ILD Detector Optimisation Strategy

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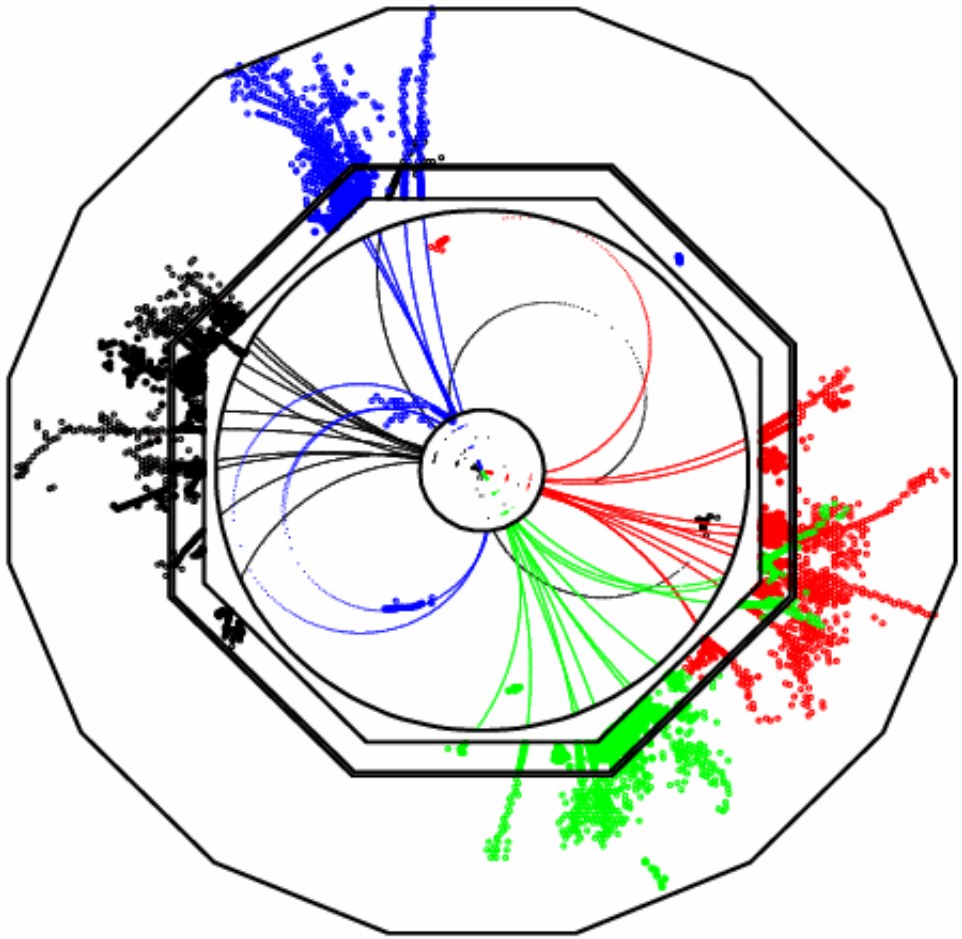


Overview:

1. What is ILD ?
2. How to Define Baseline
3. Optimisation Strategy
   - How ?
   - What ?
   - When ?
4. Summary

LDC → ILD ← GLD

★ How will GLD/LDC evolve into ILD ?

GLD/LDC have common features :

- ★ Both are Large Detector concepts, "Large" tracking volume
  - for particle separation
- ★ Both have TPC
  - for pattern recognition in dense track environment
- ★ Both have high granularity ECAL/HCAL
  - for Particle Flow

But also significant differences:

	LDC		GLD	ILD ?
Tracker	TPC		TPC	TPC
R =	1.6 m		2.1 m	1.5–2.0 m ?
B =	4 T		3 T	3–4 T
ECAL	SiW		Scint	SiW or Scint
HCAL	Steel	RPC / Scint	Scint	yes

Goal of ILD Optimisation Study

Current ILD Organisation

- ★ For the LoI phase: lightweight ILD "managerial" structure
- ★ In place for the LoI phase (will then re-evaluate)
- ★ Geared towards optimising detector on basis of physics (not just average of LDC and GLD)

ILD Steering Group:

Ties Behnke Henri Videau	Yasuhiro Sugimoto Hitoshi Yamamoto	Dean Karlen Graham Wilson

Working Groups:

Detector Optimisation:	MDI/Integration:	Costing:
Mark Thomson Tamaki Yoshioka	Karsten Buesser Toshiaki Tauchi	Akihiro Maki Henri Videau

Detector Optimisation Study

Charge of Detector Optimisation Working Group:

"Investigate the dependence of the physics performance of the ILD detector on basic parameters such as the TPC radius and B-field. On the basis of these studies and the understanding of any differences observed the WG, will make recommendations for the optimal choice of parameters for the ILD detector. It is the responsibility of the WG convenors to organize this work, while the steering board will assist them in executing the charge."

Initial Goal:

- First results from detector optimisation studies by 1st May 2008.
- At this time define baseline ILD detector parameters at the level needed to start writing the LoI

What it is not:

- The end of the story !
- Optimisation/Physics studies will continue through the EDR phase

For LoI:

- Convincingly demonstrate the ILD can meet ILC physics requirements
- Justifiable set of detector parameters optimised on scientific grounds

Optimisation Strategy

Basic Idea:

- Detector parameters optimised for physics performance
- Studies as realistic as possible:
  - Study signal + background Monte Carlo
  - Ideally include machine and underlying event backgrounds
- Use full detector simulation and reconstruction
  the tools exist for both LDC and GLD
- Aim to parameterize performance vs R_{TPC}, B, etc… (this WG)
- Then use cost model to optimize (results from this WG + cost WG)

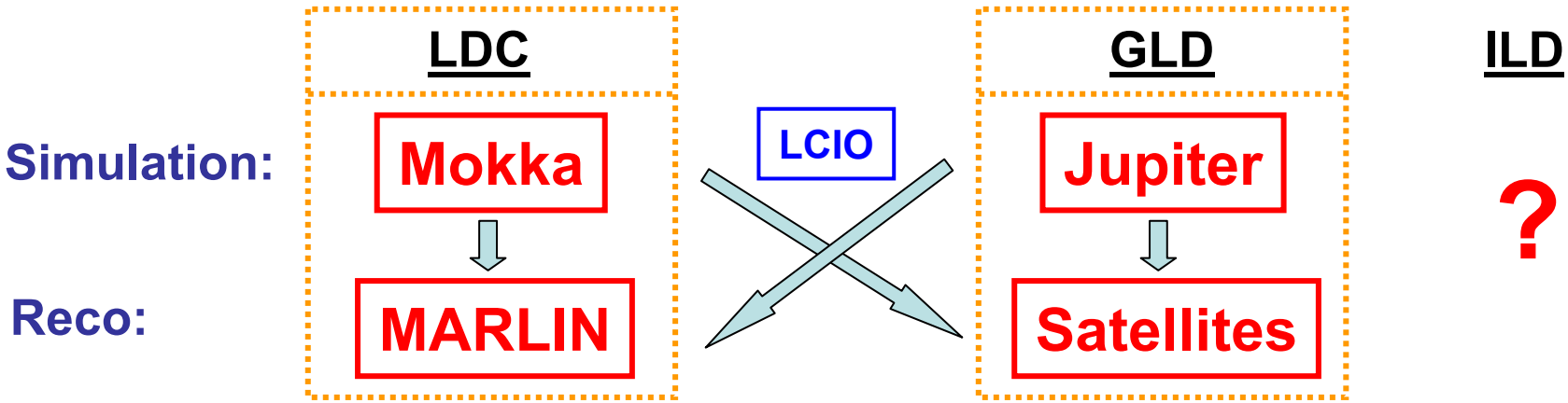
★ Given the timescale this is ambitious !
★ Need to be realistic about what can be done for the LoI
★ Need to collaborate effectively
★ Plans will evolve with experience…

Questions:

- For LoI what parameters are we optimising ?
- In practice, how we will do this ?
- On what timescale do things need to happen ?
- Manpower ?

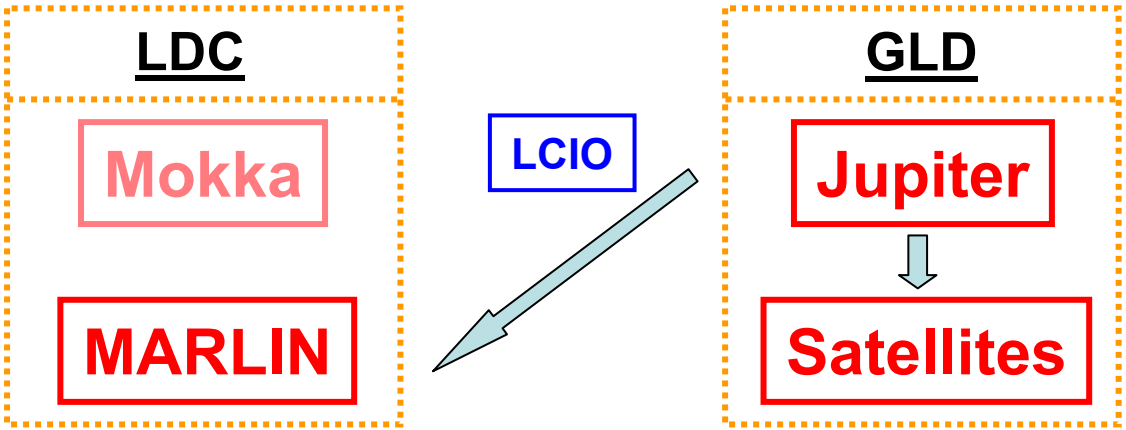
Optimisation Studies : How ?

- ★ Currently GLD and LDC use different G4 simulations/ reconstructin frameworks
- ★ Connected only by common data format

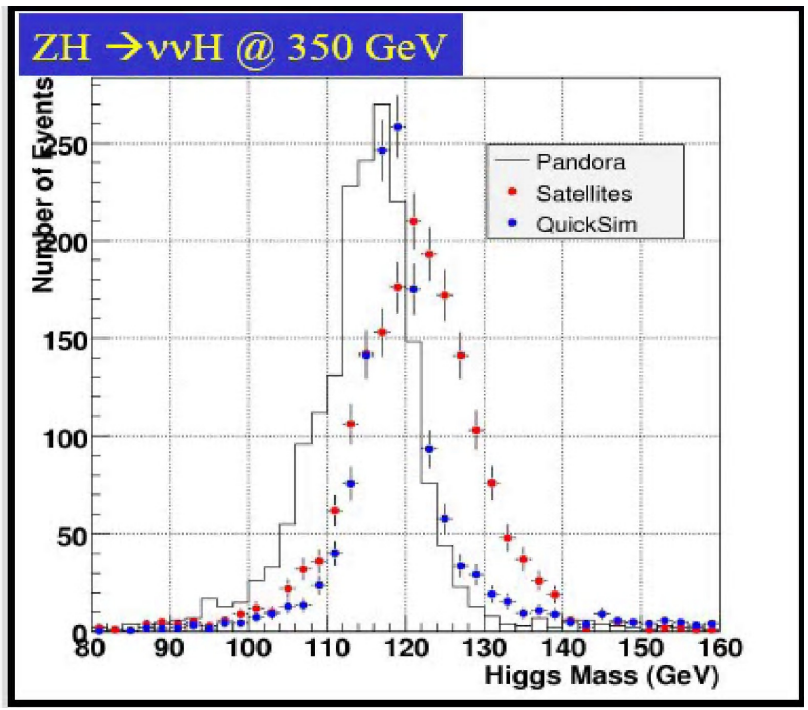


- ★ Given LoI timescale, decided to perform ILD detector studies in context of both GLD and LDC
- ★ Study physics performance dependence by changing parameters of GLD and LDC – provide some cross check of conclusions
- ★ Can directly compare results using LCIO…

e.g.



- Very nice demonstration of Marlin processing of Jupiter GLD events
- Such cross-software studies will be very important in optimisation of ILD detector
- To do this properly – software developers need to ensure that reconstruction is optimised for both LDC and GLD



LDC'/GLD' Common Parameters

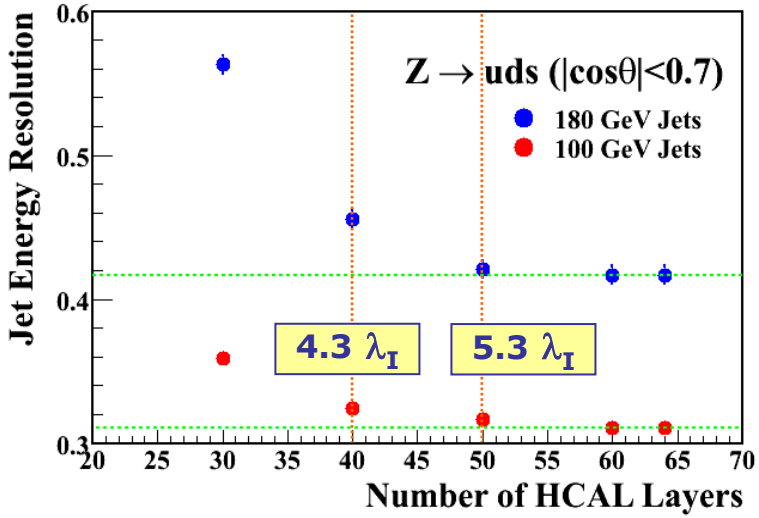
★ In addition, define and simulate a common point: LDC' and GLD' : a larger version of LDC and a smaller version of GLD

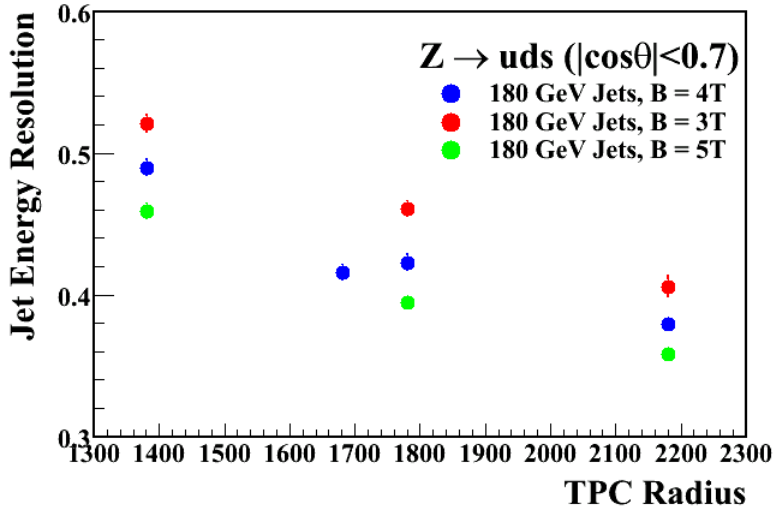
Sub-Detector	Parameter	GLD	LDC	GLD'	LDC'
TPC	R_{inner} (m)	0.45	0.30	0.45	0.30
	R_{outer} (m)	2.00	1.58	1.80	1.80
	Z_{max} (m)*	2.50	2.16	2.35	2.35
Barrel ECAL	R_{inner} (m)**	2.10	1.60	1.85	1.82
	Material	Sci/W	Si/W	Sci/W	Sci/W
Barrel HCAL	Material	Sci/W	Sci/Fe	Sci/Fe	Sci/Fe
Endcap ECAL	Z_{min} (m)***	2.80	2.30	2.55	2.55
Solenoid	B-field	3.0	4.0	3.50	3.50
VTX	Inner Layer (mm)	20	16	18	18

Region between VTX and TPC unchanged – time
*GLD TPC z_{max} = 2.3+0.2 m for readout (included in LDC z_{max})
**Fixed by TPC outer radius – LDC assumes slightly less space
***Fix ECAL z_{min} and allow this to determine TPC z_{max}

Optimisation Strategy : What ?

★ Not working in the dark - e.g. PFLOW studies





★ Very good reasons to believe ILD can deliver the require performance

★ But need to move to full physics studies to prove this

Optimisation priorities

★ Study parameter space "between" LDC and GLD

★ To study the full matrix of detector parameter space (R, B, L, …) would prove very time consuming

★ Initially concentrate on main parameters (**R** and **B**)

- will need to do this to exercise full reconstruction chain

Monte Carlo Generation

- ★ The detector optimisation studies (for different detector parameters) will require multiple large MC data-sets
- ★ Intend to generate samples centrally (use of GRID will be vital)
  - **benefit:** avoids unnecessary repetition of work
  - there already exists a proposal for SM background samples (should be discussed at another meeting)
  - base samples on SLAC STDHEP files to provide commonality with other concept studies
- ★ Ideally run reconstruction centrally (use of GRID will be vital)
  - **benefit:** ensures correct reconstruction versions/steering
  - **benefit:** some physics analysis could start from reconstructed PFOs
- ★ Backgrounds:
  - **Ultimately:** must include "beam" backgrounds (beam + $\gamma\gamma$) in physics analysis
  - **Initially:** develop analyses without "beam" backgrounds
  - **In parallel:** develop tools for including backgrounds – file merging etc.

Detector Optimisation: channels

- New research director + IDAG will define a minimal set of processes which must be included in the LoI
- Final choice will take into account input from the concepts
- Initial suggestion from RD and WWS Detector Roadmap group is to use "minimal list" of hep-ex/0603010:

0. Single $e^{\pm}, \mu^{\pm}, \pi^{\pm}, \pi^0, K^{\pm}, K^0_S, \gamma: \ 0 < |\cos\theta| < 1.0, \ 0 < p < 500\,\mathrm{GeV}/c$
1. $e^+e^- \to f\overline{f}, \ f = e, \tau, u, s, c, b$ at $\sqrt{s} = 91, 350, 500, 1000$ GeV
2. $e^+e^- \to Zh \to \ell^+\ell^- X : m_h = 120\,\mathrm{GeV}$ at $\sqrt{s} = 230/350(?)\,\mathrm{GeV}$
3. $e^+e^- \to Zh, h \to c\overline{c}, \tau^+\tau^-, WW^* : m_h = 120\,\mathrm{GeV}$ at $\sqrt{s} = 350\,\mathrm{GeV}$
4. $e^+e^- \to Zhh \ : m_h = 120\,\mathrm{GeV}$ at $\sqrt{s} = 500\,\mathrm{GeV}$
5. $e^+e^- \to \tilde{e}^+_R\tilde{e}^-_R$ at Point 1 at $\sqrt{s} = 500\,\mathrm{GeV}$
6. $e^+e^- \to \tilde{\tau}^+_1\tilde{\tau}^-_1$ at Point 3 at $\sqrt{s} = 500\,\mathrm{GeV}$
7. $e^+e^- \to \tilde{\chi}^+_1\tilde{\chi}^-_1/\tilde{\chi}^0_1\tilde{\chi}^0_1$ at Point 5 at $\sqrt{s} = 500\,\mathrm{GeV}$

- However, ILD detector optimisation studies not restricted to this list
- Should be driven by optimisation needs and physics interests of those involved (aim to maximise participation in this study)

Optimisation Strategy : Who ?

From LDC side (for GLD see Tamaki's talk)

- ★ Currently trying to build a picture of ILD physics interests
- ★ The list below is by no means complete (please email me…)
- ★ Already very encouraging !

Channel/Area	Topic	Groups
$e^+e^- \rightarrow Zh$	Recoil mass l^+l^-X	DESY-Zeuthen/MPI, LAL
	Branching Ratio	Edinburgh, Bristol,
	Direct mass	DESY-Zeuthen/MPI
	Heavy Higgs	DESY
$e^+e^- \rightarrow Zhh$		RHUL
e+e-→selectrons		MPI
e+e-→smuons		MPI, DESY
e+e-→stau stau		DESY, RHUL, LPNHE-LAL
e+e-→WWνν/ZZνν		Cambridge, DESY
e+e-→tt	6 jet final states	RAL
	ttZ tbW vertices	Krakow
de/dx	meta-stable staus	DESY(Schafer)
Single gammas	rad. χ^o	Edinburgh(Martin)
Vertex Charge	c cbar/ b bbar	Oxford(Hillert,Jeffery)
tau polarization		RHUL
Kinks	GMSB	Santa Cruz

★ **Also need effort in developing reconstruction tools:**

Vertex Reconstruction	LCFI
Particle Flow	Cambridge, DESY
Tracking	DESY-Zeuthen/MPI
Particle ID	DESY-Zeuthen/MPI
Lumi Cal.	Krakow
Forward Tracking	Indiana/Loiusiana

★ **In addition to developing these tools (the fun bit) – will need ensure they work for the different detector models…**

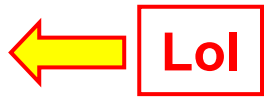
Optimisation Strategy : When ?

- ★Performing physics-based detector optimisation studies on the timescale of the LoI is not going to be easy…
- ★People can start developing analysis using current tools/detector models (this is already happening)
- ★Will soon need move to "mass production"
- ★This will require some organisation and a lot of thought…
  - make sure the simulation is right before generating large MC sample:
    e.g. for recoil mass in $Zh \to \ell^-\ell^+X$ may benefit from very good momentum resolution – ensure SET is included in LDC simulation ? (raised by Ron)
  - validate reconstruction (multiple times)
  - inclusion of backgrounds…
- ★Want first results well in advance of LoI deadline…

→ **Strawman timetable…**

Working backwards…

Task	"Deadline"	Status
Final version of Letter of Intent	Oct 08	
Refine results and LoI performance section	Aug 08	
First draft of LoI physics performance section	Jul 08	
Define ILD Baseline Parameters ! Need	May 08	
Physics Optimisation Results	May 08	
Preliminary results for TILC 08 (Sendai)	Mar 08	
Status reports of Physics Studies ILD mtg. (Europe)	Jan 08	
Start of mass reconstruction of physics samples	Jan 08	
Validation of reconstruction software	15th Dec 07	
Start of mass generation of physics samples	1st Dec 07	
GLD'/LDC' in Mokka/Jupiter	1st Dec 07	
Define GLD'/LDC'	15th Nov 07	In progress
Check Mokka/Jupiter LCIO compatibility	15th Nov 07	
LDC baseline in Mokka	15th Nov 07	In progress
GLD baseline in Jupiter	15th Nov 07	Done
Define LDC v5 baseline parameters		Done (final?)
Define GLD baseline parameters		Done
Start Developing physics analysis	ASAP	In progress



Summary

- There is a lot of ground to cover in the run up to the LoI
- Need to demonstrate ILD can deliver the required physics performance and determine "optimal" detector parameters
- Given the timescale we cannot expect to do everything (that's
- for the EDR phase)
- Important not to be overly ambitious – if in 9 months time we have well-justified choice of the detector's size and B-field based on physics this effort will have been a success (of course can hope for more)

The good news:

- The tools exist !
- The work is going to be extremely interesting !
- Potentially have significant manpower – if we can collaborate effectively, no reason why we can't succeed.