Current activities and future interests in Roma: LHCb

A. Sarti on behalf of the LHCb - Roma1 group

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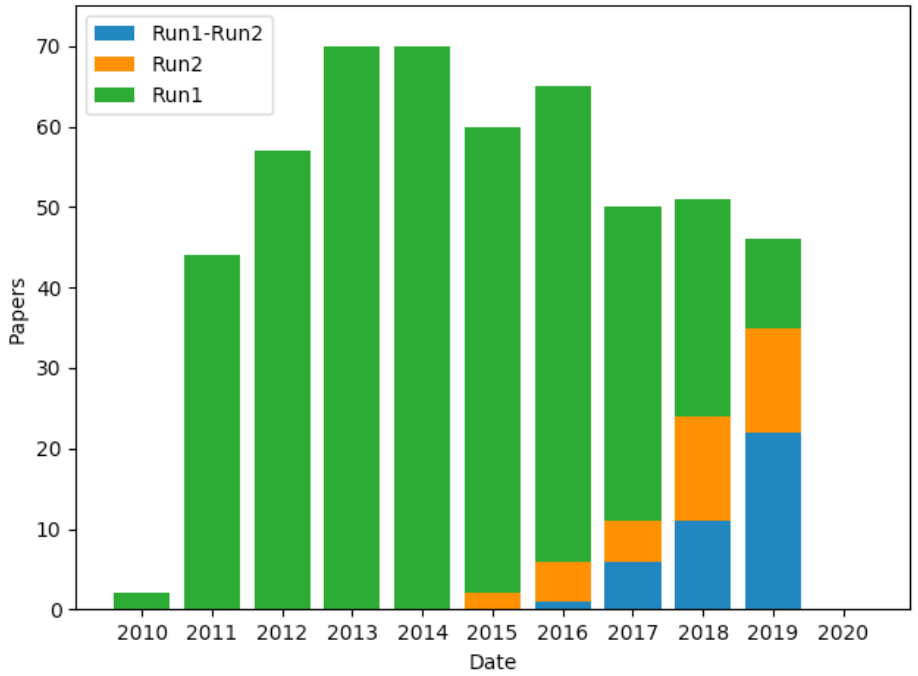
LHCb status

- In 2018 LHCb ended a successful (Run 1 + Run 2) data taking! ~10/fb on disk; installation and commissioning of the upgraded detector on going full steam
- LHCb measured a lot of "SM results" and some intriguing discrepancies wrt the SM.
- More than 500 papers published! Completion of Run 1+Run 2 data analysis can shed light on beyond SM physics. Full dataset is now equivalent to 5× more b-hadrons than Run 1

Published results per year



- Many results only statistically limited.

- Phase-I upgrade aim at collecting 10× more data with 20× more hadronic events:
  - - fully software 40 MHz trigger, - redesign most of sub-detectors, for 5×-10× peak luminosity

The LHCb group

- V. Bocci (10%), S. Kotriakhova (100%), G. Martellotti, D. Pinci (50%), R. Santacesaria (100%), A. Sarti (70%), C. Satriano (100%)
  - **D. Pinci : Deputy Muon Project Leader**
  - S. Kotriakhova: **Muon** Upgrade Electronics Commissioning Coordinator
- Common main interest/focus/involvement: **muon detector**. Nearly all the different aspects are covered by the group (detector, slow control, DAQ, event reconstruction, PID, analysis)..
  - A lot of know-how in μ-based analyses that produced, so far, results that are among the most cited in LHCb (e.g. $B_s \rightarrow \mu\mu$, BF($B \rightarrow X(3872)K^-$),..)
- **Will focus on 'active' data analysis**.. But a lot of other work is ongoing: experiment slow control, muon detector upgrade (design, simulation electronics..)..
  - And we are not that many.. (will come back on that, later..)

Data analysis

Active

- Exotic charmed states searches (tetraquarks):
  - Profiting from the experience gained in the study of Z(4430) [reconstructed from the $\psi(2s)\pi$ mass spectra] .. currently working on the search of X(3872) $\rightarrow$ J/ψ ω decay in a large $B^+ \rightarrow K^+$ J/ψ ω data sample [allows to better understand the nature of X(3872) and solve the J/ψ ω and J/ψ ϱ puzzle]

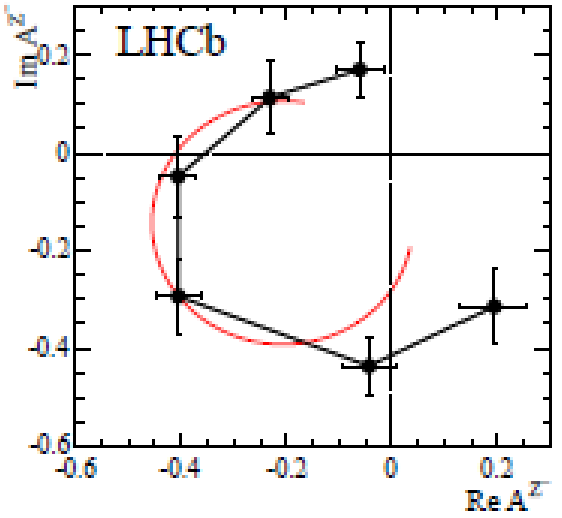
Potential / Starting

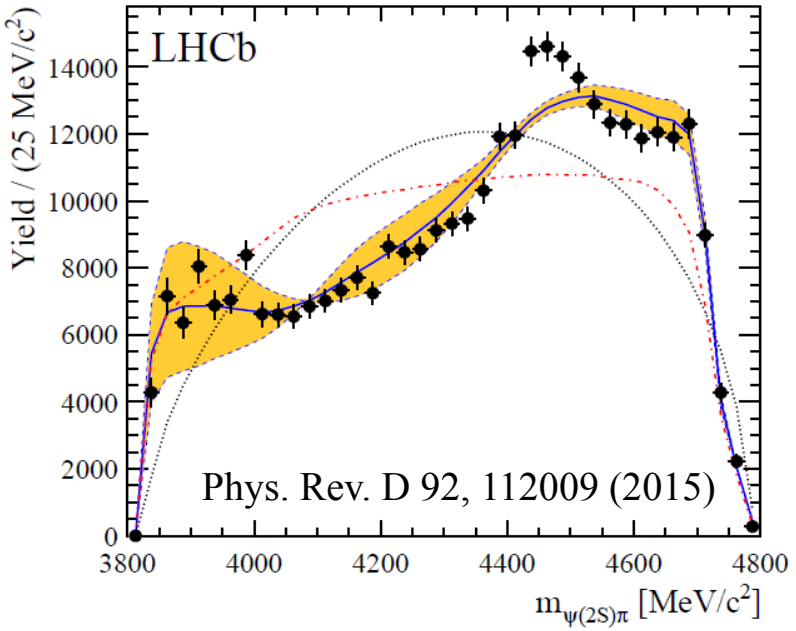
- Rare decays
  - Study of rare decays that have high impact in NP searches (e.g. $B_{s,d} \rightarrow \mu^+\mu^-$), LFV/LU with b-baryons and LFV (τ in 3μ)
- Semileptonic decays
  - Testing tree- and loop-level processes in B and Λ decays for NP searches.

Z(4430)

- Potential for exotic searches proved with Z(4430) studies:
  - The complete angular analysis of the $\pi\psi(2s)$ candidates was used to determine the resonant nature of the Z(4430) and measured its spin (1^+)
  - The shape of the M($\pi\psi(2s)$) spectrum in the $B_0 \rightarrow K\pi\psi(2s)$ decay cannot be easily explained by the reflections in the angular structure of the $K\pi$ system. The significance of the discrepancy depends on the Legendre momenta configuration that is assumed and ranges in the 8-15σ interval

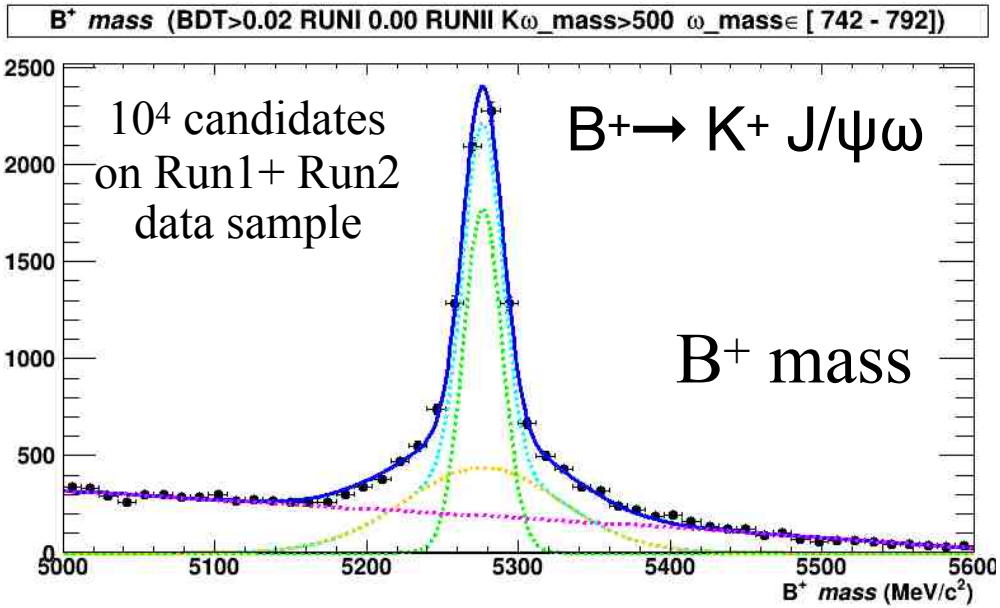
Phys. Rev. Lett. 112, 222002 (2014)

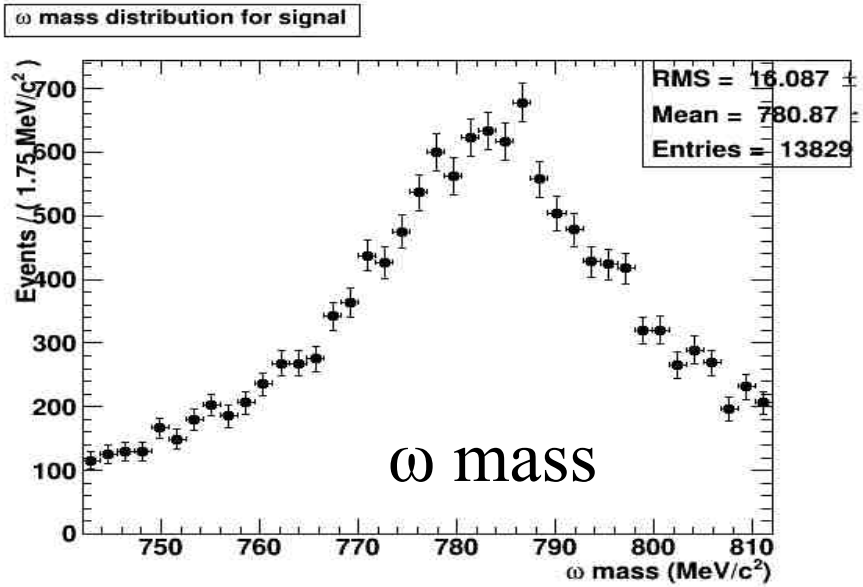




X(3872)→J/ψω search

- Status
  - Observed in BaBar. Belle reported evidence in conf. paper, never published
  - observed by BESIII (arXiv:1903.04695v1) in $e^+e^- \to \gamma\, J/\psi\, \omega$ with 5σ significance
- Feasibility @ LHCb:
  - Subthreshold decay: $M_{(J/\psi)} + M_\omega = 3879.5\ \mathrm{MeV}/c^2 > M_{(3872)}$, $\Gamma_\omega = 8.5\mathrm{MeV}/c^2$ → able to see
- We are interested to low ω mass, to reduce background we keep only $M(\omega)<792\ \mathrm{MeV}/c^2$



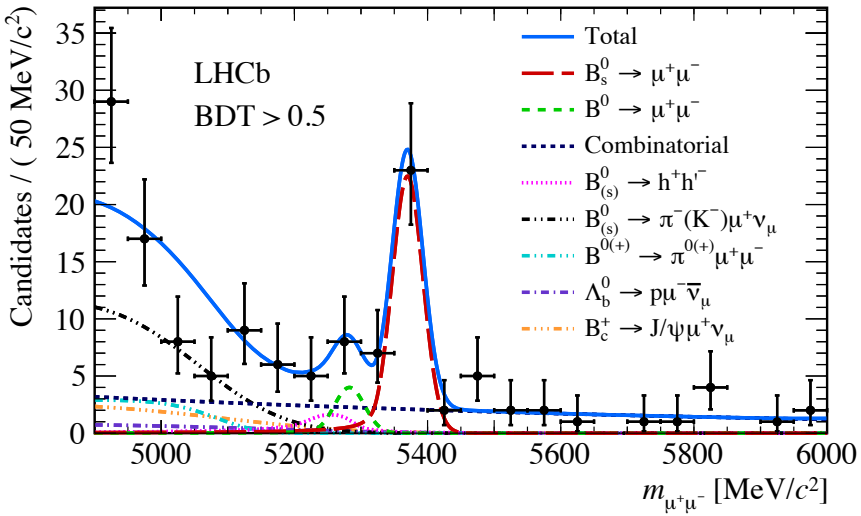


Rare decays. B → μμ..

[See talk from F. Archilli this morning]

- $B_{d,s} \rightarrow \mu\mu$:
  - Gained experience in all the aspects of the measurement (decay selection, efficiencies evaluations, background estimates, statistical treatment of the data, fit,…)
  - B_s update is expected for FPCP
  - The B_d era is approaching, P(50%) of 3σ in the next round ..

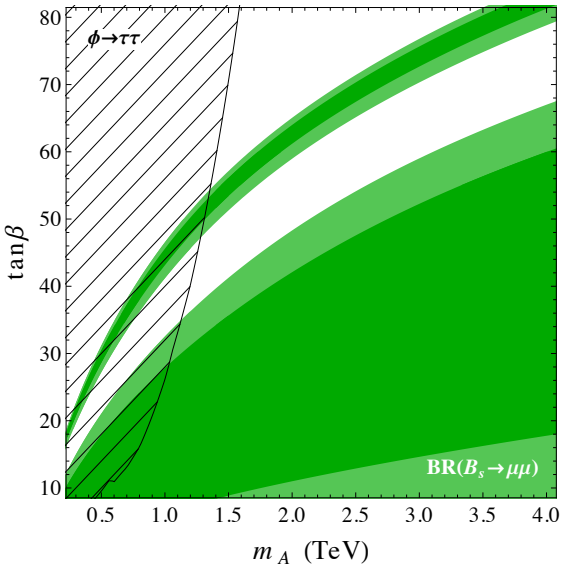
"The" observation



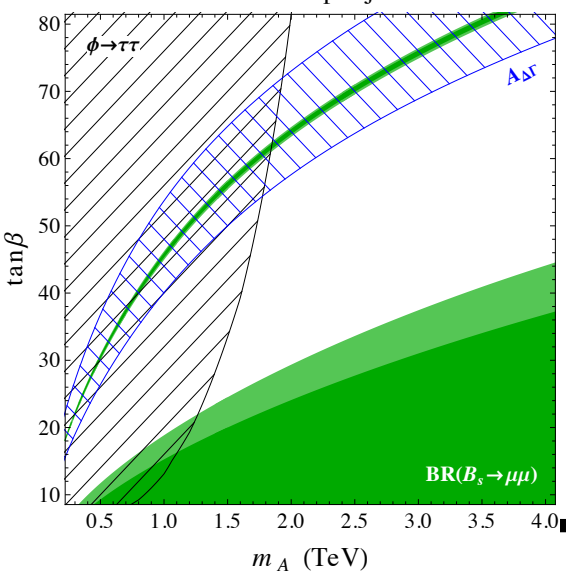
Significant impact on MSSM constraints

Complementary to direct searches of ττ resonances

present status



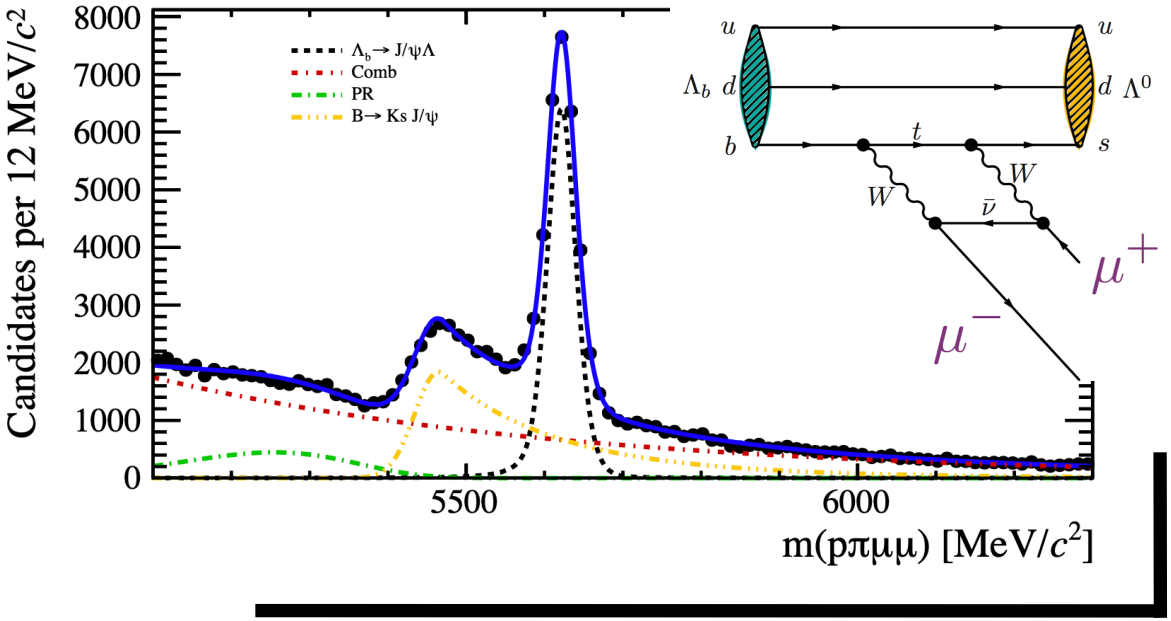
LHCb Run 4 projection



LU & LFV with Λ_b decays

[See talk from F. Archilli this morning]

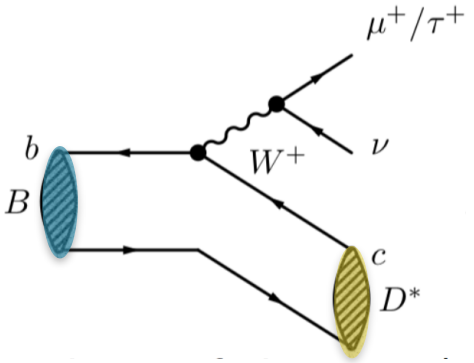
- Gained experience in the selection of $\Lambda_b^0 \rightarrow \Lambda^0 l^+l^-$ decays (different helicity structure with respect to the $B \rightarrow K l^+l^-$ decays)
  - Opened the path towards $R(\Lambda_b^0)$ measurements, as well as direct LFV measurements looking for $\Lambda_b^0 \rightarrow \Lambda^0 e^+\mu^-$ …
  - $\Lambda_b^0 \rightarrow \Lambda^0 e^+e^-$ aim for observation with two q^2 bins: [0.1,6] and [15,20] GeV^2 .. ~60 events expected with Run 1 + 2015 + 2016 data
- For the μμ and ee channels: Still working on
  - MVA optimisation
  - Background estimates
  - PID efficiencies…
- For the eμ channel: trigger and MVA studies ongoing



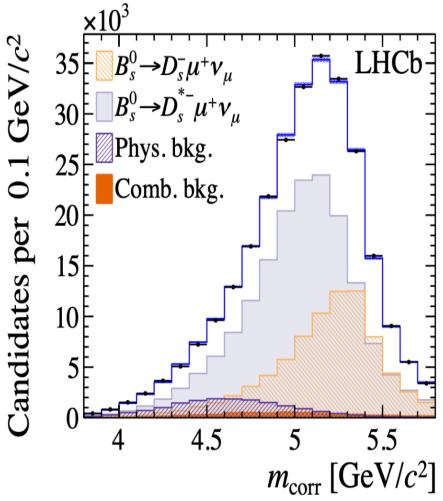
Semileptonic B decays

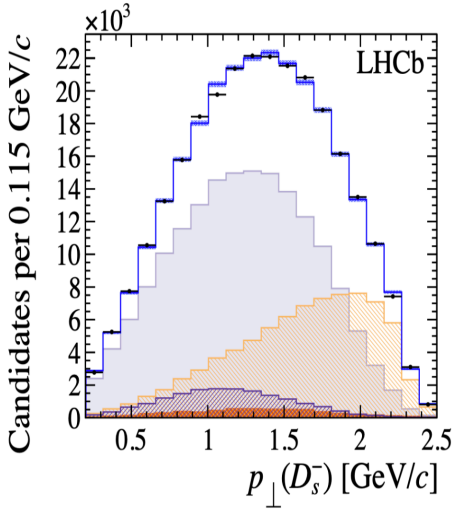
[See talk from M. Rotondo this morning]

- Searches of anomalies for processes occurring both at tree and loop level.. Here the main interest is related to the existing measurements showing a tension @ 3σ level..
  - Loop level.. Lambda decays (see previous slide)
  - Tree level. Ratio of decay width in the following two decays: $B_s \rightarrow D_s^* \tau \nu_\tau$ and $B_s \rightarrow D_s^* \mu \nu_\mu$. Here the ratio helps in canceling out some systematic uncertainties and provides a robust observable to loop for NP effects



  - The ongoing efforts are mainly related to the study of the backgrounds from Ds** decays, charmed decays of Bs and B decays; to the fitting strategy and to the combined Ds, Ds* analysis





Future prospects

- There is plenty of potential for a significant contribution in producing high impact results. A lot of 'hot topics' in heavy flavour physics that are doable @ LHCb are 'open' for contribution from the Roma1 group…
  - Luca 10, 2 "The harvest is plentiful, but the workers are few"
- The main / common ingredient to all the efforts is the presence of μ in the final states. Here, the Roma1 group has gained a lot of know how..
  - .. and is contributing to the LHCb physics program in the production of several key results (spectroscopy, rare decays, semileptonic decays)…
  - **The collaboration with other experiments and theorists and the involvement of PhD and grad students will help in improving the quantity and quality of the results**!