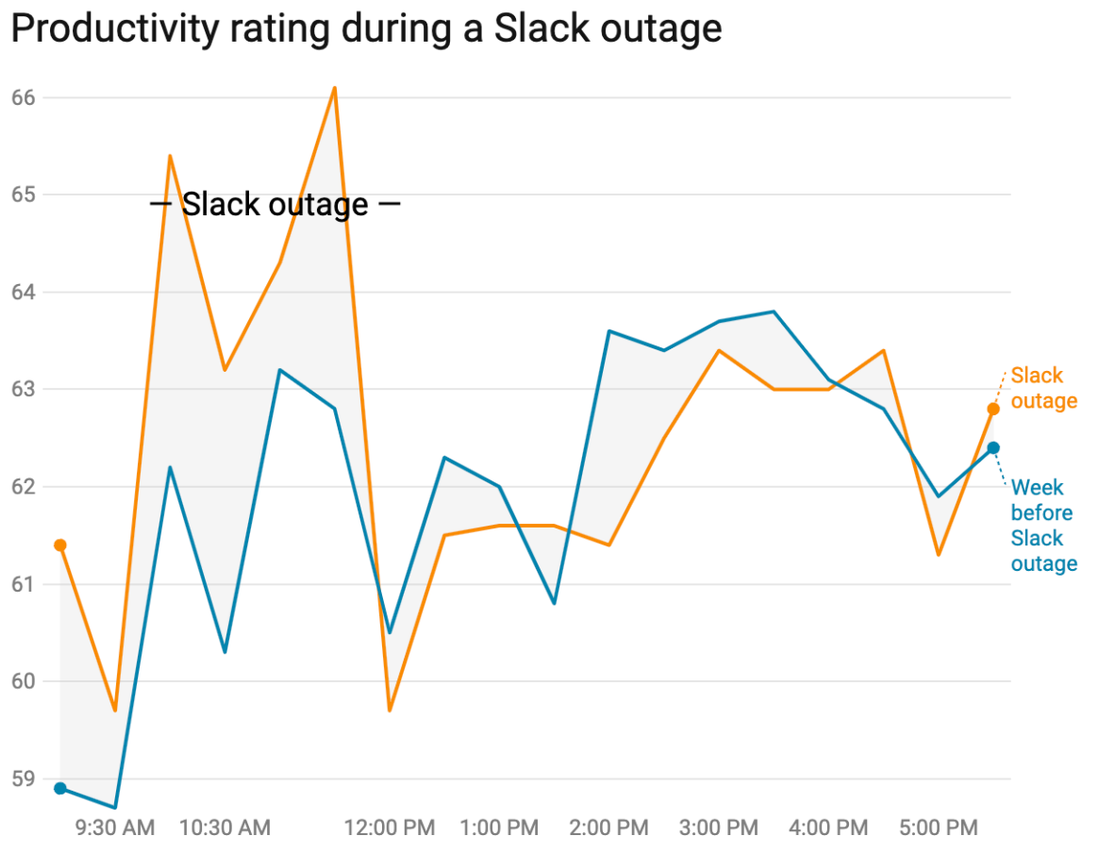
Streamling semileptonic analyses

Challenges of semileptonic decays IV



Measures the relative productivity of the apps RescueTime users used during the June 27, 2018 Slack outage compared with the Wednesday before.

Source: RescueTime

recode BY Vox

Patrick Owen, with contributions from many colleagues **27/09/24**

Introduction

From: Patrick Owen [patrick.haworth.owen@gmail.com]
Sent: 07 June 2016 11:47
To: Julian Garcia Pardinas
Subject: R(D+) info

Hi Julian,

The paper of R(D*) analysis is here

http://arxiv.org/abs/1506.08614

Ana note is here

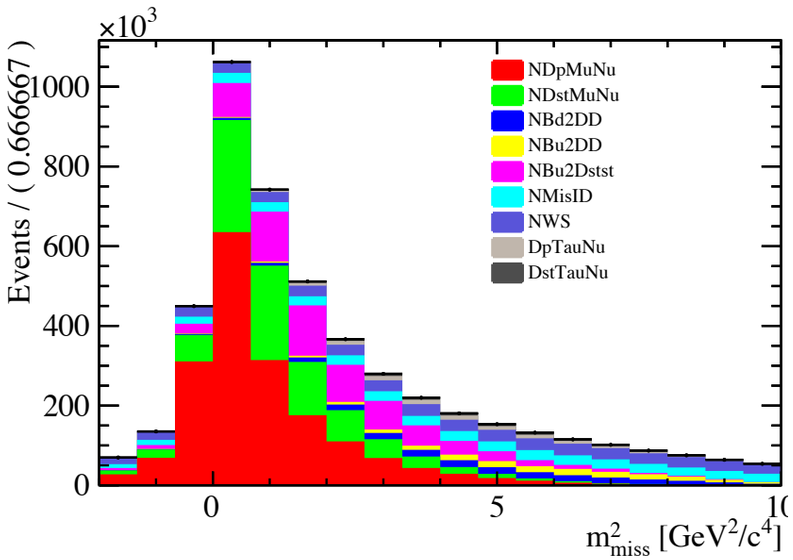
https://cds.cern.ch/record/1697787?ln=en

- Semileptonic analyses take a long time, at LHCb they take > 5 years.
  - Belle-II fairing better.
- The goals of this presentation are to:
  - Promote awareness of increasing difficulty of SL analyses.
  - Discuss some ideas of how improve things.
- Some of this might feel bit LHCb focussed, but its important here:
  - Help provide incentive to improve measurements as well as make them.
  - Maybe we can also learn something from our Belle-II colleagues.

Where is time spent

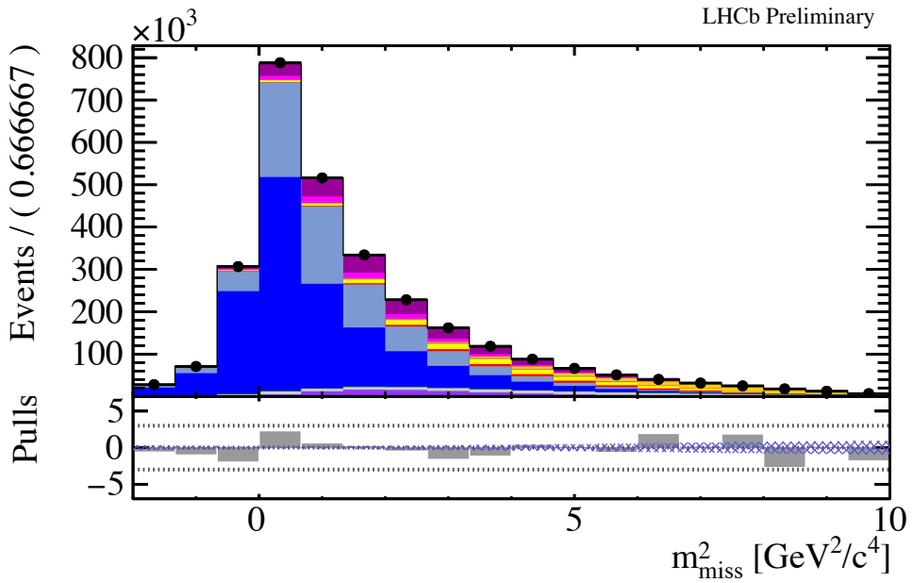
- Two LHCb theses give public glimpse into status of analysis at 2018 and 2021.

2018: J. Garcia Pardinas thesis

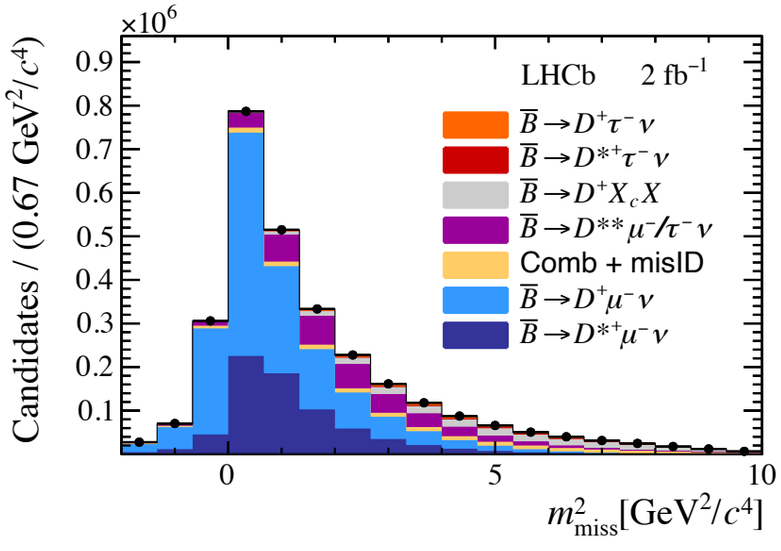


Selection finalised. Simulation of main backgrounds and fit setup.

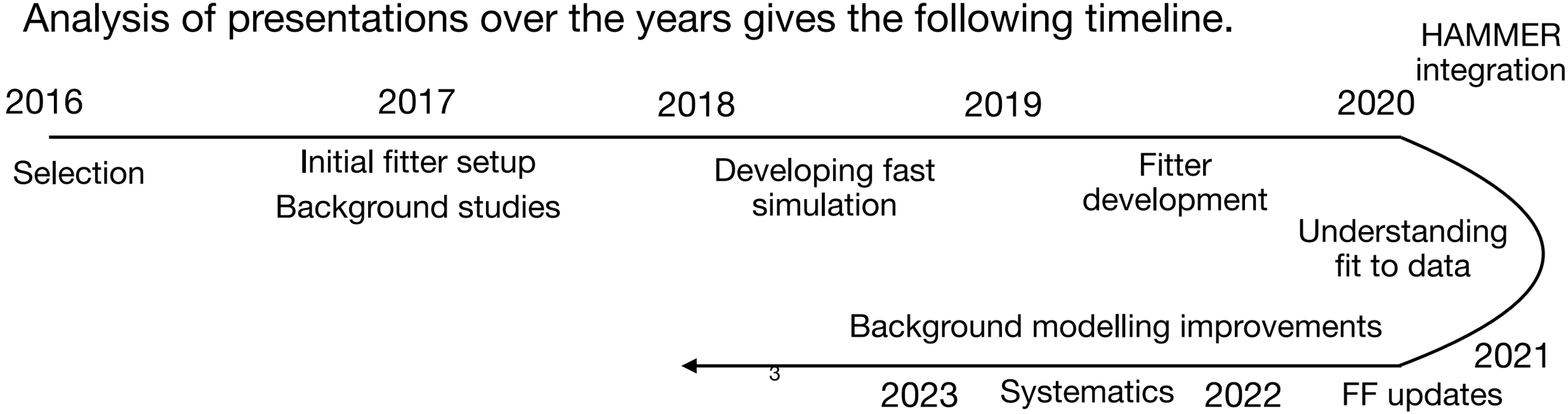
2021: S. Meloni thesis



2024: LHCb paper



- Analysis of presentations over the years gives the following timeline.

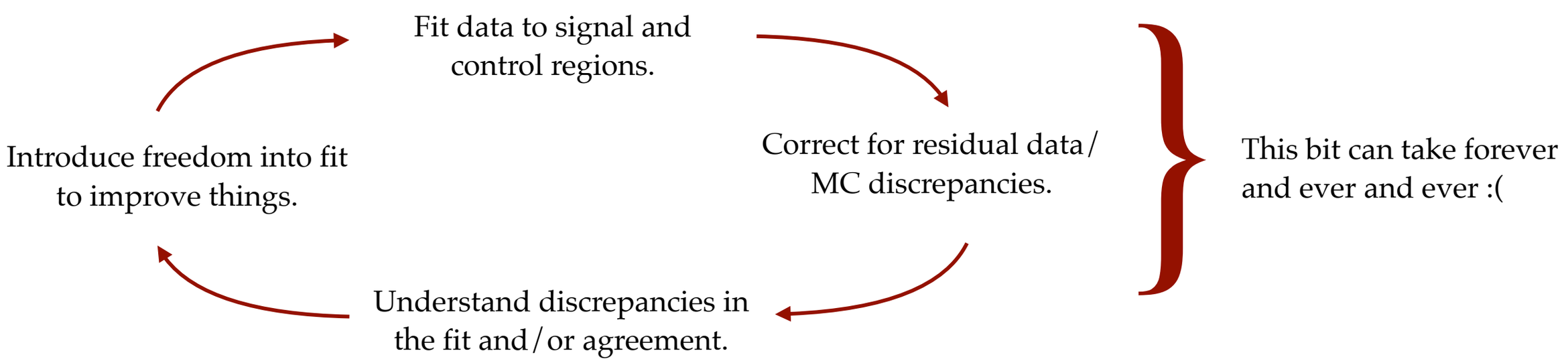


General idea for tauonic analysis

- Making the blue steps faster to get to the red part sooner seems like the easiest way forward.

- Strip data without bias to muon
- Apply trigger selection
- Require muon PID.
- Reduce non X_c background via MVA
- Calculate fit variables.
- Apply standard corrections to simulation.
- Split sample into control regions.

} Steps common to many analyses, normally no nasty surprises.



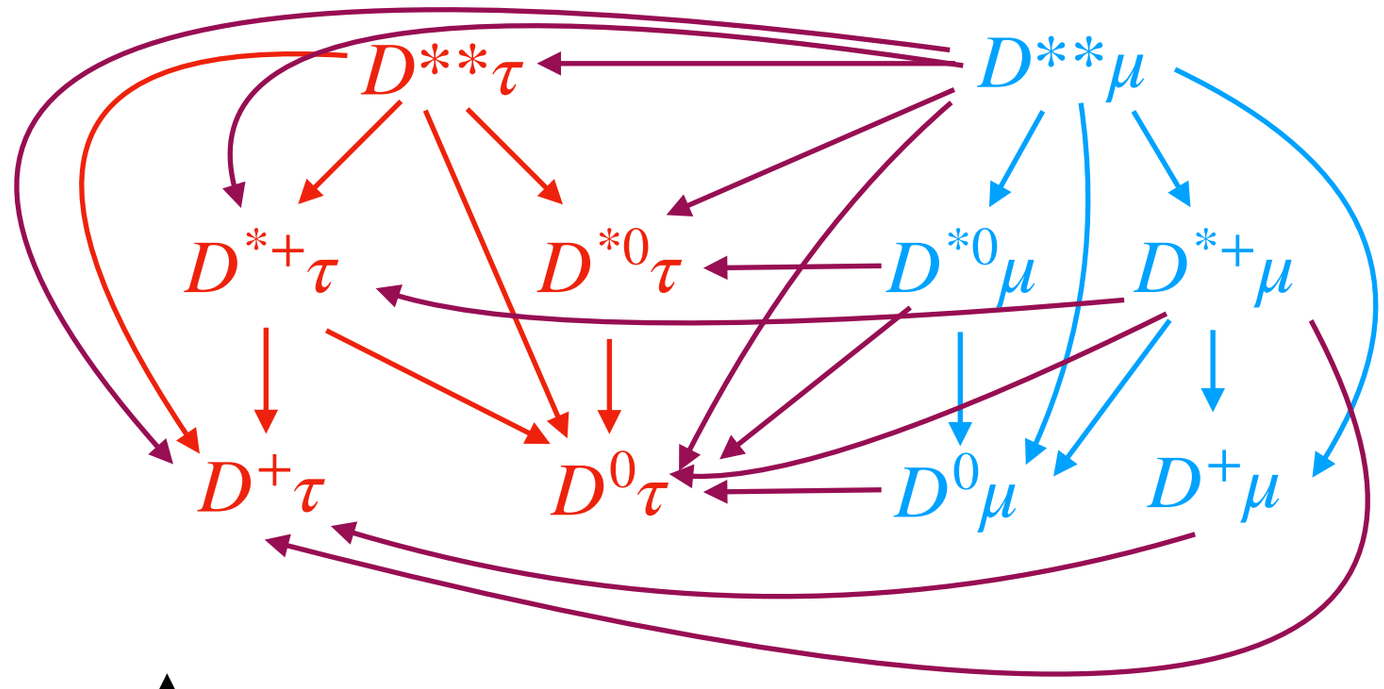
} This bit can take forever and ever and ever :(

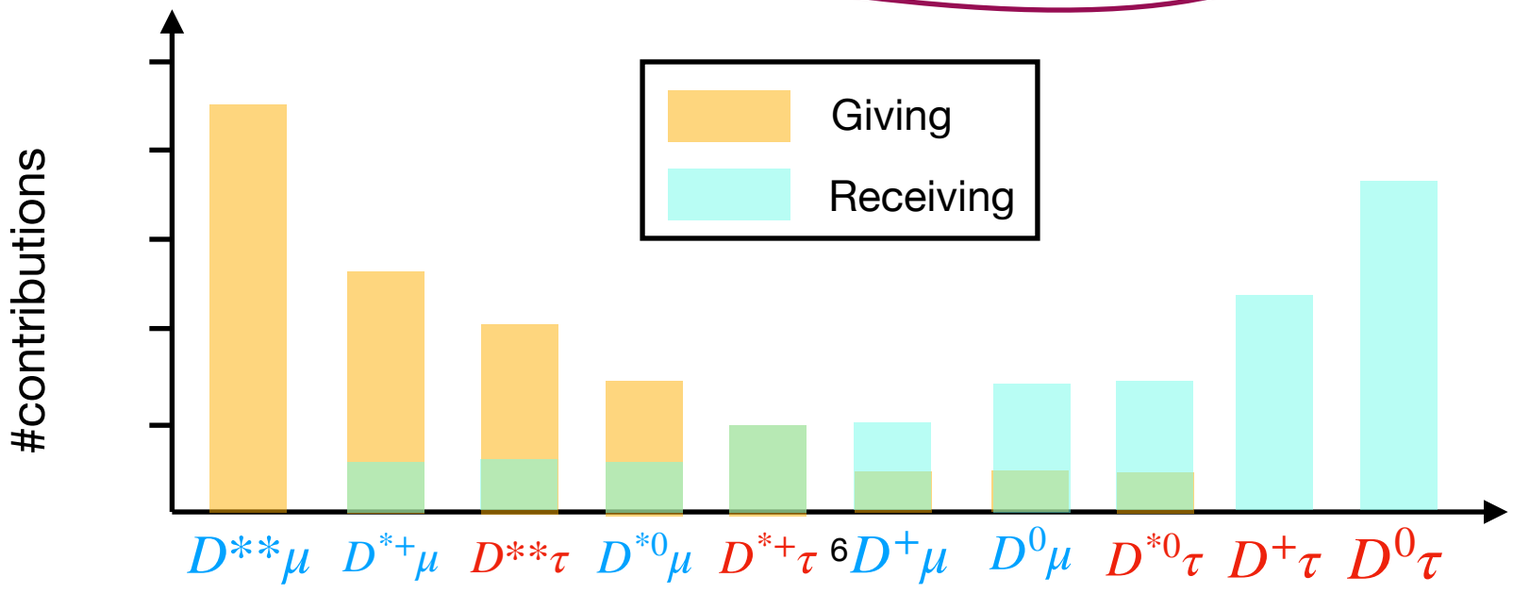
Method papers

- We (LHCb) should publish more papers about methods.
  - Gives incentives to develop tools useful for the whole field.
  - Allows Ph.D. students to get publications during their studies.
  - Implies some documentation, user friendly etc.
- This would suggest reducing measurement activities in the short-term, but long term gain is worth it.
- Potential ideas are:
  - Mis-ID background (some activities already).
  - Trigger calibration.
  - Fast simulation integration.
  - Fitter?
  - Track multiplicity, kinematic cross-sections (not measurements but correction tools).

Focus

- Different feed-down contributions in the $\tau \to \mu$ mode.





Focus

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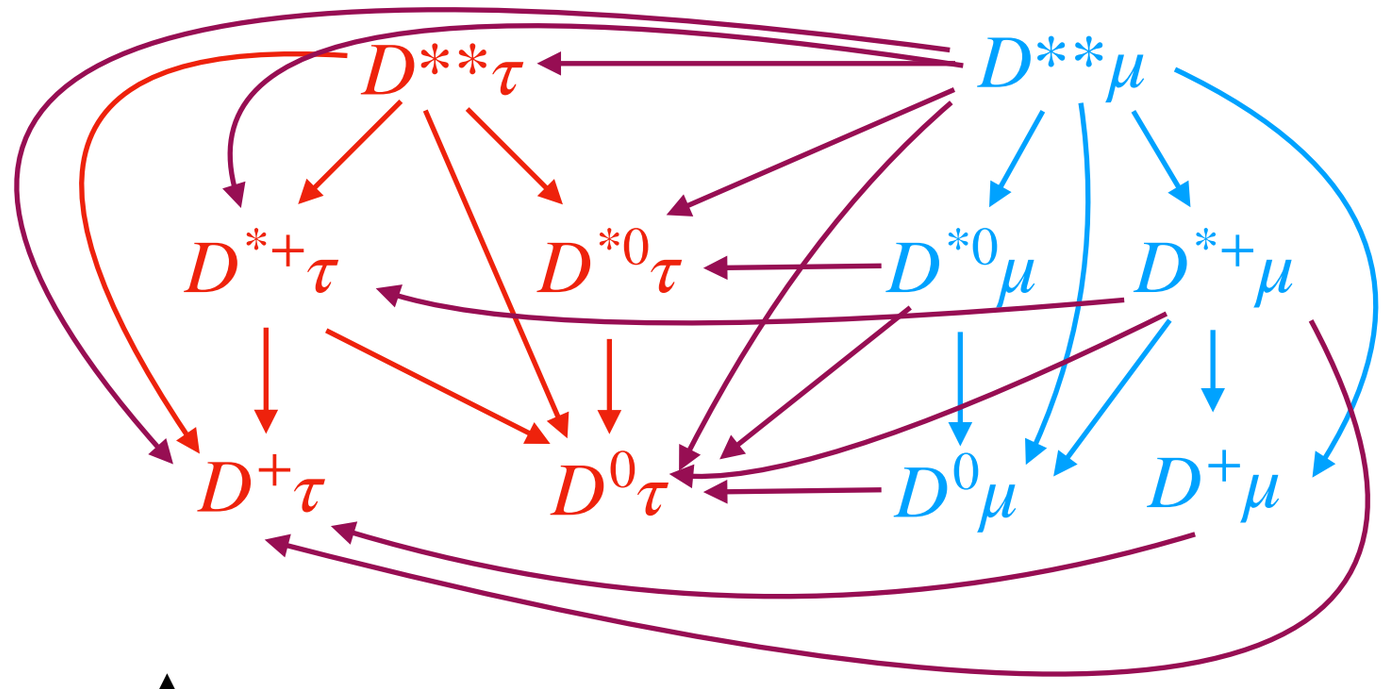
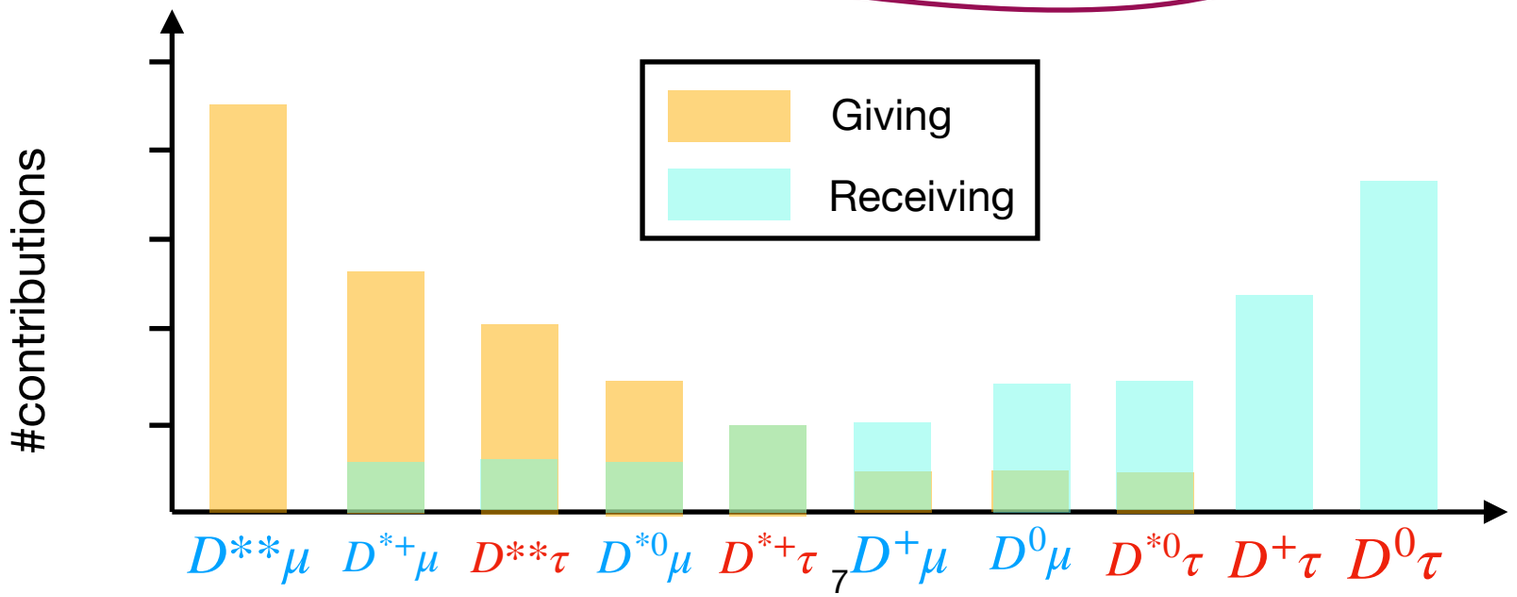
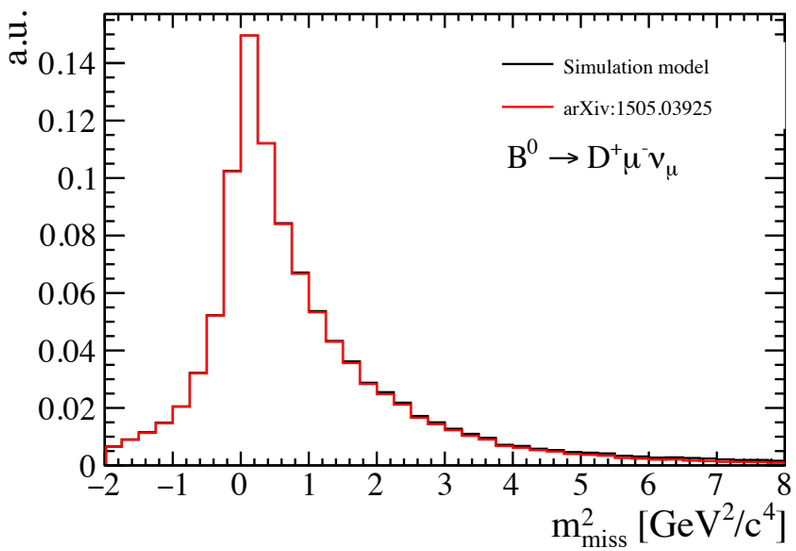
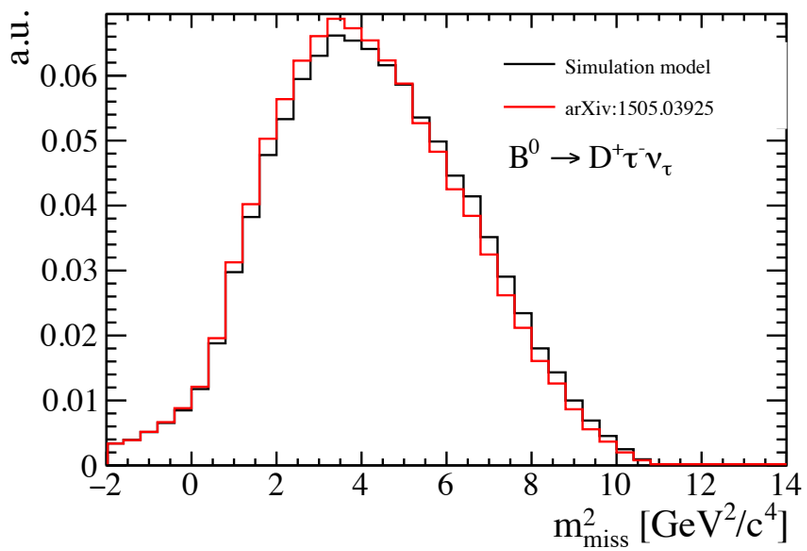




A comment about our use HAMMER

- In R(D^+) we used HAMMER to float the form factors.
  - This is because we had too much data to fix the central values and no dedicated muon measurement.
  - Floating Wilson coefficients was therefore out of the scope of paper.
- If we make dedicated measurements on the muon channels first, then perhaps some form factors can be fixed and forgotten in tauonic channels.
- This would make new physics agnostic fits more digestible.
- Muon templates tend to be less dependent on form factors as well.





Measurements of backgrounds

- One very useful set of measurements would be those of double charm background.
  - $B \to D^{(*)}(\overline{X_c} \to \mu X)X$.
- Semileptonic measurements of charm decays covered pretty well.
  - More important are measurements of the B decays into the different final states, as well as their Dalitz structure: e.g. BF($B^{+/0} \to D^{(*)+}D^{(*)-}K^{(*)+/0}$).
    - Complicated measurements by themselves, but an amplitude analysis is not necessary (just differential measurements would be fine).
- Already mentioned by Greg: inclusive measurements of $b \to c\bar{c}s$ of this would be very useful.
  - CKM suppressed modes will also be important at some level.
- Ideally this could then feed back into the simulation that we use.

Summary

- SL analyses take too long for a Ph.D. student.
- In addition to a couple of concrete suggestions here, a couple of other things.
  - Letting the best be the enemy of the good.
  - Experience from speaking to people is that SL analyses take > 80% FTE from at least one proponent: 4x20% << 1x80%.
- There are so many interesting puzzles and questions in SL decays.
- Difficulty experimentally and theoretically is comparable, unique for a system in flavour physics.
- Unlike many other areas, the physics potential is not yet realised even with data currently on tape. **This is an opportunity rather than a disappointment.**