A LYSO calorimeter for the SuperB factory

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on behalf of SuperB EMC group

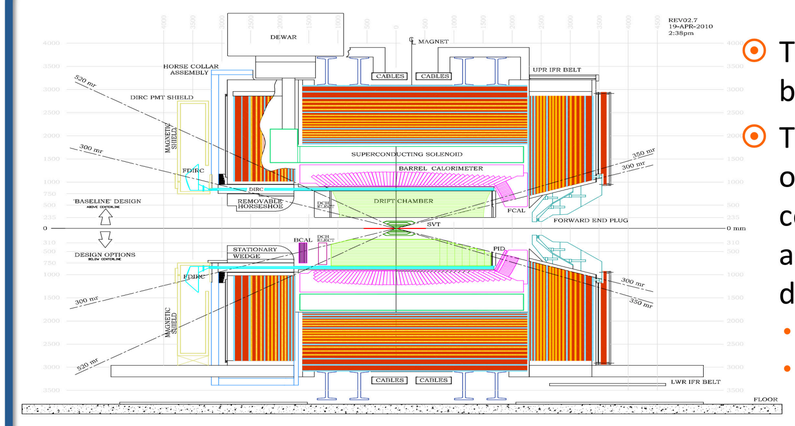
Abstract

The SuperB project is an asymmetric e^+e^- accelerator of $10^{36}cm^{-2}s^{-1}$ design luminosity, capable of collecting a data sample of 50–75 ab^{-1} in five years running. The SuperB electromagnetic calorimeter (EMC) provides energy and direction measurement of photons and electrons, and is used for identification of electrons versus other charged particles. In particular we present its design, geometry study and related simulations, as well as R&D on LYSO crystals and developments on readout electronics. A matrix of 25 crystals has been tested at the Beam Test Facility of Frascati (BTF) in May 2011 at energies between 200 MeV and 500 MeV. Results from this test are presented.

SuperB project

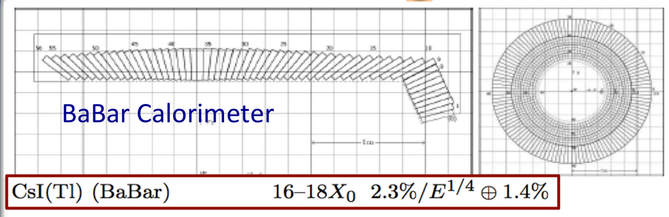
- Flavour physics at the SuperB factory would be complementary to LHC to study New Physics beyond the Standard Model in the b, c and τ sector [1]
- SuperB will run at a luminosity of 10^{36} cm^{-2} s^{-1}, 2 order of magnitude higher than previous b-factories, which correspond to 50-75 ab^{-1} in 5 years
- The machine is an asymmetric e^+e^- collider with the new colliding scheme “crab and waist” with very low emittance [2]
- The SuperB detector is based on a re-optimization of the BaBar detector [3]

SuperB Detector



- The upper half shows the baseline concept
- The bottom half shows a optional detector configuration with the addition of two sub-detector:
  - A backward calorimeter
  - A forward particle identification (PID) detector

Electromagnetic Calorimeter



Crystal	CsI(Tl)	LYSO(Ce)
Density (g/cm^3)	4.51	7.1
Radiation Legth (cm)	1.85	1.14
Moliére Radius (cm)	3.5	2.3
Interaction Length (cm)	37.0	21
Refractive Index	1.79	1.82
Luminescence (nm)	560	420
Decay Time (ns)	1300	45
Light Output (%) (wrt NaI(Tl))	165	75

- **BaBar “Barrel” EMC [CsI(Tl)]:**
  - Small radiation damage
  - Can sustain SuperB rates
- **BaBar “Forward” EMC [CsI(Tl)]:**
  - Radiation damage
  - Finer granularity and faster response are needed for SuperB rates

Lutetium and Yittrium Orthosilicate (LYSO) crystals [4]

LYSO Forward EMC prototype

Crystals

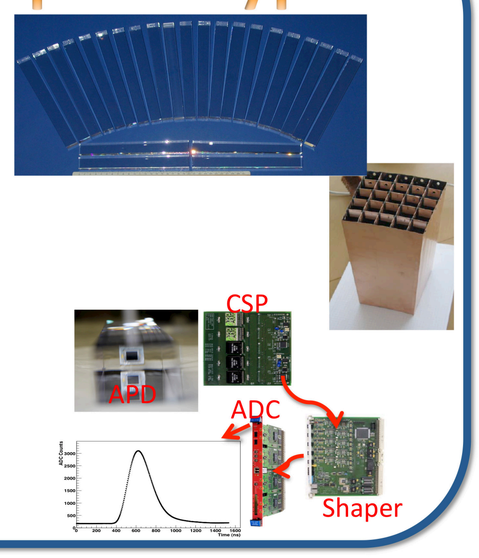
- 25 LYSO crystals (5x5 matrix)
- Crystal dimensions : 2(2.5)x2(2.5)x20 cm^3

Mechanic

- Projective mechanical structure
- Glass fiber

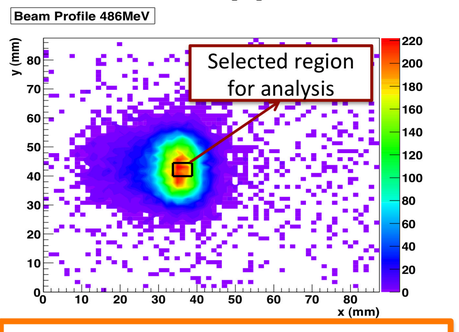
Electonics & DAQ

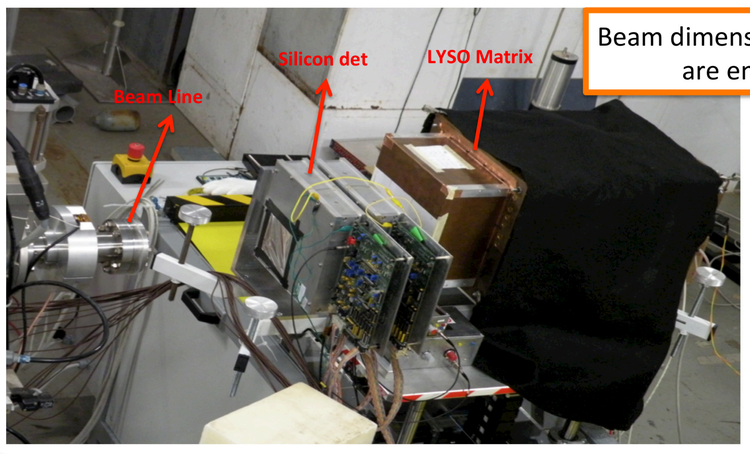
- Each crystal read by a 5x5mm^2 APD
- Cremat Charge Sensitive Amplifier (1.4V/pC)
- Cremat 100ns Gaussian Shaping
- Caen V1720 250MS/s sampling ADC



Beam Test at Frascati

- DaΦne Beam Test Facility at Laboratori Nazionali di Frascati [5]
  - Electrons and positrons
  - 50-500 MeV
  - 50Hz with 1-10^{9}e$^-$/spill
- Silicon beam monitor
  - Single side 228 µm strip
  - 2 x-y planes
  - 8.75x8.75 cm^2 active area



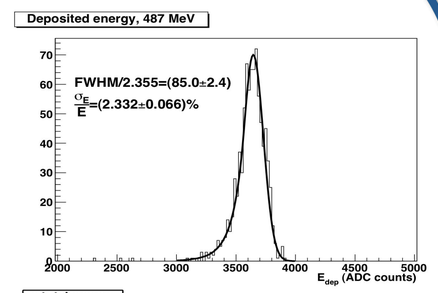


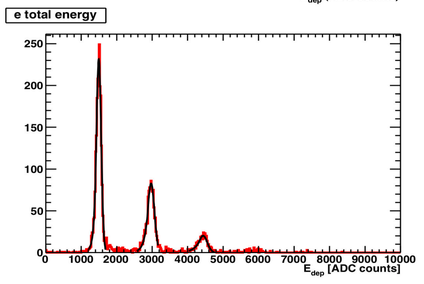
Beam dimensions and energy spread are energy dependent

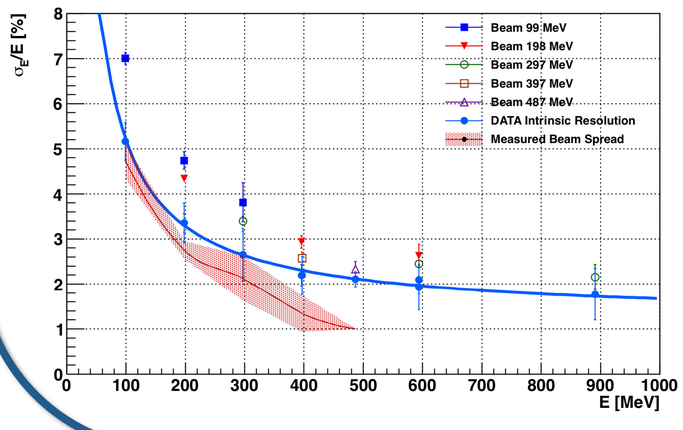
Results

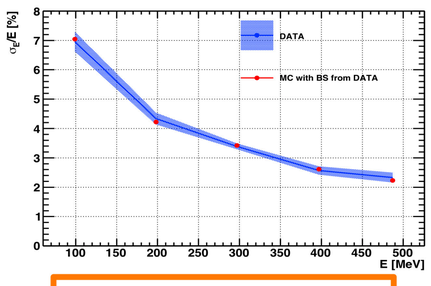
- Sum of the deposited energy in each crystal described with a Crystal Ball function
- The beam spread is estimated directly from data using events with more than one electron of the same energy
- Taking into account the beam energy spread the LYSO EMC prototype resolution is:

$$\frac{\sigma_E}{E} = \frac{1.1\%}{\sqrt{\mathrm{E(GeV}}} \oplus \frac{0.4\%}{\mathrm{E(GeV)}} \oplus 1.2\%$$









Good Data/MC agreement when beam spread is taken into account

[1] B. O’Leary et al. [SuperB Collaboration], [arXiv:hep-ex/1008.1541]
[2] M. E. Biagini et al. [SuperB Collaboration], [arXiv:physics.acc-ph/1009.6178]
[3] E. Grauges et al. [SuperB Collaboration], [arXiv:physics.ins-det/1007.4241]
[4] J.M.Chen *et al.*, IEEE Trans. Nucl. Sci., vol. 54, no. 3, 2007
[5] G. Mazzitelli, P. Valente “Commissioning of the DAFNE Beam Test Facility” LNF-03/003(P)