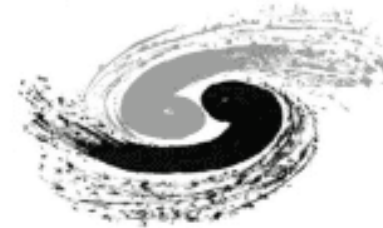


New Higgs Boson Candidates at the LHC and the Rise of Agentic AI in Particle Physics

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IHEP at the Chinese Academy of Sciences



中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

USTC Jianwei Seminar, 18/09/26

Outline

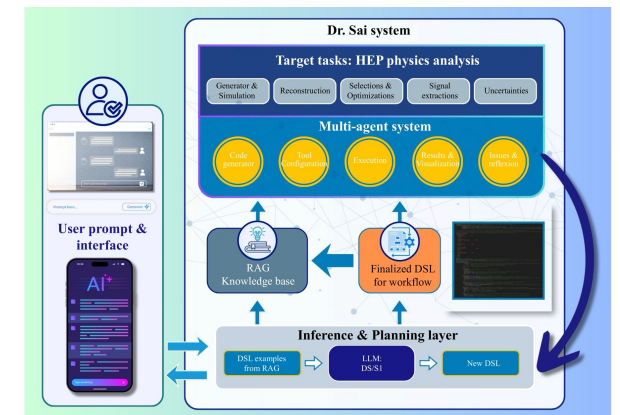
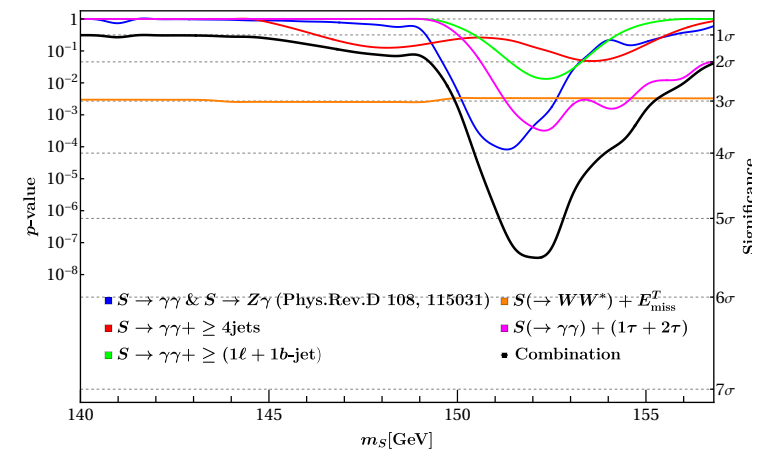
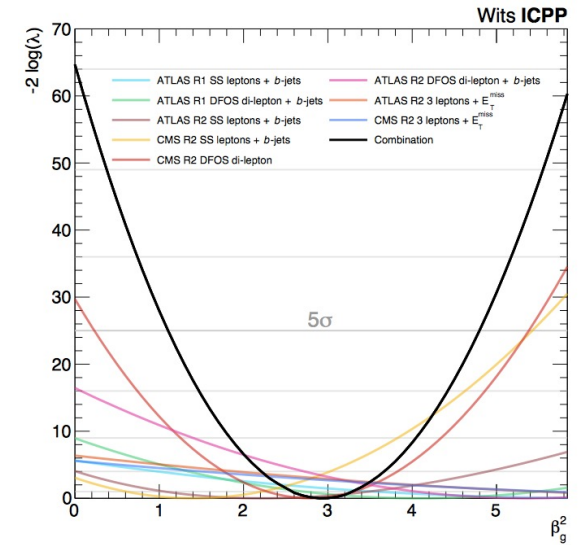
□ Introduction

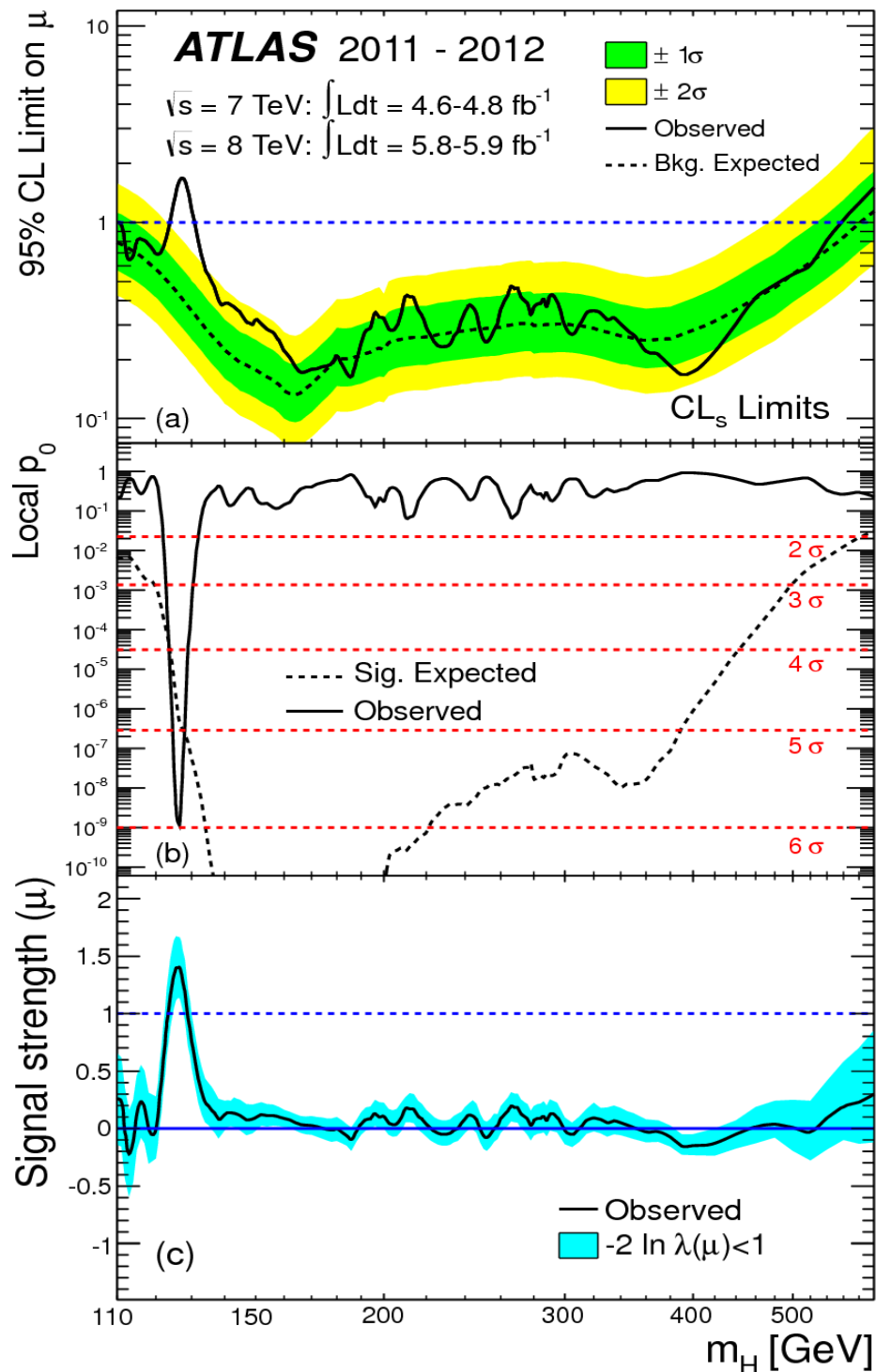
□ The multilepton anomalies

□ The $S(152)$ candidate

□ The $S(95)$ candidate

□ Agentic AI for Sciences



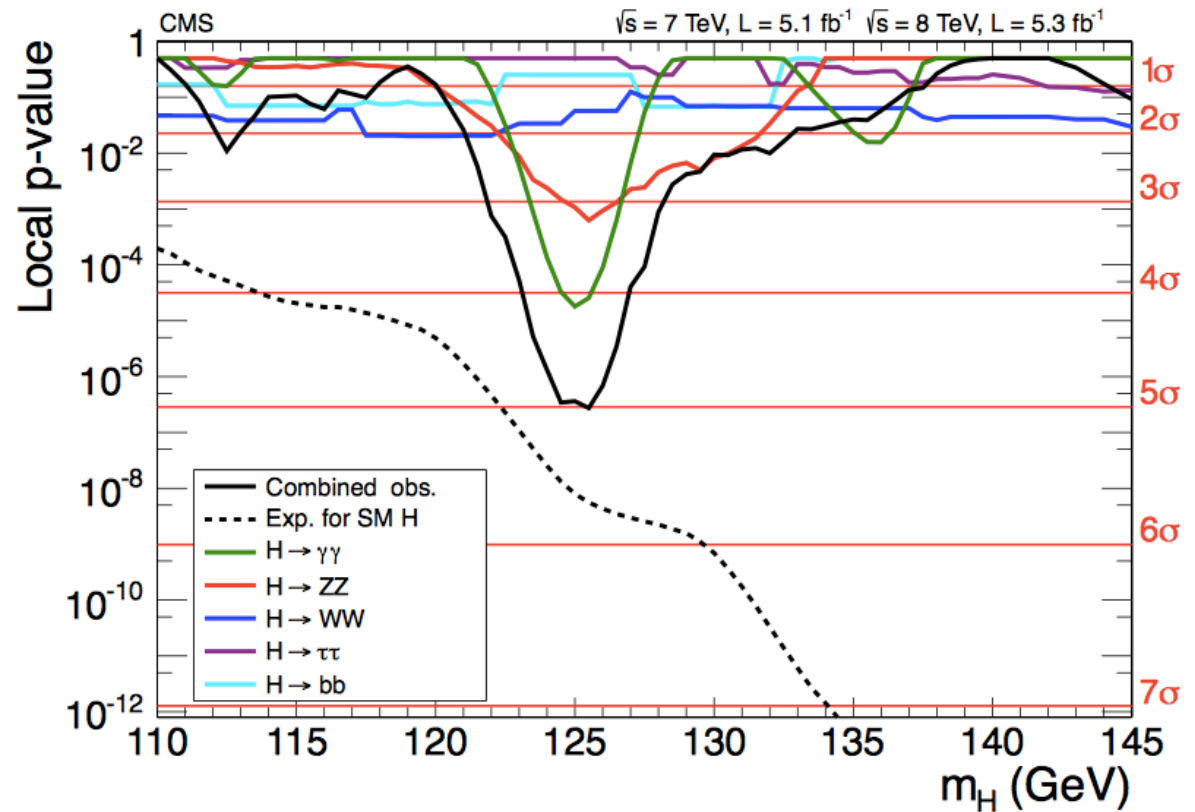


Habemus novum Boson

Phys.Lett. B716 (2012) 1-29

Phys.Lett. B716 (2012) 30-61

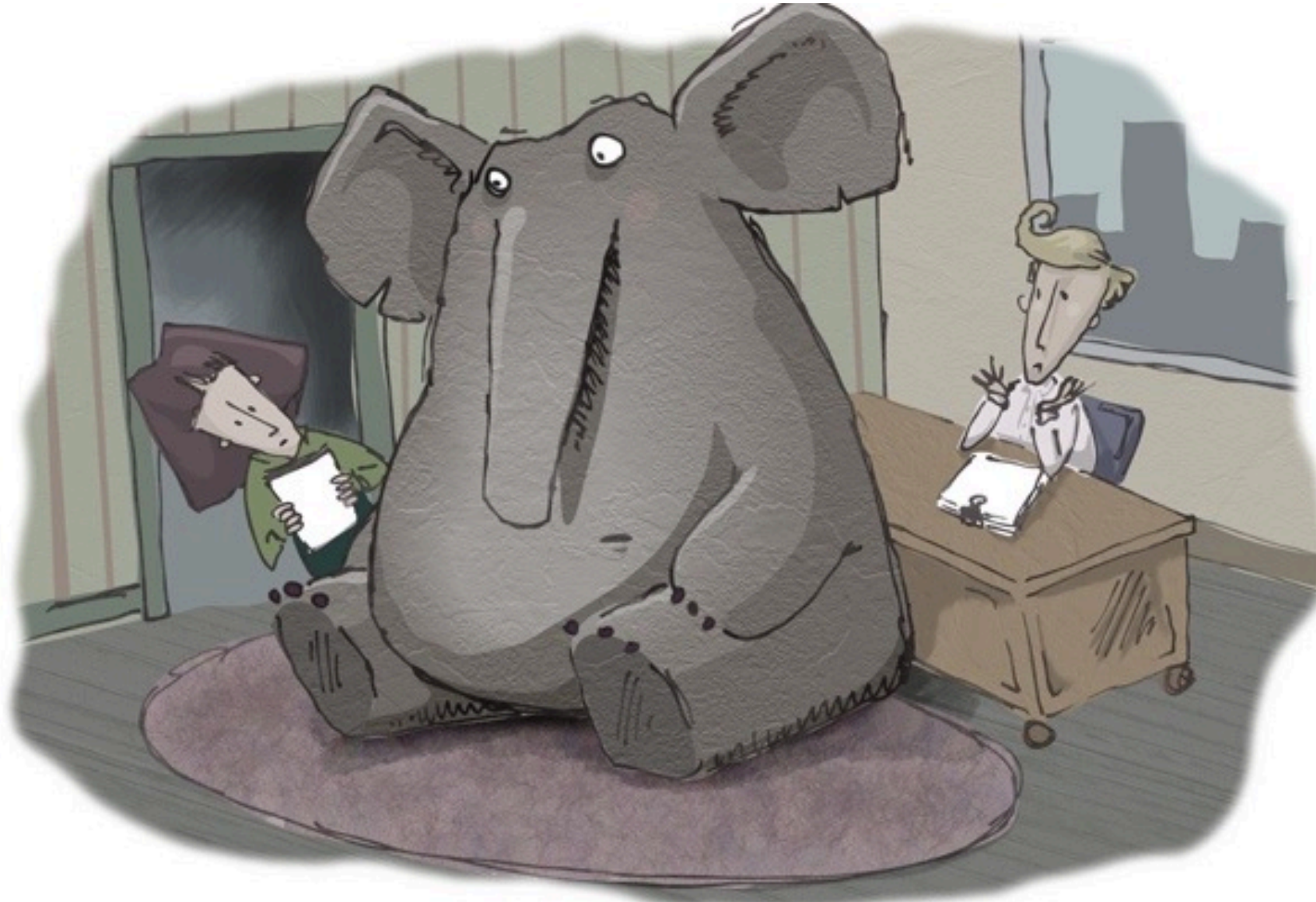
On July 4th 2012 reported both experiments reported $\sim 5\sigma$ effects

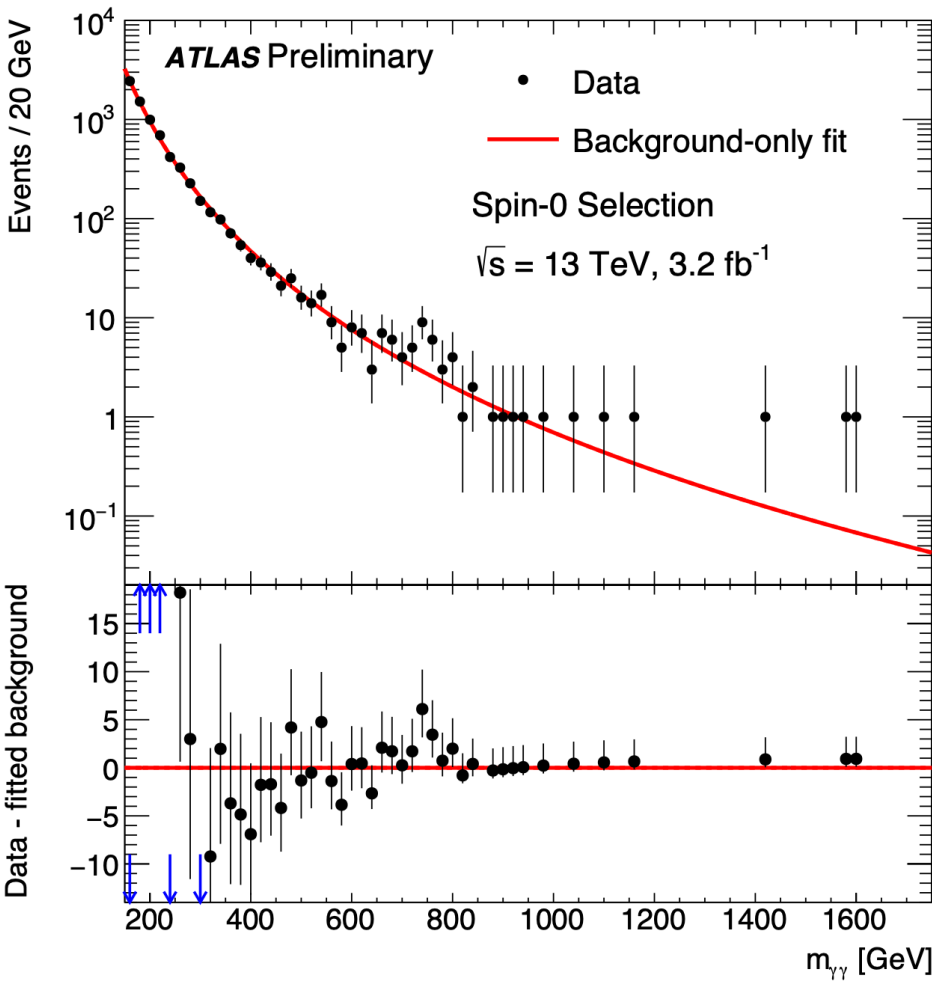
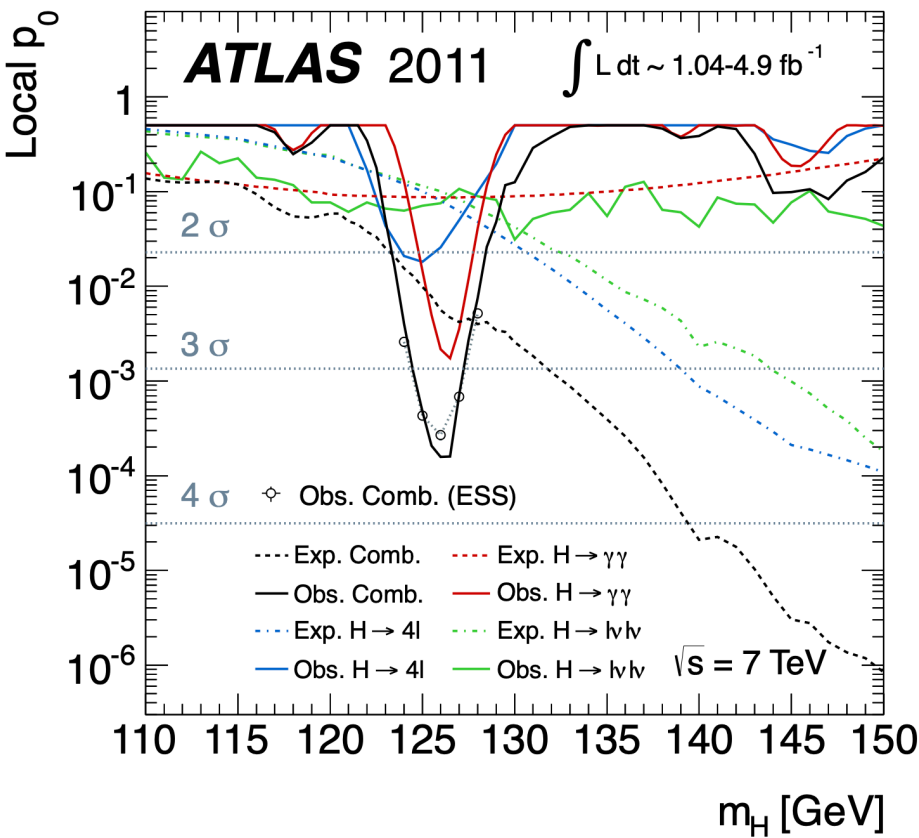


I wonder if there are
others like me.



Let's address the Big Elephant in the room





125 GeV	Criterion	750 GeV
YES	Multiple final states	NO
YES	Indirect evidence	NO
YES	Theoretical motivation and explanation	?

The 750 GeV excess had several red flags from inception

The 152 GeV Candidate

The Timeline

Nature Rev.Phys. 6 (2024) 5, 294-309

2016

Simplified di-boson model
predicting multi-lepton excesses
Eur.Phys.J.C 76 (2016) 10, 580

2019

Multi-lepton anomalies
verified in Run 2
JHEP 10 (2019) 157

2021

First narrow excess at 151.5 ± 1
GeV with jets/leptons/MET
reaching 3.9σ
Phys.Rev.D 108 (2023) 11, 115031



2015

Run 1 excesses
Motivating asymm.
Diboson final states

2017/2018

Multi-lepton anomalies in Run 1
Prediction of $m_S = 150 \pm 5$ GeV
in association with leptons/jets/MET
J.Phys.G 45 (2018) 11, 115003

2025

Narrow excess at
 152 ± 1 GeV with 5.3σ
with leptons/jets/MET
2503.16245

In 2026, continue to accumulate excesses at 152 ± 1 GeV and
exploring Triplet $Y=0$ leading to triboson excesses

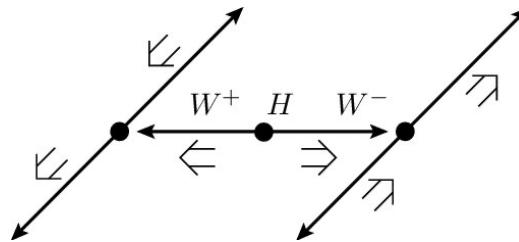
Anatomy of the multi-lepton anomalies (2024)

Final state	Characteristic	Dominant SM process	Significance
$l^+l^- + \text{jets, b-jets}$	$m_{ll} < 100 \text{ GeV}$, dominated by 0b-jet and 1b-jet	$tt+Wt$	$>5\sigma$
$l^+l^- + \text{full-jet veto}$	$m_{ll} < 100 \text{ GeV}$	WW	$\sim 3\sigma$
$l^\pm l^\pm \text{ \& } l^\pm l^\pm + \text{b-jets}$	Moderate H_T	$ttW, 4t, ttZ/tWZ$	$>3\sigma$
$l^\pm l^\pm \text{ \& } l^\pm l^\pm \text{ et al., no b-jets}$	In association with h	Wh, WWW	4.2σ
$Z(\rightarrow l^+l^-)+l$	$p_{TZ} < 100 \text{ GeV}$	ZW	$>3\sigma$

Di-lepton invariant mass in MLA predict a scalar with a mass **$150 \pm 5 \text{ GeV}$** (J.Phys. G45 (2018) no.11, 115003, see also Phys.Rev.D 108 (2023) 11, 115031 and arXiv:2306.17209) in association with leptons and jets.

Prediction from the multi-lepton anomalies.
The di-lepton invariant mass is sensitive to the mass of S .
Assuming $S \rightarrow WW \rightarrow ll\nu\nu$:

$$m_S = 150 \pm 5 \text{ GeV}$$



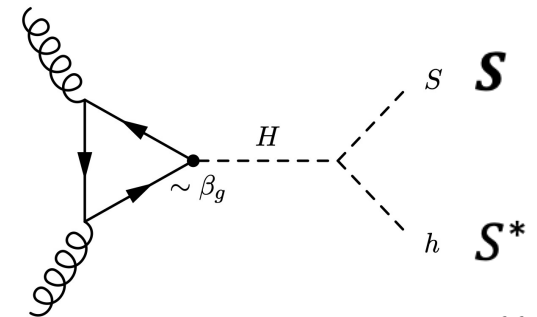
J.Phys. G45 (2018) no.11, 115003

**The 152 GeV
Candidate**

Procedure

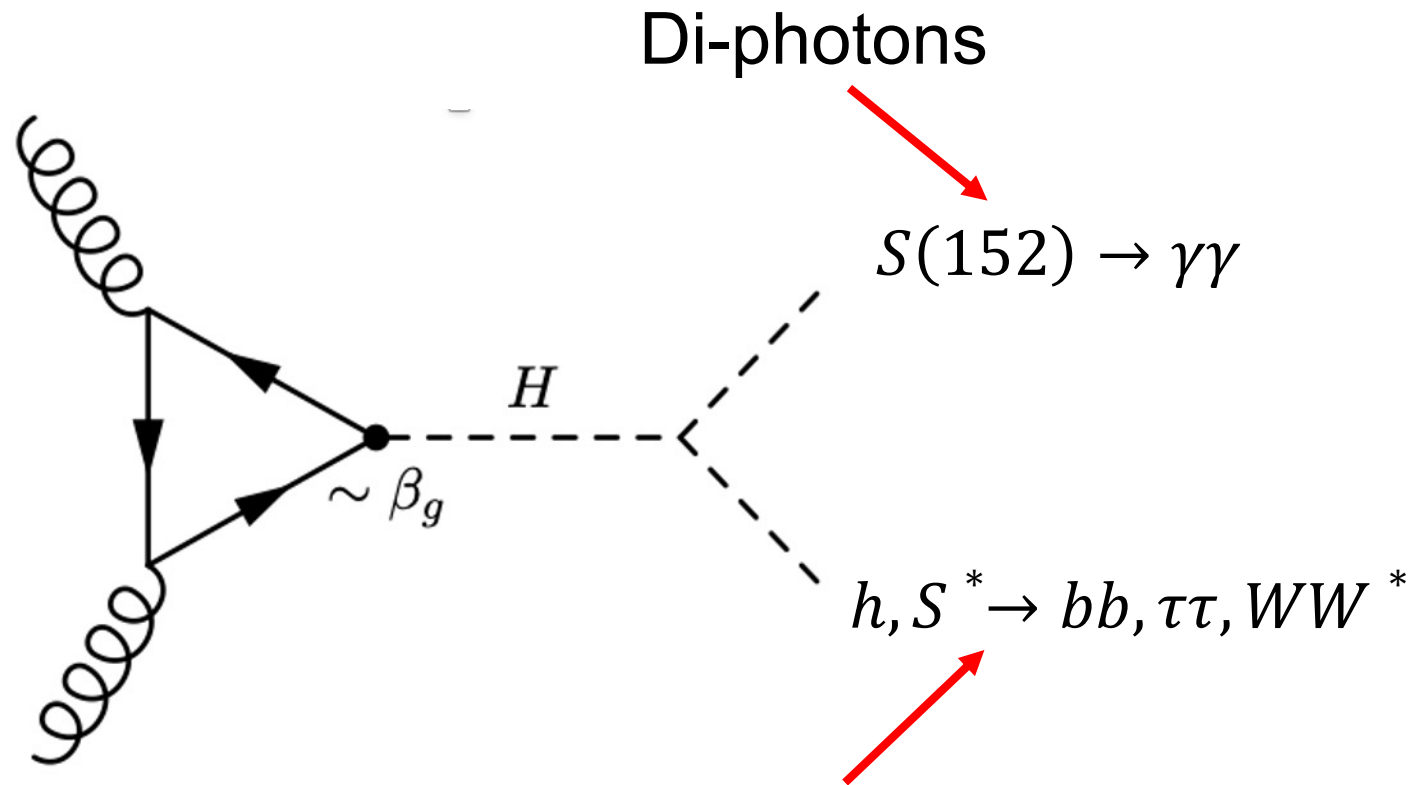
(avoiding “cherry picking”)

- ❑ **Setting a well-defined procedure is essential to the integrity of a search. Scanning nullifies significance**
- ❑ **From the di-lepton anomalies: $m_h < m_s < 170$ GeV**
 - ❑ **It is critical that search be localized and motivated**
- ❑ **Focus on $\gamma\gamma$ and $Z\gamma$ decays**
- ❑ **As per the model that described the multi-lepton anomalies, we select final state according to di-boson signatures. S is produced via the decay of something heavier and not directly**
 - ❑ **Re-use Higgs boson data**
 - ❑ **Remove VBF and boosted topologies**
 - **Related to direct production**



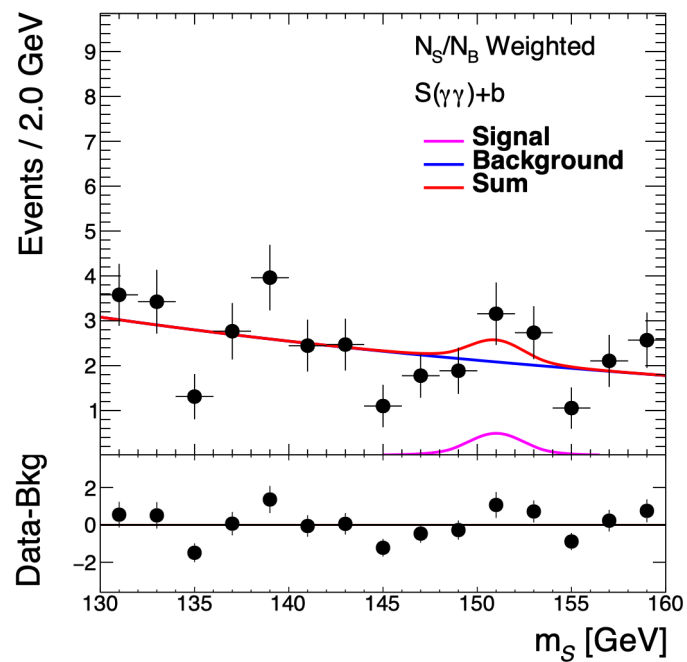
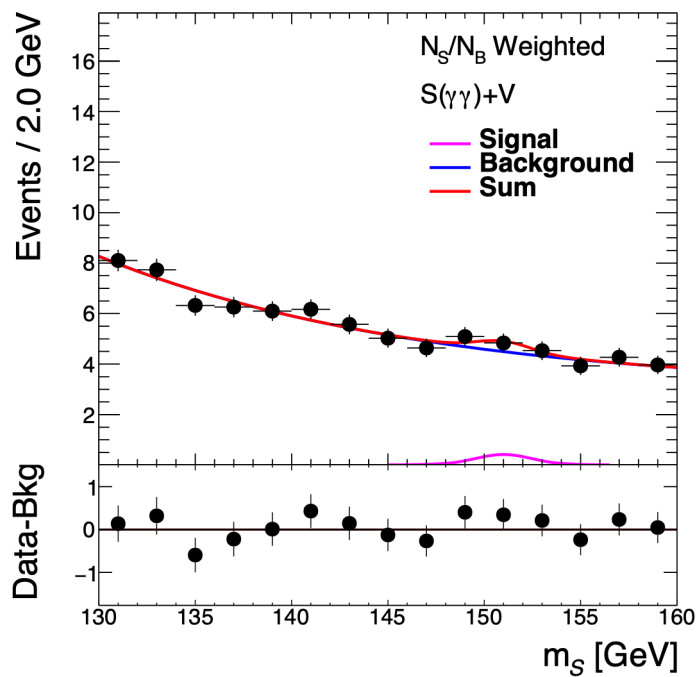
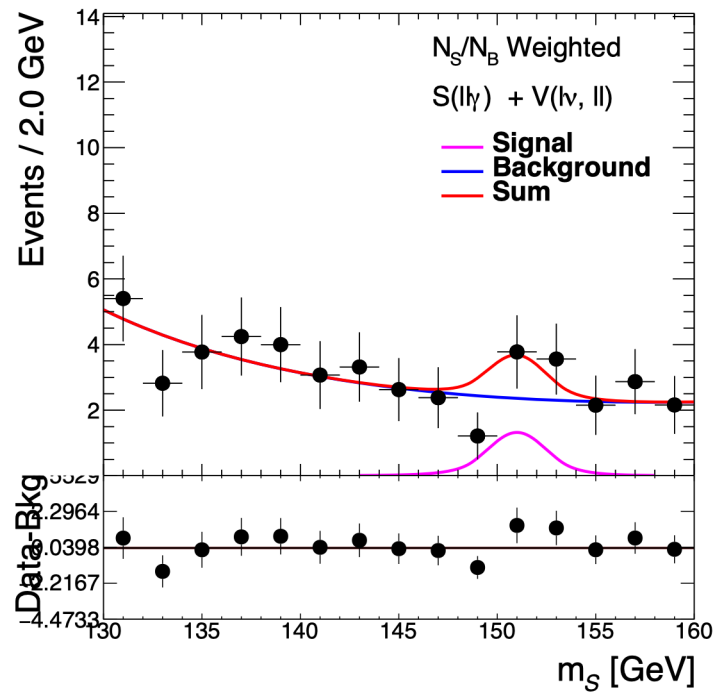
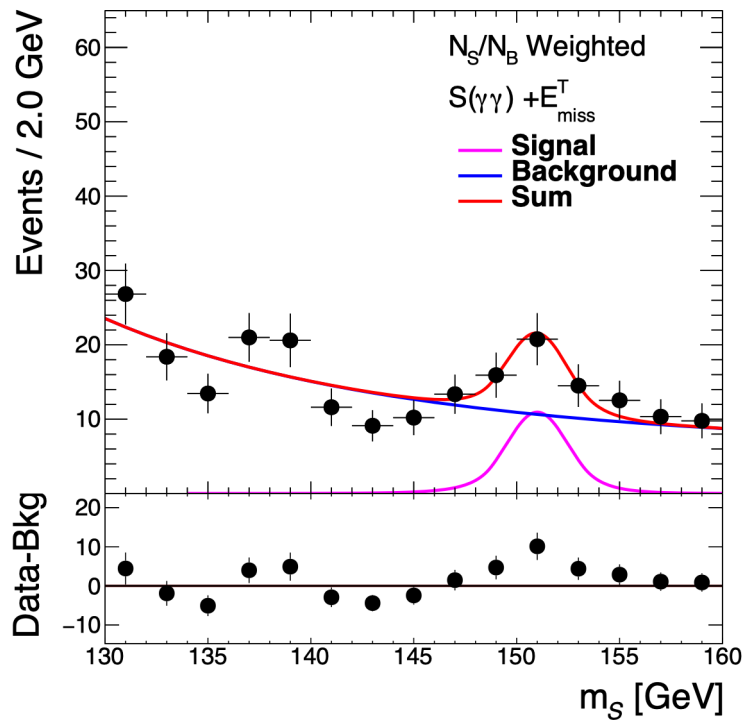
From Run 1 multi-lepton excesses model-dependent prediction of $m_s = 150 \pm 5$ GeV

Procedure to choose final state: di-photon in association with b-jets, τ -had, leptons (e/μ) and jets



Source of b-jet, τ -had, leptons, jets

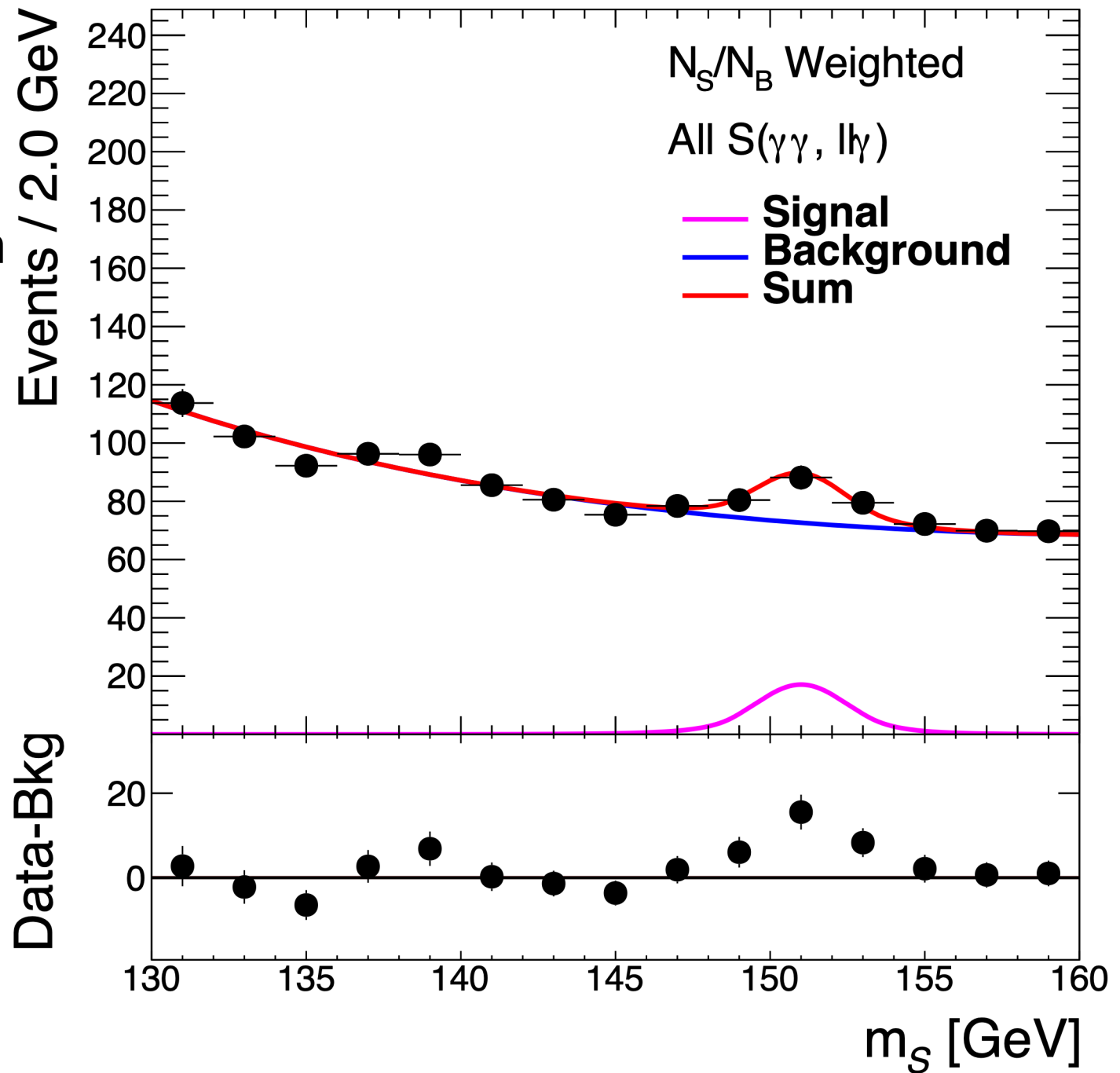
In *Eur.Phys.J.C* 76 (2016) 10, 580 also considered $S \rightarrow \text{MET}$



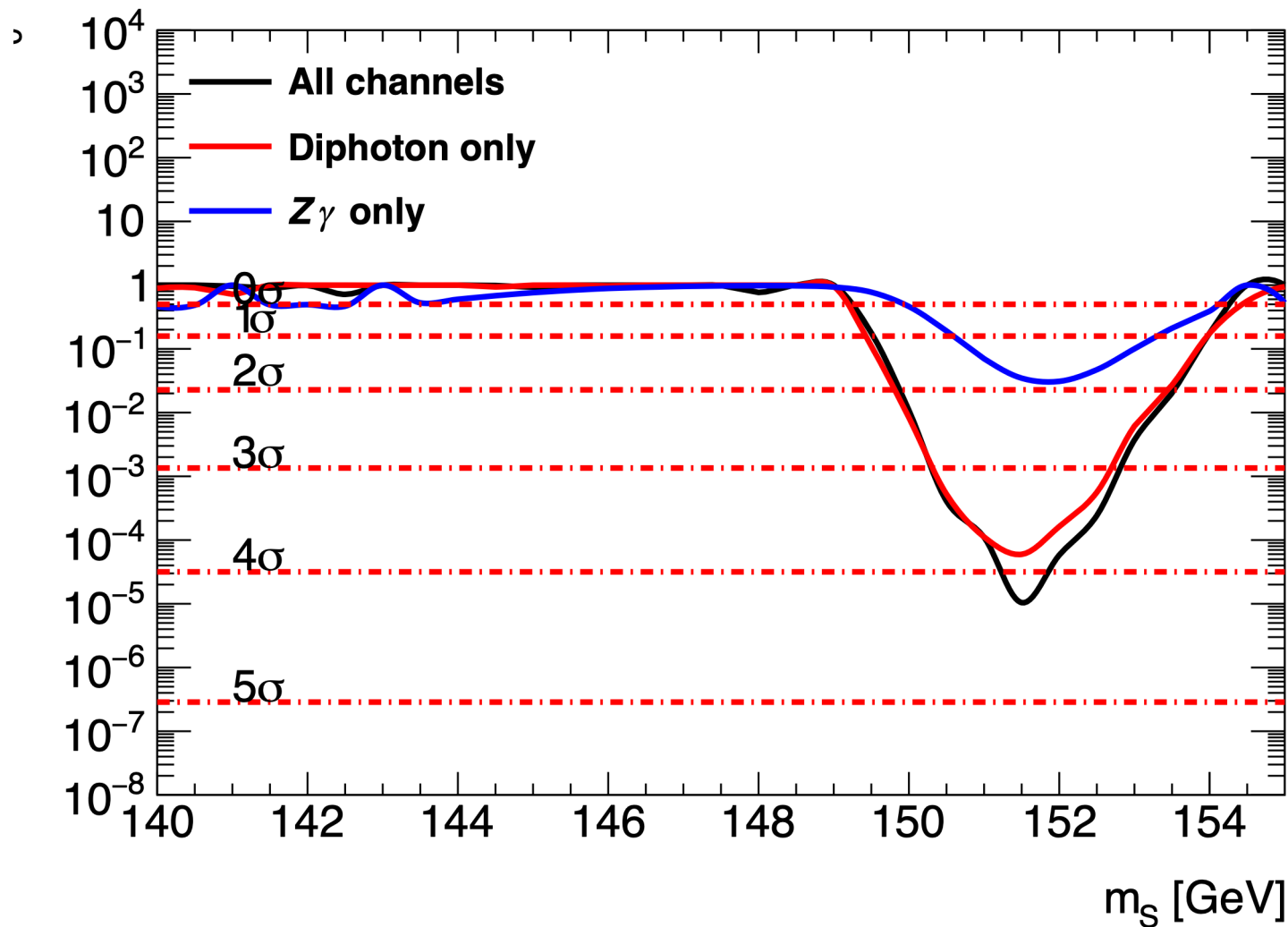
Analysis of publicly available $\gamma\gamma$, $Z\gamma$ spectra in associated production gives an excess at $m_S=151.5$ GeV.

Fiducial yields consistent with $H \rightarrow SS^*$ hypothesis with $m_H=270$ GeV, which is used for the extraction of significance.

Excess not seen in $S \rightarrow ZZ \rightarrow 4l$

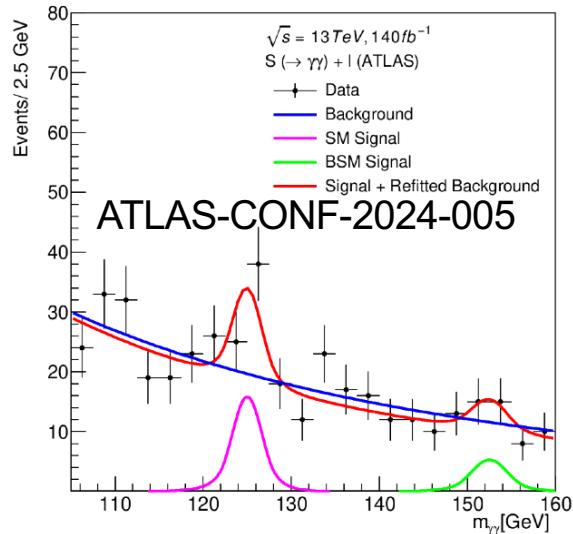


Result is obtained with public results from the LHC experiments. Using a simplified model and two degrees of freedom to include the decay of $S \rightarrow \text{MET}$ (as in Eur.Phys.J.C 76 (2016) 10, 580) and residual LEE, global significance goes to 3.9σ at 151.5 GeV.

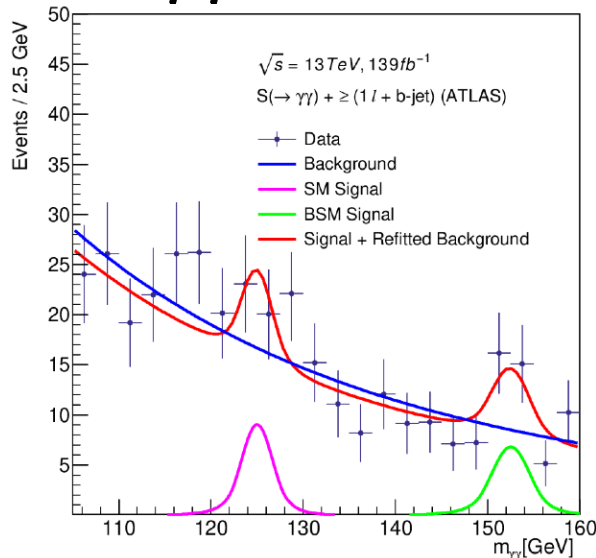


New excesses @151.5 GeV that appeared after the first combination (see above) in topologies consistent with associated production:

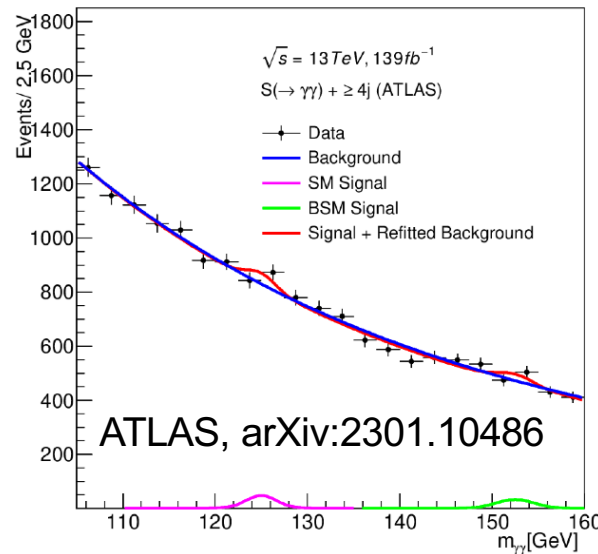
$\gamma\gamma + l (b - veto)$



$\gamma\gamma + l + b$



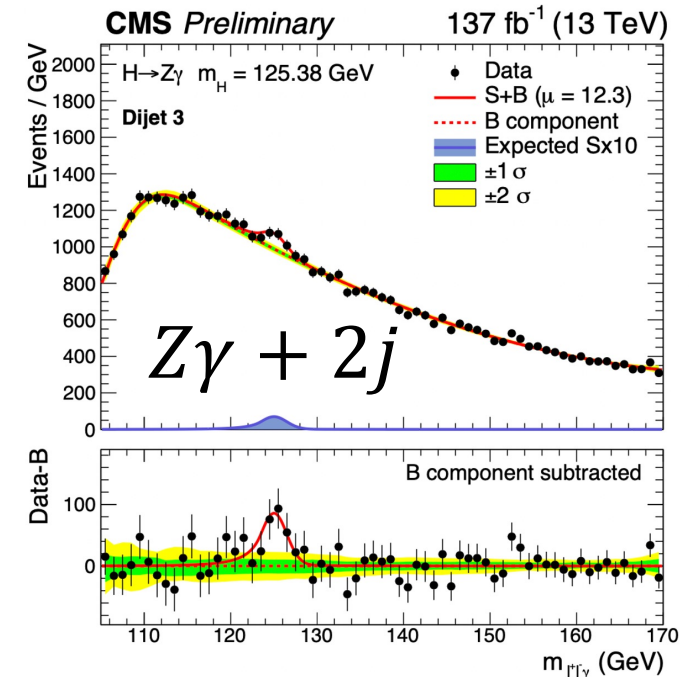
$\gamma\gamma + 4j$



Excesses appear in corners of the phase-space predicted by the naive $H \rightarrow SS^*$ model with S being SM Higgs-like. In addition, seem to see S in association with MET and, possibly, with an extra photon

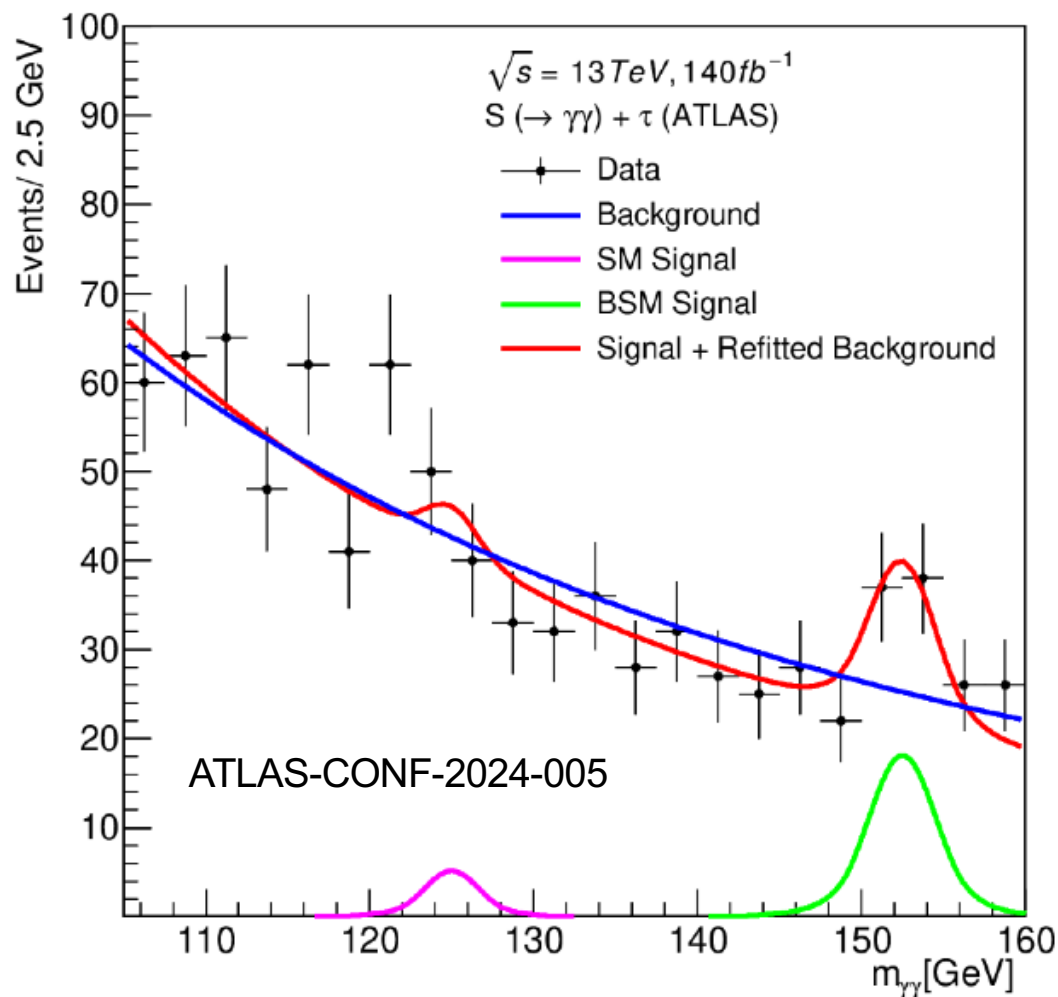
ATLAS, arXiv:2301.10486

CMS-PAS-HIG-19-014

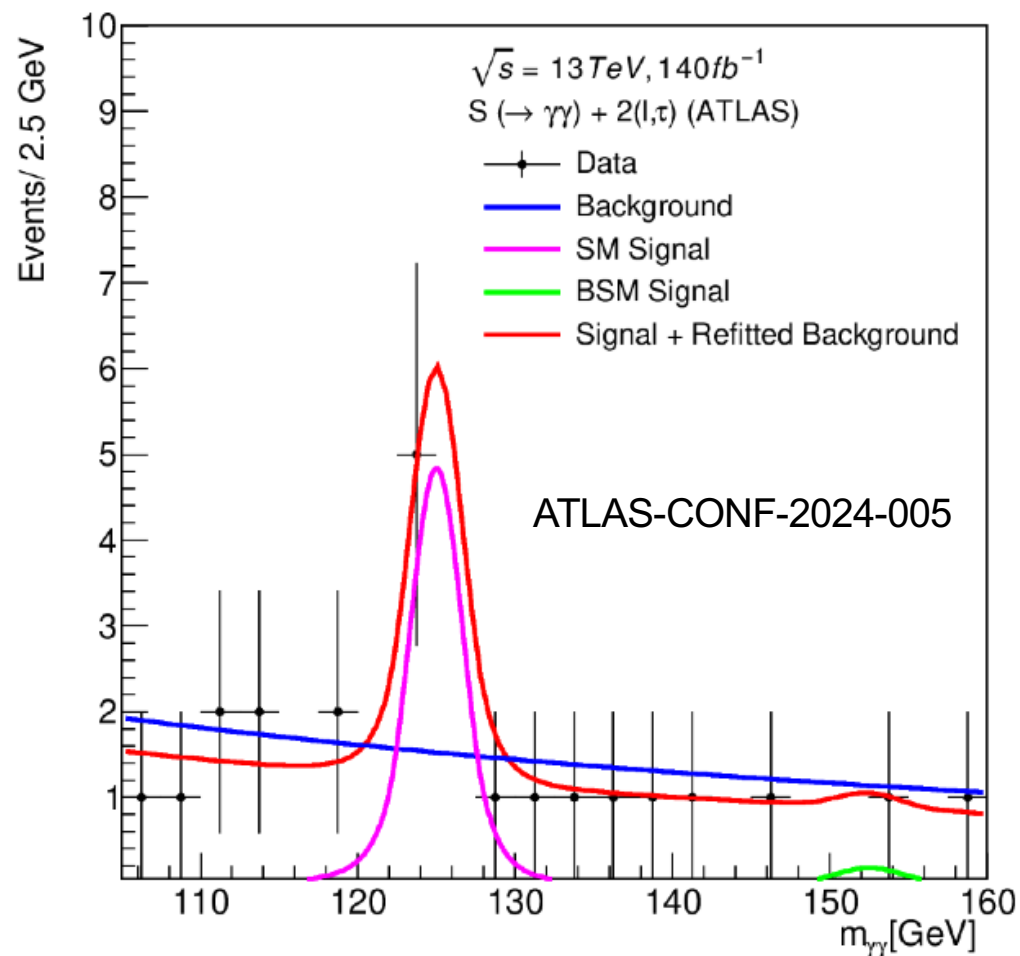


Bin for associated production VH , $t\bar{t}H$, where excess is seen with di-photons.

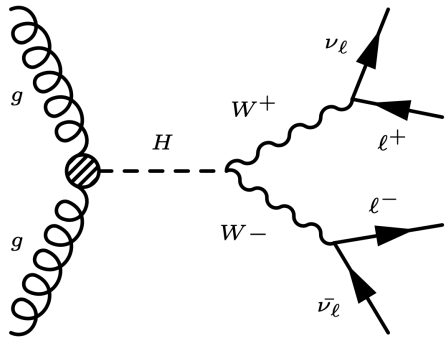
$$\gamma\gamma + \tau$$



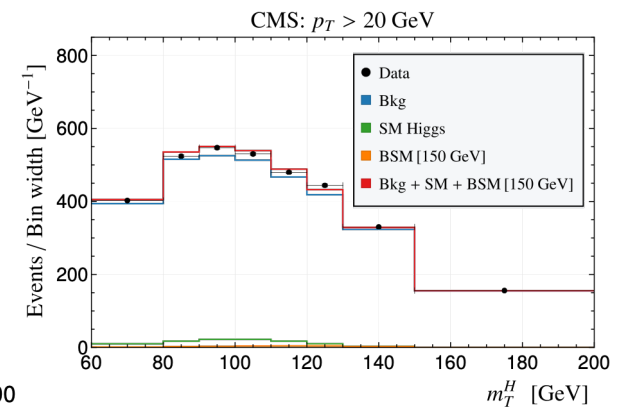
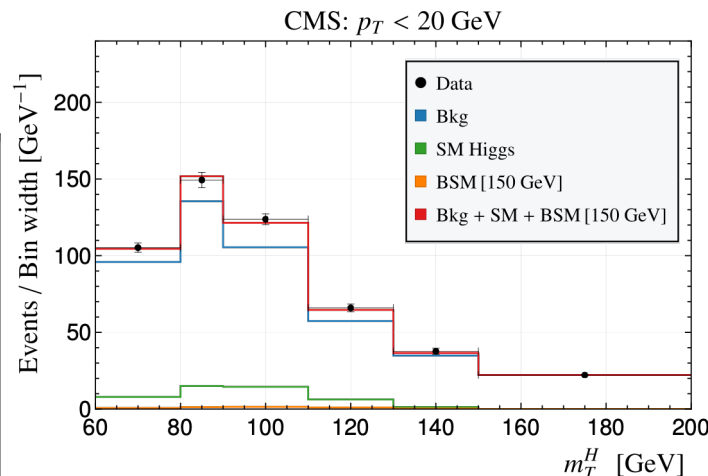
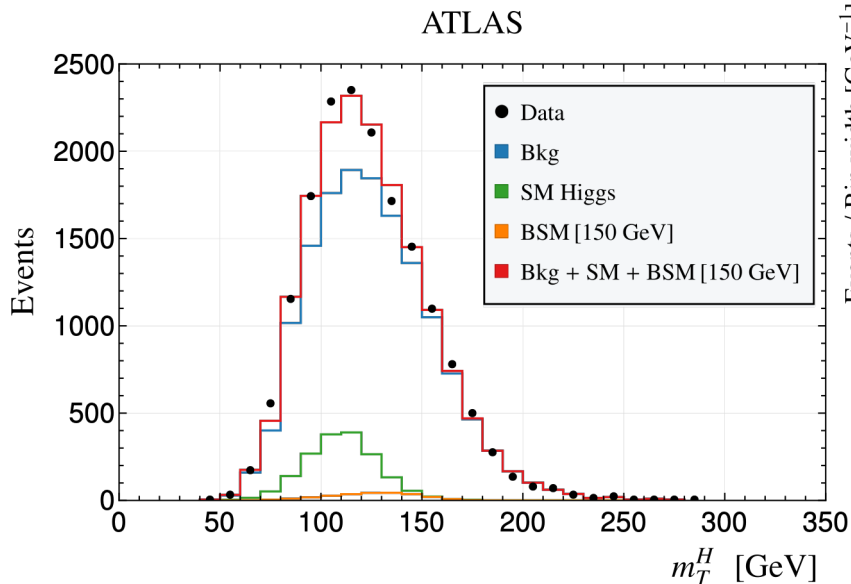
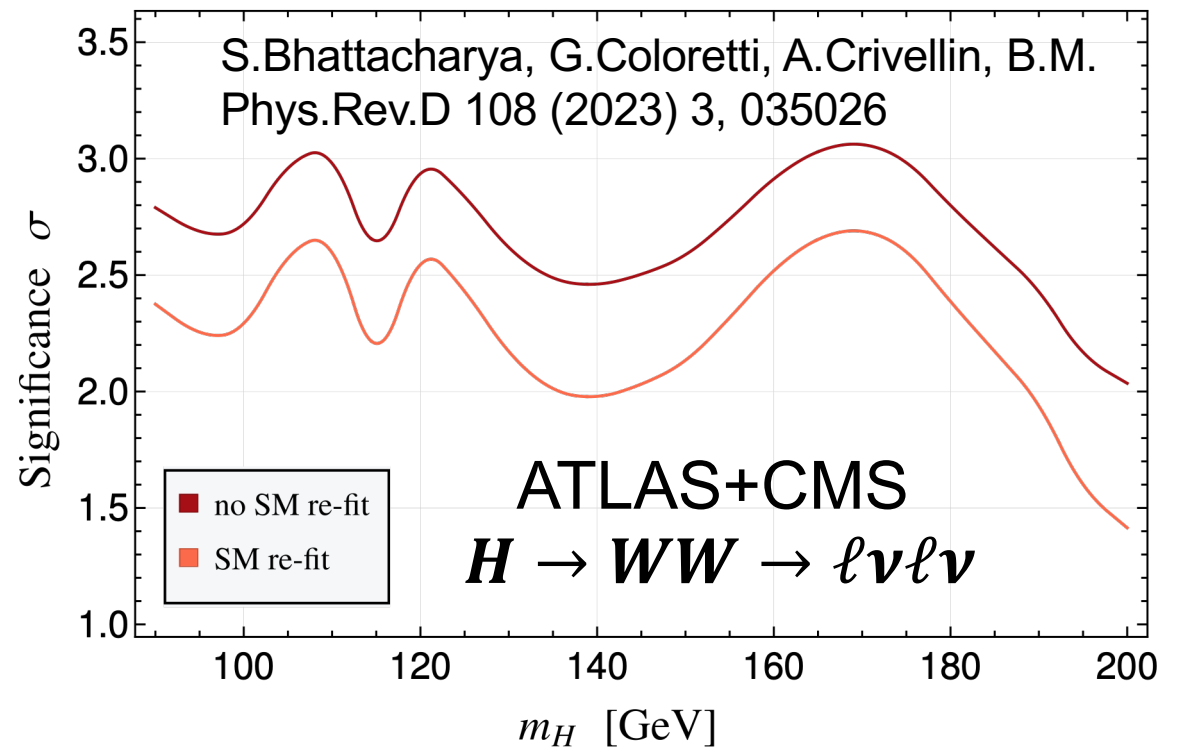
$$\gamma\gamma + 2(\tau, \ell)$$



Single and double tau are combined assuming $H \rightarrow SS^*$

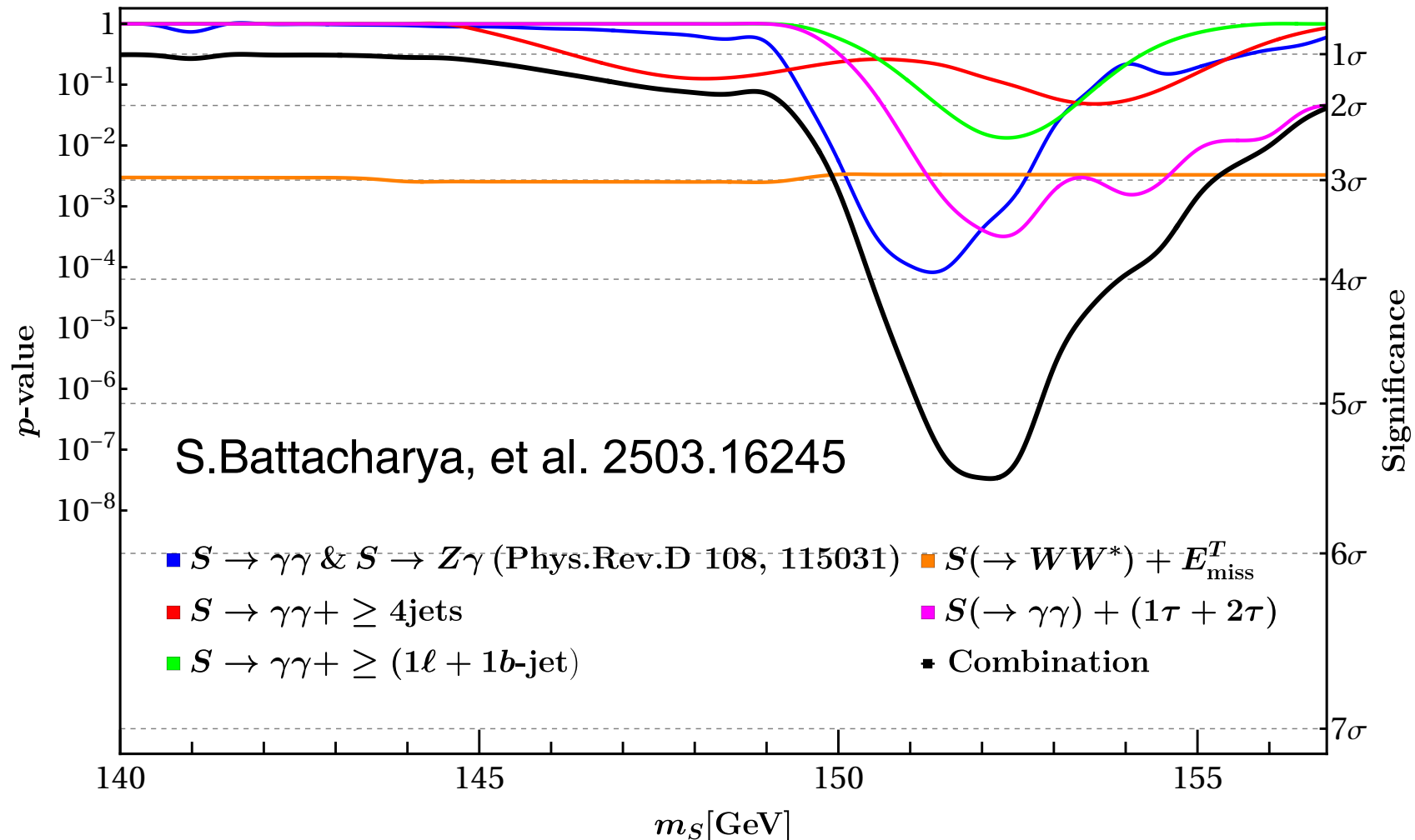


SM Higgs hypothesis alone. alone is having difficulty describing the $\ell\ell + \text{MET}$ transverse mass spectra, giving room to other Higgs-like signals, including S(151).

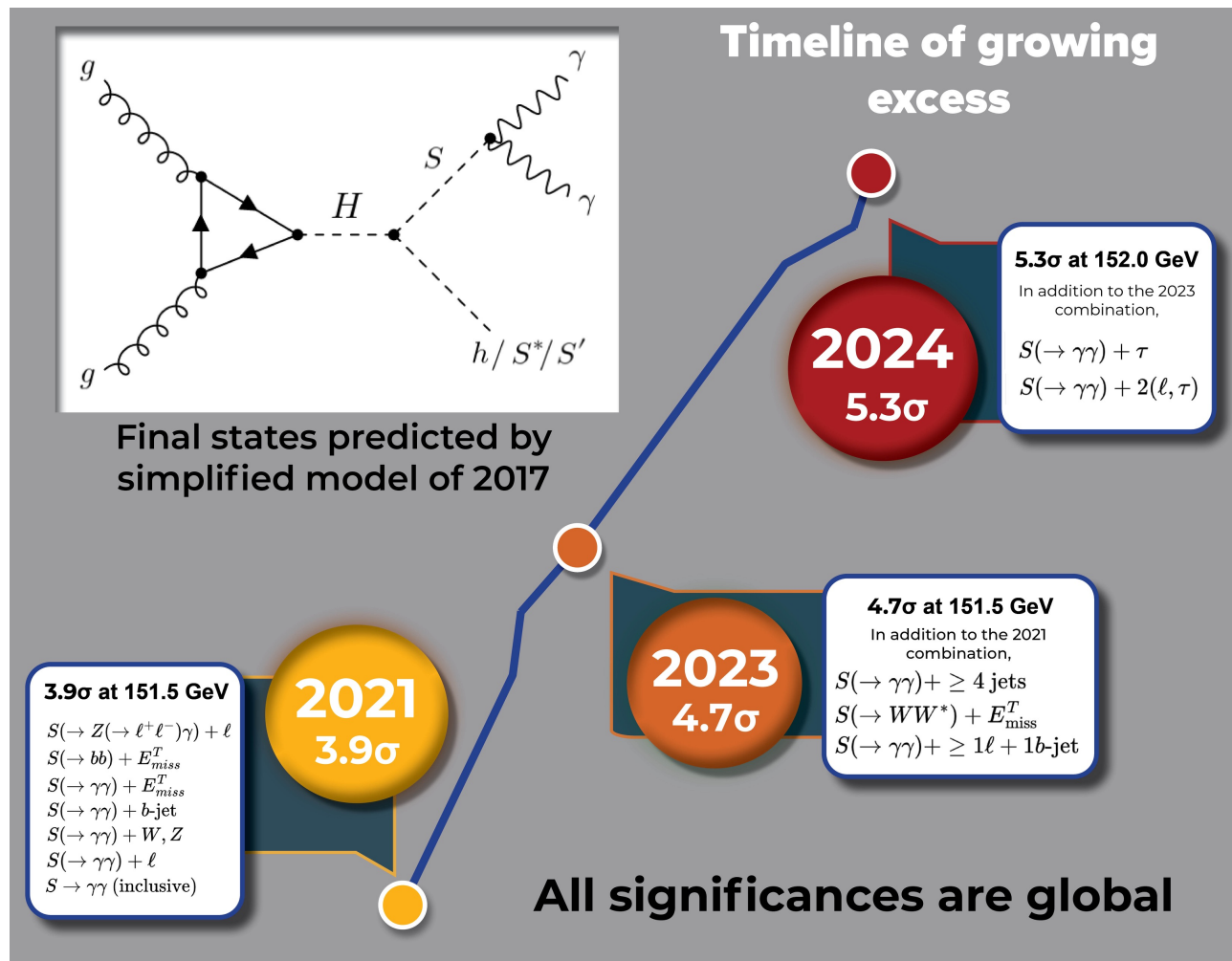


Currently, interpreting the broad excess in terms of $H \rightarrow S + \text{MET}$, which appears to be the leading final state in excess described above

Current status of the combination, based on the Fischer method with 5 n.d.o.f yields largest global significance of a narrow structure beyond the SM at the LHC

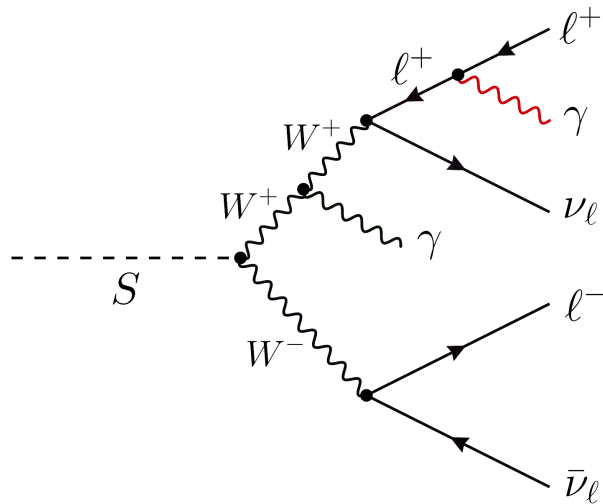


2021 (Group 1)	2023 (Group 2)	2025 (Group 3)
$\gamma\gamma + E_{\text{miss}}^T$ [20, 43] $\gamma\gamma + W, Z$ [46, 47] $\gamma\gamma + b\text{-jet}$ [48, 49] $\gamma\gamma + 2b\text{-jets}$ [52] $Z(\rightarrow \ell^+\ell^-)\gamma + 1\ell, jj$ [53]	$\gamma\gamma + \geq (1\ell + 1b\text{-jet})$ [44] $\gamma\gamma + \geq 4\text{ jets}$ [44] $WW^* + E_{\text{miss}}^T$ [50, 51]	$\gamma\gamma + \tau$ [45] $\gamma\gamma + 2(\ell, \tau)$ [45]



**Further
Confirmation of the
152 GeV Candidate**

Radiative Signature, $m_{\ell\ell\gamma}$ spectrum

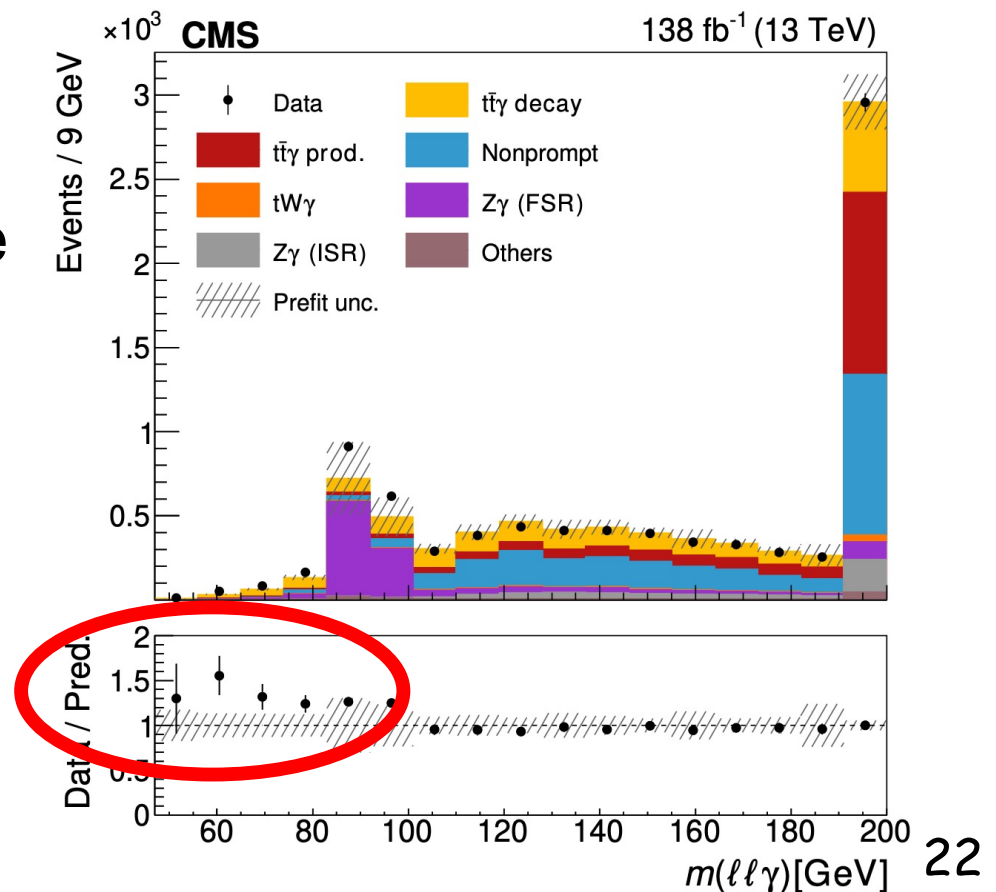


New measurement by CMS of the inclusive and differential measurements of the $t\bar{t}\gamma$ cross-section. Excess at low $m_{\ell\ell\gamma}$ compatible with the excesses in the $m_{\ell\ell}$ spectra in events with $\ell\ell$ with b -jet in $t\bar{t}$ cross-section measurement (see above)

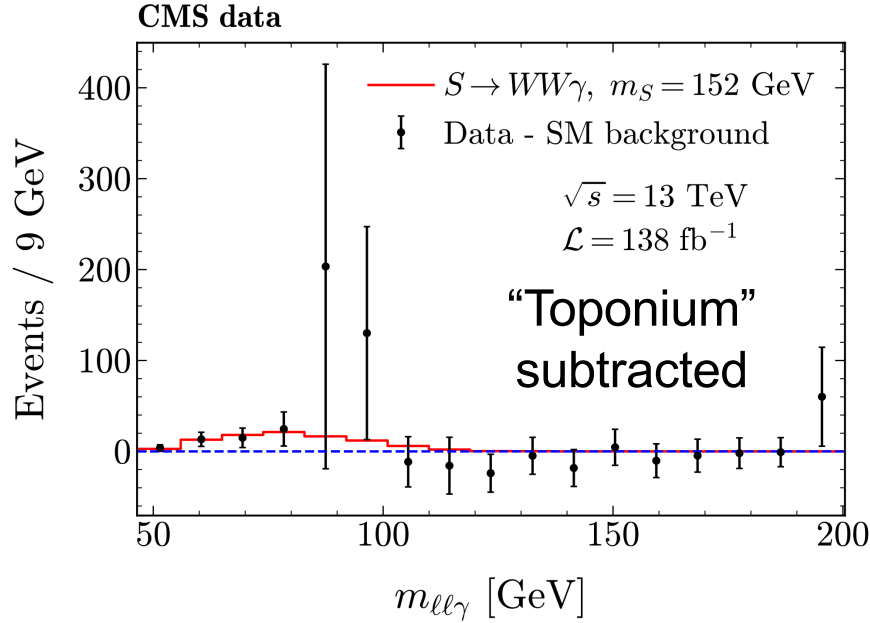
CMS, JHEP 04 (2026) 086

<https://arxiv.org/abs/2511.01995>

New excess compatible with multi-lepton anomalies in $\ell\ell\gamma$ + b -jets consistent with 150 GeV candidate



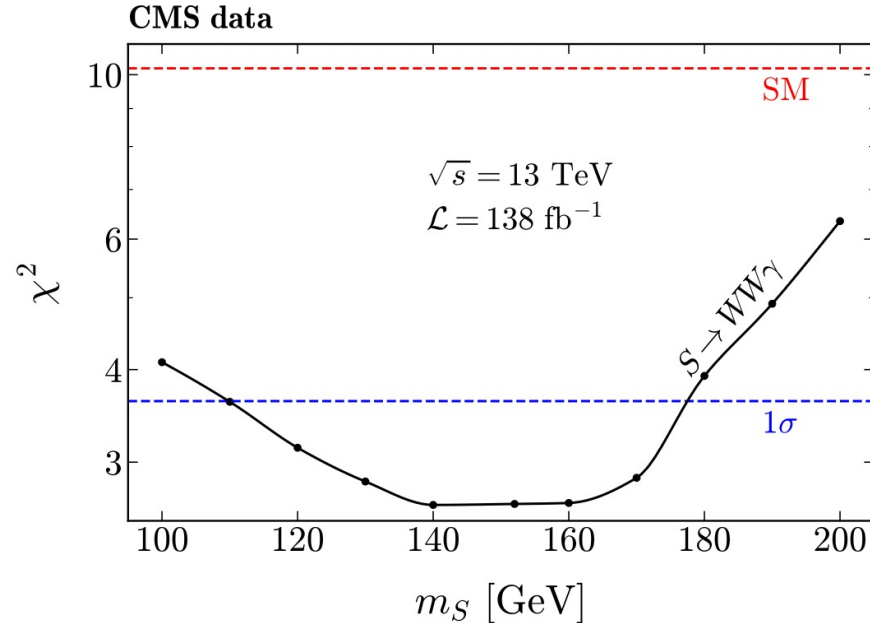
Radiative Signature, $m_{\ell\ell\gamma}$ spectrum (cont.)



<https://arxiv.org/pdf/2606.24801>, to appear in PRD

$$\frac{\sigma(S \rightarrow W^+W^-\gamma)}{\sigma(S \rightarrow W^+W^-)} = (2.14 \pm 0.77)\%.$$

Consistent with radiative correction of S(152) GeV candidate



Mass (GeV)	Channel	Reference
150^{+5}_{-5}	$S \rightarrow W^+W^- \rightarrow \ell^+\nu_\ell\ell^-\nu_\ell$ (b -jet veto applied)	[12]
150^{+7}_{-6}	$S \rightarrow W^+W^- \rightarrow \ell^+\nu_\ell\ell^-\nu_\ell$ (with associated b -jet)	[45]
152^{+1}_{-1}	$S \rightarrow \gamma\gamma, Z\gamma$	[19, 21]
140^{+35}_{-30}	$S \rightarrow W^+W^-\gamma \rightarrow \ell^+\nu_\ell\ell^-\nu_\ell\gamma$	This work

TABLE I. Mass measurements of a scalar candidate around 150 GeV (see text).

The 152 GeV candidate in Run 3 data, S+2j

EUROPEAN ORGANISATION FOR NUCLEAR RESEARCH (CERN)

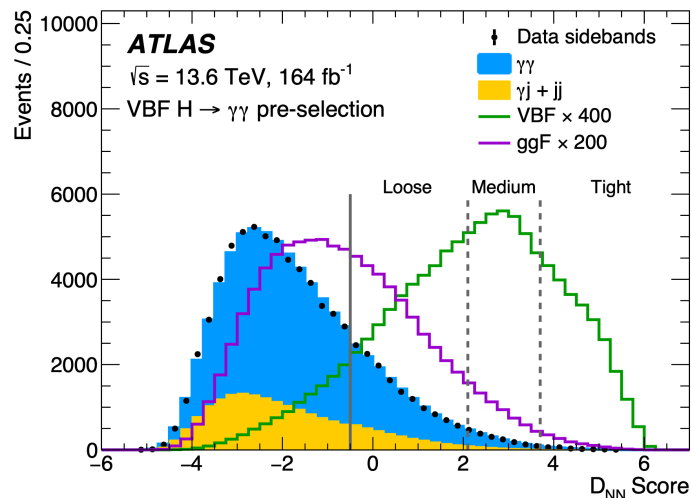


CERN-EP-2026-075
23rd March 2026

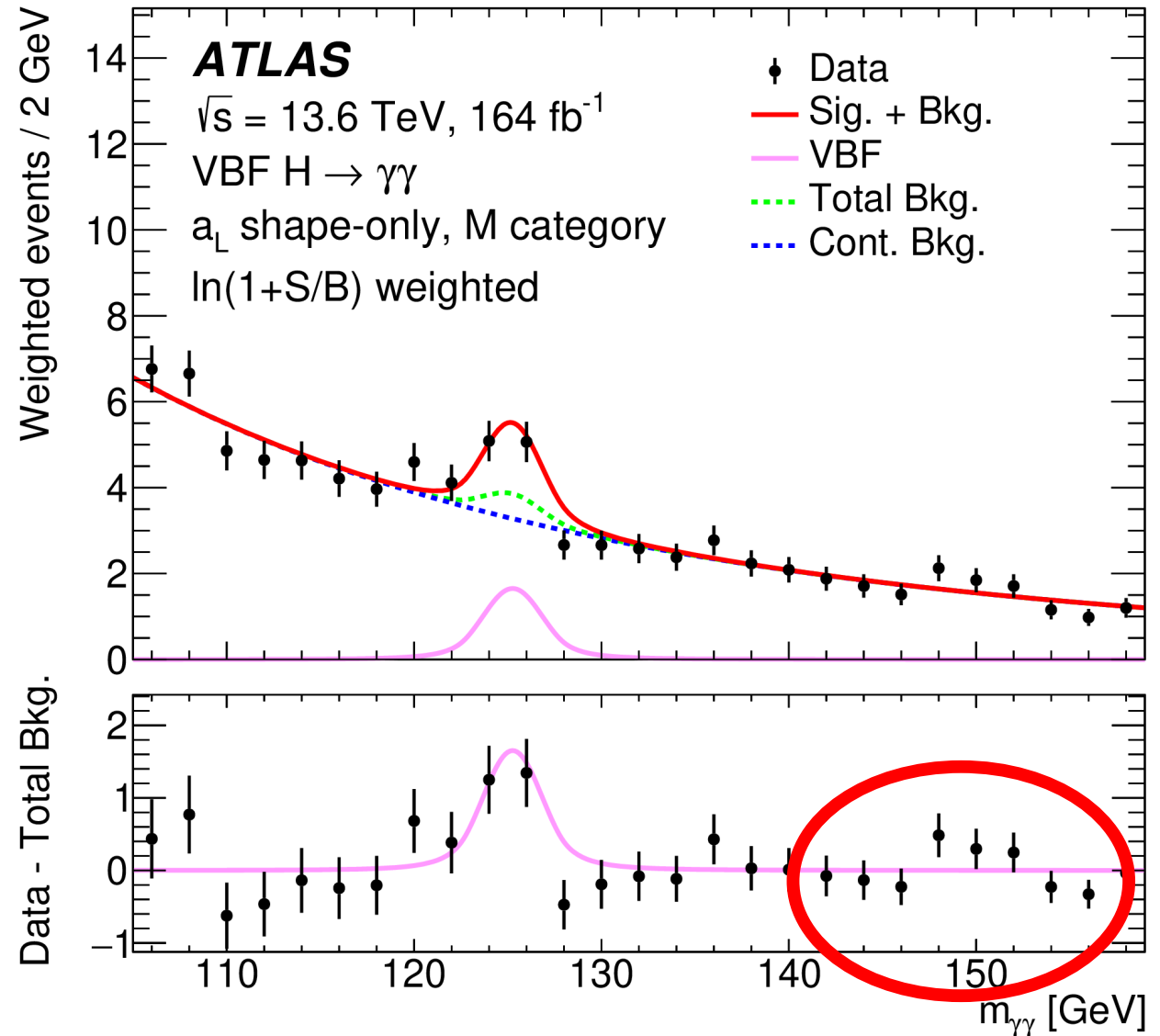
Search for anomalies in vector-boson fusion
production of the Higgs boson in $H(\rightarrow \gamma\gamma)jj$ events
using 164 fb^{-1} of pp collision data collected at
 $\sqrt{s} = 13.6 \text{ TeV}$ with the ATLAS detector

The ATLAS Collaboration

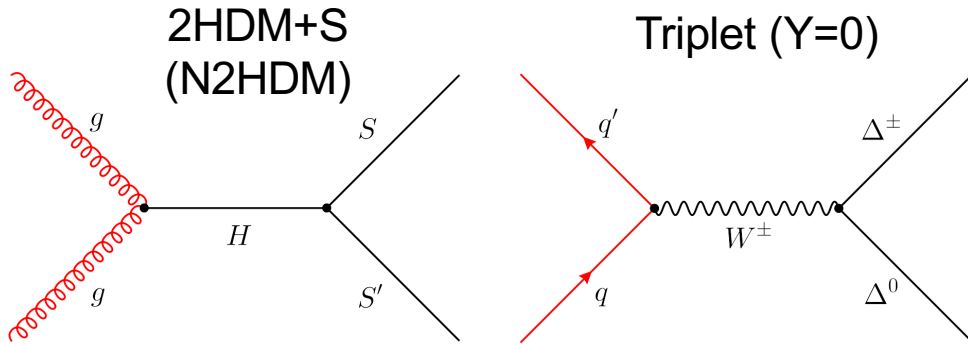
Study by ATLAS of the production
of di-photons in association with
di-jets in VBF topologies.



ATLAS, <https://arxiv.org/pdf/2603.20087>

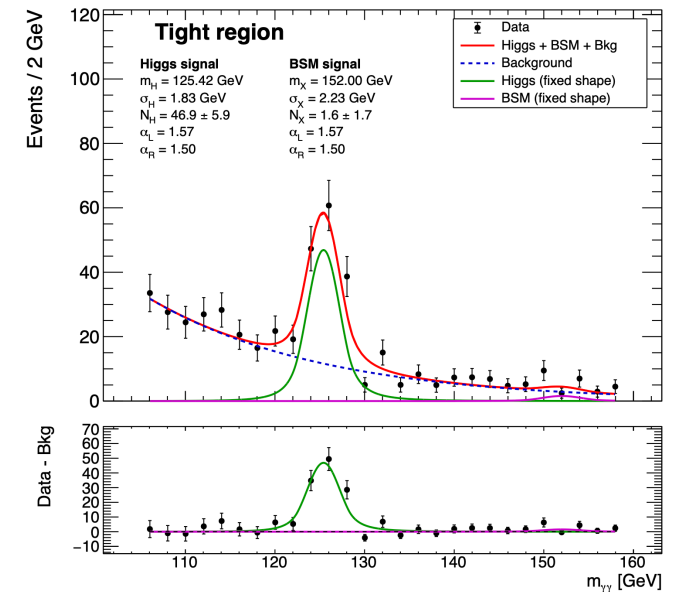
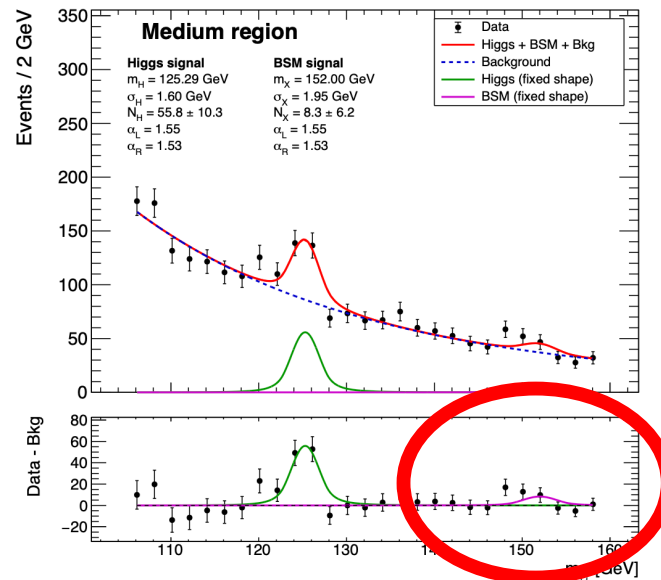
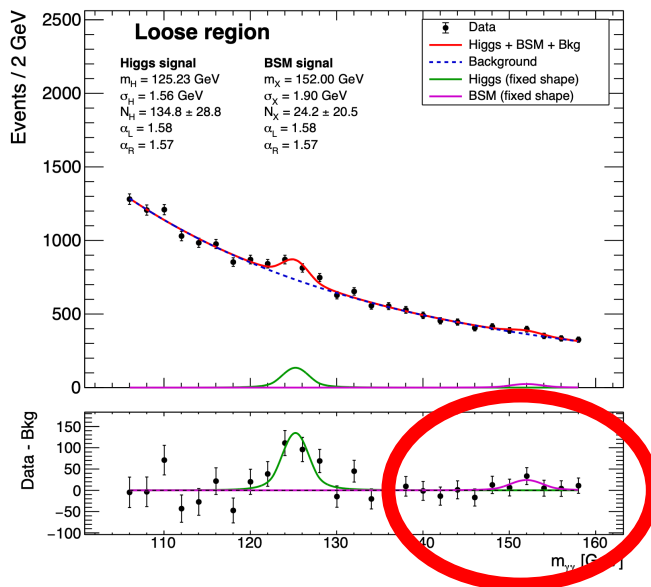


The 152 GeV candidate in Run 3 data, S+2j (Cont.)



Channel	Category	ϵ_{fid}	ϵ_{total}	ϵ_{DNN}
HTM	Tight	0.407	0.037	0.0030
	Medium	0.407	0.037	0.0780
	Loose	0.407	0.037	0.4980
N2HDM	Tight	0.331	0.075	0.0040
	Medium	0.331	0.075	0.0460
	Loose	0.331	0.075	0.2590

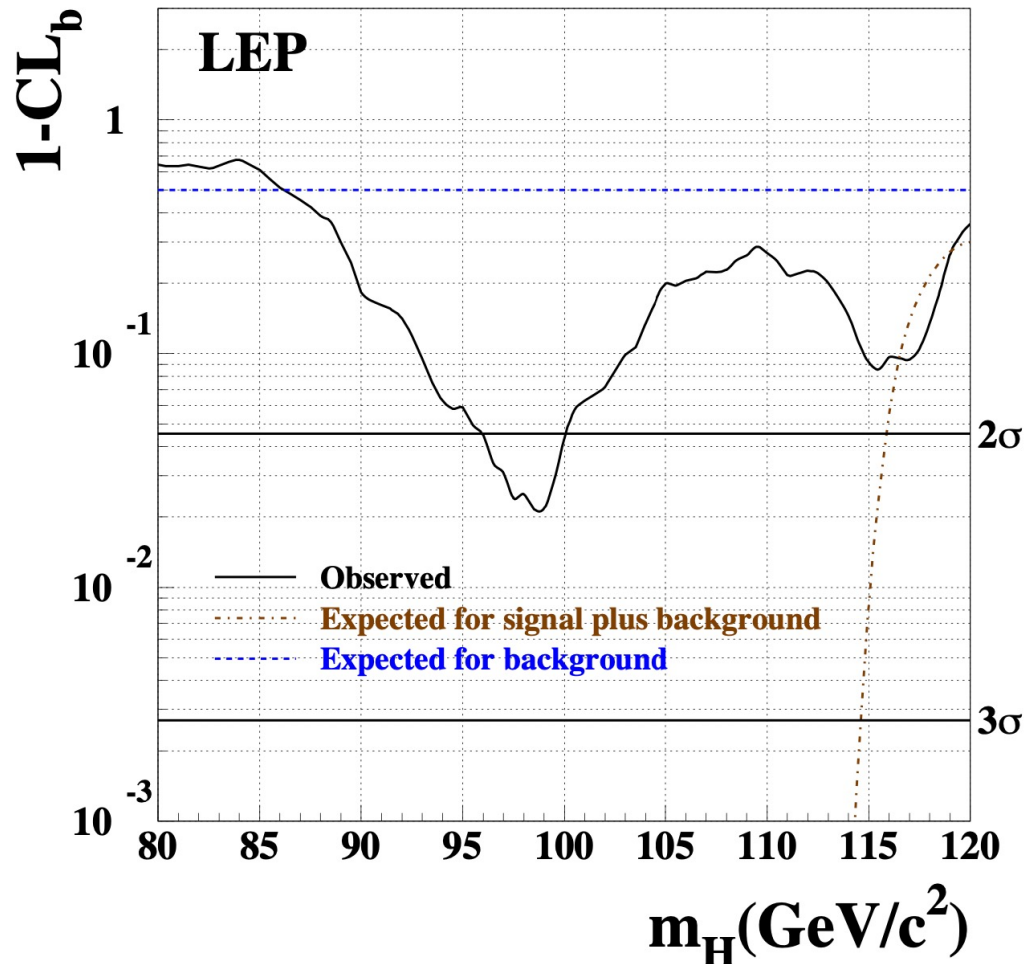
The BSM production mechanisms are distinct from SM VBF.
Expect small signal in VBF tight, but larger signal in medium and loose bins, which is what we see.



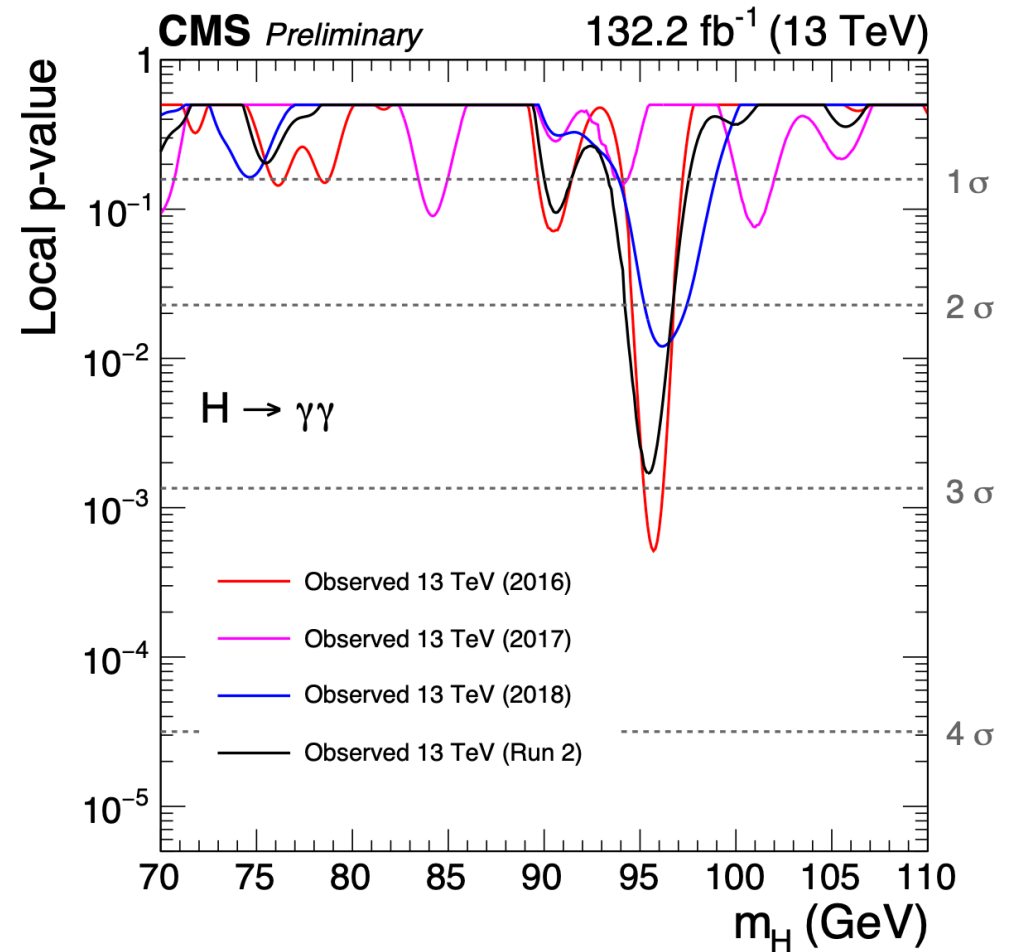
The 95 GeV Candidate

Some tantalizing results around 96 GeV from LEP and CMS, not contradicted by ATLAS. Interesting to see what the full Run 2 data set has to say. Further motivates asymmetric searches $H \rightarrow SS'$...

LEP, Phys. Lett. B 565 (2003) 61–75



CMS PAS HIG-20-002

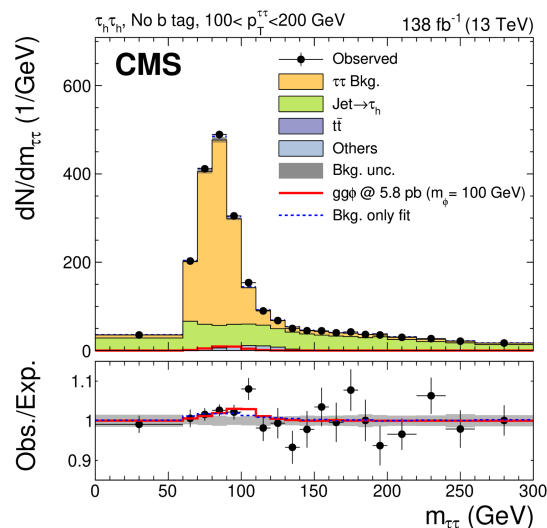
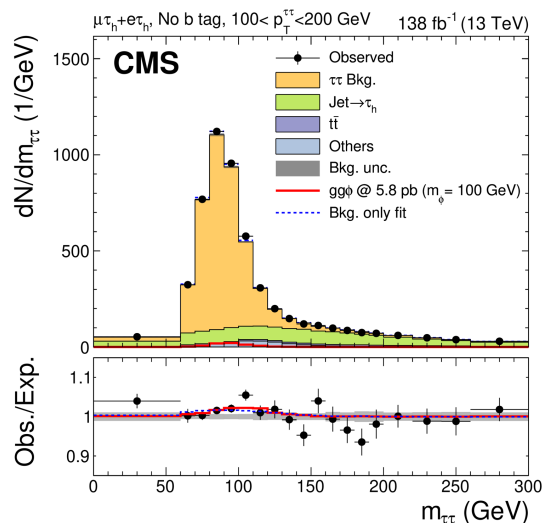


CMS, arXiv:2208.02717

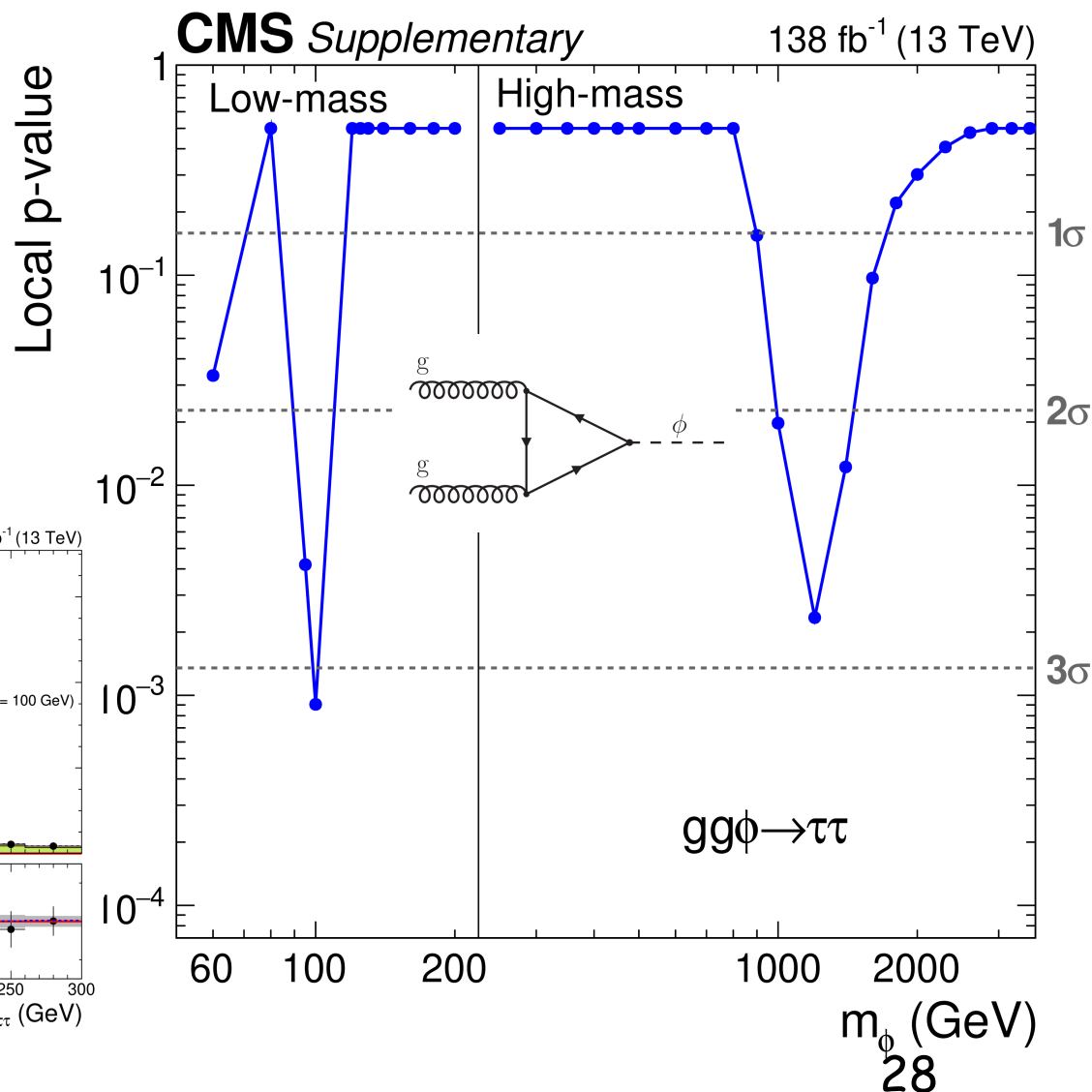
$$H \rightarrow \tau\tau$$

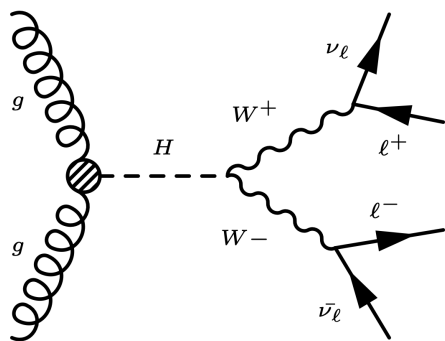
Event classification scheme

	No b-tag			b-tag		
$\tau\tau \rightarrow e\mu$	Low- D_ζ	Medium- D_ζ	High- D_ζ	Low- D_ζ	Medium- D_ζ	High- D_ζ
$\tau\tau \rightarrow e\tau_h$	Loose- m_T		Tight- m_T	Loose- m_T		Tight- m_T
$\tau\tau \rightarrow \mu\tau_h$	Loose- m_T		Tight- m_T	Loose- m_T		Tight- m_T
$\tau\tau \rightarrow \tau_h\tau_h$						
$t\bar{t}(e\mu)$						
	Signal region (SR)			Control region		

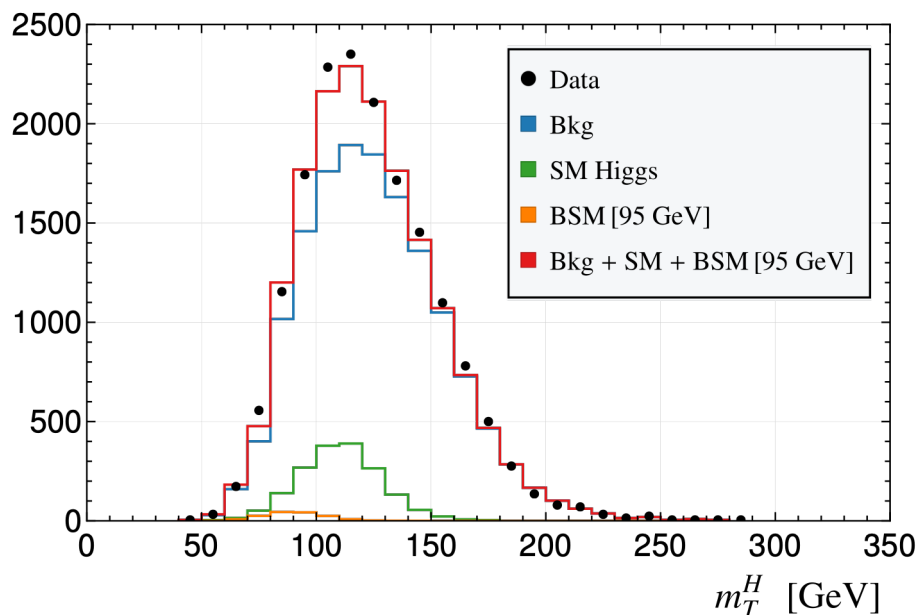


Dedicated search for scalar decaying into tau pairs. CMS observes a local (global) excess of 3.1 (2.7) σ at ~ 100 GeV.

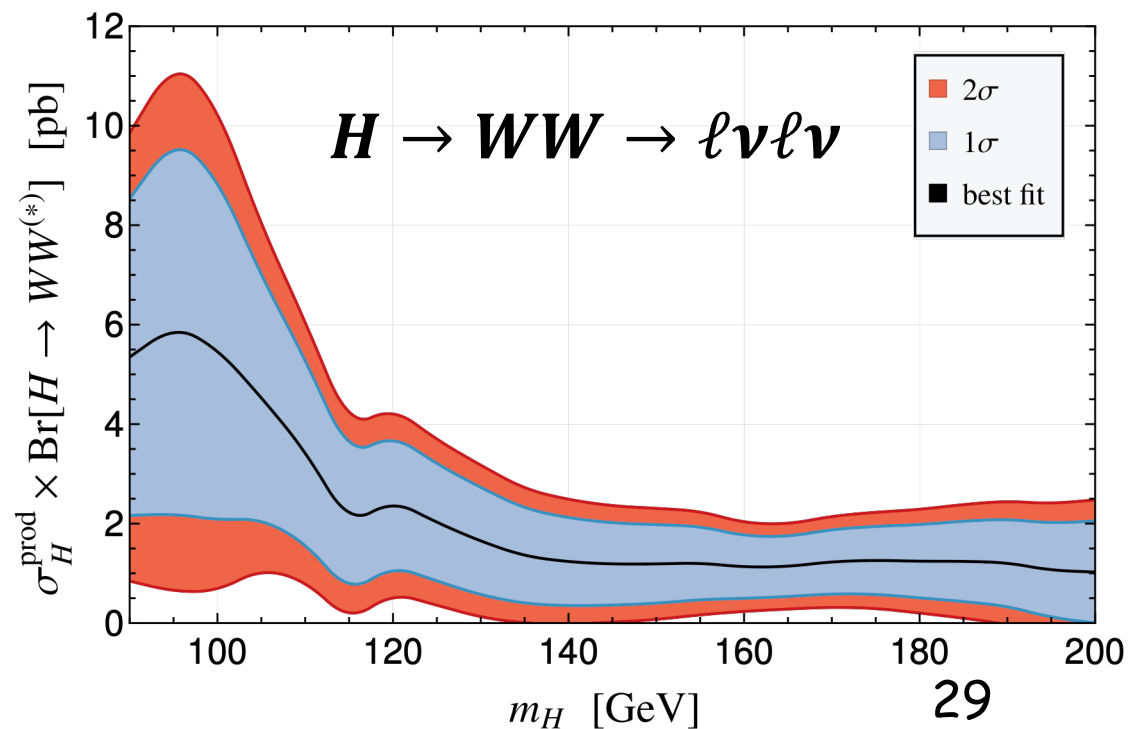
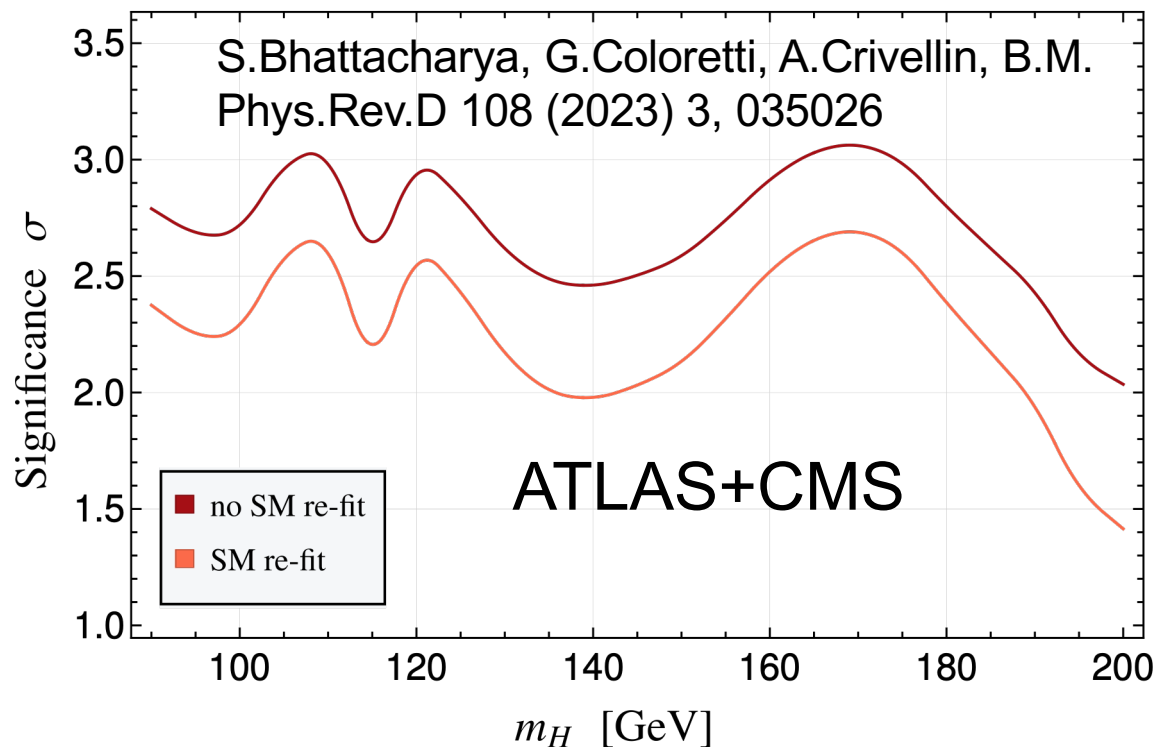




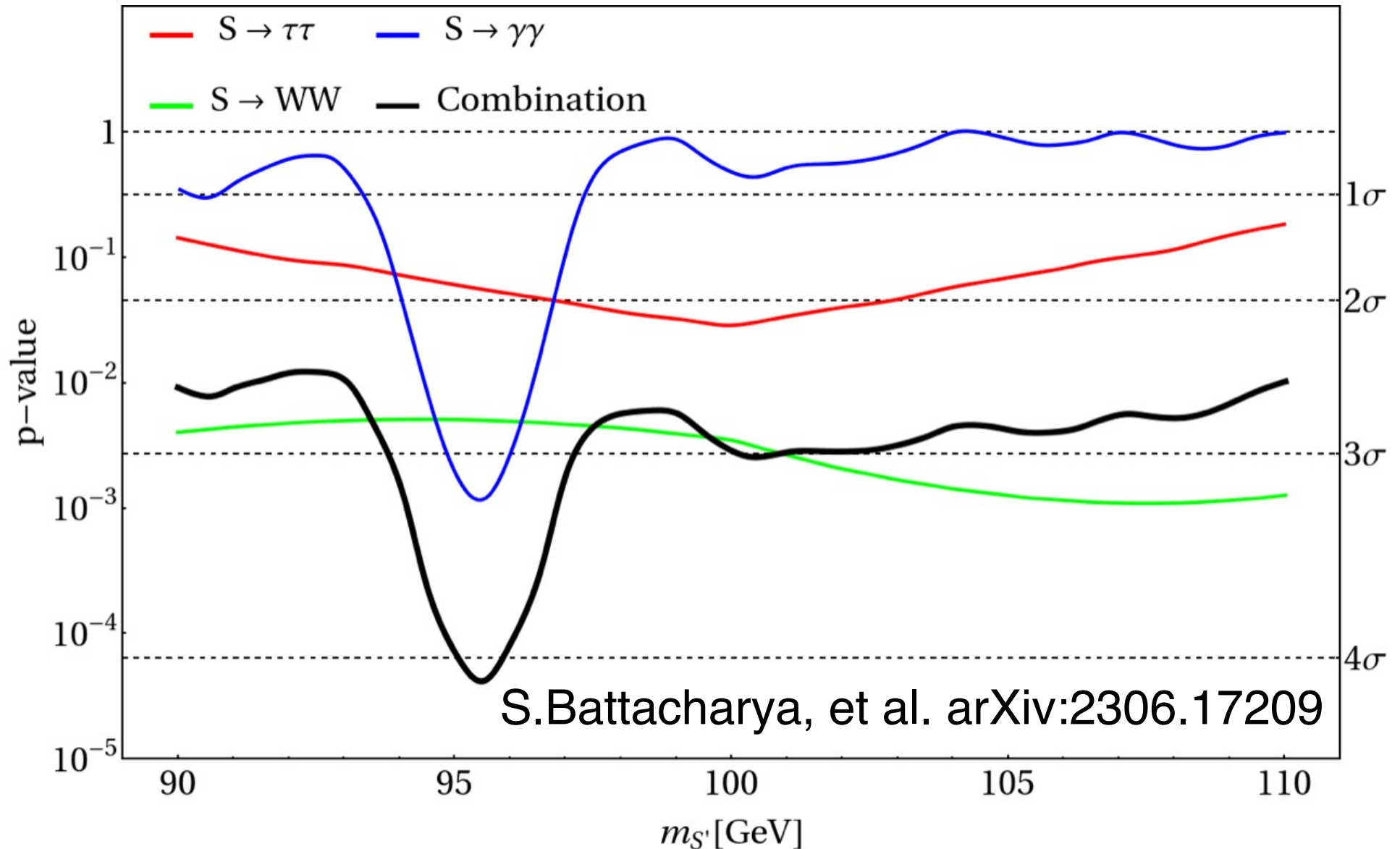
ATLAS



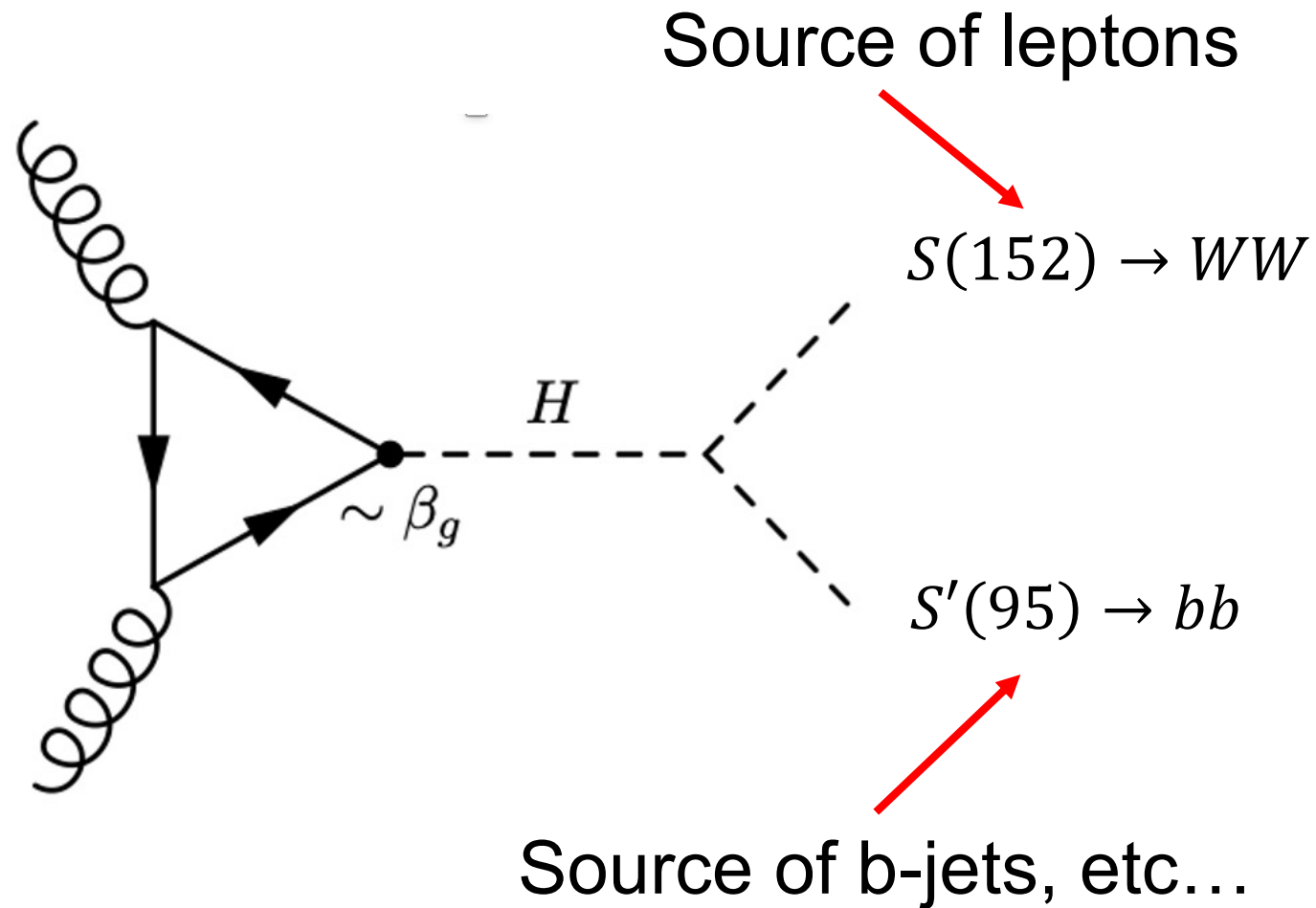
SM Higgs hypothesis alone. alone is having difficulty describing the $ll + \text{MET}$ transverse mass spectra, giving room to other Higgs-like signals. Compatibility with other signals under study.



With recent results reported by the ATLAS experiment the significance of a narrow resonance at 95 GeV has reached 3.8σ global significance.



Potential contributor to multi-lepton anomalies at the LHC



Criterion	125 GeV	750 GeV	95 GeV	152 GeV
Multiple final states	YES	No	YES	YES
Indirect evidence	YES	No	?	YES
Theoretical motivation and explanation	YES	?	YES	YES

The 750 GeV experience taught us that a large local significance is not sufficient. The situation at 95 and 152 GeV is qualitatively different. We have excesses appearing in different final states and experimental datasets.

More importantly, in the case of 152 GeV, the mass range was predicted from the multilepton anomalies before the narrow excess was identified.

Agentic AI for Particle Physics

The Complexity Ceiling

When data grows faster than understanding

Traditional workflows cannot absorb the scale, diversity and interdependence of modern data.

1 Data explosion



- Petabytes to exabytes
- Continuous streams

2 Heterogeneity



- Sensors, images, text
- Simulation + observation

3 Brittle workflows



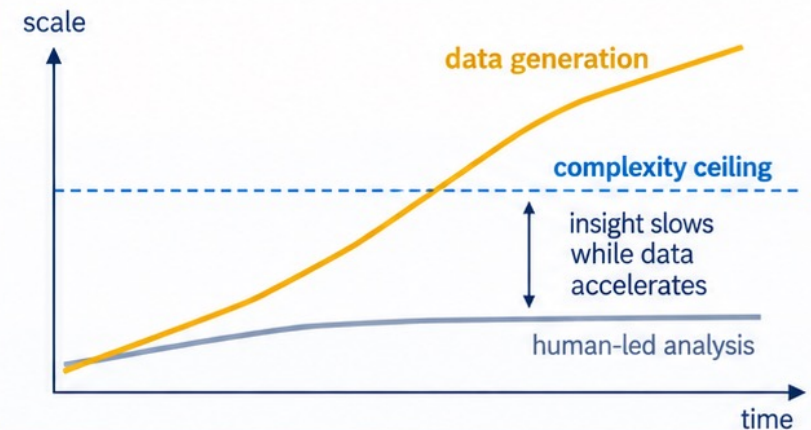
- Bespoke pipelines
- Hard to reuse or scale

4 Human bottleneck



- Scarce expertise
- Rising infrastructure cost

A crisis of scale and interpretation



The challenge is not only computational;
it is epistemic.



Message

Unless analysis itself evolves, the next generation of experiments may produce insights more slowly, less completely, or not at all.

What is Agentic AI?

AI systems that pursue goals by reasoning, planning, acting, and learning — with human oversight.



Definition

Agentic AI goes beyond answering prompts. It can break a goal into tasks, decide what to do next, use tools, evaluate results, and adapt its strategy.

How it works



Perceive

Takes in data, context, and instructions



Reason

Interprets the situation and identifies options



Plan

Chooses a sequence of actions



Act

Uses tools, software, or workflows



Reflect

Checks outcomes and improves the next step



Core characteristics

- Goal-directed
- Multi-step decision making
- Tool use and workflow execution
- Memory and context awareness
- Adaptation from feedback



Human role

Humans set objectives, define constraints, validate outputs, and remain responsible for critical decisions.



Why it matters for science

- Automates repetitive technical tasks
- Assists detector operations and monitoring
- Supports complex data-analysis workflows
- Improves efficiency while preserving traceability



In short: Agentic AI is an AI collaborator that can decide, act, and iterate toward a goal — not just respond once.

Agentic AI in Particle Physics: Selected References

Journal publications and arXiv preprints; presentations, proposals and proceedings excluded

Publications

1. Li et al., “AI agents, language, deep learning, and the next revolution in science,” *Front. Phys.* 21, 096401 (2026).
2. Nilsson et al., “MCP agents in PanDA,” *JINST* 21, C07030 (2026).
3. Hellert et al., “Agentic artificial intelligence for multistage physics experiments at a large-scale user facility particle accelerator,” *Phys. Rev. Research* 8, L012017 (2026).

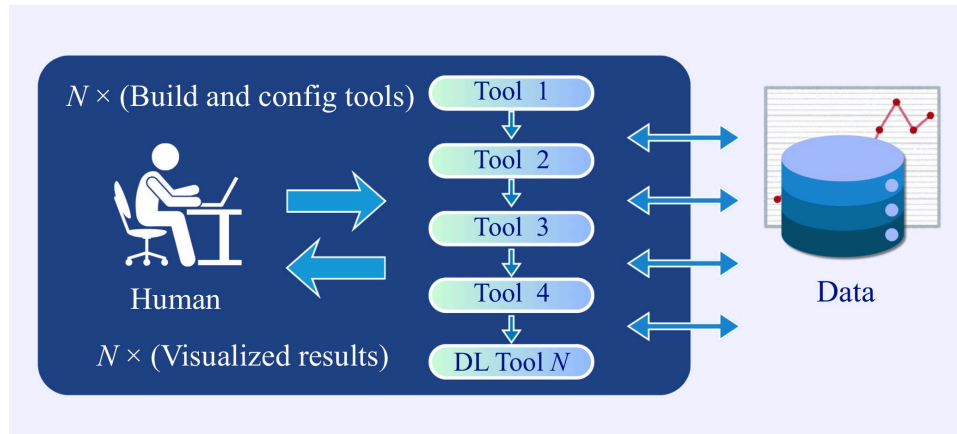
arXiv Preprints

1. He et al., “Dr.Sai: An agentic AI for real-world physics analysis at BESIII,” arXiv:2604.22541 (2026).
2. Jiao et al., “HepScript: A Dual-Use DSL for Human-AI Collaborative Data Analysis Workflows in HEP,” arXiv:2605.01423 (2026).
3. Lugato et al., “Archi: Agentic Operations at the CMS Experiment,” arXiv:2606.04755 (2026).
4. Gendreau-Distler et al., “Automating High Energy Physics Data Analysis with LLM-Powered Agents,” arXiv:2512.07785 (2025).
5. Moreno et al., “AI Agents Can Already Autonomously Perform Experimental High Energy Physics,” arXiv:2603.20179 (2026).
6. Badea et al., “Agentic AI–Physicist Collaboration in Experimental Particle Physics,” arXiv:2603.05735 (2026).
7. Hill and Ryoo, “GRACE: an Agentic AI for Particle Physics Experiment Design and Simulation,” arXiv:2602.15039 (2026).
8. Menzo et al., “HEPTAPOD: Orchestrating High Energy Physics Workflows Towards Autonomous Agency,” arXiv:2512.15867 (2025).
9. Qiu et al., “An End-to-end Architecture for Collider Physics and Beyond,” arXiv:2603.14553 (2026).
10. Menzo et al., “Agentic Diagrammatica: Towards Autonomous Symbolic Computation in HEP,” arXiv:2603.26990 (2026).

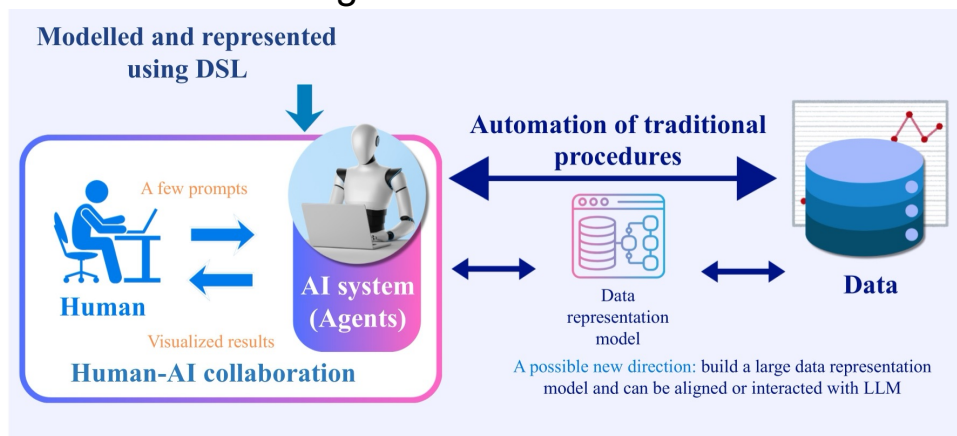
Selected sources current to September 2026

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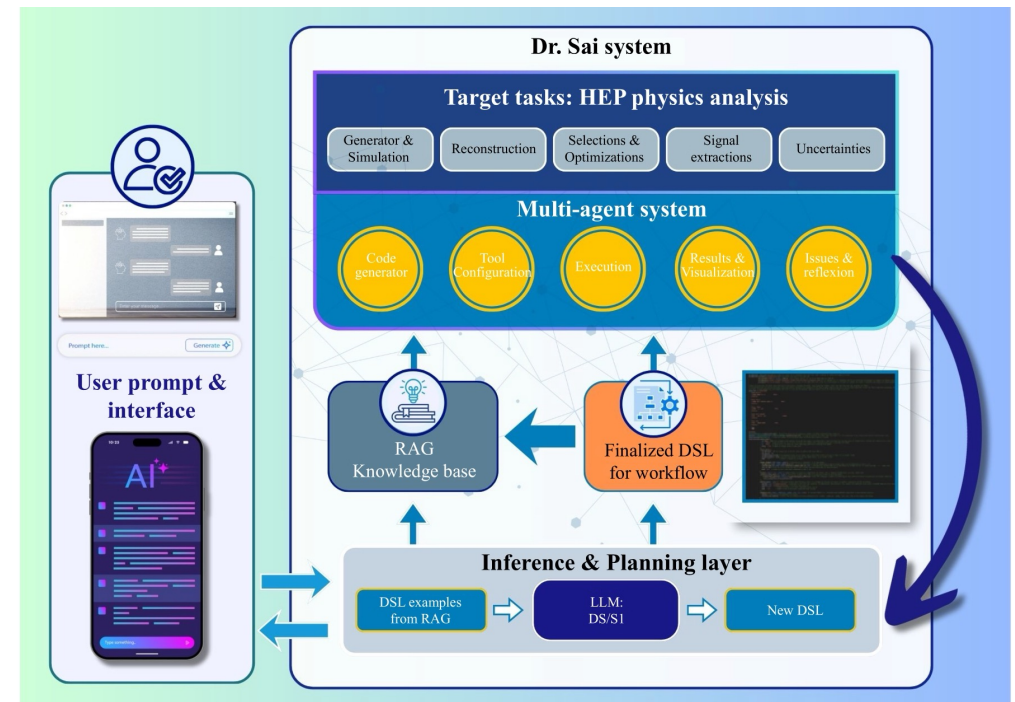
Old paradigm: Manual, tool-based analysis where humans configure and manage each stage of the data pipeline, an increasingly unsustainable model as scientific data and complexity expand.



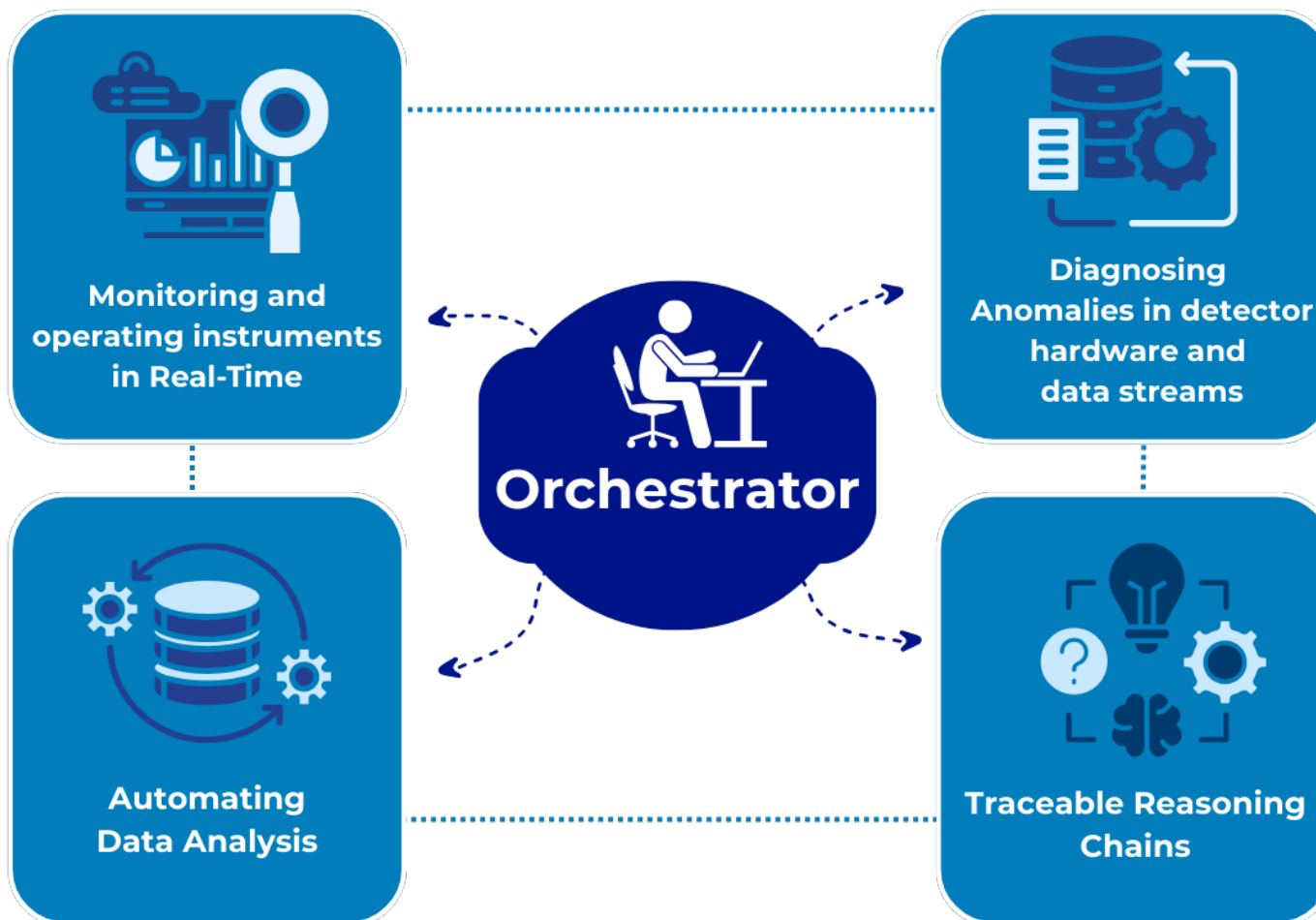
A new paradigm: Human–AI collaboration via domain-specific languages enables automation of traditional analysis while preserving transparency and human oversight.



Dr. Sai stands at the core of this transformation



Agentic AI Scientific Discovery System



Operations and Maintenance: The Intelligent Co-Pilot

- ❑ **The Manpower Challenge:** HL-LHC Phase-II upgrades place immense long-term pressure on collaboration groups, with experts stretched thin across maintenance and analysis duties.
- ❑ **Cognitive-Heavy Workflows:** Experts currently spend vast amounts of time on control room software, monitoring panels, and detector recovery procedures.
- ❑ **Dr.Sai's Role:** Acts as an Intelligent Co-pilot rather than a replacement for human experts — augmenting capability, not replacing judgment.
- ❑ **Formalized Knowledge:** Transforms operational expertise and manuals into structured, executable workflows that can be automated and reproduced consistently.
- ❑ **Human-AI Collaboration:** Automates repetitive tasks while assisting humans in real-time reasoning and decision-making during critical operations.
- ❑ **Core Value:** Ensures the traceability and reproducibility of all operational decision processes — essential for scientific rigor.

Intelligent Data Quality Monitoring (DQM)

The Challenge

- ❑ **The Critical Filter:** DQM is a vital shift task ensuring recorded data meets rigorous standards required for physics analysis.
- ❑ **Traditional Bottleneck:** Relies heavily on manual histogram checks and multi-subsystem assessments — slow, error-prone, and fatiguing.
- ❑ **Alert Fatigue:** High false-positive rates from simple threshold alarms lead to experts ignoring or delaying critical interventions.

Dr.Sai Enhancement

- ❑ **Formalized Indicators:** Converts monitoring metrics into machine-readable objects within automated workflows.
- ❑ **Smart Recognition:** Utilizes rule-based and ML methods to identify significant deviations and rare anomalies automatically.
- ❑ **Decision Support:** Assists shifters in determining if human intervention is necessary, reducing alert fatigue significantly.
- ❑ **Outcome:** Increases inspection efficiency, reduces human workload, and standardizes anomaly identification across all shifts.

Physics Analysis: Multi-Agent Collaboration

Agent Architecture

Planner Agent

Task decomposition
and workflow orchestration

Coder Agent

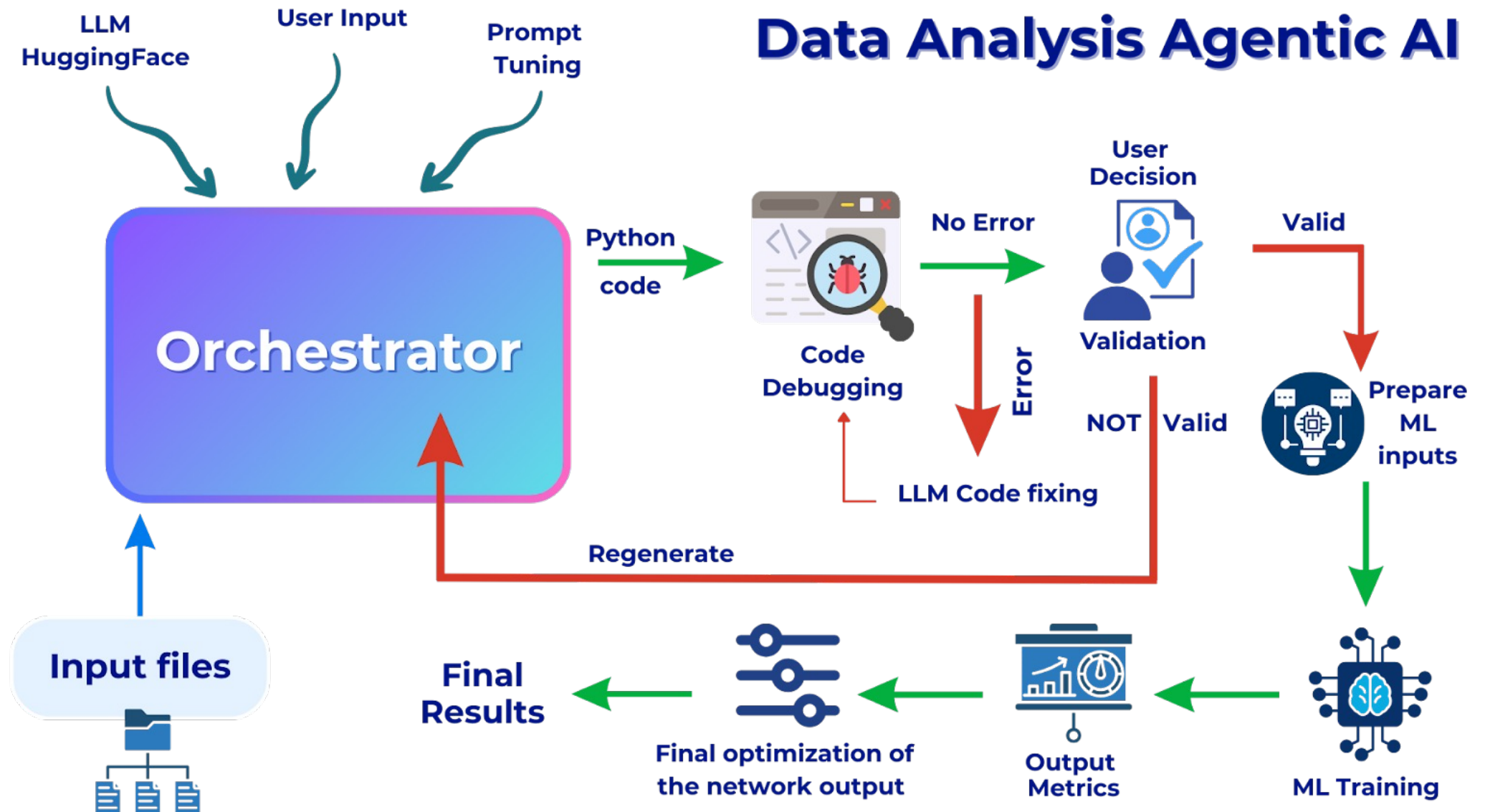
Automated code generation
and job submission

Reflector Agent

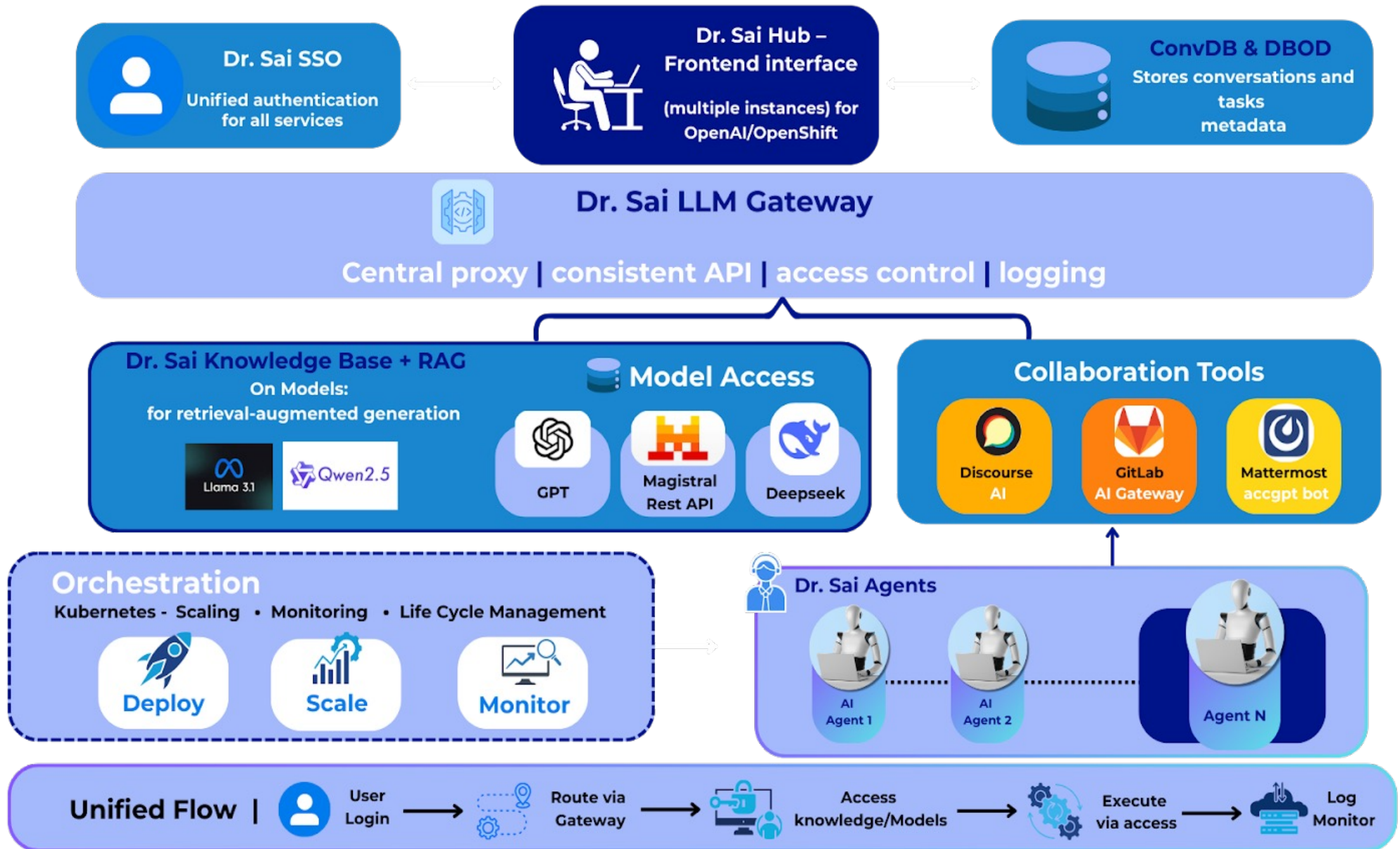
Optimization, improvement,
and introspection

- ❑ **Complexity and Scale:** Physics analysis involves PB-scale data, distributed computing, and strict requirements for traceability and reproducibility across global collaborations.
- ❑ **Grid Computing Diagnosis:** Dr.Sai identifies logic errors, site-level failures, and memory overflows to automatically trigger job resubmissions without human intervention.
- ❑ **End-to-End Automation:** The Workflow Manager + Multi-Agent design enables seamless automation from raw data ingestion to final physics results.

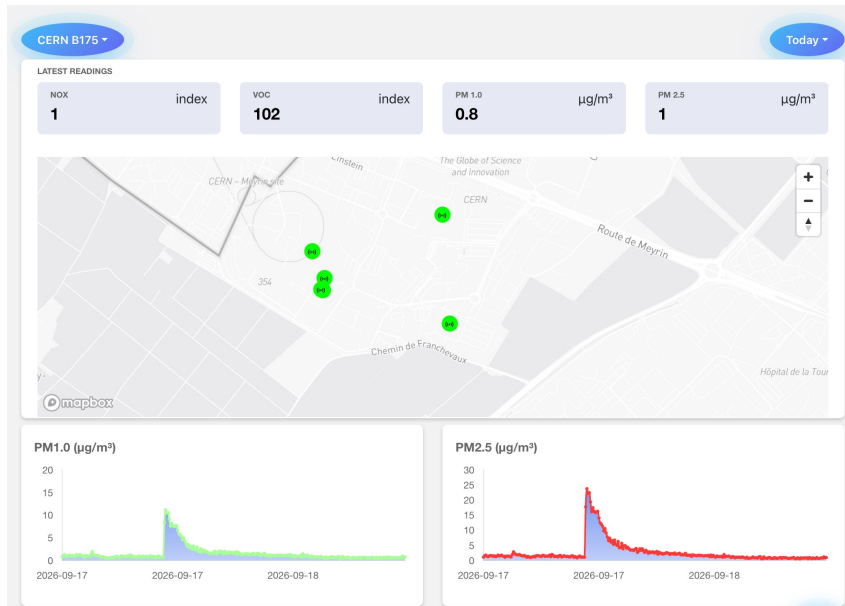
Data Analysis Agentic AI



Dr Sai AI Agent Infrastructure



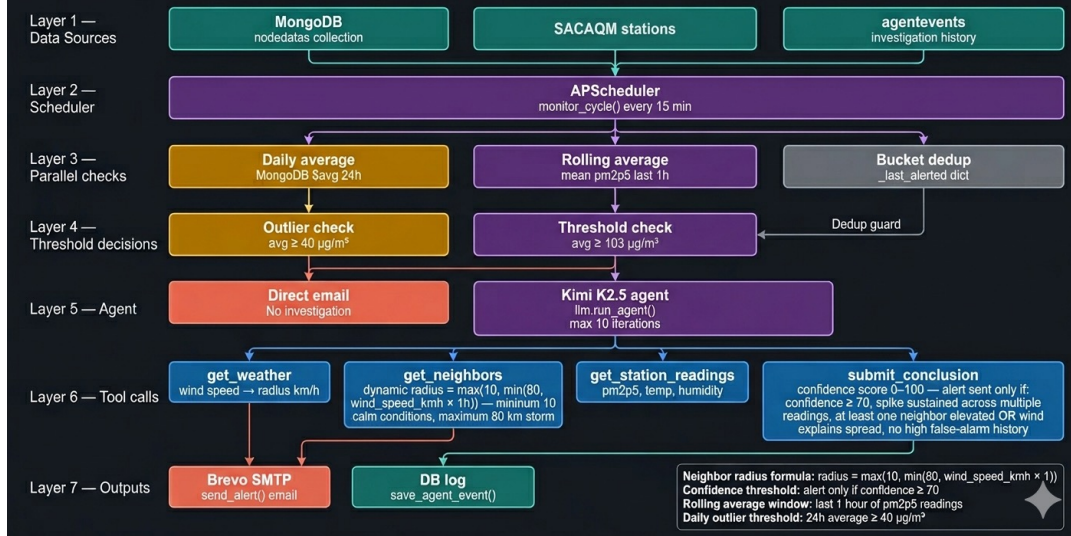
Showcase: Environmental sensing at CERN



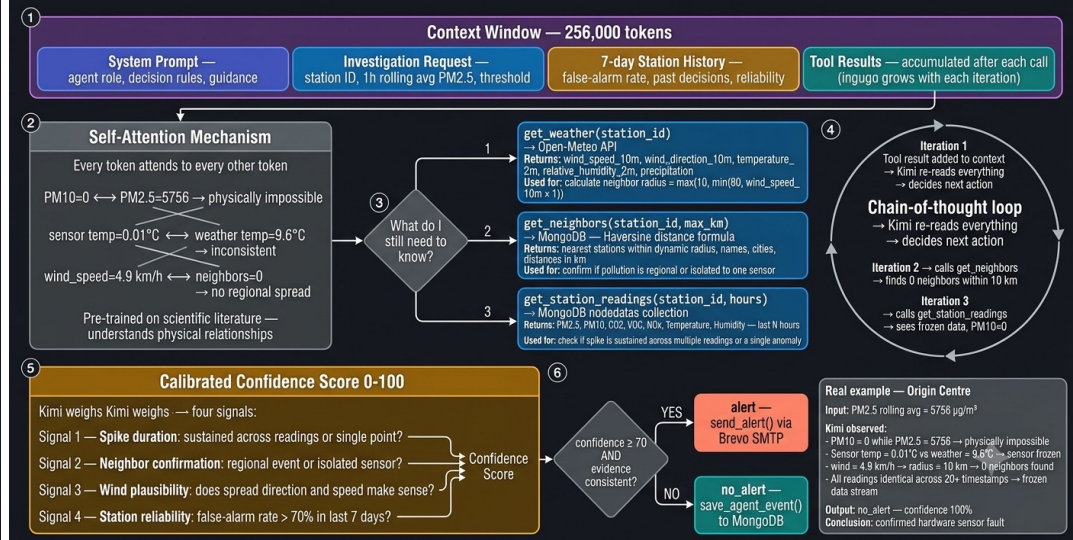
Environmental spikes and alerts handled by Agentic AI
Use several models, such as Kimi, Claude and others.

Agent constrained to a limited number of queries and tasks

SACAQM AI Agent — Technical Architecture



How Kimi K2.6 Reasons — Internal Mechanism

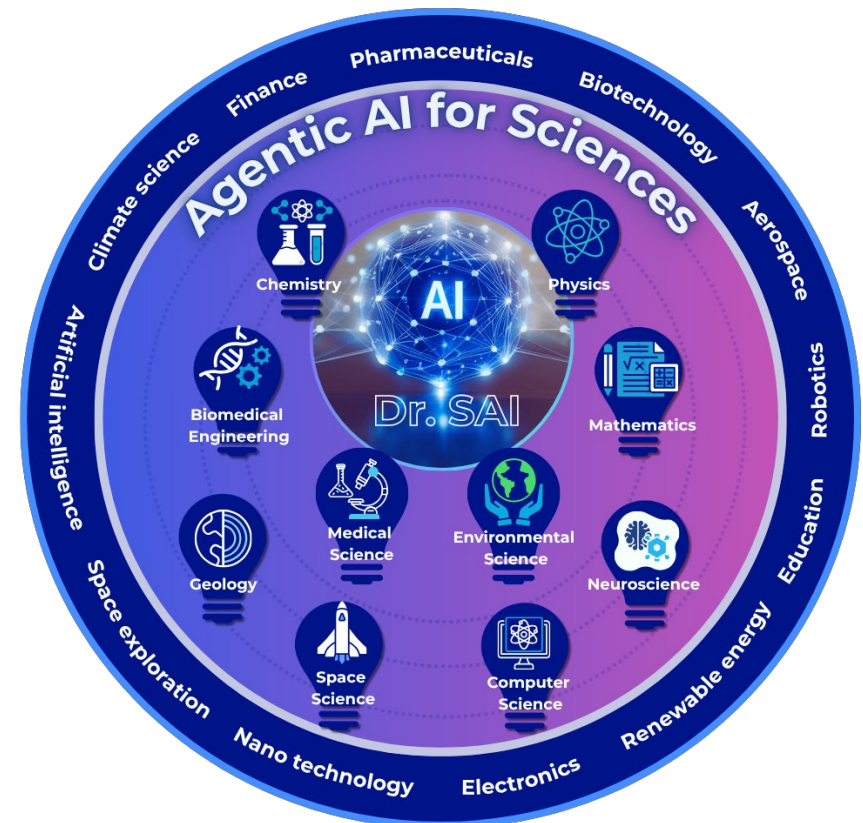


Industry Relations and Technology Transfer

- ❑ **Transferable Core Technologies:** Dr.Sai's formalized knowledge workflows, multi-agent task decomposition, and DQM anomaly detection are domain-agnostic and directly applicable wherever large-scale data quality and operational automation matter.

Partnership Pathways

Joint R&D with AI and tech companies
Licensing the Dr.Sai workflow engine
Spin-off ventures targeting smart factory ops
Government funding for dual-use AI infra



Outlook and Conclusions

- ❑ **Strong signs of new bosons** are emerging in LHC data
 - ❑ The **152 GeV candidate** is now **solidly above 5σ** with **Run 2 data**
 - Confirmation with Run 3 data underway
 - First hint available in Run 3 with $\gamma\gamma jj$ final state
 - ❑ Run 3 data will be decisive to establish **95 GeV candidate signal**
- ❑ This may be the first clear step **beyond the Standard Model Higgs sector**
- ❑ **Agentic AI** is becoming essential for data-intensive science
 - ❑ It will transform how we **operate instruments, analyze data**, and make discoveries.