Calorimeter sections for LOI

Update for HCal

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Outline for HCal hardware section of SiD LOI

1) Introduction - role of HCal in SiD (1/2)

2) HCal as subsystem of SiD - location, overall design (1)
   - engineering design, simulated design
   (coordinate with Kurt, Norman)

3) HCal physics requirements (initial version from HCal design document) (1/2)

4) HCal detector requirements (initial version from HCal design document) (1/2)

5) Technologies
   - Baseline (2-3)
   - GEM Option (1)
   - MicroMegas option (1)
   - Scintillator option (1)

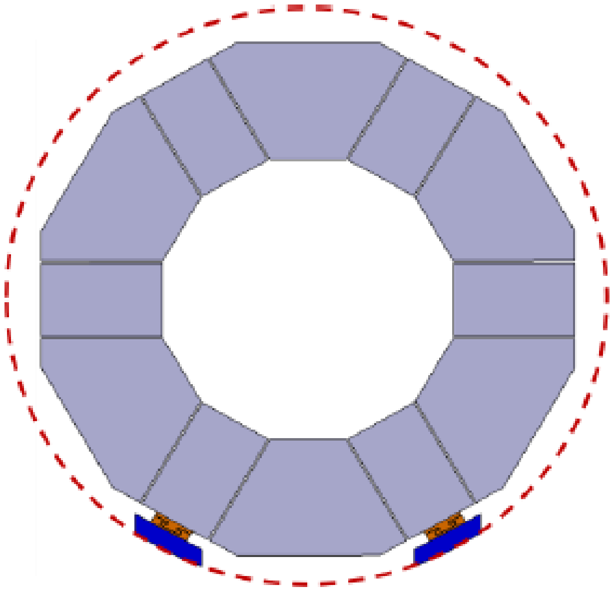
6) Development path, timeline, R&D needs. (1)

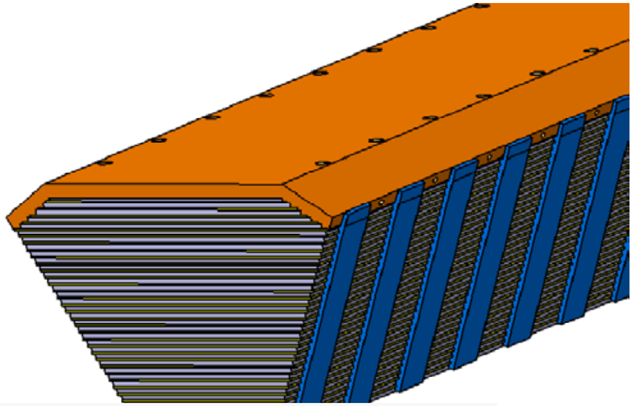
Calorimetry – introduction, from DOD

\subsection{III.D Calorimeter concept}\label{subsec:mylabel1}To measure hadronic jets of particles produced in high-energy collisions of electrons and positrons, with sufficient precision it is widely accepted that a new approach is necessary. The most promising method, named Particle Flow Algorithm (PFA), utilizes both the tracking information for charged particles and the calorimeter for the measurement of the energy of neutral particles. PFAs applied to existing detectors, such as CDF and ZEUS, have resulted in significant improvements of the jet energy resolution compared to methods based entirely on the calorimetric measurement. However, these detectors were not designed with the application of PFAs in mind. The SiD concept on the other hand accepts that a PFA is necessary and is designing the detector to optimize the PFA performance with the goal of obtaining jet energy resolutions of the order of 30{\%}/$\surd $E or better. The major challenge imposed on the calorimeter by the application of PFAs is the association of energy deposits with either charged or neutral particles impinging on the calorimeter. This results in several requirements on the calorimeter design: to minimize the lateral shower size of electromagnetic clusters theMoli\`{e}re radius of the ECAL needs to be minimized. Both ECAL and HCAL have to have imaging capabilities which allow assignment of energy cluster deposits to charged or neutral particles, which implies that the readout of both calorimeters needs to be finely segmented transversely and longitudinally. HCAL needs to be inside the solenoid to be able to do particle clusterassociation.In addition, the design of the calorimeter needs to be as uniform as possible, minimizing the use of different technologies, extendable to small angles to ensure hermeticity, and to provide enough depth for the longitudinal containment of hadronic showers. The design needs to consider the cost as an additional boundary condition. Following is a short description of the baseline designs for the ECAL and the HCAL, as defined by the study group in August 2005. For more details seethe sections which follow.

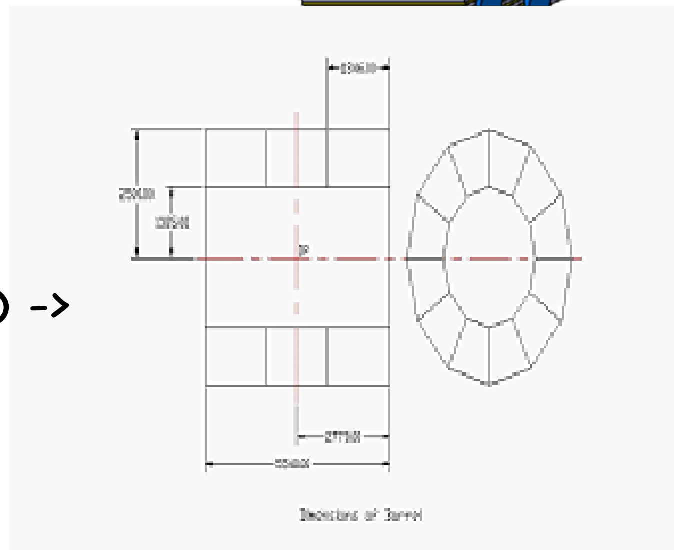
2) **HCal as subsystem of SiD - location, overall design (1)**

- engineering design, simulated design
  (coordinate with Kurt, Norman)





What we had in DOD ->



? Which design(s) to show; how much detail?

3) HCal physics requirements (initial version from HCal design document) (1/2)

It must efficiently allow tracking of charged particles through its volume.
It must have sufficient depth such that any energy loss in the coil, and/or energy measured with degraded resolution (relative to the HCal) in the outer detectors (such as a TCMT) does not significantly impact jet energy resolutions at all jet energies.
It must have a sufficiently small cell size to allow true separation and association of closely spaced energy clusters with the correct tracks – at a level that does not significantly degrade the jet energy resolution.
It must have a sufficient sampling so as not to significantly degrade the jet energy resolution via the sampling term.
Its outer radius must limit the cost of the solenoid and muon system to reasonable levels – requiring the radial size of each active layer to be as small as possible.
It must have sufficient rate capability so as not to lose information, particularly in the forward directions – using a change of technology, if necessary.

4) **HCal detector requirements (initial version from HCal design document) (1/2)**

Performance criteria:

1) MIP Efficiency/pad
2) Hit multiplicity/MIP
3) Uniformity of response across active layers
4) Need for or ease of calibration
5) Recovery time after hit(s)
6) Recovery time after a "significant beam event"
7) Rate of discharges (gas)
8) Track-cluster separability
9) PFA jet resolution at a) Z-pole, b) 250, 500, 1000 GeV
10) Magnetic field issues – signal location offsets in barrel and endcaps (gas)
11) Response to neutrons

4) **HCal detector requirements (initial version from HCal design document) (1/2)**

Technology issues:
1) Maturity and previous history
2) Reliability
3) Availability of components (in quantity)
4) Active layer thickness
5) Smallest readout unit size
6) Technical risk of approach
7) Ease of assembly/testing/installation/commissioning (often referred to as "scalability").
8) Effects of aging on performance

Cost:
1) Overall HCal cost
2) Active layer cost as a percentage of total cost
3) System development costs
4) Costs for assembly and test

5) **Technologies**

- Baseline (2-3) RPC (Jose)
- GEM Option (1) (AW)
- MicroMegas option (1) (Yannis)
- Scintillator option (1) (Vishnu)

6) **Development path, timeline, R&D needs. (1)**

- Development of HCal engineering design

Coherent with technologies development of active layers.

- Development of technologies $1m^2$, $1m^3$ level technology tests; full "technical prototype" demo by 2012? B-field? Energy range (to 1 TeV?).

- Further optimization – is 4.5λ enough? Module design, minimizing cracks, dead regions for services/readout…, revisit the absorber issue, adjusting n(layers) as real thickness of an active layer becomes known, varying absorber plate thickness with depth,…

- Timeline through TDR…?

IDAG Questions - HCal

- Calibration and Alignment

  -> Alignment: HCal (1cm2) pads relative to tracker(?), O(nx100µm)?

  -> Calibration: DHCAL- thresholds for 50M channels! KPiX – analog information, set thresholds offline, need to automate!

- Engineering model/simulation

  -> Support off cryostat (3/9 o'clock, or 4/8 o'clock?)

  - Cracks etc. yet to be simulated – post-LOI task

IDAG Questions - HCal

- Plans for R&D for detector design -> proposal: see (6)

- Detector optimization: see Marcel Stanitzki's PANDORA/"SiD-ish" etc. studies.

HCal performance section

- How to structure this?

- Separate detector and physics performance

- Detector performance – efficiency, multiplicity,... in the HCal hardware section?

- Physics performance in the PFA section?