Forward PID
DIRC like TOF detector

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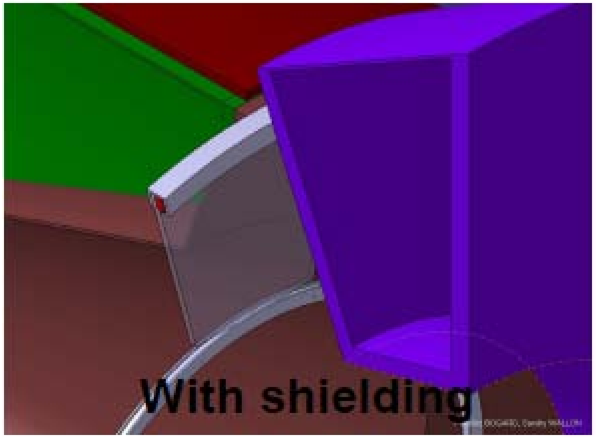
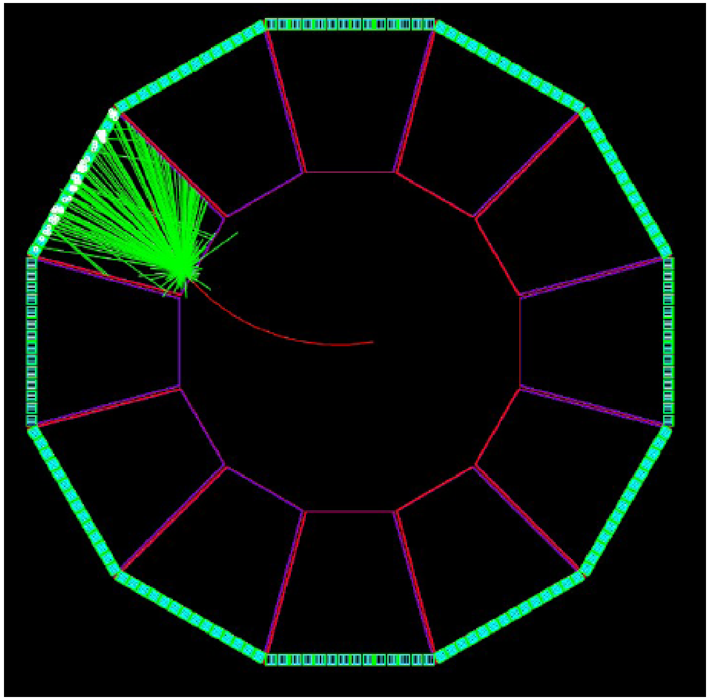
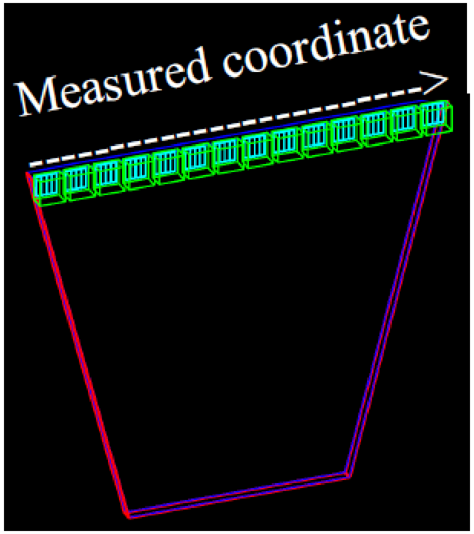
SuperB setup for FTOF



Close to the DCH and with 12 sector granularity



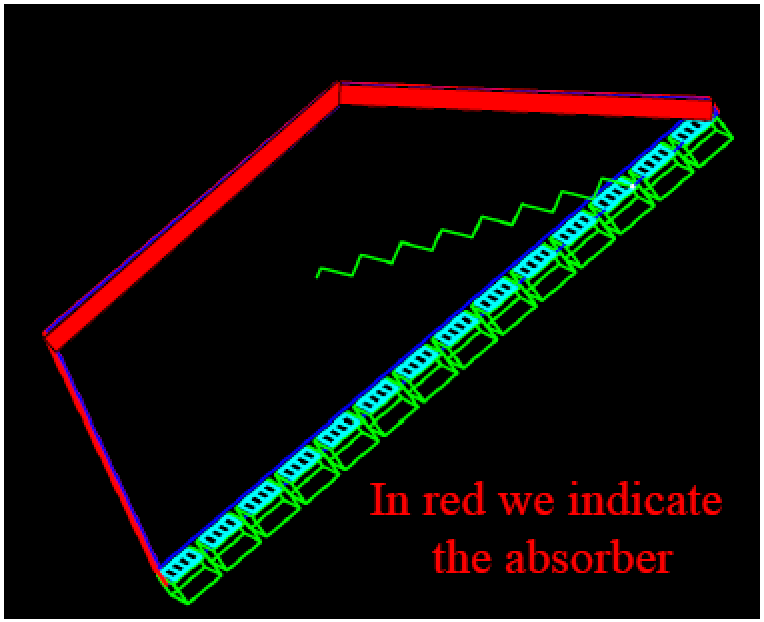


- **The detector is made of 1.5cm thick (12% X_0) quartz sectors,**
- **There are 12 sectors (30 degree in ϕ) covering $15 < \theta < 25$ degrees**
- **The PMT's are attached to the sector outer radius (14 PMT's / sector)**

Two possibilities are currently considered for the photon collections

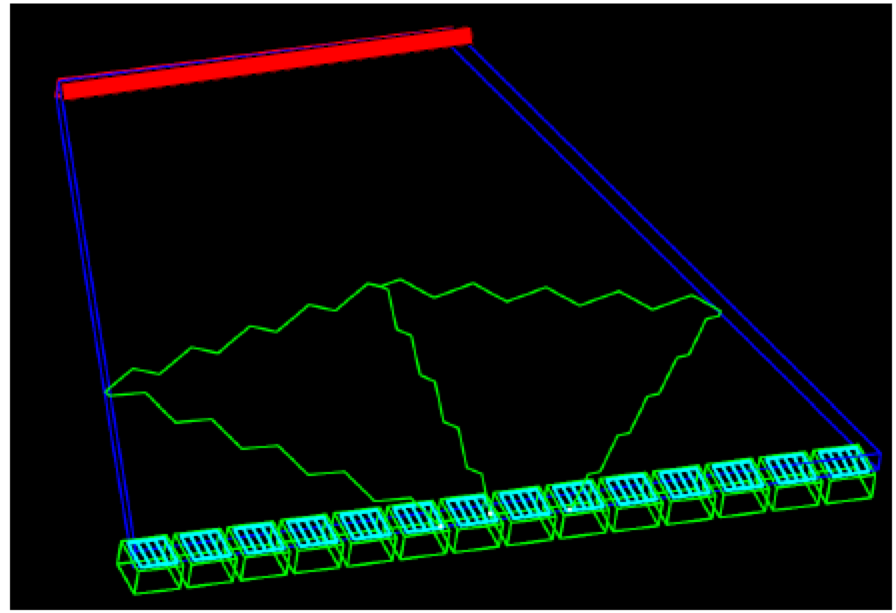
"simple geometry – with absorber"

(only direct photons are collected)



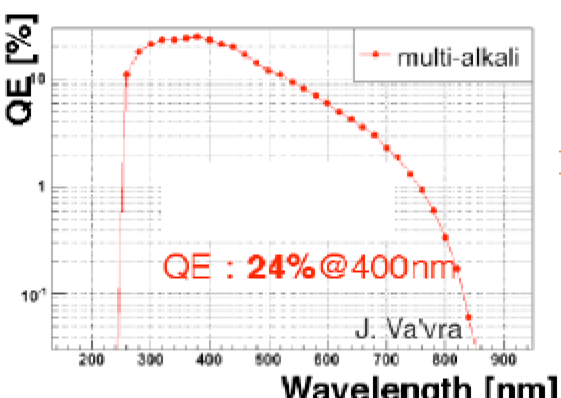
"without absorber"

(photons with different paths are collected)



For these studies we have used SL10 PMTs:

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

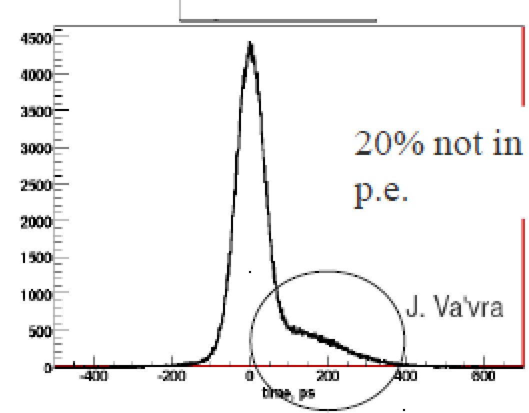


PDE: **P**hoton **D**etection **E**fficiency

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

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

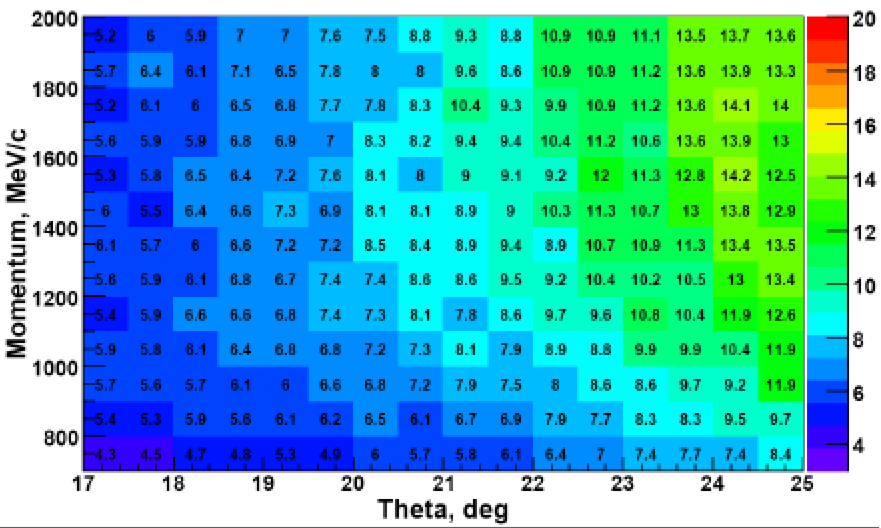
TTS



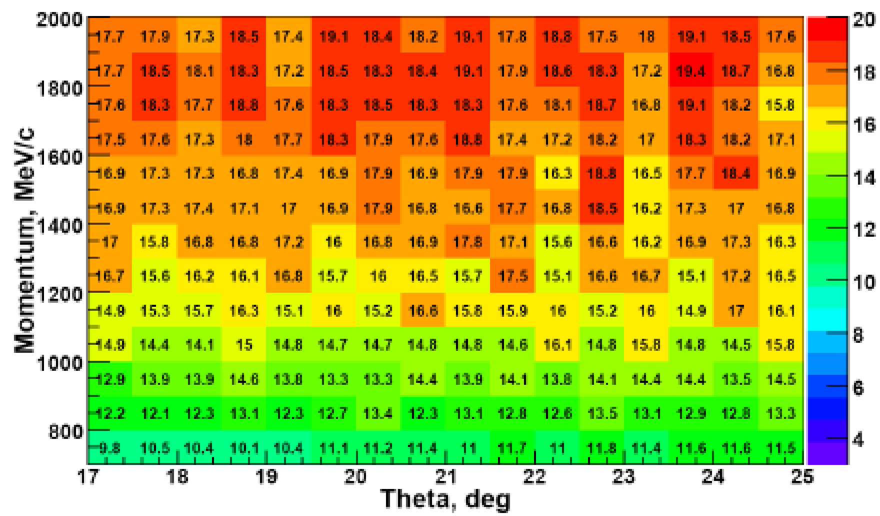
Average number of detected photelectrons (p.e.) as a function of momentum and theta

(average over phi)

“simple geometry – with absorber”

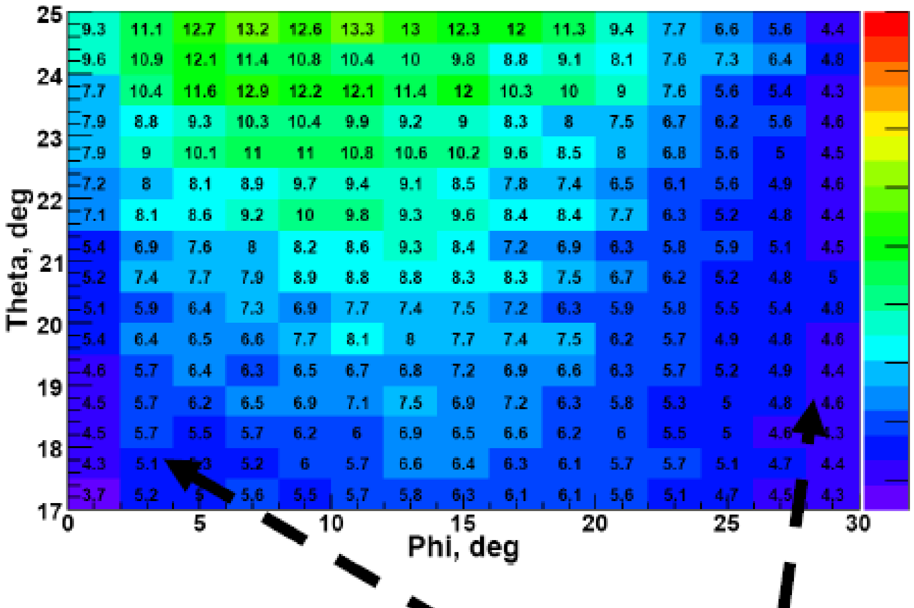


“without absorber”



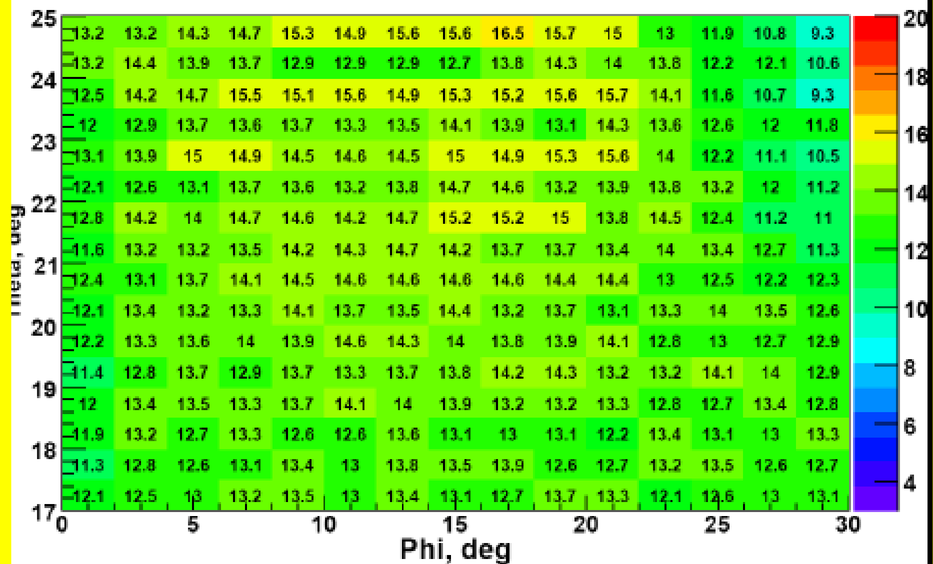
Taking a slice of the previous plot (tracks with p = 900 MeV/c) and looking at the (phi, theta) dependence of N_{phe}

"simple geometry – with absorber"



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

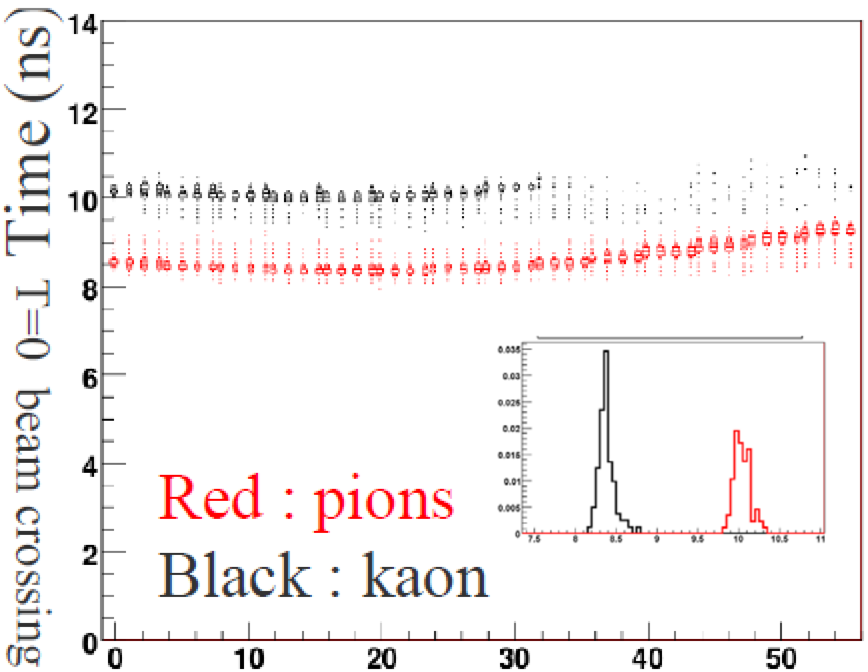
"without absorber"



Phi dependence of the number p.e is almost vanishing (within 10%)

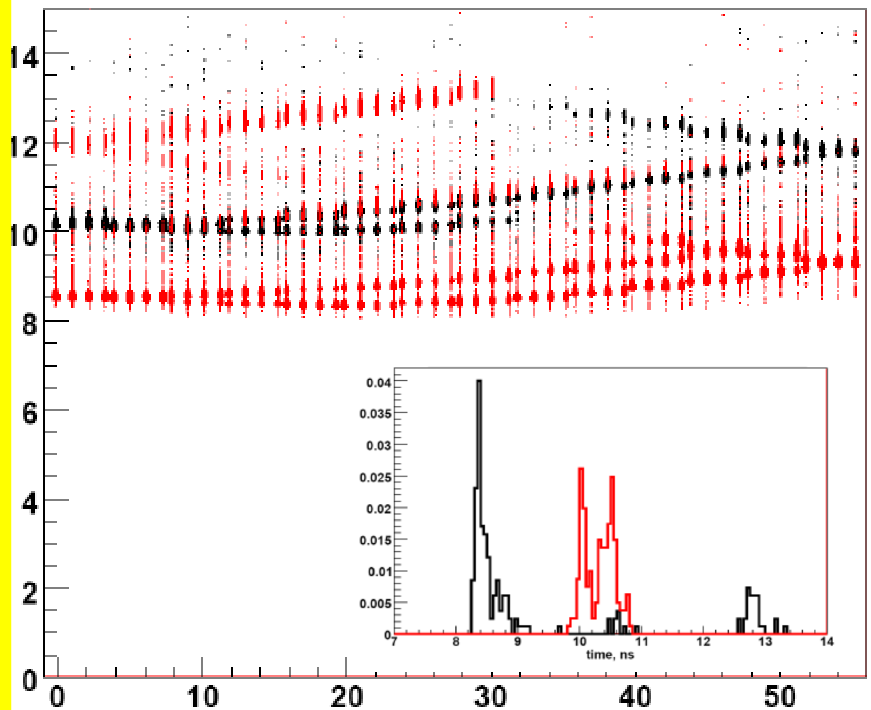
Photoelectron timing using tracks with P=700Mev , theta=17, phi=0

"simple geometry – with absorber"



Channel number
of the PMT hit

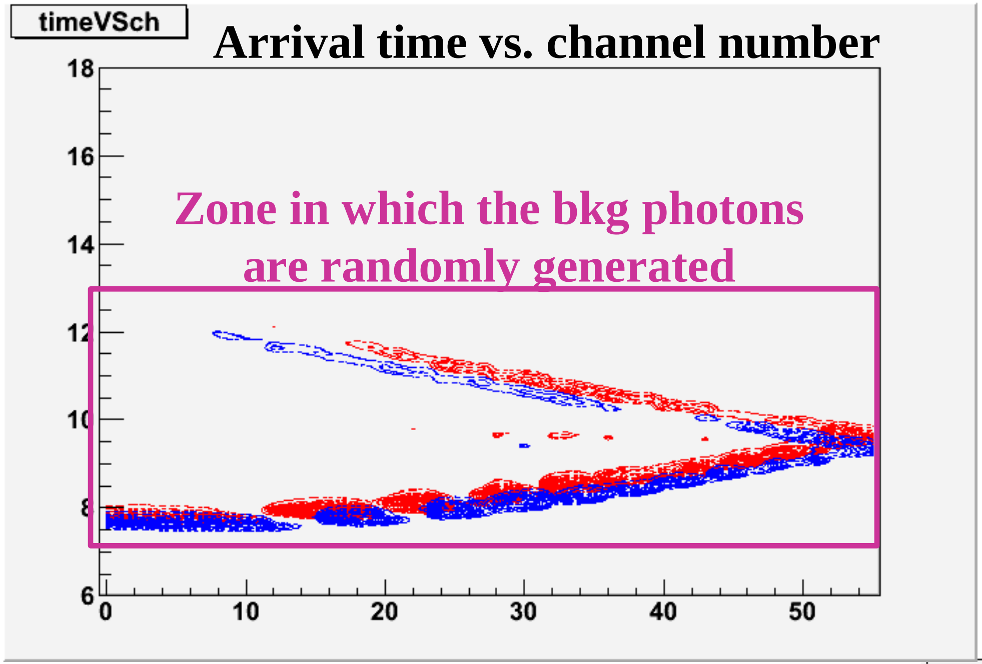
"without absorber"



More photons collected but time algorithm more difficult.

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

Could we work with complicated configurations in presence of background ?



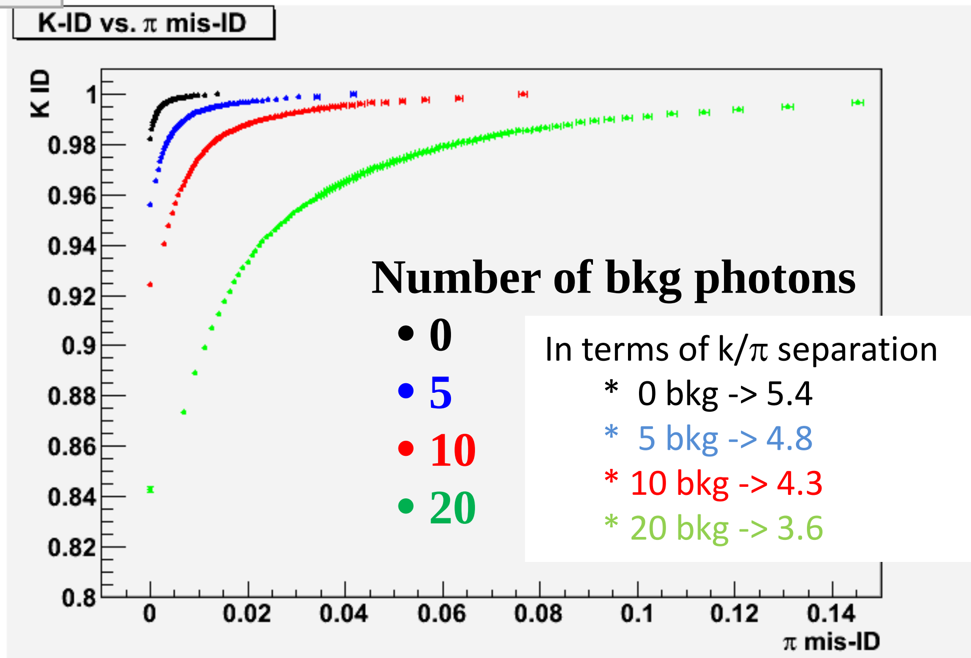
Preliminary answer

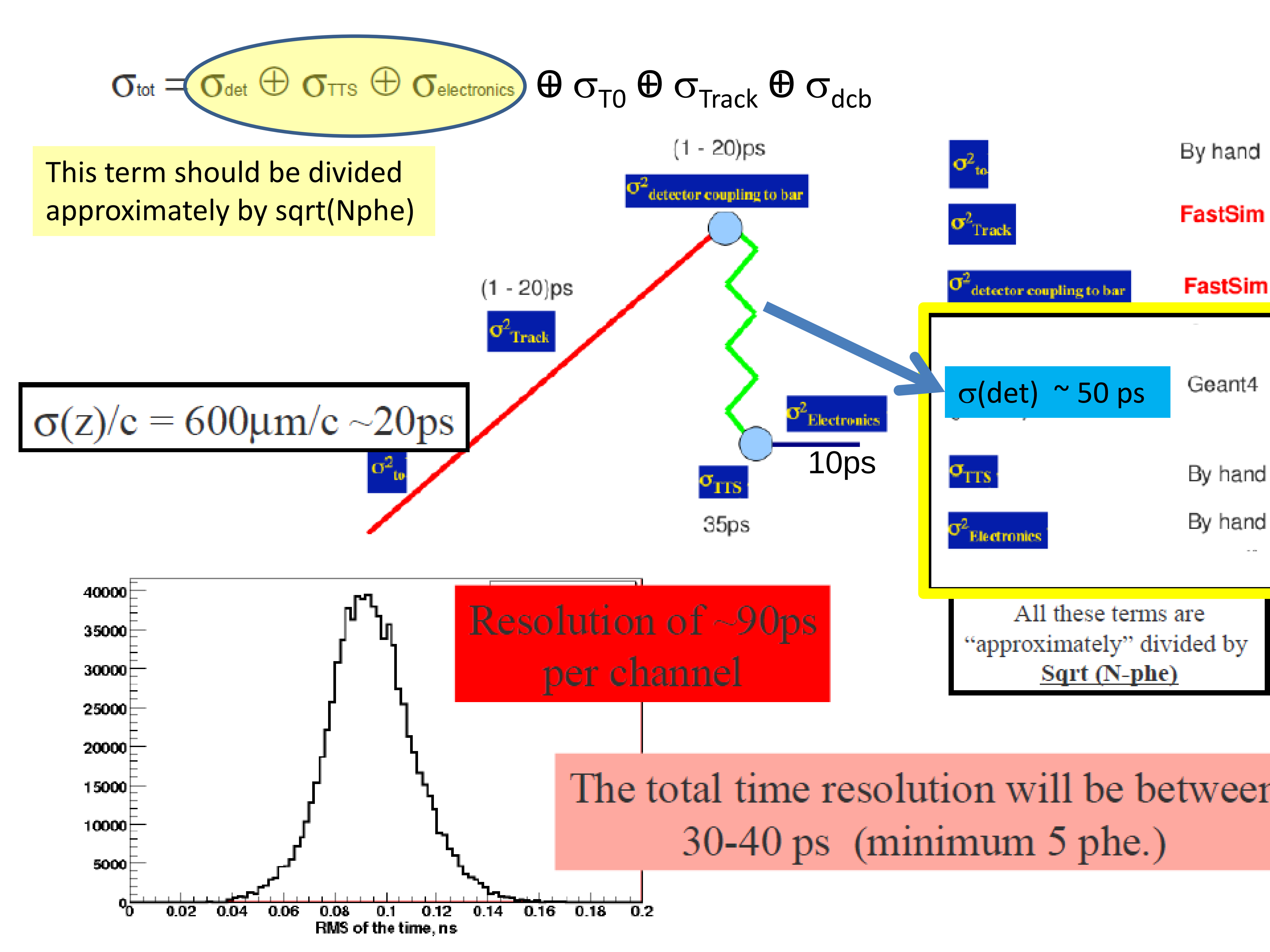
p = 2 GeV/c
θ = 20 degrees
ϕ = 0 degrees

Kaon map, 10 photons/track
Pion map, 13 photons/track

Preliminary studies (Annecy) shown that we expect ~1 event of background in FPID

It seems that the PID starts to really suffer if background is ~20events




σtot = σdet ⊕ σTTS ⊕ σelectronics ⊕ σT0 ⊕ σTrack ⊕ σdcb
This term should be divided approximately by sqrt(Nphe)
(1 - 20)ps
σ2 detector coupling to bar
(1 - 20)ps
σ2 Track
σ(z)/c = 600µm/c ~20ps
σ2 t0
σ2 Electronics
10ps
σTTS
35ps
σ2 t0
By hand
σ2 Track
FastSim
σ2 detector coupling to bar
FastSim
σ(det) ~ 50 ps
Geant4
σTTS
By hand
σ2 Electronics
By hand
All these terms are “approximately” divided by Sqrt (N-phe)
Resolution of ~90ps per channel
The total time resolution will be betweer
30-40 ps (minimum 5 phe.)
40000
35000
30000
25000
20000
15000
10000
5000
0
0.02
0.04
0.06
0.08
0.1
0.12
0.14
0.16
0.18
0.2
RMS of the time, ns

Test at the SLAC Telescope
Prototype of the DIRC-like TOF detector

Proof of principle

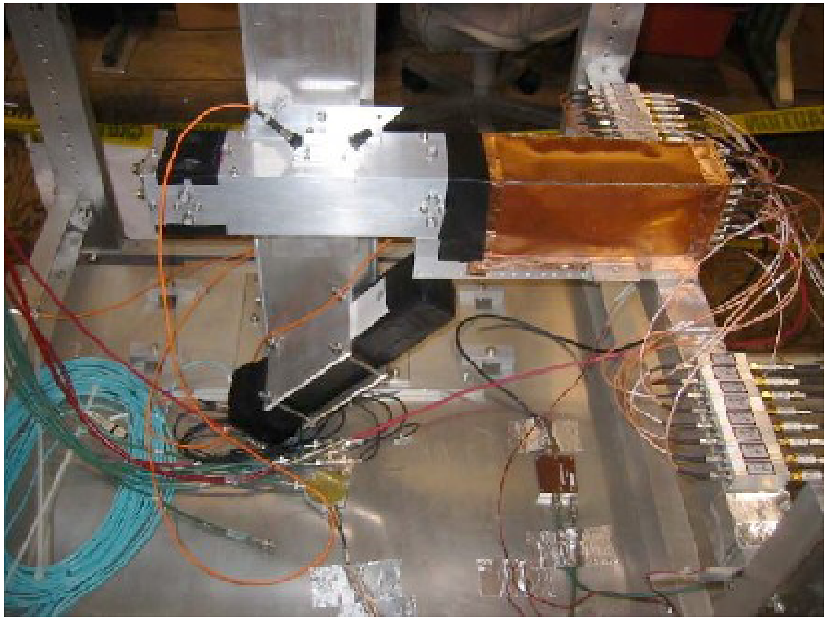
We want to the test the system : detector + PMs + electronics

We want to extract the overall single photoelectron time resolution

$$\sigma_{tot} = \sigma_{det} \oplus \sigma_{TTS} \oplus \sigma_{electronics}$$

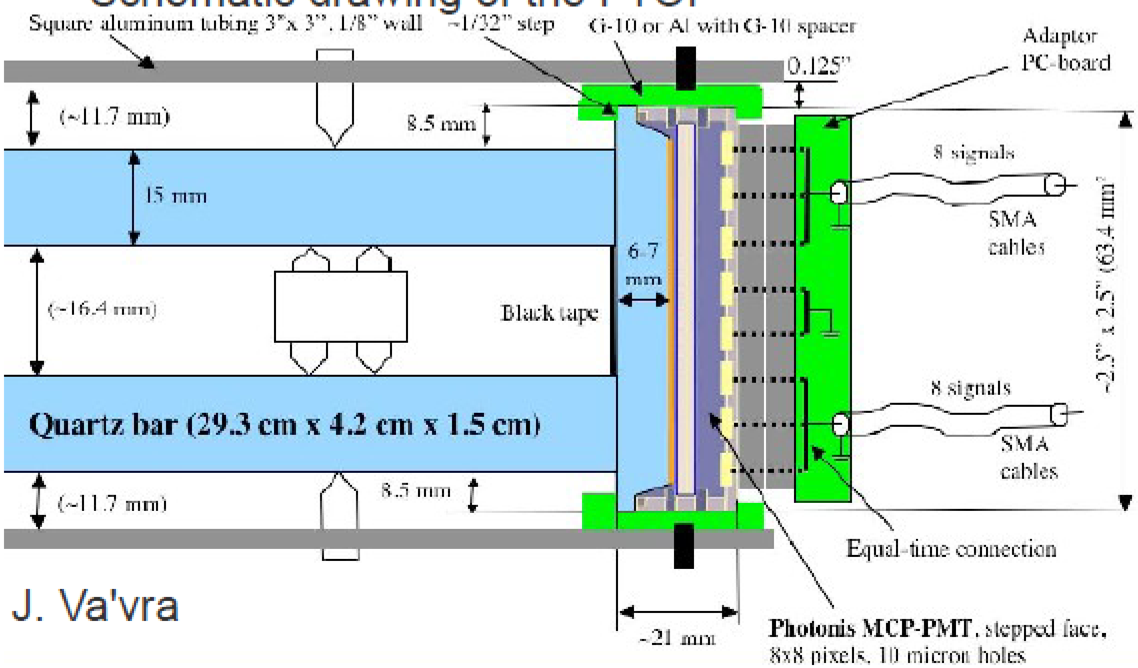
Of course in this case the σ(det) will be different than in the SuperB detector and depends on the geometry of the experiment

Prototype of the DIRC-like TOF detector

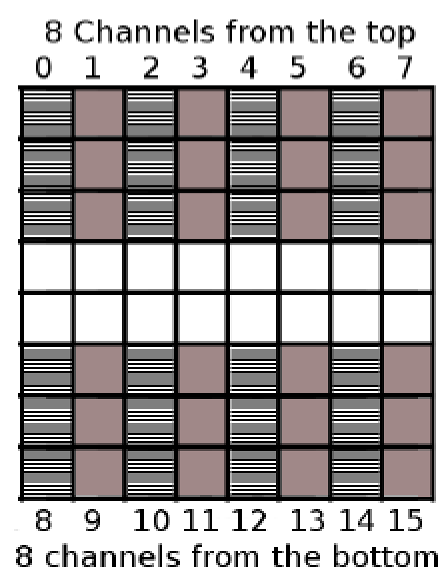


- Two quartz bars connected to one Photonis MCP-PMT (8x8 channels, stepped face, 10 micron holes).
- Tube operate at -2.7kV (gain ~ 7.0×10^5).
- 16 channels connected to the USBWC electronics developed by LAL and CEA/IRFU electronics team.
- Amplifiers (40dB).
- Filters (600MHz bandwidth).
- Installed at SLAC CRT in Fall 2010.

Schematic drawing of the FTOF

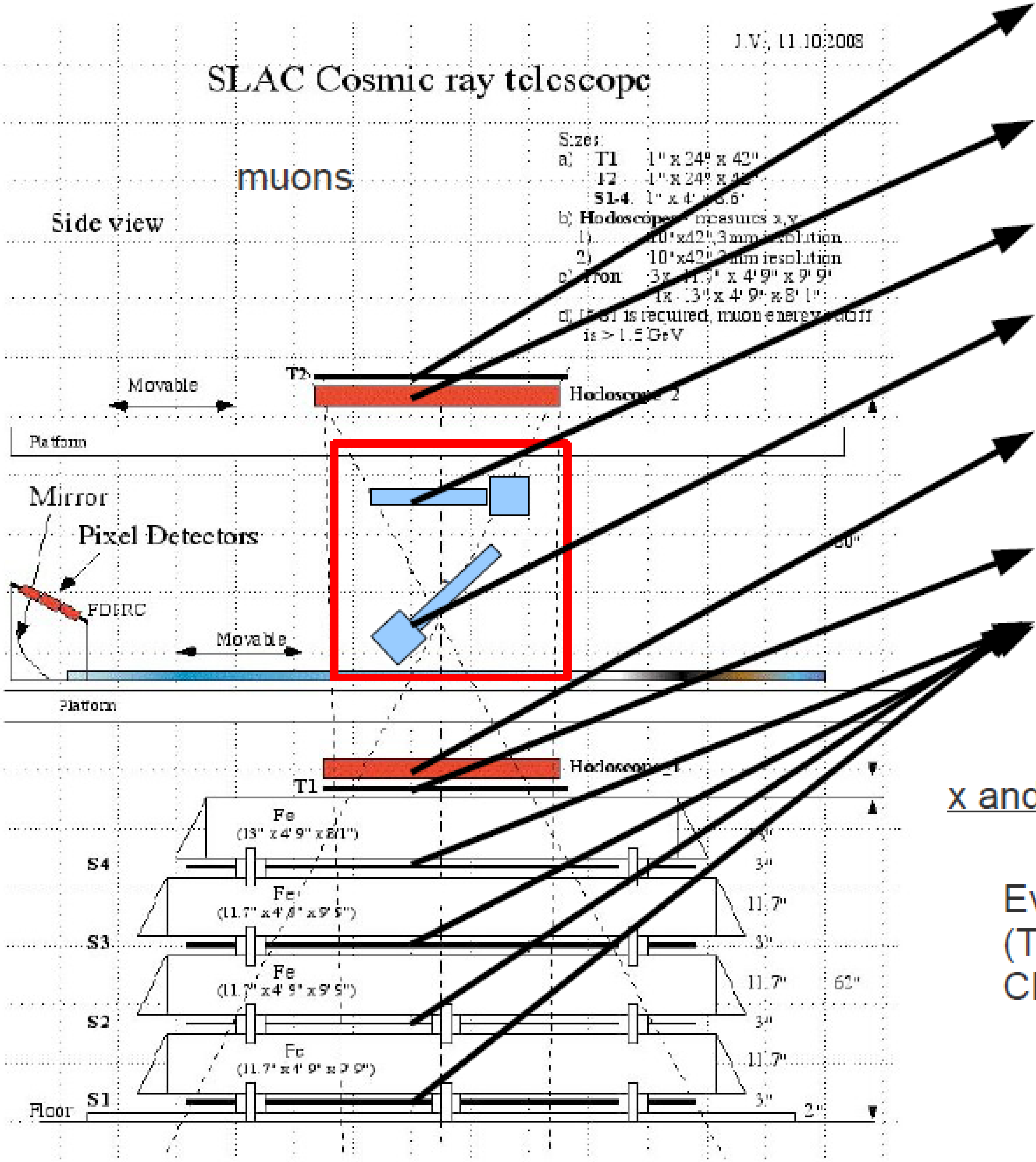


MCP-PMT pixel map



J. Va'vra

CRT



Top trigger counter (T2)

Top x and y hodoscopes(2)

FTOF prototype

Quartz start counter (QSC)

Bottom x and y hodoscopes(1)

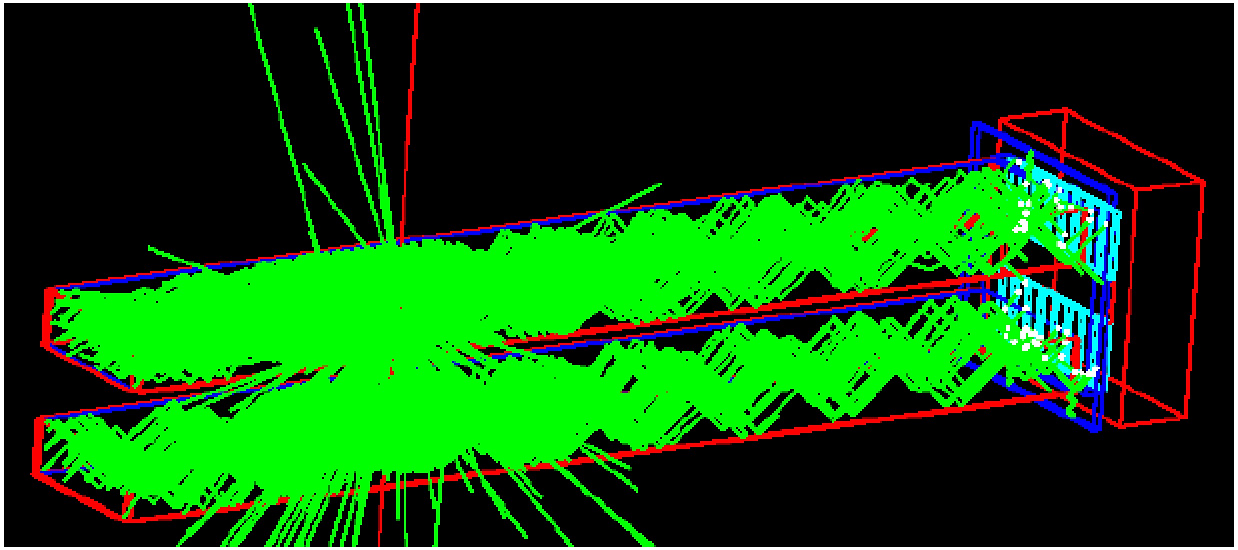
Bottom trigger counters (T1)

Stack counters for momentum measurements

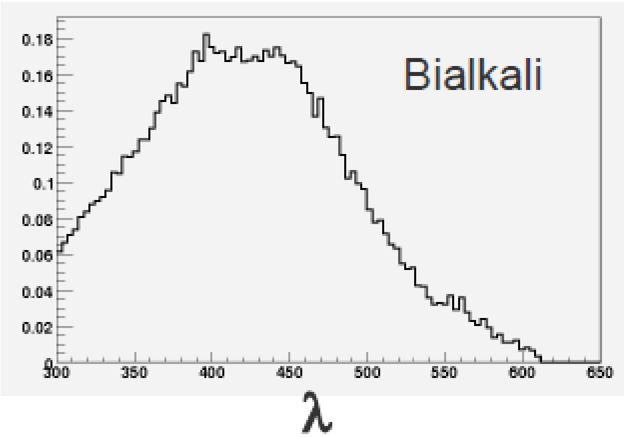
x and y position resolution is ~ 3 mm

Events with triple coincidence (T1 x QSC xT2) recorded by CRT DAQ.

Geant4 Simulation of the FTOF prototype



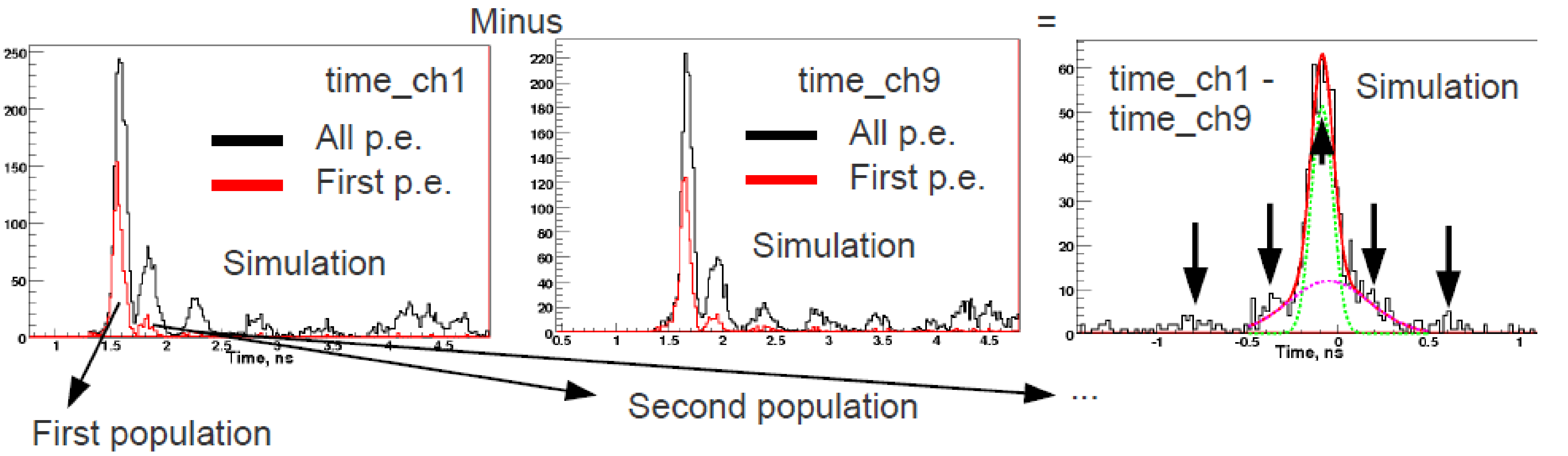
QE + electron collection efficiency (14%)



- 16 channels 6 x 18mm each
- Transit Time Spread of the MCP – PMT (TTS) = 35 ps / channel
- Electronics resolution = 10 ps / channel
- Bialkali photocathode
- **electron collection efficiency 14% = 70.0%(coll eff of the PM) * 1/5(mylar sheets)**
- Time of first p.e. arriving is taken as a time measurement for a given channel.

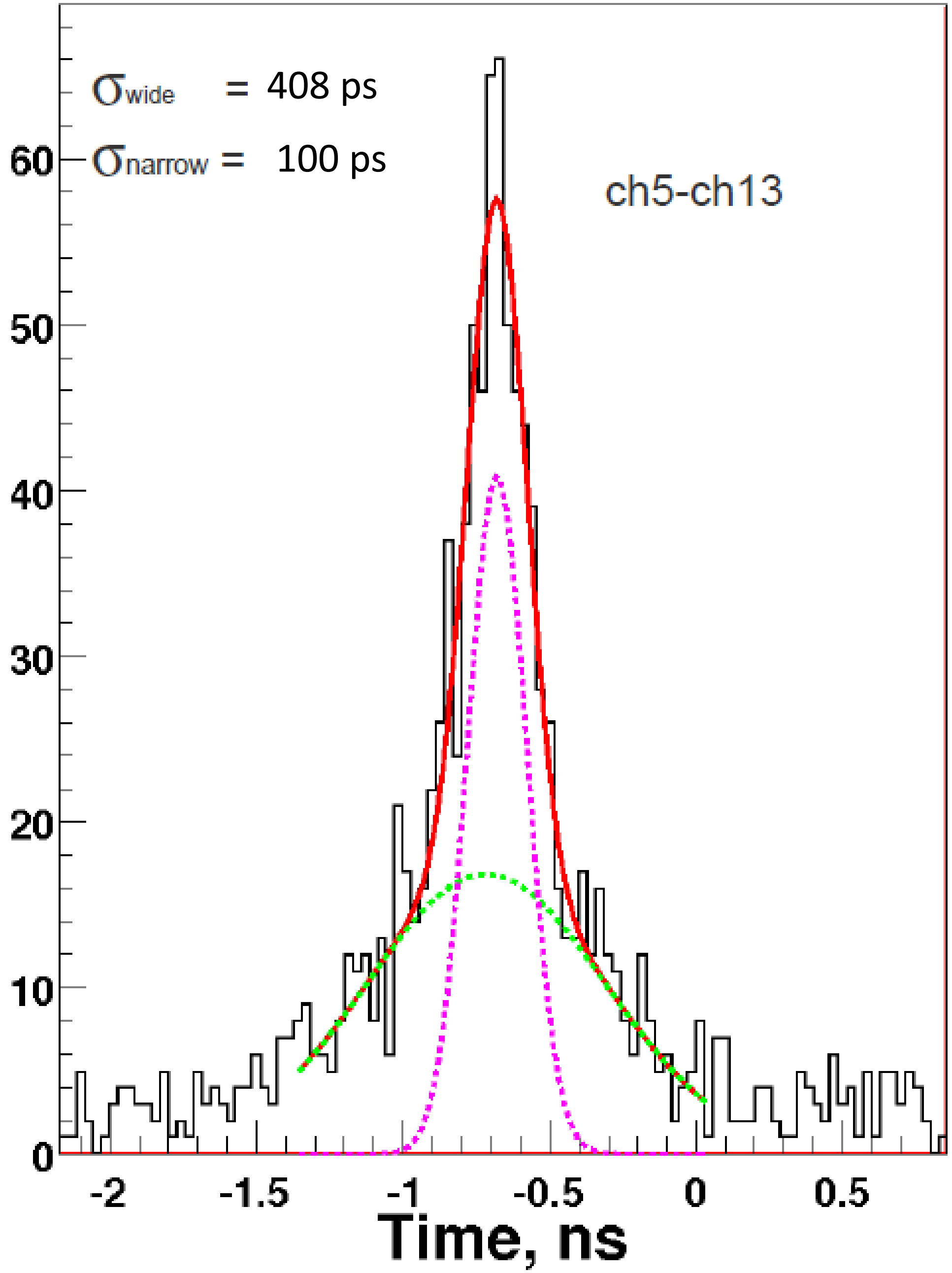
  Simulation of the waveform based on the MCP-PMT response on single p.e. (laser run)
- Simple muon generator developed

Why do we fit with two Gaussian?



- Several possible paths exist to reach same channel => several different times measured (peaks on the histogram above).
- Definition: the p.e. which belongs to a given peak are from one population.
- Due to geometry of the prototype (bars with 29.3 x 4.2 x 1.5 cm) the time distances between different populations are small, unlike in the real FTOF detector.
- Time difference between two channels will have two components: narrow and wide. Narrow component corresponds to time difference between p.e. from same populations, while wide component corresponds to time difference between p.e. from different populations.
- **We consider RMS(of narrow component)/sqrt(2) as the time resolution per channel.**

Time resolution considering all muons entering into the detector



Example for time difference expected In the simulation between two channels

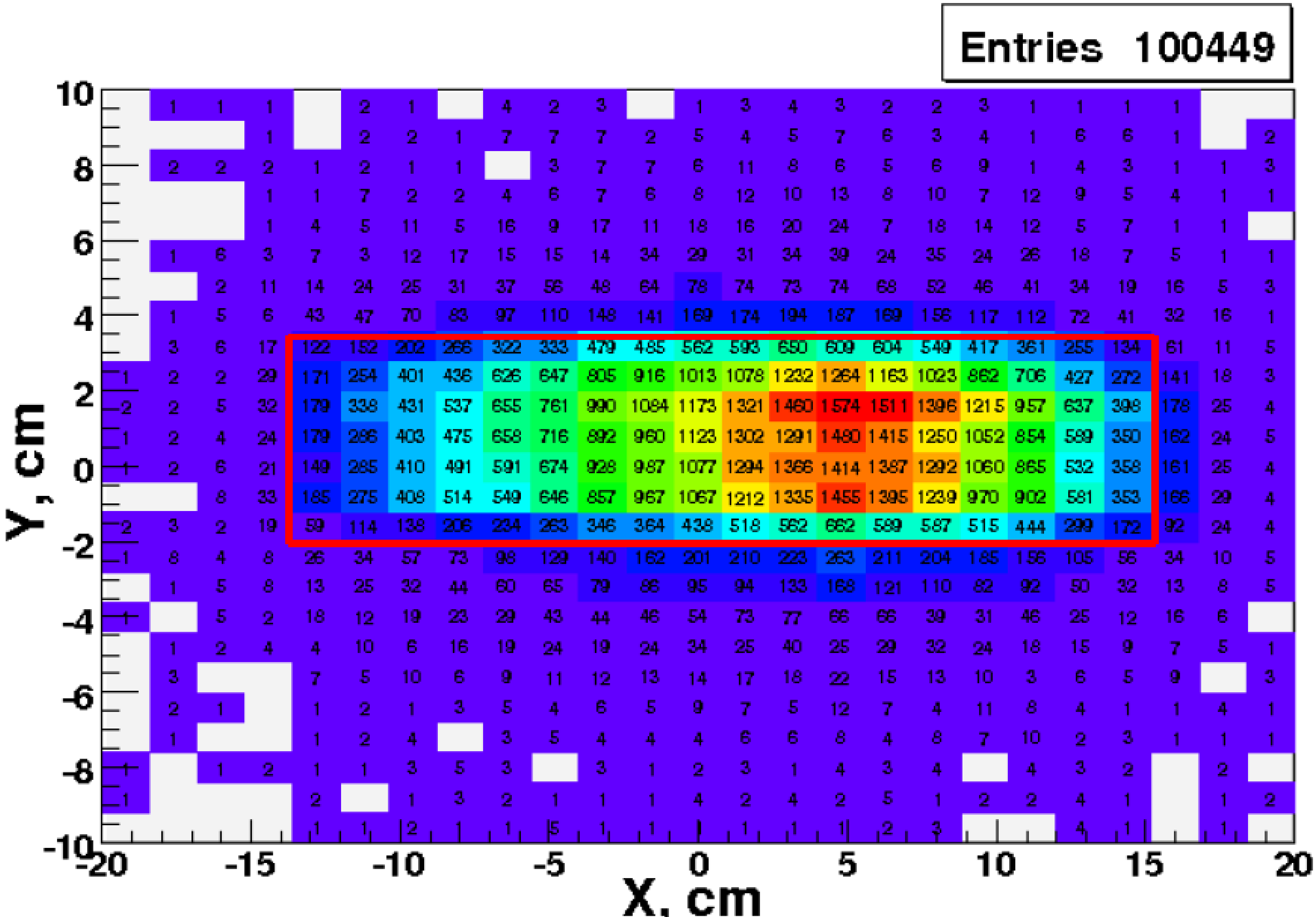
The resolution is 100/sqrt(2) ps ~ 75 ps

<u>The expected resolution is</u> rather the same when you look at different couple of channels

<u>The expected resolution is</u> not changing significantly when considering muons in a given portion of the detector

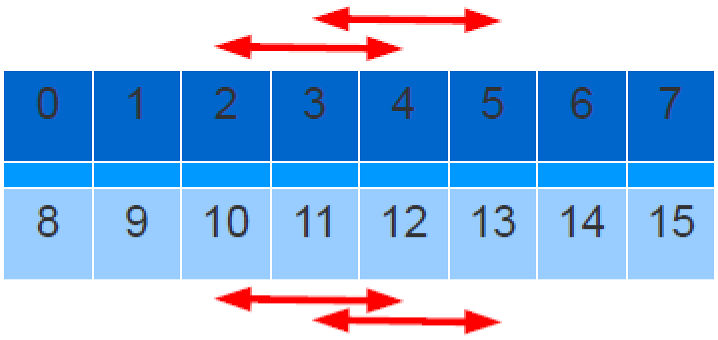
Look at DATA

Map of the reconstructed muons

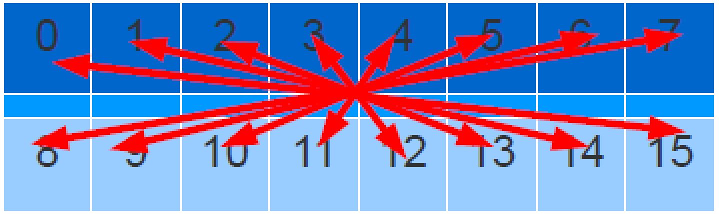


The time resolution measurements of the FTOF prototype

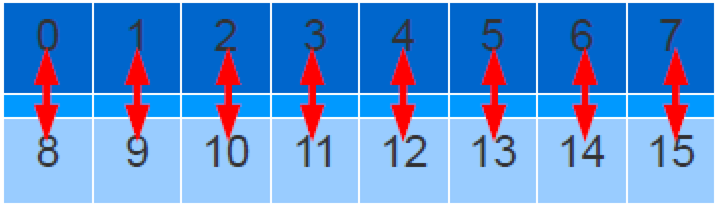
→ Time difference between channels are used in order to estimate resolution.



Type L3: not neighbor channels connected to same quartz bar

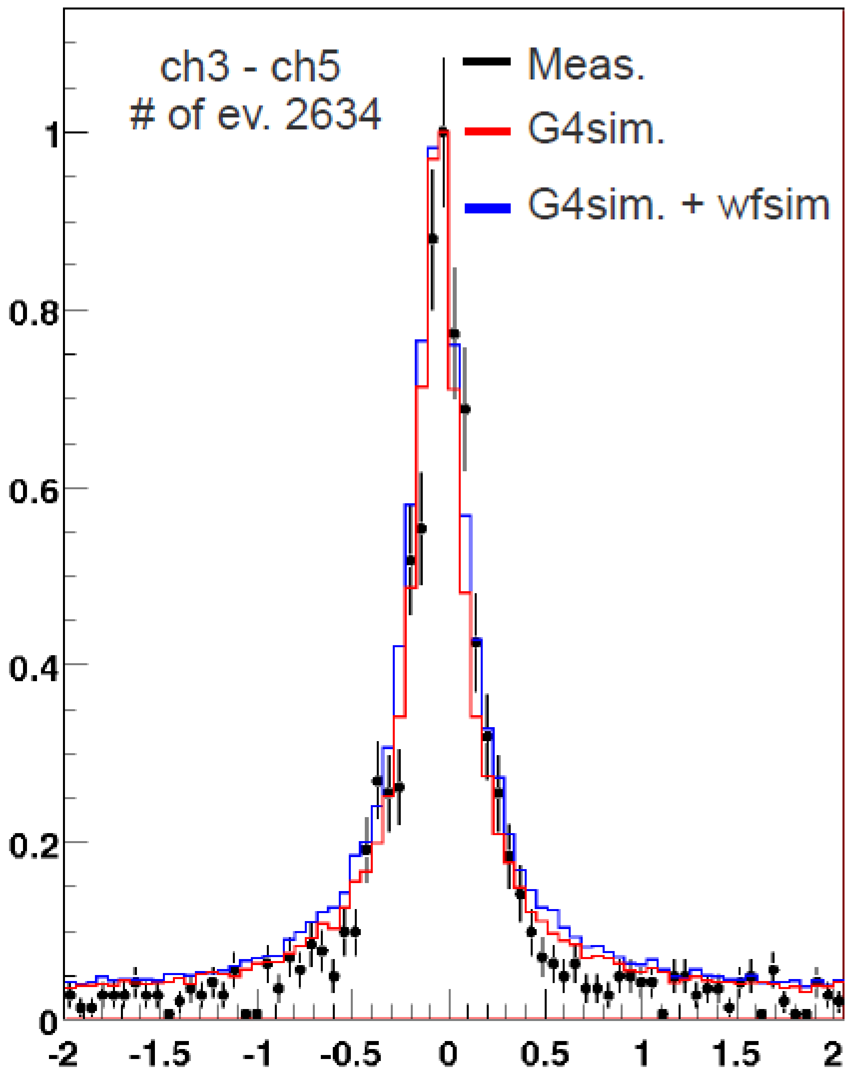


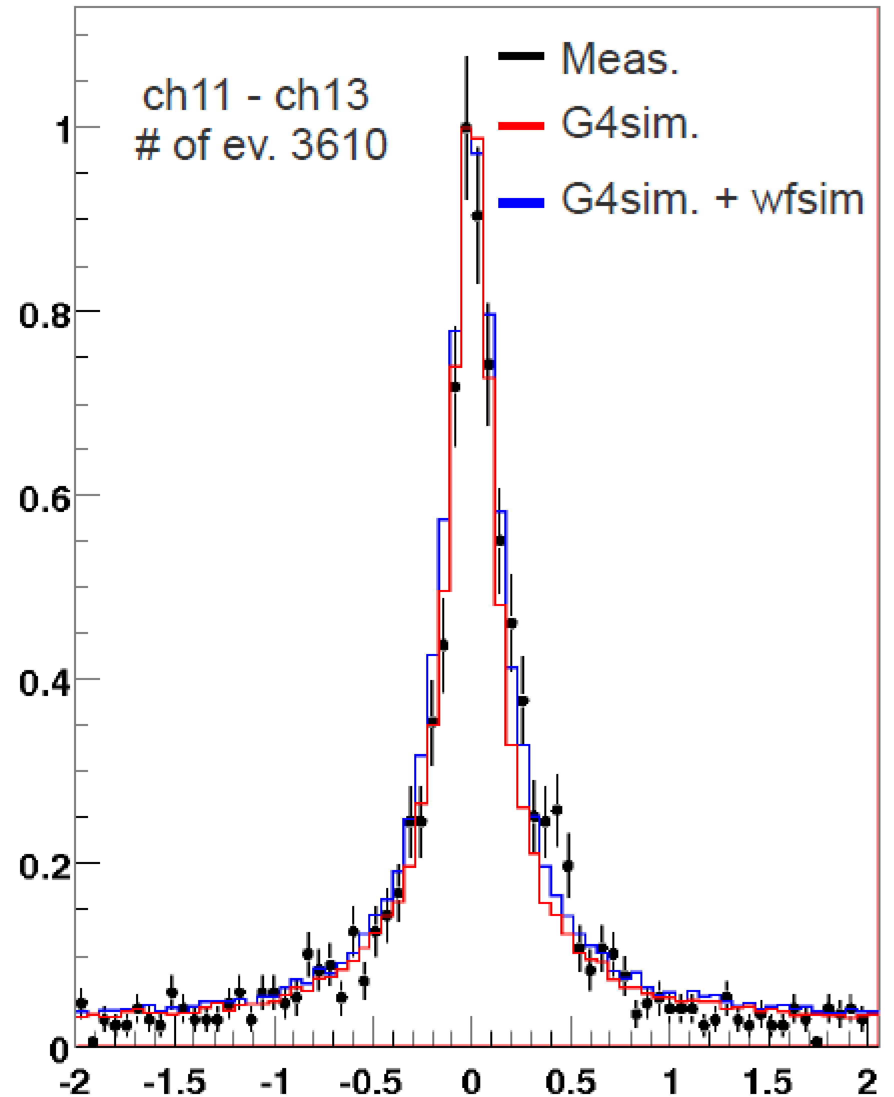
Type L4: not neighbor channels connected to different quartz bars



Type TtB: top to bottom time difference

Time difference between not neighbor channels connected to same quartz bar. (type L3)

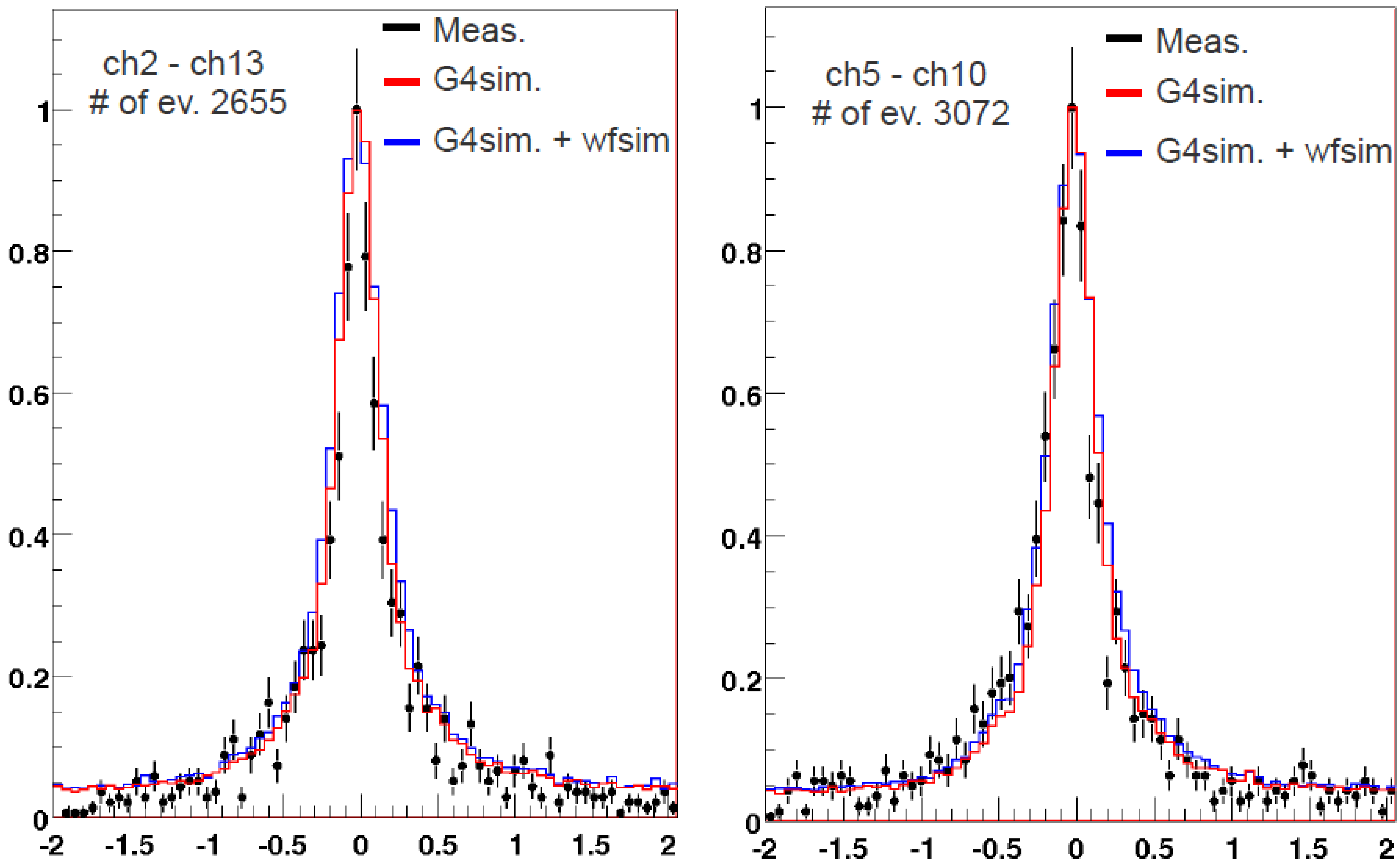




15.12.2010

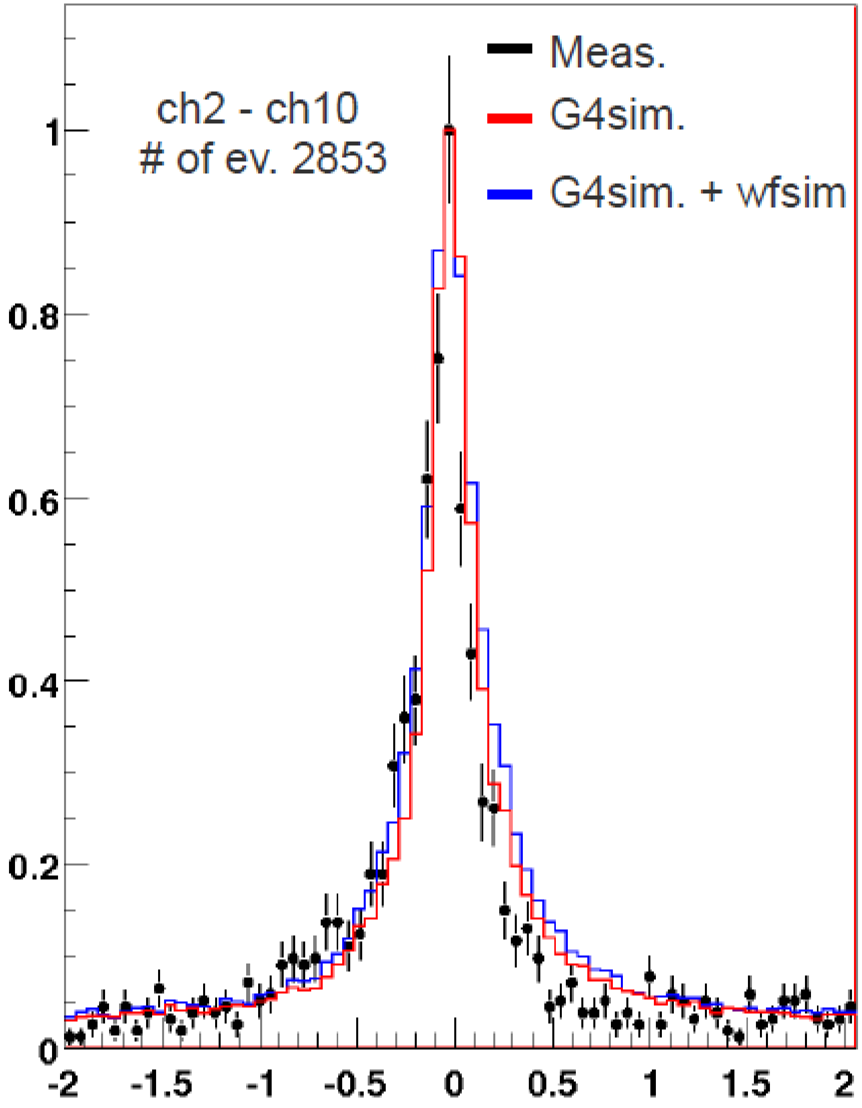
Average time resolution calculated using this type of time differences is ~110ps = **80ps/channel.**

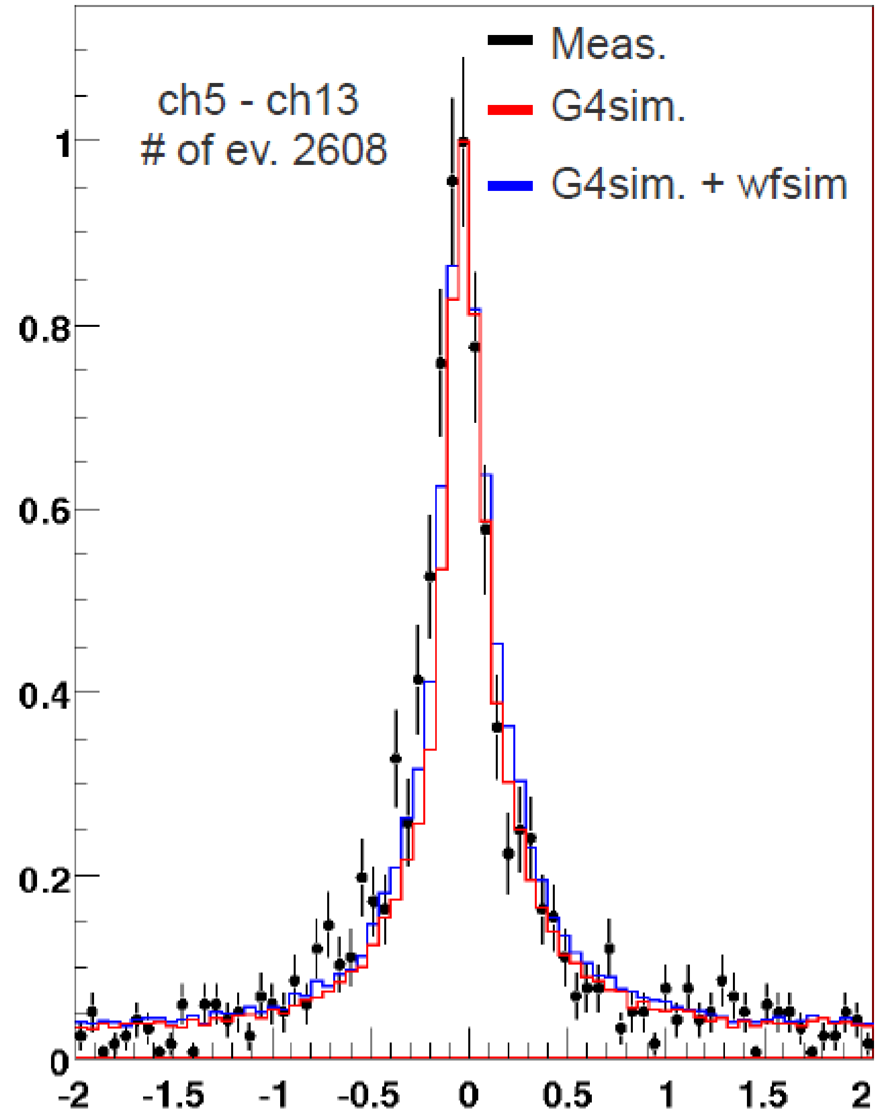
Time difference between not neighbor channels connected to different quartz bar. (type L4)



Average time resolution calculated using this type of time differences is ~100ps = **70ps/channel.**

Time difference between top and bottom channels. (type TtB)

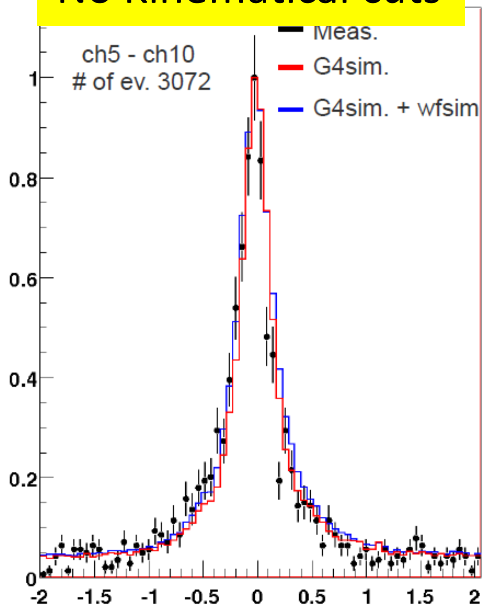


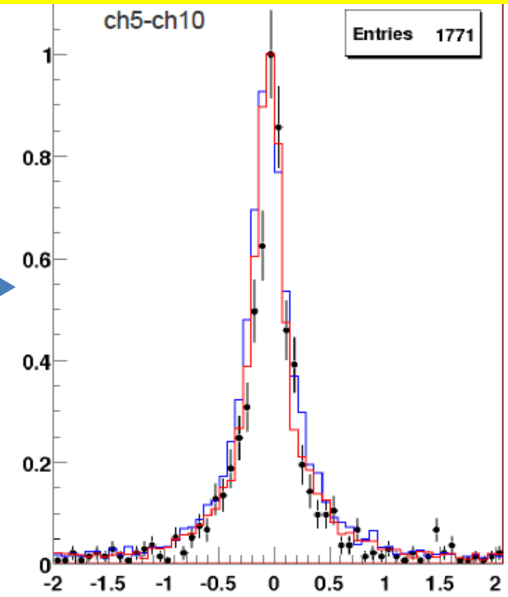


Average time resolution calculated using this type of time differences is ~100ps = **70ps/channel.**

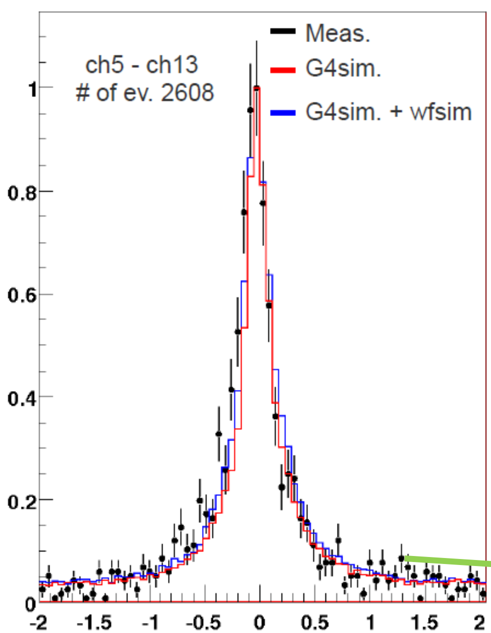
No Kinematical cuts

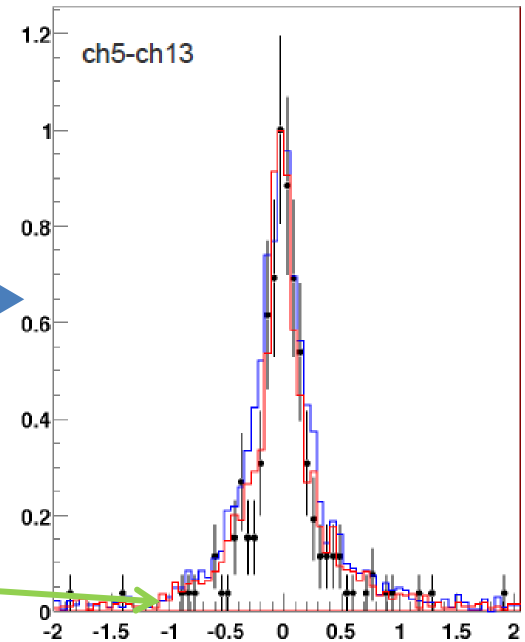
With some Kinematical cuts





Fraction of first photoelectron increased





Similar resolution but tails reduced

Conclusions

SuperB

We have a SuperB TOF set up which guarantee a time resolution of about 30-40ps
→ All the solid angle of SuperB will be covered with the same PID quality as with DIRC

The background seems not to spoil the PID using TOF technique (work in progress)

Proof of principle

CRT-TESTS

This technology (detector + PM + electronic) has been tested in the SLAC CRT

convincing results from DATA in agreement with simulation.
Total time resolution/photoelectron :

$$\sigma_{tot} = \sigma_{det} \oplus \sigma_{TTS} \oplus \sigma_{electronics} \quad \sim 75ps$$