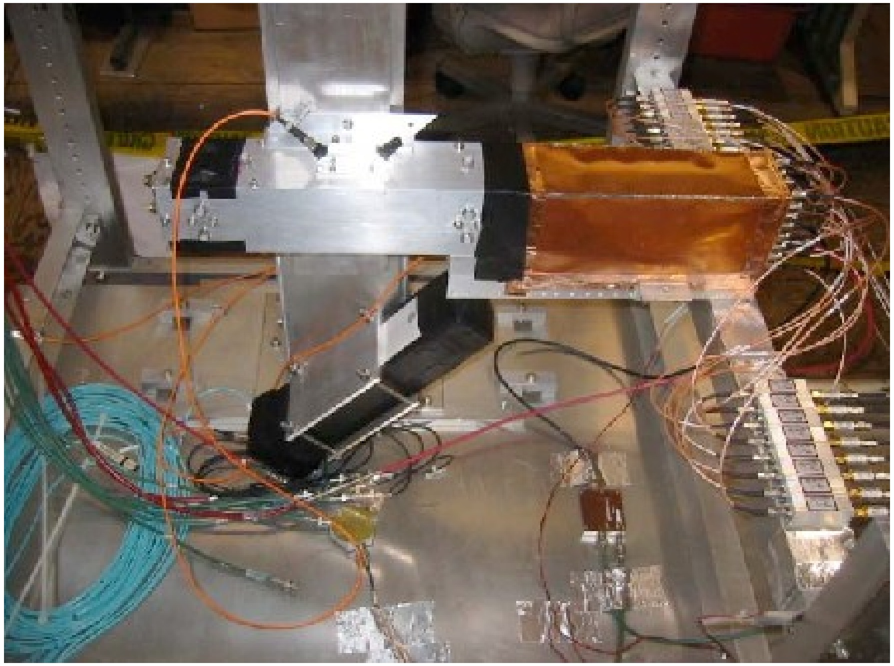
Pioneer test of the DIRC-like TOF prototype at SLAC CRT for SuperB project

Laboratoire de l Accélérateur Linéaire (CNRS/IN2P3), Université Paris-Sud 11
N. Arnaud, D. Breton, L. Burmistrov, J. Maalmi, V. Puill, A. Stocchi

SLAC National Accelerator Laboratory
J. Va'vra, D. Aston

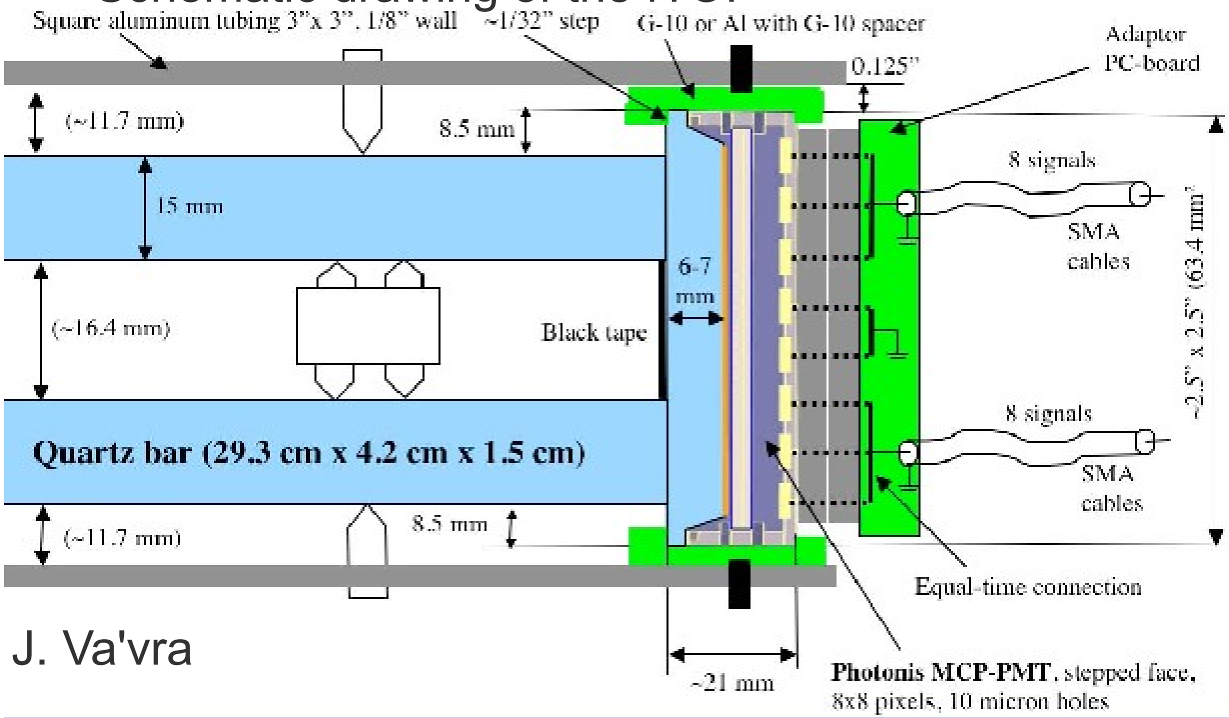
SuperB general meeting
December 15, 2010

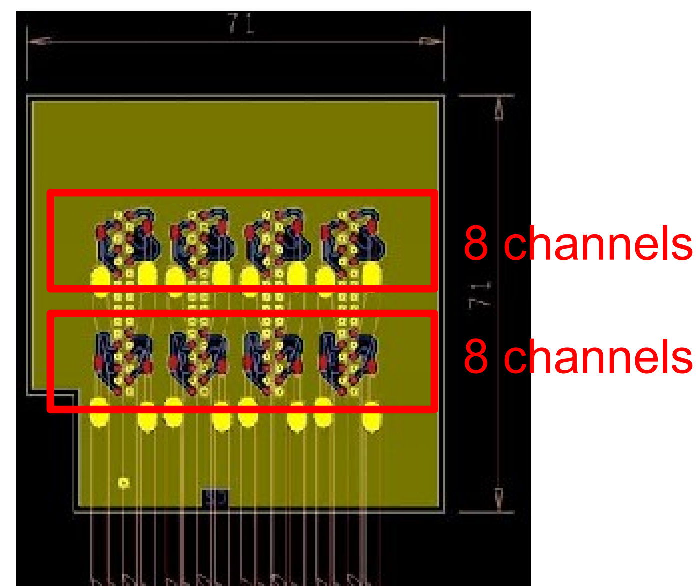
Prototype of the DIRC-like TOF detector



- 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 electronics team
- Amplifiers (40dB)
- Filters (600MHz bandwidth)
- Another quartz counter used as trigger

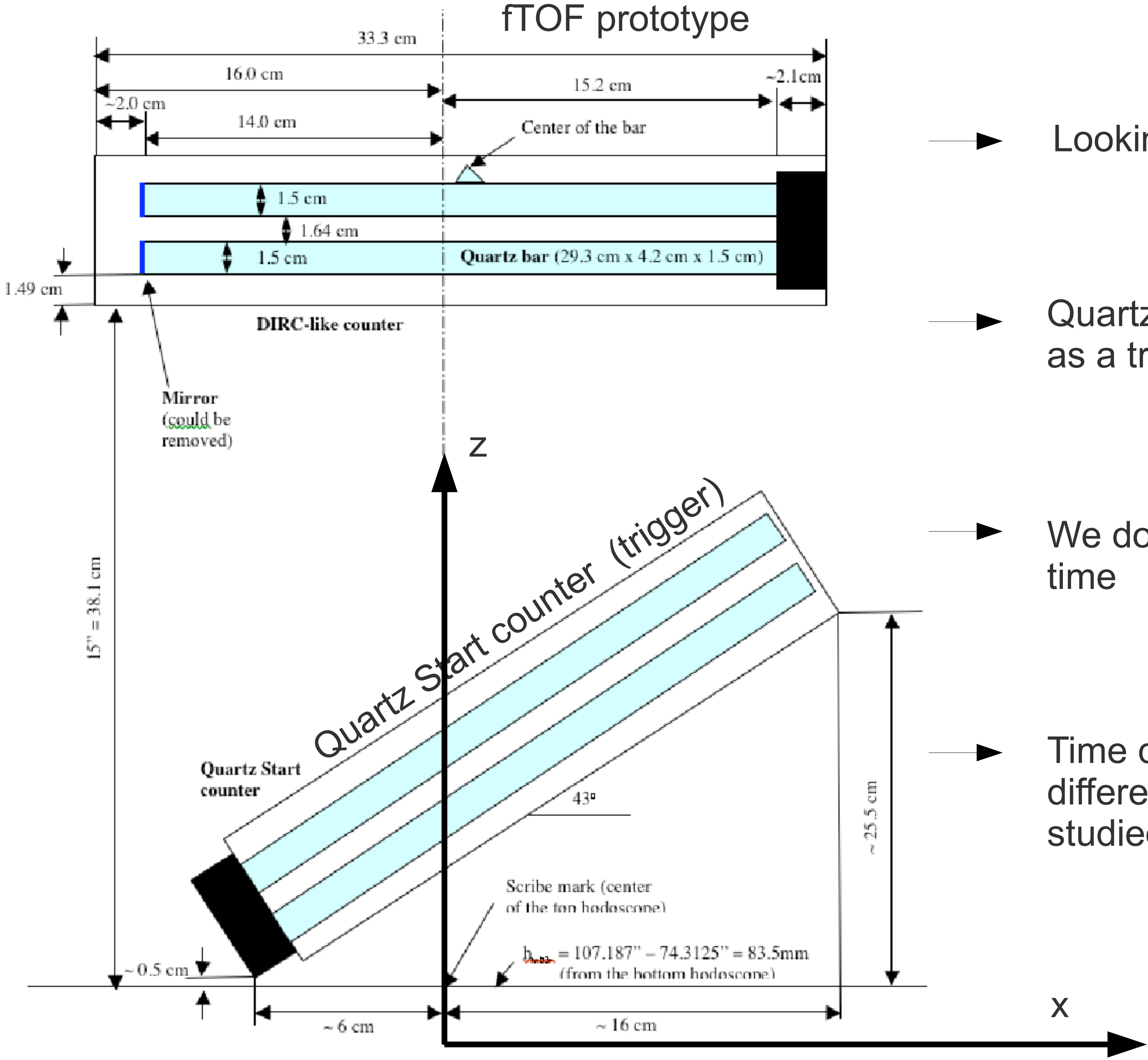
Schematic drawing of the fTOF





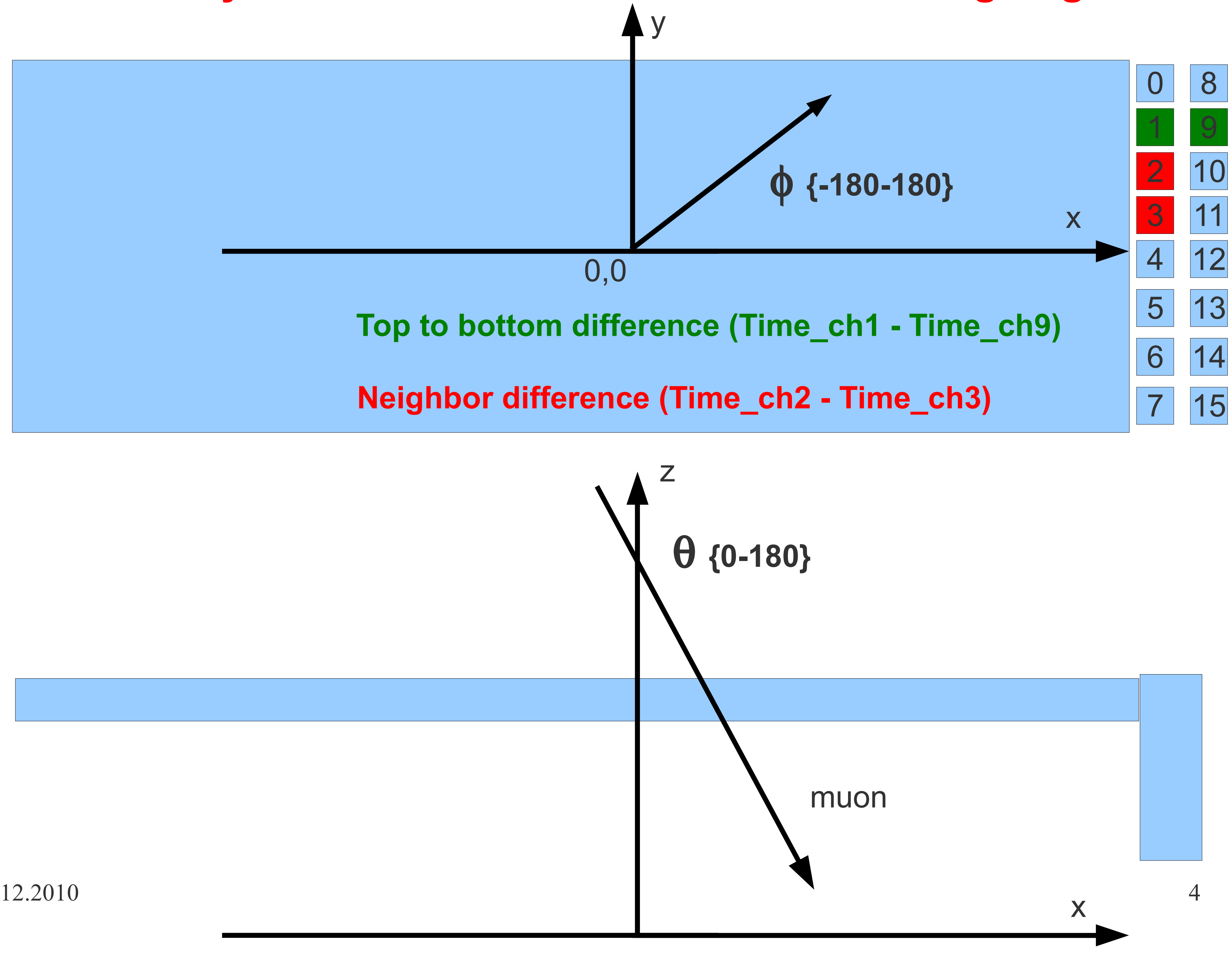
J. Va'vra

Geometry of the experiment

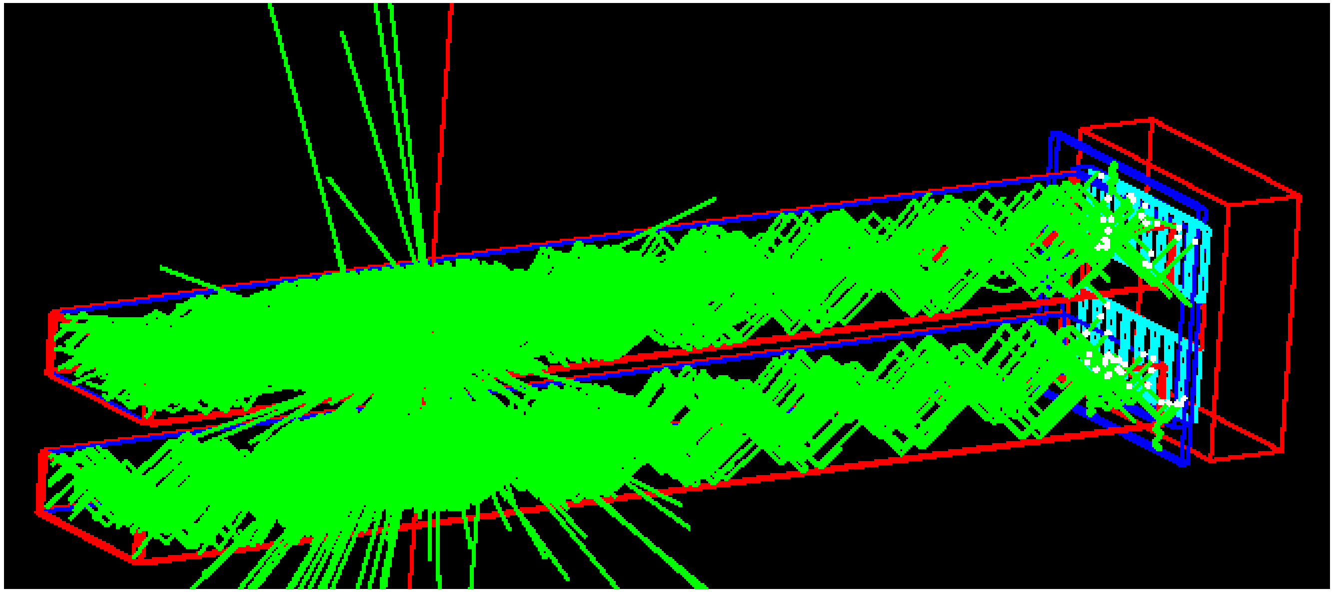


- Looking for cosmic muons
- Quartz Start counter was used as a trigger
- We do not have precise start time
- Time difference between different channels should be studied

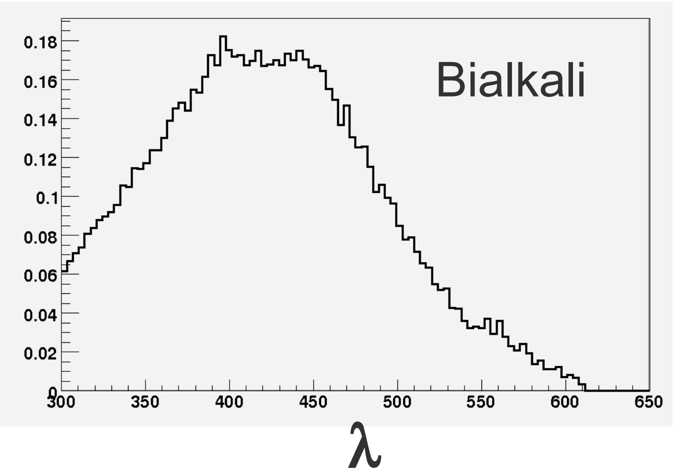
Coordinate system. Time differences which we are going to use



Geant4 Simulation of the fTOF prototype



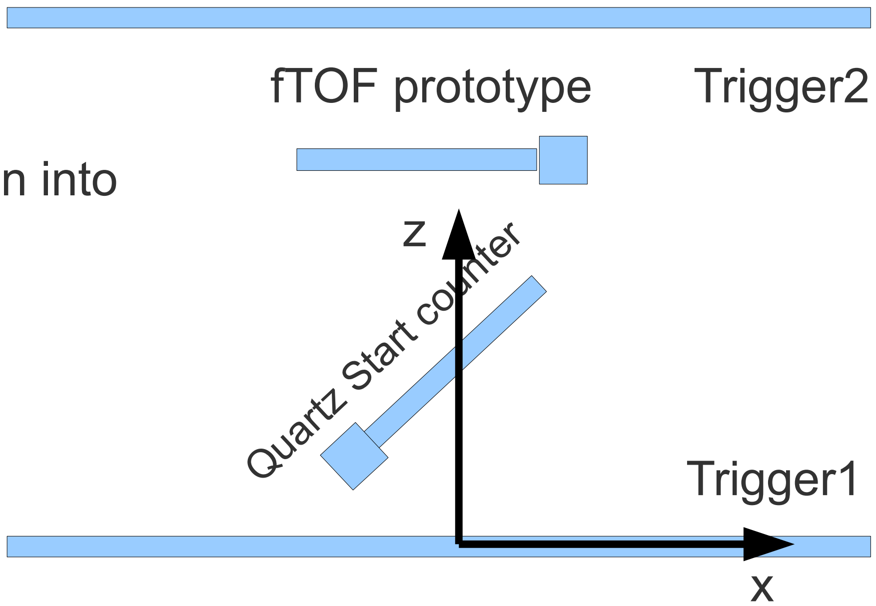
QE + electron collection efficiency



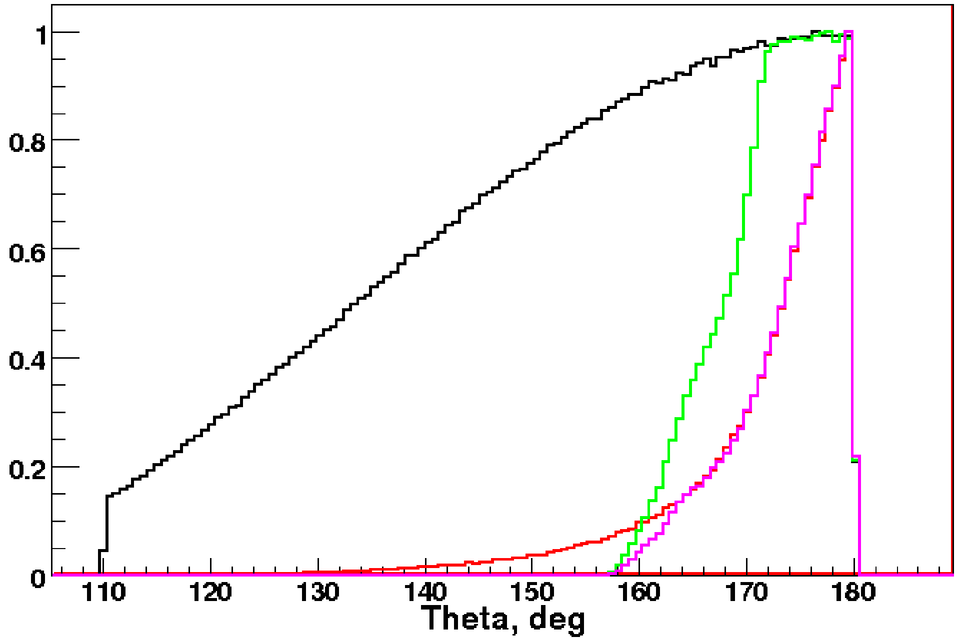
- 16 channels 6 x 18mm each
- TTS = 35 ps
- Electronics = 10 ps / channel
- Bialkali photocathode
- electron collection efficiency 70.0%
- Time of first p.e. arriving is taken as a time measurement for given channel.
- Simple muon generator was developed

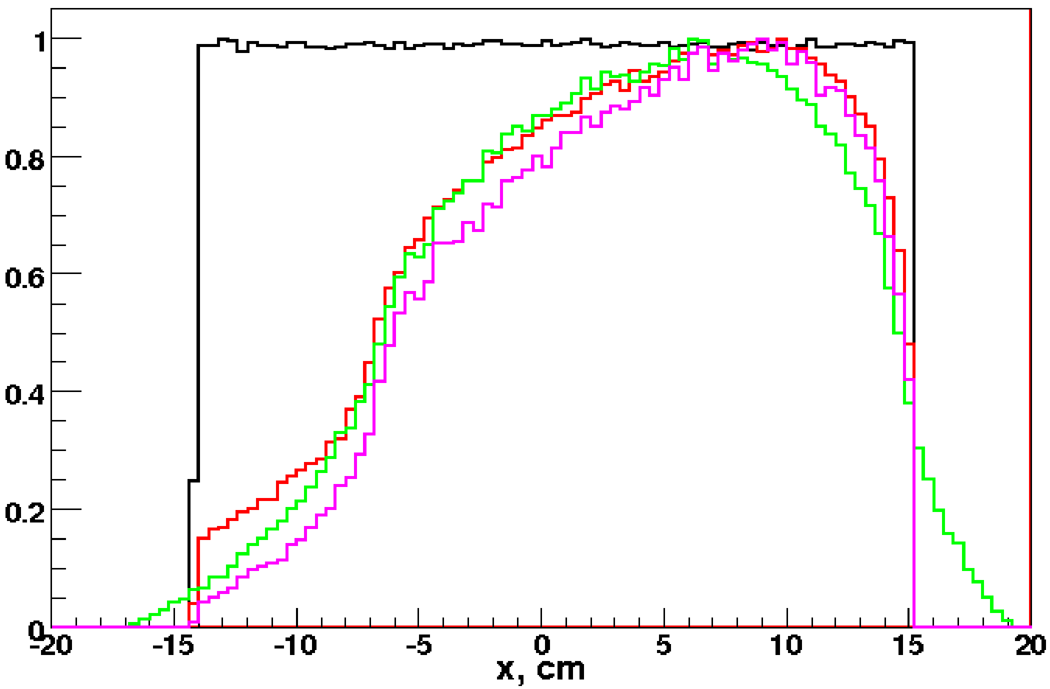
Muon generator

- $dN/d\theta \sim \cos(\theta)^{1.85}$
- ϕ, x, y of the muon have flat distribution
- Position and sizes of detectors were taken into account
- Momentum 1.5 GeV/c



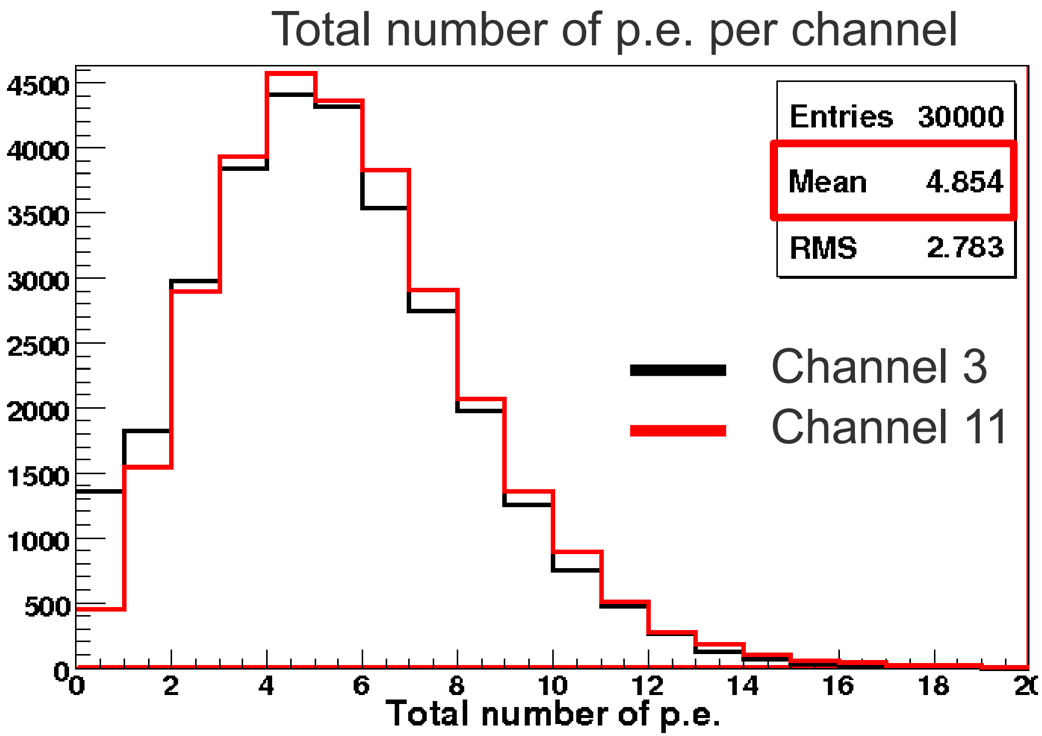
- fTOF only (black)
- Trigger1, Trigger2, Quartz srt. (green)
- Quartz srt. , fTOF (red)
- Trigger1, Trigger2, Quartz srt. , fTOF (magenta)

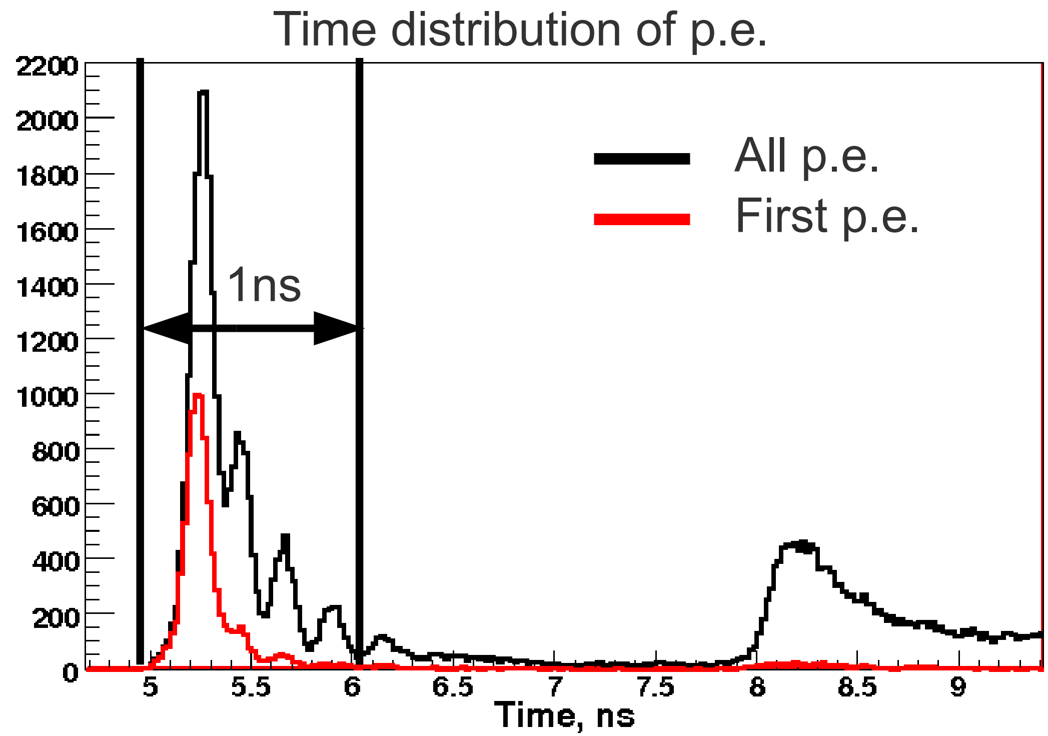




Theta and x distribution of the muons entering fTOF prototype

What we learn from Geant4 Simulation of the fTOF prototype





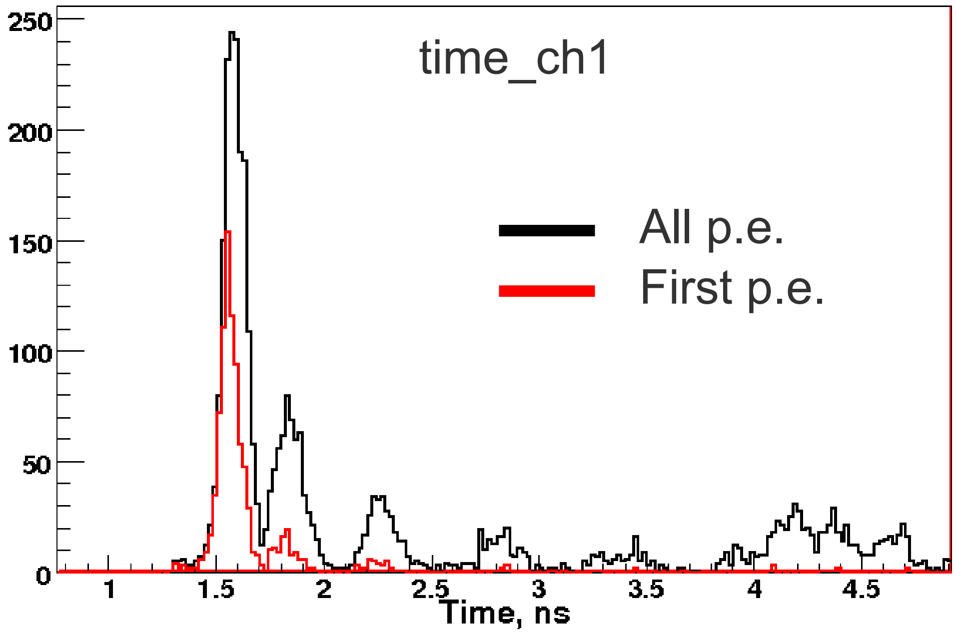
5 p.e. per channel

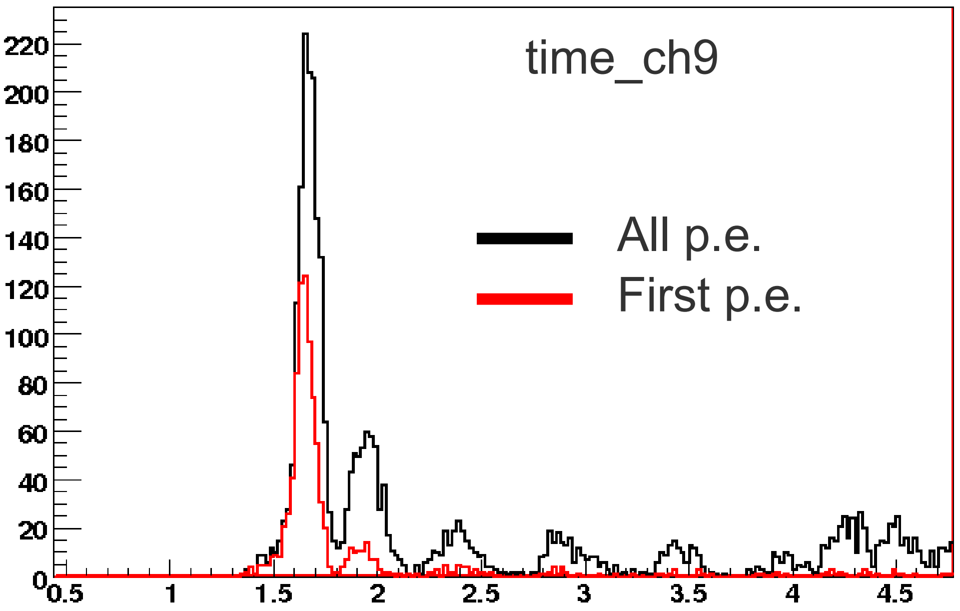
- Majority of the late p.e. arrive within rise time of the signal from first p.e. (~1ns). This will spoil rise time and amplitude of the signal, **C**onstant **F**raction (CF) algorithm will not work properly any more.

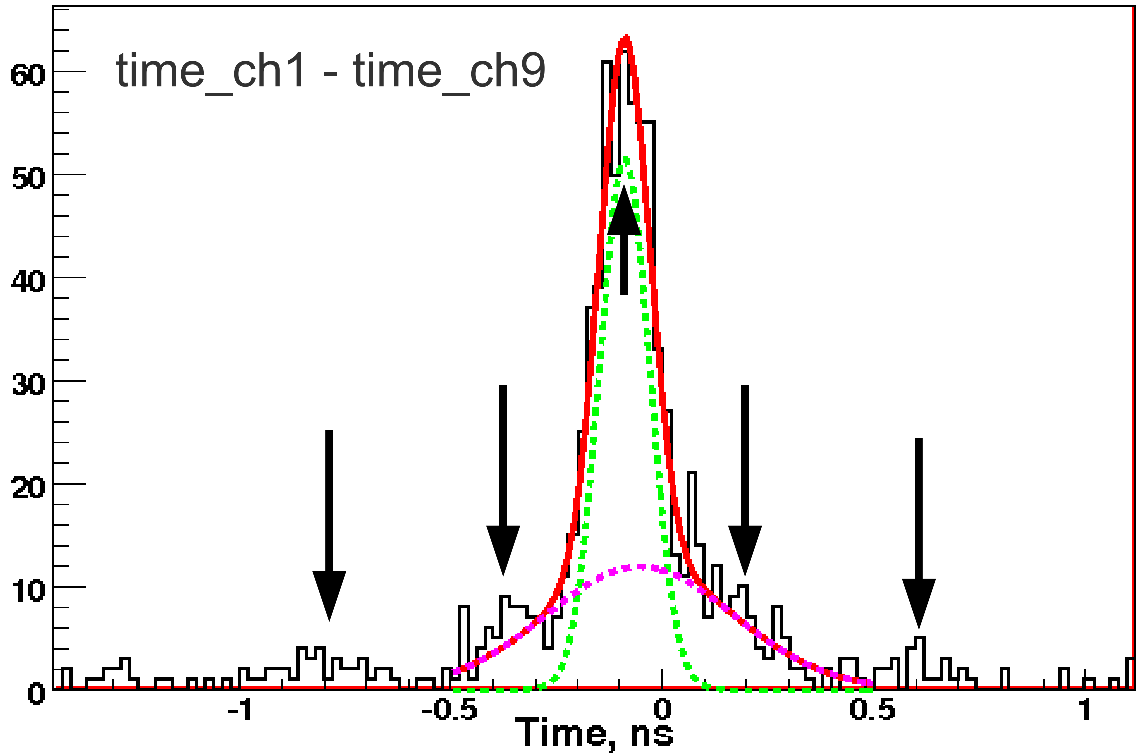
- Total number of p.e. ~80, we run at 7.0 $*10^5$ gain, this can make the phototube behave badly. We should probably run at a smaller gain.

Time difference between top and bottom channels (simulation)

Time distribution of p.e.







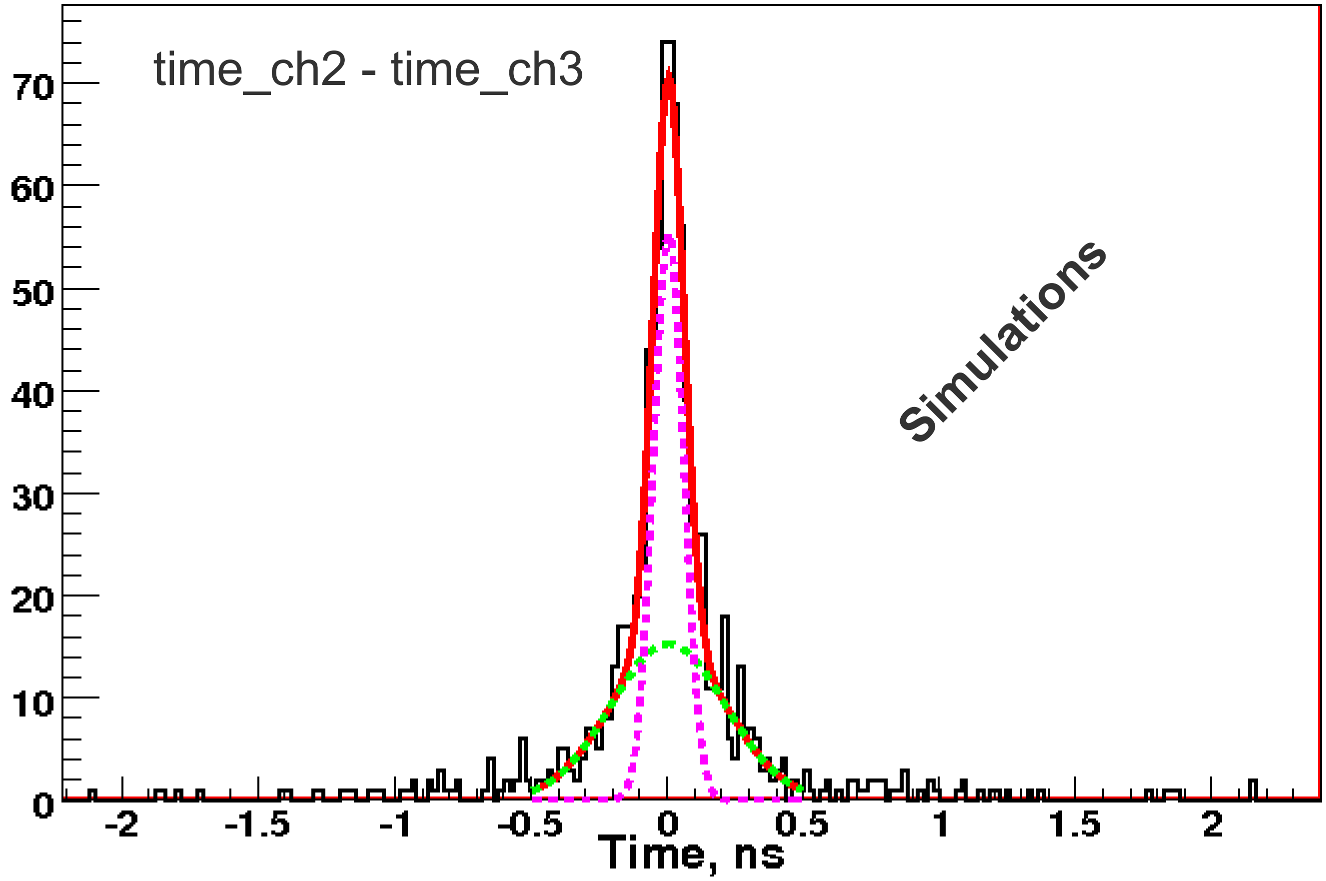
Momentum = 1.5GeV
x = 0.0
y = 0.0
$\theta = 175^{o}$
$\phi = 20^{o}$

	σ,ps	fraction, %
wide	221.5	45.5
narrow	59.5	50.5

Time difference between two neighbor channels

Momentum = 1.5GeV
x = 0.0
y = 0.0
θ = 175°
ϕ = 20°

	σ,ps	fraction, %
wide	210.9	50.5
narrow	55.9	49.5

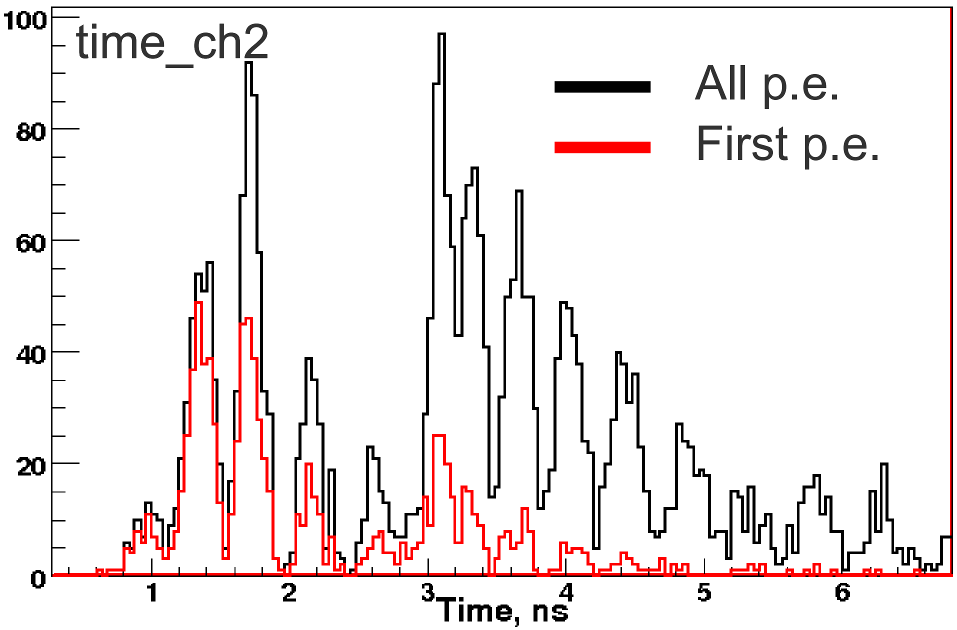


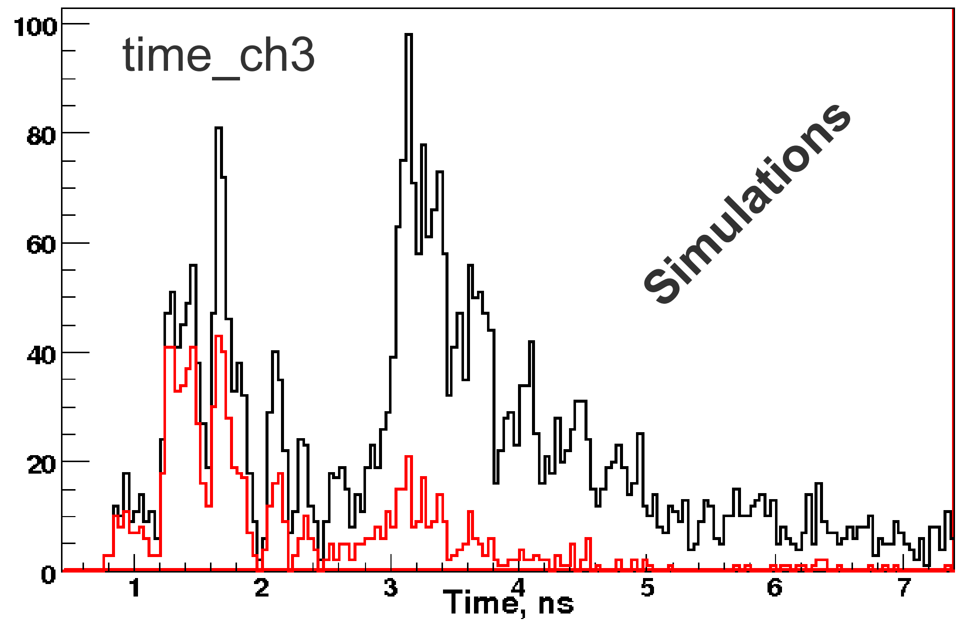
Results of simulations

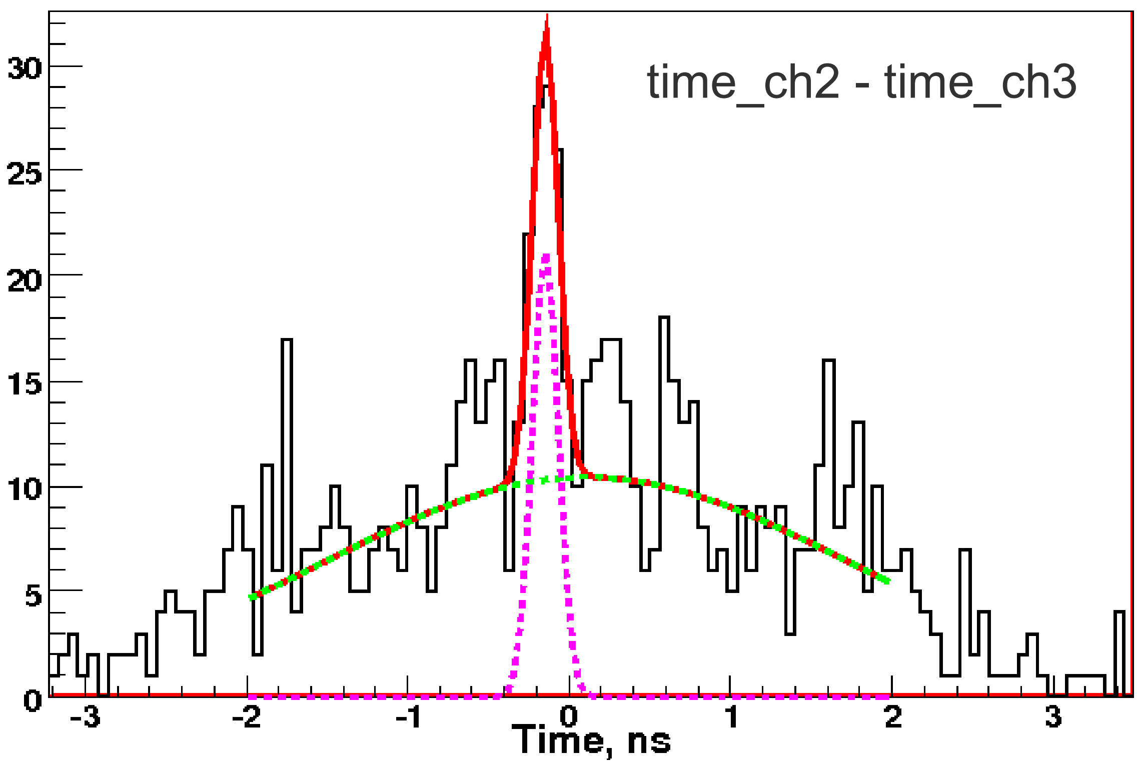
Type of time difference	x, cm	y, cm	θ^o	ϕ^o	Wide σ,ps	Wide fraction, %	Narrow σ,ps	Narrow fraction, %
ch2 - ch3	0	0	175	20	210.9	50.5	55.9	49.5
ch1 - ch9	0	0	175	20	221.5	45.5	59.5	50.5
ch2 - ch3	0	-1.5	175	180	1644	88.7	80	11.3
ch2 - ch3	14	0	170	0	--	--	45	100
ch2 - ch3	14	0	170	180	--	--	492	65
ch2 - ch3	14	0	170	90	--	--	52	100
ch2 - ch3	8	0	180	0	200	34	68	66
ch2 - ch3	8	1.5	180	0	300	28	79	72
ch2 - ch3	8	0	175	-10	165	36	55	64

average: 60ps

Time difference between two neighbor channels, with big ϕ



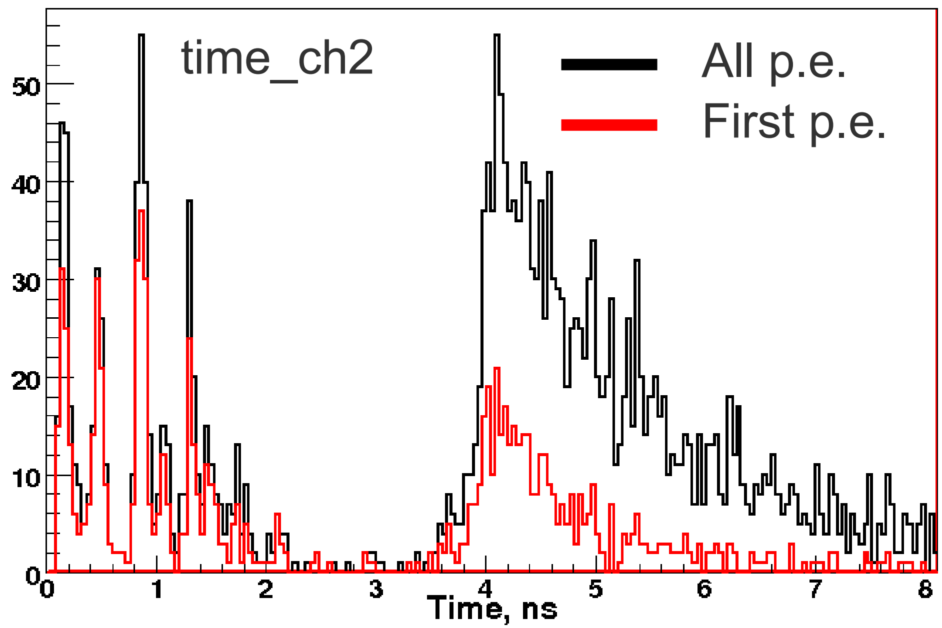


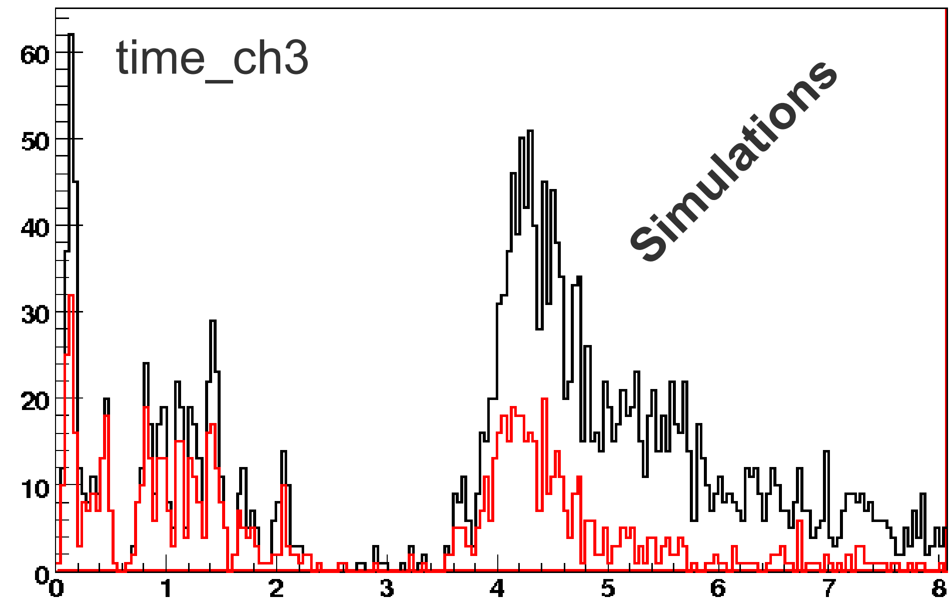


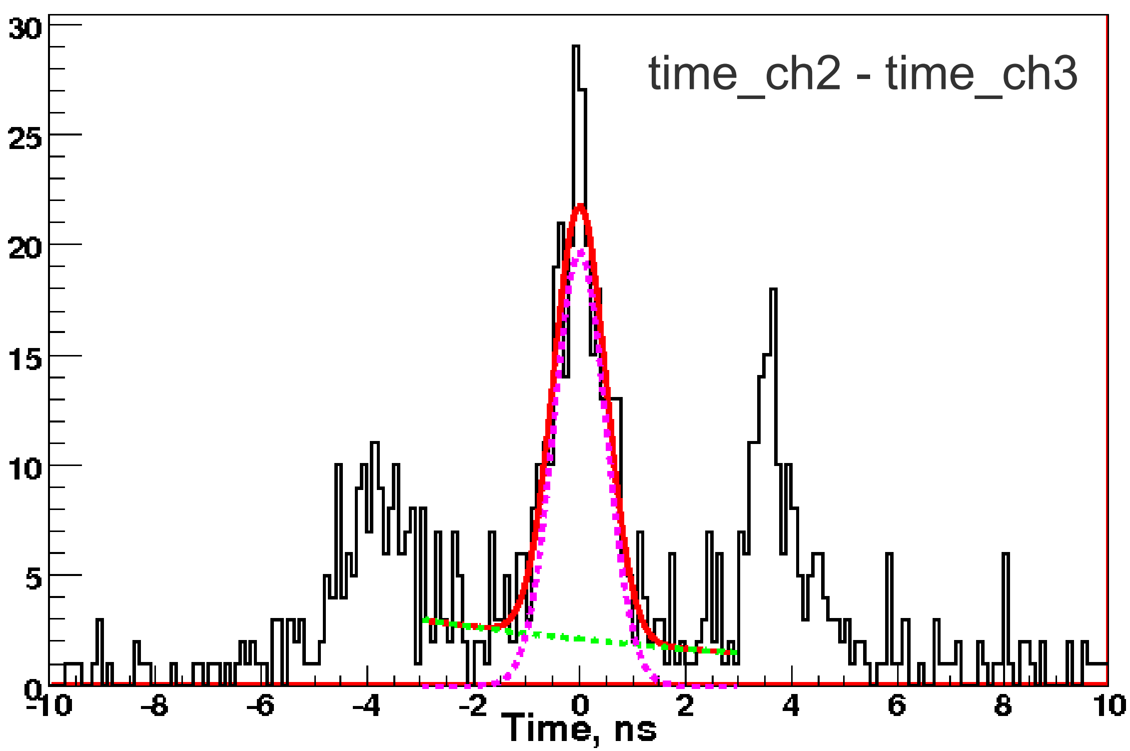
Momentum = 1.5GeV
x = 0.0
y = 1.5
θ = 175°
ϕ = 180°

	σ,ps	fraction, %
Wide	1644	88.7
Narrow	80	11.3

Time difference between two neighbor channels, with big ϕ



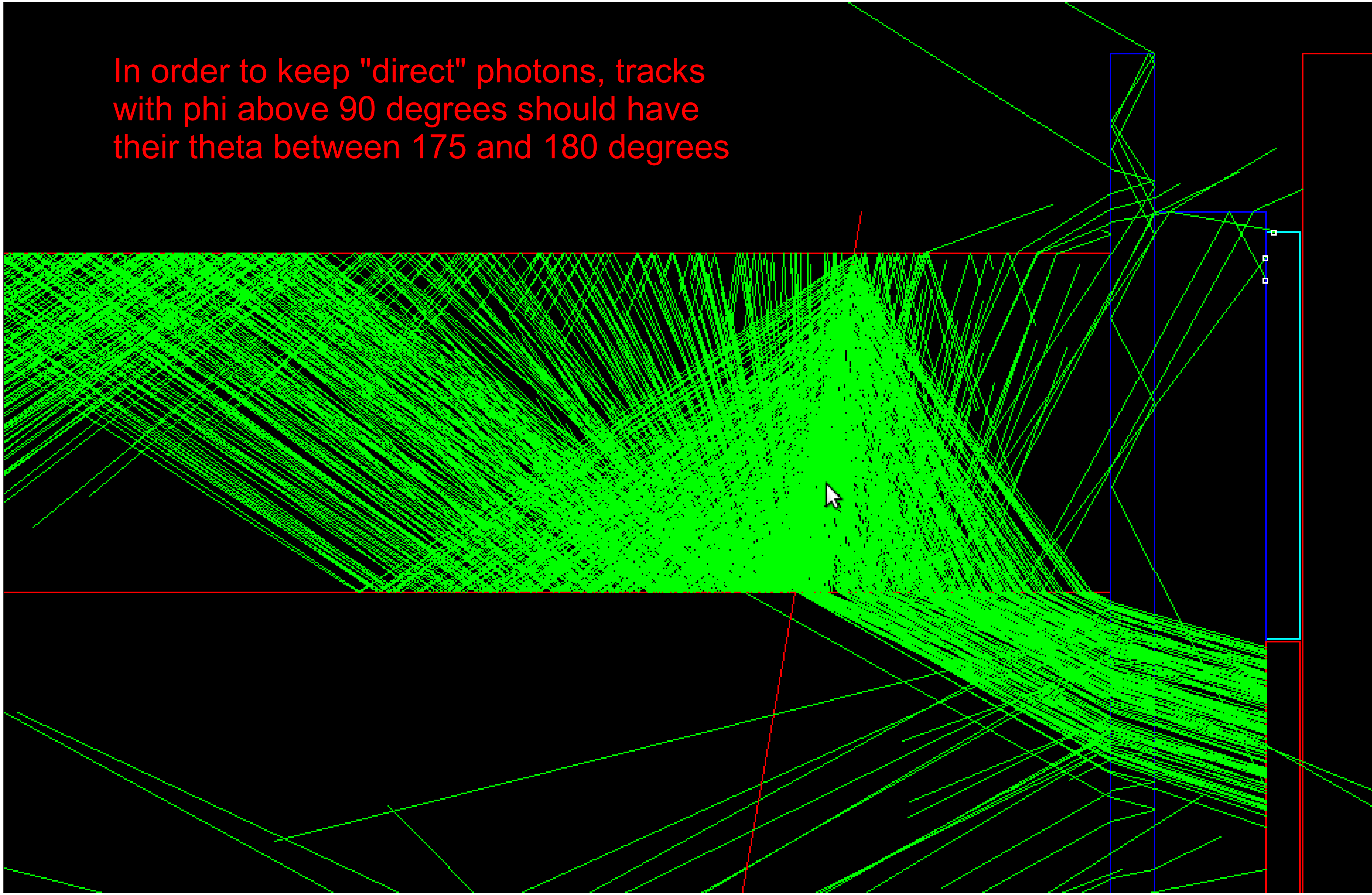




Momentum = 1.5GeV
x = 14.0
y = 0
θ = 170°
ϕ = 180°

	σ,ps	fraction, %
Wide	---	---
Narrow	492	65

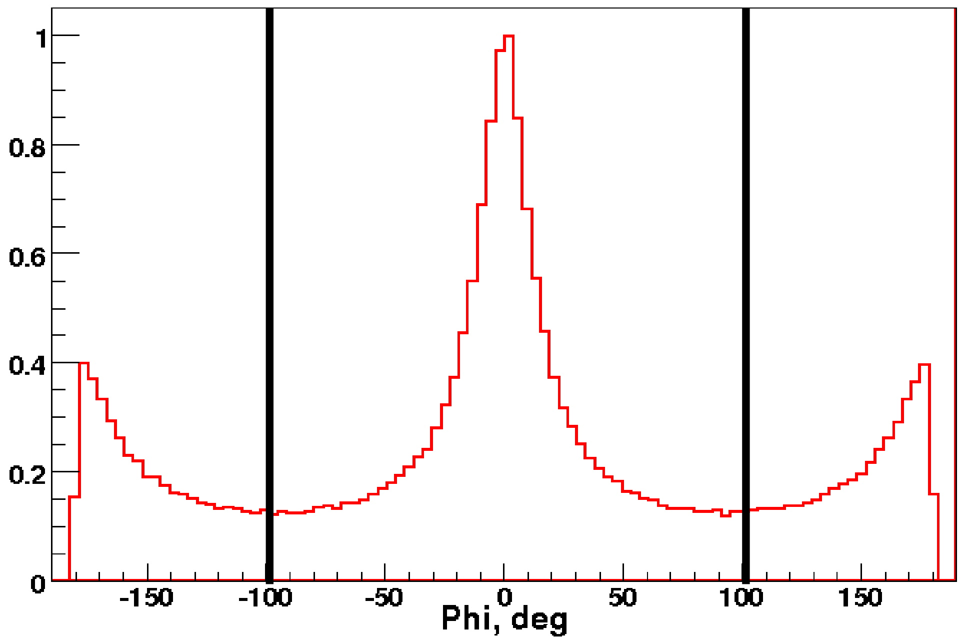
Example of a track for which most of the direct photons exit the quartz bar

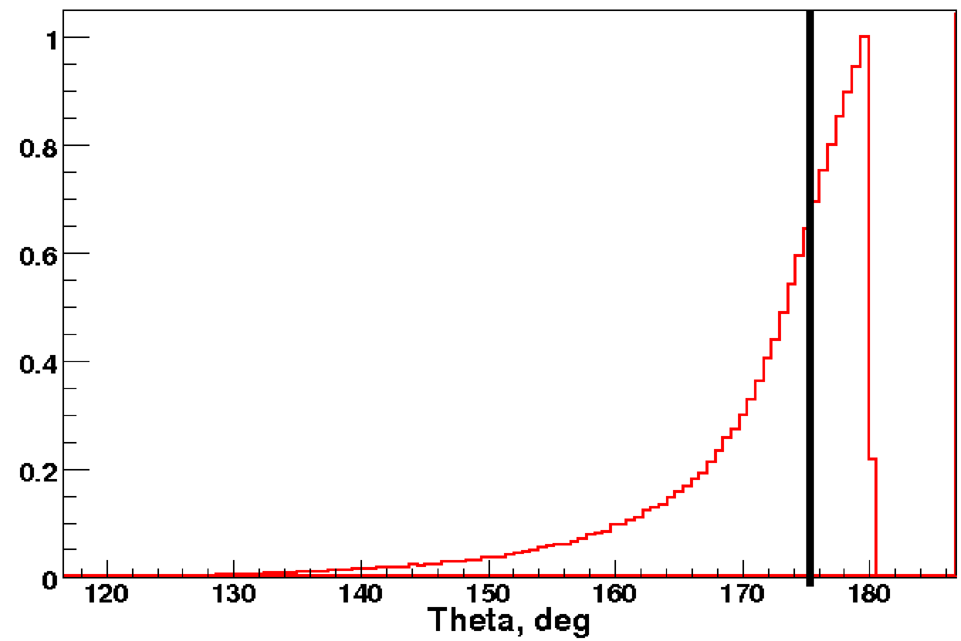


$\theta_{cherenkov}$ ~47°

Minimum angle of the photon to have internal reflection is 42°

Percentage of the events with wide time distribution





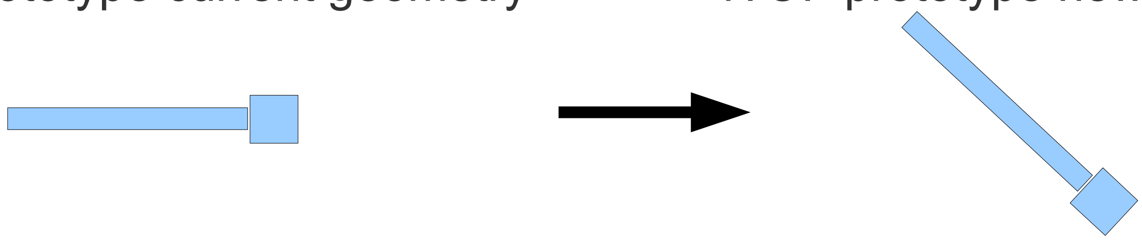
Events with not good time resolutions are this:
Theta <175° && ((90 <Phi< 180) || (-90 >Phi> -180))

16%

By tilting the detector we can remove this kind of events

fTOF prototype current geometry

fTOF prototype new geometry

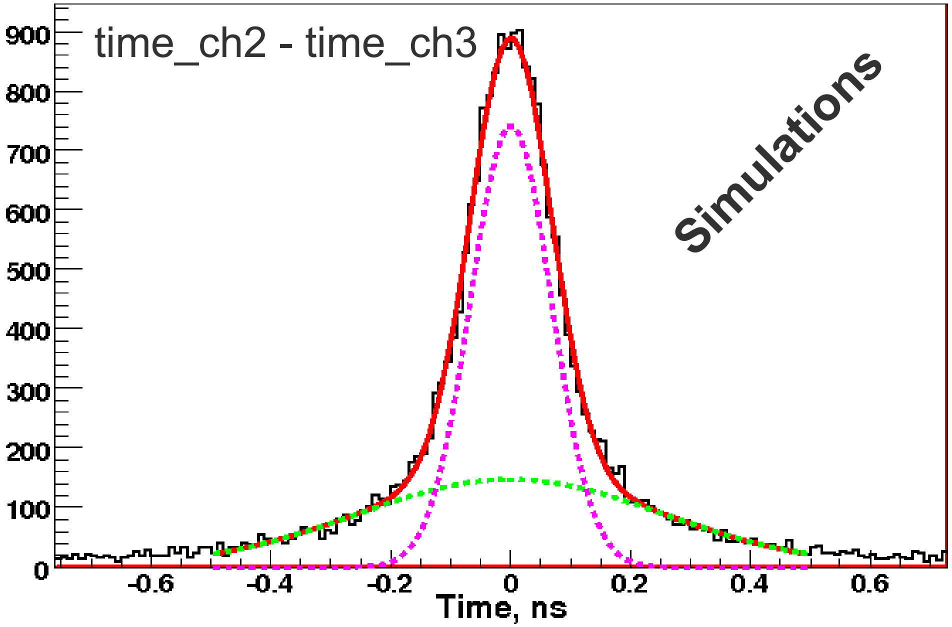


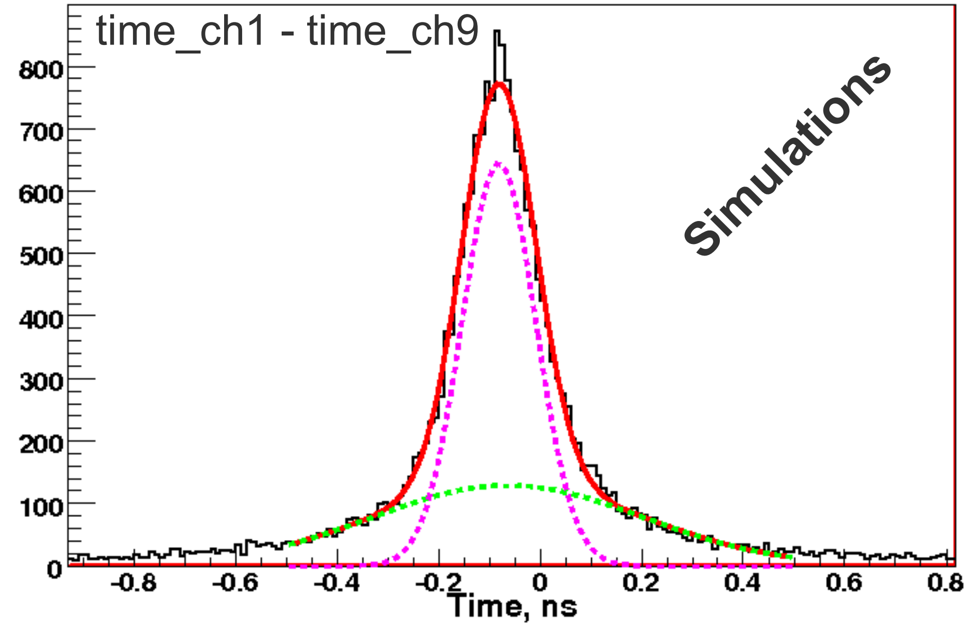
Results of simulations, integrating all muons

Coincidence with Quartz Start counter and fTOF

	σ,ps	fraction, %
wide	254.5	42
narrow	67.3	58

	σ,ps	fraction, %
wide	265.2	40
narrow	73.0	60

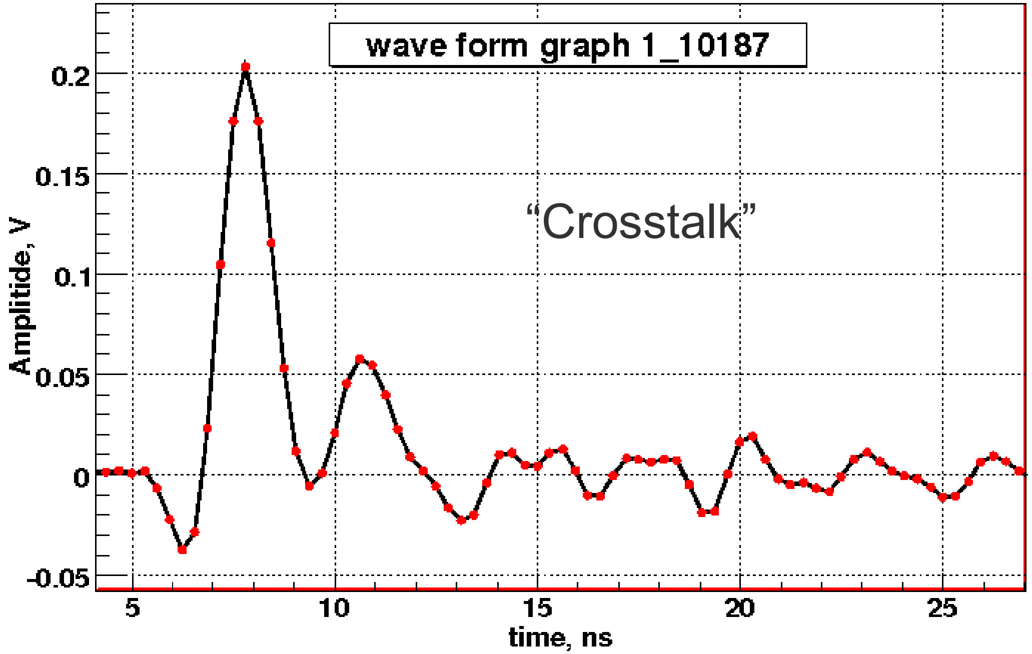




What we learnt from simulation

- 5 p.e. per channel
- Majority of the late p.e. arrive within rise time of the signal from first p.e. (~1ns). This will spoil rise time and amplitude of the signal, CFD algorithm will not work properly any more.
- Total number of p.e. ~80, we run at 7.0 $*10^5$ gain, this can make the phototubes behave badly. Probably we will have to run at smaller gain.
- Top to bottom and neighbor time difference show approximately same RMS
- Depending on position, theta and phi of the track time resolution per channel can be 60/Sqrt(2) ~ 42ps
- If we do not fix position and direction of the track (integrate all muons) time resolution per channel can be 70/Sqrt(2) ~ 50ps

Measurement with cosmic muons

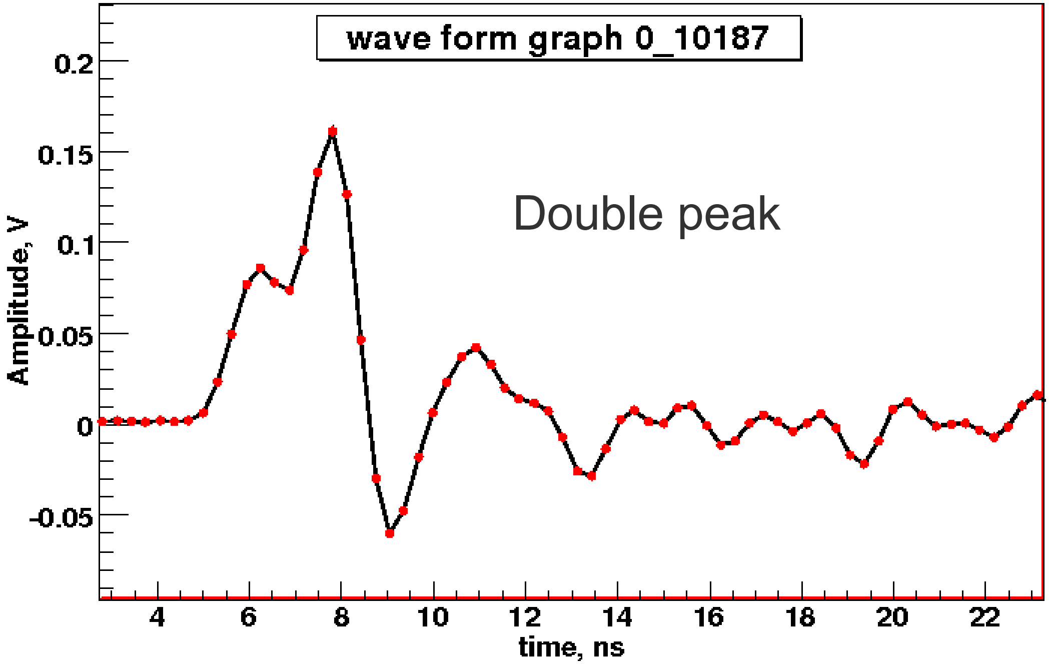


→ More than 50% of the signals don't look good for precise timing measurements

↓

Main reasons:

- More then 1 p.e. per channel
- Crosstalk
- Base line oscillation?



→ We classify the waveforms into 3 main types

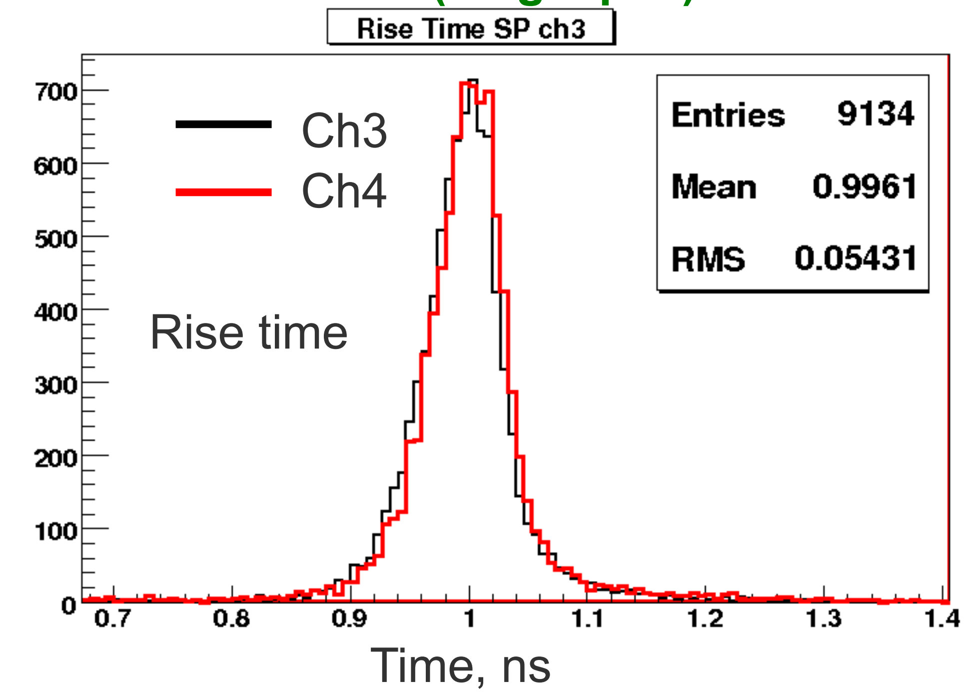
1) Good signal
2) Crosstalk
3) Double peak

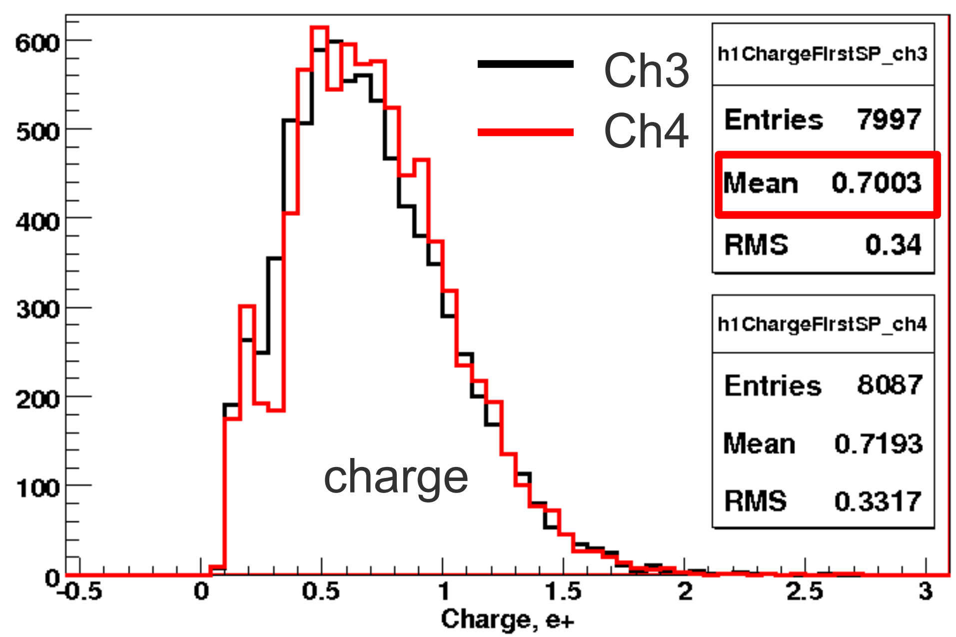
→ For all analysis described below we use just good signals

Laser run VS cosmic run

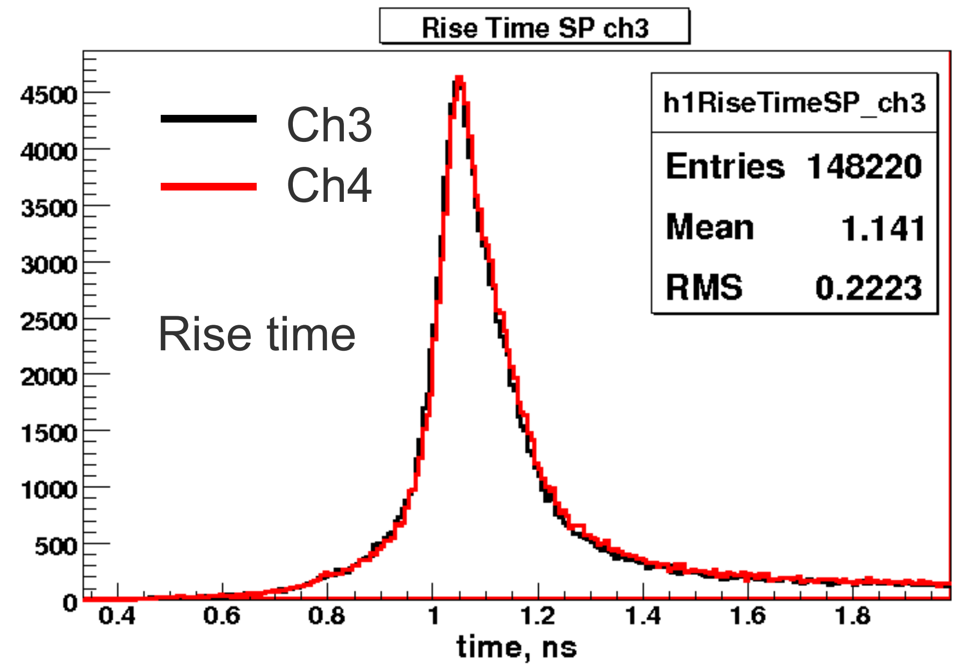
As expected rise time and charge are different

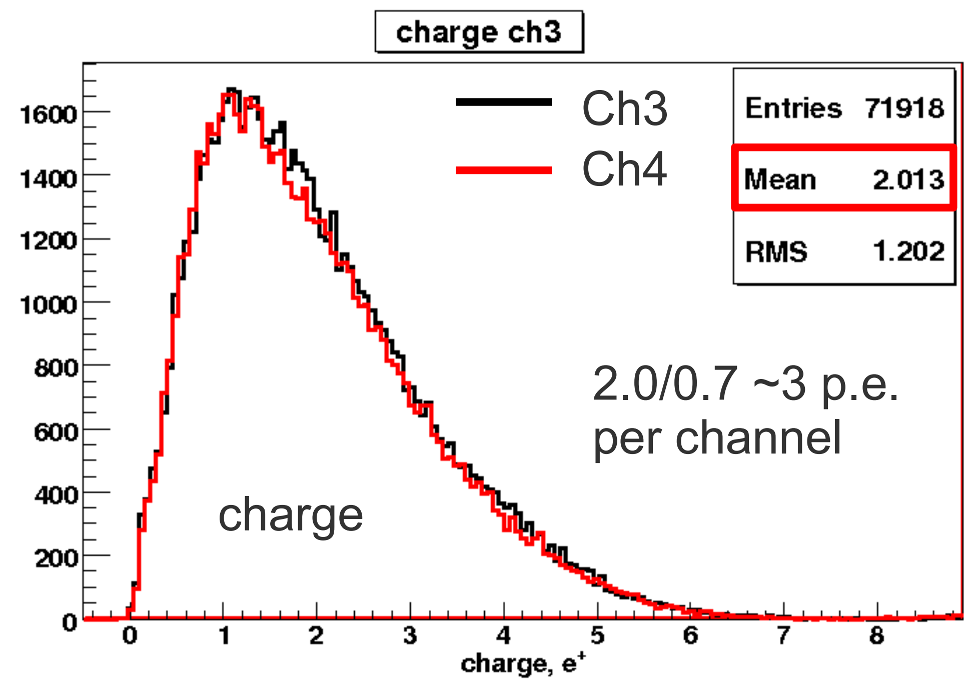
Laser (single p.e.)



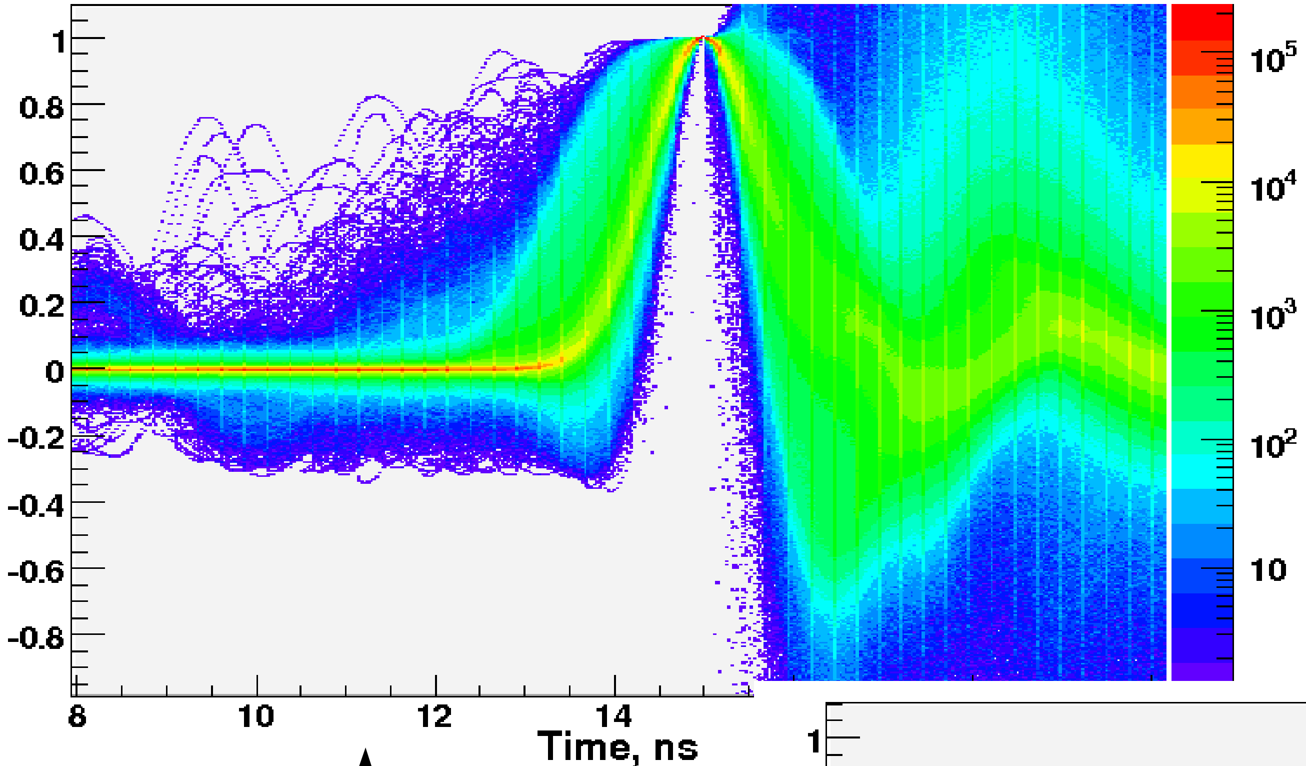


Cosmic



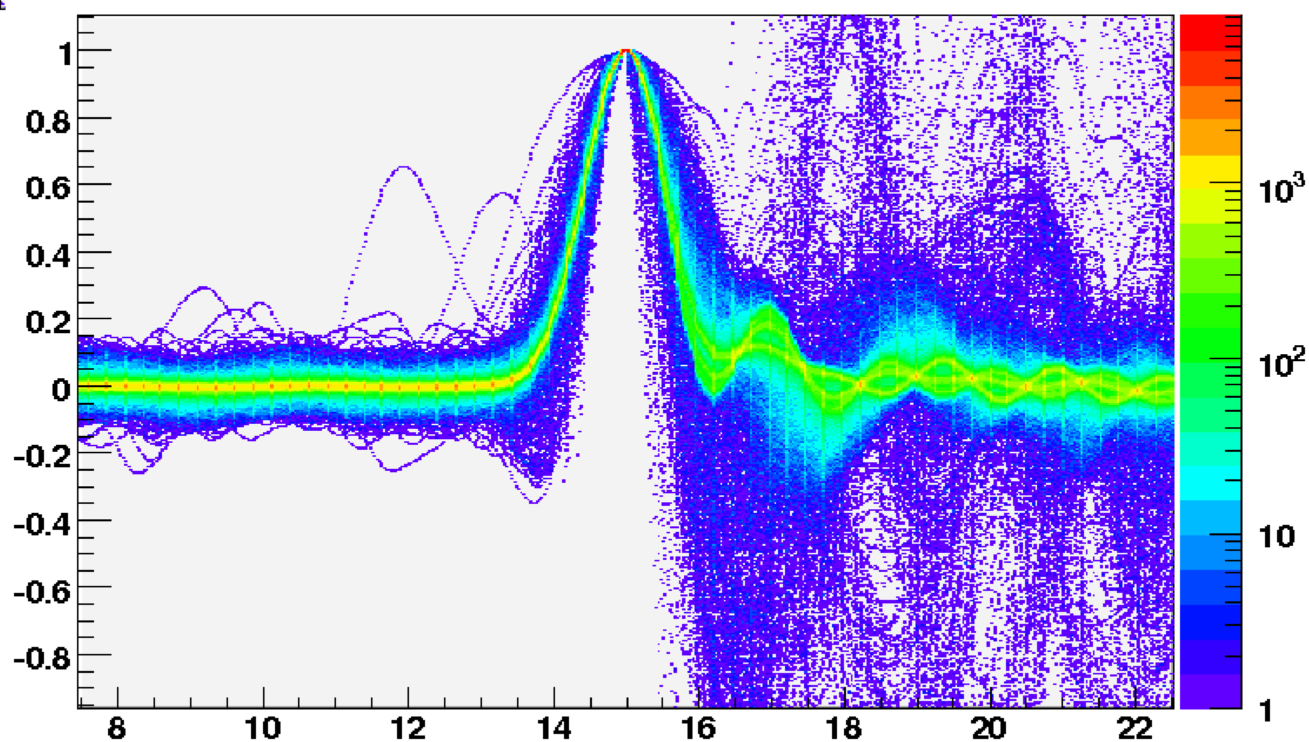


Laser run VS cosmic run



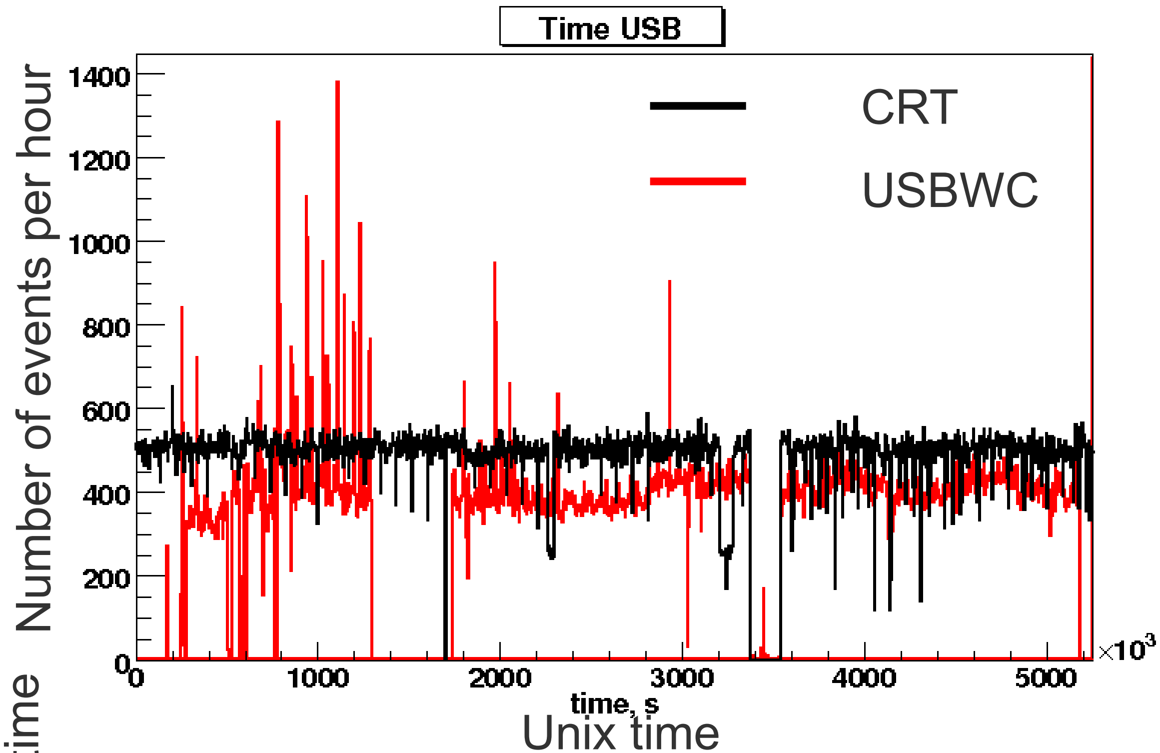
Muons

Laser



15.12.2010

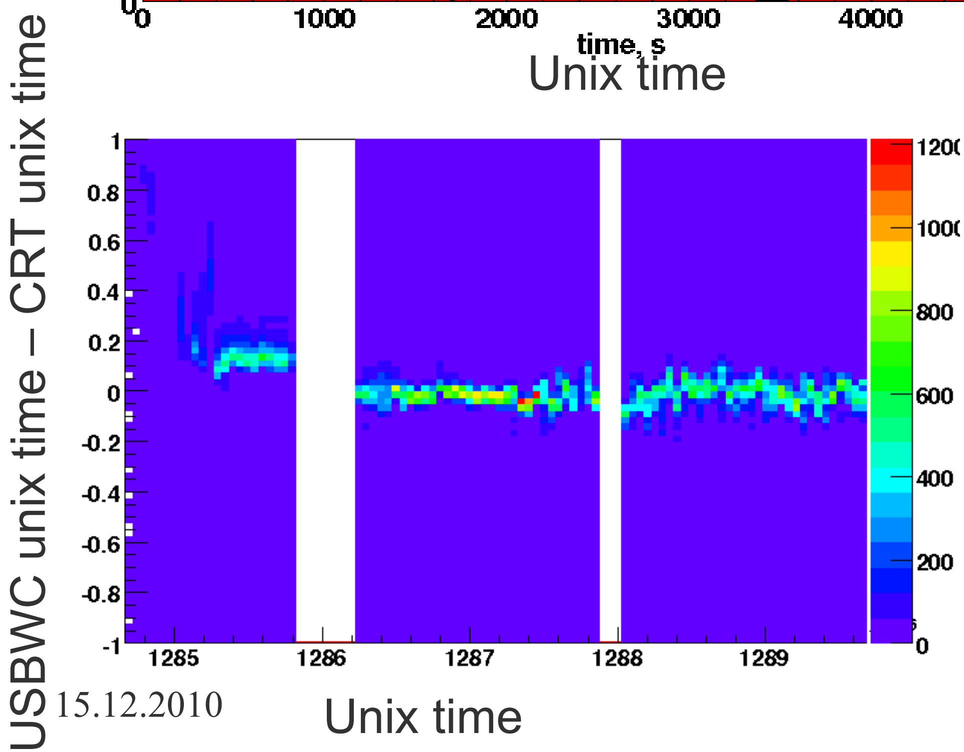
Merging CRT and USBWC data

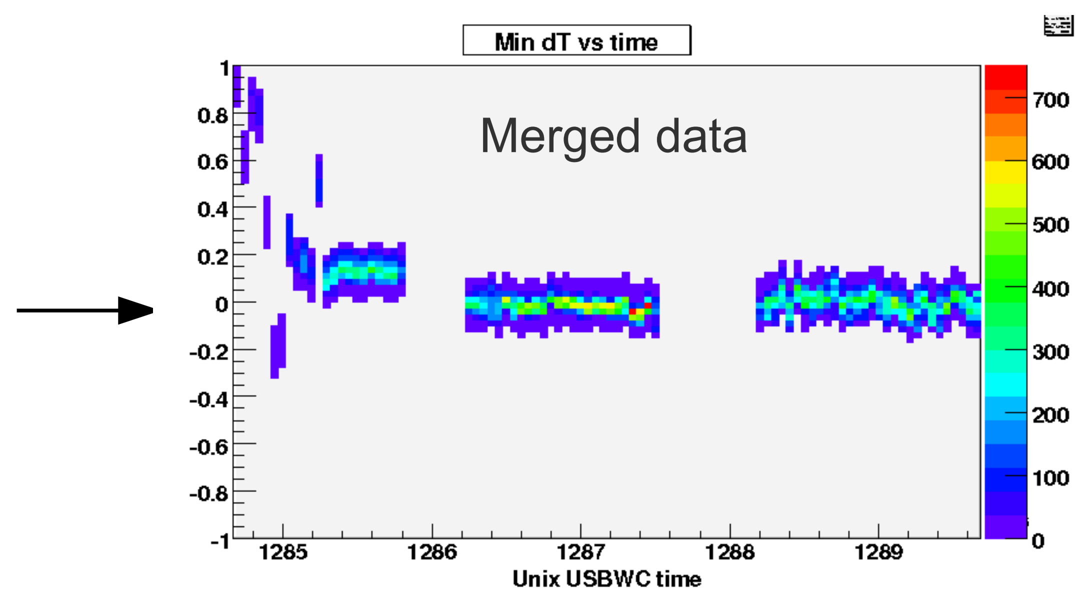


		Fraction of the events
CRT		100%
USBWC	~	80%
Merged	~	10%

Merging data is one order of magnitude less then data from CRT

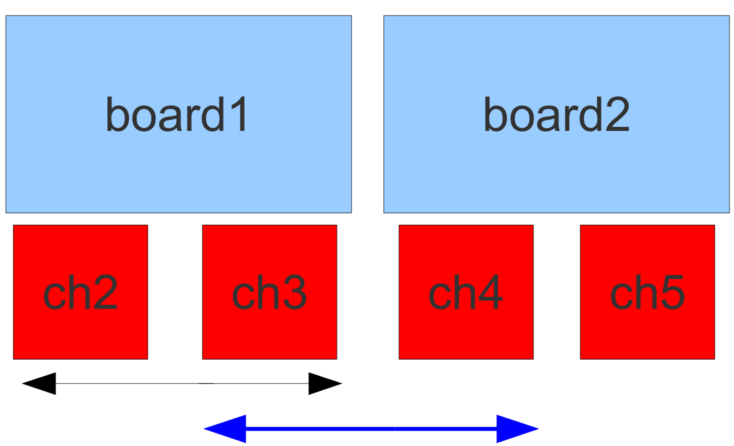
PC which take data from USBWC have to be changed from more powerful





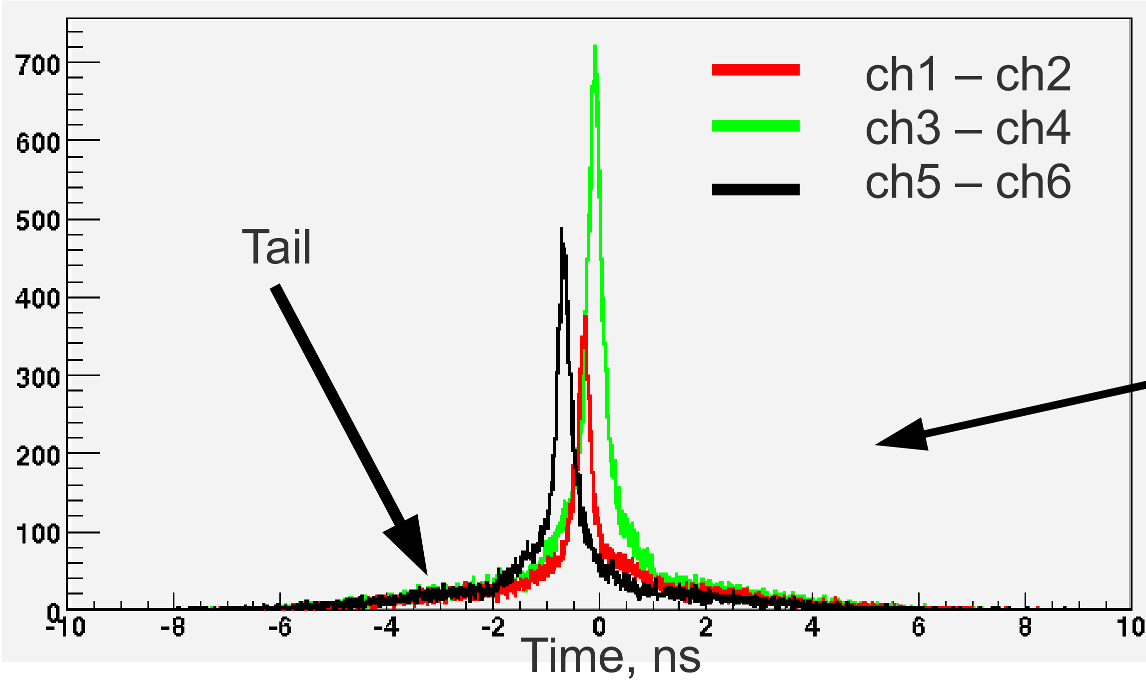
Problem in USBWC data taking. Consequences.

- We discovered some strange behavior of the waveforms on the 16 channel USBWC array at LAL (06.12.2010) .
- Events from different boards can be shifted, i.e. events written to file from USBWC can contain waveforms from physically different events.
- Thus, merged CRT-USBWC data cannot be used
- We can avoid this problem by constructing time differences using times from one board.

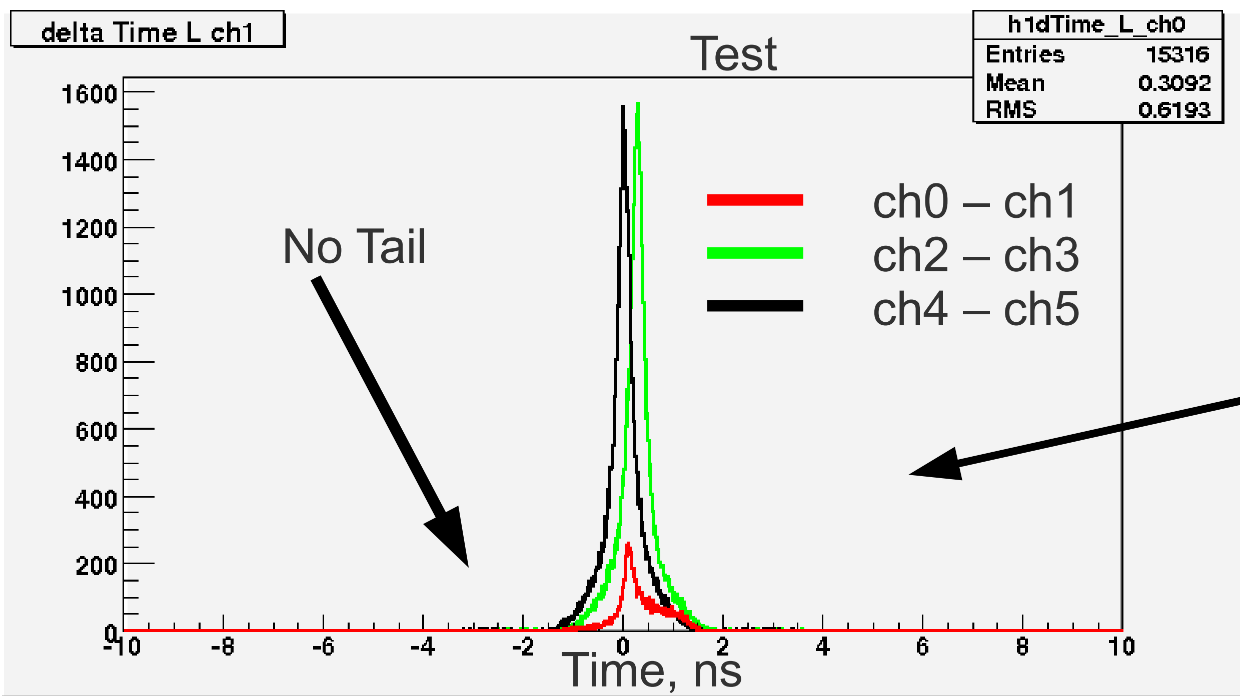


time_ch2 - time_ch3 OK

time_ch3 - time_ch4 NOT OK



Time difference between neighbor channels from different board



Time difference between neighbor channels from same board

Different strategies for data analysis

No merging with CRT	Merging with CRT	
Simple	Complicated	Very complicated 3D analysis
Time differences between channels from one board. Cuts on charge, amplitude, rise time and shape of the signal No cuts on tracking	Top to bottom time differences between channels Cuts on charge, amplitude, rise time and shape of the signal Cuts on theta, phi and position of the track	Time differences between given channels Cuts on charge, amplitude, rise time and shape of the signal Using information about the track construct expected time difference.
DONE	**NOT DONE**	**NOT DONE**

For the moment we can not perform this analysis, we plan to do it in future

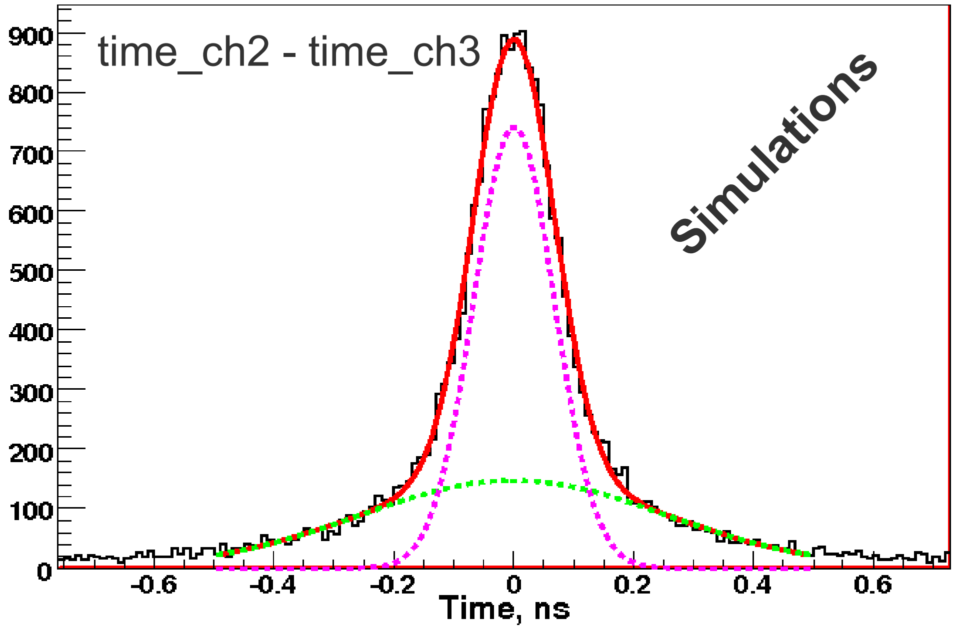
Comparison between Simulations and Measurements

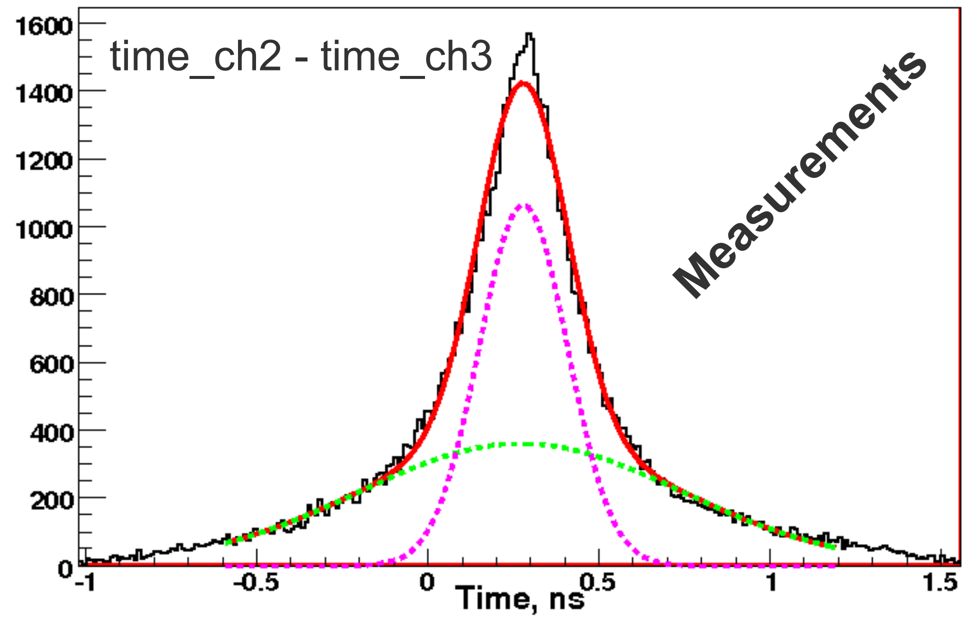
	σ,ps	fraction, %
wide	254.5	42
Narrow	67.3	58

Time resolution/channel:
67.3/Sqrt(2) ~ 50ps

	σ,ps	fraction, %
wide	470.5	54
Narrow	129.0	46

Time resolution/channel:
129.3/Sqrt(2) ~ 90ps





Discrepancies between measurements and simulation coming from existing of multiple p.e./channel and crosstalk

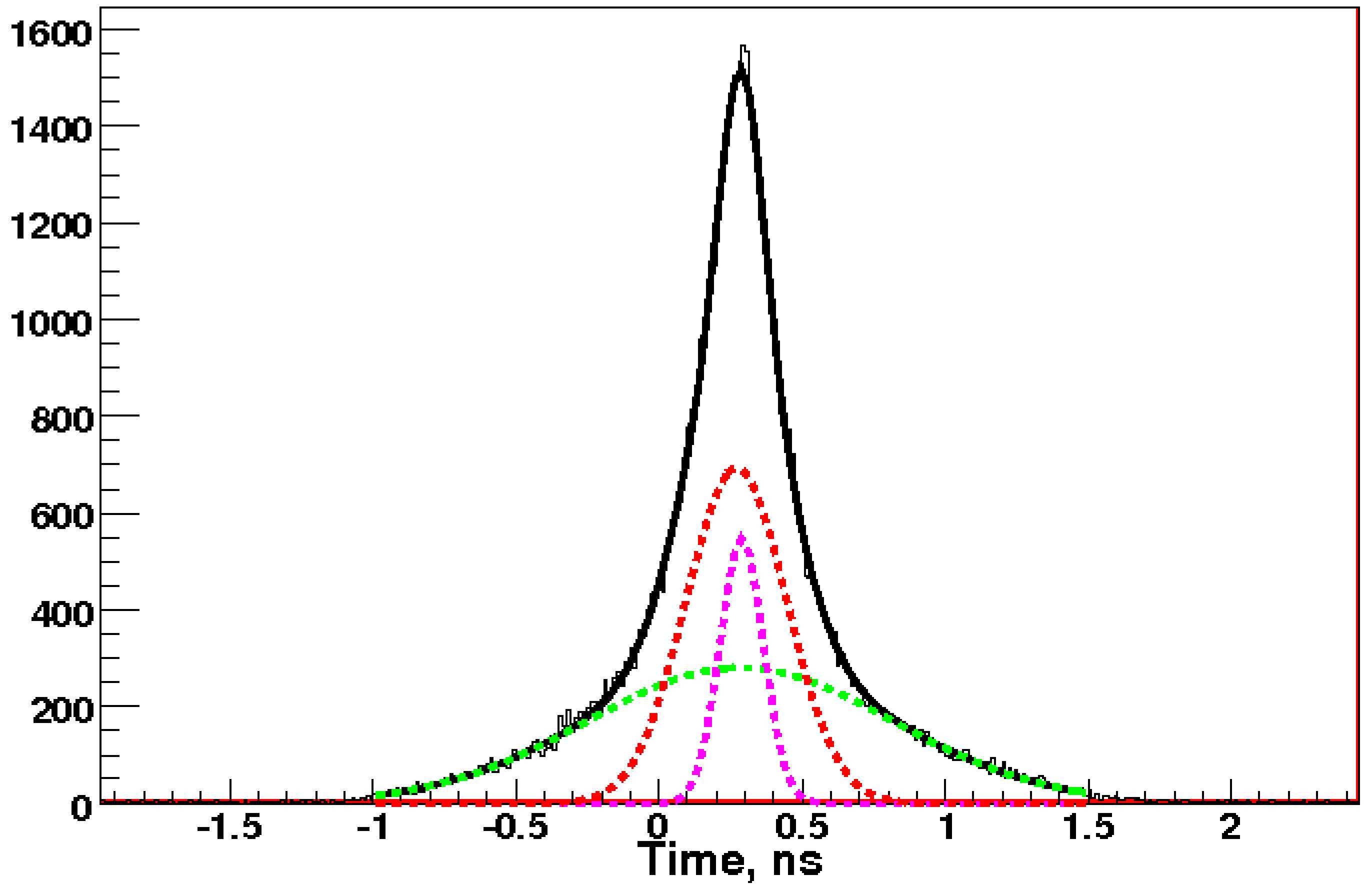
<u>Estimation and simulation of these contributions are under studying</u>

Measurements. Fit with three Gaussians

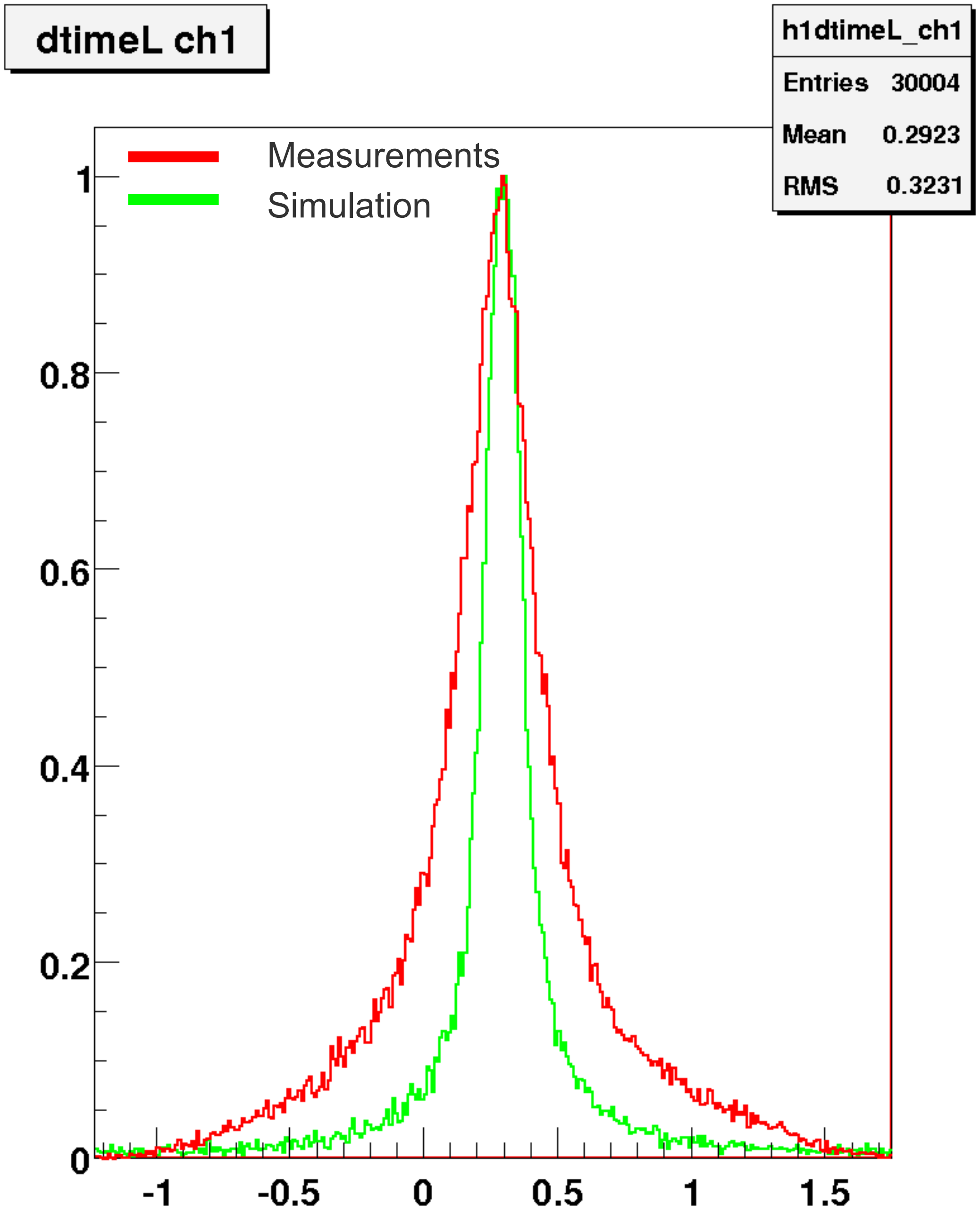
	σ,ps	fraction, %
wide	532	47
Narrow	76	13
Third	174	39

Time resolution/channel:
76/Sqrt(2) ~ 54ps

- We fit with three Gaussians, in order to reproduce better measurements
- We are able to extract narrow component 54ps



Discussion of the results. Conclusions



- Time resolution from simulation 50ps / channel
- Time resolution from measurement 90ps / channel
- Narrow component of the time resolution from measurement 54ps / channel (three Gaussian fit)

- Total number of p.e. ~50 (3p.e./channel), we run at 7.0 $*10^5$ gain, this can make the phototube behave badly.
- Effect coming from multiple p.e. and crosstalk have to be estimated

Future plans

- Within simulation we did not take into account effects coming from multiple p.e. and crosstalk. In order to estimate effect coming from multiple p.e. and crosstalk. We are going to simulate response of the MCP-PMT

Update setup

- Reduce amount of p.e. :-). Put absorber in front of MCP-PMT.

Update setup would be with MCP-PMT SL10

- Rise time 500ps
- TTS ~ 35ps
- 4 and 16 channels

Backup slides