ILC detector R&D activities at Fermilab

H.Weerts
Fermilab/Michigan State Univ.

Outline 1

Will outline current activities & program

Am spending a sabbatical at Fermilab to work on ILC
….put my efforts where my mouth is

Goal: A coherent, focused ILC detector R&D program at Fermilab emphasizing and relying on existing strengths

Status today:
- Where are we now
- Possible future directions

Typically people are working a fraction of their time
We have not asked people to work full time on topic
(exceptions are CM, HW with large fractions)

Outline of activities 2

1. Detector concept specific activities: SiD

2. Generic ILC detector R&D

Funded in US by UCLC ($0) and LCRD (~$700K/yr) +SLAC&FNAL

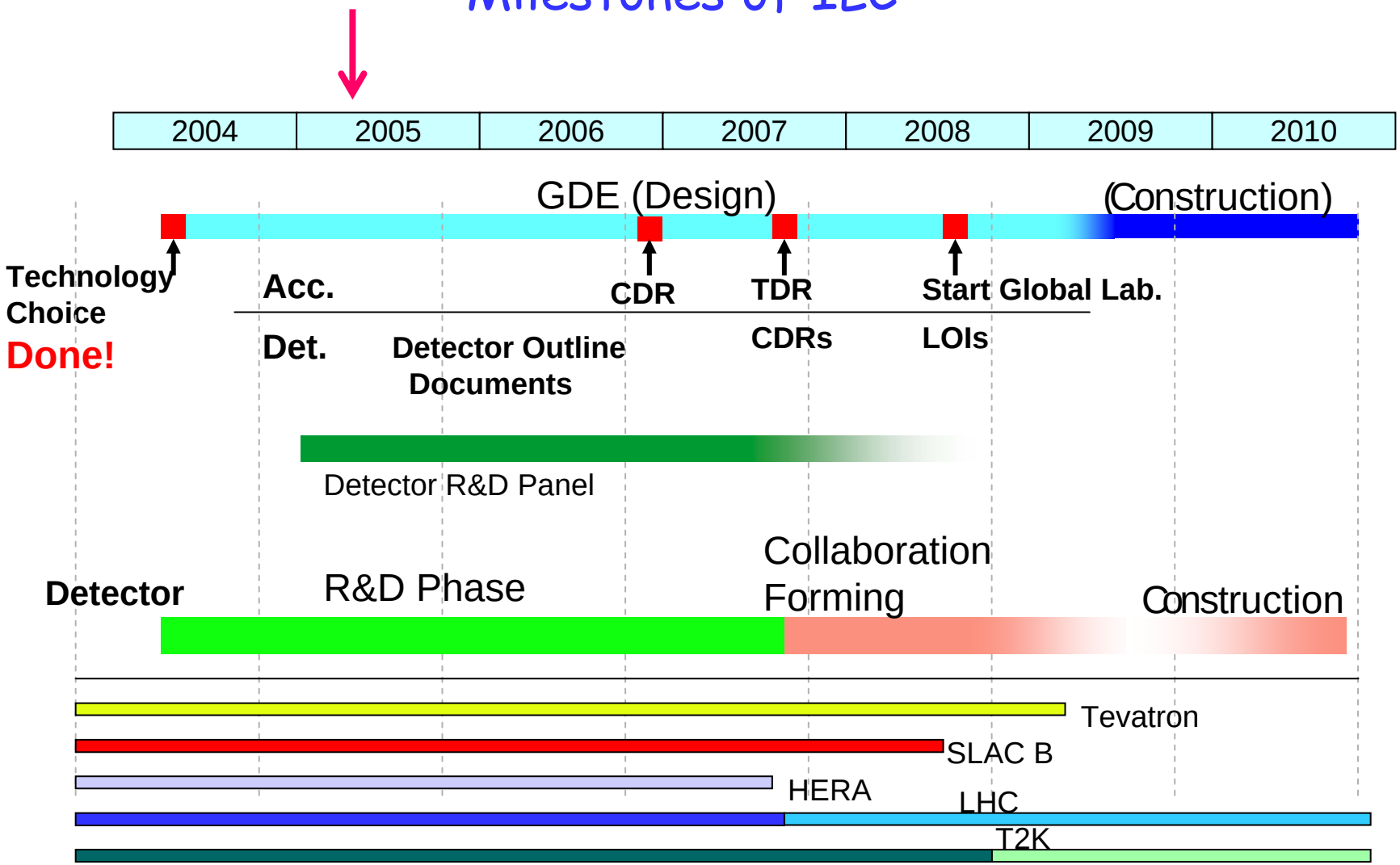
This reflects world wide activities which are centered around subdetector generic R&D, with larger and smaller efforts organized in small and large collaborations

AND

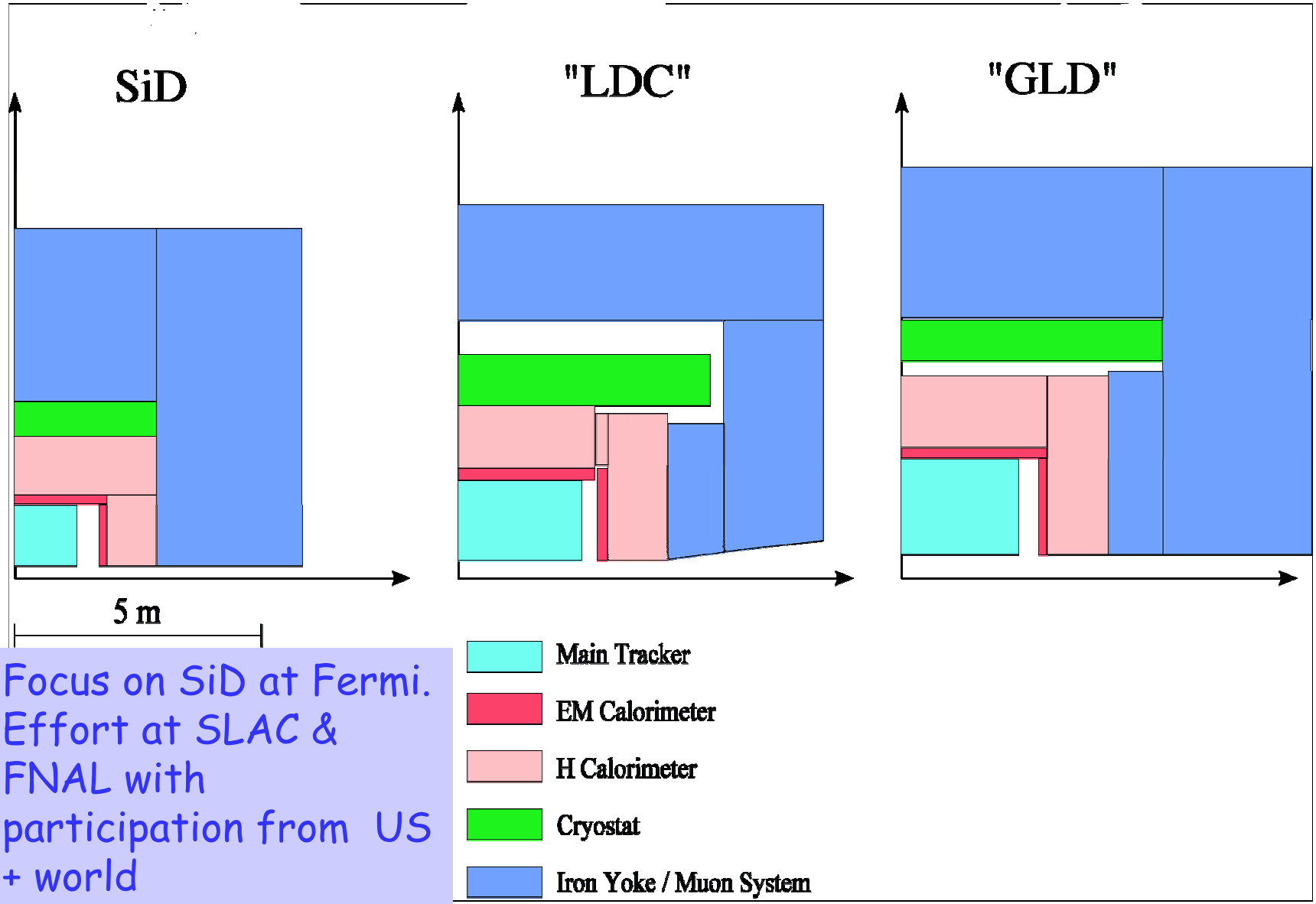
The three ILC detector design studies which started last year and are now ongoing worldwide: SiD, LCD, GLD

Current time line for ILC

Milestones of ILC



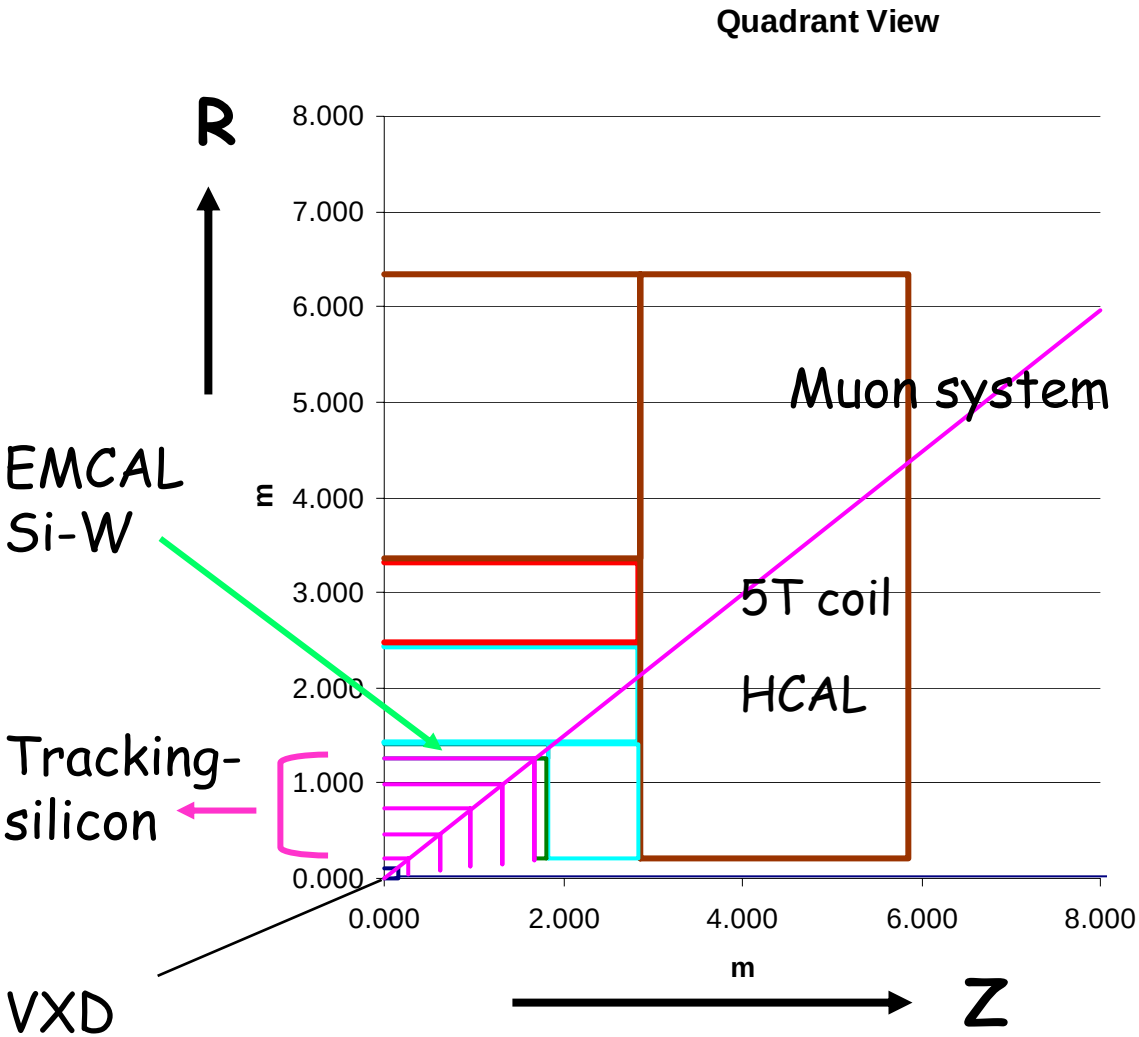
Three Detector Concepts



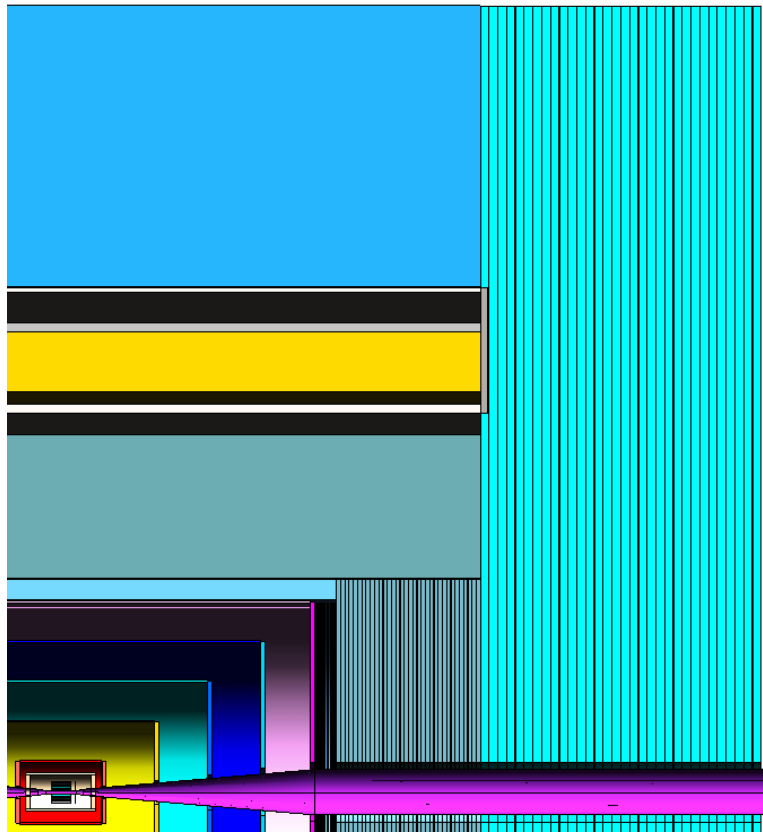
Focus on SiD at Fermi. Effort at SLAC & FNAL with participation from US + world

SiD concept overview

Very schematic drawing



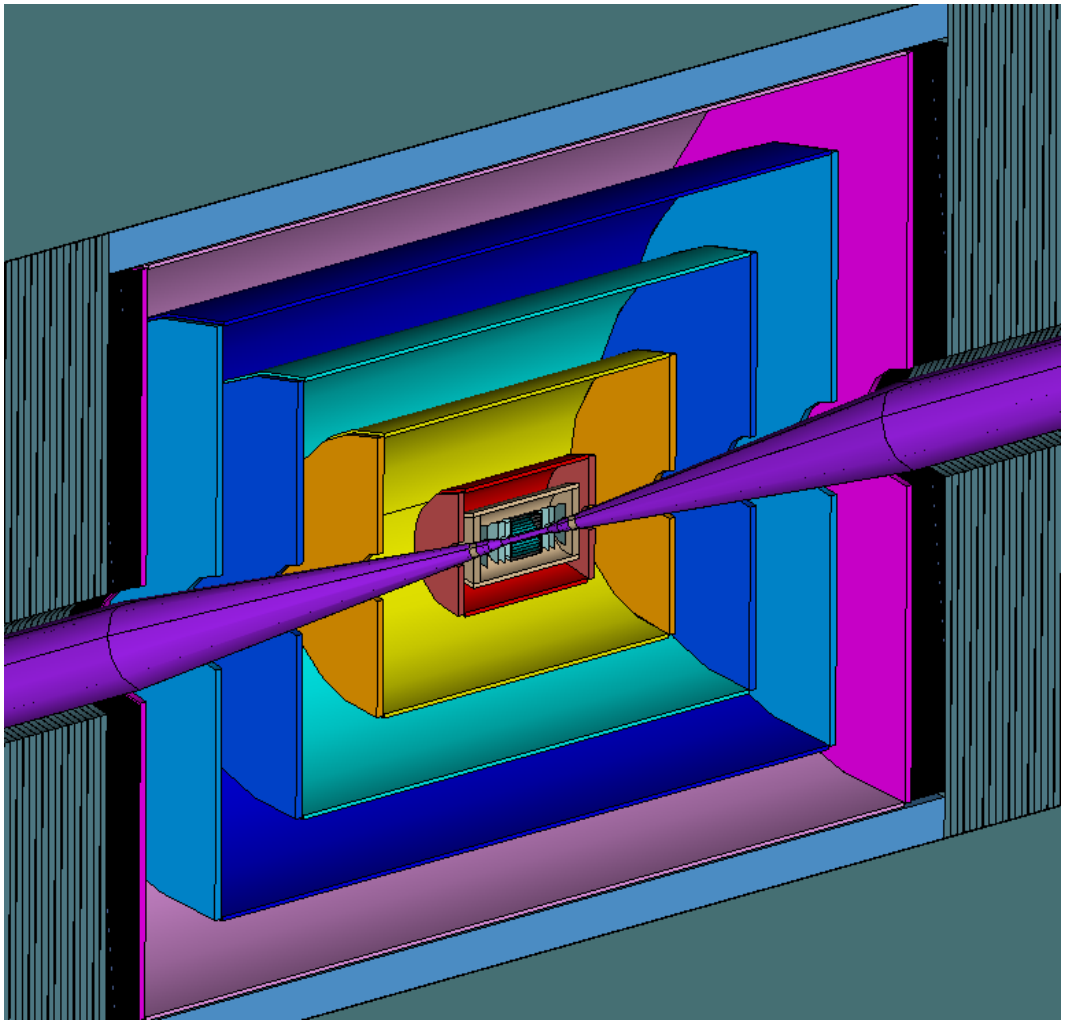
Status July 2004



Status March 2005

All model drawings by FNAL

FNAL SiD: silicon tracker



Model of what is in simulation

Design & layout led by FNAL.

W.Cooper & M.Demarteau plus technical expertise PPD

Started with first real layout for Victoria ALCPG 2004 meeting.

Effort continued over fall & winter 04/05. Have a 5 layer design based on work by W. Cooper.

Tracker effort in SiD led by Demarteau (FNAL) & Partridge (Brown)

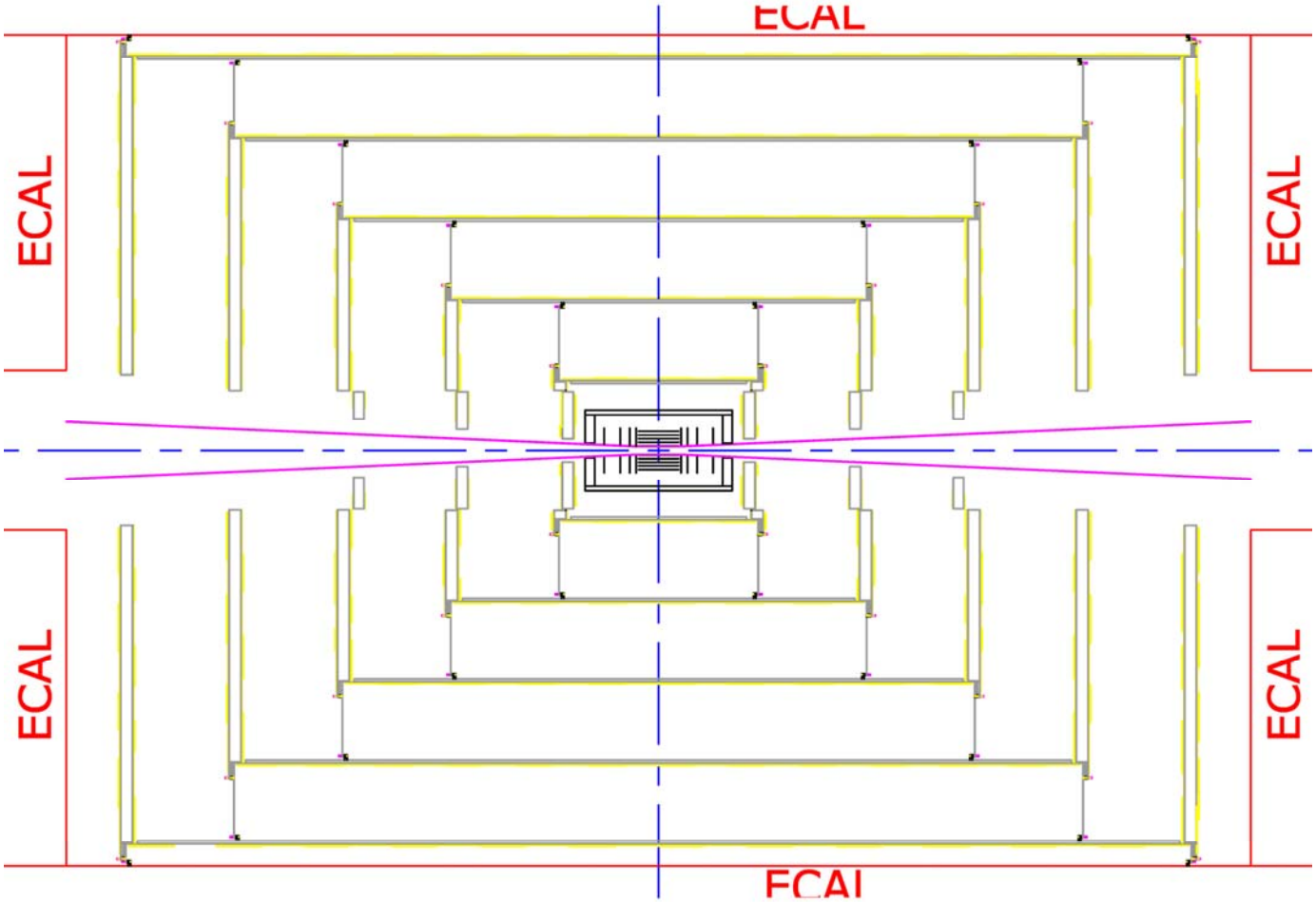
FNAL SiD Si tracker layout.

W. Cooper

H.Weerts

Real drawings; not simulation model

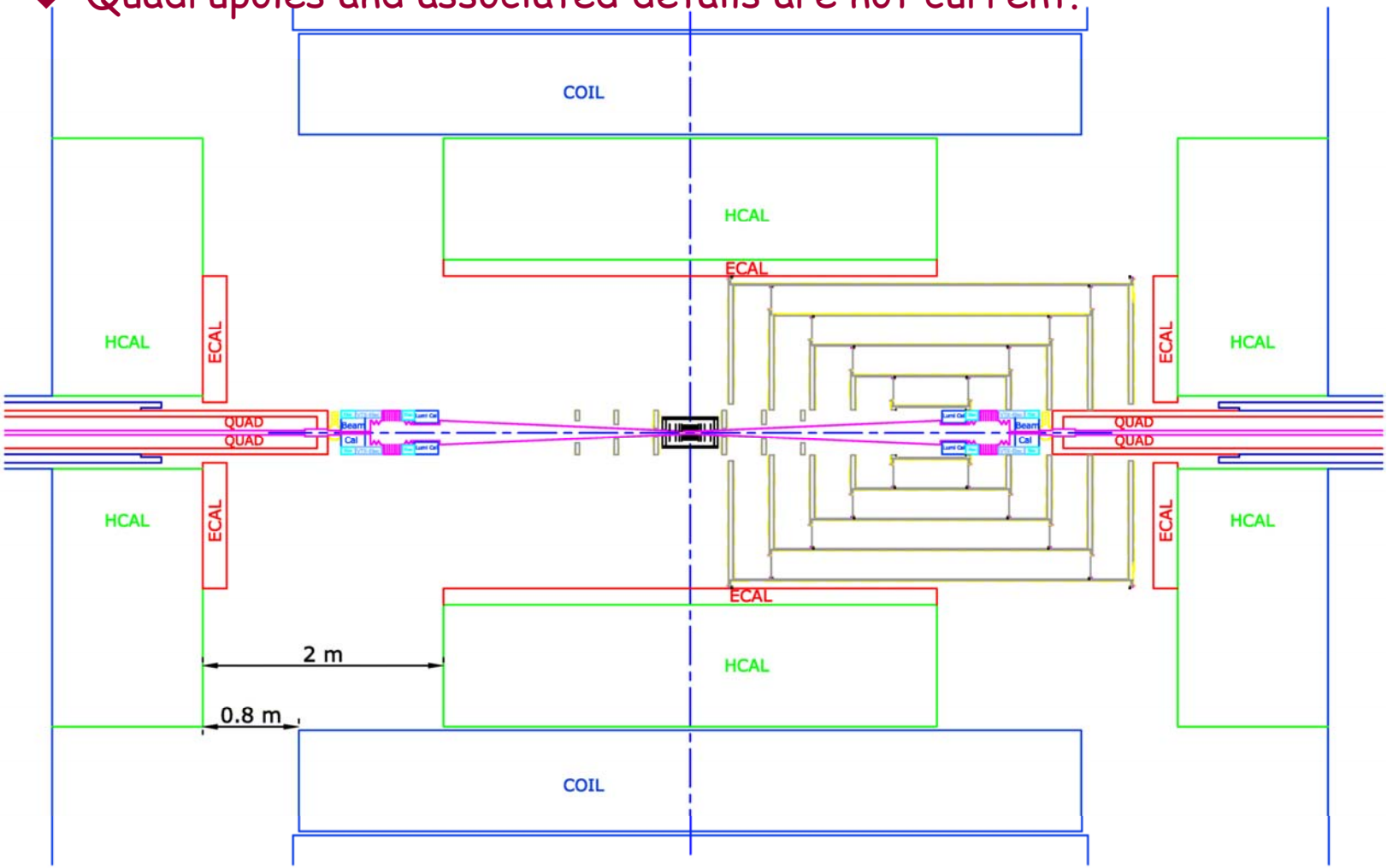
- The outer silicon tracker has been separated into a portion supported from the ECAL and a portion supported from the beam pipe to allow servicing of the VXD.
- Overlap between smaller and larger disk portions is provided by offsetting the portions at smaller radius towards Z = 0.



With quite a bit of mechanical detail

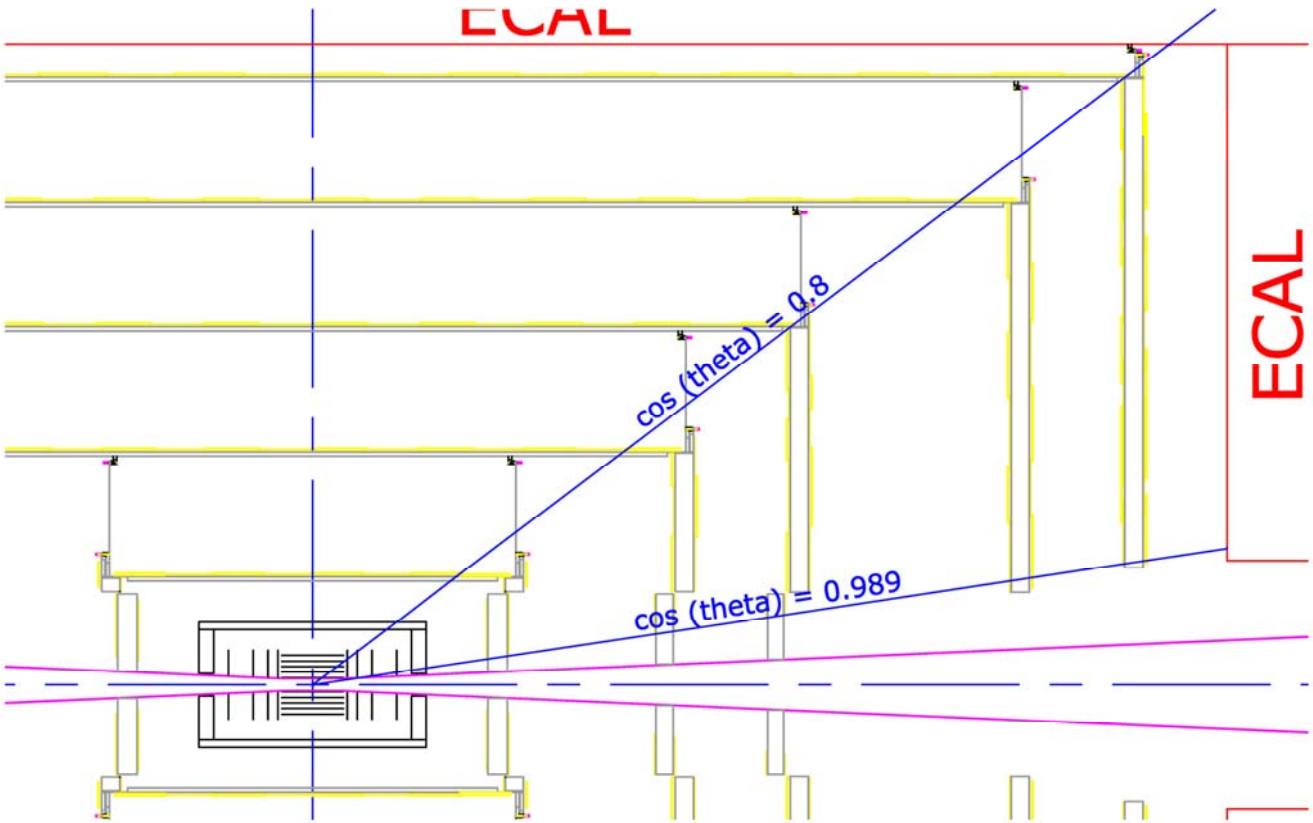
SiD tracker

- The outer tracker is moved longitudinally (in either direction) for VXD servicing while the VXD and beam line elements remain stationary.
  - Quadrupoles and associated details are not current.



SiD tracker 3

Modifications to control projective geometry



Illustrations of the work that has started on SiD tracker at FNAL

SiD tracker 4

Effort in Si tracking based on existing expertise at FNAL and especially in SiDet.

Talking to Computing Division to participate in this and strengthen in area of simulation and algorithms. Including general software support for installation and maintenance of ILC simulation, reconstruction and analysis software.

Goal: A coherent effort in tracking

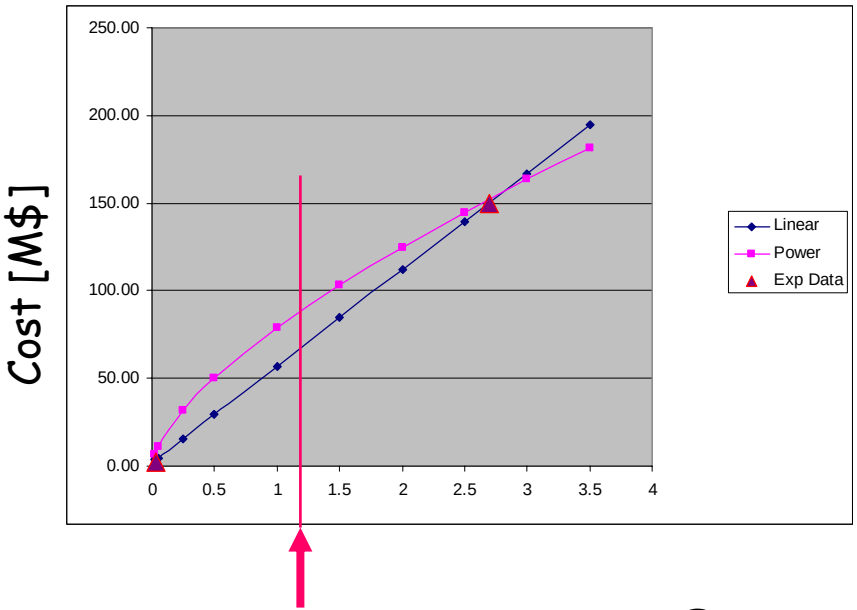
Solenoid 1

This is what I used to show

Inner radius: ~ 2.5m to ~3.32m, L=5.4m; Stored energy ~ 1.2 GJ

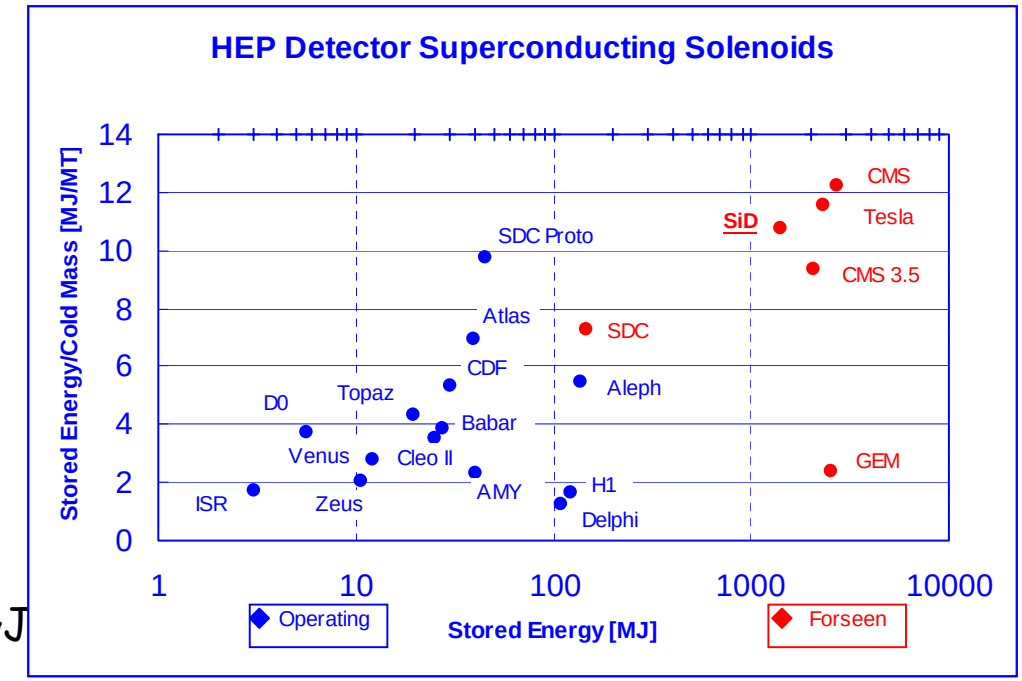
Need feasibility study in next year to at least convince ourselves that this challenging 5T solenoid can be built .

Expertise not readily available. CMS solenoid sets current scale.



Cost model

SiD



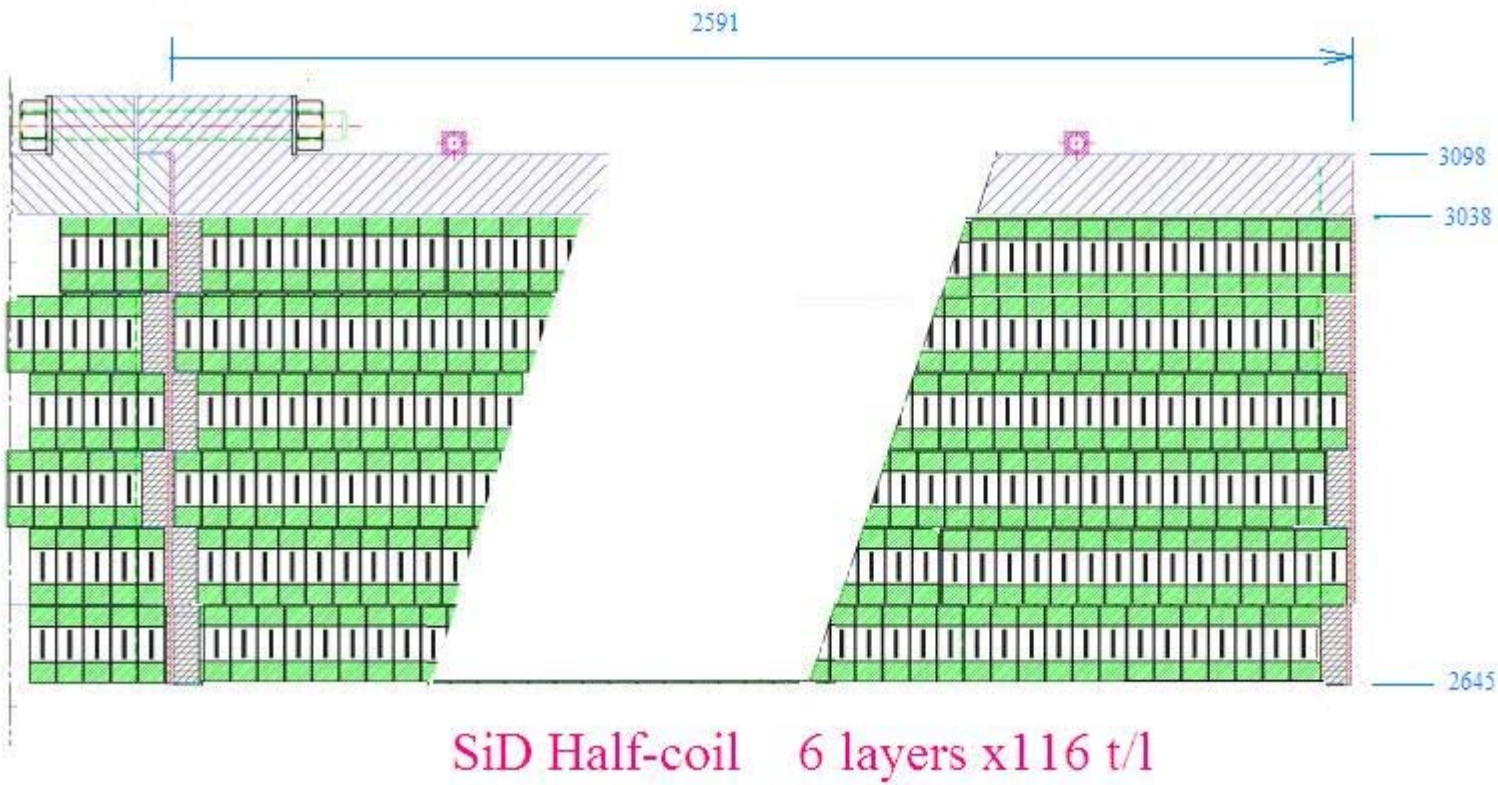
Does physics really require 5T?

Solenoid 2

Feasibility study has been done. At FNAL: R. Wands & R.Smith

Use CMS conductor design and study stresses, in cooldown and energizing

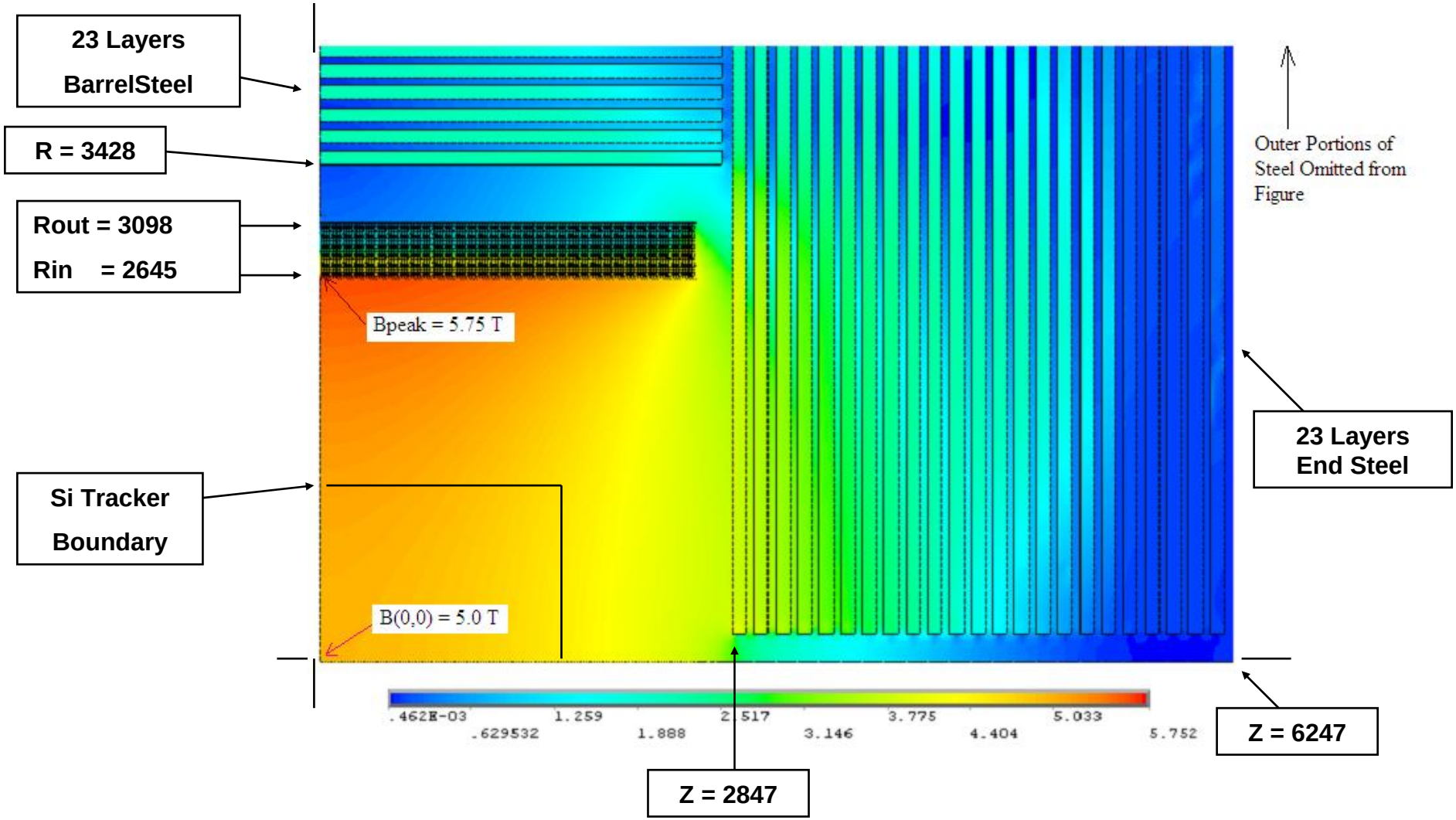
4 layers in CMS, go to 6 layers for SiD



Very nice results, experts agree that it pushes technology, but feasible

Solenoid 3

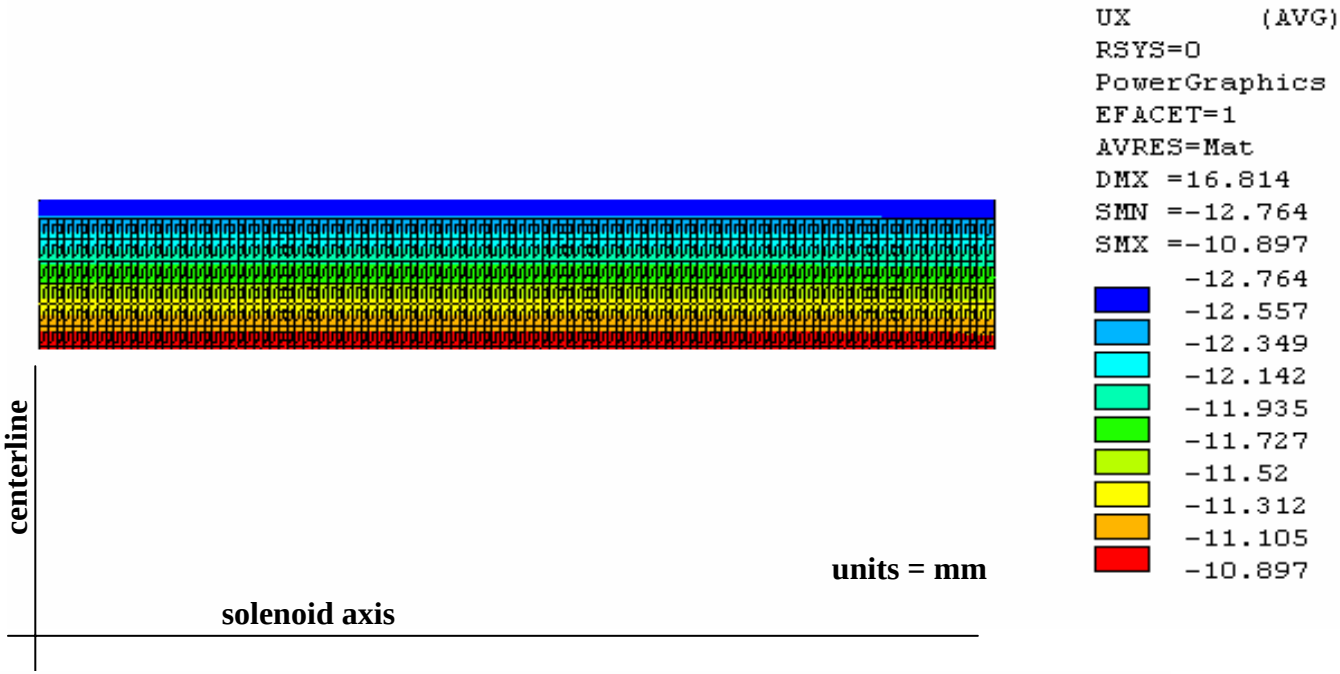
First ANSYS 2D, 3D Modeling



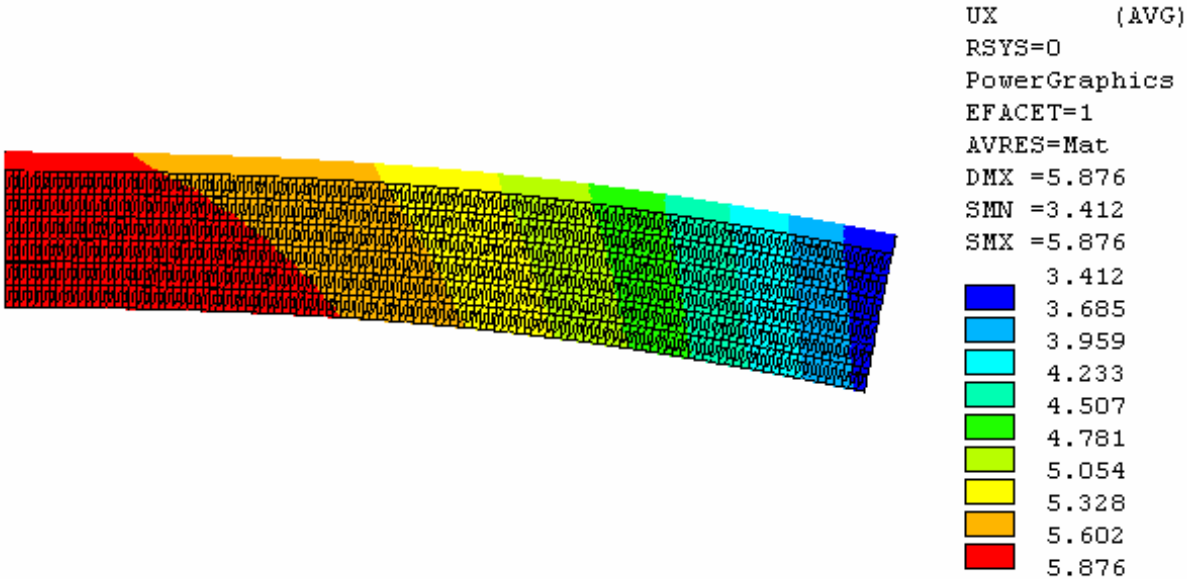
Goal: Complete feasibility study, build & lead solenoid effort

Next: detector integrated dipole (DID) with BDIR-WG4

Solenoid; cooldown and energizing modeling



Cooldown; radial displacement



Energize; radial displacement

ILC detector R&D muon 1

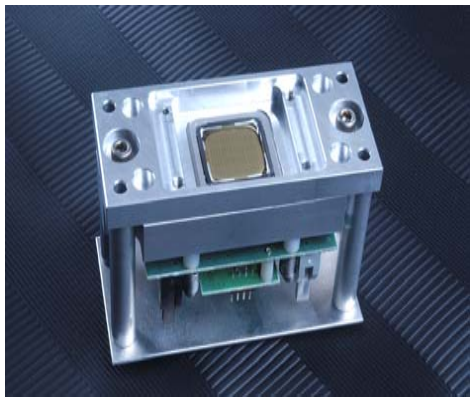
Muon system; hardware @ FNAL

H.E. Fisk, C.Milstene & collaborators

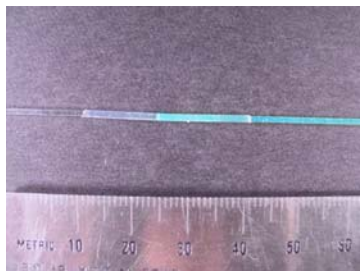
- Colo. State, UC Davis, Fermilab,
- Northern Illinois Univ.,
- Univ. of Notre Dame, Wayne State Univ.,
- Univ. of Texas Austin, INFN Frascati

- Scintillator strip panels

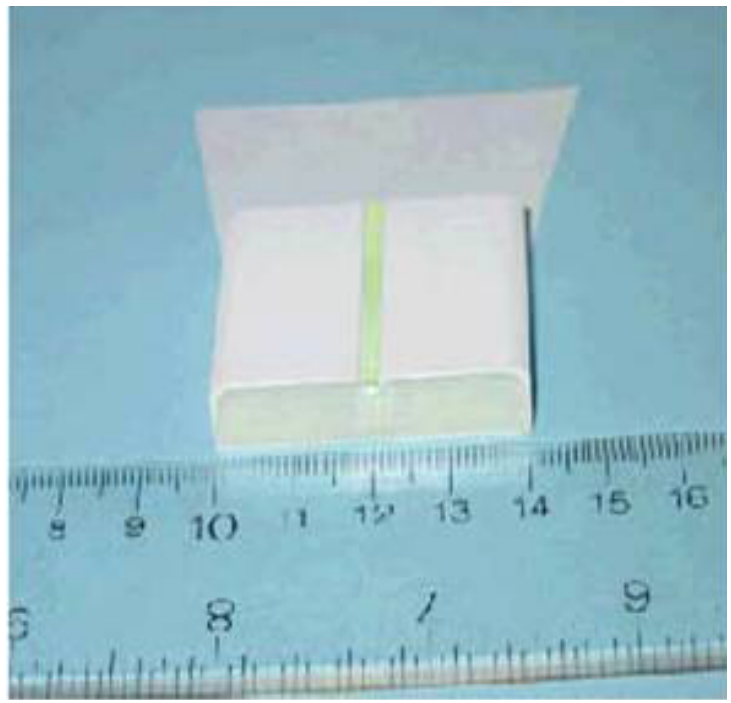
MINOS style: 4 cm X 1 cm
MAPMT 16 or 64 channels
4mm X 4mm pix / 16 ch



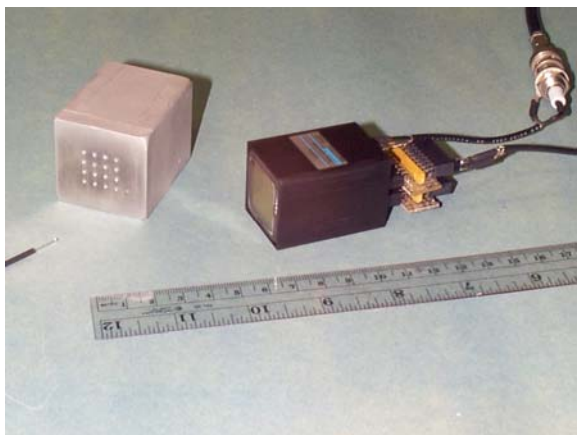
1.2mm fiber



Thermally fused splice

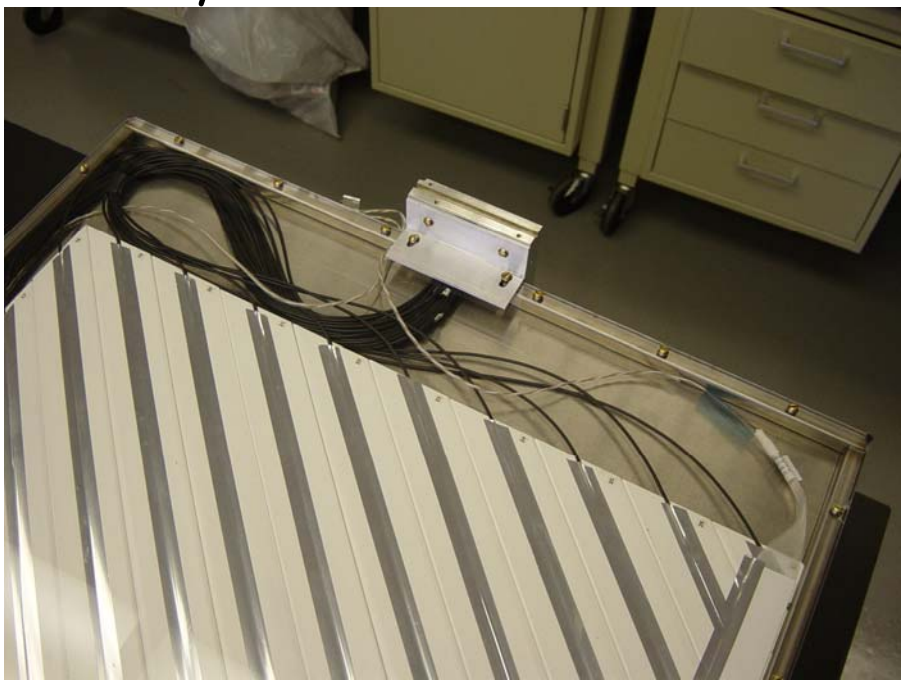


MAPMT

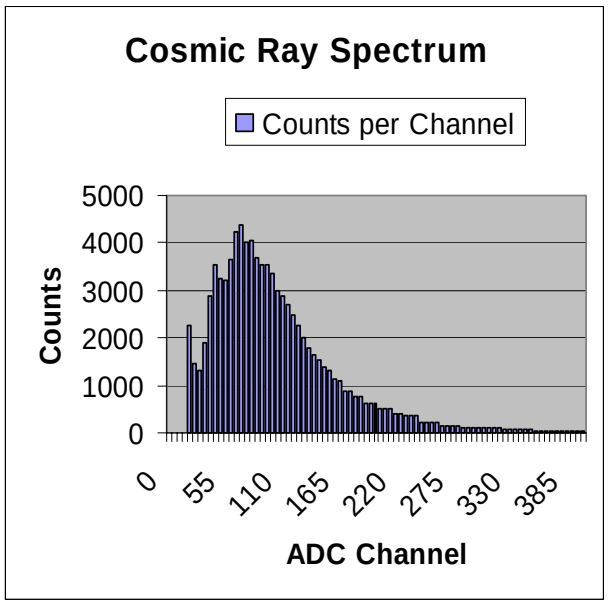


ILC detector R&D muon 2

Muon system hardware



- Reduced Size Mechanical Preprototype for $\frac{1}{4}$ Scale Module
- Built by Notre Dame U.



Spectrum observed (at FNAL).
In initial stages.
Optically better module being built.

Results presented at LCWS, R.Abrams, Indiana

ILC detector R&D: muon 3

The latest in muon hardware….

Goal: Increase effort; first modules in testbeam 2006

ILC detector R&D muon 4

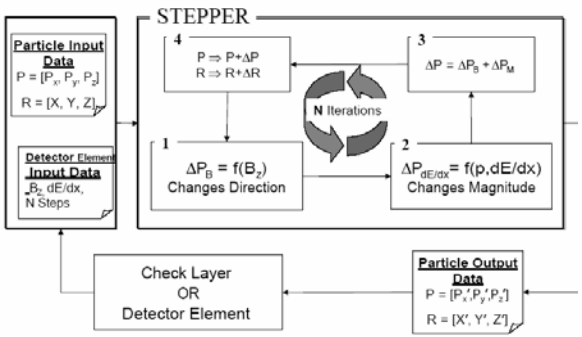
C. Milstene

Muon system; algorithms

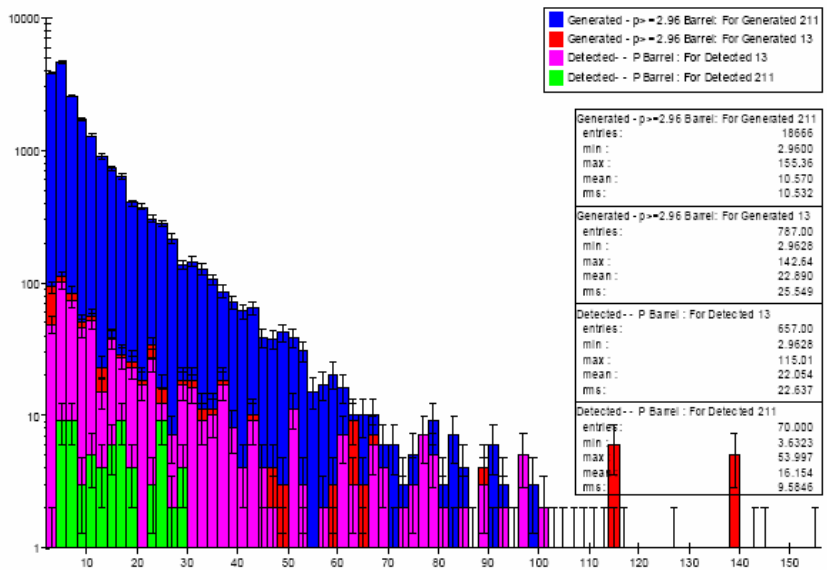
Work on muon/MIP tracking continues to be improved.

Initial stepper for algorithm was improved by adding dE/dx along road and now a Kalman filter is being added

Stepper flow:



2c-Jets: Mu& Pions Background Generated/Detected by Mu Algorithm- Out Of 10000 Pairs of b-bbar



P(GeV/c)- 2GeV/bin

Signal:

- Generated Muons in Red
- Detected Muons in Magenta

Background:

Generated Pions in Blue

Detected Pions by Mu Algorithm In Green

Remark:

Below 2.96 GeV the Particles do not reach The Muon Detector

ILC detector R&D electronics

W.Wester, R.Yarema
S.Tkaczyk

Custom electronics & chips

Fermilab ASIC development capabilities are unique in world.

Can not do justice here

Developments for ILC use:

- ASIC for Digital (DCAL chip) calorimeter readout in testbeam, with 400K channels; 64 channels/chip
- *Avalanche Photo Diodes* (APDs) can be read out using electronics based upon FNAL-developed MASDA ASIC
- New 32 channel version being developed
- Trigger pipeline ASIC for Dzero tracker; other applications ?
- High Voltage control ASIC; bias voltage control
- First FNAL device in 0.13μm CMOS

Critical for digital HCAL R&D

Goal: Use & keep this unique expertise involved

Effort starting/planned on Monolithic Active Pixels for LHC Upgrade, ILC & others(?); long term R&D and with other groups

MDI: Machine Detector Interface

Strong group in AD (N.Mokhov), working on backgrounds in machine and detector halls.

- Simulations are done with the MARS15 code
- Model describes the last ~1500 m of 20-mrad e+ line
- The model includes beam elements, collimators and tunnel
- Part of BDIR-WG4 of machine efforts

Need to interface to detector geometry.
Had a person identified last year, but did not work out.

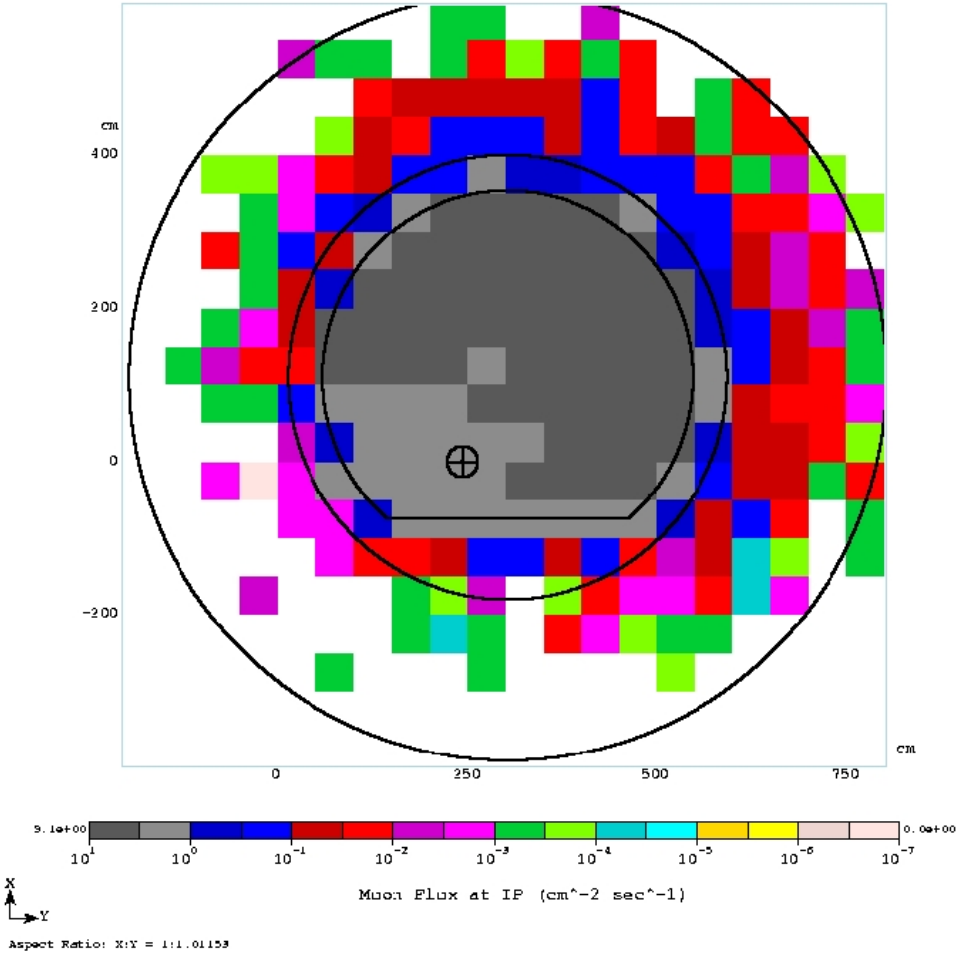
Working on other solution now.

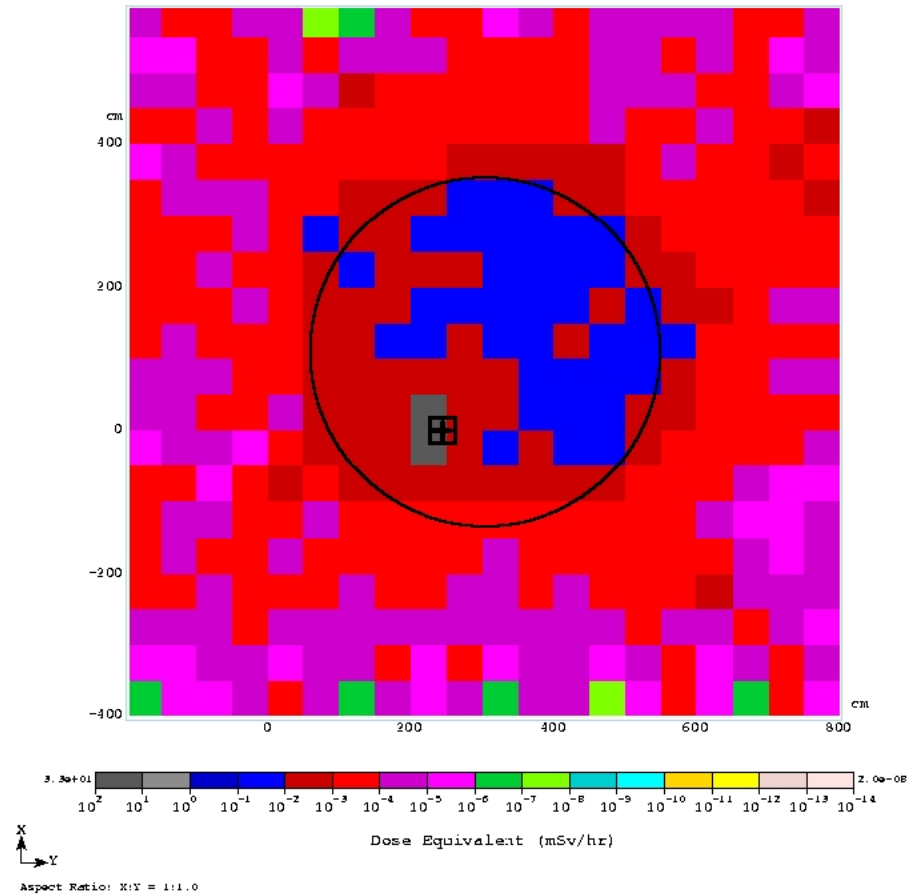
Need involvement in this for detector& physics planning.

BDIR: backgrounds

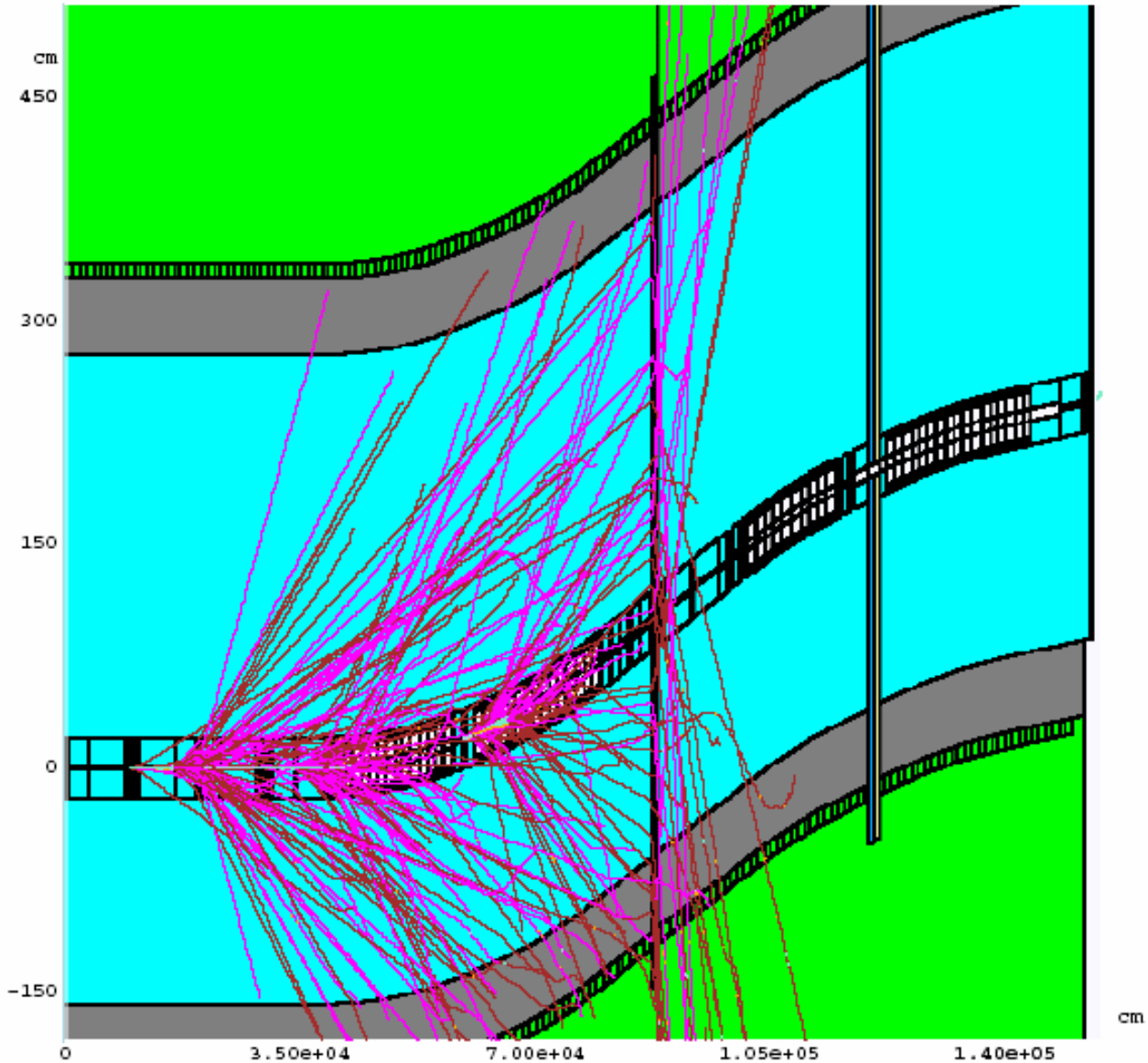
I=2.8 10^{14} sec^{-1};
0.1% hits spoiler

- $\langle N\mu \rangle$=4.6 cm^{-2} sec^{-1} , $\langle N\gamma \rangle$=4.7 cm^{-2} sec^{-1}
- For 150 bunches,$\langle N\mu \rangle$=0.0489cm^{-2} or 8855 muons in the tunnel aperture
- 'Muon spoilers' might help (L. Keller, SLAC). Needs confirmation.





BDIR latest with muon spoilers



Aspect ratio: 4:1

E_{muon}> 20 GeV

Tracing beam particles in tail, so > 2.5σ

All muons generated in collimation system

Beginning of detailed simulations; connect to detector simulation.

ILC detector R&D testbeam

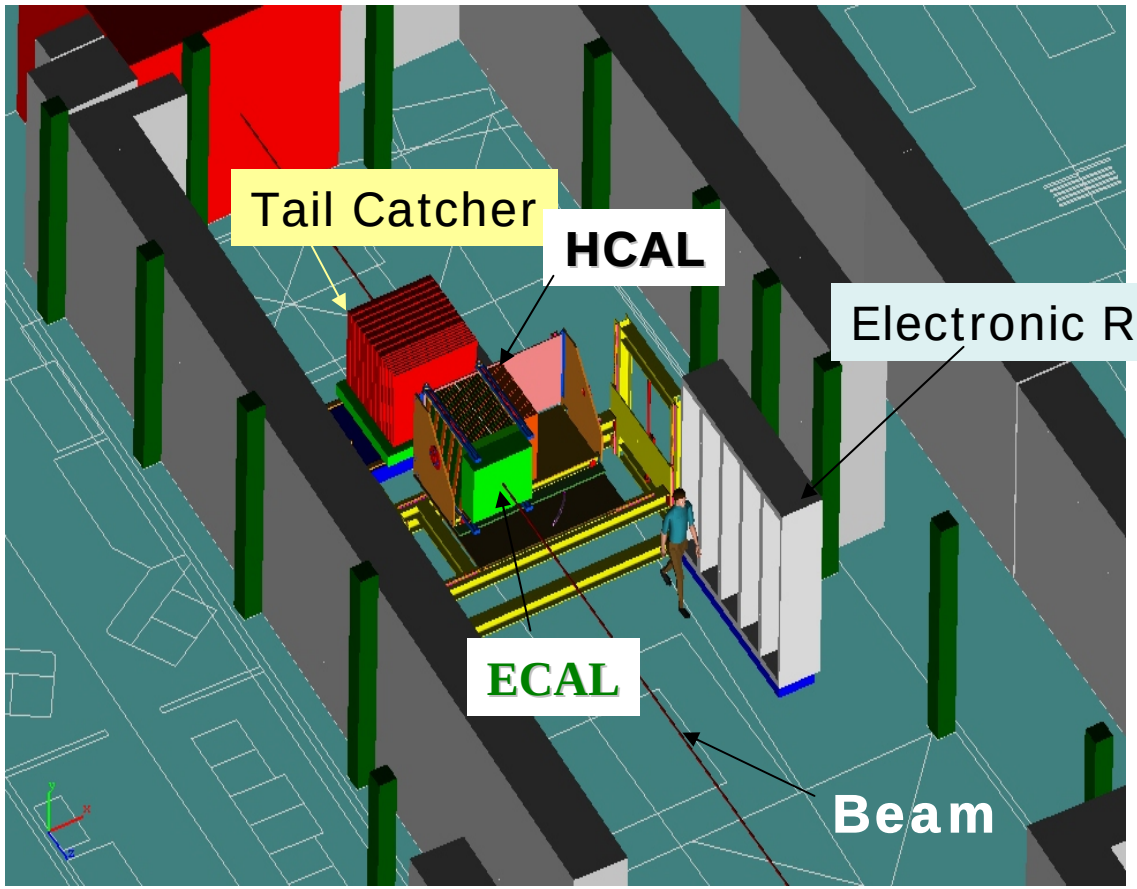
Proposal to set up multi year testbeam program for study of high performance calorimeters for ILC

Presented to PAC recently.

CALICE collaboration

Fermilab involvement ?

Working on this……



ILC detector physics (example)

M.Carena,
A.Freitas,
C. Milstene

Physics simulation

$$e^+e^- \rightarrow \tilde{t}_1\bar{\tilde{t}}_1 \rightarrow c\tilde{\chi}_0^1\bar{c}\tilde{\chi}_0^1$$

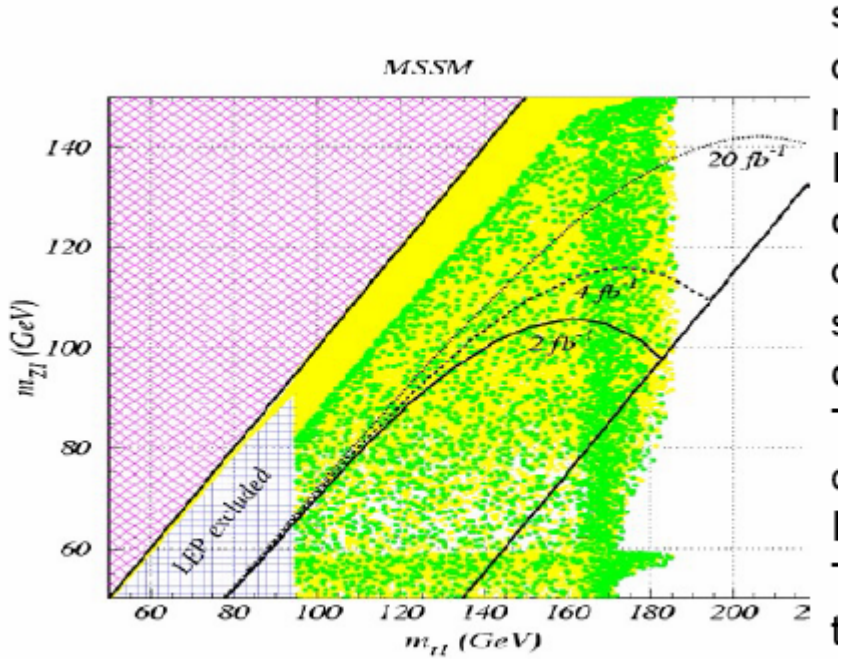
Emphasizes vertex detection at ILC.

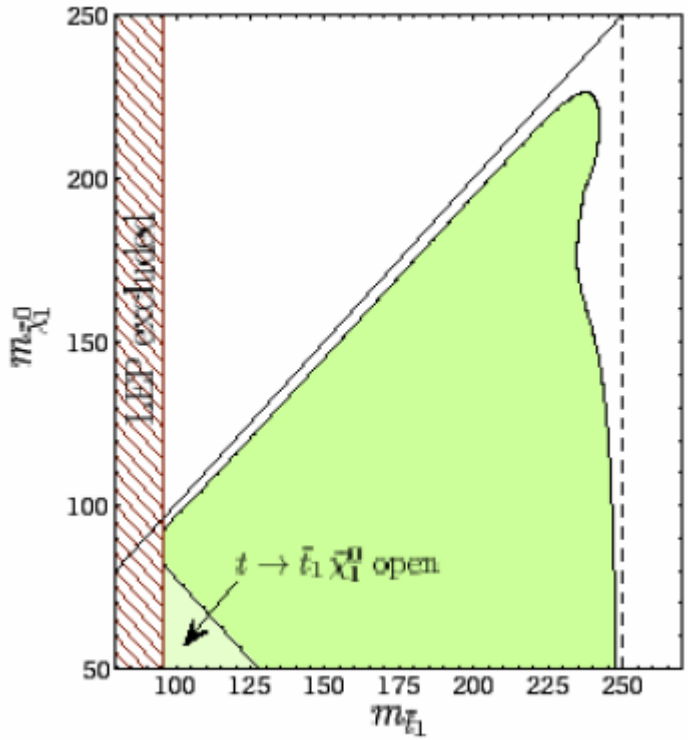
Neutralino mass vs stop mass

Tevatron

Green regions consistent with relic density a la WMAP

Preliminary ILC



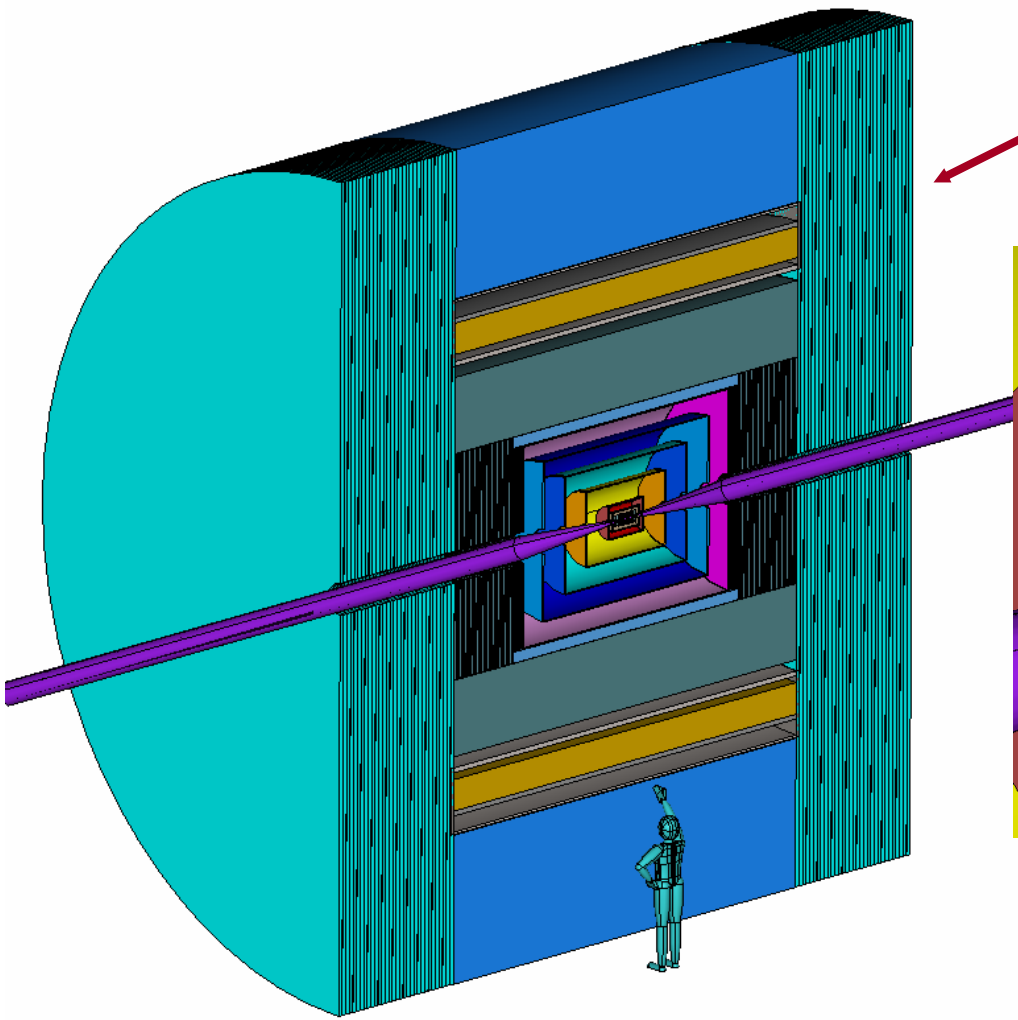


Push detector capabilities at ILC

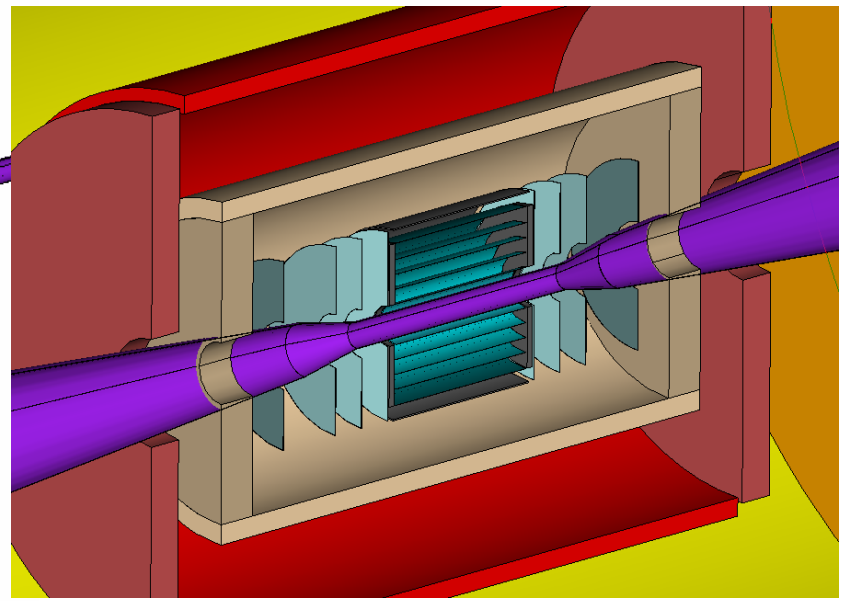
TopQCD, Higgs, NP groups: A.Juste, M.Carena, S.Tkaczyk

Modeling of SiD detector

Use strength and expertise in mechanical engineering for modeling, finite element analysis, layout of overall detector. Have a start, but this should and can grow as needed.



Overall detector



Vertex detector

ILC detector management & committees

Management & other activities in ILC detector R&D:

WWS study group
Coordination & leadership of SID detector concept
Muon R&D working group leadership
Leadership of Physics Groups (Higgs,TopQCD, New Physics)
WWS R&D panel (9 worldwide, 3 from Americas)
ALCPG exec committee
Int. & US ILC outreach committees
SID working group leaders: Silicon tracking & Solenoid
ALCPG 2005 Snowmass Organizing Comm.

New in 2004/2005

Increased Fermilab visibility in last year

Future of ILC detector R&D

Future/additional involvements in SiD design study:

-Software area and algorithms (CD)
-DAQ system (CD)
-Calorimeter detector (challenging and efforts at ANL & NIU)

Liaison with CD: G.P. Yeh very active

Future/additional involvements in generic R&D:

- front end chips & MAPS (pixels)
- testbeam and Calorimeter R&D, incl. Algorithms (PFA)
- others ?

We should not and can not be involved in all areas, but should lead in some.

Planning a review of this in next month

Conclusions

Ramped up effort on ILC detector R&D

Increased visibility of Fermilab

Identified areas of focus & leading those efforts

Slowly interest is growing

A base has been established, improve and built on it guided by expertise/interests locally and needs globally.

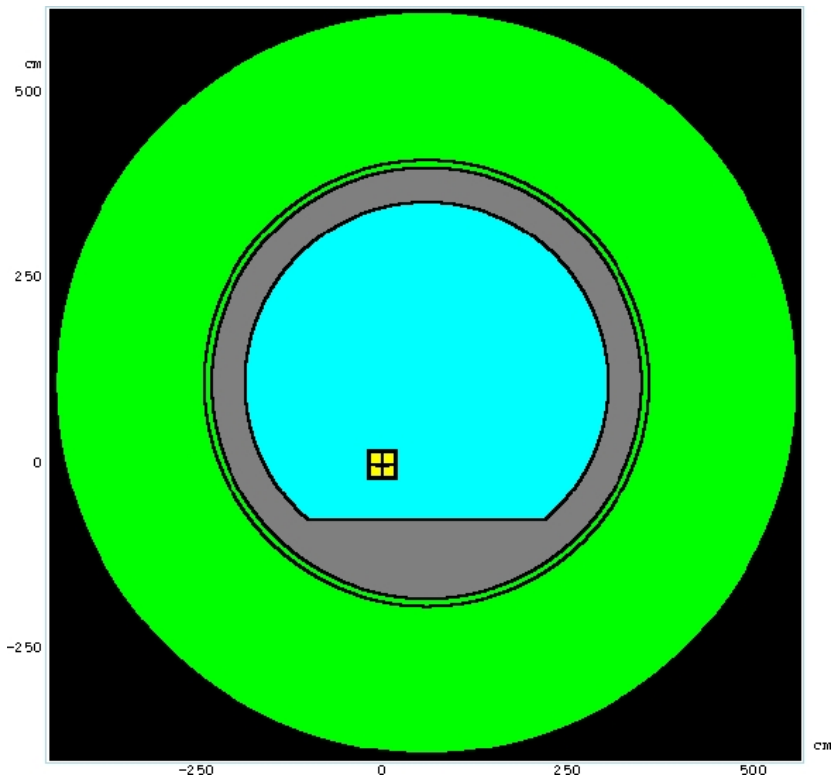
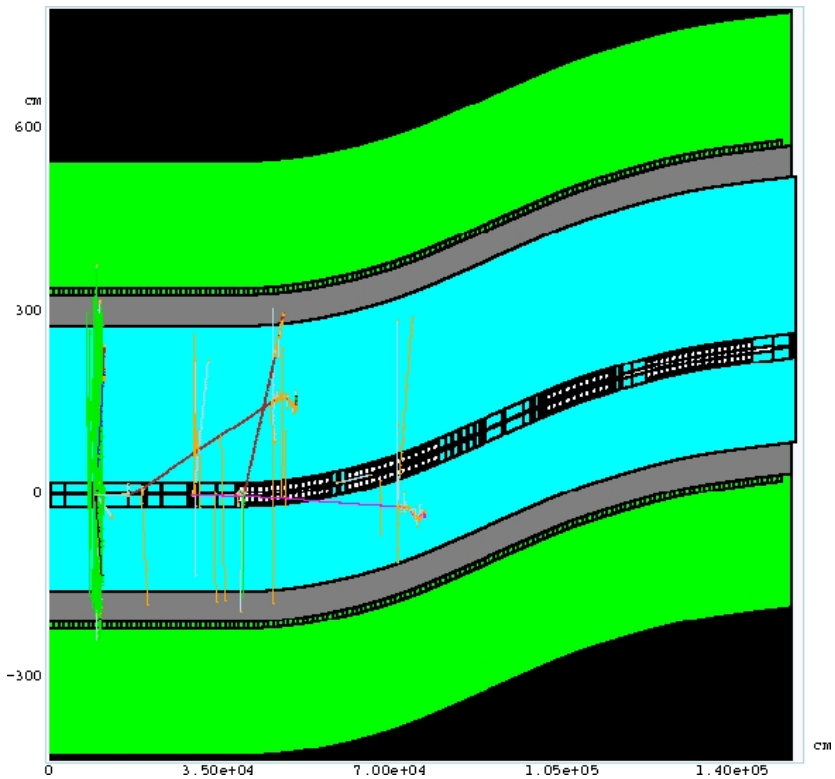
Planning review of direction and future of efforts in PPD and CD in next month

THE END

The End

MDi/WG4-BDIR backgrounds

- Simulations were done with the MARS15 code
- Model describes the last ~1500 m of 20-mrad e+ line
- e- line is similar
- The model includes beam elements, collimators and tunnel
- Collimation system was designed by A.Seryi (SLAC), A.Drozhdin (FNAL)
  - Designed to localize beam losses in a specially equipped part of the line
  - Collimation system is multistage
    - 3 spoilers intercept beam halo particles and out-scatter them
    - Out-scattered halo particles are absorbed by secondary collimators
  - Particle tracking and beam losses were simulated with the STRUCT code

Model for MDI

- Tunnel R = 2.44 m
- Concrete wall thickness = 0.46 m
- Soil layers thickness =10 cm