R&D in Bologna

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for Bologna IFR group

IFR Workshop
Krakow, 07 September 2012

Outline

1) New results on tests of muon response of IFR scintillator bar using different assemblies

2) Simulation of scintillator bar with FLUKA and comparison with experimental data

3) Preliminary results from Gelina neutron irradiation tests

Part 1:
Prototype tests

Light collection measurements

Assembly different IFR bar prototypes and study the effect on muon response of:

- WLS fiber glueing
- WLS fiber aluminizing
- bar length

M. Boldini, V. Cafaro, V. Giordano

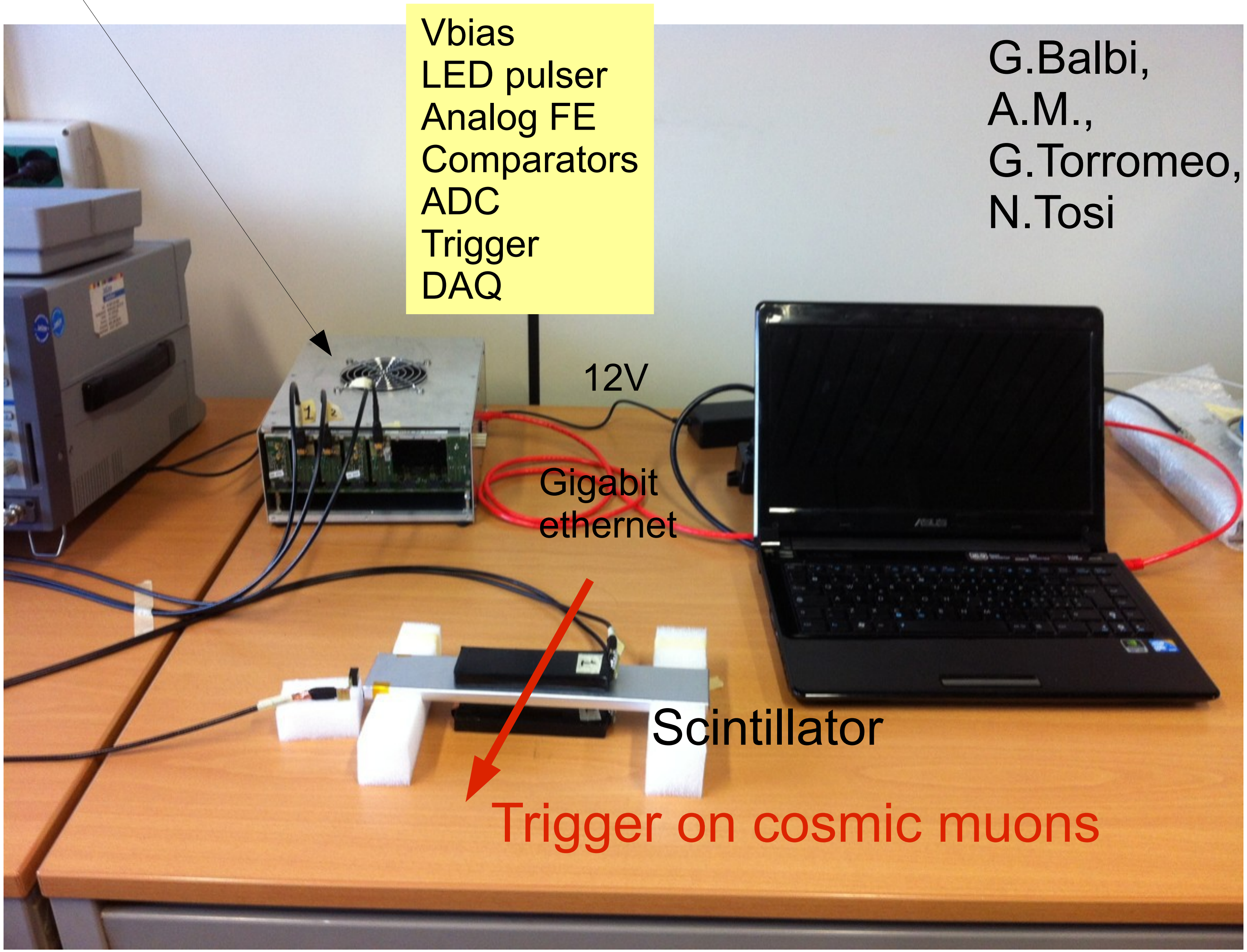
Nicolò Tosi

CAVEAT:

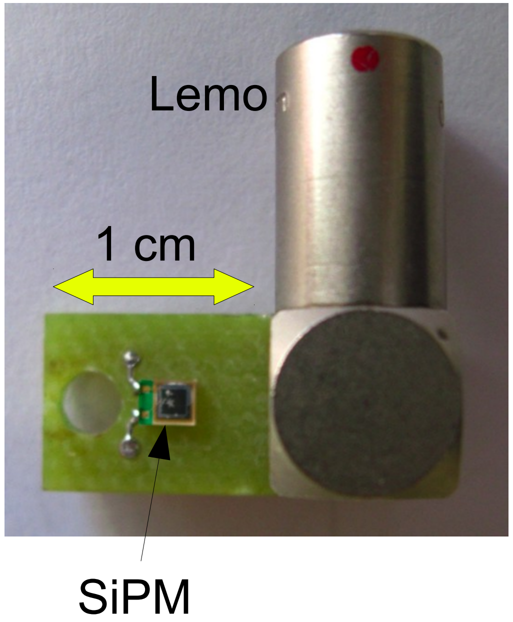
- the absolute figures depend on the type of SiPM used and on the quality of its optical coupling to the fiber
- relatives figures are more relevant

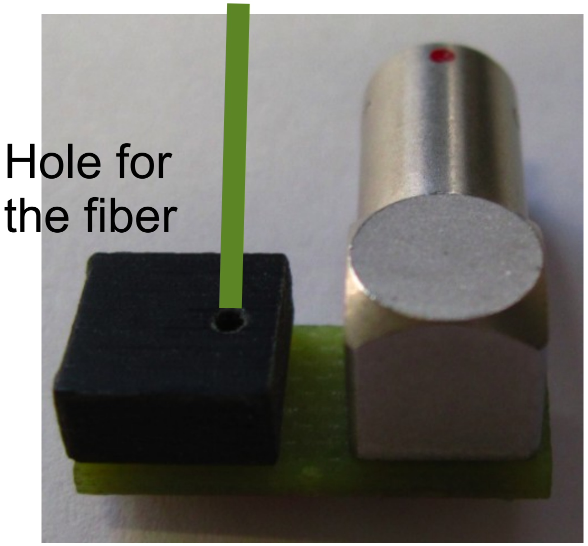
Custom readout and control system

- Versatile system for 8 channels:



SiPM used for tests



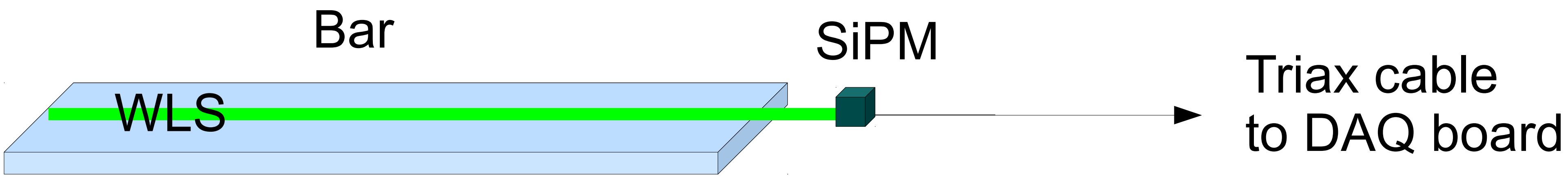


Hamamatsu 1x1 mm^2

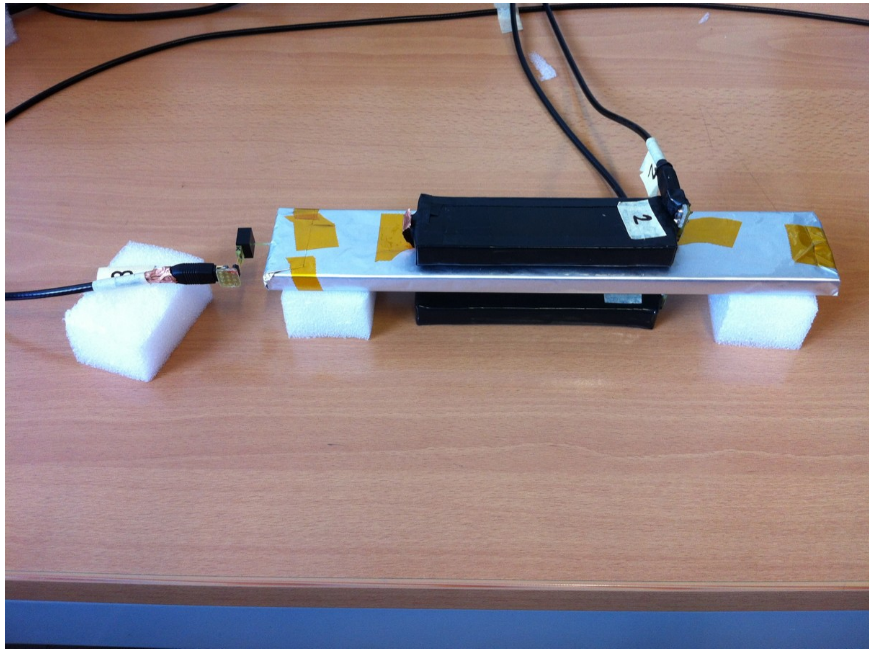
50 µm pixel

Caveat:
not optimized
optical coupling

Light collection in short scintillator bar

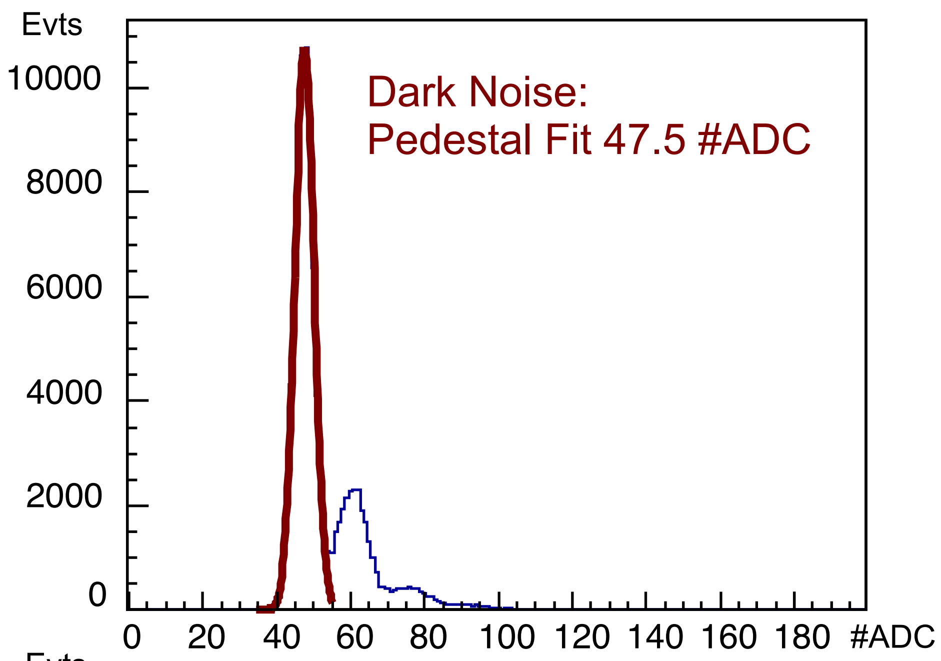


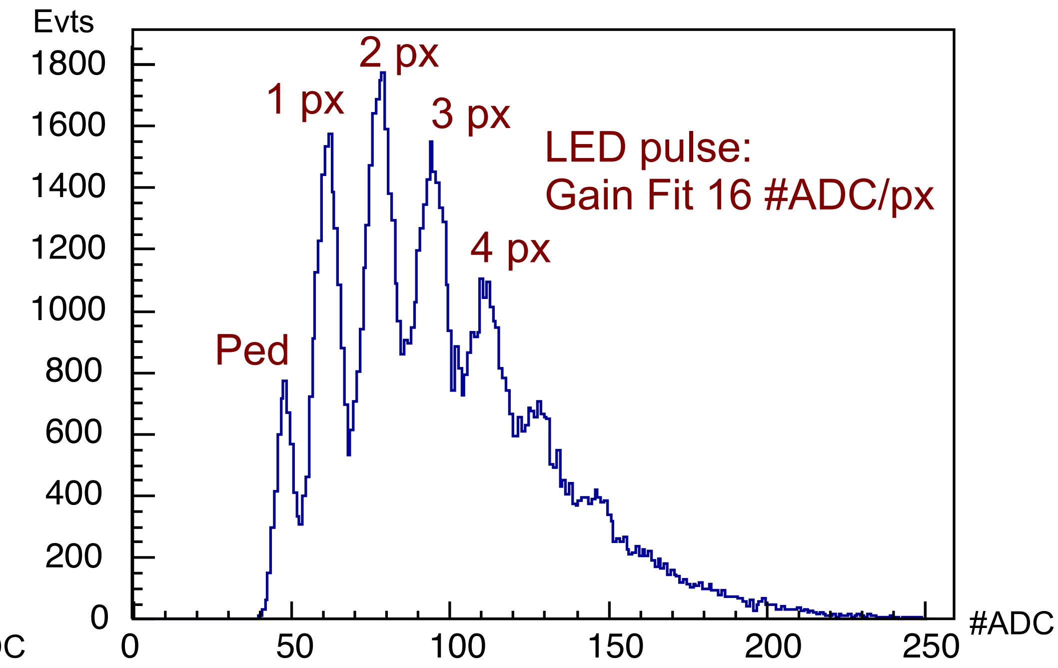
- Fermilab scintillator bar:
  - transverse size: 4.5x1.0 cm^2
  - length: 25 cm
  - one straight groove on top
- WLS: Kuraray 1 mm diameter:

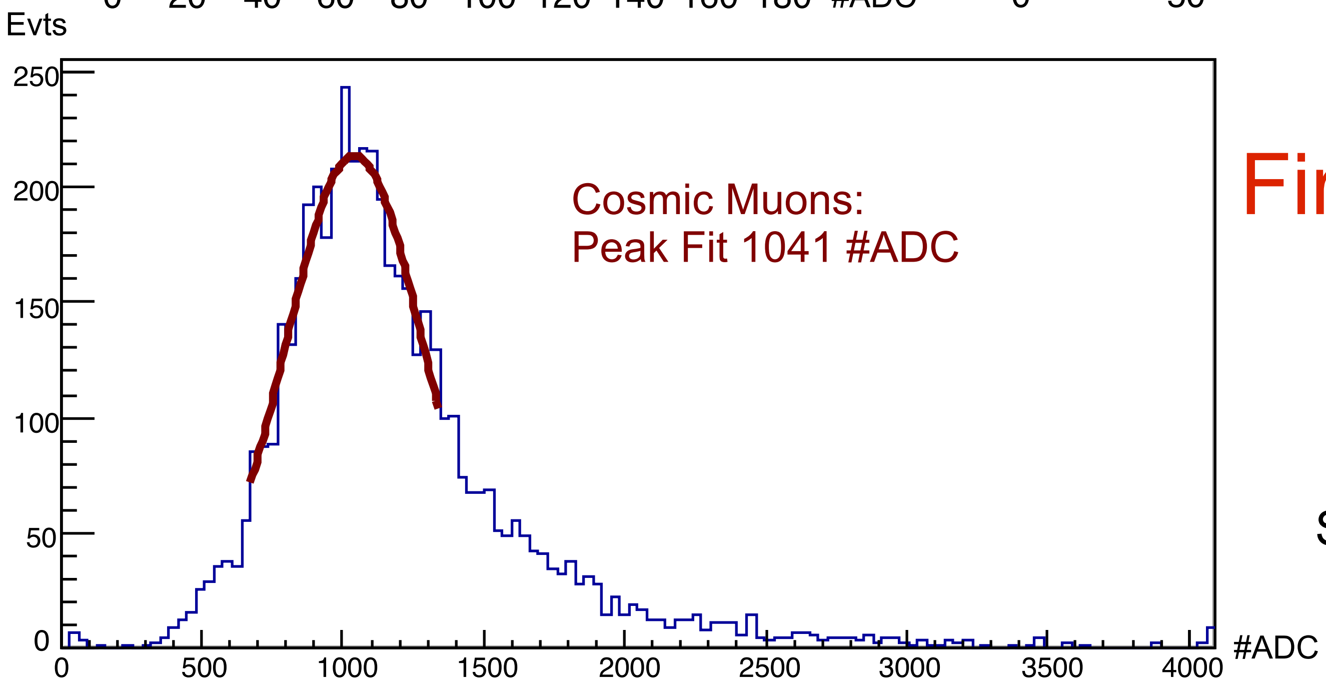


	Not Glued	Glued
Not Aluminized	√	√
Aluminized	√	

Example: WLS glued + not alumized







Fired pixels for a MIP:

$$\frac{1041-47.5}{16} \simeq 58\ px/\mu$$

Systematic error on fits: ~3 px/μ

Summary of light collection tests

- Fired pixels per MIP:

+ 57% (Not Glued → Glued)

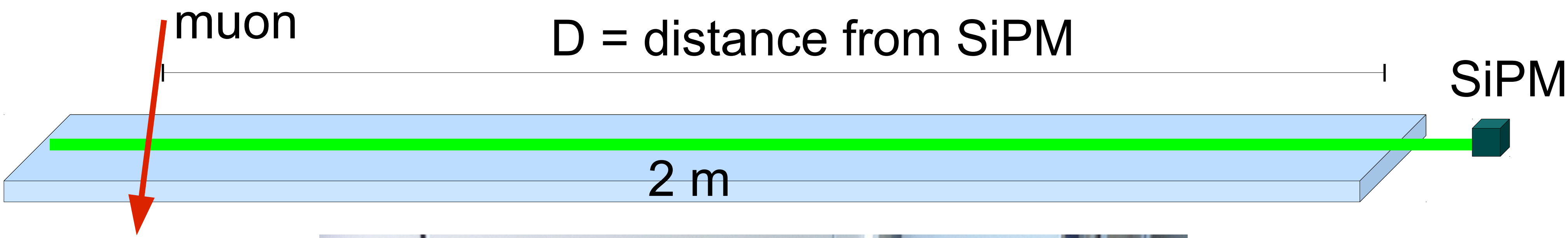
+ 24% (Not Aluminized → Aluminized)

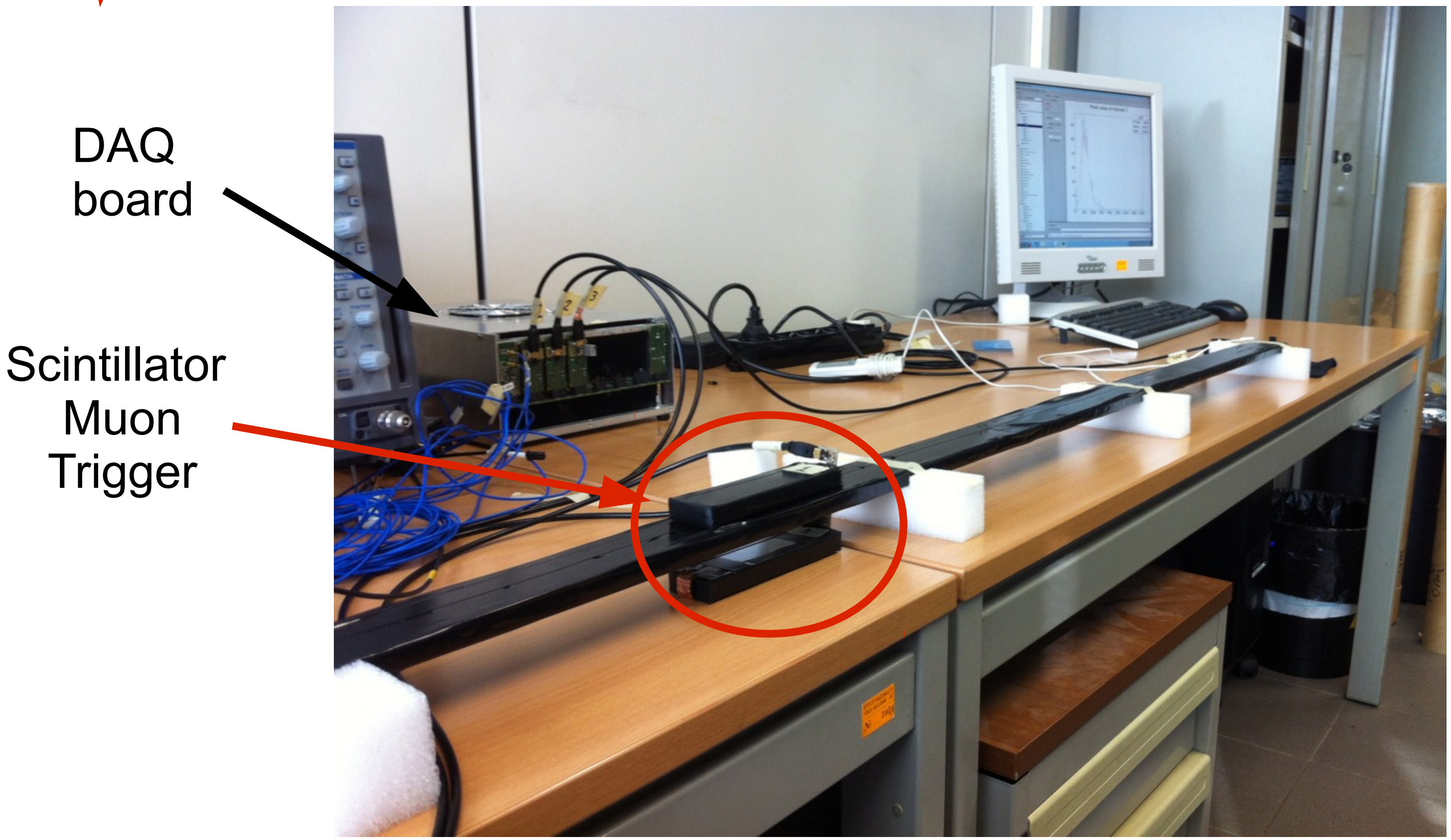
	Not Glued	Glued
Not Aluminized	37 ± 3	58 ± 4
Aluminized	46 ± 3	

Notes:
- MIP response include contributions from cross talk and afterpulse

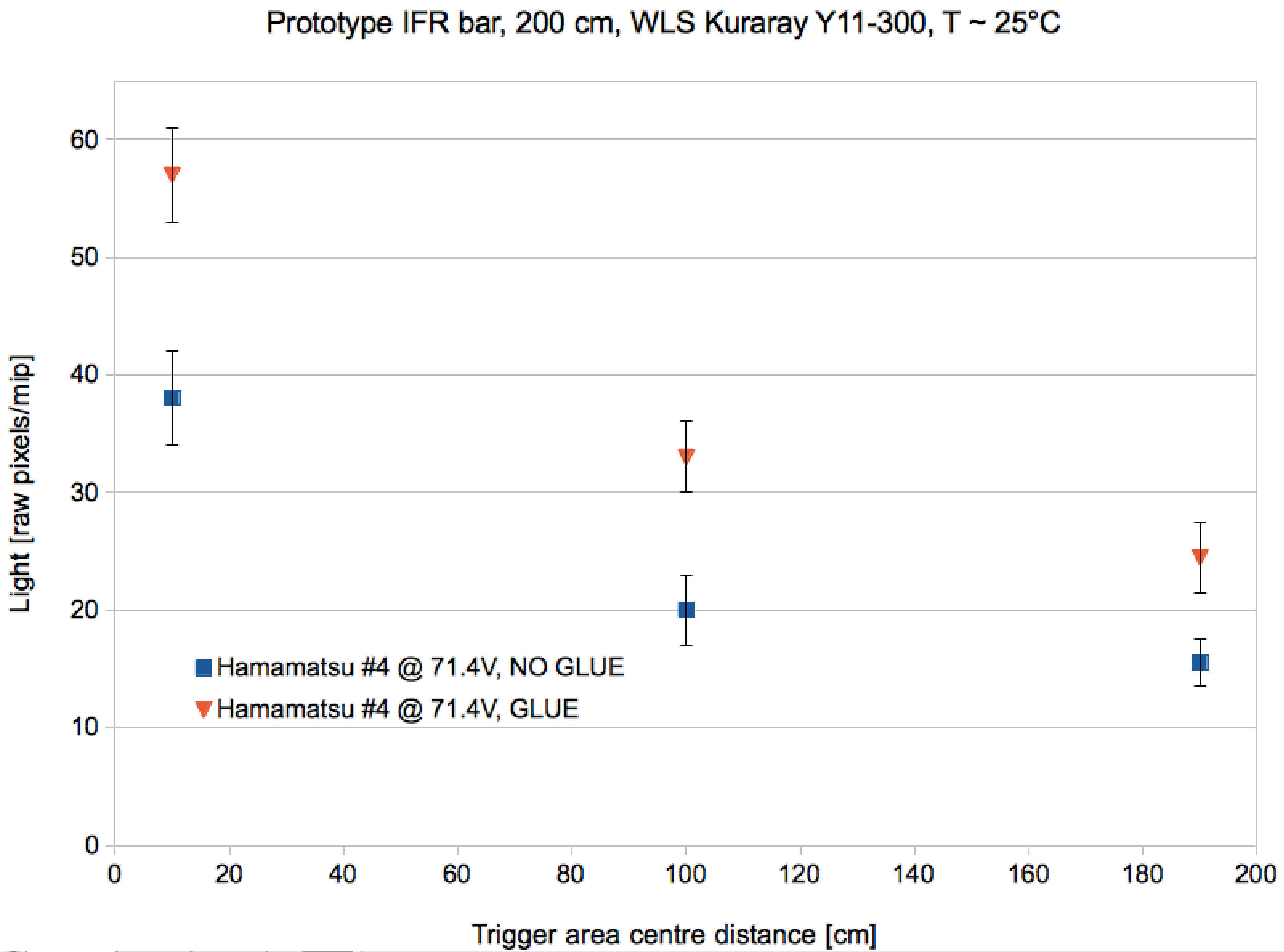
Light collection in long bar

- 2 m bar, WLS Kuraray Y11, T~25° C



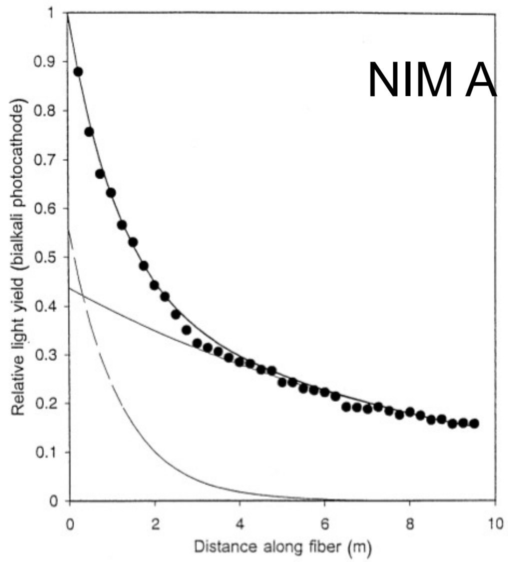


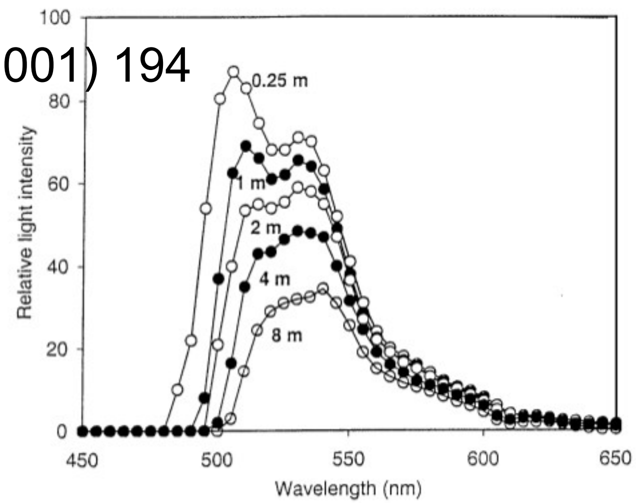
Light collection vs distance

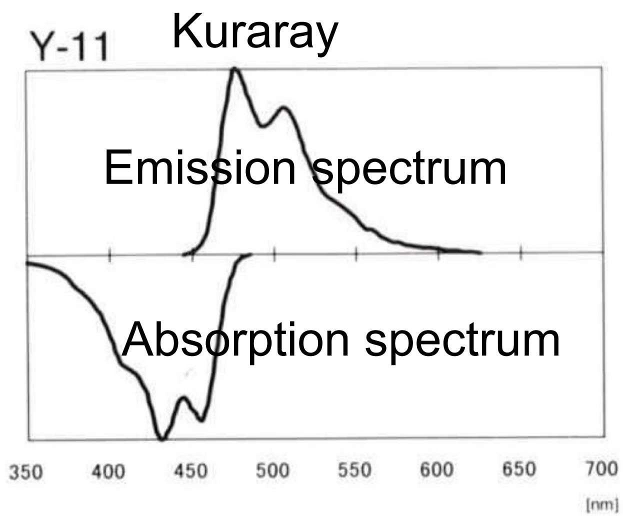


Light attenuation in WLS fiber

- Modeled by 2 exponentials :
  - long attenuation length (10 m)
  - short atten. length (0.8 m) due to self-absorbtion
    - lower part of the spectrum is more affected
- Hamamatsu is more sensitive in blue region:
  - more sensitive to attenuation !







Open issue

- How much the light attenuation affects the behavior of EFFICIENY vs POSITION ??

- The effect can be partly reduced by aluminizing the fiber..
  - How much?
  - Worthwhile?
  - Test on a long fiber aluminized...(not available now)

Conclusion

- Glueing the fiber improves light collection by +57%

- Aluminizing improves by only +24% in short bar

- Attenuation is an issue on long bar
  - more relevant in the blue region of light spectrum
  - Hamamatsu very sensitive to this effect

Part 2:
Simulation

Light collection simulation

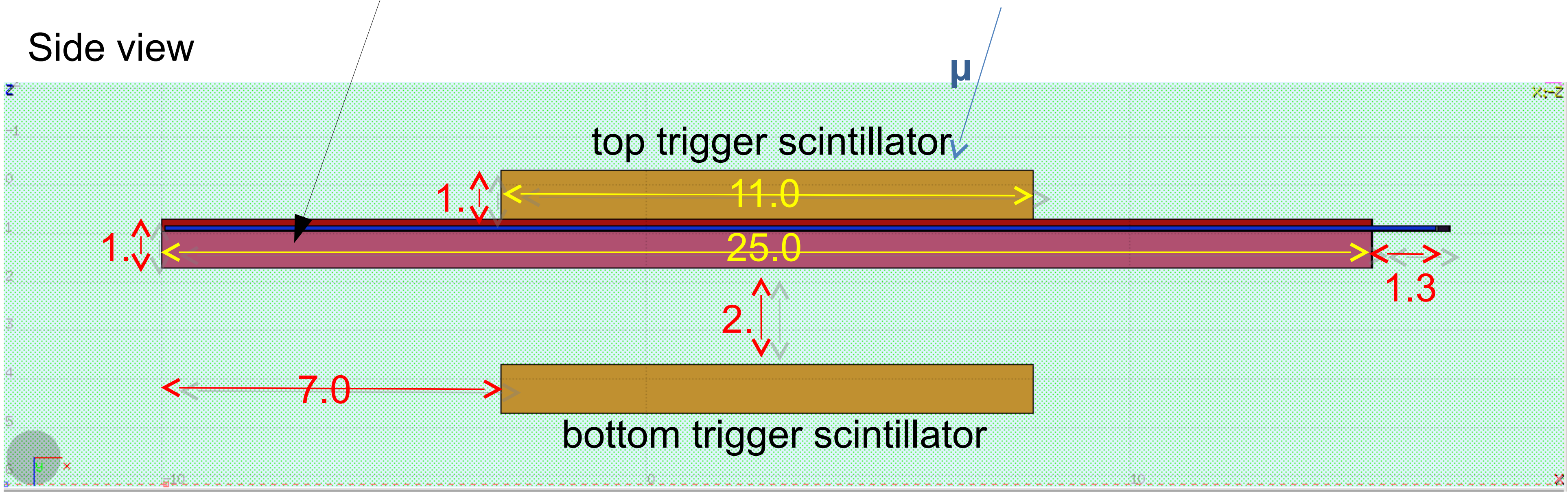
Tiziano Rovelli

- setup a detailed simulation of light production, propagation and detection in a prototype of a scintillator bar (FLUKA)
- cross check expected results from simulation with data collected from a real prototype: tune simulation free/unknown parameters
- use simulation setup to study different geometries and optical couplings
- still preliminary results..

Prototype setup

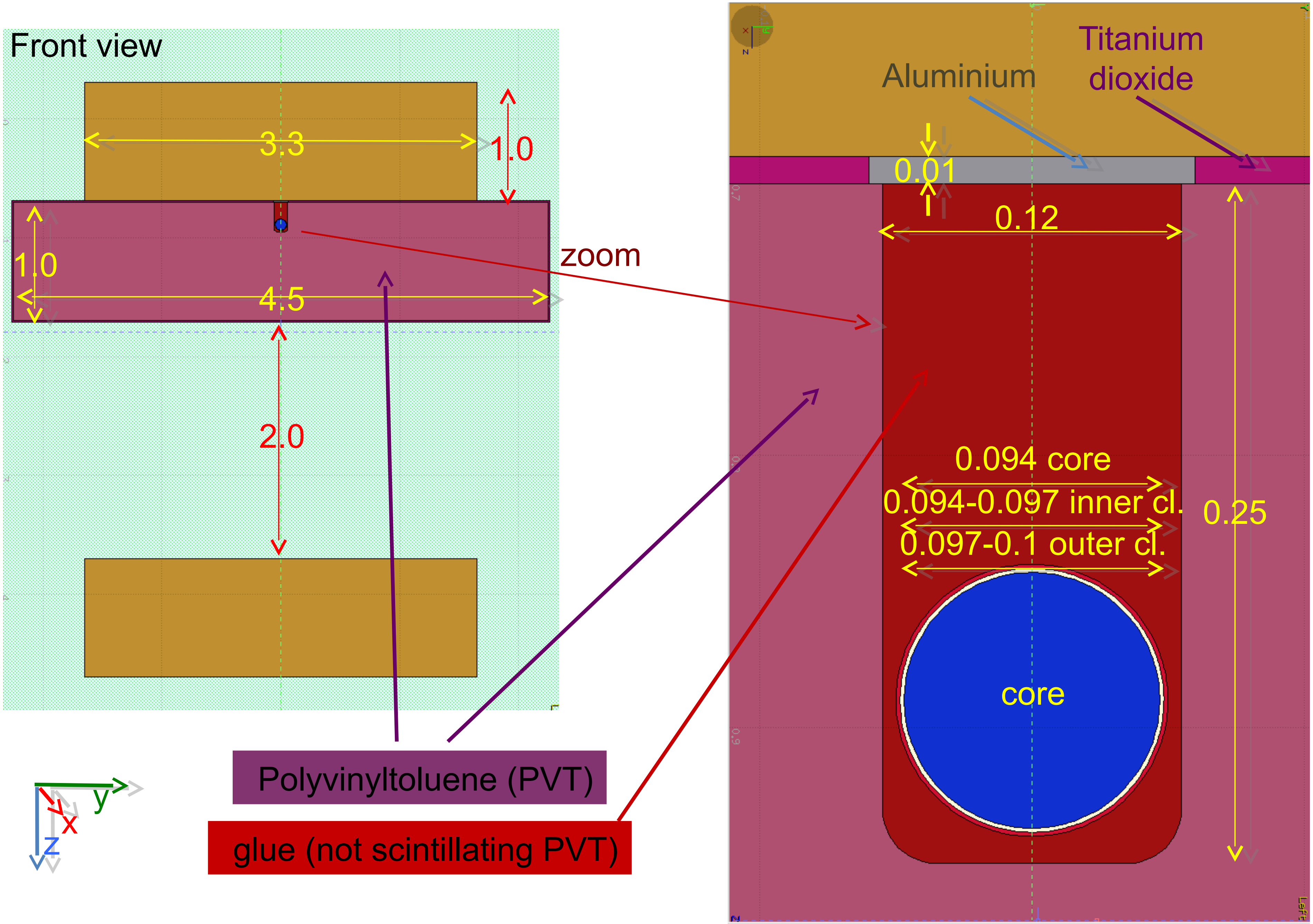
- use FLUKA (version 2011.2.13)
- simulation of bar prototype used to test MIP response (25x4.5x1 cm^3)

Side view

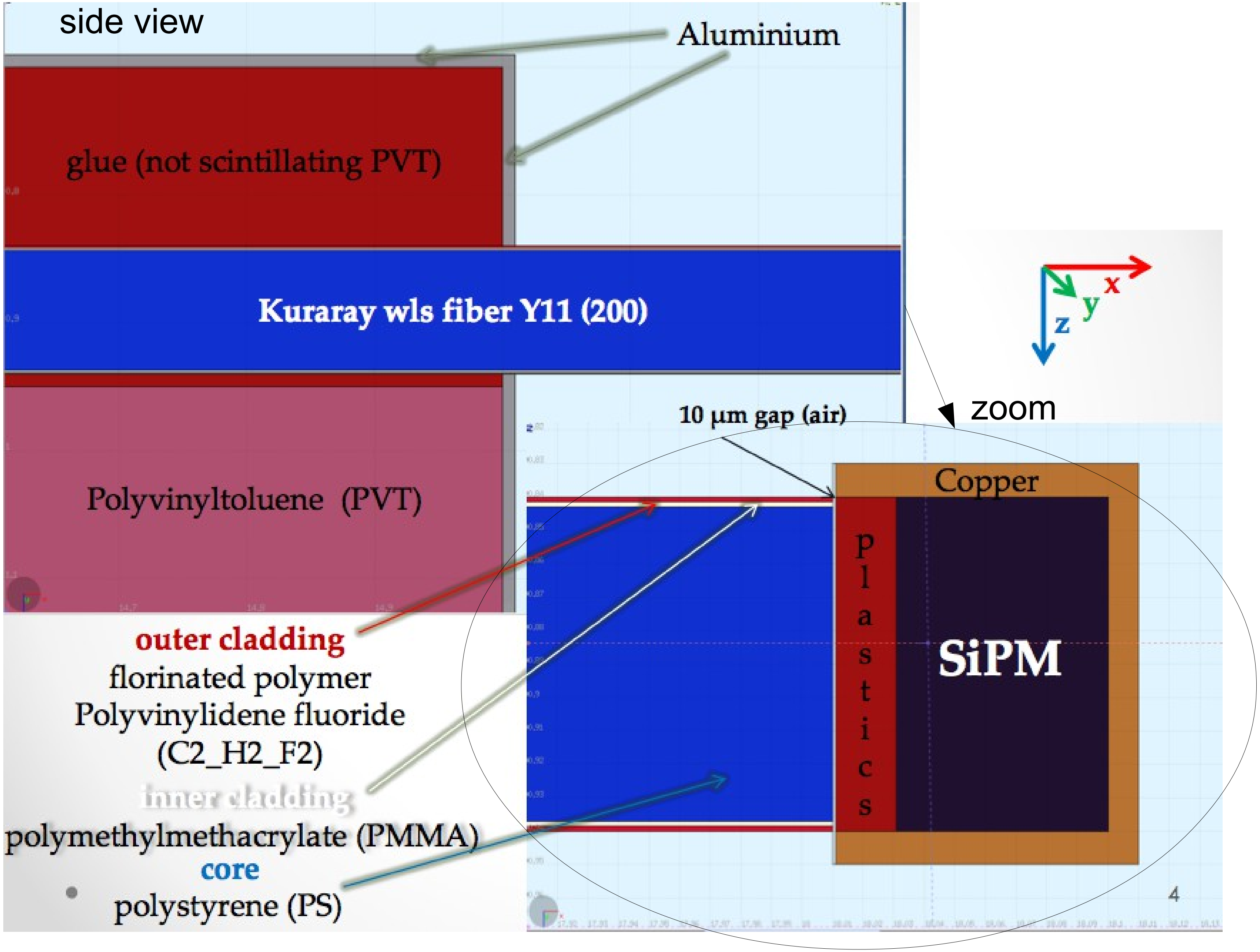


(figures in cm)

Prototype setup

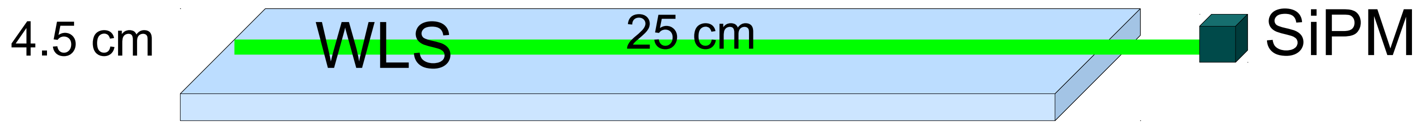


Prototype setup



Effect of glue and aluminization

- Simulate same geometry as real prototype:



+ 22% (Not Glued → Glued)

+ 31% (Not Aluminized → Aluminized)

	Not Glued	Glued
Not Aluminized	32 ± 3	39 ± 3
Aluminized	42 ± 3	

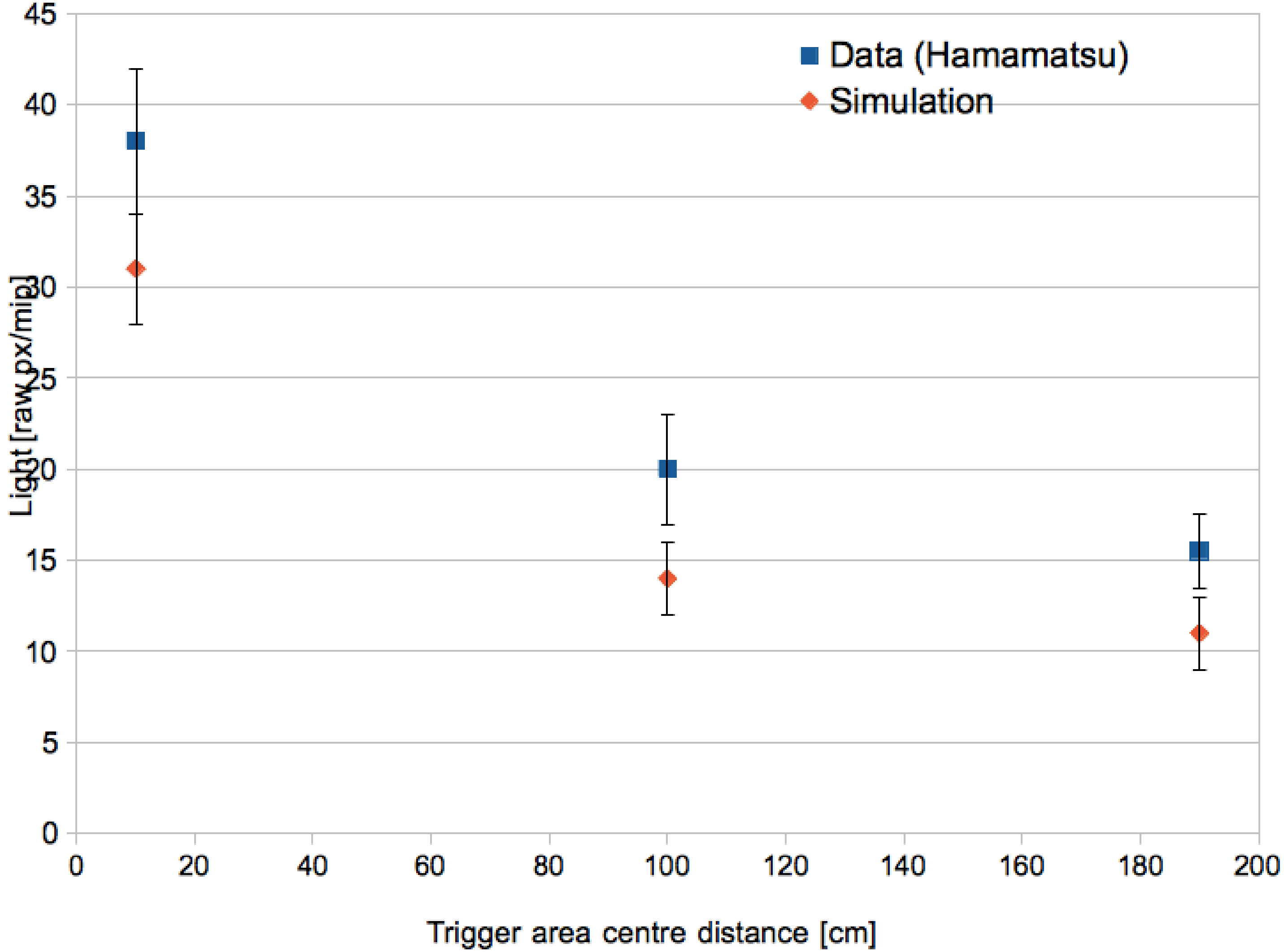
In DATA was:

	37	58
	46	

- Good agreement with data (SiPM xtalk not simulated)
- Effect of glueing is underestimated..

Long scintillator bar

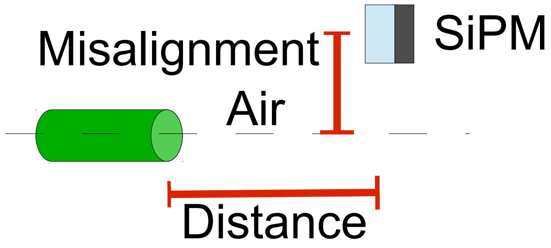
- 2 m bar, WLS Kuraray Y11 NOT GLUED

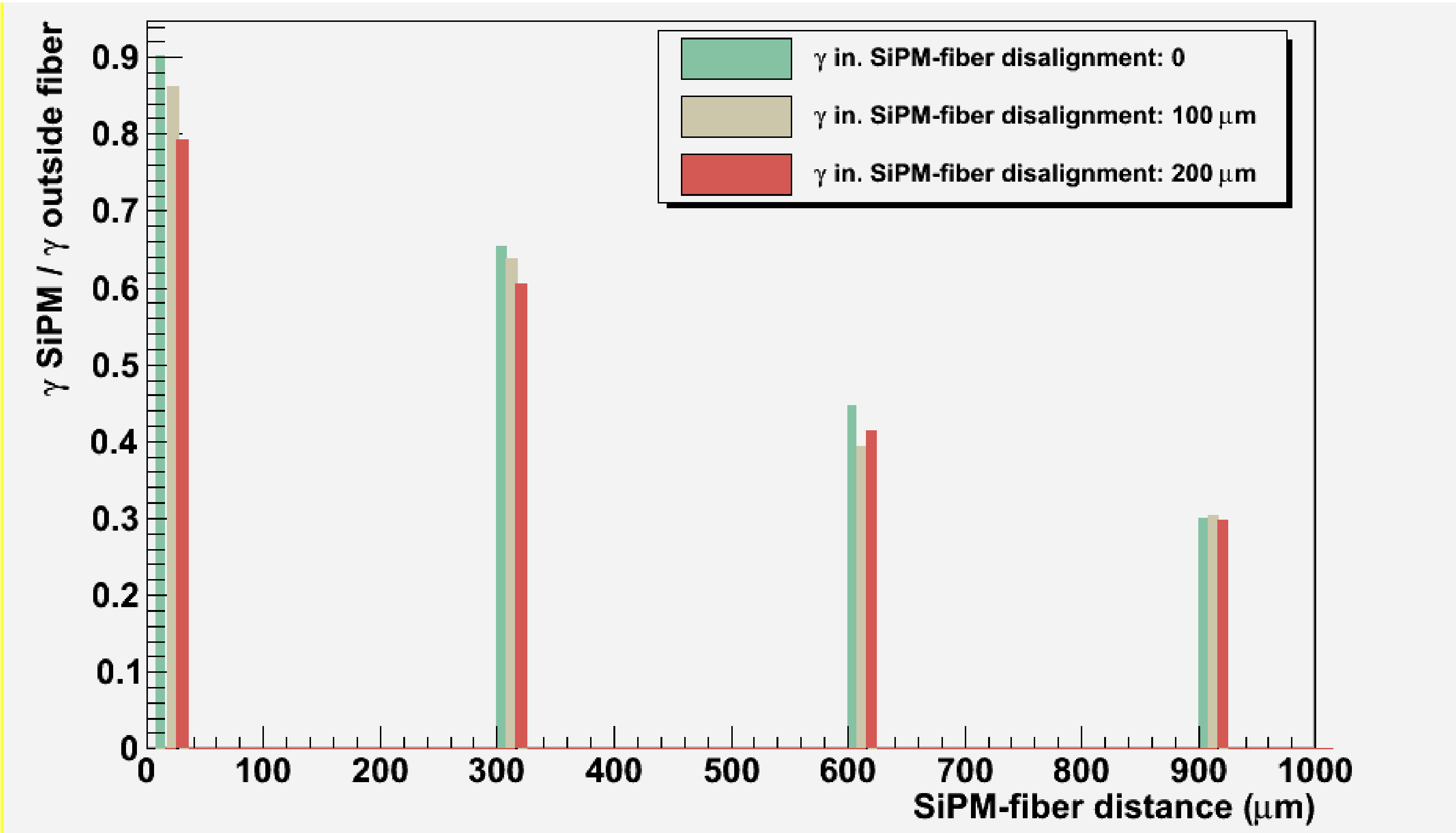


- Behavior is well reproduced

Effect of SiPM distance/misalignment from fiber

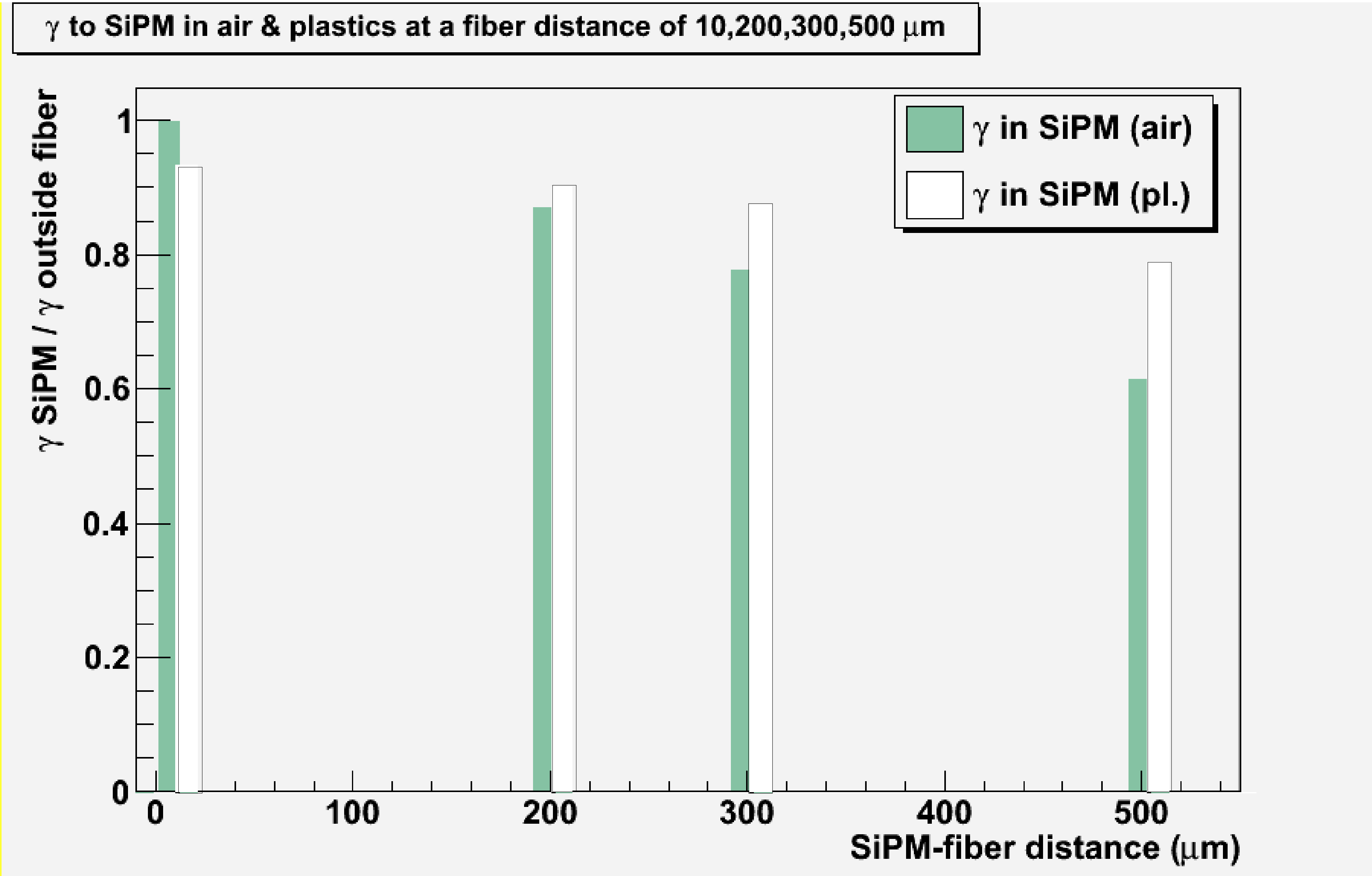
- Ratio =(γ @ SiPM)/(γ @ Fiber) (air in between)
- SiPM in plastic package (300 um)





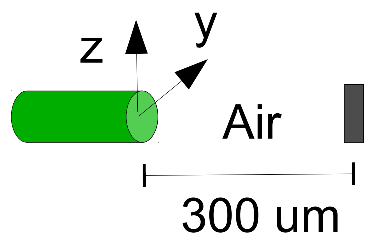
Effect of SiPM plastic package

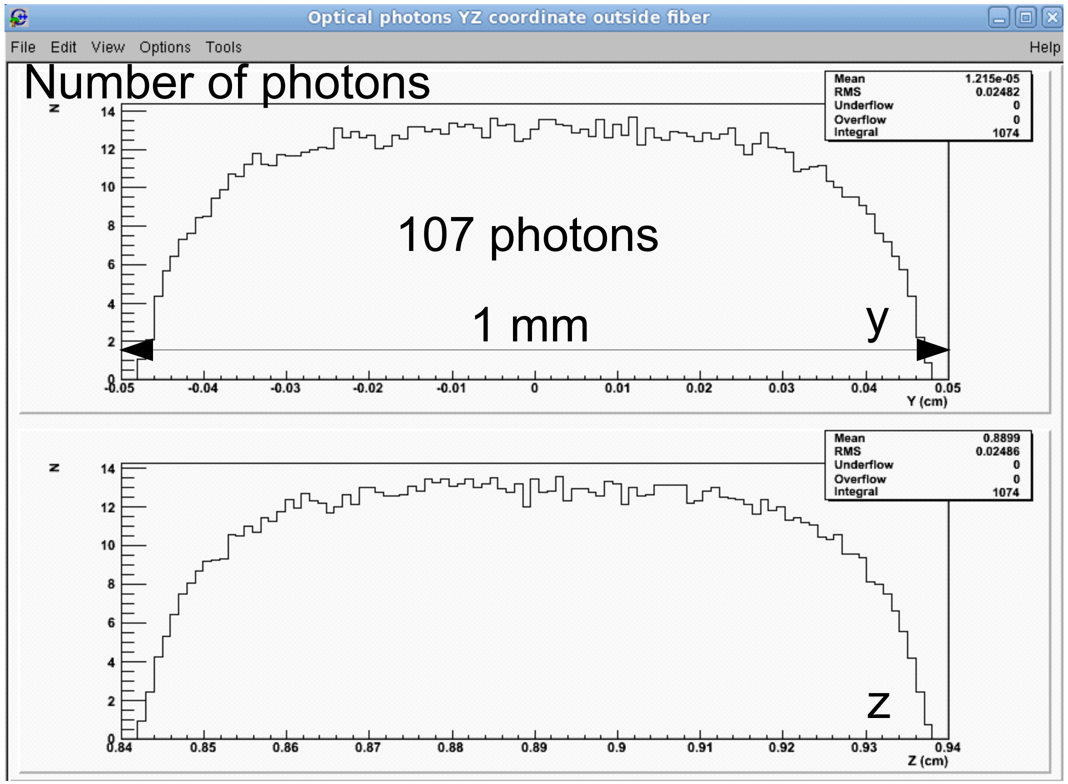
- SiPM perfectly aligned



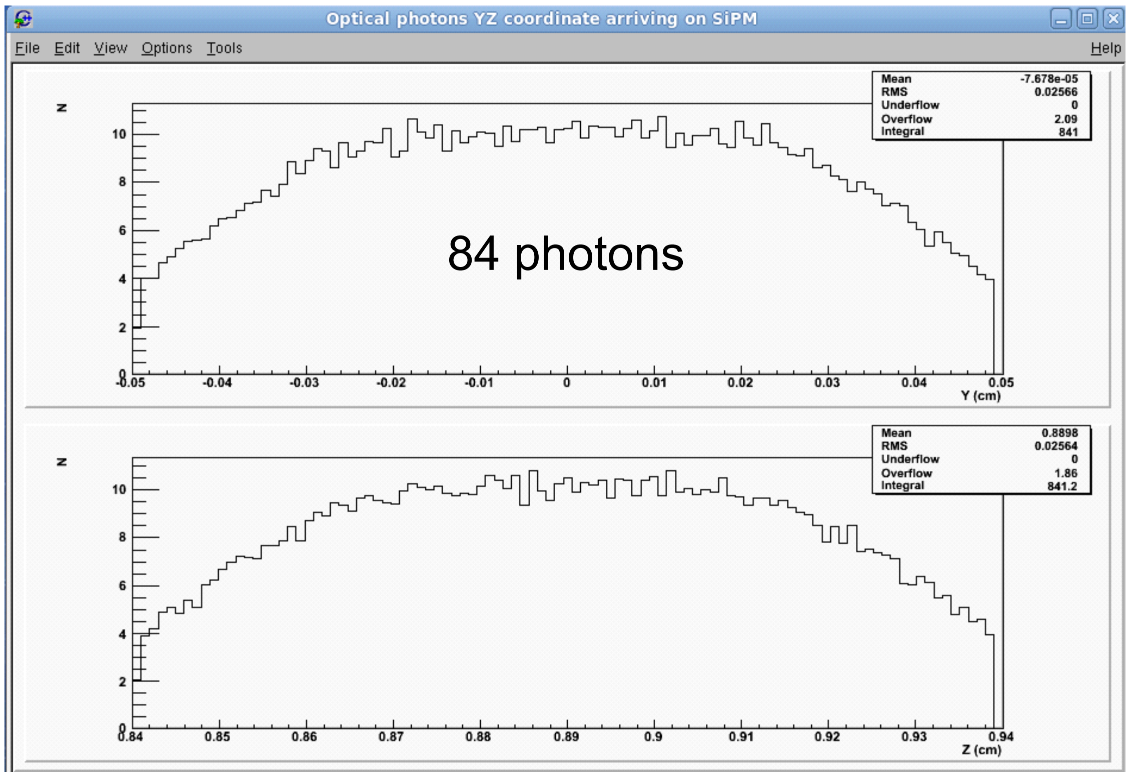
Photon beam profile

- More photons from the center of the fiber
  - Less sensitivity to SiPM misalignment



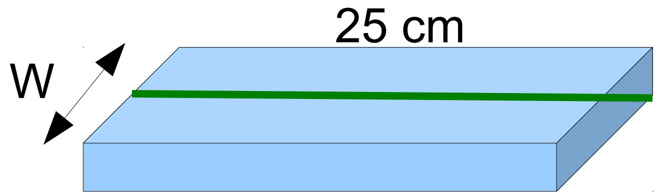


@ fiber output

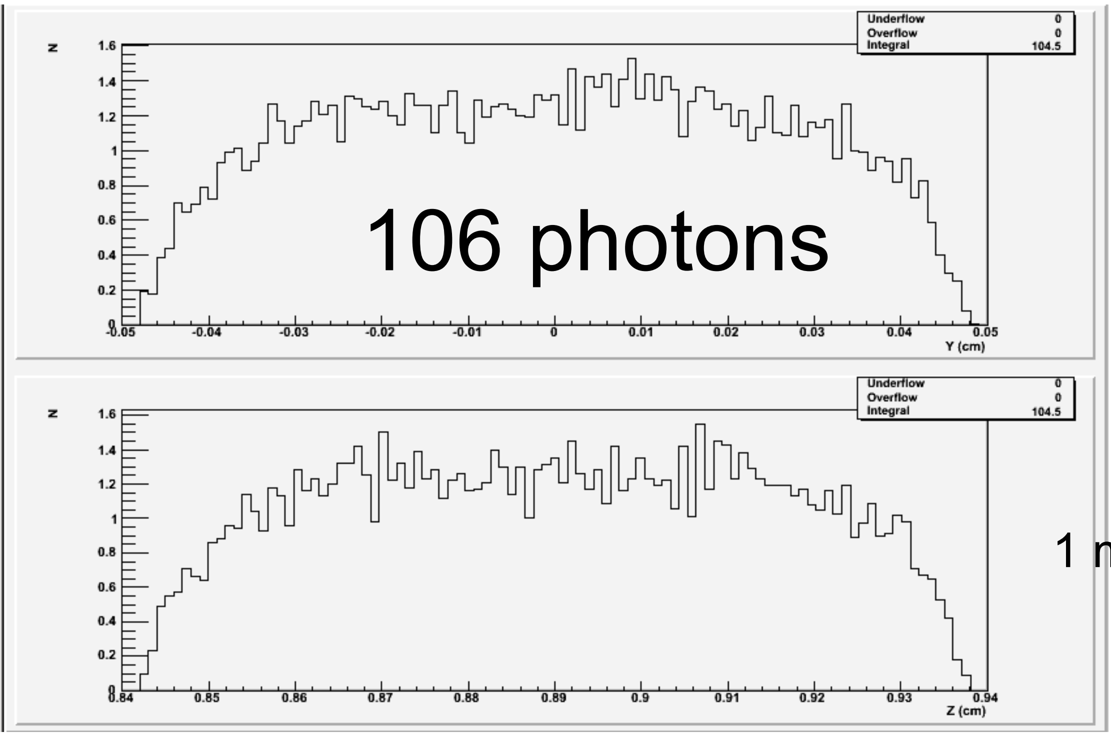


@ 300 um

Light from 1 fiber in 5 and 10 cm wide scintillator

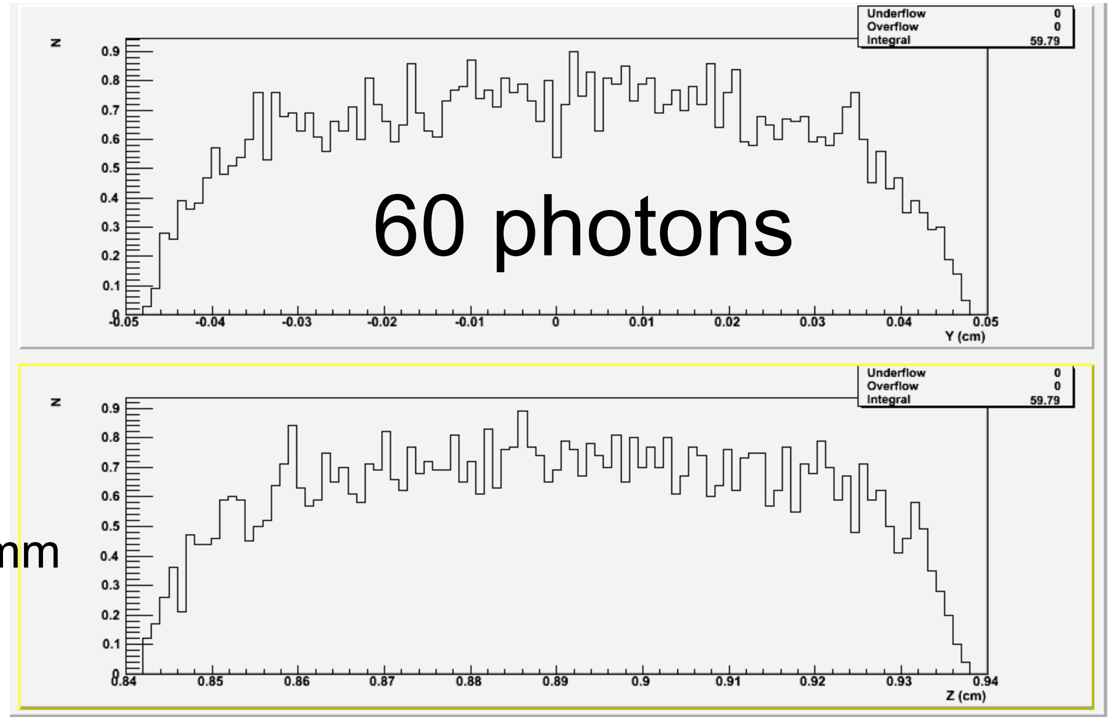


W=5 cm



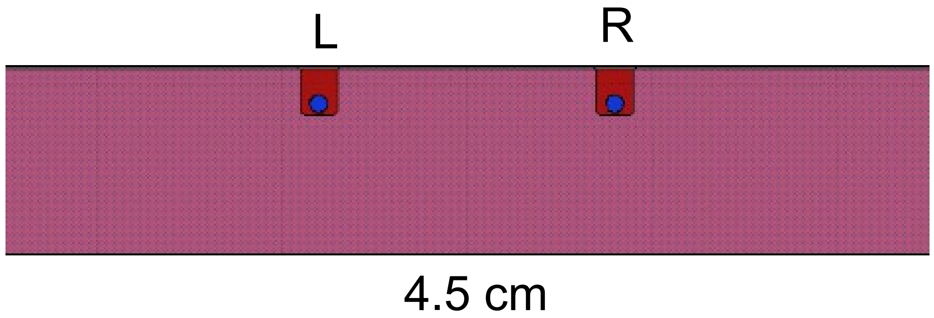
1 mm

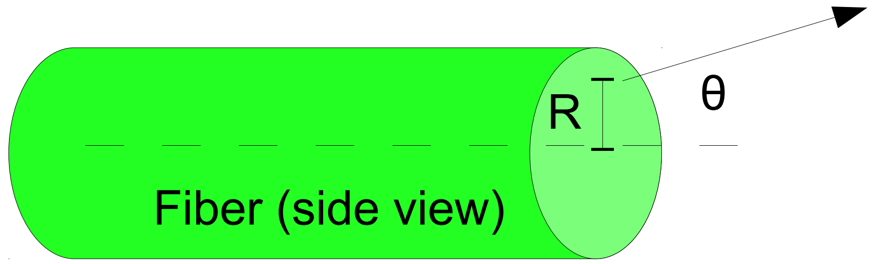
W=10 cm

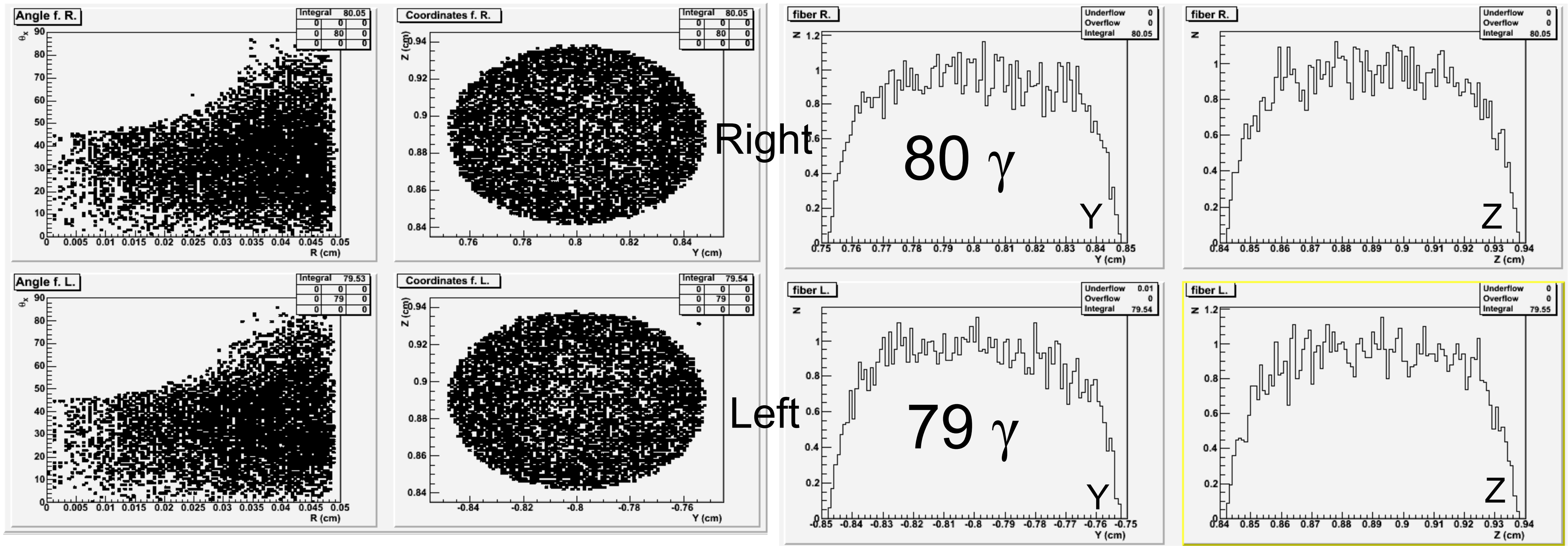


- - 43% of collected light at fiber output in 10 cm wide bar

Light from 2 fibers on same scintillator

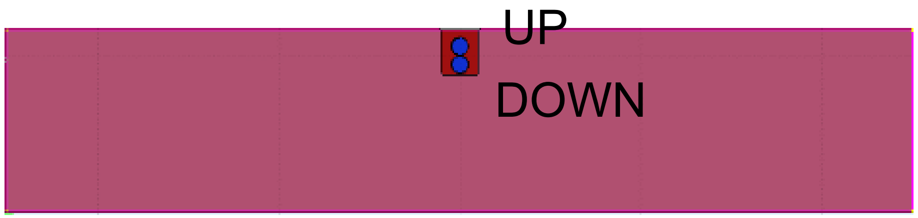


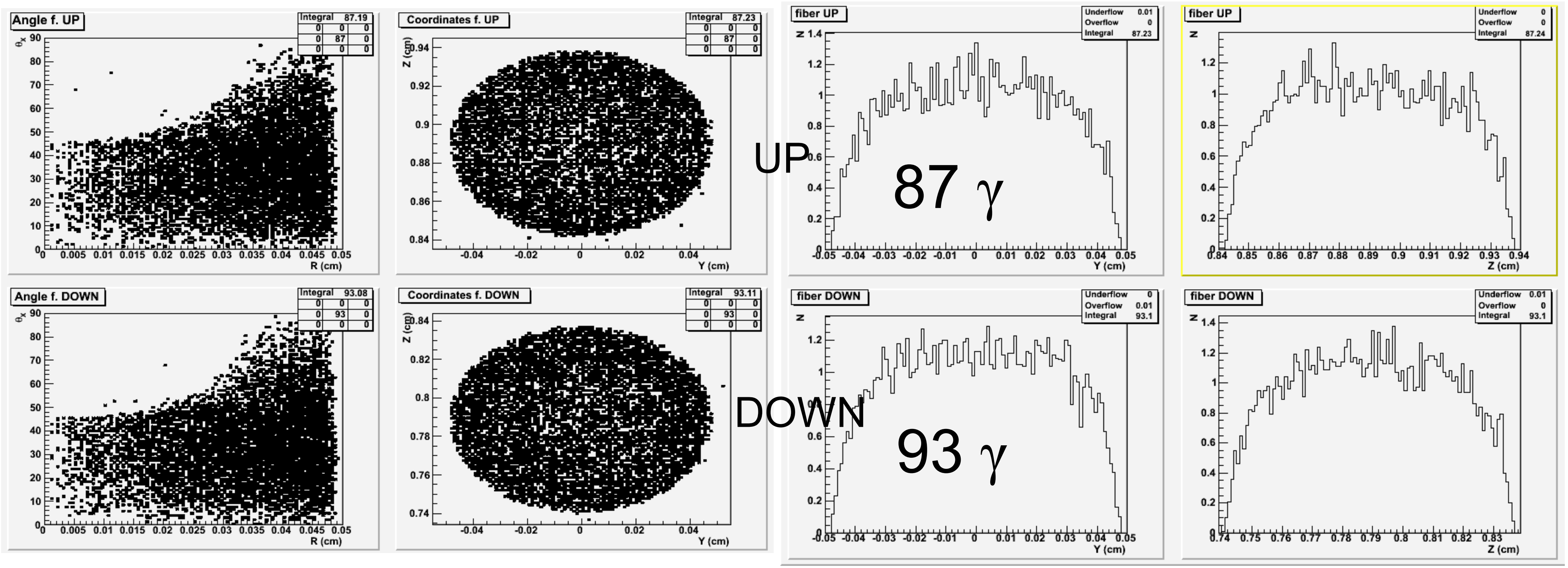




Total = 80 γ + 79 γ = 159 γ = +49% wrt 1 fiber

Light from 2 fibers on same scintillator





Total = 87 γ + 93 γ = 180 γ = +68% wrt 1 fiber

Conclusion

- First version of simulation was setup

- First tuning done by comparison with real prototype
  - data reproduced at 10-20% level
  - behavior well reproduced

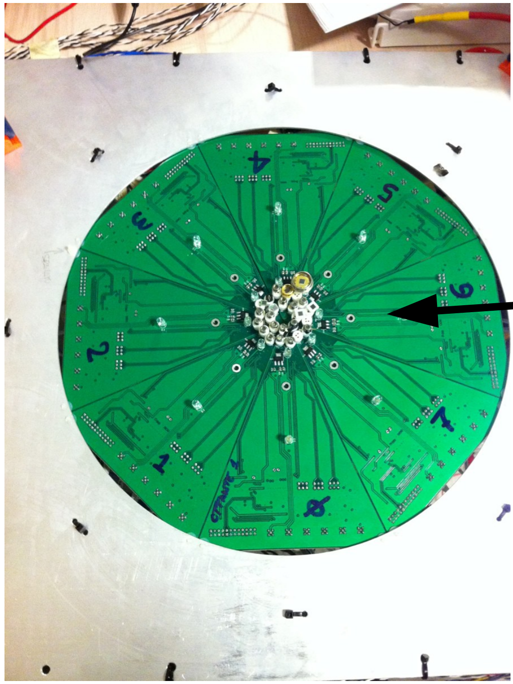
- Effect of glueing not well reproduced...

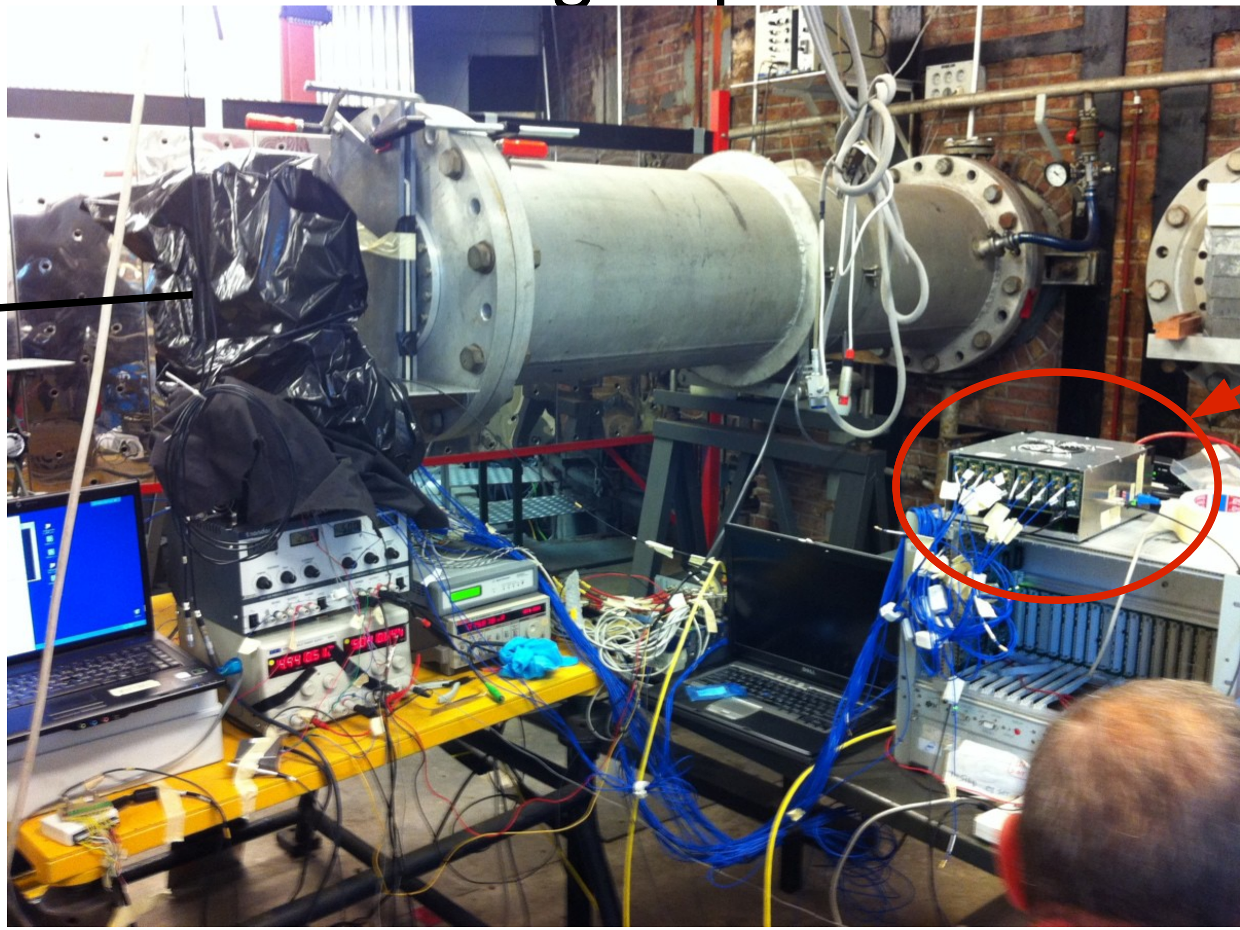
Part 3:
Neutron irradiation test

Setup at Gelina facility

- Low energy neutrons (peak at ~40 meV)
- Total fluence ~2 x 10^{10} n/cm^2
- Measure dark rates and charge spectra

A.M., N.Tosi

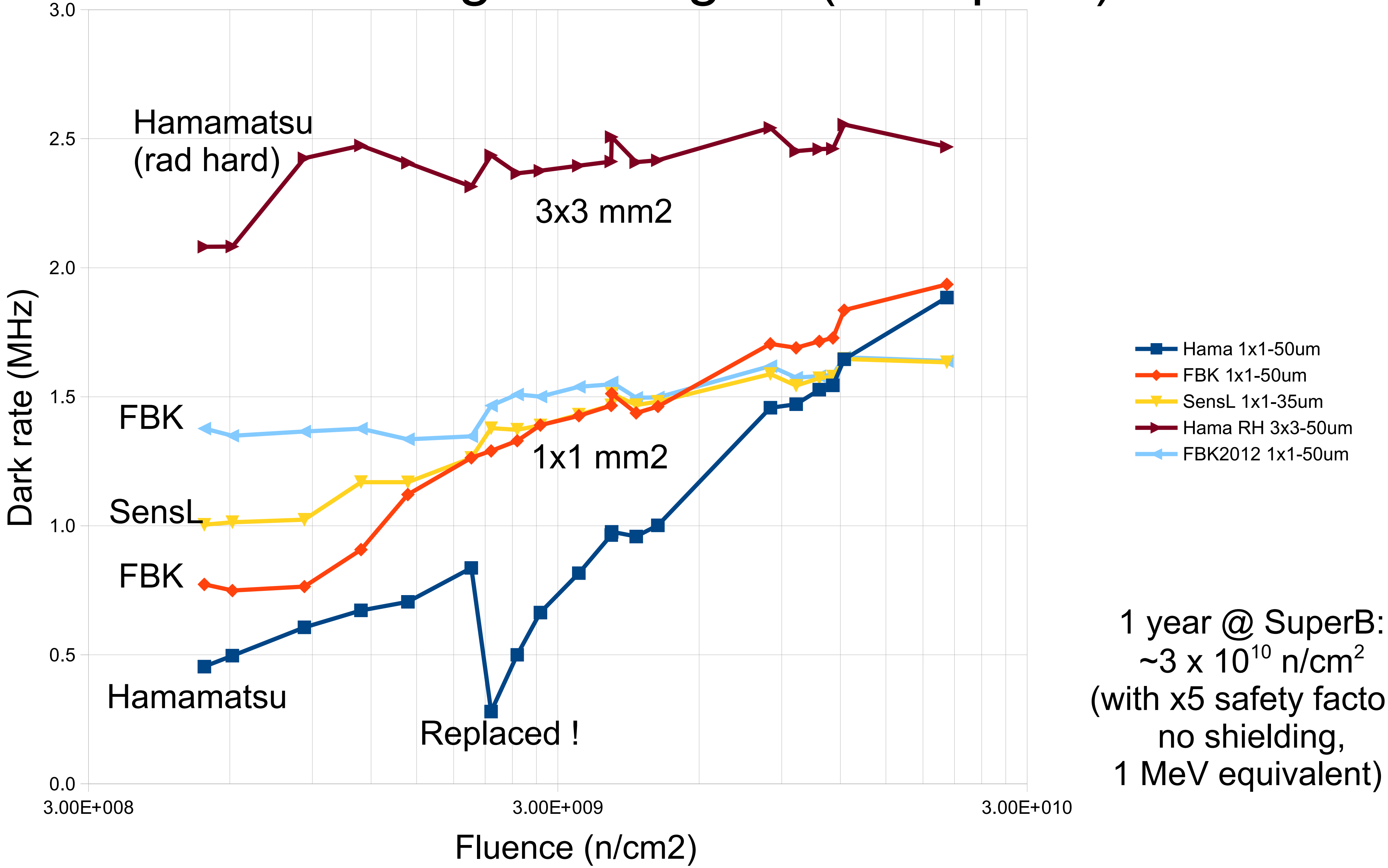




DAQ board

Dark rate vs neutron fluence

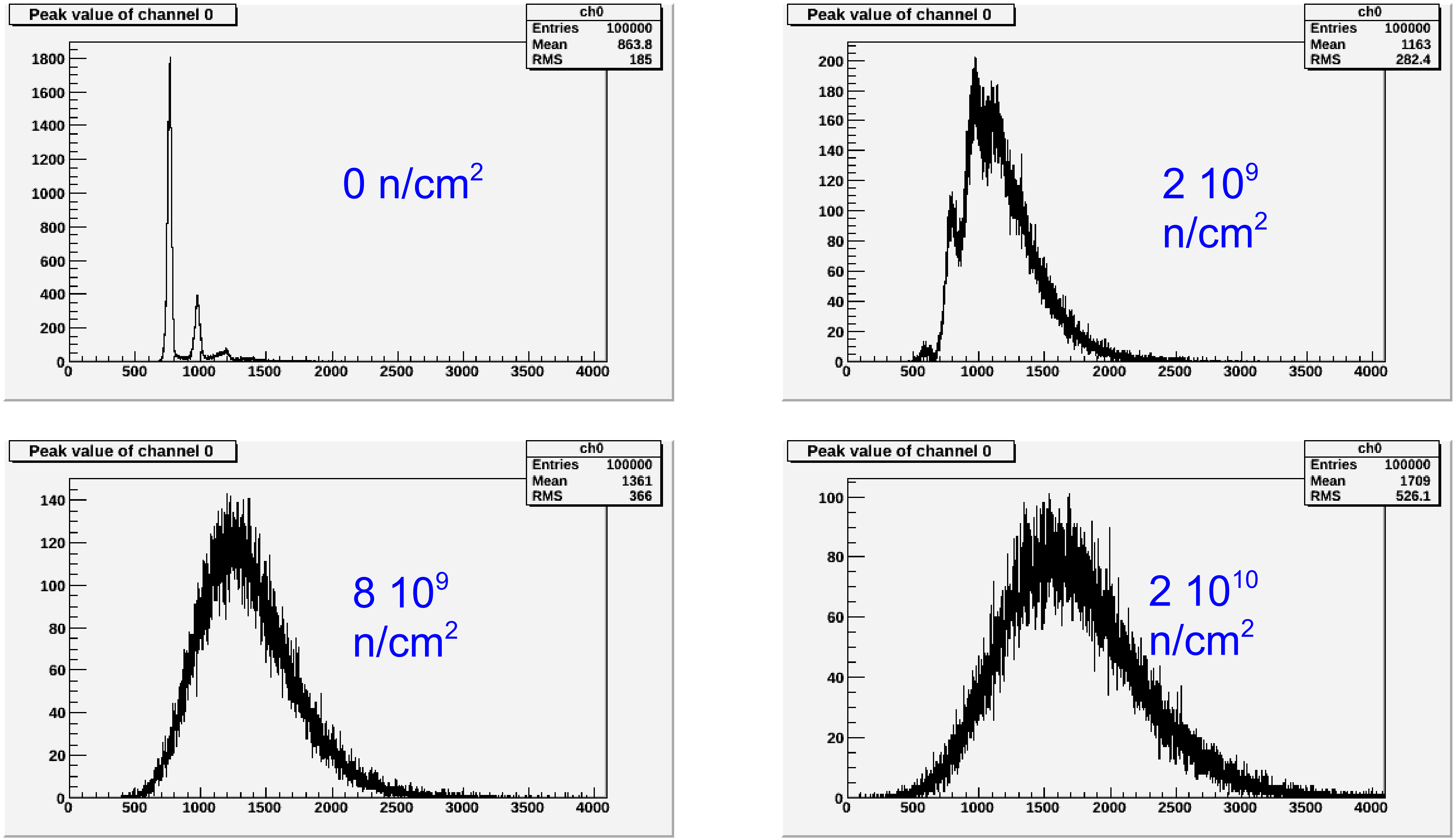
- Threshold on integrated signal (>1.5 pixel)



1 year @ SuperB:
~3 x 10^{10} n/cm^2
(with x5 safety factor,
no shielding,
1 MeV equivalent)

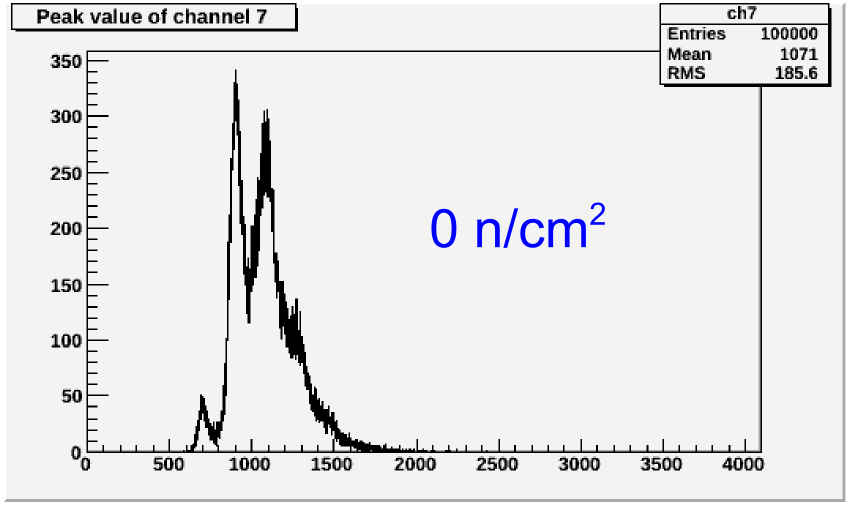
Charge spectra: example 1

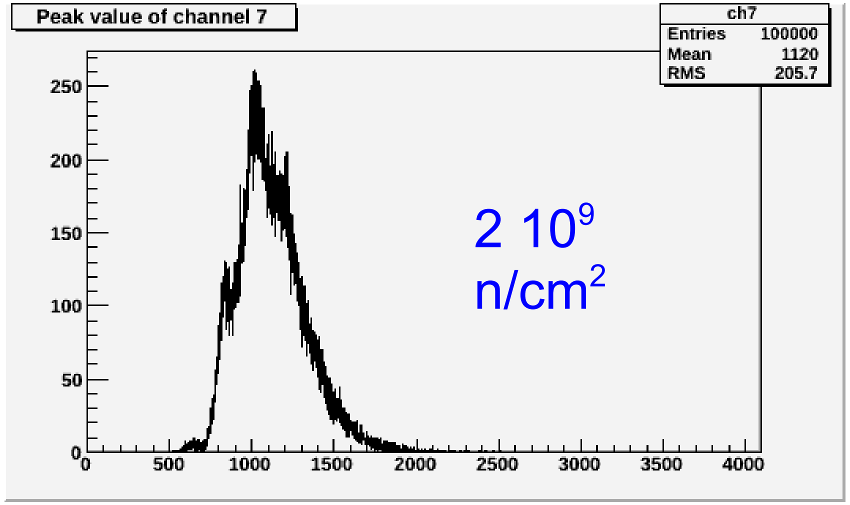
- Hamamatsu 1x1 mm2, 50 um pixel

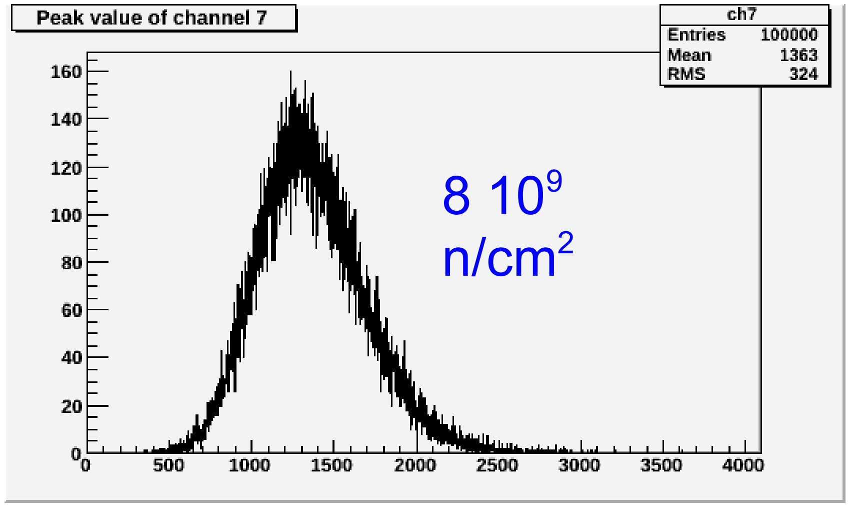


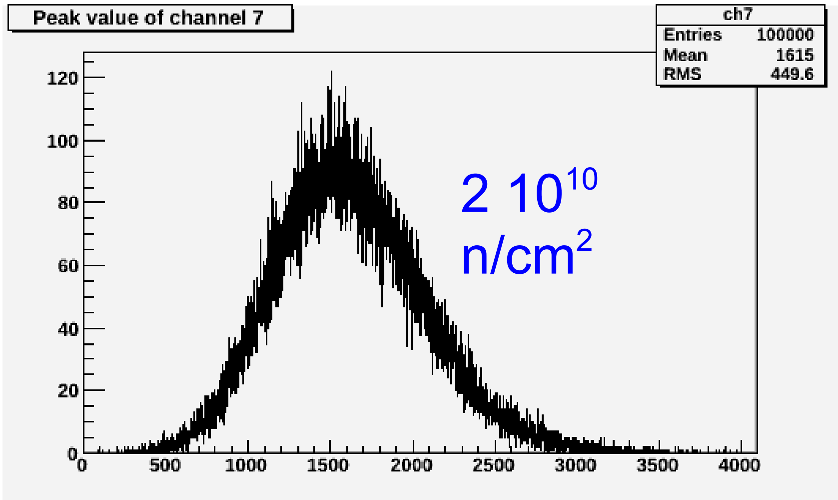
Charge spectra: example 2

- FBK 2012 1x1 mm2, 50 um pixel



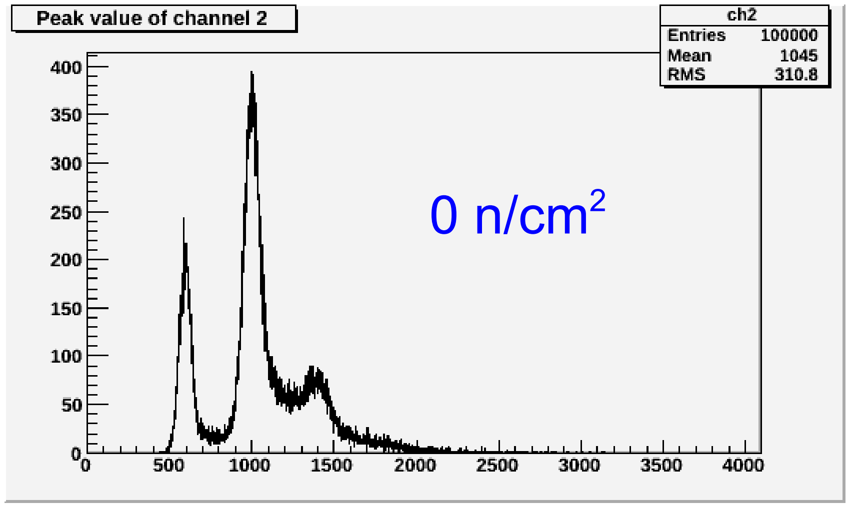


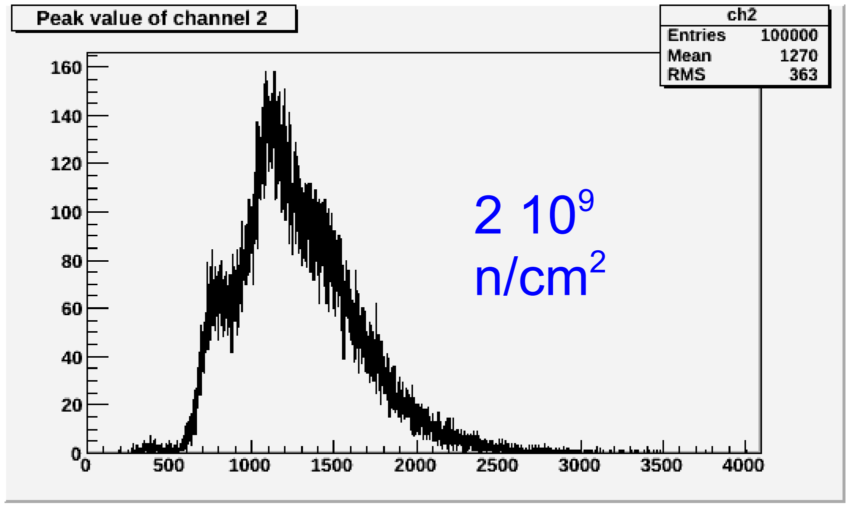


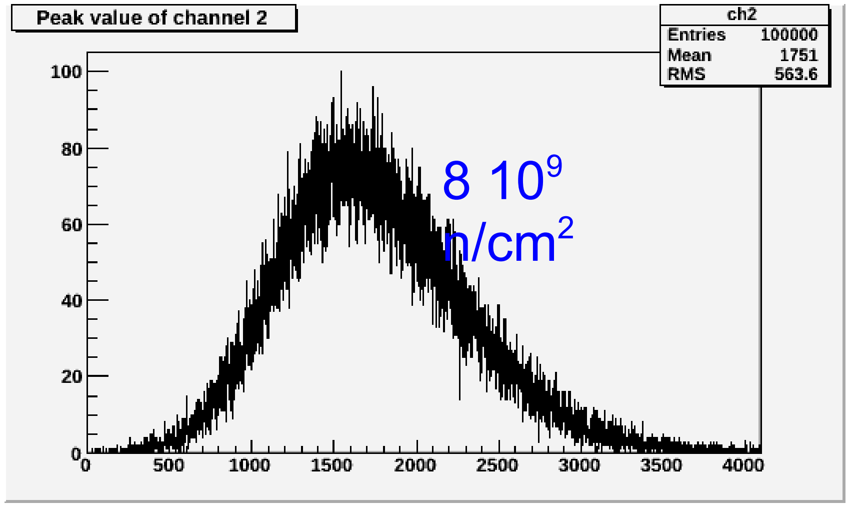


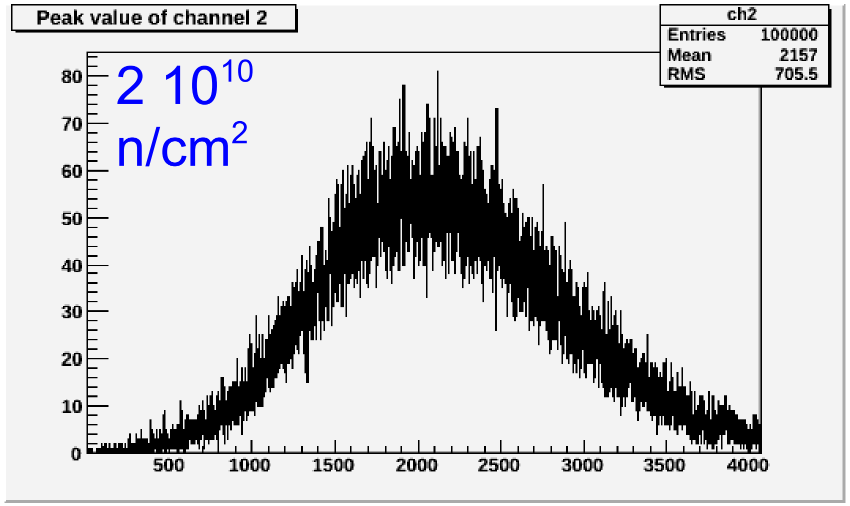
Charge spectra: example 3

- FBK 2008 1x1 mm2, 50 um pixel

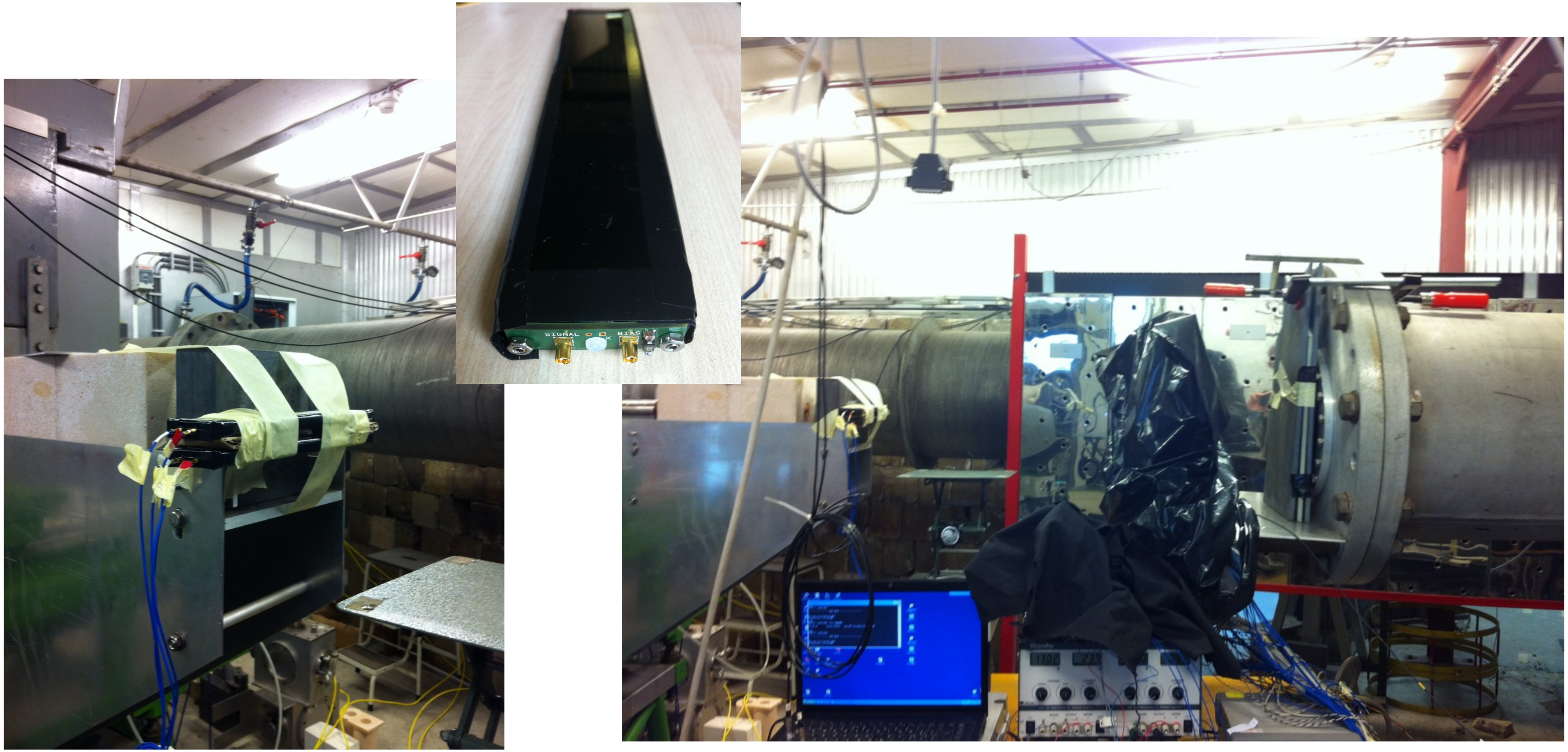








Scintillator irradiation



- 2 prototype bars (WLS w/ and w/o glue)
- Irradiated with ~2 x 10^{10} n/cm^2 (~6x10^8 1Mev eq.)
- NO measurable effect (preliminary)

Conclusion

- Very preliminary results
- Single photon capability (calibration) lost after few 10^9 n/cm^2
- Scintillator, fiber and glue not affected

Backup slides

Tables

Long bar - DATA

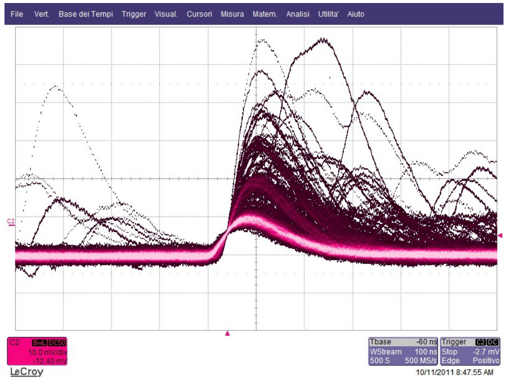
SIPM	D= 10 cm	D= 100 cm	D = 190 cm
Hamamatsu	38	20	15.5
FBK	25.5	14.8	12.8

Long bar - SIMULATION

SIPM	D= 10 cm	D= 100 cm	D = 190 cm
Hamamatsu	31	14	11

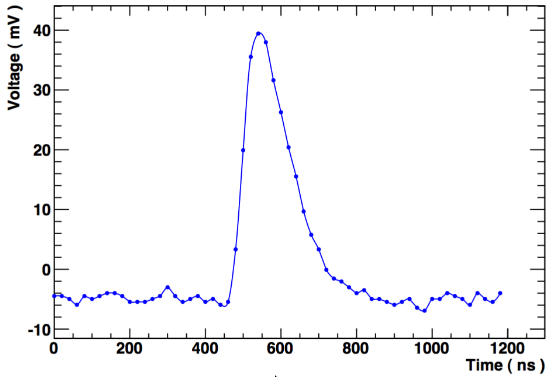
Integrated charge measurements

Slow shaper on scope



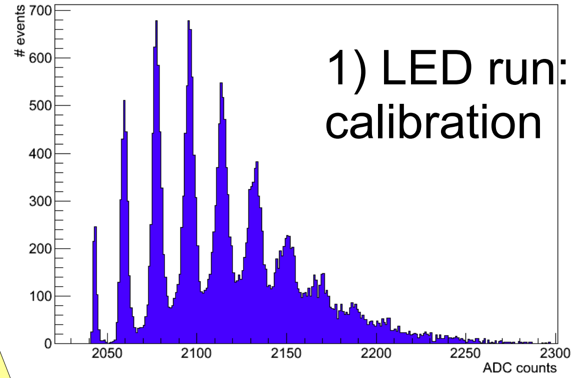
Peaking time ~70 ns

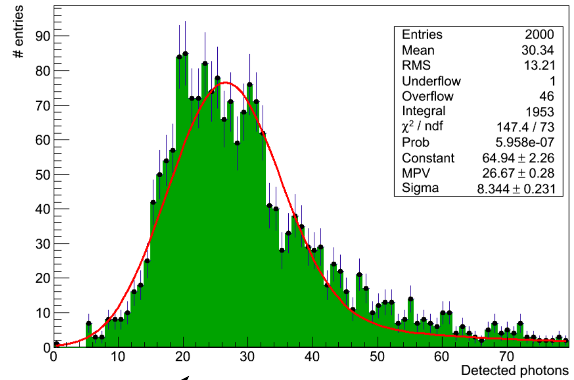
Digitized (50 Msps)



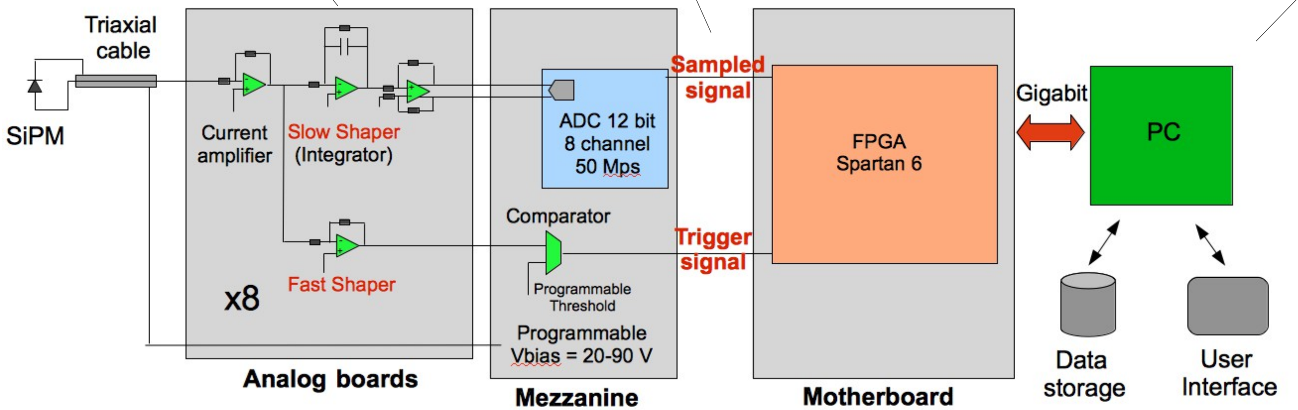
charge spectrum

1) LED run: calibration





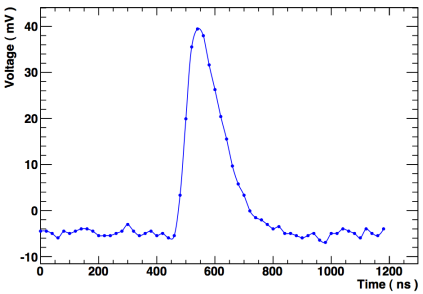
2) Muon run: MIP response



Dark Noise rate measurements

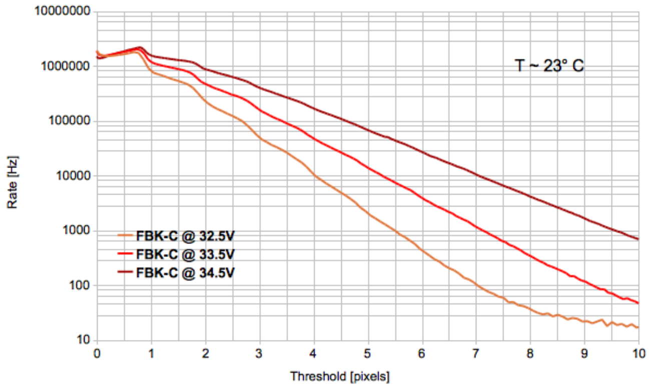
A)

Slow shaper

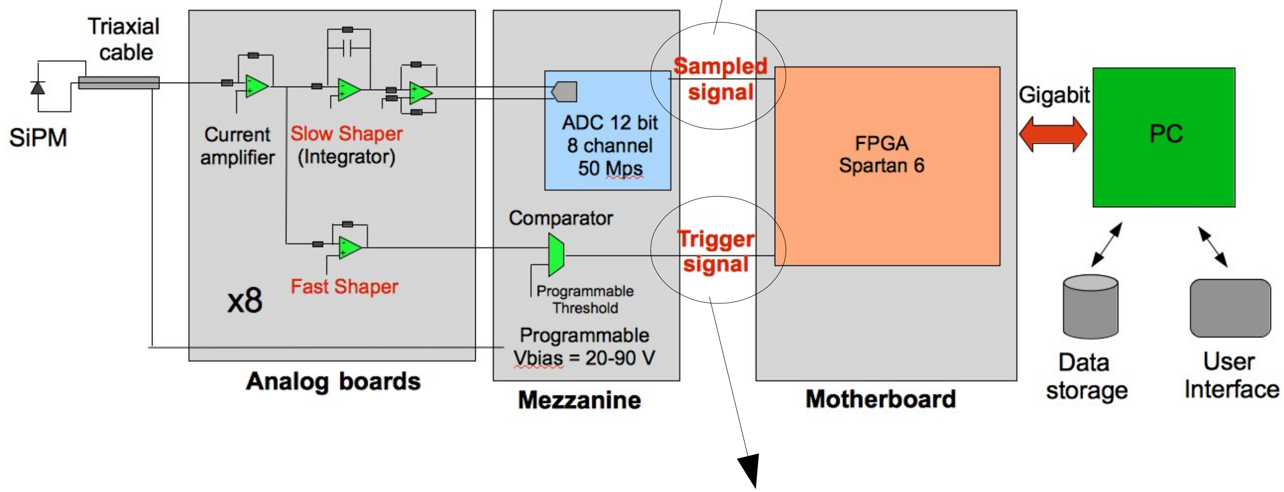


Threshold (fw) on integrated signal
Peaking time ~70 ns
Trigger counters
Threshold calibrated with LED runs

rate



number of pixel

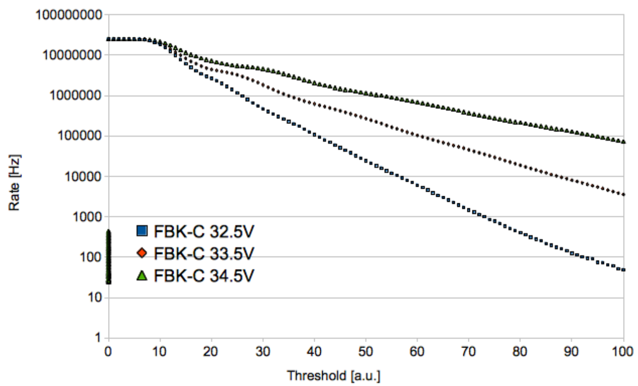


B)

Fast shaper

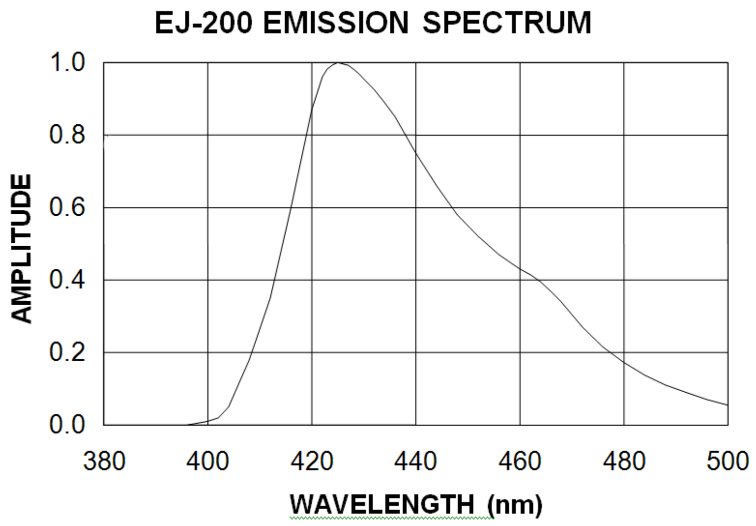
Threshold on comparators
Deadtime ~40 ns (fw limit, can be reduced to ~10 ns)
Trigger counters
Threshold not calibrated

rate

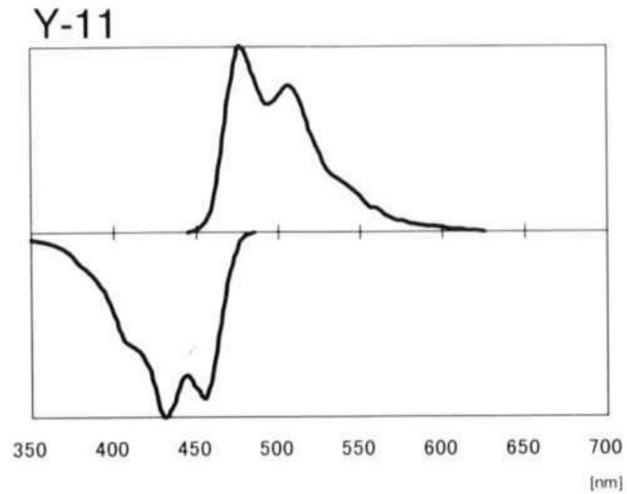


arbitrary units

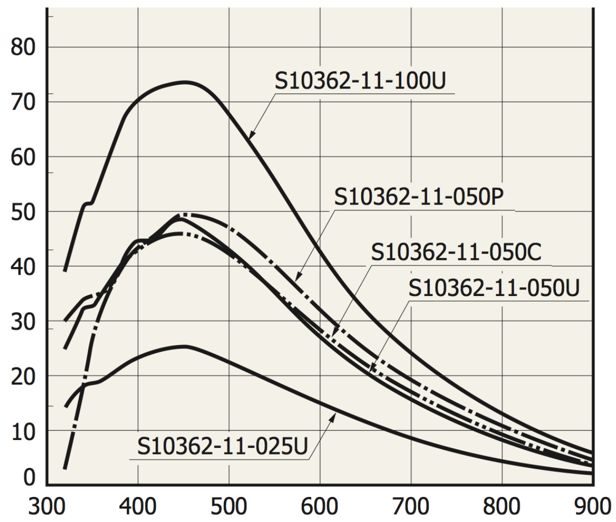
Emission/Absorption spectra



Scintillator: EJ 200



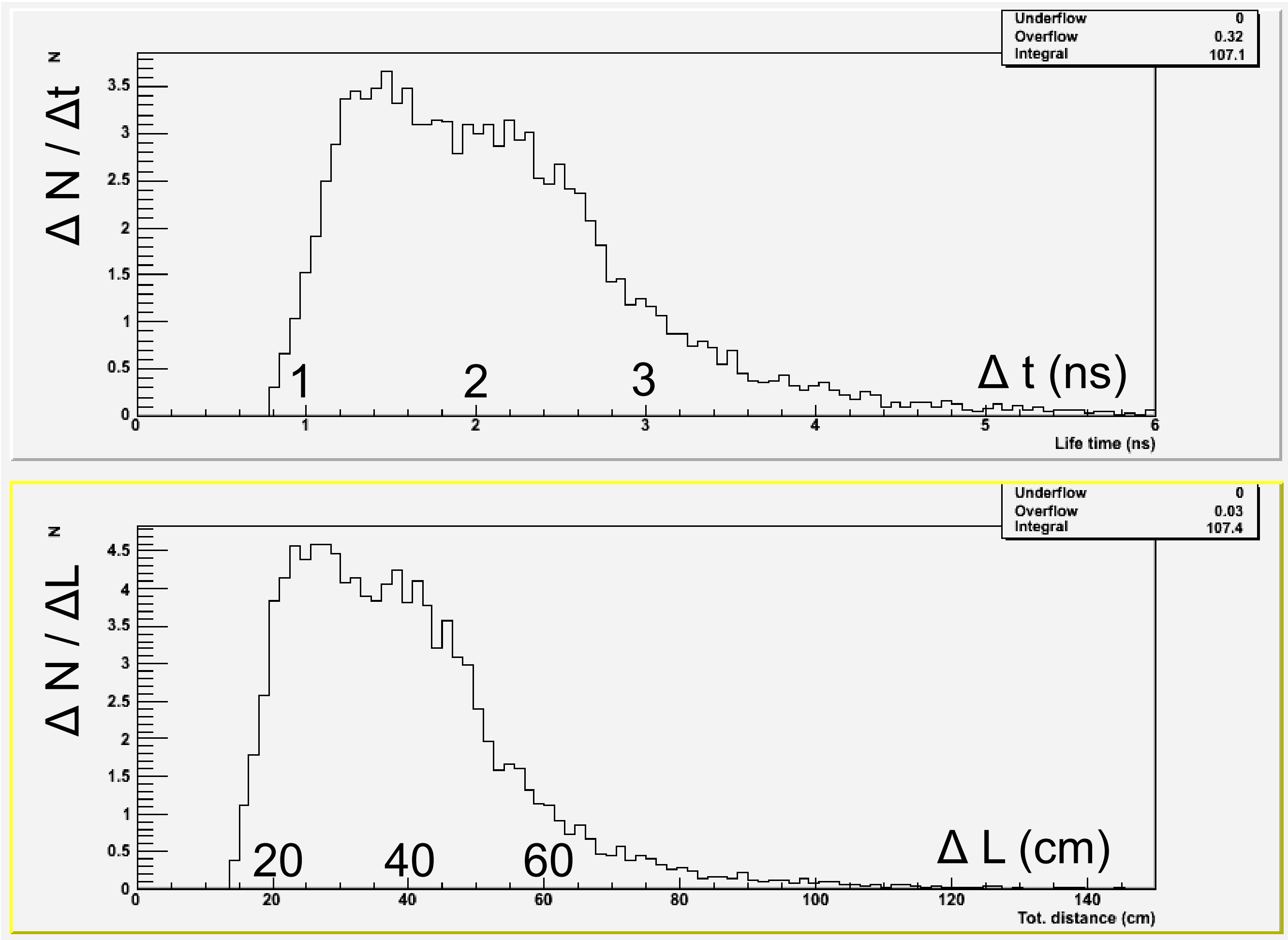
WLS fiber: Kuraray Y11



SiPM: Hamamatsu

Photons arrival times

- If scintillator and WLS fiber decay times are NOT simulated:



Photons arrival times

- Adding decay times simulation:
  - scintillator: τ = 2 ns
  - WLS fiber: τ = 7.5 ns