



ILD Detector Optimisation

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Some aspects are deliberately provocative...



What to Optimise



★ A number of aspects:

Physics Performance

Cost

Single particle response

Technical feasibility

★ **Ultimately a balance between all aspects**

- **essential element: “judgement/common sense”**

➡ **don't make too many compromises at this stage**



How to Optimise ILD?



First ask the right questions



★ The answer to any optimisation procedure will depend on the questions asked:

e.g. minimise $\left(\frac{\partial T}{\partial t}\right)_V \propto -\frac{S}{V}$



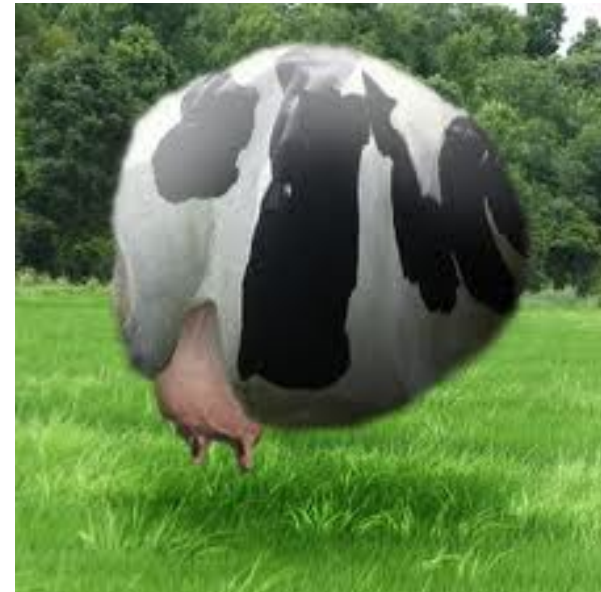


Ask the right questions



- ★ The answer to any optimisation procedure will depend on the questions:

e.g. minimise $\left(\frac{\partial T}{\partial t}\right)_V \propto -\frac{S}{V}$



- ★ unfortunately the optimised cow could not eat and died...



How to fold in cost



- ★ **Cost optimisation is very difficult:**
 - **performance at fixed cost: can make some solid statements**
 - **but if you let cost vary... a more difficult path**



How to fold in cost



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How to fold in cost

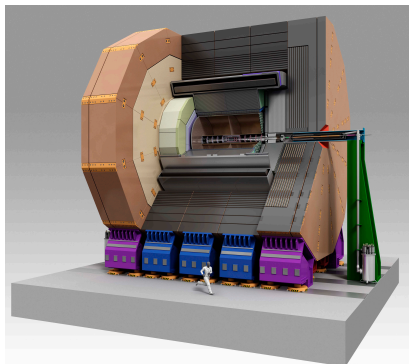


★ Cost optimisation is very difficult:

- performance at fixed cost: can make some solid statements
- but if you let cost vary... a more difficult path



ILD as of today



- ★ Probably need to move in this direction
 - but not too far...

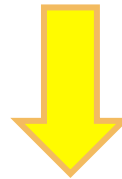


How to Proceed?



★ **Now the DBD is done and dusted...**

- we have the opportunity to revisit ILD design decisions
- but how to proceed with ILD optimisation ?



★ **Identify the key questions we wish to answer**

- divide the work into manageable tasks
- help to **focus** the effort



Heresy



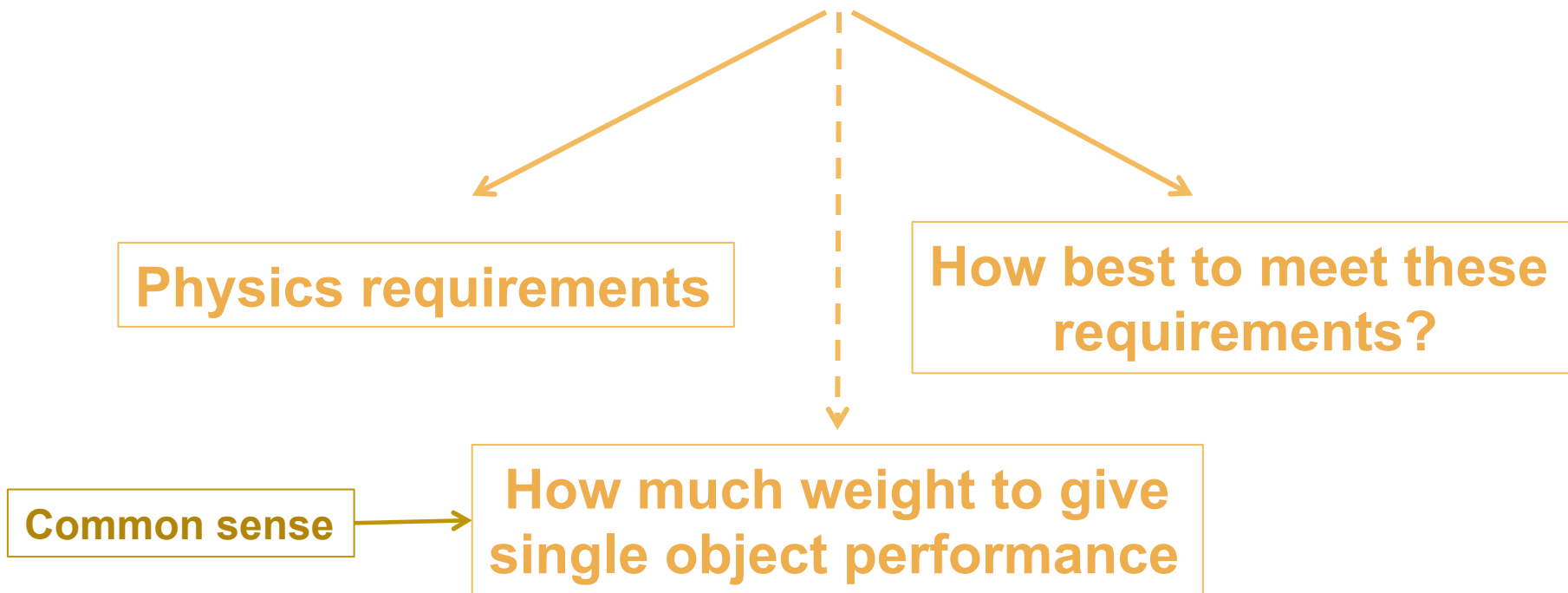
HERESY: THE OBSTINATE POST-BAPTISMAL DENIAL OF SOME TRUTH WHICH MUST BE BELIEVED WITH DIVINE AND CATHOLIC FAITH, OR IT IS LIKewise AN OBSTINATE DOUBT CONCERNING THE SAME. (CATECHISM OF THE CATHOLIC CHURCH, 2089)

- ★ Should be willing to ask the difficult questions
 - this won't happen →





What are the right questions?





Physics Requirements



ORTHODOXY

- ★ **momentum:** (1/10 x LEP)
e.g. Higgs recoil mass

$$\sigma_{p_T} / p_T^2 \sim 2 \times 10^{-5} \text{ GeV}^{-1}$$

- ★ **jet energy:** (1/3 x LEP/ZEUS)
e.g. W/Z di-jet mass separation

$$\frac{\sigma_E}{E} \sim 3.5 \%$$

- ★ **impact parameter:** (1/3 x SLD)
e.g. c/b-tagging, Higgs BR

$$\sigma_{r\phi} = 5 \oplus 10 / (p[\text{GeV}] \sin^{\frac{3}{2}} \theta) \mu\text{m}$$

HERESY

- ★ **momentum:**
 - LHC will measure Higgs mass
 - At ILC recoil mass primarily for ZH event selection $\Rightarrow g_{HZZ}$
 - Can we relax this “requirement”?
- ★ **jet energy:**
 - What ILC physics does this address
 - Pure Pflow performance always degraded in multi-jet environment
 - Can we relax this “requirement”?
- ★ **impact parameter:**
 - Not a cost driver
 - Driven by technology



Physics Sensitivity

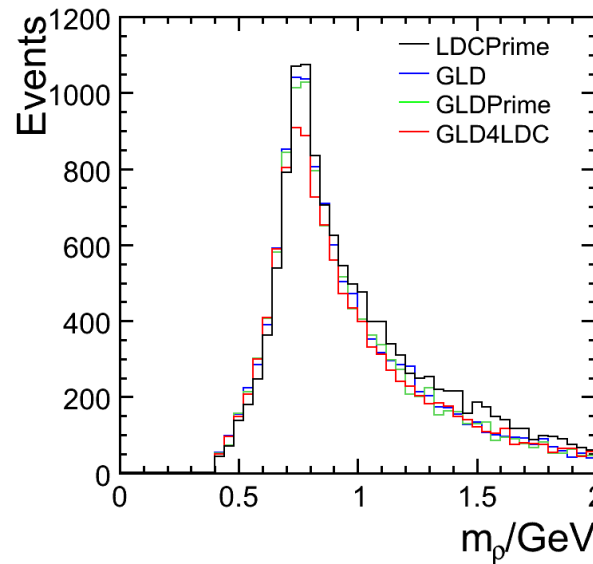
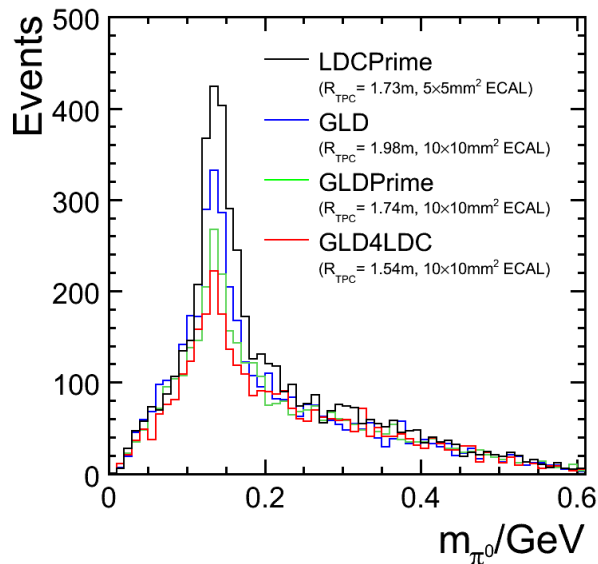
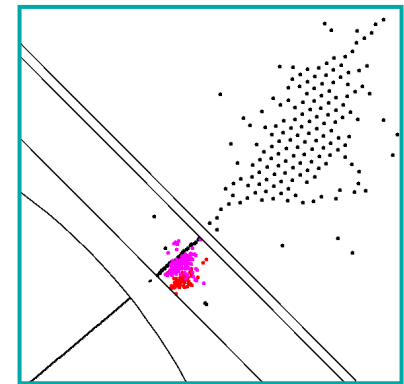


★ For ILD Lol compared physics sensitivity for various models:

Also compared physics performance for GLD and LDC based models

- Higgs mass from $e^+e^- \rightarrow ZH \rightarrow e^+e^-X/\mu^+\mu^-X$
- W/Z reconstruction in SUSY Point 5 chargino/neutralino analysis
- Tau reconstruction/polarisation

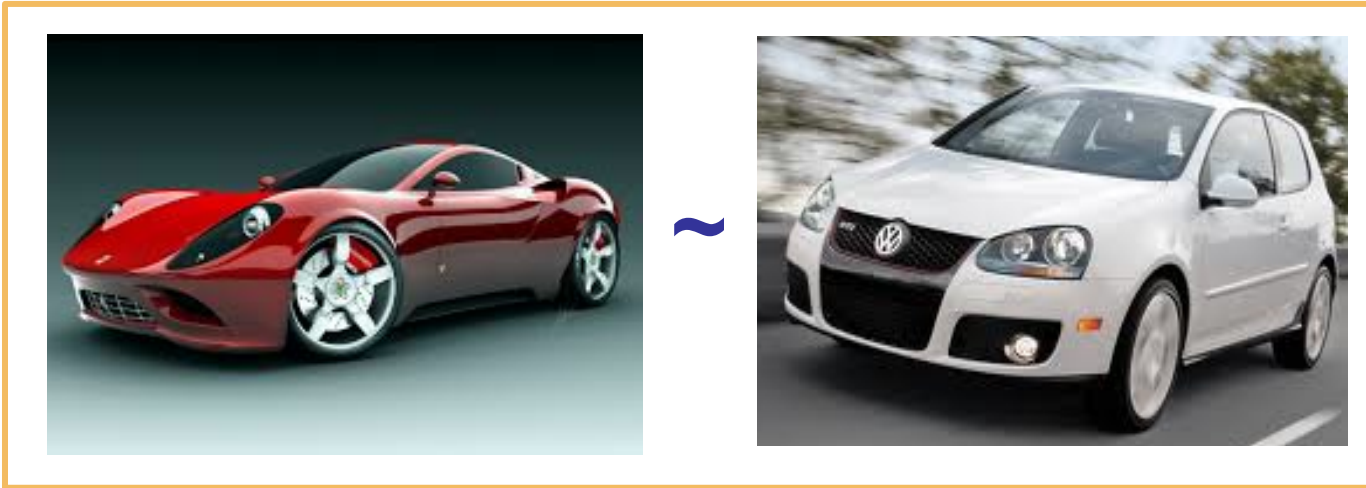
★ Only significant difference found for full reconstruction of tau decay, e.g. $\tau^- \rightarrow \rho^- \nu_\tau \rightarrow \pi^+ \pi^0 \nu_\tau$



★ But impact on physics sensitivity less pronounced



Heretical Message?



PHYSICS SENSITIVITY may not depend **STRONGLY** on raw detector performance

BUT: only true up to a point...
must retain a good general
purpose detector



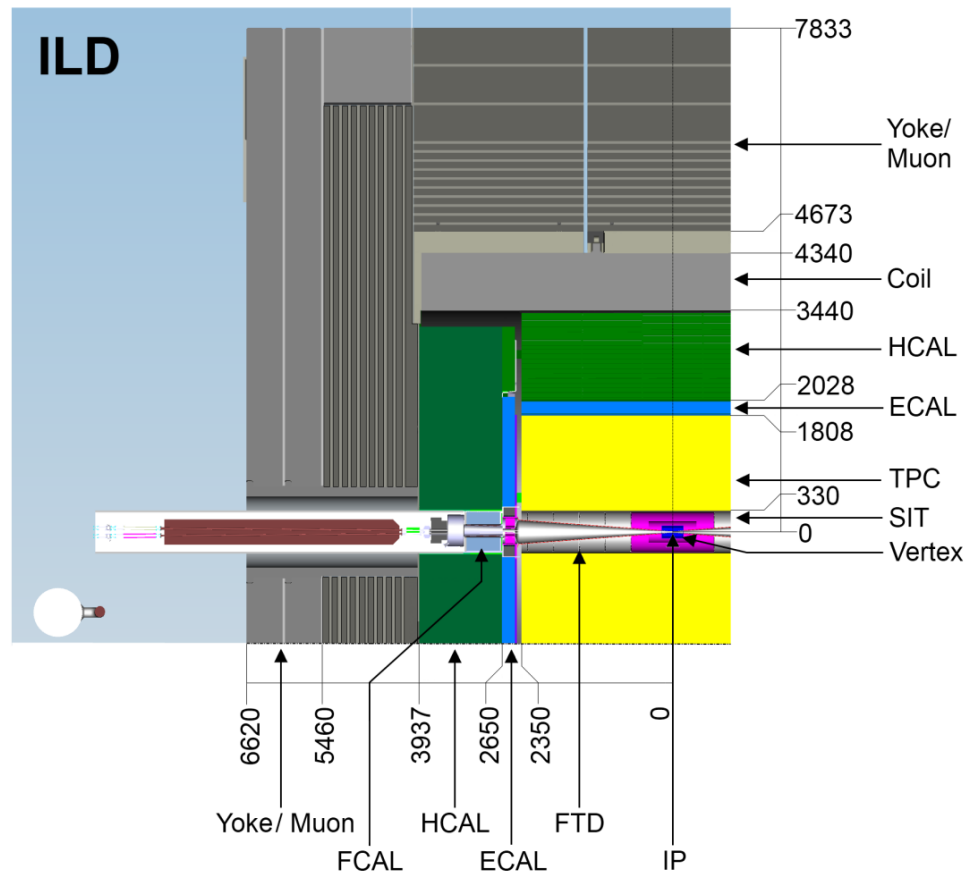
Can't just optimise on physics performance



ILD in this Light



★ What aspects of ILD can be changed
without significantly degrading the performance





TPC



- ★ ATLAS, CMS, ALICE demonstrated effectiveness of **Silicon trackers**

Heresy

- ★ **IF** a **low material budget Si tracker** can be built: why opt for a TPC ?

Opinion

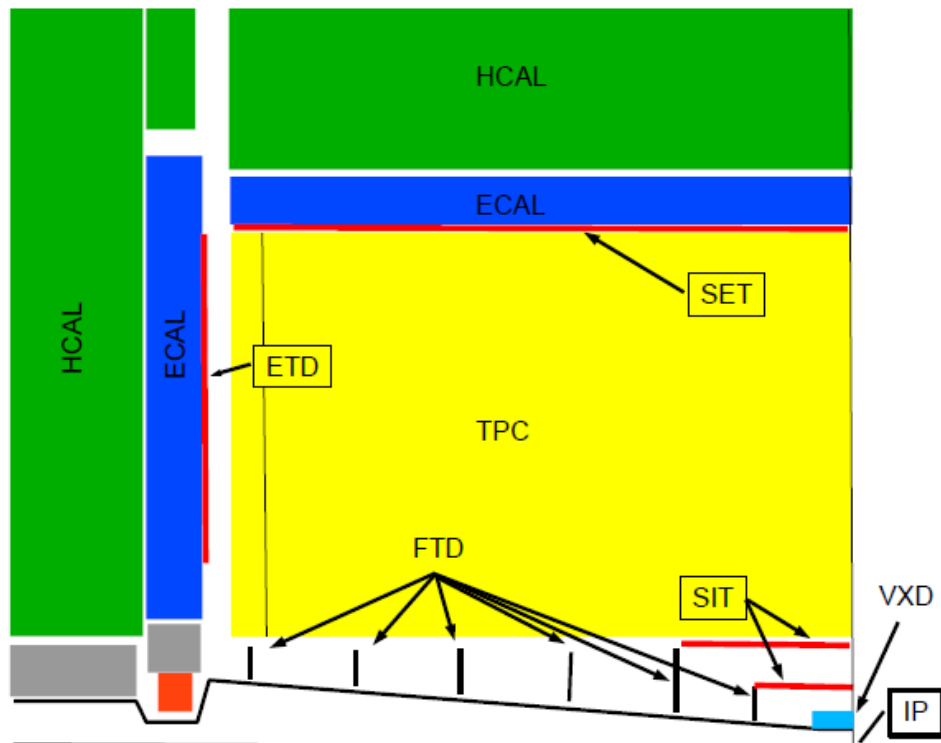
- ★ **Technical feasibility + strong R&D programme** is a powerful argument
- ? But we should try to identify a **physics advantage** for a TPC



Silicon Tracking



★ Currently **ILD** has more silicon tracking than **SiD**



ILD Heresy

★ Could we live without the **SET** ?

★ Does the **ETD** bring anything to **ILD** ?

Orthodoxy

★ Forward tracking always ends in tears

★ **FTD** under-specified ? pixels vs strips ?

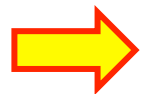




Calorimetry

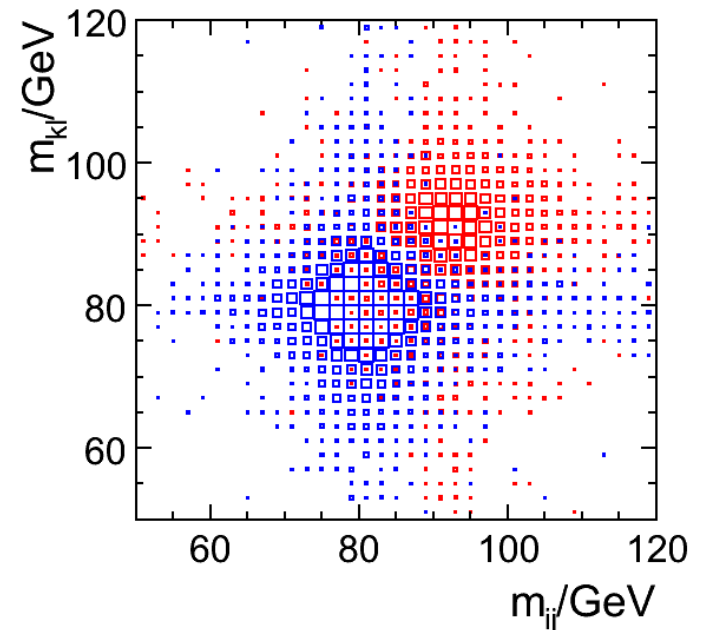


- ★ CMS has demonstrated effectiveness of **Particle Flow**
 - more than just jet energy resolution...
 - my (orthodox) belief – this is the right option for the ILC
- ★ ILD opted for
 - Large detector **AND**
 - Very high granularity calorimeter – ECAL and HCAL



Excellent performance →

but drives cost of ILD

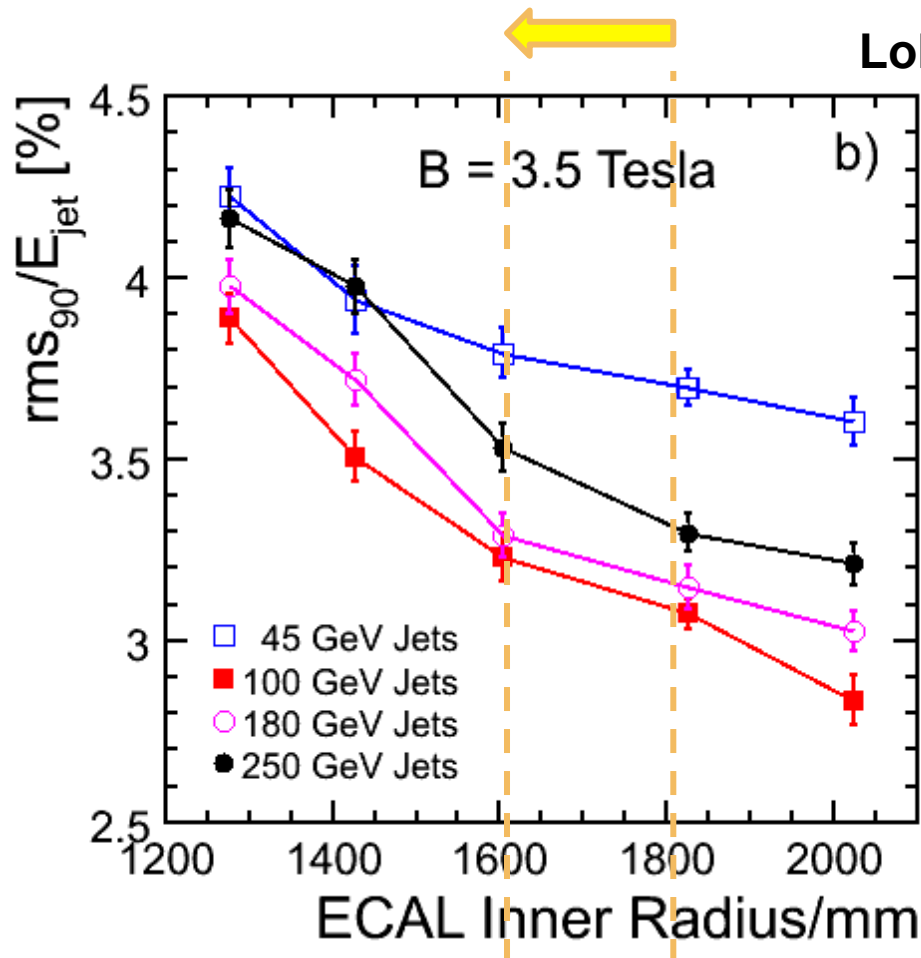




Detector Size



- ★ Biggest impact on cost would be to reduce size of ILD
 - e.g. 25 % reduction in ECAL barrel surface area



- relatively modest impact on performance
- interesting to re-evaluate with current reconstruction

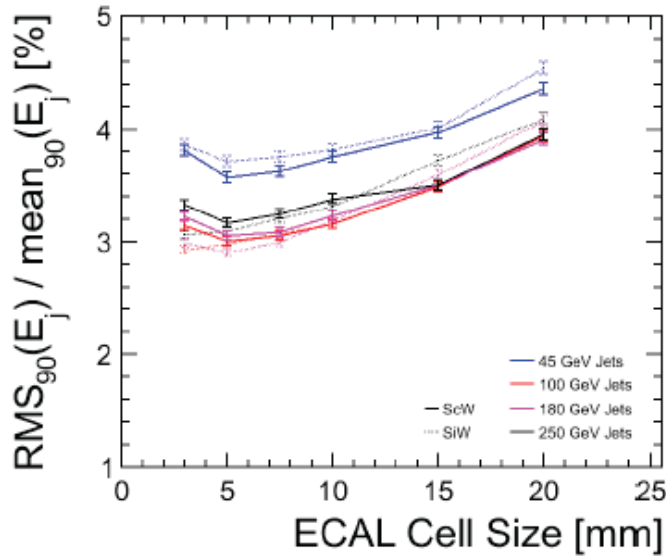
+ aspect ratio ?



Segmentation



ECAL

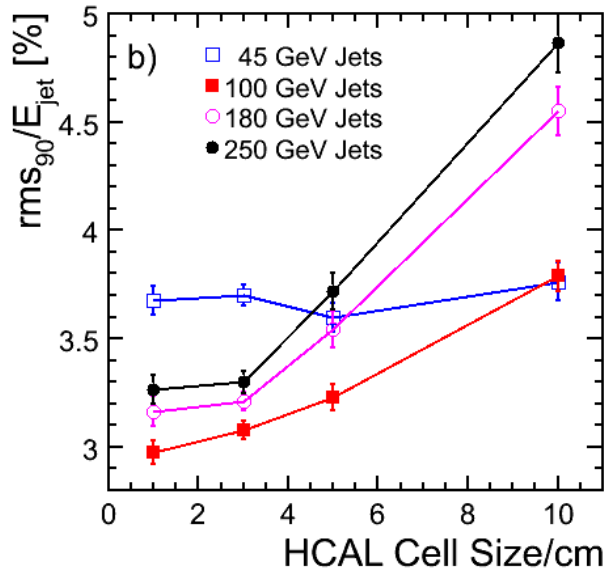


★ **5x5 mm² → 15x15 mm²**

- 10 – 15 % degradation
- but depending on technology, might not be cost effective

➔ **Detailed cost/perf. optimisation**

AHICAL



★ **3x3 cm² → 10x10 mm²**

- large degradation
- but assumes common tile size with depth...

➔ **Detailed cost/perf. optimisation**



Calorimetry Questions



Compare technologies:

- ★ **Understand cost/performance advantages**
 - **SiW vs ScW vs hybrid**
 - **AHCAL vs sDHCAL**

Optimise design:

- ★ **Understand cost/performance implications**
 - **Reducing longitudinal segmentation**
 - **Varying transverse segmentation with depth**
 - **Strips vs pixels/tiles**
 - ...

Aim to **UNDERSTAND** the options



**INFORMED
CHOICE**



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R&D – technical feasibility

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Aim to UNDERSTAND the options

R&D – technical feasibility

Judgement

**INFORMED
CHOICE**



How to proceed ?



- ★ **How to optimise the ILD detector design:**
(it will not be straightforward)
 - possible first step “**identify list of key questions/studies**”
 - need to be clear/well-defined
 - if we get this right, it will make our life easier

- ★ **The time is now...**
 - **post DBD phase provides the opportunity to restart this activity (last done for Lol)**