Exploring the LHC medium with ALICE

A. Marin,
for the ALICE Collaboration

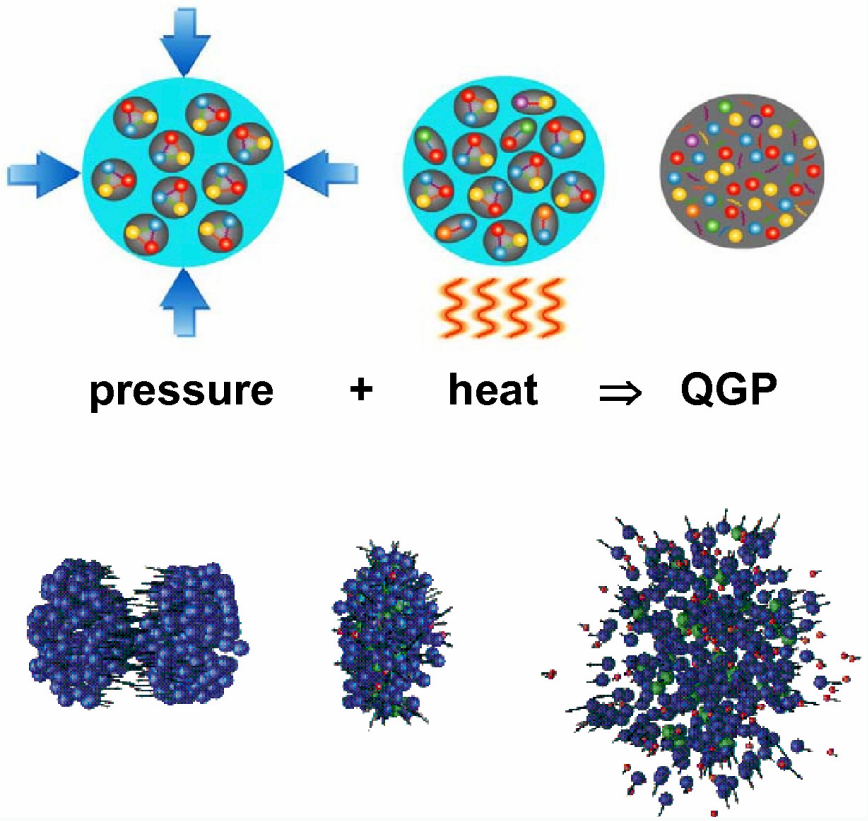
BMBF Forschungsschwerpunkt
ALICE Experiment 201

EMMI ExtreMe Matter Institute EMMI

Goals of High Energy Heavy-Ion Collisions

- Understand 2 basic properties of the strong interaction: (de)confinement, chiral symm. breaking/restoration
- Probe conditions quark-hadron phase transition in primordial Universe (few μsec after the Big Bang)
- Study the phase diagram of QCD matter: produce and study the QGP
- Study the regime of non-linear (high density) many-body parton dynamics at small-x (CGC).

QGP in the laboratory



Key parameters: Bombarding energy and collision centrality

Probing Hot QCD Matter with hard probes

Hard Probes:

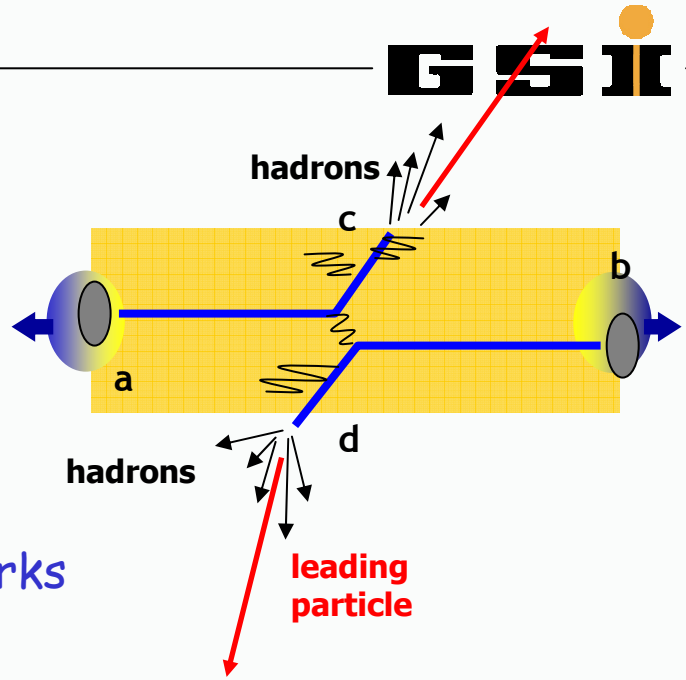
"highly penetrating observables (particles, radiation)
used to explore properties of matter that cannot be viewed directly!"

High p_T particles: π^0, η, direct γ
Heavy quarks

Hard probes

p+p:
- parton scattering → fragmentation → jet
- can be calculated in perturbative QCD
- collinear factorization

A+A:
- partons traversing medium lose energy
  gluon radiation, elastic collisions
- energy loss different for g, light/heavy quarks
  (color factor, dead cone effect)



X.-N. Wang, M. Gyulassy, Phys. Rev. Lett. ***68*** *(1992) 1480*

Goal: Use in-medium energy loss to measure medium properties

$$\frac{d\sigma^{h}_{pp}}{dy d^{2}p_{T}} = K \sum_{abcd} \int dx_{a}\, dx_{b}\, f_{a}(x_{a},Q^{2})\, f_{b}(x_{b},Q^{2}) \frac{d\sigma}{d\hat{t}}(ab \rightarrow cd) \frac{D^{0}_{h/c}}{\pi z_{c}}$$

Parton distribution function	Matrix element	Fragmentation function
measured in DIS initial state (saturation?)	pQCD	$e^{+}e^{-}$ final state (energy loss?)

Two examples of Interesting results from RHIC

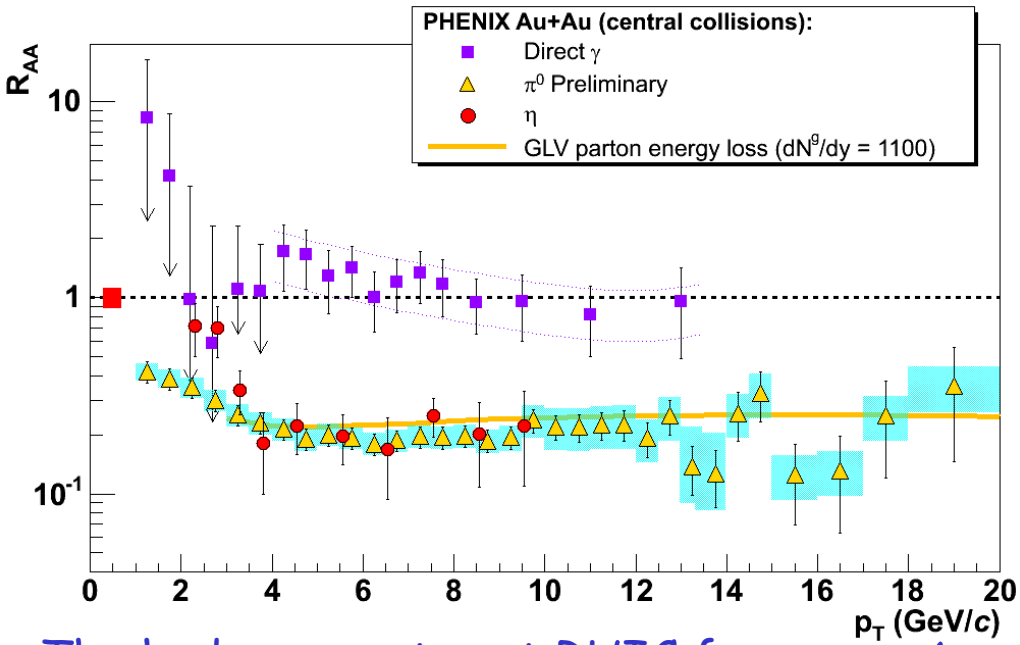
Nuclear modification factor for:

$$R_{AA}(p_t) = \frac{1}{\langle N_{coll} \rangle} \times \frac{dN_{AA}/dp_t}{dN_{pp}/dp_t}$$

- π^0, η, direct γ (not coming from neutral meson decays)
- Charm. Heavy flavour electrons (not photonic, or dielectron decays of mesons, or direct γ, or J/ψ and Υ)

and status in ALICE...

R_{AA} for π^0, η and direct γ



$R_{AA}^{\gamma} \sim = 1$

$R_{AA}^{\pi^0,\eta} \sim = 0.2$

The hadron spectra at RHIC from p+p, Au+Au and d+Au collisions establish existence of *parton energy loss* from strongly interacting, dense QCD matter in central Au-Au collisions

$\langle \hat{q} \rangle$ = 4 – 13 GeV^2 / fm

$dN^g/dy \sim 1400 +- 200$

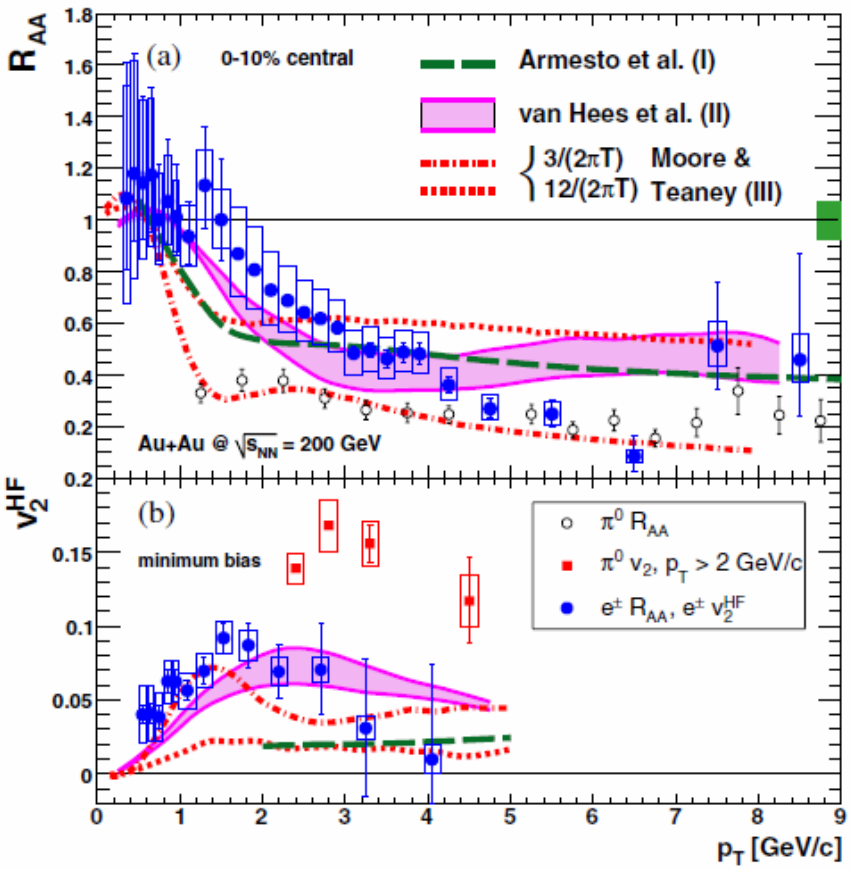
S. Bass et al. PRC79 (2009) 024901

https://wiki.bnl.gov/TECHQM/index.php/Main_page

Theory-Experiment Collaboration on Hot Quark Matter

Heavy flavour electrons

Phys. Rev. Lett. 98, 172301 (2007)



$$\Delta E_{loss}(g) > \Delta E_{loss}(q) > \Delta E_{loss}(Q)$$

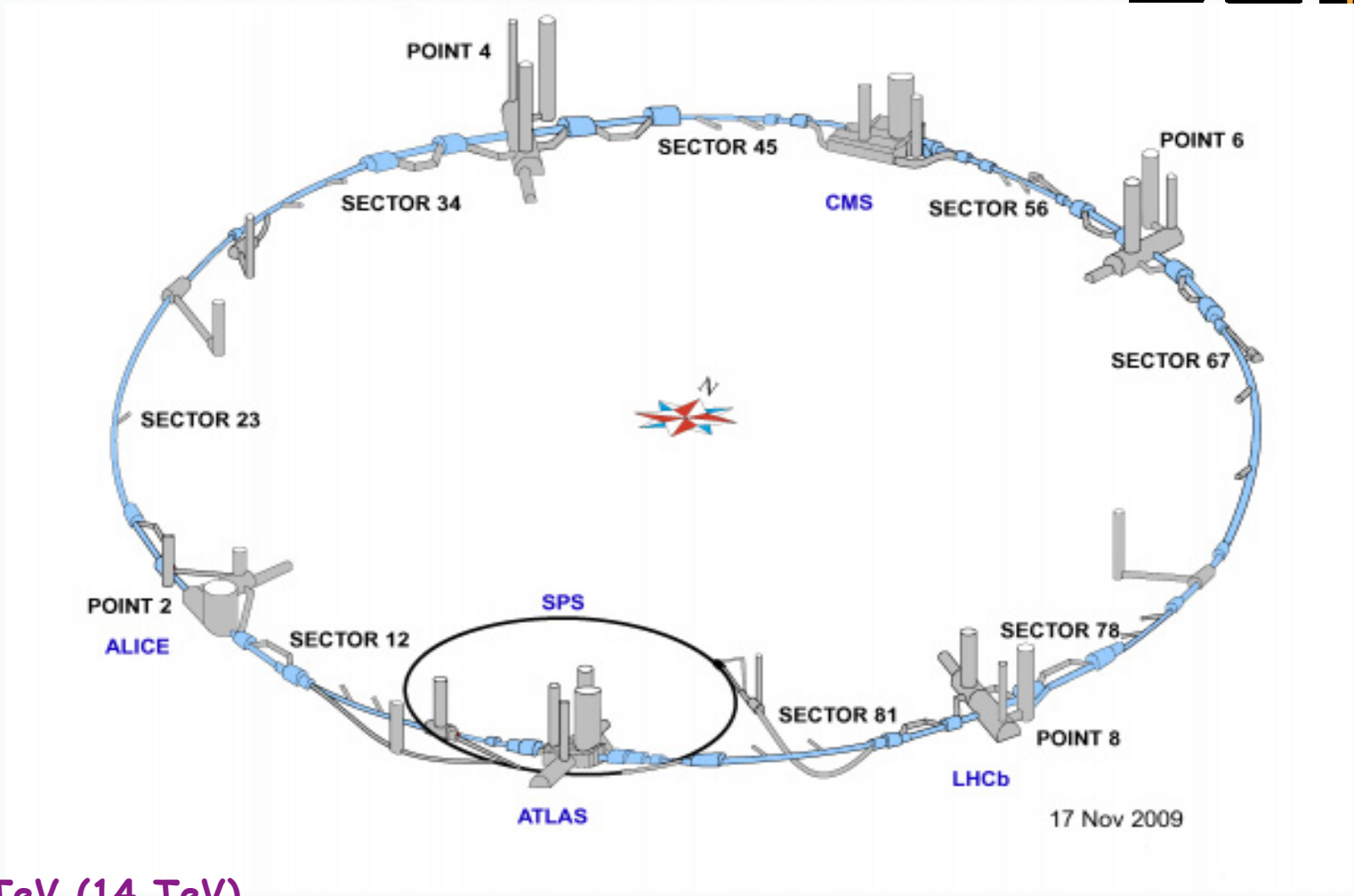
(color factor) (dead-cone effect)

But, strong suppresion of heavy flavour electrons observed

Models have difficulties to explain both R_{AA} and v_2

van Hees *et al.*: only elastic scattering mediated by resonance excitation of D and B-like states

The LHC

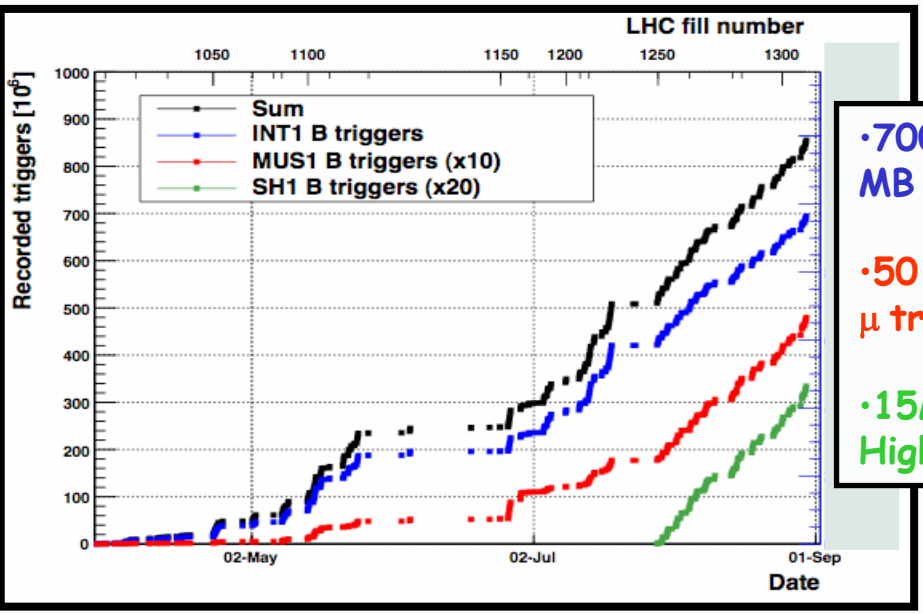


p+p @ 7 TeV (14 TeV)
Pb+Pb @ 2.76 ATeV (5.5ATeV)

Physics with pp

- collect 'comparison data' for heavy-ion program
  - many signals measured 'relative' to pp
  - requires ~ 10^9 minimum-bias event
- comprehensive study of MB@LHC
  - tuning of Event Generators

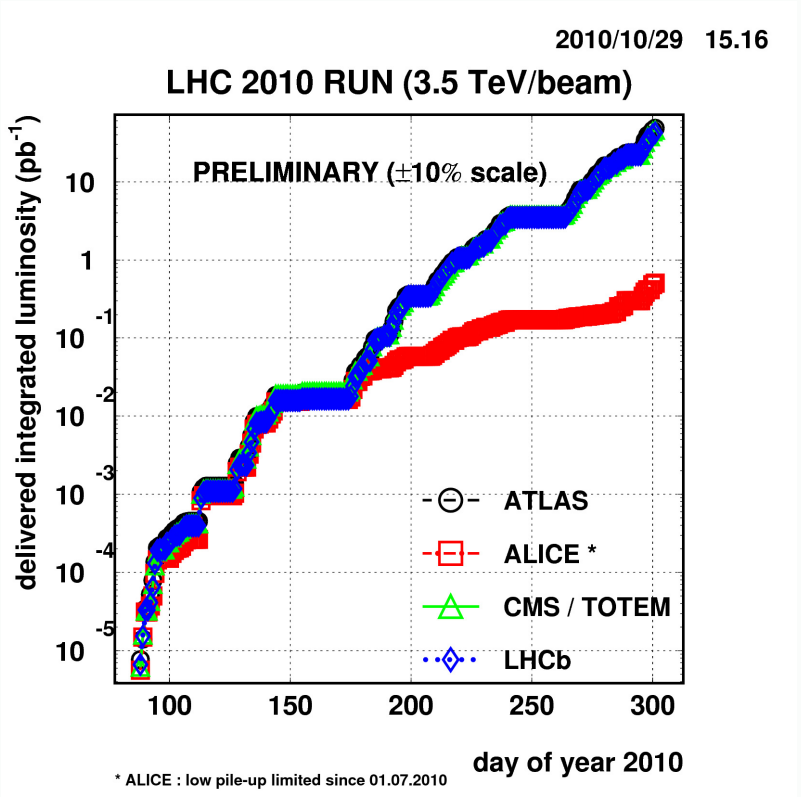
Reduced luminosity since 01/07
displaced beams (3.8σ)
μ < 0.05 (low pileup)



·700 M MB triggers

·50 M μ triggers

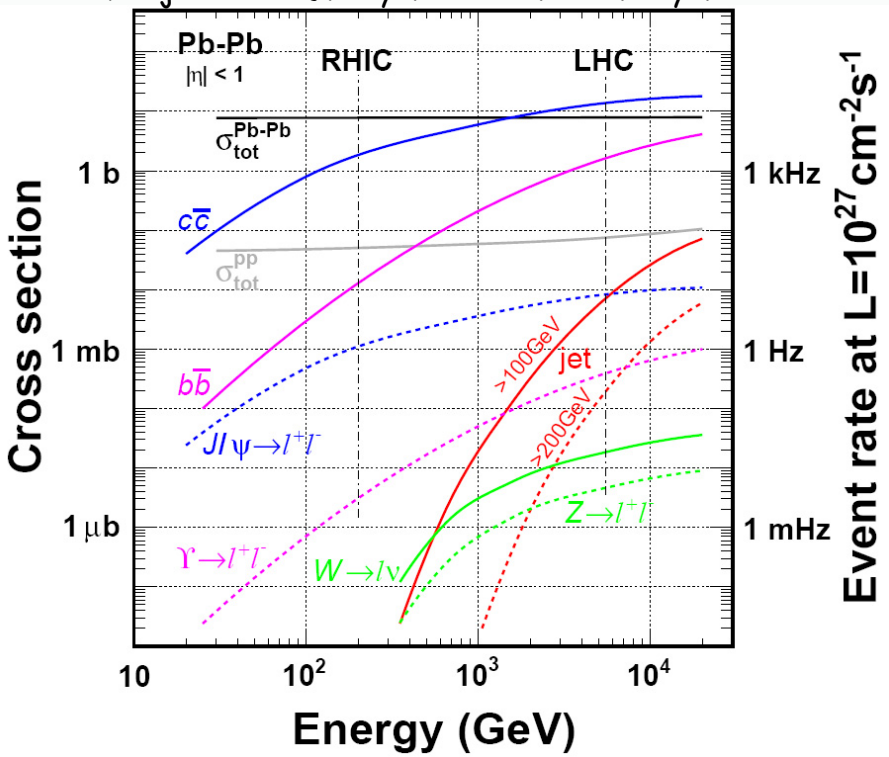
·15M High Mult



LHC: Entering a new regime

	SPS	RHIC	LHC
$\sqrt{s_{NN}}$ (GeV)	17	200	5500
dN_{ch}/dy	430	730	1000-4000
τ^0_{QGP} (fm/c)	1	0.2	0.1
T/T_c	1.1	1.9	3.0-4.7
ε (GeV/fm^3)	3	5	15-60
τ_{QGP} (fm/c)	≤2	2-4	≥10
τ_f (fm/c)	~10	20-30	15-60
V_f(fm^3)	few 10^3	few 10^4	few 10^5

C W Fabjan 2008 J. Phys. G: Nucl. Part. Phys. 35 104038



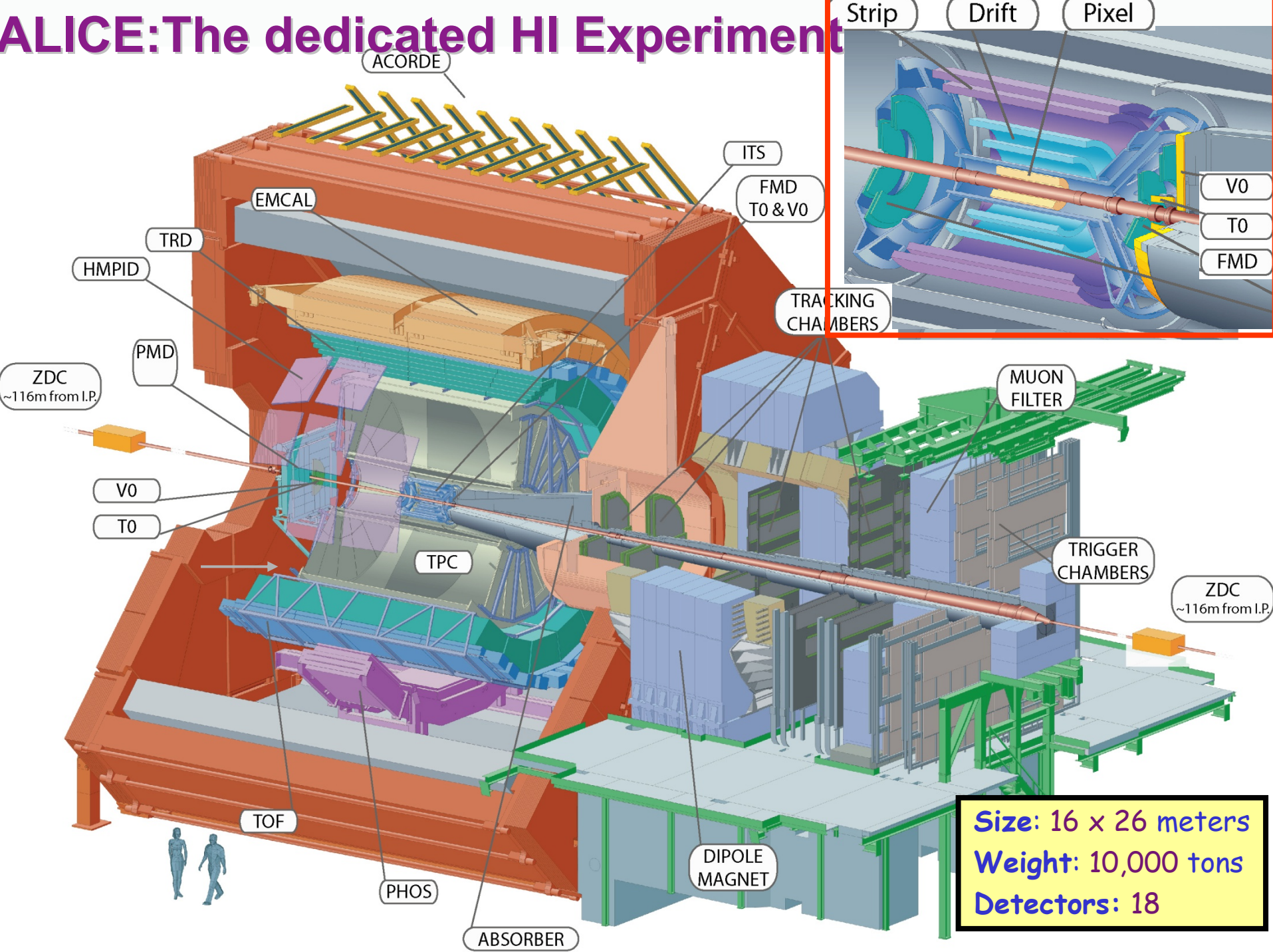
Cross-sections of interesting probes expected to increase by factors

~ 10 ($c\bar{c}$) ; ~ 10^2 ($b\bar{b}$)

~ > 10^5 (very high p_T jets) ; Hard probes of the medium accessible at LHC

Direct photons are abundantly produced at LHC

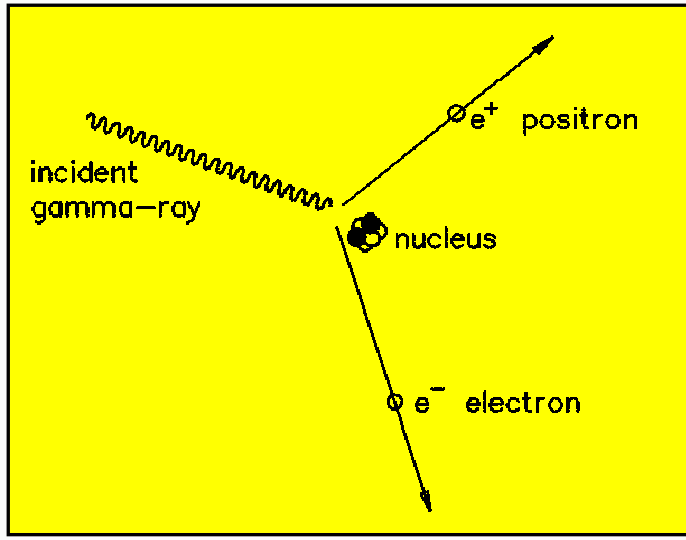
ALICE:The dedicated HI Experiment



Size: 16 x 26 meters
Weight: 10,000 tons
Detectors: 18

Interaction of photons with matter

- Photoelectric effect
- Compton scattering
- Pair production: $E\gamma > 1.02$MeV



- Electromagnetic Calorimeters:
The complete photon energy is deposited in the detector (electromagnetic shower)

- Photon measurement via pair conversions:
Determine photon momentum and direction by measuring e^+/e^- from a single γ conversion in tracking detectors

ALICE (ITS+TPC+TRD)

X-rays

Hand mit Ringen (Hand with Rings): print of Wilhelm Roentgen's first "medical"X-ray, of his wife's hand, taken on 22 December 1895 and presented to Professor Ludwig Zehnder of the Physik Institut, University of Freiburg, on 1 January 1896

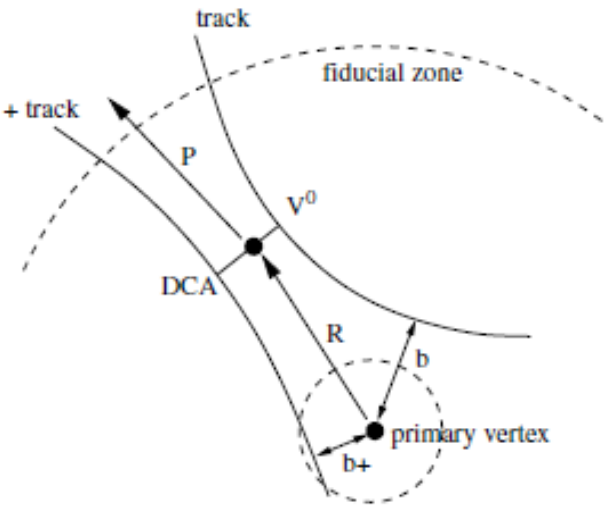
Used commonly in medicine for diagnostics of different diseases

Equipment:

- X-rays tube
- Photographic plate
- Patient

$\pi^0 \rightarrow \gamma\gamma$ (from pp collisions@LHC $\sqrt{s}$=7TeV)
Tracking Detectors (ITS+TPC)
ALICE material budget

V^0:Secondary vertex reconstruction



Reconstruction of

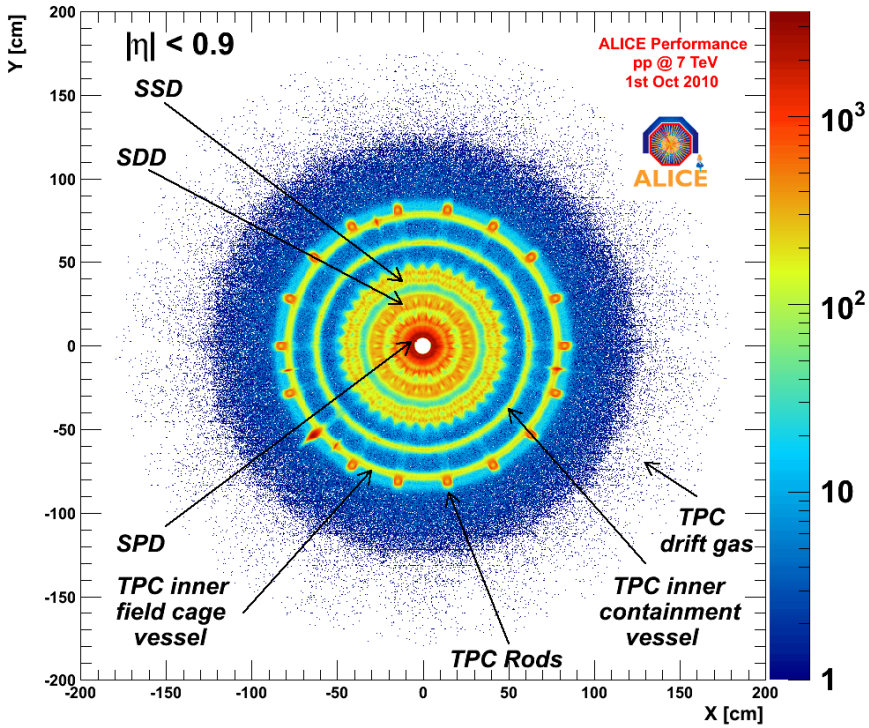
- strange hadrons:
  - K^0_S: m=497.614 MeV/c^2, $c\tau$=2.6842cm
  - $\Lambda, \overline{\Lambda}$: m=1115.683 MeV/$c^2$, $c\tau$=7.89cm
- converted photons in material (Z)
  - $\gamma Z \rightarrow e^+e^-Z$

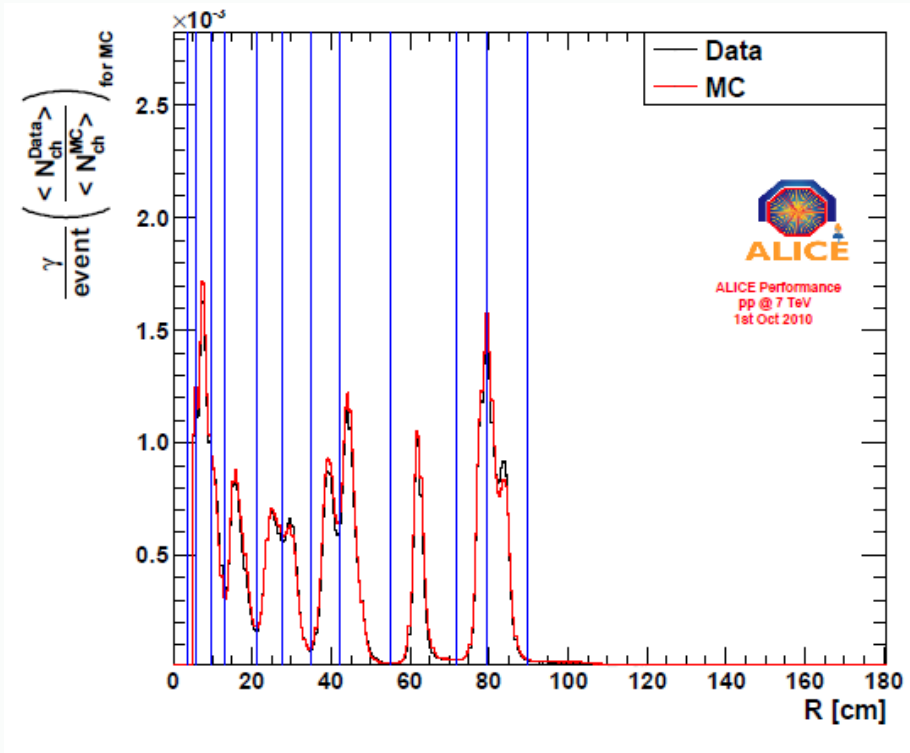
For analysis:

Package for fitting decay particles based on the Kalman Filter

Photons from pair conversions: γ-ray image of ALICE

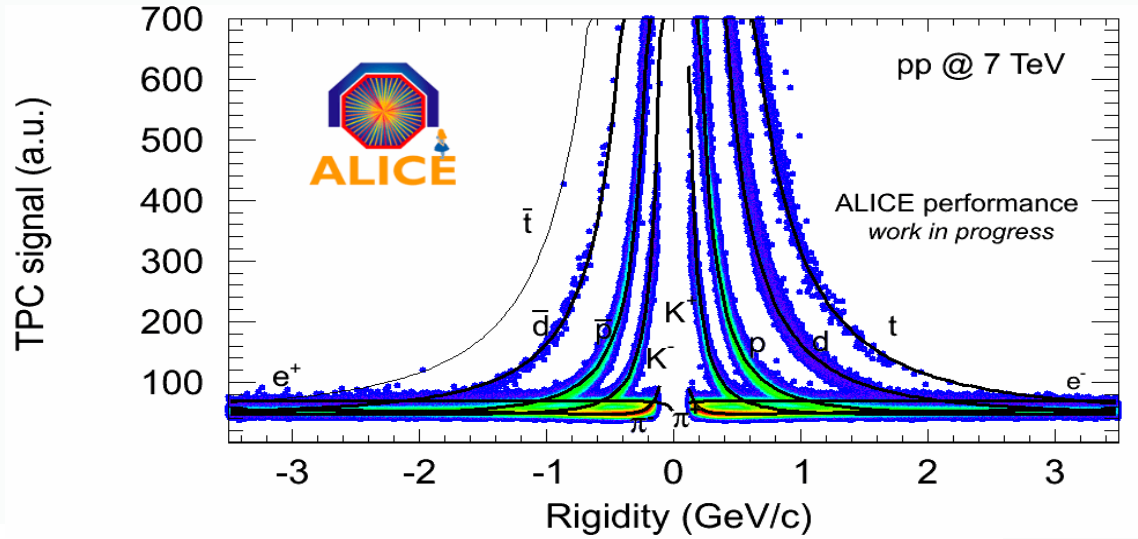
converted photons in material (Z): $\gamma Z \rightarrow e^+e^-Z$

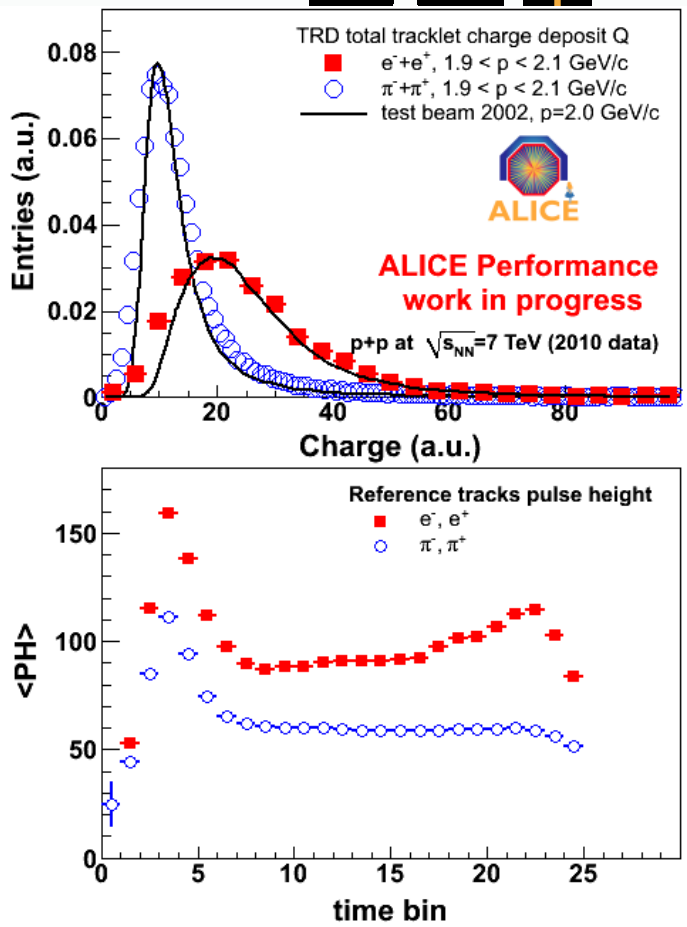


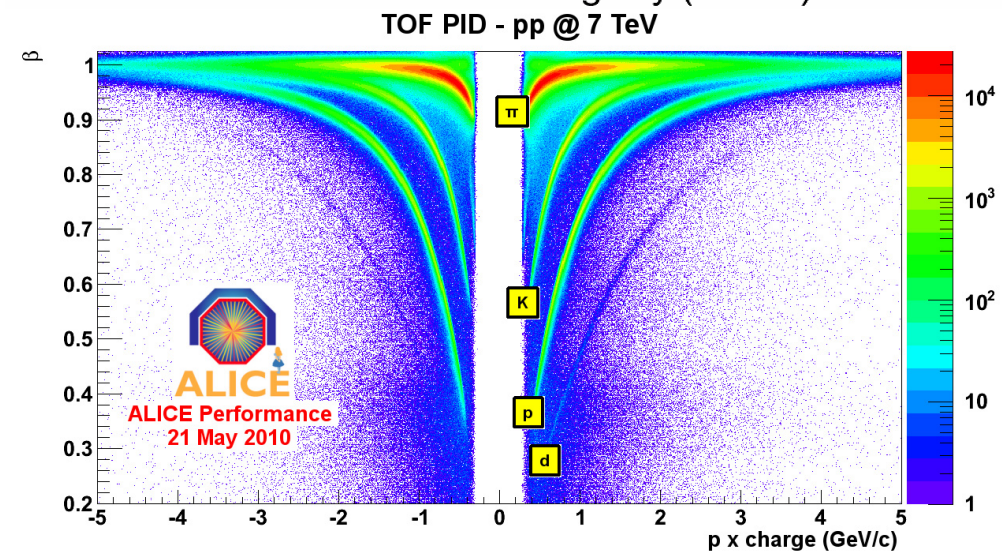


ALICE material budget agrees within +-6% with its implementation in GEANT simulations

ALICE PID capabilities



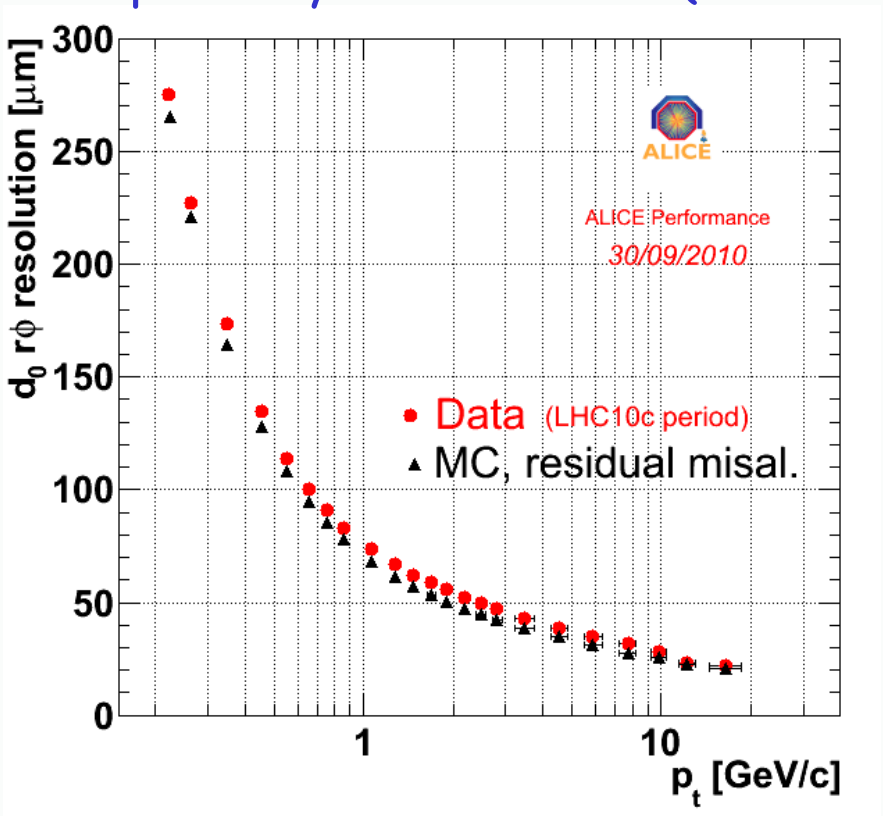


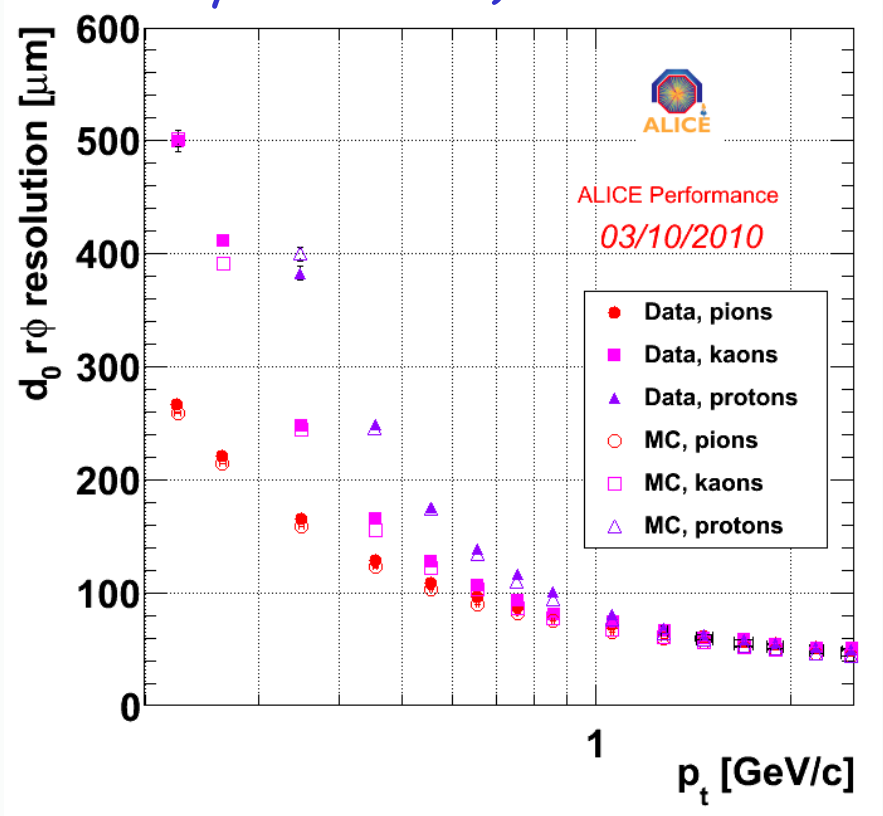


Excellent particle ID
up to ~ 50 to 60 GeV/c

Tracking and vertexing precision

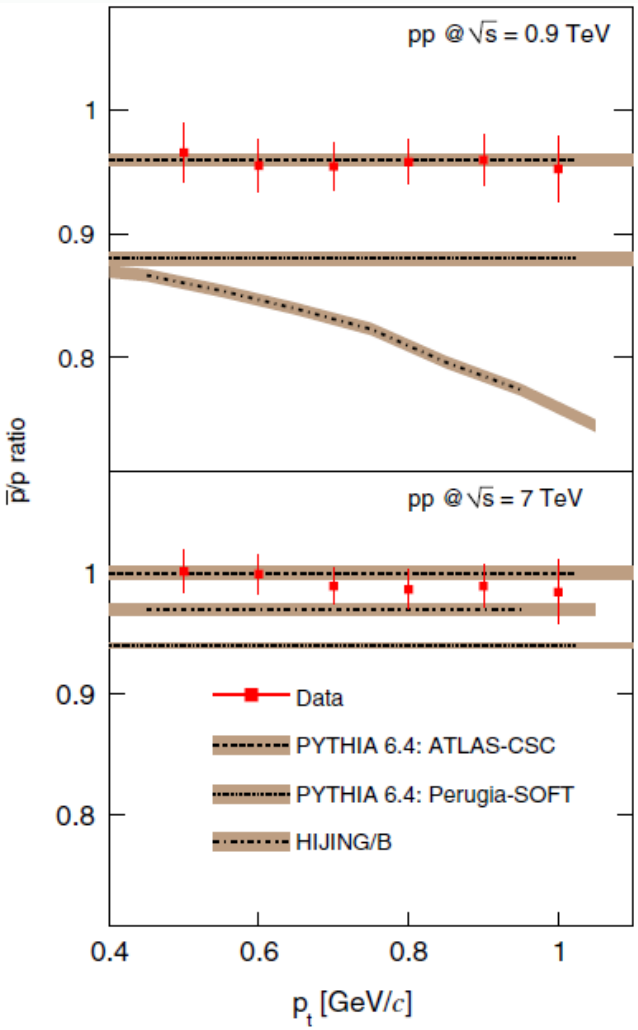
Inner Tracking System (ITS) with 6 Si layers
Two pixel layers at 3.8 cm (closest barrel layer at LHC!) and 7 cm



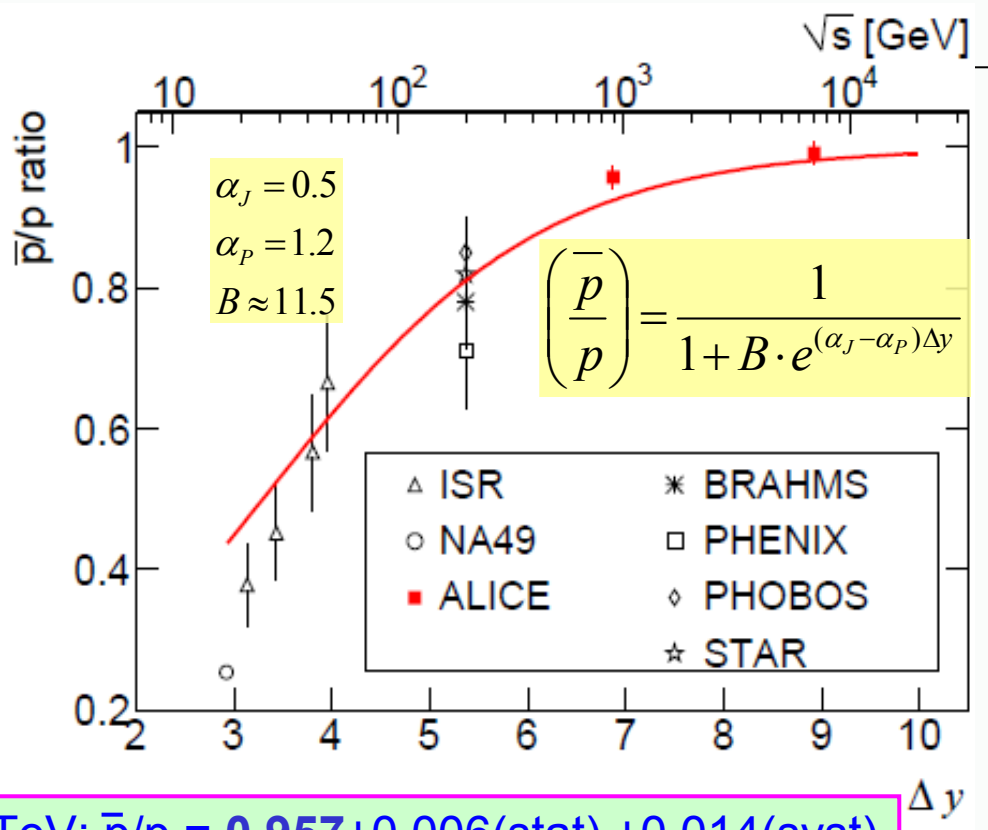


Key (together with PID) for charm and beauty measurements

$\bar{p}/p$ ratio @ LHC



PRL 105 (2010) 072002



0.9 TeV: $\bar{p}/p$ = **0.957**±0.006(stat) ±0.014(syst)

7 TeV: $\bar{p}/p$ = **0.990**±0.006(stat) ±0.014(syst)

$\bar{p}/p$ ratio ~1 at LHC

Little room for **any** additional diagrams
which transport baryon number over large rapidity gaps

Neutral meson (π^0, η) measurement:

- Test of NLO pQCD, sensitive to fragmentation function at low z
- Needed to extract direct photons
- Reference data for PbPb

π^0 and η reconstruction

$pp \rightarrow \pi^0 + X_n$

$\gamma\gamma$

$e^+e^-e^+e^-$

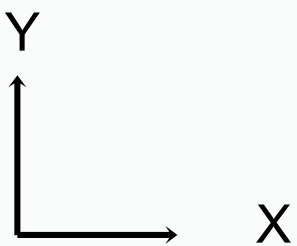
($m_{\pi 0}$ = 0.135 GeV/c^2, BR = 0.988)

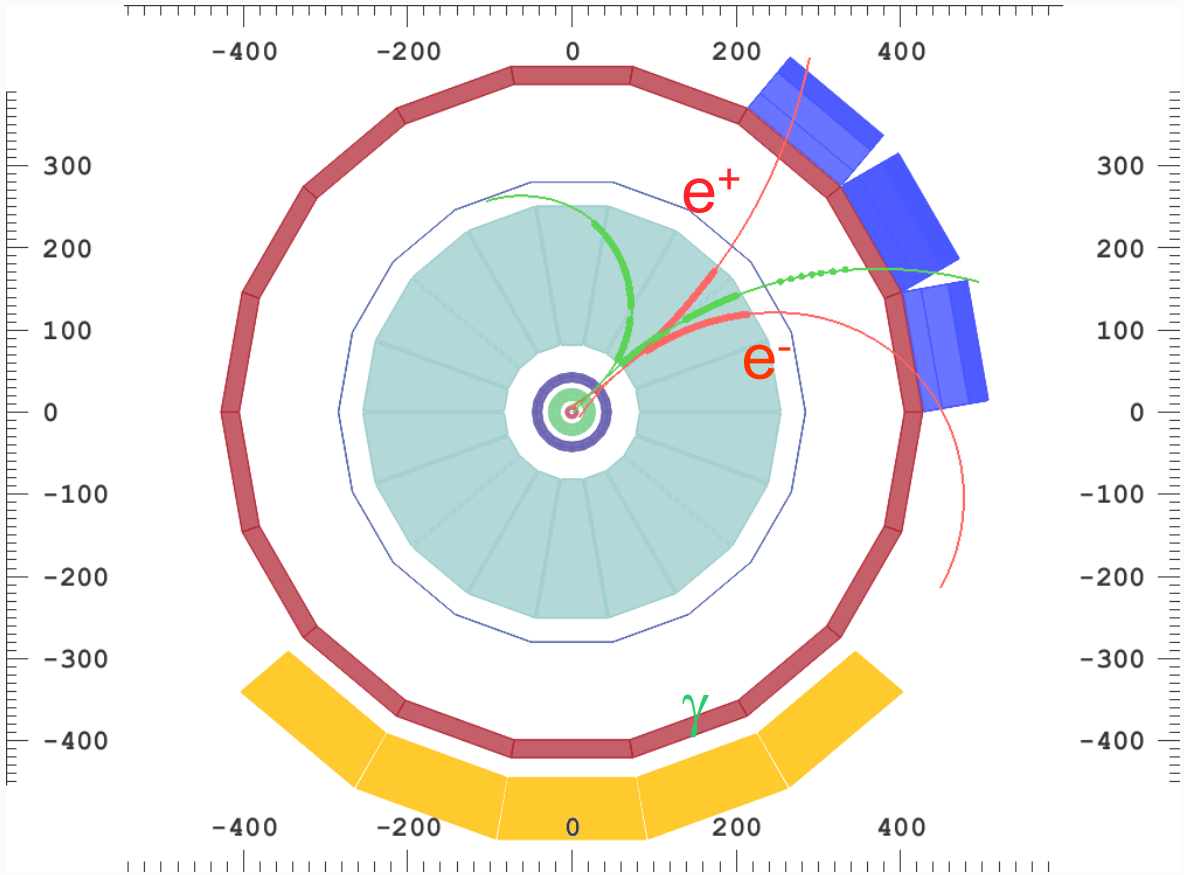
$pp \rightarrow \eta + X_n$

$\gamma\gamma$

$e^+e^-e^+e^-$

(m_η = 0.548 GeV/c^2, BR = 0.393)

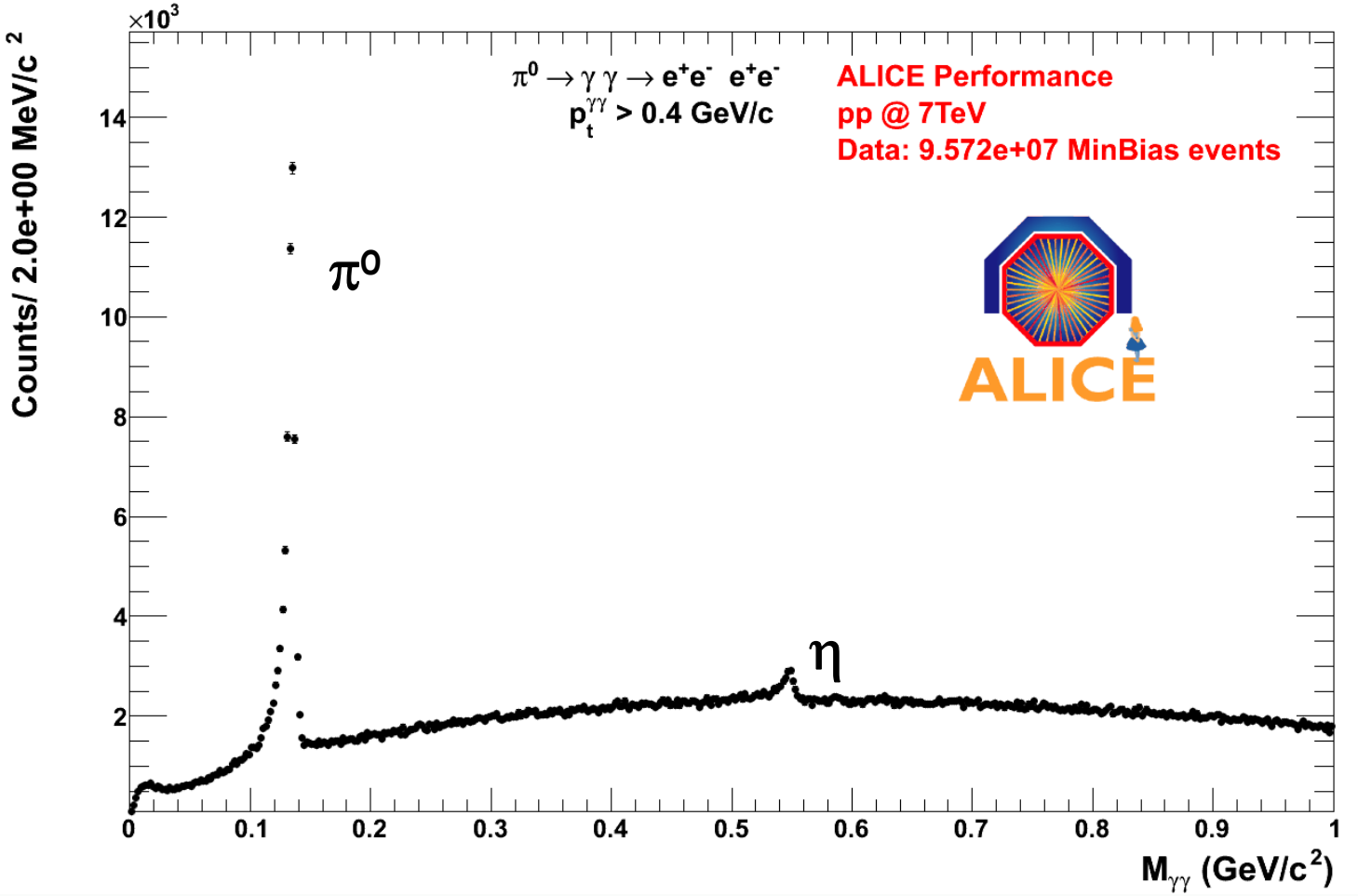




run 104792, event 2248

π^0 and η mesons @ 7TeV

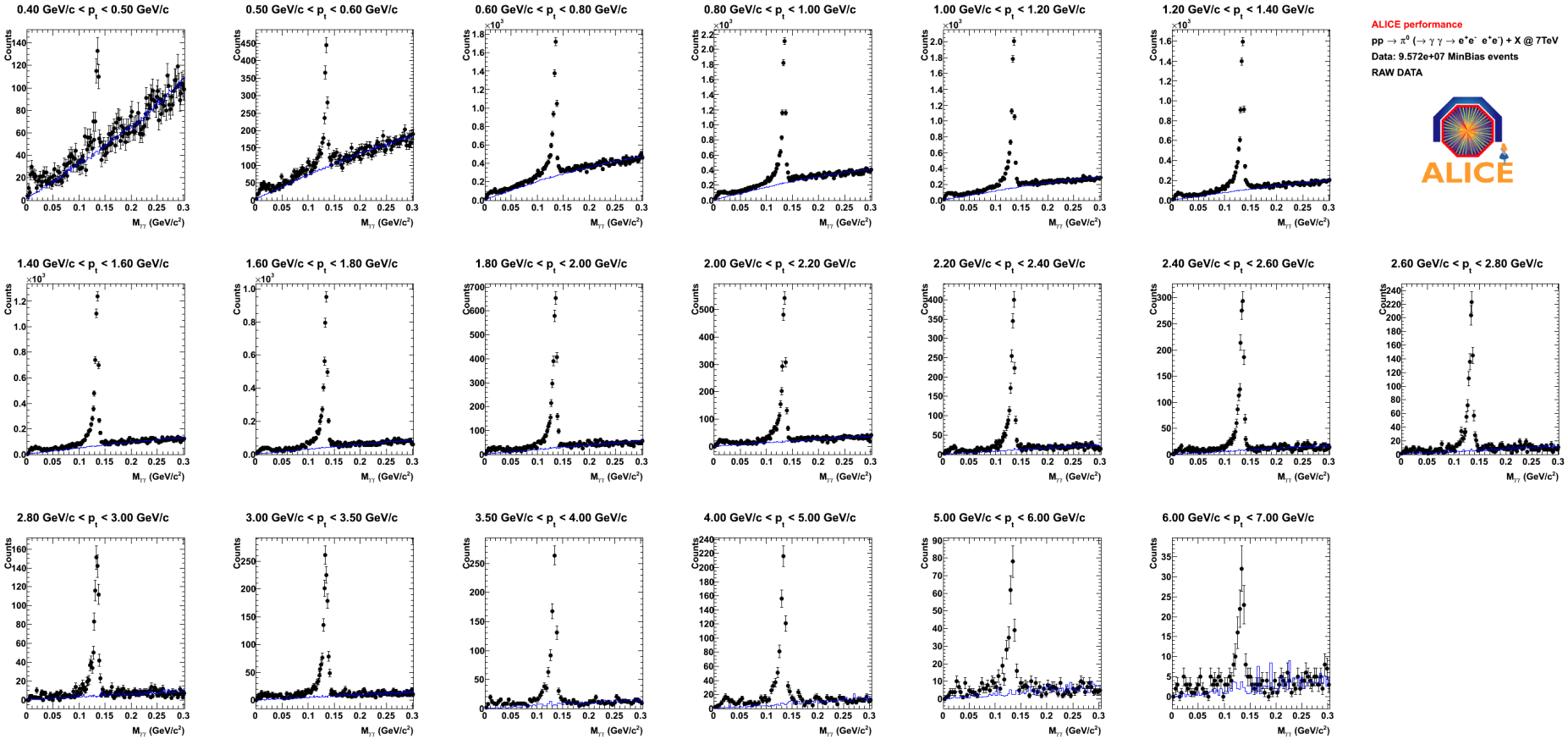
$$M_{\gamma_1\gamma_2} = \sqrt{2E_{\gamma_1}E_{\gamma_2}(1-\cos\theta_{\gamma_1\gamma_2})}$$



Data 7 TeV: π^0 invariant mass in p_t bins

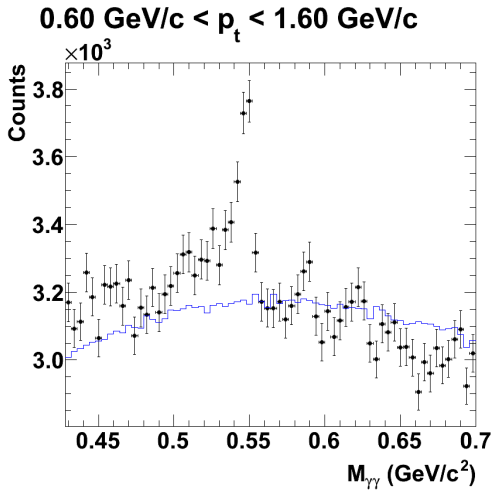
$M_{\gamma\gamma}$ 0.17-0.3 GeV/c^2 for normalization

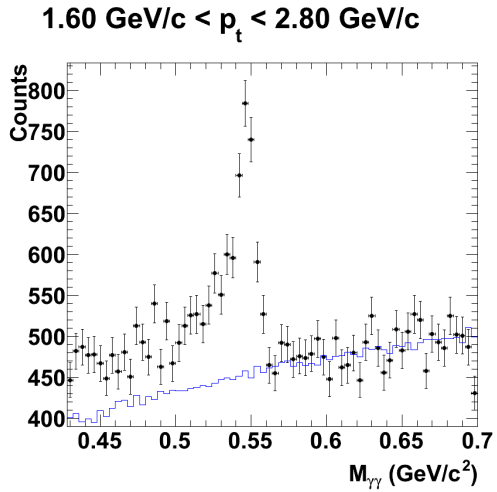
Very low p_t reached with the conversion method

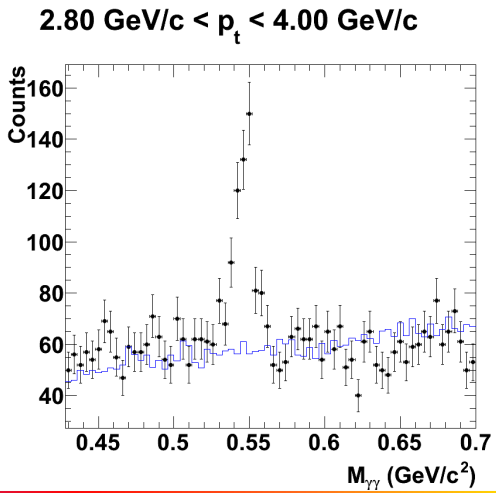


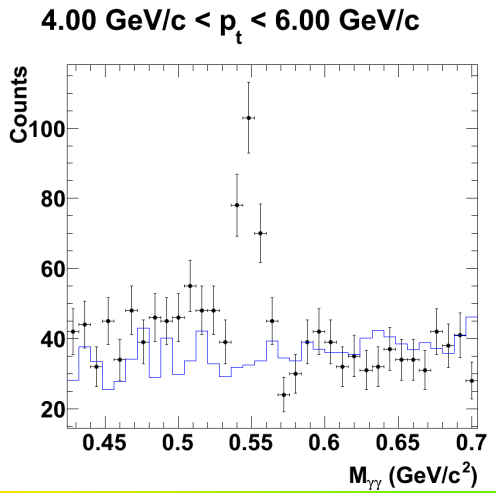
Data 7TeV: η invariant mass in p_t bins

$M_{\gamma\gamma}$ 0.6-0.7 GeV/c^2 for normalization









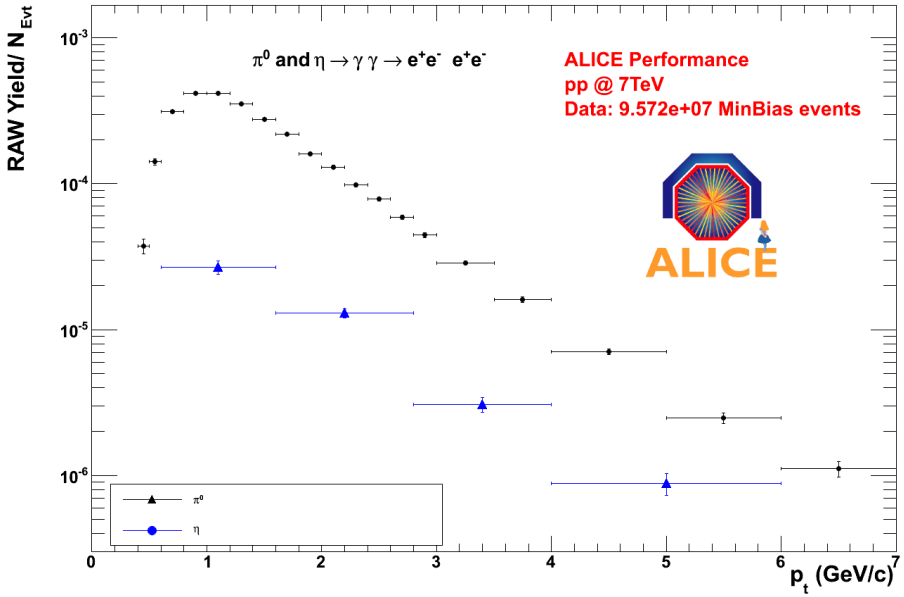
ALICE performance

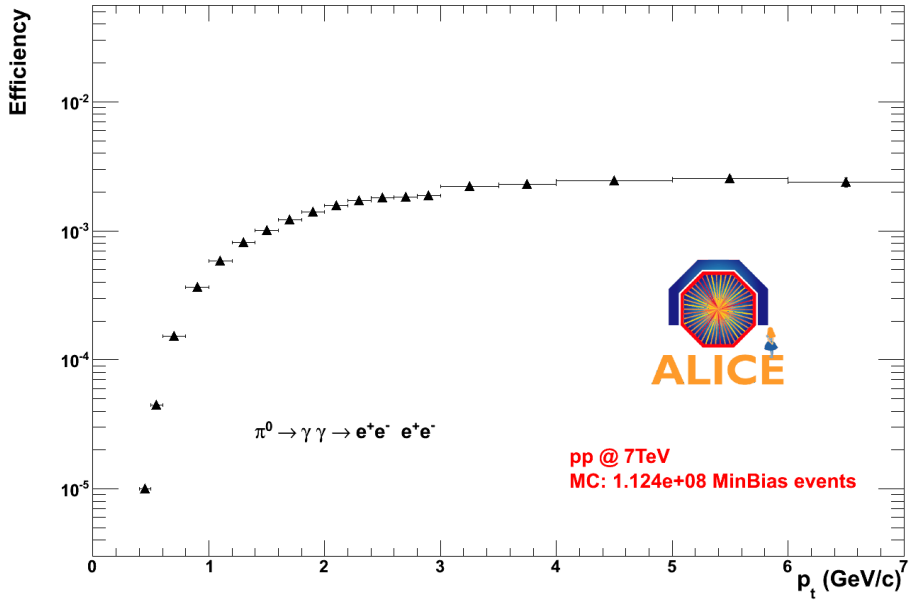
$pp \rightarrow \eta\ (\rightarrow \gamma\ \gamma \rightarrow e^+e^-\ e^+e^-) + X$ @ 7TeV

Data: 9.572e+07 MinBias events

RAW DATA

Raw yields. Reconstruction efficiency



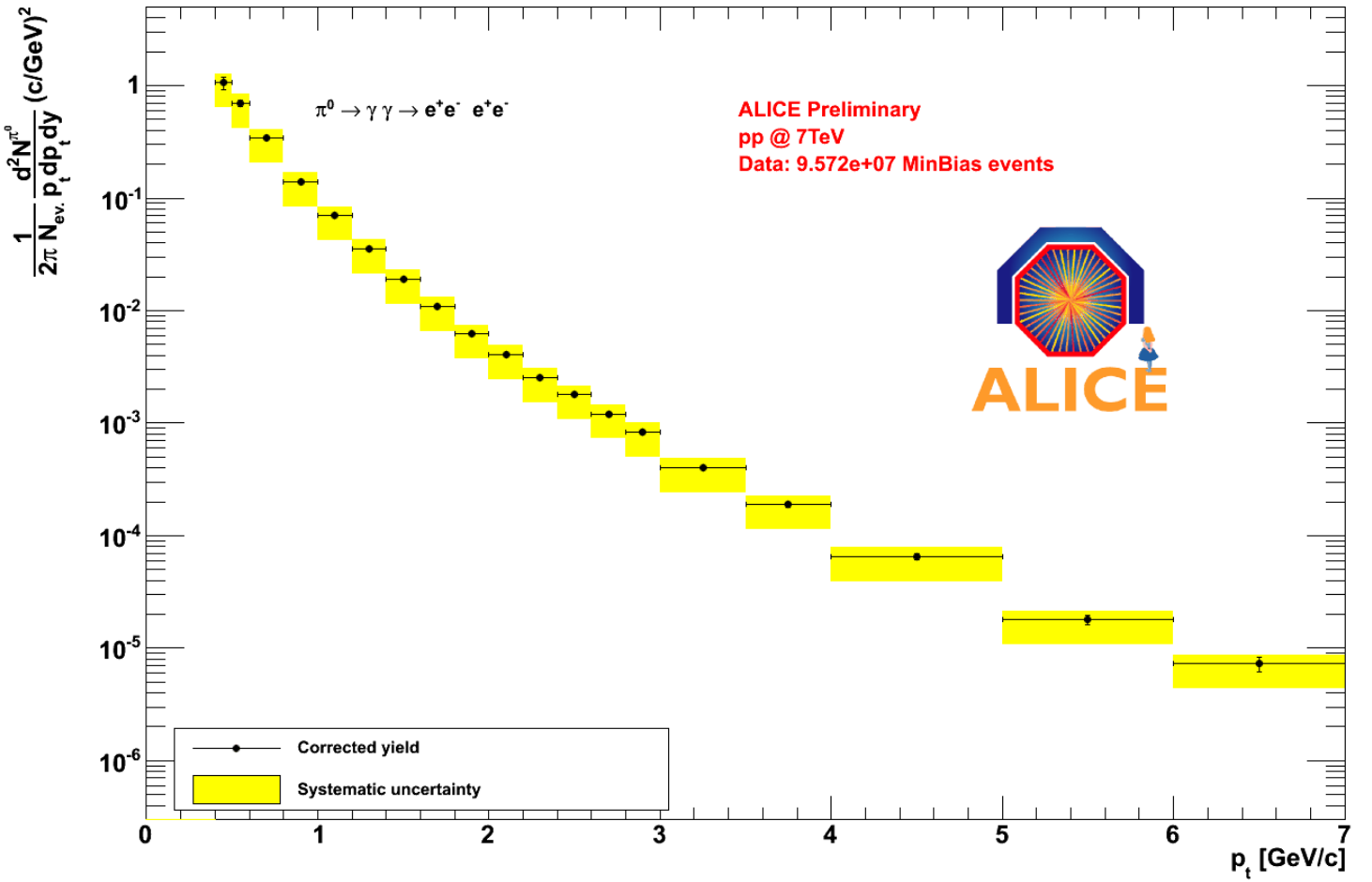


With 9.5×10^7 Minimum Bias collisions:

π^0 measured in 0.4 GeV/c < pt < 7GeV/c

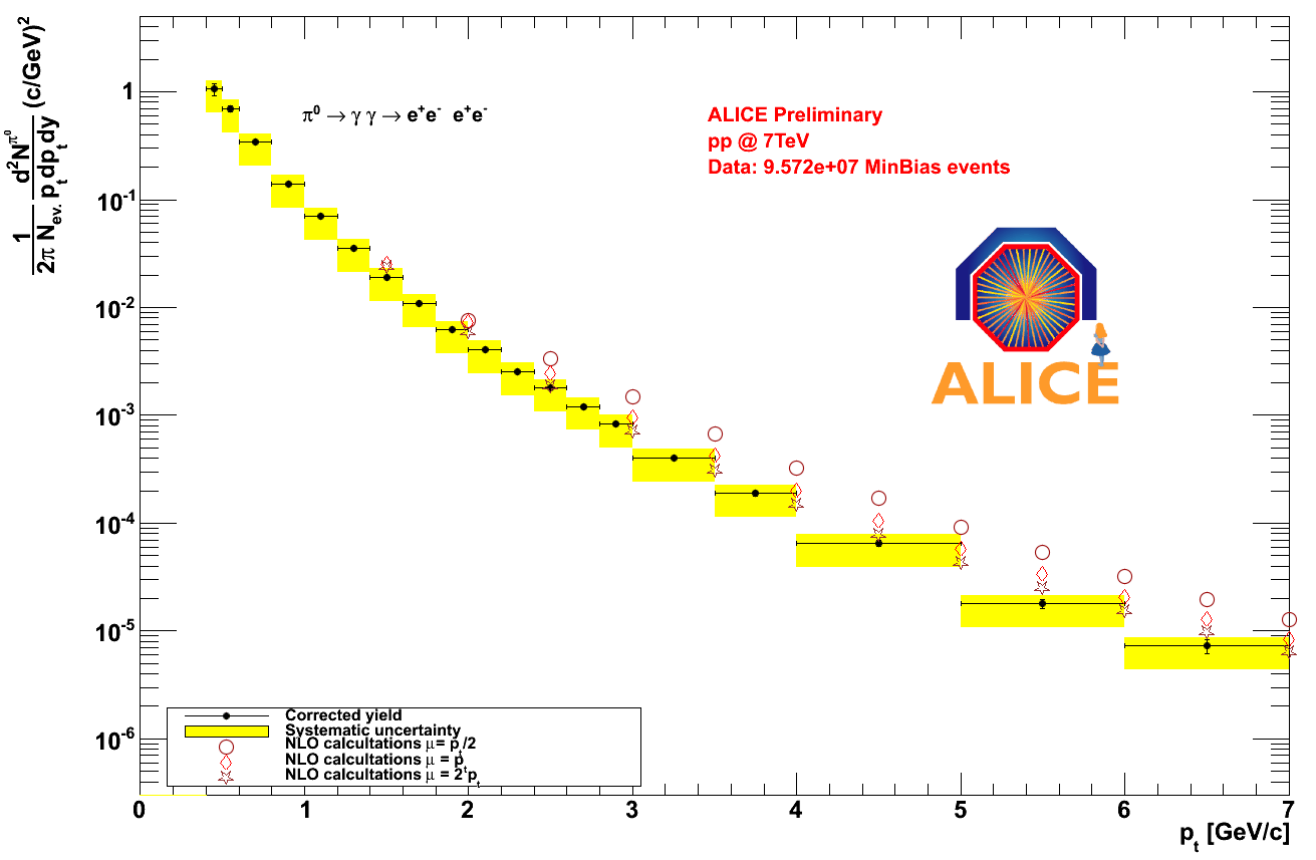
η measured in 0.6 GeV/c < pt< 6GeV/c

Fully corrected π^0 pt spectrum



π^0 spectrum measured in pp collisions@7 TeV

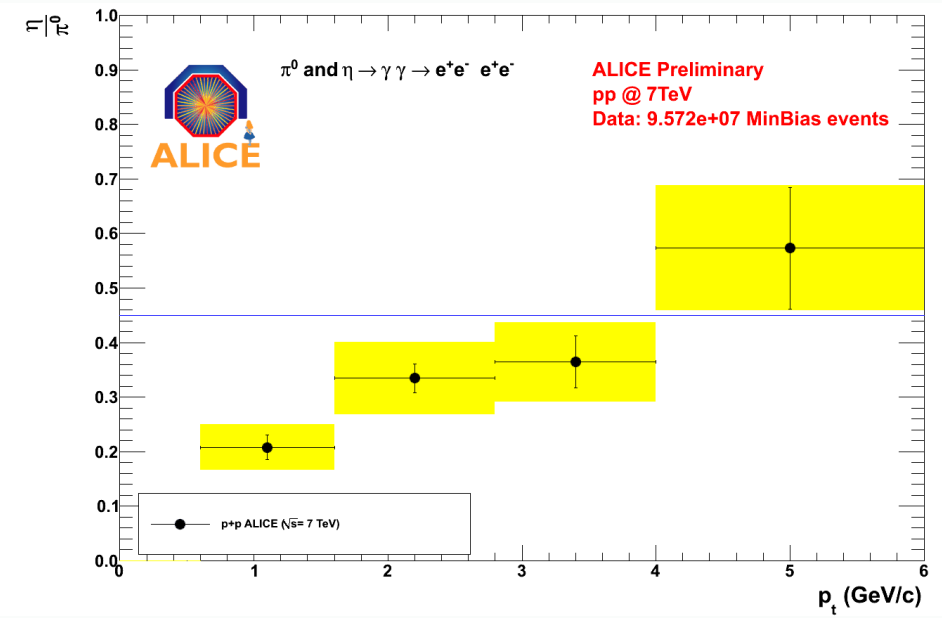
Comparsion to NLO

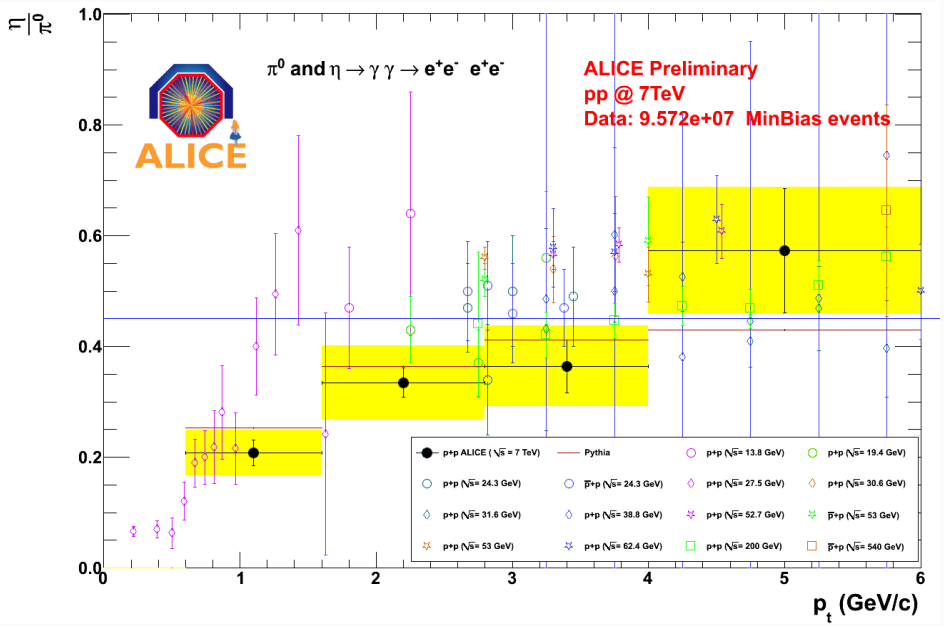


NLO predictions from W. Vogelsang

Method and calculations described in:
[1] F. Aversa et al., Nucl. Phys. B327, 105 (1989).
[2] B. Jäger et al., Phys. Rev. D67, 054005 (2003).
[3] D. de Florian, Phys. Rev. D67, 054004 (2003).

η/π^0 ratio

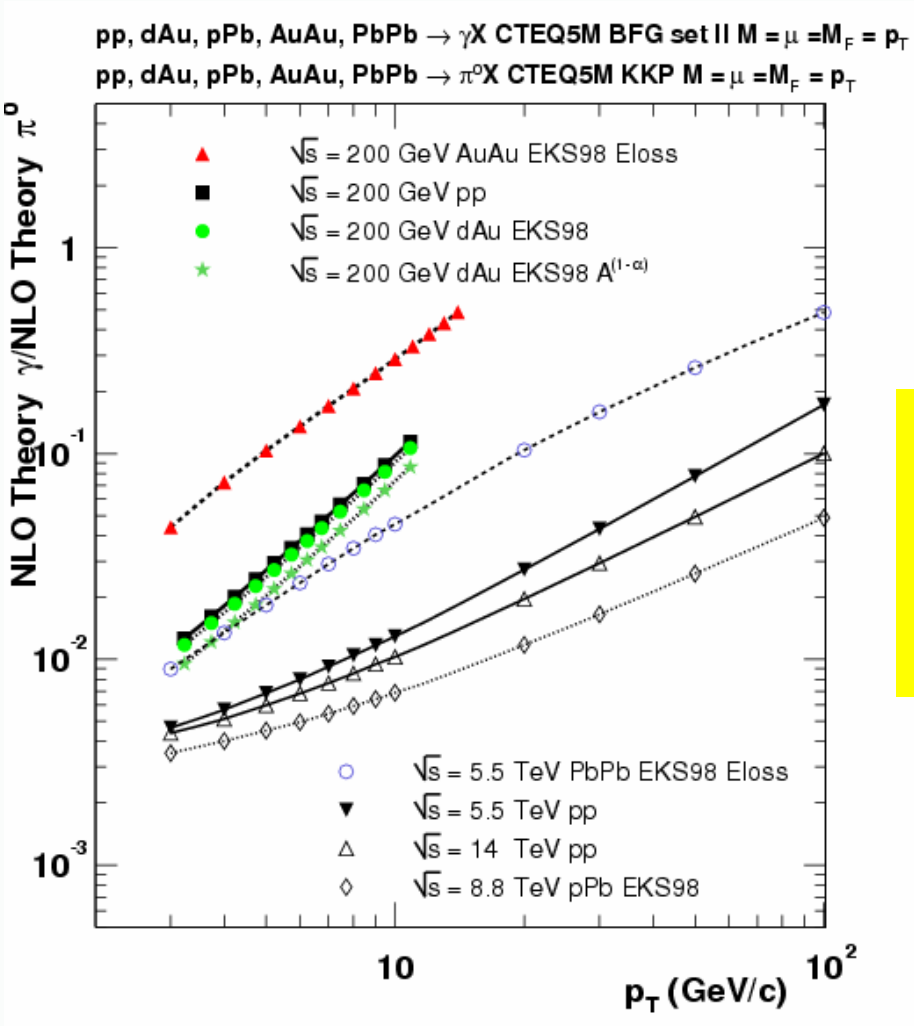




The η/π^0 ratio is measured in pp collisions @7TeV for 0.6 GeV/c $< p_t <$ 6 GeV/c.

In agreement with Pythia expectations and with the world data measured in hadron-hadron collisions, taken from Phys. Rev.C 75 0224909 (2007).

How many direct photons?



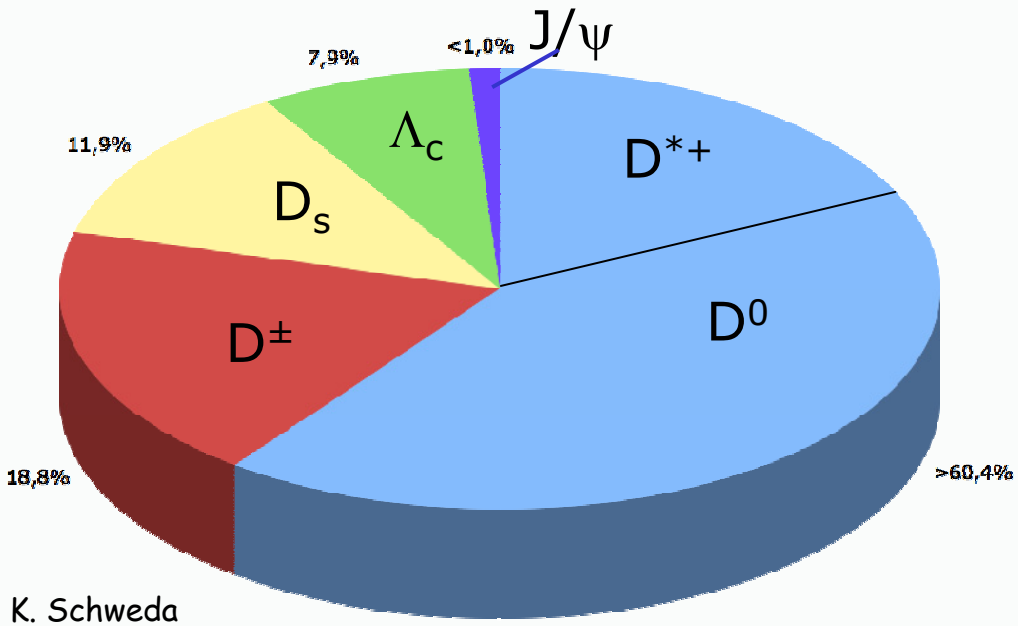
Cern Yellow Report 2004-009, hep-ph/0311131

Measurement was done at RHIC
... but more difficult at LHC
γ/π^0 = 0,01-0,1 for p_T > 20 GeV/c
We need a good distinction direct/decay γ

Charm measurement:

- Test of NLO pQCD
- Needed for quarkonia studies
- Reference data for PbPb

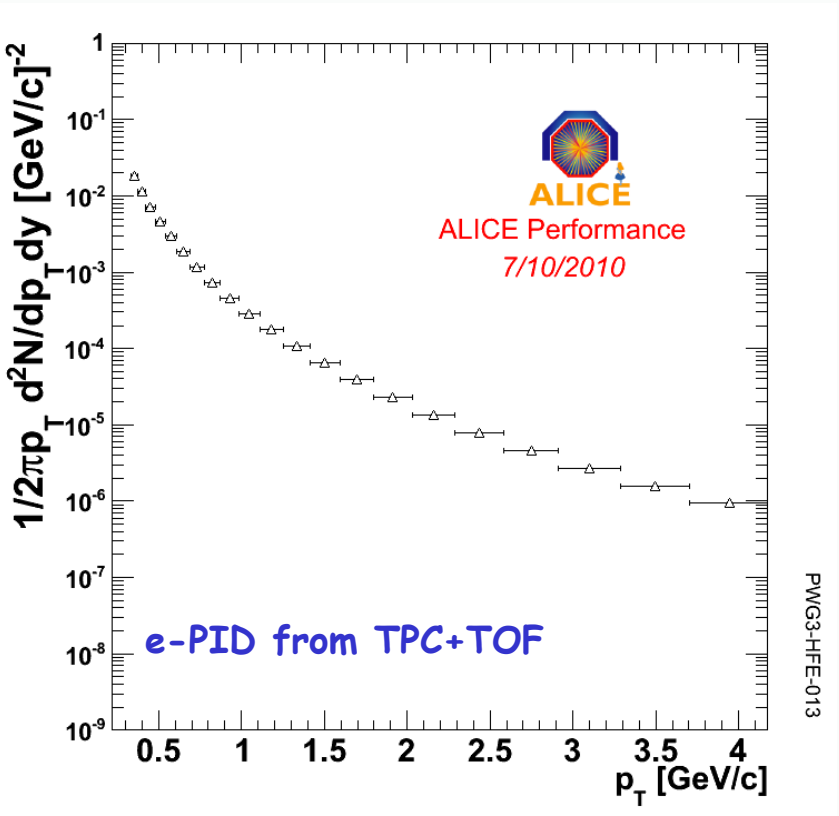
Where does all the charm go ?

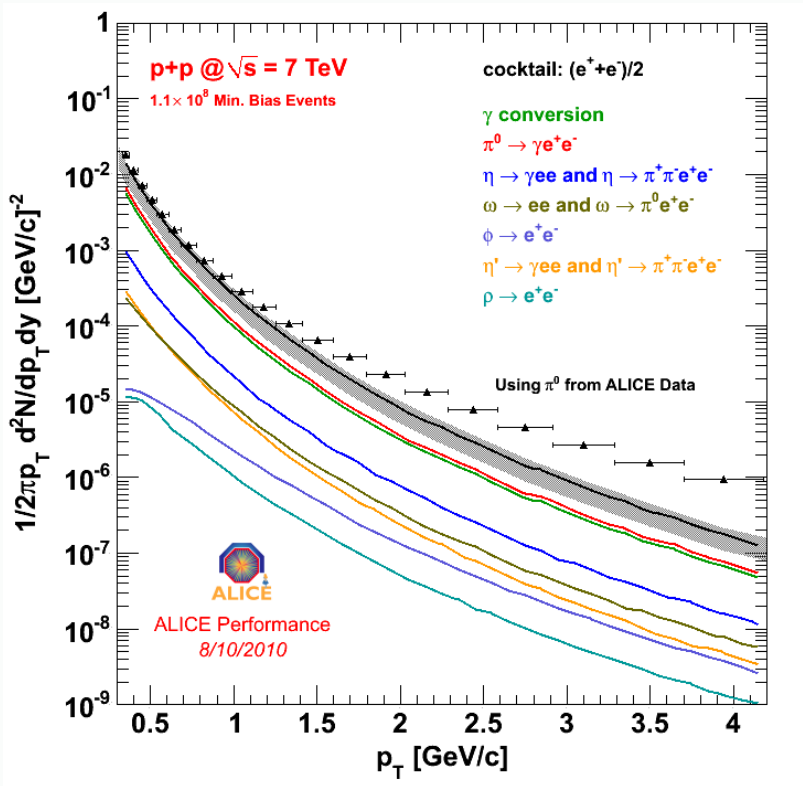


Plot from K. Schweda

Total charm cross section: **open-charmed** hadrons,
e.g. D^0, D^*, Λ_c, … or **c,b → e(μ) + X**
Quarkonia, e.g. **J/ψ** carries **≈1%** of **total charm**

Single electron spectrum and cocktail

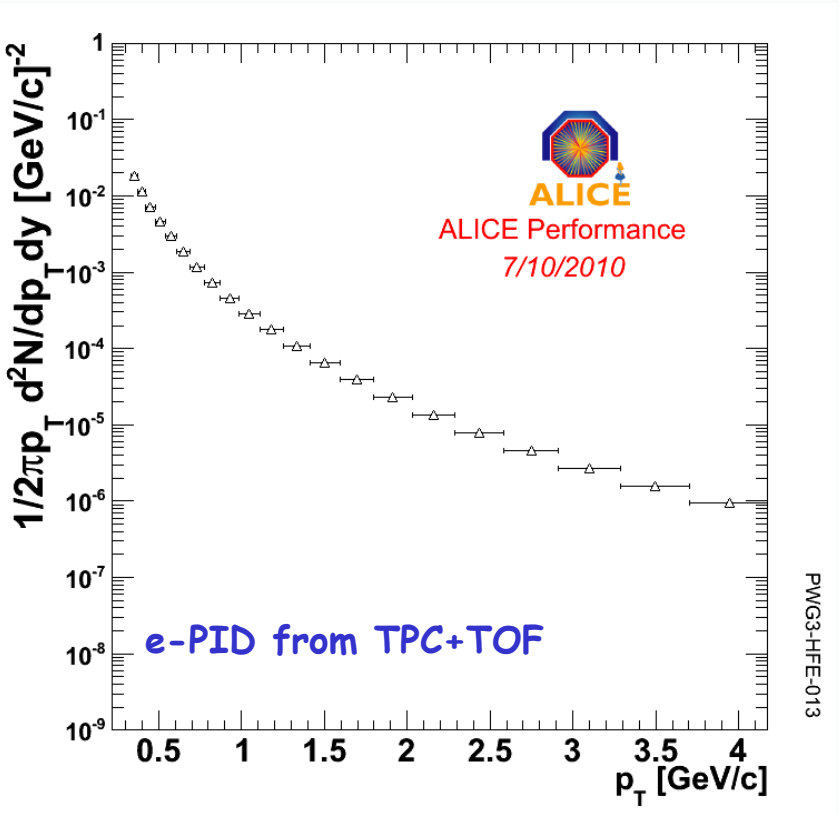


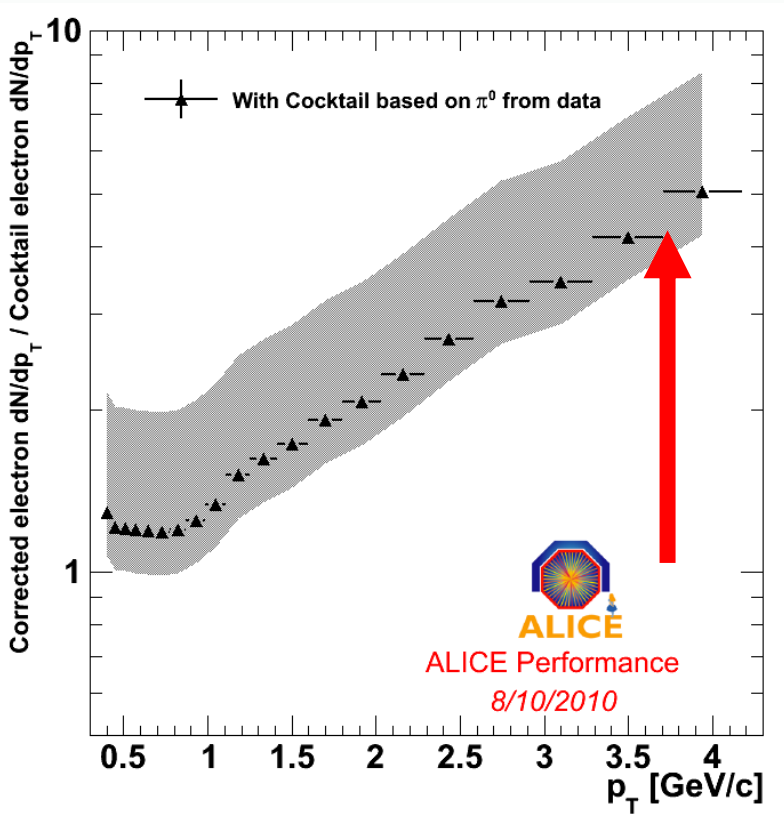


- Subtraction of residual hadronic contamination
- Corrections for acceptance and efficiency
- Correction for pT detector resolution (electron bremsstrahlung)

Excess from charm and beauty semileptonic decays, +(small contribution from J/ψ,and direct γ)

Single electron spectrum and cocktail





- Subtraction of residual hadronic contamination
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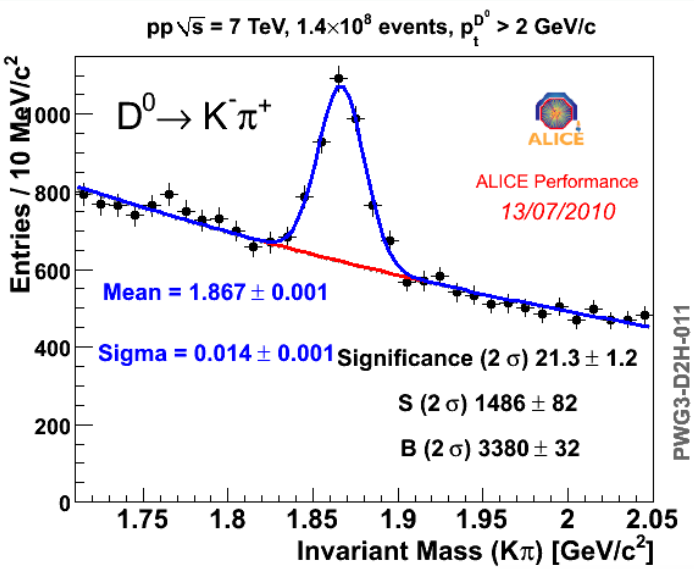
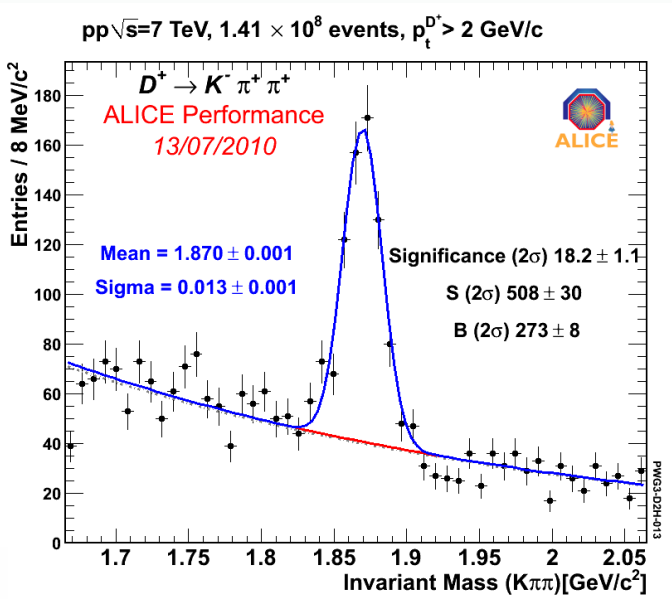
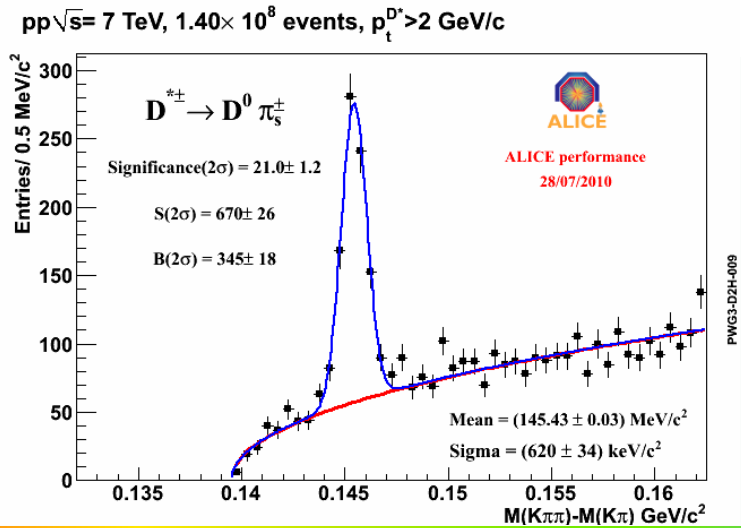
Excess from charm and beauty semileptonic decays, +(small contribution from J/ψ,and direct γ)

Open – charm from ALICE

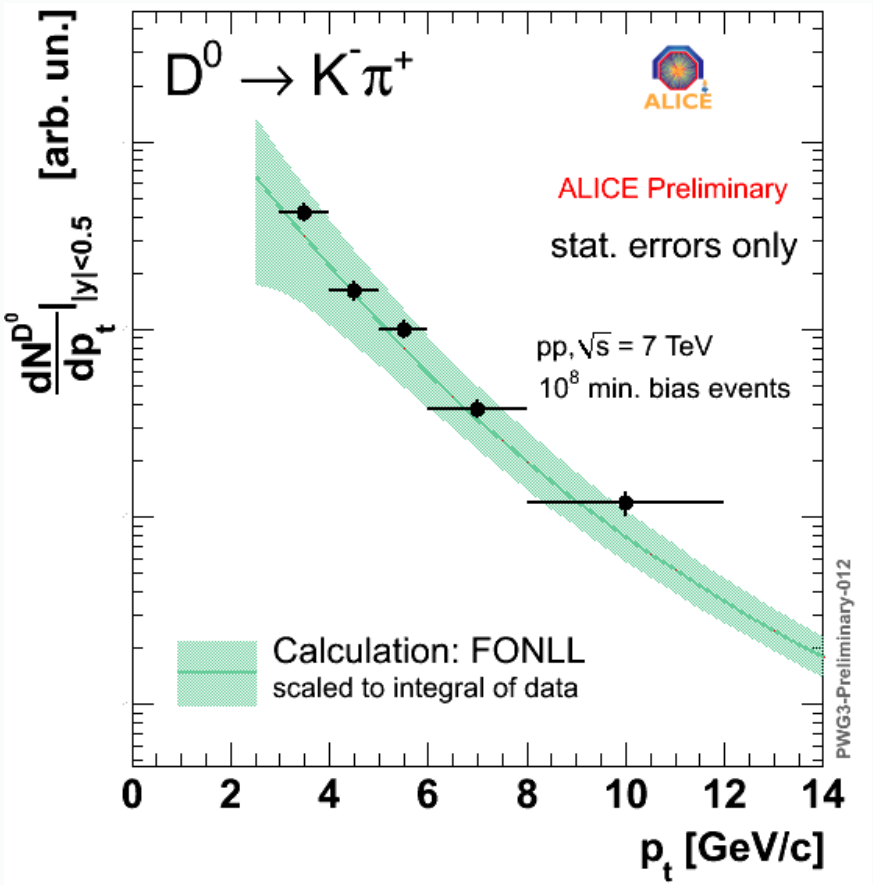


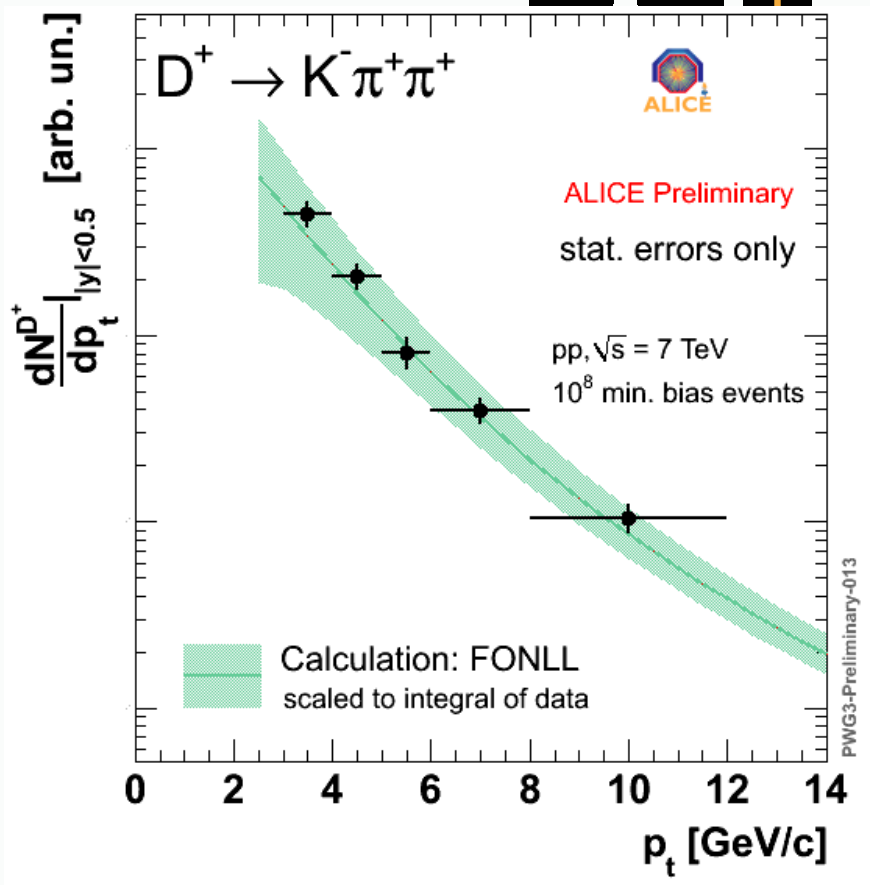




Study open charm production in as many channels as possible

D^0 and D^+ transverse momentum





Shape compares well with pQCD (FONLL)

Ongoing: extension at low p_t and absolute normalization

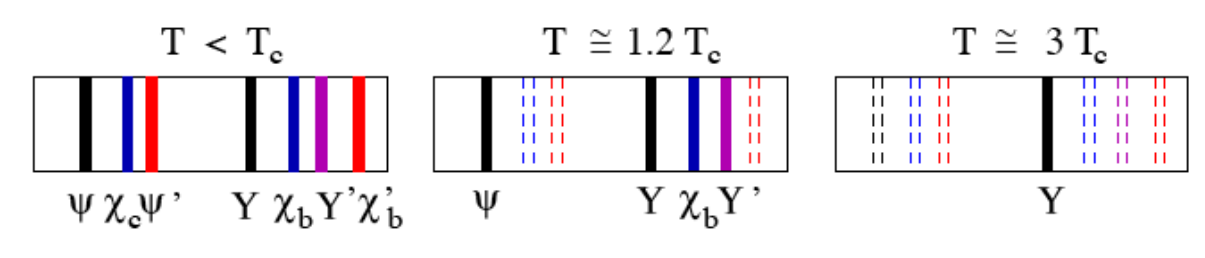
Quarkonia:

Quarkonia in Heavy-Ion Collisions

Quarkonia (J/Ψ, Υ):

20 years ago: Matsui & Satz (Phys. Lett. B178(1986) 416)
color screening in deconfined matter → J/ψ suppression = "smoking gun"

- Sequencial dissociation versus T in QGP (Matsui/Satz)

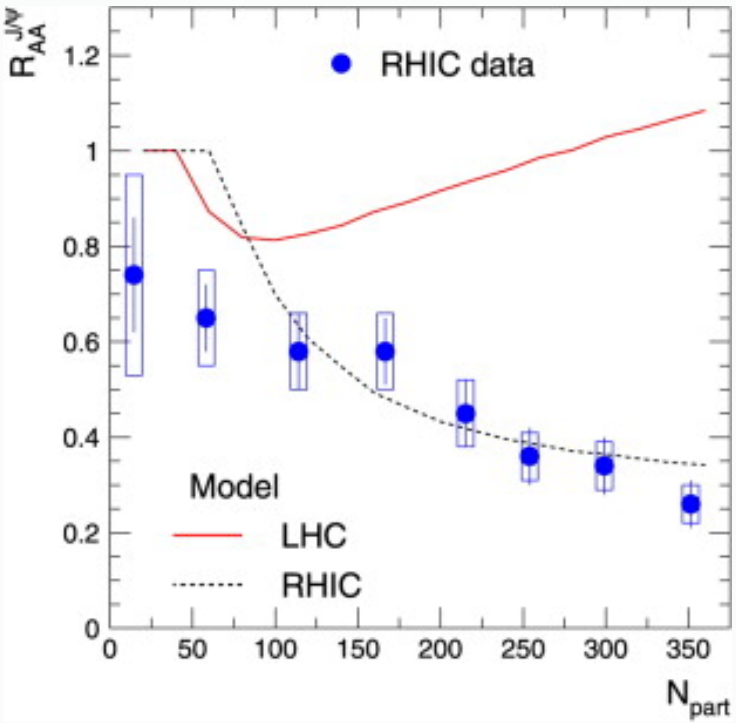


Can be used as thermometer of the medium

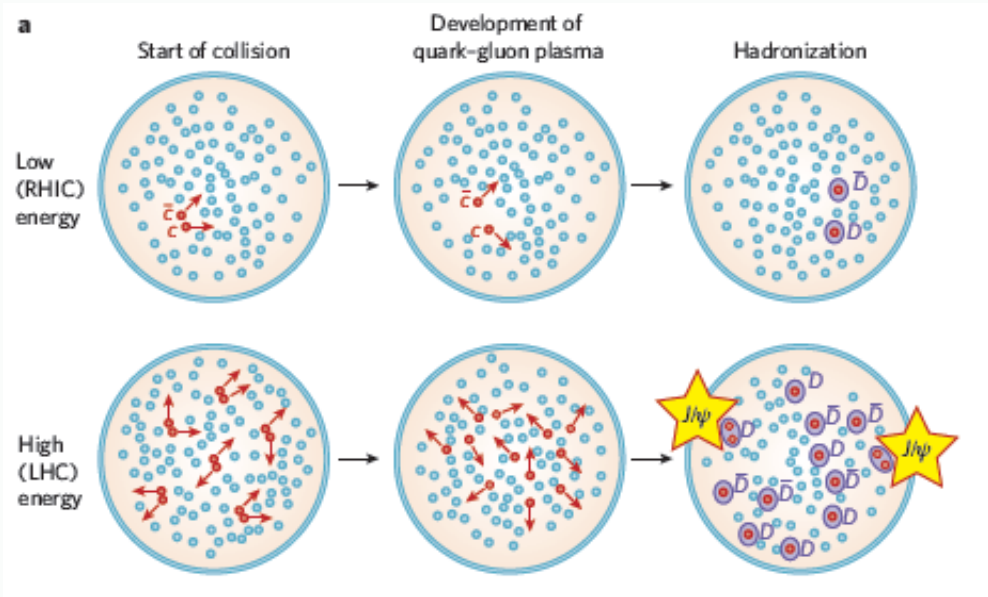
- Regeneration models give J/ψ enhancement that compensates for screening
- Feed down contribution to J/ψ from χ_c & ψ' and B needs to be known.
- Measurements in pp provide the baseline
- Upsilon physics becames available at LHC: Identification of different Υ resonances is crucial

Statistical Hadronization Model

PLB 652 (2007) 259

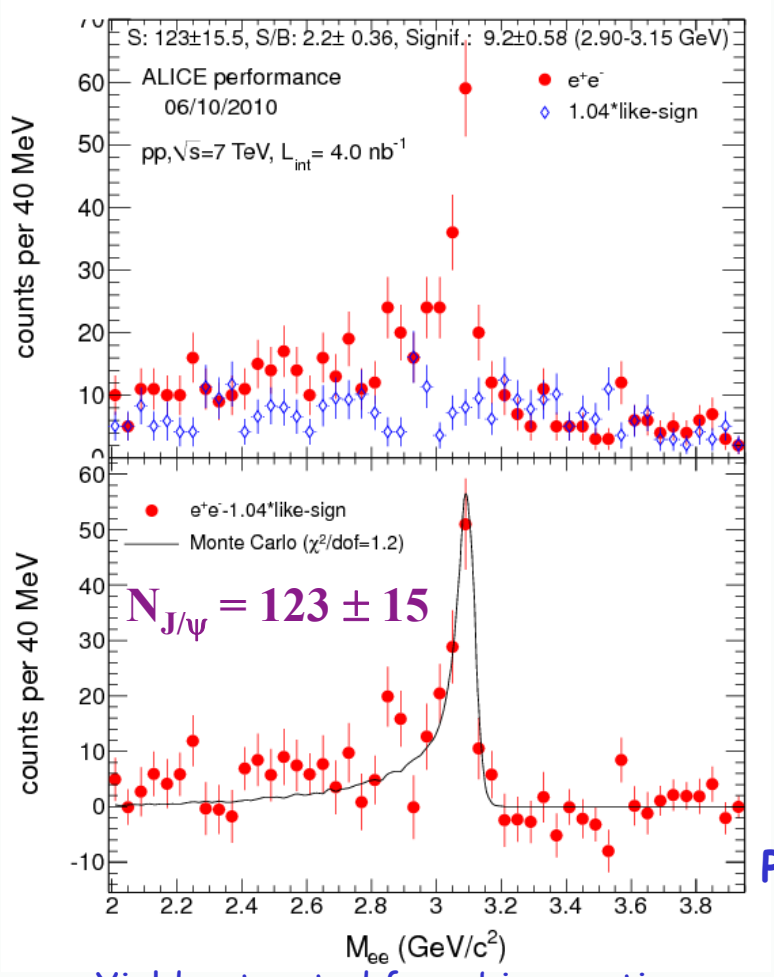


P.Braun-Munzinger & J. Stachel,
Nature 448 (2007) 302

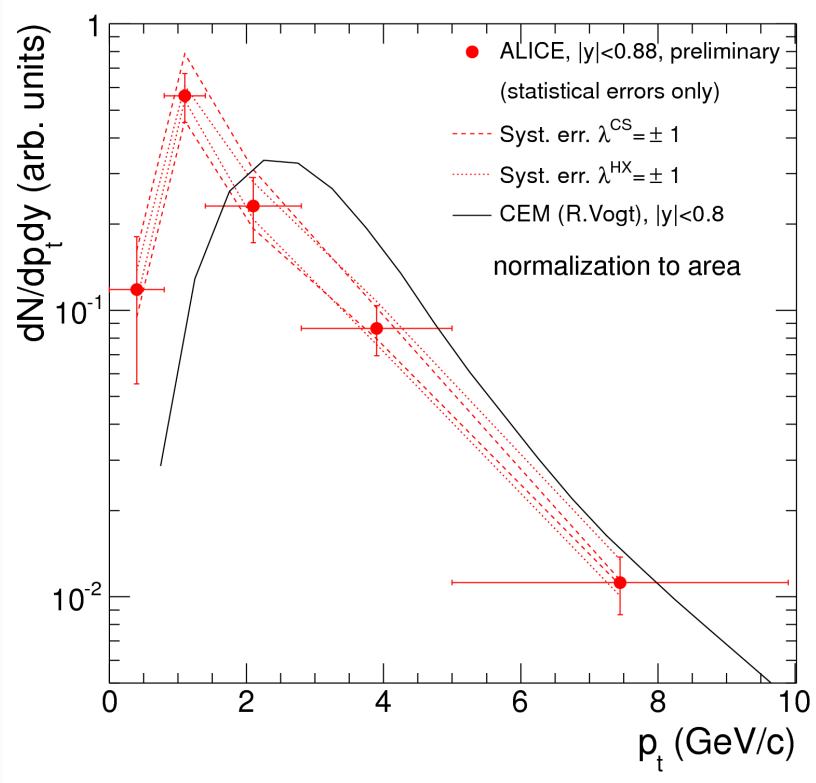


Clear signal for generation of charmonia due to statistical hadronization at the phase boundary

J/ψ → e^+e^-



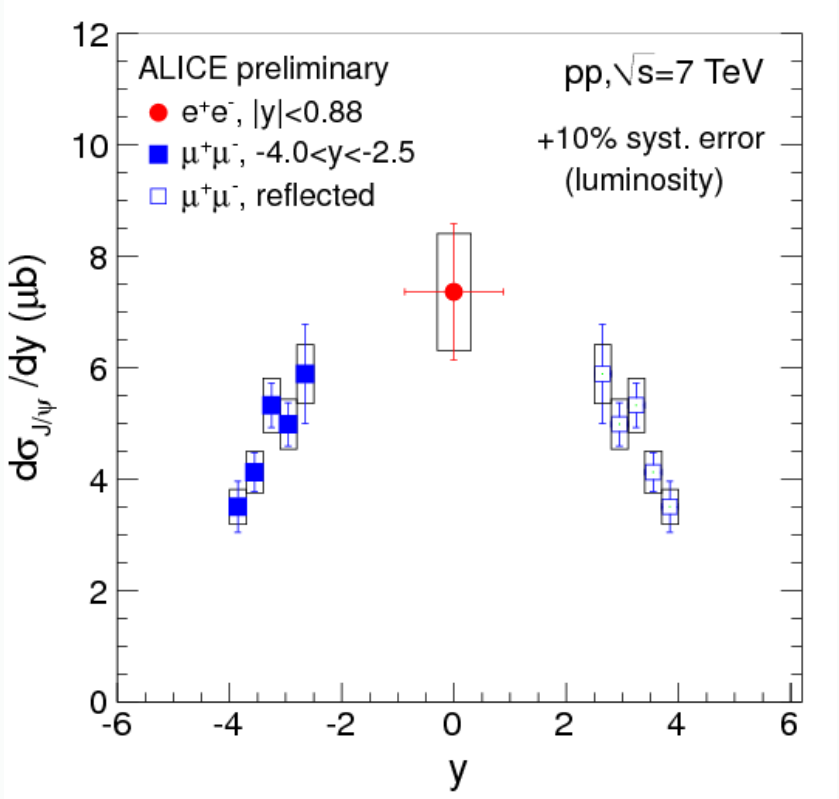
Yield extracted from bin counting (above like-sign background) in Me^+e^-=2.9-3.15 GeV/c^2



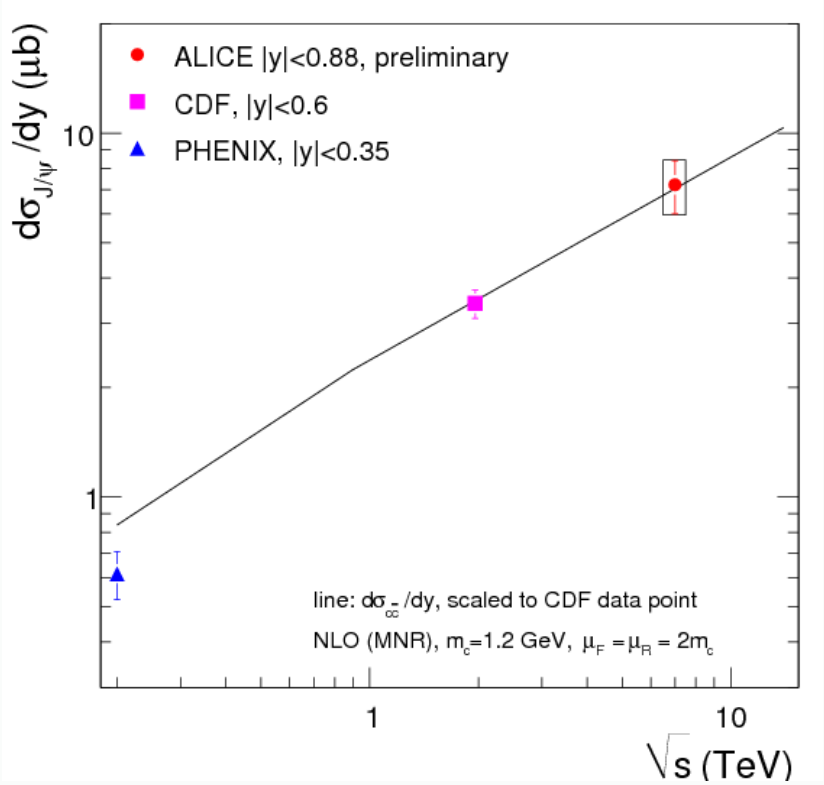
Preliminary p_T differential distribution (from a larger data sample), compared to CEM calculation

Measured spectrum is softer than the calculated one

J/ψ production cross section



J/ψ production cross section measured in the two rapidity ranges covered by the ALICE experiment



The cross section obtained at mid-rapidity is compared to PHENIX and CDF results
The curve is the MNR NLO calculation for the $c\bar{c}$ production cross section, scaled to match the CDF point

Conclusions and outlook

- With LHC we enter in a new era:
  - The energies reached at LHC will be ~30 times larger than RHIC
  - The Quark Gluon plasma formed will be hotter, larger and live longer
- ALICE is taking data since November 2009
- Several papers have been published
- A lot of analyses in pp are ongoing. These results in pp will be our reference data to study medium effects in PbPb collisions
- 1st Pb+Pb collisions at 2.76 TeV expected in few days

ALICE published results

- N_{ch} multiplicity & distributions
  - 900 GeV: EPJC: Vol. 65 (2010) 111
  - 900 GeV, 2.36 TeV: EPJC: Vol. 68 (2010) 89
  - 7 TeV: EPJC: Vol. 68 (2010) 345
- pbar/p ratio (900 GeV & 7 TeV) PRL: Vol. 105 (2010) 072002
- momentum distributions (900 GeV) PLB: Vol. 693 (2010) 53
- Bose-Einstein correlations (900 GeV) PRD: Vol. 82 (2010) 052001

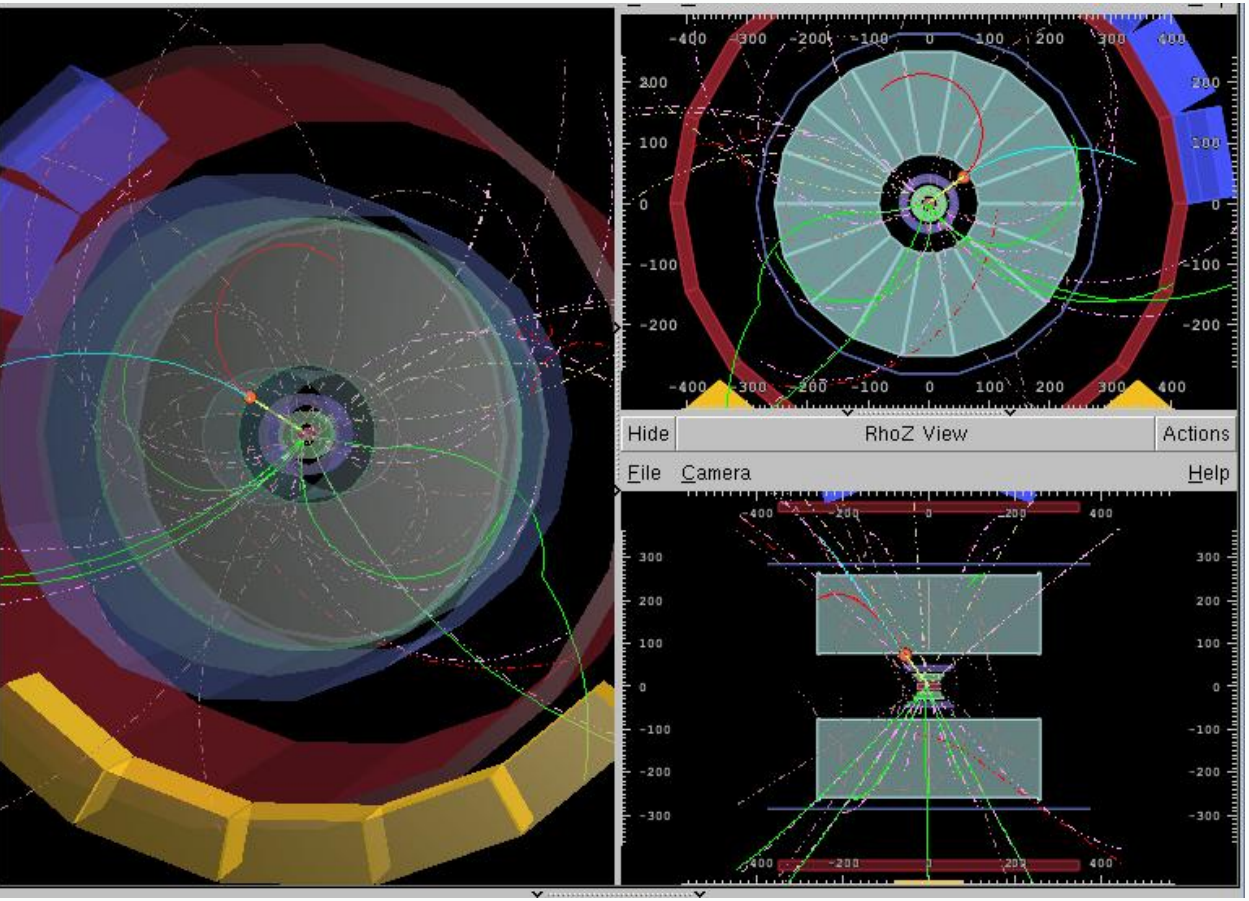
ALICE posters

- "Measurement of π^0 and η mesons with photon conversions in ALICE in proton proton collisions at $\sqrt{s}$=7TeV"
- "$J/\psi \rightarrow e^+e^-$ measurement in pp collisions at $\sqrt{s}$=7TeV with the ALICE detector"
- "D^{*+} and D^0 reconstruction in ALICE"
- "Charged particle momentum distribution in Jets in ALICE"
- "Electron identification in the ALICE experiment in p+p collisions at $\sqrt{s}$=7TeV at the LHC"
- "Electrons from heavy flavour decays with ALICE at the LHC"
- "Beauty and Beauty jet measurement with ALICE at the LHC"
- "Method to extract direct photons via conversions in p+p collisions at $\sqrt{s}$=7TeV with ALICE"

ALICE COLLABORATION

Backup slides

First event with a V^0



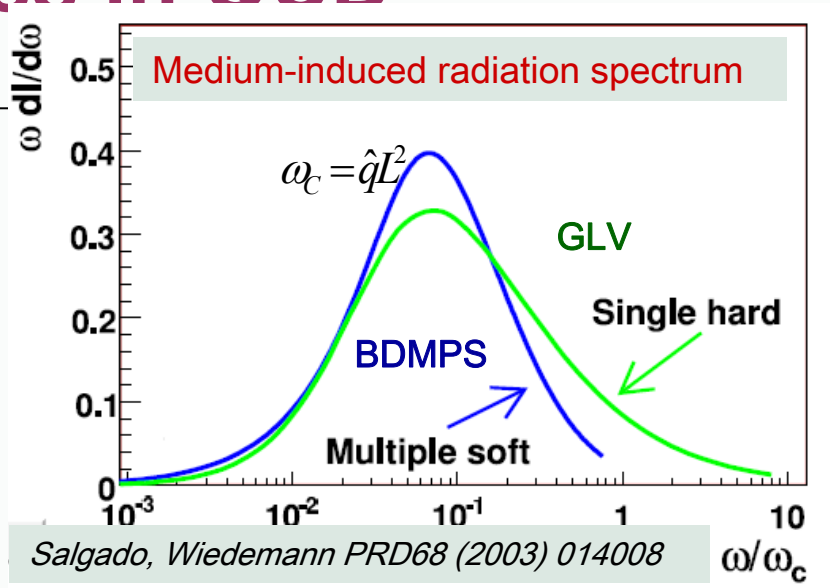
Sun 12/6/2009
10:39 AM,
R. Romita

run #104068,
18.10 evt 154

Total events collected: >1M
'Good pp interactions': 500k
- 100 k : B = 0 (alignment)
- 10 k : B reversed (syst.)
- 30 k : $\sqrt{s}$ = 2.36 TeV

Radiative energy loss in QCD

- found to be dominant for light quarks
- independent of parton energy but depends on the path length L in the medium



Salgado, Wiedemann PRD68 (2003) 014008

- two example approaches:

Thin medium: few hard interactions

GLV formalism

Gyulassy, Levai, Vitev, Wang, Wang, …

Thick medium: multiple soft interactions

BDMPS formalism

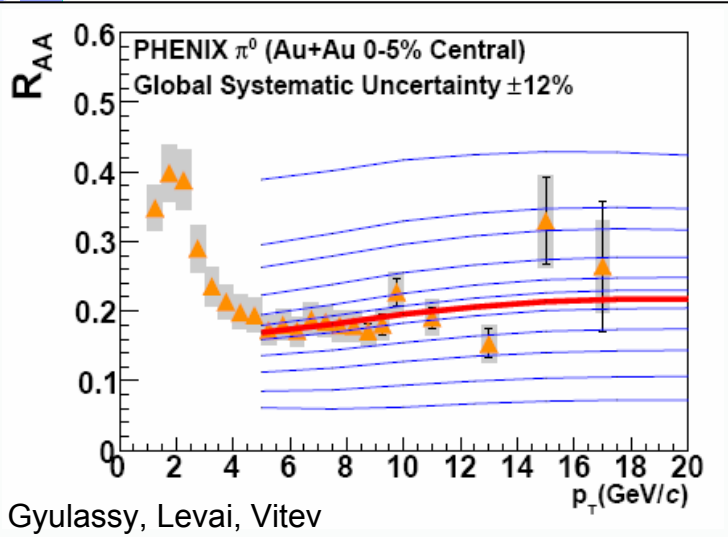
Baier, Dokshitzer, Mueller, Peigne, Schiff, Armesto, Salgado, Wiedemann, …

- medium properties can be characterized by a single constant:

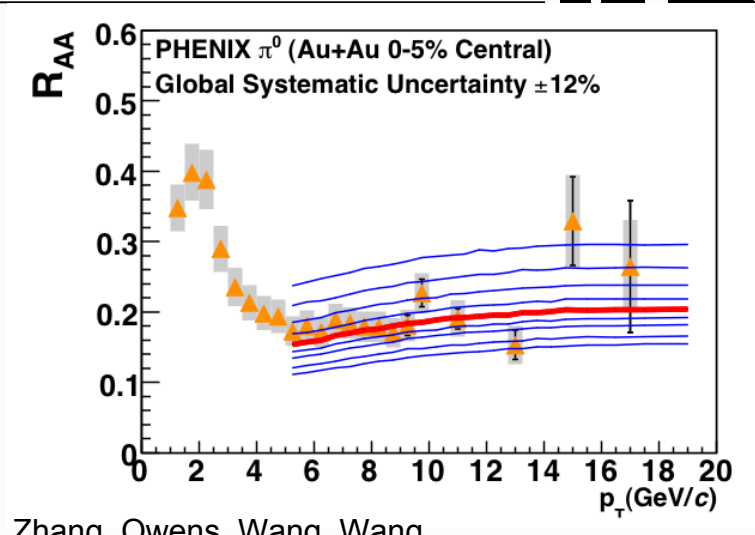
transport coefficient $\hat{q} \equiv \frac{\mu^2}{\lambda}$ 'average k_T-kick per mean-free-path'

- static medium: $\Delta E \propto L^2$ due to interference effects, expanding medium: $\Delta E \propto L$

Quantitative constraints on medium parameters



Gyulassy, Levai, Vitev



Zhang, Owens, Wang, Wang

- **Least square fit of model parameters to data including proper treatment of exp. uncertainities (point-by-point uncorrelated and correlated in p_T, normalization)**
- **caveat: theoretical uncertainties not included**

PHENIX, arXiv:0801.1655 [nucl-ex]

Medium properties constrained within ± 20-25% at 1σ level

of photons

$$N_\gamma^{observed} = N_\gamma^{produced} \cdot ConvProb \cdot \varepsilon_\gamma^{reconstruction}$$

where

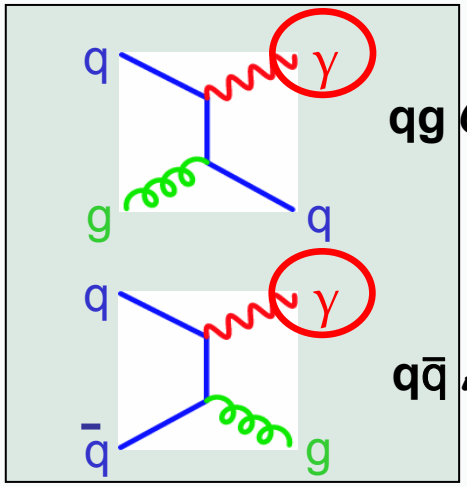
$$N_\gamma^{produced} = N_\gamma^{\pi^0} + N_\gamma^{\eta} + N_\gamma^{\omega} + N_\gamma^{\eta'} + N_\gamma^{\phi}$$

Material budget and reconstruction efficiency need to be known.
Maps of conversion points. Also in limited pt range (1<pt<3 GeV/c).

Direct photon sources

Why? Do not interact strongly.

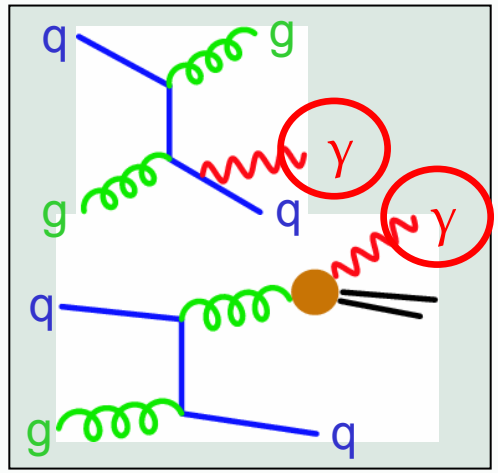
Carry information about the early state.



qg Compton Scattering

qq̄ Annihilation

Bremsstrahlung, fragmentation



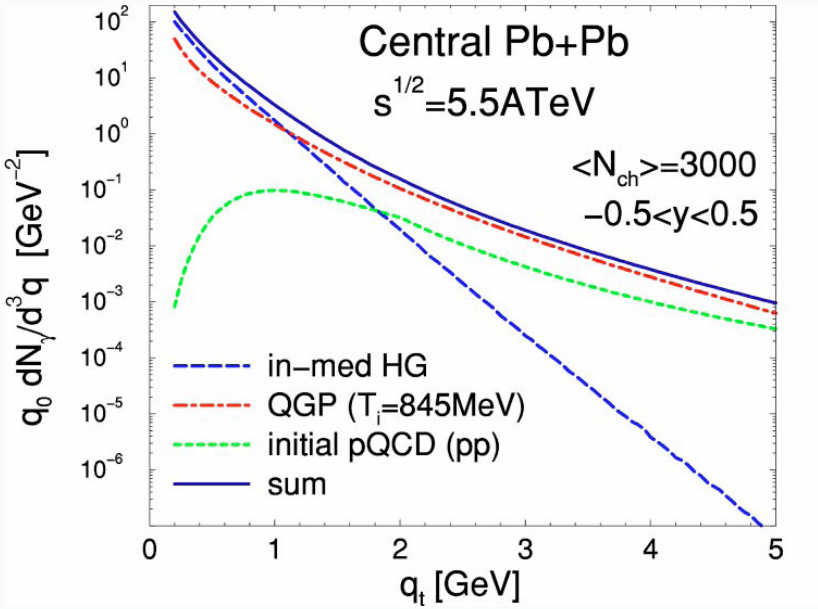
Thermal photons from QGP and hadron gas

Photons from Jet re-interaction in the medium

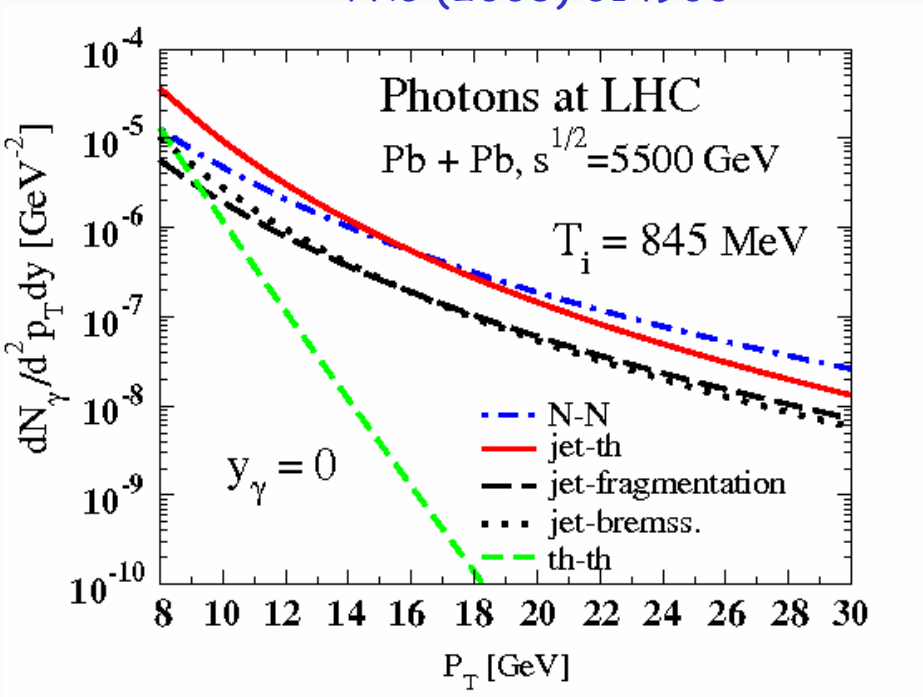
...in a large background from π^0 and η decays

Photons at LHC

S. Turbide, R. Rapp, C. Gale
PRC69(2004)014903



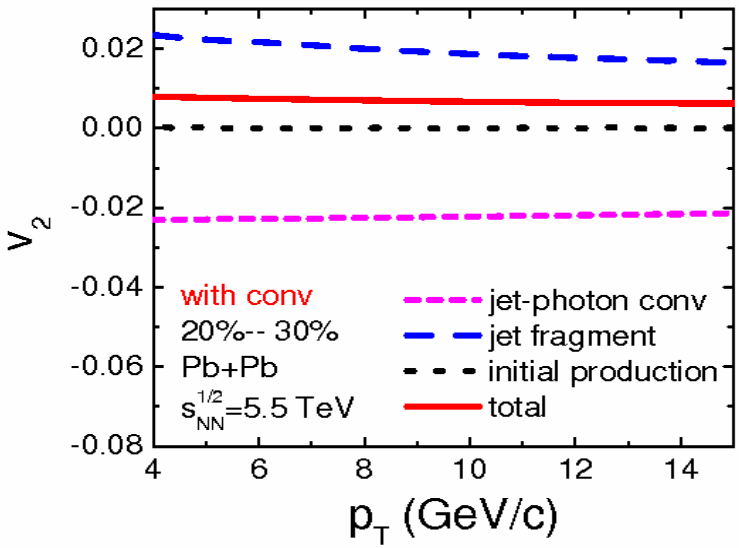
S.Turbide, C. Gale, S. Jeon, and G.D.Moore
PRC (2005) 014906



pt~3 GeV: best range to look for QGP radiation
Jet-photon conversion in the plasma dominates 8<p_T<14 GeV
Prompt hard NN scattering dominant for p_T>20GeV at LHC

How can we distinguish different photon sources?

- Prompt : R_{AA} = 1, v_2=0 (azimuthal anisotropy)
- Fragmentation: R_{AA}<1, v_2>0
- Thermal, Bremsstrahlung, Jet Conversion: R_{AA}>1, v_2<0



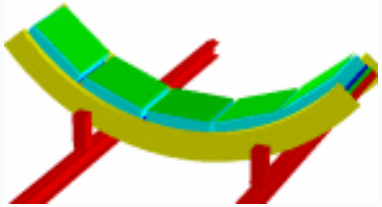
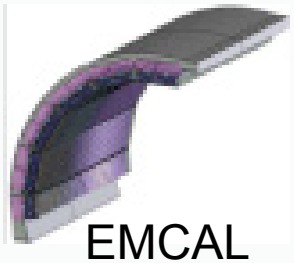
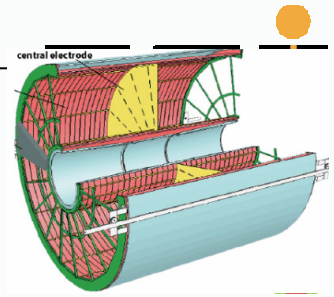
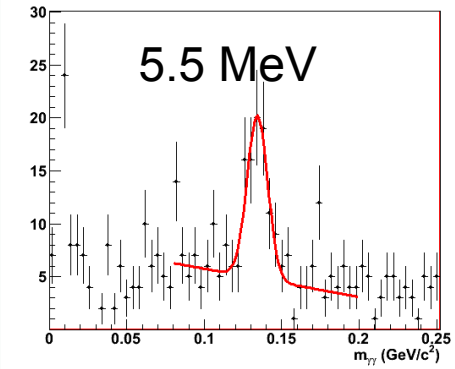
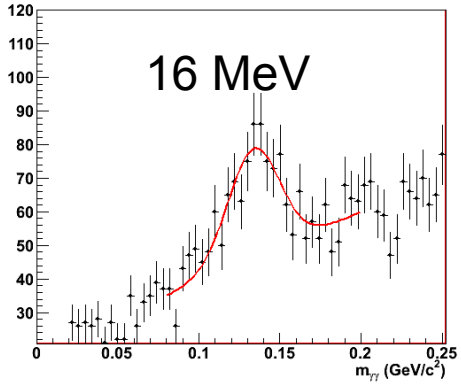
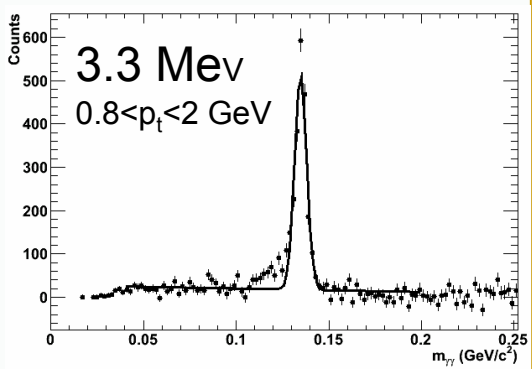
R_{AA} >1 and v_2<0
unambiguous signature of medium produced photons

W.Liu, R.J.Fries nu-th/0801.0453
Phys. Rev. C 77 (2008) 054902

Photon Detection in ALICE

- PHOS (100^0 x 0.24 in η) (PHOS/CentralBarrel=0.037)
  - high resolution (energy and spatial)
  - small coverage
- EMCAL
  - larger coverage: 120^O x 1.4 in η (EMCAL/CentralBarrel=0.26)
  - coarser spatial resolution than PHOS
  - available in 2010
- $\gamma Z \rightarrow e^+e^- Z$ Conversions (Central Barrel)
  - large coverage: 360^O x 1.8 (2.4) in η (Conversion/CentralBarrel=0.08)
  - low conversion probability : 8% (16%)

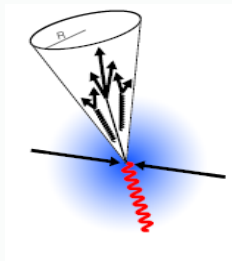
ALICE Photon detectors

	PHOS	EMCAL	ITS+TPC+TRD
			
σ_E/E (%)	$\sqrt{\left(\frac{1.3}{E}\right)^2+\frac{1.3^2}{E}+1.12^2}$	$\sqrt{\left(\frac{11.3}{E}\right)^2+\frac{1.7^2}{E}+4.8^2}$	2
σ_x (mm)	$\sqrt{\frac{3.26^2}{E}+0.44^2}$	$1.5+\frac{5.3}{\sqrt{E}}$	~1
R_{ip} (cm)	460	428	< 160
σ_π (MeV) p_t=1-2 GeV			

Taken from D.Peressounko,QM09

Photon physics in ALICE

- Measurement of π^0 and η mesons in pp@7(10)TeV
  - Highest energy available in lab
  - Test of pQCD cross section predictions
  - Reference data for PbPb
  - Main source of background in direct photon measurement
- Measurement of Direct photons (not from decays) in pp@7(10)TeV
  - Highest energy available in lab
  - Test of pQCD cross section predictions
  - Reference data for PbPb
  - PbPb: hard processes in QGP medium, thermal properties of early phase
- γ-Jet (γ-hadron)
  - Study quark energy loss in the medium
  - Fragmentation function: $E_{jet} \sim E_{\gamma}$
- $\chi_c \rightarrow J/\psi\, \gamma \rightarrow e^+e^-\gamma$



Direct photon measurement techniques

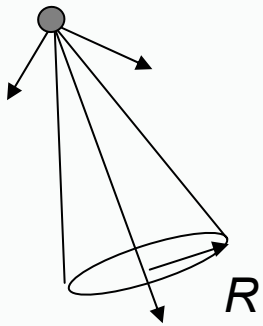
- **Subtraction (PHOS,EMCAL,conversions)**
  - Measure total photon yield
  - Measure yield of π^0, η, ω,...
  - Subtract photons from π^0, η, ω, ... decays

$$R = \frac{N_\gamma / N_{\pi^0}}{\left(N_{\gamma,decay} / N_{\pi^0} \right)_{calculated}}$$

- **Internal conversion**
  - Reduce the contribution from π^0decays

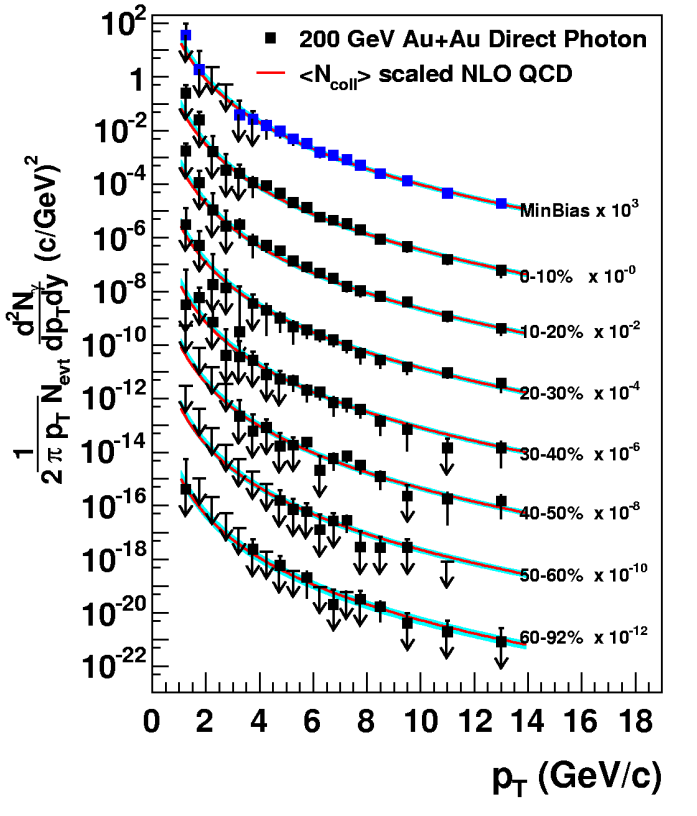
(Kroll-Wada formula) R. H. Dalitz 1951 ;*Proc. Phys. Soc. A* 64, 667-669

- **Isolation**

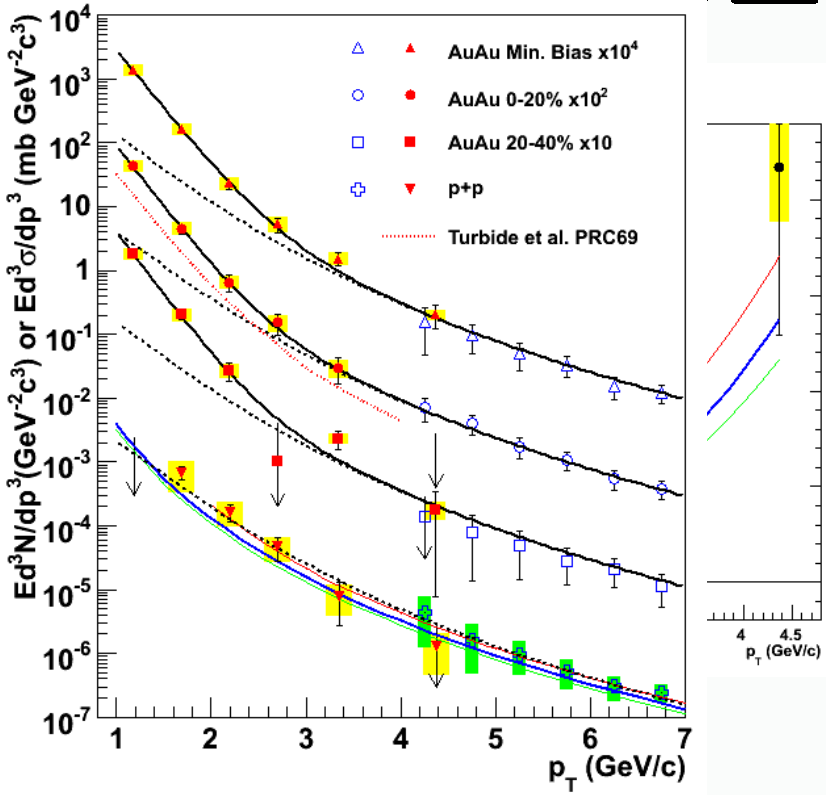


$$R = \sqrt{(\phi - \phi_0)^2 + (\eta - \eta_0)^2}$$

Direct photons at RHIC



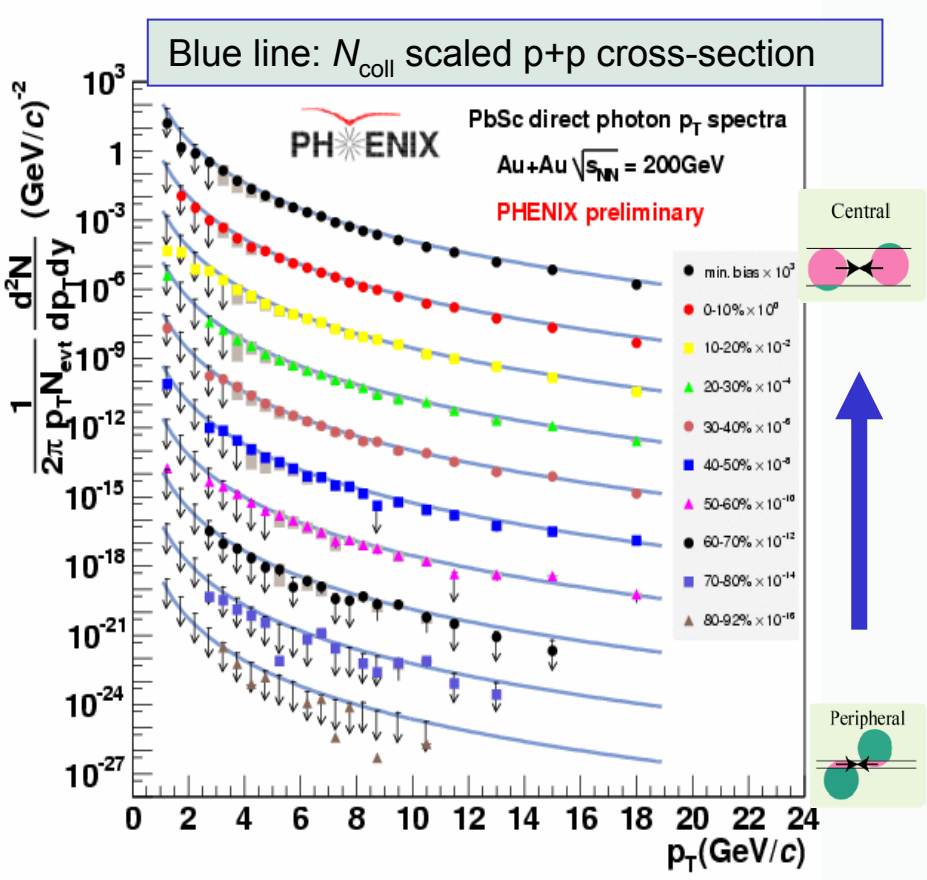
PHENIX Coll.:
Phys. Rev. Lett. 94, 232301 (2005)

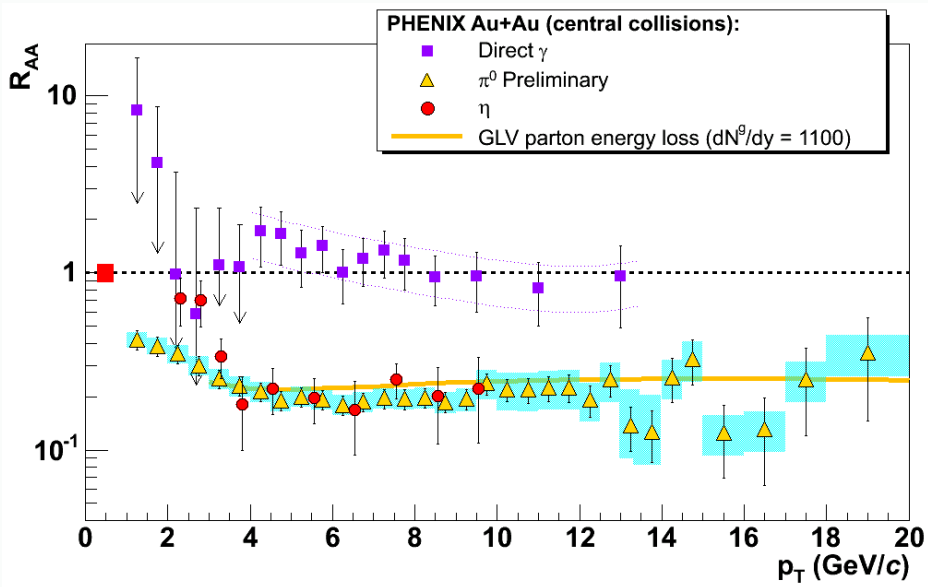


- pp consistent with NLO pQCD calculations
- AuAu larger than calculation for p_T<3.5GeV/c

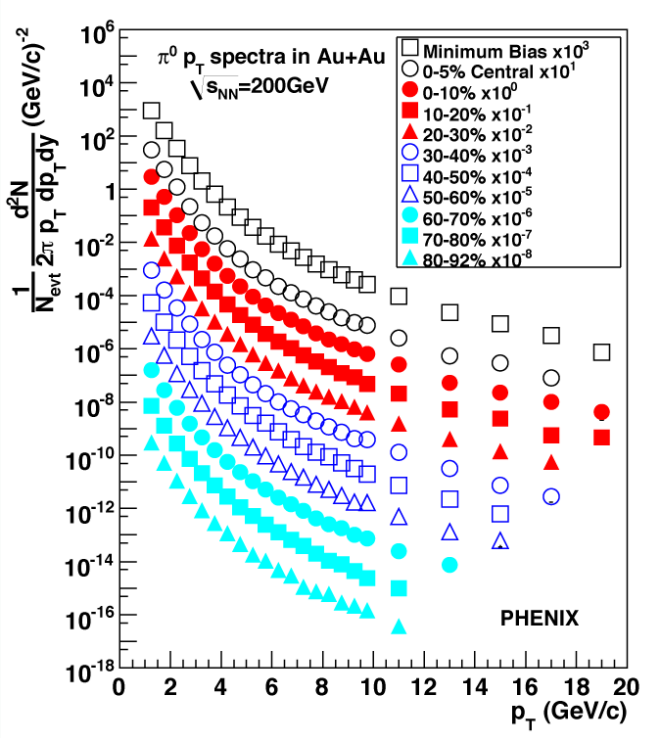
Excess exponential in p_T
T=221± 23(stat)±18(sys) MeV

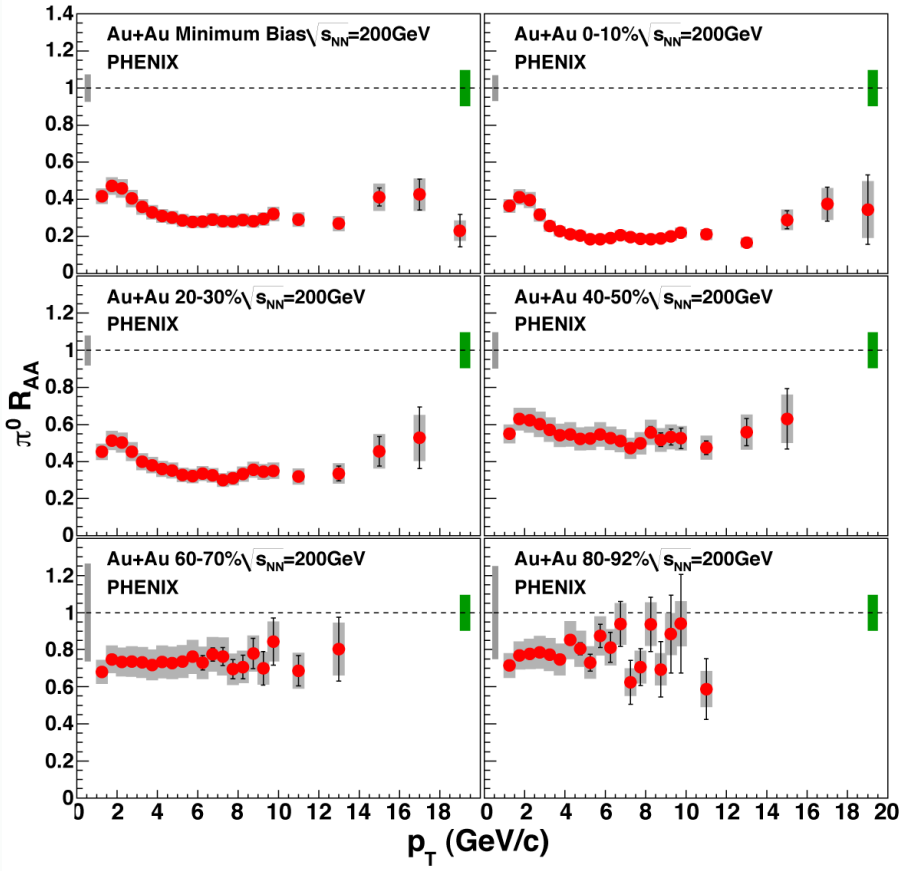
Blue line: N_{coll} scaled p+p cross-section





$$R_{AA}(p_t) = \frac{1}{\langle N_{coll} \rangle} \times \frac{dN_{AA}/dp_t}{dN_{pp}/dp_t}$$

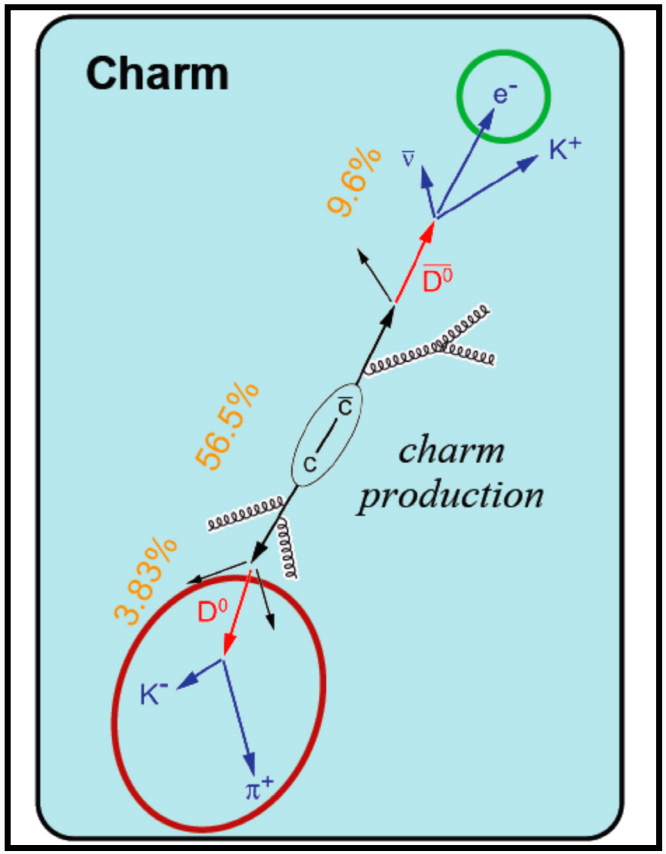




PHENIX Col. ,PRL 101,232301(2008)

RAA constrains medium properties ($\hat{q}$, dN_g/dy)

Heavy-quark detection

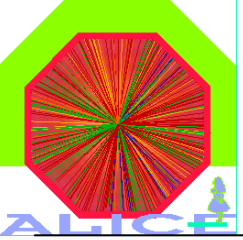


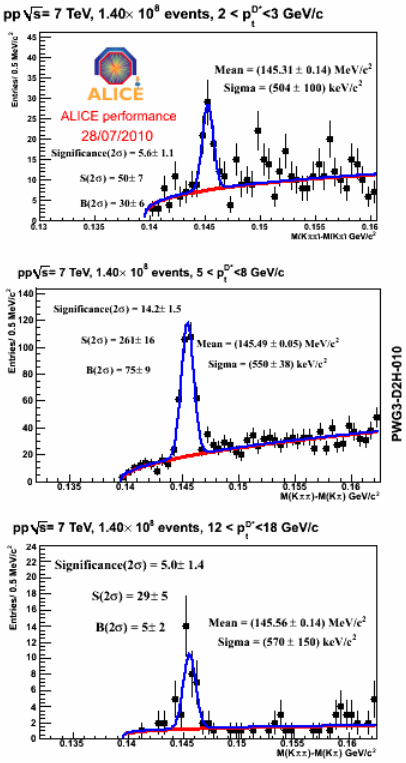
Open-charm reco. in ALICE

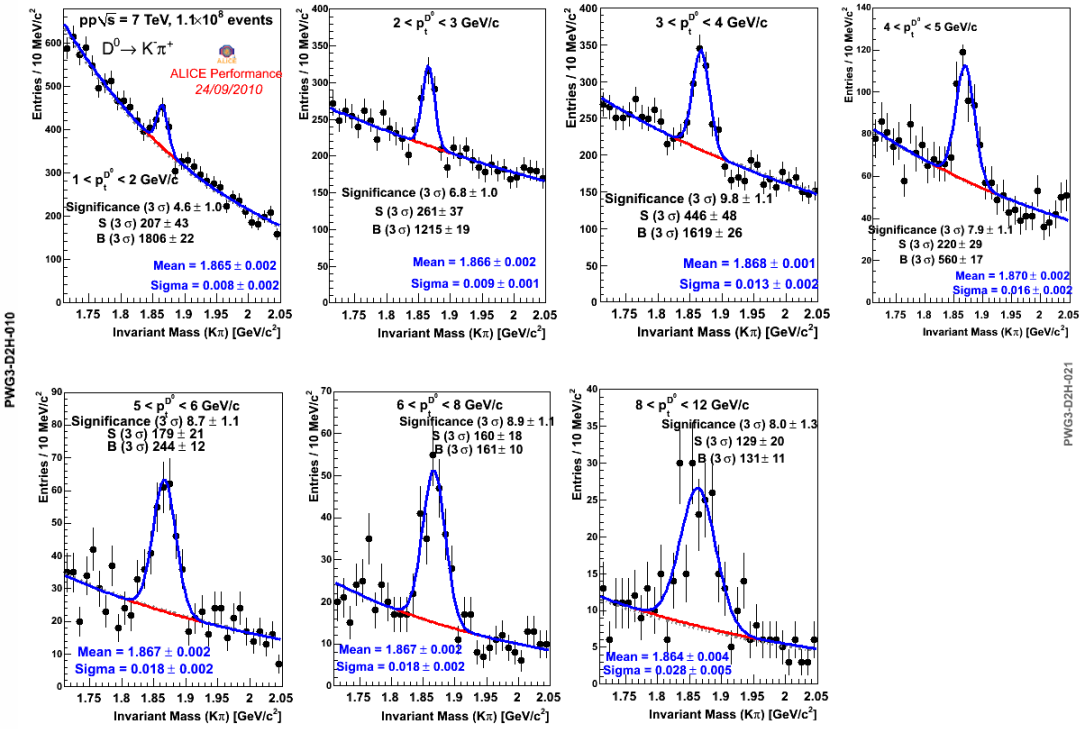
$D^0 \rightarrow K\pi$
$D^+ \rightarrow K\pi\pi$
$D^* \rightarrow D^0\pi$

Under study:
$D_s \rightarrow KK\pi$
$D^0 \rightarrow K\pi\rho$
$\Lambda_c \rightarrow pK\pi$
$\Lambda_c \rightarrow \Lambda\pi$
$\Lambda_c \rightarrow K^0_S\pi$

- **e.g., $D^0 \rightarrow K^- + \pi^+$, $c\tau$ = 123 μm**
- displaced **decay** vertex **is** signature **of** heavy-quark decay



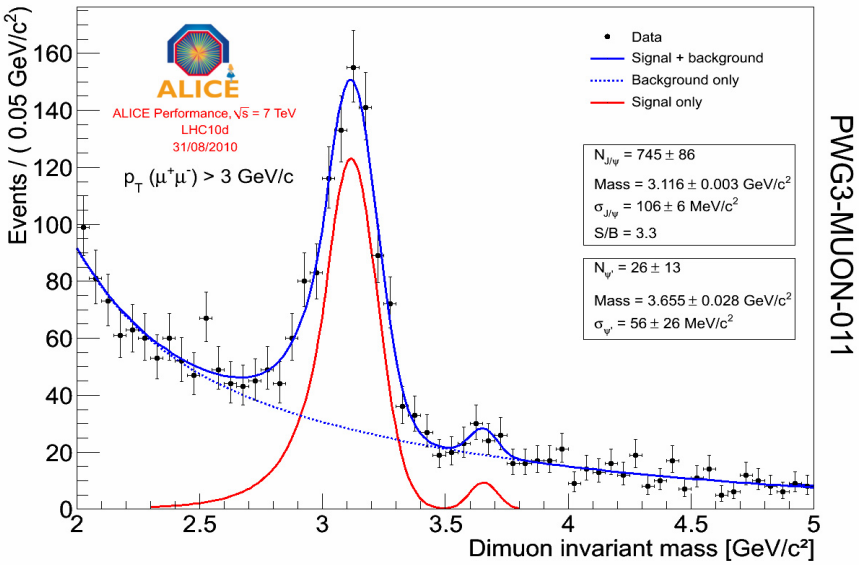


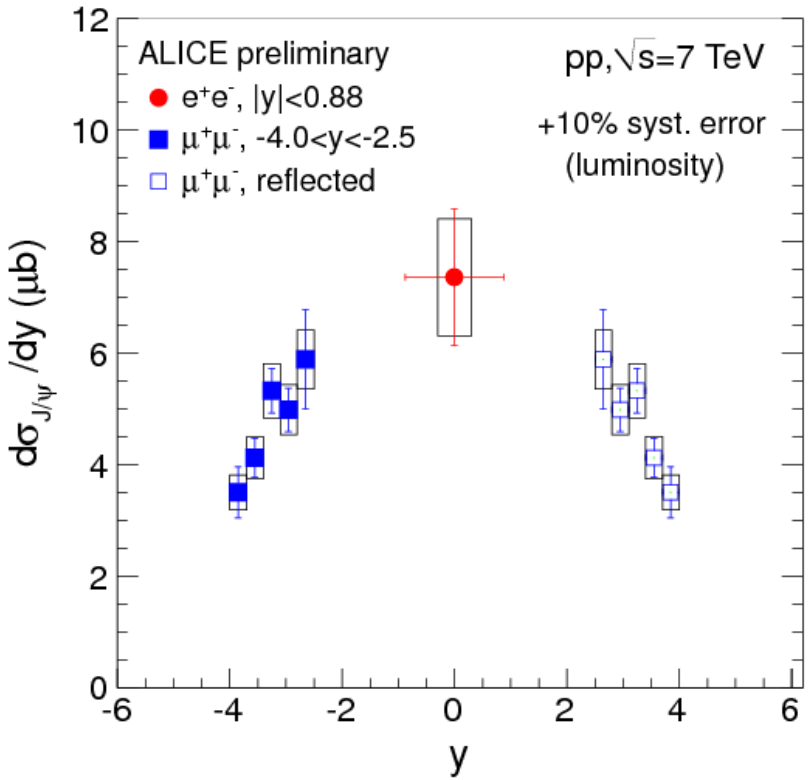


PWG3-D2H-010

PWG3-D2H-021

J/ψ → e^+e^- and J/ψ → $\mu^+\mu^-$

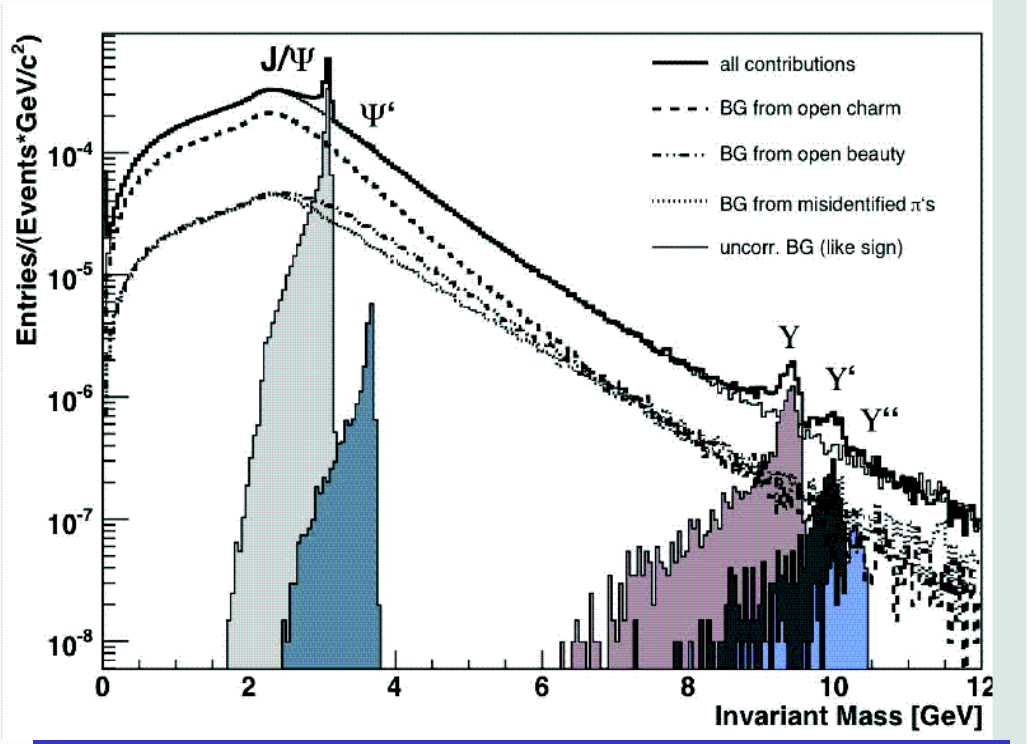




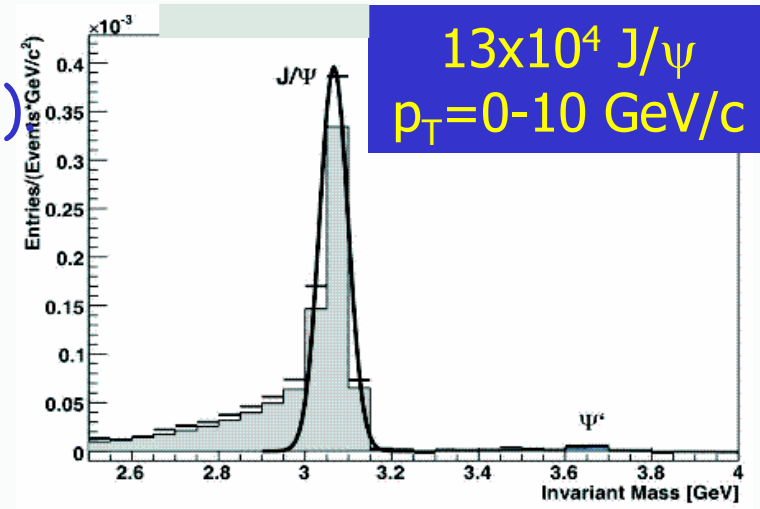
J/ψ production cross section measured
in the two rapidity ranges covered by the ALICE experiment

Quarkonia in the electron channel

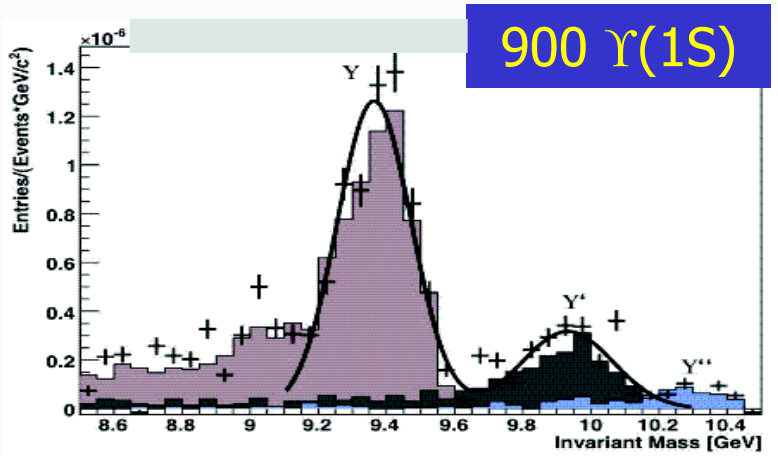
- Electron Identification (TRD+TPC);
- Tracking : ITS+TPC+TRD;
- 2×10^8 central PbPb events (no e-trigger)



10% central PbPb dNch/dy = 3000



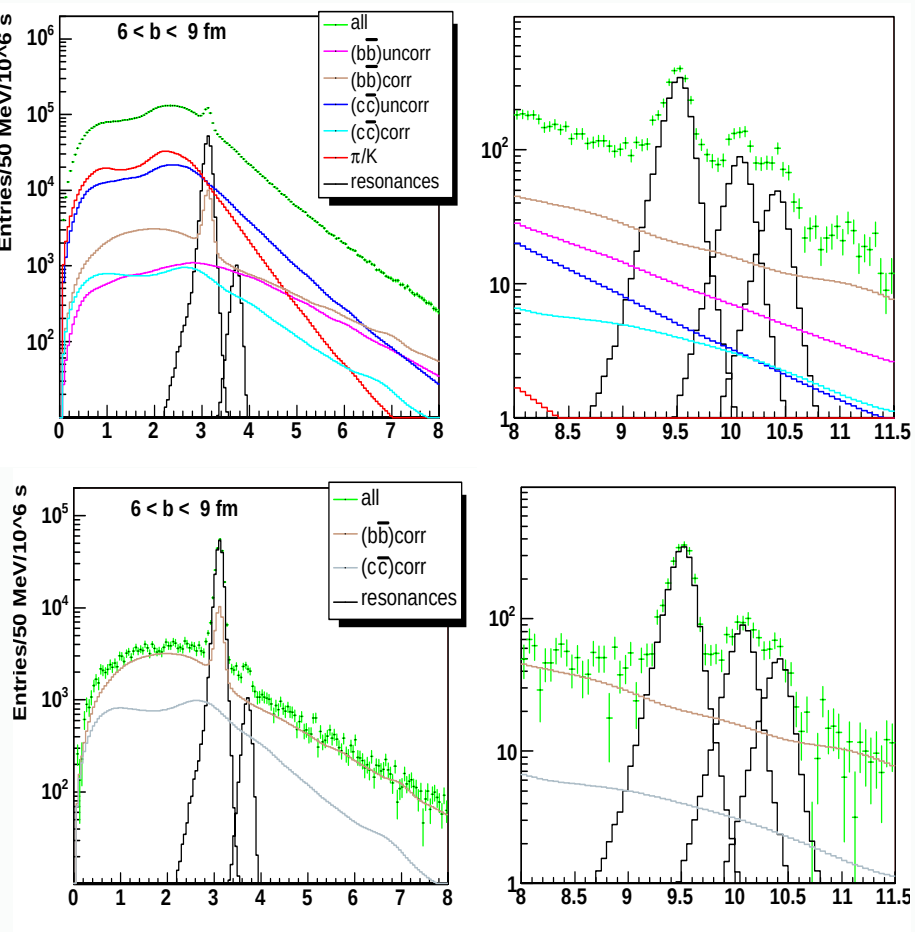
13×10^4 J/ψ
p_T=0-10 GeV/c



900 Υ(1S)

Quarkonia in the muon channel

PbPb cent, 0 fm<b<3 fm



State	S[10^3]	B[10^3]	S/B	S/(S+B)$^{1/2}$
J/Ψ	130	680	0.20	150
Ψ'	3.7	300	0.01	6.7
ϒ(1S)	1.3	0.8	1.7	29
ϒ(2S)	0.35	0.54	0.65	12
ϒ(3S)	0.20	0.42	0.48	8.1

Yields for baseline

- ϒ(1S) & ϒ(2S) : 0-8 GeV/c
- J/Ψ high statistics: 0-20 GeV/c
- Ψ' poor significance
- ϒ(3S) ok, but 2-3 run needed.

$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{NN}/dp_T d\eta}$$

ALICE Detector Installation 2009-2010

ALICE Status

Complete:

ITS, TPC, TOF, HMPID,
FMD, T0, V0, ZDC,
Muon arm, Acorde
PMD, DAQ

Partial installation:

PHOS(3/5)
7/18 TRD
2-4/6 EMCAL

~ 50% HLT