ILD Optimisation - Current Status

Frank Simon,
Max-Planck-Institut für Physik
Munich, Germany

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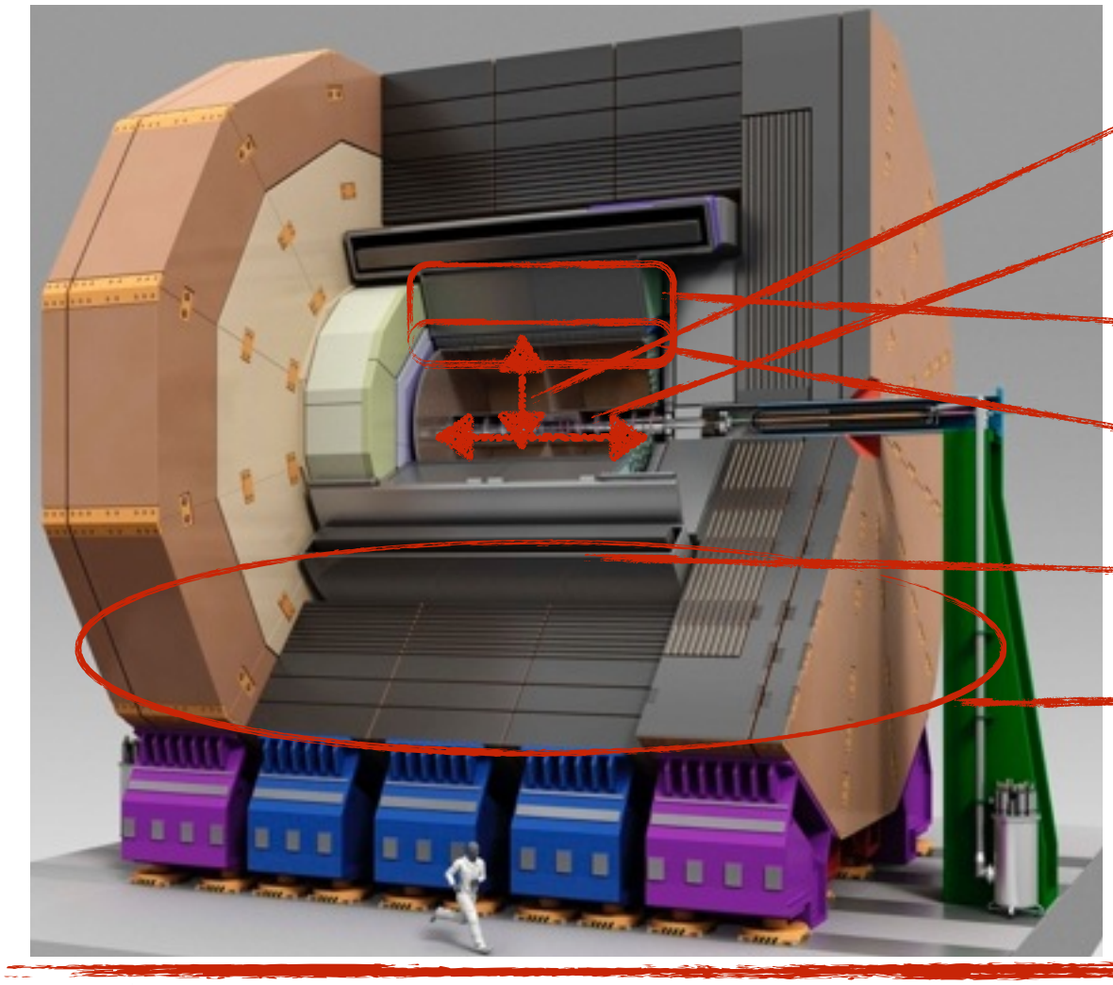
Introduction - Why to do it, what to do

- ILD is soon turning 7 - solidly in elementary school: A good time to broaden horizons and question previous beliefs
- Need to understand why ILD looks the way it does - and if it should really look that way:
  - Better understand physics drivers for performance requirements (-> Jenny)
  - Identify key performance drivers, find possible “breaking points”



main tracker radius & aspect ratio

number and placement of tracker layers

calorimeter granularity (in 3D!)

ECAL technology: Si / Scint / Hybrid

magnetic field

yoke & stray field

…

The Current Status - Based on Optimisation Meetings

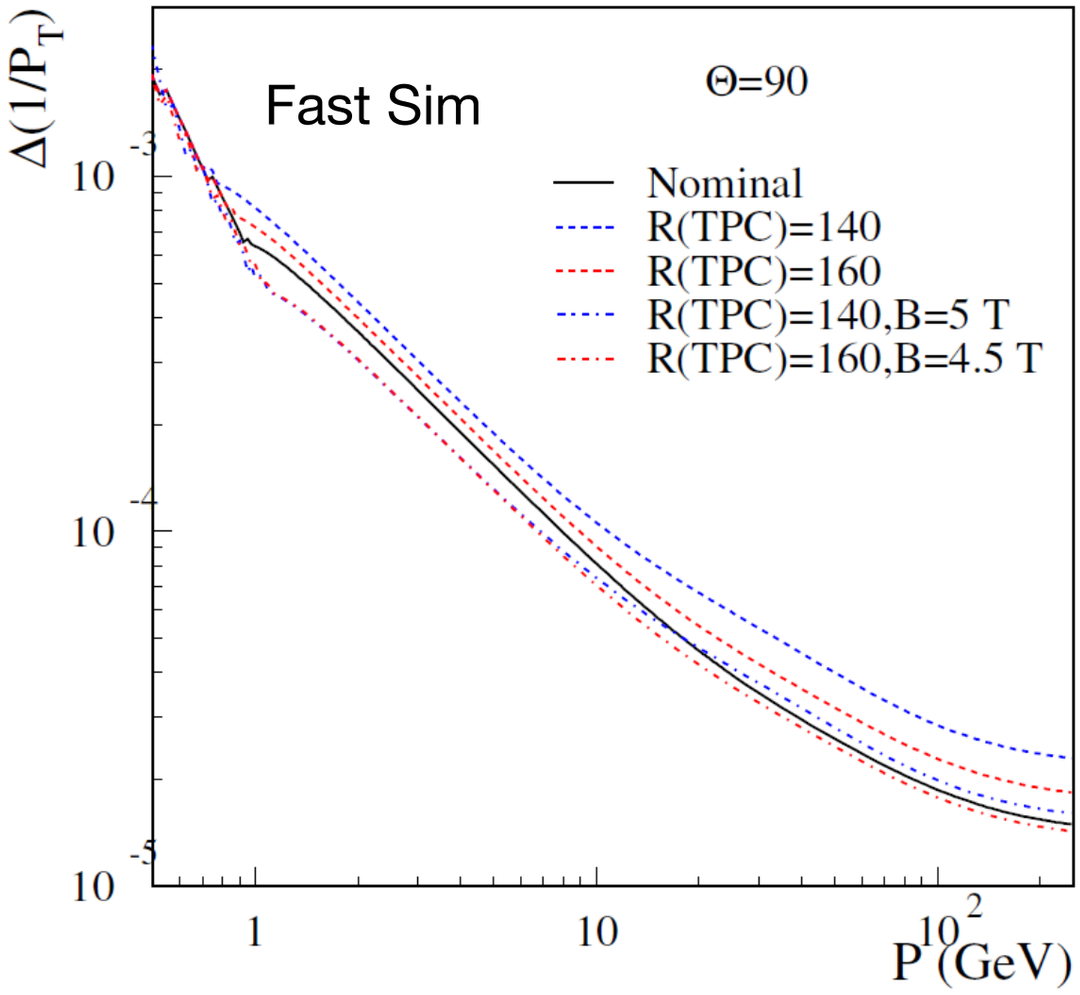
- Activities in quite a few areas
  - Increased realism / validation of detector simulations
    - ⇨ Absolutely essential - Need realistic sub-detector implementations and performance modelling to accurately simulate the full ILD system
  - Impact of ECAL radius, depth, granularity and active material on PFA performance
    - ⇨ The one study that already provides solid conclusions…
  - Impact of ECAL parameters on τ reconstruction
  - Impact of main tracker radius and B field on track resolution
  - Forward tracking - ideas for concrete implementations
  - HCAL studies beginning

…

Main ILD Parameters - Radius & B-Field - Tracking

- Trivial leading-order effects on tracking
  - Larger radius gives larger lever-arm and thus larger sagitta - better resolution
  - Larger B-Filed gives stronger bending and thus larger sagitta - better resolution

⇨ But beware: multiple scattering important at lower energies - can eliminate improvements due to R and B over a wide momentum range!



Fast / Full Sim, Voutsinas / Berggren, 02/14

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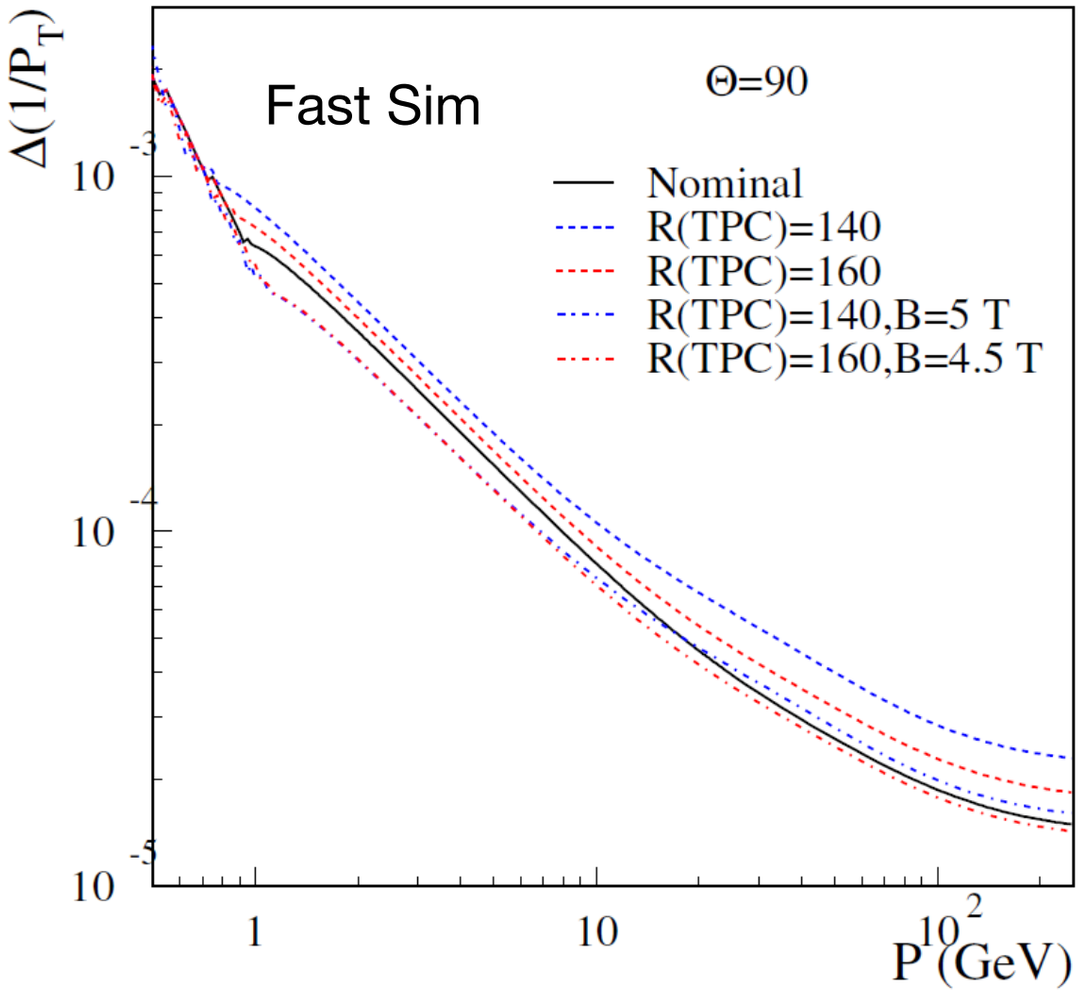

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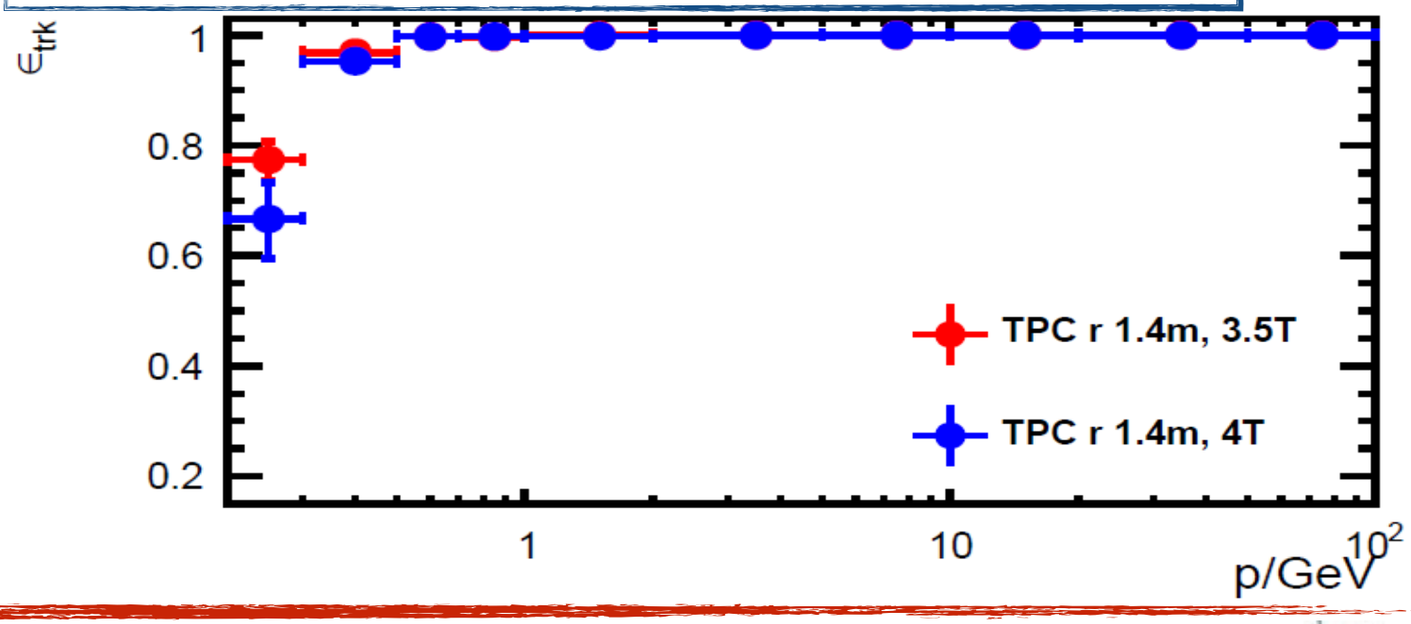
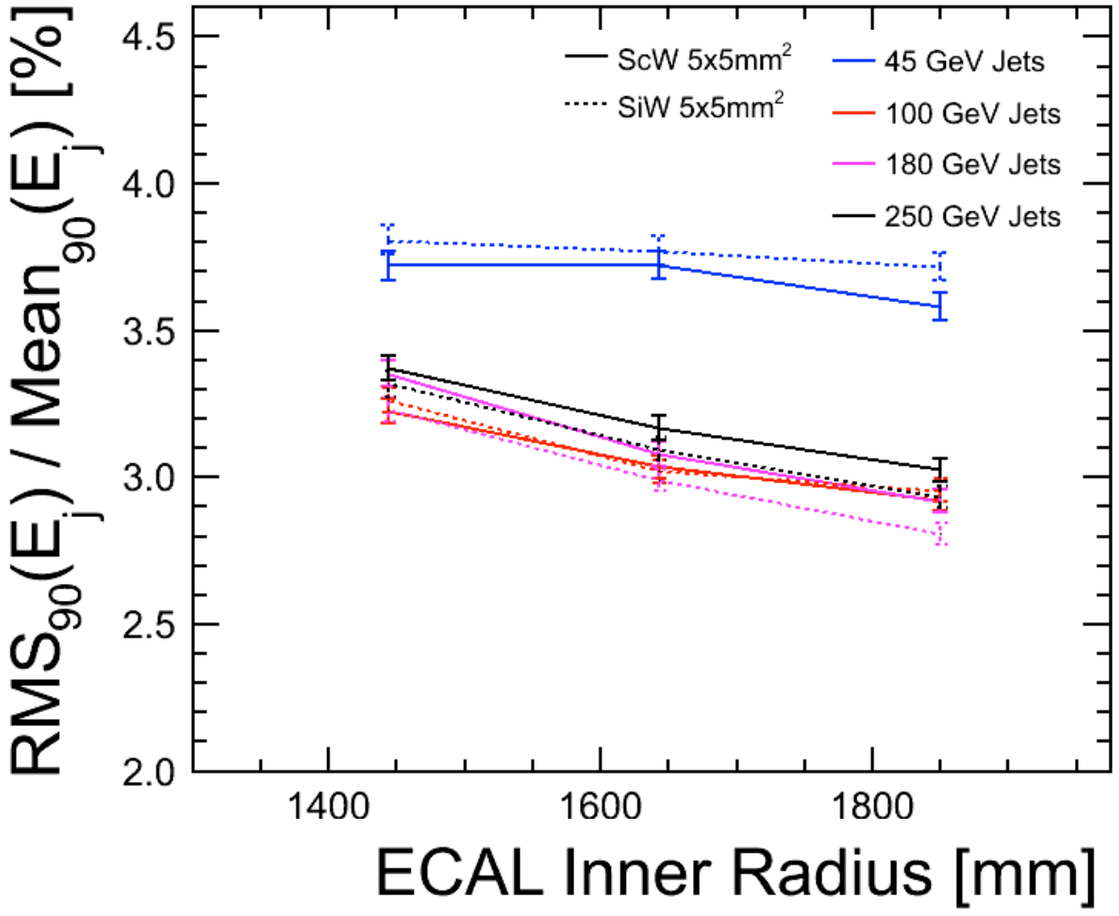
Use caution: Increased B-Field can cost efficiency at low momentum



Main ILD Parameters - Radius & B-Field - PFA

- PFA behavior more complex - many factors contribute, but still:
  - Larger radius gives larger separation of particles at calorimeter front face - reduced confusion, better resolution
  - Larger B-field gives larger separation of charged and neutral particles at calorimeter front face - reduced confusion, better resolution



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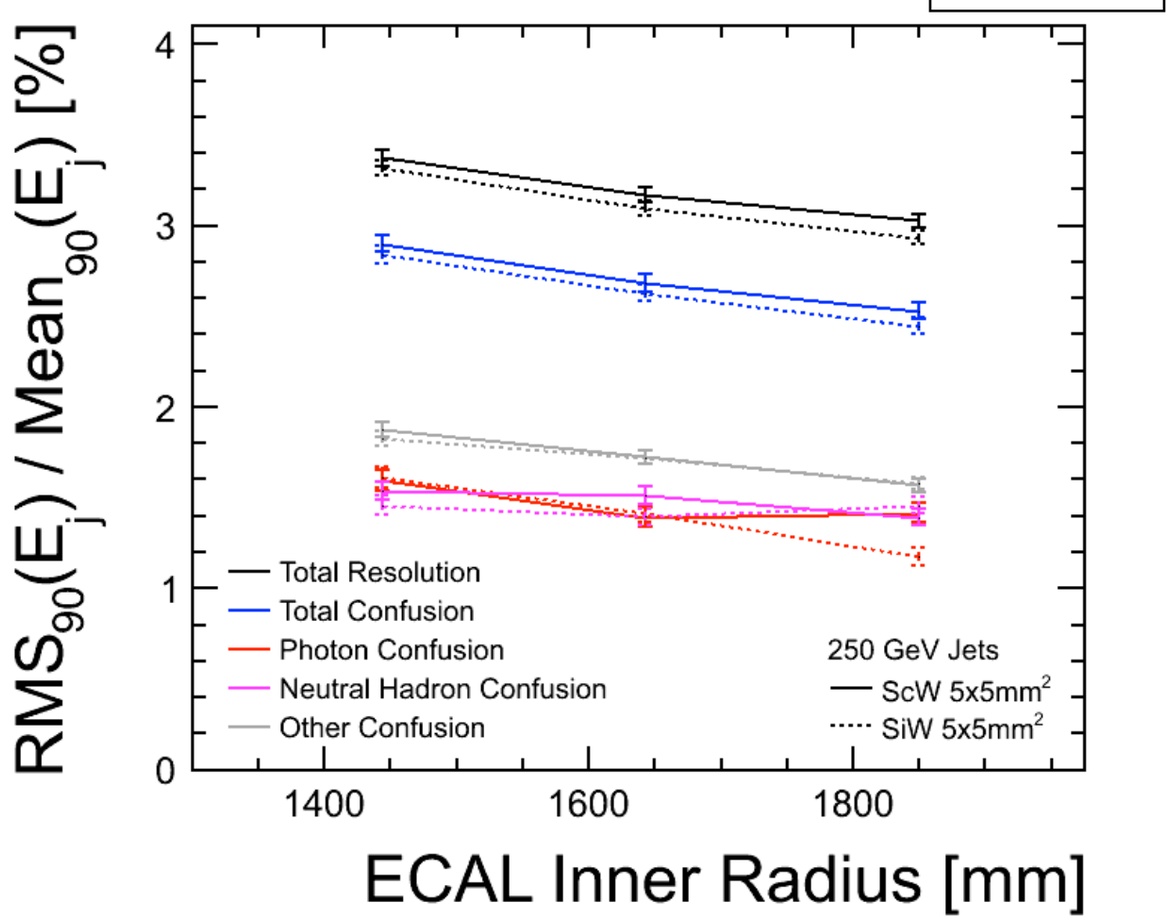

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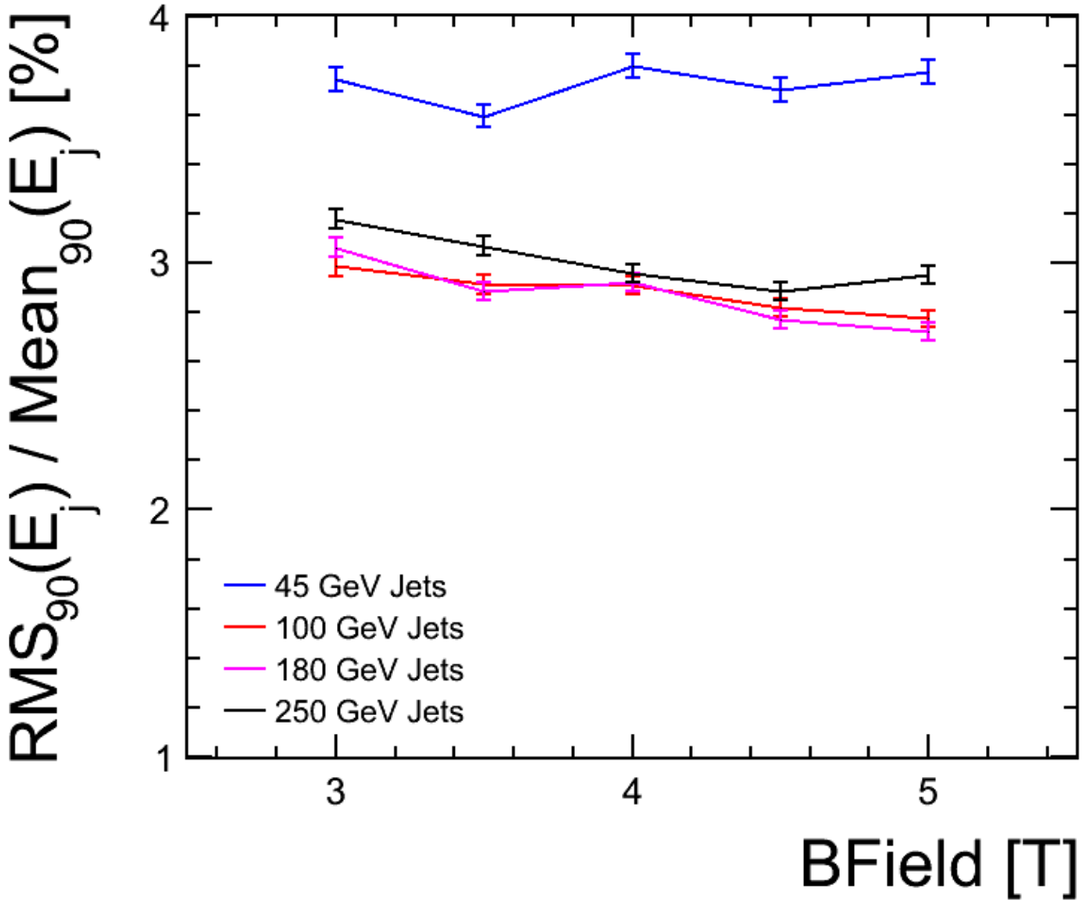
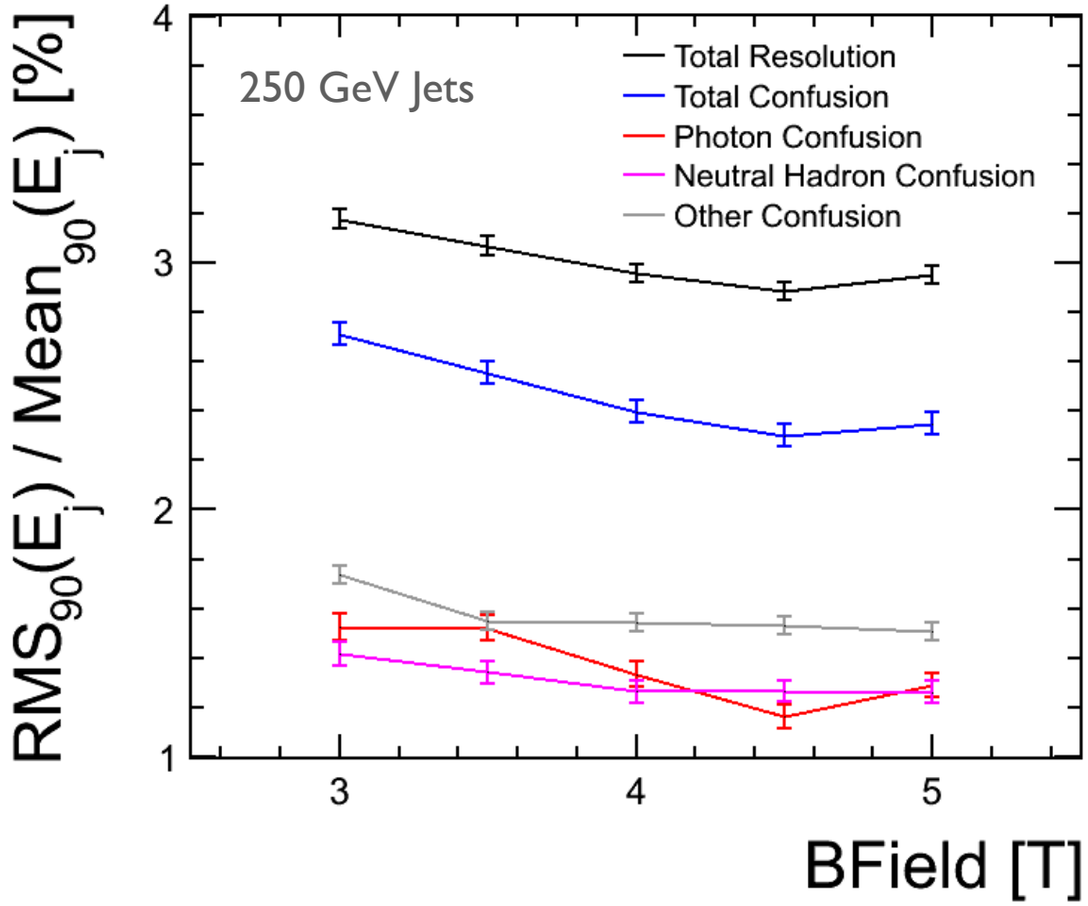
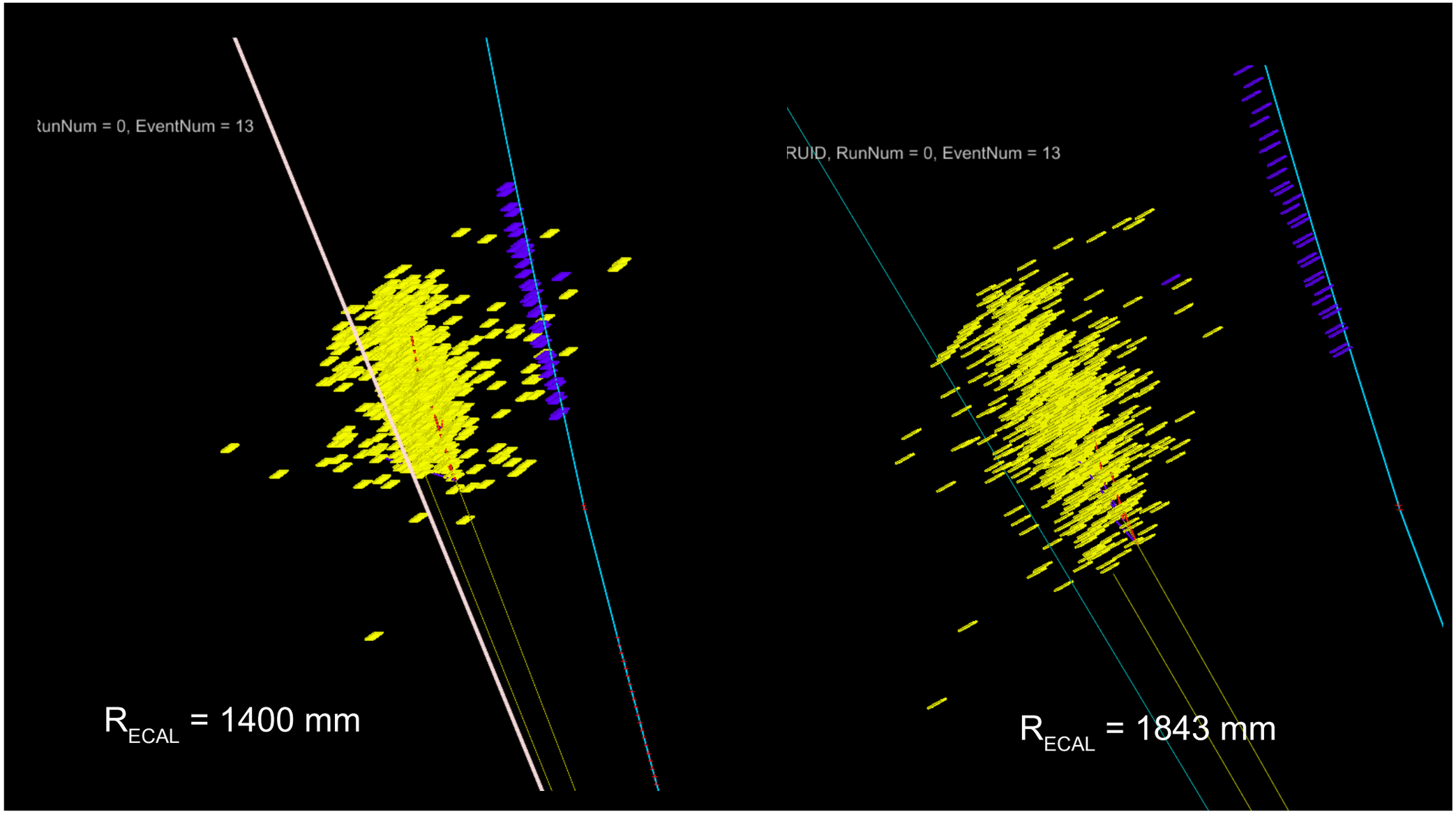




Main ILD Parameters - Radius & B-Field - Taus

- Taus, with close-by particles (due to rather low mass) are expected to be particularly sensitive - deserves a closer look!



➪ No conclusions yet - initial studies don't show substantial differences in energy reconstruction

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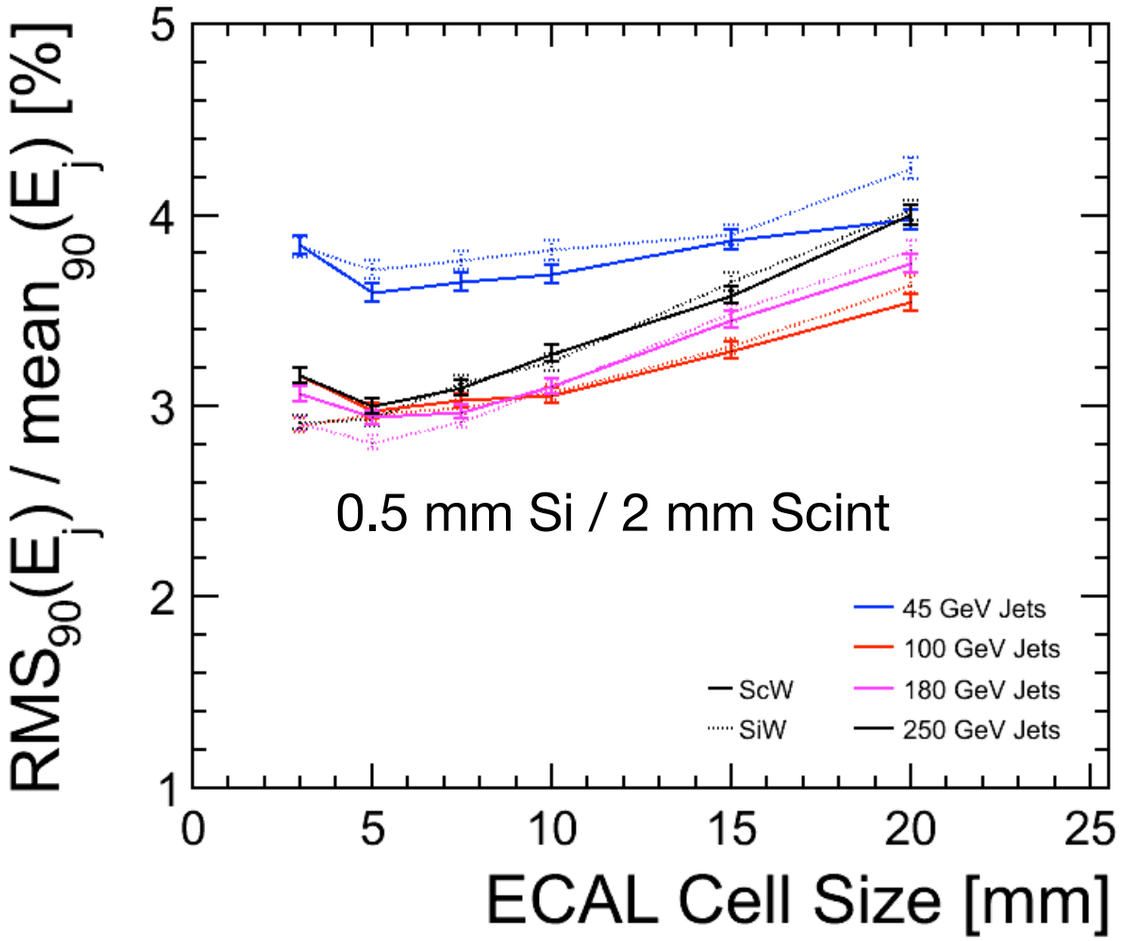
Understanding the Impact of ECAL Parameters

- As the most expensive sub-system and a driver for PFA performance, understanding what influences the ECAL performance is crucial for a meaningful optimisation of ILD

Granularity:



- Reduced granularity deteriorates PFA performance - in particular at high energy
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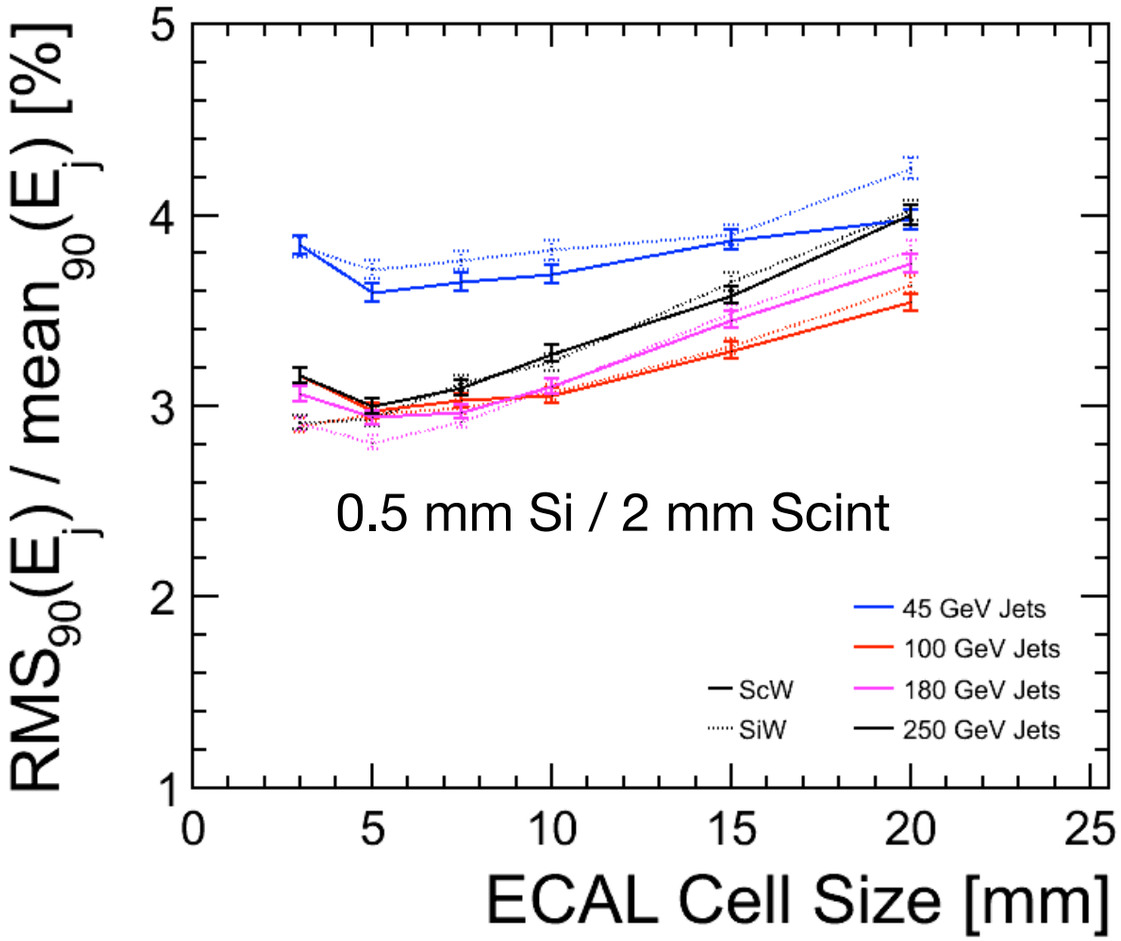

- Reduced granularity deteriorates PFA performance - in particular at high energy
  - essentially entirely due to confusion, in particular for photons
- Choice of technology has only a very small impact
  - thicker scintillator (2 mm) results in slightly better performance at low energy - better single photon energy resolution
  - Silicon marginally better at higher energies - more compact detector

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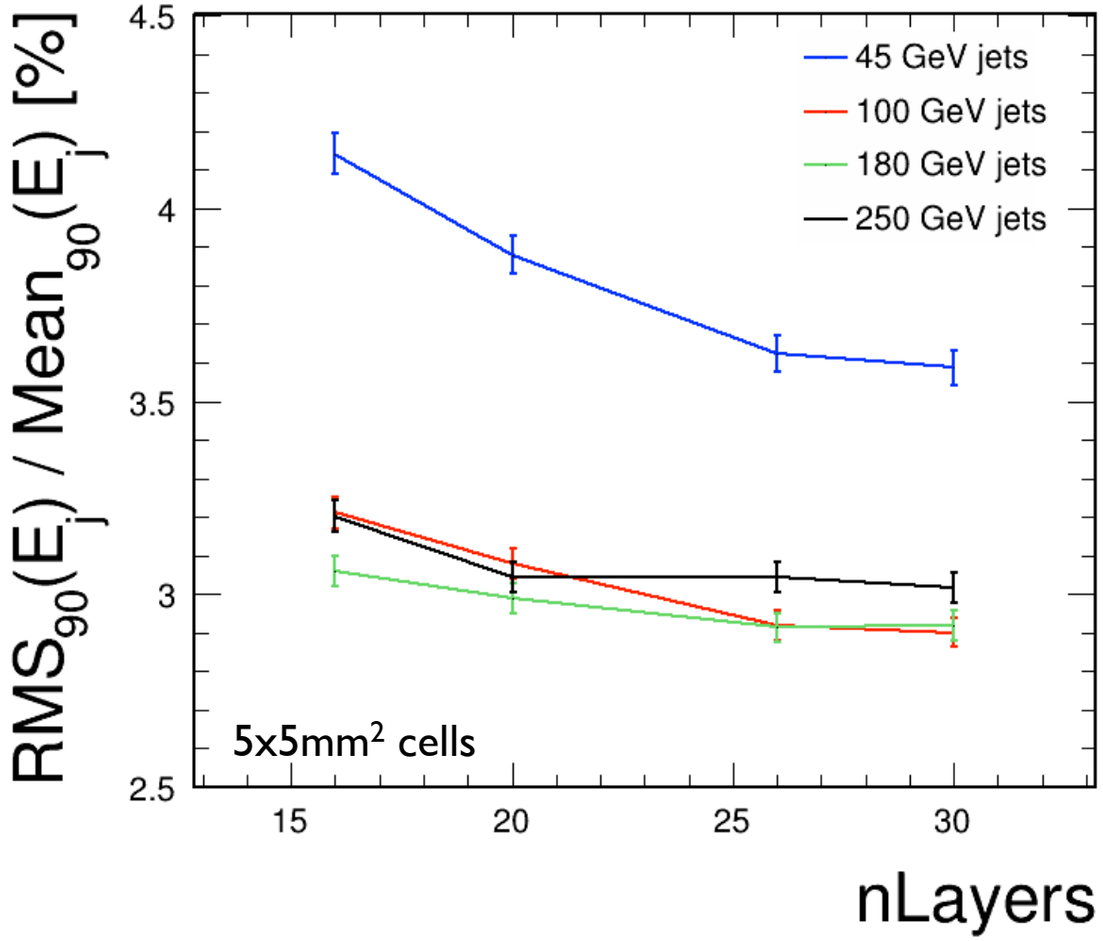
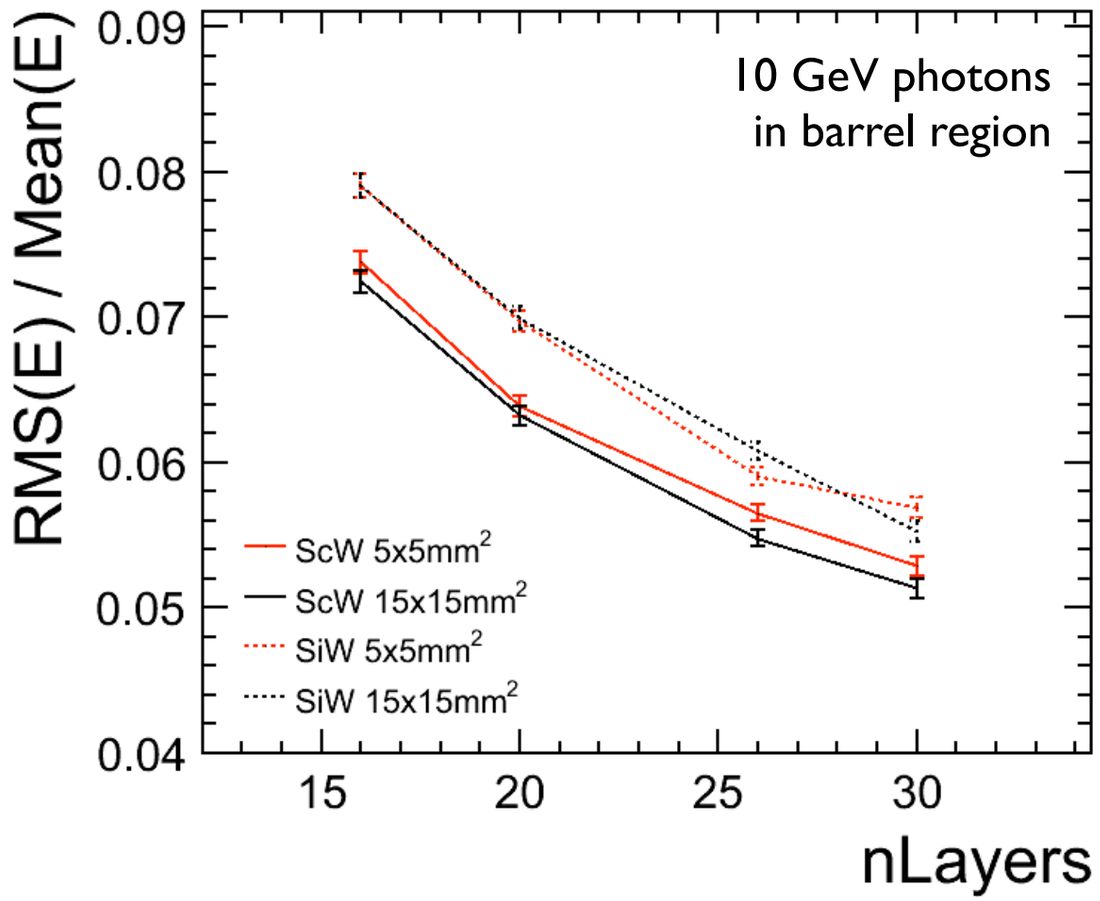
Number of Layers:



- Reduced number of layers deteriorates PFA performance - in particular at low energy
  - dominated by reduced energy resolution for photons - some influence from confusion



NB: The thickness (in X_0) of the ECAL stays ~ constant, the sampling is reduced

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Conclusions, Anyone?

- Looking for:

Conclusions, Anyone?

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- Found so far:

Conclusions, Anyone?

- What we've seen so far:
  - Things behave roughly as they should:
    - A smaller detector has somewhat worse momentum resolution and PFA performance
  - But: The slopes are in general very gentle - no "killer argument" for a particular minimum performance and with that a particular (minimum) parameter choice

My take on this - obviously biased, invitation for discussion!

- There is no clear reason why ILD has to be as large as it is at the moment - moderate reduction in radius seems to do no real harm, but potentially results in large cost saving
- No need to go to higher magnetic fields, but don't want to go too low either - there could be negative impact on machine-induced background levels
  - 3.5 T with the option to run at 4 T seems to make sense

What now? - My View

- The obvious question to ask when looking at ILD:
  Why do we have a TPC, when the general trend in HEP is to move to all-silicon trackers?

  ⇨ Need a clear answer that shows the benefits of a TPC for ILD - up to now this has not yet been done in an obvious way
  ⇨ Might also have to look at alternatives - would ILD be worse off with a silicon tracker?

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- Look at other subsystems as well: ECAL studies a model for the level of detail one can achieve (not possible for every system, I expect) - Need to understand how changes in the overall layout impact the optimum geometry for the HCAL, for example
  - Do the conclusions differ for barrel and endcaps?

What now? - My View

- An additional complexity: Technology choices
  - not only an optimisation matter - and on a longer time scale

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- For the ECAL, we have seen that both technologies (Silicon and Scintillator) provide essentially the same performance - Ideal situation in terms of optimisation - the two issues factorise - Need to see if this applies for other systems as well
- Details to consider: How does realistic detector performance impact the overall ILD performance?
  - Uniformities, operational stability, dead cells, calibration possibilities … Has an impact on the need for redundancy, additional layers (tracker), running scenarios… and with that on the overall ILD optimisation

The Final Word

- Optimisation is often seen also in the context of cost
- In my opinion, cost should **not** be the main driver for design changes
  - Irrespective of how high or low the cost is, it is likely that we'll be asked to reduce it once things start to get real…
  - It is key to capture the imagination of the community -
    Novel, cutting edge solutions - even if they are costly - make ILD attractive, and may provide possibilities in the future which we are not yet thinking of today

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⇨ The optimisation of ILD is under way, with solid results in some areas already, but it is a long road, with many steps on the way - and it will only finish once we start taking data (and probably not even then…)