Calorimeter Test Beam

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14th - 17th February 2008,
SuperB Detector Workshop I,
SLAC
Outline

- Test beam site considerations:
  - CERN/DESY/Frascati/PSI

- BaBar Test beam

- Prototype issues
  - Crystal layout
  - Example Quotes
  - Photodetector
  - Readout / Trigger

- Timescale
Test beam site considerations

1) CERN-SPS

See http://ab-div-atb-ea.web.cern.ch
Test beam site considerations

1) CERN-SPS

East Hall: 24 GeV/c primary beam with secondary momenta from 3.5 to 24 GeV/c. (e, \(\mu\), hadrons)

North Area: 20-250 GeV/c secondary beams. (e, \(\mu\), hadrons)

Primary SPS cycle: 2.4sec; with 400ms flat top.

East hall is probably fine (NA has typically \(10^{12}\) ppp for the primary beam).

See http://ab-div-atb-ea.web.cern.ch
Test beam site considerations

1) DESY

See http://adweb.desy.de/~testbeam/
Test beam site considerations

1) DESY

- 1 – 6 GeV/c beams ($e^\pm$).
- Typically $10^3$ particles per bunch.
- $1 \times 1$ cm beam spot.
- Carbon Fibre target.

See http://adweb.desy.de/~testbeam/
Test beam site considerations

1) Frascati

See http://www.lnf.infn.it/acceleratori/btf/
Test beam site considerations

1) Frascati

25-750 MeV beams ($e^\pm$). Typically $10^3$ particles per pulse. 1-10 ns pulses at a 50Hz rate.
Test beam site considerations

1) PSI
Test beam site considerations

1) PSI

590 MeV proton beam.
2mA current.

BaBar Calorimeter test beam was done on the \( \pi \)M1 beam line.
- 100 to 500 MeV/c incident particles.
- 0.1% FWHM momentum spread for selected particles.
- 20ns time structure of beam.

See http://www.psi.ch/forschung/benutzerlabor_protonen_e.shtml
The BaBar Testbeam

- Projective geometry in 1 dimension.
- 5x5 matrix of CsI(Tl) crystals.

- The crystals were encased in a light and RF tight environmental box; on a turntable.
- Took data at several incident angles.
The BaBar Testbeam

- Used $e / \pi$ beams from the beam line.
- Wire chambers and scintillators were in situ.
- Choice of two tables for rotating the calorimeter prototype.
- What could have been done better?
  - Instead of having a single long run for taking data; should have planned a short pilot run to get enough data to analyse and debug prototype, and then come back for more data.
  - The design had a problem with cross-talk between the power supplies used. This meant that data had to be recorded at low rates.
Prototype Issues

Crystal Layout
Crystal Layout

- Need a large enough prototype to contain a complete shower:
  - 5×5 or 7×7 crystals.

- All LYSO vs LYSO core with CsI (or other cheaper material around the core).

- Projective geometry of some kind vs non-projective geometry.

- Need to figure out all pros and cons.
**Crystal Layout**

- **Example:** 3x3 projective LYSO core (surrounded by one or two layers of cheaper crystals).

Just an example of a possible projective geometry:

### Assumes:

- **2.5x2.5 cm front crystal surface**
- ‘Beamspot’ 1.5m from this surface to define projectivity.

**NOTE:** The goal is to build a 5x5 or 7x7 array of crystals, this layout was investigated in a failed attempt to exploit a funding opportunity.

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**LYSO Calorimeter Test-beam Possible Geometry**

LYSO region of calorimeter will be a 3x3 array of crystals with a projective geometry as indicated here. Assume that the interaction point is a perpendicular distance of 1.5 meters from the surface of the crystals, and that the beam axis of the test beam experiment is co-incident with the axis of the central crystal.

<table>
<thead>
<tr>
<th>Front</th>
<th>Back</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>2.5 cm</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

The grey numbers in *italics* indicate crystal designation, and range from 1 (one) through 9 (nine).

All sizes in centimetres (cm) and all angles in radians (rad)

*NOT TO SCALE*
Crystal Layout

- Example: 3x3 projective LYSO core (surrounded by one or two layers of cheaper crystals).

NOTE: The goal is to build a 5x5 or 7x7 array of crystals, this layout was investigated in a failed attempt to exploit a funding opportunity.
Example Quotes

1) Non projective geometry: 9 crystals of 2.5x2.5x20cm:
   - All sides polished, LYSO
   - Cost for 9 crystals = 31 K€
   - Timescale for delivery = 8 weeks
   - Timescale / cost for 49 crystals (est) = 16 weeks (4 months) / 167 K€

2) Projective geometry outlined previously:
   - Cost for 9 crystals = 55.5K€
   - Timescale for delivery = 4 months
   - Timescale / cost for 49 crystals (est) = ? 8 months / ? 111K€

Quotes were acquired from Saint Gobain and SIPAT, and exclude tax and shipping. SIPAT were O(10% more expensive).

NOTE: The goal is to build a 5x5 or 7x7 array of crystals, this layout was investigated in a failed attempt to exploit a funding opportunity.
Prototype Issues

Photodetectors
Photodetectors

- Ren Yuan has been using Hamamatsu APDs (from CMS) for lab tests.

- Continue to use this chain for readout vs. start to investigate and adopt an alternative (also what is the cost at production level for such a readout?).

- Need to think longer term – what would we use for SuperB?

S8664-55 (5x5mm active area)
Single unit / 10+ cost 473 / 338 €

10x10mm device is also available:
Single unit / 10+ cost 1010 / 720 €
(might fit two on a crystal)
Prototype Issues

Readout/trigger
Readout / Trigger

- **Trigger:**
  - Site dependent. PSI/CERN probably have these already in place.

- **Readout:**
  - Currently using CMS readout …. If we use this for a testbeam then we save time.
    - BUT: can we use this for SuperB? If not – then it might be better to work toward a readout that would be similar/same as for SuperB.
Aim to have a test-beam ~ fall 2009

- Working backward, we would need to acquire funding for R&D soon.

- Also means we should start to design the calorimeter prototype in the next 6-9 months.

- Timescale is more relaxed if we don’t want tapered crystals.
A crude beam test budget estimate

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost ($)</th>
</tr>
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<tbody>
<tr>
<td>LYSO Crystal @ $15/cc</td>
<td>1875</td>
</tr>
<tr>
<td>LYSO Crystal @ $50/cc</td>
<td>6250</td>
</tr>
<tr>
<td>CMS type dual APD module 2 x Hamamatsu S6664-55</td>
<td>250</td>
</tr>
<tr>
<td>BABAR type photodiodes 2 x Hamamatsu S2744-08</td>
<td>500</td>
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<tr>
<td>Preamplifier/Shaper (per channel)</td>
<td>200</td>
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<tr>
<td>DAQ system</td>
<td>10000</td>
</tr>
<tr>
<td>Source carriage</td>
<td>1500</td>
</tr>
<tr>
<td>Beam test mounting structure</td>
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</tbody>
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Looks more like $5K per crystal (NP) or $9 K per crystal (P)

Looks more like $500 per channel
Is it cheaper to buy in the US?