

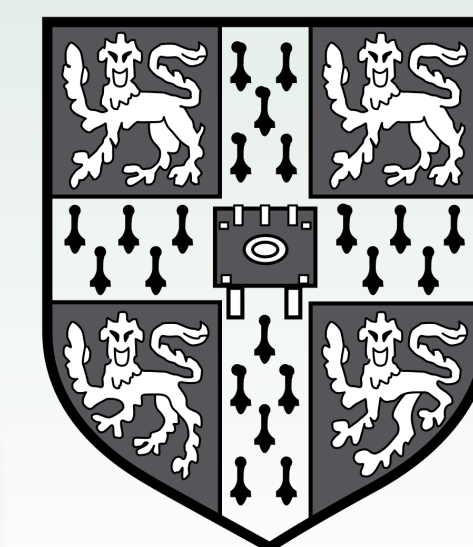
Sensitivity of the ANUBIS Detector with Various Geometries to BSM LLPs

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UK Research
and Innovation



Previous searches for beyond the Standard Model long-lived particles have thus far been hindered by experimental constraints.

How can these constraints be addressed with a modest investment in electronics and civil engineering?

Outline

Prospective ANUBIS geometries



Cavern Ceiling Configuration

Installs RPC detectors along the ceiling of the ATLAS cavern

Large coverage in solid angle which extends ~20 meters from the interaction point

PX14 Shaft Configuration

Installs four RPC tracking stations in the PX14 service shaft of ATLAS

Relatively limited coverage in solid angle which extends ~80 meters from the interaction point

Outline

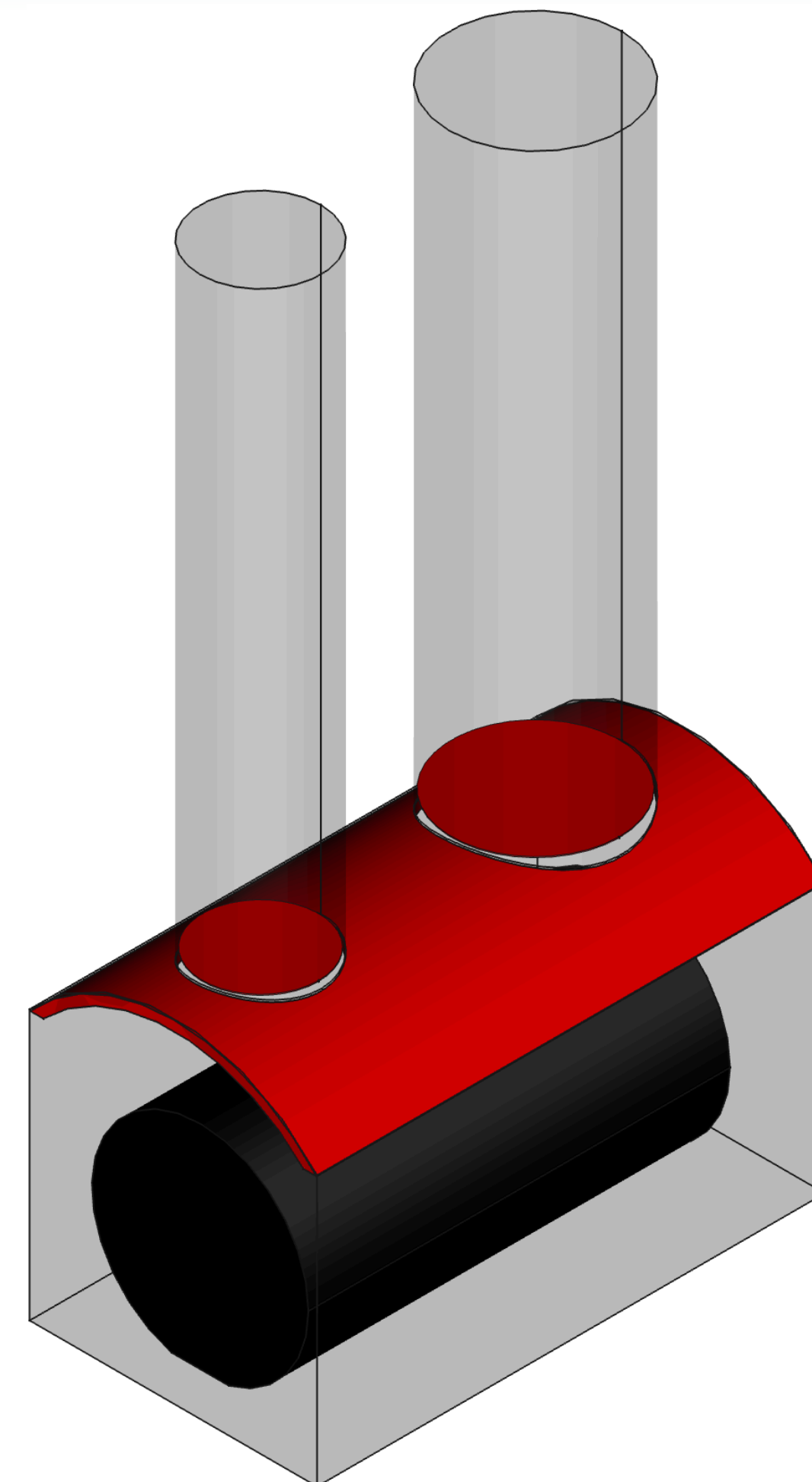
Prospective ANUBIS geometries



Cavern Ceiling Configuration

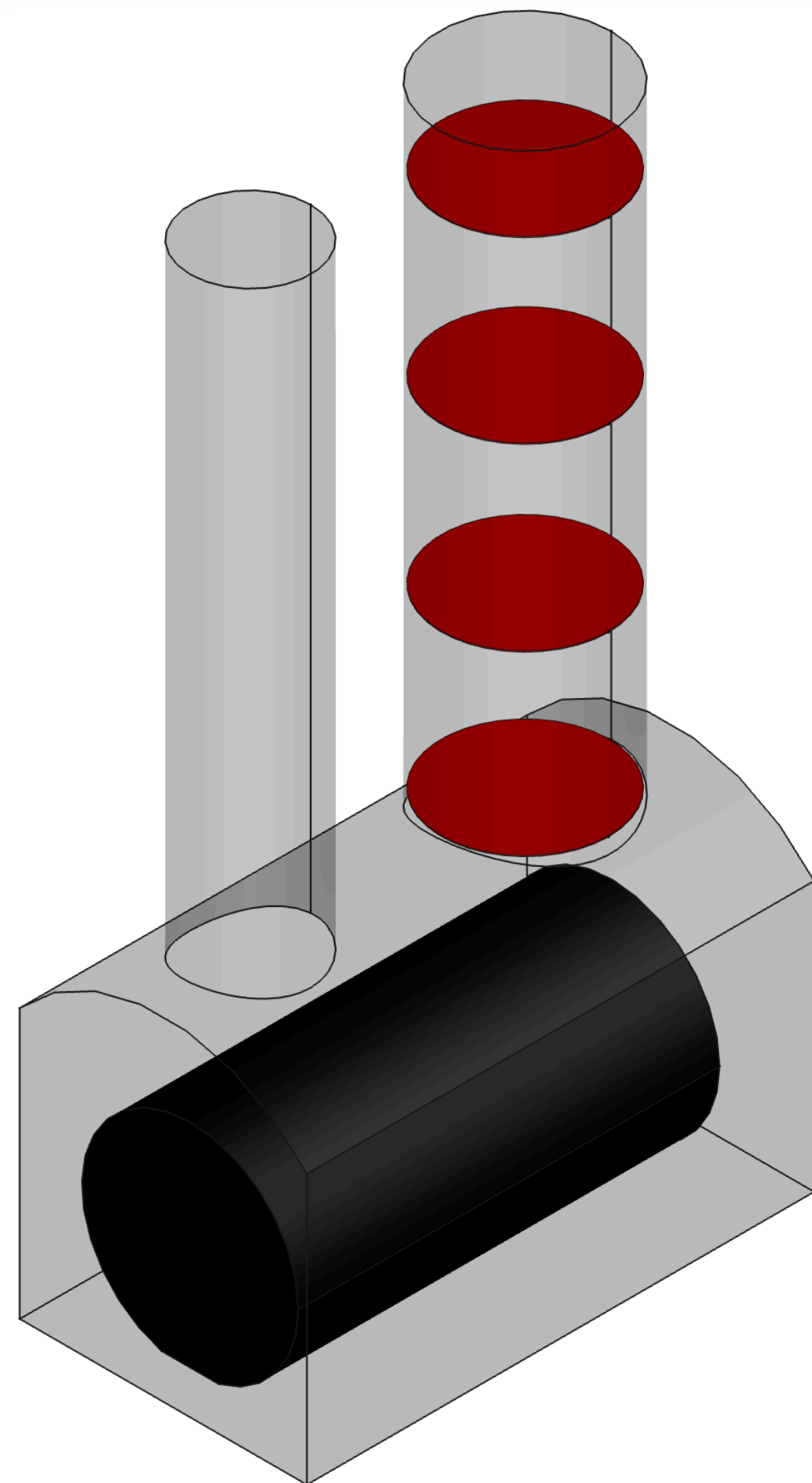
Installs RPC detectors along the ceiling of the ATLAS cavern

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Outline

Prospective ANUBIS geometries



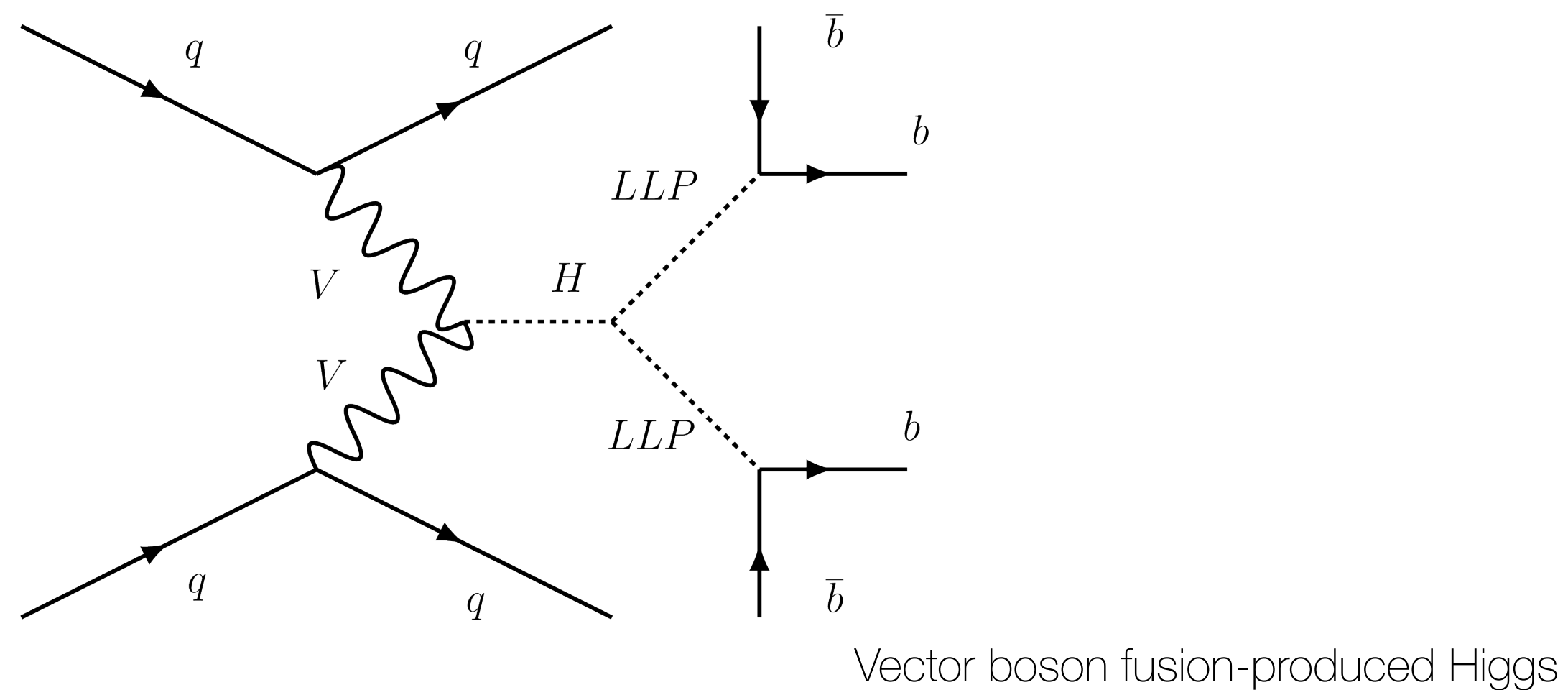
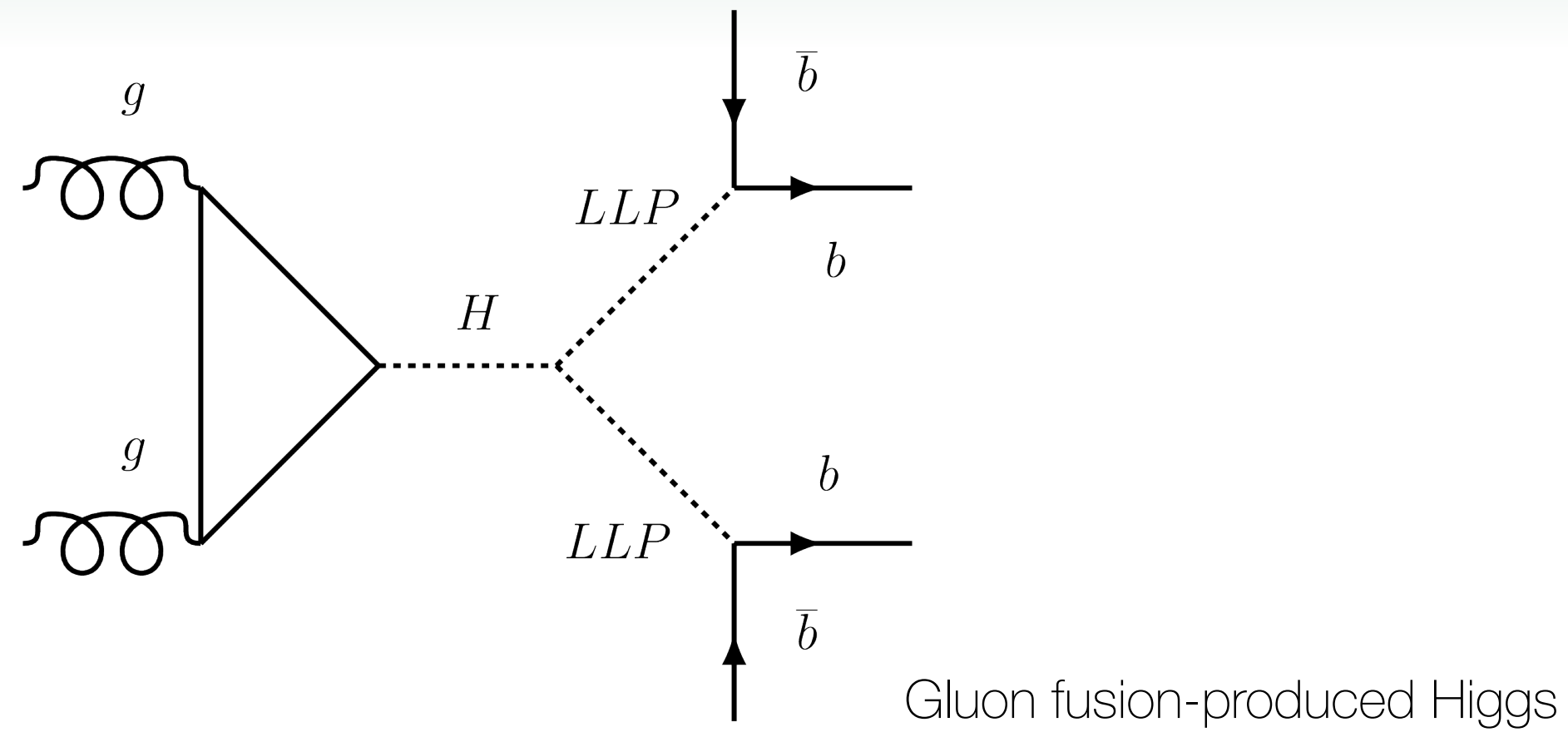
PX14 Shaft Configuration

Installs four RPC tracking stations in the PX14 service shaft of ATLAS

Relatively limited coverage in solid angle which extends ~80 meters from the interaction point

Signal sensitivity studies

Monte Carlo



Current studies investigate sensitivity to Higgs-produced BSM LLPs

Monte Carlo Higgs events produced using ATLAS LHE files with PYTHIA 8 (ggF) and PowHeg (ggF, VBF) matrix calculations are used

Each Higgs is *forced to* decay into a pair of LLPs which are *forced to* decay into a $b\bar{b}$ pair using PYTHIA 8

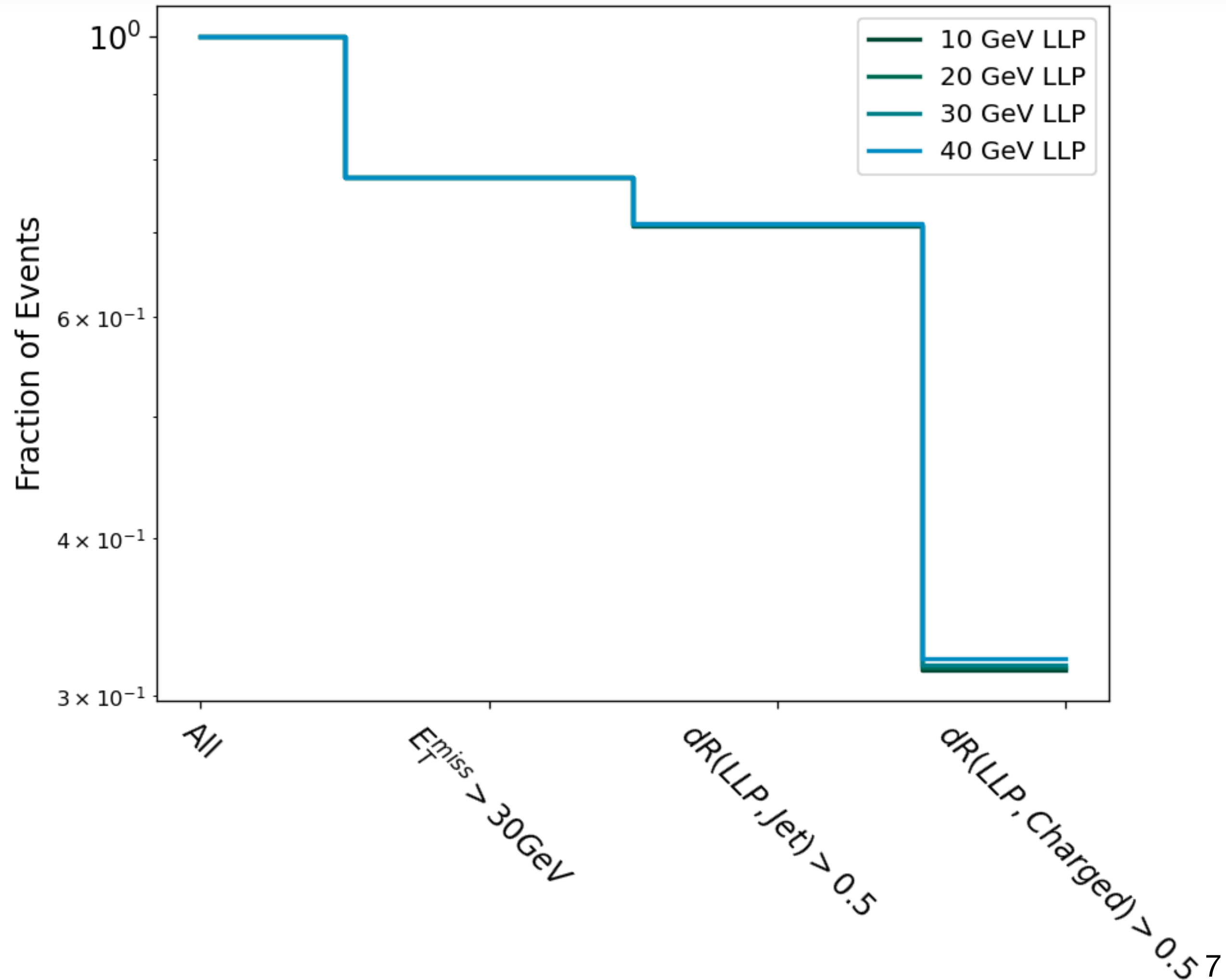
Current studies investigate a range of LLP masses ranging from 5 to 55 GeV

Event-level requirements

Signal cutflow



Higgs-Produced LLPs -- $\mathcal{O}(10^6)$ Events

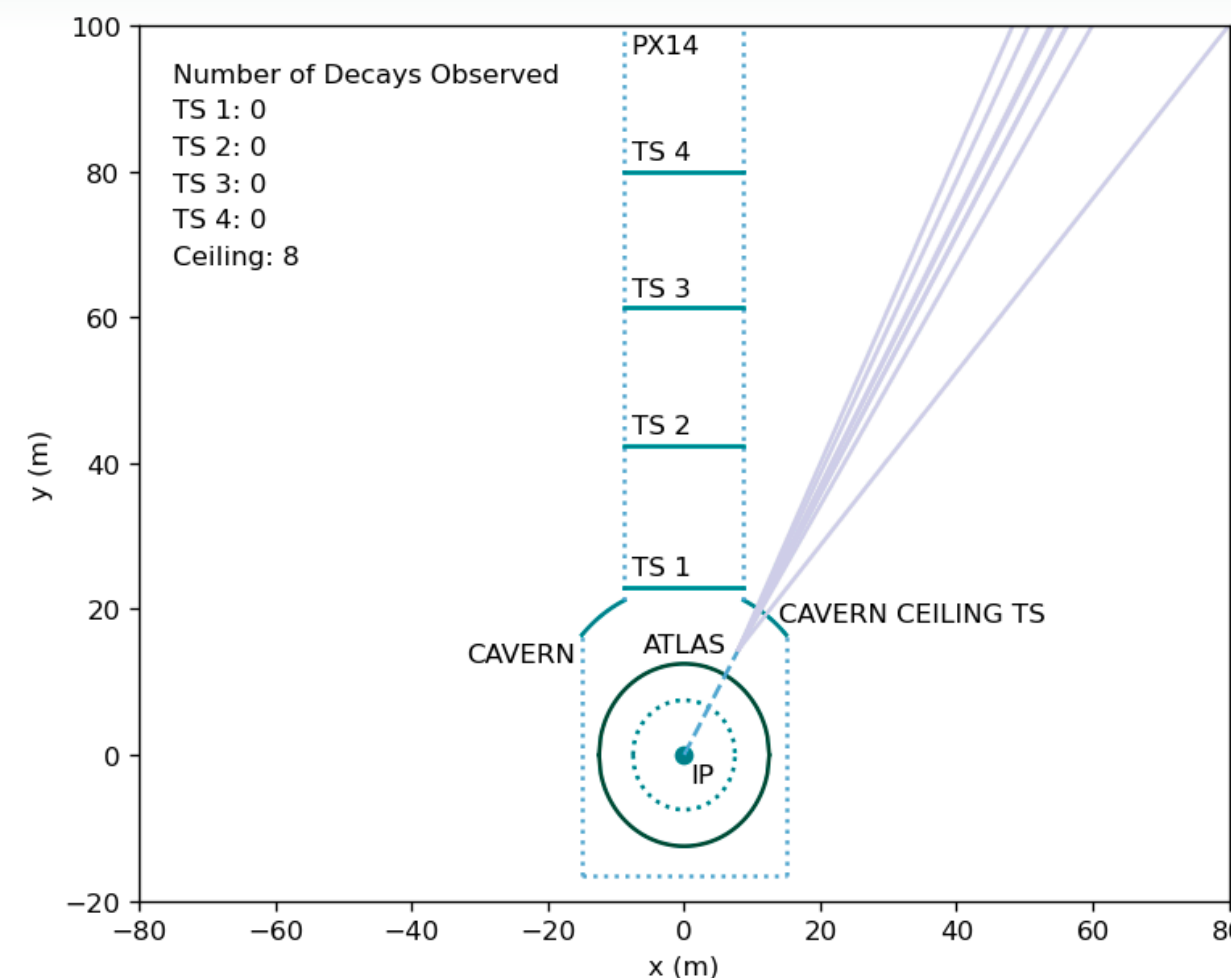
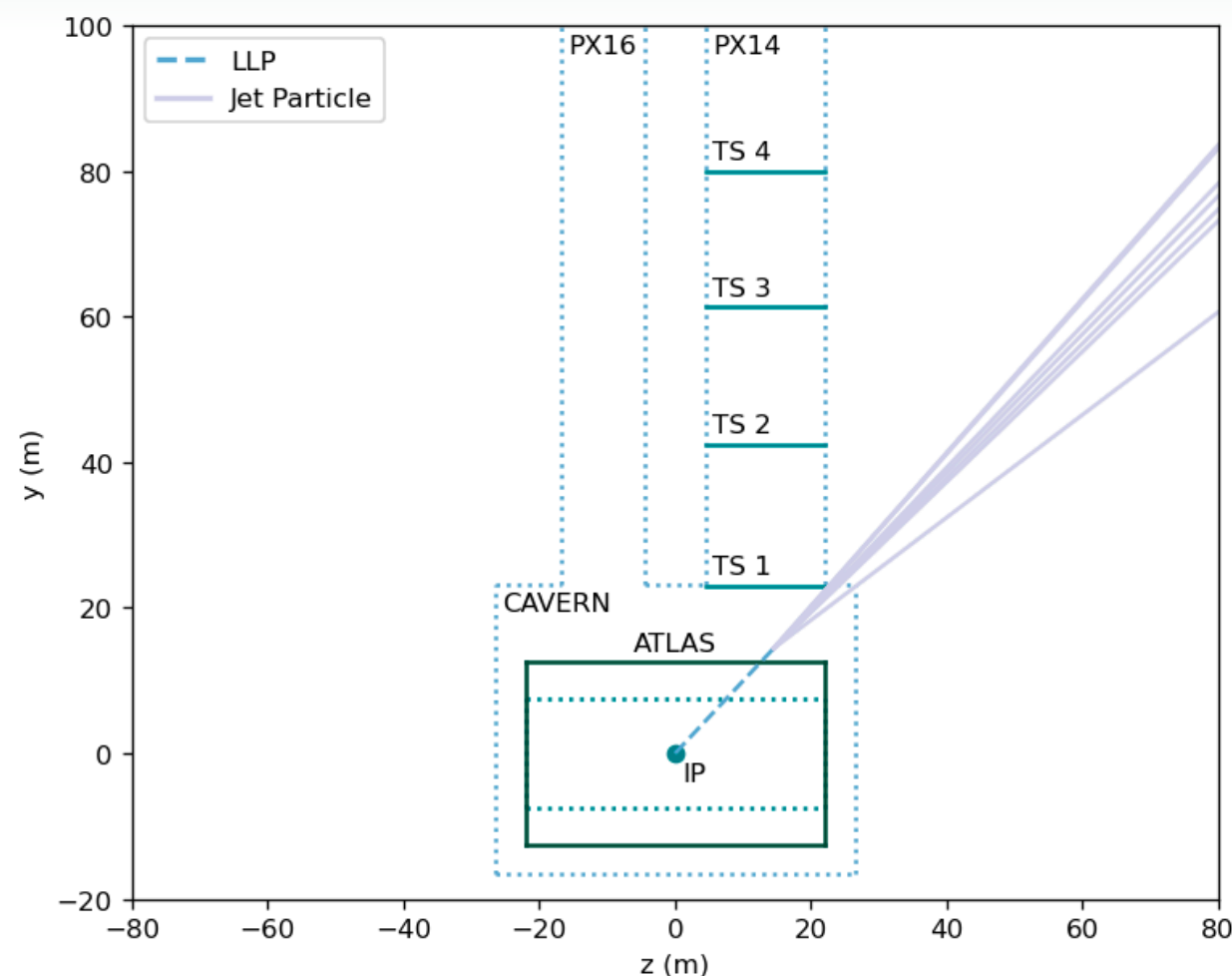


Event-level cuts are applied to help discriminate against background (see next talk from J. Burr)

These cuts preserve ~30% of signal events before considering ANUBIS acceptance

ANUBIS acceptance

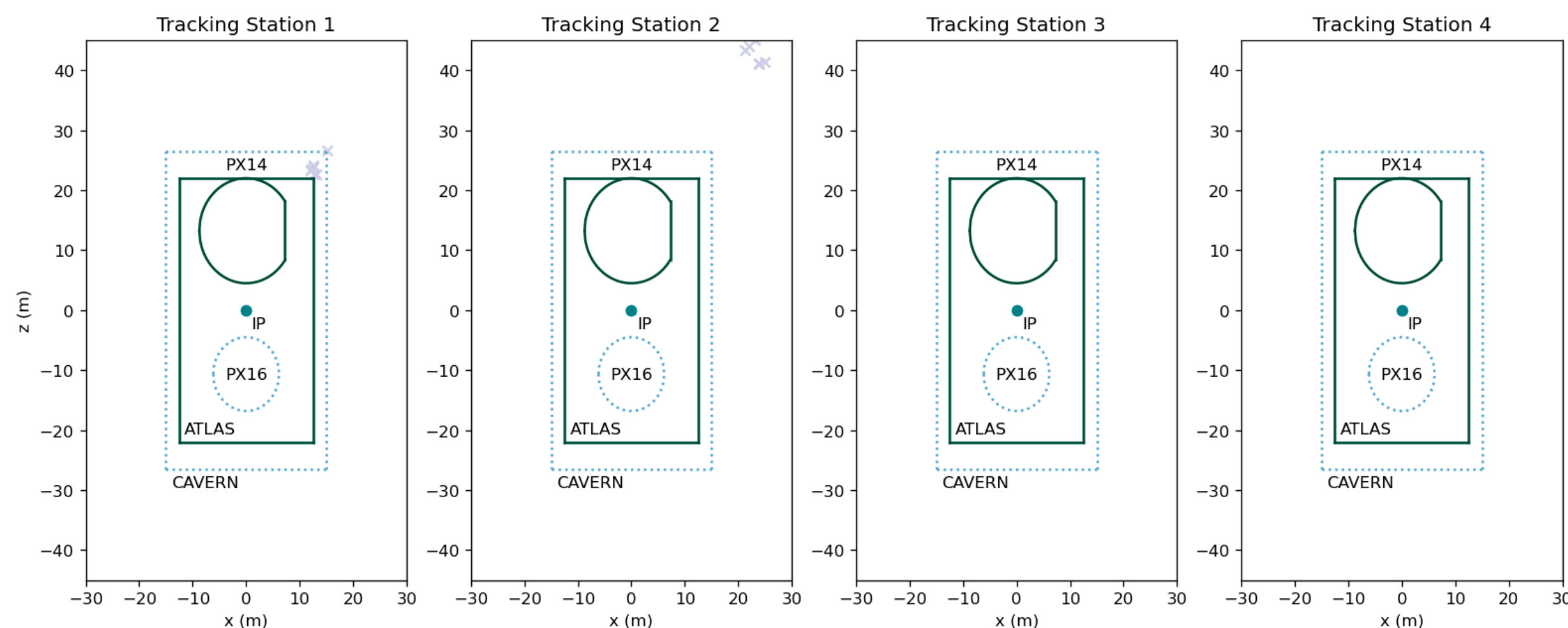
Cavern ceiling geometry



Main concern: event reconstruction using observations of charged final state particles

Cavern ceiling geometry assumes RPC coverage along the cavern ceiling, and at the bases of the PX14 and PX16 shafts

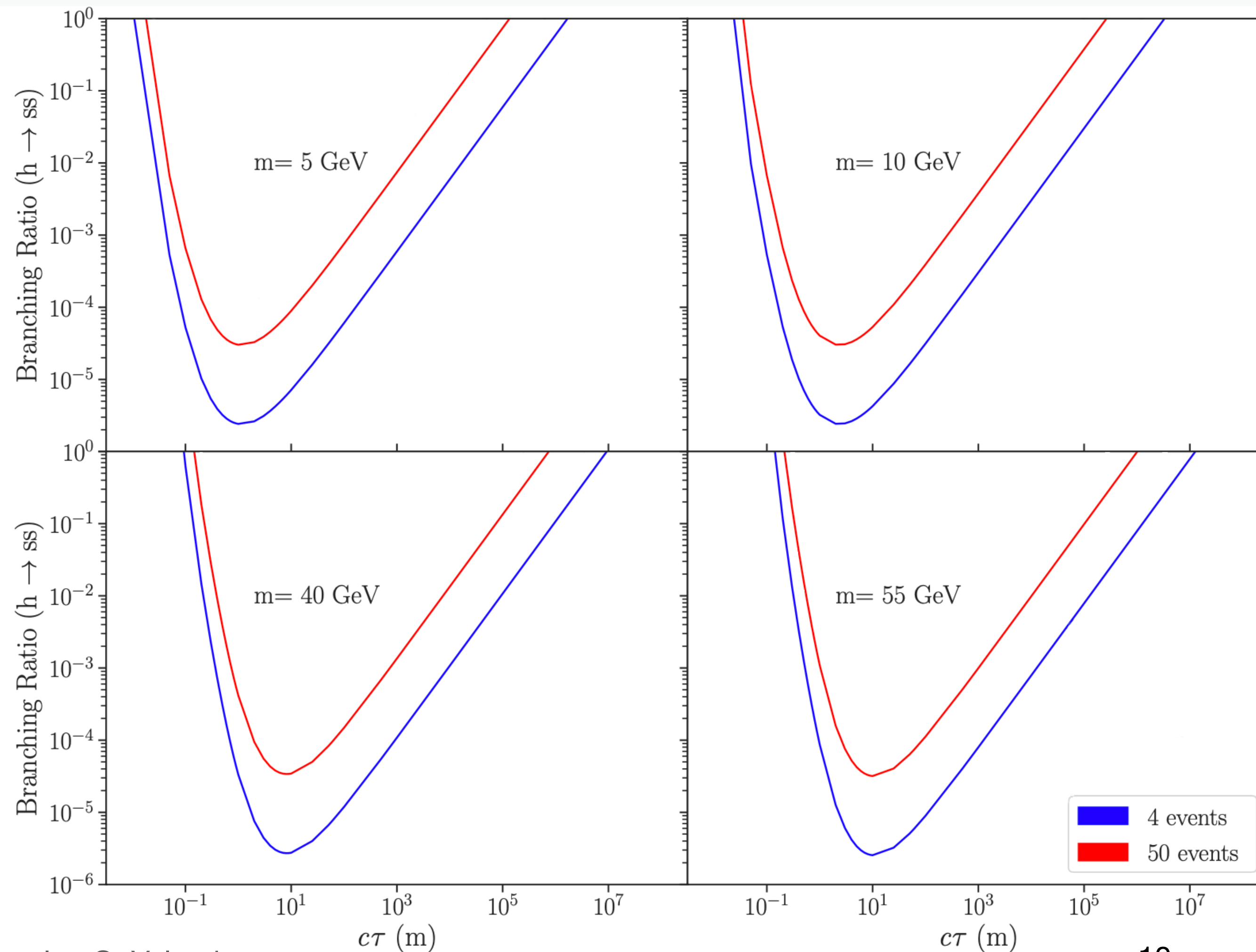
Assumes that ATLAS can be used to discriminate against background



Key question: for what branching ratios might we have the sensitivity to observe four events at HL-LHC conditions?

Branching ratio sensitivity

Cavern ceiling geometry



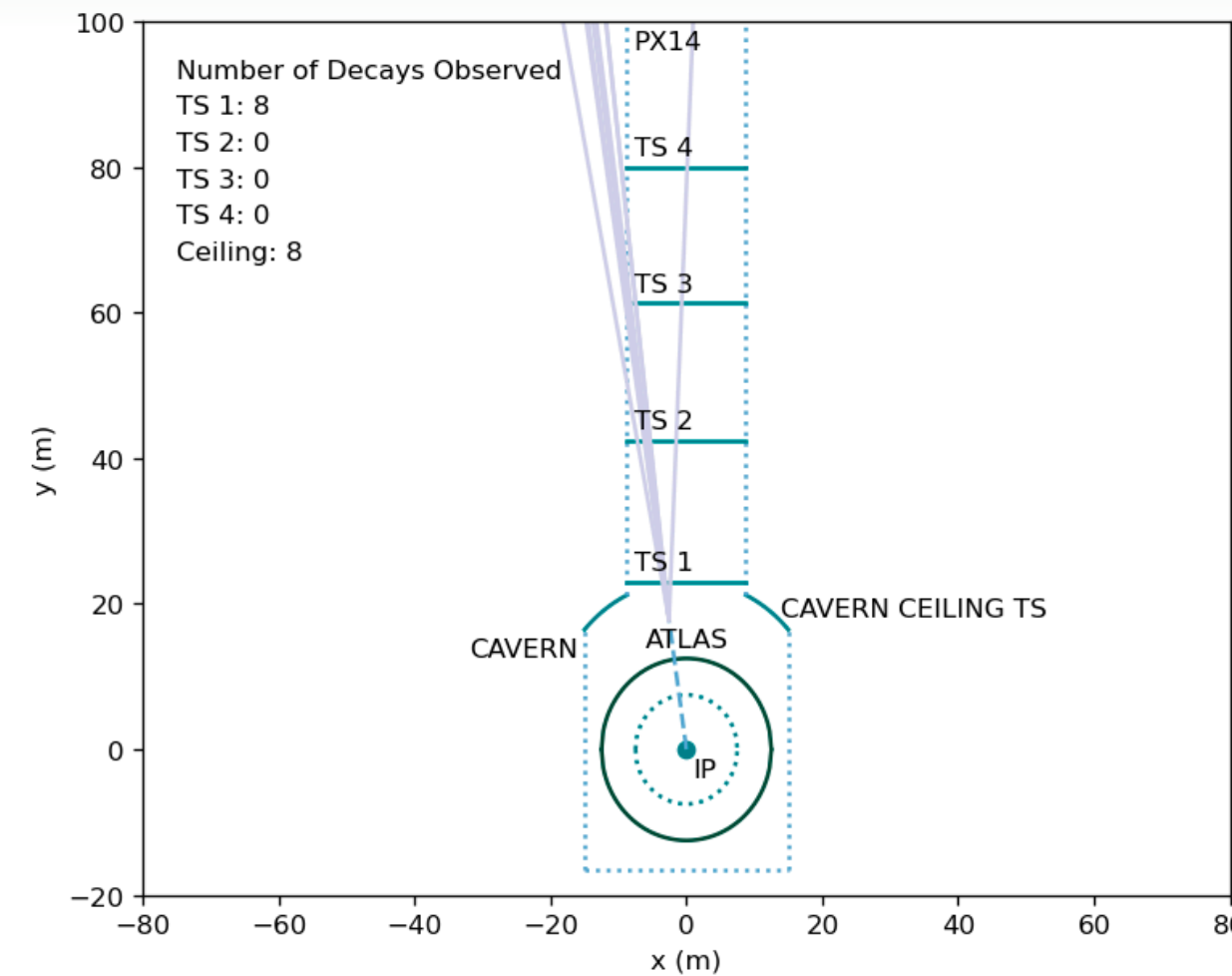
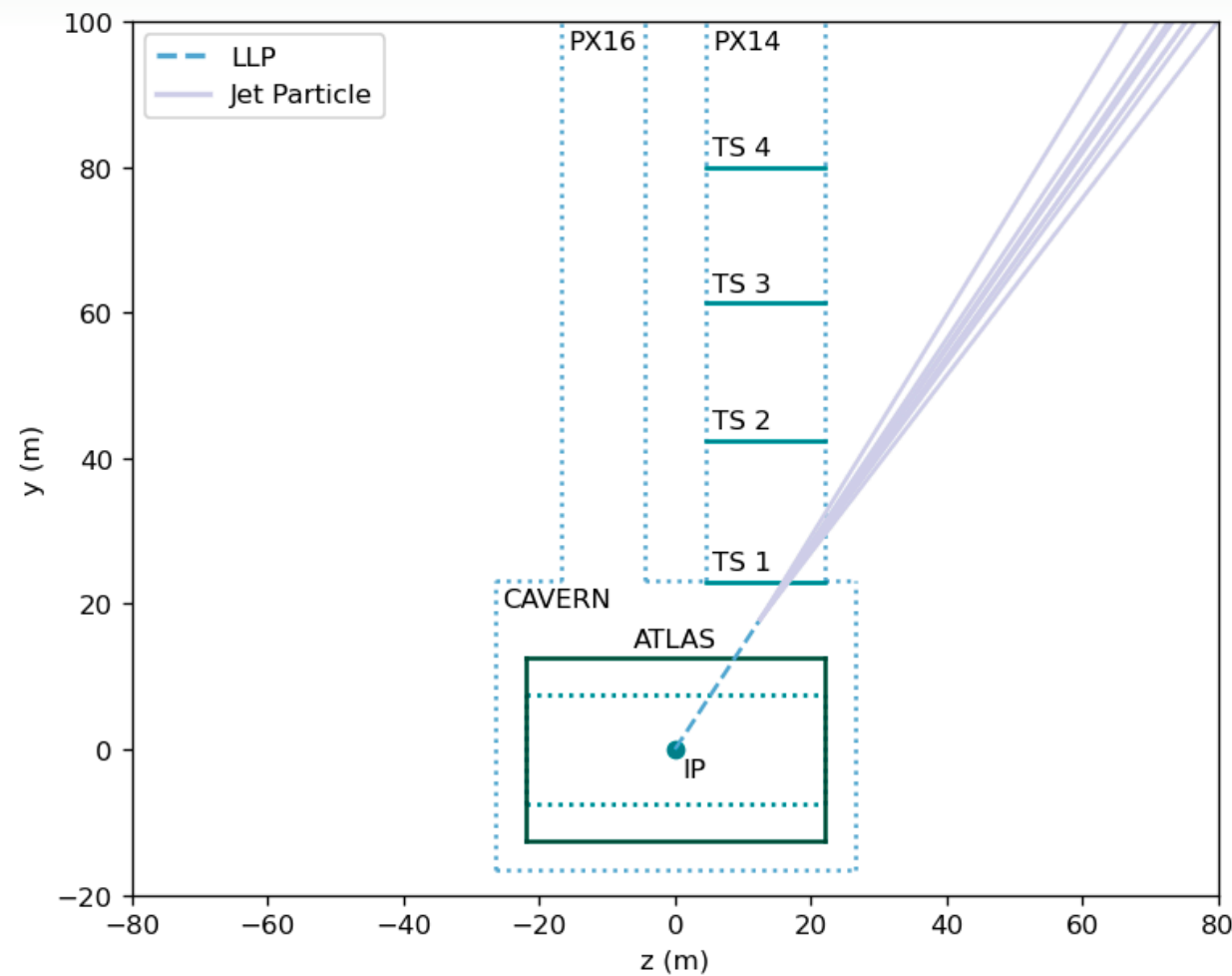
Goal: observe LLP events in 3 ab^{-1} of collisions

Looks for observing 4 or 50 events, depending on level of background

NB: studies are parton-level only and look for neutral LLPs which decay in the direction of the ceiling tracking station

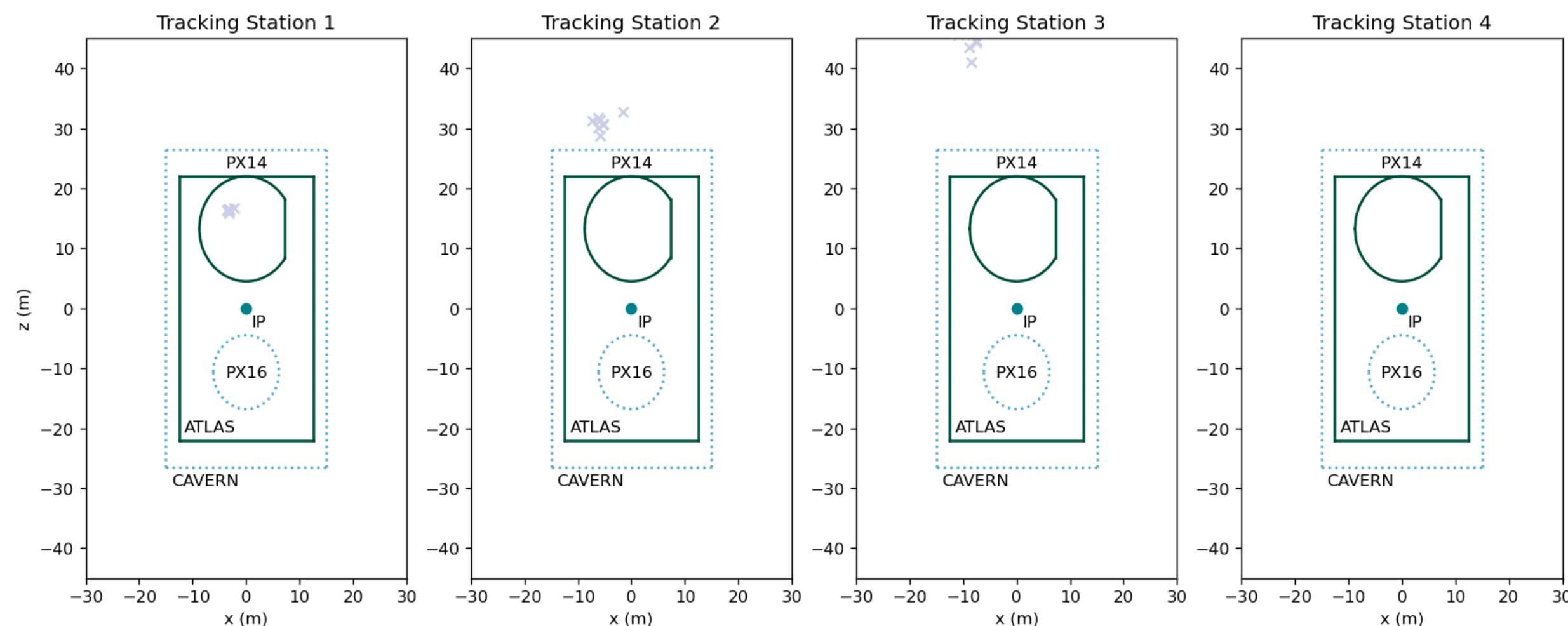
ANUBIS acceptance

PX14 shaft geometry – cavern or shaft decay regime



Main concern: event reconstruction using observations of charged final state particles

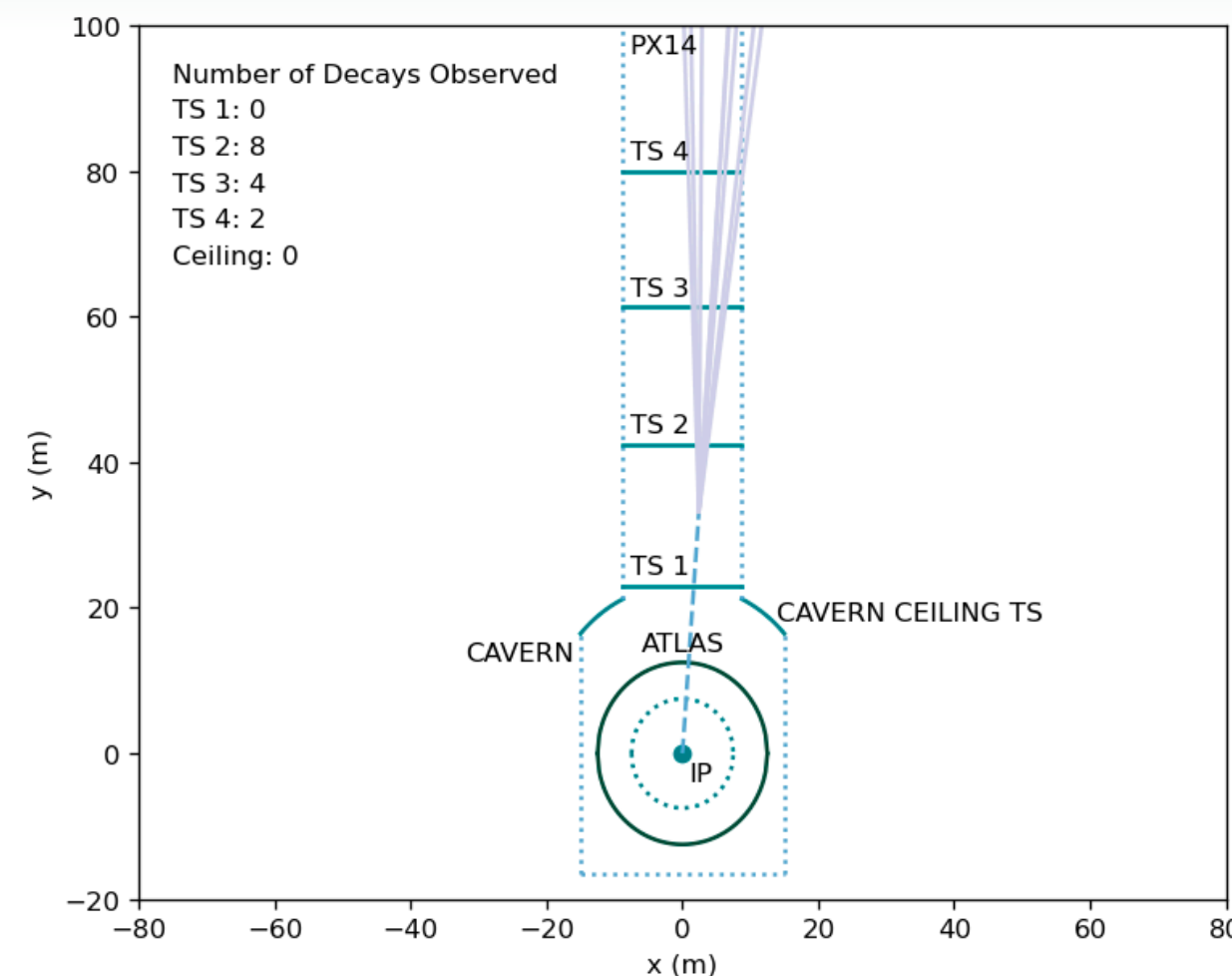
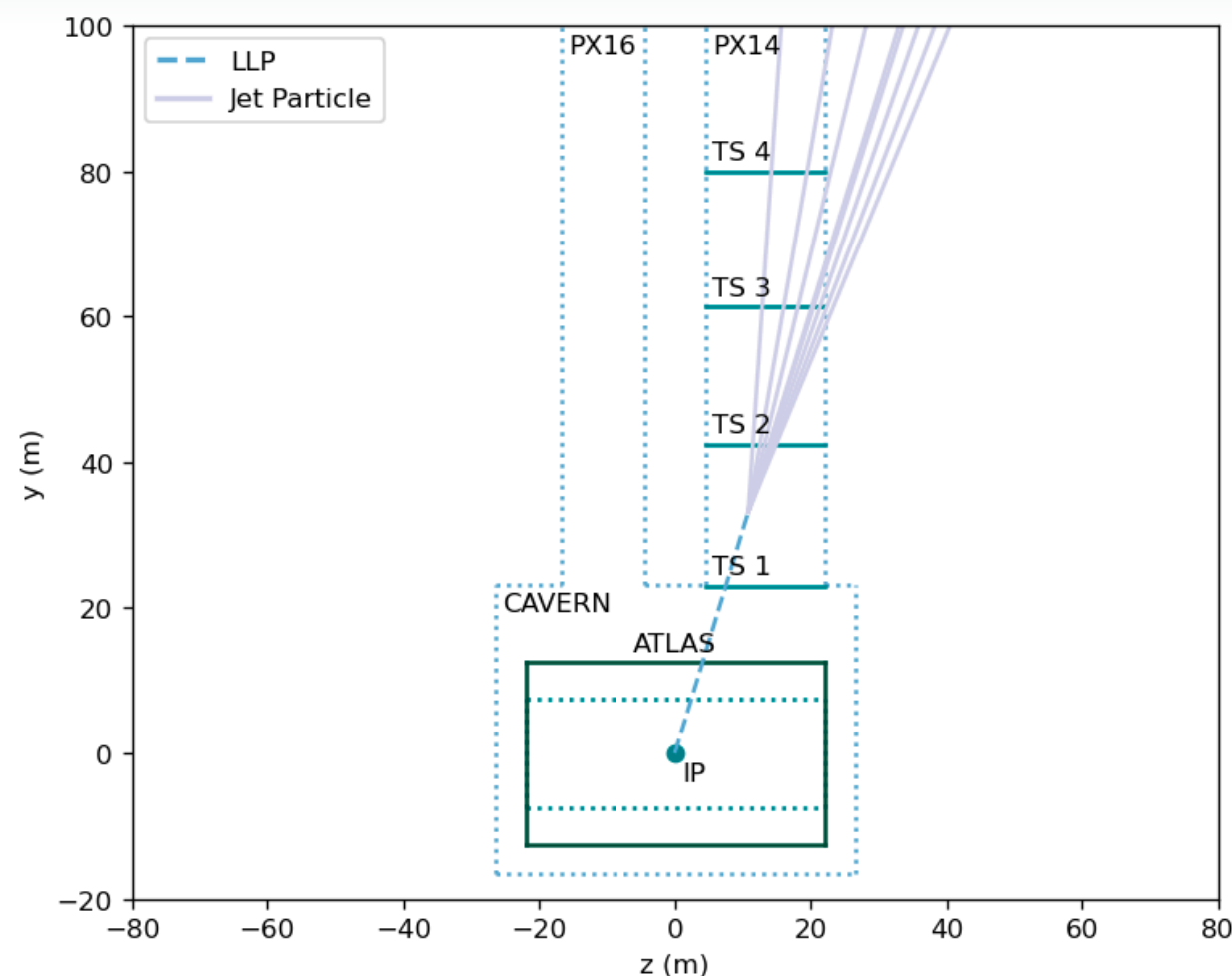
In-shaft geometry assumes four RPC tracking stations along the height of the PX14 shaft



Cavern or shaft decay regime looks for decays between ATLAS's vertexing limit and the cavern bounds, or between ANUBIS tracking stations

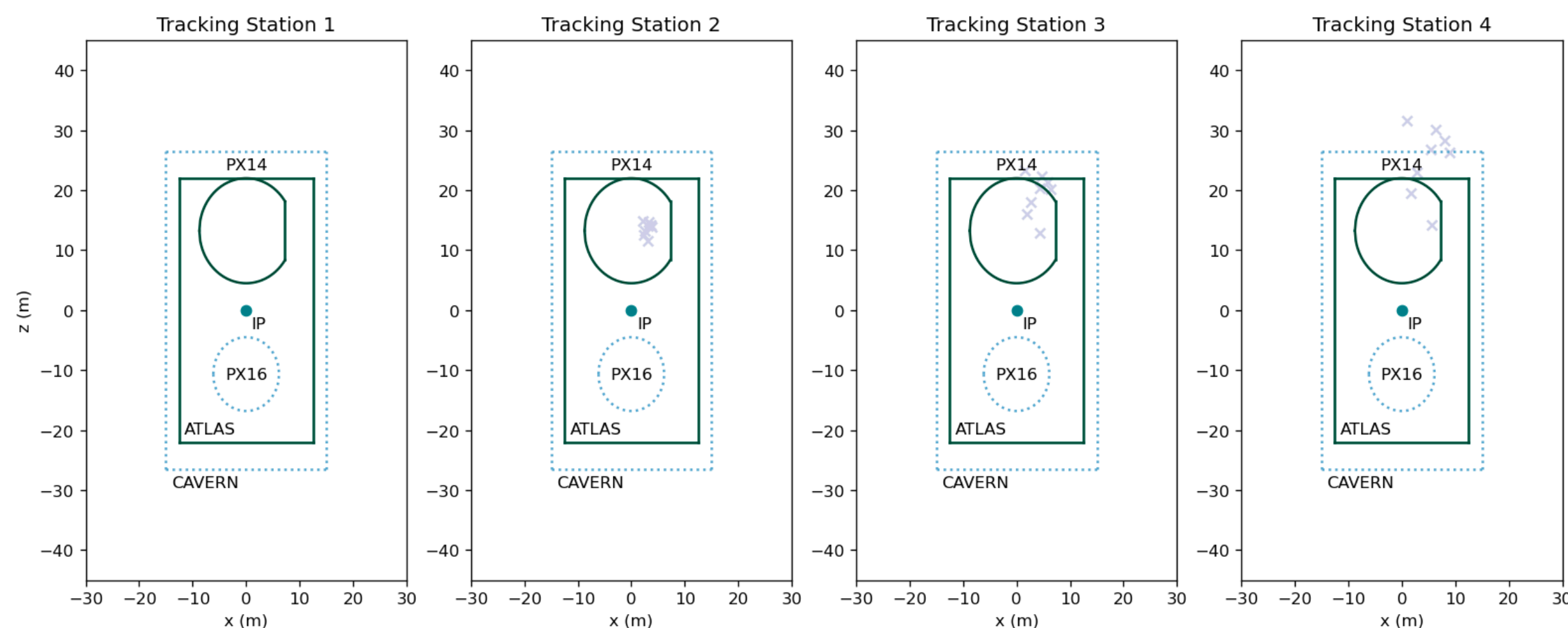
ANUBIS acceptance

PX14 shaft geometry — in-shaft decay regime



Main concern: event reconstruction using observations of charged final state particles

In-shaft geometry assumes four RPC tracking stations along the height of the PX14 shaft

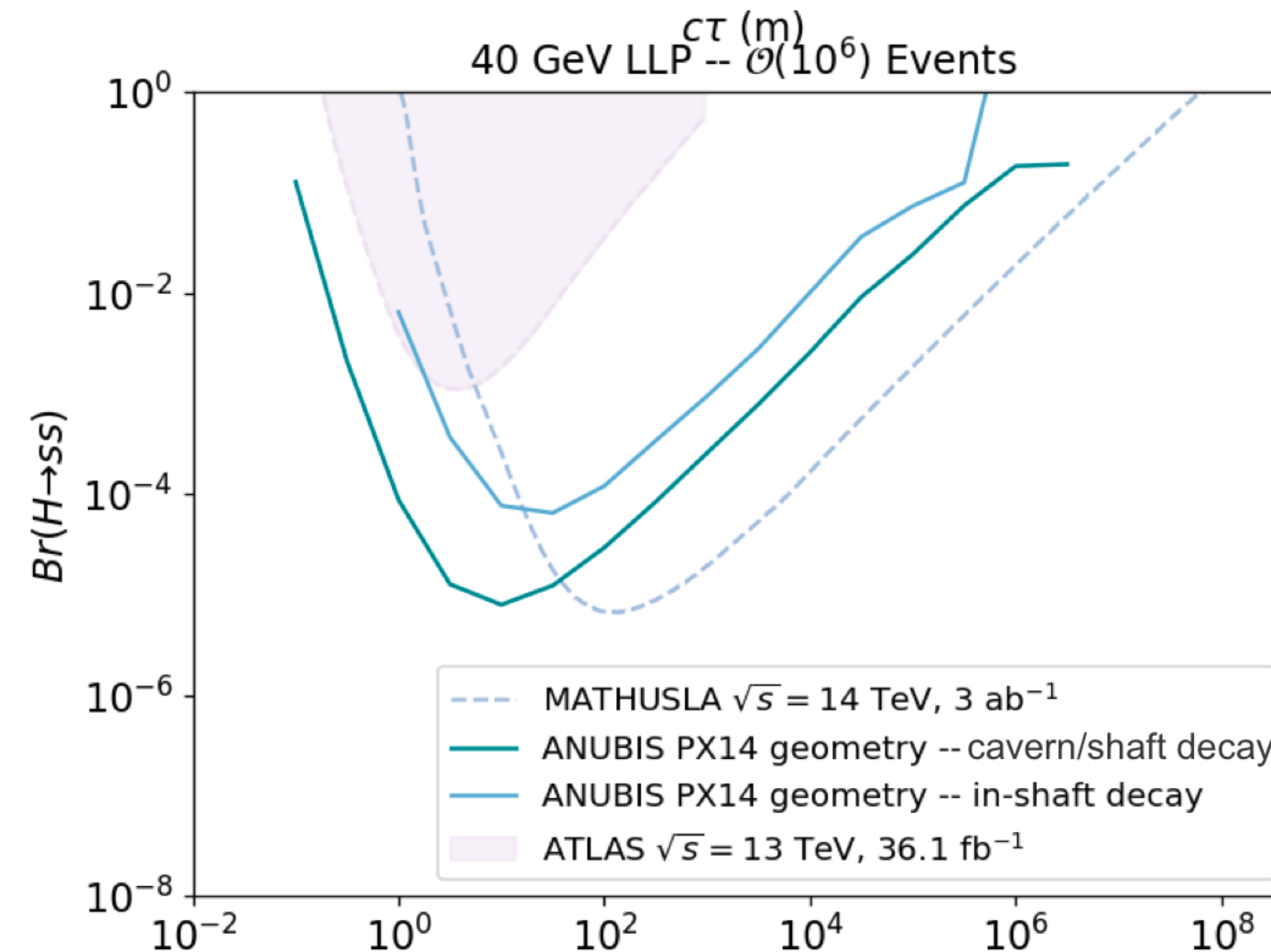
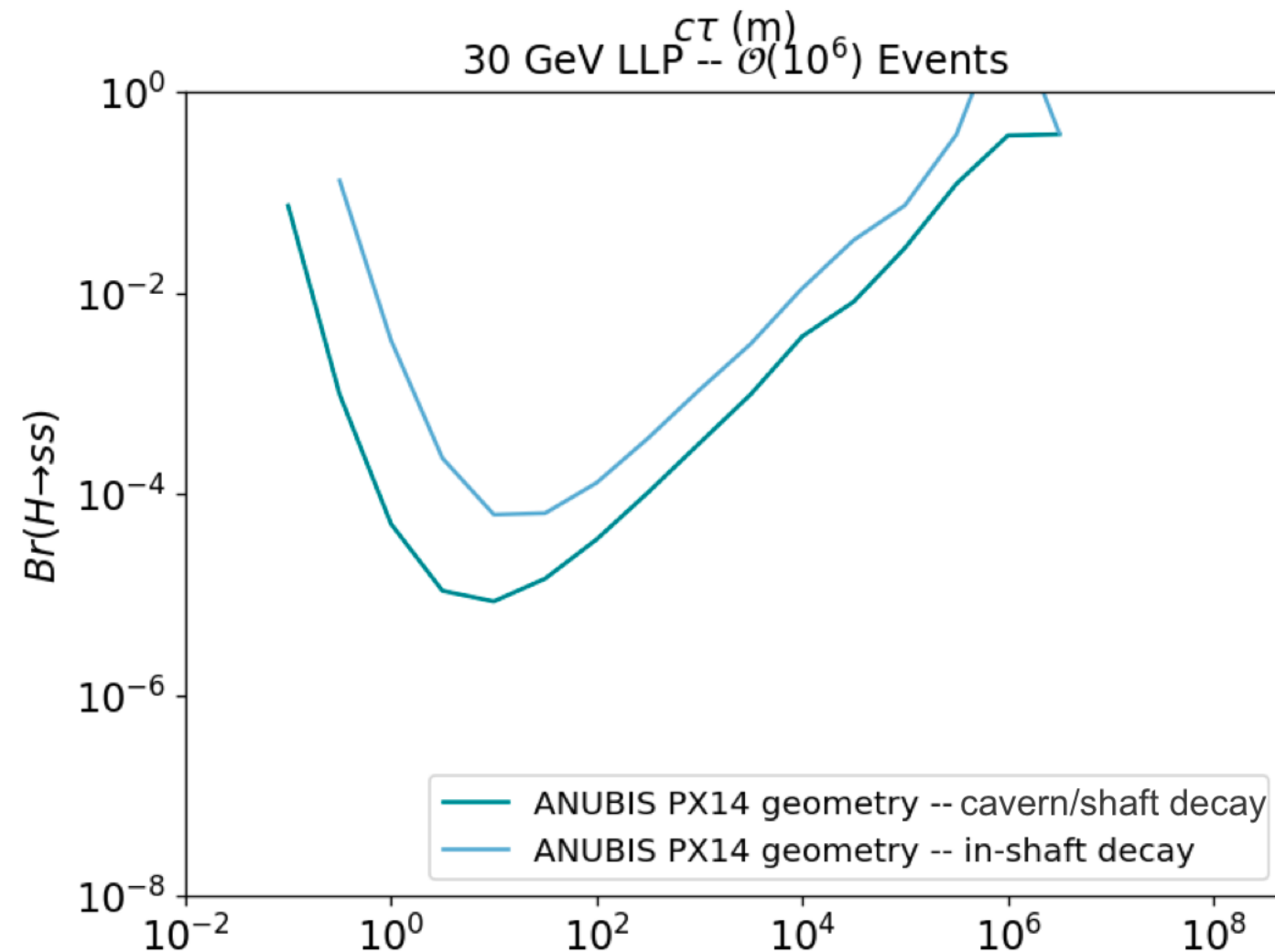
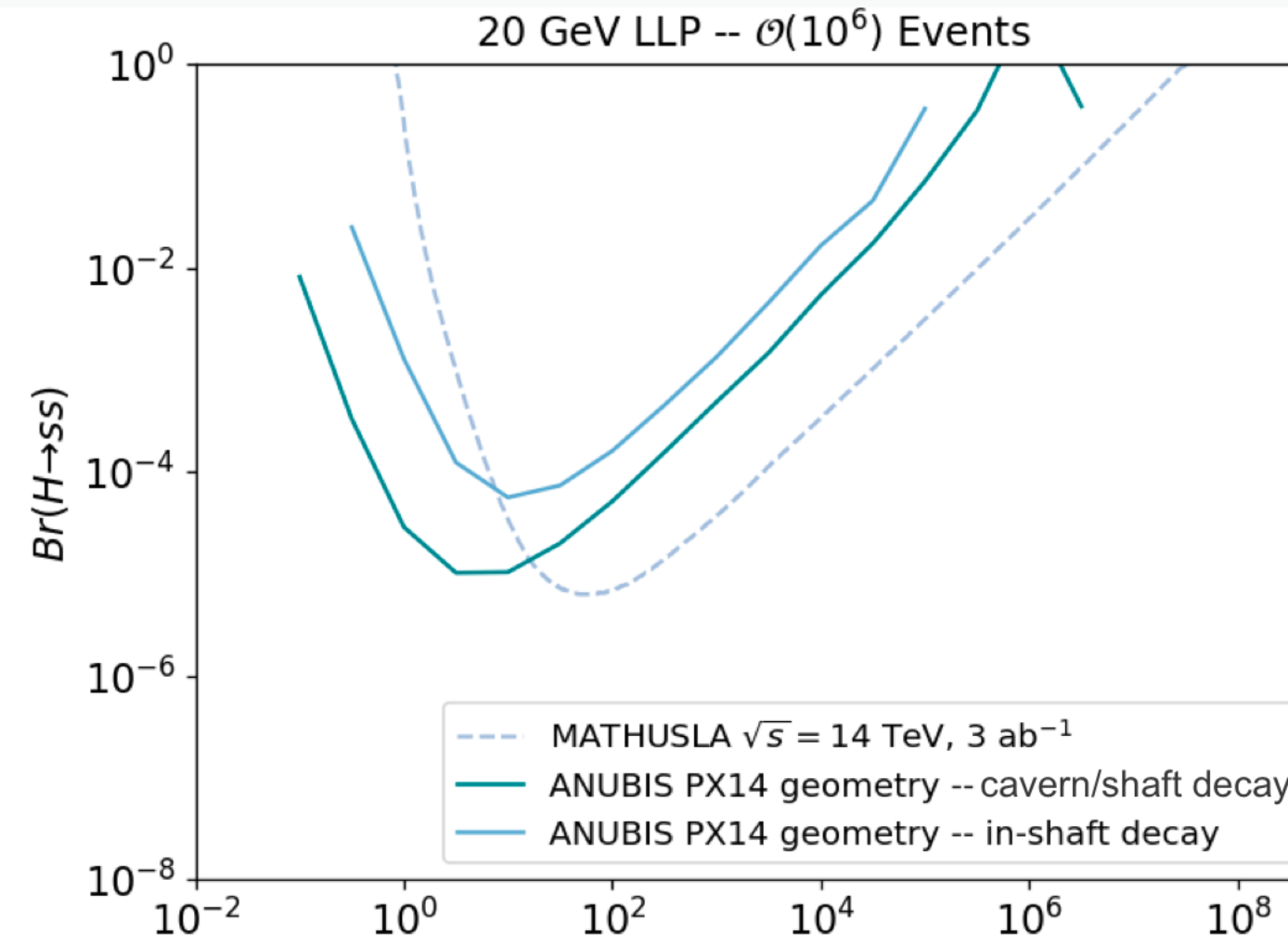
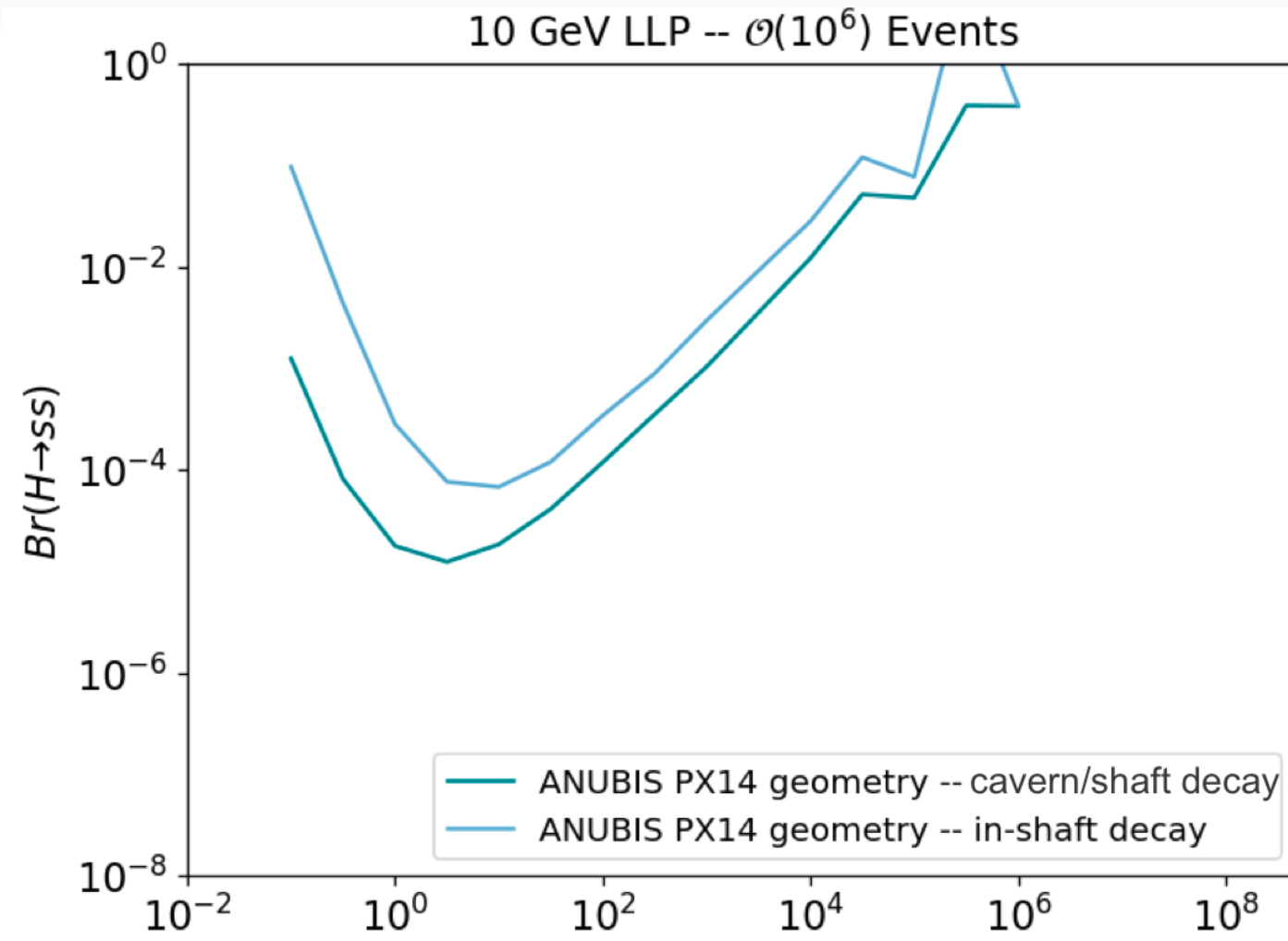


In-shaft decay regime looks for decays between ANUBIS tracking stations, using first tracking station for background rejection

Key question: for what branching ratios might we have the sensitivity to observe four events at HL-LHC conditions?

Branching ratio sensitivity

PX14 shaft geometry



Goal: observe four events in 3 ab^{-1} of collisions

Shows parton-shower level results which look for jet particles intersecting tracking stations

Still improves upon sensitivity of ATLAS while also being competitive with MATHUSLA

NB: odd behavior in high- $c\tau$ region of most curves due to low statistics (work in progress)

ATLAS Limit: [1811.07370](#)
MATHUSLA Limit: [1606.06298](#)

Outlook

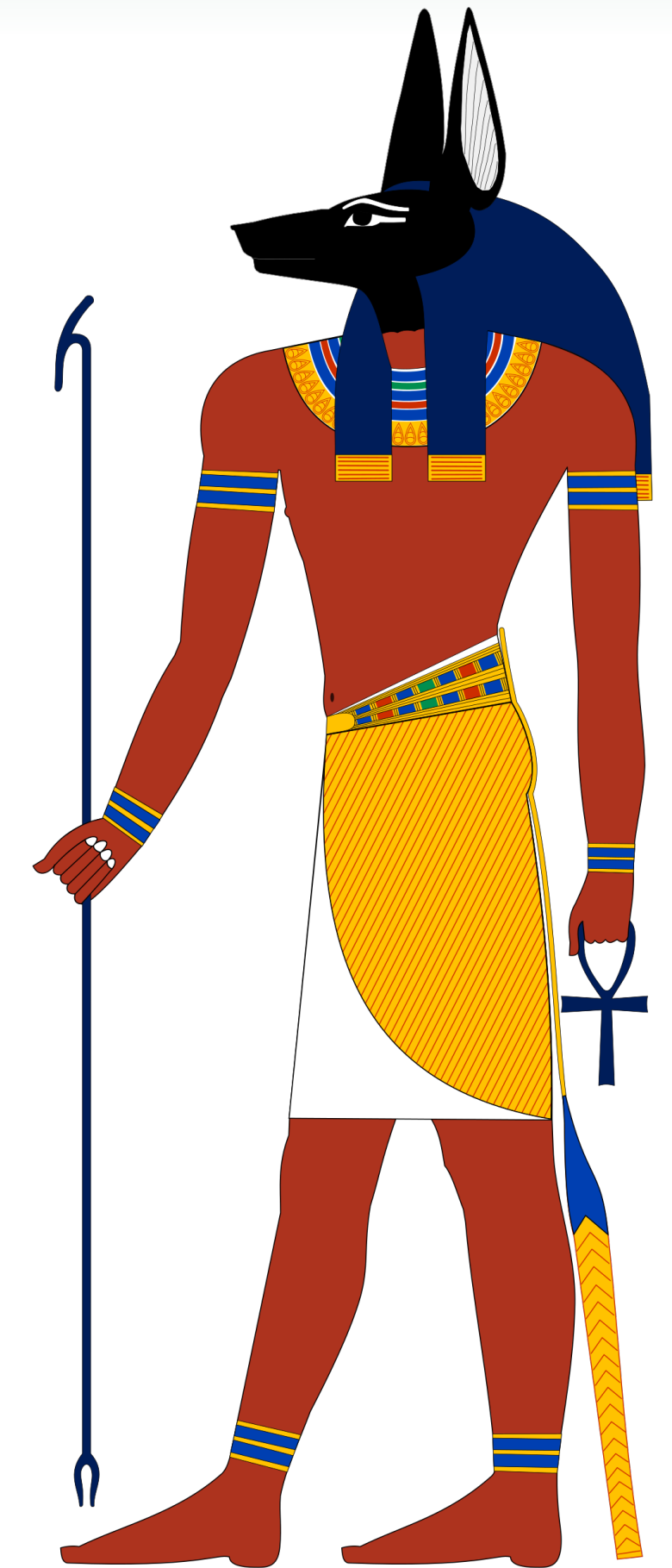
Next steps

Both potential configurations for the ANUBIS project show exciting potential for observing BSM LLPs

Work for parton shower-level results for the ceiling geometry is underway

Work to understand the background events in this region is ongoing (see talk from J. Burr)

Prototype detector to measure the background events in this region is under construction (see talk from O. Brandt)



Backup

MC data sets used



- **ggF**
 - mc15_13TeV.343981.PowhegPythia8EvtGen_NNLOPS_nnlo_30_ggH125_gamgam.evgen.TXT.e5607_tid10265946_00
 - 2000 LLP-producing events generated from each of 1000 files
 - Assumes cross section of 55 pb
- **VBF**
 - mc15_13TeV.345916.Powheg_NNPDF30_VBFH125_LHE.evgen.TXT.e6901_tid15303714_00
 - 2000 LLP-producing events generated from each of 1500 files
 - Assumes cross section of 4 pb