Proposal to test the *SuperB* FTOF-Counter at the SLAC Cosmic Ray Telescope (CRT)

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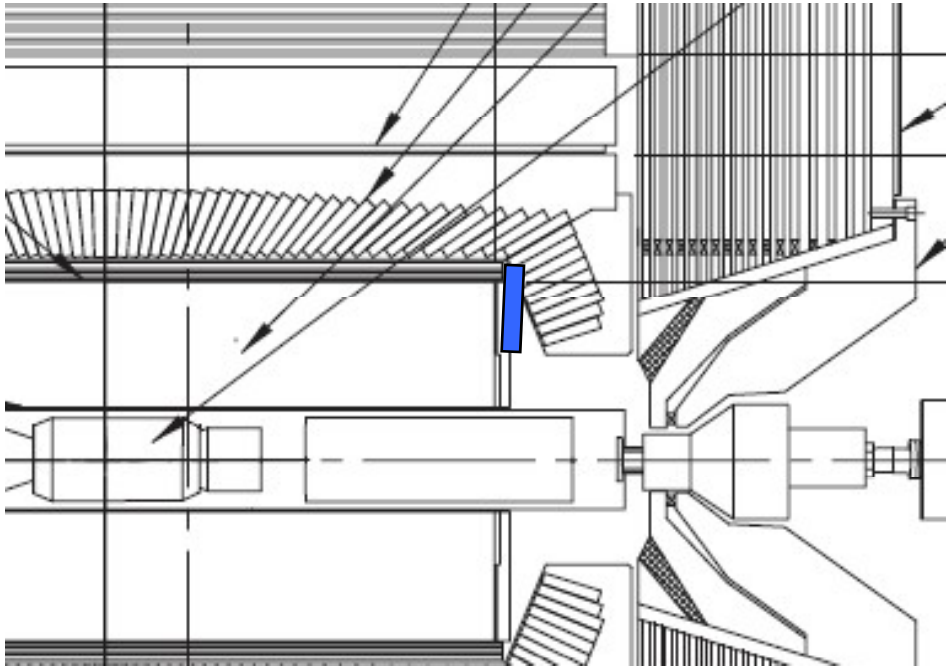
FTOF-COUNTER
for *SuperB*

State-of-the-Art
in between Annecy and Elba meetings

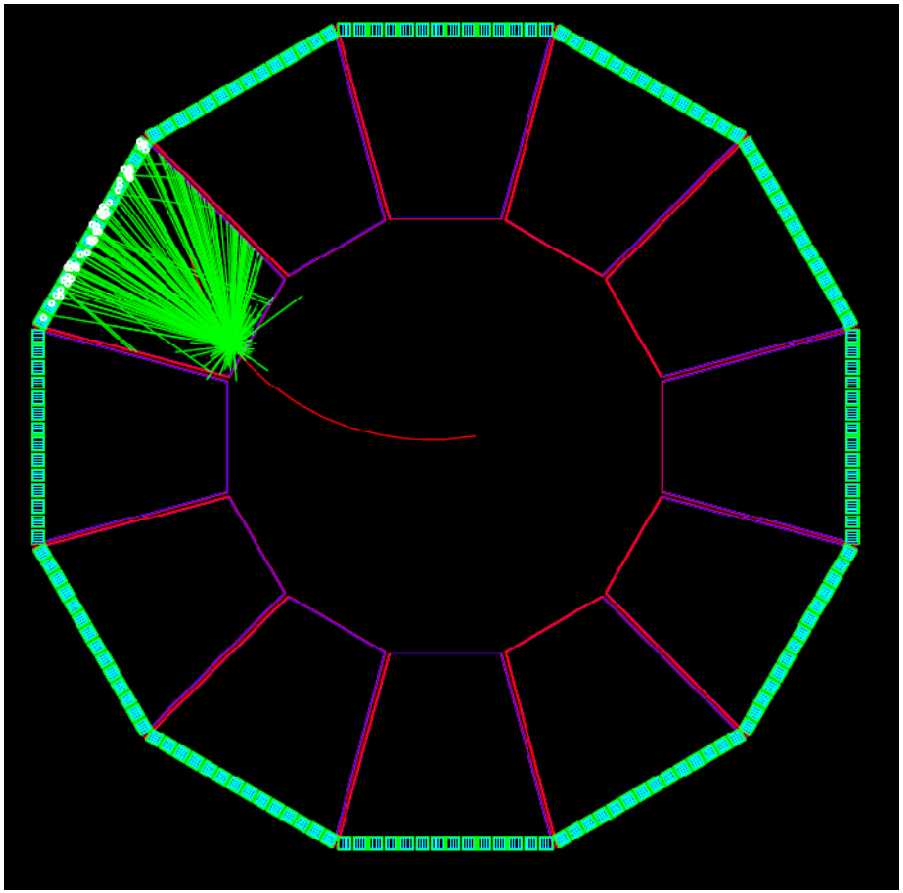
Forward PID in SuperB with a FTOF counter

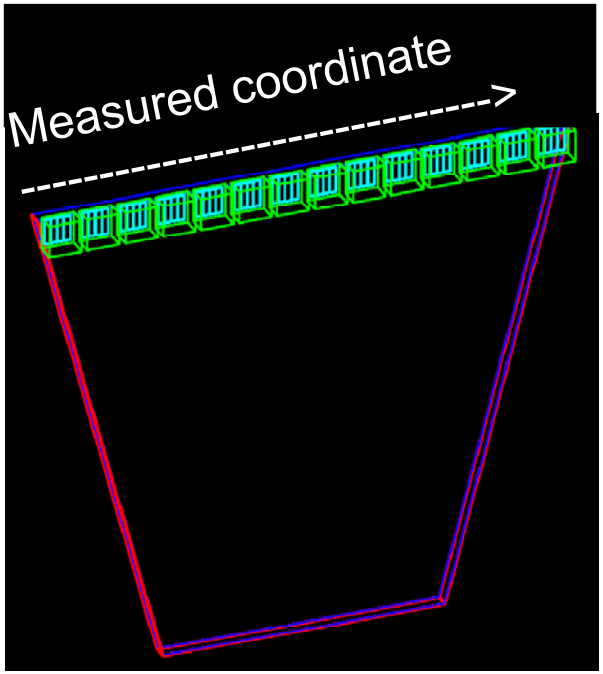


Currently, it seems that the best position for the FTOF counter
is **as close as possible and parallel to the DCH wall**

(preliminary studies show that the FTOF position has **no impact** on the FEMC energy resolution)

Up to the Annecy meeting, the FTOF was placed near and parallel to the FEMC. The last simulation studies have shown that, at that place, the number of photoelectrons was no high enough.
For details see http://agenda.infn.it/getFile.py/access?contribId=1&resId=0&materialId=slides&confId=2524



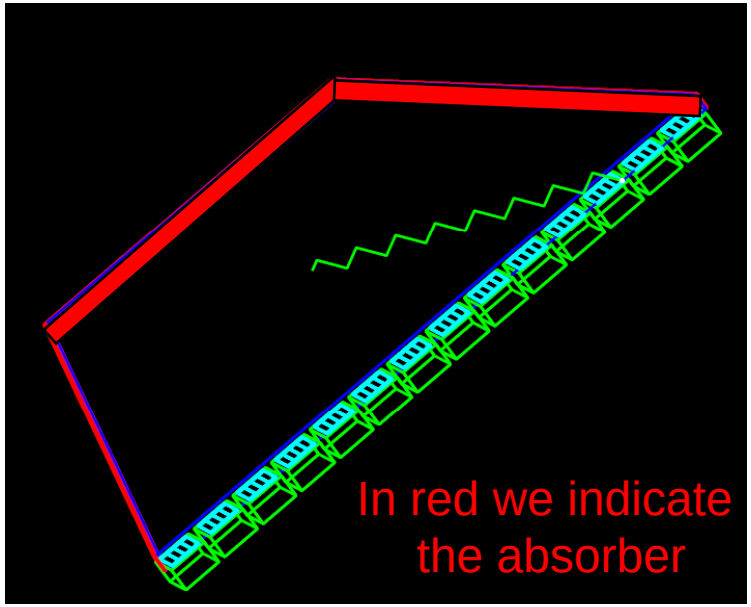


- The detector is made 1.2cm thick (**10% X_0**) quartz sectors,
- There are 12 sectors (30 degree in ϕ) covering **15 < θ < 25** degrees
- The PMT's are attached to the sector outer radius (there are 14 per sector)

Two possibilities are currently considered for the photon collections

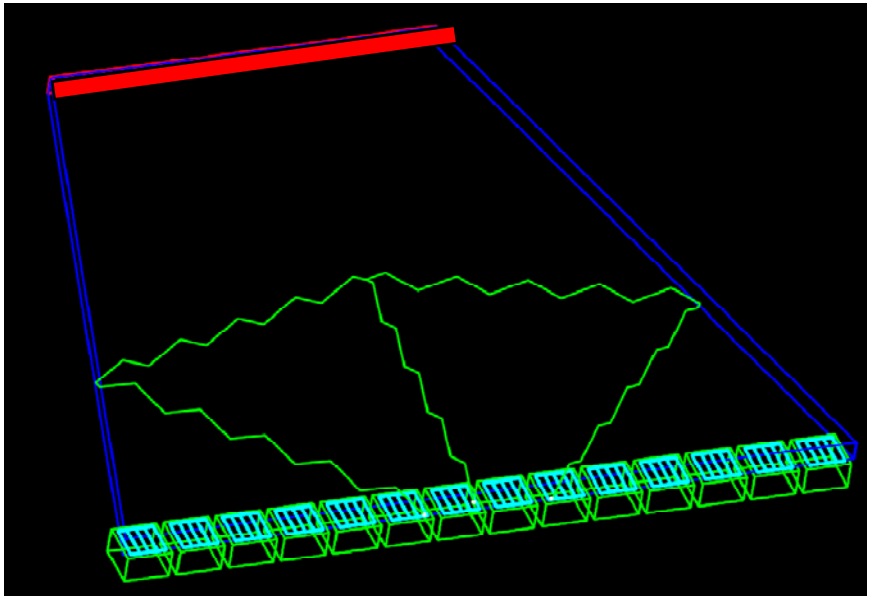
“simple geometry – with absorber”

(only direct photons are collected)



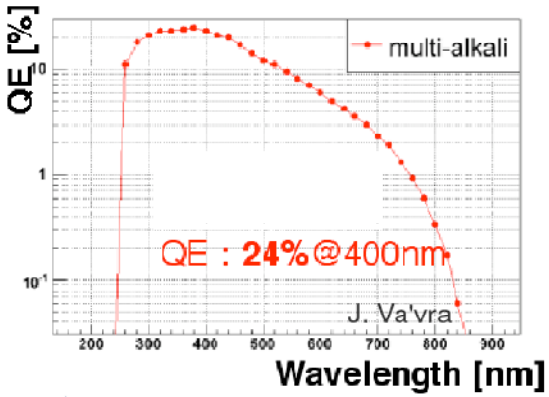
“without absorber”

(photons with different paths are collected)



For these studies we have used SL10 PMTs:

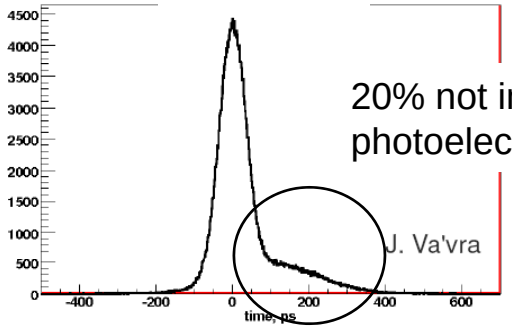
QE: PMT **Q**uantum **E**fficiency



PDE: **P**hoton **D**etection **E**fficiency

PDE = 0.24 (max.QE)
*0.65 (phot. eff)
*0.82 (pack. eff)
= ~0.13

TTS



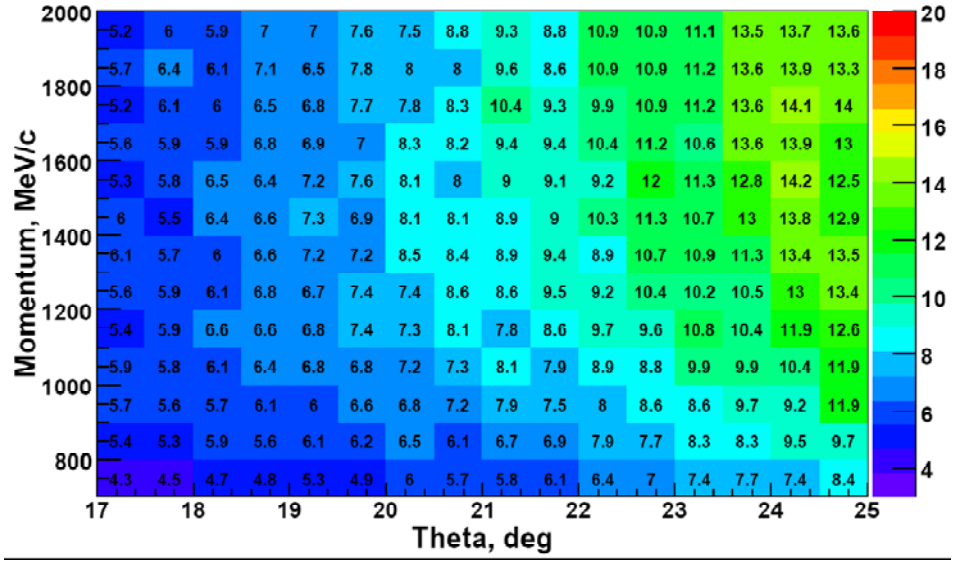
TTS: **T**ransit **T**ime **S**pread (ps)

20% not in time photoelectron

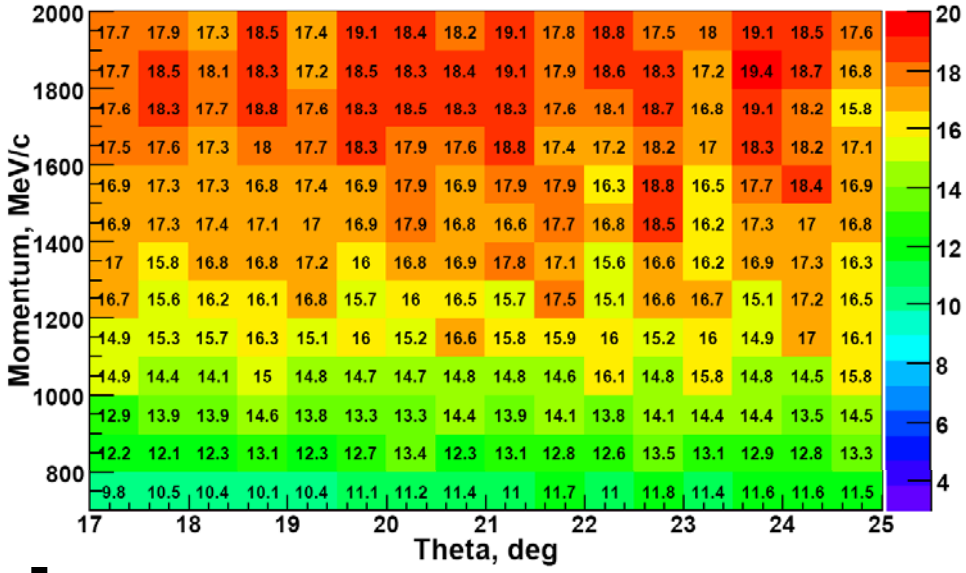
Average number of detected photelectrons (phe.) momentum vs theta

(average over phi)

“simple geometry – with absorber”

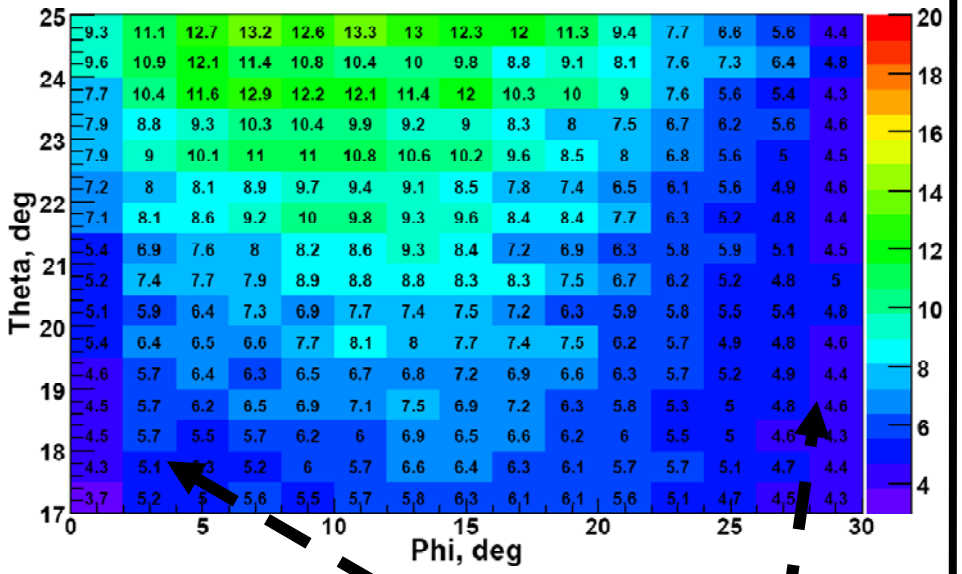


“without absorber”

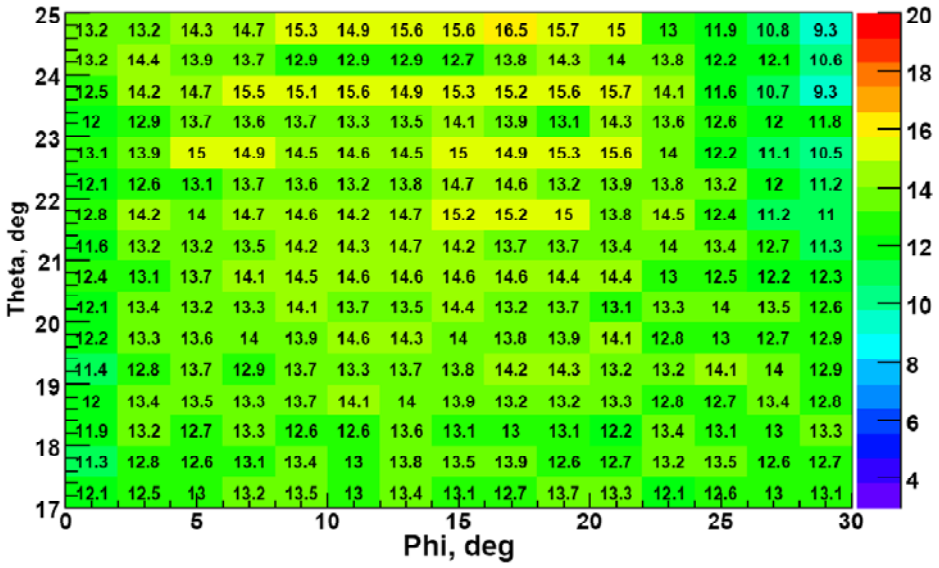


Taking a slice of the previous plot (tracks with p = 900 MeV/c)
and looking at the (phi, theta) dependence of N_{phe}

With absorber



Without absorber

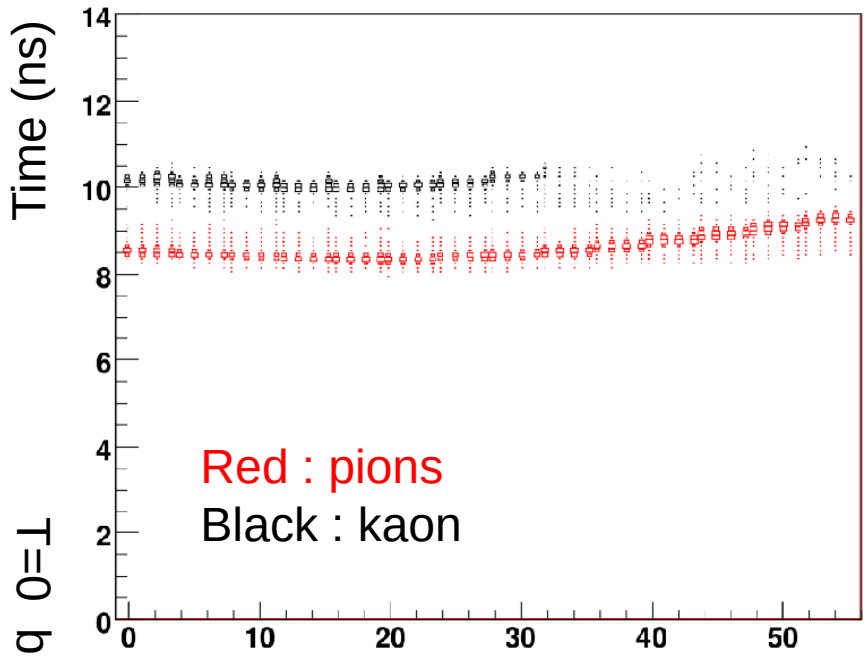


It can be noted the there is a lack
of phe.in the phi-border of the detector

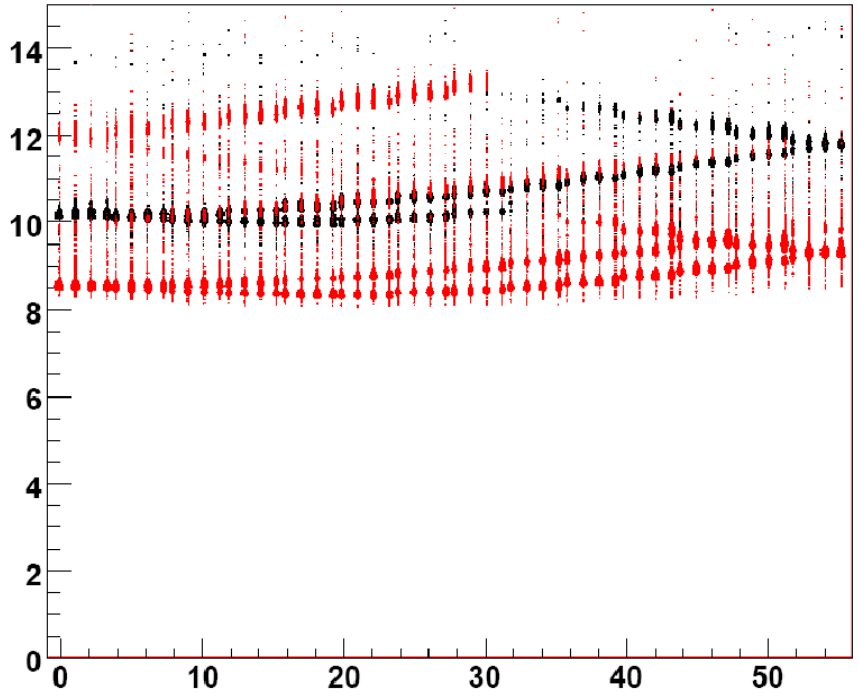
Overlap between sectors could help (under study)

Photoelectron timing using tracks with P=700Mev , theta=17, phi=0

“simple geometry – with absorber”



“without absorber”



More photons collected but time algorithm more difficult. Under study

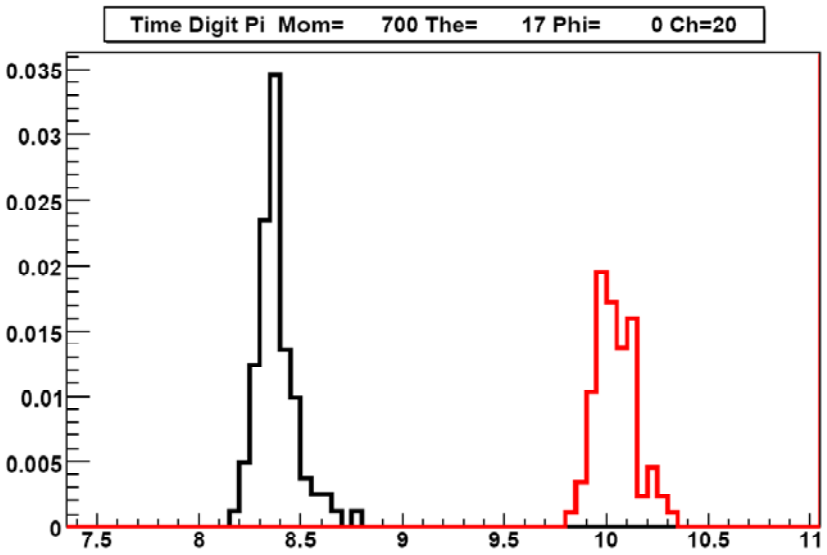
FTOF is a 2D device because it measures time vs position

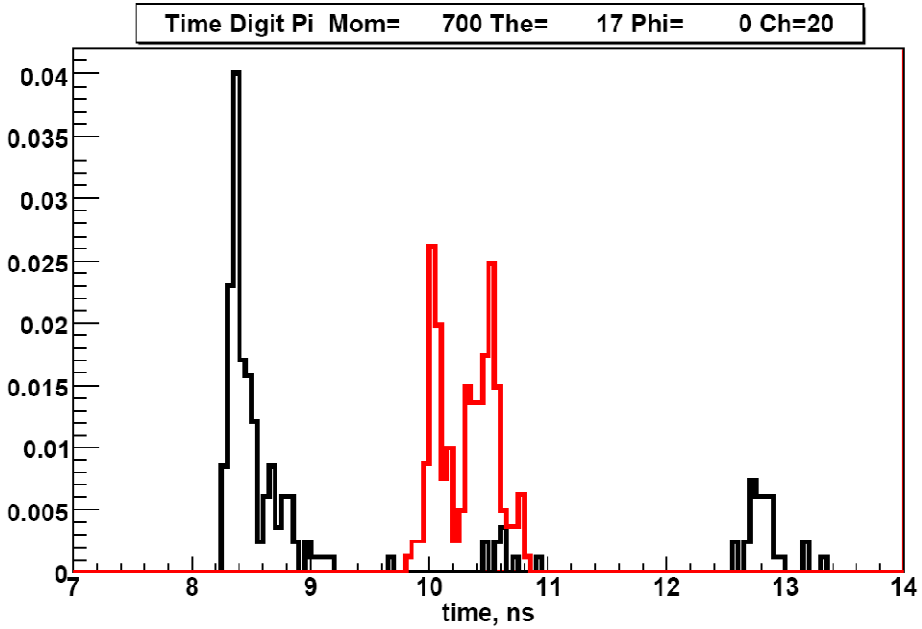
“simple geometry – with absorber”

“without absorber”

In both cases the reconstruction algorithm will be based on the time difference T(expected)-T(measured).

Clearly, in the simple geometry, the algorithm is much simpler and with no ambiguities



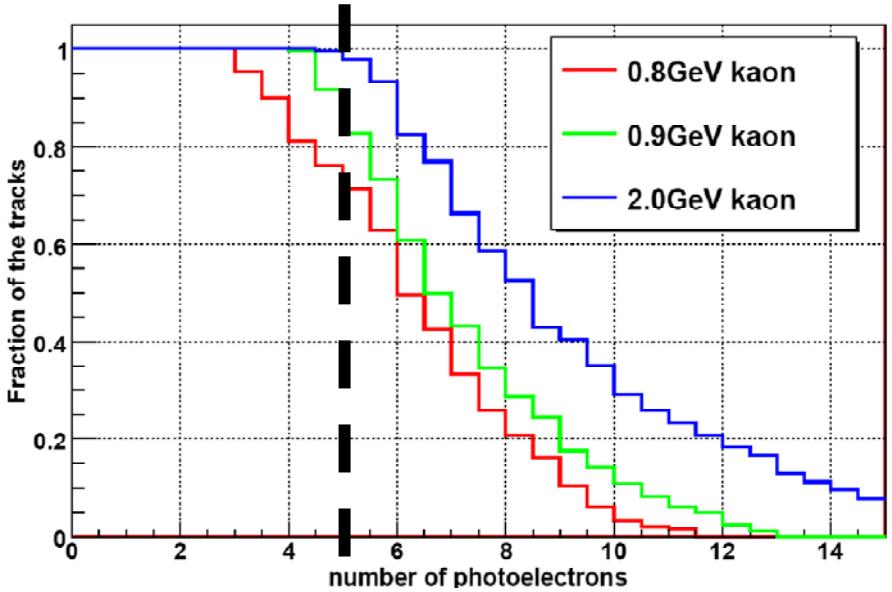


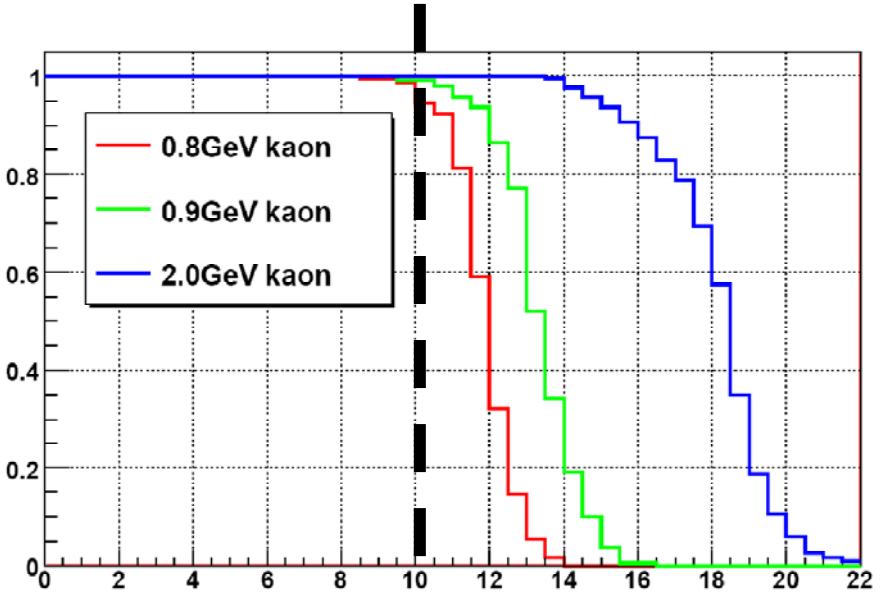
We are working on the algorithm for both layouts

“simple geometry – with absorber”

“without absorber”

Fraction of tracks of a given momentum producing more than “x” number of photelectrons





more than 5 phe. for all theta
and momentum > 0.9 GeV/c

More 10 phe. for all theta
and momentum > 0.9 GeV/c

Time vs position algorithm simple

Time vs position algorithm more complicated

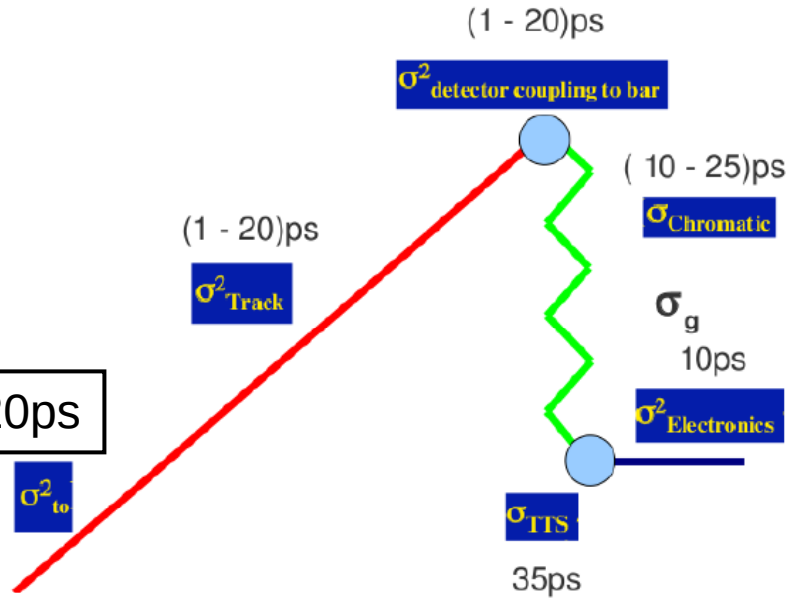
Possible improvements:

- overlap between sectors
- Thicker detector (up to 15% X_0)

Time resolution

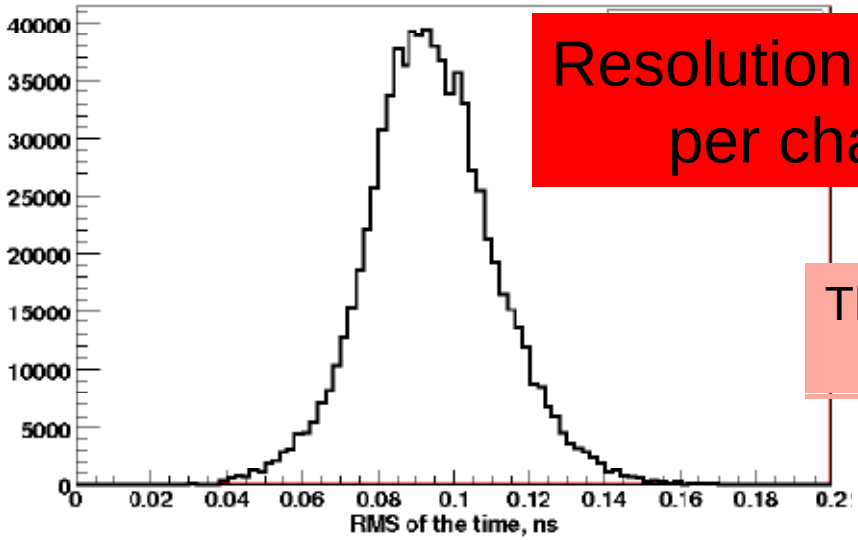
$$\sigma_{Total} \sim \sqrt{[\sigma^2_{Electronics} + (\sigma_{Chromatic}/\sqrt{(\varepsilon_{Geometrical\_loss} * N_{pe})})^2 + (\sigma_{TTS}/\sqrt{N_{pe}})^2 + \sigma^2_{Track} + \sigma^2_{detector\ coupling\ to\ bar} + \sigma^2_{to}]}$$

J. Va'vra, Forward TOF update



σ^2_{to}	By hand
σ^2_{Track}	FastSim
$\sigma^2_{detector\ coupling\ to\ bar}$	FastSim
$\sigma_{Chromatic}$	Geant4
σ_g time spread due to geometry of the detector	Geant4
σ_{TTS}	By hand
$\sigma^2_{Electronics}$	By hand

$\sigma(z)/c = 600\mu m/c \sim 20ps$

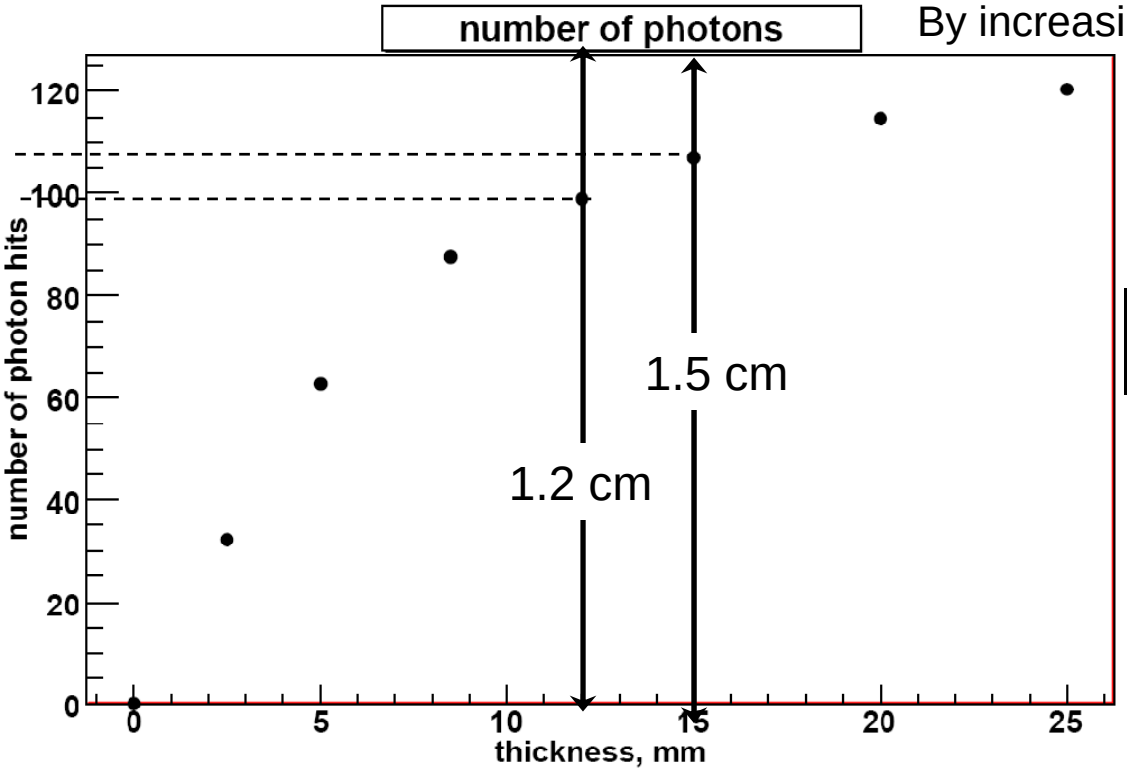


Resolution of ~90ps per channel

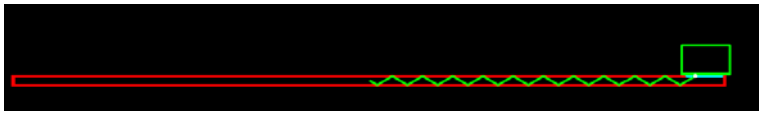
All these terms are "approximately" divided by **Sqrt (N-phe)**

The total time resolution will be between 30-40 ps (minimum 5 phe.)

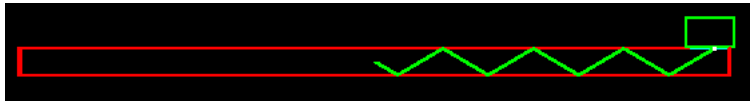
Some further studies : Impact of the detector thickness (studies done for geometry “with absorber”)



By increasing the thickness 1.2cm → 1.5cm (20%) We get 10% more photons.

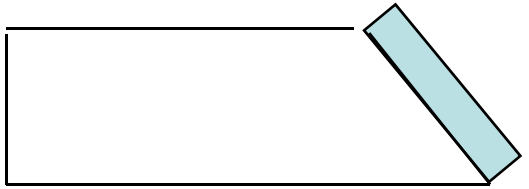


The number of collected photon is not linearly growing with the thickness of the detector: photons start getting lost when the distance between two consecutive side reflections exceeds the PMT size



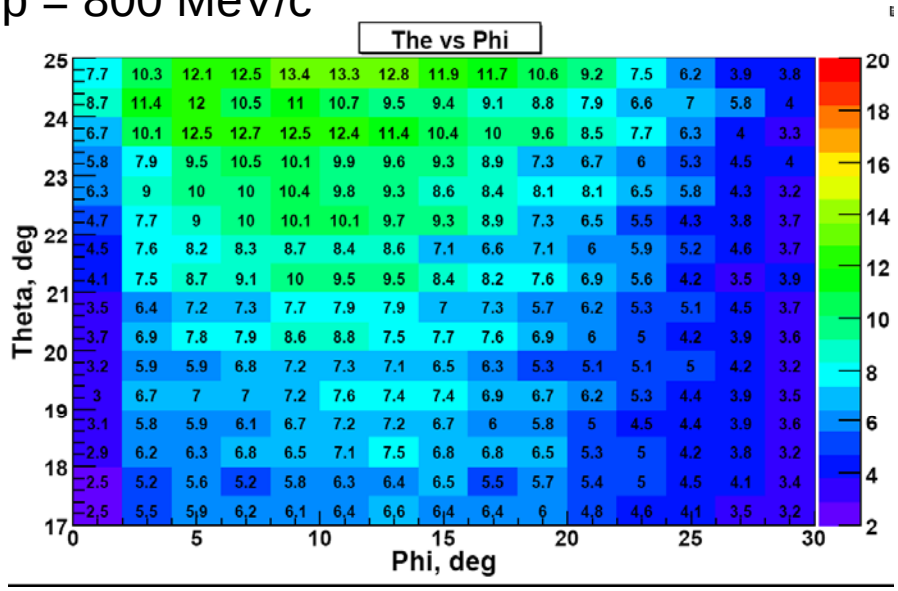
With reasonable PMT tilting angle for the magnetic field…

A possible solution could be to arrange the PMTs in a different way:

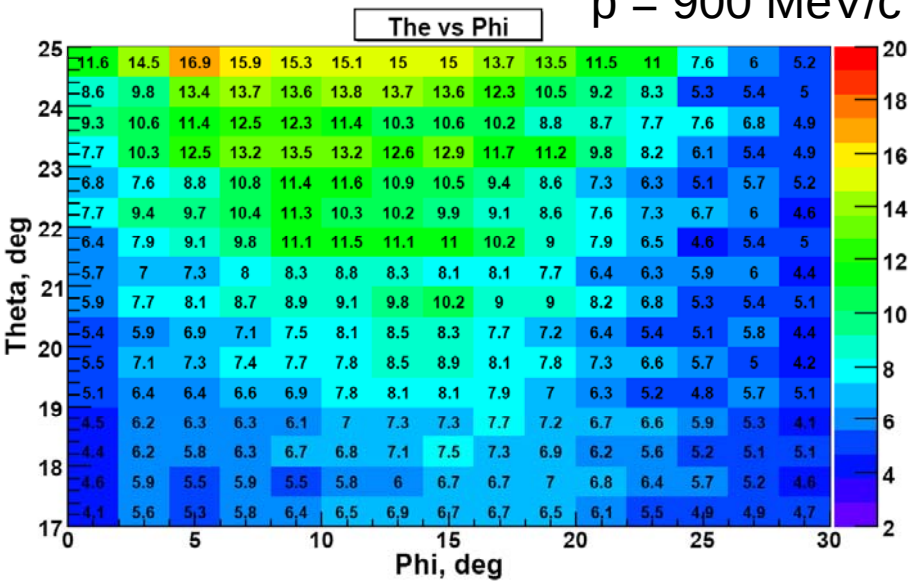


Number of photoelectrons collected for a 1.5 cm quartz thickness

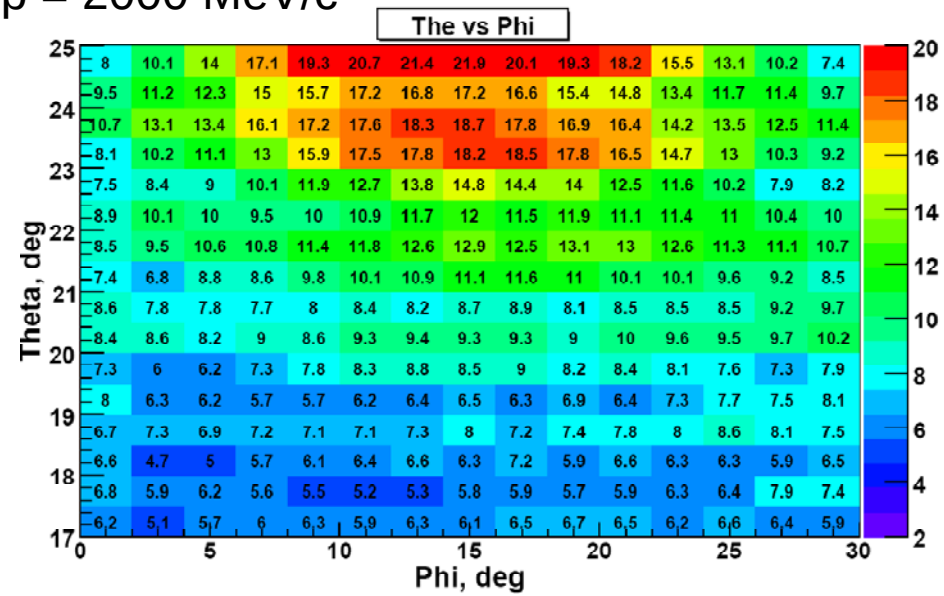
p = 800 MeV/c

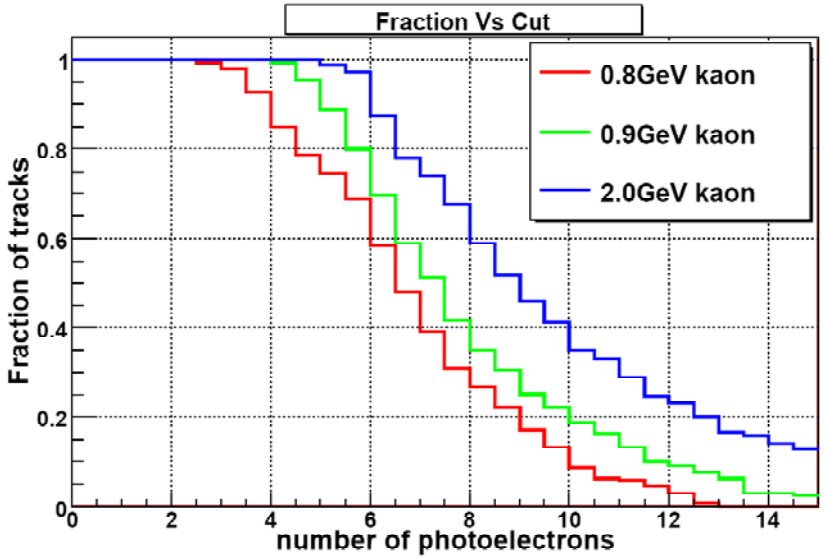


p = 900 MeV/c



p = 2000 MeV/c





Marginal improvement with respect to the 1.2cm thickness layout

Preliminary conclusions

The FTOF device for PID in the forward region located near to the DCH seems to meet the requirements of the minimum number of collected photoelectrons.

Working without absorber (all faces reflecting photons) we can collect at least 10 photoelectrons in all theta range and for p>0.9 GeV/c

The time resolution per photoelectron is about 90 ps.

CAVEAT : Machine background has to be studied.

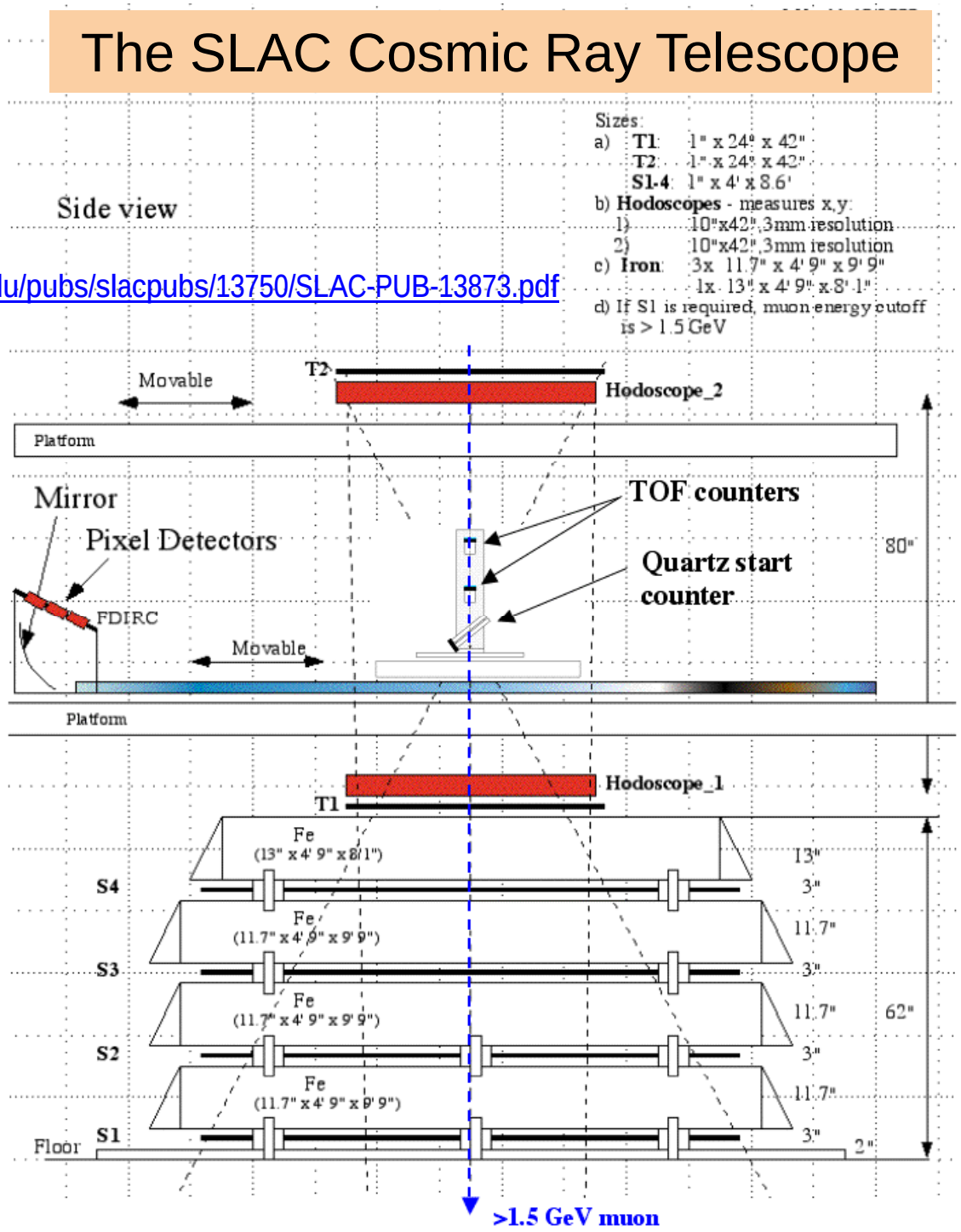
We propose to perform experiments of the FTOF counter at the SLAC CRT

Aims:

- To make detector + PMT + electronics working together
- To test and to prove on data the FTOF principle (for instance the algorithms for the geometry without absorber)

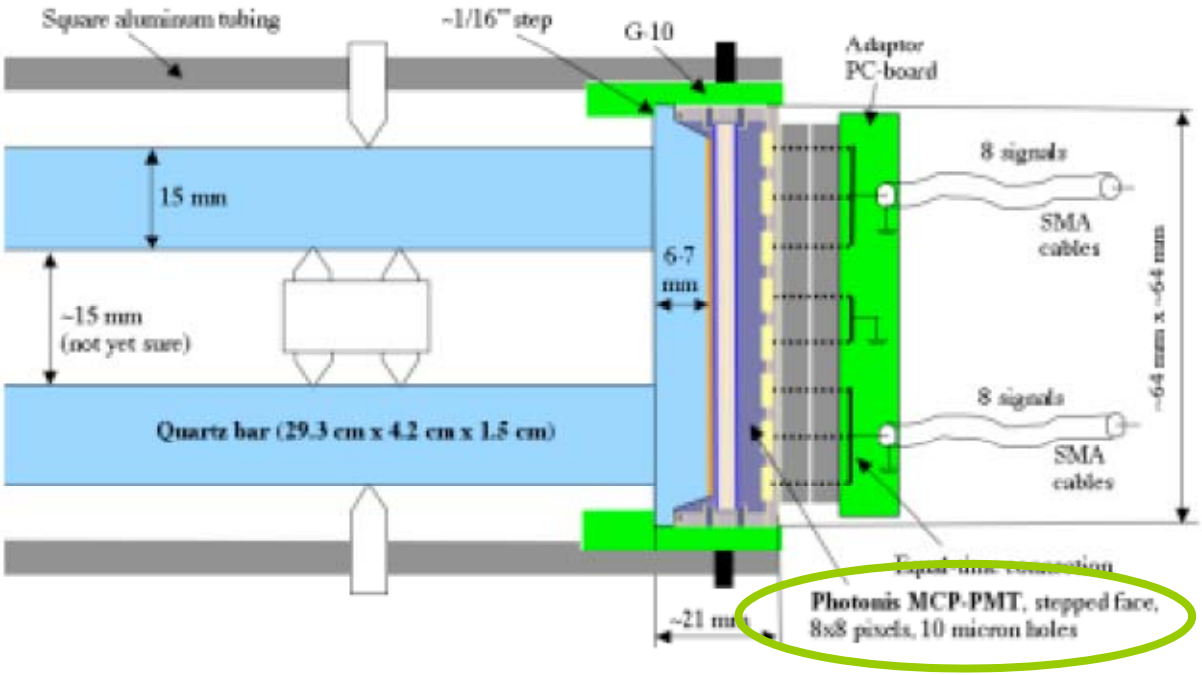
The SLAC Cosmic Ray Telescope

http://www.slac.stanford.edu/pubs/slacpubs/13750/SLAC-PUB-13873.pdf



Experiment – PHASE I

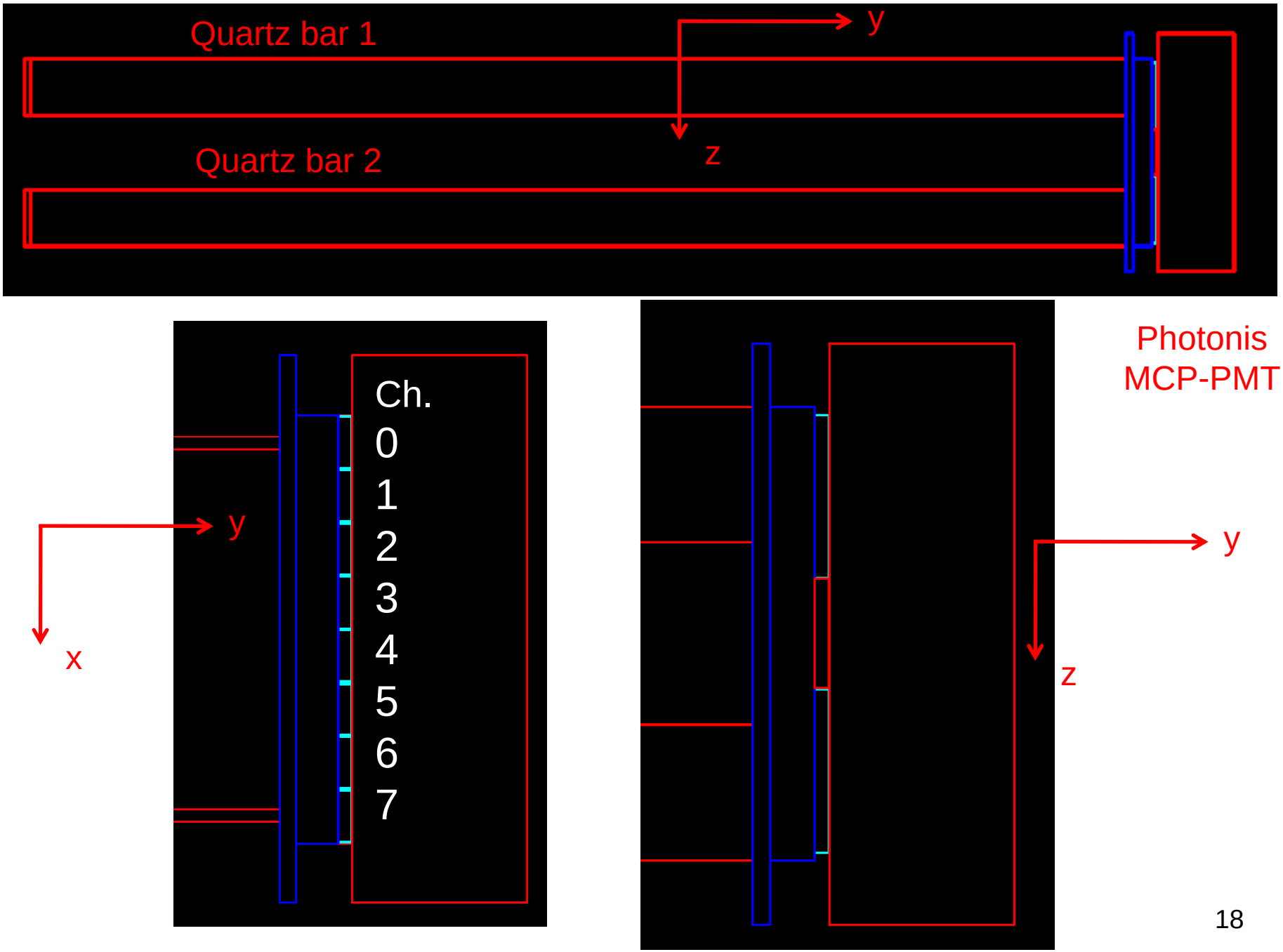
Quartz bars and a Photonis MCP-PMT (10 micron holes) are available at SLAC



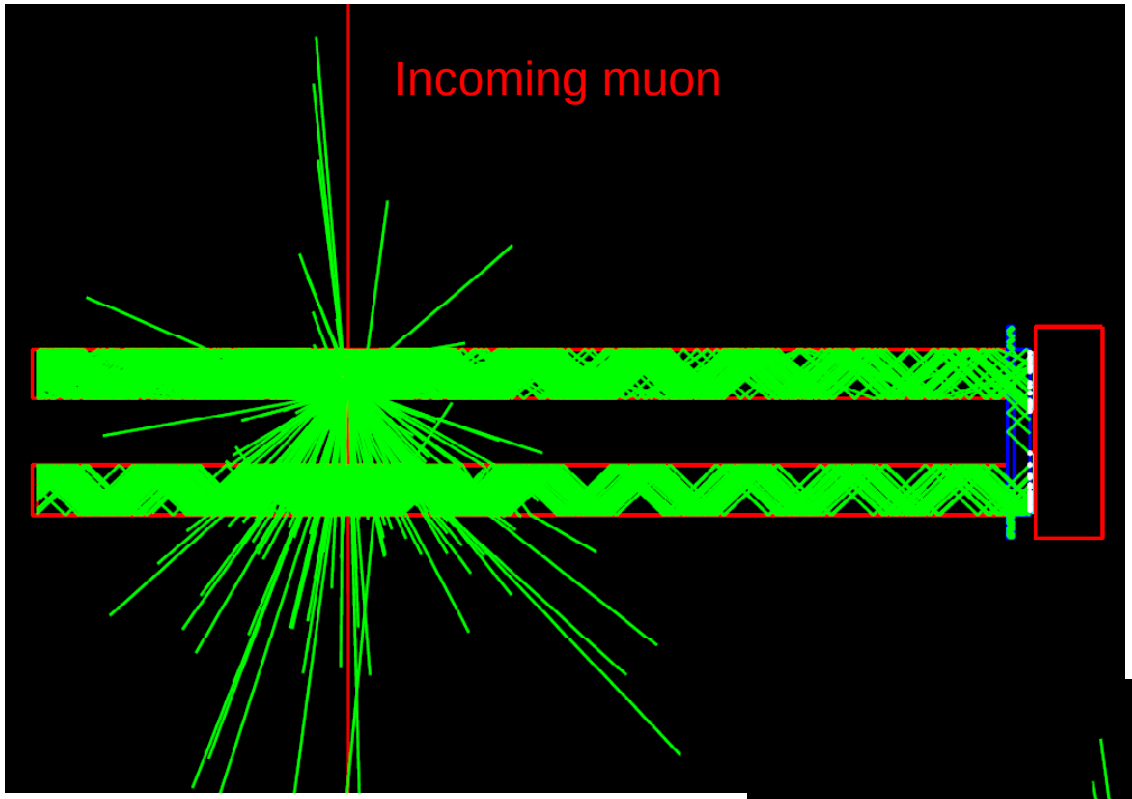
2 Quartz bars
From BaBar
29.3×4.1×1.5 cm

Photonis MCP-PMT
In this case PDE=0.2
- no packing efficiency
- no tails in TTS

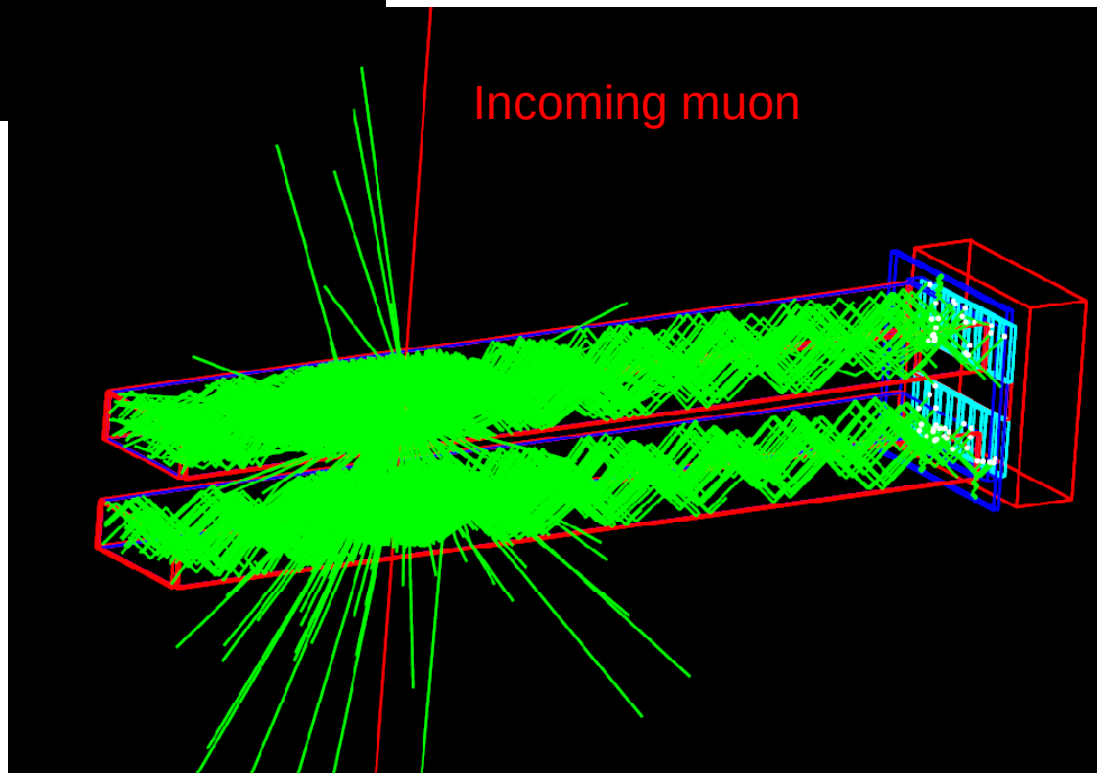
For this experiment we will need 8 Orsay 'Wavecatcher' electronic boards
(see cost evaluation at the end of the slides)

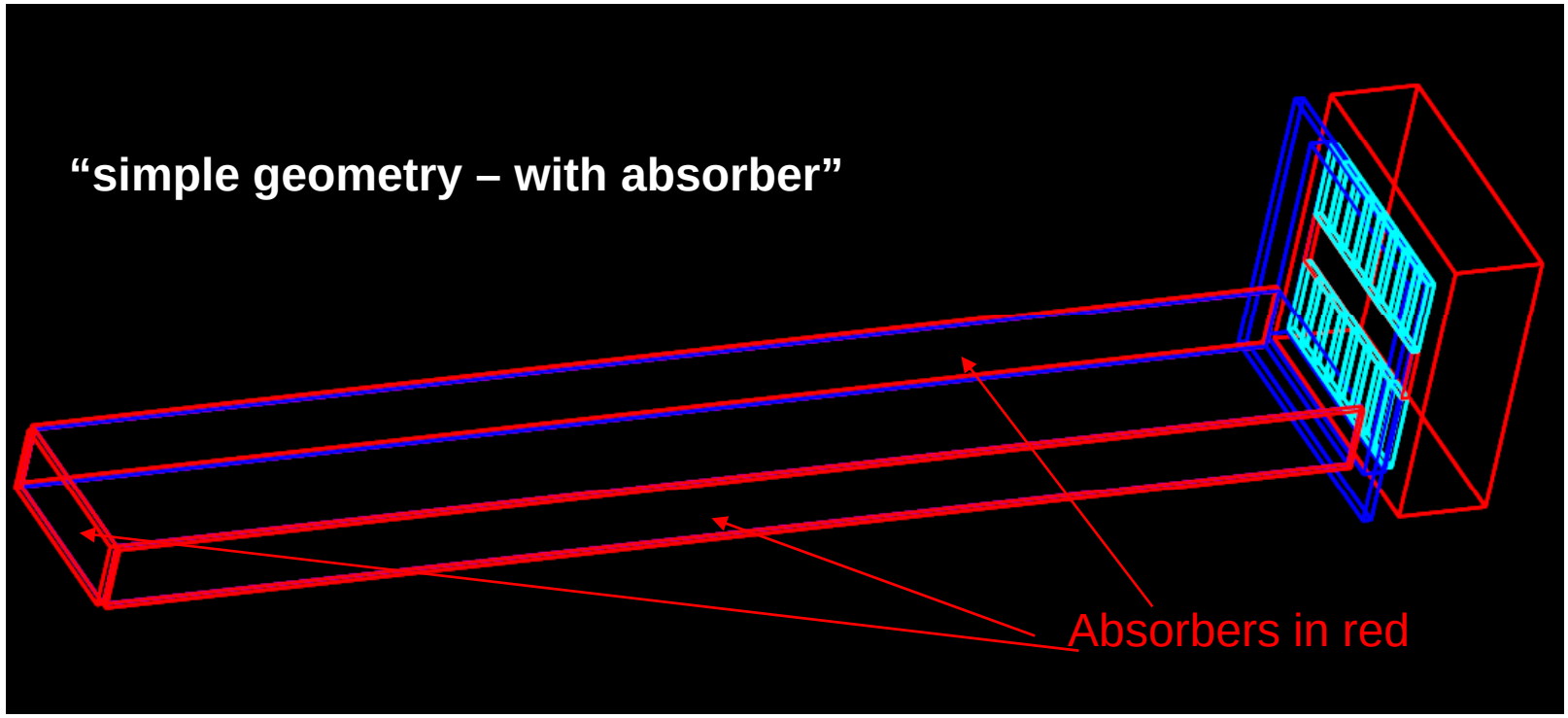


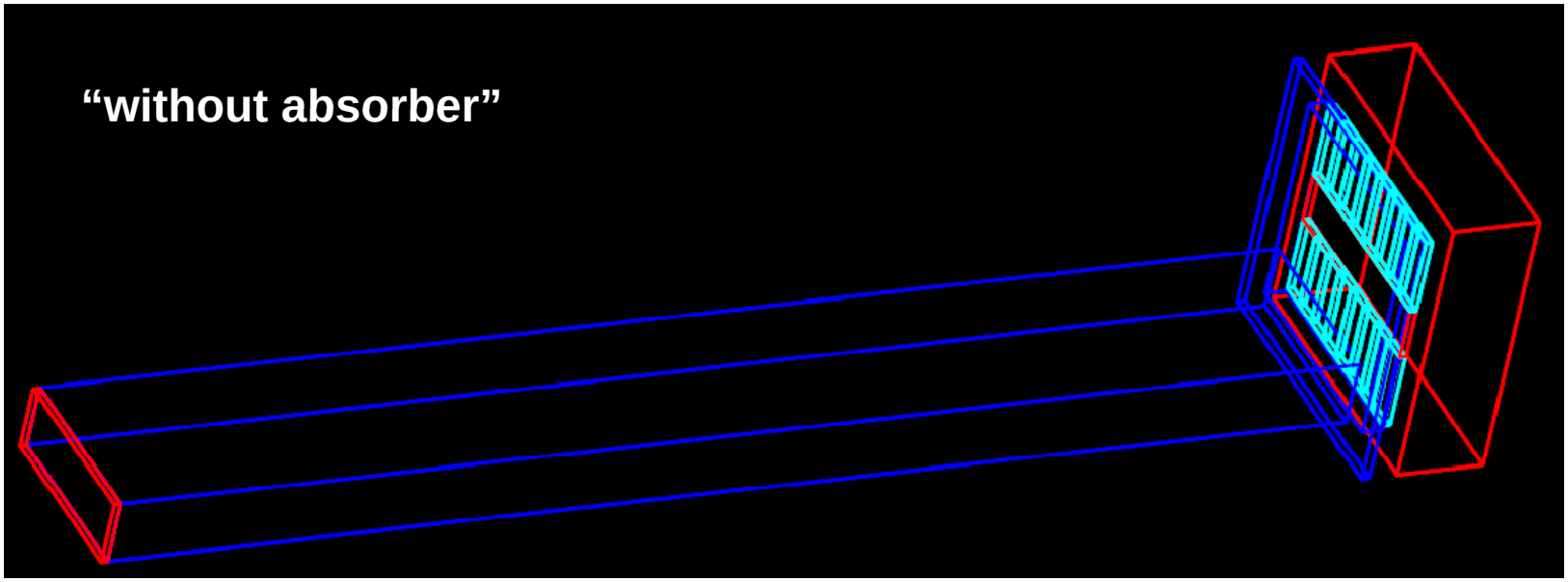
Side views – (y,z) and (x,y) – of the experimental layout

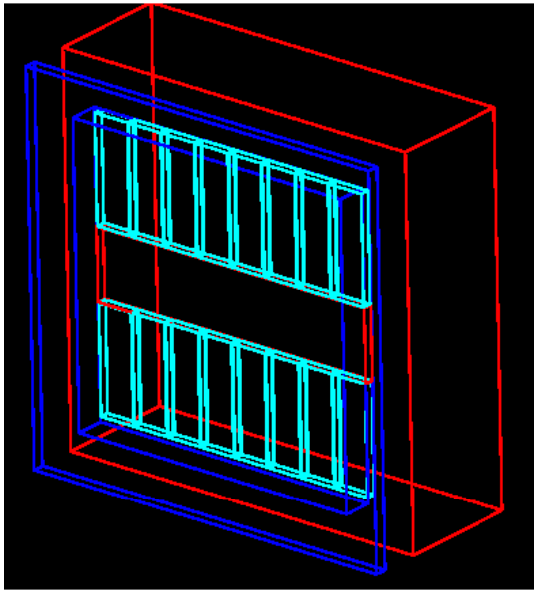


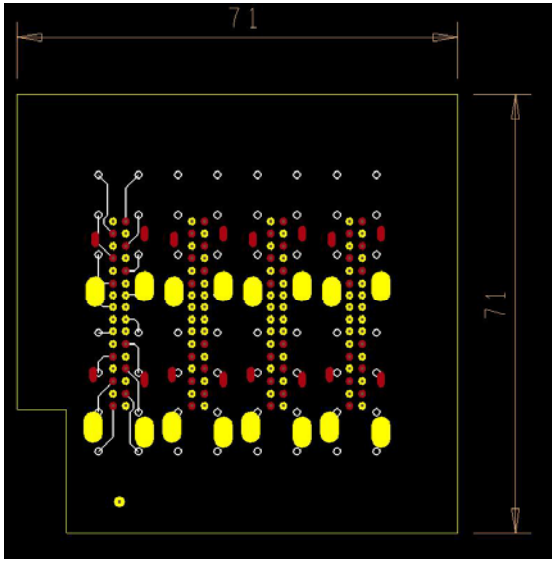
A 1.5 GeV/c muon in the layout “with absorber”




“simple geometry – with absorber”
Absorbers in red


“without absorber”

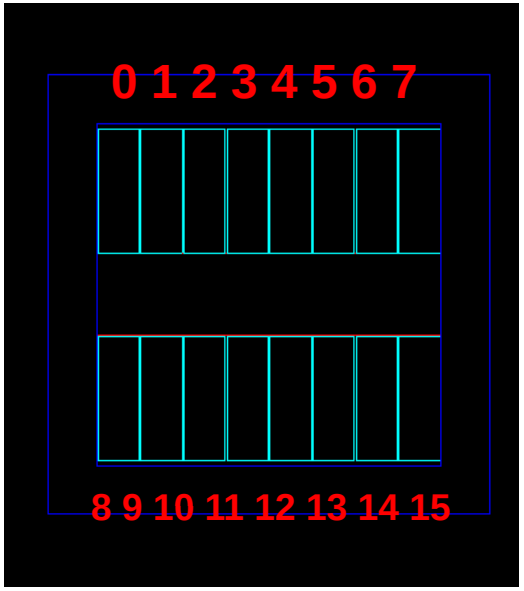


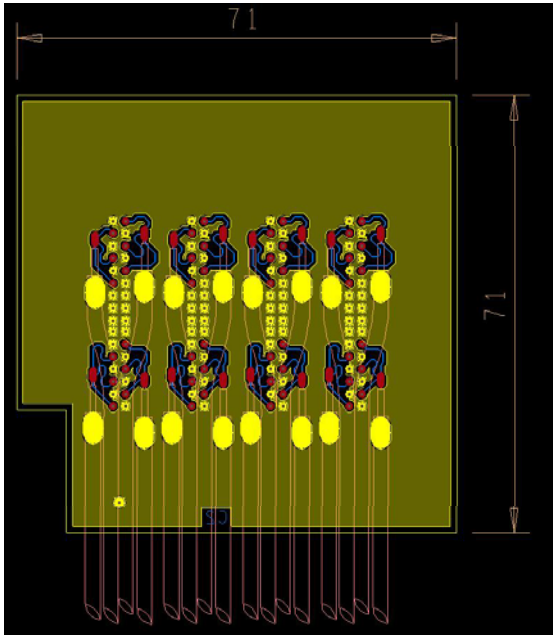


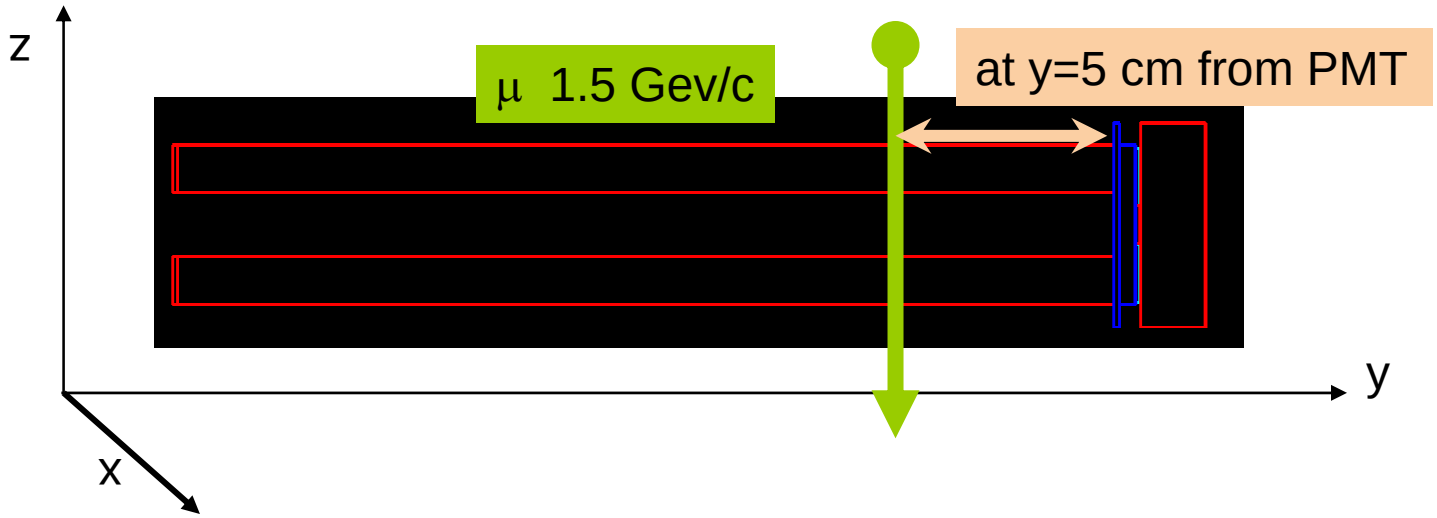
As shown on these drawings (left: from Geant4; right: the corresponding electronics design), the 8 PMT channels in the z-direction are grouped in the following way:

* the first 3 form one channel
* the next 2 are grounded
* the last 3 form another channel

The channels are numbered as shown on the left plot

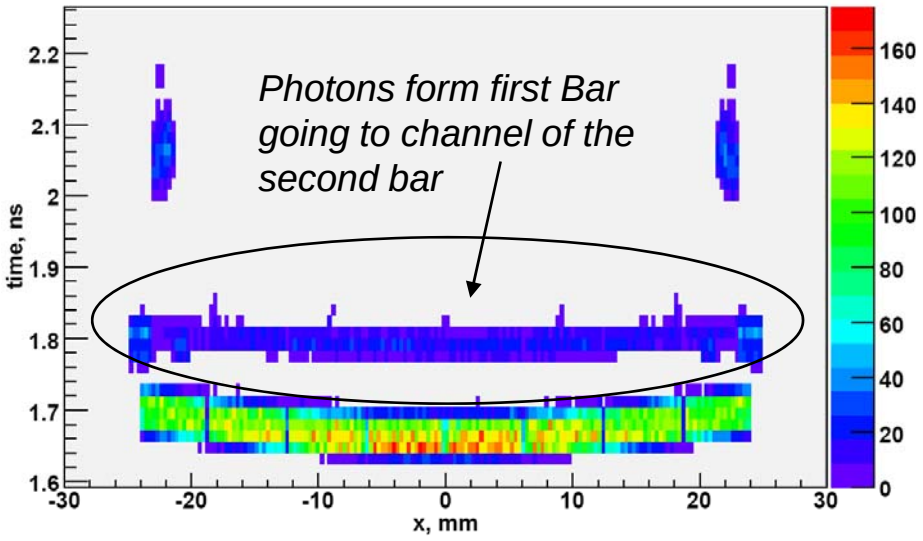




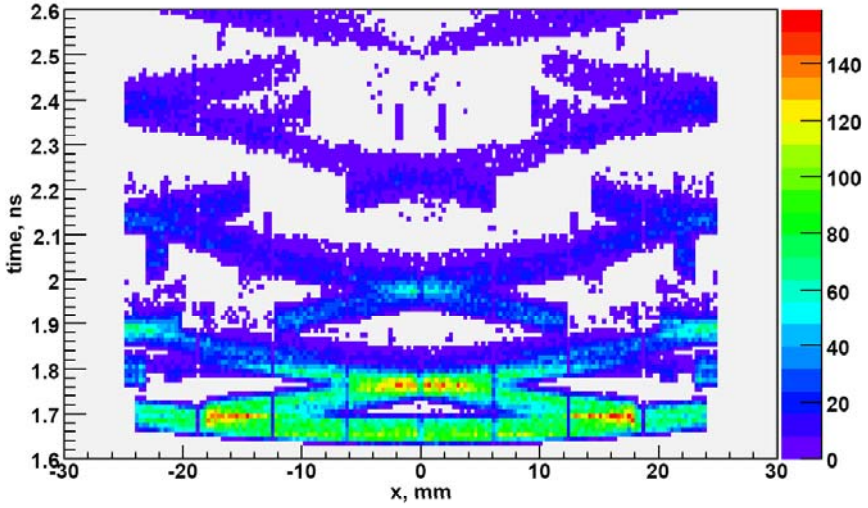


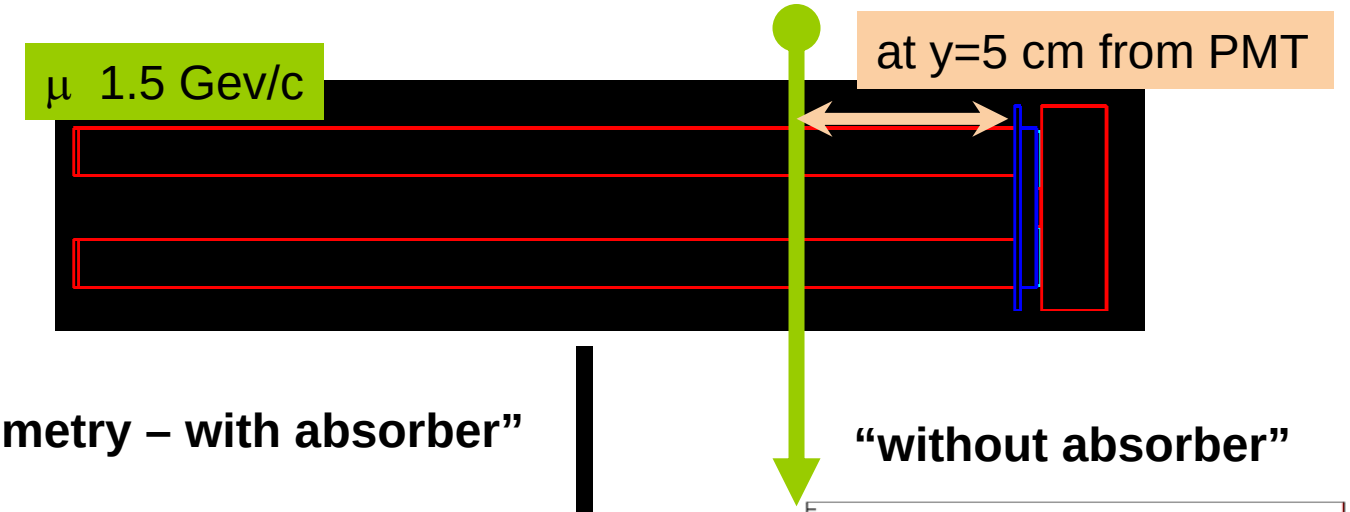
As in SuperB, we can define a simple geometry and a geometry with absorber

“simple geometry – with absorber”

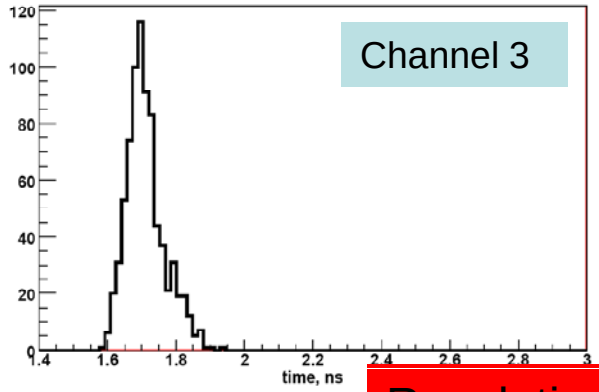


“without absorber”

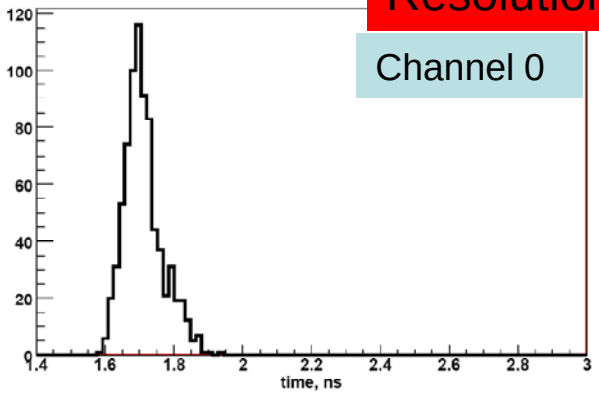




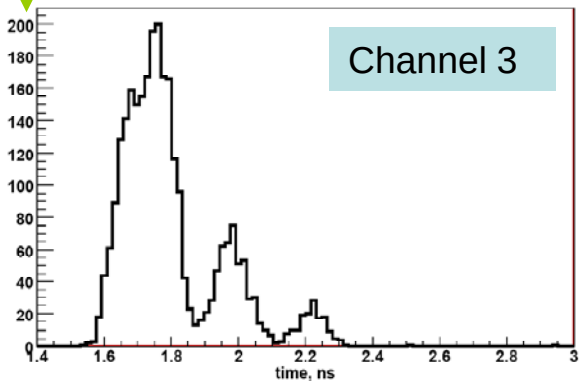
“simple geometry – with absorber”

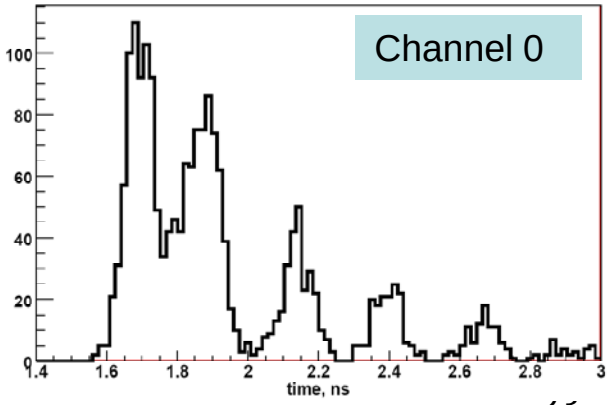


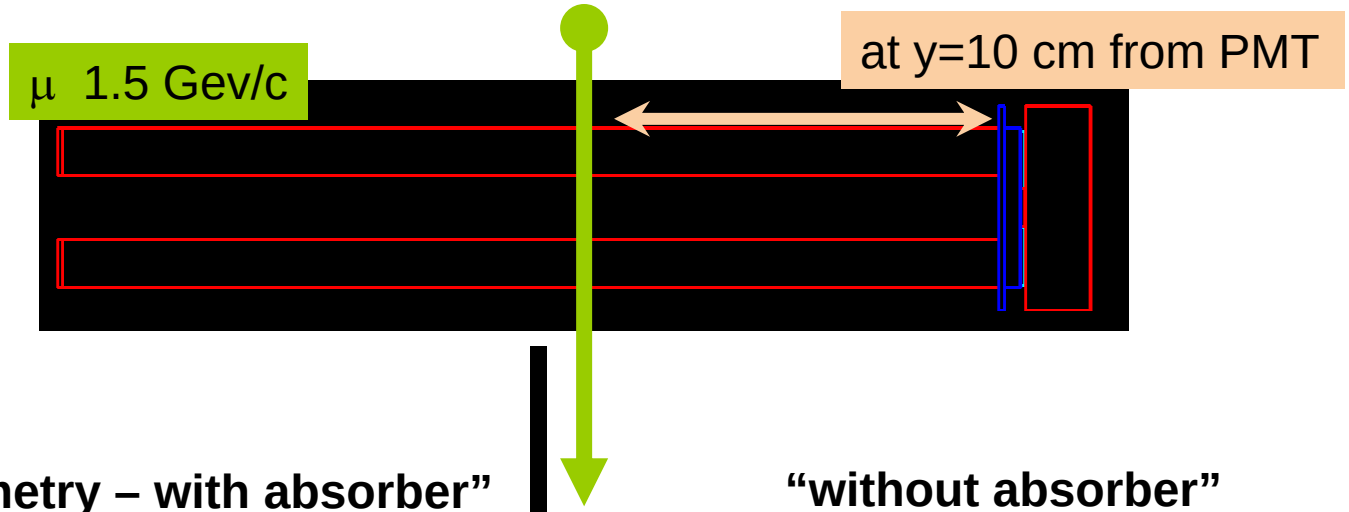
Resolution ~50ps



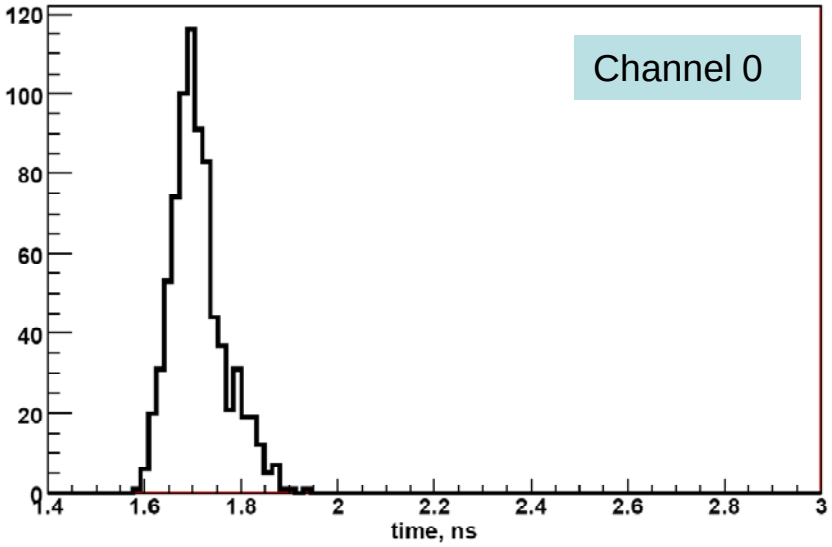
“without absorber”



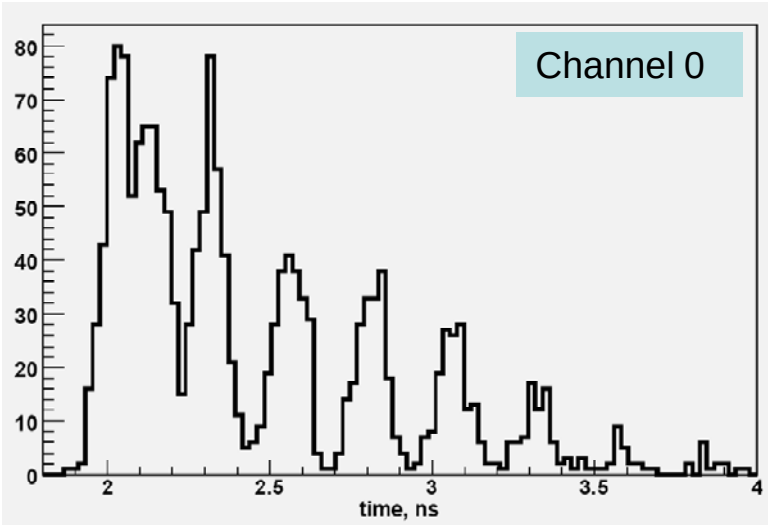


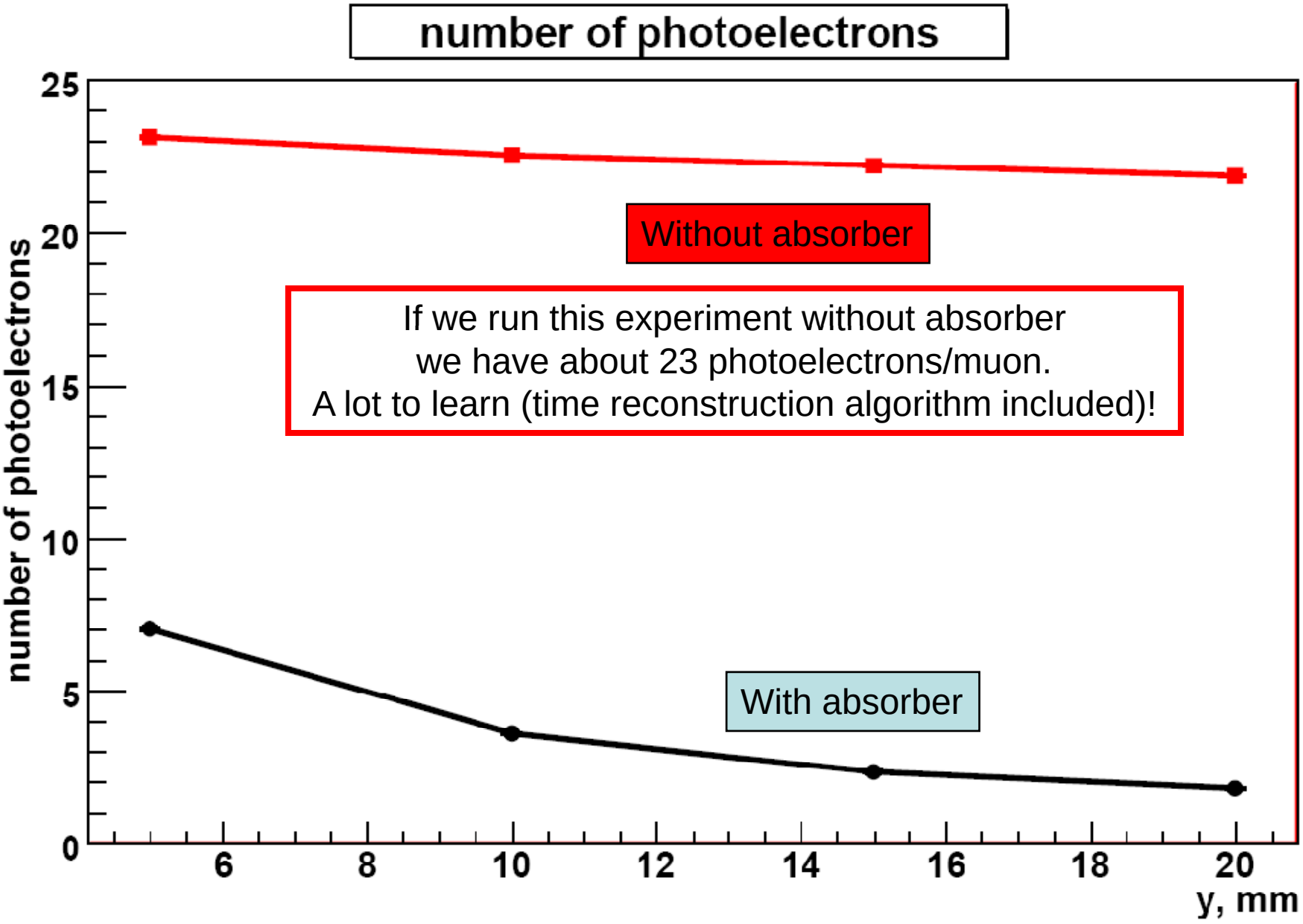


“simple geometry – with absorber”



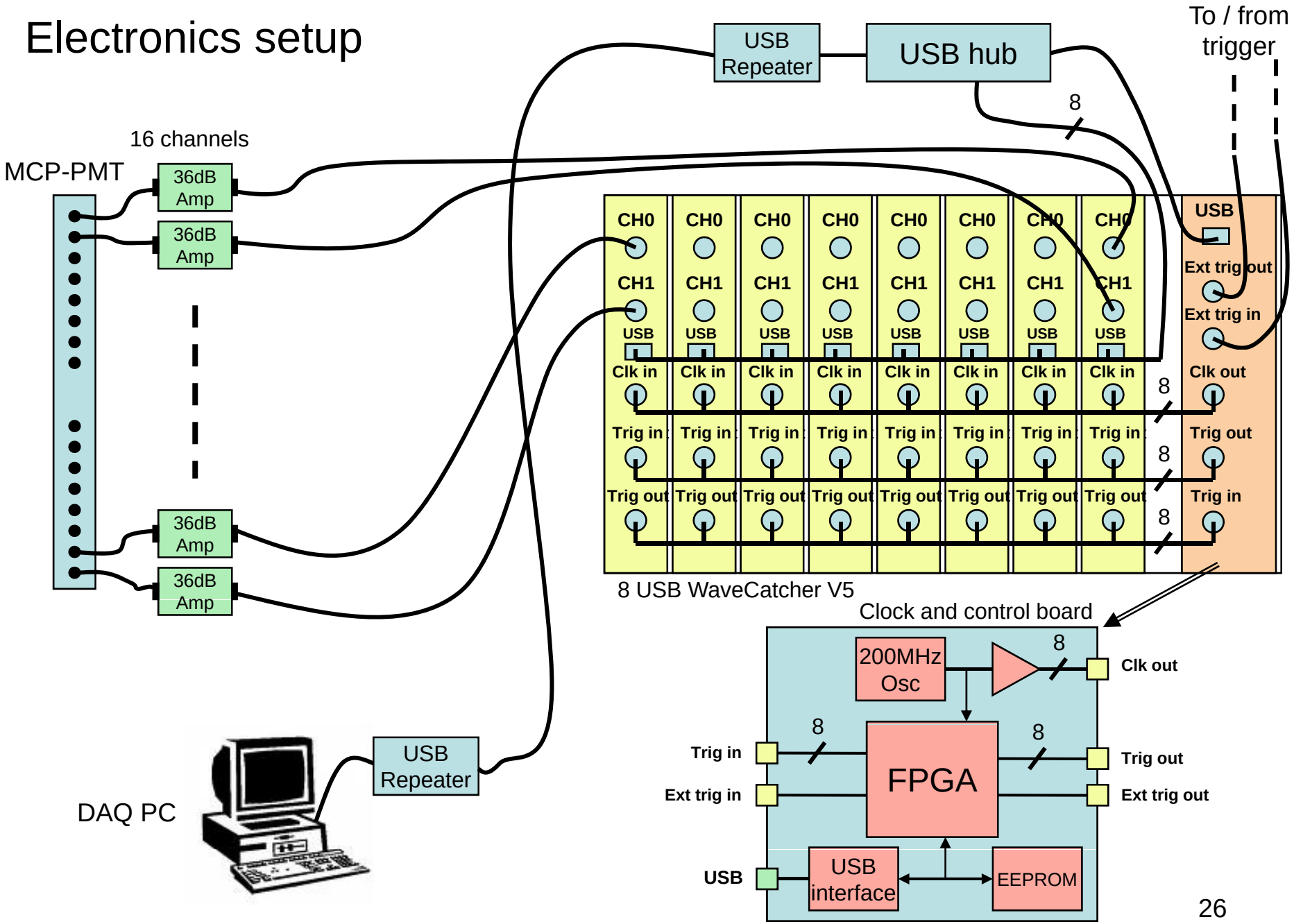
“without absorber”





Distance between the muon and the PMT along the quartz bar

Electronics setup

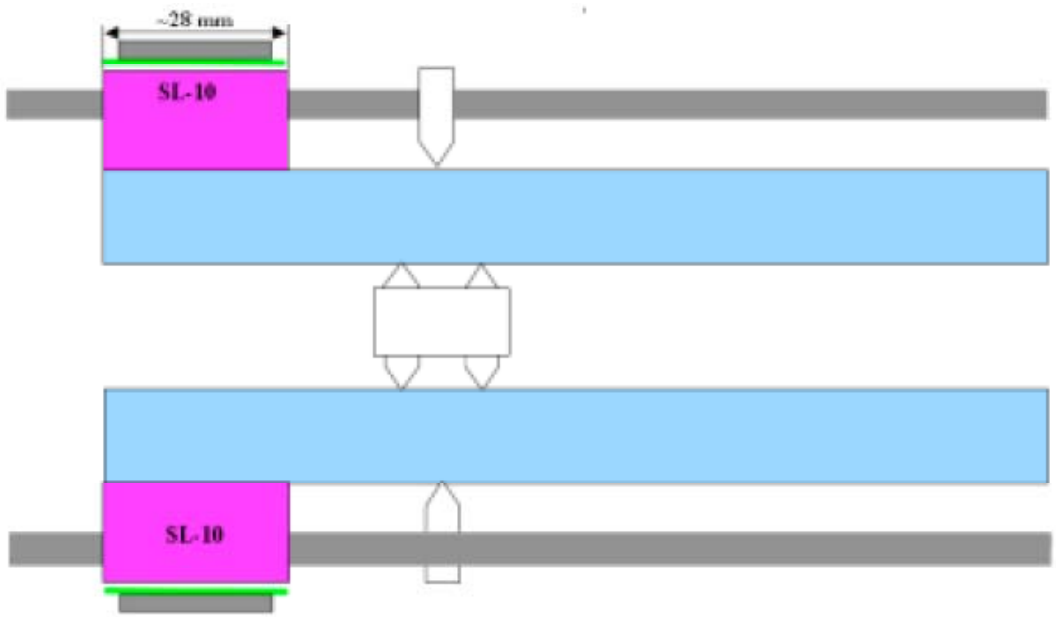


Comments about electronics

- Baseline is to use individual 36 dB amplifiers but a solution with two boards each housing 8 amplifiers with programmable gain is under study
- The clock distribution will be designed with special care in order to maintain the individual time performances of the WaveCatcher boards
- Common trigger for the WaveCatcher boards will be the OR of their individual triggers on signal
  - This will stop the signal recording into the analog memory but readout could be validated by a second signal coming from the CRT
- Remote USB will be based on a commercial set of two boards, interconnected by a CAT5+ Ethernet cable (this permits a distance up to 45m)

Experiment – PHASE II

Time and money permitting, we foresee another experiment with two SL-10 PMTs in the positions indicated on the picture below.



PMTs and geometry would be closer to the current design of the FTOF-Counter for *SuperB*.

In summary, this CRTexperiment will be very useful to :

- make detector + PM + electronics working together
- test and prove on data the FTOF principle
  [for instance the algorithms for detector without absorber]

Estimated cost

Experiment – PHASE I

Electronics cards :

- 1 PM base board (to design) => 500 Euros
- 16 amplifiers MITEQ AM-1610-1000 => 375 Euros each
- 8 USB Wave Catchers (bare board) => 600 Euros each
- 1 Clock and Control board (to design) => 1500 Euros
- 80 cables with SMA plugs => 1500 Euros
- USB repeater and cables => 300 Euros

TOTAL: 14.6 KEuros

Experiment – PHASE II

2 SL-10 PMT ➔ 11KEuros each.
Double the electronics (if yes) ➔ 14.6K Euros

TOTAL: 36.6 KEuros

Preliminary calendar	May 1st-15th	May 15th-end	Jun 1st-15th	Jun 15th-end	Jul 1st-15th	Jul 15st-end	Aug 1st-15th	Aug 15th-end	Sep 1st-15th	Sep 15th-end	Oct 1st-15t	Oct 15th-end	Nov 1st-15th	Nov 15th-end
Mechanics														
Electronics Cards Design														
Electronics Card tests														
Acquisition Software devel.														
First Test on CRT														
Installation On CRT														
Running (1 month)														
Ordering SL-10														
Test SL-10														
Running (1 month)														