UNIVERSITÀ DI TORINO

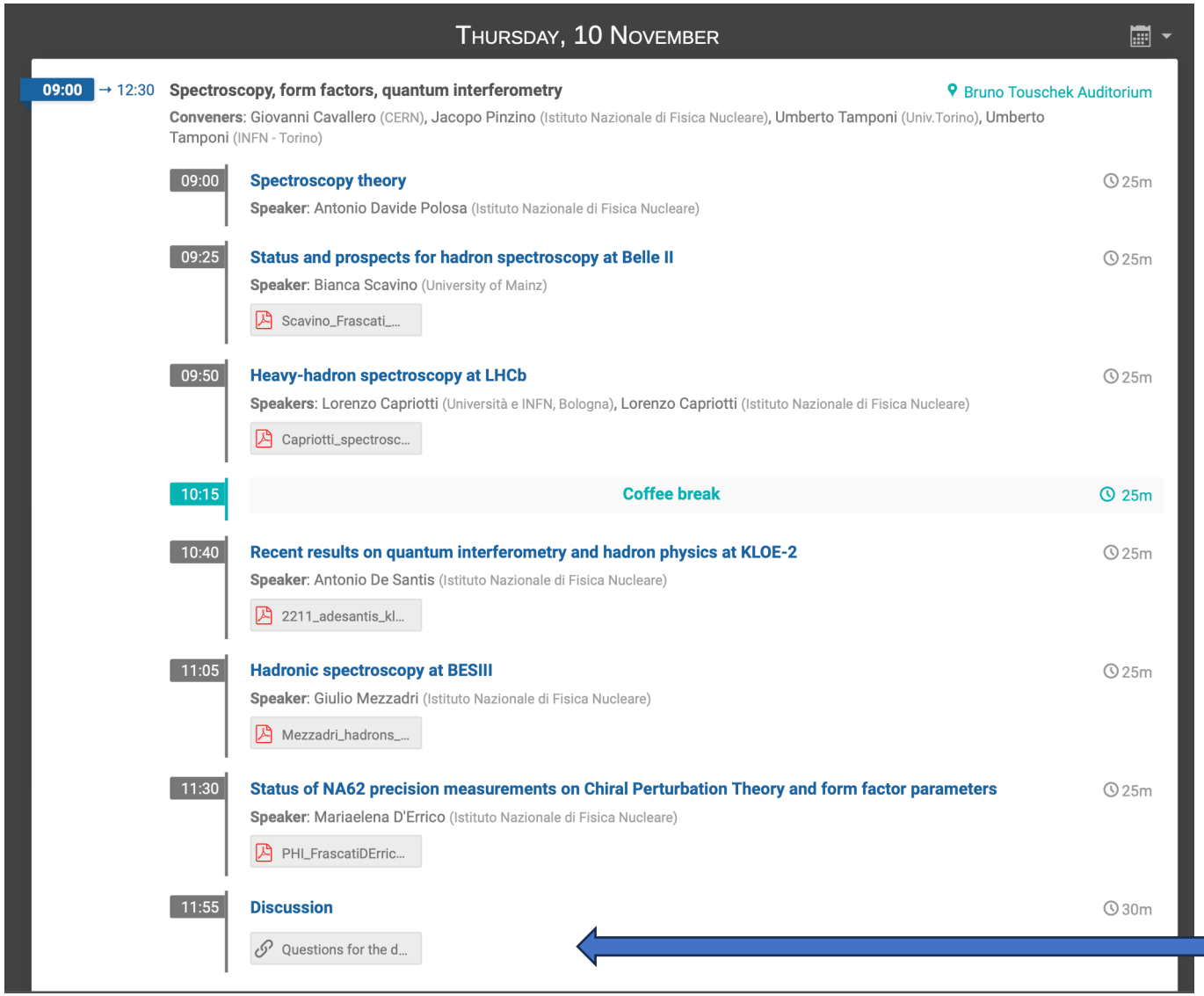
INFN Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

Spectroscopy: Introduction

Stefano Spataro, Stefania Vecchi

WIFAI 2023 – Rome – 08/11/2023

Last year - WIFAI 2022



THURSDAY, 10 NOVEMBER

09:00 → 12:30 **Spectroscopy, form factors, quantum interferometry** — Bruno Touschek Auditorium

Conveners: Giovanni Cavallero (CERN), Jacopo Pinzino (Istituto Nazionale di Fisica Nucleare), Umberto Tamponi (Univ.Torino), Umberto Tamponi (INFN - Torino)

09:00	**Spectroscopy theory** **Speaker**: Antonio Davide Polosa (Istituto Nazionale di Fisica Nucleare)	25m
09:25	**Status and prospects for hadron spectroscopy at Belle II** **Speaker**: Bianca Scavino (University of Mainz) Scavino_Frascati_...	25m
09:50	**Heavy-hadron spectroscopy at LHCb** **Speakers**: Lorenzo Capriotti (Università e INFN, Bologna), Lorenzo Capriotti (Istituto Nazionale di Fisica Nucleare) Capriotti_spectrosc...	25m
10:15	**Coffee break**	25m
10:40	**Recent results on quantum interferometry and hadron physics at KLOE-2** **Speaker**: Antonio De Santis (Istituto Nazionale di Fisica Nucleare) 2211_adesantis_kl...	25m
11:05	**Hadronic spectroscopy at BESIII** **Speaker**: Giulio Mezzadri (Istituto Nazionale di Fisica Nucleare) Mezzadri_hadrons_...	25m
11:30	**Status of NA62 precision measurements on Chiral Perturbation Theory and form factor parameters** **Speaker**: Mariaelena D'Errico (Istituto Nazionale di Fisica Nucleare) PHI_FrascatiDErric...	25m
11:55	**Discussion** Questions for the d...	30m

More heterogenous session

- Spectroscopy
- Interferometry
- Form factors

Something interesting here

Comment from the last year

While clearly huge theoretical progress has been made to try to extract a coherent picture out of the many observed exotic states, I am wondering what could be a systematic EXPERIMENTAL programme to attack the problem. In my opinion, clarifying in an unambiguous way that there exist compact 4-quark states and studying these states in detail seems to be particularly interesting and fruitful in understanding the nature of hadrons. - Anonimous

This year we (Stefania & Stefano) decided to change the design of the session

Focus more on exotics and allow time for discussion between us

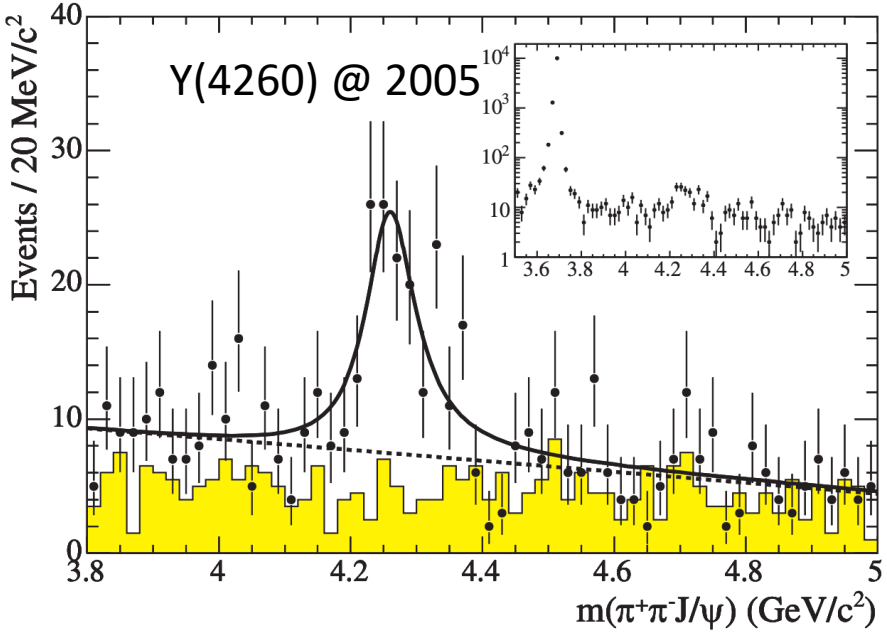
What's the actual status of exotics spectroscopy, and where are we going?

WIFAI 2023 Spectroscopy Agenda

	Introduction *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 14:30 - 14:40	
15:00	**Theory** — *Nora Brambilla* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 14:40 - 15:20	⇨ Theory Overview
	BESIII — *Marco Scodeggio* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 15:20 - 15:45	⇨ non $c\bar{c}$ states
16:00	**LHCb** — *Marco Pappagallo* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 15:45 - 16:10	⇨ tetraquark, pentaquark…
17:00	**ATLAS+CMS** — *Semen Turchikhin* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 16:45 - 17:10	⇨ double charm
	Belle II — *Alessandro Boschetti* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 17:10 - 17:35	⇨ non $b\bar{b}$ states
	JALAB-EIC — *Annalisa D'Angelo* *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 17:35 - 18:00	⇨ light and heavy
18:00	**Discussion** *Aula Magna "Adalberto Libera", Dipartimento di Architettura dell'Università Roma Tre* — 18:00 - 18:30	

The Need for High Intensity

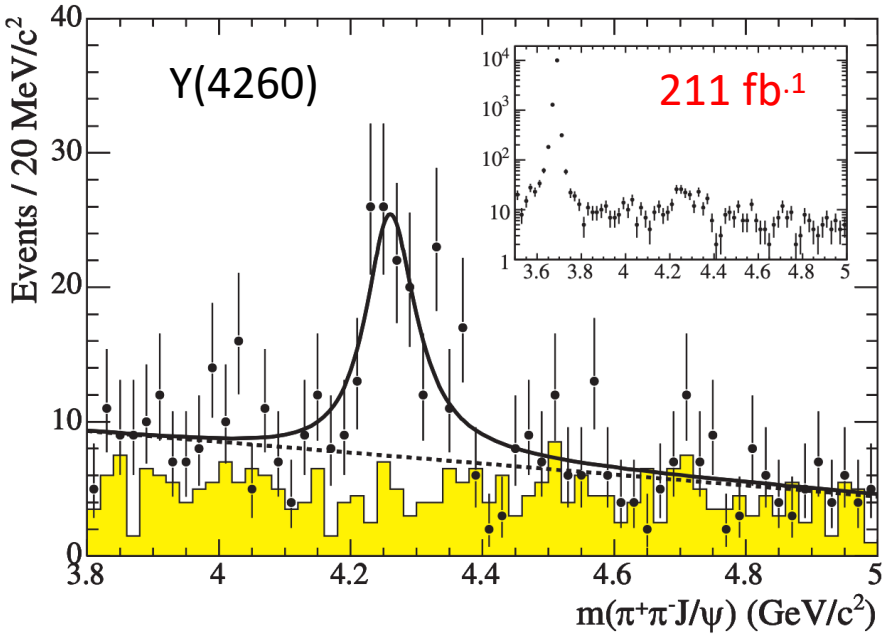
BABAR - PRL 95, 142001 (2005)



Since the single-resonance fit probability is low, we consider the possibility that the observed signal is due to two interfering resonances. Two-resonance fits with an interference term find one resonance mass close to the mass from the single-resonance fit, but with a width as low as 50 MeV/c^2, plus a second narrow resonance around 4.33 GeV/c^2. However, the fit probabilities are not significantly improved by two-resonance hypotheses. The size of our sample does not allow a statistically significant discrimination; we can neither exclude nor establish a multi- resonance hypothesis.

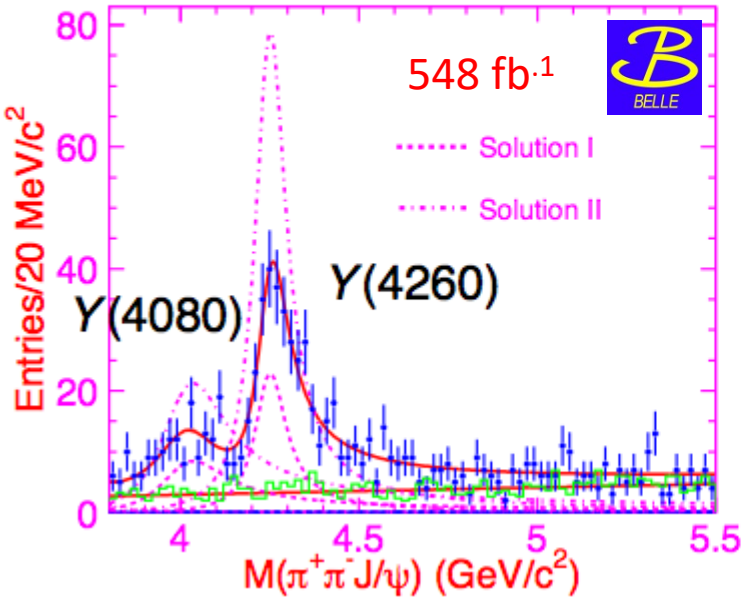
The Need for High Intensity

BABAR - PRL 95, 142001 (2005)



$e^+e^- \to J/\psi\pi\pi\gamma_{ISR}$

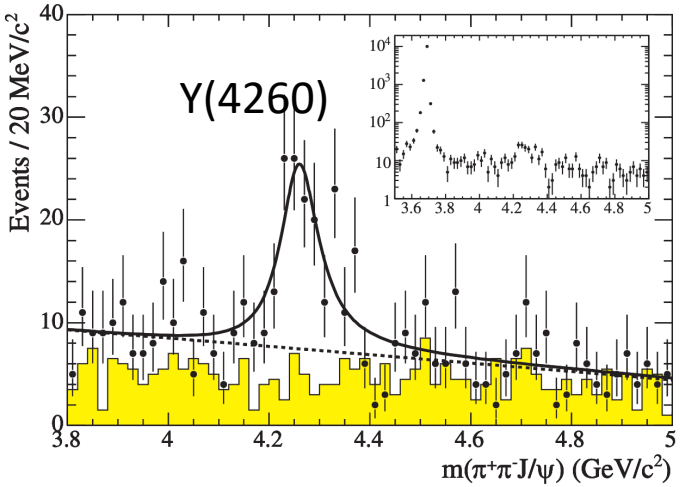
Phys. Rev. Lett. 99, 182004, (2007)



A couple of years after, different experiment, more statistics, same production technique

The Need for High Intensity

BABAR - PRL 95, 142001 (2005)



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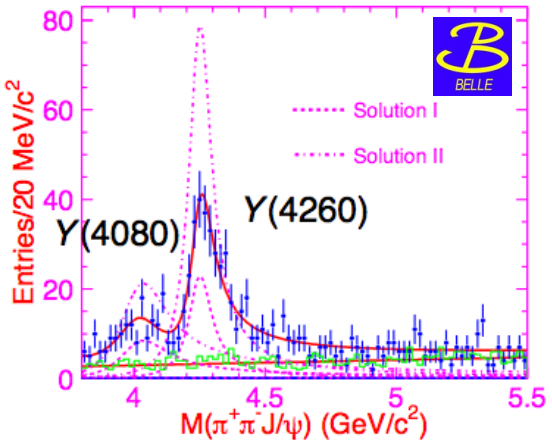
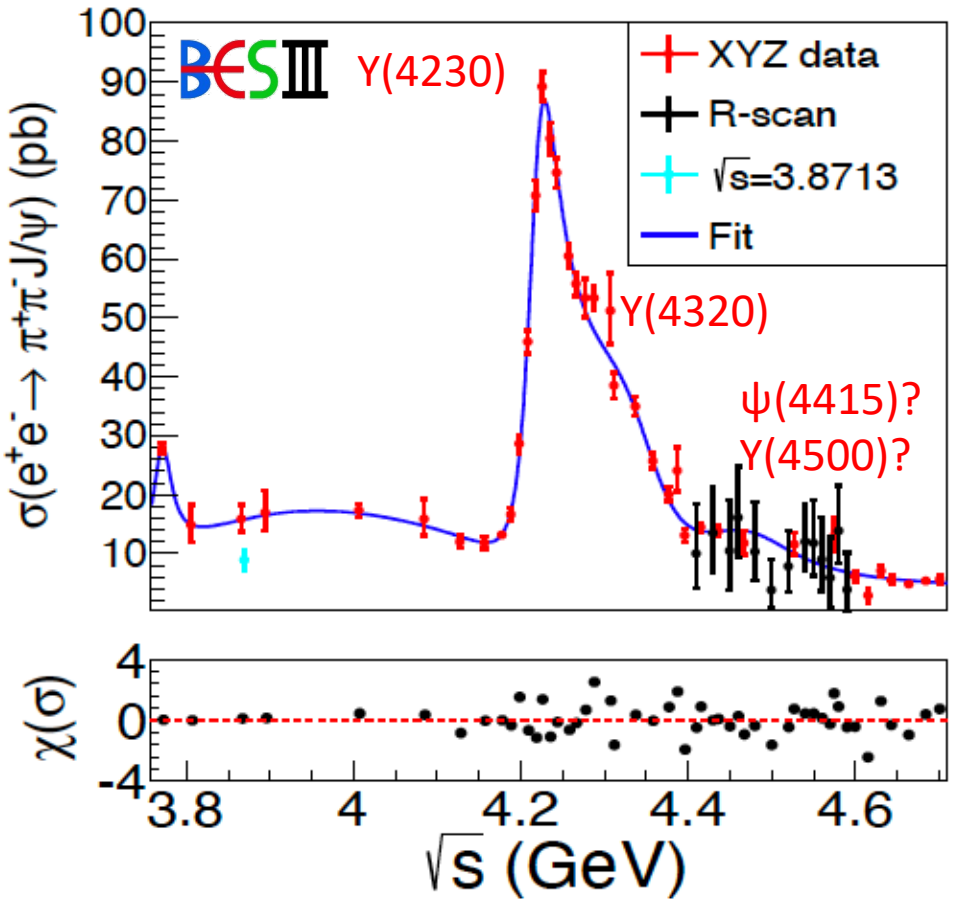
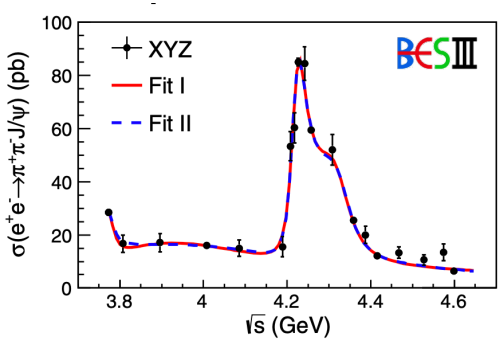


PRD 106, 072001 (2022)

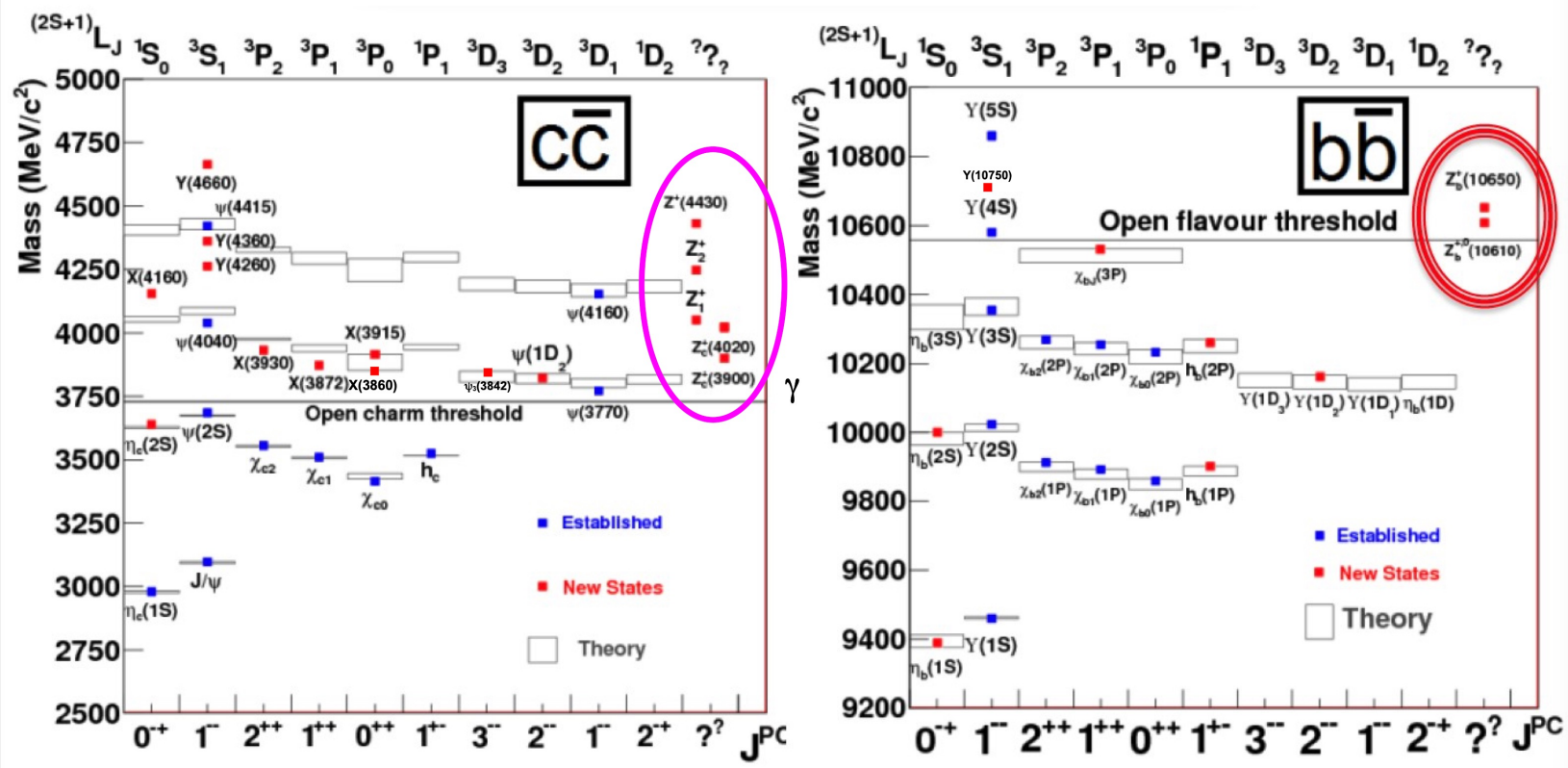


… and complimentary measurements



Parallelisms and Complementarity

Similarity between charm and beauty sector → what is in one sector should be in the other



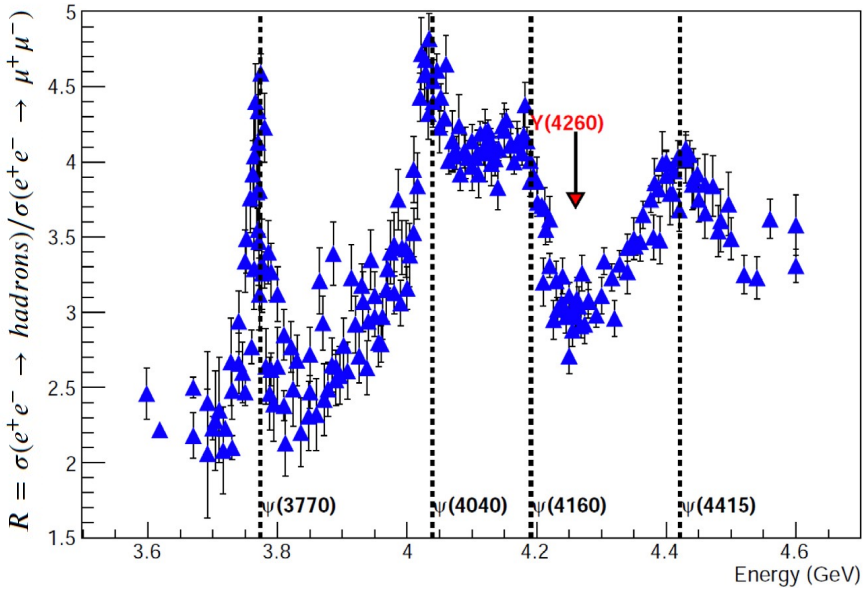
Searches also in the light sector and vice versa

BUT THERE ARE ALSO DIFFERENCES

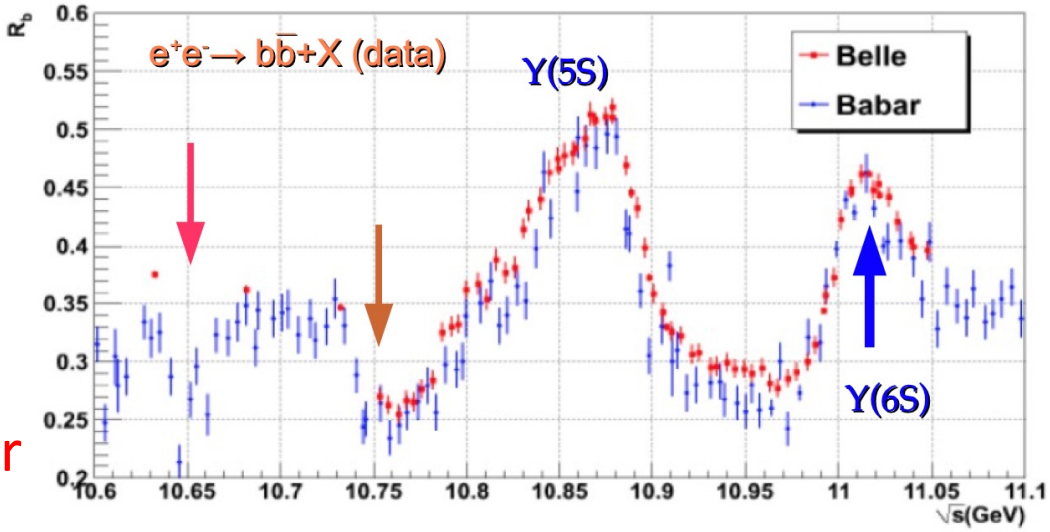
isospin symmetry breaking in D masses is not present in B mesons

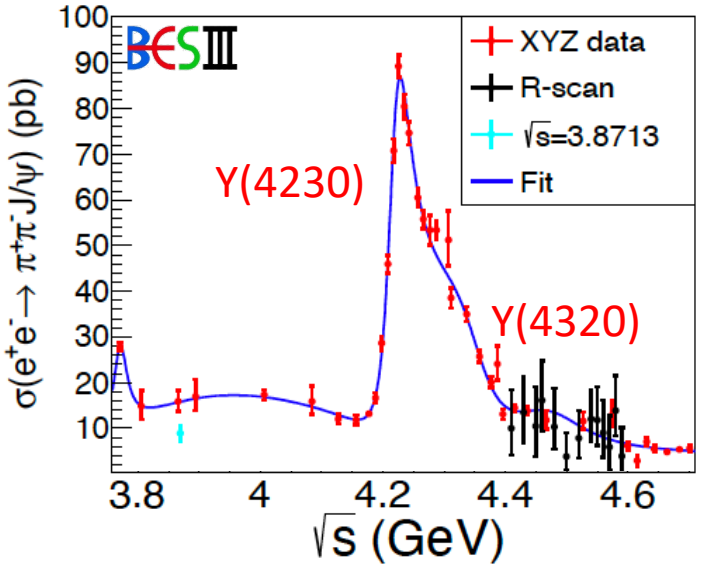
this makes everything more complicated (look at X(3872))

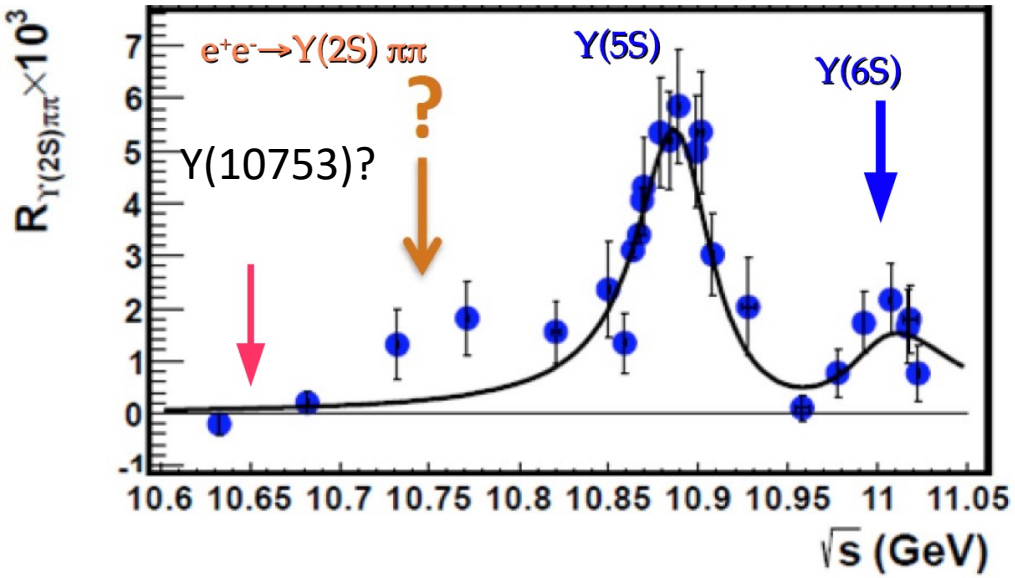
Parallelisms and Complementarity



Same Story
Different Flavour
?



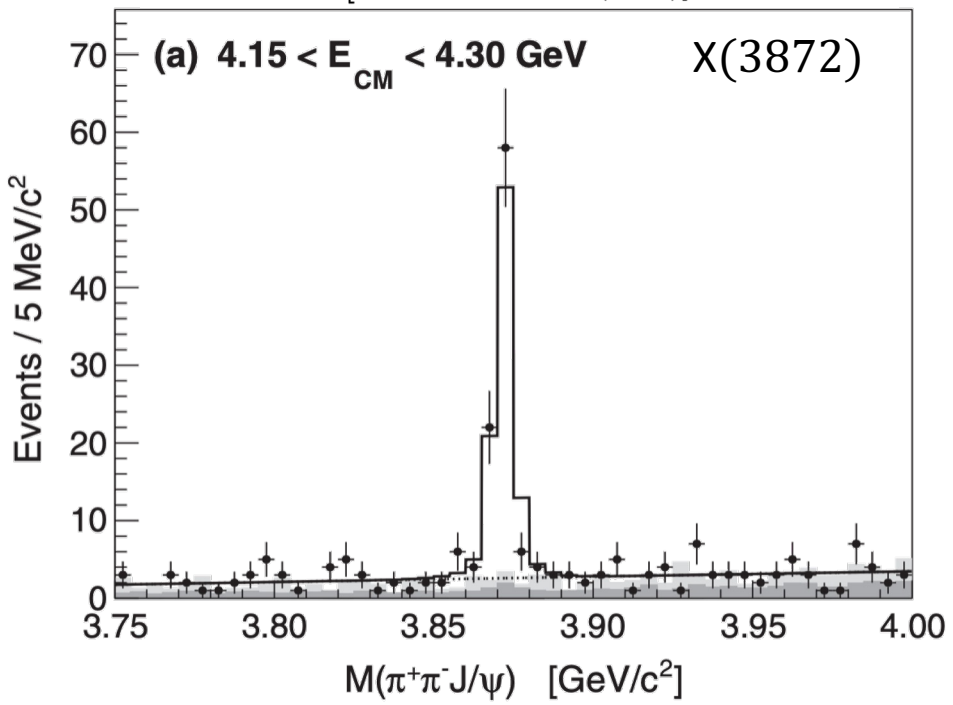




Similarity?

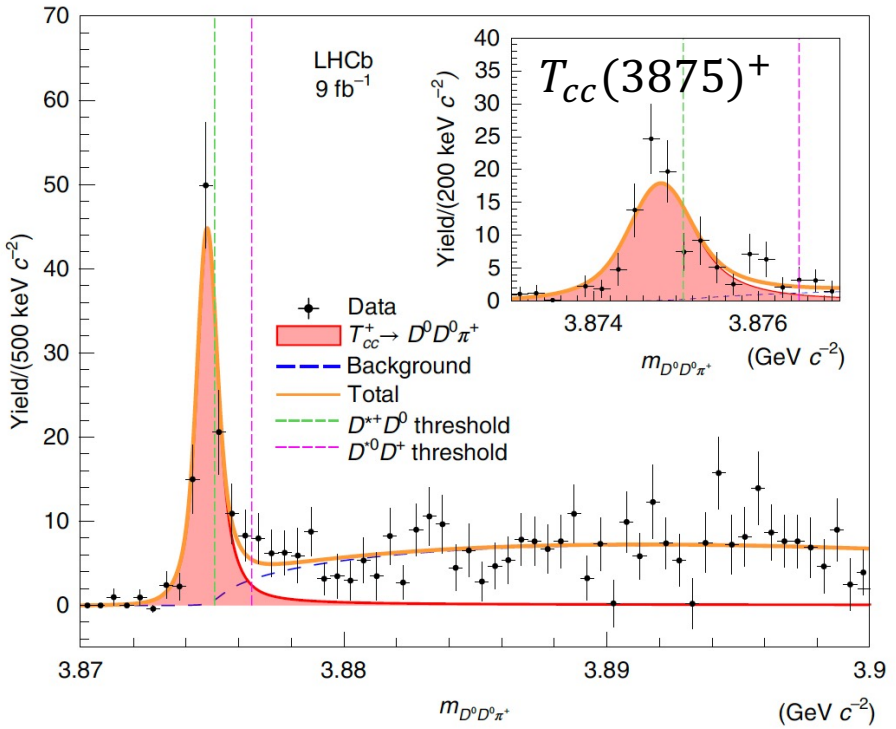
$e^+e^- \to \gamma X(3872); \quad X(3872) \to \pi^+\pi^- J/\psi$

[PRL 122, 232002 (2019)]



$M_{X(3872)} - M_{D^0D^{*0}} = 0.01 \pm 0.14 MeV$

Nature Phys. 18 (2022) 7, 751-754



$M_{T_{cc}(3875)^+} - (M_{D^{*+}} + M_{D^0}) = -0.27 \pm 0.06 MeV$

Close Friends or False Friends?

A lot of things to discuss

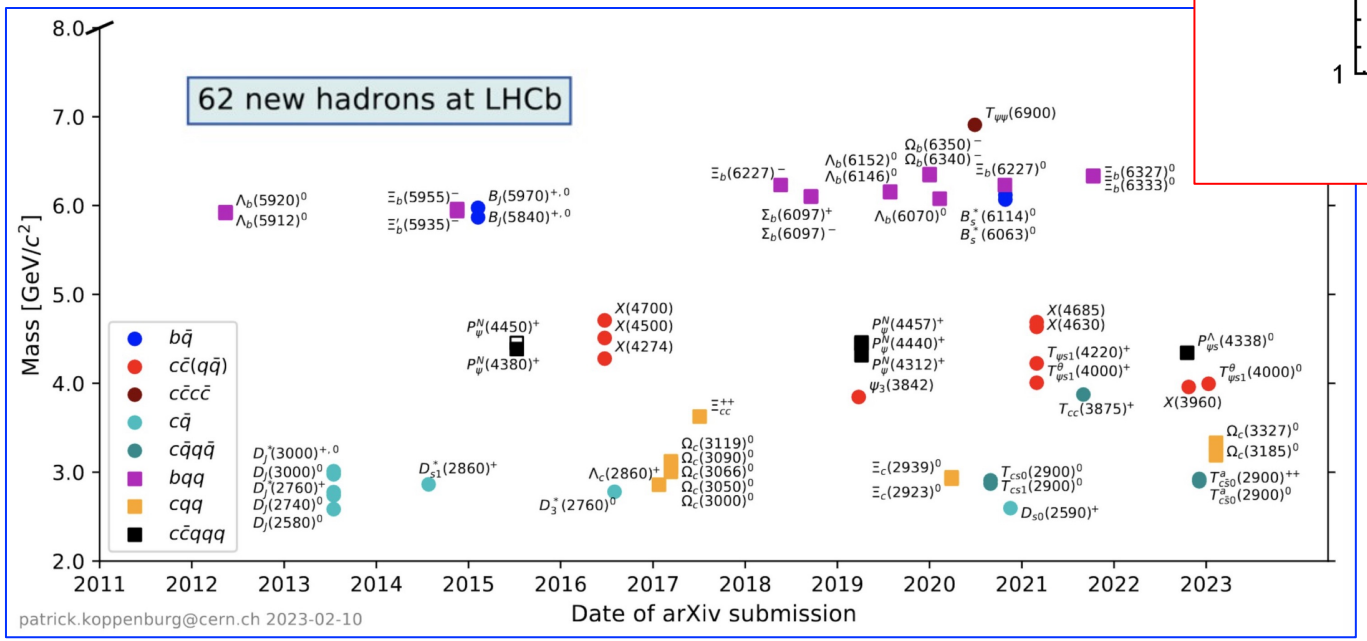
Fitting the exotic hadron spectrum with an additional quark

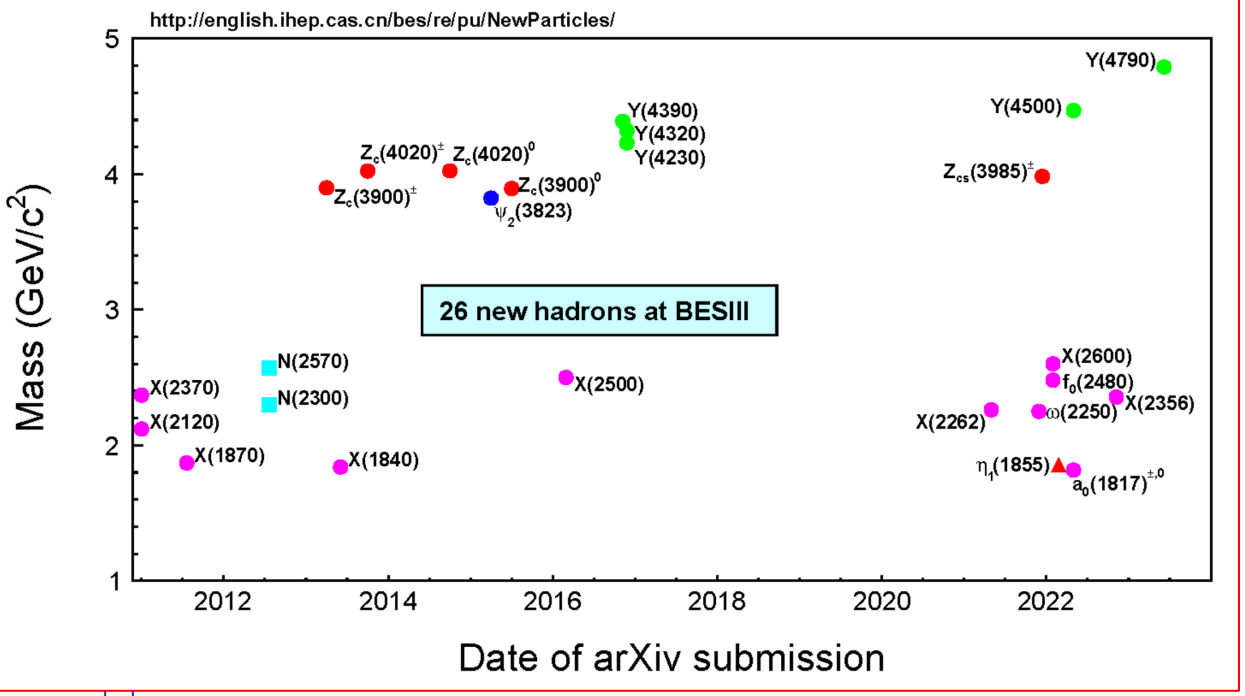
Scott Chapman[1,*]

[1] *Institute for Quantum Studies, Chapman University, Orange, CA 92866, USA*

(Dated: September 27, 2023)

arXiv:2203.03007v10





Let's Start!