

# The Energy Frontier



Sarah Demers, Yale

June 9, 2023

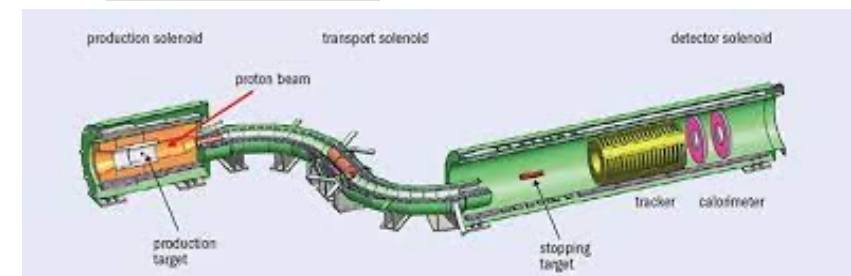
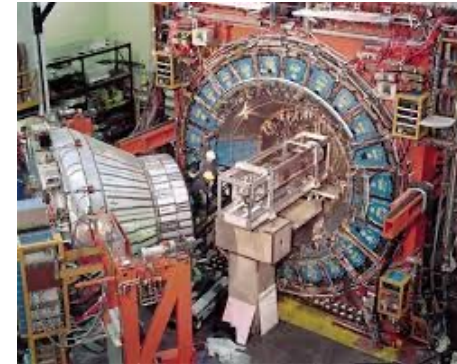
Early Career Award Workshop



Run: 450227

# My career path

- I came to particle physics as a work-study student at Harvard. Melissa Franklin was hiring students to making field sheets for an upgraded CDF experiment at Fermilab.
- Following graduate school at the University of Rochester, I was an assistant professor at Roberts Wesleyan College for two years. I joined the ATLAS experiment as SLAC's first ATLAS postdoc in 2006. I joined Yale's faculty in 2009. In 2014, I joined the Mu2e Experiment.
- At ATLAS my group contributes to TDAQ – primarily the tau trigger – and we've done various searches and measurements. At Mu2e we also contribute to TDAQ.
- I've been ATLAS upgrade physics coordinator, data preparation convener, and chair of the US ATLAS institutional board. I'm currently the US ATLAS DEI and Outreach co-manager.
- At Snowmass I was in the Community Engagement frontier, co-convening the Public Education and Outreach group.

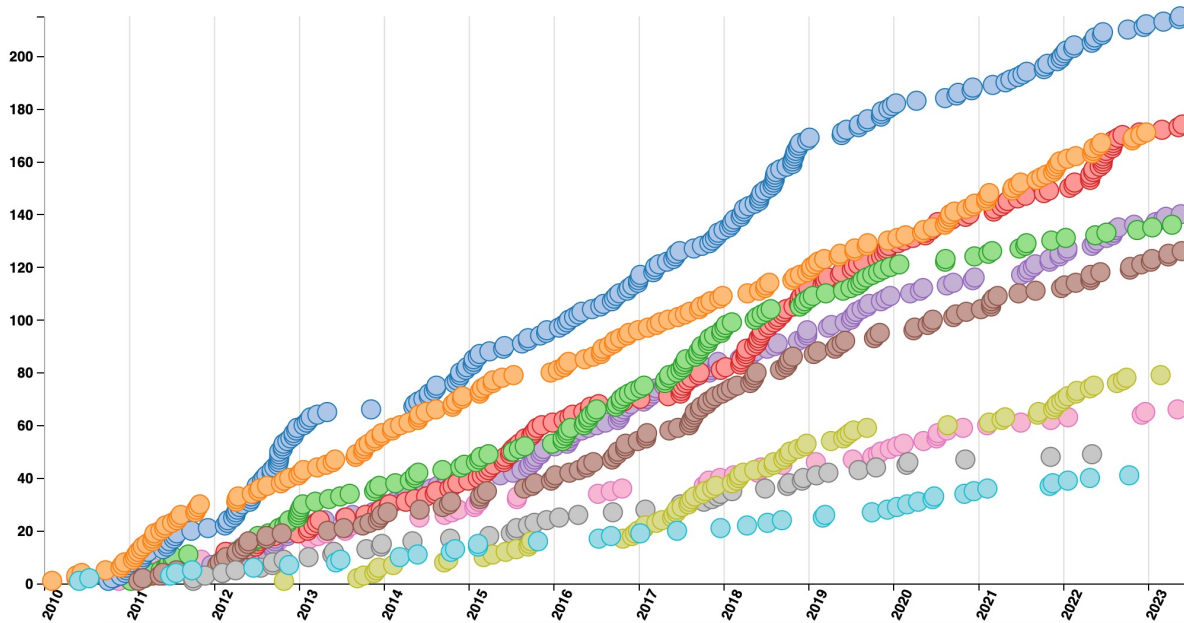




# Submitted Papers

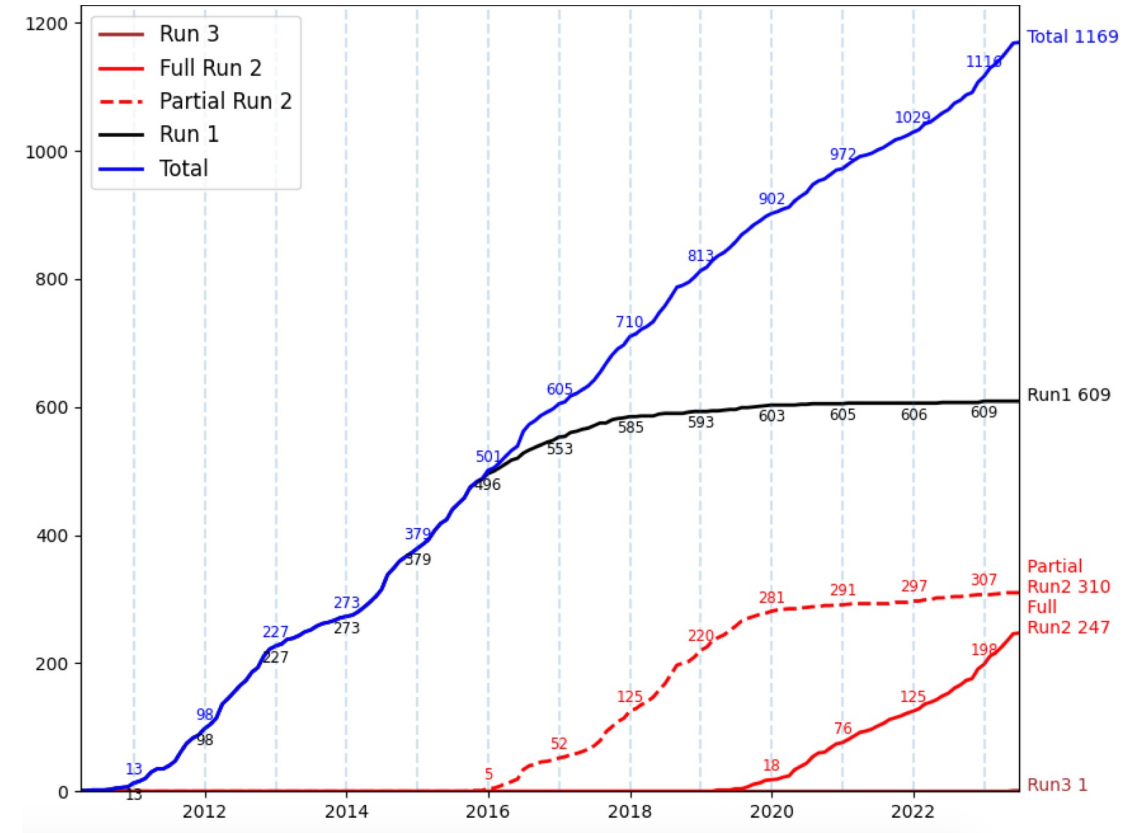
Is this “publish or perish” run amok? No! We have an exquisite dataset, a diverse physics program, and more ideas than time and people...

CMS: 1197 submitted papers



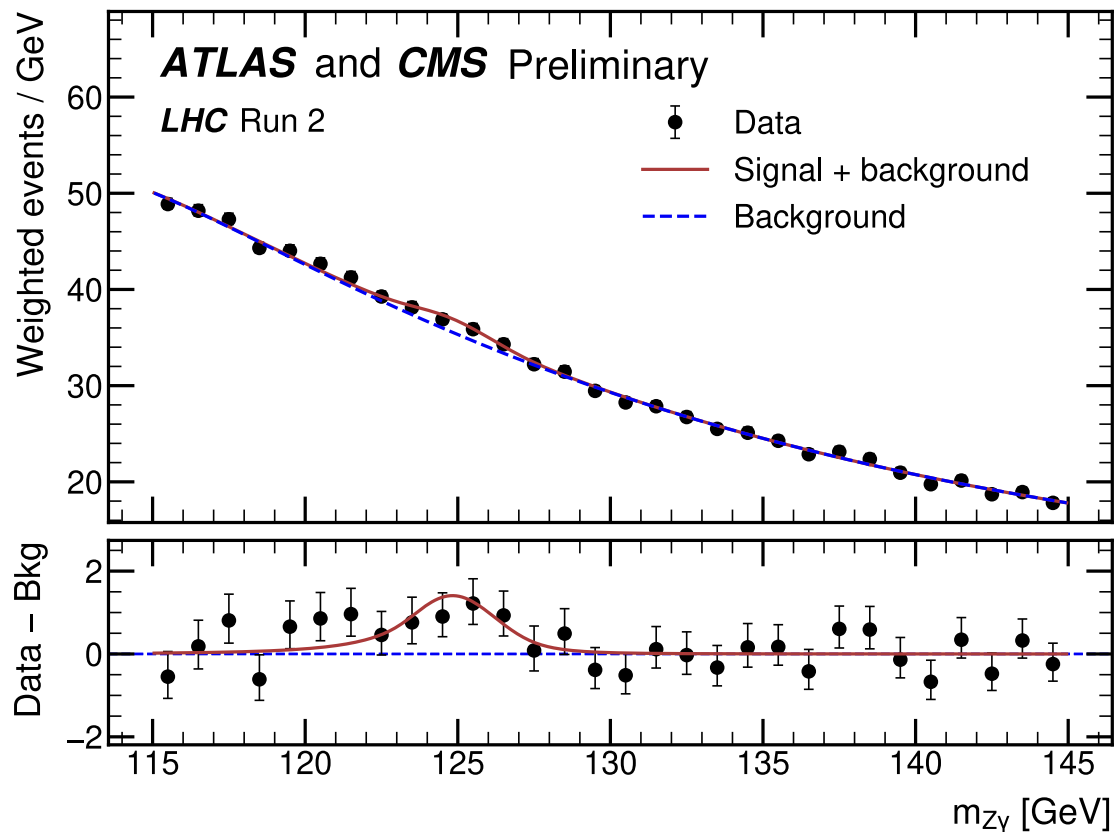
- Exotica
- Standard Model
- Supersymmetry
- Higgs
- Top
- Heavy Ions
- Forward and Soft QCD
- Beyond 2 Generations
- Detector Performance

ATLAS: 1169 submitted papers



# Higgs boson: What have you done for me lately?

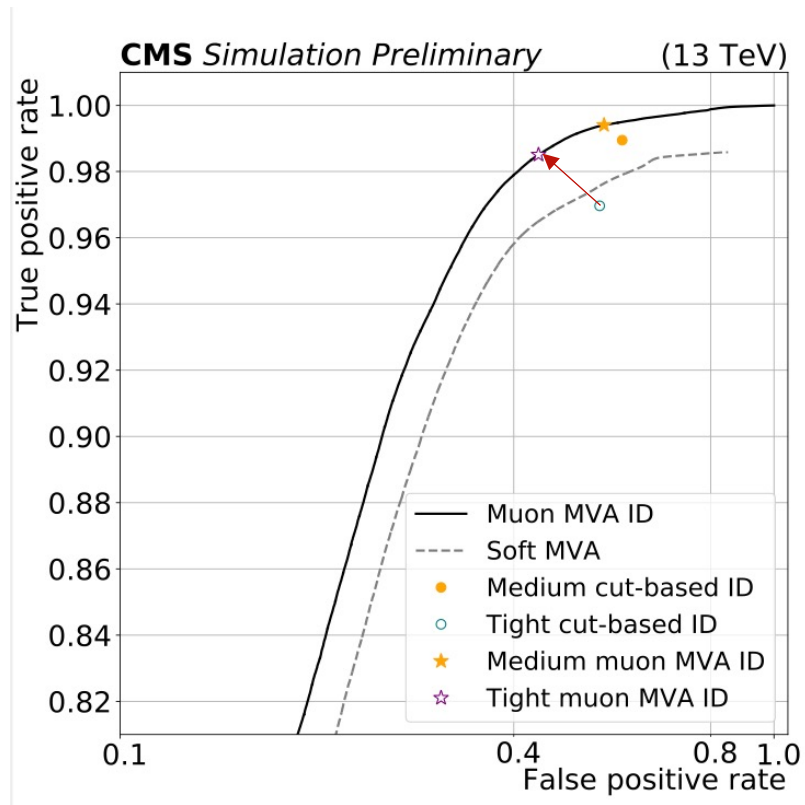
ATLAS and CMS Combination:  $H \rightarrow Z\gamma$  obs.



rare decay modes, mass, width, CP,  
and “**using the Higgs as a tool**”:

- Searches for dark matter produced in association with a Higgs boson
- Searches for VLOs decaying to  $H+X$
- Invisible Higgs decays
- Higgs decays to SM particles +  $X$
- Search for dark photons in  $ZH$
- Searches for  $HH$  production
- Searches for lepton-flavor-violating Higgs decays
- SUSY: High- or low- mass higgs bosons with a range of  $\tan\beta$  assumptions
- ...

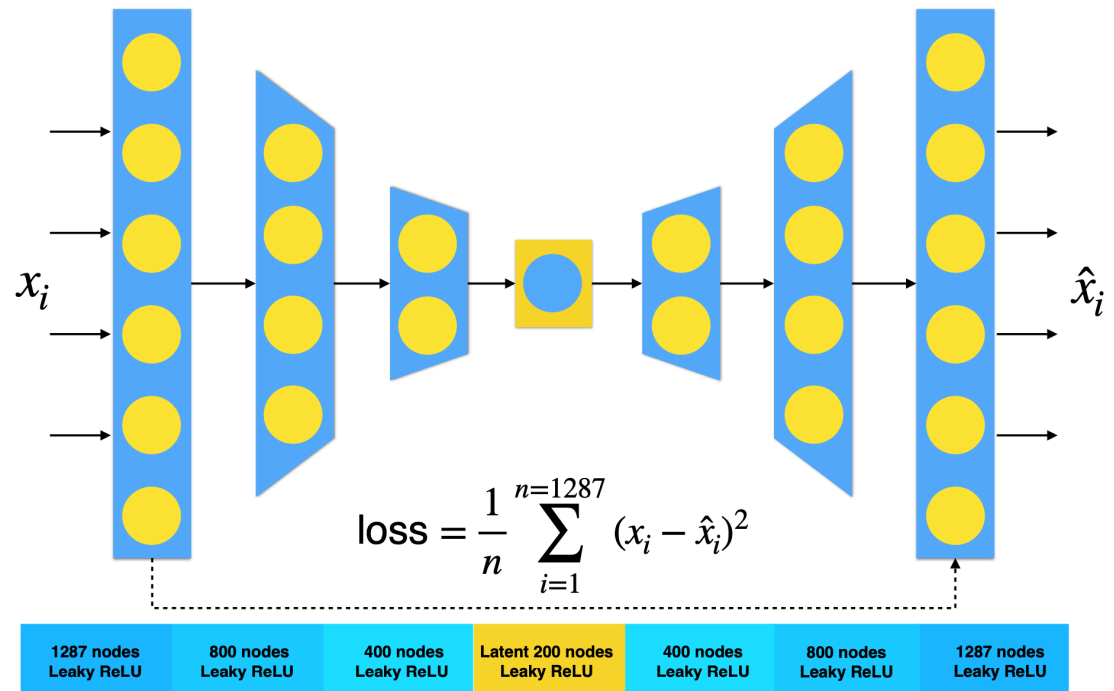
# AI/ML Everywhere!



Muon ID: random forest trained on high-level features  
([CMS-PAS-MUO-22-001](#))

Triggers, reconstruction, classification!  
Analysis building blocks, final measurement fits!

Unsupervised learning for anomaly detection

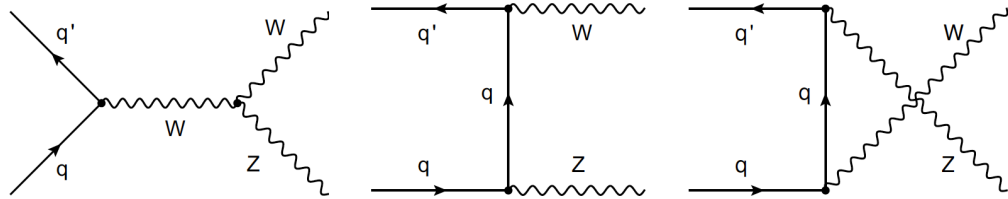


[ATLAS-CONF-2023-022](#)

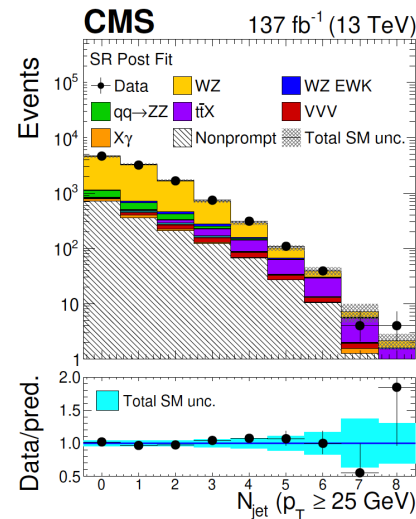
# The LHC is a precision EW Machine

CMS Collaboration Higgs boson width measurement  
[Nature Physics, 18, 1329-1334 \(2022\)](#)

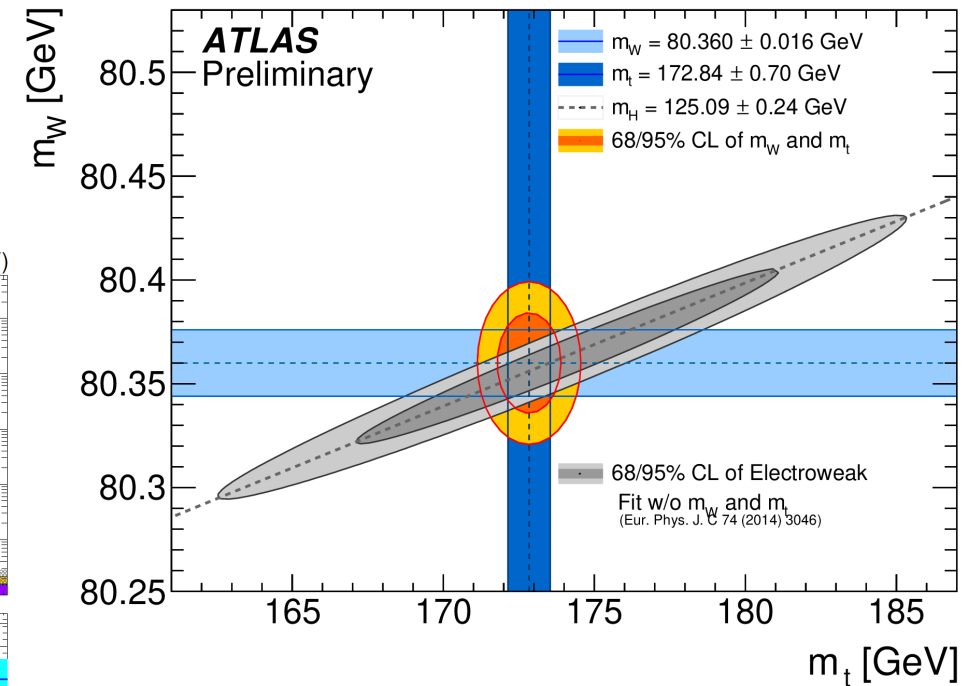
expectation, to the interval  $[0.0061, 2.0]$  at the 95% confidence level. The scenario with no off-shell contribution is excluded at a  $p$ -value of 0.0003 (3.6 standard deviations). We measure the width of the Higgs boson as  $\Gamma_H = 3.2^{+2.4}_{-1.7}$  MeV, in agreement with the standard model expectation of 4.1 MeV. In addition, we set constraints on anomalous Higgs boson couplings to W and Z boson pairs.



CMS Collaboration differential WZ production XSs  
[JHEP07 \(2022\) 032](#)



[ATLAS-CONF-2023-004](#)



# We are just getting started at the LHC

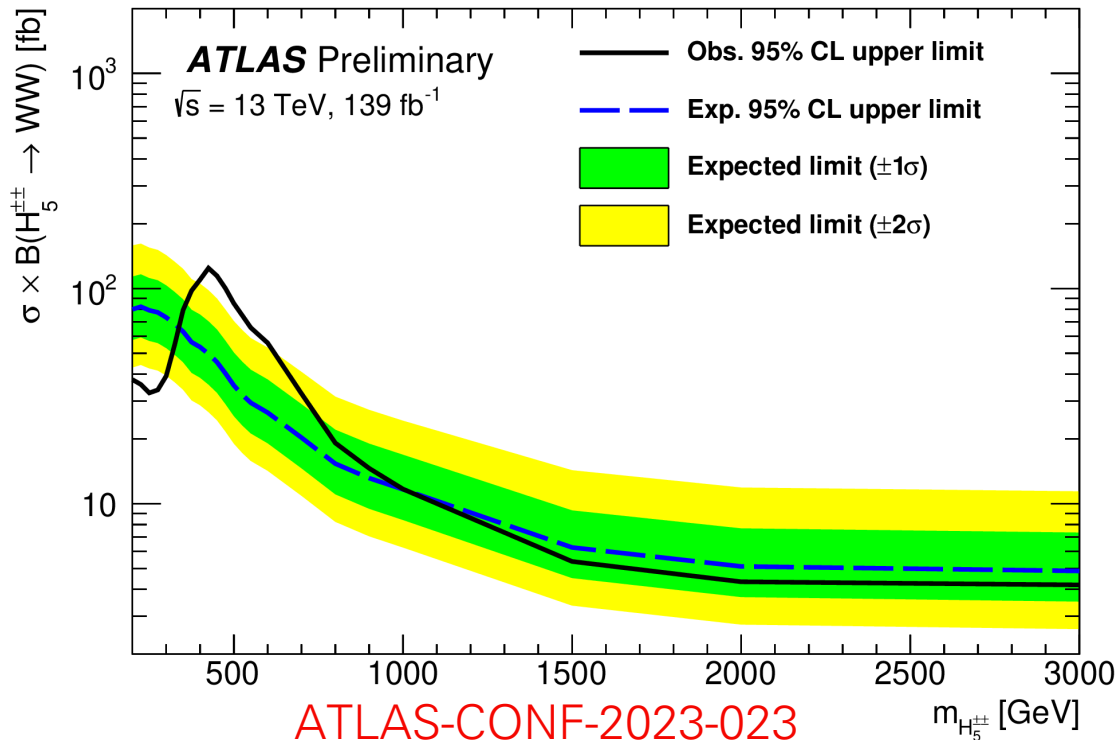
An order of magnitude more data is on the way... The hunt for dark matter, SUSY, gravitons, long-lived particles, etc. continues.



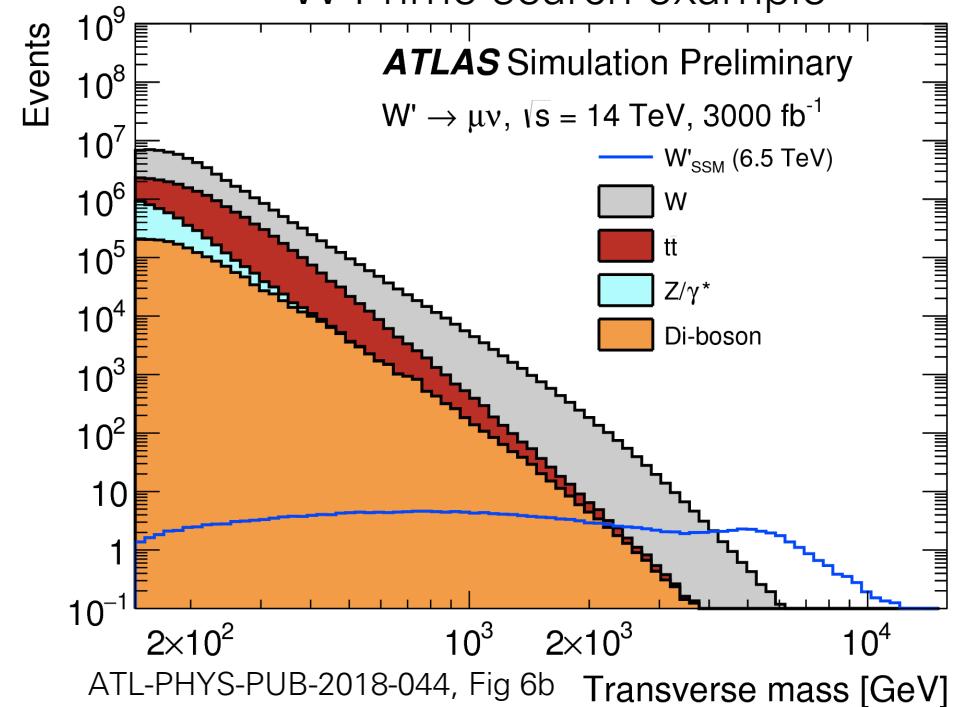
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# We have various bumps to chase and real HL-LHC discovery potential

H<sup>++</sup> search was performed in a same-sign WW analysis



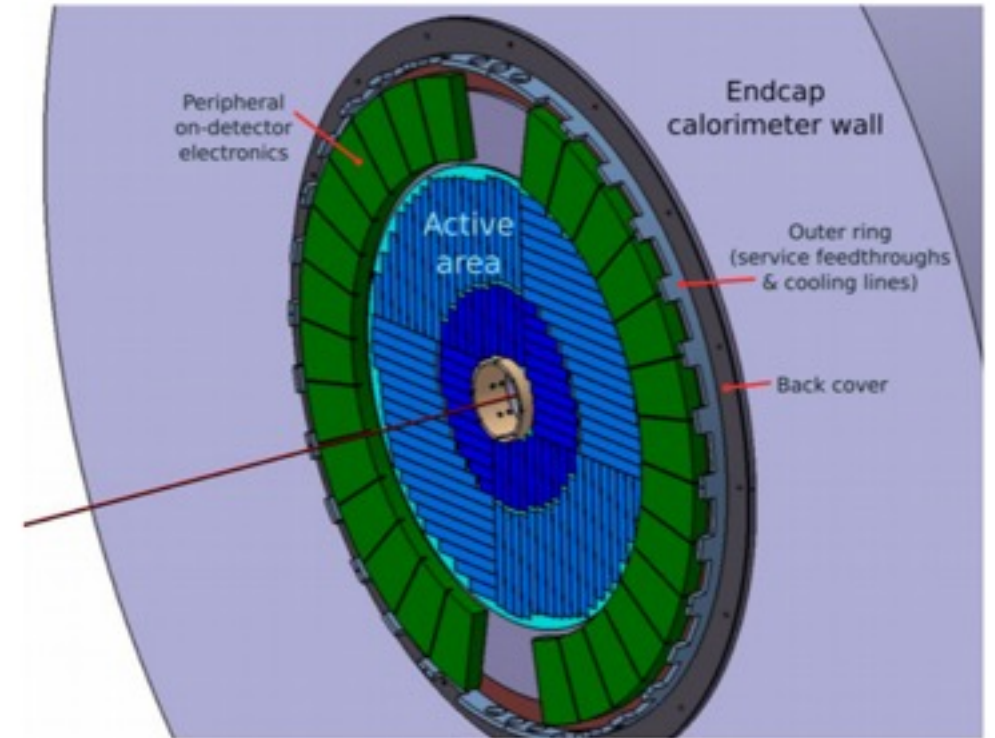
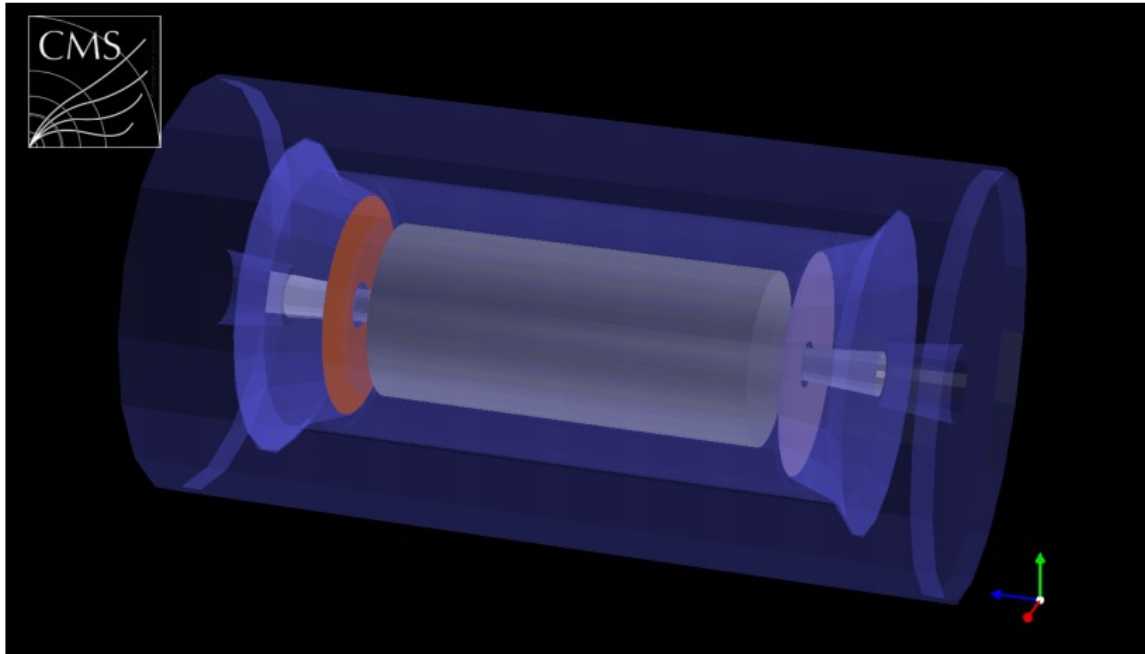
W Prime search example



HL-LHC (e +  $\mu$ ) discovery reach at 7.7 TeV  
 Exclusion limit at 7.9 TeV



# We have new handles, like timing, and the expanded reach of detectors.



# We are in this world and of this world

## CERN's Response to the Energy Crisis

- ❑ In response to the apparent shortage of (electrical) energy in Europe, and in particular in France, and as a mark of social responsibility CERN decided to
  - ❑ Start the 2022 Year-End-Technical-Stop (YETS) 2 weeks earlier (November 28 rather than mid December)
  - ❑ Prepare reduced power configurations for possible EDF load shedding scenarios
  - ❑ Reduce the operation of the accelerator complex in 2023 by 20% (YETS 2023/24 will be extended from 15 to 19 weeks beam to beam)
  - ❑ Measures to reduce energy consumption on the CERN campus have been implemented
- ❑ To address the potential longer-term impact of high electricity costs, and high inflation, discussions with CERN Council are going on

## CERN releases its second Environment Report setting out concrete actions to reduce its environmental footprint

The report covers the years 2019-2020 when the accelerator complex was in its second long shutdown, an opportunity for CERN to improve its environmental footprint on several levels

24 NOVEMBER, 2021

NEWS | 17 February 2023

## LHC physicists resolve stalemate over Russian authors

Agreement on how to list scientists at Russian organizations on research papers will help to clear journals' backlog.



10th annual report of the CERN Ombud

1<sup>st</sup> January 2020 – 31<sup>st</sup> December 2020

Pierre Gildemyn



# Some Personal Early Career Award Reflection

- Impact on tenure prospects and department perceptions
- Impact on self-identification
- Further opportunities

DOE Early Career Award Proposal  
Principal Investigator: Sarah Demers  
Title: Taus and the Trigger for Discovery at ATLAS