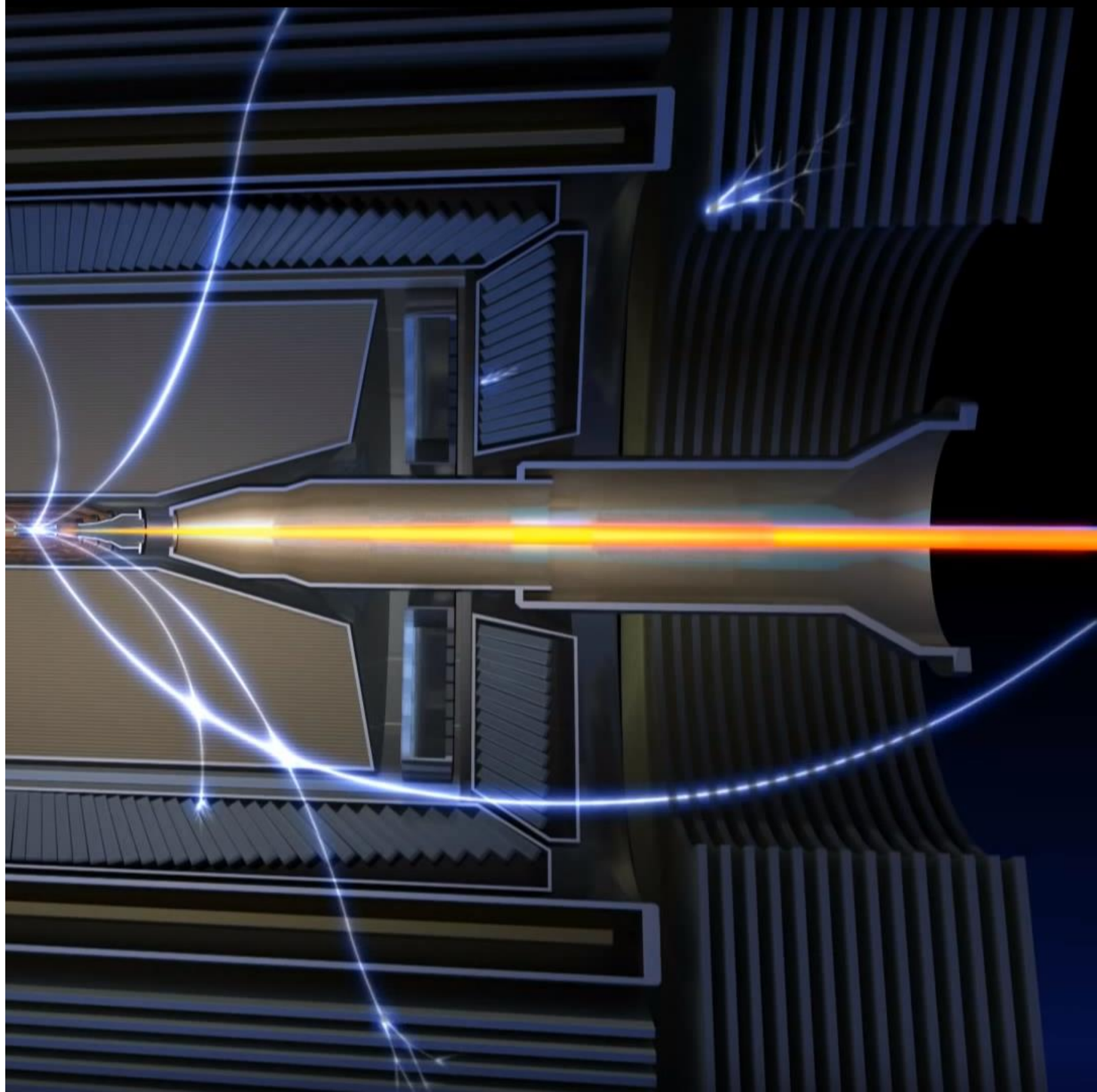
Pacific Northwest
NATIONAL LABORATORY

Hadron Spectroscopy at Belle II

Oct 02, 2020

Bryan Fulsom (PNNL)
on behalf of the Belle II Collaboration

Snowmass RPF Townhall Meeting



U.S. DEPARTMENT OF ENERGY BATTELLE

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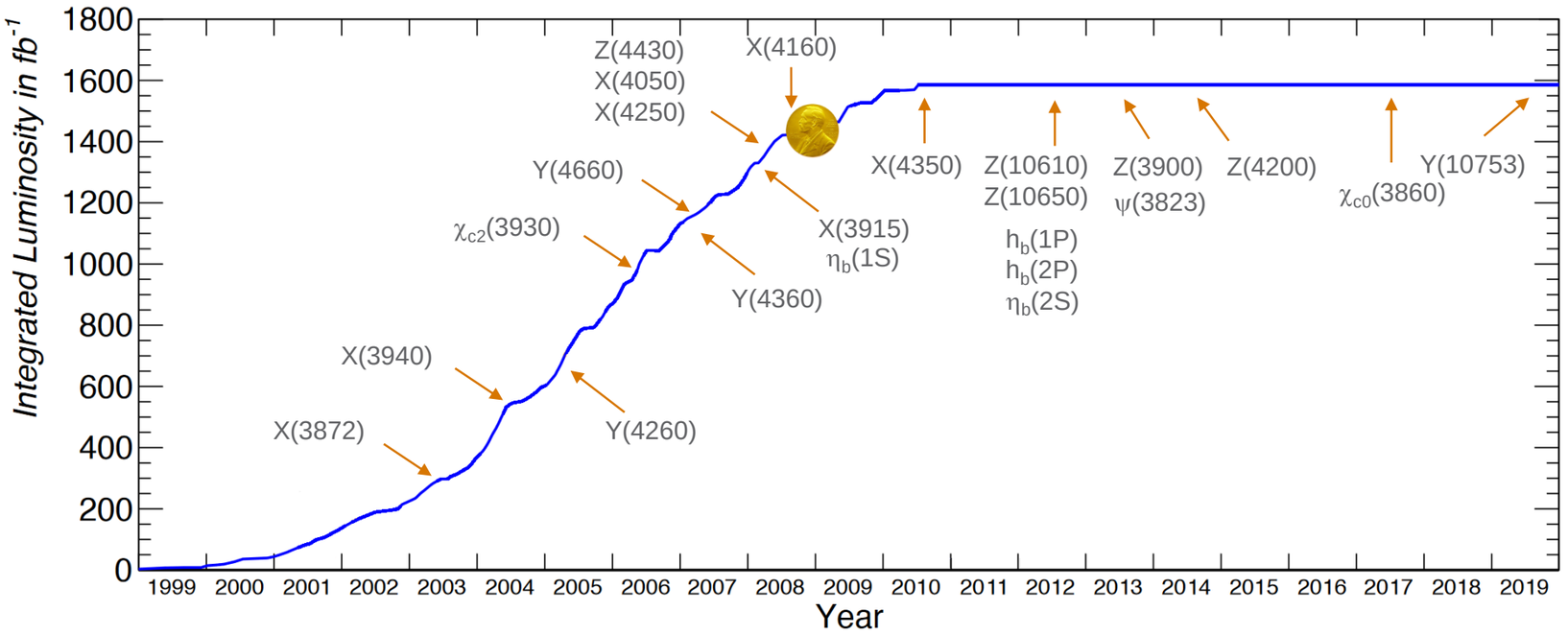
B-Factories Legacy

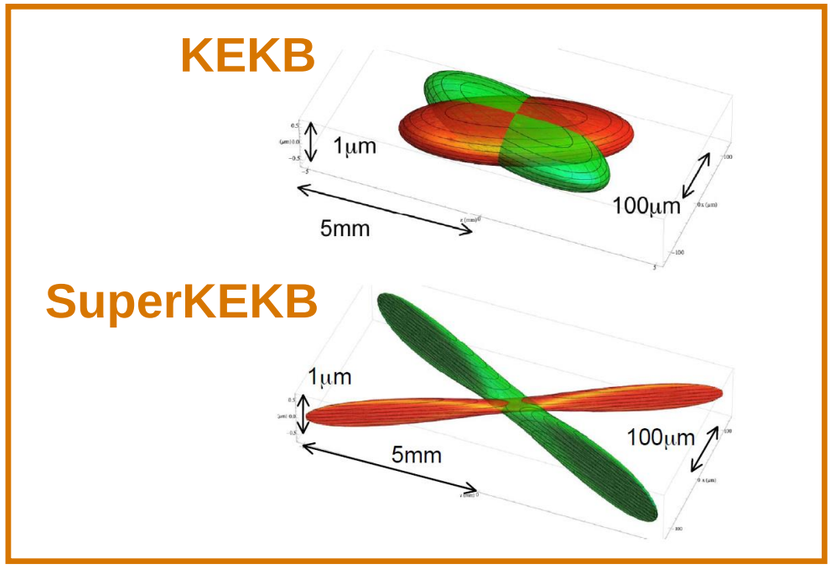
- ~2000 – 2010 : BaBar (SLAC) & Belle (KEK)
- Flavor physics: CKM/UT, CPV in B decays, hints for NP in rare processes
- New particle discoveries: “XYZ” states, conventional $q\bar{q}$/mesons/baryons



e.g.: “The Physics of the B Factories”, EPJC 74, 3026 (2014)

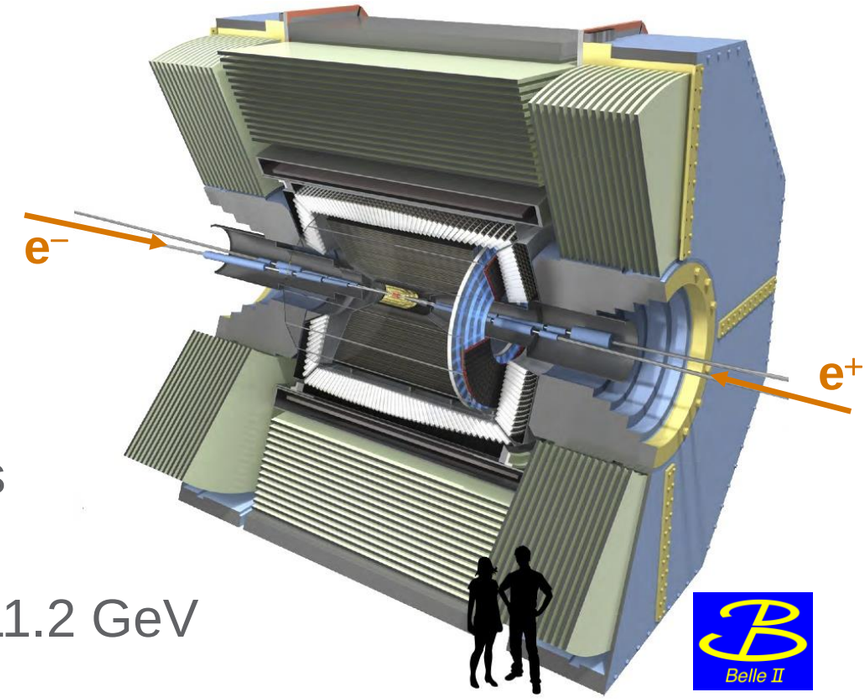
Belle II Capabilities

- Belle II is the next generation B-Factory
  - ~1000 members (~100 US @ 18 institutions)
  - ~10-year program ongoing since last year
- Upgraded detector and accelerator



- Extensive hadronic spectroscopy program
- Advantages
  - 50x instantaneous and integrated luminosity
  - Full event reconstruction and decays involving neutrals
  - Multiple production mechanisms for exotics
  - Nominal $\sqrt{s}$ = 10.58 GeV = Υ(4S), potential to reach ~11.2 GeV

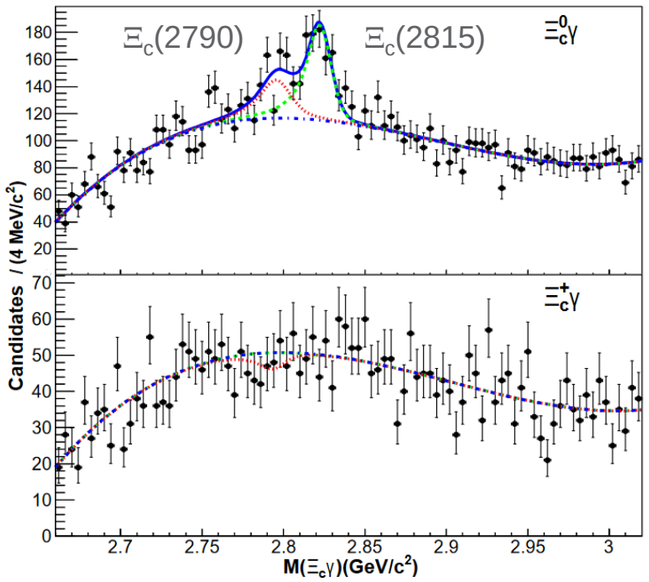
PTEP 2019 123C01 (2019)



arXiv:1011.0352 (2011)

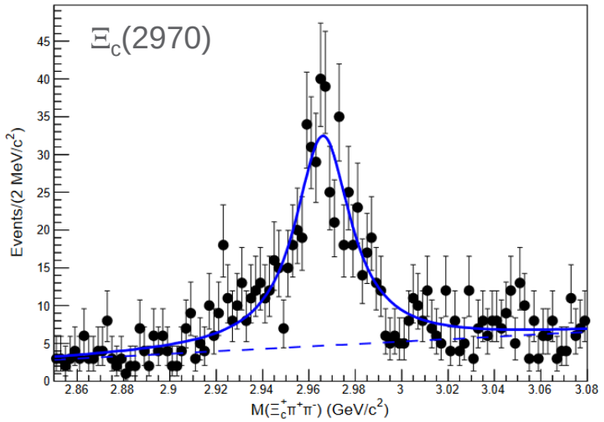
Baryons

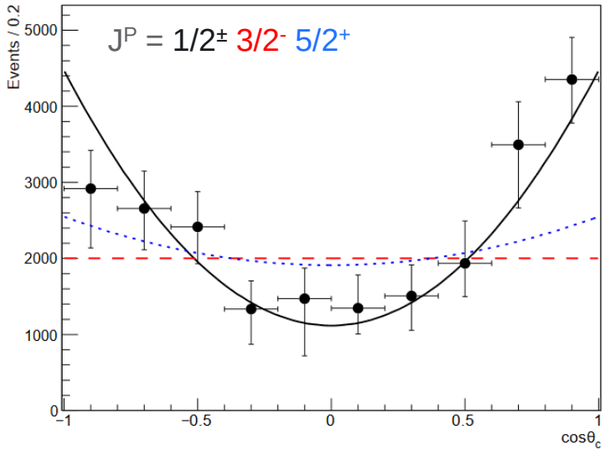
- Belle II advantages
  - Decays with neutrals (γ, π^0)
  - Spin-parity measurements
  - Weak decays of hyperons



arXiv:2009.03951 (2020)

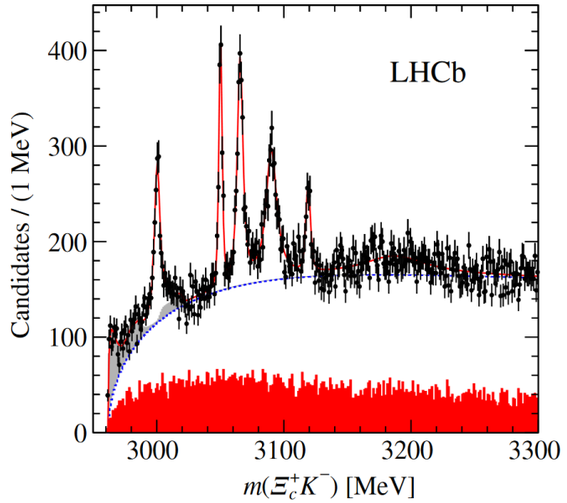
Spin-parity measurement

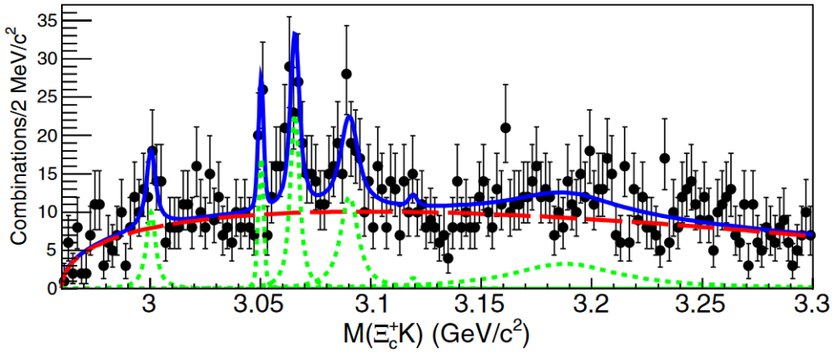




arXiv:2007.14700 (2020)

PRL 118, 182001 (2017)



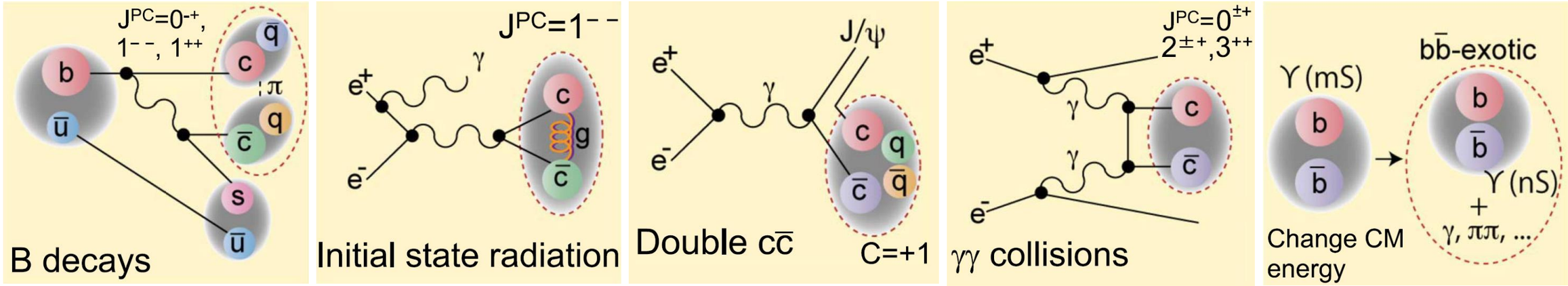


PRD 97, 051102 (2018)

Search for Ω_c radiative decays?

Production Mechanisms: Exotic and Conventional Quarkonium

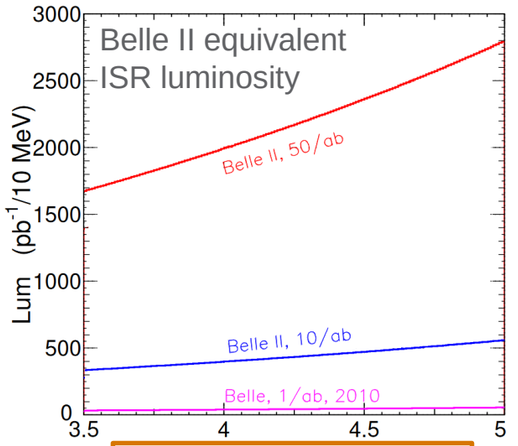
- Multiple methods to produce quarkonium/exotics at Belle II



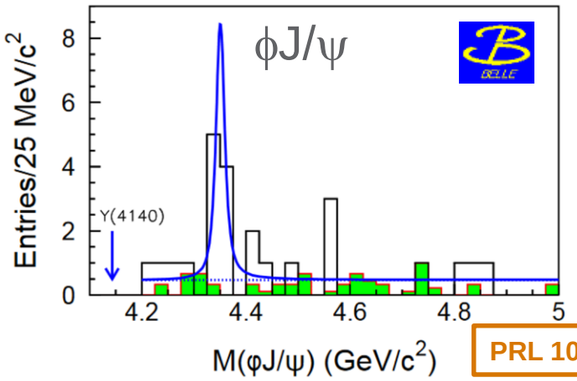
- Production mode provides important information (e.g. J^{PC}, type)
- Several of these are unique to e^+e^- colliders / Belle II

Charmonium / XYZ

- X(3872): BF[B → X(3872,3915) K], confirmation of $\Gamma_{X(3872)}$ with $D^0\bar{D}^0\pi^0$
- Y_c States (4220, 4320, 4390, 4660, …)
  - Complementary to E_{CM} scans
  - Improved $\sigma(e^+e^- \rightarrow \gamma_{ISR}(c\bar{c})(x))$
  - Higher (E>4 GeV) masses/channels (e.g. $\gamma_{ISR}\Sigma_c\Sigma_c$)
- Z_c States (3900, 4020, 4200, …)
  - Confirmation and search for neutral partners
  - B decay and ISR Y_c decay production modes
- Other
  - $\phi J/\psi$ in $\gamma\gamma$ production (Y(4140) et al.)
  - Conventional searches (η, ψ D-states, etc.)
  - Inclusive production in e^+e^- and Υ decays

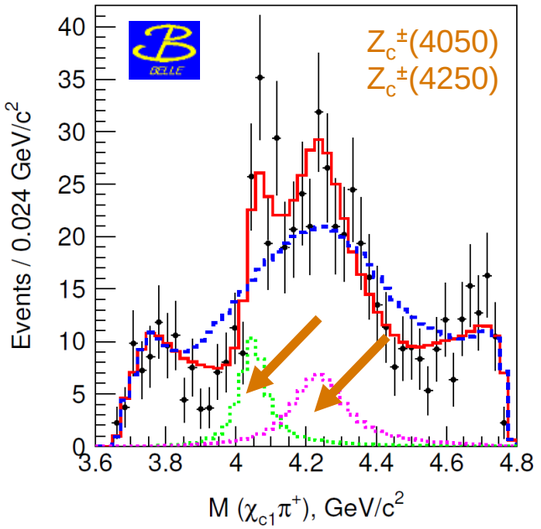


PTEP 2019 123C01 (2019)



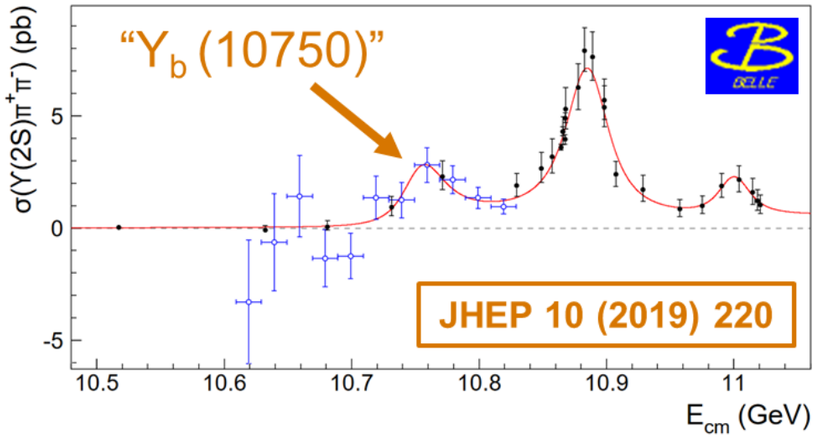
PRL 104, 112004 (2010)

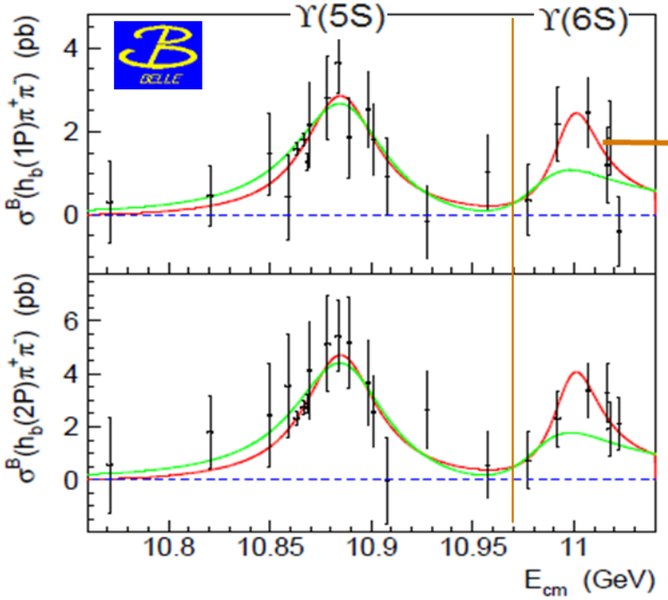
PRD 78, 072004 (2008)

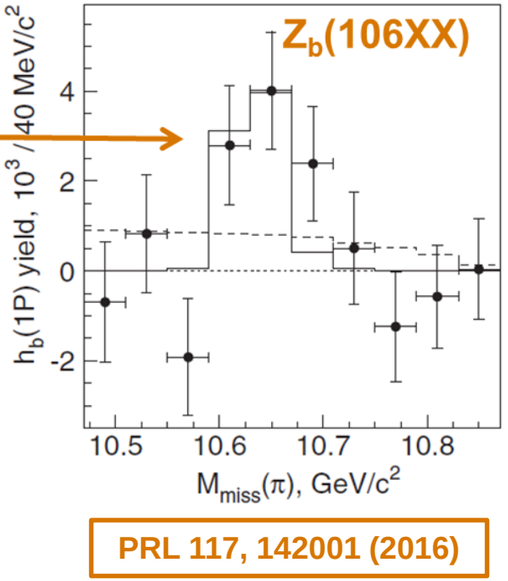


Bottomonium / XYZ

- Exotic states
  - $Z_b^{\pm}$(10610/50): study at Υ(5S/6S) energy
  - Y_b(10750): enhancement in E_{CM} scan





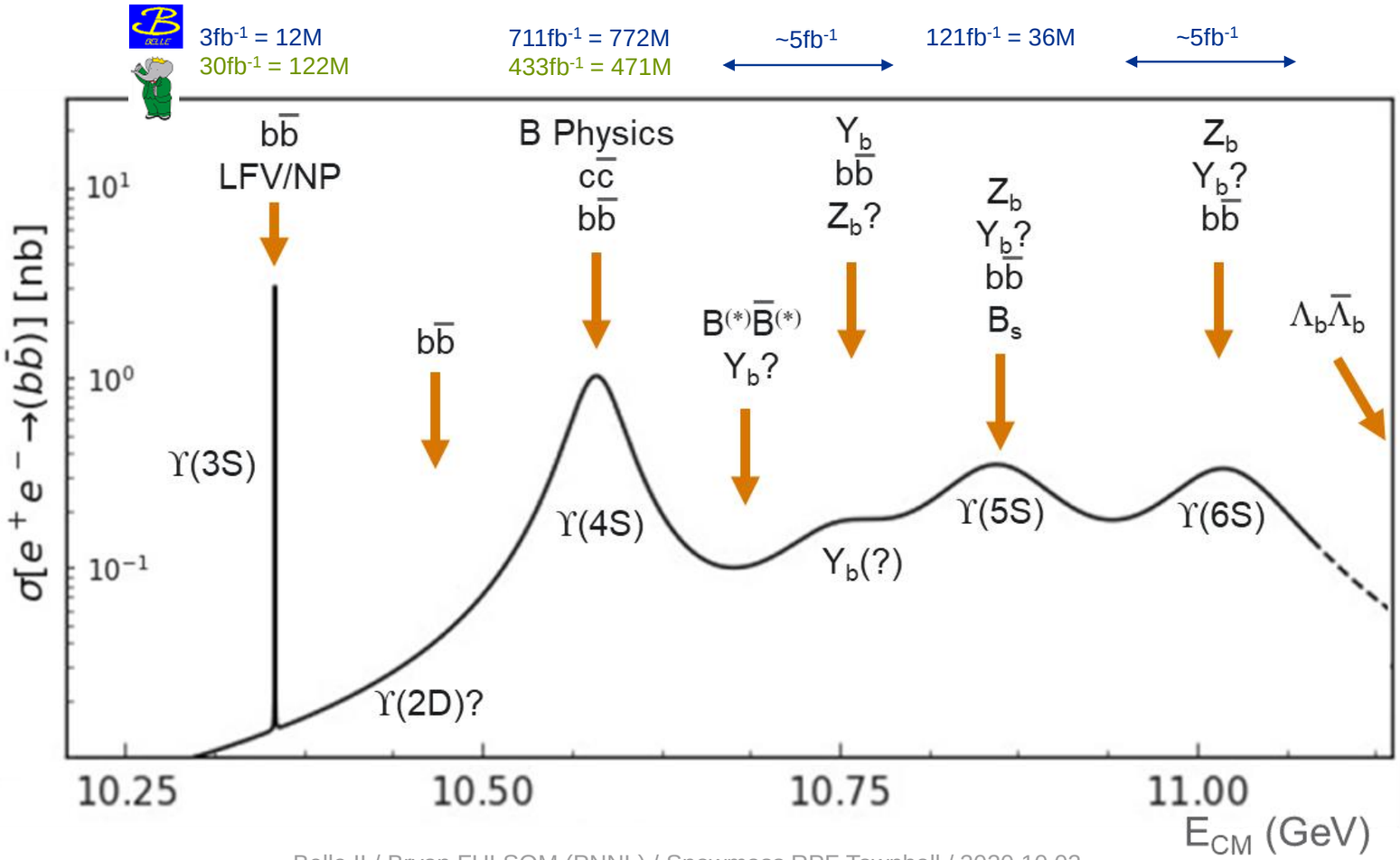


PRL 117, 142001 (2016)

- Conventional
  - Large samples of $\Upsilon(4S)\rightarrow\eta h_b(1P)$ to study h_b and η_b
  - $E_{CM}=\Upsilon(3S)$ potential for many decay mode measurements
  - Searches for missing states (D-, F-wave?) via energy scans or higher E_{CM}

A Question of Beam Energy

- Physics reach potentially extended by running at non-$\Upsilon(4S)$ energies



Summary and Snowmass Context

- Belle II: next generation B-Factory building upon success of Belle
- Wide-ranging physics program including many hadronic spectroscopic studies

- LOI: SNOWMASS21-RF7_RF0_Fulsom-062
- Next steps
  - Belle II Collaboration white paper(s)
  - Input to related LOIs: R7_RF0-082 (hadron-hadron), RF7_RF0-EF6_EF0-083 (diquark)
- Desired outcomes
  - Support/visibility for Belle II activities within the US
  - Reinforcement to Belle II of importance of hadron spectroscopy/exotics physics
  - General support for this area of physics research within US

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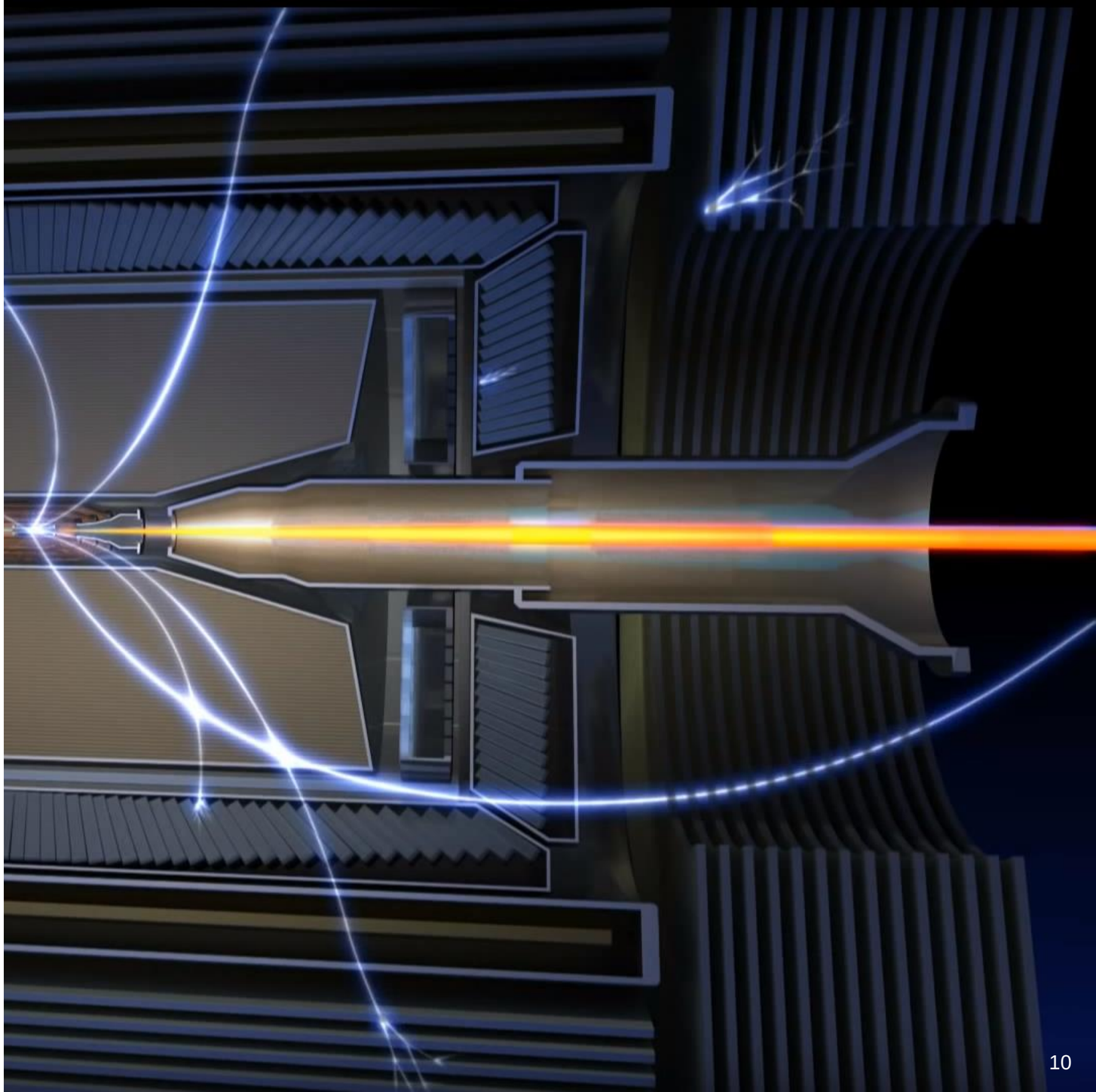
Thank you