Status of E-Flow Optimization of HCAL at ANL

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- Motivation - E-Flow Implications for Calorimetry
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Motivation

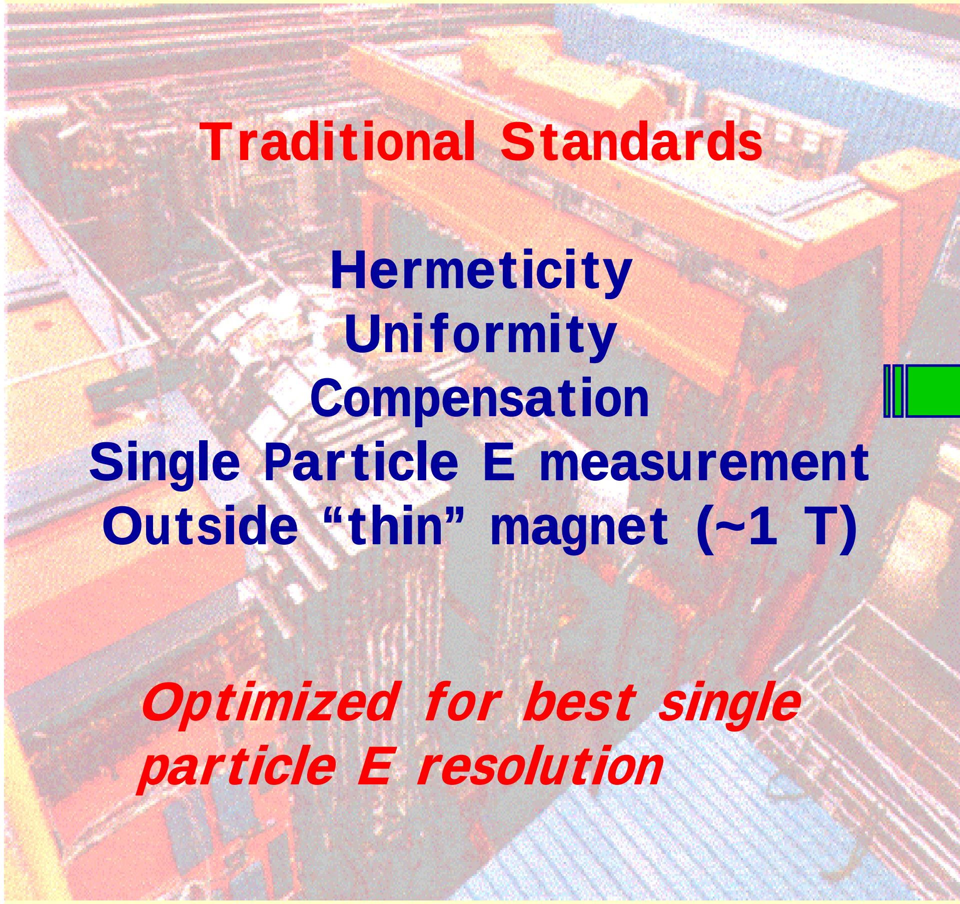
How to design and build future calorimeters for optimal jet reconstruction/resolution?

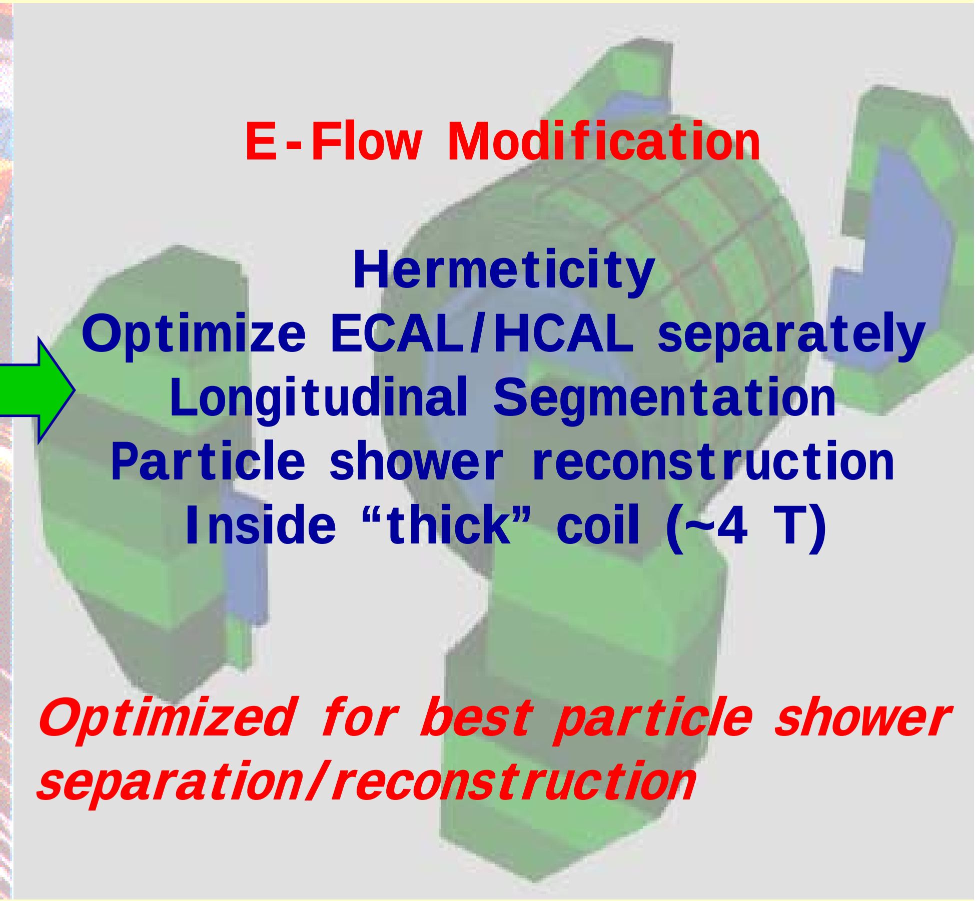
- Physics Requirements
  - **Multi-jet final states require separation of WW, ZZ, and Zh**
    -> ~few GeV mass resolution at 100 GeV

    -> ~30%/√E *jet energy resolution* as well as good angular resolution
  - **Missing energy -> *hermiticity***
  - **Heavy q tags -> lepton ID + *jet reconstruction***

- Process/Machine Requirements
  - **Signal/BACKGROUNDS (both machine and process)**
  - **High B-fields -> 4 T, ~2 m R to ECAL -> ~1 GeV min charged particle momentum to get to calorimeter -> *need for excellent tracking***

E-Flow Implications for Calorimetry





Traditional Standards

Hermeticity
Uniformity
Compensation
Single Particle E measurement
Outside “thin” magnet (~1 T)

Optimized for best single particle E resolution

E-Flow Modification

Hermeticity
Optimize ECAL/HCAL separately
Longitudinal Segmentation
Particle shower reconstruction
Inside “thick” coil (~4 T)

Optimized for best particle shower separation/reconstruction

ECAL Requirements

For electromagnetic showers in a *dense calorimeter*, the transverse size is small

-> small r_M (Moliere radius)

-> If the transverse segmentation is of size r_M, get optimal *transverse separation* of electromagnetic clusters.

If X_0/λ_I is small, then the *longitudinal separation* between starting points of electromagnetic and hadronic showers is large

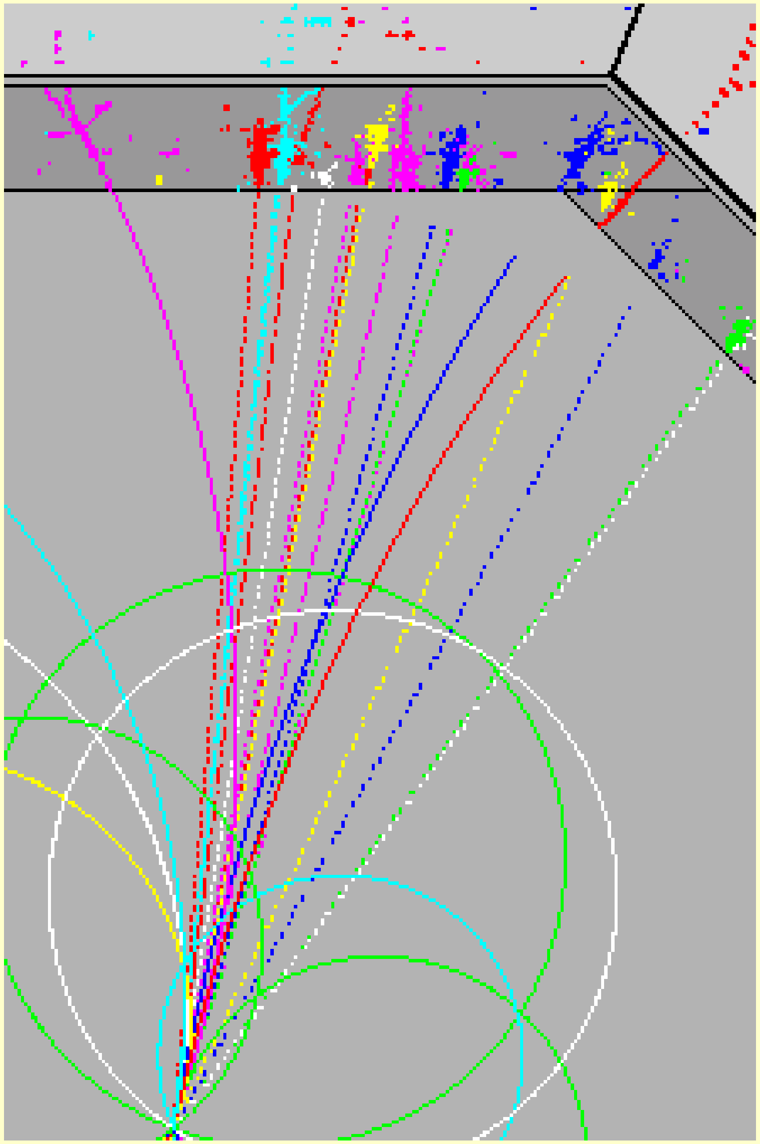
Some examples :

Material	Z	A	X_0/λ_I
Fe	26	56	0.0133
Cu	29	64	0.0106
W	74	184	0.0019
Pb	82	207	0.0029
U	92	238	0.0016

Optimal ECAL for E-Flow

A dense ECAL with high granularity (small transverse size cells) and with X_0/λ_I small is optimal for E-Flow.

-> good 3-D shower reconstruction.



TESLA/NLC SD solution -> Tungsten absorber/Silicon pad sandwich construction with 1 X 1 cm^2 transverse pad size.

Towards Optimization of HCAL

To optimize the HCAL for E-Flow requires :

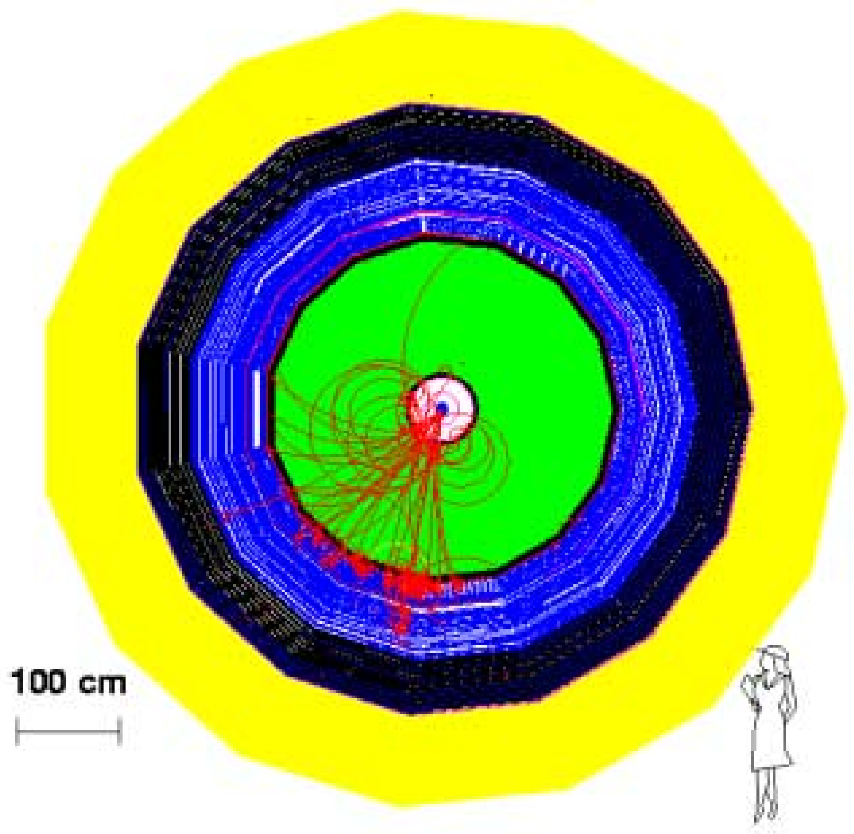
- ***full containment of (neutral) hadronic showers.***
- ***good precision on energy measurement.***
- ***high segmentation in transverse and longitudinal directions in order to separate in 3-D close-by clusters in jets.***

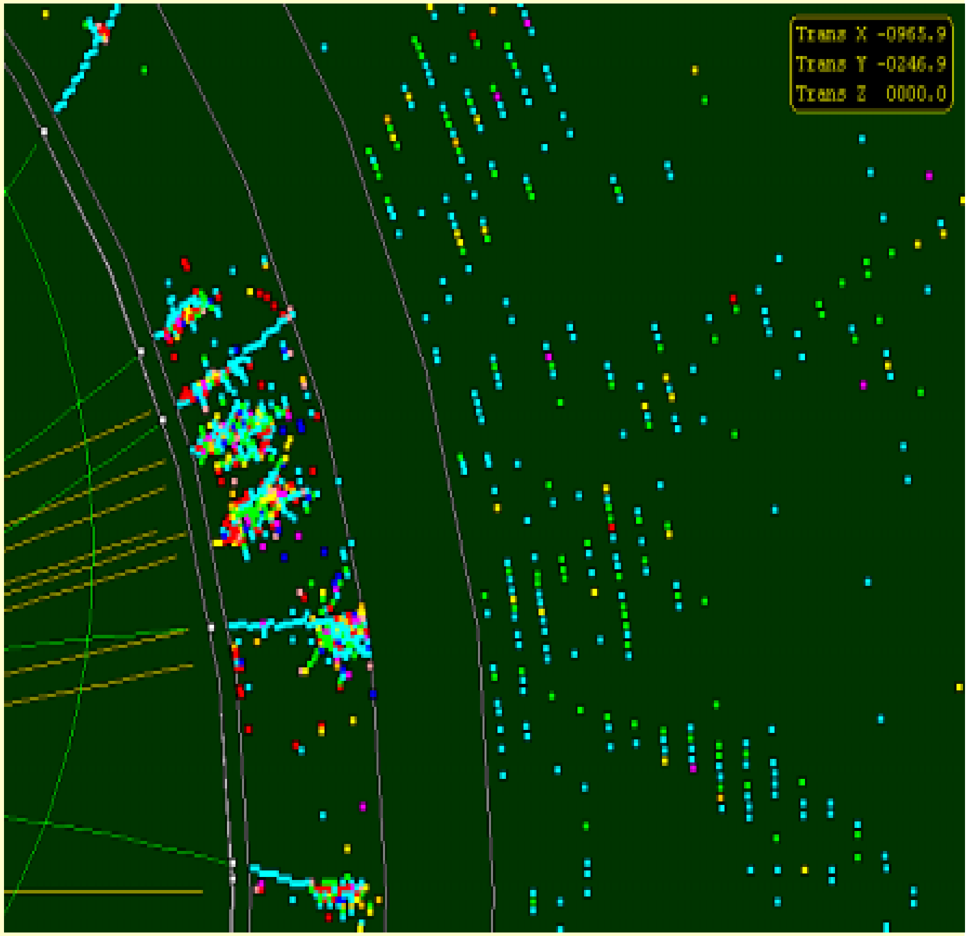
Requires integrated approach which includes other detector sub-components in the design phase and incorporating E-Flow algorithm.

- ***Assume a tracking system optimized for, e.g., di-lepton measurements.***
- ***Assume an ECAL optimized for photon reconstruction.***
- ***Vary HCAL parameters, e.g., absorber material, thickness, size of readout cells in both transverse and longitudinal directions, to determine optimal performance in an E-Flow Algorithm.***

HCAL Design Choices

Z decay in ANL GEANT program (based on TESLA TDR)

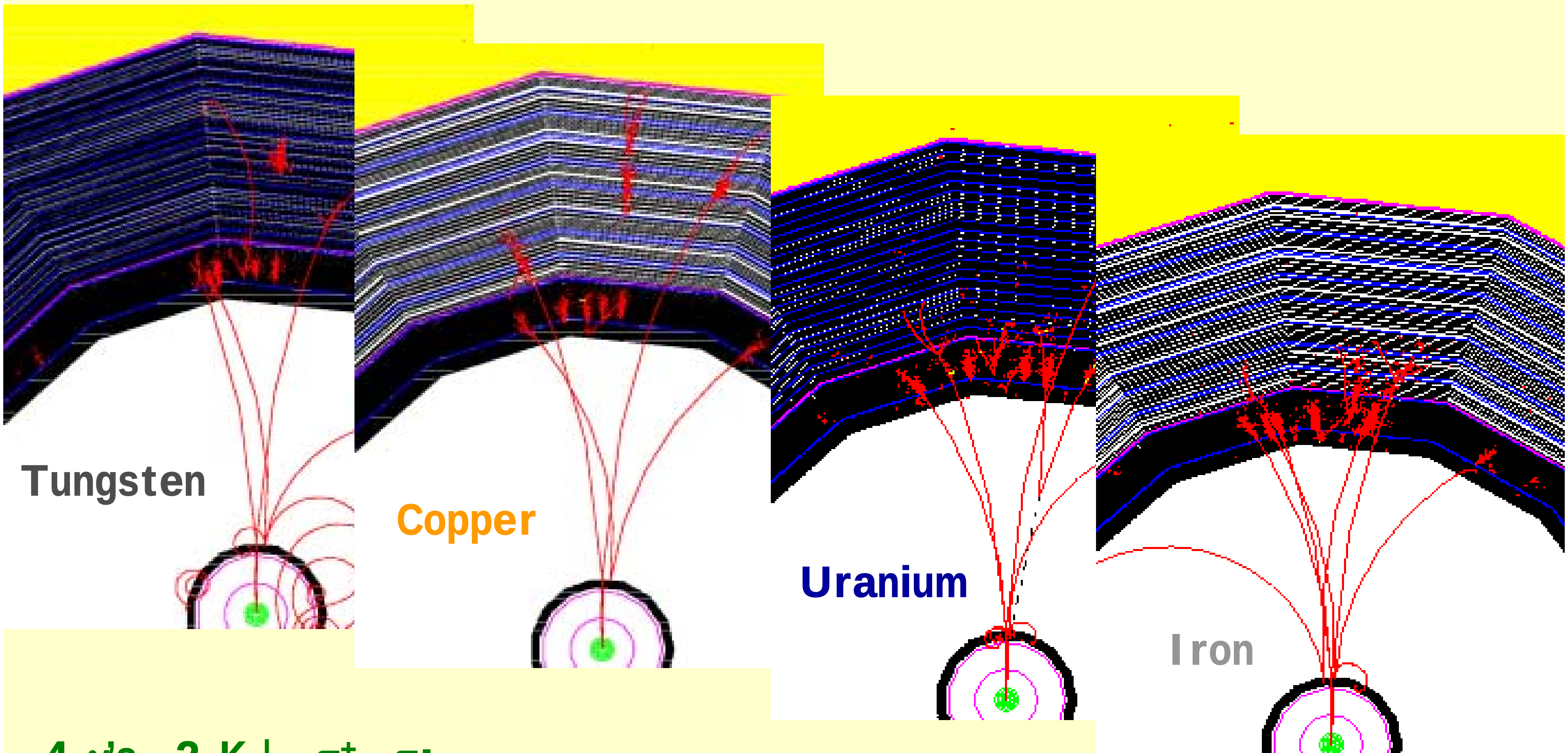




Z decay in NLC SD Detector, JAS

HCAL in LD Detector also?

Example – HCAL Absorber Choices



4 γ's, 2 K_0^L, π^+, π^-

Conclusions

- Future calorimeters will be required to measure jet energies at unprecedented precisions.
- This will require an Energy Flow approach to jet reconstruction.
- E-Flow implies an integrated approach to calorimeter design, unlike traditional methods.
- Radical departures from current calorimetric methods may be needed -> Digital Hadronic Calorimetry.