SiD Summary

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For the SiD Design Concept Study

@ 

Introduction Victoria 2004 → Snowmass 2005

Original concept for SiD from M.Breidenbach and J.Brau (2003)

Start of ILC detector concepts by WWS at ALCPG04, Victoria
First SiD kick-off meeting with interested parties
Critical SiD Questions document (still valid)

Kick off meetings at ECFA & ACFA meetings Fall ‘04

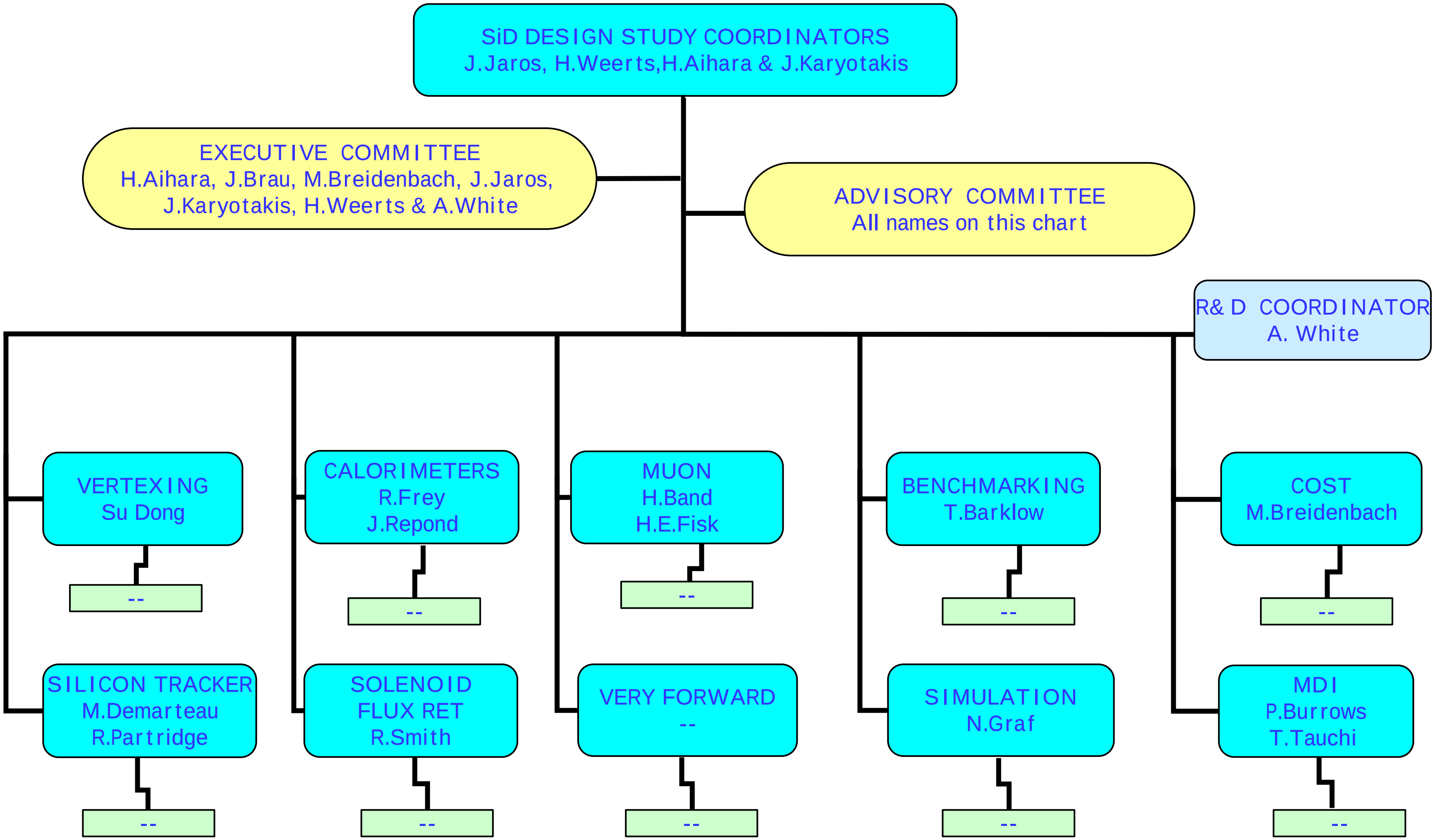
Over the last year we have had many phone meetings which were all more or less driven by subgroups.

Had one afternoon meeting at LCWS05

Snowmass 2005 is first occasion for people interested to participate in SiD to actually spend some time together and work on SiD.
This was an important step for SiD and this may be the first in a series of SiD design study meetings

SiD Organization

Put SiD organization in place in Fall & Winter '04/'05; form subgroups and start work in those: simulation, CAL/PFA, tracker layout & design starting quickly. Followed by: solenoid feasibility, vertex , benchmarking and others later.



Coming to Snowmass

Critical area for all development & progress in SiD with a **lot** of development and work done is **simulation**.

SiD now has a simulation of the detector “starting point”
First version: SIDMAY05 and now the latest SIDAUG05

Description can be found at:
http://confluence.slac.stanford.edu/display/ilc/sidmay05?showAttachments=true#attachments

This starting point is called: SiD $_{00}$

Most of the simulations done at this workshop were based on SiD$_{00}$ and it will be referred to as SiDMAY05/SiDAUG05

Thanks to simulation group for making this possible

SiD Concept Design Study Goals

- Design a comprehensive LC detector, aggressive in performance but constrained in cost.
- Optimize the *integrated* physics performance of its subsystems.
- Evolve the present starting point of SiD towards a more complete and optimized design.
- Interest the international HEP community in the experimental challenges of a LC.

Standard Physics requirements

- a) Two-jet mass resolution comparable to the natural widths of W and Z for an unambiguous identification of the final states.
- b) Excellent flavor-tagging efficiency and purity (for both b- and c-quarks, and hopefully also for s-quarks).
- c) Momentum resolution capable of reconstructing the recoil-mass to di-muons in Higgs-strahlung with resolution better than beam-energy spread .
- d) Hermeticity (both crack-less and coverage to very forward angles) to precisely determine the missing momentum.
- e) Timing resolution capable of tagging bunch-crossings to suppress backgrounds in calorimeter and tracker.
- f) Very forward calorimetry that resolves each bunch in the train for veto capability.

Detector outline considerations

Architecture arguments

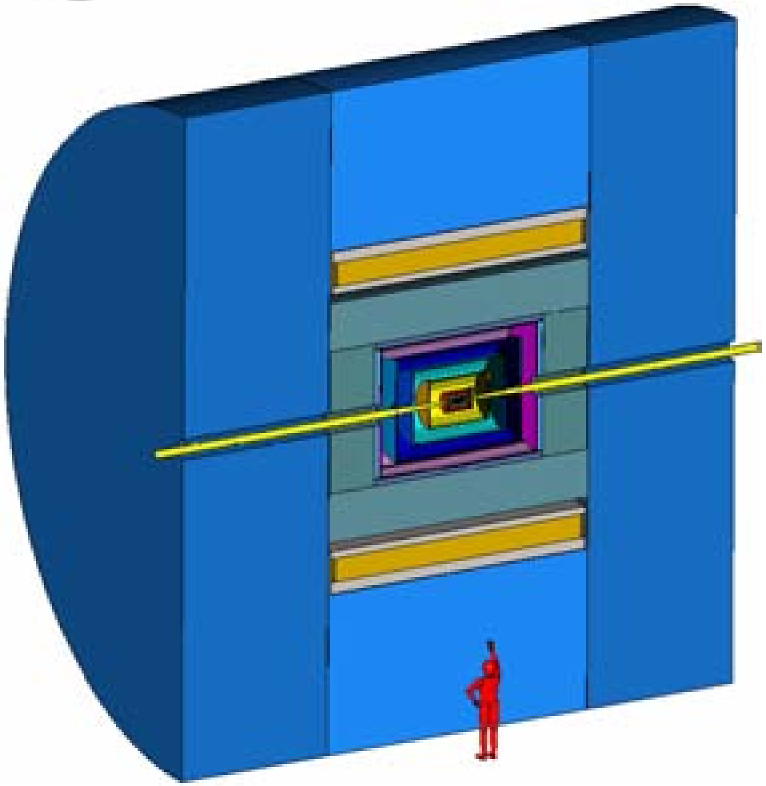
- *Accept* the notion that excellent energy flow calorimetry is required, use W-Si for EMCAL and the implications for the detector architecture…

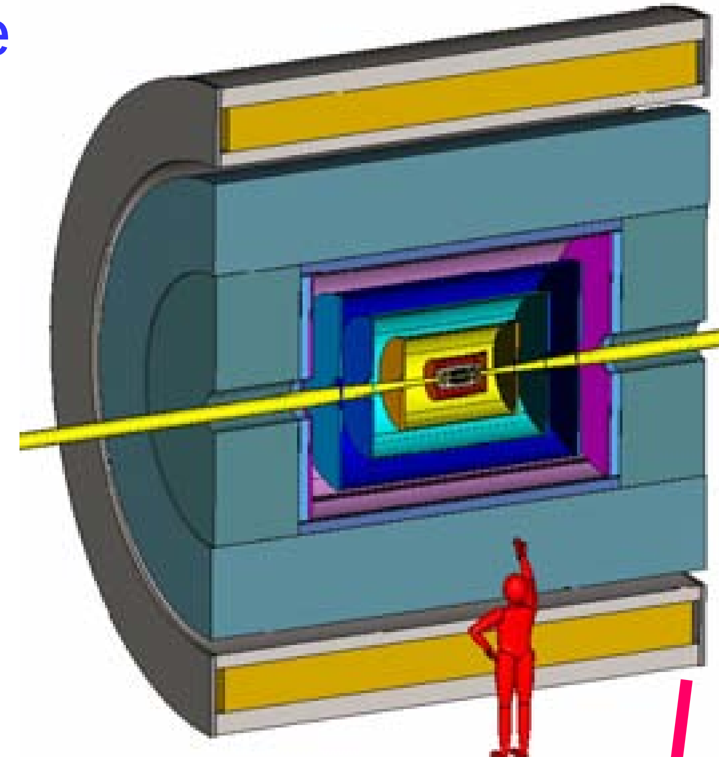
This is the **monster** assumption of SiD

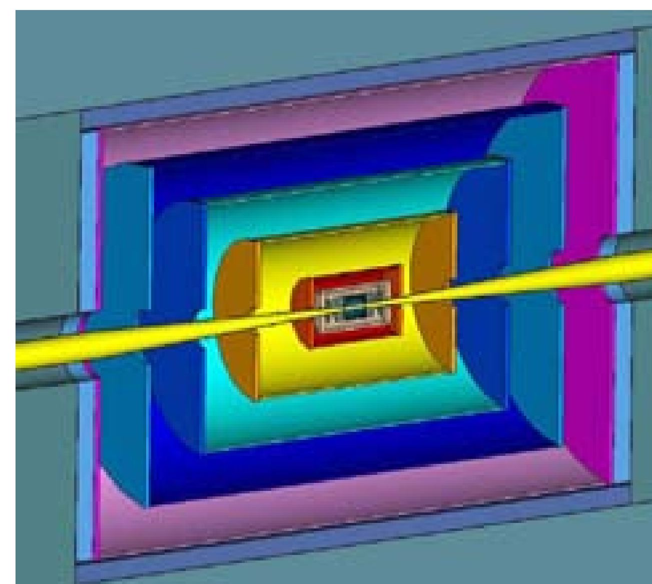
(MB quote)

- Calorimeter (and tracker) Silicon is expensive, so limit area by limiting radius (and length)
- Maintain BR^2 by pushing B (~5T)
- Excellent tracking resolution by using silicon strips
- 5T field allows minimum VXD radius.
- Do track finding by using 5 VXD space points to determine track – tracker measures sagitta. Exploit tracking capability of EMCAL for V's.

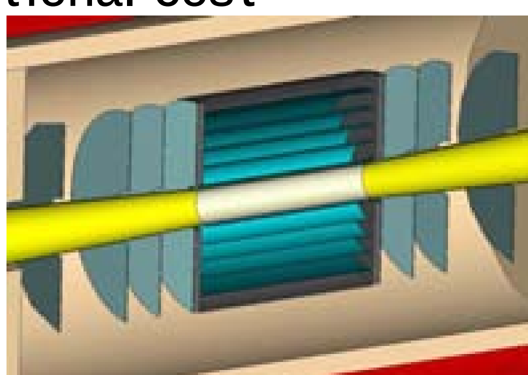
Detector outline







A high performance detector for the LC
Uncompromised performance
BUT Constrained & Rational cost



This is simulated SiD$_{00}$

Plans for Snowmass

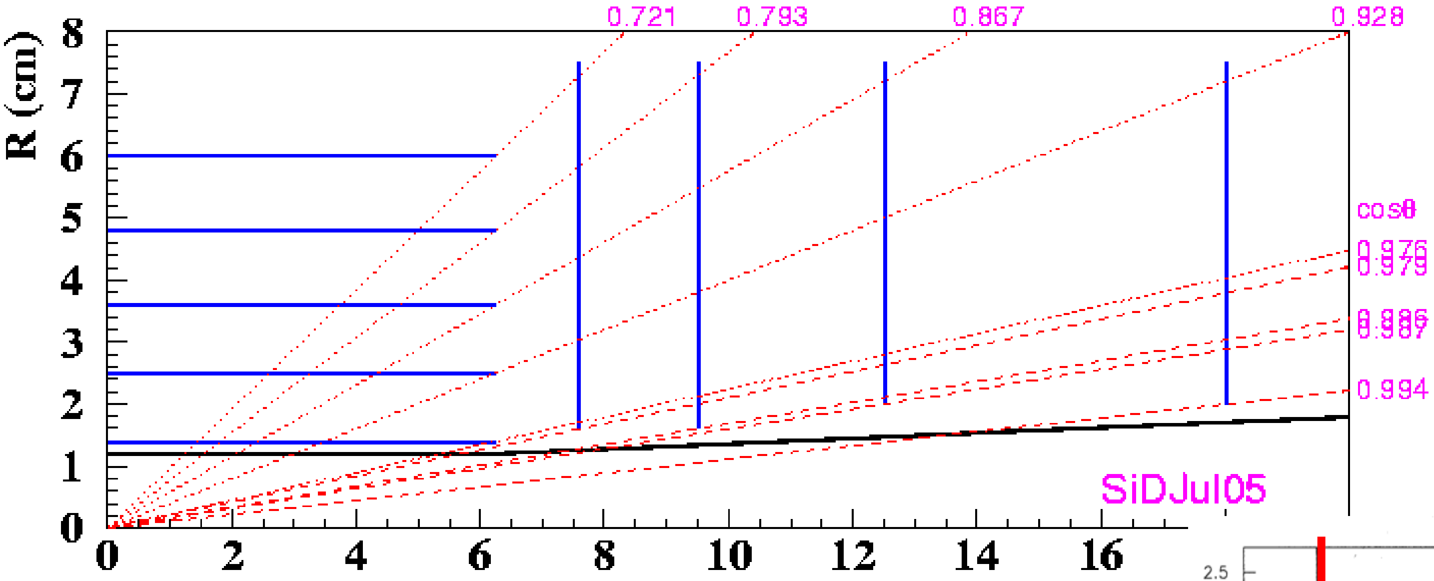
General theme: simulation and study of the baseline detector and possibly variations of that baseline, but this is rather group dependent

In following summarize (incomplete !!) some of the work done in SiD subsystems and working groups.
Start with detector subsystems at smallest radius.

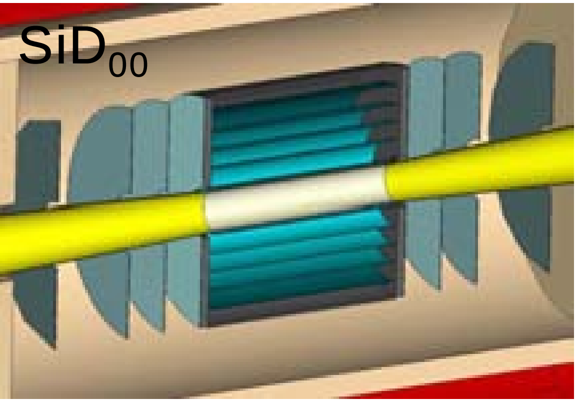
NOTE:

An integrated detector design for ILC depends critically on the Particle Flow Algorithm (PFA), which is used to measure jet energies and uses all parts of the detector. It dominates most activities, but I will cover it under calorimetry.

Vertexing= VXD

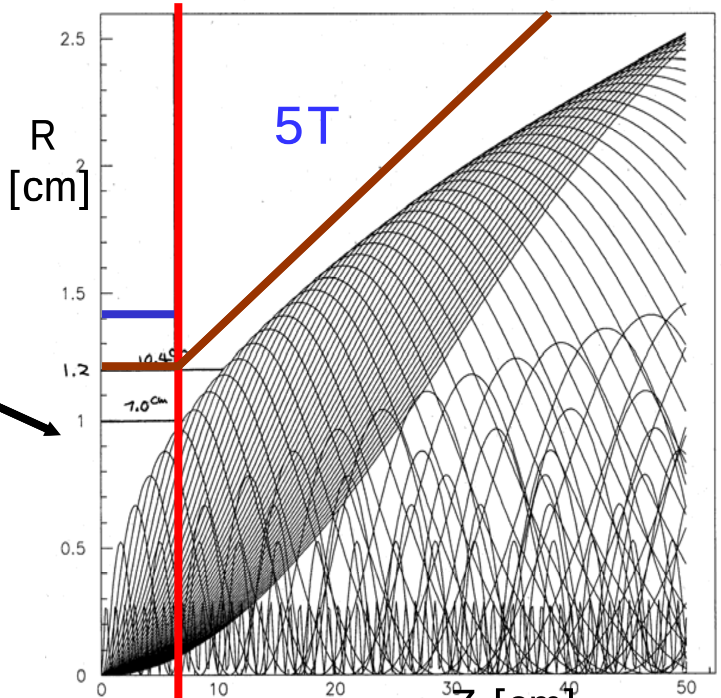


5 barrel layers
4 end disks



Design drivers:

Smallest radius possible
Clear pair background

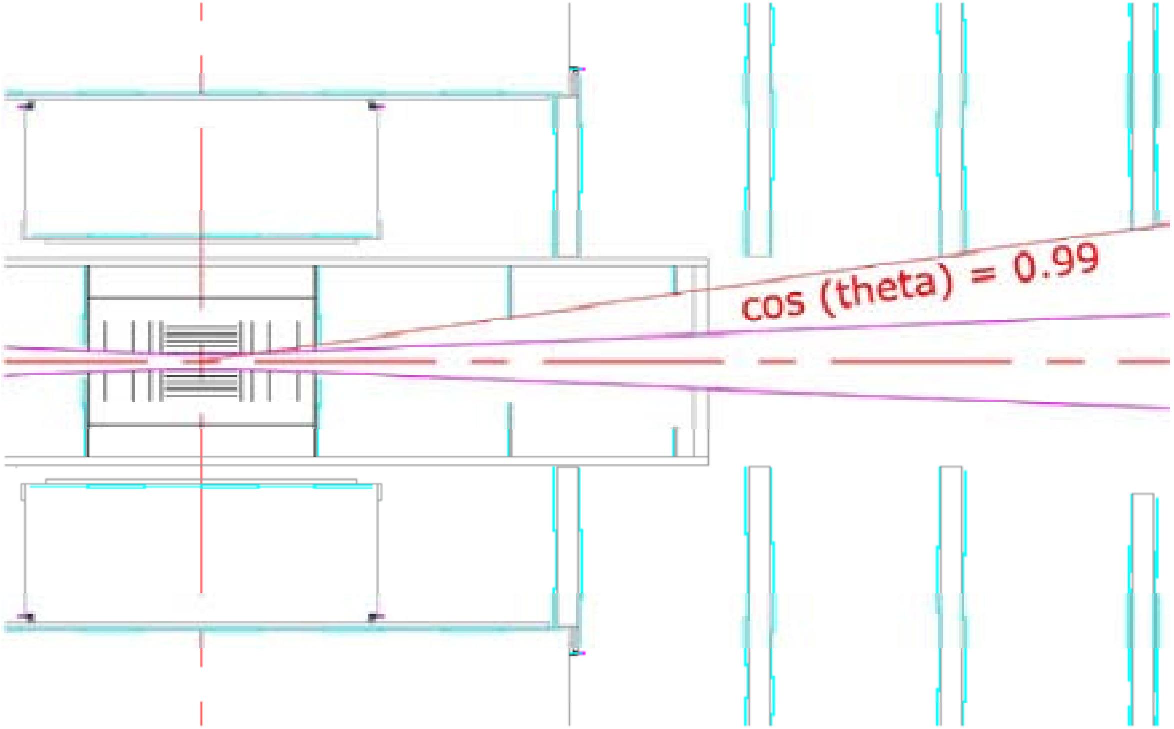


Role: Seed tracks & vertexing
Improve forward region

Work on mechanical layout of VXD

Vertexing

Concept of VXD support (started at Snowmass)



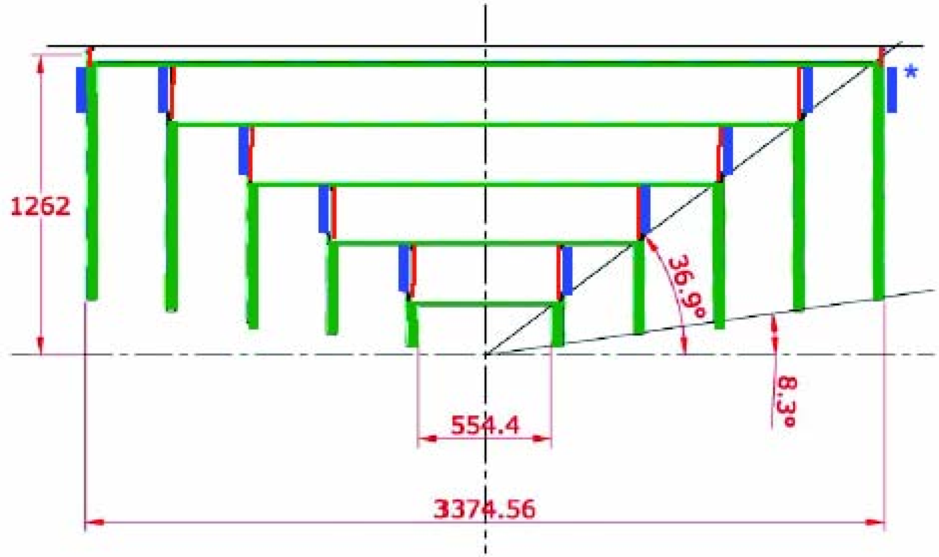
Issues considering:

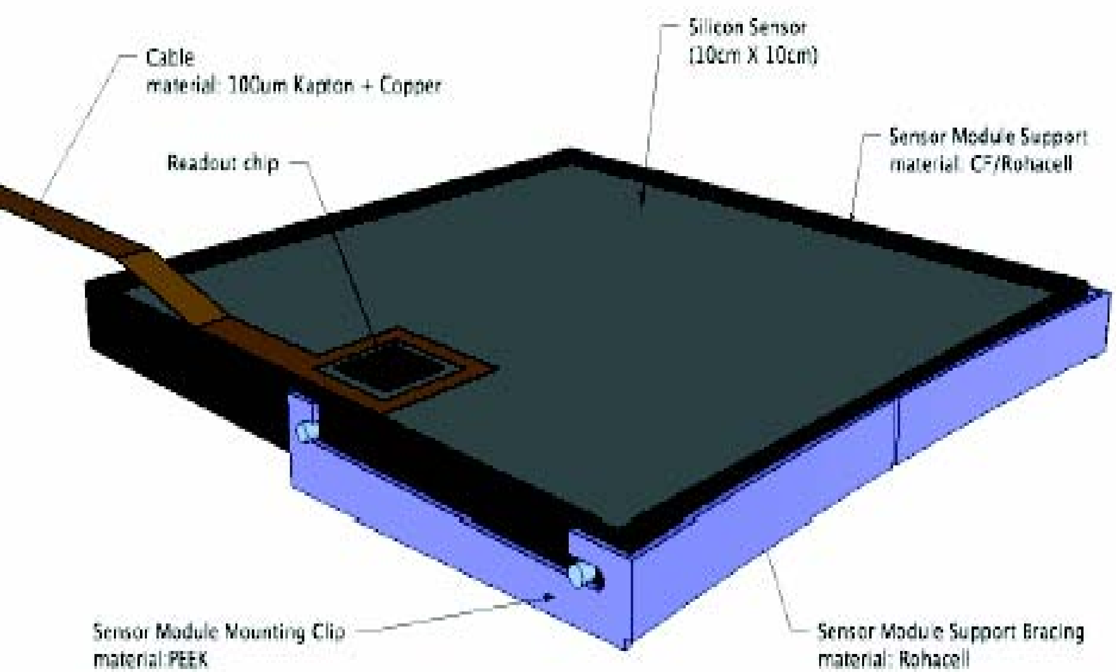
- Thickness and mechanical design of endplate & support
- Sensor technology (several being pursued; common among all concepts; more in summary)
- Increase # layers by 1 in barrel & endcap

Tracking I

SID_{00}

- Closed CF/Rohacell cylinders
- Nested support via annular rings
- Power/readout motherboard mounted on support rings





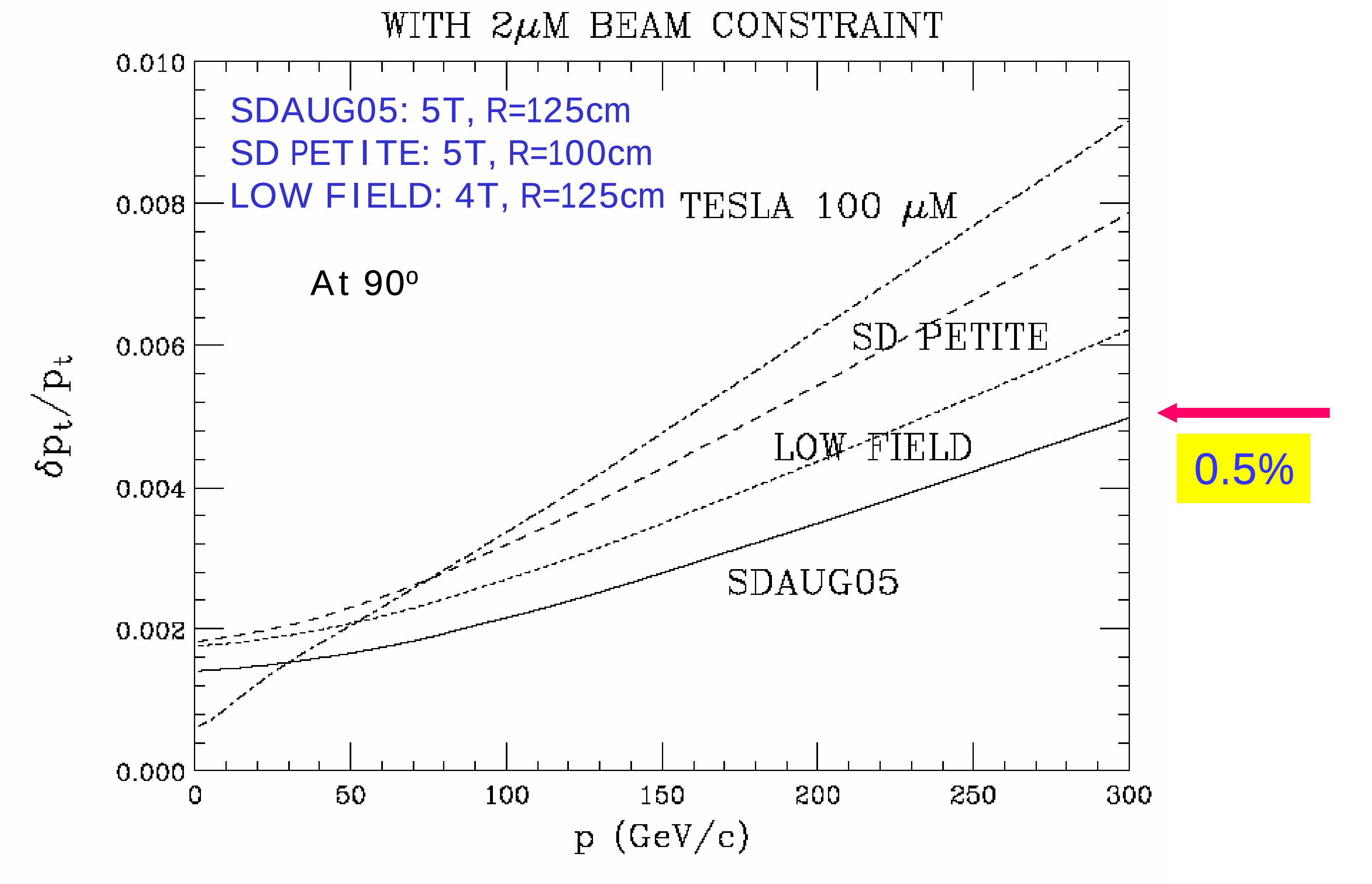
- Cylinders tiled with 10x10cm sensors with readout chip

- Single sided (ϕ) in barrel
- R, ϕ in disks

- Modules mainly silicon with minimal support (0.8% X_0)

- Overlap in *phi* and *z*

Obtained momentum resolution

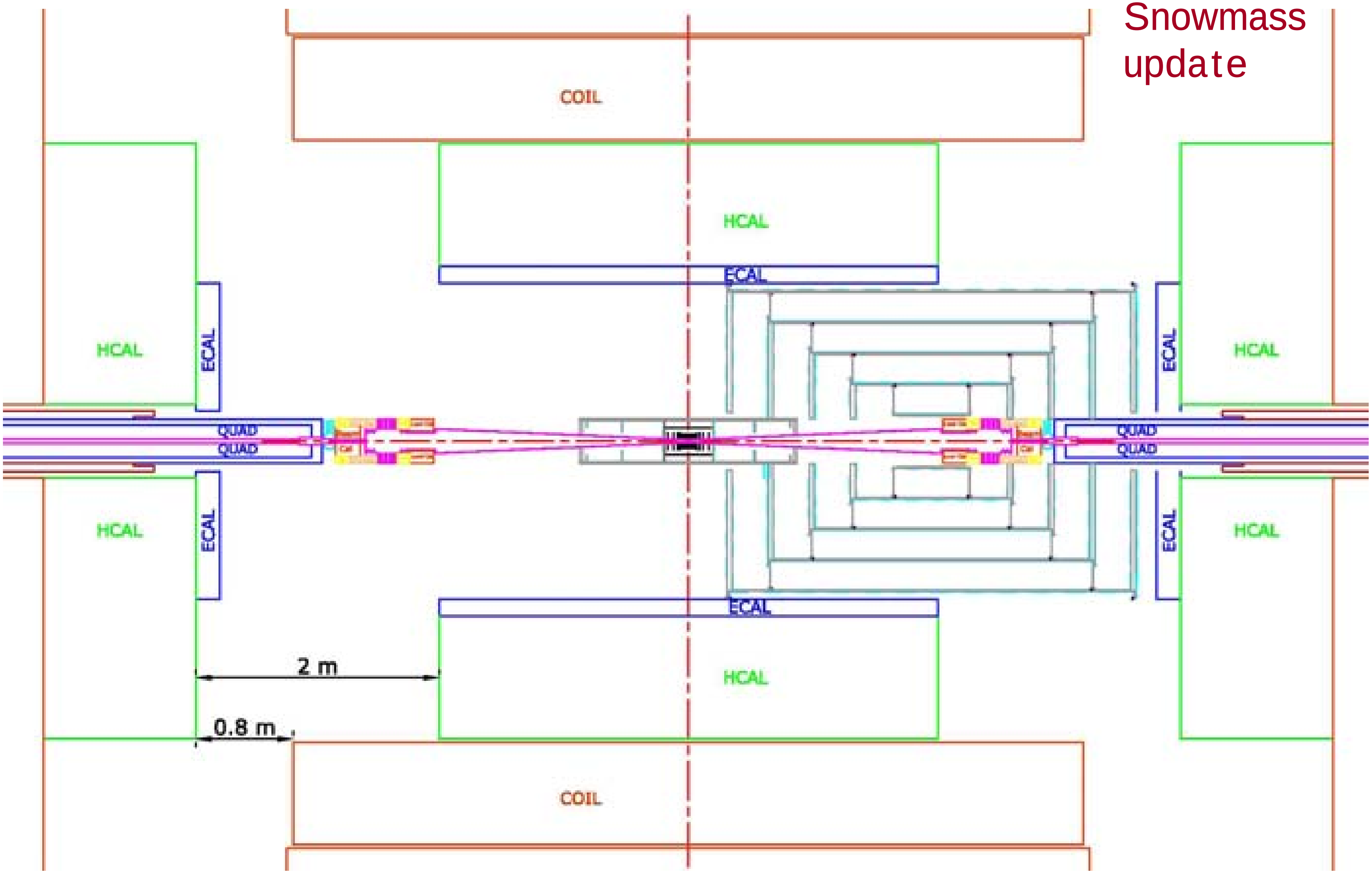


Excellent momentum resolution

Tracking III

March '05 concept of open tracker; allow access to VXD

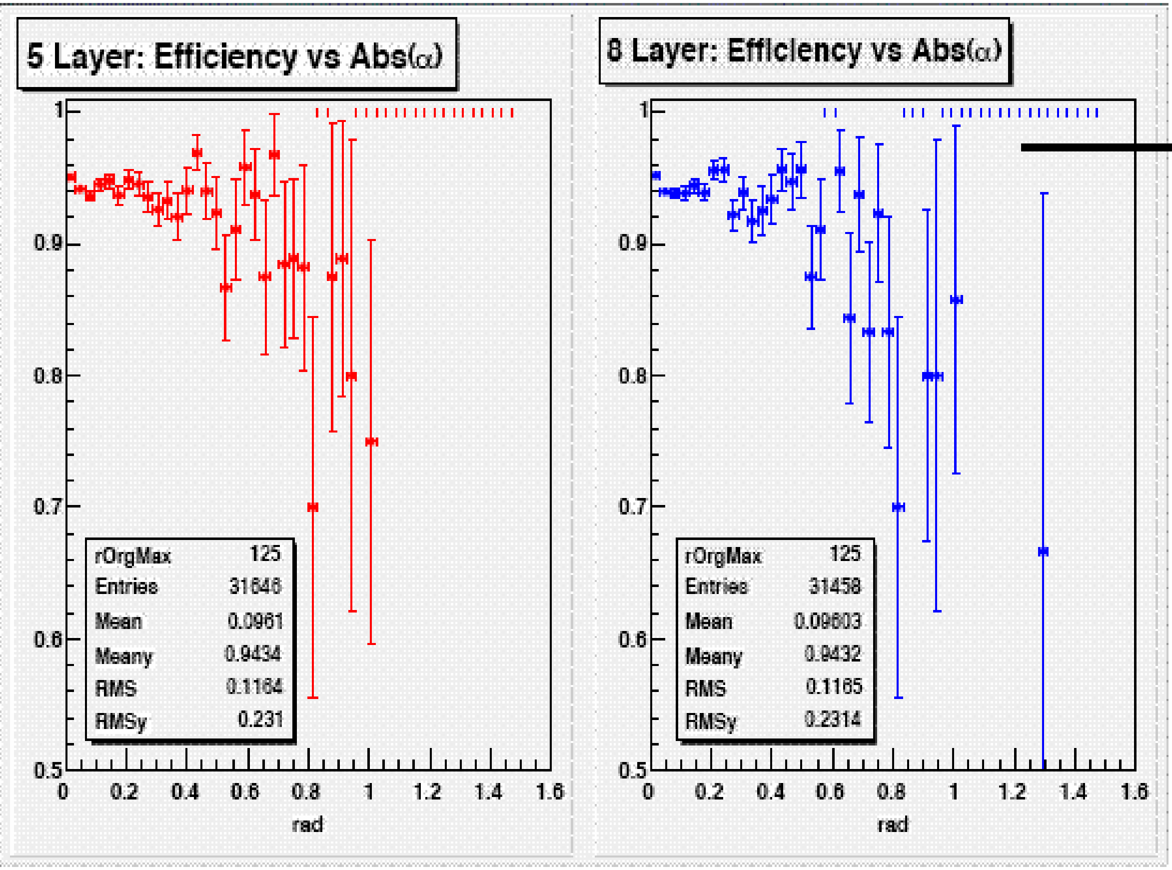
Snowmass update



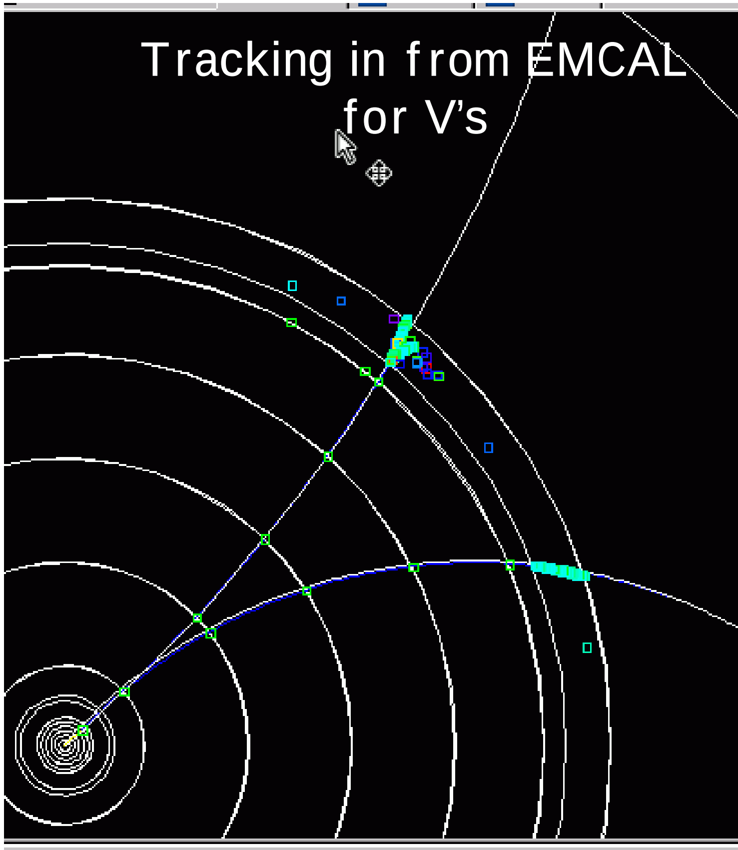
Tracking IV; examples of work done

qqbar @ 500GeV

VXD seeded tracking efficiency for 5 and 8 layer tracker as function of angle from Thrust axis.

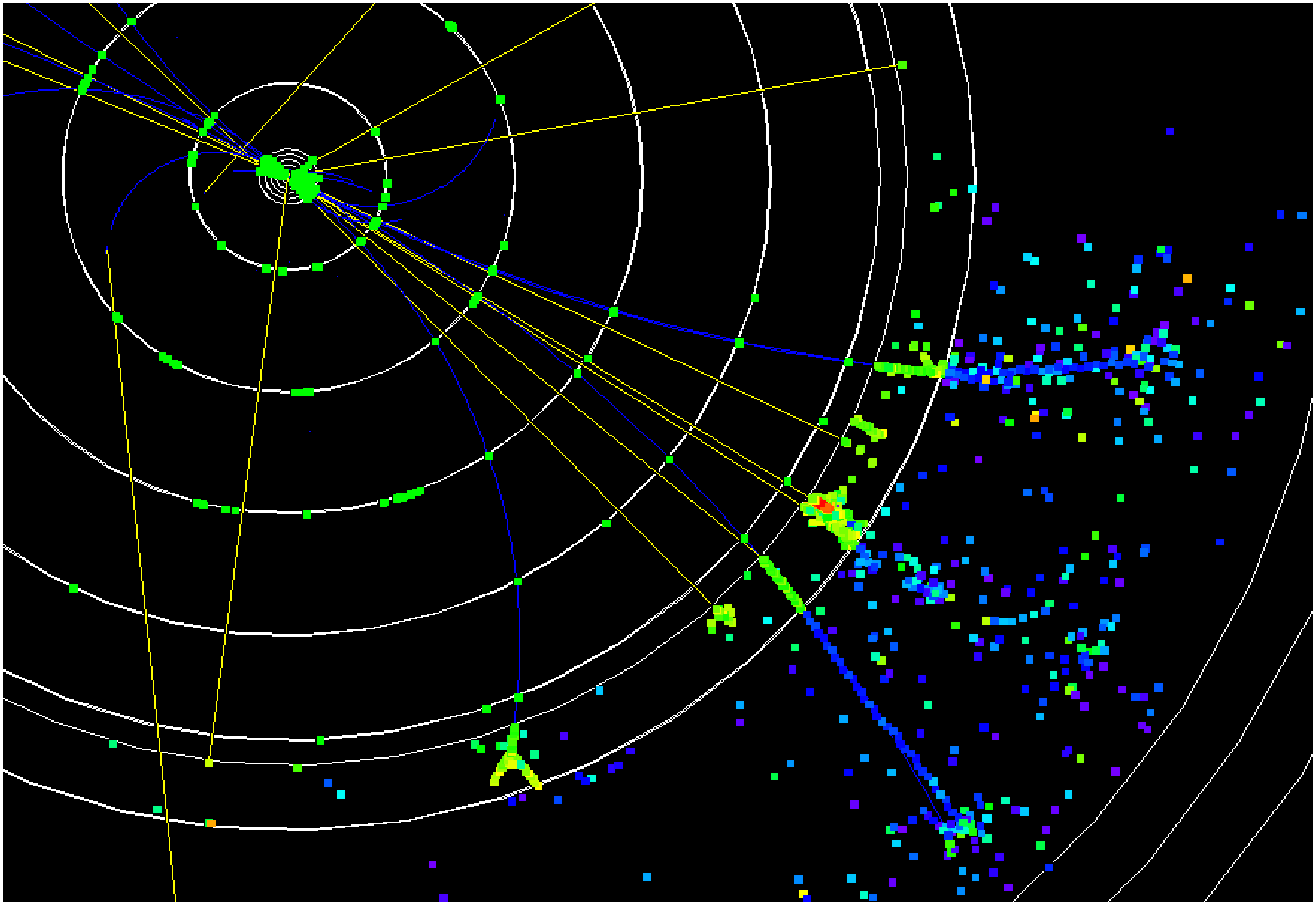


Use other track seeding for "missing" fraction (outside –in)



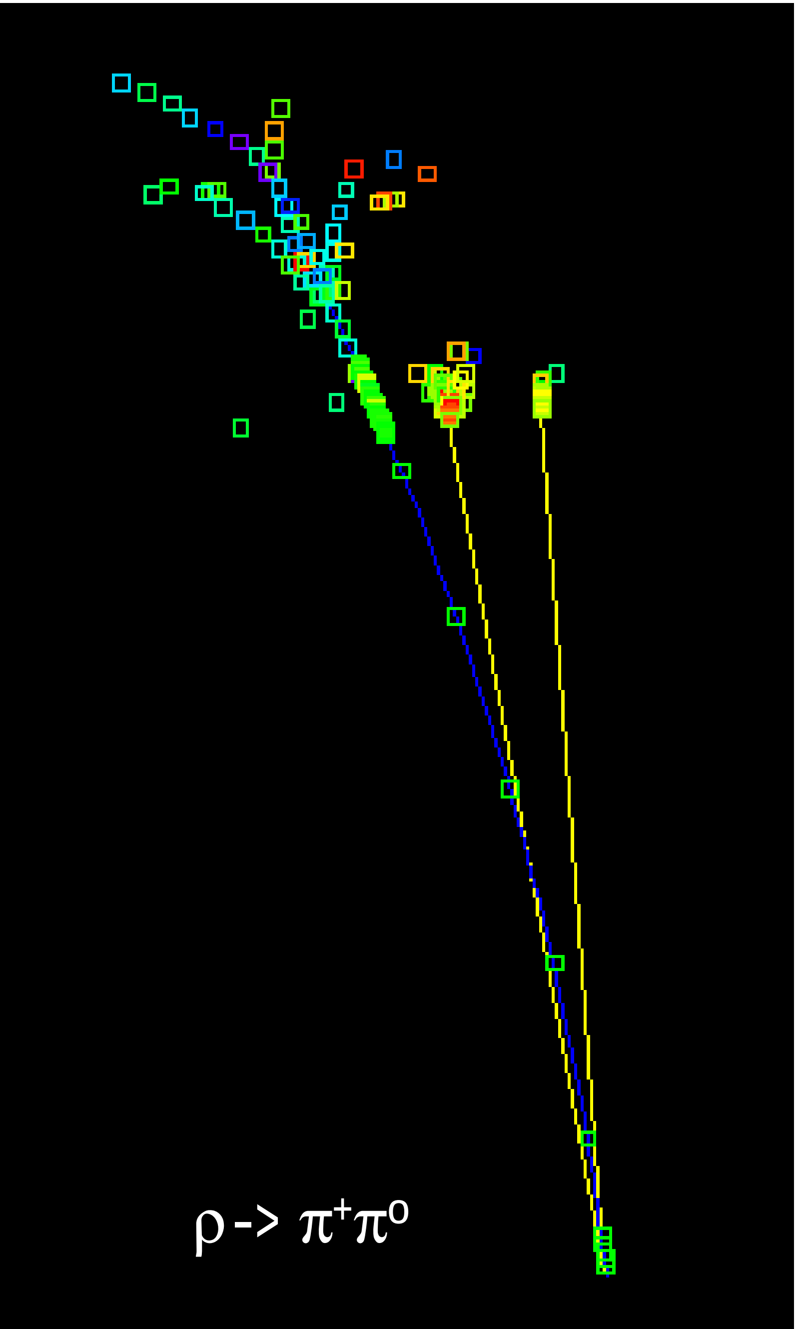
Many other studies; see summaries on SiD concept page

SiD Calorimetry



- We would like a detector which can examine new physics processes in such detail...
- Use it to obtain excellent jet energy resolution (through PFA).

EMCAL

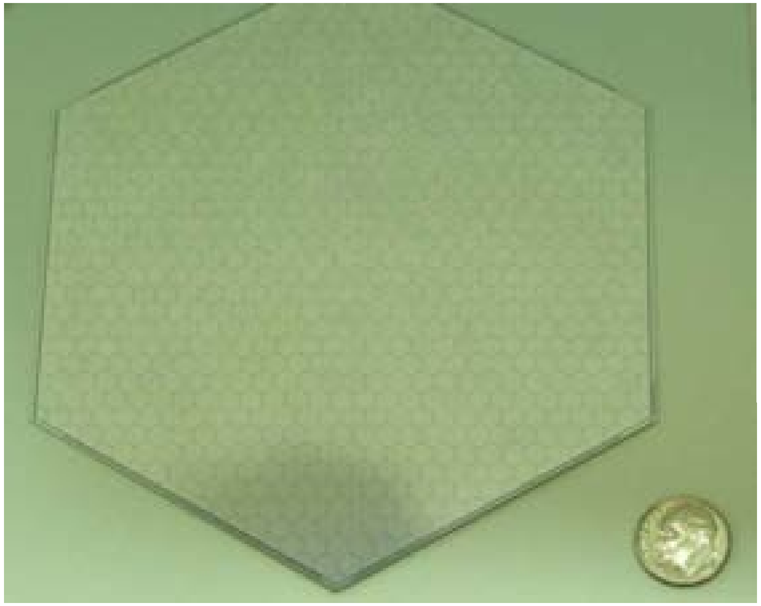


Si/W pixel size:

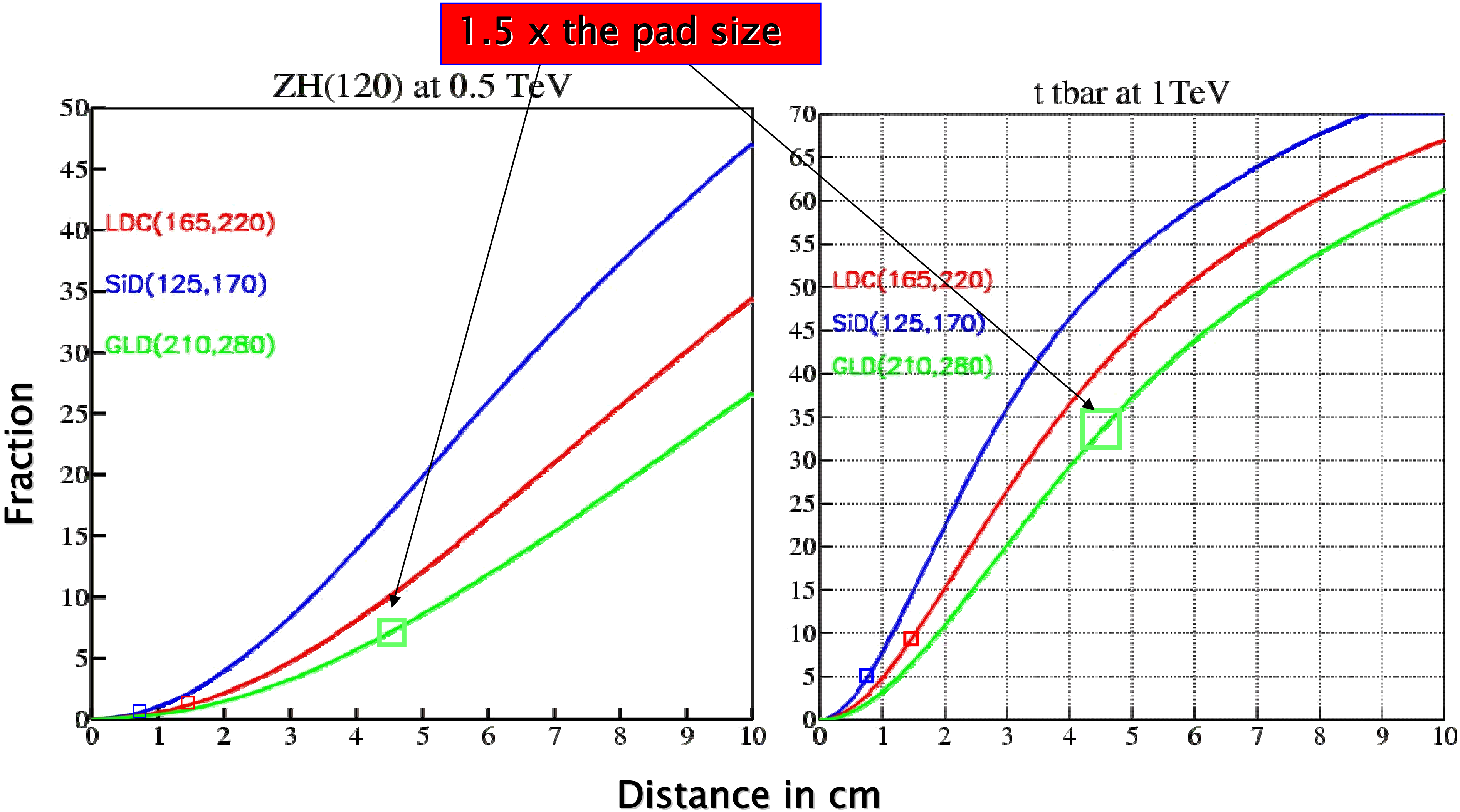
- prototypes are 16 mm^2
- readout chip: designed for 12 mm^2

How small can we go?? 2-4 mm^2 ?

Need a physics argument for smaller pixels.



Fraction of the photon(s) energy per event , closer to a charged track than some distance



J.-C. Brient

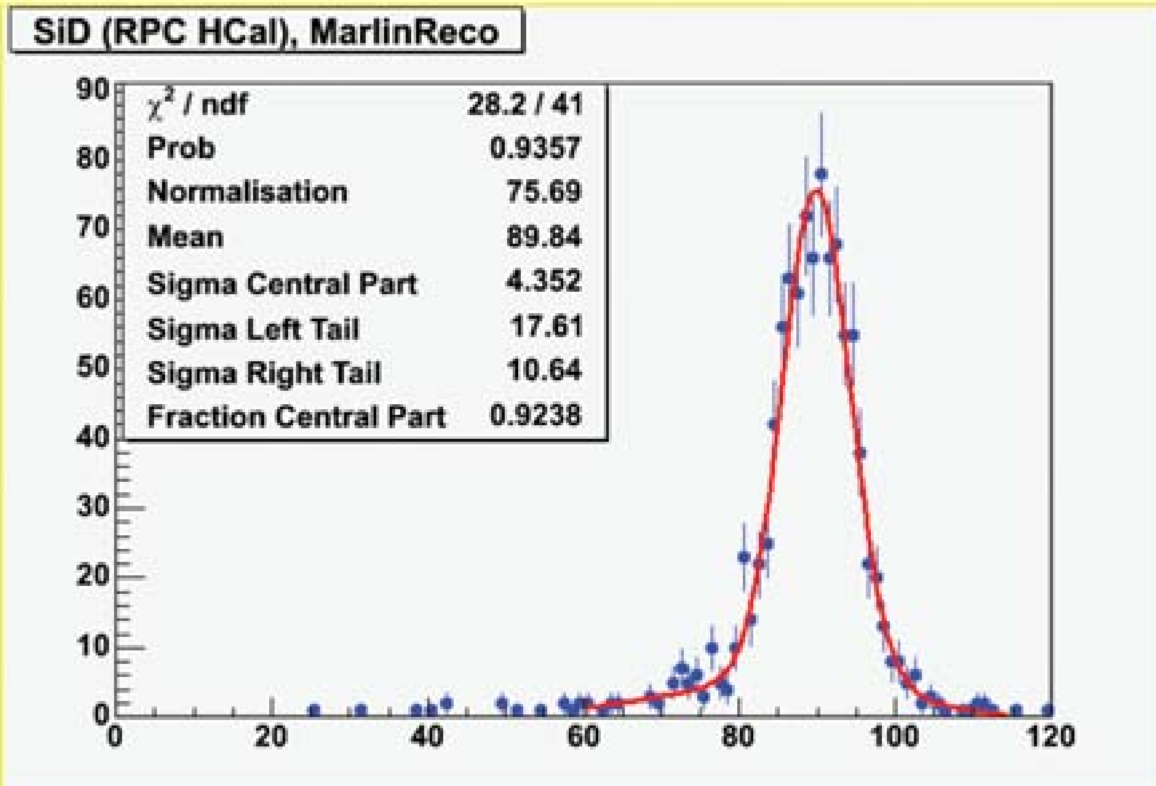
Hadron Calorimetry

Considering several options for HCal:

SS or Tungsten with any one of 3 readout technologies

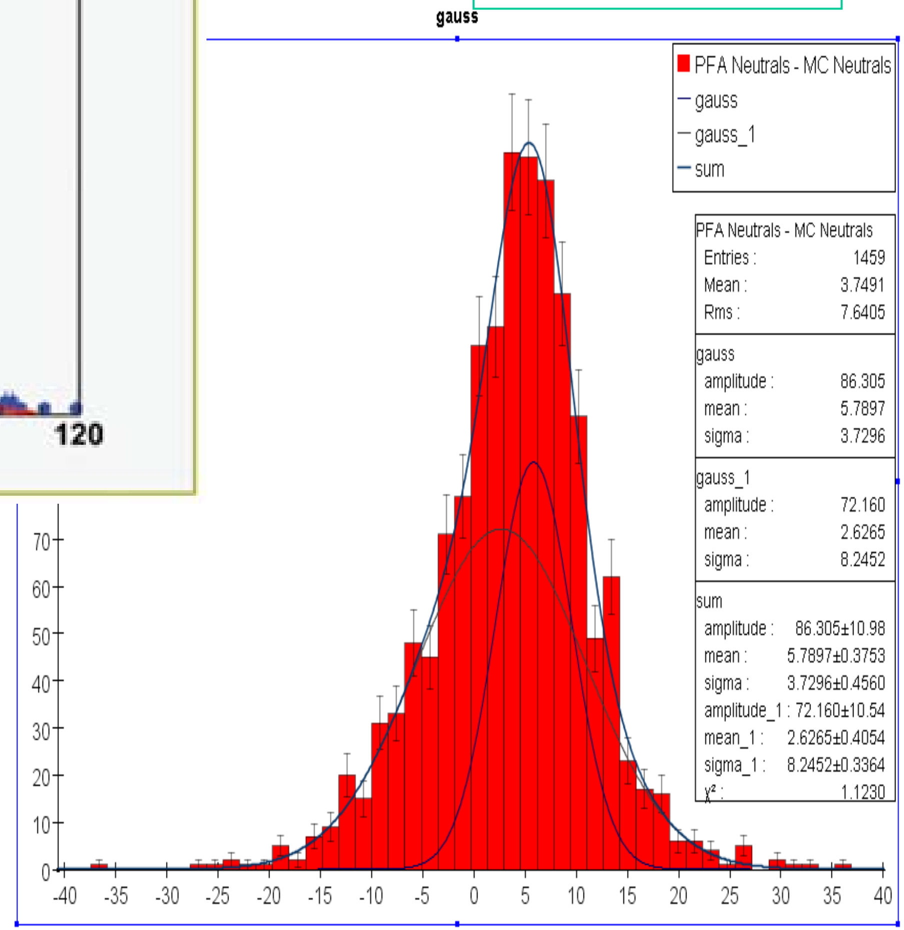
	Scintillator	GEMs	RPCs
Technology	Proven (SiPM?)	Relatively new	Relatively old
Electronic readout	Analog (multi-bit) or Semi-digital (few-bit)	Digital (single-bit)	Digital (single-bit)
Thickness (total)	~ 8mm	~8 mm	~ 8 mm
Segmentation	3 x 3 cm^2	1 x 1 cm^2	1 x 1 cm^2
Pad multiplicity for MIPs	Small cross talk	Measured at 1.27	Measured at 1.6
Sensitivity to neutrons (low energy)	Yes	Negligible	Negligible
Recharging time	Fast	Fast?	Slow (20 ms/cm^2)
Reliability	Proven	Sensitive	Proven (glass)
Calibration	Challenge	Depends on efficiency	Not a concern (high efficiency)
Assembly	Labor intensive	Relatively straight forward	Simple
Cost	Not cheap (SiPM?)	Expensive foils	Cheap

Calorimetry II: PFA's applied to SiD$_{00}$



A. Respereza

S. Magill



Note: Z→u,d,s

Area of intense work in SiD

PFA activities

Photons:	MST clustering (follow up with H-matrix id?)	N. Meyer, Iowa
	H-matrix id development	N. Graf, SLAC
	H-matrix id (preceded by n-n'bor clustering) Photon sep $\Rightarrow$ pi0 kinematic fit $\Rightarrow$ improved res. !	G. Wilson, E. Benavidez, Kansas
	H-matrix based id	S. Kuhlmann, S. Magill, ANL
hadrons:	MST clustering and fragments association	M. Charles, Iowa
	density-weighted clustering	Lei Xia, ANL
	density-weighted clustering	V. Zutshi, G. Lima, NIU
	Neural-net based id – 15 discriminators – based on Bower, Cassel, Pathek NN	S. Kuhlmann, S. Magill, ANL

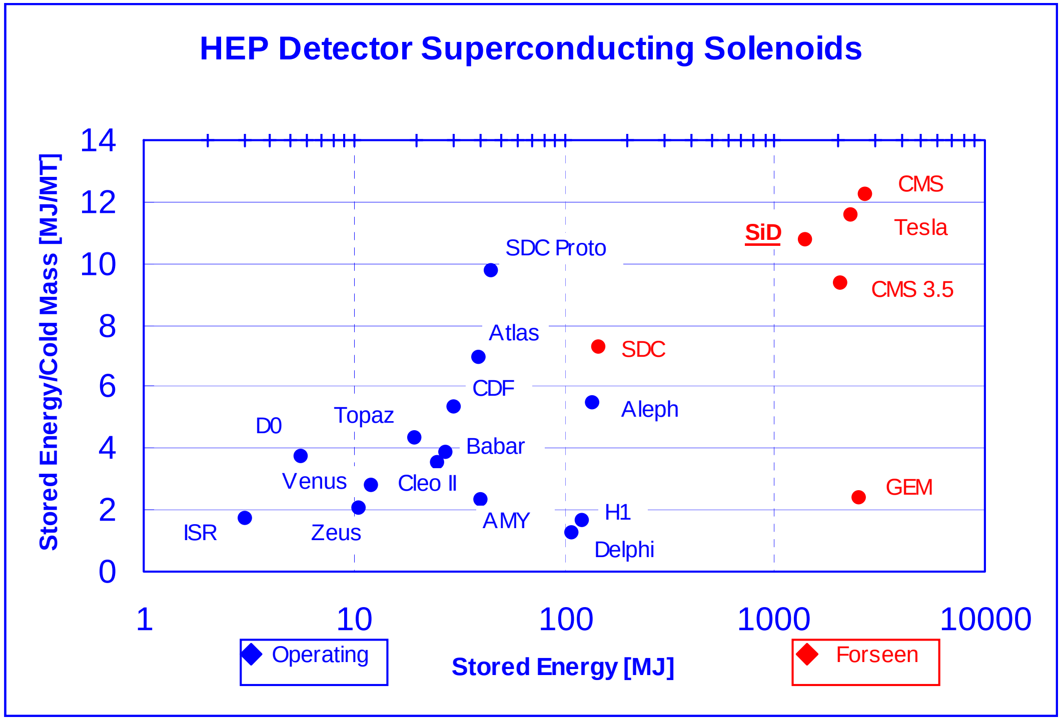
Full PFA's under development for SiD:

- ANL, SLAC – Magill, Graf, Cassell, Kuhlmann
    - H-matrix, track extrapolation, and nearest n'bor had. clust.
- ANL – Lei Xia – cluster based
- NIU – Chakraborty, Lima, Zutshi – cluster based

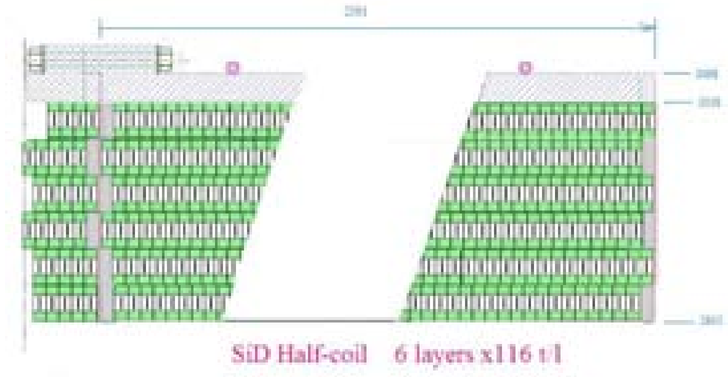
Solenoid

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

Did feasibility study and convinced ourselves & others that this 5T solenoid can be built, based on CMS design & conductor.



SiD coil



- Same conductor as CMS
- CMS (4 layer)➔ SiD (6 layer)
- CMS 5 modules 2.5 m long ➔SiD 2 modules 2.6 m long

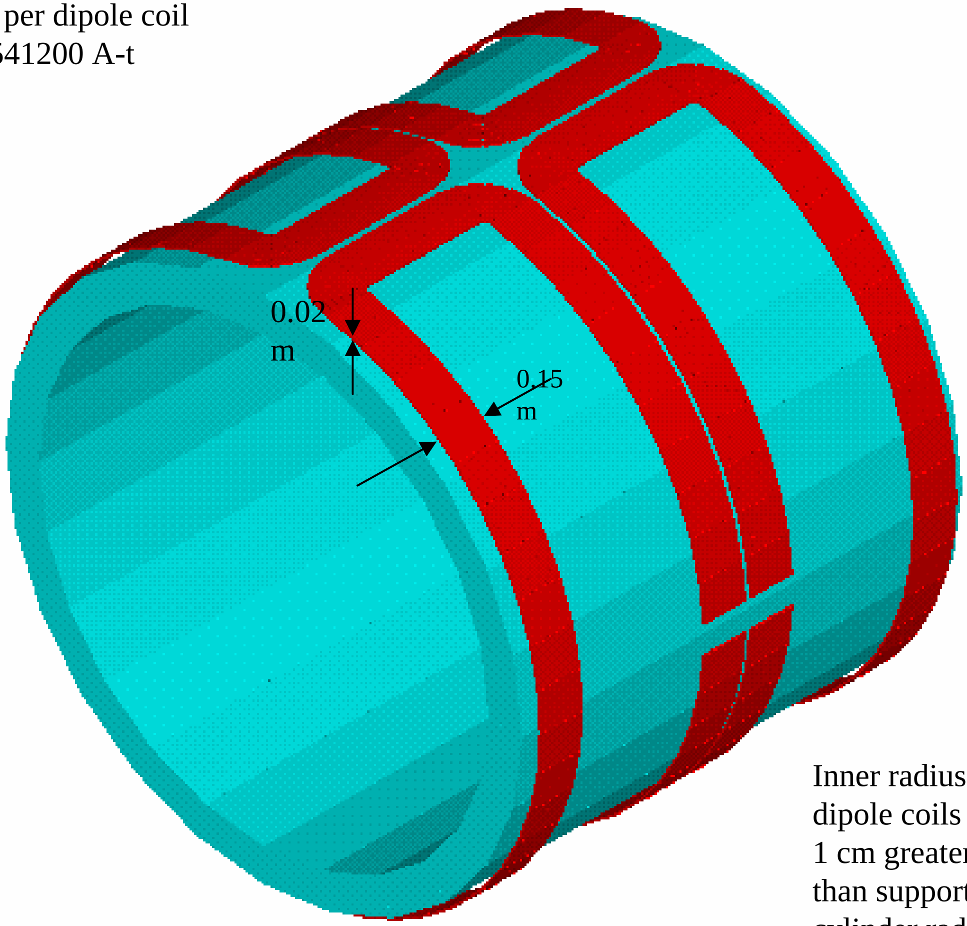
Stresses and forces comparable to CMS.

Solenoid next steps

Provides field maps for SiD and for MDI questions

Design of Detector-Integrated-Dipole (DID) for beam X-angle 9 20mrad)

NI per dipole coil
= 541200 A-t



Inner radius of dipole coils is 1 cm greater than support cylinder radius

Wrap saddle coils on support cylinder

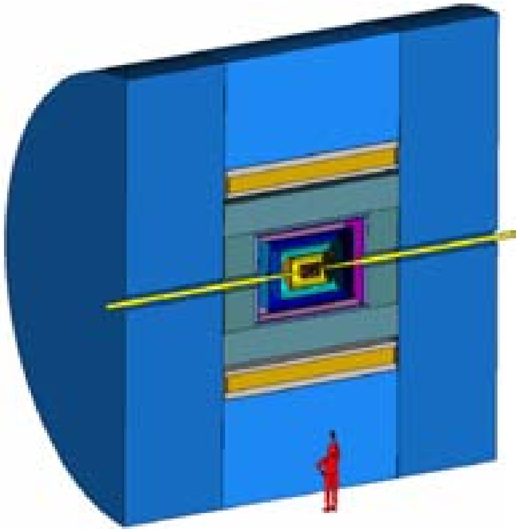
Provides required field

Forces are manageable

Developing parametric cost model based on CMS cost; solenoid is cost driver

Muon system

Muon group just started at this workshop.



SiD Muon System Strawman

- 24 10cm plates w/23 gaps. Muon ID studies done to date with 12 instrumented gaps. ~1cm spatial resolution? Start with 12 planes, more when needed (e.g. 1TeV).
- 6-8 planes of x,y, u or v upstream of Fe flux return for xyz and direction of charged particles that enter muon system.

μ Detector Technologies

Strips vs. pixels

- Glass & Bakelite RPCs –
- Scintillator and Photo-detectors
- GEMs
- Wire Chambers

Questions

- Is the muon system needed as a tail catcher?
- How many layers are needed (0-23)? Use HCAL ?
- Position resolution needed?

MDI

- 18 ‘urgent’ questions issued by WWS/MDI to 3 detector concepts
- Written responses provided pre-Snowmass
- Responses digested and summarised by WG4/MDI

- L* range under discussion by WG4: 3.5m < L* < 4.5m
  Range is acceptable to SiD
- Beampipe radius:
  effectively discussing 15 < r < 25 mm
  if backgrounds allows: SiD prefers smallest r
- Bunch spacing: 150-300 ns acceptable to SiD

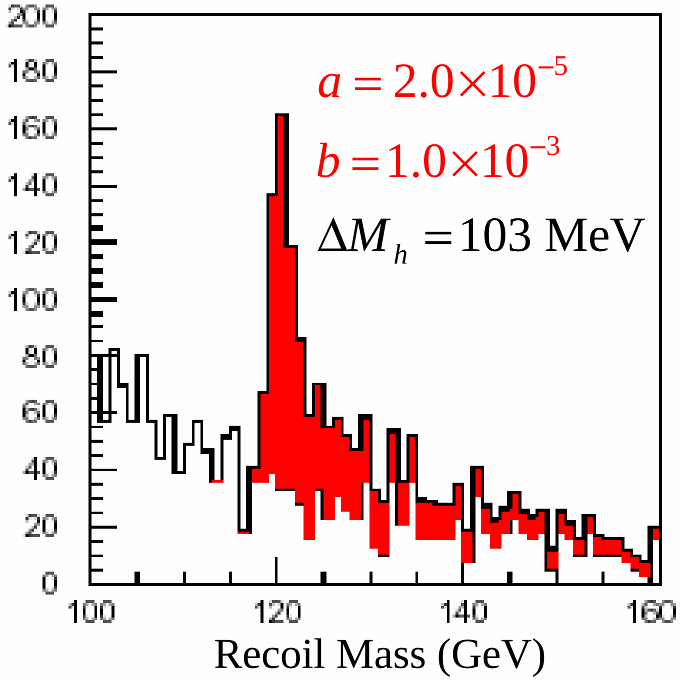
Excellent liaisons to MDIpanel/WG4: P.Burrows & T.Tauchi

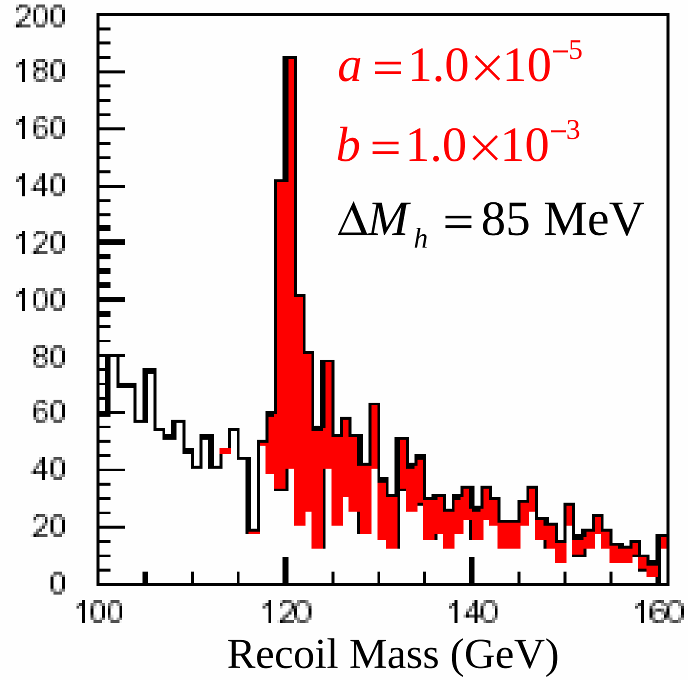
Most of the work done in WG4, but need interaction WG4 – SiD:
Need to specify tolerable background rates
Refine answers to questions MDI questions

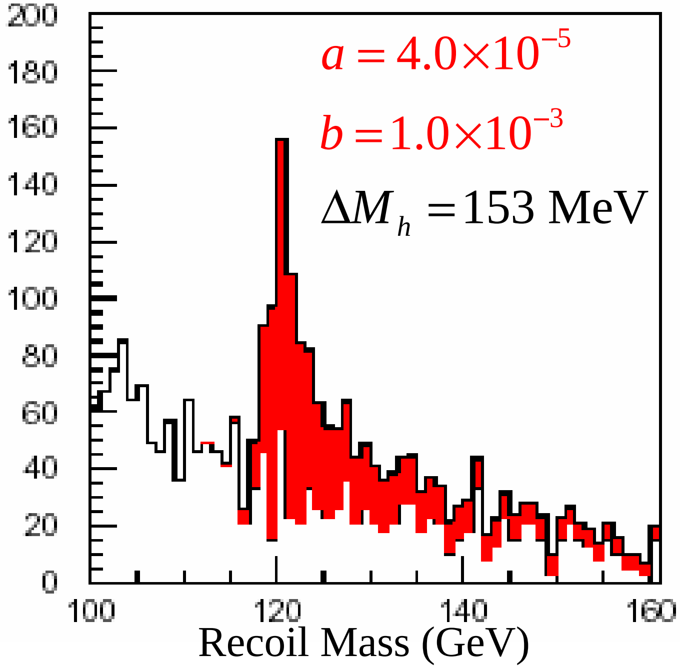
$$e^+e^- \to ZH$$
$$\to \mu^+\mu^- X$$

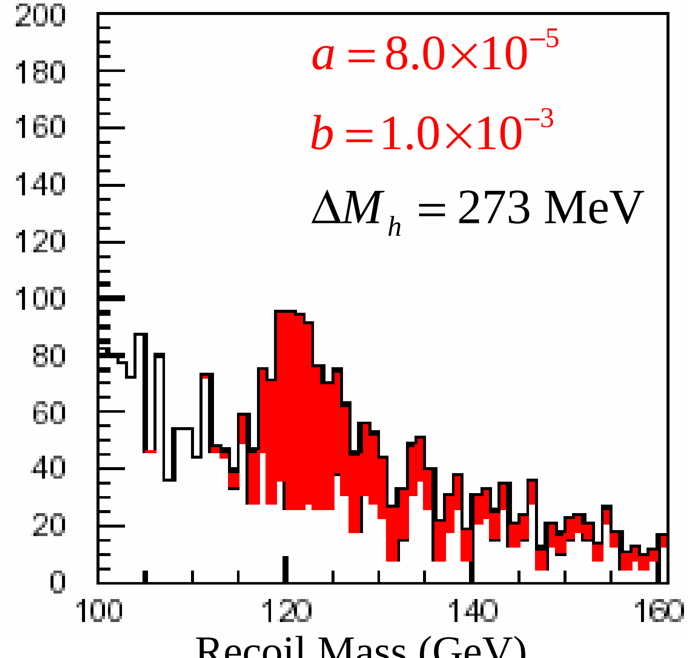
$$\sqrt{s} = 350\ GeV$$
$$L = 500\ fb^{-1}$$

$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$

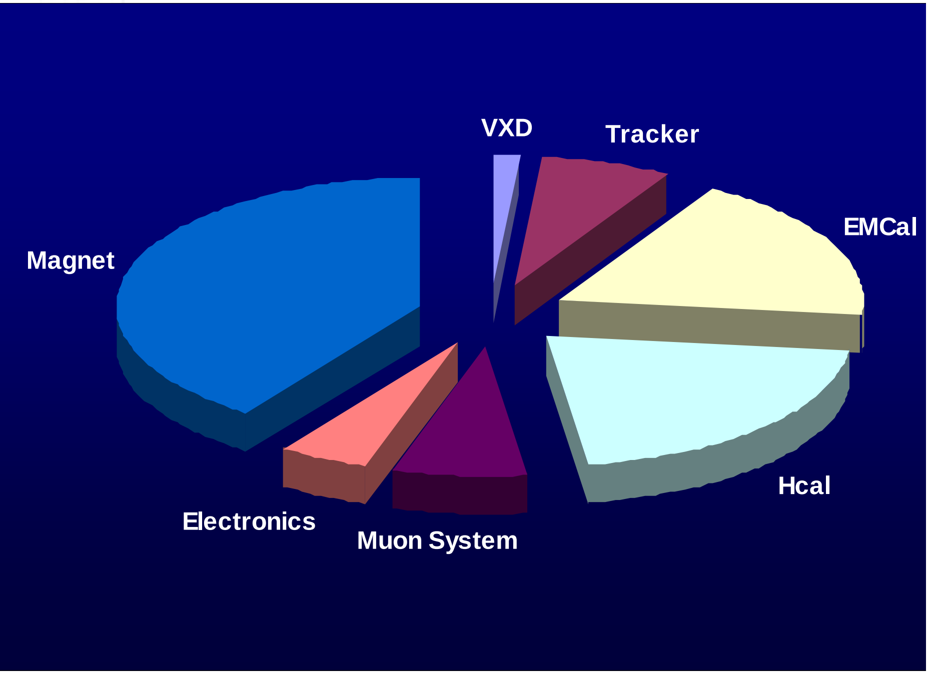






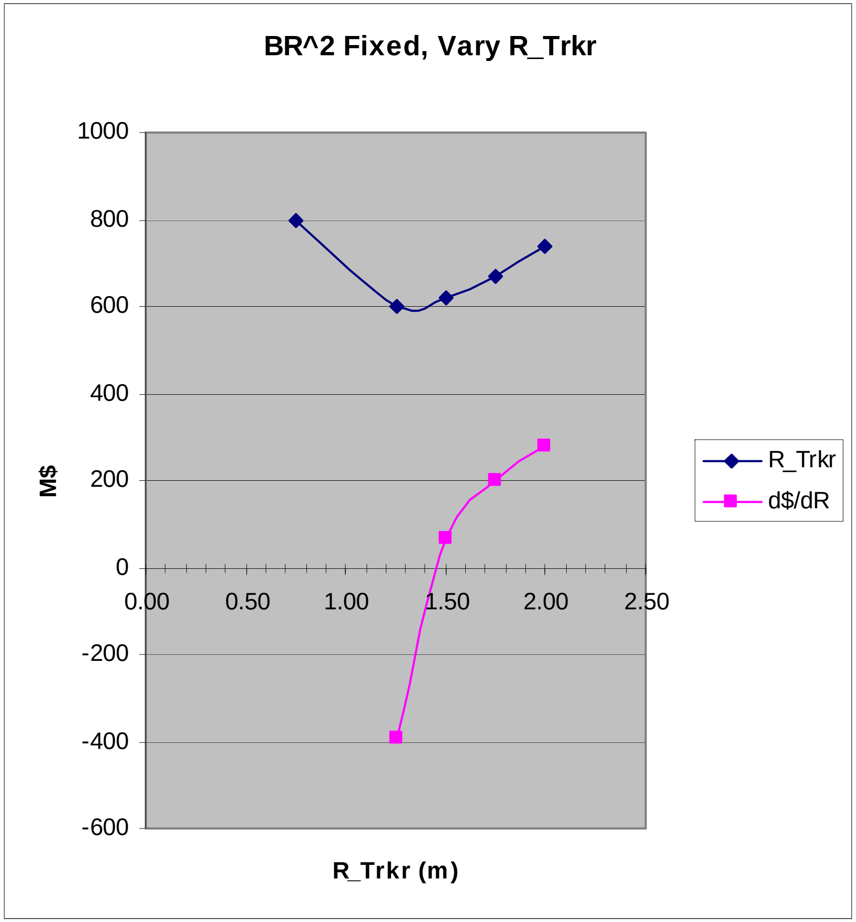


Cost



Cost by subsystem

Cost minimum
vs. tracker
radius



Much more on cost
in separate talk by
Marty Breidenbach

SiD: salient features

- Smallest L*, compatible with crossing-angle reach
- VXD: smallest radius (5T helps)
- Tracker: excellent $\delta p/p$; silicon robust; minimize material uniformly over $\cos(\theta)$; demonstrated pattern recog (in → out; out→ in, stand alone
- ECAL: excellent segmentation 4x4 mm, $R_{Moliere}$=13mm
- HCAL: excellent segmentation
- Calorimetry: imaging, hermetic
- Solenoid: feasible, 5T
- Instrumented flux return & imaging HCAL: excellent muon ID
- Time stamp/digitize bunch by bunch
- Cost: constrain cost, have a parametric model

R&D needs & priorities

Concepts have been asked to identify and prioritize their R&D needs.

Draft of R&D report submitted:

SiD Detector Concept for the International Linear Collider
Research and Development Report
for WWS R&D Panel
Introduction

The SiD design concept is continuously evolving. R&D on most detector subsystems has started, but generally with rather limited funding. For the purposes of providing information on the status and needs of R&D, this report therefore takes two approaches:
(1) We give a "top-down" estimate (separate file) based on the overall best estimate of the final SiD detector cost, by subsystem, and experienced-based estimates of the R&D as a percentage of final cost. This also involves risk assessment for each subsystem in terms of a contingency for the R&D.
(2)(below) We give a detailed list of the present SiD R&D projects as far as is known and their present/anticipated funding. Clearly there is a large gap in the figures for each subsystem deriving from the two approaches. However, we take this information to be input to the WWS R&D Panel and future deliberations, starting at Snowmass 2005.
Vertex Detector (Su Dong)

Top Down approach: R&D needs of subsystems:

SiD Subsystem	Cost	Estimated R&D %	R&D Cost	R&D Contingency %	R&D Cost With Contingency
VXD	6.0	50	3.0	20	3.6
Tracker	19.9	15	3.0	20	3.6
EMCal	74.7	20	14.9	20	17.9
HCal	74.2	15	11.1	20	13.4
Muon system	52.1	10	5.2	20	6.3
Electronics	37.5	50	18.8	20	22.5
Magnet	167.1	10	16.7	20	20.1
MDI	20.0	10	2.0	20	2.4
TOTALS/AVG	**451.5**	**22.5**	**74.7**	**20.0**	**89.7**

Next Step: Prioritize R&D needs of SiD; started at Snowmass

Looking towards near future

Evolve SiD_{00} towards a baseline: explore variations of current starting point: B, $R_{tracker}$, barrel length plus others and optimize using some benchmarks.

Need PFA with sufficient accuracy and sensitivity to do this.

These steps needed to be able to produce a draft a detector outline document by LCWS06

Task	End time	Group
Physics requirements	September 30, 2005	Benchmarking
PFA Review	October 1, 2005	Calorimeter Group + All
Internal detector variations	December 1, 2005	Sub detectors
Global parameters variations	December 15, 2005	Some group
Draft for DD	December 15, 2005	Sub detectors + EdBoard
Fix baseline	December 16, 2005	SiD meeting + ExecBoard + ...
Physics performance for SiDBL		
Provide Conceptual Designs	January 30, 2006	Sub detectors
Final DD Editing	February 1, 2006	EB

(DD= detector document)

Plan a SiD meeting (few days) middle of december

SiD socially & outside dark rooms

Conclusion of SiD @ Snowmass 2005

First time for SiD concept study participants to get together in person and for more then a few hours.

Establish working relationships which are very positive and necessary to complete the work ahead of us in the next few months and longer future.

Only a small fraction of the work done by my colleagues was described in this summary.
SID summaries yesterday took 4 hours !

Excellent progress made on understanding and simulating SiD_{00} starting point. We have put SiD on a more solid foundation.

Thanks to all who contributed to the progress on SiD

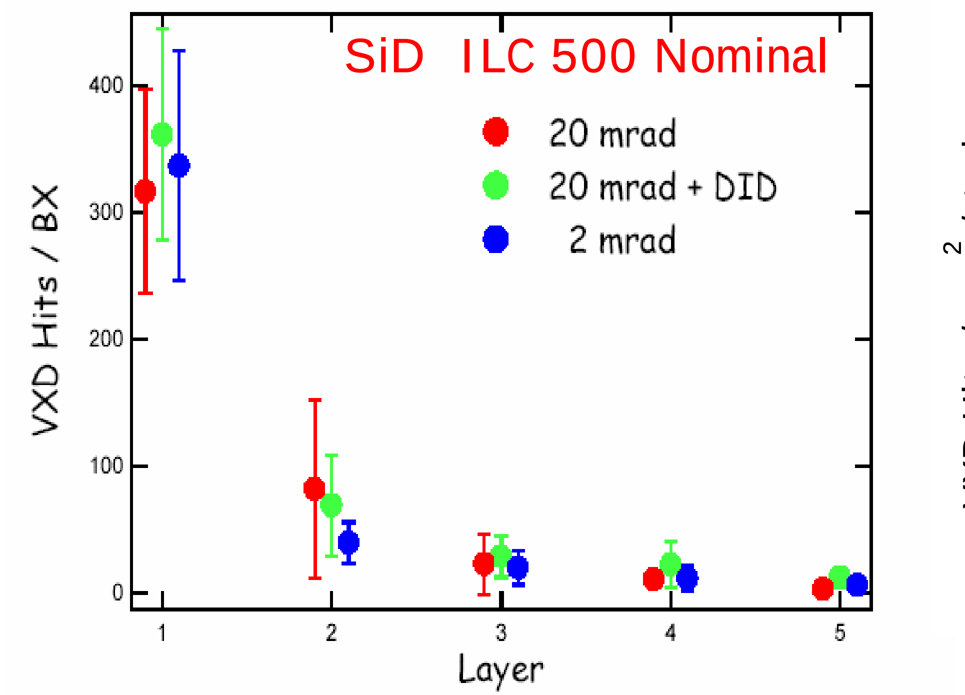
THANK YOU to organizers (and others) for making this workshop happen and allowing SiD to take a giant step forward

THE END

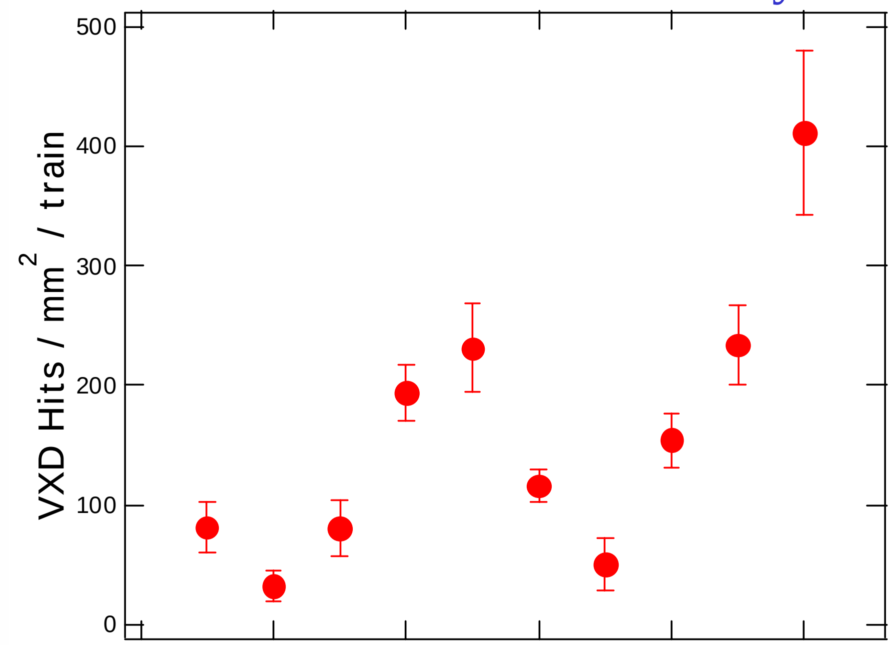
VXD backup

VXD Background rates

Takashi Maruyama



R=1.4 2.5 3.6 4.8 6.0



N Q Y P H N Q Y P H

500 GeV 1 TeV

Large rate difference between Layer 1 and outer layers

Needs at least x2 margin from nominal configuration

These are for pair background only. What about synchrotron radiation ?

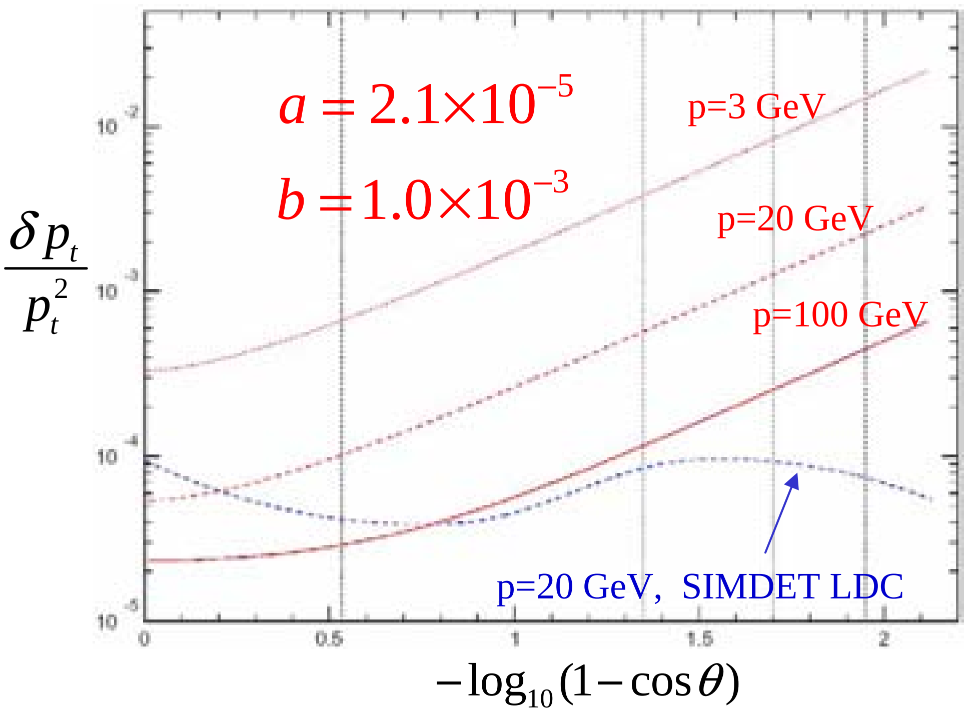
Benchmarking

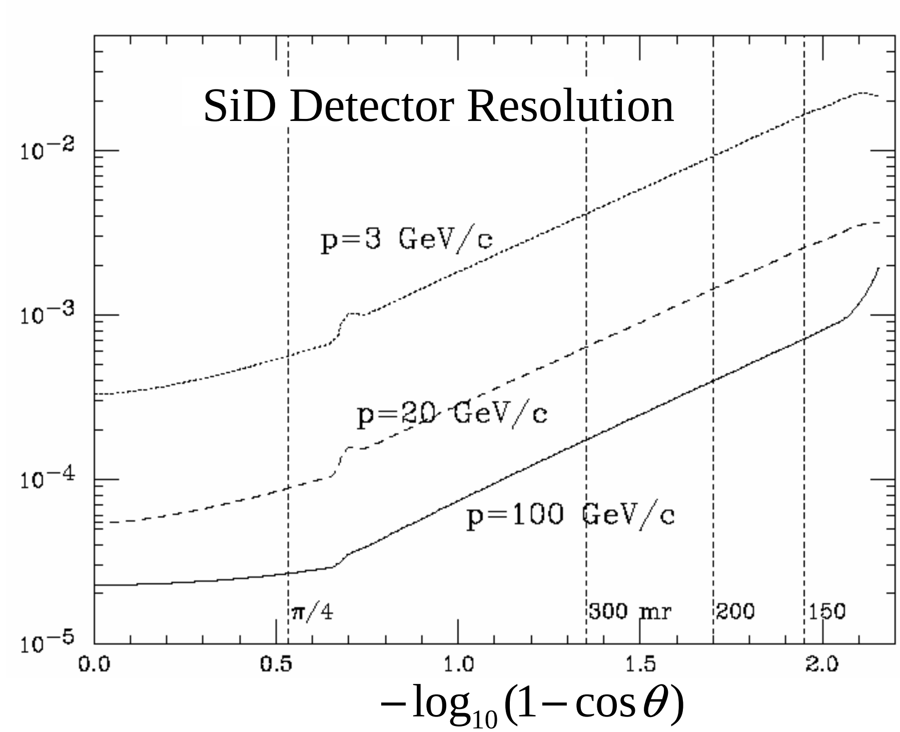
A comparison of momentum resolution vs. angle in simulations:

$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$

Fast MC

Using SID_{00}





Tracking II/backup