R&D Monte Carlo Sample Request towards a GELATO Analysis

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CCS Subgroup Meeting

17th June, 2026

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Introduction

- GELATO is a trigger sequence built using anomaly detection algorithms at both L1 and HLT

GELATO L1

Event-topology based anomaly detection algorithm running on an FPGA

GELATO HLT

Event-topology based anomaly detection algorithm running on a CPU

- Useful Links: Twiki, INT note, ATLAS ML Workshop, LUP EoI

AD Triggers by CMS: AXOL1TL, CICADA

Introduction

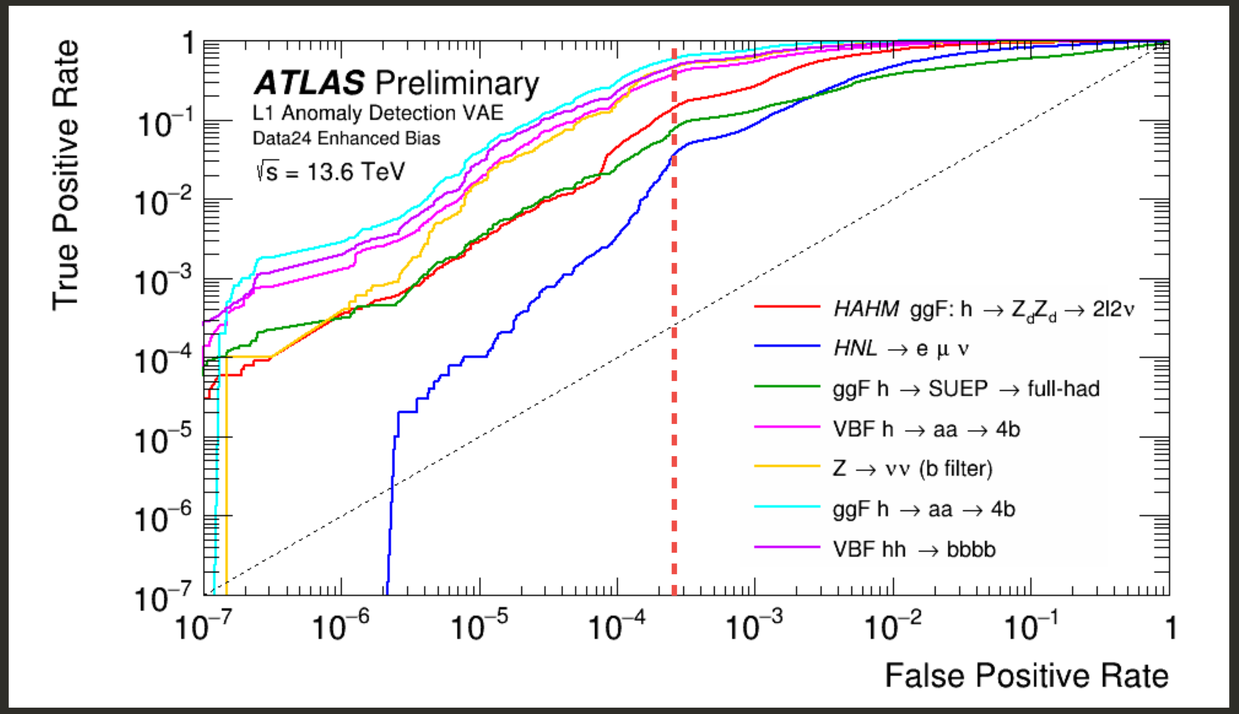
- GELATO is a trigger sequence built using anomaly detection algorithms at both L1 and HLT

- Designed to capture many physics objects with acceptance to high multiplicities - jets, e, γ, μ, and MET
- 4 chains (differentiated by anomaly score thresholds) commissioned in 2025, running with target rates in 2026:
  - **Physics Stream** (360 Hz unprescaled): HLT_anomdet**T**_L1ADVAE**T**
  - **L1 Calibration** (1 Hz prescaled): HLT_noalg_L1ADVAE**L**
  - **HLT Calibration** (4 Hz prescaled): HLT_anomdet**L**_L1All
  - **Validation** (1 Hz prescaled): HLT_anomdet**L**_L1ADVAE**L**

- **Today**: **mc23g** MC samples request for analysis strategy definition targeting ~30 fb^{-1} **2026** data

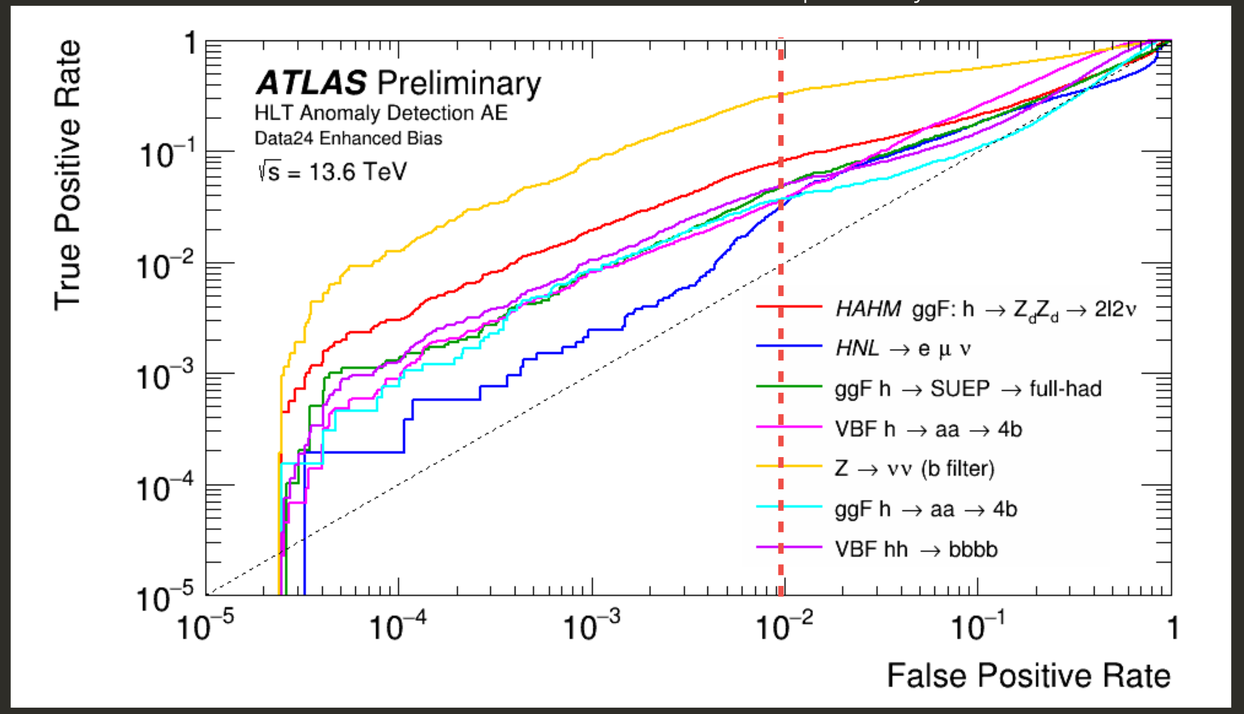
GELATO Performance Recap

GELATO L1



GELATO HLT

*Performance shown for events passed by GELATO L1 @ **1 kHz**

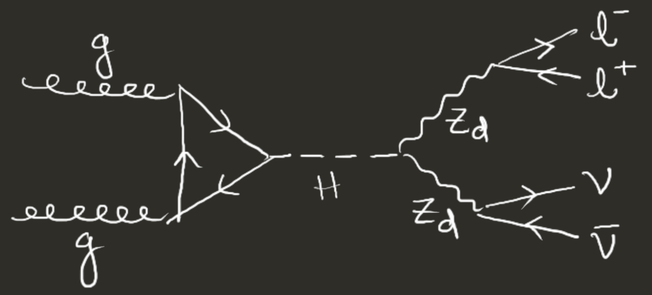


We have previously used sampleT to characterize model performance pre-deployment

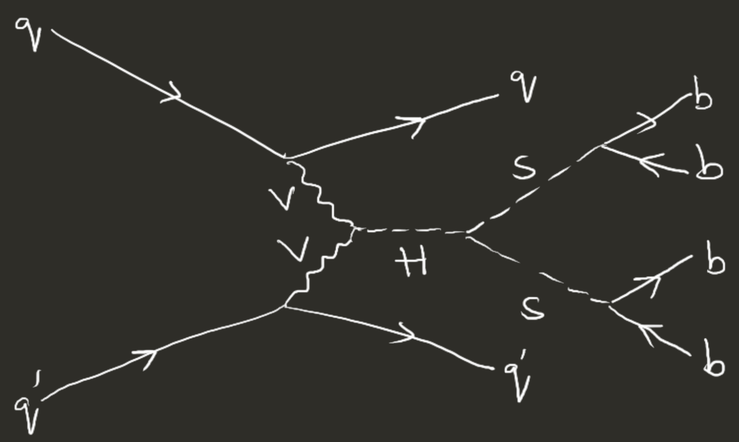
These were mc23d/e samples to give us a first idea. Now, we need mc23g samples with the GELATO trigger decision (and HLT AD scores) to design the analysis strategy

Processes are chosen based on complexity of signature rather than pure production mechanism

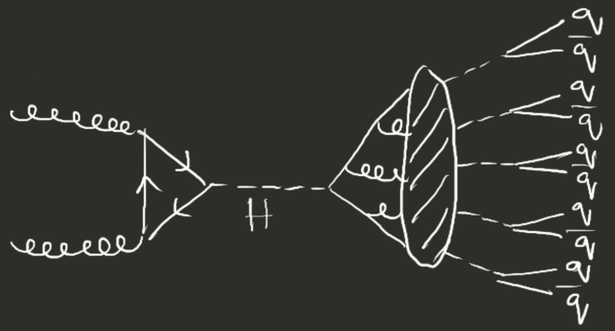
BSM Signatures 1 – Exotic Higgs



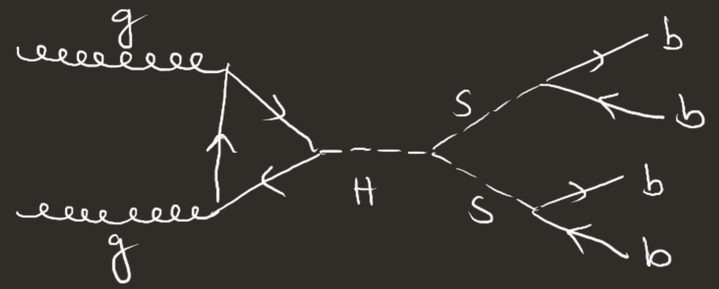
HAHM ggF H→Z_d(→$\ell\ell$)Z_d(→$\nu\bar{\nu}$)
m(Z_d) = 28 GeV



VBF H→SS→4b
m(S) = 55 GeV, cτ(S) = 1 mm

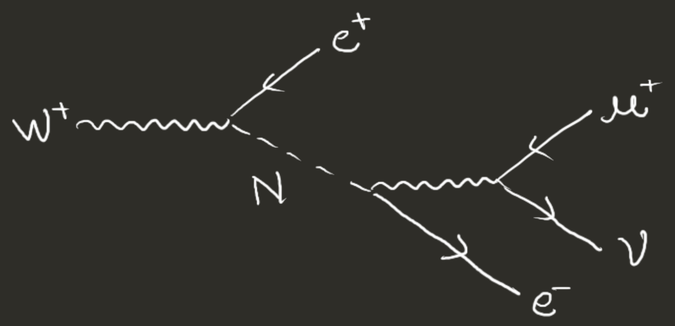


ggF H→SUEP→hadronic
m(ϕ) = 3 GeV, T = 3 GeV



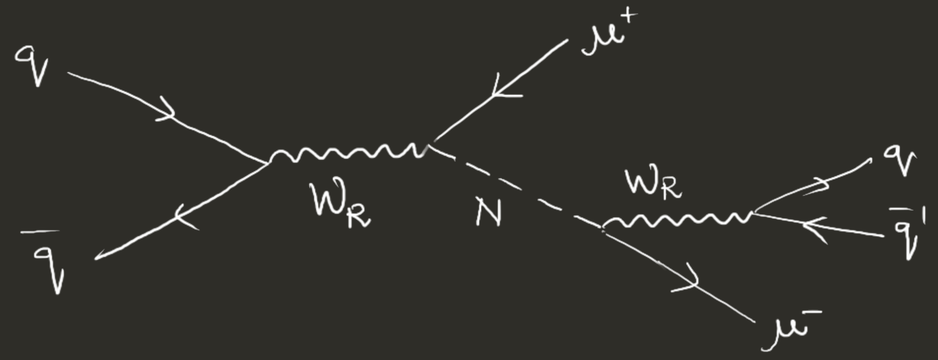
ggF H→SS→4b
m(S) = 16 GeV, cτ(S) = 10 mm

BSM Signatures 2 – Heavy Neutral Leptons



$W \to eN(\to e\mu\nu)$

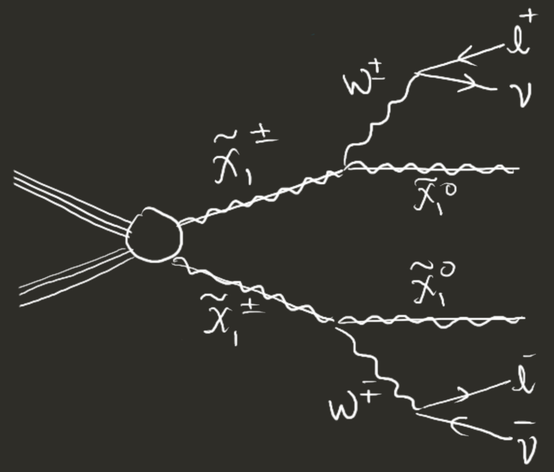
$m(N) = 7.5$ GeV, $c\tau(N) = 1$ mm



LRSM $W_R \to \mu N(\to \mu j)$

$m(N) = 30$ GeV, $m(W) = 4$ TeV

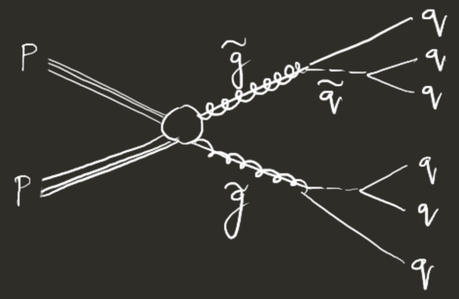
BSM Signatures 3 – SUSY



Pair-produced chargino

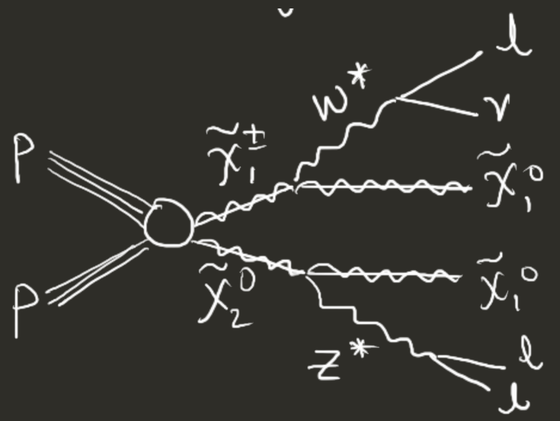
$m(\chi^{\pm}) = 300$ GeV, $dm(\chi^{\pm},\chi^0) = 30$ GeV,

$\tau(\chi^{\pm}) = 0.3$ ns



RPV UDD Multijets

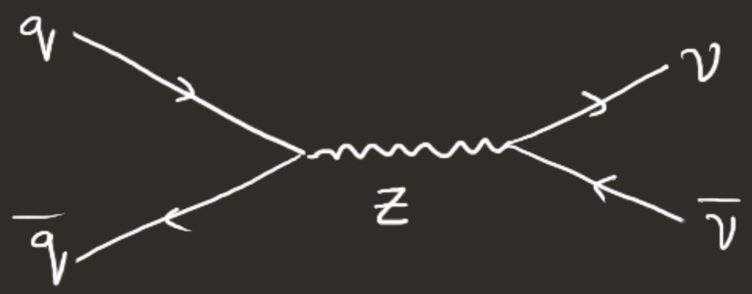
$m(\tilde{g}) = 600$ GeV, $m(\tilde{q}) = 400$ GeV



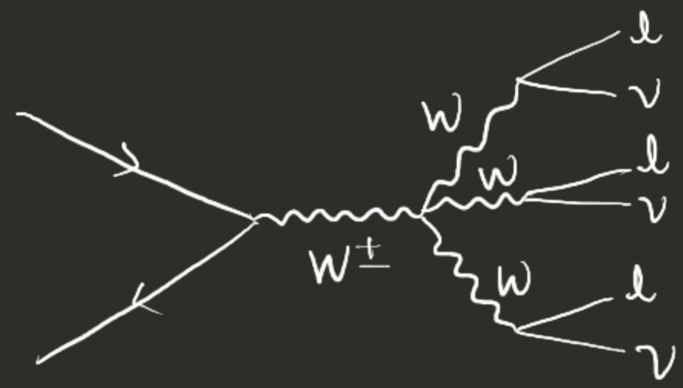
wino → bino model

$m(\chi_1^{\pm})=m(\chi_2^0)=175$ GeV, $m(\chi_1^0) = 155$ GeV

Rare SM Signatures



Z→invisible



WWW leptonic

Sample Request Metadata

Sample Name	DSID	Filter	Ongoing Analysis	Existing EVNT
HAHM ggF H→Z_d(→ll)Z_d(→$\nu\nu$)	512456	-	-	280,000
ggF H→SUEP→hadronic	802552	-	ANA-EXOT-2023-30	410,000
ggF H→SS→4b	604241	jet p_T	ANA-EXOT-2024-17	180,000
VBF H→SS→4b	604251	VBF	ANA-EXOT-2024-17	200,000
W→eN(→$e\mu\nu$)	515205	-	ANA-EXOT-2025-10	80,000
LRSM WR→μN(→μj)	562657	-	ANA-EXOT-2025-08	20,000
Pair-produced chargino (displaced leptons)	537961	-	-	20,000
RPV UDD Multijets	543456	-	ANA-HMBS-2024-19	30,000
wino→bino	569820	-	ANA-HMBS-2024-16	50,000
Z→invisible	513114	b	-	8,000,000
WWW→leptonic	701235	-	ANA-STDM-2023-15	15,000,000

*Filtered samples to be re-requested later with the filter removed

Sample Request Summary

- We would like to request **mc23g AF3** samples for these processes
- Given the small unique rate of GELATO, we request 200k events per sample for a faithful study

- Option 1: Use existing EVNT for all samples (with additions to reach the 200k count):
  - 120k (dHNL) + 180k (LRSM HNL) + 180k ($\chi^{\pm}\chi^{\pm}$) + 170k (RPVUDD) + 150k (wino→bino) = **0.8M** EVNT
  - 11*200k = **2.20 M** AF3 + recon.
- Option 2: Use existing EVNT only for filtered samples (to be later replaced with unfiltered):
  - 8*200k = **1.6M** EVNT
  - 11*200k = **2.2 M** AF3 + recon.
- Option 3: Request new EVNT for all samples
  - 11*200,000 = **2.2 M** EVNT + AF3 + recon.

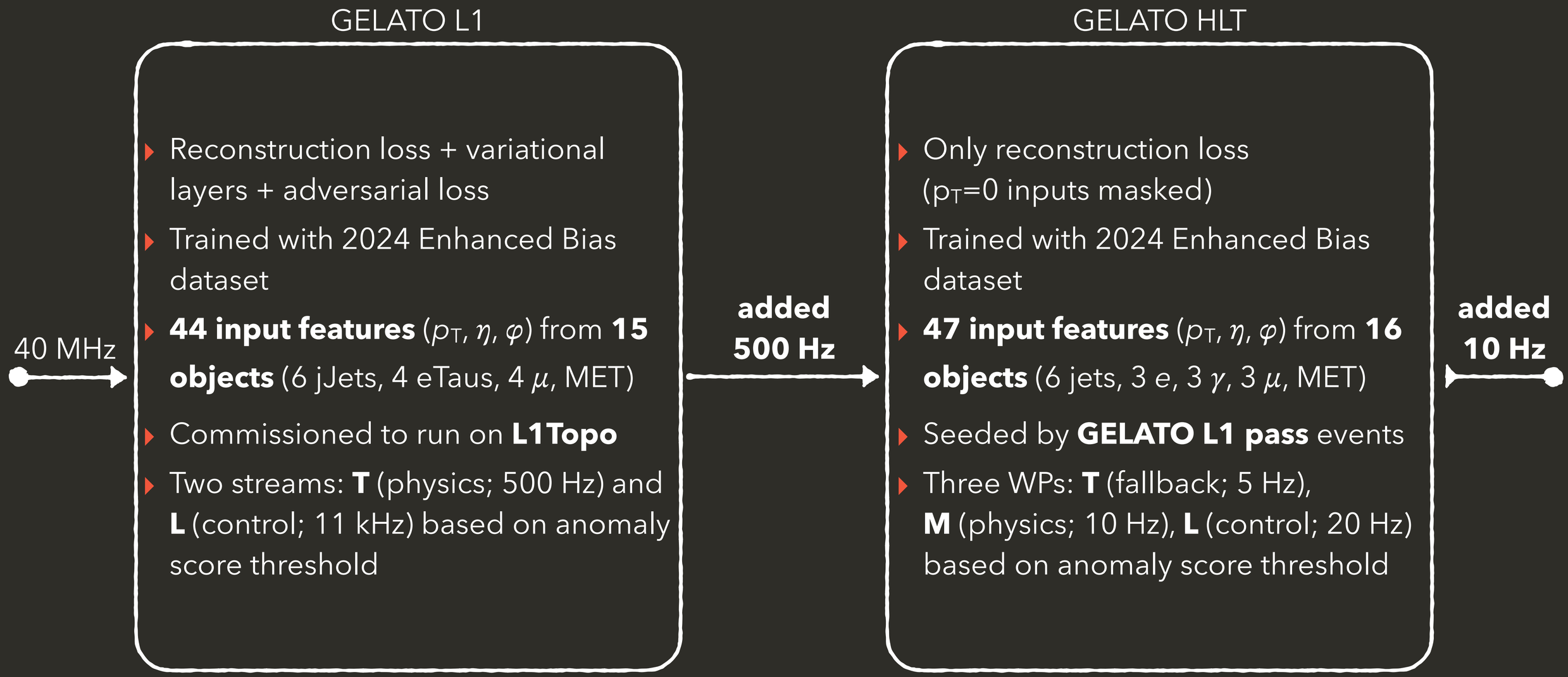
- We are happy to go forward with any of these options preferred by CCS!

ADDITIONAL MATERIAL

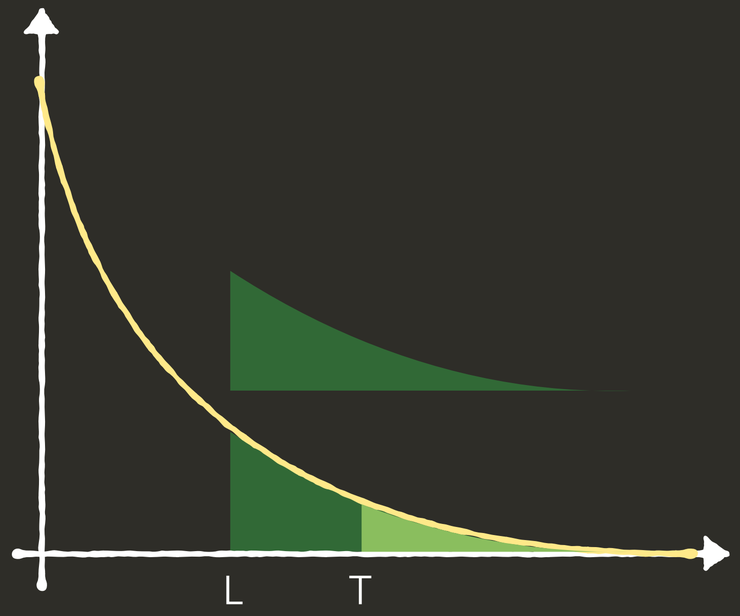
Sample Request Summary

Sample Name	DSID	mc23 EVNT
HAHM ggF H→Z_d(→ll)Z_d(→$\nu\nu$)	512456	mc23_13p6TeV.512456.MGPy8EG_A14NNPDF23LO_HAHMggfZdZd2l2nu_125_28.evgen.EVNT.e8548
ggF H→SUEP→hadronic	802552	mc23_13p6TeV.802552.Py8_HtoSUEP_ggH_fullhad_125_3p00_3p00_noFilter.evgen.EVNT.e8582
ggF H→SS→4b	604241	mc23_13p6TeV.604241.PhPy8_ggF_H125_a16a16_4b_ctau10_filtered.evgen.EVNT.e8582
VBF H→SS→4b	604251	mc23_13p6TeV.604251.PhPy8_VBF_H125_a55a55_4b_ctau1_filtered.evgen.EVNT.e8582
W→eN(→$e\mu\nu$)	515205	mc23_13p6TeV.515205.MGPy8EG_A14N23LO_HNL7p5_ctau1_eemu.evgen.EVNT.e8599
LRSM WR→μN(→μj)	562657	mc23_13p6TeV.562657.aMCPy8EG_A14N23NLO_HNL30_WR4000_muNmujj.evgen.EVNT.e8601
Pair-produced chargino (displaced leptons)	537961	mc23_13p6TeV.537961.MGPy8EG_A14NNPDF23_ChiPlusChiMinus_300_30_0p3ns.evgen.EVNT.e8559
RPV UDD Multijets	543456	mc23_13p6TeV.543456.MGPy8EG_A14N23LO_GG_qSq_RPVUDD_600_400.evgen.EVNT.e8544
wino→bino	569820	mc23_13p6TeV.569820.MGPy8EG_C1pN2_WZ_175_155_3L_3L2_MadSpin.evgen.EVNT.e8599
Z→invisible	513114	mc23_13p6TeV.513114.MGPy8EG_Znunu_FxFx3jHT2bias_SW_pTvv70_BFilter.evgen.EVNT.e8514
WWW→leptonic	701235	mc23_13p6TeV.701235.Sh_22_WWW_3l3v_EW6.evgen.EVNT.e8585

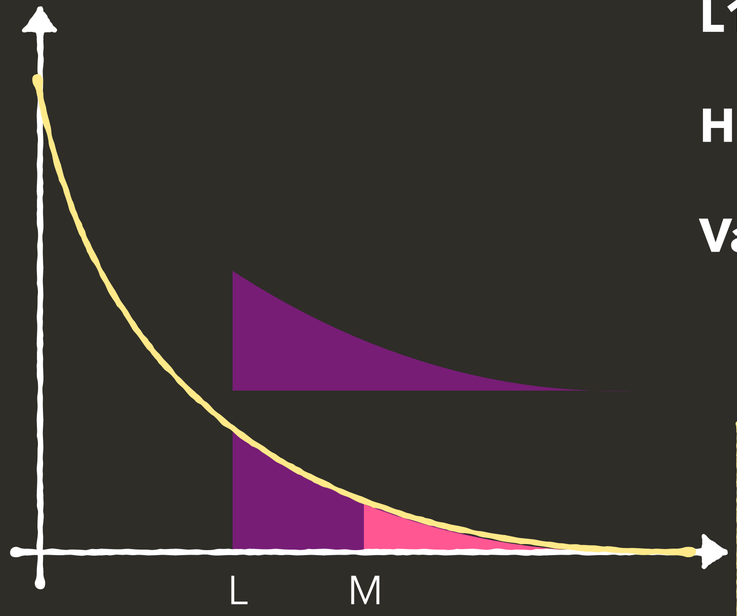
GELATO Pipeline



Trigger Chains



L1AD Anomaly Score



HLTAD Anomaly Score

Physics Stream: HLT_anomdet**M**_L1ADVAE**T**

L1 Calibration: HLT_noalg_L1ADVAE**L**

HLT Calibration: HLT_anomdet**L**_L1All

Validation: HLT_anomdet**L**_L1ADVAE**L**

Dedicated calibration chains for analysis preparedness

All chains are part of mc23g simulations and are available in the 2026 trigger menu

Commissioning Strategy

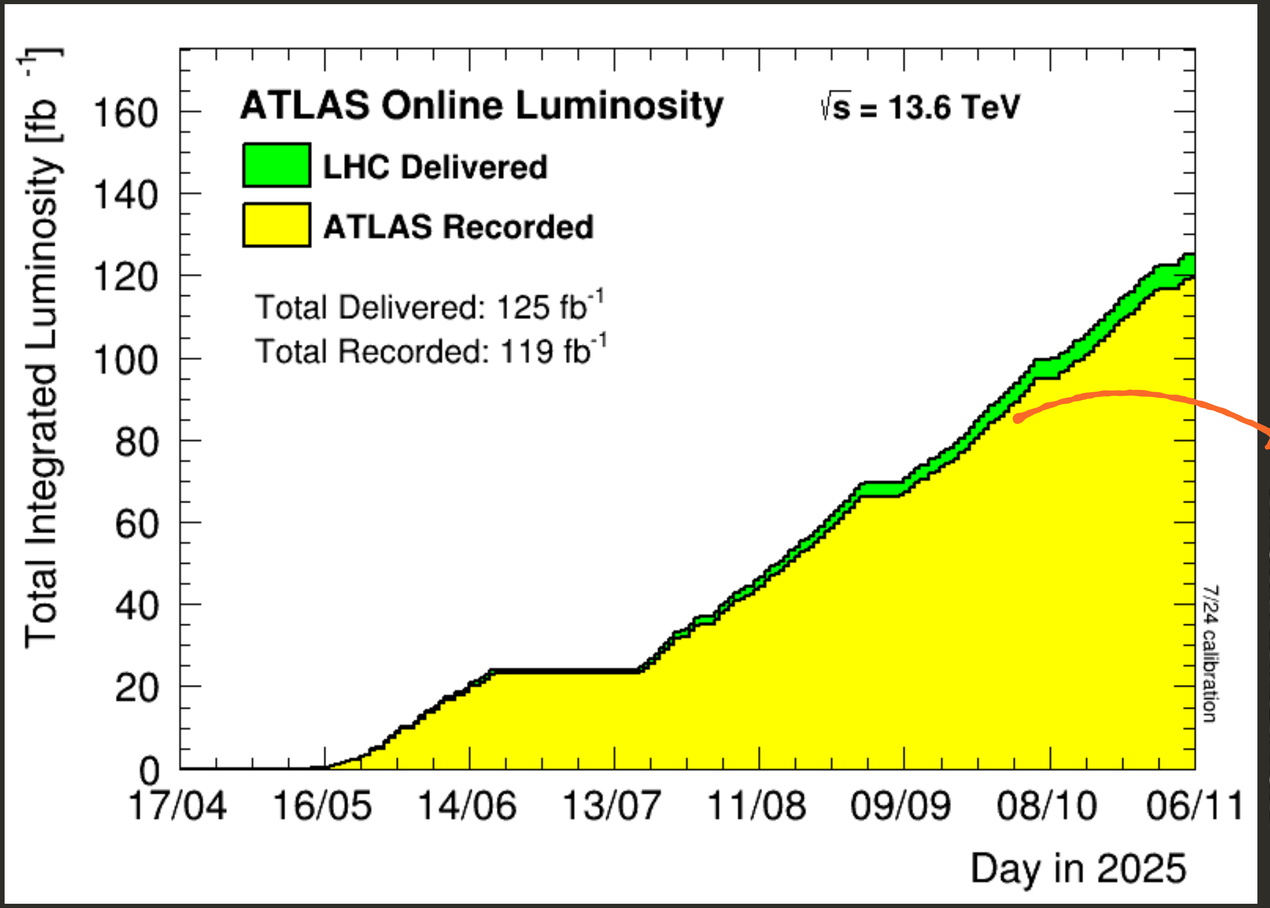
A gradual commissioning sequence was decided to ensure a safe deployment in 2025

Early ramp-up:

- Monitor GELATO L1 rates at ATLAS Central Trigger for stability without enabling the chain
- GELATO HLT disabled

First stable beams:

- GELATO L1 enabled at 1 Hz prescaled to check the collected dataset
- GELATO HLT disabled



Stable detector conditions:

- GELATO L1 enabled at 500 Hz
- GELATO HLT enabled at .1 Hz prescaled to study trigger rate and CPU cost

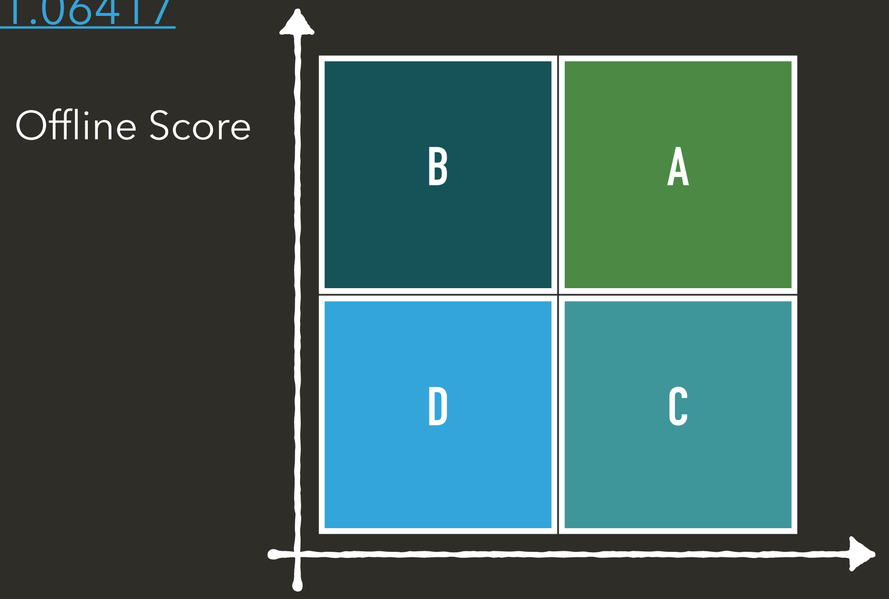
Peak data taking:

- Full chain activated with a small prescale during end-of-fill (low μ) to confirm chain stability

ATLAS Luminosity Plots

Physics Analysis Ideas

- Decorrelated sequence of autoencoders: A coupled online-offline AE pair can create a natural ABCD plane for background estimation using a decorrelated (yet simultaneous) training. Challenging to fully decorrelate post deployment arXiv:2111.06417



$$N_A = \frac{N_B \times N_C}{N_D}$$

- GELATO can be used by a variety of physics analyses – different signatures, analysis techniques, and interpretation methods. If you have a trigger limited signal model of interest, send it to us and we are happy to analyze improvements!