Forward physics with ALICE-FOCAL

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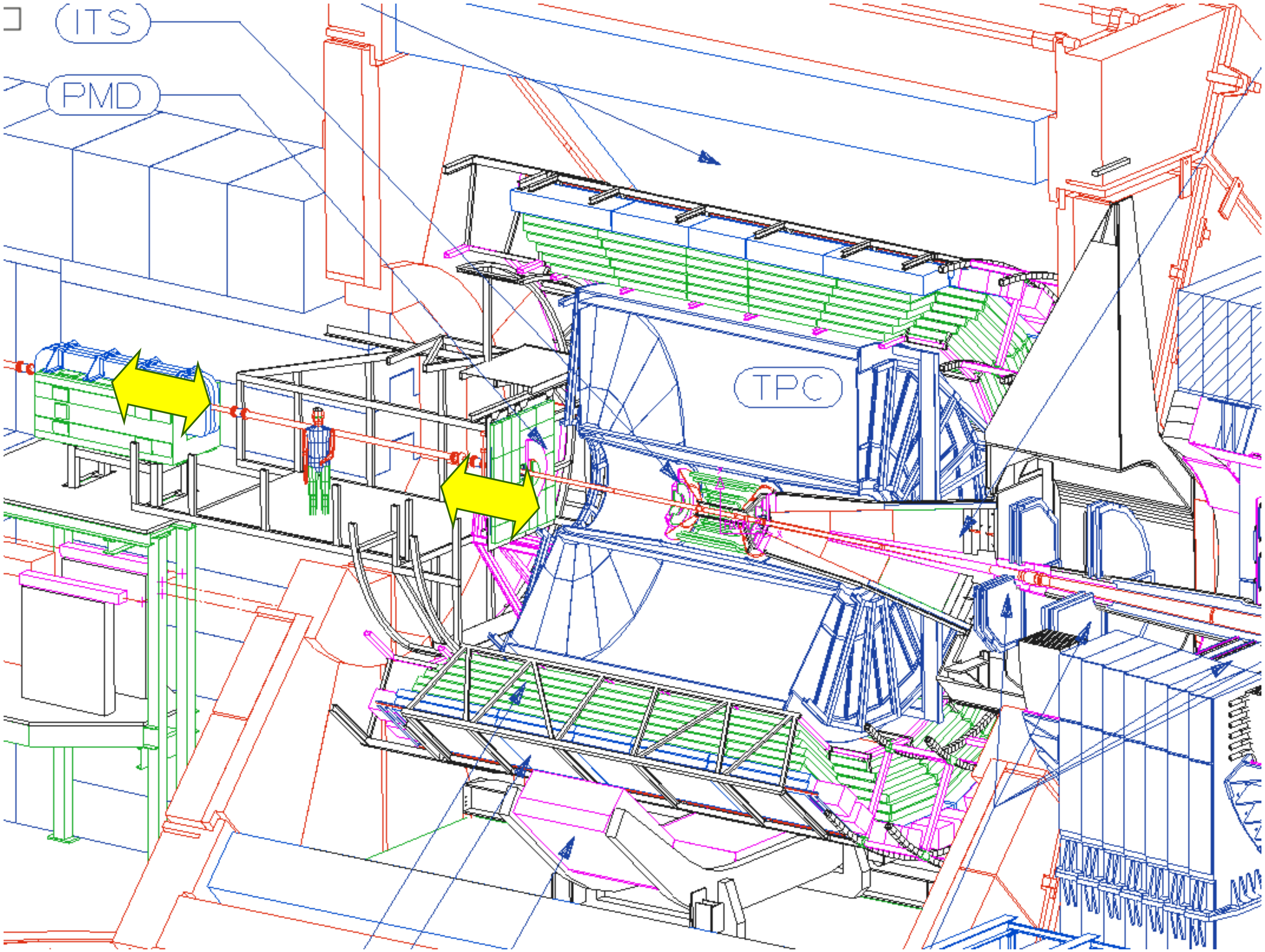
OUTLINE

- **Proposal for a new forward calorimeter (FOCAL)**
- **Physics capabilities**
- **Simulation results**
- **Test Beam Results with FOCAL mini -prototype.**
- **Summary**

Possible position of FOCAL in ALICE



F0CAL (~350 and ~800cm away from IP)

What ALICE can do without FOCAL

✓Pseudo rapidity range probed: Mid-rapidity () and Forward rapidity ()

✓Bjorken-x range: 10^{-4} to 10^{-5} in mid-rapidity

✓Jet reconstruction up to:

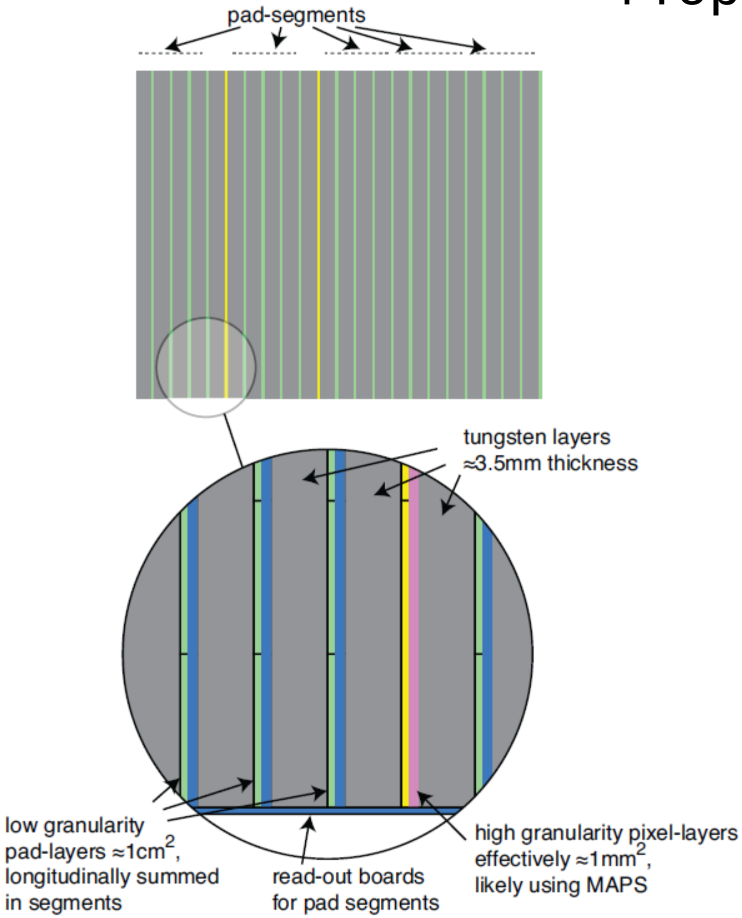
✓Direct photon measurement:

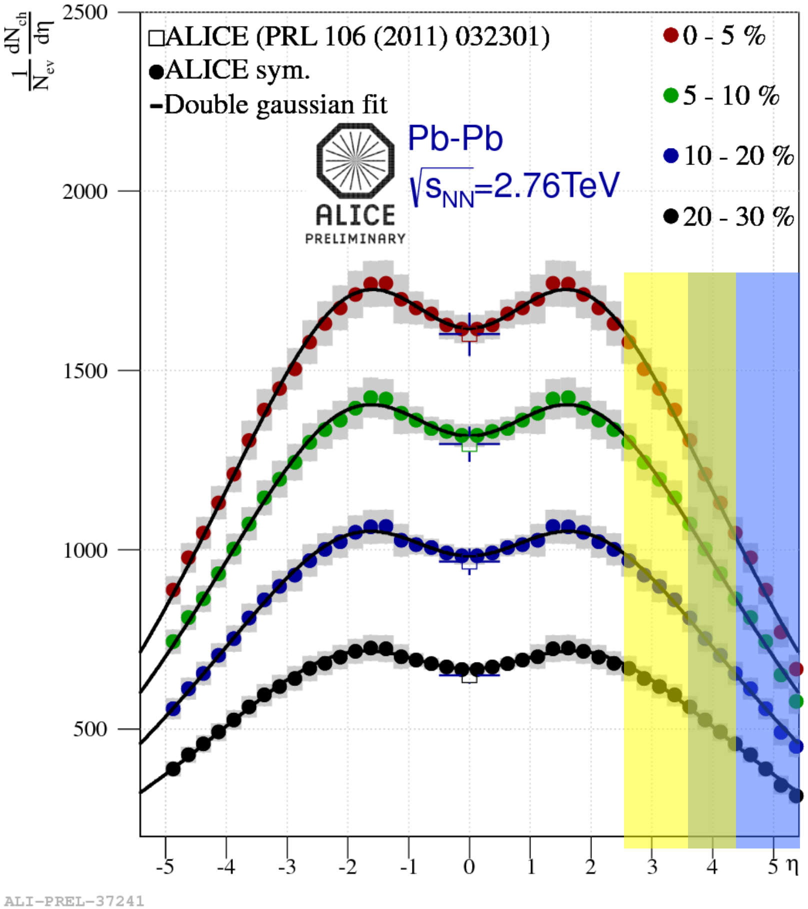
✓With EMCAL:

✓With PHOS:

✓Gamma-jet correlation studies:

Proposed FoCAL





	ATLAS Inner Wheel	CMS EndCap	LHCb ECAL	ALICE FoCal@3.5m	ALICE FoCAL@8m
η range	2.5 - 3.2	1.5 - 3.0	1.8 - 4.3	2.5 - 4.5	3.3 - 5.3
granularity [deg]	5.7	0.5	≥ 0.18	≈ 0.016	

FoCAL with unique η coverage and unique capabilities for $\pi0$, γ measurement

Physics with FoCAL

- ✓ Test of pQCD prediction (**pp collisions**)
  - ✓ In terms of Nuclear modification factor
  - ✓ Particle production

- ✓ To probe the initial condition (**p-A collisions**)
  - ✓ Distribution of Gluon density at small-x (down to 10^{-5} to 10^{-6})
  - ✓ Study of Color Glass Condensate

  }
  - Direct photon spectra, R_{pPb}
  - π^0 spectra
  - γ-π^0 and π^0-π^0 correlations
  - Jets

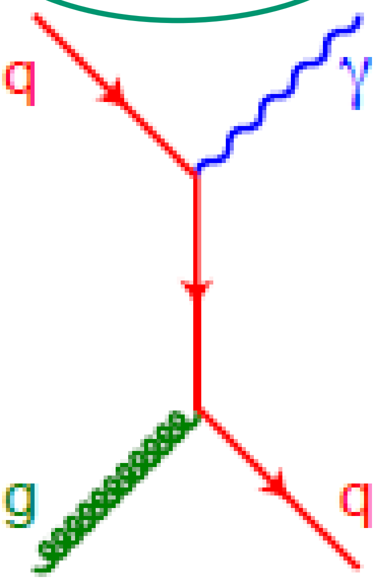
- ✓ To probe the final state effects (**A-A collisions**)
  - ✓ Measurement of opacity and the response of the medium through gamma-jets and jet-particle correlations
  - ✓ Parton energy loss in dense matter

  }
  - π^0 spectra, R_{AA}, correlations
  - Jet spectra, R_{AA}
  - Reaction plane, flow (fine segmentation: high resolution; eta-gaps)
  - Direct gammas, J/psi – Needs performance studies

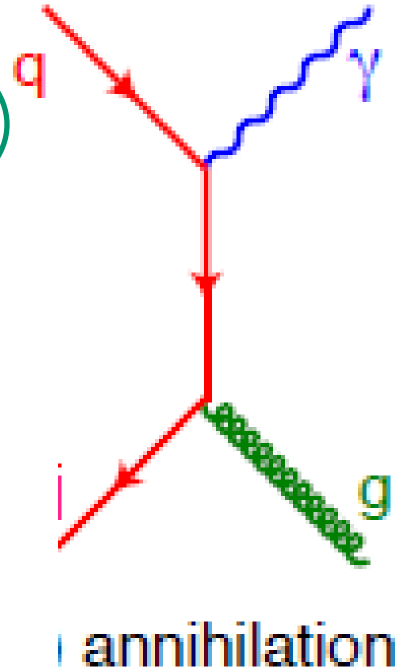
Forward Physics - Kinematics

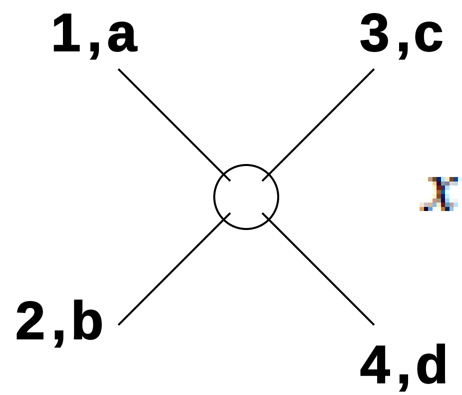
Leading Order Interaction that mainly contribute to the direct photon production

Selection of Small Bjorken-x ?



a) Compton





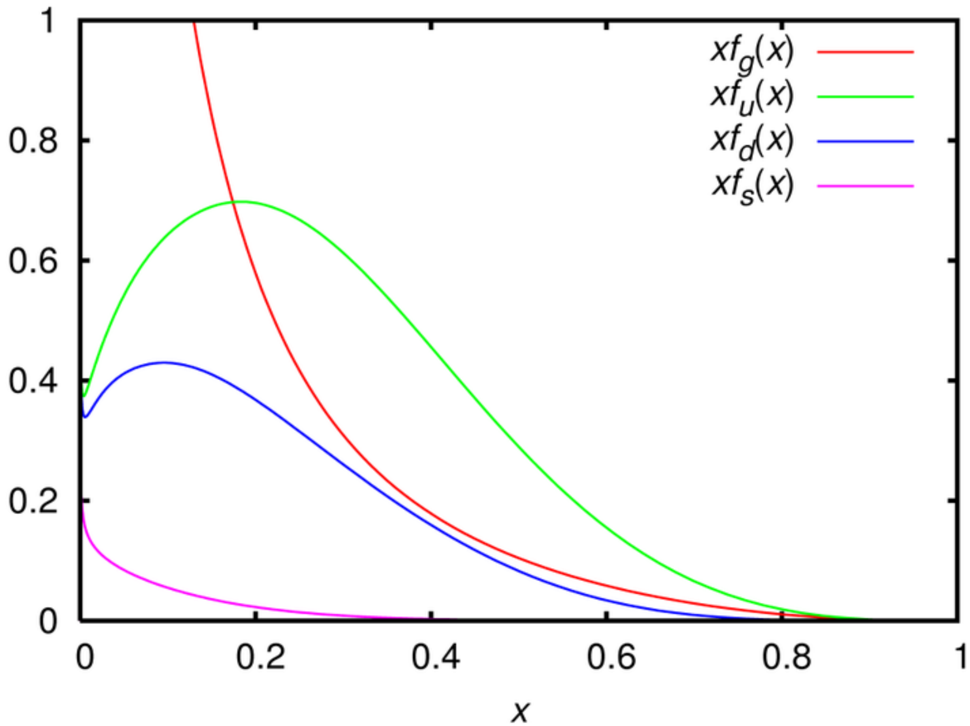
$$x_1 = \frac{p_T}{\sqrt{s}}\left(e^{y_3} + e^{y_4}\right)$$

$$x_2 = \frac{p_T}{\sqrt{s}}\left(e^{-y_3} + e^{-y_4}\right)$$

Hadron Production cross-section from a single hard scatt

$$E_h \frac{d\sigma_{AB\to h(p)}}{d^3 p_h} = \sum_{abk} \int d^3x_2 f_{b|B}(x_2) \int d^3x_1 f_{a|A}(x_1) \int dz D_{h|k}(z) E_k \frac{d\hat{\sigma}_{ab\to k}}{d^3 p_k}$$

Gluon Distribution (Proton)



⇨ There are two mechanism at small-x.

⇨ a. Gluon-splitting.

⇨ b. Gluon-recombination.

⇨ When these two mechanism balance each other.

Result : Saturation

$ **Where does saturation set in ?**

$$\rho \sigma_{gg \to g} \gtrsim 1.$$

Where ρ is gluon areal velocity
And
σ is gluon fusion cross section

n Q is less than the saturation scale Q_S

$$Q_s^2 \sim \alpha_s \frac{xg(x, Q^2)}{\pi r^2} \sim x^{-0.3}$$

For pp collision

$$Q_s^2 \sim \alpha_s \frac{xG(x, Q^2)}{\pi R^2} \sim A^{1/3} x^{-\lambda}$$

For AA collision

Detector Performance Studies

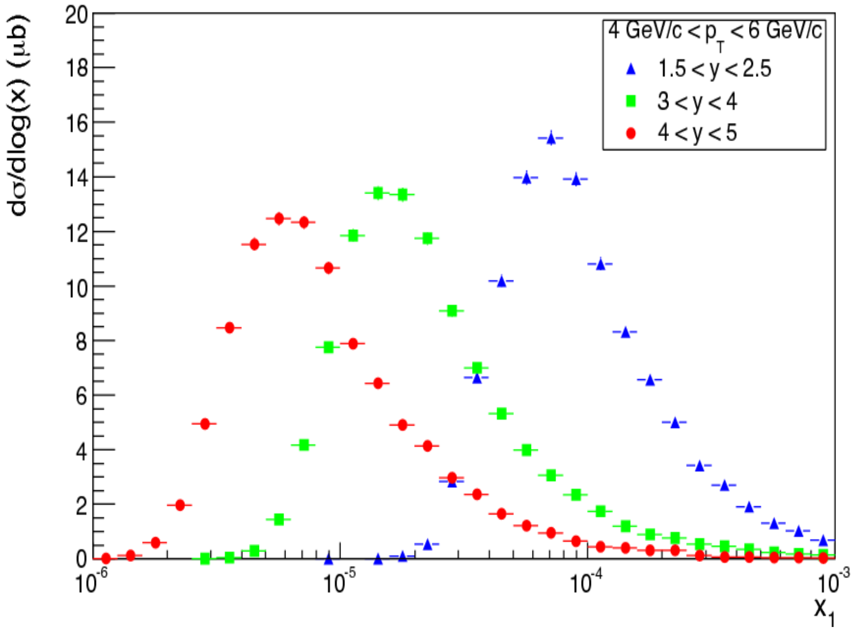
Why direct photons?

Sources

qg-compton and annihilation dominant

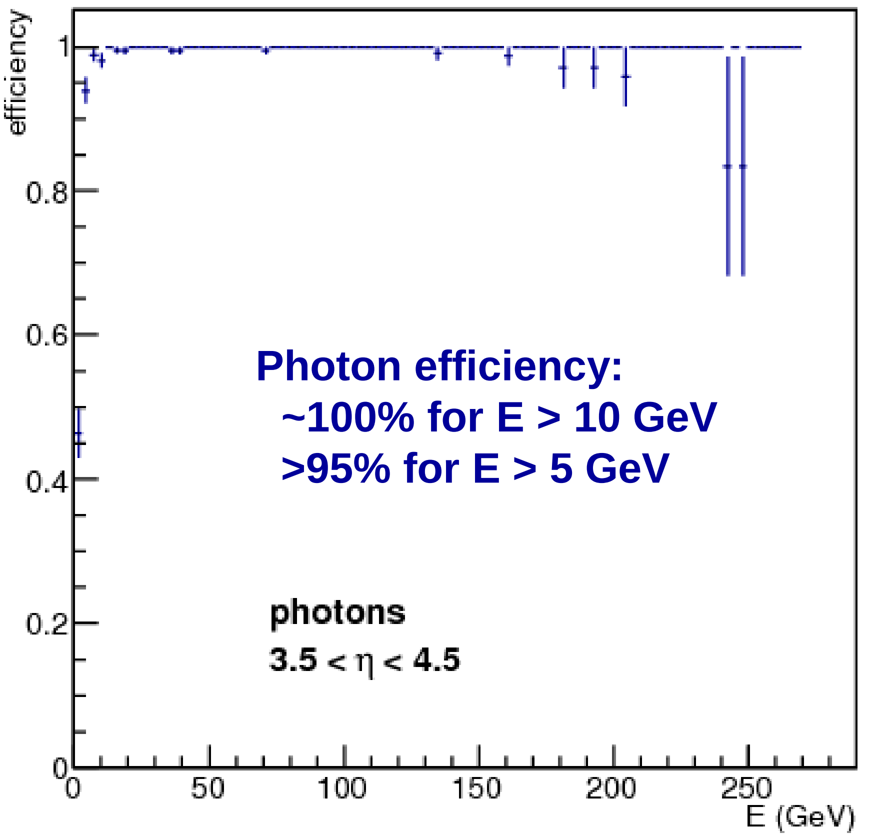
NLO corrections explored

No final state effects



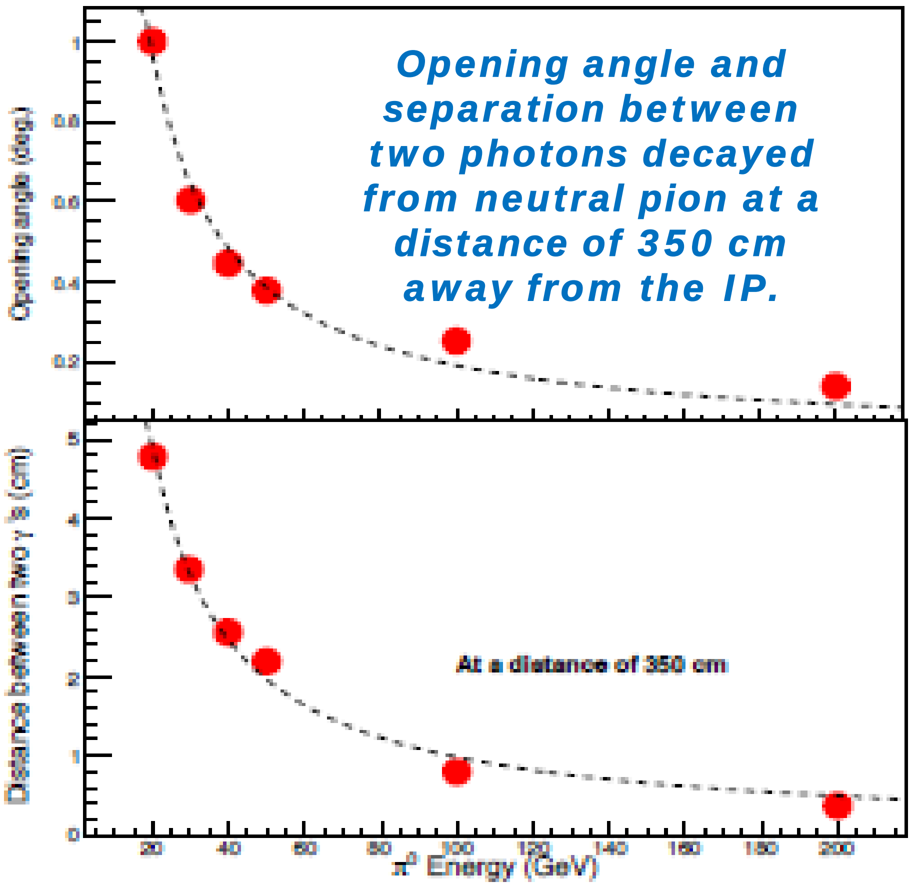
x of incoming parton for photon production with p_T > 4 GeV

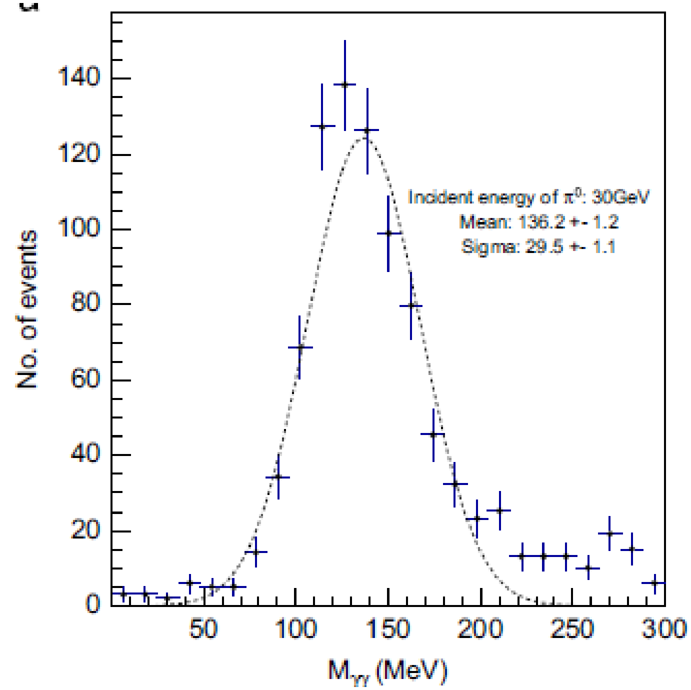
Single photon simulations, full ALICE

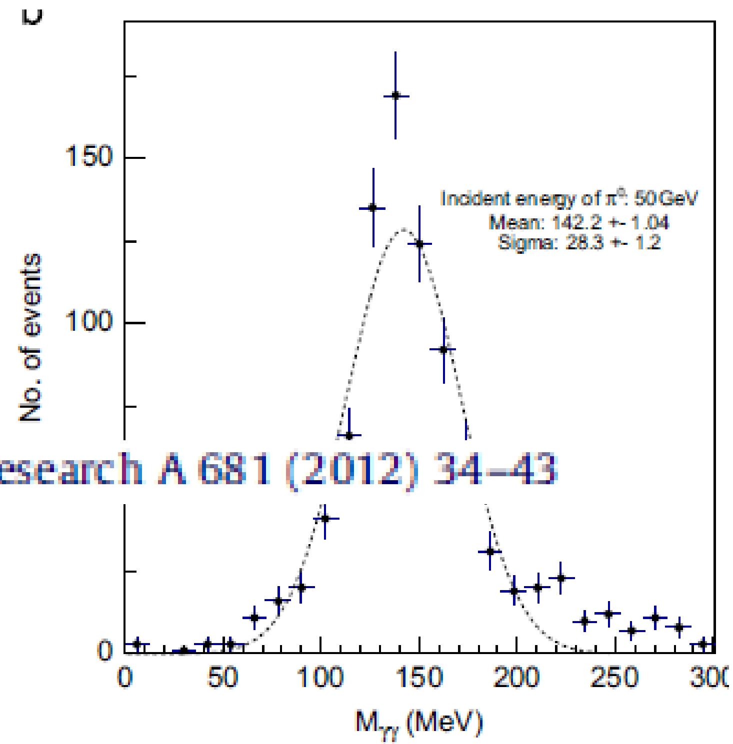


Need to be careful about contamination from other sources of photon. (eg decay photons from pi0)

Results from Simulation:







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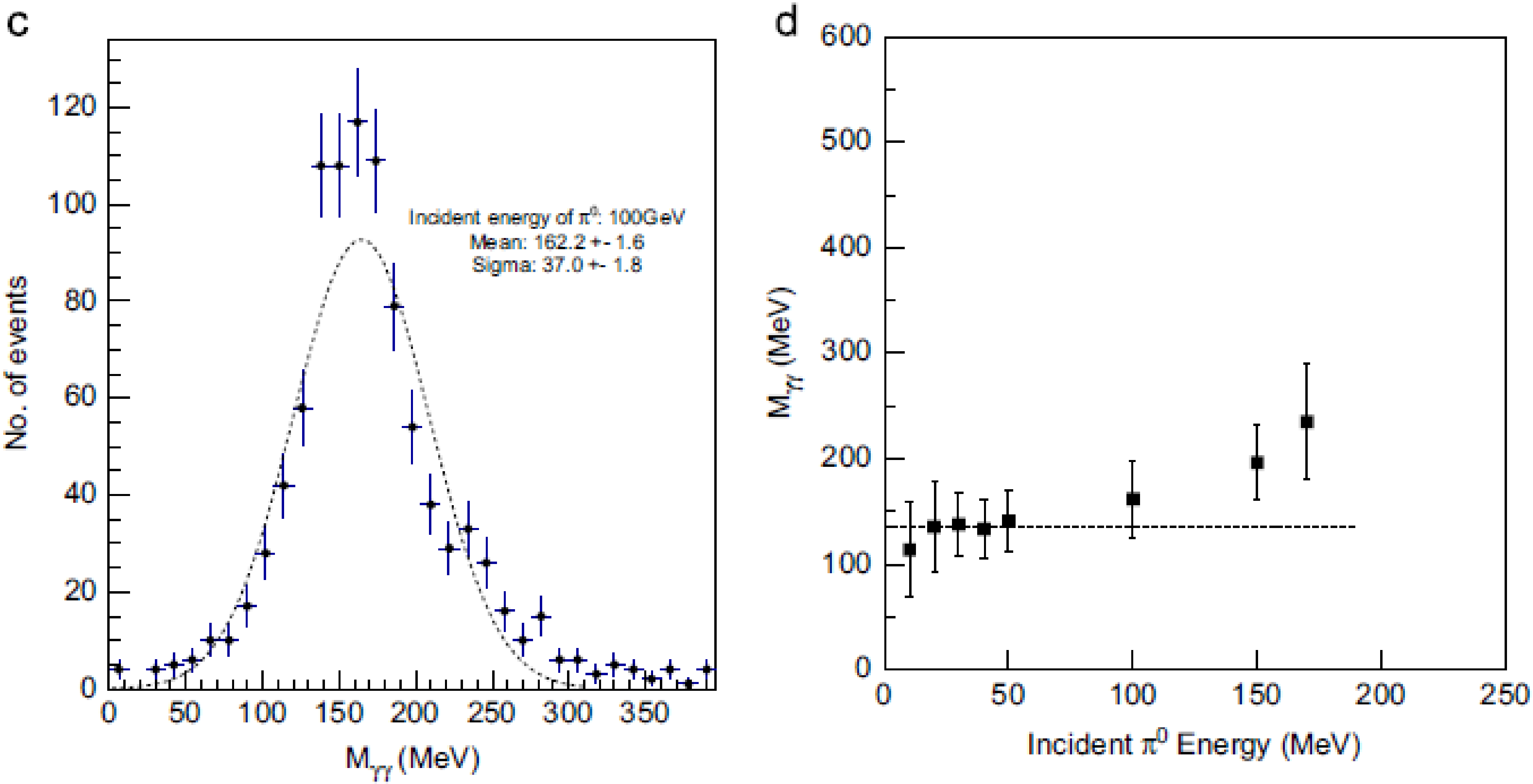

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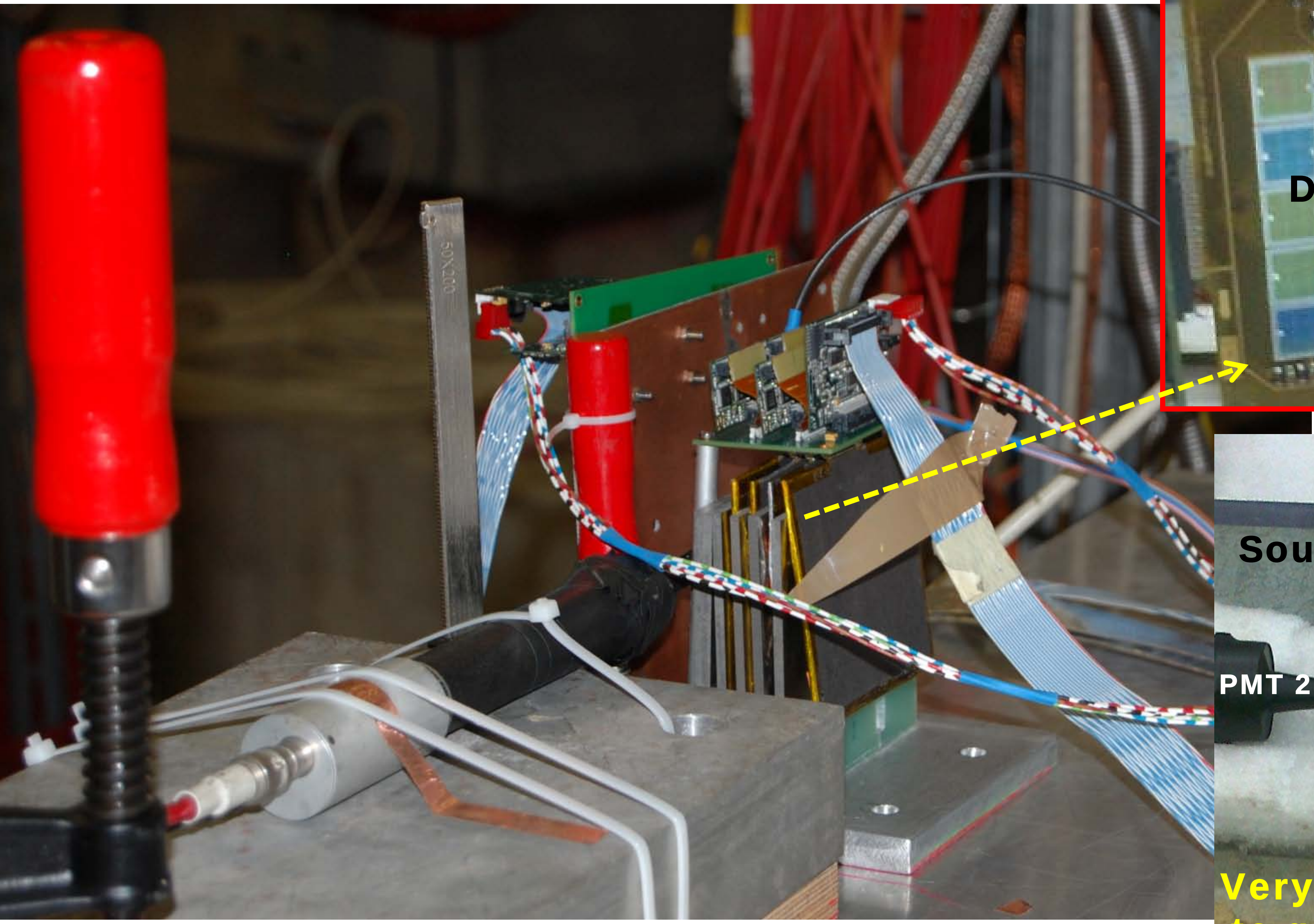
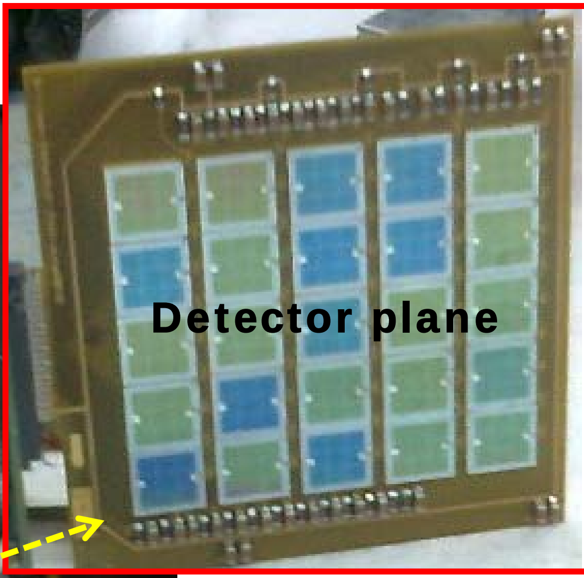
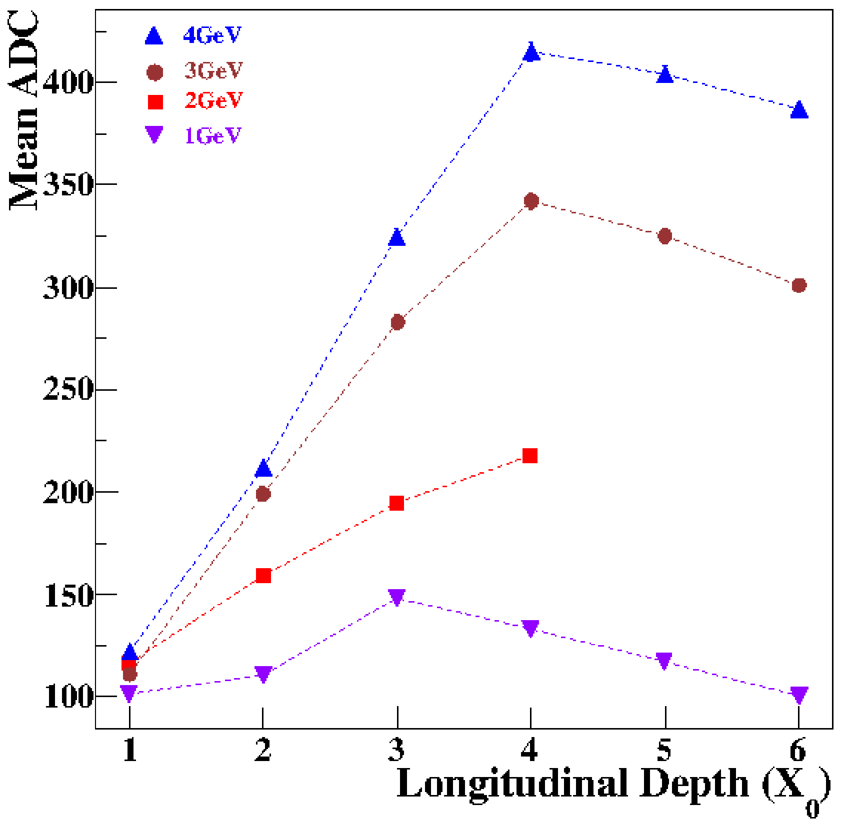
Test Beam Setup

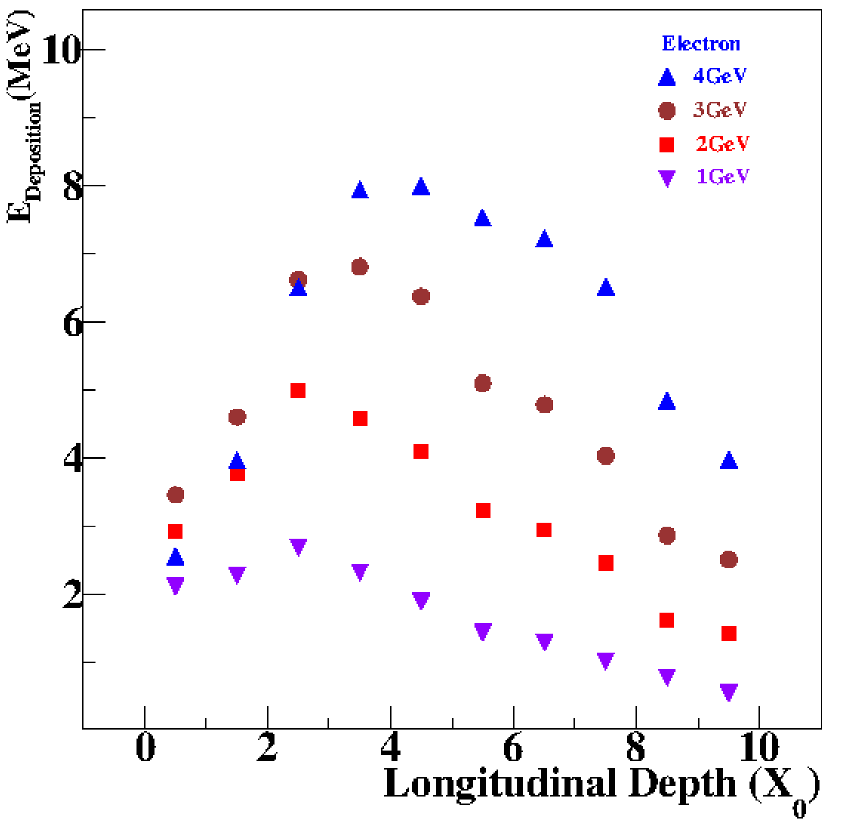




Test Beam Result

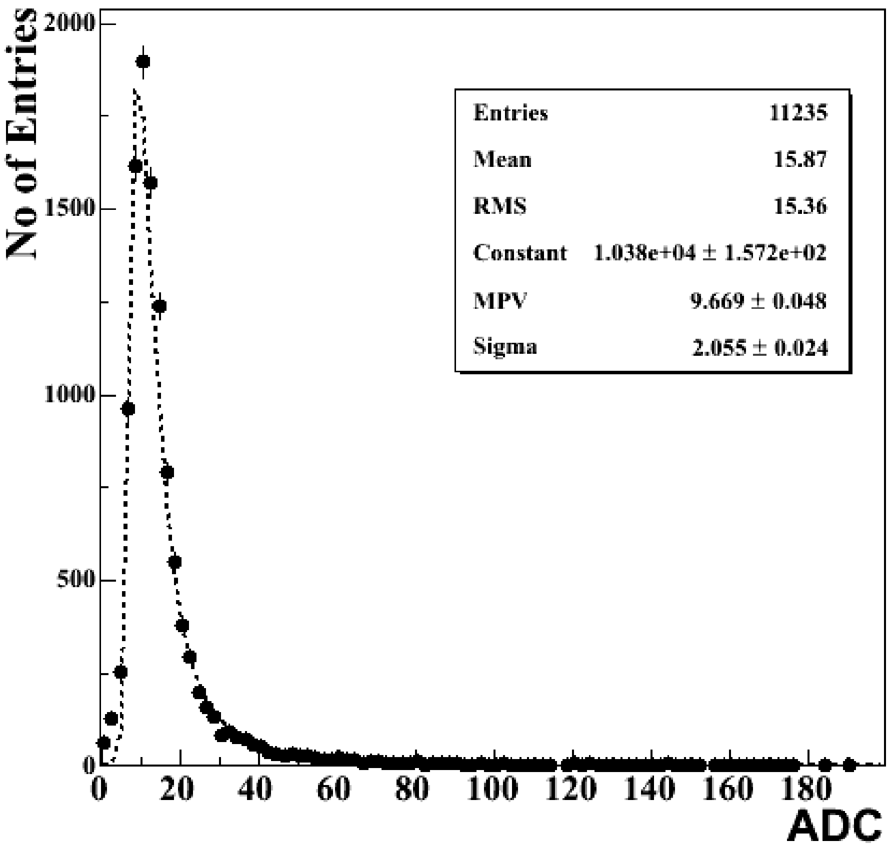
Longitudinal shower profile

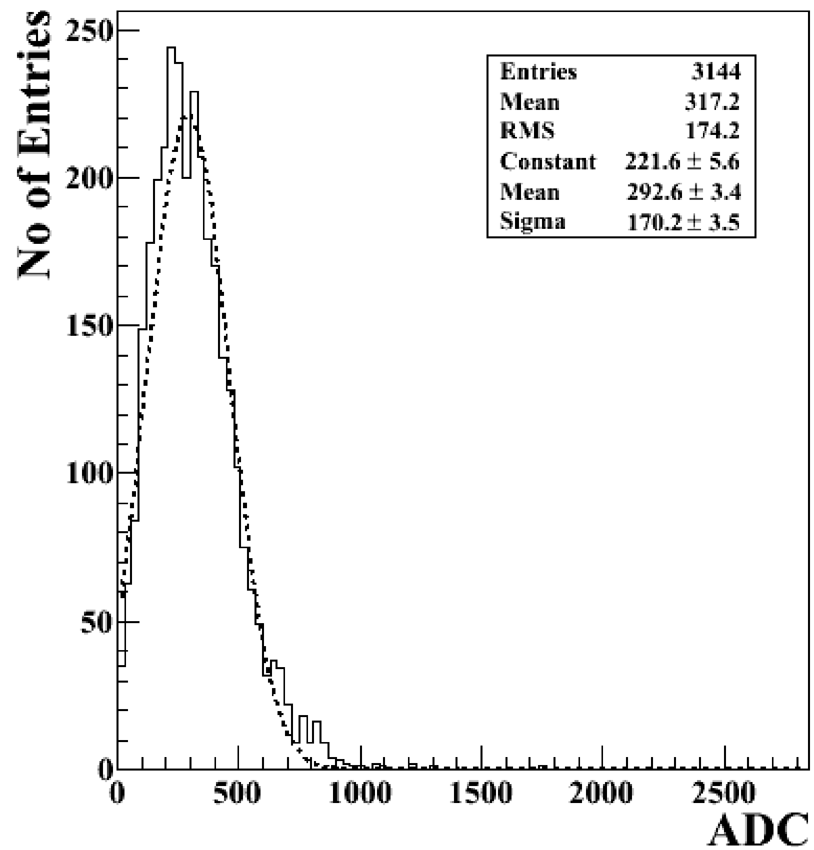




Test Beam Result

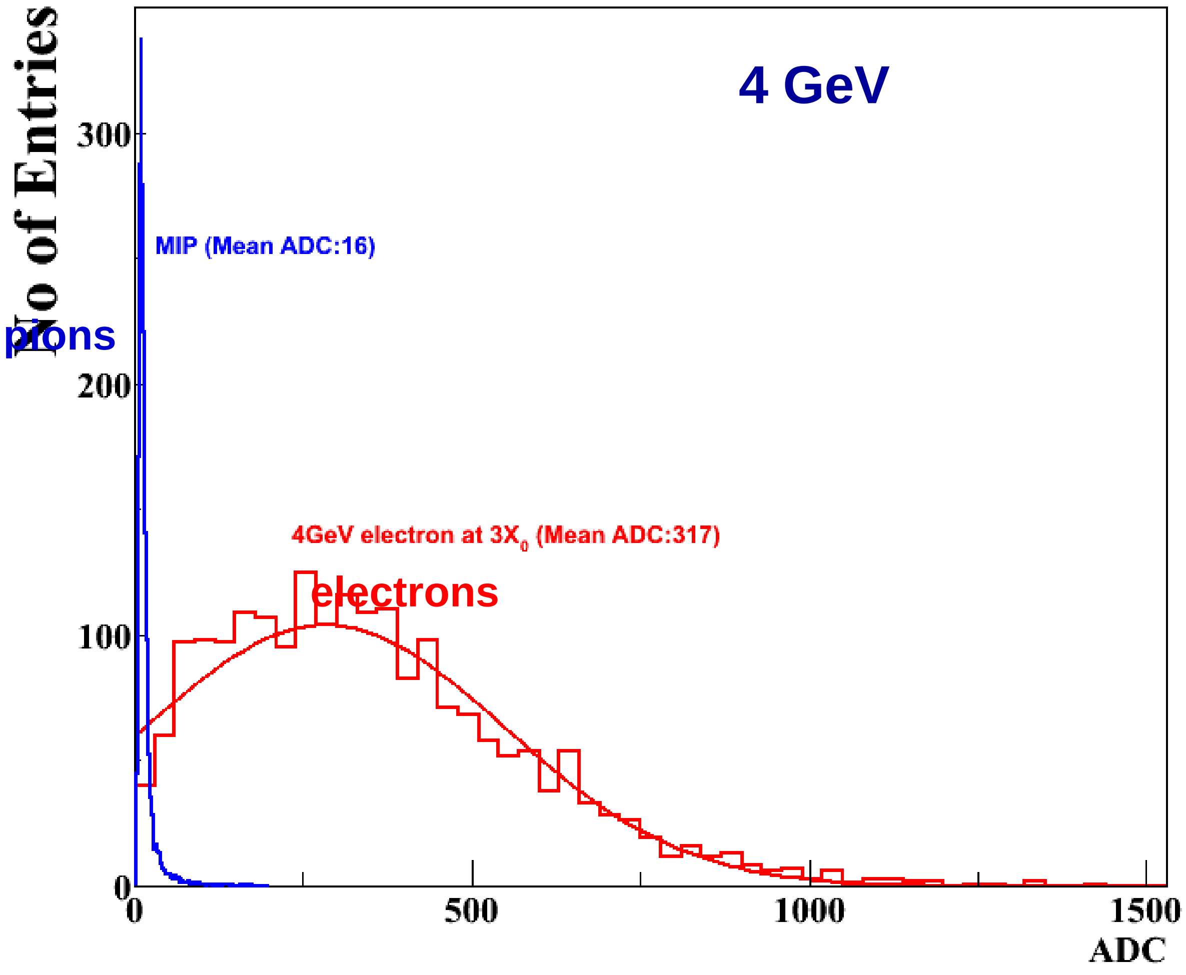
ADC distribution for MIP particle and electron





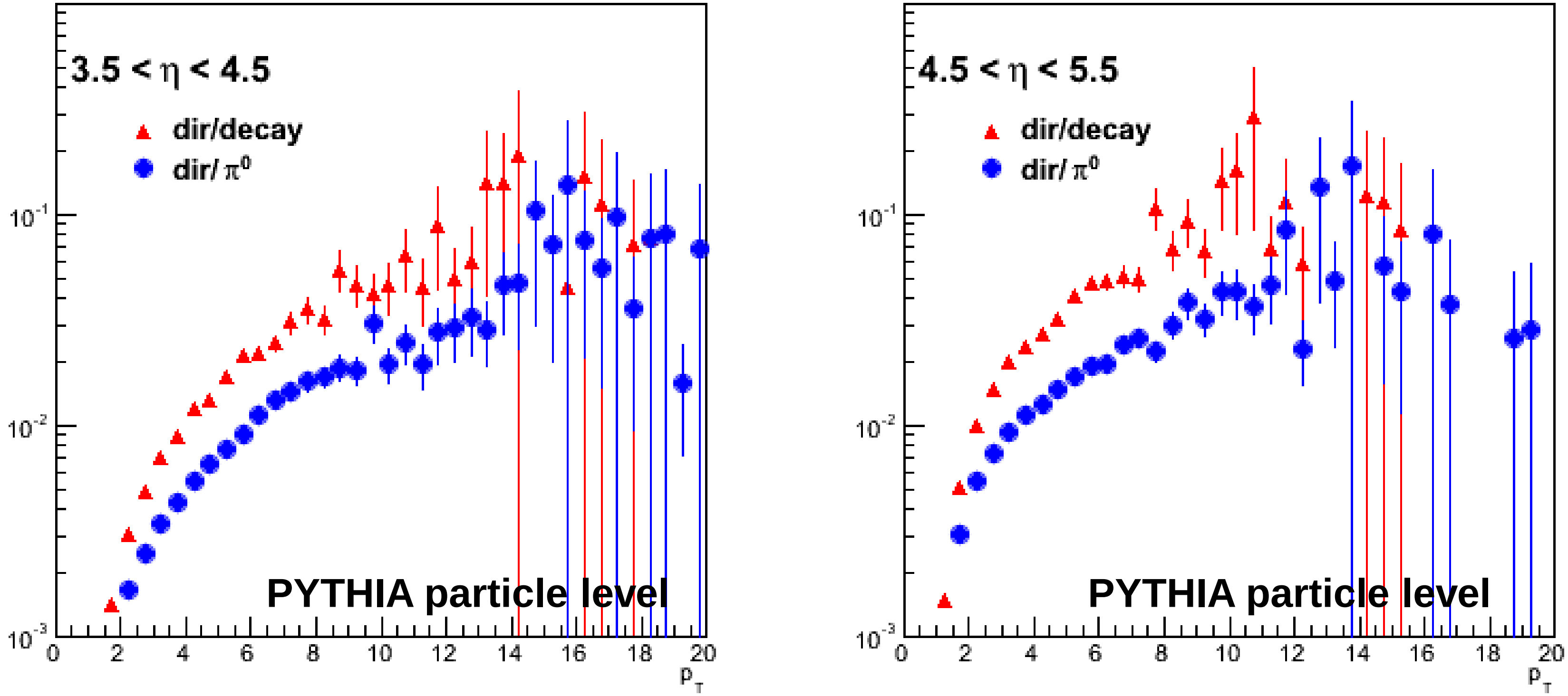
Test Beam Result

Actual Signal along with the noise (pion)



Detector Performance Studies

direct γ in p+p, p+Pb



$\gamma_{dir}/\gamma_{decay}$: a few per cent; improves with p_T, η

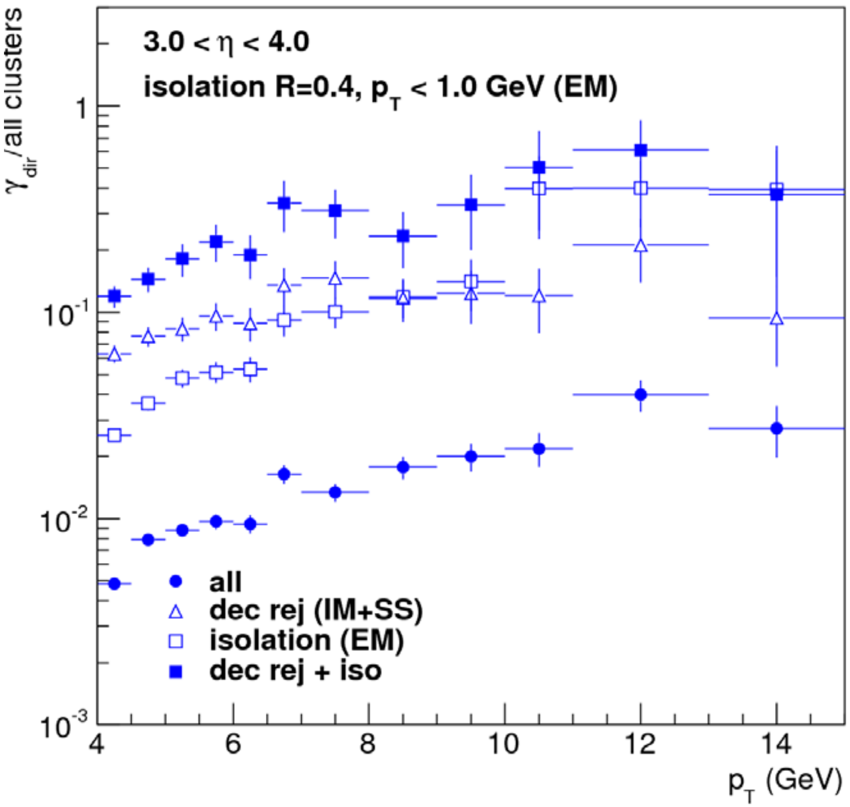
γ_{dir}/π^0 is worse; two-γ separation important

Reject decay photons by:

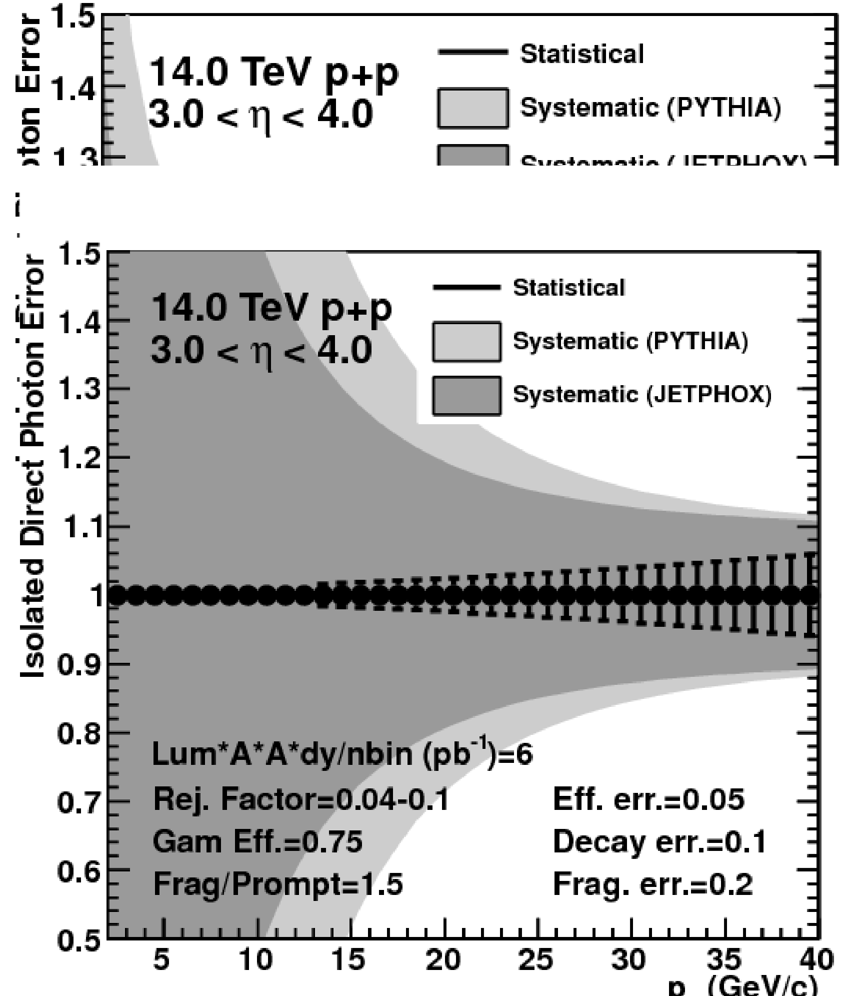
- π^0 reconstruction + mass cut
- Isolation cut

Detector Performance Studies

Direct γ performance in pp 14 TeV



Estimated uncertainty on measurement



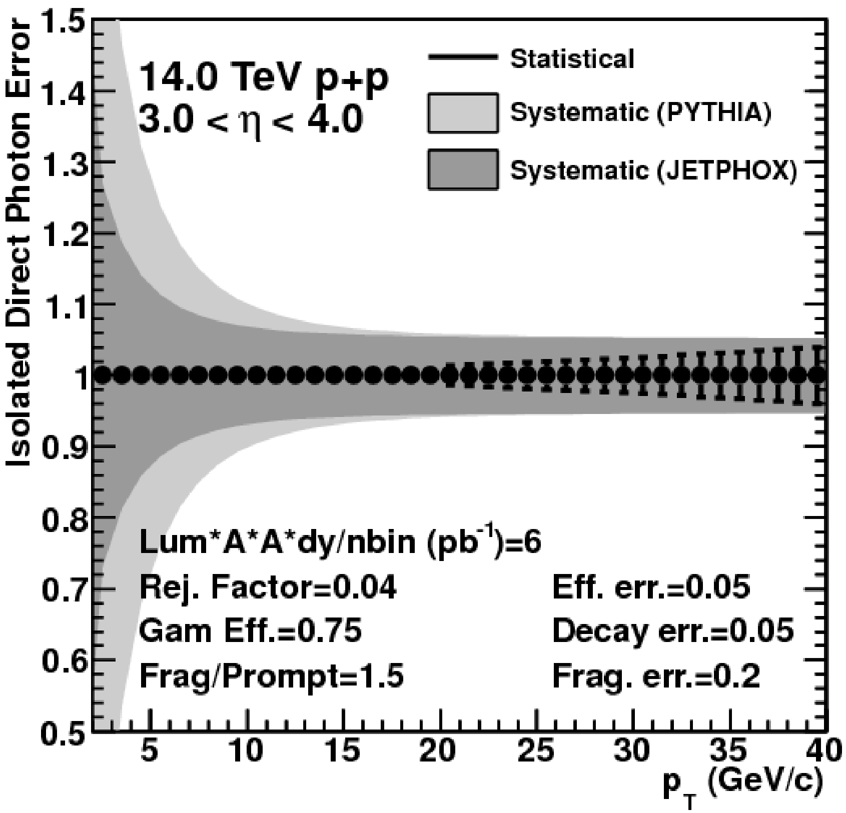
Direct γ/all > 0.1 for p_T > 4 GeV
> 0.5 for p_T > 10 GeV

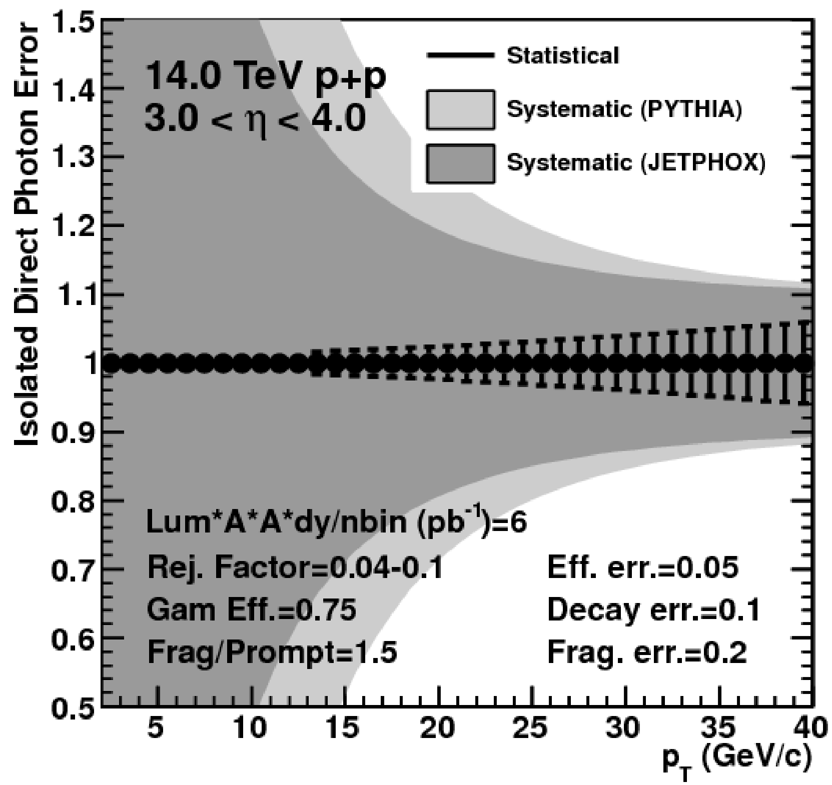
No measurement below 15 GeV/c

Miss saturation region !!

Detector Performance Studies

Estimated uncertainty on measurement





~30% uncertainty at p_T=4 GeV
Syst unc plateaus at ~ 10 GeV

No measurement below 15 GeV/c
Miss saturation region !!

Summarizing ...

- ✓ Compelling Forward Physics:
  - *Tests of pQCD predictions*
  - *Gluon distribution at low-x*
  - *Probes the initial conditions*
  - *To find out where saturation sets in*
  - *Detailed Jet study*
- ✓ **Simulation Results shows**
  - ✓**Its potential capability in detecting direct photon and decay photon**
  - ✓**Quite efficient in pp and pPb case**
  - ✓**PbPb case is under study**

- ✓Test Beam Results are satisfactory in terms of
  - ✓Longitudinal profile
  - ✓ MIP spectra
  - ✓Signal to noise separation

Thanks