



**SUPA IAC – 30th May 2019**

## ***Particle Physics***

**Theme Leader:** Victoria Martin (Edinburgh)

**Institutes:** University of Glasgow & University of Edinburgh  
**35 academics**

**Funding:** **STFC:** consolidated grants, project grants, fellowships  
plus: EPSRC, ERC, Intel, Royal Society, EC Horizon 2020 ...



## Particle Physics Theory:

- **Lattice field theory for LHC,  $g-2$ , flavour physics** at DiRAC facility & elsewhere
  - ➔ Working with HPQCD, QCDSF and RBC/UKQCD collaborations
- **Phenomenology for LHC, cosmology & beyond:** NNPDF, HEJ, flavour anomalies, warm inflation, TopFitter
- **Scattering Amplitudes:** LHC and gravitational waves
- **Formal theory:** little Higgs, Supersymmetry, extra dimensions
- Turbulence, links to condensed matter



Computing & Data Analysis: DiRAC & IRIS

Data Science & AI





- **Running experiments:**

- **Large Hadron Collider at CERN:** ATLAS and LHCb

- **Quark flavour physics:** LHCb and NA62 (CERN)

- **Neutrino physics:** T2K (Japan), MICE at RAL, proto-DUNE at CERN

- **Experiments under construction:**

- **Neutrino physics:** DUNE (USA); WATCHMAN in Boulby Mine (neutrinos from reactors)

- **Dark Matter:** LZ (South Dakota)

- **Experiments & facilities under consideration:**

- **Long-baseline neutrino physics:** Hyper-K (Japan)

- **Dark Matter:** DAMPEII satellite

- **Future colliders** (ILC, CLICdp, FCCee, CEPC)

- **Detector Development:** New silicon detectors for ATLASMaPMTs for LHCb

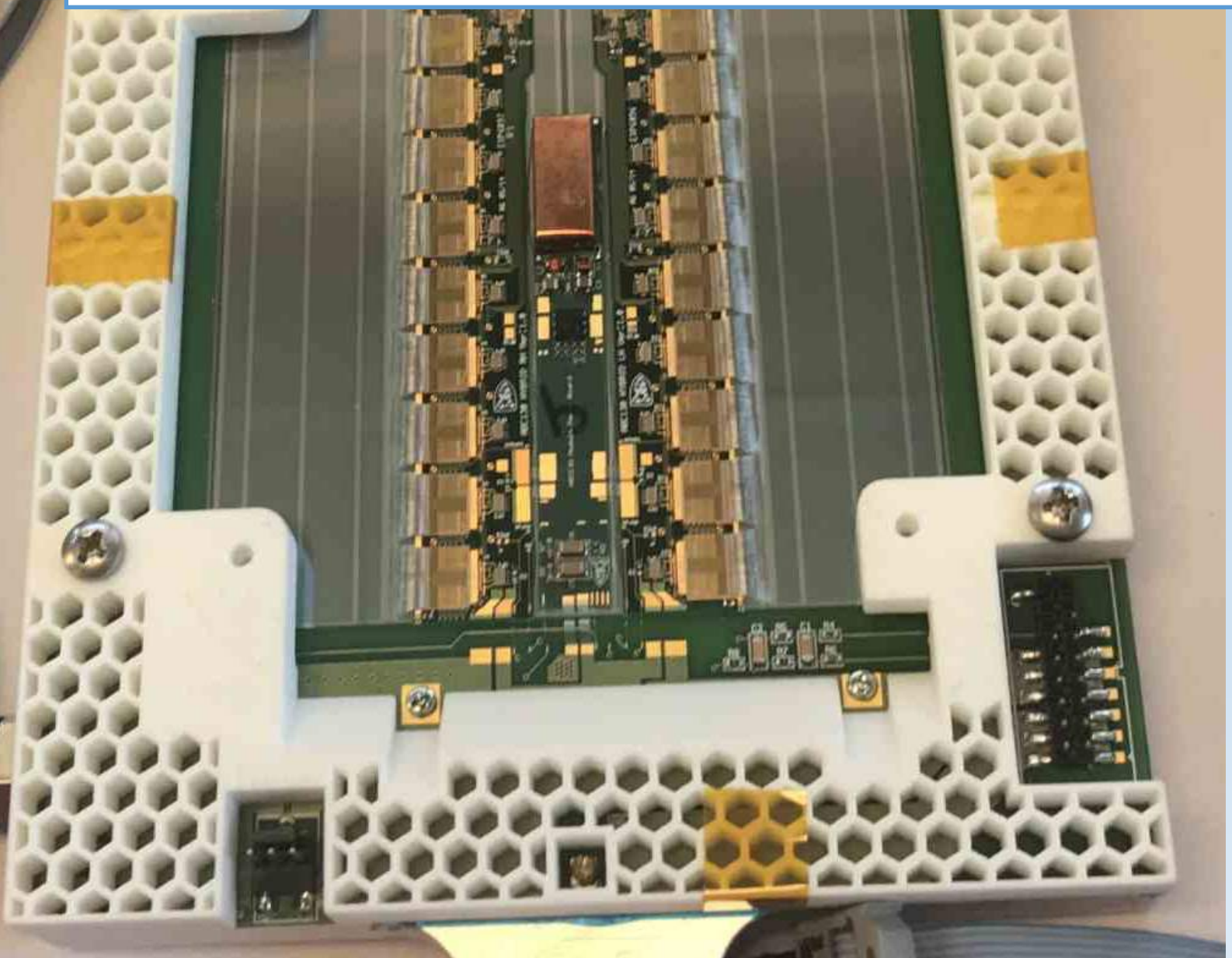
**Computing & Data Analysis:** GridPP, IRIS and **Data Science & AI**



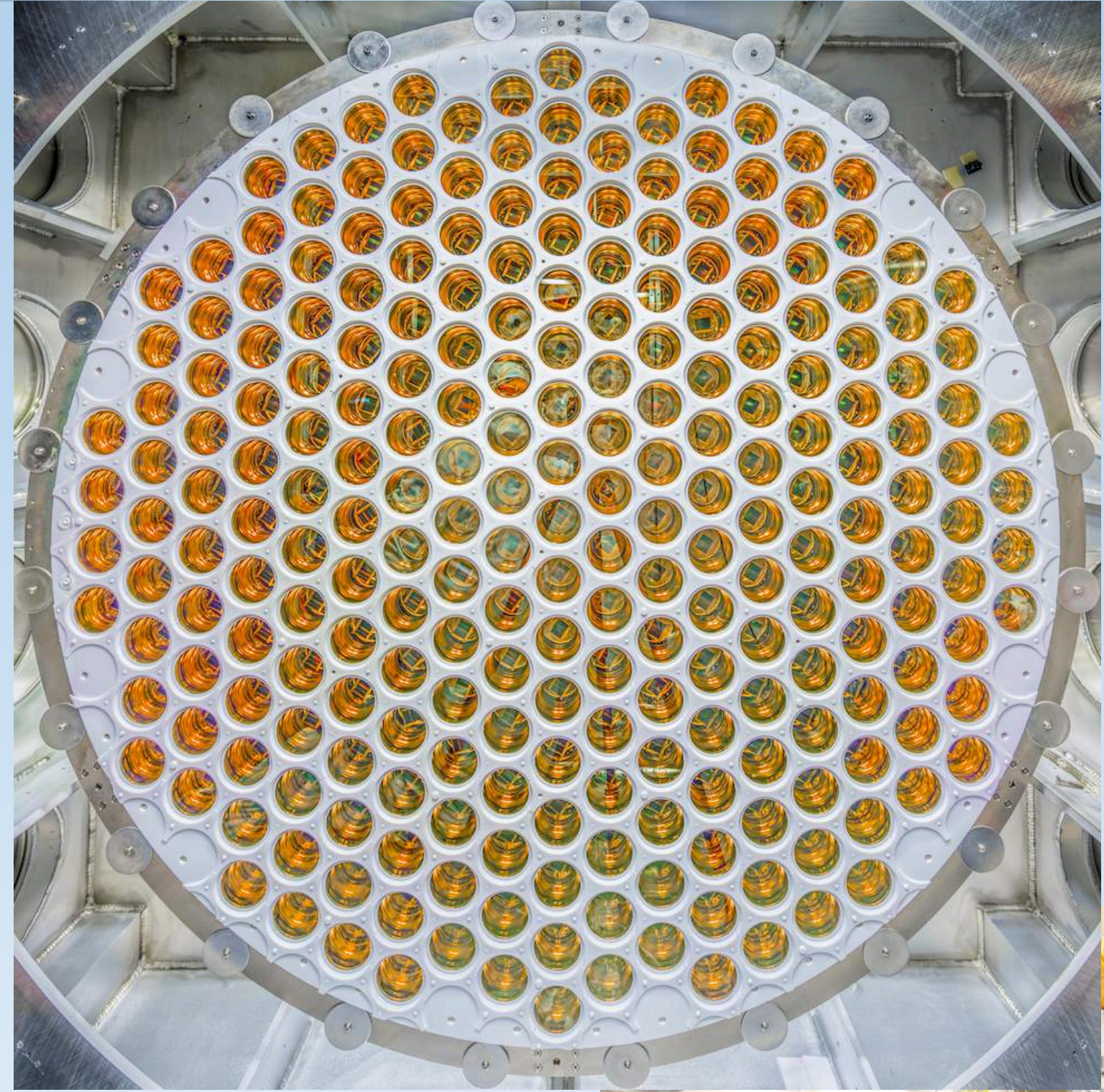


# Particle Physics: Detector Developments

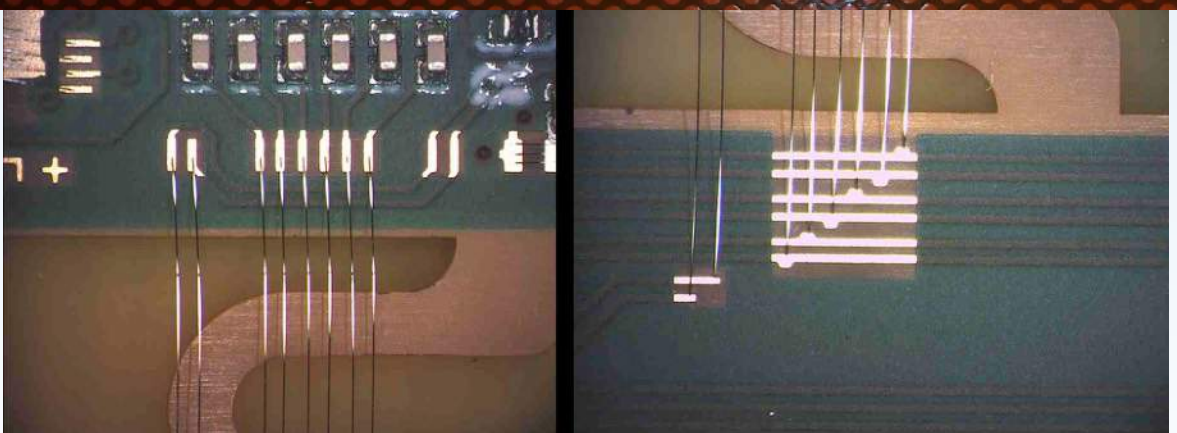
silicon strip & pixel detectors & associated electronics for ATLAS upgrade, developed in Glasgow & Edinburgh



Quality control for 3,600 MaPMTs for LHCb upgrade



LZ construction at Sanford Lab (SD)







# Particle Physics: Staffing

Particle Physics in Scotland continues to grow...

New academic appointments:

Prof Sinead Farrington (Edinburgh; ATLAS)

Dr Yanyan Gao (Edinburgh; ATLAS, DAMPEII, CEPC)

Dr Philip Litchfield (Glasgow; T2K, Hyper-K)

Looking for new Higgs Chair for Theoretical Physics

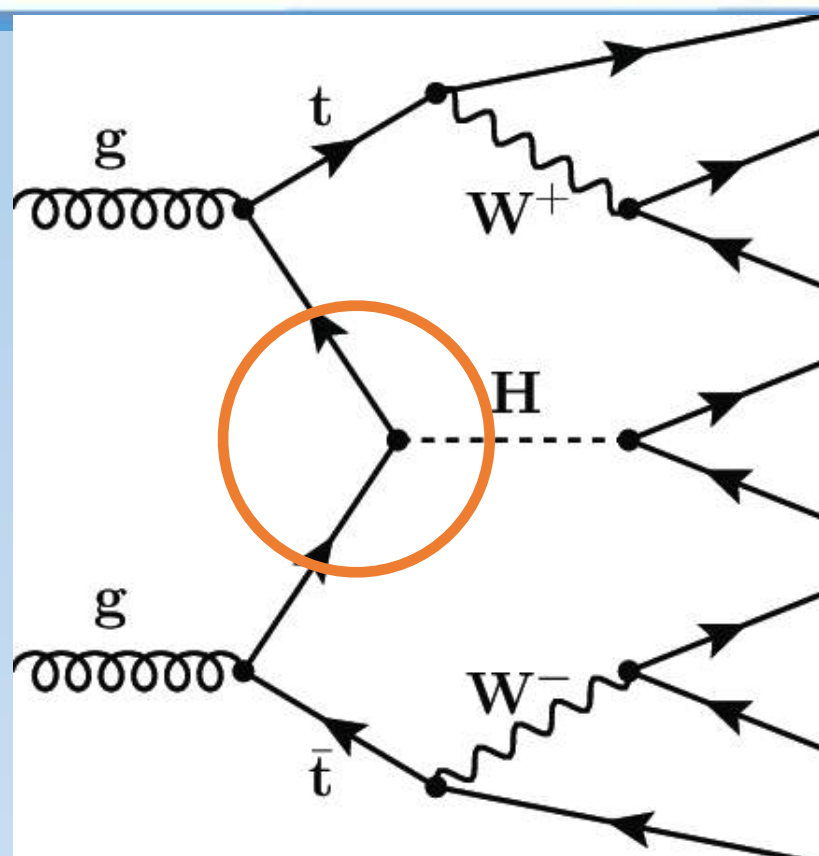
<https://www.ph.ed.ac.uk/news/2019/vacancy-higgs-chair-of-theoretical-physics-19-05-13>

Position is open to researchers in any area of theoretical physics.



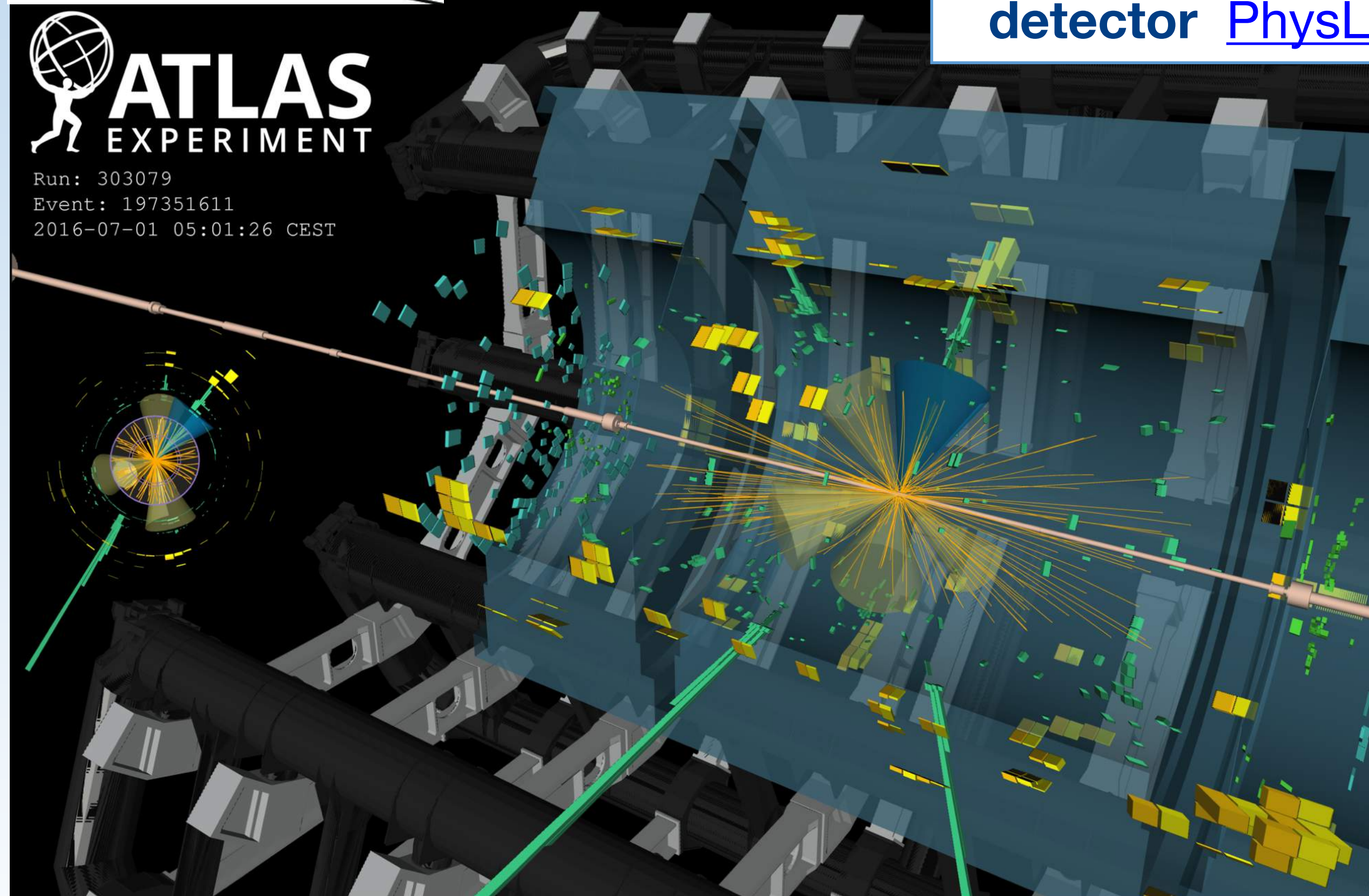
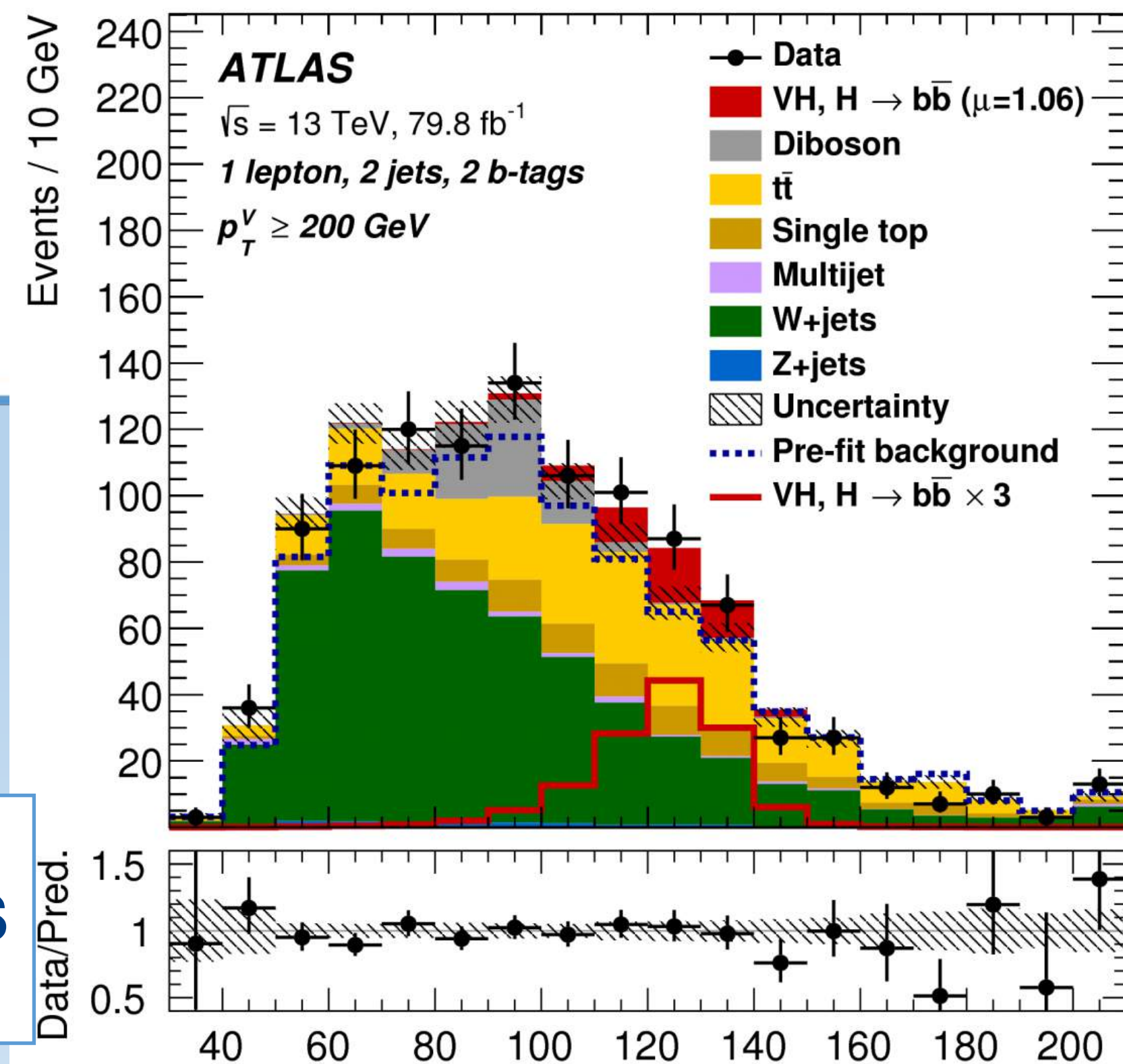
# Research Highlights:

- Higgs with top quarks
- Higgs to bottom quarks

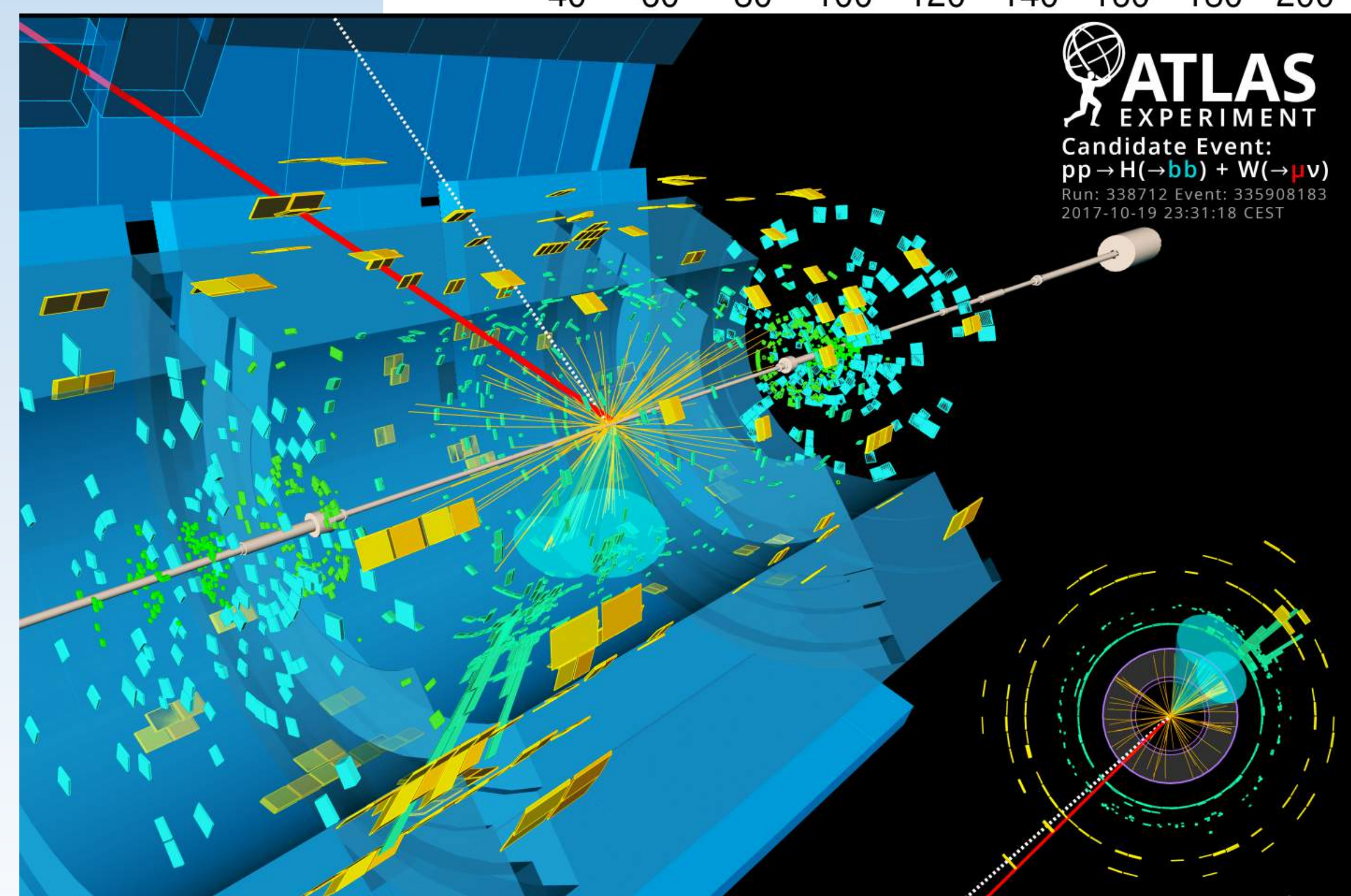


**Observation of  $t\bar{t}H$  production at ATLAS**  
[PhysLettB.2018.07.035](#)

**Observation of  $H \rightarrow b\bar{b}$  decays and  $VH$  production with the ATLAS detector**  
[PhysLettB:2018.09.013](#)



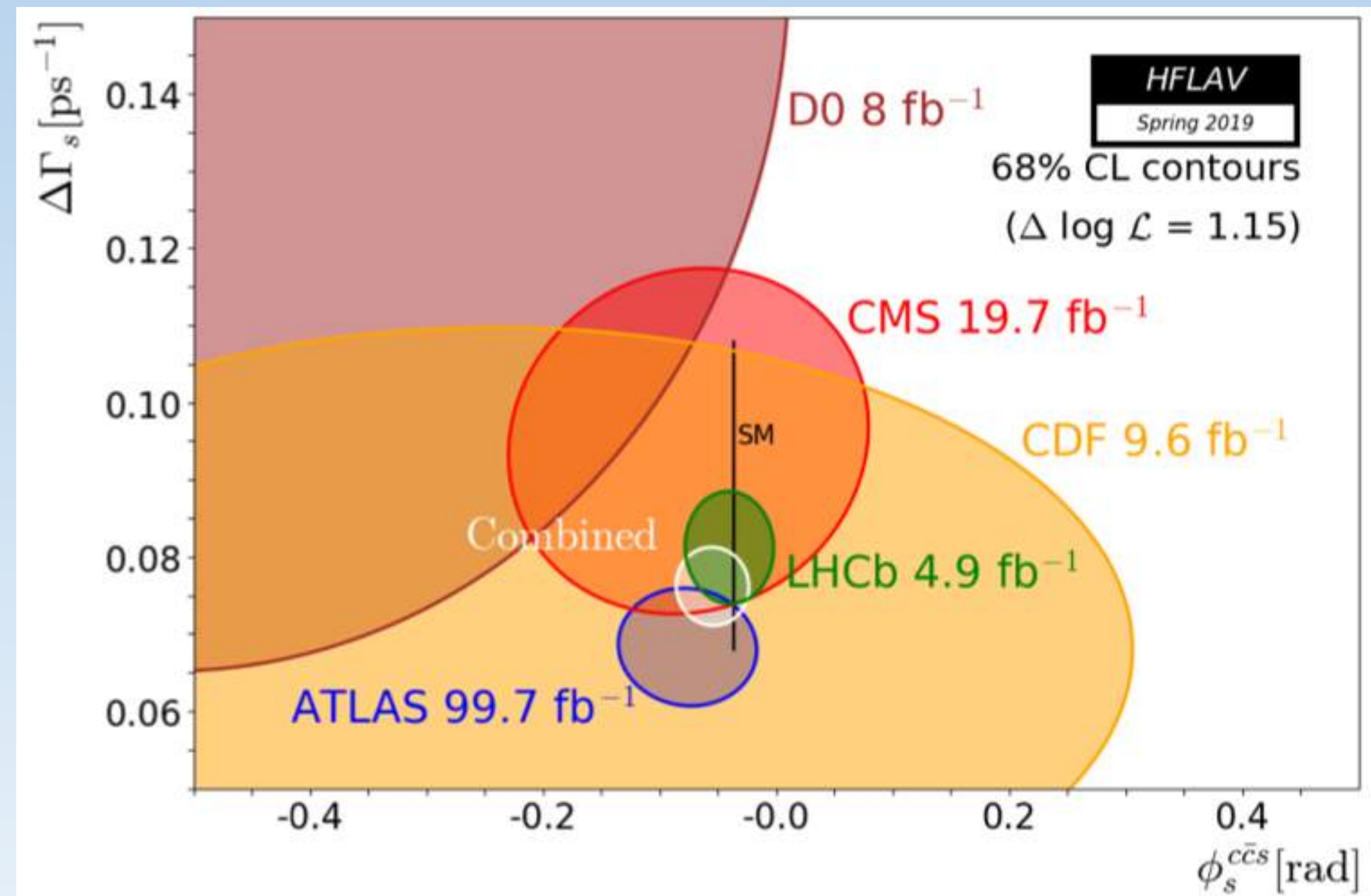
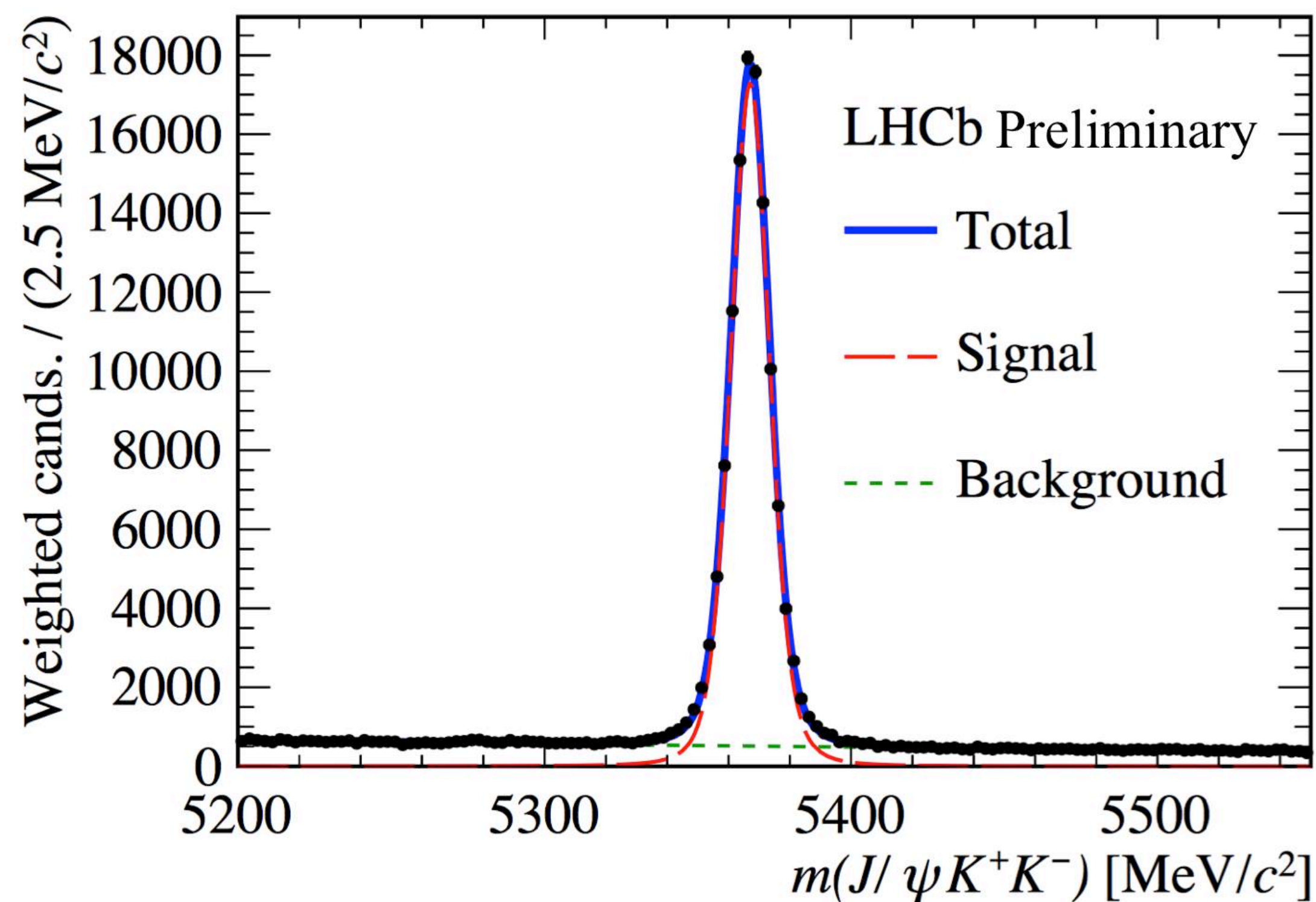
**ATLAS EXPERIMENT**  
 Run: 303079  
 Event: 197351611  
 2016-07-01 05:01:26 CEST



**ATLAS EXPERIMENT**  
 Candidate Event:  
 $pp \rightarrow H(\rightarrow b\bar{b}) + W(\rightarrow \mu\nu)$   
 Run: 338712 Event: 335908183  
 2017-10-19 23:31:18 CEST



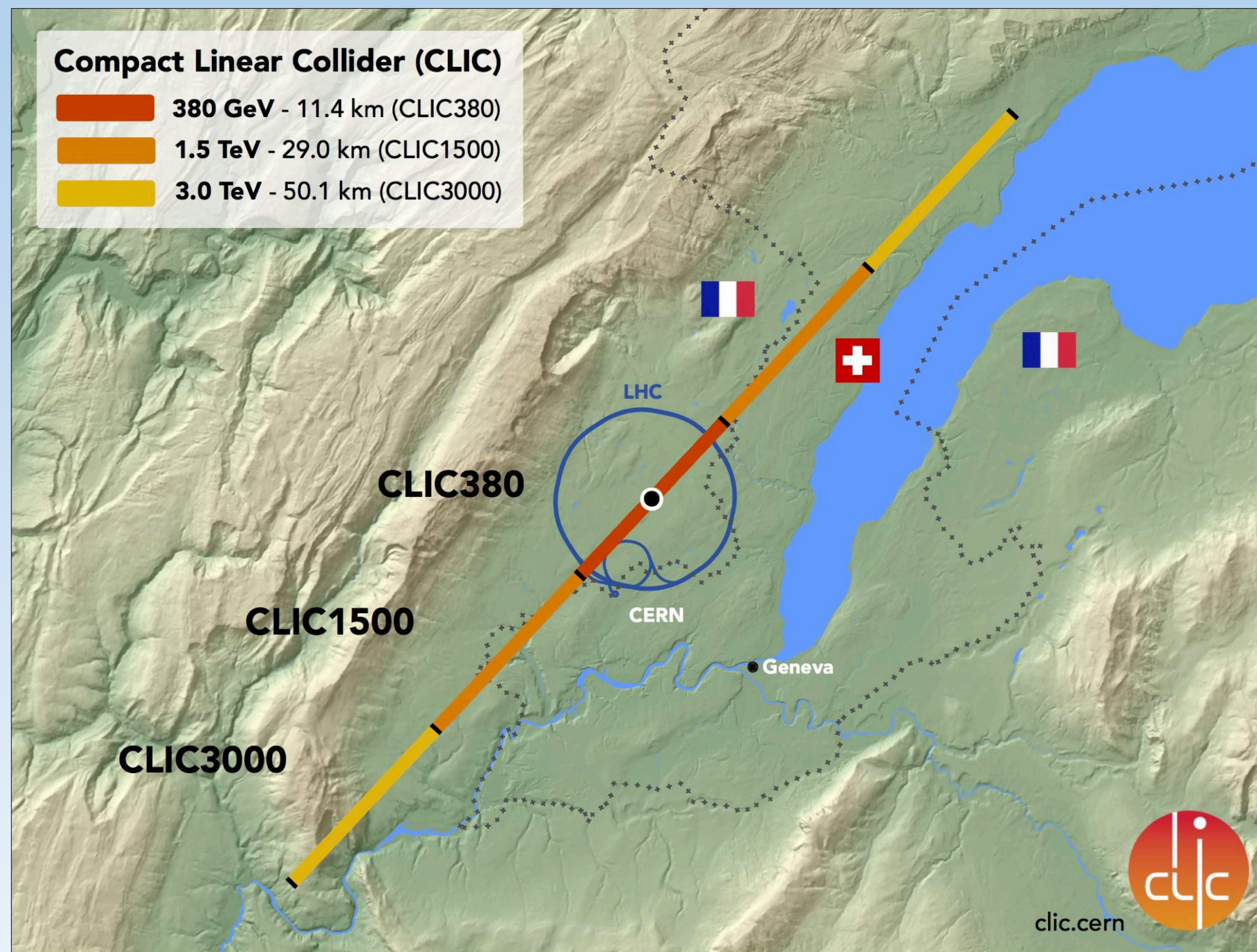
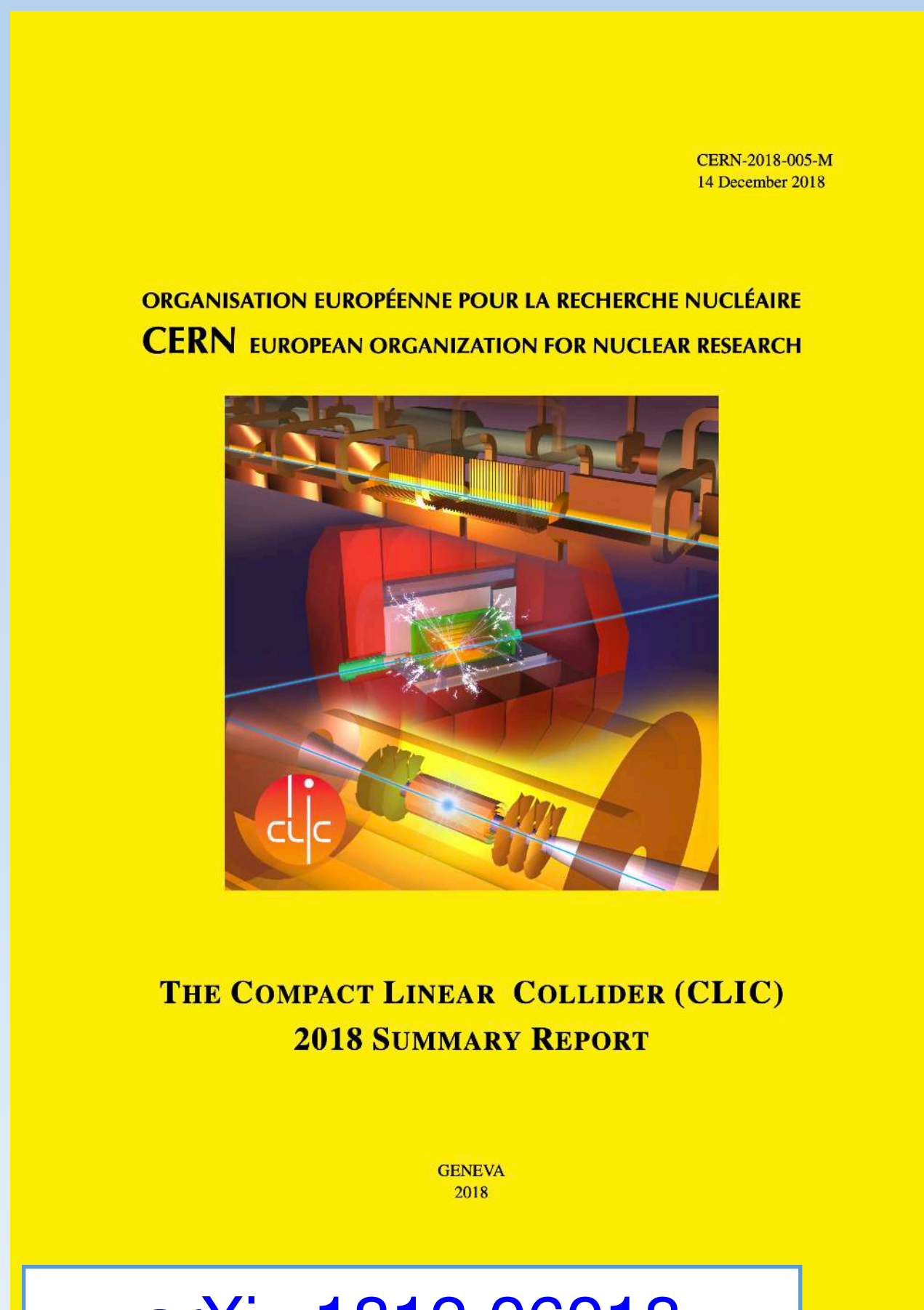
## LHCb: $B_s \rightarrow J/\psi \phi$



key test of Standard Model description of matter–anti-matter asymmetry in quarks



# Research Highlights: CLIC construction and physics case

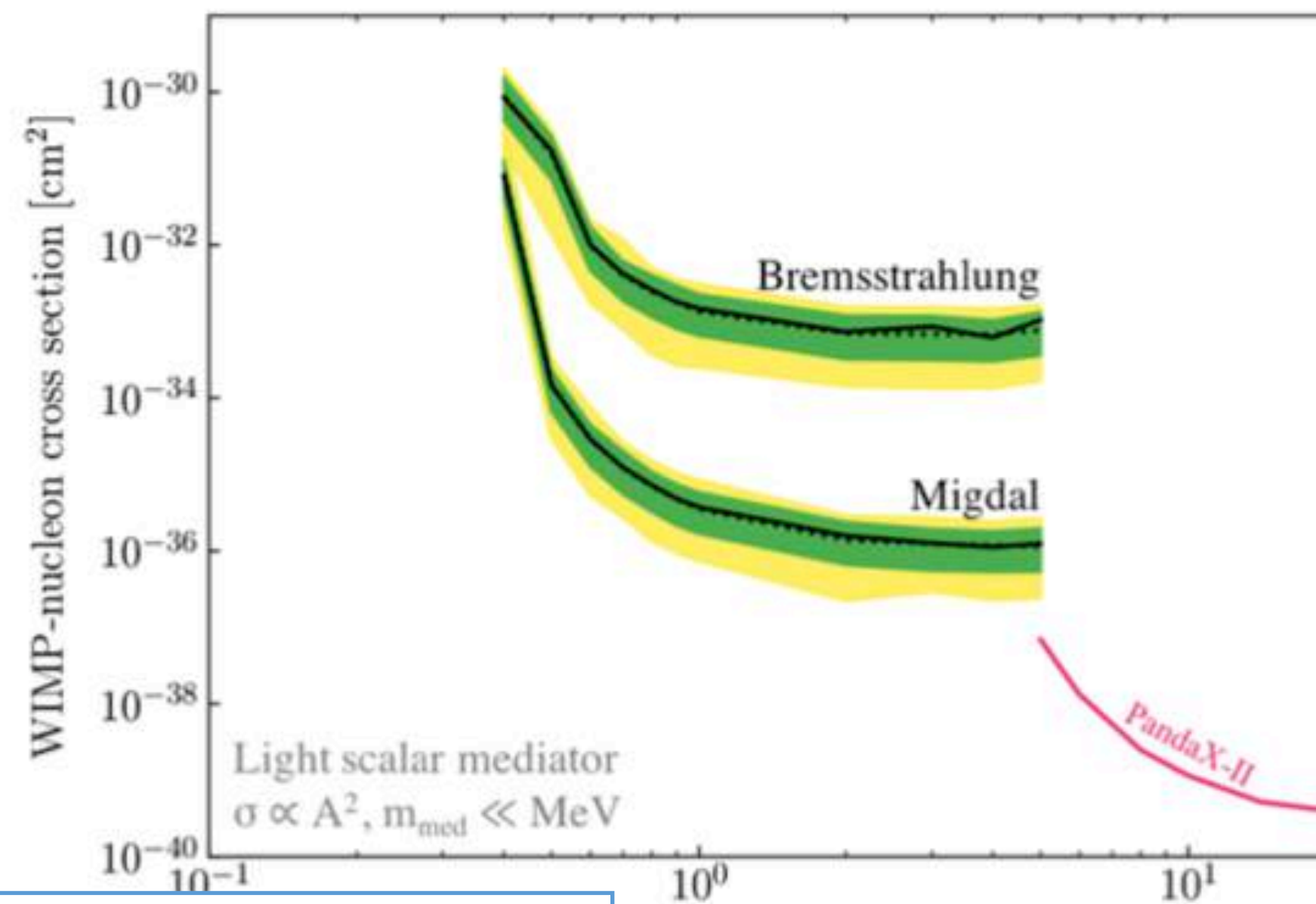
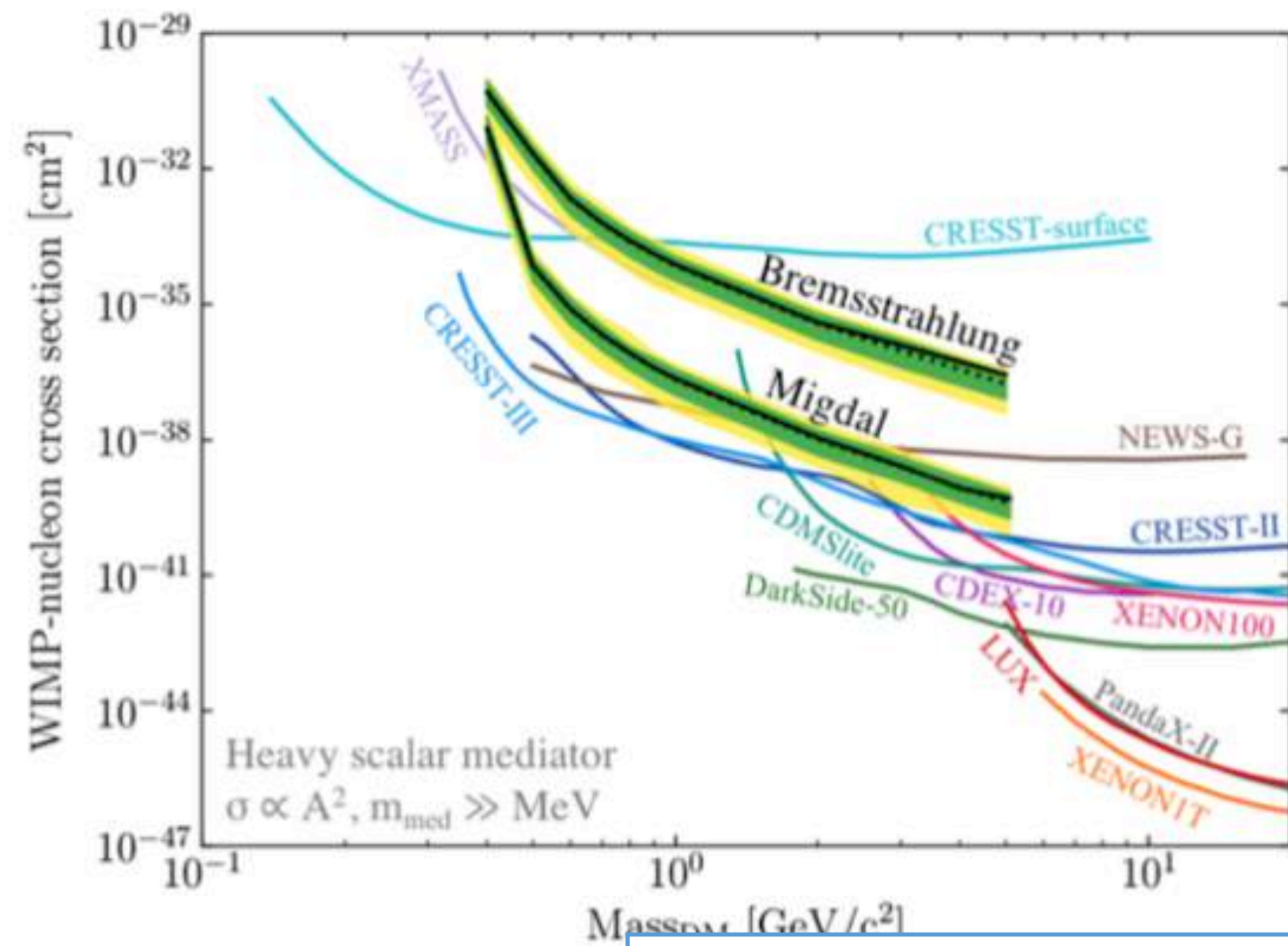


Inputs into ongoing European Strategy Update to decide post-LHC future

Aidan Robson (Glasgow) is spokesperson of CLICdp

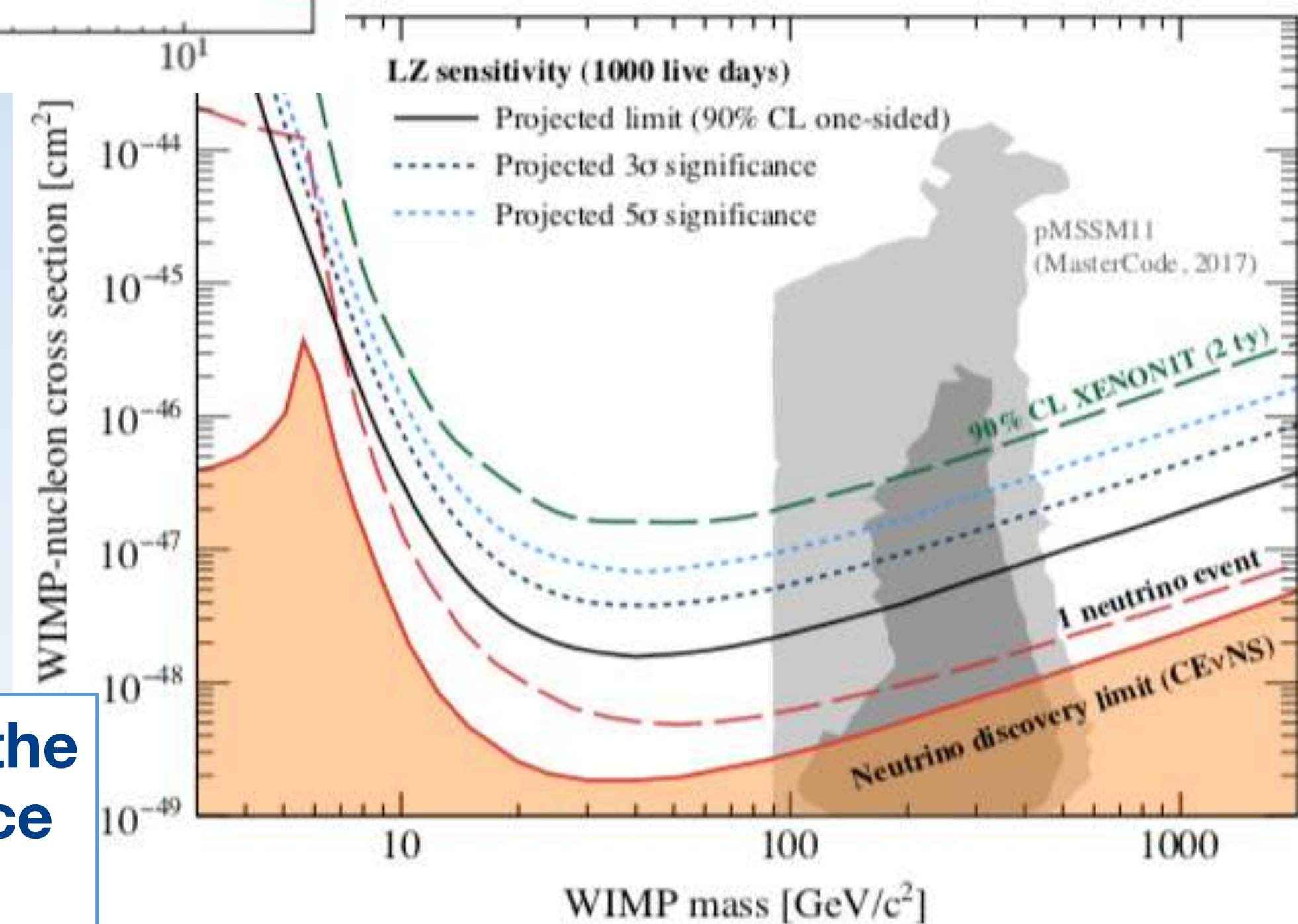


# Research Highlights: Direct limits on light dark matter



**Results of a Search for sub-GeV  
Dark Matter using 2013 LUX Data**  
[PhysRevLett 112 131301 \(2019\)](https://arxiv.org/abs/1802.06039)

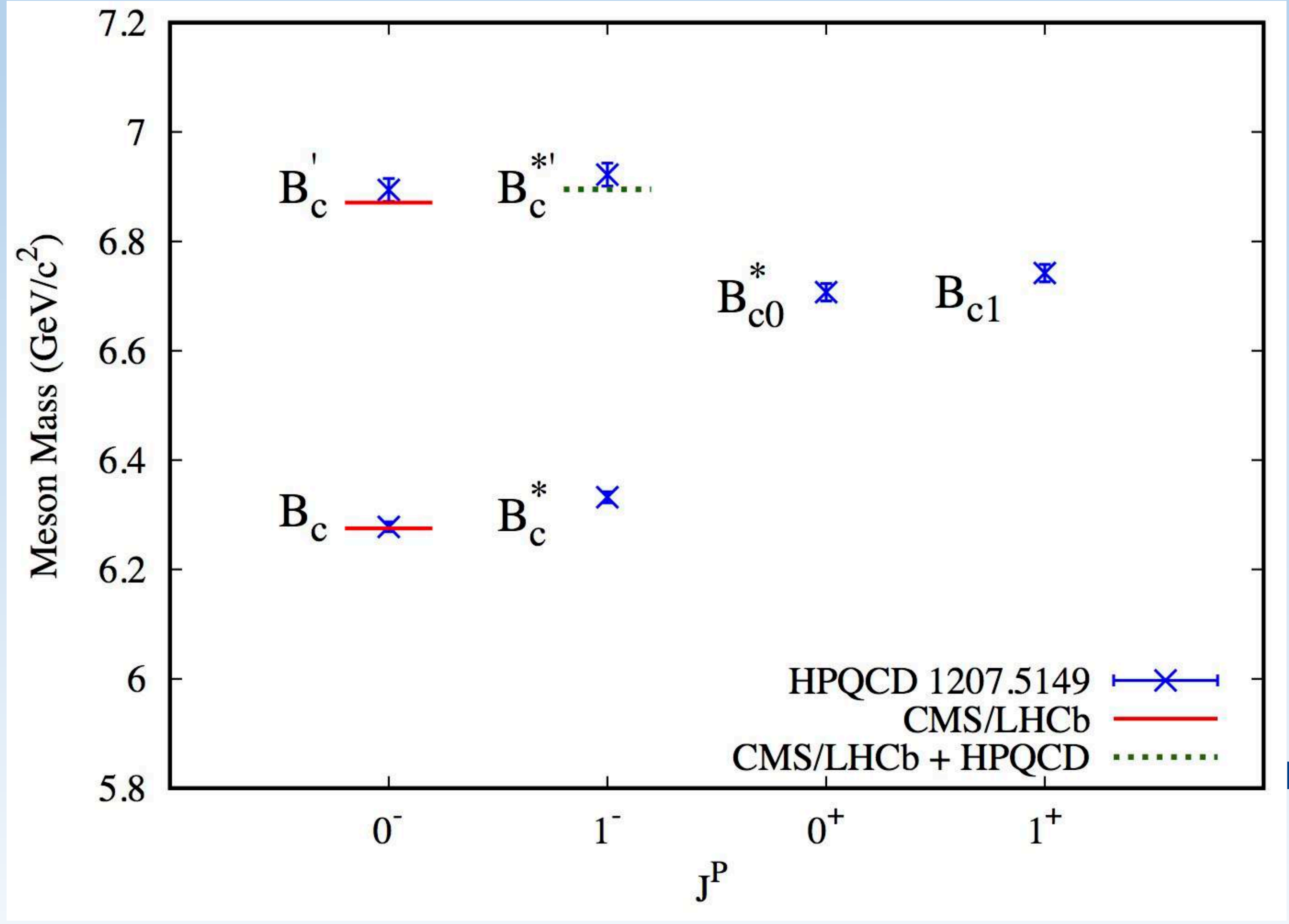
**LZ will explore more of the  
dark matter phase space**  
[arXiv:1802.06039](https://arxiv.org/abs/1802.06039)







# Particle Physics Research Highlights: B<sub>c</sub> meson mass measurements



Blue: predictions of Lattice QCD  
[arXiv.org:1207.5149](https://arxiv.org/abs/1207.5149)  
Red: measurements at LHC

Key validation of Lattice QCD methods!





# Future Plans & Priorities

- **LHC exploitation** - experimental and theoretical - remains top priority
  - ➔ Phenomenology and Parton Distribution Functions
  - ➔ Detector operations and data analysis
  - ➔ Detector upgrades
  - ➔ Exploitation and interpretation of other experiments: NA62 & MICE,  $g-2$  & PLANK satellite
- **Developments for the future**
  - ➔ Installation of LZ for dark matter searches
  - ➔ Future long-baseline neutrino experiments are a major new priority for STFC: we are already engaged in T2K (currently running) and Hyper-K & DUNE (for the 2020s)
  - ➔ SUPA physicists are leading efforts in future collider physics - both in theory & experiment - we will be prepared if any of these facilities are approved
  - ➔ Developments in precision lattice QCD & formal theory
  - ➔ Detector technology
- **Particle physics does not happen without collaboration.**
  - ➔ We need more work and **support** to bring our collaborative skills outside our research to further our impact e.g. in medical & industrial applications, data science, education ...



**SUPA**

**Happy Birthday Peter!**

PETER **90**  
HIGGS





The logo for SUPA (Scottish Universities Particle Physics and Astronomy Research Association) features the word "SUPA" in a bold, blue, sans-serif font. To the left of the text is a stylized blue graphic consisting of a circle and a sphere. A vertical dashed line is positioned to the right of the logo.

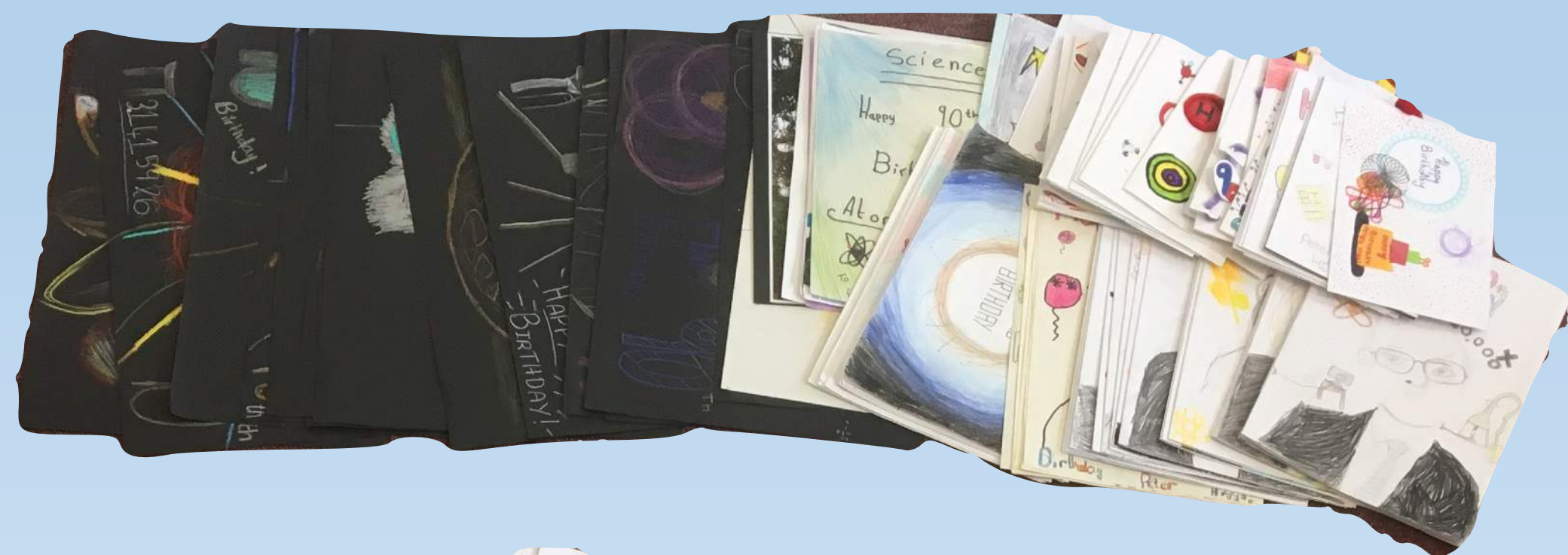
**SUPA**

**Happy Birthday Peter!**

The logo for Peter Higgs features the name "PETER HIGGS" in a black, sans-serif font. The number "90" is prominently displayed in a large, black, stylized font, with a target symbol integrated into the zero.

PETER  
HIGGS

**Save the date:  
20th September  
HiggsFest!**

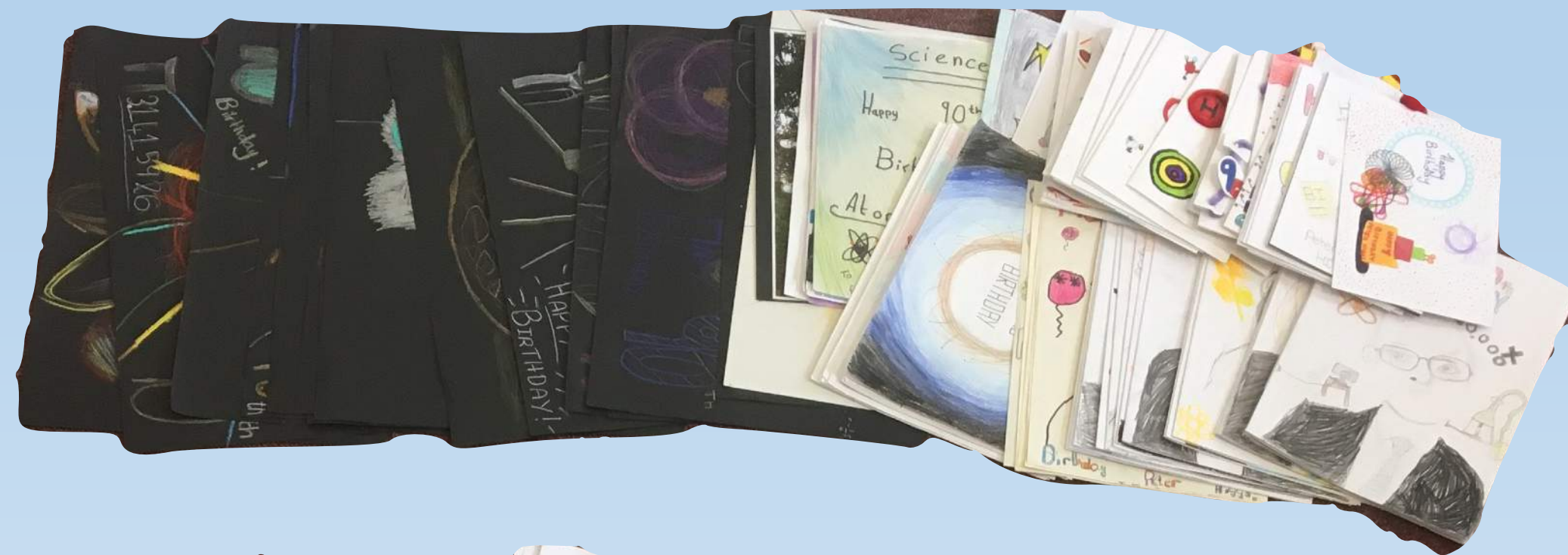




# SUPA

# Happy Birthday Peter!

PETER **90**  
HIGGS



Save the date:  
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# Backup: Major Roles & Awards

- **Personal Chair: Sinead Farrington (Edinburgh)**
- **Major Collaboration & Community Roles:**
  - Richard Ball: member, STFC Particle Physics Grants Panel
  - Peter Boyle: Member, STFC Project Peer Review Panel
  - Craig Buttar: ATLAS UK PI, 2019
  - Craig Buttar: ATLAS ITK Spokesperson, 2019-2021
  - David Britton: GridPP Project leader
  - Pete Clarke: member, STFC Science Board
  - Christine Davies: member, STFC Science Board
  - Christoph Englert: member, STFC Particle Physics Grants Panel
  - Lars Eklund: Deputy Chair, STFC Project Peer Review Panel, 2018-19
  - Christos Leonidopoulos: member, STFC Particle Physics Grants Panel
  - Richard Kenway: member, UKRI STFC Council
  - Sinead Farrington: ATLAS UK PI, 2019-2022
  - Sinead Farrington: Member, STFC Project Peer Review Panel
  - Victoria Martin: Chair, CLICdp Institute Board
  - Franz Muheim: Chair of IOP High-Energy Particle Physics group
  - Alex Murphy: Chair, LUX Executive Committee
  - Alex Murphy: Experiment advisory committee for SNOlab
  - Alex Murphy: REF Panel member
  - Aidan Robson: CLICdp Spokesperson, 2018-2019
  - Paul Soler: MICE UK PI
  - Paul Soler: member, STFC Particle Physics Grants Panel
- **Plus ... many, many internal collaboration leadership roles, including for postdocs + students!**