# Prospects of Low-Mass Dielectron Measurement in ALICE with an upgraded Central Barrel Detector

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## Motivation

Physics Case:
The measurement of electron-positron pairs in the low invariant mass region allows to study the vacuum and in-medium properties of light vector mesons. Dielectrons also probe the production of thermal photons in heavy-ion collisions. ALICE is well-suited to perform this measurement due to its excellent tracking and particle identification capabilities at very low momenta.

Experimental Challenge:
- Dalitz decays and photon conversions lead to a high combinatorial background.
- Coincident semi-leptonic decays of charm and anti-charm hadrons produce a continuum signal, which dominates over a thermal dielectron signal.

Strategy:
- **Upgrade of Inner Tracking System (ITS)** [1]
  - will improve the tracking efficiency at very low transverse momentum
  - will provide excellent detection capabilities for electrons from secondary vertices
- **Reduction of central barrel magnetic field to B = 0.2 T**
  - will extend global tracking efficiency and electron PID to lower momenta
- **High rate upgrade of Time Projection Chamber (TPC)** [1]
  - will increase the data taking rate by a factor of 100

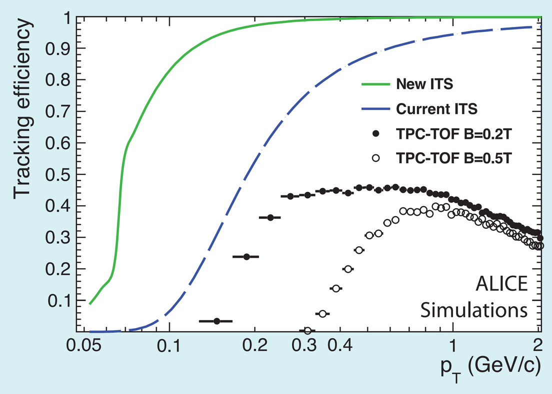



**Fig. 1:** Comparison of ITS tracking from current to new ITS and global tracking from nominal to reduced magnetic field.

## Settings of this Study

- **Dielectron signal contributions**
  - Hadronic cocktail (Exodus)
  - Correlated open charm decay
  - Thermal signal expectations (R. Rapp)
    [R. Rapp and J. Wambach, Eur. Phys. J. A6 (1999) 415]
- **Background study**
  Electron sample:
  - Pythia pp events (superimposed)
  - Geant photon conversions

  Kinematic cuts:
  - $|\eta_e| < 0.84$
  - $p_{T,e} > 0.2$ GeV/$c$ (global tracking)
  - $p_{T,e} > 0.06$ GeV/$c$ (ITS standalone)

  Conversion & Dalitz rejection:
  - $M_{ee} < 50$ MeV/$c^2$ & angle < 100 mrad

  Optional cut on significance of Impact Parameter (DCA) measured with ITS:
  - at primary e efficiency of 50% (current)
  - at primary e efficiency of 32% (new ITS)

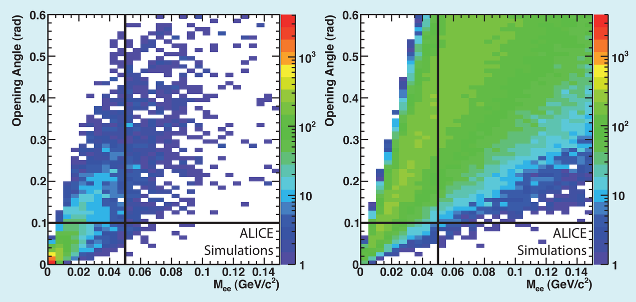



**Fig. 2:** Invariant mass vs. opening angle for real pairs (left) and fake pairs. Pair cuts are indicated.

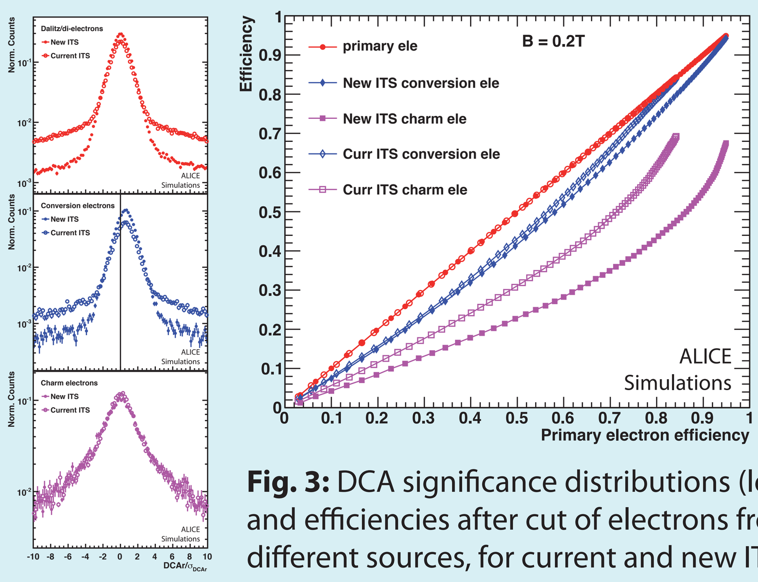



**Fig. 3:** DCA significance distributions (left) and efficiencies after cut of electrons from different sources, for current and new ITS.

## Predictions for future e+e− Measurements

Simulation of Pb–Pb collisions at $\sqrt{s_{NN}}$=5.5 TeV:

1. **Compute total signal**
   - for given $dN_{ch}/d\eta$ and $N_{coll}$
   - correct for pair efficiency
2. **For each ITS version**
   - generate combinatorial background
   - compute S/B and significance
3. **Sample signal spectrum**
   - according to number of events and significance
4. **Extract excess spectrum**
   - subtract known contributions with assumed errors (hadronic cocktail ± 10%, open charm ± 20%)
   - propagate statistical and systematic errors

- **Number of events per 10% centrality**
  - $2.5\cdot10^7$ at present readout rate
  - $2.5\cdot10^9$ at high TPC rate (50 kHz)
- **Multiplicity at $\sqrt{s_{NN}}$=5.5 TeV**
  - $dN_{ch}/d\eta$ = 1750 (0-10%) / 250 (40-60%)
  - $N_{coll}$ = 1625 / 140 (for charm)

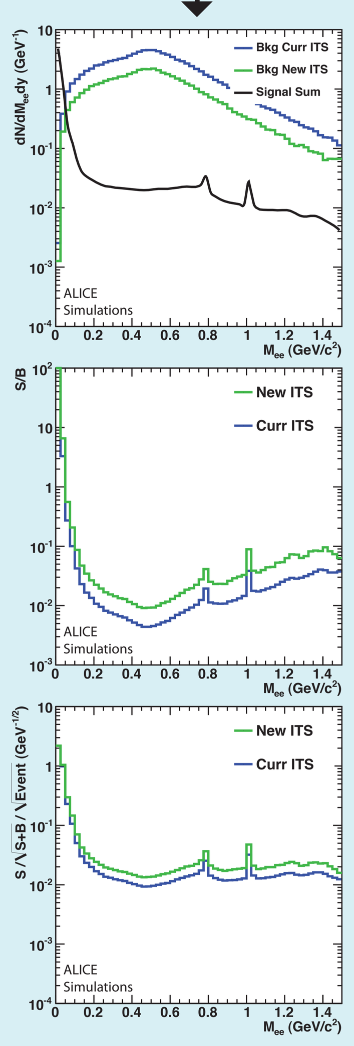
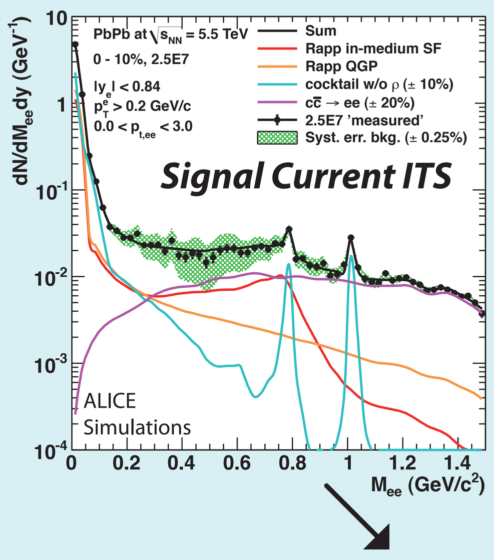
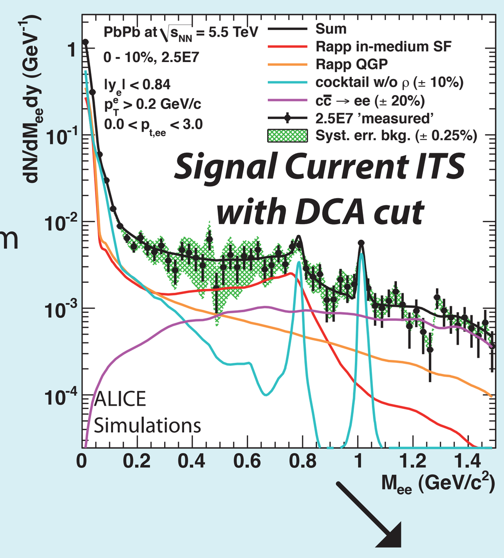



**Fig. 4:** e+e− Backgrounds and Signal, S/B, significance for current and new ITS, without DCA cuts.

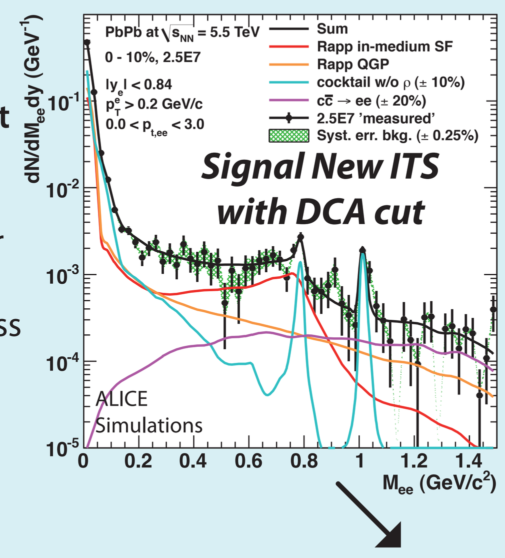
Expectations for 0 - 10% central collisions:



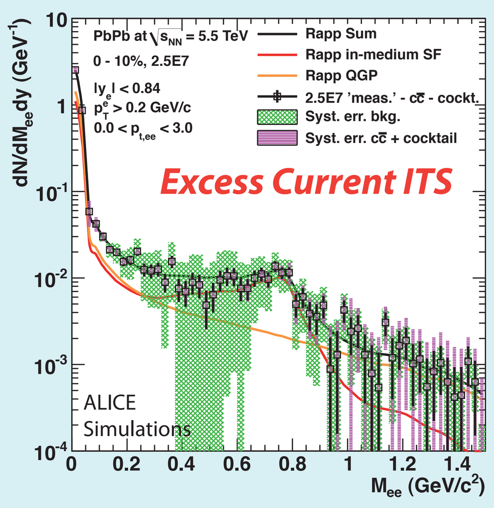

Add DCA cut:
+ suppress charm
+ reduce background (conversions)
− signal loss



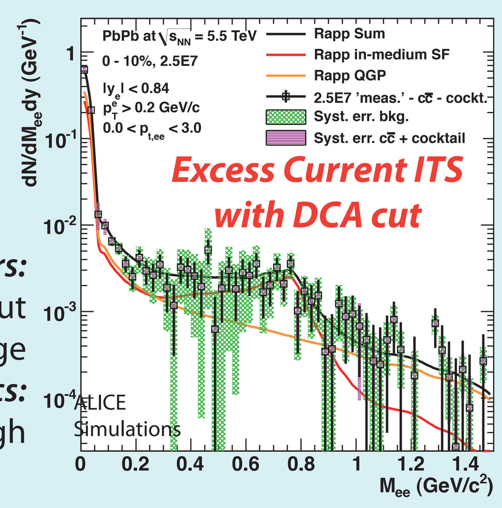

Tighten DCA cut with new ITS:
+ reach stronger suppression
− more signal loss



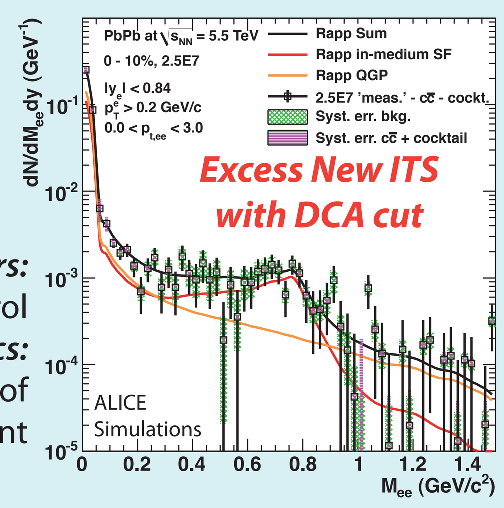

After Subtraction: large systematic errors from background and uncertainties on charm and cocktail



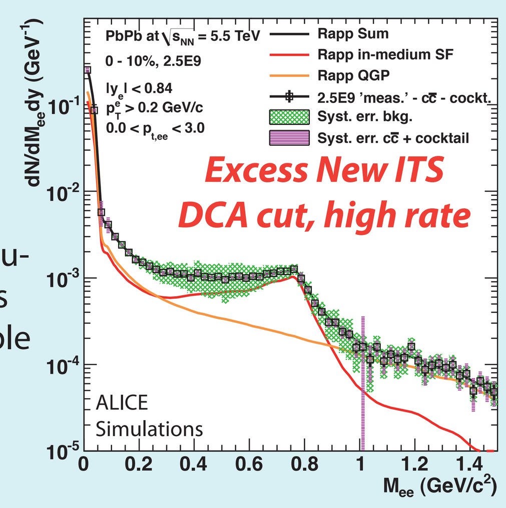

*Systematic errors:* reduced, but still too large
*Statistics:* not enough




*Systematic errors:* under control
*Statistics:* limiting factor of measurement




With high rate TPC upgrade:
significant measurement of excess spectrum possible




Expectations for 40 - 60% semi-central collisions:

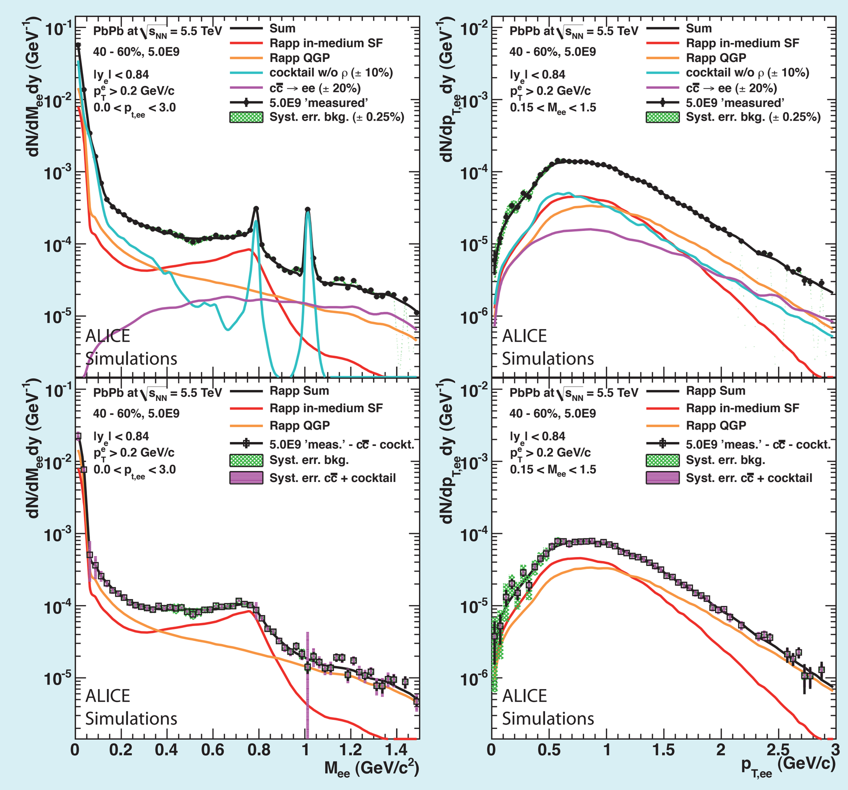



**Fig. 5:** Signal (upper) and excess spectra as function of $M_{ee}$ (left) and $p_{T,ee}$ for new ITS with DCA cut and high rate.

## Further Implications

- **Elliptic flow**
  - statistical uncertainties in excess spectra allow to estimate flow significance:
    $\sigma_{v2} \approx 0.7 / (N/\sigma_N)$ (from MC)
  - relevant for semi-central collisions
- **QGP temperature**
  - exponential fit to excess mass spectrum gives effective temperature of thermal radiation:
    $dN/dM_{ee} \sim \exp(-M_{ee}/T)$ for $M_{ee} > 0.9$ GeV/$c^2$
  - mass region dominated by charm → DCA cut

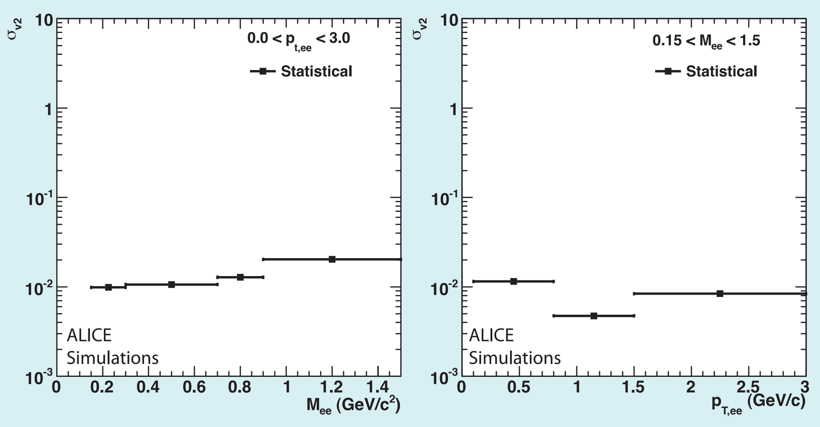



**Fig. 6:** Expected absolute statistical uncertainty on dilepton elliptic flow, calculated from the excess spectra of Fig. 5.

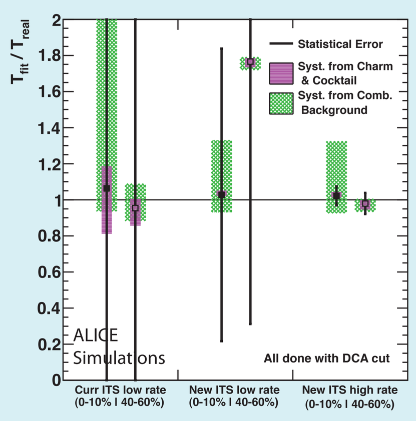



**Fig. 7:** Average values of thermal fits to excess mass spectra from central and semi-central collisions.

*From current to new ITS:*
- reduced charm & cocktail error in both centralities

*New ITS with high rate:*
- T-measurement possible
- background error in central to be optimized

## Summary & Outlook

- **Summary:**
  - Presentation of feasibility study for dilepton measurement at $\sqrt{s_{NN}}$=5.5 TeV featuring ALICE upgrade plans:
    - New Inner Tracking System & high rate upgrade of TPC
  - This will allow – for the first time – a multi-differential low-mass dielectron measurement in heavy-ion collisions
- **Expectations for other observables:**
  - Dilepton $v_2$: absolute uncertainty of the order of $\sigma_{v2}$ = 1%
  - Thermal radiation $T$: uncertainty of approximately 10%
- **Outlook:**
  - Perform QGP fits also on excess pair-$p_T$ spectra (see Fig. 8)
  - Repeat this study for current ITS at nominal B-field to compare to analysis of available Pb–Pb data
  - Try to improve analysis strategy based on experience gained from this study

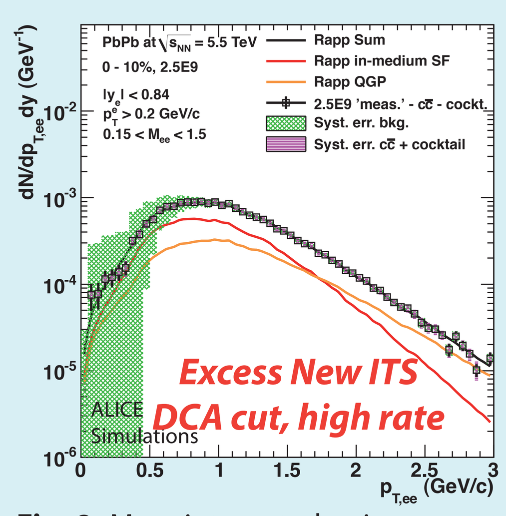



**Fig. 8:** Mass-integrated pair-$p_T$ spectrum for central collisions. **Outlook:** thermal fit after acceptance correction. High rate statistics also allow for mass-differential spectra (e.g. in the ρ region).

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[1] T. Peitzmann, "Upgrade of the ALICE experiment", talk at QM 2012 Session Parallel 6C: New Experimental Developments

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