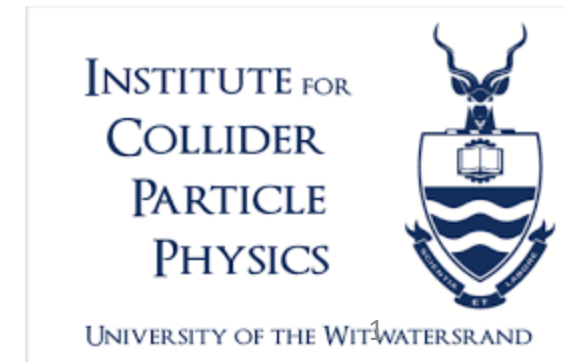


Evaluation of the significance of a scalar candidate at 95 GeV at the Large Hadron Collider (LHC)

Thabo Pilusa, Bruce Mellado, Mukesh Kumar, Srimoy Bhattacharya
University of the Witwatersrand, ICPP

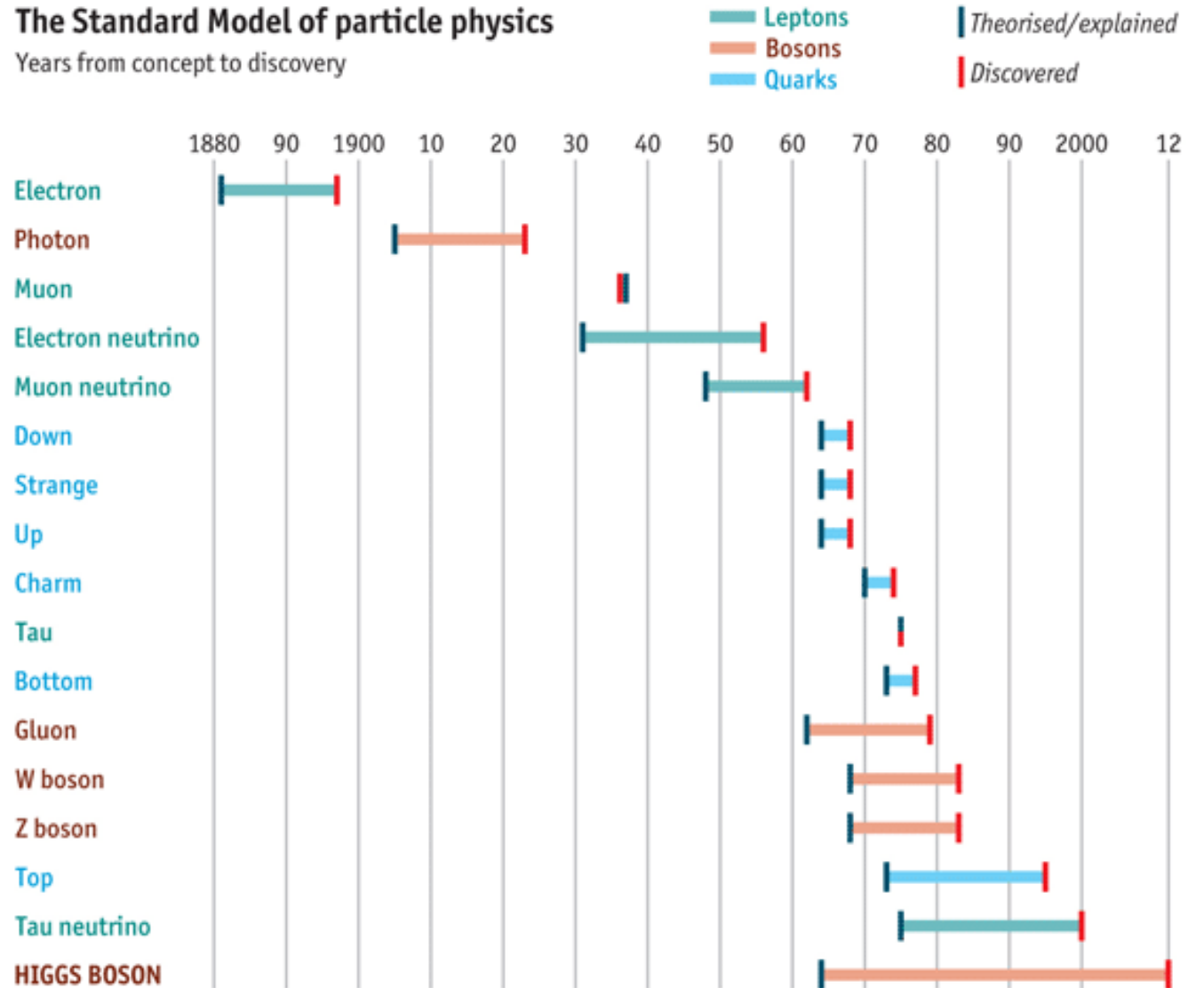


outline

- LEP 95 GeV excess
- ATLAS and CMS excess
- Connection between ATLAS and CMS

The Standard Model of particle physics

Years from concept to discovery



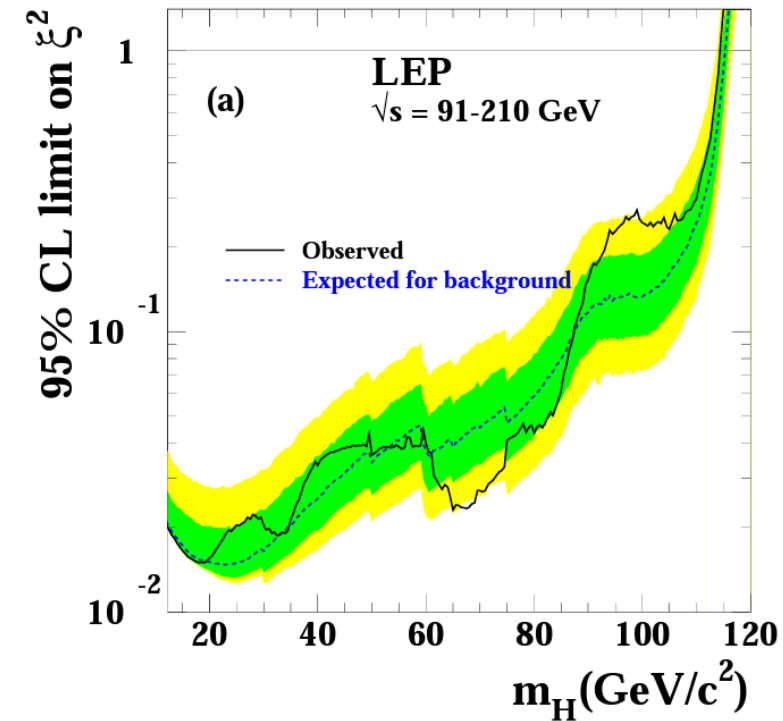
Source: *The Economist*

The four LEP collaborations, ALEPH, DELPHI, L3 and OPAL for the search of the SM Higgs boson

LEP combined all the SM Higgs-like decay modes

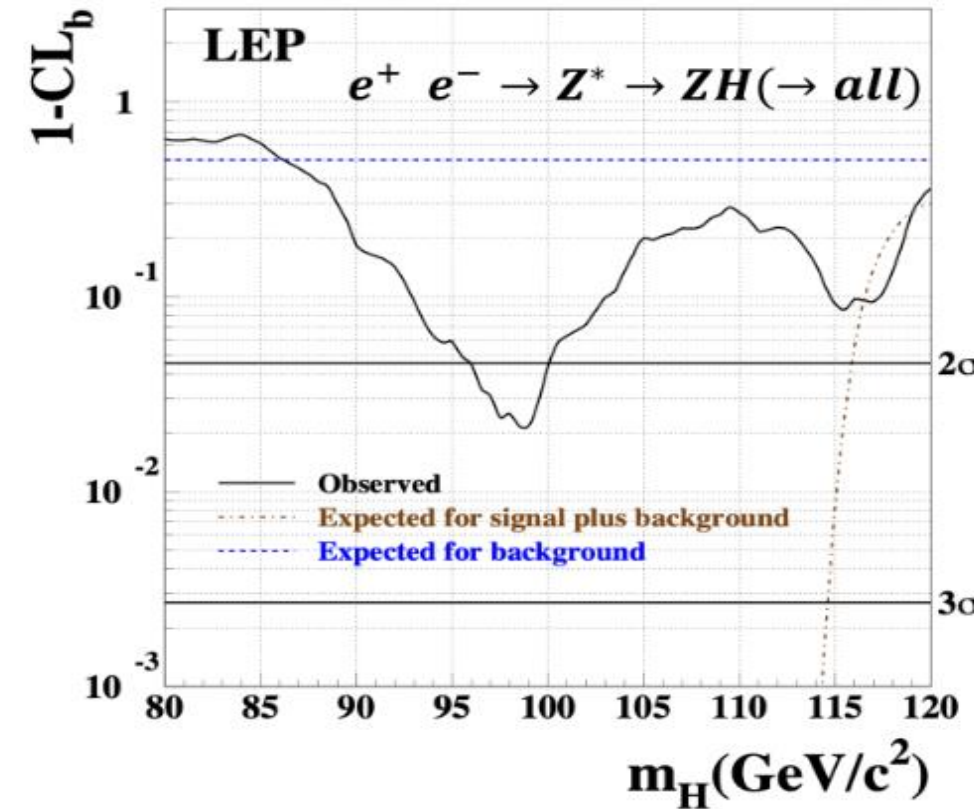
local significance of 2.3σ

CERN-EP/2003-011LEP, Phys. Lett. B 565 (2003) 61–7



How you got the p-values from significance??

Numerically using ROOT!

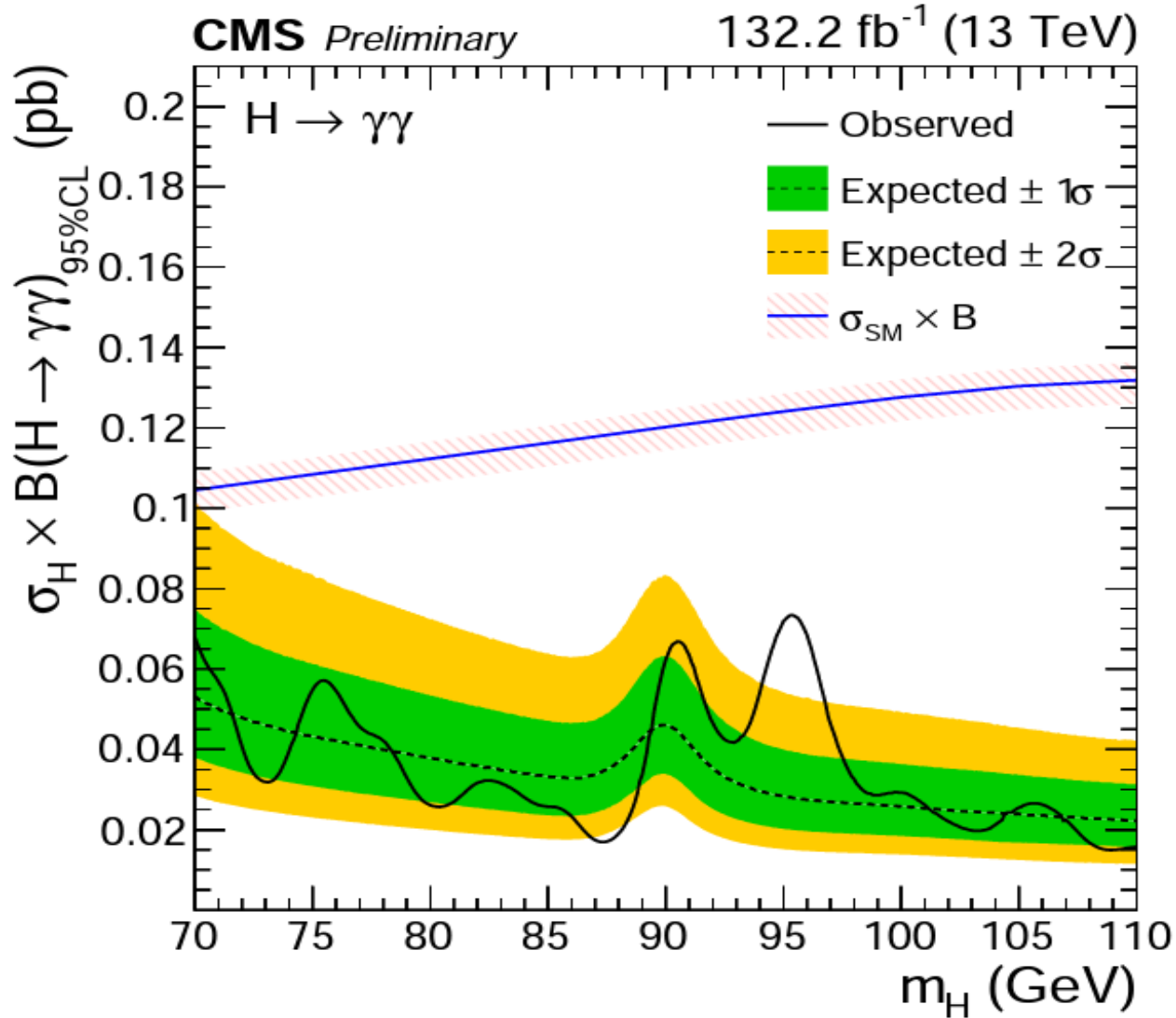


$$\xi^2 = (g_{HZZ}/g_{HZZ}^{\text{SM}})^2$$

A large circular particle detector, likely ATLAS or CMS, is shown under construction. The detector is a massive cylindrical structure with a complex internal structure. In the foreground, two workers wearing hard hats and safety gear are sitting on the floor, looking at a large sheet of paper, possibly a blueprint or technical drawing. The detector's interior is filled with various components, including cables, pipes, and structural elements. The overall scene is dimly lit, with the primary light source coming from the center of the detector, creating a dramatic effect. The text "ATLAS AND CMS EXCESS AT 95 GeV" is overlaid on the left side of the image in a large, white, sans-serif font. A small orange horizontal bar is located above the text. In the bottom right corner, there is a small number "4" and a line of text: "This Photo by Unknown author is licensed under CC BY."

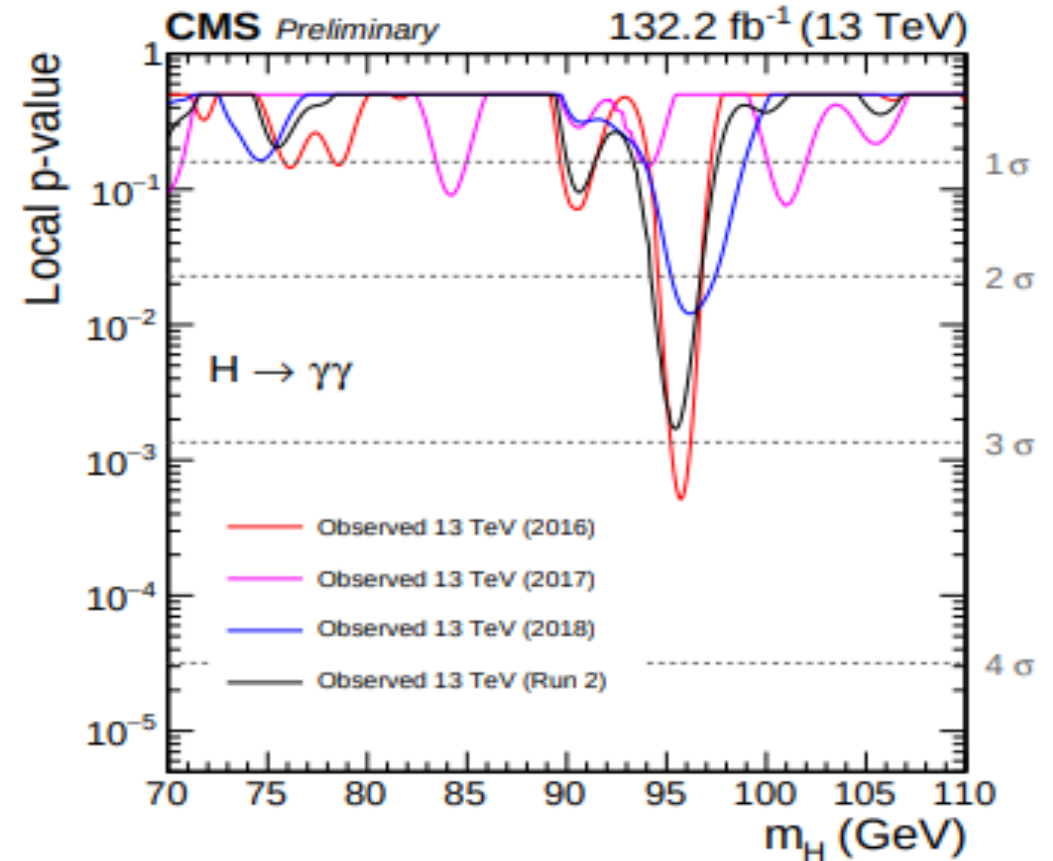
ATLAS AND CMS EXCESS AT 95 GeV

Search for SM Higgs-like boson with categorization assuming SM-like production mechanisms (ggF, VBF, VH, ttH)



CMS, PLB 793 (2019) 320
 CMS-PAS-HIG-20-002

$H \rightarrow \gamma\gamma$

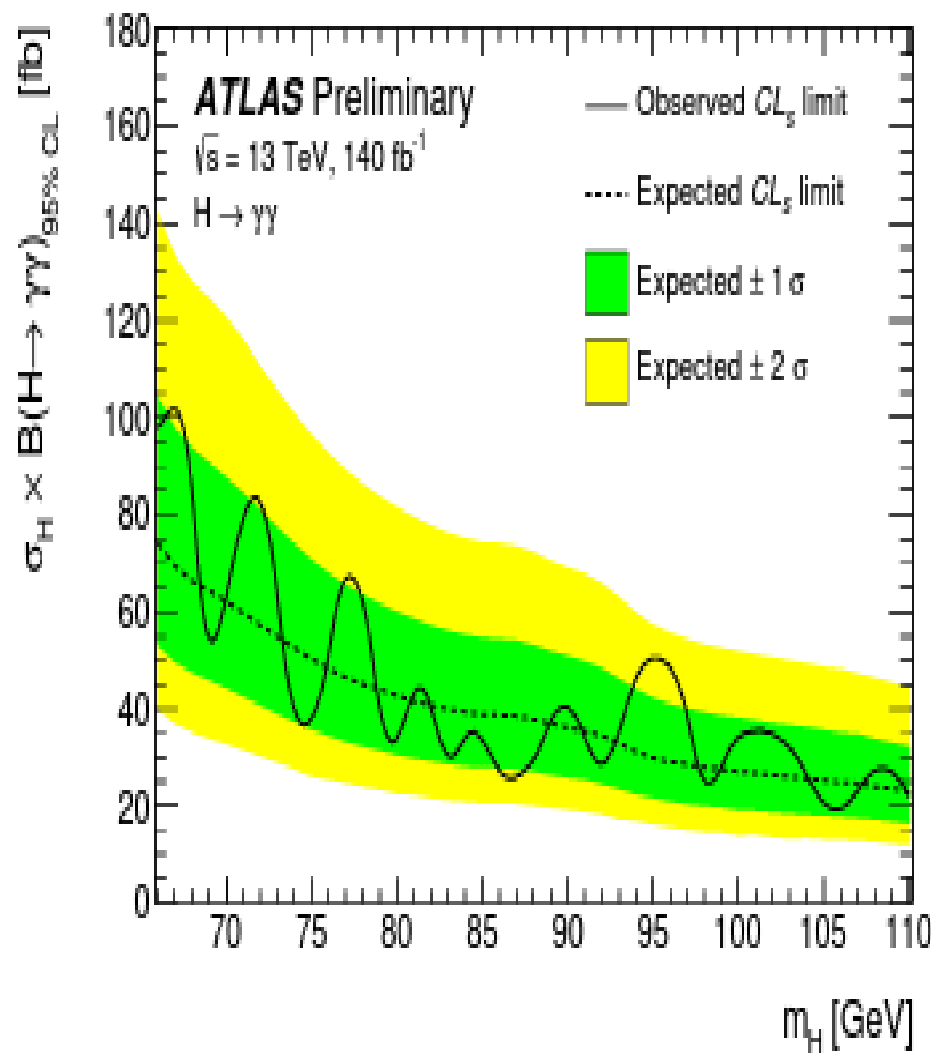
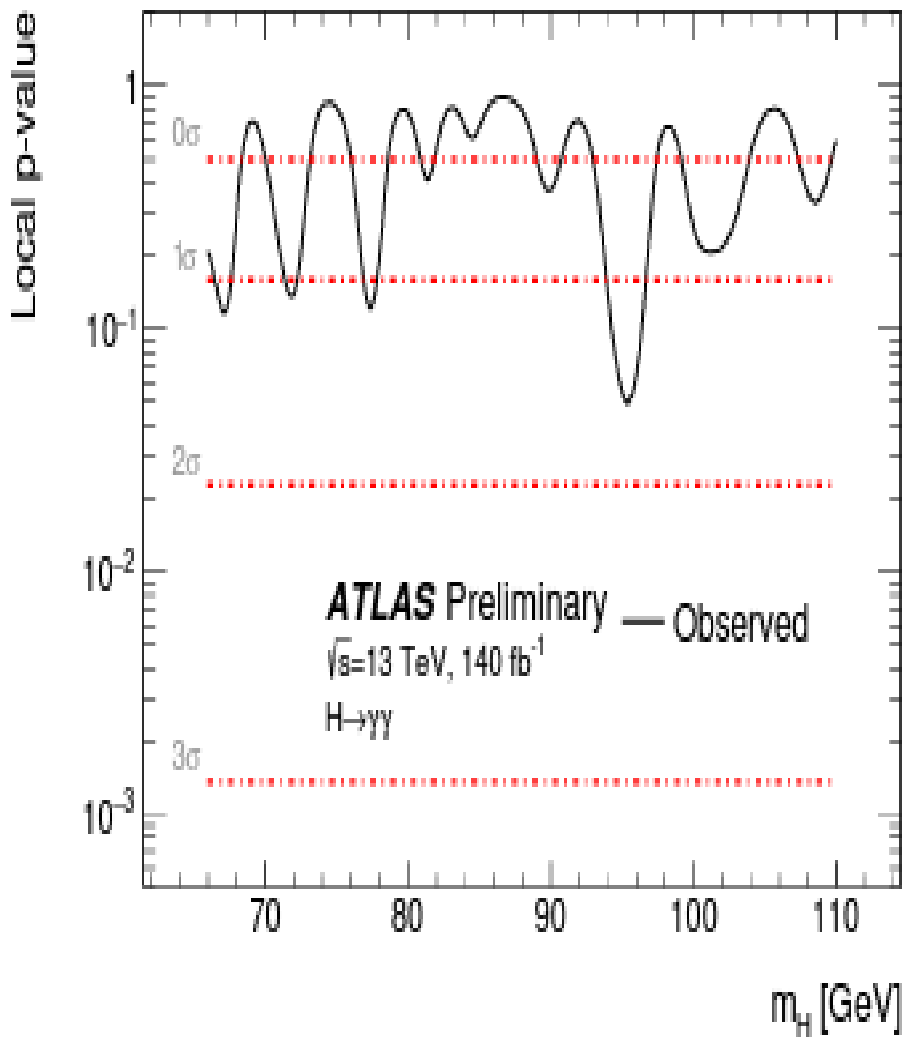


Local 2.9 σ @95.4 GeV

Purely inclusive search with classification according to photon conversions (UU,UC,CC). ATLAS has less sensitivity compared to CMS and does not exclude the excess.

ATLAS-CONF-2023-035

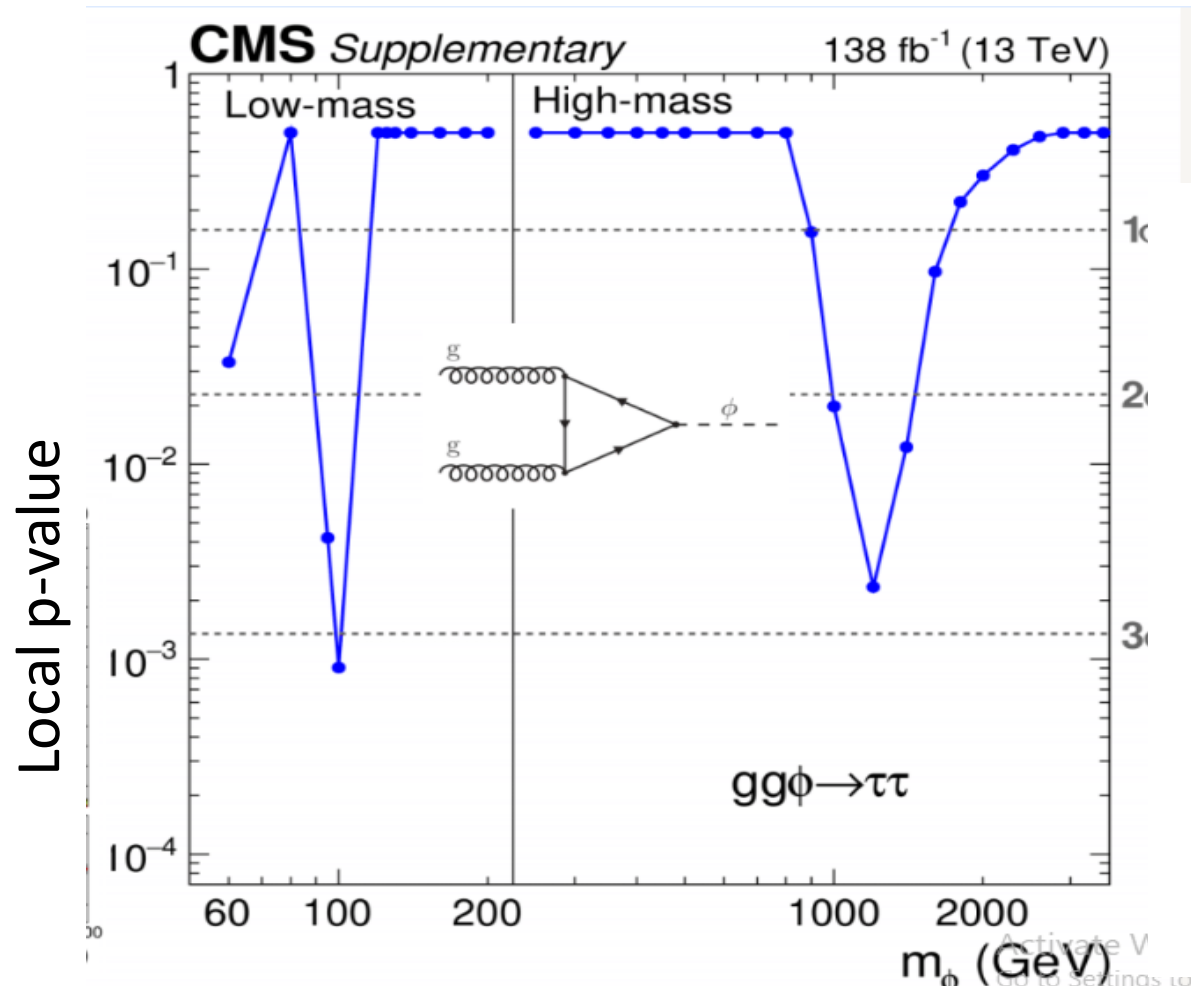
$H \rightarrow \gamma\gamma$



At 95.4 GeV, there is a local significance of 1.7σ

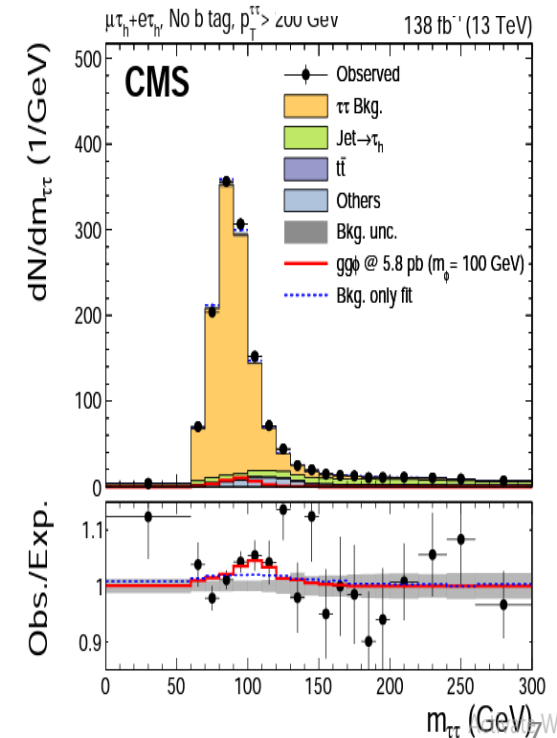
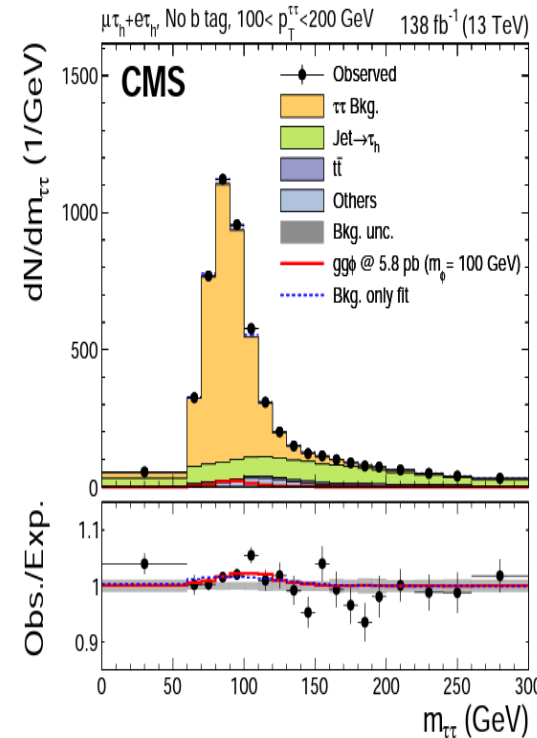
Dedicated search for scalar decaying into tau pairs.

CMS observes a **local (global) excess of 3.1 (2.7) σ** at ~ 100 GeV



CMS, arXiv:2208.02717

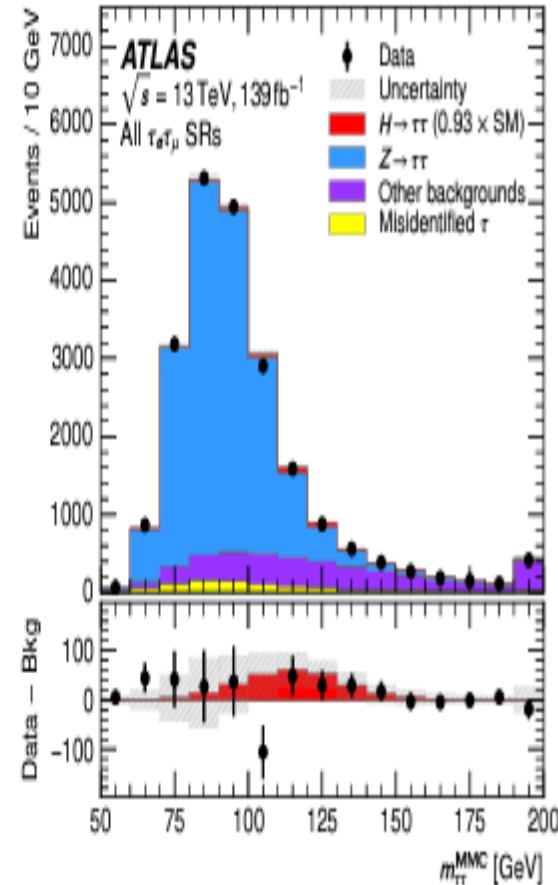
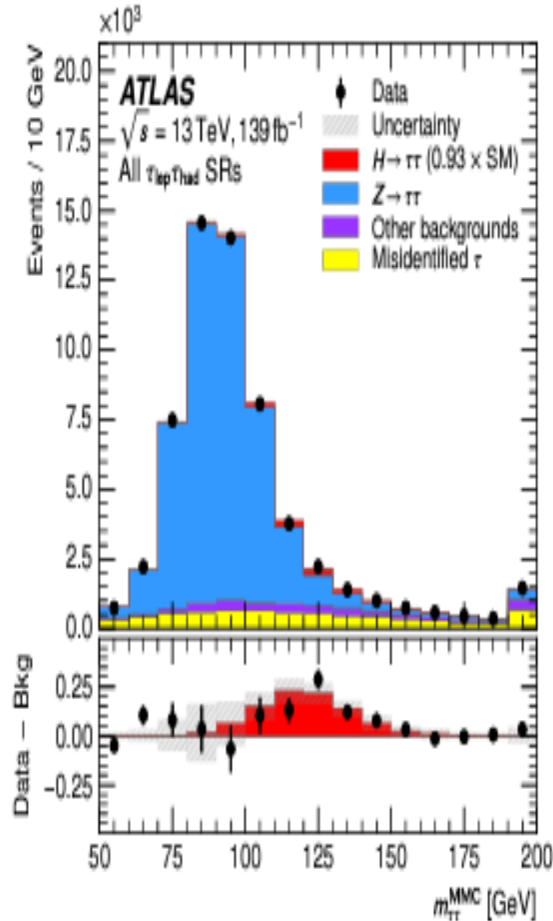
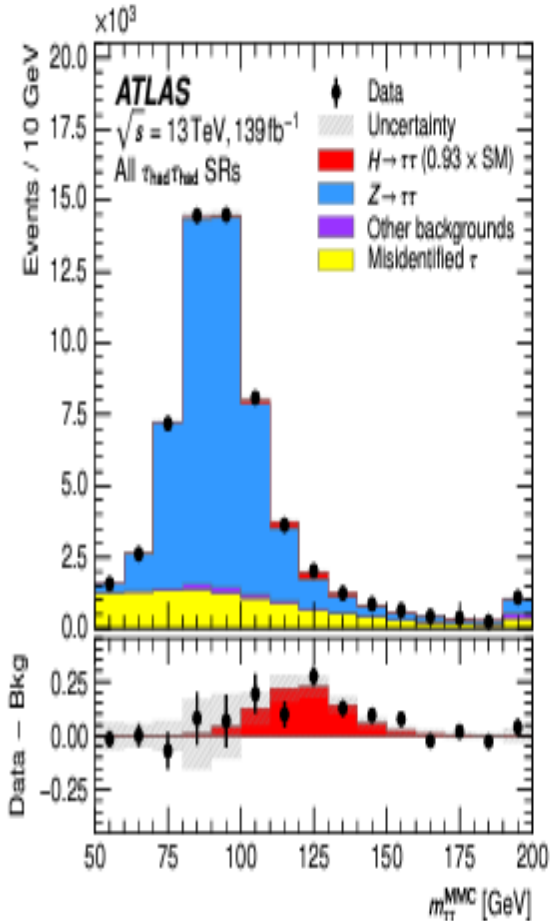
$H \rightarrow \tau\tau$



ATLAS measurements of Higgs boson cross section in $H \rightarrow \tau\tau$ decay channel

arXiv:2201.08269

$H \rightarrow \tau\tau$

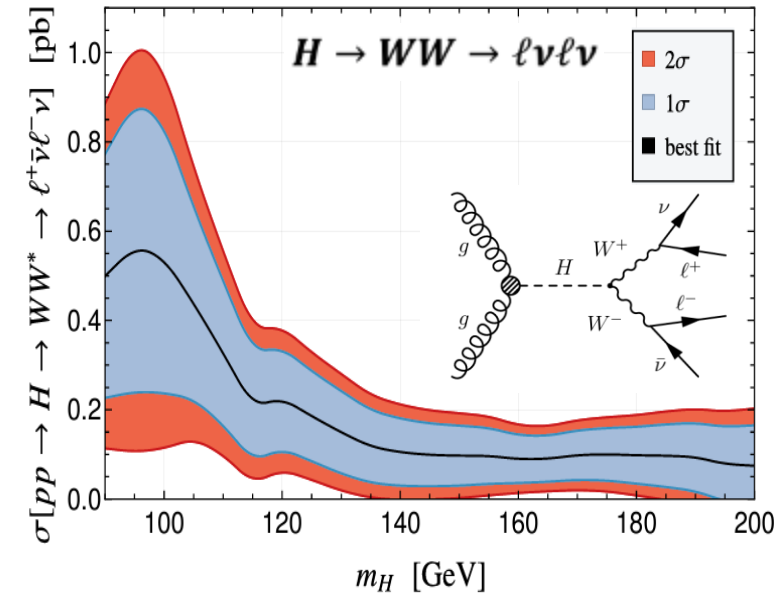
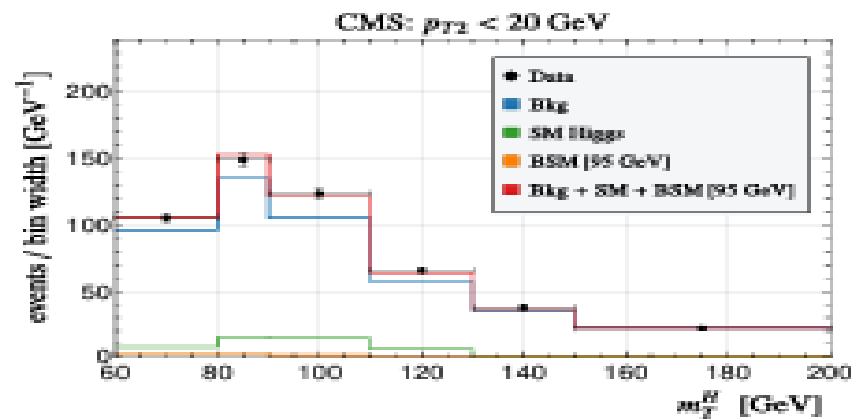
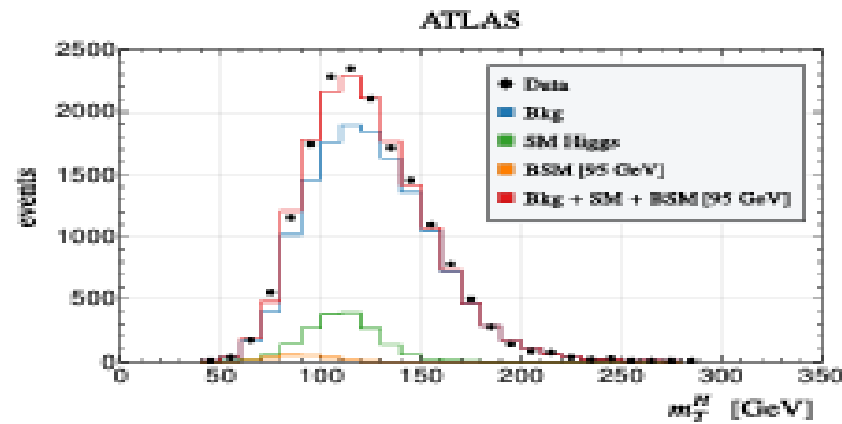
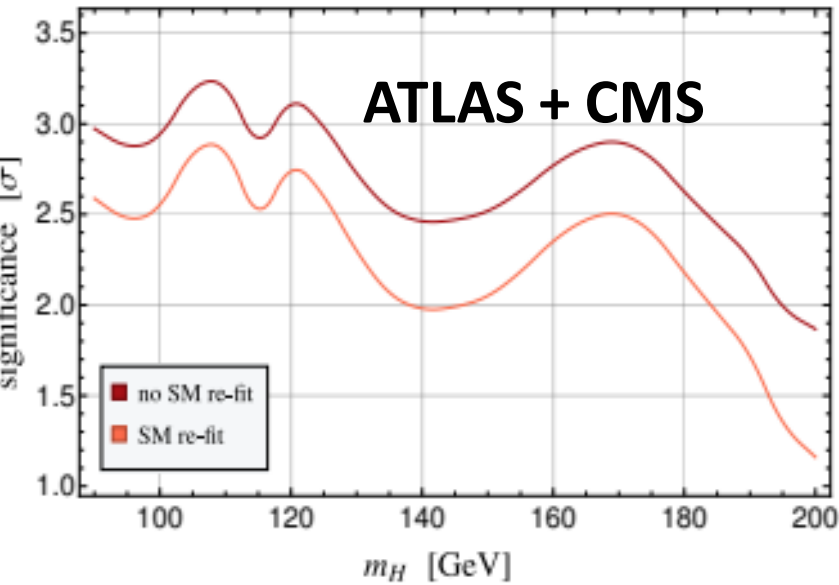


ATLAS didn't perform an explicit search in this mass range

We therefore treat this as a null result which reduces the significance of the CMS excess by a factor of $\sqrt{2}$, assuming that the ATLAS and CMS analyses have similar sensitivity.

We used the combined transverse mass distributions from ATLAS and CMS to find an excess with local significance of $\approx 2.6\sigma$

S.Bhattacharya, G.Coloretti,
A.Crivellin, B.Mellado
arXiv:2302.07276



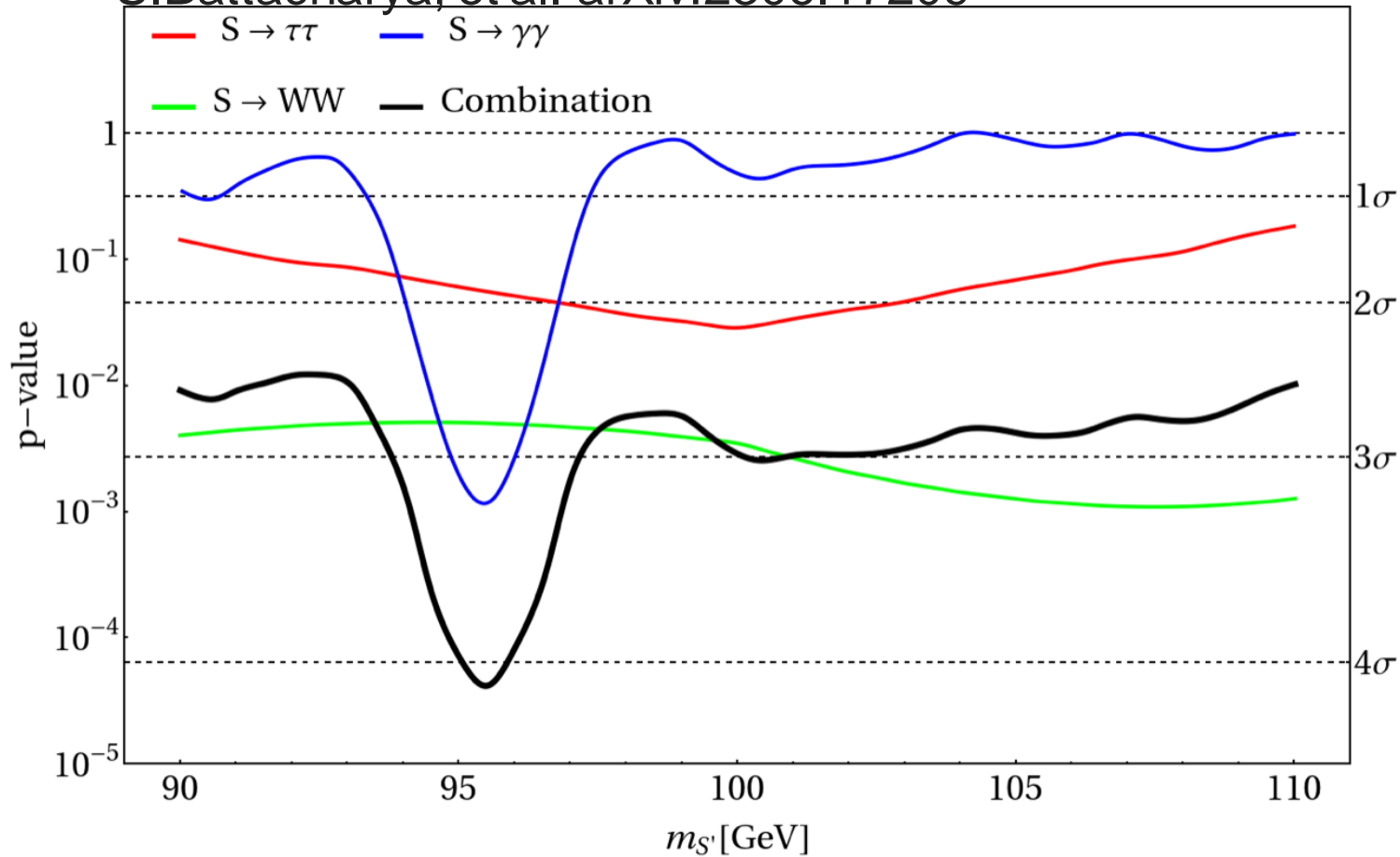
Largest cross section
around 95 GeV



For the first time, we combine the hints for a 95 GeV scalar

$$X_{2k}^2 = -2 \sum_{i=1}^k \log(p_i),$$

S.Battacharya, et al. arXiv:2306.17209



- We use *Fisher's* method for p-values combination
- Blue, Red and Green curves are combinations of ATLAS and CMS in their respective final states
- The Black curve is the combination of all the three curves with 3 degrees of freedom
- local excess of 4.1 σ

summary



we combined the hints for the presence of a scalar at $m_s \approx 95$ GeV



This opens the possibility of a decay chain explaining the multi-lepton anomalies.



More searches and analysis to see if this ever passes 5σ

The background of the slide is a dark, monochromatic image of numerous interlocking gears of various sizes, creating a complex, mechanical pattern. The gears are rendered in shades of dark gray and black, with some highlights that give them a three-dimensional appearance. The overall effect is one of precision and interconnectedness.

Thank You

email: thabo.pilusa@cern.ch