Light-neutral meson production in pp collisions at $\sqrt{s} = 13$ TeV in ALICE

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ALICE

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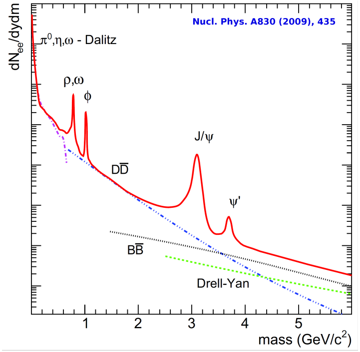
Low-Mass dilepton physics

Low mass dilepton production in AA collisions → information on the hot and dense state of strongly-interacting matter produced in high energy nucleus nucleus collisions



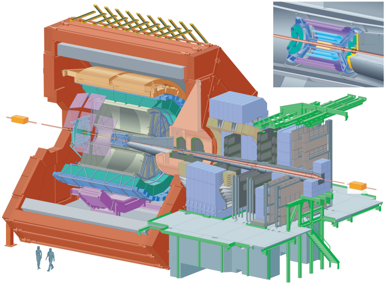
- Strangeness production via the ϕ meson
- Modification of ρ spectral function linked to the chiral symmetry restoration

Dileptons (dielectrons, dimuons)

→ negligible final-state effects

Low-Mass dilepton physics

- pp measurements : Input for Monte-Carlo generators for processes not calculable by perturbative QCD.
- Measurements in p-A collisions : Soft particle production in Cold Nuclear Matter.
- pp and p-A : - Needed reference for correctly interpreting heavy-ion observations.
  - Collective effects in small systems



Two dilepton channels in ALICE

- e^+e^- in mid rapidity : $|y| < 0.9$ in the central barrel
- $\mu^+\mu^-$ in forward rapidity : $-4.0 < y < -2.5$ in the muon arm. **channel of interest for this talk**

Collision systems:

Pb-Pb : $\sqrt{s_{NN}} = 2.76 - 5.02$ TeV

p-Pb : $\sqrt{s_{NN}} = 5.02 - 8.16$ TeV

pp : $\sqrt{s} = 2.76 - 5.02 - 7 - 8 - 13$ TeV

Combinatorial background estimation

Two ways to estimate the opposite sign combinatorial background

1. Background estimation from data themselves

$$N^{dir}_{bkg}(M) = 2R(M)\sqrt{N^{dir}_{++}(M) \cdot N^{dir}_{--}(M)}$$

with R factor estimated with mixing

$$R(M) = \frac{N^{mix}_{+-}(M)}{2\sqrt{N^{mix}_{++}(M) \cdot N^{mix}_{--}(M)}}$$

2. Event Mixing

Combinatorial background estimation

Background estimation from data :

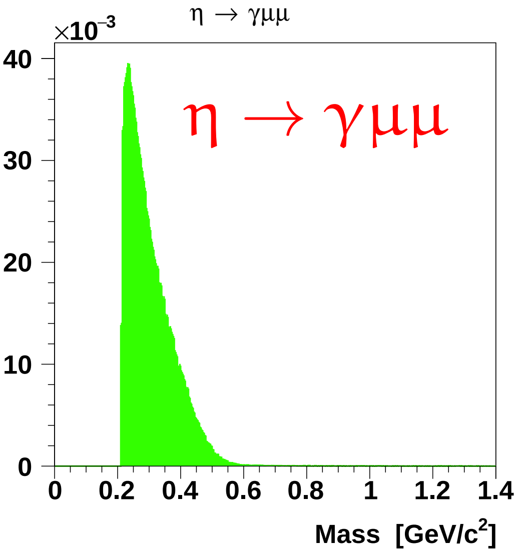
- normalization automatically fixed by the data
- statistics limited by the data

Background estimation with mixing :

- no normalization
- no statistical limits

We combine the strengths of the two methods by taking the shape from the event mixing and imposing the **data-driven normalization**

Shape of Hadronic Signal



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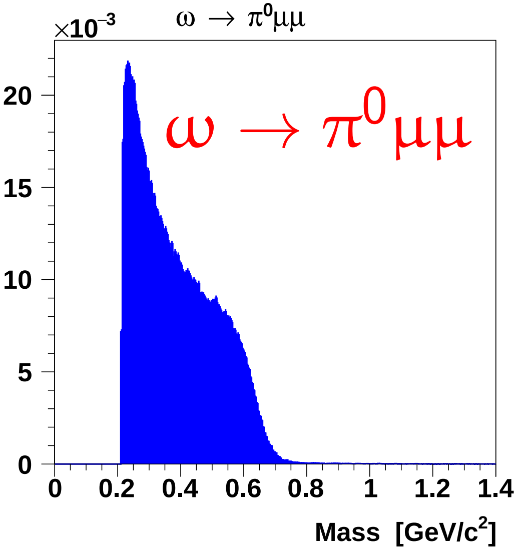

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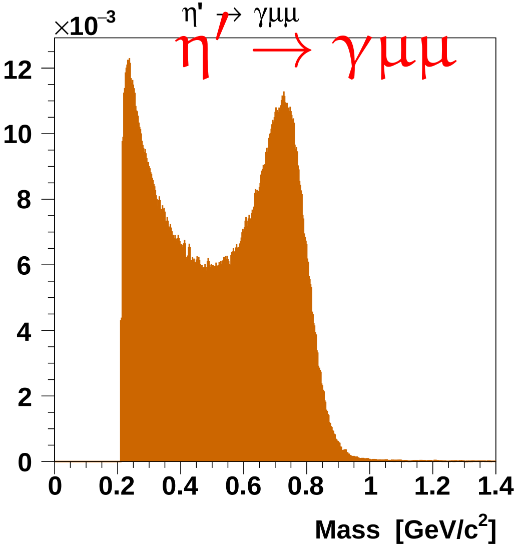

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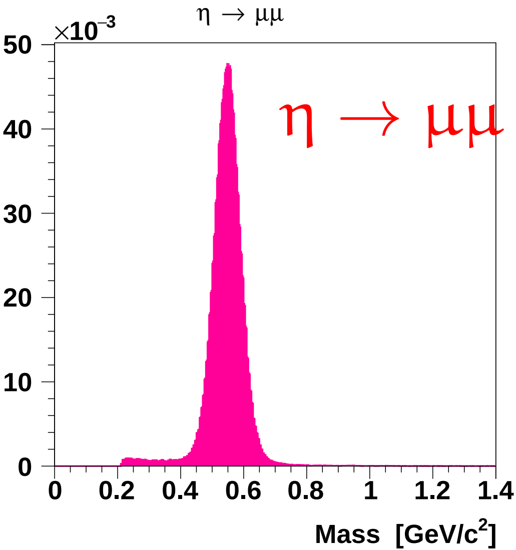
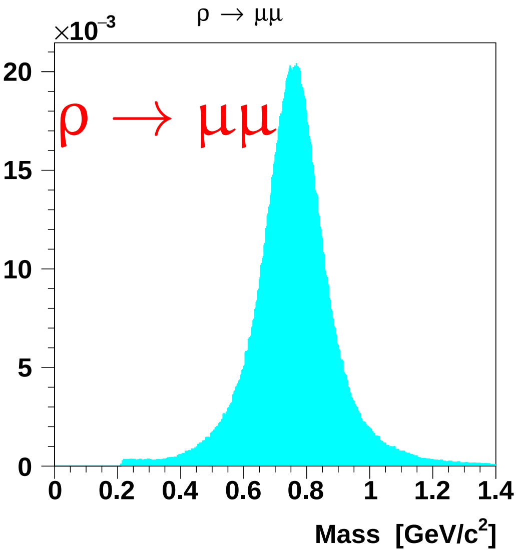


$\eta \rightarrow \mu\mu$

Shape of Hadronic Signal



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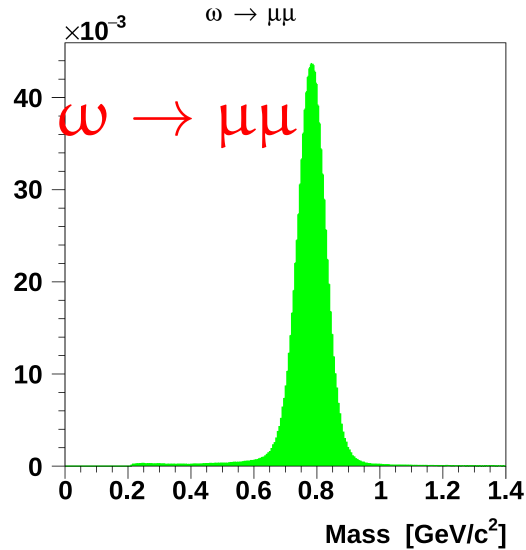

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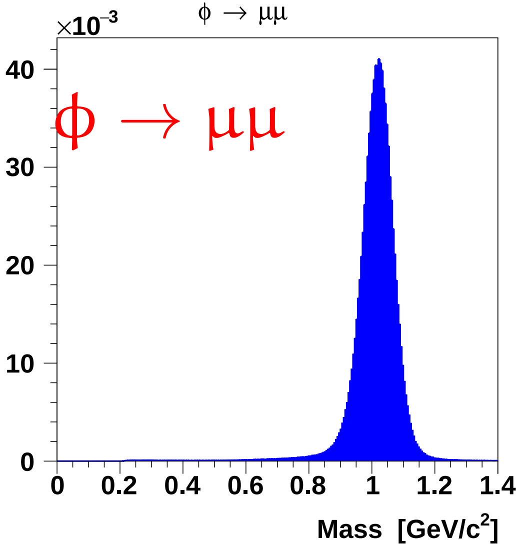

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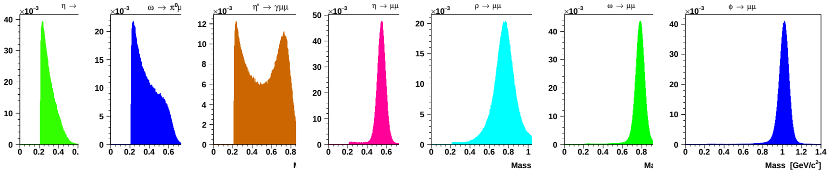
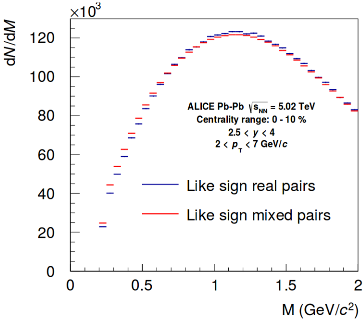
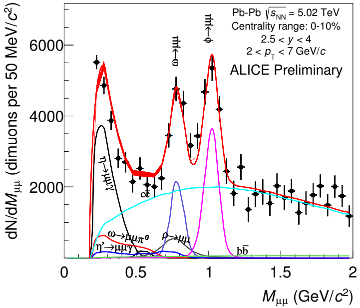


Process shapes (templates)
are kept fixed in the fit routine

- Three parameters are adjusted in the fit procedure in each of the p_T or y intervals considered in the analysis: η, ω, ϕ meson yields
- Each free parameter is linked to a process dominating in at least one region of the mass spectrum
- The remaining degrees of freedom are fixed either according to the relative branching ratios, or assuming specific hypotheses on the cross section ratios

Mass Spectrum in central collisions 0-10%





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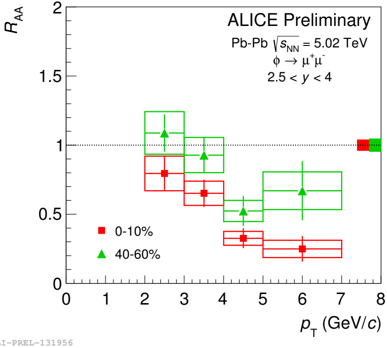
Integrated luminosity: $225\ \mu b^{-1}$

R_{AA}



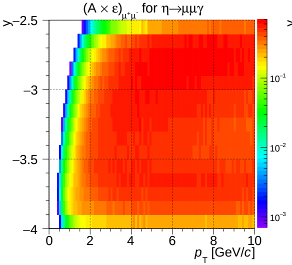
R_{AA} as a function of N_{part}

R_{AA} as a function of p_T

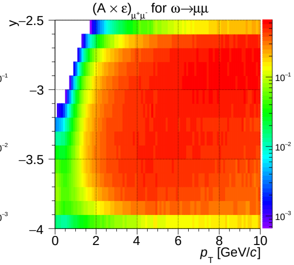
Data set

- Data : 2016 periods. Single μ thr. ≈ 0.5 GeV/c
- Single Muon selection:
  - Muon tracks must match a trigger tracklet
  - Eta cut : $-4.0 < \eta < -2.5$
- $L_{\rm int} = 8.44 \pm 0.42$(syst.) $\rm pb^{-1}$: evaluated with VdM scan of 2015

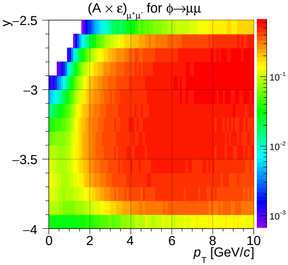
Acceptance times Efficiency



$(A \times \varepsilon)$ for
$\eta \to \mu^+\mu^-\gamma$



$(A \times \varepsilon)$ for
$\omega \to \mu^+\mu^-$



$(A \times \varepsilon)$ for
$\phi \to \mu^+\mu^-$

Combinatorial Background Evolution

$0.0 < p_T < 0.2$ GeV/c
$3.75 < y < 4.00$

$0.8 < p_T < 1.0$ GeV/c
$3.25 < y < 3.50$

$6.0 < p_T < 6.5$ GeV/c
$3.25 < y < 3.50$

Correlated Continuum Treatment and Fit Procedure

Fit procedure based on semi-empirical approach

- Hadronic Cocktail for the Dalitz and two-body decays
- Correlated continuum: sum of 3 data-driven templates evaluate from simulation of correlated and uncorrelated dimuon sources

Example of Fit Procedure

Summary on Systematic Uncertainties

Evaluation of the Cross-Section

$$N_{\rho/\omega,\ \phi}(p_T, y) = \frac{N^{rec}_{\mu\mu}(p_T, y)}{[A \times \varepsilon]_{\mu\mu}(p_T, y) \cdot BR \cdot \Delta p_T \cdot \Delta y}$$

$$\frac{d^2\sigma(p_T, y)}{dp_T dy} = N_{\rho/\omega,\phi}(p_T, y) \times \frac{1}{L_{int}}.$$

Evolution of the ρ/ω cross-section as function of y and p_T

Comparison with Theoretical Prediction

ω Cross-Section Comparison as a function of y

Comparion with previous ALICE measurements

Evolution of the ϕ cross-section as function of y and p_T

- Possibility to extend the y range thanks to the dikaon measurements

Comparison with Theoretical Prediction

ϕ Cross-Section Comparison as a function of *y*

Comparion with previous ALICE measurements

ϕ Cross-Section as function of $\sqrt{s}$

Cross-Section Evaluation for the Dalitz decay of η meson

$$N^{\text{gen}}_{\mu\mu}(p_T, y) = \frac{N^{\text{rec}}_{\mu\mu}(p_T, y)}{[A \times \varepsilon]_{\mu\mu}(p_T, y) \cdot \Delta p_T \cdot \Delta y}$$

Cross-Section Evaluation for the Dalitz decay of η meson

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$$N_{\eta\to\mu\mu\gamma}(p_T, y) = T^{-1} \cdot \; N^{gen}_{\mu\mu}(p_T, y) \;,$$

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$$N_{\eta \to \mu\mu\gamma}(p_T, y) = T^{-1} \cdot N^{gen}_{\mu\mu}(p_T, y) ,$$

Correction with BR for going from $N_{\eta \to \mu\mu\gamma}(p_T, y)$ to $N_{\eta}(p_T, y)$

Cross-Section Evaluation for the Dalitz decay of η meson

$$N^{\mathrm{gen}}_{\mu\mu}(p_{\mathrm{T}}, y) = \frac{N^{\mathrm{rec}}_{\mu\mu}(p_{\mathrm{T}}, y)}{[A \times \varepsilon]_{\mu\mu}(p_{\mathrm{T}}, y) \cdot \Delta p_{\mathrm{T}} \cdot \Delta y}$$

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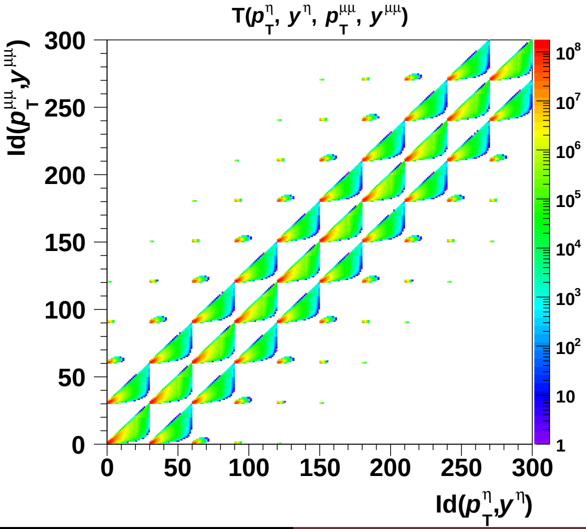
Correction with BR for going from $N_{\eta\to\mu\mu\gamma}(p_{\mathrm{T}}, y)$ to $N_{\eta}(p_{\mathrm{T}}, y)$

$$\frac{\mathrm{d}^2\sigma(p_{\mathrm{T}}, y)}{\mathrm{d}p_{\mathrm{T}}\mathrm{d}y} = N_{\eta}(p_{\mathrm{T}}, y) \times \frac{1}{L_{\mathrm{int}}}.$$

$N^{gen}_{\mu\mu}(p_T, y)$ for the η Meson in Dalitz Decay

Kinematics Correlation Matrice of η Meson and Dimuon Genereted



Summary

- PbPb at $\sqrt{s_{NN}} = 5.02$ TeV
  - Signal extracted in 9 centrality classes, for $2 < p_T < 7$ GeV/c
  - In R_{AA} vs N_{part} is ~ 1 in peripheral collisions and small decrease from semiperipheral to (semi)central collisions in the intermediate p_T region are shown
  - In R_{AA} vs p_T a clear decrease for $p_T > 4$ GeV/c in central collisions, effect less pronouced for semi-peripheral collisions
- pp at $\sqrt{s} = 13$ TeV
  - Double differential (p_T-y) study of light-neutral meson are performed
  - Possibility to going to $p_T = 0$ GeV/c for the ρ/ω and ϕ mesons
  - ρ/ω meson measurement does not reproduced by the theoretical prediction
  - ϕ meson measurement has reproduced by the models
  - Measurements of η, (ρ/ω) and ϕ offer the possibility to precise study in p_T-y both at central and forward rapidity

Backup