EMC SUMMARY

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Mainly devoted to Beam Test (Alessandro, Bertrand, Chi-Hsiang, Davide, Elisa, Stefano
+
Update on LYSO, mechanics and electronics (RenYuan, Michel, Valerio)
+
Backward EMC status and physics impact (Gerald, Elisa, Sasha)

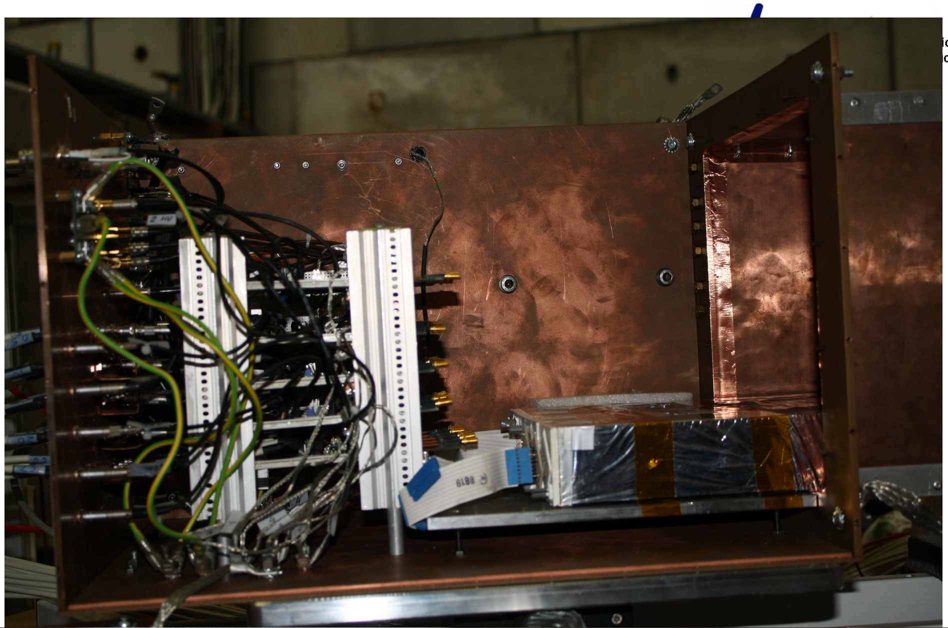
Test Beam at CERN October 11th – 31st

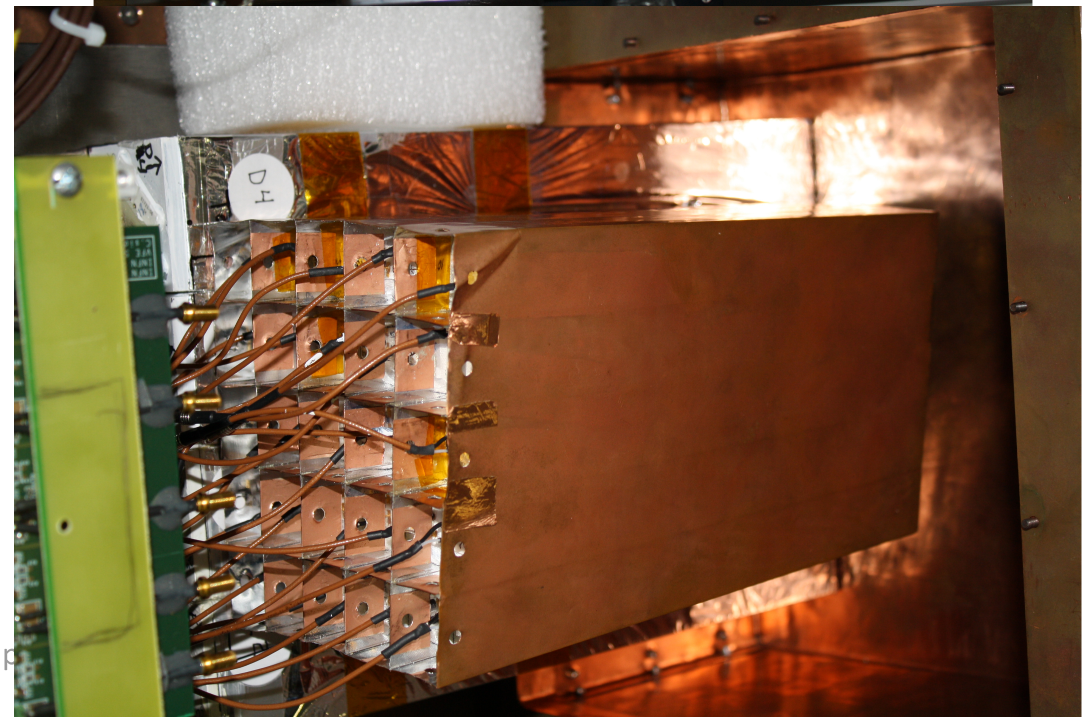
SETUP

	Ring 6	Ring 7	Ring 8	Ring 9	Ring 10
Shaper 0 PiN	Sipat 13	Sipat 7-4	Sipat 12	SG X	SG X
Shaper 1 APD	Sipat 14	Sipat 7-3	SG 005-3	SG X	SG X
Shaper 2 APD	Sipat 17	Sipat 18	Sipat 11	SG X	SG X
Shaper 3 APD	Sipat 15	Sipat 19	SG 005-4	SG X	SG X
Shaper 4 APD	Sipat 16	Sipat 7-5	Sipat L9	SG X	SG X

(green)	Temperature 1
(blue)	Temperature 2
(yellow)	Temperature 3
(red)	Temperature 4
(purple)	Temperature 5

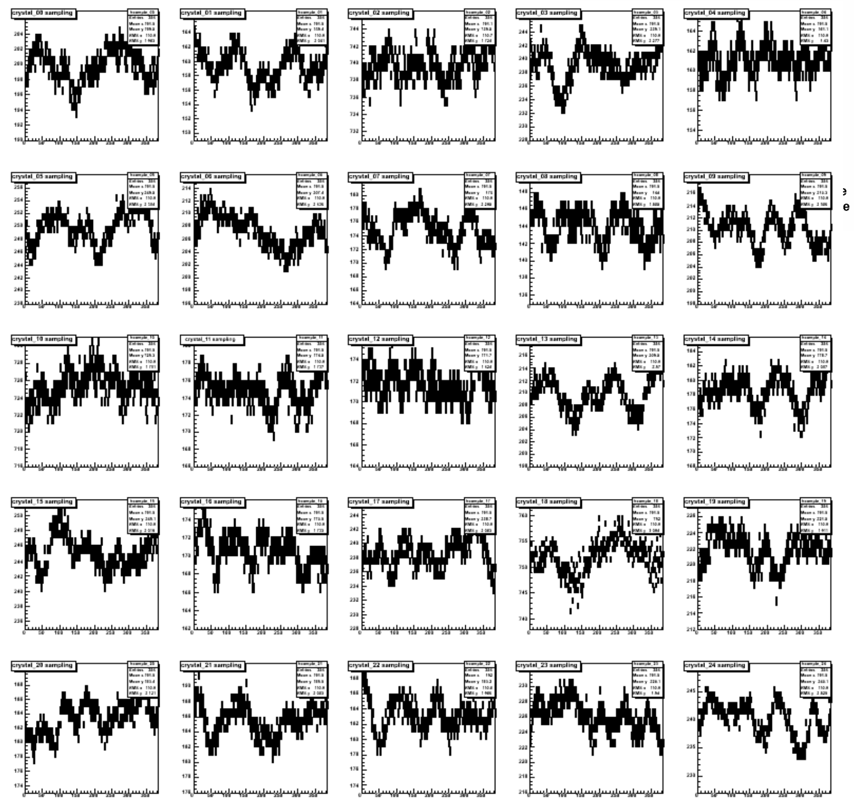
	Ring 6	Ring 7	Ring 8	Ring 9	Ring 10
Shaper 0 PiN	Ch5	Ch4	Ch3	Ch2	Ch1
Shaper 1 APD	Ch10	Ch9	Ch8	Ch7	Ch6
Shaper 2 APD	Ch15	Ch14	Ch13	Ch12	Ch11
Shaper 3 APD	Ch20	Ch19	Ch18	Ch17	Ch16
Shaper 4 APD	Ch25	Ch24	Ch23	Ch22	Ch21





Data collected at energies of:
1 – 1.5 – 2 – 3 – 4 GeV
+ data with material (Aluminum and quartz) in front of the matrix.
Percentage of electrons in the beam decreasing with the energy (65% at 1 GeV, 25% at 4 GeV)

Test Beam cont'd



Noise

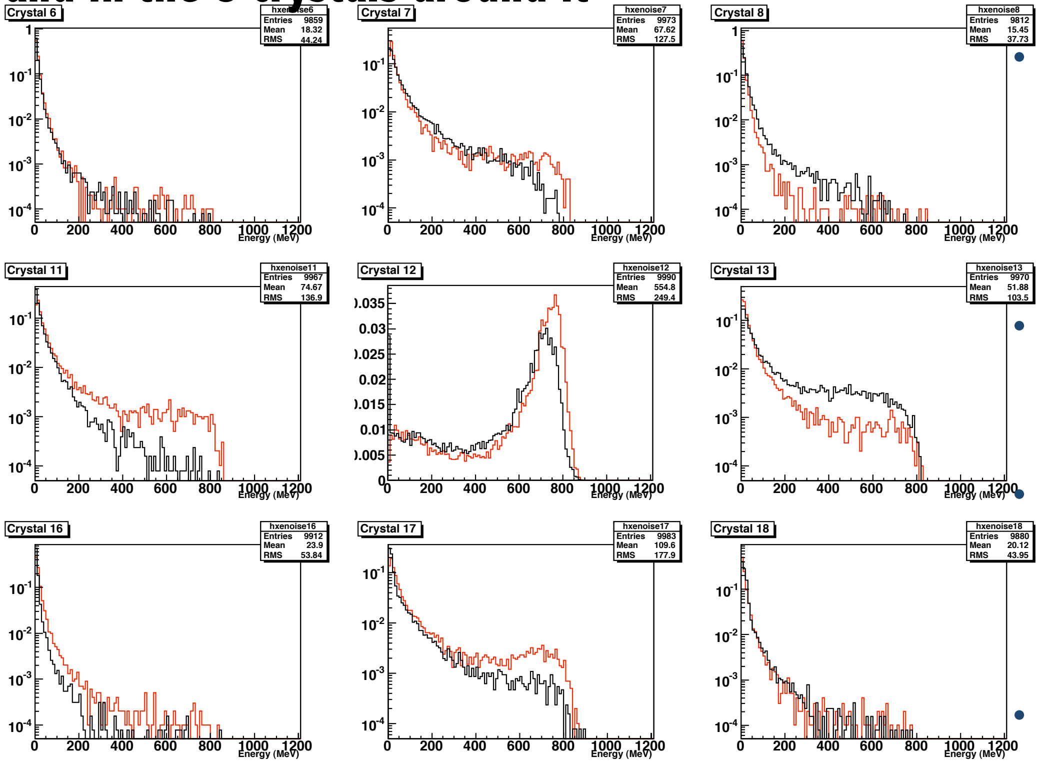
- With this first data we found a resolution worse than what we expected from MC simulation (5% against ~2%)
- We found noise in the signal baseline
- we decided to raise the APD voltage (and accordingly the gain) to increase the S/N
  - APD HV from Run349 ~380V

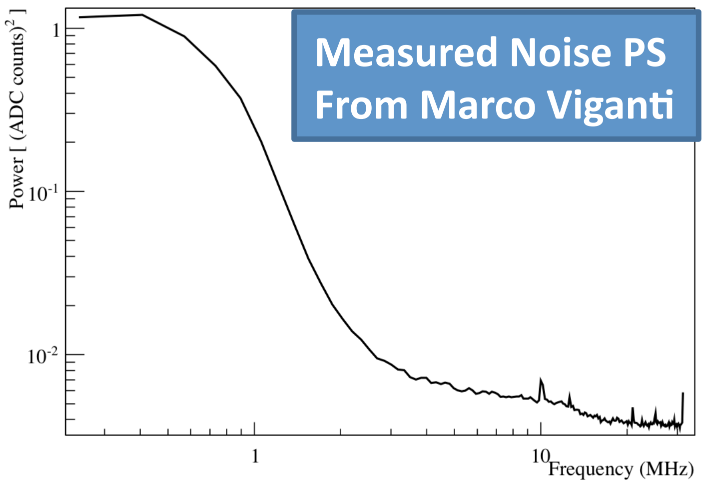
- With this new APD Bias we restart from the intercalibration:
  - Run from 350 to 387: scan centering the beam on each crystals with APD
- Resolution at 1GeV is now ~3.6%

- With this configuration we took also data with material in front of the matrix (run 392-397, 403-406, 446-447):
  - Alluminium: 20mm, 40mm and 80mm
  - Quartz: 5mm, 15mm and 30mm
  - Active Quartz Bar (DIRC like)

First look at the data….

Electron energy deposited in the central crystal (12) and in the 8 crystals around it



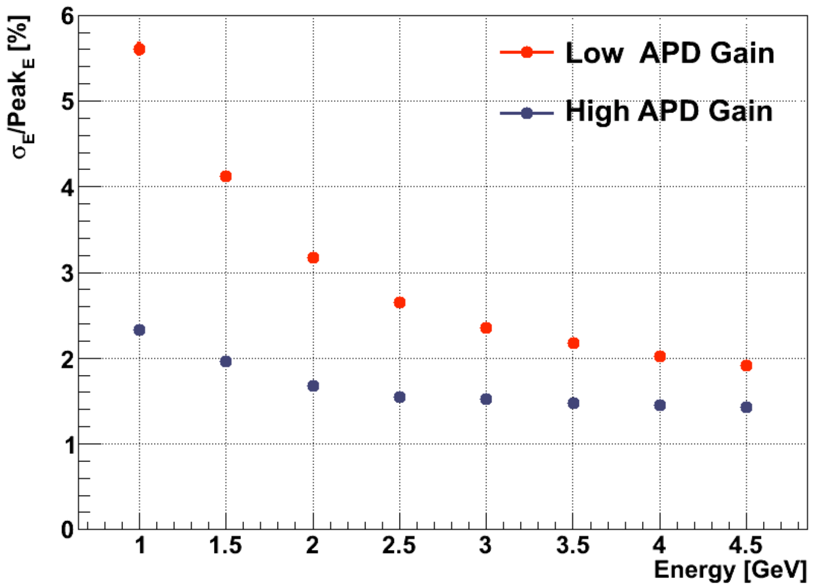


MC tuning is under way

- **Crystals LY non-uniformity**
  - Use Gauss distribution to assign non uniformity from RY measuremnts
    - Mean = 4.5% RMS = 0.6%
- **Photstatistics**
  - 450 p.e./MeV
- **Intercalibartion Error**
  - Default is 1% (maybe to small)
  - Need to be estimated correctly
- **Beam Energy Spread**
  - 0.7% from T10 line desciprtion
- **Noise and Signal**
  - Use measured noise PS for each crystal (from Marco Vignati)
  - Use ADC counts/MeV as measured in the data
  - Emulate ADC sampling procedure
    - Add fixed shape Gauss function to random noise accoridng to PS and noise RMS

Resolution vs Energy

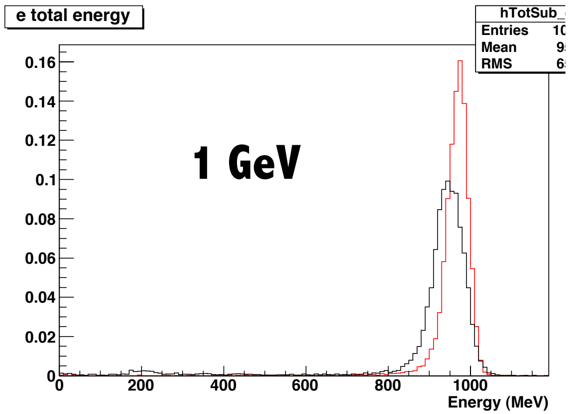
Perugia INFN Istituto Nazionale di Fisica Nucleare

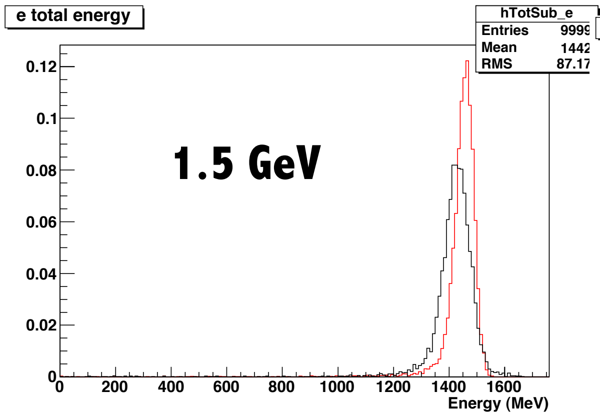


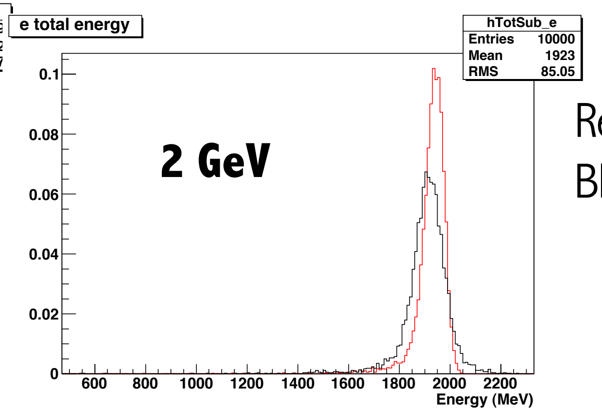
-Beam energy spread → Significant dependece of resolution on bema energy spread (nominal 0.7%)

-Impact beam position in the crystal → Small dependence of resolution on beam position

-Intercalibration error → Precise Intercalibration Error estimate may be an issue for High APD gain, peak position is also affected by intercalibration error







Red MC
Black data

Resolution from data:

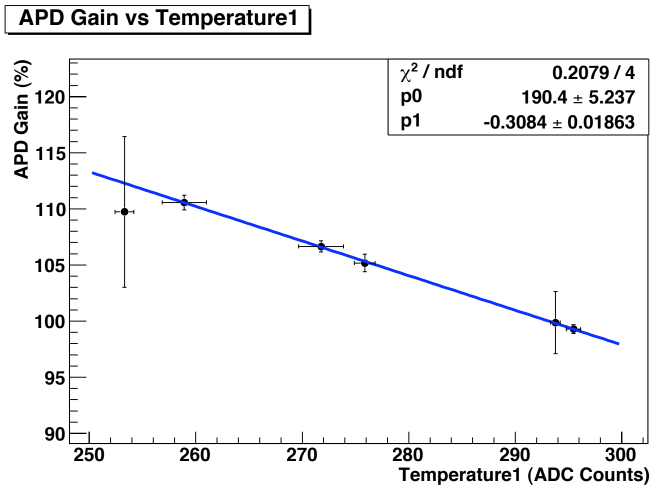
Low Gain → in agreement with MC at 1 GeV, 1.5 GeV, and 2 GeV then data tend to be flat, intercalibration effect?

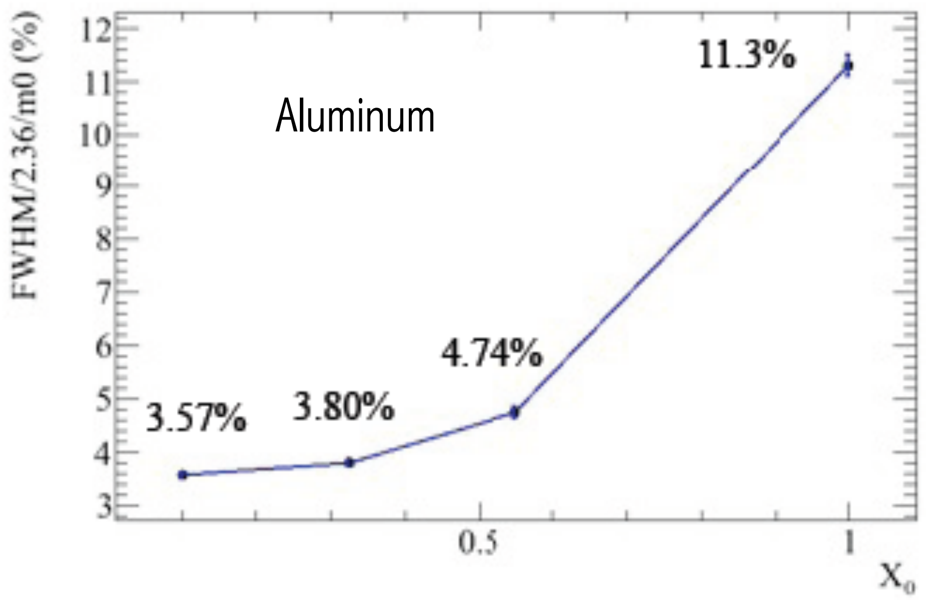
High gain→MC and data differ by about 1 %

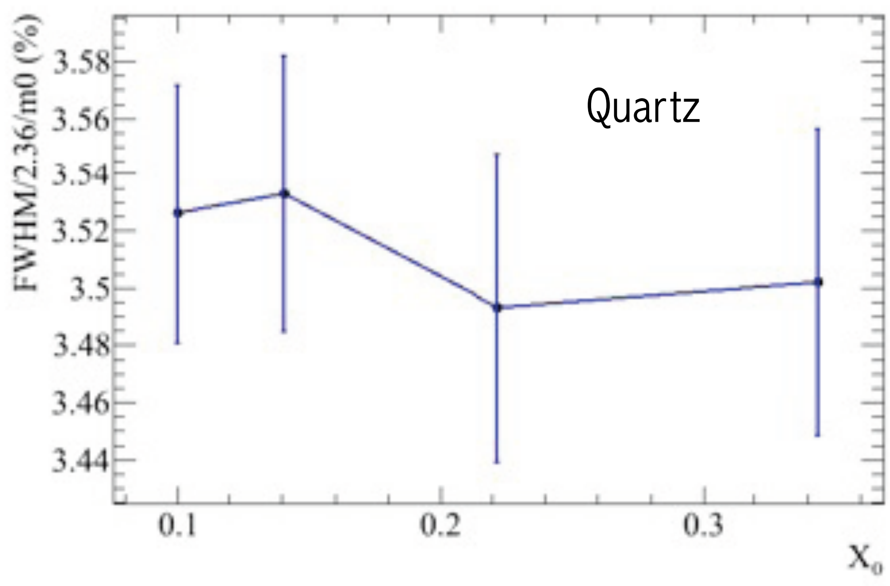
Material in front of the calorimeter

Aluminum blocks (~3feet? away)		
run	thickness	X0
350	0	0
393	20 mm	0.22
395	2×20 mm	0.45
392	4×20 mm	0.90

Quartz plates (close to the box)		
run	thickness	X0
407	0	0
405	5 mm	0.041
404	15 mm	0.122
403	30 mm	0.244



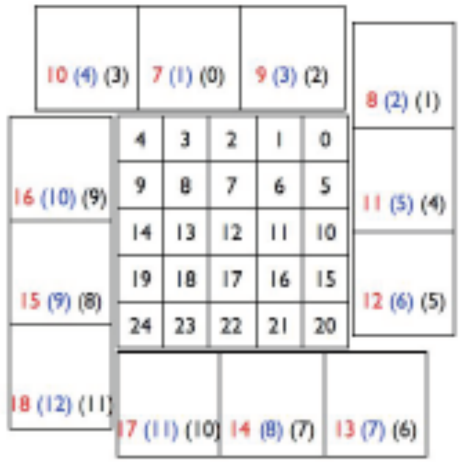




Include also CsI crystals in the analysis

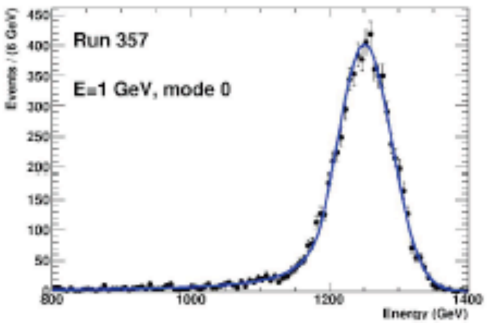
0) no CsI data
1) include energy from all crystals (except dead ones)
2) include energy from crystal only if above a certain threshold (>10 MeV*)
3) include only most energetic crystal if energy > 10 MeV*
4) veto mode, use the event only if energy in all Csi crystals < 20 MeV*
   (similar result with vetoing the most energetic crystal < 10 MeV)

Crystal layout viewed from upstream of the beam

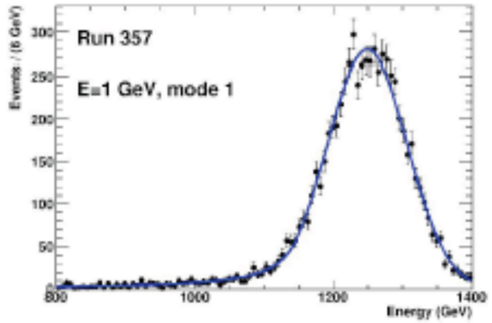


Black: software channel # = ADC minus 7

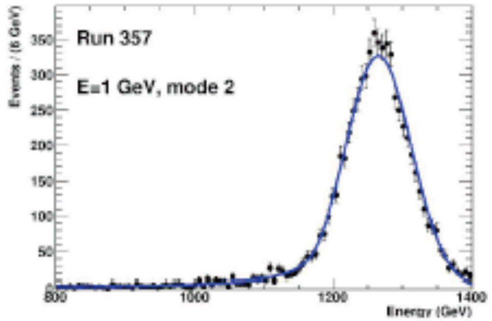
no Csi



All

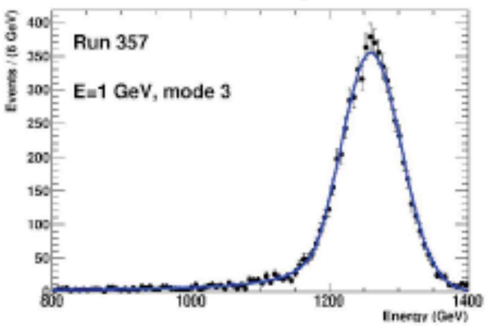


All if above threshold

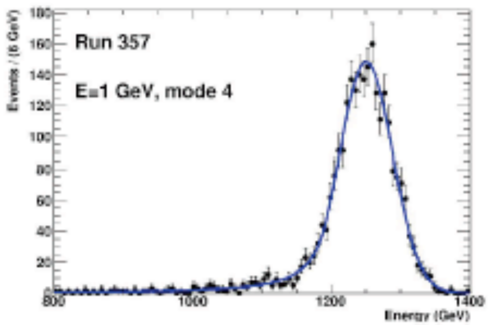


Improve the noise in order to use CsI array in a useful mode.

Most energetic



Veto mode



Mode	Core resolution
0	3.14 ± 0.05 %
1	4.63 ± 0.06 %
2	3.76 ± 0.04 %
3	3.46 ± 0.04 %
4	3.05 ± 0.04 %

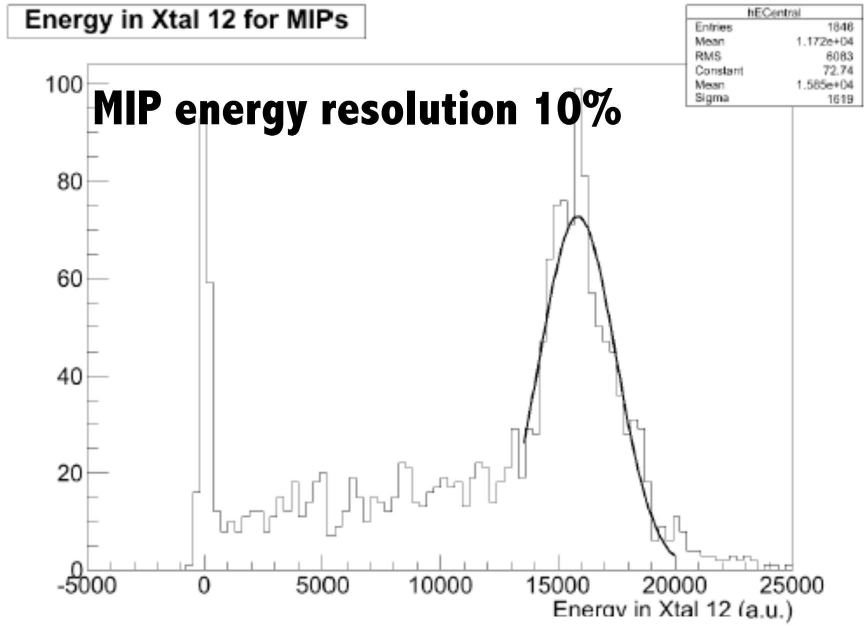
At low energy slight improvement is present for run where showers are near the boundaries of the matrix

Slight improvement in veto mode

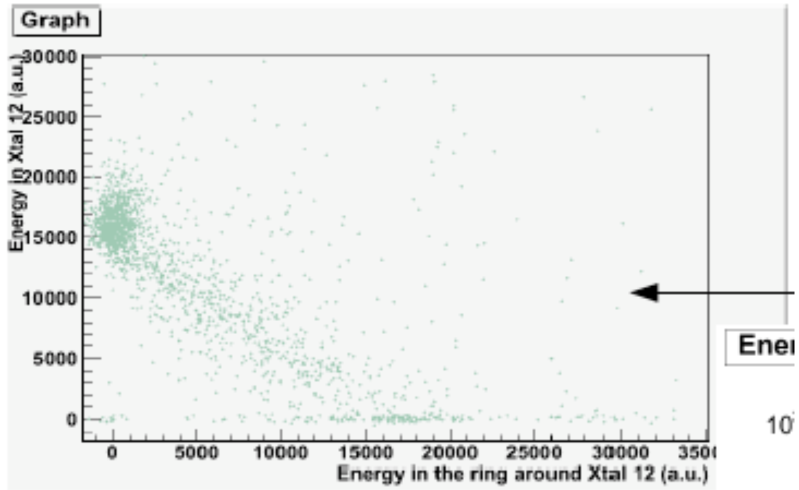
There is a non-negligible systematic coming from definition of fit range

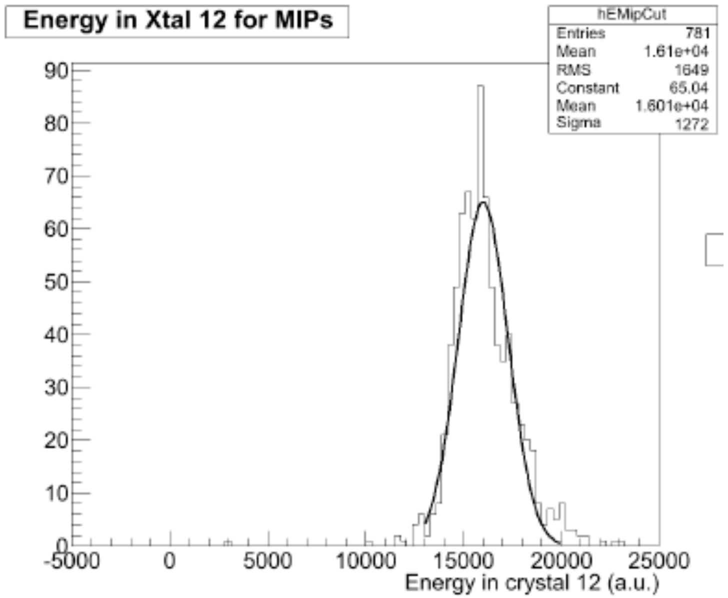
First look at the data cont'd (MIP study)

MIP energy resolution 10%

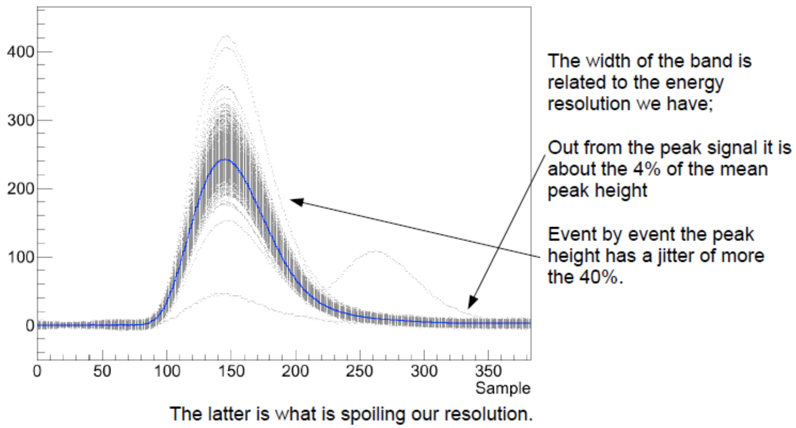


MIP energy is not contained in only one crystal





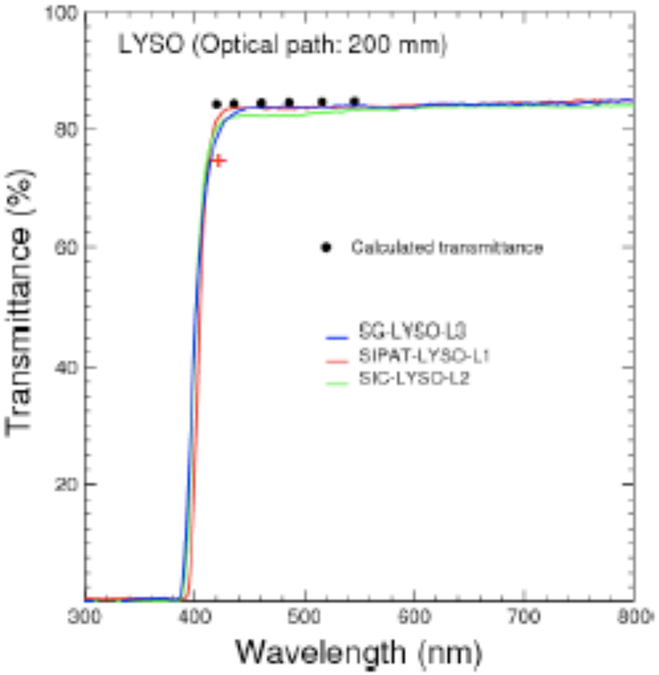
Resolution of the MIP asking for zero energy in the ring around the hit crystal is 8%



Waveform of the signal has been studied but the lack of resolution seems not to be totally explained by noise or shaper instability → geometrical effects? LY uniformity? Under study

Update on LYSO

- LYSO vendors – Saint-Gobain and SIPAT used in test beam. Recent large crystal (2.5 × 2.5 × 20 cm^3 from SIC looks good, light output is very good. Ordering a tapered crystal.



Sample ID	Candle1 (618ch)
SG-3 (350ch)	56.6
SIPAT-1 (289ch)	46.8
SIPAT-5 (360ch)	58.3
SIPAT-6 (269ch)	43.5
SIC-2 (402ch)	65.0

- LYSO uniformity simulations – 5% uniformity is probably sufficient; studies in lab continuing to optimize uniformity vs light loss

Update on mechanics

Mechanical design is already well advanced → next step is the Finite Element Analysis (FEA)

- The proposed analysis purpose is the best possible knowledge of the state of **stress and strain of the shell**
- The **elastic properties of the super element** (first deduced from **computation**, then obtained by the proposed **load tests**) are used as input data for the most realistic loading case of the shell in the FEA
- **Global deformations of the alveolar array** are significant, and essential for checking the absence of interference with the shell inside (inner and outer cone) and the absence of crystal stressing (cell bending < play) in a first approximation

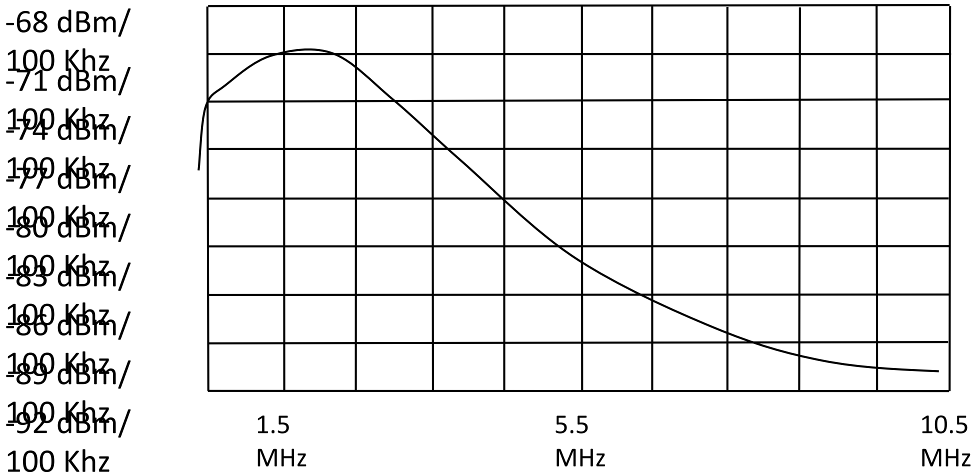
We have ordered a module to be used to perform stress test which will be done in Ancona

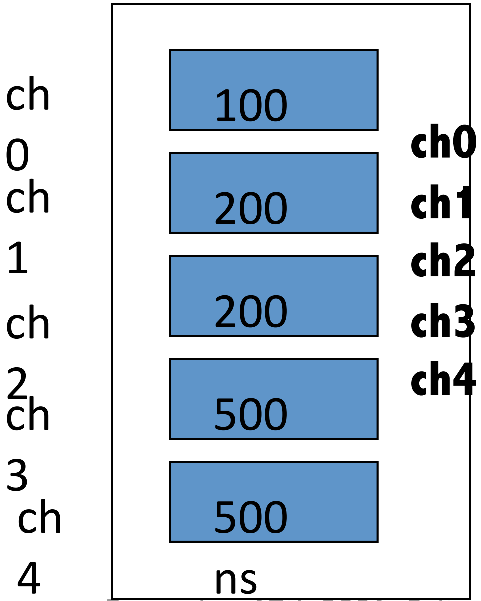
There is a problem of the responsibility of the mechanics, who will take care after ML?
He is with SuperB up to the end of March 2011

Update on electronics

Frequency domain approach to study the noise has been adopted (with a spectrum analyser and using and ADC and DAQ system

Power Spectrum 100 ns Shaper





ch0: 1.97878 -> 965.264 uV
ch1: 1.7537 -> 855.464 uV
ch2: 1.39712 -> 681.736 uV
ch3: 1.29801 -> 633.424 uV
ch4: 1.43141 -> 698.328 uV

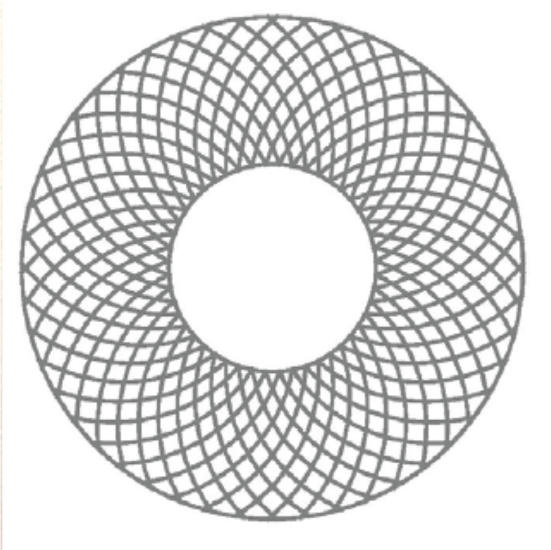
We integrate the noise spectrum and we have evaluated the noise level in Veff

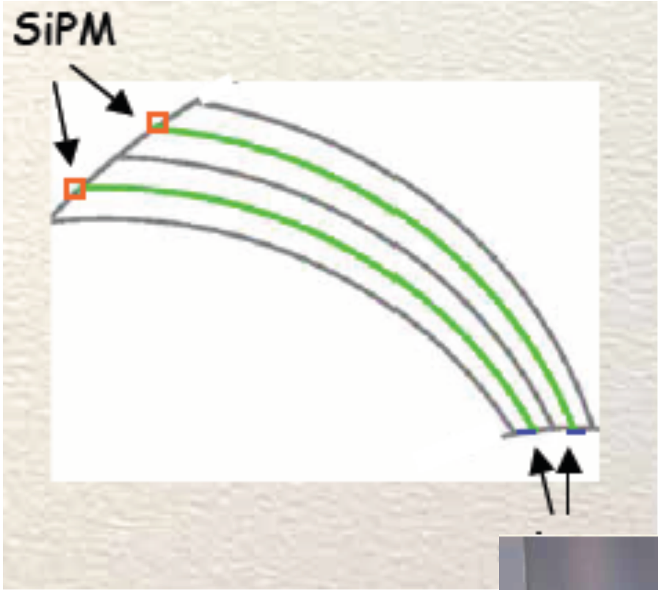
- **100ns -> 745 uVeff(0.5-10.5 MHz)**
- **200 ns -> 565 uVeff (0.5-3.5 MHz)**
- **500 ns -> 418 uVeff (0.1-2.1 MHz)**

- The frequency domain analysis does not show any contribution from interference frequencies.
- The noise level is well know, **consistent with the one measured at the BT** and can be inserted in the simulation
- The "oscillation" we see in time domain is simple bandlimited noise.
- The rms value for the 100 ns shaper is consistent with 2.1 count (shap+ADC) and 1 count (ADC alone) measured with cern data
- The rms value of the shaper board is better than shaper data sheet value.
- The use of 100 ns shaper respect the 500 ns shaper used in frascati give more noise
- We can learn from this how short shaping time give more noise and we have to find action to reduce this noise.

Backward endcap

12 X0 Pb-scintillator sampling calorimeter, 24 layers of 0.3 mm thick scintillator strips and 0.28 mm thick Pb plates





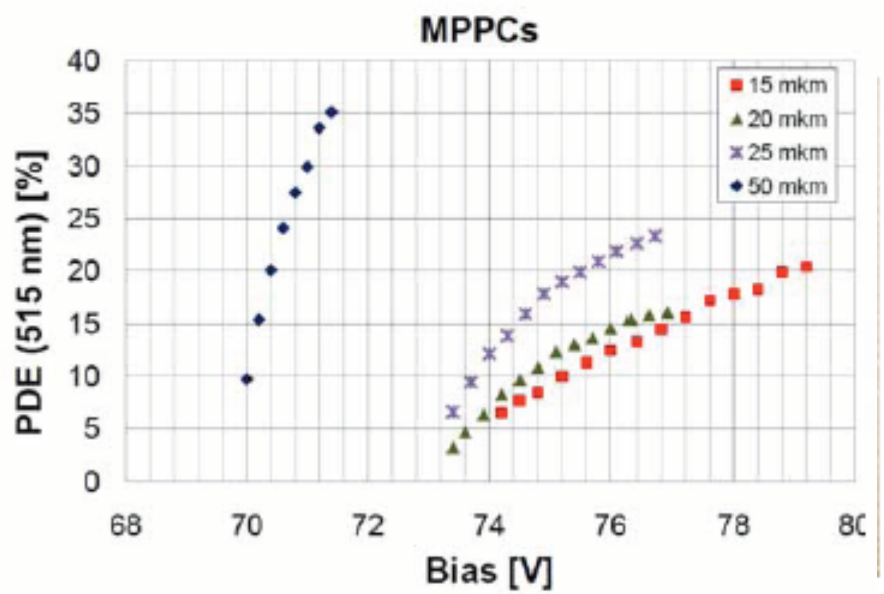
NEW MPPC's

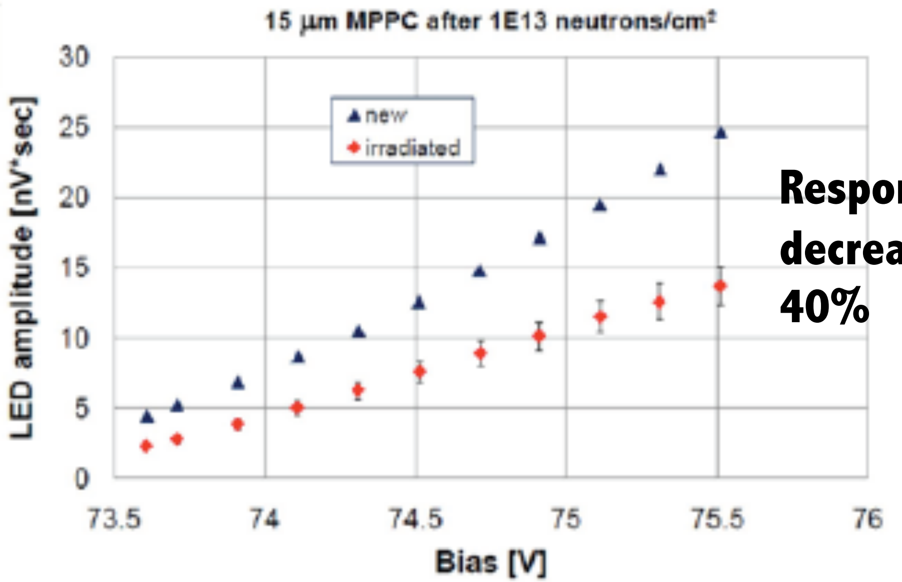
Hamamatsu has produced two new photodetectors with 2500 and 4489 pixels 20μm and 15 μm pitch respectively.
(25μm pitch old one)

Prototype preparation, 48 left handed spirals and 48 right ended

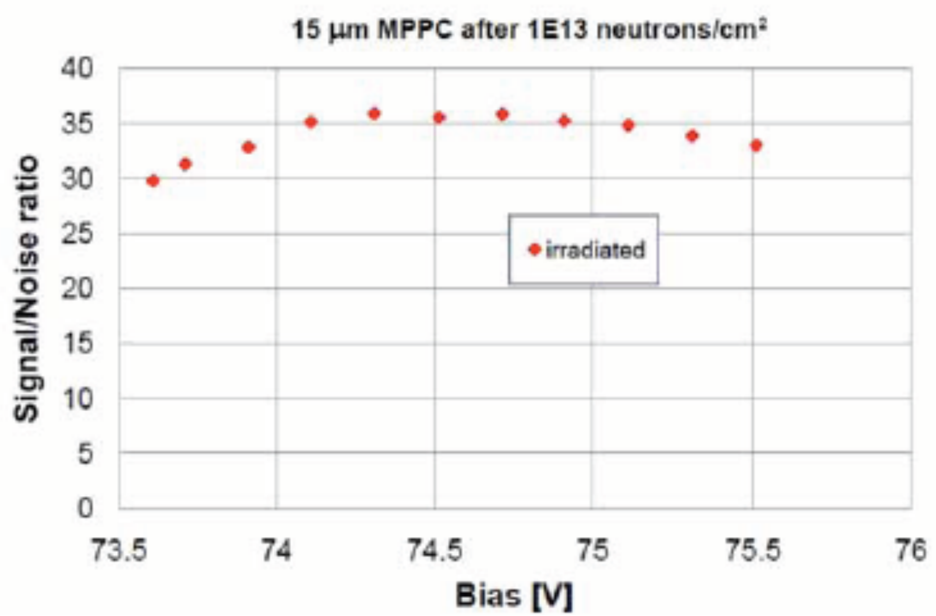
In ten years (200 days running) estimate $6.1*10^{11}$ n/cm^2 or $6.1*10^9$ n/mm^2

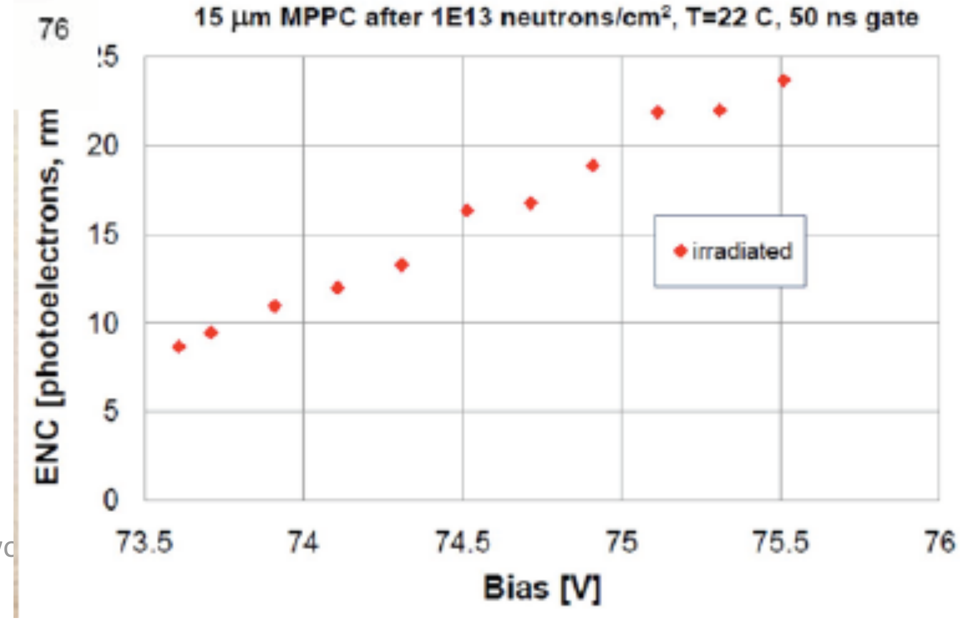
Backward endcap cont'd





Response is decreased by 40%





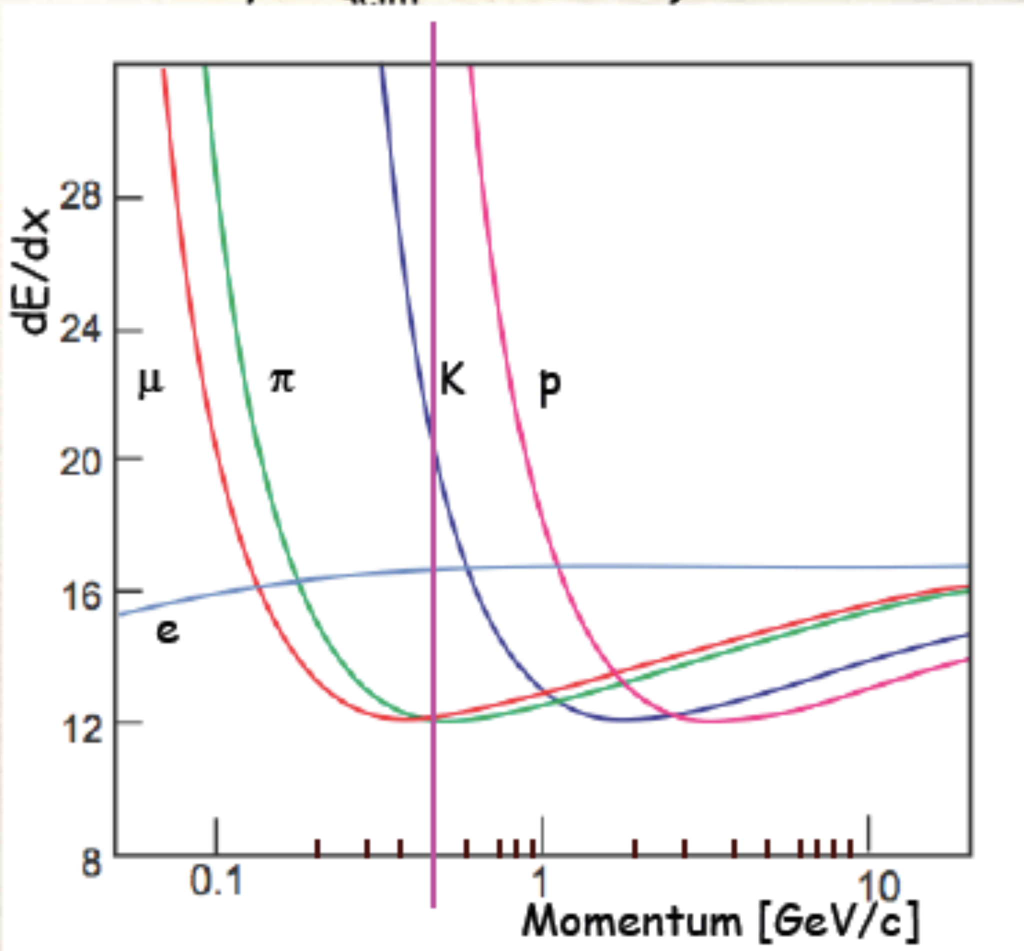
Backward endcap for PID based on dE/dx

- Do dE/dx pattern recognition for hadrons ➔ for MIP-like particles energy losses are (dE_{Pb}=4.3 MeV, dE_{scint}=0.6 MeV)

A 0.5 GeV π is at the minimum while a 0.5 GeV K is below the minimum

For MIPs, ΔE= 100 MeV in 24 layers

For particles below minimum dE/dx increases with depth ($1/\beta^2$)



➔ look at dE/dx pattern and combine it dE/dx information from SVT and DCH ➔ improve K/π separation (3σ) up to 0.6-0.7 GeV

Backward endcap for PID based on TOF

ToF application ➔4 time constants

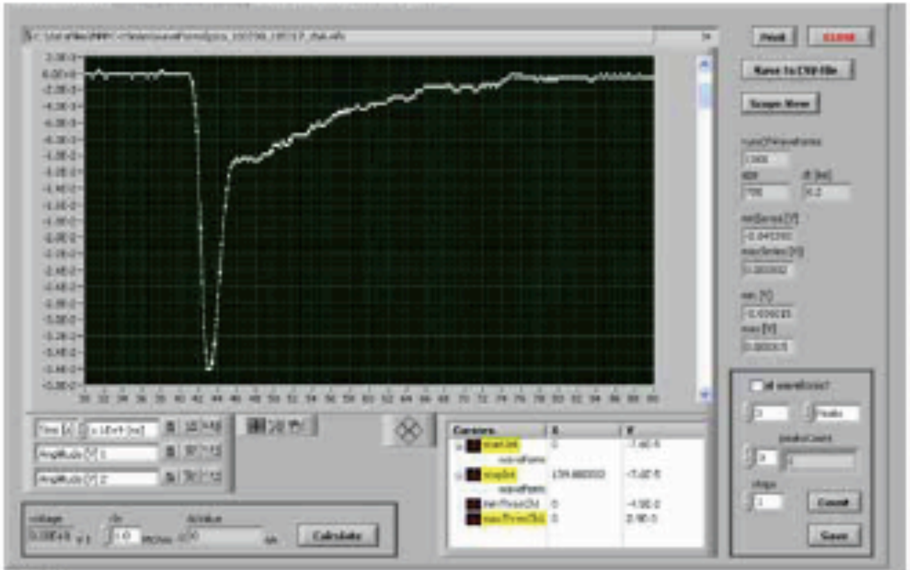
- Scintillator τ_{sc}=2.2 ns
- Y11 fiber τ_{fiber}=2.3 ns
- MPPC rise time resolution σ_{MPPC}~0.1 ns
- transition time in fiber t_{fiber} =2 ns (56 cm)

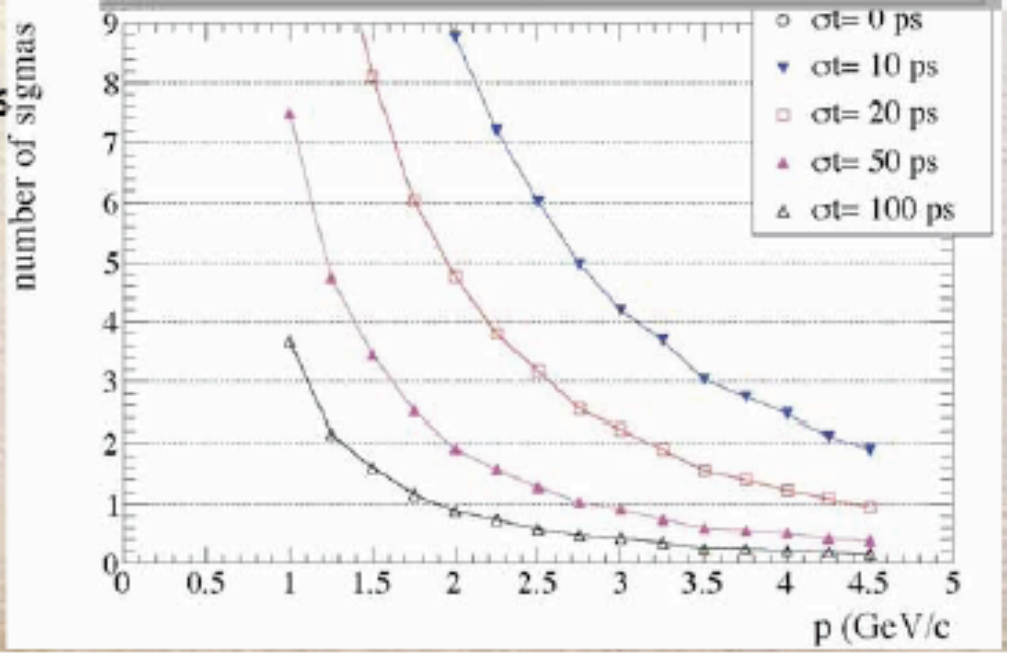
MPPC signal is trigger by arrival of first photon

We have up to 24 measurements

Need a measurement for spiral strip

With TOF measurements K/π separation (3σ) may be improved to >1.2 GeV





Physics impact of Backward EMC $B \to K^* \nu\nu$ hadronic tag

* EextraBwd < 0.05 GeV:

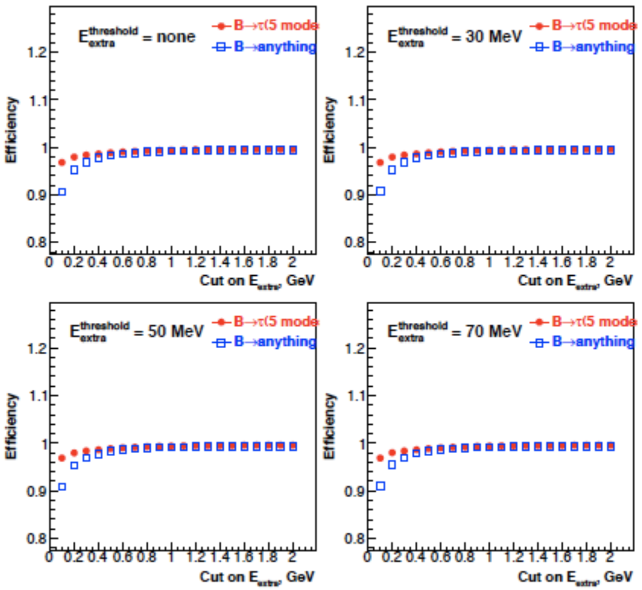
$B^0 \to K^{*0}\nu\bar{\nu}$					
Sample	$N_{\rm sel}$	$\varepsilon_{\rm tot}$	$N_{\rm sel,Bwd}$	$\varepsilon_{\rm tot,Bwd}$	$\delta\varepsilon/\varepsilon$
$B^0 \to K^{*0}\nu\bar{\nu}$	727	$(24.5 \pm 0.9) \times 10^{-5}$	719	$(24.2 \pm 0.9) \times 10^{-5}$	$(-1.1 \pm 0.4)\%$
B^0 had cocktail	76	$(20 \pm 2) \times 10^{-8}$	60	$(16 \pm 2) \times 10^{-8}$	$(-21 \pm 7)\%$
$S/\sqrt{B}$	83 ± 7		93 ± 9		
$B^+ \to K^{*+}(K_s\pi^+)\nu\bar{\nu}$					
Sample	$N_{\rm sel}$	$\varepsilon_{\rm tot}$	$N_{\rm sel,Bwd}$	$\varepsilon_{\rm tot,Bwd}$	$\delta\varepsilon/\varepsilon$
$B^+ \to K^{*+}\nu\bar{\nu}$	223	$(7.1 \pm 0.5) \times 10^{-5}$	222	$(7.0 \pm 0.5) \times 10^{-5}$	$(-0.5 \pm 0.4)\%$
B^+ had cocktail	48	$(12.0 \pm 1.7) \times 10^{-8}$	40	$(10.0 \pm 1.7) \times 10^{-8}$	$(-17 \pm 7)\%$
$S/\sqrt{B}$	32 ± 4		35 ± 5		

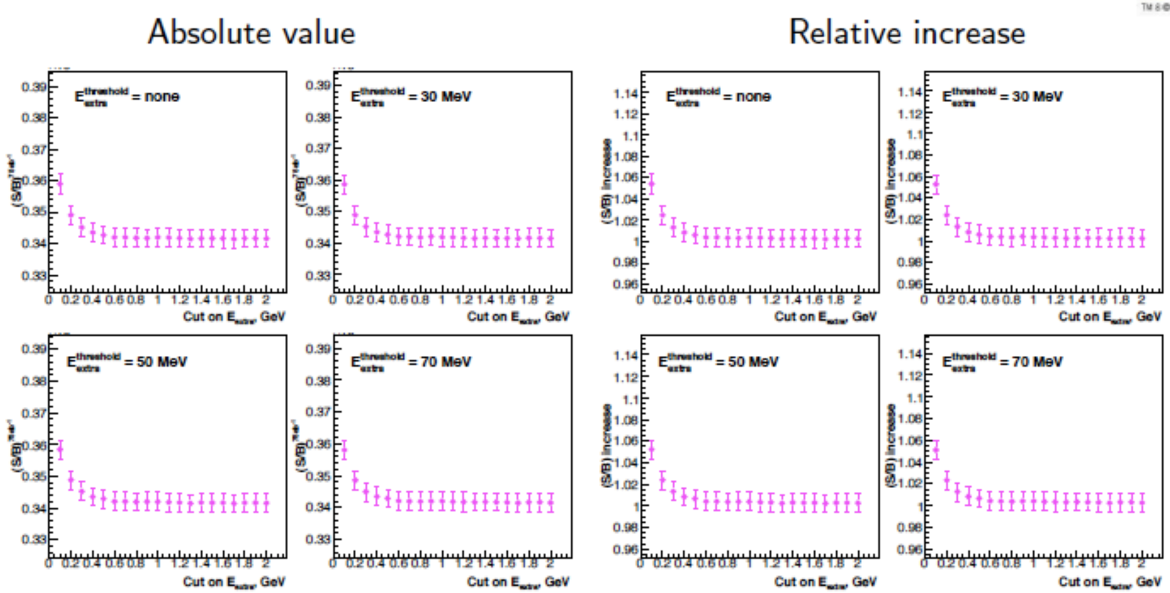
$$\delta\left(\frac{S}{\sqrt{(B)}}\right) = \frac{\left(\frac{S}{\sqrt{(B)}}\right)_{bwd} - \left(\frac{S}{\sqrt{(B)}}\right)_{nobwd}}{\left(\frac{S}{\sqrt{(B)}}\right)_{nobwd}} =$$

$K\pi : (10 \pm 3)\%$

$K_s\pi : (8 \pm 3)\%$

Physics impact of Backward EMC   B→τν hadronic and SL tag





Reduction signal 1-2 %
Reduction of background 5-10%

Cutting on Eextra S/B ratio for 75 ab-1 is increased by 3%

Cutting on E_{extra} in Backward EMC improves:

- S/B ratio at 75 ab^{-1} by about 5 - 10%
- $S/\sqrt{S+B}$ at 75 ab^{-1} by about 1 - 2%

for both hadronic and semi-muonic tag $B_{tag} \to \mu D^0, D^0 \to K\pi$

Conclusions

- 3 weeks of test beam at CERN, data are being analysed still some work to be done to understand data and tune the Monte Carlo accordingly

- Still work is ongoing for the LYSO characterization in particular uniformity of LY and investigation of other vendors

- Mechanics is well advanced but responsibility after TDR could be an issue

- Electronics: TB has raised very important point on the electronics development that need more discussion in future in view of the final design

- Backward EMC group is working in the prototype + the investigation of new photodetectors to handle with the known problem of neutron flux in MPPC's and performance degradation

- Physics impact of EMC backward has been studied → results are stable since last meeting.