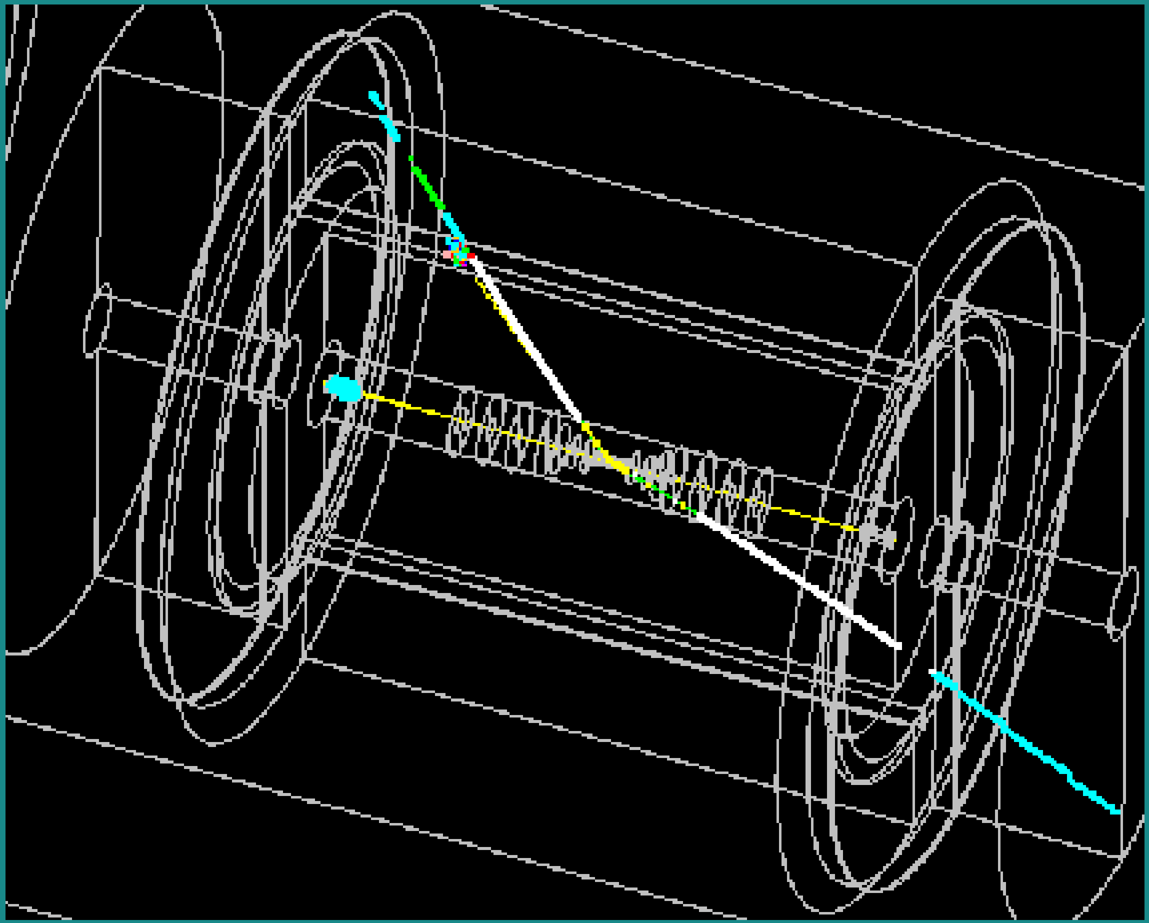
# Design Study for the LC Large Detector



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UC Berkeley and LBNL
& **Mike T. Ronan**
LBNL

# ALCPG Detector Design Study

- ALCPG to sponsor a Detector Design Study of SiD and LD detector designs;
- Produce two white papers for detector design reports by 2005 giving moderately detailed description of detector, optimisation and performance assessment based on physics benchmark reactions;
- M.B. and M.T. Ronan to lead LD Study

# American Large Detector Simulation

**Gismo**

**Lelaps**

**Geant4 Detector Simulation**

to provide detector hits

**LCD Analysis Modules**:

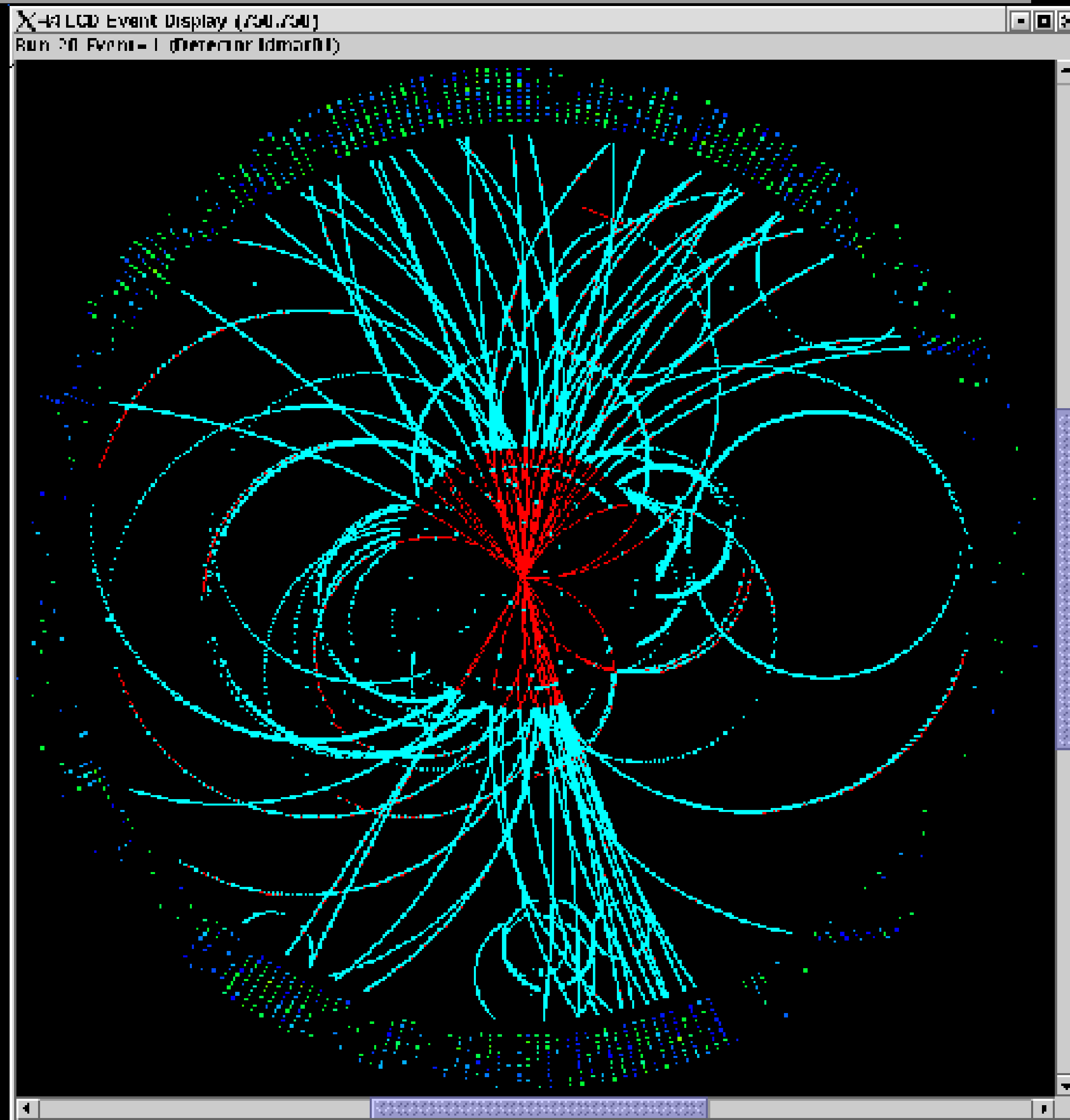
- Pattern recognition
- Track Reconstruction
- Calorimeter clustering
- Jet Flavour Tagging
- Event display

Based on LCIO

JAS histos & AIDA tuples

**Hybrid Simulation Model**

<u>Detector</u>: **ldmar01**



# Physics Benchmarks

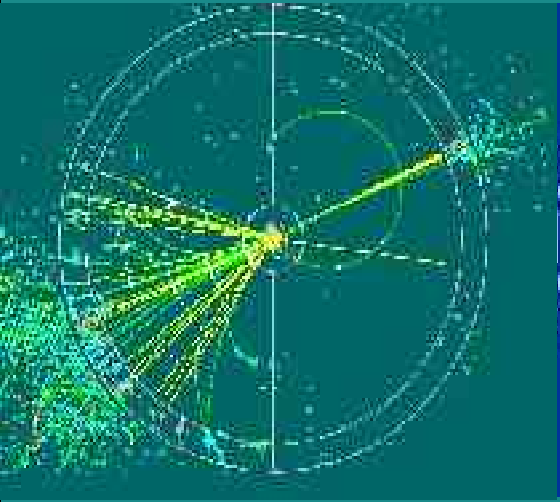
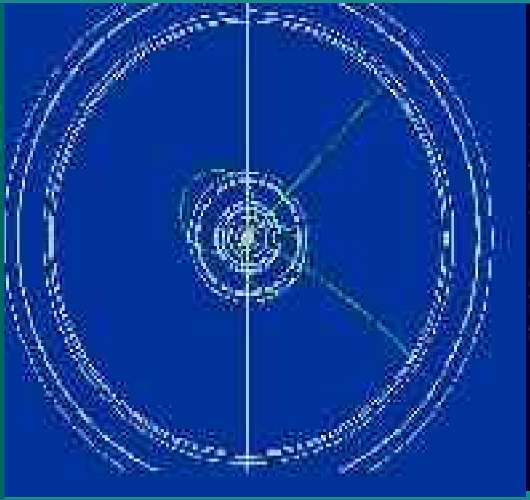
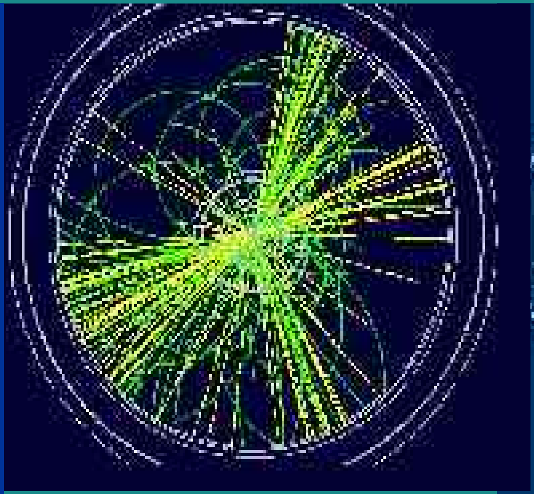
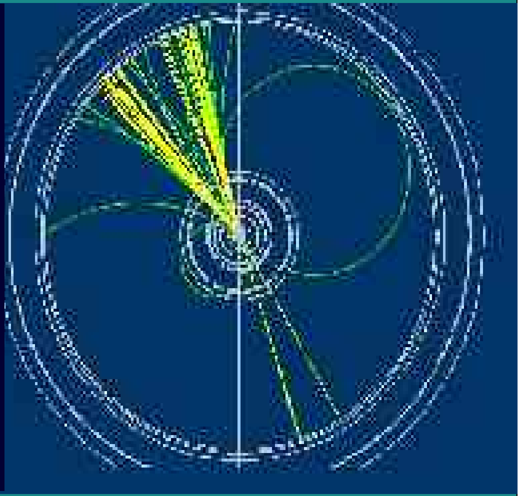
Consider Physics Benchmarks probing tracking and vertexing features:

e+e- -> Z H(120) -> X ff  at Ecm = 0.5 TeV

e+e- -> H(420)A(420) -> bbbb
at Ecm = 1 TeV in A annihilation funnel

e+e- -> sleptons with varying $M_{slepton} - M_{LSP}$
at Ecm = 0.5 TeV and 1 TeV along CDM co-annihilation tail

e+e- -> WW, ZZ at Ecm = 1 TeV

# W/Z separation



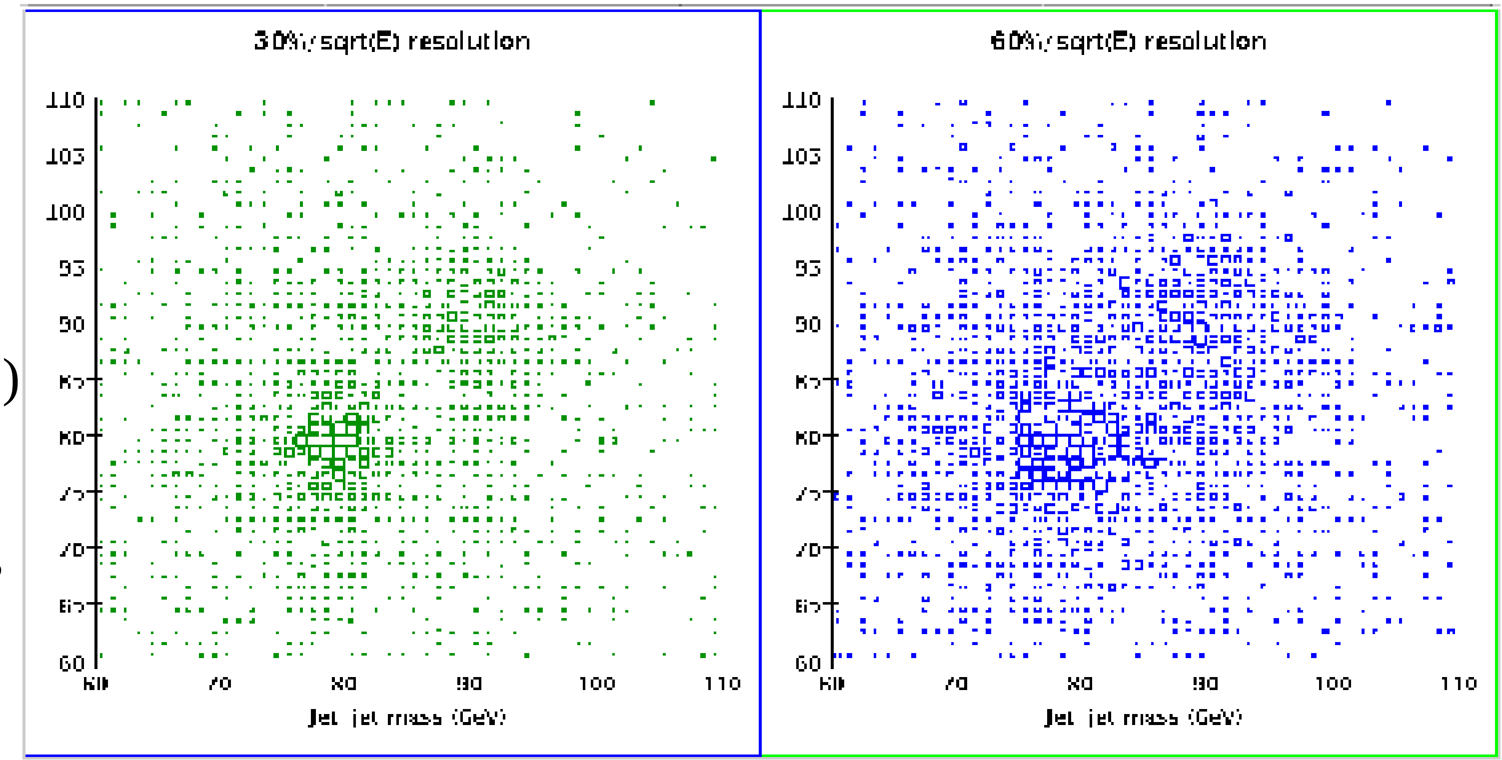
One should choose detector simulations carefully. Some detector models can be much more realistic than others, but are often less flexible.

**Simple detector models**: Smear MC Particle jets.

The required detector performance for reconstructing jets is often given as

dE/E(jet) = 30%/sqrt(E)

The resulting separation of WW and ZZ events is shown in comparison to what was achieved by the LEP detectors.




**Ideal detector models**: Fast Monte Carlo's (FMC's)

Fast Simulation Tools: e.g. SimDet and QuickSim

**Full detector simulation**: LCD Framework packages and Hybrid Monte Carlo system.

# American Large Detector Design

## Large (TPC) reference detector

Large TPC Chamber

- dimensions: dia. 2 m, half-length 2.5 m
- pad layout: 144-256 pad rows
- readout options: Wire or GEM or Micromegas

Electronics

- Next generation over 1M channels

Solenoid

- outside Cal.: B = 3-4 T

## Reconstruction **3D Pattern Recognition**

LCD Java Framework

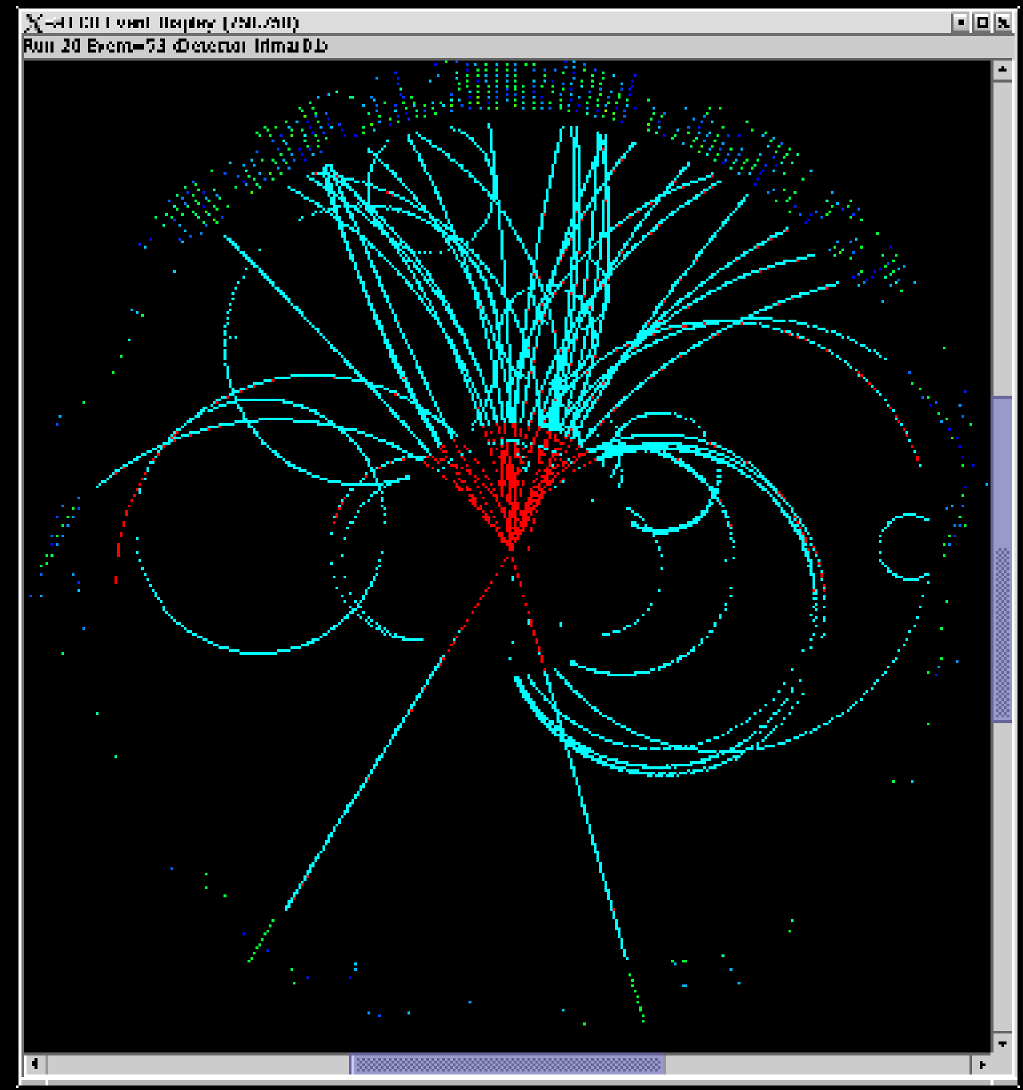
- modular design

TPC Simulation

- smear space points with 60-140 m resolution
- no-detector effects

Tracking efficiency ~ 99%

ZH Event



Hits: TPC (cyan), EM Cal (blue)
Tracks (red), Clusters (green)

# Hybrid MC Scheme

**Using a Hybrid MC system to study detector effects.**

<u>FMC – Ideal detector simulation</u>:
  Perfect tracking and cluster efficiency
  Perfect energy flow reconstruction

<u>Smeared MC Particle Jets</u>
  Includes hadronization effects.

  30%/sqrt(E)  - LC design goal

  60%/sqrt(E)  - ALEPH reference

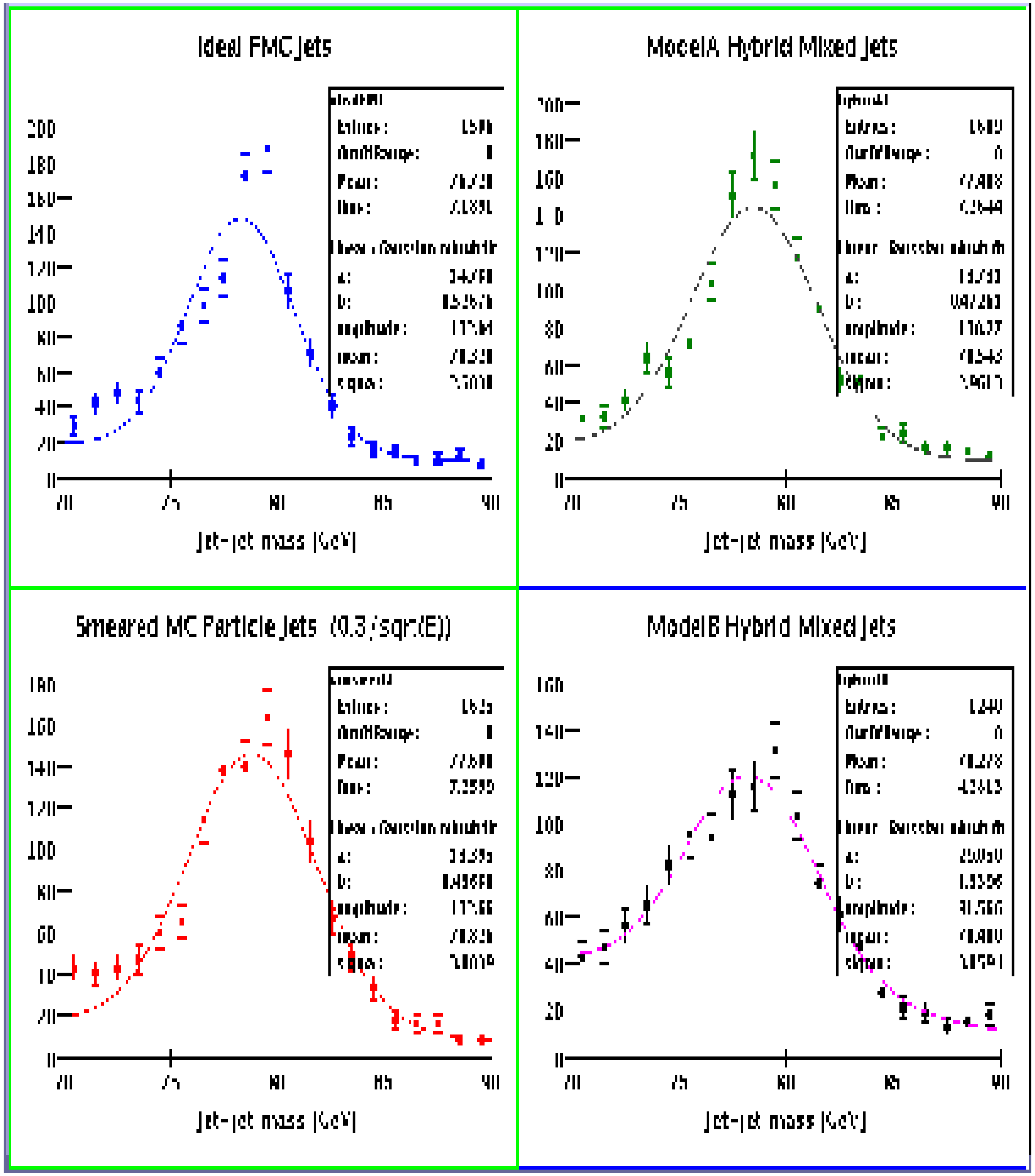
<u>Hybrid MC “Reconstructed” Jets</u>

  - Use reconstructed charged tracks and clusters with an energy flow algoritm.
  - Add missing tracks and clusters from FMC simulation or MC information.

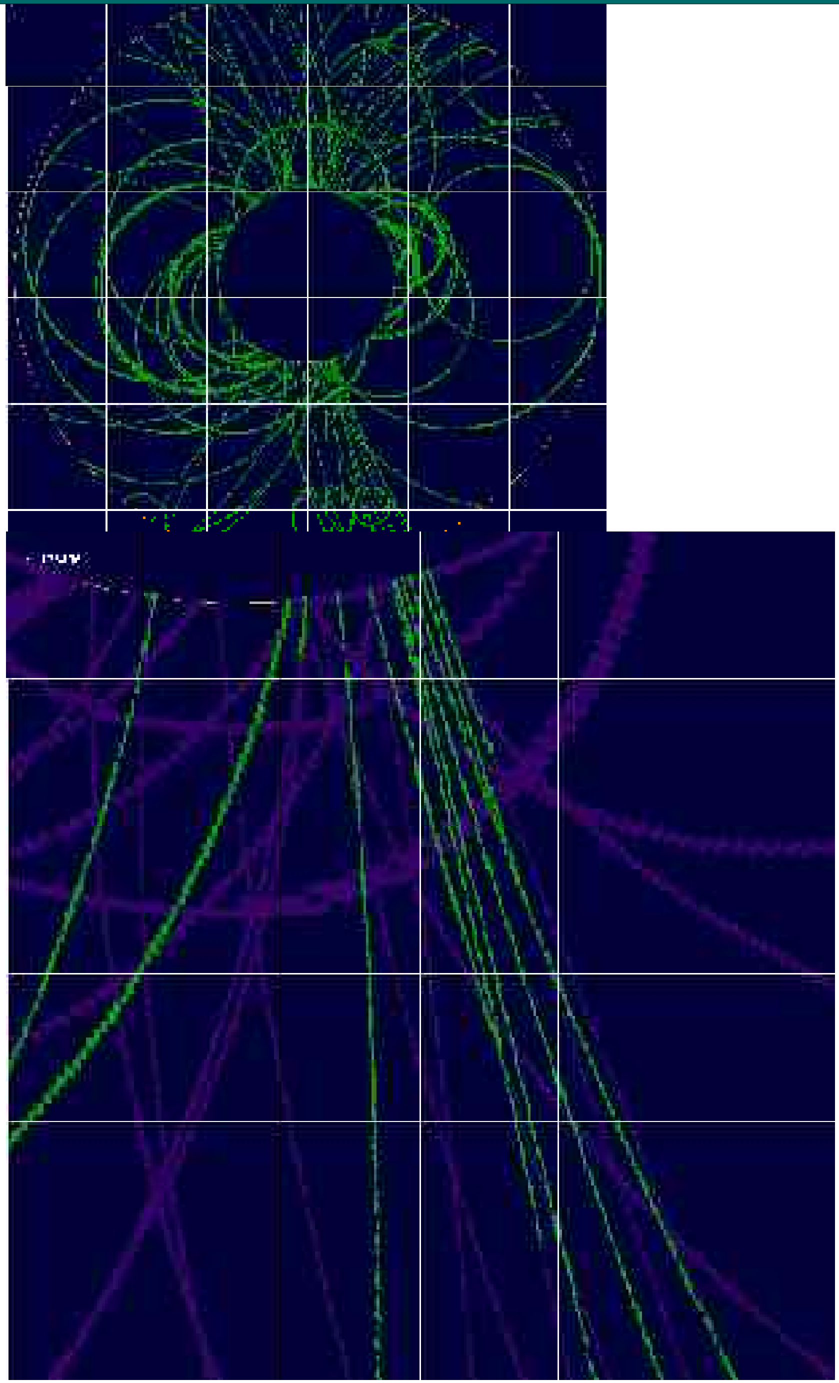
  Hybrid A  - Use reconstructed tracks

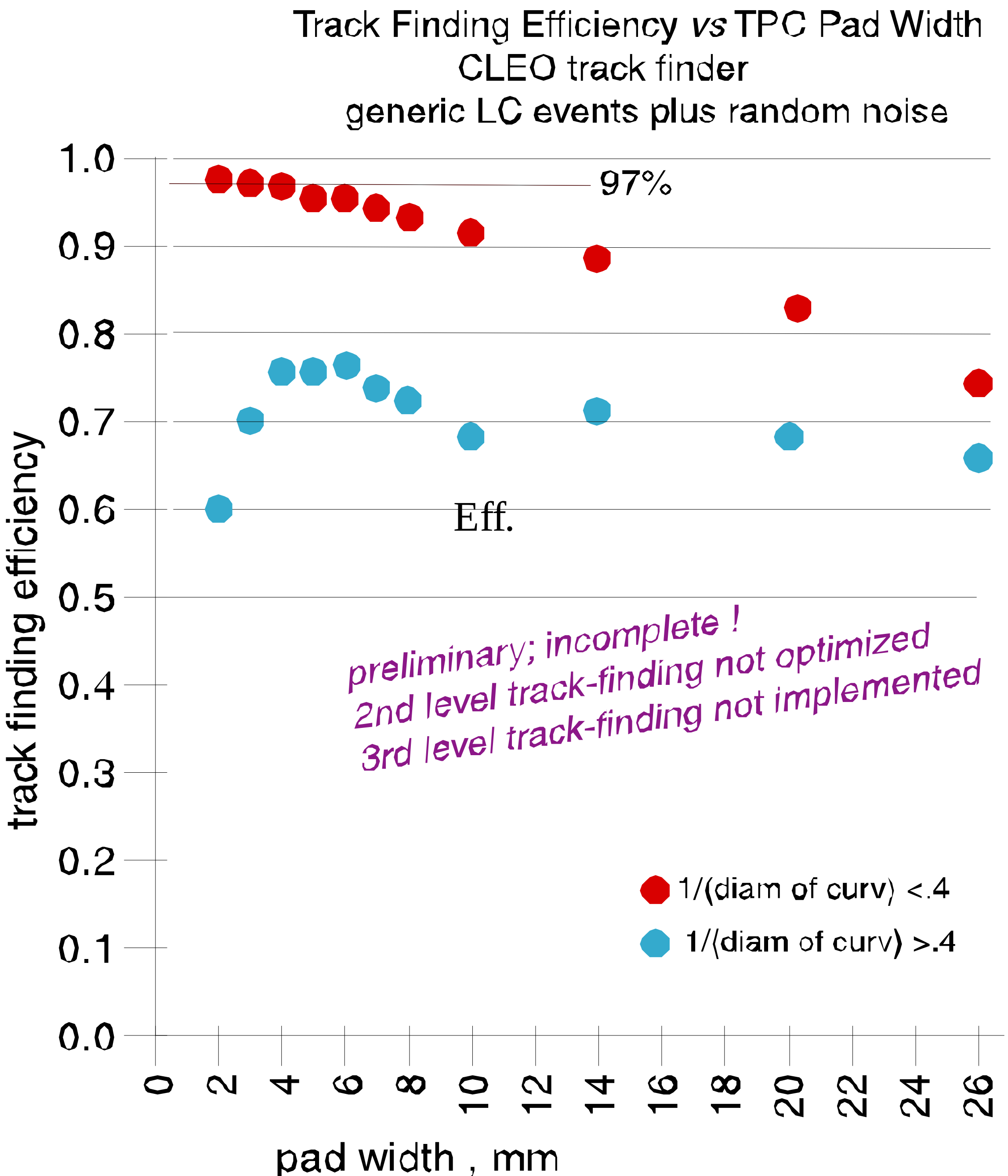
  Hybrid B  - Use reconstructed tracks and clusters with perfect energy flow.

**W mass fits**



# Detailed simulations of Patrec and Trk Reconstruction





# Intermediate Tracker and Forward Regions

Intermediate tracker options:

**Scintillating fiber**

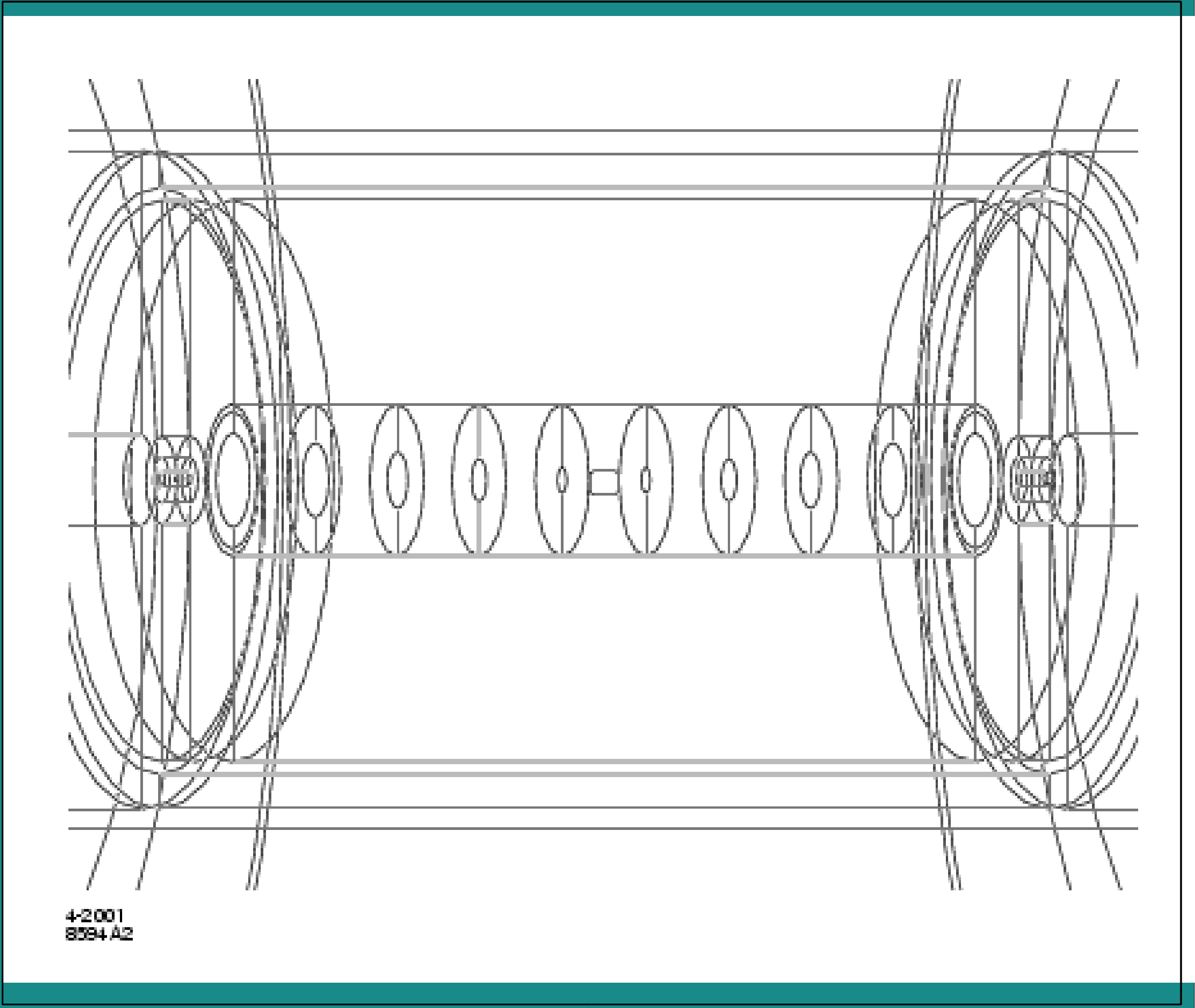
**Silicon strips**

**Bunch Timing capability**

Small angle tracking:

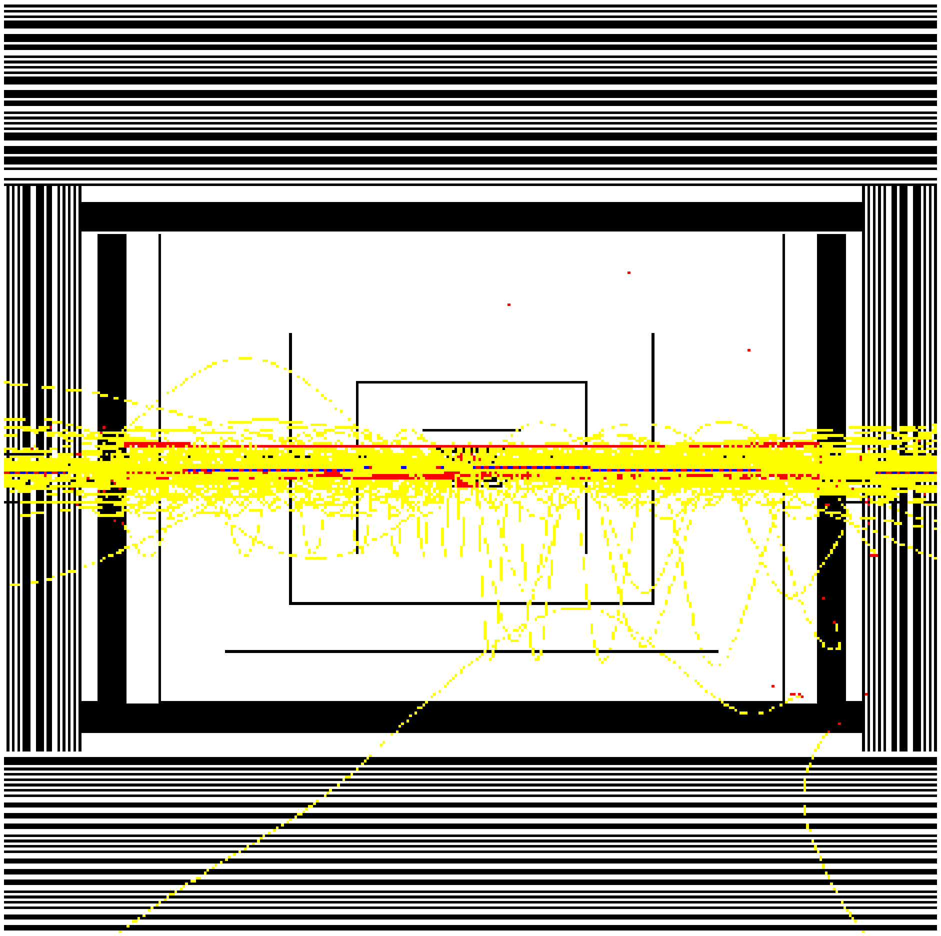
**GEM or Micromegas planes**

**Silicon disks**
**microstrips or pixels**



# Machine-induced Backgrounds

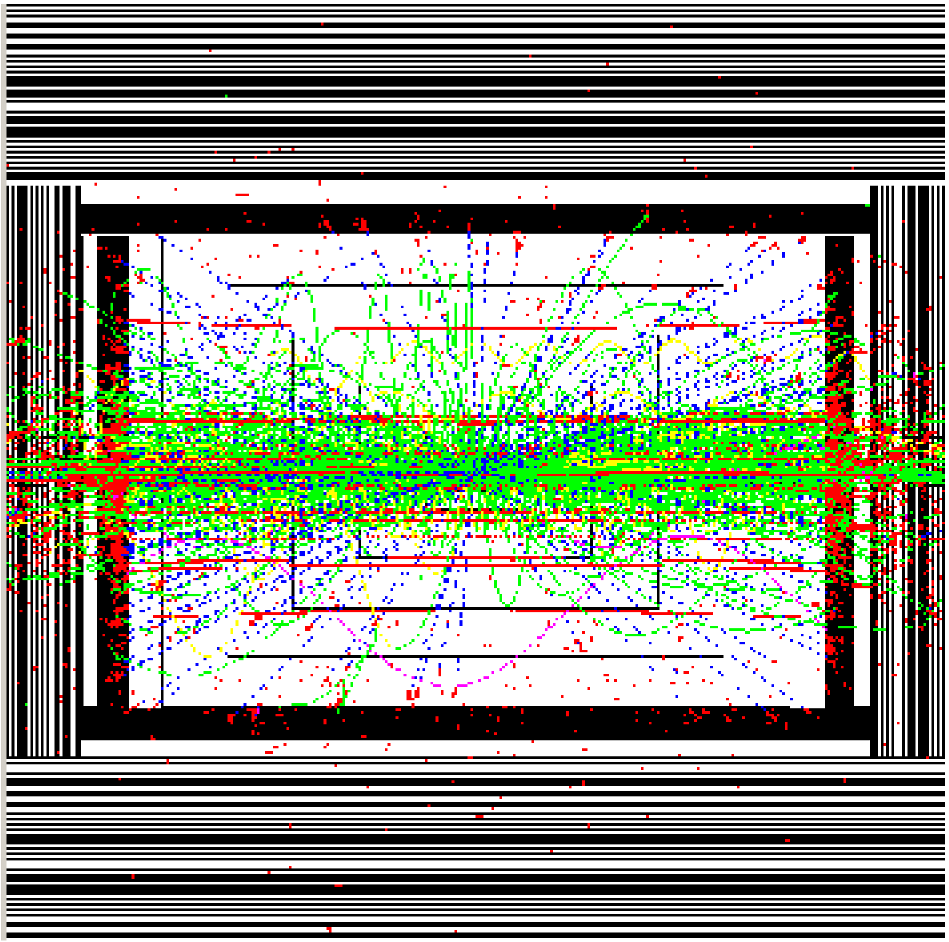
## Pairs



154 pairs / train

56 GeV / train detected energy
24 detected charged tracks / train

## Two Photon Events



56 hadronic events / train no pt cut
454 GeV / train detected energy
100 detected charged tracks / train

# Momentum Resolution Studies

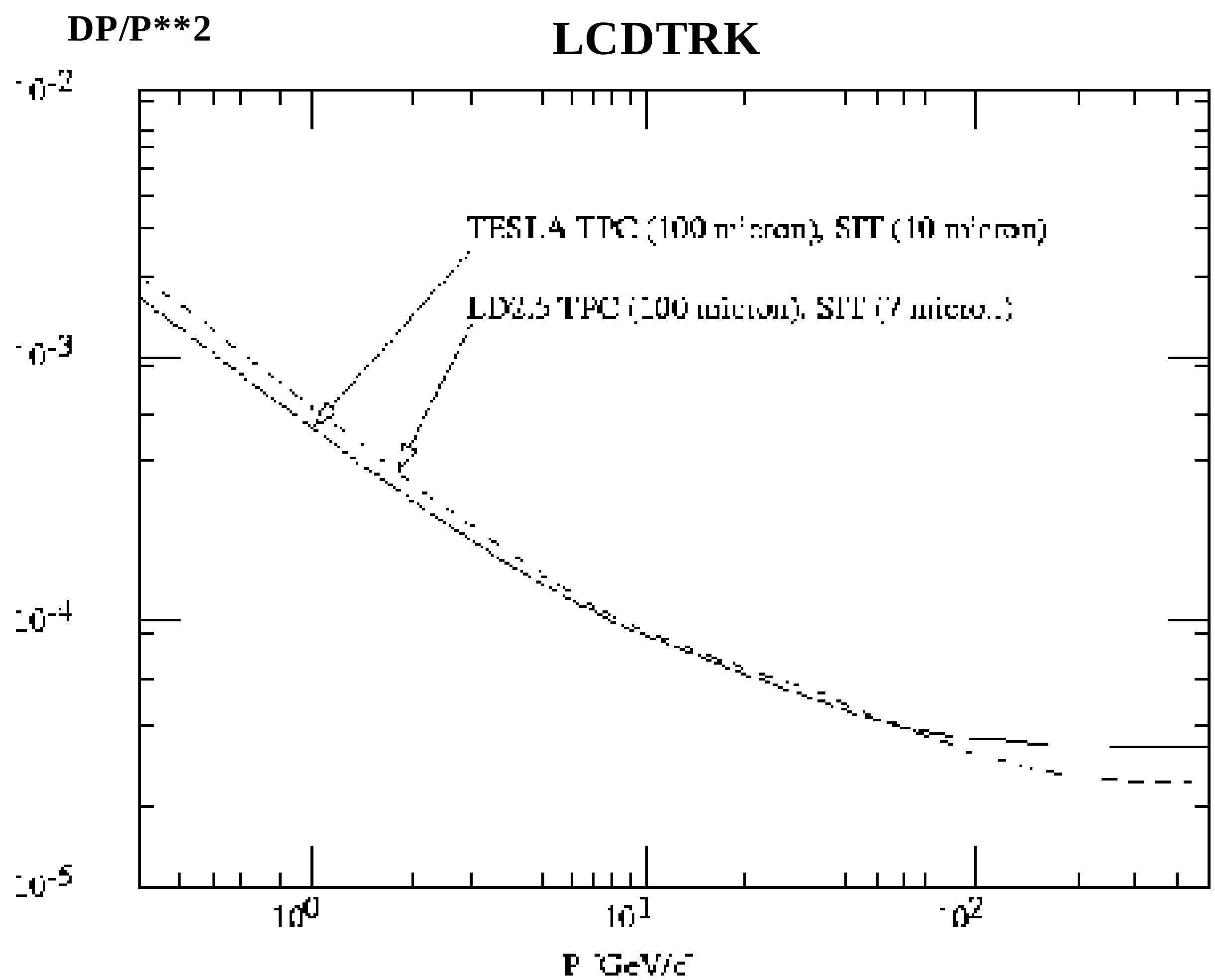
**LCDTRK** to calculate expected momentum resolution for different detector designs and basic resolutions and geometries

Full Simulation for detailed studies

Example for modified American LD detector and TESLA TPC:

Both TPCs have same pad size and point resolution.

TESLA TPC has better low momentum resolution due to smaller inner radius.




Comparison of TESLA TPC and updated American Large Detector (LD2.5) momentum resolution.

# LD Detector Design Study and Physics Benchmarks

- ALCPG Design Study offers opportunity to reconsider detector design and its optimisation with guidance from a limited number of well defined physics processes and including technical feasibility evaluation, engineered design and cost considerations
- Design Study to proceed along with Detector Working groups and findings will motivate and direct future detector R&D
- Groups and individual physicists are invited to join and contribute expertise and activities.