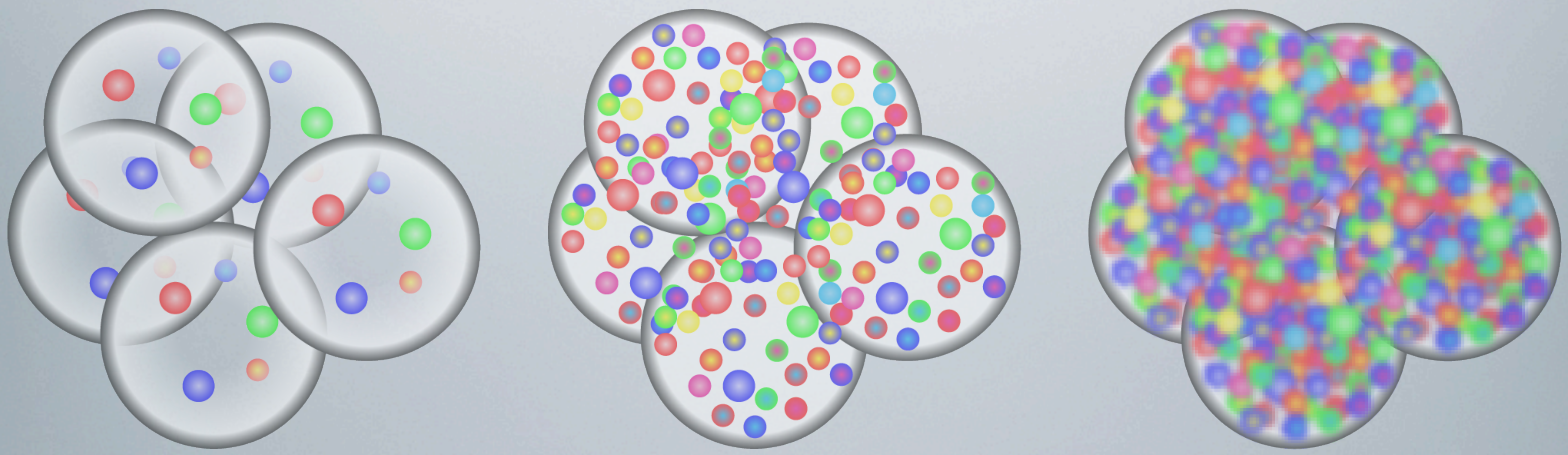


Forward Physics and the FoCal project in ALICE

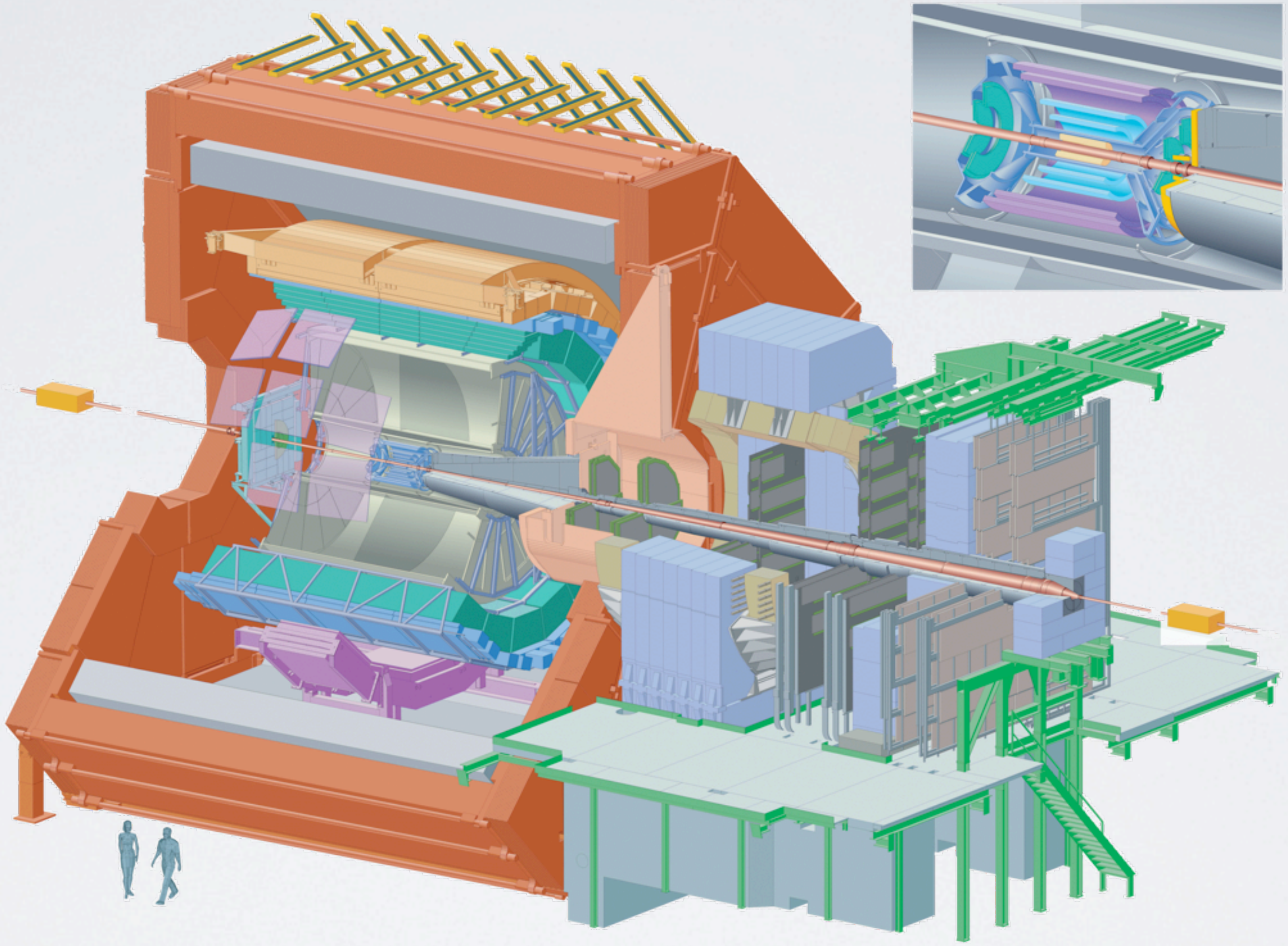
T. Peitzmann (Utrecht University/Nikhef)

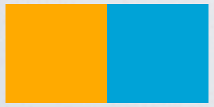
ALICE

Outline

- ALICE FoCal detector
- Physics motivation: forward photon measurements

ALICE Detector Upgrades




approved by LHCC

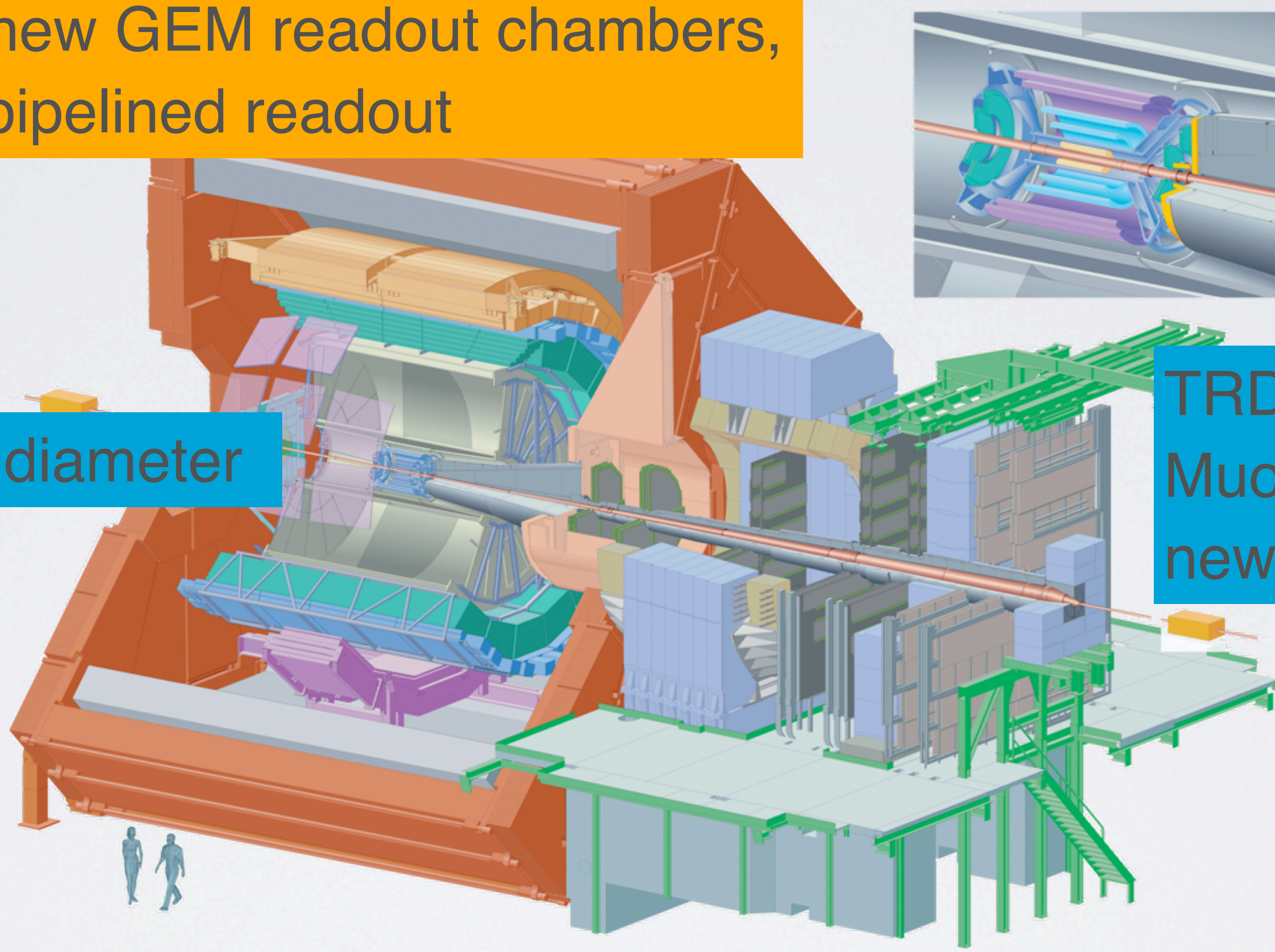

under internal review

ALICE Detector Upgrades

EMCal: extension by DCAL (LS1)

new ITS: high resolution,
low material budget

TPC: new GEM readout chambers,
pipelined readout



new beam pipe: smaller diameter

TRD, TOF, PHOS, EMCal,
Muon spectrometer:
new readout electronics

Upgrade of forward/
trigger detectors
(ZDC, VZERO, T0)

MFT project

approved by LHCC

under internal review

ALICE Detector Upgrades

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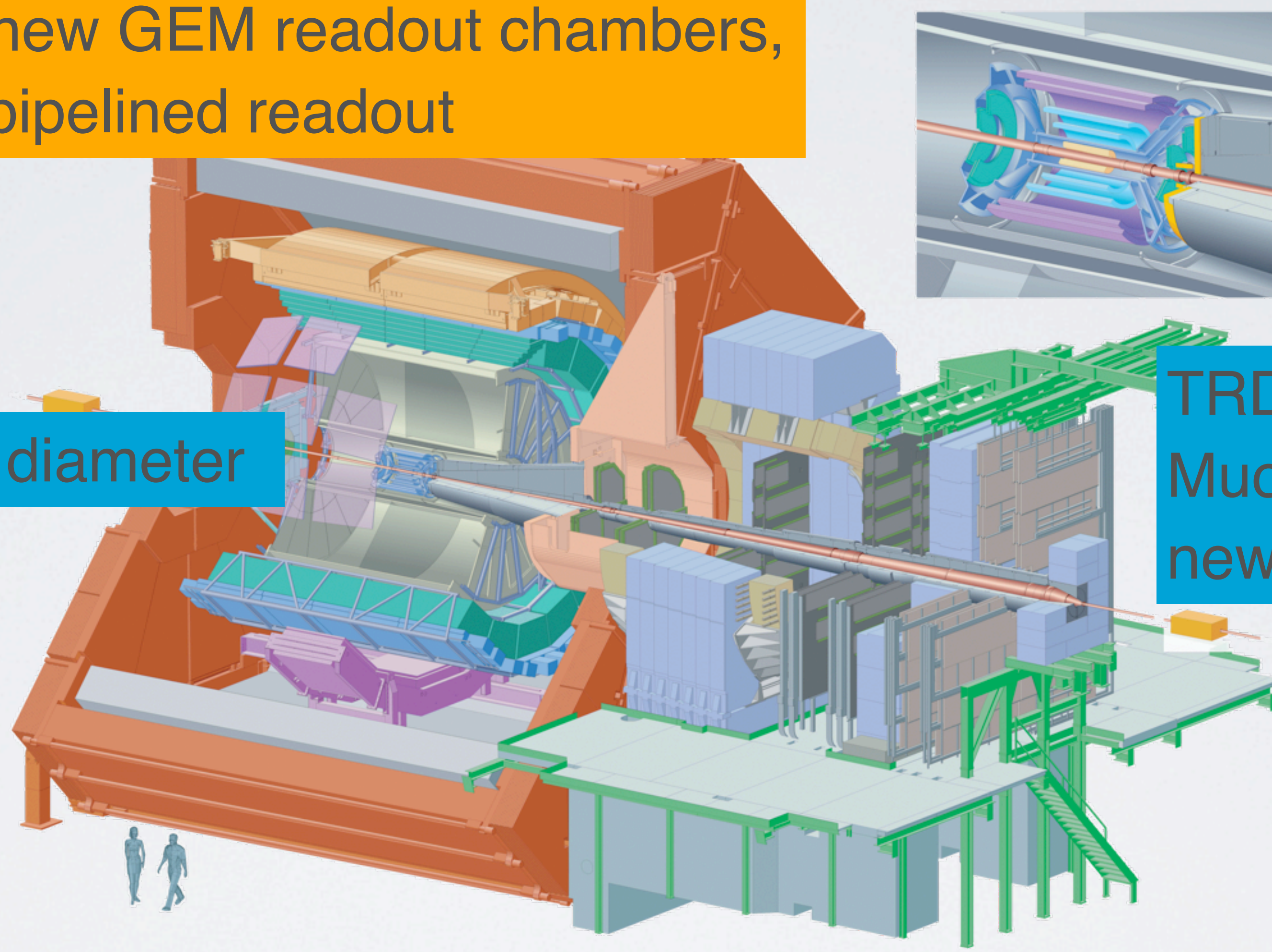
FoCal project



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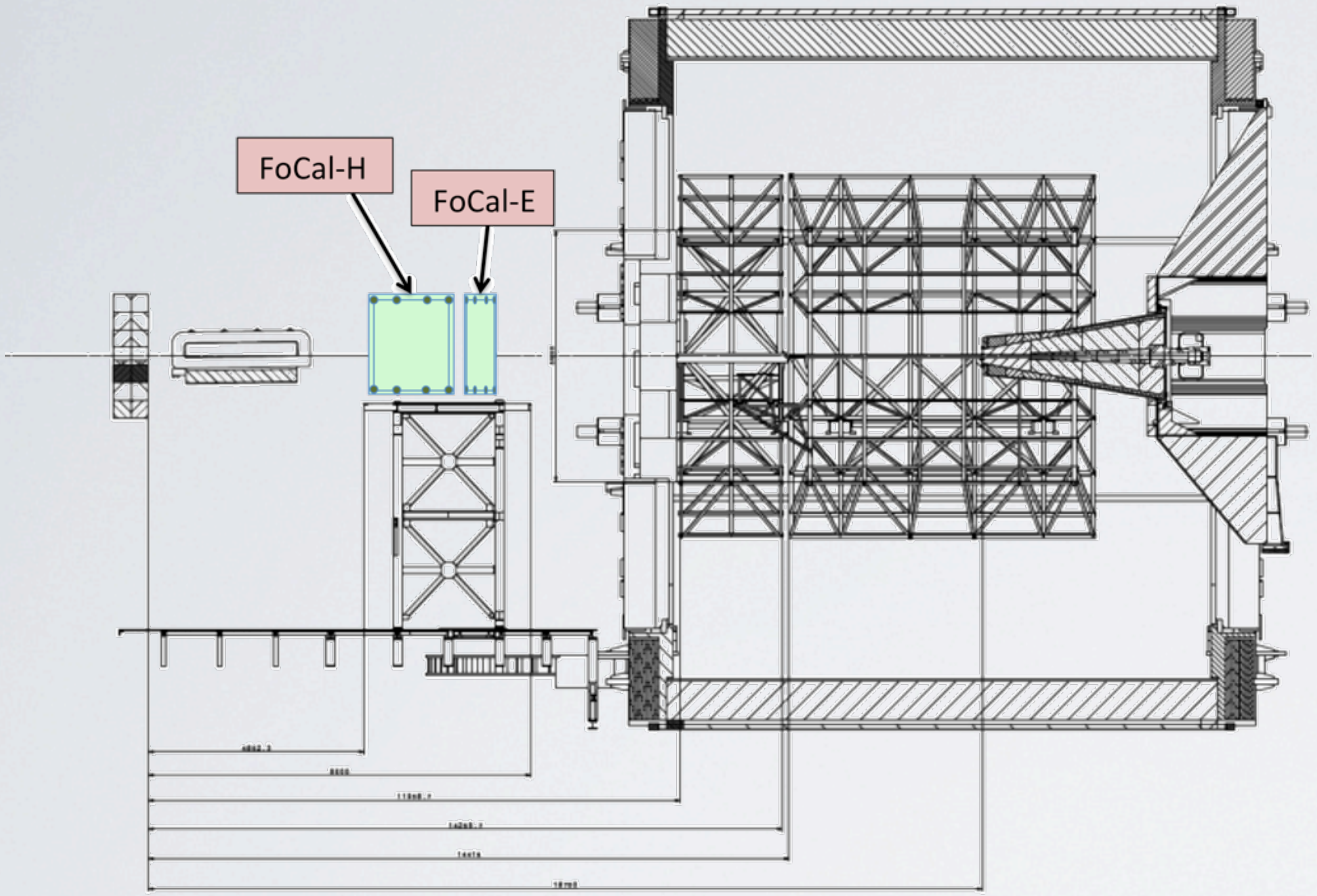
FoCal in ALICE

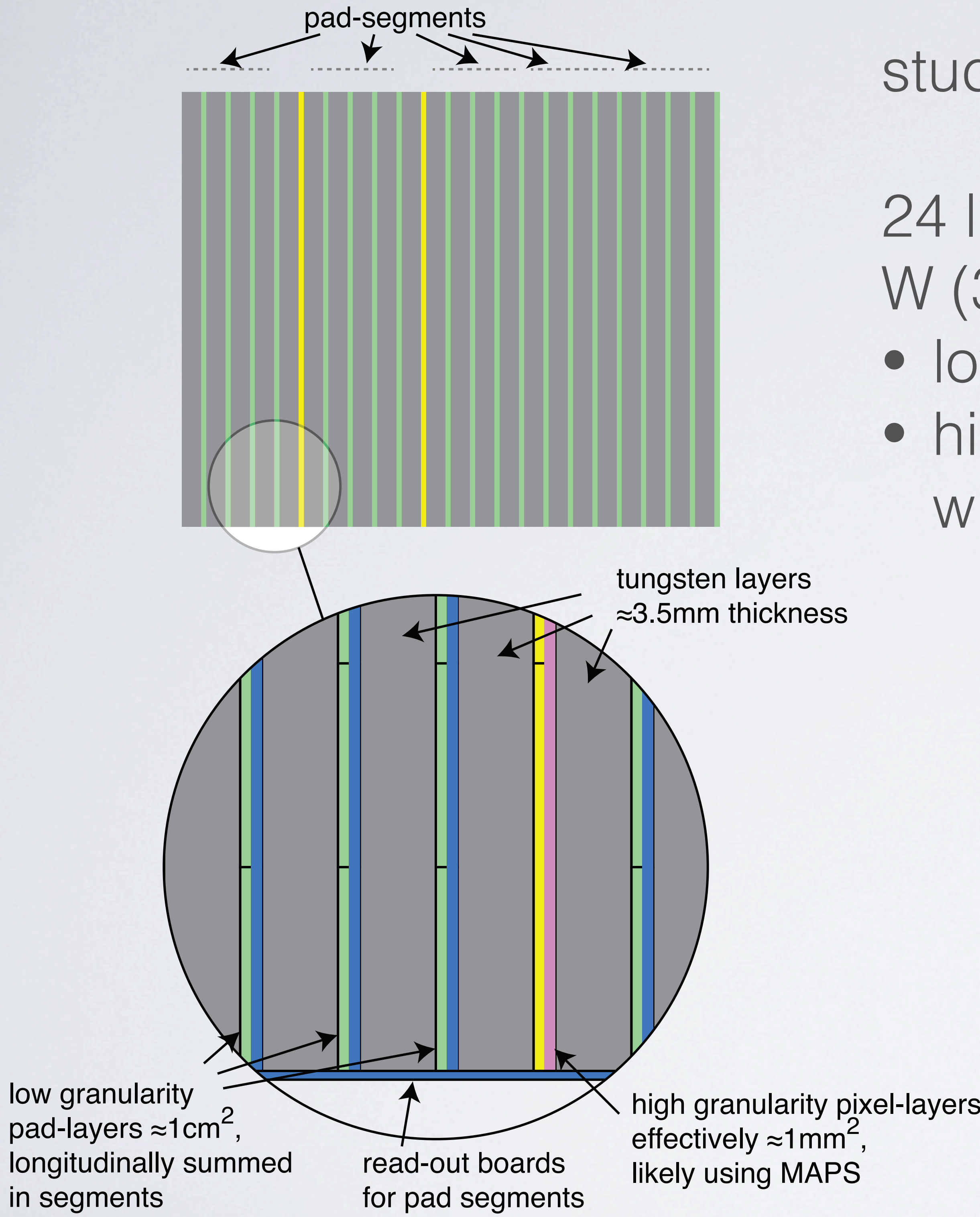


electromagnetic calorimeter for γ and π^0 measurement
+ **hadronic calorimeter** for isolation and jet measurement

baseline scenario:
at $z \approx 7$m (outside magnet)
$3.3 < \eta < 5.3$

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

Strawman Design

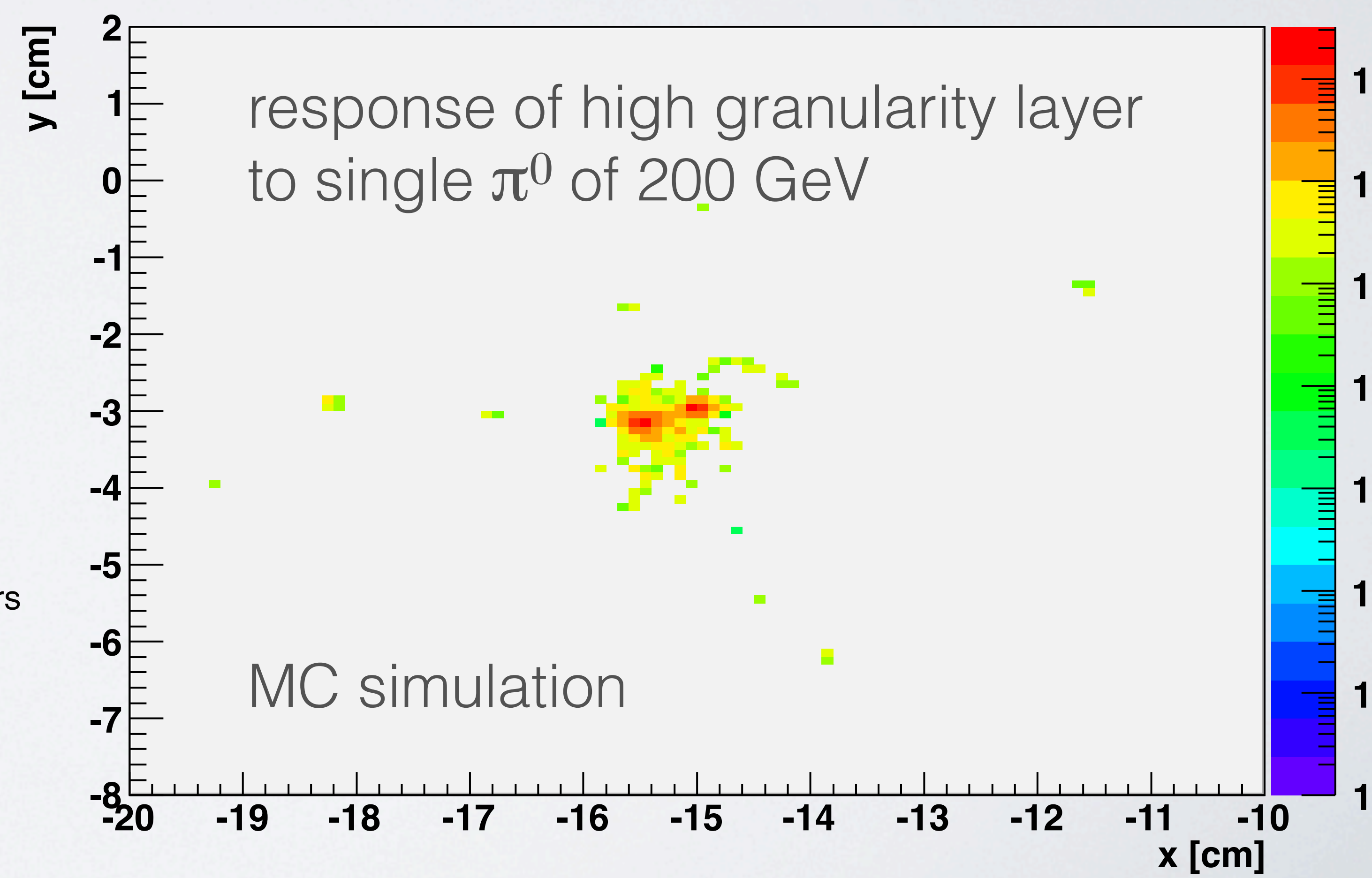


studied in performance simulations:

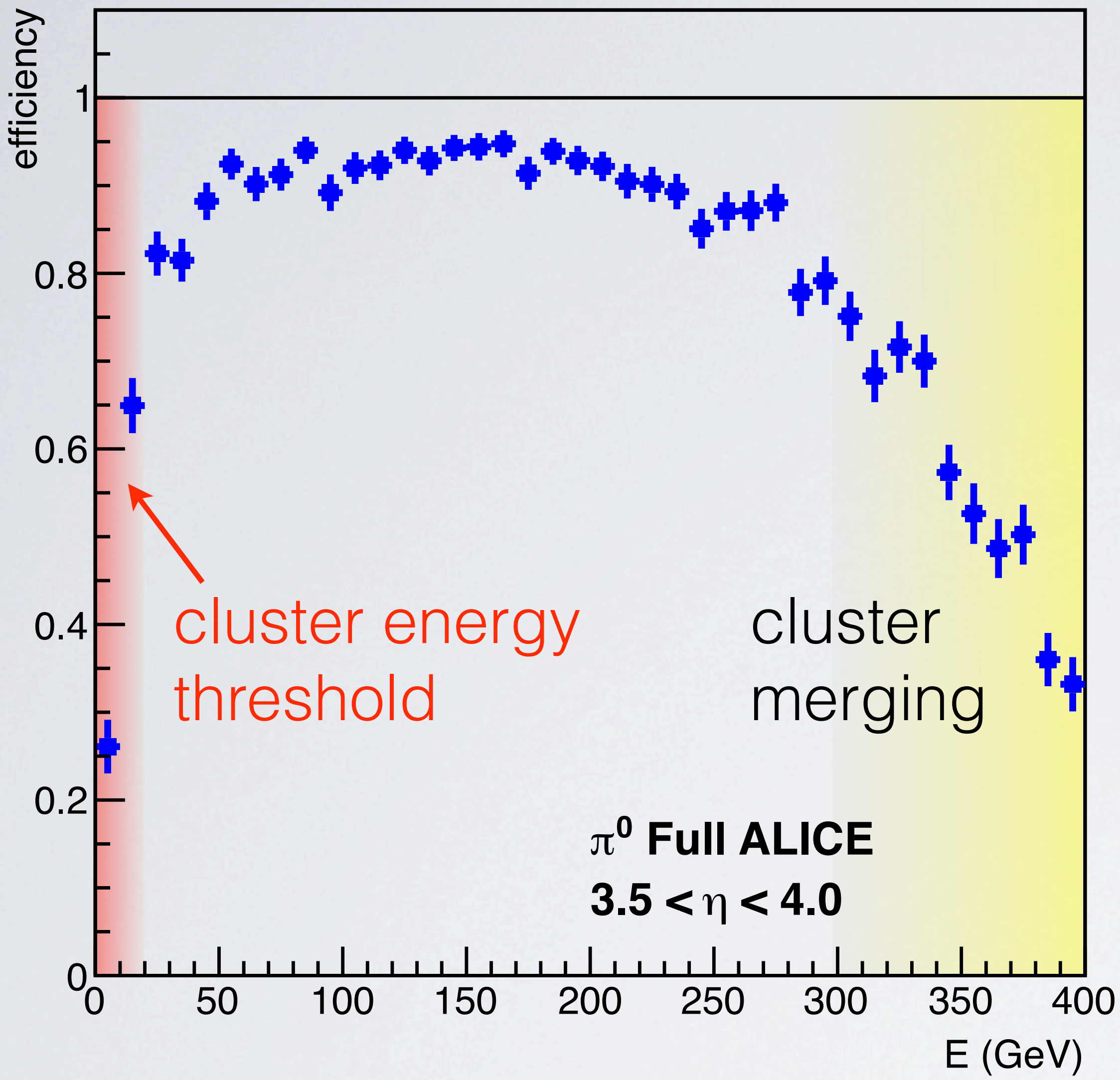
24 layers:

W (3.5mm ≈ 1 X_0) + Si-sensors (2 types)

- low granularity (LGL, ≈ 1 cm^2), Si-pads
- high granularity (HGL, ≈ 1 mm^2), obtained with pixels (e.g. CMOS-MAPS)

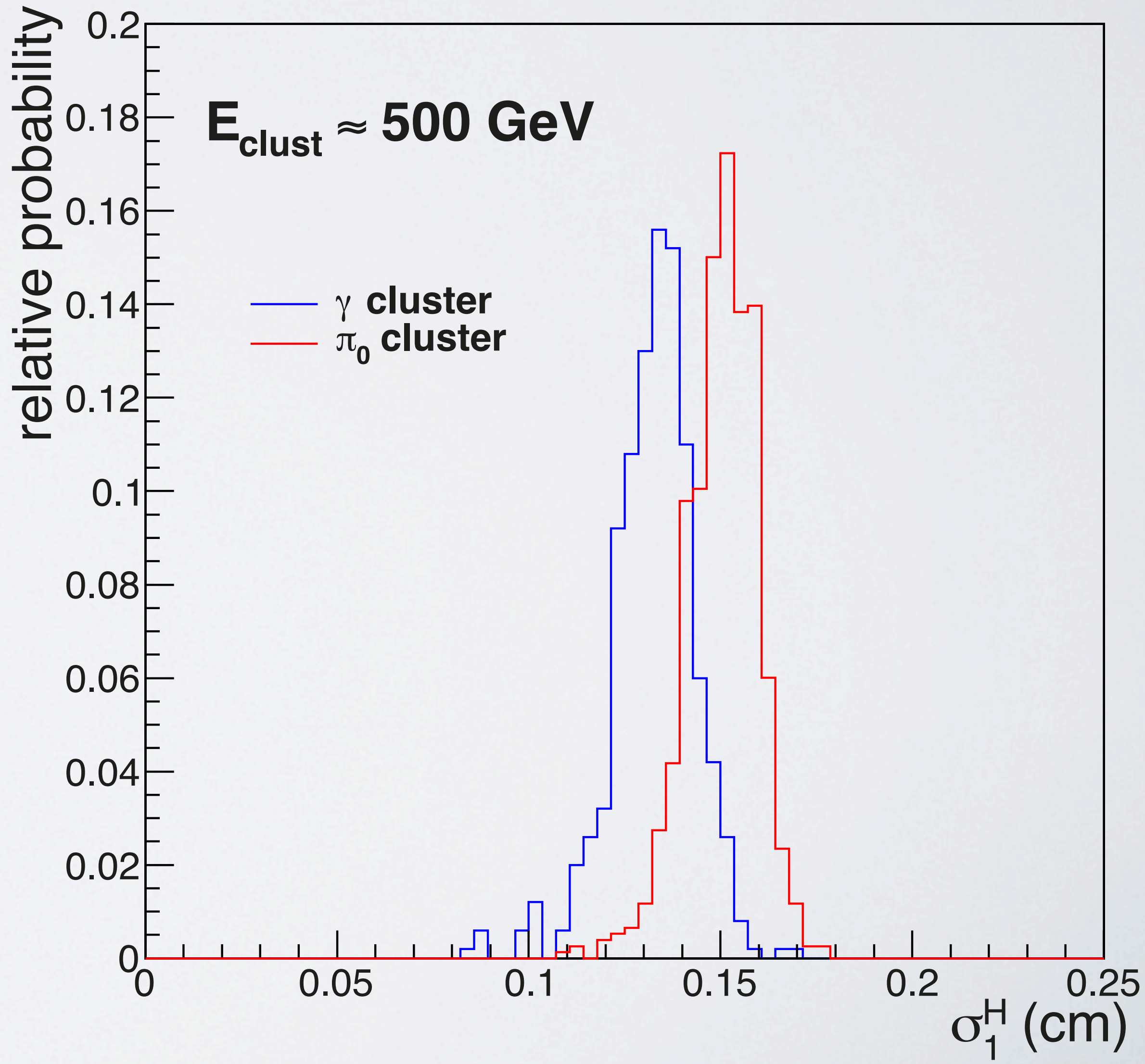


π^0 Efficiency



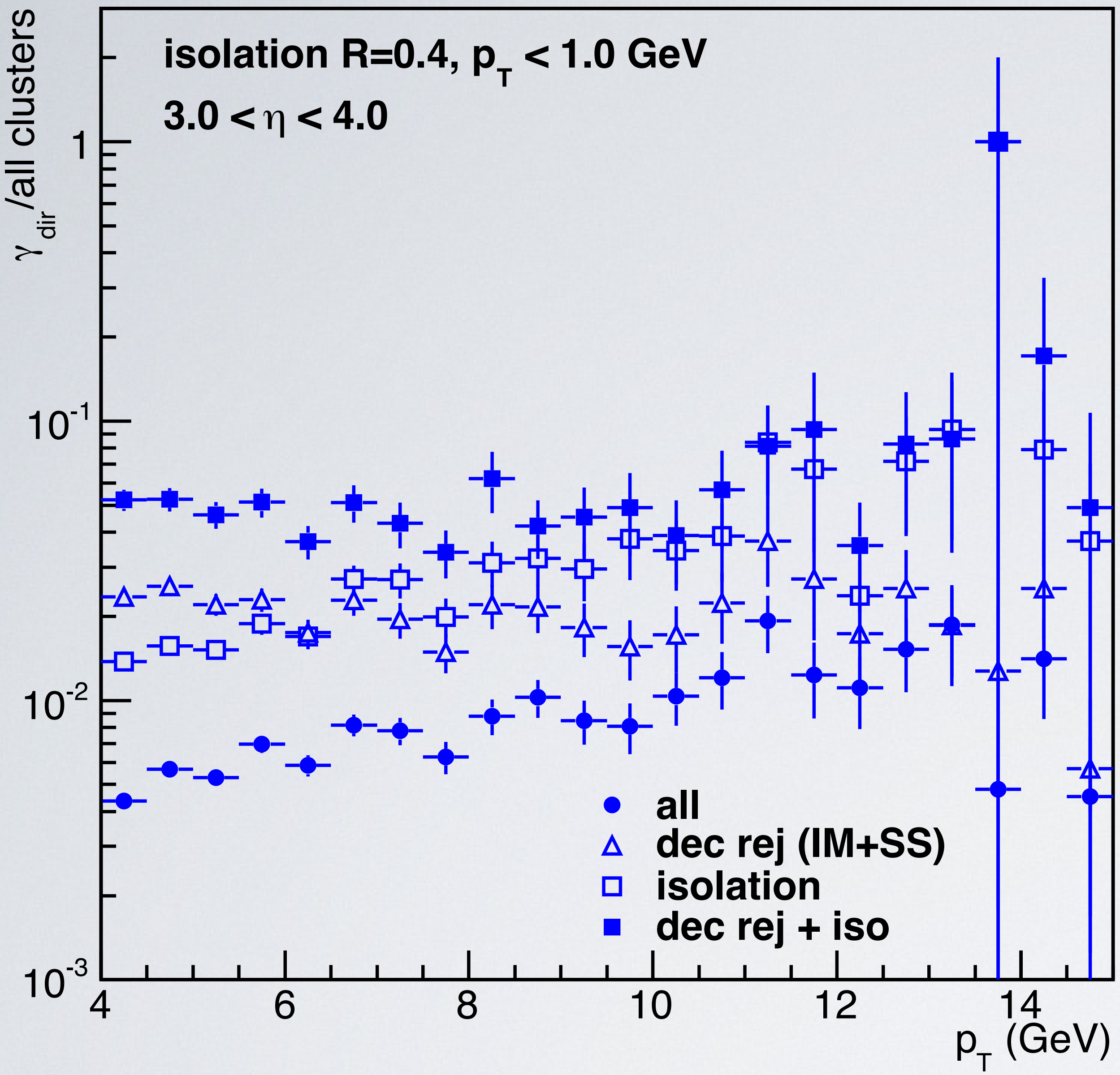
single particle simulation in full ALICE setup, good efficiency up to E ≈ 300 GeV (p_T ≈ 10 GeV/c)

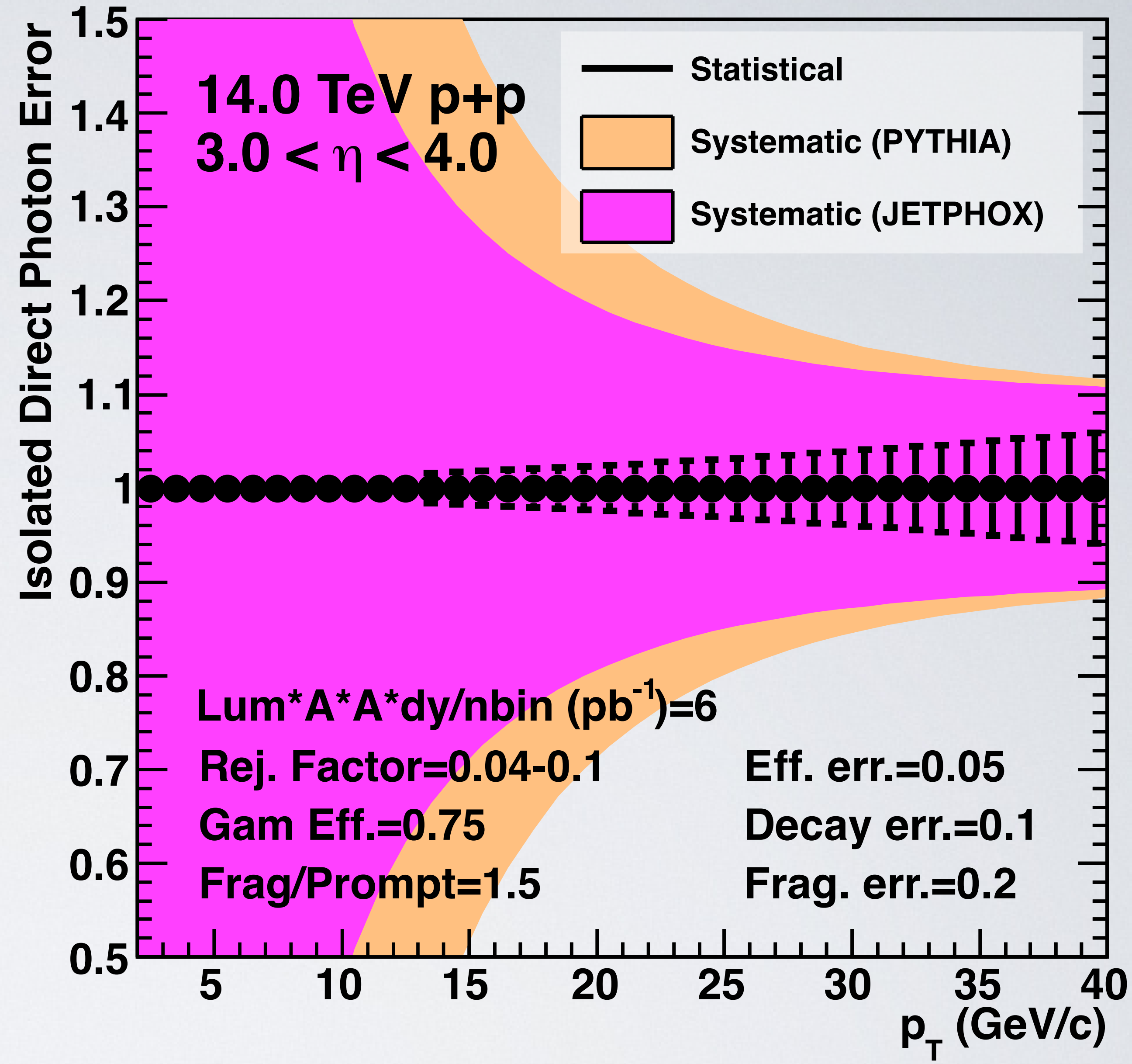
can still be improved by shower shape analysis in HGL



expect good discrimination from HGL info up to E ≈ 500 GeV

Direct γ - Low Granularity



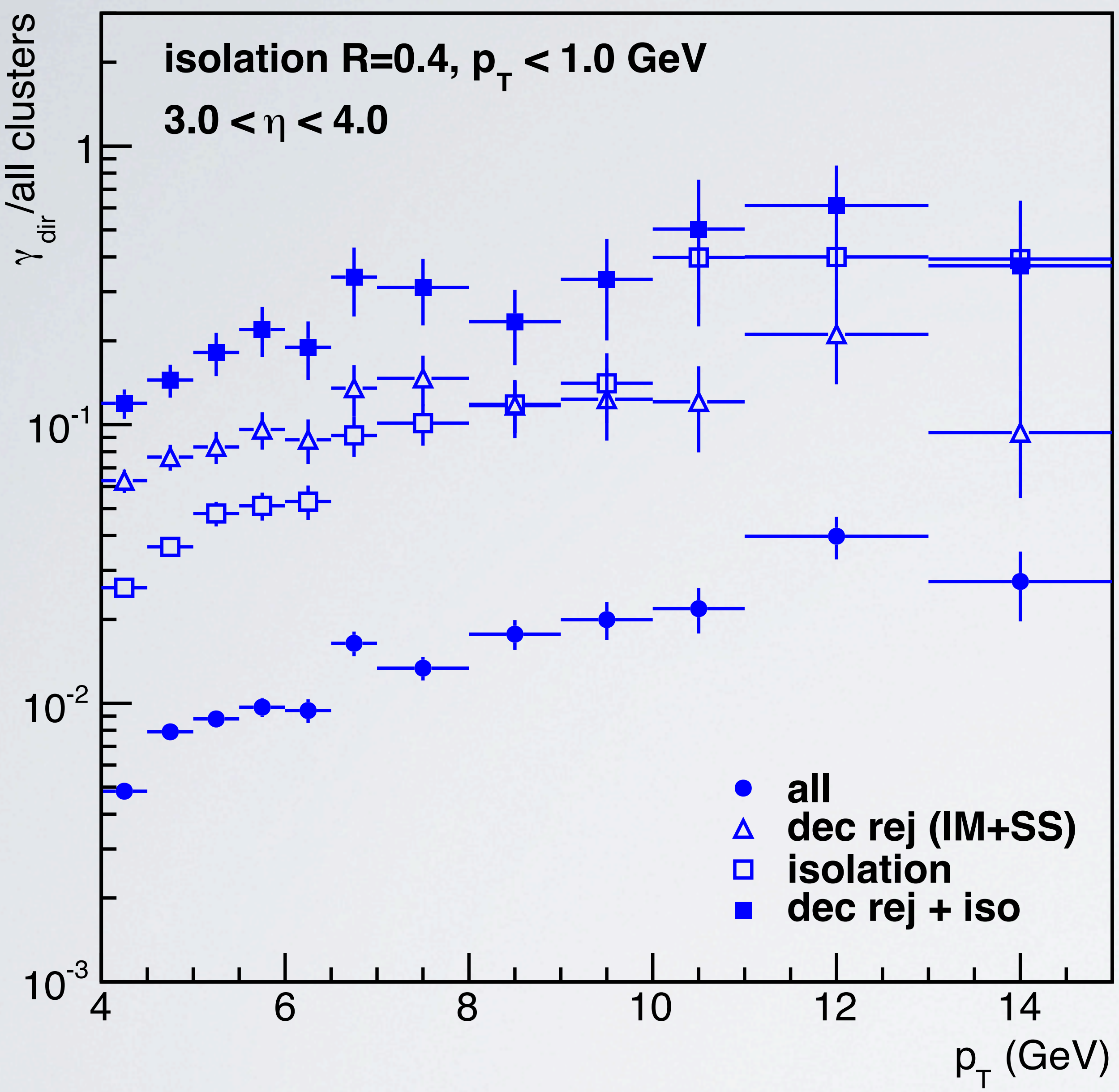


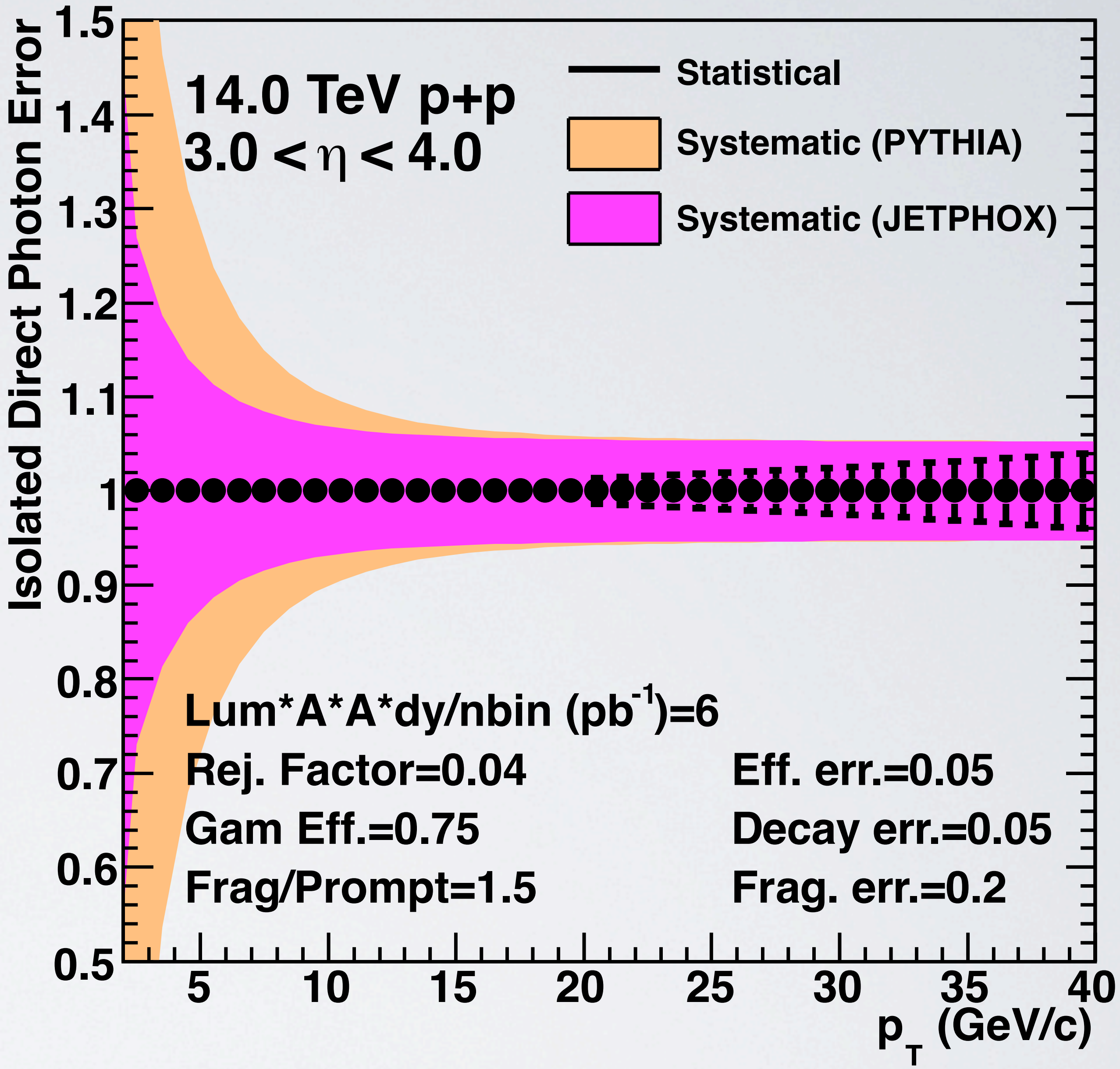
- low granularity ($1cm^2$) does not allow efficient decay rejection
- direct photon/all ≈ 0.05 for all p_T

significant measurement not possible at low p_T

NB: conditions similar to LHCb

Direct γ - High Granularity



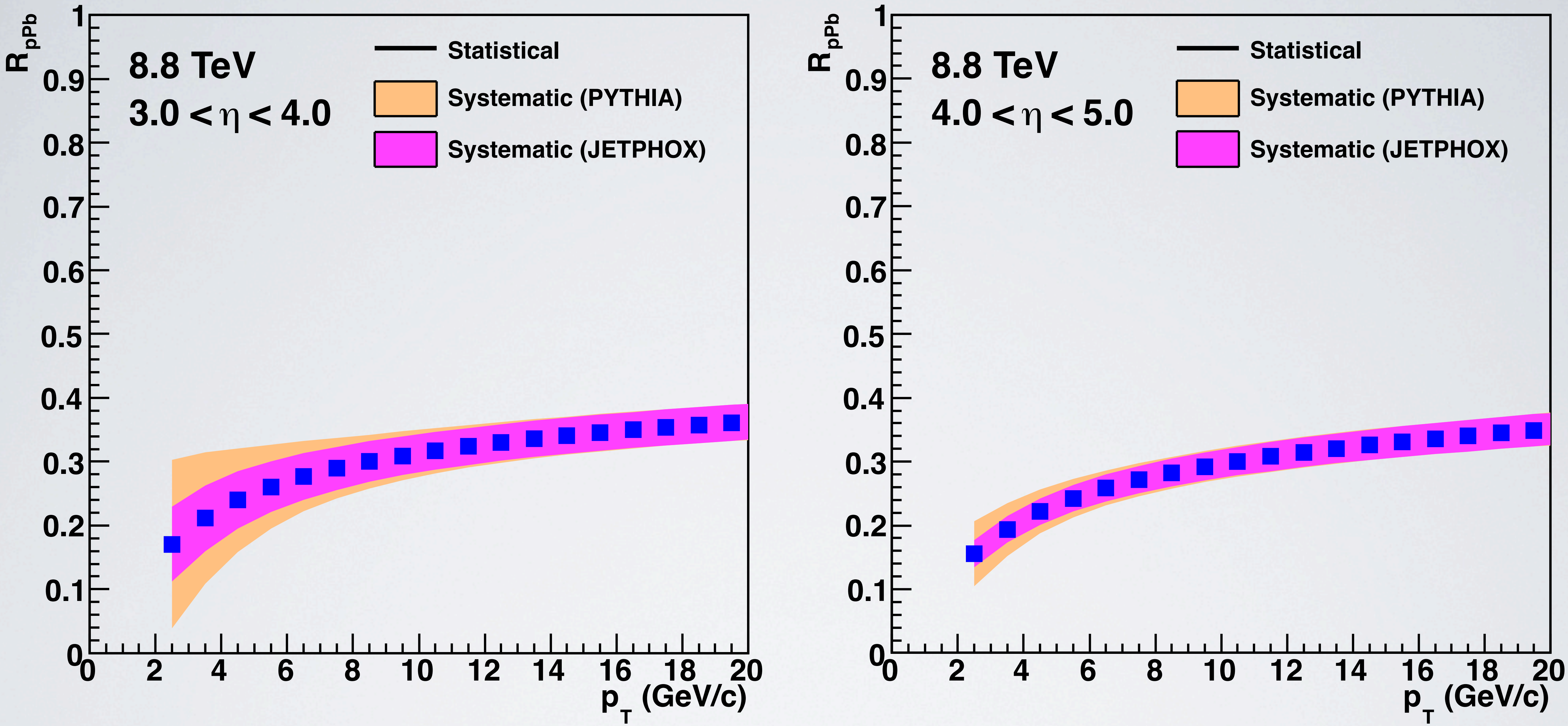


direct photon/all > 0.1
for p_T > 4 GeV/c

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

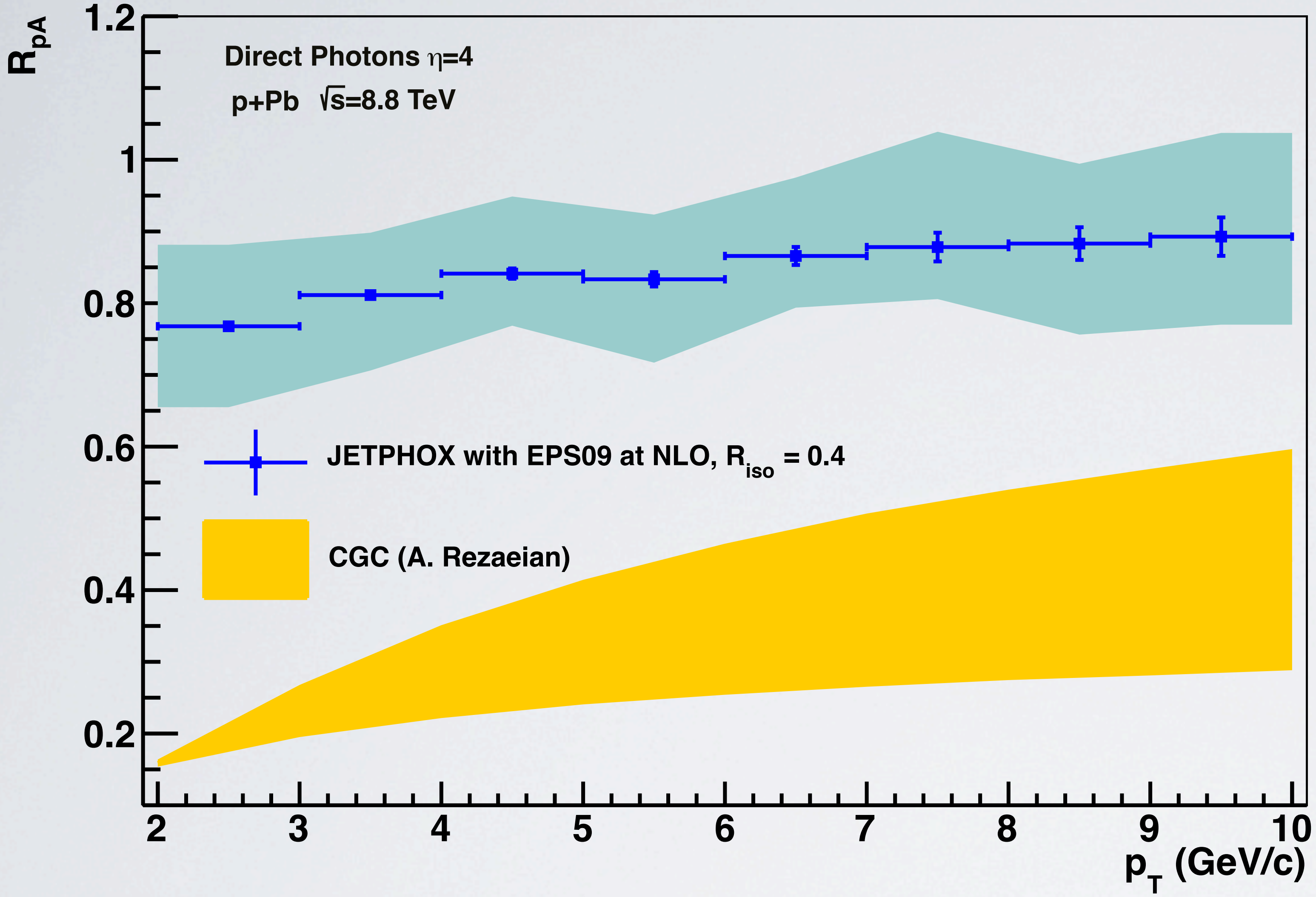
high granularity enables low p_T direct photon measurement

Performance in R_{pPb}



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

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

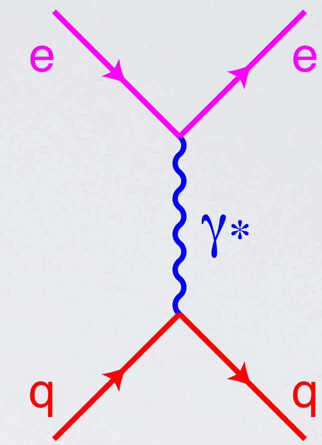
- strong suppression in direct γ R_{pA}
- signals expected at forward η, low-intermediate p_T
  - transition expected - where?

Open Questions

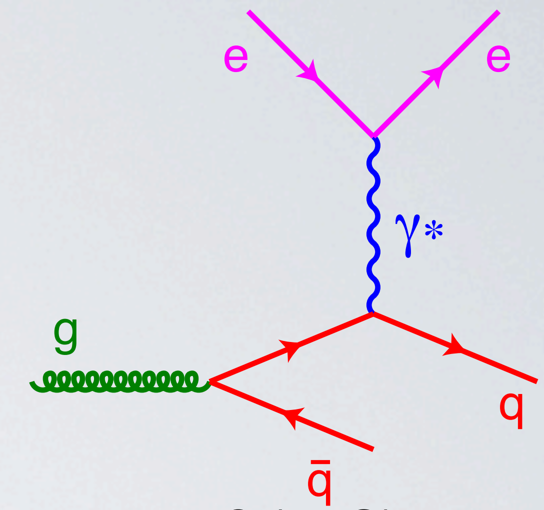
- What is the x,Q^2-sensitivity of different probes?
  - NLO - DGLAP?
  - final state effects?
- Are there other competing suppression/enhancement mechanisms?
- What are the uncertainties in pQCD and saturation?
  - Is there a possibility of a unified approach?

Sensitivity to Gluons 1

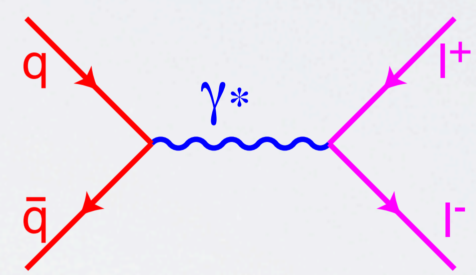
DIS	not accessible now similar information as DY
DY	very small cross section indirect sensitivity to gluons (NLO/DGLAP)
photons	reasonable cross section direct sensitivity to gluons



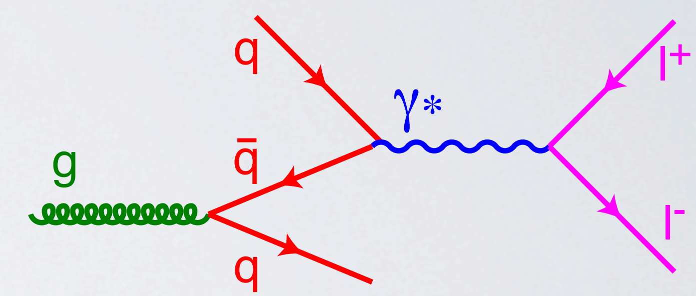
DIS (LO)



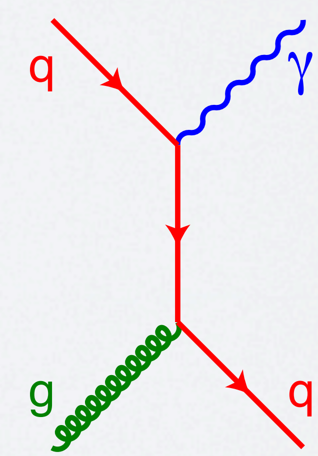
DIS (NLO)



DY (LO)



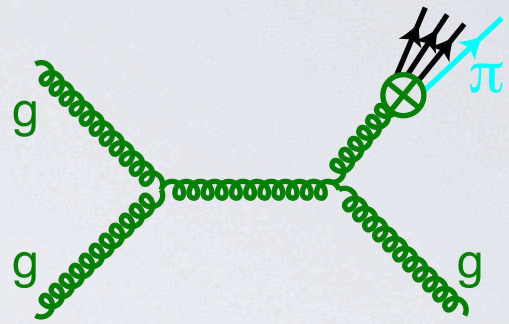
DY, virtual Compton (NLO)



direct-γ, Compton (LO)

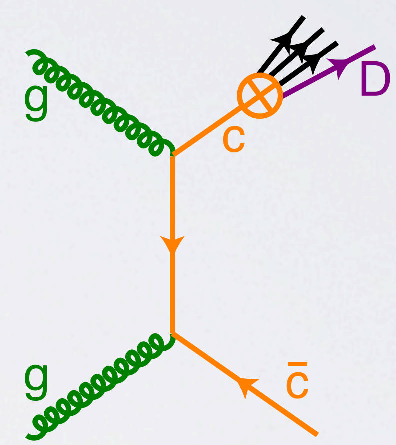
Sensitivity to Gluons 2

light hadrons	hadronization uncertainty higher orders
charm	moderate (?) hadronization uncertainty higher orders
J/ψ	model uncertainty higher orders



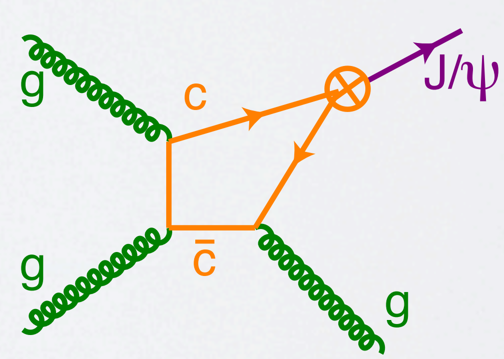
light hadron

NLO ...



heavy hadron

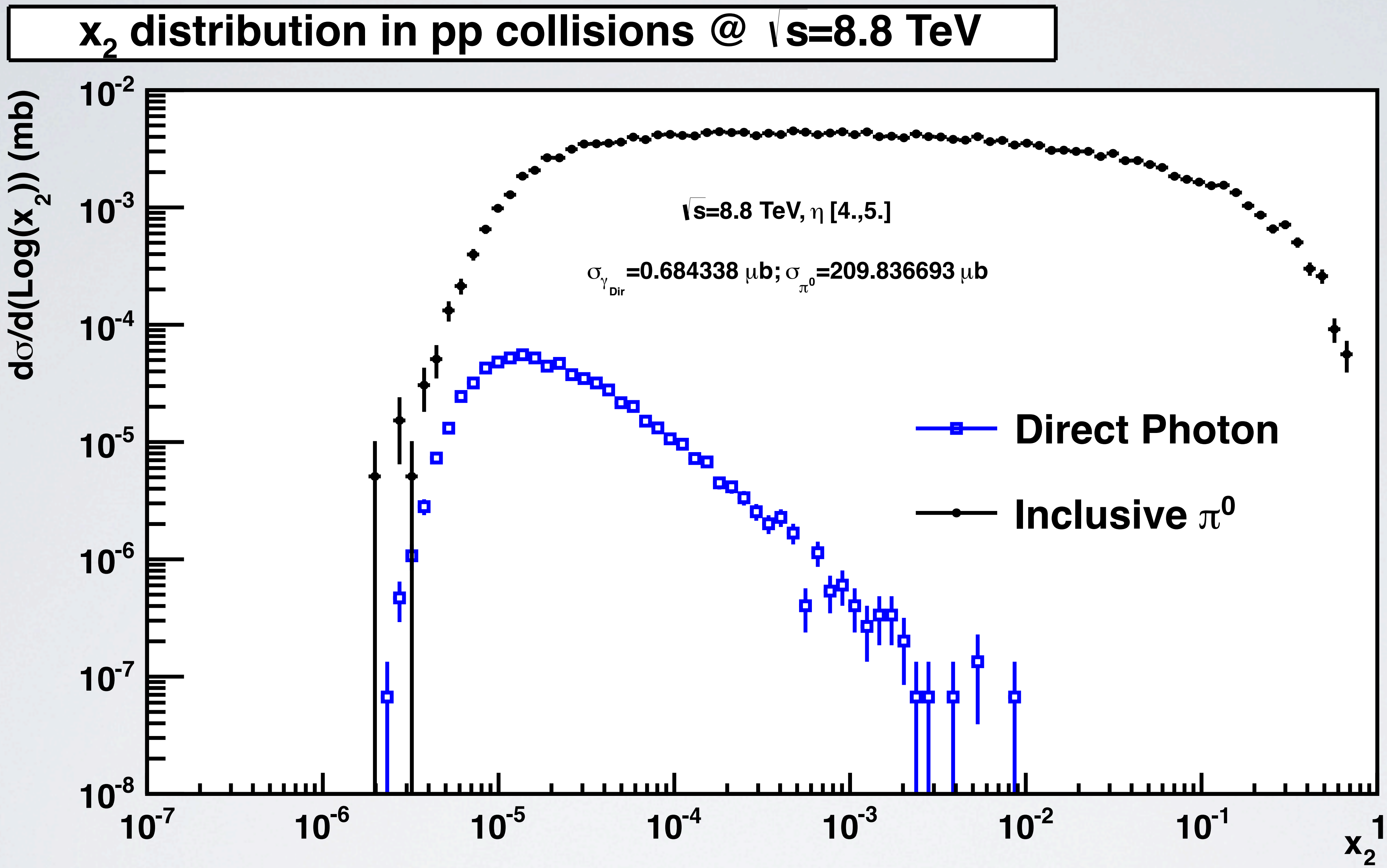
NLO ...



J/ψ

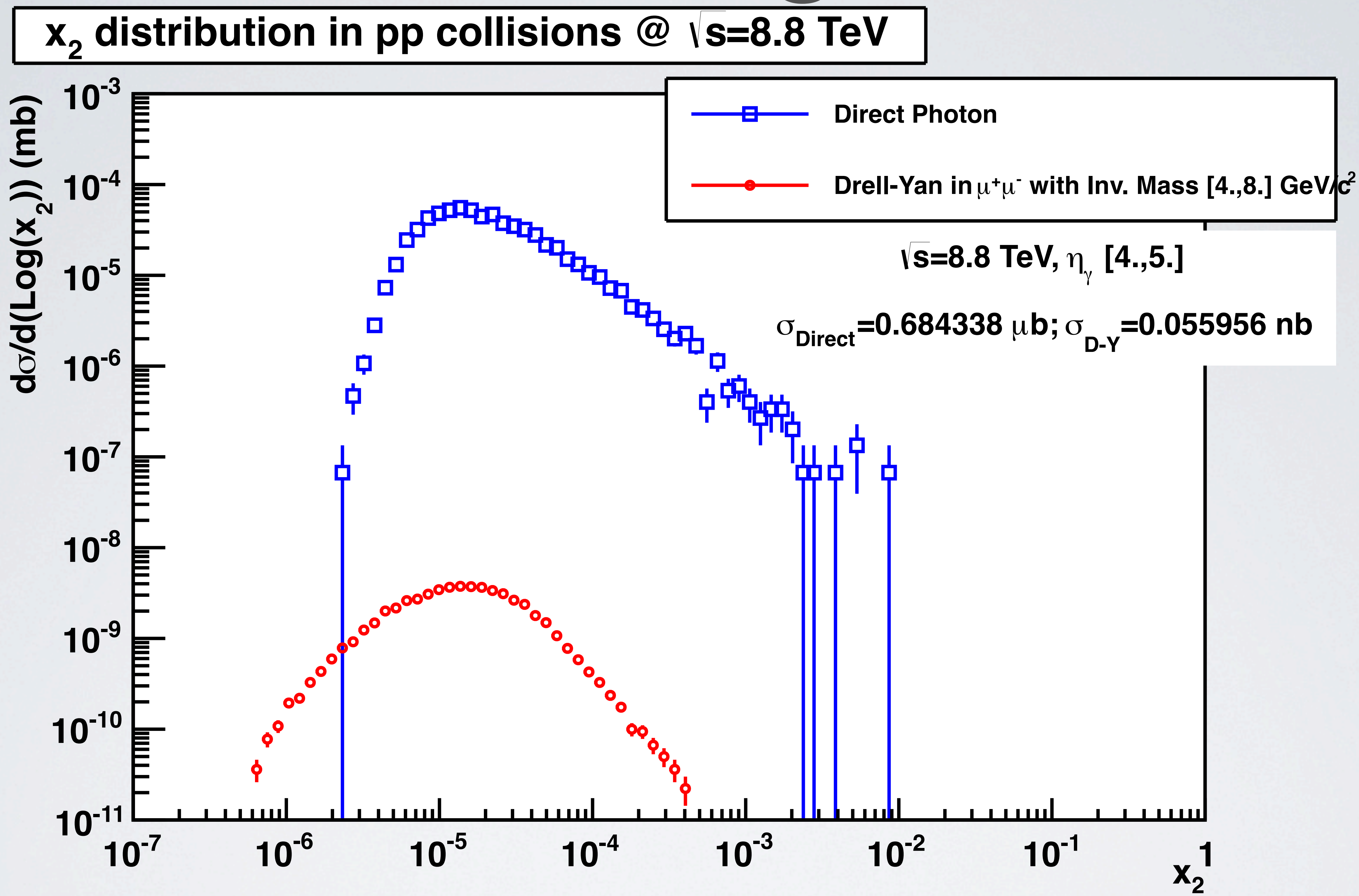
NLO ...

x-Ranges



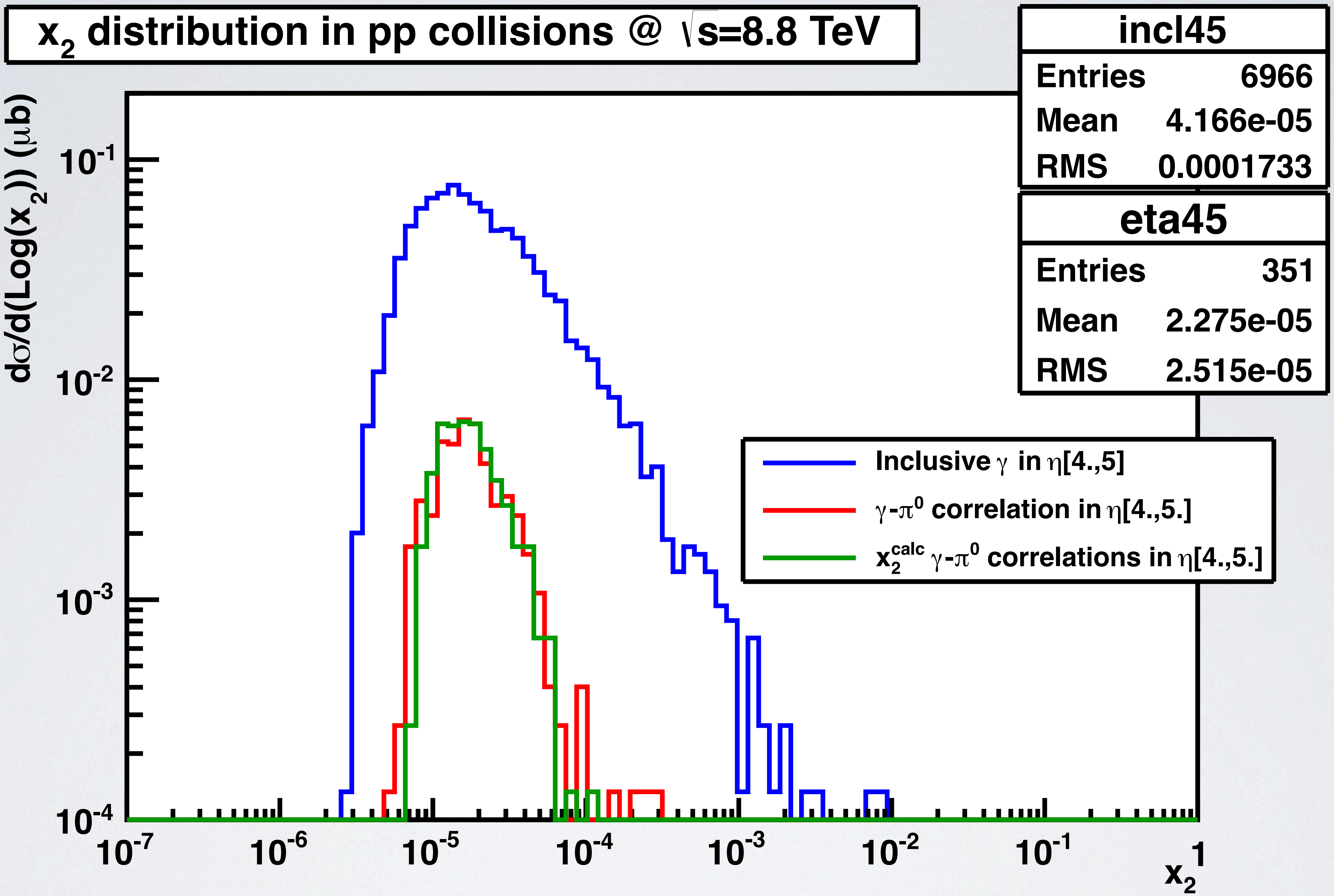
PYTHIA simulations (D. Lodato)
neutral pions: p_T > 2.5 GeV/c
direct photons: p_T > 4 GeV/c

x-Ranges



PYTHIA simulations (D. Lodato)
direct photons: p_T > 4 GeV/c
Drell-Yan: 4 GeV/c^2 < M < 9 GeV/c^2

x-Ranges

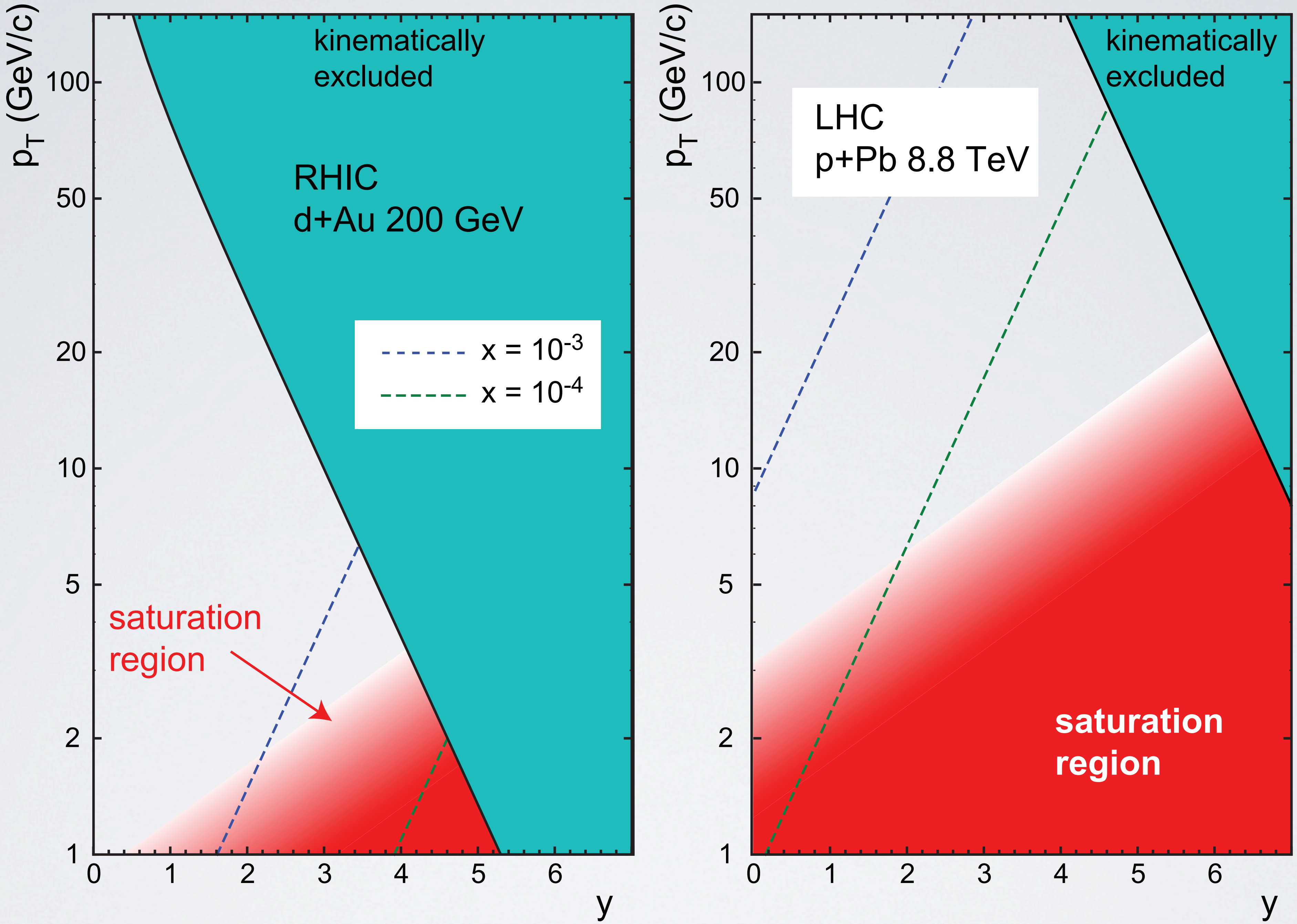


PYTHIA simulations (D. Lodato)

direct photons: p_T > 4 GeV/c , neutral pions: p_T > 2.5 GeV/c

Backup Slides

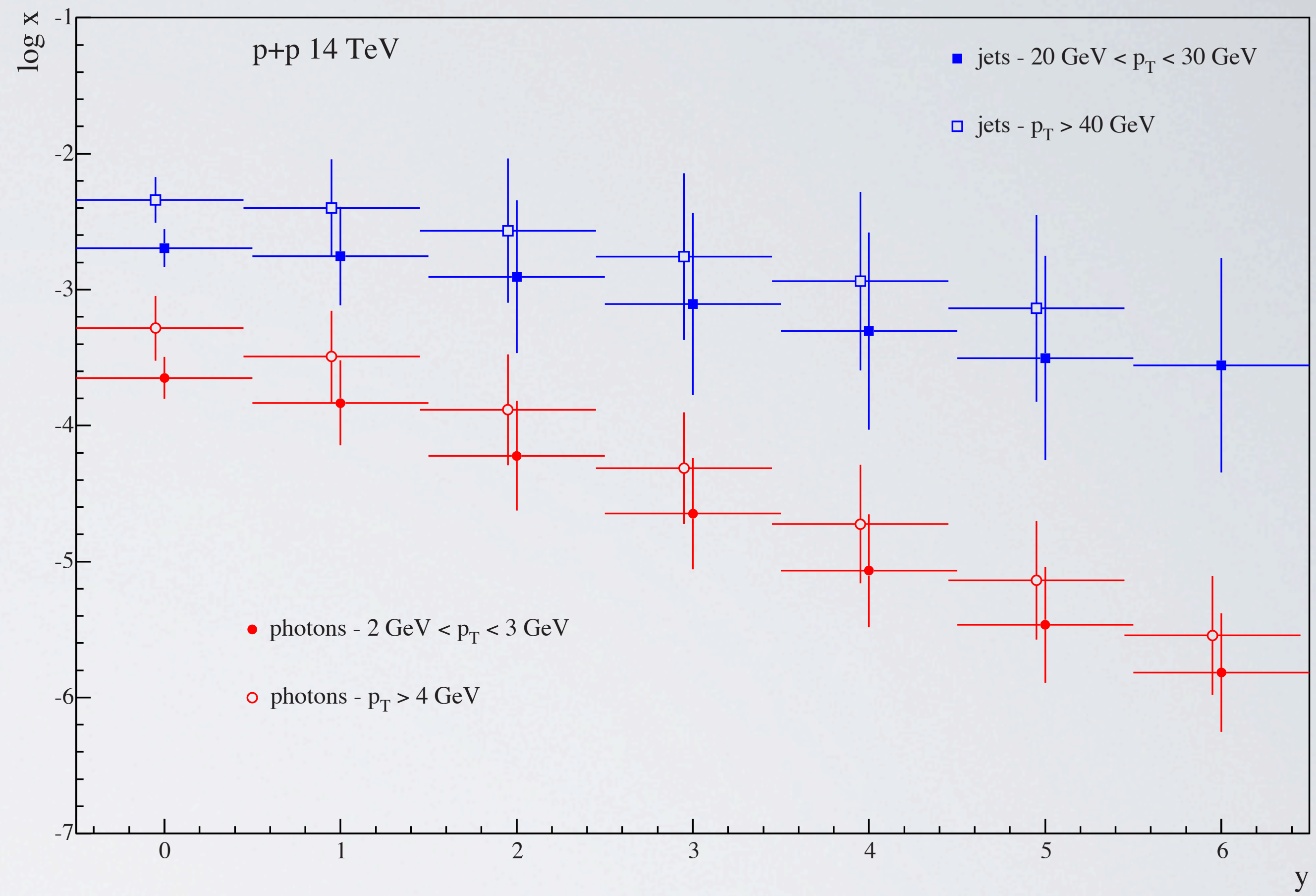
LHC vs RHIC



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

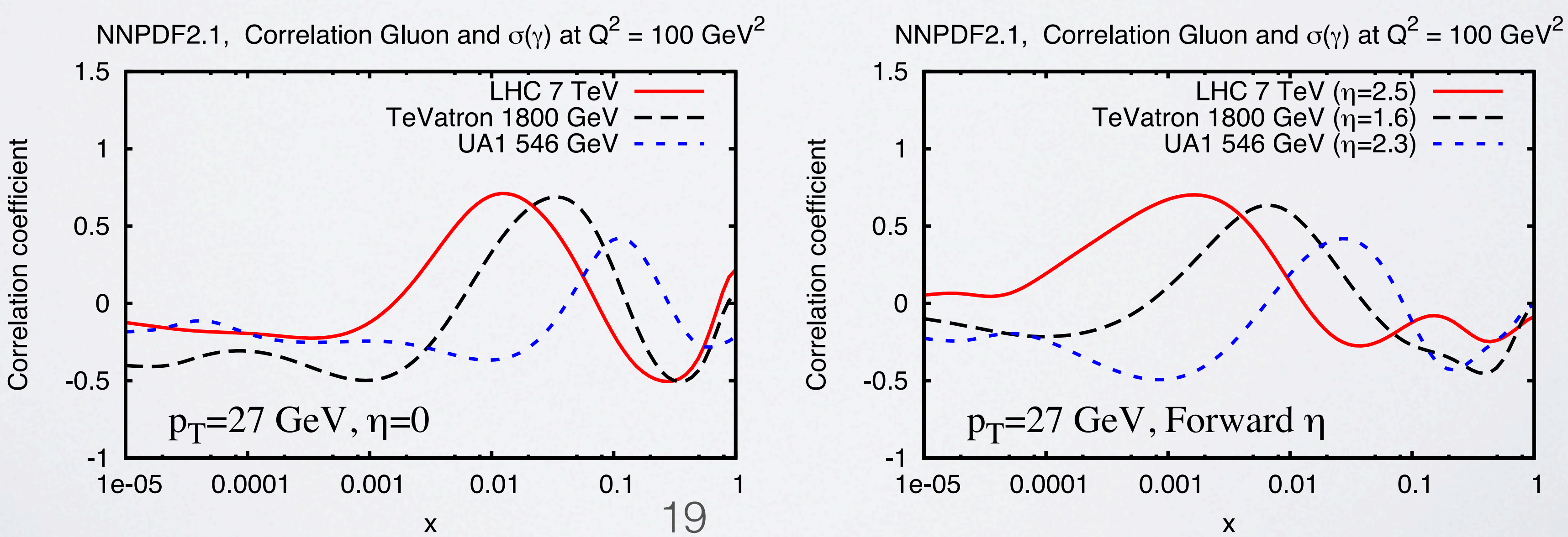
Kinematic Constraints

- large y prompt photons effective to constrain kinematics to low x
  - obvious in LO (PYTHIA)

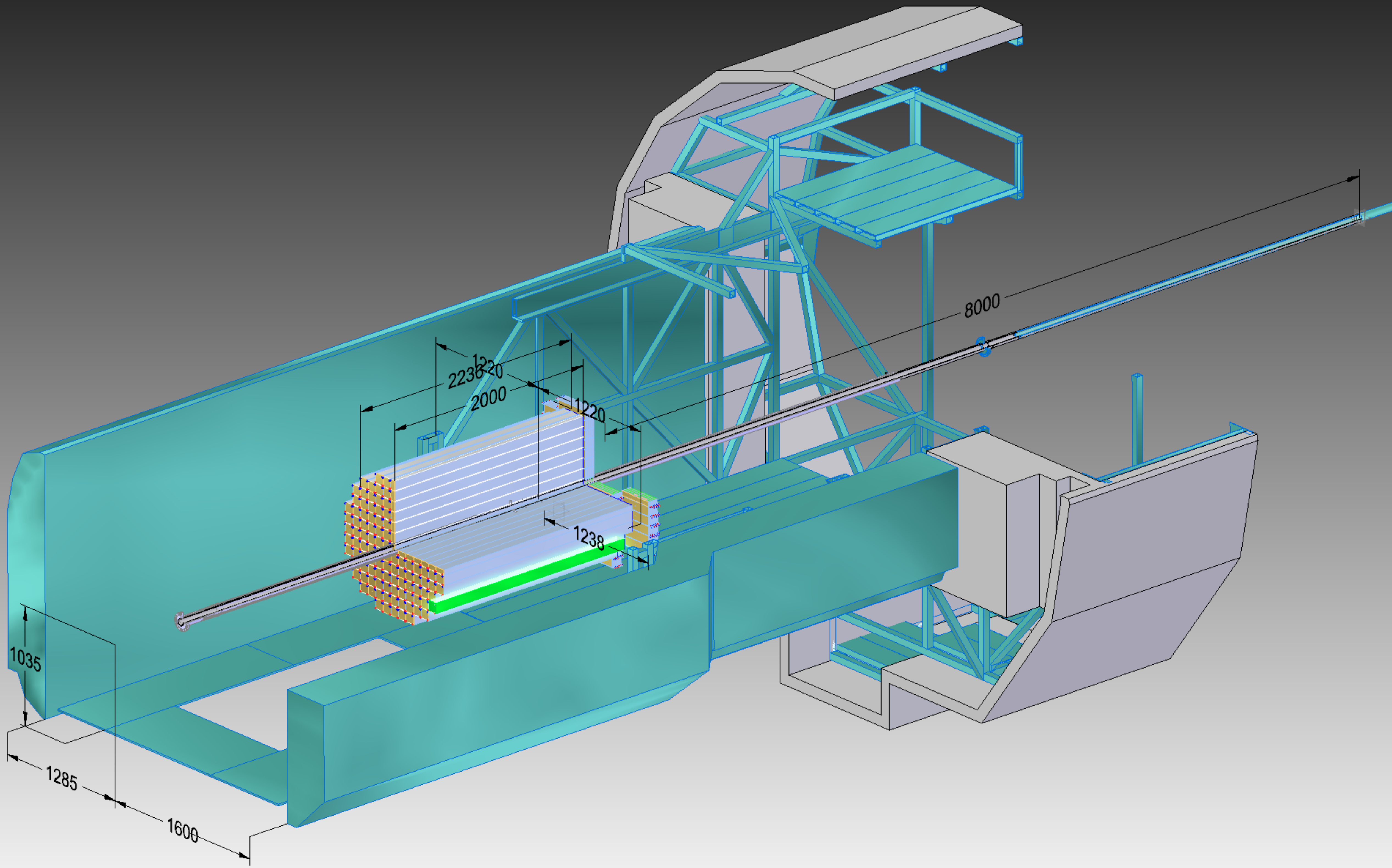


- NLO studies in JETPHOX:
  - indicate clear sensitivity of isolated photons, dedicated calculations under way

from D. d'Enterria and J. Rojo, arXiv:1202.1762



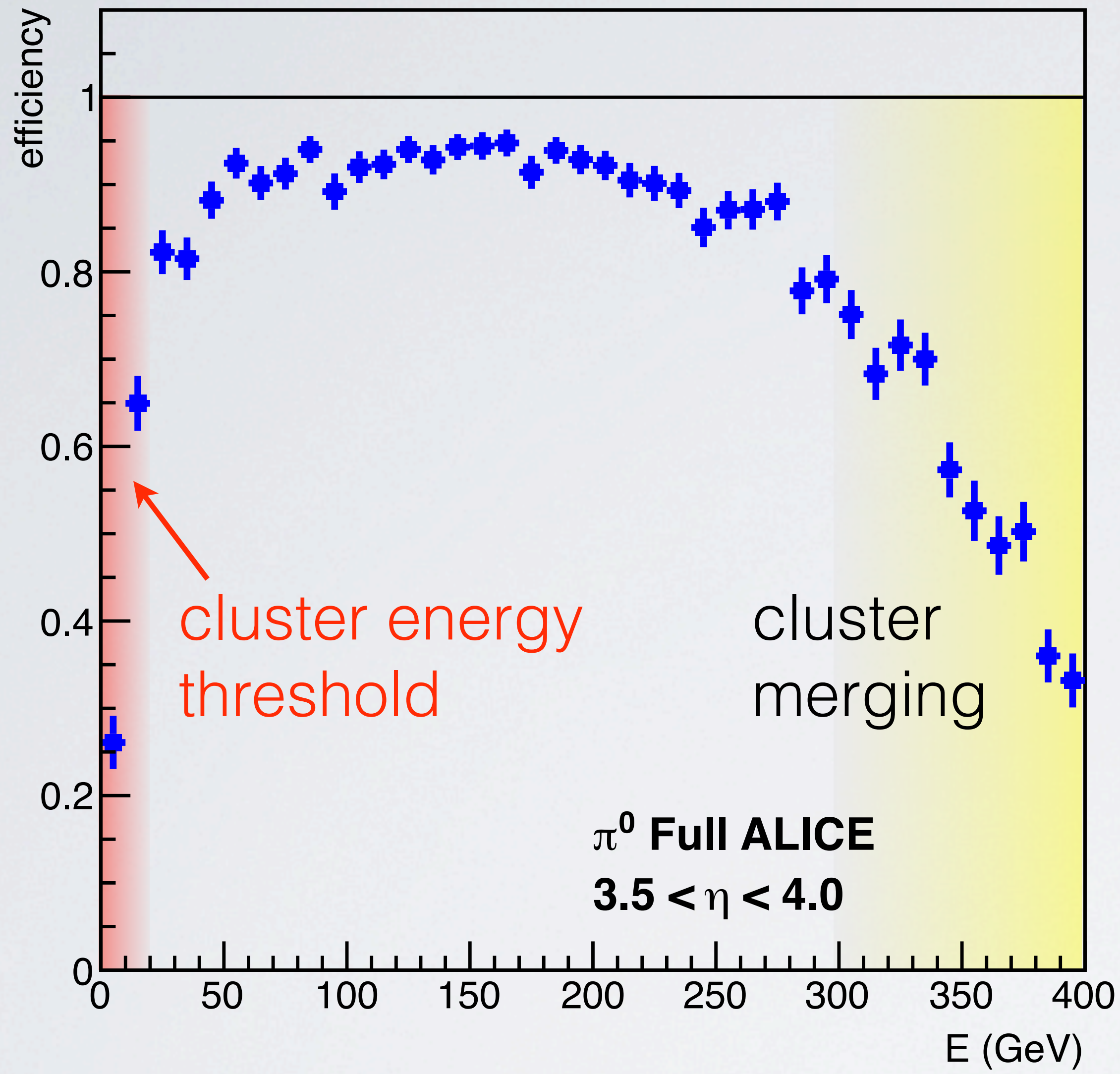
FoCal in ALICE

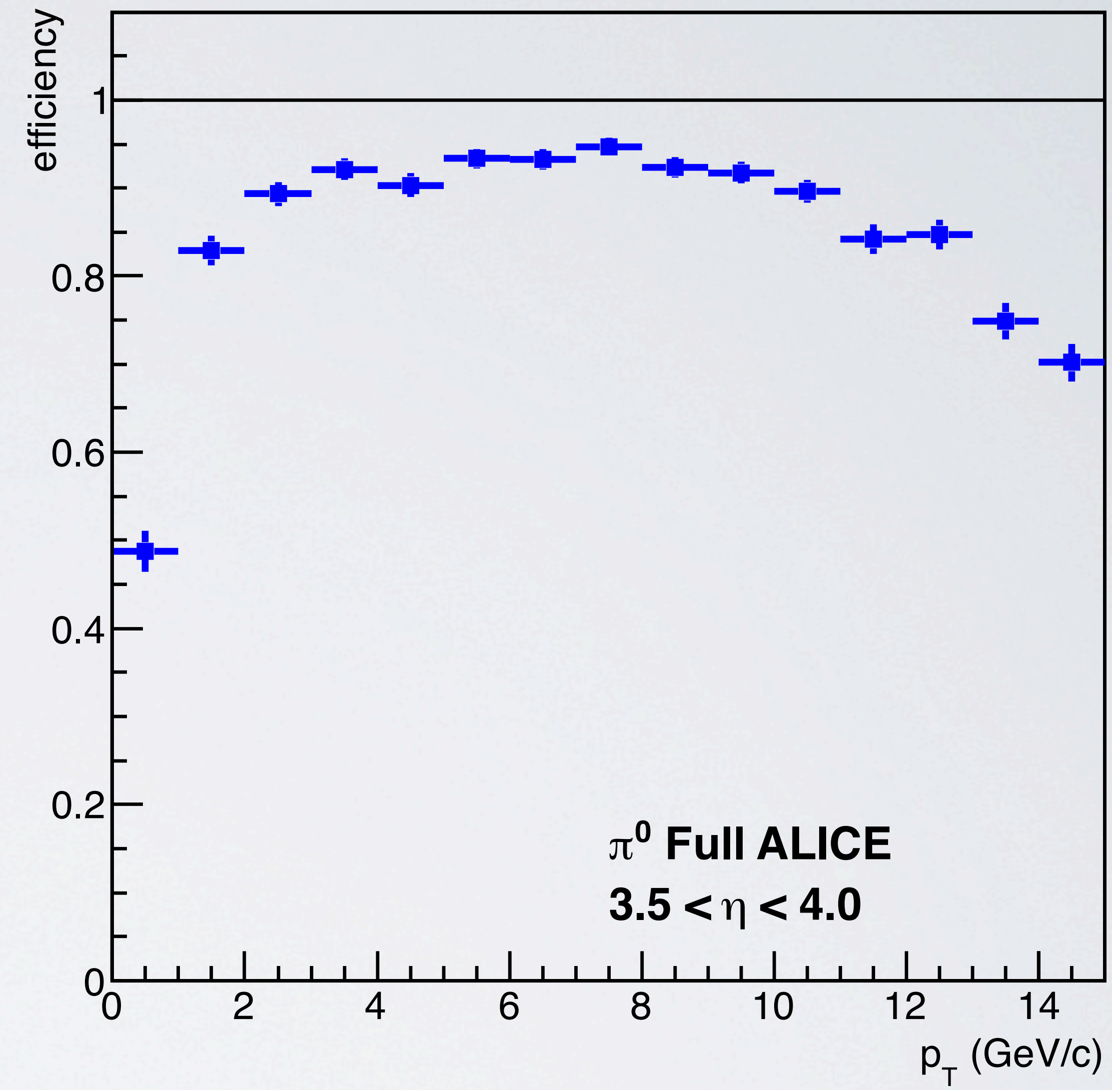


FoCal Physics Program

- p+Pb: saturation/CGC effects
  - forward direct γ spectra, γ-hadron/jet correlations (unique!)
  - π^0 spectra, π^0-π^0 correlations, possibly jets (had. calorimeter!)
- p+p: reference measurements
  - constraints on PDFs?
- 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, ...

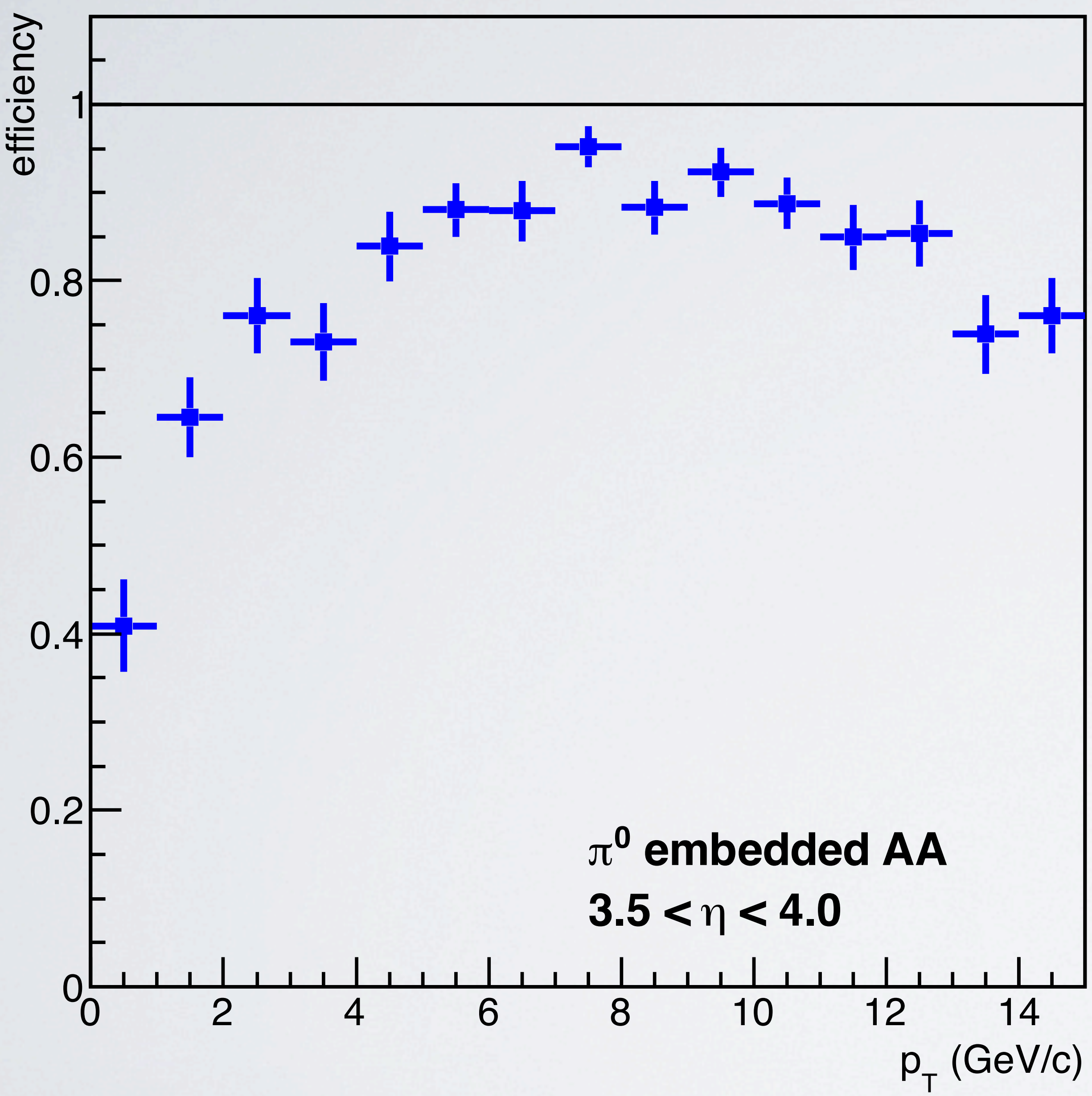
π^0 Efficiency





- results of single particle simulations using full ALICE setup
- excellent π^0 efficiency for $20 < E < 300$ GeV, $2 < p_T < 10$ GeV/c

Performance in Pb+Pb



performance in π^0 measurement:

- good efficiency
- expect larger uncertainty than in pp

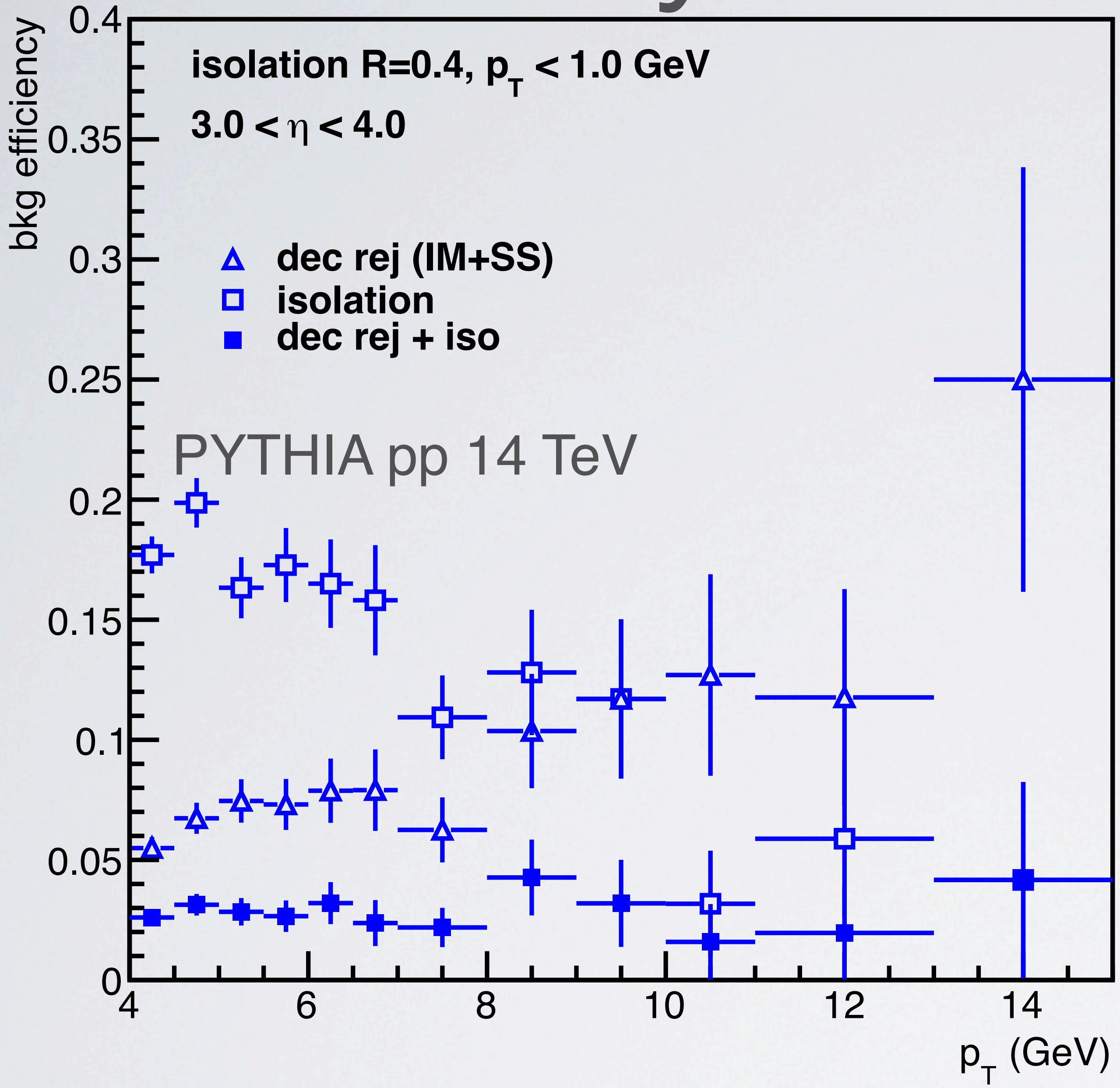
enables π^0 R_{AA} for $7 < p_T < 20$ GeV/c allows study of parton energy loss, medium density vs. η

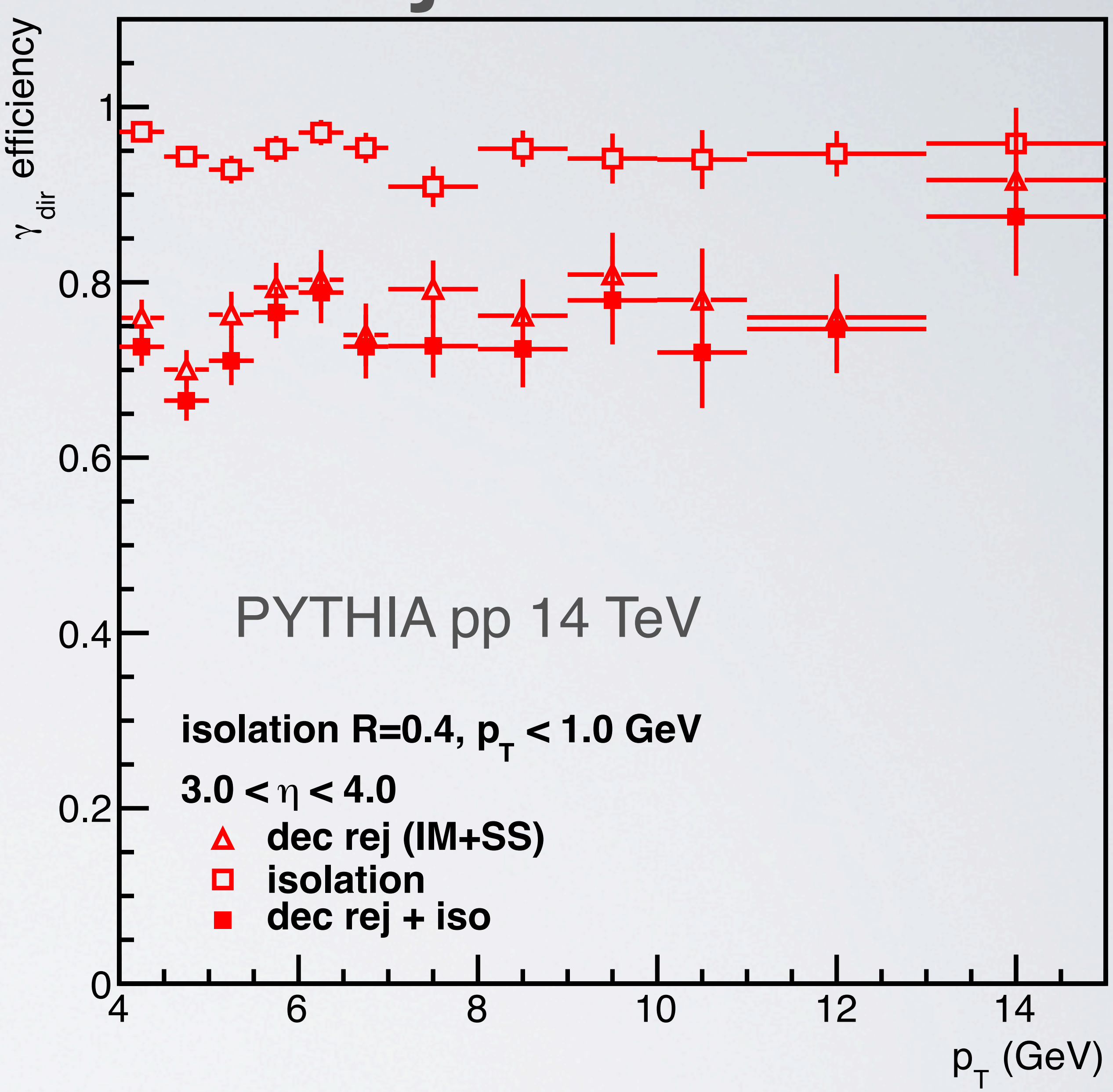
also other observables, but significant thresholds due to underlying event bkg

- di-hadron correlations
- jet spectra, R_{AA}, di-jet correlations for $p_T > 20$ GeV/c
- direct photons in limited p_T range (tbc)

work in progress!

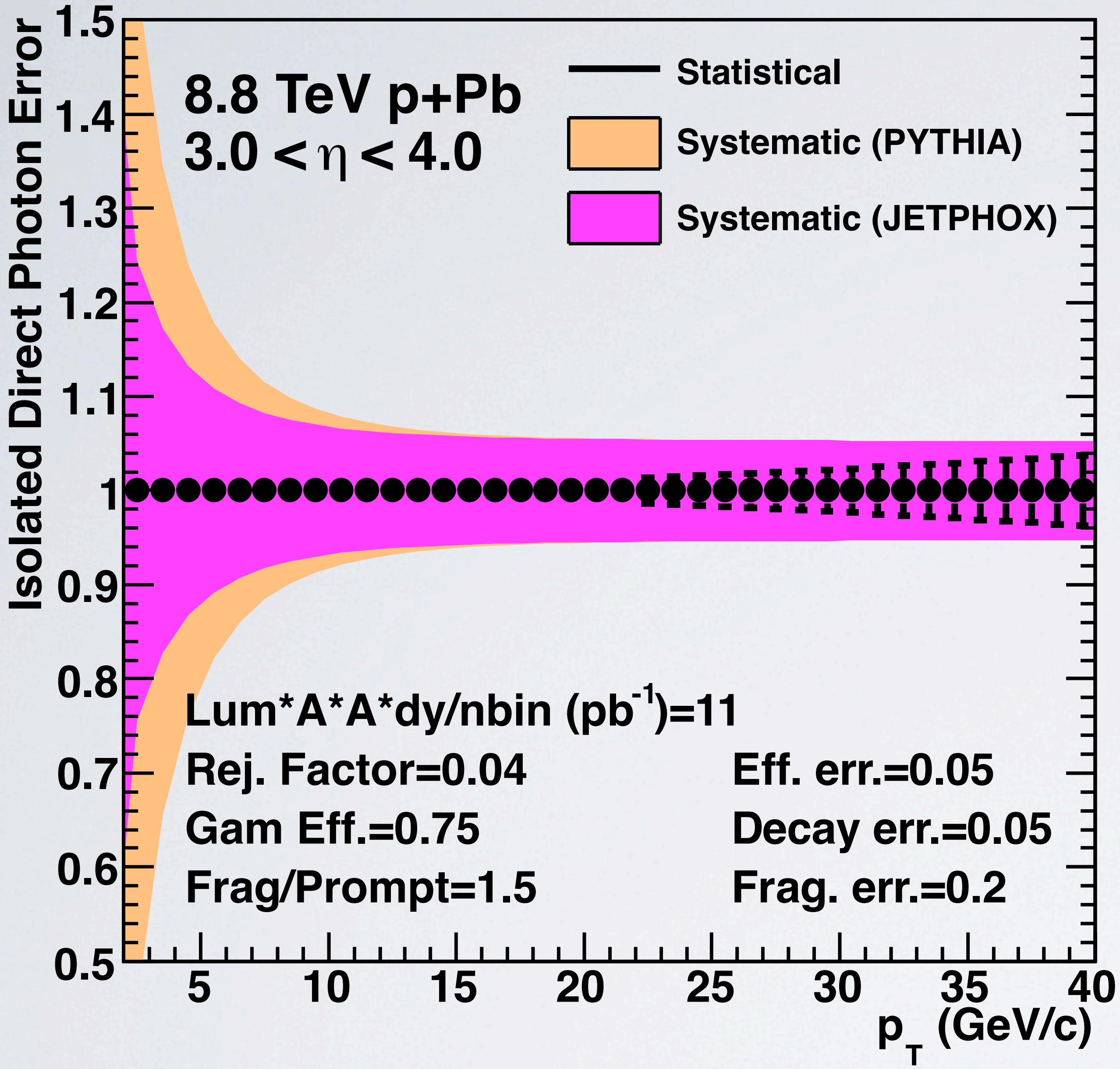
Decay Photon Rejection

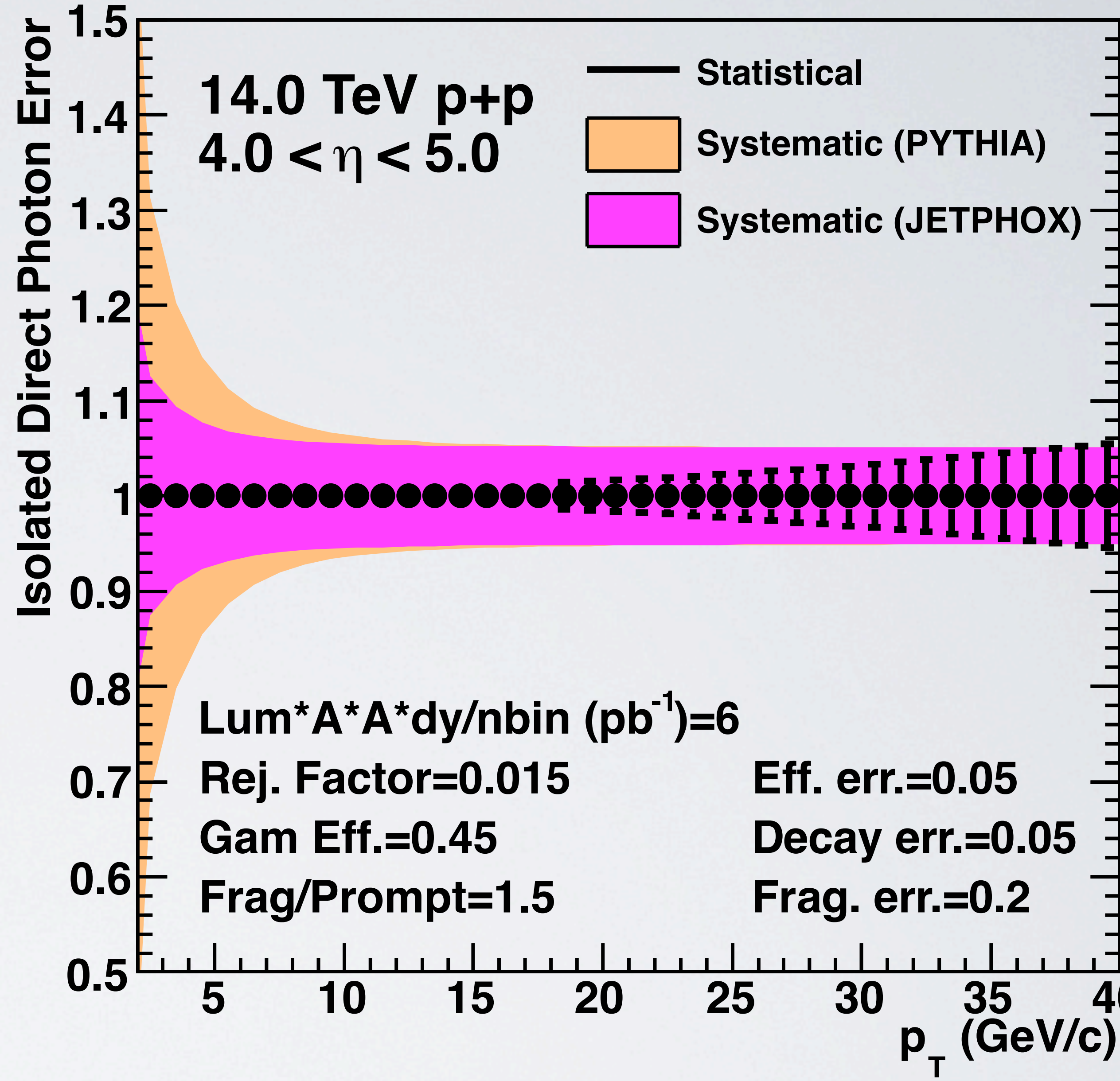




- combined rejection (invariant mass + shower shape, isolation)
- rejection factor ≈30, direct photon efficiency ≈75%
  - largely p_T-independent

More Performance ...





better performance for 8.8 TeV (pA equivalent to pp)

better performance for larger η (only possible for z=8m, requires more integration work)

signal properties

observable	sensitivity to gluons	Q^2	final state effects	cross section
light hadrons	LO/NLO	?	yes	++
jets	LO/NLO	high	yes	+
J/ψ	LO/NLO	low?	yes	+
isolated photons	LO	low	no	+
Drell-Yan	NLO	low	no	-