CALO5D
A new dimension in shower reconstruction

~~Review of Physics Channels Relevant for Calorimeter Timing~~
Very prelim. thoughts on channels possibly sensitive to timing

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ÉCOLE POLYTECHNIQUE
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cnrs NUCLÉAIRE & PARTICULES

Physics processes for timing

Expected improvement from timing might come from

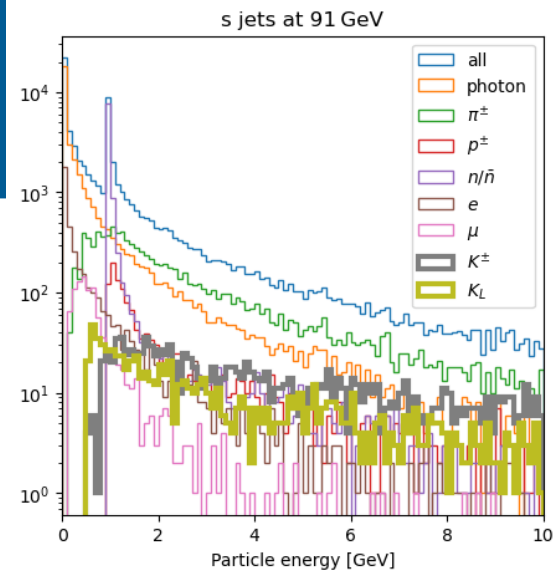
- PID by ToF:
  - Charged: complementary (dE/dx || dN/dx)
    OK at low momentum
    - Proton vs pions vs $K^{\pm}_L$
      Lastest TPC+OTK @CEPC: https://arxiv.org/pdf/2507.18164v1
    - But need check for high |cosθ}, medium E
  - Neutral : no [ToF vs Ecalo]
    - Neutrons vs K^0_L
    - Except: late neutrons, backscattered
- Improved impact location in cluster
  - Position of earliest hit → imporved position resol.
  - Ex: → 2 photons:
    (see pres. of JCB at DRDCalo and LCWS25).
- Beam Induced backgrounds
  → Beam-pipe off-scattering:

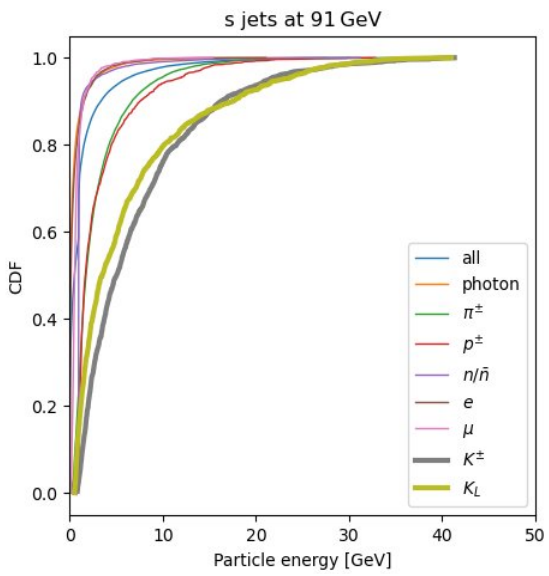
Physics channels

Discussion ML+Timing IHEP+LLR+IP2I+IJCLab (June 2025)

- Higgs and Weak Bosons : PFA / Jets (All)
  - S-jets / tagging by the K's [but high E]
  - C-jets / tagging : in flight decays ?
  - B-jets
- Flavour physics
- T-jets
  - T-physics :
    γ and π^0's
    in final states
- τ final states
  - Rare decays…

← Jesus' presentation


s jets at 91 GeV
all
photon
$\pi^{\pm}$
$p^{\pm}$
$n/\bar{n}$
e
μ
$K^{\pm}$
K_L
Particle energy [GeV]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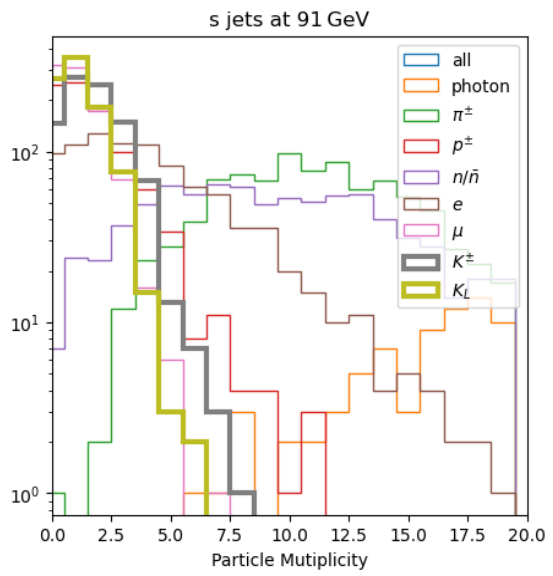
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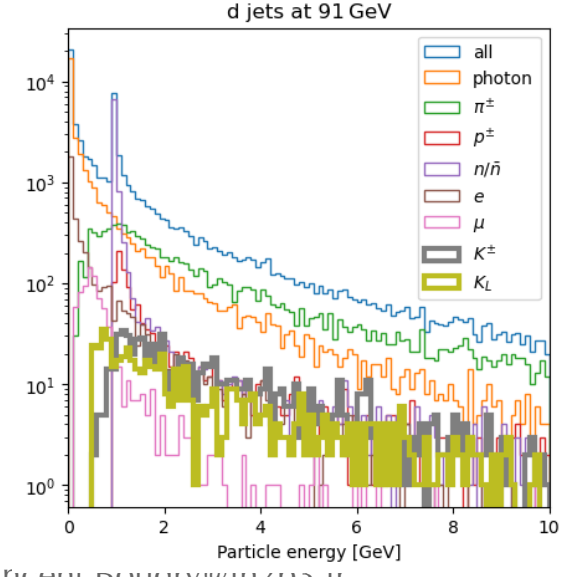
Particle Mutiplicity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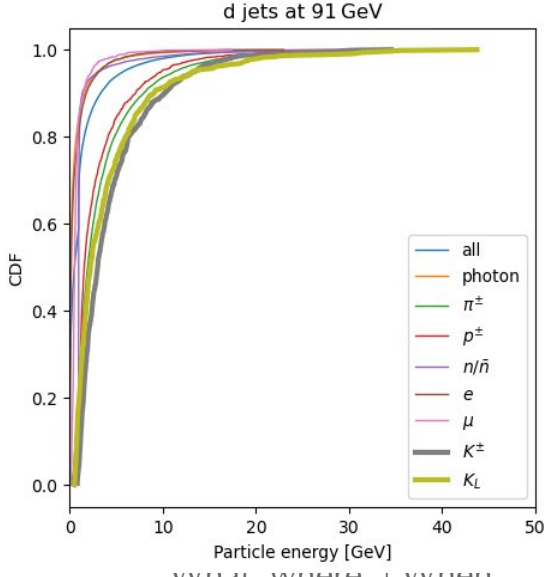
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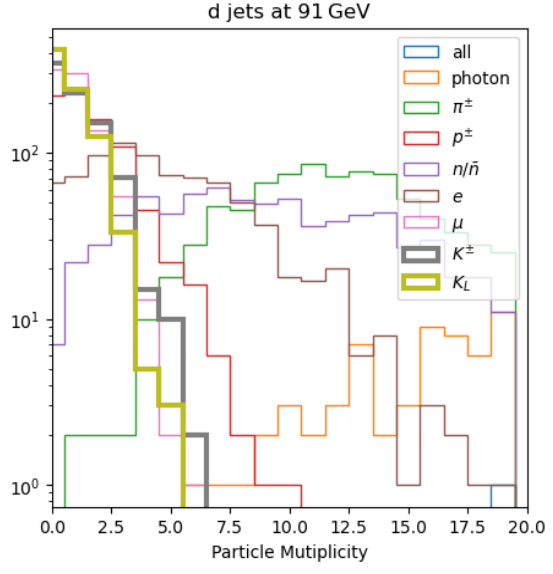
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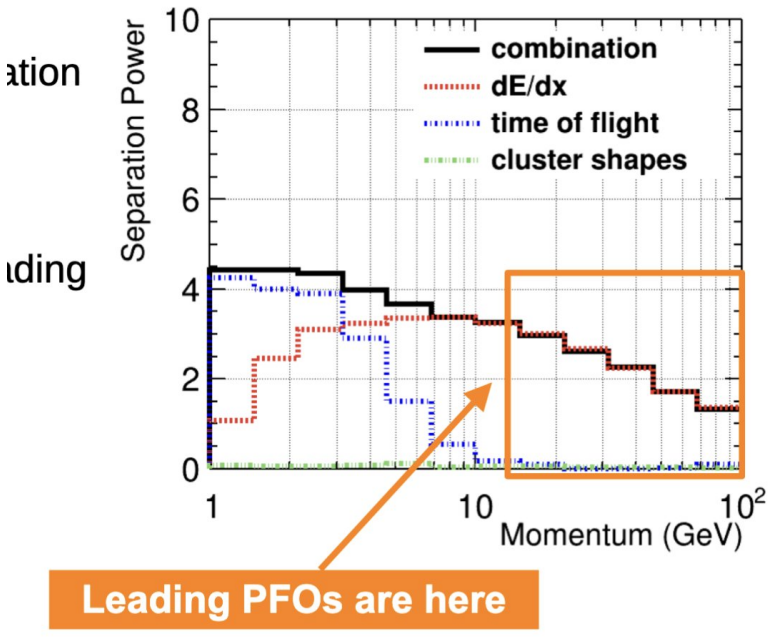
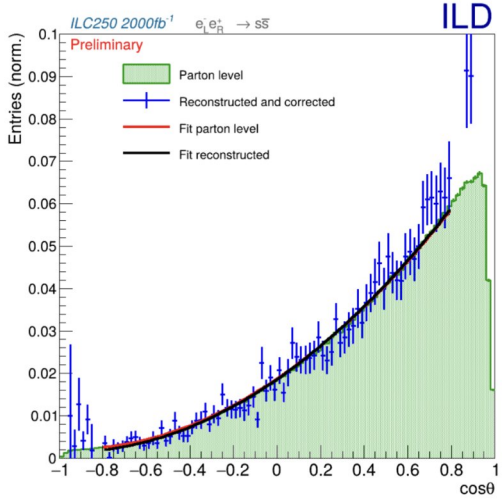
Timing for h → ss ?

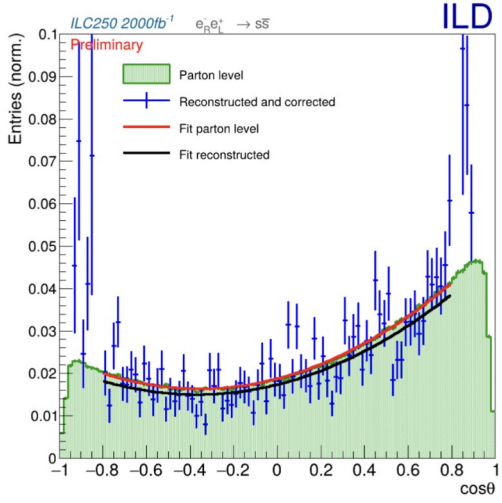
From Jesus pres. (Today)



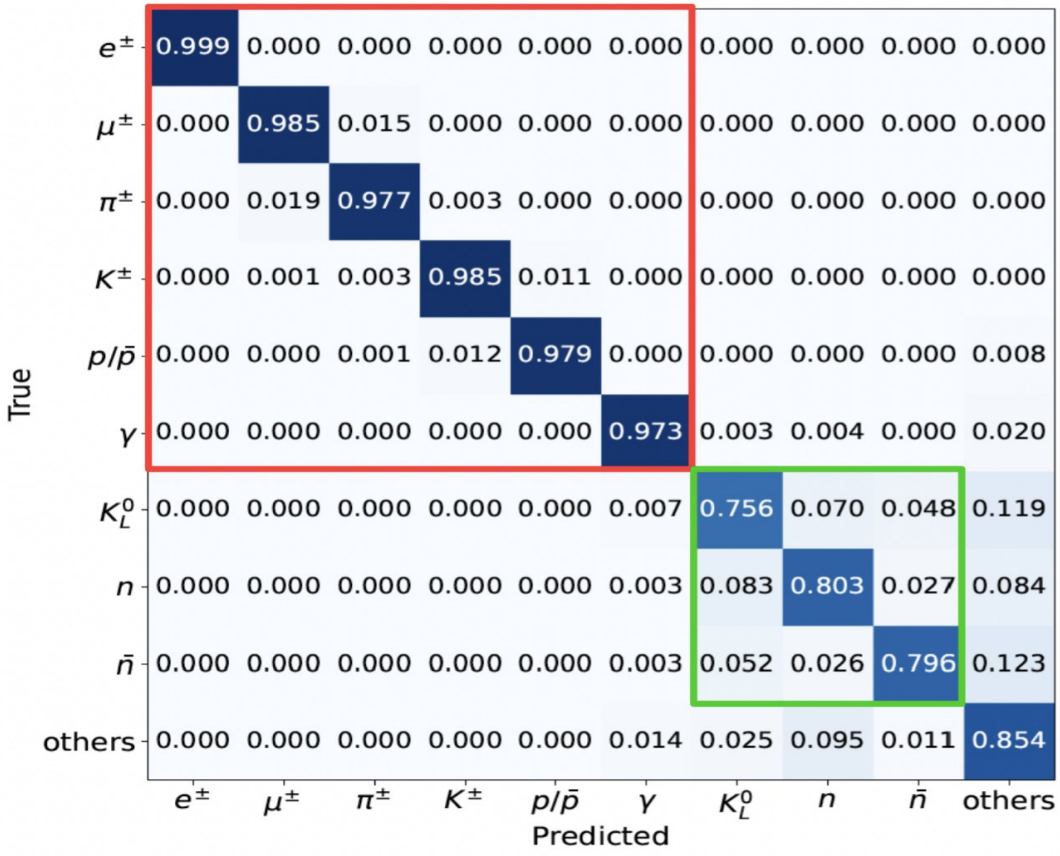
To checked potential in endcaps:

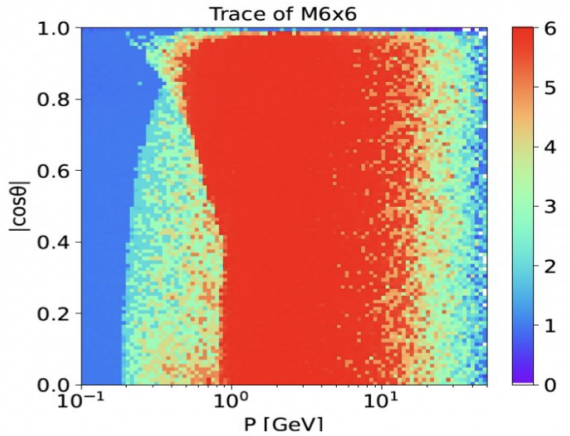
- Track length ↗ + timing
  - Track length depends on P_T
  - Where most statisitics is





Pid: differential performance





M. Ruan, June 2025

https://indico.in2p3.fr/event/36599/contributions/157991/attachments/93124/142444/2025-06-12_BMR-Holistic-LLR.pdf

AI usage: Jet origin id

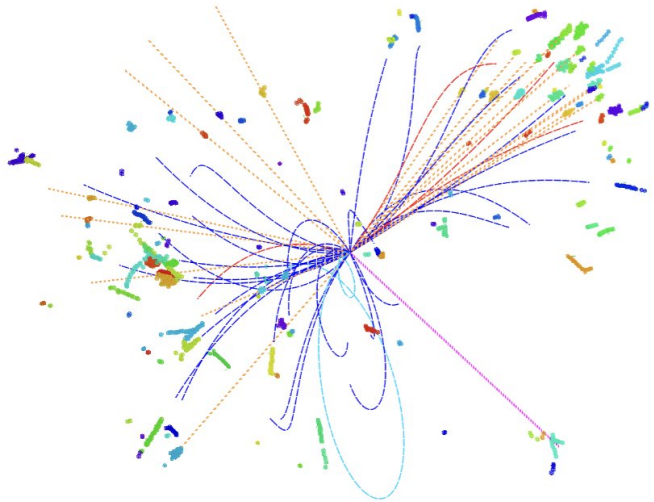
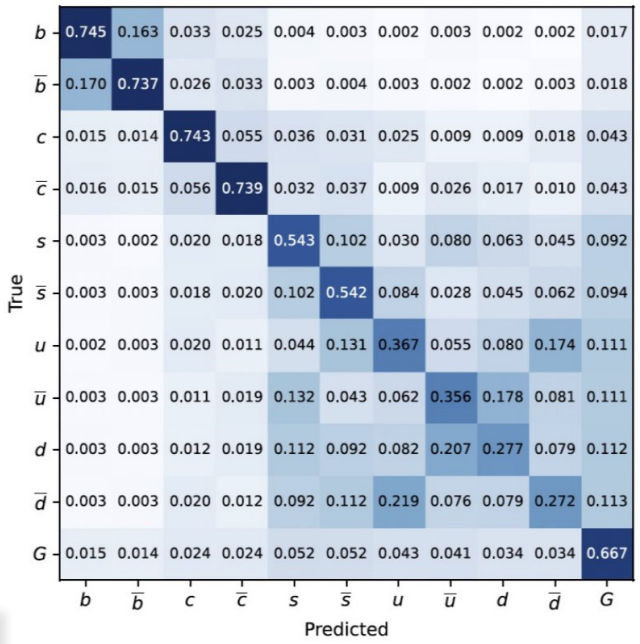
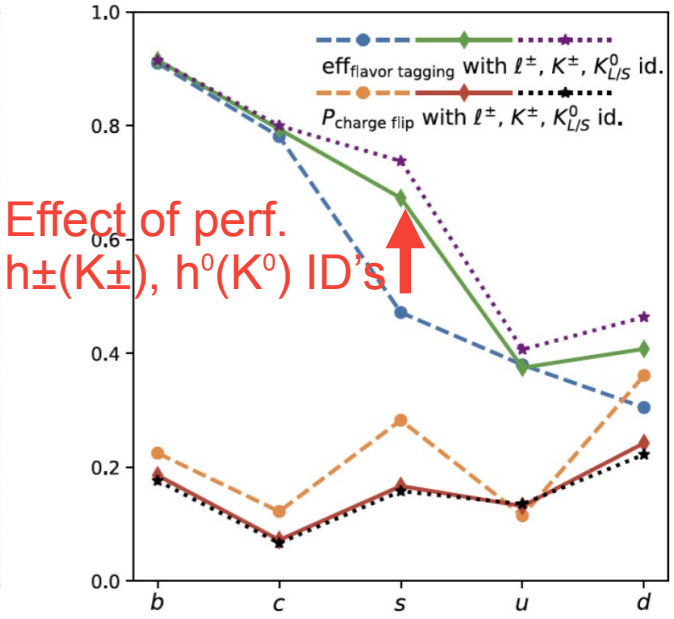


FIG. 1. Event display of an $e^+e^- \to \nu\bar{\nu}H \to \nu\bar{\nu}gg$ ($\sqrt{s} =$ 240 GeV) event simulated and reconstructed with the CEPC





Effect of perf. h±(K±), h⁰(K⁰) ID's

- Distinguish jets originated from 11 different kinds of colored particles: 5 quarks, 5 anti-quarks, and gluon.
- Strong impact on the physics reach:
  - Higgs rare & exotic hadronic decay up limits improved by 3 times – 2 orders of magnitudes, i.e., H->ss be limited to 3 times the SM prediction.
  - EW & Flavor Physics measurements.

M. Ruan, feb 2025

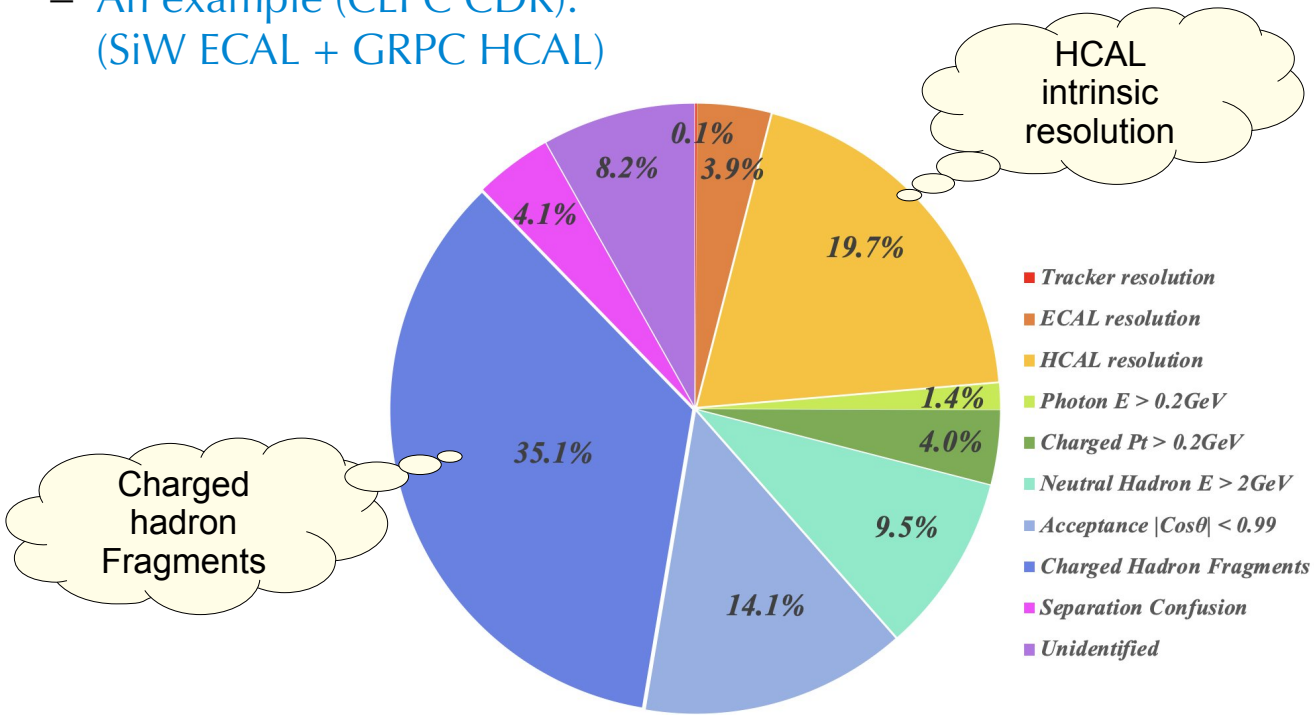
Seminar@LLR

https://arxiv.org/abs/2310.03440

Effects on JER / BMR : work from Manqi's team

Contribution from JER/BMR (2015)

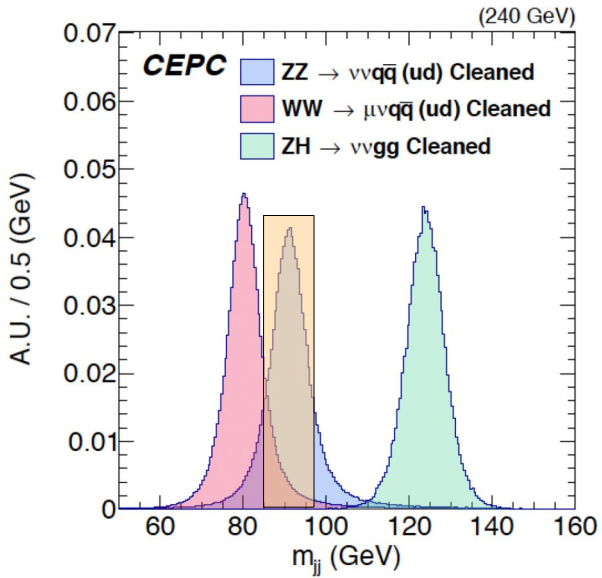
– An example (CEPC CDR):
(SiW ECAL + GRPC HCAL)



Much improved since thanks :

– 1-to1 correspondance

– Jet-Origin identification

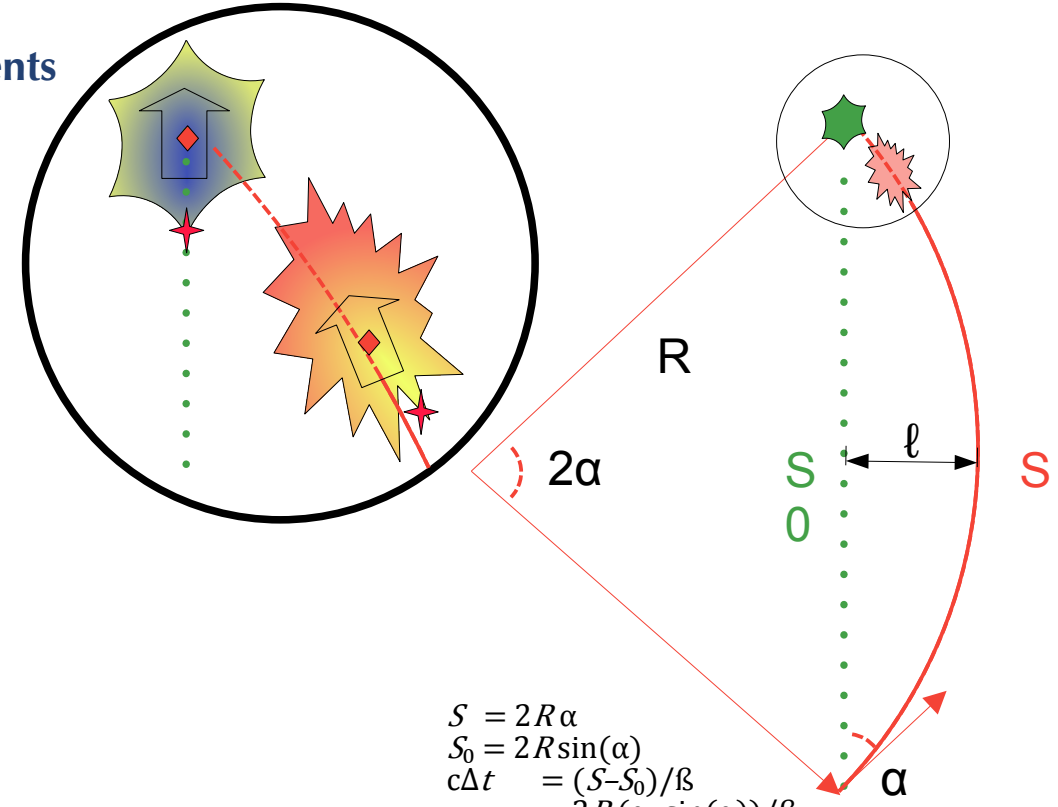


Bulk of distribution matters (less the tails): σ, fraction ⊃ 2σ

Timing in PFA

Separation merging of neutral / charged fragments

- Examples
  - Compatibility with ToF
  - Compatibility of cluster with time profile
    - Simplier: Centroid + Time arrow
      - From cluster vertex?
        - How defined?
          - Earlierst cell?
          - Outmost cell in gradiant?
          - …
      - From cluster centroid ?
    - More complex = Time profile of shower
- Non-trivial issue: how to handle time resolution



$S = 2R\alpha$
$S_0 = 2R\sin(\alpha)$
$c\Delta t = (S - S_0)/ß$
$= 2R(\alpha - \sin(\alpha))/ß$
$= S_0(\alpha/\sin(\alpha) - 1)/ß$
$R = P/qB$
$\ell = R(1 - \cos\alpha)$

Openings (Not conclusions)

This presentation is too early…

- New results coming JCB, IHEP (AURORA)

JER/BMR still the main topic

- Higgs Boson prodiuction and weak boson production.
  - ZH main but ννH should also be considered (cleaner)
    - H→ss (in ννH ?)
      - To be clarified what the K id (with ToF) can do
  - Weak bosons to be looked at.

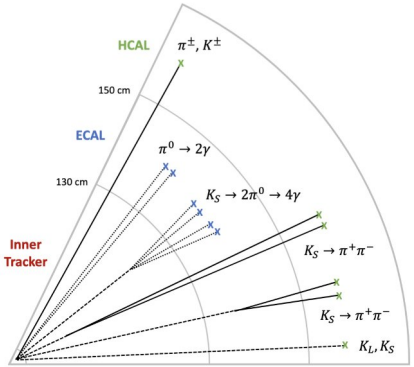
Flavour (b) and τ physics

- (all channels with π^0 and γ)
  Now: impoact of granularity. Timing to be added

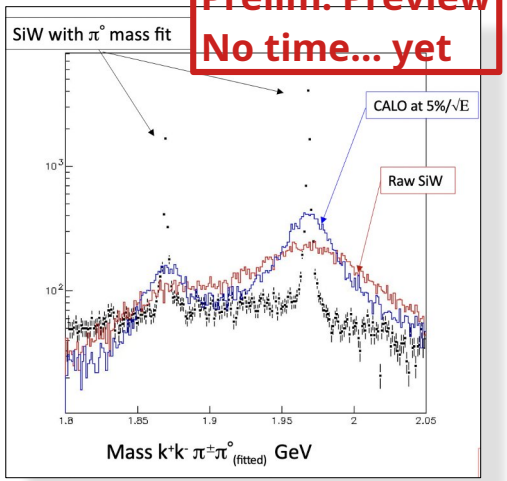
can be interesting to looked at

Reminder: all neutrals can't be timed with a single dedicated layer (SET/ OTK like)

https://arxiv.org/pdf/2003.09517



Prelim. Preview
No time… yet



Jean-Claude at DRDCalo Ancona & LCWS25

1. Bs decays to Ds $\pi^{\pm}$, Ds $K^{\pm}$
2. $B^{\circ} \to \pi^{\circ}\pi^{\circ}$
3. Transition from quark $b \to s\ \gamma$
4. τ physics rare decays
5. τ polarisation and AFB measurement