MSc projects in LHCb

Exciting states of D_s mesons

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VU VRIJE UNIVERSITEIT AMSTERDAM

Nikhef

LHCb

Who am I?

- BSc from UCR, Middelburg
- MSc at UvA/Nikhef
- PhD in Manchester
- PostDoc in Frascati

→ mainly LHCb data analysis

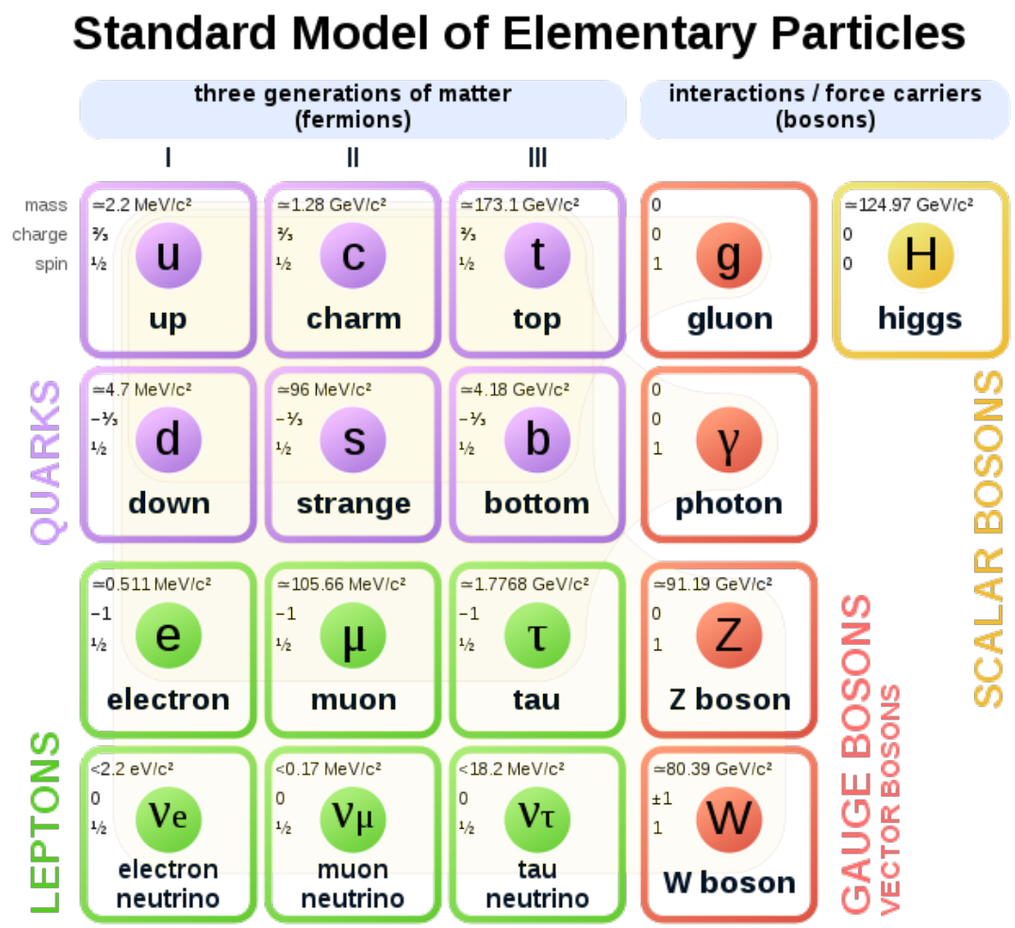
- PostDoc at VU/Nikhef (Veni)

→ also software development and data quality monitoring

Lepton flavour universality

In the SM there are three families of fermions:

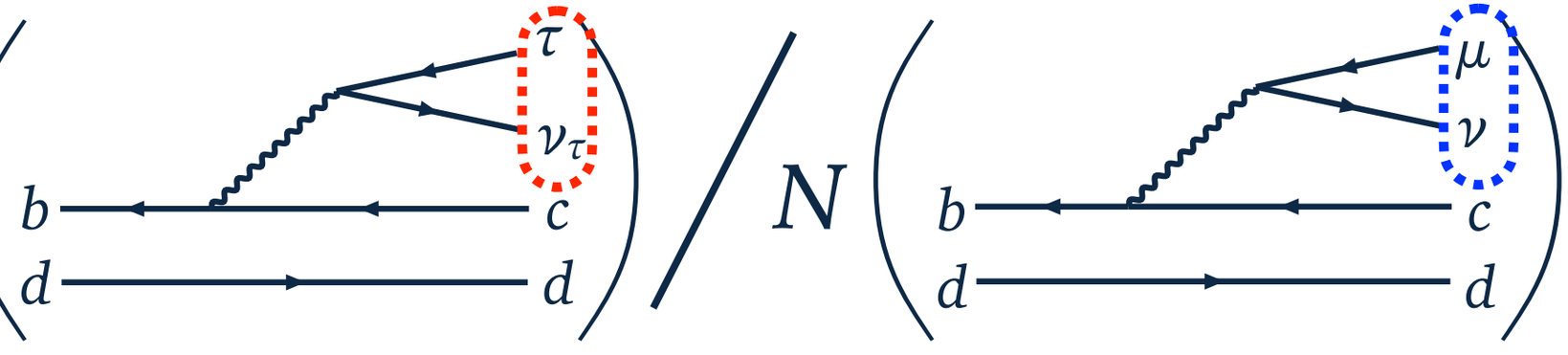
- same gauge charge assignments → same coupling (**universality**)
- only difference from the Yukawa couplings with the Higgs field, resulting in **CKM** and **PMNS** matrices and **different masses**
- measure lepton universality in **ratios**: CKM elements cancel, and only difference is in **lepton mass**



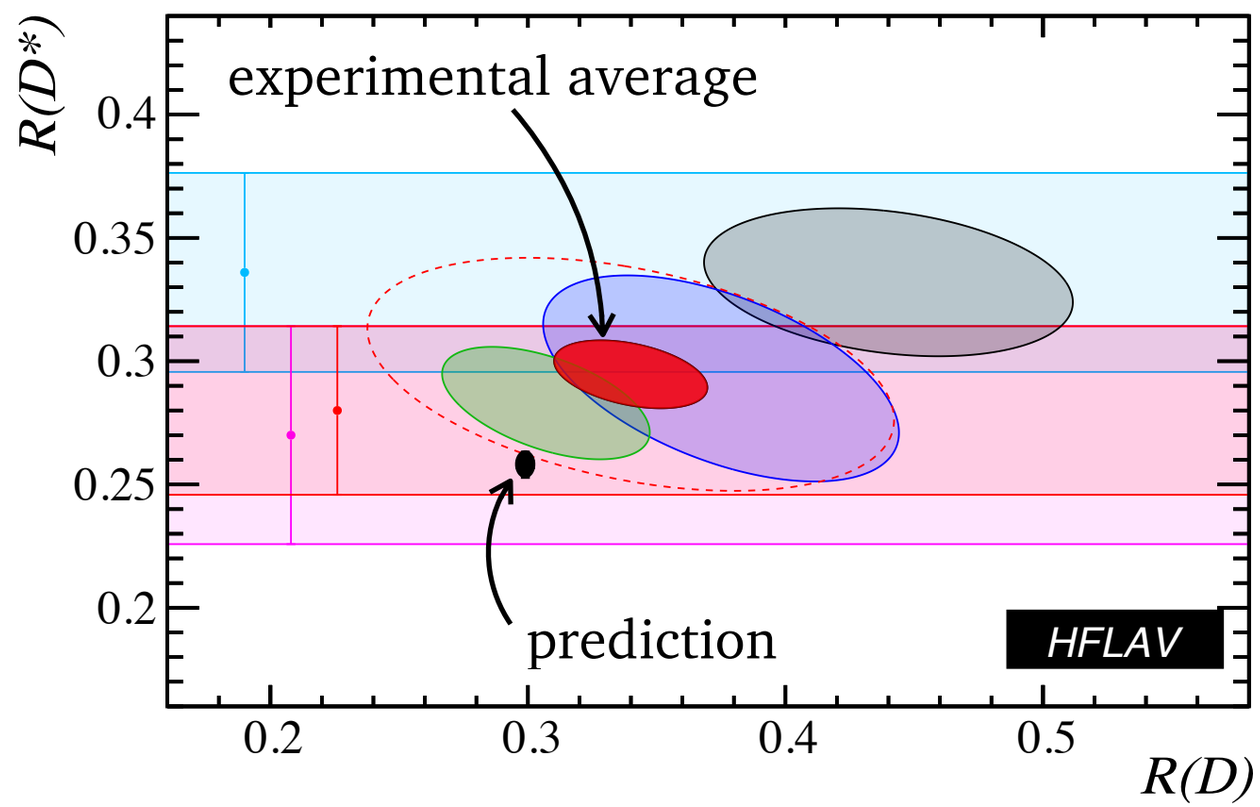
Overview *R(D)*

$$\mathcal{R}(D^*) = \frac{\overline{B}^0 \to D^{*+}\tau^-\overline{\nu}_\tau}{\overline{B}^0 \to D^{*+}\mu^-\overline{\nu}_\mu}$$

$$R(D) = N\left(\right. \quad \Big/ \quad N\left(\right.$$



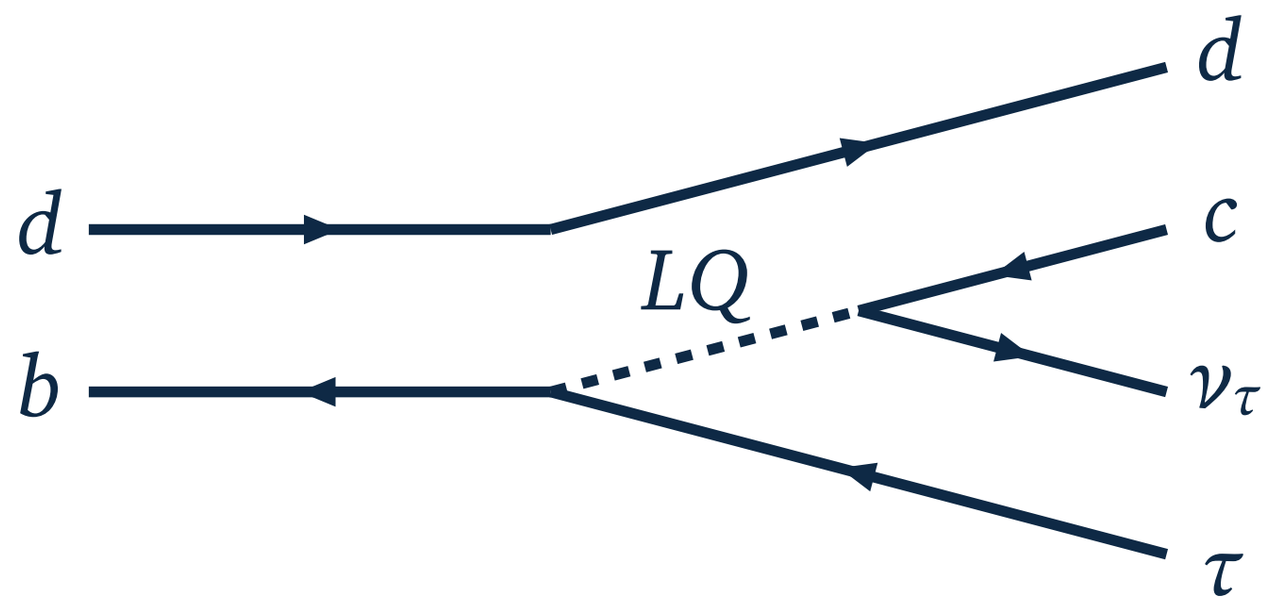
- $R(D) \neq 1$, because $m_\tau \neq m_\mu$
- Tree-level processes are sensitive to new physics.
- Predictions are theoretically clean.
- 3-4σ tension with the SM for $R(D)$-$R(D^*)$.



https://hflav-eos.web.cern.ch/hflav-eos/semi/spring19/html/RDsDsstar/RDRDs.html

Where does tension come from?

- Could there be **new physics**?
- What could this be? Z'? Leptoquarks?

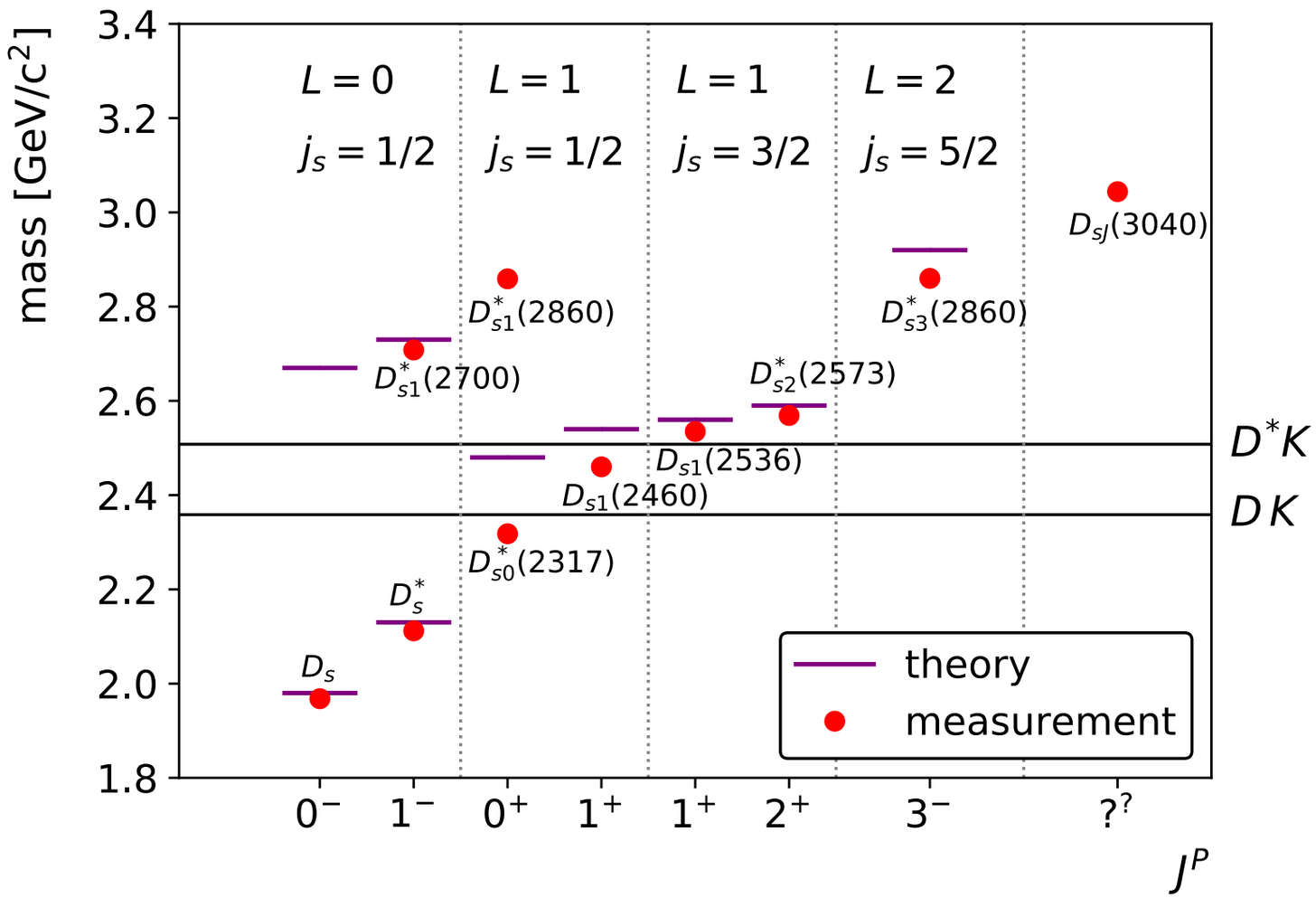


- More measurements needed! :)
  - other ratios: use B_s decays instead of B
  - different quantities, different types of particles

MSc project

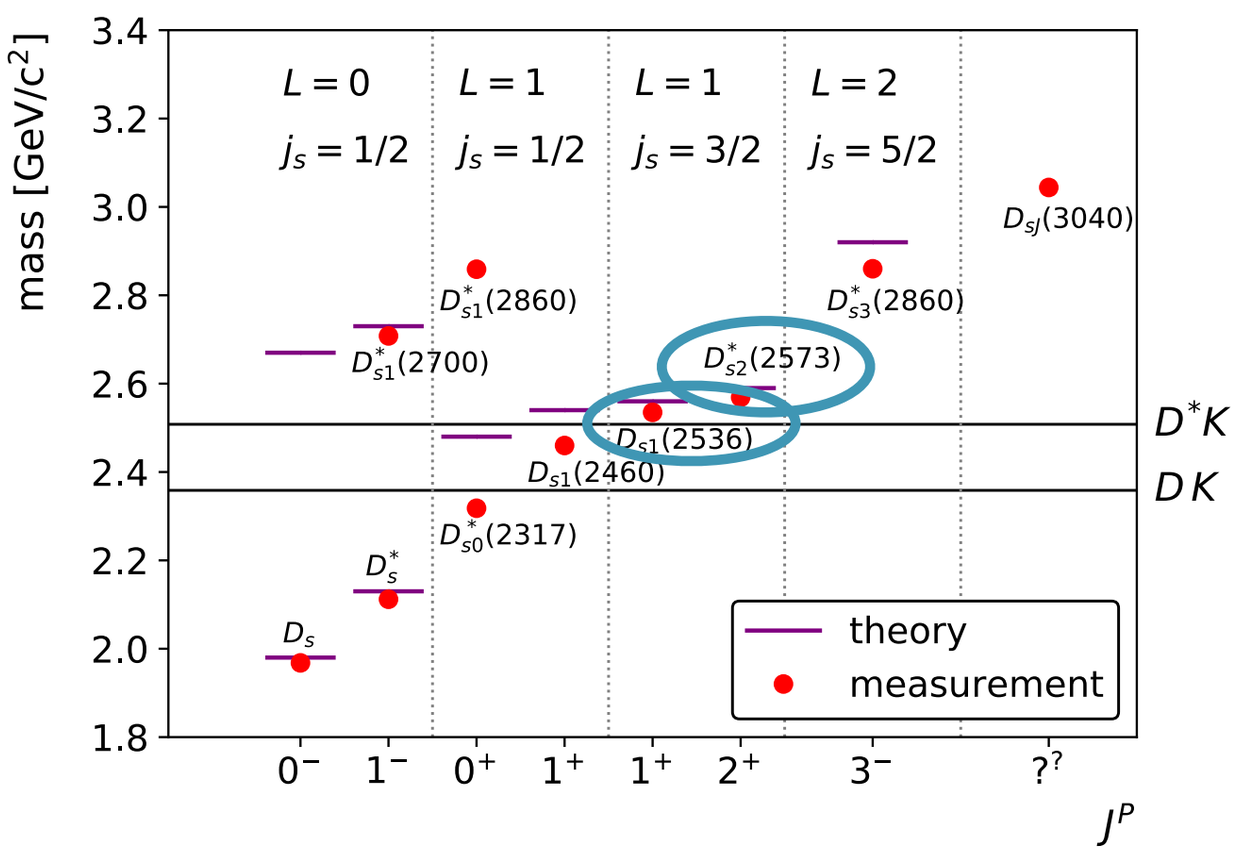
Excited states of D_s mesons

- Analogous to hydrogen atom, mesons can have radial and orbital excited states



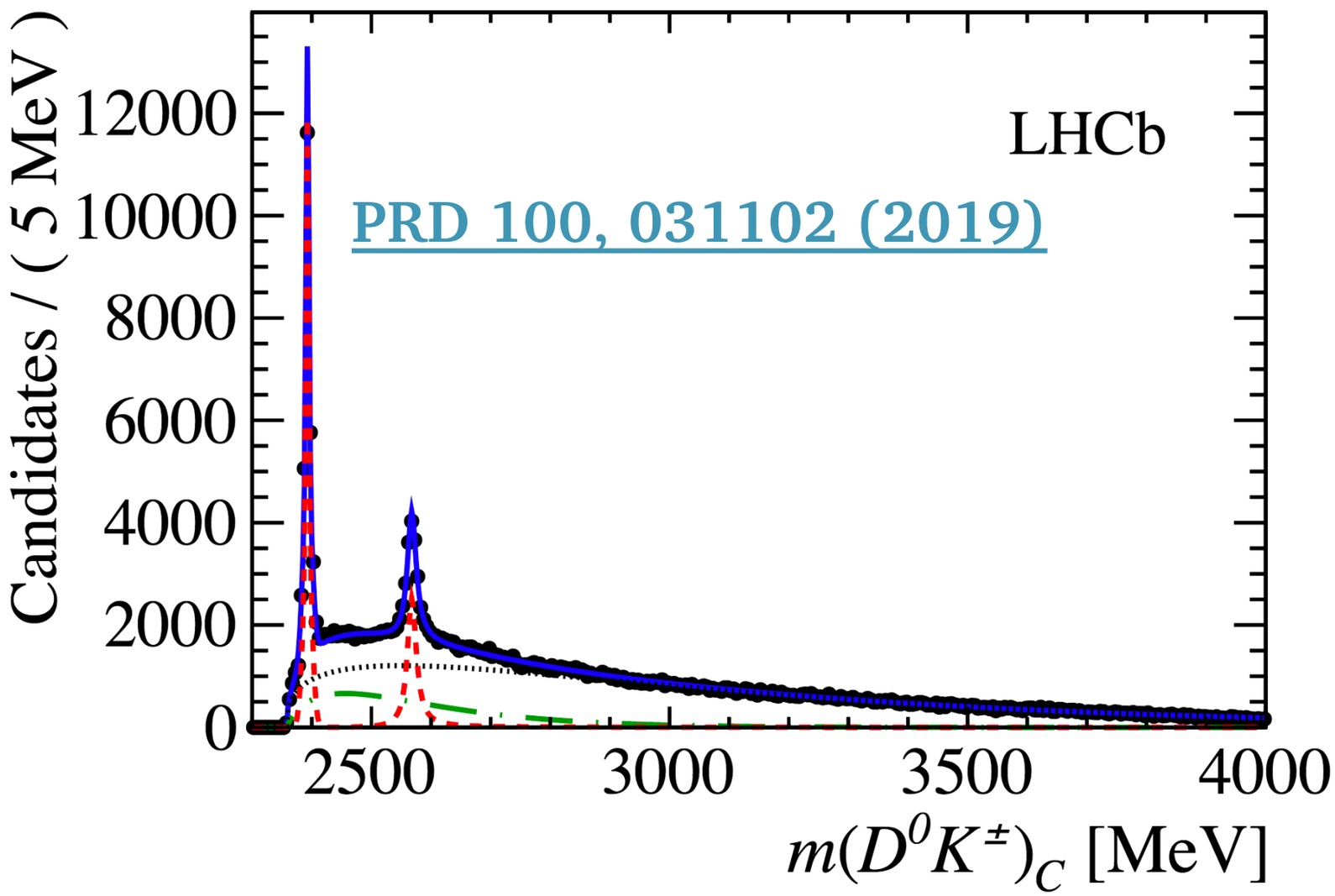
$R(D_s^{**})$

- Excited (radially and/or orbitally) states have access to different new physics couplings PhysRevD.95.014022
- Best place to look for it is in B_s decays
  - sharp, narrow peaks
- Ratio with $B_s \to D_{s1}(2536)\tau\nu$ and $B_s \to D_{s2}^*(2573)\tau\nu$
- New type of measurement
- Feasibility study



$R(D_s^{**})$

- Decay to D^0K final state: easy to reconstruct and beautifully narrow peaks.



Skills you can learn

- Prerequisites:
  - Particle physics courses, some programming
- To learn:
  - Many!
    - Data analysis
    - Physics
    - Programming: python/C++
    - Machine learning
    - Presenting to experts
    - Be part of a small international team