CMS Postdoc opening at University of Florida

Job Matching Event (JMEv) Spring 2023

3 May 2023

Yuta Takahashi (presenter), Andrey Korytov, Jaco Konigsberg,
Philip Chang, Guenakh Mitselmakher, Paul Avery

University of Florida (UF)

Public research university with ~55,000 students

Physics department hosts: ~50 faculties, ~12 scientist,

~25 staff, ~20 Postdoctoral researchers, ~140 graduate students

The UF-CMS group

https://www.phys.ufl.edu/wp/index.php/people/faculty/

We are one of the largest US university groups in the CMS experiment, comprising faculty members, students, postdocs, scientists, and engineers

- 6 faculty
- 6 postdoctoral researchers
- 7 students
- 2 engineers
- Tier-2 center staff/computing professionals


A. Korytov


J. Konigsberg


P. Chang

- The group currently leads several projects and teams:
  - Data analysis (e.g. Higgs, a variety of new physics searches)
  - Detector (Muon detector, trigger upgrades and operations)
  - Software developments (Parallelizable Track Pattern Recognition, Track-trigger developments for HL-LHC)
  - T2 computing, and software


G. Mitselmakher


P. Avery


Y. Takahashi
(1st Jan. 2024 –)

About the position

- Primary supervisor: Yuta Takahashi
- Work location: **UF (Gainesville, US) or CERN**
- Expected starting date: **beginning of 2024**
- Duration: **2 years + possible extension**
- Expected to take a leadership roles in
  1) new physics searches that can distinguish flavours (~0.7 FTE);
  2) Firmware/Software development of L1 algorithms with tracks for HL-LHC (~0.3 FTE).
- Candidate must have:
  - Deep understanding of the CMS detector, particle identification, data analysis
  - Machine learning experience is considered a plus
  - Expertise in programming (c++ and python)

A successful research group is driven by successful postdocs and students!

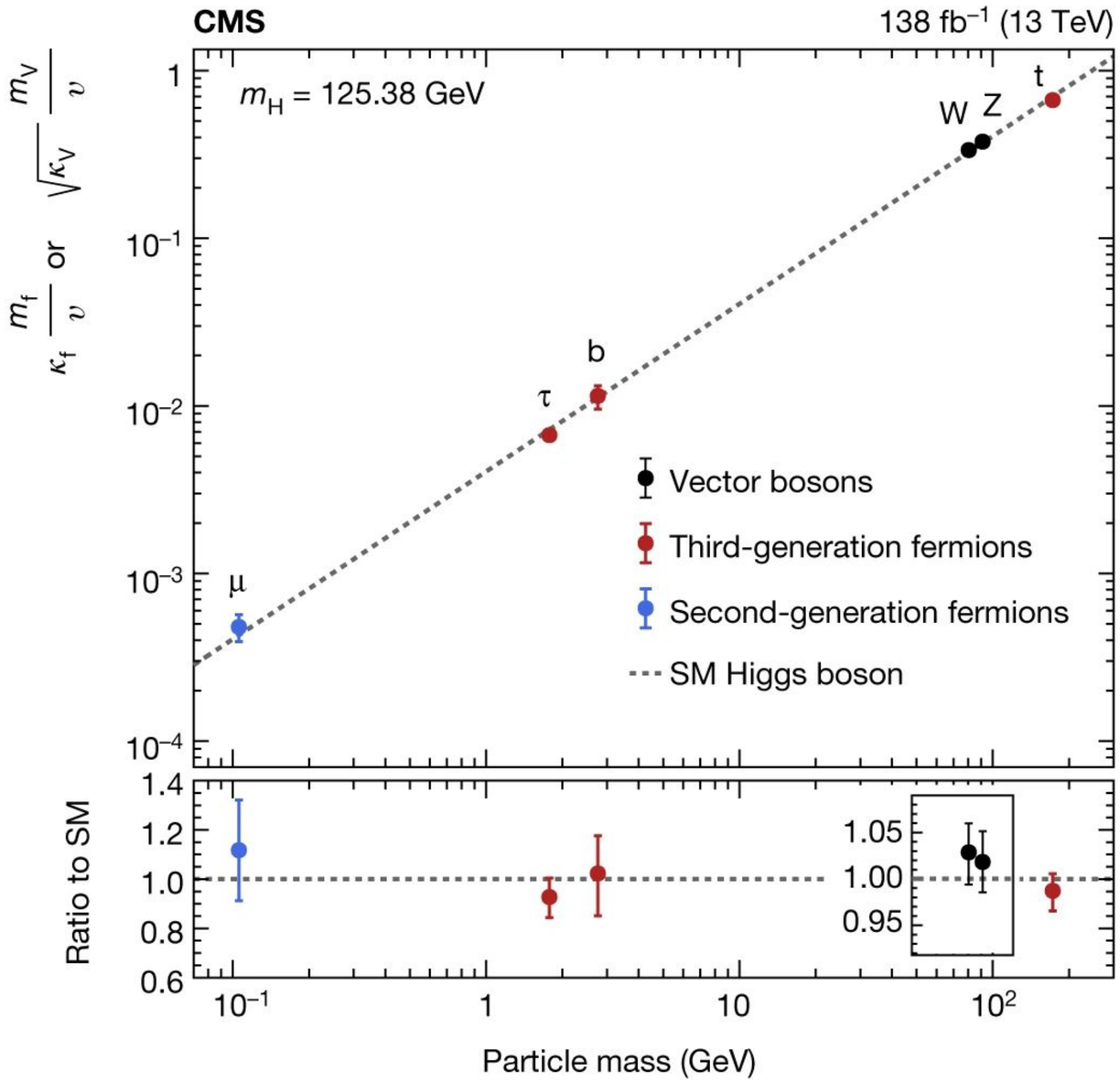
- We will make sure our people are visible within CMS collaboration
  - Presentations at working group meetings
  - Convenership experiences
  - Conference talks

- We will try to be a good mentors
  - Regular interactions with faculty
  - Provide opportunities to mentor students

- We believe that our compensation is competitive

- We will make sure you are successful and to have successful in job placement that follows

New physics searches that can distinguish flavours



Question:

— Why do Higgs boson couplings span at least 5 orders of magnitude?

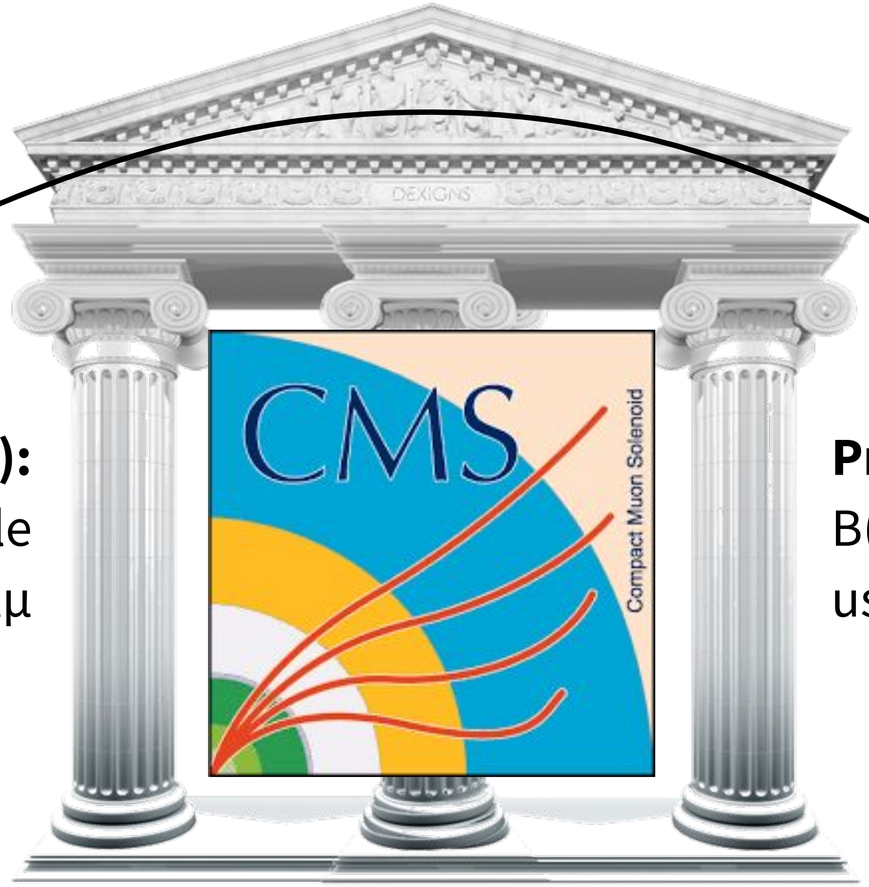
Fermions

A big picture

Physics: reveal new interaction that can distinguish flavours

Direct search

Indirect search



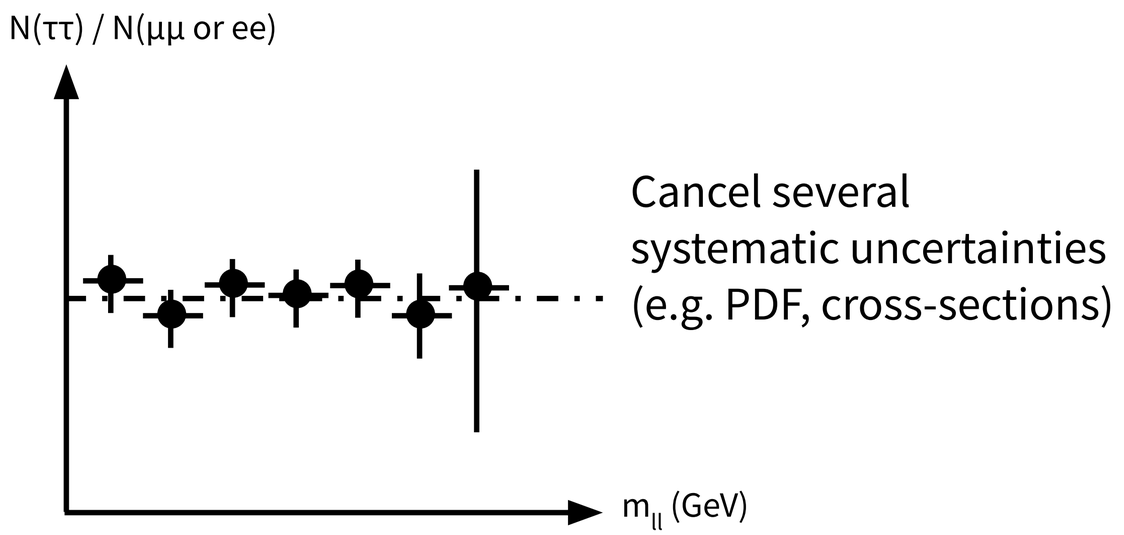
Project 1 (P1):
LFU tests at high-energy scale
by comparing ττ to ee or μμ

Project 2 (P2):
$B(B_s \rightarrow \tau\tau)$ measurement
using top-quark pair creation ($t\bar{t}$) events

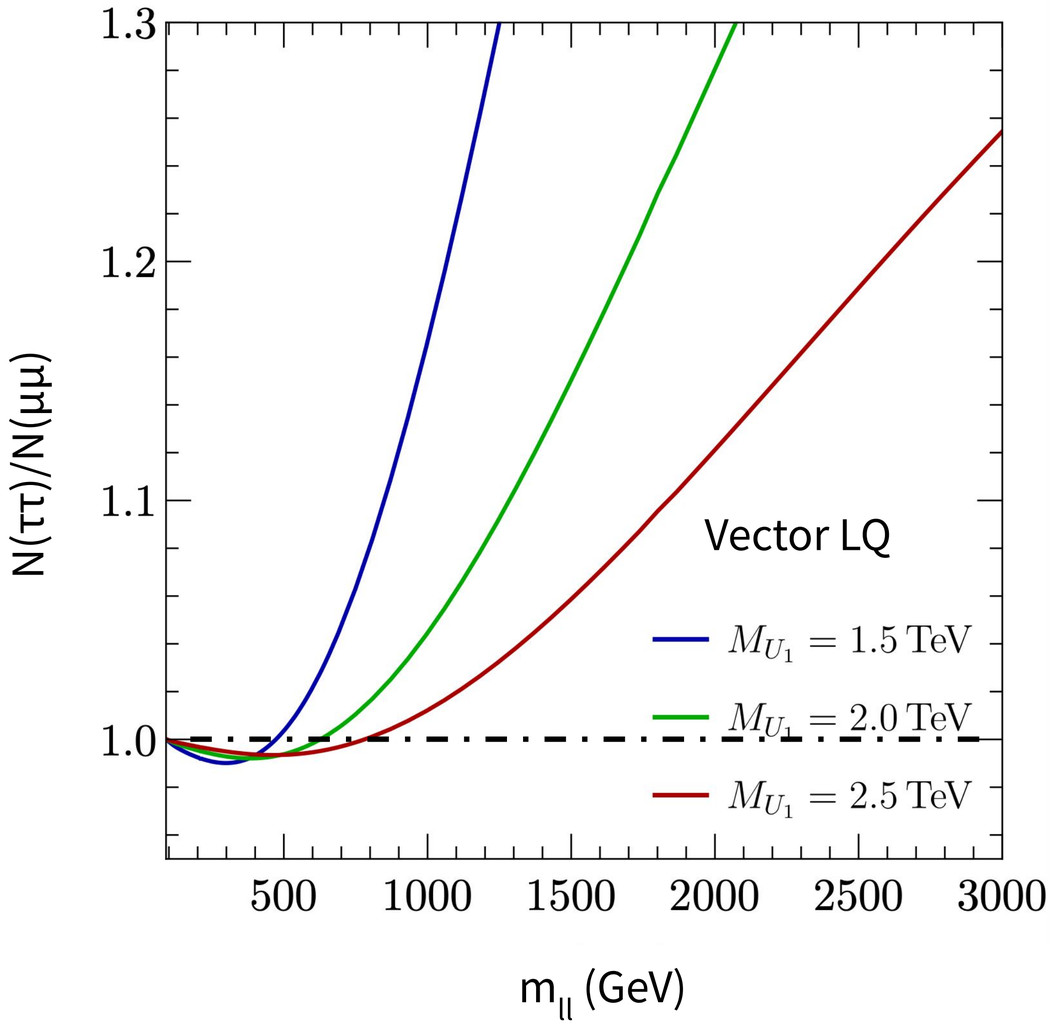
Project 3 (P3)
Develop the τ-lepton triggers
for the future HL-LHC operation

P1: LFU tests at high-energy scale

- B-physics anomalies → new particle at O(1)TeV with preferable couplings to the 3rd generation fermions
- This can be best searched for by looking at the LFU: ττ v.s μμ or ee at high-energy scale



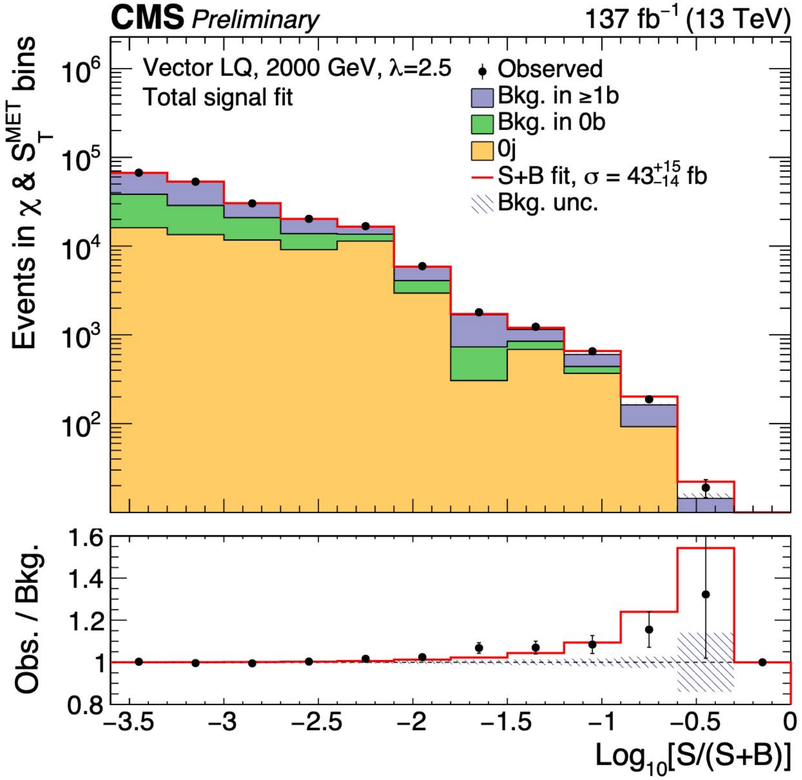
Cancel several systematic uncertainties (e.g. PDF, cross-sections)



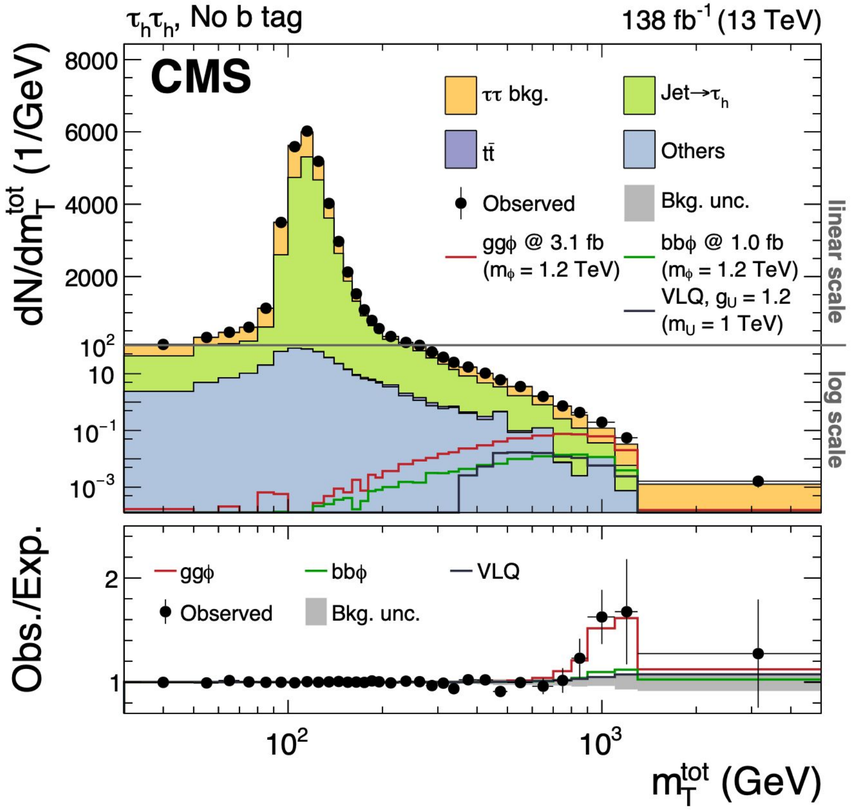
- We do this in bins of (b)-jet multiplicities
- We also plan to extend this measurement using Forward-Backward Asymmetry (AFB) instead of the mere event yield

This is motivating given 2—3σ excesses found in ττ final state in Run 2

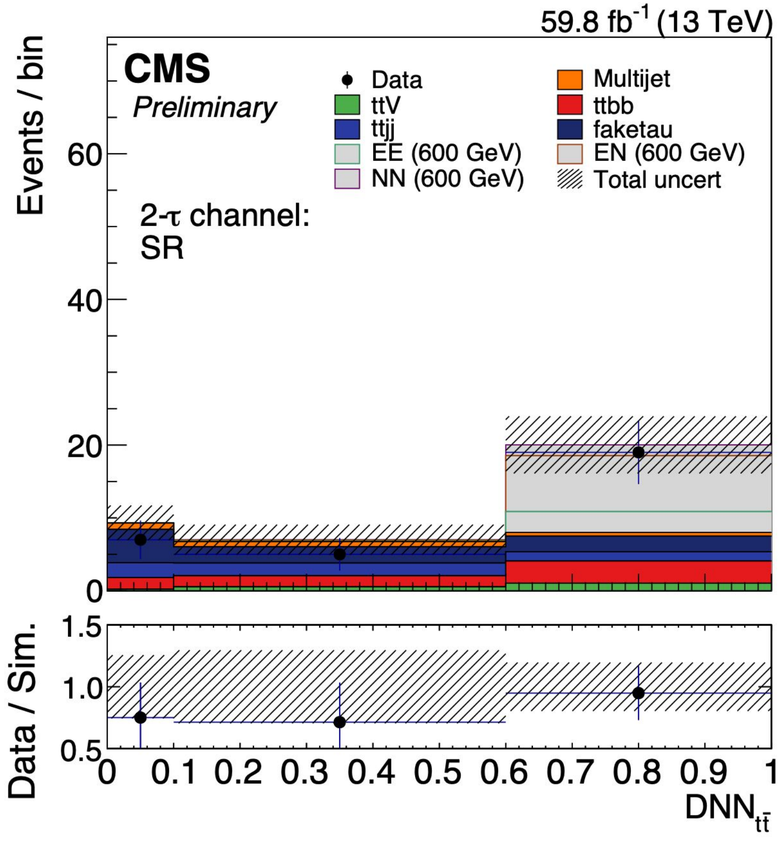
LQ searches [ref]



MSSM Higgs boson searches [ref]

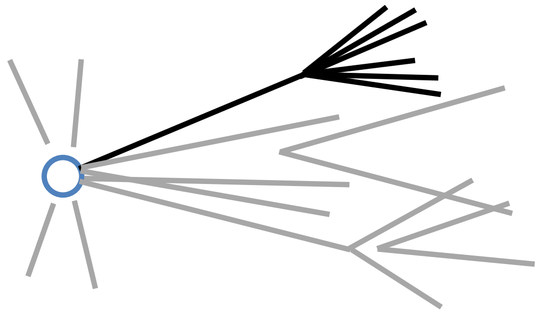


Vector-like lepton searches [ref]

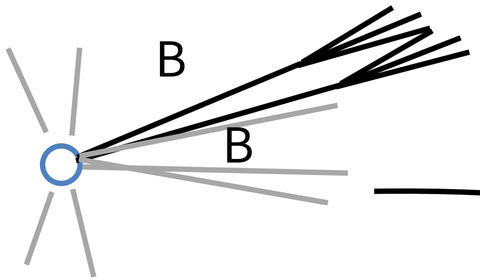


P2: measurement of $B(B_s \to \tau\tau)$ using $t\bar{t}$

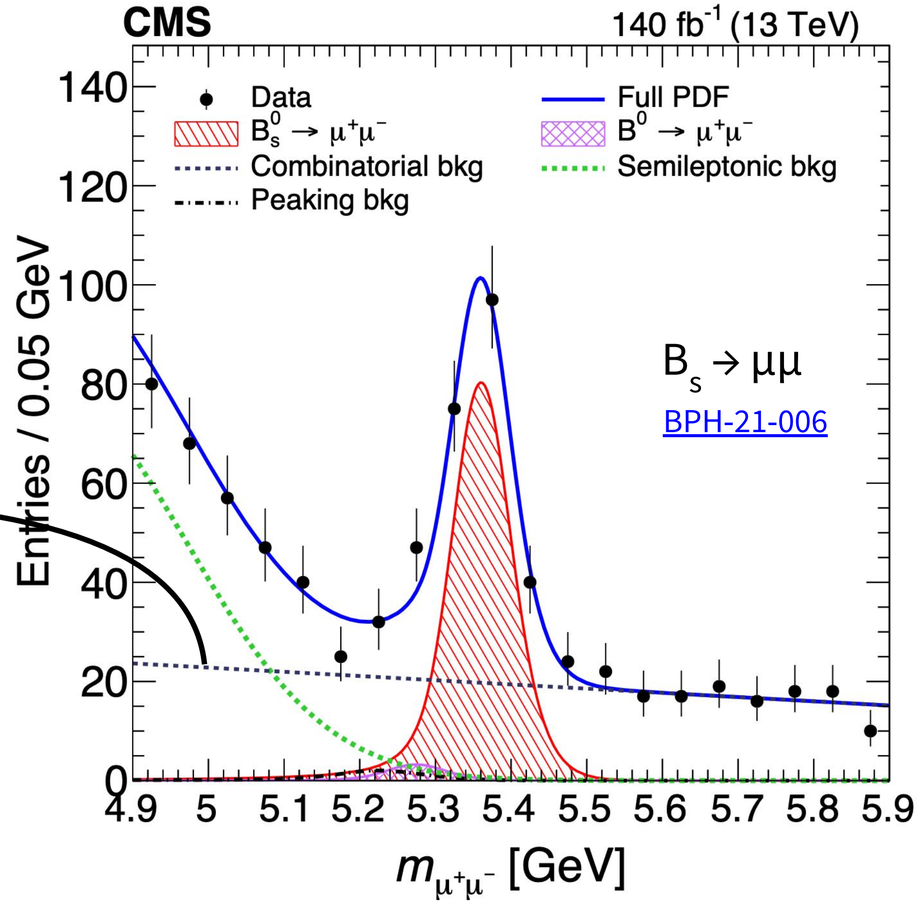
- Why $B_s \to \tau\tau$: because it will be enhanced by ~1000 if the B-anomalies are real (but also many NP scenarios)
  - $Br(B_s \to \tau\tau) = 7.7 \times 10^{-7}$ (SM) → $\sim 10^{-4}$ (NP): smoking gun
- However, this has been difficult due to **two** reasons



All hadronic final states with everything low p_T
→ **low trigger eff. & low τ reconstruction efficiencies**



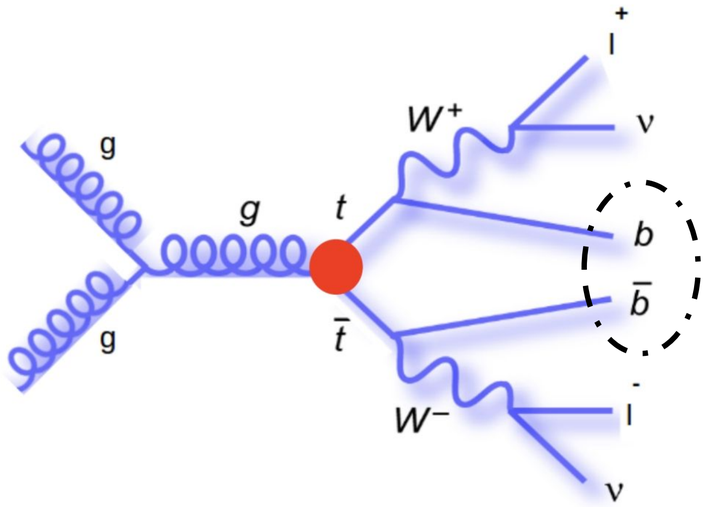
Huge "combinatorial" backgrounds where two B's overlapping each other leading to 6 hadrons final state



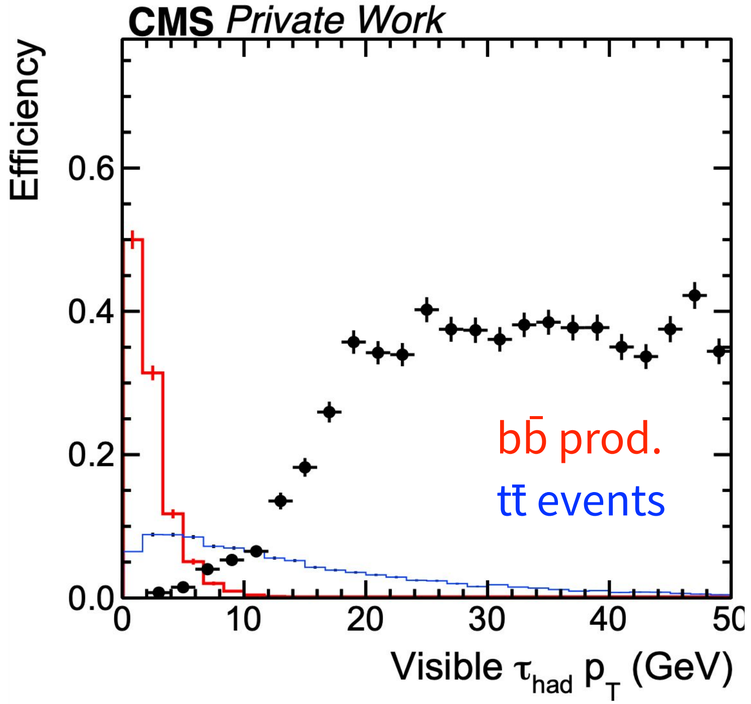
- So far, only weak constraint from LHCb: $B(B_s \to \tau\tau) < 6.8 \times 10^{-3}$

Phys. Rev. Lett. 118, 251802 (2017)

By using tt̄, we can solve these problems at once!

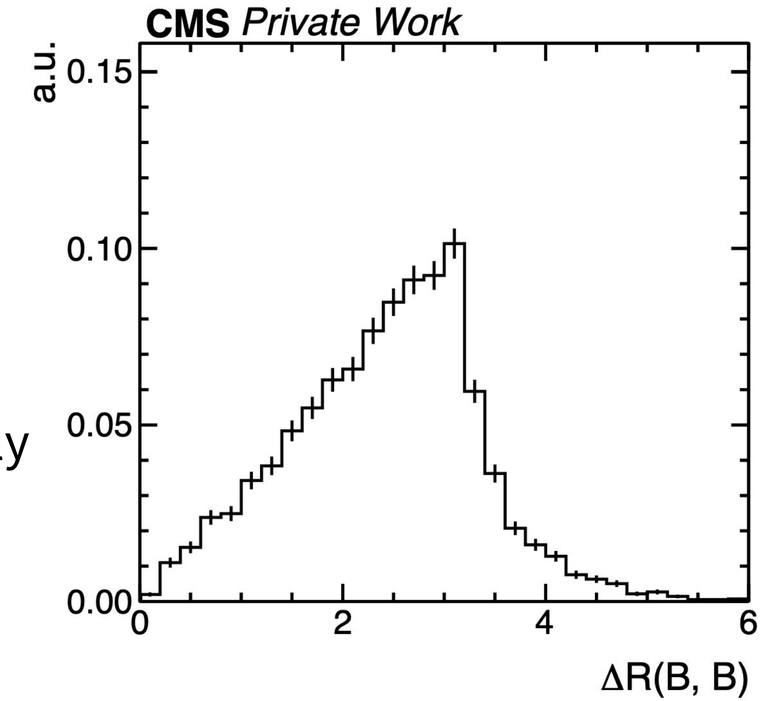


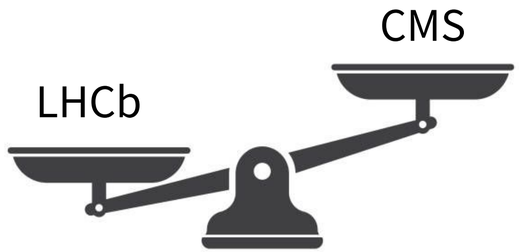
- Easy to trigger!
- Top-quark is heavy
  → everything high p_T
  → easy to reconstruct taus

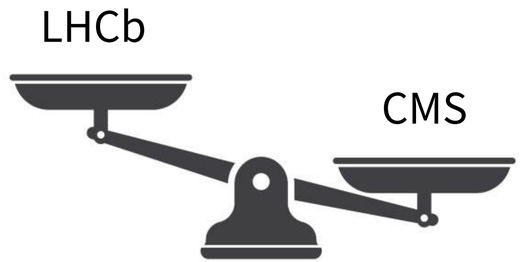


Tau ID efficiency

- There are ~no combinatorial backgrounds, as two B's are produced separately





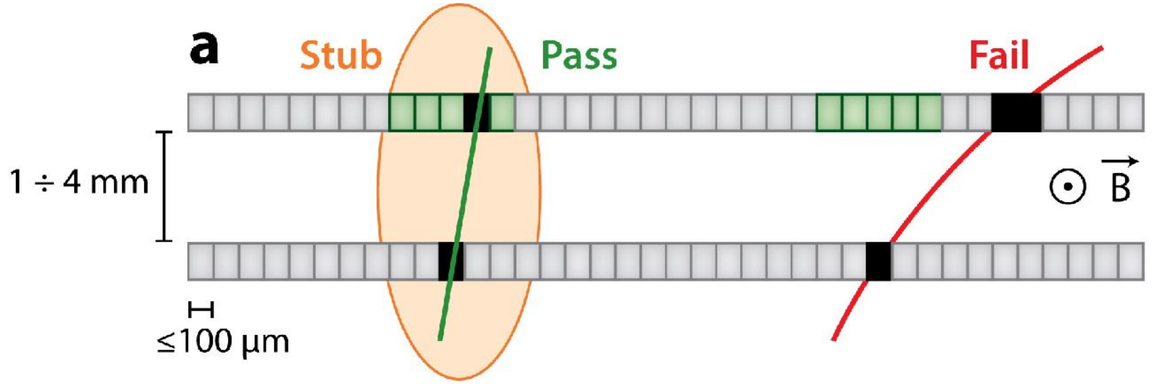


Sensitivity

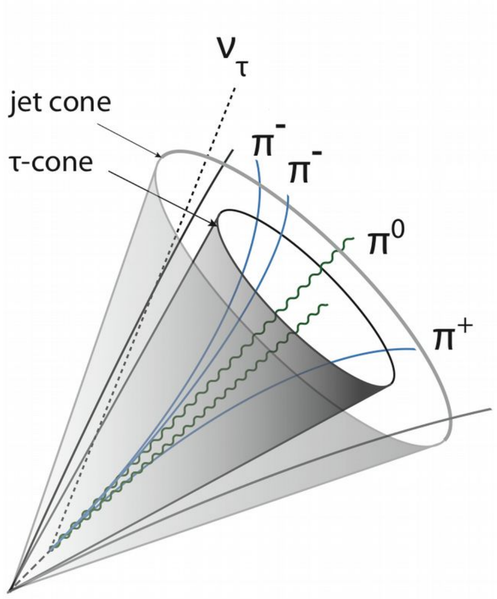
Nobody thought possible from energy-frontier experiment!

P3: τ-lepton triggers for the HL-LHC

- We need more “τ-lepton data” from HL-LHC (2029 —)
- However, HL-LHC will be operated x5 higher luminosity than now
- Trigger must be more selective (e.g. increase p_T threshold) → lead to loss of sensitivity
- To accommodate this, CMS is introducing track-trigger machinery
- Potential game-changer for CMS because we could trigger τ_h more efficiently than now at L1 by targeting “jet” with 1 or 3 charged tracks in it



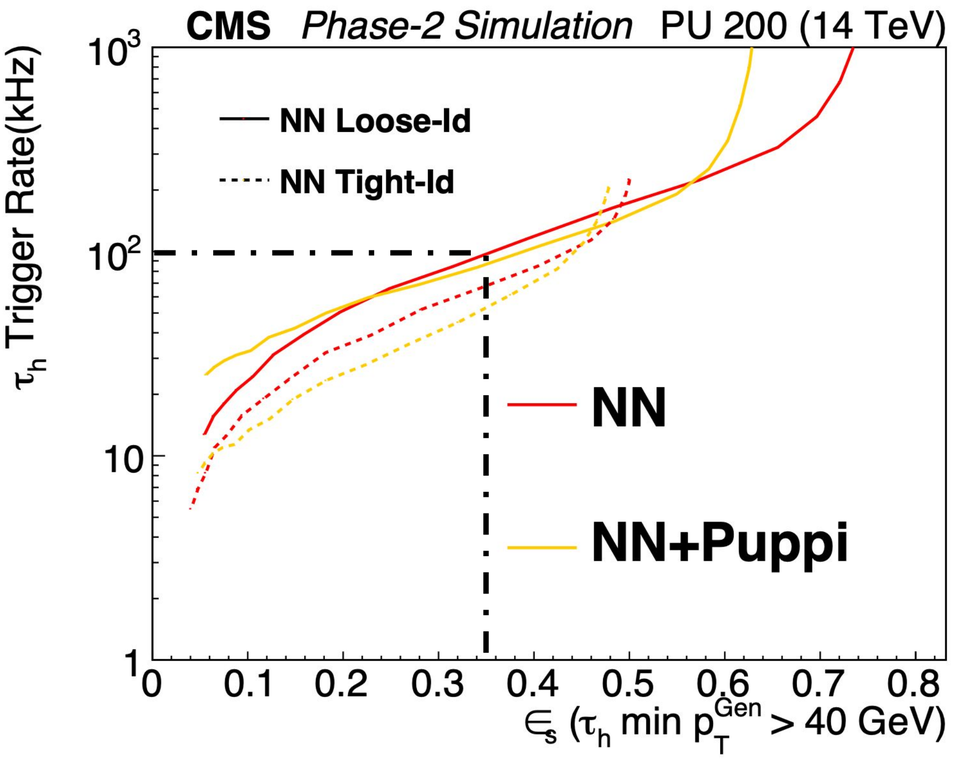
Key: track information already available **at the first stage** of the online event selection (L1-trigger)



If made, this is going to be the first in hadron collider to trigger jets with **substructure** at L1!
(ATLAS does not have a track-trigger machinery)

Develop τ_h trigger for the HL-LHC

State-of-the-art: single τ_h trigger developed [ref]



100 kHz at 35% signal efficiency for H → ττ
→ good start but not practically useful

1. **Improve τ_h trigger performance at L1**
   - Exploit lower-level "track" information
   - Architecture improvements to the NN
2. **Develop exclusive $\tau_h\tau_h$ resonance trigger at L1**
   - Impose m($\tau_h\tau_h$) to be within e.g. m_H and thereby lower the p_T cut for τ_h
   - Aim O(1) kHz with 80% eff. for H →ττ
3. **Integrate $\tau_h\tau_h$ trigger into scouting**
   - Established technique to trigger events at higher rates than nominal by reducing stored event size

- Could gain x1.5 — 2 statistics for the K_λ measurement using HH →ττbb
- Might extendable to the $b\bar{b}$ resonance trigger!

Join our team!

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