Beam Test:
data for analysis

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on behalf of the beam test and analysis team

Outline

- Improvement since the previous beam test
- A first look at the data
  - MWPC data
  - TOF
  - Trigger studies
- Data and Datasets
- Prototype performances
- Summary and conclusions

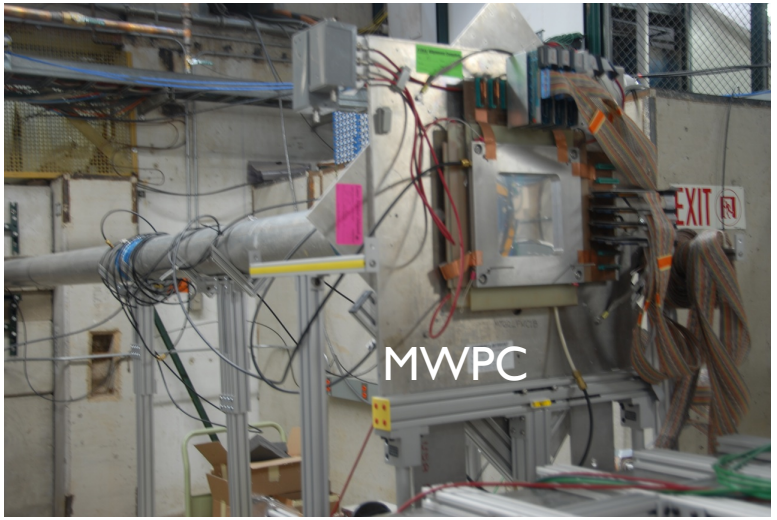
Improvement since last beam test

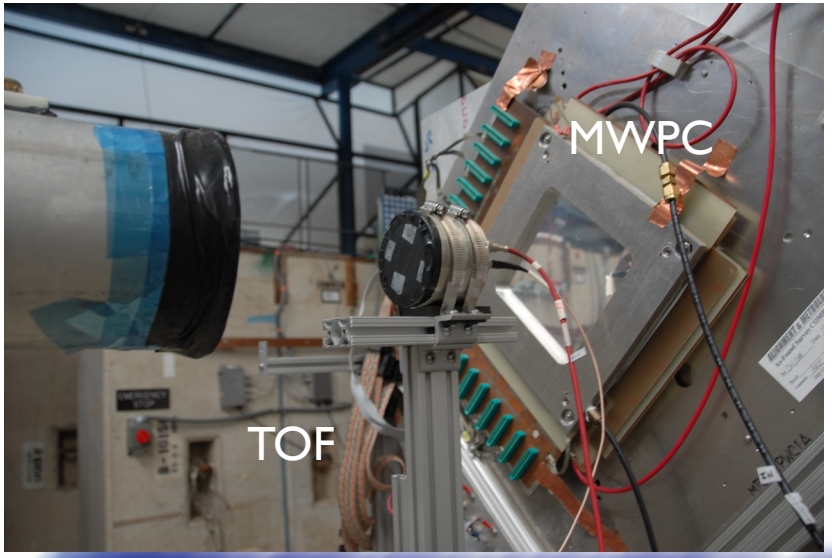
- A lot of planning and developing has been done since December test in order to improve the overall quality of the results:
  - Online Detector Control finally working online, and with new feature (Rate Meter log, temperature log, Vbias automatic correction with the temperature variation)
  - Improved the DAQ program stability and logging
  - Improved setup:
    - More compact apparatus
    - Larger backward scintillators
  - New FEE feature:
    - Doubled the number of BiRO samples from 5 to 10
    - Added an additional communication port to allow ODC and DAQ to operate simultaneously
  - Trigger crate located outside the experimental area

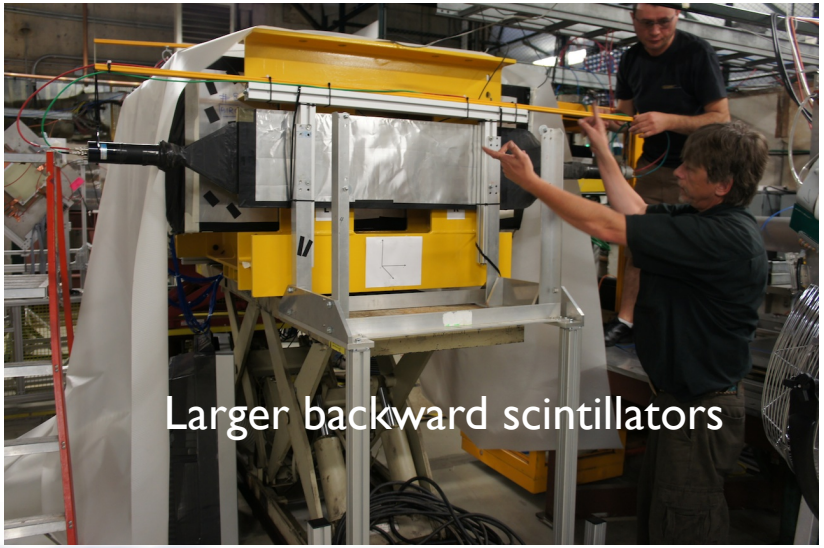
Improvement (part II)

- In addition some improvements have been requested to the FNAL facility:
  - One Multi Wire Proportional Chamber
  - A Time Of Flight Device with ~30ps resolution
  - Usage of the C4F8O gas

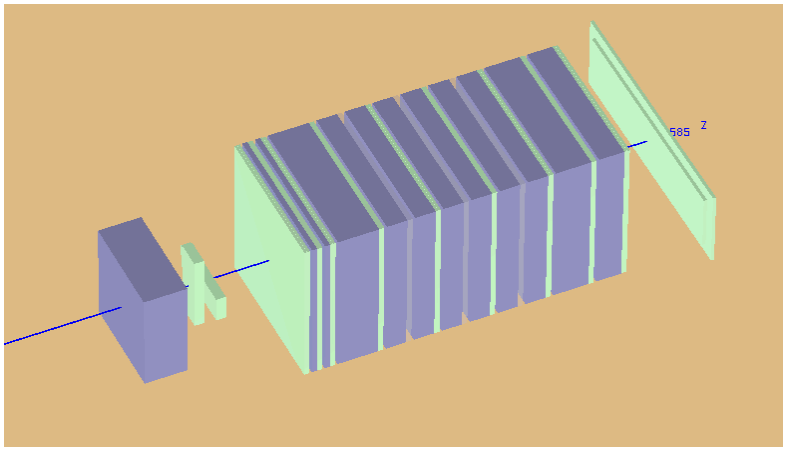
Setup improvements in pictures



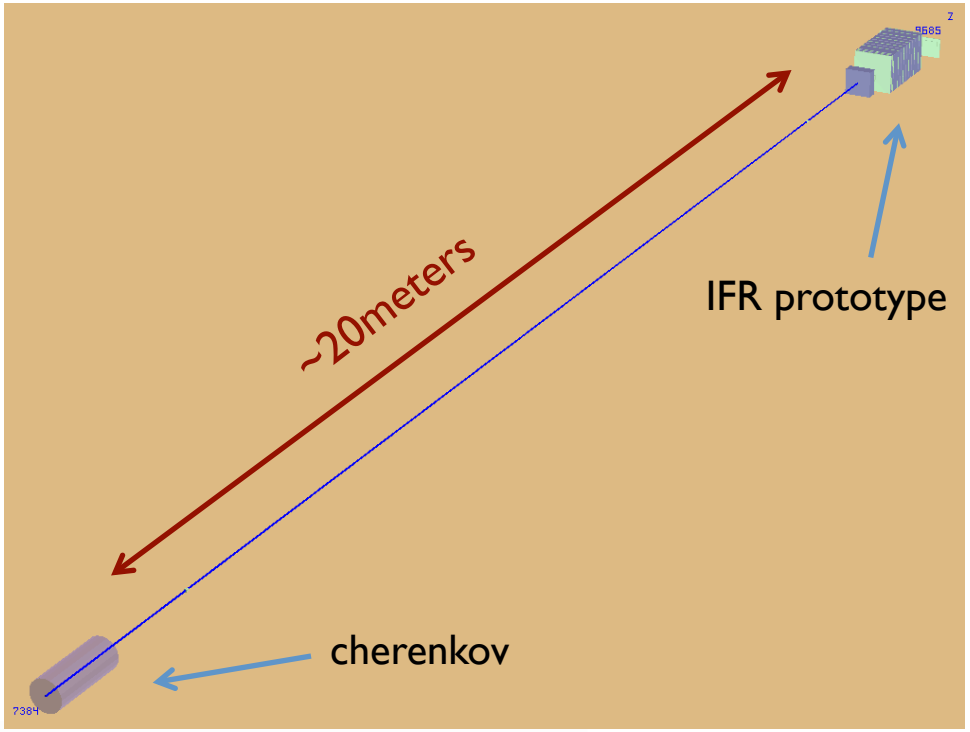




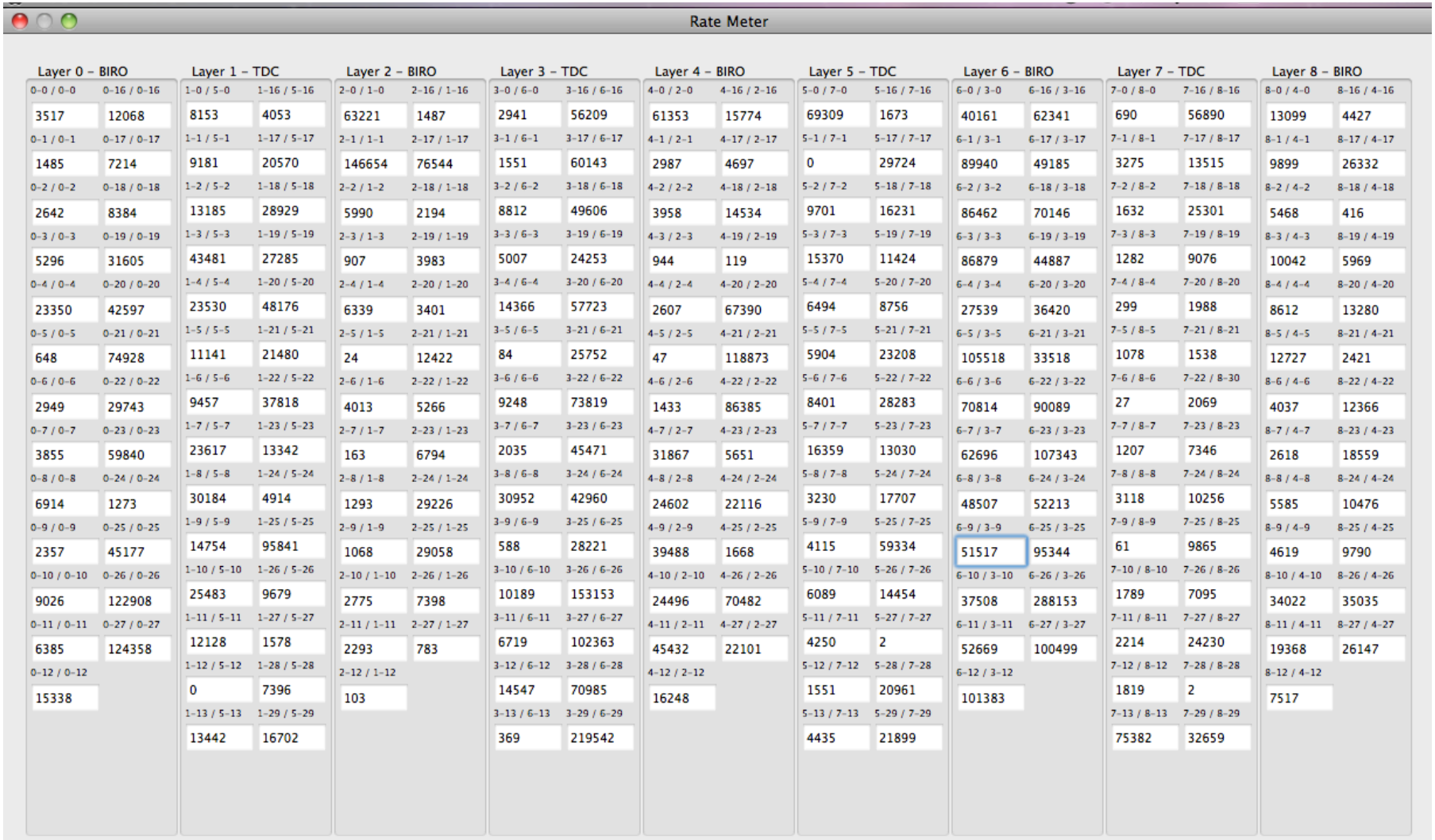
MC simulation



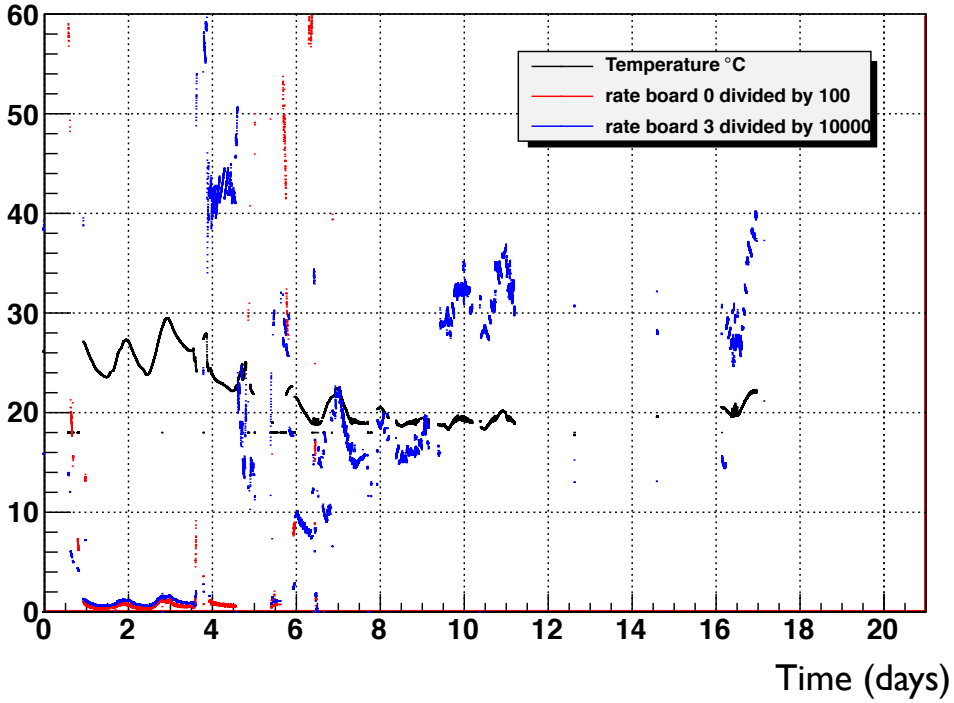
A detailed description of the beam test setup has been done to perform reliable Monte Carlo studies.
Bruno Full Sim package has been used as framework.

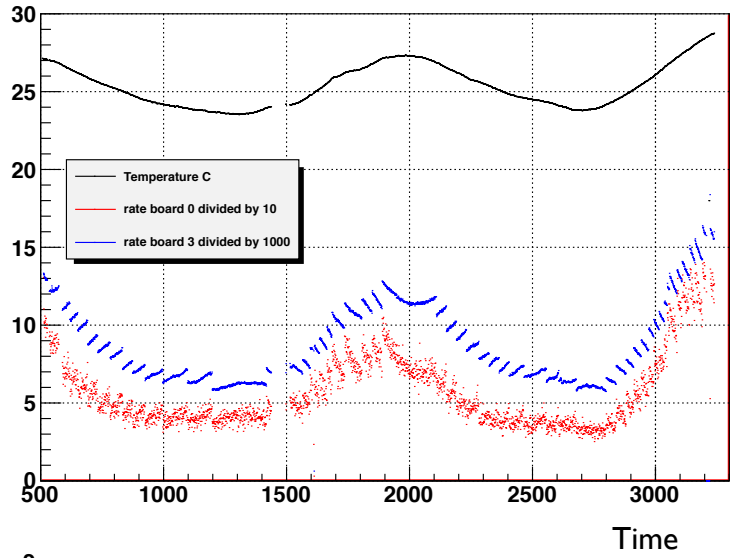


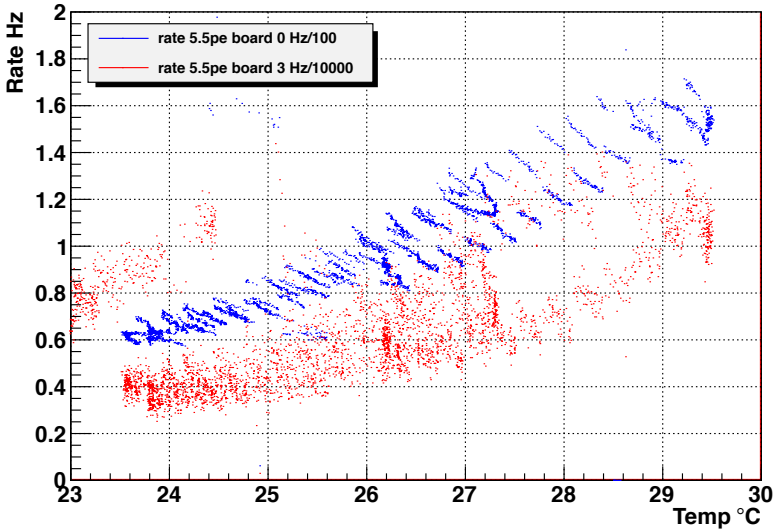
Rate Meter log panel



Temperature monitoring and Vbias correction



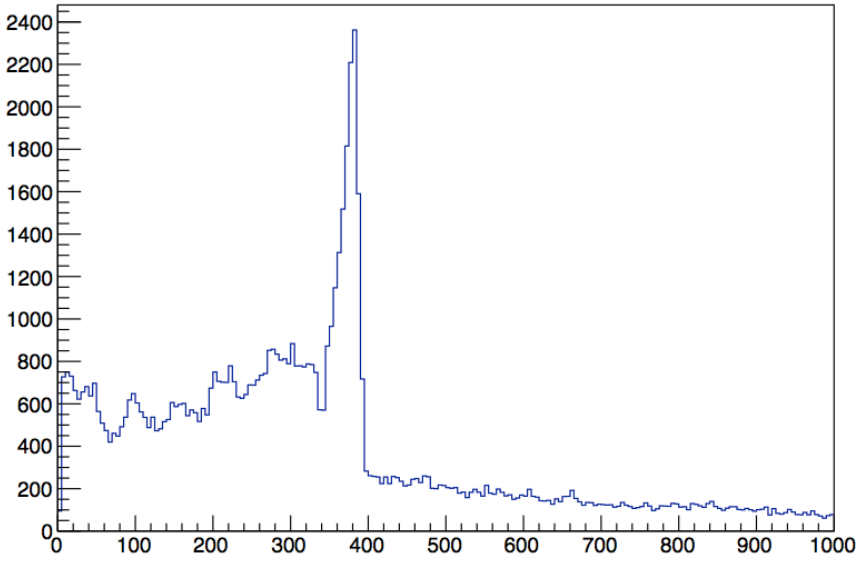


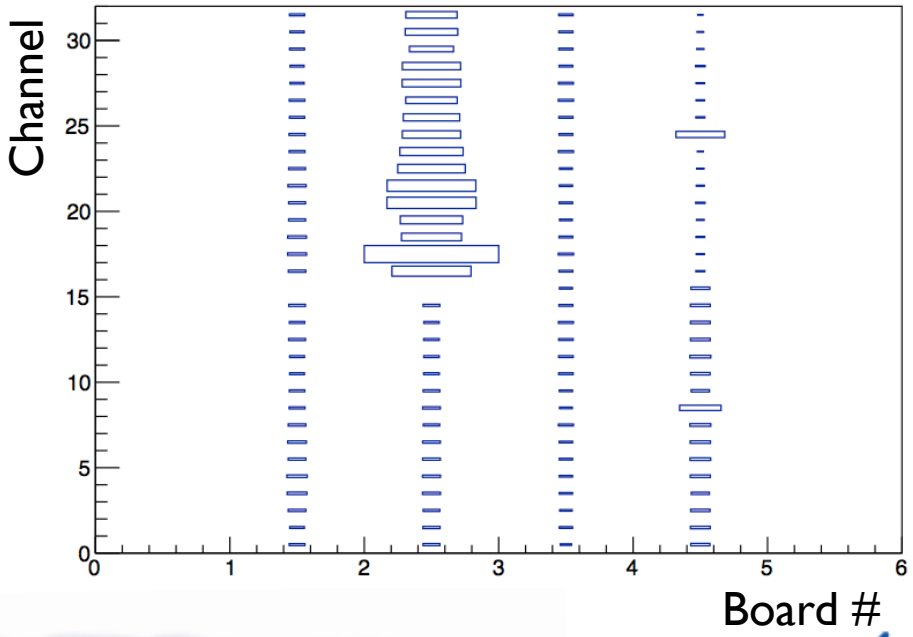


Automatic correction of the Vbias to follow the temperature changes, in order to keep the SiPM gain constant over the time.

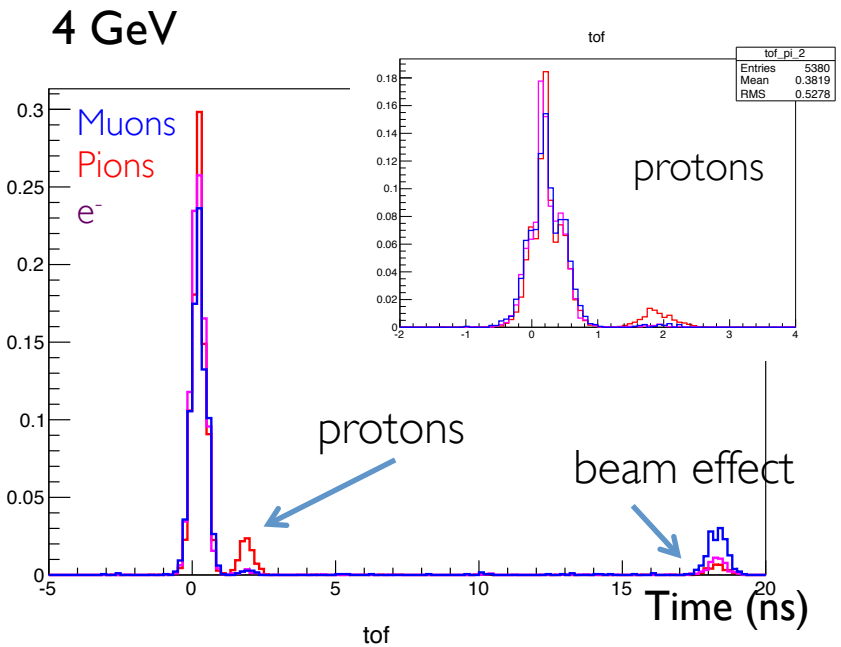
MWPC

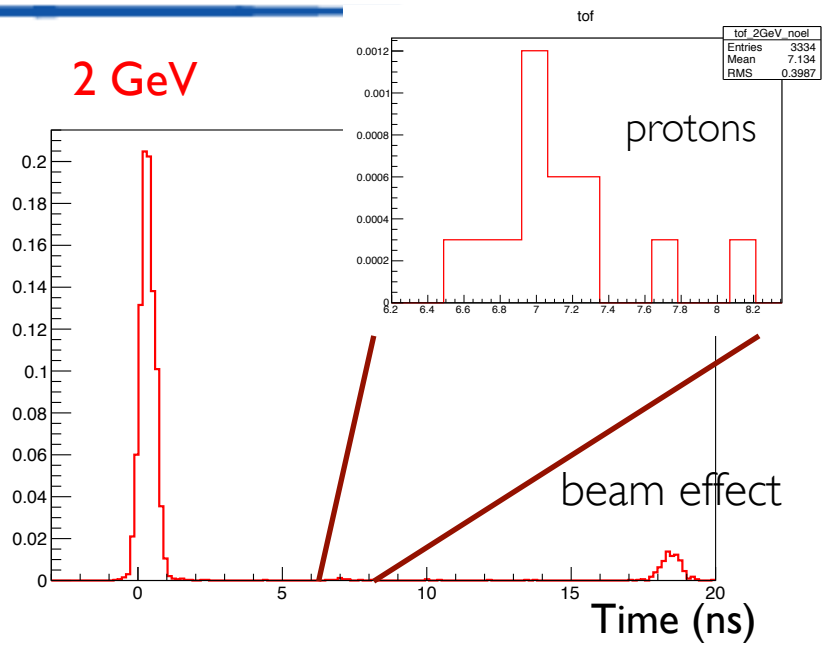
- I didn't spent much time looking at the MWPC data (we had them only for the last few days).
- I had to redo some coding since the FNAL processing code is in FORTRAN.
- It looks that maybe some there's some on time signal, but the hit-maps are don't show anything useful.

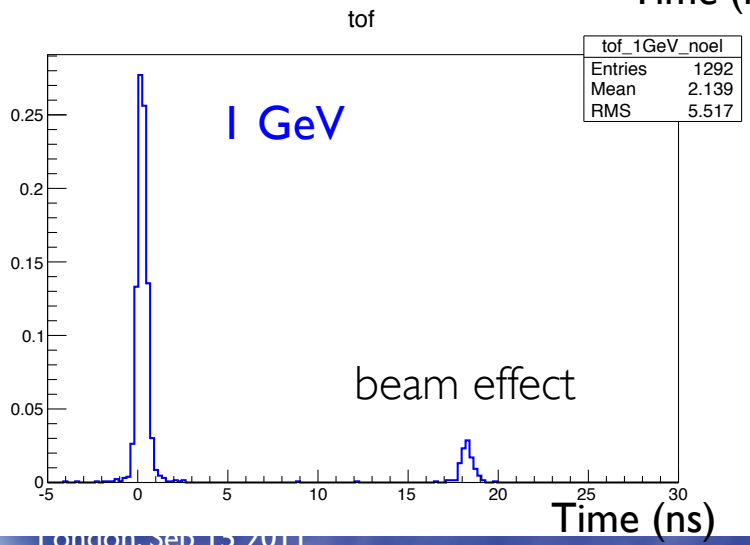


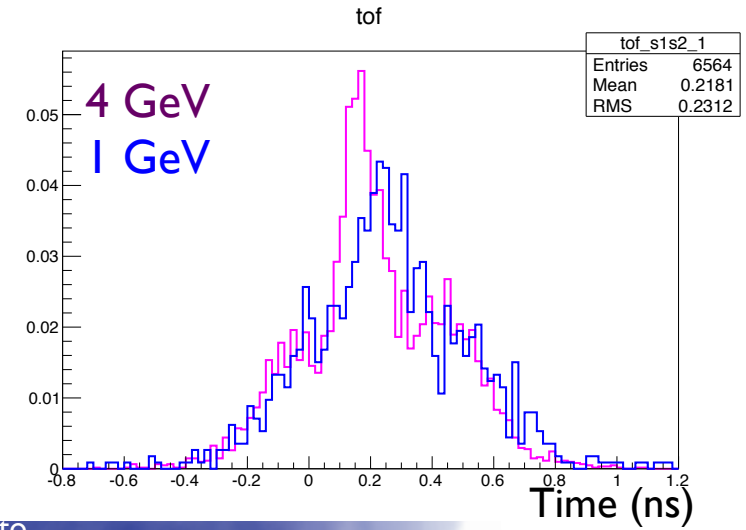


TOF data


4 GeV
tof
tof_pi_2
Entries 5380
Mean 0.3819
RMS 0.5278
protons
Muons
Pions
e⁻
protons
beam effect
Time (ns)


2 GeV
tof
tof_2GeV_noel
Entries 3334
Mean 7.134
RMS 0.3987
protons
beam effect
Time (ns)


tof
tof_1GeV_noel
Entries 1292
Mean 2.139
RMS 5.517
1 GeV
beam effect
Time (ns)


tof
tof_s1s2_1
Entries 6564
Mean 0.2181
RMS 0.2312
4 GeV
1 GeV
Time (ns)

Trigger logics

- Different trigger logics have been generated in order to take Muon/Pion enriched samples and for trigger studies.

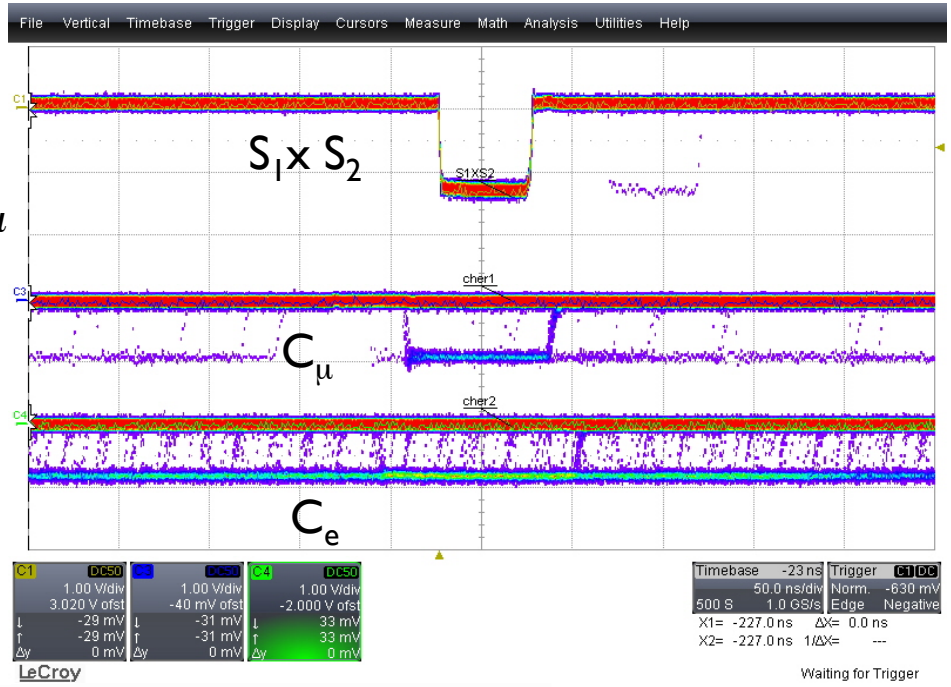
Triggers:

Muon tracks $\Rightarrow S_1 \times S_2 \times \overline{C_e} \times C_\mu$

Pion tracks $\Rightarrow S_1 \times S_2 \times \overline{C_e} \times \overline{C_\mu}$

Mu + Pi tracks $\Rightarrow S_1 \times S_2 \times \overline{C_e}$

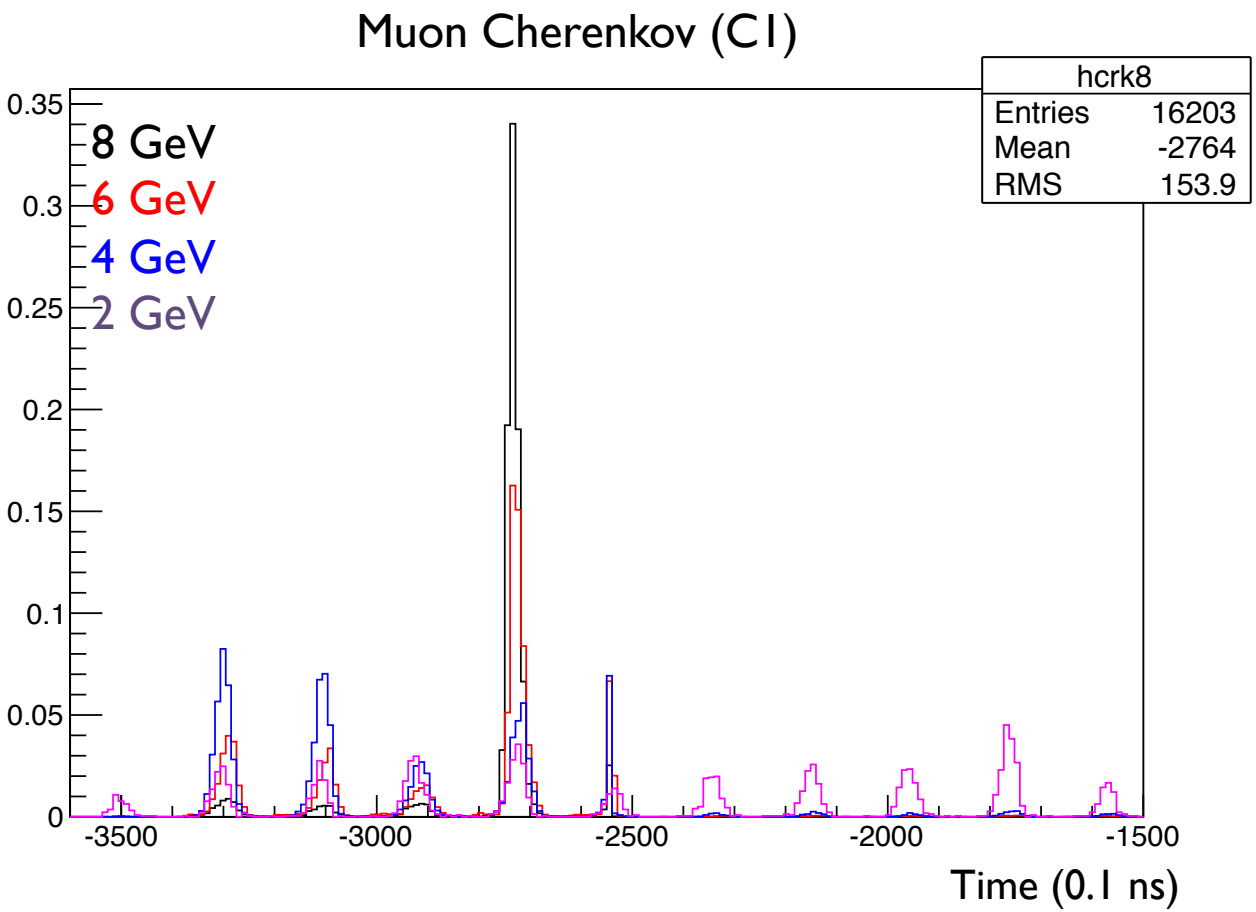
Min Bias $\Rightarrow S_1 \times S_2$



Timing of Cherenkov Signal (I)

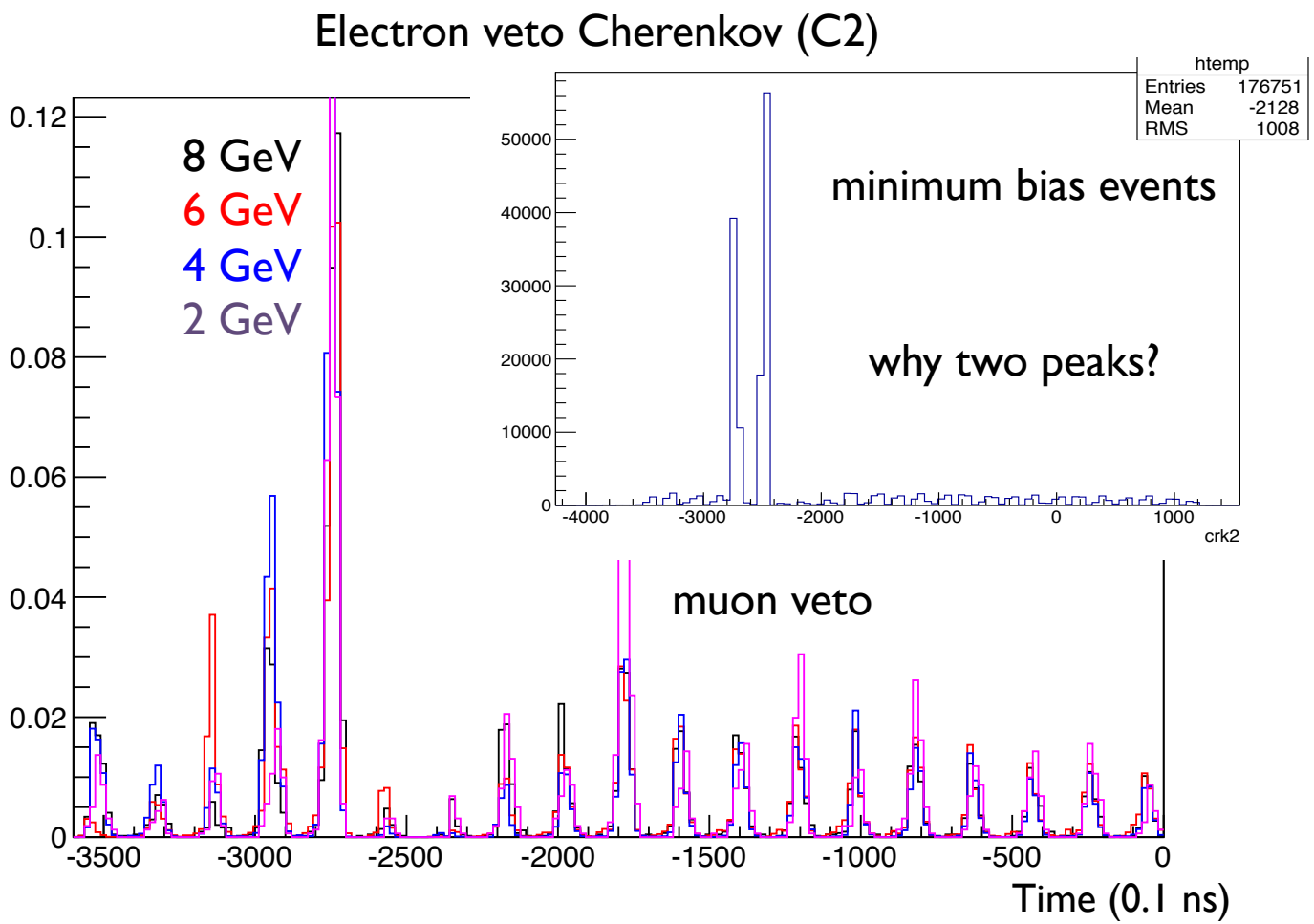
- Lowering the beam momentum the Cherenkov signals get worst and difficult to understand.

- That is the Cherenkov used to separate muons and pions.

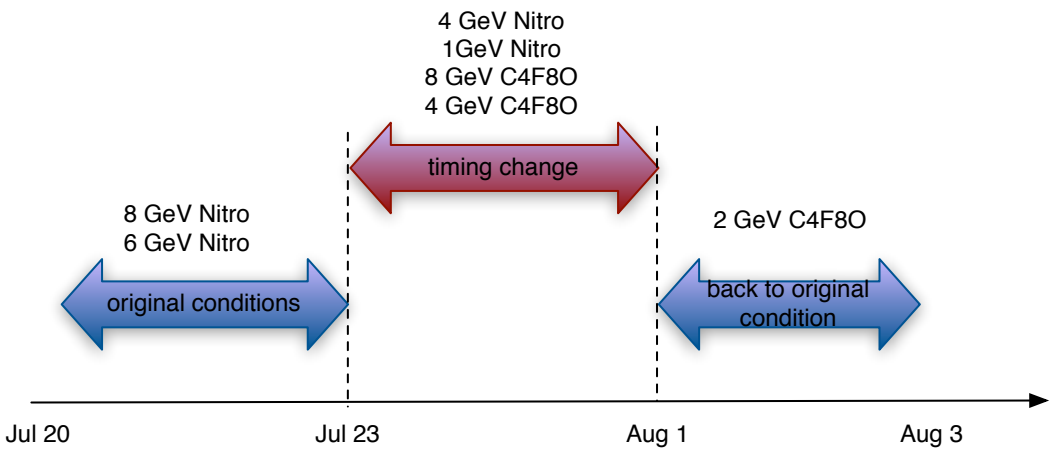


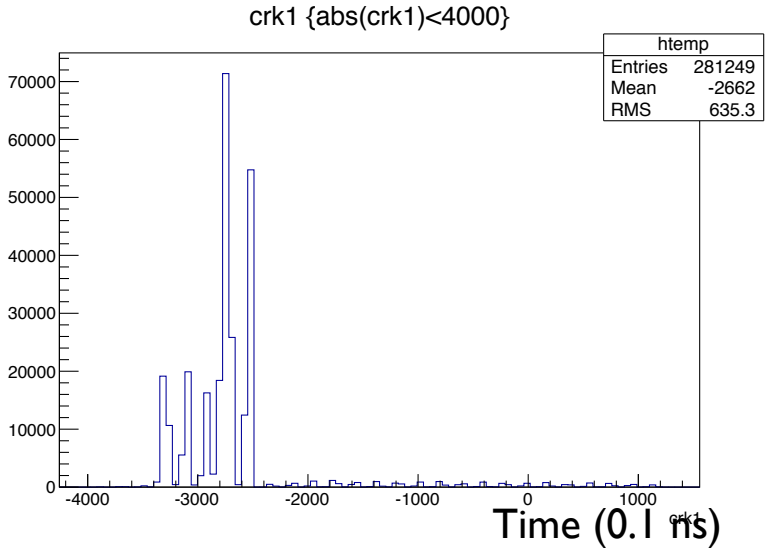
Timing of Cherenkov Signal (II)

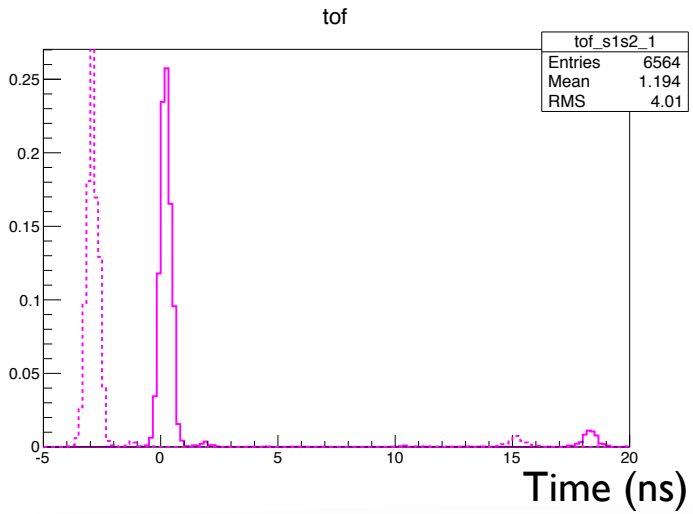
- Muon trigger data: the veto seems to work but its width should be increased.
- Beam bunch structure clearly visible.

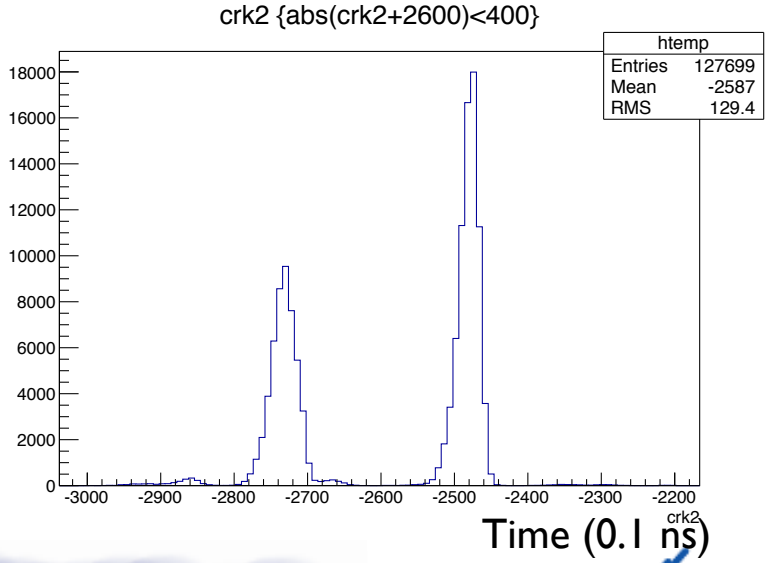


Changing conditions







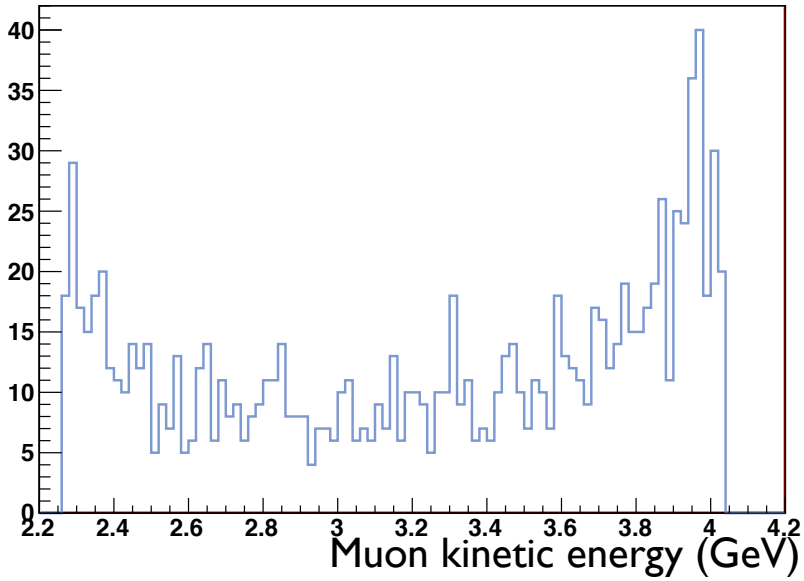


Pion decays

To add more difficulties understanding the data the momentum selecting magnet is placed ~70 meters upstream the Cherenkov counter.

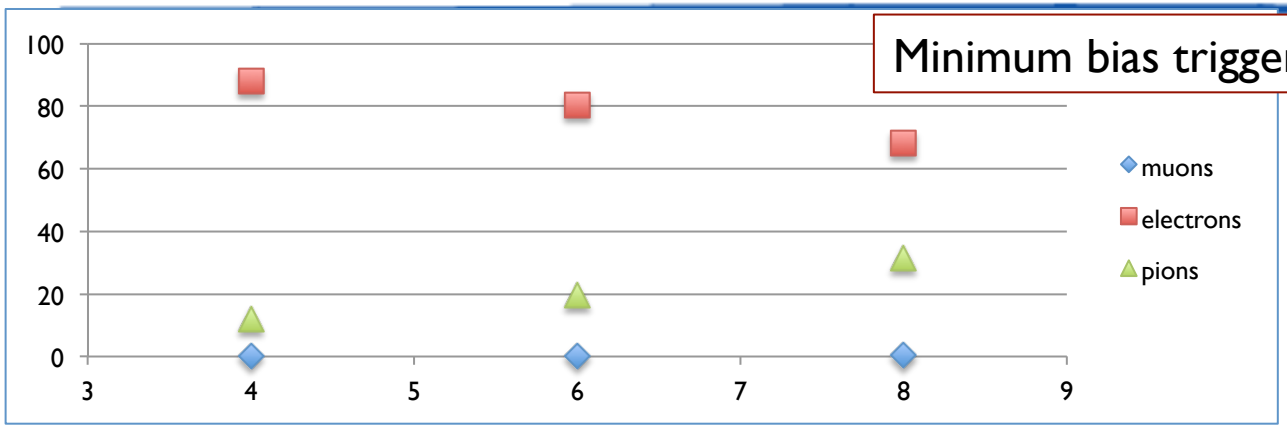
A fraction of the pions decays in fly into muons and a fraction of those muons reach the Cherenkov with wrong momentum being identified as a pion.

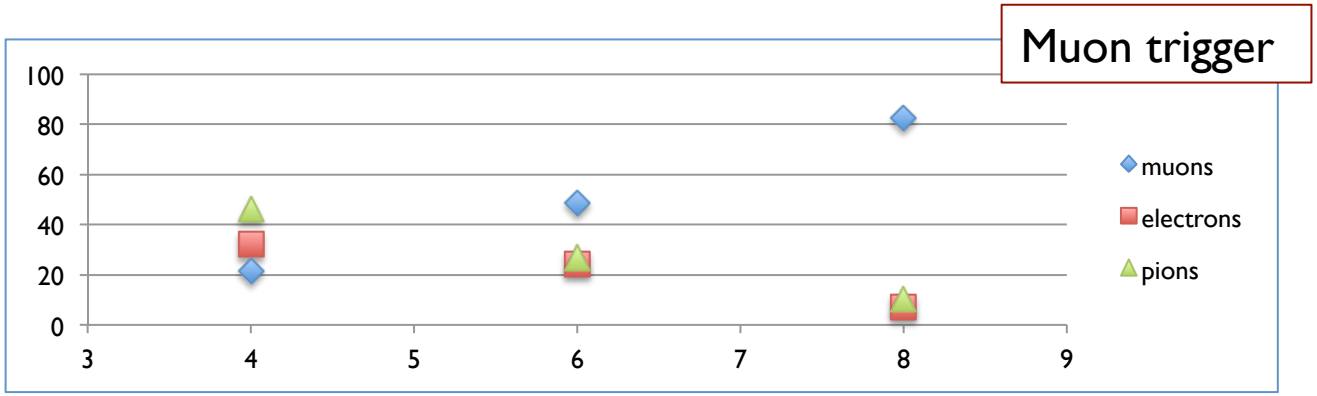
This feature has been implemented in the MC simulation and the results are summarized in this table

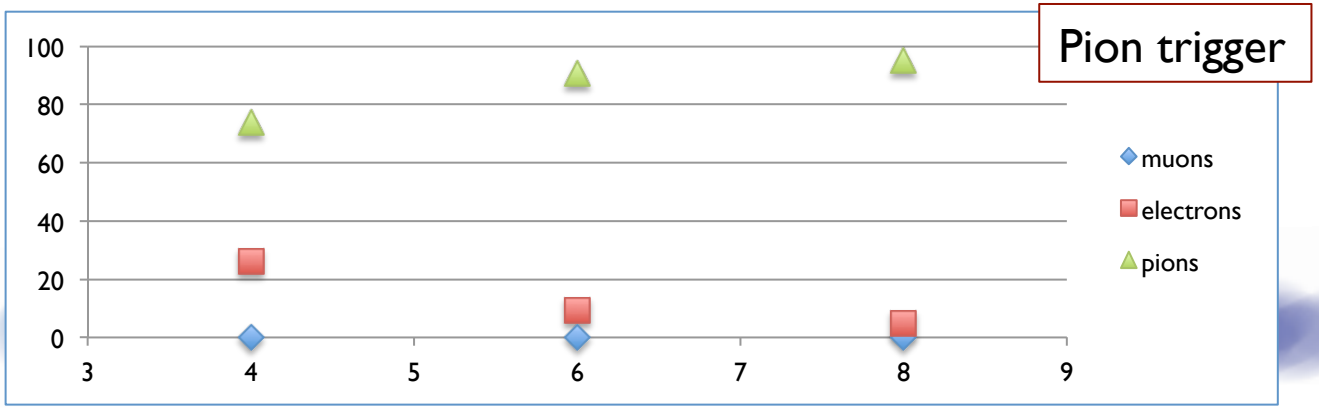


Energy	Pions at Crk	Muons at Crk	Muon Energy
1 GeV	30%	5%	0.5 – 1 GeV
2 GeV	50%	9%	1 – 2 GeV
4 GeV	72%	10%	2 – 4 GeV
6 GeV	80%	11%	3.5 – 6 GeV
8 GeV	85%	11%	4.5 – 8 GeV

Trigger studies (I)

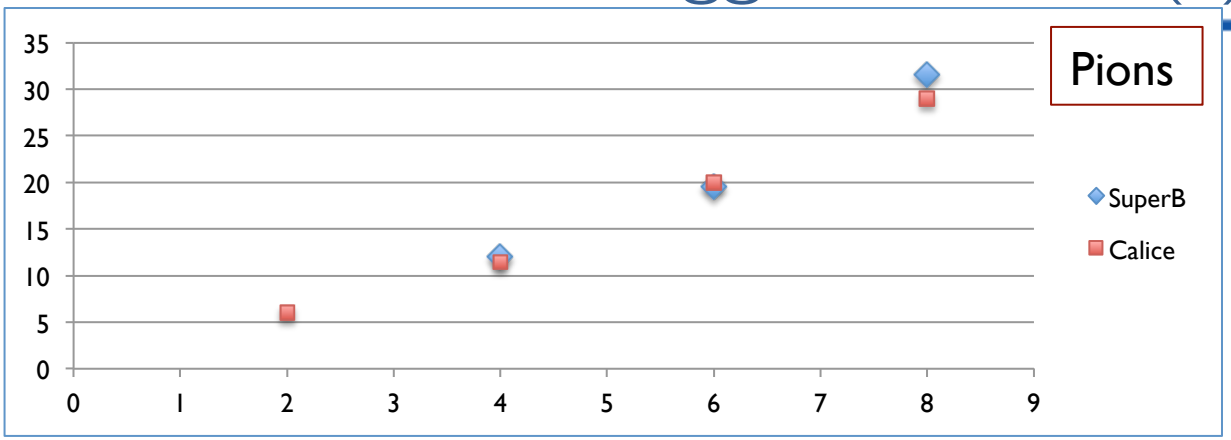


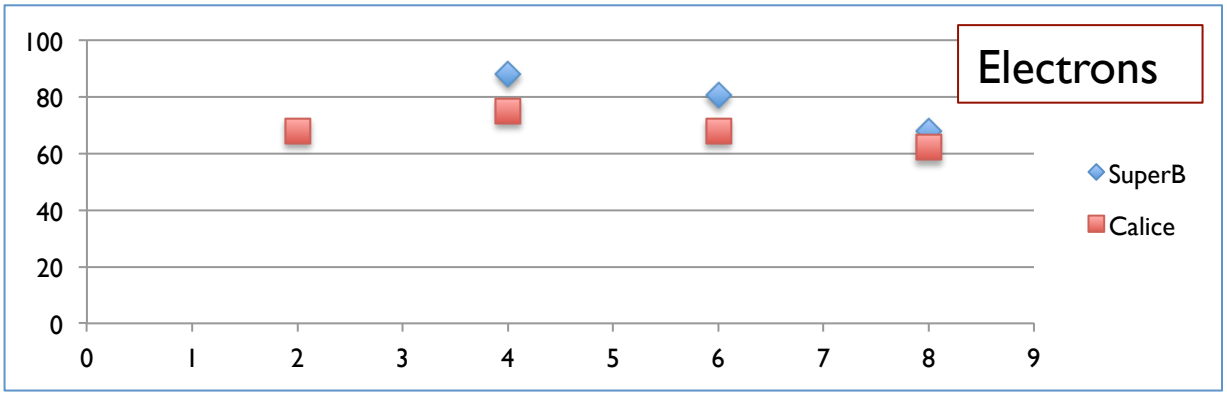


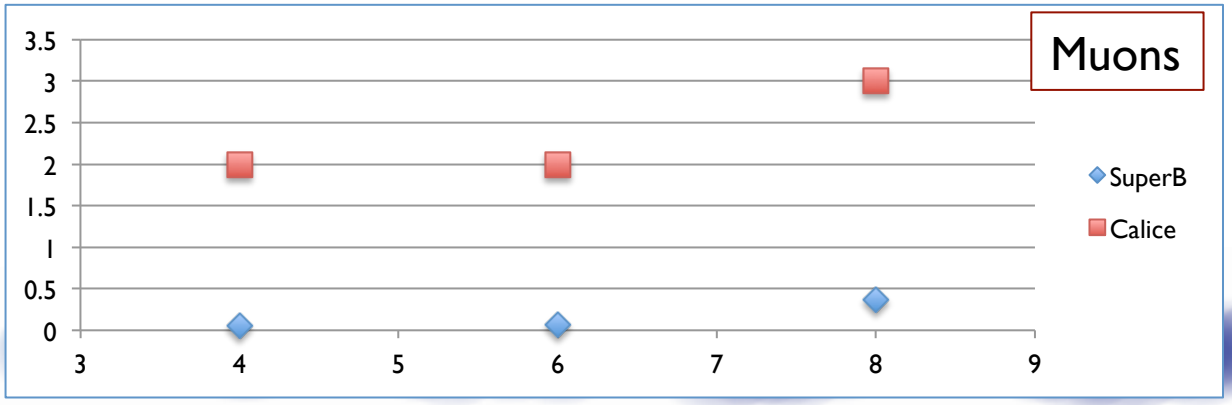


Fraction of events passing the offline ontime trigger selection over the total of events selected with a certain trigger.

Trigger studies (II)







Comparison of beam composition measurements with Calice results.

Data and Datasets

Energy	Total Events	Min Bias	Electrons	No Electrons	Muons	Pions
1 GeV	398124	384509	11031	373478		
2 GeV	221415	213727	4521	209206		
4 GeV	790682	690276	195107	495169	16760	478409
6 GeV	157050	129466	40073	89393	20202	69191
8 GeV	226089	204060	33369	170691	57447	113244
Det. Studies	113883	75996	12511	63485		
Total	**1907243**	**1698034**	**296612**	**1401422**		

data_8GeV_ThSc_Nitro.C
data_8GeV_S1S2_Nitro.C
data_8GeV_S1S2_C4F8O.C
data_8GeV_PiPi_Nitro.C
data_8GeV_PiPi_C4F8O.C
data_8GeV_MuMu_Nitro.C
data_8GeV_MuMu_C4F8O.C

data_6GeV_S1S2_Nitro.C
data_6GeV_PiPi_Nitro.C
data_6GeV_PiMu_Nitro.C
data_6GeV_MuSt_Nitro.C
data_6GeV_MuMu_Nitro.C
data_6GeV_MuAb_Nitro.C

data_4GeV_S1S2_Nitro.C
data_4GeV_S1S2_C4F8O.C
data_4GeV_PiPi_Nitro.C
data_4GeV_PiPi_C4F8O.C
data_4GeV_PiMu_C4F8O.C
data_4GeV_NoEl_Nitro.C
data_4GeV_NoEl_C4F8O.C
data_4GeV_MuMu_Nitro.C
data_4GeV_MuMu_C4F8O.C

data_2GeV_NoEl_C4F8O.C
data_1GeV_NoEl_Nitro.C

A couple of example from the logbook

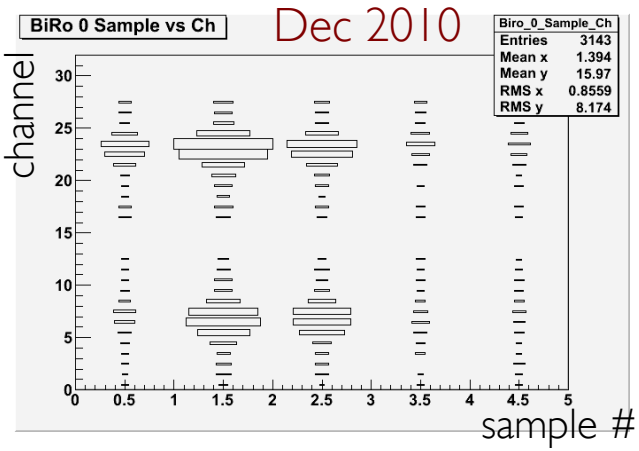
Run	Day	Start	Stop	Energy	Trigger	Events	Crk gas	Crk press (psi)	###	Note
1227	Jul 21	4:29		8	mu	10073	N	5.55	###0#	steady run
1231		4:56		8	pi	21392	N		#####	steady run
1232		5:13		8	mu	10315	N		###0#	thr scan 3.5
1237		5:45		8	mu	10463	N		###0#	thr scan 4.5
1240		6:15		8	mu	10150	N		###0#	thr scan 5.5
1241		6:44		8	mu	10280	N		###0#	thr scan 6.5
1242		7:15		8	mu	10631	N		###0#	thr scan 7.5
1243		7:45		8	mu	17129	N		###0#	steady run
1244		8:40		8	mu	20308	N		###0#	steady run
1245		9:40		8	mu	12661	N		###1#	steady run
1247		10:20		8	s1s2	20252	N		###1#	min bias
1248		10:48		8	pi	32279	N		####	steady run
1249		11:..	11:40	8	pi	28630	N		#####	steady run
1250		11:54		6	mu	8573	N		##10#	pressure CRK scan

Run	Day	Start	Stop	Energy	Trigger	Events	Crk gas	Crk press (psi)	###	Note
1316	Jul 23	14:55	15:55	4	mu	16014	N	scan	###0#	pressure CRK scan
1317		17:47	18:14	4	mu	6204	N	scan	###0#	pressure CRK scan
1320		18:16	21:10	4	mu	46689	N	Scan(19 finale)	###0#	pressure CRK scan
1324		21:30	22:11	4	pi	60169	N	19	#####	steady run
1325		22:13	22:53	4	s1xs2	35544	N	–	###1#	steady run

Run	Day	Start	Stop	Energy	Trigger	Events	Crk gas	Crk press (psi)	###	Note
1326	Jul24	5:35	6:35	4	mu	15301	N	15-16 psi	###0#	steady run
1328		6:38	7:38	4	mu	14420	N	16-17,5	###0#	steady run
1330		7:50	8:07	4	mu	4542	N	05/17/18	###0#	steady run
1333		8:11	?	4	pi	33792	N	18-19	#####	steady run
1335		8:41		4	s1xs2	24158	N	19	#####	steady run

A first look at the prototype data

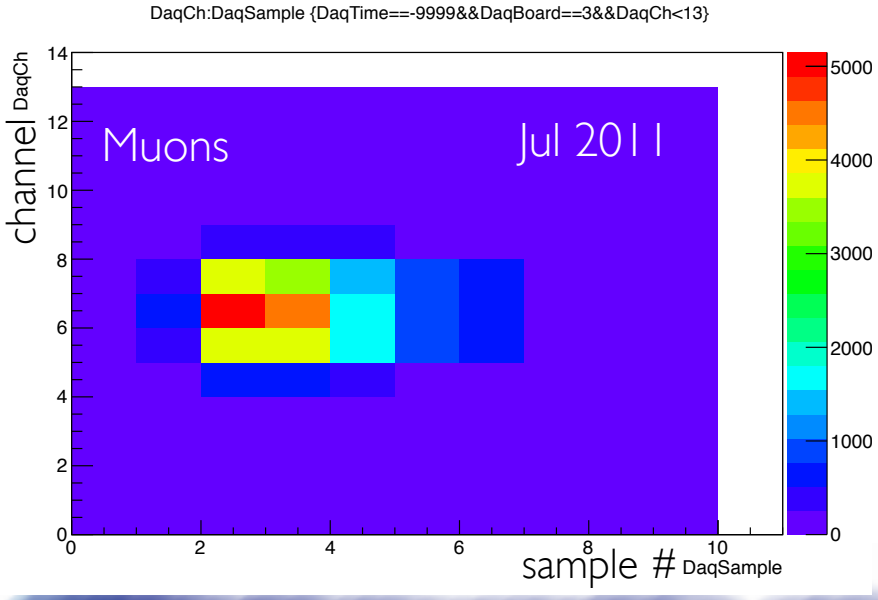
Increasing of the number of samples

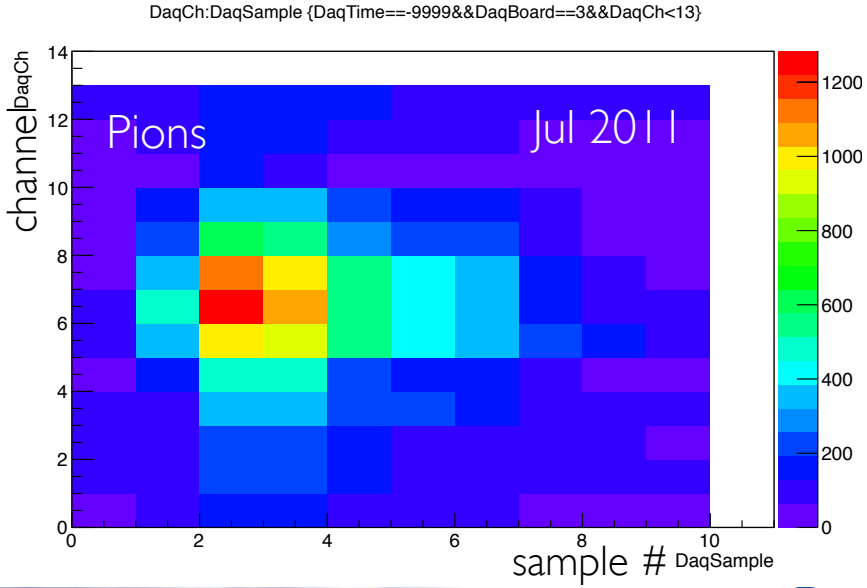


That's a feature of the Binary Readout that could be very helpful for the muon ID.

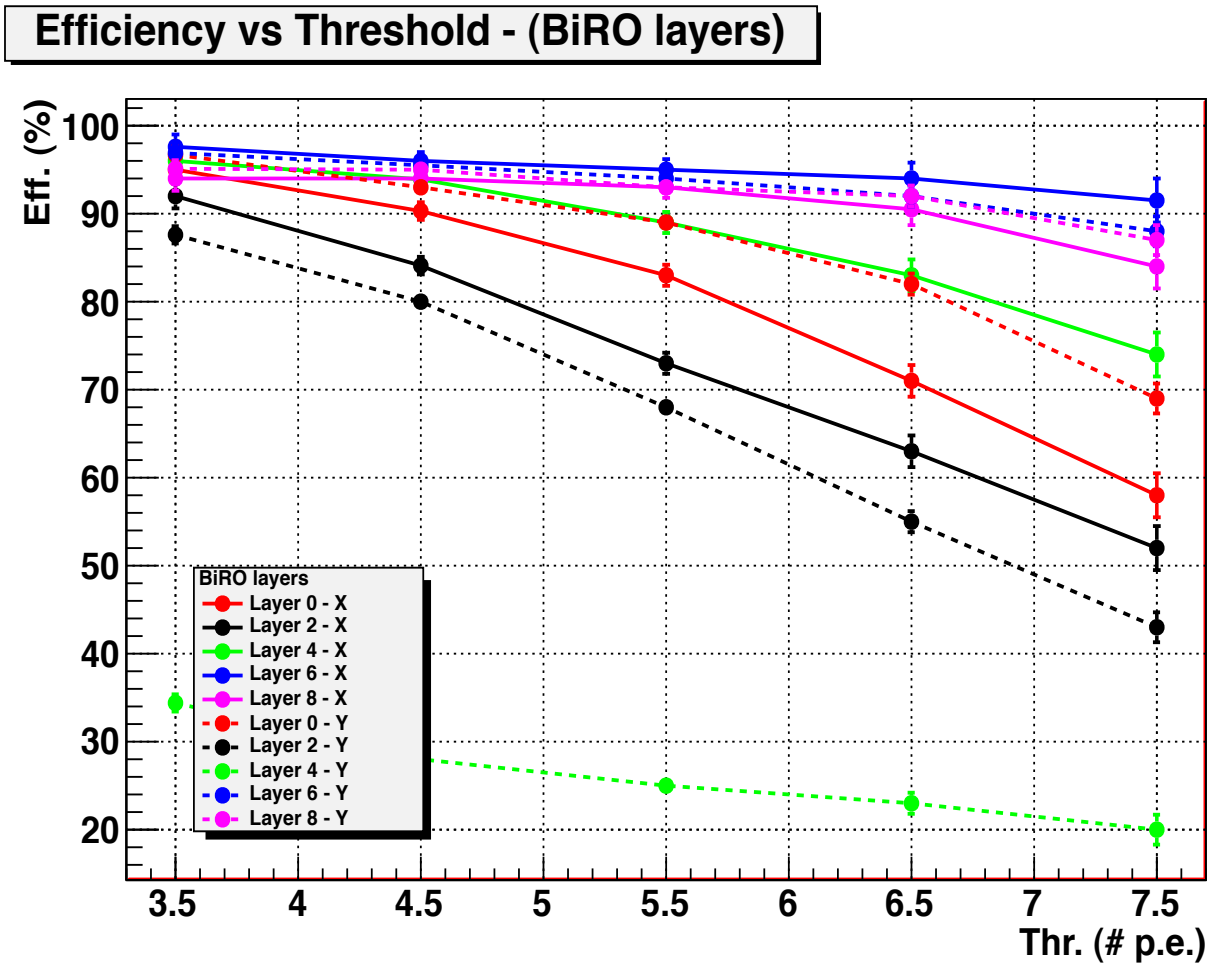
The number of samples has been doubled since the December test, allowing the possibility to detect the slowest part of the hadronic shower.

Results are not always easy to understand.



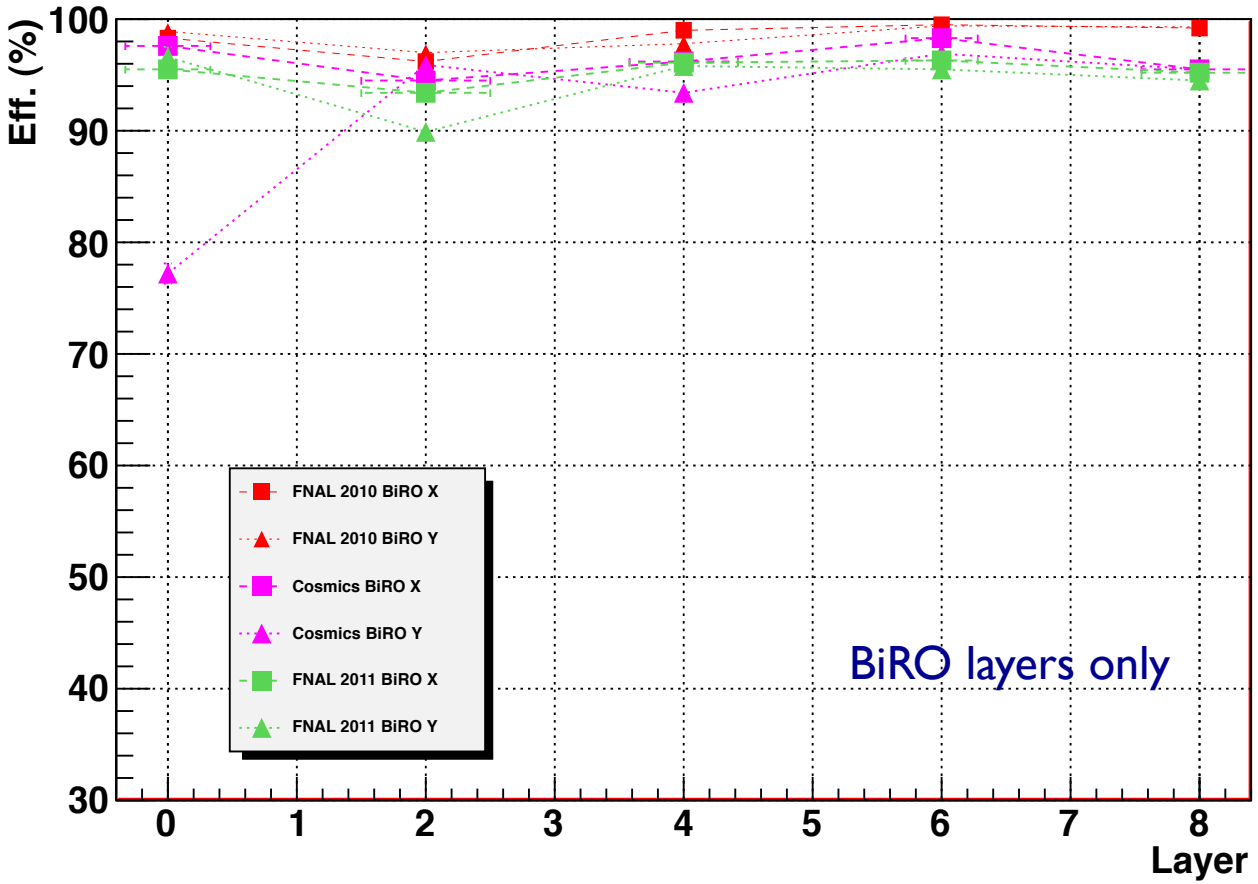


Efficiency measurement



- BiRO layer efficiency as function of the threshold.
- Efficiency > 90% at 4.5 p.e. (except ½ layer)
- That does not include the dead channel recovery done by Roberto Malaguti.

Efficiency measurement



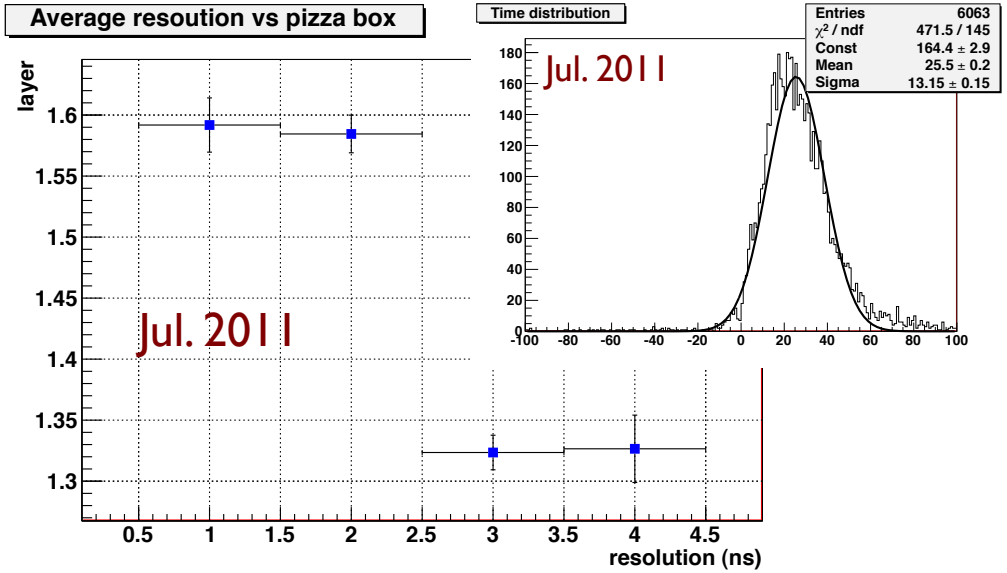
Raw (sandwich) detection efficiency calculated using muon events.

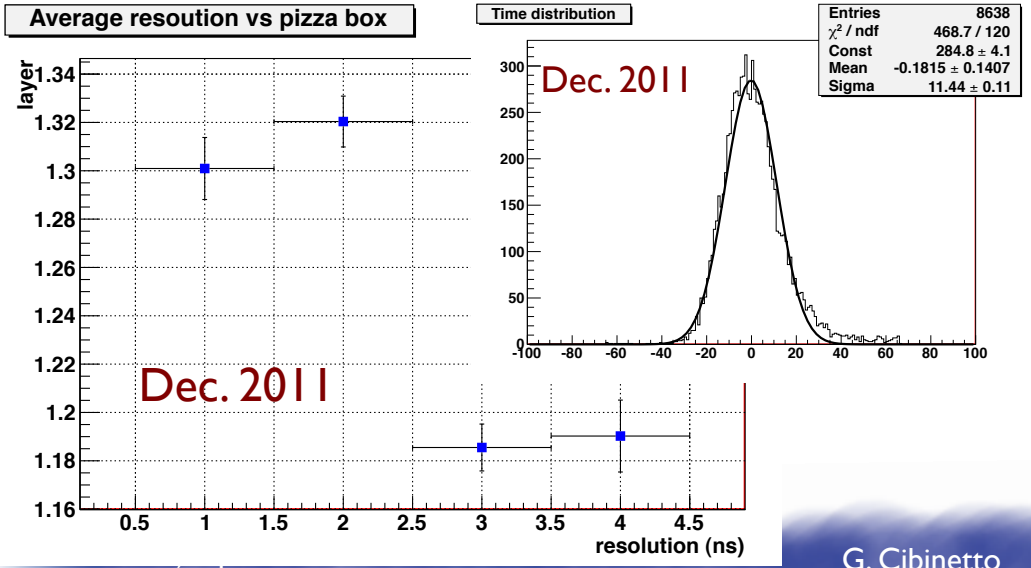
Performances are confirm previous results.

Efficiency for Time readout modules (not shown) are also in agreement with previous results.

More precise efficiency evaluation (done fitting the tracks) is under way: see Jarek talk for more details.

Preliminary time resolution





Time resolution got worst of about 0.3ns in all the time readout sections.

It's a bit strange, and can be due to some timing issue of the trigger (?).

Anyway more investigation is needed

Summary and conclusions

- Our prototype was fine
- Main problems from the FNAL facility
- Other issues from the trigger going down with the momentum
- To be meaningfully analyzed the data sample must have several tens of kevents: we should avoid to take small sample with the same condition.
- Next time we don't have to reinvent the wheel, my proposal is to do
  - (4, 3 and 2 GeV)
  - with no TOF but with MWPC
  - with C4F8O