Update for UK-ECFA

Oleg Brandt for ANUBIS

UNIVERSITY OF CAMBRIDGE

UKRI FLF

Isaac Newton Trust

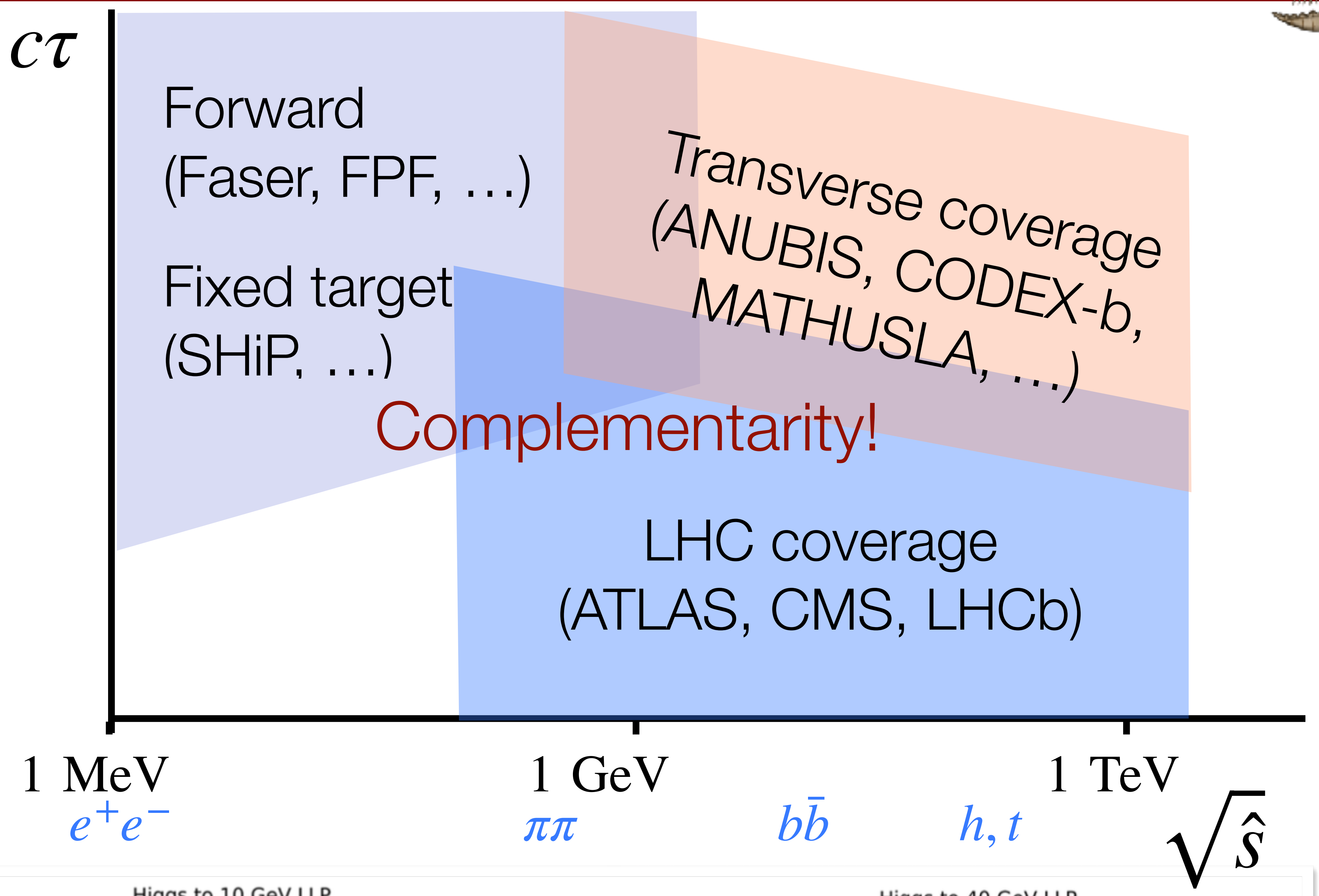
ATLAS EXPERIMENT

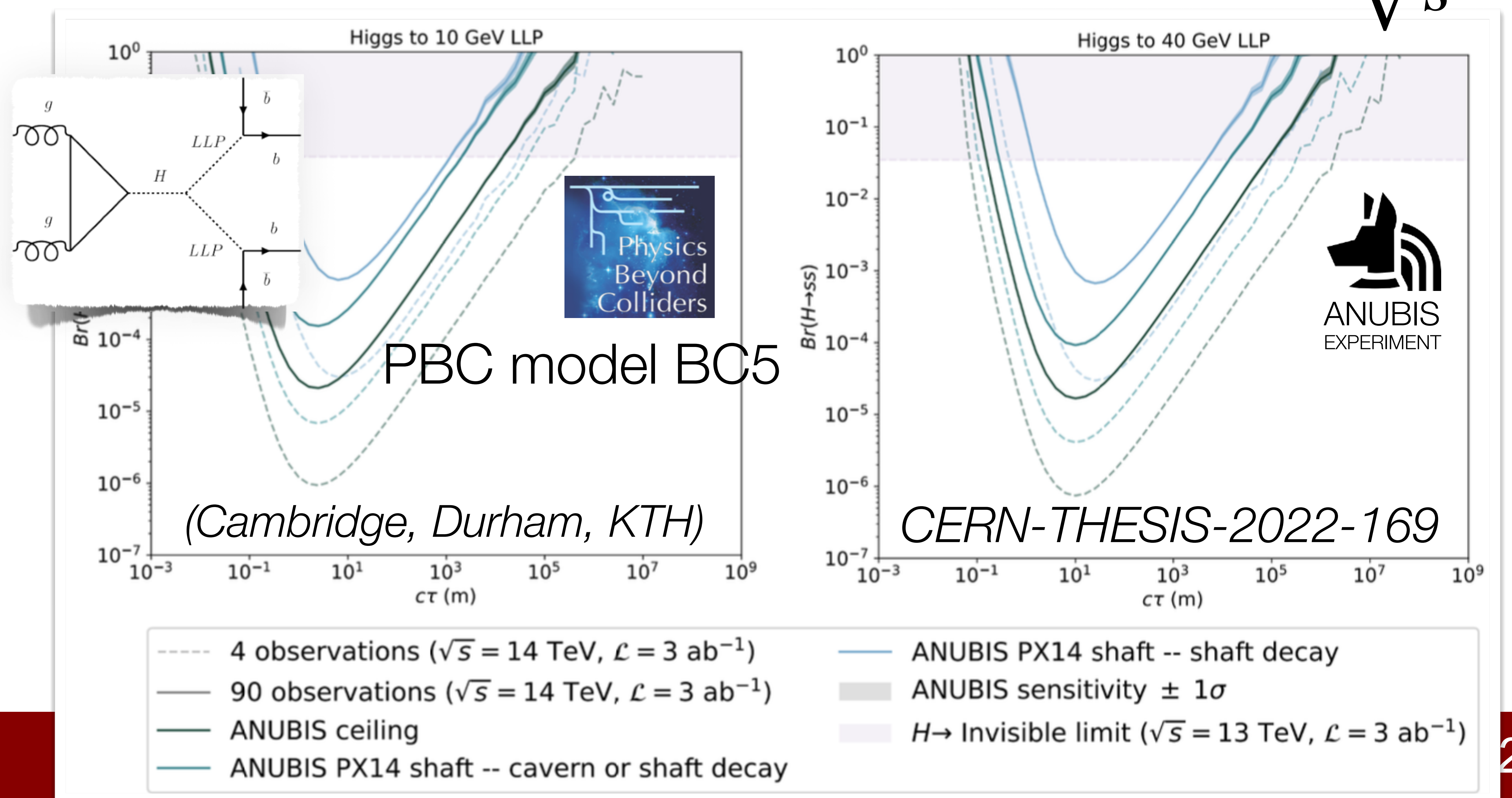
ANUBIS EXPERIMENT

CERN

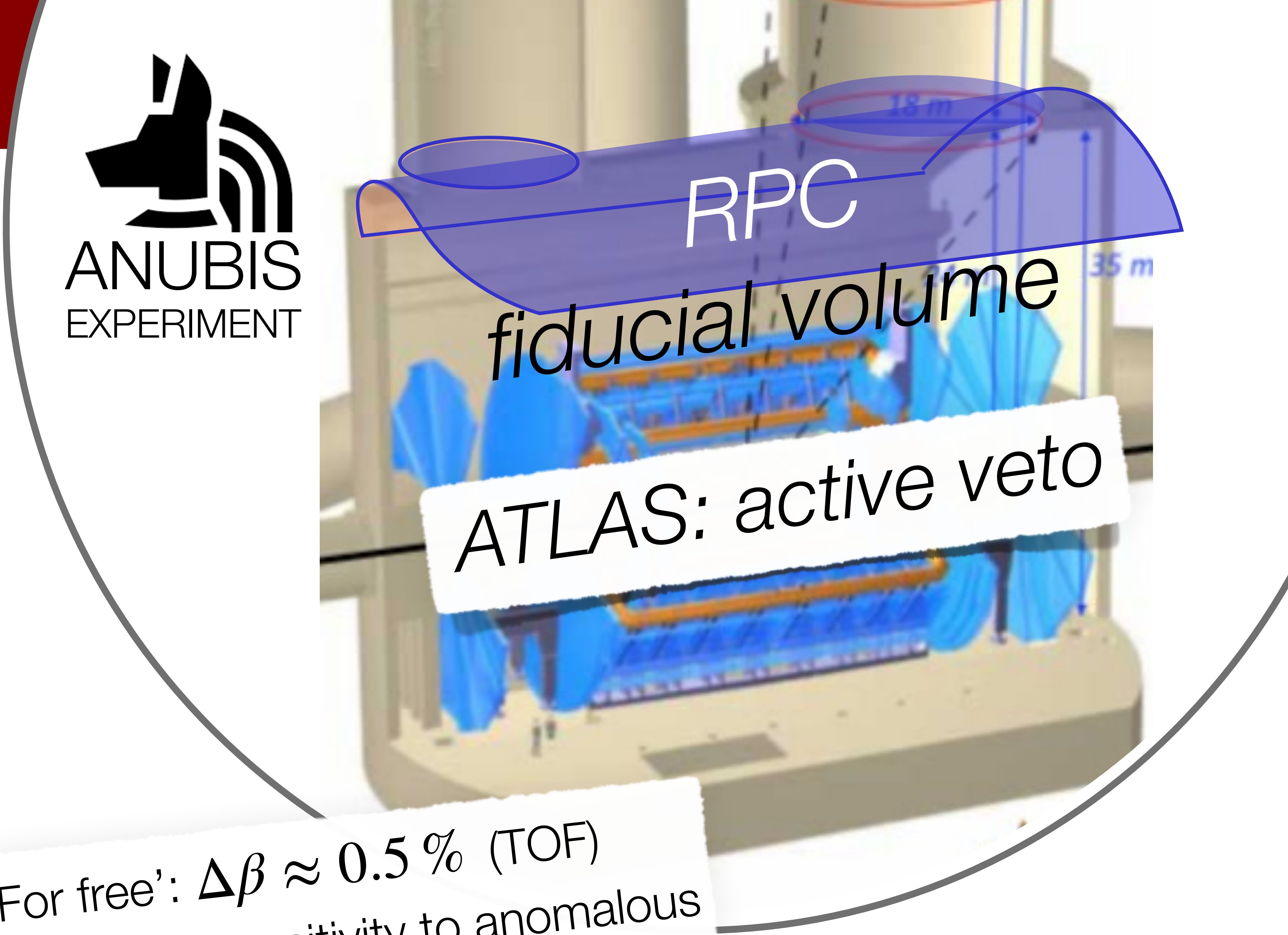
ANUBIS: KEY PHYSICS DELIVERABLES

1. Unique probe of LLPs produced at the electroweak scale and above with $1 \lesssim c\tau \lesssim 10^6$ m
2. Exclude $BR(H \to \mathrm{LLP})$ down to 10^{-6}, exceeding LHC sensitivity for $c\tau \gtrsim 10$ m
3. Exclude HNLs up to $BR(W \to \mathrm{HNL}) \lesssim 10^{-10}$ for large $c\tau$
4. Exclude photophobic ALPs in $H + \mathrm{ALP}$, $Z + \mathrm{ALP}$, and $W + \mathrm{ALP}$ with $\sigma \ll 1$ pb
5. Unique probe of muon-like slow charged LLPs ("smuons") using unique TOF with $\delta(\beta) = 0.5\,\%$ (cf. dE/dx excess)





- Datasets and running/exposure time
  - HL-LHC pp dataset of $\approx 3\ \mathrm{ab}^{-1}$, running with partial detector from 2030 and full detector from LS4
- Environmental cost of construction (in units of tonnes of CO2 equivalent)
  - $\approx 2 \times 10^3\ \mathrm{t}$ CO2 equivalent
    - $\rightarrow$ mostly steel support structures, minor contributions from detector material (bakelite, PCBs)
    - no civil infrastructure needed for ANUBIS
- Environmental cost of operation per year (in units of tonnes of CO2 equivalent)
  - $\rightarrow$ Only $\mathcal{O}(1k\ \mathrm{t})$ CO2 equivalent assuming R&D on eco-friendly RPC gas mixtures delivered
    - (current CO2 emissions from CERN detectors: $100k\ \mathrm{t}$)
  - “parasitic” on HL-LHC



‘For free’: $\Delta\beta \approx 0.5\ \%$ (TOF)
$\rightarrow$ unique sensitivity to anomalous slow *charged* particles (dE/dx)

ANUBIS Detector requirements:

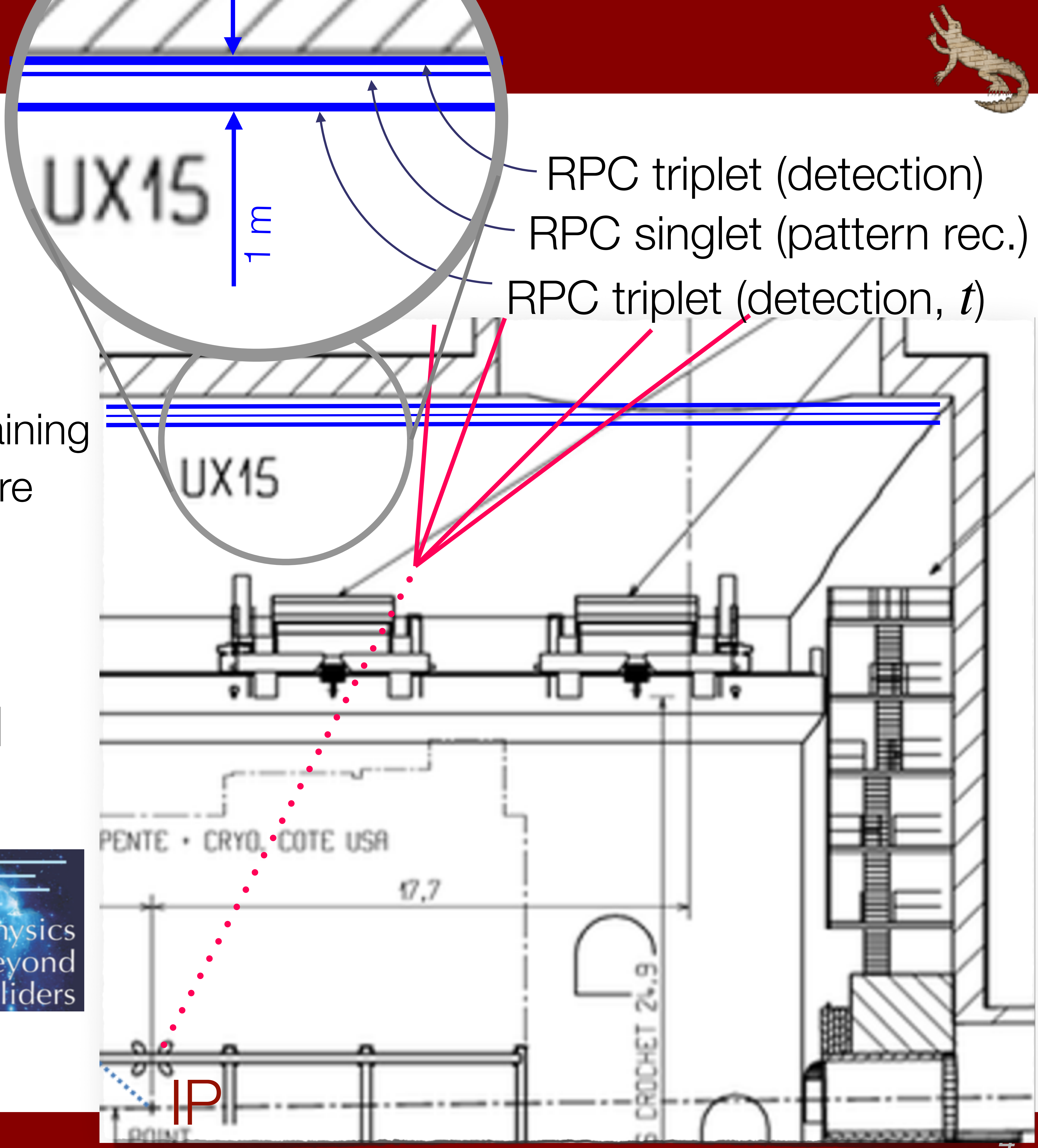
Parameter	Specification
Time resolution	$\delta t \lesssim 0.5$ ns
Angular resolution	$\delta\alpha \lesssim 0.01$ rad
Spatial resolution	$\delta x, \delta z \lesssim 0.5$ cm
Per-layer hit efficiency	$\varepsilon \gtrsim 98\%$

$\rightarrow$ all over-fulfilled by ATLAS Phase 2 RPCs!

ANUBIS: FINANCIAL COSTS & ESPPU SUBM.

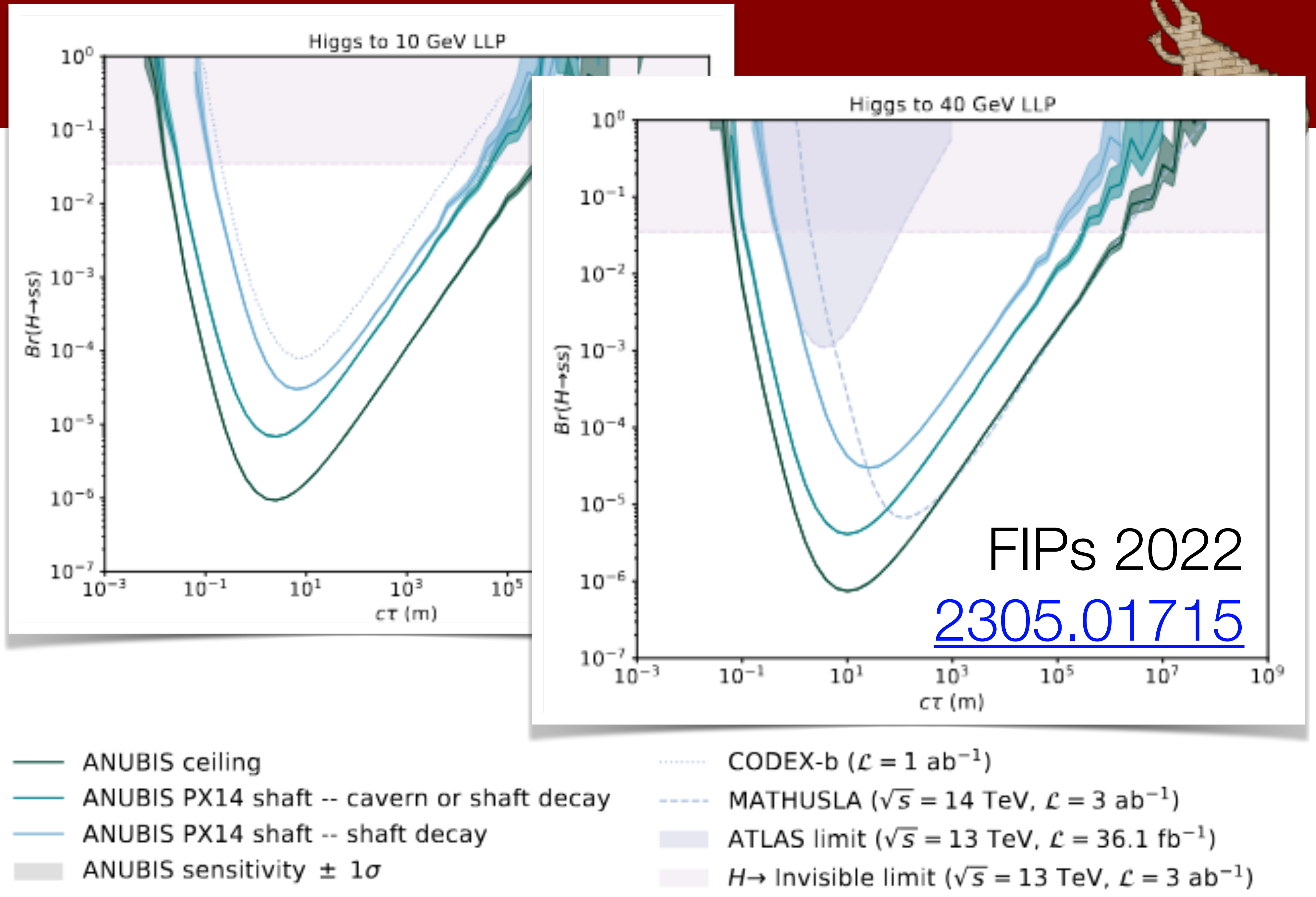
- Estimate of financial costs
  - R&D phase: $\mathcal{O}(1$ MCHF)
    - [low cost: using ATLAS Phase 2 technology]
    - → main R&D items:
      - Eco-friendly RPC gas mixture
      - FE electronics: Manchester receiver, daisy-chaining
      - Bunching and serialisation of DAQ infrastructure
      - Engineering of retractable shaft plug & cavern dome suspension
  - construction phase: ≈ 10-20 MCHF
    - [core costs, from ATLAS Phase 2 MS upgrade]
  - operations phase: ≈ 500 kCHF/a
    - [RPC gas, power, cooling, maintenance]
- Plans for dedicated submission(s) for ESPPU
  - a) through PBC / FIPs
  - b) dedicated submission (possibly together with other transverse expts)

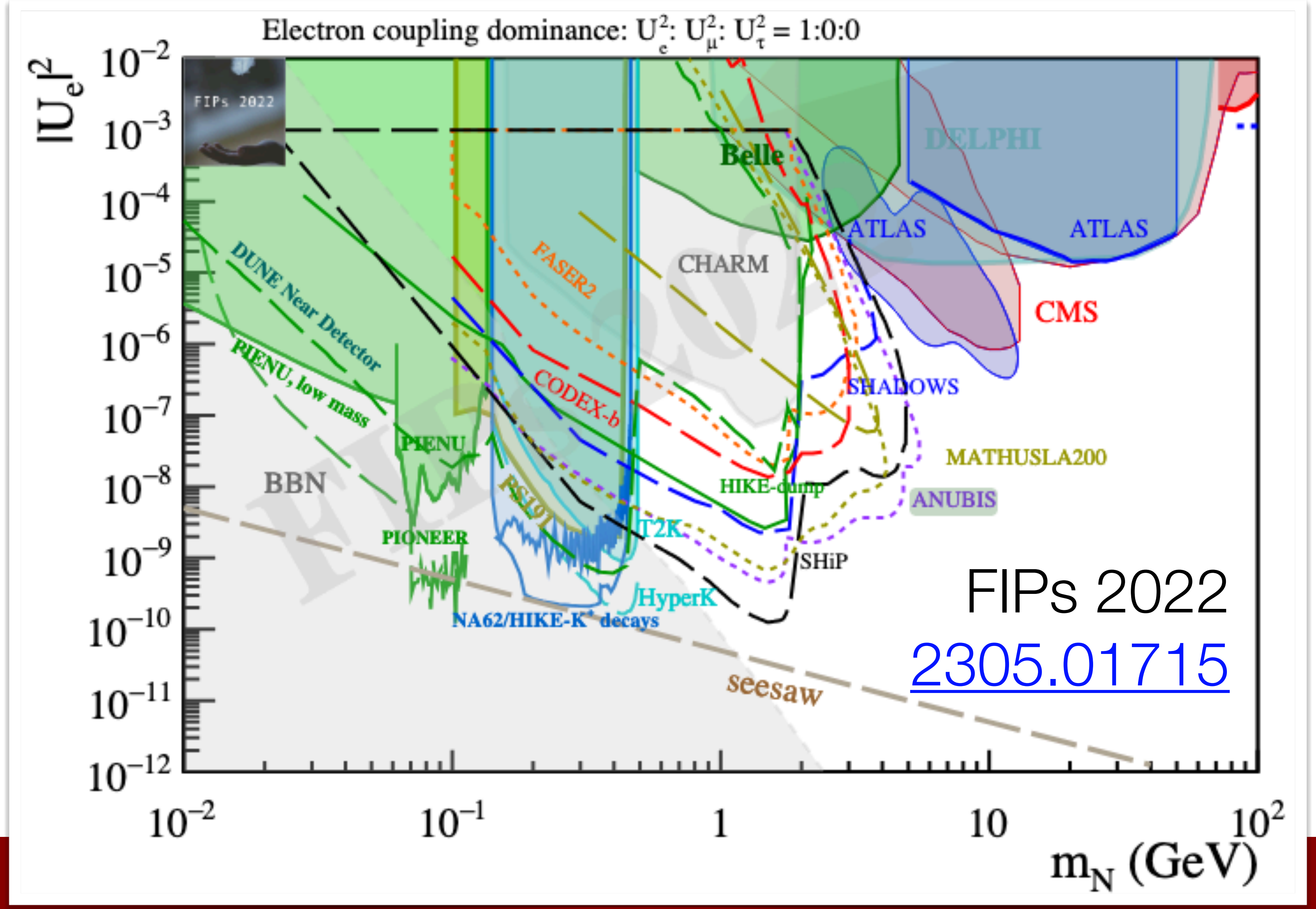
Physics Beyond Colliders



COMPARISON WITH STATE OF THE ART AND COMPETITORS

- Comparison of physics goals with state of the art
  - No existing or approved detectors capable of probing LLPs with $c\tau \gtrsim 10\ \mathrm{m}$ produced at electroweak scale and above
- Project's main advantages compared to competitor projects
  - Probe LLPs with $c\tau \gtrsim 10\ \mathrm{m}$ produced at electroweak scale and above (ATLAS, CMS, forward detectors FPF, SHiP can't)
  - Full picture of the event: LLP decaying in ANUBIS + any associated prompt particles registered in ATLAS
    - Unique sensitivity to many scenarios (Z+ALP, SUSY, …)
      - Not at CODEX-b (LHCb is a forward spectrometer)
      - Hardly possible at MATHUSLA given the distance
  - Measure invariant mass of decay vertex using ATLAS residual B-field
  - Relatively low cost (no civil engineering)
  - Last chance to discover LLPs with $c\tau \gtrsim 10\ \mathrm{m}$ at electroweak scale or above if no collider beyond HL-LHC!





ANUBIS: LOCATION, TIMELINE & RISKS

- Preferred location for the project
  - ATLAS cavern ceiling ($1{,}600\ \mathrm{m}^2$ instrumented):
    - dome of UX15, bottom of PX14 & PX16 shafts
- Project timeline: → see graphic →
- Main risks/obstacles for realisation of physics goals
  - No major risks since using established ATLAS Phase 2 upgrade RPC technology
  - Minor risks:
    - R&D on eco-gases expected to converge given low rates
    - Integration of ANUBIS support structures (engineering)
    - Technology/Ansatz validation with proANUBIS demonstrator

Gaseous detector R&D, DRD1: FCC long-term goal

2033+: FCC detector construction & exploitation

2035+: Run 5 full ANUBIS+ATLAS data taking

2033+: bulk ANUBIS deployment in cavern (LS4)

2030+: Run 4 partial ANUBIS data taking

2028+: partial ANUBIS deployment in cavern (LS3)

2026+: ANUBIS detector R&D (electronics, R/O)
engineering for cavern deployment

2025: proANUBIS data analysis, Letter of Intent

2024: PBC model #7 (#8, #9), proANUBIS data taking

2023: finalise geometry, PBC model #6, proANUBIS

2022: seed funding for proANUBIS

2021: ANUBIS location & prototype conception

2020: proANUBIS sensitivity studies

2019: ANUBIS conception

ANUBIS: INVOLVEMENT AREAS

- Anticipated area(s) of UK involvement
  - Eco-gas R&D
    - → in-line with CERN goals & net zero 2050
  - RPC detector production
    - → unique opportunity to establish and lead gaseous detector technology in the UK (FCC)
  - DAQ system (bunching, serialisation)
    - → traditional strength of UK community
  - Operation
  - Exploitation
- Total number of FTE /year required for construction/ operation. What is the expected UK FTE?
  - Construction: <40 FTE/a (strong industry involvement)
    - UK: 5-10 FTE/a
  - Operation: 3-5 FTE/a
    - UK: 1-2 FTE/a

ANUBIS collaboration UK-lead:
Ideal starting point for UK leadership in the future!
→ unique opportunity to join an exciting project with a unique discovery potential (until FCC)
→ interesting hardware project with non-trivial electronics component after Phase II
→ strong UK position for FCC detector R&D

Co-Spokesperson (theory)
Martin Bauer
martin.m.bauer@durham.ac.uk

Co-Spokesperson (expt)
Oleg Brandt
oleg.brandt@cern.ch

Outreach coordinator
Louie Corpe
l.corpe@cern.ch

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Physics Coordinator
Michael Revering
M.Revering@cern.ch

Simulation Coordinator
Paul Swallow
paul.nathaniel.swallow@cern.ch

Technical Coordinator
Aashaq Shah
aashaq.shah@cern.ch

R&D Co-coordinator
Giulio Aielli
giulio.aielli@cern.ch

R&D Co-coordinator
Luca Pizzimento
luca.pizzimento@cern.ch

Project inputs to drafting days (to be provided in <= 5 slides)

For all projects :

Key physics deliverables (name up to 5). Be quantitative where relevant/possible.
Please quote the datasets and running/exposure time required for the numbers above.
Environmental cost of construction (in units of tonnes of CO_2 equivalent)
Environmental cost of operation per year (in units of tonnes of CO_2 equivalent)
Estimate of financial costs (provide separate numbers for R+D phase, construction phase and operations phase)
Does your project plan dedicated submission(s) for the ESPPU (if so, give details).

*'here information ɿot available, ase note this**

Collider projects:

For each energy stage:

- centre-of-mass energy
- integrated luminosity
- number of interaction points
- time running at stage
- wall power
- accelerator length
- estimated year for first collisions
- future upgrade paths

Non-Collider Projects:

- Comparison of physics goals with the current state of the art in the area.
- List the project's main advantages compared to competitor projects.
- Preferred location for the project
- Project timeline (if possible provide separate by the R&D, construction and exploitation periods)
- Main risks/obstacles for realisation of physics goals (e.g. development of new technologies, construction of a new facility)
- Anticipated area(s) of UK involvement
- Total number of FTE /year required for construction/operation. What is the expected UK FTE?