Beam Test: data for analysis

G. Cibinetto

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









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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.





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Rate Meter log panel

								Rat	te Meter								
Laver 0 -	BIRO	Laver 1 –	TDC	Laver 2 –	BIRO	Laver 3 –	TDC	Laver 4 -	BIRO	Laver 5 –	TDC	Laver 6 -	BIRO	Laver 7 –	TDC	Laver 8 –	BIRO
0-0 / 0-0	0-16 / 0-16	1-0 / 5-0	1-16 / 5-16	2-0 / 1-0	2-16 / 1-16	3-0 / 6-0	3-16 / 6-16	4-0 / 2-0	4-16 / 2-16	5-0 / 7-0	5-16 / 7-16	6-0 / 3-0	6-16 / 3-16	7-0 / 8-0	7-16 / 8-16	8-0 / 4-0	8-16 / 4-1
3517	12068	8153	4053	63221	1487	2941	56209	61353	15774	69309	1673	40161	62341	690	56890	13099	4427
0-1 / 0-1	0-17 / 0-17	1-1 / 5-1	1-17 / 5-17	2-1 / 1-1	2-17 / 1-17	3-1 / 6-1	3-17 / 6-17	4-1 / 2-1	4-17 / 2-17	5-1 / 7-1	5-17 / 7-17	6-1 / 3-1	6-17 / 3-17	7-1 / 8-1	7-17 / 8-17	8-1 / 4-1	8-17 / 4-1
1485	7214	9181	20570	146654	76544	1551	60143	2987	4697	0	29724	89940	49185	3275	13515	9899	26332
0-2 / 0-2	0-18 / 0-18	1-2 / 5-2	1-18 / 5-18	2-2 / 1-2	2-18 / 1-18	3-2 / 6-2	3-18 / 6-18	4-2 / 2-2	4-18 / 2-18	5-2 / 7-2	5-18 / 7-18	6-2 / 3-2	6-18 / 3-18	7-2 / 8-2	7-18 / 8-18	8-2 / 4-2	8-18 / 4-1
2642	8384	13185	28929	5990	2194	8812	49606	3958	14534	9701	16231	86462	70146	1632	25301	5468	416
0-3 / 0-3	0-19 / 0-19	1-3 / 5-3	1-19 / 5-19	2-3 / 1-3	2-19 / 1-19	3-3 / 6-3	3-19 / 6-19	4-3 / 2-3	4-19 / 2-19	5-3 / 7-3	5-19 / 7-19	6-3 / 3-3	6-19 / 3-19	7-3 / 8-3	7-19 / 8-19	8-3 / 4-3	8-19 / 4-1
5296	31605	43481	27285	907	3983	5007	24253	944	119	15370	11424	86879	44887	1282	9076	10042	5969
0-4 / 0-4	0-20 / 0-20	1-4 / 5-4	1-20 / 5-20	2-4 / 1-4	2-20 / 1-20	3-4 / 6-4	3-20 / 6-20	4-4 / 2-4	4-20 / 2-20	5-4 / 7-4	5-20 / 7-20	6-4 / 3-4	6-20 / 3-20	7-4 / 8-4	7-20 / 8-20	8-4 / 4-4	8-20 / 4-2
23350	42597	23530	48176	6339	3401	14366	57723	2607	67390	6494	8756	27539	36420	299	1988	8612	13280
0-5 / 0-5	0-21 / 0-21	1-5 / 5-5	1-21 / 5-21	2-5 / 1-5	2-21 / 1-21	3-5 / 6-5	3-21 / 6-21	4-5 / 2-5	4-21 / 2-21	5-5 / 7-5	5-21 / 7-21	6-5 / 3-5	6-21 / 3-21	7-5 / 8-5	7-21 / 8-21	8-5 / 4-5	8-21 / 4-2
648	74928	11141	21480	24	12422	84	25752	47	118873	5904	23208	105518	33518	1078	1538	12727	2421
0-6 / 0-6	0-22 / 0-22	1-6 / 5-6	1-22 / 5-22	2-6 / 1-6	2-22 / 1-22	3-6 / 6-6	3-22 / 6-22	4-6 / 2-6	4-22 / 2-22	5-6 / 7-6	5-22 / 7-22	6-6 / 3-6	6-22 / 3-22	7-6 / 8-6	7-22 / 8-30	8-6 / 4-6	8-22 / 4-2
2949	29743	9457	37818	4013	5266	9248	73819	1433	86385	8401	28283	70814	90089	27	2069	4037	12366
0-7/0-7	0-23 / 0-23	1-7 / 5-7	1-23 / 5-23	2-7 / 1-7	2-23 / 1-23	3-7 / 6-7	3-23 / 6-23	4-7 / 2-7	4-23 / 2-23	5-7 / 7-7	5-23 / 7-23	6-7 / 3-7	6-23 / 3-23	7-7 / 8-7	7-23 / 8-23	8-7 / 4-7	8-23 / 4-2
3855	59840	23617	13342	163	6794	2035	45471	31867	5651	16359	13030	62696	107343	1207	7346	2618	18559
0-8 / 0-8	0-24 / 0-24	1-8 / 5-8	1-24 / 5-24	2-8 / 1-8	2-24 / 1-24	3-8 / 6-8	3-24 / 6-24	4-8 / 2-8	4-24 / 2-24	5-8 / 7-8	5-24 / 7-24	6-8 / 3-8	6-24 / 3-24	7-8 / 8-8	7-24 / 8-24	8-8 / 4-8	8-24 / 4-2
6914	1273	30184	4914	1293	29226	30952	42960	24602	22116	3230	17707	48507	52213	3118	10256	5585	10476
0-9 / 0-9	0-25 / 0-25	1-9 / 5-9	1-25 / 5-25	2-9 / 1-9	2-25 / 1-25	3-9 / 6-9	3-25 / 6-25	4-9 / 2-9	4-25 / 2-25	5-9 / 7-9	5-25 / 7-25	6-9 / 3-9	6-25 / 3-25	7-9 / 8-9	7-25 / 8-25	8-9 / 4-9	8-25 / 4-2
2357	45177	14754	95841	1068	29058	588	28221	39488	1668	4115	59334	51517	95344	61	9865	4619	9790
0-10 / 0-10	0-26 / 0-26	1-10 / 5-10	1-26 / 5-26	2-10 / 1-10	2-26 / 1-26	3-10 / 6-10	3-26 / 6-26	4-10 / 2-10	4-26 / 2-26	5-10 / 7-10	5-26 / 7-26	6-10 / 3-10	6-26 / 3-26	7-10 / 8-10	7-26 / 8-26	8-10 / 4-10	8-26 / 4-2
9026	122908	25483	9679	2775	7398	10189	153153	24496	70482	6089	14454	37508	288153	1789	7095	34022	35035
0-11 / 0-11	0-27 / 0-27	1-11 / 5-11	1-27 / 5-27	2-11 / 1-11	2-27 / 1-27	3-11 / 6-11	3-27 / 6-27	4-11 / 2-11	4-27 / 2-27	5-11 / 7-11	5-27 / 7-27	6-11 / 3-11	6-27 / 3-27	7-11 / 8-11	7-27 / 8-27	8-11 / 4-11	8-27 / 4-2
6385	124358	12128	1578	2293	783	6719	102363	45432	22101	4250	2	52669	100499	2214	24230	19368	26147
0-12 / 0-12		1-12 / 5-12	1-28 / 5-28	2-12 / 1-12		3-12 / 6-12	3-28 / 6-28	4-12 / 2-12		5-12 / 7-12	5-28 / 7-28	6-12 / 3-12		7-12 / 8-12	7-28 / 8-28	8-12 / 4-12	
15338		0	7396	103		14547	70985	16248		1551	20961	101383		1819	2	7517	
15550		1-13 / 5-13	1-29 / 5-29	105		3-13 / 6-13	3-29 / 6-29	10240		5-13 / 7-13	5-29 / 7-29	101505		7-13 / 8-13	7-29 / 8-29	1311	
		13442	16702			369	219542			4435	21899			75382	32659		





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.



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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



Trigger logics

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



Timing of Cherenkov Signal (I)

Lowering the Muon Cherenkov (CI) beam 0.35 momentum the 8 GeV Cherenkov 0.3 6 GeV signals get 4 GeV 0.25 2 GeV worst and difficult to 0.2 understand. 0.15 0.1 That is the Cherenkov 0.05 used to 0 -3500 -3000 -2500 separate muons and pions.



-1500

Time (0.1 ns)

-2000

hcrk8

16203

-2764

153.9

Entries

Mean

RMS

Timing of Cherenkov Signal (II)





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	Energy	Pions at Crk	Muons at Crk	Muon Energy
in this table	I GeV	30%	5%	0.5 – I GeV
	2 GeV	50%	9%	I – 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_SIS2_Nitro.C data_8GeV_SIS2_C4F8O.C data_8GeV_PiPi_Nitro.C data_8GeV_PiPi_C4F8O.C data_8GeV_MuMu_Nitro.C data_8GeV_MuMu_C4F8O.C

data_6GeV_SIS2_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_SIS2_Nitro.C data_4GeV_SIS2_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_IGeV_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	Τ
1316	Jul 23	14:55	15:55	4	mu	16014	N	scan	₽ ###0#	pressure CRK scan	Τ
1317		17:47	18:14	4	mu	6204	N	scan	₽###0 #	pressure CRK scan	Ι
1320		18:16	21:10	4	mu	46689	N	Scan(19 finale)	₽###0 #	pressure CRK scan	Ι
1324		21:30	22:11	4	pi	60169	N	19	o #####	steady run	Ι
1325		22:13	22:53	4	s1xs2	35544	N	-	₽###1 #	steady run	Τ
											Ι
											Т
Run	Day	Start	Stop	Energy	Trigger	Events	Crk gas	Crk press (psi)	*****	Note	+
Run 1326	Day Jul24	Start 5:35	Stop 6:35	Energy 4	Trigger mu	Events 15301	Crk gas N	Crk press (psi) 15-16 psi	₩₩₩₩₩₩ ₩###0#	Note steady run	
Run 1326 1328	Day Jul24	Start 5:35 6:38	Stop 6:35 7:38	Energy 4 4	Trigger mu mu	Events 15301 14420	Crk gas N N	Crk press (psi) 15-16 psi 16-17,5	••••••• •###0# •###0#	Note steady run steady run	
Run 1326 1328 1330	Day Jul24	Start 5:35 6:38 7:50	Stop 6:35 7:38 8:07	Energy 4 4 4	Trigger mu mu mu	Events 15301 14420 4542	Crk gas N N N	Crk press (psi) 15-16 psi 16-17,5 05/17/18	••••••• •###0# •###0# •###0#	Note steady run steady run steady run	
Run 1326 1328 1330 1333	Day Jul24	Start 5:35 6:38 7:50 8:11	Stop 6:35 7:38 8:07 ?	Energy 4 4 4 4	Trigger mu mu mu pi	Events 15301 14420 4542 33792	Crk gas N N N N	Crk press (psi) 15-16 psi 16-17,5 05/17/18 18-19	₩₩₩₩ ₩₩₩0 ₩₩₩0 ₩₩₩0 ₩ ₩₩₩0 ₩	Note steady run steady run steady run steady run	
Run 1326 1328 1330 1333 1335	Day Jul24	Start 5:35 6:38 7:50 8:11 8:41	Stop 6:35 7:38 8:07 ?	Energy 4 4 4 4 4 4	Trigger mu mu mu pi s1xs2	Events 15301 14420 4542 33792 24158	Crk gas N N N N N N	Crk press (psi) 15-16 psi 16-17,5 05/17/18 18-19 19	************************************	Note steady run steady run steady run steady run steady run	

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A first look at the prototype data

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Increasing of the number of samples

DaqCh:DaqSample {DaqTime==-9999&&DaqBoard==3&&DaqCh<13}

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.

DaqCh:DaqSample {DaqTime==-9999&&DaqBoard==3&&DaqCh<13}

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