

TOF for the MINERvA TestBeam Detector

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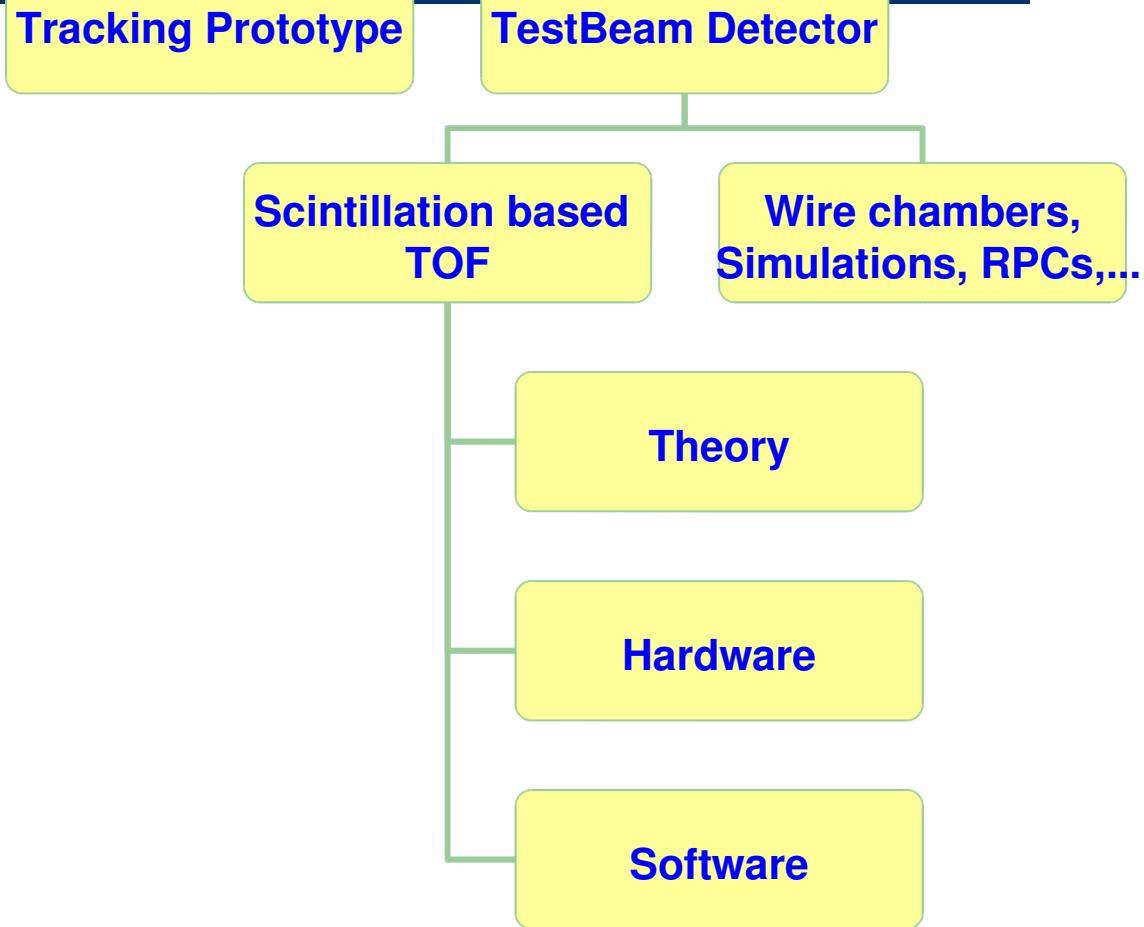


Internship for Physics Majors
July 30, 2008

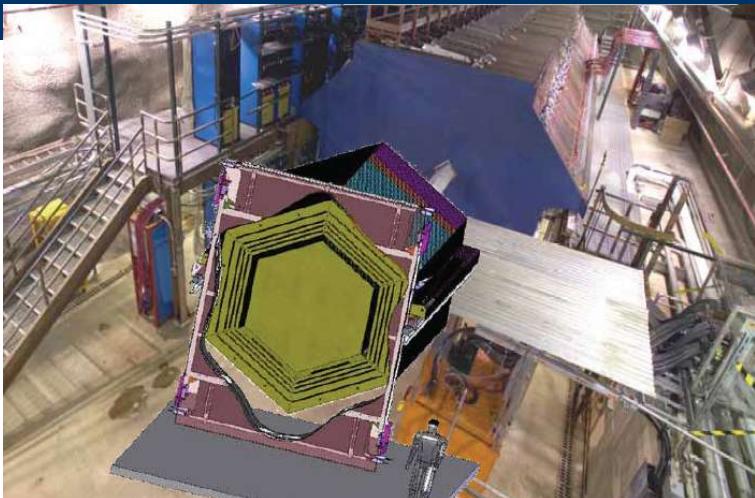


MINERvA

Main INjector ExpeRiment for ν -A



MINERvA in Brief



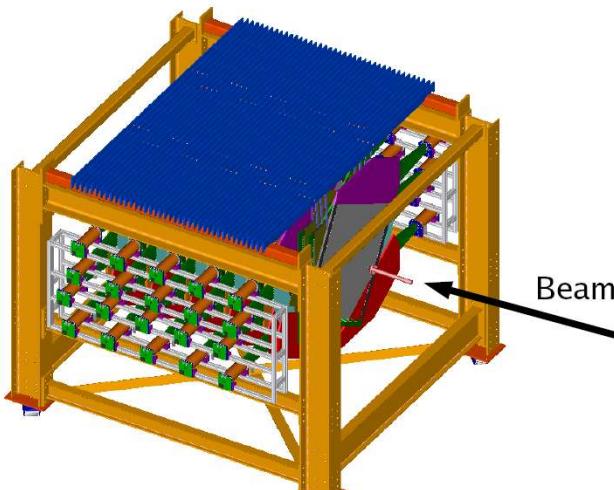
The 5.87 tons detector will be placed in the NuMI beam line directly upstream of the MINOS Near Detector

- MINERvA is a neutrino scattering experiment which uses the NuMI
- MINERvA seeks to measure low energy neutrino-nucleus interactions both in support of neutrino oscillation experiments and also to study the strong dynamics of the nucleon and nucleus that affect these interactions.

MINERvA is currently in its final prototyping stage and is preparing for full-scale construction



TestBeam



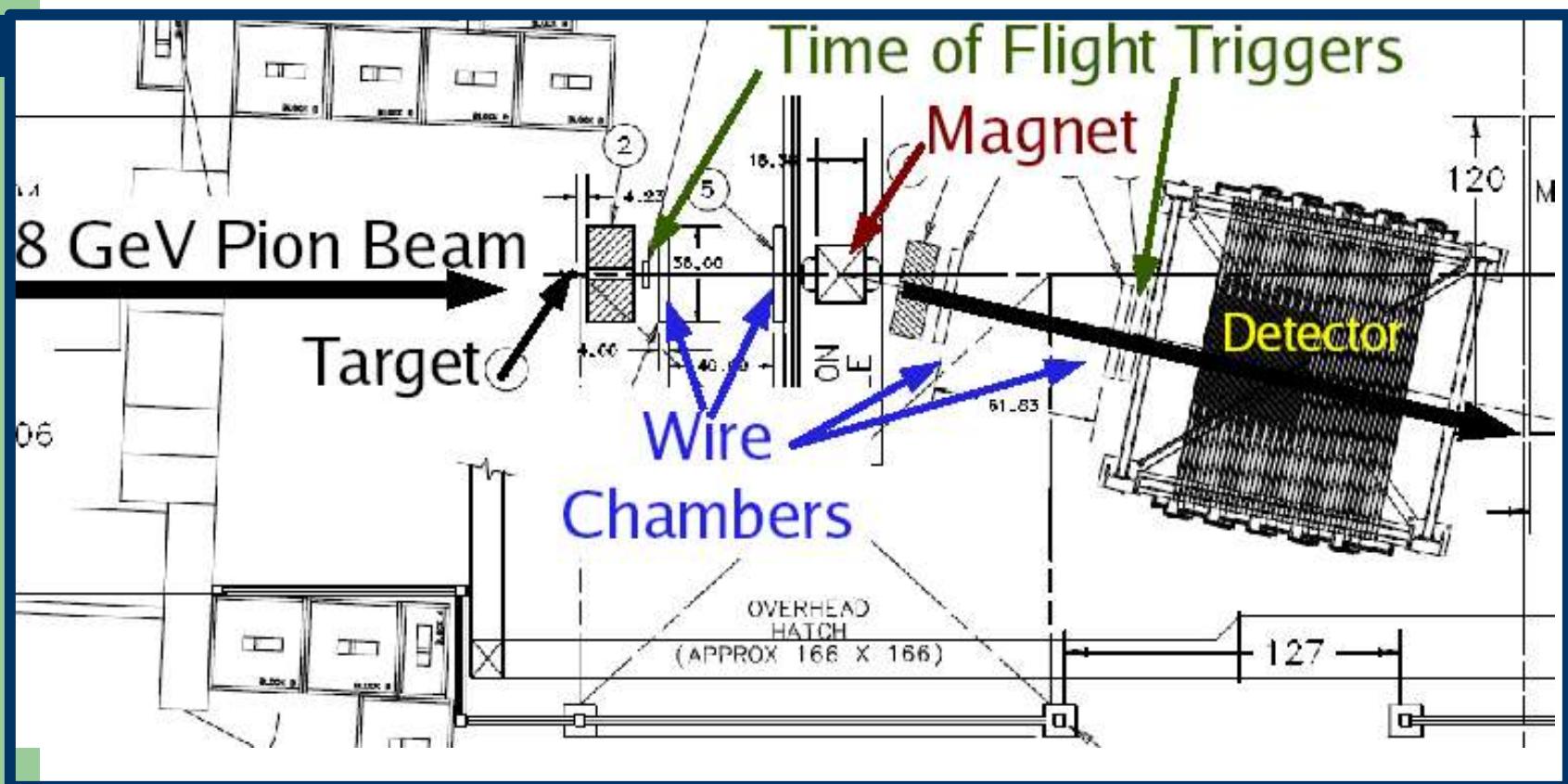
Detector for the Meson Test Facility
HCAL 0.2 - 4 GeV/c

Tracking Prototype



TP plane at Lab5
ECAL 1-10 GeV/c

Meson Test Facility



The Problem

We need to distinguish protons from pi mesons
coming in the TestBeam

Does the current Scintillator based time of flight
system at the Meson Test Facility is suitable for this?
(160 psec)

Or

Do we need to use a Resistive Plate Chambers
based time of flight system? (80 psec)

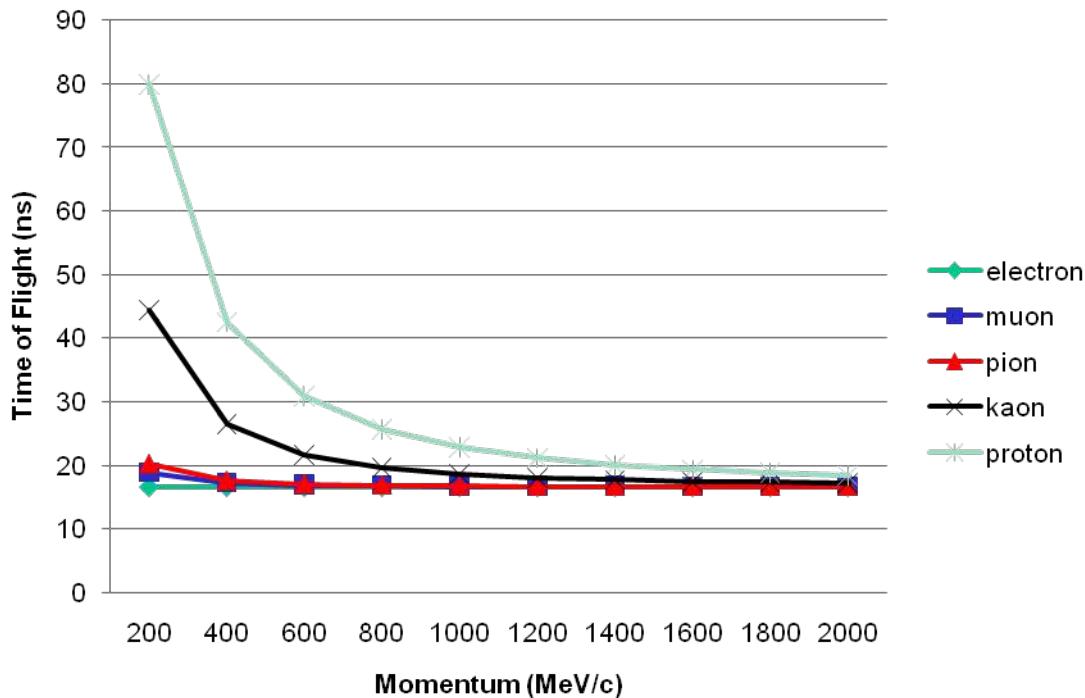
TOF Basics

$$t = \frac{L}{v} \rightarrow v = \frac{p}{m\gamma} \rightarrow M = \frac{L}{pc} \left[(m_1 c^4 + p^2 c^2)^{1/2} \right]$$

L=particle's path between two counters
t=time to traverse L
v=particle speed

Time of flight for different particles

5 m path length



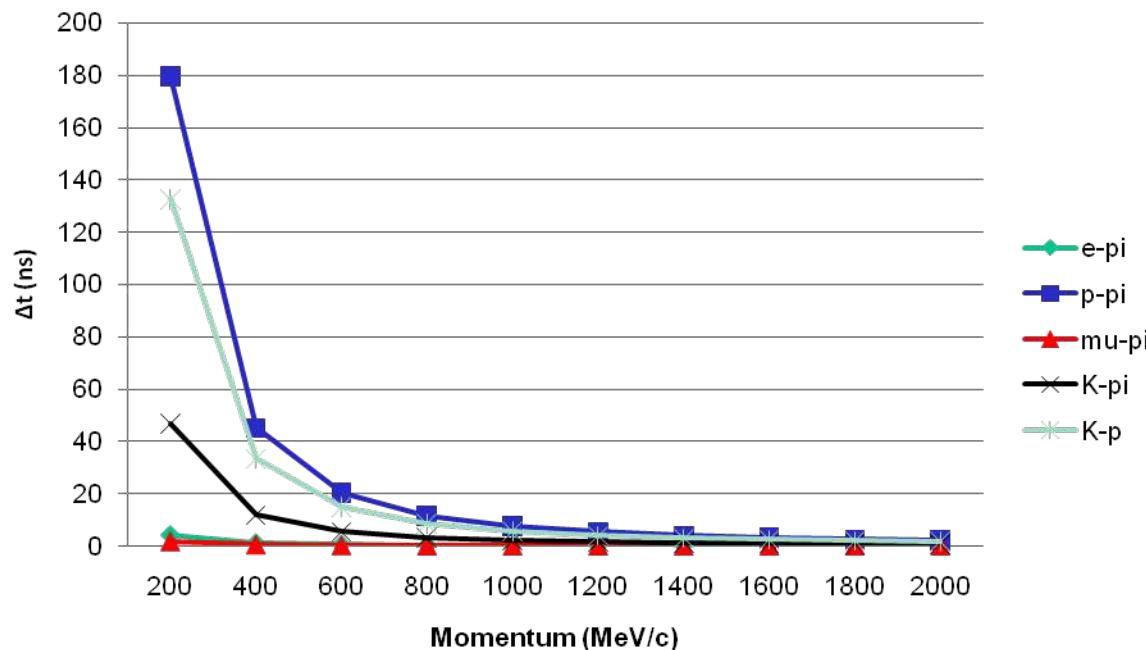
TOF Basics

Time of flight difference of two particles at a given momentum p:

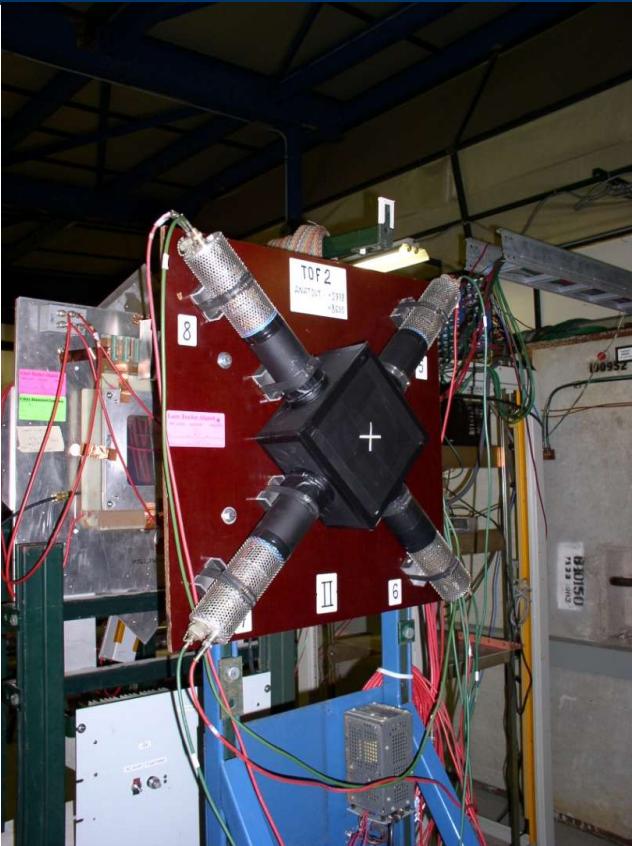
$$\Delta t_{1-2} = \frac{L}{c} \left(\frac{1}{\beta_1} - \frac{1}{\beta_2} \right) = \frac{L}{c} \left(\sqrt{1 + m_1^2 c^2 / p^2} - \sqrt{1 + m_2^2 c^2 / p^2} \right)$$

The time difference for e- π , p- π , μ - π , K- π and K-p as a function of momentum

5 m path length



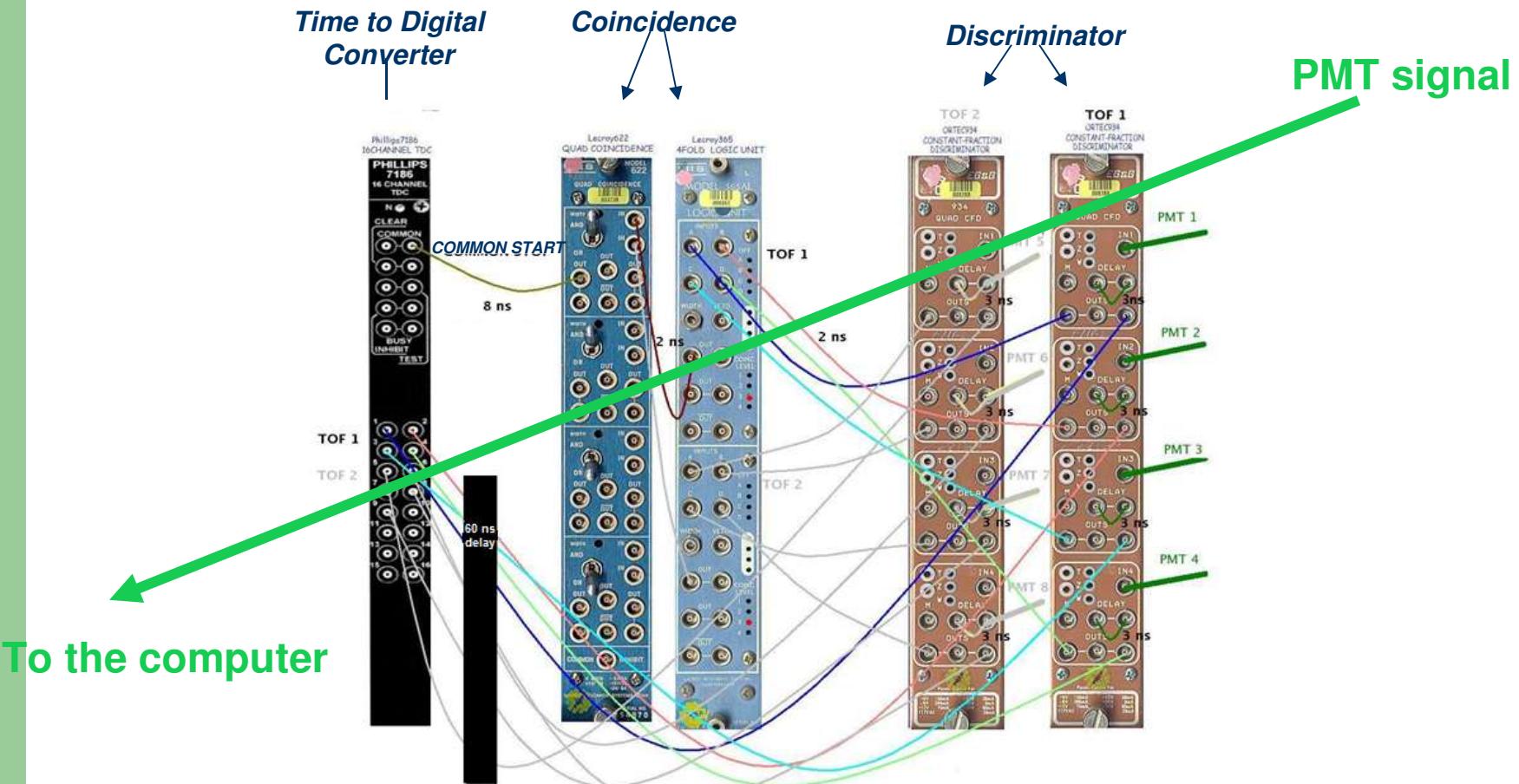
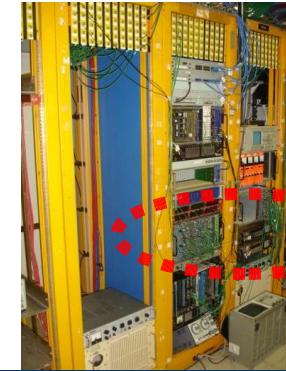
Current TOF at MTest



There are two stations like the one shown in the picture

- + 10 cm octagonal scintillators
- + 4 PMT readouts
- + 5 mm thick 1st station gives 200 psec
- + 20 mm thick gives 160 psec

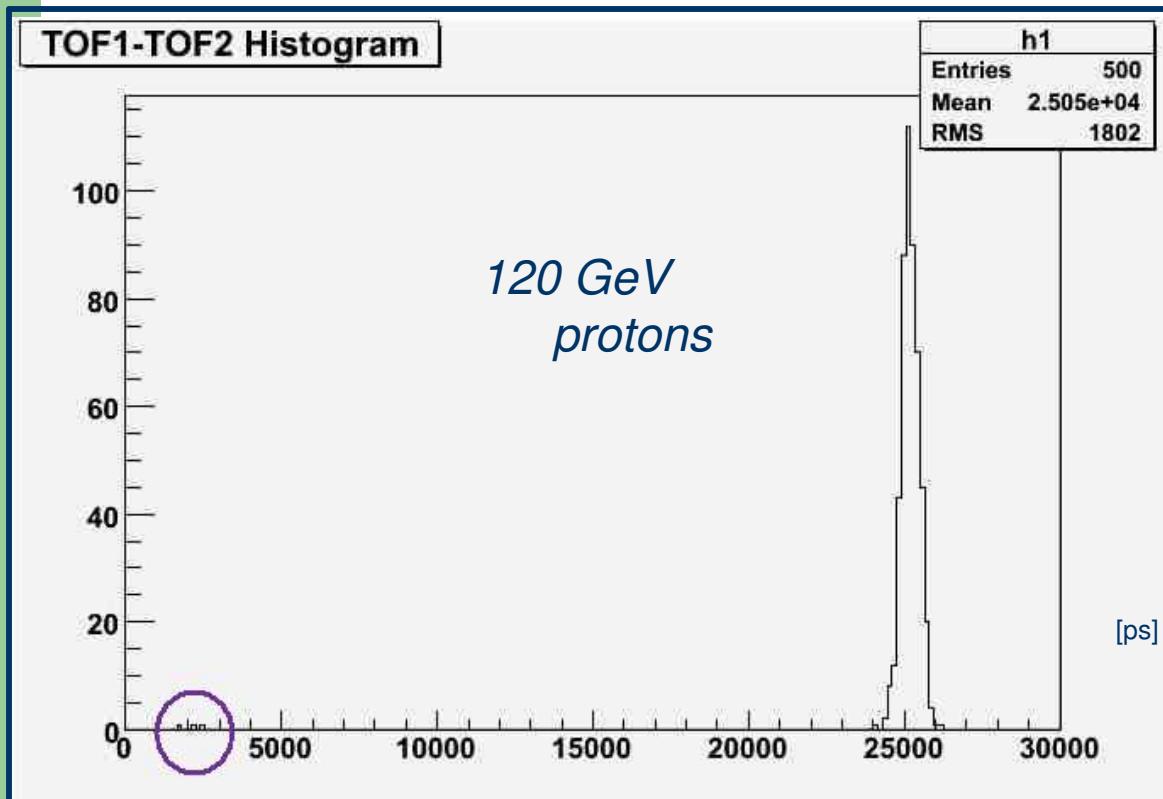
Electronic devices (common start)



1st Analysis (19 June)

Software: C and Root

Goal: familiarize ourselves with the data processing by studying the resolution of the TOF measurement at MTest (old data)

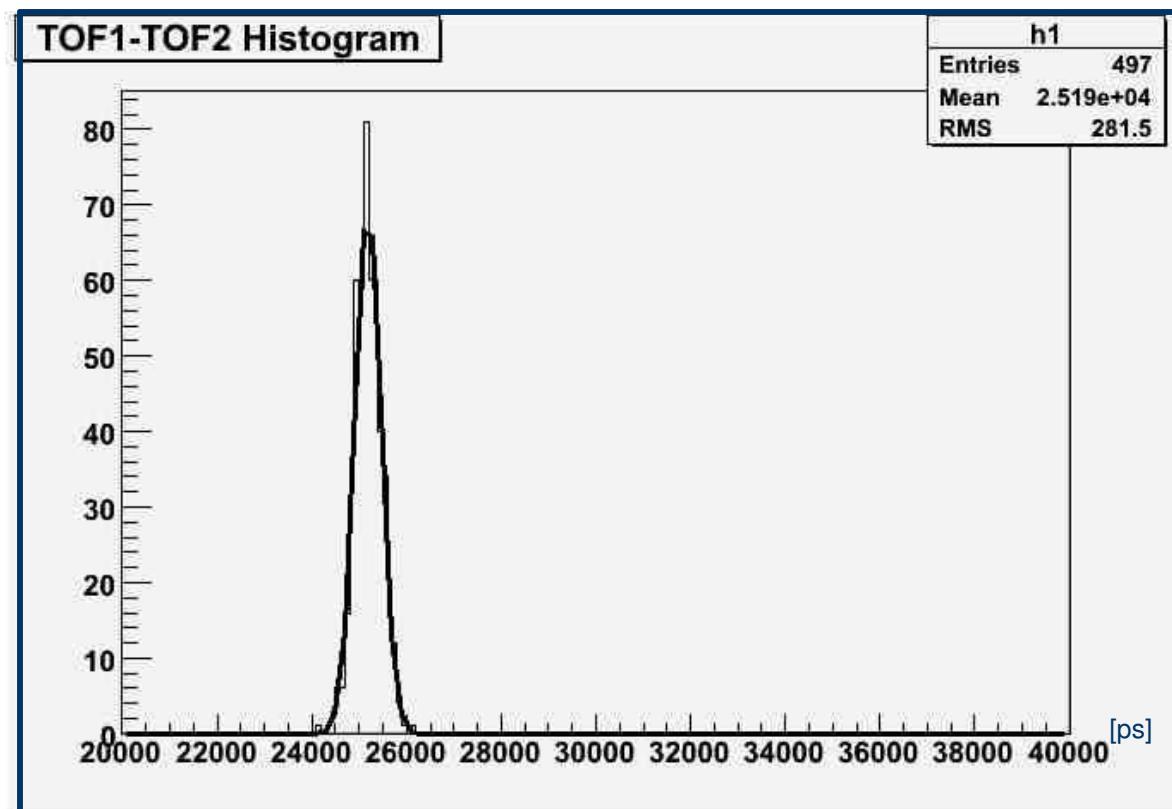


Standard Configuration	
Range	Resolution
100 nSec	25 pSec

1	1206	1	1204	1	1202
2	1722	2	1730	2	1746
3	1810	3	1817	3	1795
4	1236	4	1247	4	1212
5	467	5	466	5	463
6	455	6	471	6	460
7	534	7	543	7	528
8	457	8	468	8	439
9	4095	9	4095	9	4095
10	4095	10	4095	10	4095
11	4095	11	4095	11	4095
12	4095	12	4095	12	4095
13	4095	13	4095	13	4095
14	4095	14	4095	14	4095
15	4095	15	4095	15	4095
16	4095	16	4095	16	4095

Rejecting the 3 outliers

EXT NO.	PARAMETER NAME	VALUE	ERROR
1	Constant	7.07134e+01	4.02061e+00
2	Mean	2.51957e+04	1.25679e+01
3	Sigma	2.73102e+02	9.46542e+00



We expected a resolution below 200 psec...

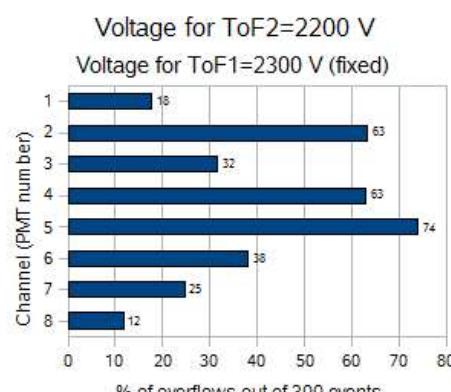
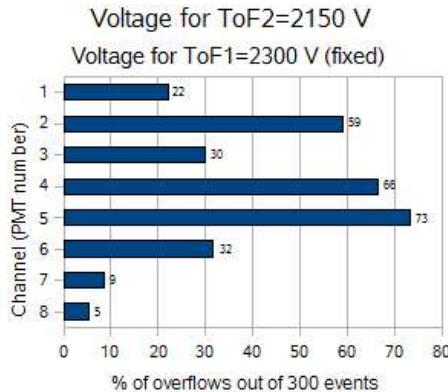
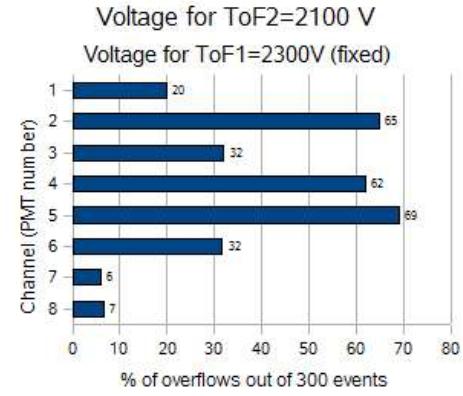
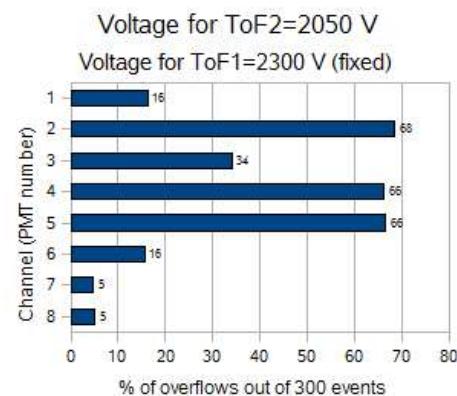
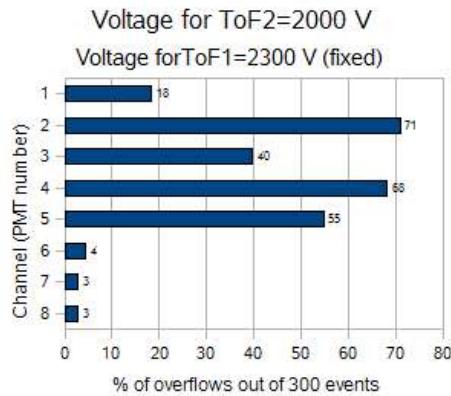
Due to cable length?

To investigate the reason: take actual data

2nd Analysis (1 July)

Software: Fortran

Goal: study the TOF resolution as a function of the voltage in the PMTs.
Change TDC to common stop.



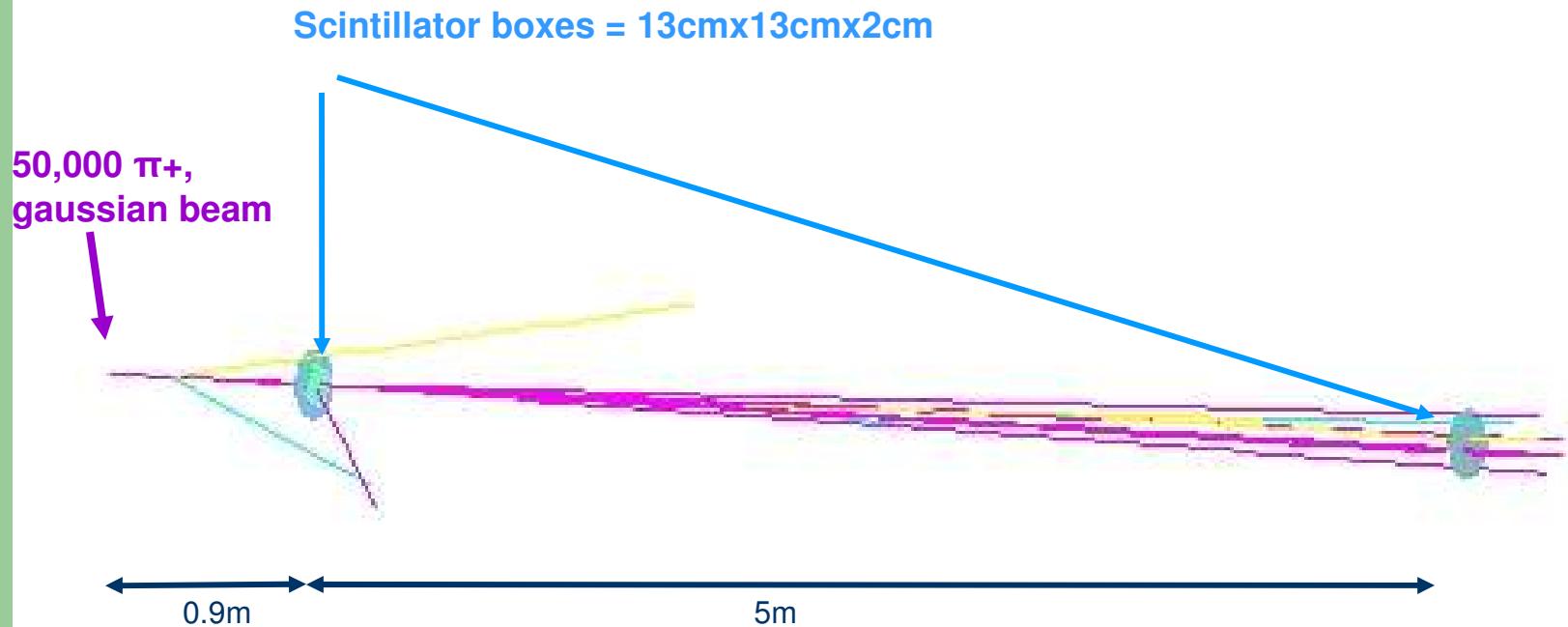
Overflow:
No signal
coming out
of the PMT

*It was difficult to
make any sense of
the data we got*

3rd Analysis (15 July)

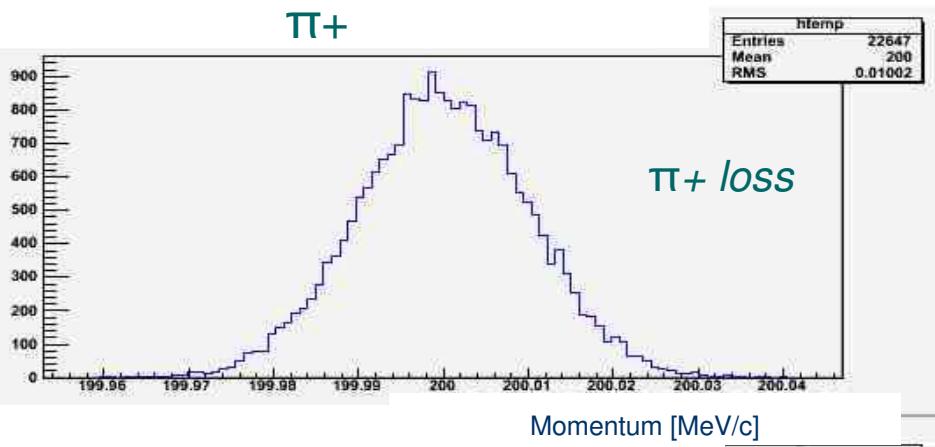
Software: C and Geant4Beamline

Goal: to simulate a π^+ beam going through 40 mm of scintillator

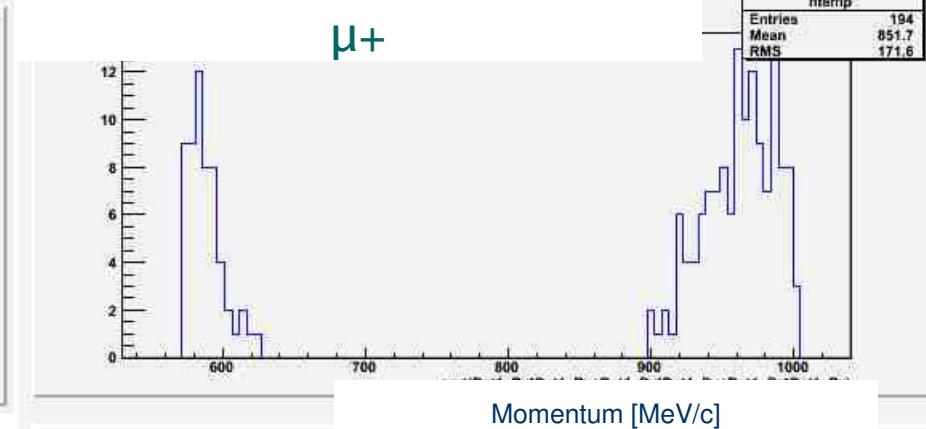
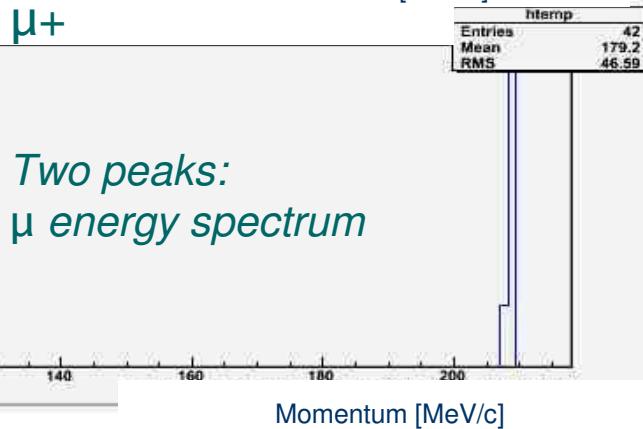
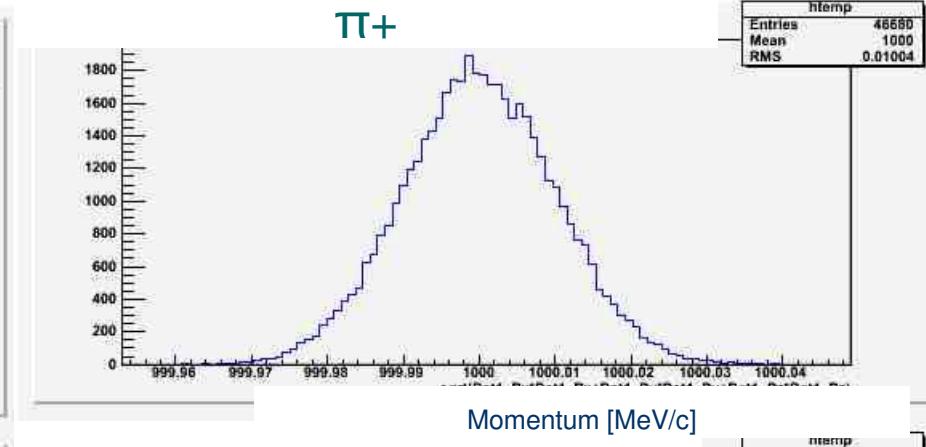


TOF 1

Initial momentum=200 MeV/c



Initial momentum=1000 MeV/c

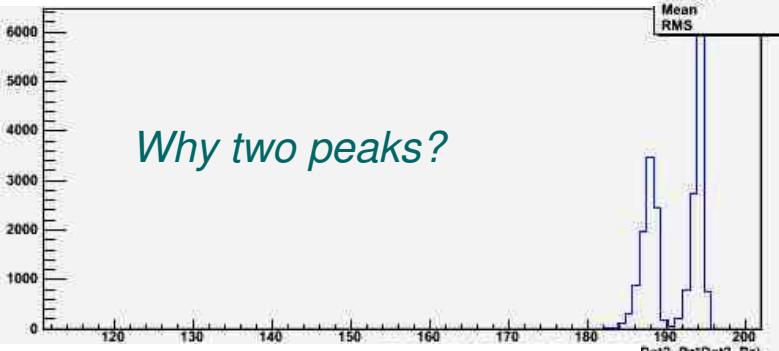


TOF 2

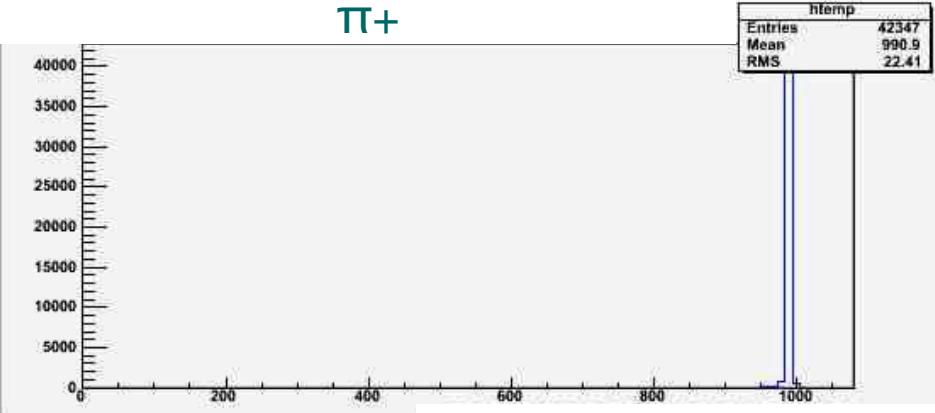
Initial momentum=200 MeV/c

Initial momentum=1000 MeV/c

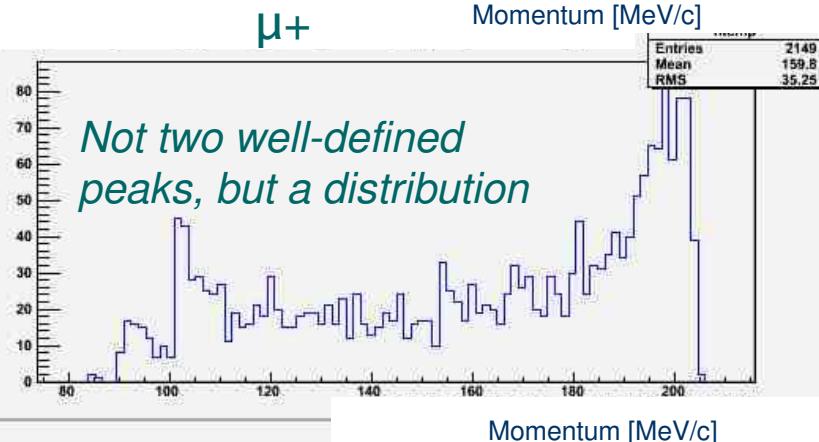
π^+



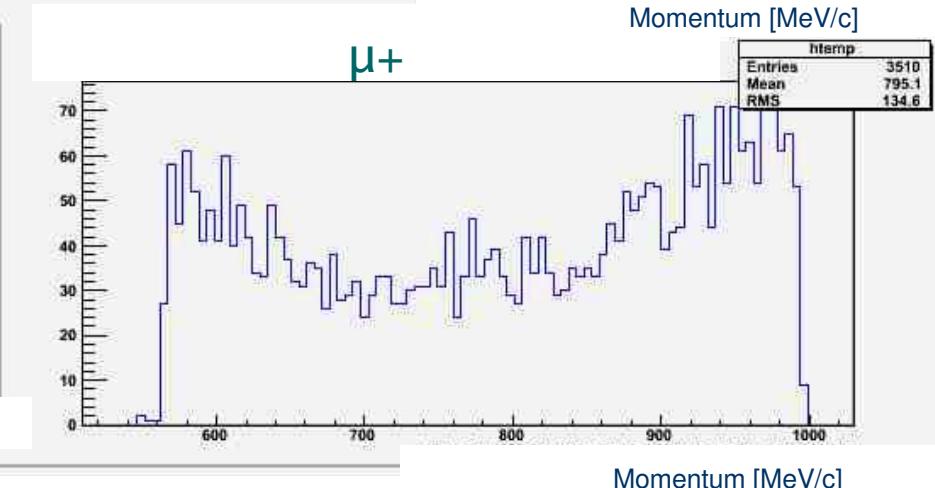
π^+



μ^+



μ^+



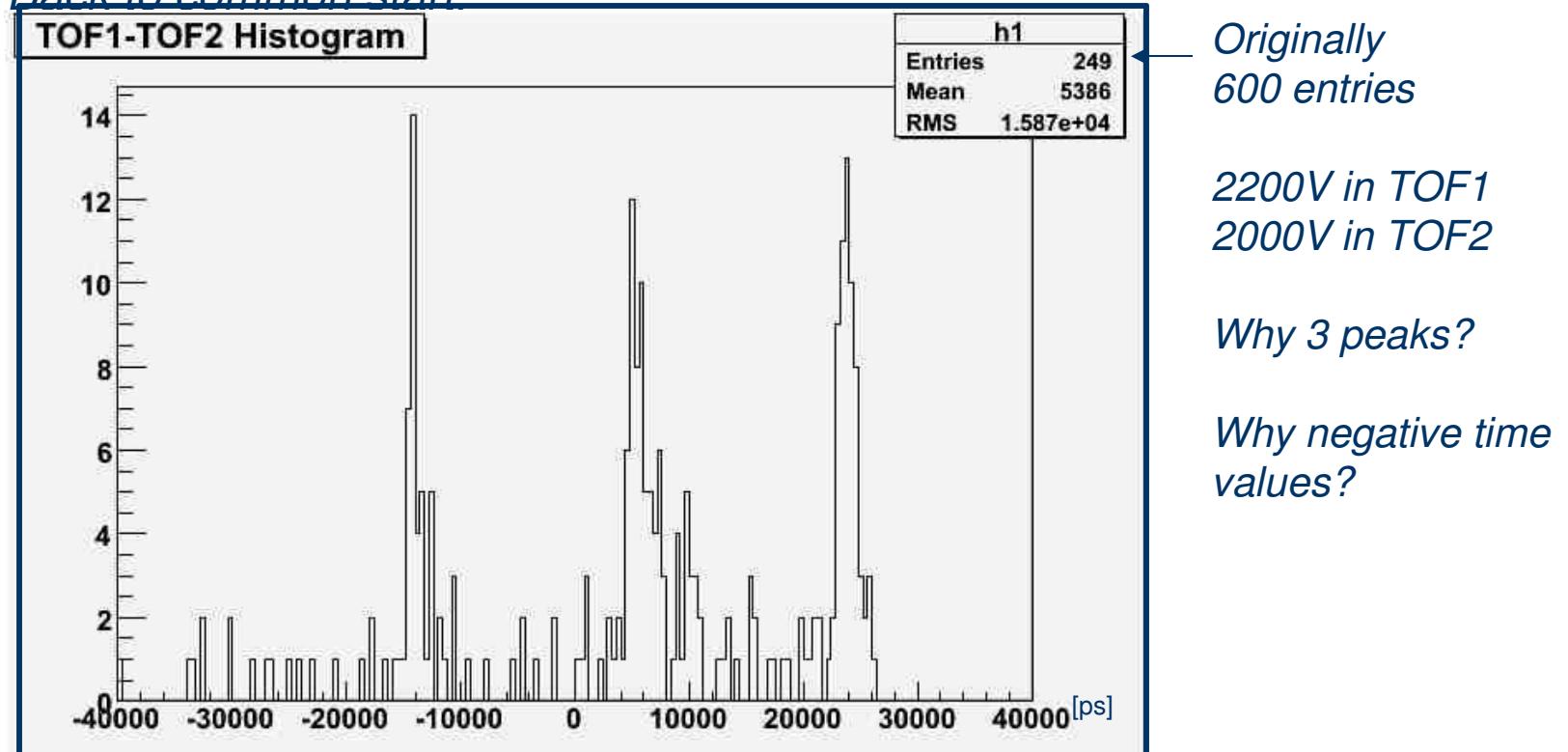
Not two well-defined peaks, but a distribution

Momentum [MeV/c]

4th Analysis (23 July)

Software: C and Root

Goal: Study TOF resolution varying voltage, again. This time using the μ beam of the CALICE experiment. TOF2 was not in the beamline, though.
Back to common start.



CONCLUSION

NEXT

I  FNAL

- Answer the questions regarding the data
 - Why so many overflows?
 - Why 3 peaks in the last data?
- Apply optical grease to the scintillator-phototube connexion (collect more light)
- Replace the 5mm thick scintillator in TOF1 for a 20mm one

Thanks to

Erik Ramberg, Roger Dixon and Jean Slaughter (SULI/IPM Directors)

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Carmen Araujo :)

Kenyi Hurtado, Carlos Perez and Arturo Fiorentini (Peru)

Summer interns

Backup slides

Time of Flight (TOF) Basics

$$t - \frac{L}{v}$$



$$v - \frac{p}{mY}$$



$$t = \frac{L}{pc^2} \left[(m_2 c^4 + p^2 c^2)^{1/2} \right]$$

L=particle's path between two counters

t=time to traverse L

v=particle speed

p (MeV)	Time of flight (ns)				
	electron	muon	pion	kaon	proton
5.10999E-01	1.05658E+02	1.39570E+02	4.93677E+02	9.38272E+02	
200	1.66651E+01	1.88476E+01	2.03217E+01	4.43831E+01	7.99379E+01
400	1.66650E+01	1.72366E+01	1.76503E+01	2.64718E+01	4.24948E+01
600	1.66650E+01	1.69214E+01	1.71099E+01	2.15810E+01	3.09334E+01
800	1.66650E+01	1.68097E+01	1.69167E+01	1.95827E+01	2.56855E+01
1000	1.66650E+01	1.67578E+01	1.68265E+01	1.85852E+01	2.28521E+01
1200	1.66650E+01	1.67295E+01	1.67773E+01	1.80202E+01	2.11544E+01
1400	1.66650E+01	1.67124E+01	1.67476E+01	1.76708E+01	2.00615E+01
1600	1.66650E+01	1.67013E+01	1.67283E+01	1.74402E+01	1.93191E+01
1800	1.66650E+01	1.66937E+01	1.67150E+01	1.72804E+01	1.87932E+01
2000	1.66650E+01	1.66882E+01	1.67055E+01	1.71652E+01	1.84078E+01

TOF Basics

Time of flight difference of two particles at a given momentum p:

$$\Delta t_{1-2} = \frac{L}{c} \left(\frac{1}{\beta_1} - \frac{1}{\beta_2} \right) = \frac{L}{c} \left(\sqrt{1 + m_1^2 c^2 / p^2} - \sqrt{1 + m_2^2 c^2 / p^2} \right)$$

$\Delta e/\pi$ (ns)	$\Delta p/\pi$ (ns)	$\Delta \mu/\pi$ (ns)	$\Delta K/\pi$ (ns)	$\Delta K/p$ (ns)
4.05905624	179.384738	1.73287655	4.67254E+01	1.32659E+02
1.01476406	44.8461845	0.43321914	1.16814E+01	3.31648E+01
0.45100625	19.9316375	0.19254184	5.19171E+00	1.47399E+01
0.25369101	11.2115461	0.10830478	2.92034E+00	8.29121E+00
0.16236225	7.17538952	0.06931506	1.86902E+00	5.30637E+00
0.11275156	4.98290939	0.04813546	1.29793E+00	3.68498E+00
0.08283788	3.66091302	0.03536483	9.53580E-01	2.70733E+00
0.06342275	2.80288653	0.0270762	7.30085E-01	2.07280E+00
0.05011181	2.21462639	0.02139354	5.76857E-01	1.63777E+00
0.04059056	1.79384738	0.01732877	4.67254E-01	1.32659E+00