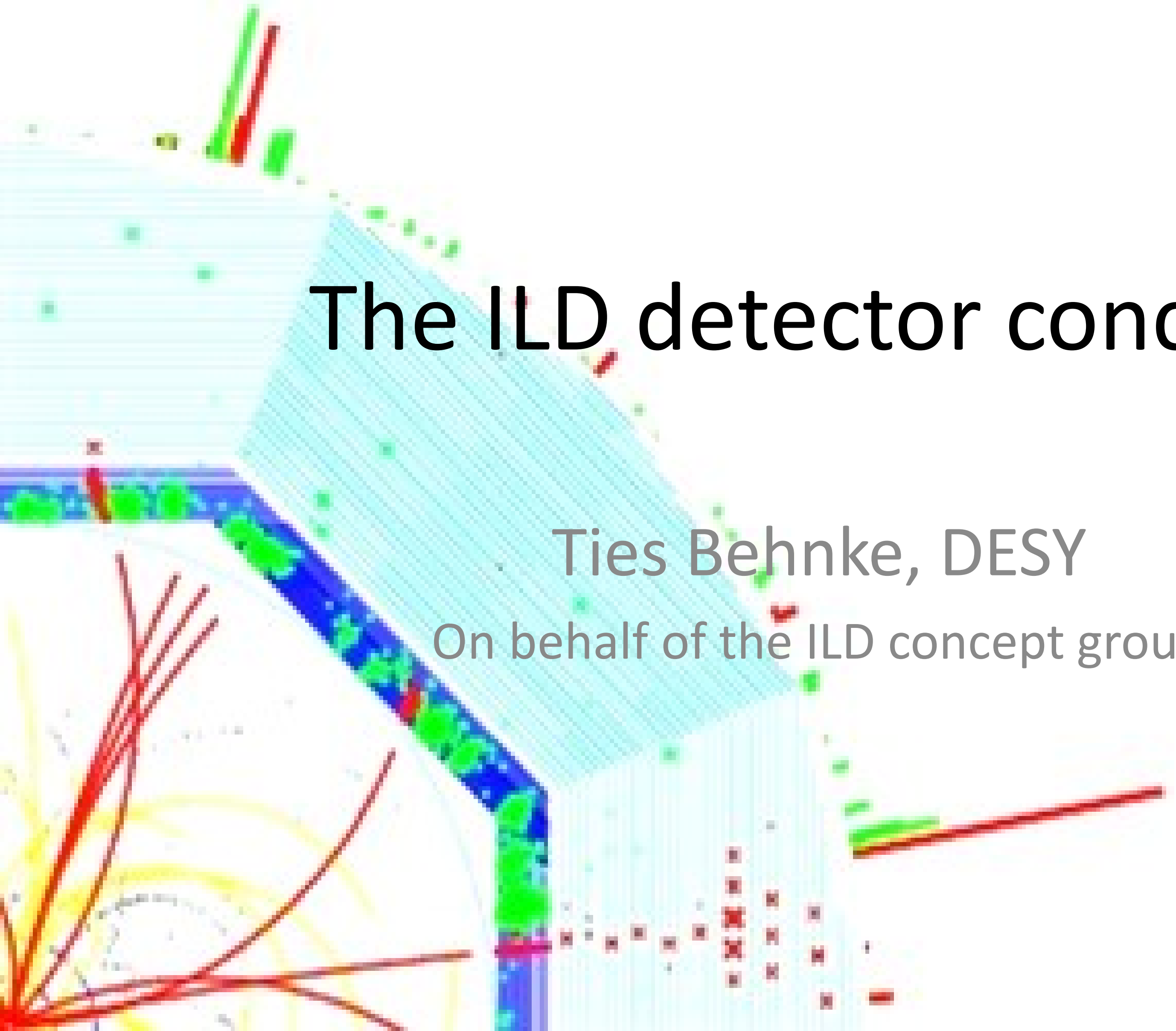
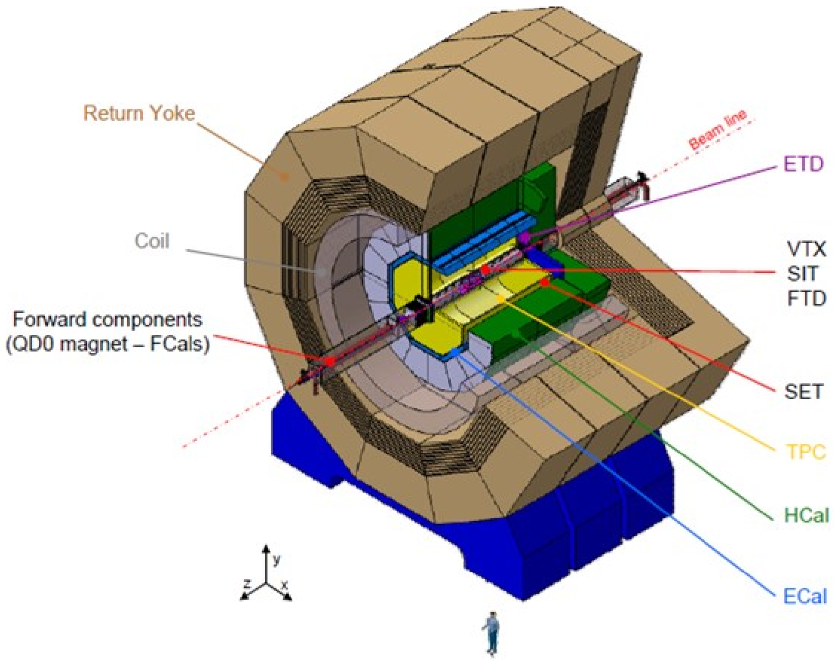
The ILD detector concept

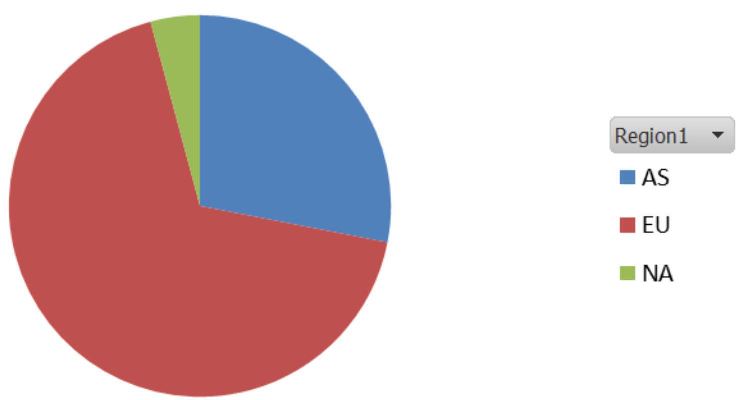


Ties Behnke, DESY

On behalf of the ILD concept group

What is ILD





Multi purpose detector for linear collider physics

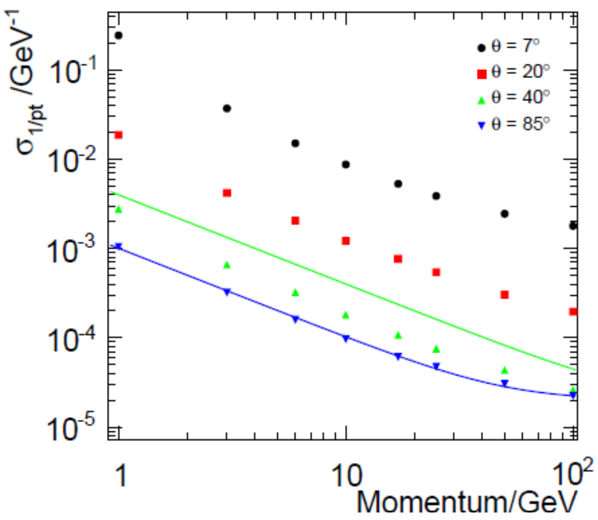
- ILC version
- CLIC version

Particle flow as driving principle

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

ILD: International group with strong participation in EU and Asia

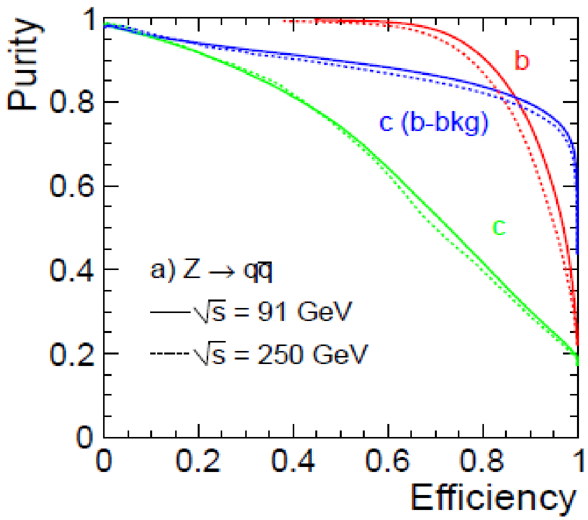
Performance of ILD

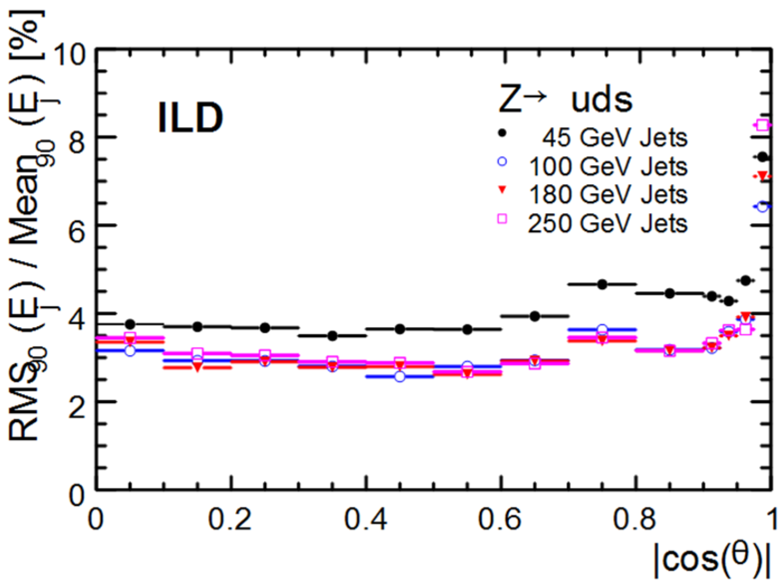


Performance goals are very ambitious:

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

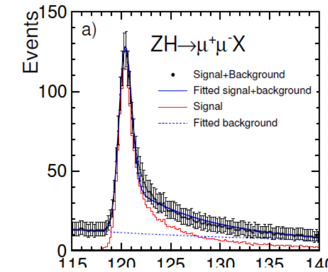


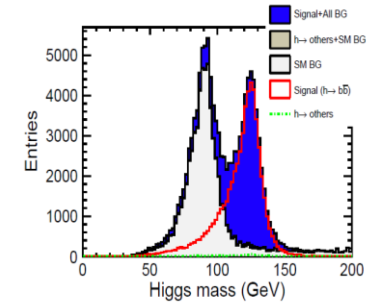


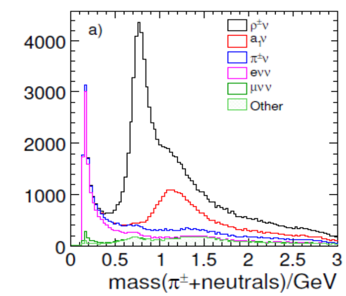
Physics with ILD

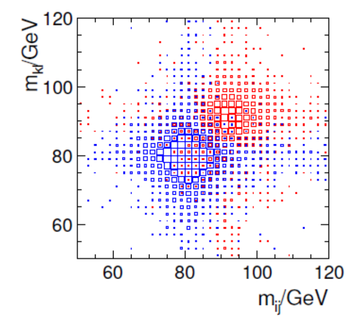
Comprehensive physics program has been worked out and quantified

$\sqrt{s}$	Observable	Precision	Comments
250 GeV	$\sigma(e^+e^- \to Zh)$	± 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}	± 0.0025	$\theta_{\tau^+\tau^-} > 178°$
	P_τ	± 0.007	excluding $\tau \to a_1\nu$
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
	Γ_t	27 MeV	fully-hadronic only
	Γ_t	22 MeV	+ semi-leptonic
	A_{FB}^t	± 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	$m(\tilde{\tau}_1)$	$0.1\,\text{GeV} \oplus 1.3\sigma_{LSP}$	SPS1a'
1 TeV	α_4	$-1.4 < \alpha_4 < 1.1$	SPS1a'
	α_5	$-0.9 < \alpha_5 < +0.8$	WW Scattering









Quo Vadis ILD

2013

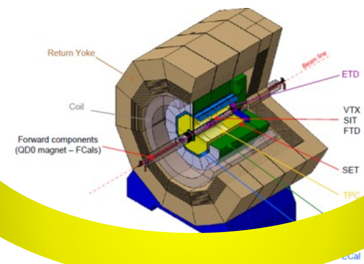
optimization

2013+??

Start +8

Conceptual
design

Engineering design
Detailed plan
Build



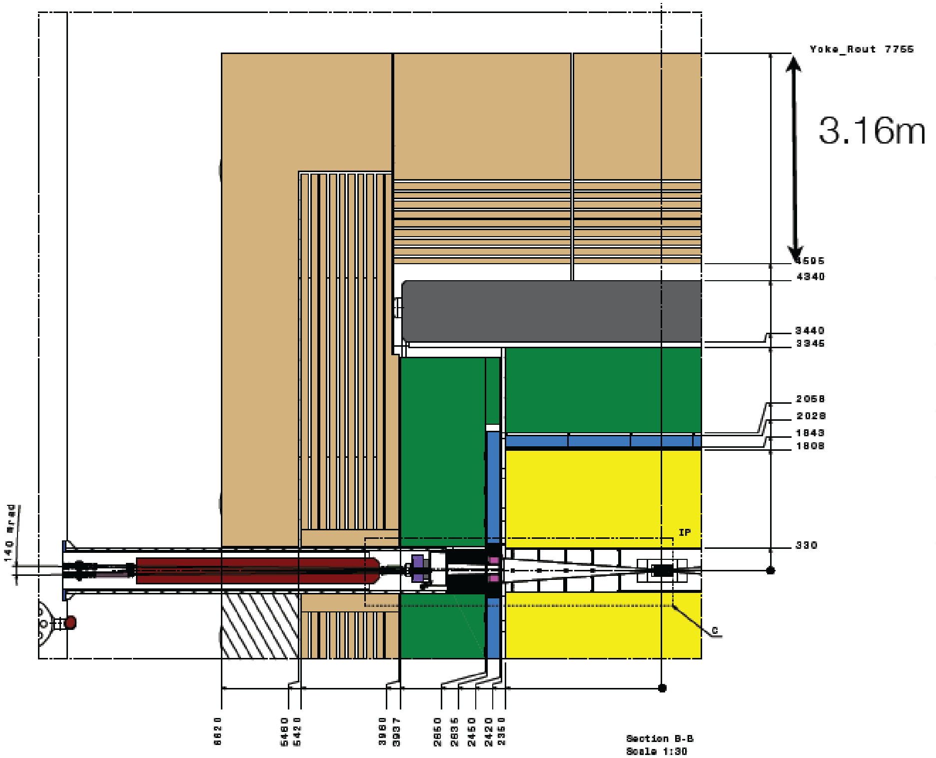
R&D

Detector baseline
Document
2012

Estimated 8 years after approval
for final design and building

Integration,
engineering

Engineering/ Integration



Overall detector engineering and integration:

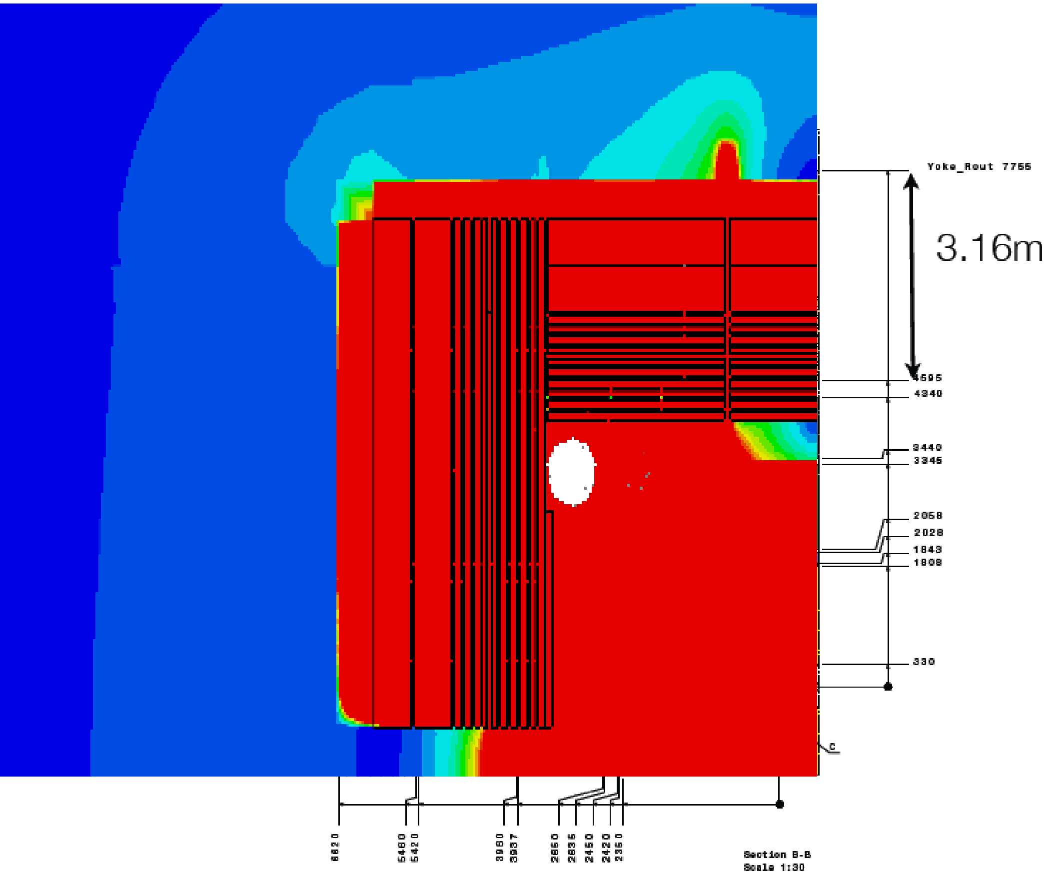
- Push pull design
- Integration into experimental hall
- Together with SiD

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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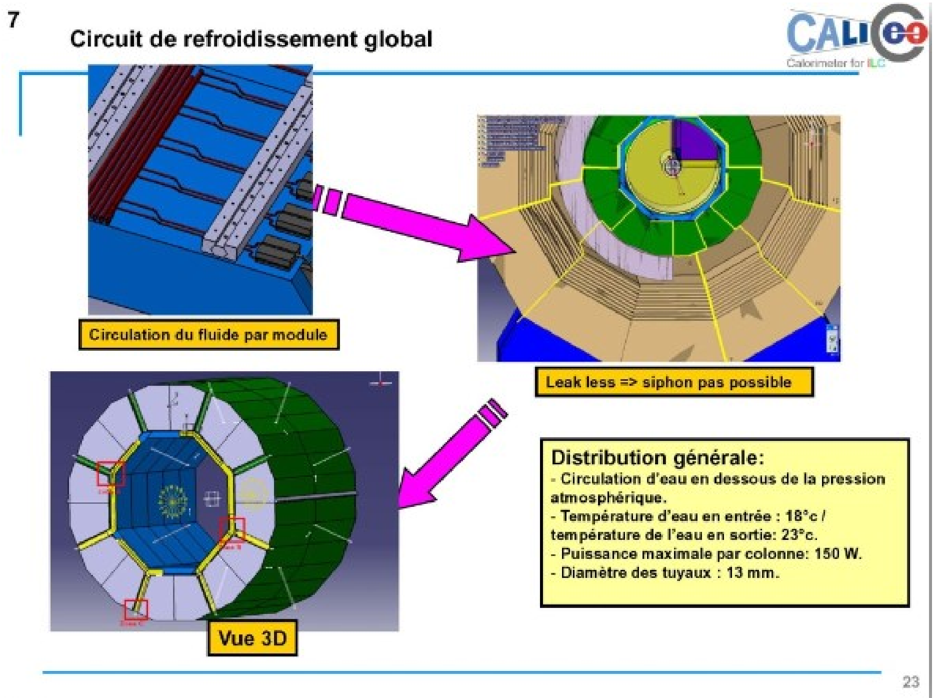
Integration Challenges



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

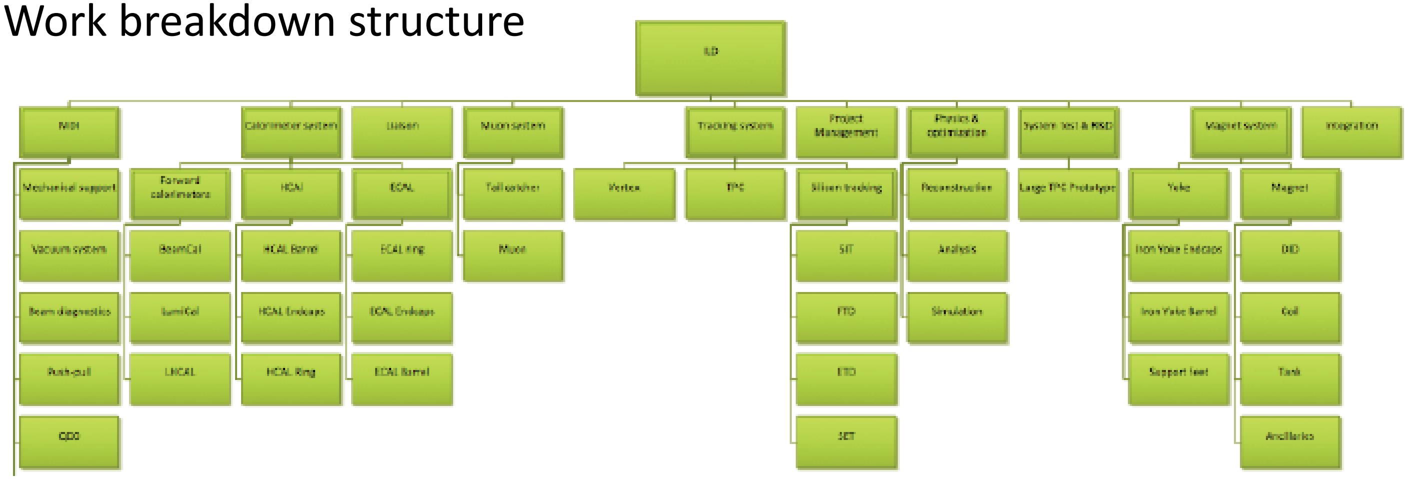
- Central 3D model of the detector
- Central documentation facility (EDMS) for ILD
- Centrally planned and executed integration strategy

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

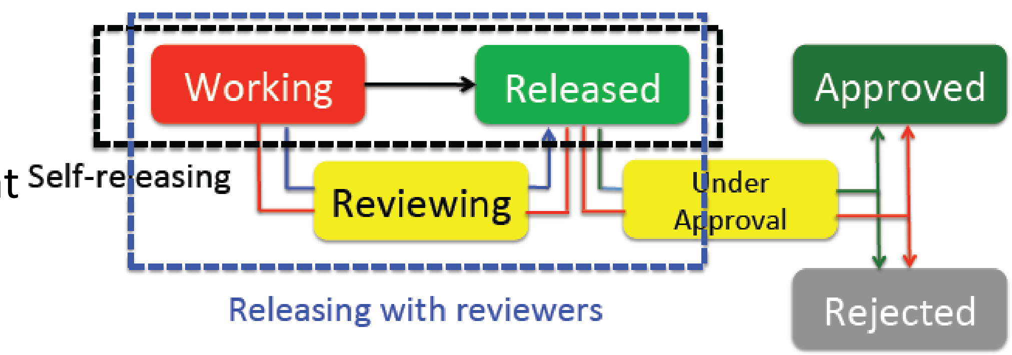
Managing Integration

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

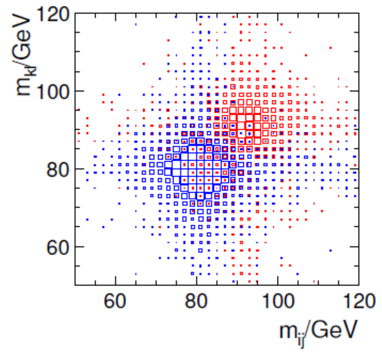


ILD: The Re-Optimization Challenge

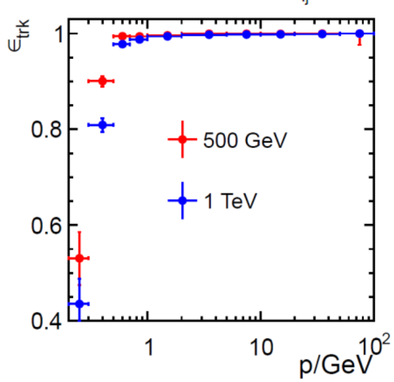
After Higgs discovery the physics program is taking shape:	• Need to stress the capabilities • Need to argue the performance in terms of the physics

From technical performance

Jet energy resolution

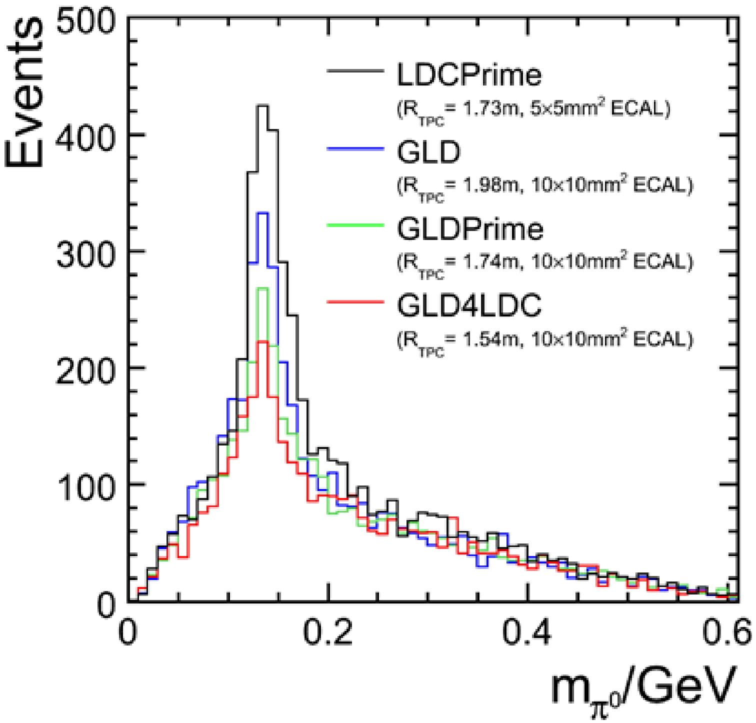


Tracking efficiency



to physics impact

Tau reconstruction: pi0 mass

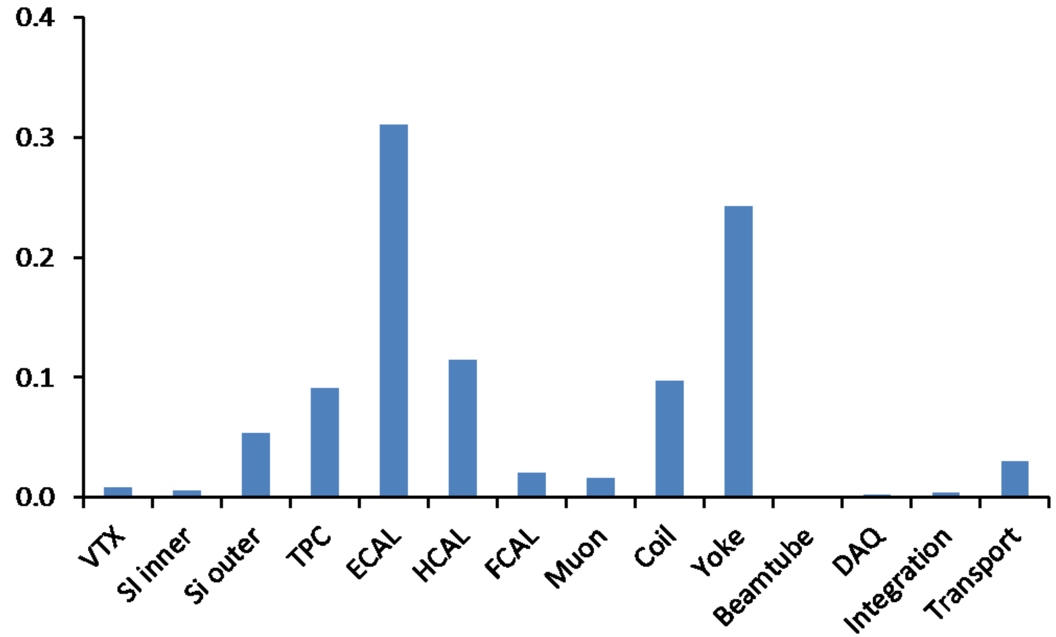


The Costing Challenge

Total ILD cost:

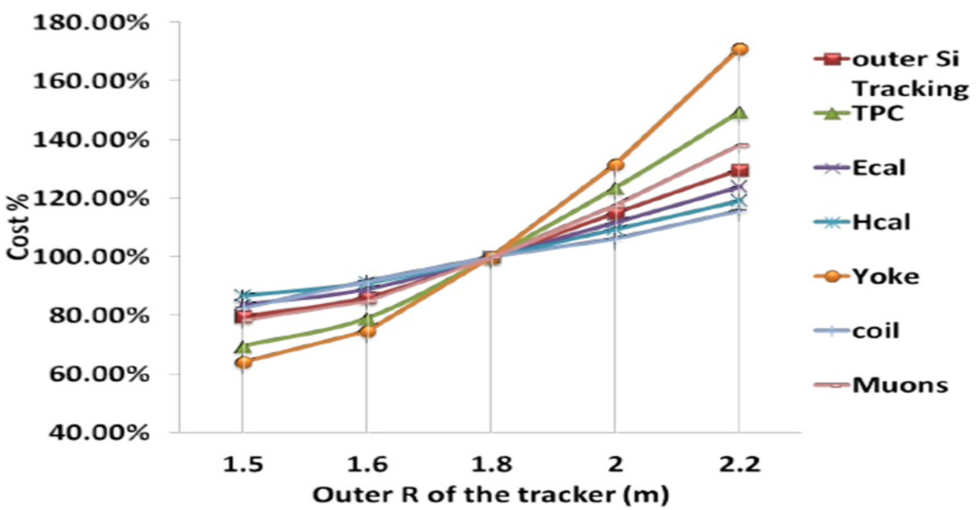
Estimated based on serious studies and experience from R&D

390 Mio ILCU
(+ personpower)

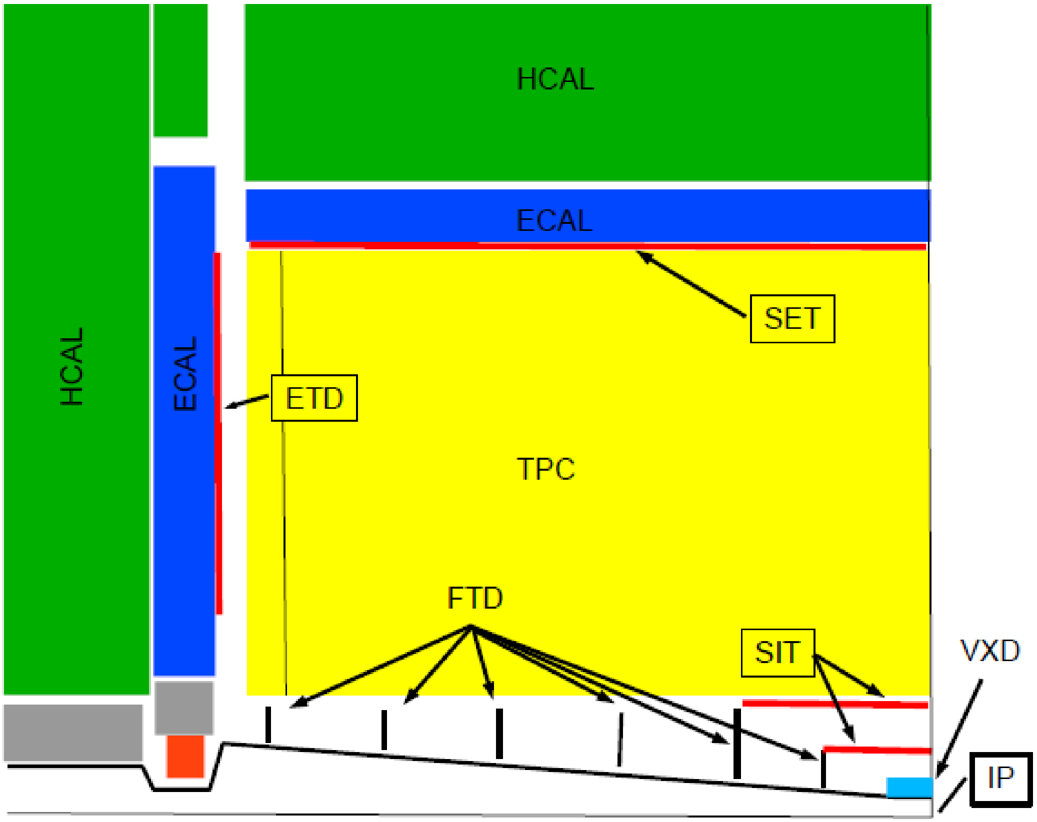


Current design is cost conscious, but not necessarily cost optimized

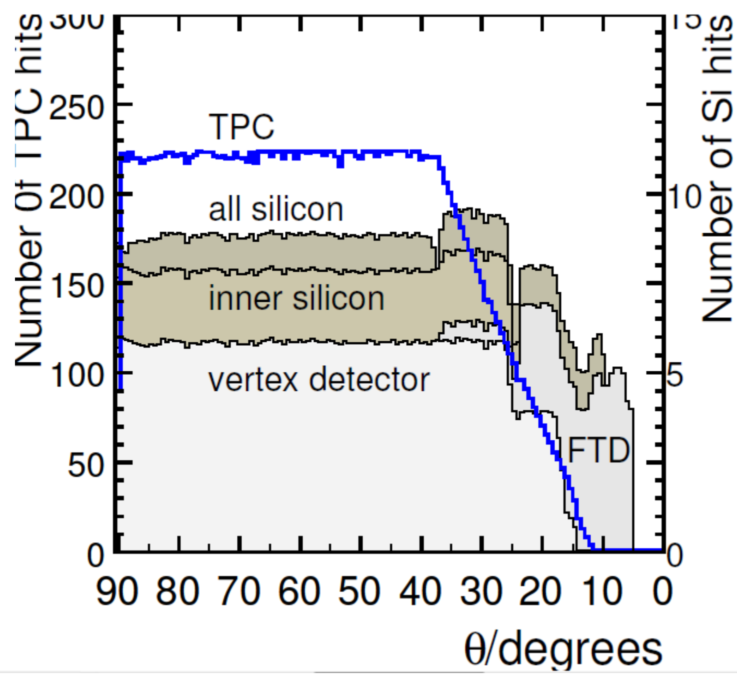
Need to move to a full cost – performance optimized system



ILD Tracking System



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

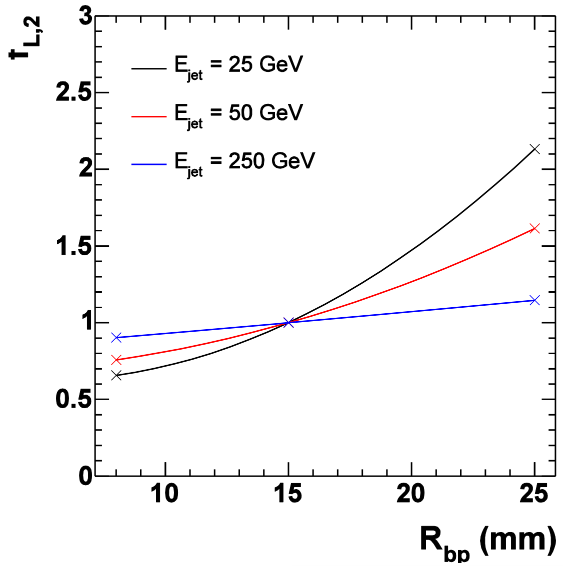


Hermetic, coverage down to very small forward angles.

ILD tracking

Vertex charge vs.
Inner radius

(S. Hillert, 2007)

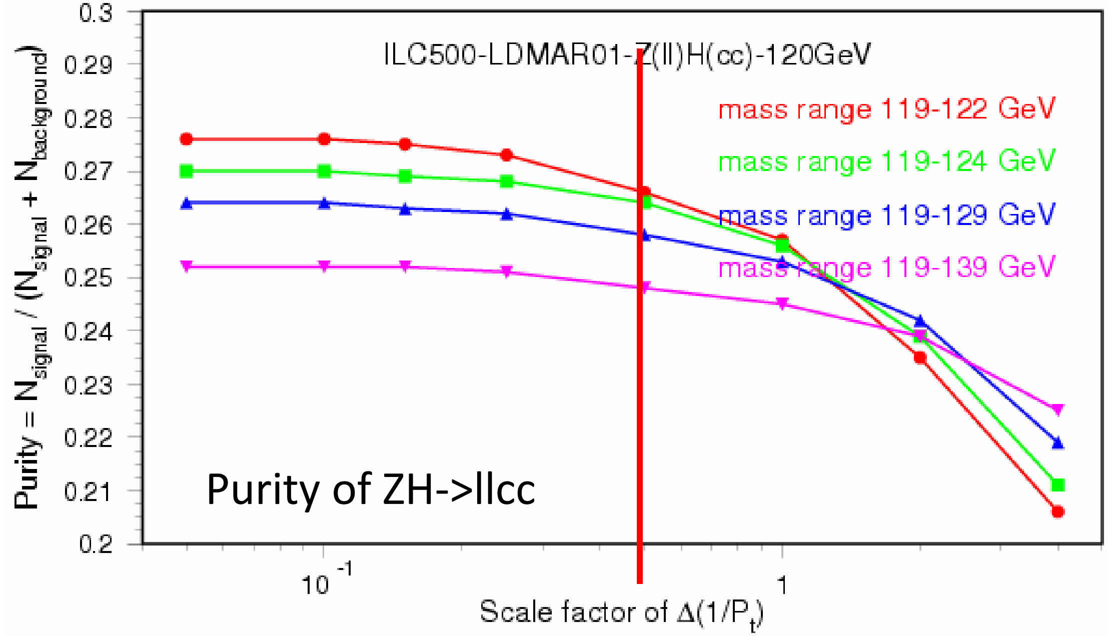


Impact on specific physics analyses?

Example (study by K.Riles, 2005):

Impact of momentum resolution on purity in ZH->llcc

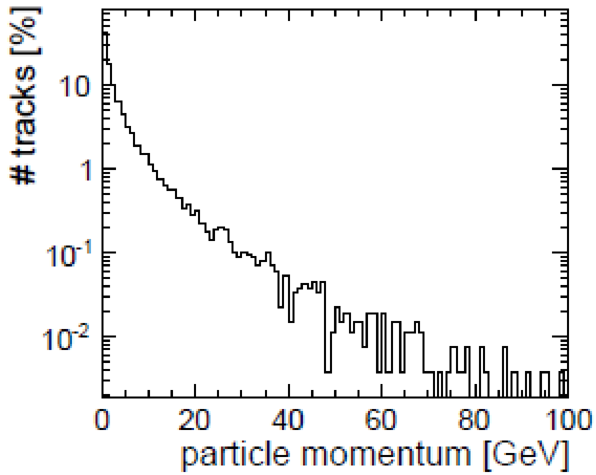
ILD needs to sharpen the arguments which define the ILD requirements.



Tracking issues

Low momenta

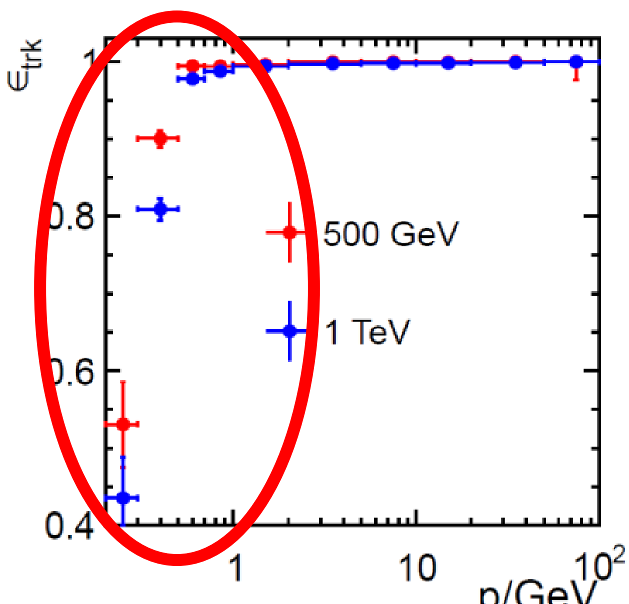
Zqqqq @ 500 GeV
42% of tracks <1 GeV

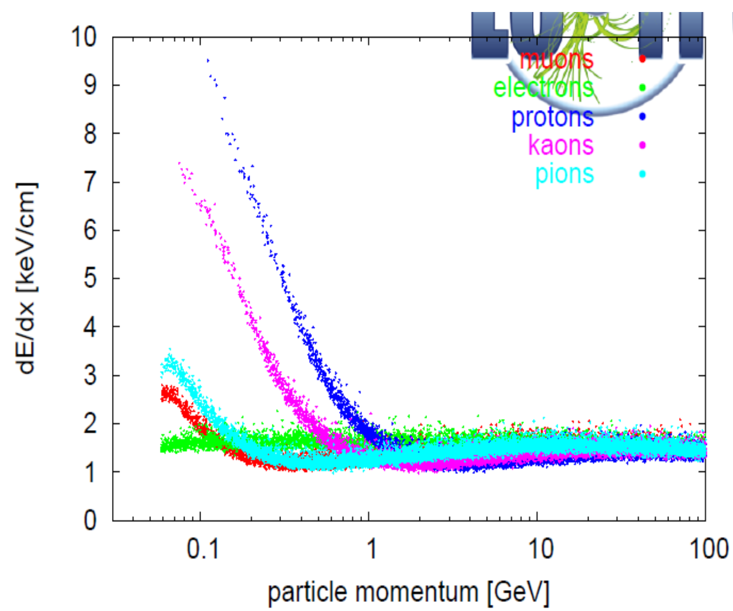


Low momentum reconstruction is an issue

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

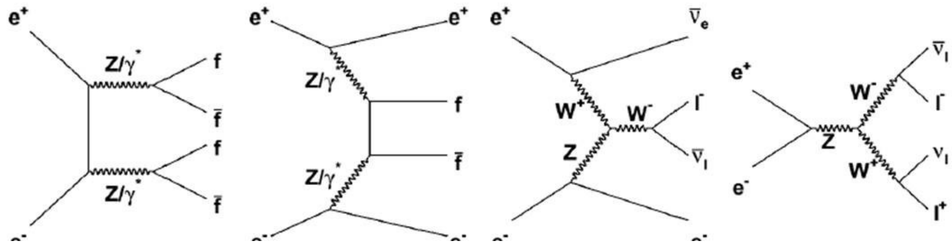
Efficiency for low momenta drops fast (<1 GeV)

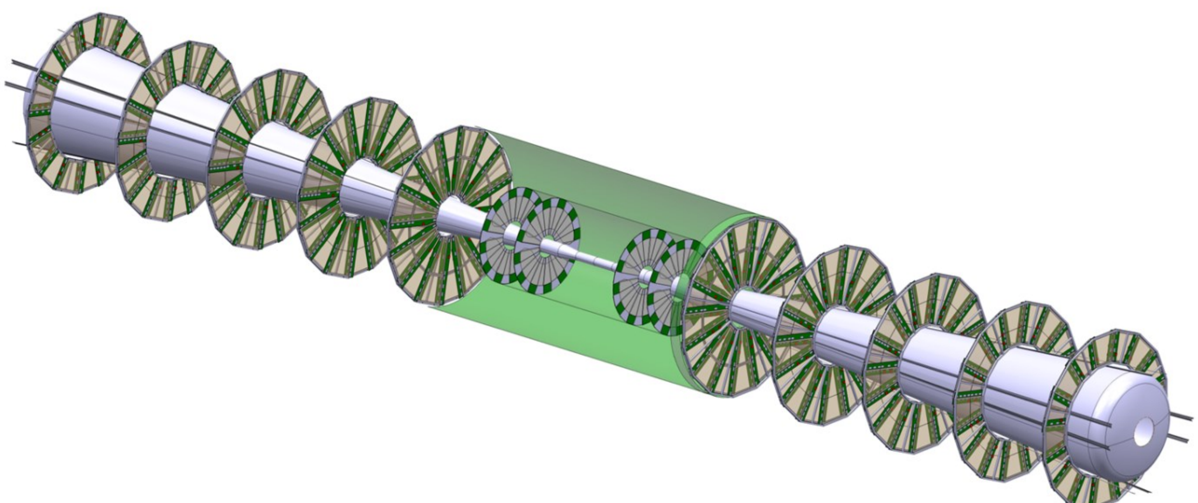




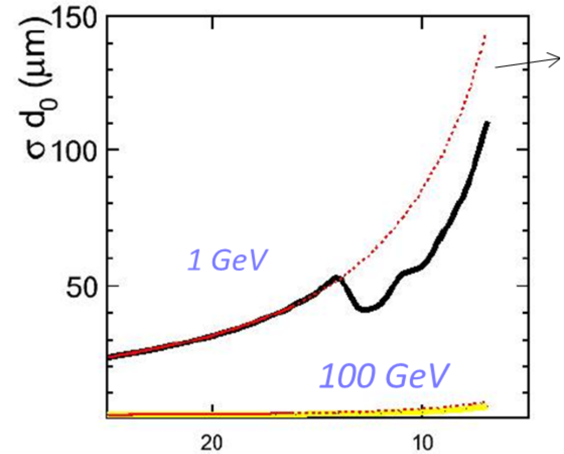
Forward Tracking

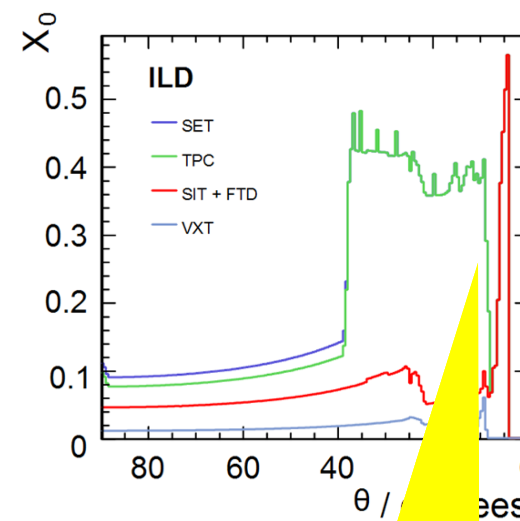
ILC physics:
Forward region is increasingly important





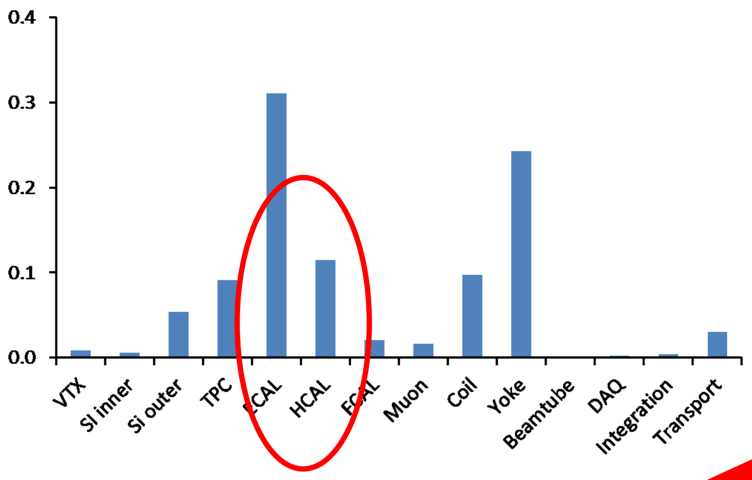
Forward tracking integral part of ILD
Purely Silicon based





Can we do better?

Calorimeter System



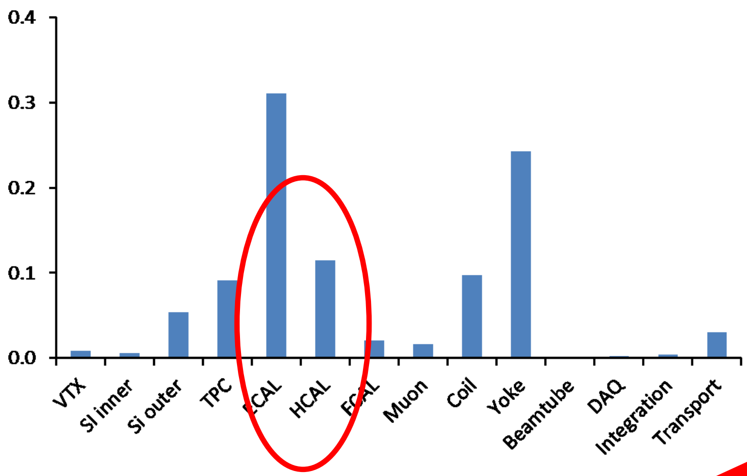
Calorimeter system is major cost driver

Technological developments
- Unit costs
- Alternative technologies

De-scoping

Optimization
- Layout
- size

Calorimeter System



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~~De-scoping~~

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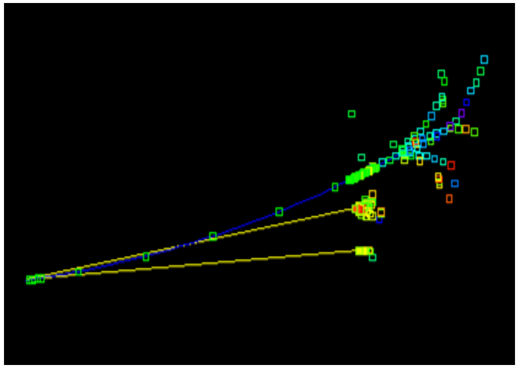
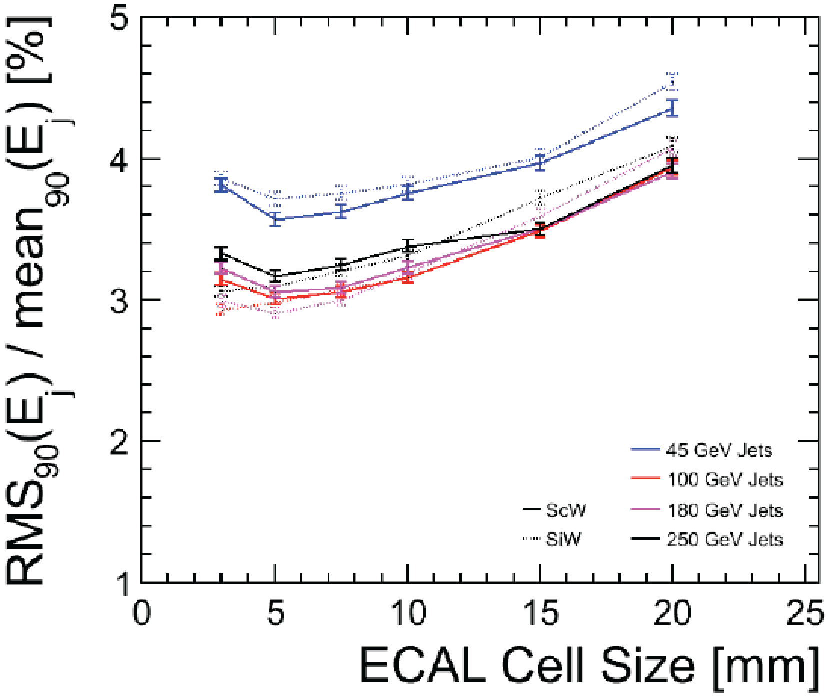
ECAL



SiW technology is current baseline:

- 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

ECAL

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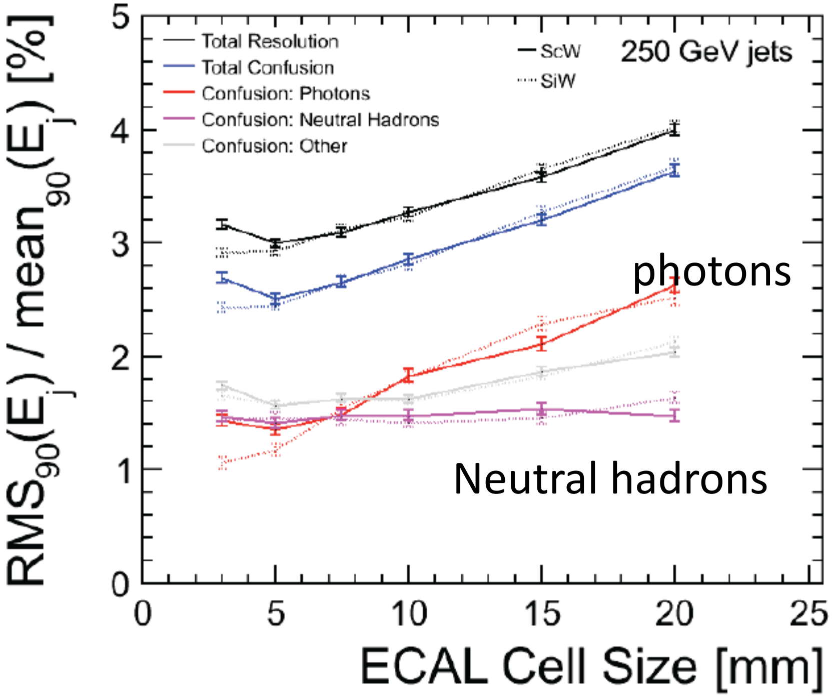

M.Thomson,J.Marshall, ILD meeting 2010

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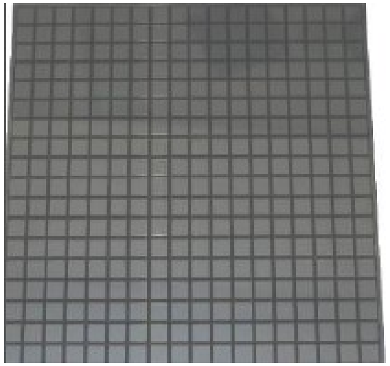
Confusion term for photons: compatible results
Hadron confusion: independent

Confirms previous studies by many authors

ECAL



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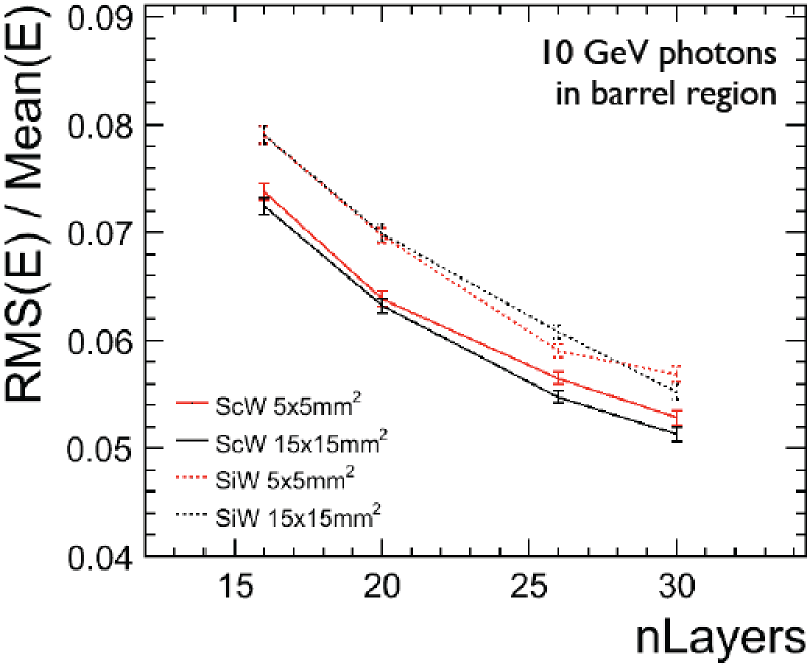

M.Thomson,J.Marshall, ILD meeting 2010

Studies have started to re-evaluate

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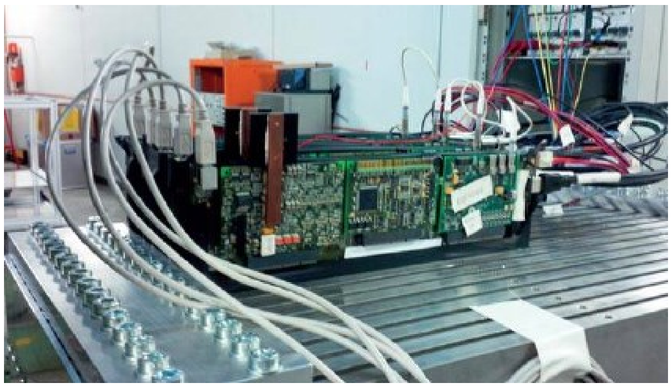
- Alternative technologies

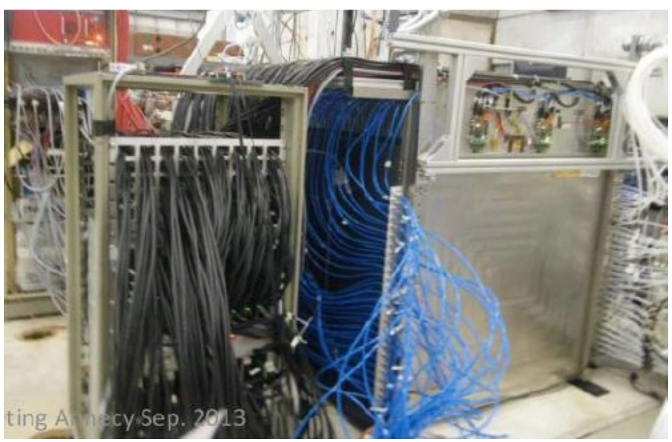
Number of layers: clear loss in performance expected and seen in simulation

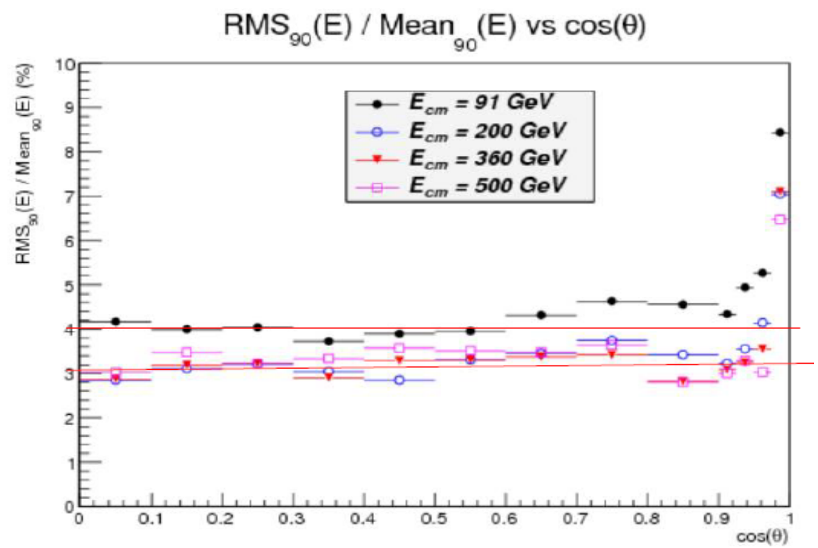
These studies are a start

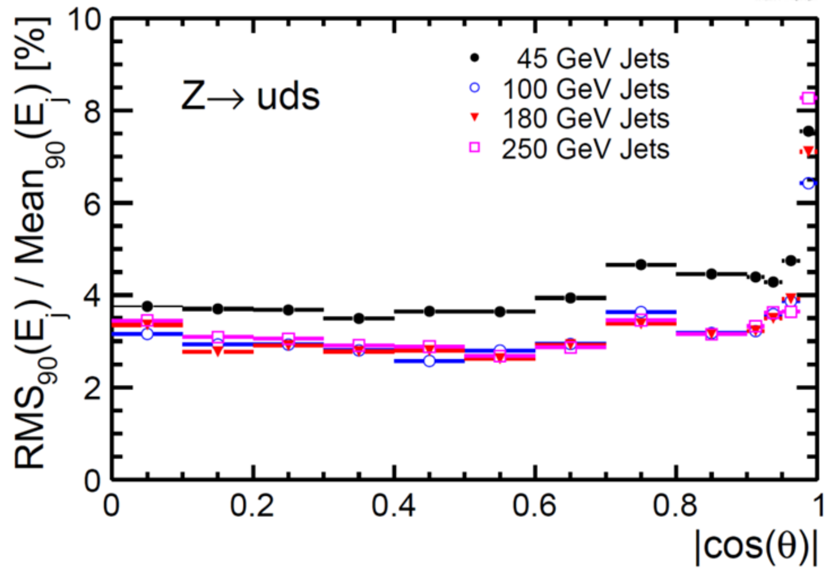
HCAL

HCAL performance is critical for PFLOW calorimeter





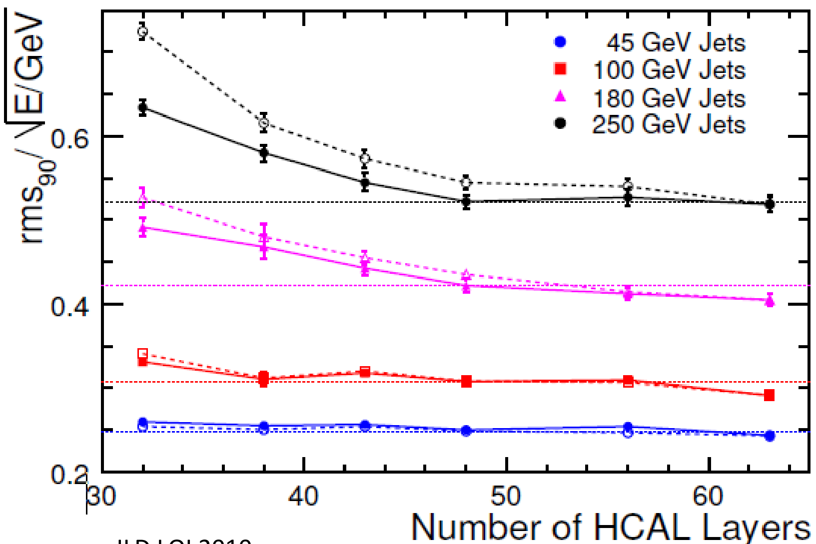




Jet-mass resolution for both HCAL technologies (analogu, semidigital)

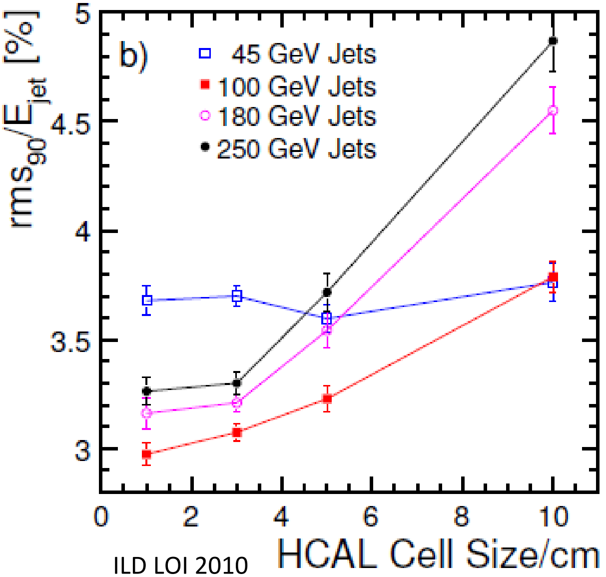
HCAL: Optimization

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

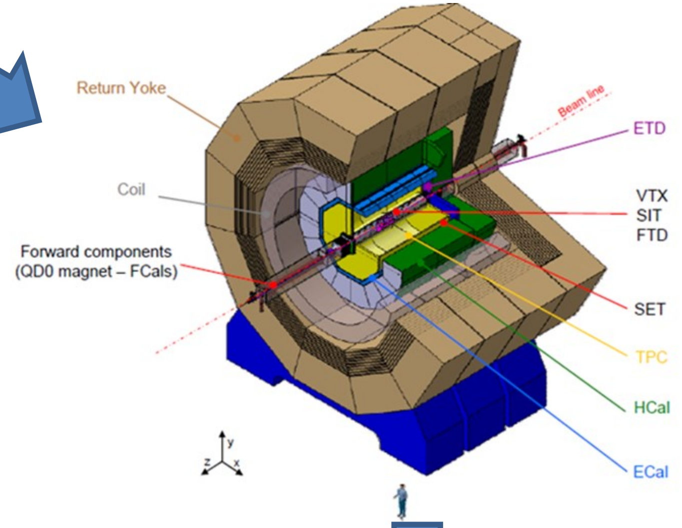
Needs to be re-visited for both technological options and with new code and algorithm.

Physics Impact

Standard model precision measurements

Higgs physics
(Recoil studies)

BSM physics



newILD

Apologies

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

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

To the enormous amount of R&D work done which I did not discuss

To the hard work and dedication of the physics group which I only touched

To the small but dedicated group which develops and provides the software and reconstruction tools

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


ILD meeting in Cracow, September 2013