

# Update on particle separation CAN057:

“Separation of 2 overlapped electromagnetic or electromagnetic-hadronic showers in CALICE highly granular physics calorimeter prototype using Pandora, Garlic and Arbor Particle Flow Algorithms”

**Kostiantyn Shpak, LLR - Ecole polytechnique**

*CALICE meeting, Arlington, September, 16th, 2016*



# Introduction

**CAN057:** — last report: ECFALC2016 CALICE

<https://agenda.linearcollider.org/event/7014/contributions/34580/attachments/30129/45043/ShpakPresentationRMSNEW.pdf>

— 1st version of note is under review

referees: Henri Videau, Evgueny Tarkovsky, Mary Cruz Fouz

**This talk:** update (2nd version of CAN057 is under preparation)

— change of phys. prot. MIP->GeV ECAL calibrations

— new Pandora (Aug'16, v02).

Currently only for 5x5mm<sup>2</sup> ECAL ILD.

For the TB/ILD 10/2.5 mm photon likelihood optimisation might be required.

We'll see what could be done with this optimisation before the **deadline**: 1st report outside CALICE at IEEE, 29 October

— Arbor crashes for pion-photon events, if pion does not have hits in ECAL. This results in limited statistics on plots, now these events are skipped

# New CALICE ECAL TB&MC calibrations

Before, in the 1st version CAN057 I was using different MIP->GeV calibration factors (but they were very close to each other) for different runs for FNAL'11 ECAL, to put peaks of energy distribution to the correct values (my BACKUP slides at ECFALC2016).

In version 2 I'm switching to constant MIP->GeV factor 0.0048 for all FNAL'11 runs, which was chosen to set all energies to adequate values.

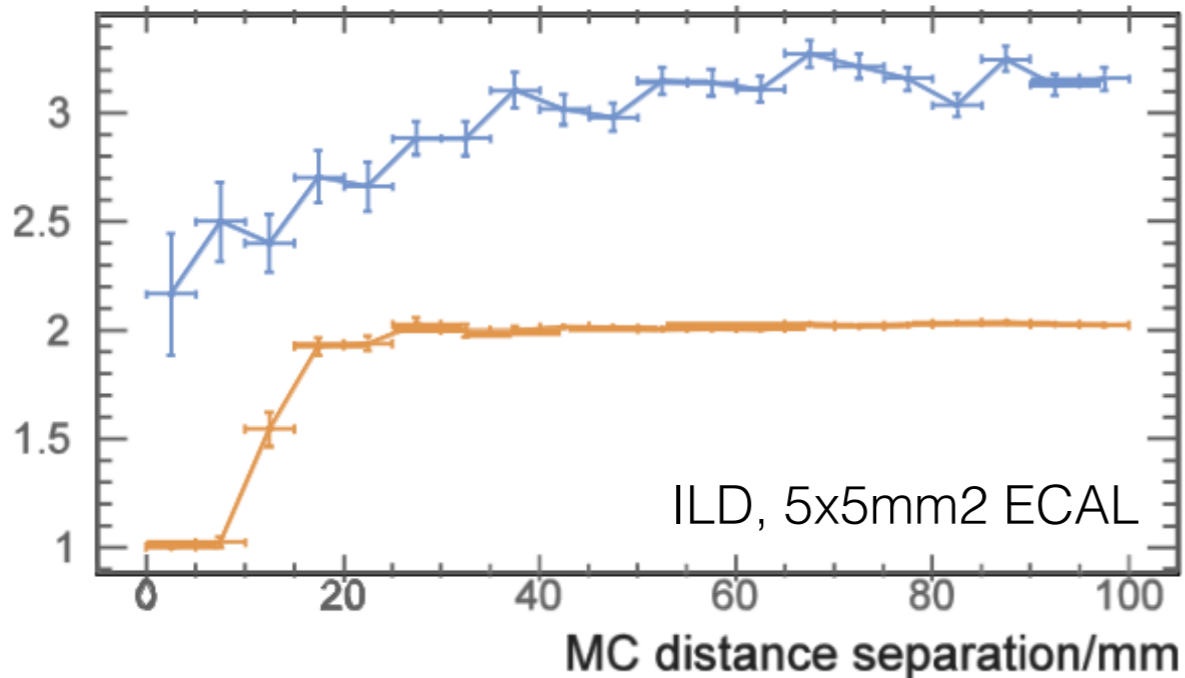
# New Pandora, June'16

ECFALC2016 Boruo Xu presentation

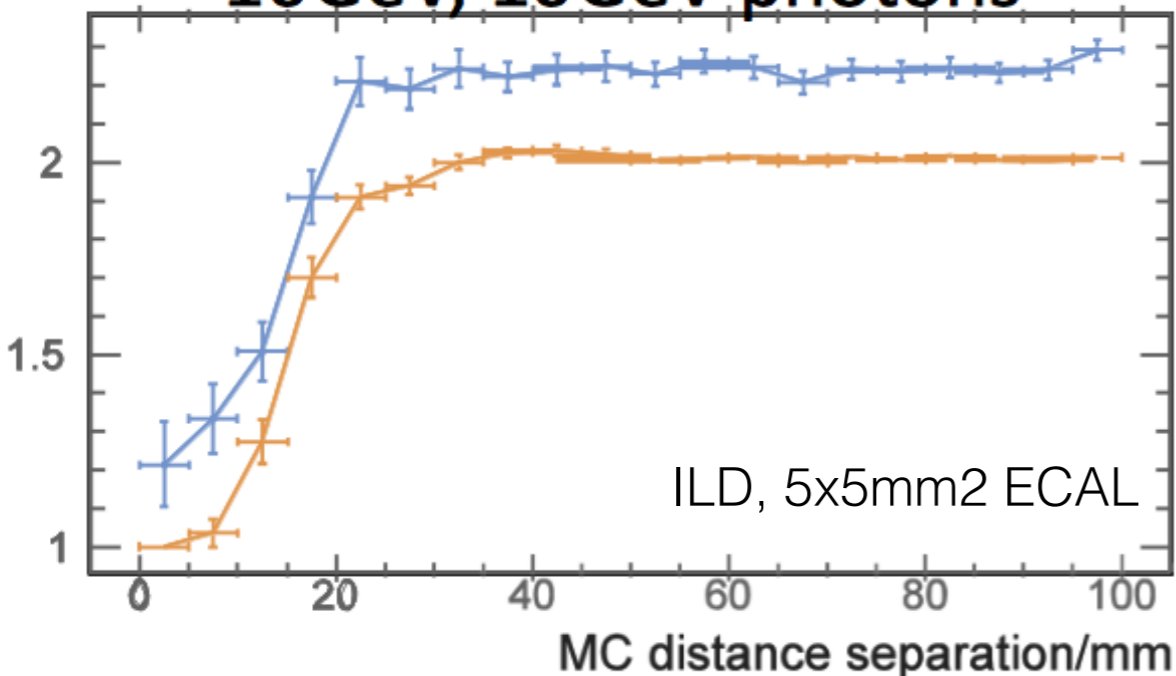
<https://agenda.linearcollider.org/event/7014/contributions/34617/attachments/30164/45084/Boruo.Xu.20160526.ECFA.pandora.v3.pdf>

much improved results of  
New Pandora (orange line)

## 50GeV, 50GeV photons



## 10GeV, 10GeV photons



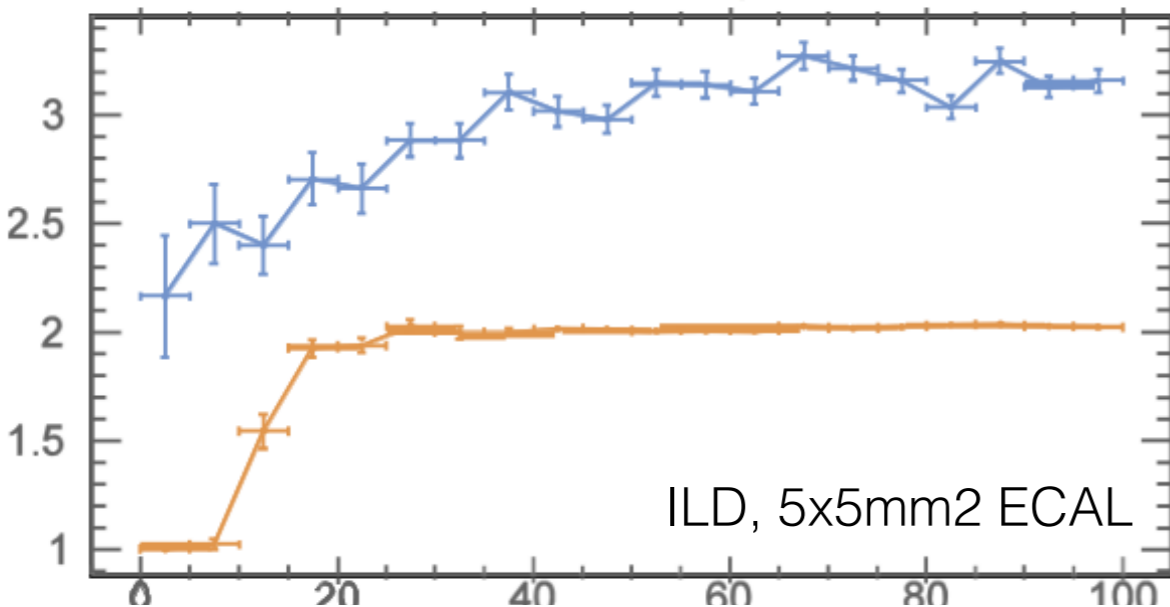
Average number of reconstructed  
photons in 2-photon sample

# New Pandora, June'16

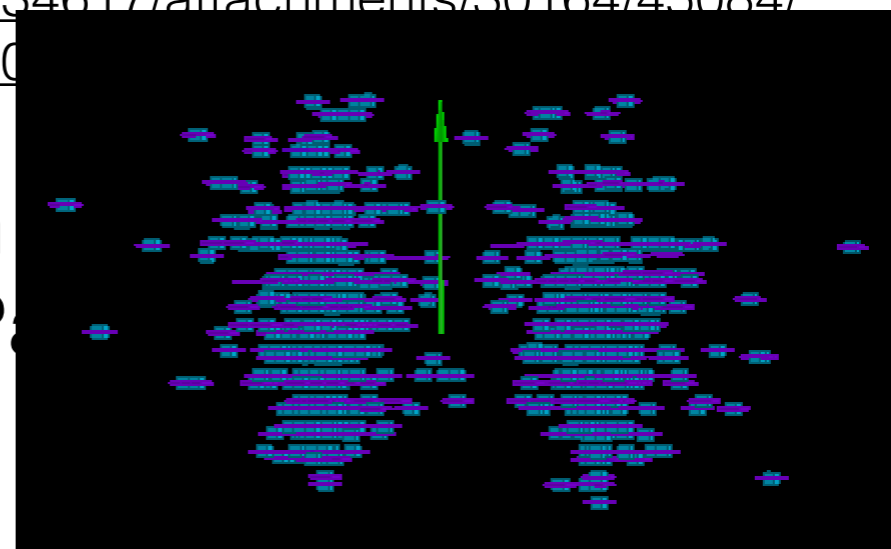
50GeV, 50GeV photons

ECFALC2016 Boruo Xu presentation

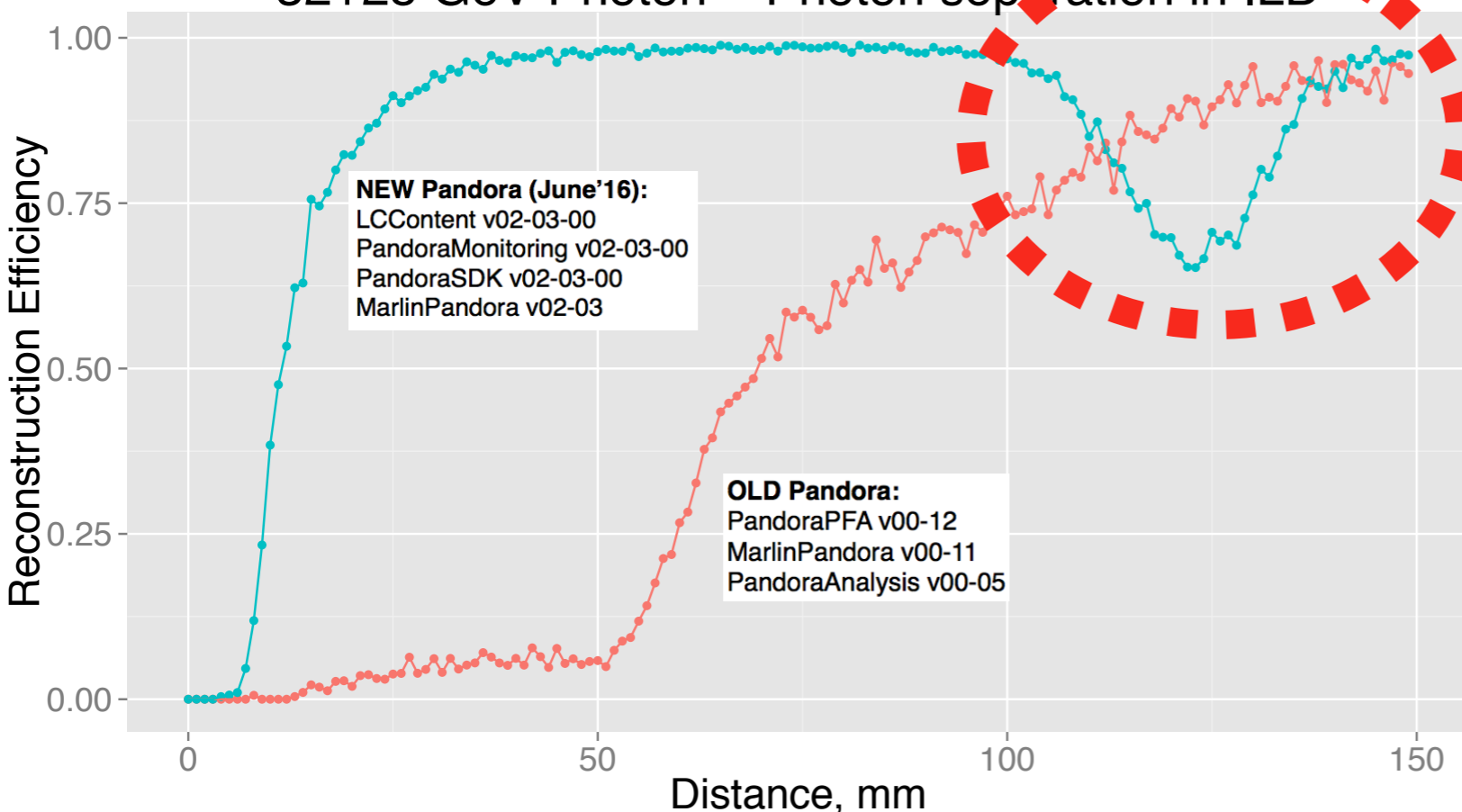
<https://agenda.linearcollider.org/event/7014/contributions/34617/attachments/30164/45084/Boruo.Xu.20160623.pdf>



much  
New P



32+25 GeV Photon – Photon separation in ILD



However, we found problem in reconstruction for distances 100..150mm: 2 photons were reconstructed as single neutron.

It was fixed by Cambridge Pandora group in August'16 version.

Eff. of 2-photon rec. with correct energies ( $\pm 20\%$ ) and barycenters ( $\pm 5\text{mm}$ )

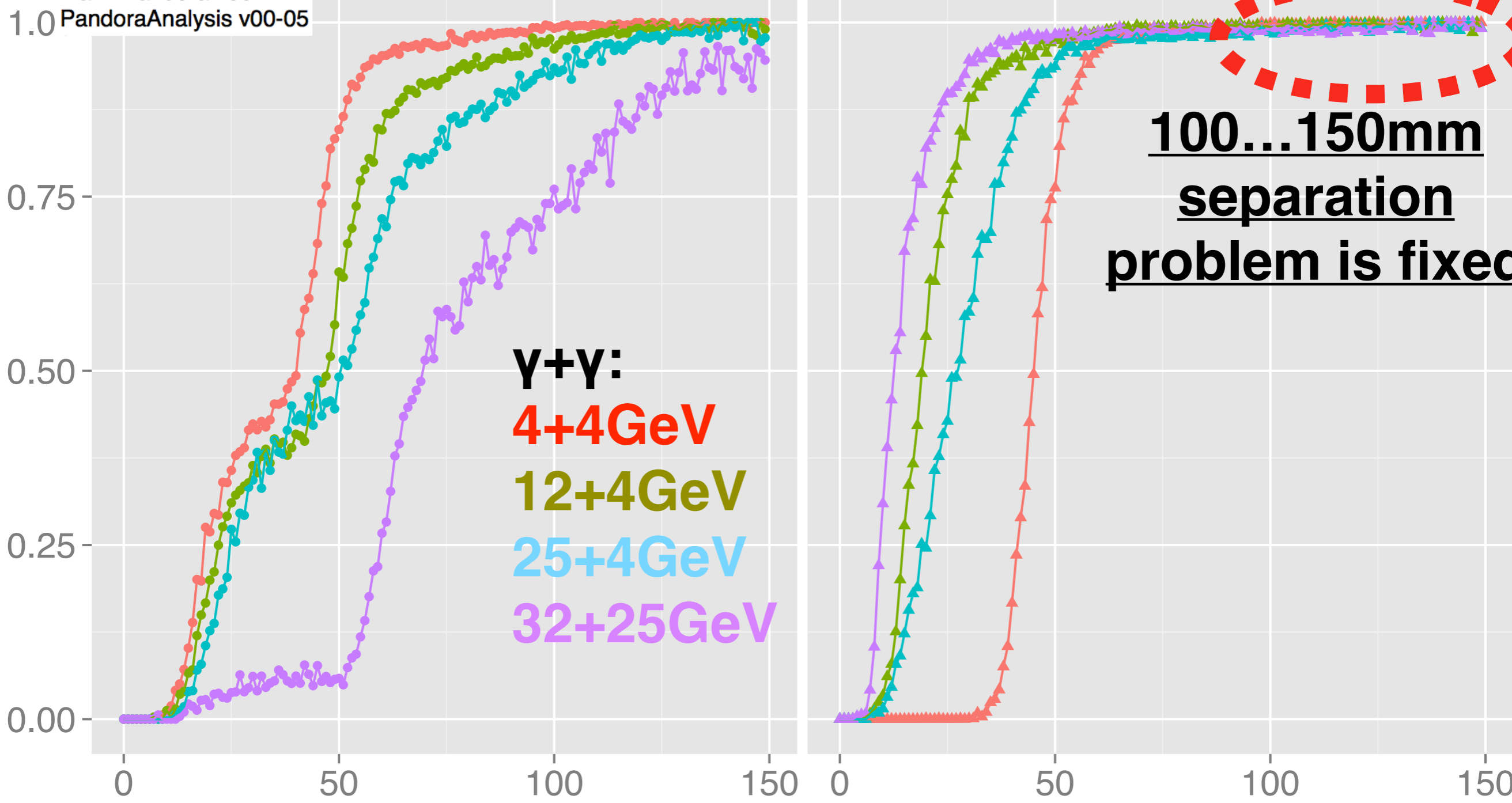
**NEW Pandora (August'16):**  
LCContent v02-04-00  
PandoraMonitoring v02-03-00  
PandoraSDK v02-03-01  
MarlinPandora v02-04

# Pandora: NEW (August'16) vs OLD

**OLD Pandora:**  
PandoraPFA v00-12  
MarlinPandora v00-11  
PandoraAnalysis v00-05

Pandora.ILD\_5.0

PandoraNEW.ILD\_5.0



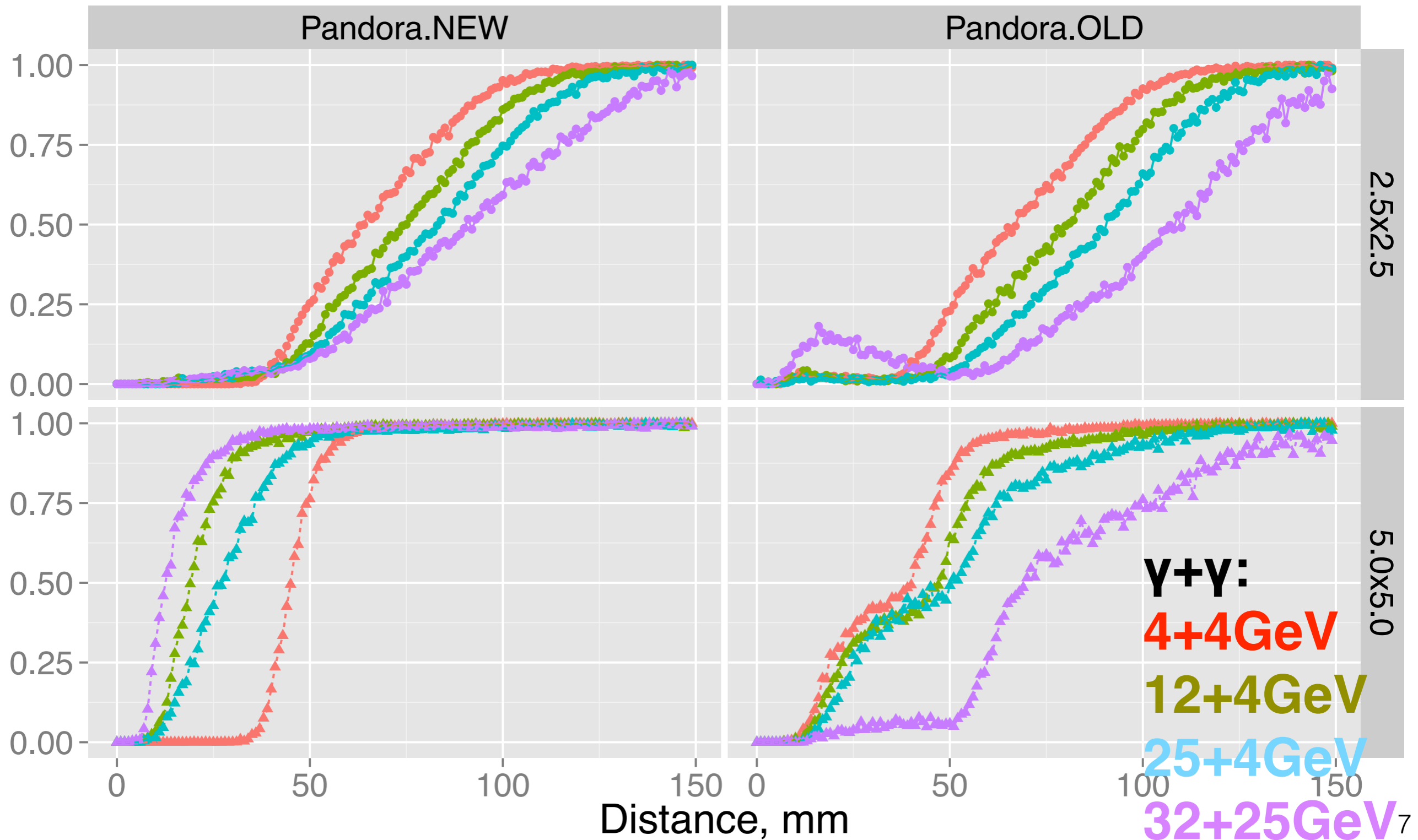
Distance, mm

New Pandora has better efficiency for **32+25**, **12+4**, **25+4** GeV,  
but slightly less efficiency for **4+4** GeV

# Pandora: NEW vs OLD & 5x5 vs 2.5x2.5

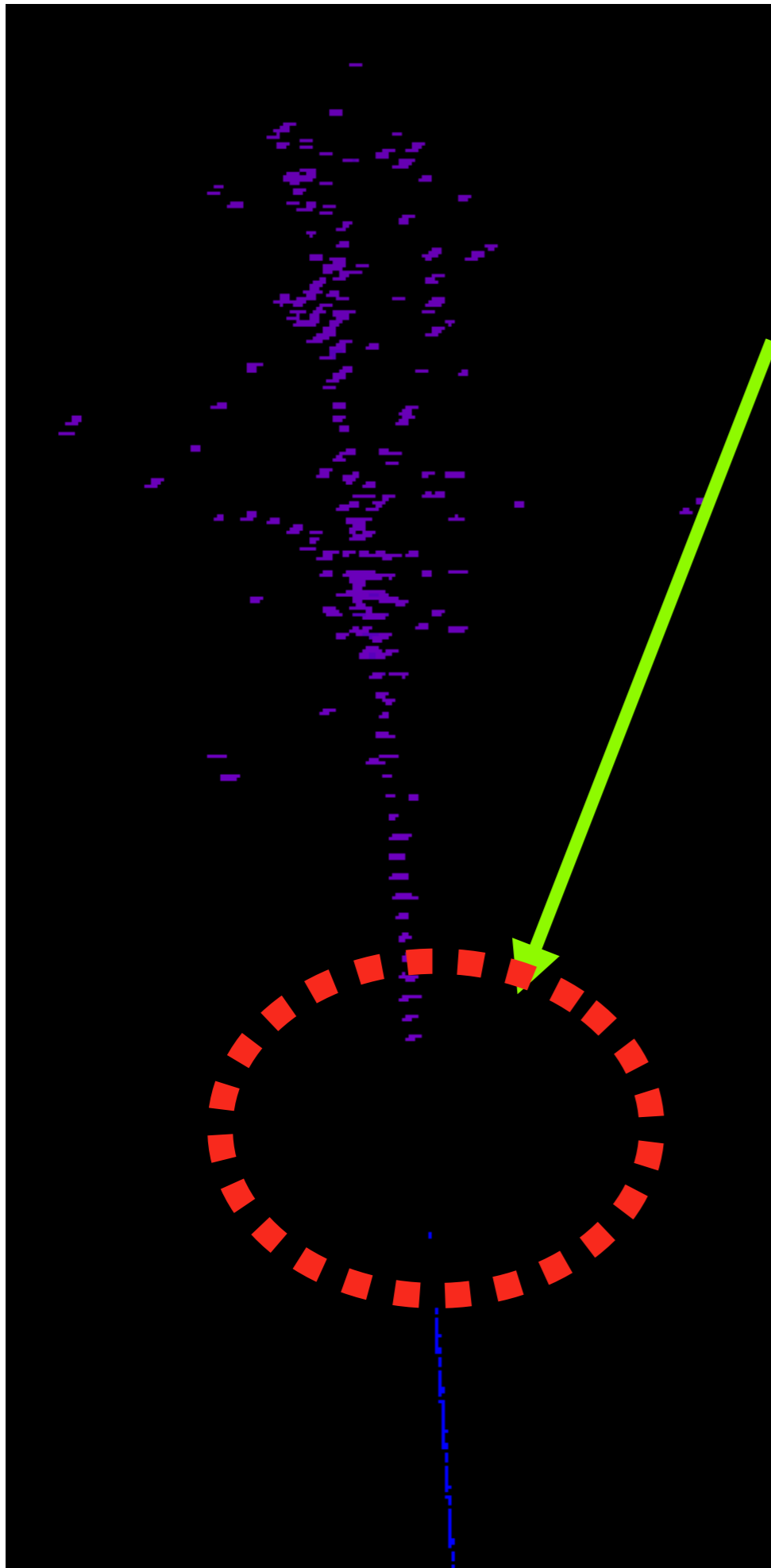
Data: ILD, event mixing only for ECAL (5x5mm<sup>2</sup> and 2.5x2.5mm<sup>2</sup>)

Particles:  $\gamma$  &  $\gamma$



## Arbor problem in ILD

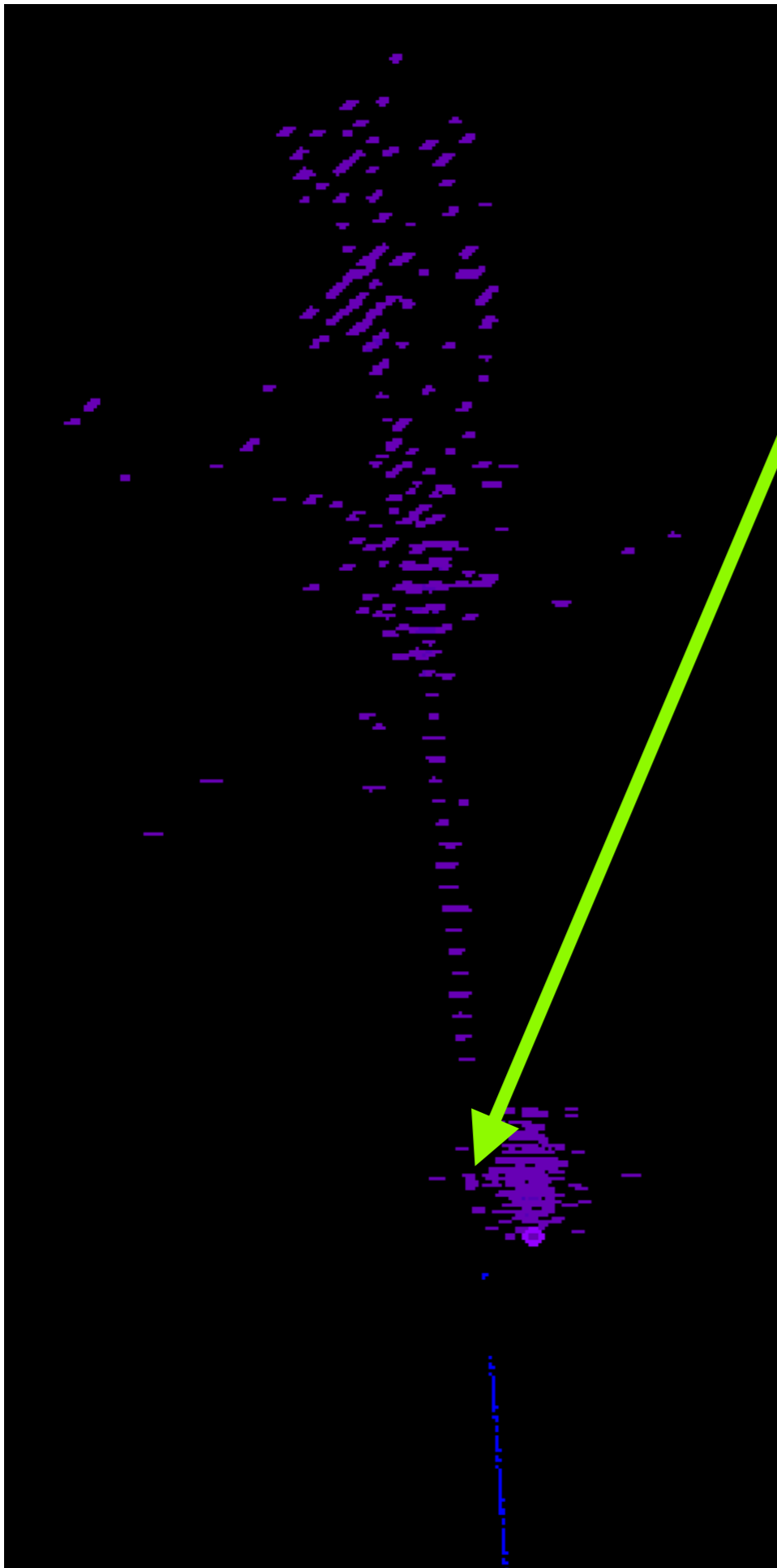
- Pion is passing through ECAL without hits ( $<1$  event per  $10^4$ ).
- These events cause crash in old version of Arbor for pion-photon events, but not for single pion events.
- This problem limits the statistics for analysis.
- These events were skipped from the analysis
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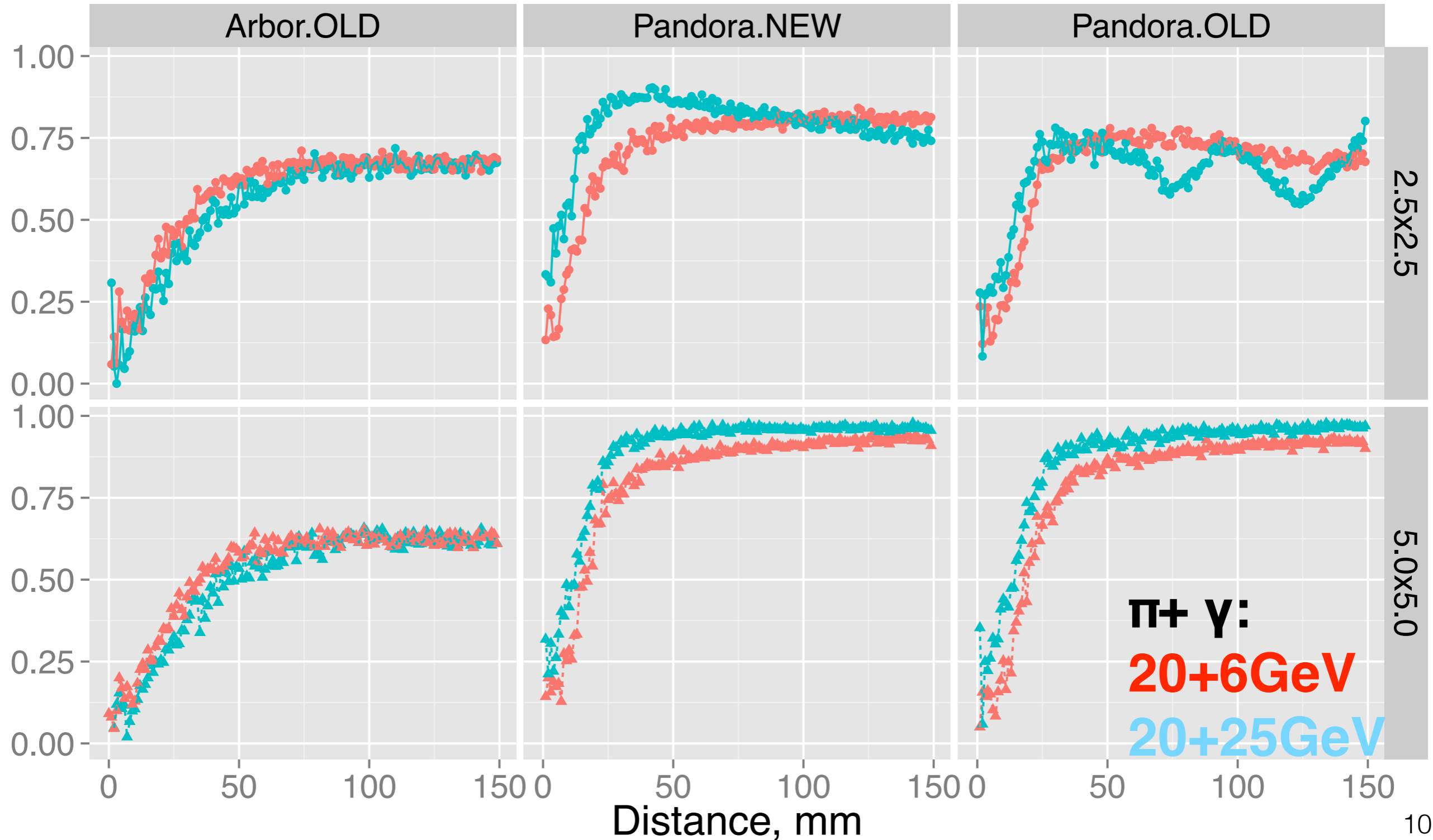


# Pion-photon separation in ILD

Data: ILD, ECAL(5x5mm<sup>2</sup> & 2.5x2.5mm<sup>2</sup>)+(AHCAL or SDHCAL)

PFA: Pandora (AHCAL), Arbor (SDHCAL)

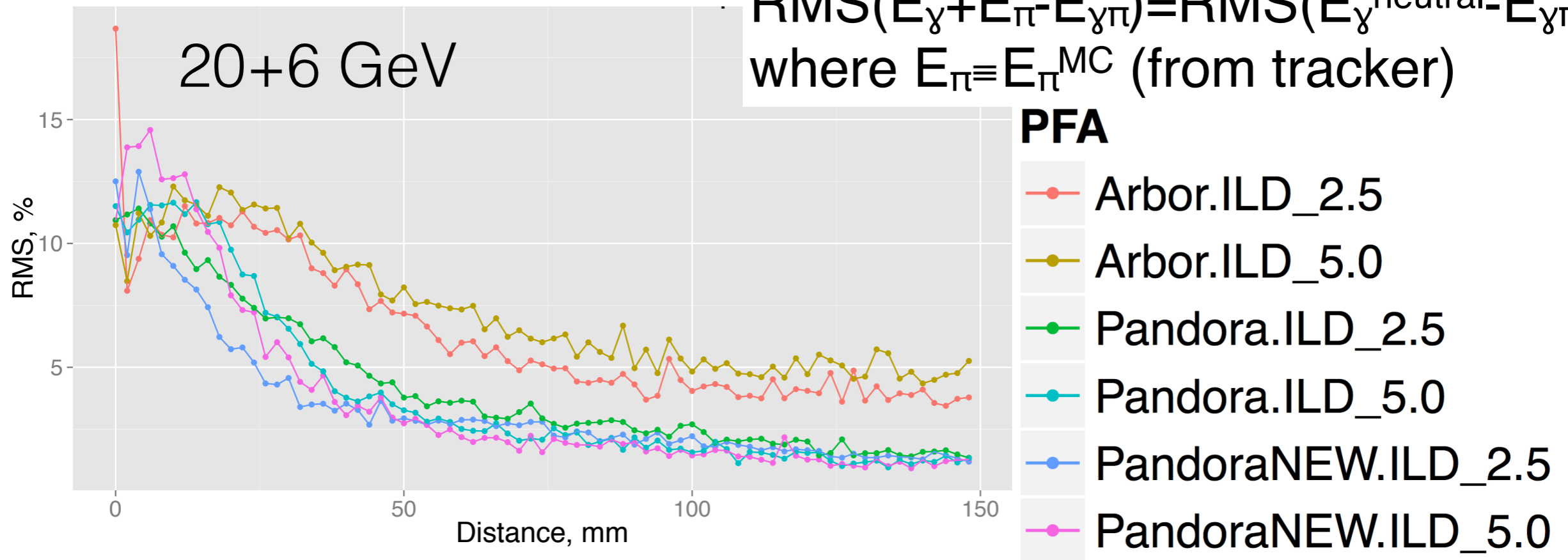
Particles:  $\gamma$  &  $\pi^+$



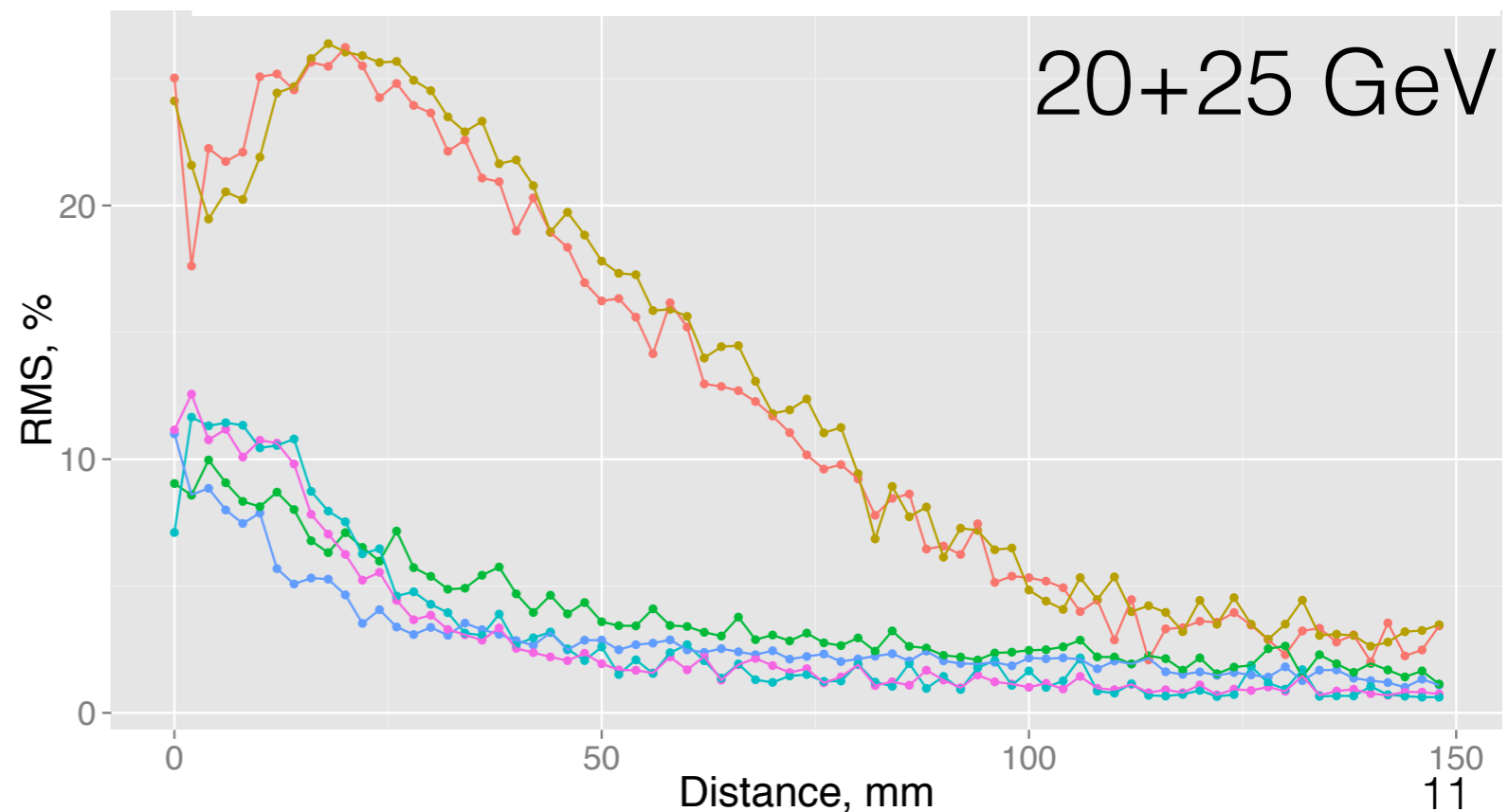
# RMS, pion-photon, ILD

$$\text{RMS}(E_\gamma + E_\pi - E_{\gamma\pi}) = \text{RMS}(E_\gamma^{\text{neutral}} - E_{\gamma\pi}^{\text{neutral}})$$

where  $E_\pi \equiv E_\pi^{\text{MC}}$  (from tracker)



- 1) For jets it is essential to have correct energy estimation, without knowing number of particles in jet
- 2) RMS: Energy difference between initial unoverlaid particles and final reconstructed particles versus distance
- 3) Charged particle energies were estimated with tracks



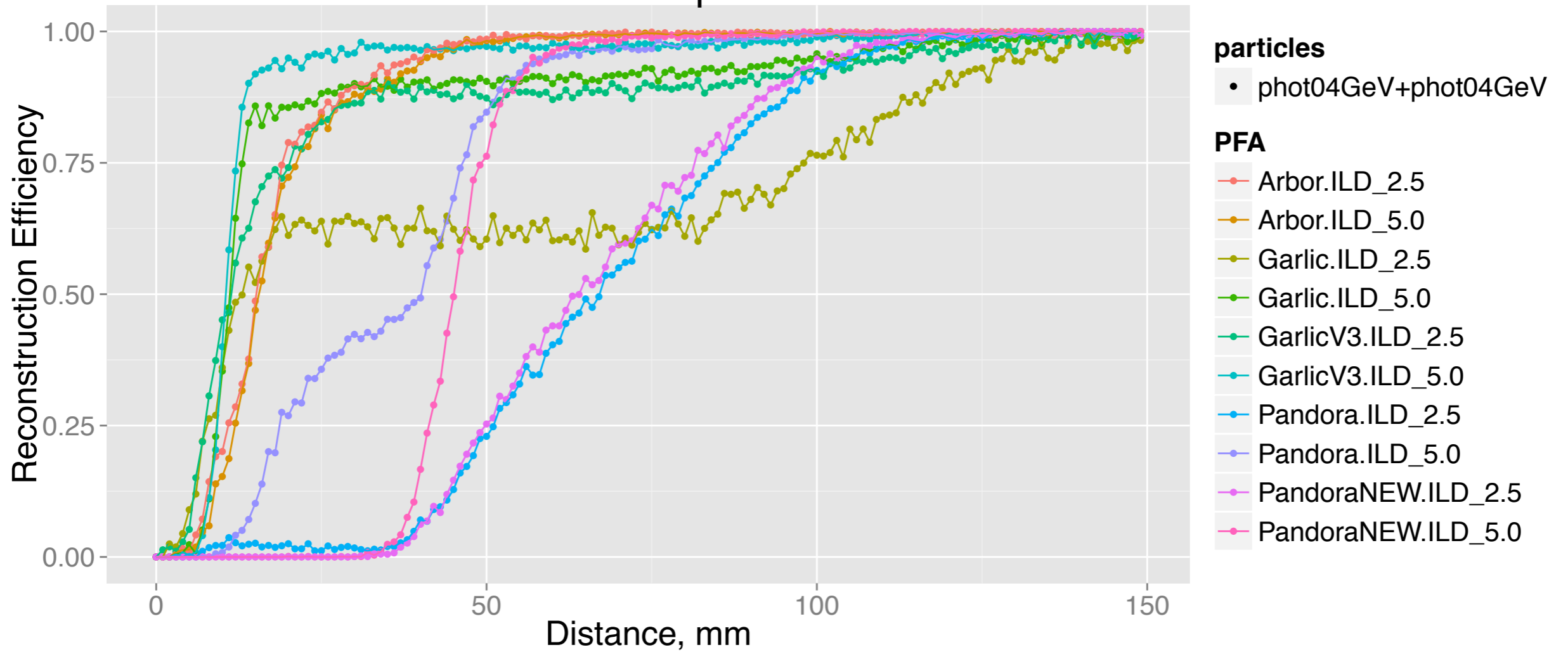
# Conclusions

- 1) New Pandora shows significantly better performance for higher energies, there is some place for improvement at lower energies
- 2) 2.5x2.5mm<sup>2</sup> ECAL require additional software optimisation
- 3) Arbor crashes on pion-photon events where pion has no hits in ECAL. Fix is ready.
- 4) CAN057:
  - v1 comments from E.Tarkovsky received (thanks!!!)
  - v2 under preparation
  - deadline: IEEE, end of October

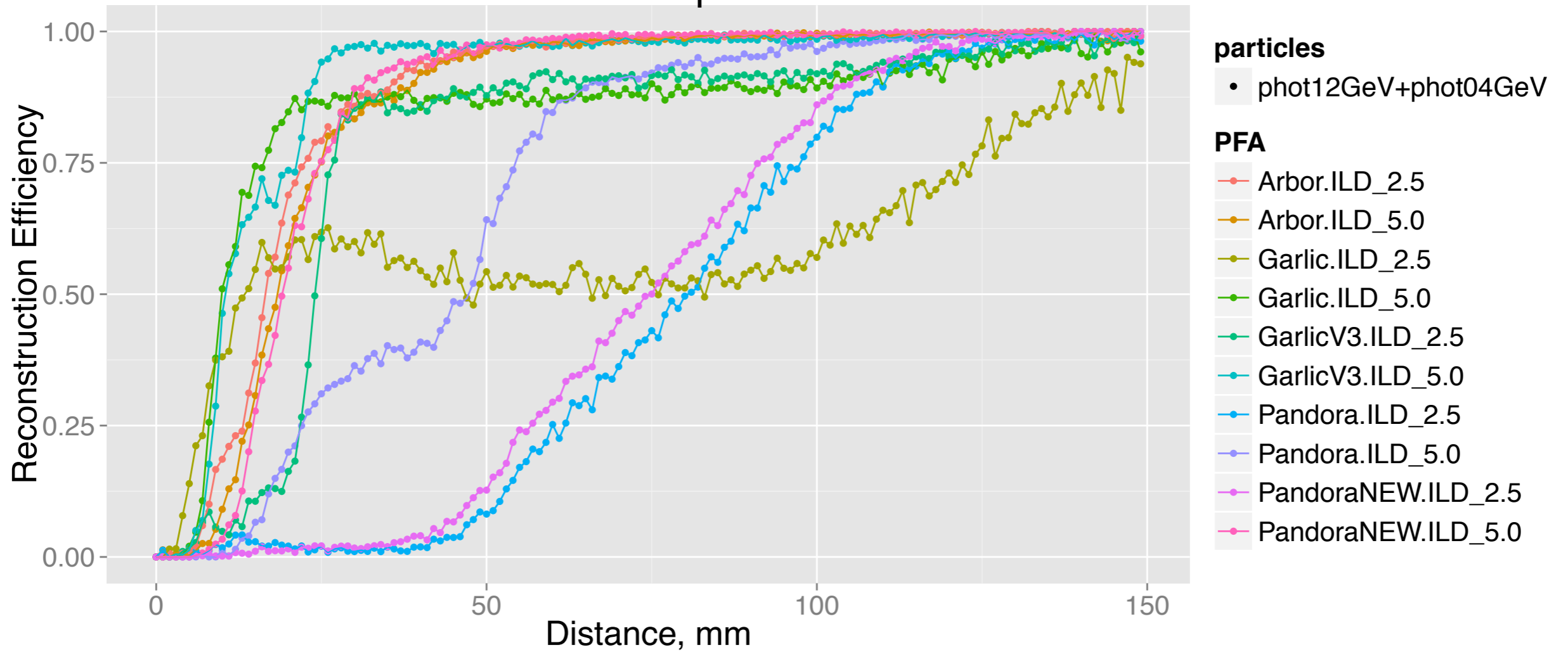
**THANK YOU!!!**

# **BACKUP**

# Photon – Photon separation in ILD

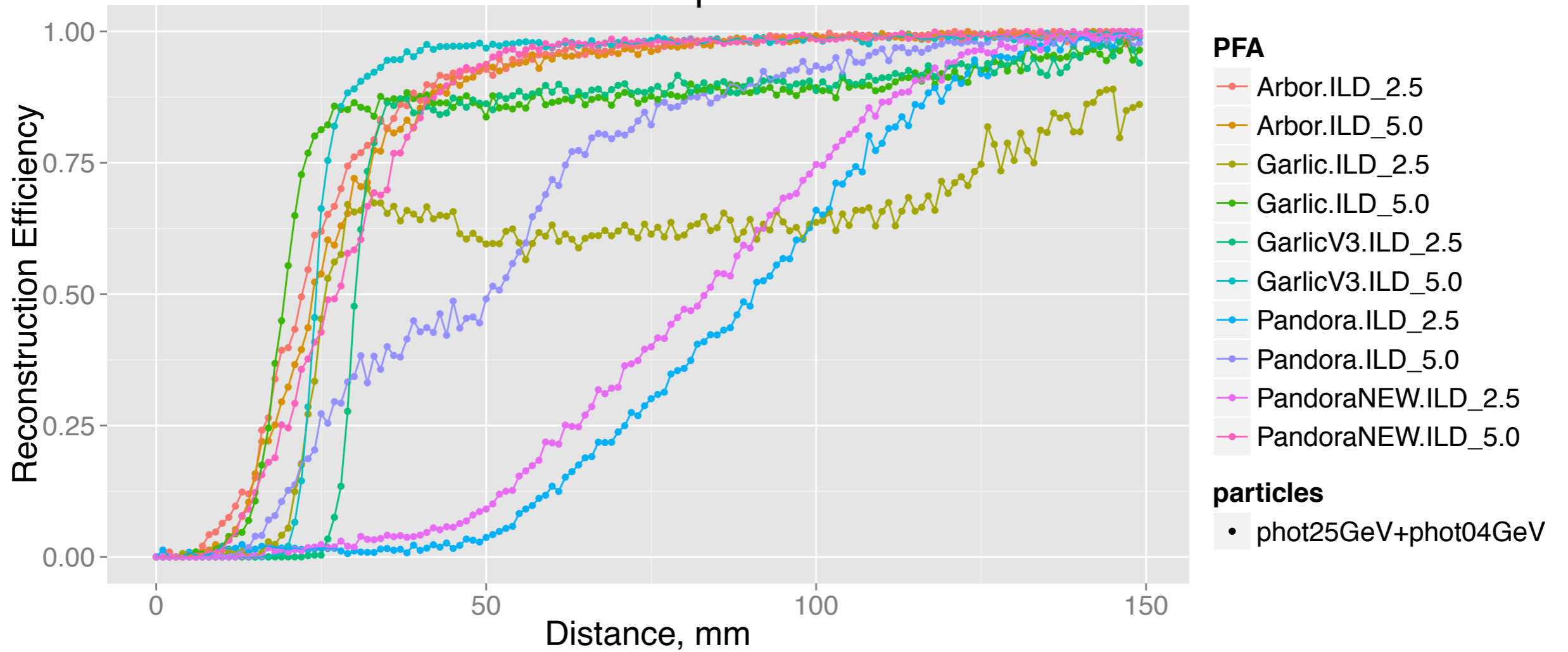


# Photon – Photon separation in ILD

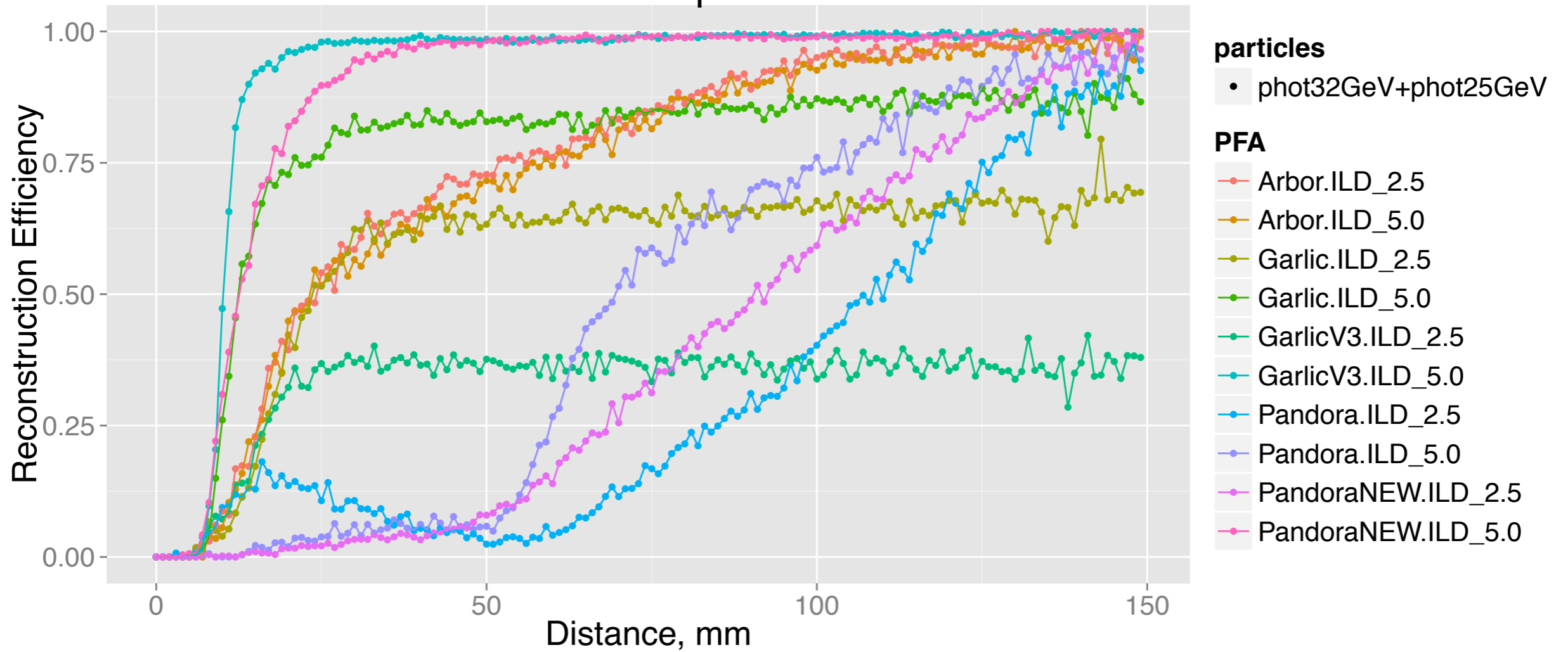




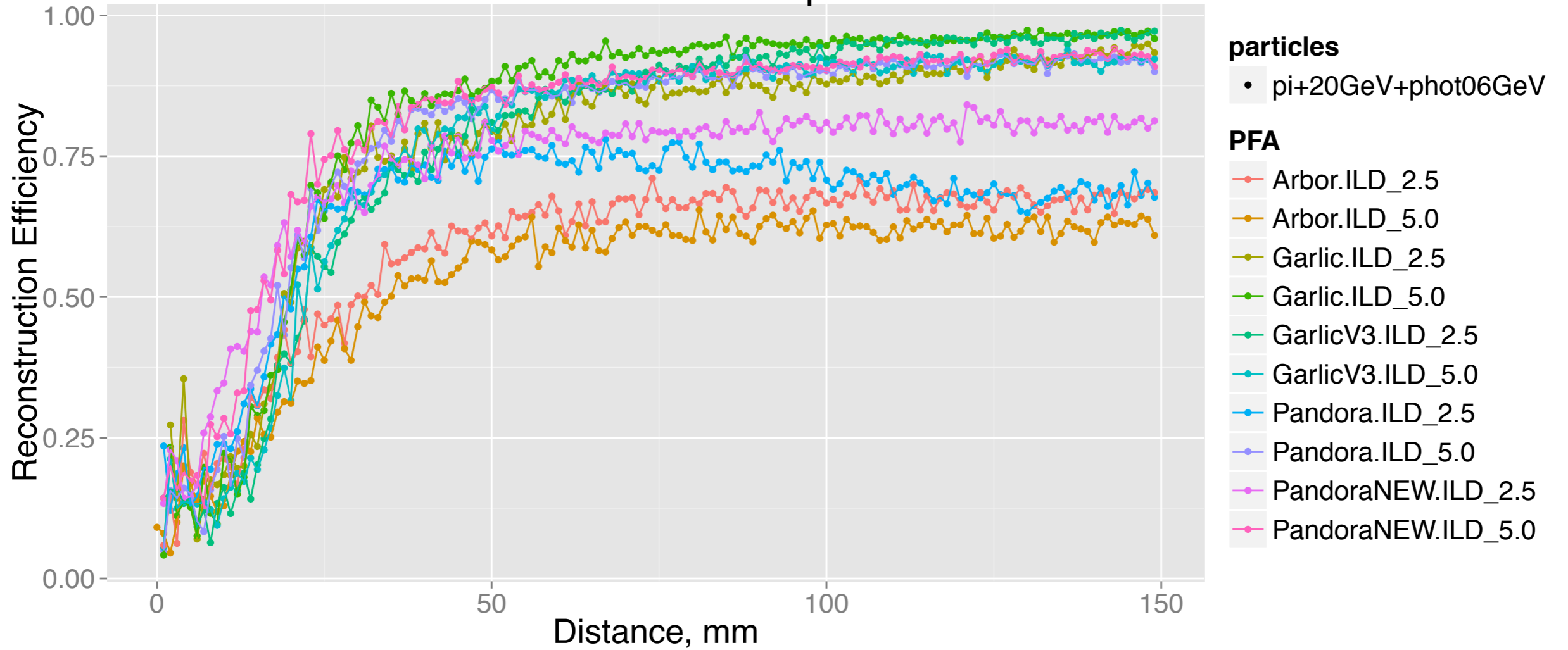
# Photon – Photon separation in ILD



# Photon – Photon separation in ILD



# Pion 20GeV – Photon 6GeV separation in ILD



# Pion 20GeV – Photon 25GeV separation in ILD

