ILD and the UK

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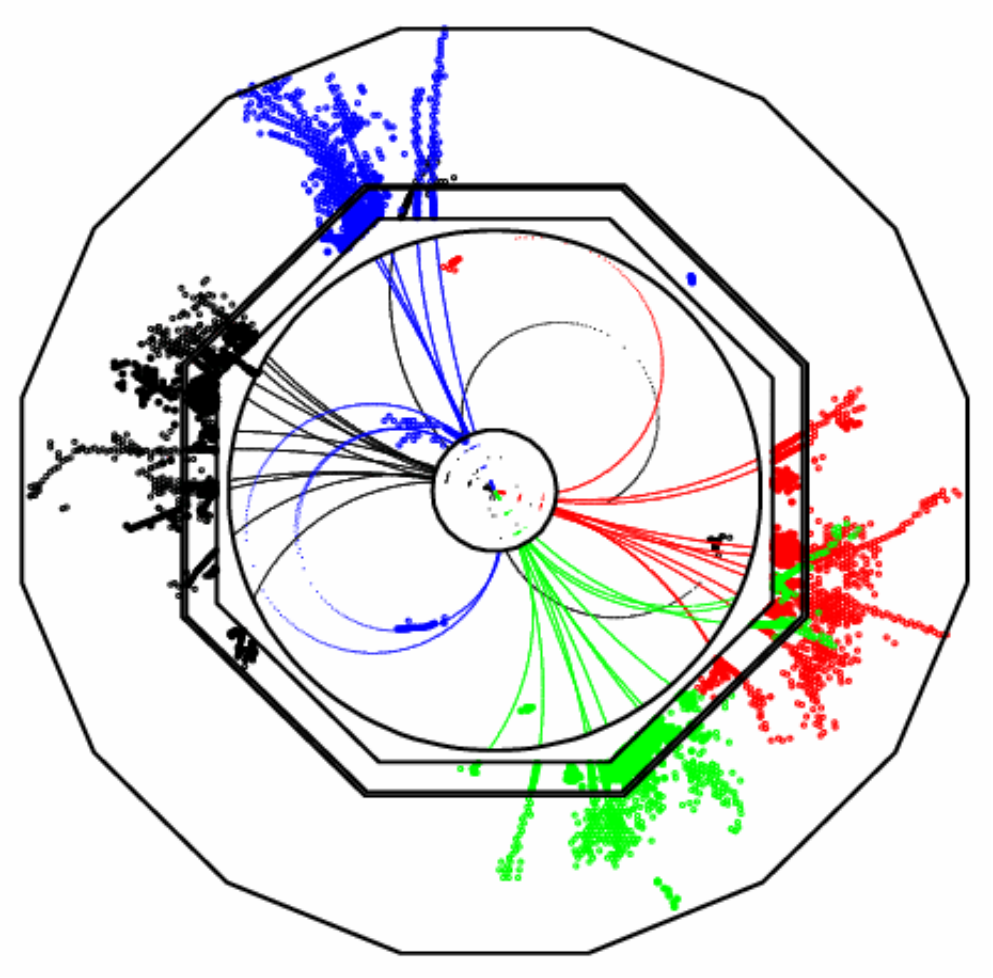


This talk:

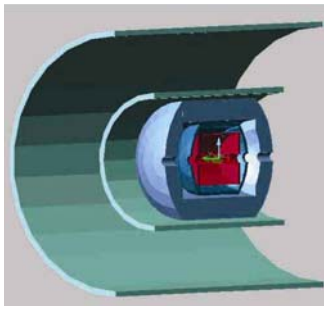
1. ILD and the UK context
2. Relation to CALICE/LCFI
3. LDC → ILD ← GLD
4. ILD-UK
5. Detector Optimisation
6. Summary
7. BaaQuack

❶ Global Context : 4 become 3

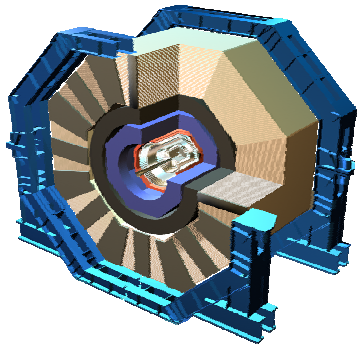
ILC Detector Concepts:

- ★ Until recently ILC Detector Design work centred around 4 detector "concepts"
- ★ 3 of these concepts "optimised" for PFA Calorimetry SiD, LDC, GLD
- ★ Recently GLD and and LDC agreed to work towards joint detector concept

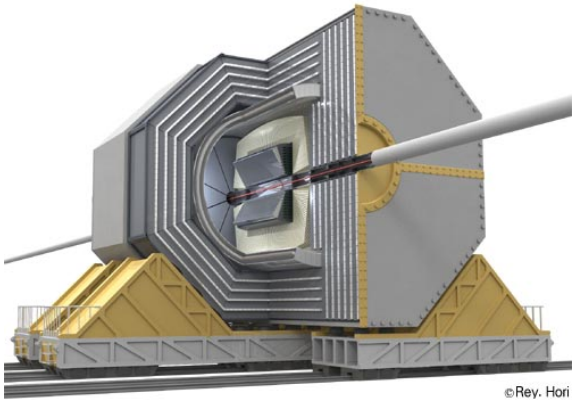
"4th"



SiD : Silicon Detector



GLD : Global Large Detector



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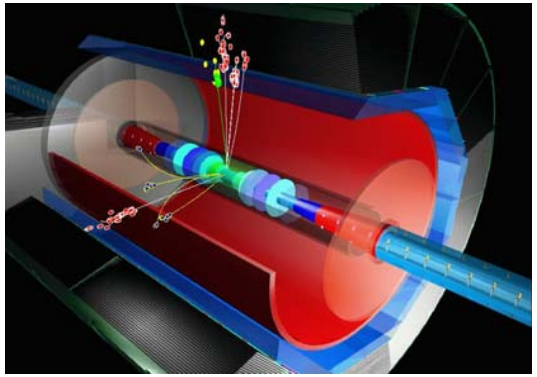
LDC : Large Detector Concept
(spawn of TESLA TDR)



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ILD

ILD Organisation

- ★ For the LoI phase: lightweight ILD "managerial" structure
- ★ Only in place until LoI is out of the door (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

UK Context

- **Currently main GLD/LDC effort:**
  - **LDC: Germany, France + UK**
  - **GLD: Japan, Korea**

  } **ILD**

- **Conveniently, this is the ideal time for the UK to join ILD effort:**
  - **ILD is not fixed in stone – over the next year there will be major effort to choose/optimise parameters (size, B-field, etc.) based on ILC physics sensitivity**
  - **The simulation/software tools exist - UK has already made a major contribution here – build on this expertise + vast experience from LEP (ALEPH, DELPHI, OPAL)**
  - **Need to input realistic engineering details, e.g. power, cooling, DAQ, and cost; all will impact design.**
- **Real opportunity for UK to play a leading role in these studies**

❷ Relation to CALICE, LCFI, LC-ABD

- ★ **Need to consider UK involvement in ILD in light of existing (and extremely successful) UK activities**
  - **Calice**
  - **LCFI**
  - **LC-ABD**
  - **Phenomenology**
- ★ **UK ILD involvement needs to build on this strength**
  - **In immediate future (LoI) "unlikely" to get much new funding**
  - **Difficult to start genuinely new activities**
    - ⇨ **so the approach is to focus current efforts towards ILD**
  - **Take care not to fragment/harm existing LCUK programme**
- ★ **ILD ↔Calice/LCFI**
  - **If handled carefully, ILD involvement should benefit ongoing R&D projects:**
    - **Place work in the larger context**
    - **Build closer ties between activities, e.g. vital for studies of physics sensitivities**

❸ LDC → ILD ← GLD

★ How will GLD/LDC evolve into ILD ?

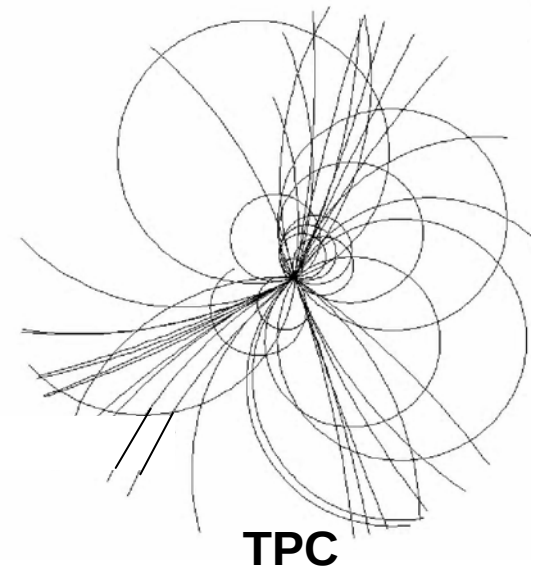
GLD/LDC have common features:

- ★ 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

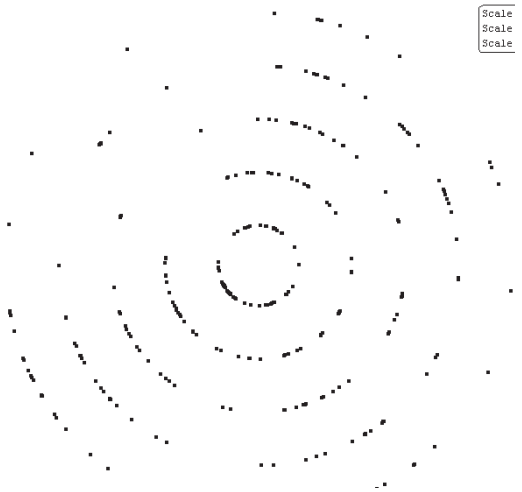
	LDC		GLD	ILD ?
Tracker	TPC		TPC	TPC
R =	1.6 m		2.1 m	1.5–2.0 m ?
B =	4 T		3 T	3–4 T
ECAL	SiW		Pb/Scint	SiW or Pb/Scint
HCAL	Steel	RPC / Scint	Pb/Scint	yes

Goal of ILD Optimisation Study

Design Issues : why a TPC ?



TPC



Silicon Tracker

★ Large number of samples vs. “few” very well measured points

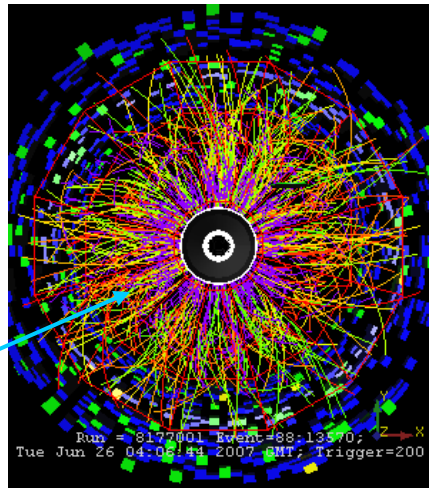
★ From point of view of momentum reconstruction both can deliver required momentum resolution

So why a TPC ?

★ Good pattern recognition capability even in a dense track environment

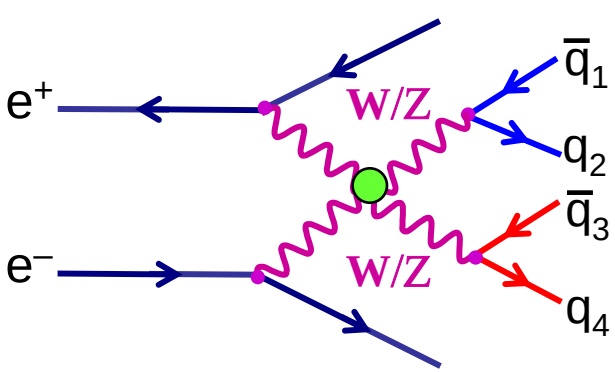
- This is important for particle flow
  – need high efficiency reconstruction of “loopers” and “kinks”

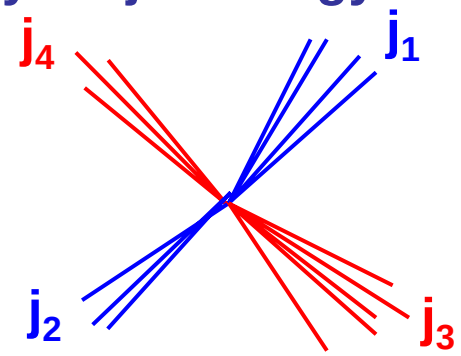
★Tried and test technology (ALEPH, DELPHI, STAR,…)



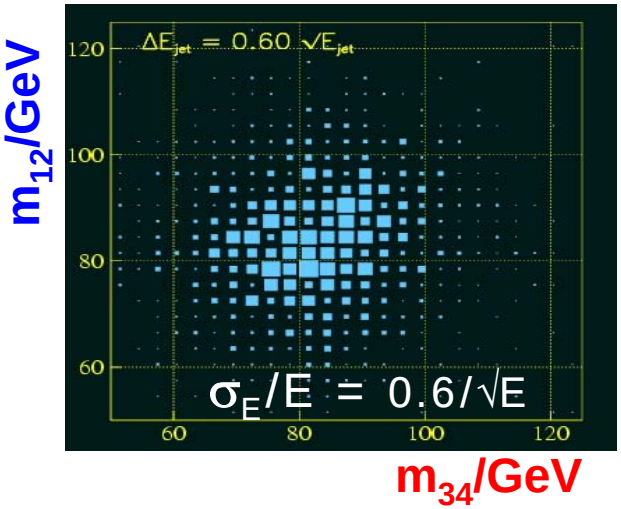
Design Issues : Calorimetry

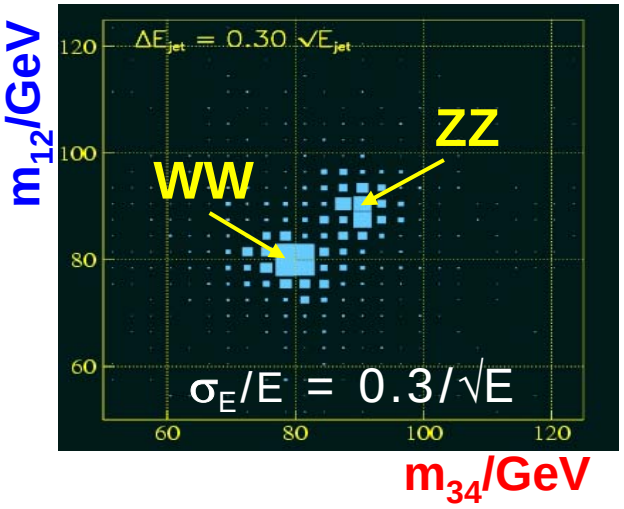
★ ILC Physics performance - depends strongly on jet energy resolution





Reconstruction of two di-jet masses discriminates WW and ZZ final states





★ Particle Flow most promising approach

★ Demonstrated that LDC (i.e. an ILD sized detector, with "CALICE-style" ECAL/HCAL, B = 4 T, and a TPC) can deliver the required performance

ILD Calorimetry

ILD designed for particle flow:

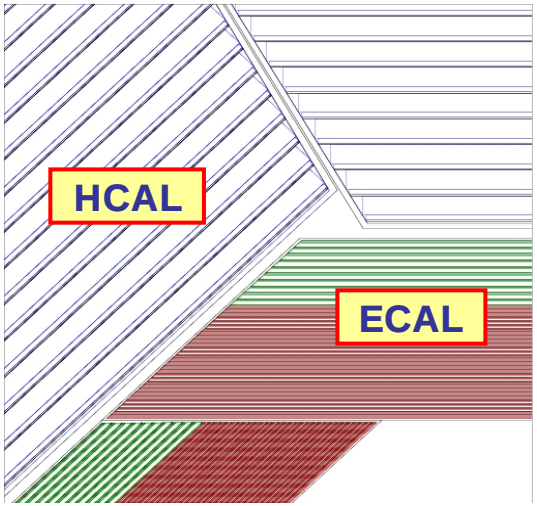
- ★ECAL and HCAL inside coil
- ★Very high segmentation (transverse and longitudinal)

ILD ECAL

Two options…

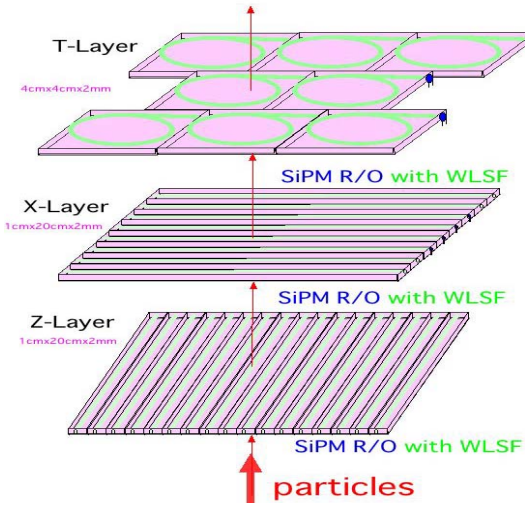
★**CALICE-style SiW calorimeter:**

- Lateral segmentation: ~1cm^2 ~ $R_{Moliere}$
- Longitudinal segmentation: 30 layers
- Typical resolution: $\sigma_E/E = 0.15/\sqrt{E(GeV)}$



★**GLD-style Scint-W calorimeter:**

- Achieve effective ~1cm^2 segmentation using strip/tile arrangement
- Strips : 1cm x 20cm x 2mm
- Tiles : 4cm x 4cm x 2mm



ILD Hadron Calorimeter

Again Highly Segmented – for Particle Flow

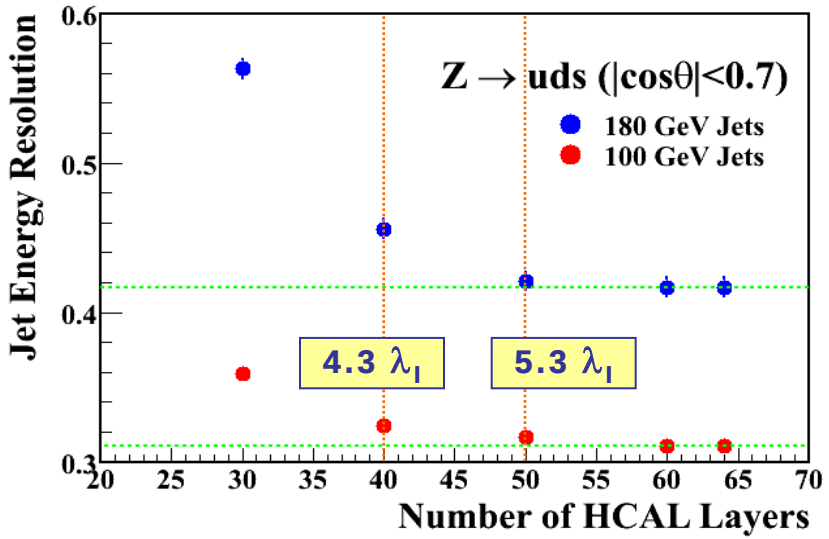
- **Longitudinal: ~40 samples**

Two main options:

- **Tile HCAL (Analogue readout)**
- **Steel/Scintillator sandwich or Pb/Scintillator sandwich**
- **Segmentation ~ 3x3 cm2**

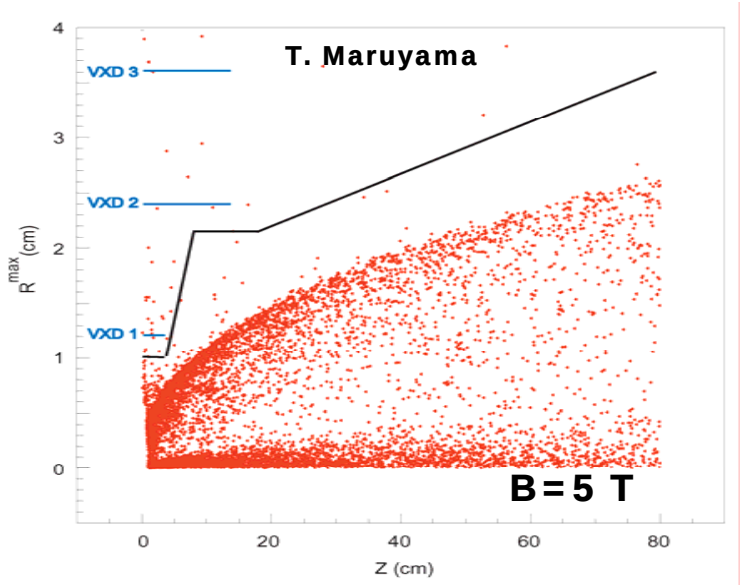
- **Digital HCAL**
- **Segmentation**
- **RPCs, wire chambers, GEMS…**

★ **Optimisation studies needed (many interesting questions)**



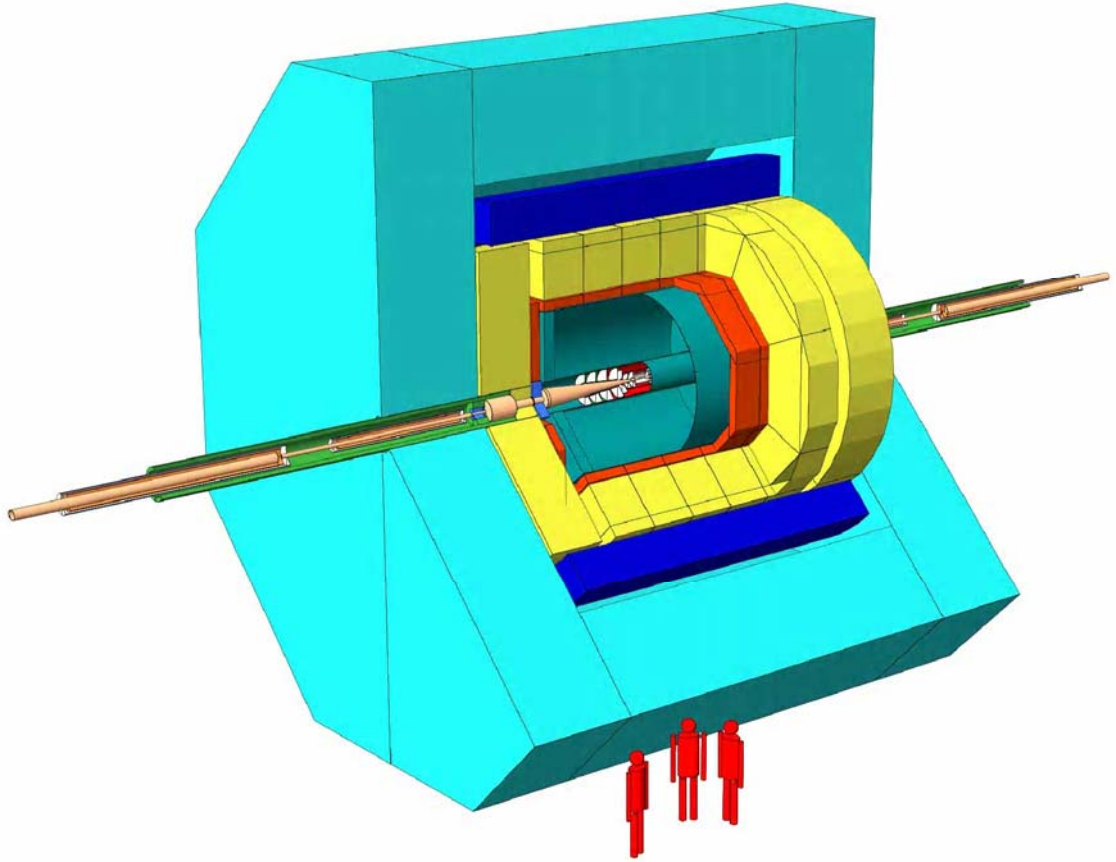
+global considerations

- ★ For PFA want : Large B-field + large radius
- ★ BUT MANY OTHER CONSIDERATIONS…
  - Tracking:
    - momentum measurement argues for large detector
  - Flavour tagging:
    - want inner layer of Vertex detector as close to IP as possible
    - limited by beam background
    - argues for large B



ILD Baseline

- ★ As starting point for ILD optimisation need to define baseline detector
- ★ Not just an average of GLD/LDC parameters
- ★ Not working in the dark - build on TESLA/LDC/GLD studies
- ★ Will be defined very soon
- ★ A larger version of **LDC** with **GLD** calorimetry an option ??????



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❹ UK Participation in ILD

- ★ ILD only recently formed
  - ★UK involvement still evolving…
- ★ Currently 6 UK groups intend to participate in ILD studies
  - Birmingham
  - Cambridge
  - Edinburgh
  - Glasgow
  - Liverpool
  - Manchester

  + 3 groups interested but undecided
- ★ Started to discuss ILD-UK organisation
  - nothing finalised - wait until final make-up of ILD-UK known (all groups involved in the discussion)
  - but (for LoI phase) aim to keep this as lightweight as possible
- ★ Have a good feeling of general areas of participation (next slide)
  - again exact plans will evolve
  - intend to make this a coherent effort

ILD-UK plans

★**Emphasis:** build on areas of UK strength

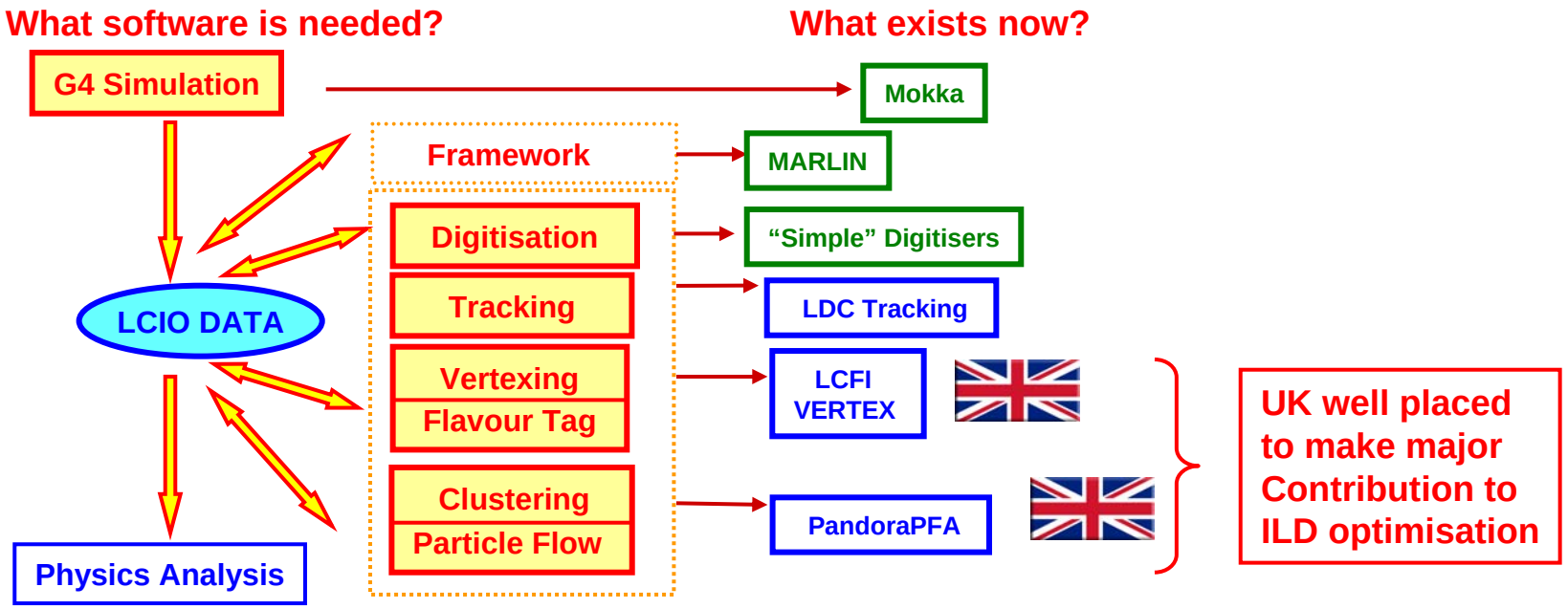
Current ILD-UK interests:

- ★ Vertex Detector Engineering
  - UK expertise in design/construction of Silicon detectors
- ★ Vertex Detector Reconstruction/Optimisation
  - UK already leading this through LCFI work (ties in physics)
- ★ Core Software
  - Expertise + close link to physics
  - Interest in GRIDifying European software framework
- ★ Calorimetry
  - Particle Flow Calorimetry + MAPS in ILD
- ★ Forward Region
  - Real opportunity here, hole in ILD
  - e.g. people starting to think about forward tracking
- ★ DAQ/Mechanical engineering
  - Build UK contributions in CALICE/EUDET
- ★ Physics Studies/Detector Optimisation
  - Build on PFA/vertexing expertise, i.e. combine CALICE/LCFI

❺ ILD Detector Optimisation

This will be THE main ILD effort leading up to LoIs (~1 year from now).

- ★ **Determine optimised "baseline" ILD parameters**
- ★ **At this point, must be based on realistic simulation/reconstruction**
- ★ **Challenging but:**
  - **Good starting point: well advanced GLD/LDC studies (+TESLA TDR)**
  - **Have the software tools needed (UK expertise)**



★ **Strongly couple UK work with "global" ILD Detector Optimisation study**

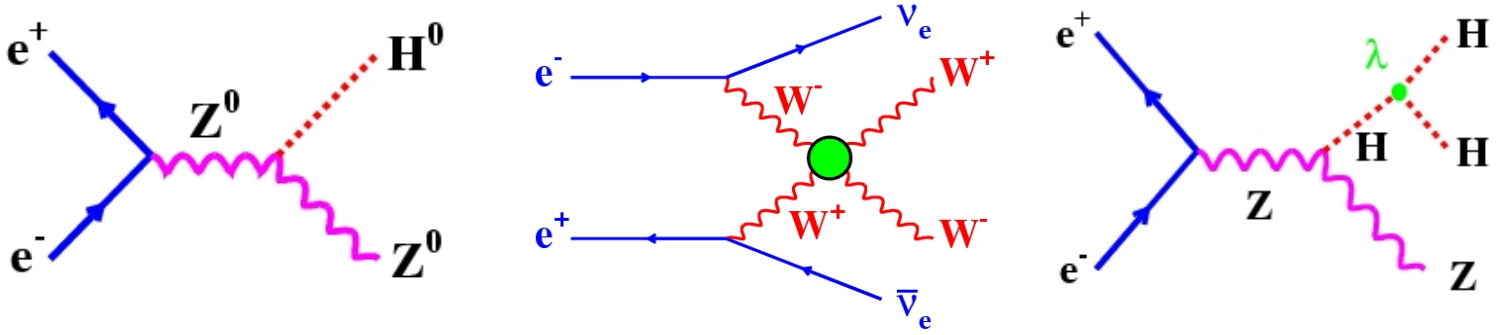
- **within ILD this effort is about to start in earnest**

ILD-UK Physics Strategy

TWO main aspects:

① physics analysis

★ UK will concentrate on a few key "benchmark" processes which challenge detector, for example (although not yet decided)…



★ ILD work for LoI geared towards optimising ILD

- rather than comparing ILD with SiD (unless RD requests a direct comparison)

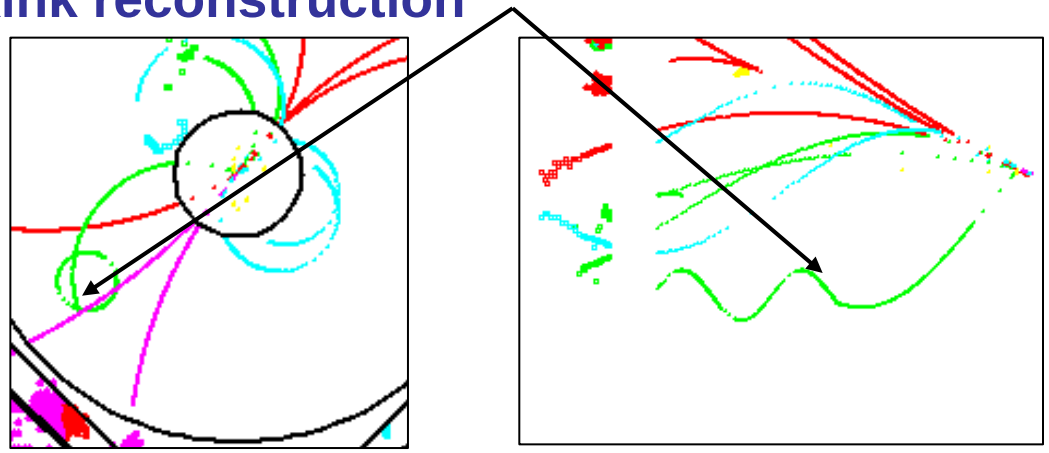
② Understanding how to use an ILC detector

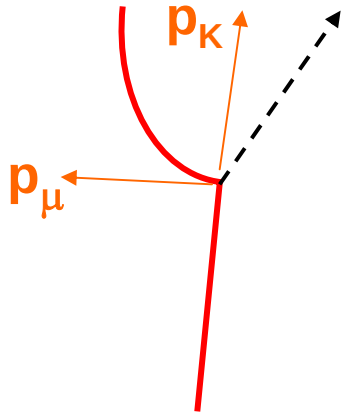
★ ILC detectors are very different from previous detectors

- Large improvements in performance c.f. other detectors (jet energy, impact parameter, momentum)
- Need to learn how to take advantage of this….

e.g. Kink reconstruction

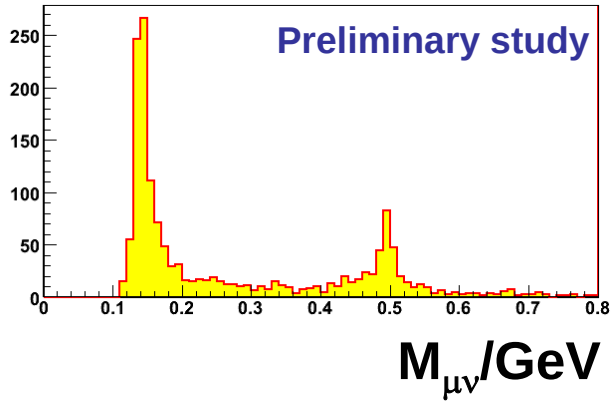
★ e.g. kink reconstruction





★ Identify kink in TPC

- Consider hypothesis, e.g. $K^{\pm} \rightarrow \mu^{\pm}\nu$
- Use Helix fits to start and end of tracks
- Can then reconstruct primary mass
- If consistent with $K^{\pm} \rightarrow \mu^{\pm}\nu$ or $\pi^{\pm} \rightarrow \mu^{\pm}\nu$ tag decay and effectively measure ν energy

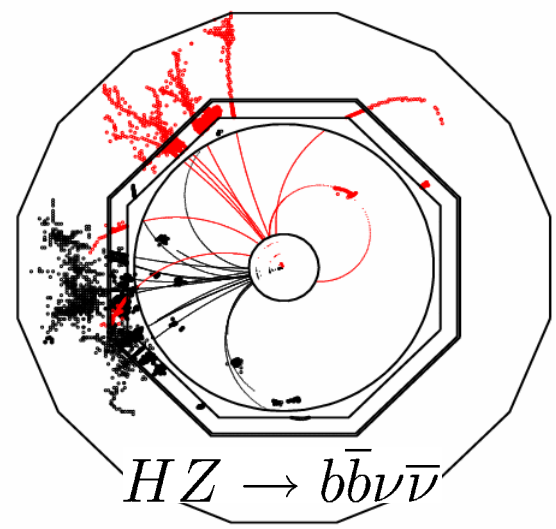


★ By taking advantages of TPC pattern recognition + excellent momentum improve PFA performance

Further Ideas

Two important areas with ILD-UK interest:

★ **b-jet energy reconstruction**



- **If there is a light Higgs**
- **Reconstruct mass from $H \to b\bar{b}$**
- **PFA jet energy resolution is important**
- **BUT mass resolution limited by neutrinos from semi-leptonic b decays**
- **Given excellent vertex detector, excellent**
- **momentum resolution + PFA particle reco.**

⇨ **reconstruct neutrino momentum**

Could have very large impact on ILC physics performance

★ **PFA + Vertexing : UK very well placed to study this**

★ **τ identification/decay reconstruction**

- **Identifying τ decay mode, e.g** $\tau^- \to \pi^- \nu_\tau$

vs. $\tau^- \to \rho^- \nu_\tau \to \pi^- \pi^0 \nu_\tau \to \pi^- \gamma\gamma \nu_\tau$

⇨ **handle on tau polarization**

PFA + Impact parameter

Summary

- ★ Many areas where UK can take the leading role in ILD
  - Build on expertise from CALICE/LCFI
- ★ Precise ILD-UK plans/organisation still evolving
  - Should be clearer in a few weeks time
- ★ Over next 6 months – detector optimisation is the highest priority
- ★ Full ILD simulation/reconstruction chain is "ready for real physics studies"
- ★ Already demonstrated LDC can meet ILC "detector goals" presumably ILD will be even better…
- ★ The time to start physics-based ILD optimisation
- ★ Already looks like we will have significant number of UK groups working in this area
- ★ Potential to build a very strong ILD-UK physics group – a great time to get involved in ILD…

to end: the important question…

UK-ILD or ILD-UK