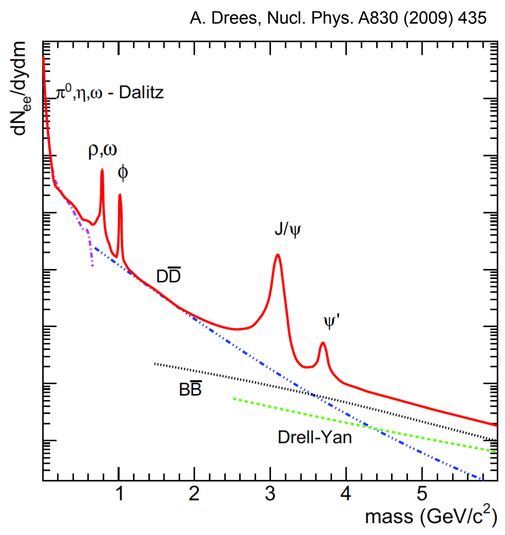
Measurement of low-mass dielectrons in pp collisions at $\sqrt{s}$ = 13 TeV with ALICE

Ivan Vorobyev* for the ALICE Collaboration

Motivation

Low-mass dielectrons − penetrating probe to study the system created in high-energy heavy-ion collisions
- Produced during all stages of collisions
- Unaffected by strong interactions
- Approximate mass ordering of production time

Proton-proton collisions
- Medium-free reference (min. bias)
- Heavy flavour production cross sections



New (or heavy-ion like) phenomena in high-multiplicity pp events?
- Production / destruction of ρ meson, direct photons, …
- *Idea*: produce a ratio of dielectron spectra in high multiplicity (HM) over min. bias (MB) triggered events

$$\frac{\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{MB})\rangle}{\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{HM})\rangle} \times \frac{1/N_{\mathrm{HM}}\,\mathrm{d}N_{\mathrm{ee}}/\mathrm{d}m_{\mathrm{ee}}|_{\mathrm{HM}}}{1/N_{\mathrm{MB}}\,\mathrm{d}N_{\mathrm{ee}}/\mathrm{d}m_{\mathrm{ee}}|_{\mathrm{MB}}}$$

Experimental Setup

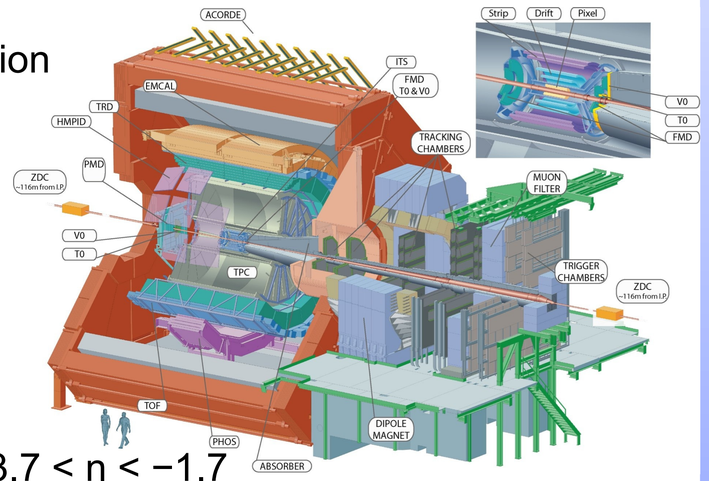
Central barrel detectors (2π coverage, |η| < 0.8)

Inner **T**racking **S**ystem
- Collision vertex reconstruction
- Tracking
- Particle Identification

Time **P**rojection **C**hamber
- Tracking
- Particle Identification

Time **O**f **F**light
- Particle Identification

V0 scintillators
- V0A: 2.8 < η < 5.1, V0C: −3.7 < η < −1.7
- MB trigger: coincidence of V0A & V0C signals
- HM trigger: coincidence of V0A & V0C signals, threshold on V0M amplitude



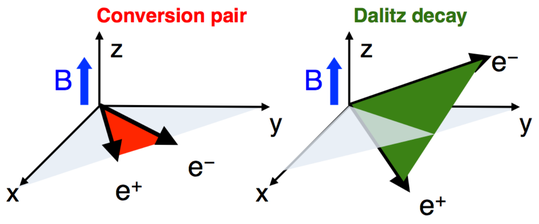
In total 103.9 M min. bias and 48.1 M high multiplicity events
$\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{HM})\rangle/\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{MB})\rangle = 4.36$ (measured at η ~ 0)

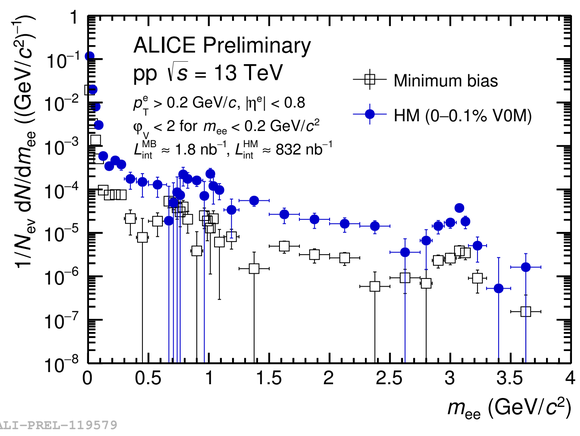
Pair Analysis

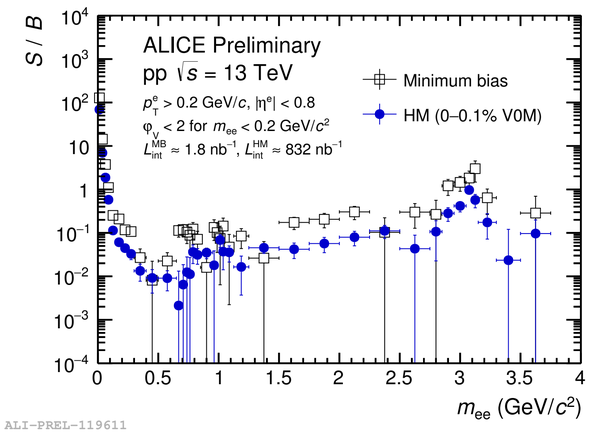
- Signal calculation: $S = N_{+-} - B \cdot R$
- Combinatorial background from geometric mean of like-sign pairs from same event: $B = 2\sqrt{N_{++} \cdot N_{--}}$
- Acceptance correction factor from mixed events:

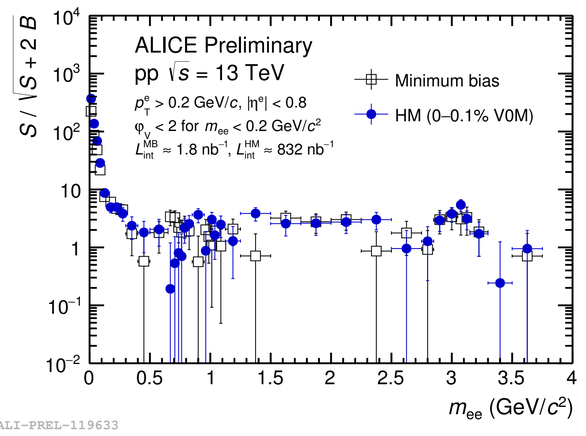
$$R = \frac{N_{+-,\,\mathrm{MIX}}}{2\sqrt{N_{++,\,\mathrm{MIX}} \cdot N_{--,\,\mathrm{MIX}}}}$$

- Rejection of photon conversions: pair orientation relative to the magnetic field (φ_V angle)





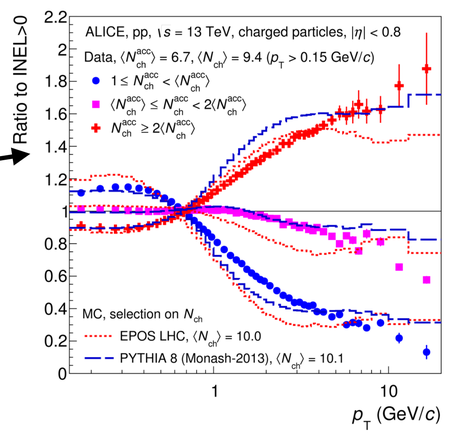




Raw signal normalised by number of events (left), signal / background ratio (middle) and statistical significance (right) in two event classes (HM and MB)
- Clear signs of vector mesons (ω, ϕ, J/ψ)
- Naive expectation: signal is proportional to N_{ch}, combinatorial background grows like N_{ch}^2
  → Signal / background ratio is lower for high multiplicity events
  → Statistical significance is comparable in background-dominated mass region

Cocktail Calculations

Cocktail calculations based on preliminary ALICE π± measurements
- m_T scaling for other hadrons (with asymptotic values fixed to 7 TeV if avail.)
- Include observed modification of p_T spectrum in events with higher charged particle multiplicities [1]
  - Red curve − lower limit (~3× in $\langle N_{\mathrm{ch}}\rangle$)
  - Red / blue − upper limit (~6× in $\langle N_{\mathrm{ch}}\rangle$)
- Take into account also p_T-dependent electron efficiency

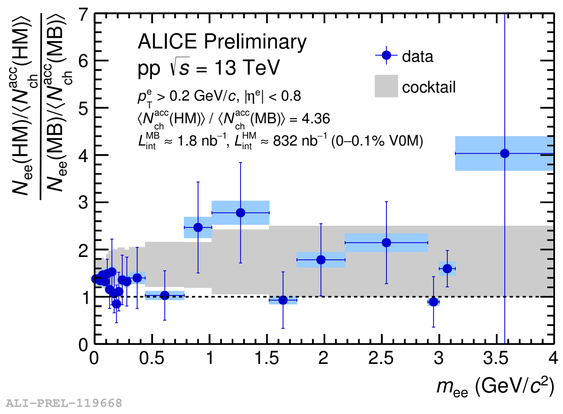


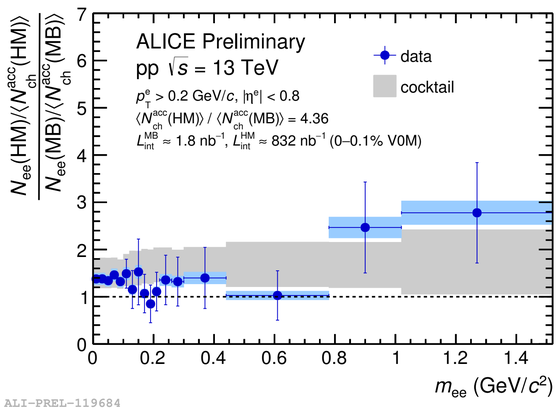
Heavy flavour contribution:
- PYTHIA simulation of open charm production
- Multiplicity dependent production of D meson in pp at 7 TeV [2]
  - At $N_{\mathrm{ch}} / \langle N_{\mathrm{ch}}\rangle \approx 4$ for $2<p_T<4$ GeV/c the relative yield increases to $N_D / \langle N_D\rangle$ = 9.02±0.57(stat)±0.47(syst)+1.67−0.0(feed-down)

→ Expect $\dfrac{N_{\mathrm{c\bar{c}}\to\mathrm{ee}}(\mathrm{HM})/\langle \mathrm{N_{ch}(HM)}\rangle}{N_{\mathrm{c\bar{c}}\to\mathrm{ee}}(\mathrm{MB})/\langle \mathrm{N_{ch}(MB)}\rangle} \approx 1 - 2.5$

Results

Ratio of dielectron spectra in high multiplicity over minimum bias events (right - zoomed in low mass region)
- Scaled with multiplicity factor $\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{HM})\rangle/\langle N_{\mathrm{ch}}^{\mathrm{acc}}(\mathrm{MB})\rangle = 4.36$





In agreement with cocktail expectations everywhere
- π^0 mass region: ratio > 1 due to change of hadron p_T spectrum [1]
- Low mass region: more data are needed to investigate the spectrum modification in details
- Intermediate mass: in agreement with D meson results at 7 TeV [2]
- J/ψ consistent with parallel analysis (S. Weber, Session 1.2)
- Outlook: ~5× more pp data from 2016 will be analysed

References

[1] ALICE Collaboration, "Pseudorapidity and transverse-momentum distributions of charged particles in proton-proton collisions at √s = 13 TeV", Phys. Lett. B 753, 319 (2016)
[2] ALICE Collaboration, "Measurement of charm and beauty production at central rapidity versus charged-particle multiplicity in proton-proton collisions at √s = 7 TeV", JHEP 09, 148 (2015)

* Technische Universität München, Excellence Cluster Universe, ivan.vorobyev@cern.ch