Communications from
Light Mesons (LM), Charmonium (CC) and Charmonium-like Exotics (CCE) PWG

Frank Nerling, Marc Pelizaeus
GSI Darmstadt, U Bochum

Ongoing Analyses

CCE:

- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$ (L.Bianchi et al., FZJ)
  - FullSim studies started/ongoing
  - Nothing yet released (prod. numbers, summarised in IN)

- Zc(3900) production and decays into pbar d (A.Blinov et al., INP)
  - FullSim studies started
  - On hold since a year, nothing yet released

- X(3872) → DDbar decays (M.Barabanov et al., JINR)
  - FullSim studies started/ongoing,
  - Nothing yet released

- X(3872) energy scan (K.Götzen et al., FZJ)
  - FullSim studies completed
  - ✓ Released

Ongoing Analyses

CC:

- $\psi(^3D_2) \rightarrow \gamma\chi_{c1}\ \pi^{-/+} \rightarrow \gamma\gamma J/\psi$ (Z.Liu, U Mainz))
  - D wave charmonium states (X(3823))
  - Sim studies started/ongoing
  - FullSim studies started/ongoing
  - First draft of a release note since a while

Common DPM Central Mass Production

Finally first samples centrally produced:

- Detector set-up: Phase-1 set-up
- Beam momentum p_beam:

  Close to production threshold of X(3823) and X(3872): Ecms = 3.872 GeV

  (assumption: inelastic background should not significantly depend on the two slightly different p_beam => samples can be used for either X(3823) and X(3872) decays)
- Filter (generator level) settings:
  - At least two charged tracks (opposite sign)

    (multiplicity does not provide a really large lever arm)
  - J/psi mass window cut: 2.6 < M(ll)< 3.6 GeV/c^2

    (according to filter study by Klaus: => ~150 suppression factor)
- Number of events needed: ~5x10^10 evts then.

After ~10days, samples provided (Paul Buehler), run on KRONOS:

/lustre/nyx/panda/pbuehler/production/productions/day1/DPM3872/output/run[x]/

Acknowledgements: Paul made (and is willing to further do) a great job!

Summary

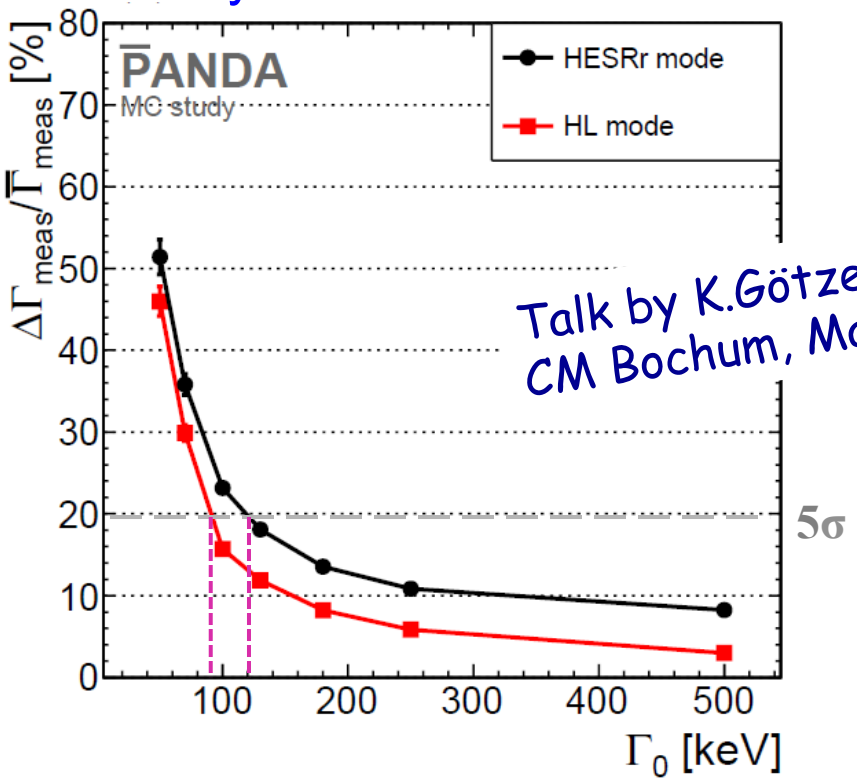
- Only a few analyses ongoing ....
  - Still the staged journal publication plan towards Physics Book
- Common central DPM bkgd mass production started, very efficient
- Need more channels being analysed in fullSim, also better coverage of the 3 physics topics

Additional slides

Main results (σ = 100nb assumed)

- Achievable precision in measured BW width Γ
- Clarify nature by lineshape measurement (distinguish virtual/bound state)

Sensitivity

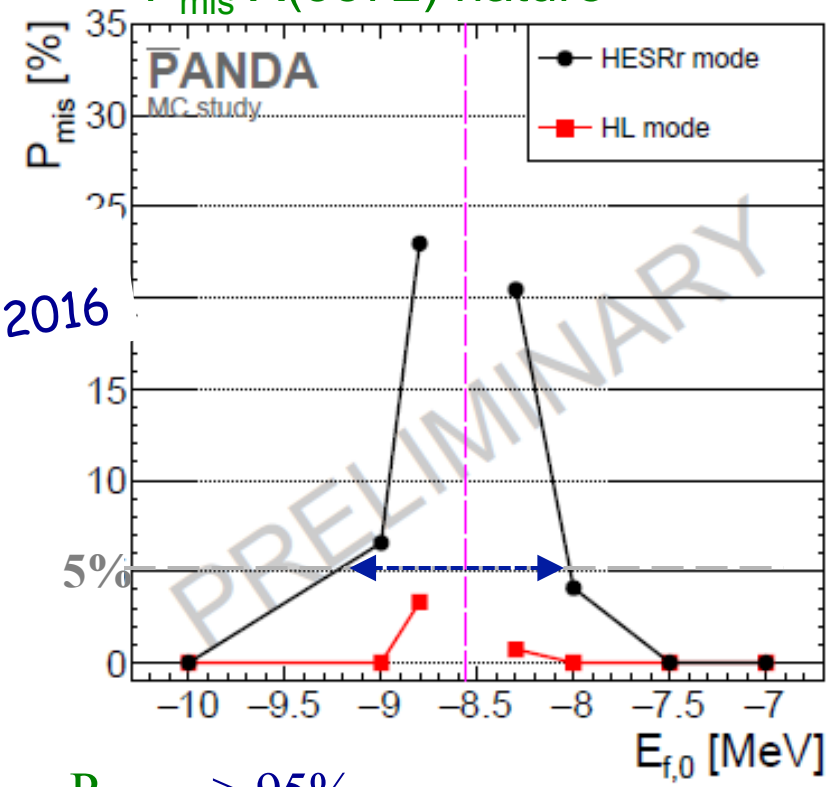


Talk by K.Götzen, CM Bochum, Mar 2016

$\Delta\Gamma/\Gamma$ =20% : Γ= 90 ... 120 keV

HL HESRr

P_{mis} X(3872) nature



P_{HL} > 95%

P_{HESRr} > 95% for $|E_f - E_{f,th}| \gtrsim 0.75$MeV

[RN-QCD-2016-002]

Rough estimate of stats

- X(3872) energy scan
  - 140 evts (on peak) / 1-2 days => 40 scan points x 2 days = 80 days

- X(3872) → DDbar decays
  - X → DDbar: In principle 10-20 x Xscan case, (90% / 5% = factor 20)
  - Nb of DDbar evts? Many individ.decays, with relatively small BR (~5%)

- X(3872) → $Z^{\pm}(3730)\pi^{-/+}$
  - $J^P = 0^+$ (l=1), X(3872) production: 50k – 145k, plus:
  - BR(Z→ $\chi_{c1}\pi$) =?, BR(X→ $Z\pi$) ≤ 10% => 50-145k x 0,34 x 0,115
    = 2200 – 5700 x 0,10 x 0,xx => ≤ 220 -570 /day
    plus reco-effi ≤ 20% => 45 -100 /day

  Assume Xscan data, 30 points: rough estimate factor 1/3 => 15 -30 evts /day
  => 80 days = N_{Zrec}= 1200 -2500

Rough estimate of stats

- Zc(3900) production and decays into pbar d
  - Zc production not neccessarily suppressed (OZI argument, vs ccbar))
  - W(P_N< P) = probability for neutron momenta < P

    => W(n) <= 200 MeV (90%)
  - Ecms = ~4 GeV: FWHM = 160 MeV => sigma = 60-70 MeV

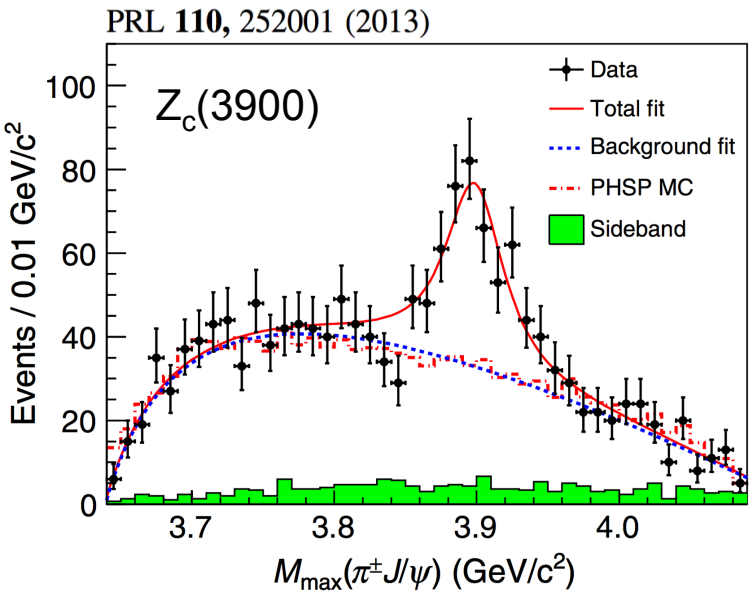
    => ppbar: sigma = 80 -180 keV (X scan)

    pbar d: sigma = 70 MeV => factor 1000 worse

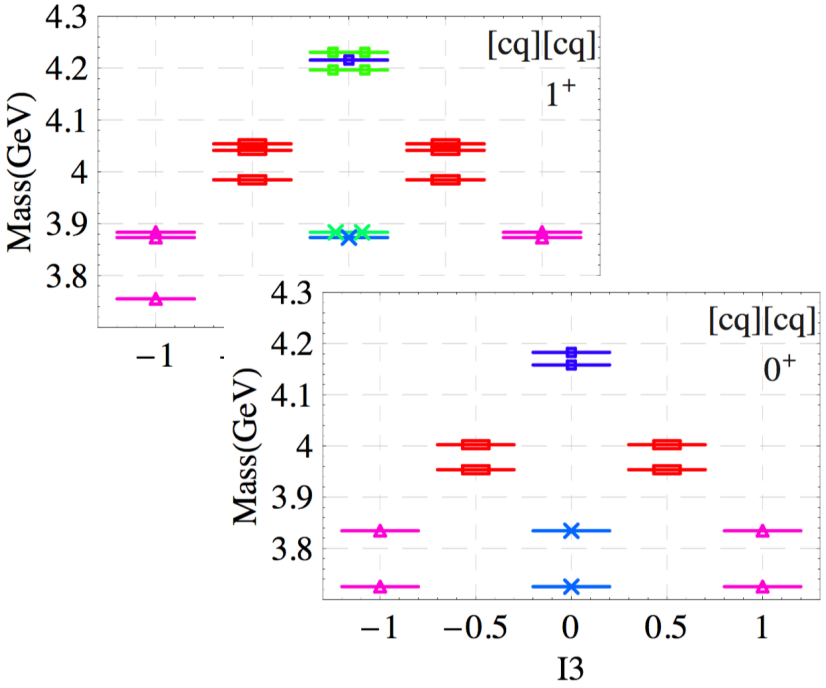
    but no recoils, need clever idea, anyhow:

    => NO energy scan really possible, but observation

Motivation



[N.Drenska et al., Riv. Nuovo Cim. 033 (2010) 633]



unexpected,
manifestly exotic!

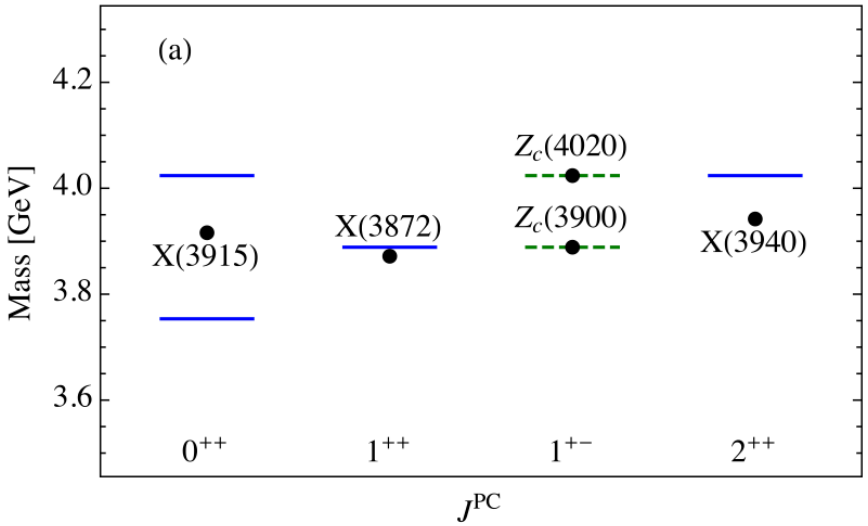
Complete multiplets to be observed?

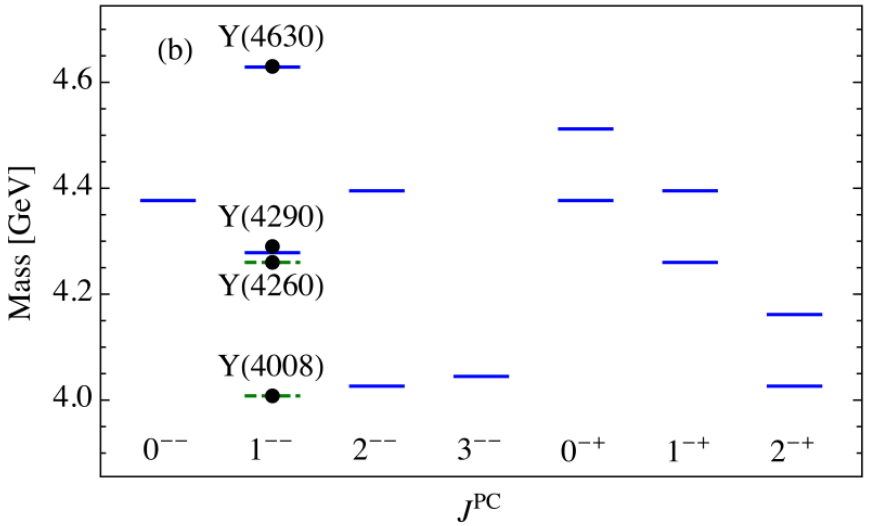
→ *e.g. 0^+, 1^+, 2^+, ... spin partner states*

→ *further charmonia channels needed*

Further channels of interest – many, still in 2025? what counts for us most, uniqueness!

Cleven et al., arXiv:1505.01771





- Many more charged and neutral channels predicted than observed
  - 67 among 80 ground states still to be discouvered
- Only PANDA has discovery potential for high spin states *(angular momentum barrier)*
  - e.g. predicted J = 3 state
- Observation of complete multiplets needed to solve X,Y,Z puzzle

=> PANDA

[C.Hahnhart, GSI, May 2015]