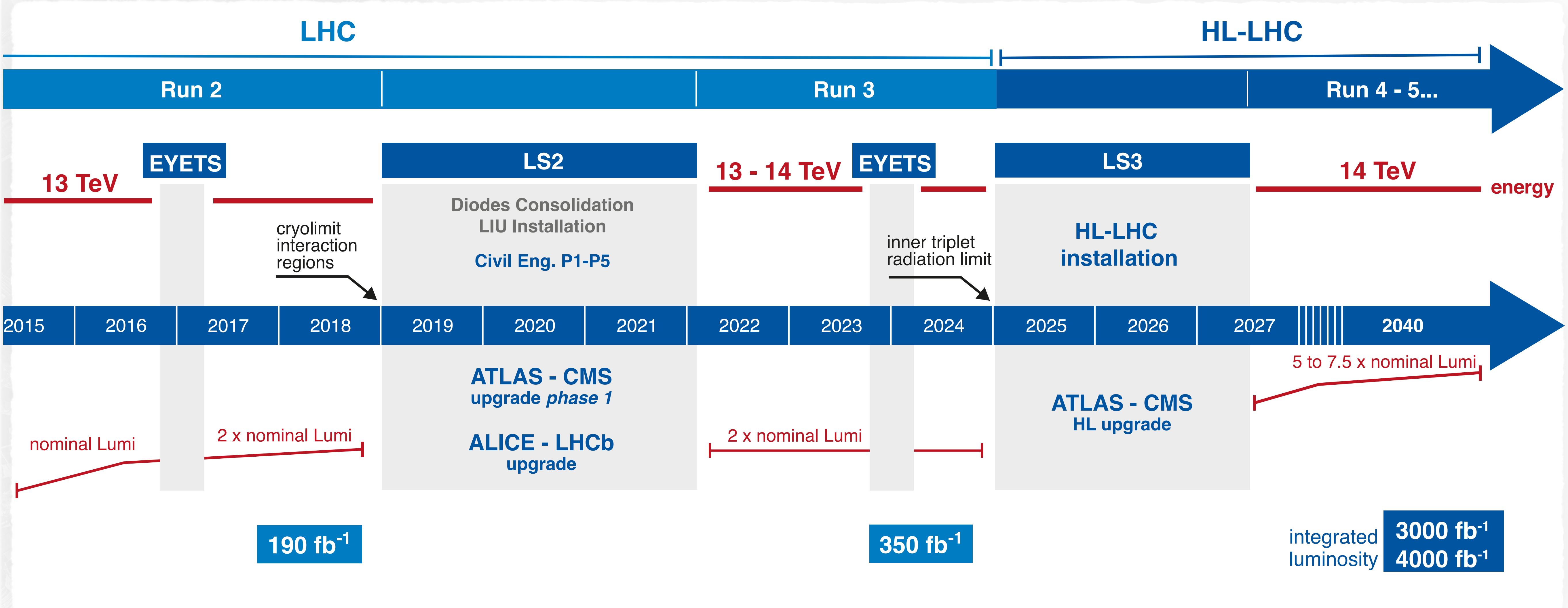
Istituto Nazionale di Fisica Nucleare
Sezione di Roma

Prospects for BSM at LHC (experimental vision)

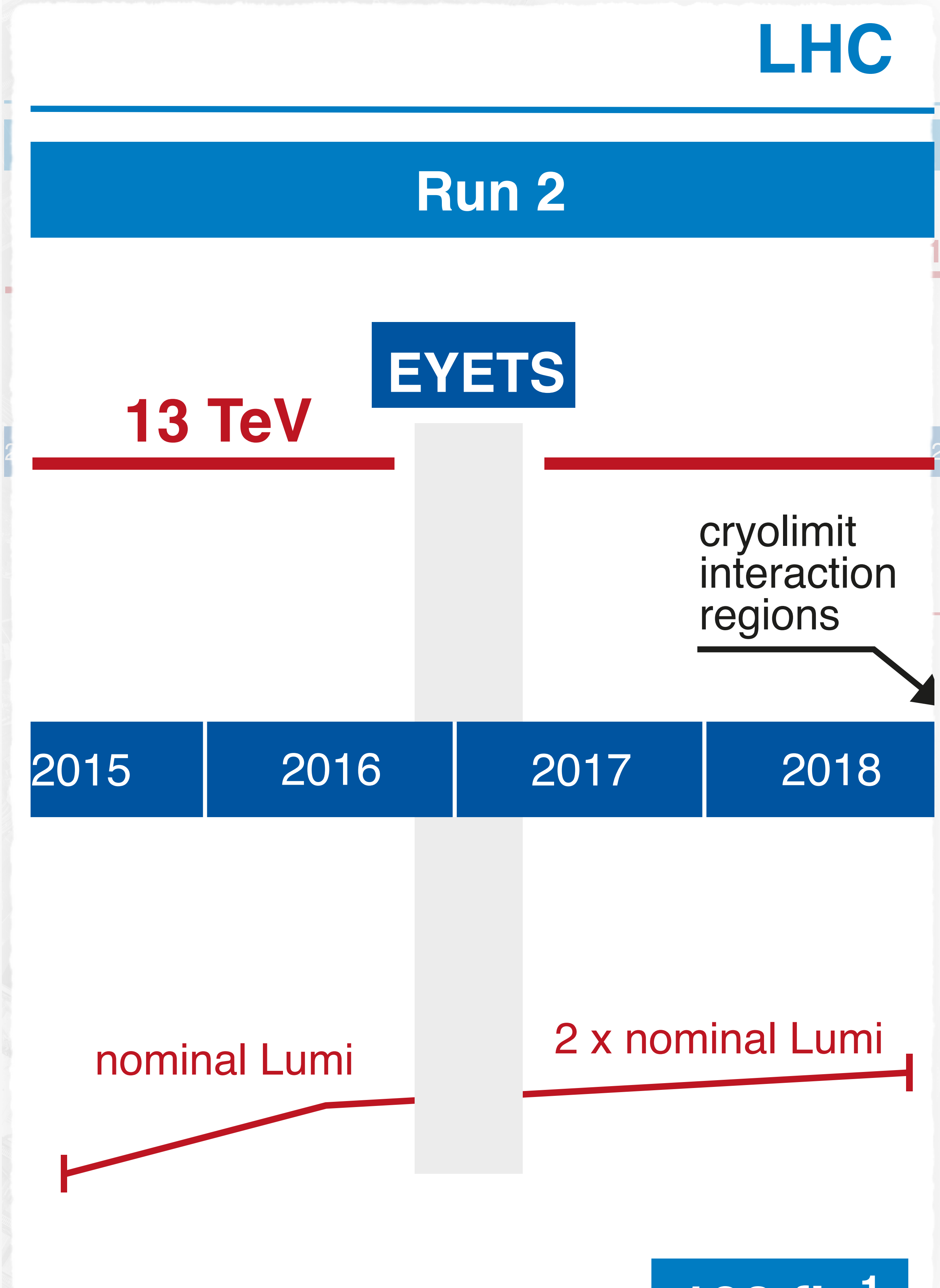
Livia Soffi on behalf of ATLAS and CMS Collaboration

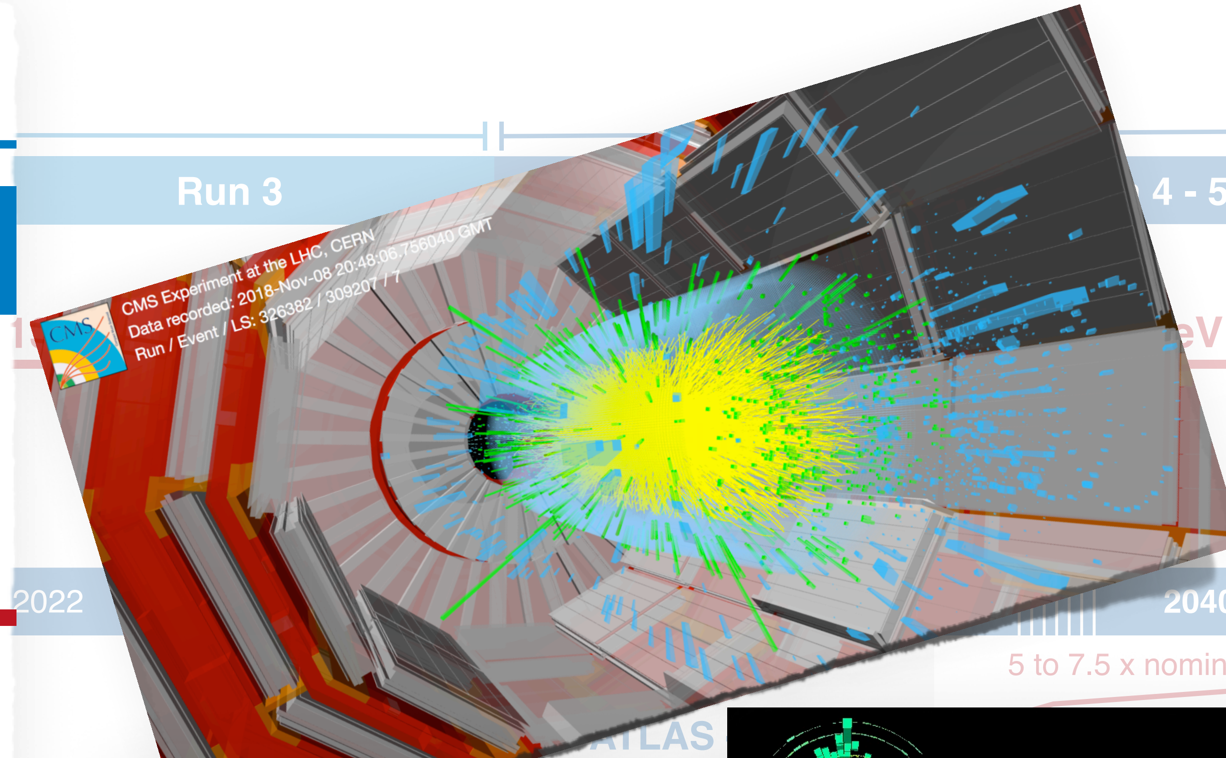
Setting the stage

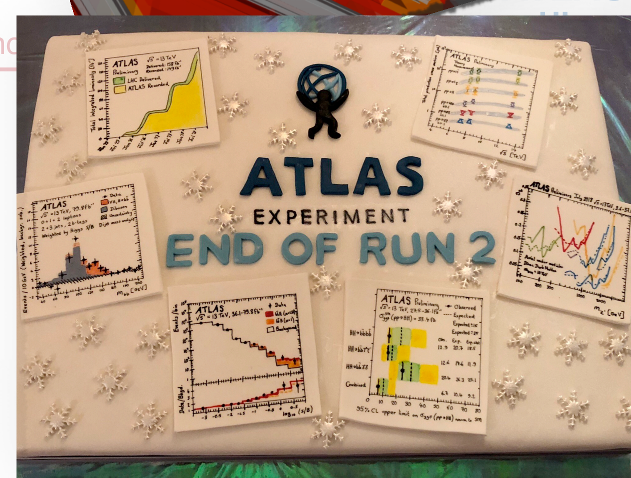


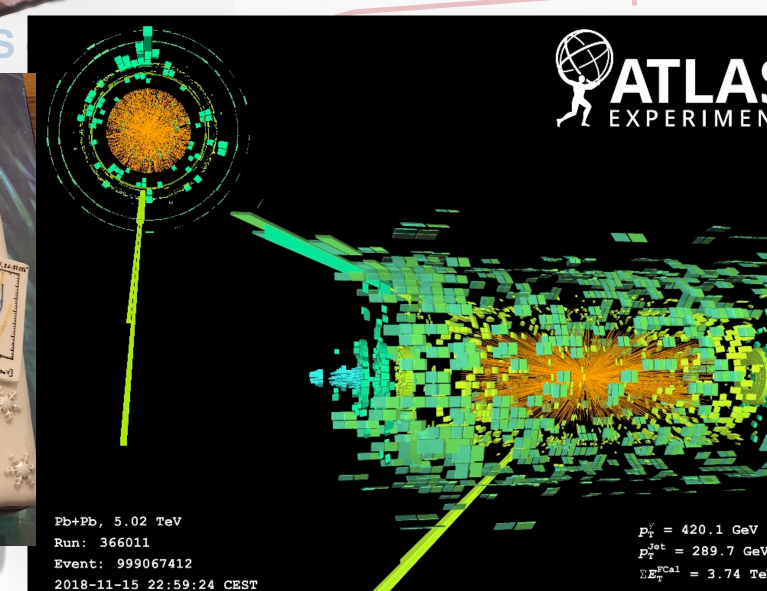
- **Long Shutdown 2** (Phase-1 upgrade) preparing **Run 3**
  - Luminosity at 2 x $10^{34}/cm^2/s$, possible increase to $\sqrt{s}$=13.5 or 14 TeV
- **Long Shutdown 3** (Phase-2 upgrade) preparing **HL-LHC**
  - Luminosity at 7.5 x $10^{34}/cm^2/s$ at $\sqrt{s}$=14 TeV
  - Large data samples and major experimental challenges

Run 2 close out



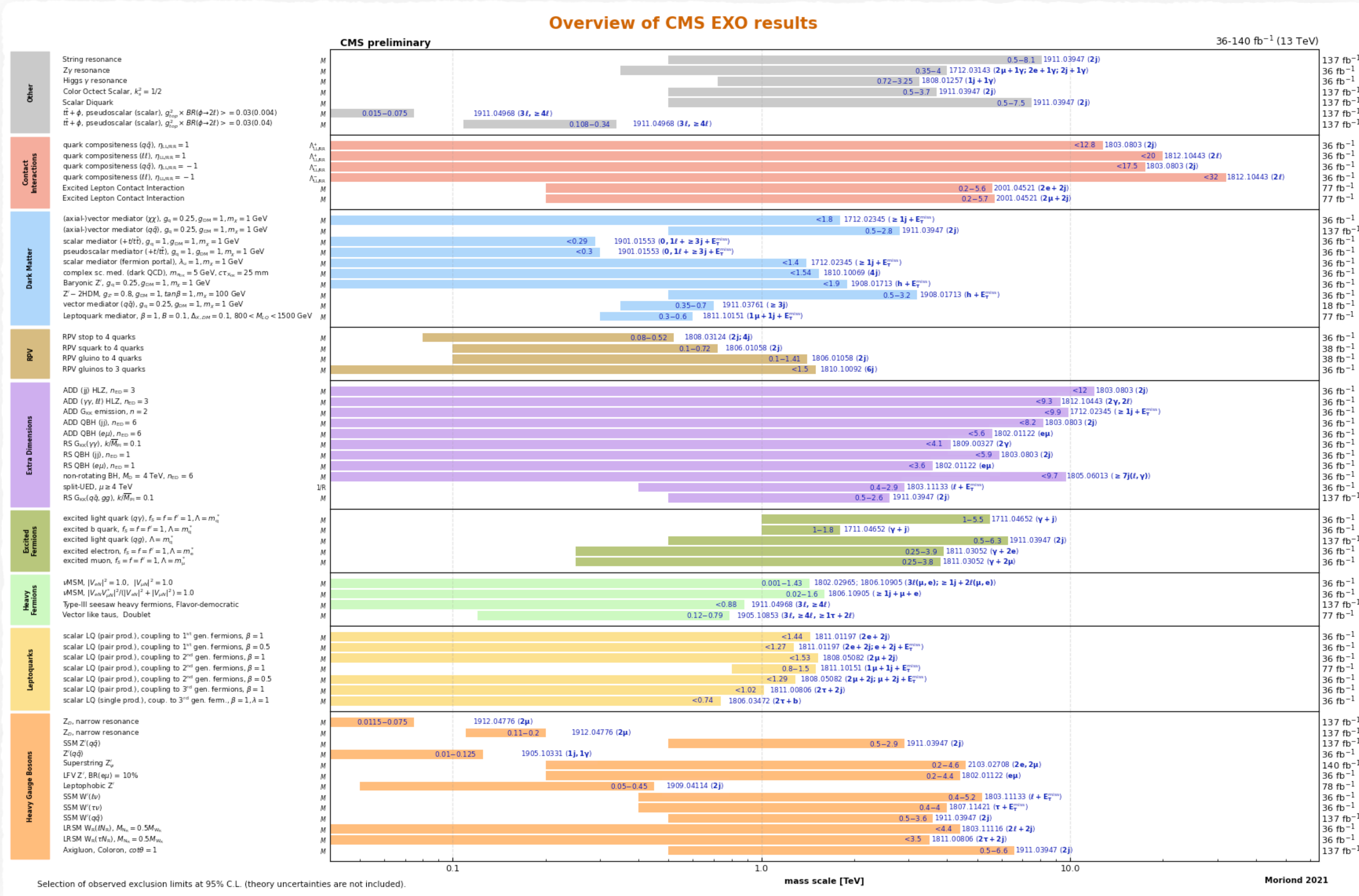






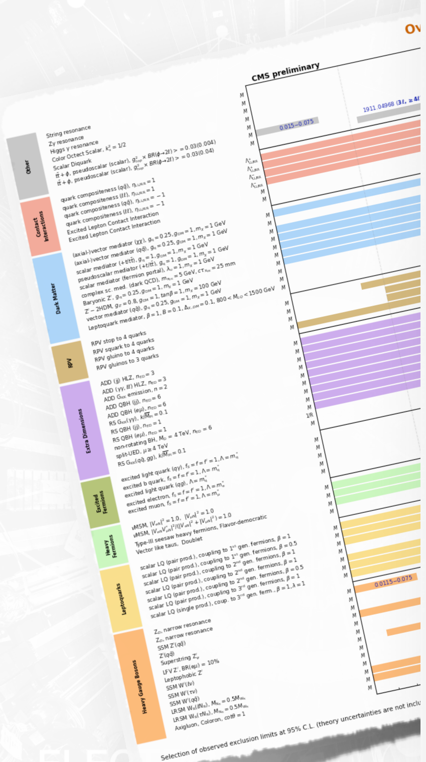
Run 2 extraordinary exploration of the high-energy frontier!

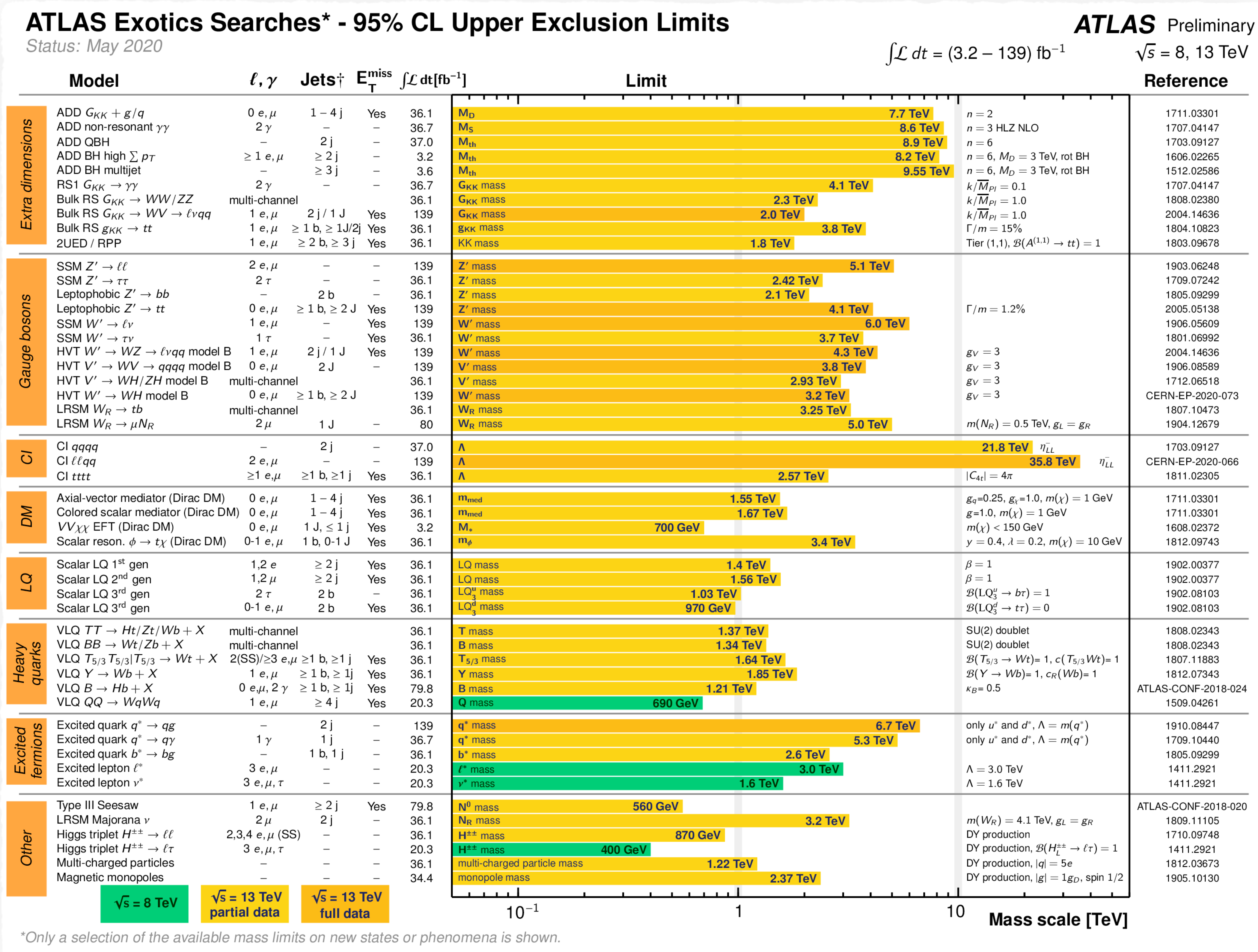
A New Understanding of Particle Physics



CMS EXOTICA Summary 2021

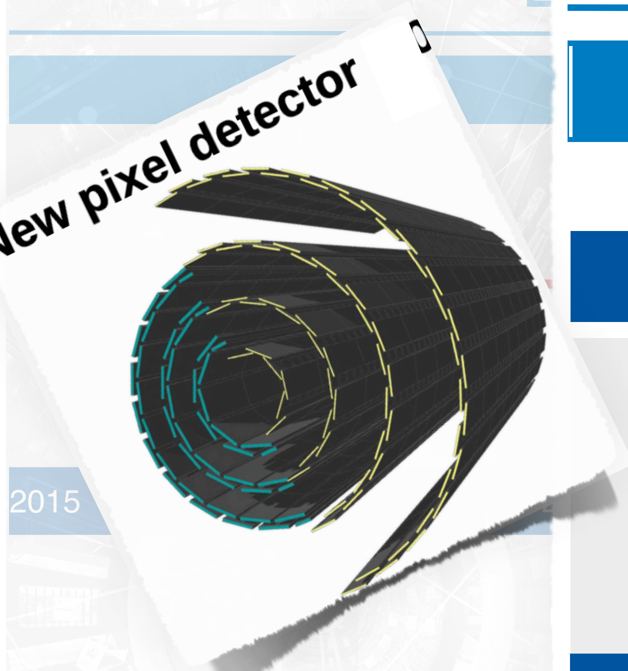
A New Understanding of Particle Physics

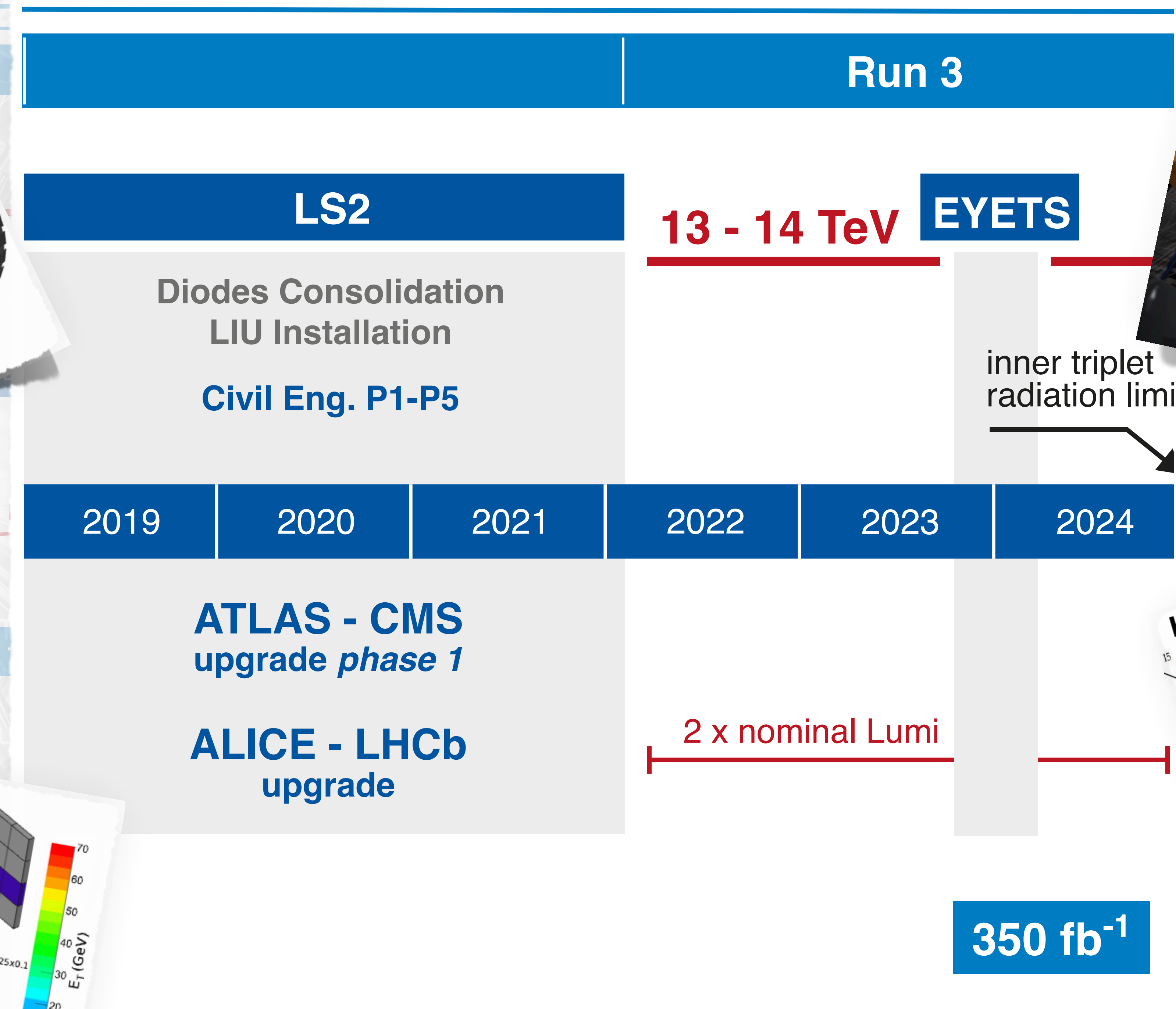


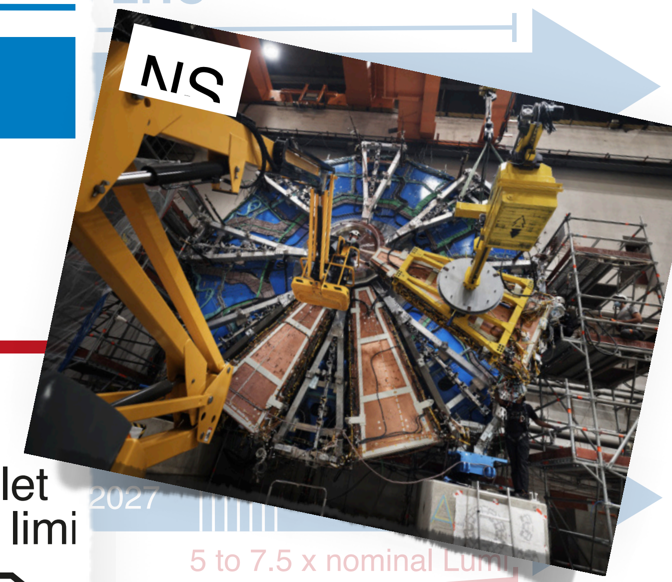


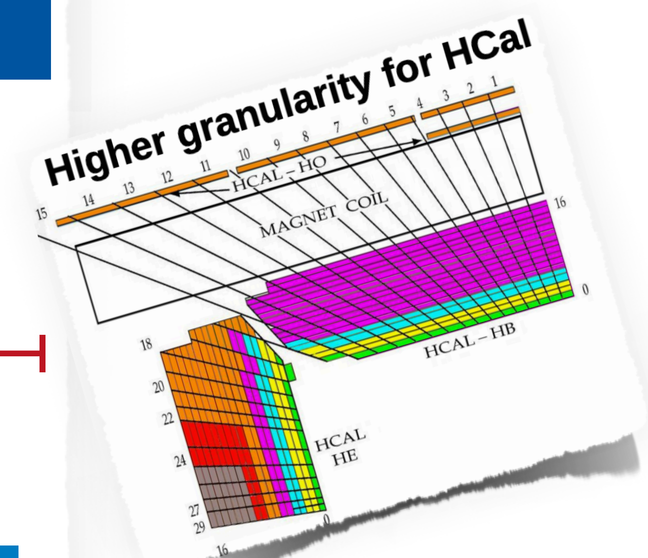
ATLAS EXOTICA Summary 2021

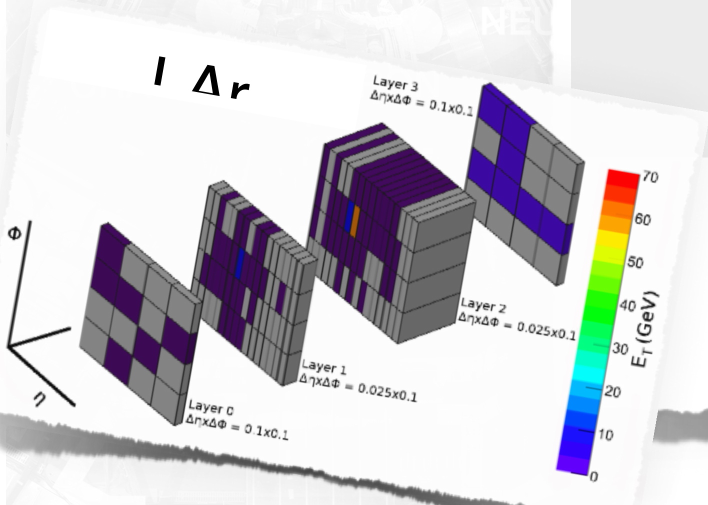
Long Shutdown 2: preparing for Run 3







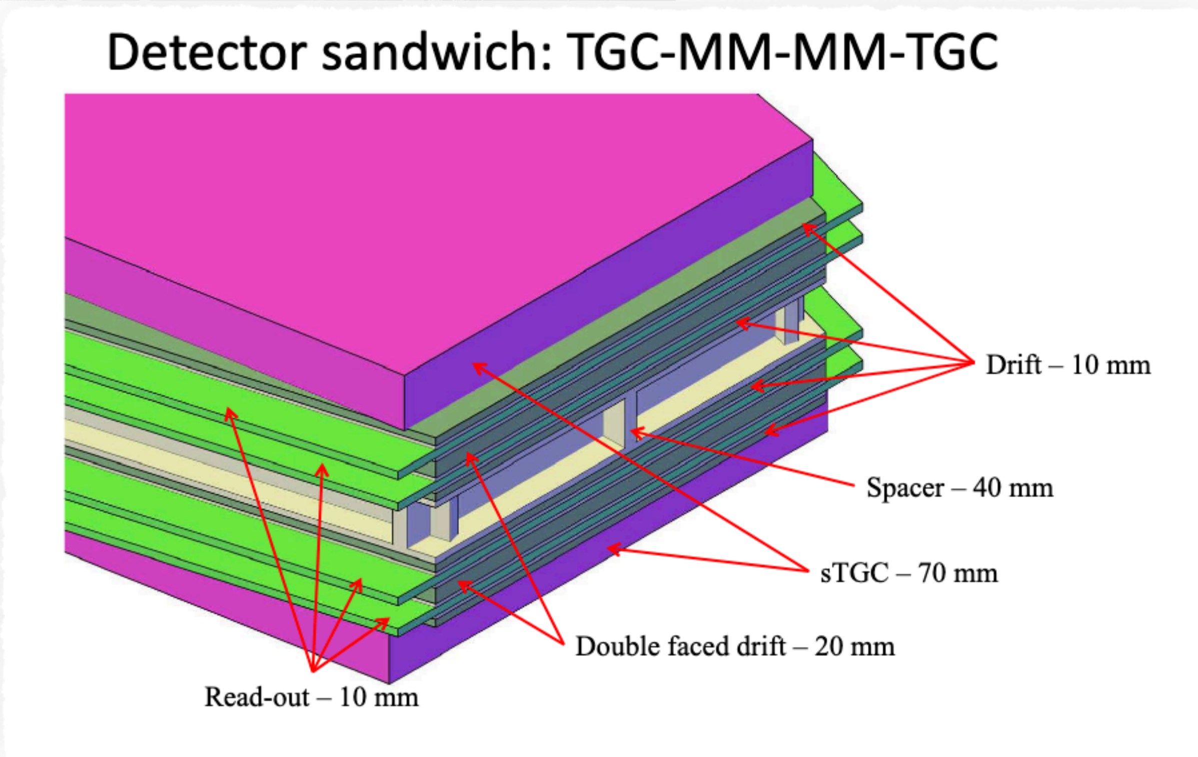




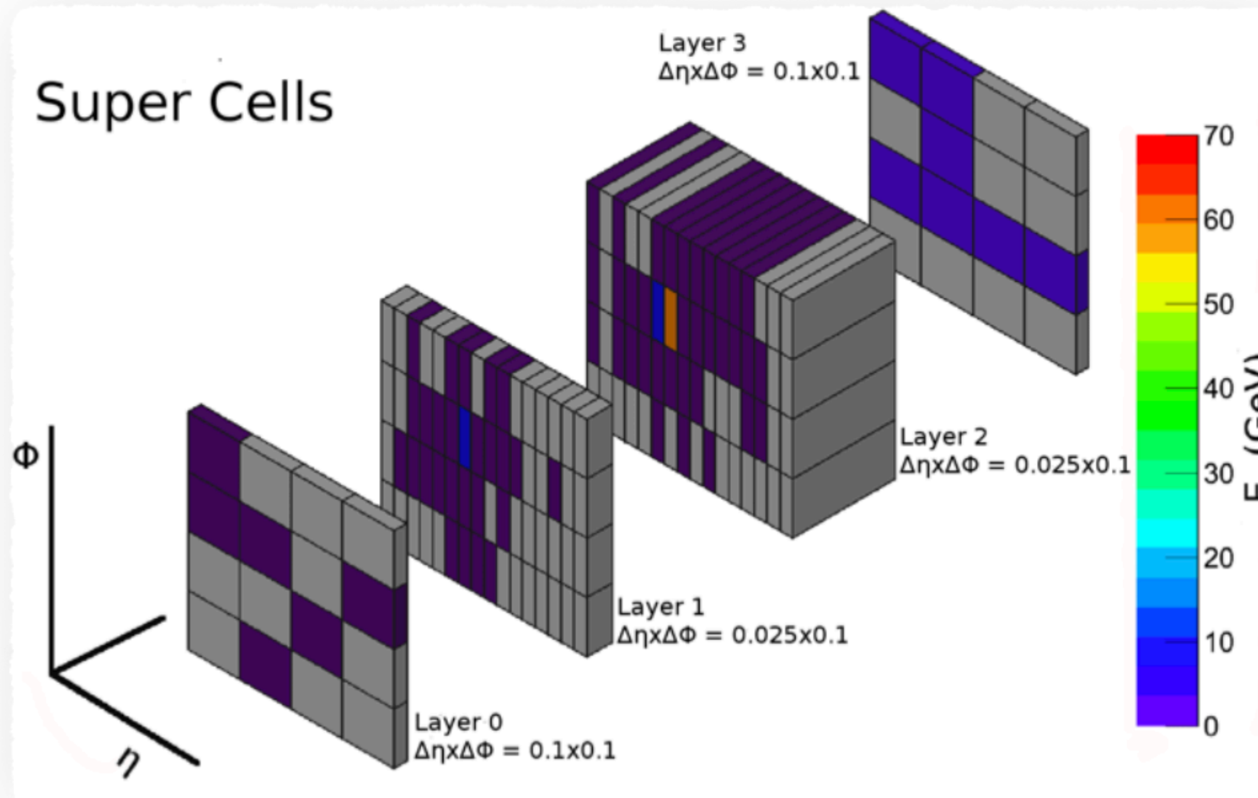
Run 3 approaching fast.. getting ready!

Some new opportunities at Run 3

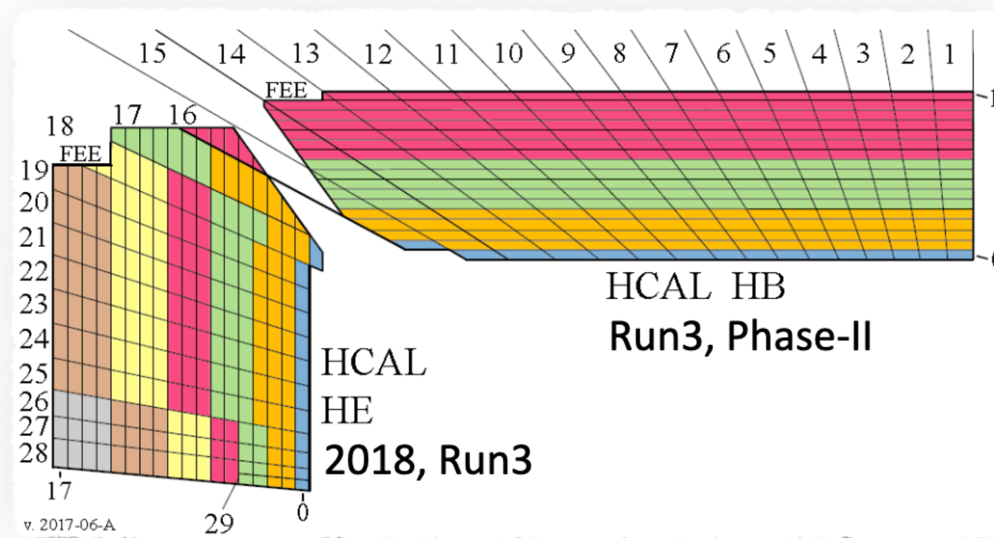
- **ATLAS New Small Wheel**: Fast readout and precision tracking resolution



- **ATLAS LAr L1**: super cells improved energy resolution and identification efficiency



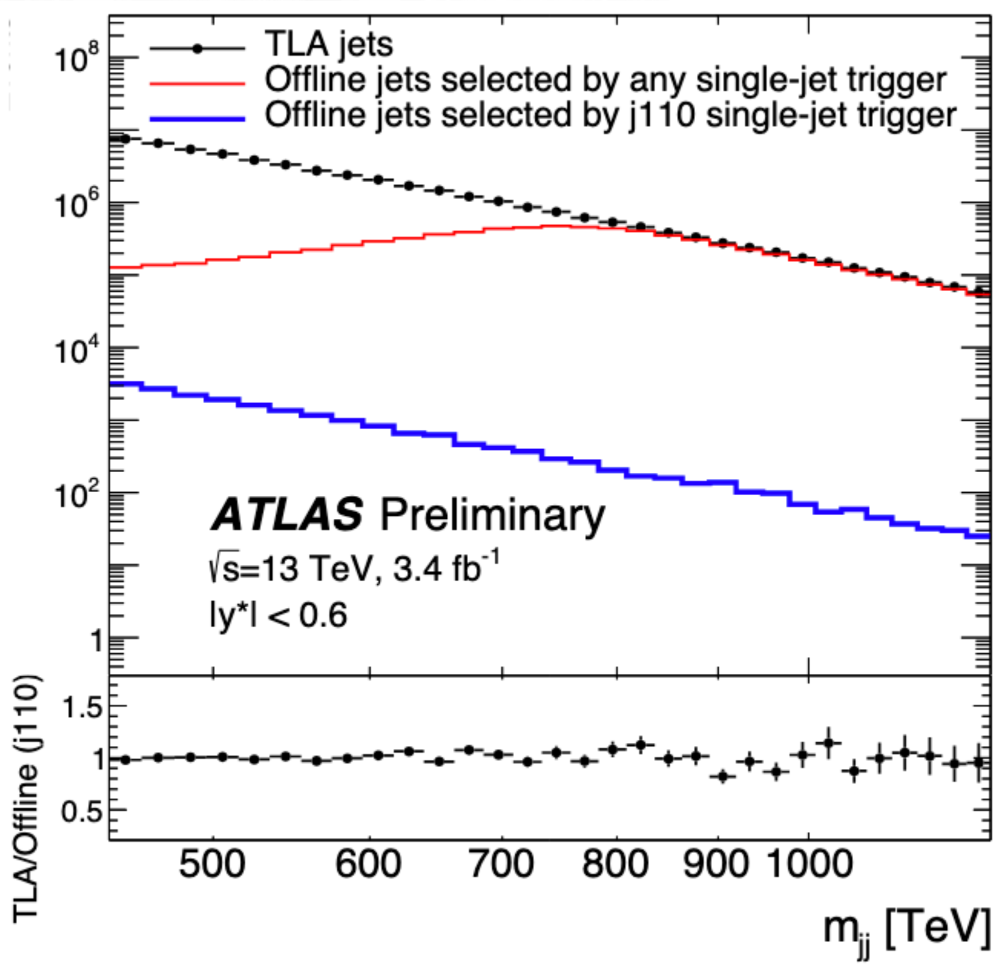
- **CMS HCAL** electronics upgraded now read out in 4-7 depths

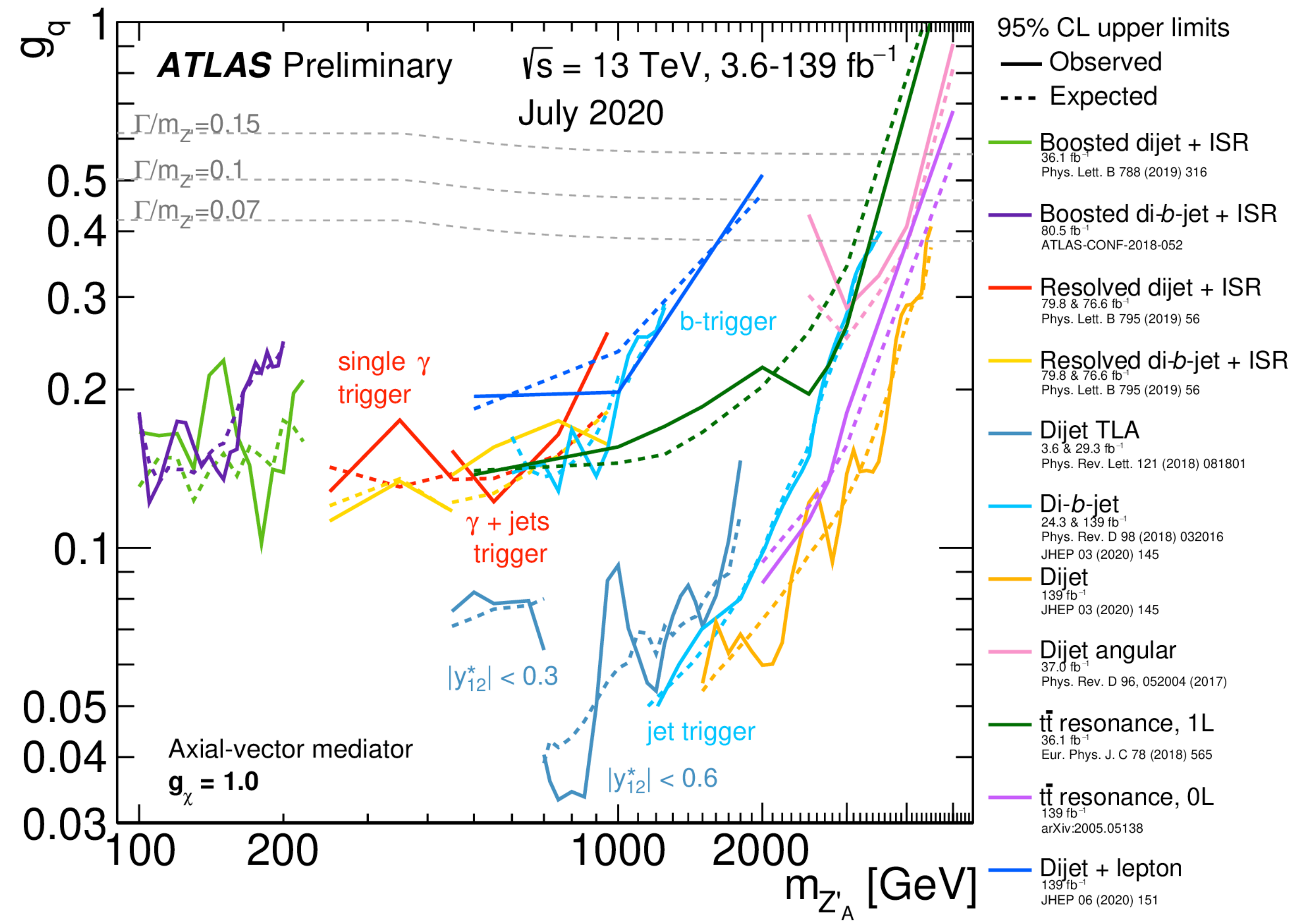


Unconventional Data Taking

- Novel idea to **circumvent bandwidth limitation** w/ **partial event building**
- Going beyond the 1-kHz limit in two ways:
  - **"data parking"** → offline reconstruction is delayed.
  - **"data scouting"** → saving only objects reco'd at trigger level

ATLAS-CONF-2016-030

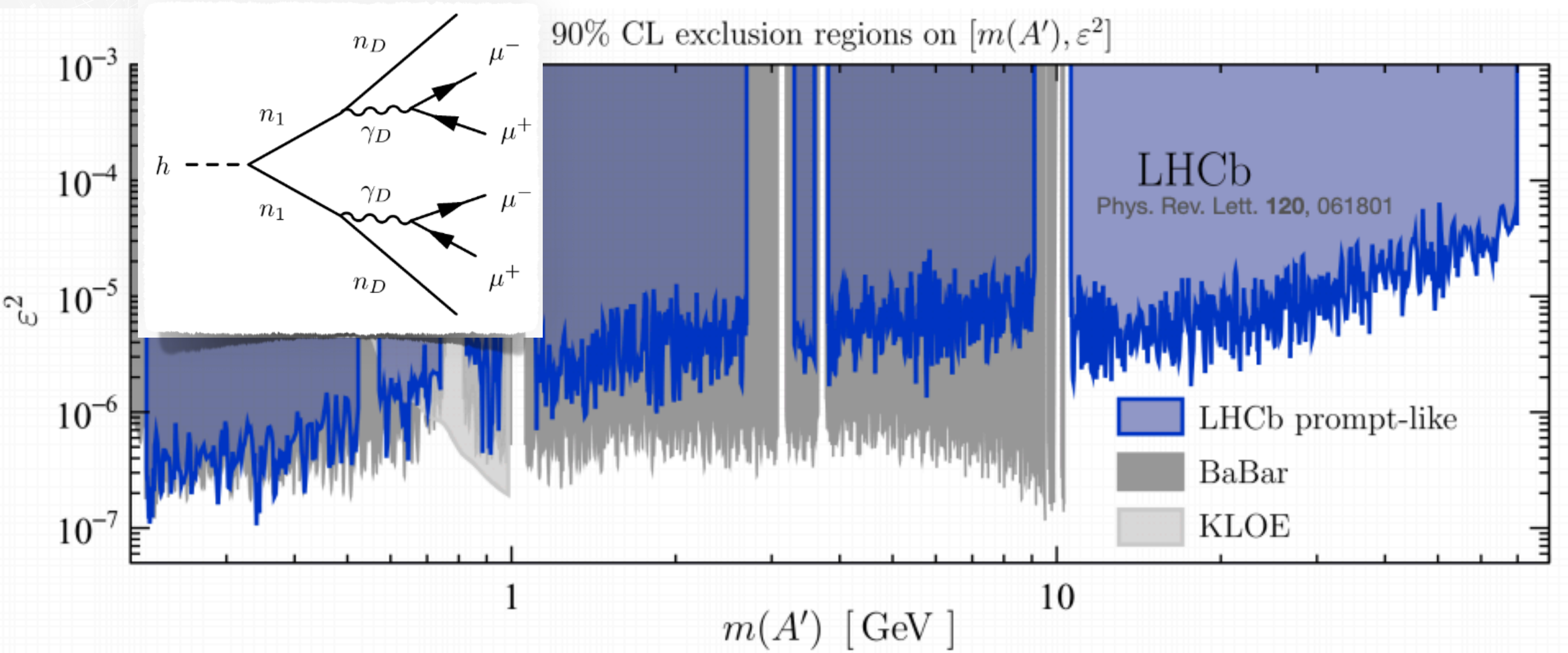




ATLAS EXOTICA Summary Plots 2021

Keep an eye on the other side of the ring

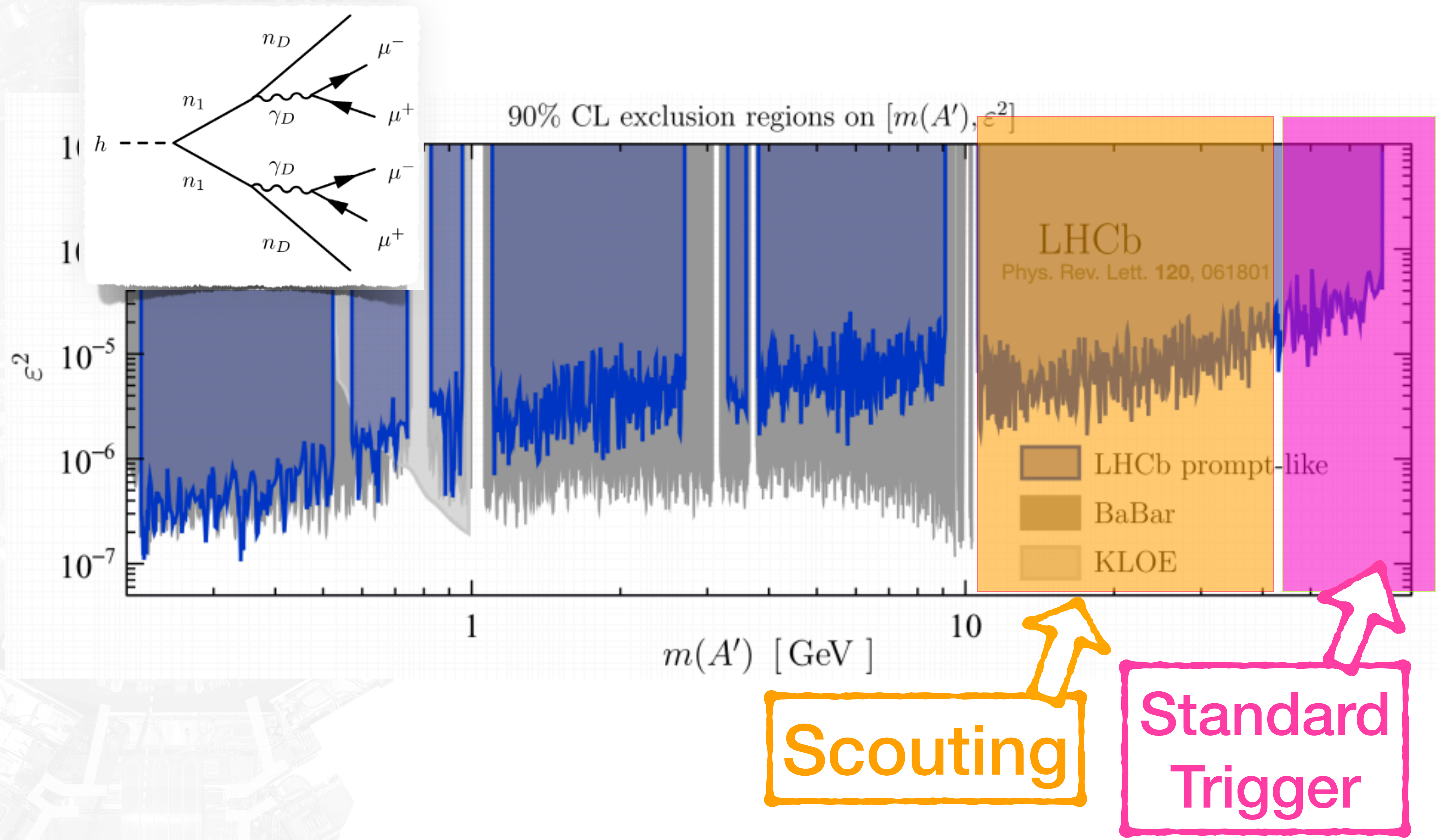
- Most spectacular example of vector portal address SM problems: dark photon



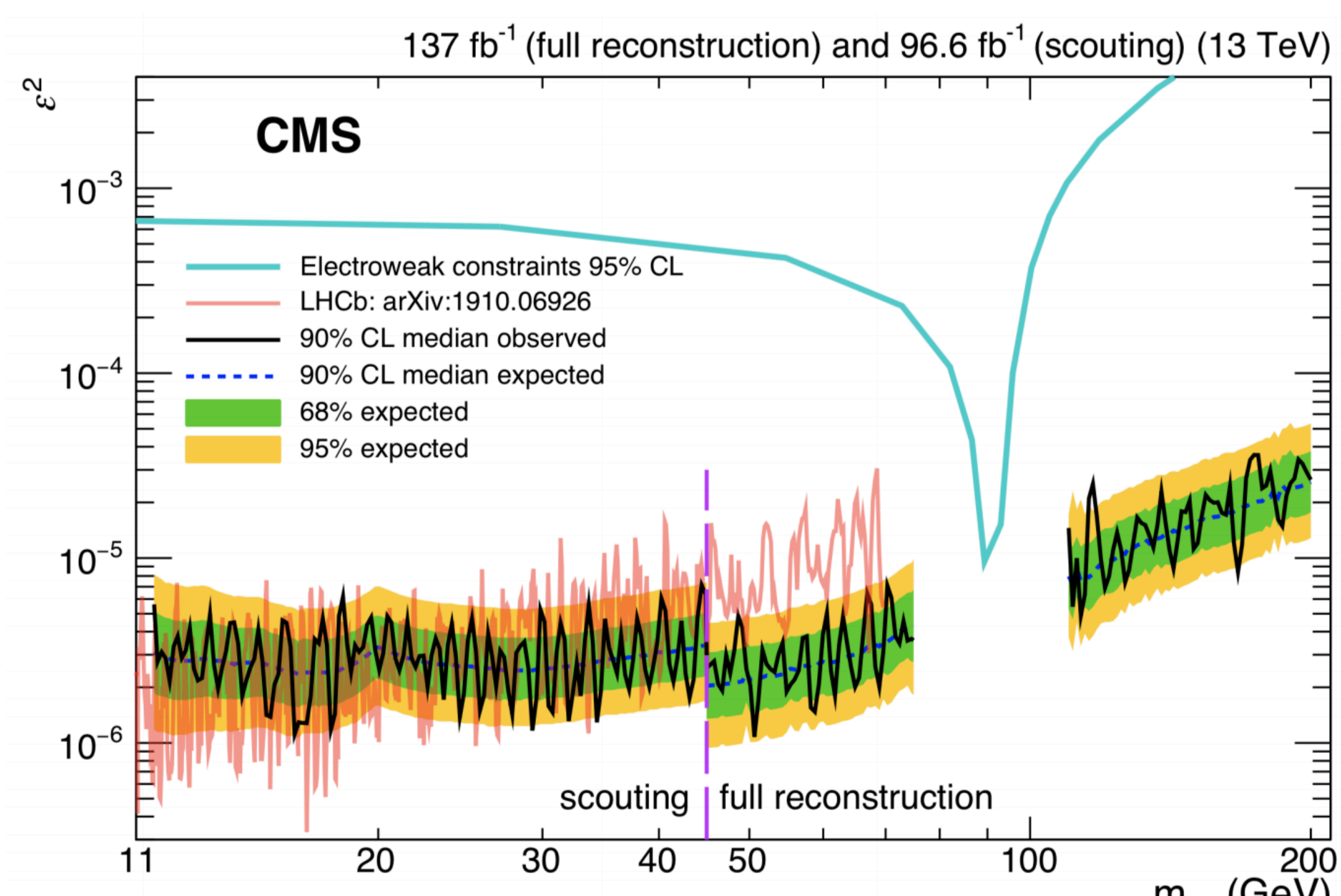
PhysRevLett.120.061801

- If epsilon < 10^{-5} A' **can be longlived**
- Main **challenge for ATLAS/CMS is triggering** and discriminating backgrounds

Scouting Dark Photons at CMS



Scouting Dark Photons at CMS

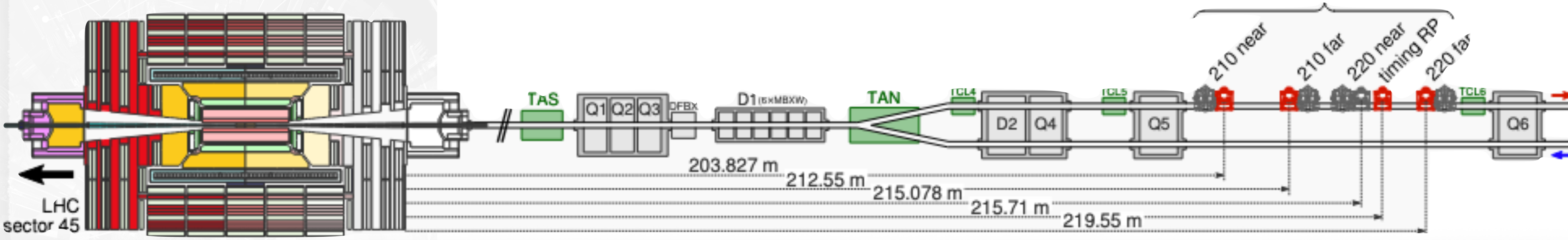


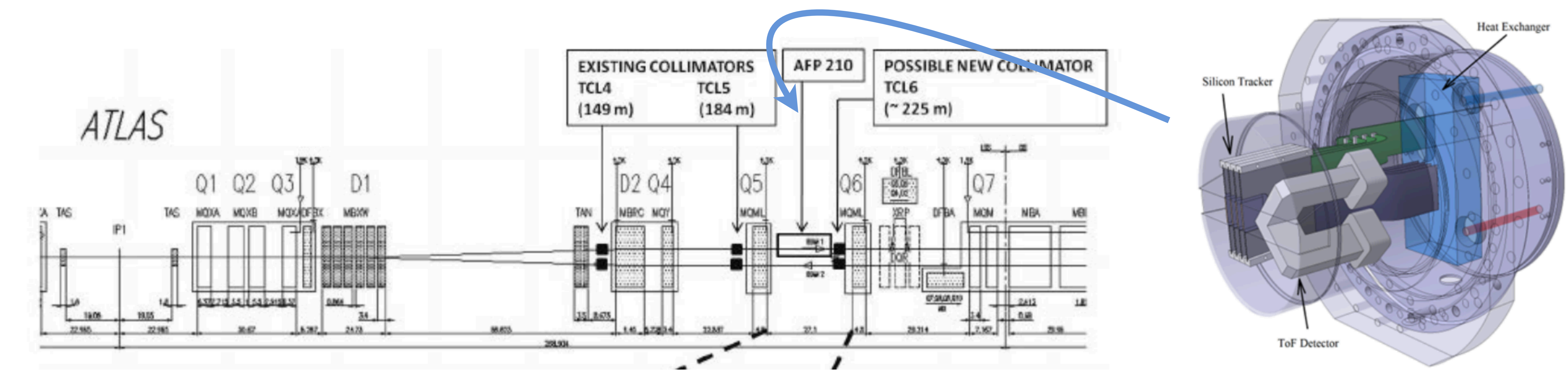
11.5-45 GeV scouting

45 – 75, 110 - 200 GeV: full reconstruction

Phys. Rev. Lett. 124 , 13 (2020) 131802

New forward detectors have their say





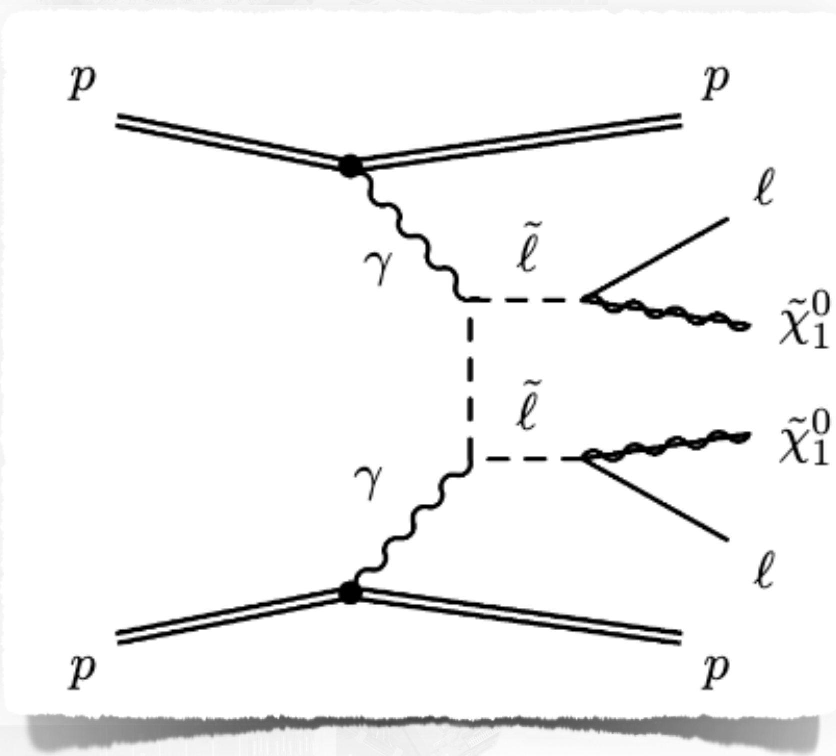
- Significant **extension to the physics reach** by tagging and measuring momentum and emission angle of very forward protons

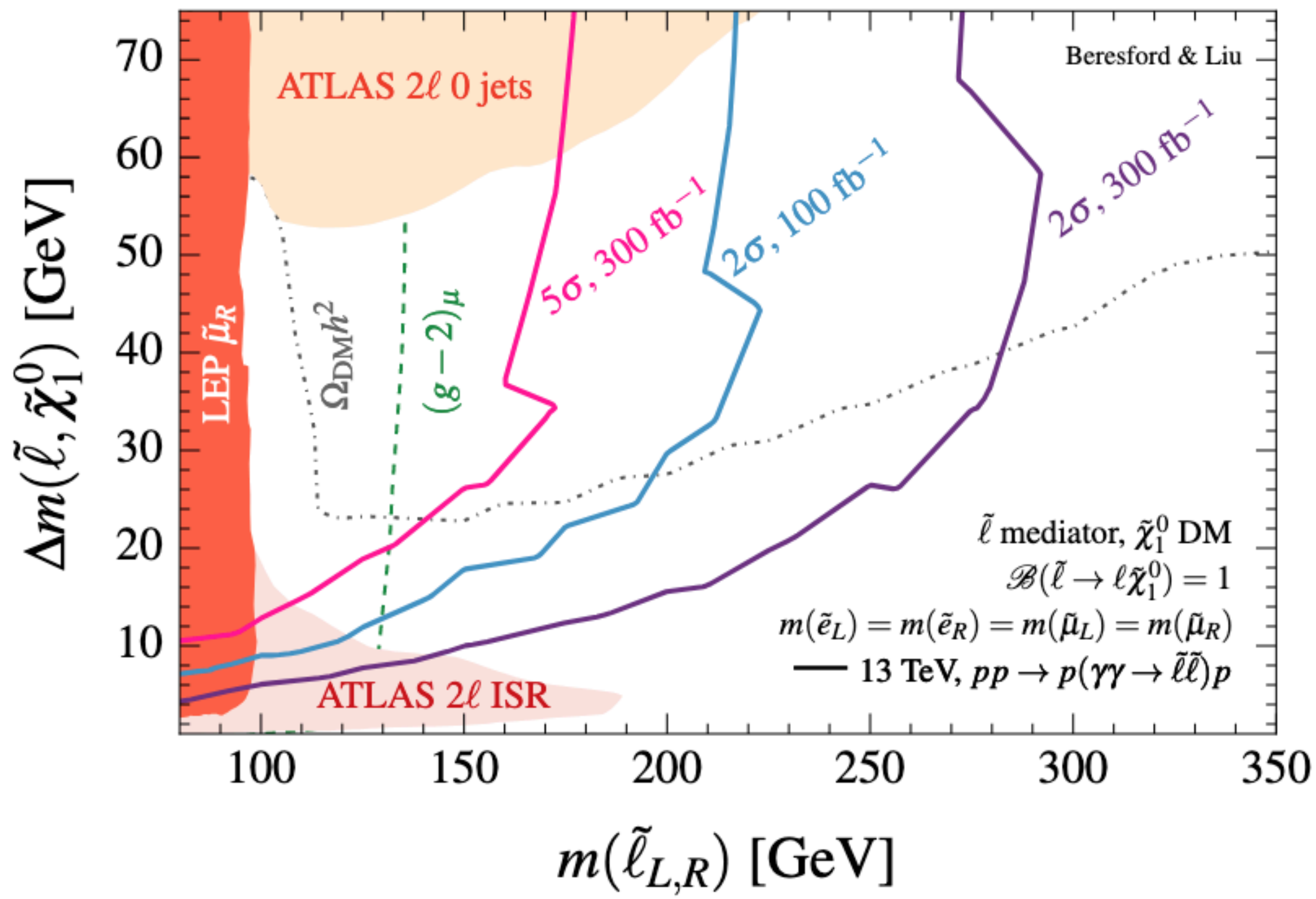
Exploring Squeezed Mass Spectra

- Forward detectors offer a **unique opportunity to probe γγ and gluon-gluon collisions**

- **Complete measurement of the final state**

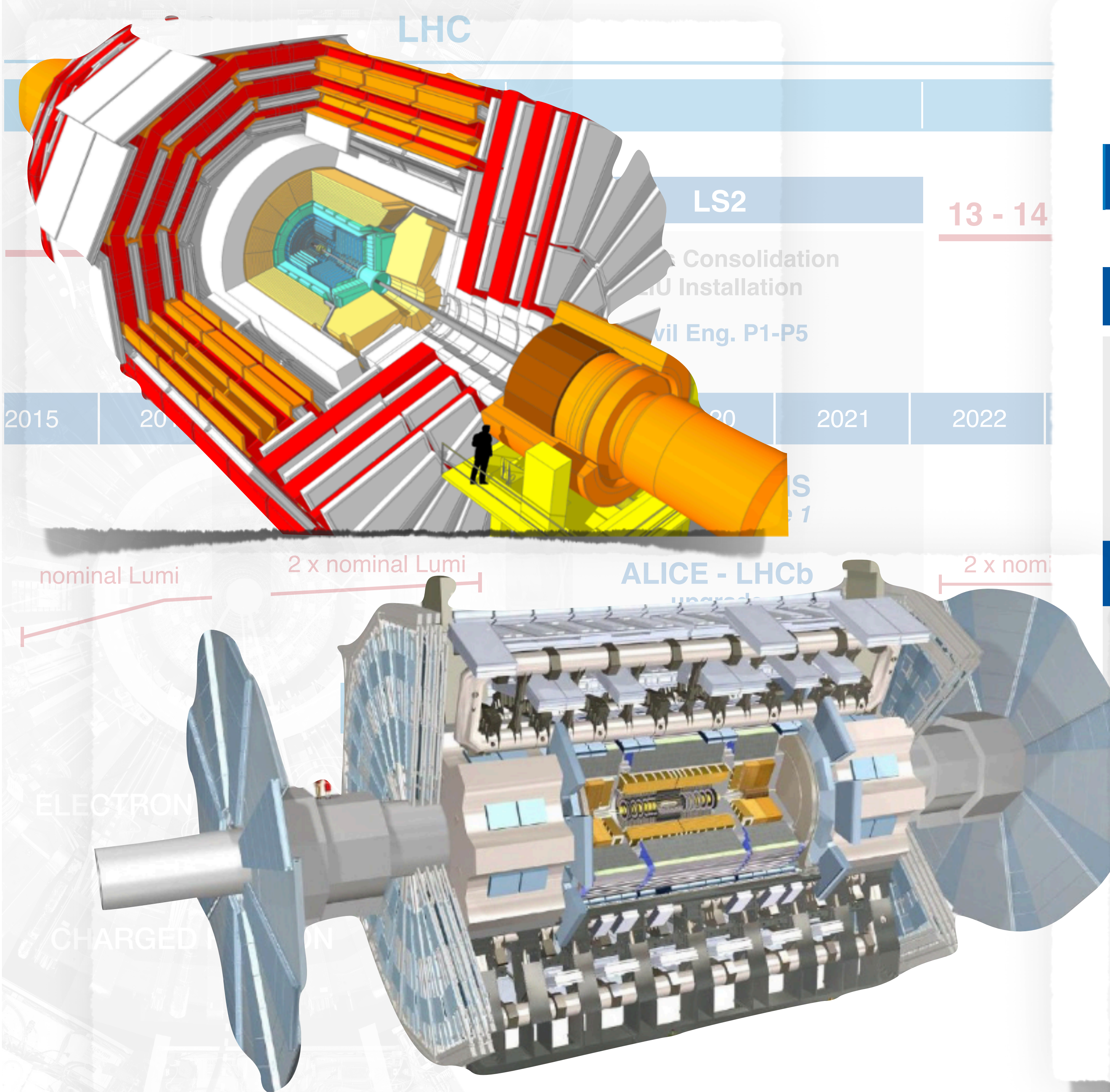
- Example: Inelastic Dark Matter or Split SUSY

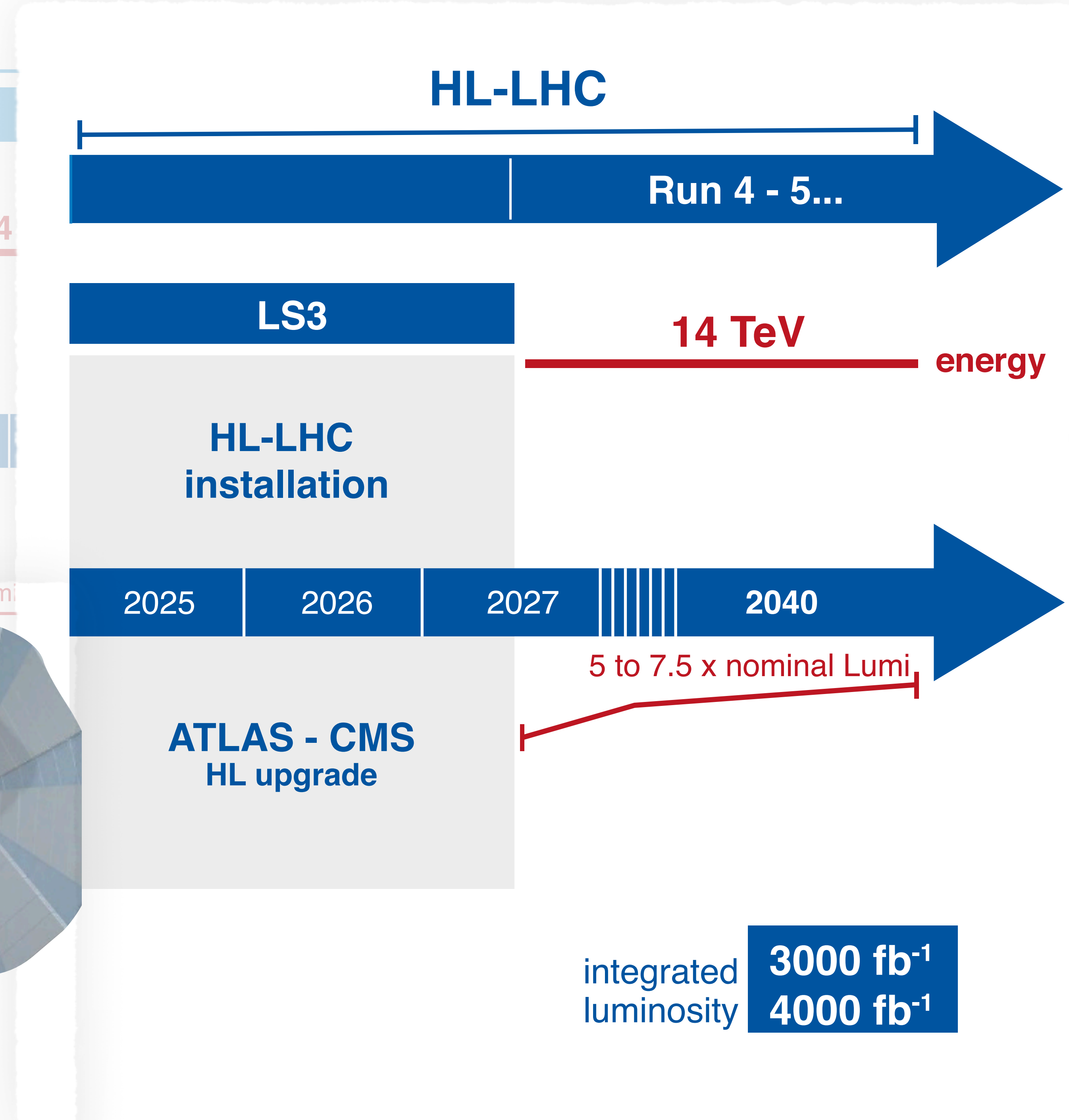




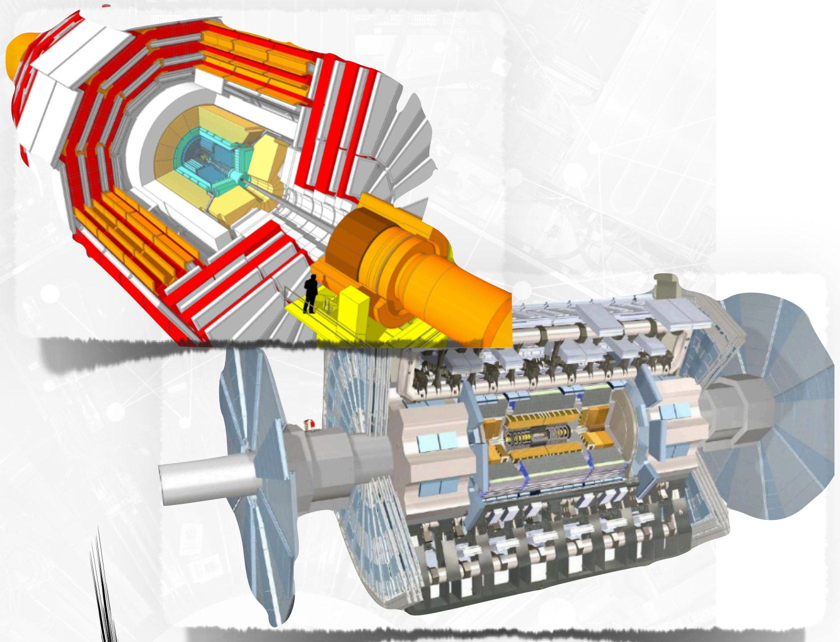
arXiv:1811.06465

Looking forward for High Lumi





HL LHC Physics Opportunities



- **<u>Large data sample</u>**:
  - Lower experimental uncertainties

- **<u>New tools for searches</u>**:
  - timing information
  - extended tracking for forward boosted physics
  - new trigger strategies

- **<u>Common Effort</u>**

  [CERN-LPCC-2018-05]

  [European Strategy]

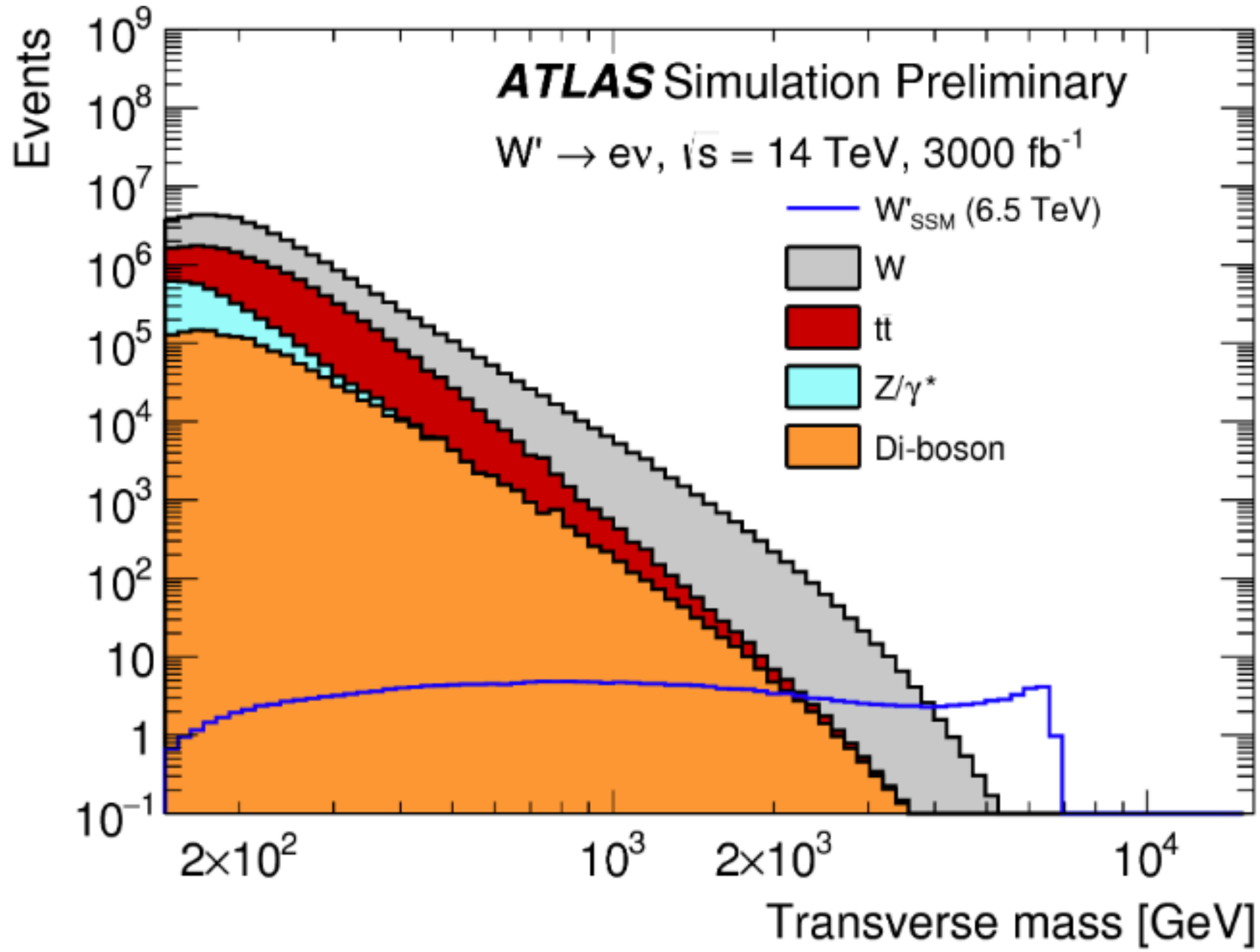
  [SnowMass2021]

Accumulating data

- **High mass sensitivity** dominated by statistics and object performance at high energy

- **Leptonic channels** (Z'/W') reach 6-8 TeV mass sensitivity

- **1-2.5 TeV better than Run 2**



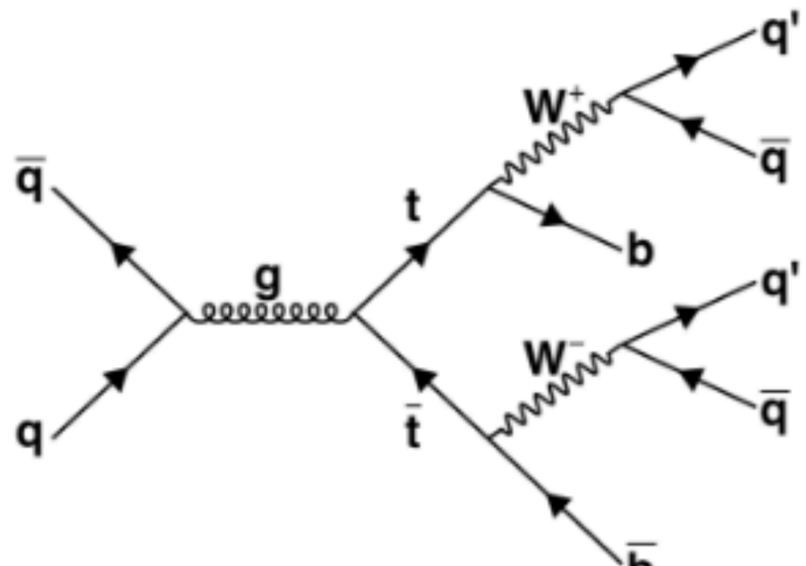
ATL-PHYS-PUB-2018-044

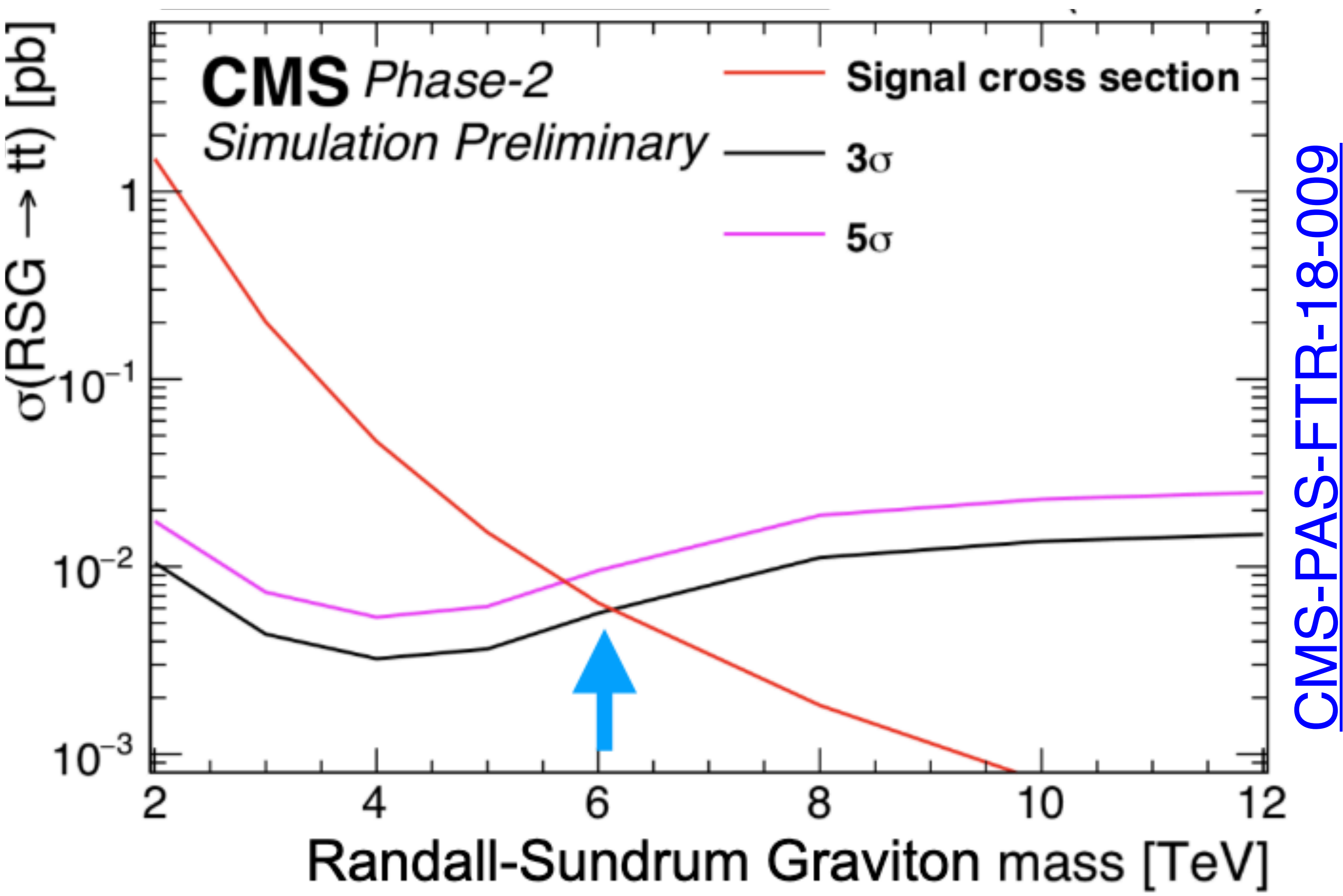
Accumulating data

- **High mass sensitivity** dominated by statistics and object performance at high energy

- **Hadronic channels** dominated by top final states

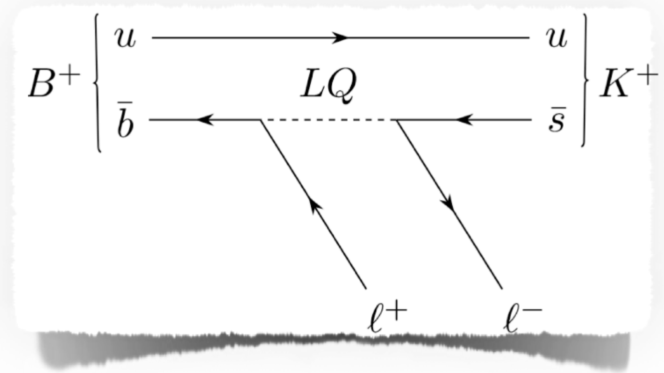
  - Good **b-tagging** efficiency
  - Phase2 **high granularity and timing/New trigger**

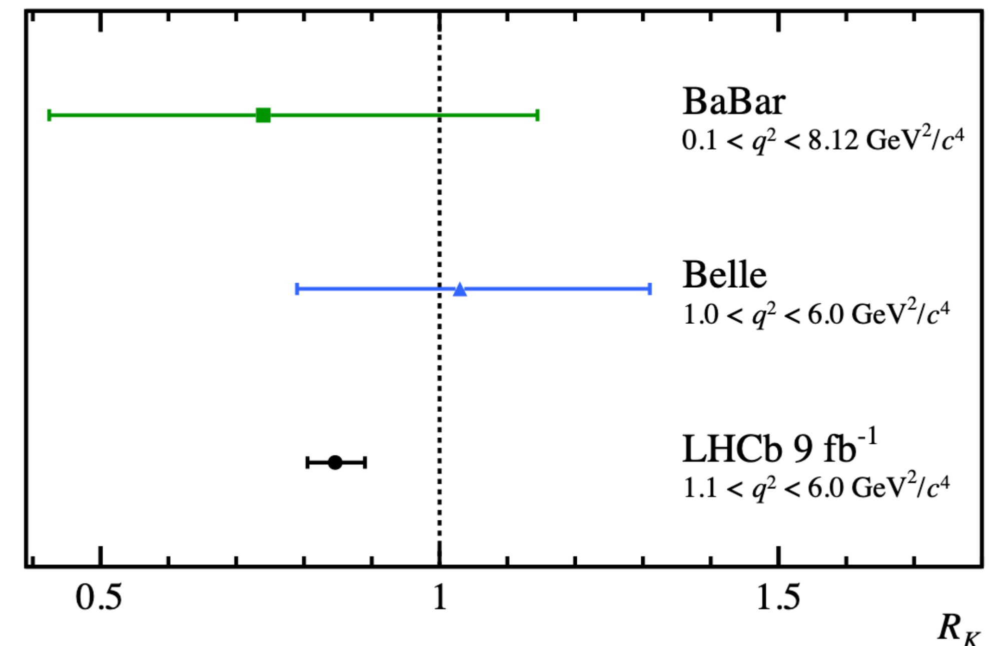




Being inspired by Run 2

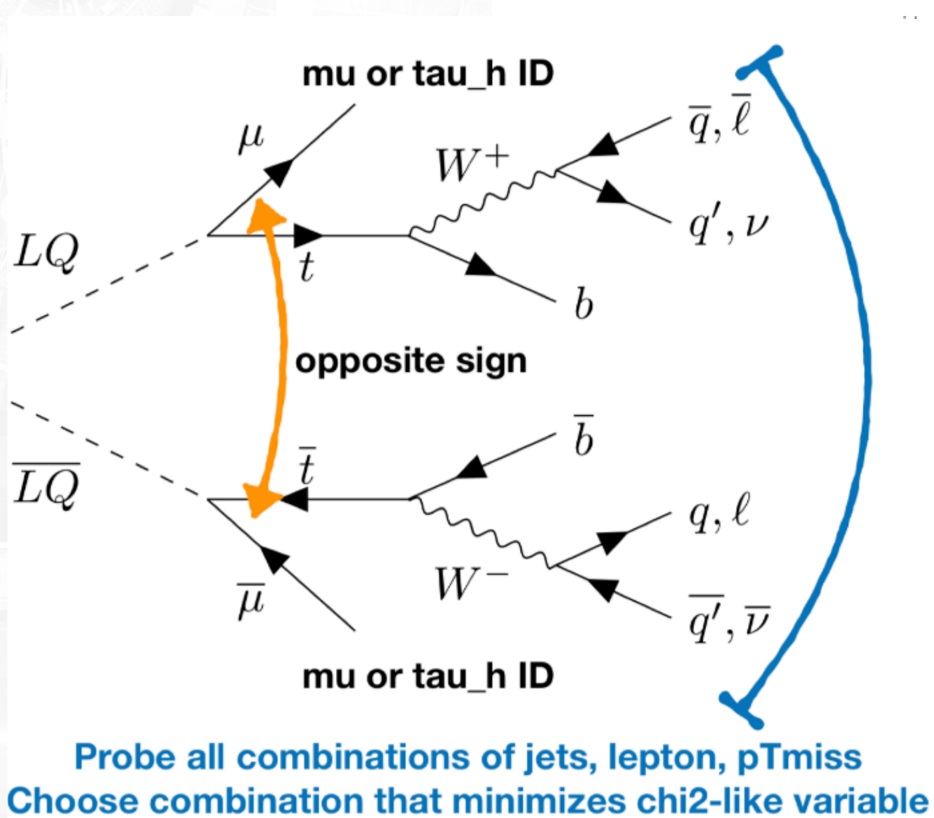
- Pattern of **interlinked anomalies** emerged in experimental studies of **LFU**

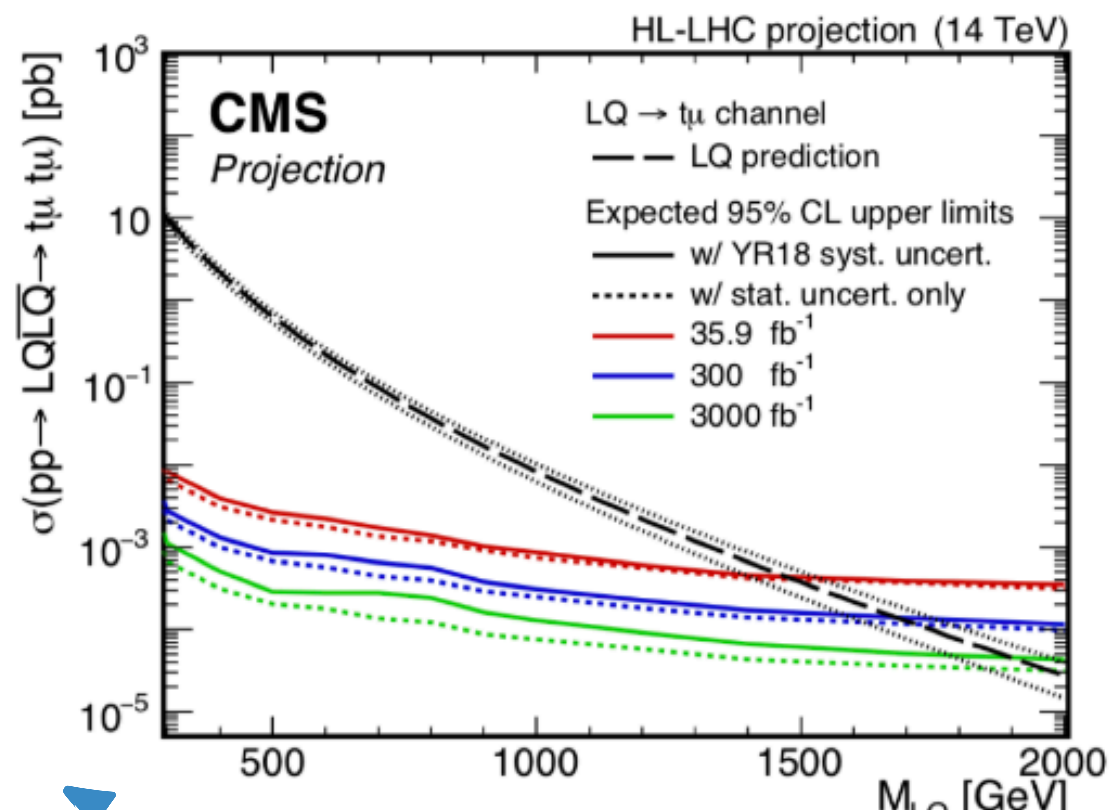




arXiv:2103.11769

- Renewed interest in Models with **third generation LeptoQuarks**





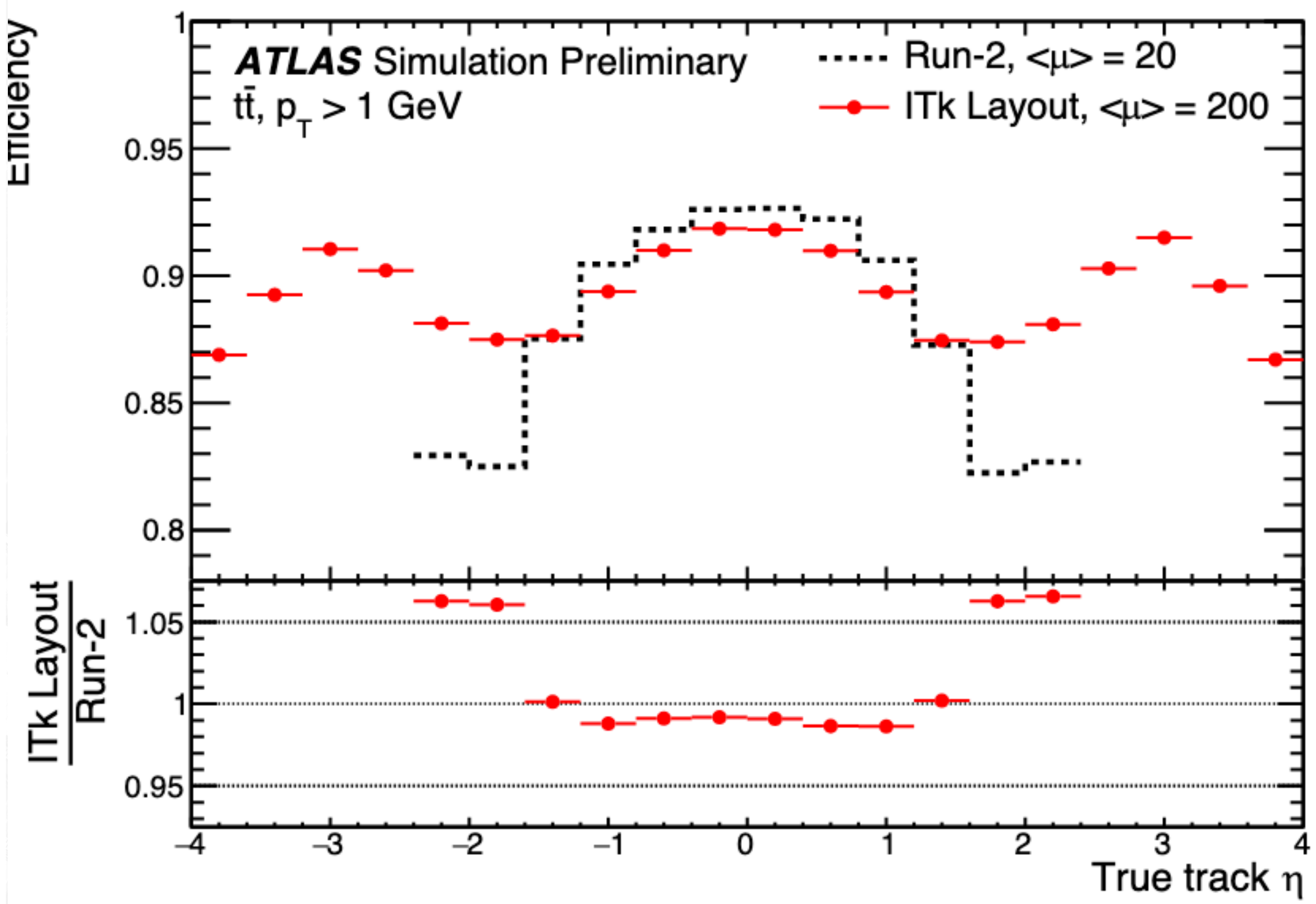
Mass limit 1.9 TeV

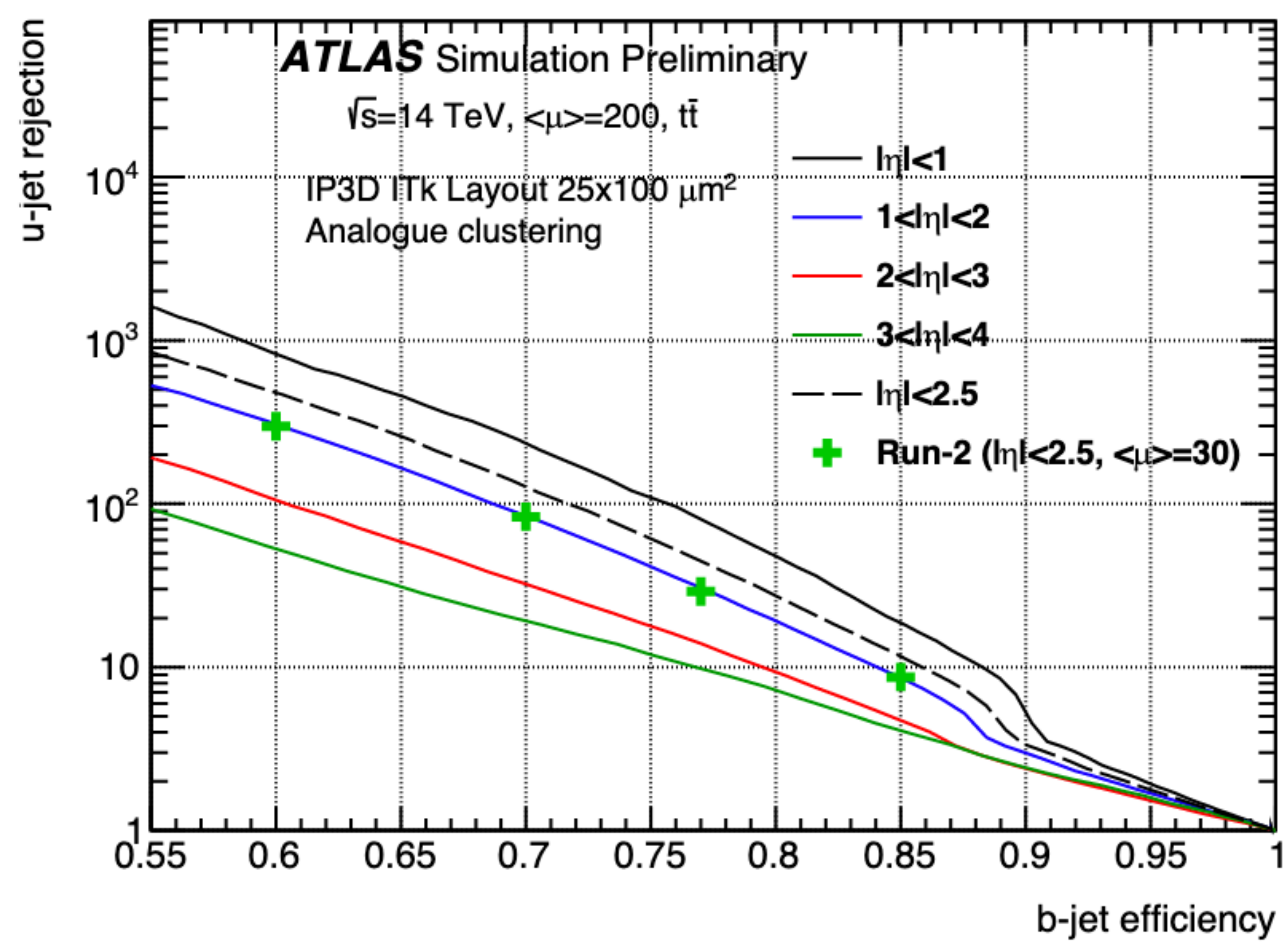
CMS-PAS-FTR-18-008

ATLAS ITk Silicon Tracker upgrade

ATL-ITK-SLIDE-2018-073

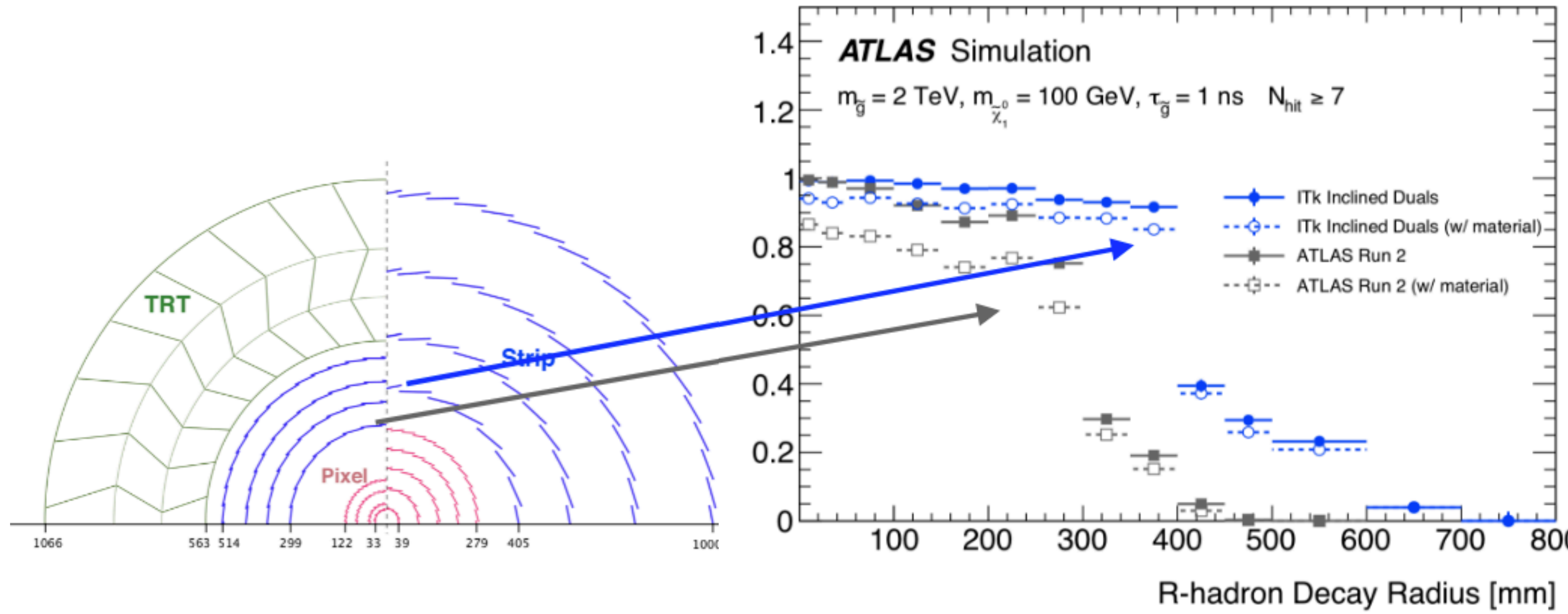
- Nearly 13 m² of pills and 165 m² of strips with **improved coverage and novel readout electronics**
- Improves **tracking and b-tagging** performance compared to Run 2



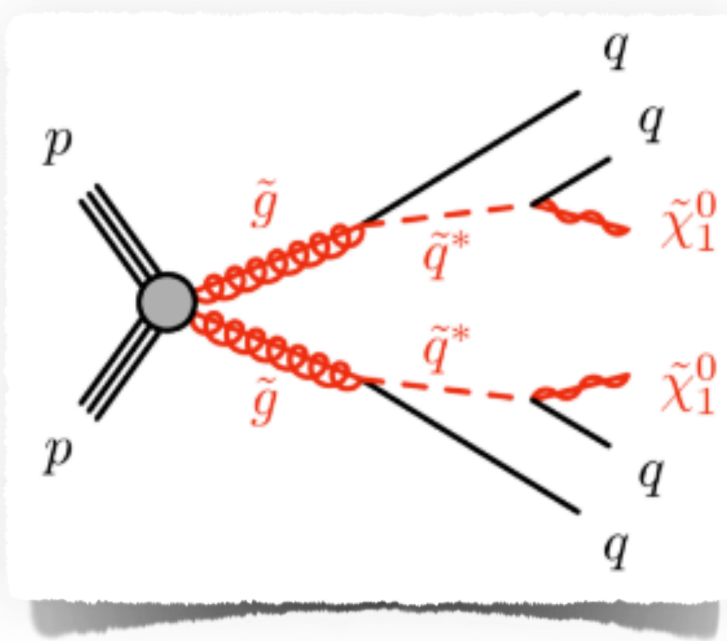


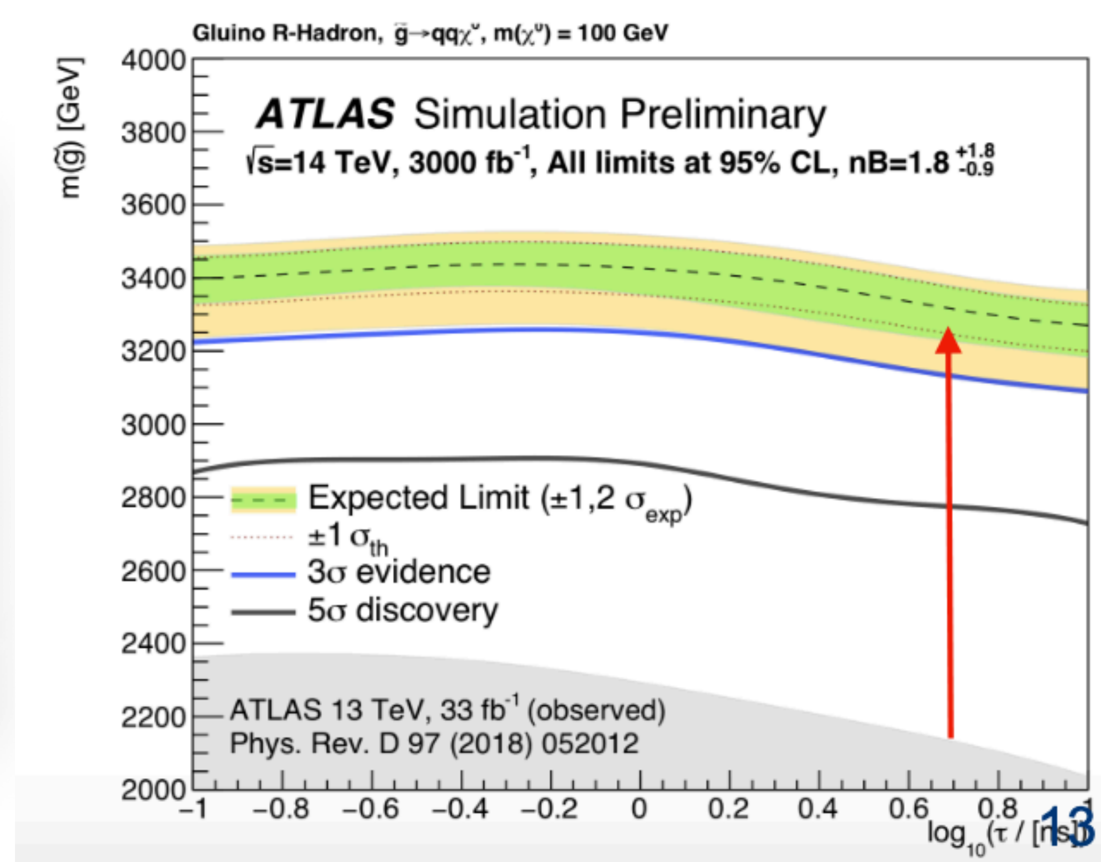
Displaced Tracks at HL-LHC

- Higher **reco efficiency** with ITk detector
- Improved geometry and l**arger volume w/ lower material budget**



- Sensitive to **long-lived particles with τ ~10 ps-10 ns** decaying to multiple charged particles

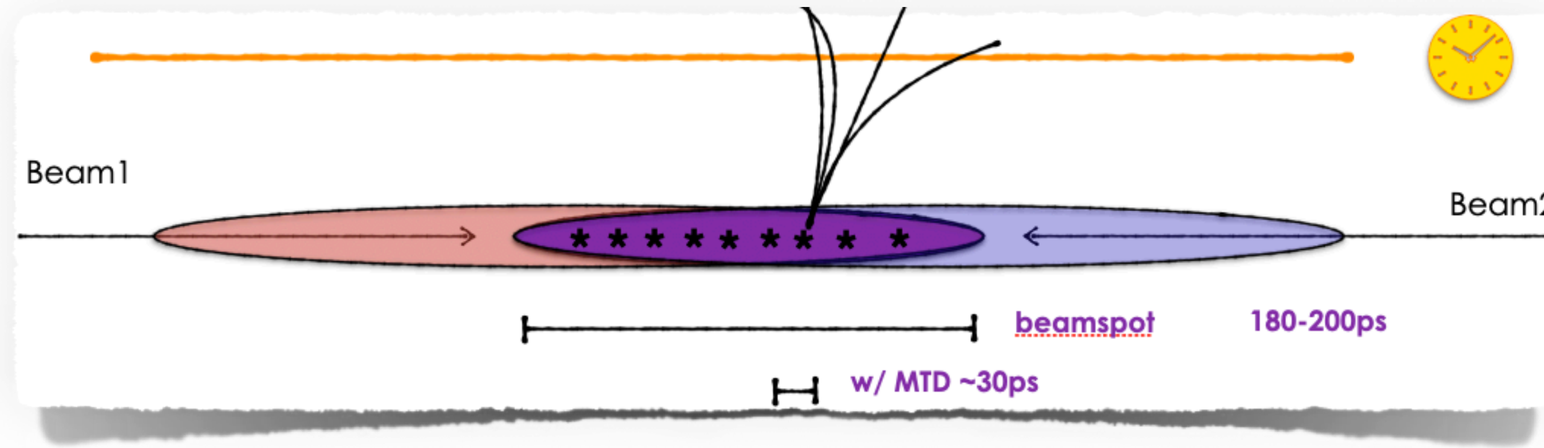




ATL-PHYS-PUB-2018-033

CMS New MIP Timing Detector

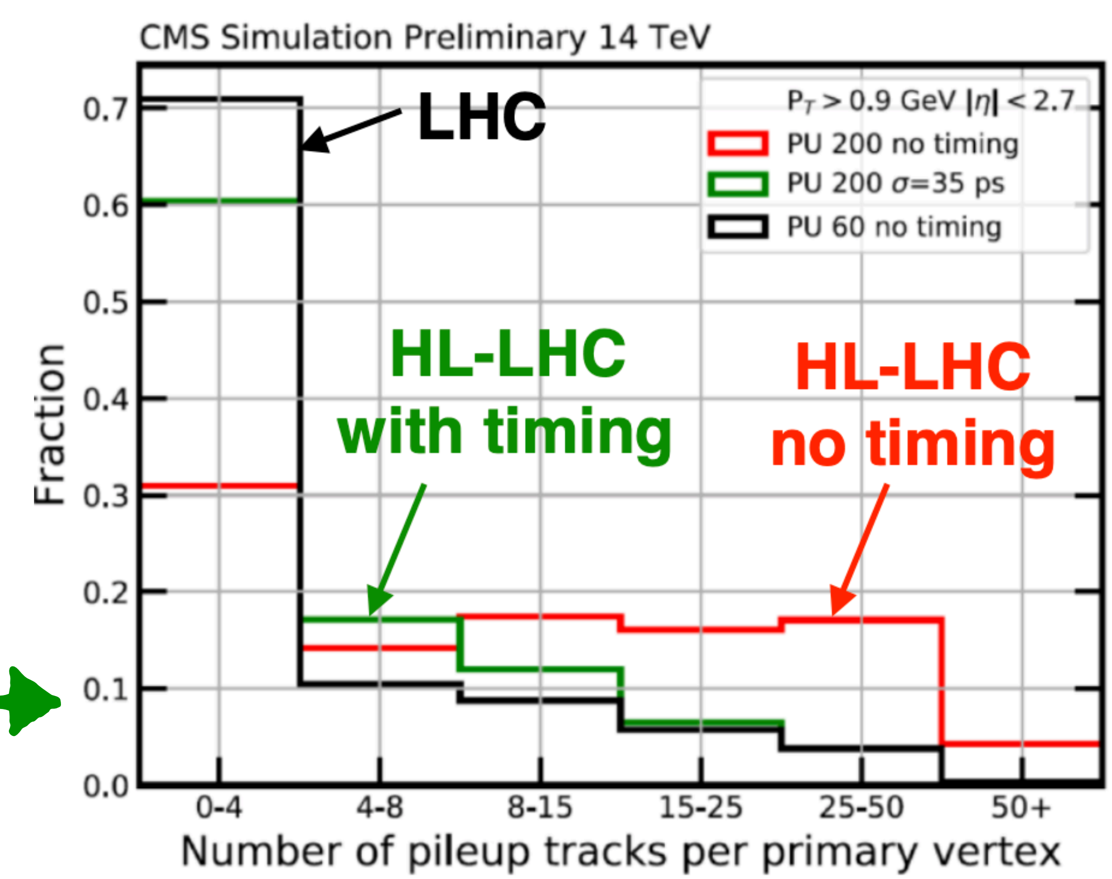
- Significant **PU contamination** and whole **event reconstruction degradation at HL-LHC**



- New **Hermetic timing detector** with various technologies optimized for different radiation levels

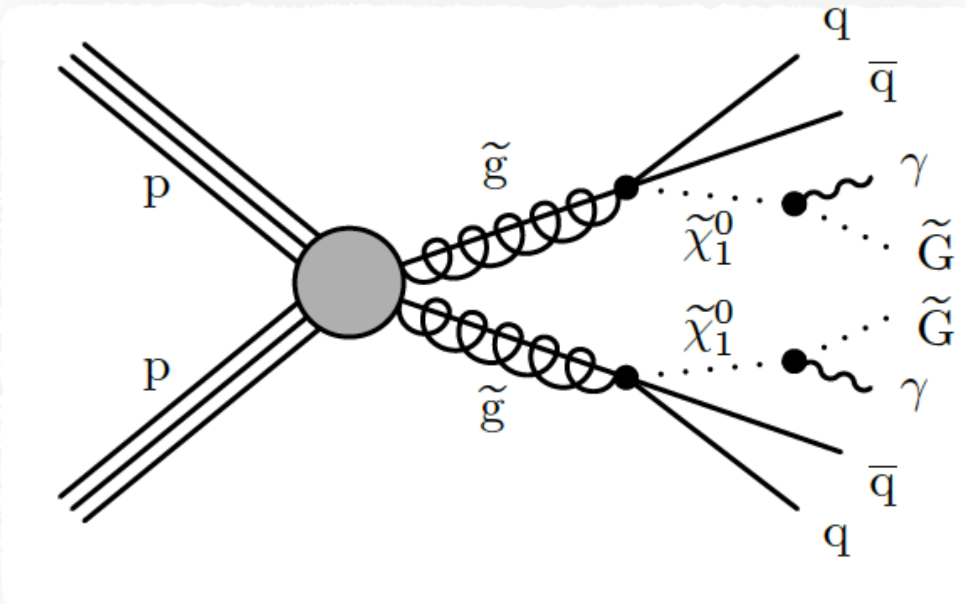
- Require time compatibility within O(30ps) for **track vertex association**

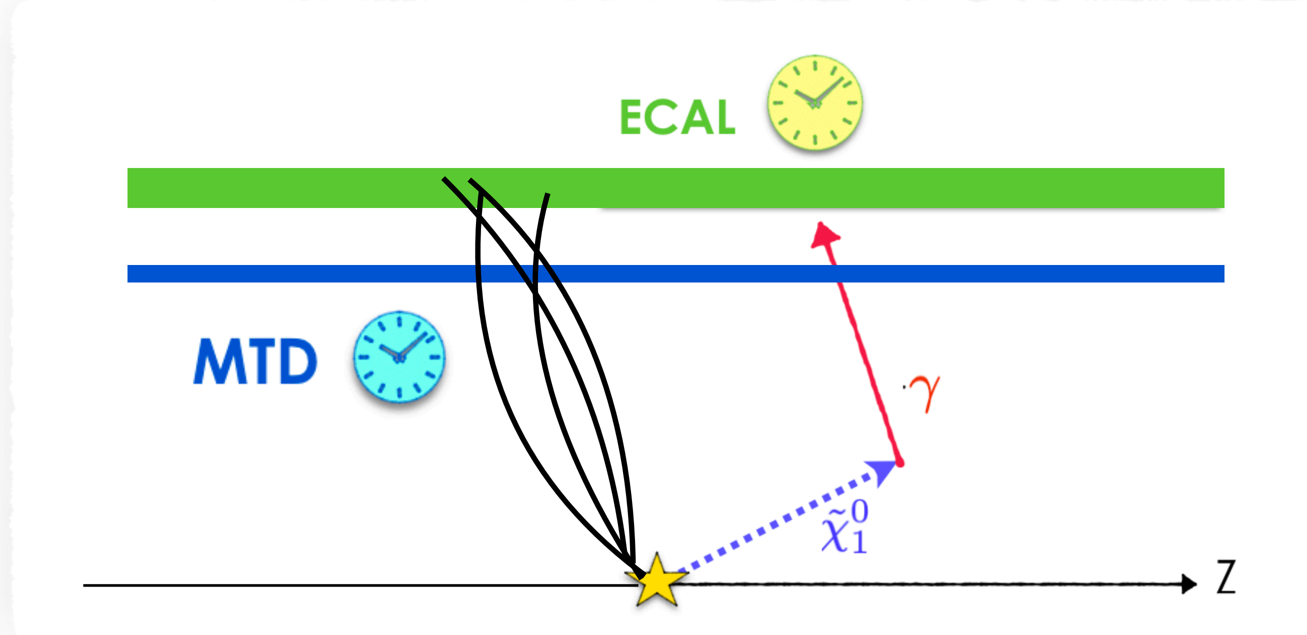
  - Effectively **reduce actual pileup** to level of the current LHC well handled by CMS detector



CERN-LHCC-2019-003

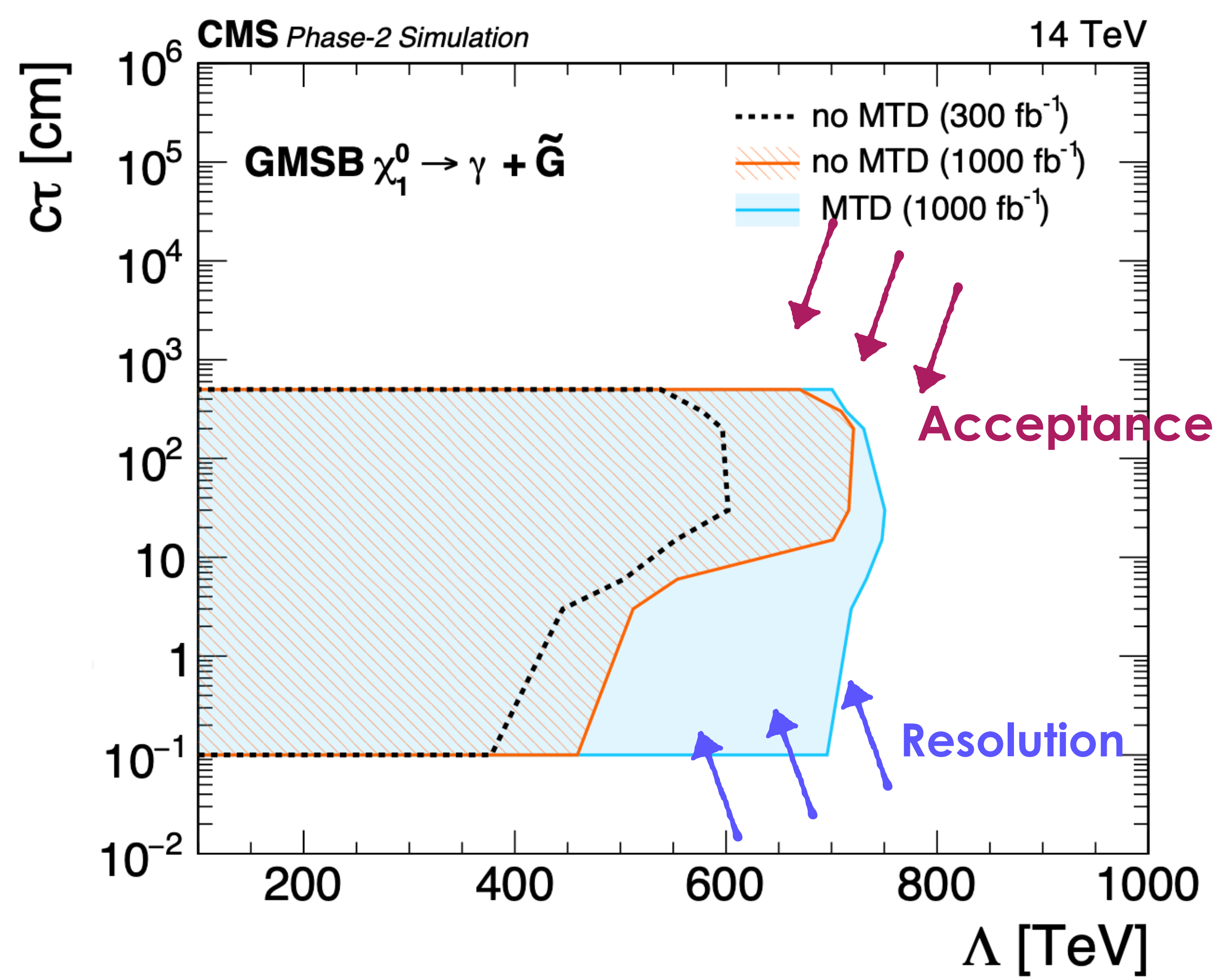
Displaced Photons w/ MTD





- Exploit **MTD to reduce BS timing information** crucial to **evaluate photons TOF w/ ECAL**

- Sensitivity of the analysis is explored requiring **at least one displaced photon and making a 0 background assumption.**

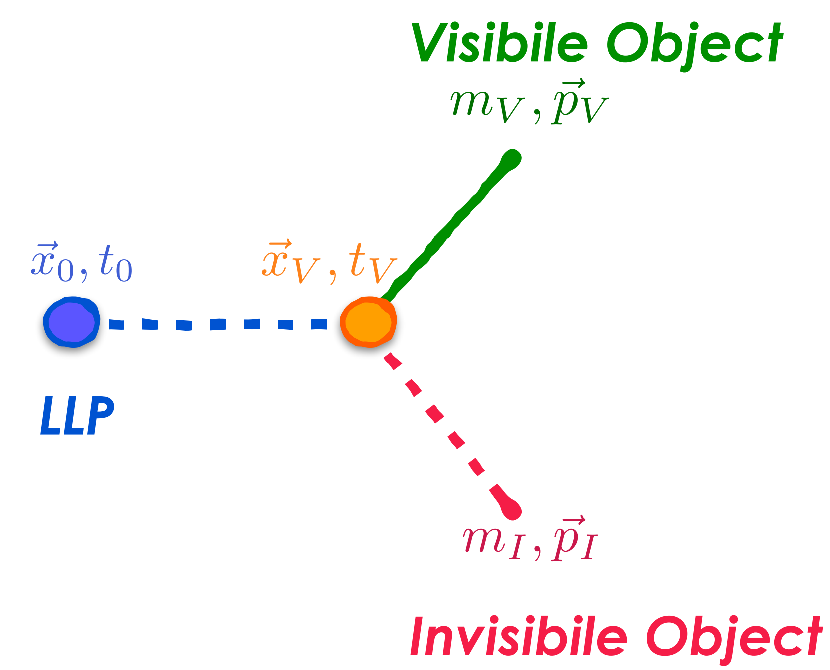


CERN-LHCC-2019-003

Being creative with timing

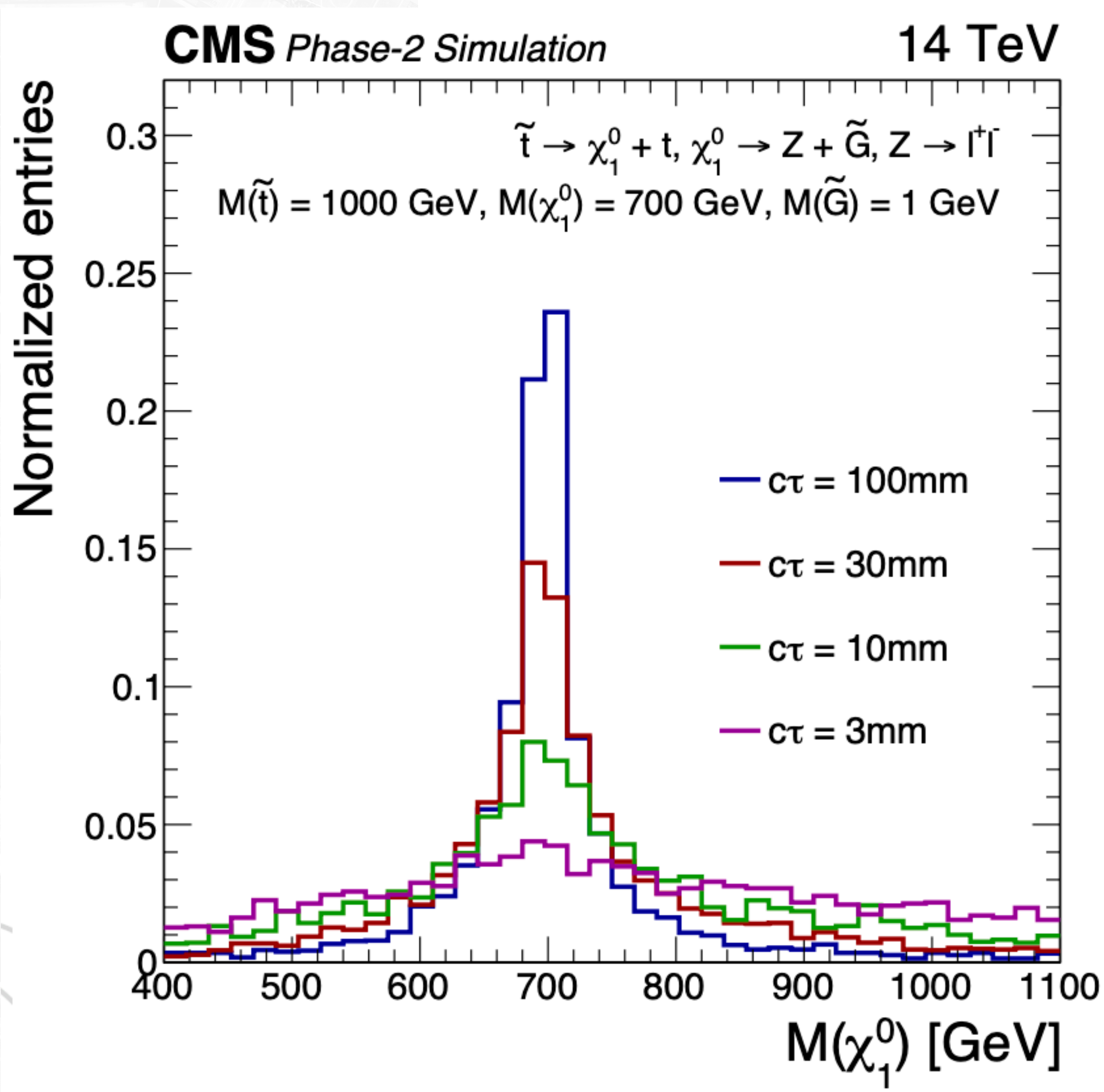
- **Reconstructed vertex to measure the TOF** of LLPs

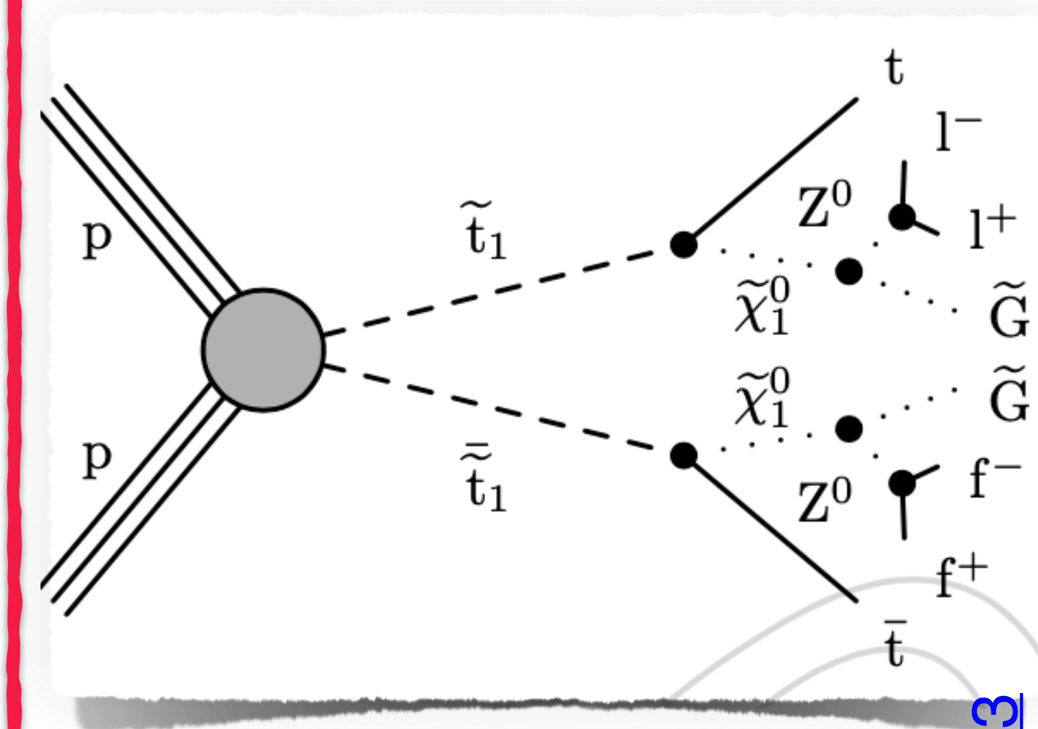
- **Kinematic closure:** direct measurement of the **LLP mass**



Neutralino mass reconstruction

- **Stop production with LL neutralino** decaying into Z and Gravitino





CERN-LHCC-2019-003

Conclusions

- Direct searches for **BSM signatures important part of the (HL) LHC** programme
- These signatures could have been missed or thrown away as noise: Important to c**heck all our blind spots**!

Conclusions

Non Conventional Signatures →

- **Dedicated trigger algorithms**
- **Unique object reconstruction, discriminating variables, or data processing**
- **Re-defined analyses strategies w/ atypical backgrounds**

Conclusions

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Dedicated trigger algorithm

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…ies, or data processing

Re-defined analyses strategies w/ atypical backgrounds

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Looking for Forward for Run 3 Pilot Run in October!