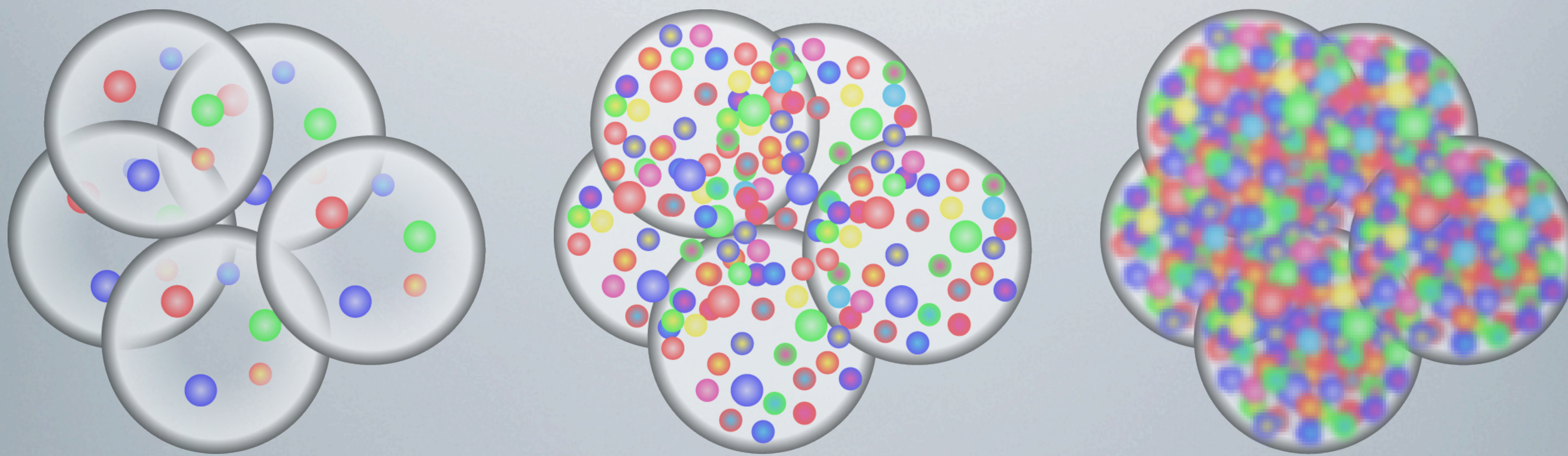

Forward Direct Photons with FoCal in ALICE

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for the ALICE FoCal collaboration

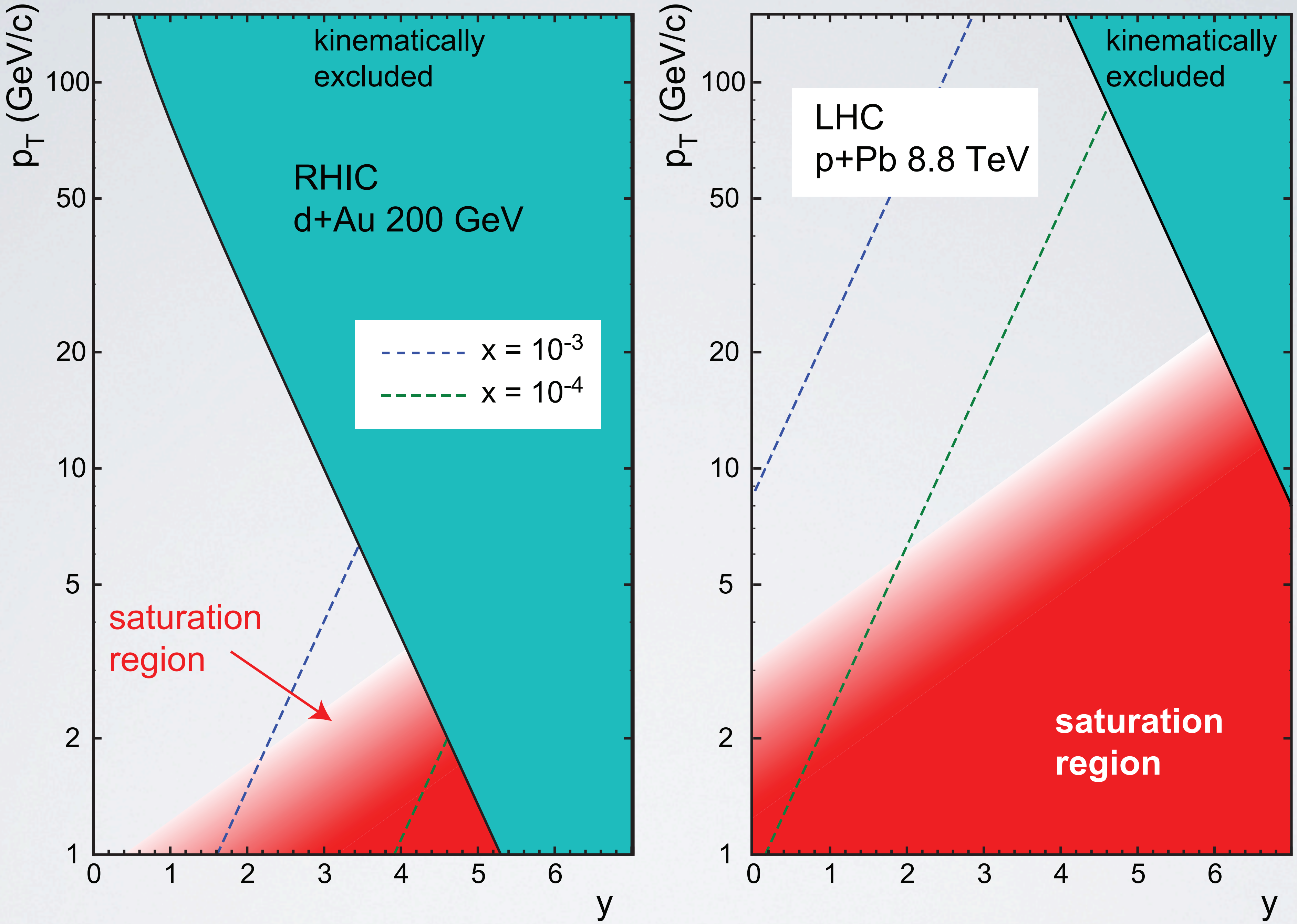
ALICE

LHC Forward Physics and Diffraction WG Meeting, CERN, Feb. 19-20, 2014

Outline

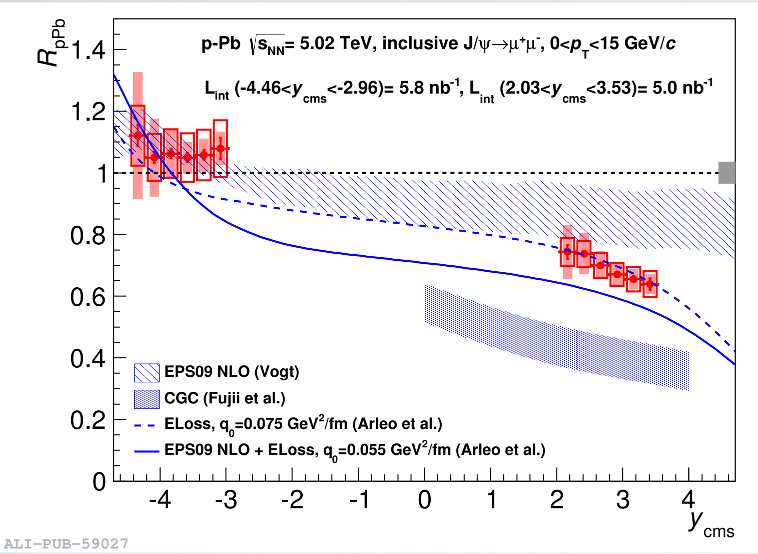
- physics motivation: isolated photons at forward rapidity as a signature for small-x gluons
- requirements: detector, beam time

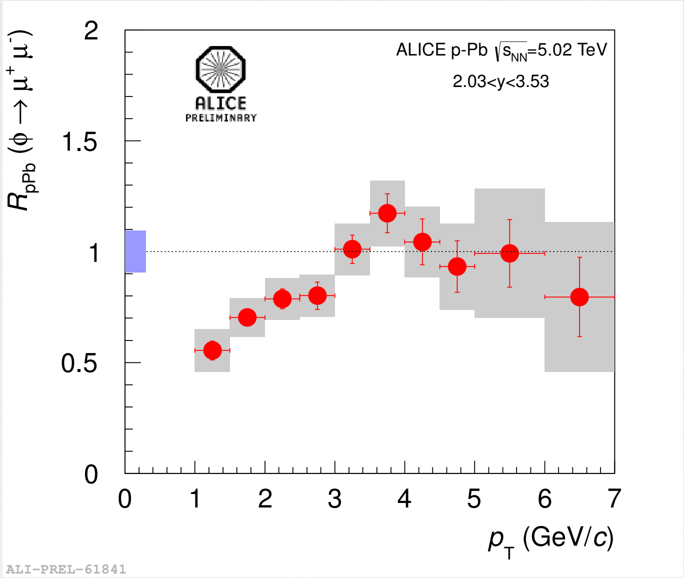
LHC vs RHIC

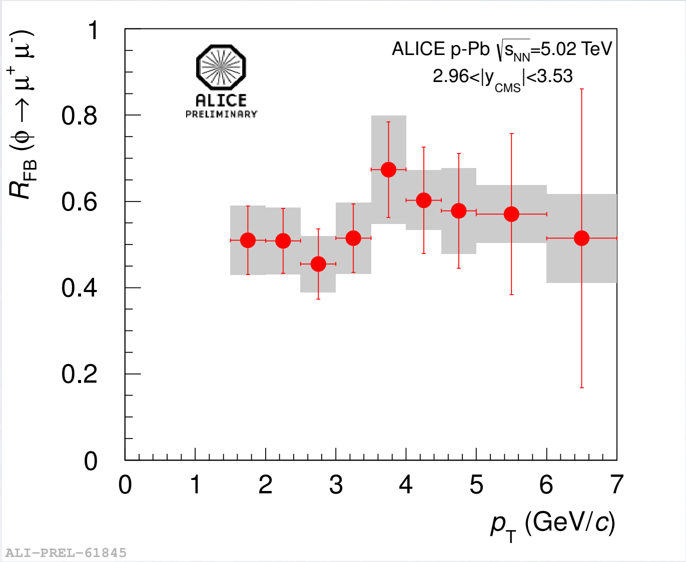


- Q_{sat} larger: saturation in perturbative regime?
- larger energy: lower x at same rapidity, not constrained by kinematic limit

Forward Hadron Production from p-A at LHC







$J/\psi \to \mu^+ + \mu^-$

- R_{pPb} compared to models

ALICE, arXiv:1308.6726

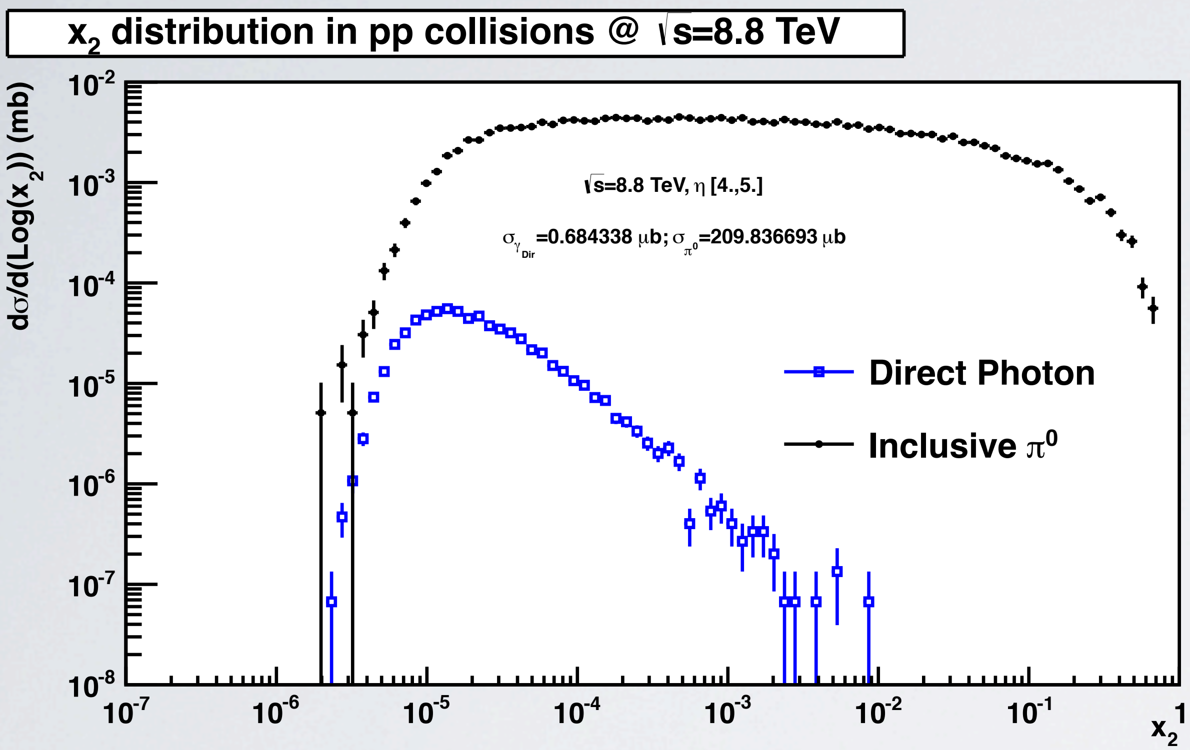
$\phi \to \mu^+ + \mu^-$

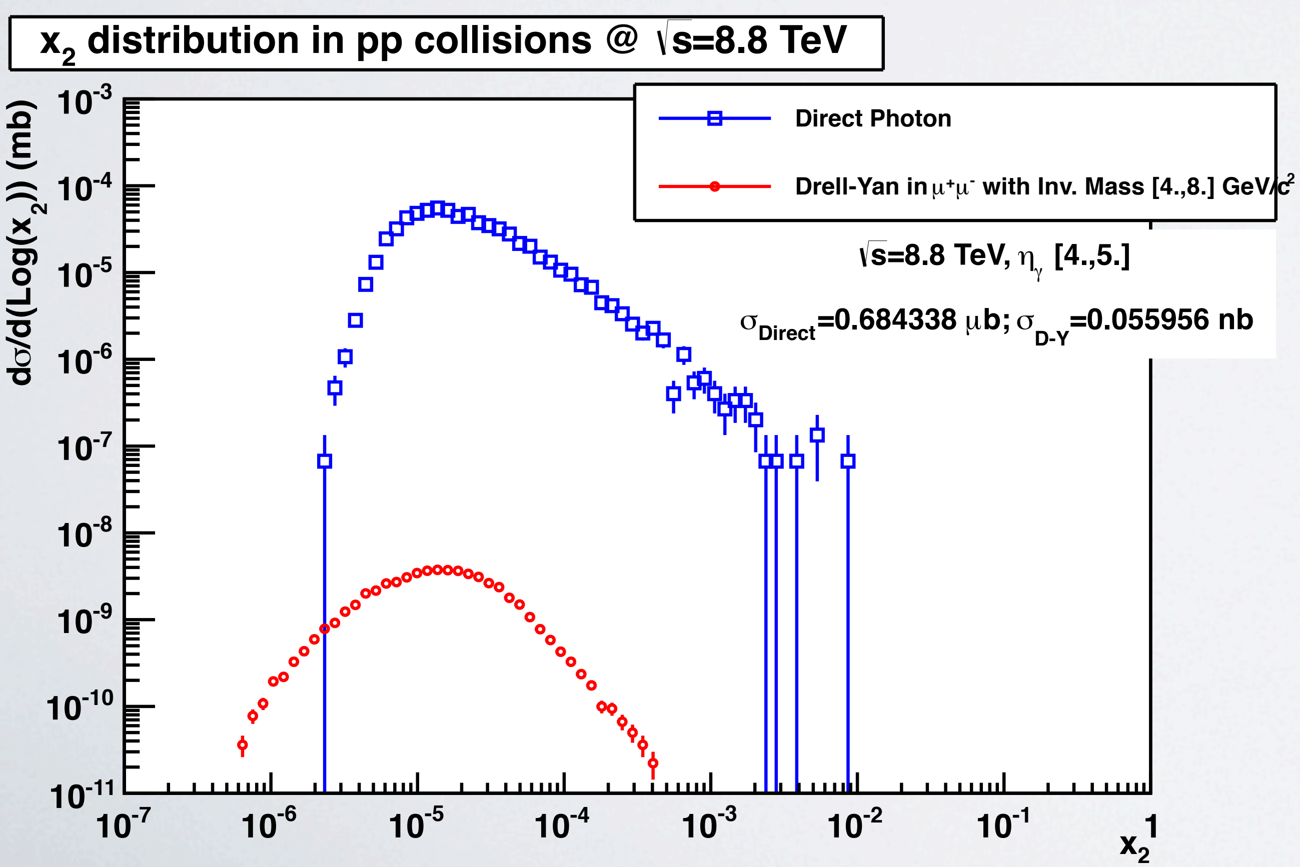
- R_{pPb} at forward rapidity + forward/backward ratio

- hadron suppression on forward (proton-going) side at low p_T
  - J/ψ not described by nPDFs nor by a CGC calculation
- uncertainties on
  - production mechanism (x,Q^2 -sensitivity)
  - other nuclear modifications (e.g. energy loss, thermalization in pA?)
- difficult to obtain conclusive data for hadrons!

x-Sensitivity from PYTHIA

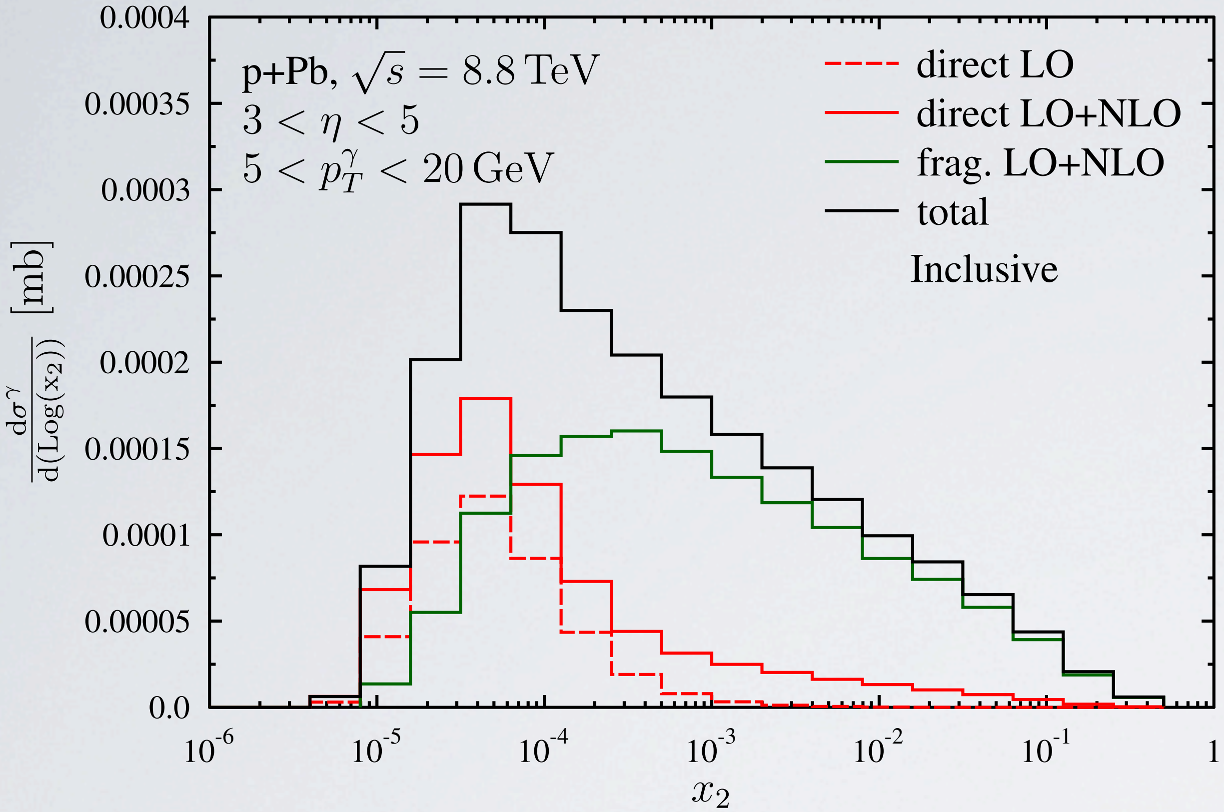
neutral pions: $p_T > 2.5$ GeV/c
direct photons: $p_T > 4$ GeV/c
Drell-Yan: 4 GeV/c^2 < M < 9 GeV/c^2

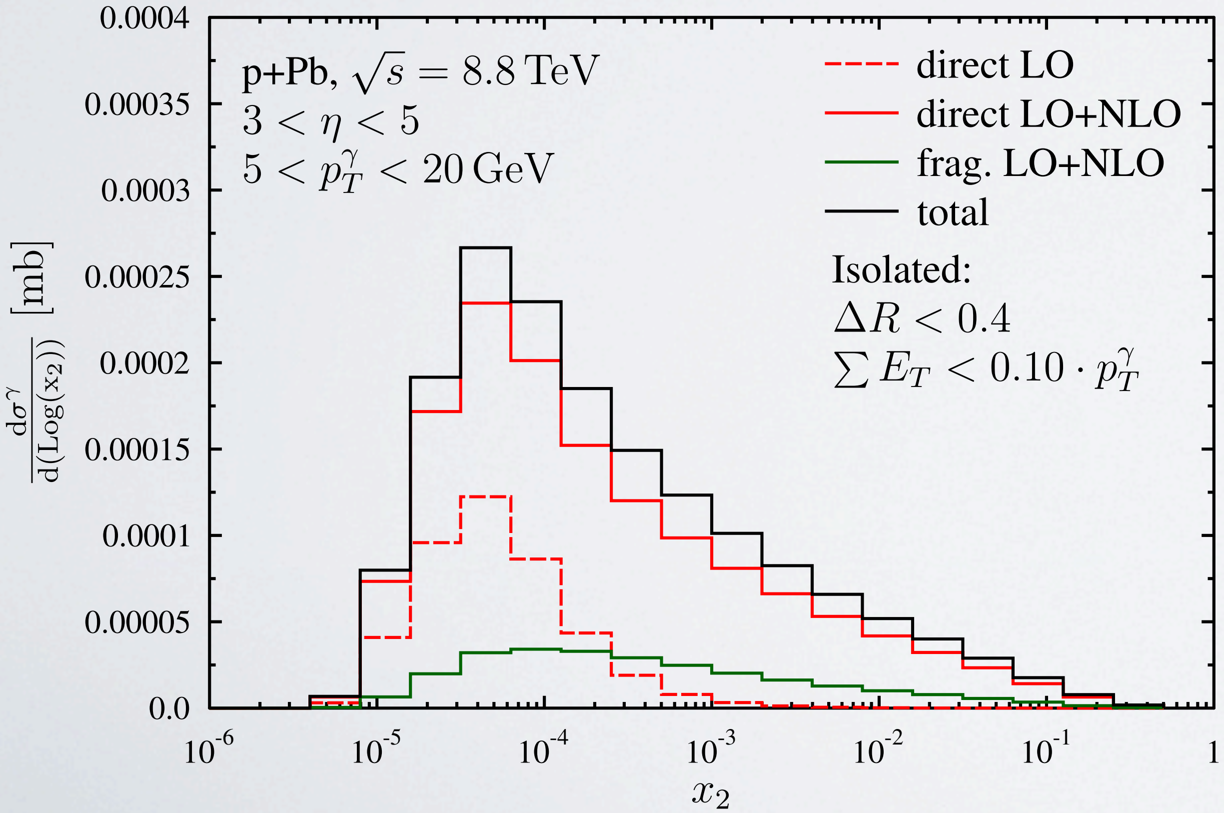




- very limited sensitivity with light hadrons
- much better sensitivity with Drell-Yan and direct photons
- much lower cross section for Drell-Yan
  - not sufficient for measurement in p–Pb
- direct photons are optimum observable for gluon saturation
  - check at NLO!

x-Reach with Direct Photons

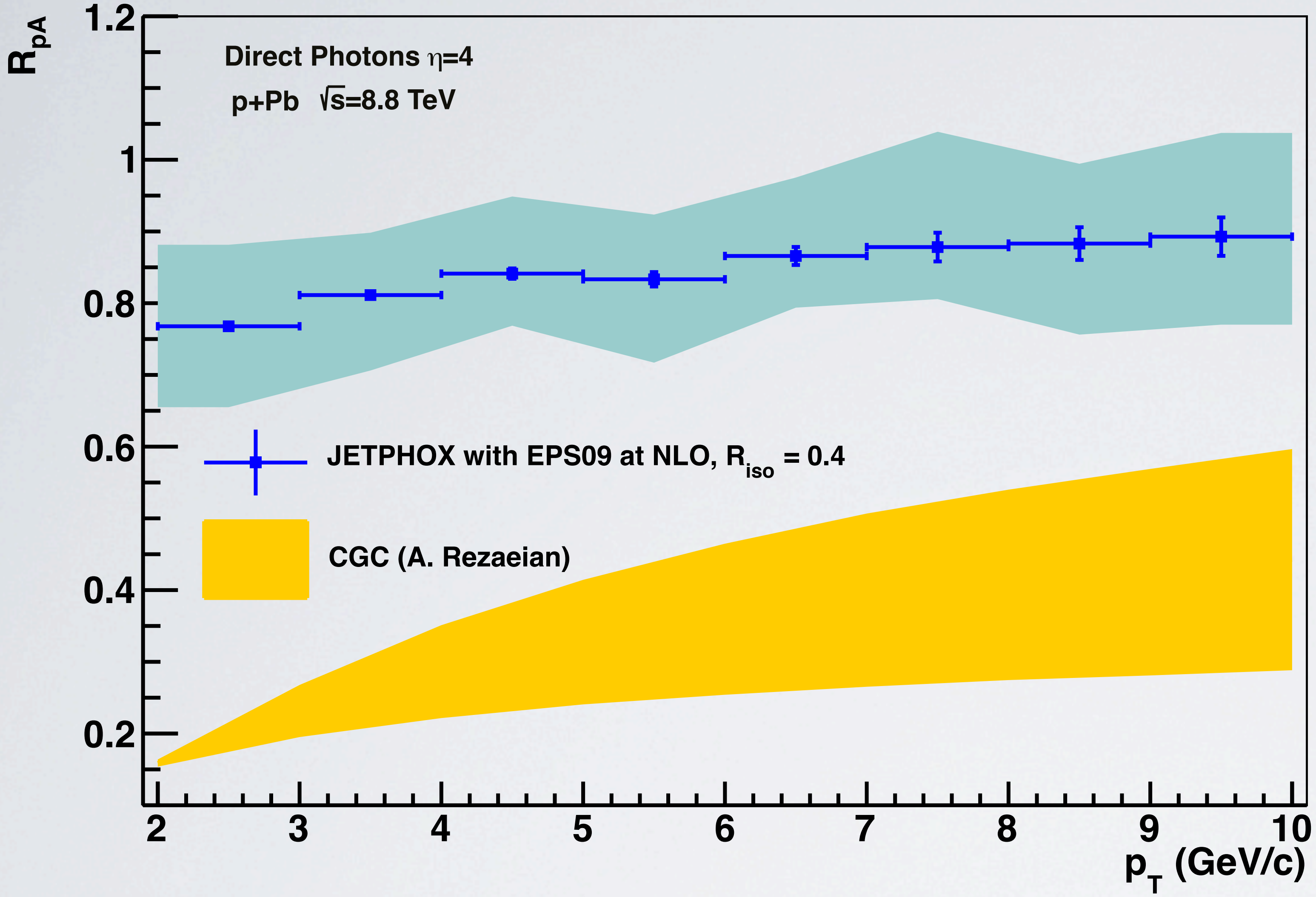




- still reasonable x-sensitivity at NLO
  - significant contribution from fragmentation
- isolation cuts effective to suppress fragmentation
- can obtain very good x-sensitivity
  - maximum at $x < 10^{-4}$
  - continue to optimize isolation cuts, rapidity windows

Helenius, Paukkunen, Eskola
work in progress

nPDF/DGLAP vs CGC

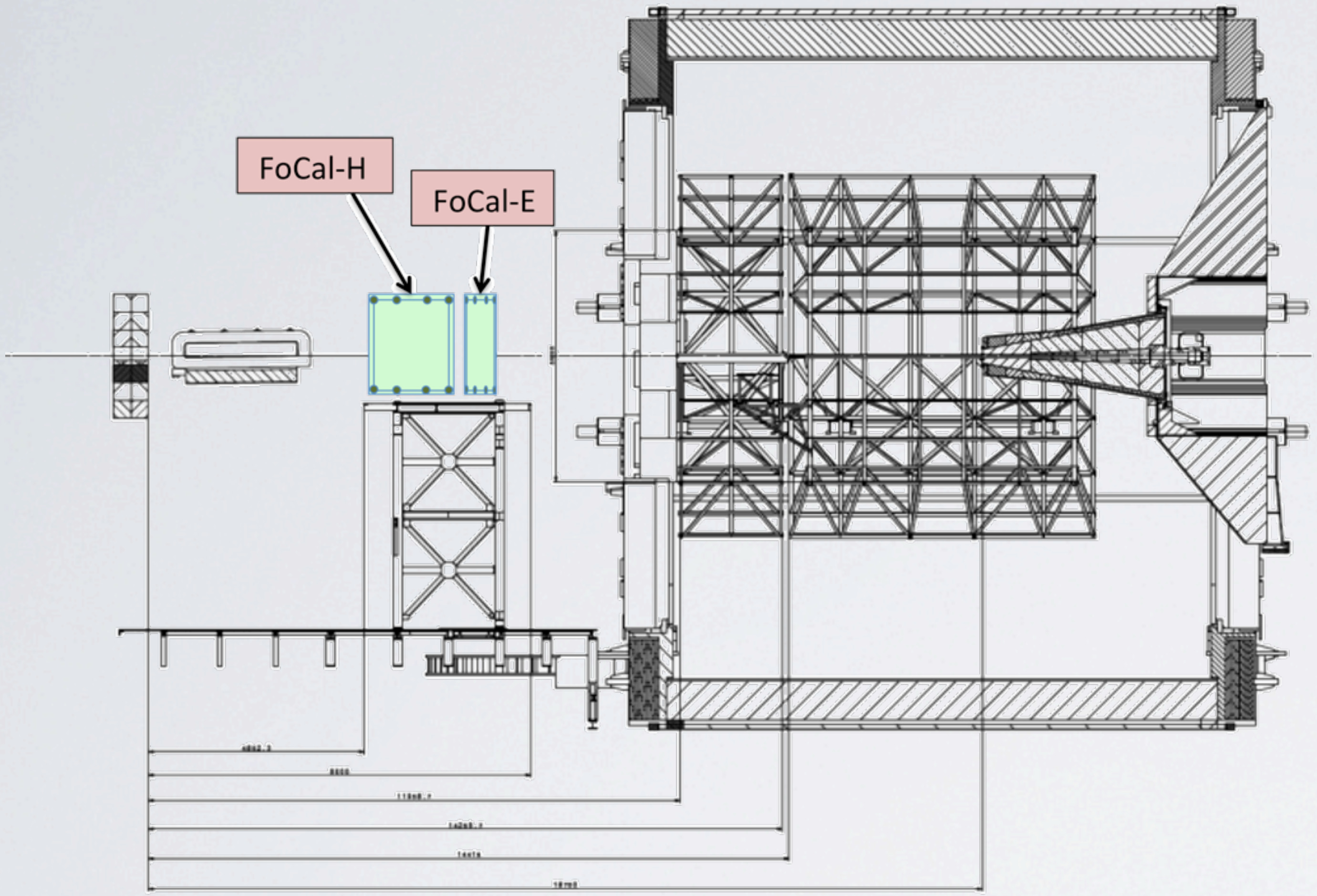


two scenarios for forward γ production in p+A at LHC:

- normal nuclear effects
  linear evolution, shadowing
- saturation/CGC
  running coupling BK evolution

- strong suppression in direct γ RpA
- signals expected at forward η, low-intermediate p_T
  - transition expected - where?

FoCal in ALICE



electromagnetic calorimeter for γ and π^0 measurement

two scenarios:

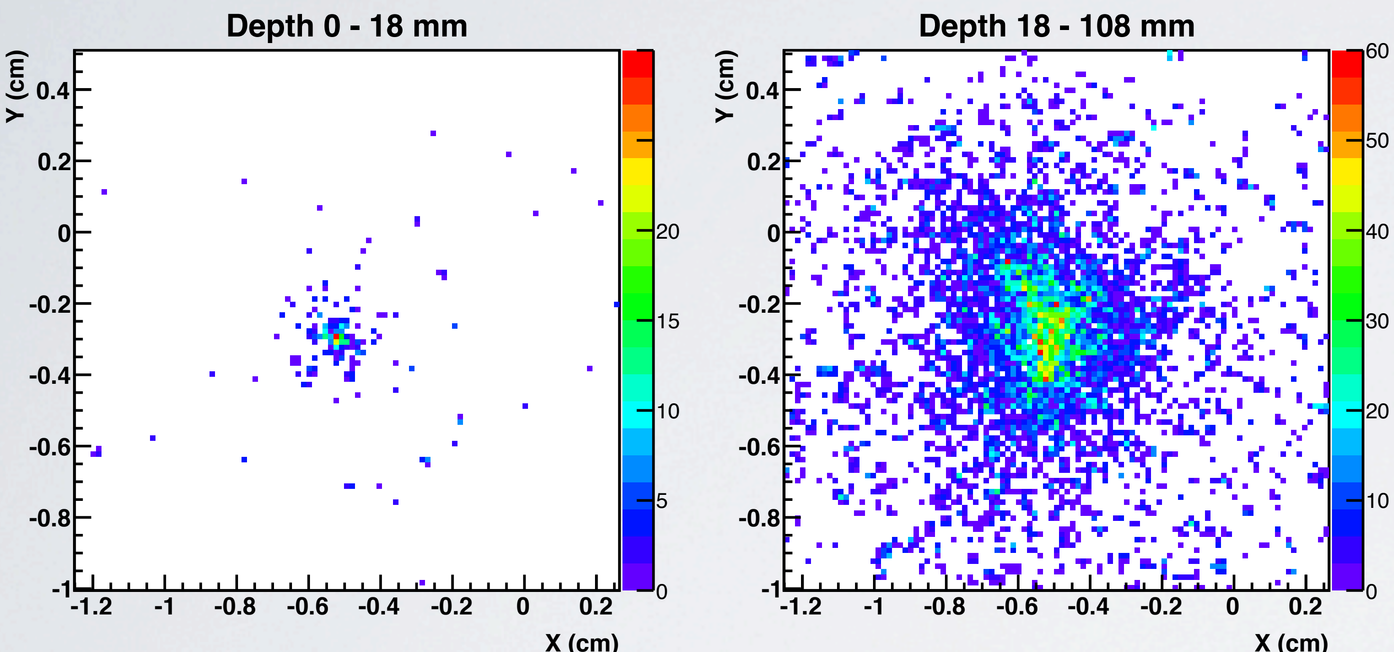
- at $z \approx 8$m (outside magnet)
  $3.3 < \eta < 5.3$
  (space to add hadr. calorimeter)
- possible also at $z \approx 3.6$m
  (not preferred)
  $2.5 < \eta < 4.5$

- main challenge: separate γ/π^0 at high energy
- need small Molière radius, high-granularity read-out
  - Si-W calorimeter, granularity ≈ 1mm^2

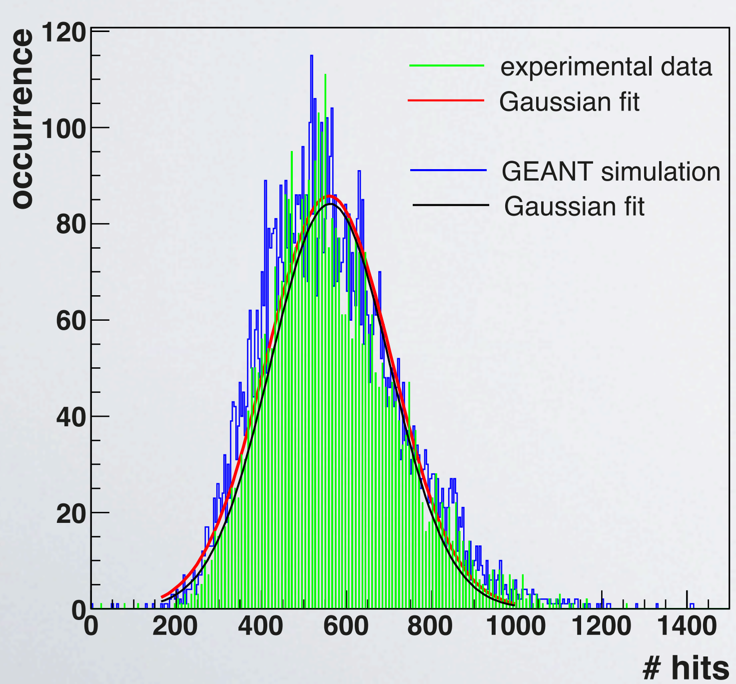
FoCal R&D

high granularity (Utrecht/Nikhef, Bergen): full MAPS prototype

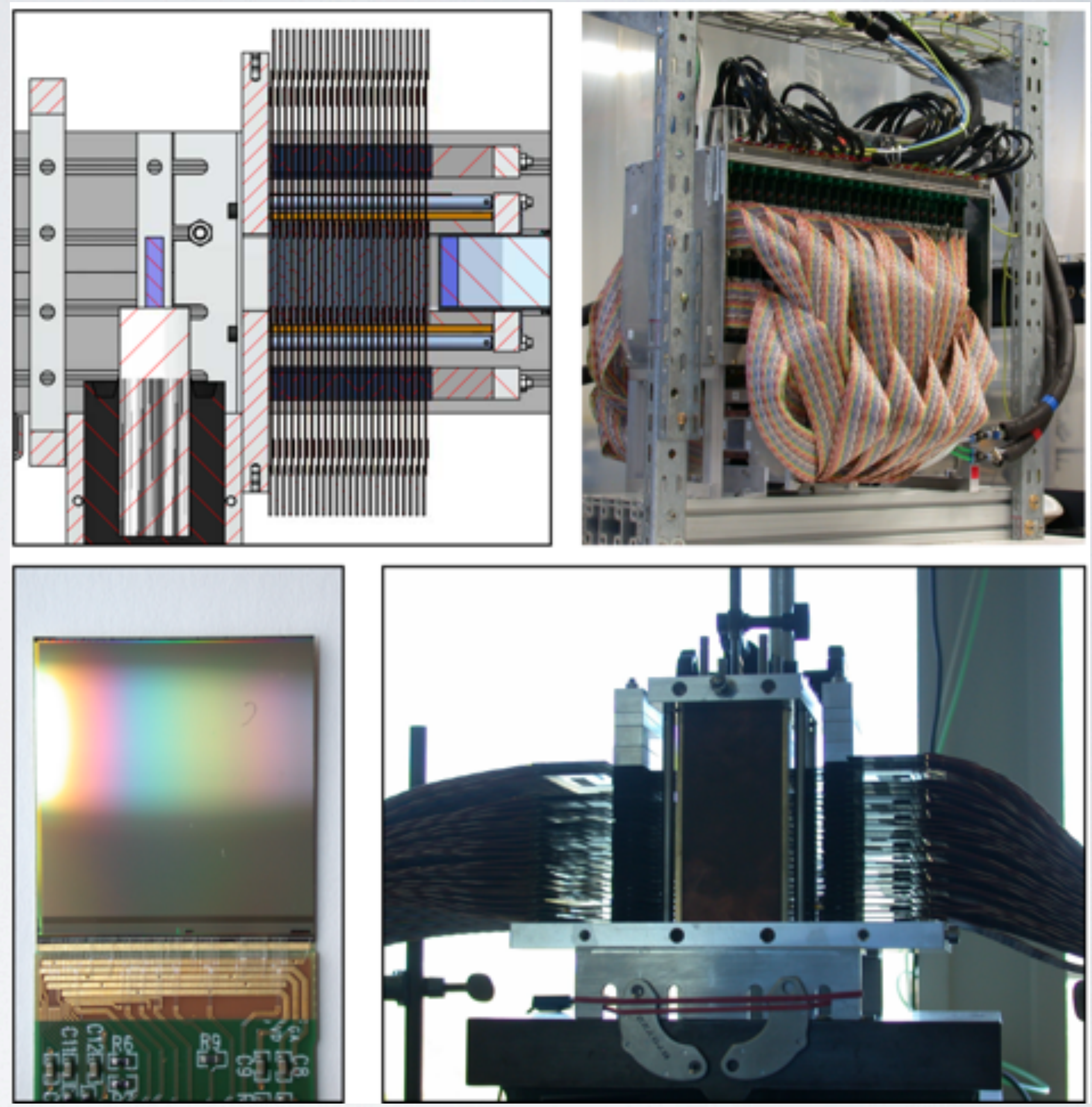
- R_M = 11 mm
- 39 M pixels in 4x4x10 cm^3 !



single electron (200 GeV)

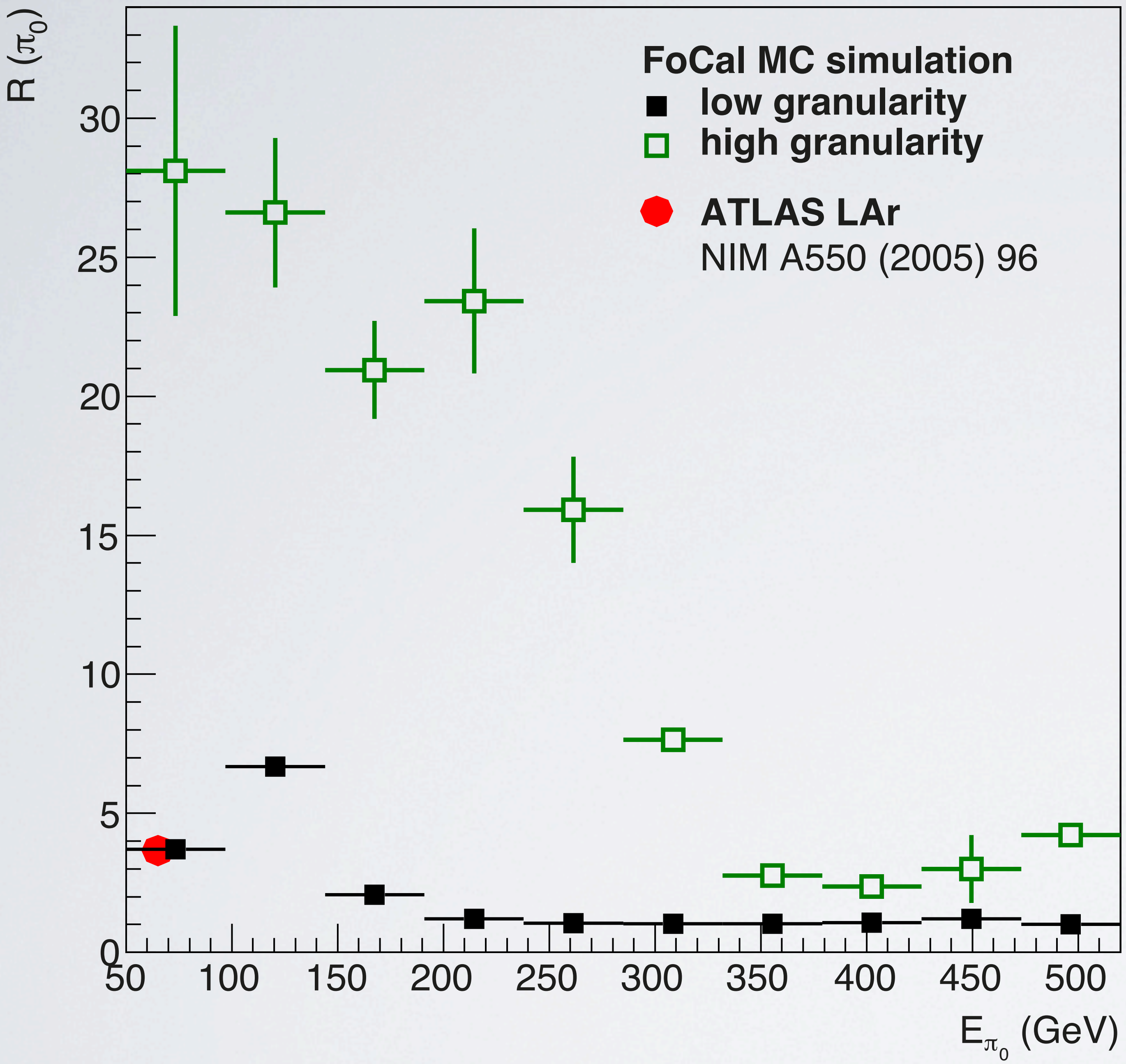


single layer resolution (30 GeV electron) agrees with MC simulation



other R&D with prototypes ongoing at Tokyo, ORNL, Tsukuba, Kolkata, ...

Pion Rejection

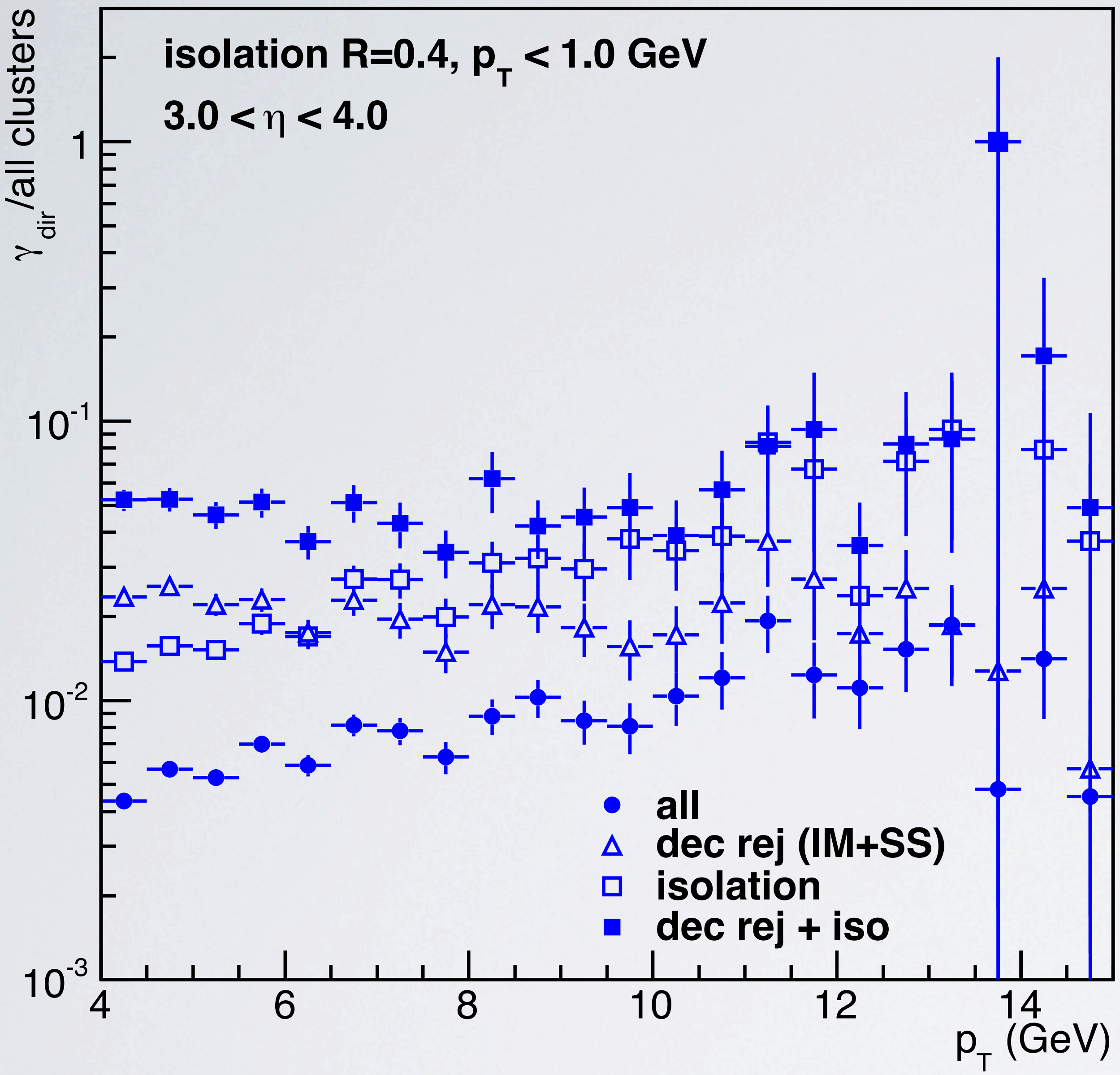


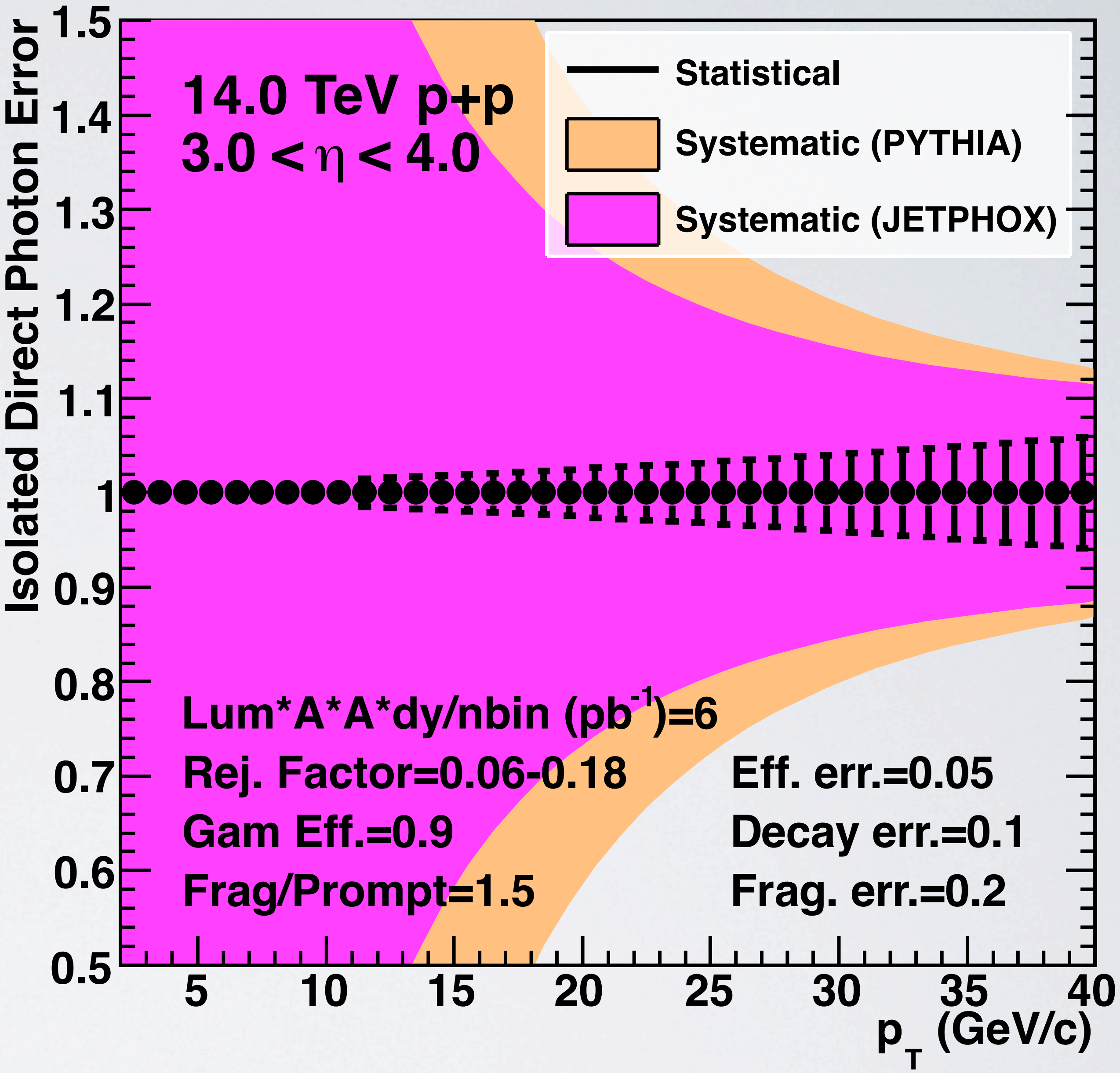
π^0 rejection factor from two-shower separation and shower shape analysis

compare “conventional”, i.e. low-granularity, and high-granularity calorimeters

- high-granularity is key for efficient pion rejection in addition to isolation

Low Granularity Measurement



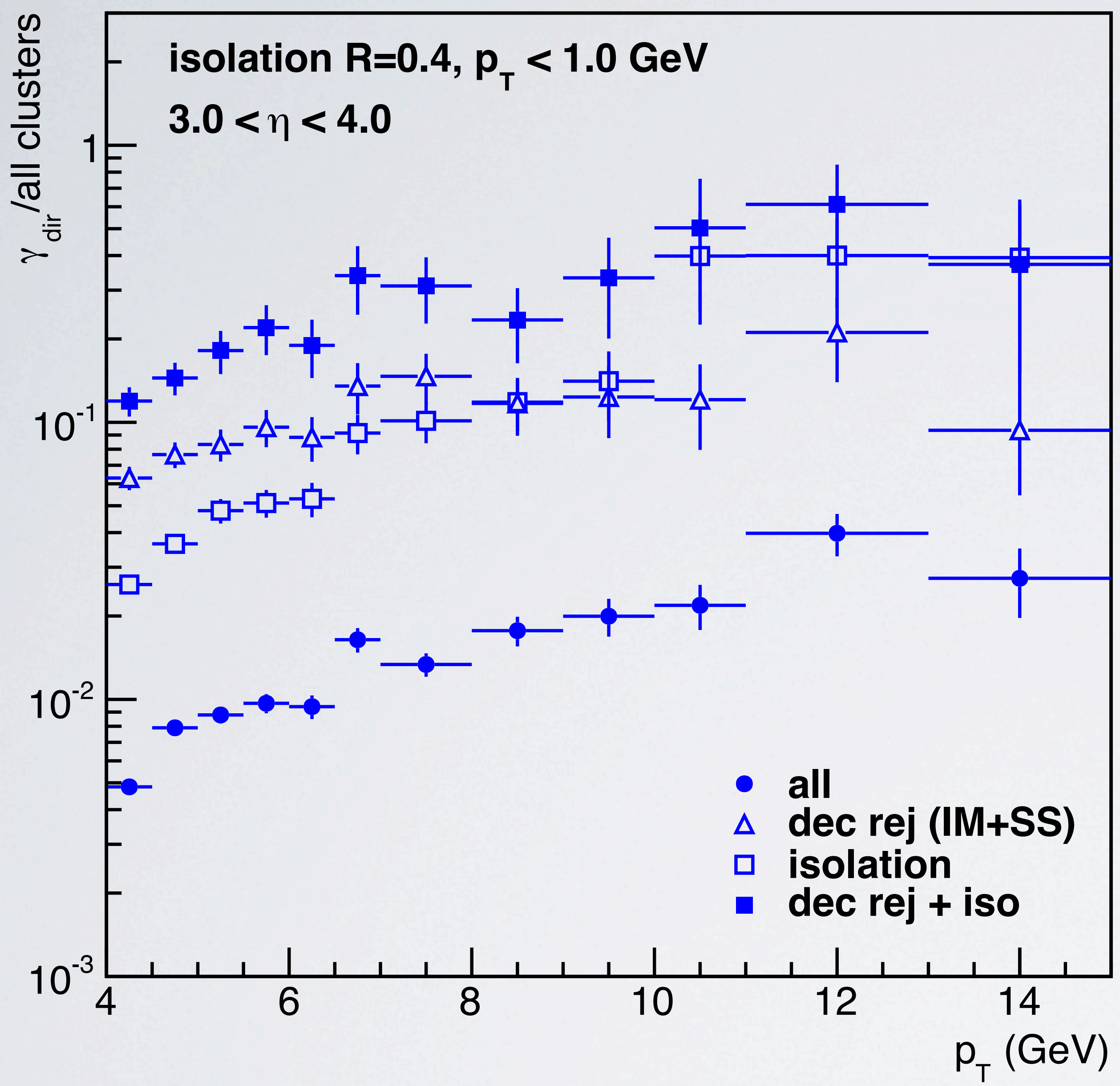


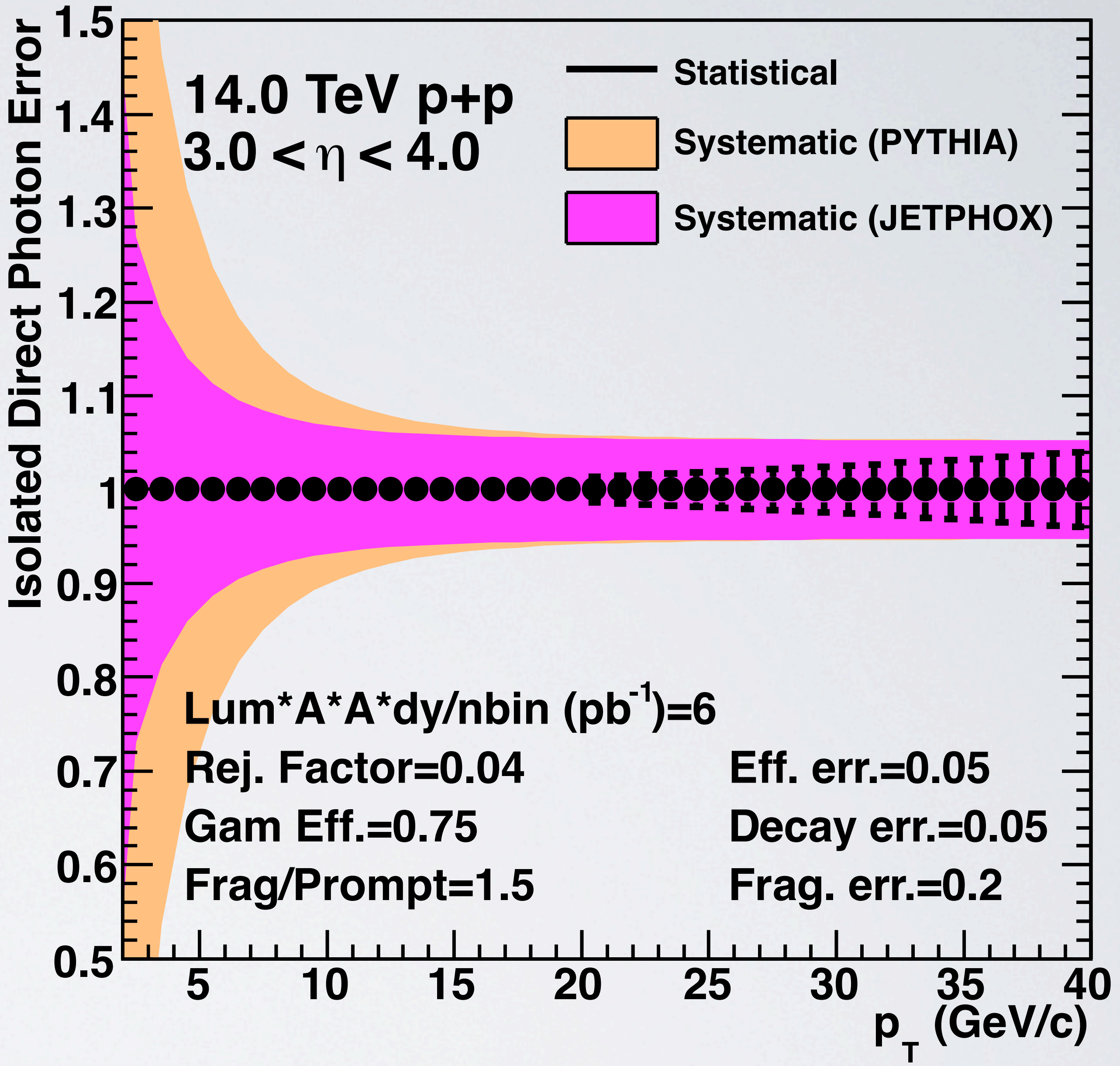
- low granularity ($1 cm^2$) does not allow efficient decay rejection
- direct photon/all ≈ 0.05 for all p_T

significant measurement not possible at low p_T

NB: conditions similar to LHCb

Direct γ Performance in pp

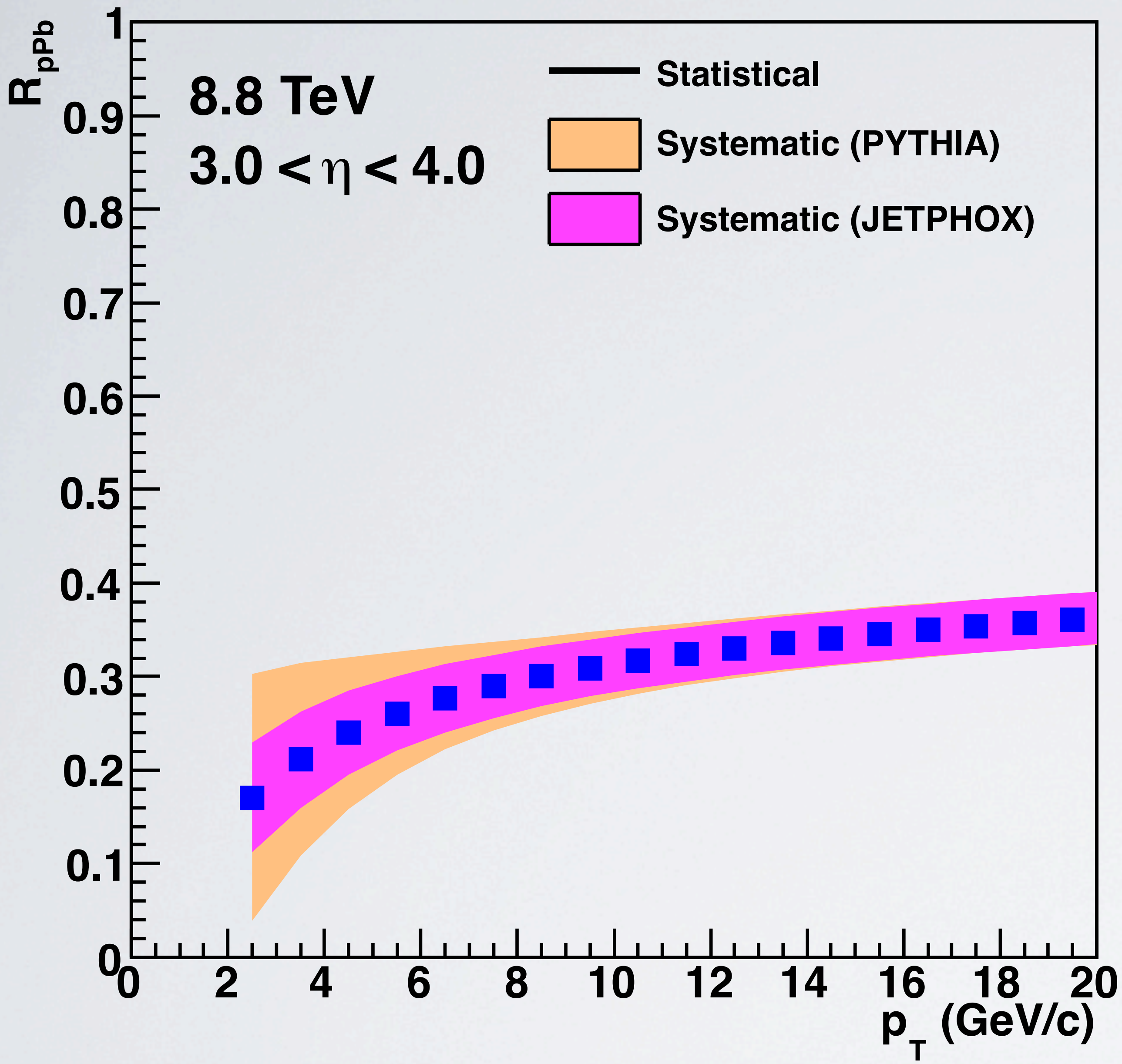


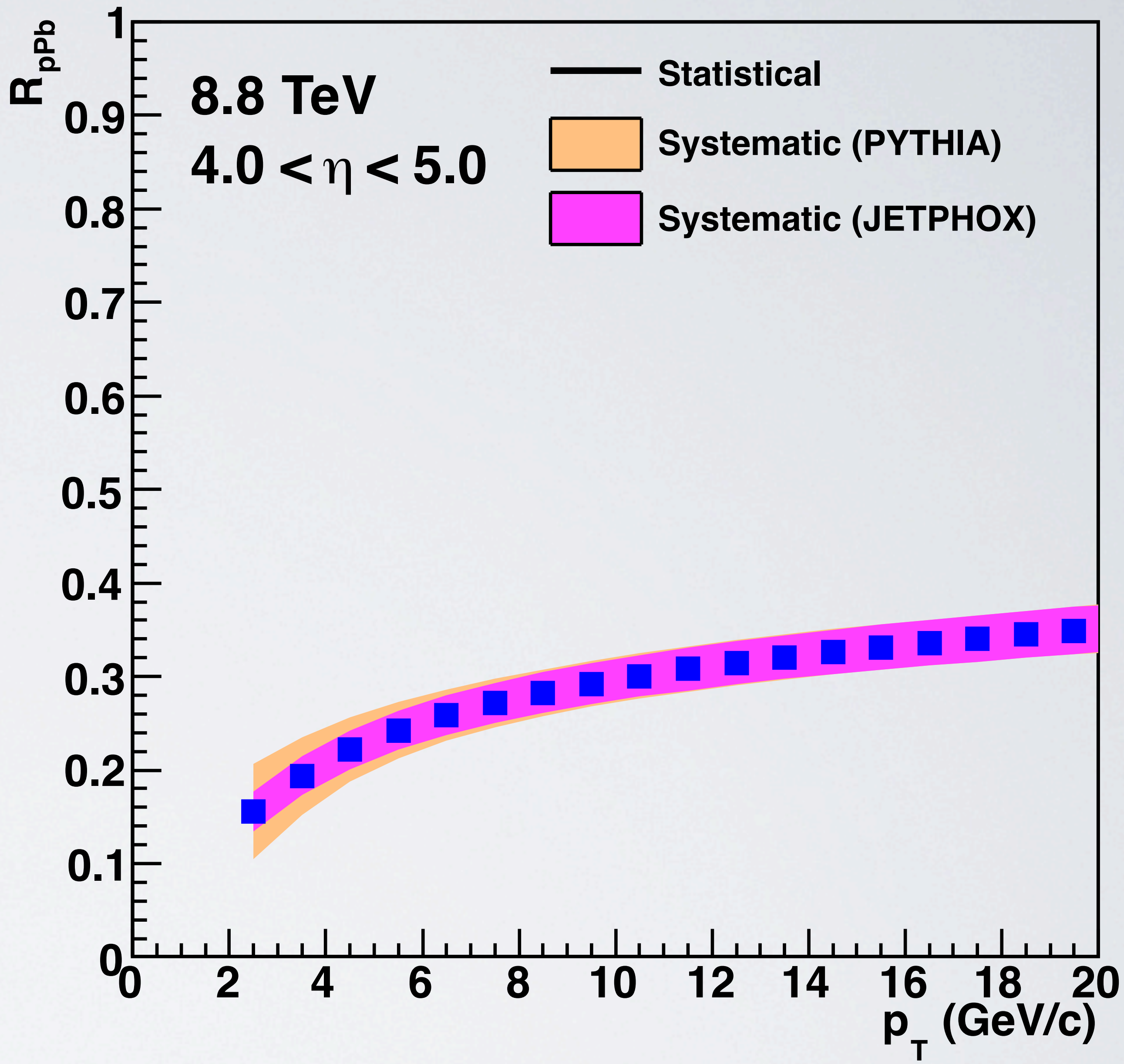


direct photon/all > 0.1
for p_T > 4 GeV/c

20-40% uncertainty
at p_T = 4 GeV/c
decreases with increasing p_T

Performance on R_{pPb}





- expect significant constraint on direct photon R_{pPb}
  - confirm or refute CGC effects, constrain nPDF

Running Scenario

- FoCal installation in LS3 (≈2024), measurements together with full ALICE setup
- participation in Pb–Pb runs
  - luminosity: 7×10^{27} $cm^{-2}s^{-1}$, max event rate 50 kHz
- p–Pb run (e.g. 2026)
  - luminosity: 10^{29} $cm^{-2}s^{-1}$, max event rate 200 kHz
  - int. luminosity: 50 nb^{-1}
- pp reference run, preferably same $\sqrt{s}$ as p–Pb (?)
  - luminosity: 3×10^{30} $cm^{-2}s^{-1}$, max event rate 200 kHz
  - int. luminosity: ≈6 pb^{-1}

FoCal Physics Program

- p-Pb: saturation/CGC effects
  - forward direct γ spectra, γ-hadron/jet correlations (unique!)
  - π^0 spectra, π^0-π^0 correlations, jets (had. calorimeter!)
- p+p: reference measurements
  - constraints on PDFs?
  - diffraction (jets with rapidity gap)
- Pb-Pb: QGP studies
  - extend acceptance for γ-hadron/jet, π^0-π^0 correlations
  - π^0 R_{AA} forward
    - longitudinal density profile, compare to forward J/ψ
  - event plane determination, ...

Conclusions

- forward isolated direct photons at LHC are unique signal for low-x gluons and saturation
- not possible with existing detectors
  - need high granularity calorimeter for installation in LS3: FoCal proposal in ALICE
- p–Pb and (dedicated, low luminosity) pp running after LS3
- potential of new detector for diffraction under investigation
- rich additional physics program in Pb–Pb