A Large Ion Collider Experiment

ALICE

Dielectron production in pp collisions at 13 TeV with low B-field

ECT* Workshop – Trento
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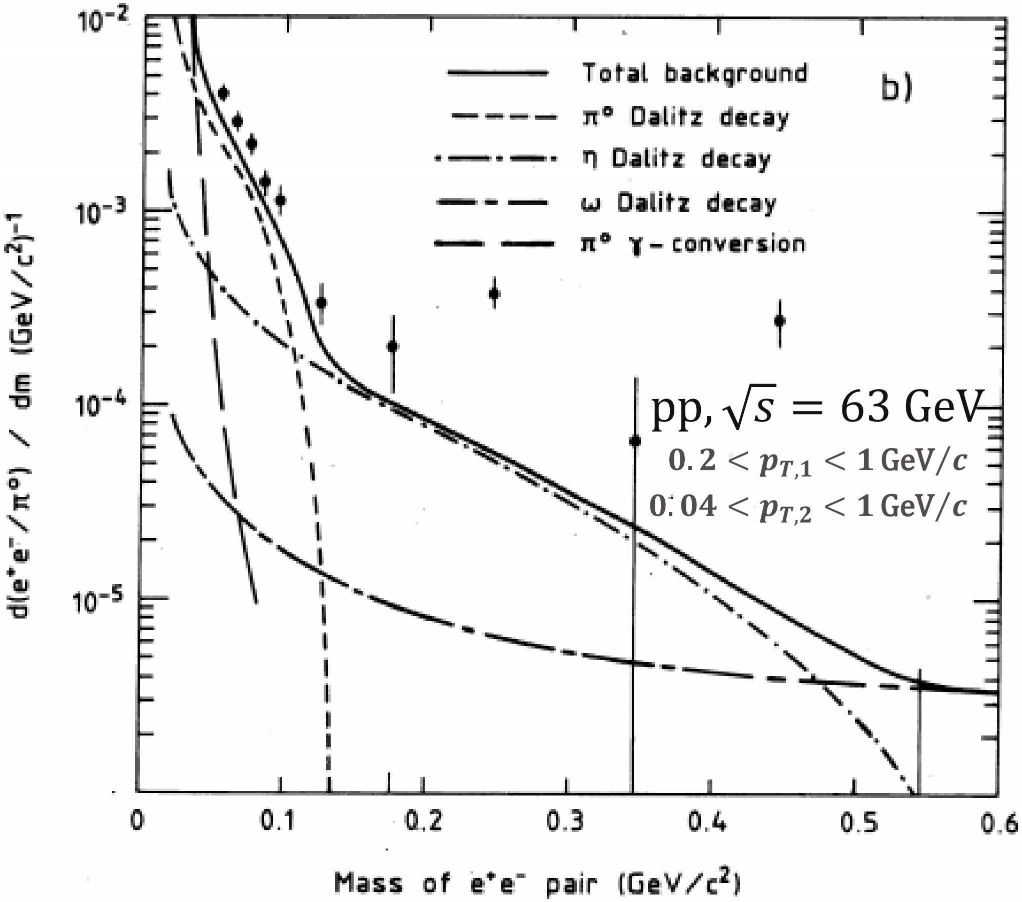
BMBF Forschungsschwerpunkt ALICE Experiment 202
ALICE

Motivation

‘anomalous’ dileptons in pp



V. Hedberg, PhD thesis, Lund (1987)

CERN ISR – AFS (1987):
Excess of dielectrons over expectation from known hadronic sources in a ‘elementary’ collision system

Low-mass region (LMR) excess:
- $0.05\ GeV/c^2 < m_{ee} < 0.6\ GeV/c^2$
- $p_{\mathrm{T,ee}} < 1$ GeV/c

- No other experiment could probe this region

30 years of Heavy Ions:
(H. J. Specht ,2016):
- Remaining open issue
- “Challenge for the future”

Motivation

Dedicated low-mass dielectron runs

Reduced field of the ALICE L3 solenoid magnet: (B = 0.5 T → 0.2 T)

→ Overall charged-particle acceptance increased

→ Bulk of the dielectron yield is located at low momenta

→ Improve background rejection capabilities

→ Access to low-p_{T} particle production

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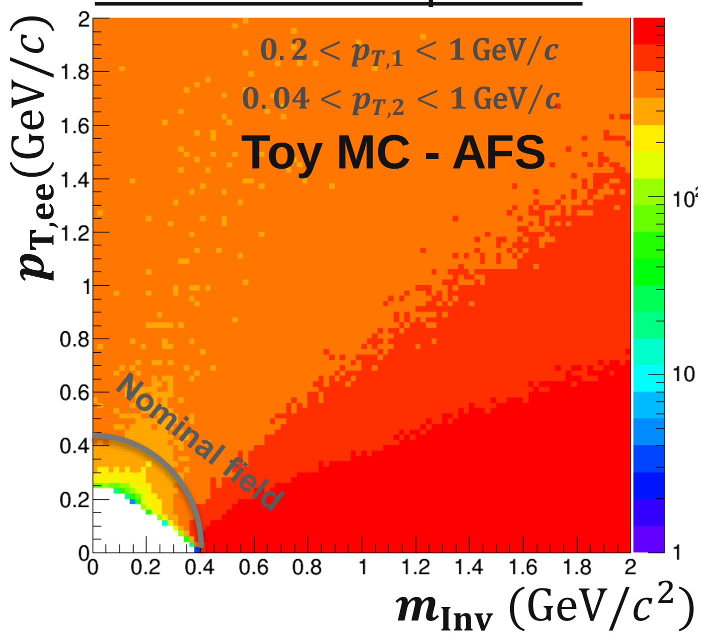

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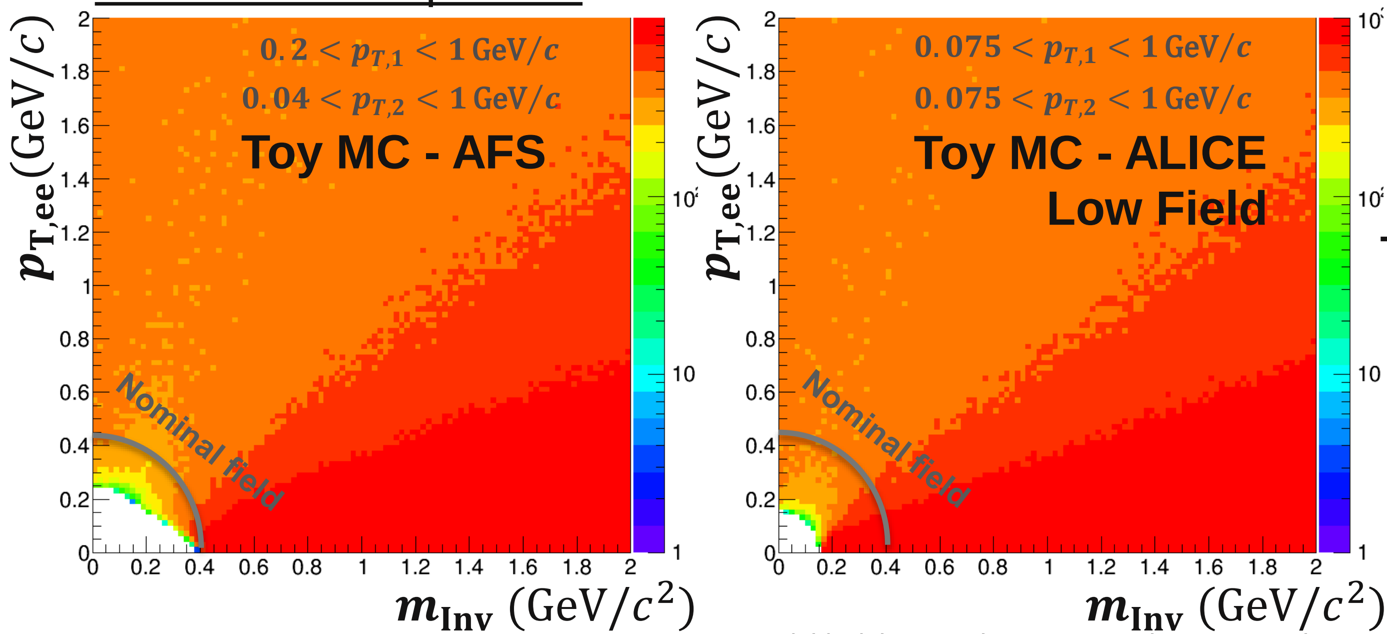
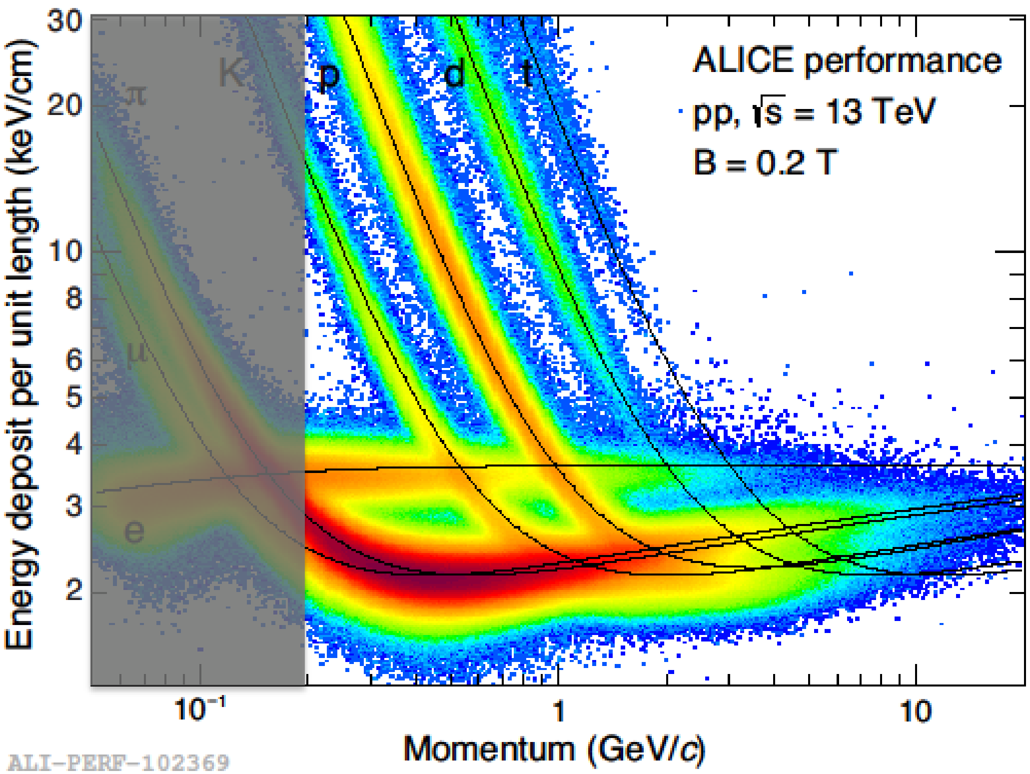


→ Allows us to challenge the AFS measurement for the first time with even better acceptance

Effects of low magnetic field

Particle identification



Specific energy loss in the TPC

Nominal B-field configuration:

– Low-$\boldsymbol{p}$ cut-off at 150 MeV/*c*
  → Limits analysis to $p_{\mathrm{T}} \geq 0.2$ GeV/*c*

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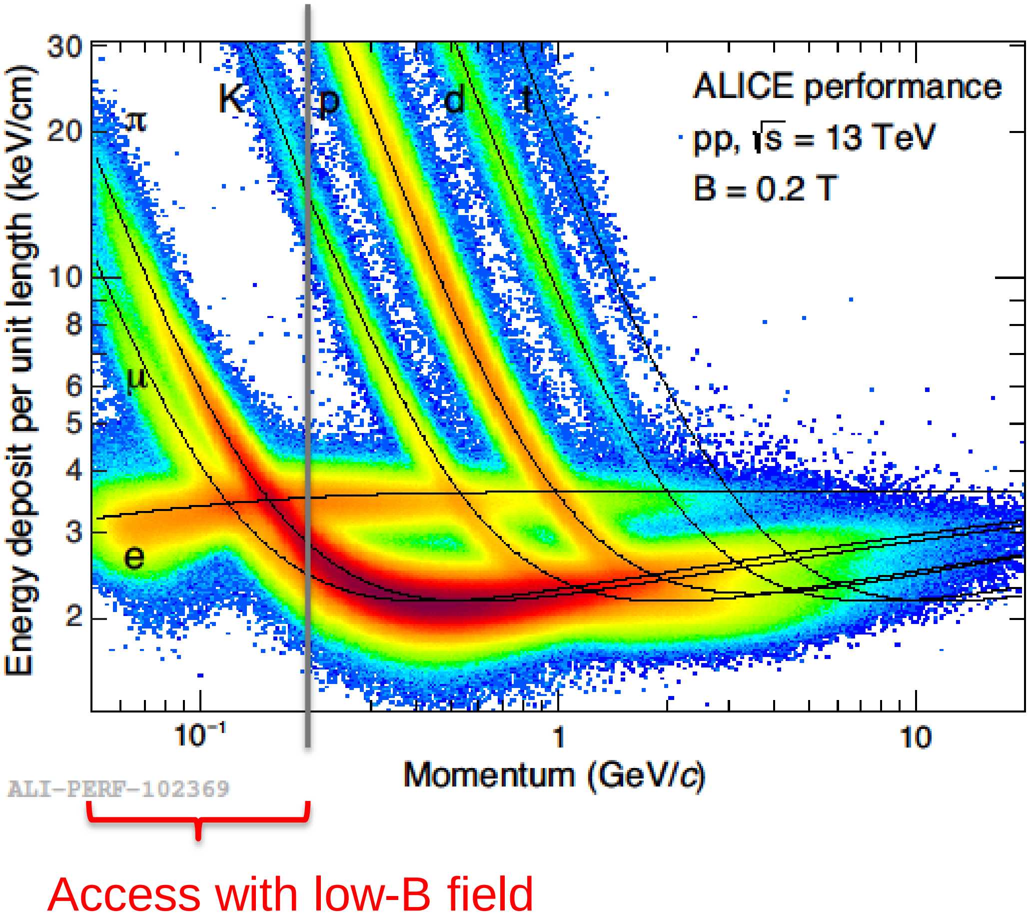

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Low B-field configuration:

- Enables single-leg p_{T}-cut of $p_{\mathrm{T}} \geq 0.075$ GeV/c

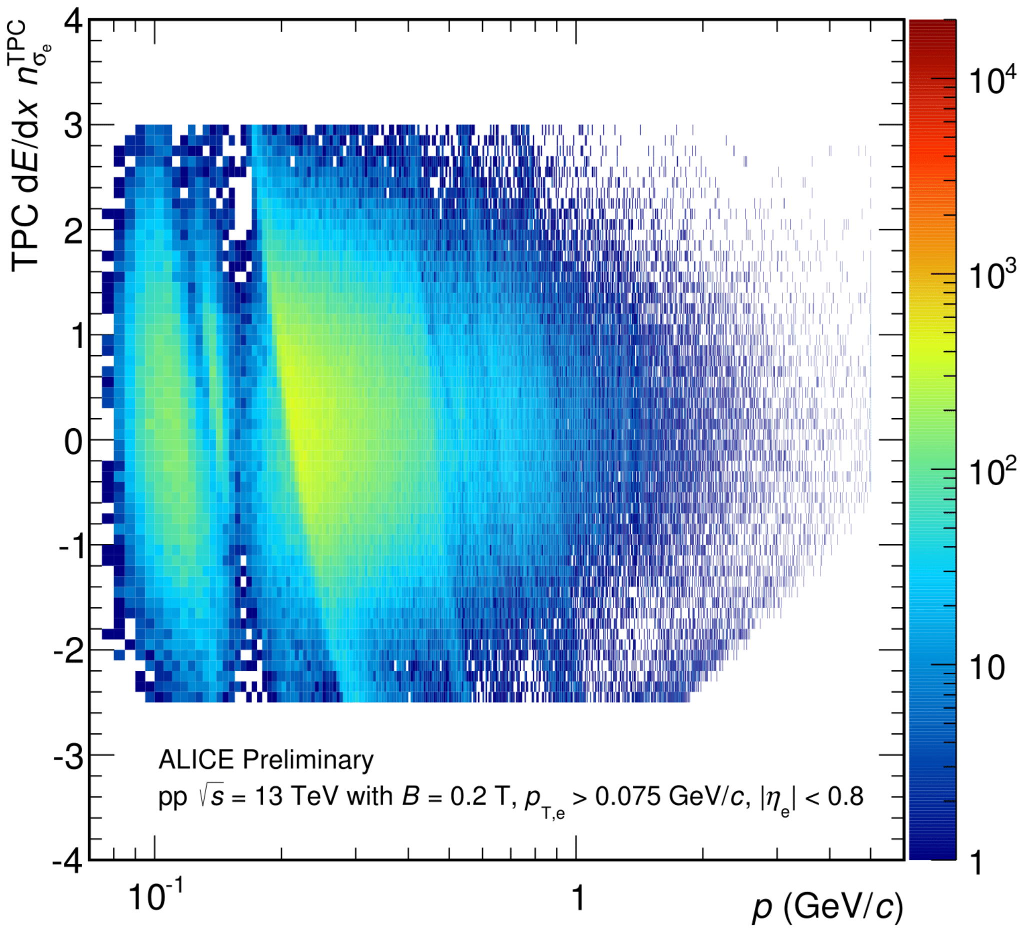
New Challenge:

- Pion crossing
- No ITS PID available in RUN 3

→ New eID approach required

Electron identification

New Scheme



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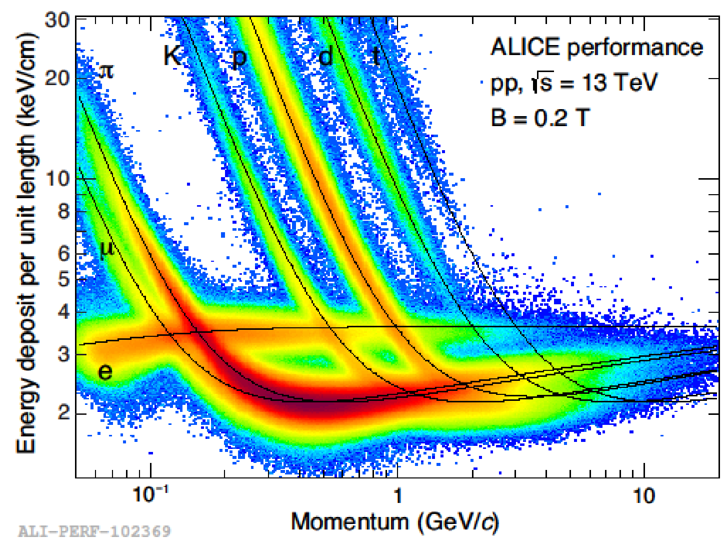
$$n_{\sigma_e} = \frac{\left(\frac{dE}{dx}\right)_{\text{measured}} - \left(\frac{dE}{dx}\right)_{\text{expected}}}{\sigma}$$

– Electron 3σ selection using TPC dE/dx & TOF if available

→ Residual hadron contamination



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Electron identification

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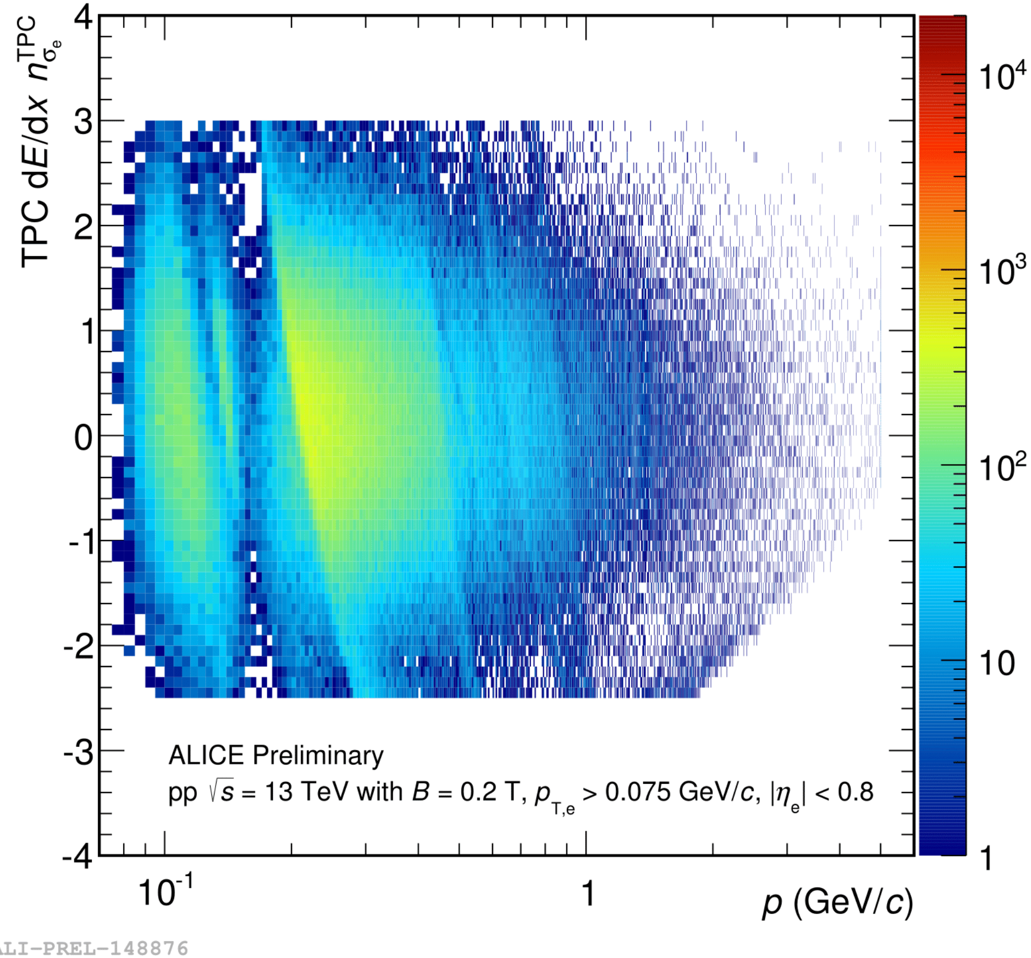

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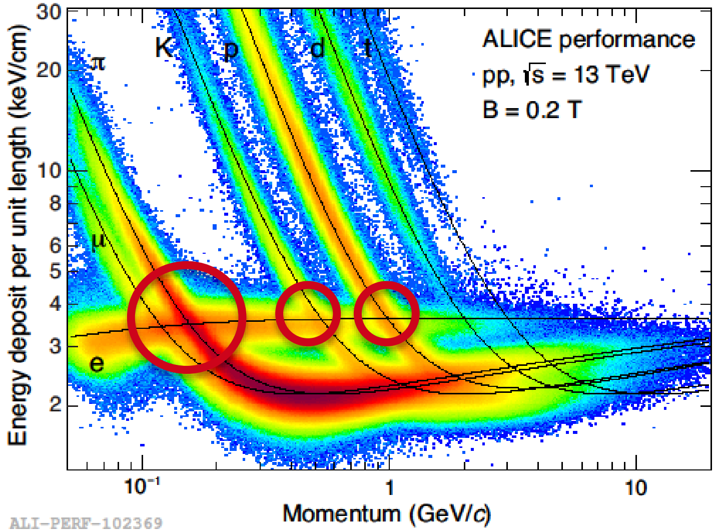

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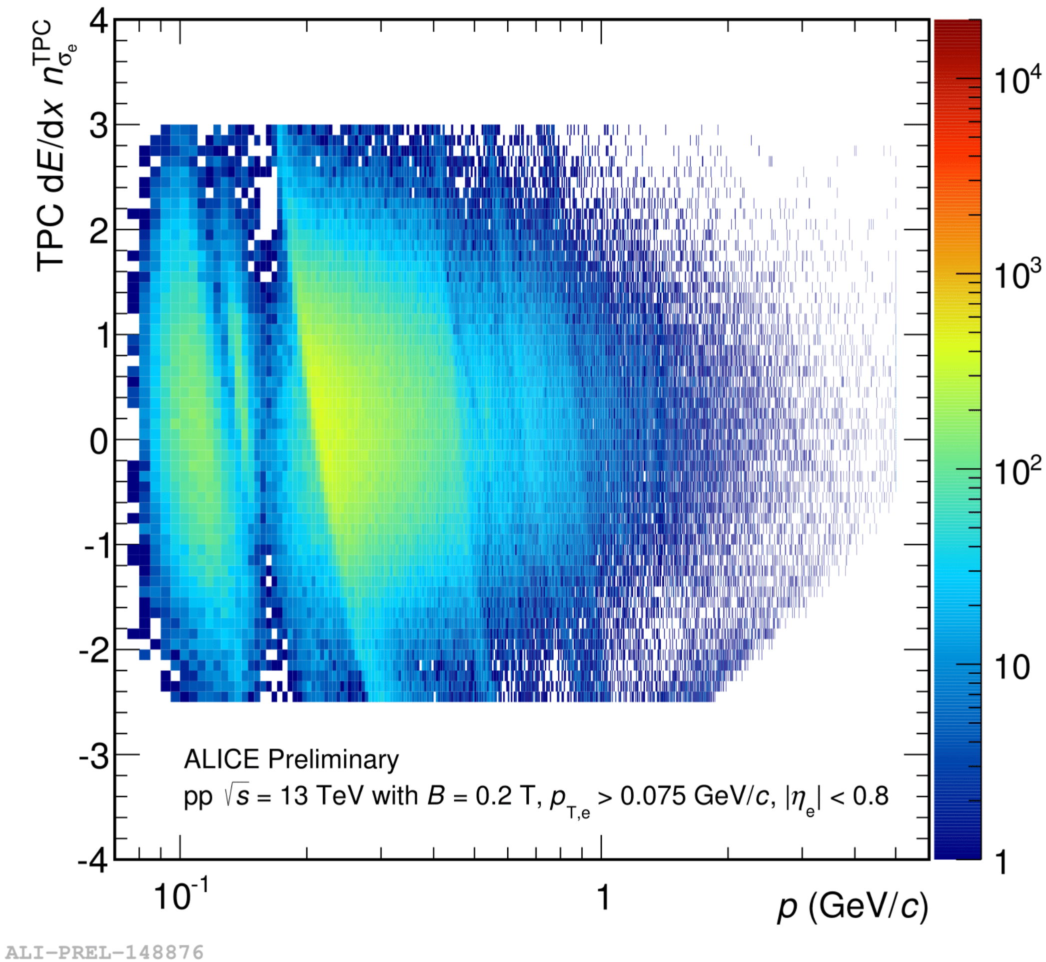

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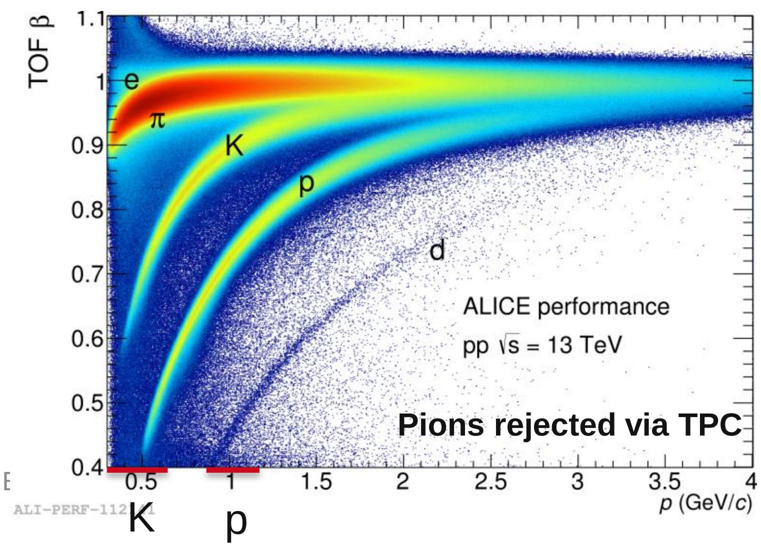
- 3σ hadron rejection in the TPC
- TOF info to recover electron



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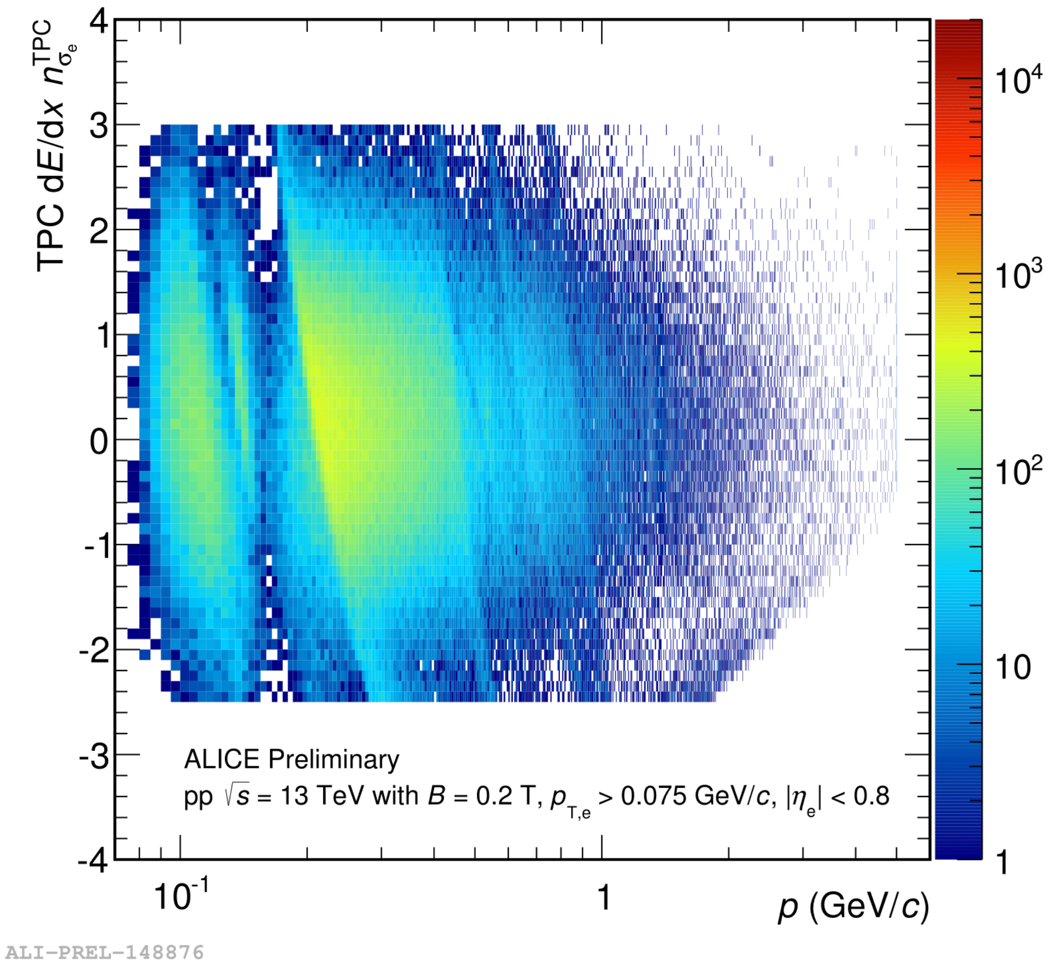

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- Electron 3σ selection using TPC dE/dx & TOF if available
  → Residual hadron contamination
- 3σ hadron rejection in the TPC
- TOF info to recover electron

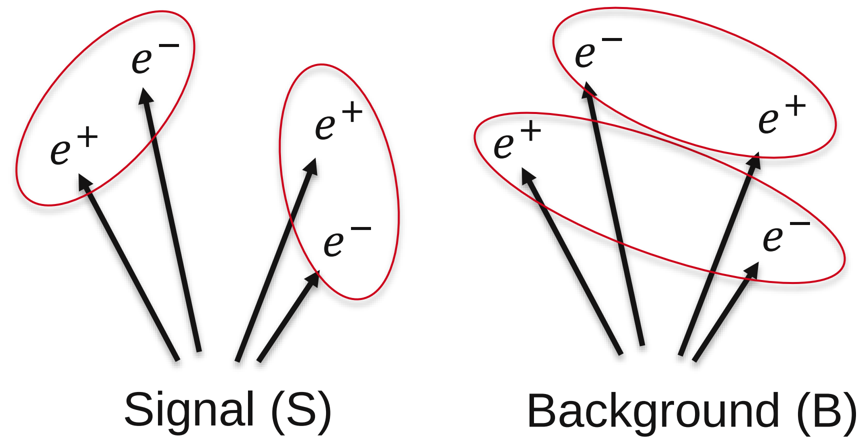
→ Similar electron purity but higher electron selection efficiency compared to requiring TOF, down to p_{T} < 0.075 GeV/c

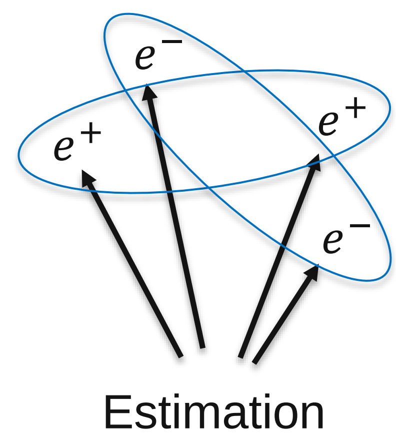
Signal extraction

Combinatorial pairing of all electron and positron candidates:

– Unlike-sign (ULS) pairs:
contain real signal, correlated & combinatorial background

– Like-sign (LS) pairs:
contain correlated & combinatorial background





→ Signal **S** = ULS – 2 R · $\sqrt{\mathrm{LS}_{++}\mathrm{LS}_{--}}$
R: rel. acceptance correction factor
$R = \mathrm{ULS}_{\mathrm{mix}} / (2\sqrt{\mathrm{LS}_{\mathrm{mix},++}\mathrm{LS}_{\mathrm{mix},--}})$

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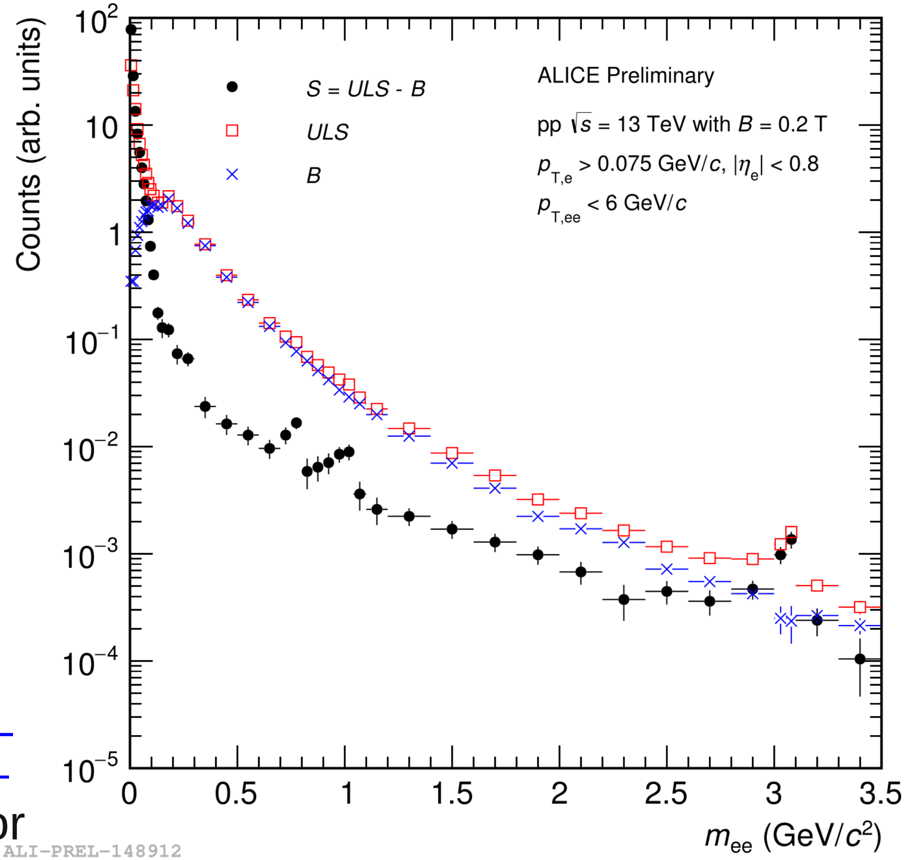


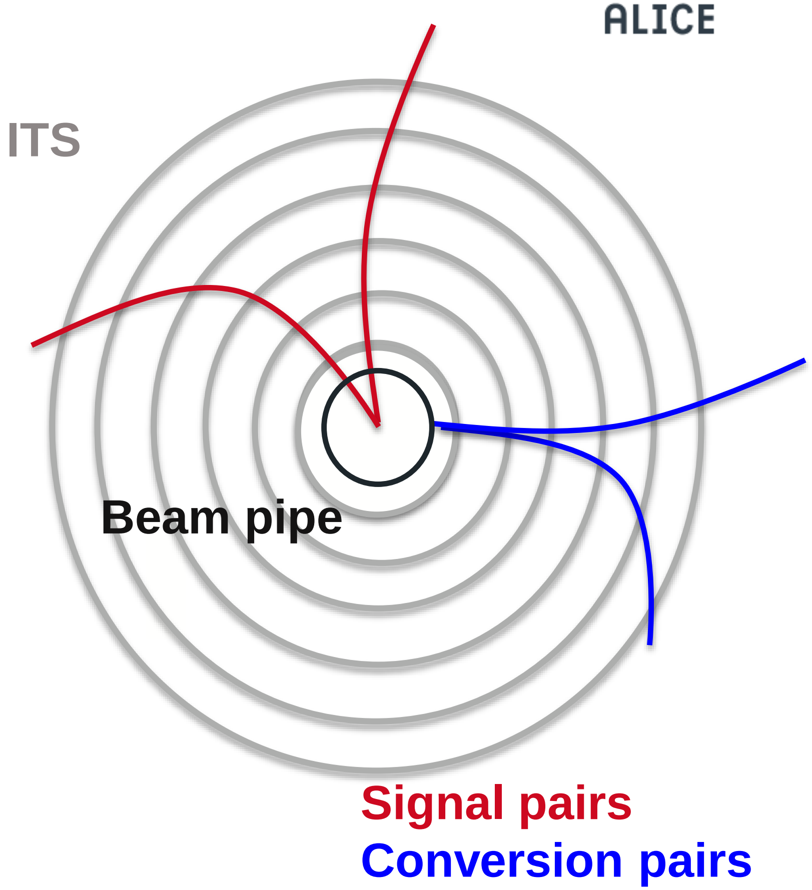
Low S/B: Reduction of combinatorial background key aspect of this analysis

Combinatorial background

Dominated by combinatorial pairs originating from

- π^0-Dalitz decays
- Conversions from beam pipe

Conversion pairs are “close” pairs
→ More likely to share an ITS cluster



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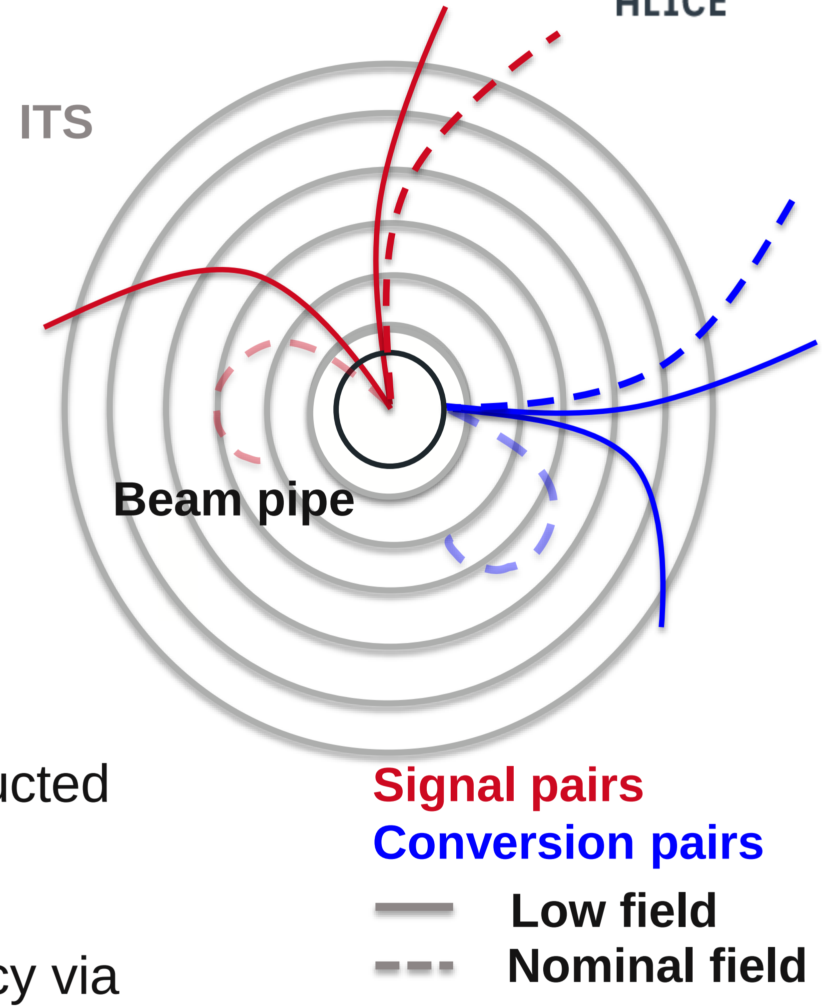


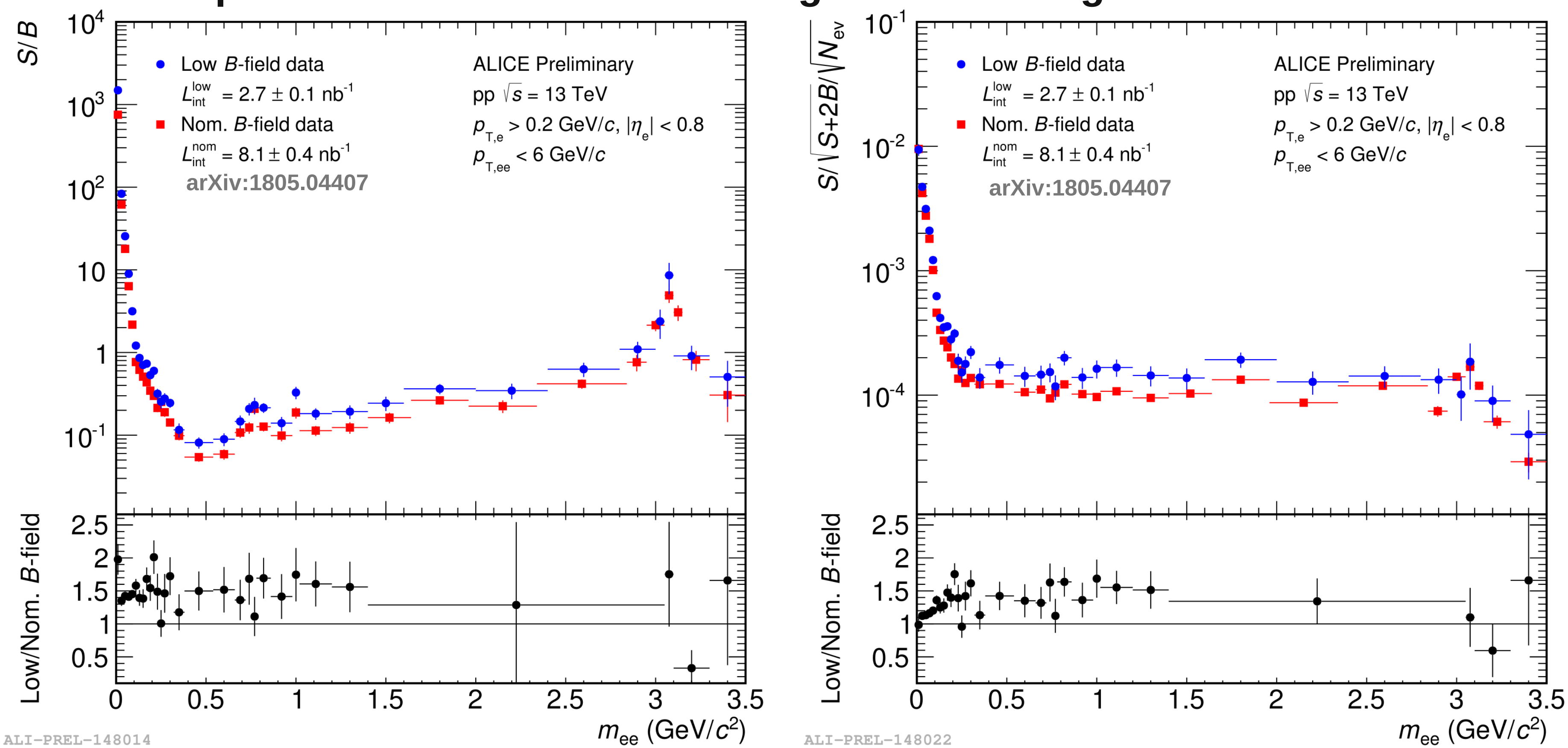
Low-field configuration:

- More conversion pairs get reconstructed (especially asymmetric pairs)

→ Higher conversion rejection efficiency via a veto on shared clusters in the ITS

Effects of low field

Comparison to nominal field setting in S/B and significance



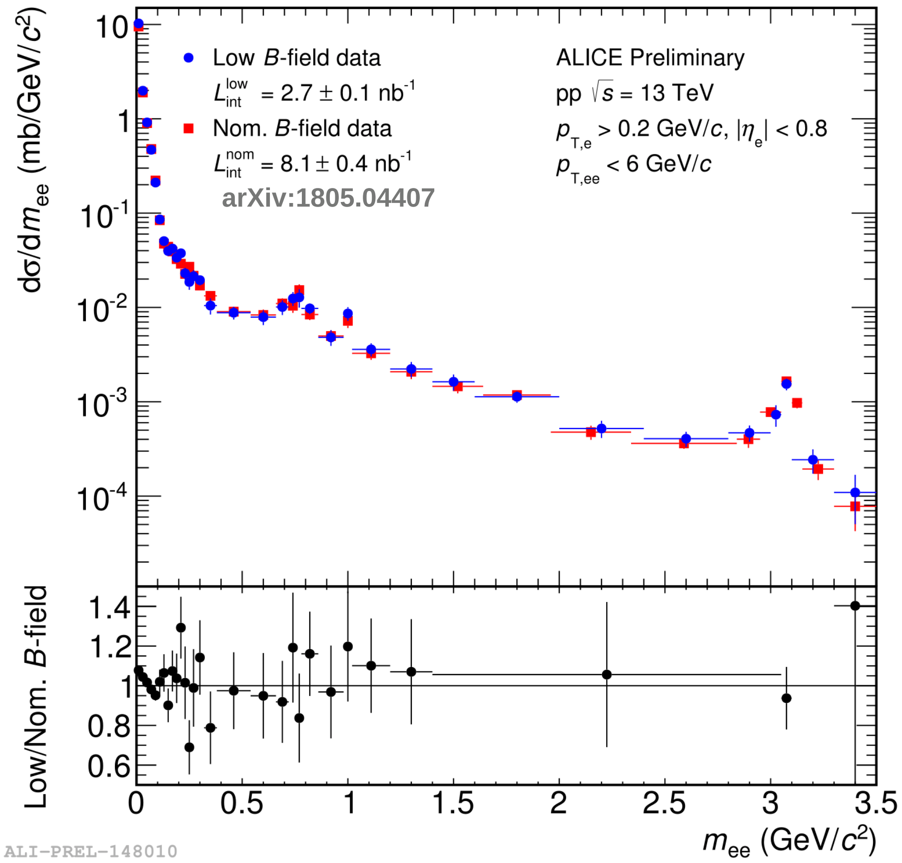
Higher tracking and PID efficiency in **low field**:

– Improvement in S/B especially for low invariant masses

– Clear boost in significance per event: reduction of stat. uncertainty

Corrected spectra

Comparison to nominal-field setting



Comparison with published data within same kinematic region: ($p_T \geq 0.2$ GeV/c)

– Good agreement within statistical uncertainties

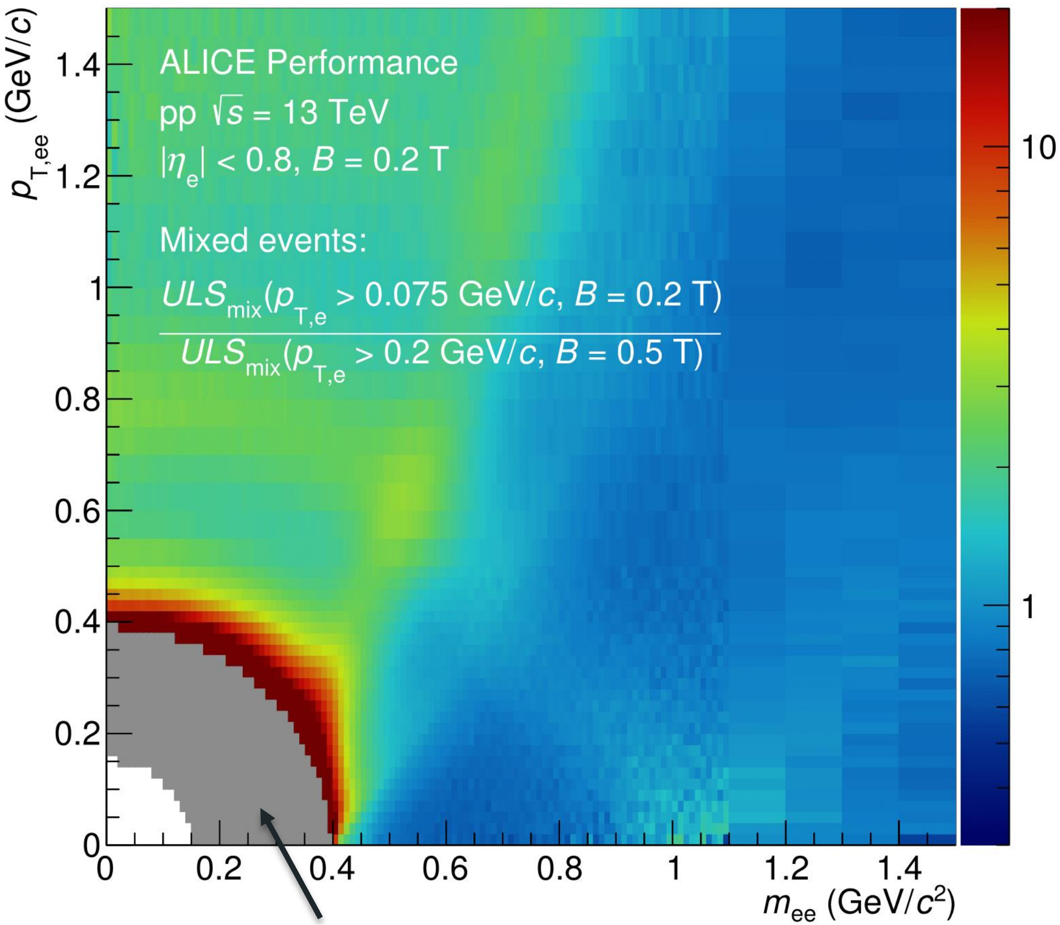
– Effect of low-field configuration on the resolution small within the given statistics

– Similar significance compared to measurement at nominal field (~ $440 \cdot 10^6$ vs. ~ $150 \cdot 10^6$ events)

Low-B-Field Acceptance

Effects of the magnetic field

Mixed events: **Low Field** ($p_{\mathrm{T}} > 75$ MeV/c) / **Nom Field** ($p_{\mathrm{T}} > 200$ MeV/c)



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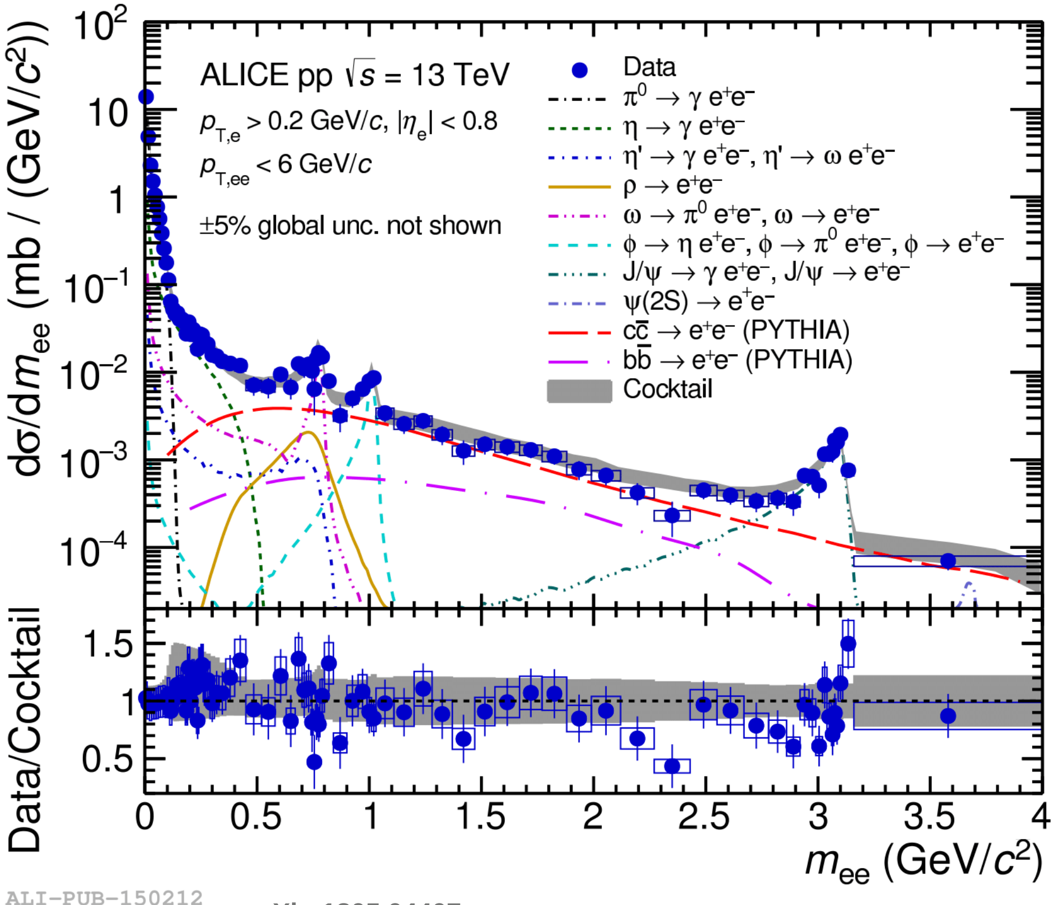
No access with nom. field

Gain in phase space with low field:

- Acceptance: lower single-leg p_{T}
- Efficiency: TOF

→ Increase sensitivity for soft virtual-photon production

Corrected spectra & hadronic cocktail



arXiv:1805.04407

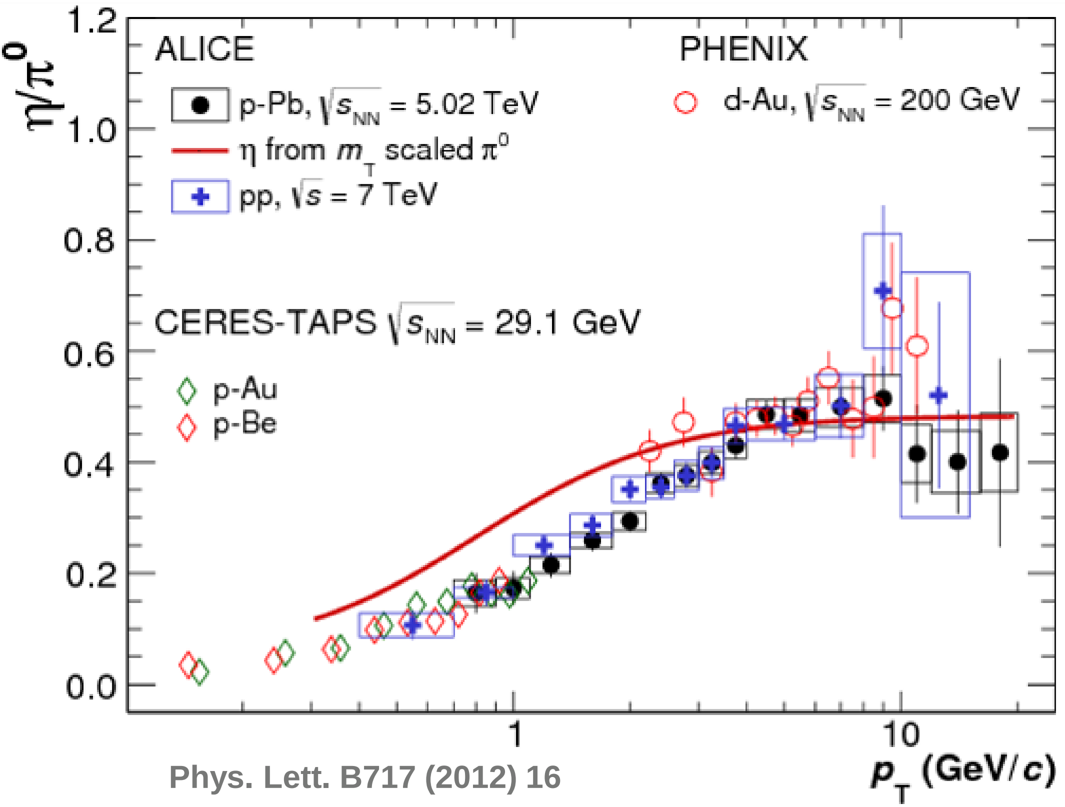
Cocktail: (analogous to nom.-field ana.)

- LF based on 13 TeV $\pi^{\pm}$ parametrisations combined with particle ratios for η, ρ and ω
- m_T scaling for remaining particles
- HF generated with Pythia6 scaled with FONLL cross sections to 13 TeV
- J/ψ based on 7 TeV parametrisation scaled with FONLL to 13 TeV

→Good agreement within uncertainties

Hadronic Cocktail

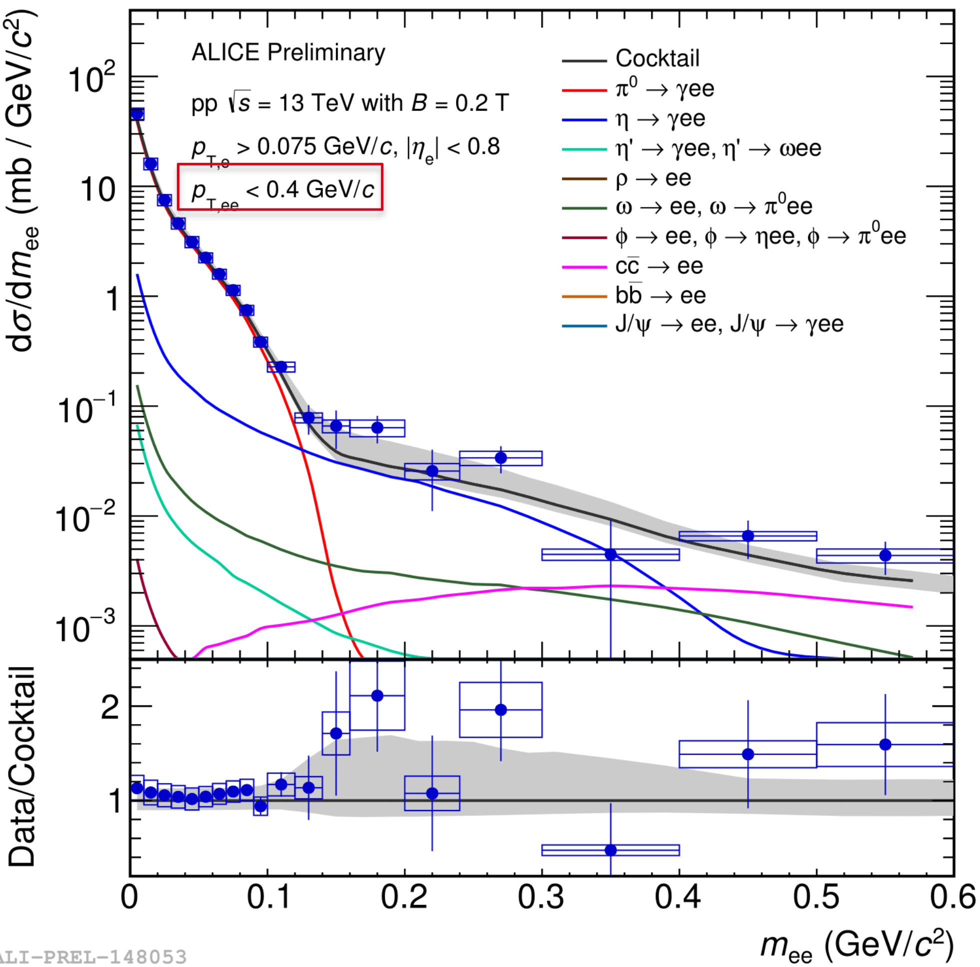
Low-p_{T} η parametrization



Phys. Lett. B717 (2012) 16

- η contribution dominant in the LMR
- ALICE measurement only down to $p_T < 0.4$ GeV$/c$
- m_{T} scaling overshoots η at low p_T
- Ceres – Taps measurement used to further constrain the cocktail at low p_{T}
- η/π^0 ratio independent of collision system and energy
- Higher estimate compared to AFS

Invariant-mass spectra in LMR



- Hint for enhancement at LHC energies?
  → 2.2σ stat. significance integrated over $0.14 < m_{ee} < 0.6\ \mathrm{GeV}/c^2$ over the central value of the cocktail

- Cocktail uncertainties from m_{T} scaling
  → overpredicts η at low p_{T}

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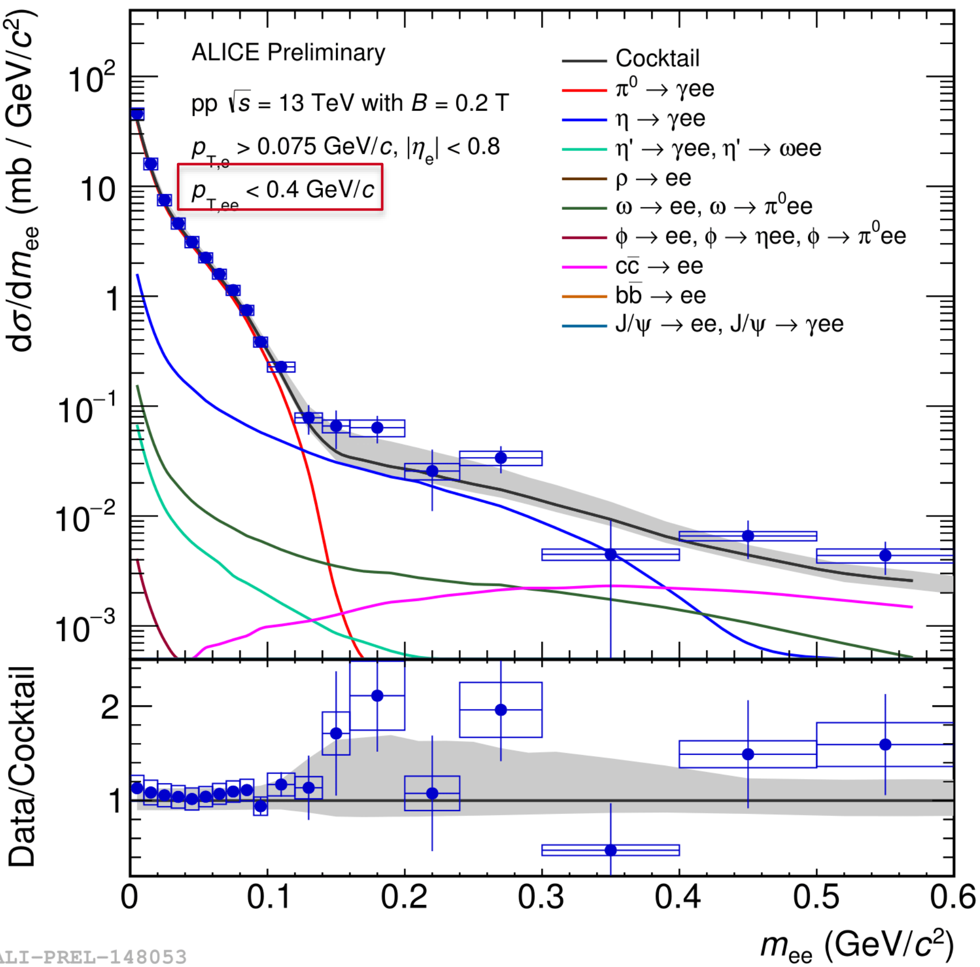

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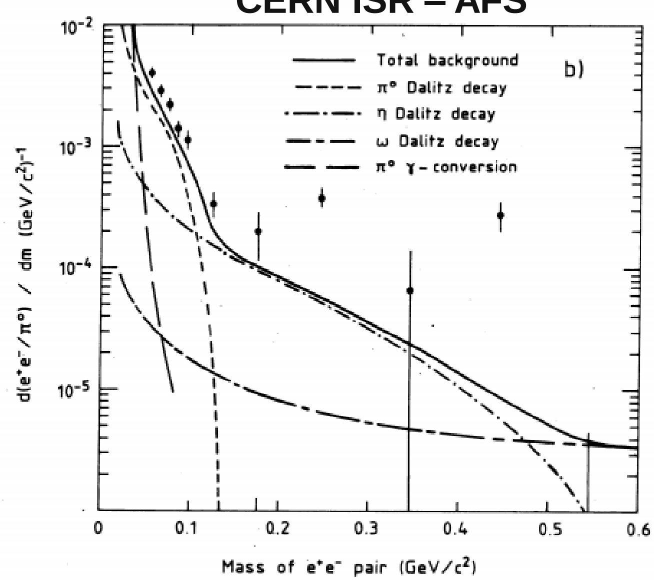
CERN ISR – AFS



V. Hedberg, PhD thesis, Lund (1987)

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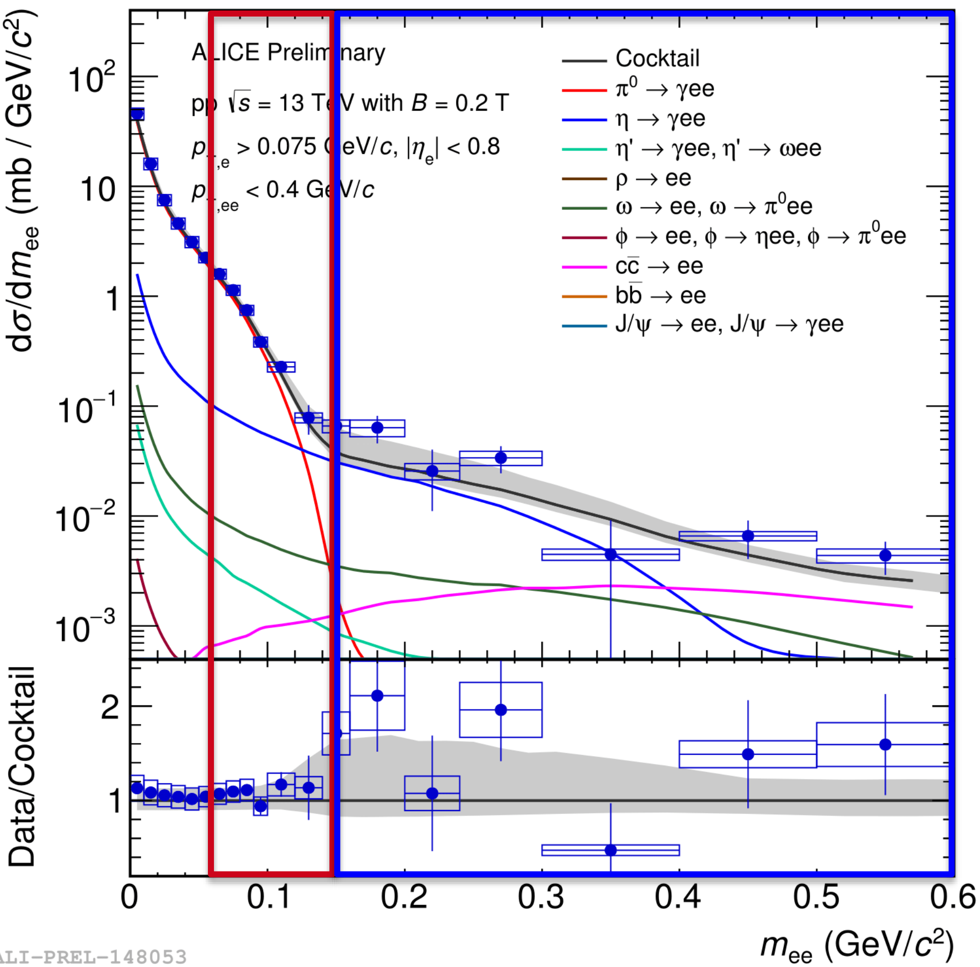
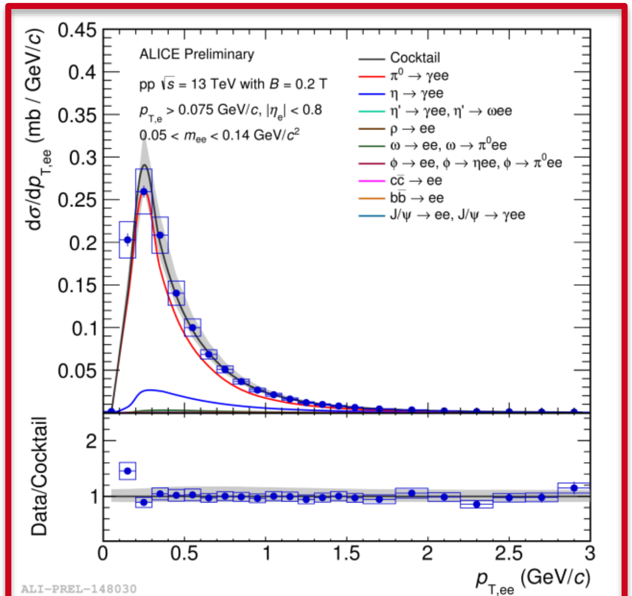
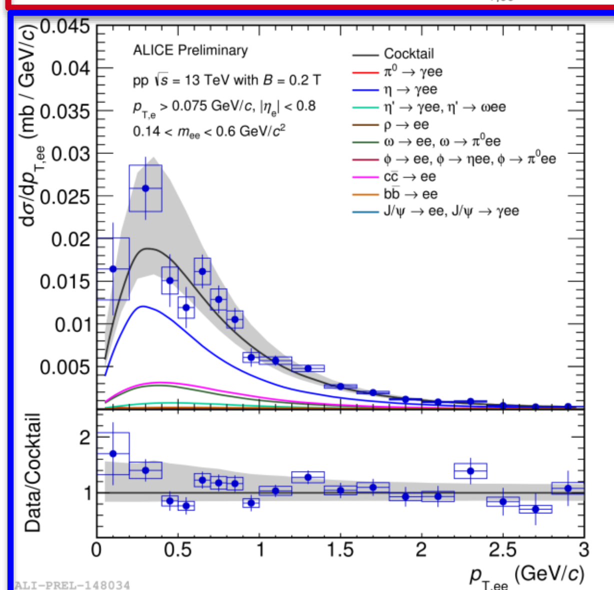




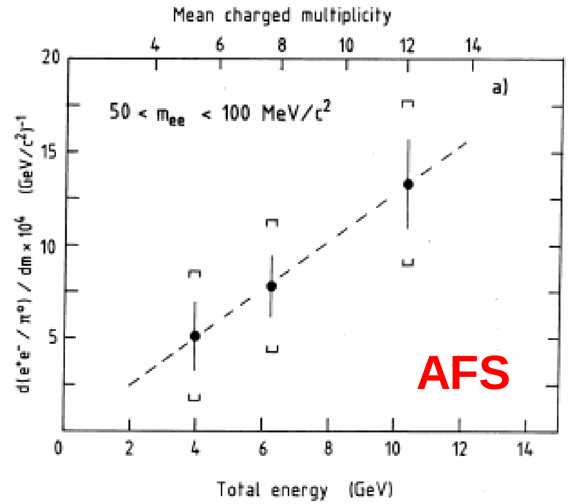
π dominated region

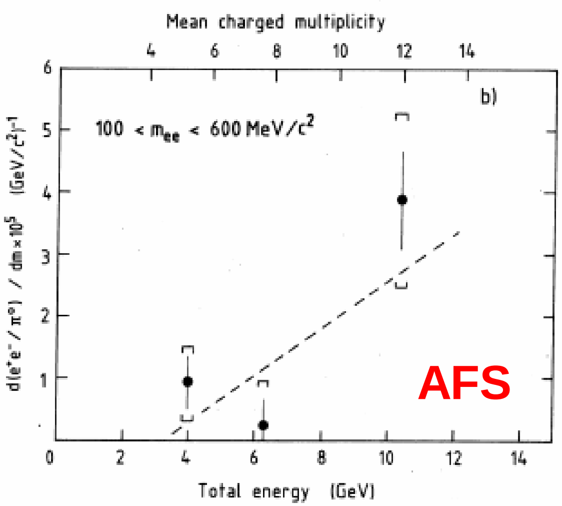


η dominated region

Outlook

Multiplicity dependence of the LMR excess

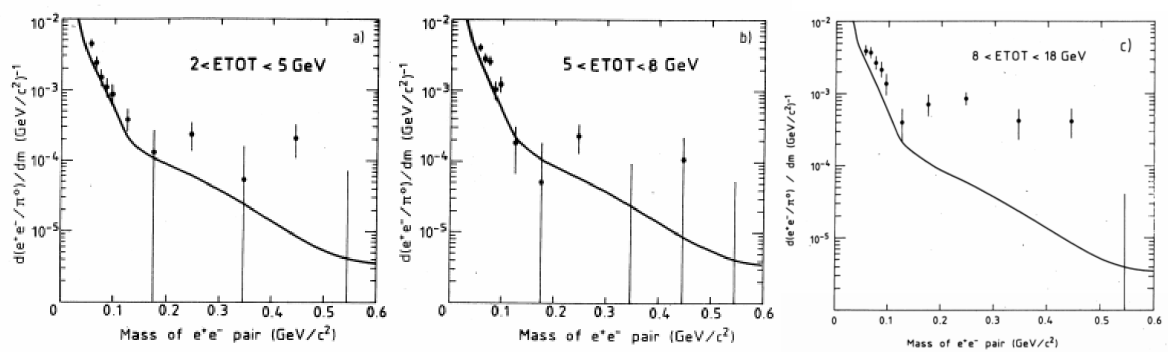




Dielectron signal after subtraction of hadronic sources as a function of multiplicity

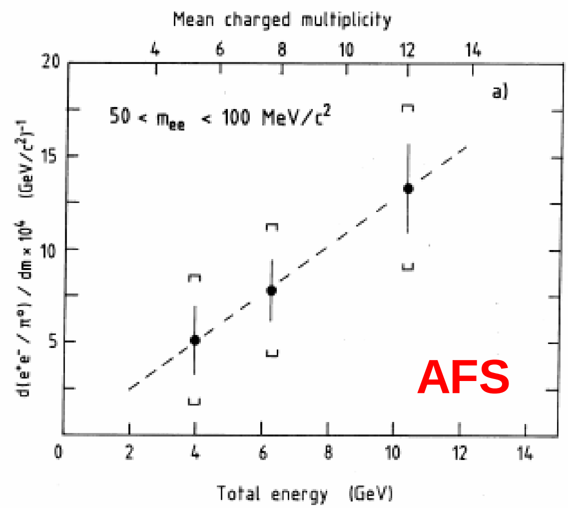
Idea:
Multiplicity dependence gives insight into the underlying production mechanism

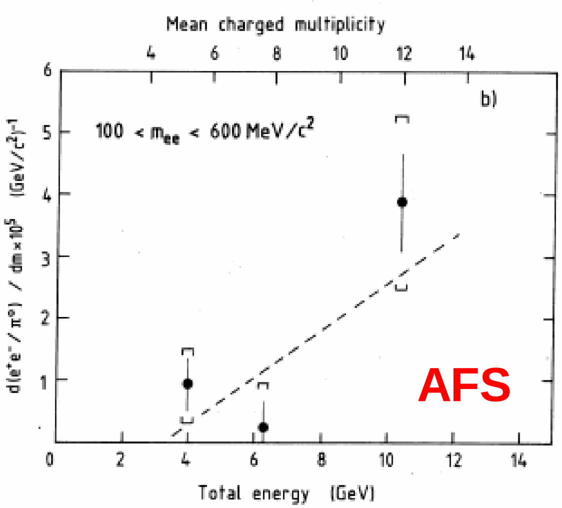
→ Soft annihilation processes expects quadratic dependence



Outlook

Multiplicity dependence of the LMR excess





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New low-B field data taking in 2018:
- Increase in statistics by a factor of 3

→ Expect to reach a stat. significance of about 3σ

- Study multiplicity dependence at LHC energies?

→ Constrain for the underlying production mechanism

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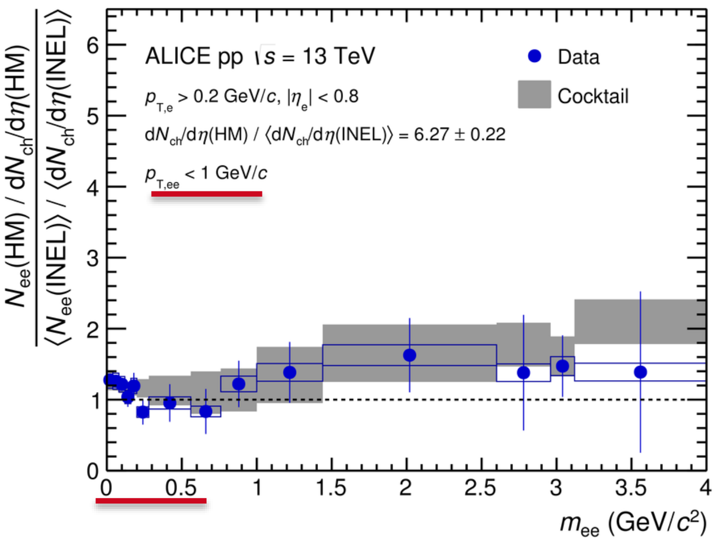
Multiplicity dependence of the LMR excess



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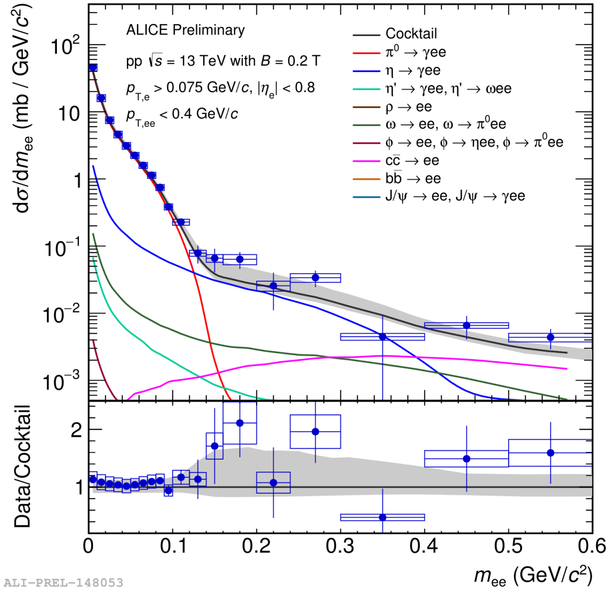
Conclusion

- First preliminary results of the dielectron measurement in pp collisions at $\sqrt{s}$ = 13 TeV with the low-field configuration
- Good agreement within stat. uncertainties with published nom.-field analysis
- **Low field**: Increase in significance and S/B
- Low-field gives access to a new phase space at low momenta

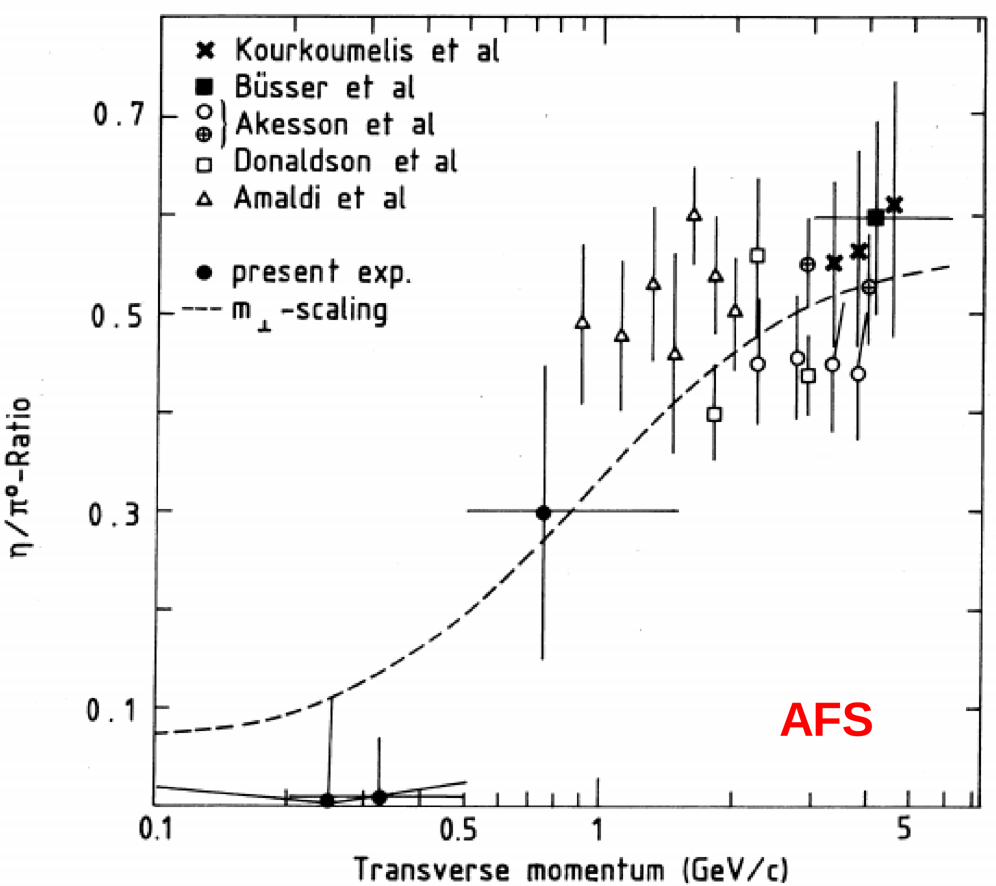
→ Sheds new light on the LMR excess seen at the ISR

However: Low-p_T η measurement required for a final conclusion



Hadronic Cocktail

Low-p_T η parametrization



AFS measurement:

P_T (MeV/c)	η/π
200 – 500	0.01±0.06
500 – 1500	0.30±0.15

- Even lower value compare to CERES/TAPS
- Large uncertainties ignored

→ Leads to a bigger LMR excess