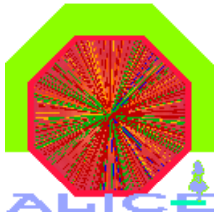


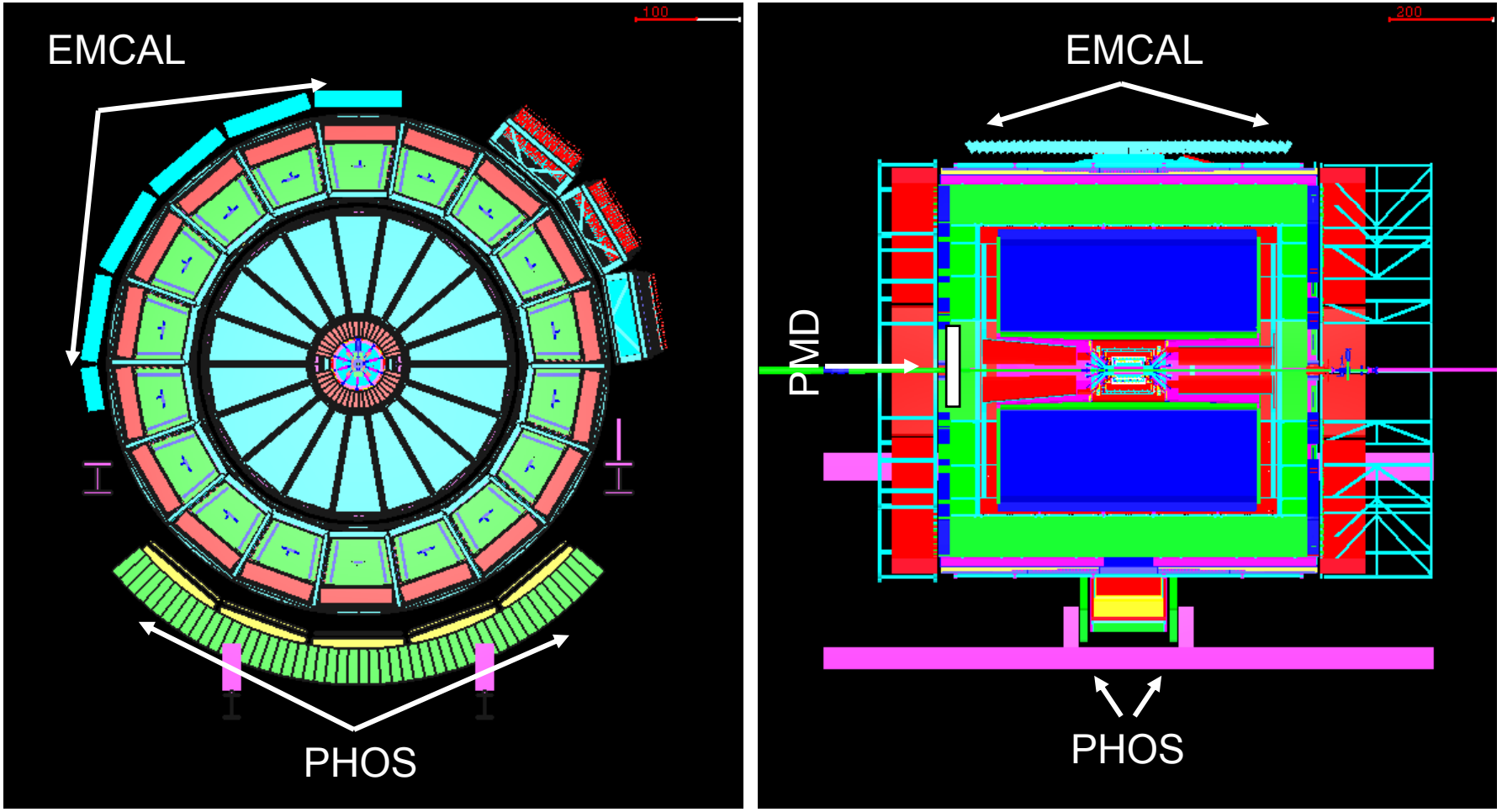
Photon physics with ALICE

Yuri Kharlov

(for ALICE collaboration)

IHEP, Protvino

ALICE photon detectors



ALICE photon detectors

PHOS:

- high-granularity photon spectrometer
- energy resolution: $\Delta E/E=3\%/\sqrt{E}\oplus 1\%$
- acceptance: $\Delta\varphi=100^\circ$, $|\eta|<0.12$
- consists of 18k $PbWO_4$ crystals 2.2×2.2 cm^2.
- 5 modules 64×56 crystals each
- energy range: 0-100 GeV

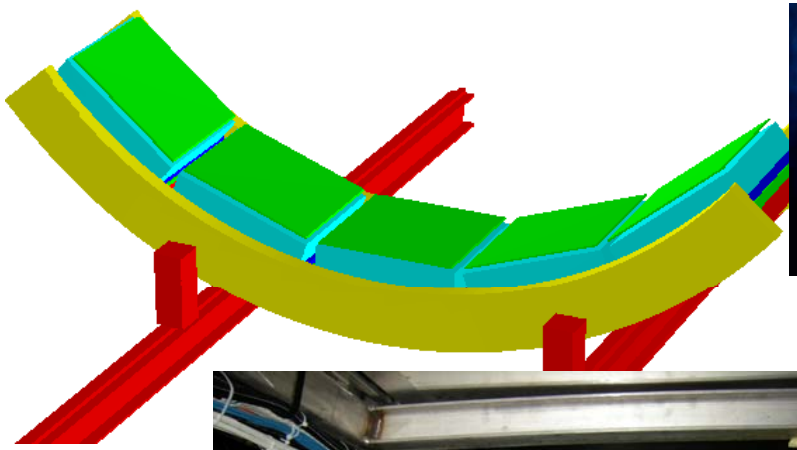
PMD

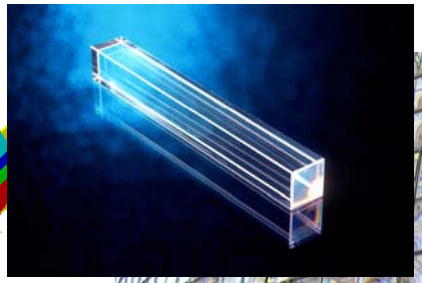
- Photon preshower detector (2.7 X_0)
- Acceptance: $2.3<\eta<3.5$
- Consists of 180 k ROC with granularity: 0.22 cm^2 at L=361 cm

EMCAL

- large aperture Pb-Sci electromagnetic calorimeter
- energy resolution: $\Delta E/E=11\%/\sqrt{E}\oplus 1.6\%$
- acceptance: $\Delta\varphi=110^\circ$, $|\eta|<0.7$
- consists of 13k towers 6×6 cm^2.
- 11 supermodules 24×48 towers each
- energy range: 0-250 GeV

PHOS status



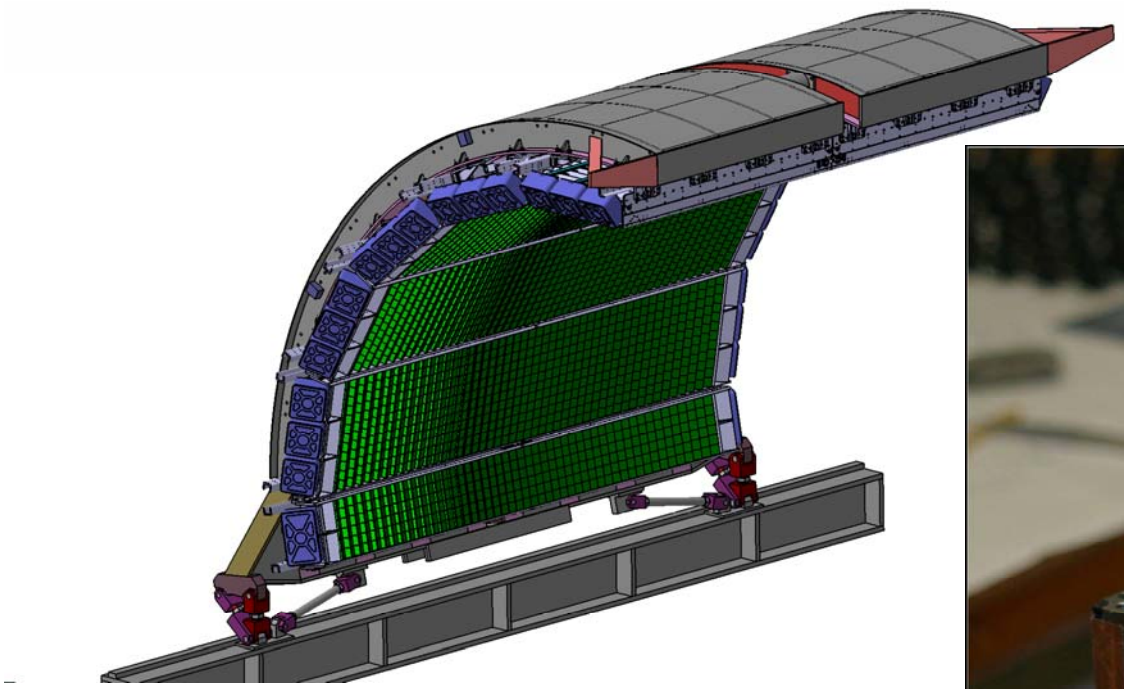


1 module is installed and commissioned in ALICE

2 modules are fully equipped, to be installed before the next LHC start

Completed (all 5 modules) in 2009-2010

EMCAL status



TDR passed.

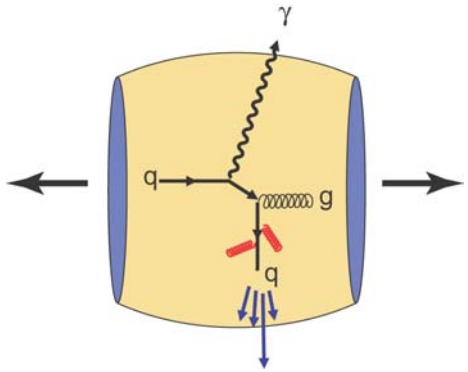
2 supermodules to be installed in 2009.

Completed (11 modules) in 2011.

Why to measure photons in HIC?

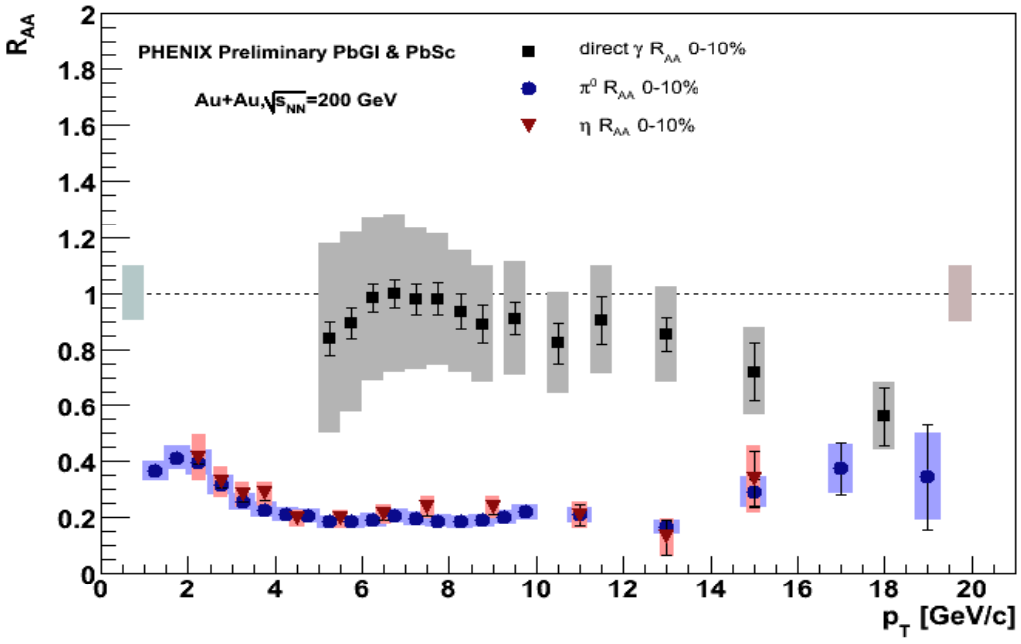
- Photons, having negligible final state interaction, carry undistorted information about various stages of the nuclear matter evolution.
- Direct photons are produced in elementary interaction acts in the nuclear matter:
  - ***prompt photons***, produced in hard scatterings of partons of colliding nuclei, dominate at high p_T:
  - this also includes ***fragmentation photons***, produced in NLO hard processes
  - ***thermal photons***, produced in thermalized nuclear matter radiation at low p_T,
    - photons emission from QGP (qq^- annihilation and Compton scattering, etc)
    - photons emission from hadron gas ($\pi\rho\rightarrow\pi\gamma$, $\pi\pi\rightarrow\rho\gamma$, $\omega\rightarrow\pi^0\gamma$)
    - jet-photon conversion (annihilation and Compton scattering of hard and thermal partons)
    - bremsstrahlung of hard partons in the medium
- Decay photons reveal medium-induced modifications of hadron properties.
- Interferometry of photons can be used as a tool to measure space-time dimensions of the source.

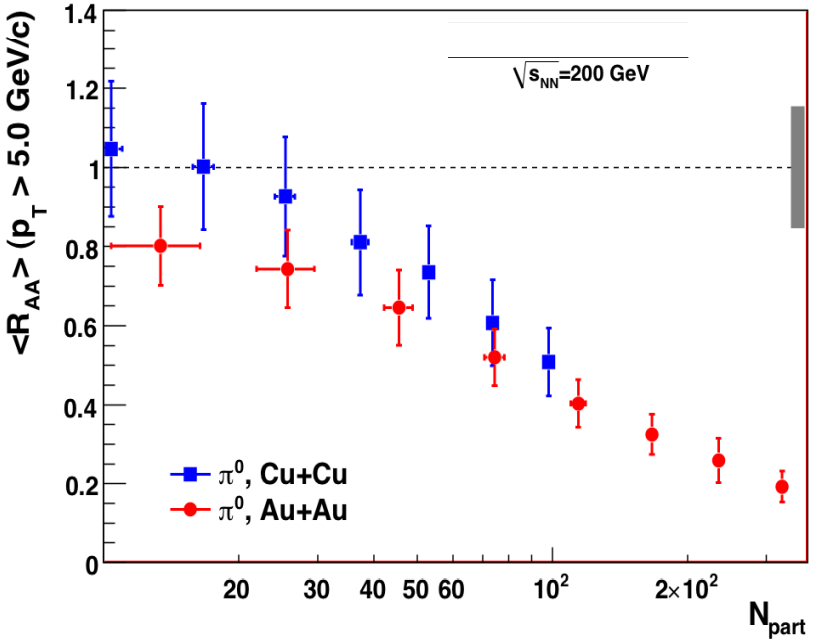
Direct photons and π^0 in AA collisions



[PHENIX, QM2008]

R_{AA} scales with N_{part}

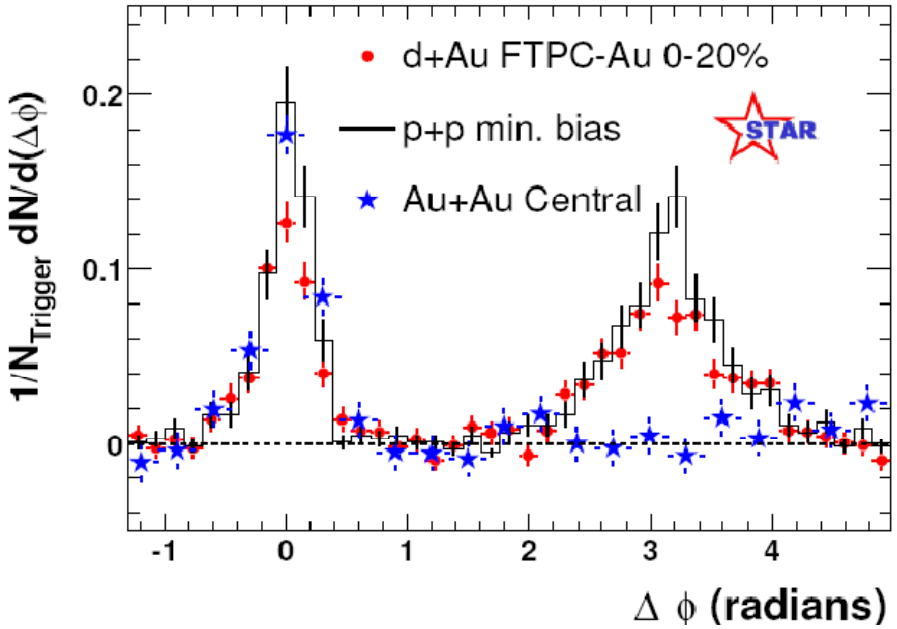




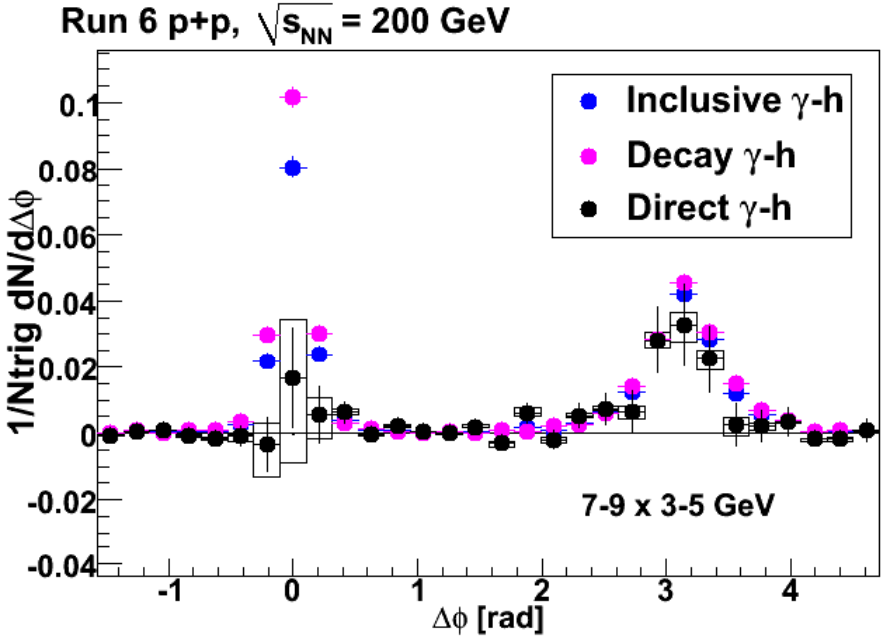
Photon-hadron correlations

h-h correlations

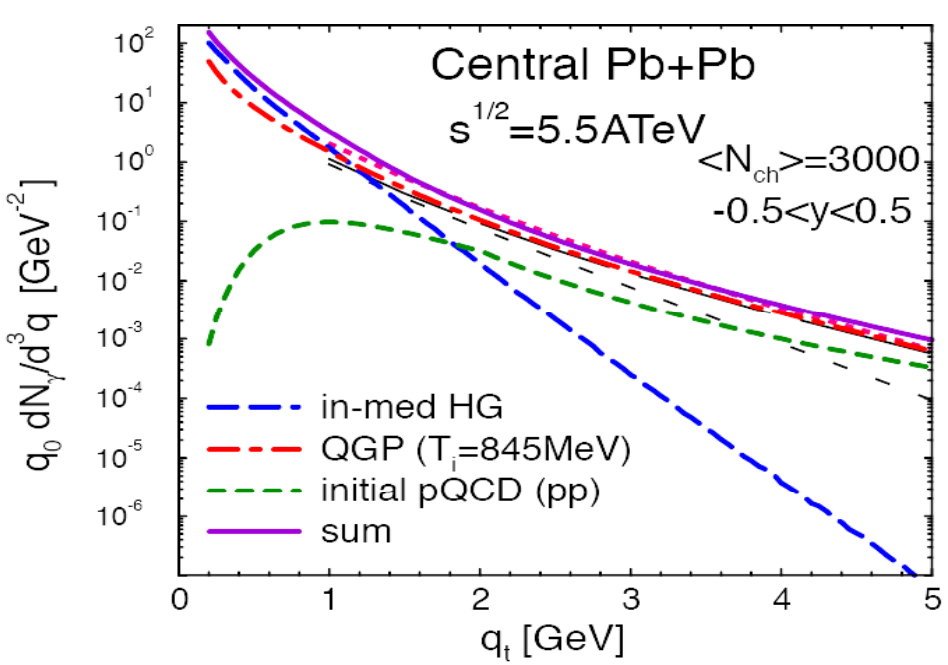
STAR

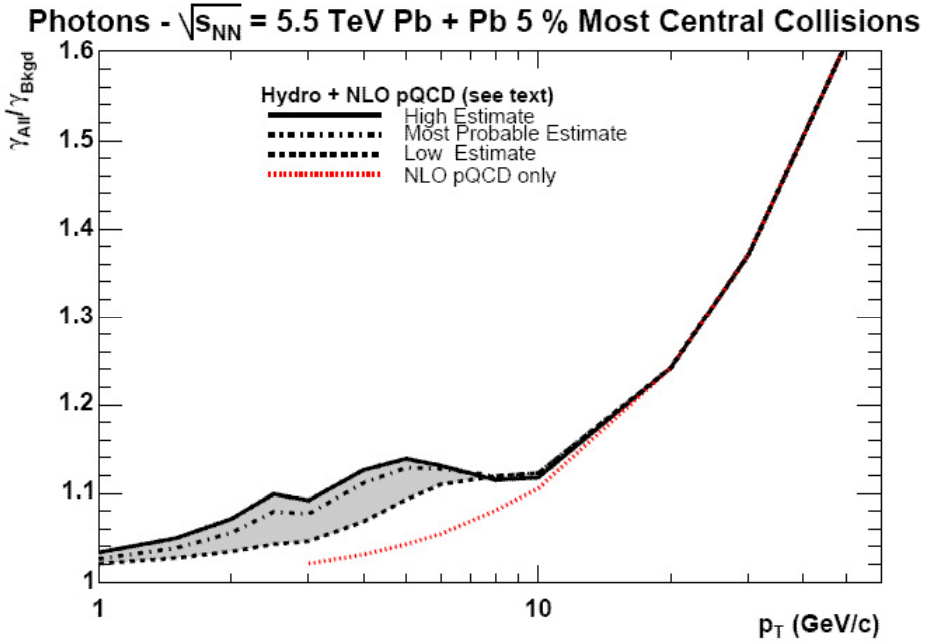


γ-h correlations
[PHENIX, QM2008]



Thermal photons





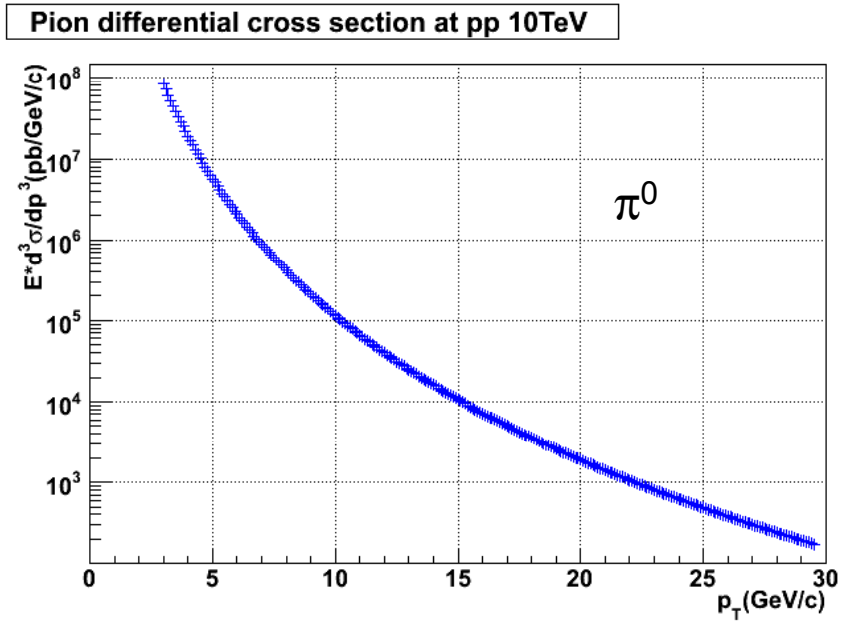
[F.Arleo et al., arXiv:hep-ph/0311131]

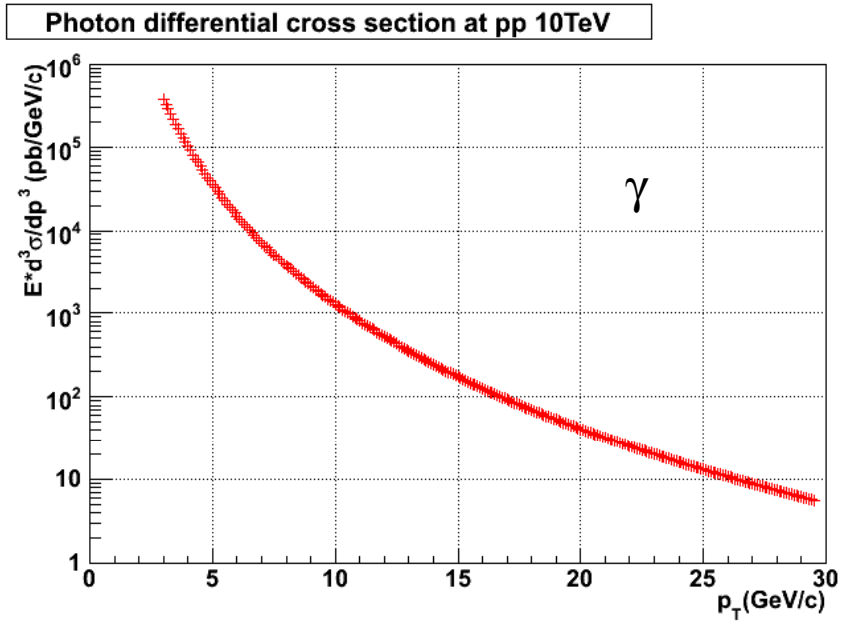
First results anticipated from PHOS

Inclusive spectrum on pp collisions at $\sqrt{s}$=10 TeV:

- Reference for AA collisions
- Validate NLO calculations

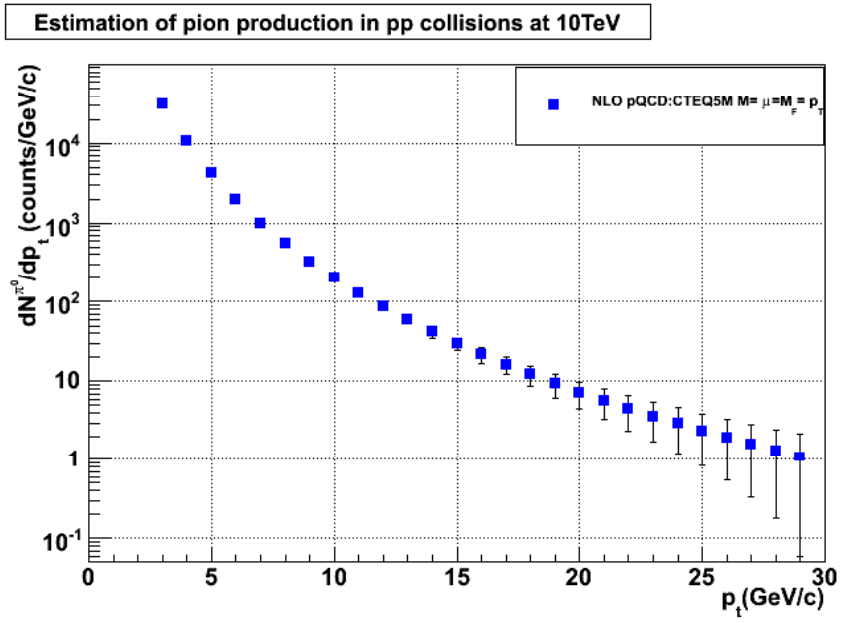
NLO pQCD + CTEQ5M
JetFox. P. Aurenche, et al., Eur. Phys. J. C 13,347 (2000)

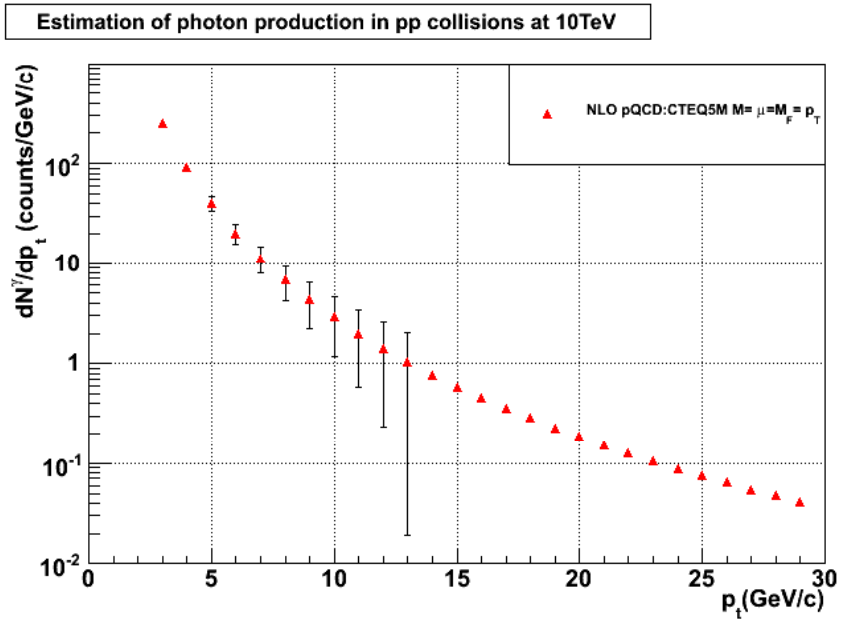




Event rate in PHOS

√s (TeV)	10TeV
L ($cm^{-2}s^{-1}$)	0.5×10^{29}
Run time	30 days (duty factor is 0.1)
1 PHOS module	$\Delta\eta \times \Delta\phi = 0.24 \times 20°$, $\varepsilon_\gamma = 0.9$





Inclusive π^0 spectrum

$$E\frac{d^3\sigma}{dp_T^3} = \frac{1}{2\pi p_T \Delta p_T}\cdot\frac{1}{LT}\cdot C_{\text{trig}}\cdot C_{\text{geom}}\cdot C_{\text{rec}}\cdot C_{\text{offvtx}}\cdot N^{\pi^0}$$

$N^{\pi 0}$: number of detected π^0 in selected p_T-bin (raw spectrum)

L: luminosity

T: run time

C_{eff} : geometrical acceptance

C_{rec} : reconstruction efficiency

C_{conv} : correction due to conversion loss

C_{trig} : trigger bias correction

Geometrical acceptance of π^0

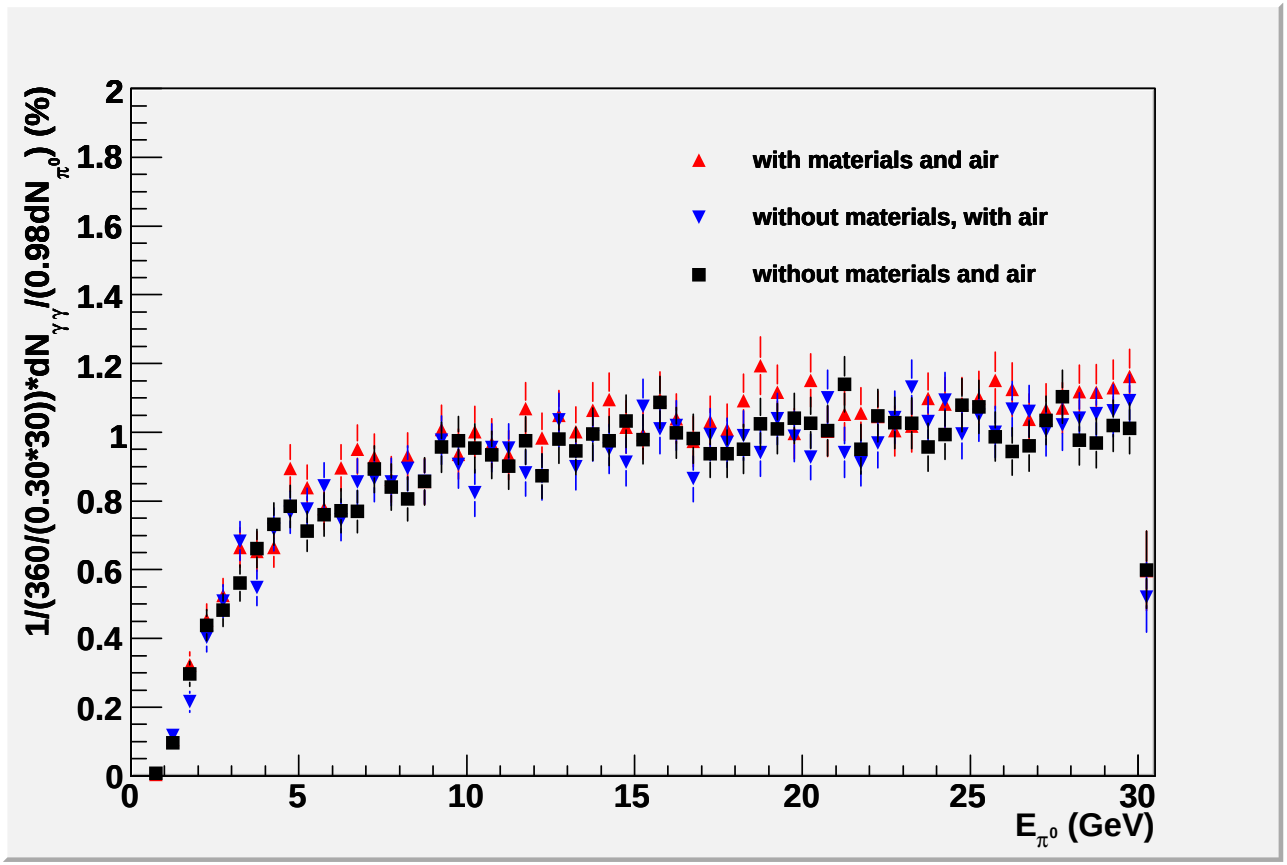
$$\varepsilon_{\text{geom}} = \frac{N(\pi^0 \rightarrow \gamma\gamma \text{ in PHOS})}{N(\pi^0, \Delta\varphi = 2\pi, \Delta y = 1)}$$

Single π^0 generator:

0<pT<30 GeV/c

|y|<0.5

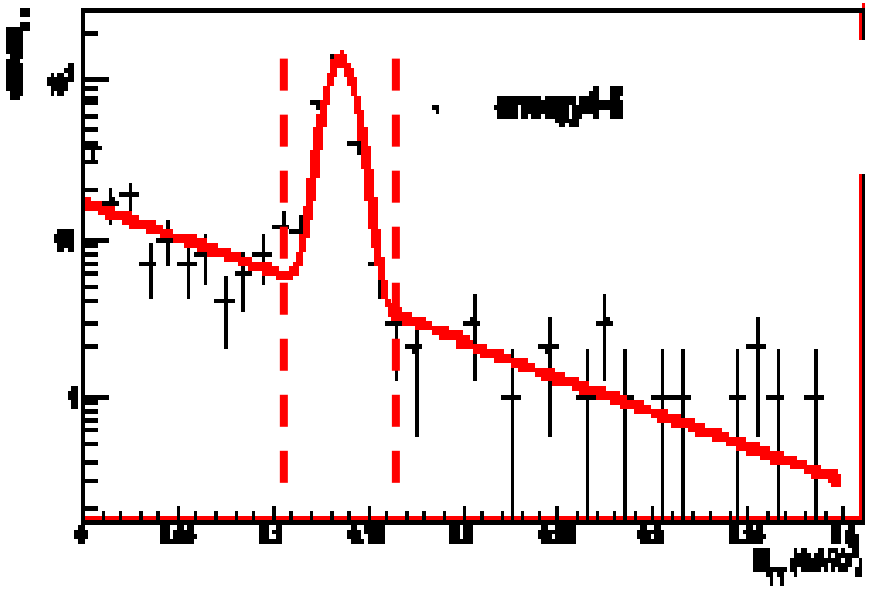
$\Delta\varphi=2\pi$



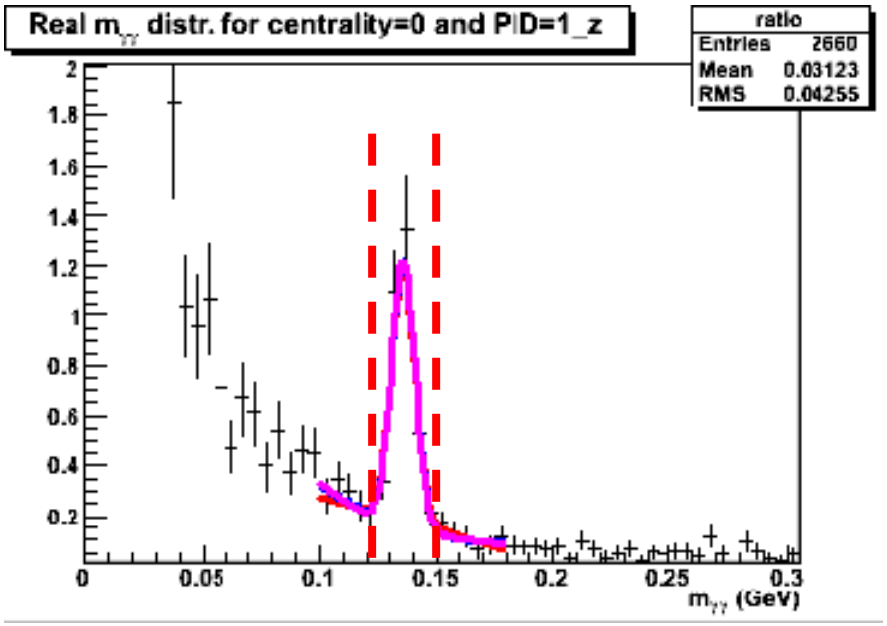
Reconstruction of π^0

$$N(M_{\gamma\gamma}) = \text{Gaussian}(M_{\gamma\gamma}) + \text{polynomial}(M_{\gamma\gamma})$$

$$N_{\pi^0} = \int \text{Gaussian}(M_{\gamma\gamma}) dM_{\gamma\gamma}$$



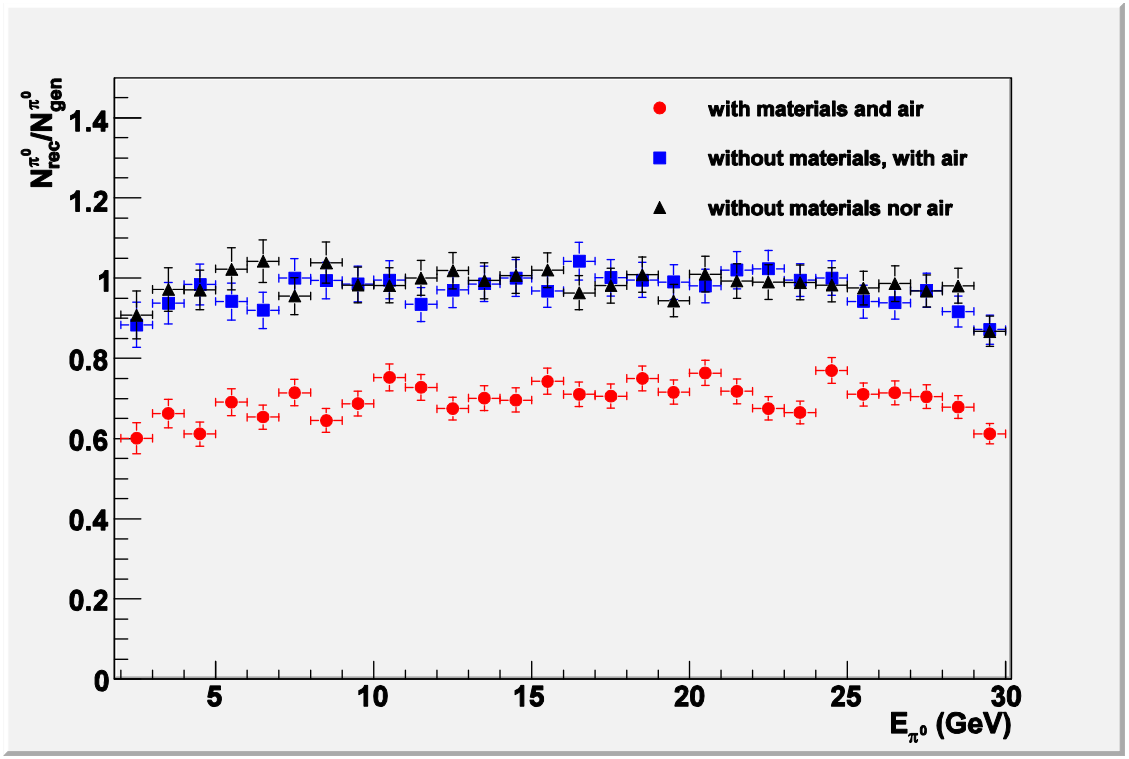
Single π^0 generator



π^0 in min.bias pp (Pythia)

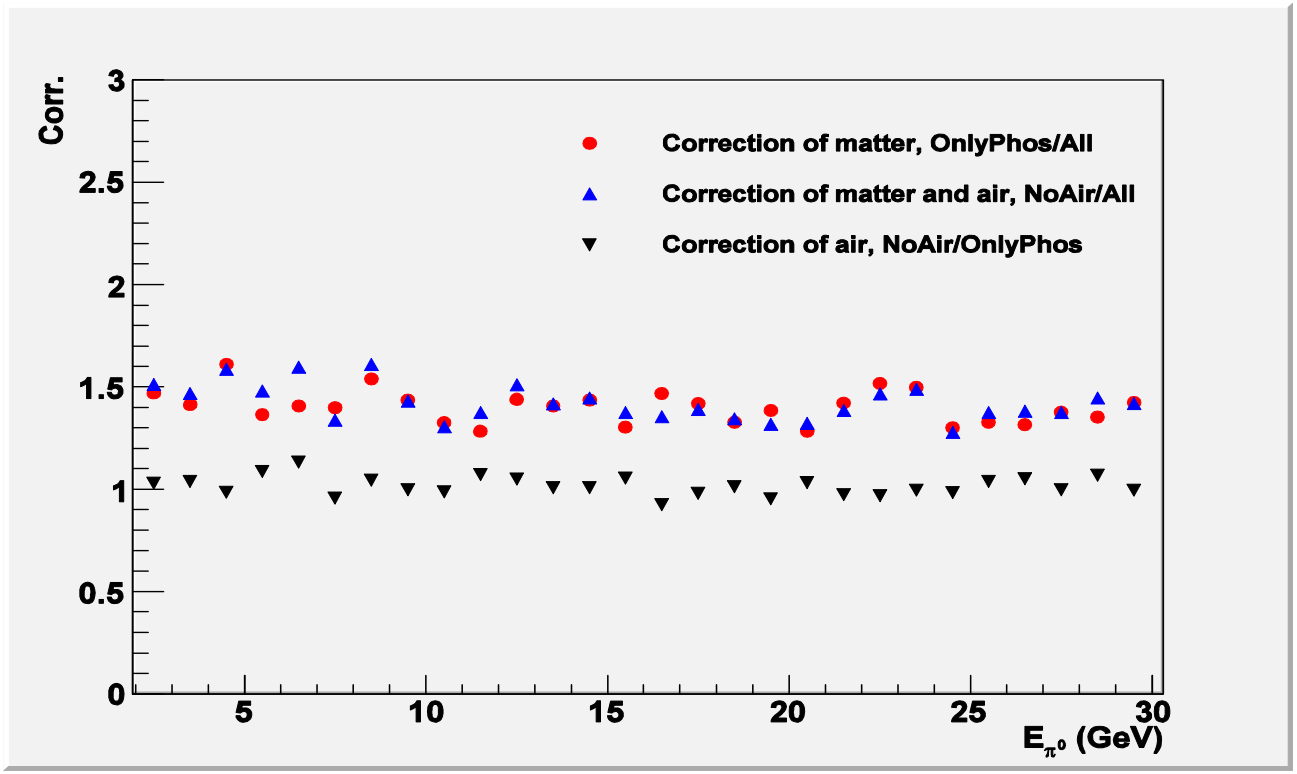
Reconstruction efficiency × conversion probability

$$\varepsilon_{\text{rec}} = \frac{N(\text{reconstructed } \pi^0)}{N(\pi^0 \to \gamma\gamma \text{ in PHOS})}$$

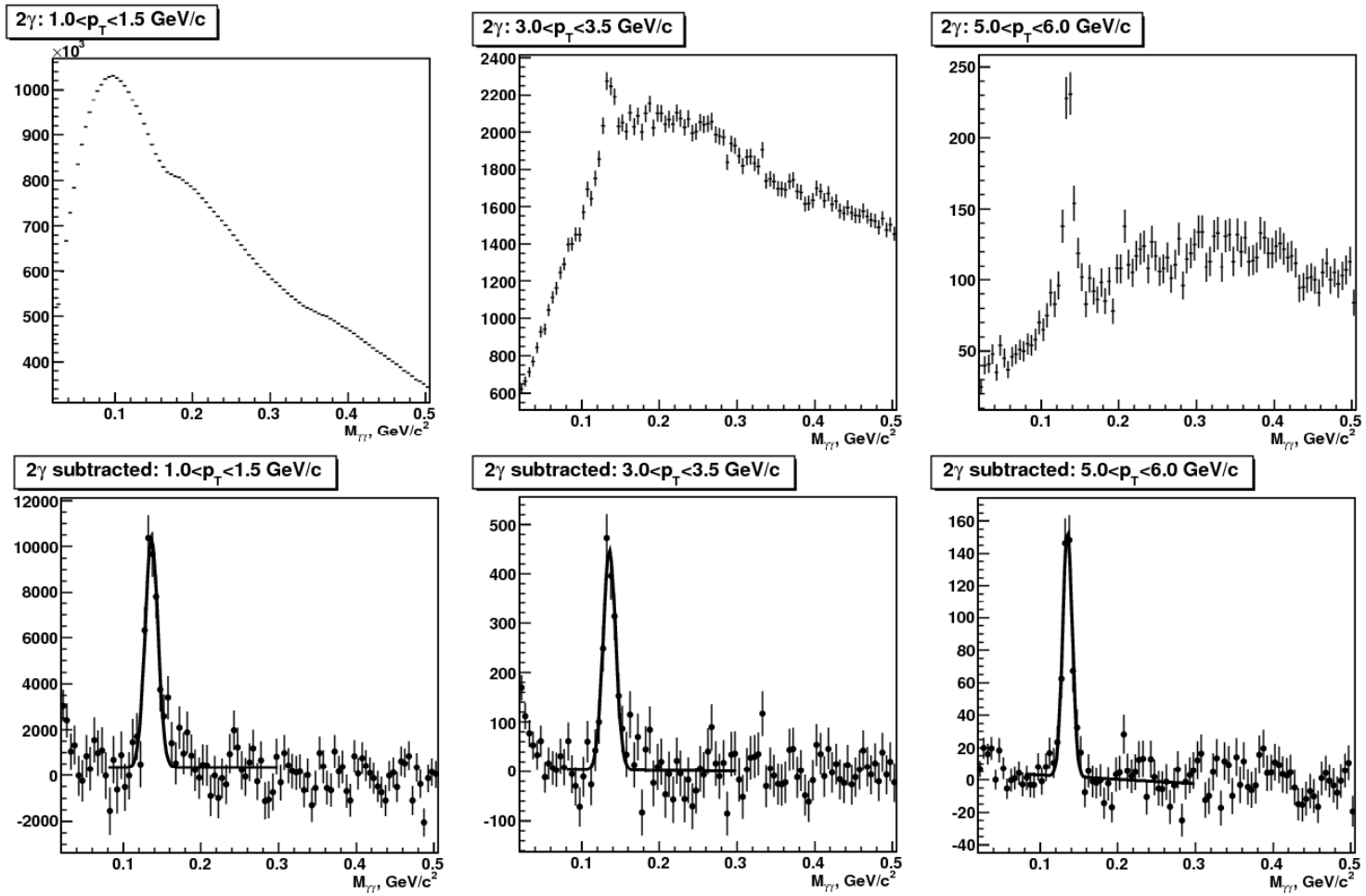


Correction due to conversion

Reconstruction efficiency without interactions in front of PHOS and one with realistic material budget lead to the correction factor due to photon conversion



π^0 in central Pb-Pb collisions at 5.5 ATeV



Only mixing event technique reveals π^0 peak at low p_T

Systematic errors in thermal photon spectrum in central Pb-Pb collisions

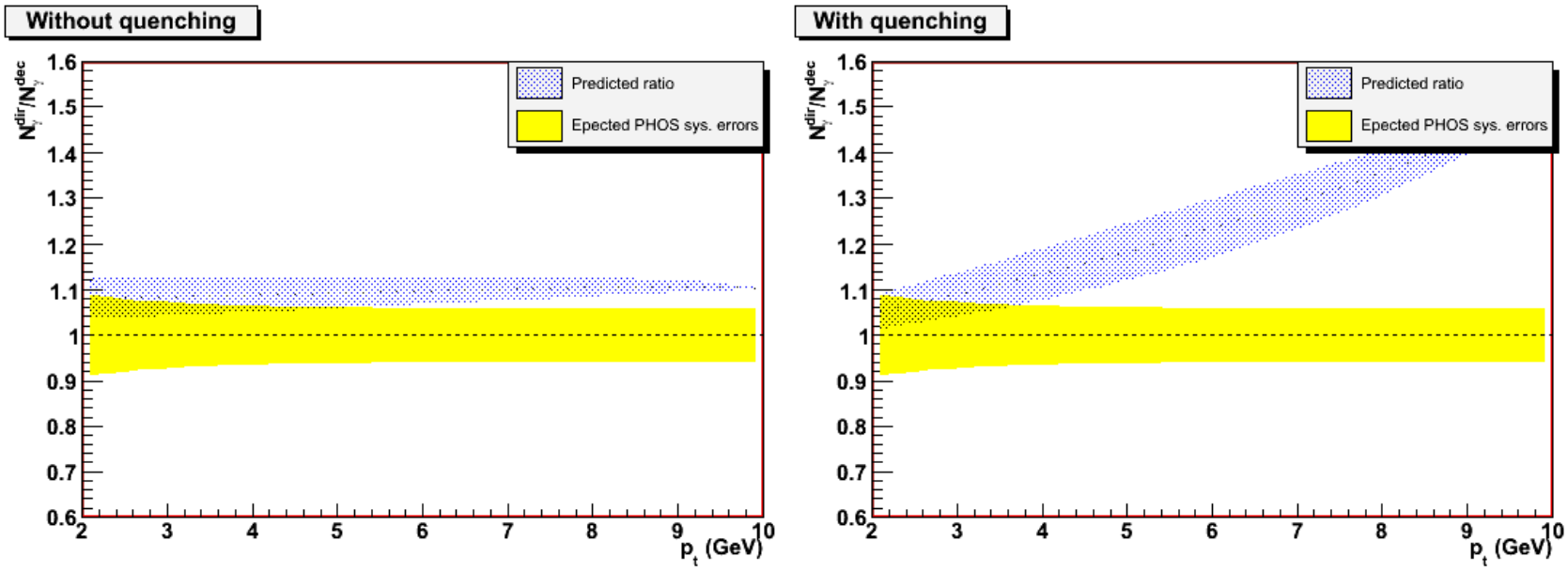
π^0

π^0 p_t (GeV/c)	2	6	10	16
Peak extraction (%)	3.7	2.5	2.4	2.3
Acceptance (%)	1.0	1.0	1.0	1.0
PID efficiency (%)	5.8	4.1	4.3	4.1
Energy scale linear (%)	4.0	4.0	4.0	4.0
Energy scale non linear (%)	1.7	0.7	0.5	0.5
Merging (%)	0.0	0.0	0.0	0.0
Non vertex (%)	2.0	2.0	2.0	2.0
Conversion (%)	3.4	3.4	3.4	3.4
Total (%)	**9.1**	**7.5**	**7.8**	**7.0**

γ/π^0

γ p_t (GeV/c)	2	6	10	16
Peak extraction (%)	3.7	2.5	2.4	2.3
Charged contamination (%)	2.4	2.4	2.4	2.4
Neutron contamination (%)	2.0	0.1	0.1	0.1
Other mesons contribution (%)	6.0	3.0	3.0	3.0
Acceptance (%)	0.7	0.7	0.7	0.7
PID efficiency (%)	3.0	2.0	2.0	2.0
Energy scale non linear (%)	1.7	0.7	0.5	0.5
Merging (%)	0.0	0.0	0.0	0.0
Non vertex (%)	2.0	2.0	2.0	2.0
Conversion (%)	1.8	1.8	1.8	1.8
Total (%)	**8.9**	**5.8**	**5.7**	**5.7**

Sensitivity for thermal photons in central Pb-Pb collisions



Summary

- ALICE is well equipped by photon detectors
  - PHOS in 2008-2010
  - EMCAL in 2009-2011
  - PMD installed
- ALICE will measure direct photon, neutral meson spectra, γ-hadron and γ-jet correlations, jet fragmentation functions
- The first 1-month LHC run with pp@10 TeV results in π^0 spectrum at p_T<25 GeV/c
- In a standard heavy-ion run at LHC PHOS can measure direct photon spectrum at p_T>3-4 GeV/c