Istituto Nazionale di Fisica Nucleare

Observations/Comments/Perspectives
At the closure of the workshop

Implications of LHCb measurements and future prospects

Cern (virtually!)
October 28th-30th, 2020

Fulvia De Fazio
INFN Bari

Thanks to the organizers

Alexander Lenz
Danny van Dyk
Jure Zupan
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Guy Wilkinson
Marco Pappagallo
Monica Pepe-Altarelli
S Fajfer

More than a Flavour Factory

1. Mixing and CP violation in charm and beauty
2. Rare, radiative and electroweak penguin decays
3. Semileptonic decays
4. QCD Spectroscopy and Exotic Hadrons
5. Exotica and Heavy Ion Physics

I will not focus on all of them
I will not review the state of the art
I will not summarize the workshop
I will try to provide
- starting points for discussion
- a personal view of open problems/perspectives

More than a Flavour Factory

1. Mixing and CP violation in charm and beauty
2. Rare, radiative and electroweak penguin decays
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Many common points

Theory: a common leading principle

Quoting **Stefan Pokorski**:

electron life-time	$> 4.3 \times 10^{23}$ years (68% C.L.)
neutron life-time for the electric charge non-conserving decays ($n \to p$ + neutrals)	$\gtrsim 10^{19}$ years
proton life-time	$> 10^{32}$ years

- Conservation of electric charge is proven more poorly than that of baryonic charge
- Nobody is contesting electric charge conservation
- Experiments searching for proton decay belong to the present frontiers of Physics

REASON:

Electric charge is protected by gauge invariance

$\Rightarrow$ Looking for underlying symmetries is our leading principle

1. Mixing and CP violation in charm and beauty
2. Rare, radiative and electroweak penguin decays
3. Semileptonic decays
5. Exotica

- Determining more and more precisely SM parameters
- Looking for BSM i.e. New Symmetries

Requires *getting rid* of hadronic uncertainties
(That's why we often look for ratios!)

A step behind is *understanding* strong interactions

We know the symmetry there!
…but not *completely* how it works

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4. QCD Spectroscopy and Exotic Hadrons
5. Heavy Ion Physics

Really look at the basics of QCD
- How quarks and gluons bind together
- Behaviour of hadronic matter under extreme conditions

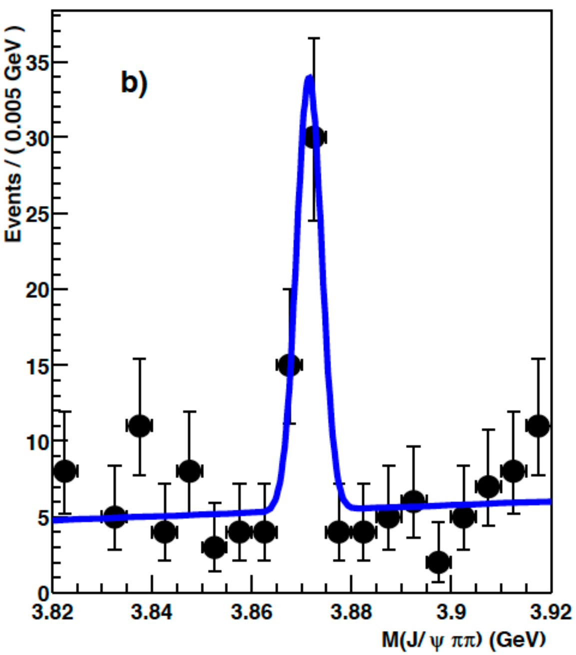
4. QCD Spectroscopy and Exotic Hadrons

Plenty of new observations of

- *Ordinary* states: hadrons that fit in the quark model, i.e. either $q\bar{q}$ or qqq
- *Exotic* states: all those that are *not ordinary* states

4 milestones:

1) 2003: X(3872)



- Discovered by Belle in B -> KX, X->J/ψ π+π-
- Produced in B decays, prompt hadron production radiative decay of Y(4260) (?) (BES III)
- Observed decays: J/ψ π+π- , J/ψ ω, $D^*\bar{D}$, J/ψ γ, , ψ(2S) γ
- Mass at threshold $M_X - M_{D^{*0}} - M_{\bar{D}^0} = 0.01 \pm 0.18$ MeV
- Narrow width Γ = 1.39 +- 0.24 +- 0.10 MeV
  (LHCb 2005.13419)
- No isospin partners found
- $J^{PC} = 1^{++}$

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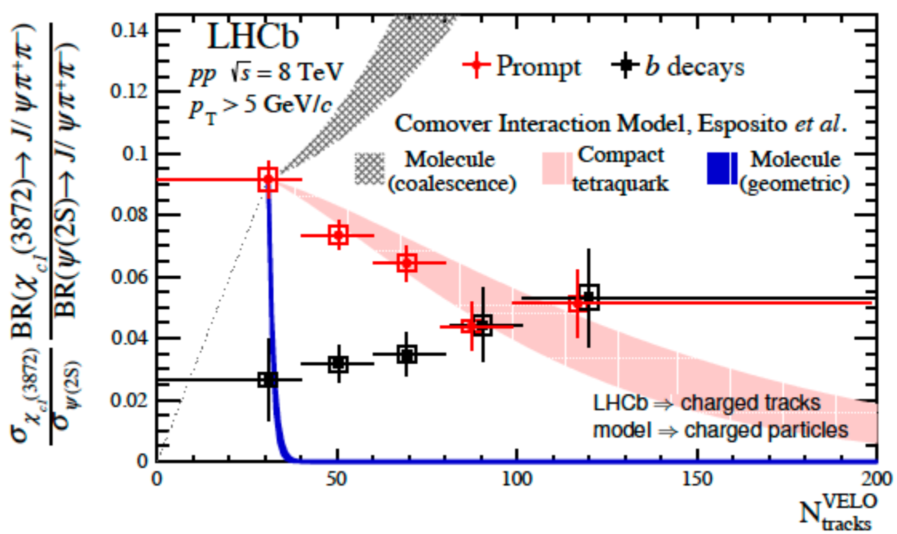
Learnt wednesday: (talk by Jana Crkovskaj)



Observation of multiplicity-dependent prompt $\chi_{c1}(3872)$ and $\psi(2S)$ production in pp collisions
PAPER-2020-023, arXiv:2009.06619 (submitted to PRL)

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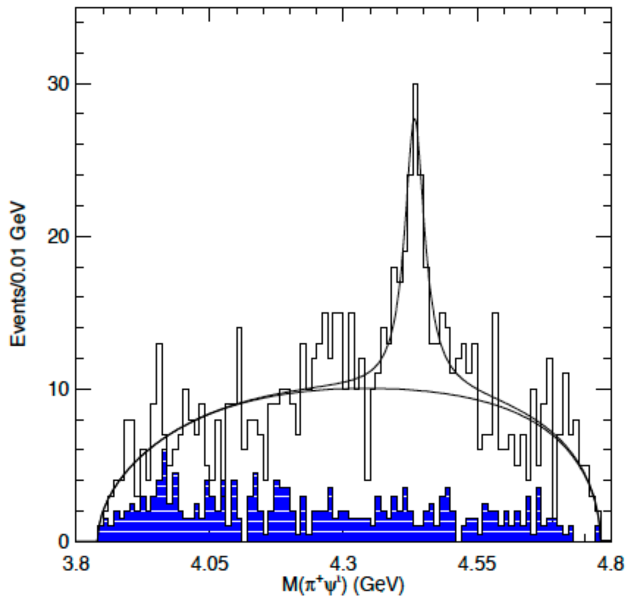
4 milestones:

2) 2008: $Z_c(4430)^{\pm}$



- Discovered by Belle in B -> $KZ^{\pm}$, $Z^{\pm}\to\psi(2S)\,\pi^{\pm}$
- First electrically charged charmonium state: four q candidate
- Not confirmed by BaBar : not found in $\psi(2S)\,\pi^{\pm}$ neither in $J/\psi\ \pi^{\pm}$
- Belle observes also decay to $J/\psi\ \pi^{\pm}$
- LHCb observes the decay $Z^{\pm}\to\psi(2S)\,\pi^{\pm}$
- $J^P = 1^+$

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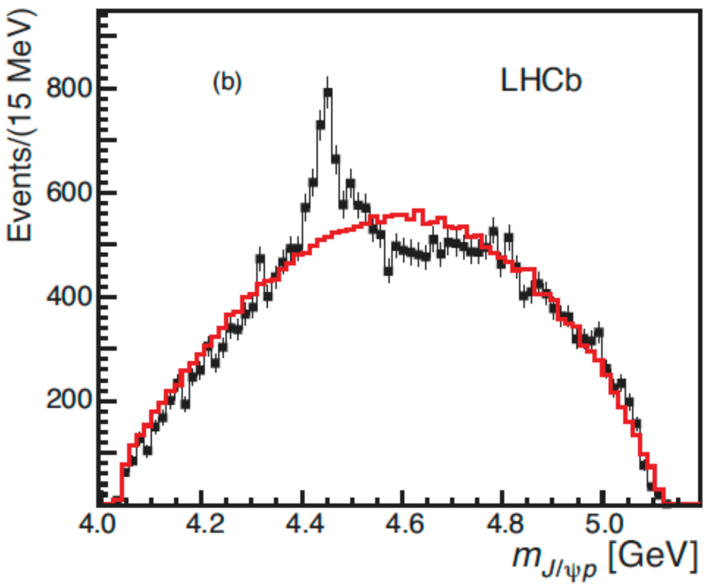
3) 2015: $P_c(4380)$ & $P_c(4450)$



- Riported by LHCb in the amplitude analysis of $\Lambda_b \to K^- J/\psi\, p$

- $J^P = \left(\frac{3}{2}^-, \frac{5}{2}^+\right)$ favoured but

$\left(\frac{3}{2}^+, \frac{5}{2}^-\right)$ $\left(\frac{5}{2}^+, \frac{3}{2}^-\right)$ not excluded

New Hadron Spectroscopy

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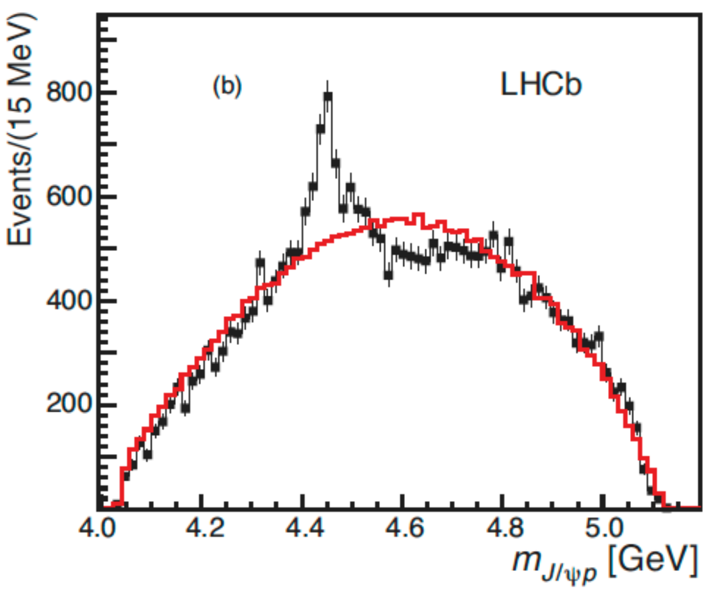

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P_{cs} candidate observed in $\Xi_b^- \to J/\psi\, K^- \Lambda$
19 MeV below $\Xi_c^0\, \bar{D}^{*0}$ threshold

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4 milestones:

4) LHCb 2020: - observation of 4c tetraquark candidate X(6900)
- observation of an exotic hadron with open charm candidate X(2900)

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- observation of an exotic hadron with open charm candidate X(2900)

✧ Only states with 2 heavy quarks observed before

✧ Recent improvement in ordinary spectroscopy with Ξ_{cc} discovery (LHCb 2017)

✧ 4b tetraquarks sought for by LHCb and CMS

✧ Theory predictions for the mass of T_{cccc} in [5.8,7.4] GeV

New Hadron Spectroscopy

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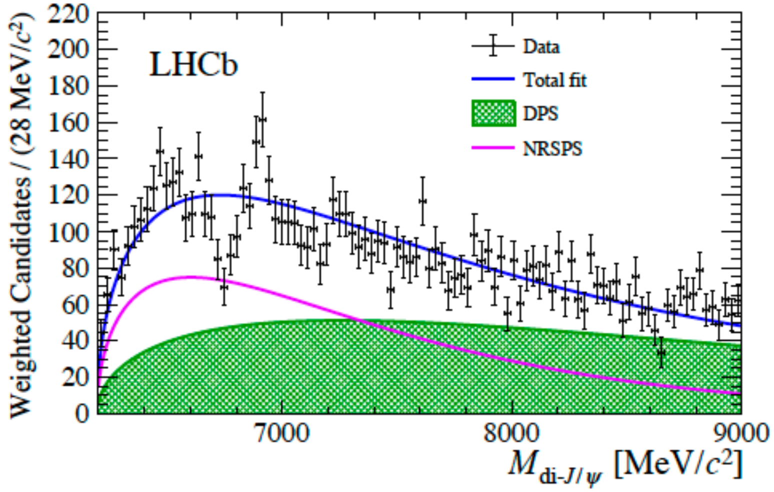

Observed in di J/ψ invariant mass spectrum

Alternatives not excluded, i.e.
rescattering of two charmonium states produced close to their mass threshold

Talk by Carla Marin Benito

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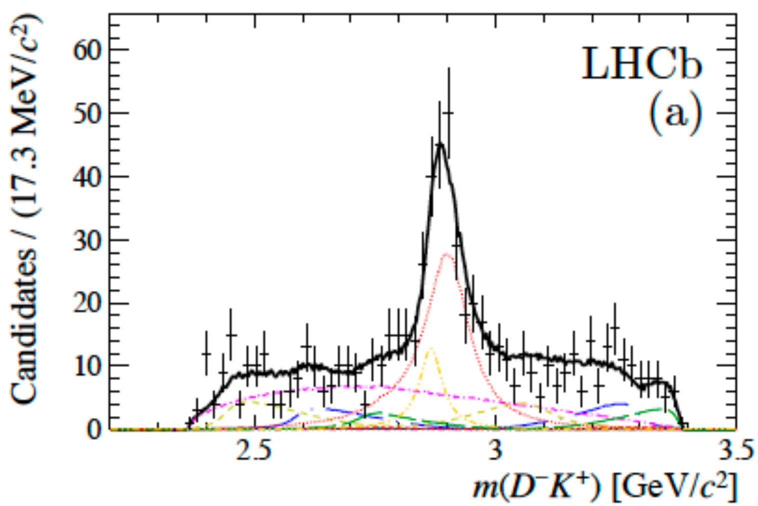
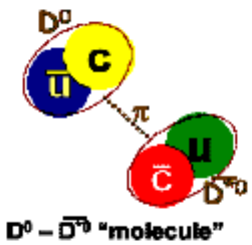


- Observed in $B^+ \to D^+D^-K^+$
- Minimal content $cds\bar{u}$
- If confirmed first exotic hadron with open charm (probably 2)

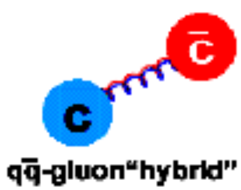
(see talk by T. Burns)



Molecular state:
loosely bound state of mesons.
Dominant binding mechanism: π exchange.
Being weakly bound, mesons tend to decay as if they were free

Distinctive features of multiquark picture:
- prediction of many new states
- possible existence of ccbar states with non-zero charge, strangeness or both

Tetraquark:
Bound state : diquark-antidiquark
quarks group into colour triplet scalar or vector clusters.



Charmonium hybrids
States with an excited gluonic degree of freedom
0+-, 1-+, 2+-…(not possible for $c\bar{c}$ states)
→ unambiguous signal of an exotic state
Lattice and model predictions for the lowest lying hybrid:

$$M \cong 4200 \quad \text{MeV}$$

Threshold effects
Experimental enhancement of cross section that may not indicate a resonance.

Pictures from Godfrey, Olsen

Proposed interpretations of exotic states

- Quark Model : provided a scheme to classify hadrons

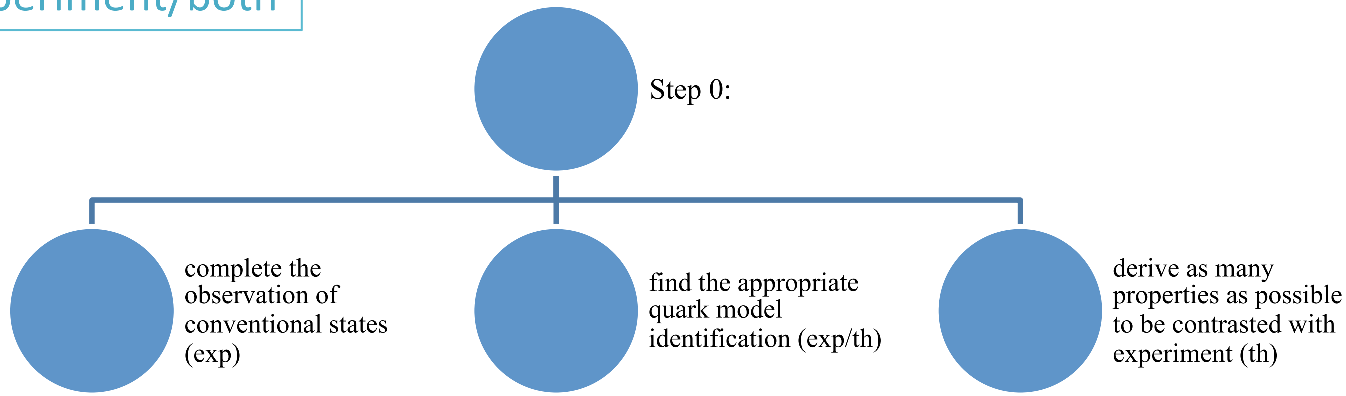
    - possibility to fit all observed hadrons
    - predictions for missing hadrons
    - predictions have been verified !

- None of the proposed scheme provides an analogous systematic framework nor a complete explanation for all new observations

- Let's start from what we do not understand…

Understanding exotic states

List for theory/experiment/both



Understanding exotic states

List for theory/experiment/both

Step 0:

- complete the observation of conventional states (exp)
- find the appropriate quark model identification (exp/th)
- derive as many properties as possible to be contrasted with experiment (th)

Are there supernumerary states?

Understanding exotic states

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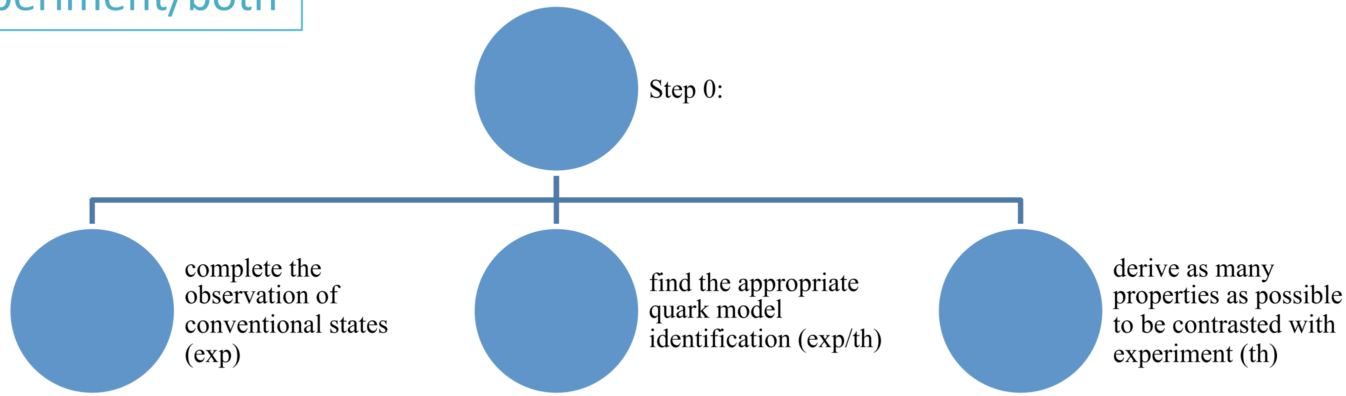

Are there supernumerary states?

1st. example: overpopulated region 3.8-4.2 GeV

Z(3930) observed by Belle, BaBar, LHCb now identitifed with χ_{c2}(2P) :

$\boxed{\chi_{c2}(3930)}$

$I^G(J^{PC}) = 0^+(2^{++})$

χ_{c2}(3930) DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$\gamma\gamma$	seen
Γ_2	$K\overline{K}\pi$	
Γ_3	$K^+K^-\pi^+\pi^-\pi^0$	
Γ_4	$D\overline{D}$	seen
Γ_5	D^+D^-	seen
Γ_6	$D^0\overline{D}^0$	seen
Γ_7	$\pi^+\pi^-\eta_c(1S)$	not seen
Γ_8	$K\overline{K}$	not seen

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Discussed also in Mengzhen Wang talk

$I^G(J^{PC}) = 0^+(2^{++})$

Why decay to D $\underline{D}^*$ not seen?

$\chi_{c2}(3930)$ DECAY MODES

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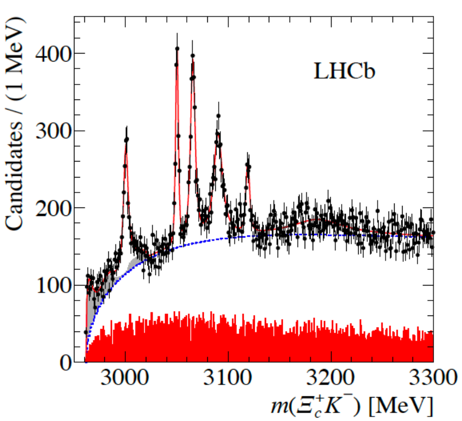
Are there supernumerary states?

2nd. example: observation (2017) of Ω_c baryons

- witnesses the great contribution of LHCb to the advances in hadron spectroscopy



- five new narrow states observed

$\Omega_c(3000)^0$, $\Omega_c(3050)^0$, $\Omega_c(3066)^0$, $\Omega_c(3090)^0$, and $\Omega_c(3119)^0$

- Orbital excitations (L=1?), radial excitations?

- Ω_c(3050) and Ω_c(3119) might be pentaquarks

The only one not confirmed by Belle

- look at new decay modes/production channels (exp)

- predict the properties of ordinary baryon excitations (th)

Understanding exotic states

List for theory/experiment/both

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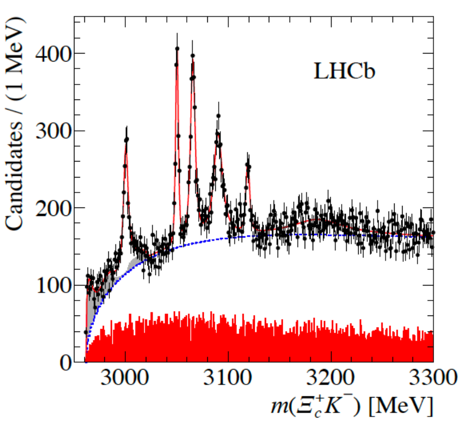
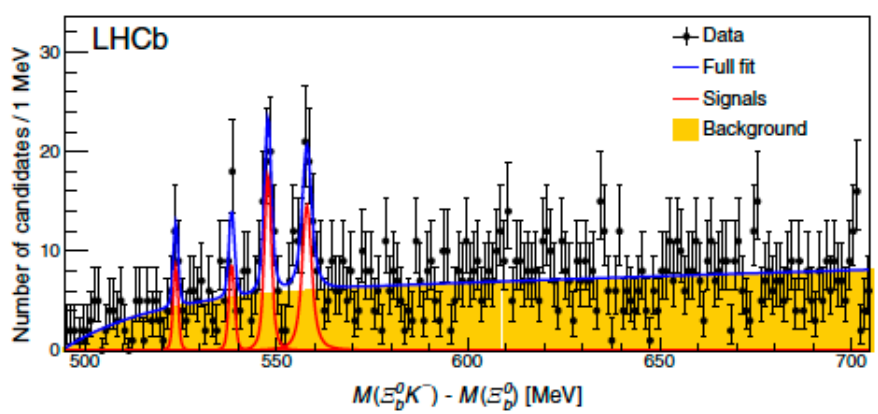
Are there supernumerary states?

2nd. example: observation (2017) of Ω_c baryons

Notice the similar observation of 4 Ω_b baryons (LHCb 2020):





Understanding exotic states

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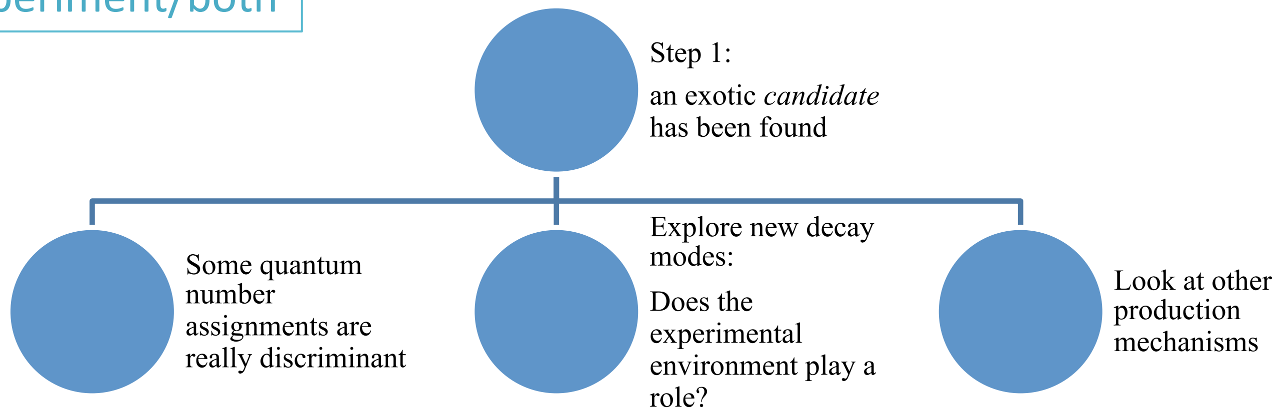


Understanding exotic states

List for theory/experiment/both

Step 1:
an exotic *candidate* has been found

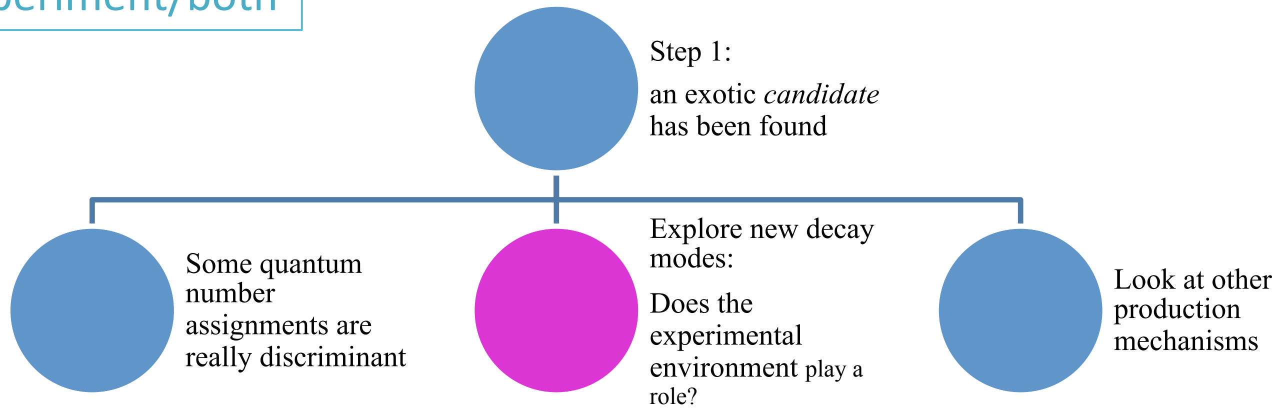
- Some quantum number assignments are really discriminant
- Explore new decay modes:
  Does the experimental environment play a role?
- Look at other production mechanisms

In the case of mesons, conventional $q\underline{q}$ states cannot have

- ➢ $J^{PC}=0^{--}, 0^{+-}, 1^{-+}$...
- ➢ cannot have Q >1
- ➢ Cannot have isospin or strangeness I>1, S>1

Understanding exotic states

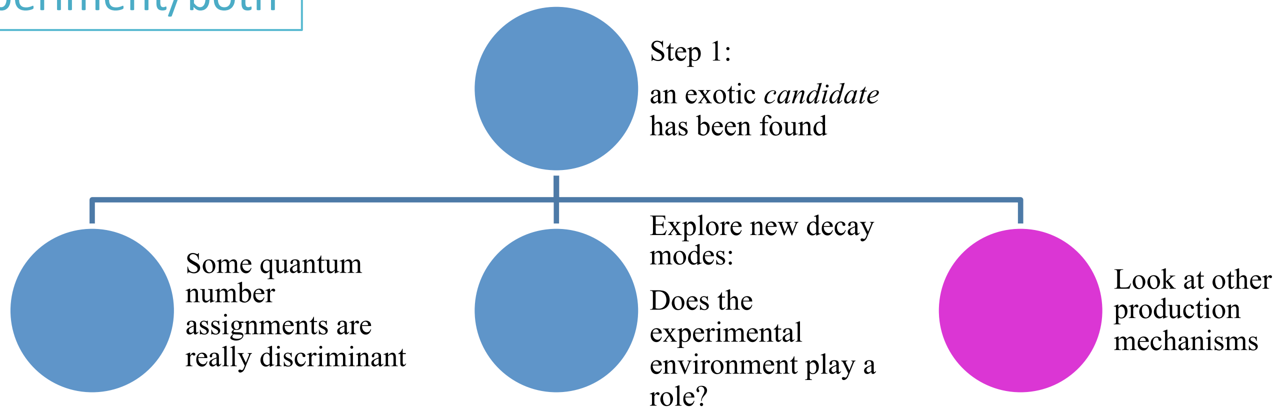
List for theory/experiment/both



Q(no A)
Why all the observed exotica have been observed decaying to heavy mesons and never to light ones?
(role of threshold effects?)

Understanding exotic states

List for theory/experiment/both



- For states produced in B decays: look at other B and Λ_b modes
- Comparison among different production mechanisms

Understanding exotic states

The *soul searching* of the good theorist:

- What are real possibilities/limitations of my method/model?
- Can it really discriminate between ordinary/molecule/multiquark…?
- Can I disentangle threshold effects?

Similar questions in the conclusions of Mengzhen Wang' talk yesterday!

Understanding exotic states

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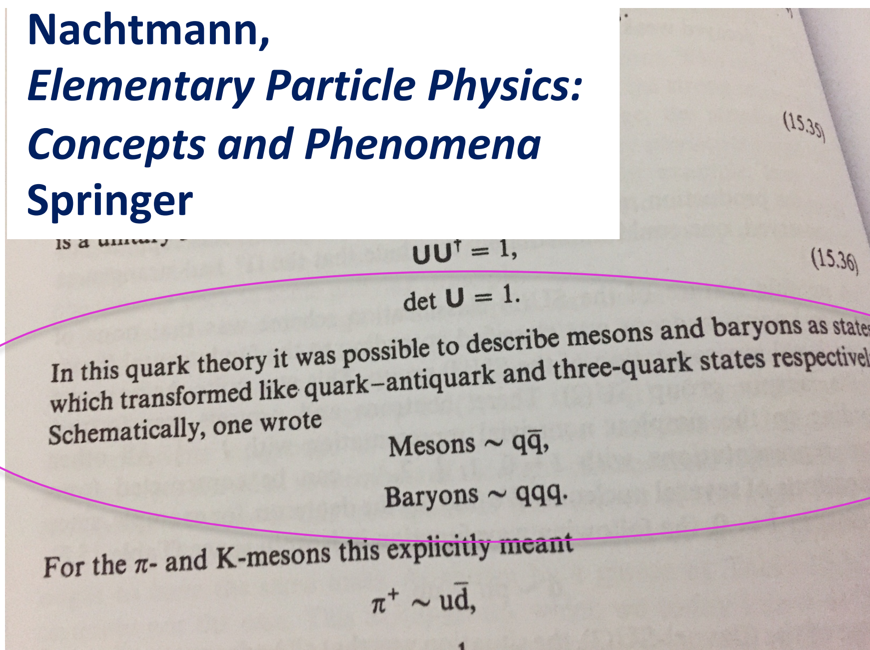
Nachtmann,
Elementary Particle Physics: Concepts and Phenomena
Springer



(15.35)

$$\mathbf{U}\mathbf{U}^{\dagger} = 1, \quad (15.36)$$

$$\det \mathbf{U} = 1.$$

In this quark theory it was possible to describe mesons and baryons as states which transformed like quark–antiquark and three-quark states respectively. Schematically, one wrote

$$\text{Mesons} \sim q\bar{q},$$

$$\text{Baryons} \sim qqq.$$

For the π- and K-mesons this explicitly meant

$$\pi^{+} \sim u\bar{d},$$

A great responsibility:
Writing again textbooks!

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2. Rare, radiative and electroweak penguin decays
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Correlated pattern of deviations from SM predictions
BSM Physics jointly invoked by Particle/Astroparticle/Cosmology

(nothing new….
…cosmic rays were sources of discoveries at the dawn of particle Physics)

No summary of the anomalies!

Ideal classification of the processes suitable to look BSM:

1) SM allowed processes: deviations $\rightarrow$ NP

2) SM forbidden processes: observation $\rightarrow$ NP

No summary of the anomalies!

Ideal classification of the processes suitable to look BSM:

1) SM allowed processes: deviations $\rightarrow$ NP

- tree level decays ($R(D^{(*)})$ & co.)
- loop (rare) decays ($R(K^{(*)})$, P'_5, …)
- puzzling quantities (V_{cb}, V_{ub}, ε'/ε, g−2…).

2) SM forbidden processes: observation $\rightarrow$ NP

- LFV decays $\tau \rightarrow 3\mu$, $\mu \rightarrow e\,\gamma$ …

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- Observation of deviations in tree level observables does not mean anymore unexpected (better: we are using new probes, i.e. τ leptons)
- many hints of LFU violation in the first class → relation between 1) and 2) now expected
- LFV already established in ν Physics
- Many NP models predict both LFUV and LFV

- Emerging a complicated but probably more coherent picture of deviations

ex. Problems with V_{cb} and V_{ub} determinations might be correlated
with observed anomalies in tree level modes

No summary of the anomalies!

Ideal classification of the processes suitable to look BSM:

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We are entering the Flavour precision era:
Great discovery potential of Flavour Physics
Not only discovery but path to identification!

Systematic extension of the SM

ν oscillations

$$\boxed{\mathcal{L}_{SMEFT} = \mathcal{L}_{SM} + \frac{1}{\Lambda_{(5)}}\mathcal{O}^{(D=5)} + \sum_i \frac{1}{\Lambda_i^2}\mathcal{O}_i^{(D=6)} + \dots}$$

NP

$$\overbrace{\underbrace{\mathcal{L}^{kin} + \mathcal{L}^{gauge} + \mathcal{L}^{Higgs}}_{\text{Accidental symmetries}} + \underbrace{\mathcal{L}^{Yukawa}}}$$

Accidental symmetries

- Violates accidental symmetries
- Source of (SM) CP violation
- Fermion mass terms

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$$\mathcal{L}^{kin} + \mathcal{L}^{gauge} + \mathcal{L}^{Higgs} + \mathcal{L}^{Yukawa}$$

NP

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Main objects of our investigations

Systematic extension of the SM

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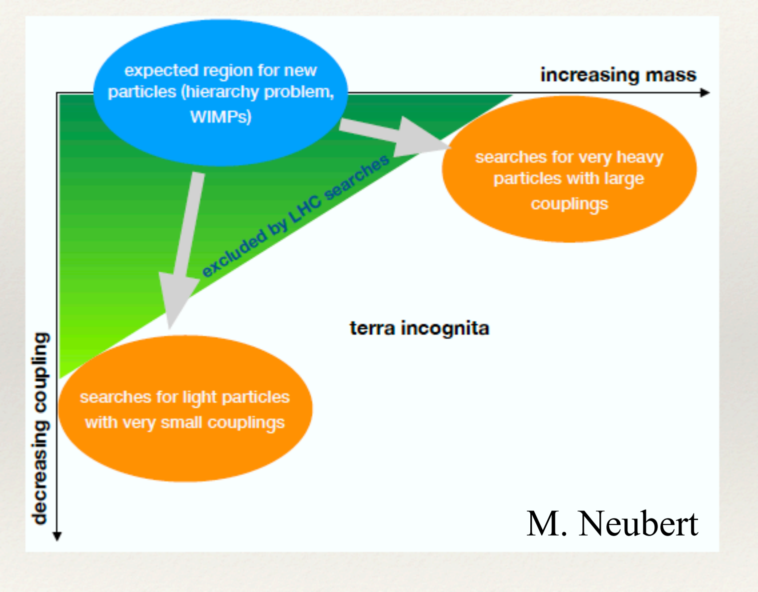


coupling/mass

Semileptonic b decays

Exclusive b $\rightarrow$ c modes

- Identifications of suitable observables (talk by Novoa Brunet)
- Issue of FF uncertainties (talks Davies, Bordone)

Unsolved debate: role of the parametrization: BGL vs CLN in heavy-to-heavy FF
Proposed to reconcile inclusive vs exclusive V_{cb} determinations

🤔 what about V_{ub}?

Semileptonic b decays

- Exclusive $b \to u$ modes
- Inclusive b-baryon decays: the case of Λ_b and its polarization

Basem Khanji talk :

in the LHCb to-do list

Only exclusive modes @LHCb !

Semileptonic b decays

- Exclusive b → u modes
- Inclusive b-baryon decays: the case of Λ_b and its polarization

Common starting point (U=c,u)

$$
\begin{aligned}
H_{\rm eff}^{b\to U\ell\nu} = \frac{G_F}{\sqrt{2}} V_{Ub} \Big[& (1+\epsilon_V^\ell) \left(\bar{U}\gamma_\mu(1-\gamma_5)b\right) \left(\bar{\ell}\gamma^\mu(1-\gamma_5)\nu_\ell\right) \\
& + \epsilon_S^\ell \left(\bar{U}b\right) \left(\bar{\ell}(1-\gamma_5)\nu_\ell\right) + \epsilon_P^\ell \left(\bar{U}\gamma_5 b\right) \left(\bar{\ell}(1-\gamma_5)\nu_\ell\right) \\
& + \epsilon_T^\ell \left(\bar{U}\sigma_{\mu\nu}(1-\gamma_5)b\right) \left(\bar{\ell}\sigma^{\mu\nu}(1-\gamma_5)\nu_\ell\right) \\
& + \epsilon_R^\ell \left(\bar{U}\gamma_\mu(1+\gamma_5)b\right) \left(\bar{\ell}\gamma^\mu(1-\gamma_5)\nu_\ell\right) \Big] + h.c. \quad .
\end{aligned}
$$

Extends the SM effective hamiltonian

- Exclusive b → u modes
- Inclusive b-baryon decays: the case of Λ_b and its polarization

Common starting point (U=c,u)

SM

$$H_{\rm eff}^{b\to U\ell\nu} = \frac{G_F}{\sqrt{2}} V_{Ub} \Big[(1+\epsilon_V^\ell)\,(\bar{U}\gamma_\mu(1-\gamma_5)b)\,(\bar{\ell}\gamma^\mu(1-\gamma_5)\nu_\ell) + \epsilon_S^\ell\,(\bar{U}b)\,(\bar{\ell}(1-\gamma_5)\nu_\ell) + \epsilon_P^\ell\,(\bar{U}\gamma_5 b)\,(\bar{\ell}(1-\gamma_5)\nu_\ell) + \epsilon_T^\ell\,(\bar{U}\sigma_{\mu\nu}(1-\gamma_5)b)\,(\bar{\ell}\sigma^{\mu\nu}(1-\gamma_5)\nu_\ell) + \epsilon_R^\ell\,(\bar{U}\gamma_\mu(1+\gamma_5)b)\,(\bar{\ell}\gamma^\mu(1-\gamma_5)\nu_\ell) \Big] + h.c. \; .$$

New complex LF-dependent couplings

Extends the SM effective hamiltonian

Semileptonic b → u decays

Look for deviations similar to those observed in the analogous b → c modes

- Ratios analogous to R(D), R(D*),…
- Possible correlation to the problem of $|V_{ub}|$ determination (inclusive vs exclusive)

About the couplings:

- Different channels are sensitive to different couplings
- Constrained by data

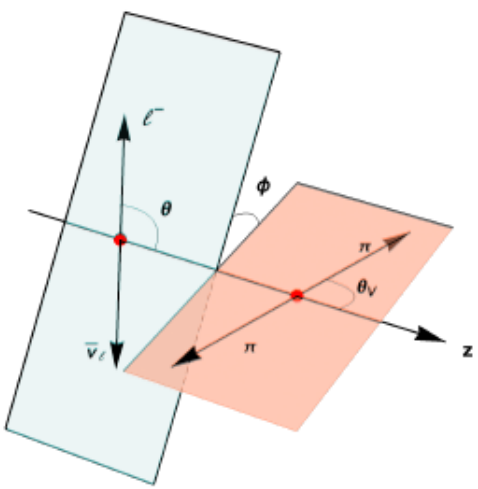
	ϵ_V^ℓ	ϵ_S^ℓ	ϵ_P^ℓ	ϵ_T^ℓ
$B^- \to \ell^- \bar{\nu}_\ell$	✔		✔	
$\bar{B} \to \pi \ell^- \bar{\nu}_\ell$	✔	✔		✔
$B \to \rho \ell \bar{\nu}_\ell$	✔		✔	✔
$B \to a_1 \ell \bar{\nu}_\ell$	✔	✔		✔

If the tensor operator is absent :
two modes are sentive to S and the other two to P

$B \to \rho \ell \bar{\nu}_\ell$

Fully differential width in B ->ρ (π π) ℓν sensitive to BSM effects

$$\frac{d^4\Gamma(\bar{B} \to \rho(\to \pi\pi)\ell^-\bar{\nu}_\ell)}{dq^2\, d\cos\theta\, d\phi\, d\cos\theta_V} = \mathcal{N}_\rho |\vec{p}_\rho| \left(1 - \frac{m_\ell^2}{q^2}\right)^2 \Big\{ I_{1s}^\rho \sin^2\theta_V + I_{1c}^\rho \cos^2\theta_V$$
$$+ \left(I_{2s}^\rho \sin^2\theta_V + I_{2c}^\rho \cos^2\theta_V\right) \cos 2\theta$$
$$+ I_3^\rho \sin^2\theta_V \sin^2\theta \cos 2\phi + I_4^\rho \sin 2\theta_V \sin 2\theta \cos\phi$$
$$+ I_5^\rho \sin 2\theta_V \sin\theta \cos\phi + \left(I_{6s}^\rho \sin^2\theta_V + I_{6c}^\rho \cos^2\theta_V\right) \cos\theta$$
$$+ I_7^\rho \sin 2\theta_V \sin\theta \sin\phi \Big\} ,$$



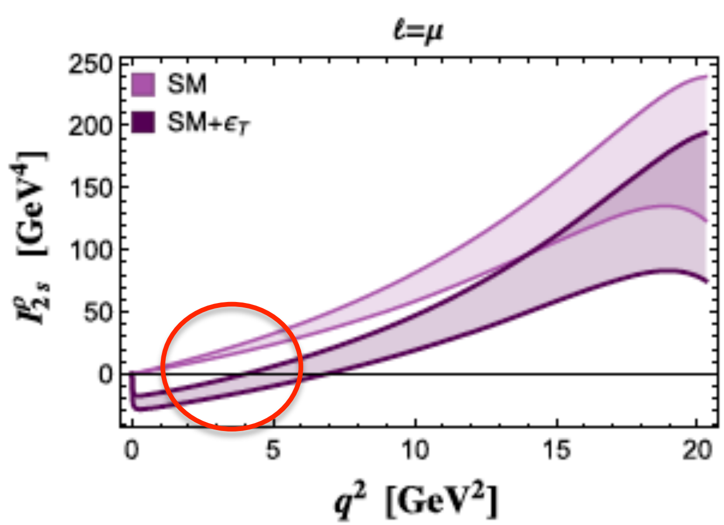
Angular coefficients
Can distinguish SM from NP
Hard for LHCb?
Possibly Belle II

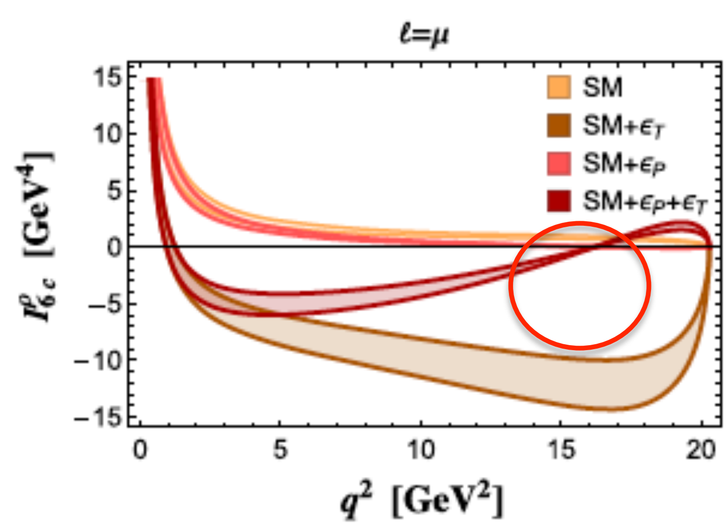
$B \to \rho \ell \bar{\nu}_\ell$

Fully differential width in B ->ρ (π π) ℓν sensitive to BSM effects

P. Colangelo, F. Loparco, FDF
PRD 2019

$$\frac{d^4\Gamma(\bar{B} \to \rho(\to \pi\pi)\ell^-\bar{\nu}_\ell)}{dq^2\, d\cos\theta\, d\phi\, d\cos\theta_V} = \mathcal{N}_\rho |\vec{p}_\rho| \left(1 - \frac{m_\ell^2}{q^2}\right)^2 \Big\{ I_{1s}^\rho \sin^2\theta_V + I_{1c}^\rho \cos^2\theta_V$$
$$+ \left(I_{2s}^\rho \sin^2\theta_V + I_{2c}^\rho \cos^2\theta_V\right)\cos 2\theta$$
$$+ I_3^\rho \sin^2\theta_V \sin^2\theta \cos 2\phi + I_4^\rho \sin 2\theta_V \sin 2\theta \cos\phi$$
$$+ I_5^\rho \sin 2\theta_V \sin\theta \cos\phi + \left(I_{6s}^\rho \sin^2\theta_V + I_{6c}^\rho \cos^2\theta_V\right)\cos\theta$$
$$+ I_7^\rho \sin 2\theta_V \sin\theta \sin\phi \Big\} ,$$





SM+T shows a zero in q^2 absent in SM only

The zero depends on the inclusion of P

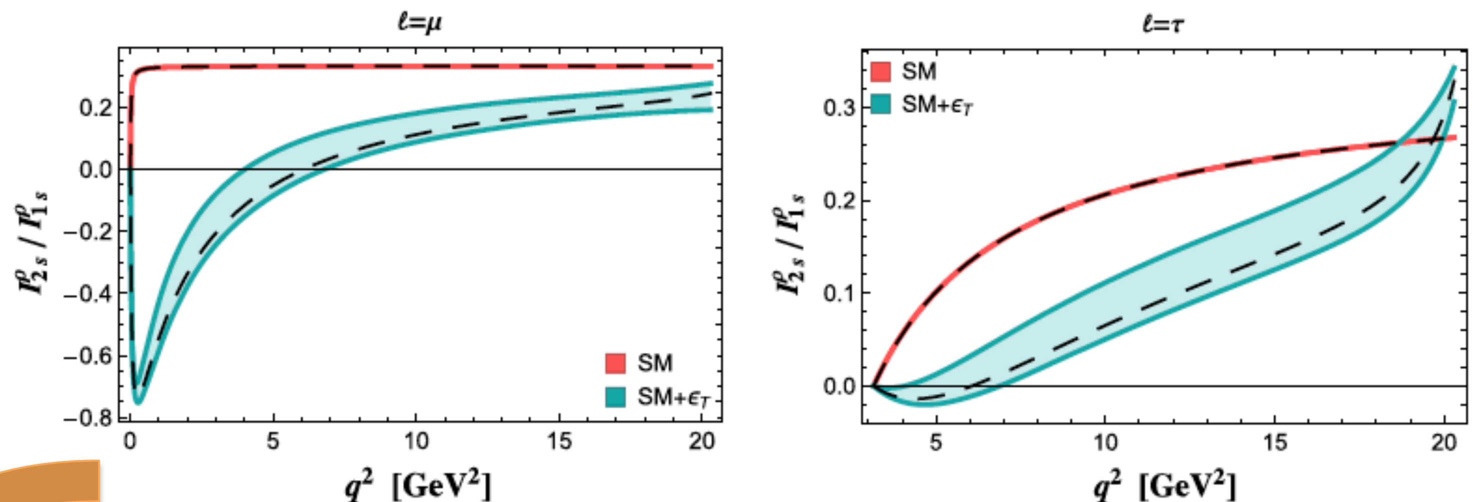
$B \to \rho \ell \bar{\nu}_\ell$

In the Large Energy limit B -> ρ FF depend only on two functions $\xi_\perp^\rho$, $\xi_\parallel^\rho$

Consider the ratios:

$$R^\rho_{2s/1s}(q^2) = \frac{I^\rho_{2s}(q^2)}{I^\rho_{1s}(q^2)}$$

I_{1s}, I_{2s} depend only on $\xi_\perp^\rho$



In the LE limit the position of the zero gives access to ε_T
Both μ and τ modes can be exploited → test of LFUV in NP

$$|\epsilon_T^\mu|^2 = \frac{q^2_{0,\rho}}{16 m_B^2} \frac{\lambda(m_B^2, m_\rho^2, q^2_{0,\rho}) + 2 m_B^2 m_\rho^2}{\lambda(m_B^2, m_\rho^2, q^2_{0,\rho}) + 2 q^2_{0,\rho} m_\rho^2}$$

P. Colangelo, F. Loparco, FDF PRD 2019

b-baryon decays

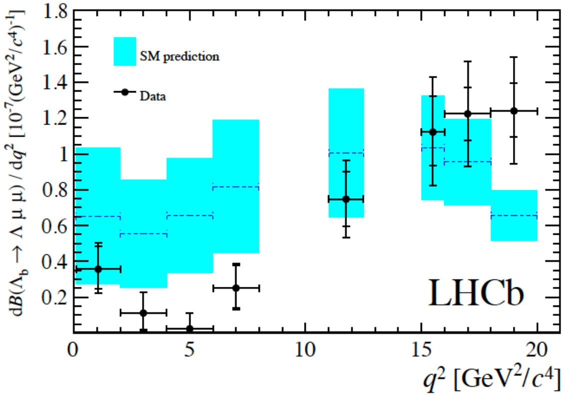
- Investigate correlations to similar processes in meson (B_s, B_c) decays and in b-baryon ($\Lambda_{b,}$ $\Xi_{b,}$ Ω_b) decays

- inclusive widths : use OPE in $1/m_b$

Exclusive b-baryon decays

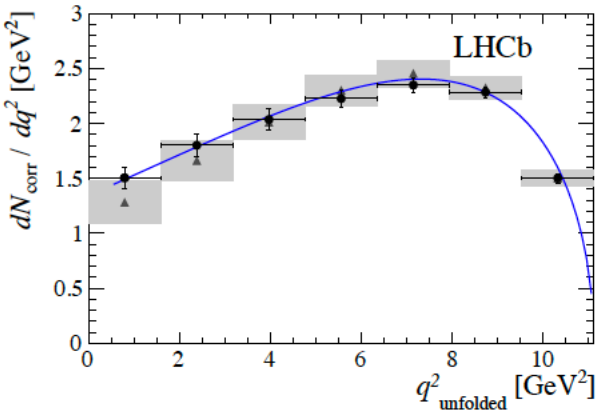
- Less explored than mesons
- Complementary testing ground
- Several results from LHCb for Λ_b baryon

Rare decays (LHCb 2015):
$\Lambda_b \to \Lambda \mu^+ \mu^-$



Th (most recent):
Blake et al. PRD 2020

FF lattice
Detmold & Meinel
PRD 2016



b $\to$c (LHCb 2017):
$\Lambda_b \to \Lambda_c \ell \nu$

FF lattice
Detmold et al PRD 2015

see also C. Davies talk
for recent FF refs

$$R_{pK}^{-1} = \frac{\mathcal{B}(\Lambda_b^0 \to pK^- e^+ e^-)}{\mathcal{B}(\Lambda_b^0 \to pK^- J/\psi(\to e^+ e^-))} \Bigg/ \frac{\mathcal{B}(\Lambda_b^0 \to pK^- \mu^+ \mu^-)}{\mathcal{B}(\Lambda_b^0 \to pK^- J/\psi(\to \mu^+ \mu^-))} = 1.17^{+0.18}_{-0.16} \pm 0.07$$

LHCb JHEP 2020

Polarization: in principle source of other observables
In practice Λ_b produced unpolarized at LHCb
Measurement at production: P_b=0.06 +- 0.09 PLB 2013
See also LHCb JHEP 06 (2020) 110

Λ_b fully differential inclusive semileptonic width

Identification of observables sensitive to Λ_b polarization and to BSM effects
(Longitudinal polarization expected for Λ_b resulting from b quark produced in top or Z^0 decays)

$$\boxed{\frac{d\Gamma(\Lambda_b \to X_U \ell \bar{\nu}_\ell)}{d\cos\theta_P} = A_\ell^U + B_\ell^U \cos\theta_P}$$

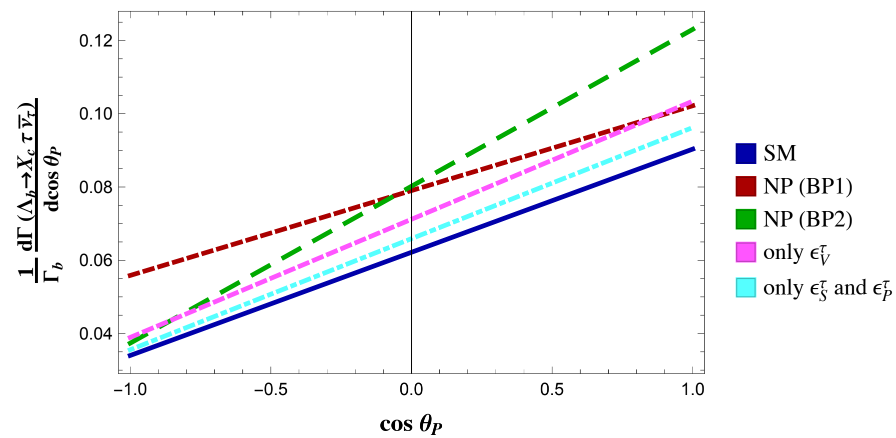
angle between
ℓ^- direction and Λ_b spin

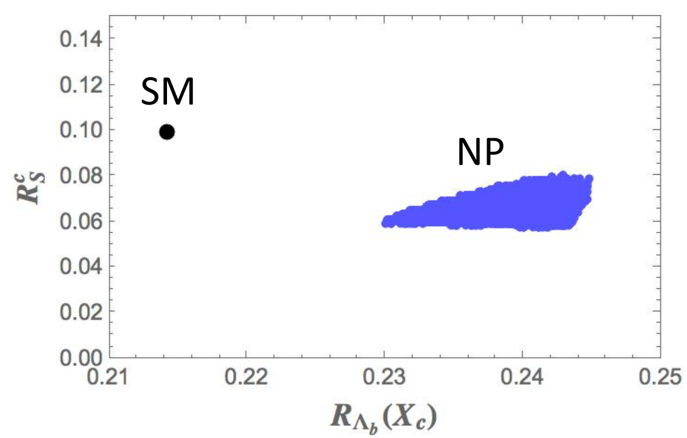
$$\boxed{R_{\Lambda_b}(X_U) = \frac{A_\tau^U}{A_\mu^U}}$$

$$\boxed{R_S^U = \frac{B_\tau^U}{B_\mu^U}}$$

analogous to $R(D^{(*)})$ does not require considering polarization

slope ratios for $\ell=\tau$ and $\ell=\mu$





Clean but hard to measure at LHC
Future lepton facilities

P. Colangelo, F. Loparco, FDF
JHEP (2020), arXiv:2006.13759

Yet another possibility…

Introduce a new heavy Z' with

- Flavour non universal quark and lepton couplings
- Cancellation of gauge anomalies
  involving simultaneously quarks and leptons of the 3 generations
- Very few new parameters: $M_{Z'}$, $g_{Z'}$, + 2 new charges

Particle content: SM fermions + 3 RH neutrinos
Fermion charges under U(1)':

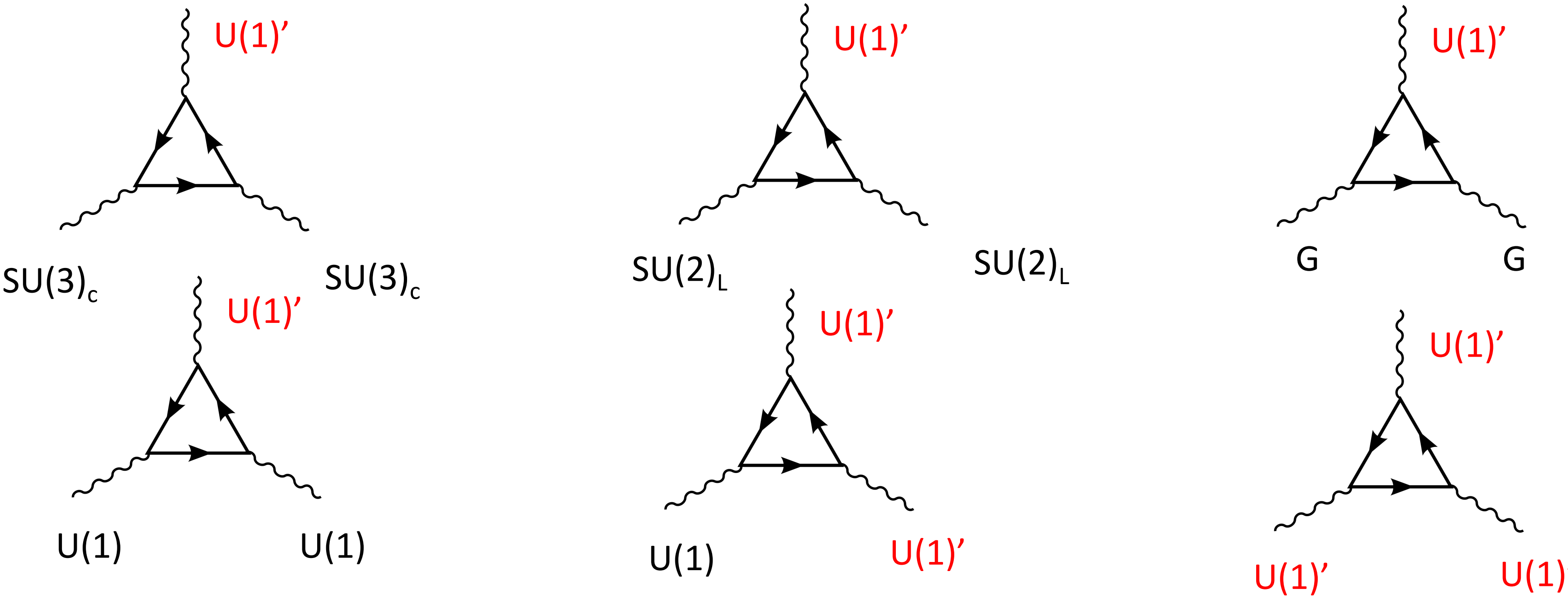
$$z_{f_i} = y_f + \epsilon_i$$

$f = q,\, u,\, d,\, \ell,\, e,\, \nu$

i=1,2,3 generation index

SM hypercharge

Yet another possibility…



Anomaly cancellation constrains the couplings of fermions to Z'

$$\boxed{\epsilon_3 = -\epsilon_1 - \epsilon_2}$$

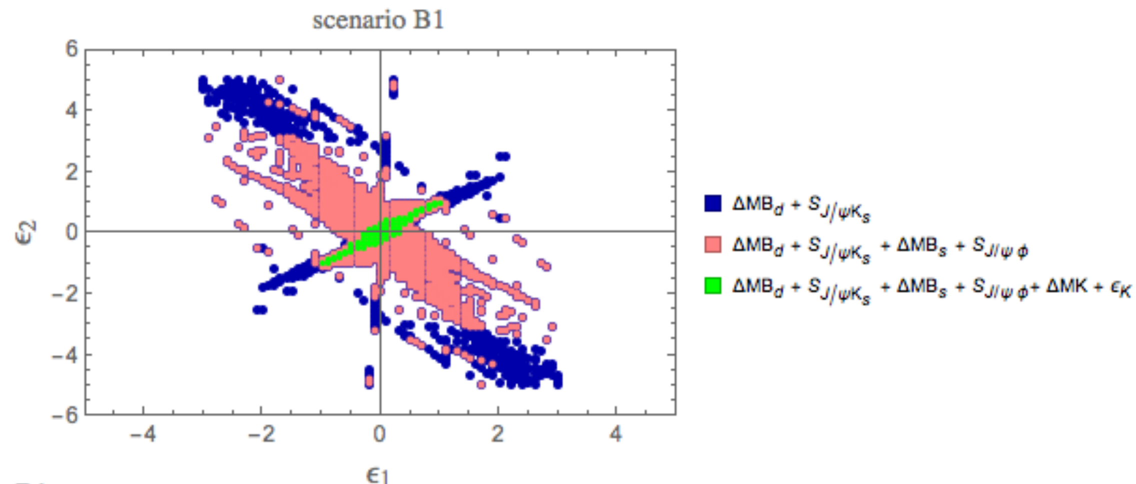
- Data constrain ε_1 and ε_2
- Correlations between lepton and quark flavour observables are found

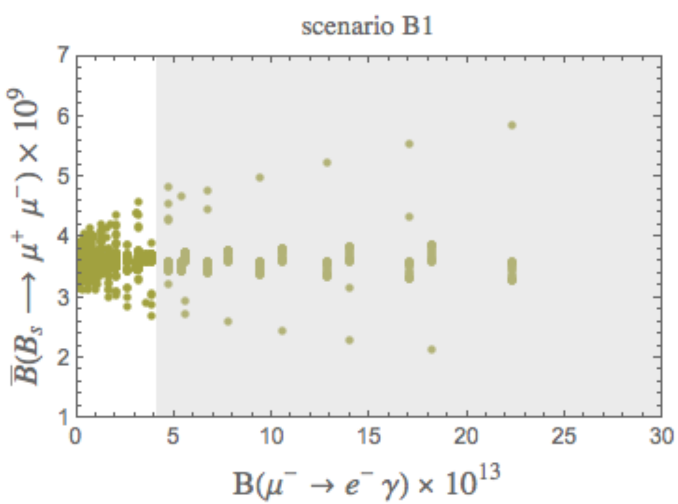
J. Aebischer, A.J. Buras, M. Cerda-Sevilla, FDF
JHEP02 (2020) 183

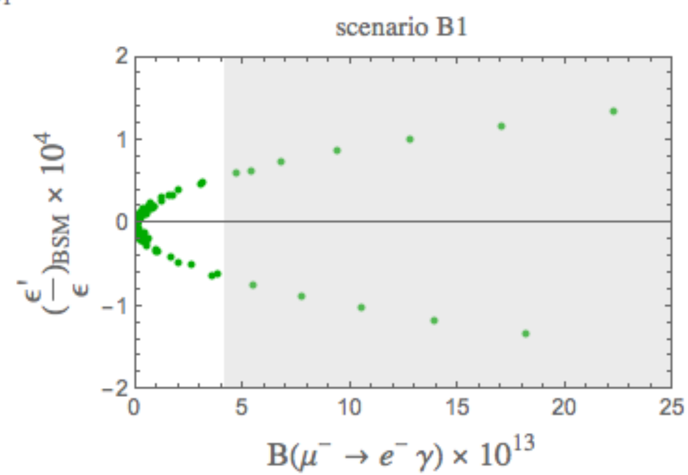
Yet another possibility…

Main feature of the model:

- observables can individually largely deviate from SM
- quark and lepton sectors mutually act to prevent each other from large deviations







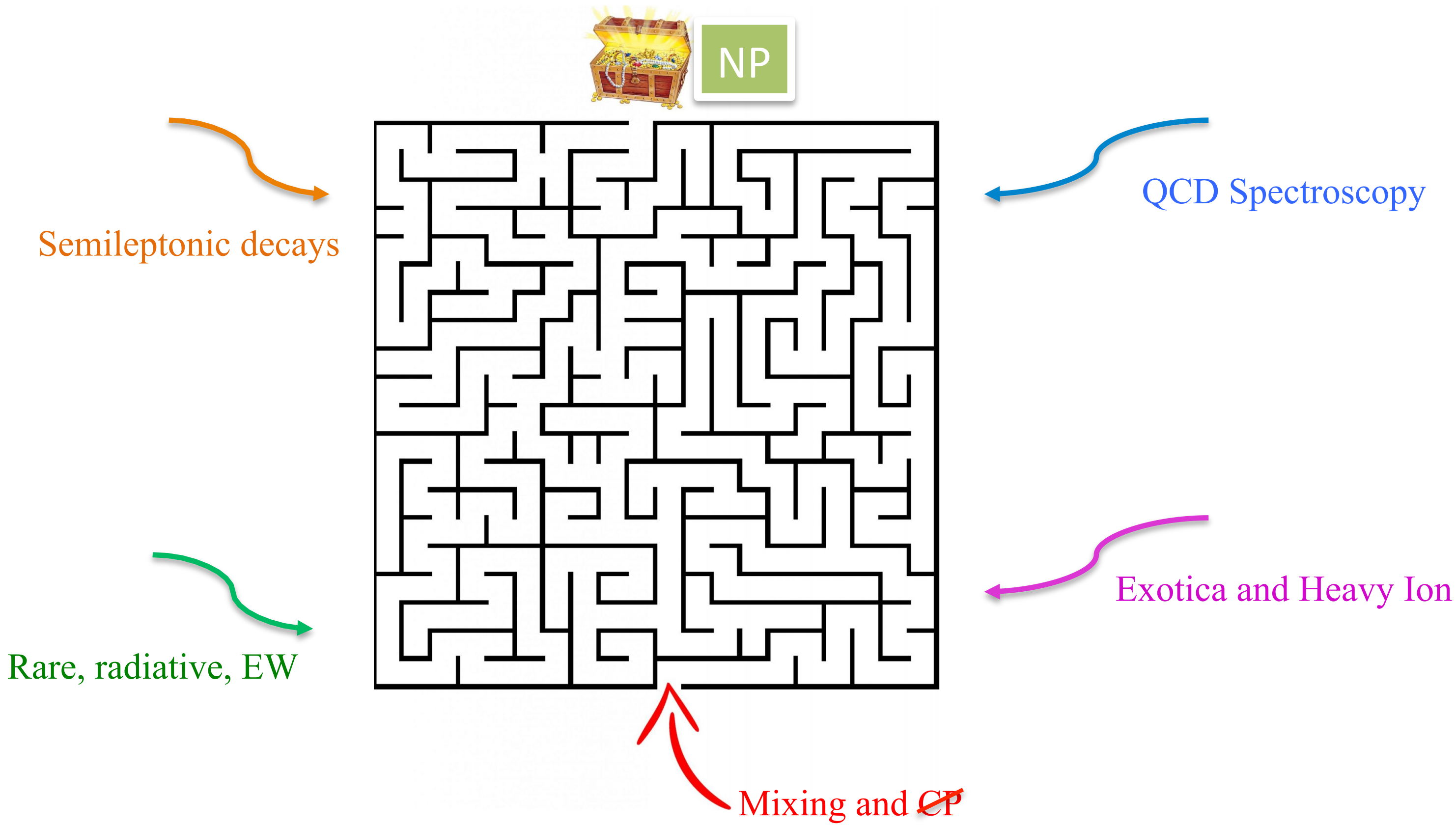
J. Aebischer, A.J. Buras, M. Cerda-Sevilla, FDF
JHEP02 (2020) 183

Conclusions

The 5 streams in this workshop represent 5 crossing paths to NP

Anomalies found in different sectors of particle Physics
excellent results from LHCb!

- It's no more time to look for NP in just one *stream*
- Correlations among different and previously unrelated sectors



End of 2020 Workshop

Looking forward 2021 edition at CERN!!
Thank you