Upgrade of the ALICE Experiment

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for the ALICE Collaboration

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Universiteit Utrecht

NIKHEF

Outline

- Physics Motivation and Strategy
- Core Upgrade
  - ITS Upgrade
  - High Rate Capabilities
  - Physics Performance Examples
- Further Additions (under consideration)
  - VHMPID, MFT, FoCal
- Summary

Physics Motivation

- measurement of heavy-flavour transport parameters
  - study of QGP properties via transport coefficients
- charmonium states down to p_T=0
  - statistical hadronization vs. dissociation/recombination
- measurement of low-mass and low-p_T dileptons
  - chiral symmetry restoration, thermal radiation
- jet quenching and fragmentation (with PID)
- heavy-nuclear states

- possible addition: measurement of large rapidity direct photons
  - low-x structure and gluon saturation

Upgrade Strategy

- most physics signals are rare, but untriggerable
  - increase rate capabilities for minimum bias heavy-ion collision
    - upgrade of TPC and ITS, all readout electronics, etc.
  - target: inspection of 50 kHz of minimum bias Pb+Pb
    - factor 100 increase in statistics (for untriggered probes)
  - collect $> 10\ nb^{-1}$ of integrated luminosity
    - upgrade in LS2, implies running few years after LS3
- ALICE is unique in low-p_T/low-mass measurements and particle identification
  - further enhance capabilities, in particular with upgraded ITS
    - closer to beam, less material, better resolution

ITS Upgrade

factor 3 better secondary vertex resolution:

- inner layer as close as possible (R = 2.2 cm)
- less material budget
  - thin sensors
  - thinner beam pipe (ΔR = 800 μm)

fast readout

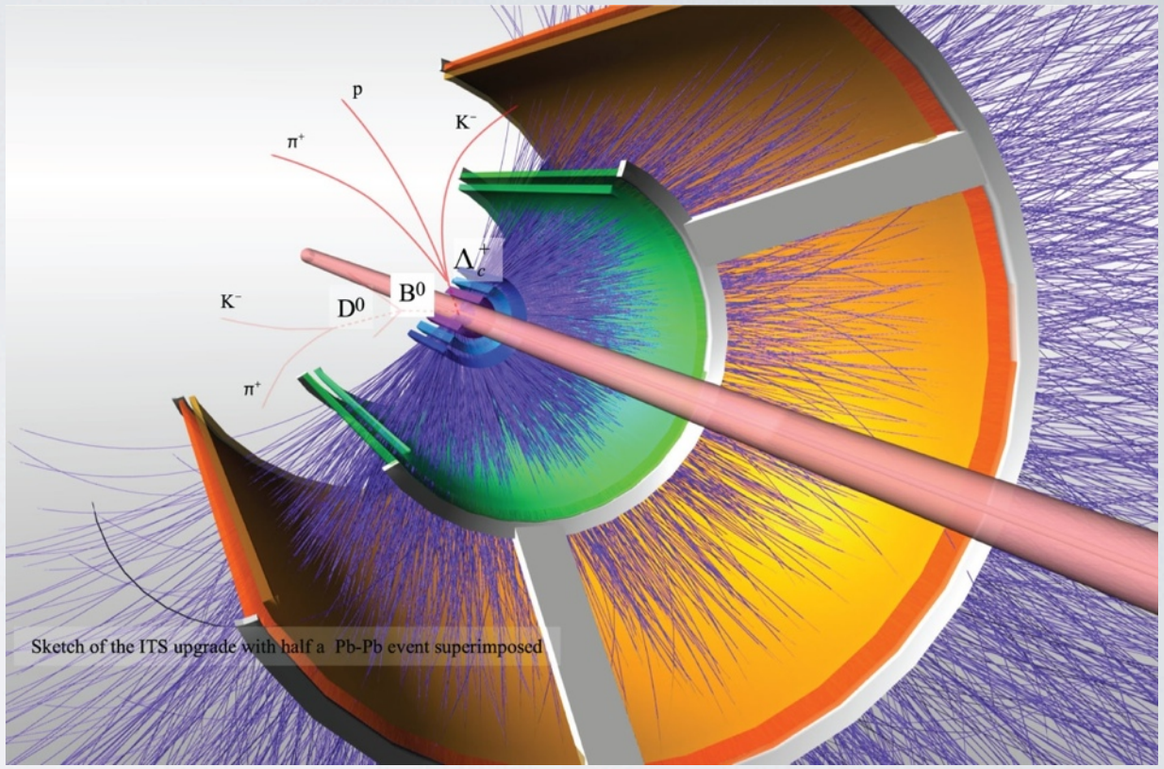
- allow 50 kHz rate in Pb+Pb

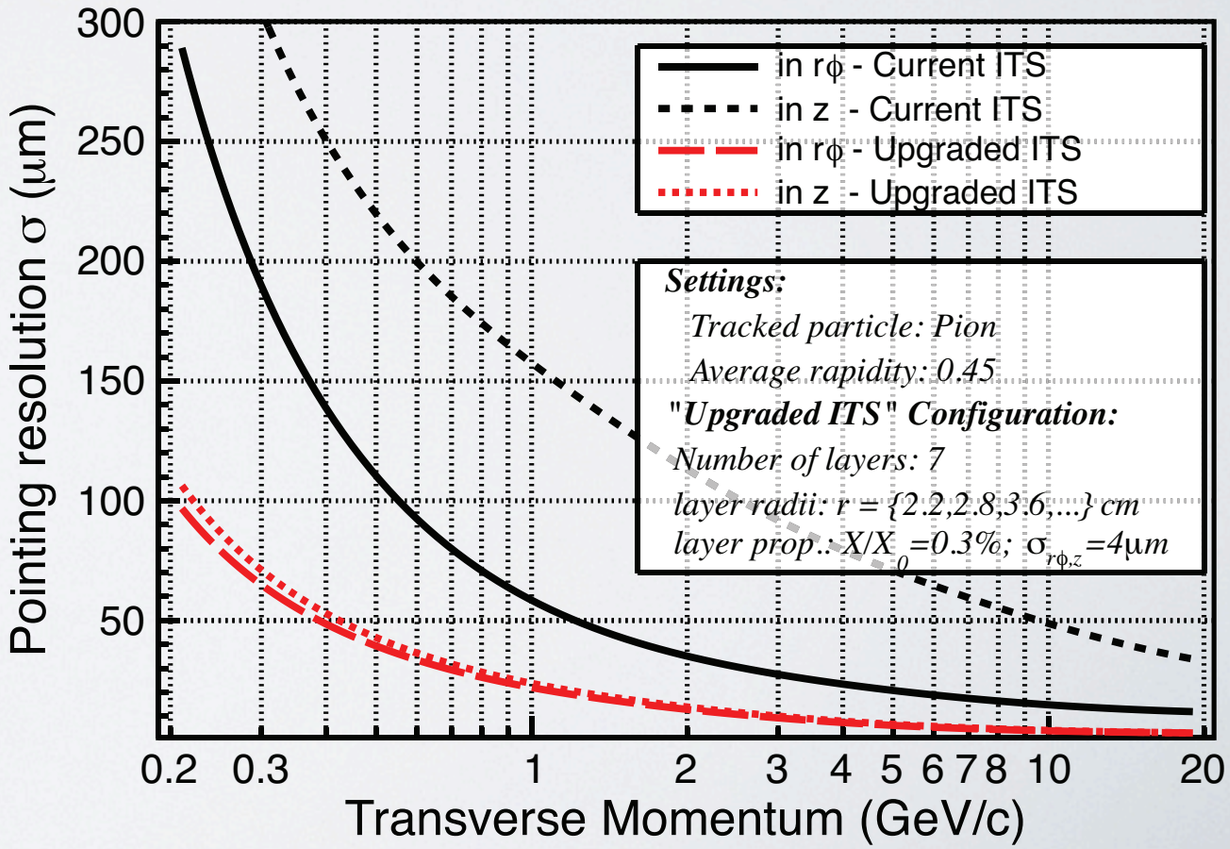
two technologies investigated

- hybrid pixels
- monolithic active pixels

to be used as all-pixel (7 layers) or pixel(3)+strip(4)

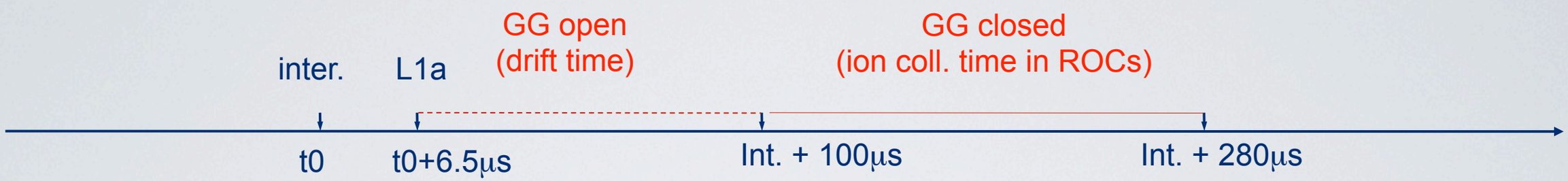
- possibly new Si-strip sensors





talk by R. Lemmon, this session,
poster by G. Contin (ID 601)

Limits of Current TPC

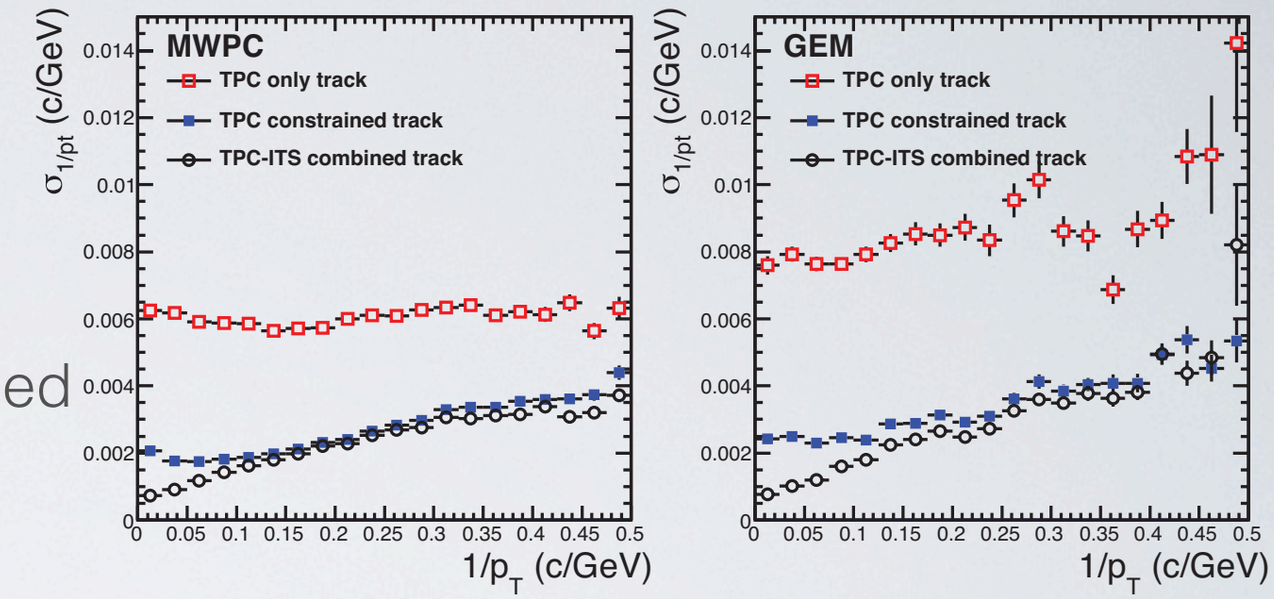


- gating grid of readout chambers closed to avoid ion feedback
  - limit space charge to tolerable level
  - effective dead time ≈280 μs, maximum readout rate: ≈3.5 kHz
- alternative: gating grid always open
  - ion feedback ≈ 10^3 x ions generated in drift volume
  - large space charge effects (of the order of electrical field)
    - space point distortions of order of 1 m - not tolerable!

TPC Upgrade

new readout chambers

- replace MWPC with GEMs
- no gating, small ion feedback
- usage of existing pad-planes possible
  - momentum resolution for constrained tracks not affected



continuous sampling at 10 MHz, ship data unsuppressed off detector

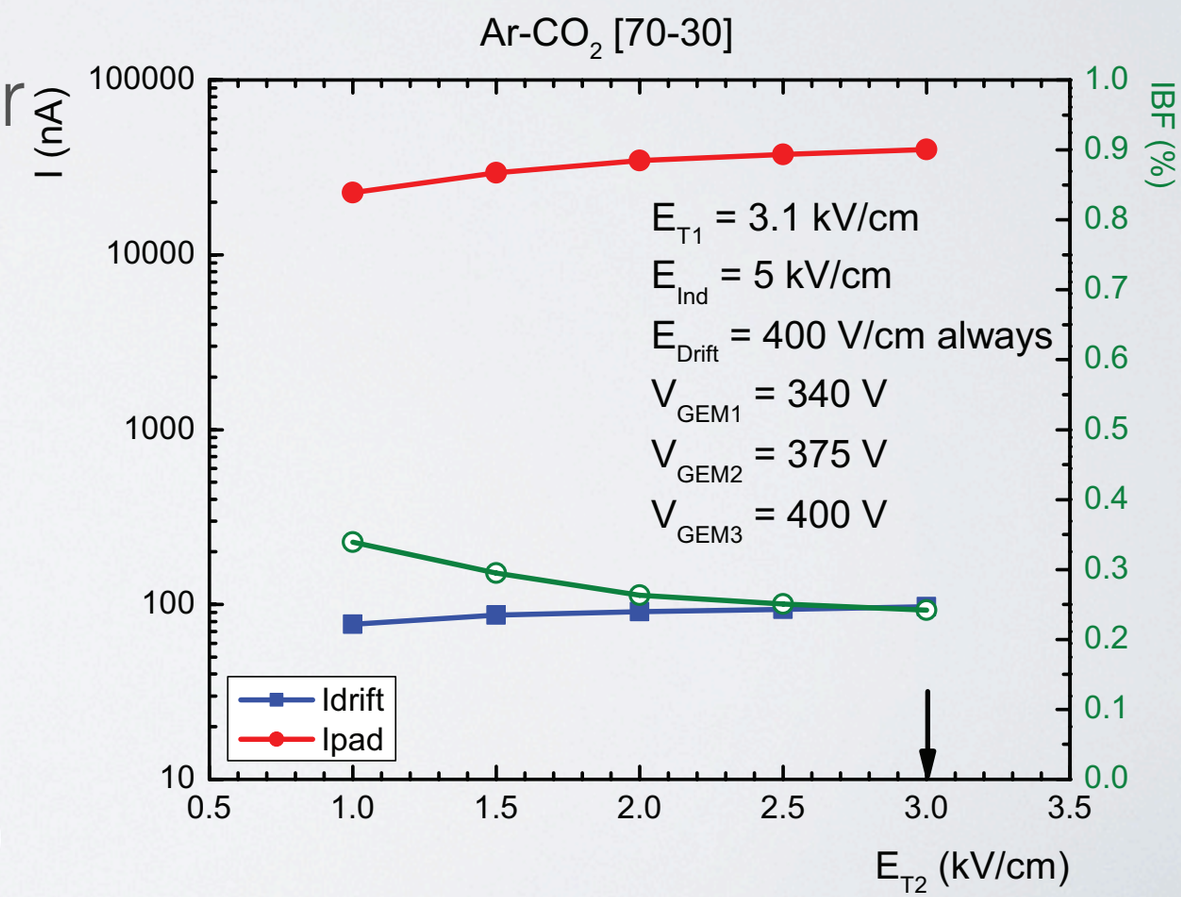
- needs new electronics

extensive R&D program ongoing with lab tests

- confirm low ion feedback
  - goal: 0.25% at gain of 2000
- gain stability?

... and in ALICE cavern (November)

- performance under LHC conditions?



poster by T. Gunji (ID 496)

Central Barrel: More Upgrades

- other detector systems under investigation
  - upgrade of PHOS calorimeter
    - better time resolution to reduce background
    - miscellaneous improvements
  - upgrade of trigger detectors (T0/V0)
- upgrade of all readout electronics
  - pipelined readout of major ALICE detectors
- new DAQ/HLT
  - data compression requires on-line calibration and tracking
- common computing framework (DAQ/HLT/Offline)

Event Size and Rates

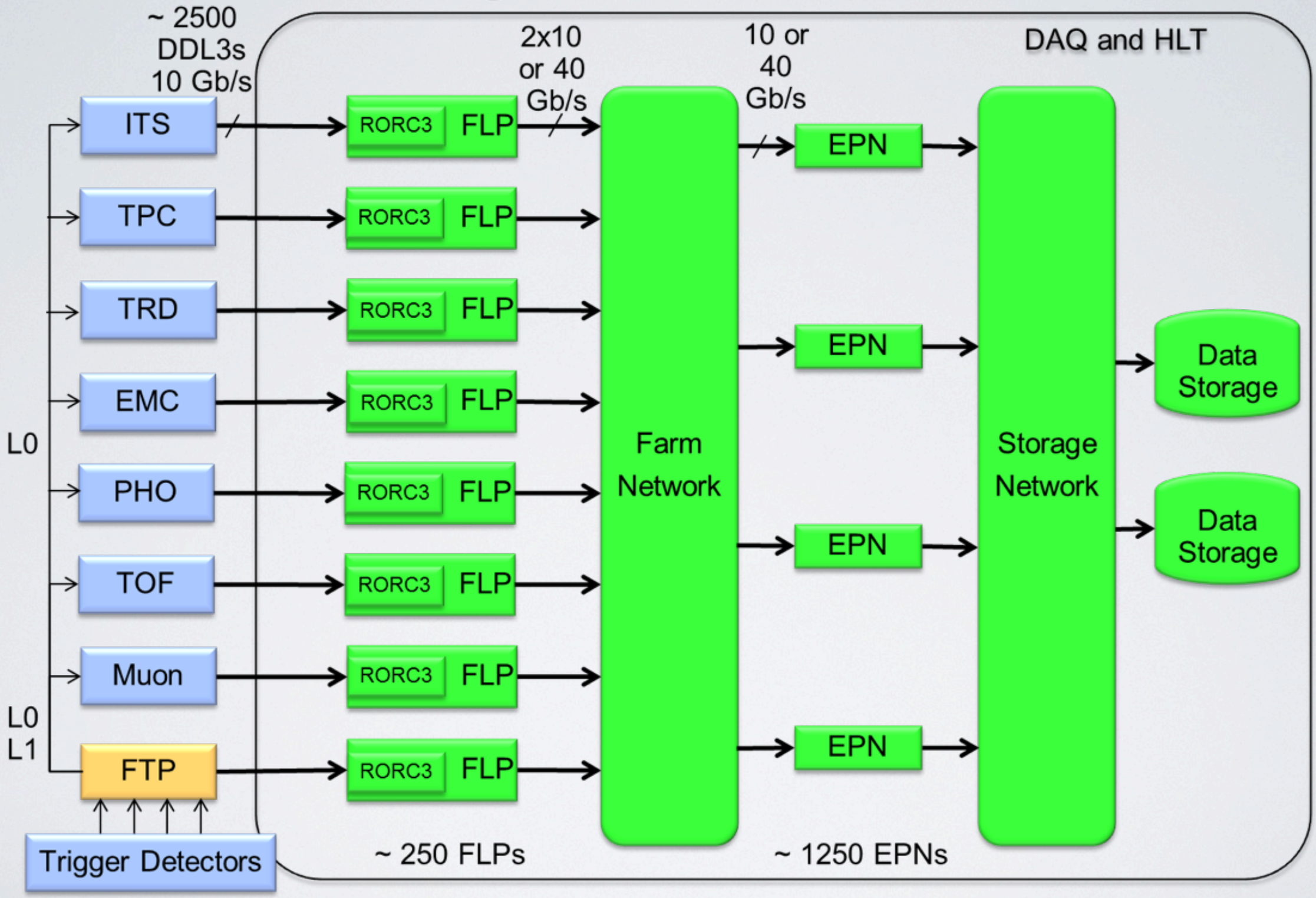
- event size of major systems, I/O rates of online system
  - assume average minbias rate to tape of 20 kHz

Detector	Event Size (MByte)		Input to Online System (GByte/s)	Compressed Output to data storage (GByte/s)	
	After Zero Suppression	After Data Compression		Peak	Average
ITS	0.8	0.2	40	10.0	4.0
TPC	20.0	1.0	1000	50.0	20.0
TRD (20 kHz)	0.3	0.1	6	2.0	2.0
Others (1)	0.5	0.25	25	12.5	5.0
Total	**21.6**	**1.55**	**1071**	**74.5**	**31.0**

- data reduction for TPC: clustering, reconstruction

Data Format	Data Reduction Factor	Event Size (MB Pb-Pb) (MByte)
Raw data	1	700
Zero suppression (FEE)	35	20
Clustering (HLT)	5-7	~3
Remove clusters not associated to relevant tracks (HLT)	2	~1.5
Data format optimization (HLT)	2-3	< 1

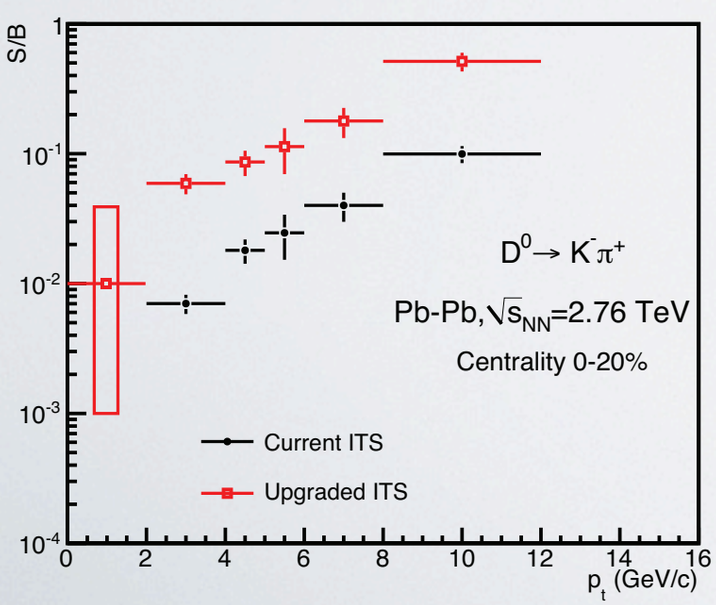
Online Upgrade Architecture

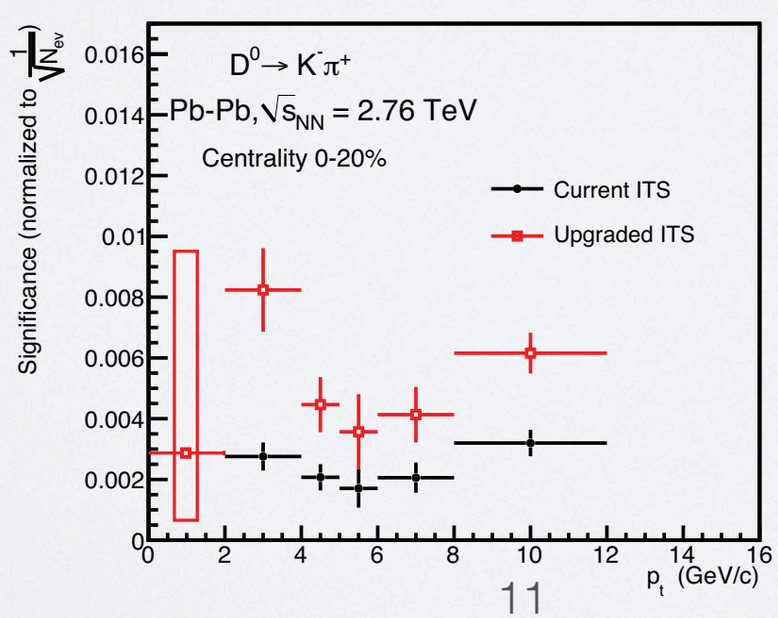


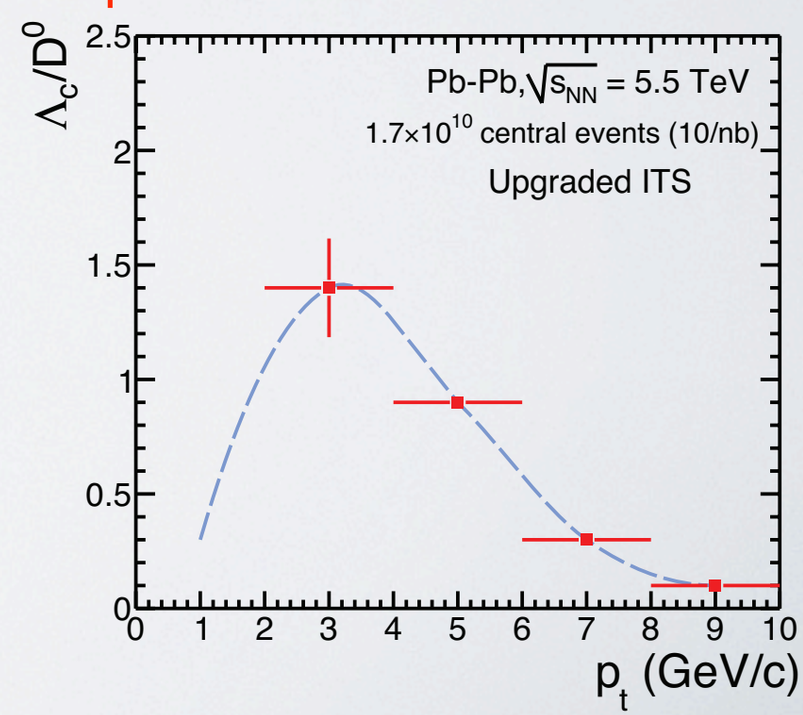
FTP: Fast Trigger Processor FLP: First-Level Processor EPN: Event-Building and Processing Nodes

Performance: Open Charm

- strong reduction of background with new ITS
  - improved S/B and significance
- with high rate should make possible for the first time:
  - D^0 measurement at low p_T (0-2 GeV/c) in Pb+Pb
  - Λ_c measurement in Pb+Pb
  - ...
- precision measurements of open charm transport

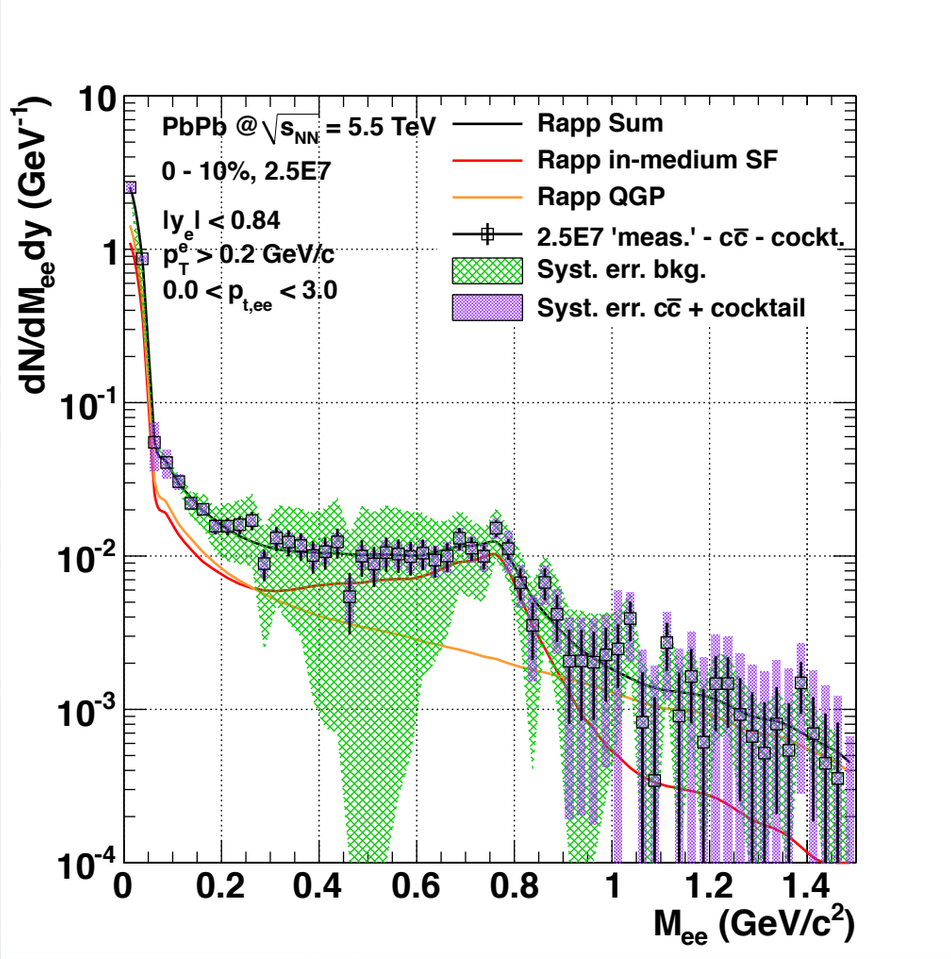


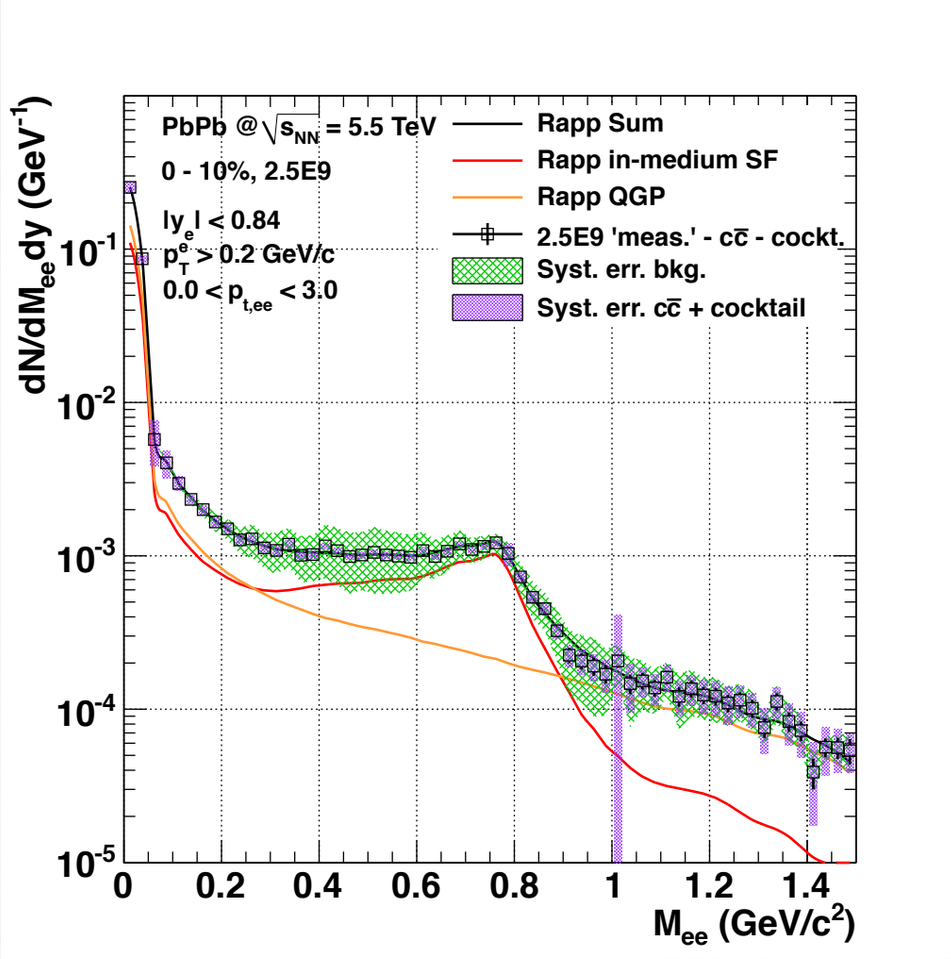




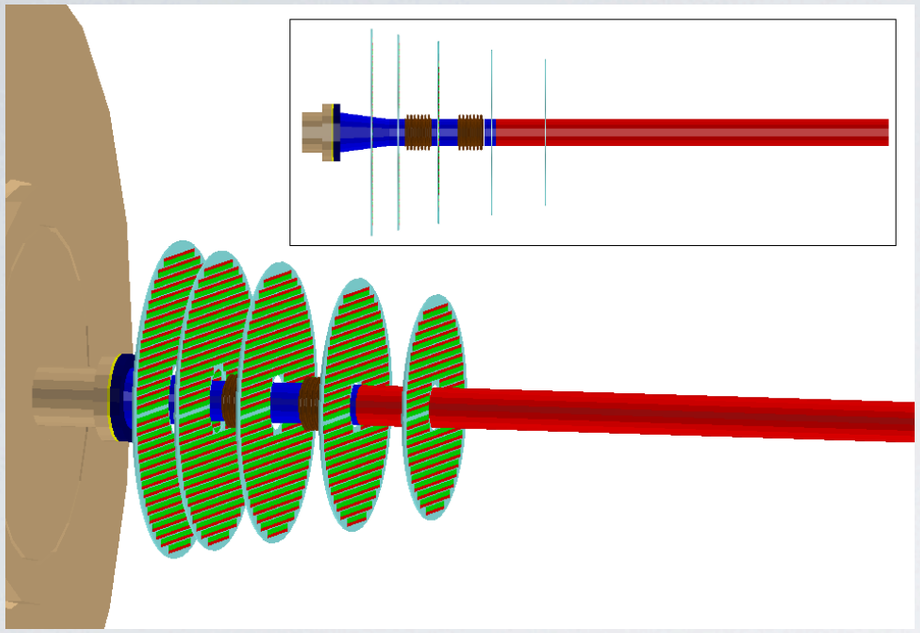
Dielectron Measurement

- uncertainties with current ITS
  - limited by background subtraction and statistics
- high rate measurement with new ITS
  - more efficient cuts to reduce background, high statistics: allows detailed measurement of low mass dielectrons





Muon Forward Tracker



5 circular Si-pixel planes
covering muon arm acceptance

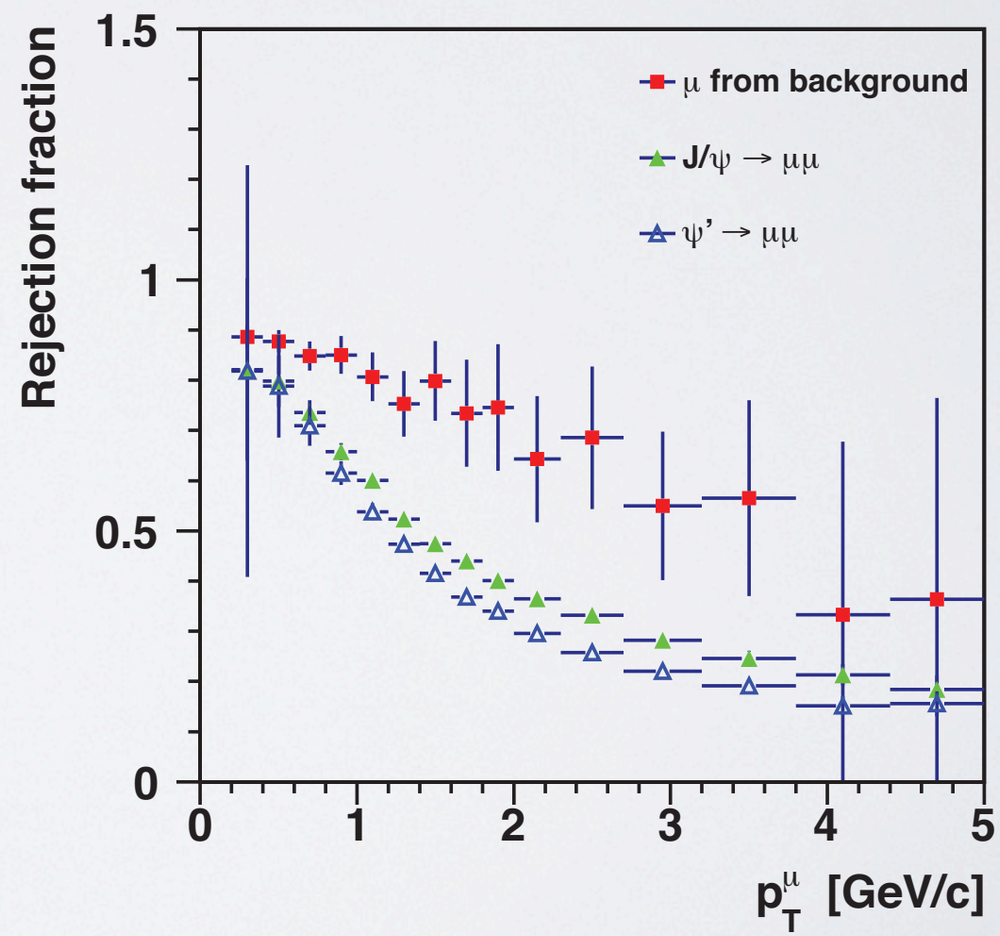
pixel size ≈ 25 μm x 25 μm

technology of choice:
monolithic active pixels

complement muon arm with
tracking in front of absorber

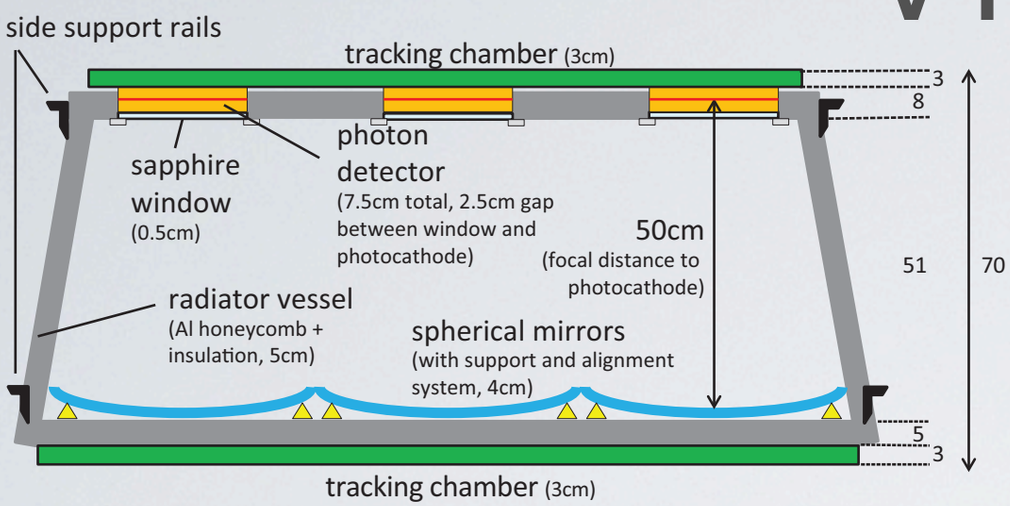
- secondary vertex measurement
- better background rejection
- improved mass resolution

access prompt vs. secondary J/ψ,
possible sensitivity to chiral
symmetry via low-mass dileptons



poster by A. Uras (ID 501)

VHMPID



radiator pressure (atm)	1	2.5	3	3.5
π threshold (GeV/c)	2.5	1.6	1.5	1.3
K threshold (GeV/c)	9	5.6	5.1	4.8
p threshold (GeV/c)	17	11	9.8	9.1

focusing RICH

C_4F_8O radiator, pressurized

CsI photocathode with MWPC

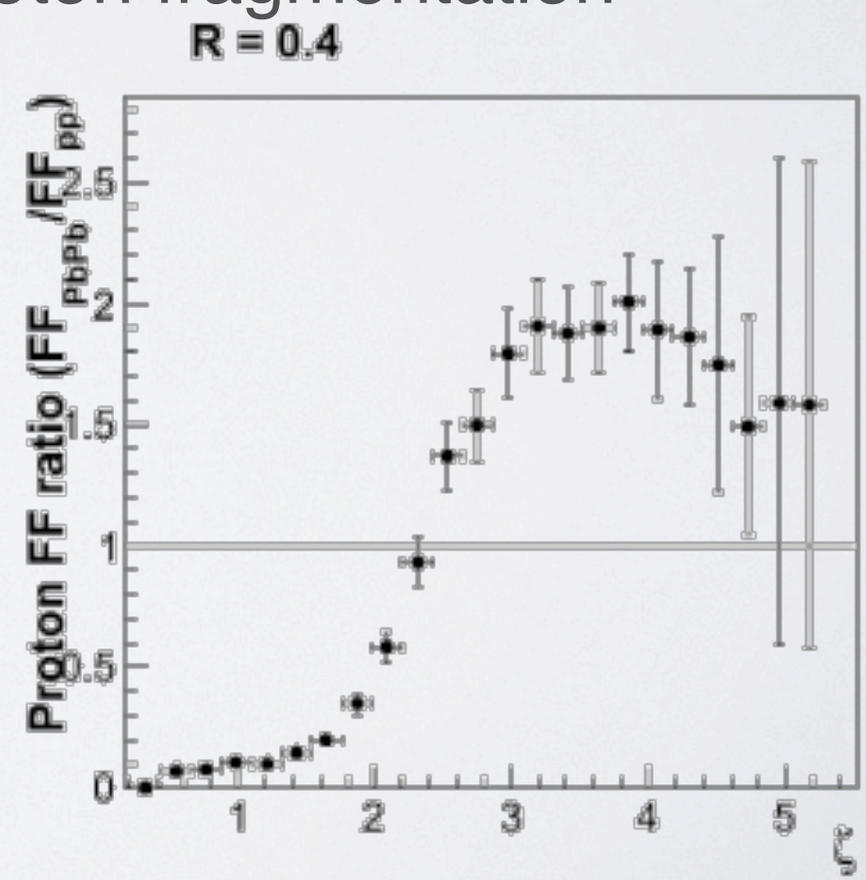
readout: HMPID FEE (Gassiplex)

possibly dedicated trigger detector

combine VHMPID with DCAL in the same acceptance

study hadron PID in jets!

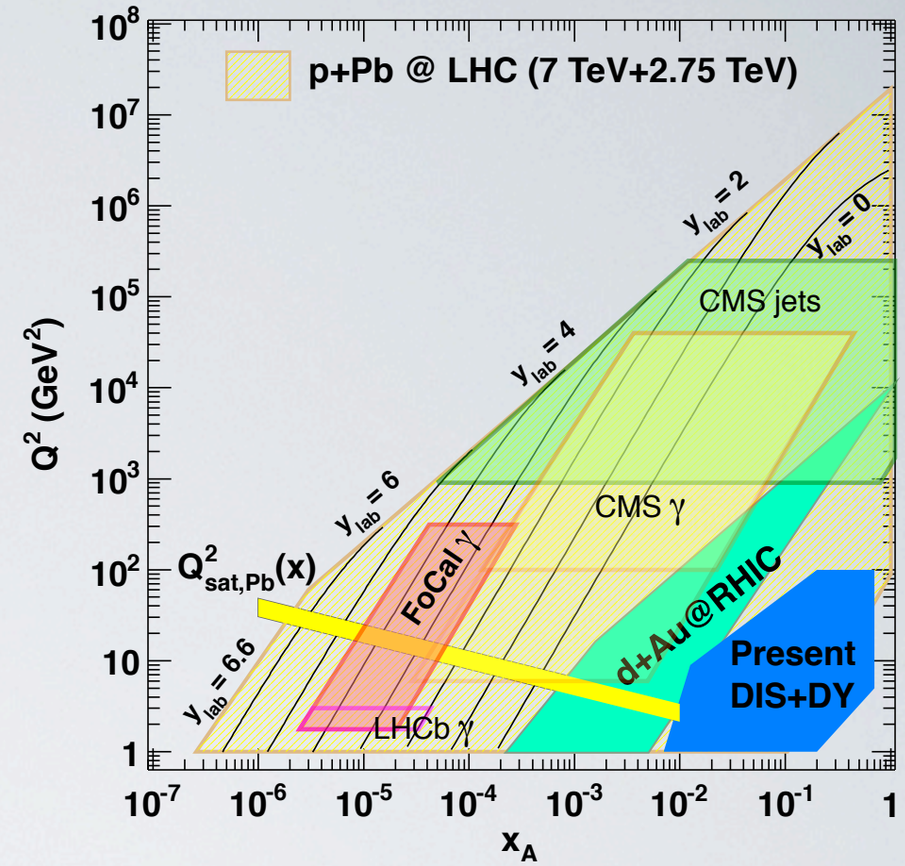
e.g. nuclear modification of proton fragmentation

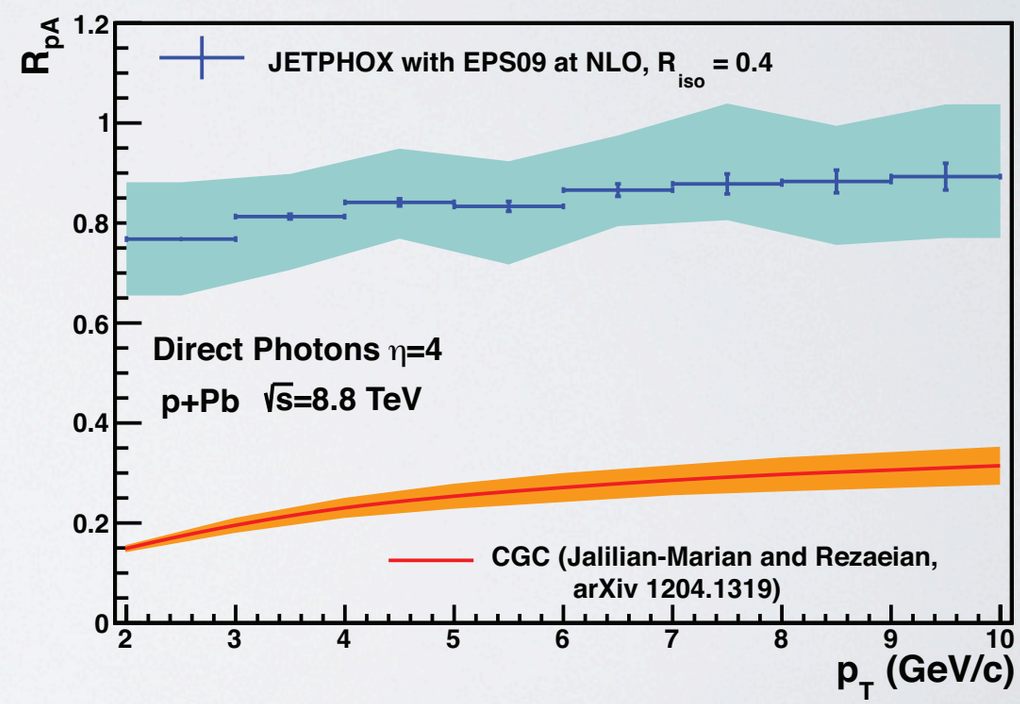


poster by A. Harton (ID 499)

Small-x Physics

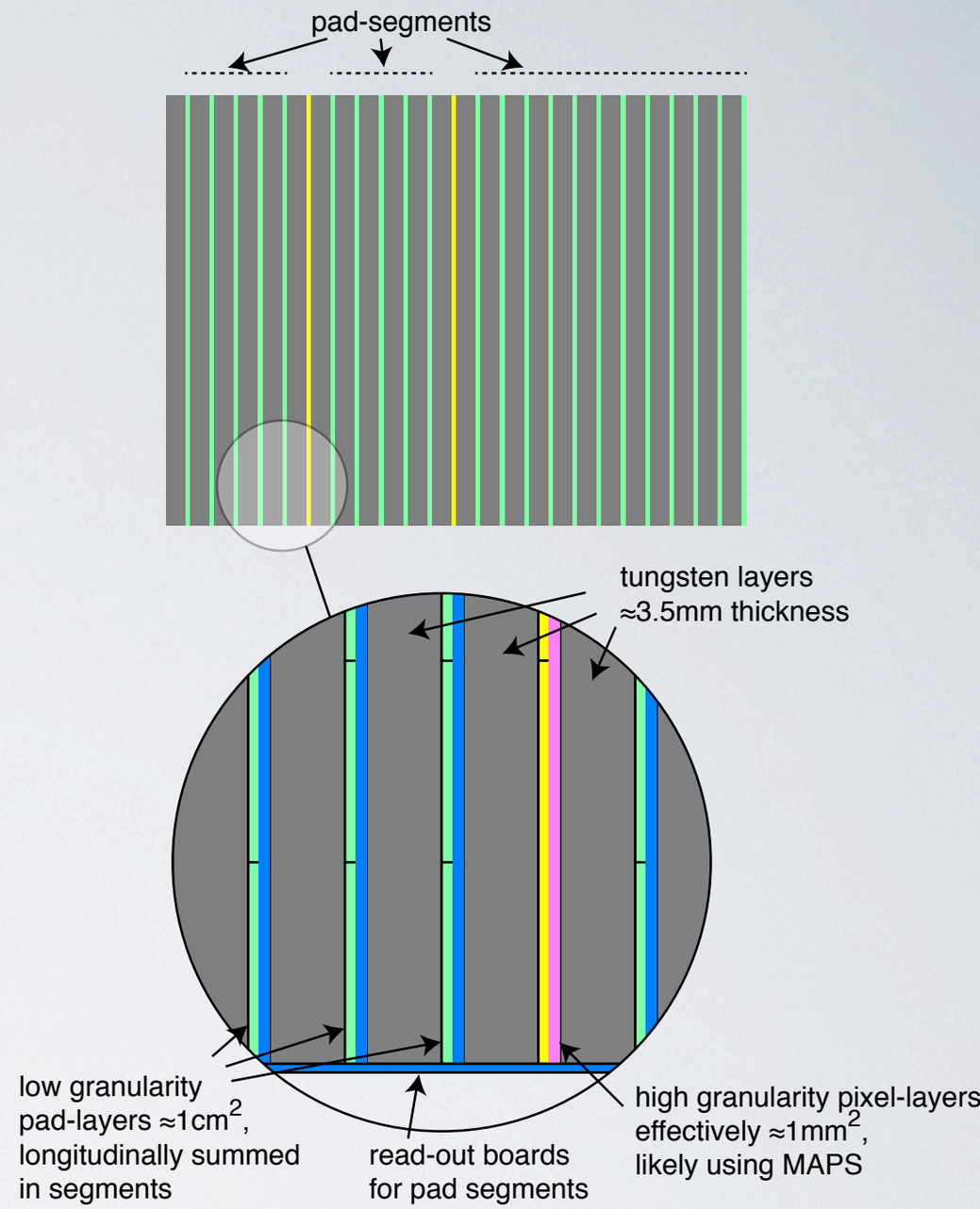
- enters new regime at LHC
  - larger phase space than at RHIC
- unique opportunity for ALICE
  - use highest rapidity possible ($\eta > 3$), with significant p_T range
  - direct photon measurement cleanest!
    - x-sensitivity, no final state effects
- studies of gluon saturation
  - expect transition from pQCD to CGC
  - p_T and y not precisely known
  - requires significant p_T coverage for direct photons at large y

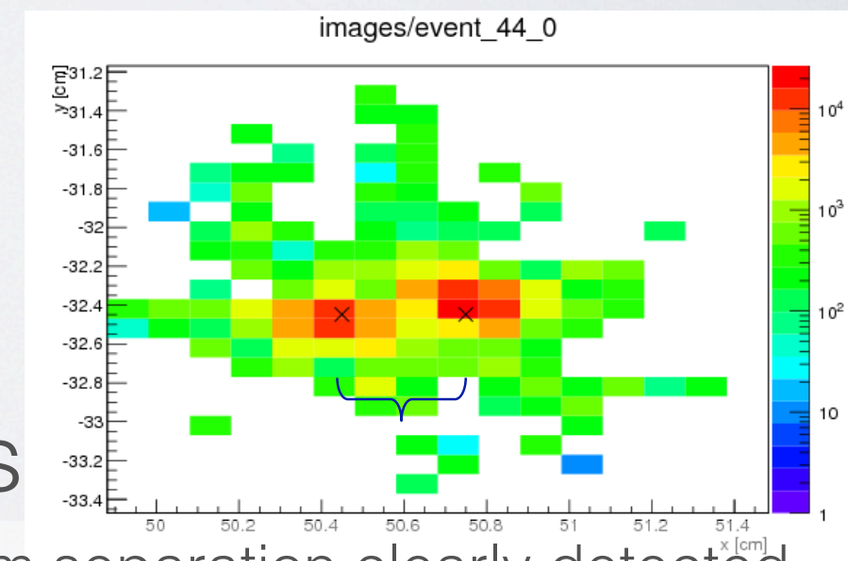




FoCal

- SiW electromagnetic calorimeter
  - two options for location
    - 3.5 m from IP, $2.5 < \eta < 4.2$
    - 8 m from IP, $3.3 < \eta < 5.0$
    - optional hadronic calorimeter
- 2 technologies
  - low-granularity conventional Si-pads
  - high-granularity ≈ 1 mm^2
    - needed for π^0/γ discrimination
    - likely using MAPS
- also allows studies of γ-jet correlations





4mm separation clearly detected

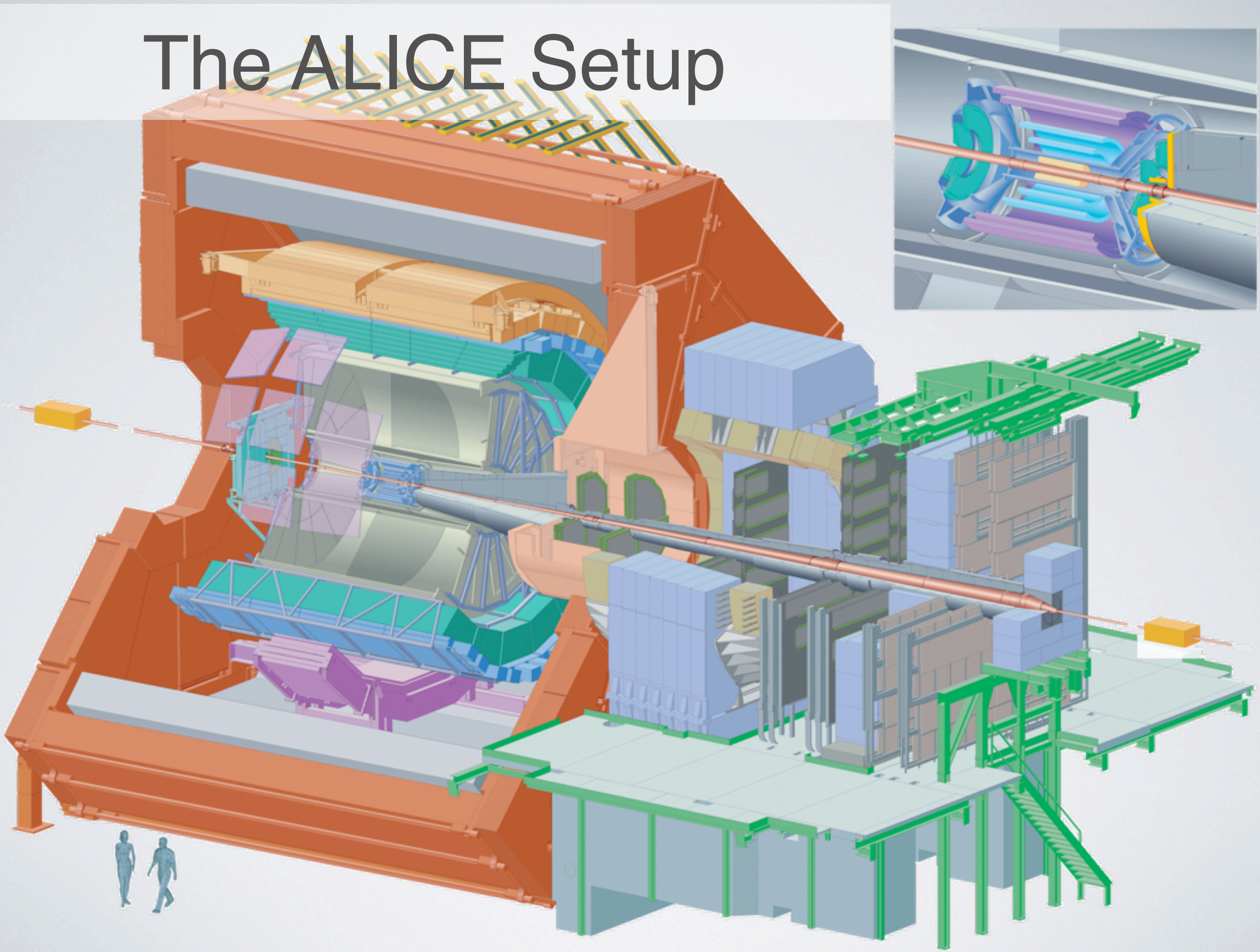
posters by T. Gunji (ID 498, 143),
N. Poljak (ID 118)

Summary

- ALICE has strong physics program for precision QGP studies
  - unique in rare low-p_T probes
  - requires ITS upgrade, enhanced rate capabilities + running beyond LS3
    - significant R&D program for upgrades
- further enhancement of the ALICE setup under investigation, possibly
  - strengthening muon measurement and high p_T hadron ID
  - exploring forward physics

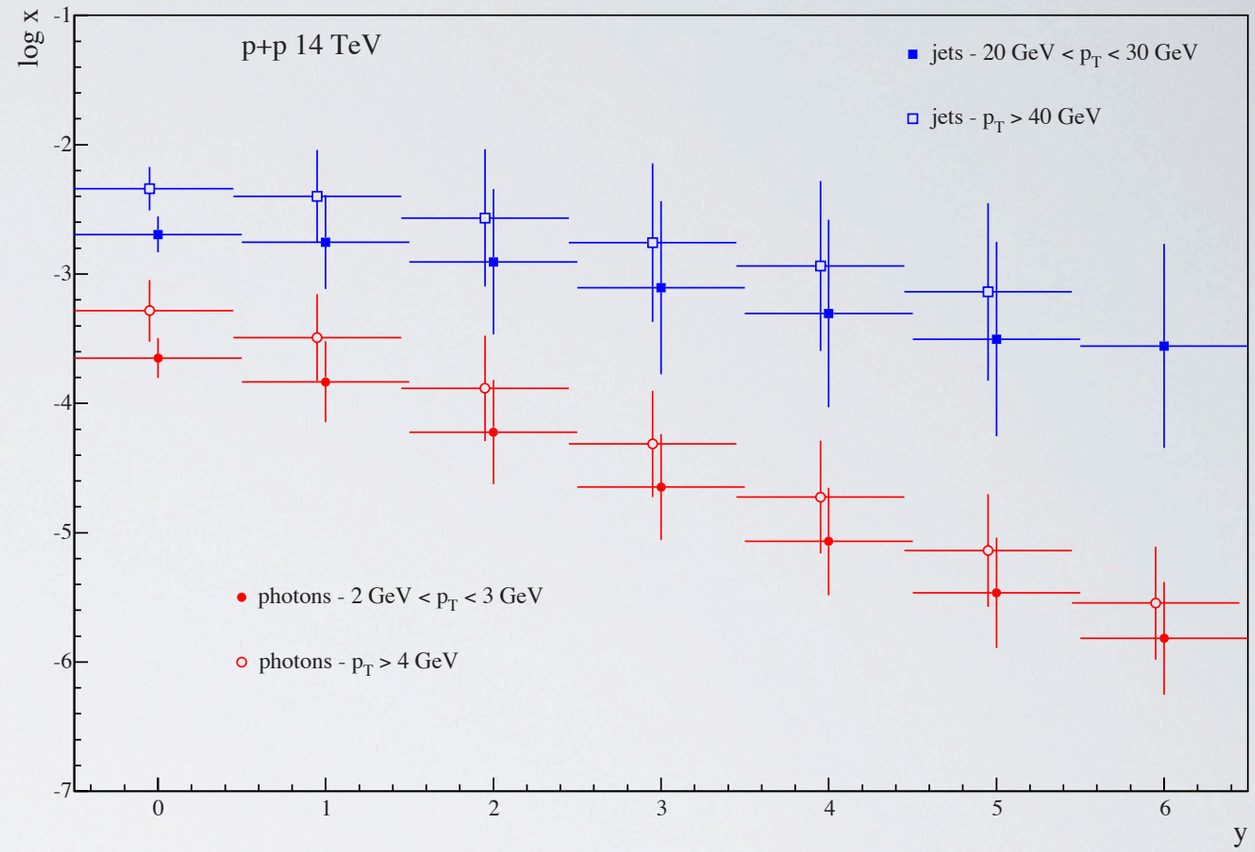
Backup Slides

The ALICE Setup



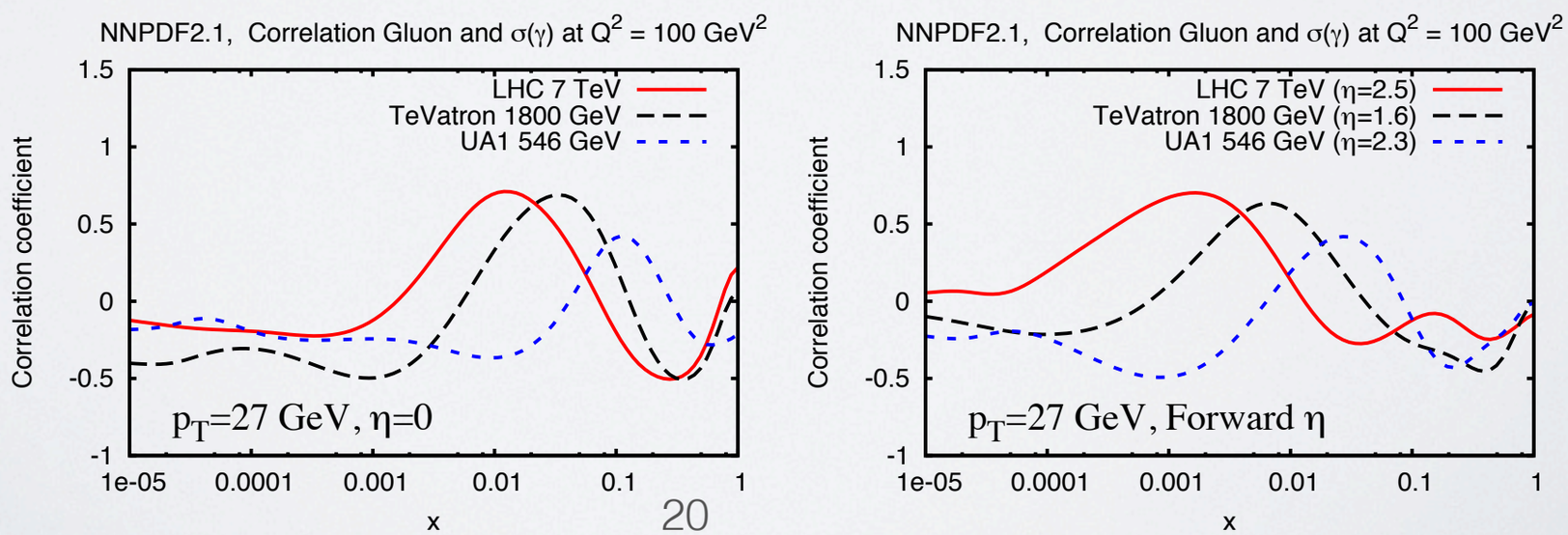
Kinematic Constraints

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

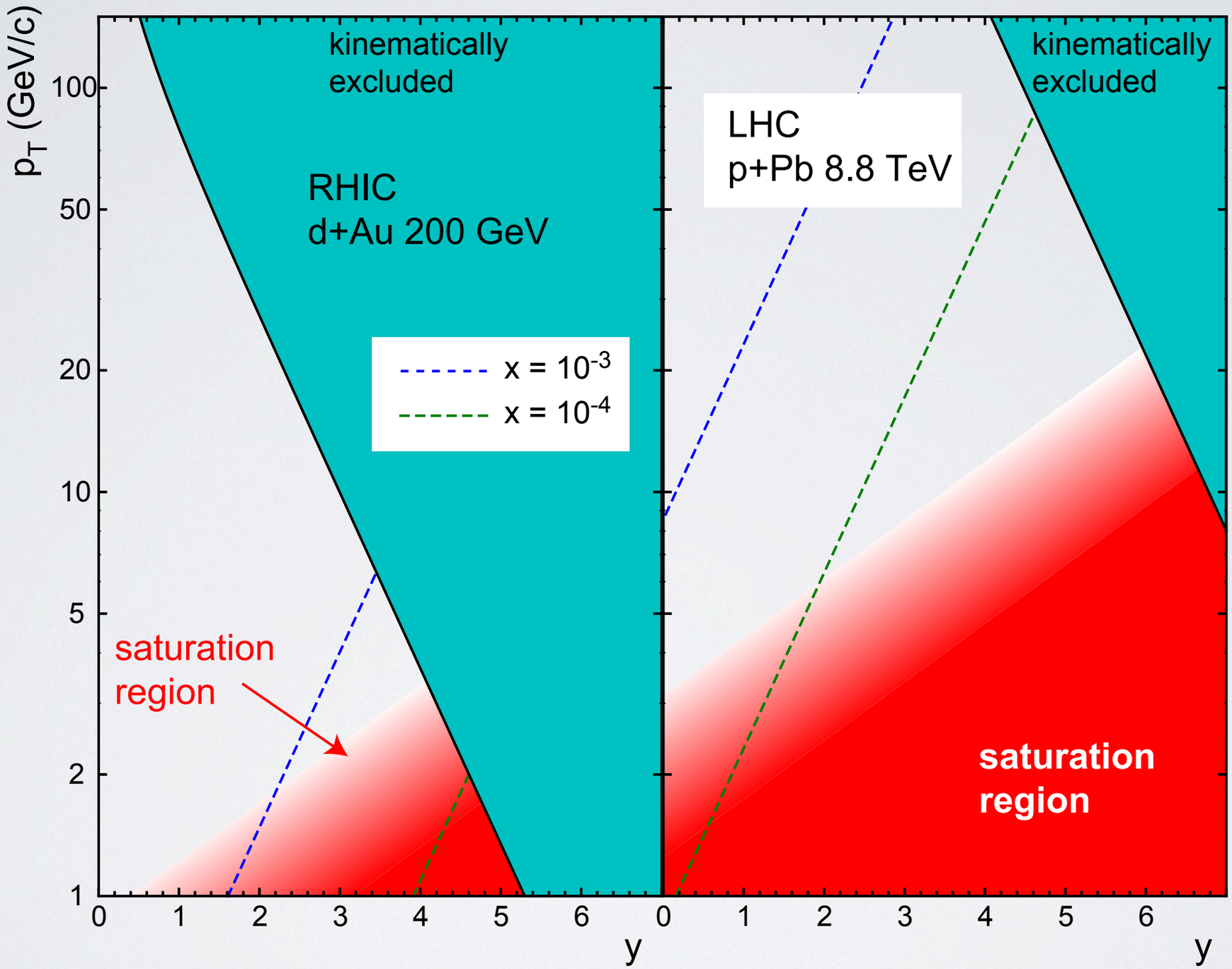


- NLO studies in JETPHOX:
  - indicate clear sensitivity of isolated photons, dedicated calculations under way

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



Saturation at RHIC and LHC



larger phase space for saturation effects at LHC