External Si tracking: a review of the ILD system and its performance

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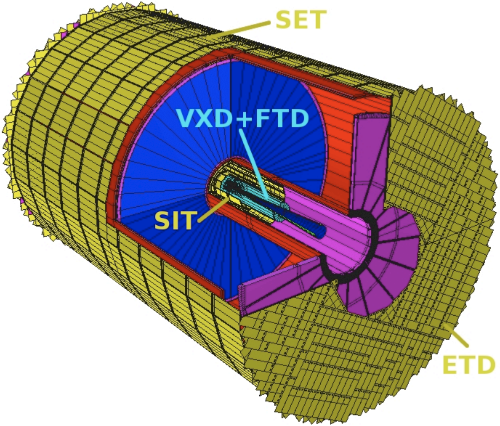
Outline

Introduction

External Si-tracking system:

- SET
- ETD

Main objective initially: Get an asymptotic momentum resolution as good as possible (=SiD).



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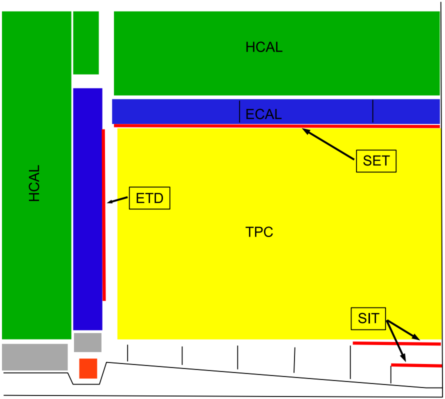

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What are the expected benefits/drawbacks on

- Direct tracking performance ?
- Indirect (ie. survey/calibration) tracking performance ?
- Calorimeter performance ?
- Combined PFlow ?

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- What does this mean for Physics ?
- What do we need to study to substantiate this?

Effects on tracking performance

Master formula:

$$\Delta(1/p) = \frac{8 \times 330 \sin\theta \sigma_{sagita}}{BL^2_{coda}}$$

- SET:
  - up to 30% better $\Delta(1/p)$.
  - Amelioration still sizeable down to $\sim$ 10 GeV.
  - Amelioration at all angles for p=250 GeV.
  - Almost no effect on $\Delta(D_0)$
- ETD:
  - Very modest amelioration for p > 25 GeV.

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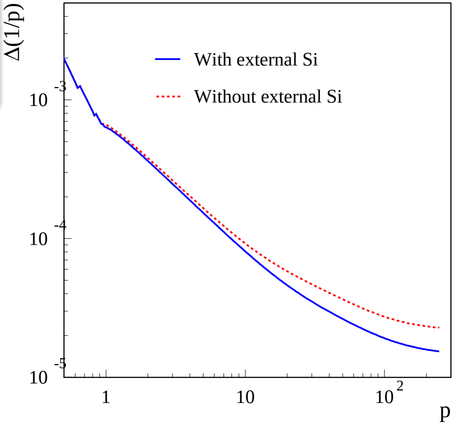

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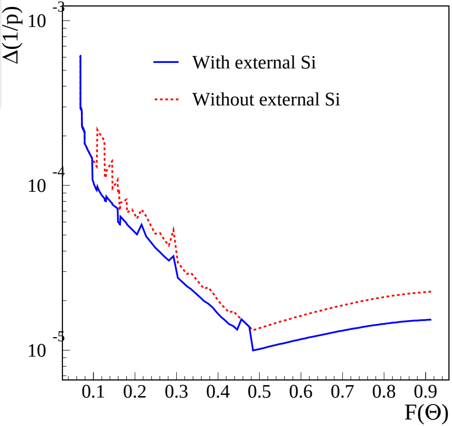

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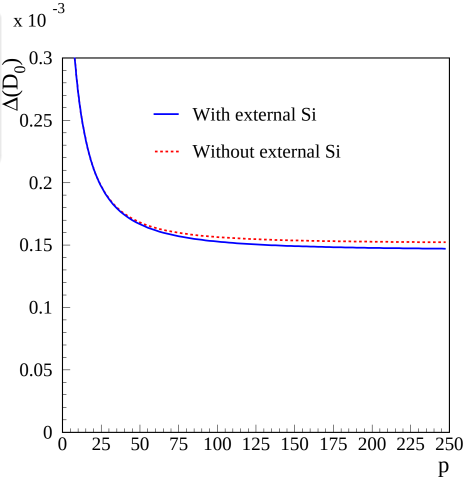

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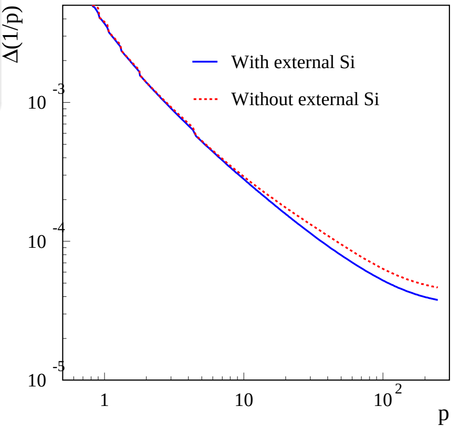

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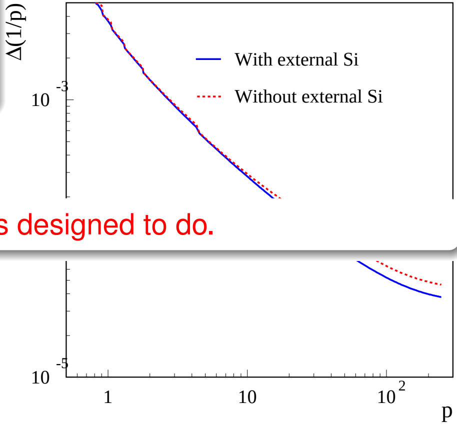

The Si-envelope delivers what it was designed to do.

Effects on calorimeter performance

- More material
  - SET: 0.7 % X_0, but only 0.15 % λ.
  - **EM**: expect very small effect from γ conversions and brems: low probability, short lever-arm $\rightarrow$ in the rare cases where there is an interaction, the clusters probably will be reconstructed as one with the same uncertainty on the total energy.
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Likely that there would be neither benefits nor drawbacks.

Effects on TPC performance

- Assigning tracks to the right BX:
  - Bunch spacing: 554 or 366 ns and drift-velocity 6-8 cm/μs.
  - $\Rightarrow$ 2.2 - 4.4 cm displacement. Cleraly separable - $\sigma_z < 1$ mm in TPC.
  - Is the ECAL with 5mm pads enough to separate ? Or scintilator strips ?!
  - Or the SIT, with σ_z 50 μm ? Remember occupancy inside jets, decays in-flight, ghost hits !!

NB: This is an issue in the barrel only - in the forward, there would be a precise last point with drift-time $\sim$ 0 from the TPC itself !

Effects on TPC performance

- Study distortions:
  would having a very precise point outside be of use? DELPHI experience would indicate so.
- Effect of entierly due to a few 100 μm un-corrected distortions in a region in the barrel-endcap transition region, where there was on “SET”.

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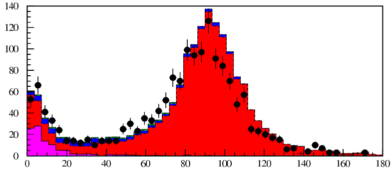

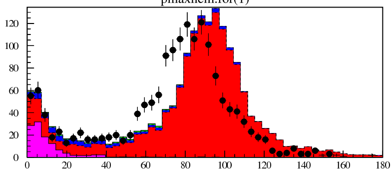

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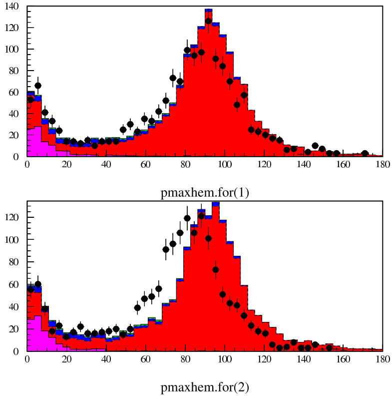

Realistic studies needed for both these features to answer.

Effects on PFlow performance

- Better momentum measurement $\rightarrow$ better measurement of charged part.
- But: Doesn't matter for PFlow - the uncertainty is completely dominated by the neutrals.
- Somewhat more interactions before the calorimeters.
- But: Very low probability, and short lever-arm.
- Question: Could the fact of having a precise point after the scattering in the TPC end-plat/field cage help Pandora?
  - In this context: Would a track-element in the forward region help?
  - If so, can it be formed by Last (zero-drift length) TPC point + one ETD layer + First ECal point ? Ie. by σ_{point} = 60-20 μm + 10 μm + 150 μm ?

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Key number

$\Delta(p) \approx$ 100 MeV at p = 100 GeV.

- Higgs mass:
  - Momentum resolution does matter (at E_{CMS}=350 GeV; at 250 beam-spectrum dominates.
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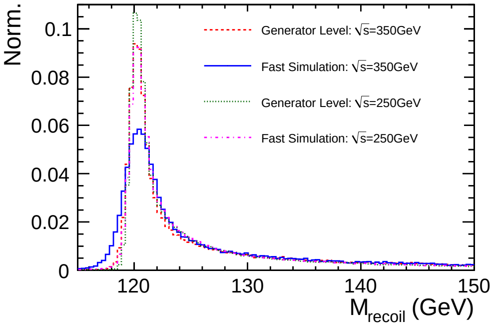

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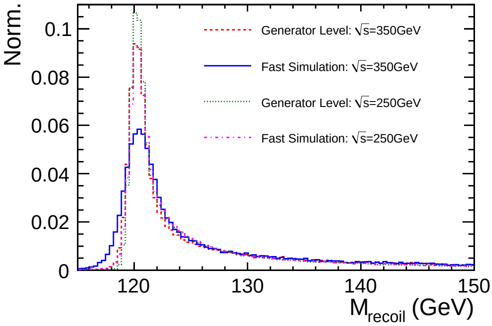

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  - Width of peak $\propto \Delta(p)$, so S/B better if $\Delta(p)$ smaller.
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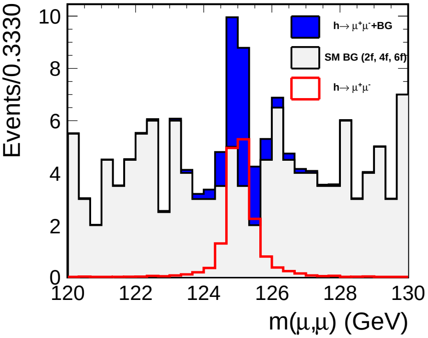
  - "Normal" with mass of sparticles from edges: beam-spectrum dominates largely.
  - If constrained system, eg. in cascade decays: Mass resolution would be sensitive to $\Delta(p)$.



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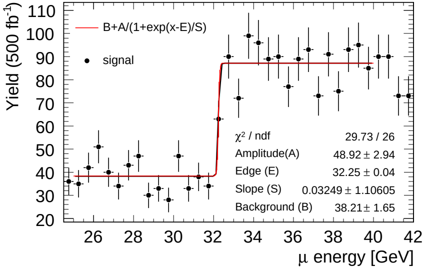

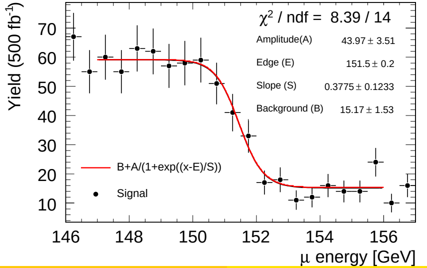

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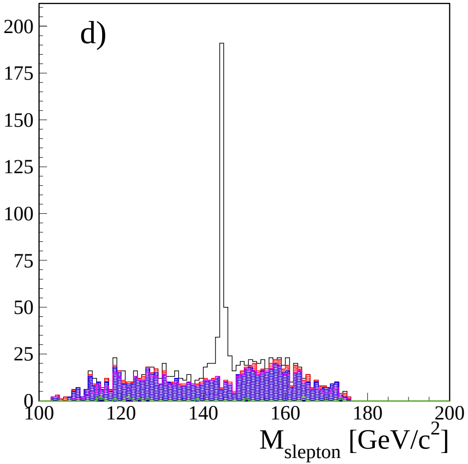

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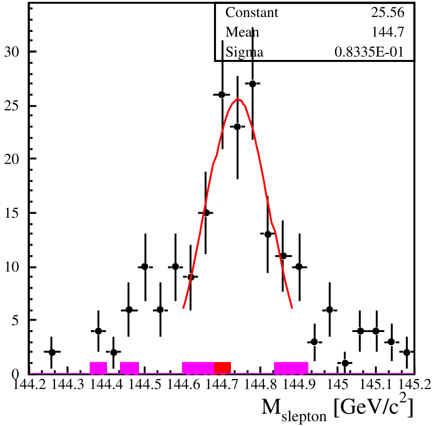

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Far from obvious that there would be any direct physics benefit.

Needed studies

What do we need to do to substantiate the effects ?

- The direct effect on momentum and ip resolution are clear.
  - Clear effect from SET, very marginal of ETD.
  - But: alignment ? If we believe SiD (which we should) it should be OK...
- The direct effects on physics, the case is fairly clear:
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SGV fast-sim is adequate for these questions. Just need to fold in alignment uncertainty.

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- Calorimeter and PFlow:
  - Need serious FullSim on models with or without the measurements, material and geometry of the external Si system.
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- FullSim models of ILD with and without SIT/ETD needed. No-Si model should exploit emptied space (bigger TPC/closer Calo's ?)
- Dedicated reconstruction and Pandora

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Bottom line

Given the modest impact on physics, the results of the PFlow and TPC studies are crucial to be able to make a rational decision.

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