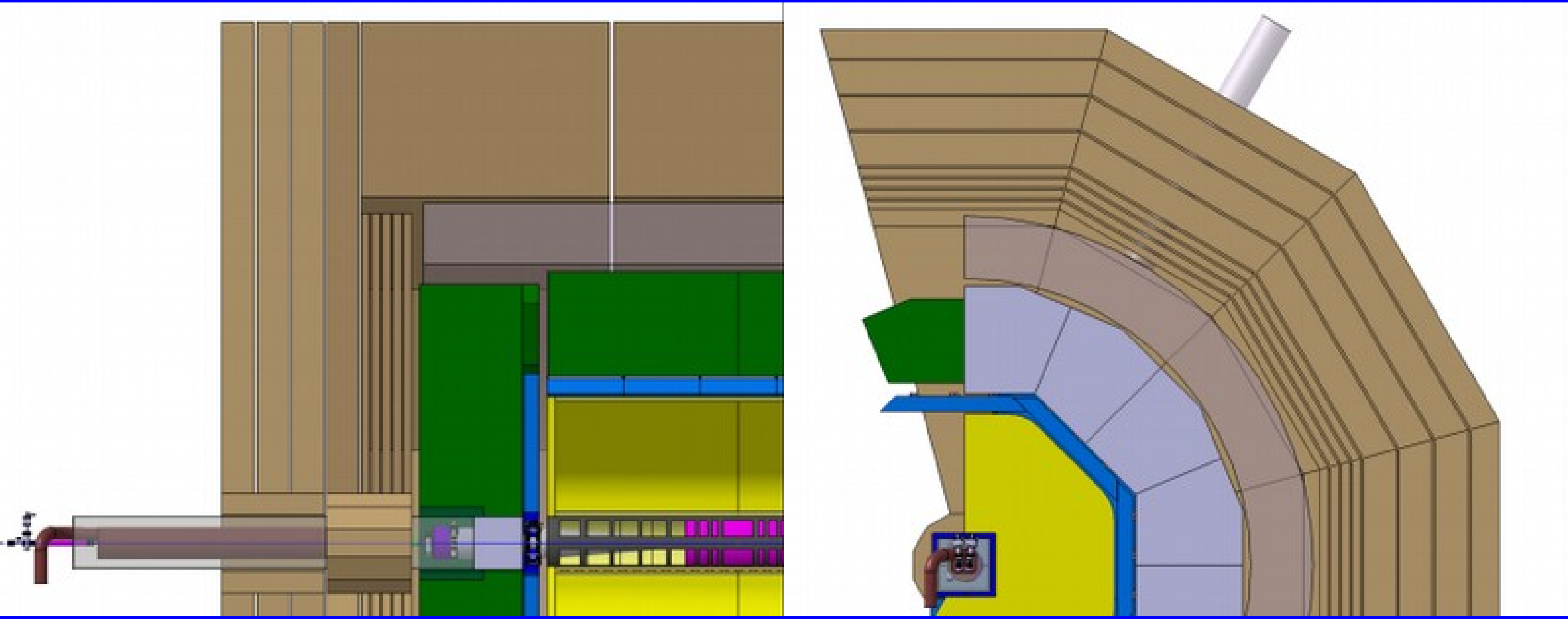
Status and Progress of the ILD concept

(ILD: a Large Detector for the ILC)



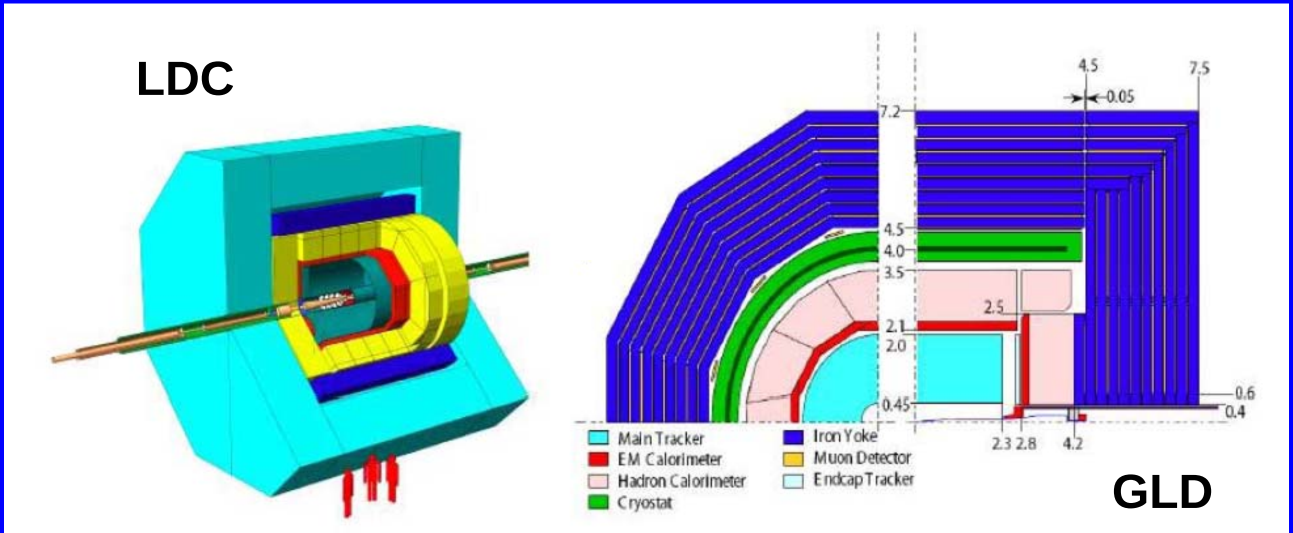
Graham W. Wilson (Univ. of Kansas)
for the ILD concept group

Outline

- Introduction (GLD ⊕ LDC → ILD)
- Detector Concept (Broad-brush)
- Goals and Scope of Current LOI Process
- Group Organization
- Making a joint LOI a reality (Cambridge workshop)
  - Detector Sub-system Overview
  - Detector Performance Studies: Single Particles, Particle Flow
  - Status of Physics Benchmark Studies
  - Defining the ILD reference detector (ILD00)
  - A baseline model with options
- MDI/Integration
- Status/Plans for Component R&D

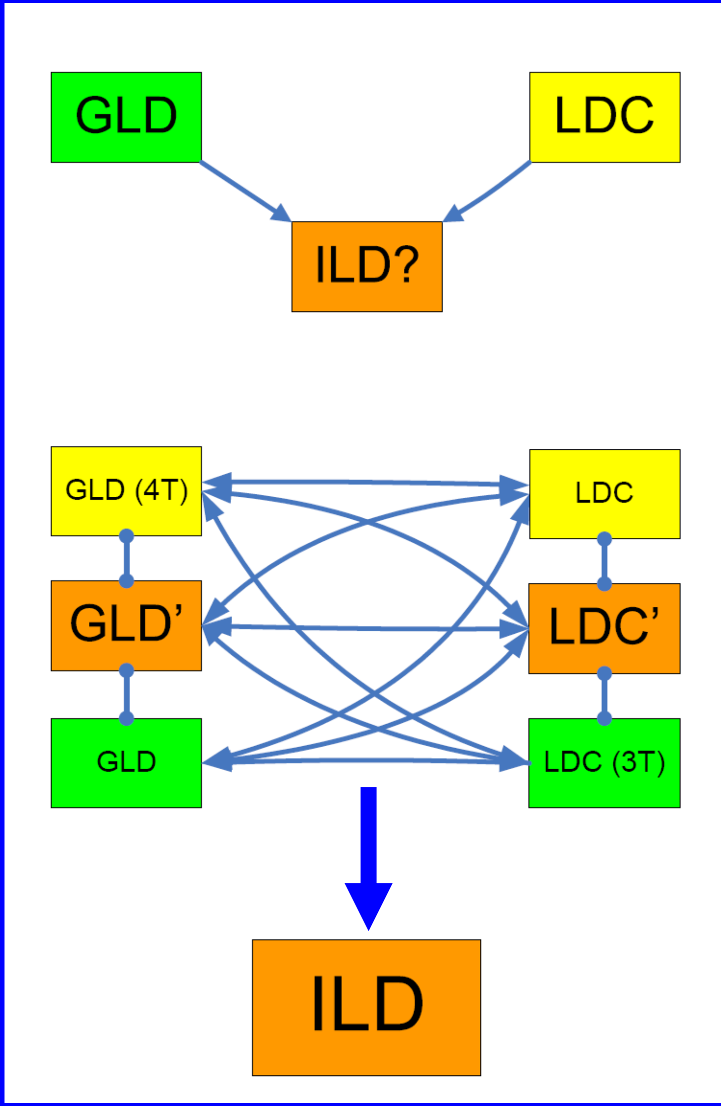
ILD

- Origins in the TESLA, JLC and LD detector concepts.
- First conceptual reports in the mid 90s.
- ILC Reference Design Report (RDR) 2007
  - GLD Detector Outline Document (DOD) arXiv:physics/0607154
  - LDC DOD http://www.ilcldc.org



Introduction

- ILD Conception
  - At LCWS07, we agreed to work towards a merger of the GLD and LDC detector concepts
  - Plan to (at least) explore the phase-space between GLD (B=3T, R_{ECAL}=2.1m) and LDC (B=4T, R_{ECAL}=1.6m)
- Transition Process
  - Create scalable simulation models, GLD', LDC' with intermediate parameters (B=3.5 T, R_{ECAL}=1.85 m)
    - GLD (Jupiter), LDC (Mokka)
  - Study performance as a function of major parameters
  - Reach a consensus on the ILD reference detector ?
- ILD Reality
  - We have reached a consensus at the Cambridge workshop and have agreed to move forward in a unified and pragmatic way towards the LoI.
    - A reference detector model (ILD00) with options
    - We have chosen parameters ***not*** technologies
      - Based on current best knowledge
    - Converged to one software framework under joint leadership



ILD

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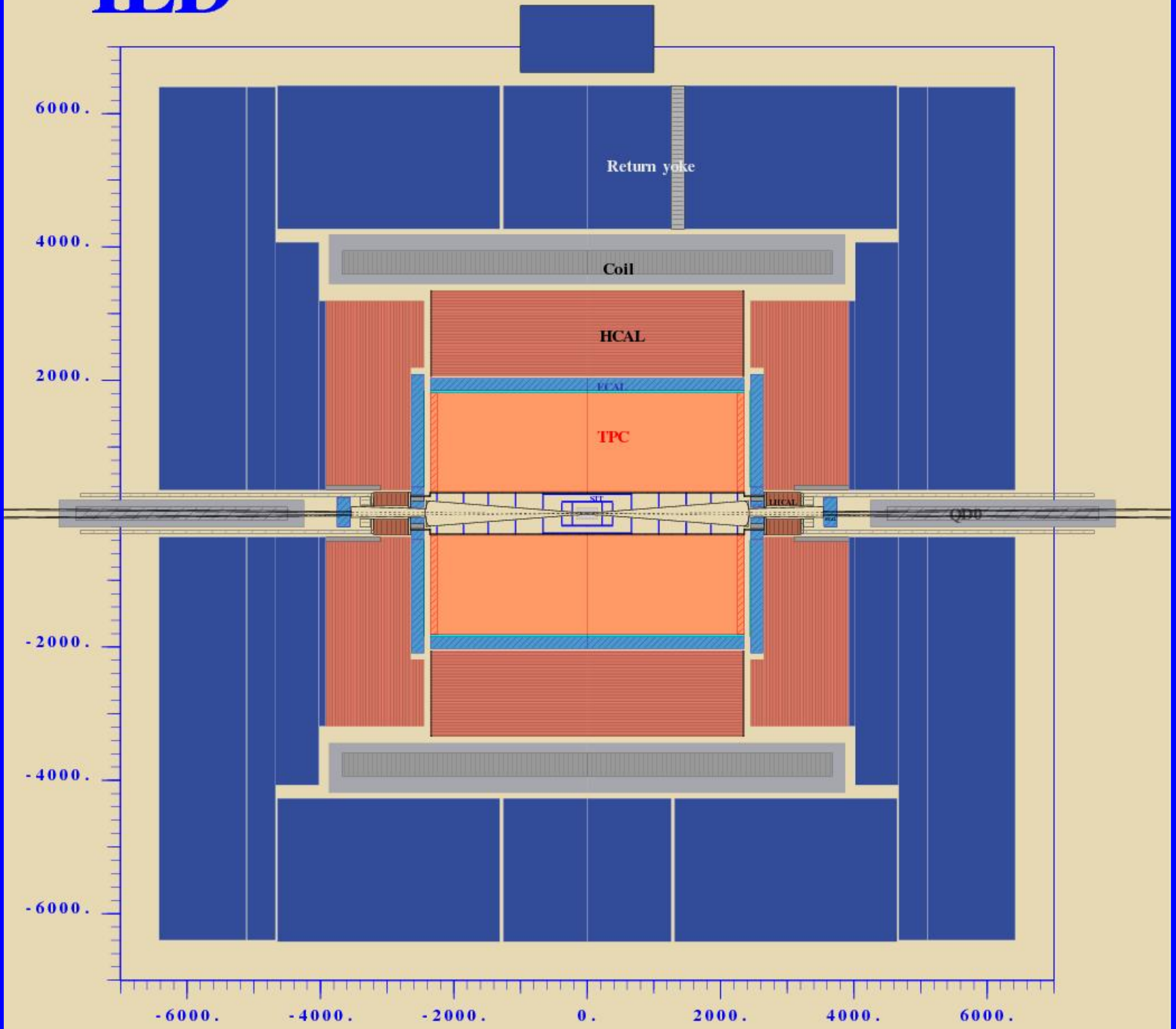
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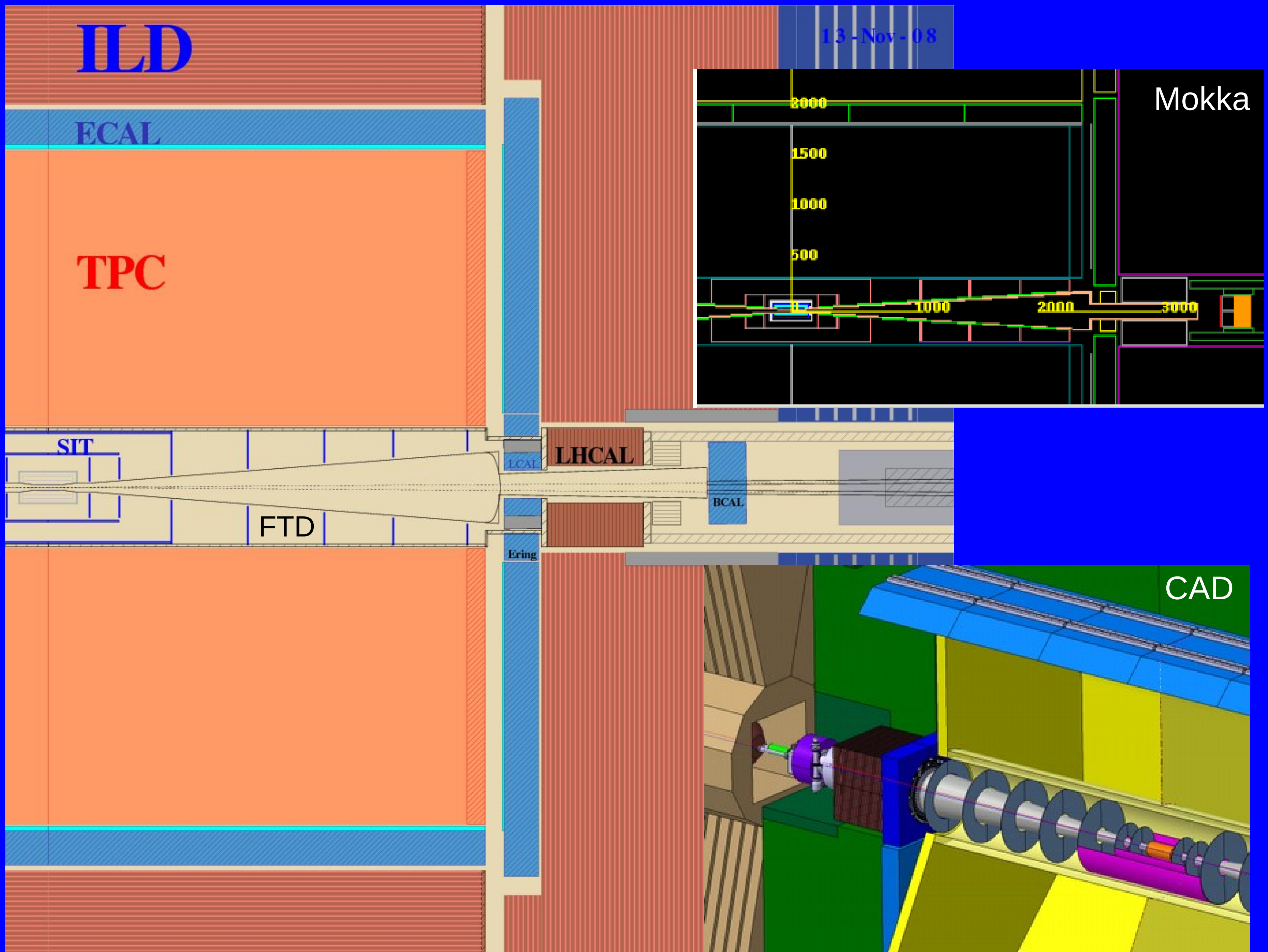
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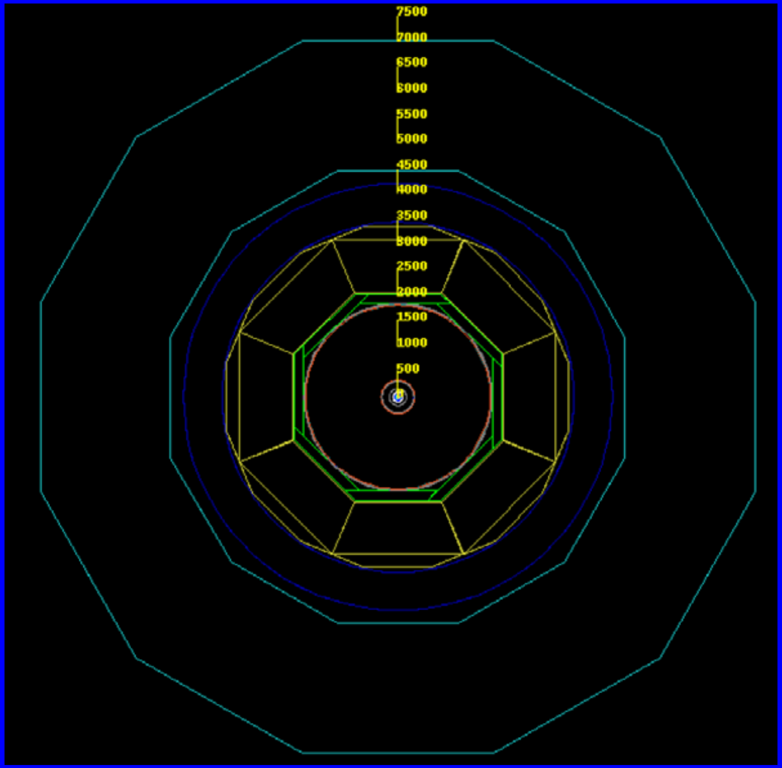
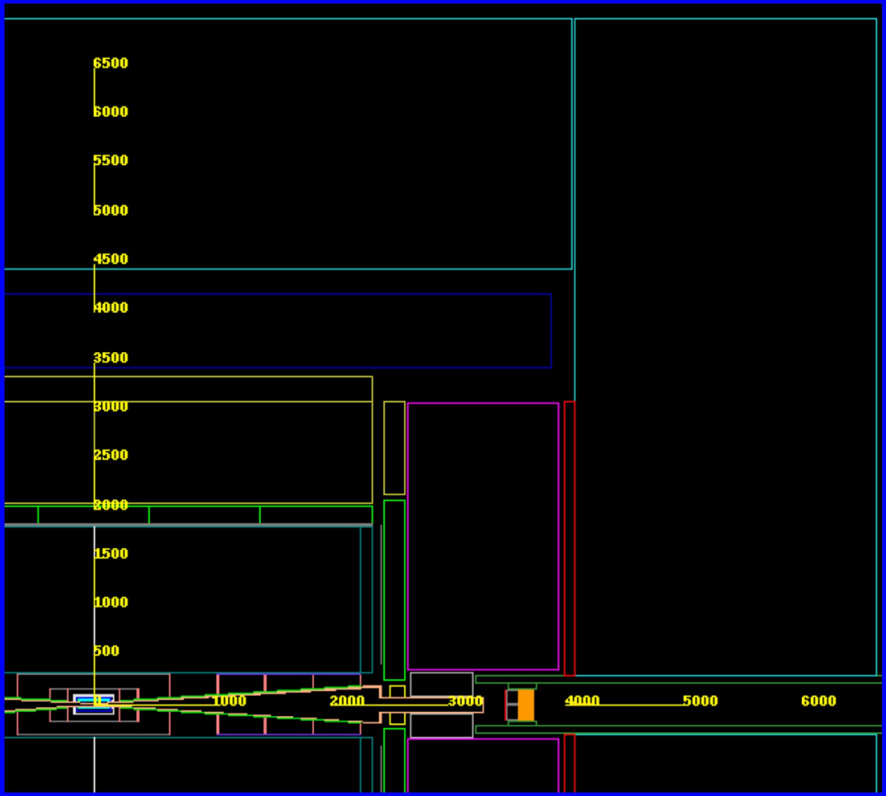
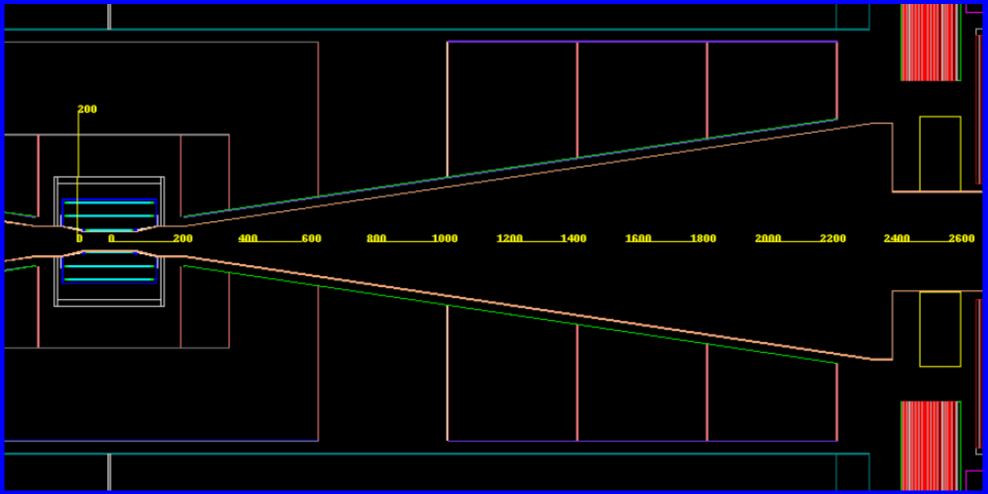
ILD00 detector model in Mokka (G4) simulation







ILD Detector Concept

- Physics needs drive the detector design
- Experience, particularly from LEP, points towards:
  - Particle-flow for complete event reconstruction
  - A highly redundant and reliable TPC-based tracking design emphasizing pattern recognition capabilities and low mass tracking
    - "dE/dx for free", and V^0 reconstruction (K_S, Λ, γ conversion)
  - A fine granularity calorimeter capable of particle-flow
  - Ultra-hermetic
- Accelerator and tracking system designed with sufficient safety margin to operate reliably.

What kind of physics ?

- Processes central to the perceived physics program :
  - f fbar at highest energy
  - Zh
  - $\nu\nu$h
  - Zhh
  - Sleptons
  - Charginos
- These will emphasize:
  - Jet energy resolution (assumed to be done with particle flow) aiming for W/Z separation
    - For W,Z the intrinsic width contributes $\Gamma/(2.4\ M) = 1.1\%$ in resolution.
  - Hermeticity
  - Granularity
  - Leptons, taus, b, c tagging

Detector design requirements

- Detector design should be able to do excellent physics in a cost effective way.
  - both the physics we expect, and the new unexpected world that awaits
- Very good **vertexing** and **momentum** measurements

$\sigma_b = 5 \oplus 10/(\ p\ \beta\ \sin^{3/2}\theta)\ \mu m$ $\sigma(1/p_T) \leq 5 \times 10^{-5}\ GeV^{-1}$

- Good **electromagnetic energy** measurement.

$$\sigma_E/E \approx 15\%/\sqrt{E}\ (GeV) \oplus 1\%$$

- The physics demands hermeticity and the physics reach will be significantly greater with state-of-the art **particle flow**
  - Close to 4π steradians.
  - Bubble chamber like track reconstruction.
  - An integrated detector design.
  - Calorimetry designed for resolving individual particles.

$$\sigma_{E_{jet}}/E_{jet} \approx 30\%/\sqrt{E_{jet}}\ (GeV)$$

Remarks on Goals and Scope of LOI process

- Deliver a credible LOI that is "validated"
  - Can do the physics
  - Is feasible
  - Proponents are capable
- But the LOI is just the next milestone in working towards a fully fledged technical design for the ILC project proposal.
- ILD puts a major emphasis on detector optimization using full realistic detector simulations
  - Justify global detector parameters
  - Identify and remedy design flaws
  - Compare technology options and foster relevant detector R&D
  - Receptive to new ideas
- Full simulation of signal and background processes
  - Comprehensive physics channel results for benchmark processes
  - AND, will revitalize the physics studies

Making Detector Models More Realistic

- A work in progress
  (balance between realism and reasonableness)
  - Buildable polygons
  - Inter-wafer gaps
  - Guard rings
  - Spaces for cables
  - Support structures
- Not usually implemented yet
  - Nuts and bolts
  - Readout electronics
  - Cooling

ILD Organization

Executive Board

Management

- Joint Steering Board
  - T. Behnke, D. Karlen, Y. Sugimoto, H. Videau, G. Wilson, H. Yamamoto
- Optimization
  - Y. Takubo, M. Thomson
- MDI/Integration
  - K. Buesser, T. Tauchi
- Cost
  - H. Videau, A. Maki
- Technical Coordinators
  - M. Joré, K. Sinram, H. Yamaoka
- Software
  - F. Gaede, A. Miyamoto

Subdetector Contacts

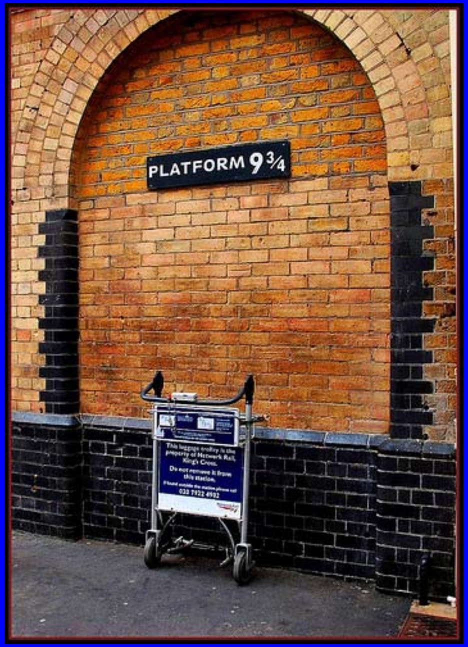
- Vertex Detector
  - Y. Sugimoto, M. Winter
- Silicon Tracking
  - A Savoy-Navarro, H. Park
- TPC
  - K. Fujii, R. Settles
- ECAL
  - J-C. Brient, K. Kawagoe
- HCAL
  - F. Sefkow, I Laktineh
- FCAL
  - W. Lohmann
- DAQ
  - G. Eckerlin, M. Wing

Common Task Representatives

- LOI Representatives
  - T. Behnke, Y. Sugimoto
- MDI
  - K. Buesser, T. Tauchi
- Engineering Tools
  - C. Clerc
- R&D
  - D. Chakraborty, T. Takeshita, J. Timmermans
- Physics
  - K. Desch, K. Fujii
- Software
  - F. Gaede, A. Miyamoto

ILD maintains close ties to the LCTPC, CALICE, LCFI, SILC and FCAL R&D Collaborations, and encourages continued support of the “horizontal” R&D collaborations

Gripping people's imagination on the way to Cambridge



Sept. 10th 2008

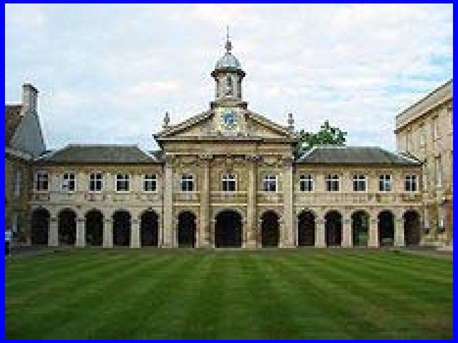
Magic was in the air, and lots of people were really interested in the field we love.

Very encouraging to see how the LHC start-up has helped to engage many people with our science.

They also seemed really interested in the results:

http://hasthelargehadroncolliderdestroyedtheworldyet.com **NOPE.**

London news-stand headlines read:
"The world survives, so far"



Lots of new results at Cambridge

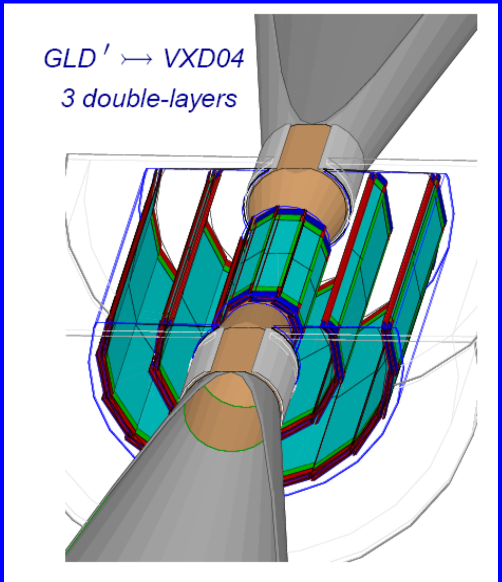
See http://ilcagenda.linearcollider.org

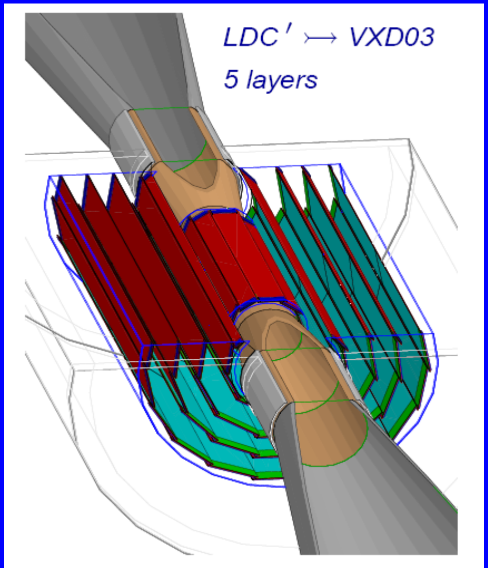
Detector Subsystem Over-view

Quick Tour

- Vertex detector
- Silicon tracking elements
  - Silicon Inner Tracker (SIT), Forward Tracking Disks (FTD)
  - Silicon External Tracker (SET), Endcap Tracking Detector (ETD)
- TPC
- ECAL
- HCAL
- Forward Calorimeters: LCAL, BCAL, LHCAL
- Solenoid
- Instrumented Yoke

Vertex Detector



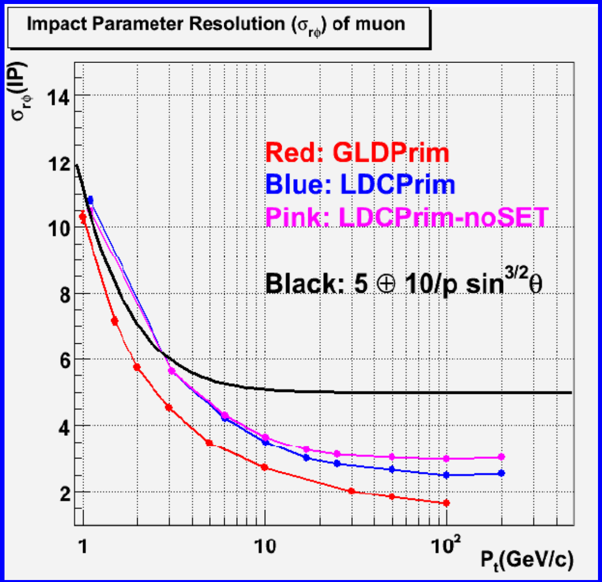


Several different technologies:

pixel sensors, readout scheme, material budget

Pairs background => Inner radius ~ √B

Studying two "technology-neutral" geometries :
3 double-layers, 5 layers



Performance studies indicate better resolution particularly at high p_T for 3 double-layers (GLD' model)

Studies ongoing and plan to include backgrounds

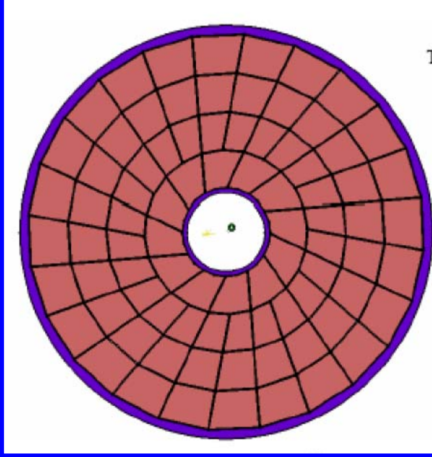
Inner layer at r=1.6 cm for B=3.5 T

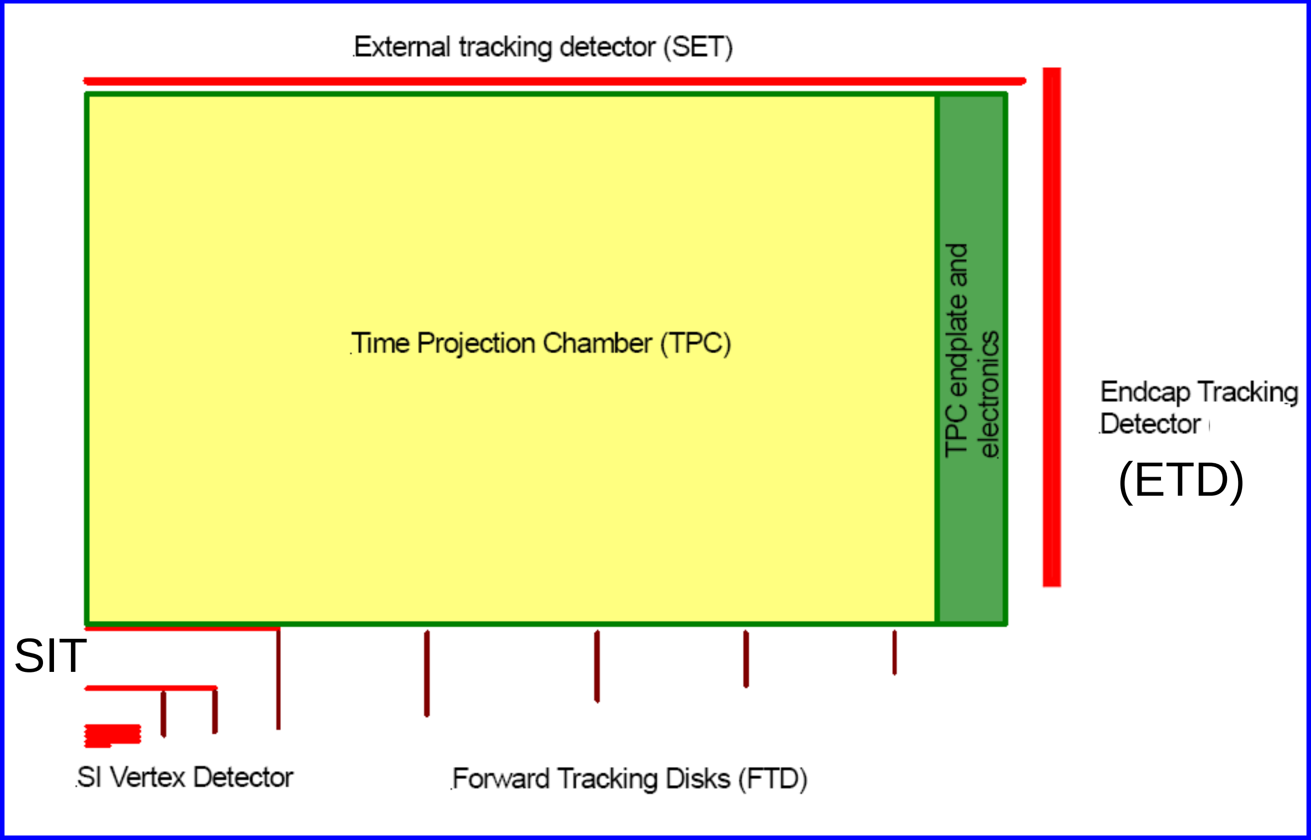
Main Tracker: TPC

Si-trackers are supported by SiLC

Supplemented by stand-alone VTX tracking, SIT + Forward tracking disks.

SET and ETD are track-cal linking options.





$3\ 10^9$ volume pixels.

226 points per track.

Single-point resolution

50 - 75 μm r-ϕ,

400 μm r-z

$|\cos\theta| < 0.985$ (TPC)

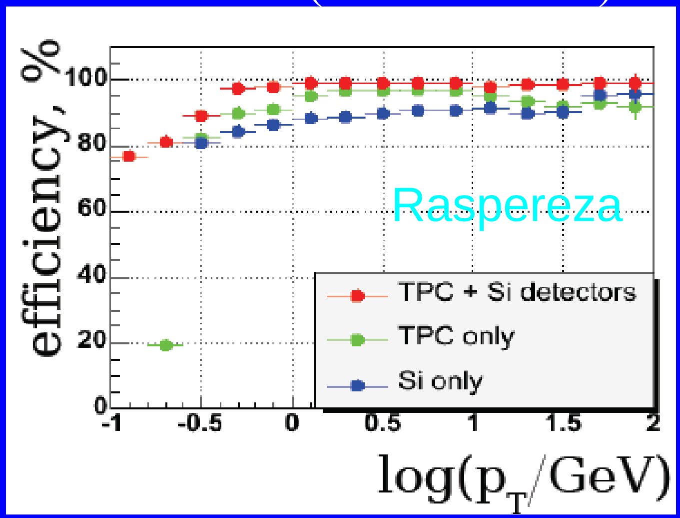
$|\cos\theta| < 0.996$ (FTD)

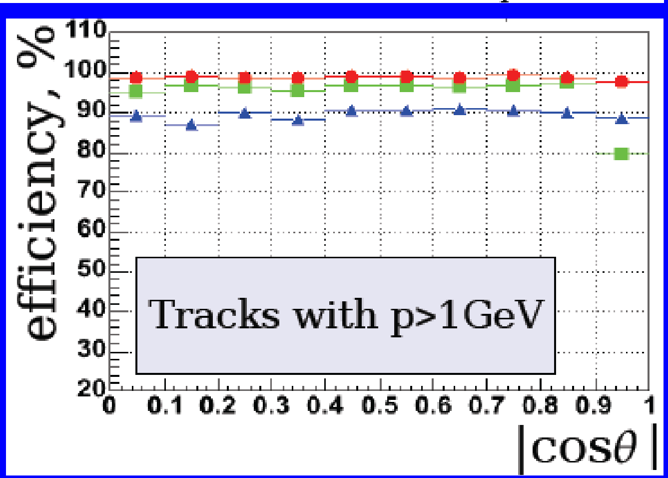
Readout options: GEM, Micromegas, Silicon Pixel

SIT and FTD are essential elements of an integrated design.

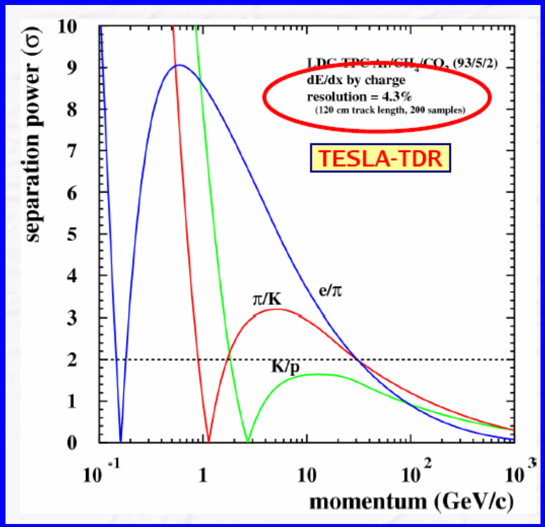
Overall Tracking Performance

$e^+e^- \rightarrow t\,\bar{t}$ ($\sqrt{s}$=500 GeV)





Highly efficient tracking



dE/dx performance similar to ALEPH, OPAL

Straightforward V^0 reconstruction

Expected occupancy < 0.5%

TPC tracking should be robust to ×20

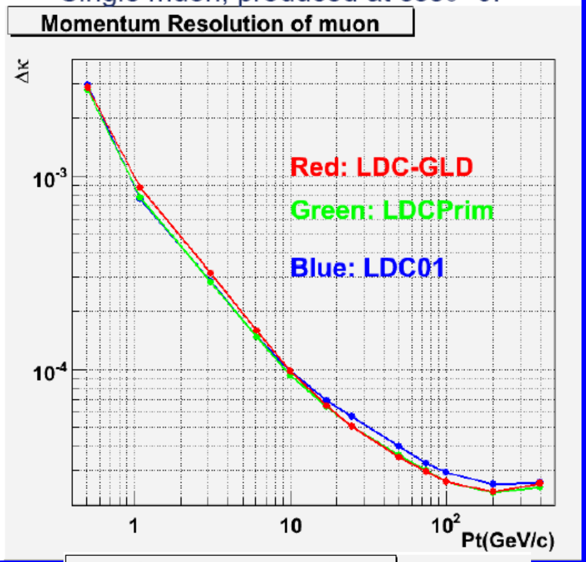
(Si-only tracking is background sensitive)

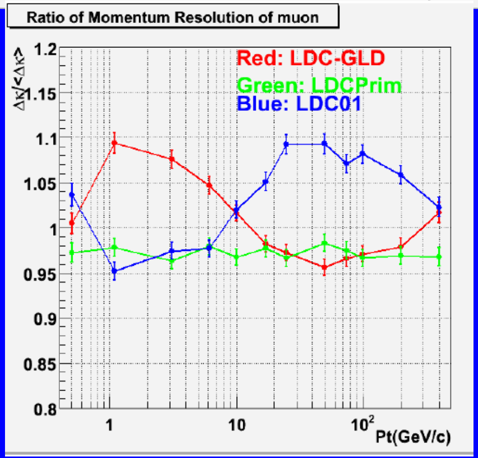
Global Detector Optimization: Tracking

Extensive comparison studies: B(T) = 3, 3.5, 4

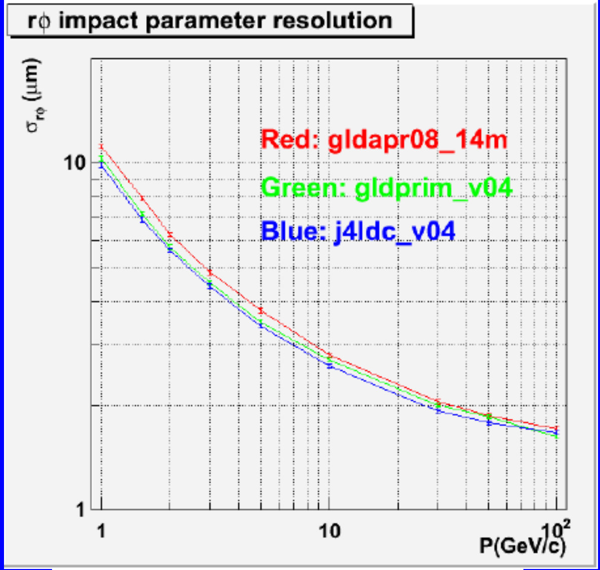
BR_{TPC}^2 (Tm^2) = 9.1, 10.5, 11.2

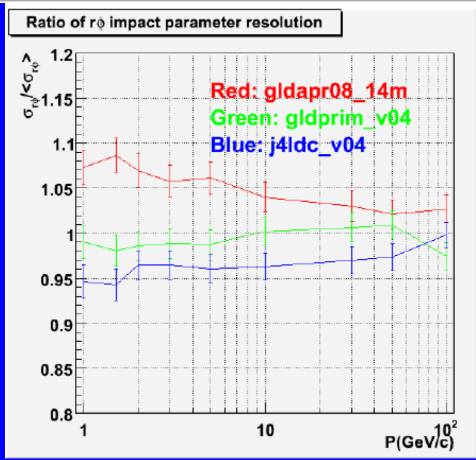
Single muon, produced at cosθ=0.





r_1 (cm) = 1.5, 1.6, 1.75

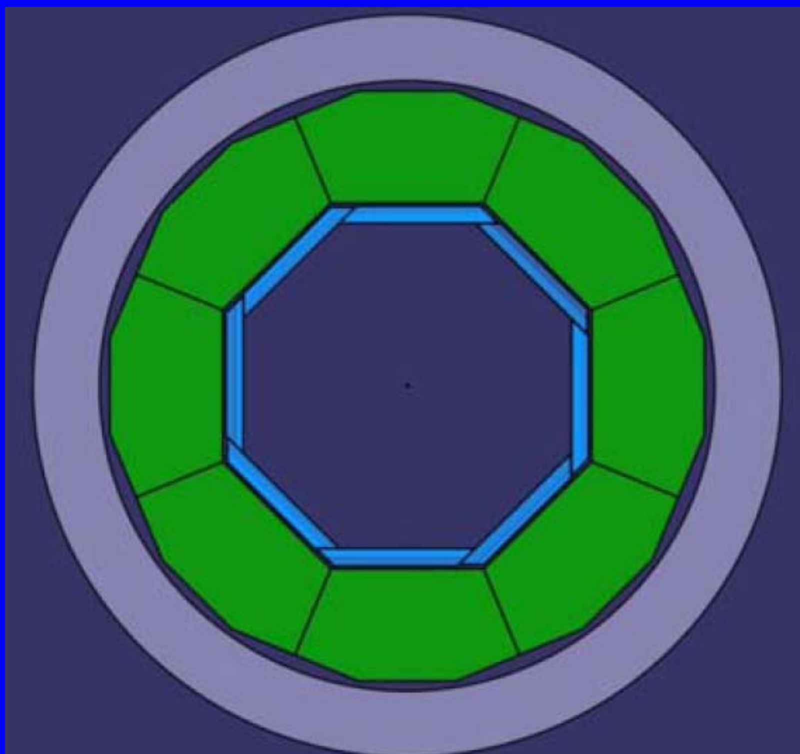


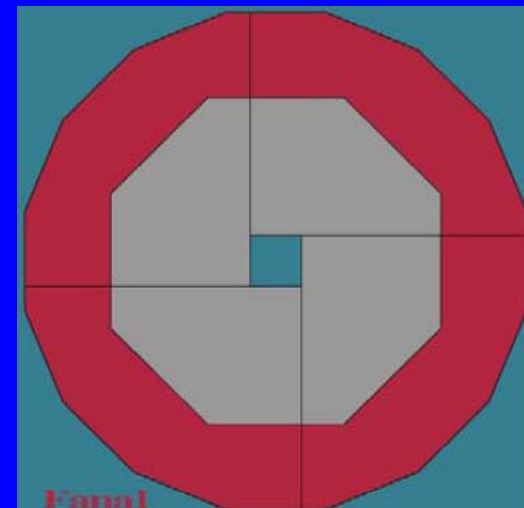


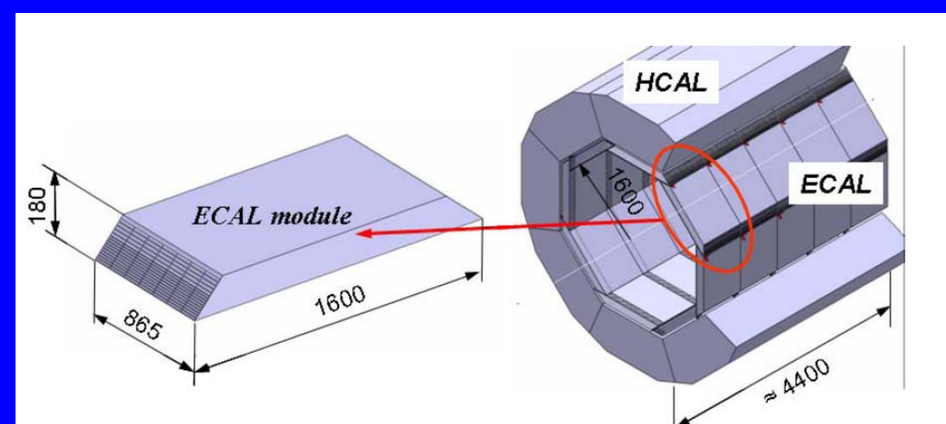
Aplin, Miyamoto, Yoshida

Note: most intrinsic tracking resolution studies done only with muons (also need electrons)

Calorimetry



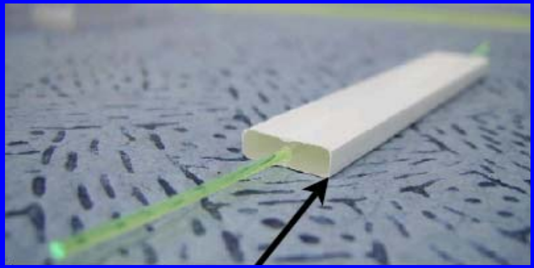


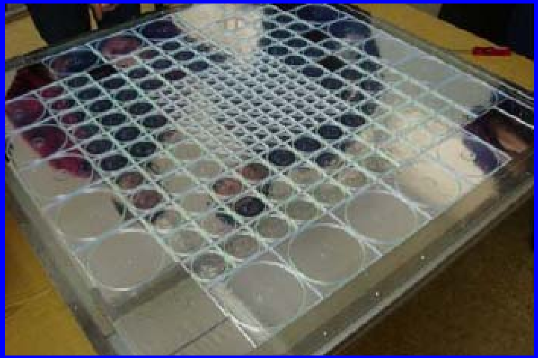


8-fold and 12-fold structures are studied.

8-fold is currently most mature, 12-fold has some pros and cons.

Calorimetry Technologies





All are studied by CALICE

- ECAL (23 X_0 : 20 x 0.6 X_0 + 9 x 1.2 X_0)
  - Silicon-W
    - transverse cell-size 5mm X 5mm
  - Scintillator-W with MPPC readout
    - 10mm X 40 mm X 2mm strips
  - Digital: MAPS
- HCAL
  - Analog : Scintillator + Stainless Steel.
    - Tiles with Si-PM readout
    - 5mm Sc, 3cm X 3cm.
  - Digital : Gas + Stainless Steel.
    - Glass RPCs or Micro-megas//GEMs, 1cmX 1cm

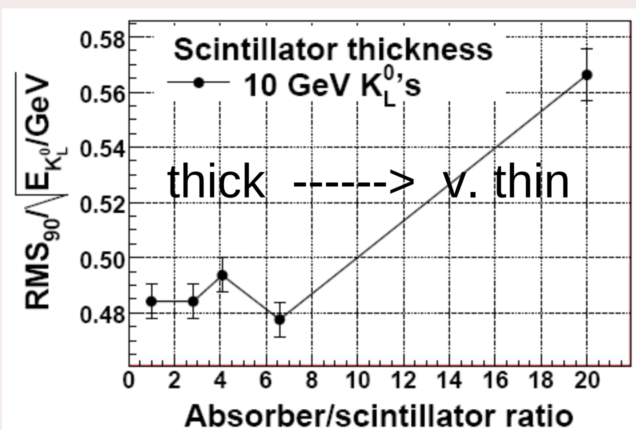
HCAL Optimization

Studies of neutral hadron and jet energy resolution as detector parameters are varied: scintillator thickness, sampling frequency, size of dead areas.

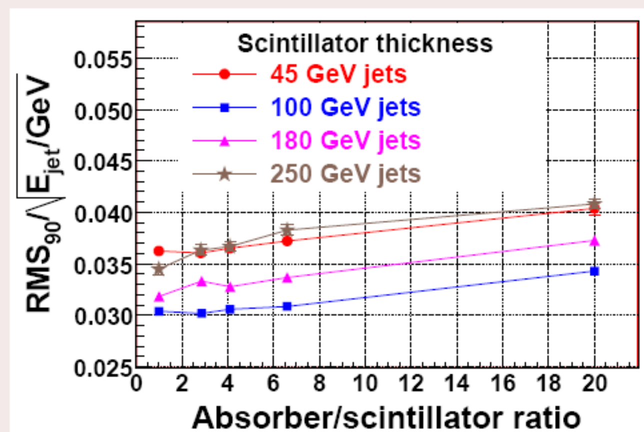
Scintillator Thickness with PFA

- Default configuration: 20 mm absorber + 5 mm scintillator i.e. $\mathrm{absorber/scintillator} = 4$
- Modify scintillator thickness (everything else unchanged)

For K_L^0's used for calibration:



For $Z \to u\bar{u},\ d\bar{d},\ s\bar{s}$:



- $Z \to u\bar{u},\ d\bar{d},\ s\bar{s}$: $\Longrightarrow$ Small differences ($< 5\%$) in jet energy resolution for $\mathrm{absorber/scintillator} < 7$

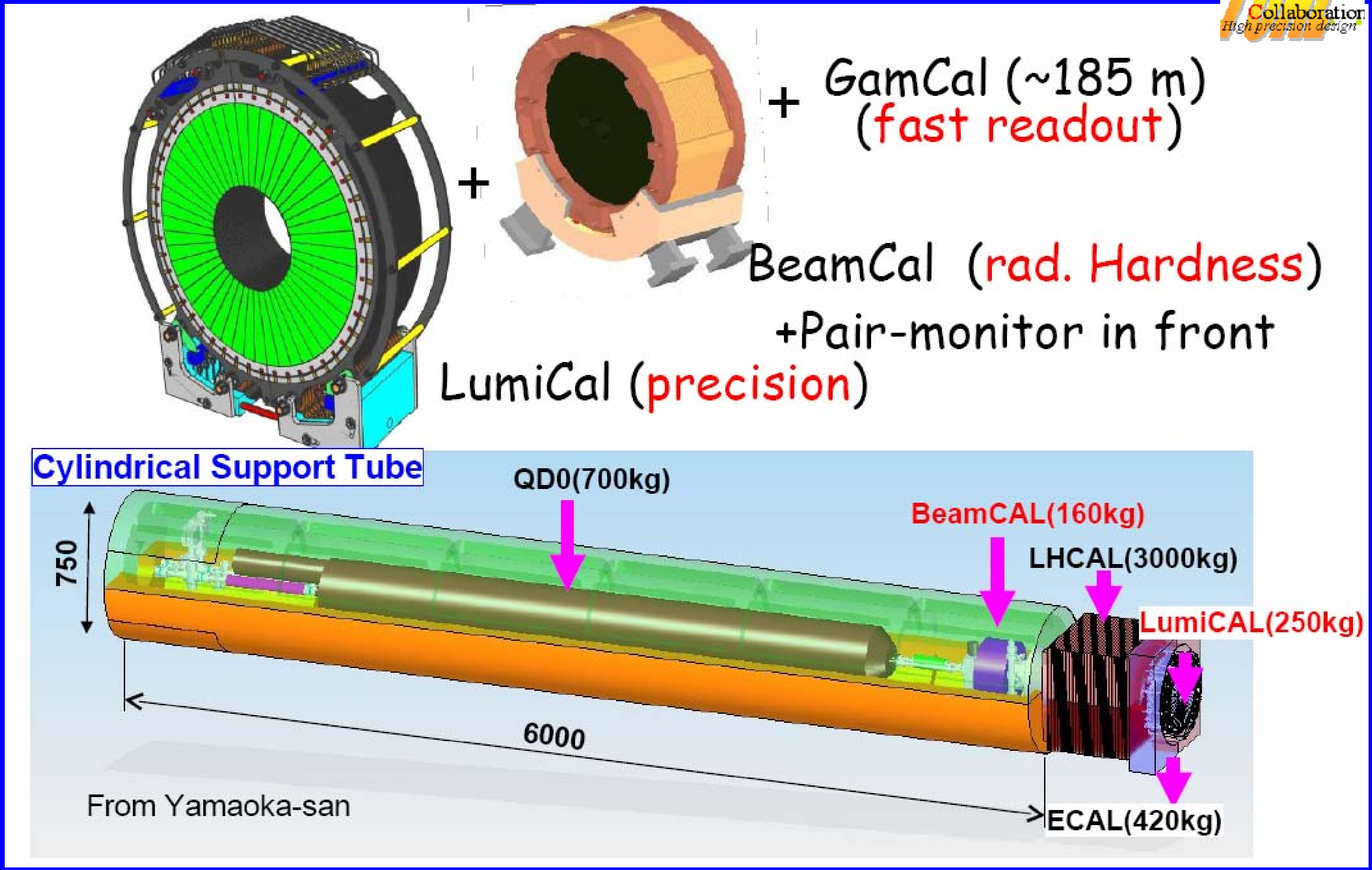
Similar studies by all sub-detectors are actively encouraged.

Can help focus detector R&D on pressing issues for the overall detector design.

Note: also need confidence in description of hadronic showers

Forward Region

Goals: Measure precision luminosity and provide hermeticity down to around 5 mrad. Accommodate 14 mrad crossing angle.



Particle Flow Algorithm (PFA) Performance

Updated performance numbers based on more realistic/buildable detector model.

Gaps, cracks etc.

Note: track reconstruction inefficiencies are included (no cheating)

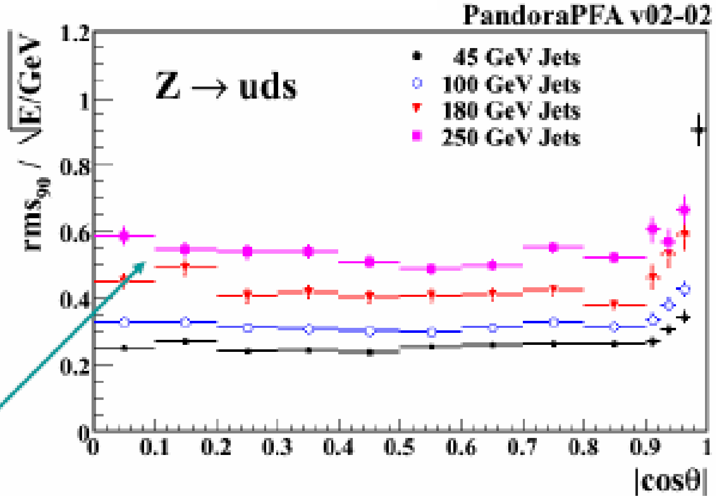
❶ PFA Performance

Studies in this talk start from:

- ★ Use standard Mokka LDCPrime model : LDCPrime_02Sc
- ★ OPAL tune of Pythia
- ★ Full reconstruction chain:
  - PandoraPFA v02-02 (essentially the released version)
  - FullLDCTracking

PandoraPFA v02-02

E_{JET}	$\sigma_E/E = \alpha/\sqrt{E_{jj}}$ $\lvert\cos\theta\rvert<0.7$	σ_E/E_j
45 GeV	24.9 %	3.7 %
100 GeV	30.7 %	3.1 %
180 GeV	43.0 %	3.2 %
250 GeV	52.2 %	3.3 %



Leakage not completely negligible ?

See David Ward's talk tomorrow for more details

Starting to understand PFA (and how to improve it further)

Measure performance using various amounts of MC truth information

Algorithm	σ_E/E			
	45 GeV	100 GeV	180 GeV	250 GeV
PandoraPFA	3.7 %	3.1 %	3.2 %	3.3 %
+CheatedTracks	3.6 %	3.0 %	3.1 %	3.2 %
+CheatedPhotons	3.6 %	2.8 %	2.7 %	2.7 %
+CheatedNeutralHs	3.4 %	2.4 %	2.1 %	2.0 %
+PerfectFragRem	3.2 %	2.3 %	2.1 %	2.0 %
PerfectPFA	3.1 %	2.1 %	1.7 %	1.6 %

Estimate contribution from each source

Contribution	σ_E/E			
	45 GeV	100 GeV	180 GeV	250 GeV
Calo. Resolution	3.1 %	2.1 %	1.5 %	1.3 %
Leakage	0.1 %	0.5 %	0.8 %	1.0 %
FullLDCTracking	0.7 %	0.7 %	1.0 %	0.7 %
Photons "missed"	0.4 %	1.2 %	1.4 %	1.8 %
Neutrals "missed"	1.0 %	1.6 %	1.7 %	1.8 %
Charged Frags.	1.2 %	0.7 %	0.4 %	0.0 %
"Other"	0.8 %	0.8 %	1.2 %	1.2 %

Comments:

- ★ For 45 GeV jets, jet energy resolution dominated by ECAL/HCAL resolution
  - ▪ don't expect much dependence of σ_E/E on B, R etc.
- ★ Track reco. not a large contribution (FullLDCTracking ≈ CheatedTracking)
- ★ "Satellite" neutral fragments not a large contribution
  - ▪ efficiently identified and removed by normal FragmentRemoval alg.
- ★ Leakage only becomes significant for high energies (more on this later)
- ★ Missed neutral hadrons dominant confusion effect
- ★ Missed photons, important at higher energies (somewhat surprising !)

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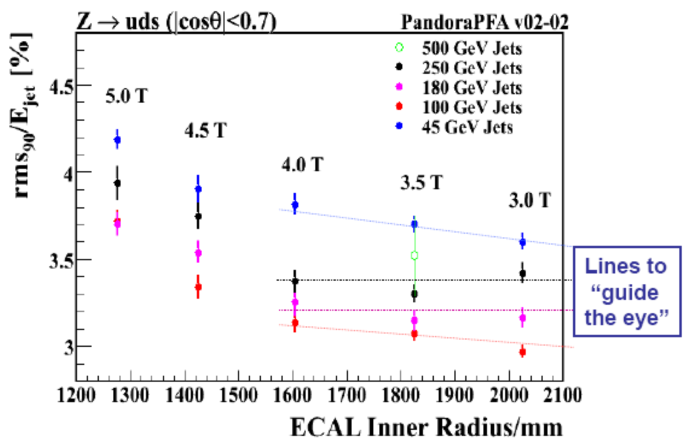
For more details, see Mark's talk at the Cambridge meeting

Compare Global Detector Designs with 2 implementations

LDC vs LDCPrime vs LDC4GLD

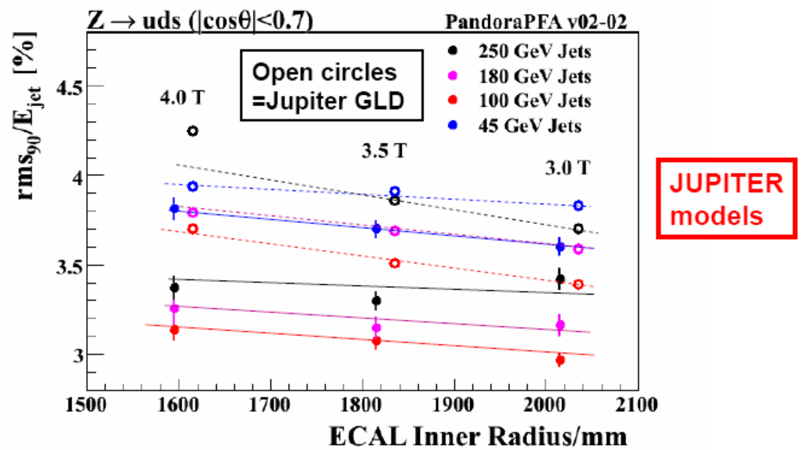
★ Direct Comparison of LDC, LDCPrime and GLD



★ In terms of jet energy resolution: LDC ≈ LDCPrime ≈ "LDC4GLD"

GLD vs GLDPrime vs J4LDC

★ Can compare with similar J4LDC, GLDPrime, GLD studies (Taikan Suehara)



★ In terms of jet energy resolution: GLDPrime ≈ "GLD"
: J4LDC worse but thin HCAL

Fairly modest differences among these models which are between LDC and GLD.

PFA Bottom-Line

(with current understanding, algorithm and simulation)

B vs. R Interpretation

★ All results shown are fairly well described by (best fit) $\chi^2/\mathrm{dof} = 48/52$

$$\frac{\sigma_E}{E} = \frac{0.21}{\sqrt{E}} \oplus 0.01 \oplus 0.02 \left(\frac{R}{1825}\right)^{-1.0} \left(\frac{B}{3.5}\right)^{-0.35} \left(\frac{E}{100}\right)^{+0.4}$$

Resolution | Tracking/Leakage/Fragments | Confusion

★ R is more important than B

★ Use parameterisation for comparison of LDC, LDCPrime, LDC4GLD

Relative to LDCPrime	Confusion	Relative σ_E/E vs E_{JET}/GeV			
		45	100	180	250
LDC	1.06	1.02	1.03	1.05	1.06
LDCPrime	1.00	1.00	1.00	1.00	1.00
LDC4GLD	0.95	0.99	0.98	0.97	0.96

- LDC4GLD slightly (< 4 %) better than LDCPrime
- But LDC, LDCPrime, LDC4GLD differences are small

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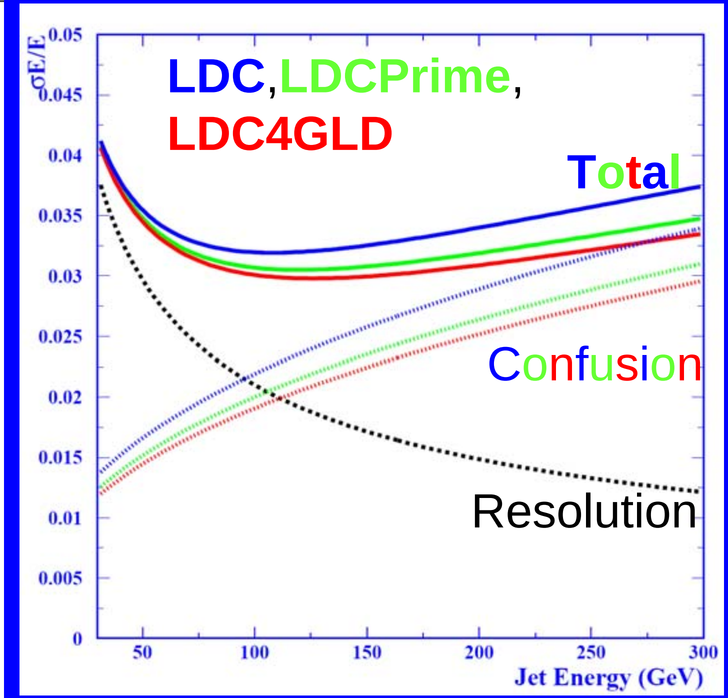
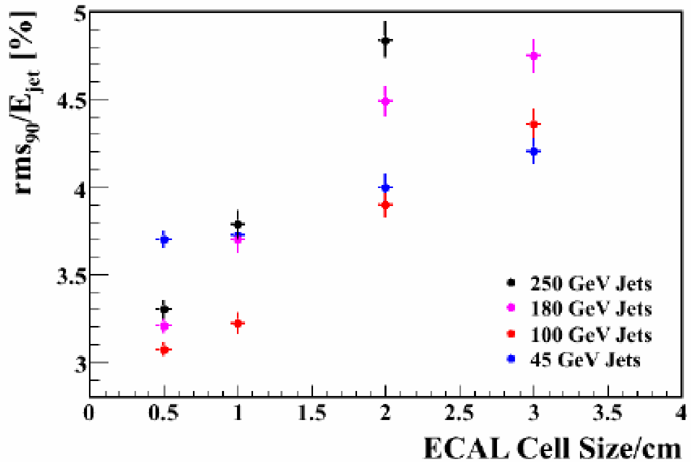


R is more important than B

ECAL Granularity

Optimisation: ⑤ ECAL Segmentation

- ★ Start from LDCPrime with 5×5 mm² SiW ECAL pixel size
- ★ Investigate 10×10mm², 20×20mm² and 30×30mm²
  - Note: required changes in PandoraPFA clustering parameters



- ★ Performance is a strong function of pixel size
- ★ Probably rules out segmentation of >10×10mm² !!!!

⚠ Is latest version of PandoraPFA optimal for larger pixels ?
- no obvious problems seen yet…

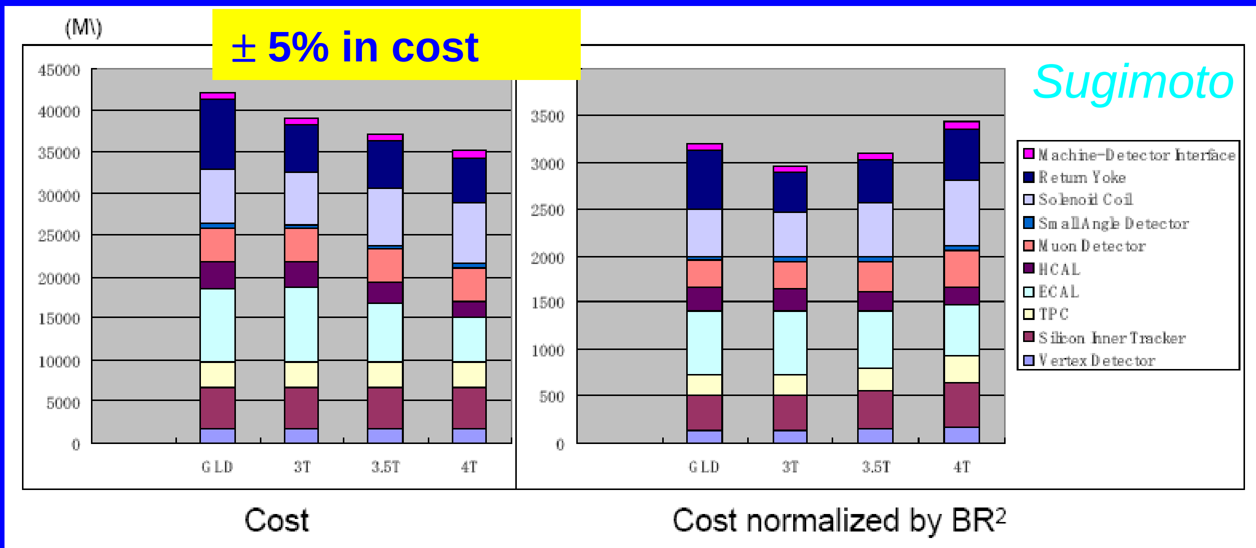
ILD Workshop, 11/9/2008 Mark Thomson 18

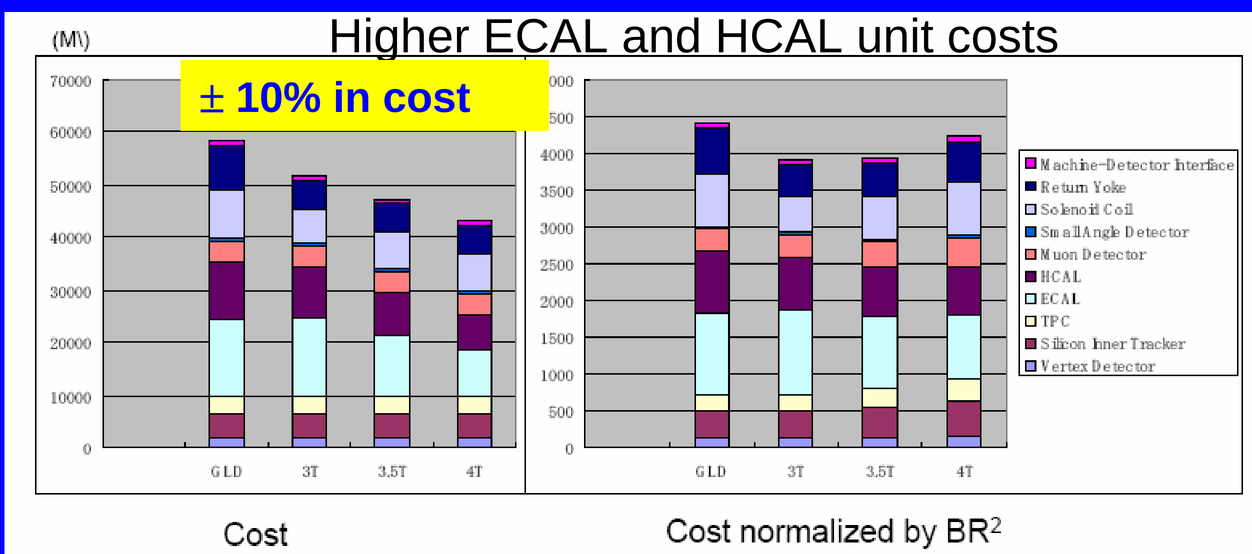
ECAL segmentation appears to be rather important

Needs further study and clarification

Cost

GLD Cost Model





LDC cost model gives ± 15% wrt LDC' (R scaling only).

Conclusion: higher performance costs more.

Uncertainties in unit costs and actual detector technologies
=> inappropriate to over-emphasize cost now.

Let's emphasize understanding how to make the detector better, and how this impacts the physics capabilities

Status/Plans for Benchmark Studies

10:05	[21] Tau analysis	Dr. SUEHARA, Taikan
10:30	[45] A study of the sensitivity of the ILC to the neutralino2 in the di-muon final state.	Mr. D'ASCENZO, Nicola

Physics based optimisation/benchmarking II - Queen's building lecture theatre (11:15-13:00)

time	[id] title	presenter
11:15	[30] ZH Recoil Mass	ITO, Kazutoshi
11:35	[34] Higgs Branching Ratio from ZH -> Hll	GRIMES, Mark
12:00	[38] ZH --> qqbb study with neural network	Dr. YAN, Wenbiao
12:25	[41] Sensitivity to the Higgs self-coupling with full simulation	Mr. GIANNELLI, Michele

Physics based optimisation/benchmarking III - Queen's building lecture theatre (14:15-16:00)

time	[id] title	presenter
14:15	[36] SUSY Analysis	Dr. SUEHARA, Taikan
14:35	[37] Chargino/Neutalino fully hadronic analysis	Dr. KAEFER, Daniela
14:55	[39] WW scattering at 1000GeV	Dr. YAN, Wenbiao
15:15	[35] ttbar 500GeV benchmarking	Dr. IKEMATSU, Katsumasa
15:40	[40] Top pair production at the ILC	Mr. MOLL, Andreas

Towards ILD - Queen's building lecture theatre (16:30-18:30)

time	[id] title	presenter
16:30	[42] Summary of Physics based detector optimisation studies	Dr. TAKUBO, Yosuke

Many talks at Cambridge studying physics performance with fully simulated samples of signal and background with the LDC and GLD based samples.

- ZH-jet : Yoshida, Wenbiao
  - $Br(H \rightarrow cc)$ (@ 250GeV)
- Top analysis : Katsumasa, Andreas
  - σ, A_{FB}, ΔM_{top} (@ 500GeV)
- ZH-recoil mass : Li, Kazuto
  - $\Delta\sigma(ZH)$, ΔM_H (@ 250GeV)
- SUSY-jet mode : Jenny, Taikan, Daniela
  - $\Delta\sigma(\chi^+\chi^-, \chi_2^0\chi_2^0)$, ΔM_χ (@ 500GeV)
- $Z^* \rightarrow \tau\tau$: Taikan
  - σ, A_{FB}, $Pol(\tau)$ (@ 500GeV)

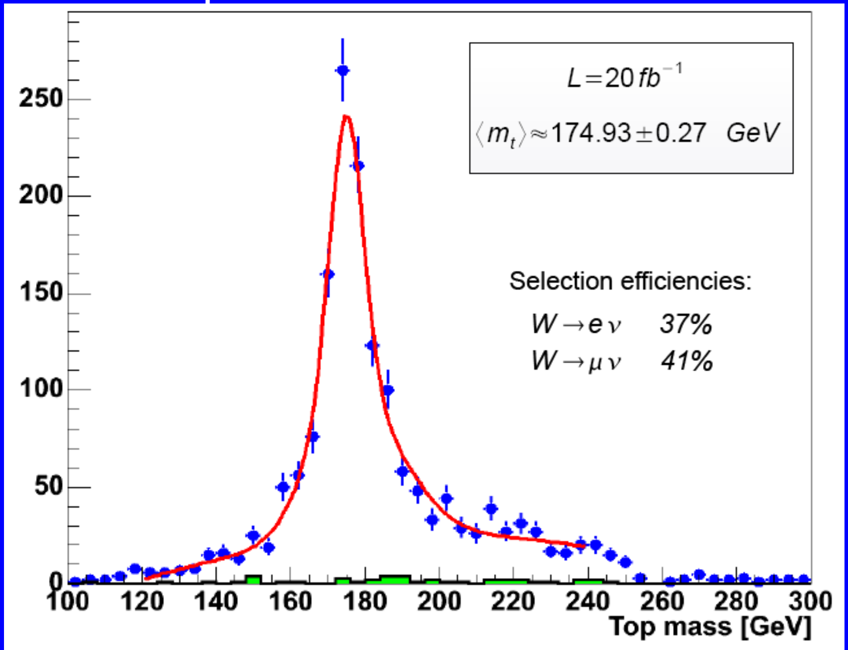
Benchmark processes are under study with people assigned and reporting progress.
We also expect several results in addition to the benchmarks.

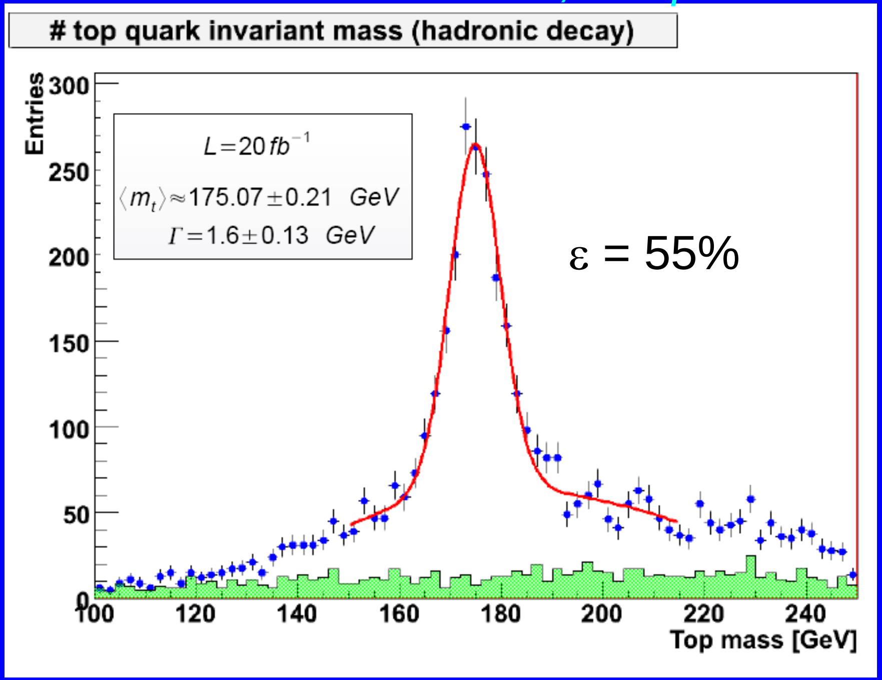
Benchmark 5: top-pair production

√s = 500 GeV. Full simulation, LDC' detector model

Moll, Raspereza

semi-leptonic channel





ε = 55%

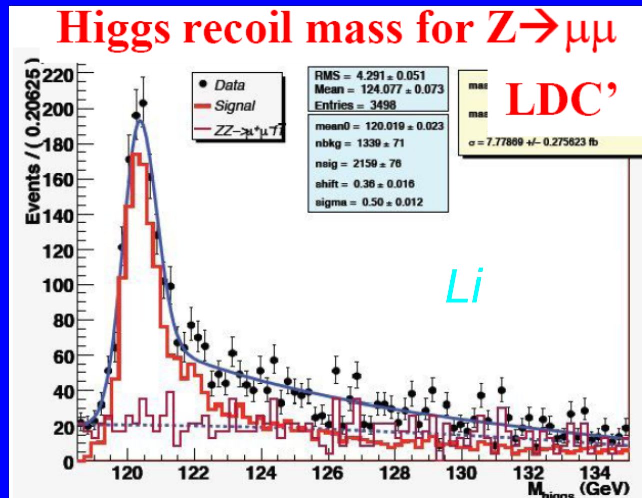
Analysis uses Pandora PFA, b-tagging (LCFI), and kinematic fit.

Result: statistical error of 32 MeV for 500 fb^{-1}

(Factor of 2.5 improvement in sensitivity over hadronic-only study of PRD 67, 074011 (2003).

Benchmark 1 (ZH →ll X)

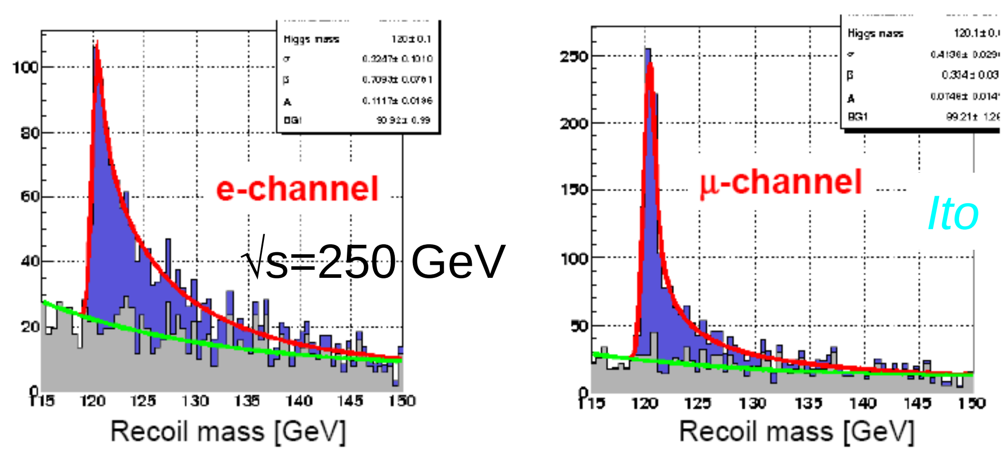
√s=250 GeV



	e^+e^-	$\mu^+\mu^-$	
ΔM_H (MeV)	66	33	(Scaled to 250 fb^{-1})

Improvements expected in the electron channel

- Background parameter is fixed except for normalization.



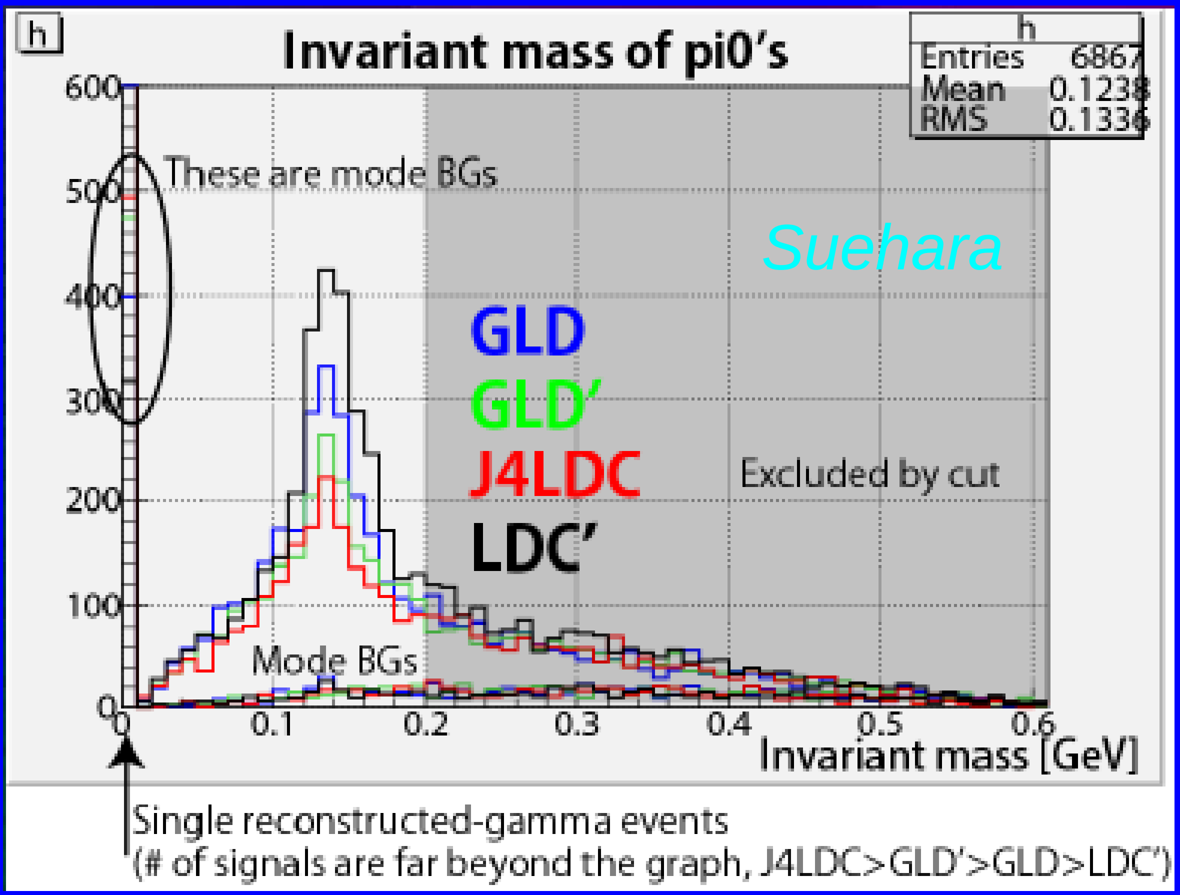
- Electron channel
  - Measurement accuracy for 250 fb^{-1}:
    - M_H = 120.0 +/- 0.10 GeV
    - σ(ZH) = 7.5+/- 0.35 fb
- Muon channel:
  - Measurement accuracy for 250 fb^{-1}:
    - M_H = 120.1 +/- 0.041 GeV
    - σ(ZH) = 7.7 +/- 0.29 fb

The electron channel is an excellent test of the ability to track electrons as they bremsstrahlung.

We need to put more emphasis on electron momentum meeasurement in the single particle studies when investigating the tracker/calorimeter tradeoffs.

Benchmark 4

$e^+ e^- \rightarrow \tau^+ \tau^-$ ($\sqrt{s}$= 500 GeV)



GLD > GLD' > J4LDC

(larger is better with same segmentation)

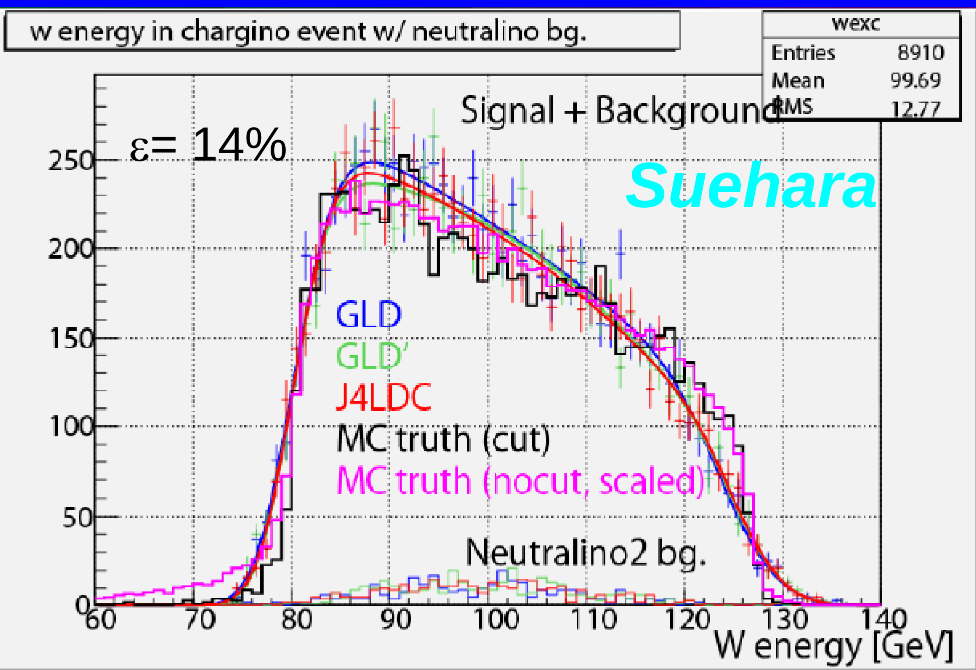
5 mm Si significantly better than 10 mm Scintillator for π^0s from 250 GeV taus

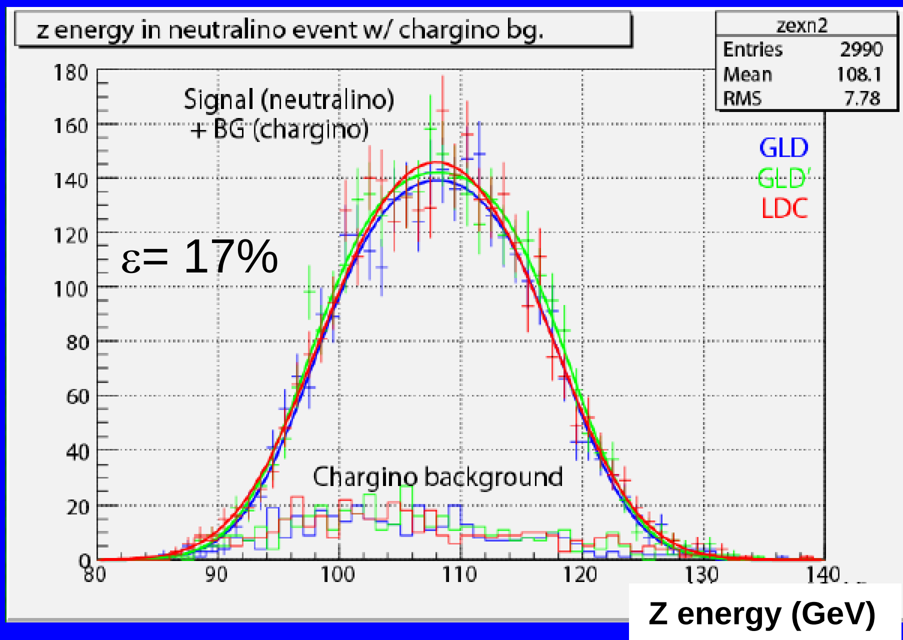
Benchmark 6

$C_1\ C_1 \rightarrow W^+\ W^-\ N_1\ N_1$ $N_2\ N_2 \rightarrow Z\ Z\ N_1\ N_1$

Masses (GeV): C1(210), N2(211), N1(117)

Here consider all-hadronic decay modes at √s=500 GeV





WW/ZZ separation rather good.

Room for improvement in efficiency?

Also analysis in progress by Kaefer making extensive use of kinematic fits. See talk at LCWS08 (Wed 11.15 AM)

Decisions

- Based on the studies presented at Cambridge, we came to a consensus to move forward with a detector with B= 3.5 T (nominal) and R_{ECAL}= 1.85 m.
- Arguments for Larger
  - PFA
  - high p_T muon momentum resolution
  - π^0 reconstruction (τ)
- Arguments for Smaller
  - Impact parameter at low p_T
  - Cost
  - Background Sensitivity of VTX (needs more study)

Reference Detector/Technologies/Options

- Reference Detector model chosen. Dimensions and segmentation are specified to serve as a basis for the performance studies to be presented in the LoI.
  - We have specified a reference detector for the simulations needed for the performance and physics studies.
  - There are several technologies with the potential to achieve the specified performances, so **no decisions on technology have been made at this point.**
- VTX: 3-double layer, 5-layer
- TPC Geometry: Cylindrical, Rounded Polygon
- Si-tracking: Include SET&ETD
- ECAL: Silicon, Scintillator, MAPS
- HCAL: Analog (Scintillator), Digital (Gas)
- CAL Geometry : Octagon, Dodecagon
- Yoke Instrumentation: Coarse Tail-Catcher
- LCAL: Si-W
  - Underlined options are those chosen for the simulation model for the mass production
    - Also reflects maturity of associated simulation model / reconstruction.
  - **We plan on including all of the options listed in the LoI.**

Plans for Benchmark Studies

- First round of partial benchmark studies done.
  - Powerful software framework and dedicated analyzers already getting impressive results with full simulation and reconstruction N years before beam.
  - Sometimes some insights on detector optimization
- We have recently frozen the updated ILD00 simulation model in Mokka.
  - Main substantive differences are:
    - 3 doublet-layer VXD model
    - Instrumented LHCAL
    - Dodecagonal yoke
    - Tighter correspondence with CAD model
- Starting mass generation of simulated samples with ILD00 on the GRID.
- Updated reconstruction will become the next focus.
  - Will need checking
- Starting to see benefits of working in a more unified way.
- We fully expect to have comprehensive results on the benchmark channels for the LoI.

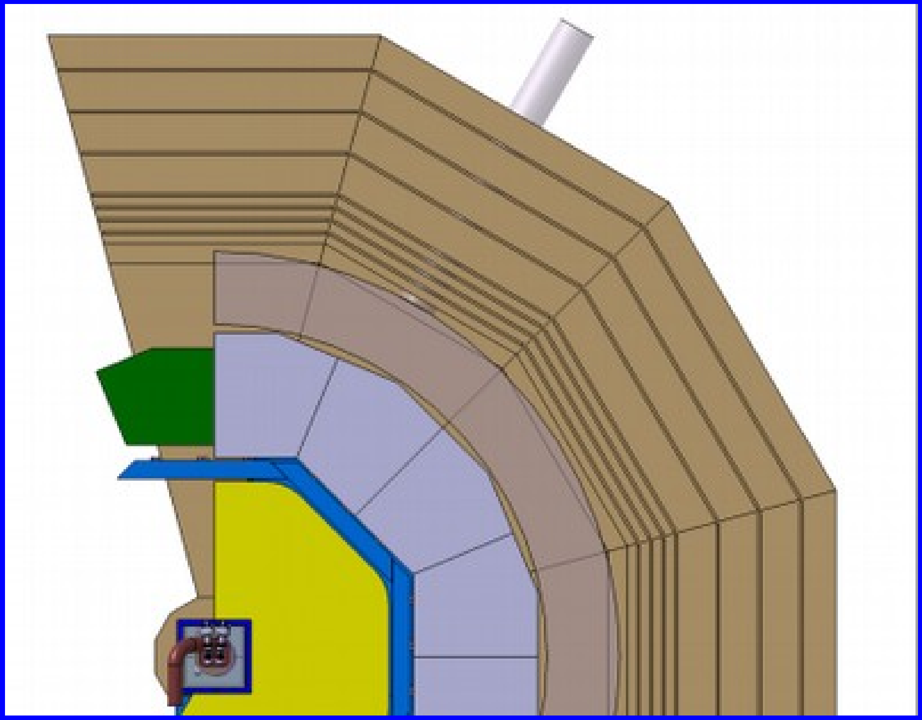
Designing a Detector with Margin

- Our primary concern at this stage is making sure the performance of the designed detector meets or exceeds those currently envisaged for the physics
  - Design philosophy is cost-conscious and physics optimized, not cost optimized
- We have chosen to keep a solenoid engineered for 4T capability with a nominal field of 3.5T
- We have chosen to increase the depth of the HCAL (6.8 λ_I incl. ECAL)
  - More margin for higher energy jets / higher $\sqrt{s}$
- We have chosen an ECAL cell size of 5mm X 5mm.
- We are studying the merits of the additional tracking sub-detectors
  - Increased precision, redundancy, more material

MDI / Detector Integration

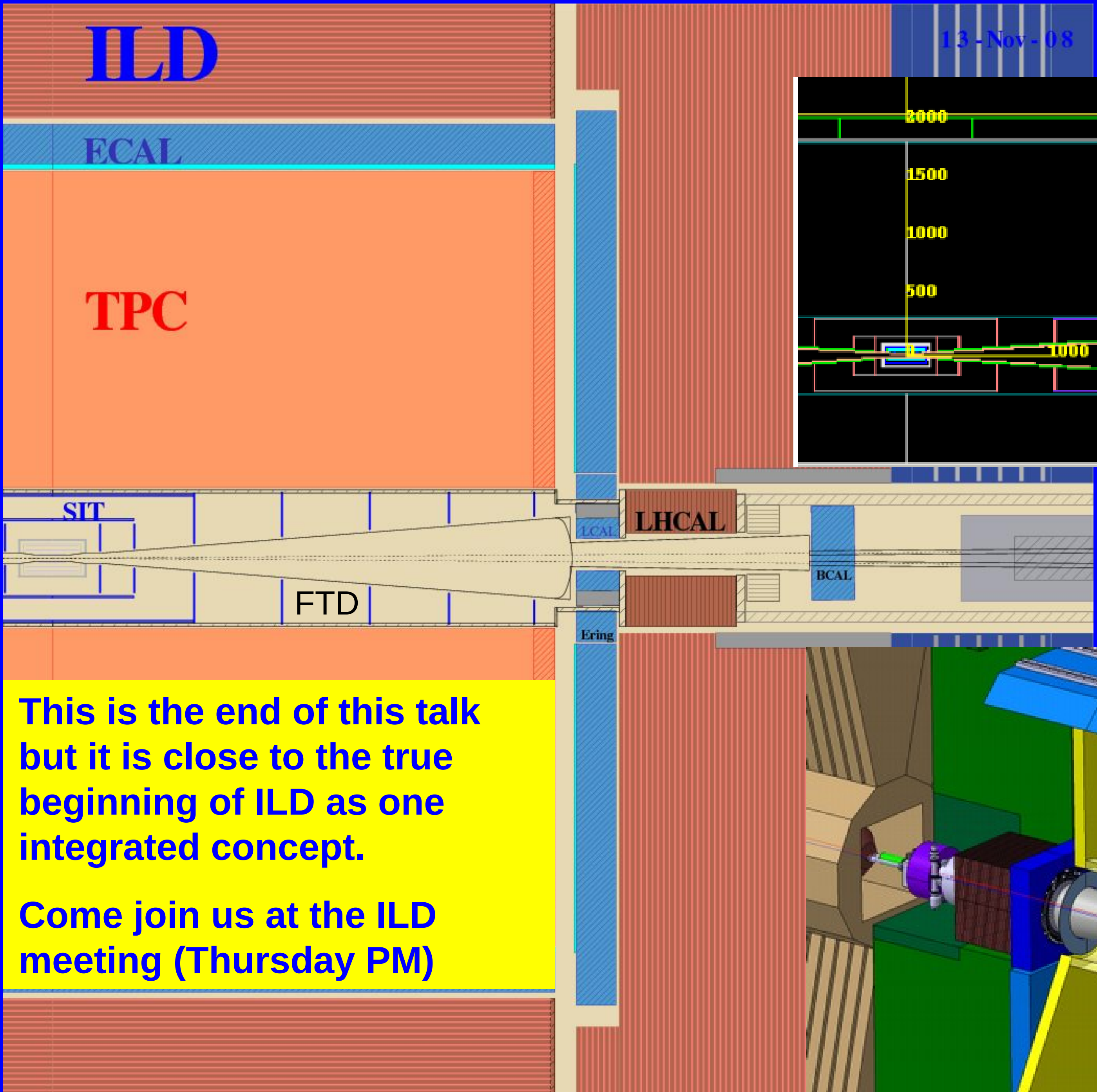
- Real-world engineering and design issues are investigated
  - Detector assembly and maintenance
  - Push-pull
  - Backgrounds
  - Alignment, power, cooling, cables
  - Etc/etc
- So far no show stoppers
- Will need extensive engineering support as we move forward

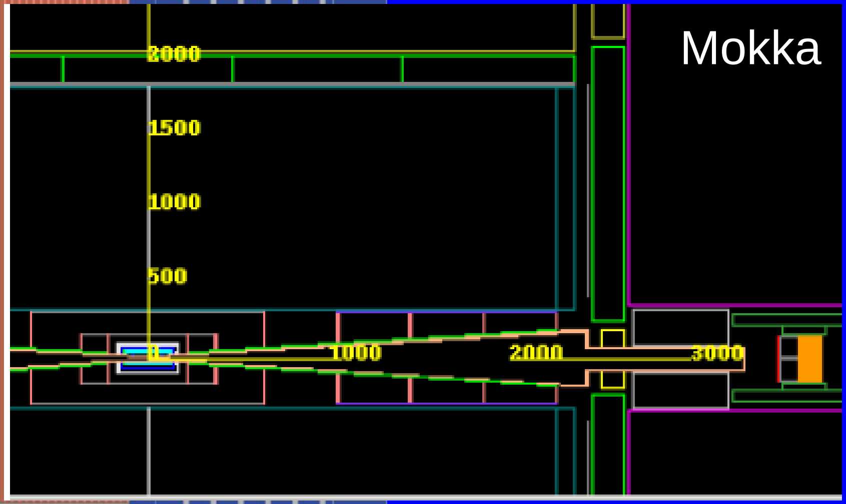
Joré

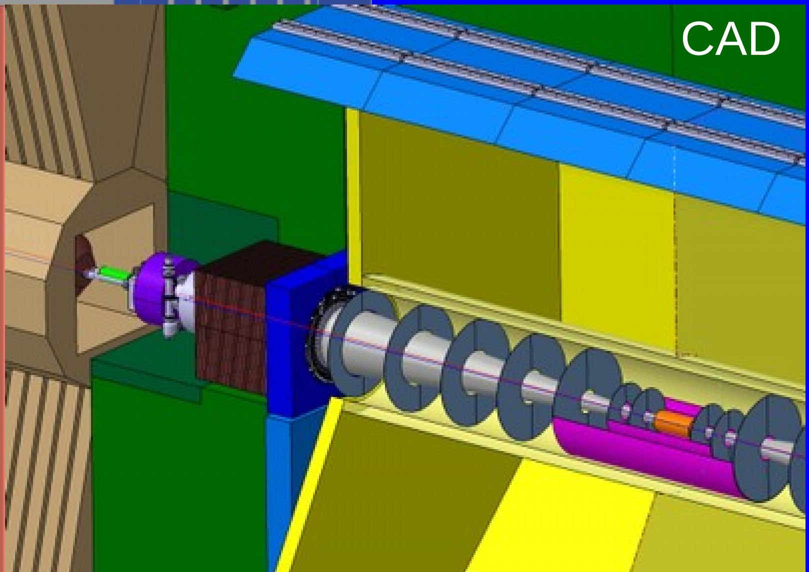


Status / Plans for Component R&D

- ILD has close ties to the on-going R&D work in the "horizontal" R&D collaborations: LCTPC, SILC, CALICE, LCFI and FCAL
- Most of the R&D is done by the R&D collaborations
- ILD does not at this point have its own R&D program
- With funding problems, it is difficult for people to participate as fully as they would like in both
  - Detector R&D
  - Detector Concept Development
- We should re-visit this question once the LOI is submitted. We expect that the detector optimization process will lead to a better appreciation of the most relevant detector R&D issues.



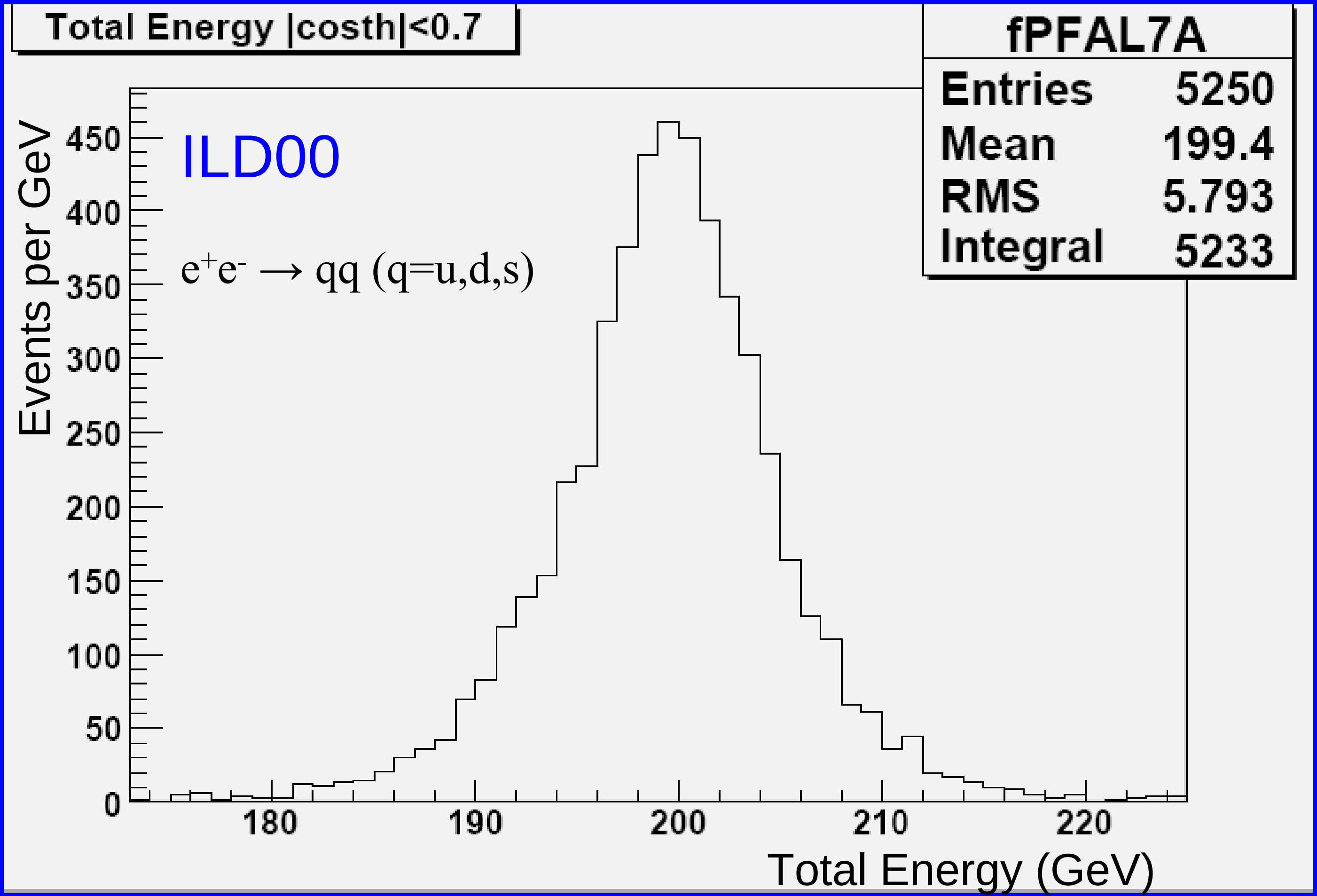




This is the end of this talk but it is close to the true beginning of ILD as one integrated concept.

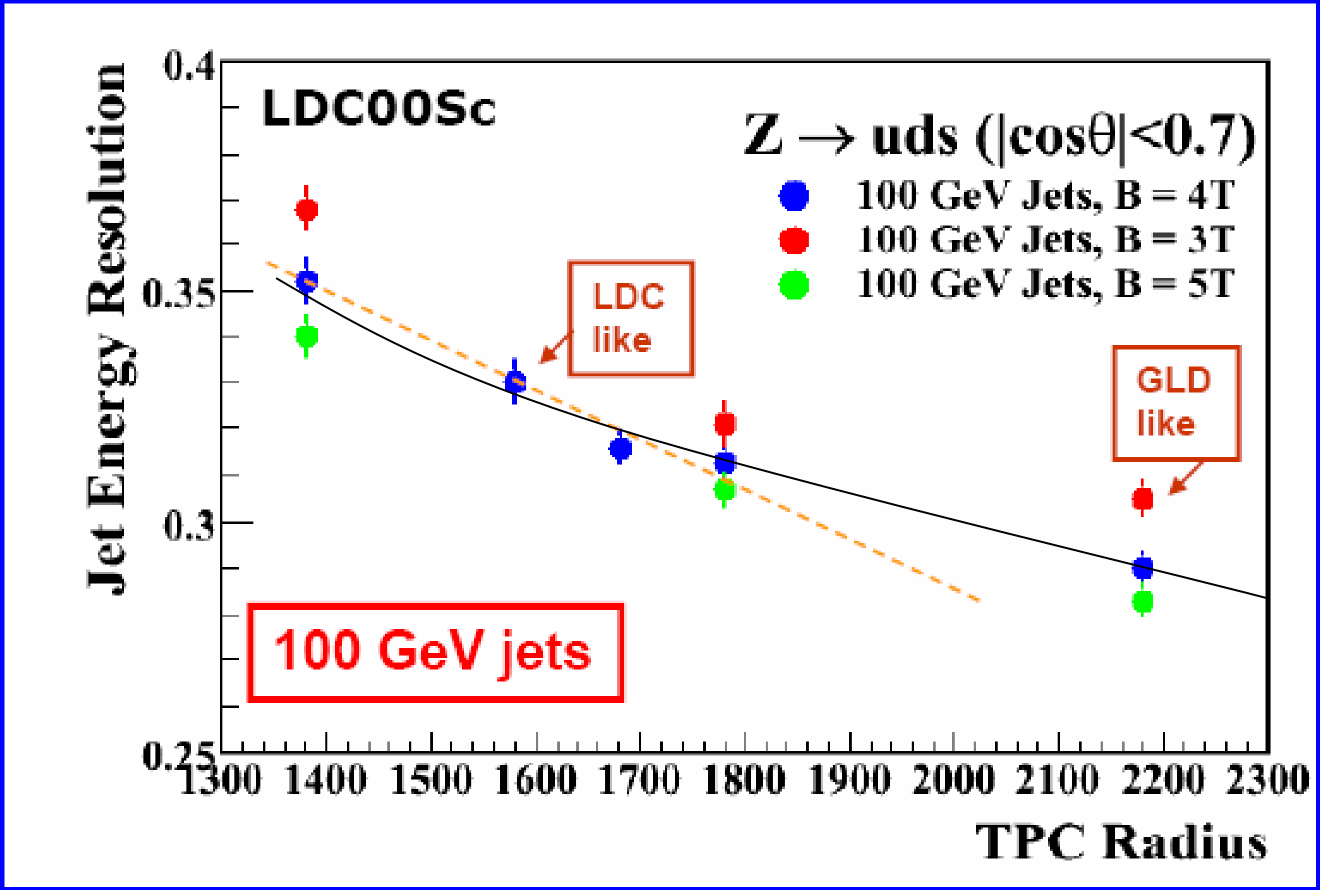
Come join us at the ILD meeting (Thursday PM)

Backup Slides



rms_{90} : $(29.2 \pm 0.4\%) / \sqrt{E_{jet}}$ (GeV)

Particle-flow → Detector directions ?

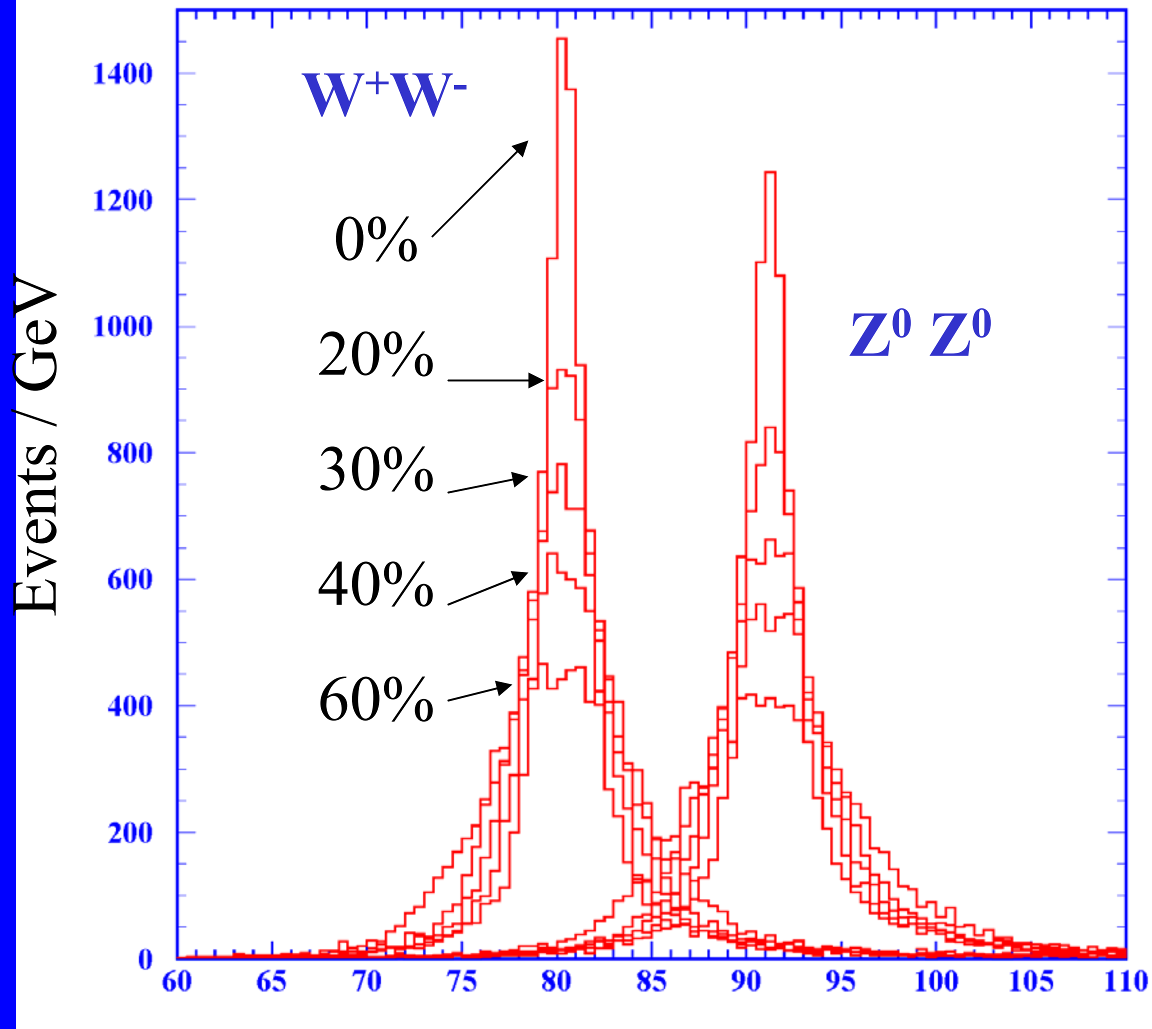


Higher R much more valuable than high B.

Presumably the decreasing slope implies that intrinsic resolution not confusion starts to dominate at high R.

(The ultimate PFA would potentially have very little dependence on B, R)

Di-jet mass distribution vs E_{jet} resolution



No kinematic fits, just direct measurement

Comparing $e^+e^- \rightarrow WW$ and

$e^+e^- \rightarrow ZZ$ at $\sqrt{s}$=300 GeV

(hadronic decays only, assume WW:ZZ = 1:1 for illustration, and assuming perfect assignment of particles to bosons)

Reality = 7:1 !

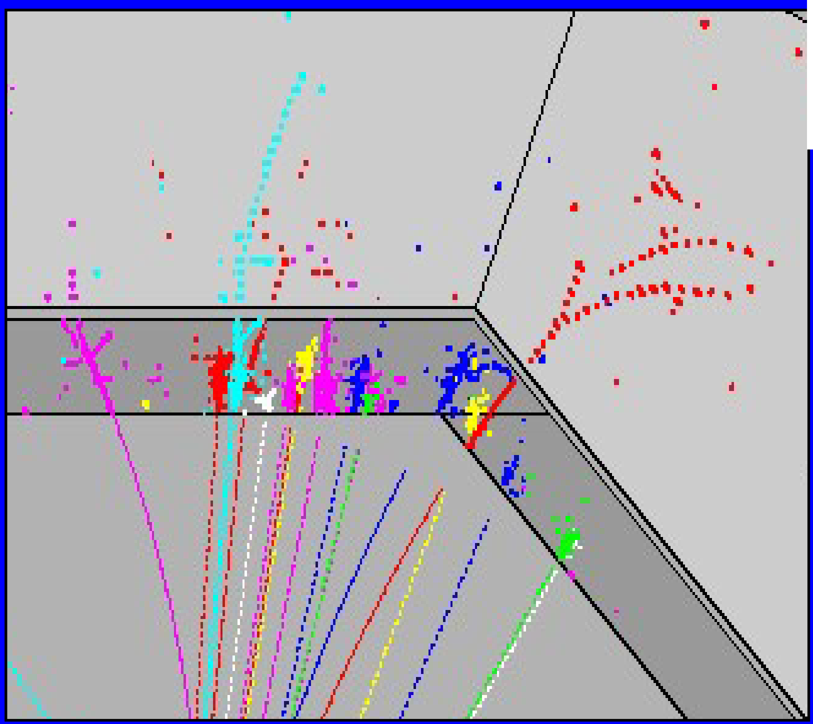
$\sigma(E_{jet})$ = xx%$\sqrt{E_{jet}}$(GeV)

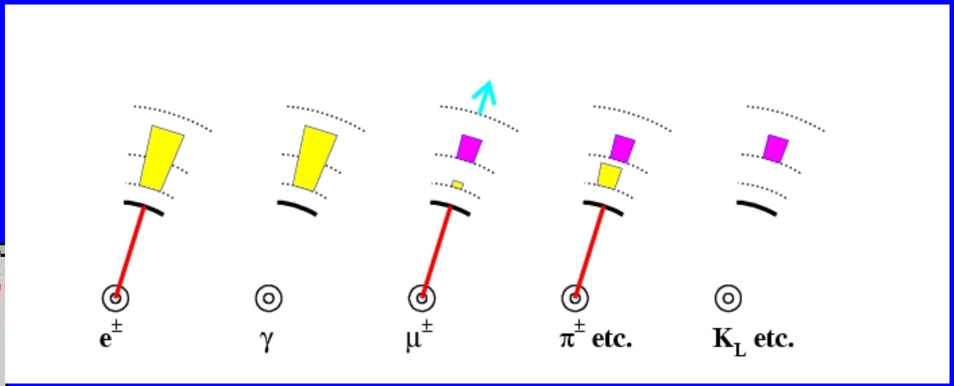
30%$\sqrt{E_{jet}}$ is a good target for 75 GeV jets. Physics (Γ_w=2 GeV) may demand even more !

What is particle flow ?

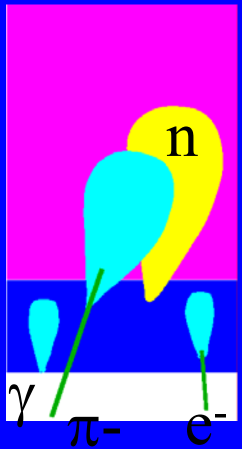
See Henri Videau's talk at Paris LCWS for a thorough introduction

Particle-by-particle event reconstruction





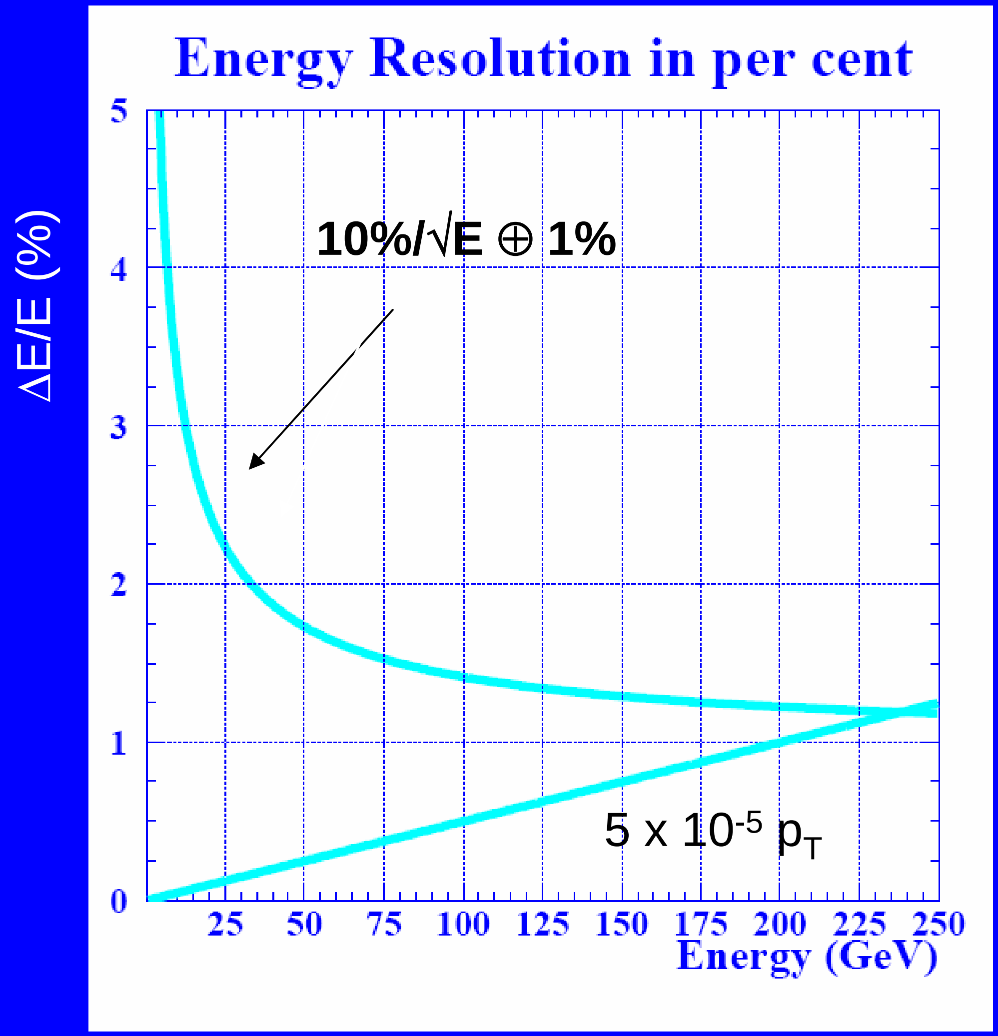
T E T T H



HCAL

ECAL

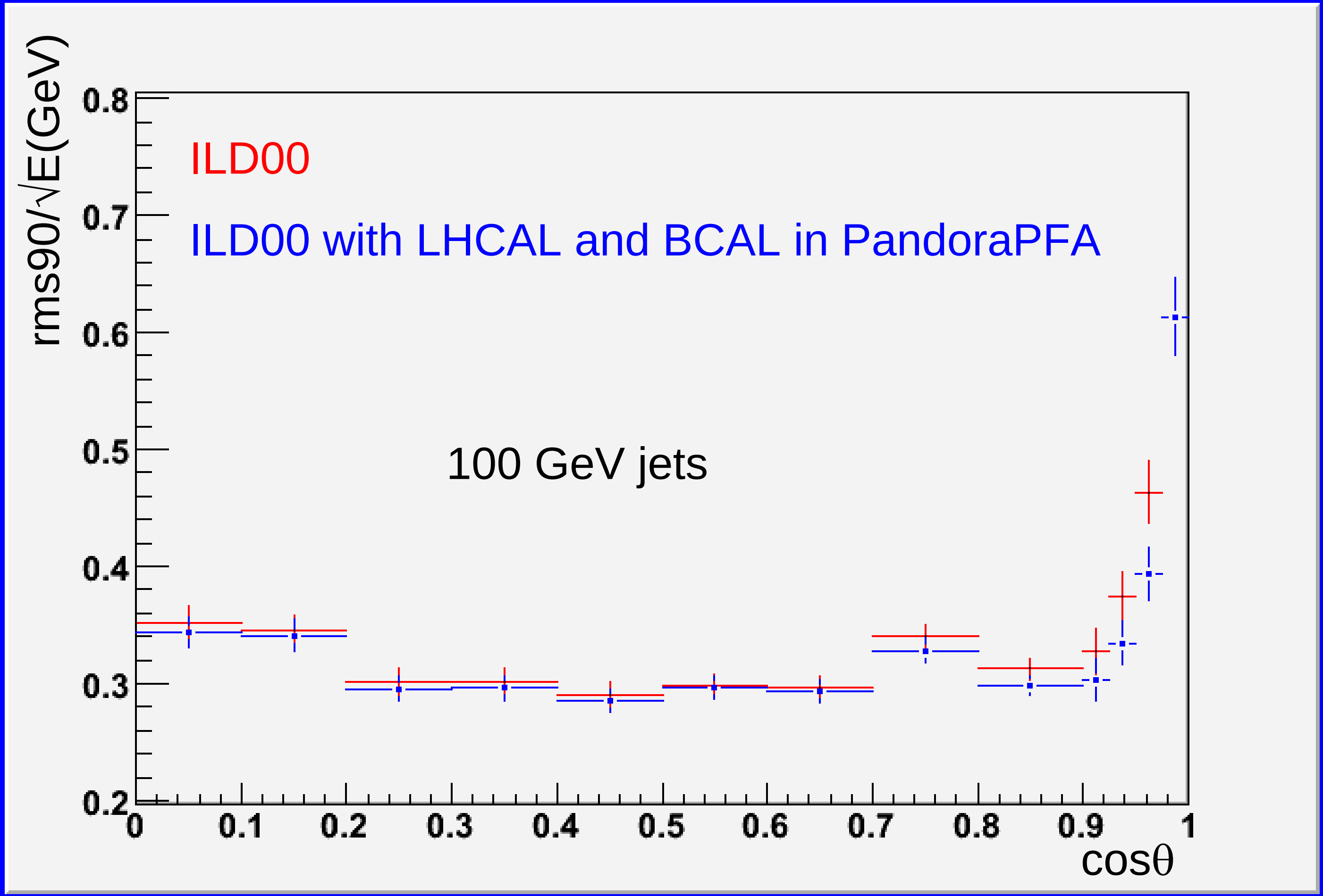
Comparison of tracker momentum resolution with ECAL energy resolution vs Energy



Even for electrons, the tracker should do better than the calorimetry …… (modulo bremsstrahlung ….)

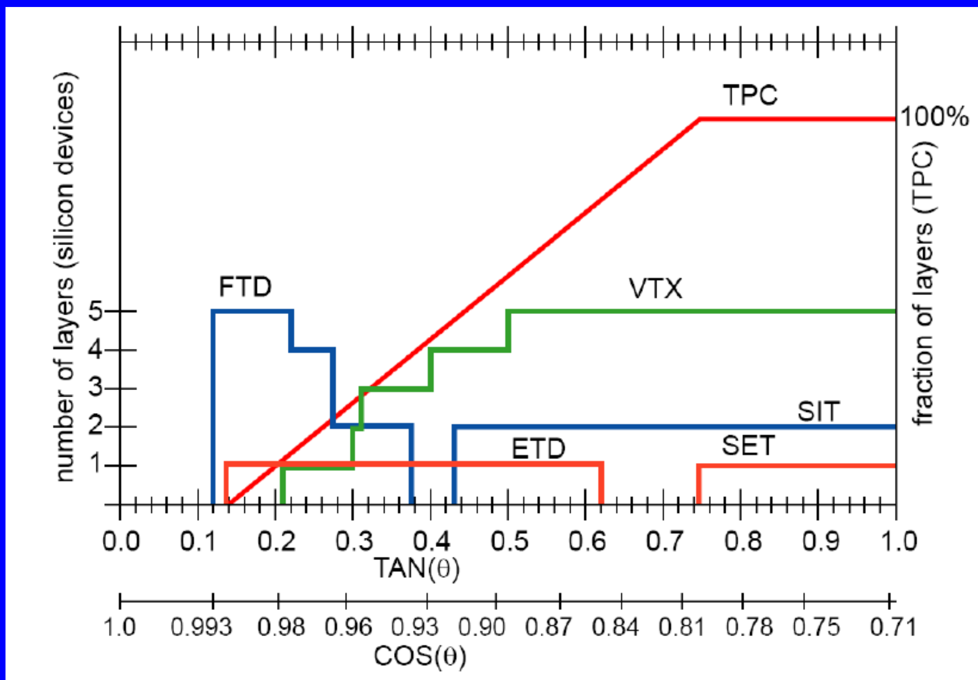
For charged pions, it is even clearer that intrinsic calorimeter charged pion resolution is not the issue IF we have a highly efficient tracker and can identify which energy depositions in the calorimeters are caused by charged pions.

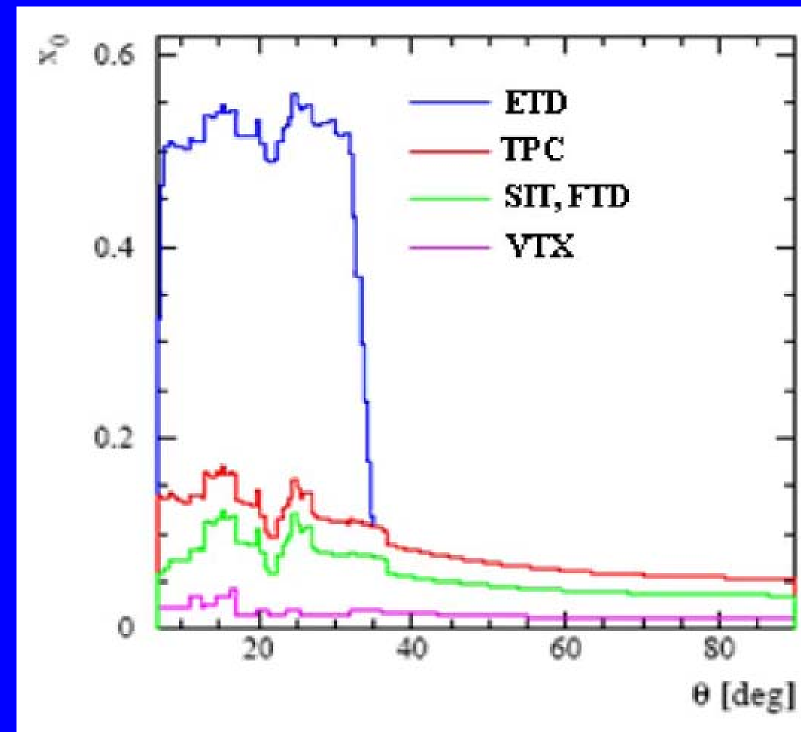
What is the LHCAL good for ?



Marked improvement in homogeneity at forward angles

Tracking: Acceptance + Material

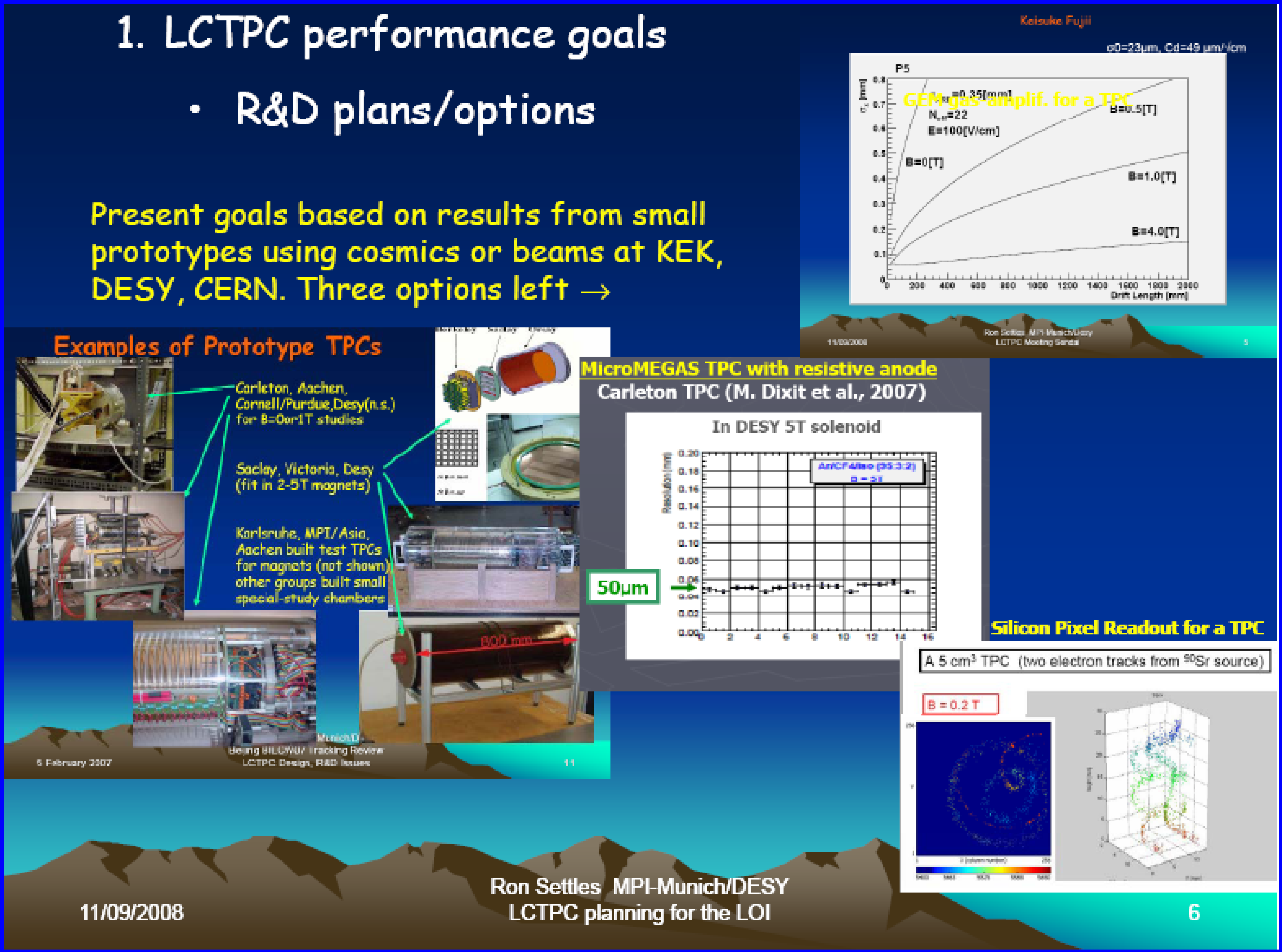




Forward tracking disks should ensure good quality track reconstruction to the edge of the TPC acceptance.

(ETD material only an issue for track-cal matching).

Does the VTX have enough layers if it is also needed for reconstruction of soft tracks ?



1. LCTPC performance goals
• R&D plans/options
Present goals based on results from small prototypes using cosmics or beams at KEK, DESY, CERN. Three options left →
Keisuke Fujii
GEM gas-amplif. for a TPC
B=0[T]
B=0.5[T]
B=1.0[T]
B=4.0[T]
E=100[V/cm]
Drift Length [mm]
Examples of Prototype TPCs
Carleton, Aachen, Cornell/Purdue,Desy(n.s.) for B=0or1T studies
Saclay, Victoria, Desy (fit in 2-5T magnets)
Karlsruhe, MPI/Asia, Aachen built test TPCs for magnets (not shown), other groups built small special-study chambers
800 mm
5 February 2007
LCTPC Design, R&D Issues
MicroMEGAS TPC with resistive anode
Carleton TPC (M. Dixit et al., 2007)
In DESY 5T solenoid
50μm
Silicon Pixel Readout for a TPC
A 5 cm³ TPC (two electron tracks from ⁹⁰Sr source)
B = 0.2 T
11/09/2008
Ron Settles MPI-Munich/DESY
LCTPC planning for the LOI
6

cosθ dependence of muon curvature resolution