# The ILD Detector Concept
# The Situation in Europe

Ties Behnke, DESY

JSPS Tokusui Workshop
17.12.2013

# The ILC Situation

Higgs discovery: The physics case is there

- See e.g. snowmass white paper
- But needs to be continually remade and restated.
- We need to convince our collegues and politics to support this

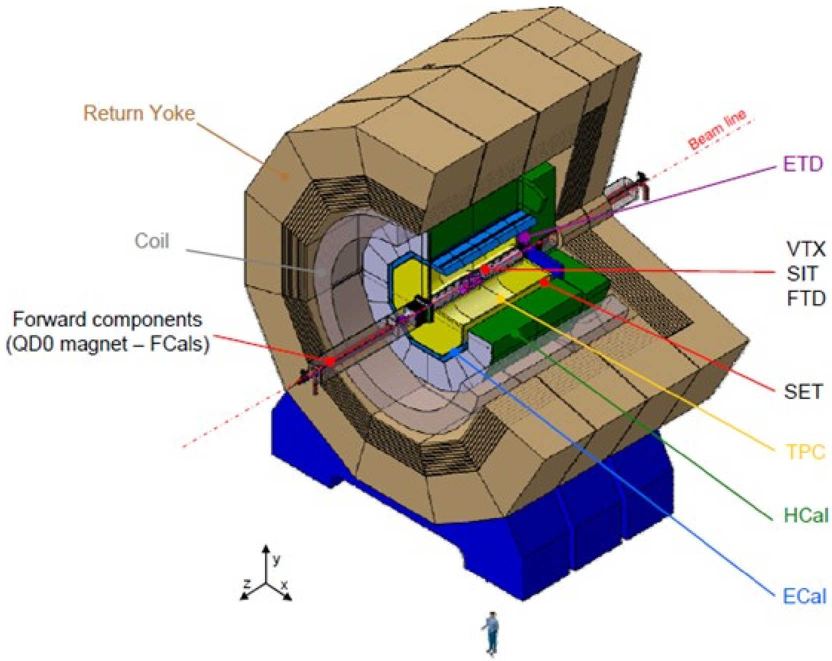
Europe: Strategy has been accepted, ILC in in

USA: Snowmass process was positive, P5 process has started, outcome will be crucial to the project

Asia/ Japan: you know better than me.

We (ILD, SiD) need to make a sound proposal for affordable detectors!

# The ILD Detector Concept




Multi purpose detector for linear collider physics

- ILC version
- CLIC version

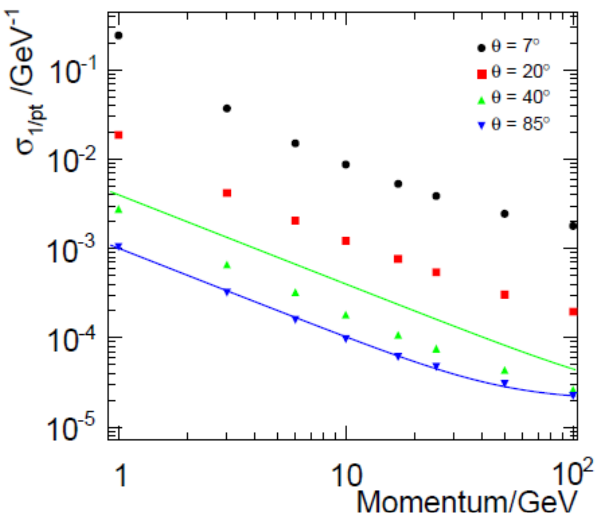
Particle flow as driving principle

- efficient, robust tracking
- High precision vertexing
- Particle flow calorimetry
- hermetic

ILD: international group,
strong participation from Asia and Europe
Current co-contacts: Yasuhiro Sugimoto, KEK, Ties Behnke, DESY

http://www.ilcild.org

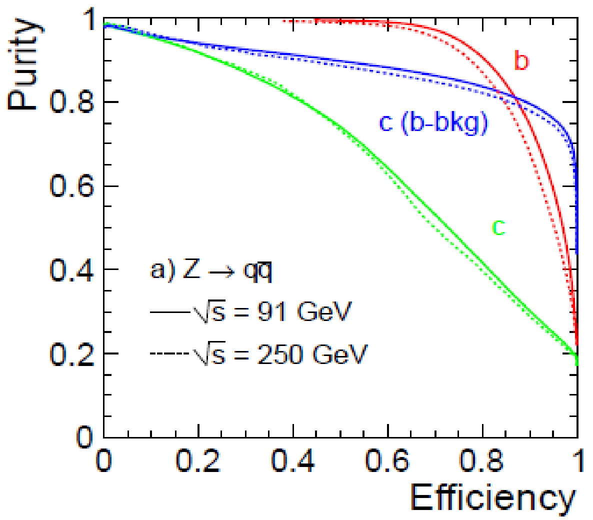
# Performance of ILD

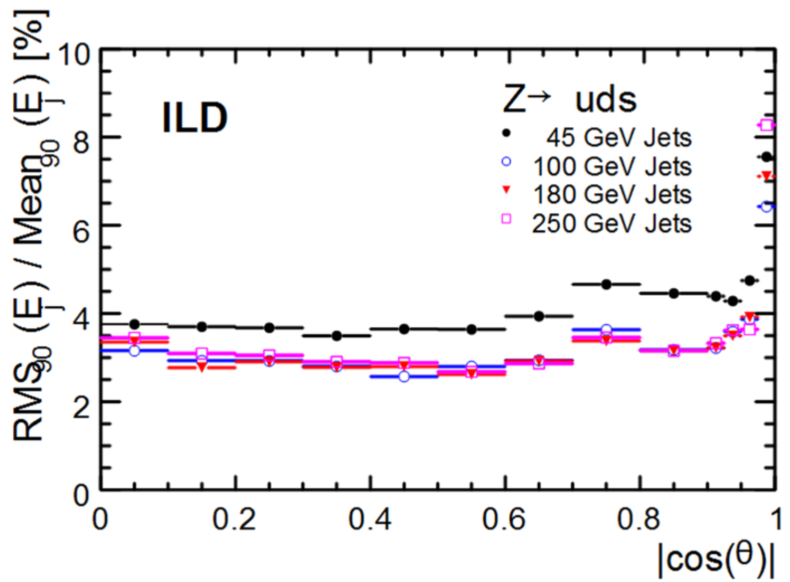



Performance goals are very ambitious:

Performance has been demonstrated

- Based on full and detailed simulation studies including backgrounds
- Based on realistic and – in many cases – prototype demonstrated performance and design

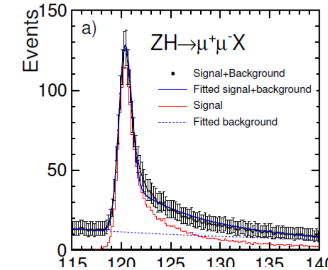


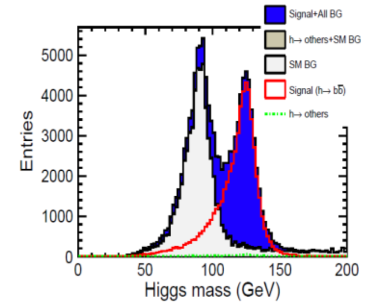



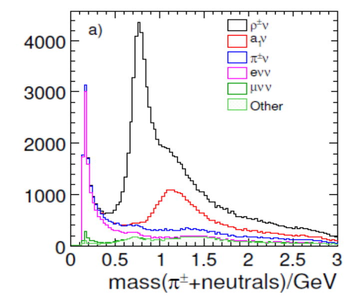
# Physics with ILD

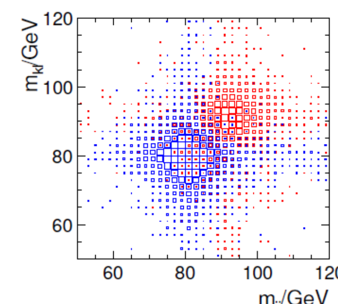
Comprehensive physics program has been worked out and quantified

| $\sqrt{s}$ | Observable | Precision | Comments |
|---|---|---|---|
| 250 GeV | $\sigma(e^+e^- \to Zh)$ | $\pm 0.30$ fb (2.5 %) | Model Independent |
| | $m_h$ | 32 MeV | Model Independent |
| | $m_h$ | 27 MeV | Model Dependent |
| 250 GeV | $Br(h \to b\bar{b})$ | 2.7 % | includes 2.5 % |
| | $Br(h \to c\bar{c})$ | 7.3 % | from |
| | $Br(h \to gg)$ | 8.9 % | $\sigma(e^+e^- \to Zh)$ |
| 500 GeV | $\sigma(e^+e^- \to \tau^+\tau^-)$ | 0.29 % | $\theta_{\tau^+\tau^-} > 178°$ |
| | $A_{FB}$ | $\pm 0.0025$ | $\theta_{\tau^+\tau^-} > 178°$ |
| | $P_\tau$ | $\pm 0.007$ | exclucing $\tau \to a_1\nu$ |
| 500 GeV | $\sigma(e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^-)$ | 0.6 % | |
| | $\sigma(e^+e^- \to \tilde{\chi}_2^0\tilde{\chi}_2^0)$ | 2.1 % | |
| | $m(\tilde{\chi}_1^\pm)$ | 2.4 GeV | from kin. edges |
| | $m(\tilde{\chi}_2^0)$ | 0.9 GeV | from kin. edges |
| | $m(\tilde{\chi}_1^0)$ | 0.8 GeV | from kin. edges |
| 500 GeV | $\sigma(e^+e^- \to t\bar{t})$ | 0.4 % | $(bq\bar{q})$ $(\bar{b}q\bar{q})$ only |
| | $m_t$ | 40 MeV | fully-hadronic only |
| | $m_t$ | 30 MeV | + semi-leptonic |
| | $\Gamma_t$ | 27 MeV | fully-hadronic only |
| | $\Gamma_t$ | 22 MeV | + semi-leptonic |
| | $A_{FB}^t$ | $\pm 0.0079$ | fully-hadronic only |
| 500 GeV | $\sigma(e^+e^- \to \tilde{\mu}_L^+\tilde{\mu}_L^-)$ | 2.5 % | |
| | $m(\tilde{\mu}_L)$ | 0.5 GeV | |
| 500 GeV | $m(\tilde{\tau}_1)$ | $0.1\,\mathrm{GeV} \oplus 1.3\sigma_{LSP}$ | SPS1a' |
| 1 TeV | $\alpha_4$ | $-1.4 < \alpha_4 < 1.1$ | SPS1a' |
| | $\alpha_5$ | $-0.9 < \alpha_5 < +0.8$ | WW Scattering |

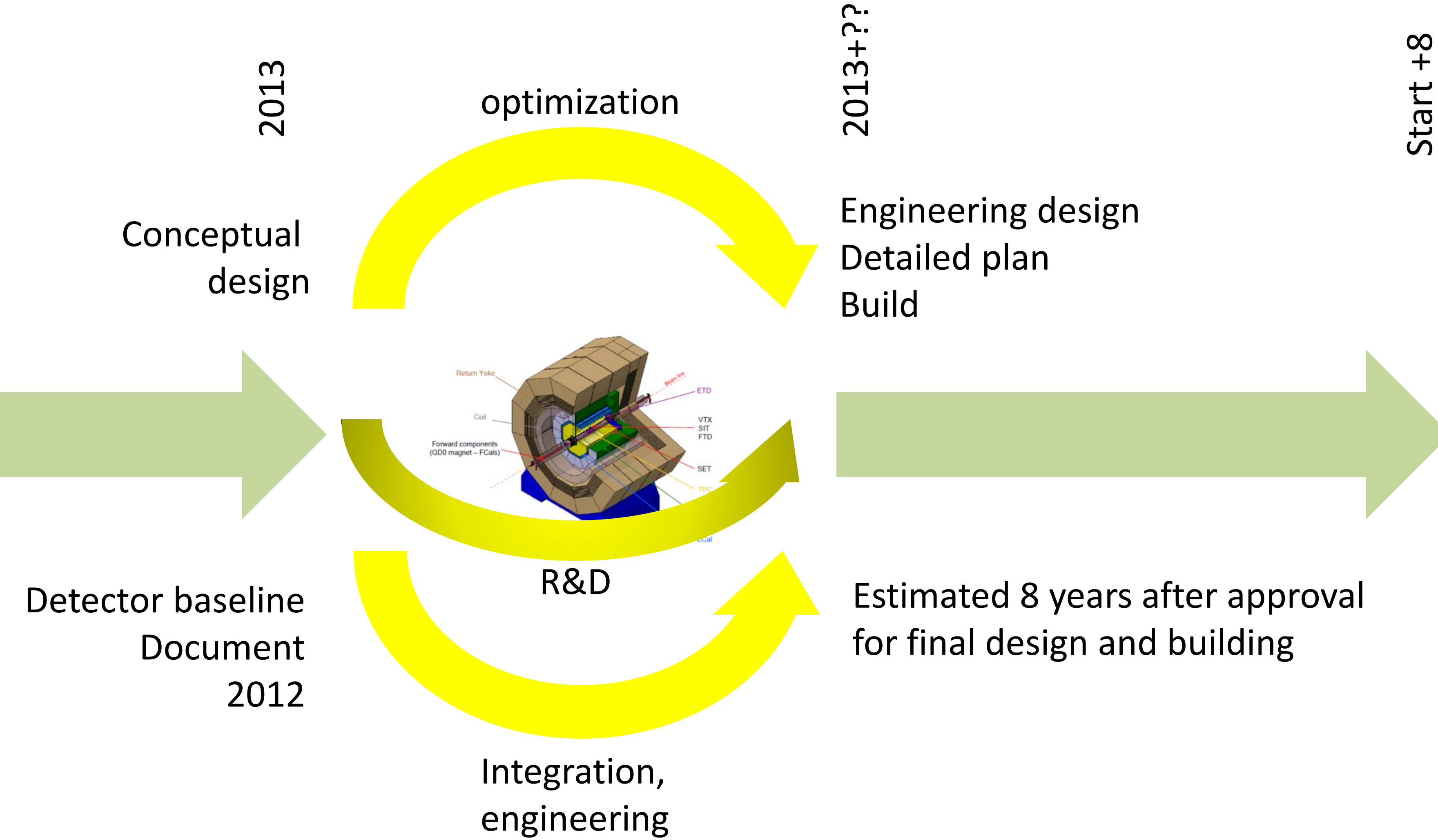


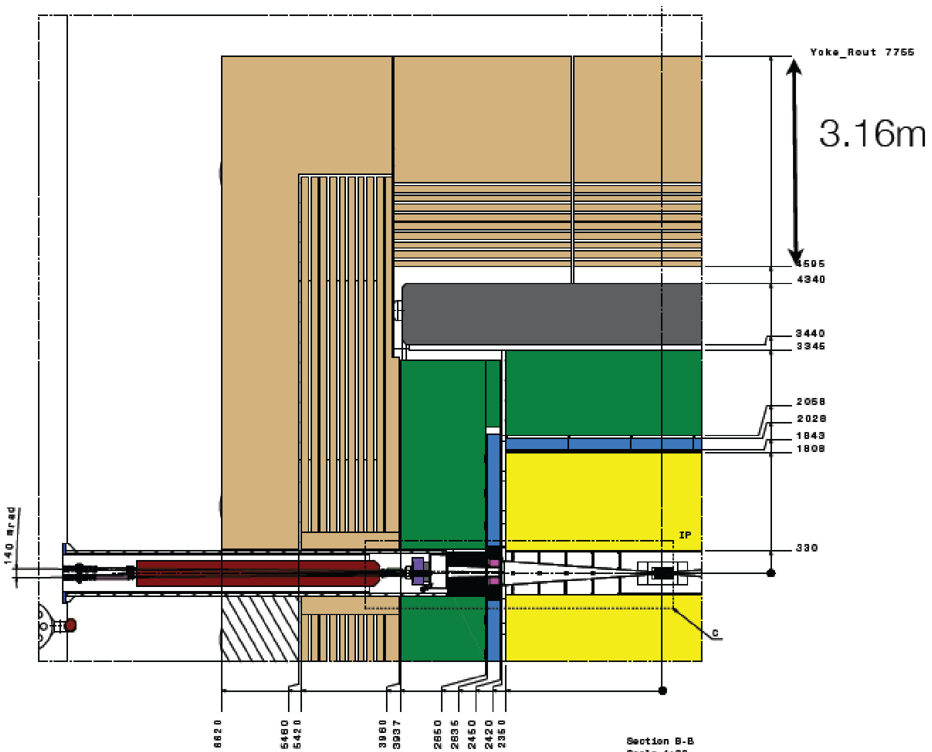



# Quo Vadis ILD



# Engineering/ Integration




Overall detector engineering and integration:

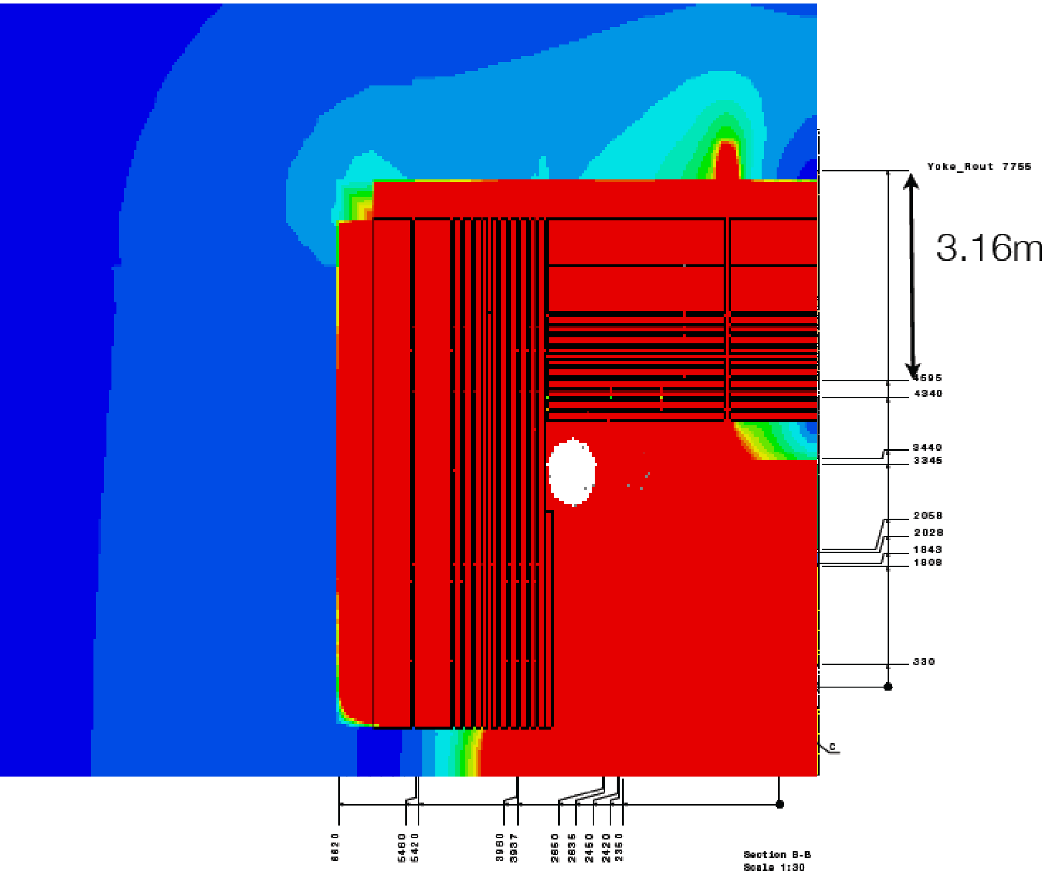
- Push pull design
- Integration into experimental hall
- Together with SiD

To make progress we need to

- Develop a coherent model of ILD which is realistic
- Adopt the model to the site requirements
- Move towards engineering solutions

Which fringe field is acceptable?
Current design: 50G: major iron yoke needed
Cost impact and size impact

# Engineering/ Integration

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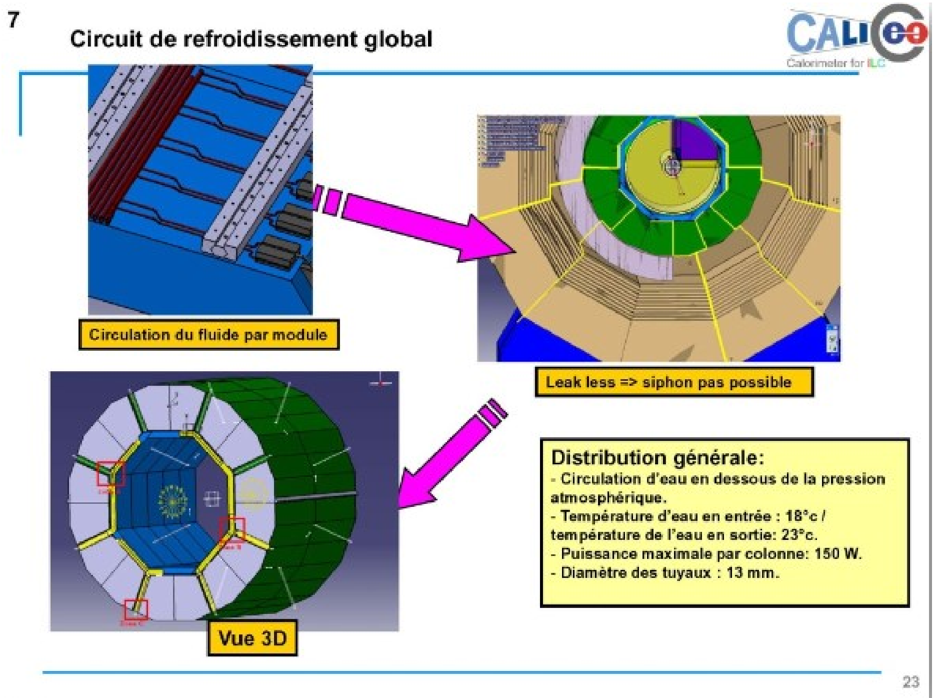
# The Integration Challenges




Cooling integration: Julien Giraud, LPSC

Detector integration is a significant challenge

- Technological know how is available per sub-detector
- Coherent integration needs central structures and coordinated efforts

- Central 3D model of the detector
- Central documentation facility (EDMS) for ILD
- Centrally planned and executed integration strategy

Challenge: Coordinated this with an parallel effort on re-optimization and re-evaluation of the ILD baseline.

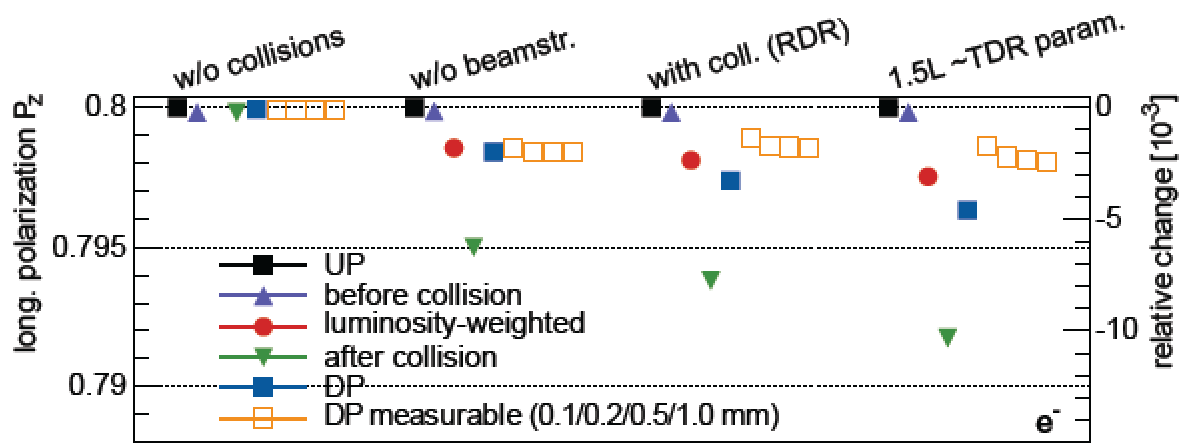
# The Precision Challenge

We want a real high precision experiment:

Need to push in all areas,

do not forget the "auxiliary" measurements:

Polarimetery
Luminosity
others?

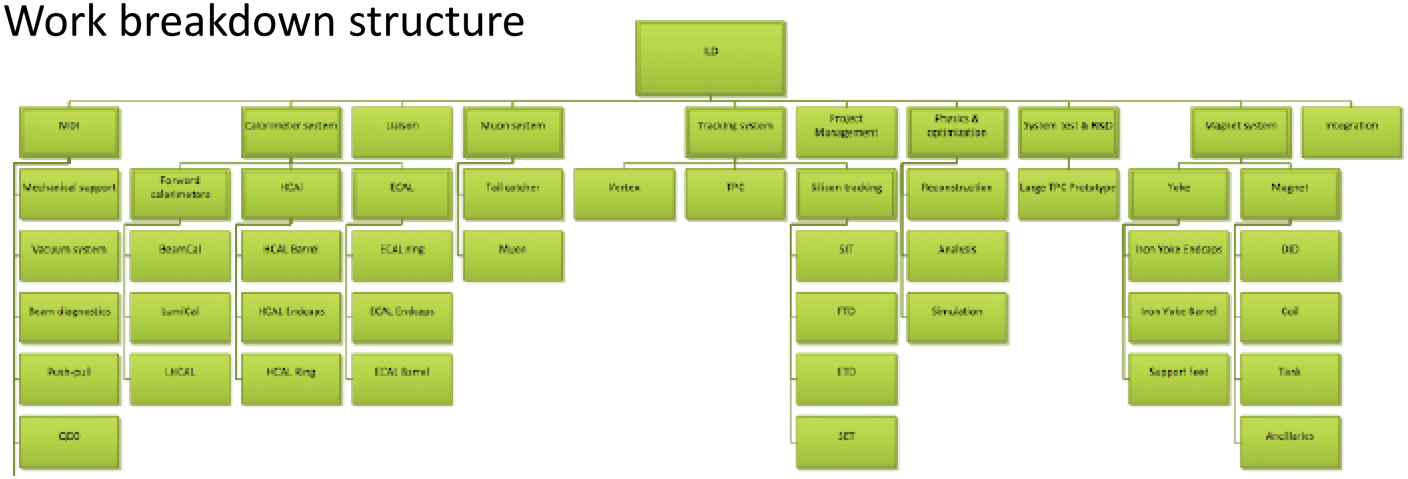



| | effect on $P[10^{-3}]$ |
|---|---|
| Beam and detector alignment at polarimeters ($\Delta\theta_{bunch} = 50\,\mu$rad, $\Delta\theta_{pol} = 25\,\mu$rad) | 0.72 |
| Variation in emittances | 0.03 |
| Crabbing | < 0.01 |
| Detector magnets | 0.01 |
| Emission of synchrotron rad. | 0.005 |
| random misalignments (10 μm) | 0.43 |
| Total | 0.85 |

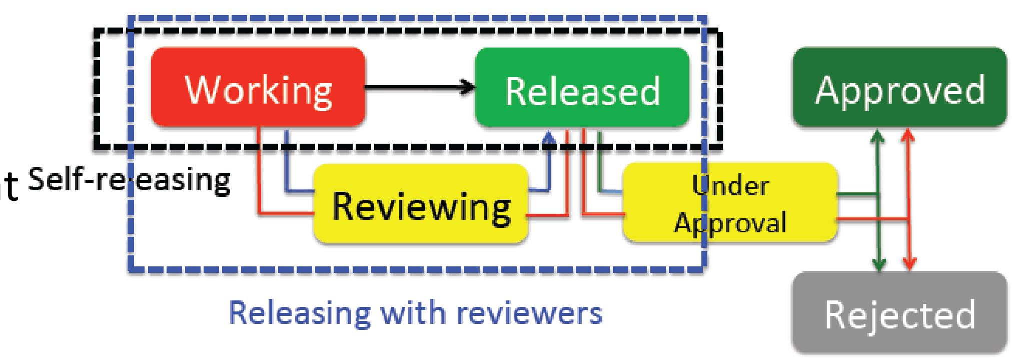
# Managing Integration

Need to move to a more formal system to manage and control the evolution of the detector design:

Work breakdown structure




Manage information for the ILD detector:
Need to set this up so that we re-gain control of our information

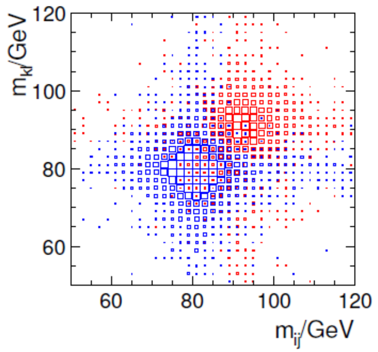


# ILD: The Re-Optimization Challenge

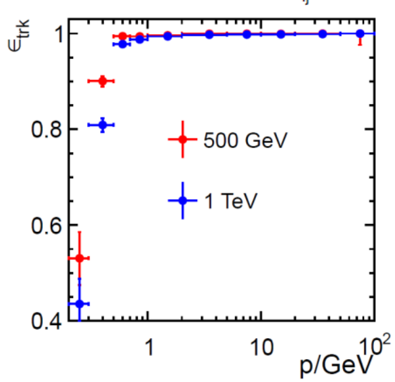
| After Higgs discovery the physics program is taking shape: | • Need to stress the capabilities<br>• Need to argue the performance in terms of the physics |
|---|---|

From technical performance

Jet energy resolution

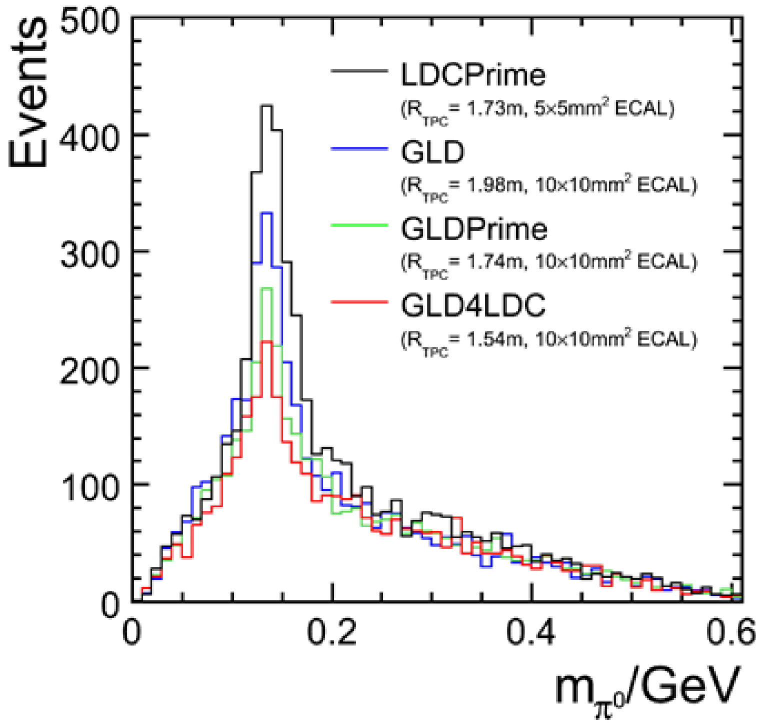



Tracking efficiency




to physics impact

Tau reconstruction: pi0 mass

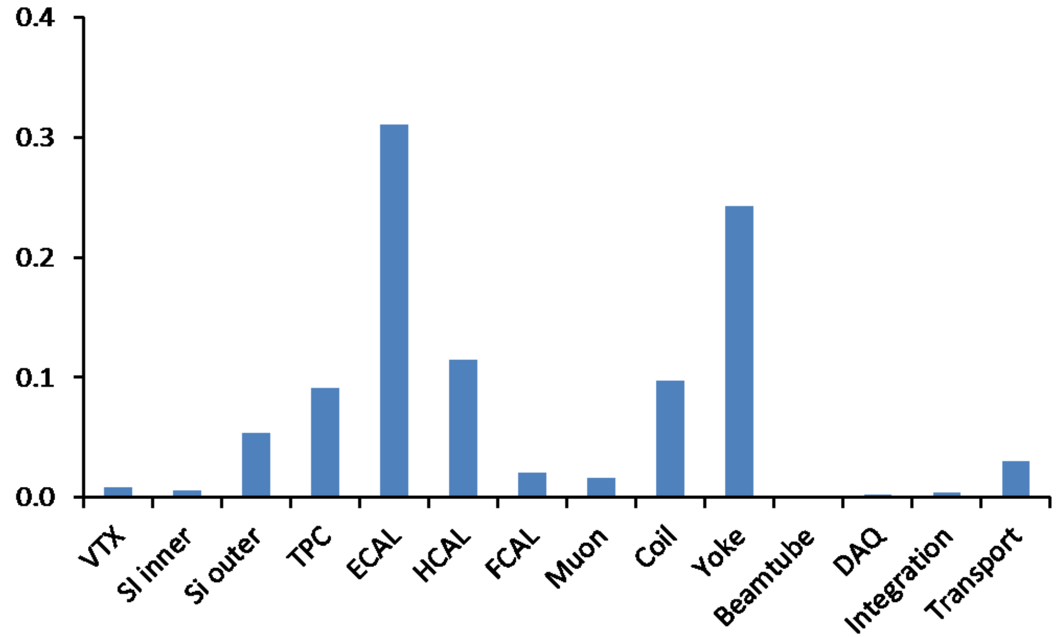


# The Costing Challenge

Total ILD cost:

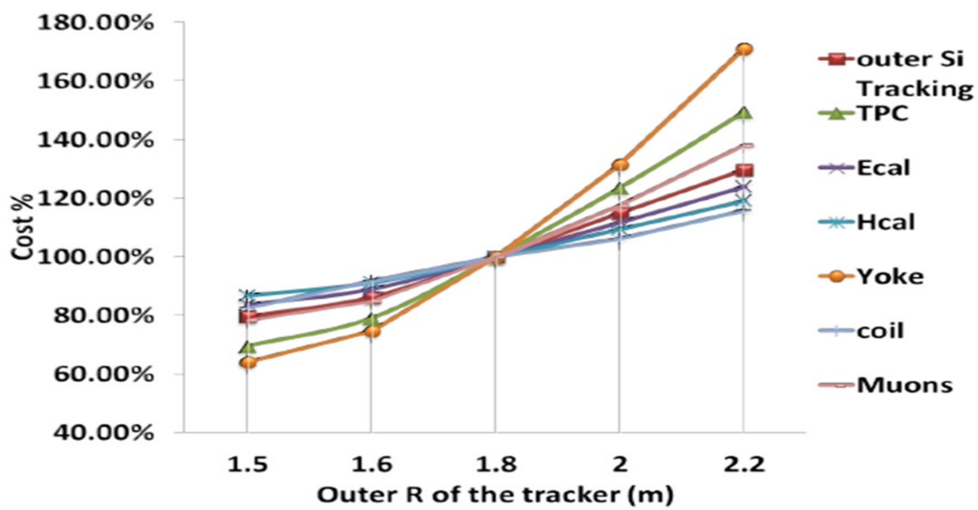
Estimated based on serious studies and experience from R&D

390 Mio ILCU
(+ personpower)

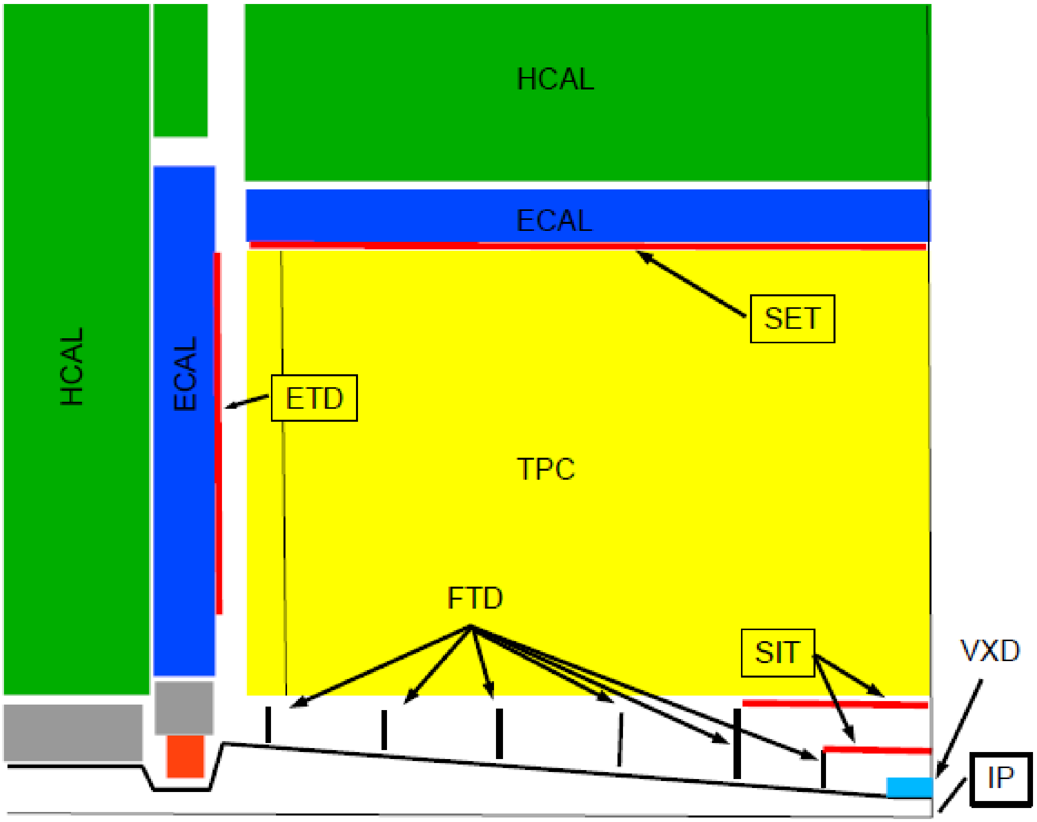



Current design is cost conscious, but not necessarily cost optimized

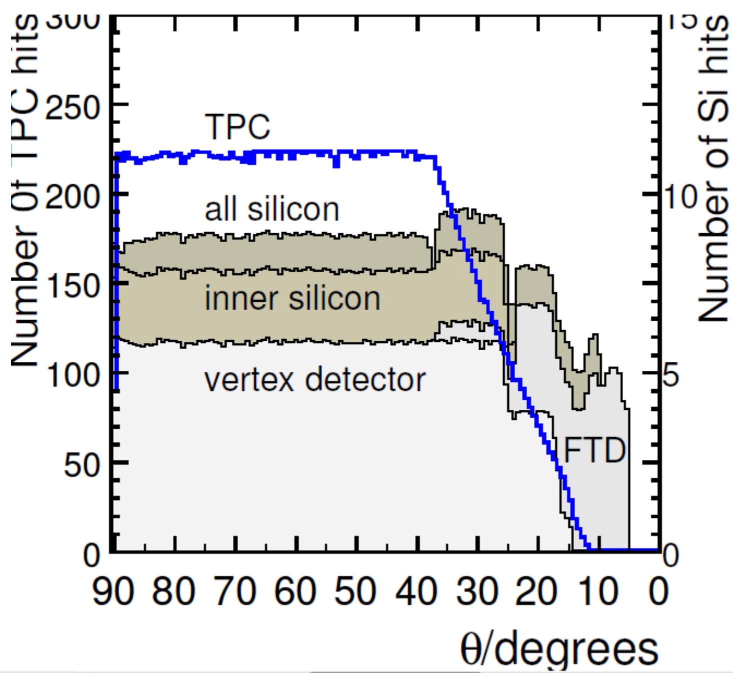
Need to move to a full cost – performance optimized system



# ILD Tracking System




ımbitious hybrid system
- TPC for robustness and efficiency
- Silicon for ultimate resolution and vertexing

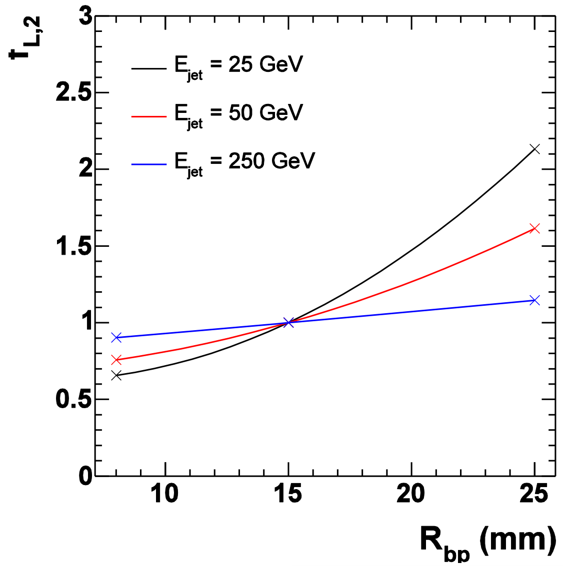



Hermetic, coverage down to very small forward angles.

# ILD tracking

Vertex charge vs. Inner radius

(S. Hillert, 2007)

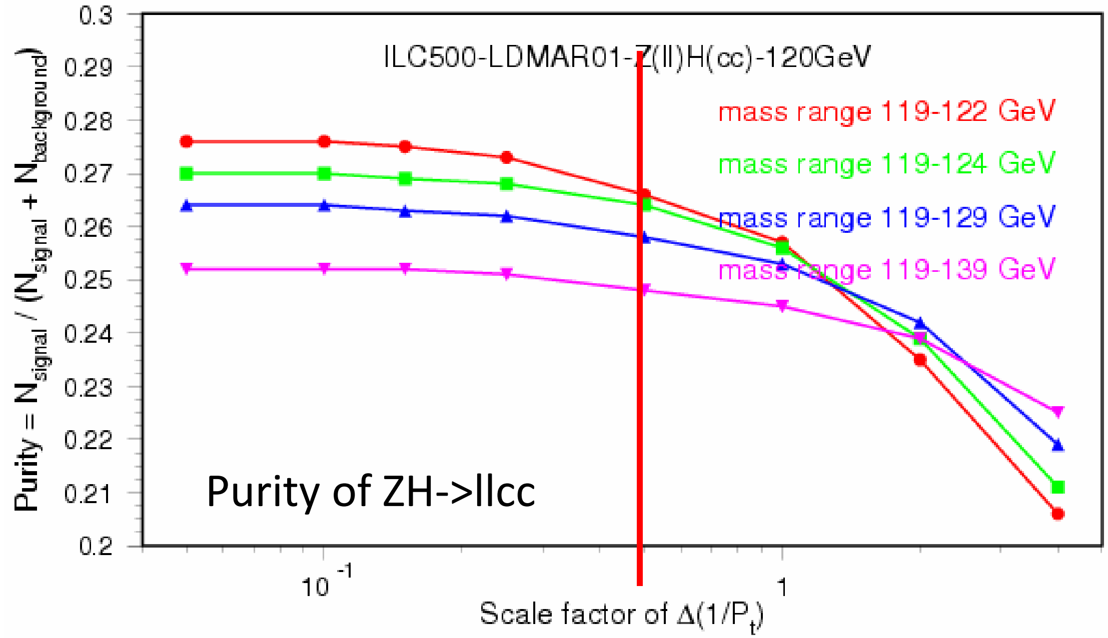



Impact on specific physics analyses?

Example (study by K.Riles, 2005):

Impact of momentum resolution on purity in ZH->llcc

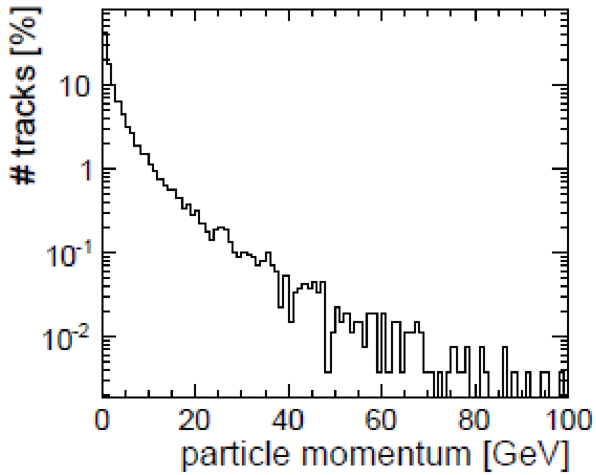
ILD needs to sharpen the arguments which define the ILD requirements.



# Tracking issues

Low momenta

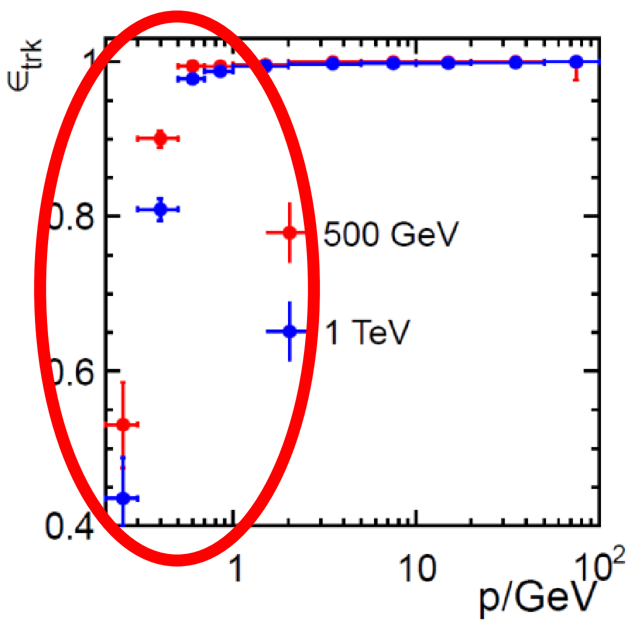
Zqqqq @ 500 GeV
42% of tracks <1 GeV

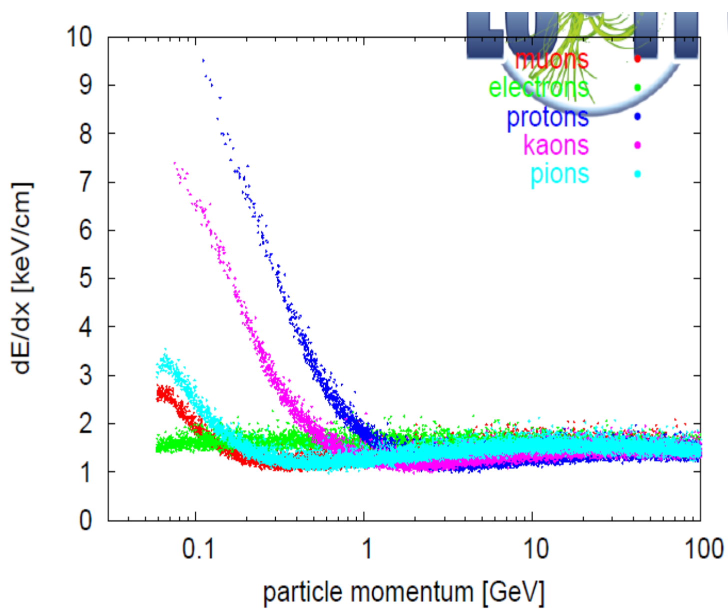



Low momentum reconstruction is an issue

dEdx not really exploited
(in particular powerful
for low momenta)

Efficiency for
low momenta
drops fast
(<1 GeV)



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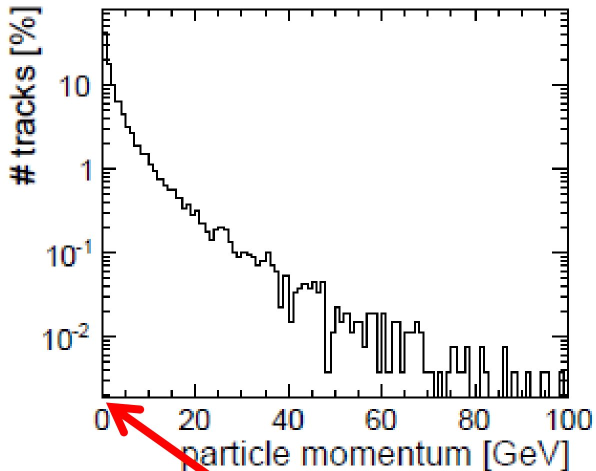


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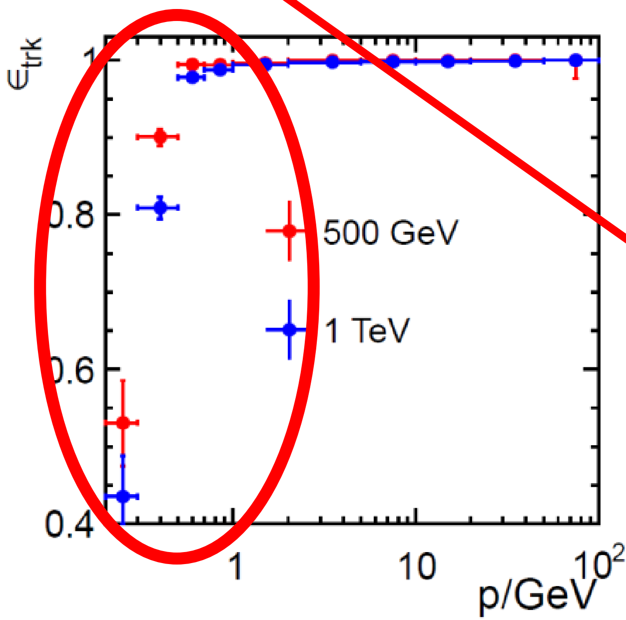
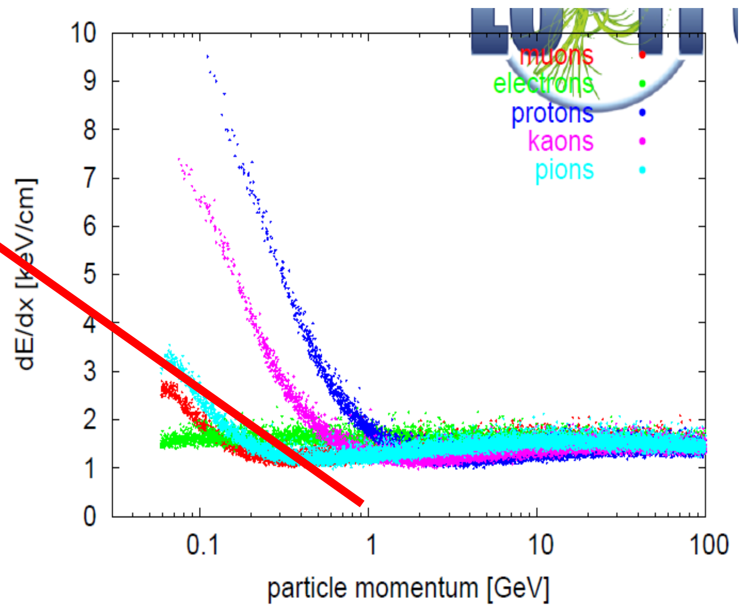
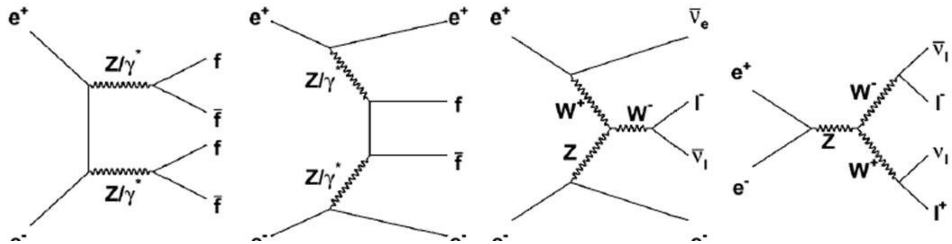
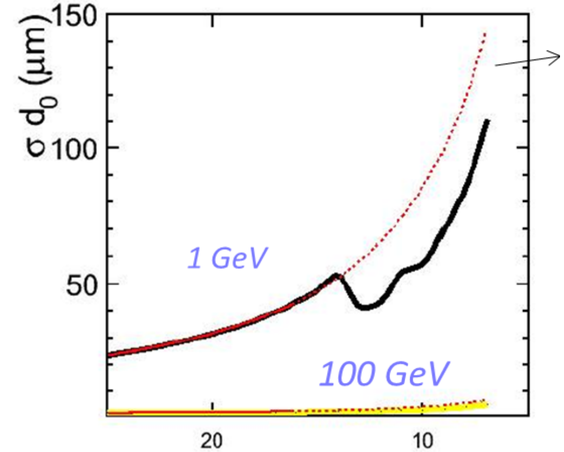


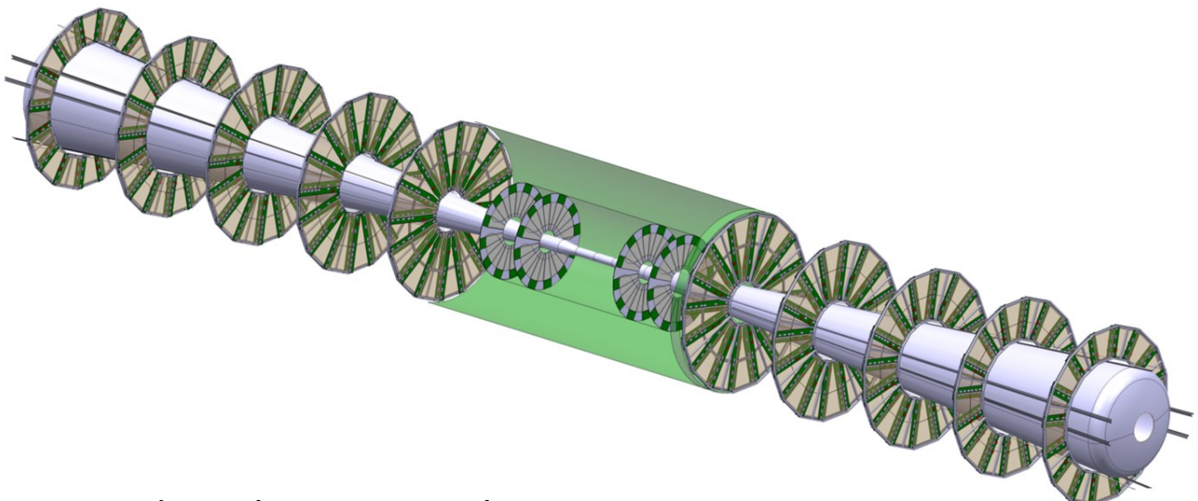



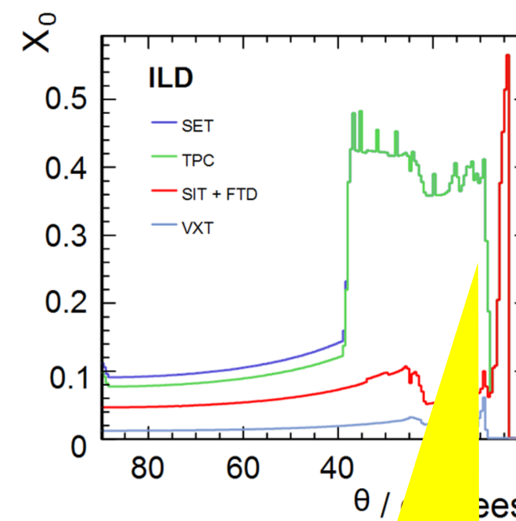
# Forward Tracking

ILC physics:
Forward region is increasingly important





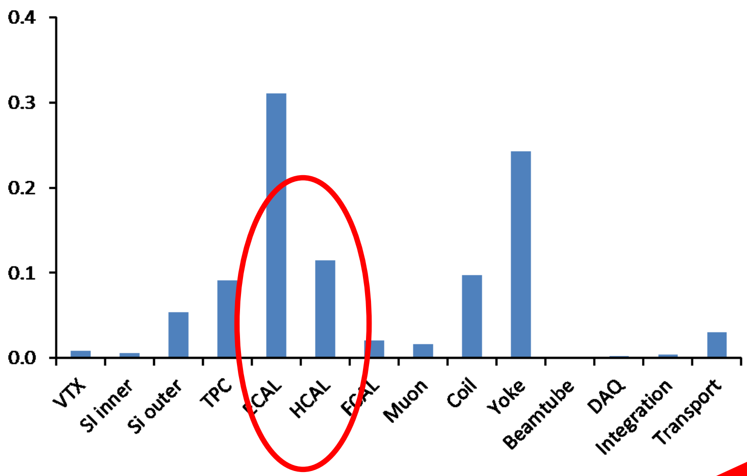






Forward tracking integral part of ILD
Purely Silicon based

Can we do better?

# Calorimeter System



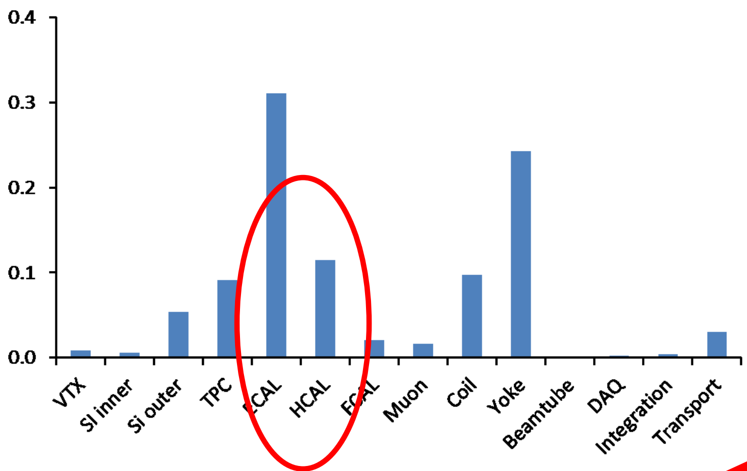

Calorimeter system is major cost driver

Technological developments
- Unit costs
- Alternative technologies

De-scoping

Optimization
- Layout
- size

# Calorimeter System

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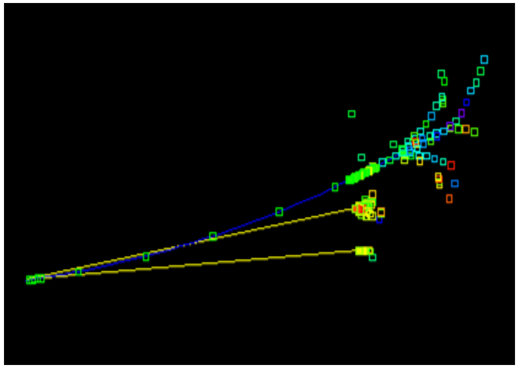
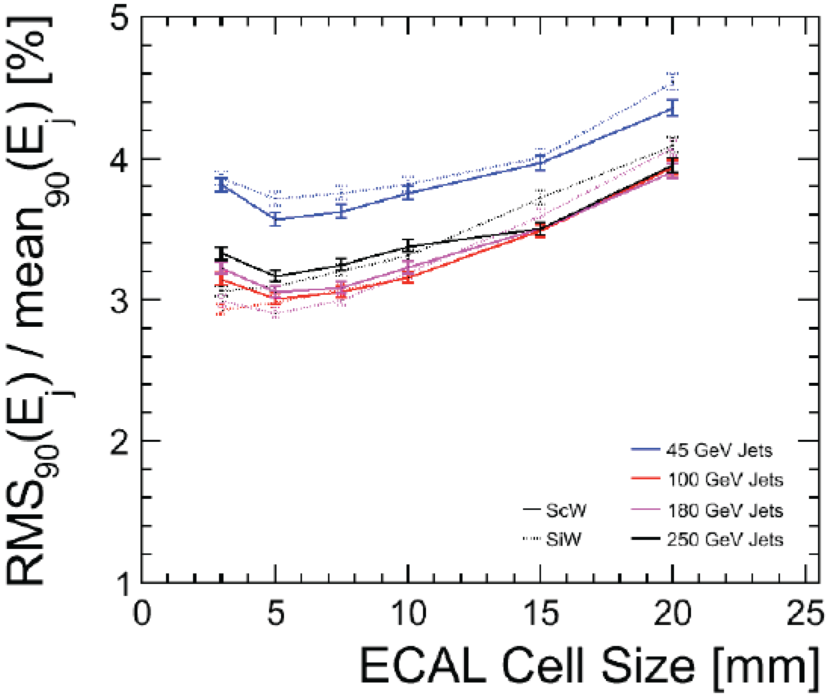
# ECAL



SiW technology:

- Very powerful
- Has undergone rigorous R&D program, well understood




M.Thomson,J.Marshall, ILD meeting 2010

Studies have started to re-evaluate

- Cell size
- Number of layers
- Alternative technologies

**Cell size**: 5x5 mm$^2$ is about optimum

Confirms previous studies by many authors

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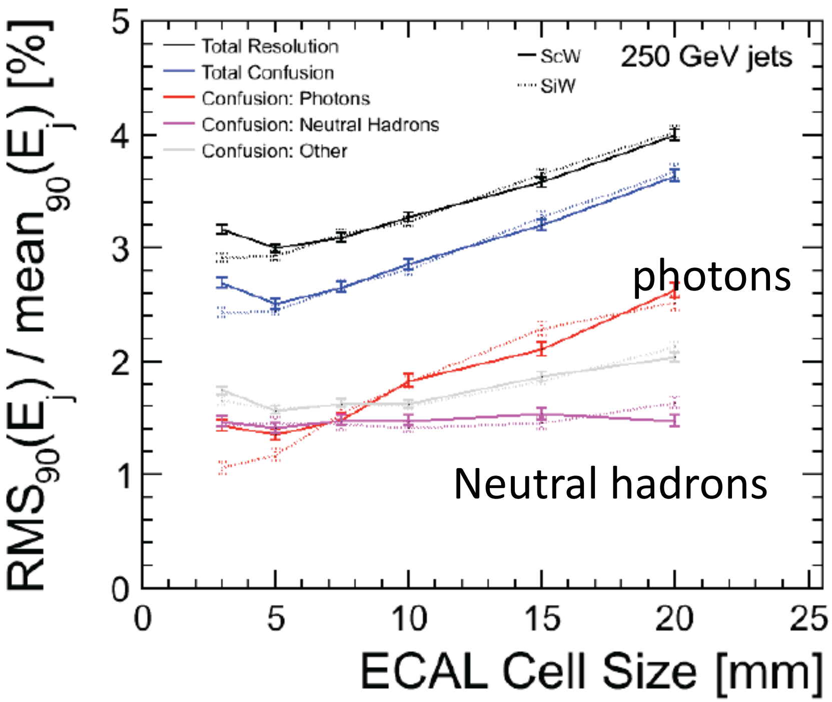


M.Thomson,J.Marshall, ILD meeting 2010

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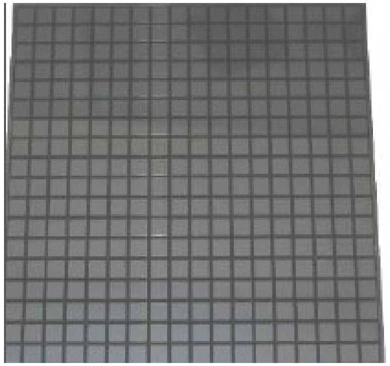
**Confusion term** for photons: compatible results
Hadron confusion: independent

Confirms previous studies by many authors

# ECAL



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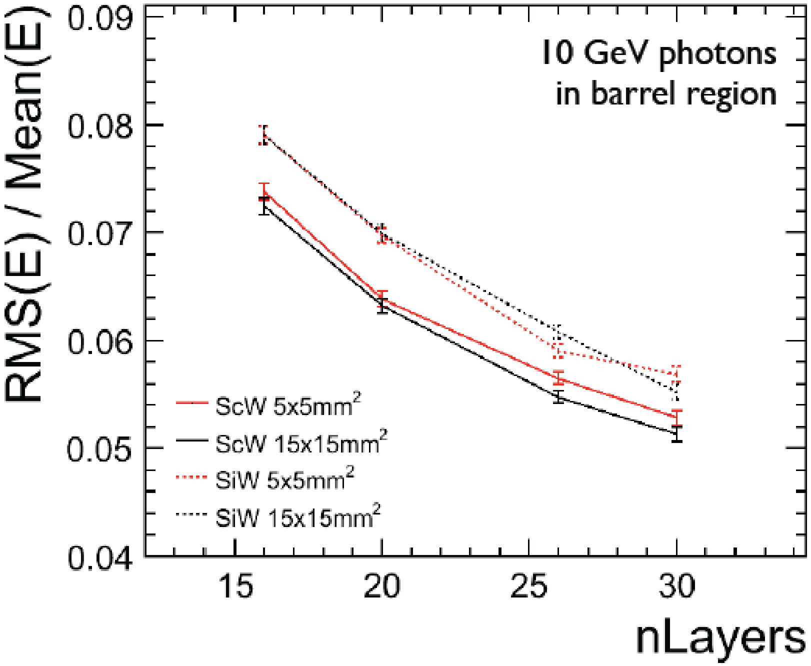


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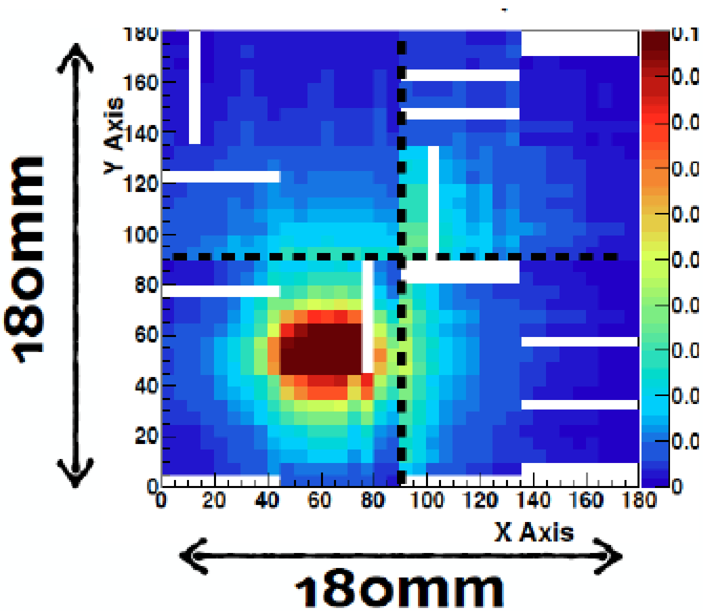
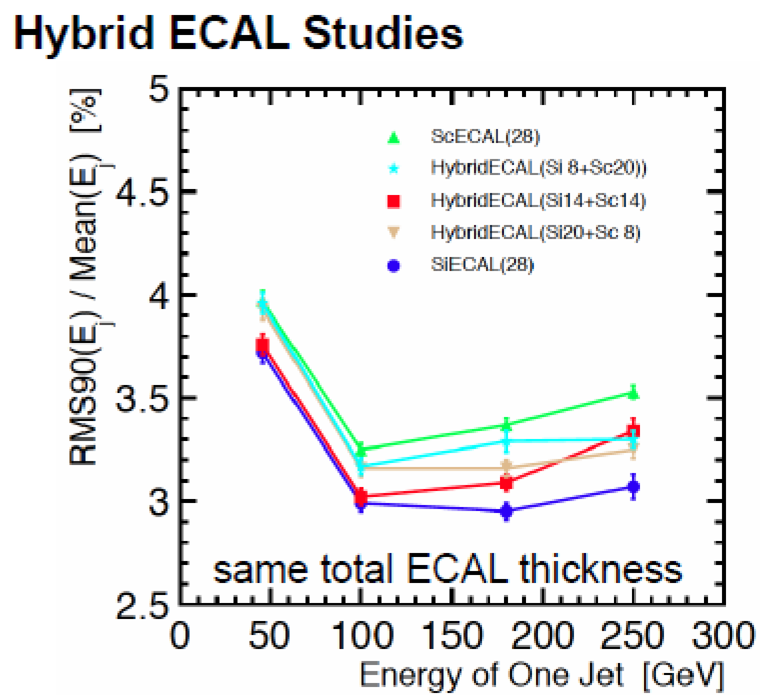
**Number of layers**: clear loss in performance expected and seen in simulation

These studies are a start

# Strip ECAL

ECAL option: based on scintillator  strips (technology similar to AHCAL)

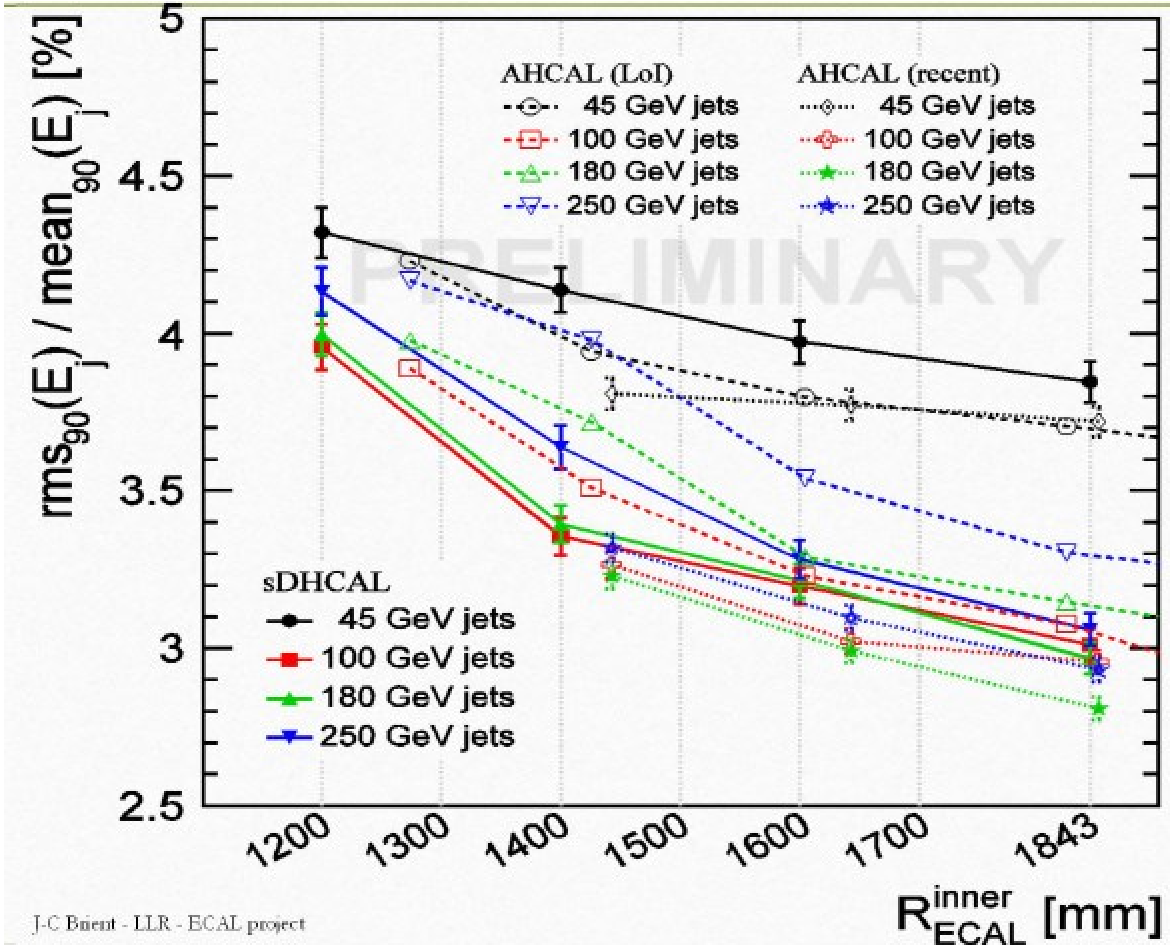



H. Ueno
T. Ogawa

Enormous progress over the past few years,
Performance looks very encouraging!

# Scaling the detector




Compilation based on the work by

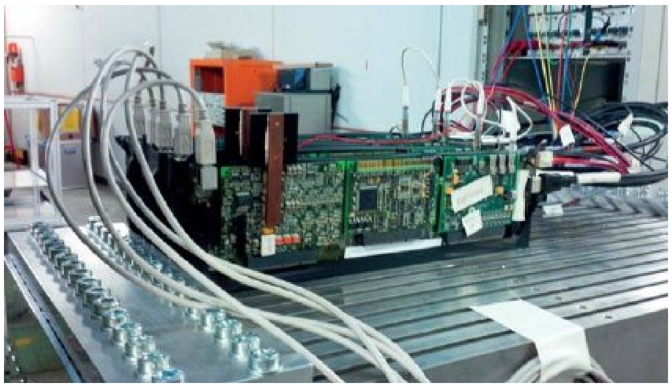
J.Marshall (Cambridge)
T.H.Tran (LLR)

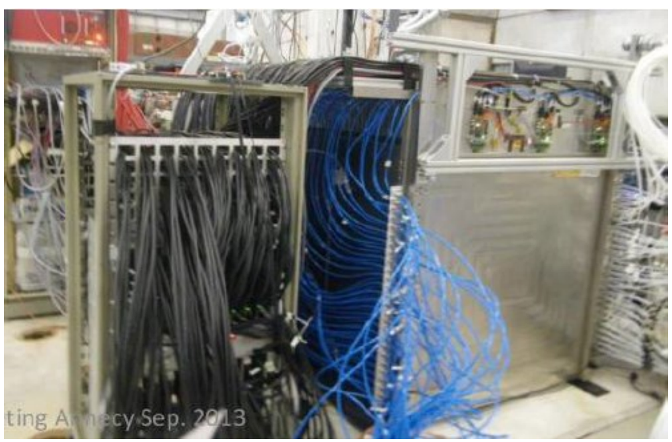
Note:
JM: only vary r
THT: constant ratio R/z

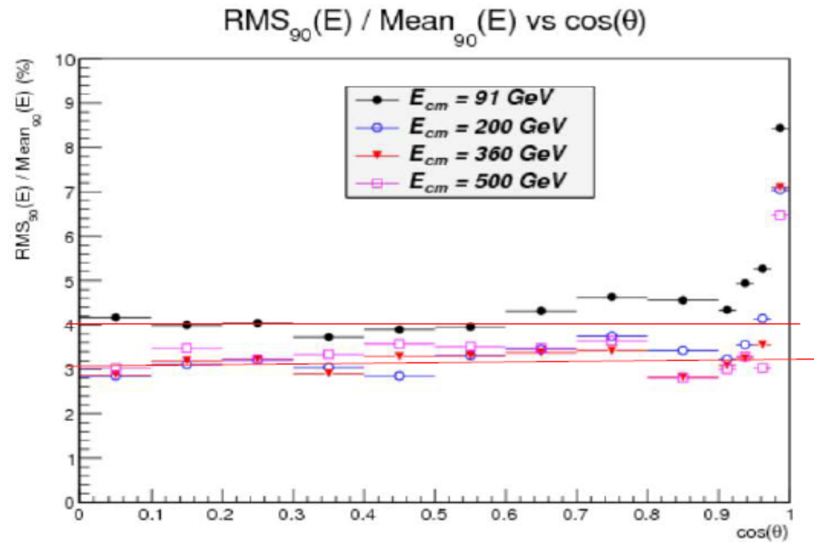
Reported at LCWS2013

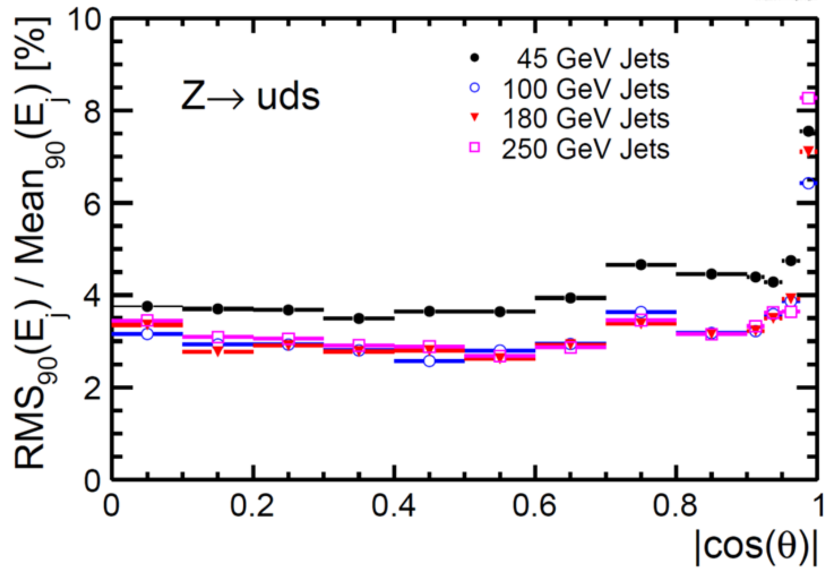
# HCAL

HCAL performance is critical for PFLOW calorimeter





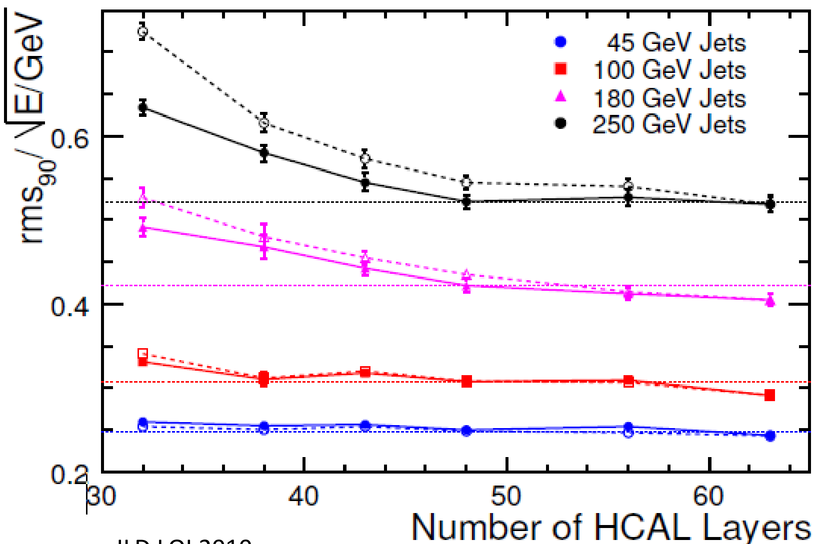



Jet-mass resolution for both HCAL technologies (analogu, semidigital)

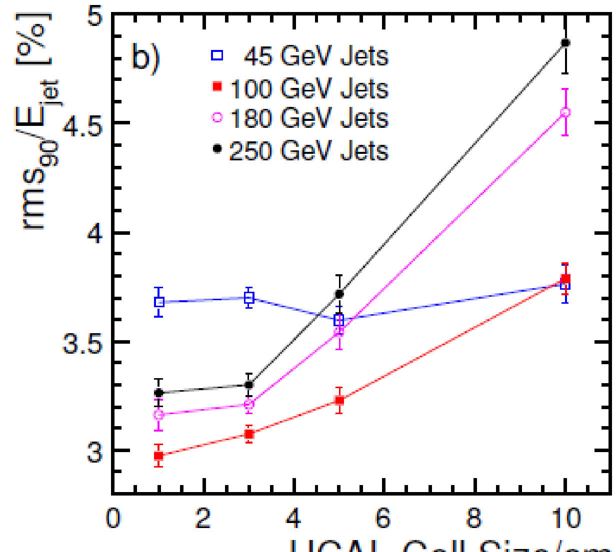
# HCAL: Optimization

Dependence of Jet-mass resolution on number of HCAL layers.




ILD LOI 2010

and AHCAL cell size




ILD LOI 2010

At moderate energies:

- Weak dependence on HCAL design
- At high energies steep dependence

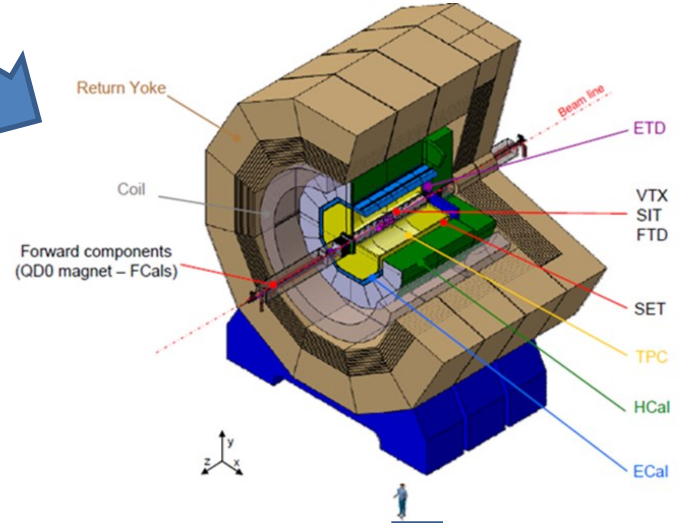
Needs to be re-visited for both technological options and with new code and algorithm.

# Physics Impact

Standard model precision measurements

Higgs physics
(Recoil studies)

BSM physics




newILD

# Outlook

Apologies To the many systems and sub-detectors in ILD which I did not discuss

e.g. FCAL, Muon, … nor many alternative technologies

The major challenge for ILD for the next 2-3 years will be the re-optimization.

We should carefully balance physics reach with detector performance and costs

The current moment might be our last chnace to do such an overall optimization carefully and thouroughly!

Announcement: we will start a series of monthly optmization meetings in January 2014:

**First meeting January 22, 2014, at 13:00 hour GMT+1 (10pm in Japan)**

# ILD in Europe

ILD has traditionally a strong European Component

- France: Calorimeter, VTX, TPC
- Germany: Calorimeter, TPC
- UK: Particle Flow
- Spain: Forward tracking, Silicon tracking
- Poland: Forward Calorimeter
- Russia: Calorimetery

Funding is through

- National programs
- European money: EUDET (until 2010), AIDA (since 2011)

# ILC and Europe

European Strategy:

- Clear support for an ILC project in Japan
- Second only to LHC upgrade

In many countries:

- Discussions are ongoing on an increased involvement in ILC
    - Italy: summer 2013, concrete plans are slow to come though
    - France: ILC meeting in November, strong ILC community
    - UK: ILC meeting September, ILC is back in the system, but small
    - Germany: ILC meeting in September, community meeting in November
        - Increased involvement from universities
        - Anticipate a call for R&D money next year

Overall: Momentum is building up, a significant involvement by European scientist
is anticipated.

# ILC and Europe

AIDA: Program to fund research infrastructure from European money

duration 2011-2014, 8 MIO EUR in total, about 40% IL

Negotiations have started on a follow up program: AIDA-2

- Call has just been published, detector R&D is included
- Volume will be similar: max 10 Mio for 4 years
  - Shared between LHC/ ILC/ Neutrino, fractions unclear

Current thoughts:

- Towards an ILD slice test (focus is on common DAQ for test beams)
- Development of a new, modular and powerful simlulator based on DD4HEP
- ILD project office for Europe (engineering support)

Close cooperation with SiD is sought.

# Conclusion

The ILD detector concept is mature and highly performant

It is based on significant R&D and technology developments.
ILD starts to develop an integration strategy and proposal
Site specific studies are starting

A new round of optimization will

- Streamline the design towards our new physics knowledge
- Focus more on a full cost-performance benefit analysis

Optimization studies have started, we are looking forward to an interesting period of discussion and optimization.

European scientists are getting organized for a strong participation in an ILC project in Japan