

Early Measurements Task Force

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[Mattermost](#)

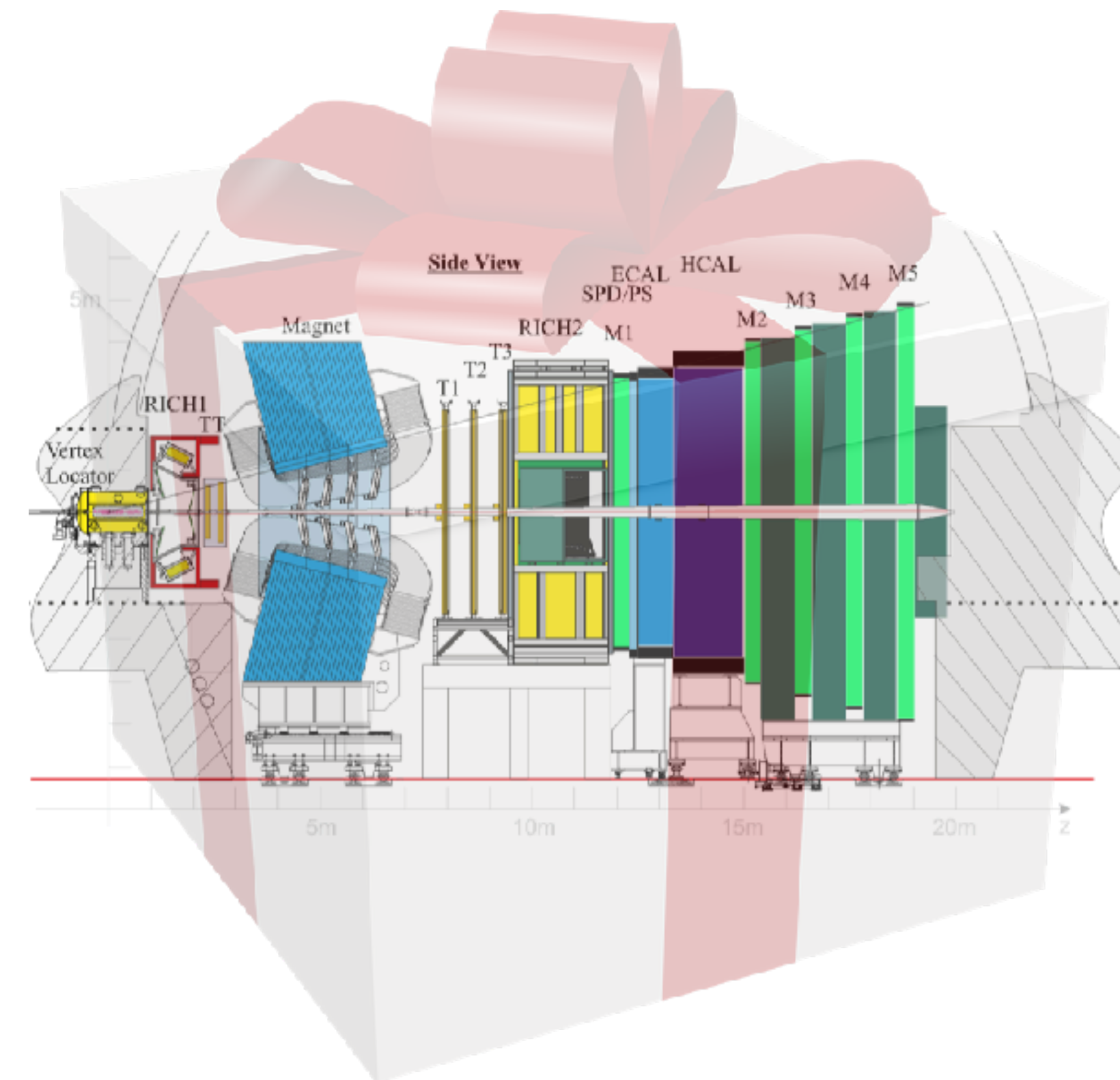
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Starterkit EMTF session
2nd December 2022

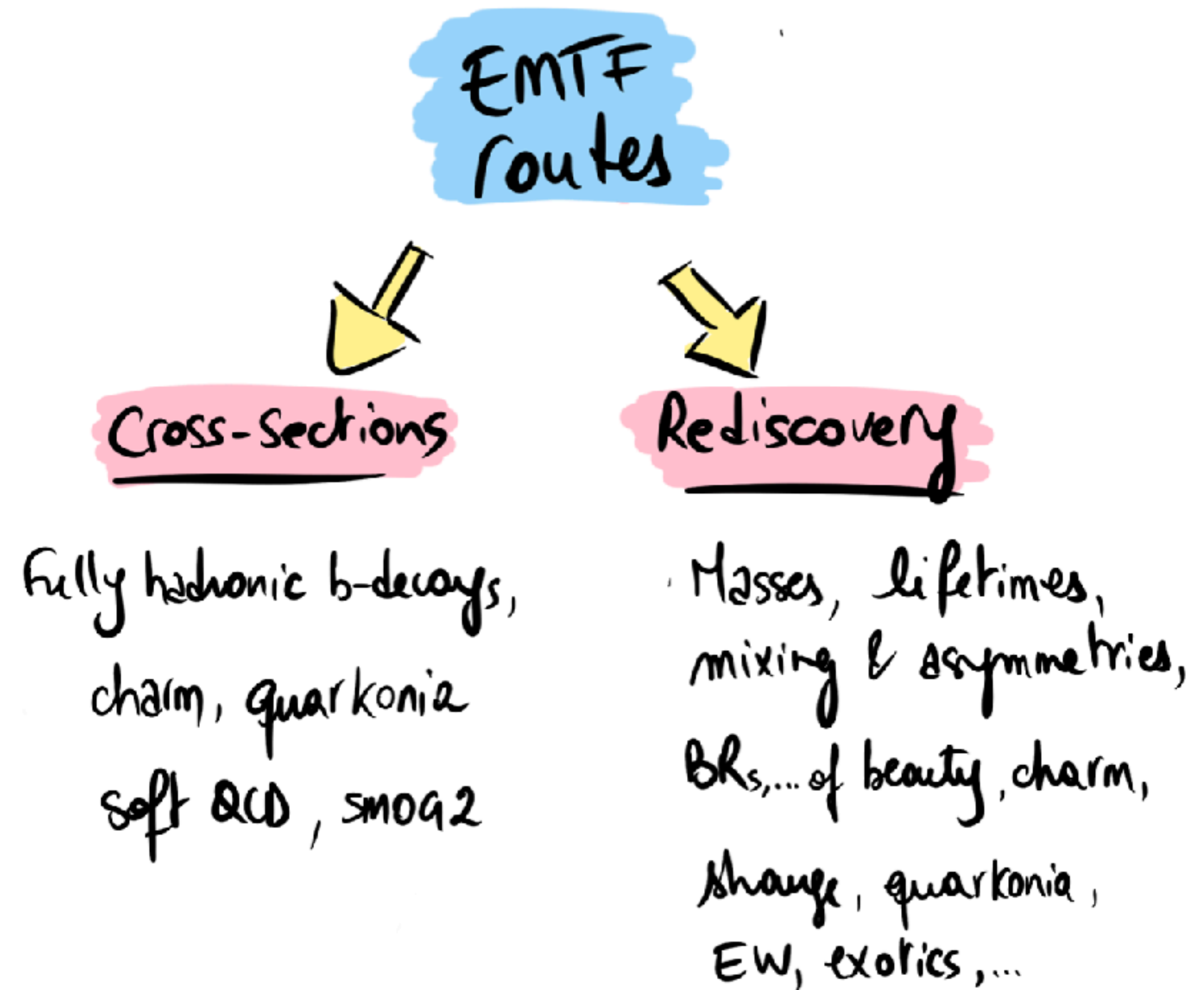
New detector!

- Motivation for EMTF: help with the **commissioning** and **validation of the analysis chain for Run 3**
 - We want to understand the data we take, the performance of the detector, agreement of data and simulation
 - ... and be ready to analyse the data as soon as it arrives
- Compare performance to Run2
- ▶ Targeting a bug-free system is a nice dream, but unreal → a healthier approach is to have a **good bug-finding strategy** and deal with them as soon as possible



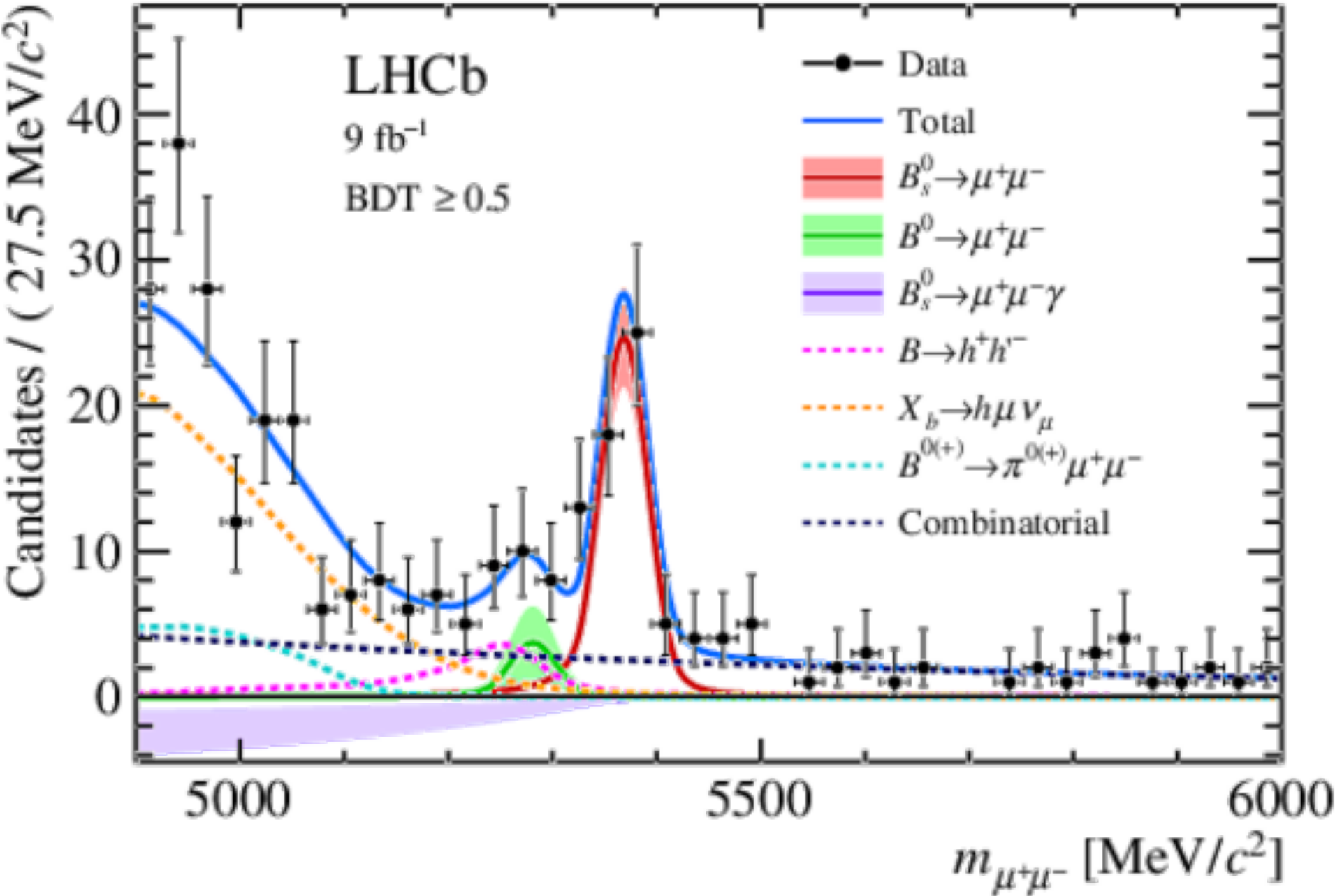
What do we call Early Measurements?

- Historically: start of a new run \rightarrow higher \sqrt{s}
 - Cross-Sections are relevant inputs to improve our knowledge of QCD processes, strong physics interest to get new results (less of a motivation for Run3)
- Validation of the detector data: known processes 'easy to find' in our data
 - Advanced: ratios of selection efficiencies
- Standard candles: well established values



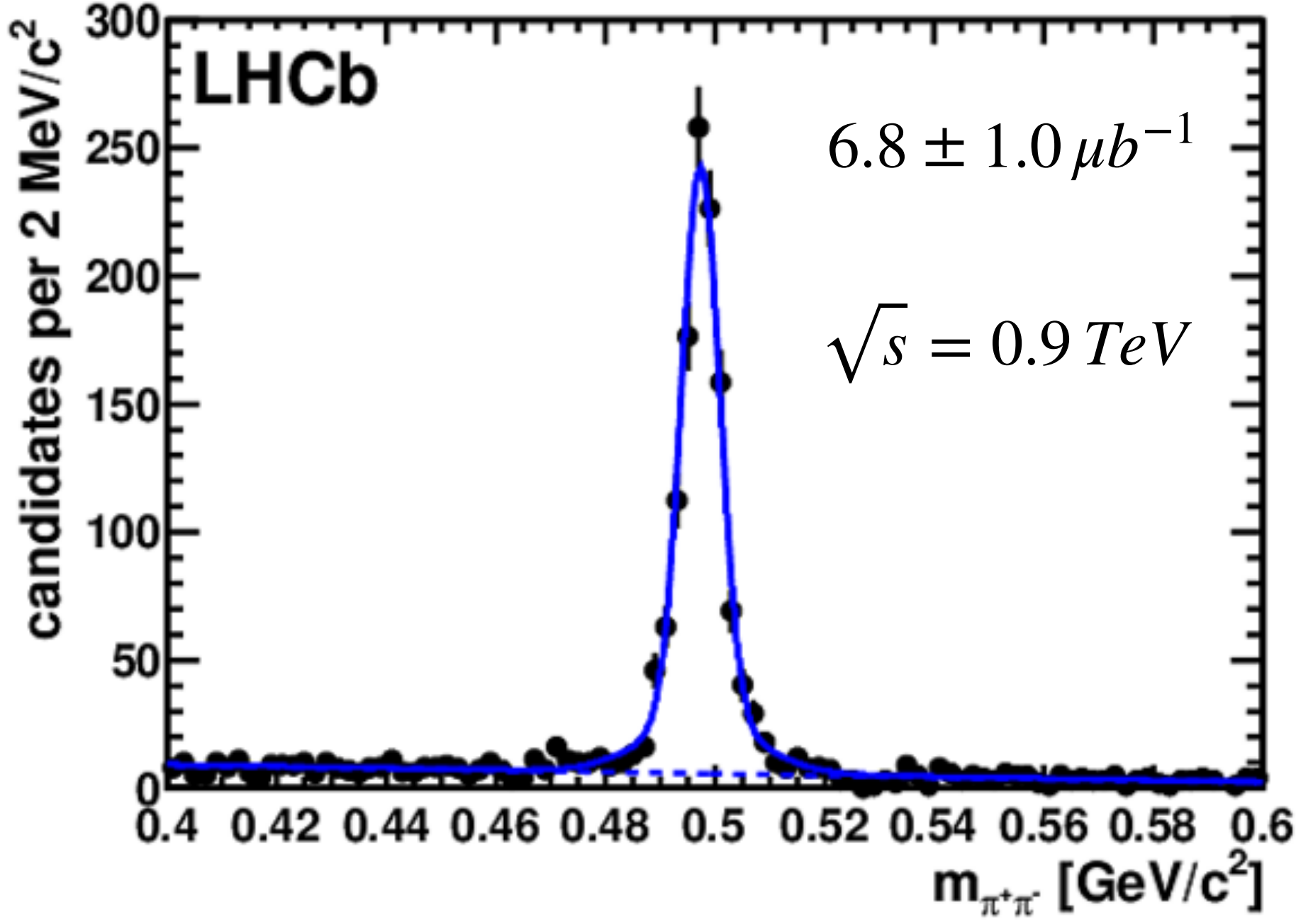
Production x Branching Ratio x efficiency

[Phys. Rev. Lett. 128, (2022) 041801]



~ 6 years

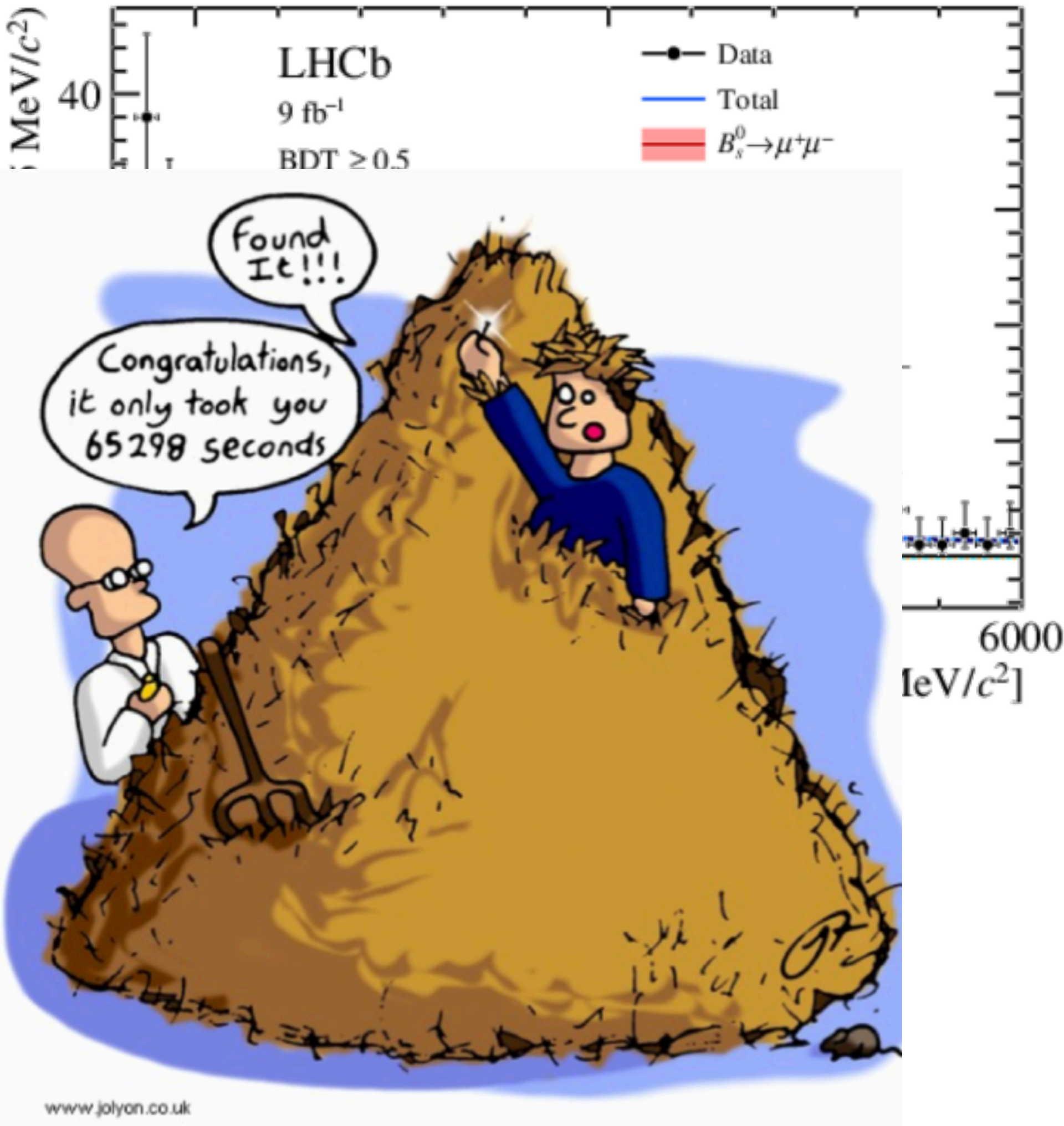
[Physics Letters B 693 (2010) 69–80]



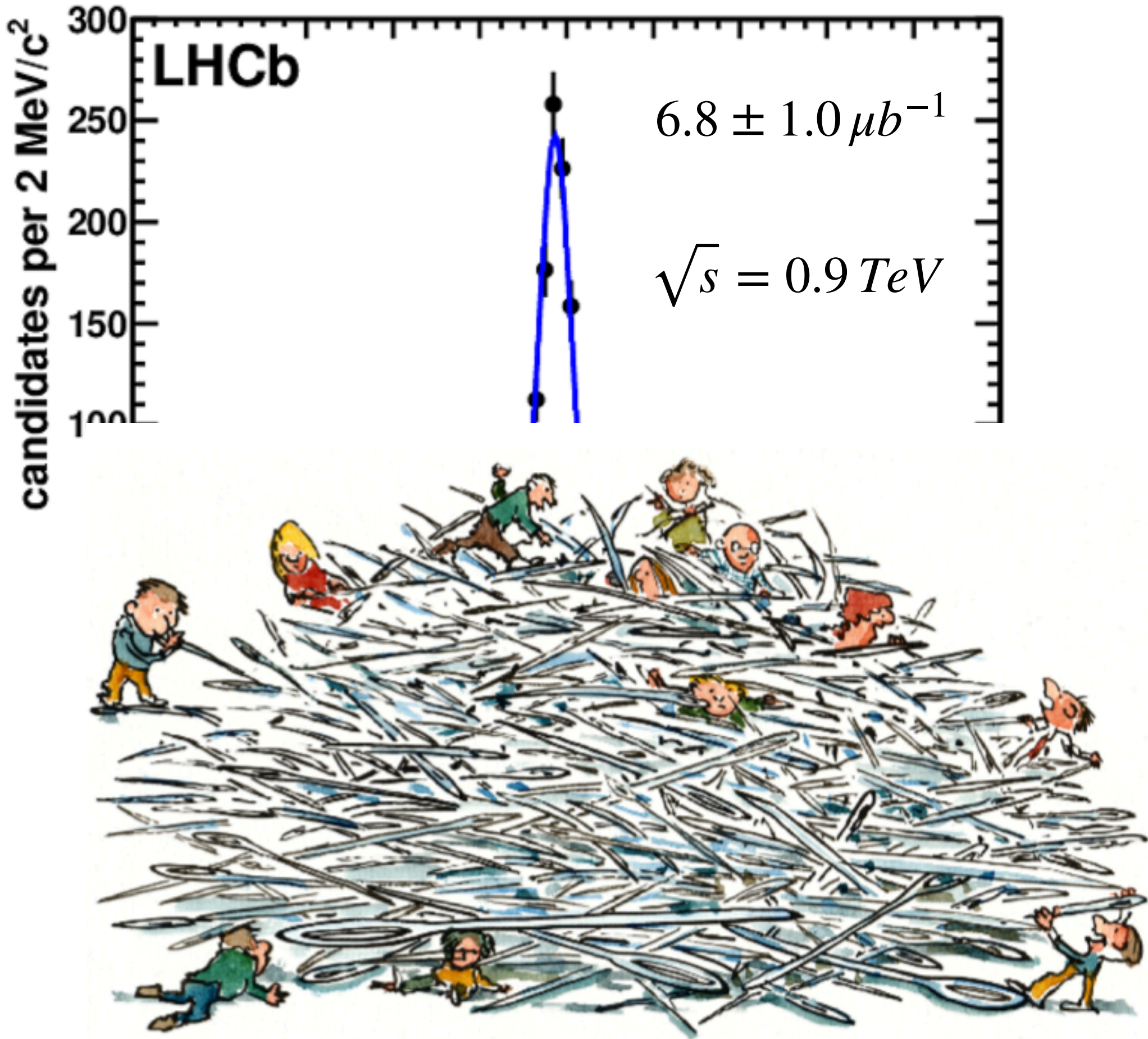
~ 2 weeks

Production x Branching Ratio x efficiency

[Phys. Rev. Lett. 128, (2022) 041801]



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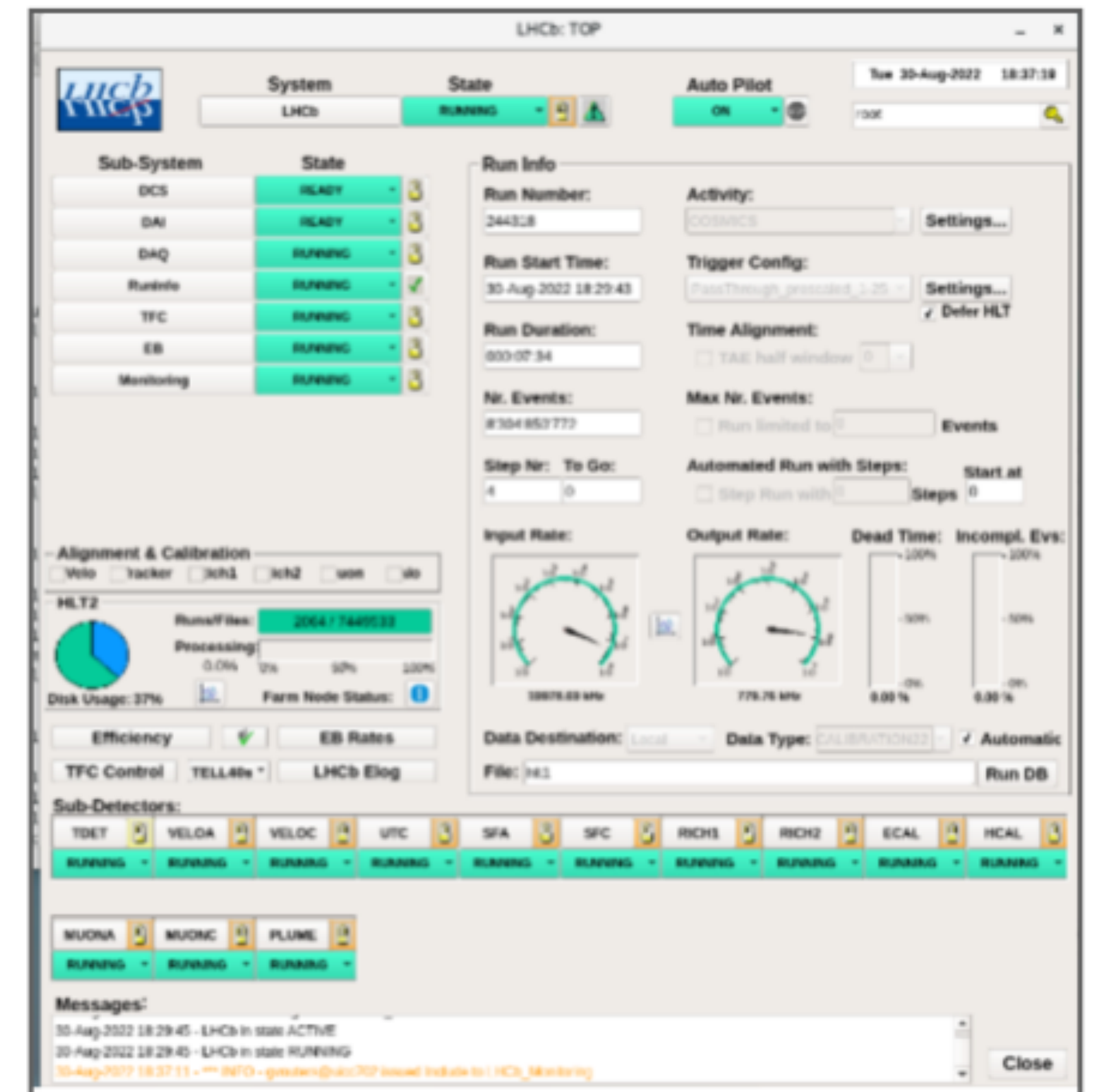
What do we need to look at?

We have:

- In good approximation, a new detector
- A new way of reading out the data
- Different data flow w.r.t. Runs 1&2
- New Simulation version

Getting to trust the detector data

- Key word: **Commissioning!**
 - Huge effort, both at Point 8 and remotely to bring the data taking process to a smooth and stable operation
- Want to be a part of this? **Sign up for shifts!**
 - **Can be done from Point 8** (on-call experts, data manager, shift leader) **and remotely** (data quality, computing and simulation)
- ... and **always document** in the shift elog what you see in the monitoring plots



... and getting ready to analyse it!

- Understand the detector's running conditions that should be reproduced in **Simulation**
 - **Data/MonteCarlo agreement** needs careful inspection
- Collect **control samples** to set up data-driven corrections for efficiencies
- Validate the **analysis and data processing chain**
 - In practice, for LHCb: Analysis productions, Snakemake and monitoring continuous integration tests of the code
 - Trying to process preliminary data works very well as bug catching strategy!

Towards a Cross-Section measurement

- Key point: how many events are seen in a region of phase-space
- External inputs:
 - Luminosity
 - Pre-defined bins in the relevant observables
 - Total branching fraction

$$\frac{d^2\sigma}{dy dp_T} = \frac{N(J/\psi \rightarrow \mu^+\mu^-)}{\mathcal{L} \times \epsilon_{\text{tot}} \times \mathcal{B}(J/\psi \rightarrow \mu^+\mu^-) \times \Delta y \times \Delta p_T},$$

- From the analysis:
 - Number of signal events
 - Efficiency of the whole selection process (with inputs from simulation and data-driven corrections)

Computing efficiencies in a nutshell

Spoiler alert: similar strategy as for Run2 analyses

Particle identification:

- Software: PIDCalib2
- Idea: PID response can be parameterised in terms of topological and kinematic variables → build maps from control data and get a per-track efficiency

Tracking:

- Software: TrackCalib2
- Idea: Tag-and-probe method: using $J/\psi \rightarrow \mu\mu$ events, tag one track and study the efficiency reconstructing the other

Detector acceptance and selection effects:

- Relying on simulated data

A few selections from our activities

Snapshot session

- **Aim:** get a quick overview of the status of all ongoing activities


- **Suggested format:**


- ◆ 3-5 min talk, ideally including:

- ◆ Full list of proponents


- ◆ Status of the MC samples (if needed, update info [here](#))

- ◆ Information on the analysis:

- ◆  Code readiness

- ◆  Analysis note status

- ◆ Does the analysis exist in the corresponding WG database? (Links [here](#))

- ◆  If available, timescale



Please sign up
(email us) for your
preferred option!

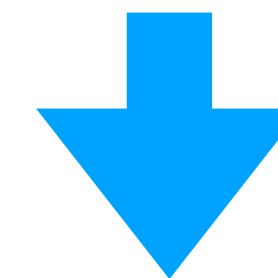
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*Why not in report in the Physics WGs?

→ 1-2 analyses/WG

→ Similar tools dependencies

→ Software/tools evolve FAST



Early Measurements Task Force!

Summary of planned analyses

- Differential production cross sections of:
 - Beauty to Charm ($B_s \rightarrow D_s \pi, B^0 \rightarrow DK, \Lambda_b \rightarrow \Lambda_c \pi \dots$) + update of the production rates f_s/f_d
 - Charm hadrons: $D^{*+}, D^+, D^0, D_s^+, \Lambda_c^+, \Xi_c^+, \Xi_c^0$
 - Z+jet in the forward region
 - $J/\psi, \Upsilon(nS)$ and ϕ
- Ratios of production cross-sections for K_s^0, Λ_b^0 and $\bar{\Lambda}_b^0$
- Other observables:
 - Ratios of branching fractions
 - Angular observables in $B_s^0 \rightarrow \phi\phi$



←A bit more rare

Ratio of V^0 productions

Goal

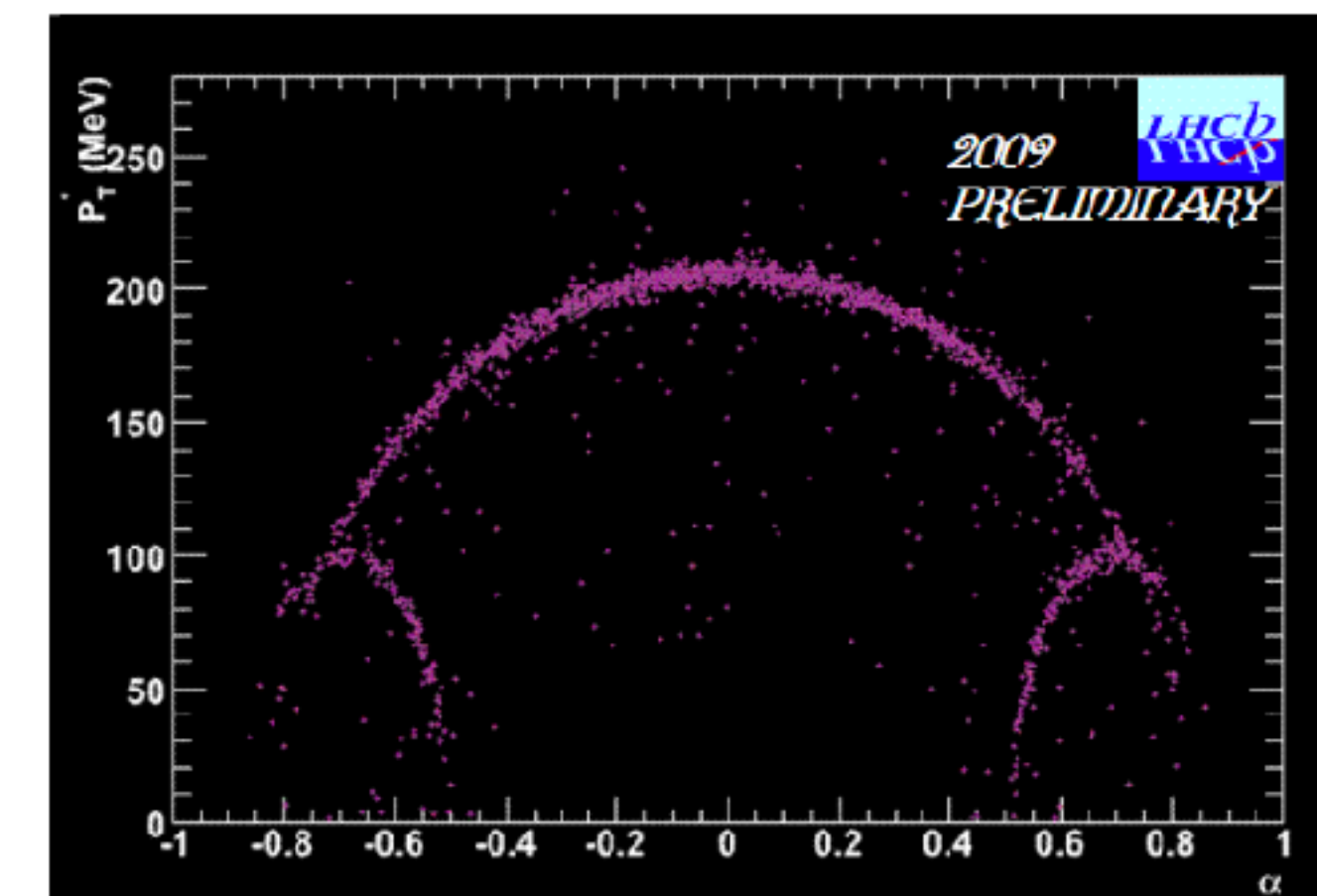
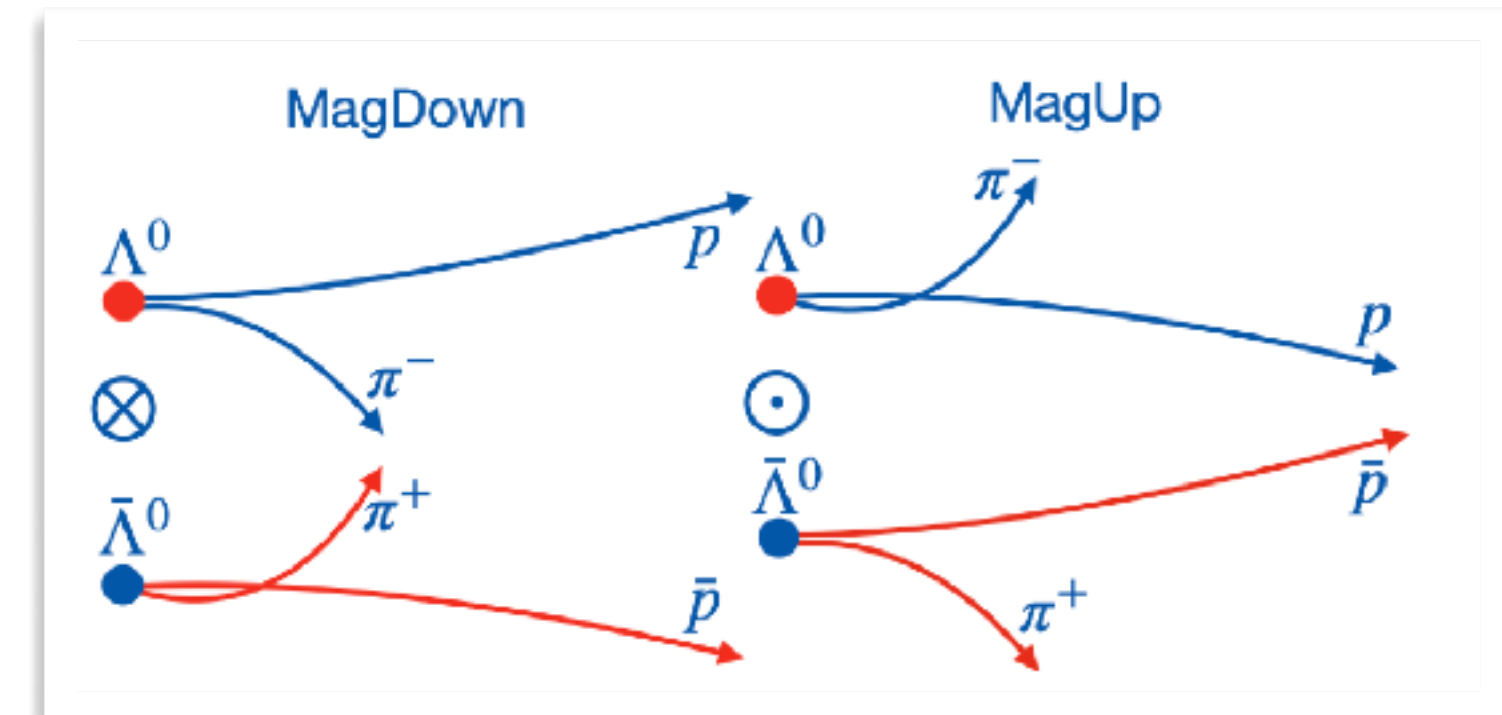


- Measure $V^0 = K_S^0, \Lambda^0, \bar{\Lambda}^0$ production cross-section ratios on early Run 3 data as function of p_T and y

$$R(\bar{\Lambda}^0, \Lambda^0) = \frac{\sigma(pp \rightarrow \bar{\Lambda}^0 X)}{\sigma(pp \rightarrow \Lambda^0 X)}, \quad R(\bar{\Lambda}^0, K_S^0) = \frac{\sigma(pp \rightarrow \bar{\Lambda}^0 X)}{\sigma(pp \rightarrow K_S^0 X)}$$

- Compare results to Run 2 NoBias data from 2018 and study potential difference from detector and increased centre-of-mass energy
- Developed minimal selection on Run 2 data based on

$$\mathcal{F}_{\text{IP}}(V^0 \rightarrow h^+ h^{(\prime)-}) = \log_{10}(\text{IP}(h^+)) + \log_{10}(\text{IP}(h^{(\prime)-})) - \log_{10}(\text{IP}(V^0))$$



Also used in Run1 for first performance checks: here, selection on AP plane to check PID

Validating jets



Analysis aims

- Measure the differential cross sections of Z+jet production in the forward region at 13.6 TeV
- We can use this process to validate the main tools for QEE in Run3 such as the muon efficiencies and jet reconstruction
- Exploit the balancing between Z and jet momentum to calibrate jets in data
- It is a test of pQCD predictions and can be used to constrain PDFs at low Bjorken-x



Next steps

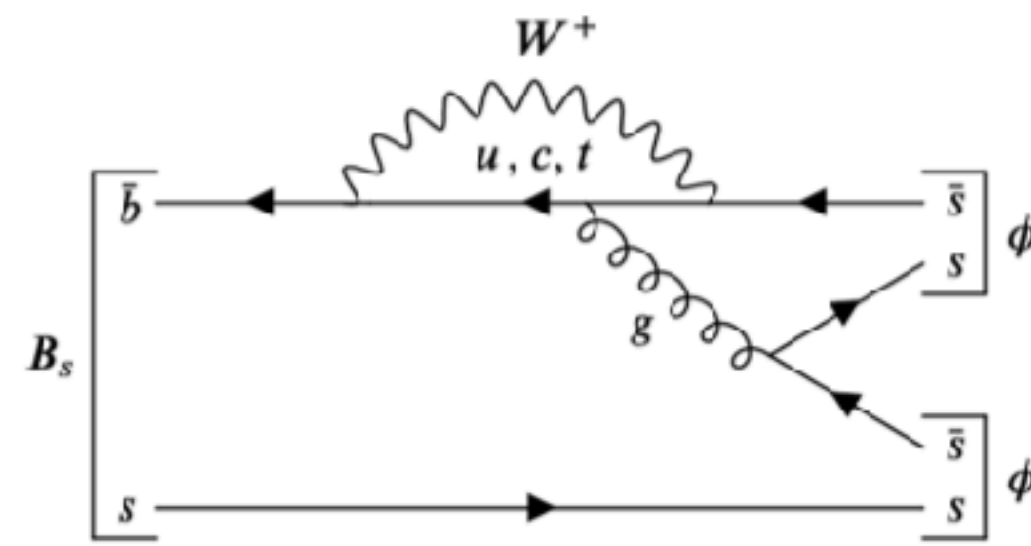
- Study Background and Unfolding
- Study theoretical predictions
POWHEG, ResBos, MCFM and FEWZ
- Find a way to require a common Z+jet PV in the offline analysis
- Implement the missing jet identification observables
- Tune a jet identification algorithm for removing fake jets
- Aim to the summer conference of 2023



Angular analyses

Introduction

- **Golden channel** to study CP violating phase ϕ_s in $b \rightarrow s$ penguin loop transitions.
- CP violation **predicted to be zero** in SM \rightarrow deviations could show new physics
- This channel will be a **test of success for the upgrade** as we expect to see at significant increase in the yield per fb^{-1} from removal of L0 trigger



21/11/22

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What we aim?

- Compare Run 2 and Run 3 expected performance
- Develop tools to analyse $B_s \rightarrow \phi\phi$ events with Run 3 data
- Set benchmarks for yield/ fb^{-1} , **time resolution**
- Study **mass** and **decay time** and **angular acceptances**
- Measure **branching fraction/triple products** with early data – a few 100 pb^{-1} would be competitive for the BF
- Prepare an internal note on the analysis similar to pre-Run 1 note on “*Measuring the weak phase in the decay $B_s \rightarrow \phi\phi$ at the LHCb experiment*” (LHCb-PUB-2009-025)

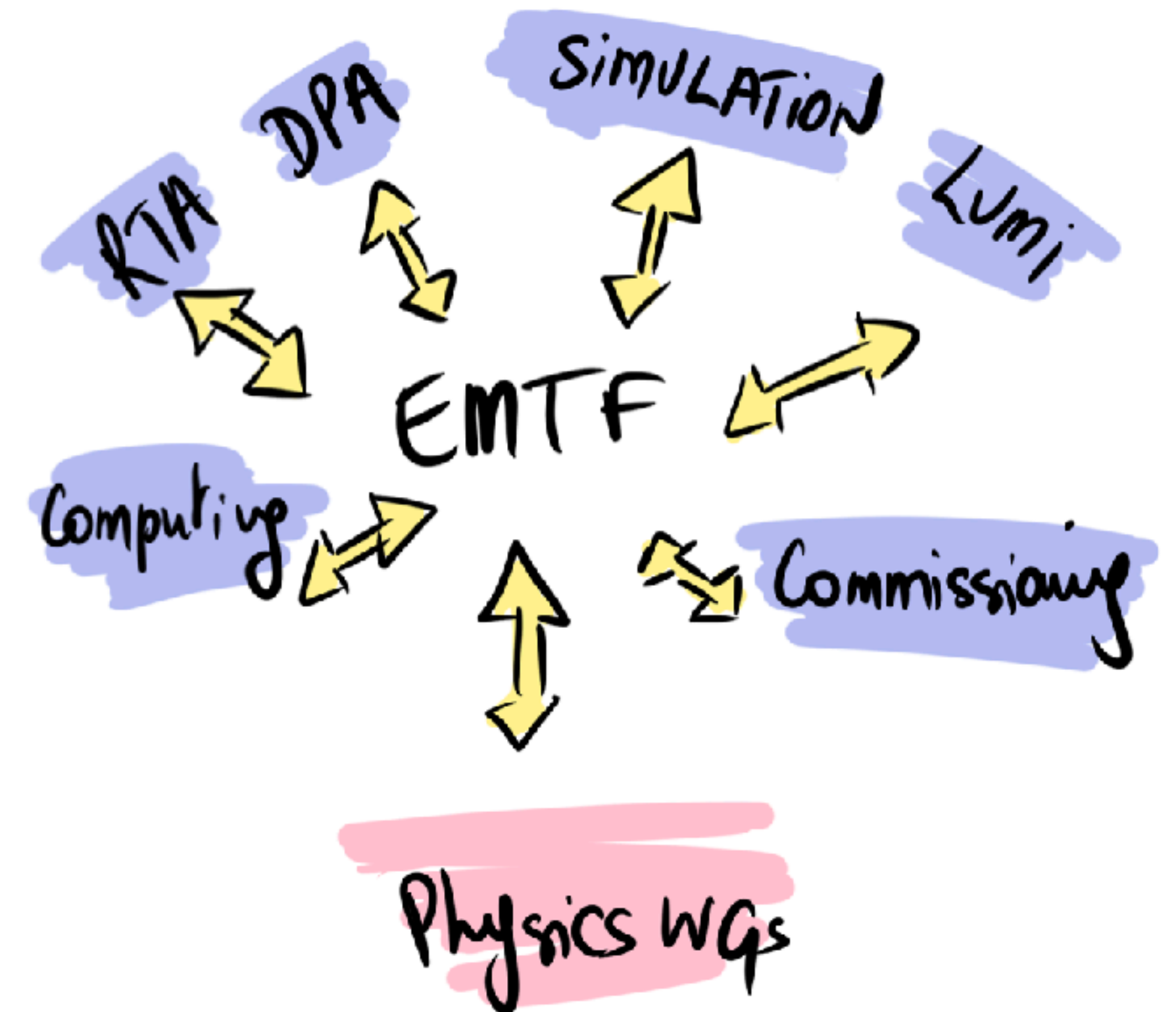
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Conclusions

- Having new data from a new detector is very exciting!
 - But analysing it at first might be frustrating: fast evolution of the software, unstable conditions, many details and exceptions ...
- The Early Measurements Task Force serves as a common forum to discuss common needs and share expertise
- Aim at exercising the analysis chain and discovering shortcomings before they are critical
- Analysis with quick turnover and competitive outcomes that will help understanding our new detector
- We have liaisons with the Physics and Physics Performance Working Groups. They report about news and issues spotted across the board.



Kudos to Yasmine Amhis for these illustrations!

Thanks for your attention!

Questions

