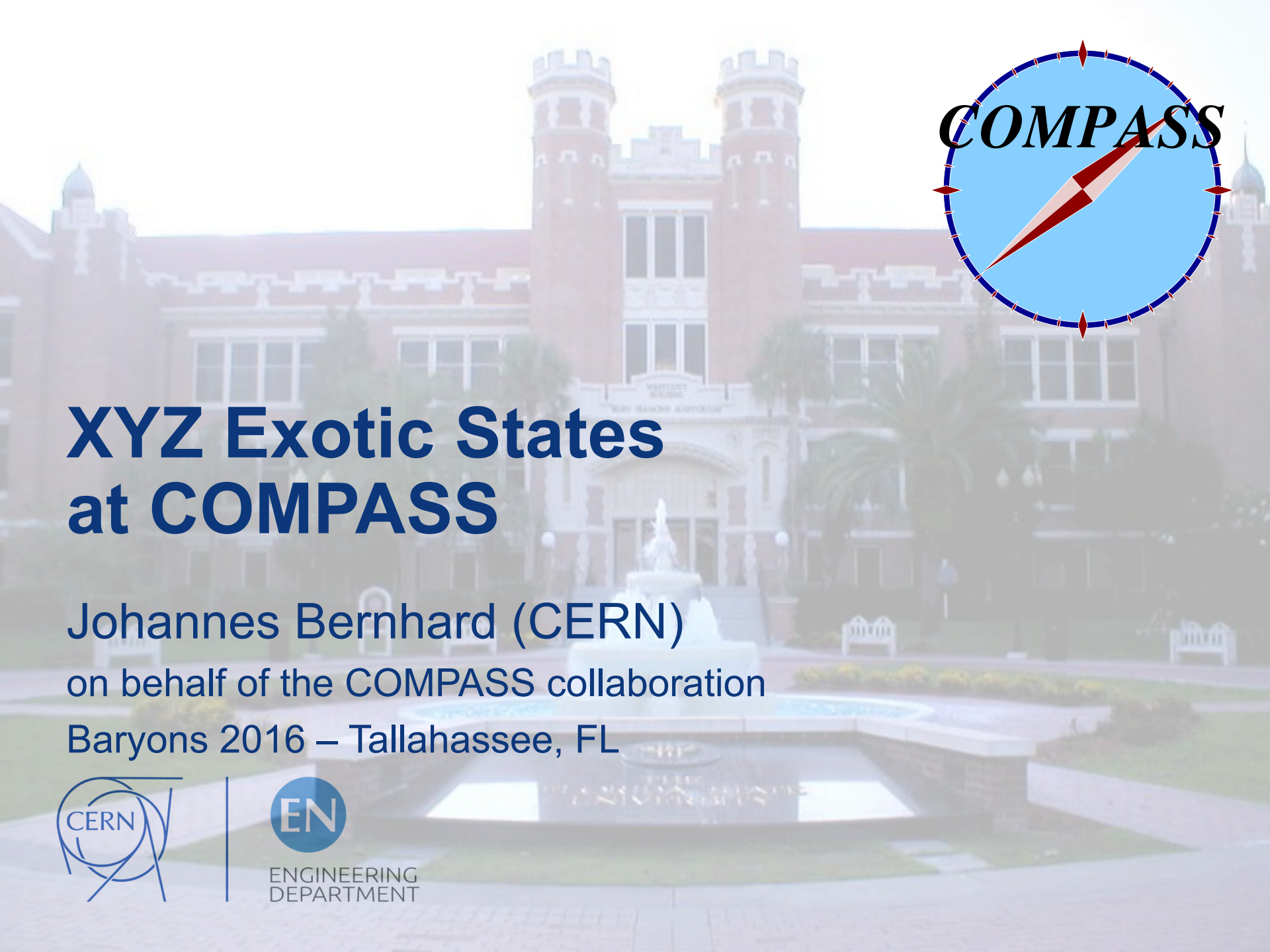


XYZ Exotic States at COMPASS

Johannes Bernhard (CERN)

on behalf of the COMPASS collaboration

Baryons 2016 – Tallahassee, FL

CERN | EN ENGINEERING DEPARTMENT

COMPASS - A facility to study QCD

Large Q^2:

Nucleon structure

- Helicitiy, transversity PDFs
- TMDs and GPDs (2015-17)

Low Q^2:

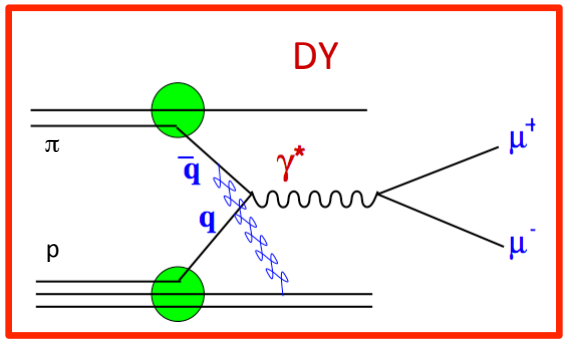
Spectroscopy

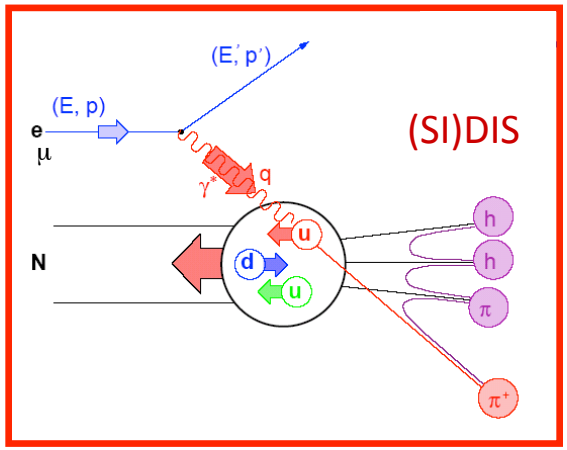
- Hadronic mass spectrum
- Gluonic excitations / spin-exotics

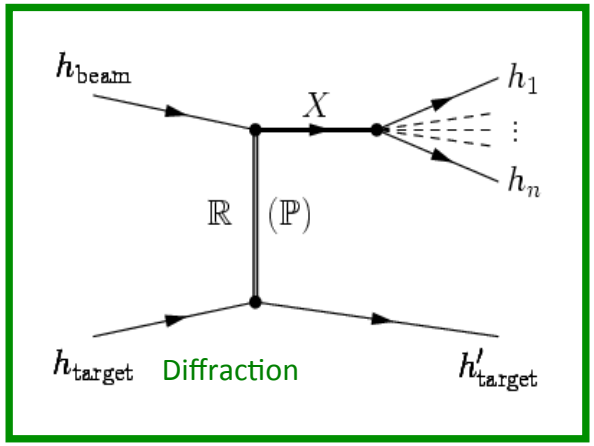
Very low Q^2:

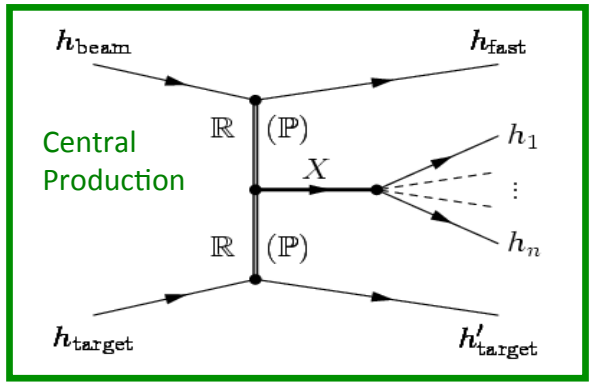
Chiral dynamics

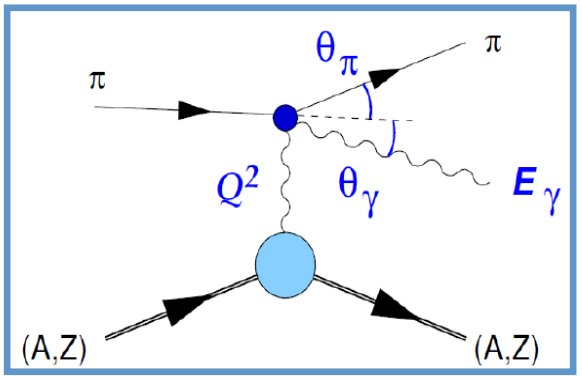
- π and K polarisibilities
- radiative widths





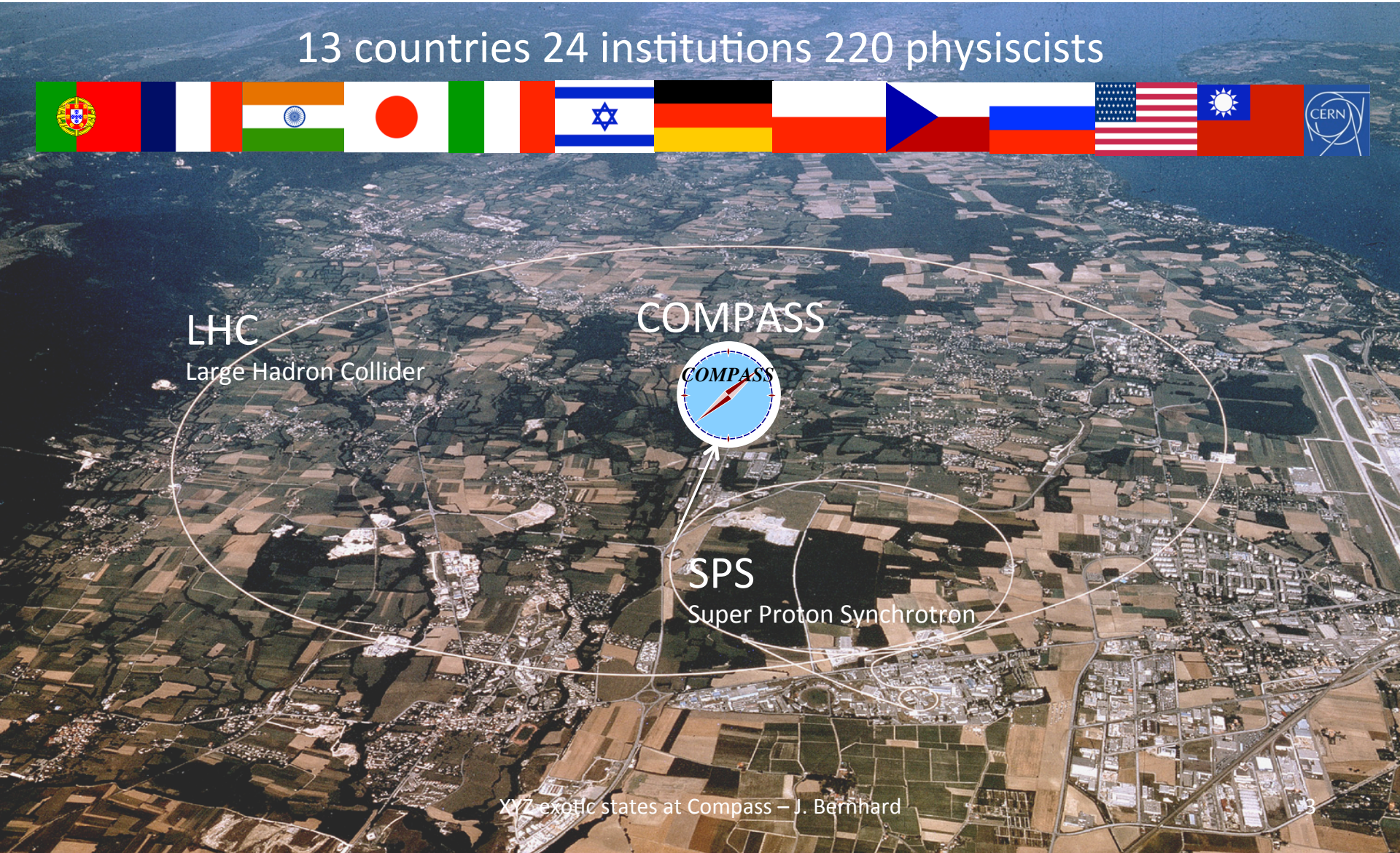




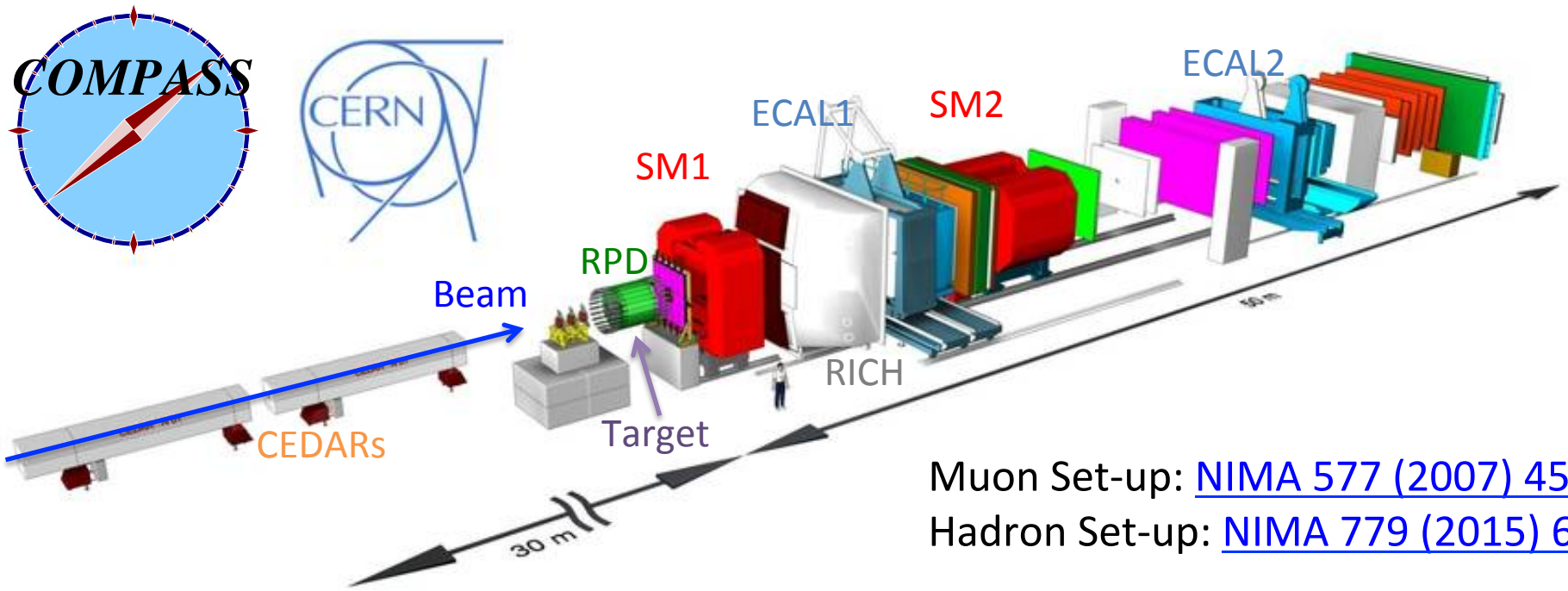


The COMPASS experiment at CERN

COmmon **M**uon and **P**roton **A**pparatus for **S**tructure and **S**pectroscopy



The COMPASS spectrometer

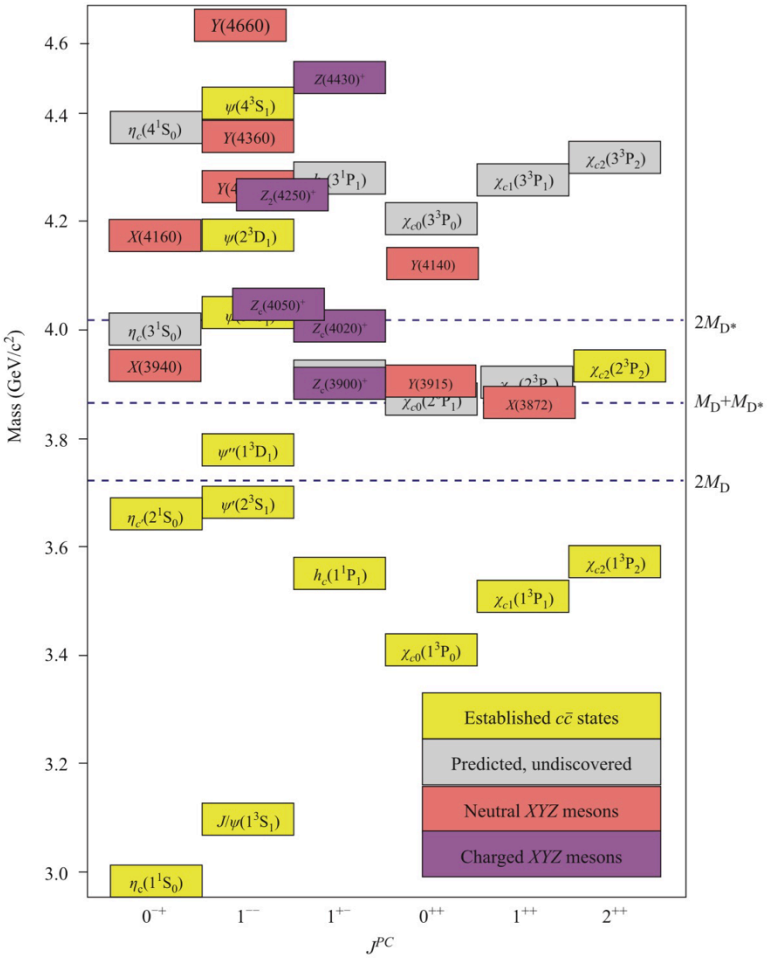


Muon Set-up: NIMA 577 (2007) 455
Hadron Set-up: NIMA 779 (2015) 69

- Two-stage magnetic spectrometer with large acceptance, high momentum res.
- Data taking since 2002 with 160 GeV/c – 200 GeV/c μ beams and 190 GeV/c hadron beams ($\pi^{\pm}$, $K^{\pm}$, p, $\bar{p}$)
- Targets: Polarised targets (LiD, NH_3), liquid hydrogen, several metallic targets

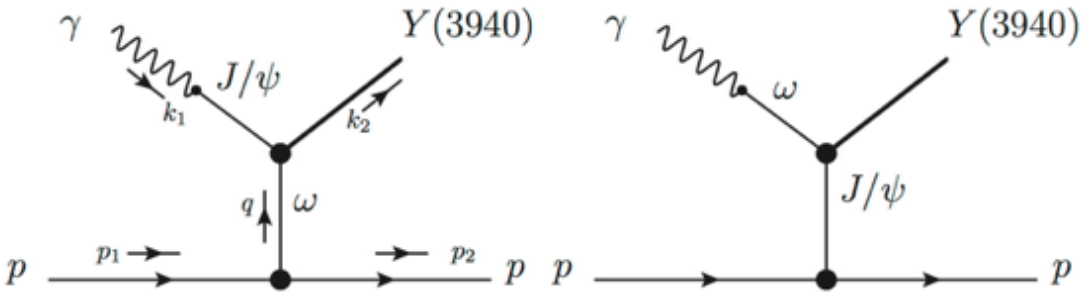
Search for XYZ exotics

- XYZ states usually observed as decay products of heavy mesons or inclusively produced in pp collisions



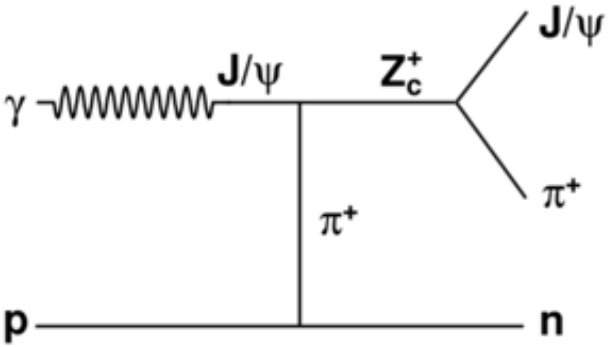
Search for XYZ exotics

- XYZ states usually observed as decay products of heavy mesons or inclusively produced in pp collisions
- first COMPASS approach: photo-production with muon beams
  - exclusive production
  - access to partial widths of decays
  - plenty of data taking (8 years and more upcoming with COMPASS-II)



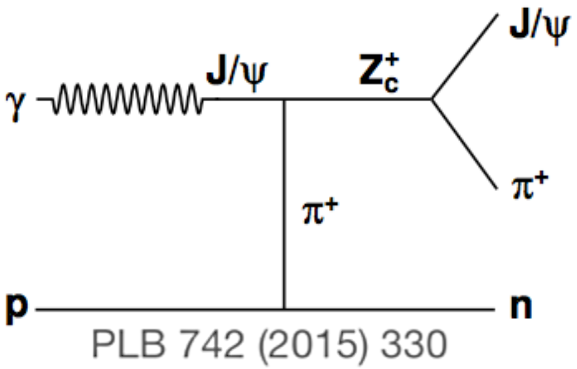
Q. Lin *et al.* Phys. Rev. D 89 034016 (2014)

J. He, X. Liu, Phys. Rev. D 80 114007 (2009)



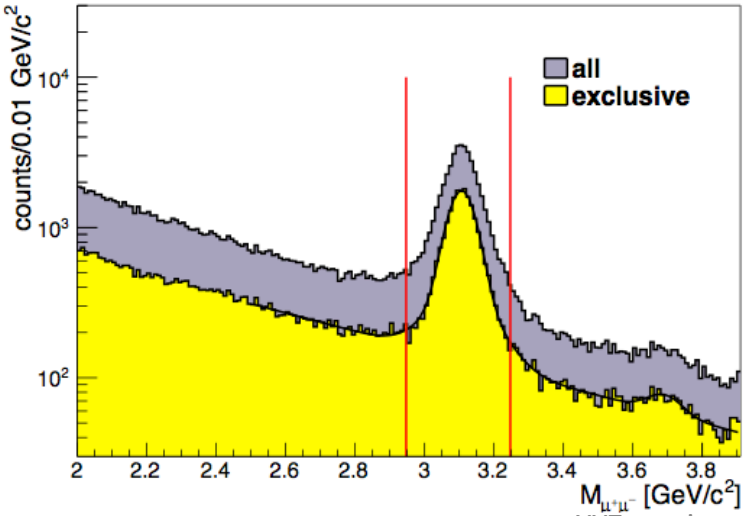
PLB 742 (2015) 330

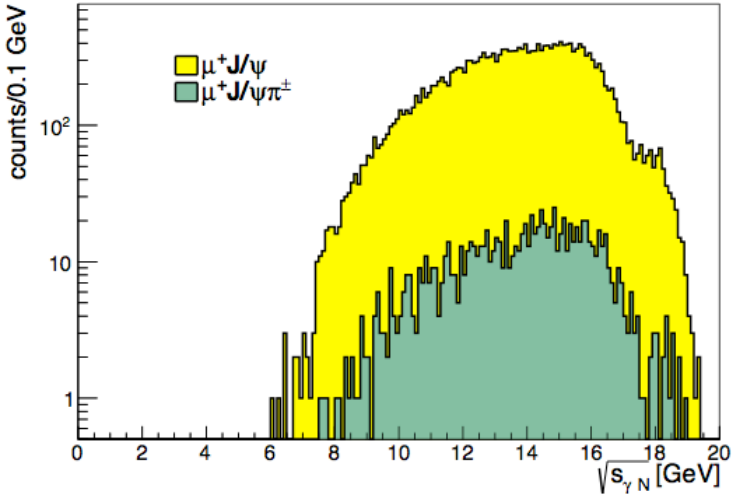
Search for $Z_c^{\pm}(3900)$



PLB 742 (2015) 330

- sizable cross section [Q.-Y. Lin et al., PRD 88 114009 (2013)]
- branching ratio seems to be small
- search with exclusive J/ψ $\pi^{\pm}$, J/ψ -> μμ production in muon beam data
- normalise to μN -> J/ψ N cross section (acceptances cancel largely, only acceptance for $\pi^{\pm}$ left)





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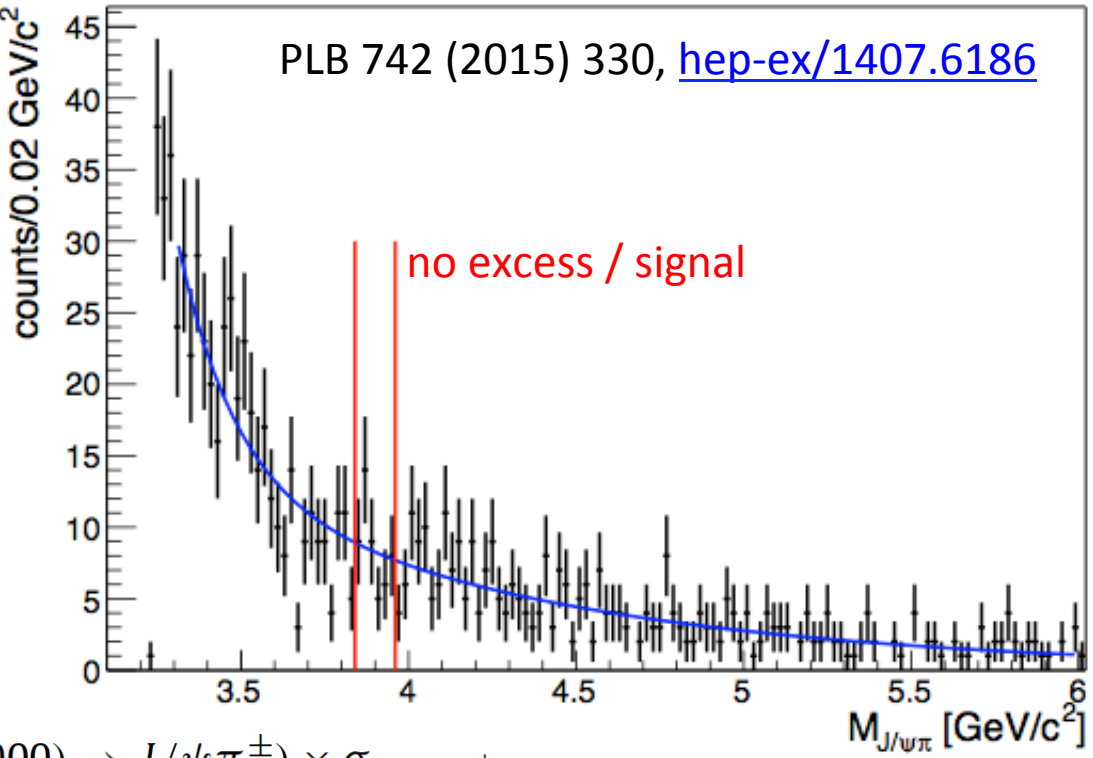


- $\frac{BR(Z_c^{\pm}(3900) \rightarrow J/\psi\pi^{\pm}) \times \sigma_{\gamma N \rightarrow Z_c^{\pm}(3900)N}}{\sigma_{\gamma N \rightarrow J/\psi N}}$ < 3.7 10^{-3}

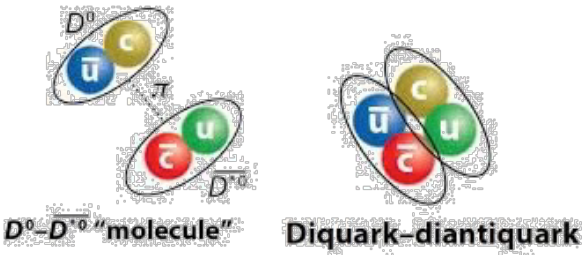
- use NA14 cross section for μN -> J/ψ N for normalisation:

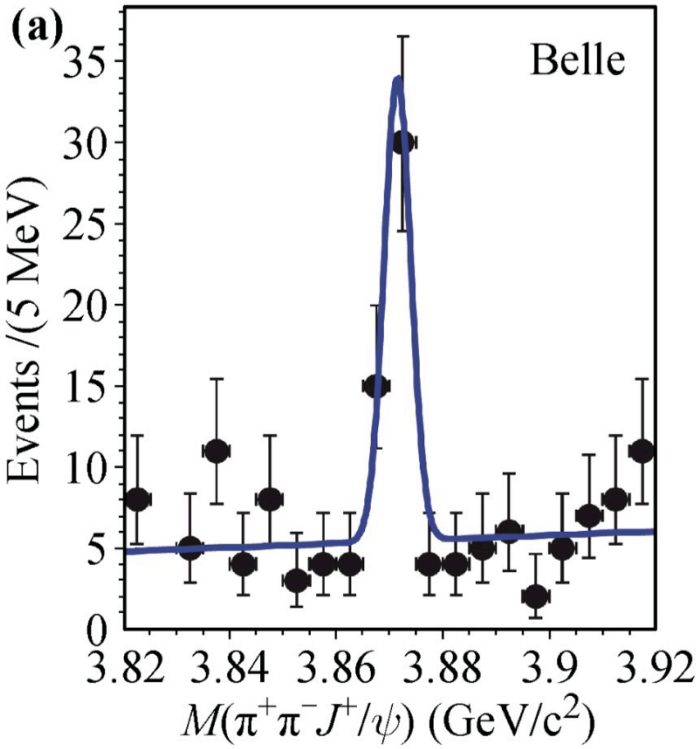
  $BR(Z_c^{\pm}(3900) \rightarrow J/\psi\pi^{\pm}) \times \sigma_{\gamma N \rightarrow Z_c^{\pm}(3900)N}$ < 52 pb

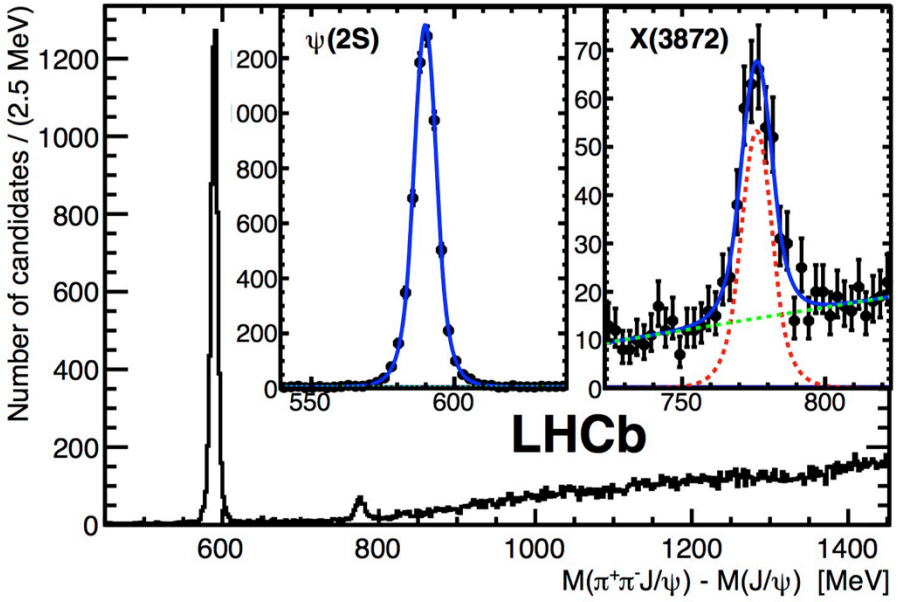
- Conclusion: $Z_c^{\pm}(3900)$ -> J/ψ $\pi^{\pm}$ not dominant decay mode

Search for X(3872)

- found 2003 (Belle), well-studied (Belle, BaBar, CDF, D0, LHC-B, CMS, …)
- quantum numbers constrained: $J^{PC} = 1^{++}$ (LHC-B)
- nature of X(3872) disputed, more input needed







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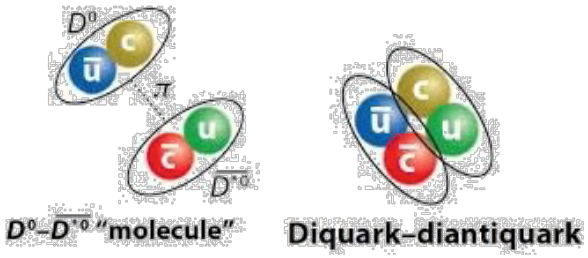
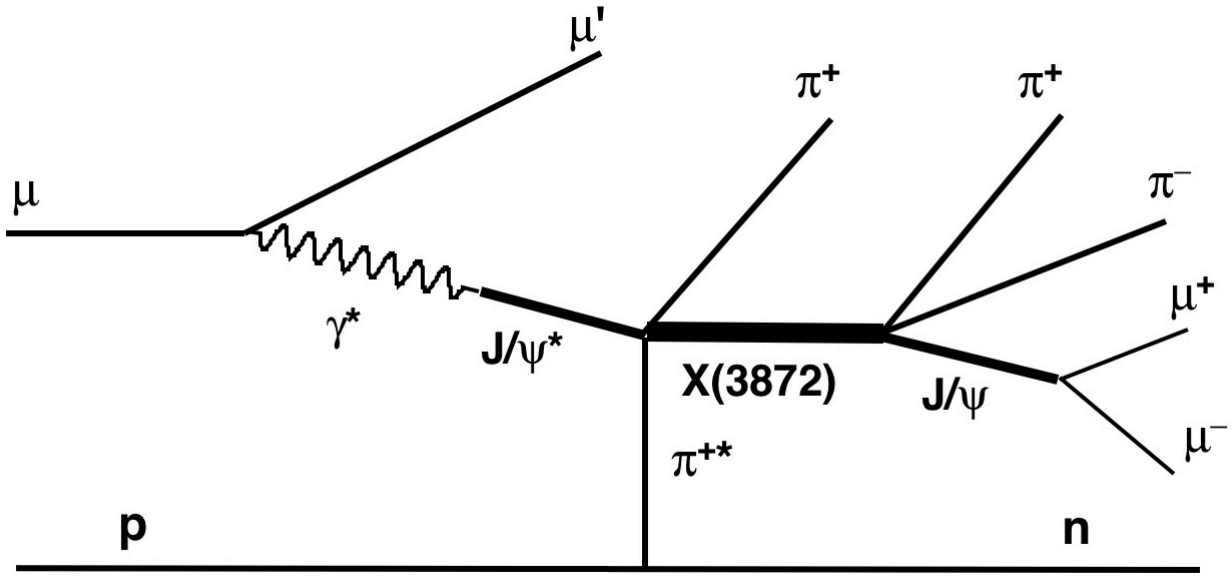
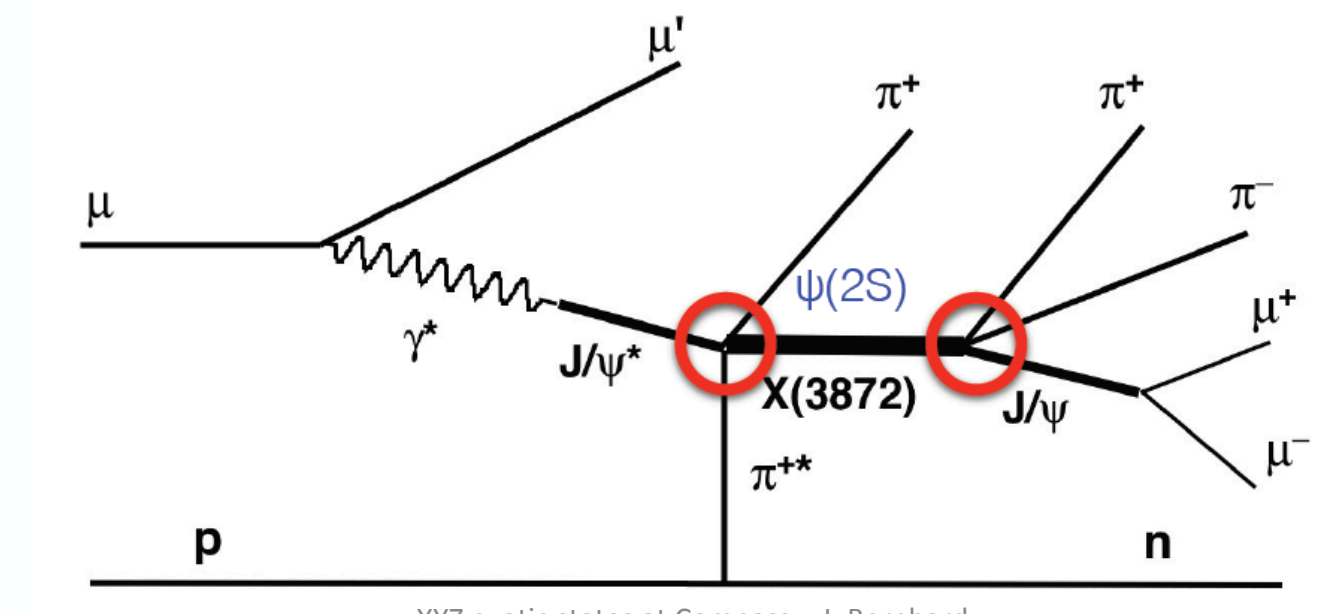


- COMPASS: associative photo-production with muon beams



Search for X(3872)

- idea: extract partial width by comparison to reference process
  - $\mu^+ N \to \mu^+ N' \pi^\pm X(3872) \to \mu^+ N' \pi^\pm \pi^+ \pi^- J/\psi$
  - $\mu^+ N \to \mu^+ N' \pi^\pm \psi(2S) \to \mu^+ N' \pi^\pm \pi^+ \pi^- J/\psi$
  - $\Gamma_{X(3872)\to J/\psi\pi\pi} = \Gamma_{\psi(2S)\to J/\psi\pi\pi} \sqrt{\frac{\Gamma_{X(3872)}}{\Gamma_{\psi(2S)}} \frac{N_{X(3872)}}{N_{\psi(2S)}}}$



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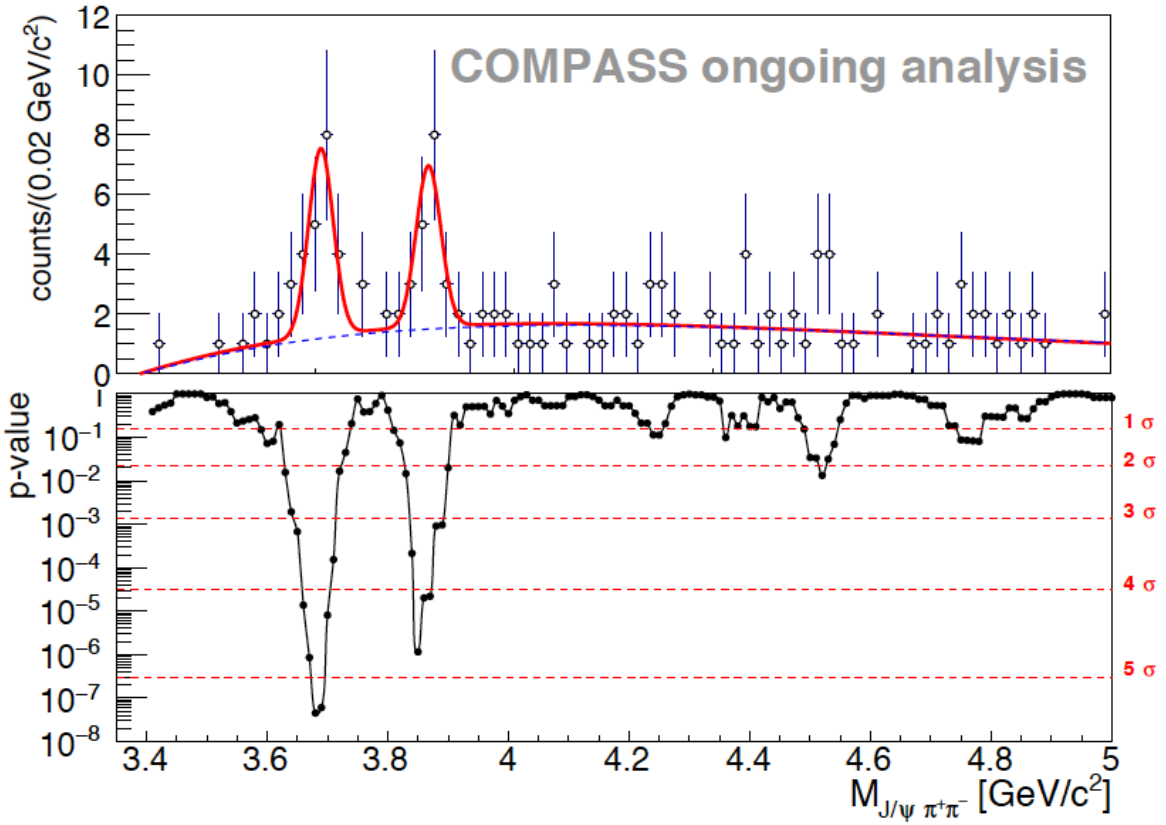

- ongoing analysis
- first mass spectrum extracted, yields/fit not final!
- need careful study of production mechanisms (ψ(2s) vs X) and more background studies

Conclusions and Outlook

- COMPASS starts to explore XYZ exotic states
- access to exclusive photo-production with muon beam data
- decay of $Z_c^{\pm}(3900)$ -> $J/\psi\ \pi^{\pm}$ studied, branching ratio and cross section constrained
- X(3872) found first time in exclusive photo-production
- next step: extract lower limit for X(3872) width, results upcoming
- further studies started using hadron beam data
- Y states accessible and to be studied
- more data incoming: GPD data taking just started, 2 additional years high-intensity μ beam

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