Measurement of ω Mesons in pp Collisions at $\sqrt{s}$ = 13 TeV at the LHC with ALICE

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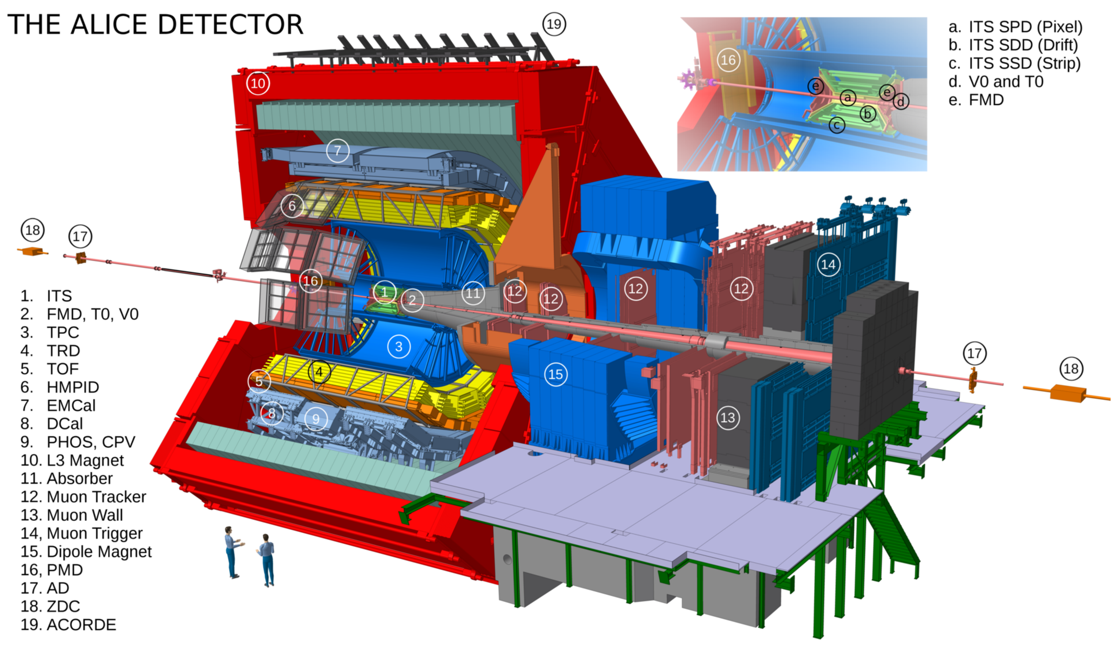
Introduction



ALICE [1] is a dedicated heavy-ion experiment and focuses on the properties of the Quark-Gluon Plasma (QGP), a state of strongly interacting matter expected to be formed in heavy-ion collisions.

Neutral mesons (like the ω meson) created in high-energy collisions are valuable probes for the properties of the QGP, as well as particle production in general. For the ω meson reconstruction, its decay into a neutral pion and two charged pions is used.

Motivations for Light-Meson (ω) Production Cross Section in pp Collisions

Theoretical Motivation:

- Constrain fragmentation function and parton distribution function needed for pQCD at high p_T
- Verify phenomenological models, describing low p_T regime

Experimental Motivations:

- Direct photons produced during different stages of collision need precise measurements of neutral meson spectra for background estimation
- Hot medium effects on ω production in QGP: need precise pp reference
- Theoretical studies of ω fragmentation lack input from experimental data

Data Sample and Event Selection

- Data used in this analysis were taken in pp collisions at $\sqrt{s}$ = 13 TeV:
  - Recorded at the LHC from 2016 to 2018 with a minimum bias (MB) trigger and additional triggers
- Triggered on events with energy deposit in calorimeters above a certain threshold (≈ 3.5 GeV and ≈ 8 GeV).
  - Measurement possible up to $p_T = 50\,\text{GeV}/c$ with EMCal triggers

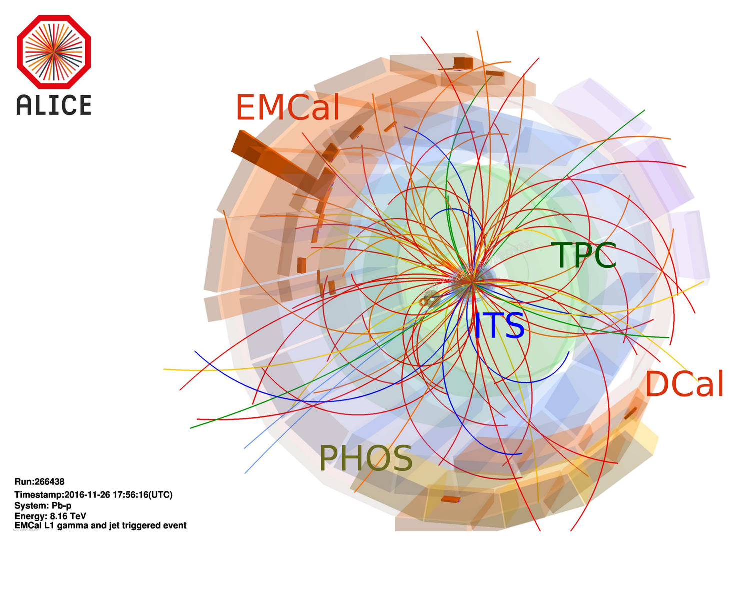
$\omega(782)$ [2]

$m = 782.65(12)\ \text{MeV}/c^2$
$\Gamma_{\text{Tot}} = 8.49(8)\ \text{MeV}/c^2$

Decays:
$\Gamma_{\pi^+\pi^-\pi^0}/\Gamma_{\text{Tot}} = 89.20(7)\,\%$
…

Neutral Pion Measurement

Neutral pions cannot be measured directly and have to be reconstructed via their decay into two photons. Five different reconstruction methods using photon conversion (PCM) and calorimeters (EMCal, DCal, PHOS):
PCM, EMC (EMCal and DCal), PHOS, PCM-EMC and PCM-PHOS



Photon Conversion Method (PCM):

- Photons have probability of $\approx 8.5\,\%$ to convert within inner detector material: $\gamma \to e^+ + e^-$
- Reconstruction at mid-rapidity with TPC
- Low statistics but good resolution

EMC [3]:

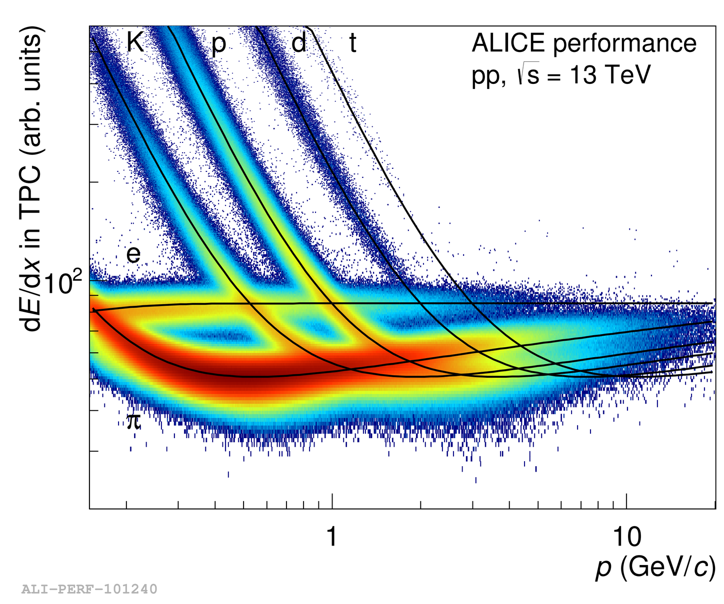
- Pb scintillator with alternating lead and scintillator segments
- Designed for high-p_T measurements

PHOS [4]:

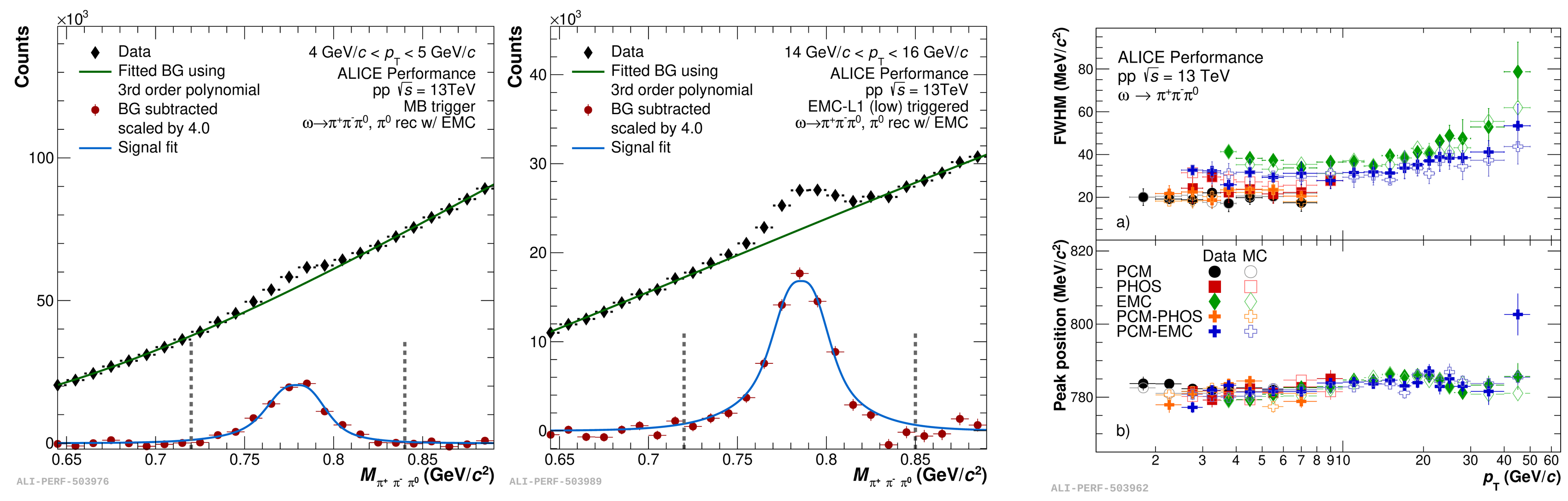
- Consists of lead-tungstate crystals
- Smaller coverage than EMCal but higher granularity

Charged Pion Selection

- Identification of $\pi^\pm$ with their specific energy loss
- Use ITS-TPC [5] hybrid tracks
- Coverage: $|\eta| < 0.9$, $0° < \varphi < 360°$

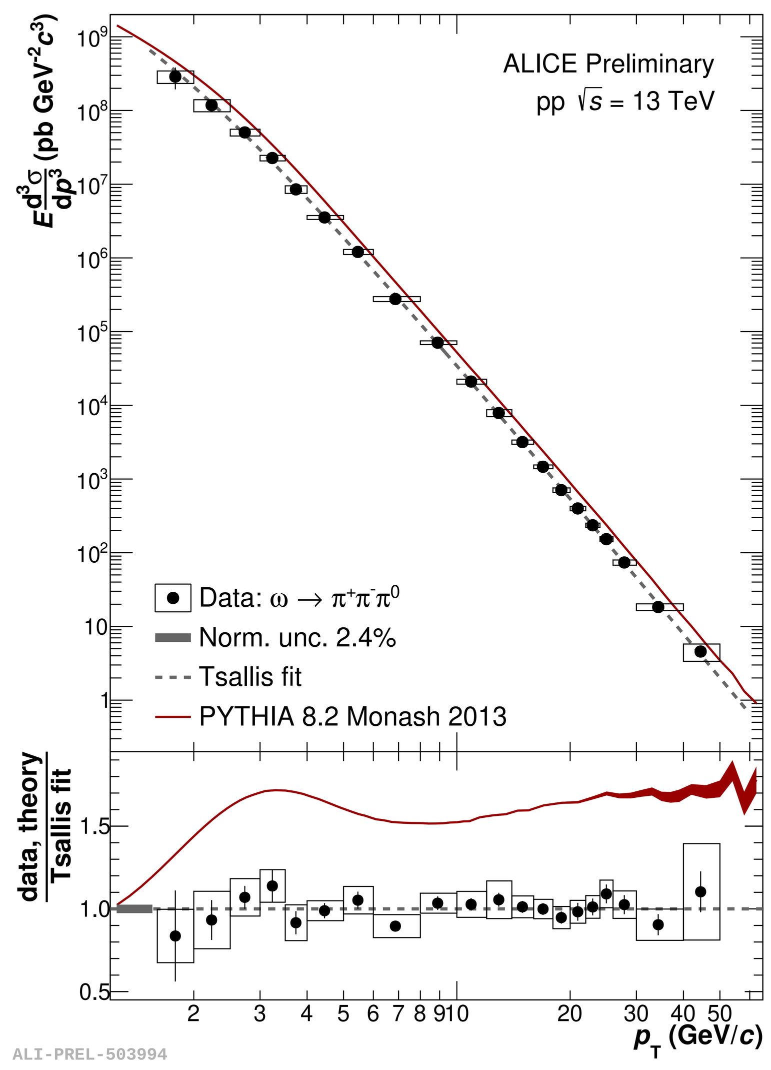


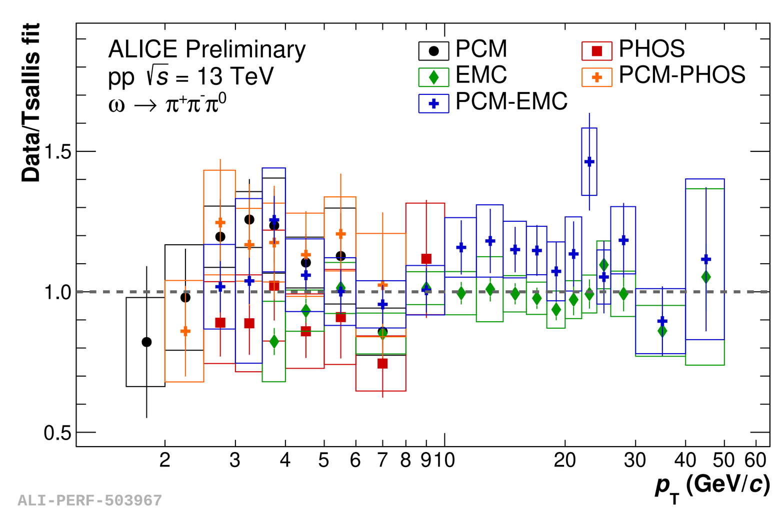
Signal Extraction



- Four-momentum vectors of neutral pion and two charged pion candidates are summed up and result is used to calculate invariant mass of ω meson
- Underlying background described by third order polynomial fit with additional Gaussian for signal
- To obtain ω mass position, signal distribution (background subtracted) is fitted with Gaussian with additional exponential tail on both sides
- Meson yield is extracted by bin counting within $\pm 3\sigma$ of Gaussian

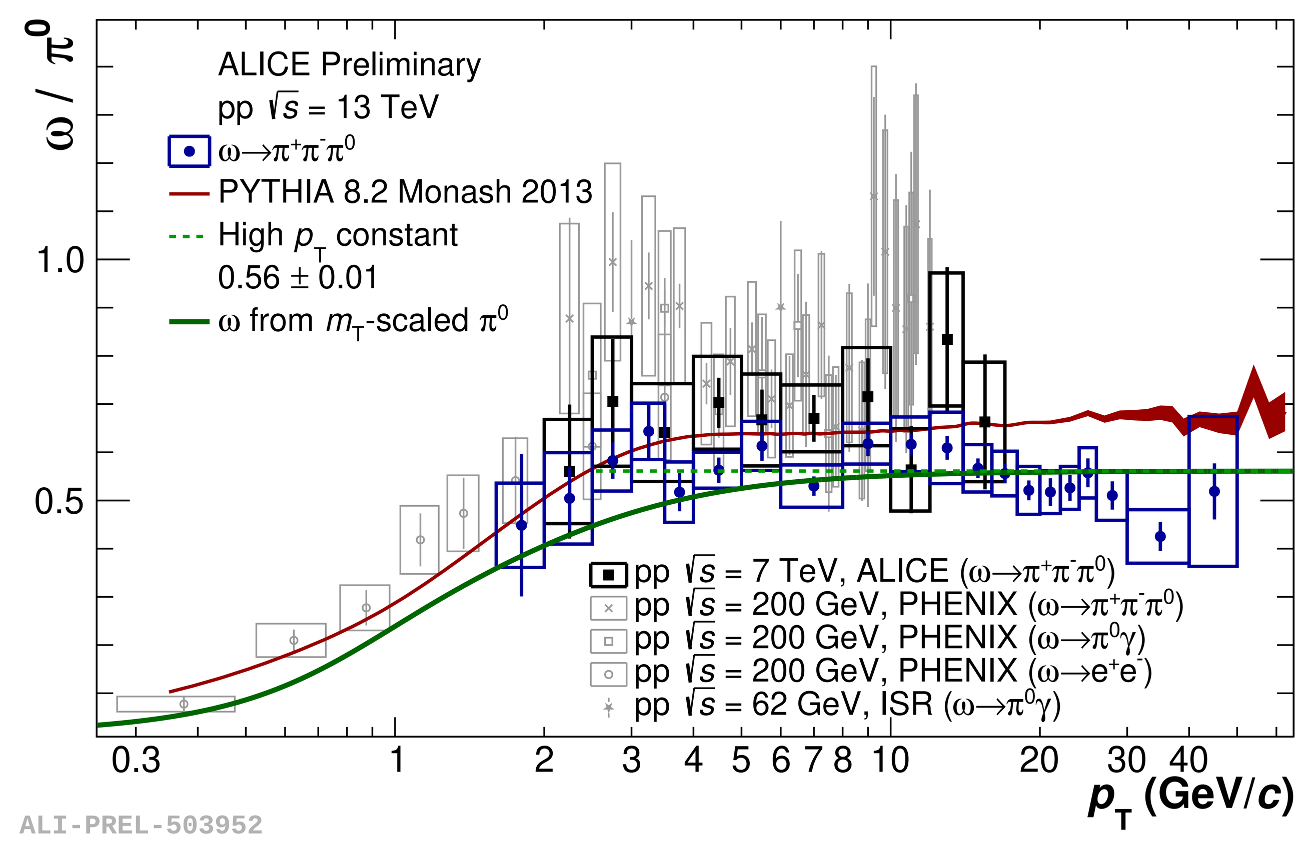
Combination of ω Cross Section Measurements





- Agreement of individual measurements within uncertainties
- Combination of individual measurements is taking correlations of statistical and systematic uncertainties into account
- Overall uncertainties in the order of 10%
- All points in agreement with combined Tsallis fit within uncertainties
- PYTHIA with Monash 2013 describes overall shape but overestimates data

ω / π^0 Ratio



- Agreement with previous measurements within uncertainties
- PYTHIA describes ω/π^0 ratio well at low p_T but shows disagreement for high p_T
- High-p_T constant in 13 TeV fitted from $4\,\text{GeV}/c$ to $50\,\text{GeV}/c \to 0.56 \pm 0.01$
- Extending p_T reach of previous measurements by a factor of ≈ 3
  - Provide important constraints for theoretical understanding of vector meson fragmentation

References

[1] K. Aamodt et al. The ALICE experiment at the CERN LHC. *JINST*, 3:S08002, 2008.

[2] M. Tanabashi et al. Review of particle physics. *Phys. Rev. D*, 98:030001, Aug 2018.

[3] P Cortese et al. ALICE Electromagnetic Calorimeter Technical Design Report. Technical Report CERN-LHCC-2008-014. ALICE-TDR-14, Aug 2008.

[4] V Man'ko et al. ALICE Photon Spectrometer (PHOS): Technical Design Report. Technical Report CERN-LHCC-99-004, 1999.

[5] B. Abelev et al. Performance of the ALICE Experiment at the CERN LHC. *Int.J.Mod.Phys.*, A29:1430044, 2014. arXiv:1402.4476.