Feasibility Study of χ_c identification with ALICE

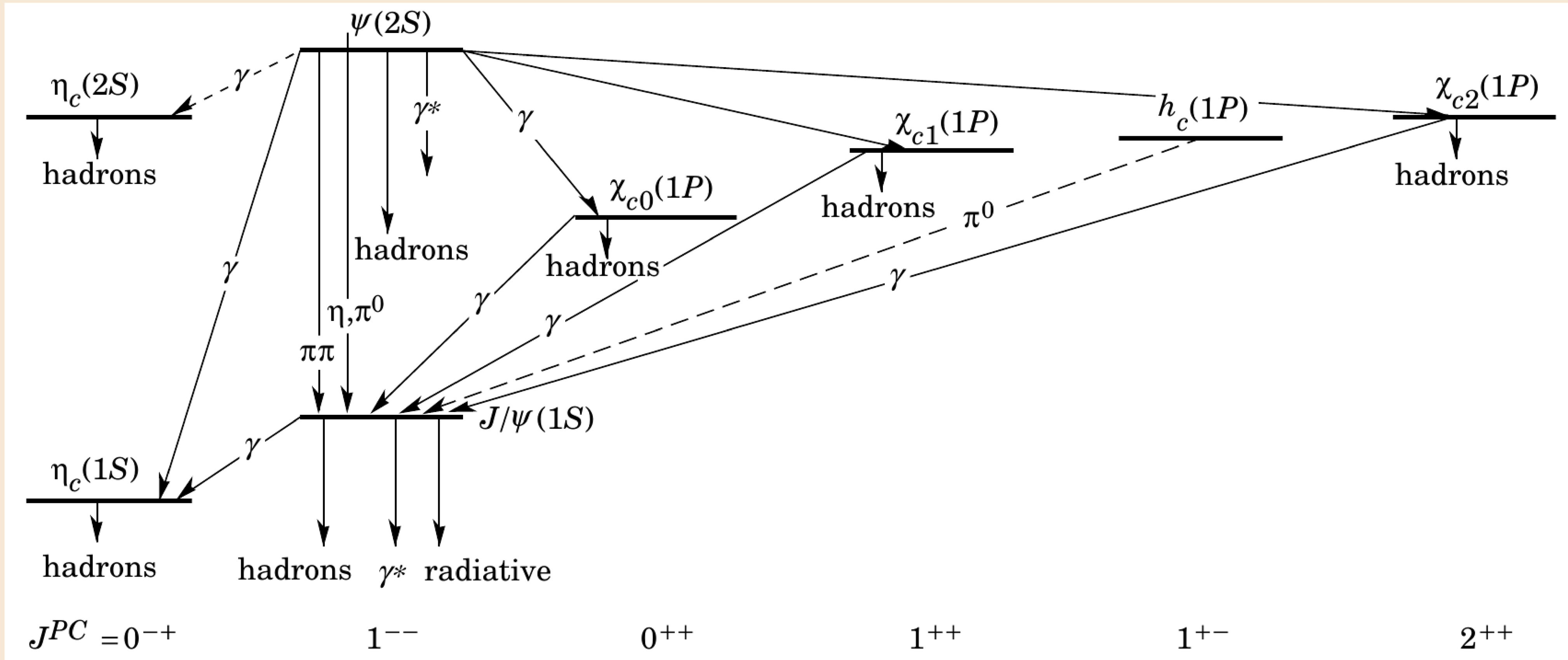
Steffen Weber[1] for the ALICE collaboration

[1]Technische Universität Darmstadt, Germany

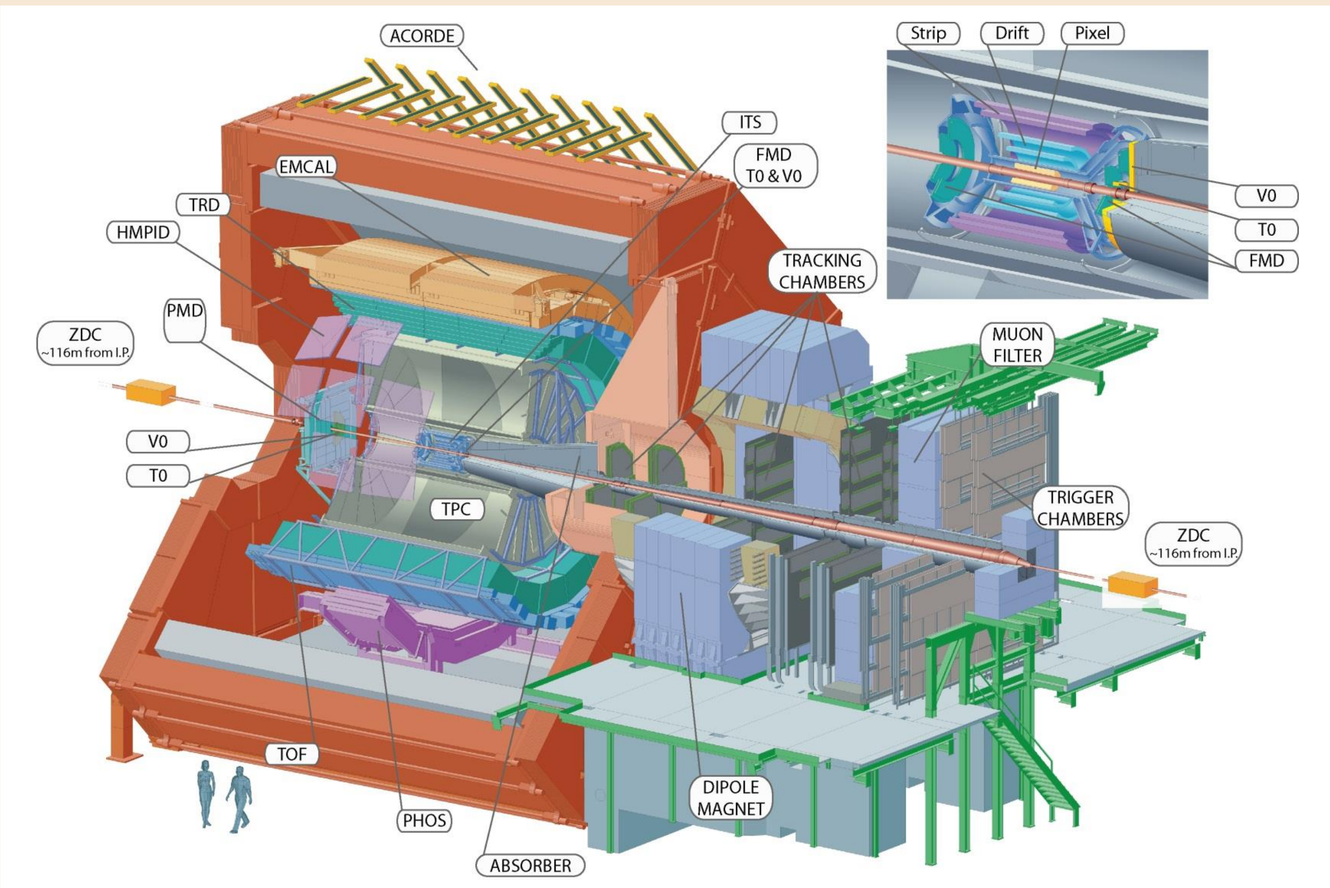
Charmonium

Bound pairs of charm and anticharm quarks

- J/ψ: $m = 3097\ \mathrm{GeV}/c^2$, discovered in 1974, proved existence of 4th quark
- χ_c: 1P triplet state:
  - χ_{c0}: $m = 3415\ \mathrm{GeV}/c^2$ (not covered here, because of low BR to J/ψ)
  - χ_{c1}: $m = 3511\ \mathrm{GeV}/c^2$
  - χ_{c2}: $m = 3556\ \mathrm{GeV}/c^2$



ALICE detector system



Charmonium and the QGP

Charmonium plays a crucial role as probe for the Quark-Gluon Plasma (QGP). Early on, a suppression mechanism in QGP based on color screening was proposed. Later, the idea of charmonium (re)generation in the QGP came up. It is described by competing models:

- In the **statistical hadronization model**, charm-anticharm quark pairs are produced in the initial hard collisions, thermalize in the QGP, and are distributed into hadrons at the chemical freeze-out.
- In the **transport (kinetic) model**, a continuous dissociation and regeneration of charmonium takes place in the QGP over its entire lifetime.

Measurements of the production rates of different charmonium states in Pb-Pb collisions at LHC should provide a definite answer to the question of charmonium production in the QGP and thereby answer fundamental questions about QGP and the QCD phase diagram.

Nuclear modification factor

The nuclear modification factor R_{AA} is defined as the ratio of the yield in nucleus-nucleus (AA) collisions to that expected from binary nucleon-nucleon collisions scaling (of production in pp collisions).

$$R_{AA}(p_T) = \frac{1}{N_{coll}} \cdot \frac{d^2N_{AA}/dp_T dy}{d^2N_{pp}/dp_T dy}$$

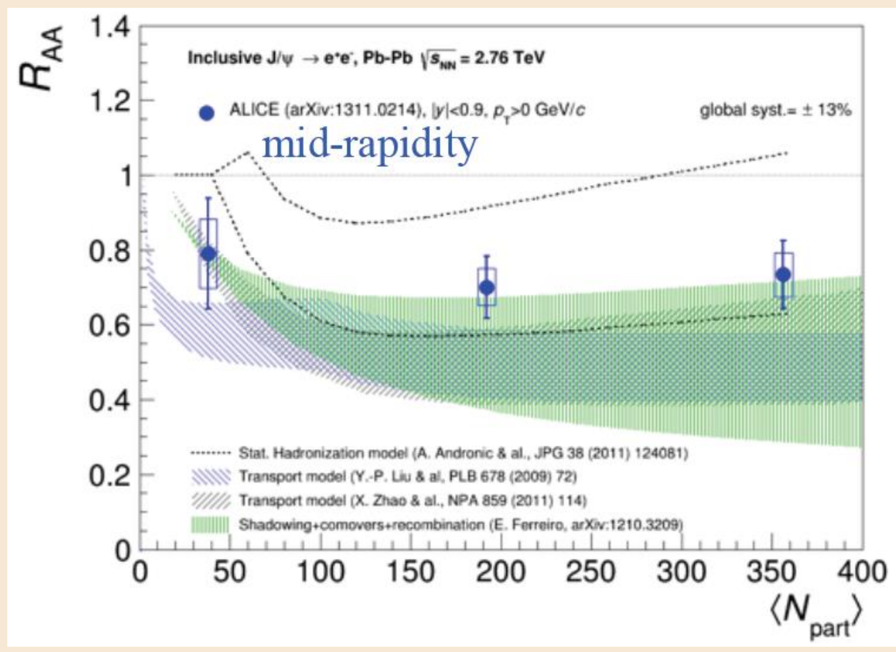
Two main mechanisms determine R_{AA} of charmonium:

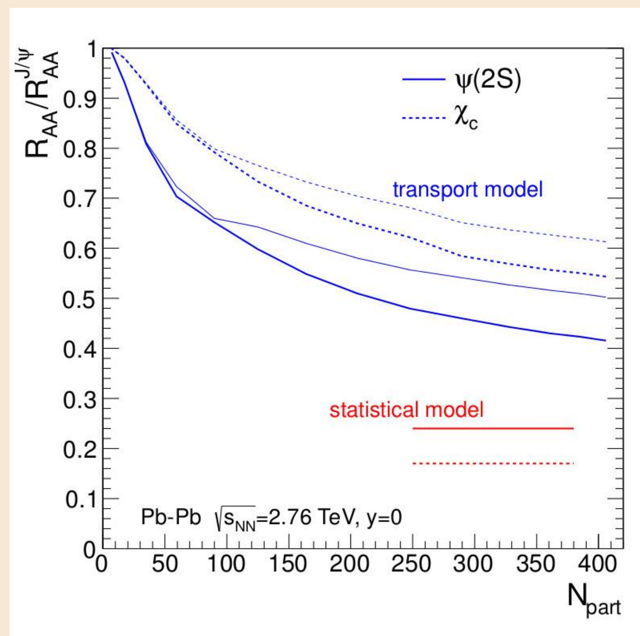
- **Suppression** by color screening
- **Enhancement** through (re)generation in the QGP/ at phase boundary

At LHC energies, the R_{AA} is significantly larger than at lower energies.

Model predictions

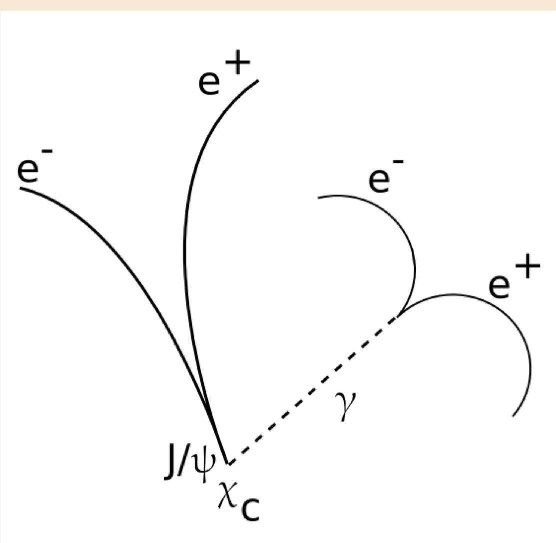
- The competing models successfully describe the basic features of $J/\psi\ R_{AA}$.
- For heavier charmonia, such as $\psi(2S)$ and χ_c, they make different predictions.

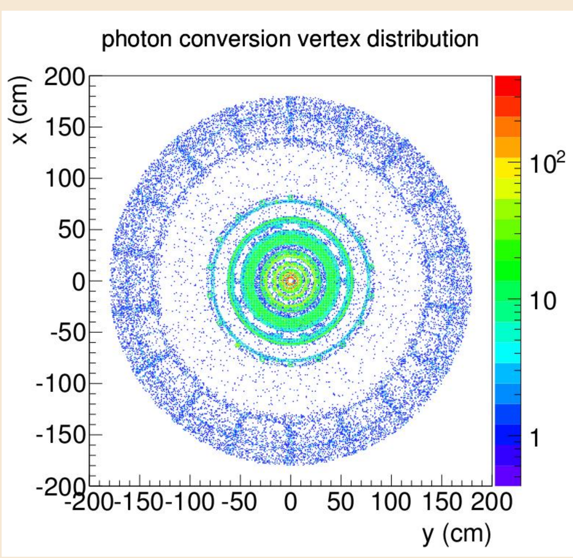


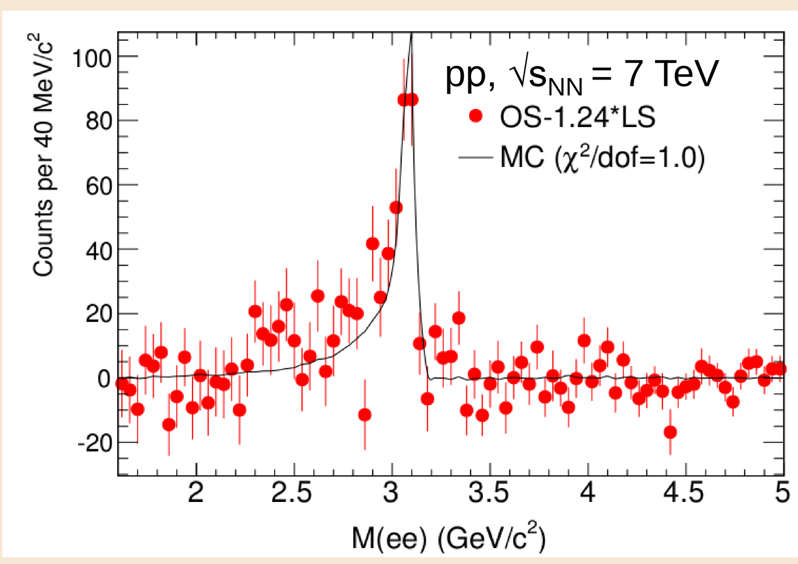


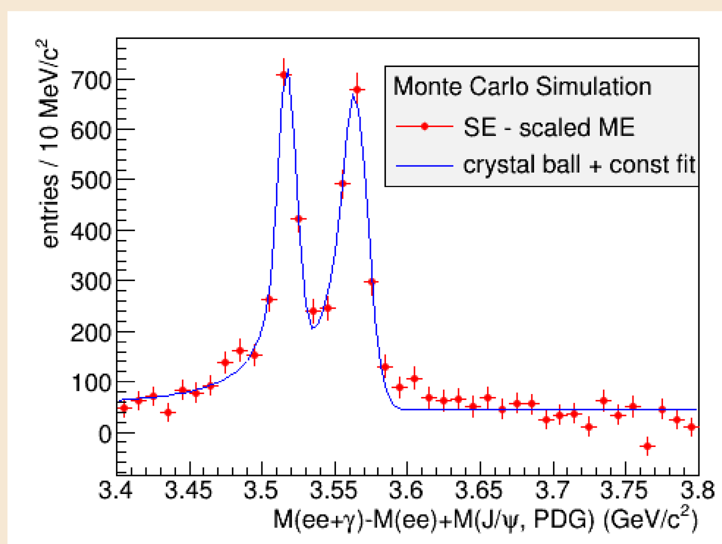
χ_c reconstruction in ALICE

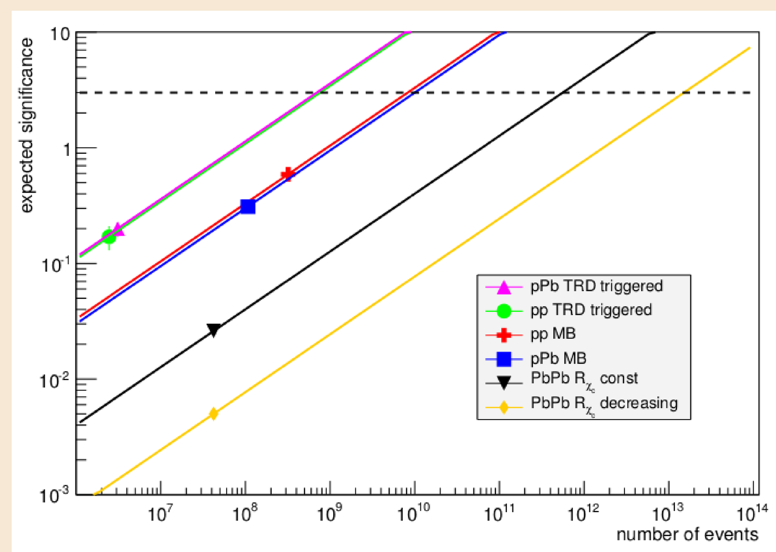
- Used radiative decay channel $\chi_c \to J/\psi + \gamma$ (BR 34 %, 20 %)
- J/ψ reconstructed in dielectron decay channel (BR 5.94 %)
- Photons via conversion in detector material (probability ≈ 8 %)
- Very good momentum resolution allows to distinguish individual χ_c states.
- Yield too low to extract signal in current data.
- About $L_{int} = 0.1\ \mathrm{pb}^{-1}$ in pp collisions needed to see a signal (estimation).
- Usage of TRD electron PID will improve significance in Pb-Pb.











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EMMI ALICE TECHNISCHE UNIVERSITÄT DARMSTADT GSI