Muon Collider Physics&Detector

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Work on physics and detector simulation for the Muon collider is just starting in earnest.

In the Summer 2010 DOE lepton physics review Fermilab proposed:

- Physics and detector report at the end of 2011 covering physics requirements on beam specifications and the comparison of physics opportunities at a muon collider with those at CLIC and ILC
- Conceptual design report in 2013-14

We are beginning the follow-up by reviewing the technical simulation options (yesterday) and beginning to consider the organization of the simulation effort.

The effort will build on the work that was done in the 1995-2000 studies

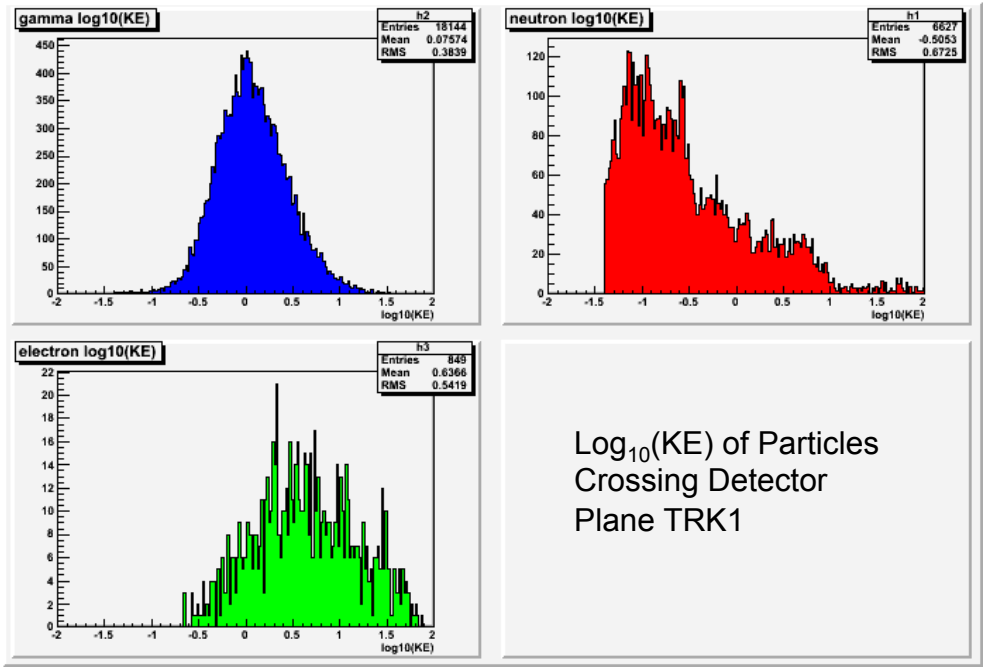
A convincing case needs to be built both for physics capabilities and plausibility of experiments in the background environment.

Simulation

We are building a simulation group including a laboratory core with substantial university participation.

- Establish core simulation group
- Select simulation and analysis framework
- Parallel initial studies
  - Backgrounds
  - Physics benchmarks

  ->Integration of physics with background



Aim to have initial results in a workshop summer 2011

Start with existing ILC/CLIC concepts (SiD, ILD)

Use existing tools

Integrate university groups

(Muons inc)

Simulation Challenges

There is a huge flux of particles associated with beam muon decays

Full simulation with the entire flux of background particles is impracticable

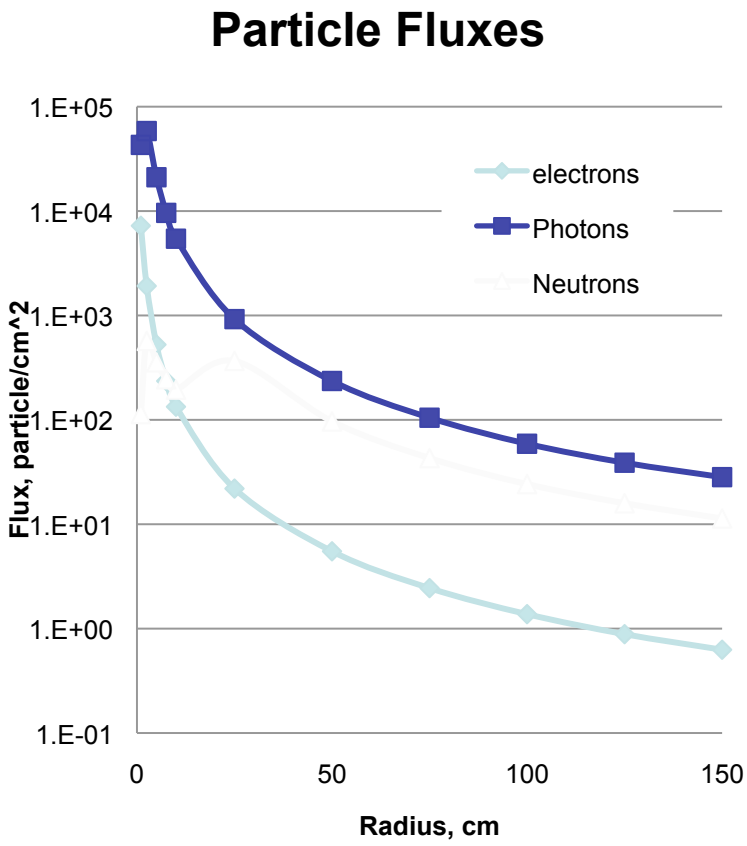
- Large particle weights
- Computing time

Schemes to improve performance

- Change weighting scheme
- Parameterize low energy, high flux backgrounds
- Full simulation of high Pt backgrounds

Calorimeter energy simulation

- Is timing useful?
- Characterize background energy pedestal and fluctuations

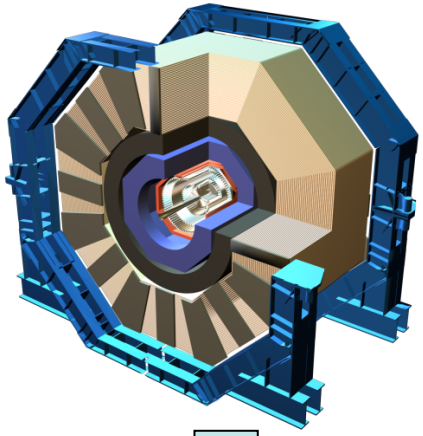


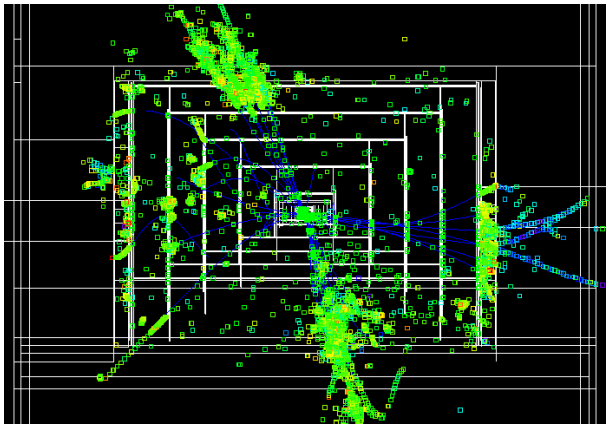
(Muons inc)

Simulation of ILC Concepts

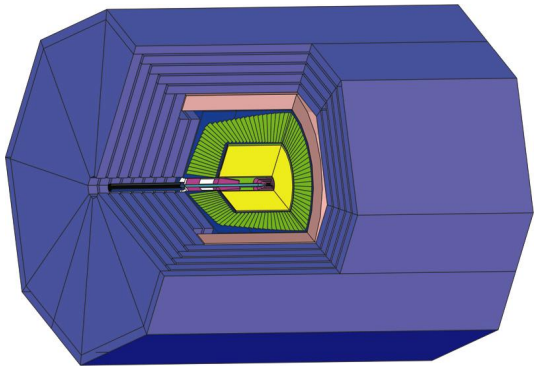
Use software and detector concepts developed for ILC (LCSIM, ILCROOT)
Modify existing concepts, compare directly to ILC, CLIC capabilties

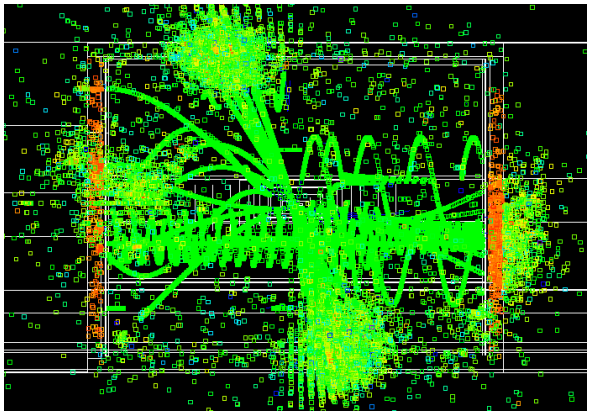
SiD



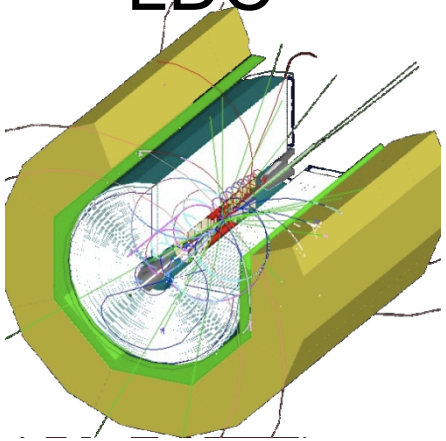


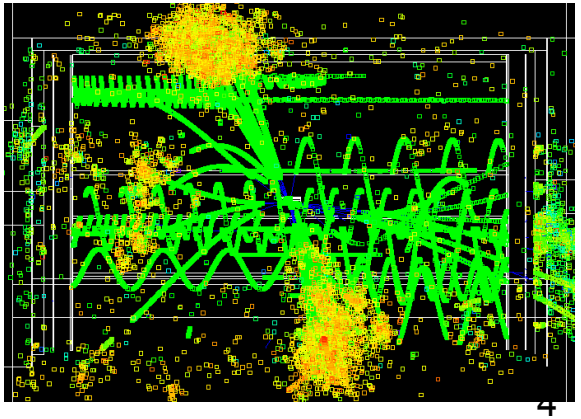
GLD



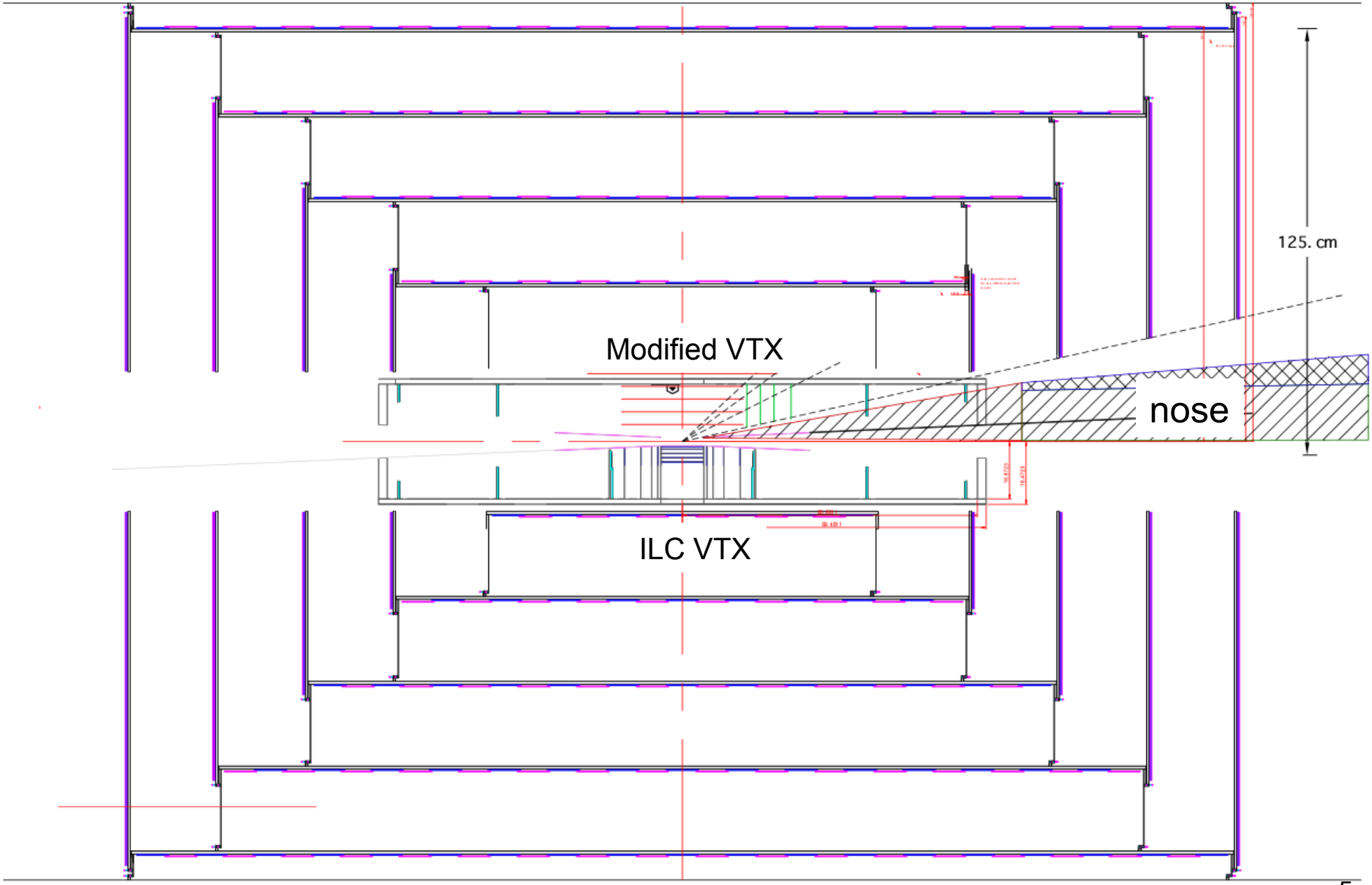


LDC





SiD->SiD”



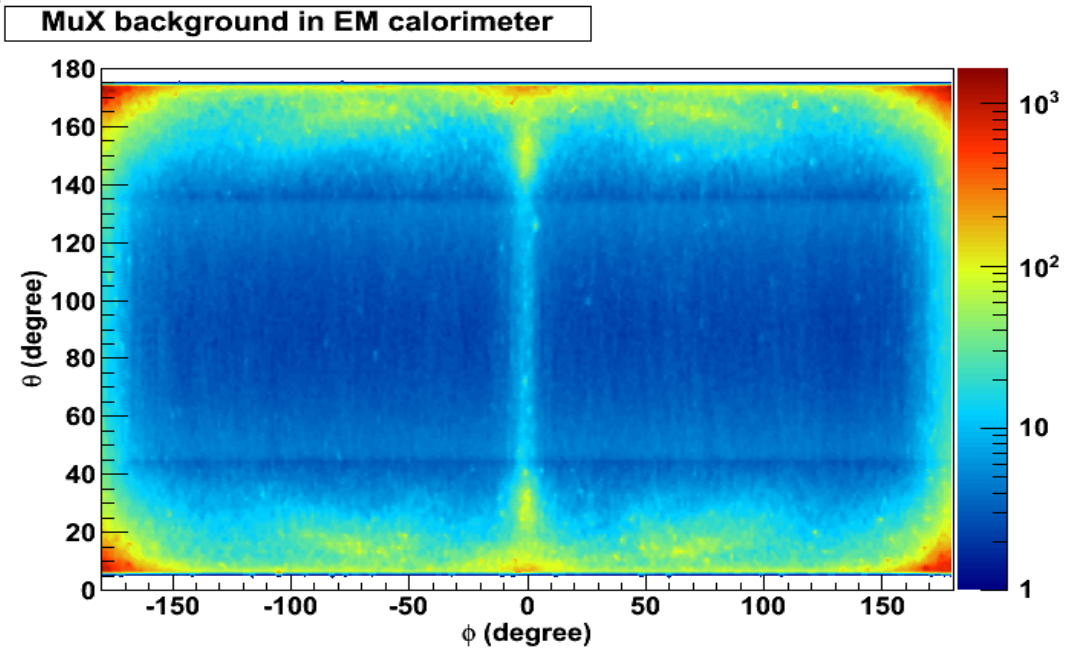
ILCROOT (INFN Lecce)

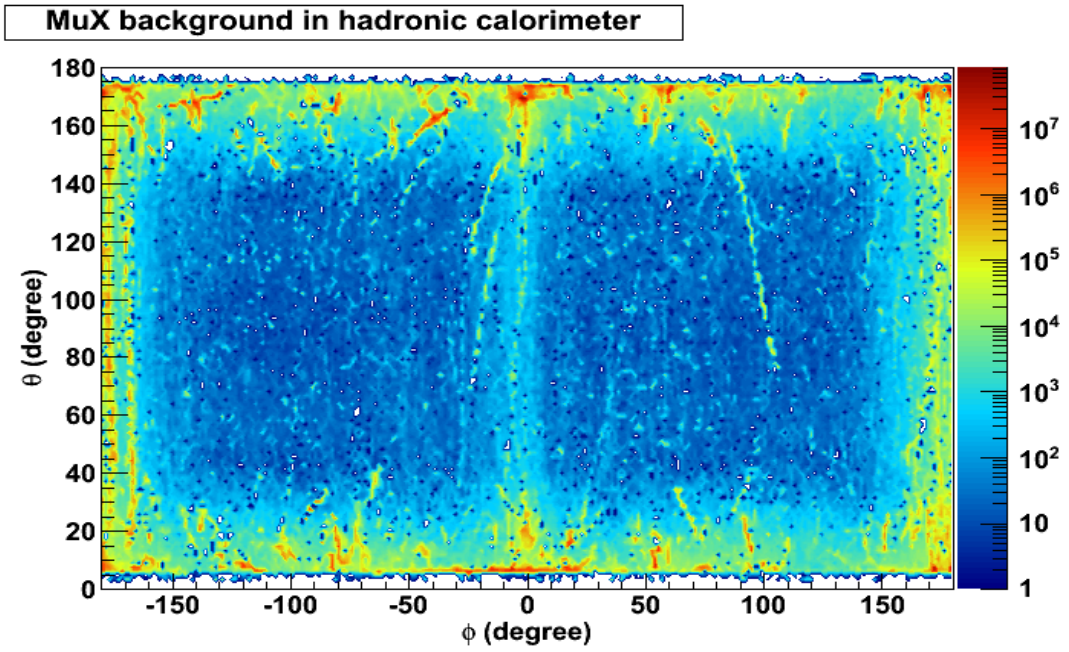
Most advanced effort – began ~1 yea ago.

Developed through ILCROOT framework.

Successful importation of MARS backgrounds into a experiment.

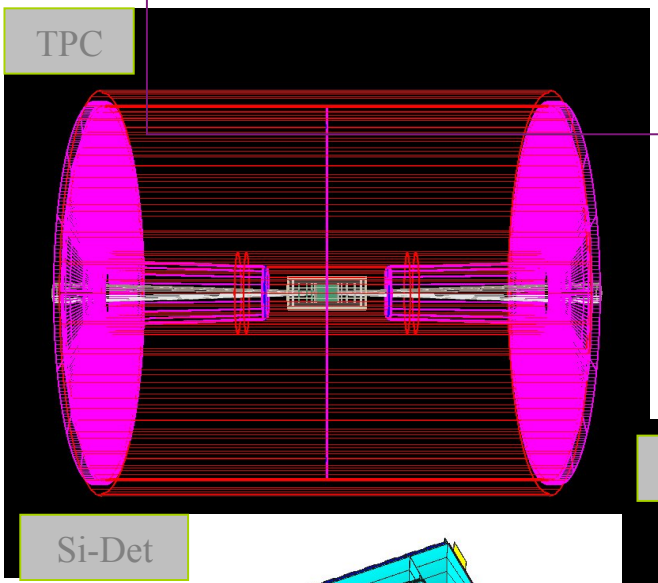
- Backround source from 1 collision (MARS - Dec. 2009)
- E_{CM} = 1.5 TeV
- Calorimeter coverage $6° < \theta < 174°$
- Weighted particles method
- MDI separation plane: 7.5 m from I.P.
- No pre-cuts
- Full G4 simulation
- 1 bin = 4x4 cm^2 cell



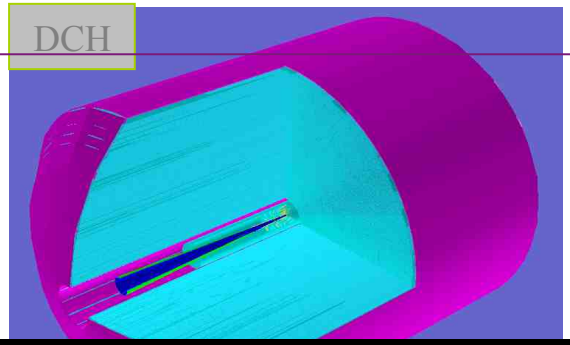


Detectors in ILCroot

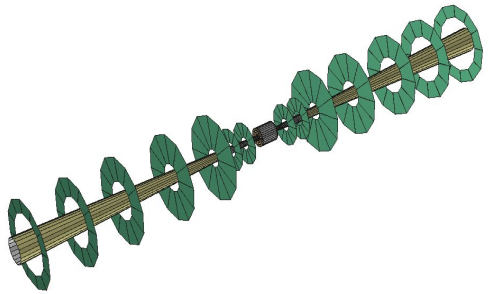
TPC



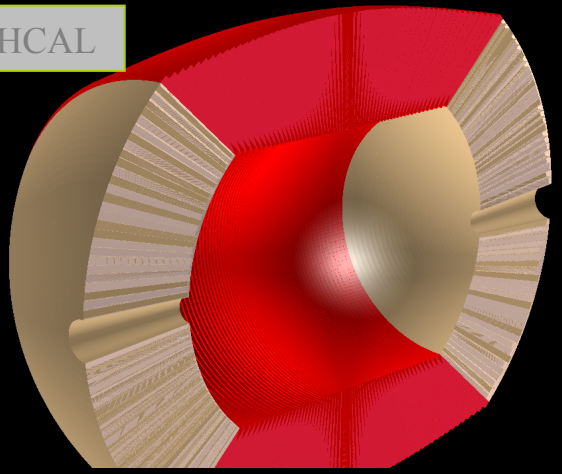
DCH

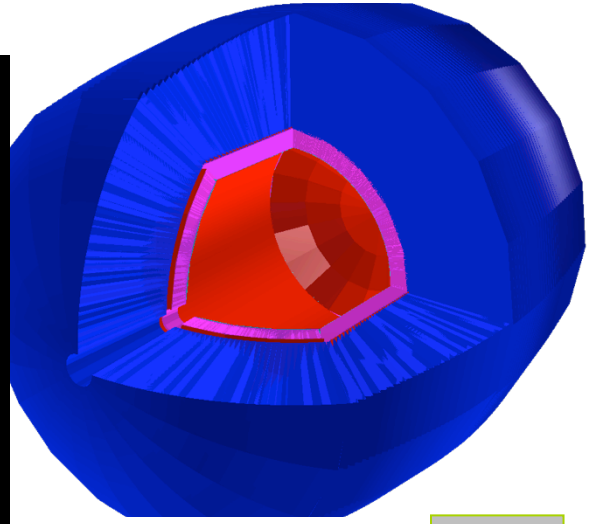


FTD

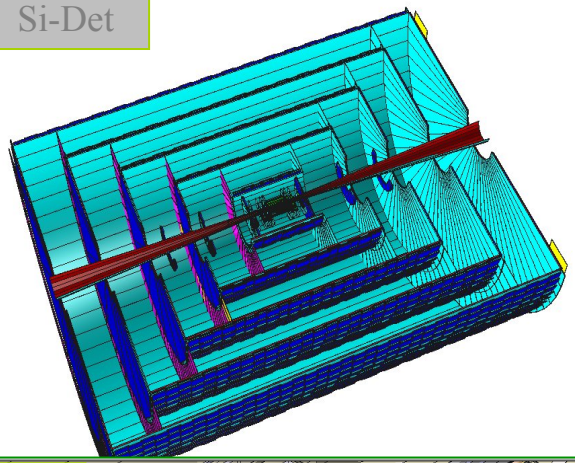


HCAL

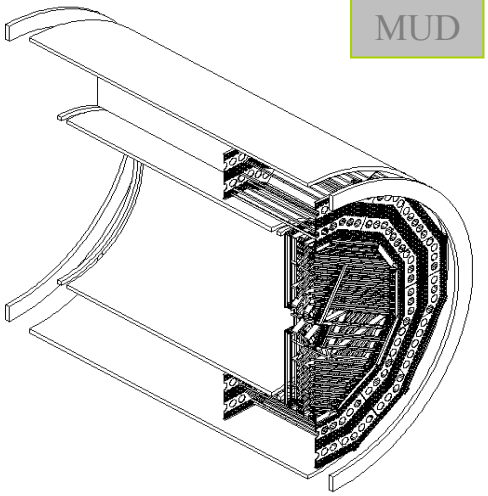




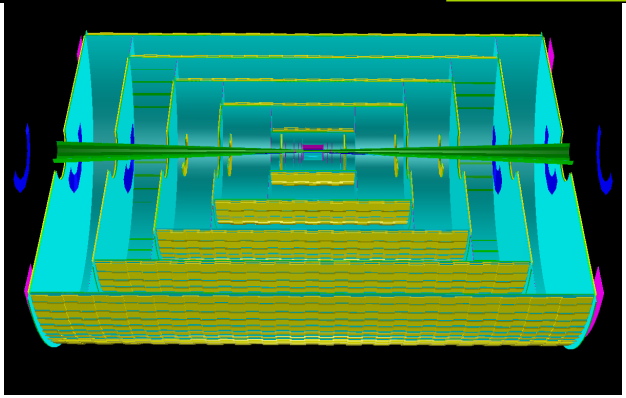
Si-Det



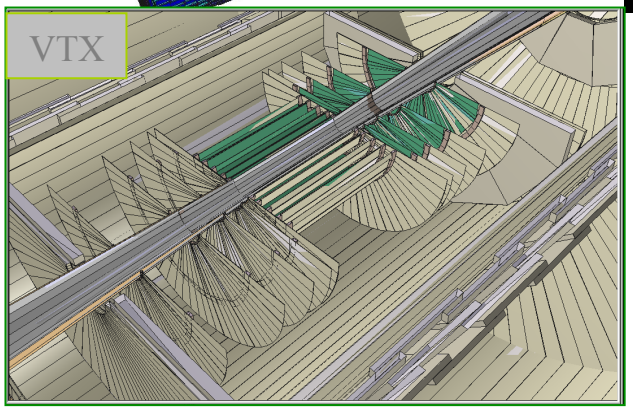
MUD



MC/CLIC



VTX



First Physics Process being Study in ILCroot (Gatto)

- Production of a single Z_o in a fusion process:

$$\mu^+\mu^- \rightarrow \nu_\mu \underline{\nu}_\mu + Z_o \rightarrow \text{2-jets}$$

- How well can the invariant mass of the Z_o be reconstructed from its decay into two jets?
- In particular, could the Z_o be distinguished from a $W^\pm$ decaying into two jets in the process

$$\mu^+\mu^- \rightarrow \mu^- \underline{\nu}_\mu + W^+$$

if the forward μ^- is not tagged?

(Vito Di Benedetto Ph.D thesis)

Steps

- Soon – Pick framework(s) (LCSIM, ILCRoot, PGS, CMS sim … other candidates)
- Interface the framework to background simulations
- Integrate a toy detector (SiD'')
  - Study background rates and distributions
    - Radial distribution
    - Time distribution
    - Energy flux
  - Modify detector, shielding
- Integrate beam/physics simulations
- Study simple physics processes
  - Compare with some ILC/CLIC benchmarks

The hope is to have a set of preliminary results available for the Summer 2011 Muon Collider workshop.