Progress on full simulation of the forward DIRC-like TOF detector

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Outlook

- Reminder of the main open questions from Frascati meeting
- More realistic simulation of the fTOF detector (size, position, field, PMTs)
- Optimization of the detector geometry
- Studying σ_{track} and $\sigma_{detector\ coupling\ to\ bar}$ with FastSim
- Studying influence on time resolution of the 2mm Al foil in front of the fTOF
- Conclusion
- Event reconstruction and K/π separation (by Ganna Dolinska)

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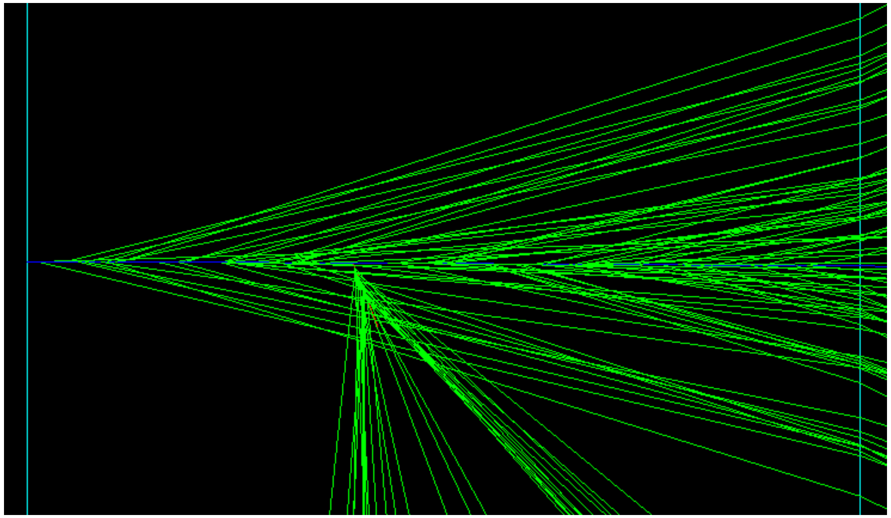
Reminder of the main open questions from Frascati meeting

see Simulation of the DIRC-like TOF @ http://agenda.infn.it/conferenceDisplay.py?confId=1165



1) Kaons up to 1.2 GeV hitting the quartz sector perpendicularly will produce Cerenkov photons which will leave detector volume

However particles with 1.2 GeV will propagate in the 1.5 Tesla magnetic field so in reality not **all** tracks will hit sector @ 90 deg to the surface.

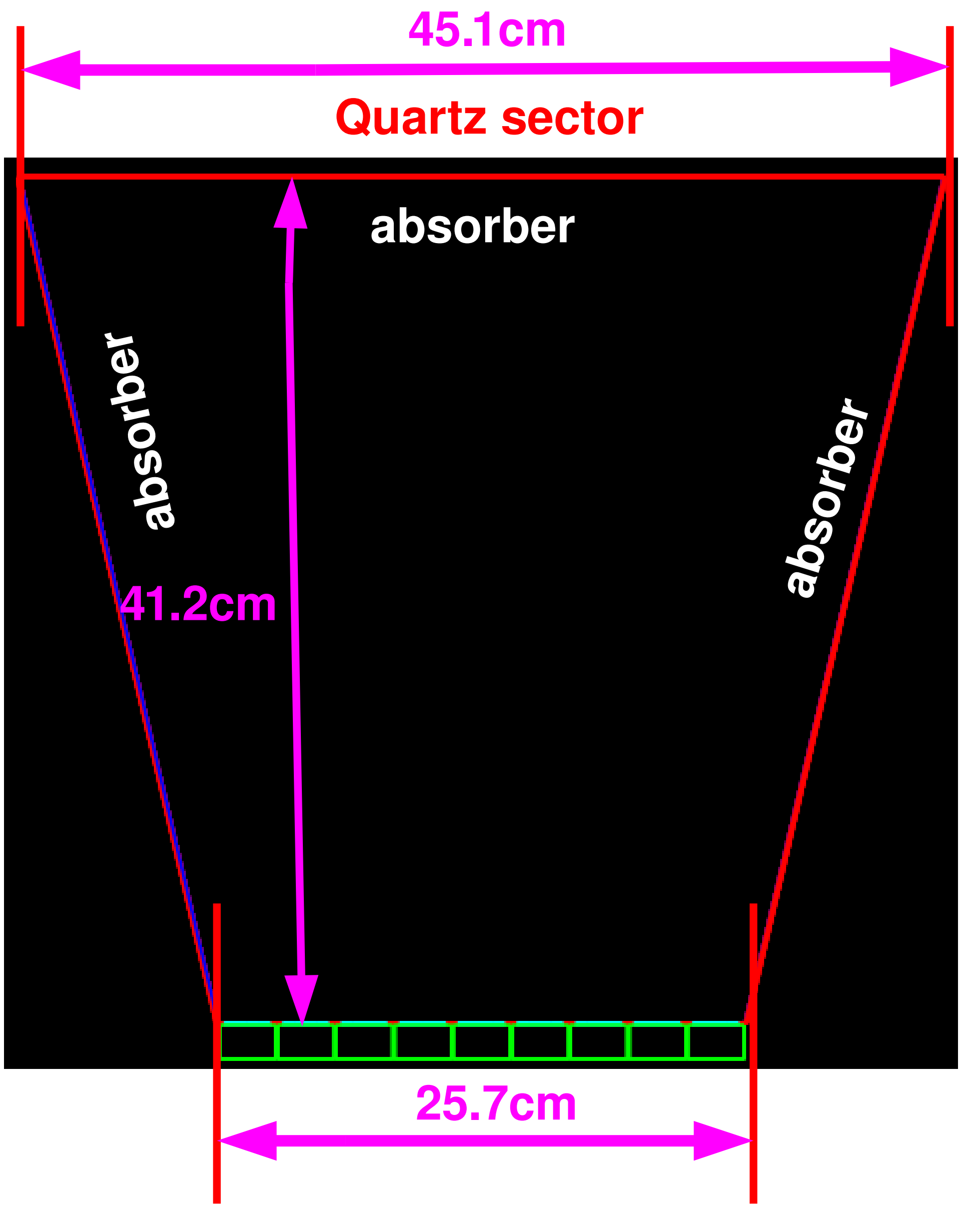
2)Number of detected Cerenkov photons is not only a function of β but also depends on the position and on the direction of the particle entering the detector.

3) What is the optimal geometry of the detector ? Where absorbers have to be placed ? How much has the detector to be tilted?

4) What is the best position of the photomultiplier?

5) How to analyze the data and what is the K/π separation? (by Ganna Dolinska)

More realistic standalone simulation of the DIRC-like forward TOF detector



A very similar implementation of the fTOF is now available in Bruno. Few details (volume overlaps in particular) still need to be worked out.

Increase the number of PMTs

We put 12 sectors at right position

Implementation of the magnetic field

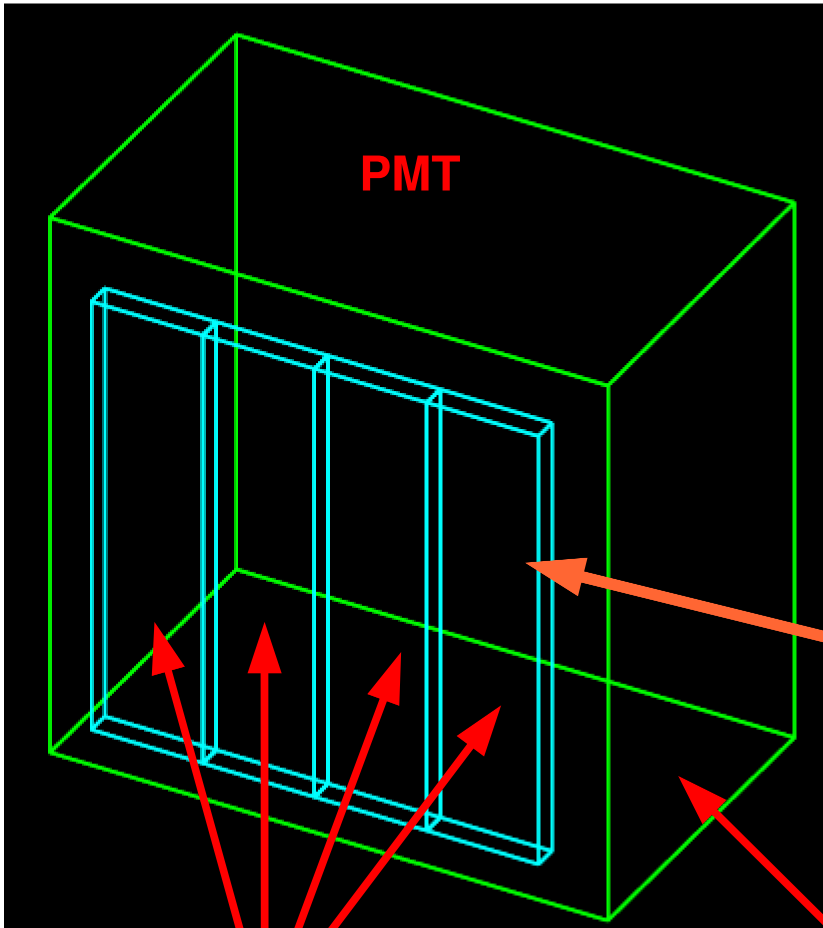
Reminder
Thickness of the quartz sector is 1.2cm ~ 10% of radiation length

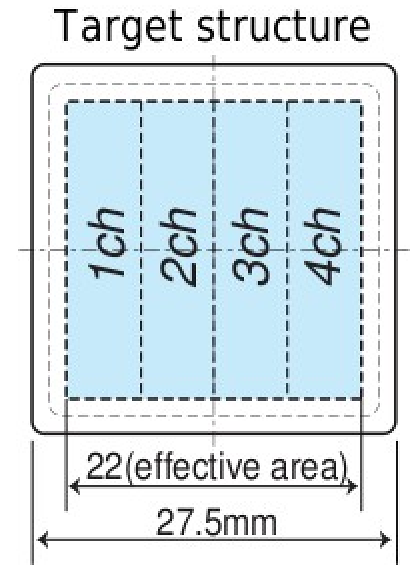
Enough space for 9 MCP-PMTs (see next slide for details)

MCP-PMT SL10

2.75cm x 2.75cm x 1.66cm

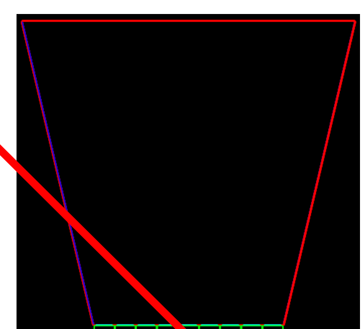
arXiv:0803.0594v1





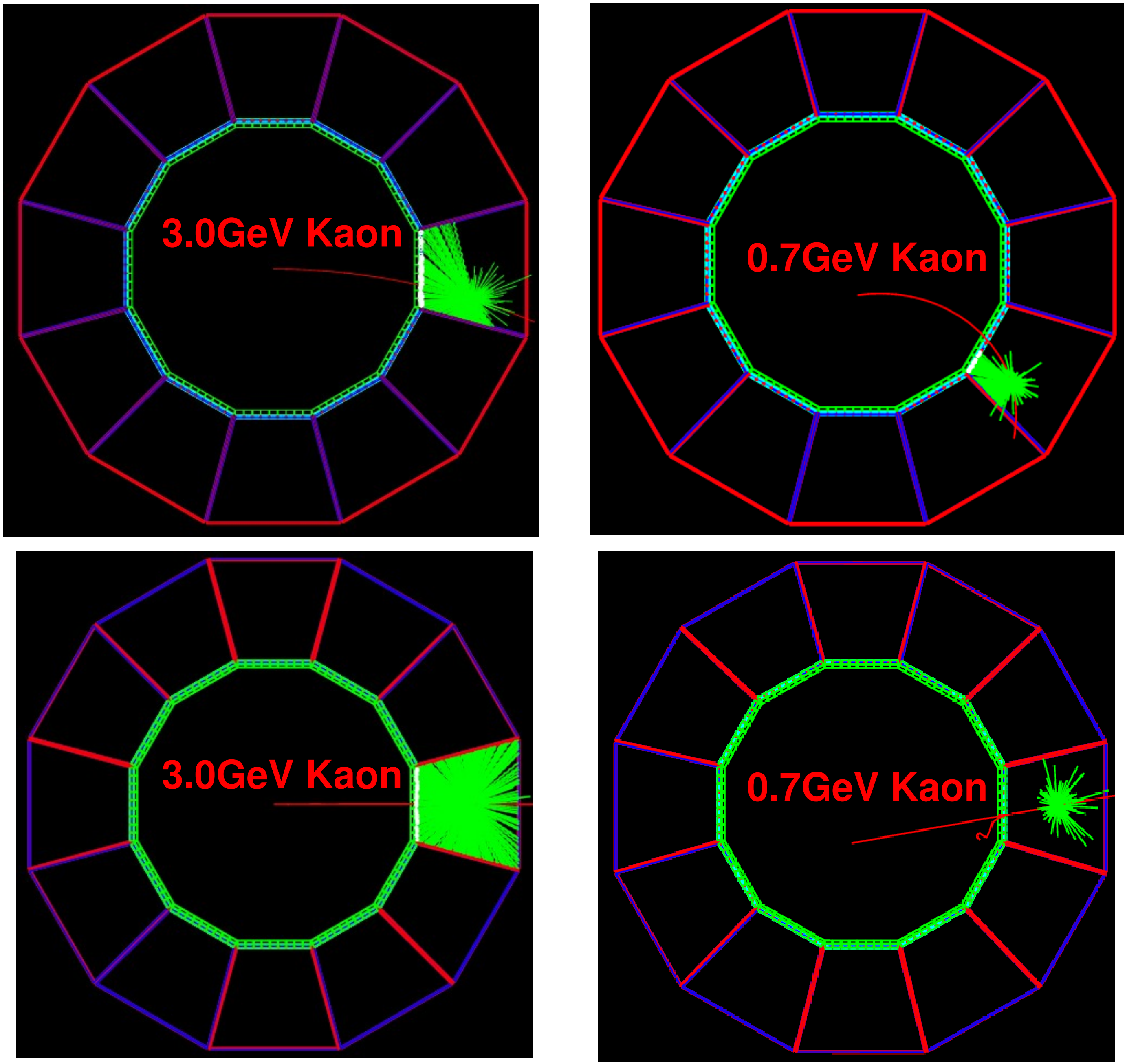
Dimension of each channel is
2.2cm x 0.55cm x 0.12cm

Sensitive surface correspond to the readout channel



In total 9x4 = 36 channels

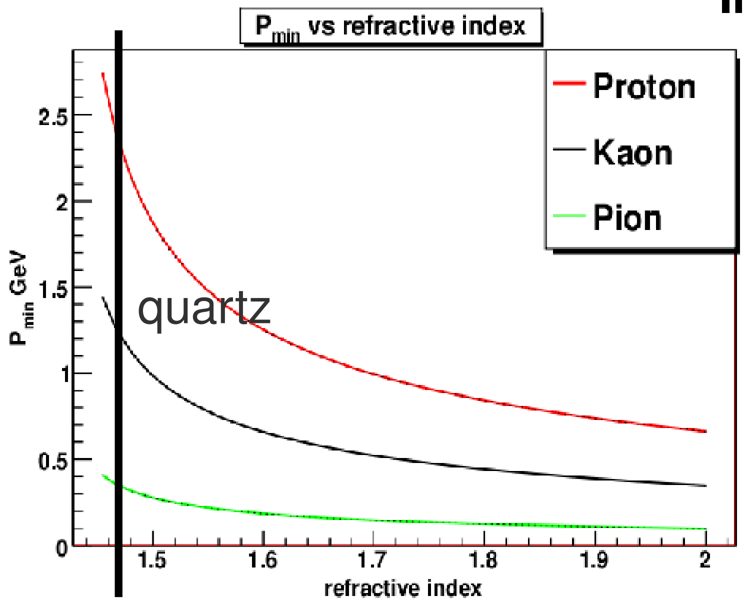
We put 12 sectors B field to Geant4 simulation



Magnetic field
1.5 Tesla

No field

How to get more photons



Increase of the refractive index

P_{min}[GeV]=m[GeV]/sqrt(n^2-2)

We didn't consider this possibility further
- manpower is limited

Should we discuss it ?

Optimization of the geometry

Three possibilities have been studied

→ **Remove part of absorbers**

→ **Effect coming from the magnetic field**

→ **Tilting the detector**

No tilting correspond to fTOF parallel to forward EMC

Remove part of absorbers

Most simple geometry have absorbers everywhere, for now this is base line geometry

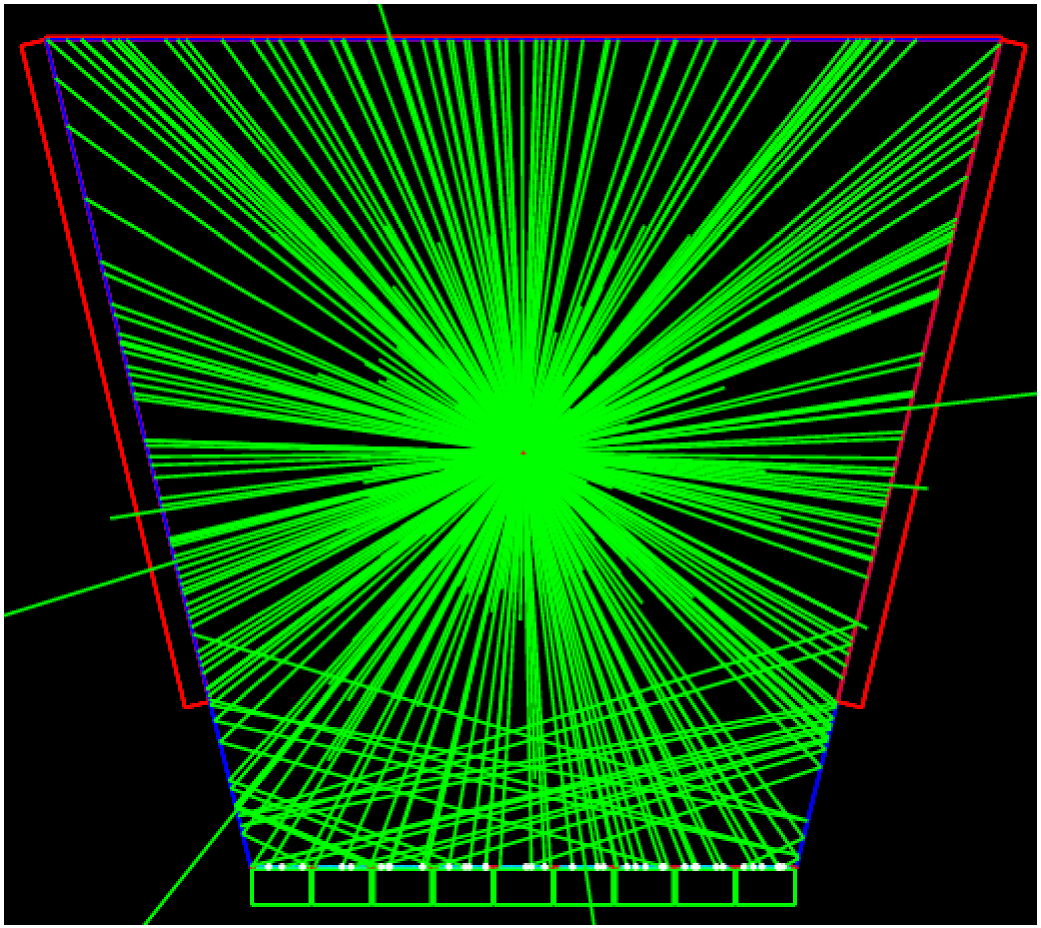
To increase number of incoming photons absorbers can partially removed.

A)

Lower part of the left and right absorbers removed

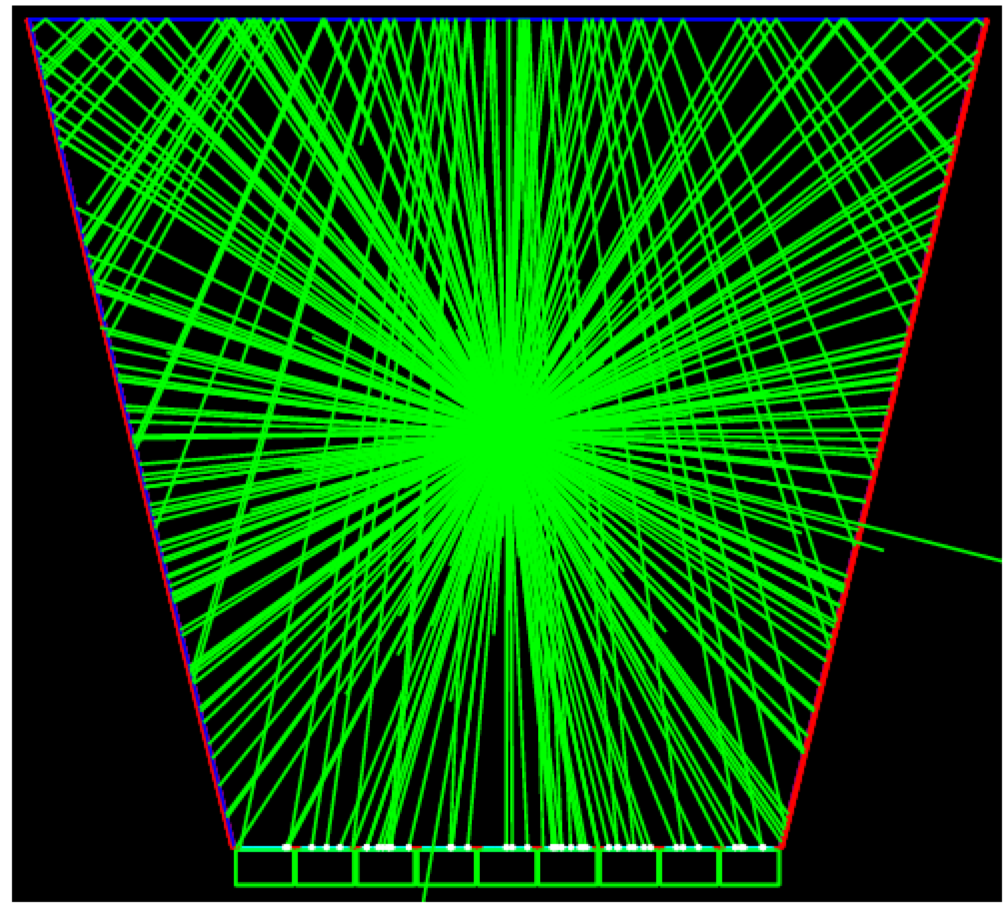
For example:

80% of the side surface covered with absorber



B)

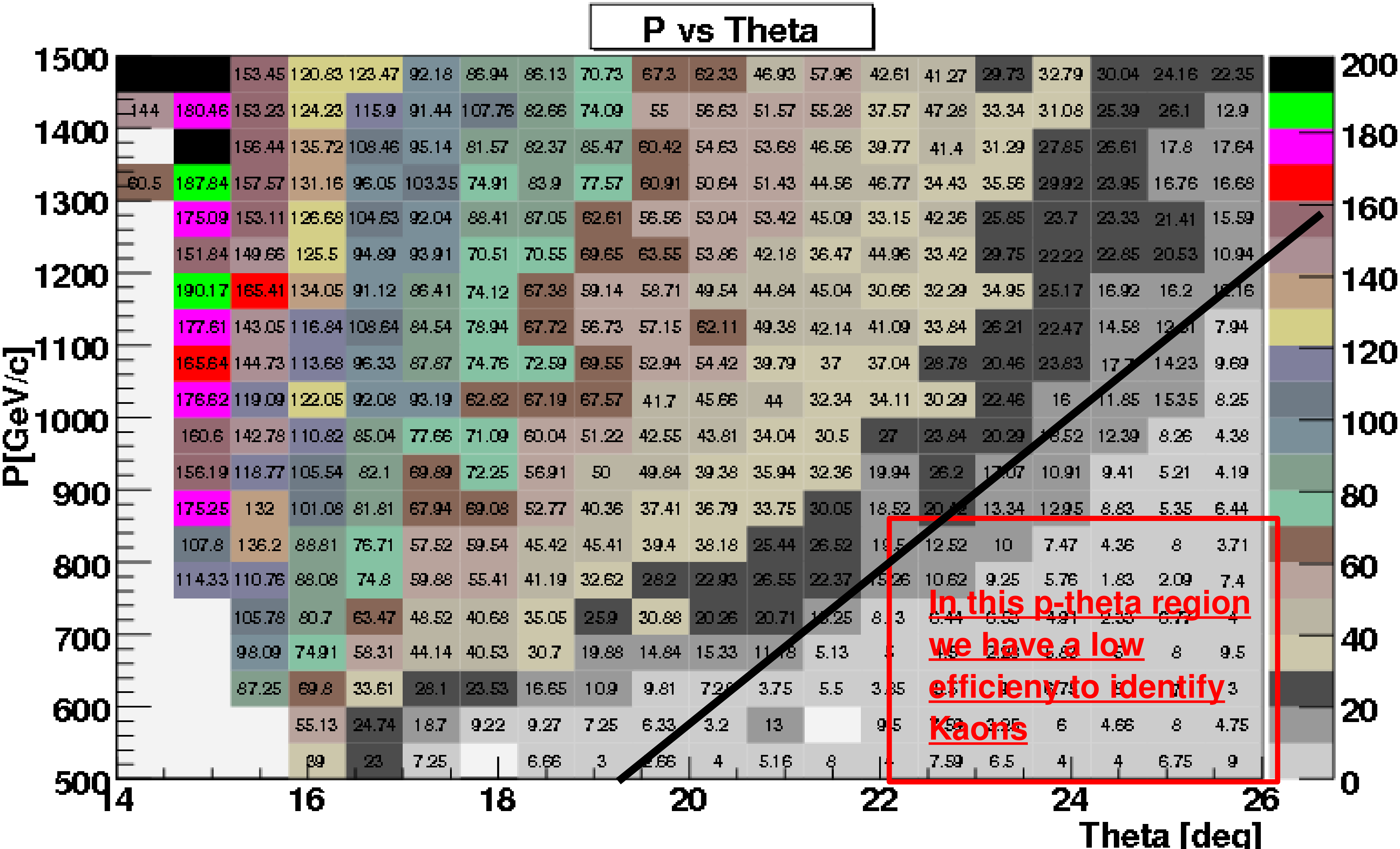
Top absorber removed



Reconstruction becomes more complicated , time window for measurements will increase so background will increase too

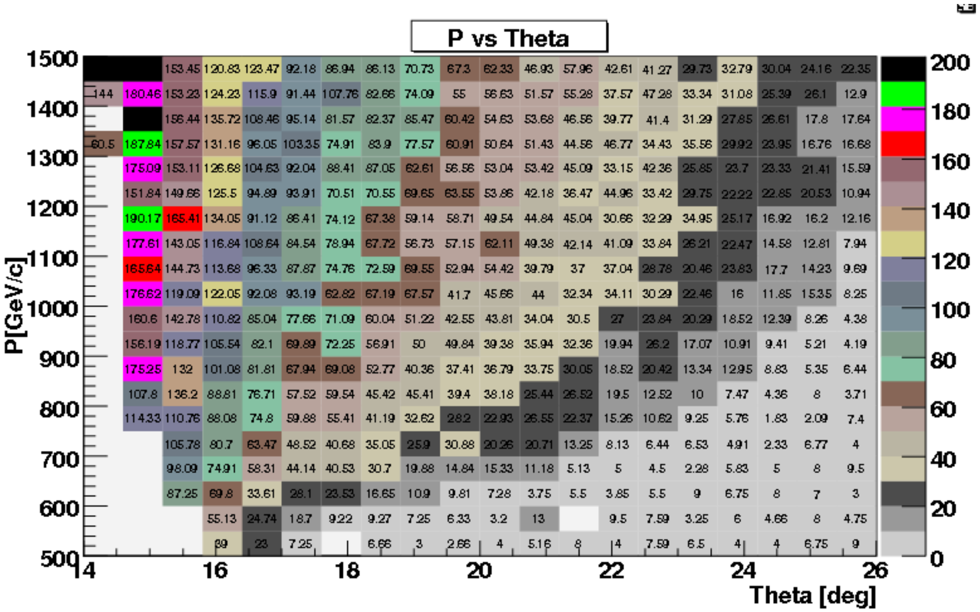
P vs theta for all possible phi

20 incoming photons will yield ~ 3 photons (due to QE).

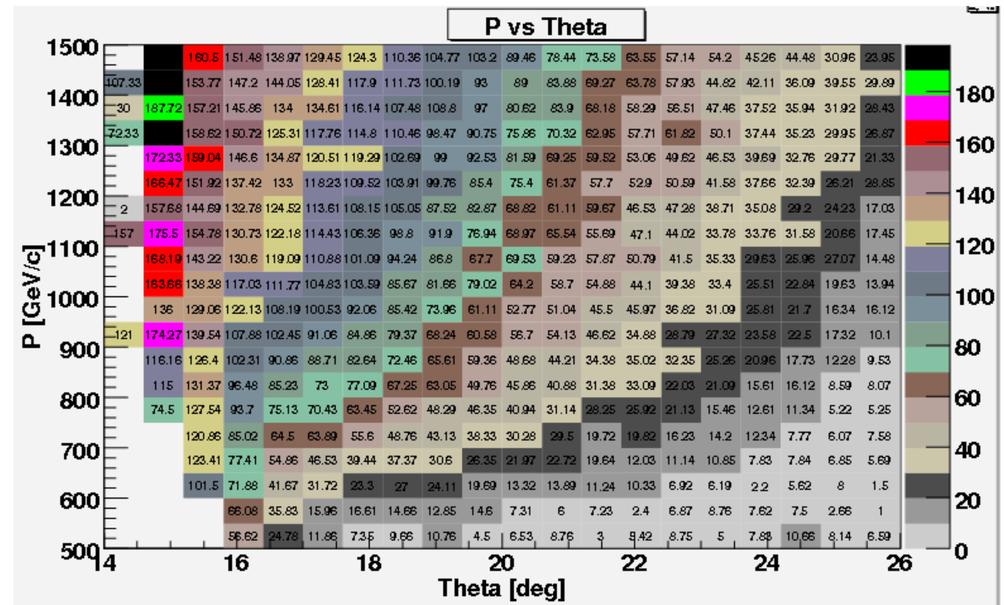


Color correspond to average number of the photons in the PMT's

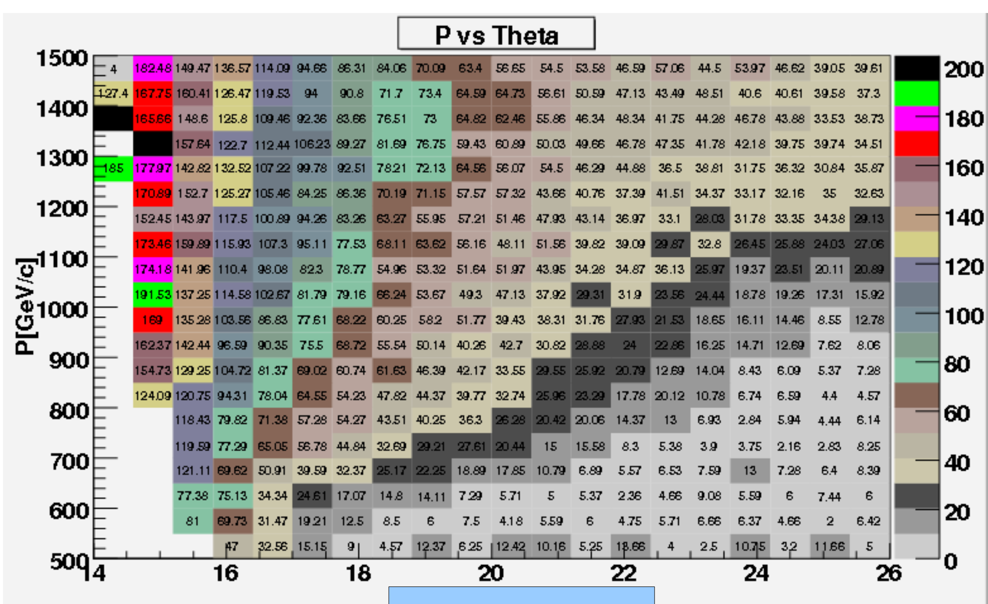
P vs theta for all possible phi



Baseline

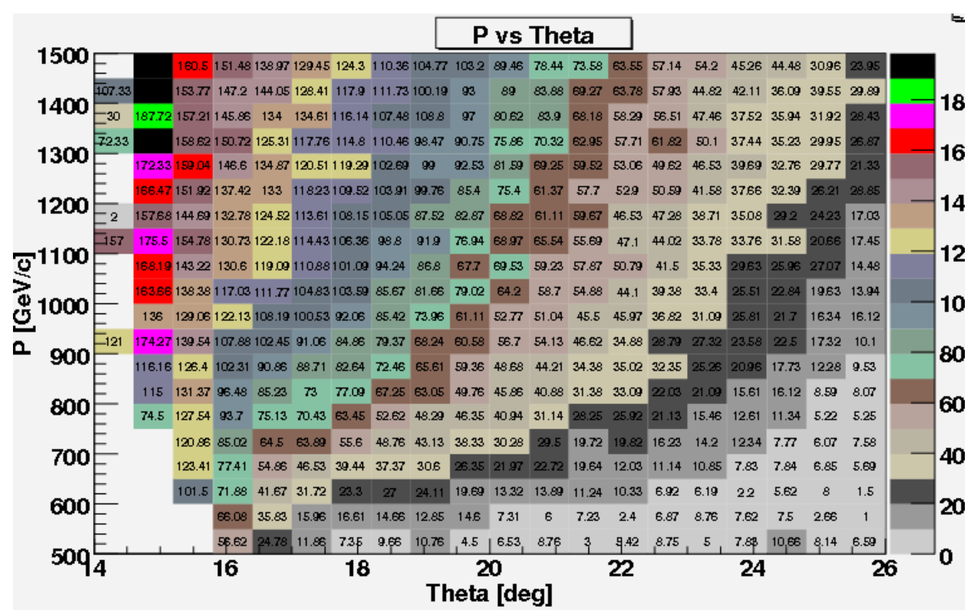


60% of the left and right absorber



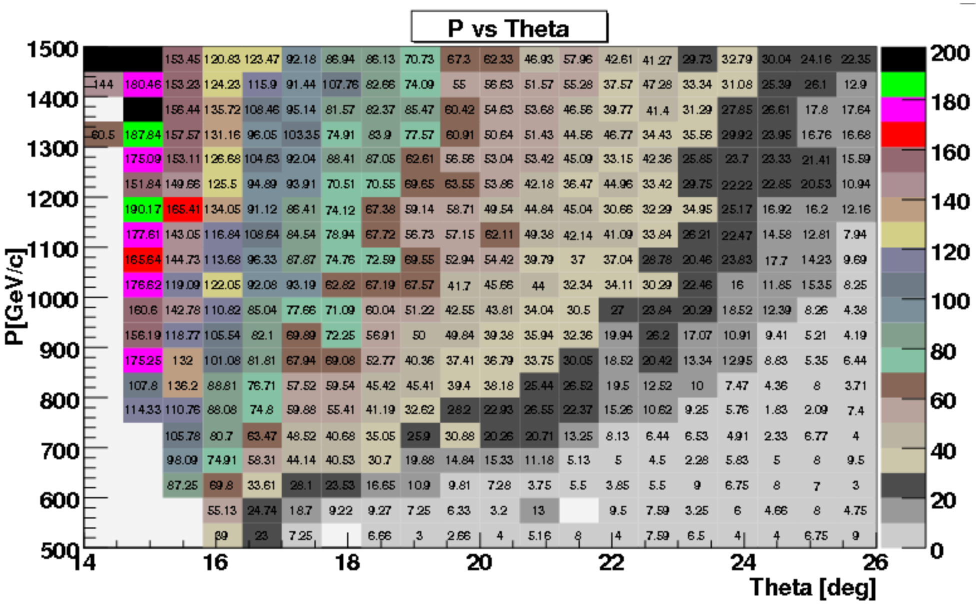
No top absorber

Theta[deg]

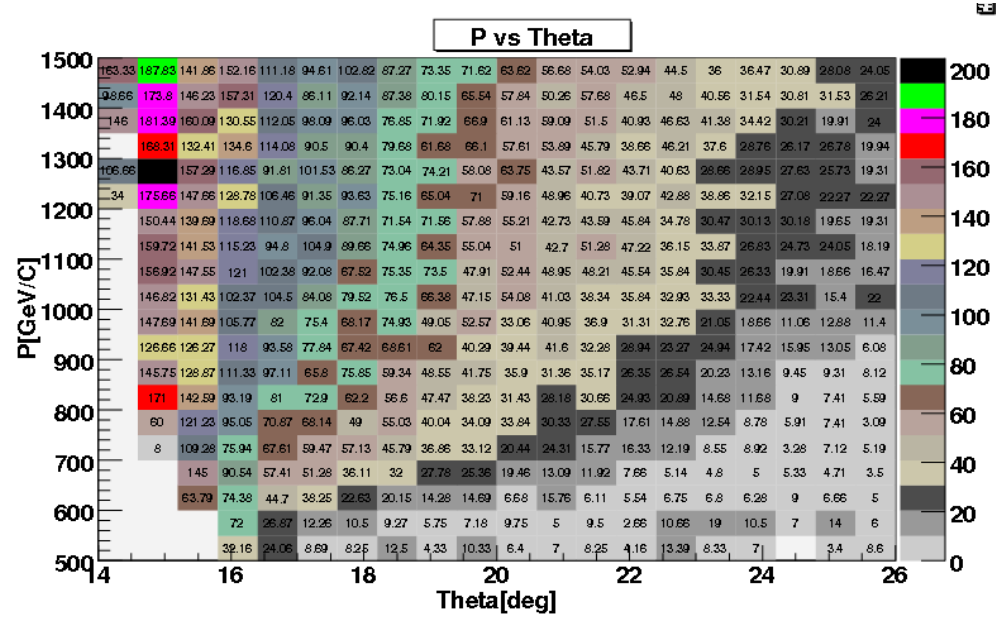


70% of the left and right absorber

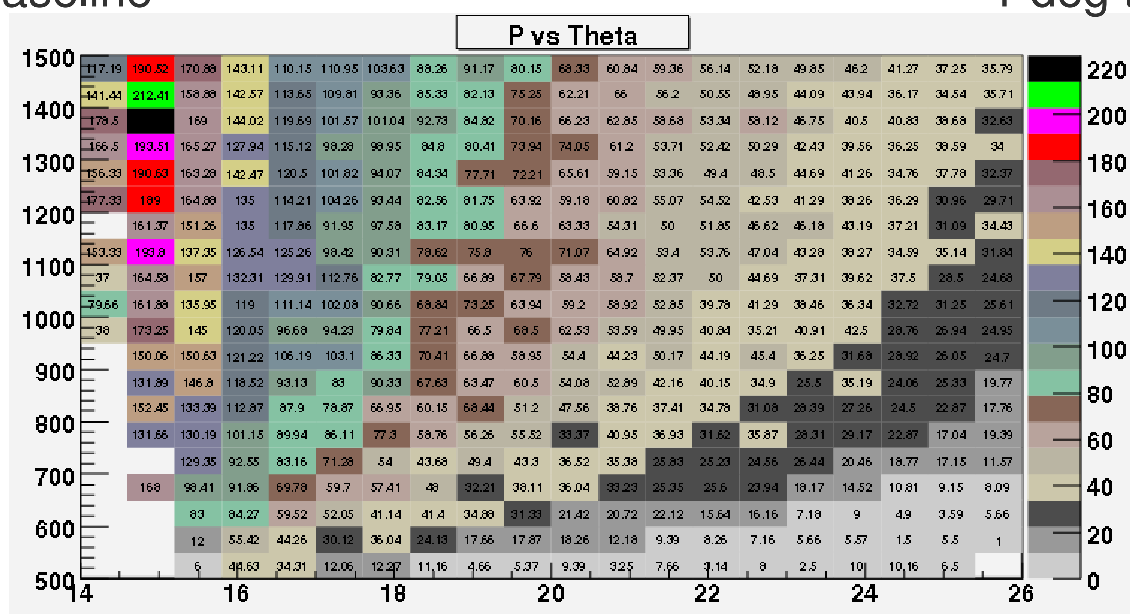
P vs theta for all possible phi (theta tilting of the detector)



Baseline

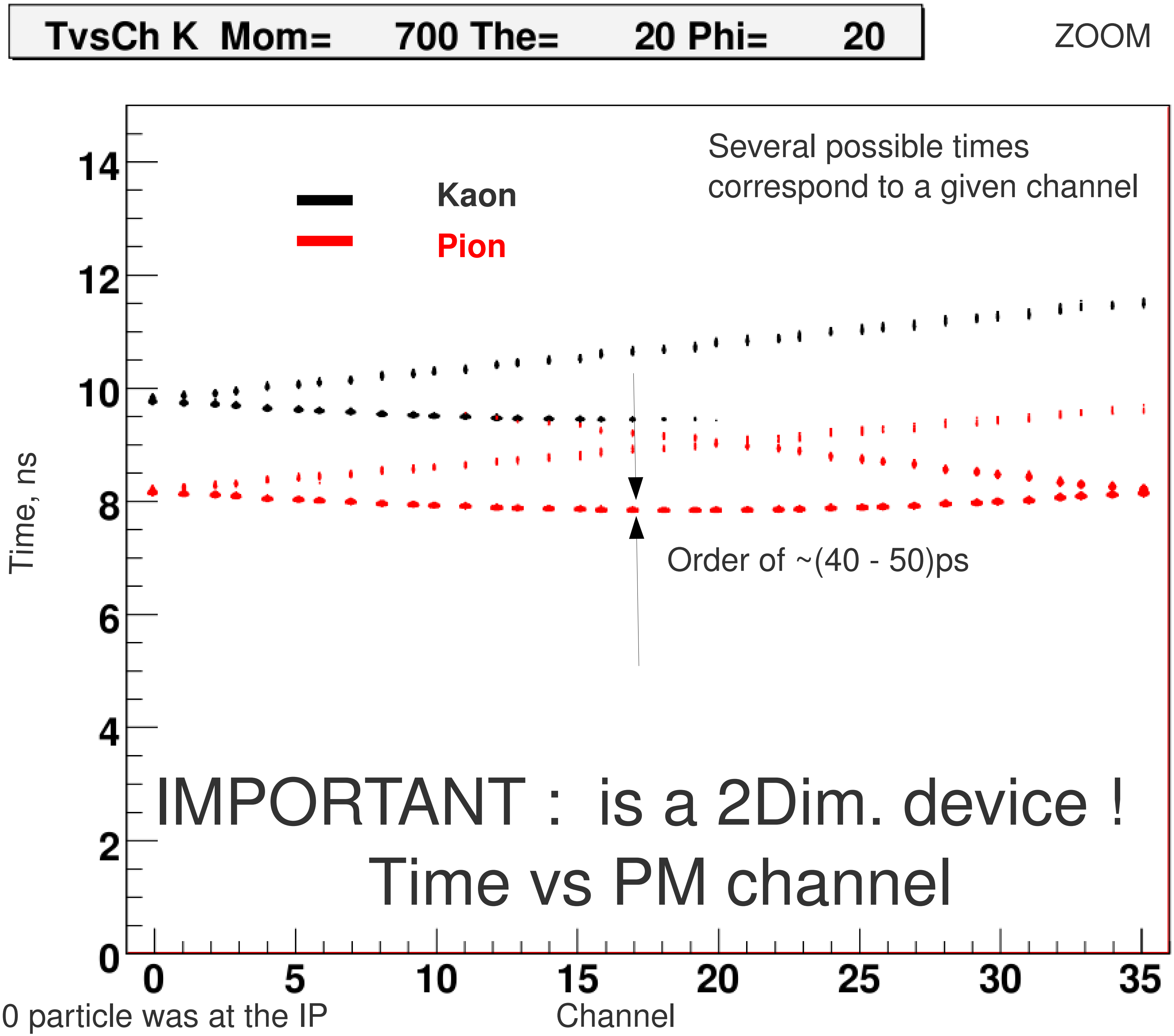


1 deg tilting



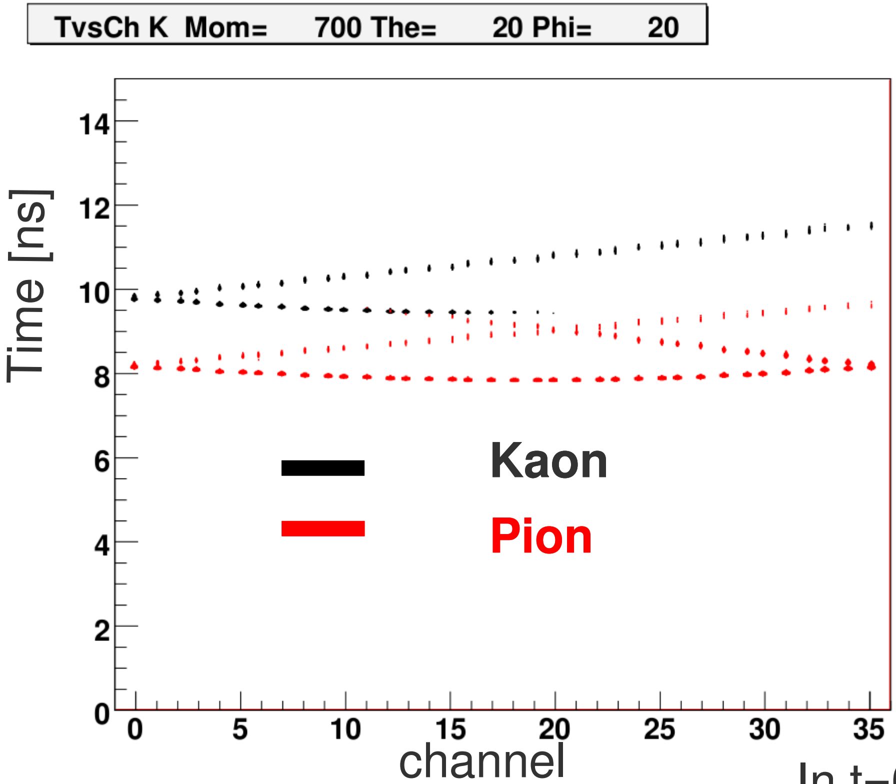
4-5 deg tilting (need 4 -5 cm additional space in z direction)

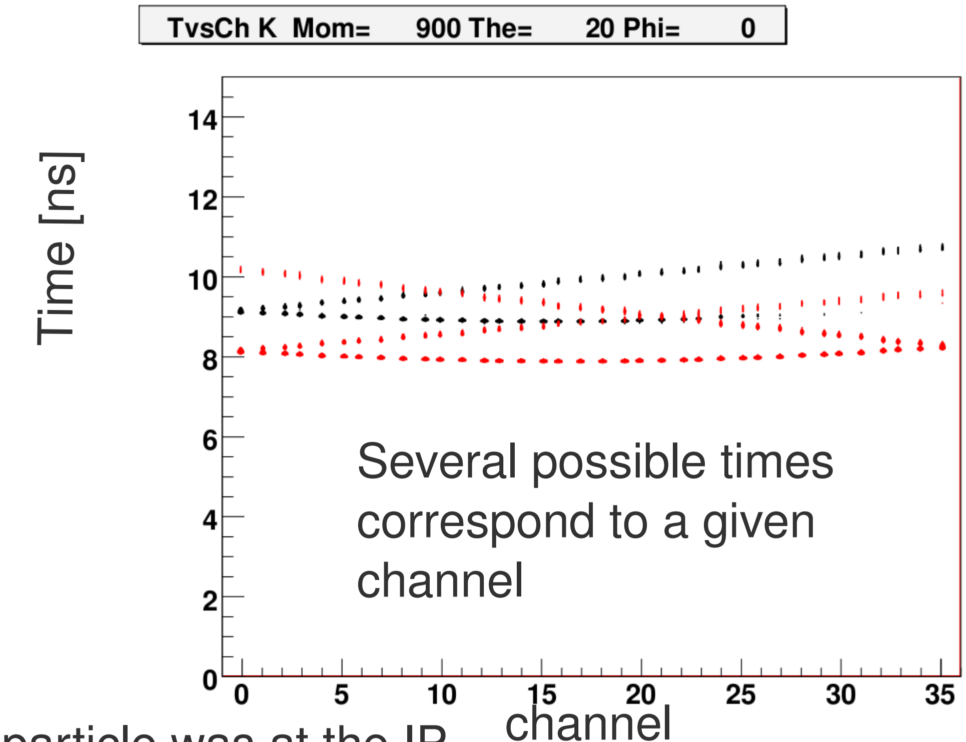
Geometrical coverage (i.e. efficiency in p vs theta space) with tilted detector is as good as the one obtained with complicated geometry



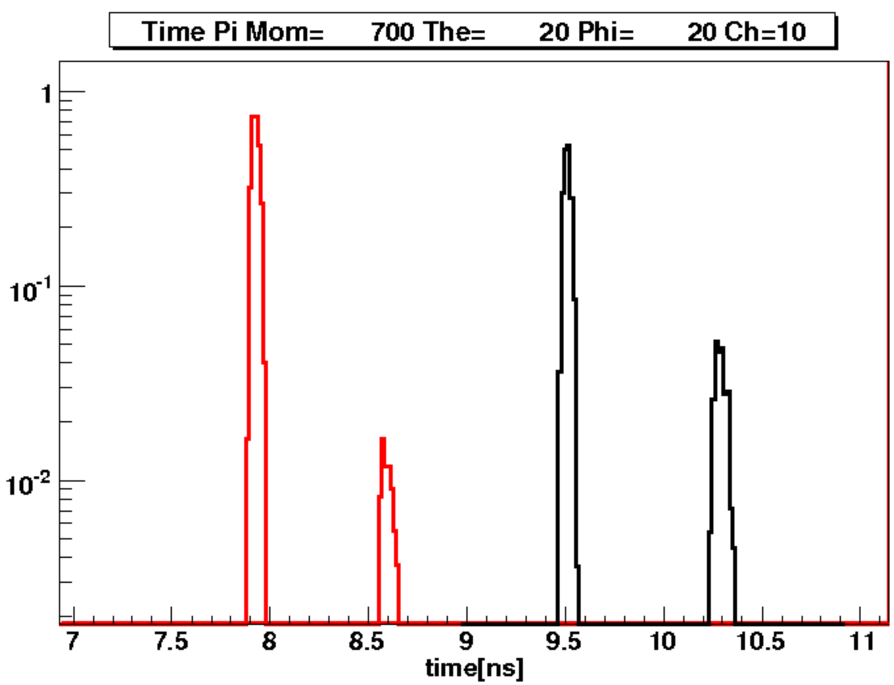
In t=0 particle was at the IP

Time vs channel in case of 60% coverage with left and right absorber

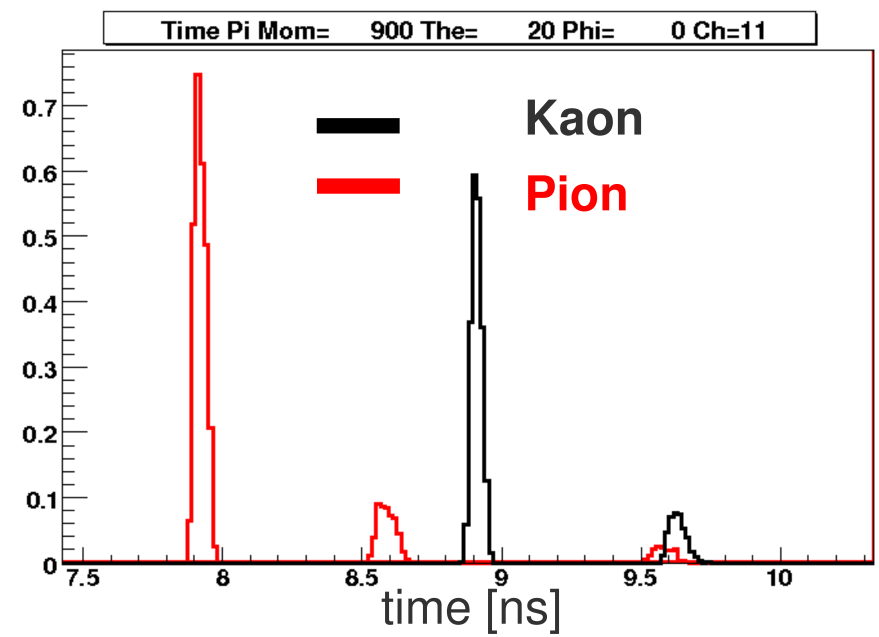




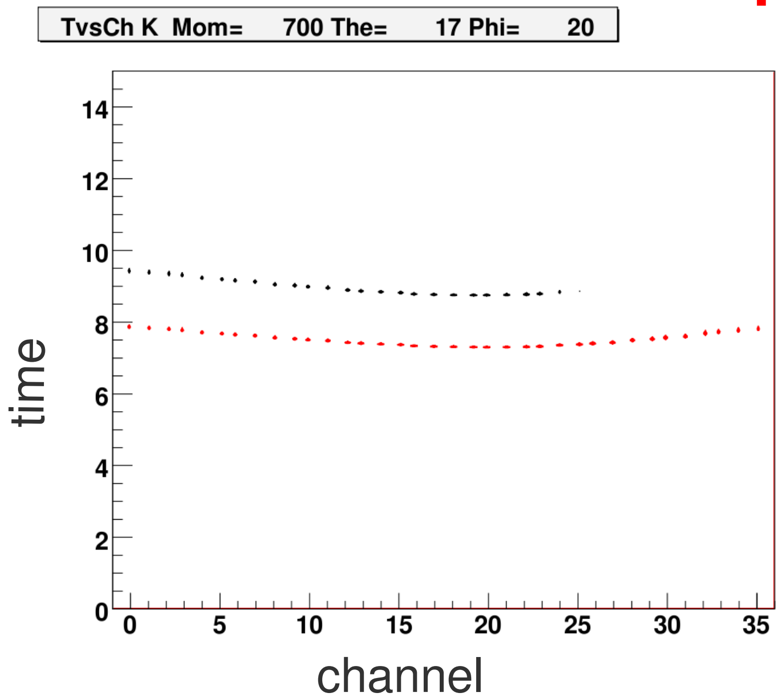
In t=0 particle was at the IP

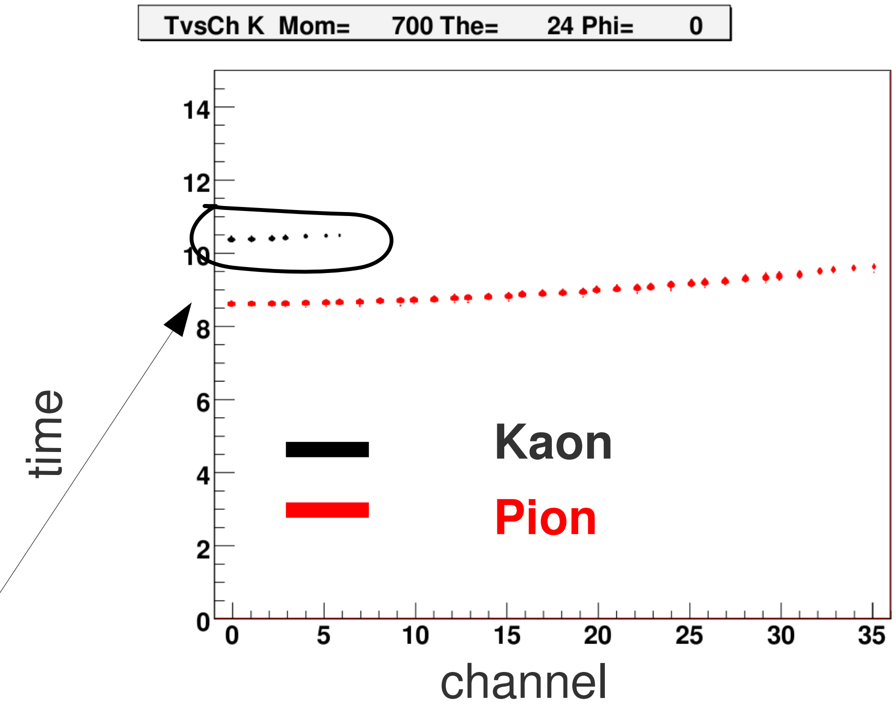


Time for given channel

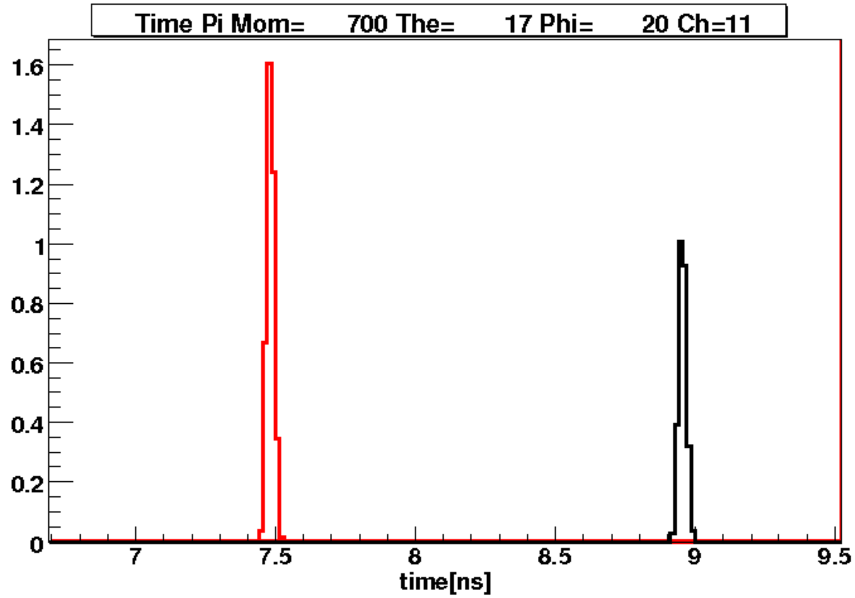


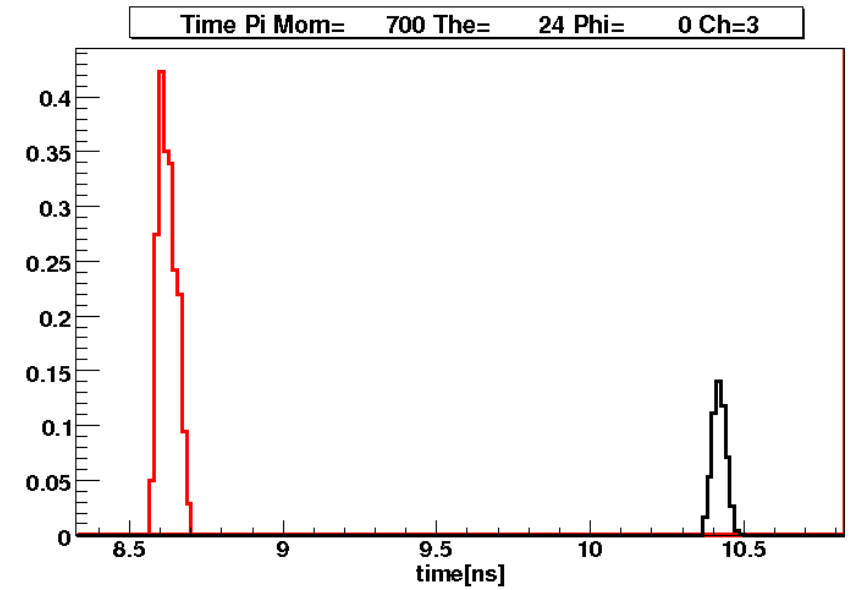
Simple geometry (with tilting)





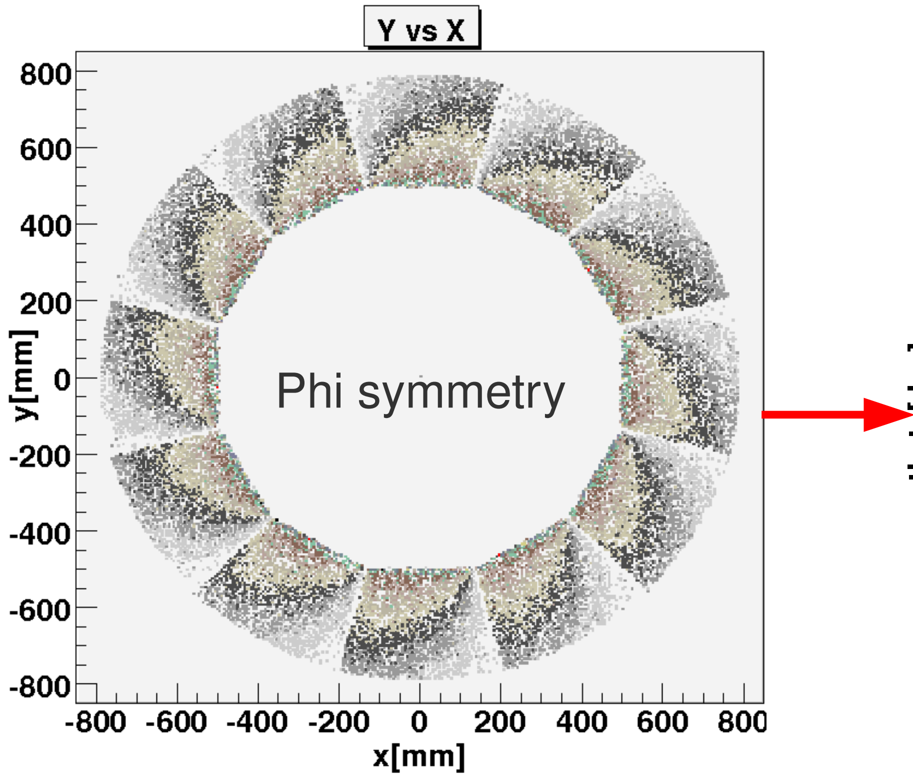
Number of channels which give a signal can be used as well for K/π separation



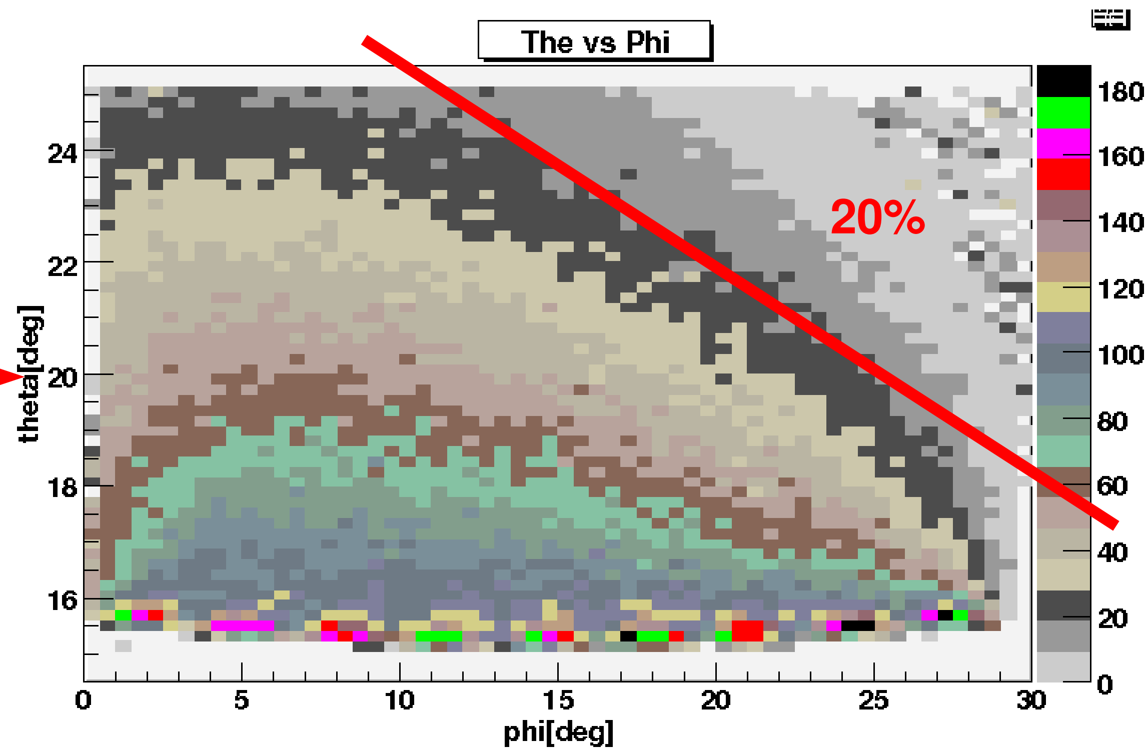


How much kaons with low momentum will give enough light ?

For this test we generate kaons with constant momentum but with uniformly distributed theta and phi, and then build two dimensional histograms theta vs phi, color correspond to average number of photons collected by PMT's

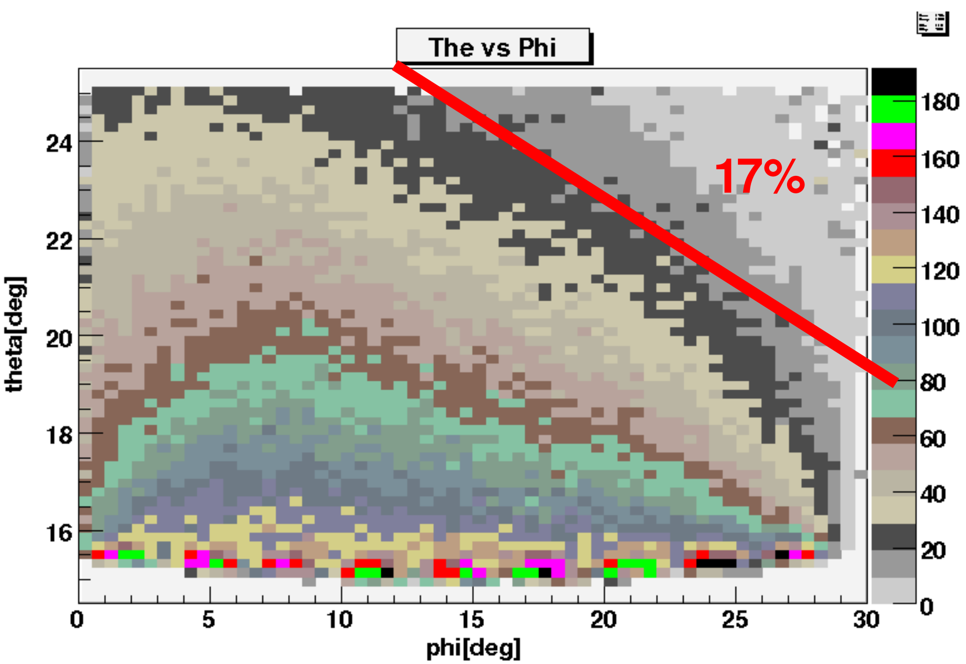


Kaon @ 0.7 GeV

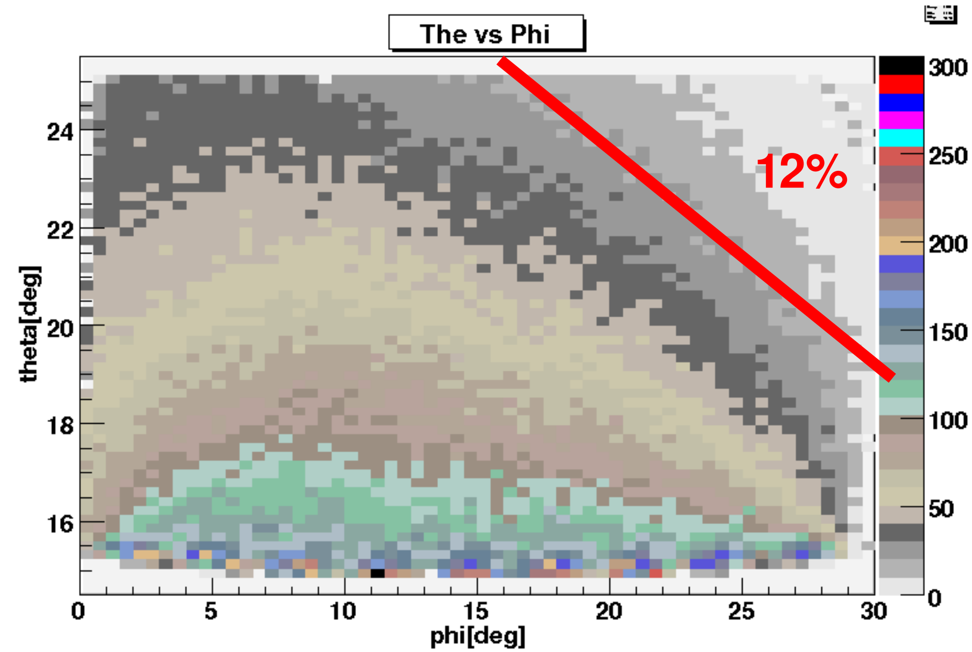


Kaon @ 0.7 GeV

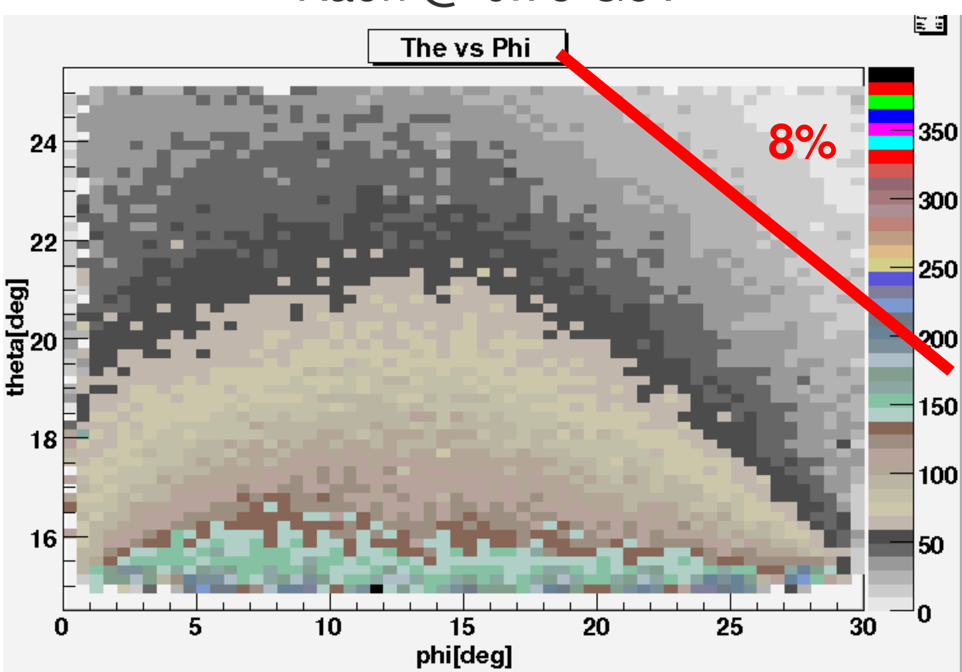
Warning colour code is changing from one plot to the other



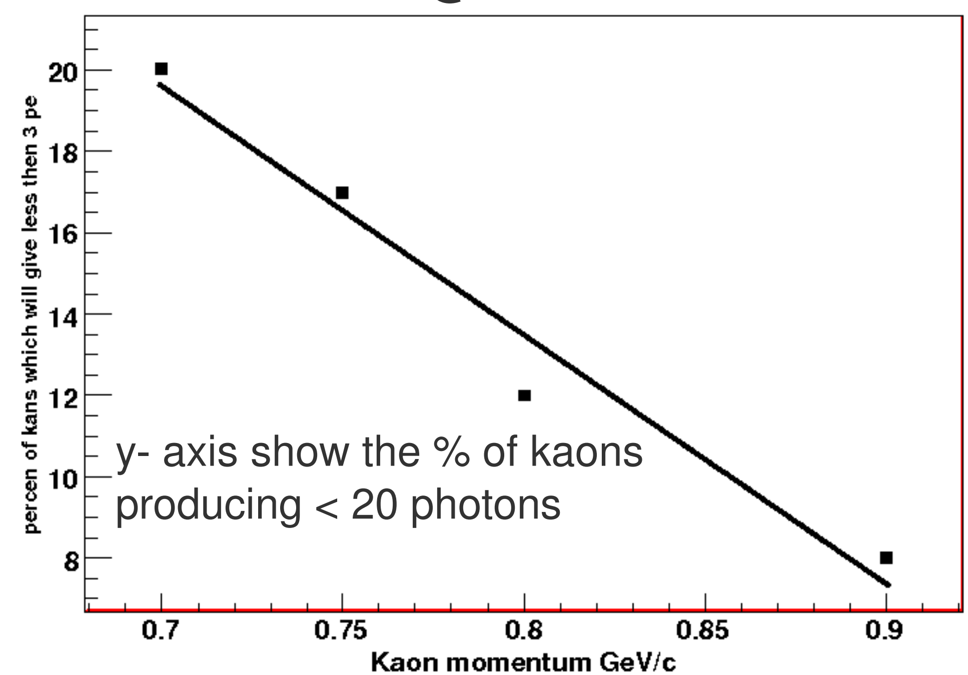
Kaon @ 0.75 GeV



Kaon @ 0.8 GeV

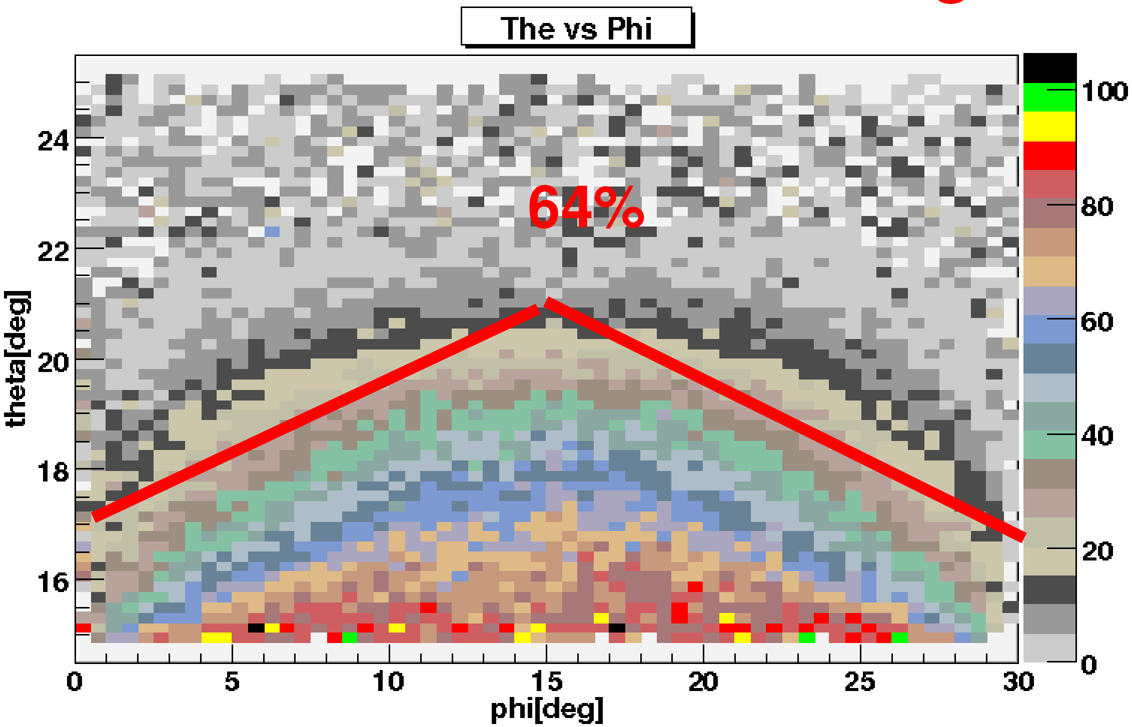


Kaon @ 0.9 GeV



Goes down linearly with momentum

Effect coming from the magnetic field

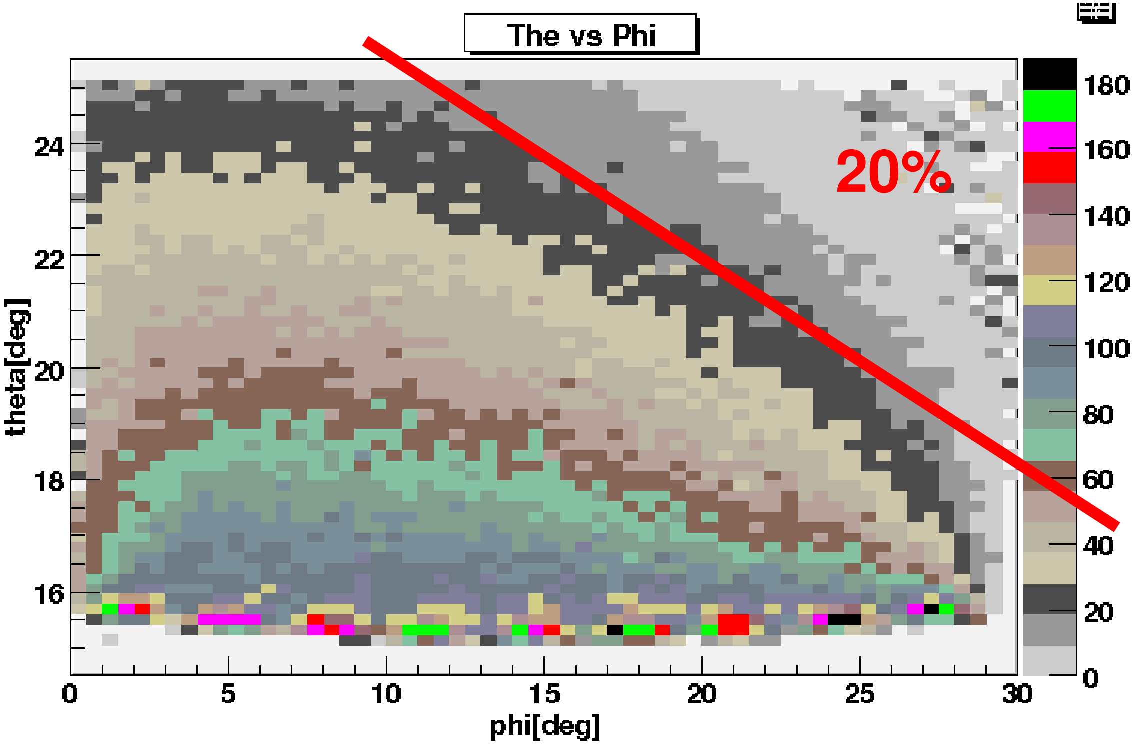


Kaon @ 0.7 GeV/c
With flat distributed theta and phi

Color correspond to average number of the photons

← No field

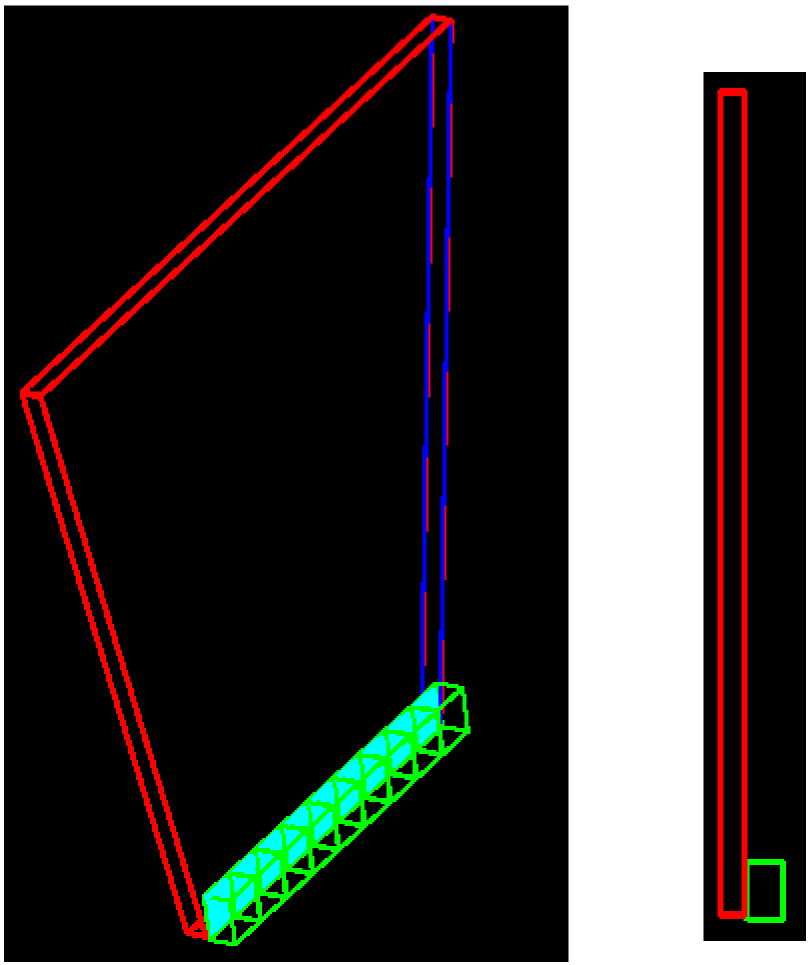
64% of tracks will yield small amount of photons



← With field

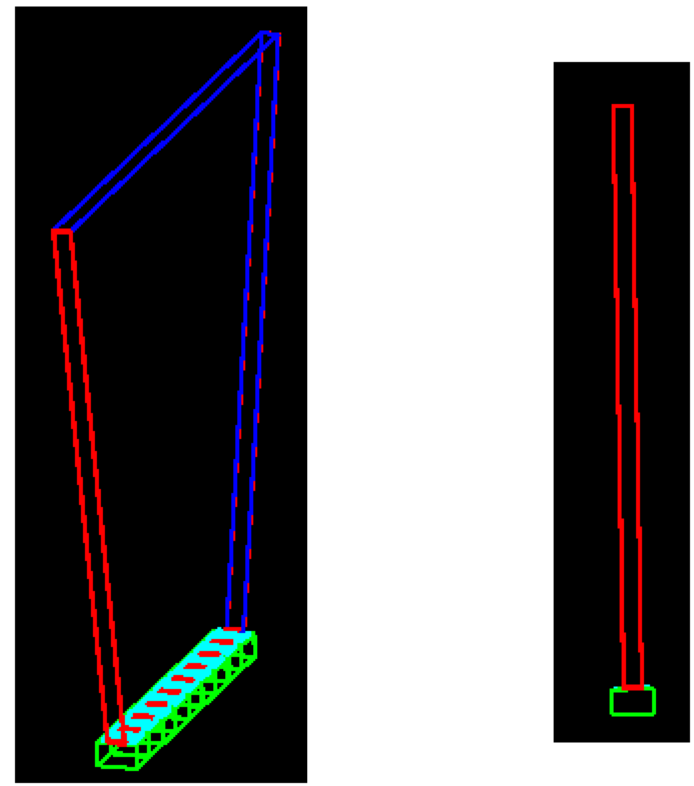
Where PMT's have to be placed

C)



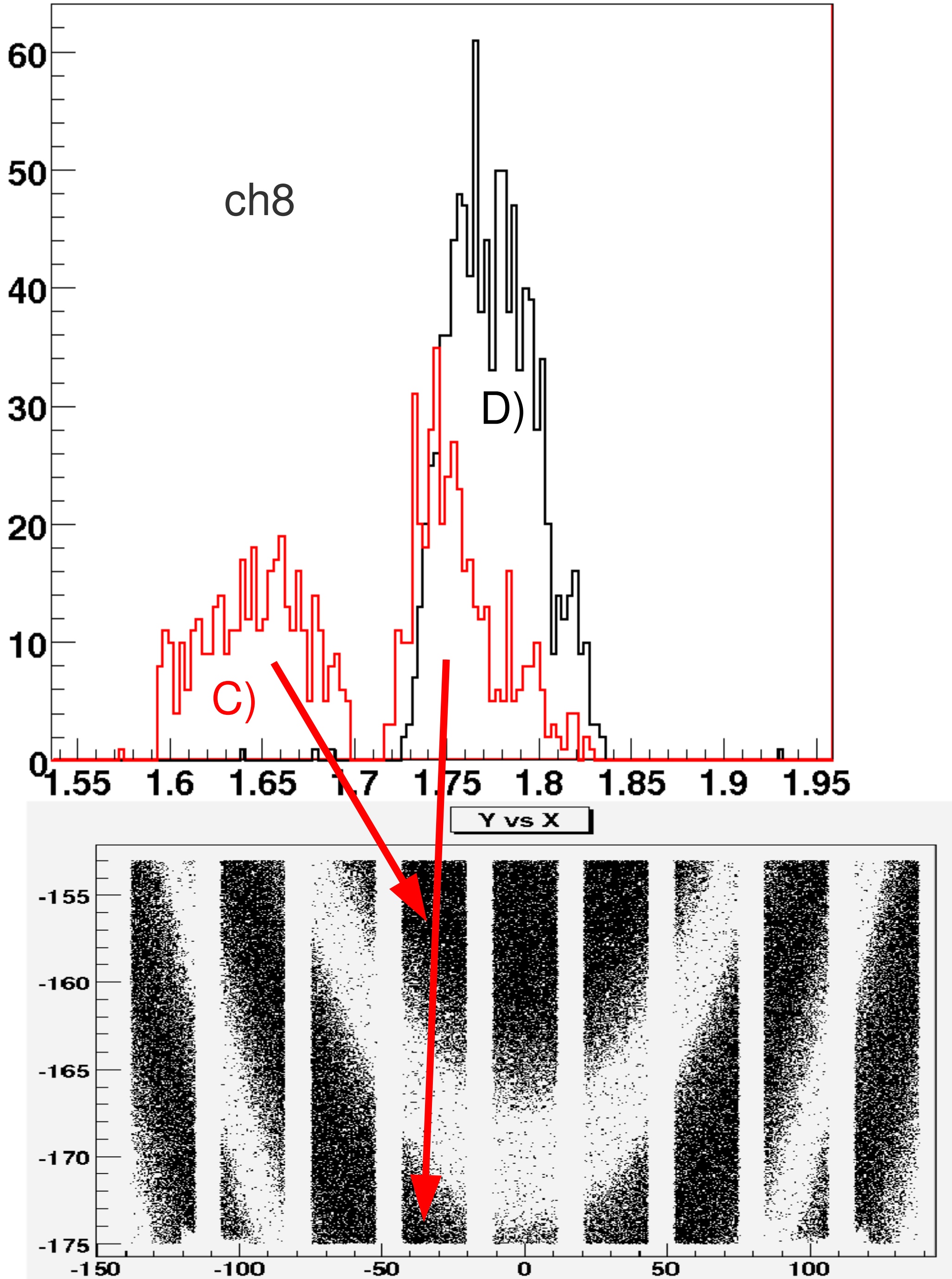
Time spread of the photon arriving is bigger for geometry C and number of the collected photons is smaller (see next slide). **Good angle** to the magnetic field

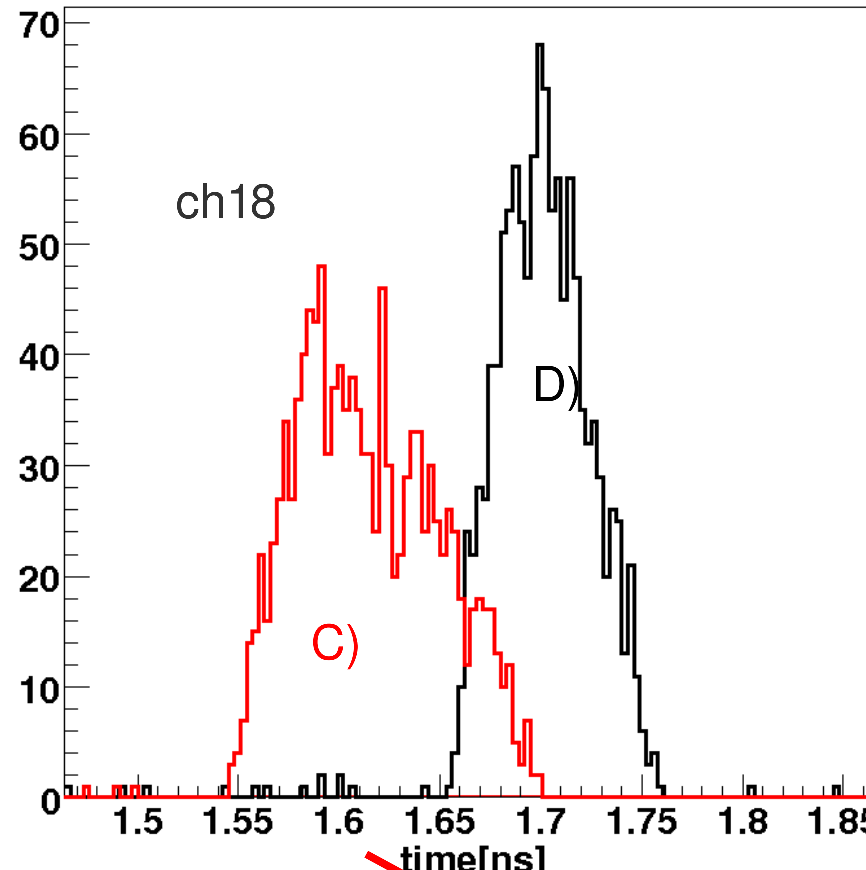
D)

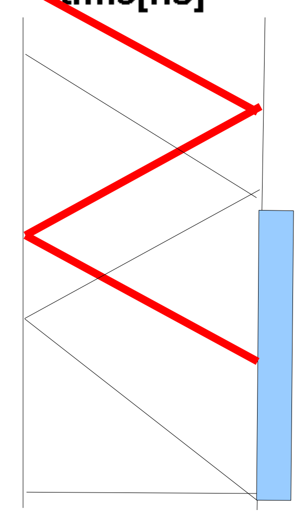


Bad angle to the magnetic field. We need to work at high gaining. But gain is dropped down with decreasing angle between magnetic and MCP- PMT

Influence on single channel time resolution of the PMT position





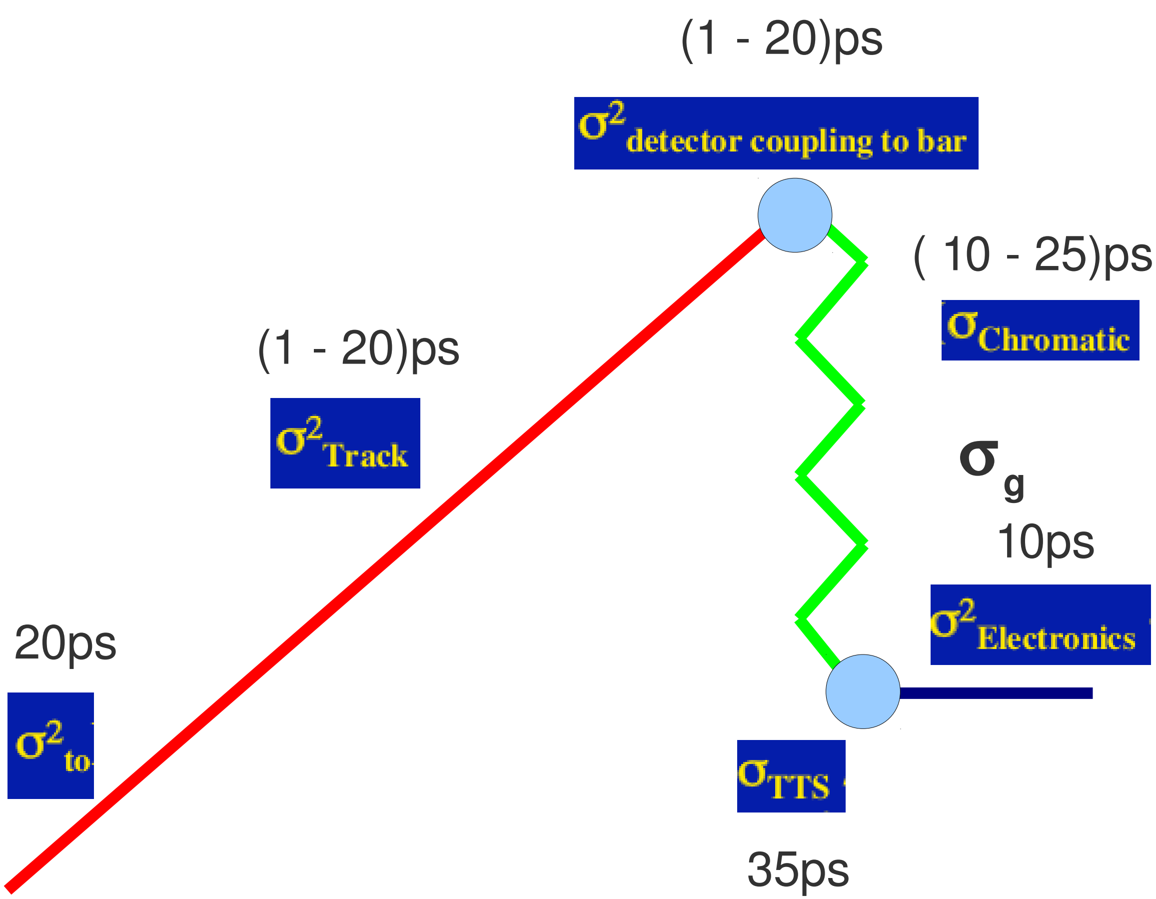


Studying σ^2_{Track} and $\sigma^2_{detector\ coupling\ to\ bar}$ with FastSim

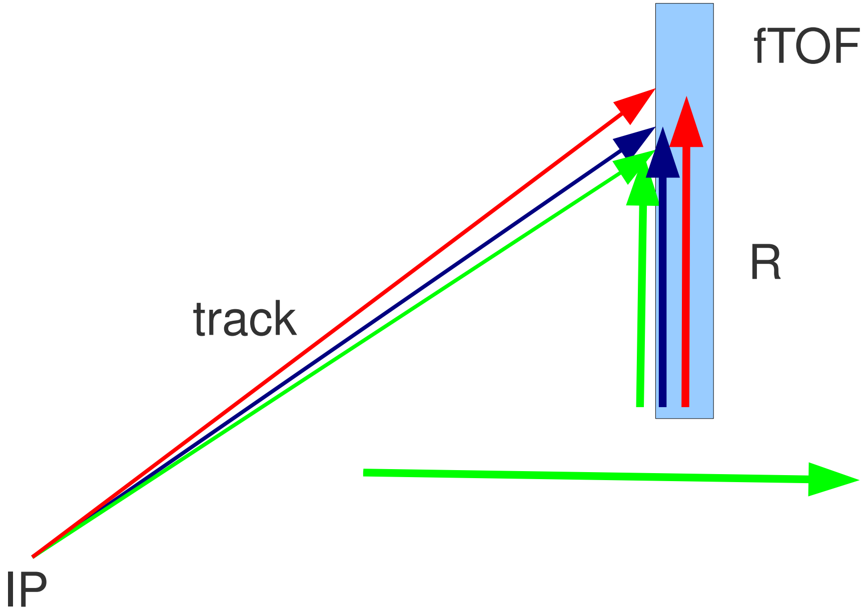
Reminder

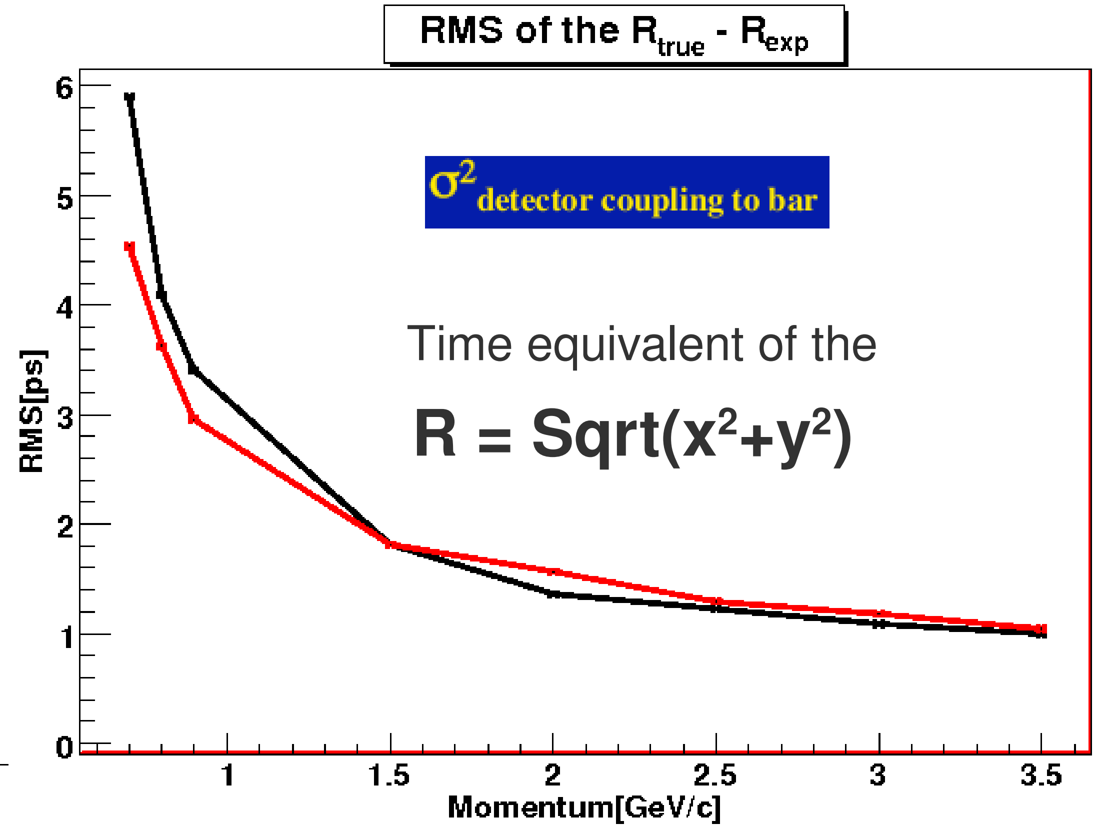
$$\sigma_{Total} \sim \sqrt{[\sigma^2_{Electronics} + (\sigma_{Chromatic} / \sqrt{(\varepsilon_{Geometrical\_loss} * N_{pe})})^2 + (\sigma_{TTS} / \sqrt{N_{pe}})^2 + \sigma^2_{Track} + \sigma^2_{detector\ coupling\ to\ bar} + \sigma^2_{to}]}$$

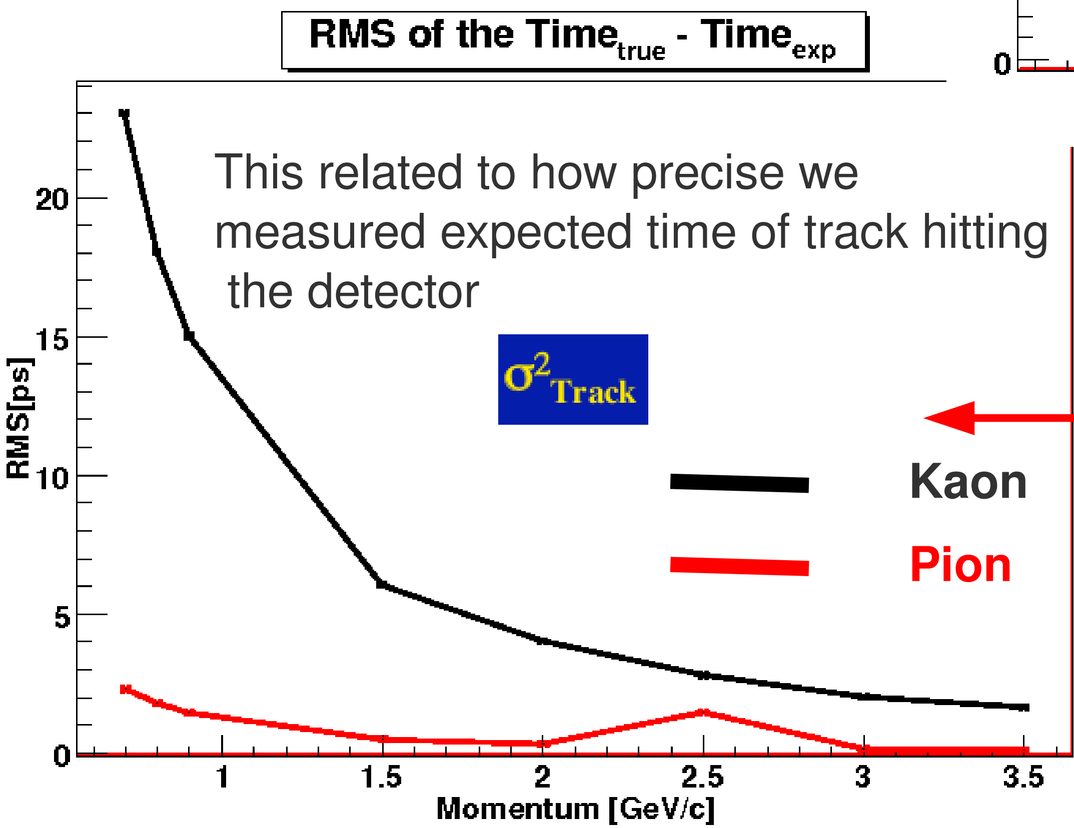
J. Va'vra, Forward TOF update



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





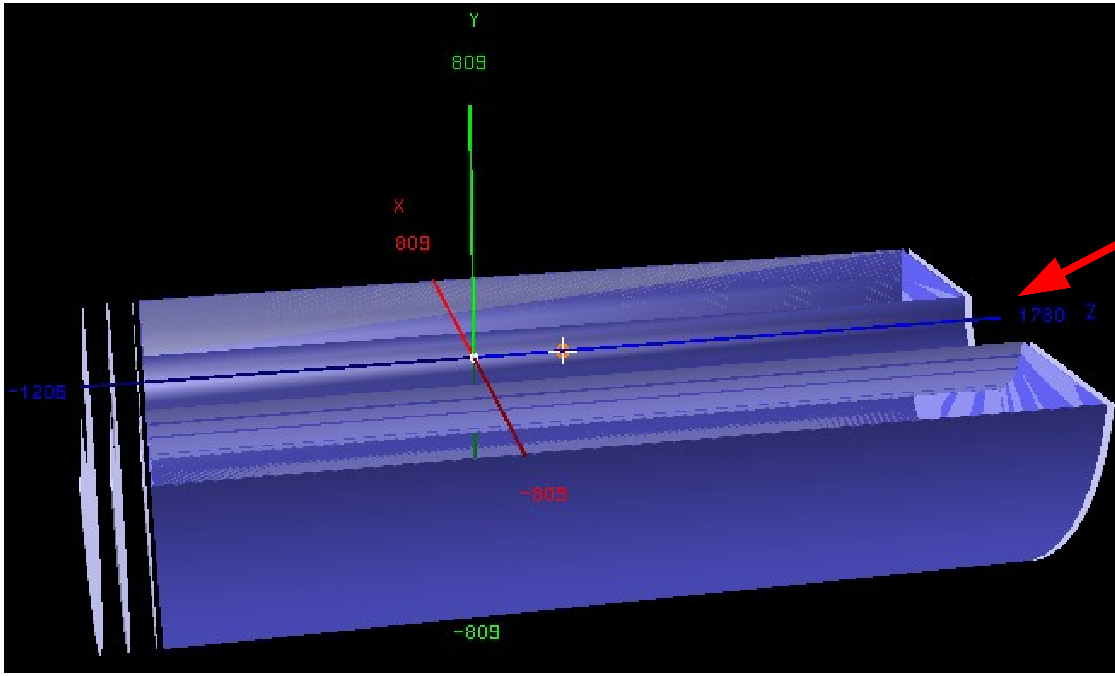


Not yet taken into account

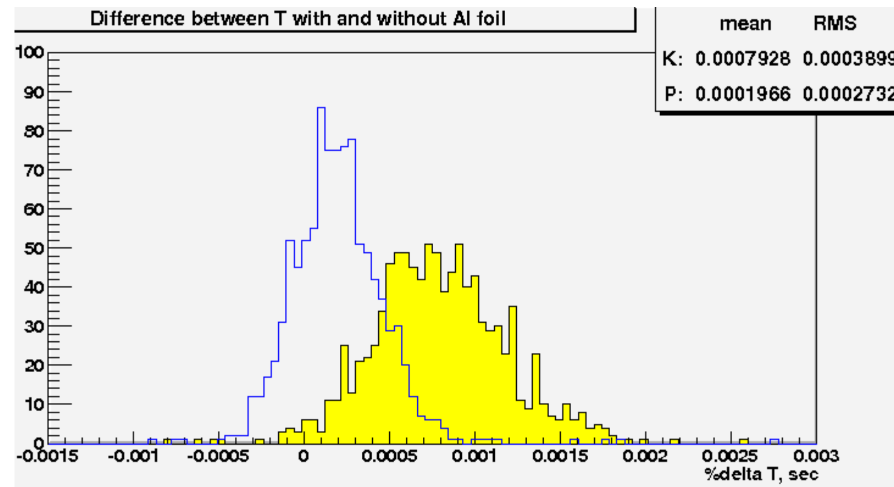
This effect can be reduced by using more precise algorithm for expected time reconstruction

Current algorithm does not take into account the fact that momentum change with time.
We take reco momentum at fTOF

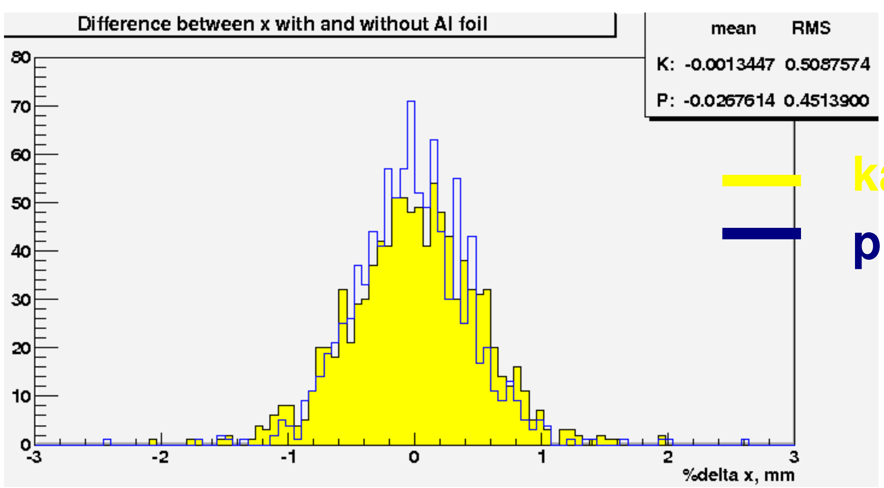
Influence of 2mm aluminum foil in front of fTOF detector on time spread



There is 2 mm Al foil in front of the fTOF detector

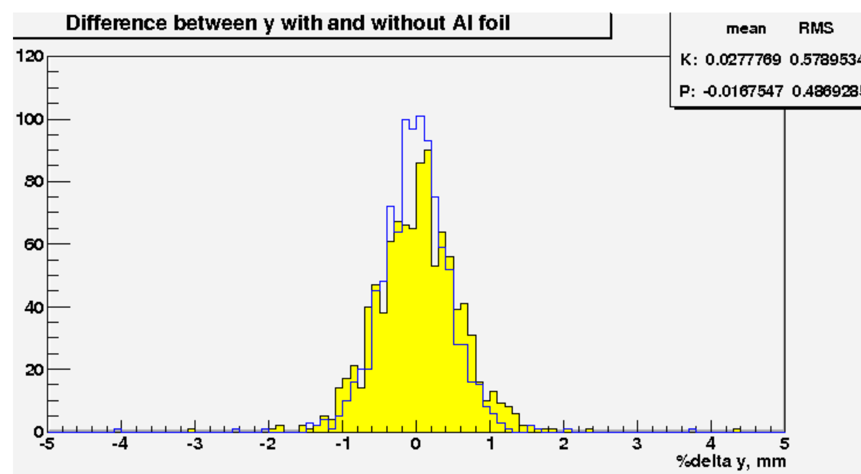


Not yet taken into account



kaon

pion



Very small effect

Conclusion

TOF is a 2dimensional detector time vs PM channel

Different geometries have been studied

→ The one with absorber everywhere and PMT's on the bottom side has been "chosen"

→ With new geometry and theta tilted detector we can push the threshold of kaon identification down to 0.7 GeV

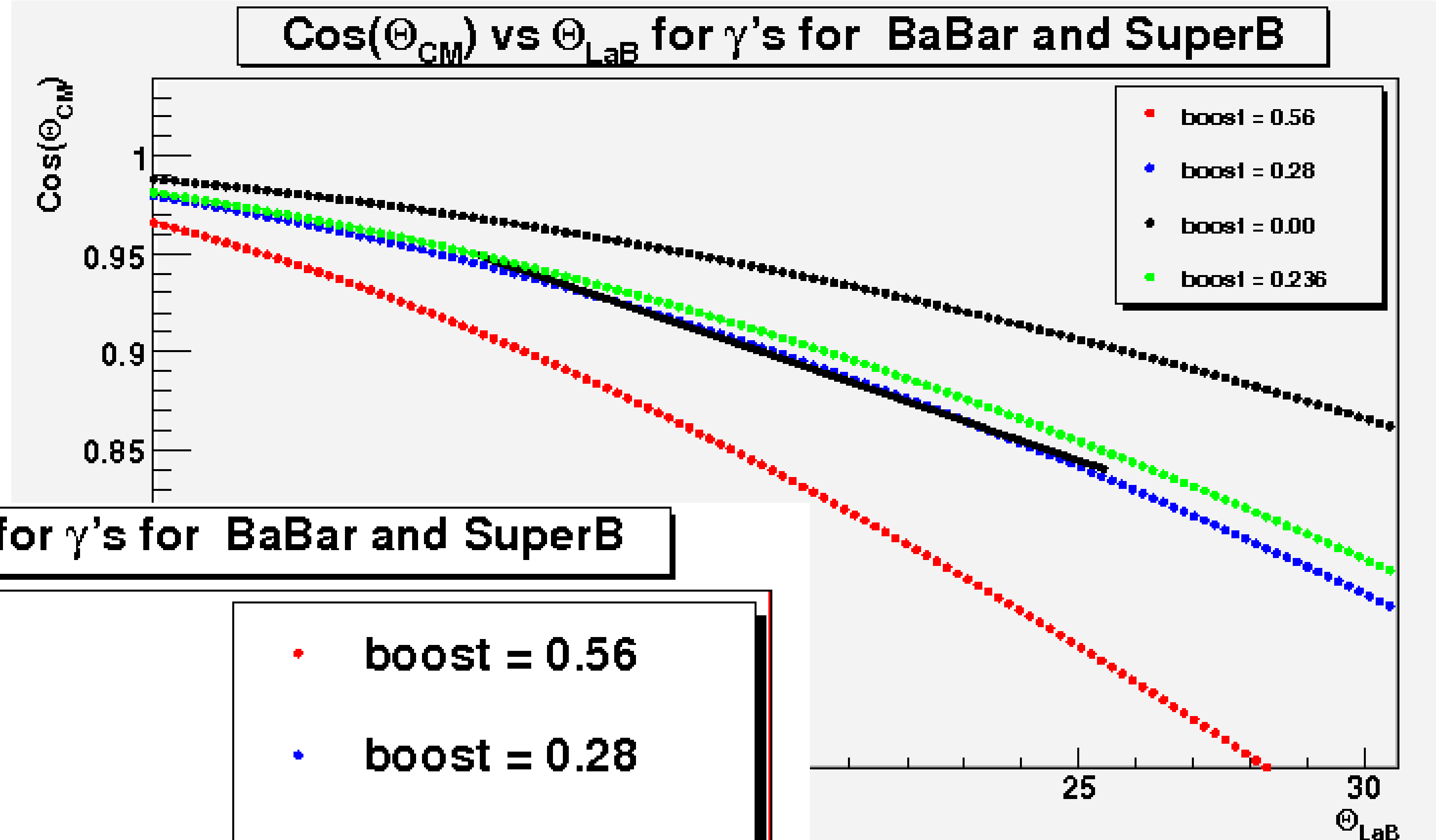
→ σ_{track} and $\sigma_{detector\ coupling\ to\ bar}$ have been studied with FastSim.

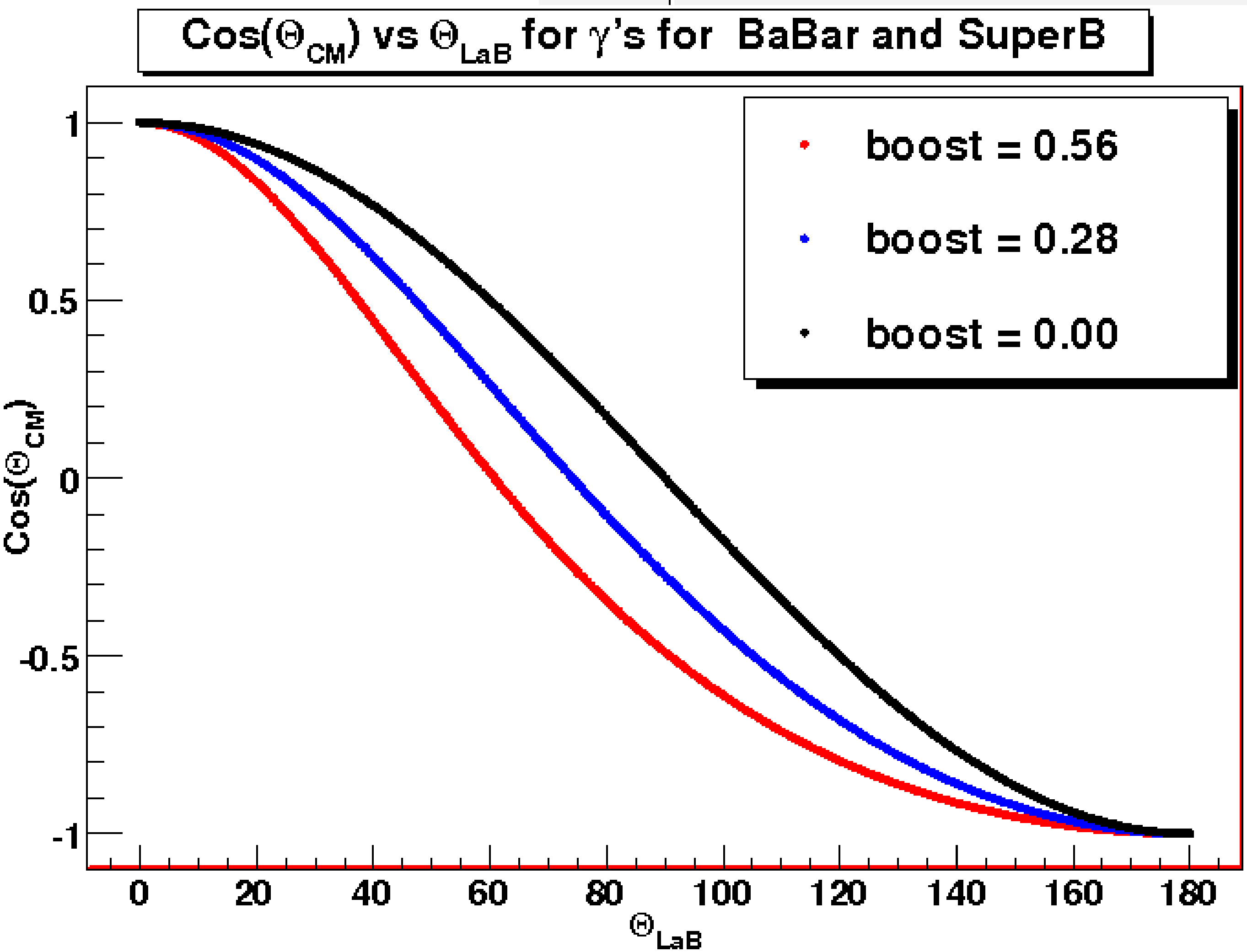
→ 2mm Al foil in front of the fTOF detector will not contribute much to the time resolution

→ Background simulation have to be studied

→ More accurate simulation of the electronics have to be done

backup





In small theta_lab frame Cos(Theta_mc) is flat distributed