

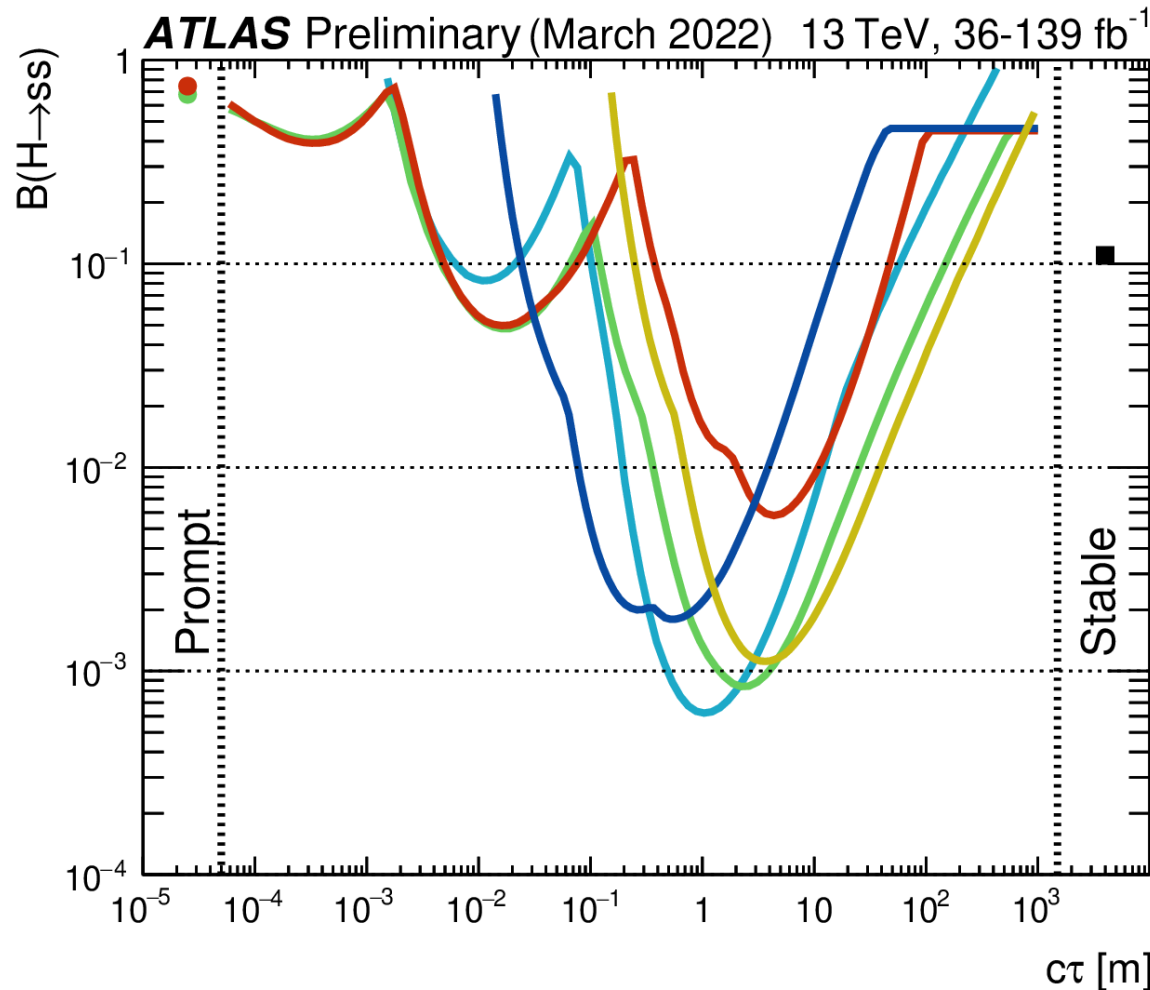


# Update on (pro)ANUBIS detector proposal

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# Motivation



Hidden Sector,  $m_H = 125$  GeV  
 Selected **ATLAS** results  
 95% CL observed limits

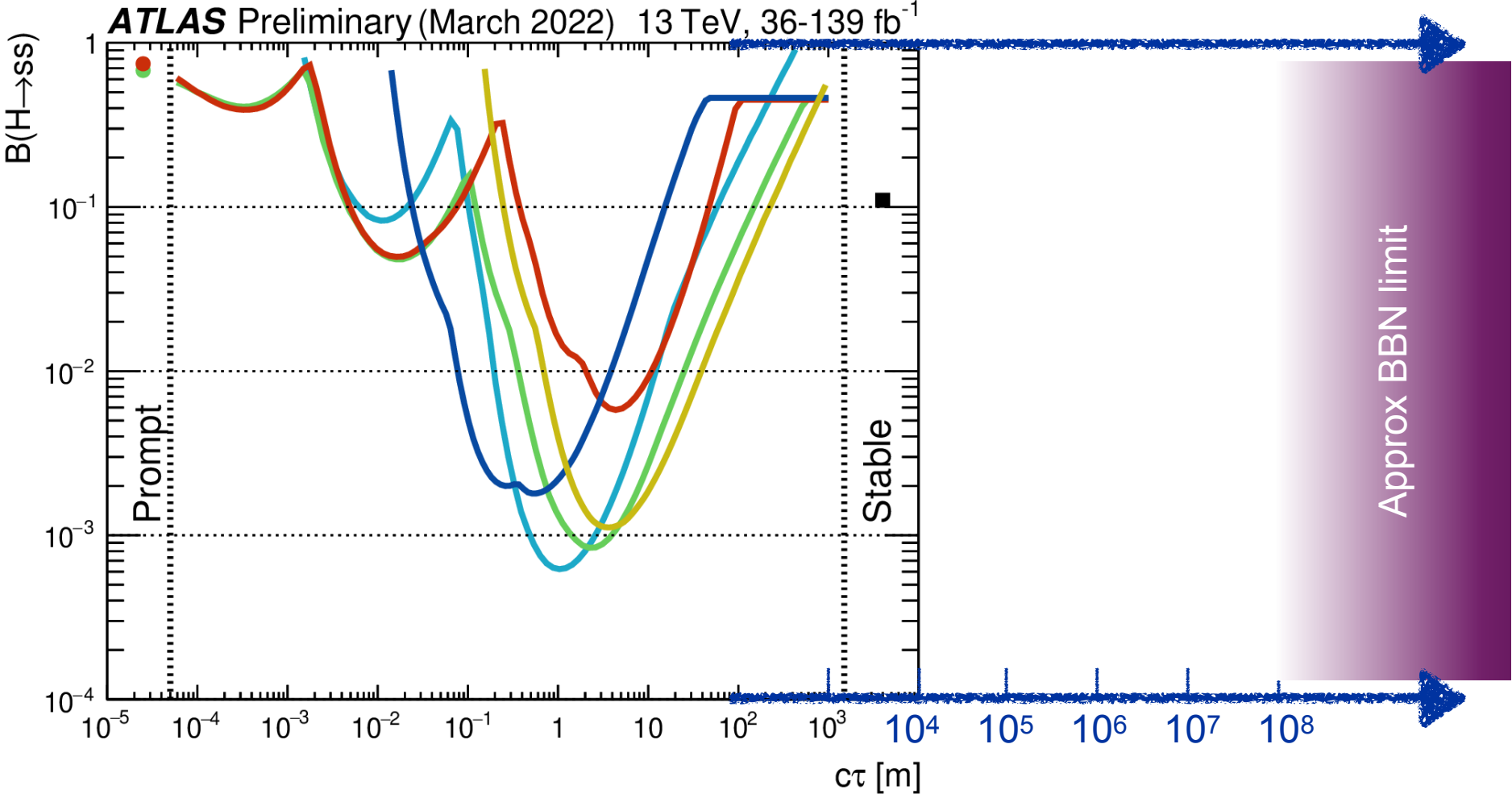
**Contributing searches:**

- **Muon System (2 Vtx Only), 139 fb<sup>-1</sup>**  
arXiv:2203.00587
- **Muon System (1 Vtx + 2 Vtx), 36 fb<sup>-1</sup>**  
Phys. Rev. D 99 (2019) 052005
- **Calorimeter, 139 fb<sup>-1</sup>**  
arXiv:2203.01009
- **Tracker+Muon System, 36 fb<sup>-1</sup>**  
Phys. Rev. D 101 (2020) 052013
- **Tracker (LRT), 139 fb<sup>-1</sup>**  
JHEP 11 (2021) 229
- **Tracker (b-tag), 36 fb<sup>-1</sup>**  
JHEP 10 (2018) 031
- **Monojet, 139 fb<sup>-1</sup>**  
ATL-PHYS-PUB-2021-020
- **H → inv, 7-8-13 TeV combination**  
ATLAS-CONF-2020-052

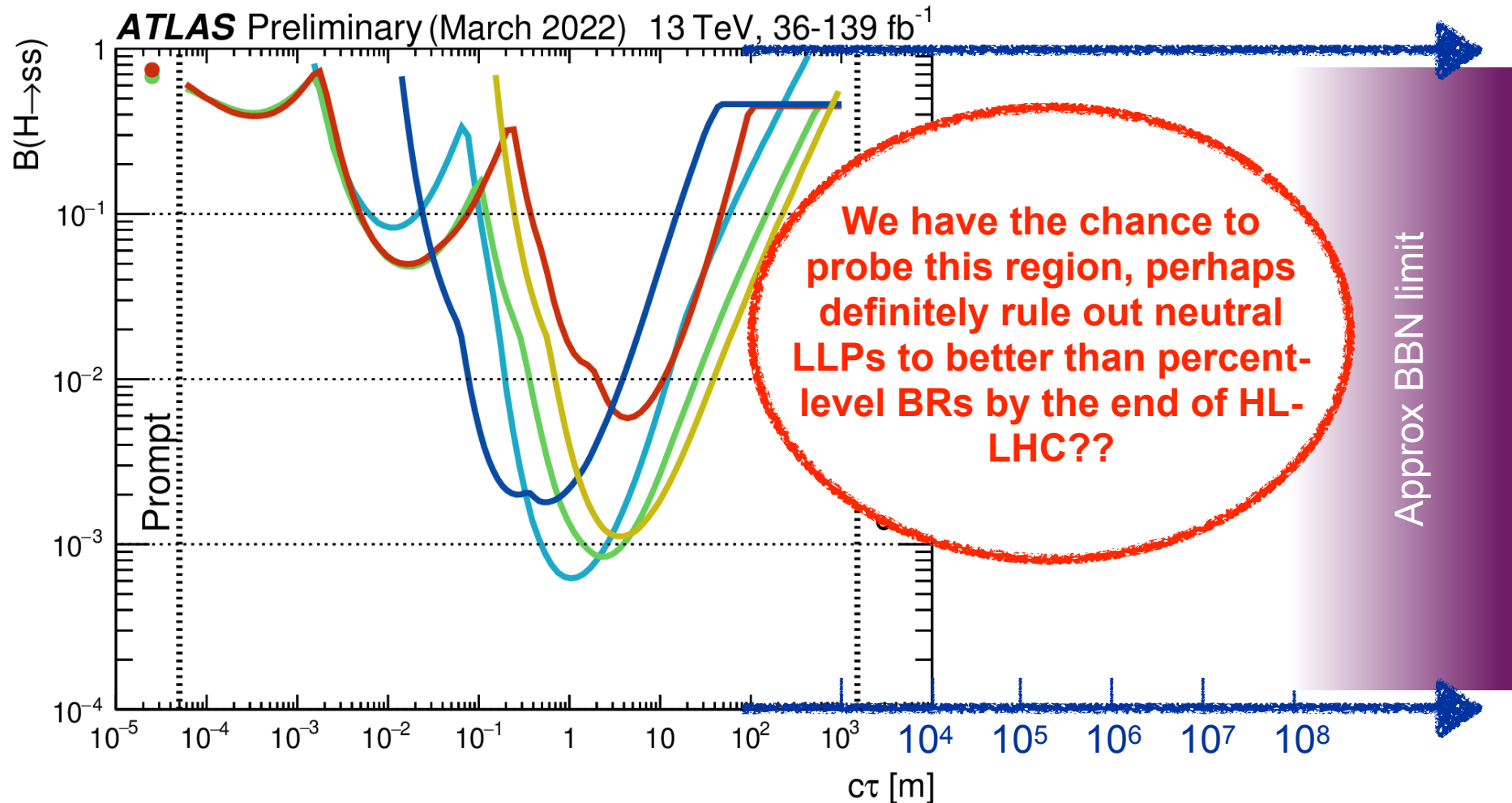
**LLP masses:**

- 5-8 GeV
- 15-20 GeV
- 25-35 GeV
- 40 GeV
- 45-60 GeV
- Any

# Motivation



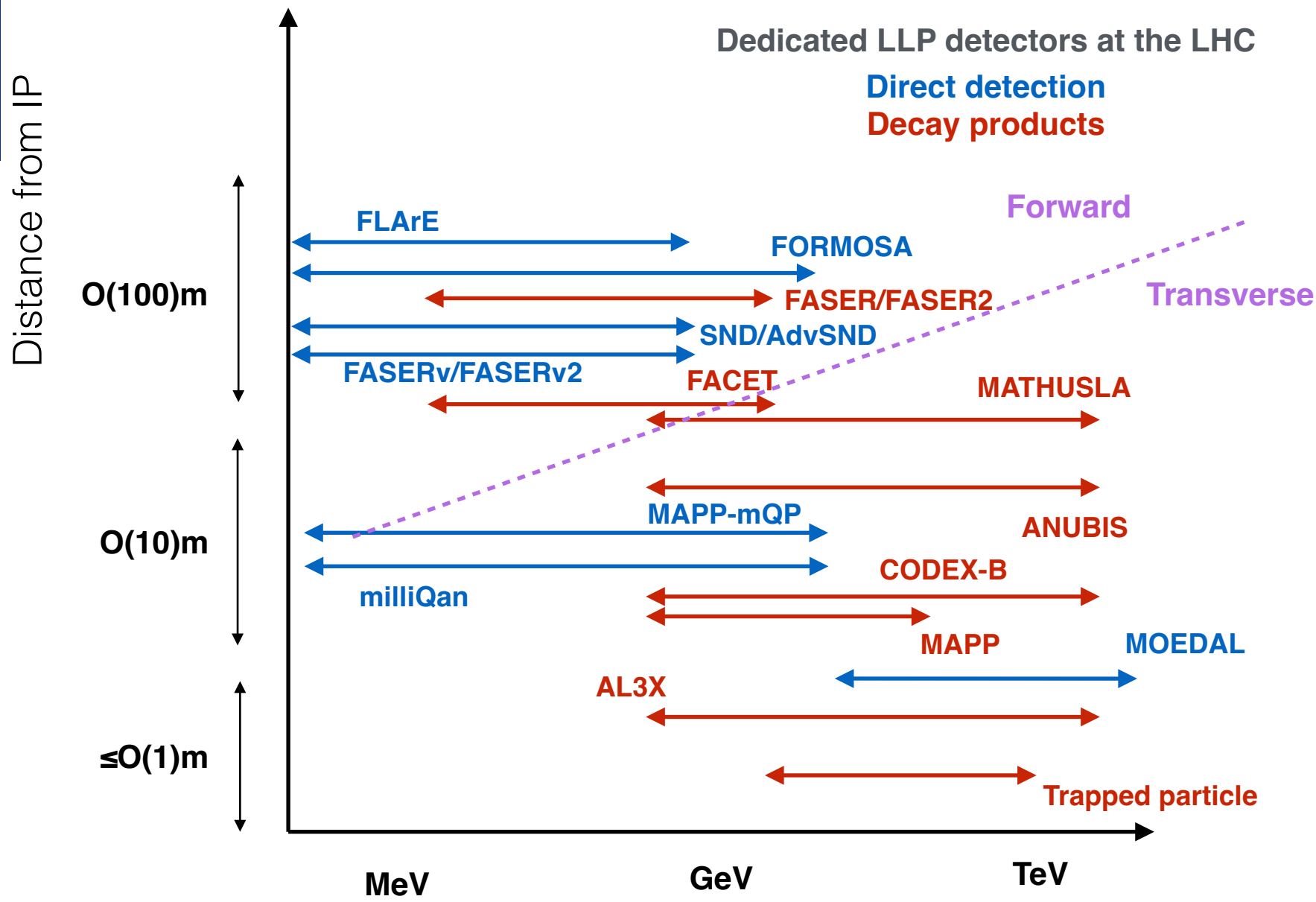
# Motivation



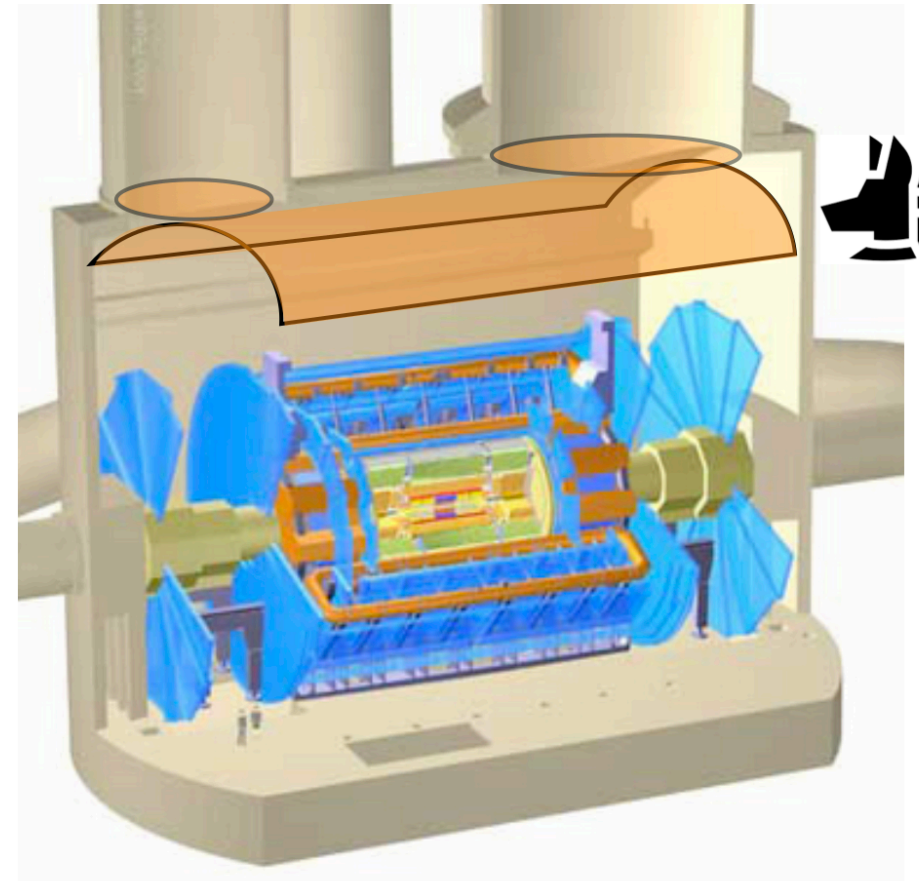


# Accessing LONG-lived particles?

- Many proposals to access BBN limit
- Make good on multi-billion dollar LHC investment
- Incremental investment, avoid disaster scenario where NP discoverable, but we were looking in wrong place.
- Will discuss one proposal: **ANUBIS**



- **AN** Underground **B**elayed **In-S**haft detector
- No longer propose to instrument entire ATLAS access shaft, but instead only shaft bottom + cavern ceiling
- Avoids serious difficulties in removal of detector for access
- Shorter distance to IP more than compensated by larger solid angle  
-> better sensitivity
- Detector ~25m from IP: use cavern volume for decays
- Use ATLAS itself as active veto.
- Incorporated as an official sub-project of ATLAS





# Questions for ANUBIS

- How close can you get to BBN limit?
- Can ATLAS really be used as active veto?
- How can costs be kept down?
- Is your background model realistic?
- Can you prove it will work?



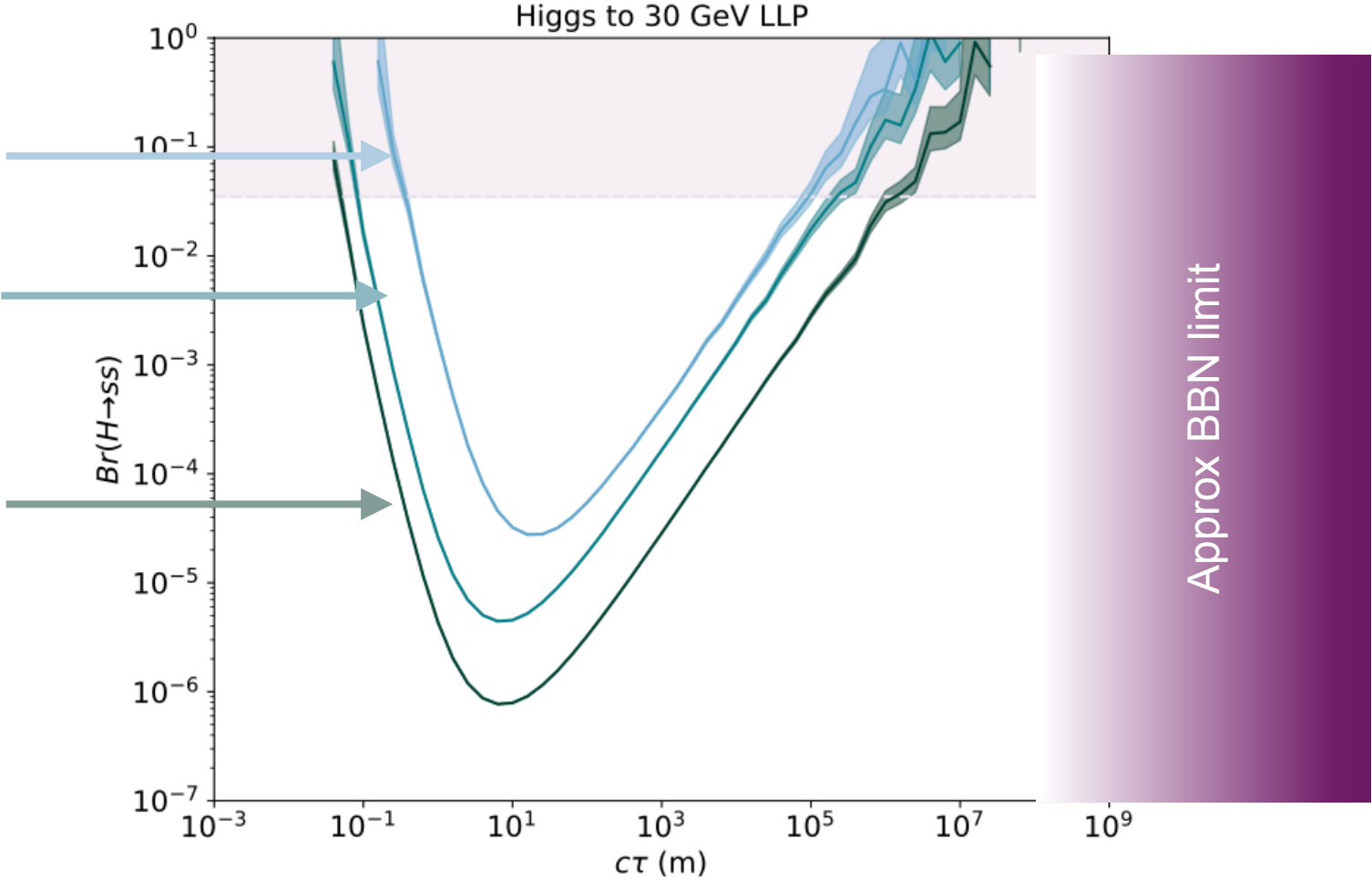
From  
[inonibird.deviantart.com](http://inonibird.deviantart.com)

# How close to BBN limit?

Original ANUBIS shaft-only proposal

ANUBIS shaft, including cavern decays

Current proposal: ANUBIS ceiling configuration



Assuming zero backgrounds

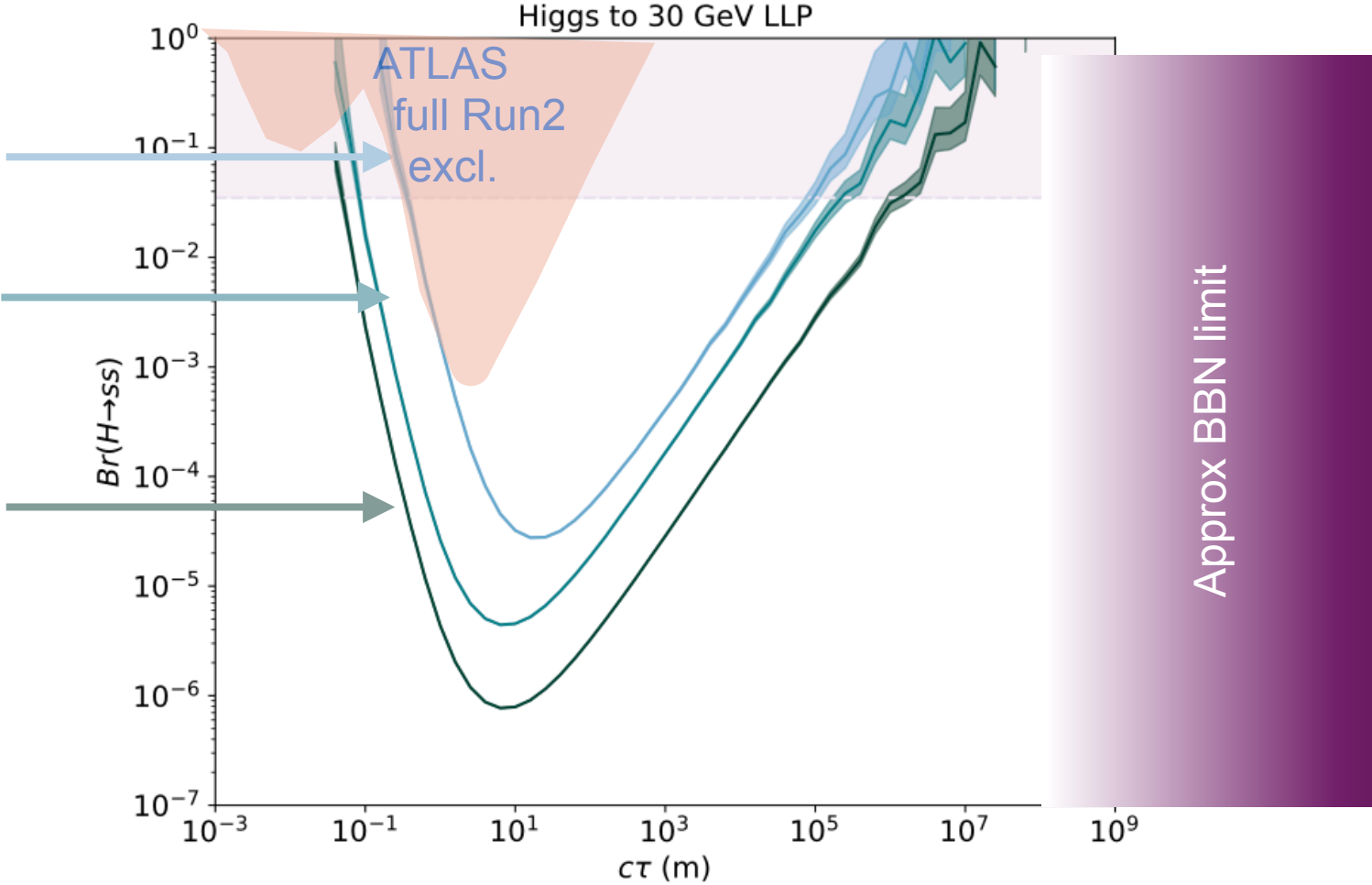


# How close to BBN limit?

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# ATLAS as active veto?

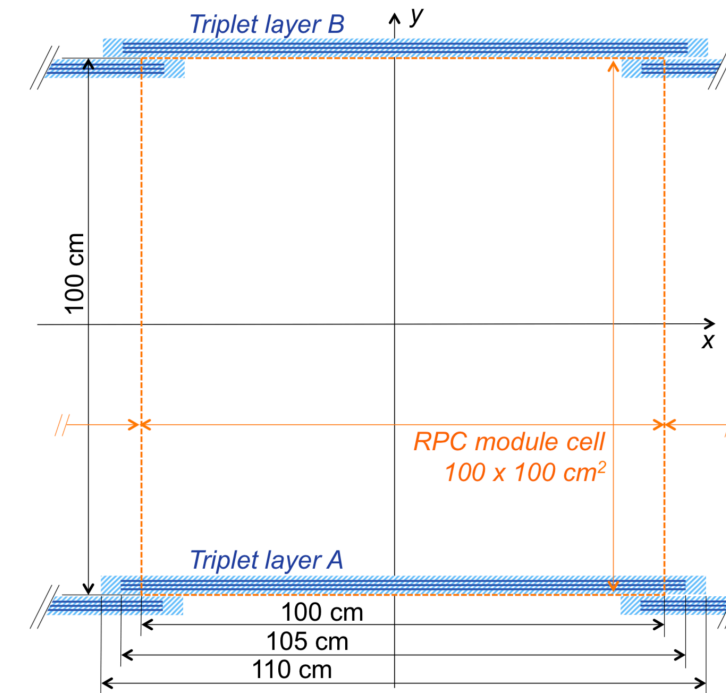
- Idea: ATLAS event information to veto decays of SM hadrons before muon system.
- Requires trigger information to be shared between ATLAS and ANUBIS
- ATLAS trigger latency  $O(10\mu\text{s})$ .  
Return trip ATLAS $\leftrightarrow$ ANUBIS at speed of light  $O(0.5\mu\text{s})$
- Plenty of time to readout, trigger, and communicate trigger decision!
- As a bonus: in case of discovery, can try to correlate with production of additional objects.



# Detector design and question of costs

- To keep costs down, piggyback on existing technology developments for ATLAS muon system: BIC78 resistive plate chambers.
- No dedicated R&D, share production run with ATLAS : economies of scale.
- Layers of RPC triplets separated by air-gap
- Estimated cost:  $\sim 10\text{k€} / \text{m}^2$  instrumented

	Standard RPC	BIS78 RPC
FEE		
Effective threshold	1mV	0.5mV
Power consumption	30 mW	6 mW
Technology	GaAs	BJT Si + SiGe
Discriminator	Embedded	Separated
TDC embedded	No	No
Detector		
Gap Width	2 mm	1 mm
Operating voltage	9600 V	5800 V
Electrode thickness	1.8 mm	1.4 mm
Time resolution	1 ns	0.4 ns

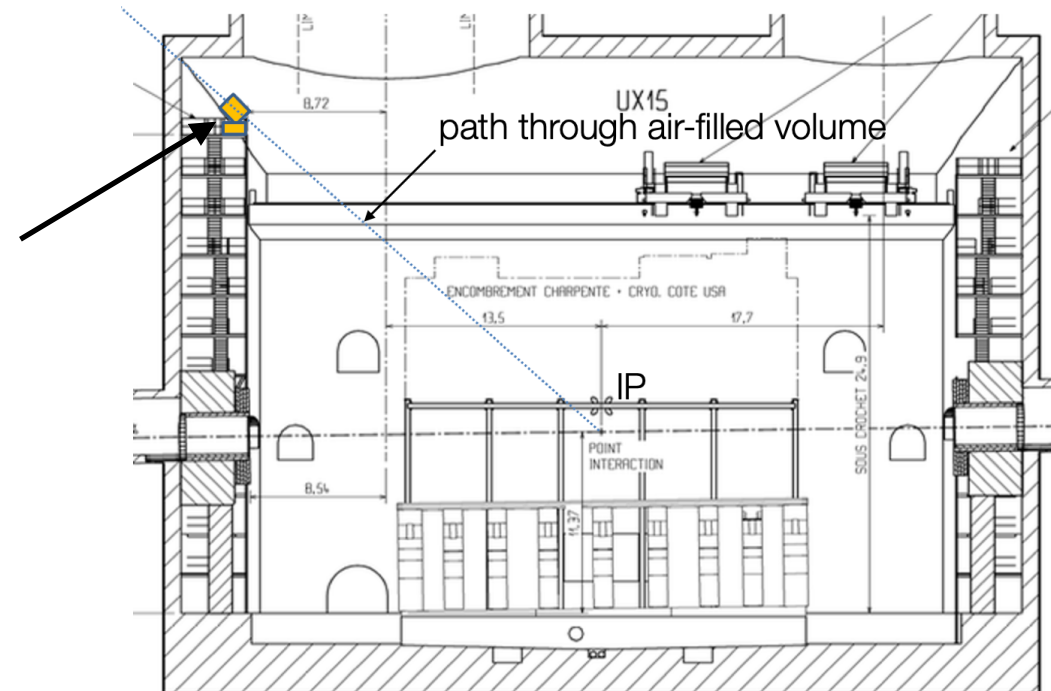
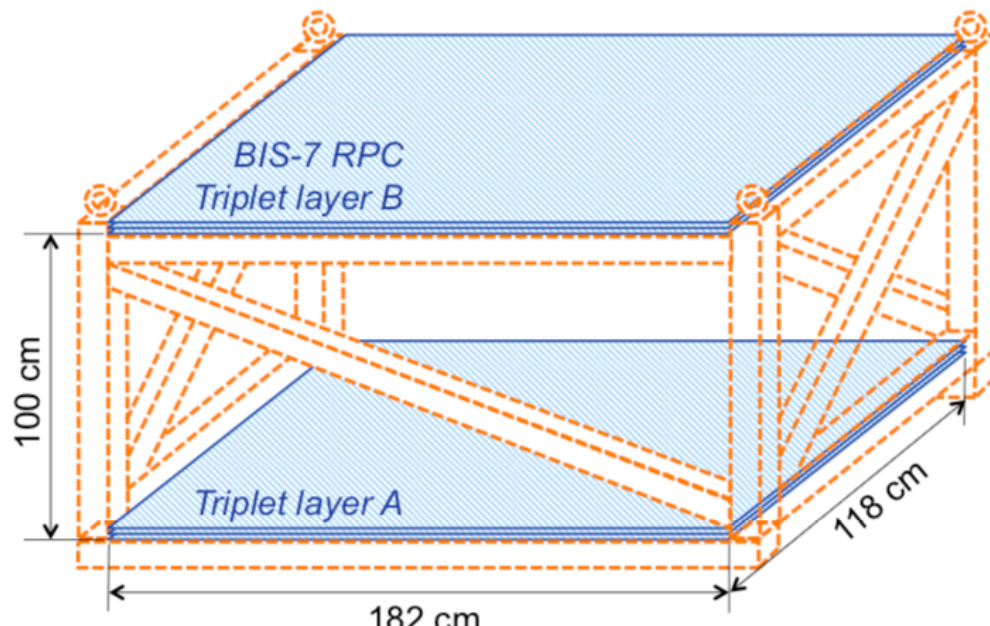


Parameter	Specification
Time resolution	$\delta t \lesssim 0.5 \text{ ns}$
Angular resolution	$\delta \alpha \lesssim 0.01 \text{ rad}$
Spatial resolution	$\delta x, \delta z \lesssim 0.5 \text{ cm}$
Per-layer hit efficiency	$\epsilon \gtrsim 98\%$

# Possible backgrounds & Demonstrator

- Neutron-air interactions, kaon decays and interactions: sources of background Likely controllable from collimated pairs of charged tracks. But need to validate background model in-situ... Calls for a prototype!

*proANUBIS*

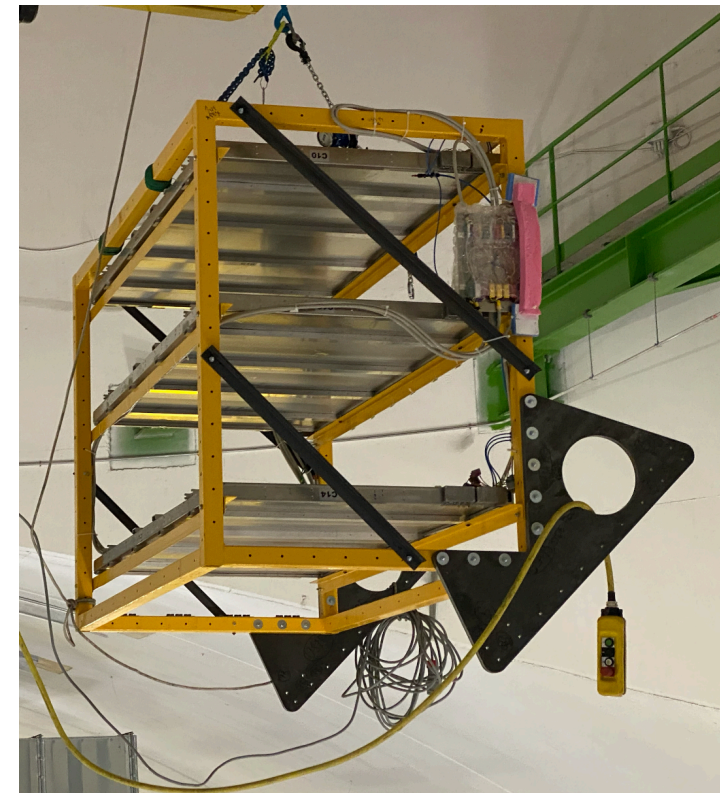
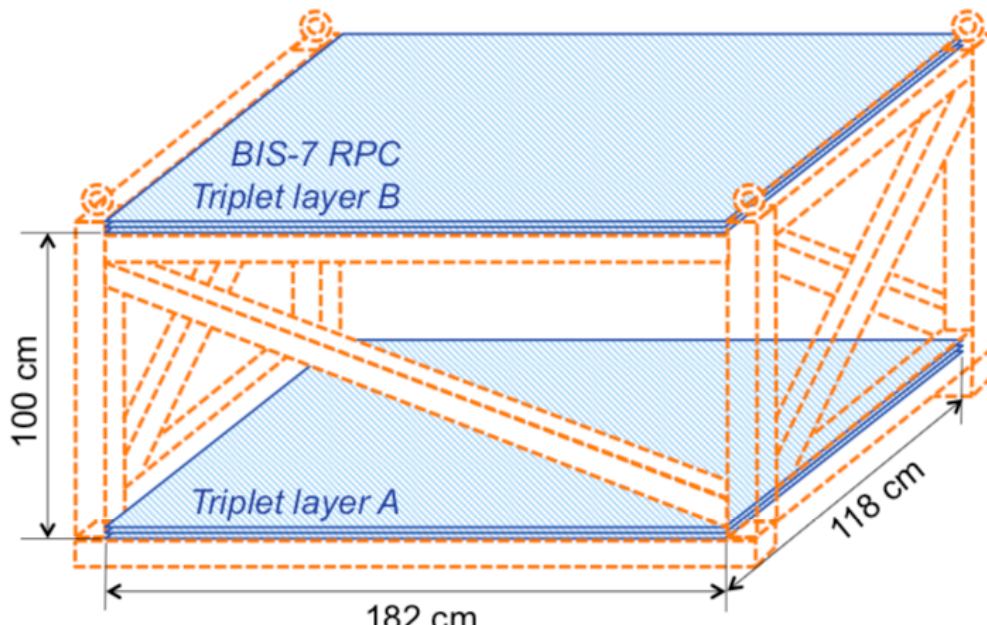




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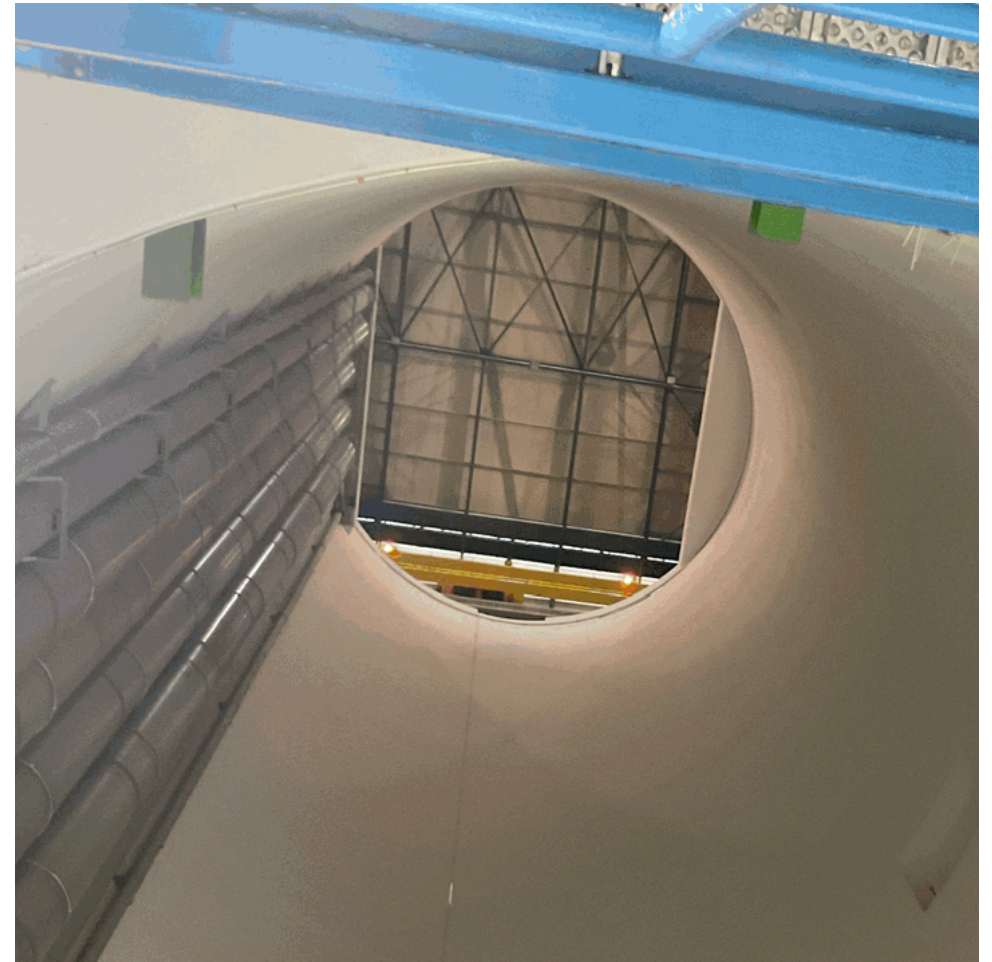
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*pro*ANUBIS



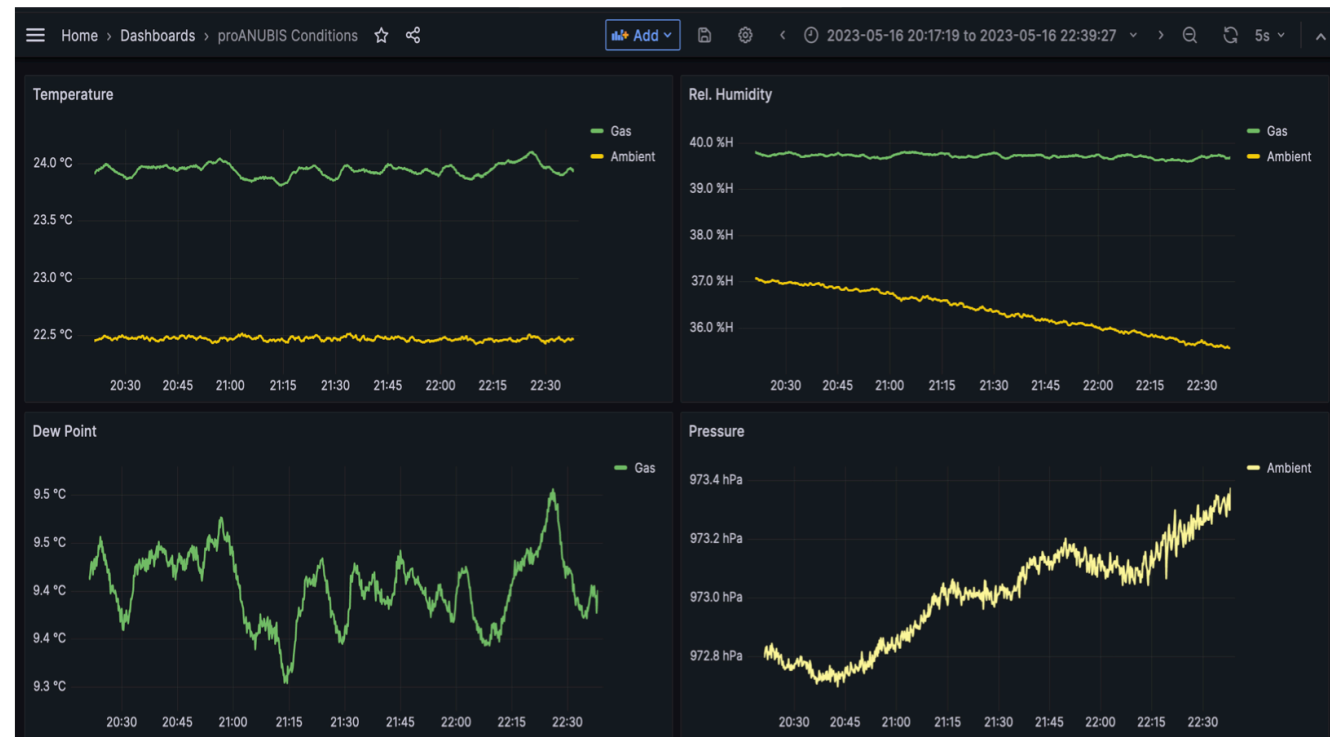
# Can you prove it will work?

- ProANUBIS constructed during 2022, installed in ATLAS cavern in March 2023
- Mais mission:
  - Measure hit/track efficiency
  - Identify muons from ATLAS triggers!
  - Validate background model
  - Measure punch-through rates
  - Measure cosmics
- Currently commissioning!



# Commissioning activities

- Gas/ambient "weather station" (temp, pressure, humidity monitors). In place!

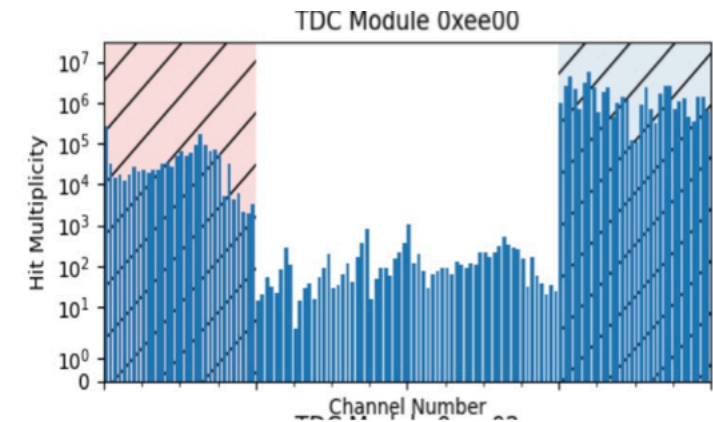




# Commissioning activities

- Gas/ambient "weather station" (temp, pressure, humidity monitors). In place!
- Detector readout... progressing!

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Reading Buffer: F84001A6; Byte Stream: 1111100001000000000000110100110; Header with Event No.: 422;
Reading Buffer: 4F100614; Byte Stream: 01001111000100000000011000010100; Channel No.: 79; Time Measurement: 1244.80 ns;
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Reading Buffer: F84001A7; Byte Stream: 1111100001000000000000000110100111; Header with Event No.: 423;
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Reading Buffer: 491005F0; Byte Stream: 01001001000100000000010111110000; Channel No.: 73; Time Measurement: 1216.00 ns;
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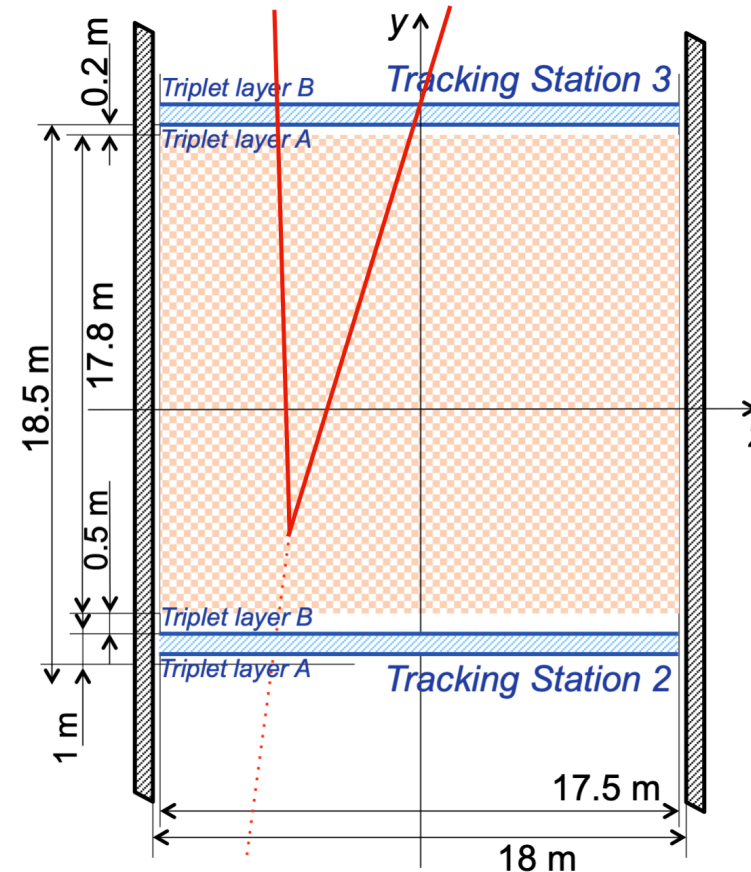
# Commissioning activities

- Gas/ambient "weather station" (temp, pressure, humidity monitors). In place!
- Detector readout... progressing!
- HV/LV remote control. In place!



# Commissioning activities

- Gas/ambient "weather station" (temp, pressure, humidity monitors). In place!
- Detector readout... progressing!
- HV/LV remote control. In place!
- Tracking software... progressing!



# Let's make it happen



Plenty of room for more collaborators!

- Help with commissioning
- Data analysis of cosmics + pp data
- Debugging of DAQ
- Tracking developments

If we as a community want one of the proposed LLP extensions to be come reality, we need people to contribute to the efforts to prove concepts and push towards an official approval!



- ANUBIS is one of the proposals to extend the reach of the HL-LHC programme to LLPs towards the BBN limit
- Latest ANUBIS proposal is to instrument ATLAS ceiling instead of shaft: wider solid angle implies gain in sensitivity despite proximity to IP
  - Sensitivity to  $c\tau \sim 10^6$  m or so: not quite to BBN limit, but 4 orders of magnitude improvement over ATLAS reach alone.
- Piggyback on development of BIC78 technology and benefit from ATLAS production run for economies of scale
- Most exciting: proANUBIS prototype is current IN THE CAVERN and being commissioned! Watch this space for exciting results and validation of ANUBIS proof of concept!