Photon physics in ALICE

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RRC “Kurchatov institute”

for the ALICE collaboration

Photons in heavy ion collision

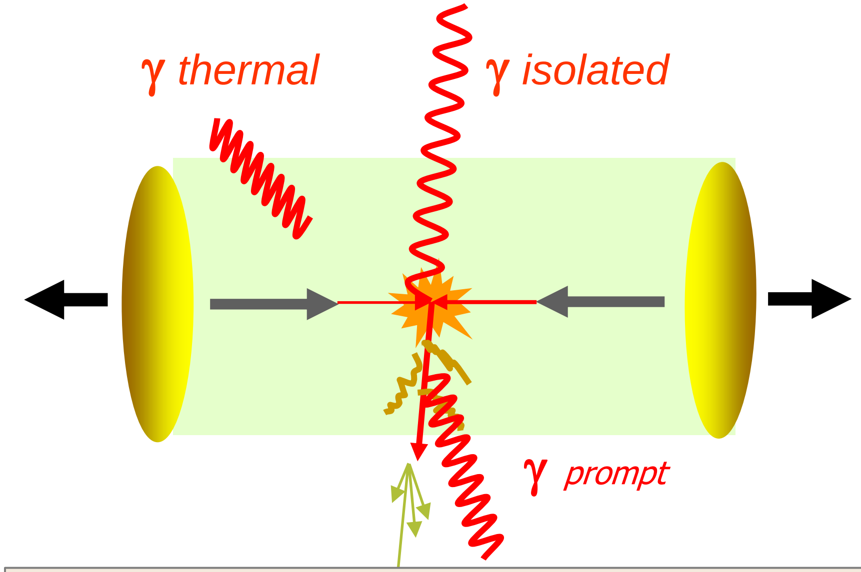
Direct photons:

photons not originated in hadron decays.

- ***prompt photons**:*
  photons created in collisions of incoming partons and in parton fragmentation
- ***thermal photons**:*
  thermal emission of hot matter

Isolated photons:

photons without hadron activity in some cone



Spectrum: *temperature, fireball lifetime*

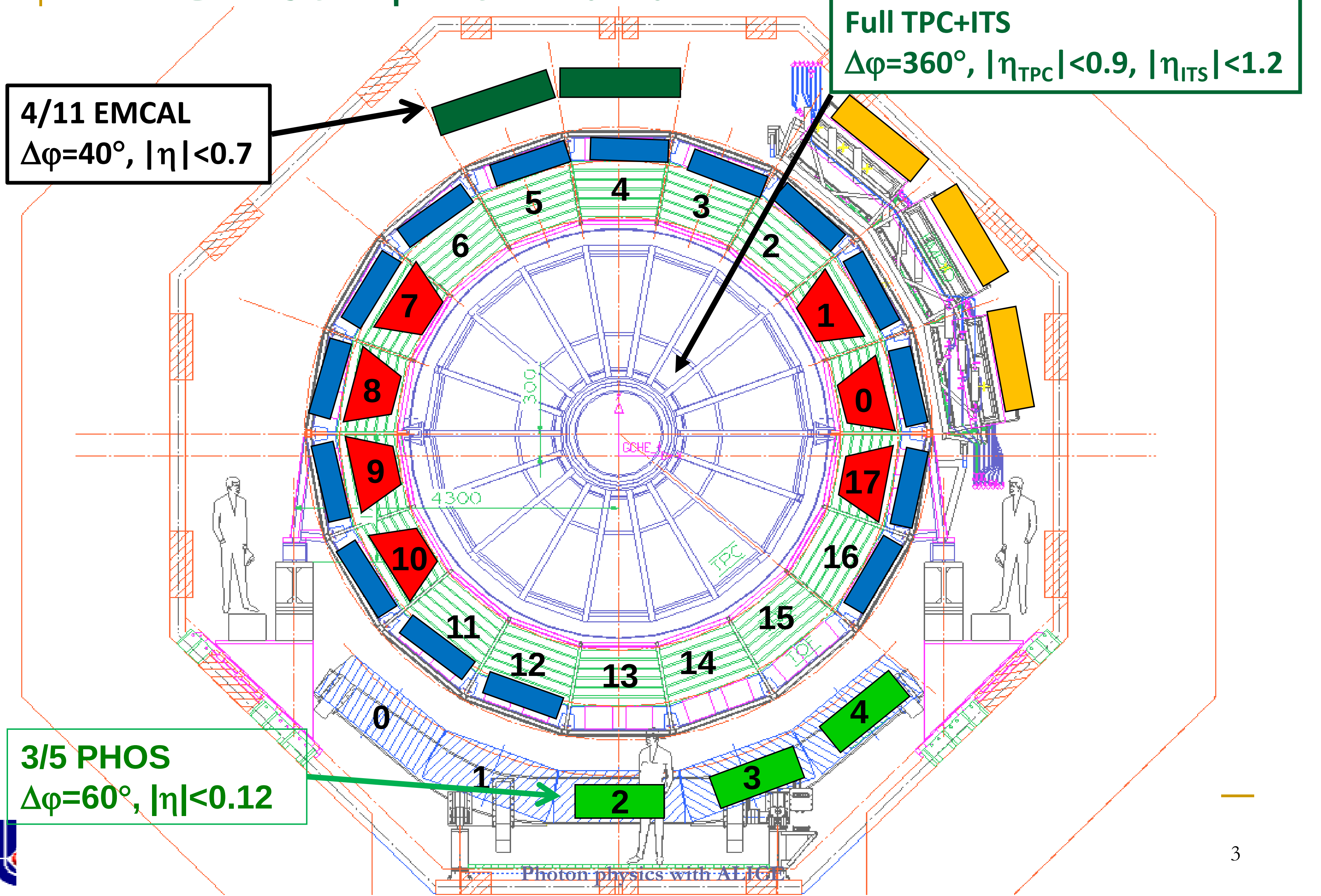
R_{AA}: *control of initial state*

Collective flow: *flow development on early stages*

HBT: *space-time dimensions of hot matter*

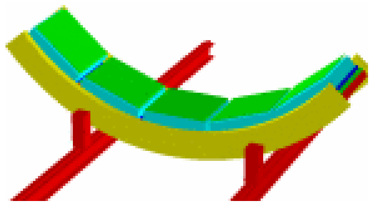
Jet tagging: *calibrated jets, fragmentation function modification in matter*

ALICE setup for 2010



Calorimeters: PHOS and EMCAL

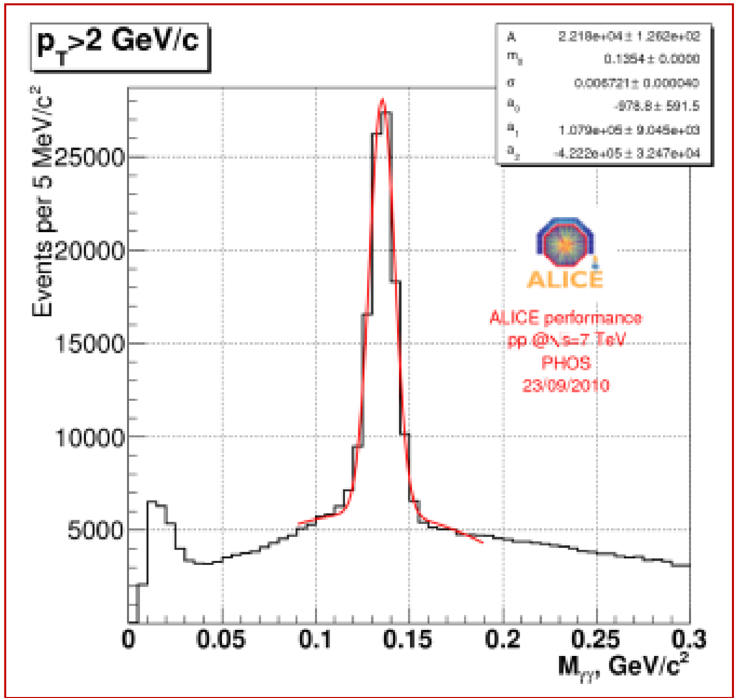
PHOS



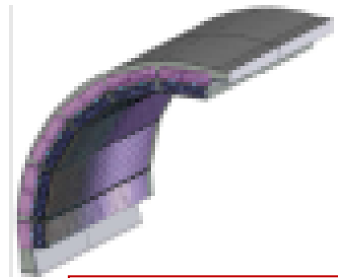
σ_E/E (%) $\sqrt{\left(\frac{1.3}{E}\right)^2 + \frac{3.3^2}{E} + 1.12^2}$

σ_x (mm) $\sqrt{\frac{3.26^2}{E} + 0.44^2}$

R_{ip} (cm) 460



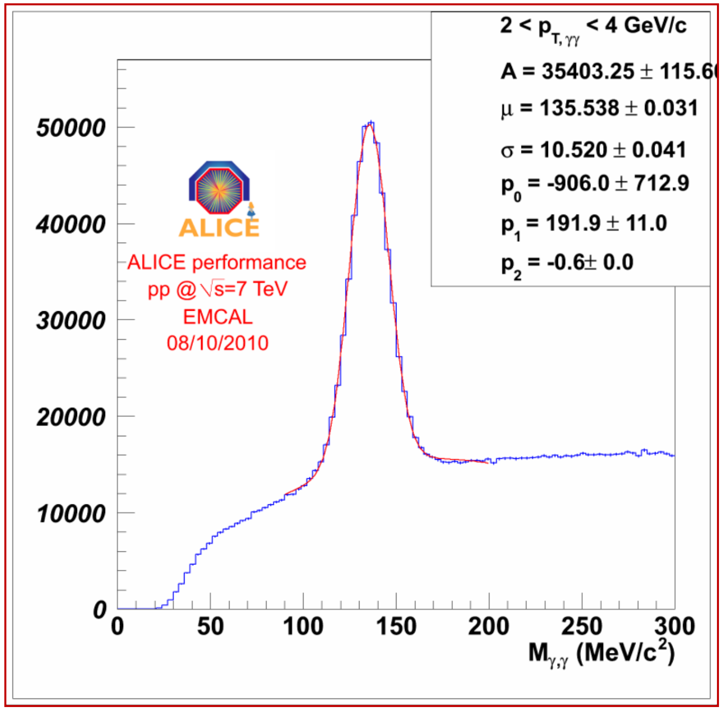
EMCAL



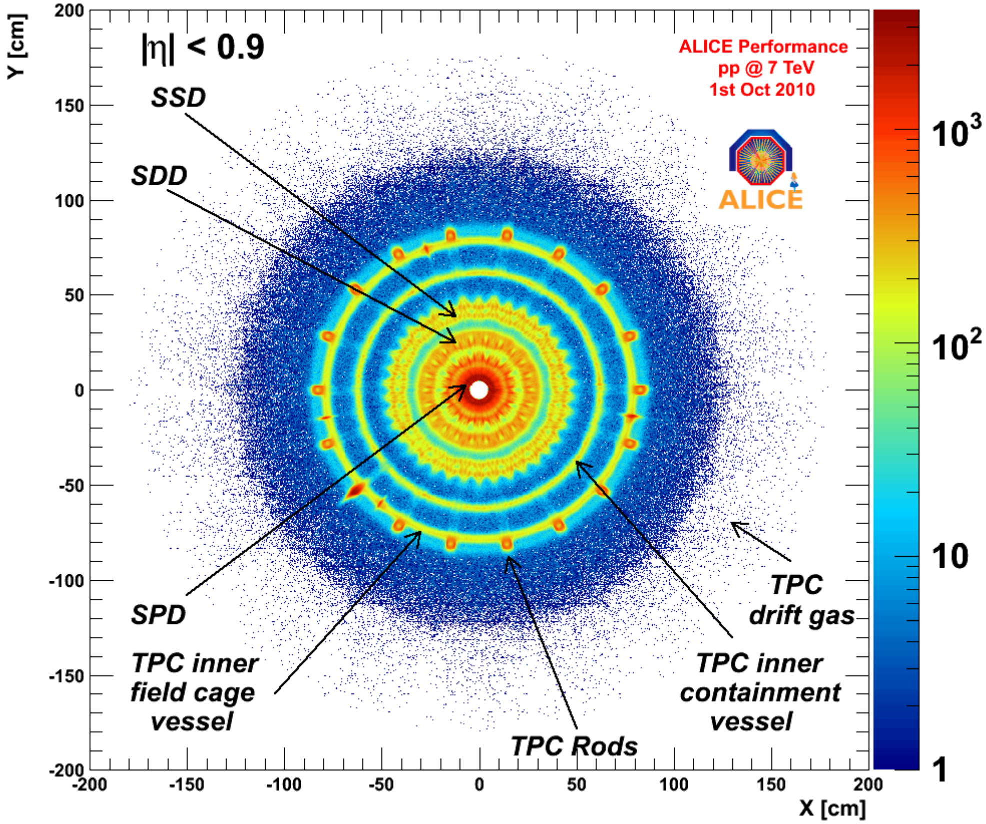
σ_E/E (%) $\sqrt{\left(\frac{1.7}{E}\right)^2 + \frac{11.3^2}{E} + 4.8^2}$

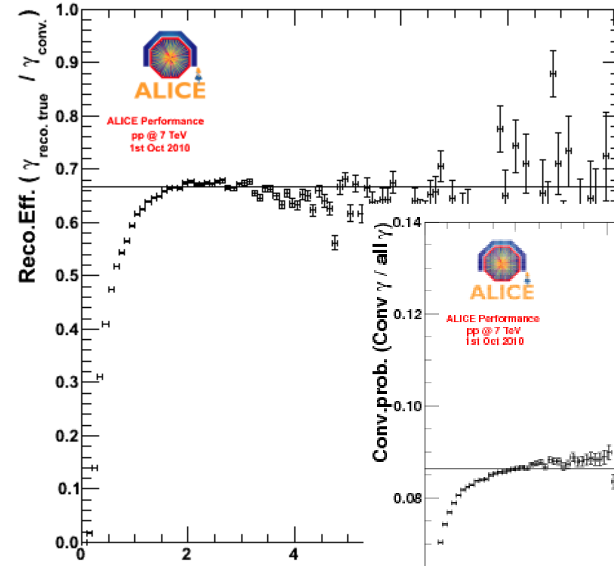
σ_x (mm) $1.5 + \frac{5.3}{\sqrt{E}}$

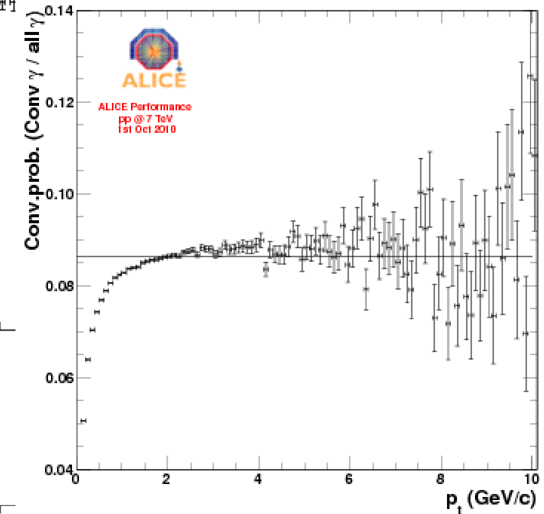
R_{ip} (cm) 428

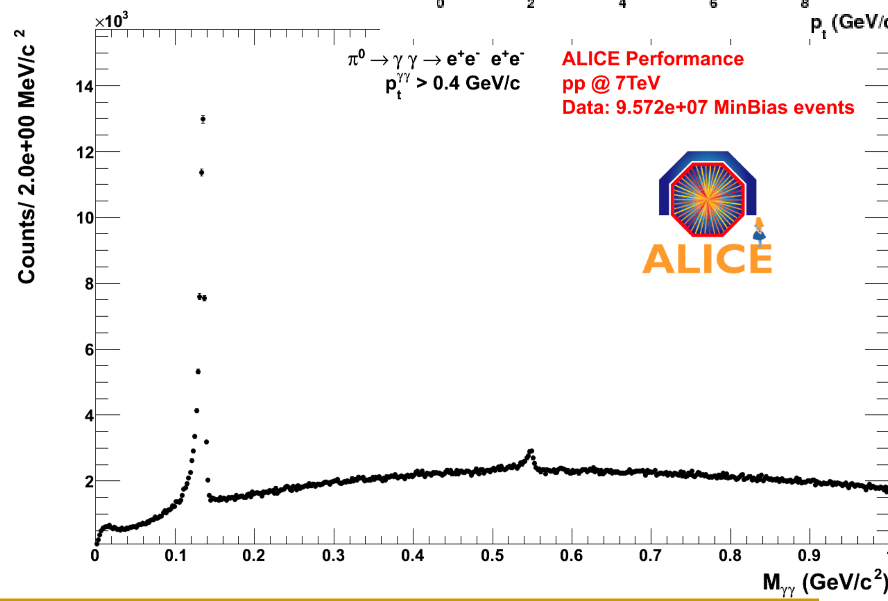


Conversion method

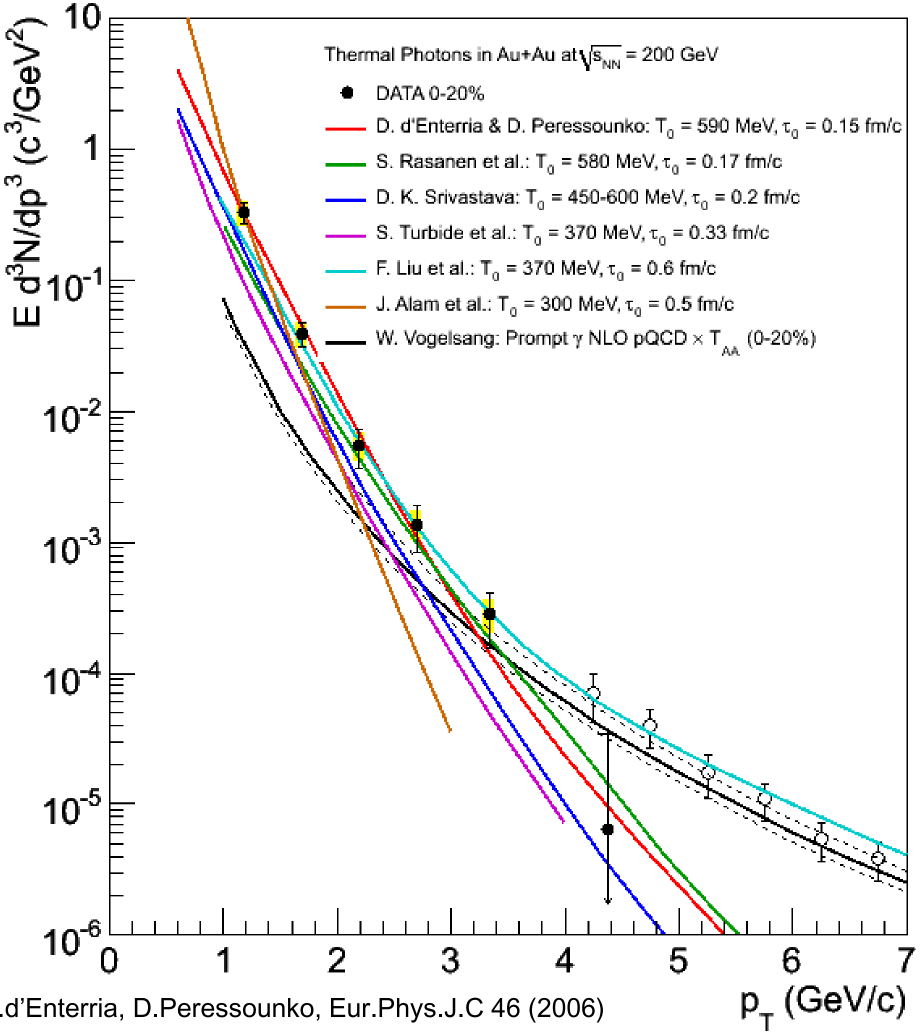




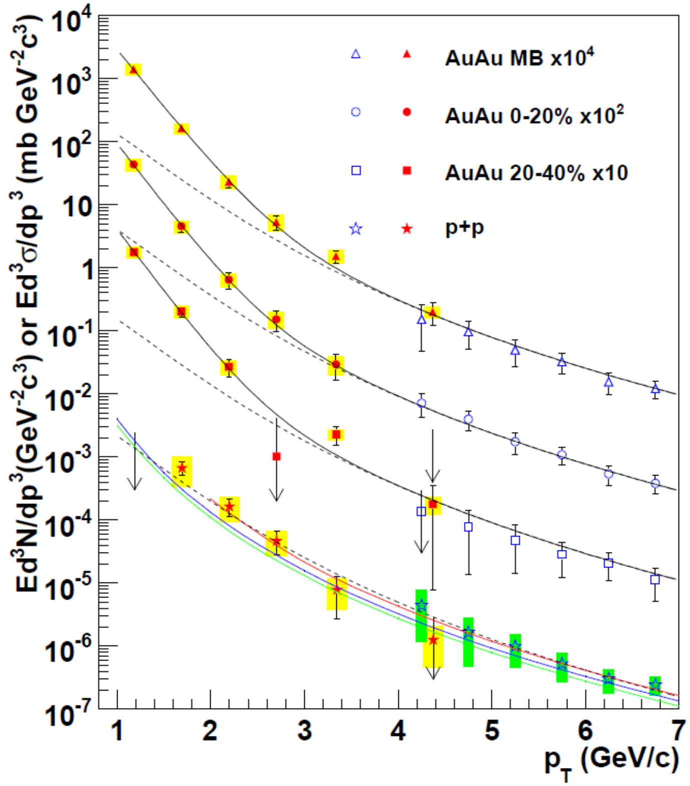




Spectrum of direct photons: PHENIX

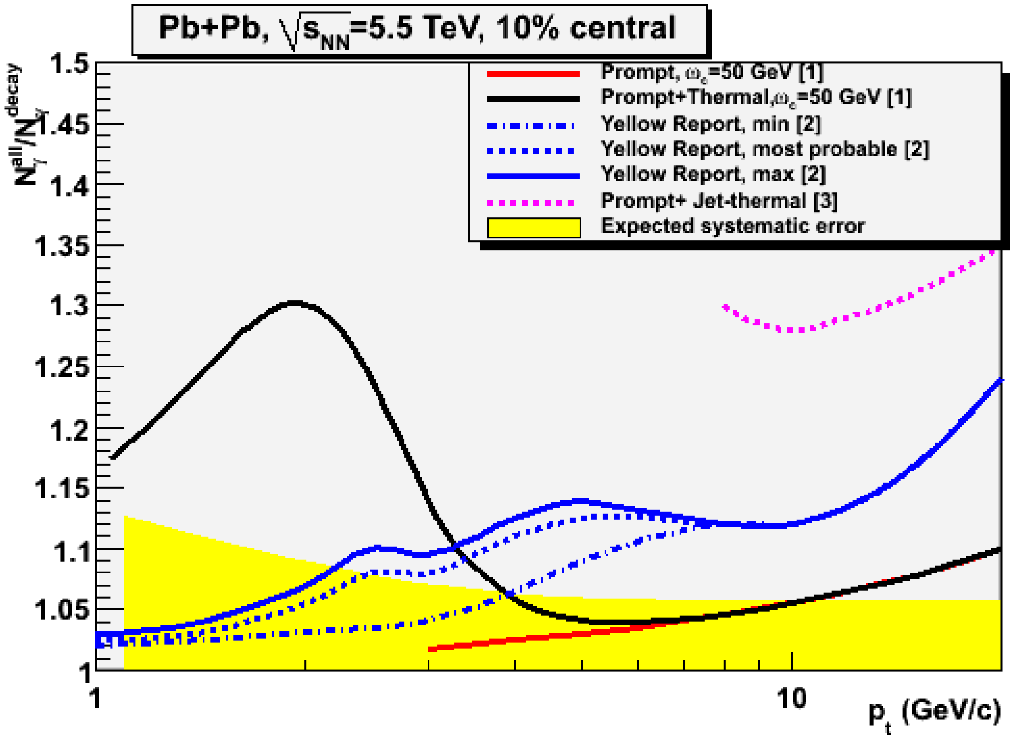


D.d'Enterria, D.Peressounko, Eur.Phys.J.C 46 (2006)



T_{ini} = 300 to 600 MeV
τ_0 = 0.15 to 0.5 fm/c

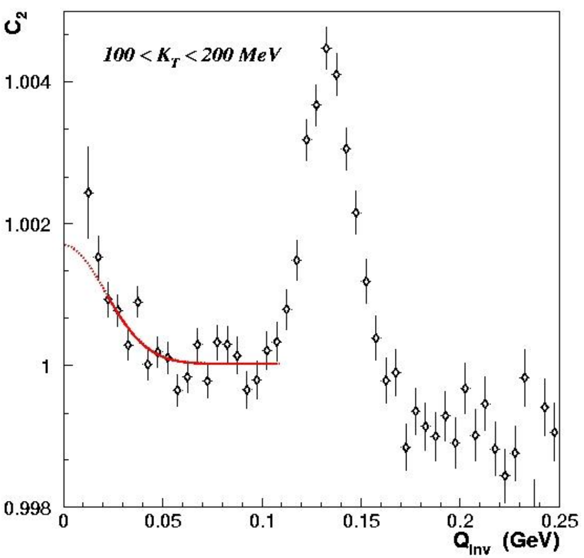
Spectrum of direct photons: ALICE



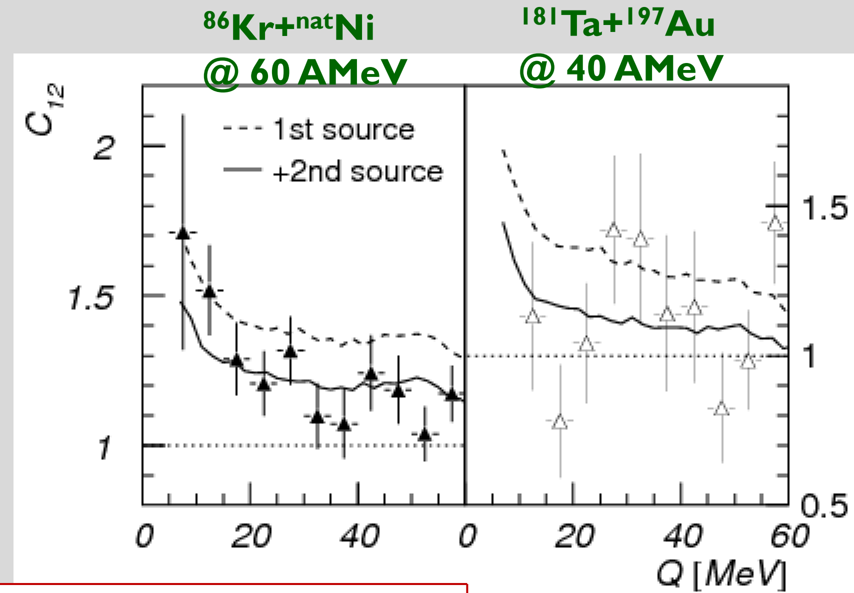
[[1] N. Armesto, (ed.) et al. F.Arleo et al,
J.Phys.G35:054001, 2008
2+1 hydro, T_{in}=650 MeV, reach RHG EOS
pQCD: CTEQ6.5M + nDSg, AKK+ω_c=50 GeV
[[2] F. Arleo *et al.,(Yellow Report)* **hep-ph/0311131**
pQCD:CTEQ5M,KKP(BFGII for γ),
EKS98+Eloss(0 for γ)
[[3] S.Tubide et al., **Phys.Rev.C72:014906,2005**

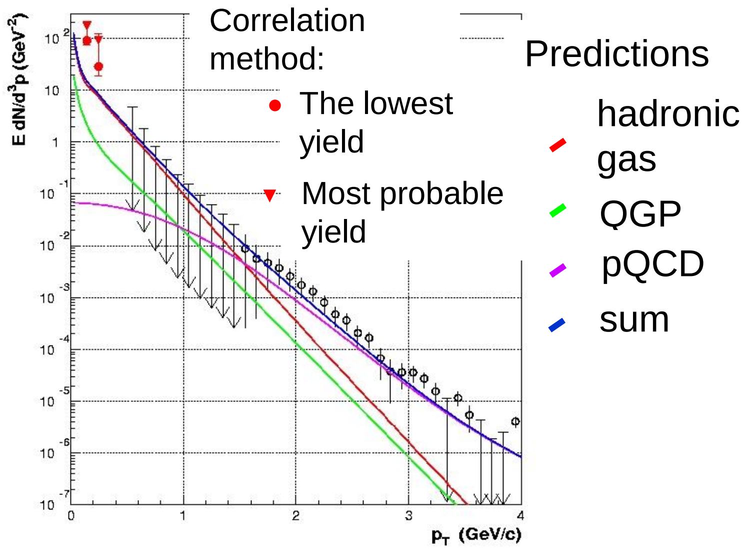
To estimate expected systematic error extrapolate PHENIX results to ALICE accounting S/Bg ratio, difference in amount of material, resolutions etc.

Direct photon HBT



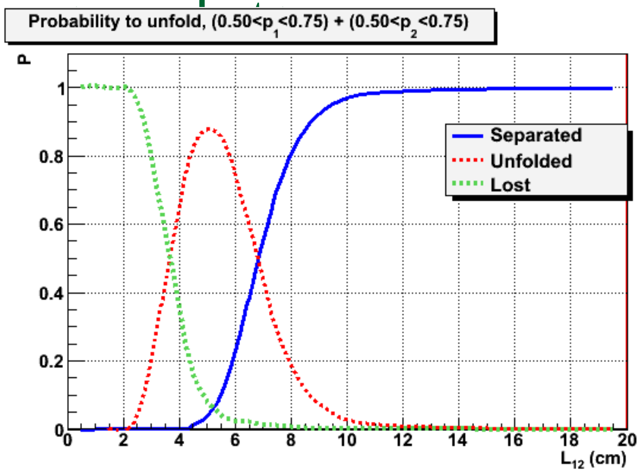
M.M. Aggarwal et al.,Phys.Rev.Lett.93:022301,(2004)

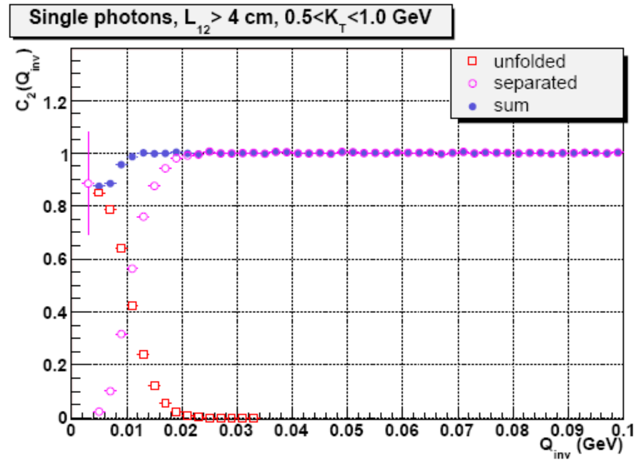


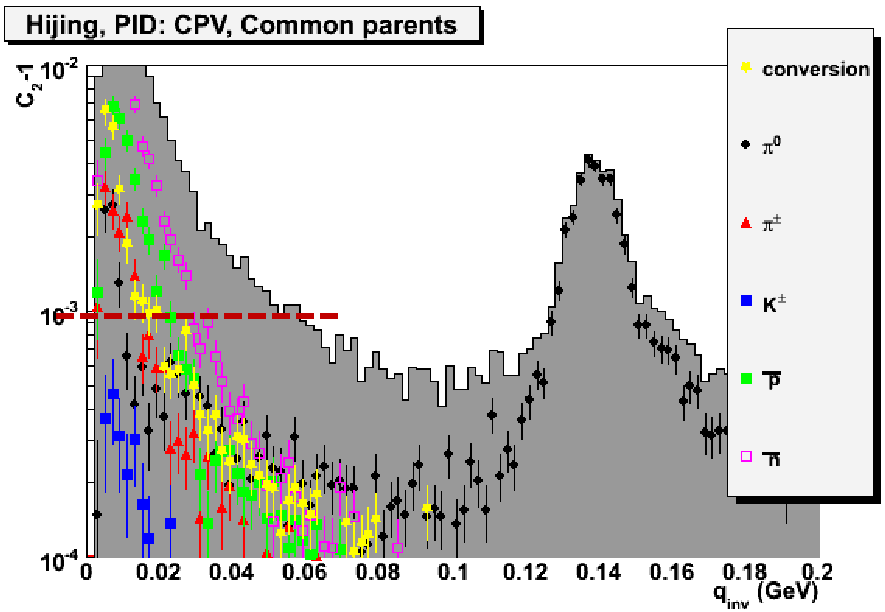


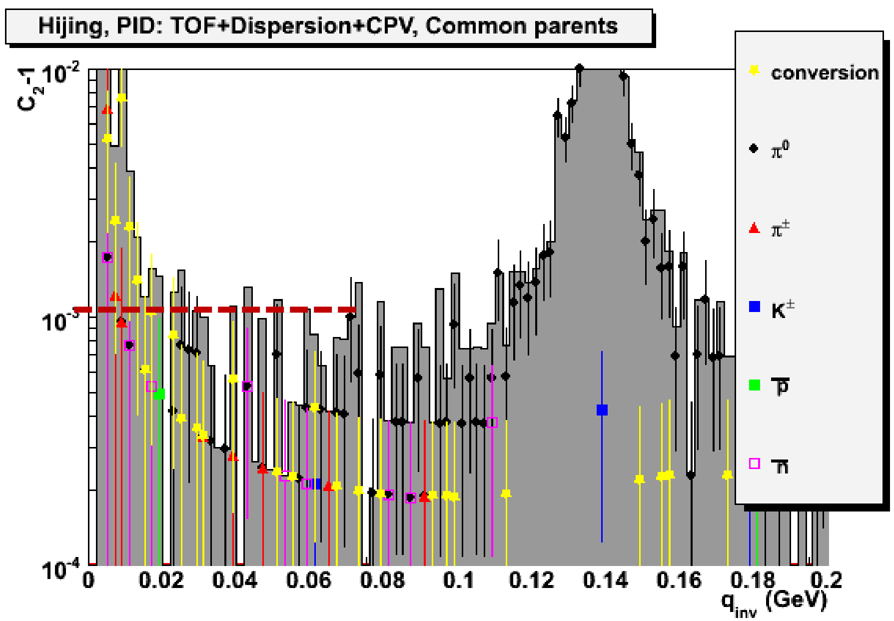
M.Marques et al., (TAPS collaboration) PRL 73 (1994) 34.

Direct photon HBT in ALICE/PHOS, MC



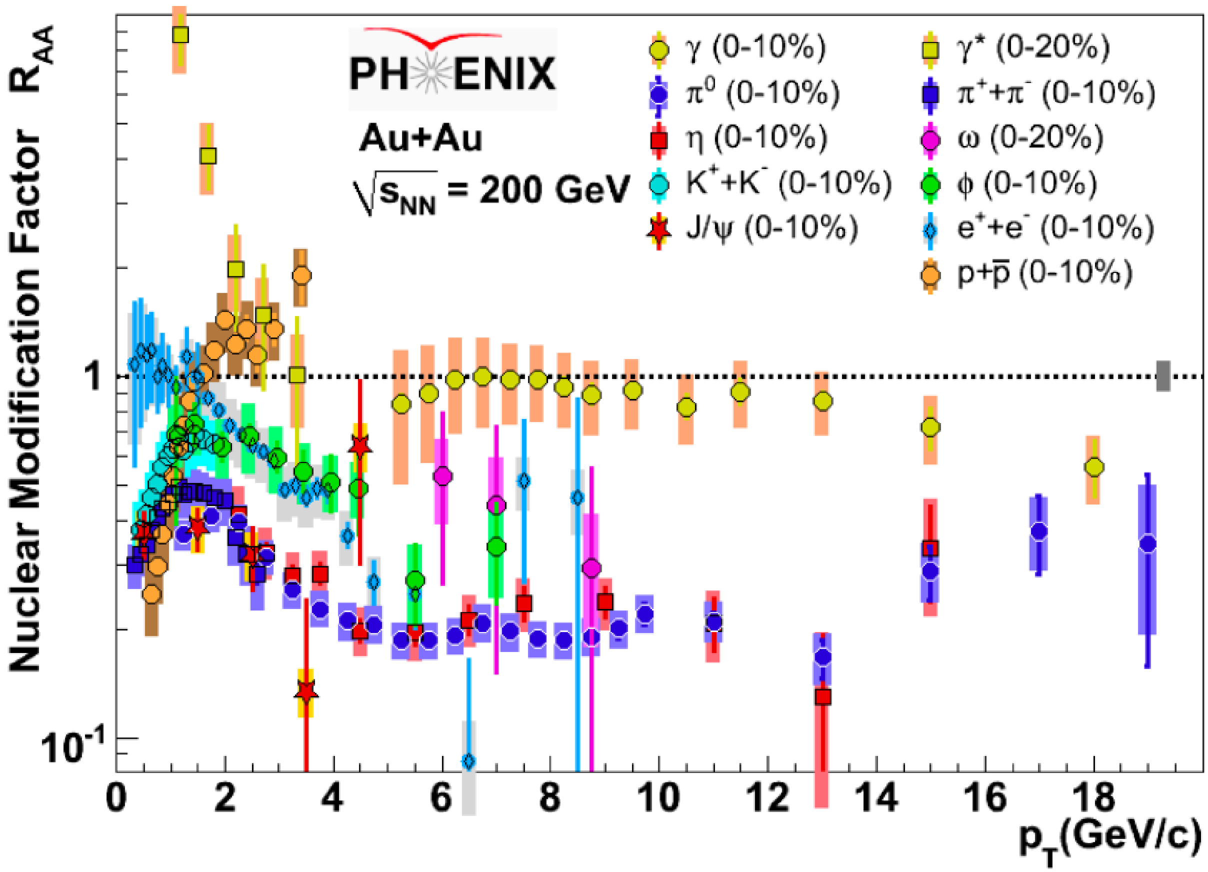






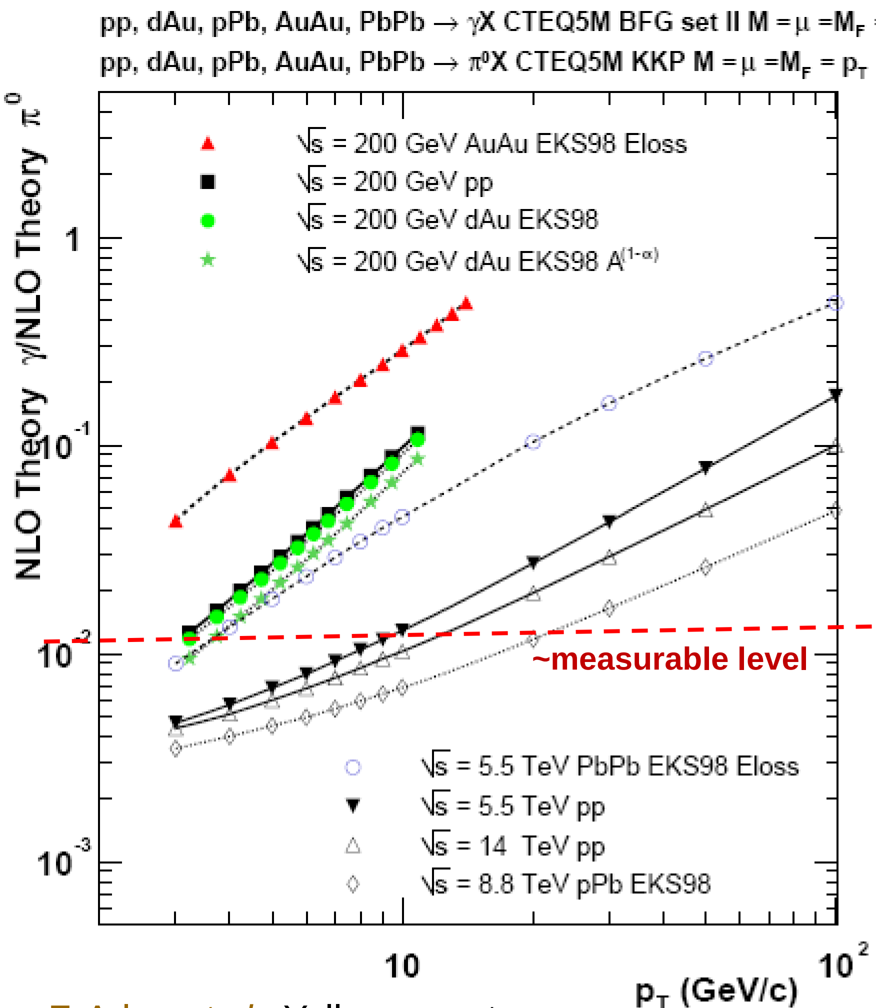
Direct photons and hadron R_{AA} in AA collisions: RHIC

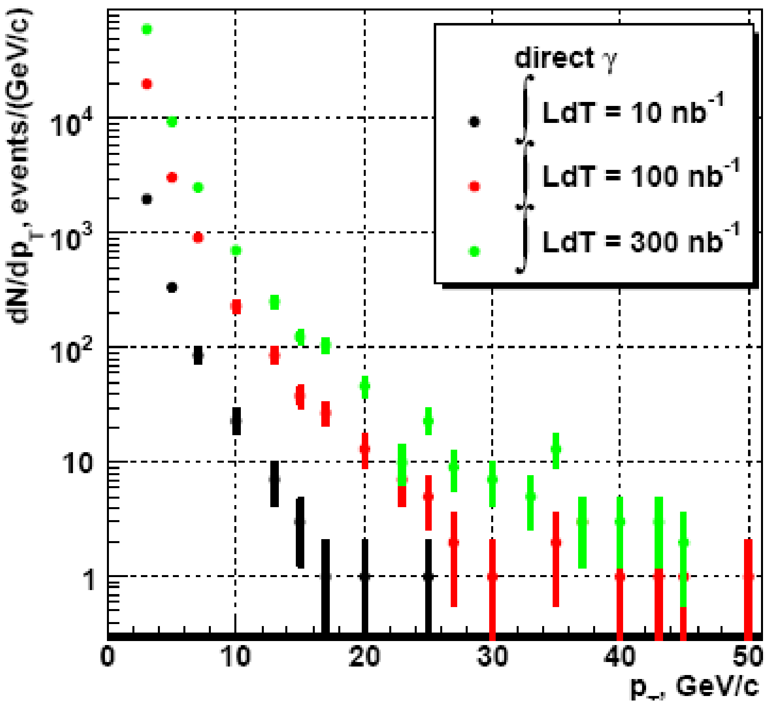
[PHENIX, QM2009]



Direct photons scale as with N_{part} and provide calibration of the initial state of AA collisions.

Direct photon R_{AA} in ALICE

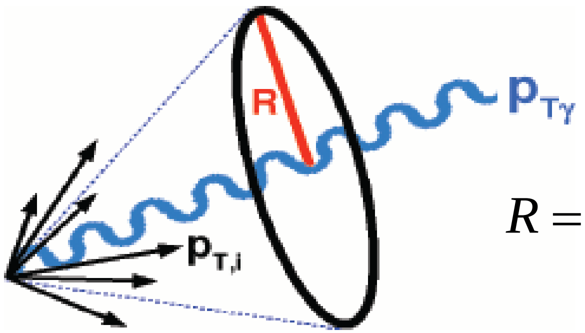




So far ALICE collected ~15 nb^{-1}

F. Arleo *et al.* Yellow report,
CERN-2004-009-D, **hep-ph/0311131**

Isolated photons



$$R = \sqrt{\Delta\eta^2 + \Delta\varphi^2}$$

In pp collisions:

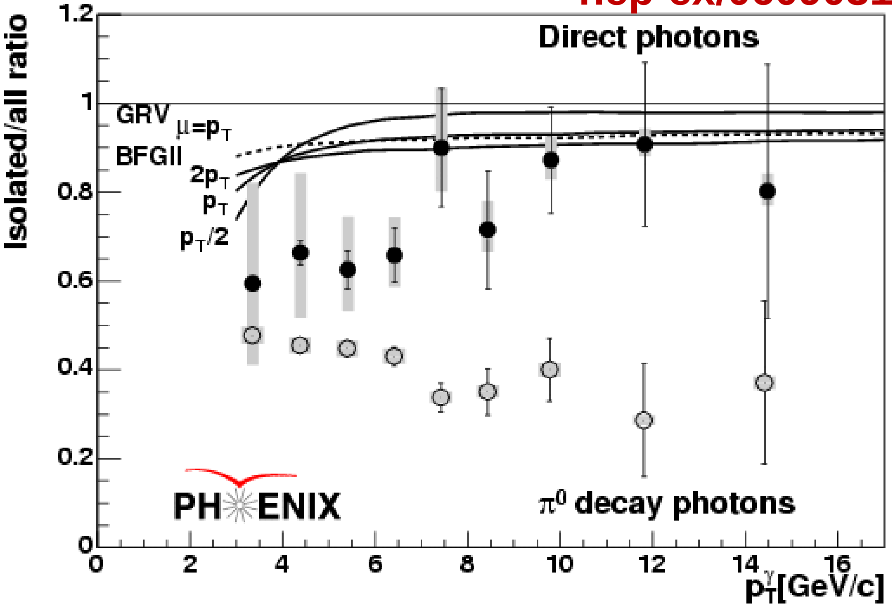
$$\sum p_{T_i} \le \varepsilon \cdot p_{T_\gamma}$$

In PbPb collisions

$$\sum p_{T_i} \le p_T^{cut}$$

Due to underlying event one should use fixed cut

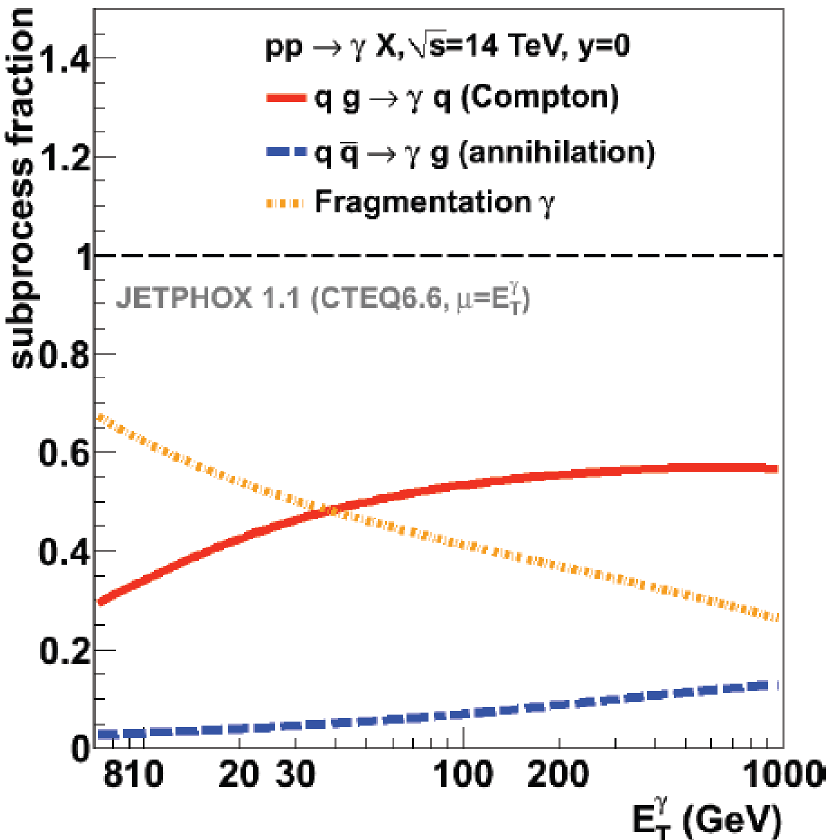
hep-ex/0609031



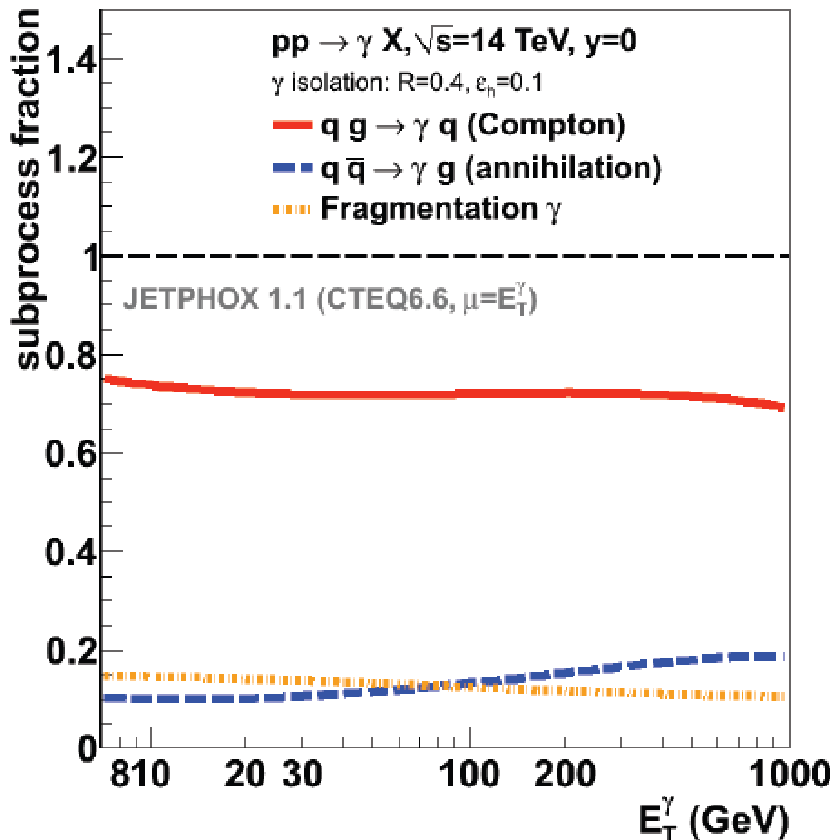
Due to limited acceptance of ALICE use R = 0.4

Isolation of fragmentation photons

All direct photons



Isolated

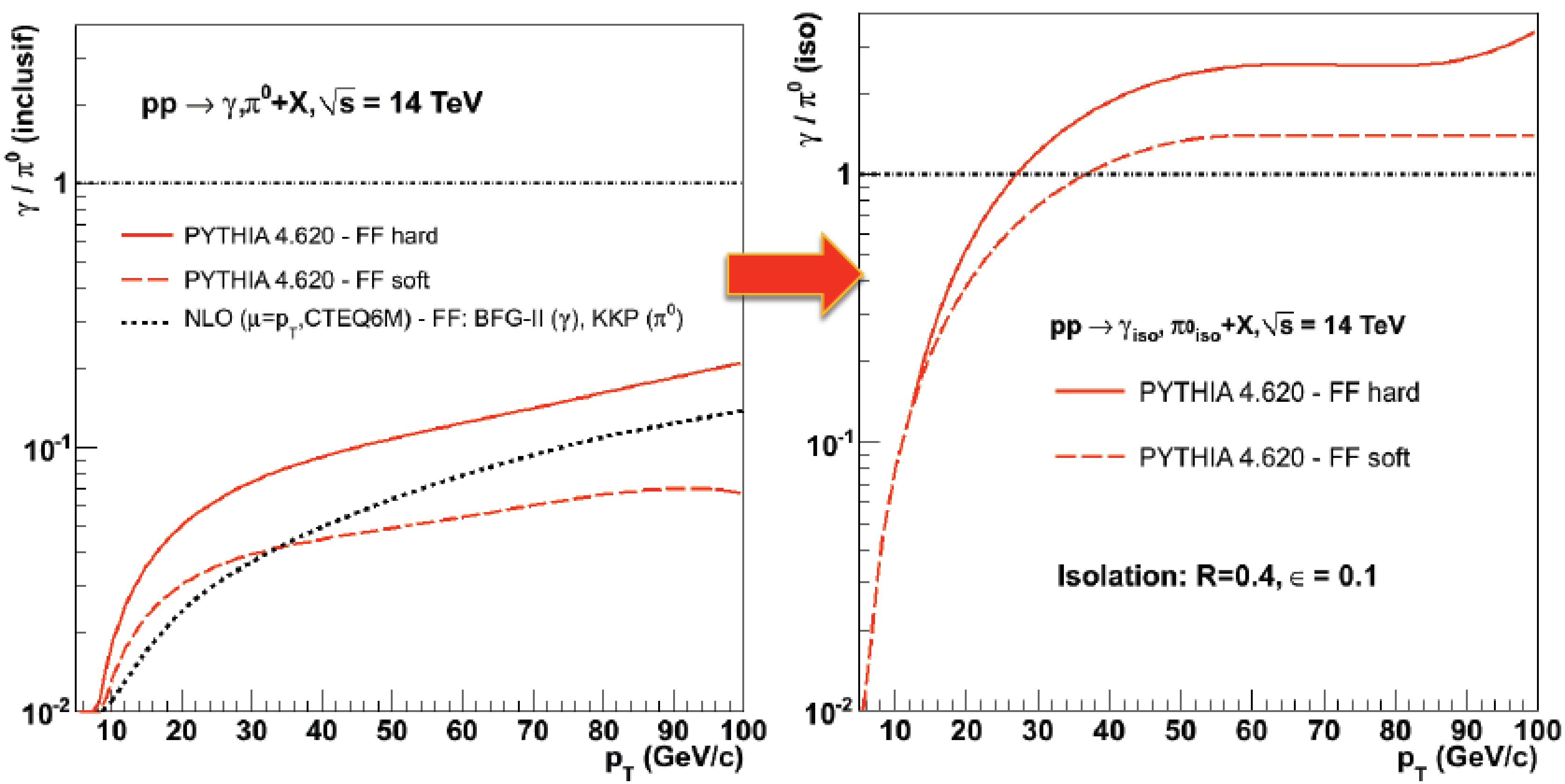


- The fragmentation channel dominates al low p_T
- After ~ 35 GeV the Compton channel dominates.

- Increase the Compton (and annihilation) contributions.
- Decrease strongly the fragmentation channel

Raphaelle Ichou, Ph.D thesis 2010

Isolated photons: spectrum

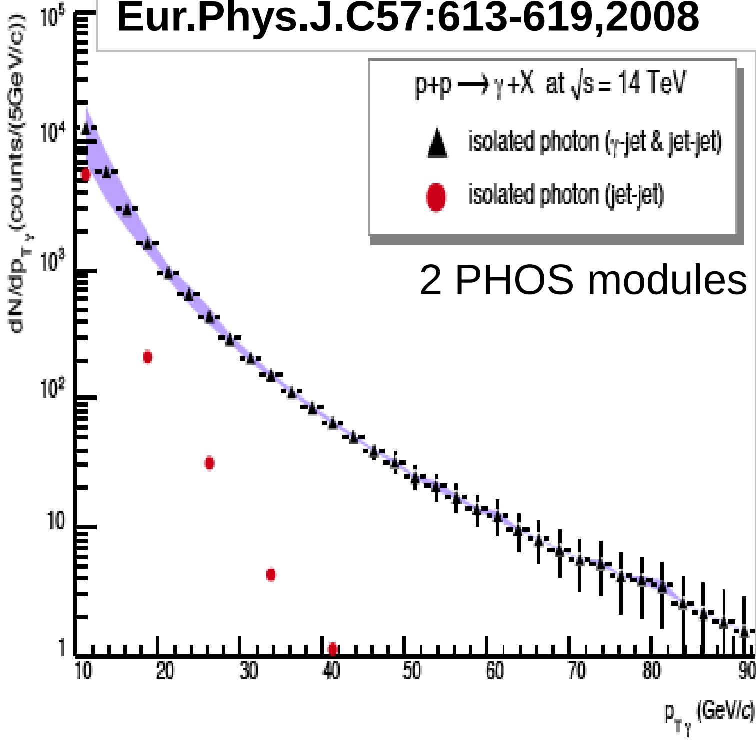


$$E\frac{d^3\sigma^{iso\,\gamma}}{d^3p} = \frac{1}{2\pi p_T}\frac{1}{p(\gamma\,|\,\gamma)}\left[\frac{N^{iso}_{cluster}id\,\gamma}{L\times\varepsilon_{iso}\times\varepsilon_{reco}\times A\times\Delta y\times\Delta p_T} - p(\gamma\,|\,\pi^0)\frac{d\sigma^{iso\,\pi^0}}{dp_T}\right]$$

Raphaelle Ichou, Ph.D thesis 2010

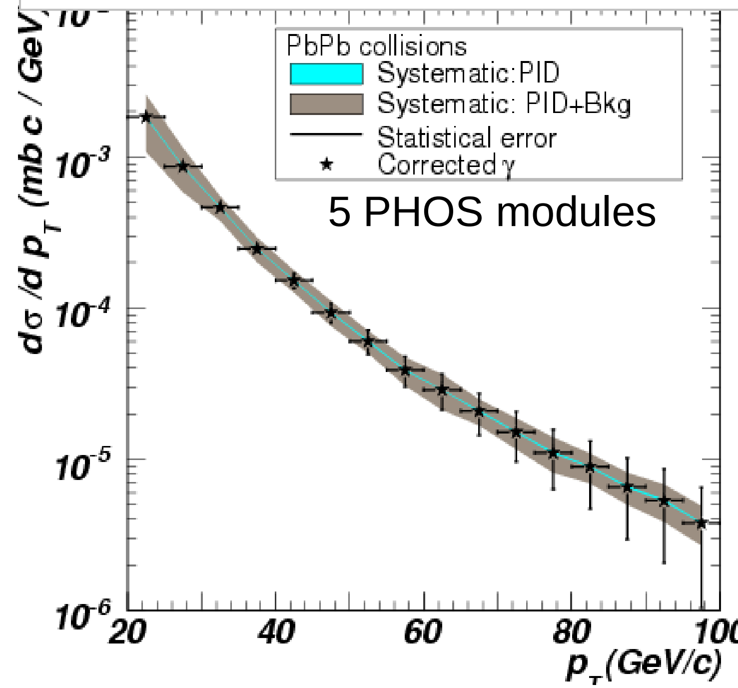
Isolated direct photons

Y. Mao et al.,
Eur.Phys.J.C57:613-619,2008



2 PHOS modules

G. Conesa et al.,
ALICE-INT-2005-014, NIM A 580 (2007) 1446

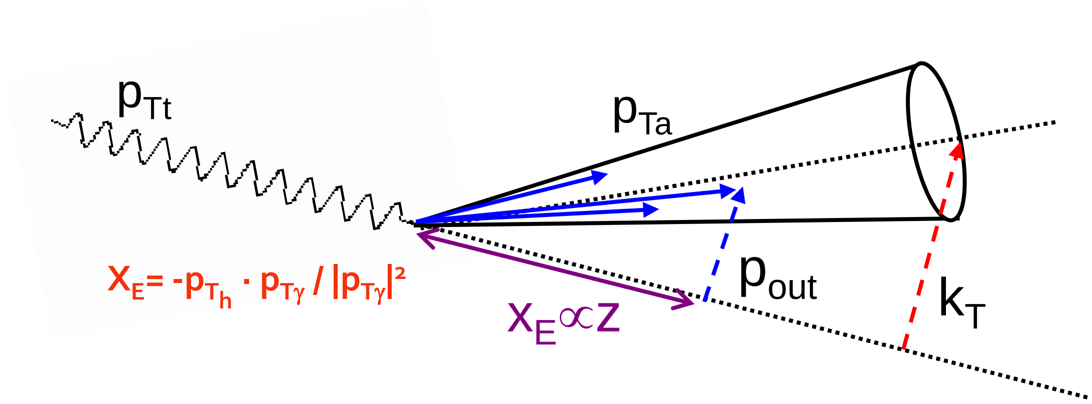


5 PHOS modules

IC: R =0.3, $\Sigma(p_T)$=2 GeV/c

IC: R =0.2, p_T>2 GeV/c

Isolated photons: jet tagging



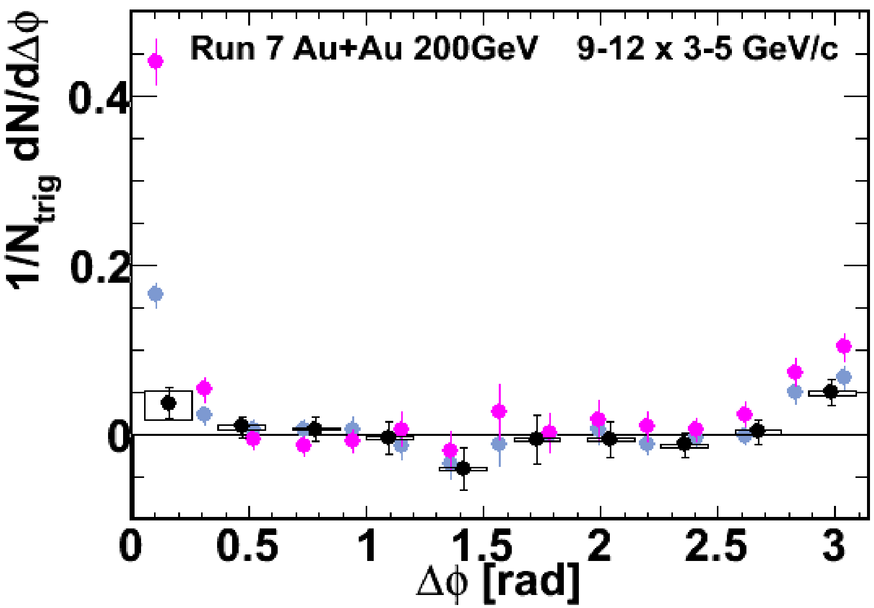
- Direct access of jet modification & medium response
- Clean way to measure Fragmentation Functions: approximate z with x_E
  - Caveat: k_T smeares relation z<-> x_E
- Systematic control on geometrical bias

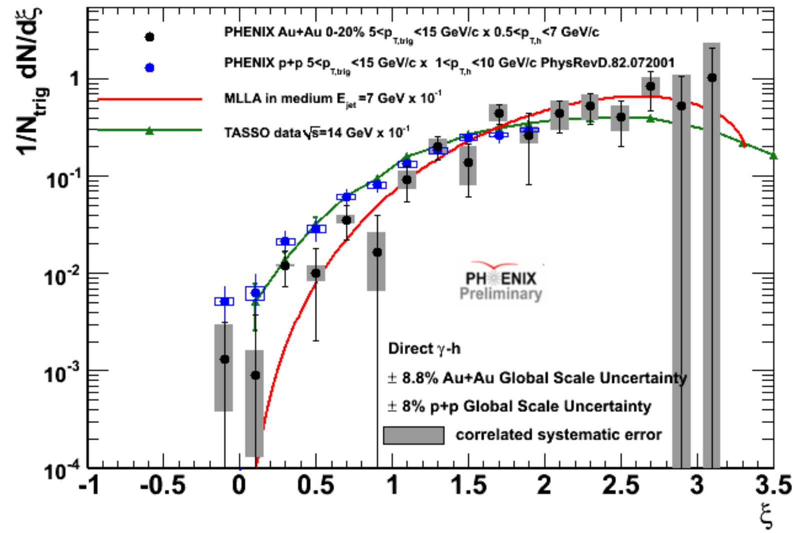
$$I_{AA} = \frac{(N^{ta}/N^{t})_{Au+Au}}{(N^{ta}/N^{t})_{p+p}}$$

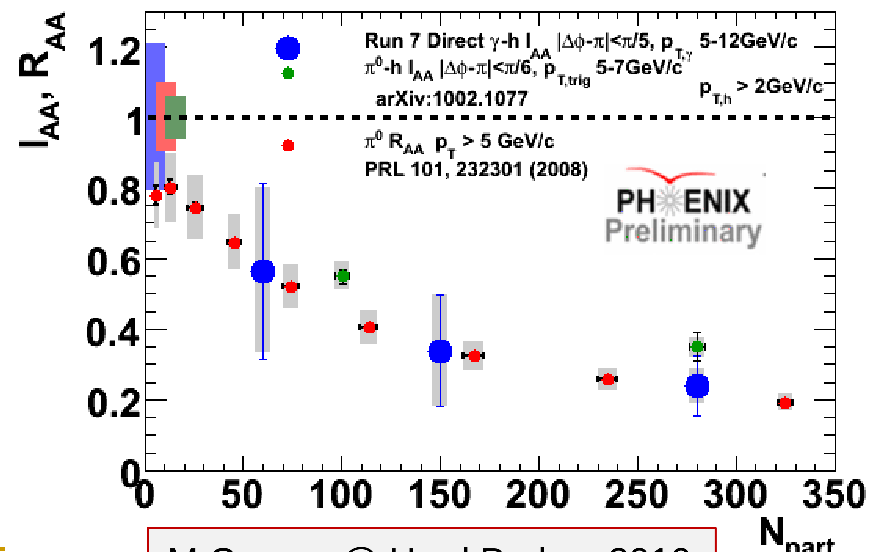
Look at modification of FF in AA collisions with respect to pp

Gamma-jet correlations: PHENIX

A. Adare et al (PHENIX) PRC 80, 024908 (2009)

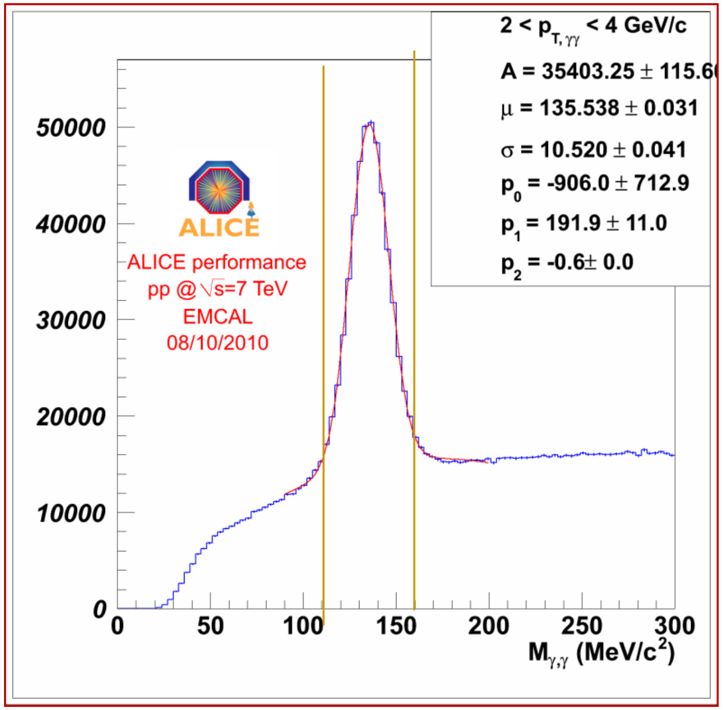


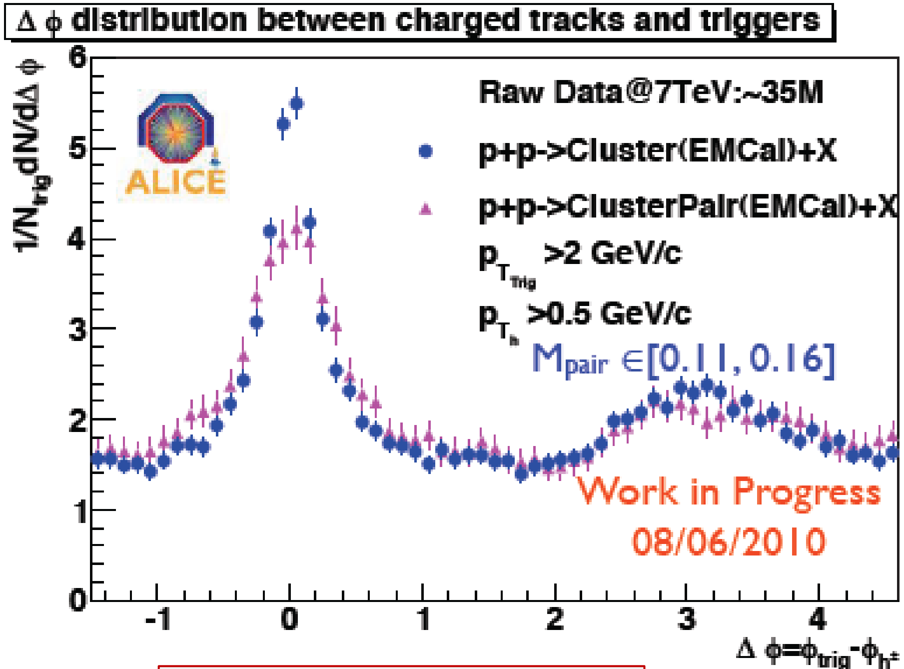




M.Connor @ Hard Probes 2010

Correlation function with direct photons

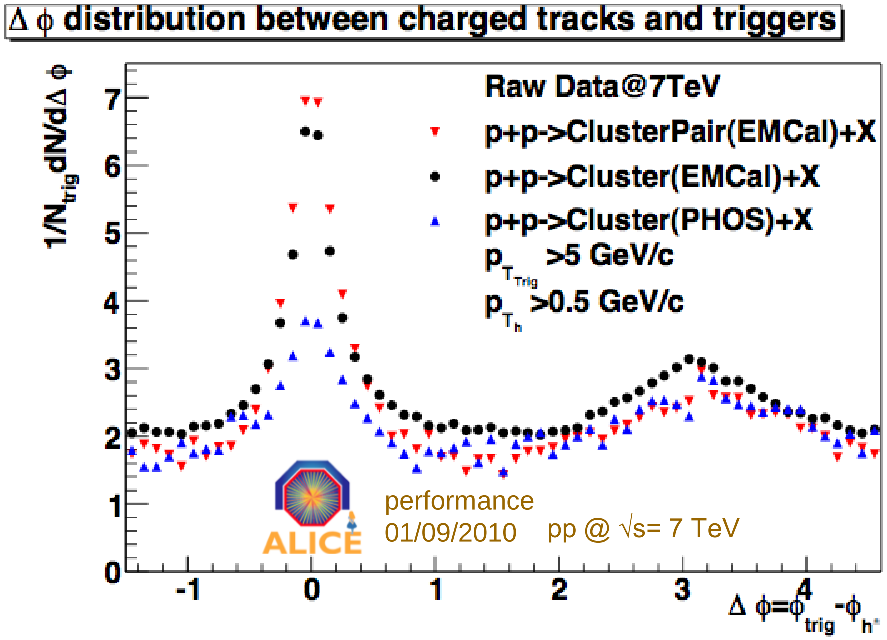


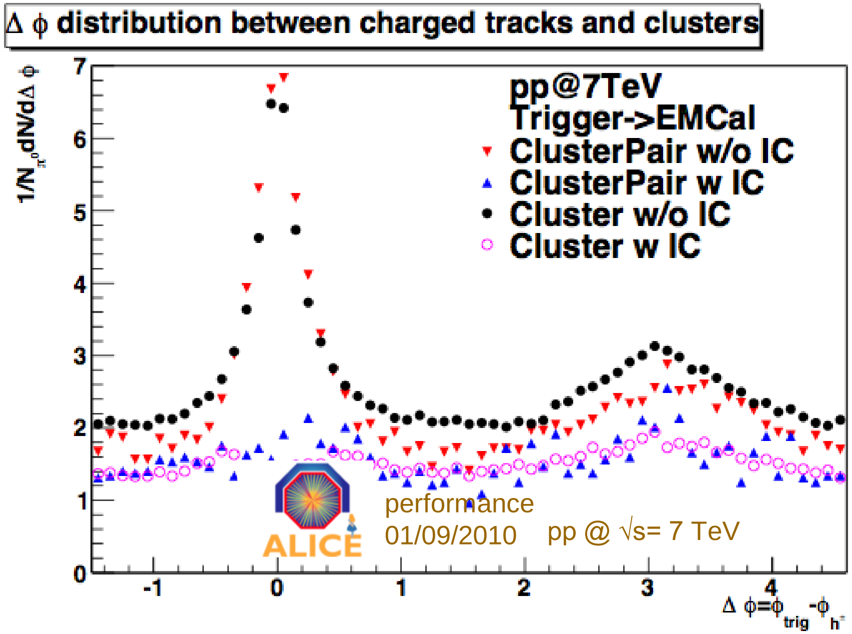


Y.Mao @ Hot Quarks 2010

- Started analysis
- First results are promising…

Correction functions with isolated triggers





- Correlation of Charged Tracks / PHOS clusters / EMCAL clusters with charged hadrons measured in TPC+ITS.
  - Left Plot: Near (mainly π^0 for EM calorimeters) and away side correlation shows a jet-like structure
  - Right plot: Applying isolation cuts to clusters or π^0, the away side correlation remains: single pi0 - jets and/or direct-photon - jet ?

- Consolidate the isolation cut, extract kT, FF.

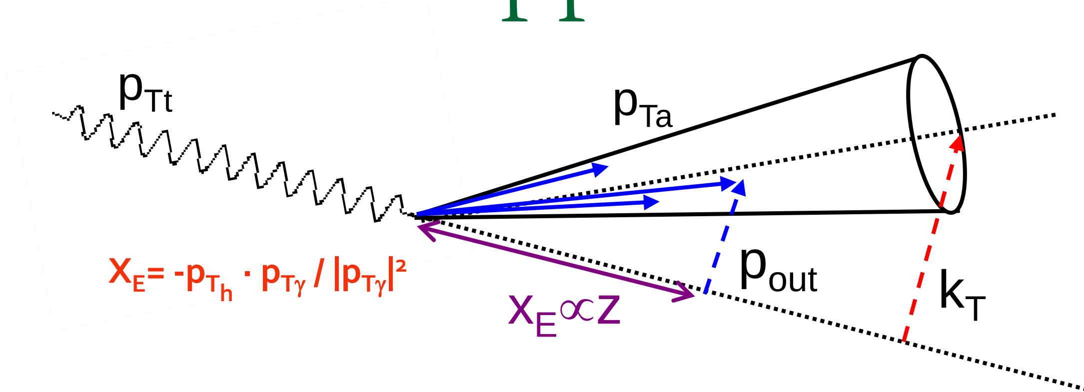
Y.Mao @ Hot Quarks 2010

Conclusions

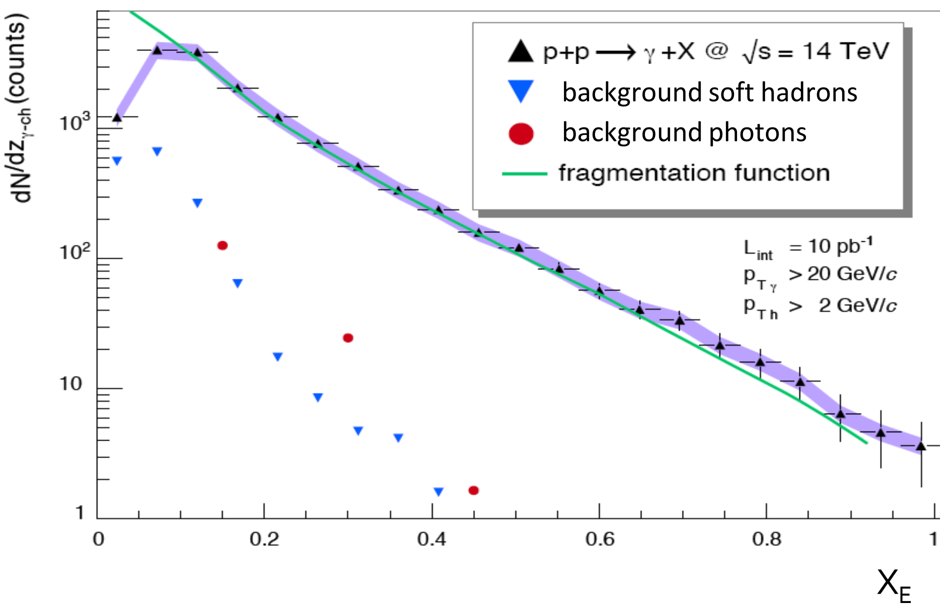
- Photons provide the possibility to study a large variety of characteristics of heavy-ion collisions
- ALICE measures photons in detectors based on different technologies which provide reliable cross-check
- Ongoing analyses look promising.

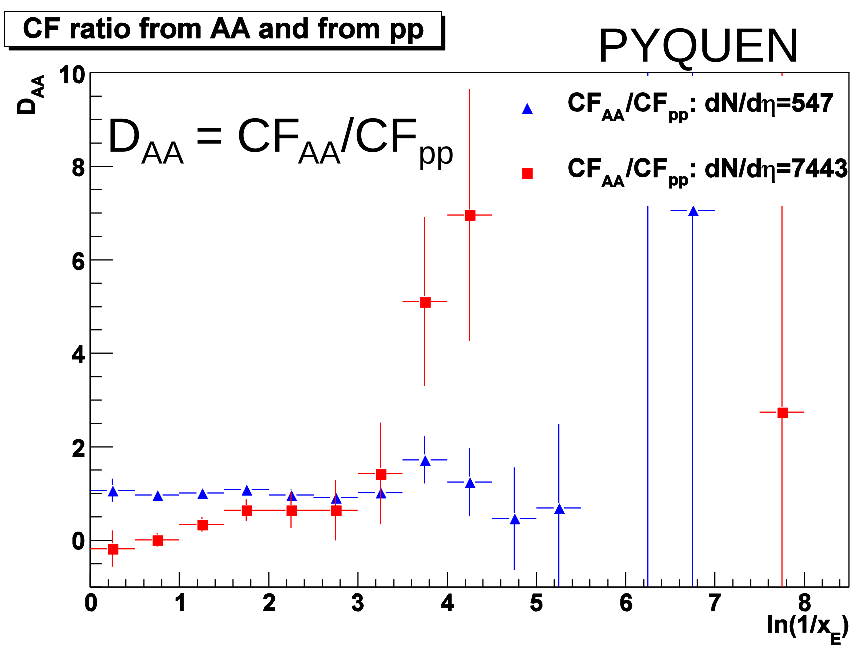
Backup slides

γ-h correlation in pp and AA



EPJC (2008) 57: Y. Mao

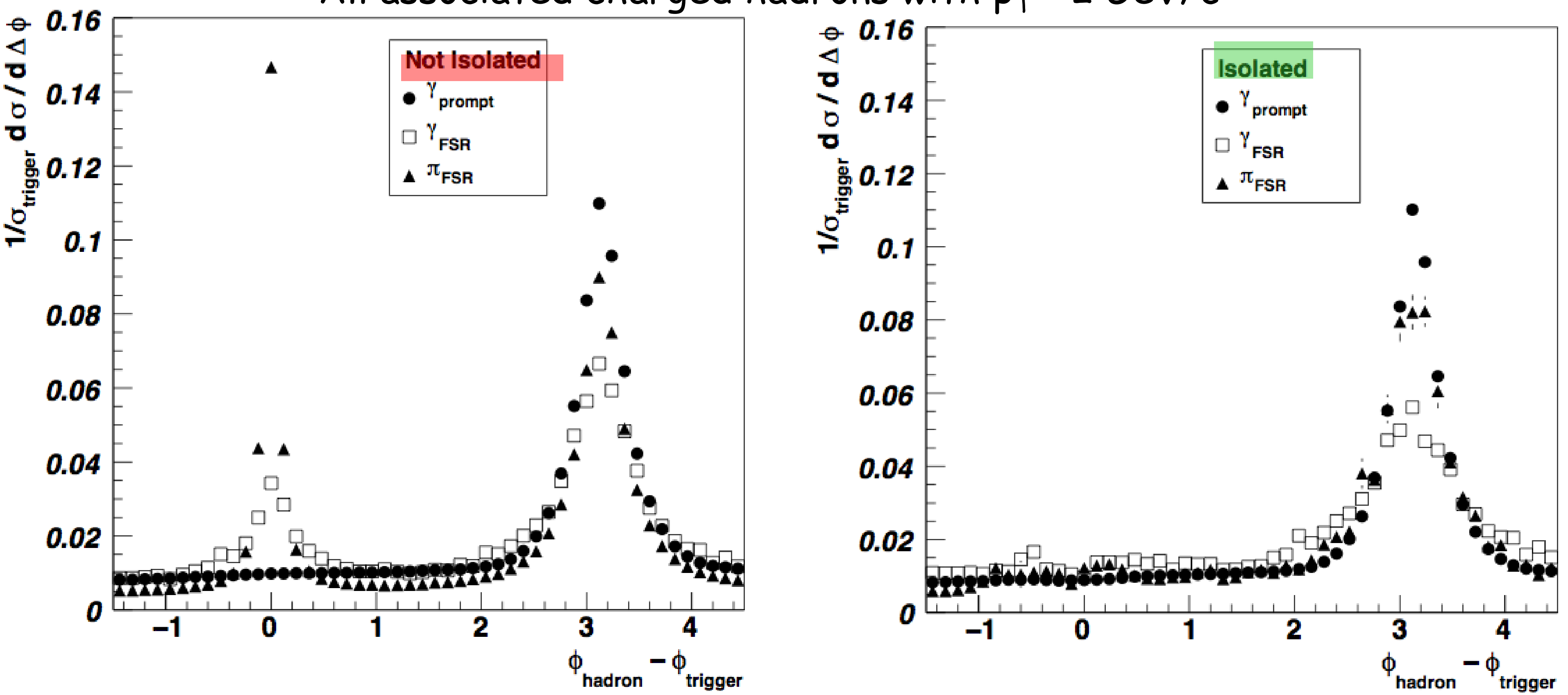




γ-hadron correlations

PYTHIA pp collisions $\sqrt{s}$=14 TeV

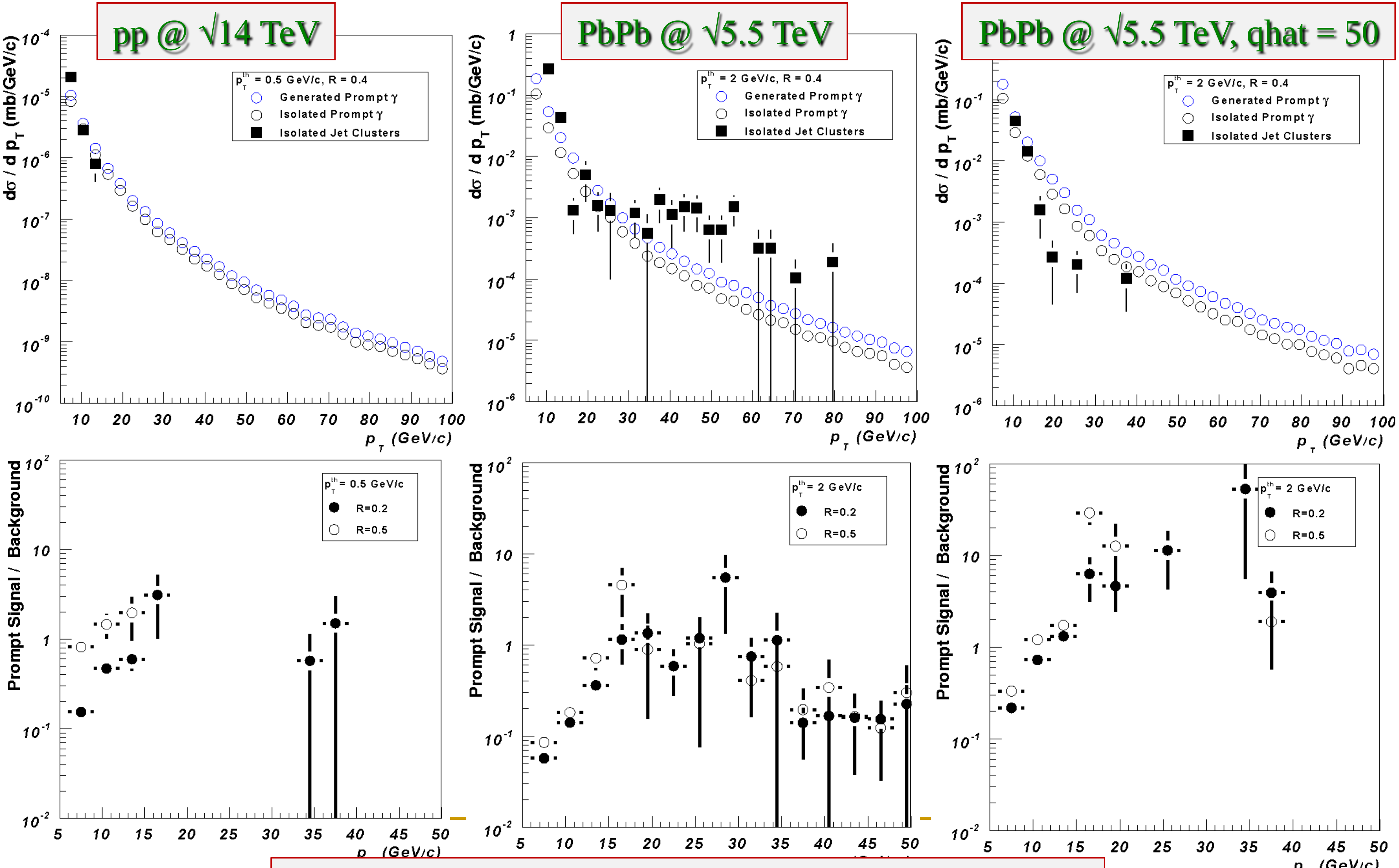
All associated charged hadrons with p_T > 2 GeV/c



G. Conesa, Proceedings of Science, PoS (HIGH-pTLHC) 003

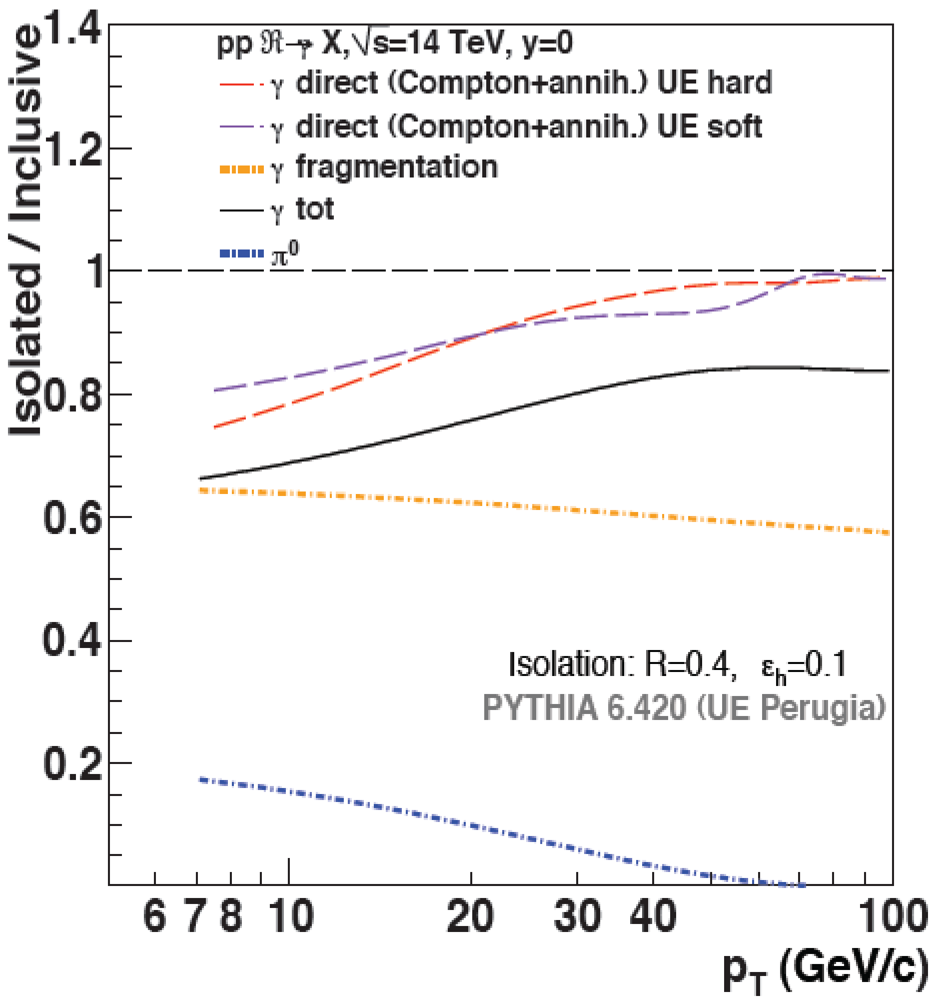
Isolated Spectra in EMCAL

pp = PYTHIA
PbPb =PYTHIA (signal) +HIJING (UE)
Full reconstruction in ALICE



γ-jet (signal); jet-jet (π^0-hadron background)

Influence of isolation on different sources

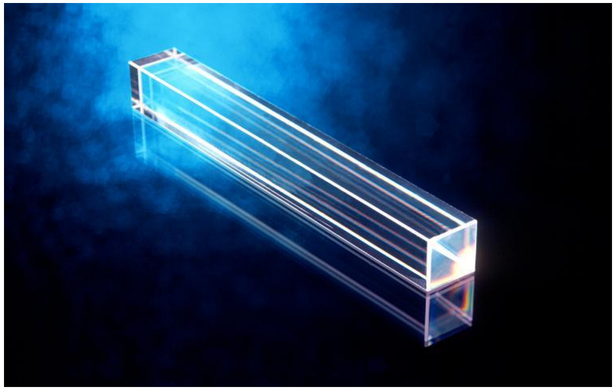


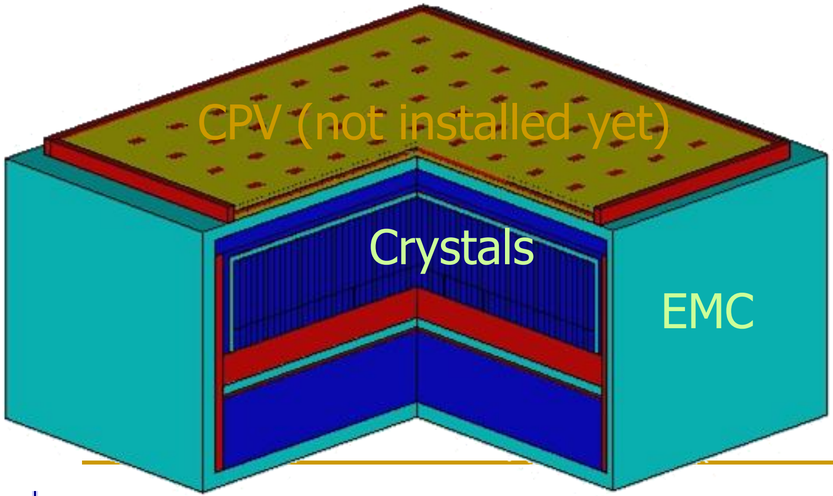
Pythia MSUB(14) =1 : Annihila5on ON
Pythia MSUB(29) =1 : Compton ON
PYTHIA6.420 :
* UE Perugia hard :
more ISR/FSR, less MPI & beam remnants
* UE Perugia sol :
less ISR/FSR, more MPI & beam remnants

- 80%-100% of Compton and annihila5on photons
- 60% of fragmenta5on photons
- 70%-85% of total photons
- 20%-1% of π0

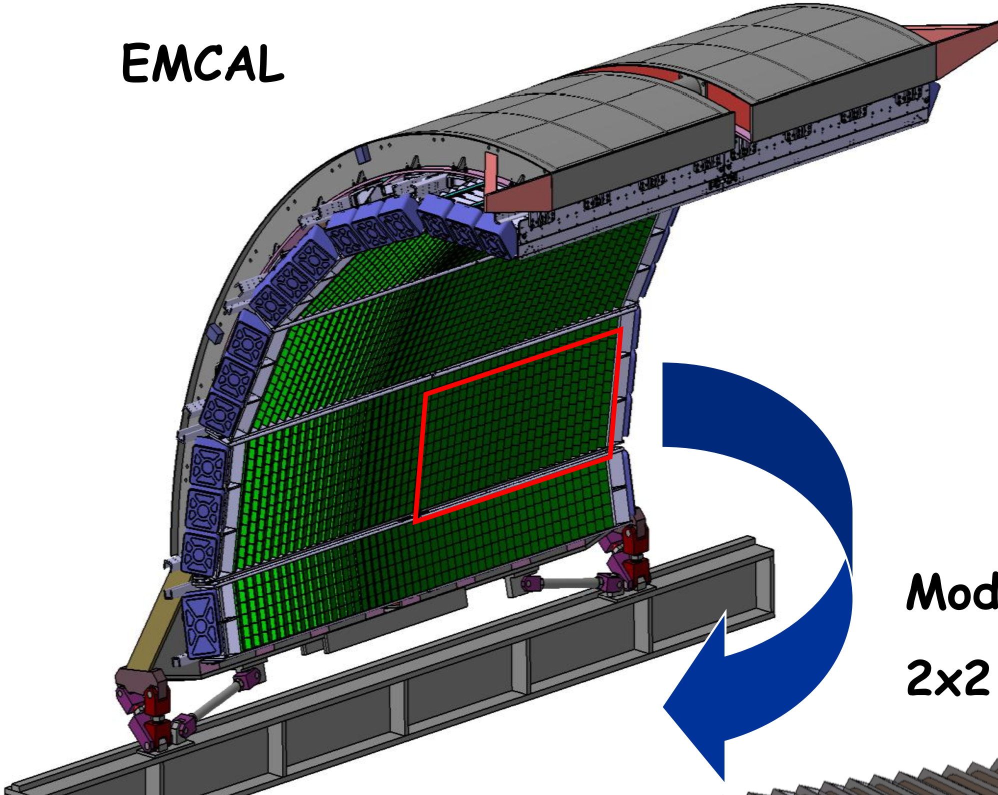
Raphaelle Ichou, Ph.D thesis 2010

PHOton Spectrometer: PHOS



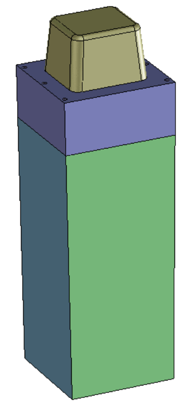


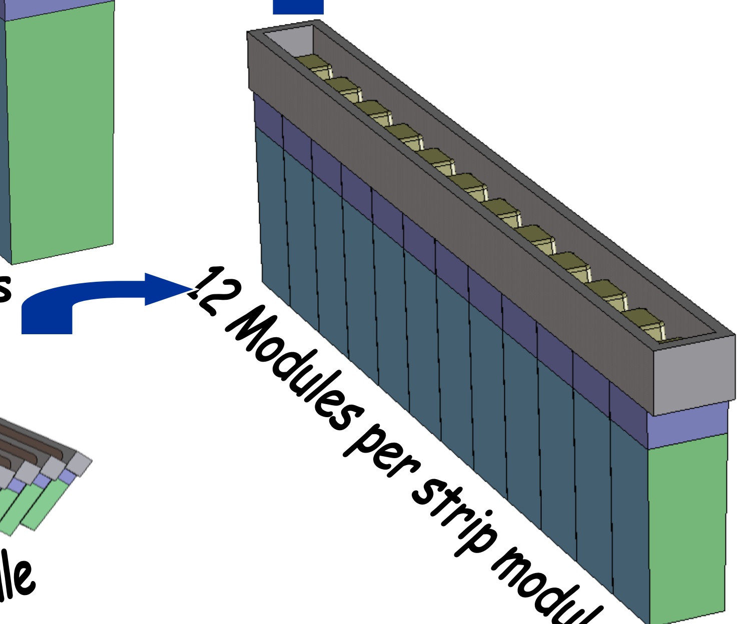
- High granularity and resolution spectrometer:
  - 10,752 (17,920) lead-tungstate crystals ($PbWO_4$), 3(5) modules (56×64 crystals per module)
  - crystal size: $22 \times 22 \times 180$ mm^3
  - depth in radiation length: 20
  - Distance to IP: 4.4 m
  - Acceptance:
    - pseudo-rapidity [-0.12,0.12]
    - azimuthal angle 60º(100º)
  - For E > 10 GeV,
    $\Delta E/E < 1.5\%$ and $\sigma_x = [0.5,2.5]$ mm
- Focus on low and moderate p_T
  - High resolution π^0 and η
  - Thermal photons

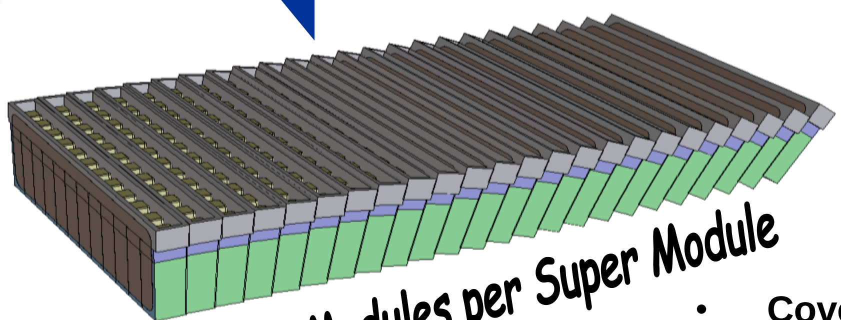


Pb/Sc Shashlik

- 13K channels
- 4 SM for 2009-2010 runs
- Complete for 2011? runs







- **Coverage $\Delta\eta=1.4$, $\Delta\phi=40^{o}$ (107^{o})**
- **Granularity $\delta\eta = \delta\phi = 0.014$**
- **Resolution $\delta E/E=11\%/\sqrt{E}$, σ_x=[3,50]**
- **Focus on moderate to high p_T**
  - **π^0 and η**
  - **prompt direct photon**
  - **jet**