Forward EMC Discussion

Frank Porter

March 28, 2012

Question – Do we change baseline for forward EMC in TDR?

- Discussions after last Wednesday – It is not a foregone conclusion that we change forward technology baseline.
  - Looking at whether backgrounds can be reduced
  - May be able to improve clustering and pile-up
  - Maybe shouldn't be using $5\times$ background for performance optimization
- Suppose we find that the present nominal background is appropriate (either by improving backgrounds and their impact and/or by deciding on a safety factor < 5)?
  - Does this mean we should stick with the present all-LYSO baseline? That is, is the cost realistic to propose?
    - If yes, need to continue background-related studies for a decision. Cutoff time for TDR decision?
    - If no, we move discussion to the alternatives.

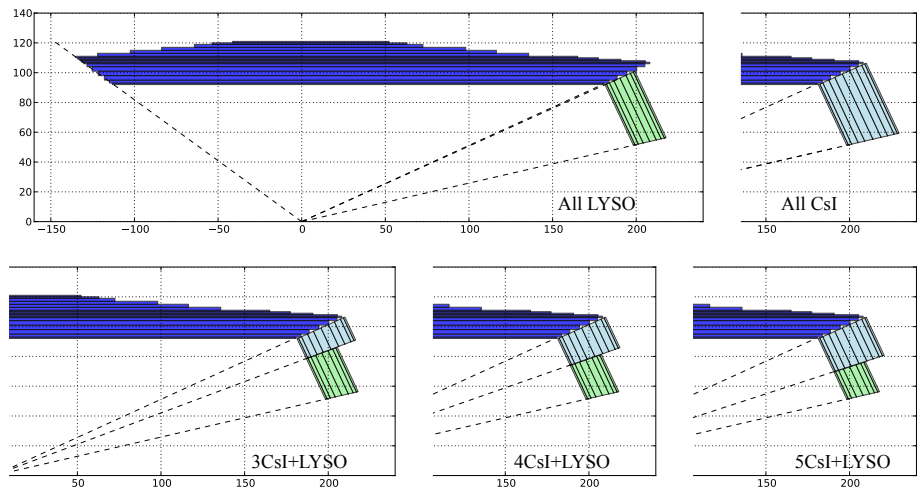
Forward EMC – Cost estimates

	Crystals (M$)	Readout (M$)	Calibration system (M$)	Mechanical structure (M$)	Total (M$)
LYSO	11.9	0.9 (2 APD)		1.5	14.3
CsI pure	2.7	0.75 (photopentode)		0.25	3.7
BGO	3.6	0.9 (2 APD)	1	1.5	7.0
PWO	2.0	2.5 (2 LAAPD)	1	1.5	7.0

Option	Number of new crystals	New crystal volume (cc)	Crystal cost/cc ($)	Crystal cost (M$)	Photo-detectors (M$)	Laser/LED system (M$)	Mounting structure (M$)	Total cost (M$)
LYSO full (baseline)	4500	401622	25.00	10.04	0.57	-	2.27	12.88
LYSO old structure	3600	401622	25.00	10.04	0.57	-	0.25	10.86
Hybrid (CsI(Tl)+LYSO)								
3 CsI(Tl) + 6 LYSO	2160	244734	25.00	6.19	0.49	-	0.25	6.93
4 CsI(Tl) + 5 LYSO	1760	197911	25.00	4.95	0.40	-	0.25	5.60
5 CsI(Tl) + 4 LYSO	1360	153783	25.00	3.84	0.31	-	0.25	4.40
Pure CsI	900	692220	5.09	3.52	0.56	-	0.25	4.33
BGO	4500	392181	9.00	3.53	0.57	1.2-3.0	2.27	7.57-9.37
$PbWO_4$	4500	305714	5.00	1.53	0.57	1.2-3.0	2.27	5.57-7.37

Forward EMC Possibilities

- Current baseline is LYSO in a thin structure.
- Alternative forward schemes under discussion:
  - BaBar endcap structure or new structure
  - Hybrid LYSO/existing *BABAR* endcap crystals. Possible staging towards more LYSO.
  - Pure CsI (in existing structure)
  - BGO (in existing or new structure)
  - PWO (in existing or new structure)



(Non-contoversial?) Overview of some pros and cons follows

Pure CsI

- Appears to be cheapest option (possibly excepting L3 BGO)
- Choice for Belle-II endcaps, can benefit from their R&D
  - Selected over BSO and PWO2
- Decay time comparable to LYSO
- Low light yield, large crystal size $\Rightarrow$ vacuum photopentode readout
  - Lose redundancy
  - Gain (and effective noise) depends on magnetic field
  - Large size (50 mm depth) $\Rightarrow$ Need to understand space implications
  - We have not tested(?)
- Large Molière radius
- We have not studied radiation hardness yet, others see variations among boules
- We have no vendor qualification yet

PWO2

- Shortest X_0, Molière radius
- Shortest decay time (10 ns)
- Lowest light yield $\Rightarrow$ large area APD readout
  - Maybe cool to -25°C to improve light yield
- Light yield is dose rate-dependent
- Need to qualify vendors for PWO2

BGO

- X_0, Molière radius similar to LYSO
- Potentially very inexpensive if can re-use L3 BGO
  - Othewise, similar to PWO and (3+6)-ring hybrid
- Light output 1/4 of LYSO
- Light yield is dose rate dependent
- Decay time (300 ns) fairly long
- Would need to qualify vendors if new BGO

Hybrid CsI(Tl) – LYSO

- Re-use existing (BaBar) structure
  - LYSO is mechanically strong $\Rightarrow$ Can stack 2×2 LYSO with minimal material
- Provides LYSO in most demanding region of detector
  - High light output
  - Short decay time
  - Radiation hard
  - Vendors qualified
- Performance in region near barrel will match forward barrel, since backgrounds and doses are similar
  - CsI(Tl) has longest decay time ($O(1300)$ ns)
  - CsI(Tl) is not radiation hard
- Fallback in number of rings
- Possible to stage to more LYSO
- Adds some complexity with additional transition region.

Reference

Reference - 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	rate dep.	-0.9	300	480
$PbWO_4$	0.0029	0.89	2.00	rate dep.	-2.7	10	420

(Mostly from RPP)

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

Charge for advisory committee

Provide input on the following questions:

1. Five times background seems to be a reasonable criterion for radiation hardness, providing a safety margin for the survival of the detector. However, as a criterion for optimizing detector cost/performance, this seems less clear. What should the criterion be for this optimization?
2. Can the present backgrounds be significantly mitigated?
3. A set of costs for various forward calorimeter technologies has been developed, based on some assumptions. Are these assumptions and costs plausible? If not, what revisions should be made?

The focus should be on the baseline choice in the TDR. Independent of this choice, the TDR will also include a discussion of potential alternatives and the R&D being pursued.