A catalogue of

Simulation/ Detector Performance/ Reconstruction session

6th November 2015

K. Kotera Shinshu University

at LCWS2015 in Whistler BC CANADA

Sessions

2: simulation/ detector performance/reconstruction
Dec 3rd, 5th,

2: joint sessions with
Calorimetry, Dec 4th,
vertex/tracking, 5th,

1: Physics/detector (ILD, SiD, CLICdp: plenary) Dec 3rd

talks

- Tools × 5
  - DD4hep
    - Reconstruction (Nikiforos Nikiforou)
    - Simulation with DD4hep
      - CLIC simulation Model (Marko Petric)
      - ILD simulation Model (Shaojun Lu)
  - Dirac Grid,
    - ILD Drac (Marko Petric)
    - Mass production (Constantino Calancha)

- PFA algorithm ×5
  - PandoraPFA (John Marshall, Steven Green, Boruo Xu)
  - ArborPFA (Manqi Ruan, Remi Ete)

- High level reconstruction and performance ×4
  - Full Tau reconstruction (Daniel Jeans)
  - Beam spectrum Bah bar (Tomohiko Tanabe),
  - $\gamma\gamma\rightarrow$Hadron Background (Swathi Sasikumar)
  - Detector Optimization (Hiroki Sumida)

talks

Tracking + vertex × 4 (covered by ....)
(Andrea Mathias Nunberg,
Bruce Schumme, Ann Schuetz, Rosa Simoniello, Frank Gaede)*

Plenary
Physics/Detectors Joint session of ILD, SiD, and CLICdp ×6

- Event Generation (Mikael Berggren)
- Simulation Tools (Nikiforos Kikiforou)
- Track Reconstruction (Frank Gaede)
- Particle Flow and Clustering (John Marshall)
- Flavor Tagging (Masakazu Kurata)
- Grid Production Tools (Marko Petric)

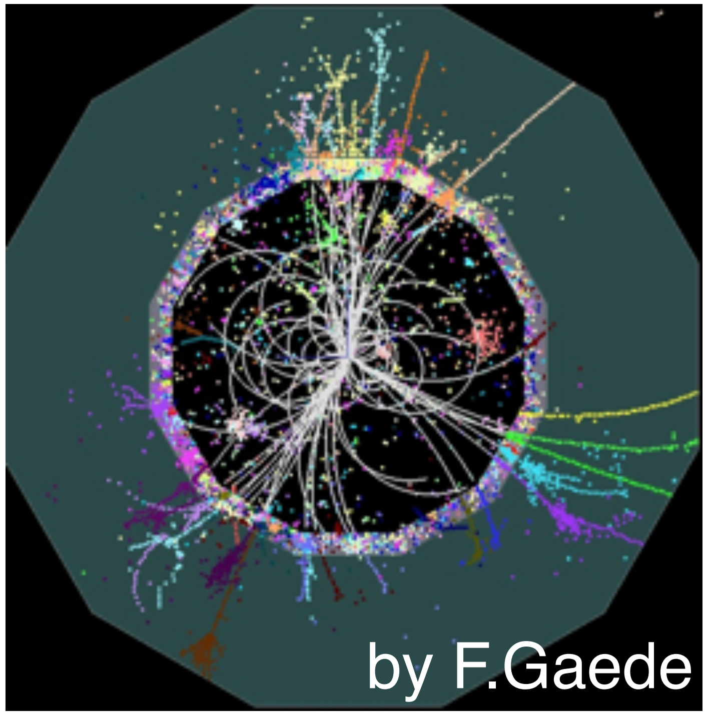
Total 24 talks

DD4hep-Based Reconstruction

Nikiforos Nikiforou

coherent set of Detector Description (tool) for Hep

- Complete detector description
  - Includes geometry, materials, visualization, readout, alignment, calibration, etc.
- Support full experiment life cycle
  - Detector concept development, detector optimization, construction, operation
  - Easy transition from one place to the next
- Consistent description, single source of information
  - Use in simulation, reconstruction, analysis, etc.
  - All steps can call it in a unified way
- Few places to enter information
- Ease of use
- Minimal dependencies



DD4hep sim & rec for SID

ILD,CLICdp are moving to DD4Hep

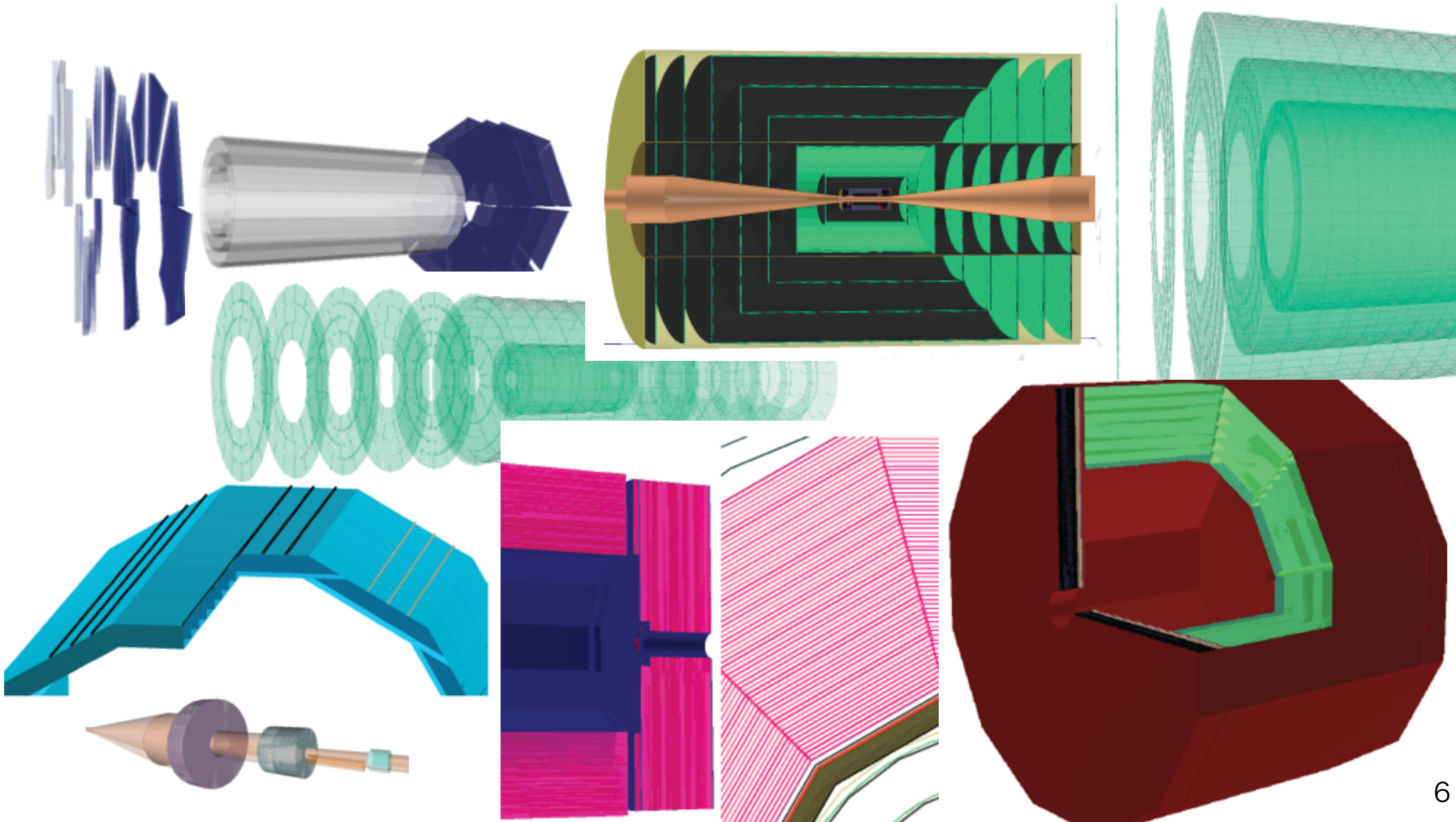
core developing → User validation

Simulation using DD4Hep

CLIC Simulation Model

Marko Petric

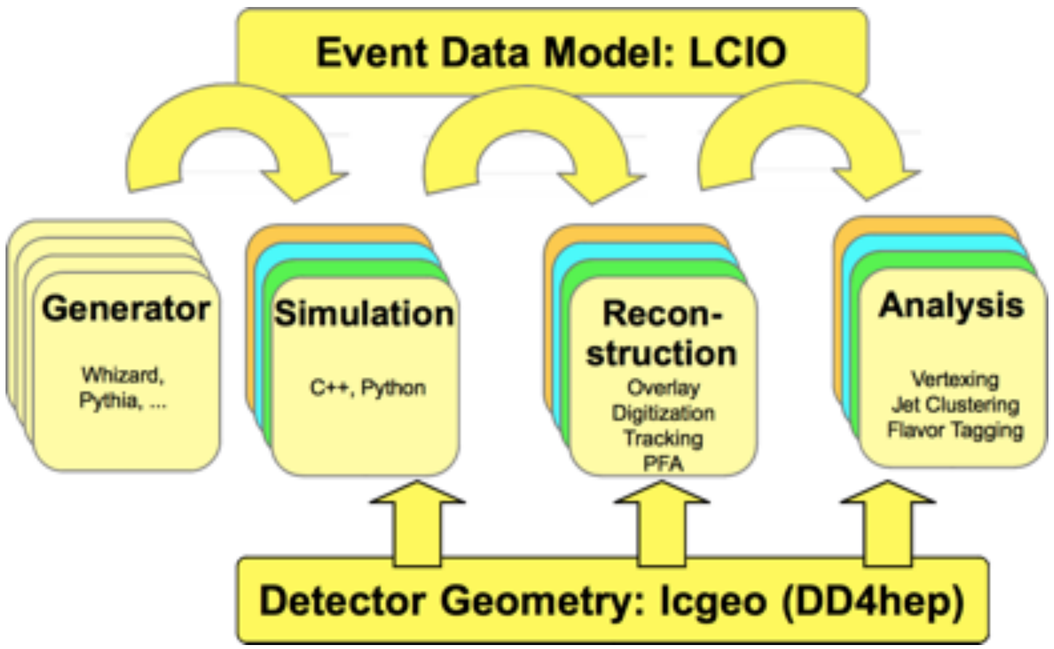
Moving to DD4hep arrived to validation step,



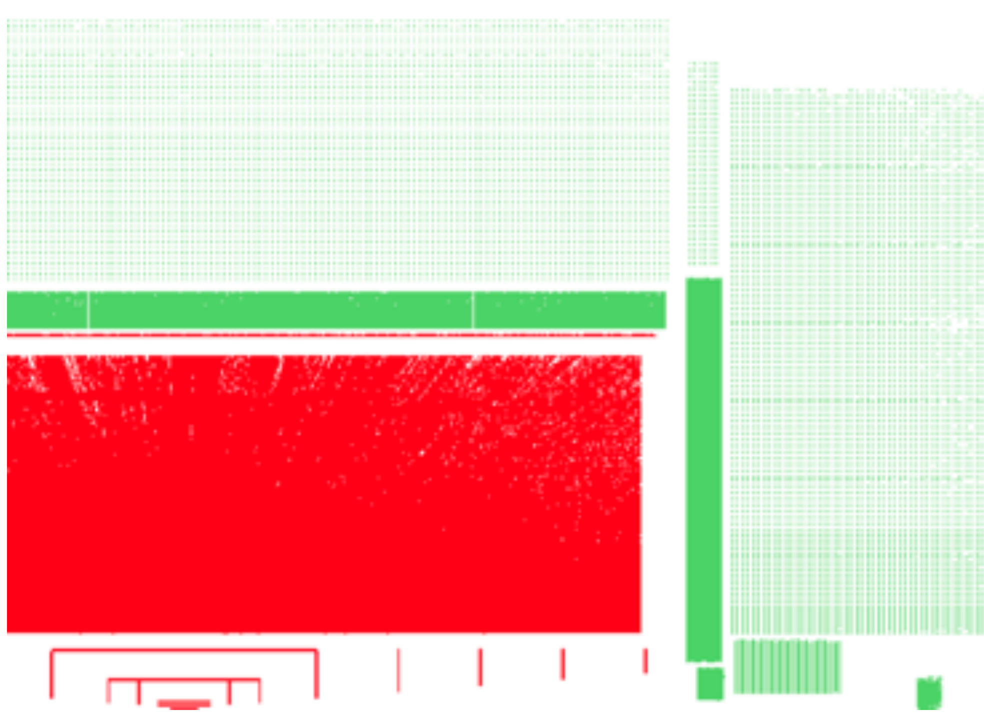
Simulation using DD4Hep

ILD Simulation Model

Shaojun Lu



lcgeo drives geometry via DD4hep



Mokka (DBD model)

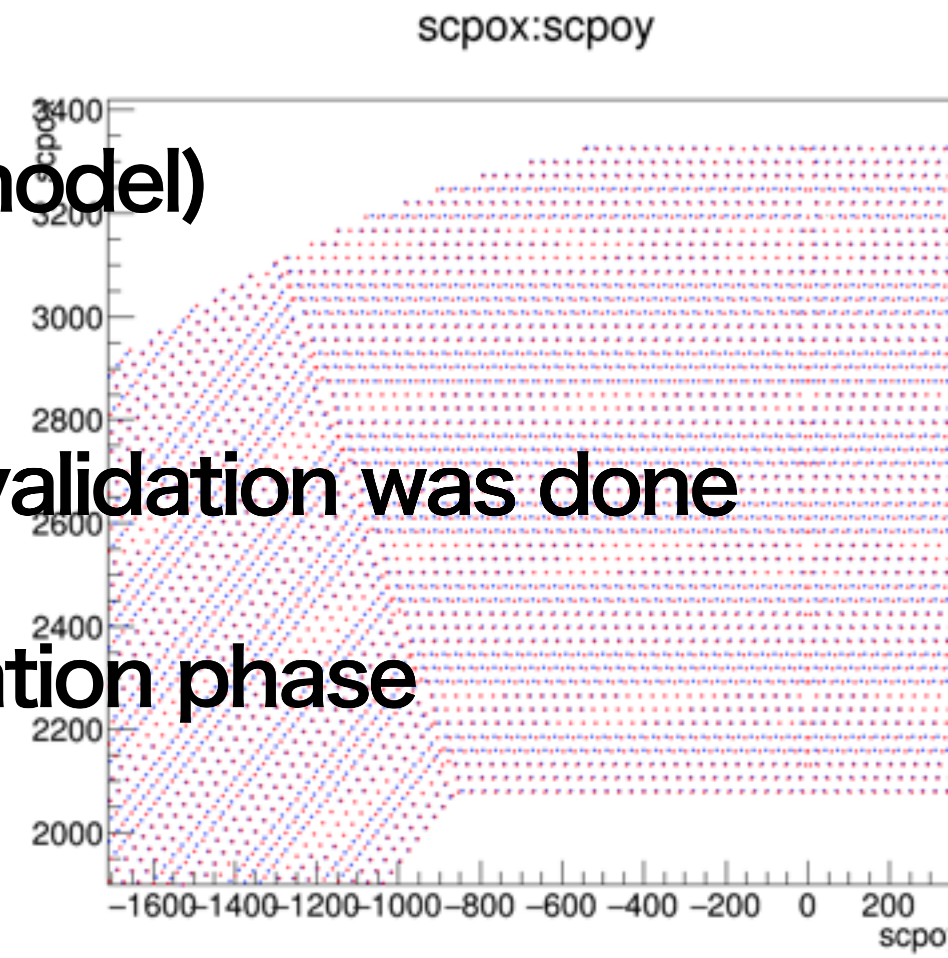
↓

DD4hep/lcgeo

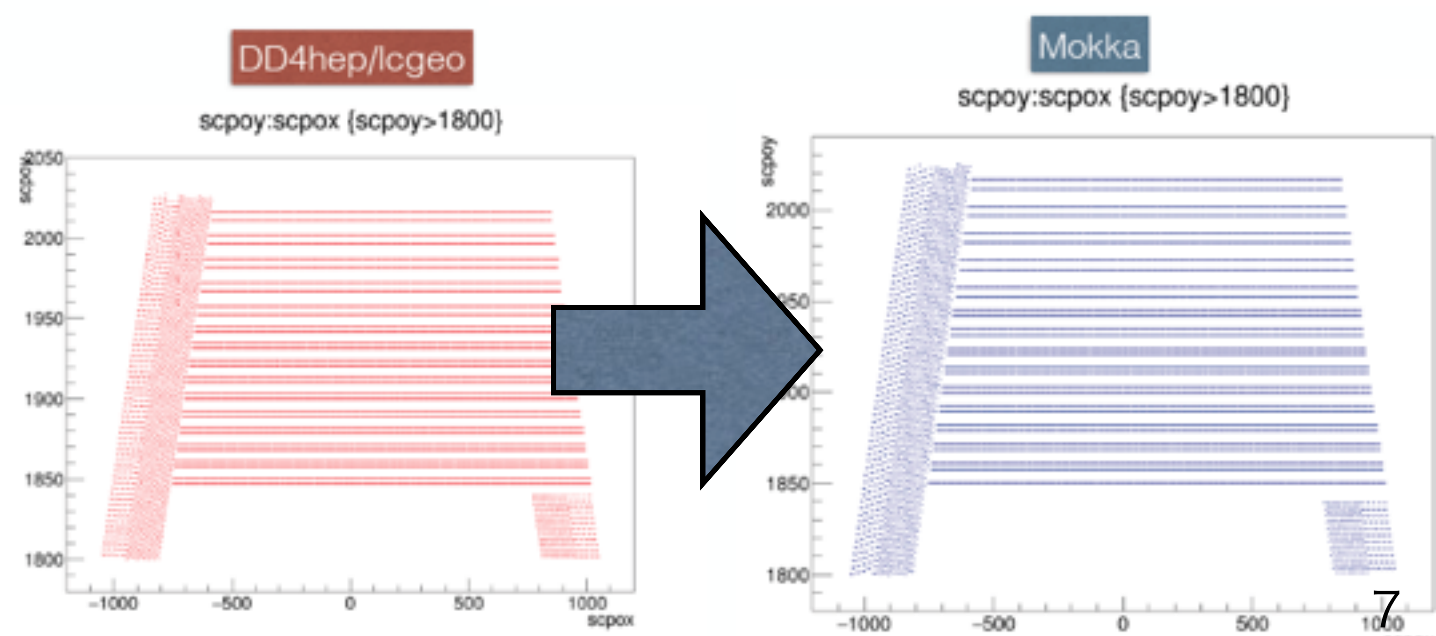
preliminary validation was done

↓

expert validation phase



Ecal Hits



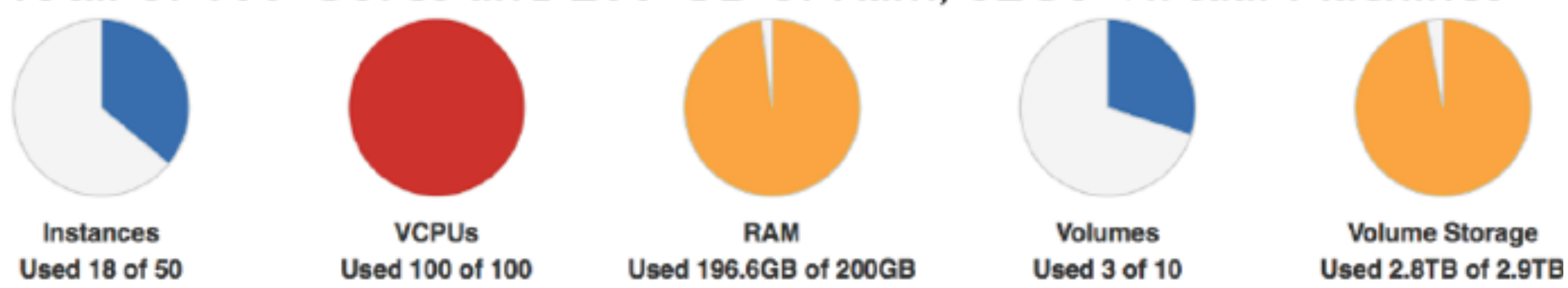
Developments in ILC Dirac and Grid tools

Marko Petric

- iLCDirac is offering an easy interface for users to run jobs on the GRID
- Enables centralised production of MC
- The LC community can now use all available resources
- Adopted by all detector concepts and
- Easy to use for individual simulation, reconstruction or analyses
- No major changes to user interface foreseen

iLCDirac Server Setup

Total of 100 Cores and 200 GB of Ram, SLC6 Virtual Machines



- Increase of supported sites from 24 to 41
- Now able to run at peak 12 000 jobs in parallel
- Running on all sites (41) that support ILC VO and CALICE VO
- We are open to utilizing new ground

Tool: iLCDirac

Status of ILD Mass productions Using ILCDirac

Constantino Calancha Paredes,

special Grid tool → iLCDirac

- ILD has adopted `ilcdirac` for its mass productions.
  - Reliable, scalable, easy to use, good experts support.
  - Other experiments already using it: `CLic`, `BelleII`, `Sid`.

Improving existing tools

- set/remove metadata faster/easier.
- Extending tools for monitoring the productions.

6-fermion events have been recreated.

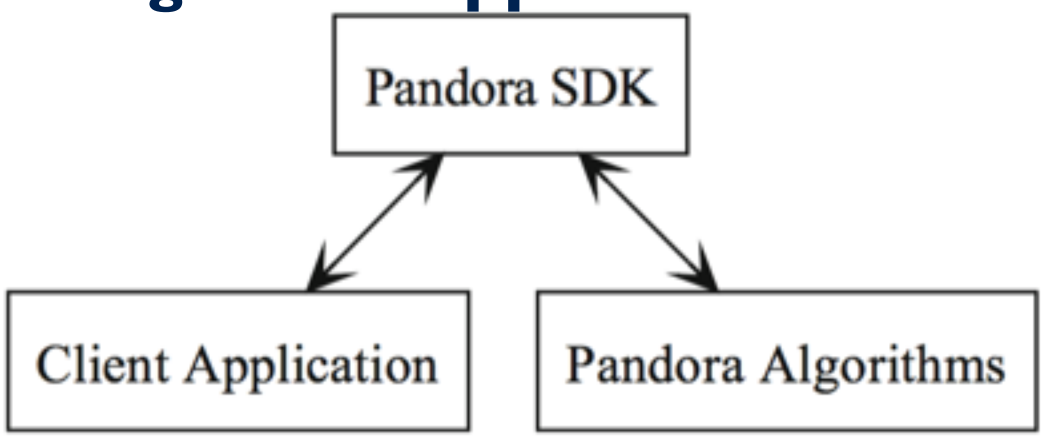
- Large statistics: $L = 15\ \mathrm{ab}^{-1}$ per process.
  - Total N events: $<\approx$ 31 Mevts.

PandraPFA Development

John Marshall

Pandora Software Development Kit.

- **Functionality provided by the Pandora SDK allows implementation of novel, multi-algorithm approaches to solving pattern recognition problems.**

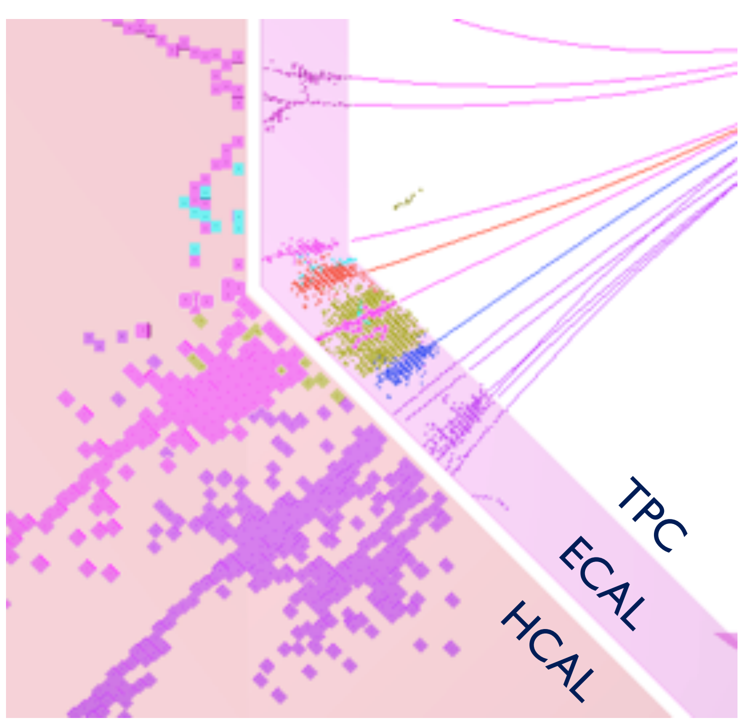


https://www.github.com/PandoraPFA
EPJC.75.439

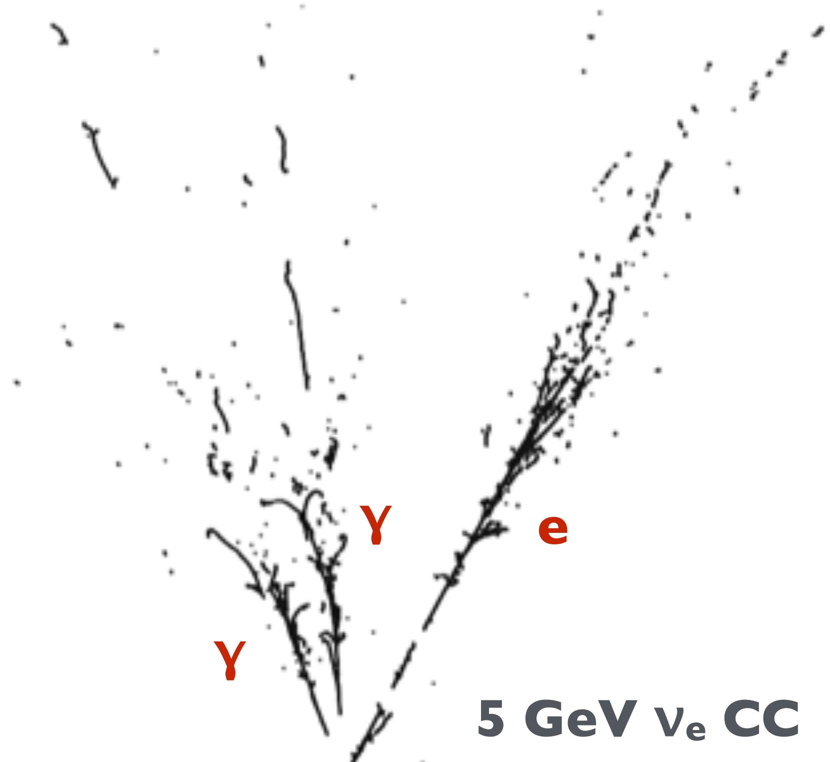
See

you can implement your own algorithm into any client App.

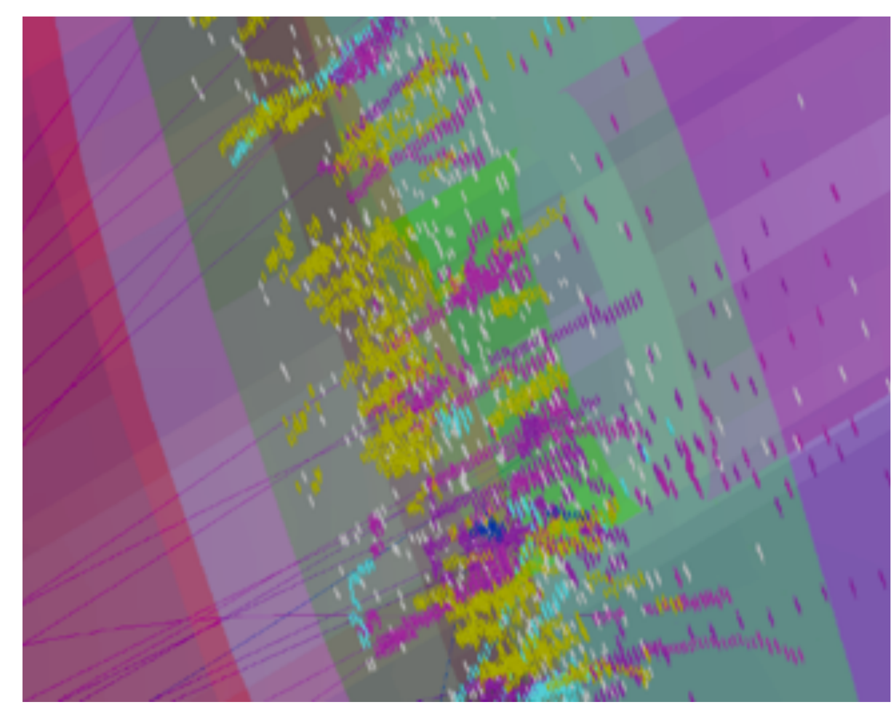
ILC/CLIC event topology



Example LAr TPC event topology



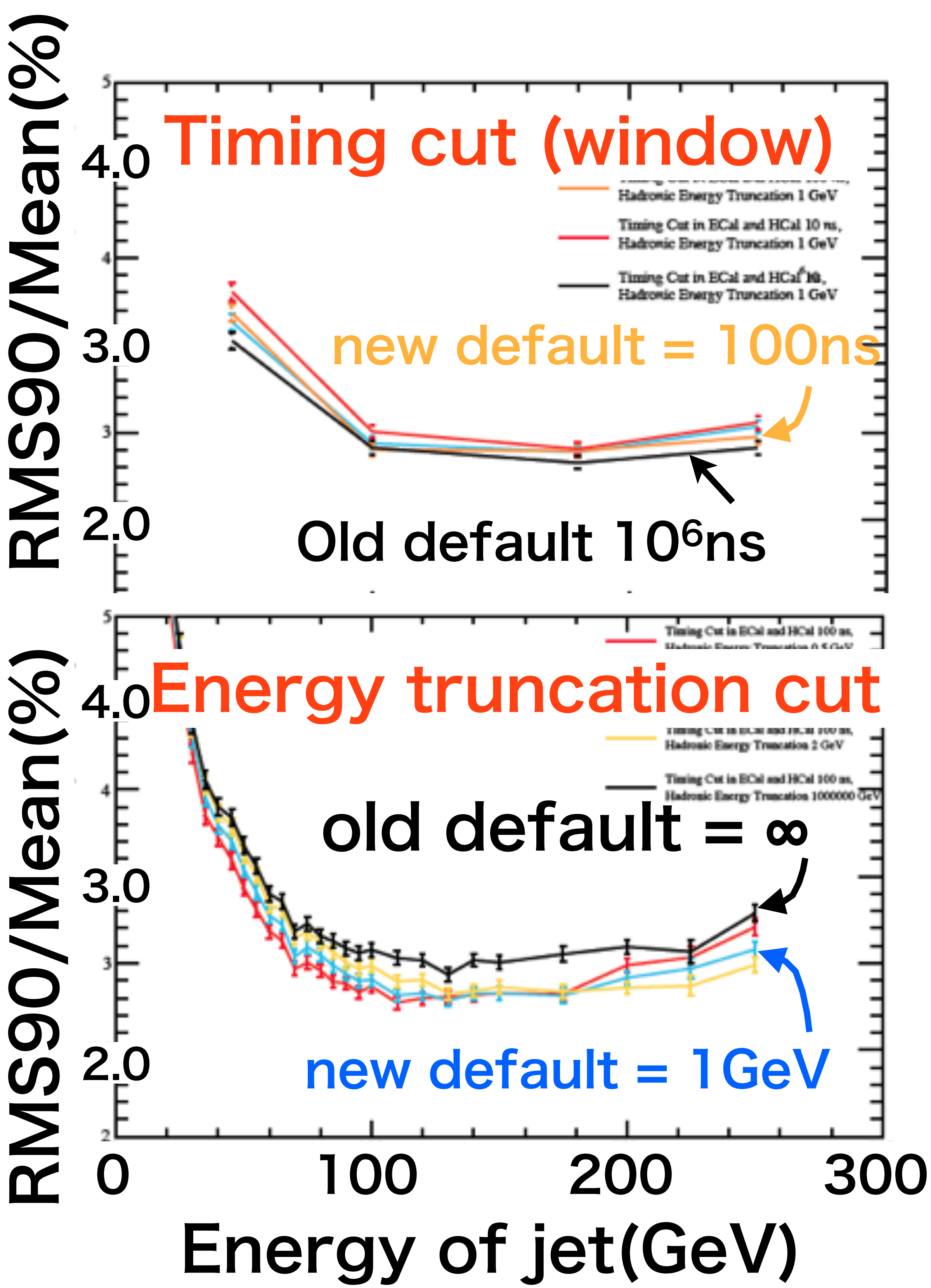
Showers in CMS HGCAL

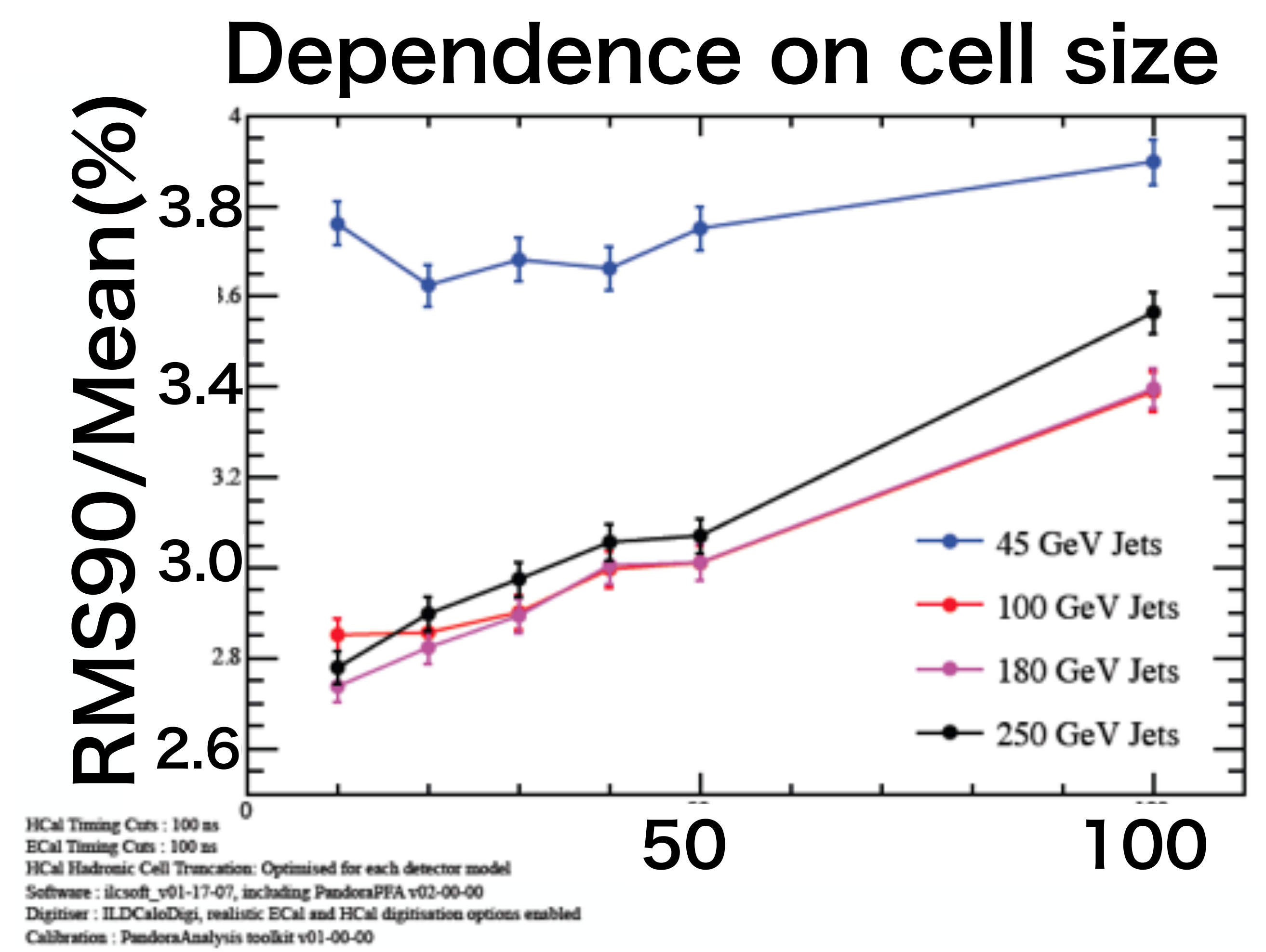


PFA Algorithm: PandoraPFA

Approach to the Hcal optimization Studies for the ILD

Steven Green





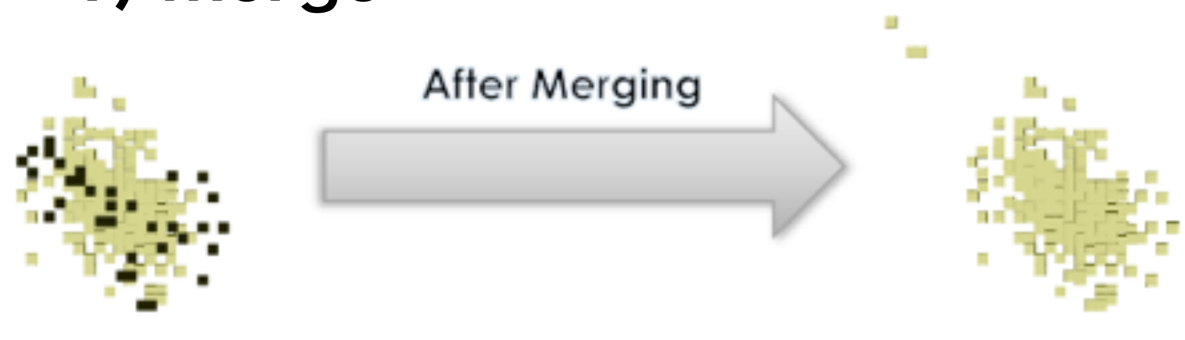
Those must be optimized for each detector to get accurate results for optimization studies.

PFA Algorithm: PandoraPFA

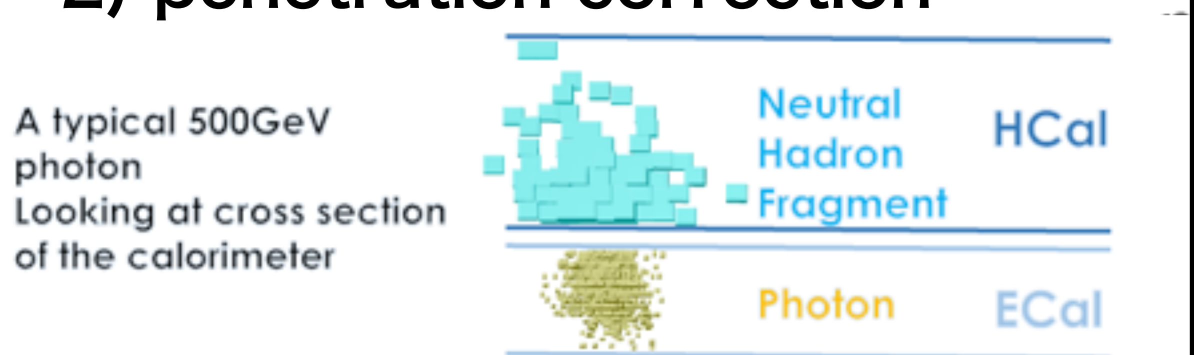
Improvement of photon reconstruction in PandoraPFA

Boruo Xu

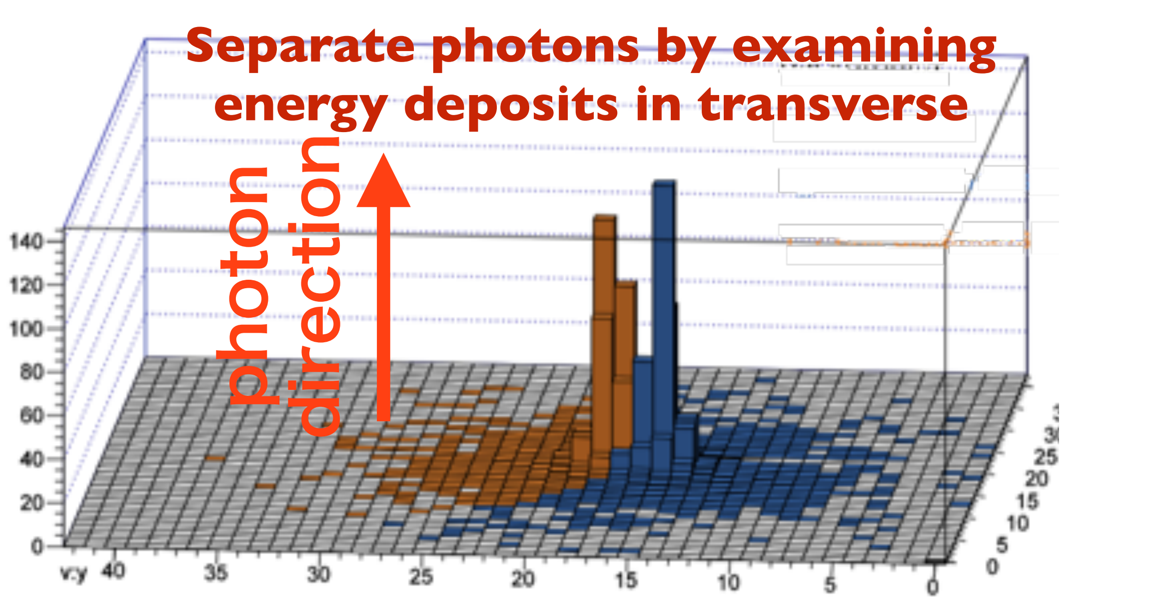
1) merge



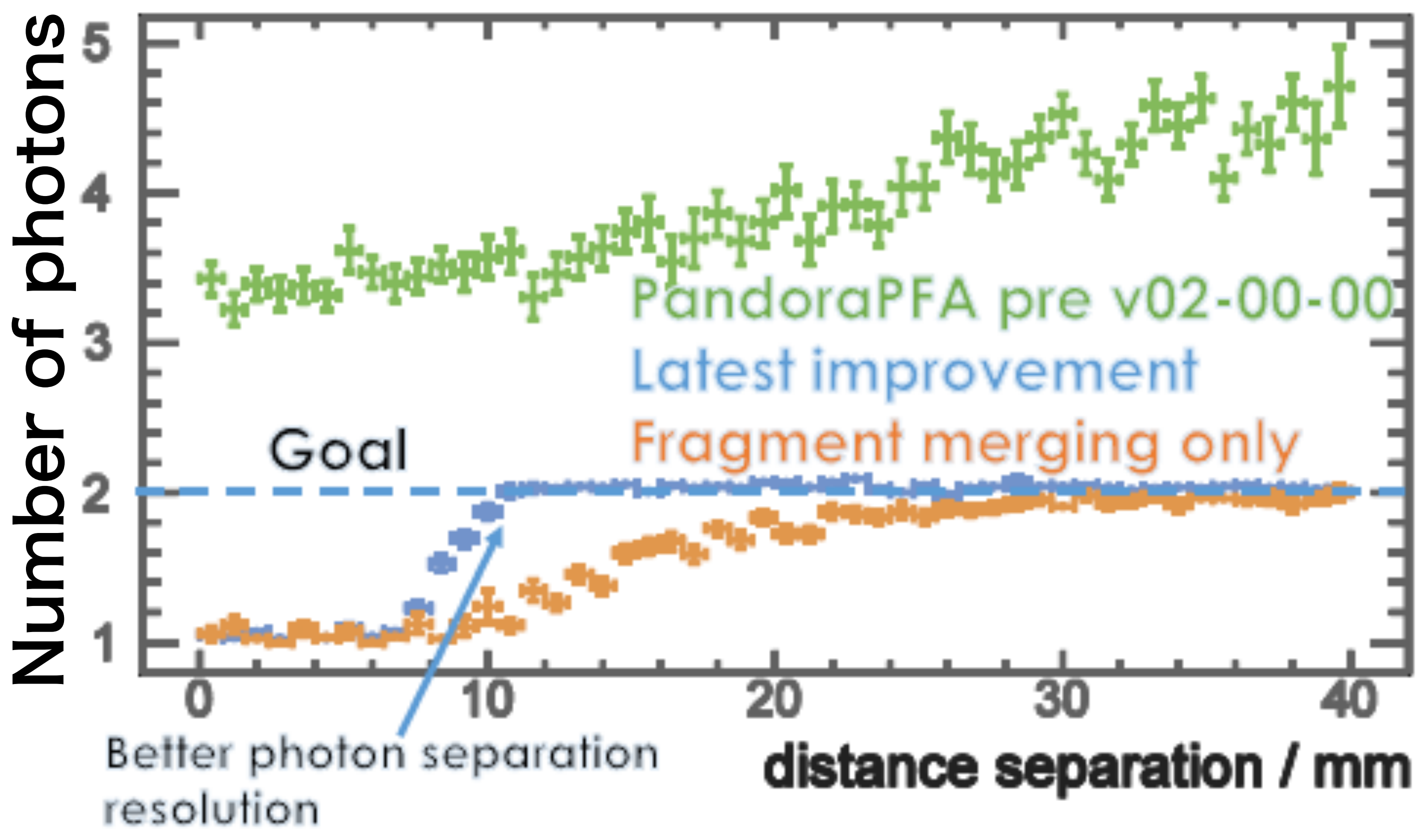
2) penetration correction



3) peak finding



E.g. Separation of nearby high energy (500GeV) photons:



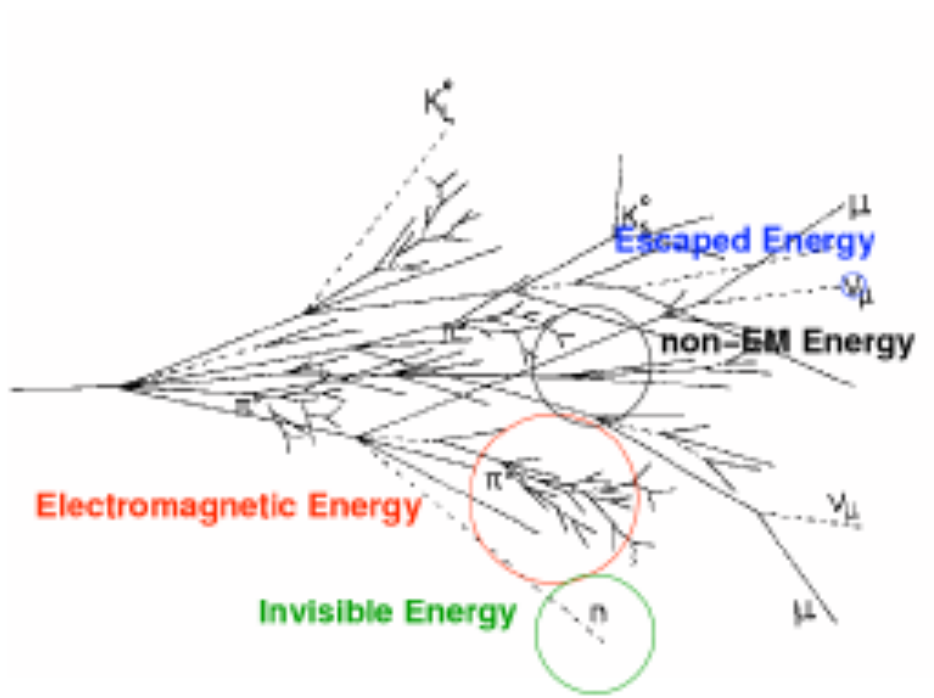
Mean of the numbers of photon significantly improved

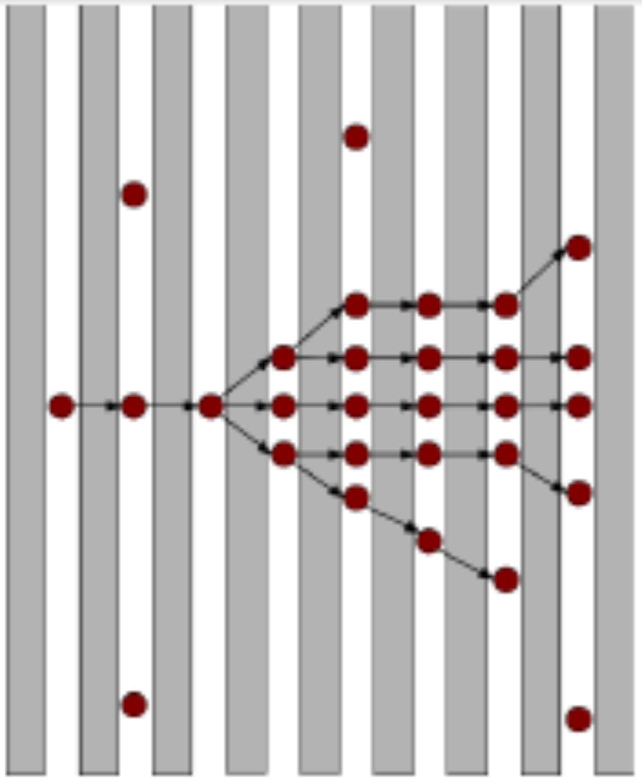
ArborPFA

From Remi Ete's sides

Principle

Particle Flow Algorithm based on hadronic shower **tree-like topology**.

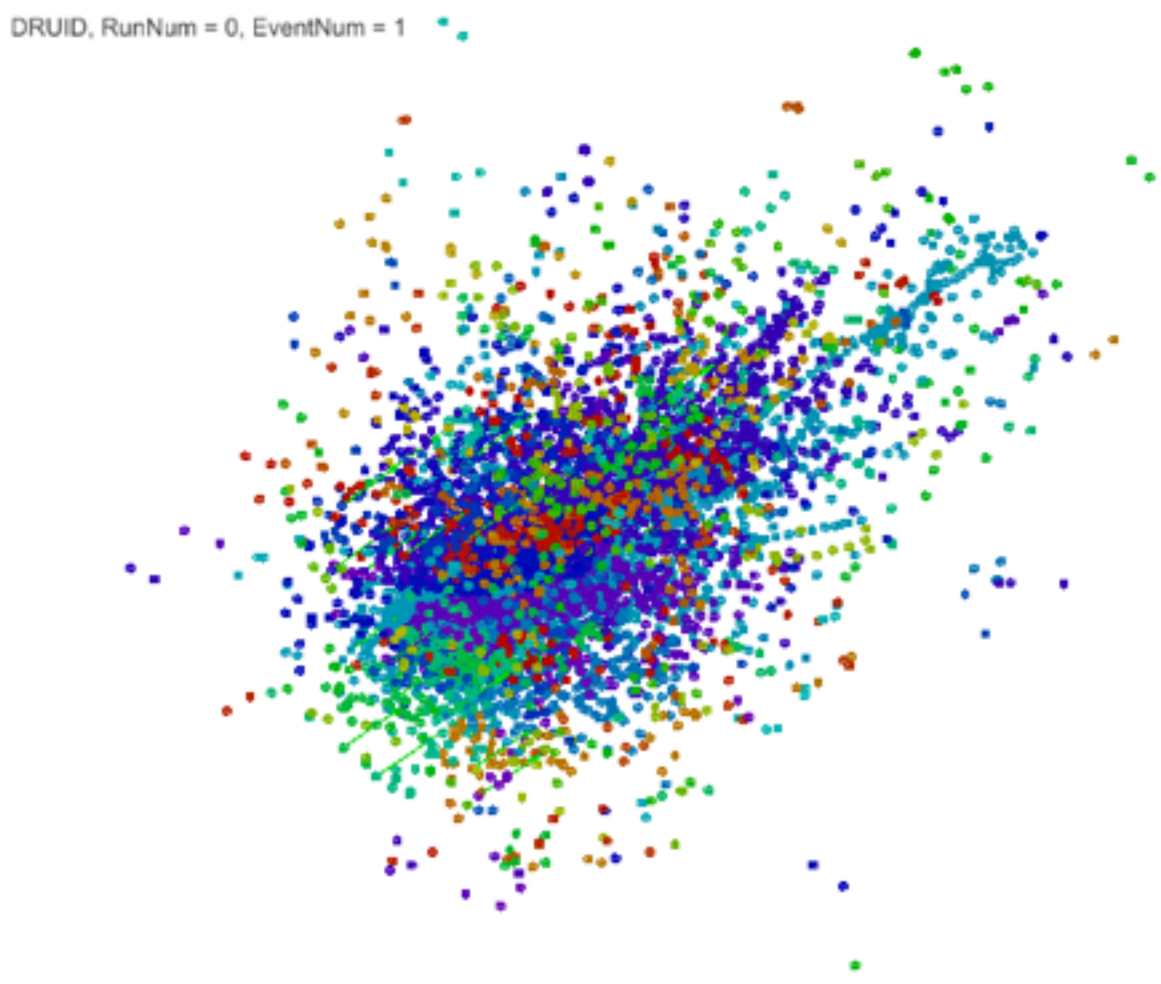




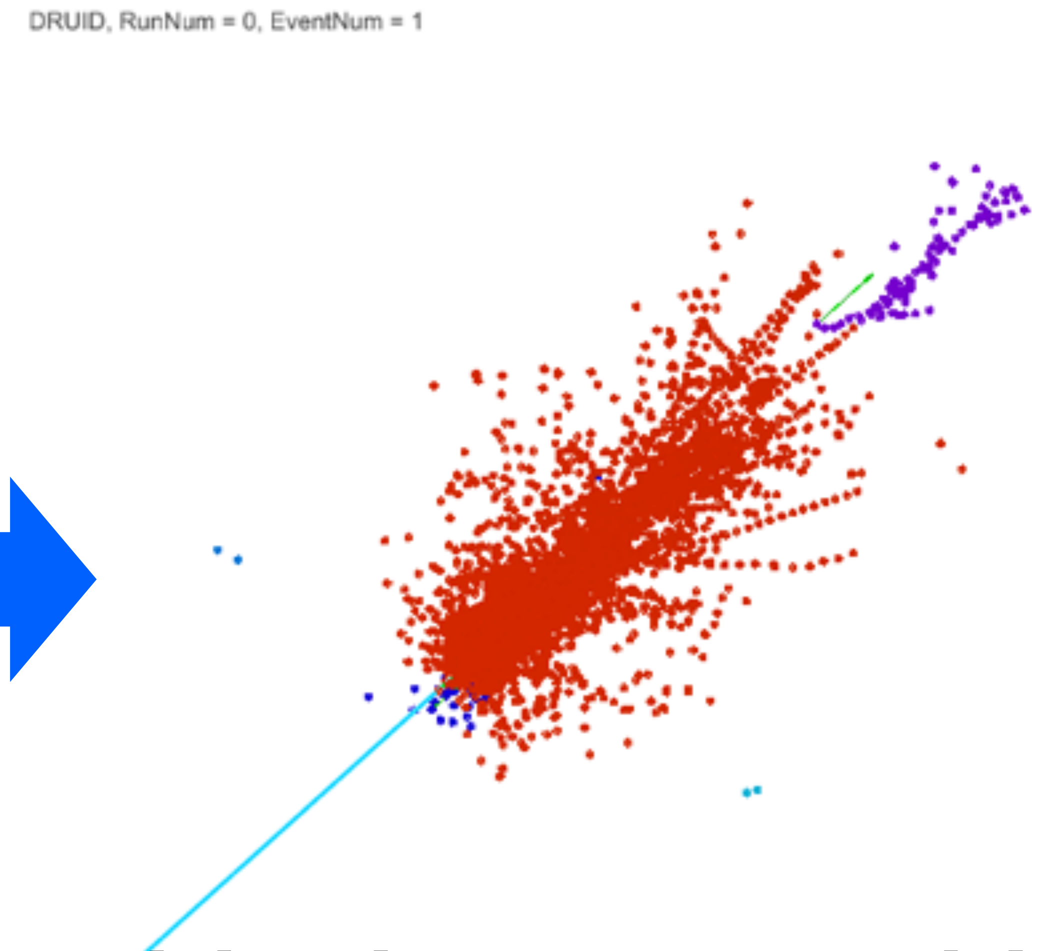
Arbor Status & Plan

Mauqi Ruan

1 TeV pion for PP collider



Original Arbor



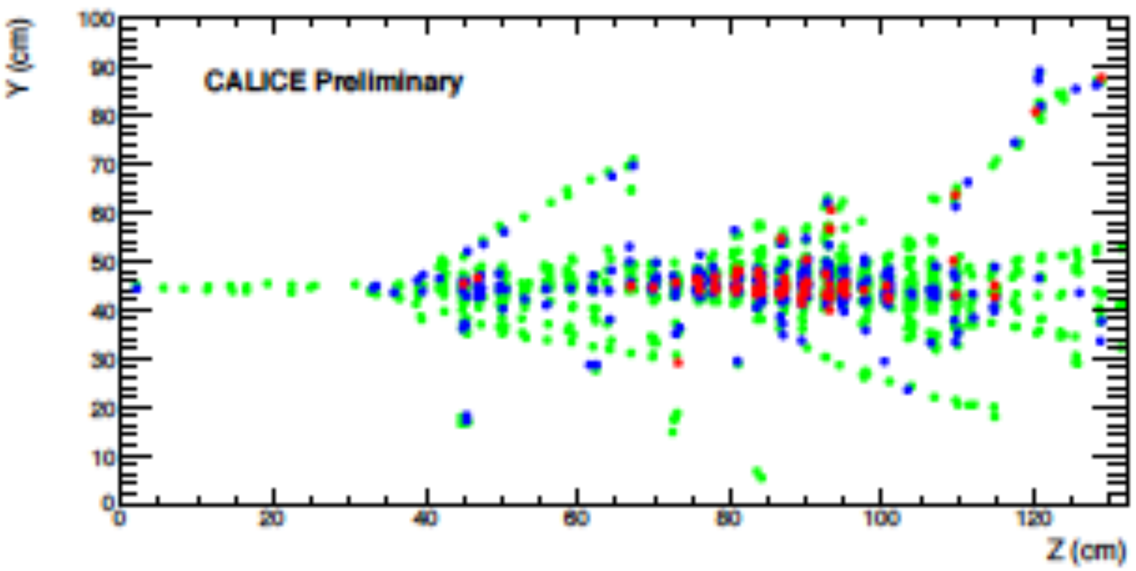
with clean up on hit time and energy+ cluster merge

Separation of Nearby Hadronic Shower using ArborPFA

Remi Ete

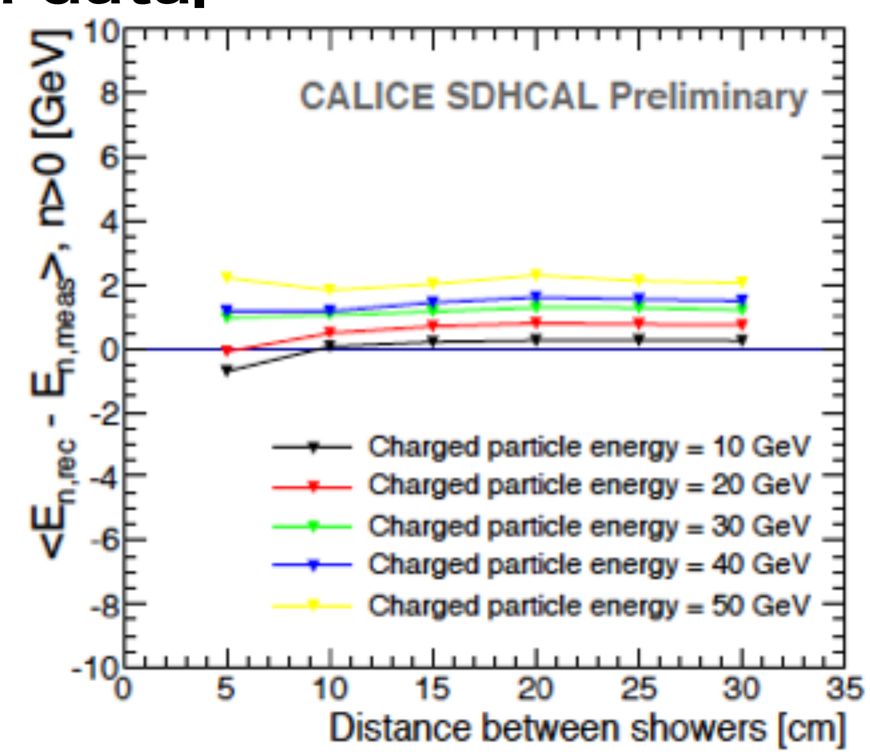
Remi applied ArborPFA on their SDHCAL data

CALICE SemiDigitalHCAL 1.3 m^3 ,48 layer, Steal abs.
1x1cm2 lateral segmentation
with GRPC



Separation

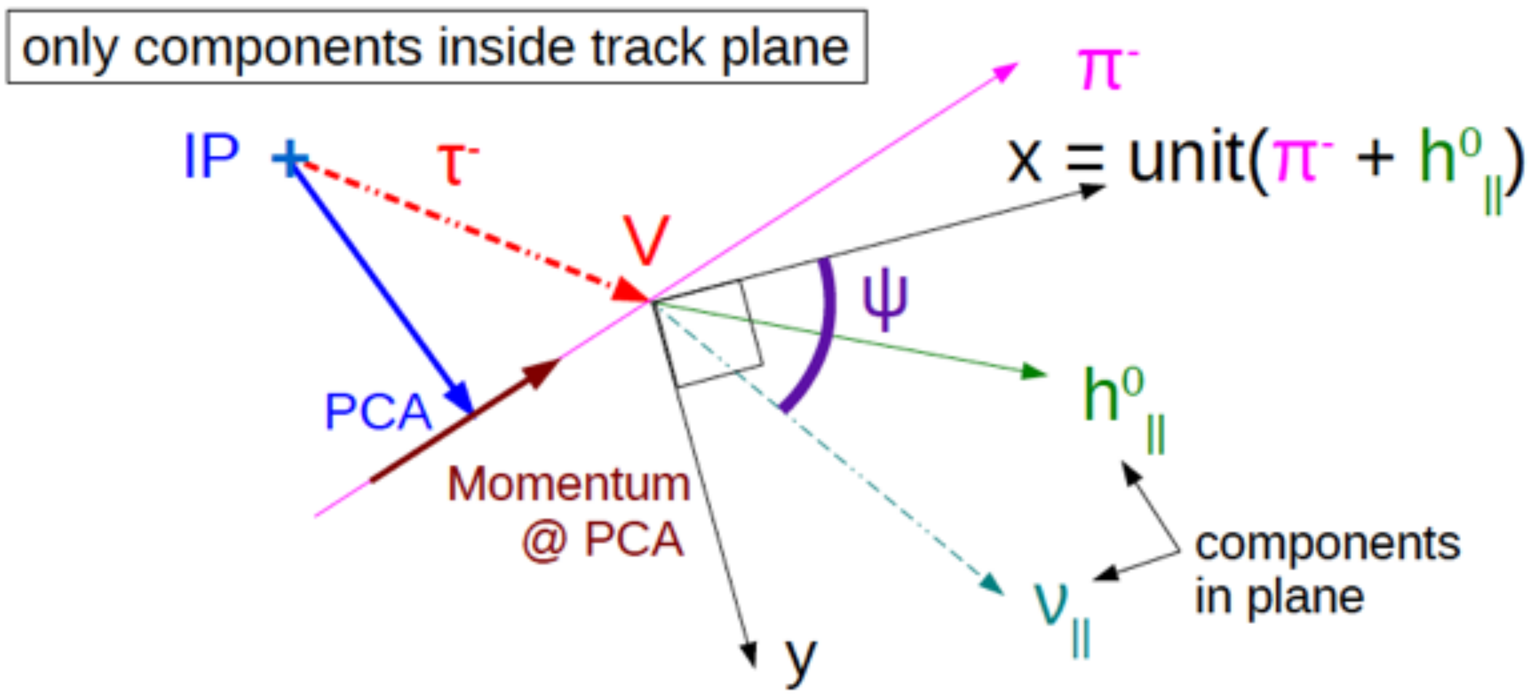
In each event, a neutral hadron overlaid on a 10 GeV charged π was emulated from real data.

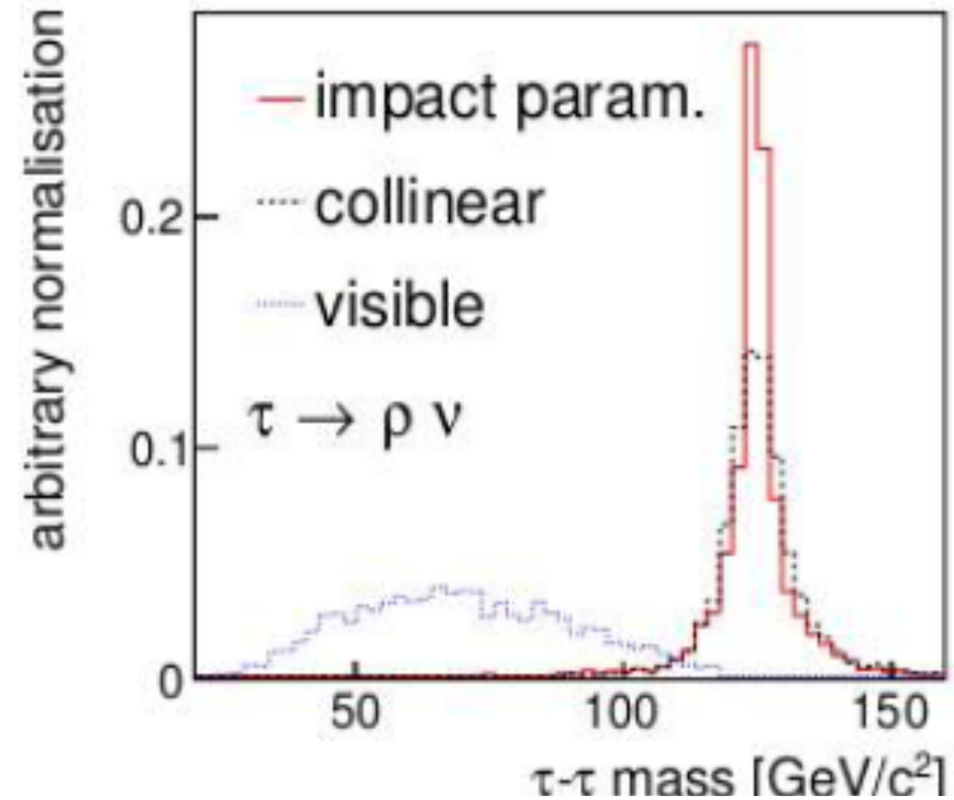


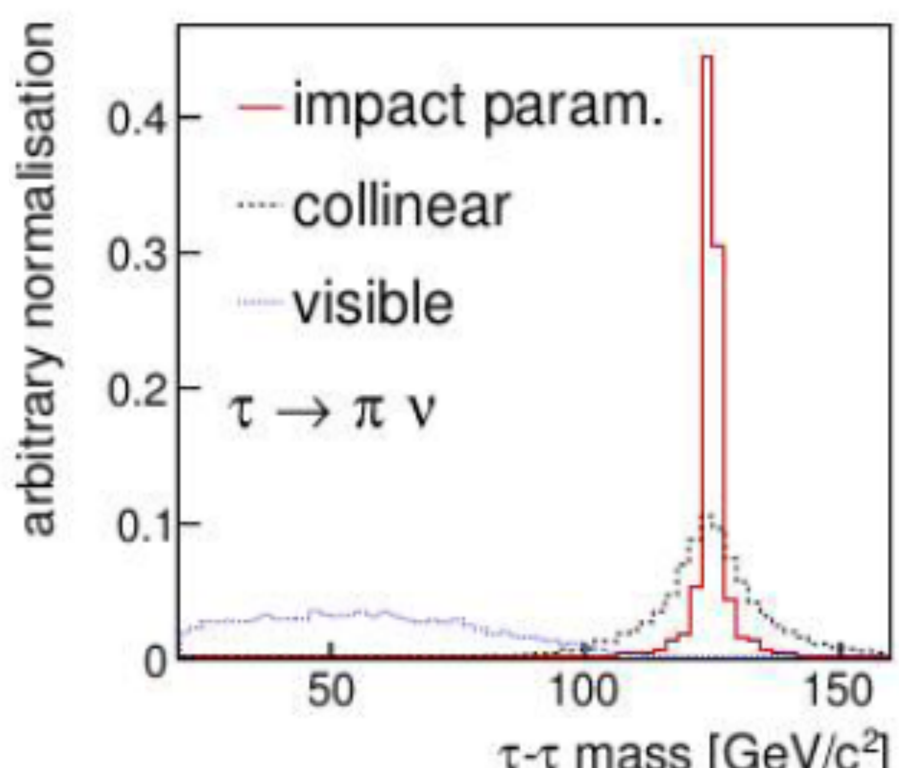
Energy reconstruction is OK till 5 cm.

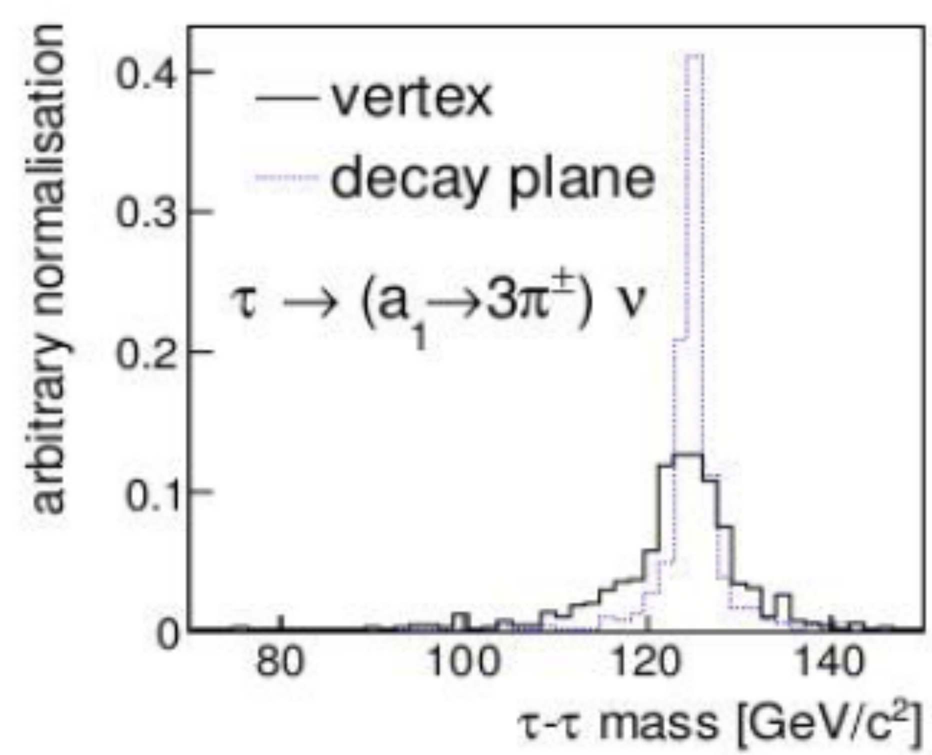
τ reconstruction using impact parameters

Daniel Jeans





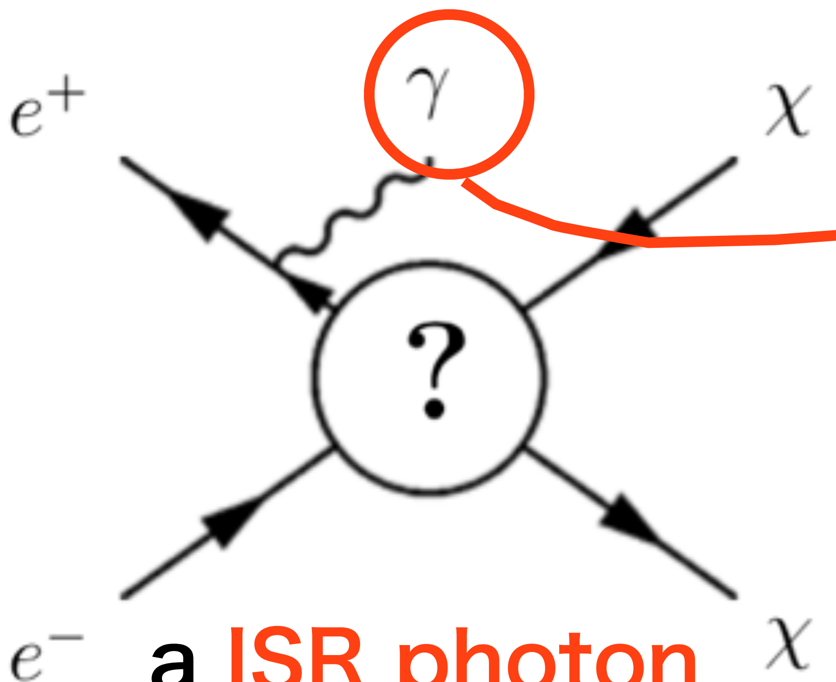




Beam spectrum, Bha-bha veto & Photon reconstruction for Mono photon analysis

Tomohiko Tanabe

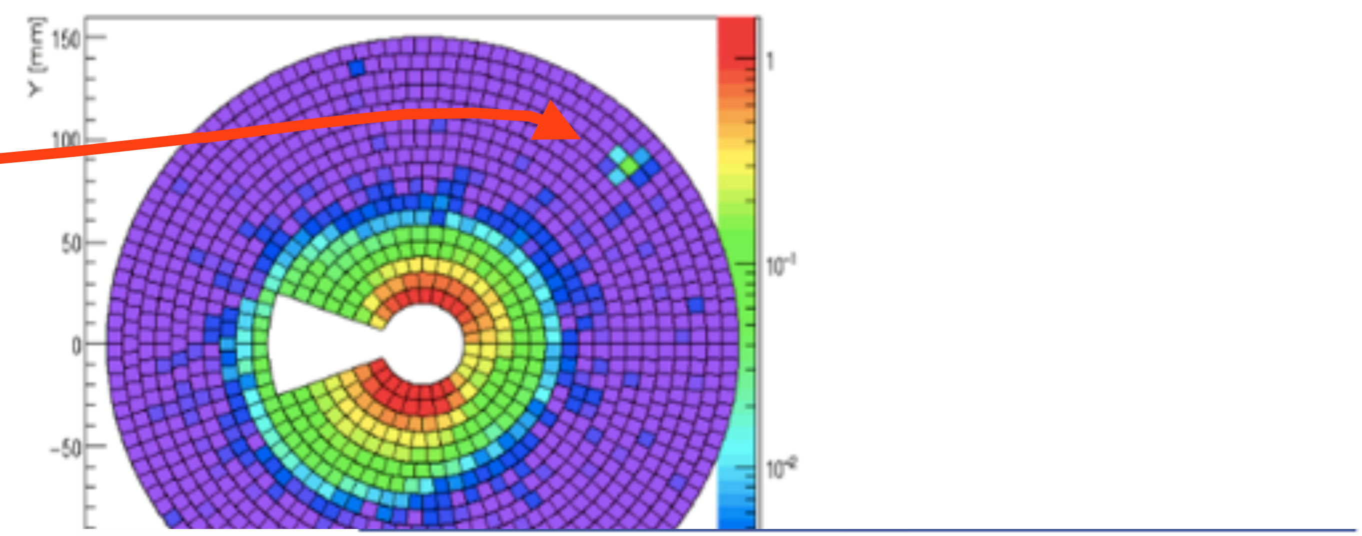
WIMP search at ILC

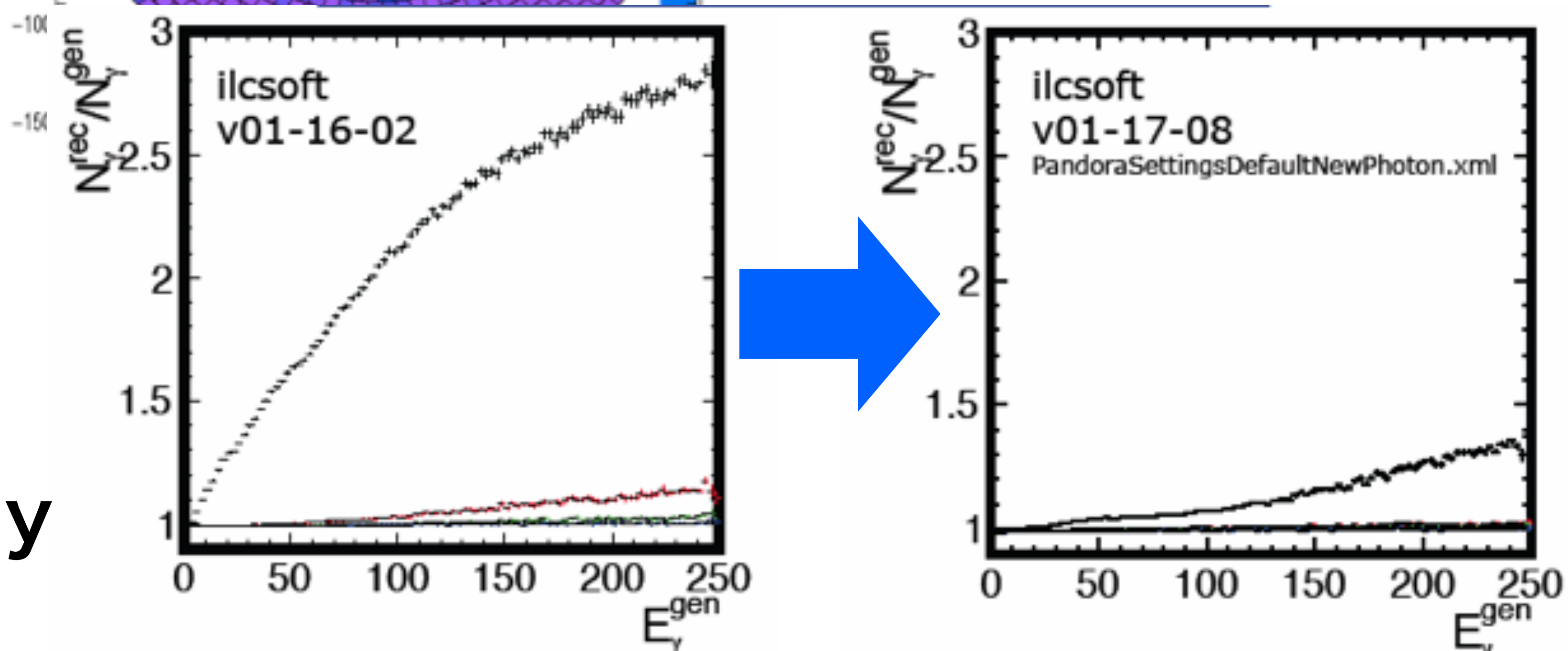


a ISR photon
+ missing E,p
search for mono-photon event(E_γ,E_θ)

- Reconstructed energy spectrum of beam.
- Bahbah veto in BCal.

Beam Cal





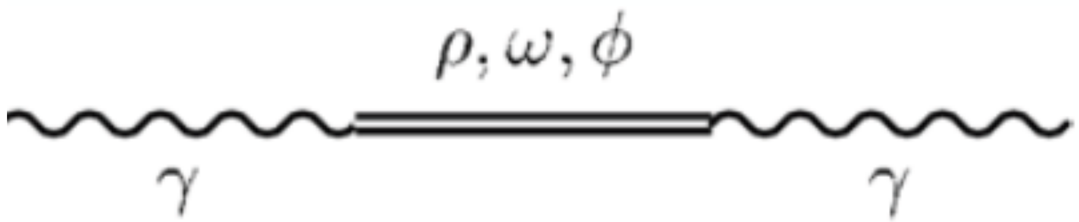
Improvement in fragmentation seen as expected
→ Impact on photon energy resolution is now being studied.

Hadron Production in Photon-Photon processes at the ILC

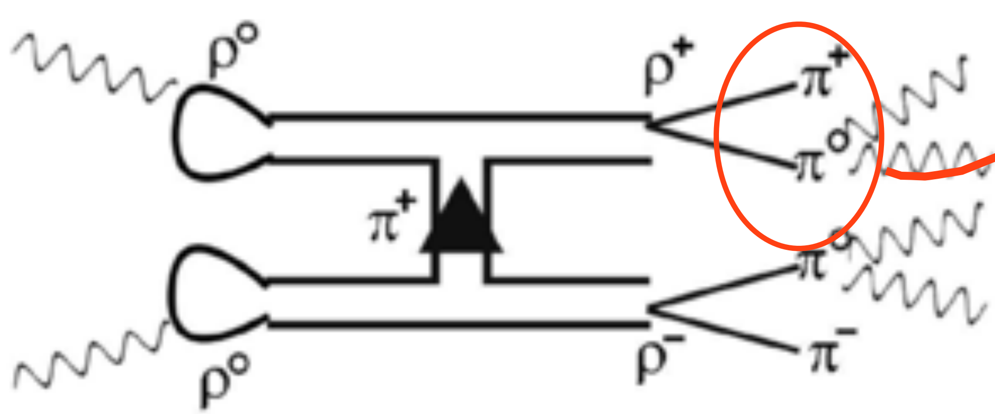
Swathi Sasikumar,

Photon : $J^{PC} = 1^{--}$

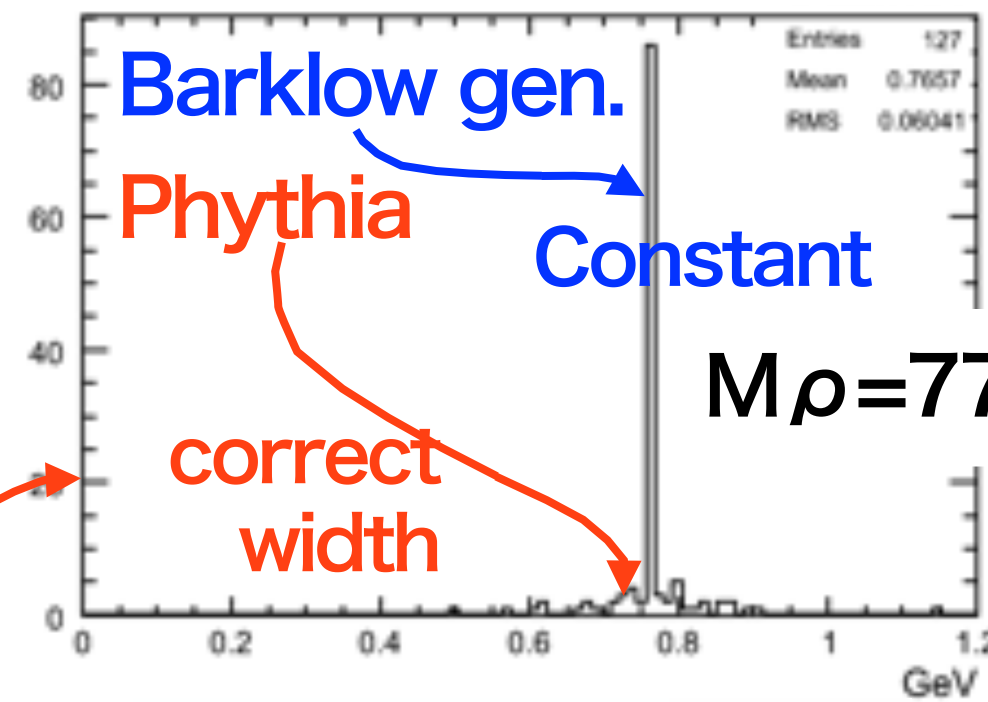
Vector meson dominance



via VMD, soft hadron



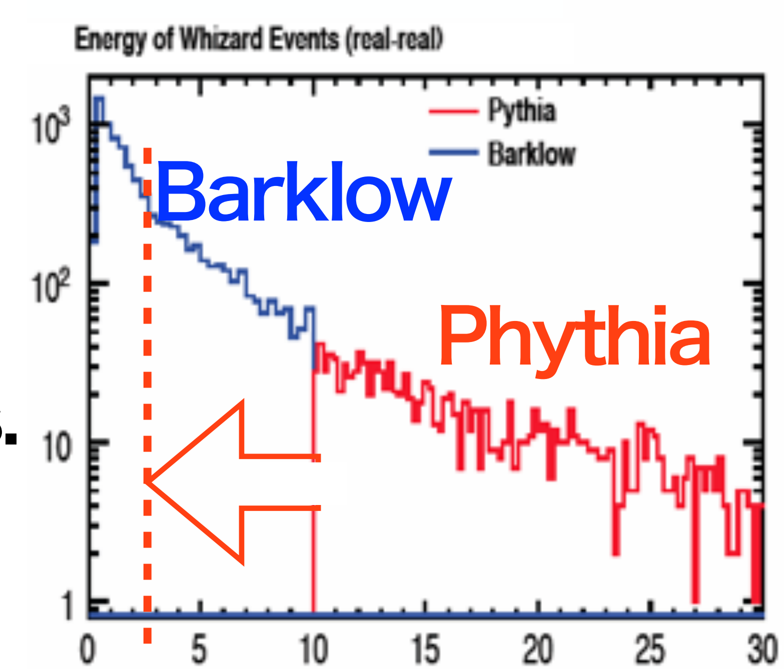
Current Whizard events



$M\rho$=770MeV

important part of $\gamma\gamma$ Background

Current Whizard events are mix of Phythia and Barklow generator's events.
Boundary is 10 GeV
Phythia can work till 2.5 GeV

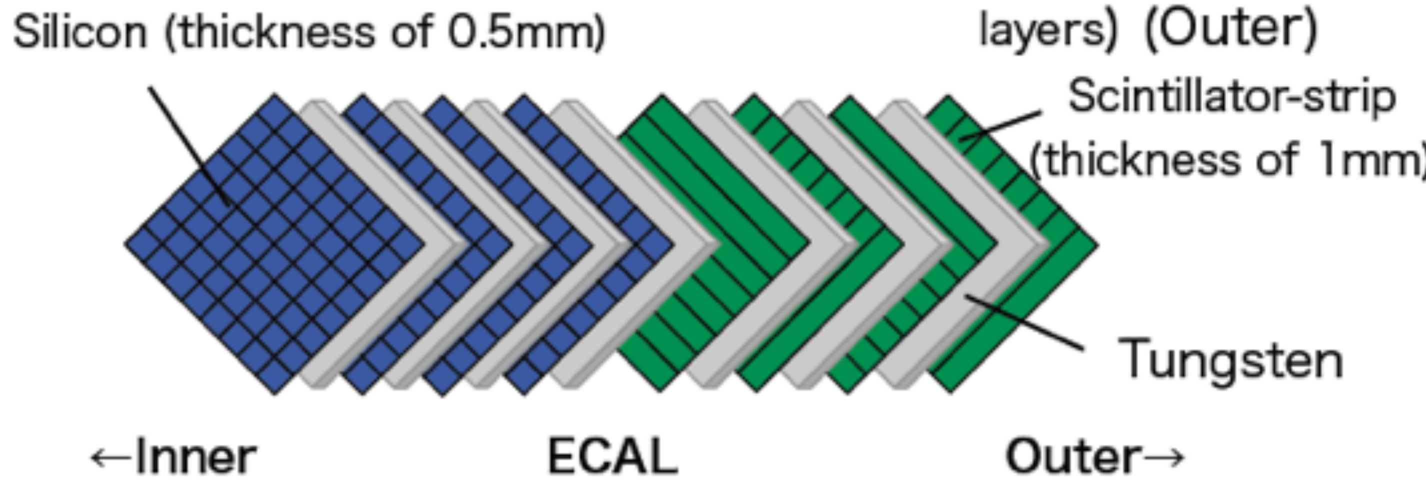


Optimization of layer composition for ILD ECAL

Hiroki Sumida

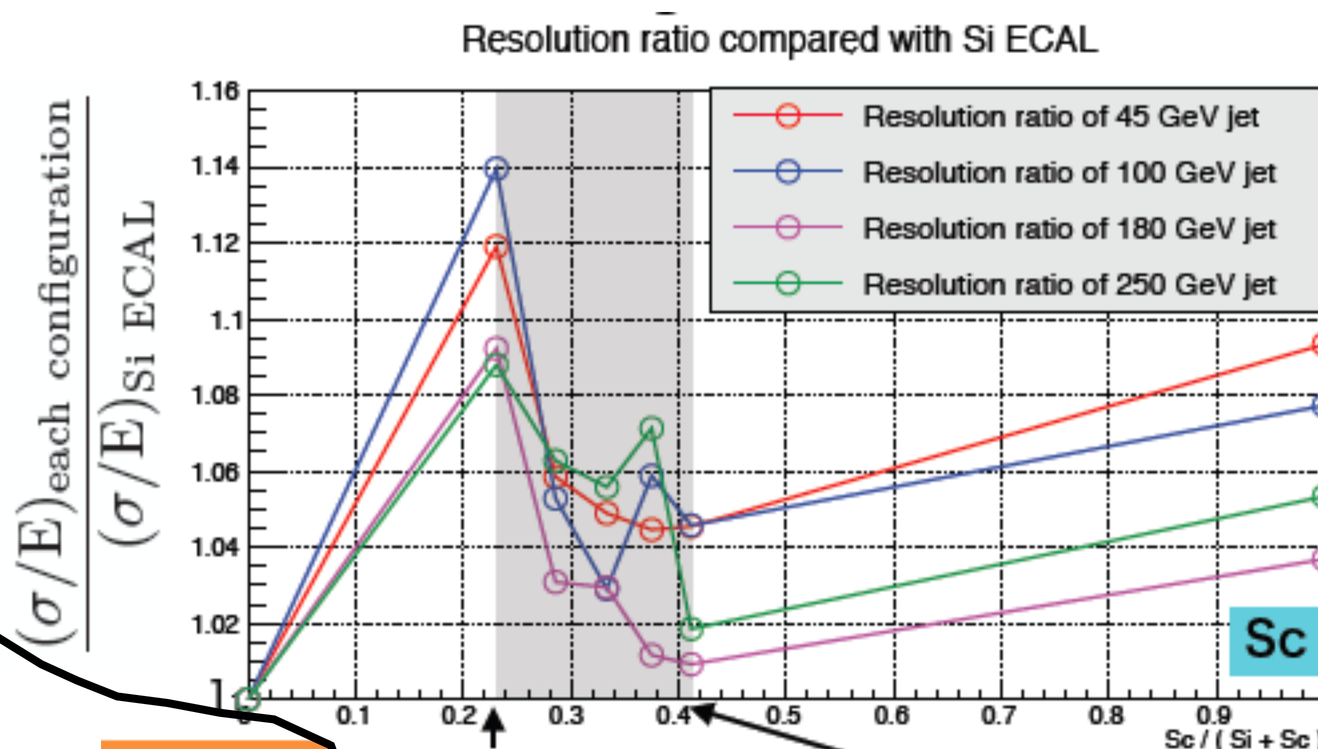
Sensitive detector : Si x 20 layers (Inner) (fixed)、 Sc x (following number of layers) (Outer)

- Sc x 6 layers
- Sc x 8 layers
- Sc x 10 layers
- Sc x 12 layers
- Sc x 14 layers



Total absorber (tungsten) thickness is $22.8X_0$ (fixed)

Si layer $5x5mm^2$ Sc layer, $45x5mm^2$ lateral seg + SSA.



Degraded energy resolution with 6 layer Sc case drastically recovered with two more additional (8 layer) Sc layers

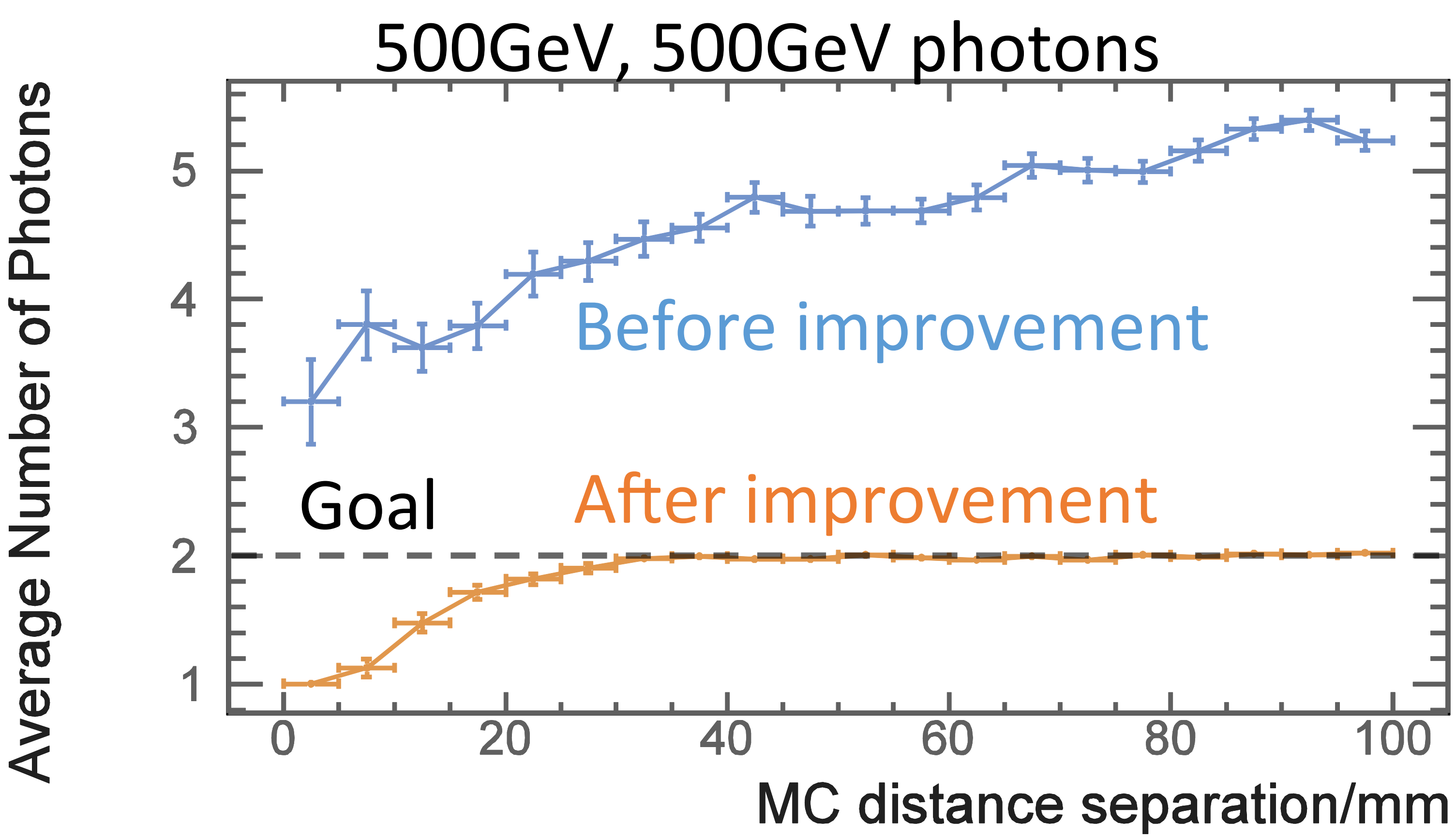
Note: default 29 layer SiECAL

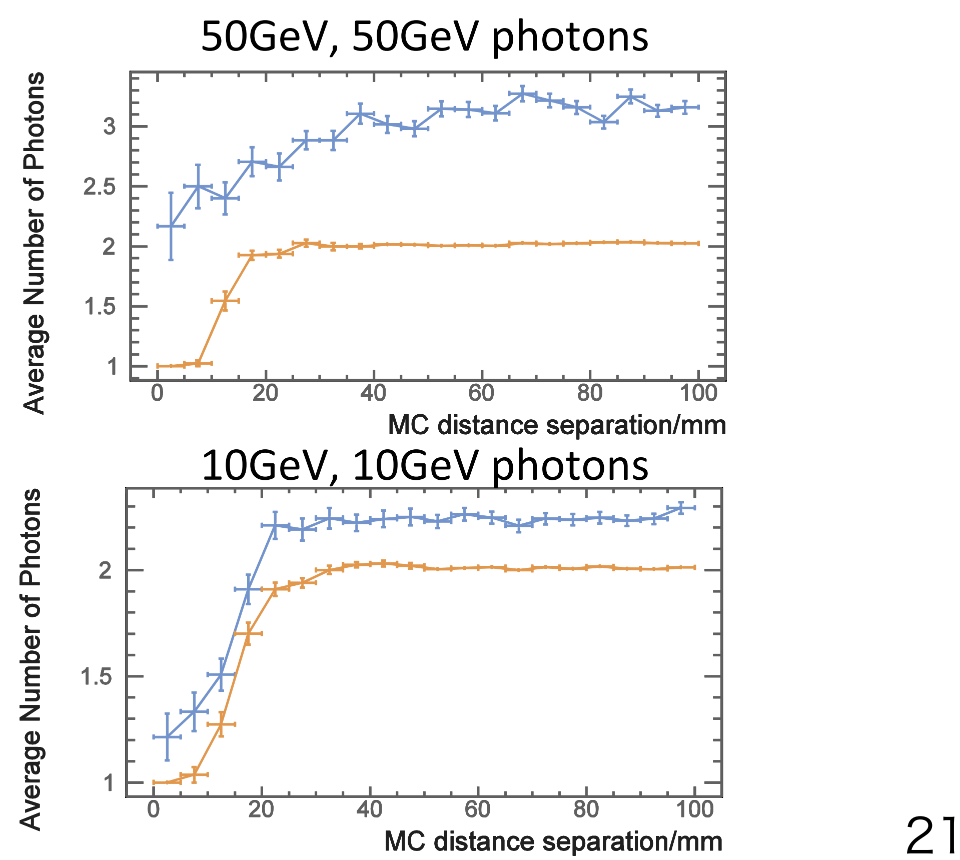
Thanks for all amazing speakers and audiences!!

Improvement of photon reconstruction in PandoraPFA

Boruo Xi

- Improve completeness of reconstructed photons, particularly at high energies, where small fragments of EM showers could often be reconstructed as separate particles.
- Two new Pandora algorithms carefully compare candidate photon clusters, collecting evidence of association, based on cluster separation and energy profiles.
- Performance plots below show average number of reconstructed photons (as a function of true separation) for samples consisting of two photons, generated with random directions.





PandraPFA Development

John Marshall(U-Cambridge)

Pandora key points

- **Pandora is not trying to be iLCSoft. It is a framework for pattern recognition algorithms.**
- **It is generic and is used successfully across multiple (very different) projects.**
- **Its powerful functionality enables complex algorithms using e.g. recursion or reclustering.**
- **Design philosophy: support multi-algorithm approach, gradually build-up picture of event.**

Pandora Summary

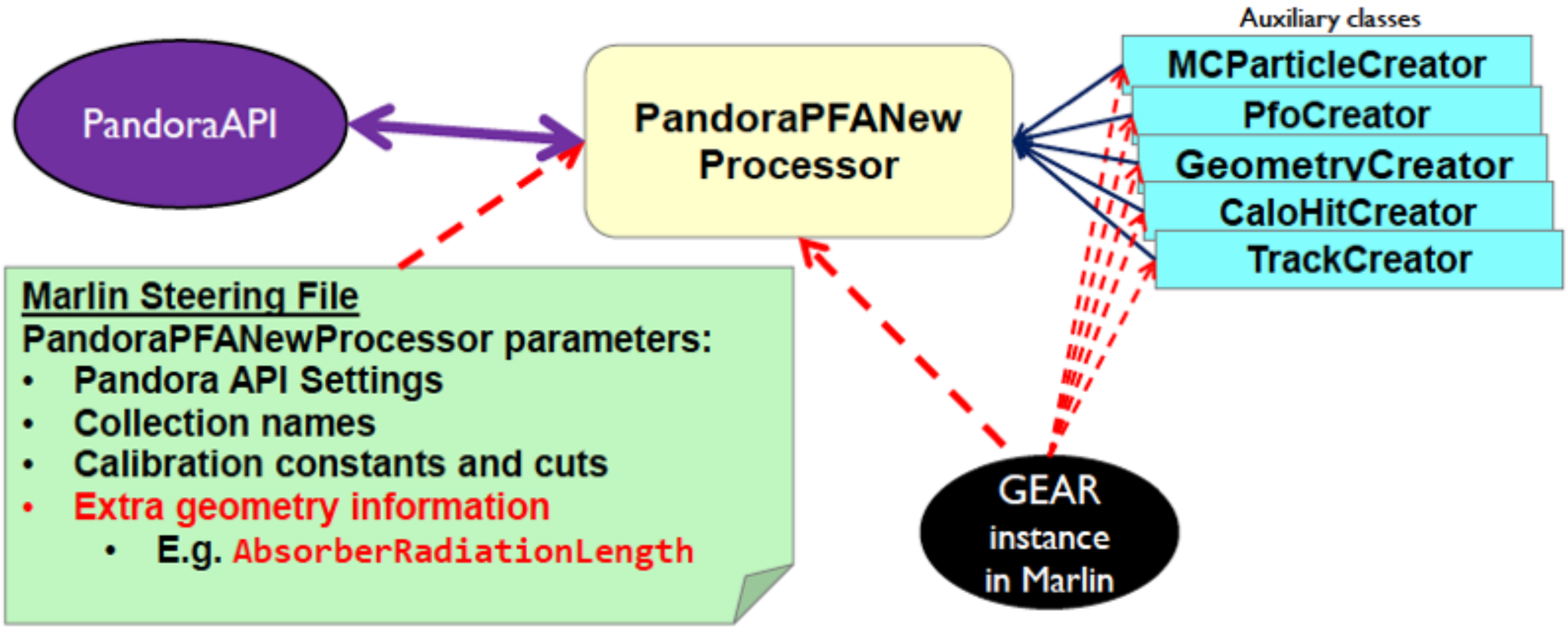
- **Pandora provides an easy and fast development platform. It has no external dependencies beyond ROOT, which it uses purely for event visualisation and monitoring purposes.**
- **Visualisation APIs provide simple access to user-customised event displays in algorithms, enabling a rapid and rewarding visual approach to debugging/development.**
- **Pandora can provide a complete standalone environment for rapid development. Need only run the iLCSoft app once to persist input Hits in Pandora binary or XML formats.**
- **Pandora is ideally suited for distributed development i.e. people can work on standalone algorithms, which can then be slotted into the reconstruction via simple XML config.**

DD4hep-Based Reconstruction

Nikiforos Nikiforou CERN

Currently: PandoraPFA and GEAR

- Pandora is the main user of the high-level geometry information provided by GEAR
  - Package **MarlinPandora** translates the GEAR geometry (and LCIO Calorimeter hits/tracks) to the format required by the Pandora API
    - It's also significantly tied to the ILD detector concept

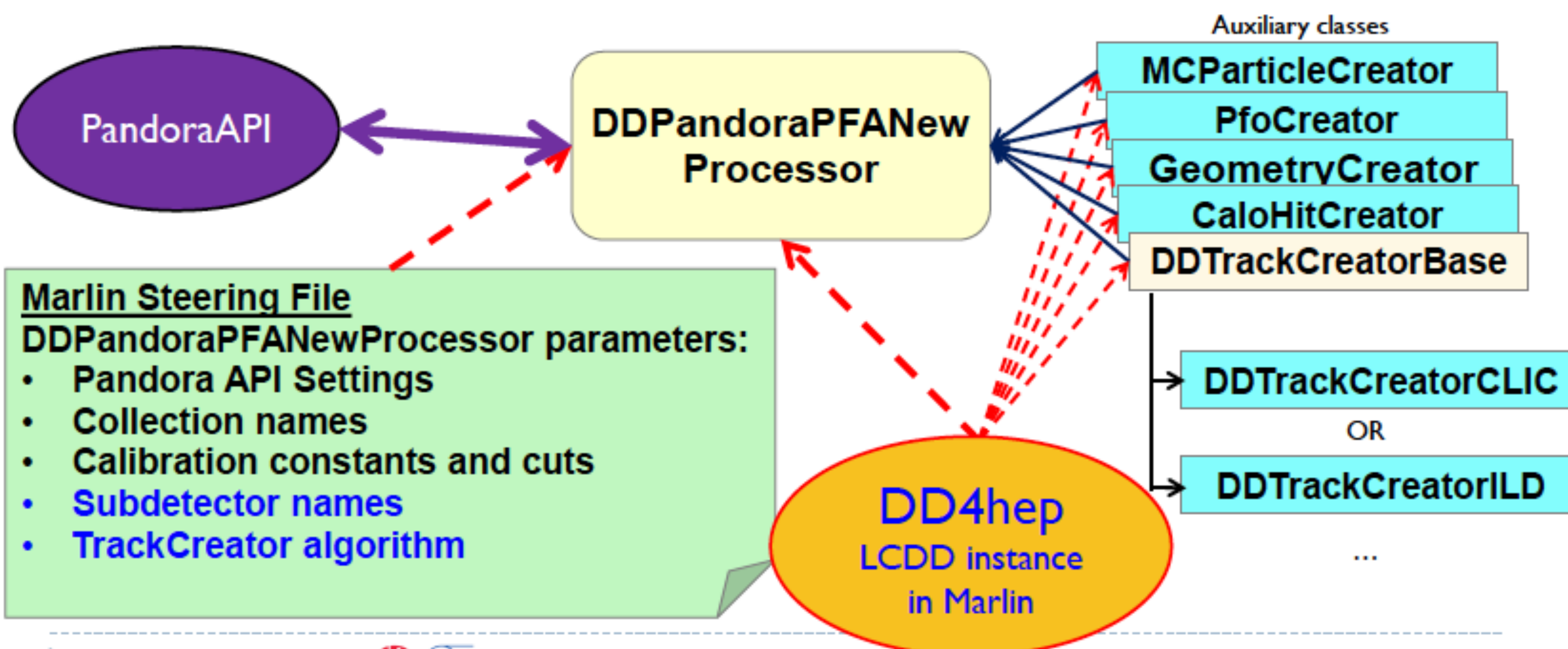


DD4hep-Based Reconstruction

Nikiforos Nikiforou CERN

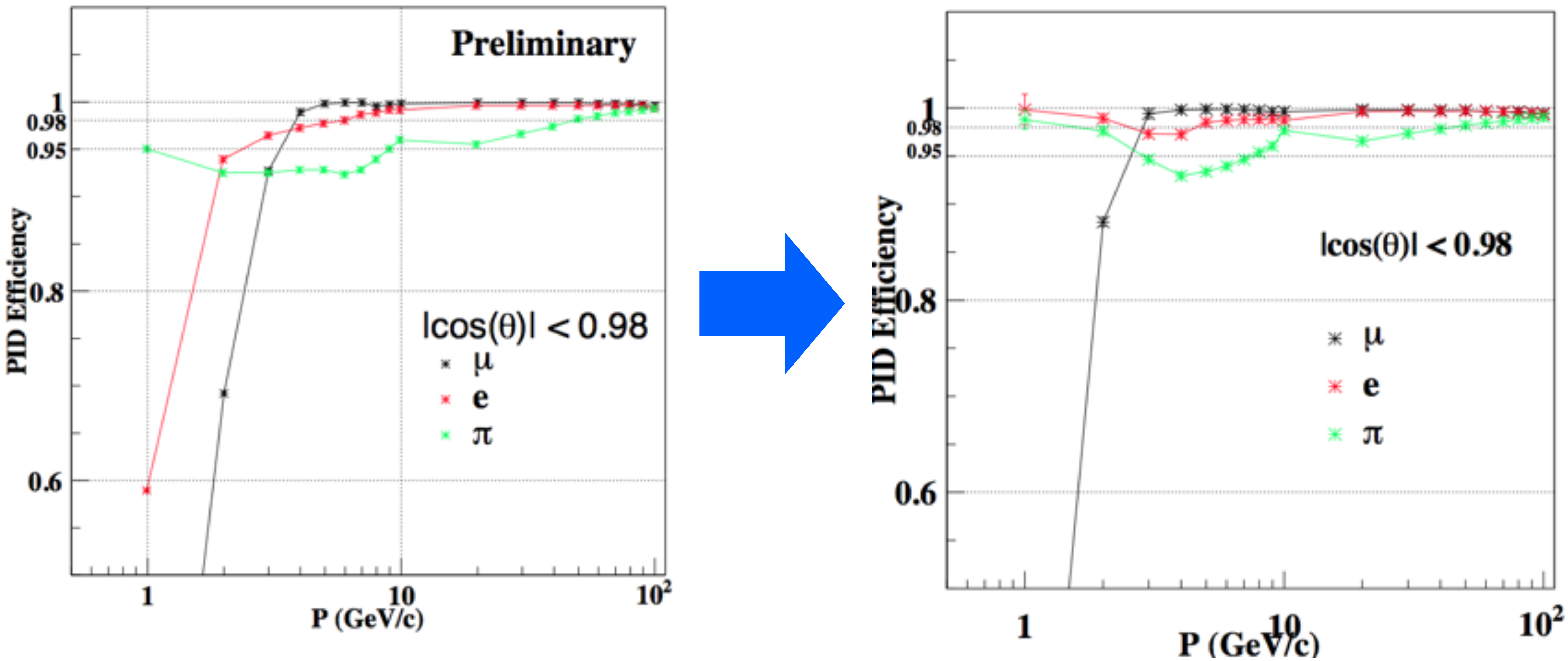
DDMarlinPandora

- New package **DDMarlinPandora**, direct copy of **MarlinPandora**
- DD4hep as single source of information
  - No material or other geometry info in processor parameters
- Also tried to uncouple from ILD-specific geometry



Arbor Status & Plan

Mauqi Ruan

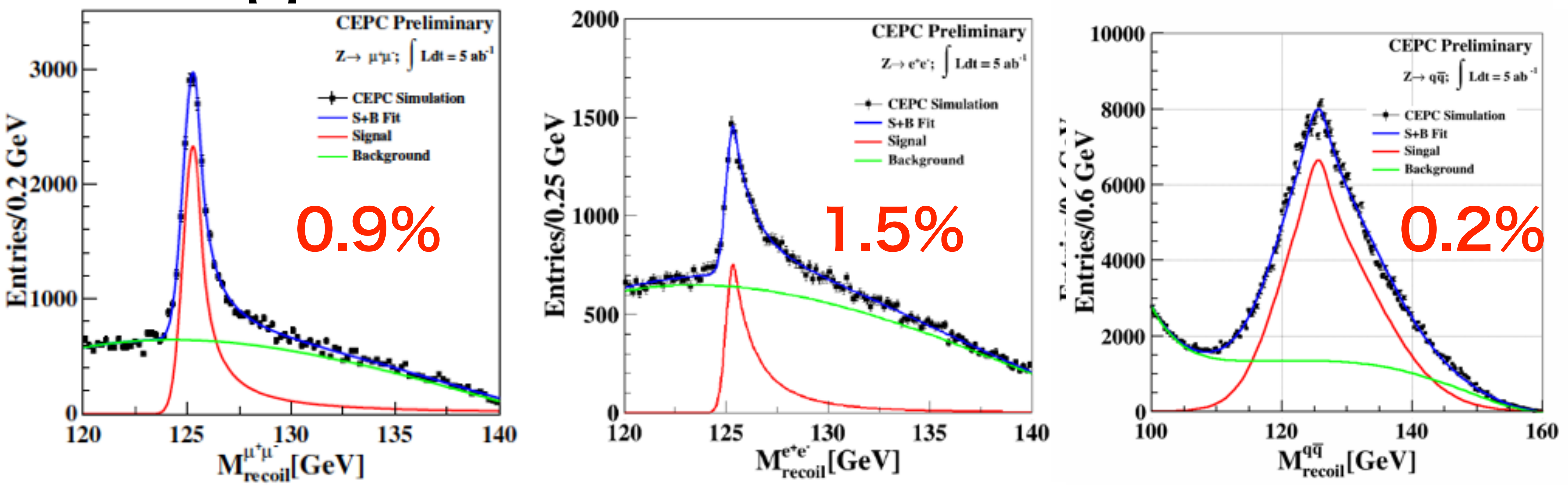


include dEdx information, particle ID performance is drastically improved.

Arbor Status & Plan

Mauqi Ruan

dedx applied to X→ℓ ℓ



Higgs exclusive X section measurement at di-lepton channels

Higgs invisible branching ratio limit

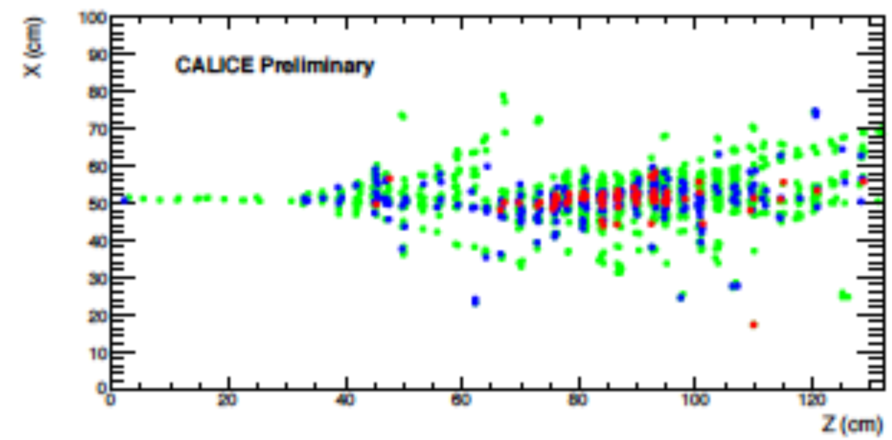
Separation of Nearby Hadronic Shower using ArborPFA

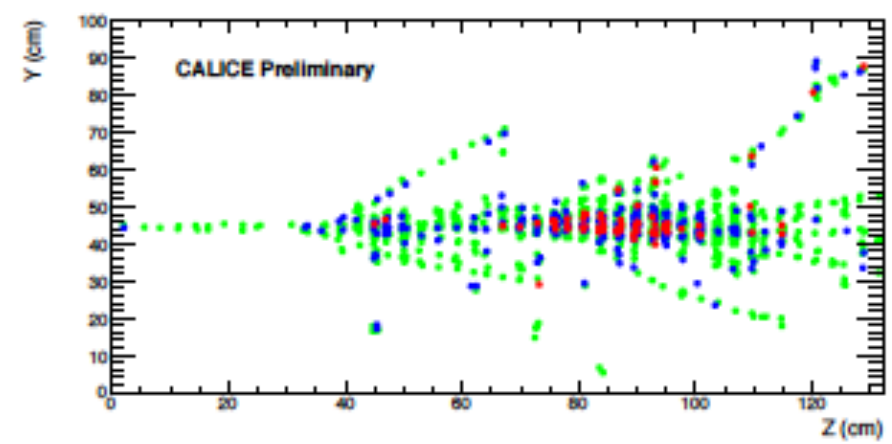
Remi Ete

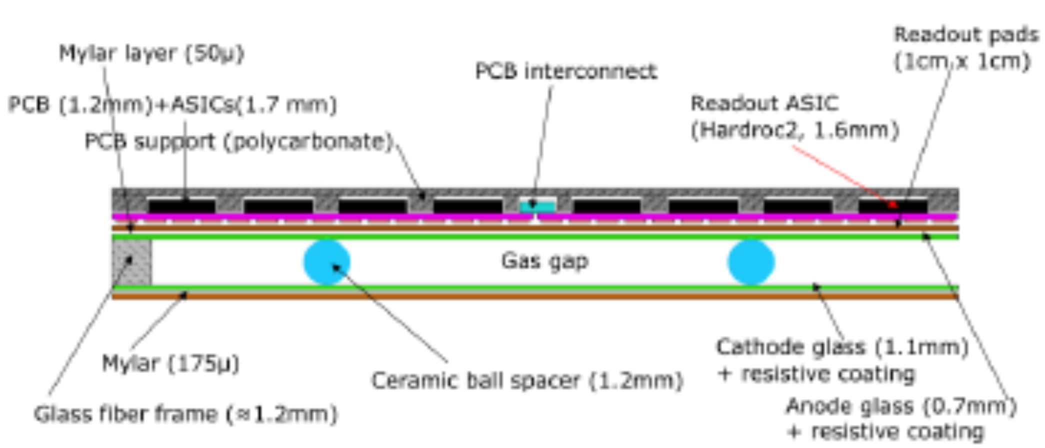
Remi applied ArborPFA on their SDHCAL

Semi-Digital Hadron Calorimeter

- Sampling calorimeter
- 48 layers :
  - Steel absorber
  - Sensitive medium : GRPC
- Segmentation :
  - Transverse : 1 cm x 1 cm
  - Longitudinal : 2.67 cm (abs. + sens)
- Semi digital readout with 3 thresholds



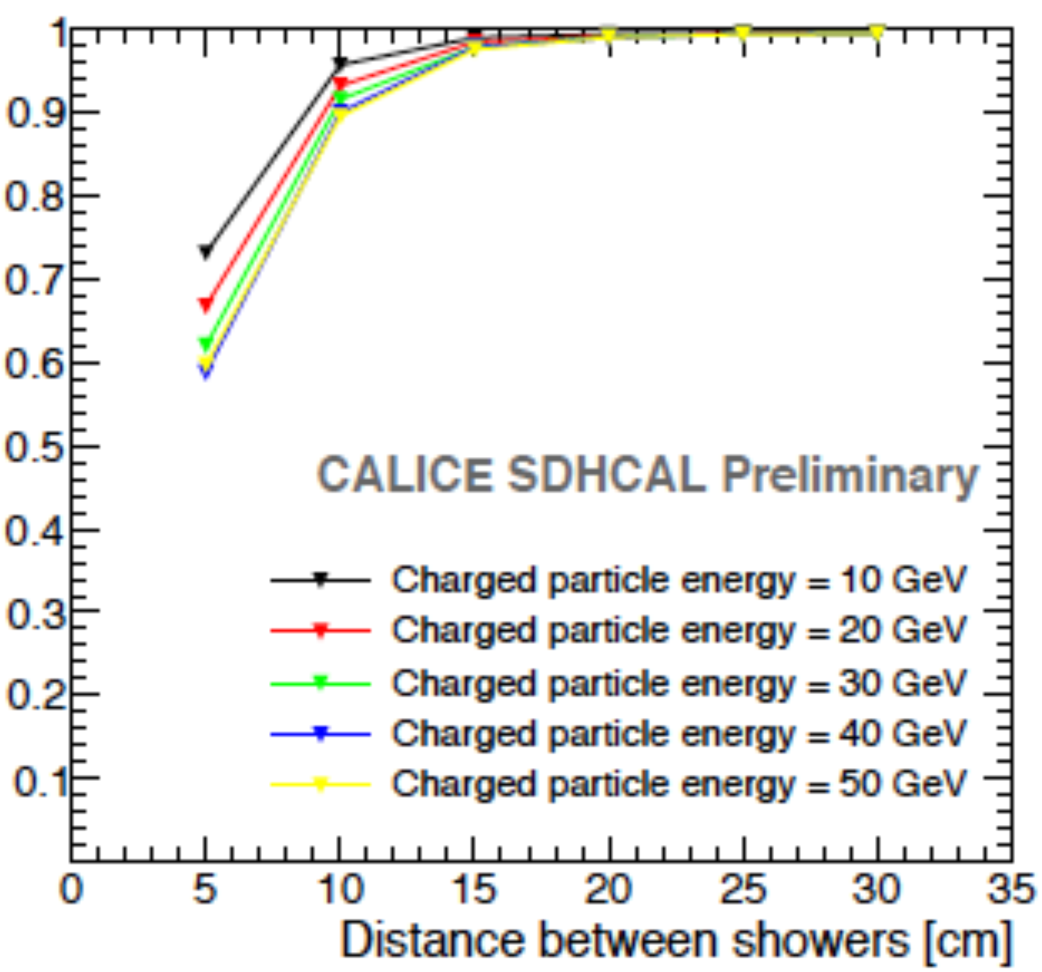


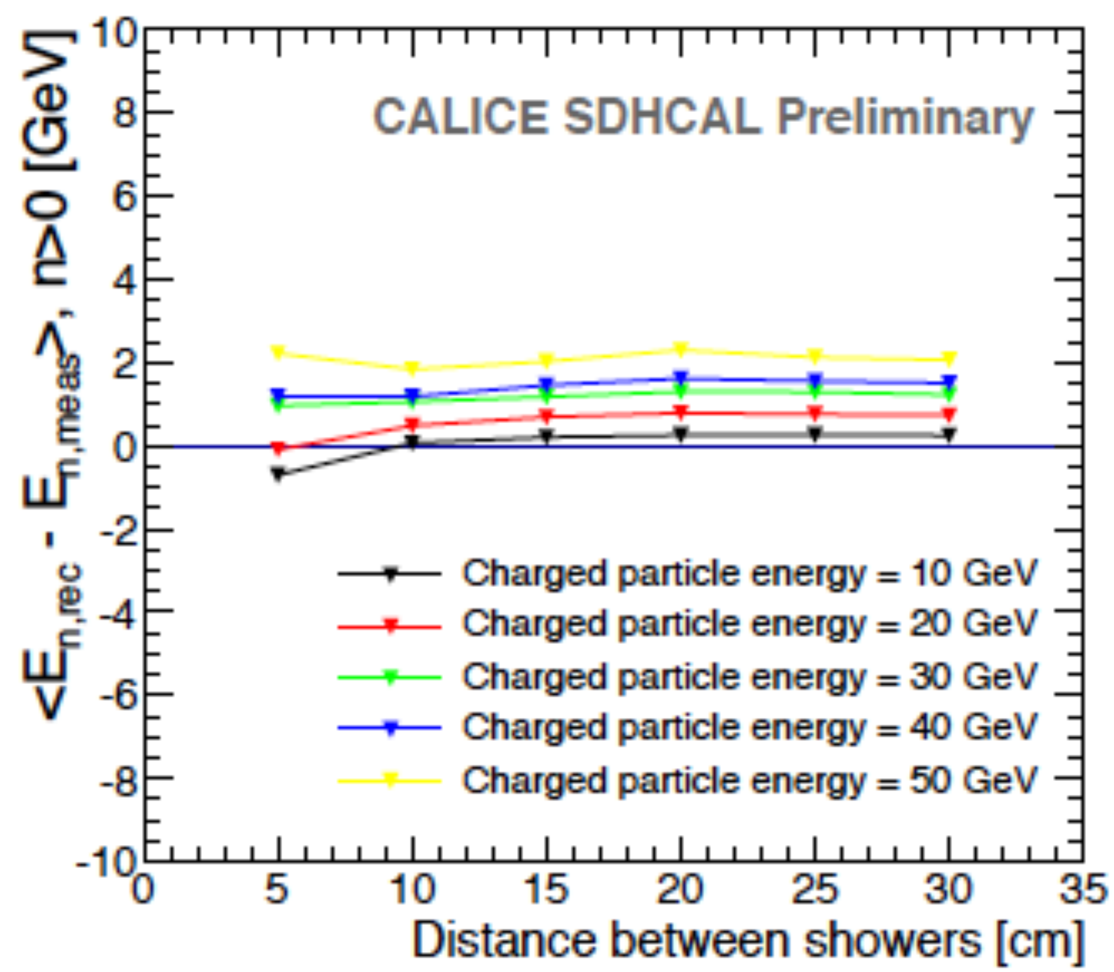


Separation of Nearby Hadronic Shower using ArborPFA

Remi Ete

Neutral hadron of various energies overlaid on 10 GeV charged π was emulated from real

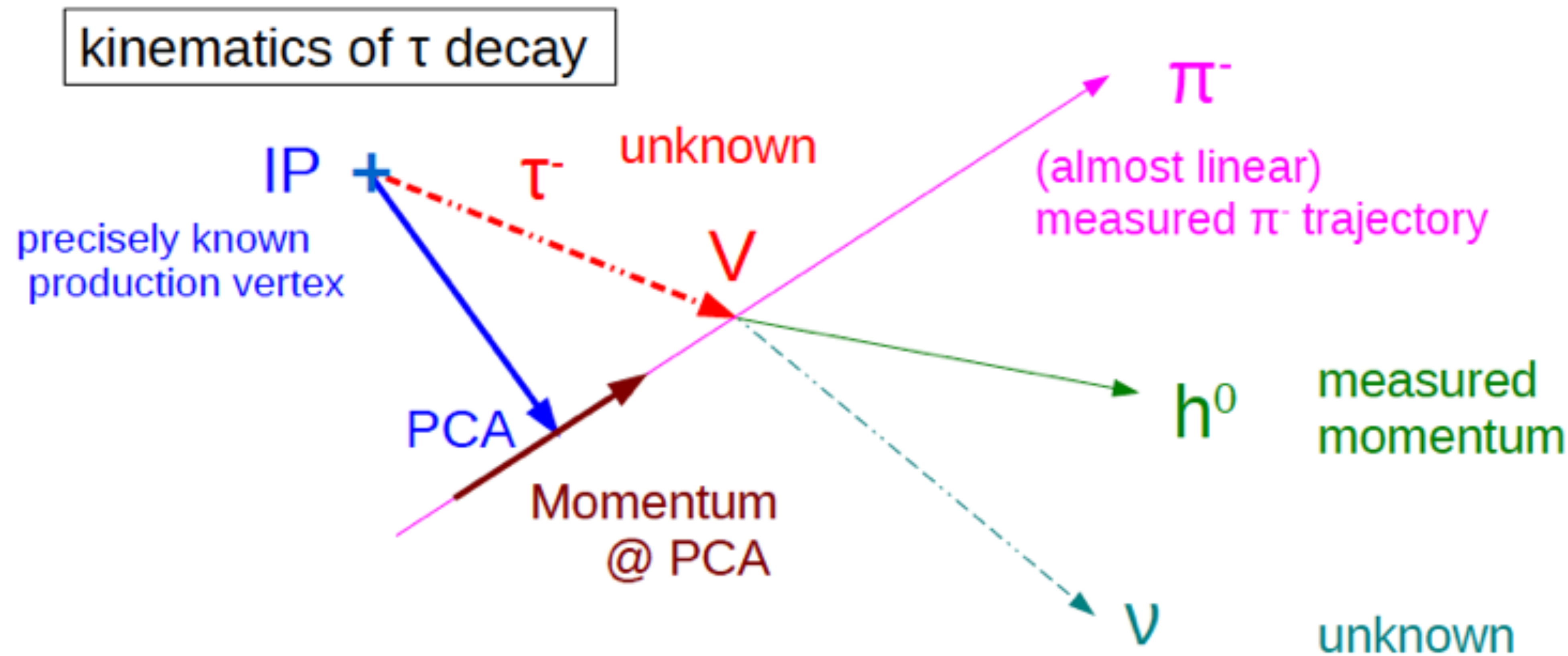




Energy reconstruction is OK till 5 cm.

τ reconstruction using impact parameters

Daniel Jeans



"track plane" defined by IP-PCA and Momentum@PCA

(these two vectors are perpendicular for 3d PCA)

→ requires well measured IP and π^- trajectory

τ momentum lies inside track plane (linear approx.)

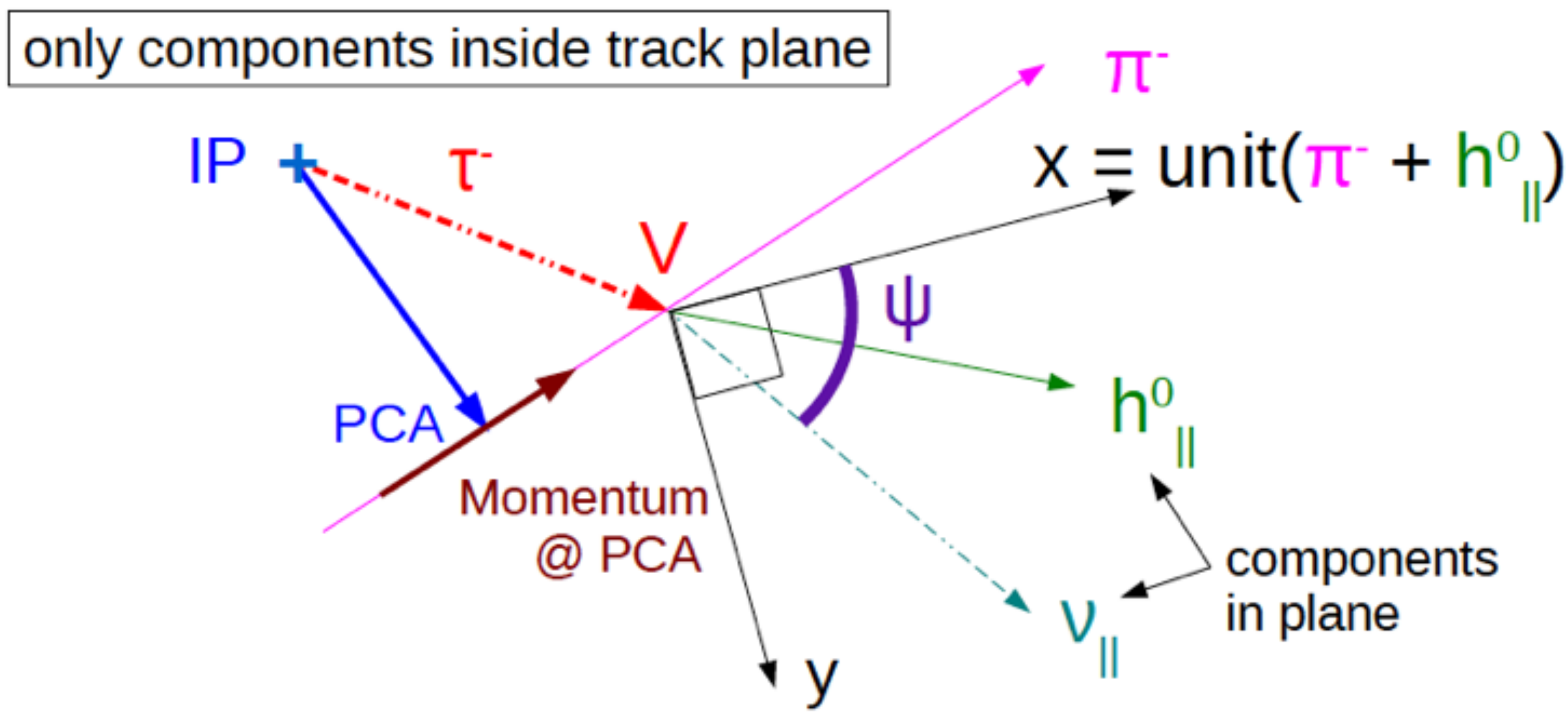
→ (h^0 + ν) momentum lies in track plane

→ ν momentum out of plane = - h^0 momentum out of plane

→ **we have used the track plane information to infer one component of the neutrino's momentum**

τ reconstruction using impact parameters

Daniel Jeans



parameterise ν momentum inside plane:

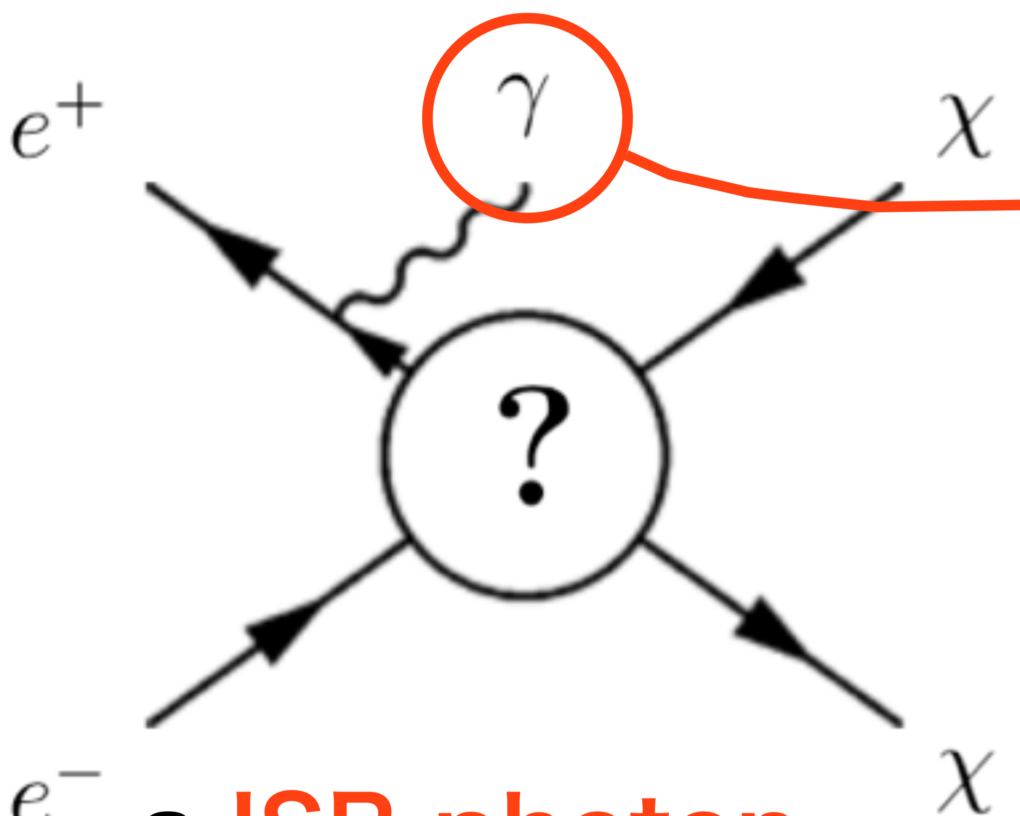
- x is unit vector parallel to hadronic momentum inside plane
- y is unit vector in plane, perpendicular to x
- Q is magnitude of momentum in plane

$$\nu_{||} = Q\,(\,x \cos\psi + y \sin\psi\,)$$

Beam spectrum, Bha-bha veto & Photon reconstruction for Mono photon analysis

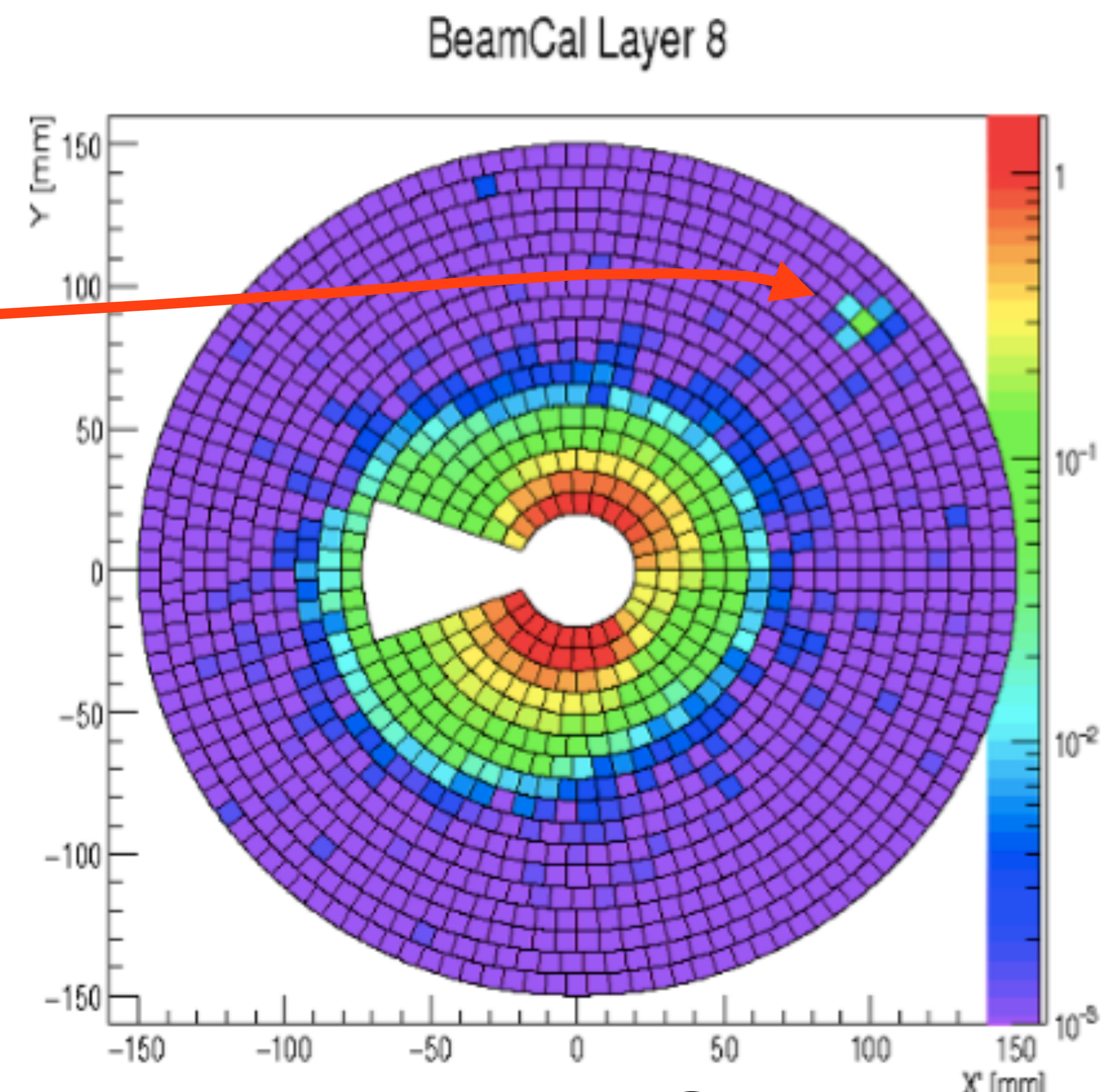
Tomohiko Tanabe

WIMP search at ILC



a ISR photon
+ missing E,p

search for mono-photon event(E_γ,E_θ)



Beam Cal