EMC Summary

Frank Porter & Claudia Cecchi

For the EMC group

September 15, 2011

EMC sessions

1. Stefano Germani – Update on simulations
2. Corrado Garguilo – Mechanical engineering
3. All – Future test beam discussion
4. Daniel Chao – Fastsim background studies
5. Alessandro Rossi – CsI measurements
6. Davide Pinci – BGO resolution studies
7. Gerald Eigen – Backward EMC status
8. All – TDR

Plus talks in other sessions, summarized by others:

1. Stefano Germani – Detector development and wishlist: Calorimetry
2. Valerio Bocci – Status of EMC front-end electronics
3. Stefano Germani – EMC background report
4. Paolo Branchini – Setup and preliminary results from CsI(TI) crystals

Crystal properties

Crystal	LY[1]	X_0 cm	r_M cm	Rad hard	$d(LY)/dT$ %/°C	$\tau_{\rm decay}$ ns	$\lambda_{\rm max}$ nm
NaI(Tl)	1	2.59	4.13	no	-0.2	230	410
LYSO(Ce)	0.83	1.14	2.07	yes	-0.2	40	402
CsI(Tl)	1.65	1.86	3.57	no	0.3	1300	560
CsI	0.036	1.86	3.57	maybe	-1.3	35	420
BGO	0.21	1.12	2.23	maybe[2]	-0.9	300	480
$PbWO_4$	0.0029	0.89	2.00	no	-2.7	10	420

(Mostly from RPP)

[1]Relative to NaI(Tl), small crystals, corrected for QE, room T

[2]Initial loss of LY, then stable at high doses (10s of Mrad)

Techincal Possibilities – Forward EMC

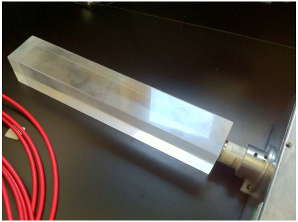
1. Baseline: LYSO with new mechanical support structure
2. Alternatives:
    - 2.1 LYSO in BaBar support structure
    - 2.2 Partial BaBar CsI(Tl), LYSO in BaBar support structure (Variants: staged upgrade approach; Could be in new structure as "complete" upgrade.)
    - 2.3 BGO in new mechanical support structure
    - 2.4 BGO in BaBar support structure
    - 2.5 Pure CsI in BaBar support structure

	LYSO	LYSO/CsI(Tl)	BGO	Pure CsI
New Support	baseline		alternative	
BaBar Support	alternative	alternative	alternative	alternative

(LYSO and BGO in BaBar support would be four crystals per cell.)

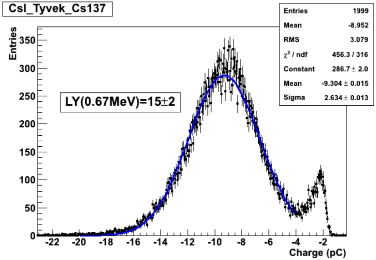
R&D program to evaluate and compare options.

Pure CsI study (Rossi)



Crystal dimension:
5x5x30 cm^3

- No way to see rad. sources with VPT
  - To low gain (10x)
- Measurements performed with a standard PMT
  - Photonis XP2266b
- No grease on PMT surface
- Crystal wrapped with tyvek
- Source: Cs137 (γ 0.667KeV)



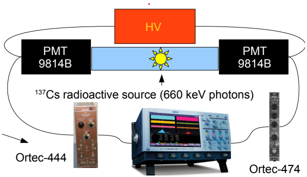
Pure CsI study

- Few electron seen with a standard photocathode at 315nm
- Measures very similar to the PDG value:
  - CsI light output w.r.t. NaI ~ 4.7% (PDG)
  - LYSO light output w.r.t. NaI ~ 83% (PDG)
  - CsI/LYSO ratio ~ 4.7/83 ~ 5.6% (PDG)
    - Taking into account the PMT and crystal surface: CsI LY reduced by a factor 20.4/25~0.82
    - CsI/LYSO ratio ~ 4.6% (PDG)
  - Measured CsI/LYSO ratio : 4.8%
- More studies on uniformity, decay time etc. will be performed soon
- By the end of September also measurement with Hamamatsu Photopentode

Also radiation hardness needs to be studied.

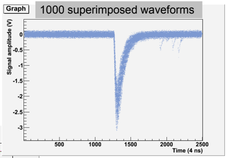
BGO study (Pinci)

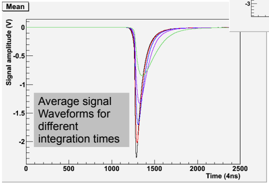
- Energy resolution
- Impact of front-end integration time on performance
- $2 \times 2 \times 18$ cm^3 L3 BGO crystal



In an off-line analysis, event by event, all waveforms were studied;

For every integration time we acquired 15k events;



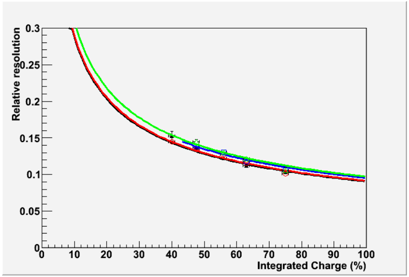


RC	20 ns	50 ns	100 ns	200 ns	500 ns
f(peak)	40.0%	47.5%	56.0%	63.0%	75.0%

BGO

Our hypothesis is that the relative resolution obtained by looking at the peak amplitude is mainly due to the number of integrated p.e. and thus it improves with the square root of the fraction of the integrated charge *f* ;

Since the pedestals are negligible, no other terms are summed → $\frac{\sigma_A}{A} = \frac{\sigma_0}{\sqrt{f}}$



Results from the fits are:

High HV + Gain 10
σ_0 = 90.8 ± 0.6;

High HV + Gain 10
σ_0 = 91.6 ± 0.5;

High HV + Gain 2
σ_0 = 95.4 ± 1.0;

Low HV + Gain 10
σ_0 = 97.3 ± 1.1;

100 ns integration time gives 56% integrated charge and resolution 12.7% (0.66 MeV).

Implies 1.5% contribution to resolution at 50 MeV

Possibility of 100 L3 crystal matrix test beam in Spring 2012

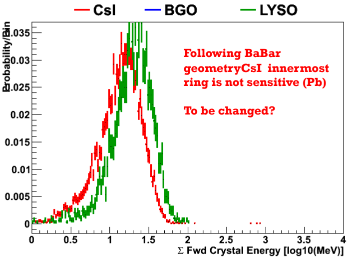
Simulations of different technologies (Germani)

Setting up to study alternative crystals/geometries in fullsim

- LYSO (baseline)
- LYSO/CsI(Tl) hybrid
- CsI (pure)
- BGO
- PWO

Aim to study energy resolution with backgrounds

Fwd Endcap Energy



Mechanical Engineering (Gargiulo)

➢Forward

1) re-use of BaBar structure (CsI crystals)

   Structure re-qualification (not yet started)

2) new structure (LYSO, BGO crystals)

   Design, structural analysis, experimental validation(in progress)

➢Barrel

main intervention is on electronics

how this change affect mechanics and services?

(not yet started, need input from electronics group)

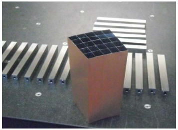
➢Services

Cooling system

Calibration system

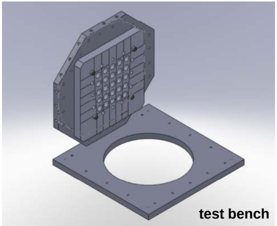
(not yet started)

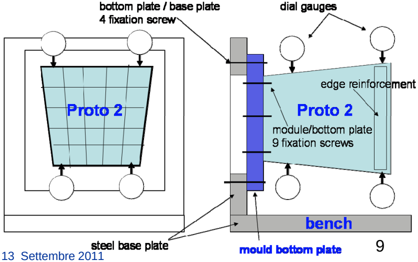
Protoype 2 Alveolar for LYSO



➢Load test

A load test campaign will be performed for module mechanical caractherization.
Test will be performed at Dip. di Fisica e Ingegneria dei Materiali e del Territorio, Università Politecnica delle Marche, under Fabrizio Davì, Daniele Rinaldi.
Test bench production, tets procedures, test schedule will be defined in a meeting at INFN Perugia next week (tentative)





Corrado Gragiulo, 13 Settembre 2011 9

BaBar emc **shipment**, storage

➢Shipment

A transport strategy shall be defined within SuperB collaboration (under discussion with Integration Group)

- ***HOW***

EMC to define the requirements for the shipment of the crystals/structure: shipping frame, dumping systems, thermal control, …

- ***WHEN***

EMC to define timing request for the shipment

EMC to verify if any constraint /limitation on controlled storage at SLAC could affect shipment time

- ***WHERE***

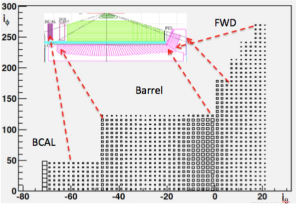
EMC to define storage area location and dimensions requirements

Forward and barrel calorimeter will go through several processing phases from the reception to the final integration.

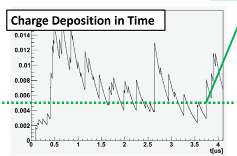
An hardware flow and processes sequence should be defined and optimized to minimize crystal/hardware transport, handling and to avoid duplication of jig&tools

EMC technical meeting to discuss these aspects is suggested

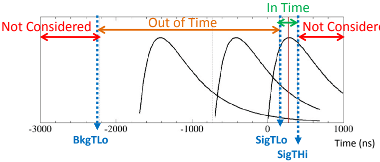
Background pile-up study (Chao)



$$\sigma_E = \sigma_{p.e.} \oplus \sigma_{elec} \oplus \sigma_{intrinsic} \oplus \sigma_{pedes}$$

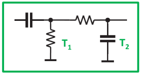


Implemented improved model of electronics in Fastsim

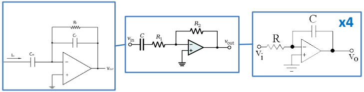


- Cluster with arrival time assigned in the **green region is kept**.
- Particles arriving in **red region is not considered**.
- Particles in the **orange region contributes to pileup, but clusters with time assigned in this region are rejected.**

Before:



Now (Conceptually):



- SPICE simulation (**Luigi Recchia** and **Valerio Bocci**) generates a lookup table of the shaper output.
- FastSim reads in the lookup table to get the pulse shape.

Background pile-up study

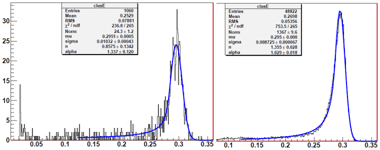
- Background Frame:
  - Bunch crossing: 200 MHz.
  - **Window length of 2μs**. ~400 bunch crossings.
- Background frame particle cuts:
  - Z coordinate of creation (in cm): $-300 < z < 200$
  - **Minimum Energy: 10 MeV**
- Preamp Model:
  - 140 μs of integration time.
  - **100 ns of shaping time.**
- Cluster formation cuts:
  - **L1 threshold: 0.1 MeV**
  - **Crystal Threshold: 0.01 MeV**
- Time window:
  - BkgLo: -25 μs (this is irrelevant because it is limited by window length)
  - SigTHi: 120 ns
- Noise Cleanup:
  - Remove Out of Time.
  - Keep clusters with energy above 10 MeV, and highest energy digi above 1 MeV.
- Generate single photons at various energies and shoot them in the forward barrel region. Generated 50000 events for signal only, 1000 events for sig + bkg.

Can't implement all the changes we would like because it would take way too long to run!!

More on this in later section.

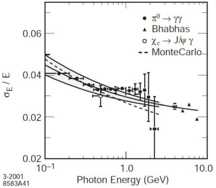
Background pile-up study (forward barrel)

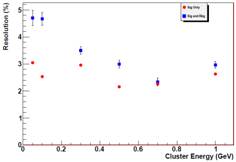
Crystal Ball Fits to Cluster Energy



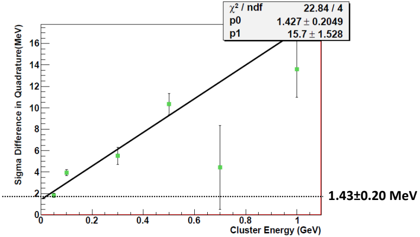
- Generated Photon Energy: 300 MeV.
- Left: Sig + Bkg, Right: Sig only.

Resolution (red is no background; blue is with background)





Results at 10 MeV Energy Cut



$$\sigma_{pileup} = 15.7E + 1.43 \Rightarrow \frac{\sigma_{pileup}}{E} = \frac{(1.57 \pm 0.15)\%}{E}$$

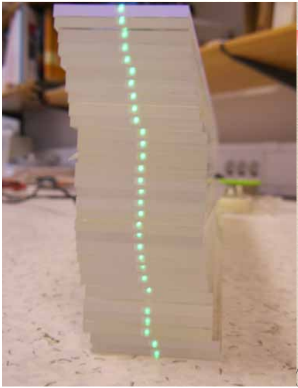
... Cleary something here to be understood (behavior confirmed by analysis of FWHM)

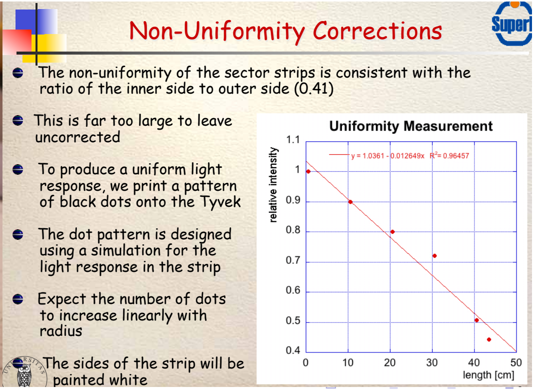
Future test beam

- Had planned for a fall test beam at MAMI/Mainz
  - E_γ from $\sim$30 MeV to $\sim$1.5 GeV
  - Well-measured γ energy
- Improved uniformity by roughening crystal side
- Sum 2 APDs per crystal
- Electronics crosstalk eliminated
- Unfortunately, Mainz schedule has slipped, earliest chance $\geq$ January
- Also looked at Frascati, SLAC, DESY, FNAL; beams either unsuitable or earliest is next year.

Backward EMC – Prototype construction (Eigen)

- Prototype is $6 \times 24 = 144$ readout channels
- Straight strips 2/3 done
- Spiral strips to be done at DESY
- Uniformization procedure (e.g., black dots)
- Need to acquire 30 m Y11 fiber (1 mm)
- Manpower improving, still need new collaborators





TDR – Calorimeter chapter

1. Detailed outline exists
2. Expecting around 60 pages
3. Editors for major calorimeters sections:
    - Barrel: Kevin Flood
    - Forward: Ric Faccini
    - Backward: Gerald Eigen
4. Need to converge quickly on reducing alternative geometries/technologies for forward calorimeter

EMC Conclusions

- Effort is increasing substantially on R&D on alternatives to LYSO baseline
- Mechanical testing of alveolar prototype 2
- SLAC visit to discuss engineering for barrel
- Continuing studies of backgrounds
  - Improved modeling of electronics in simulation; pile-up study
- Next test beam for LYSO in limbo for now
- TDR writing is being organized
- Plenty of room for new collaborators