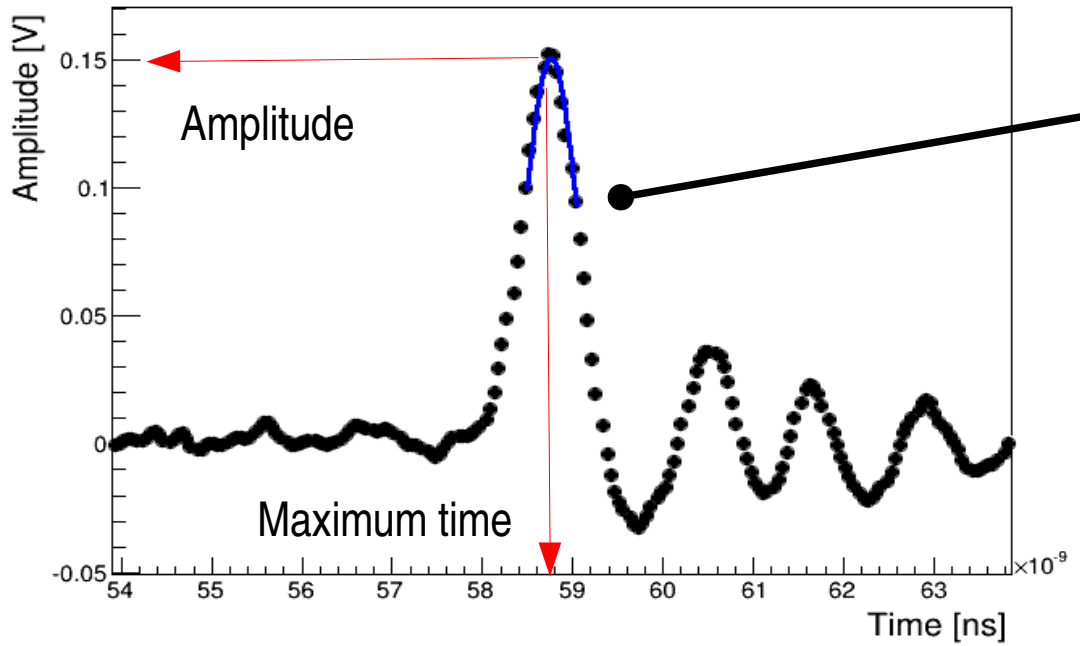
Thresholds are applied in the signal processing in order to reject the pedestal

V_trh(amplified) ~ 50 mV
V_trh(not amplified)]~ 2 mV

Gaussian fit of the pedestal provides an estimation of the number of photoelectrons

Signal processing – I

DC offset is subtracted fitting the first points of the waveform

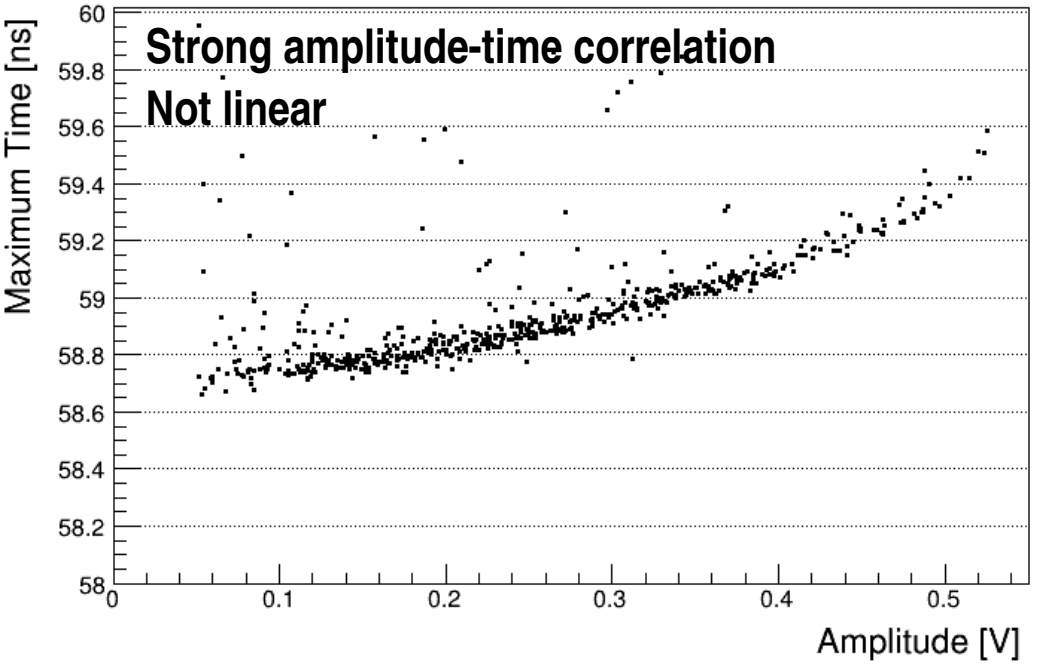


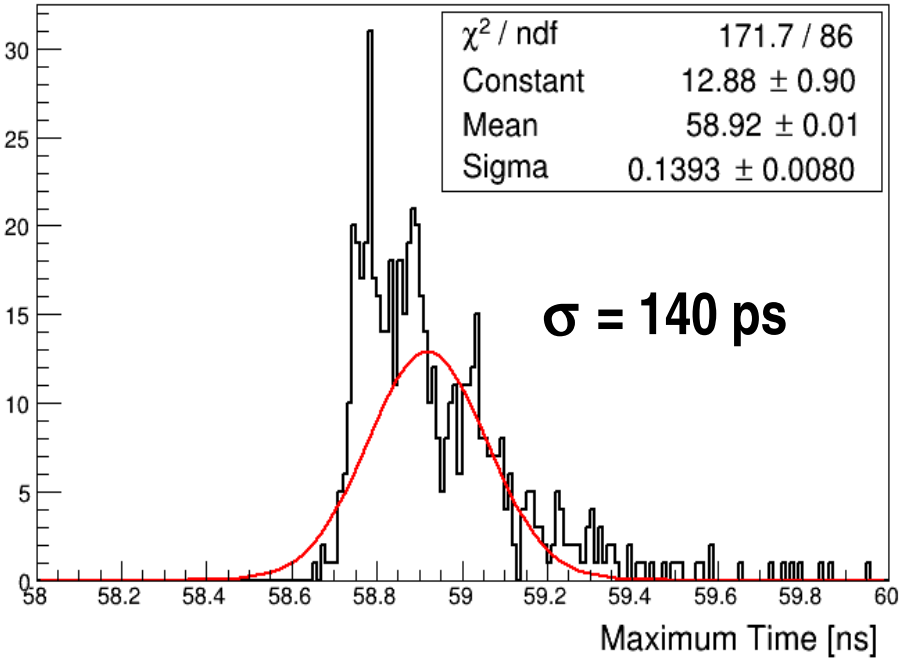
Gaussian fit around the maximum Point.

Determination of:

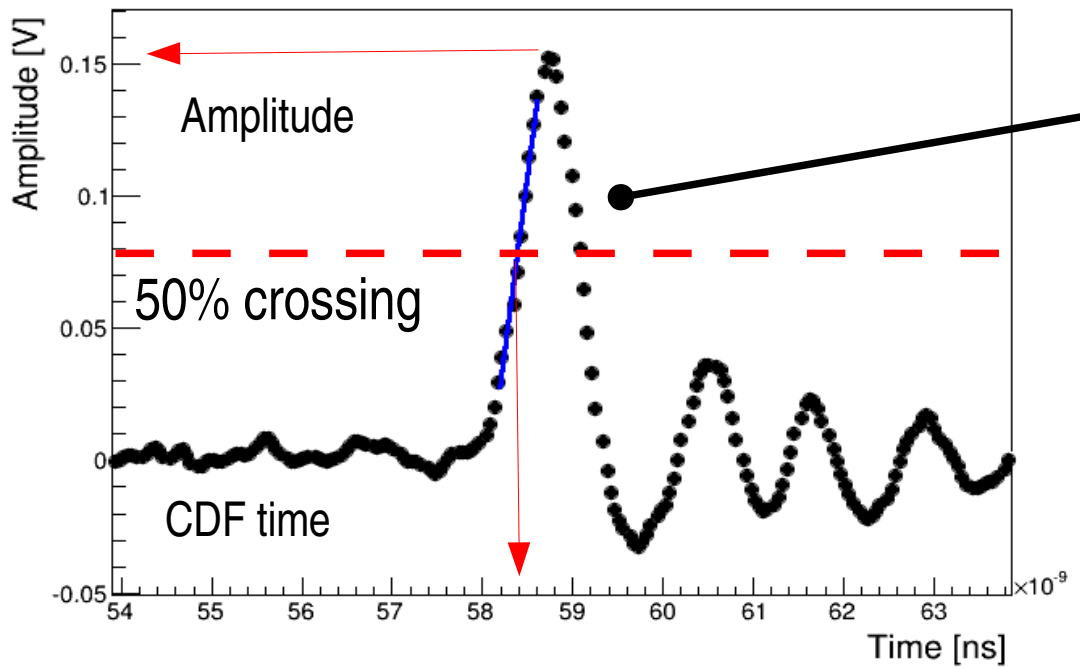
→ Signal amplitude

→ Maximum time





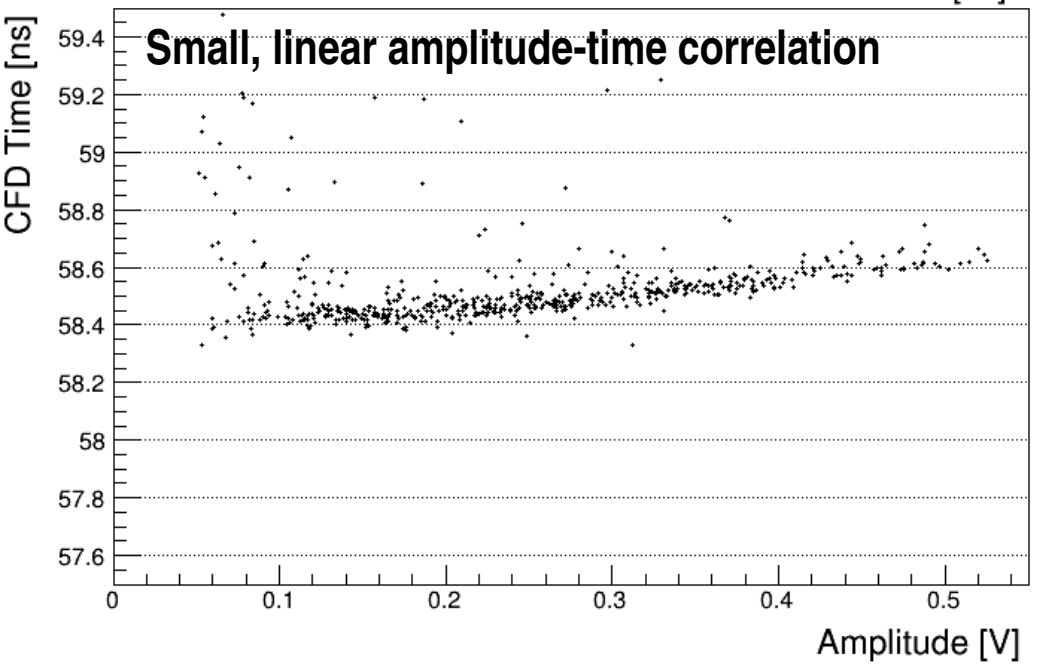
Signal processing – II

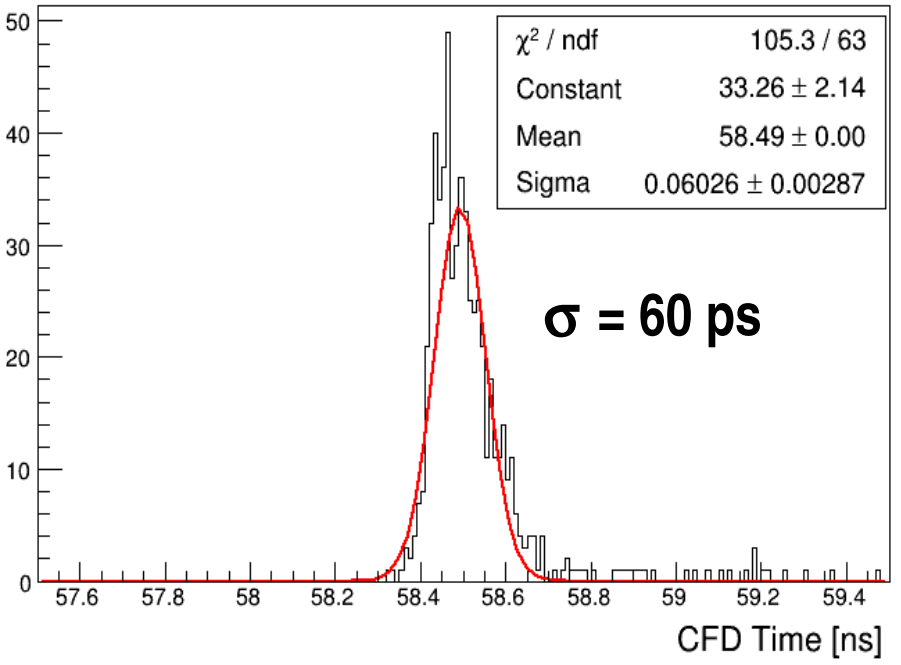


Linear fit around the 50% crossing

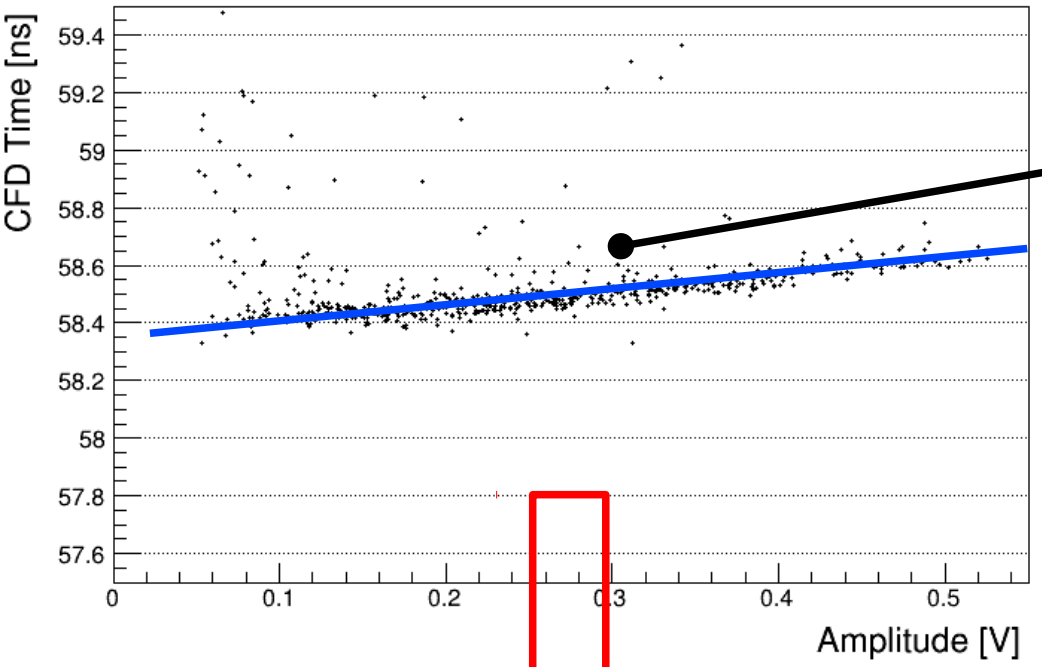
Determination of:

→ 50% crossing time (CFD time)





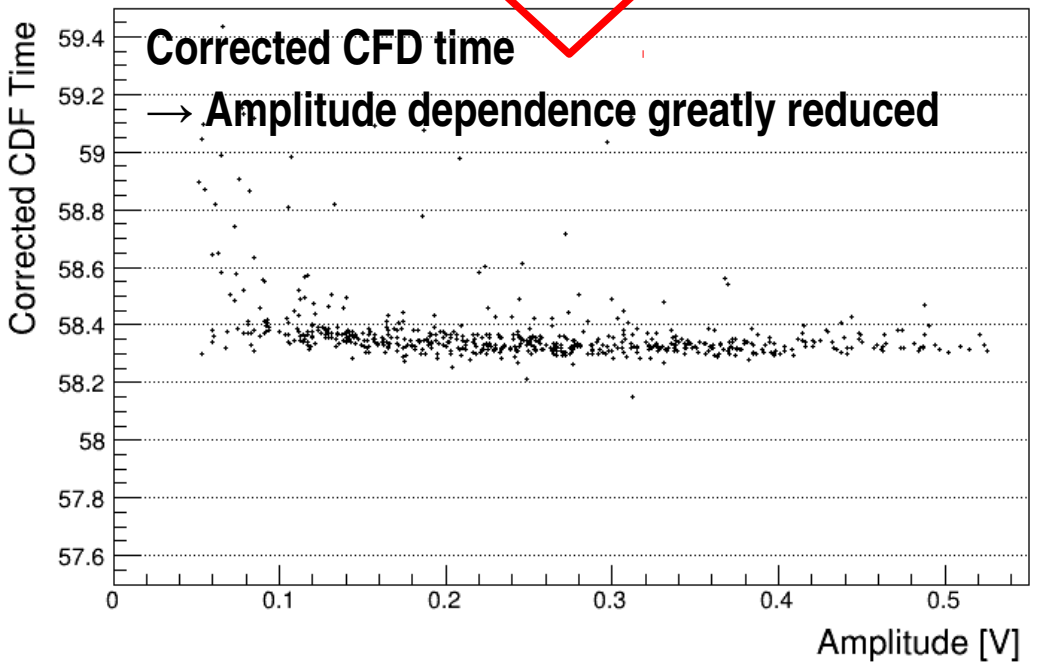
Signal processing – III



Linear fit of the Amplitude VS CFD time Distribution

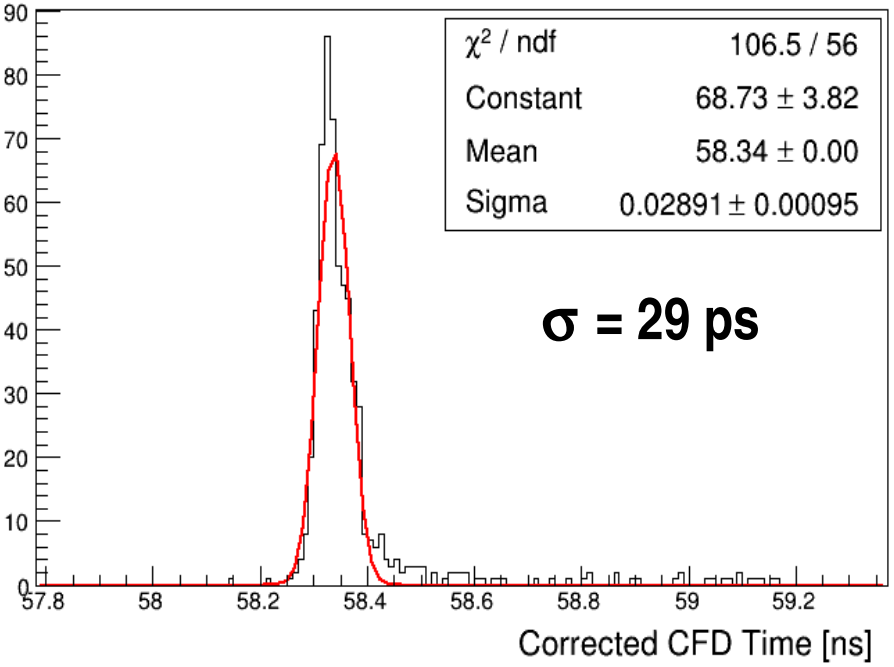
Determination of:

→ corrected CFD time



Corrected CFD time

→ Amplitude dependence greatly reduced

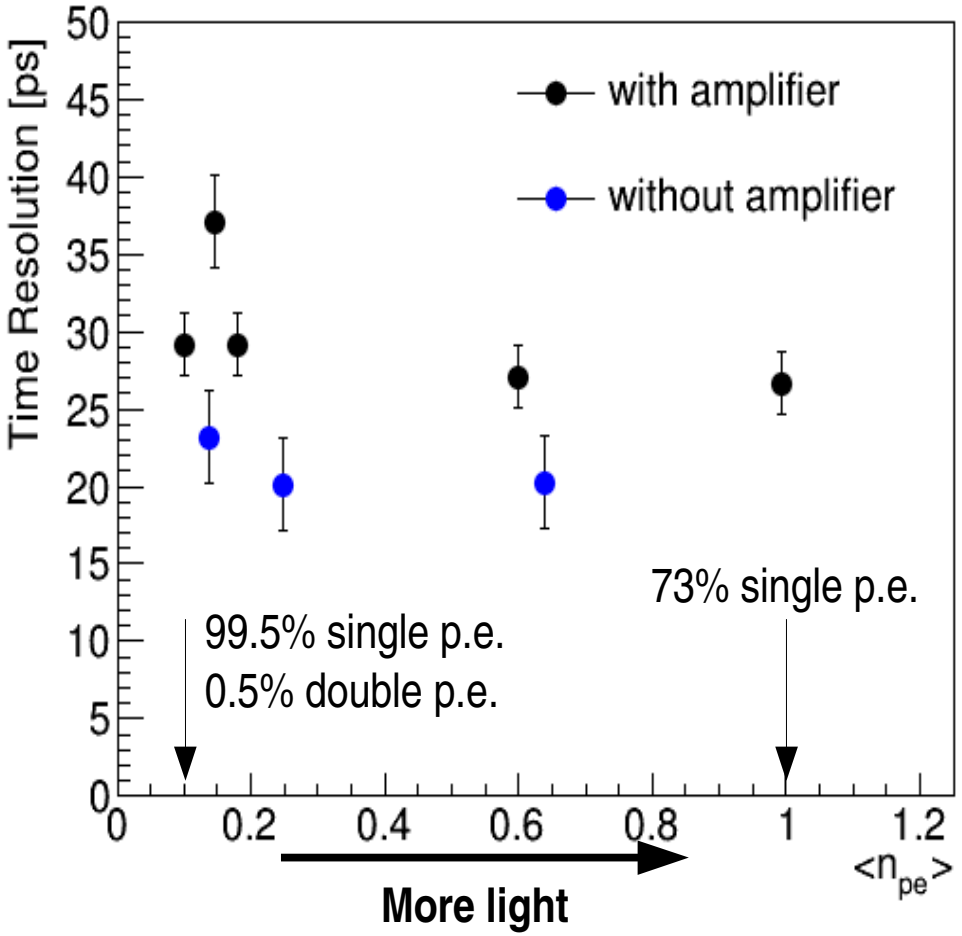


σ = 29 ps

Results

Time resolution study repeated for different laser tunings and different HV values

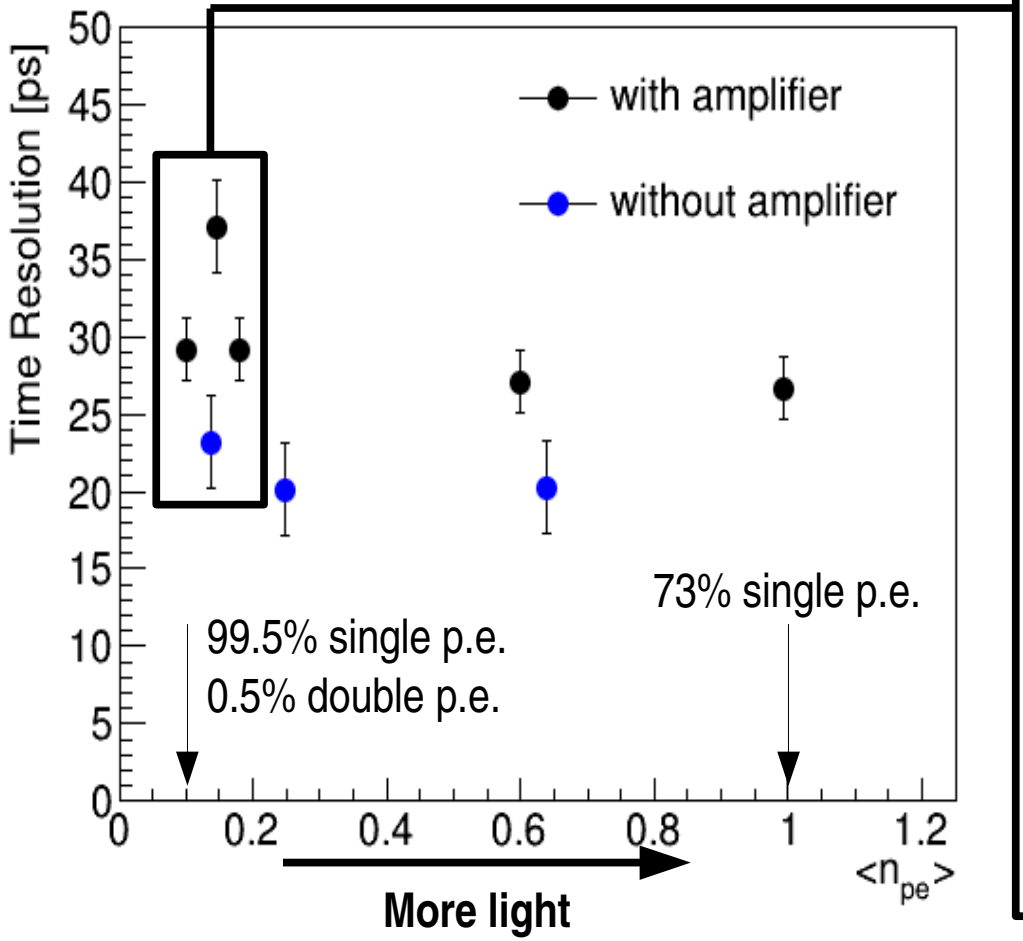
From <n_pe> the contamination from > 1 photoelectron events can be calculated

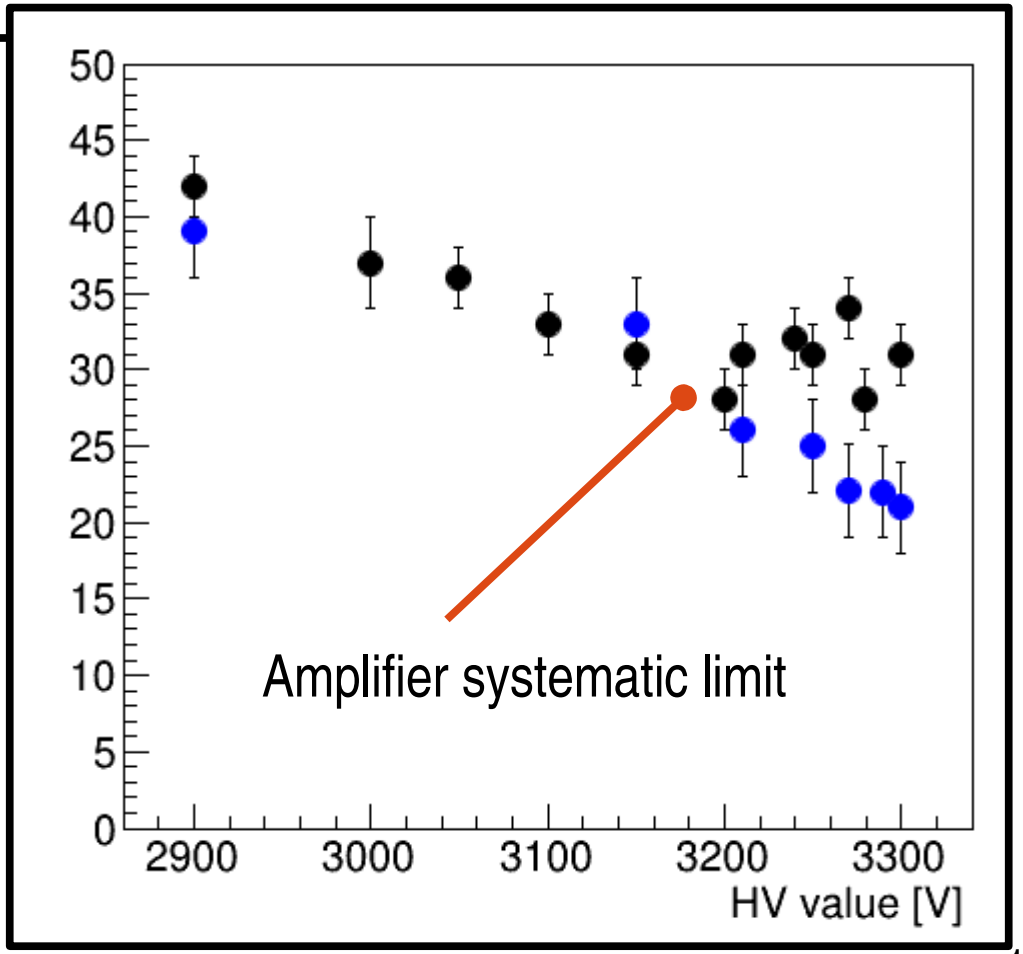


Results

Time resolution study repeated for different laser tunings and different HV values

Resolution is expected to drop with reduced gain
→ only one study is available so far
→ confirmation is highly desired



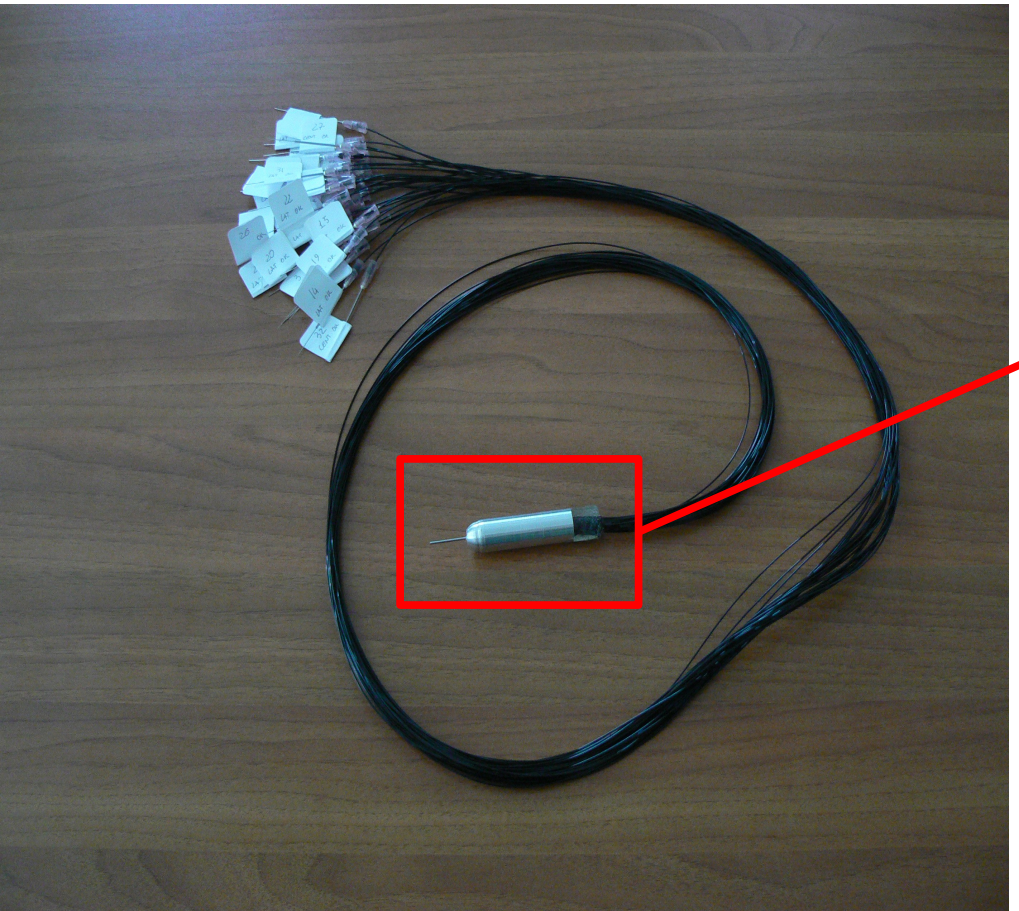


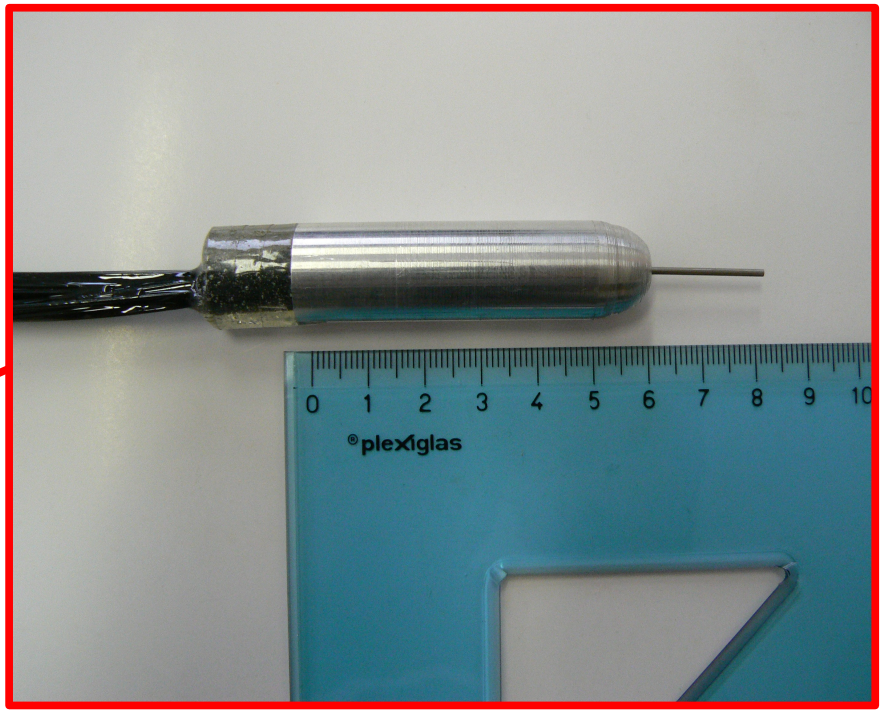
Bundle prototype

With a < 30 ps time resolution over a wide range of conditions, we are getting ready for Testing an SM bundle prototype produced in INFN-TO workshop by Oscar Brunasso

λ = 405 nm $\rightarrow$ Cladding = 125 um
Core = 4 um

Prototype: 32 fibers x 1.5 m





Bundle's head hosting 32 fiber cores

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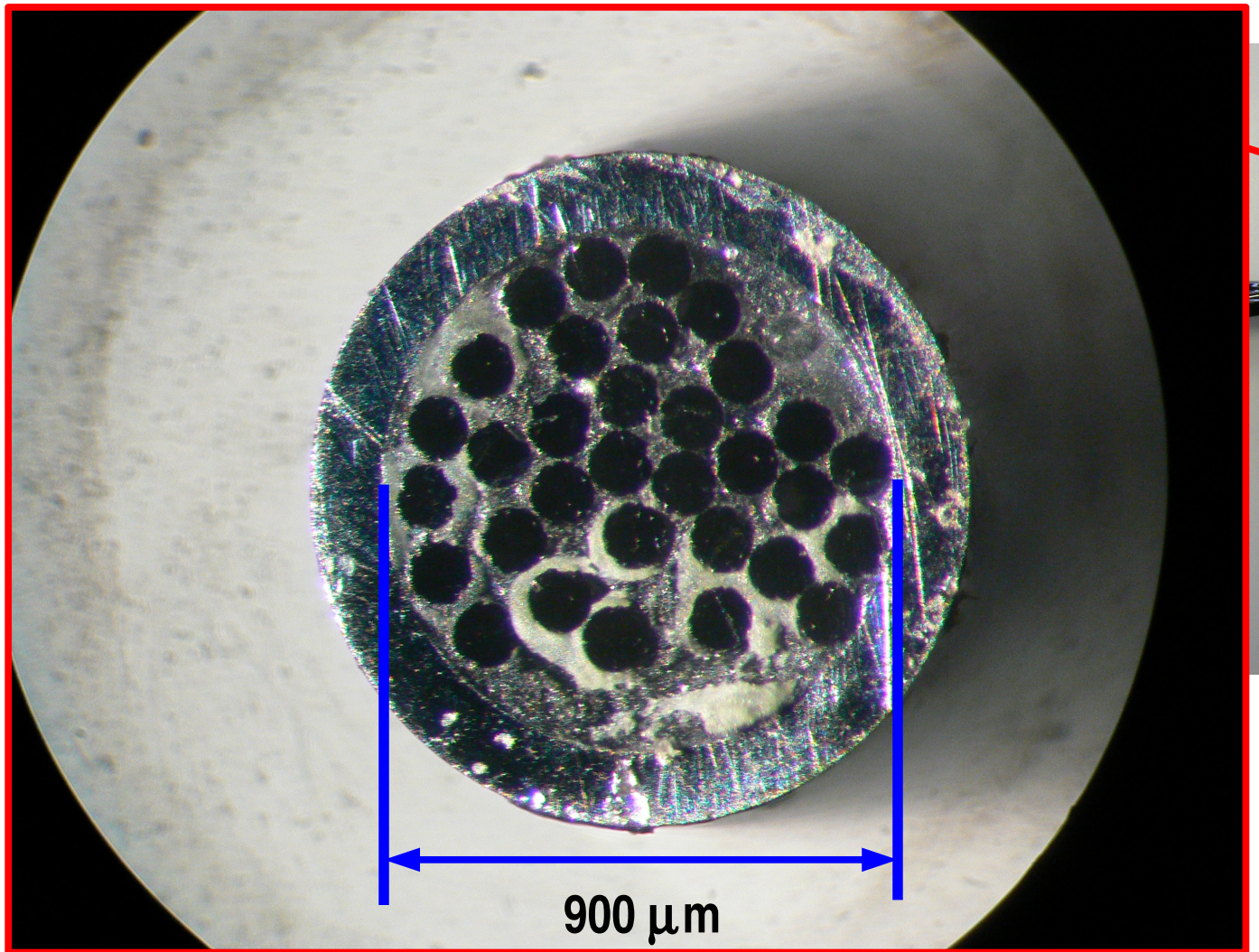

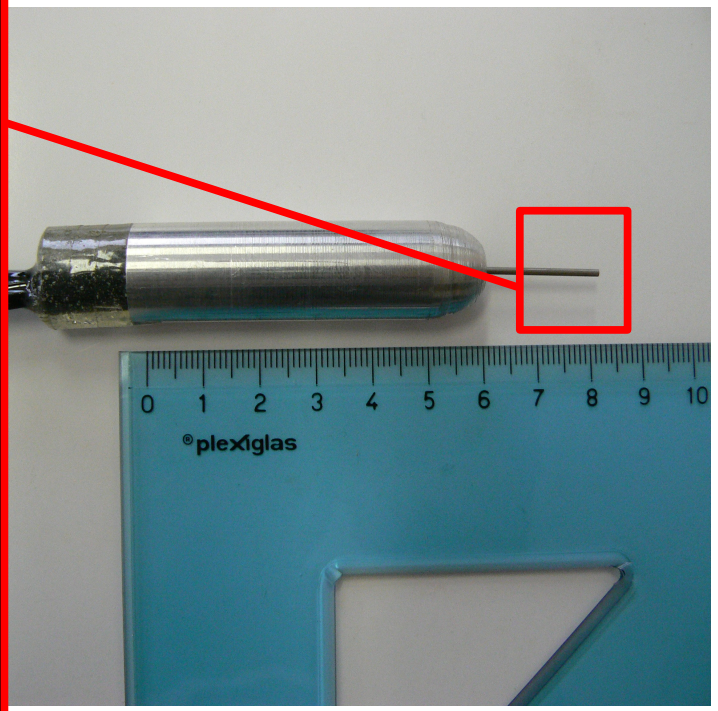

Bundle's head
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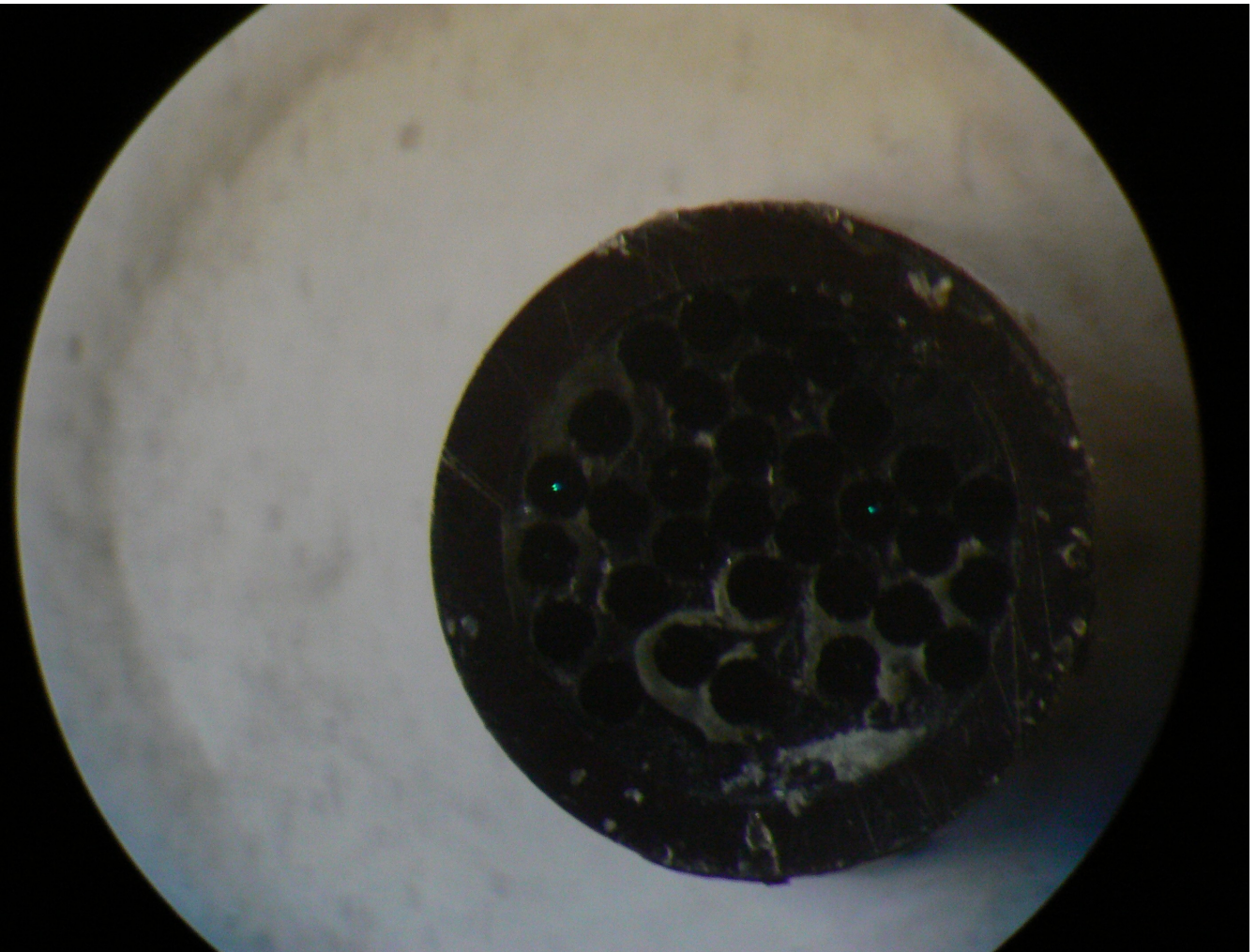


Next steps:

$\rightarrow$ Determine piping efficiency
$\rightarrow$ Check time resolution VS radial position in the bundle

Conclusions

Time resolution < 30 ps with offline CDF

→ Goal resolution for the validation and test of the calibration system

→ Torino can effectively contribute to different PMT and readout studies

→ Working on cross check with independent electronics (TOF-PET ASIC)

→ Active discussion with G.Varner and G. Visser

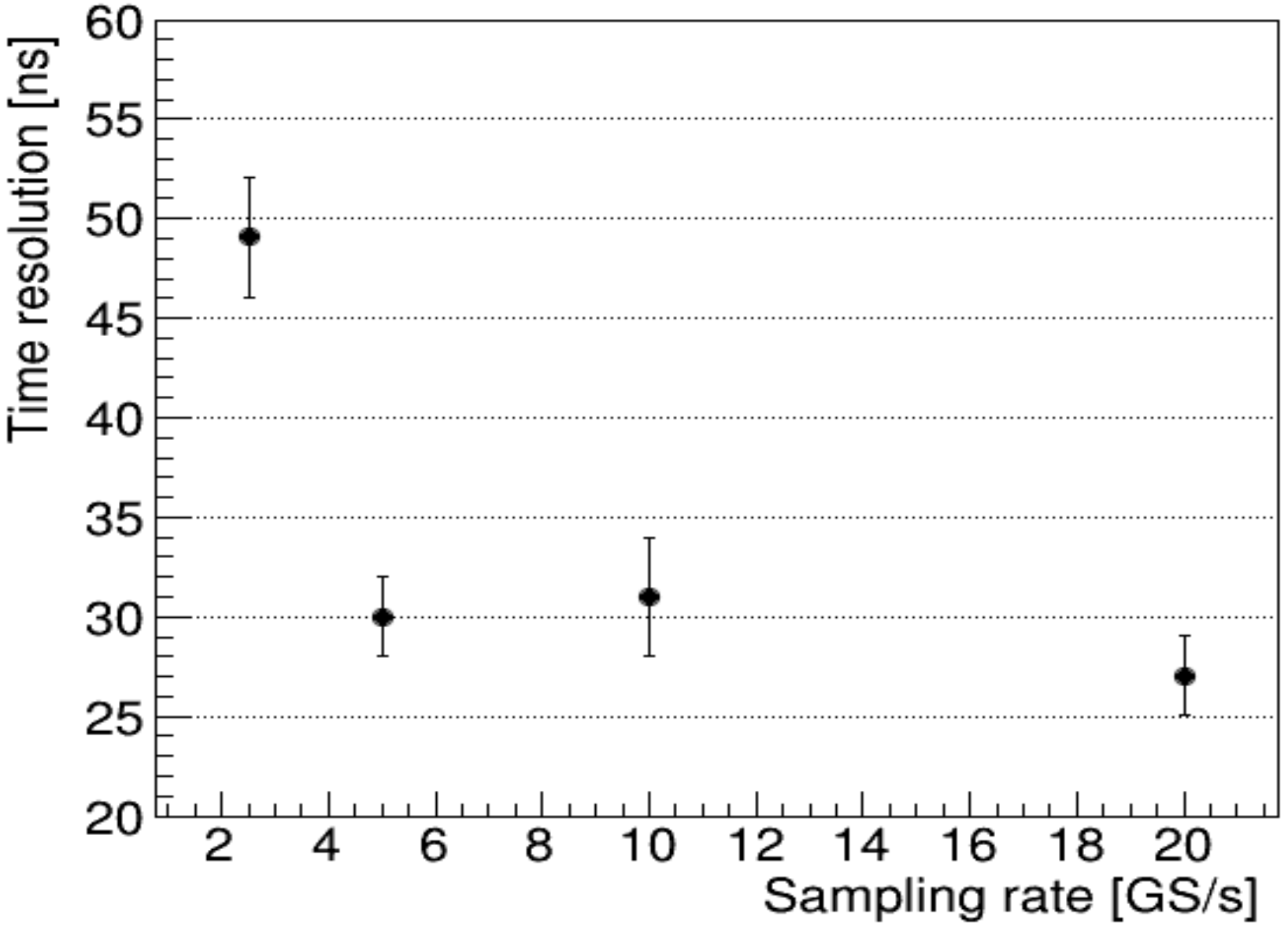
SM bundle prototype is ready

→ The final bundle can be built in Torino without buying it from external firms

→ Piping efficiency and time resolution studies are ongoing

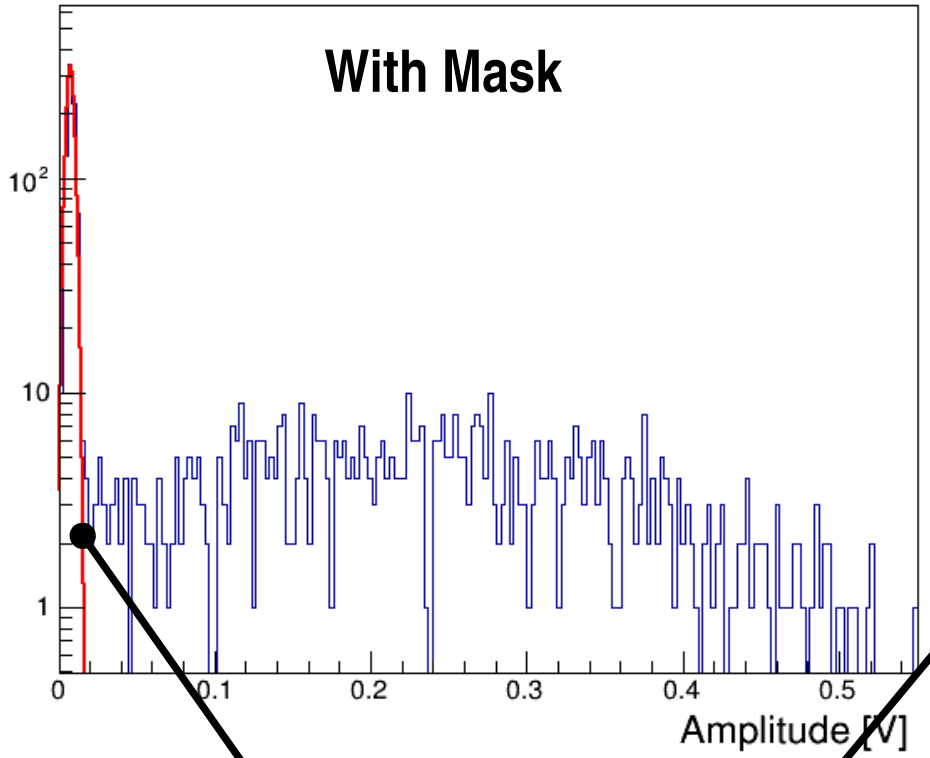
Backup

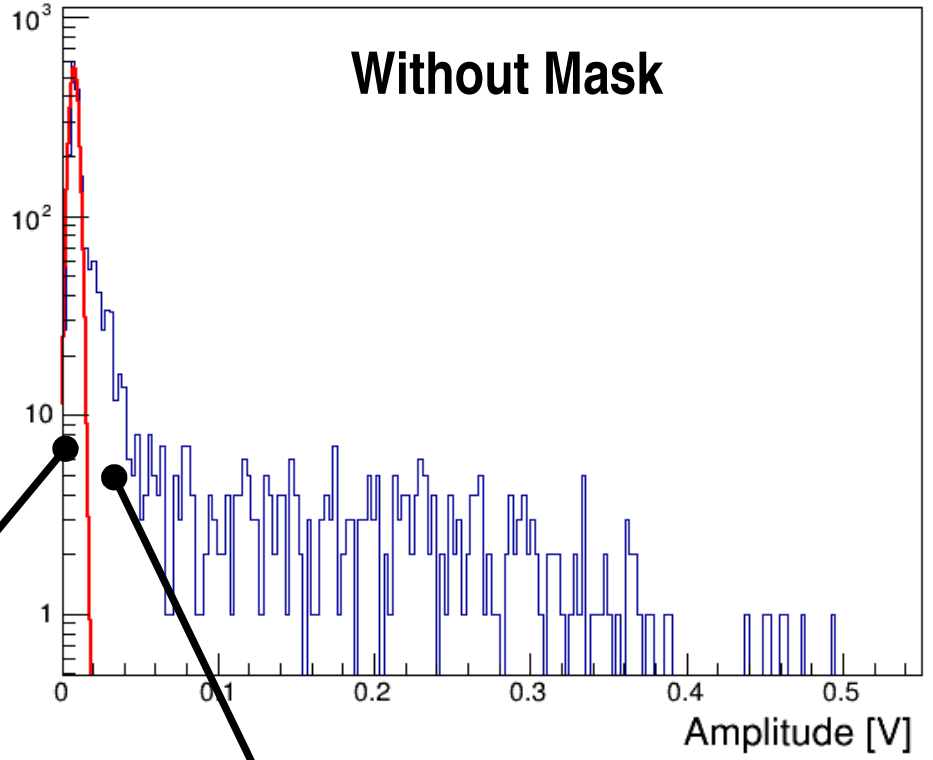
Time resolution VS sampling rate



PMT screen and cross talk

Same geometry
Same laser settings





Gaussian pedestal
Mean = 8 mV
σ = 2.5 mV

Non -gaussan tail: crosstalk events