ATLAS new physics Highlight

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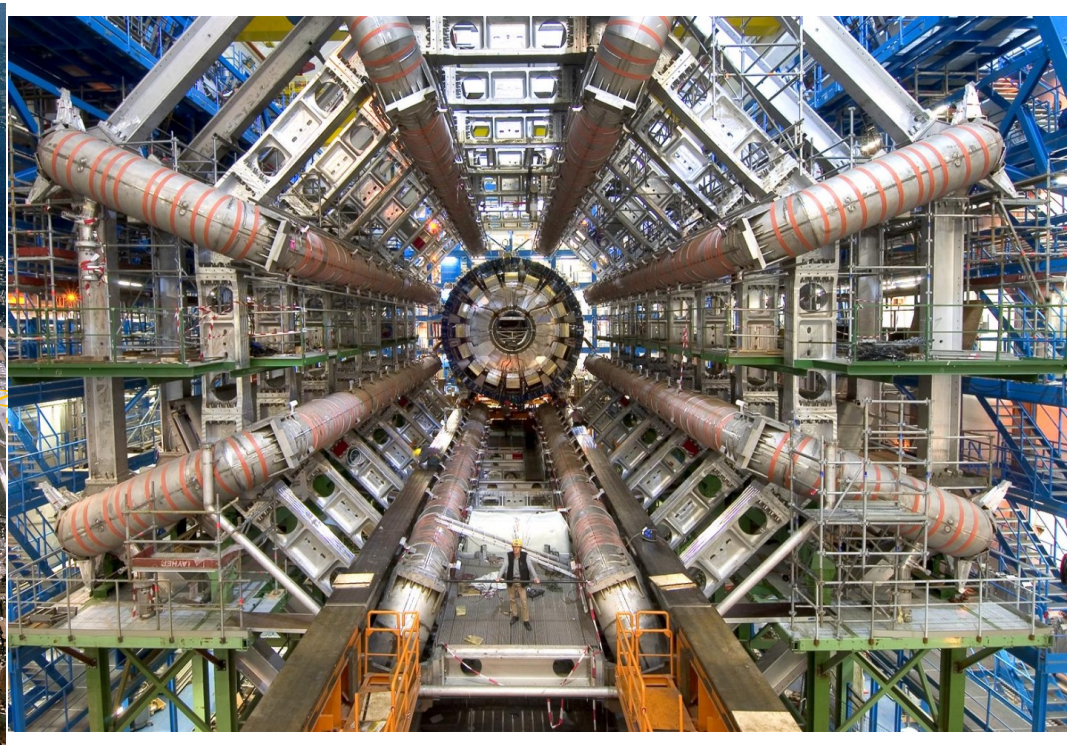
on behalf of ATLAS China group

梁志均，中国科学院高能物理研究所
代表ATLAS中国组

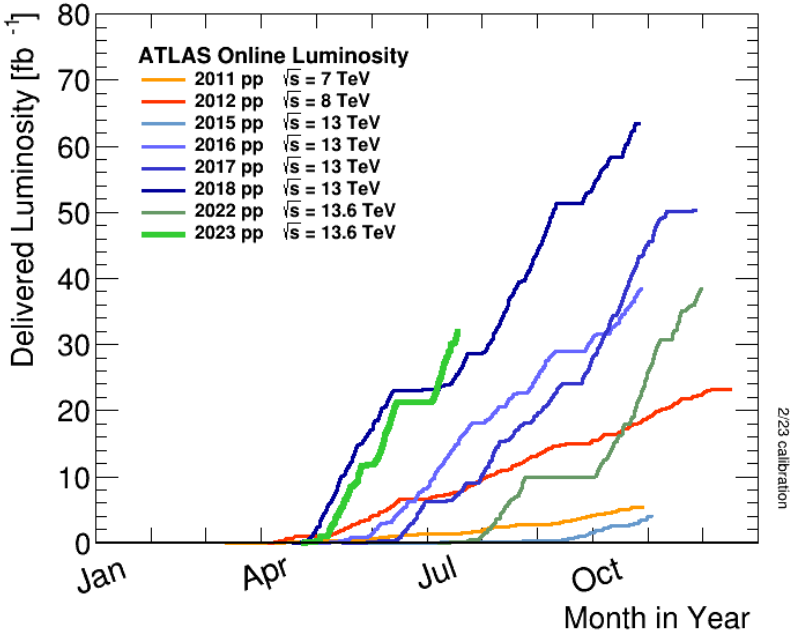
The large hadron Collider and ATLAS detector

The large hadron Collider

The ATLAS detector



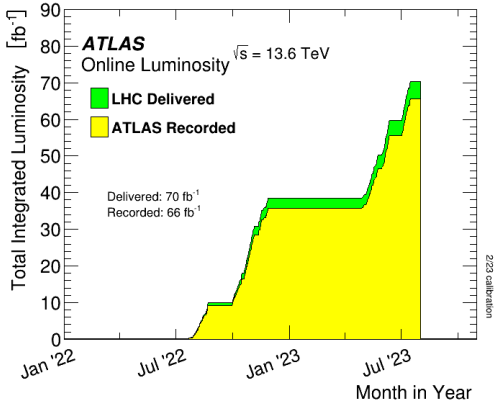
ATLAS detector operation status

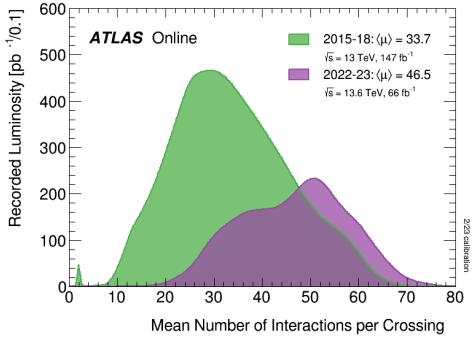


Integrated lumiosity vs year：

Run I pp (7+8 TeV): ~20 fb^{-1}

Run II pp (13 TeV): ~140 fb^{-1}

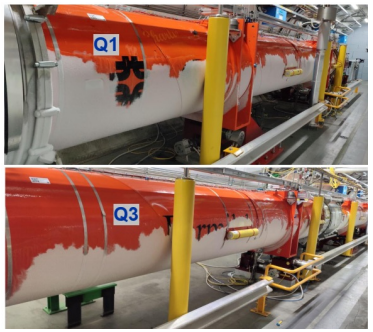




13.6 TeV pp 对撞：

2022 → 35.7 fb-1，2023 → 29.9 fb^{-1}

踏入更高堆积效应pile-up区间



7月份LHC超导磁铁液氦泄露

→停机维修至九月，停了一半pp取数

→9-10月特殊取数、重离子取数

ATLAS China group

在科技部、基金委、中科院支持下的中国大陆科研团队：
各类人才计划支持下的既能**独立开展仪器研制**又能**发挥特色引领物理研究**的科学家团队

中国科学院高能物理研究所 Institute of High Energy Physics Chinese Academy of Sciences — 18/33

南京大学 NANJING UNIVERSITY — 6/18

清华大学 TSINGHUA UNIVERSITY 1911 — 2/5

中山大学 SUN YAT-SEN UNIVERSITY — 3/2

中国科学技术大学 1958 University of Science and Technology of China — 15/33

上海交通大学 SHANGHAI JIAO TONG UNIVERSITY 1896 — 5/14

李政道研究所 TSUNG-DAO LEE INSTITUTE — 3/8

山东大学 SHANDONG UNIVERSITY 1901 — 6/13

郑州大学 ZHENGZHOU UNIVERSITY — 1/1

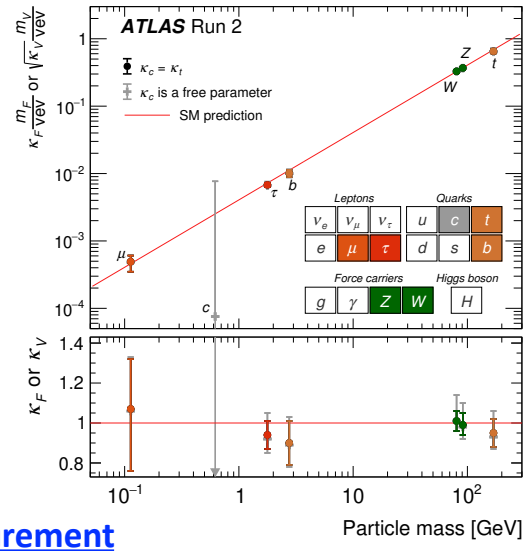
2023年以
cluster member
新加入ATLAS！

- 九家单位组合成两个cluster: 共59名M&O人数，127名作者，占**合作组的4%**
- 单位徽标下数字：**M&O人数/作者人数**
- 中科院苏州纳米所作为Technical Associate member

ATLAS: highlights of standard model physics results

Higgs property combination for Higgs 10th Anniversary

Nature 607, (2022) 52



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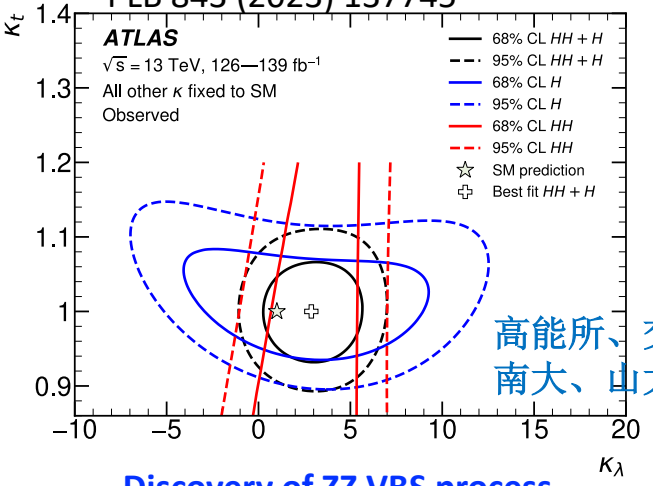
Higgs self-coupling with H+HH

PLB 843 (2023) 137745



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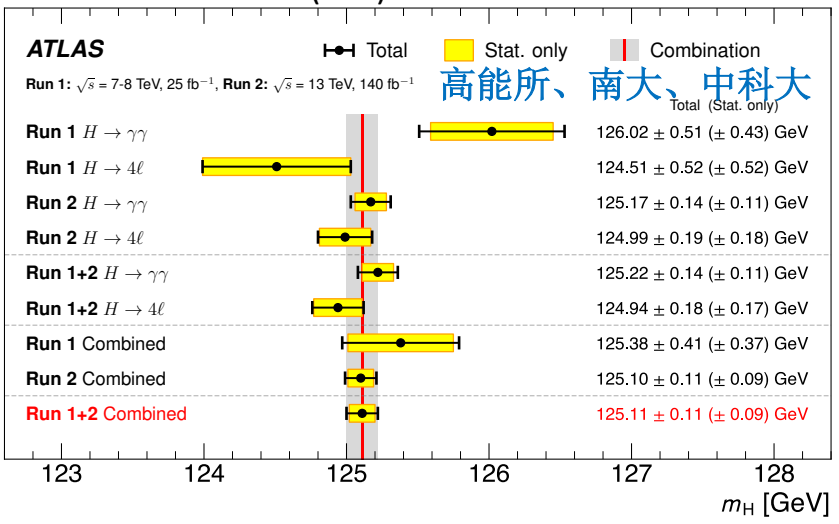
Precise Higgs mass measurement

arXiv:2308.04775(PRL)



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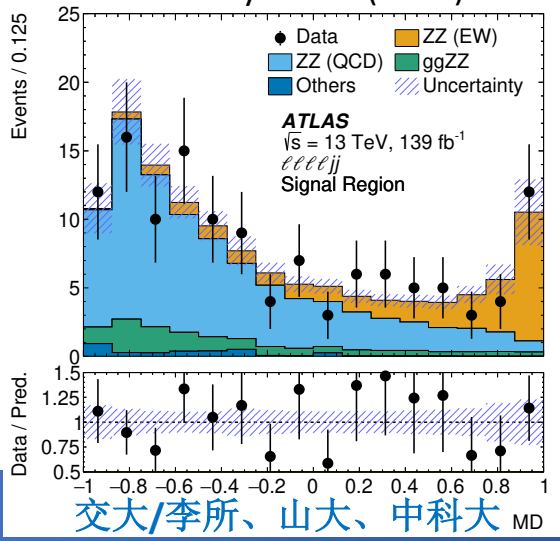
Discovery of ZZ VBS process

Nature Physics 19 (2023) 237



交大/李所、山大、中科大

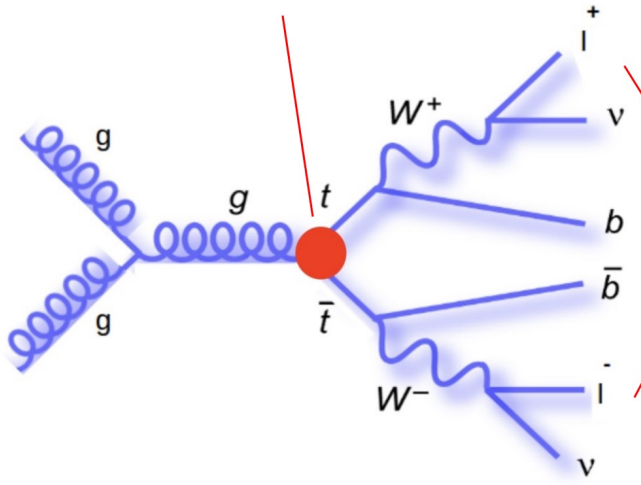
Quantum Entanglement measurement @ ATLAS

Quantum Entanglement in ttbar events

- 2022 Nobel prize “for experiments with entangled photons
- 2023: Entanglement is observed in $t\bar{t}$ pairs for the first time
  - Entanglement measured is higher than expected in signal region (340,380) GeV

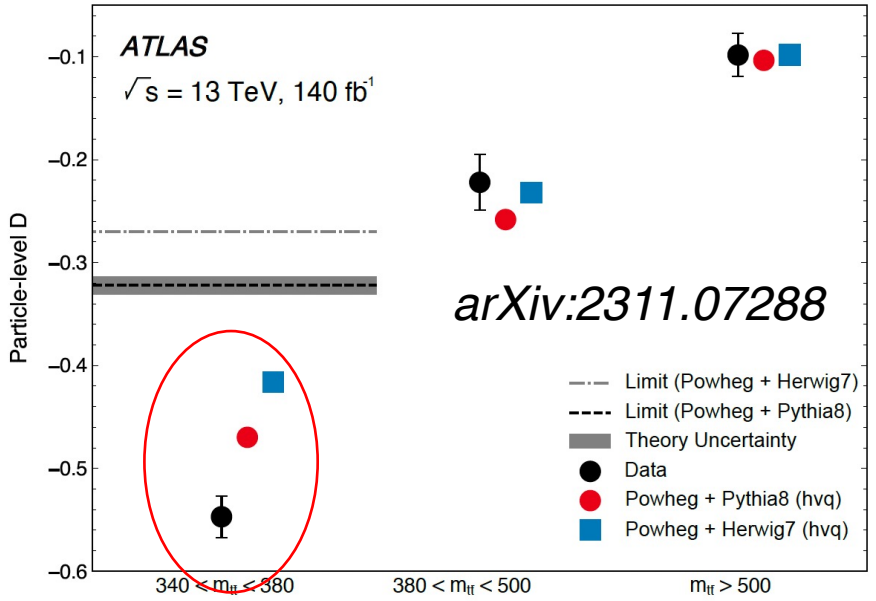
High energy collisions

Source of entangled particles: pp → $t\bar{t}$



Two polarimeters:
top quark decay
t → Wb, W → $l^{\pm}\nu$

Afik & de Nova, EPJPlus
ATLAS, arXiv:2311.07288



D < -1/3: Entanglement (new!)

In $t\bar{t}$ production, an entangled system must yield:

Afik & de Nova, EPJPlus, 2021

D < -1/3,

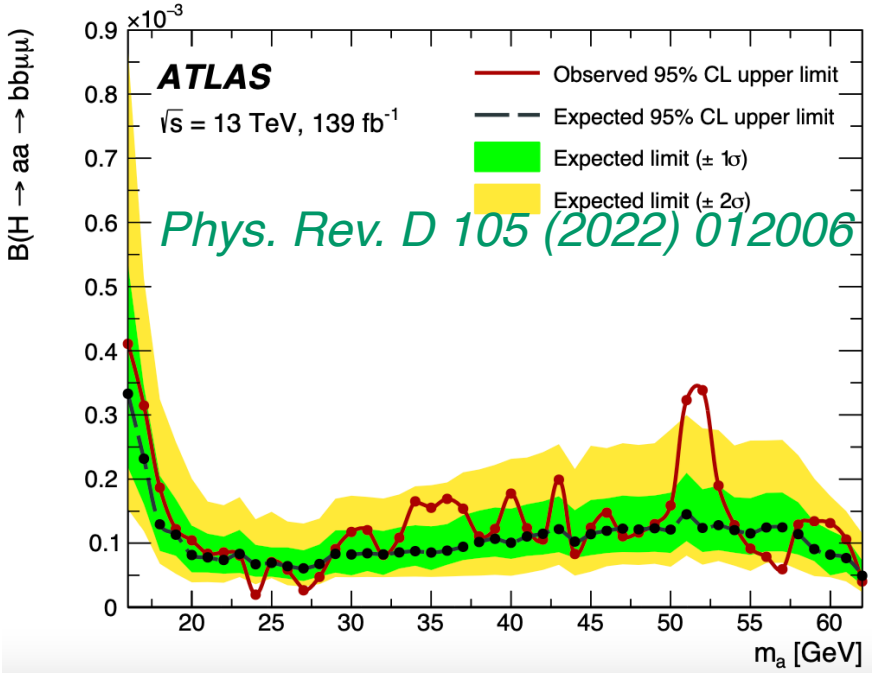
where D = angle between decay leptons in t and $\bar{t}$ rest frames

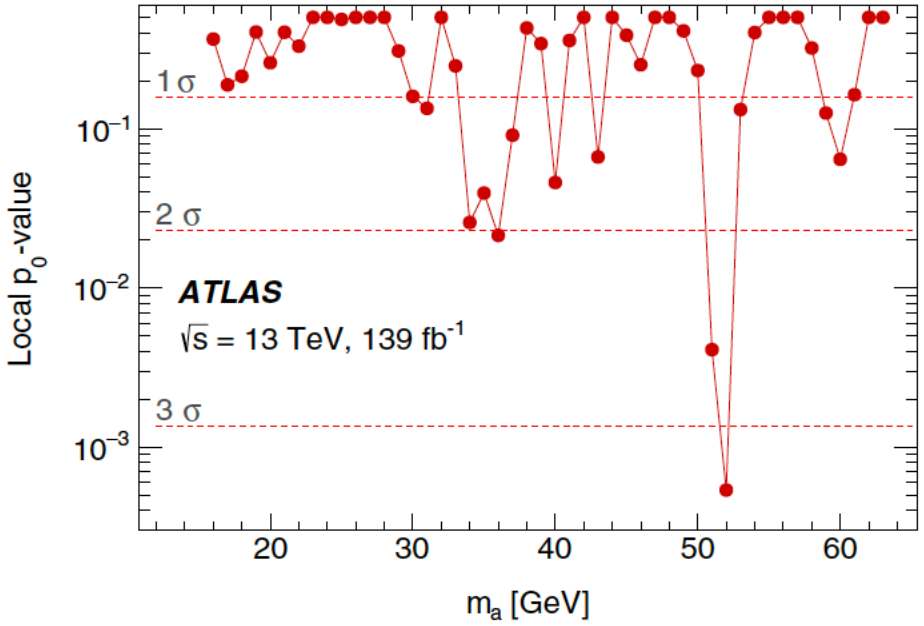
New physics Search using Higgs Boson

Search for H→aa→bbμμ

- BDT trained to separate sig. from SM bkg. (DY+jets, ttbar)

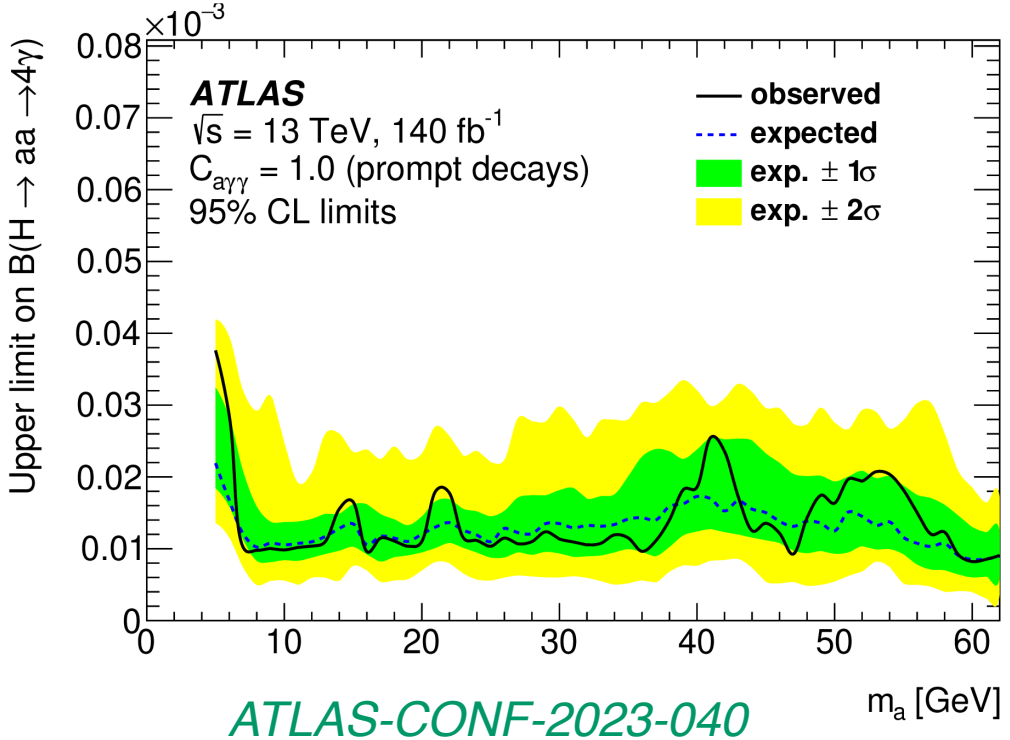
Local (global) significance @ 52GeV：3.3 (1.7)σ



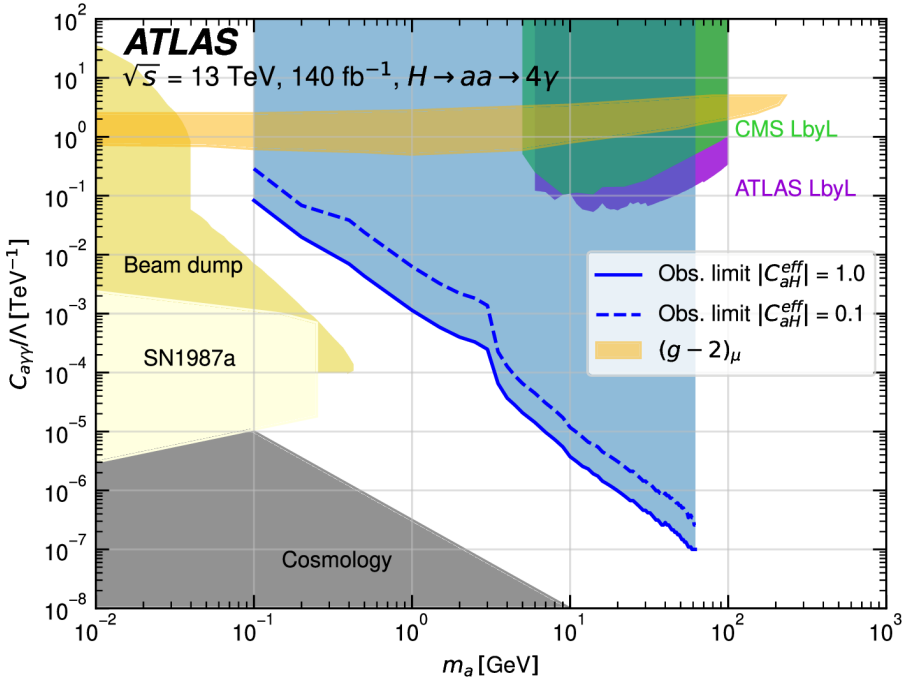


Search for H → aa → 4γ at ATLAS

- *Axion-like particles (ALPs) decaying into $\gamma\gamma$ is sensitive to various models that could explain (g-2)μ discrepancy*
- *Signal signature depending on the axion mass (collimated/resolved photons) and $C_{a\gamma\gamma}$ (long-lived/promptly decaying)*

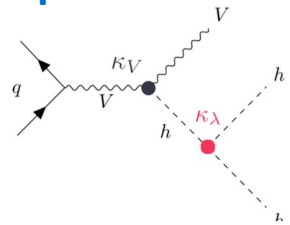


ATLAS-CONF-2023-040

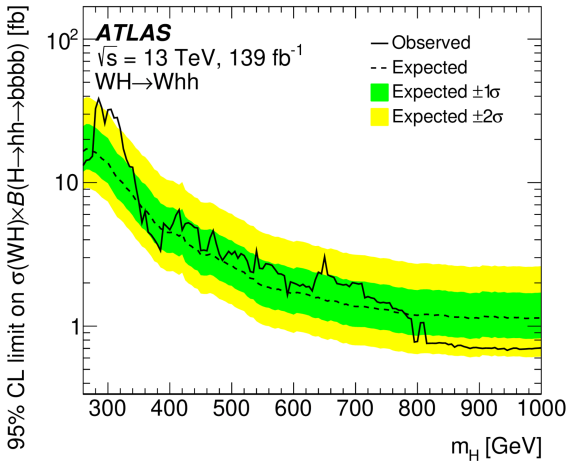


Vhh and X→Wg/Zg

First search on Vhh (lepton, b quark final state)

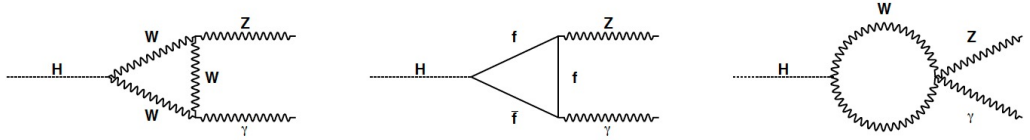


EPJC 83 (2023) 519

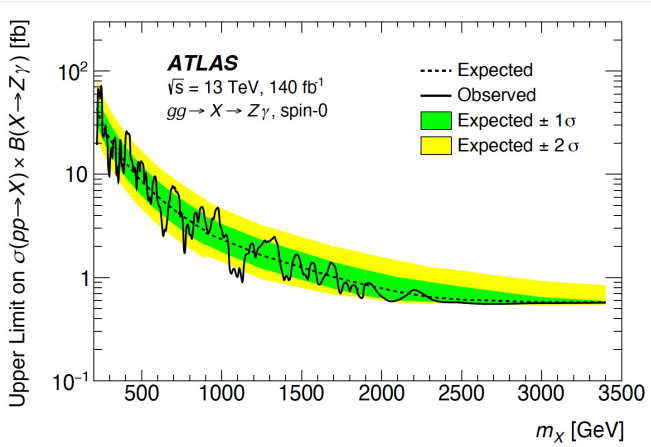


山大

Large mass range heavy boson X→Wγ/Zγ search (leptonic/hadronic final state + photon)

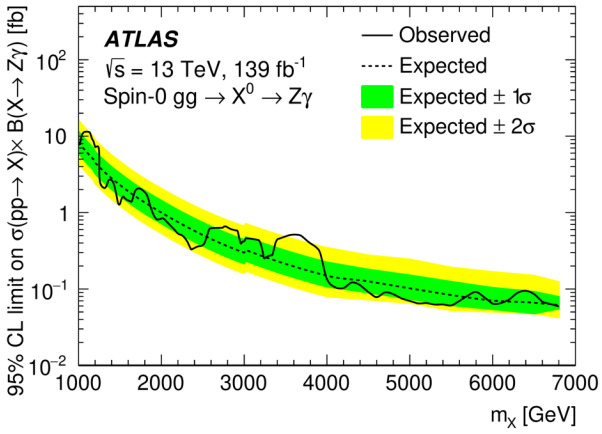


arXiv:2309.04364,submitted to PLB



高能所

JHEP 07 (2023) 125



高能所、交大/李所

首次对VHH产生过程进行研究，对重希格斯粒子进行限制（轻子+b夸克末态）

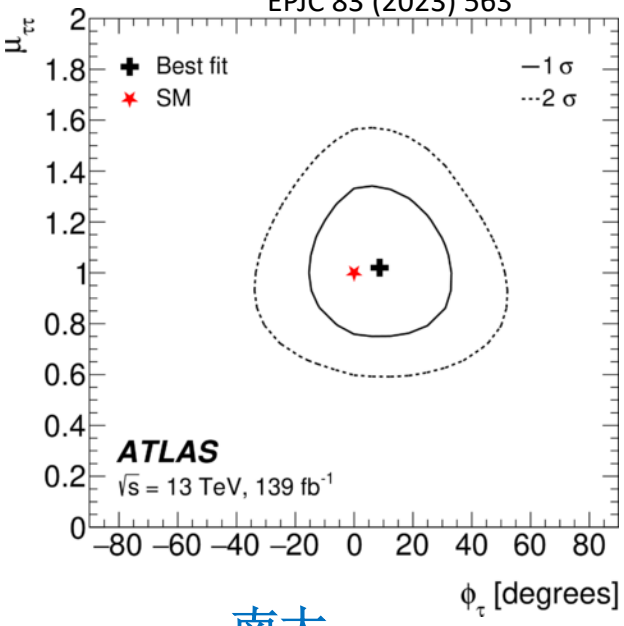
对X→Wγ/Zγ进行大质量区间搜索，获得严格统计限制（轻子/强子末态+光子）

Higgs CP study

- *No indication of CP odd coupling in Higgs sector by far*

Higgs CP study
H→ττ

EPJC 83 (2023) 563

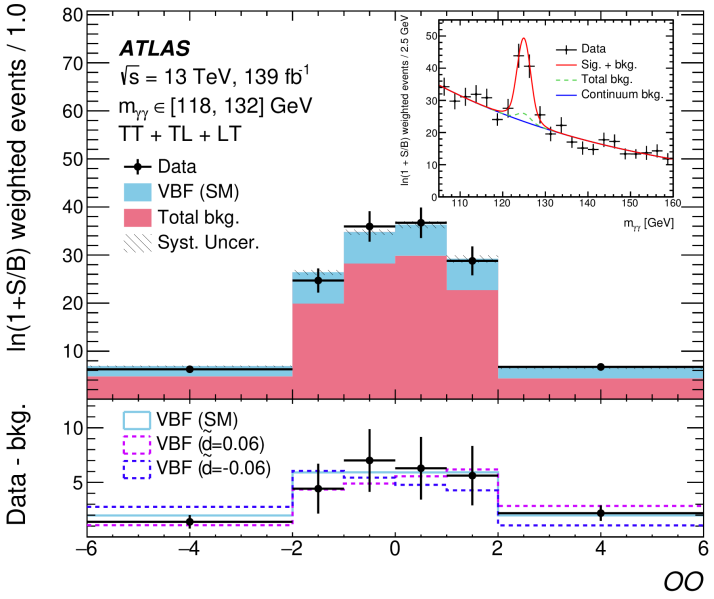


南大

利用τ轻子衰变研究对**H→ττ过程的CP研究**

Higgs CP study
VBF H→γγ

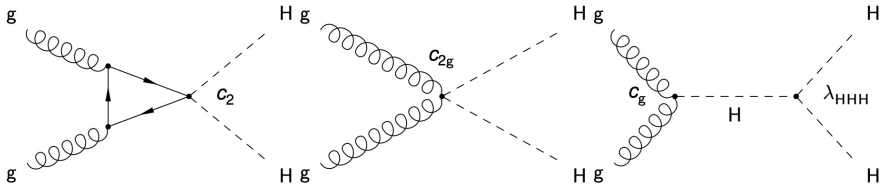
PRL 131 (2023) 061802



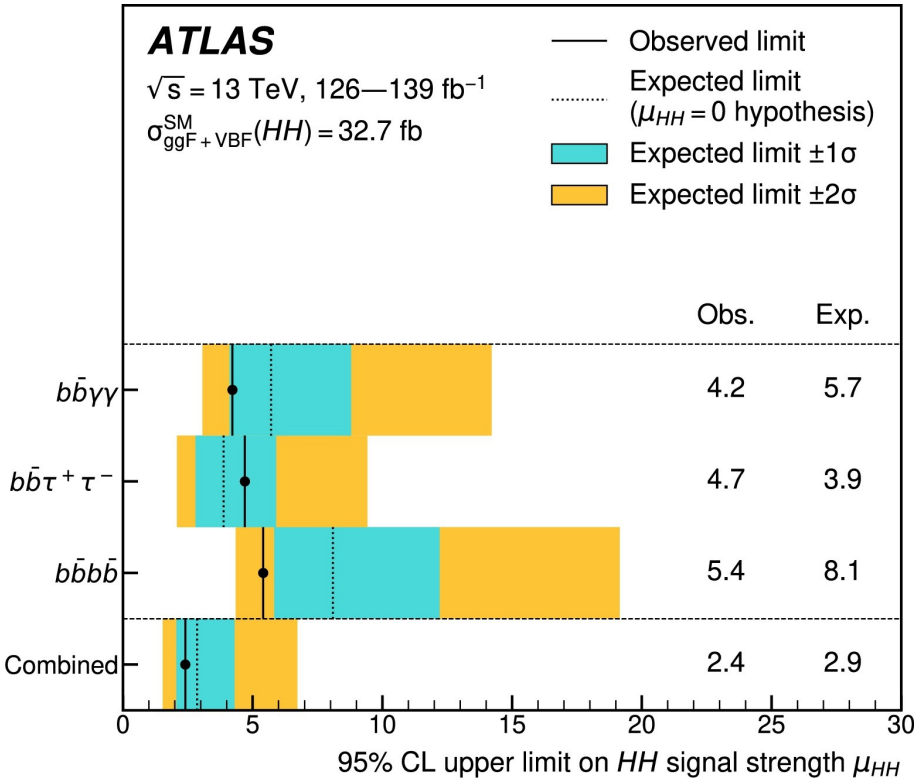
利用希格斯VBF产生动力学的**Optimal Observable的CP研究（VBF H→γγ）**

高能所、南大

Di-Higgs study

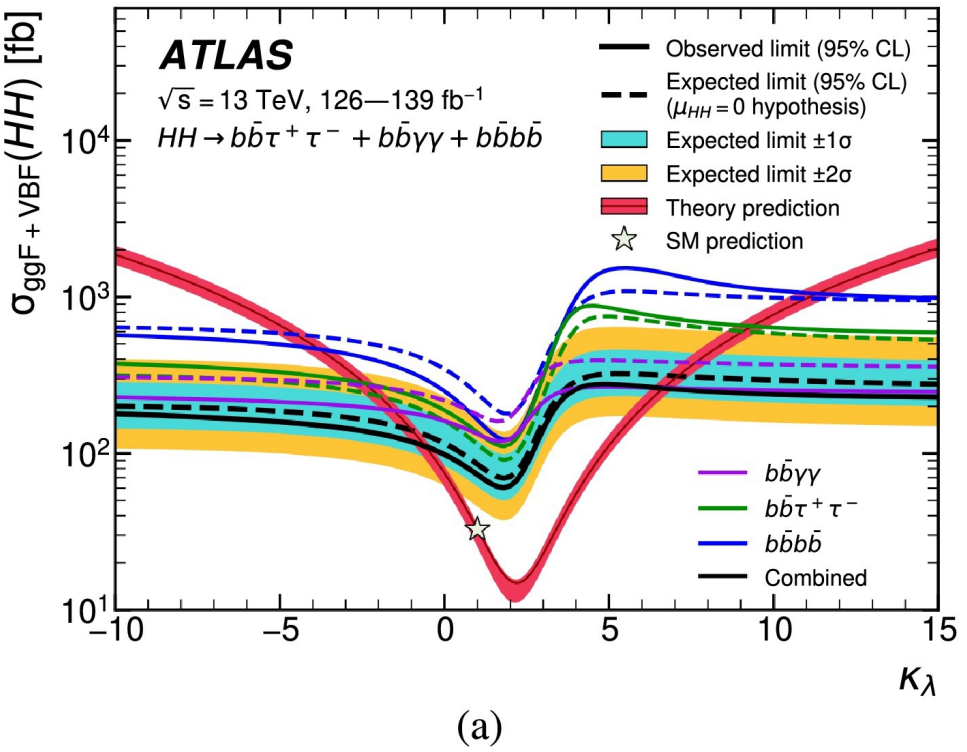


Upper limits on HH signal strength



Upper limits of different couplings values, compared to theory prediction

Phys. Lett. B 843 (2023) 137745



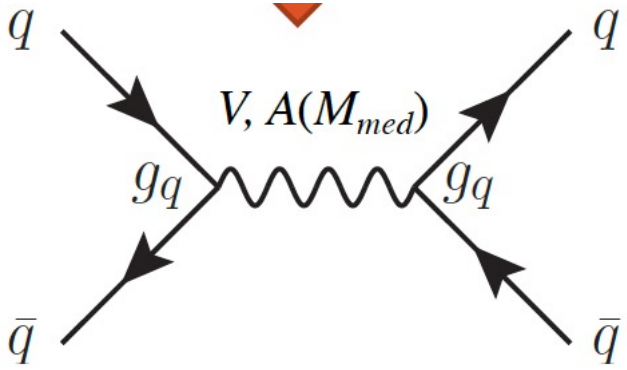
(a)

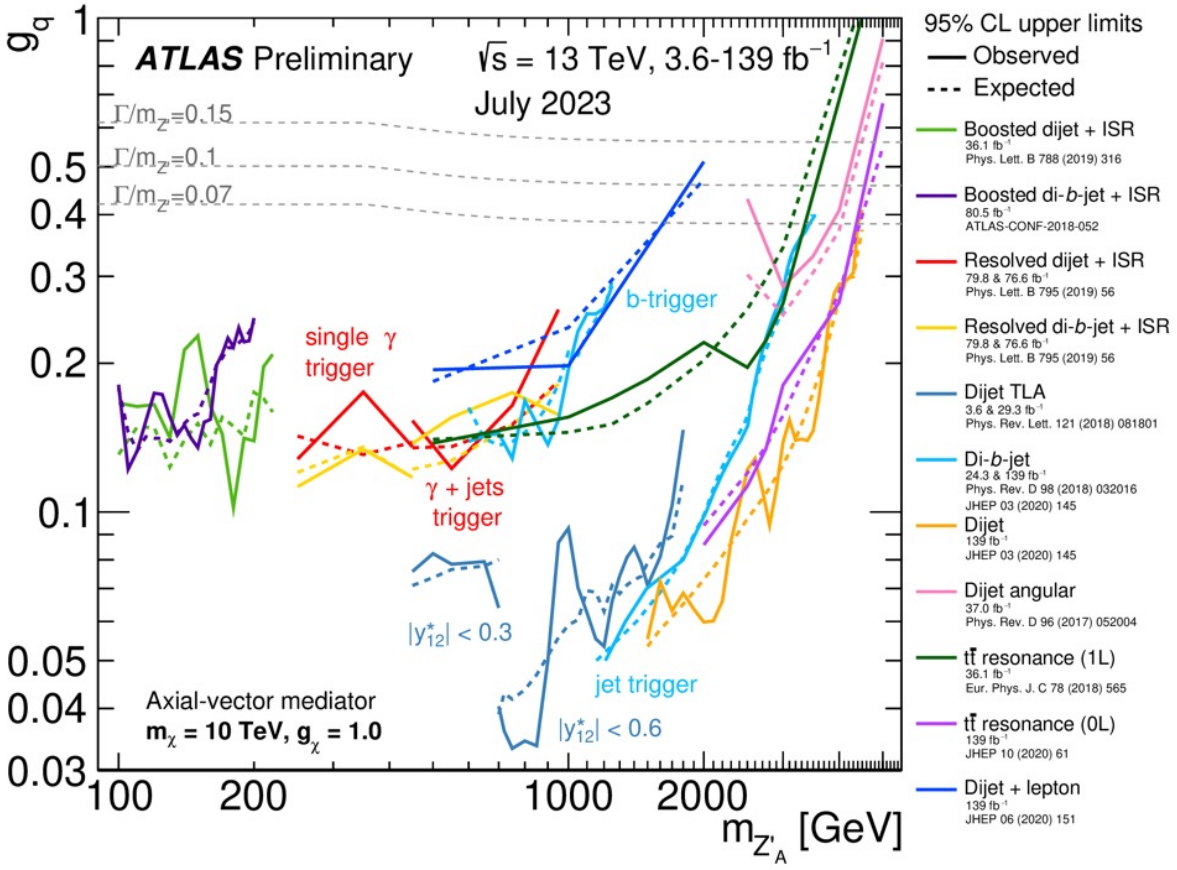
Dark matter search

Dark matter： Mediator search

- *Techniques to extend to lower or higher mediator mass region*
  - *dijet+ISR, dijet angular analysis*
  - *dijet TLA (trigger level analysis)*

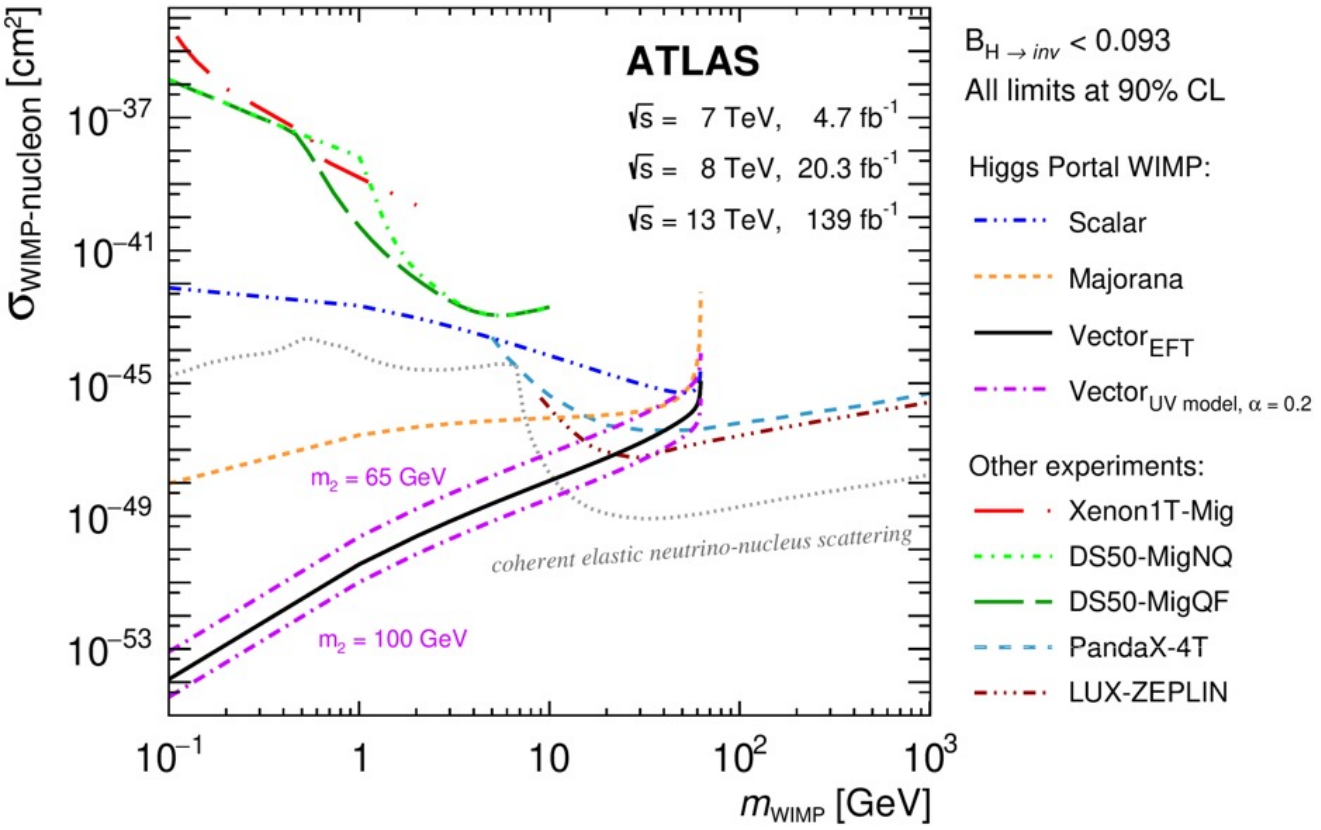
ATL-PHYS-PUB-2023-018





Higgs-portal dark matter search

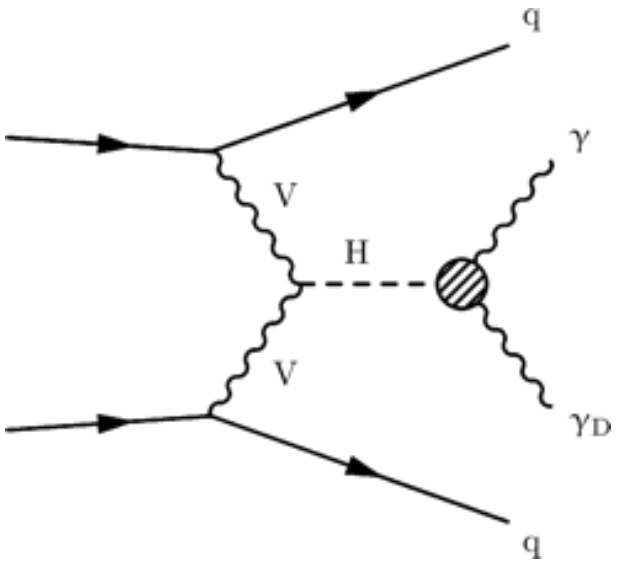
- *Scalar mediator-- spin-independent interaction*
- Sensitivity to mass between 0.1GeV to ½*m_{Higgs}

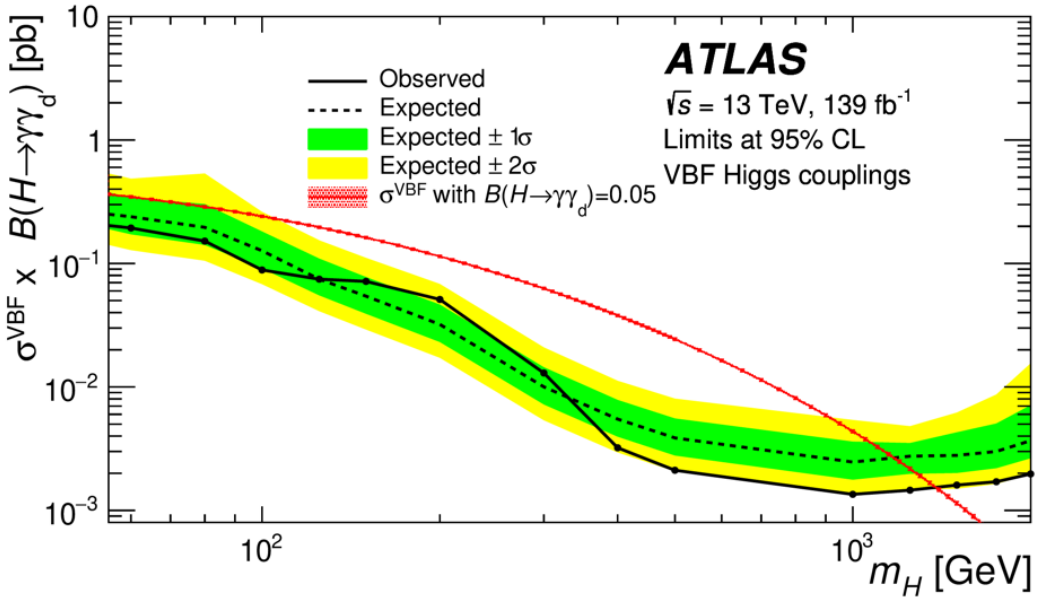


ATL-PHYS-PUB-2023-018

Dark photon search in VBF Higgs process

- *Higgs decay to dark photon in VBF process*
  - *Br(SM h->$\gamma\gamma_D$) < 0.018 at 95% CL*



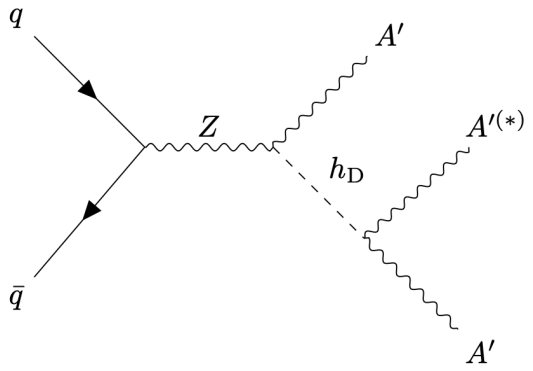


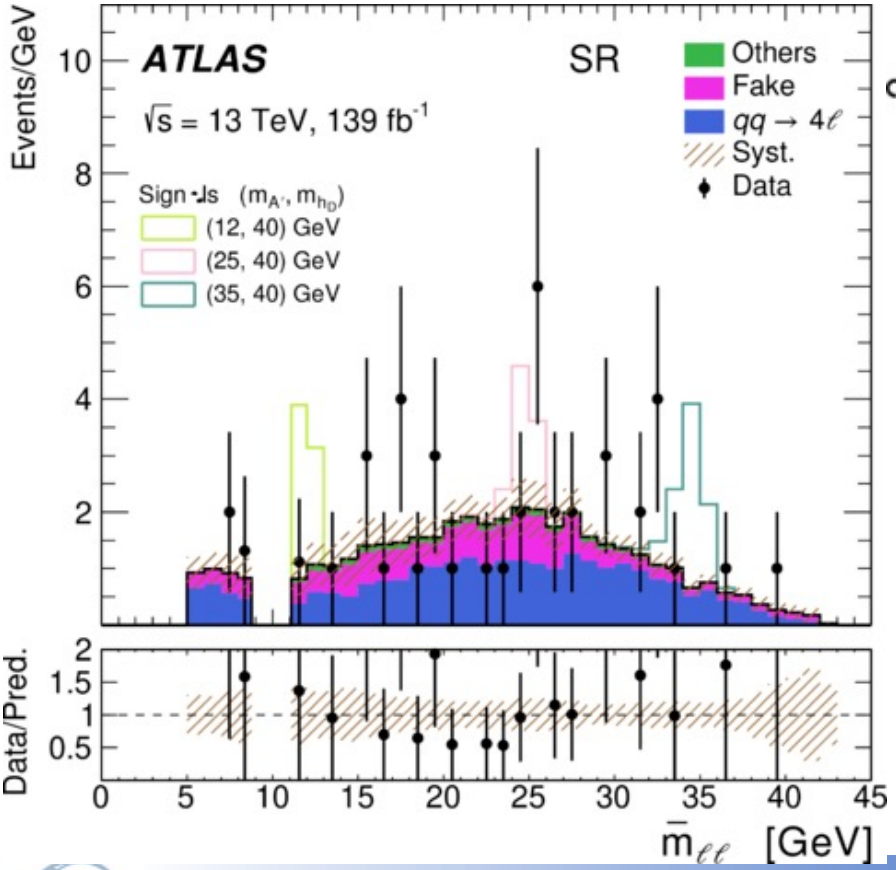
Eur. Phys. J. C 82 (2022) 105

高能所

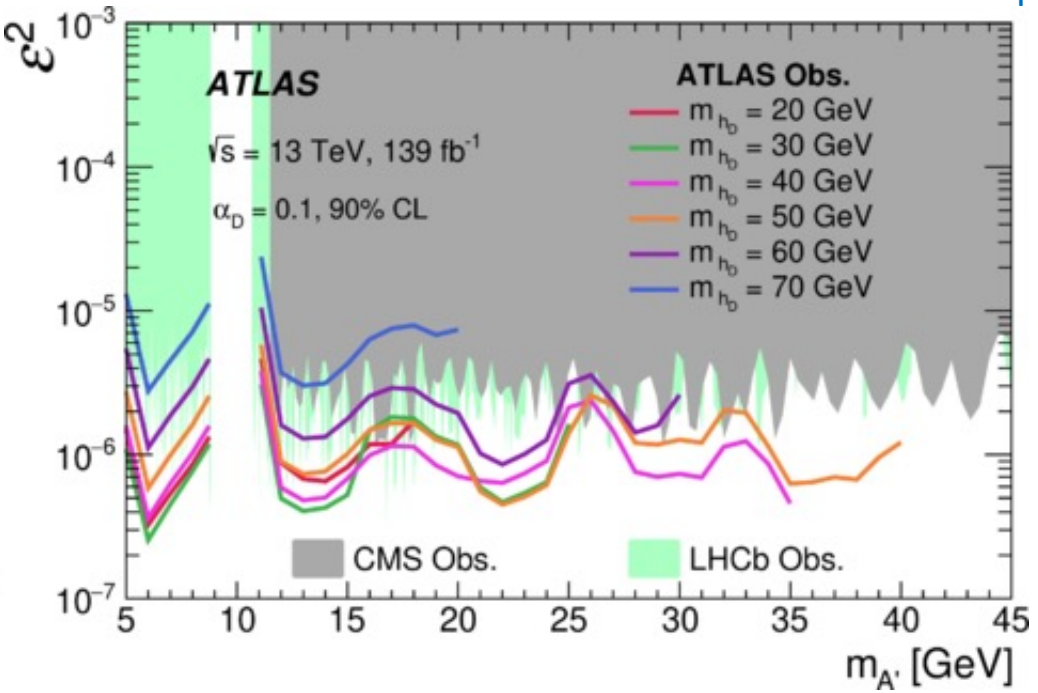
Search for dark photon and dark Higgs

- Search for dark photon and dark Higgs in four lepton final state
- Unique phase space explored





arXiv:2306.07413， PRL accepted

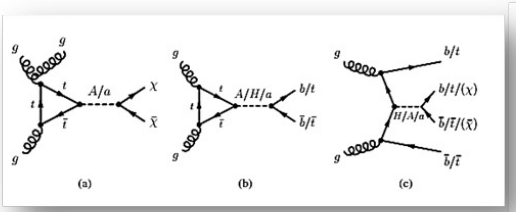


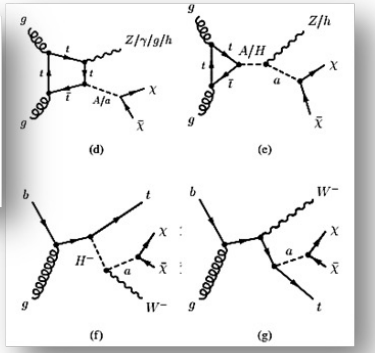
中科大

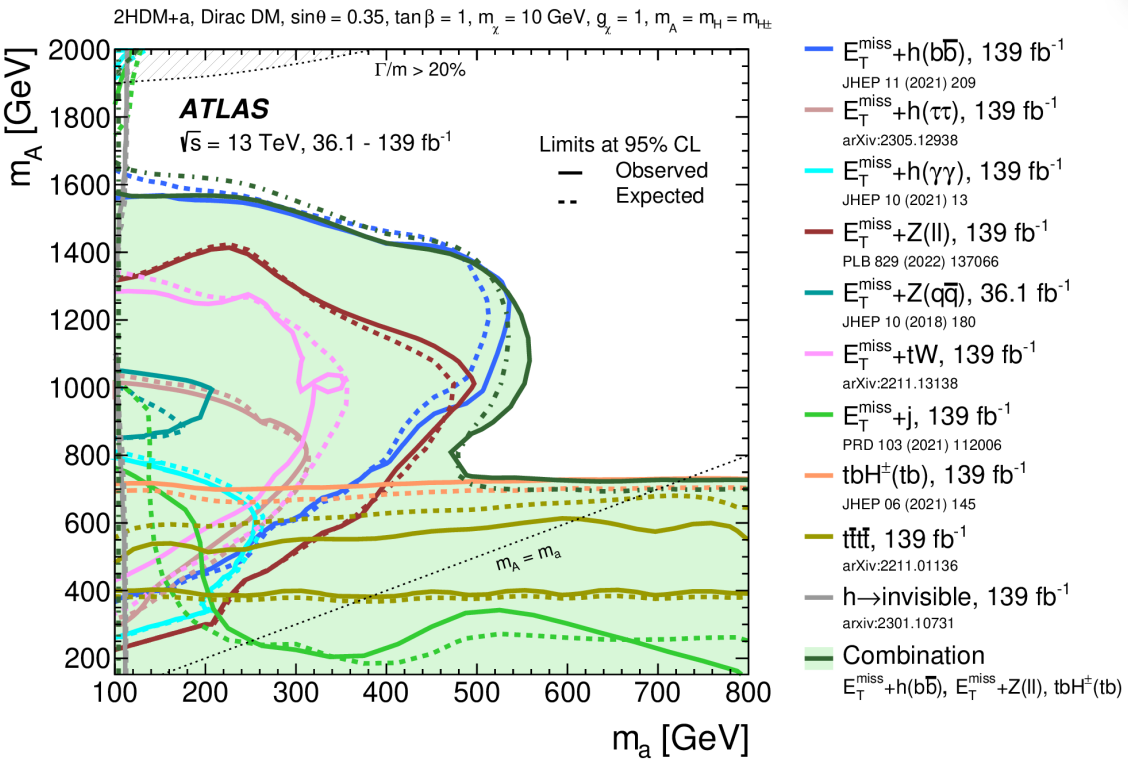
2HDM+a DM model combination

2HDM+a model

- *based on type-II 2HDM* (***h, H⁰, H±, A***)
- *additional pseudo-scalar mediator a*





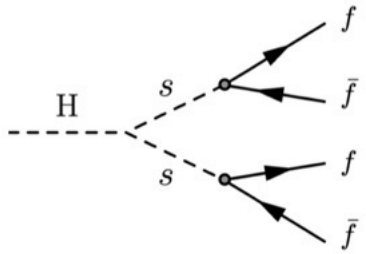


arXiv:2306.00641，Science Bulletin accepted

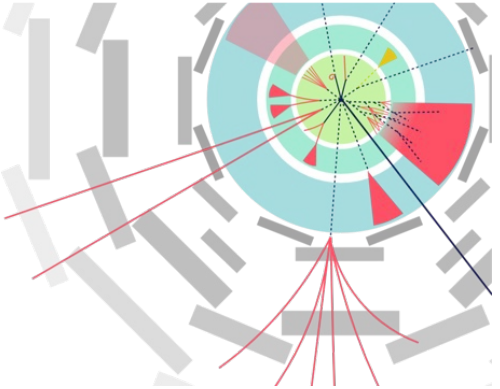
合并主要搜寻过程，针对2HDM+a模型进行统计联合，**给出最灵敏限制**

交大/李所，中科大

Higgs decays into long-lived particles



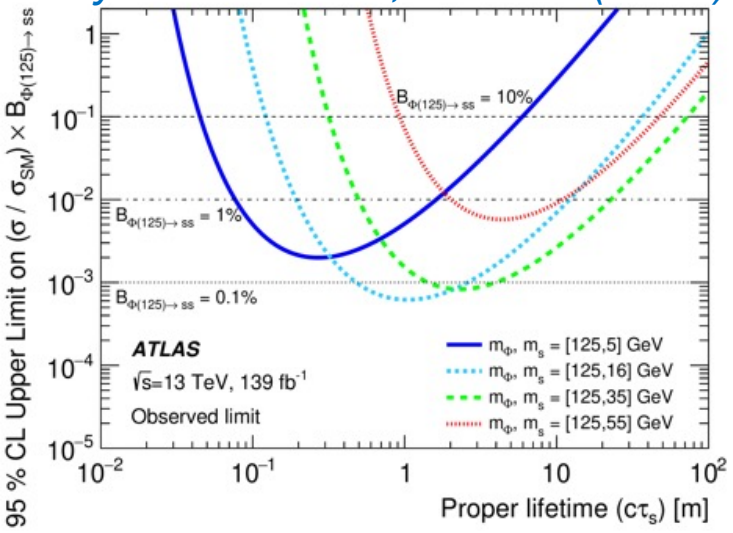
- *Higgs-portal hidden-sector：* *Pair of long-lived particles(LLP)*
- *Using non-standard object signature reconstruction*
  - *E.g. a pair of displaced vertices in muon spectrometer*
  - *LLP decaying into jets 3 – 14m displacement from PV*

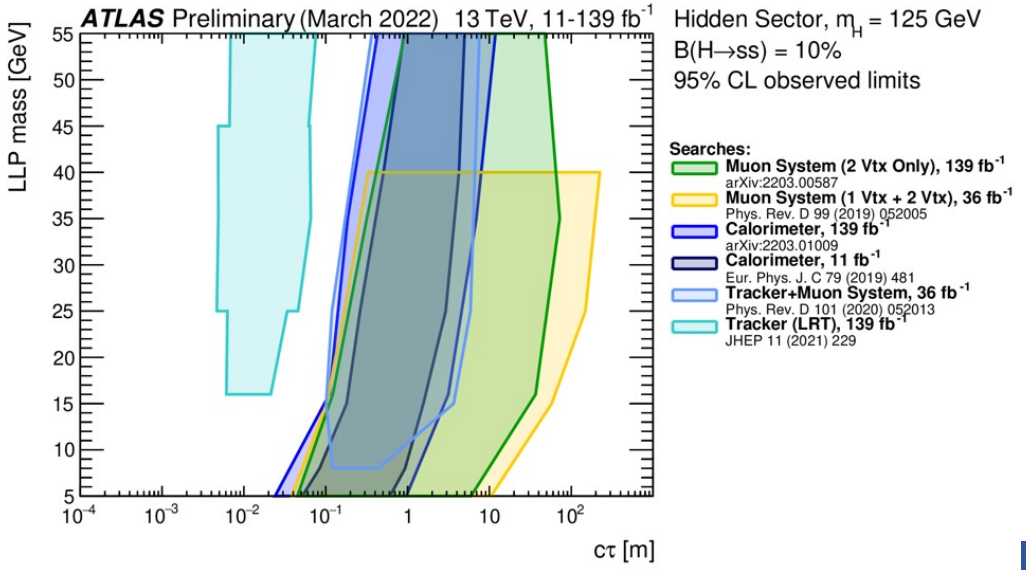


Displaced muons

- *Constraints from tracker, calorimeter, muon systems*

Phys. Rev. D106, 032005 (2022)

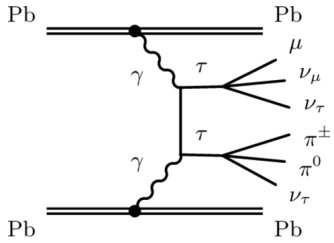




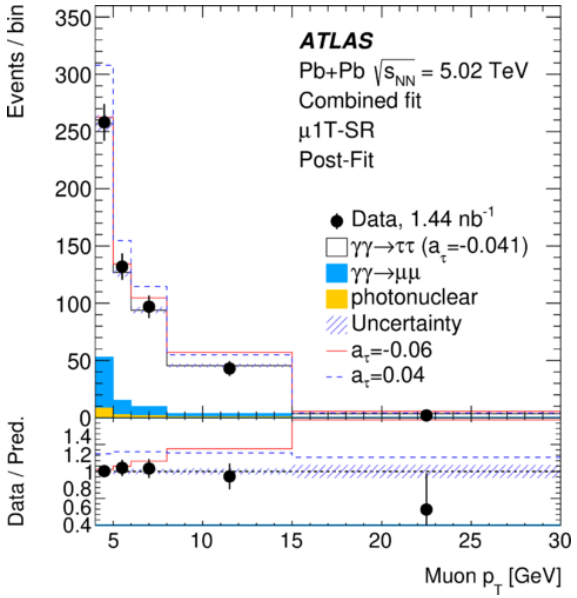
Rare process search

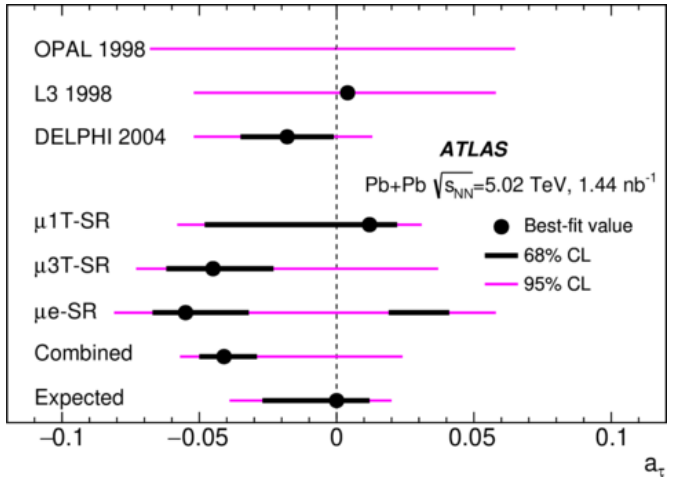
$\gamma+\gamma \rightarrow \tau\,\tau$ anomalous magnetic moment

- First τ anomalous magnetic moment in heavy ion data in ATLAS
- ATLAS constraints are competitive with DELPHI @LEP



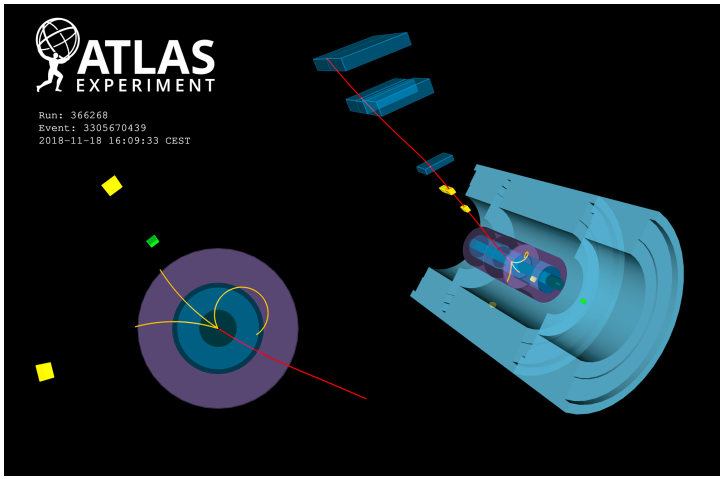
PRL 131 (2023) 151802, 编辑推荐





山大

首次观测到重离子对撞产生γγ→ττ过程，并测量τ反常磁矩

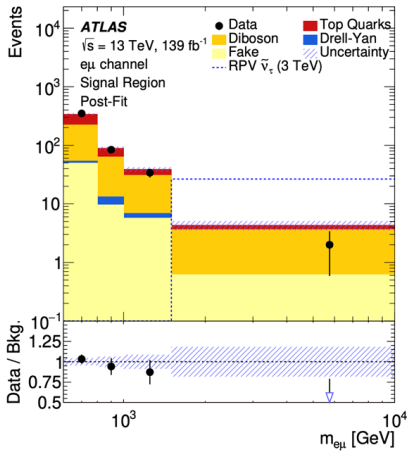


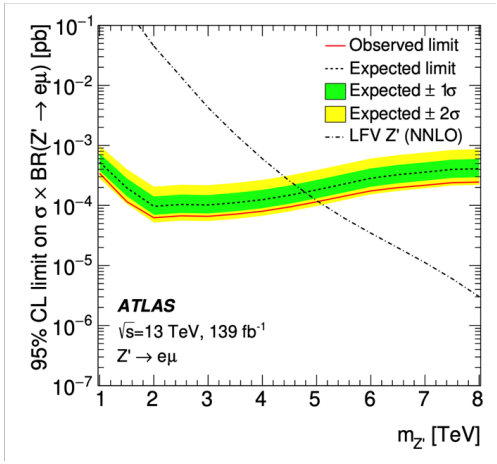
Lepton flavor violation

Search for Z' decays to lepton flavor violating lepton pairs

The most stringent limits on LFV decays of the Higgs boson (H→e μ , H→ μ τ)
Upper limit is ~0.1% level

JHEP 10(2023) 082

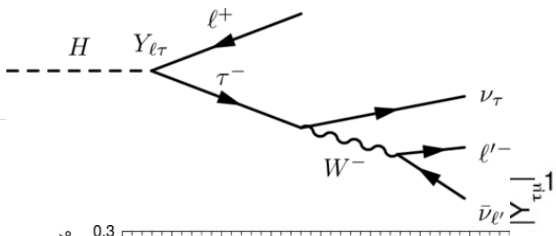


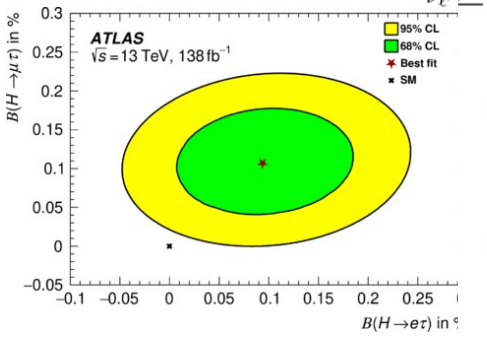


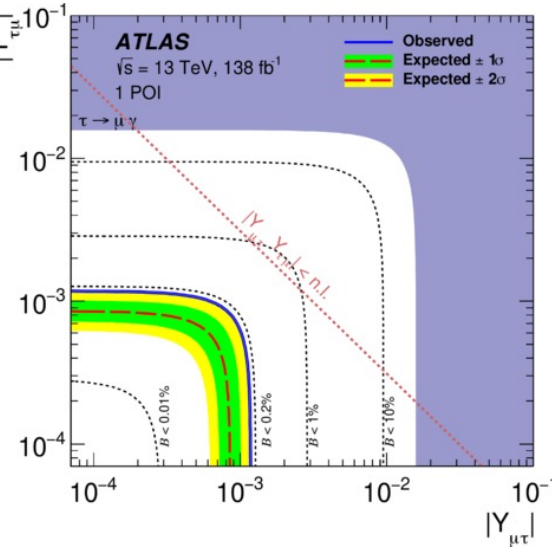
交大/李所，中科大

寻找**Z'→轻子味道破缺轻子对**，给出对**高能段的最佳限制**（eμ, eτ, μτ）

JHEP 07 (2023) 166





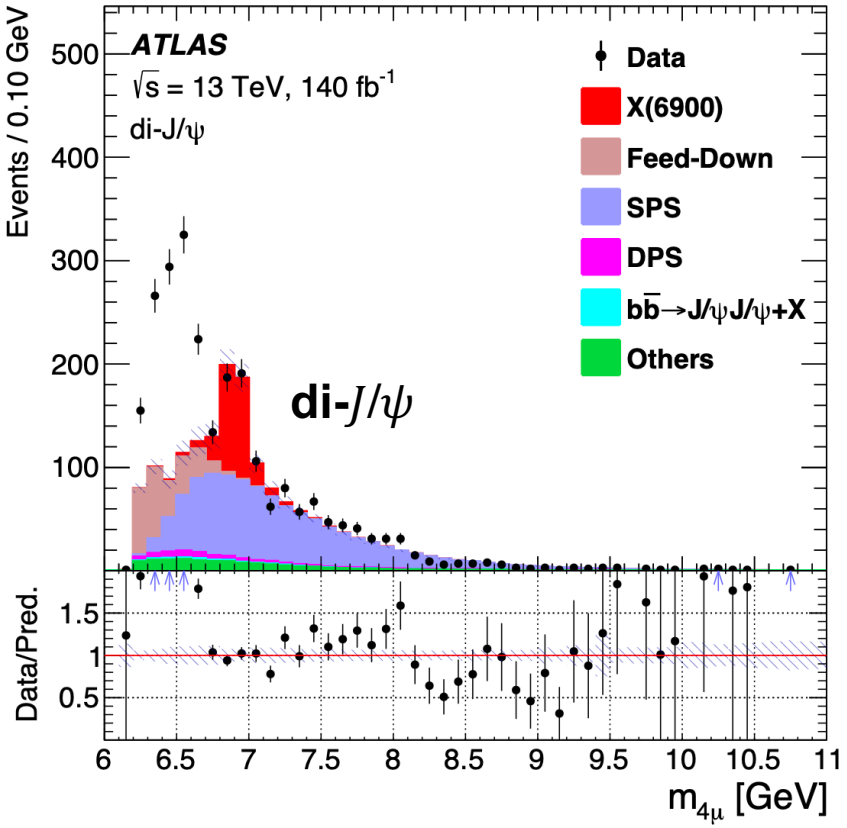


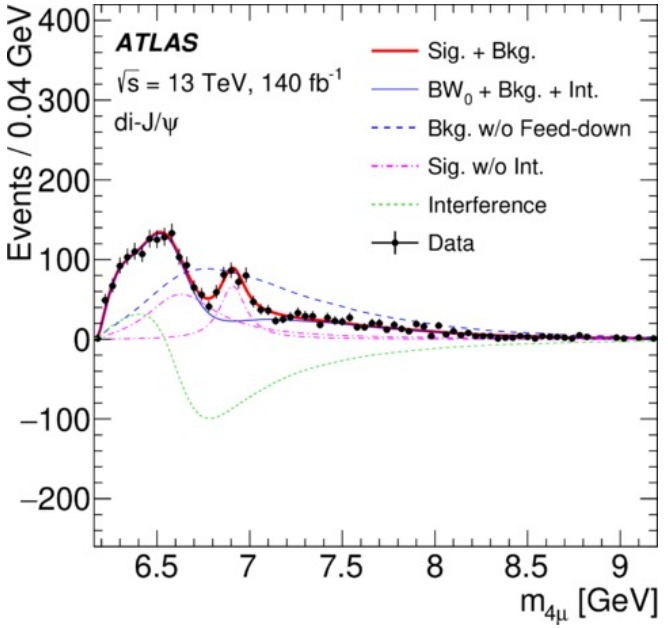
南大、清华、中大

获得对**希格斯LFV衰变为τ+e/μ的最紧致限制**，分支比上限千分之一

Double charmonium study @ ATLAS

- The peak around **6.9 GeV** is consistent with the LHCb observed X(6900) (arXiv:2006.16957), with significance far above 5σ



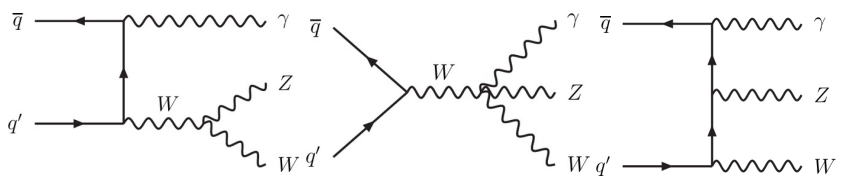


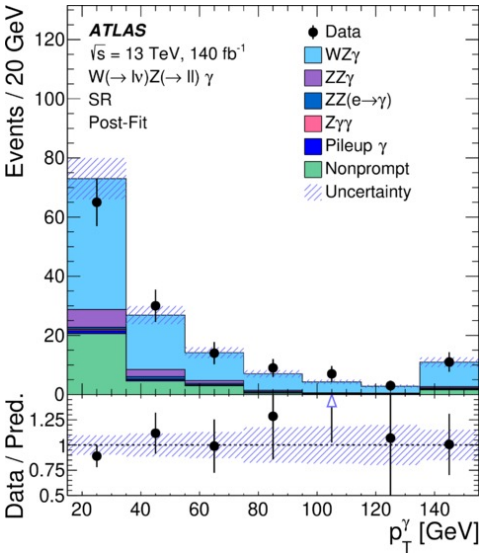
ATLAS实验上研究双粲偶素
质量谱 (四缪子末态)

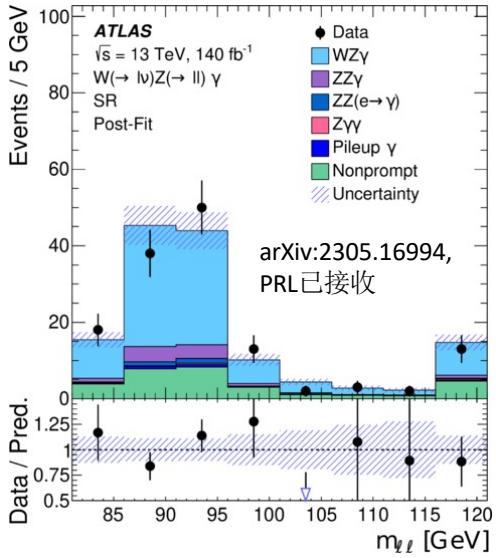
Phys. Rev. Lett. 131 (2023) 151902

Tri-boson and four-top process

First observation of WZγ Tri-boson process





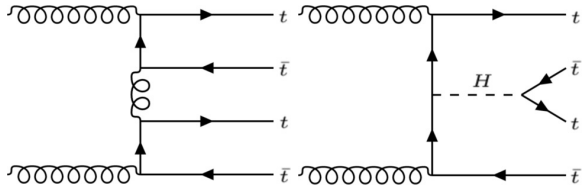


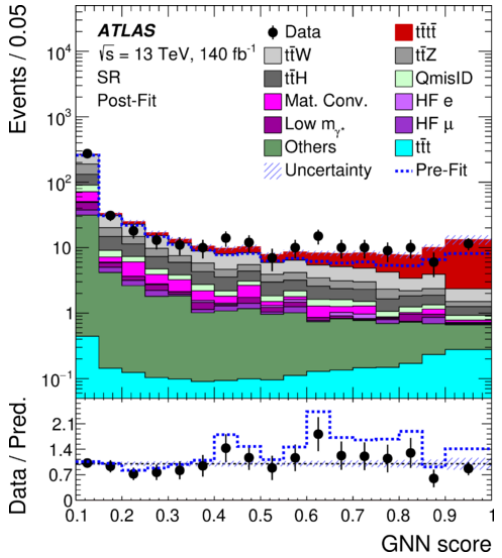
arXiv:2305.16994,
PRL已接收

郑大

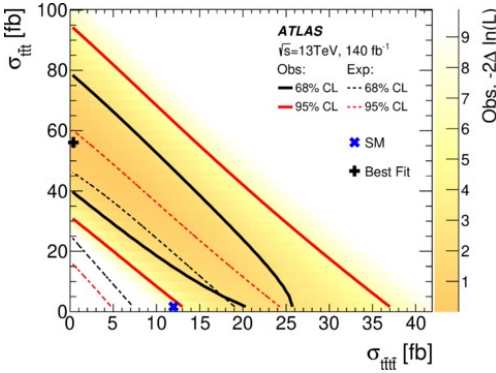
首次观测到**WZγ**三玻色子过程
6.3σ（三轻子+光子衰变道）

First observation of 4 top-quarks process





EPJC 83 (2023) 496



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中科大

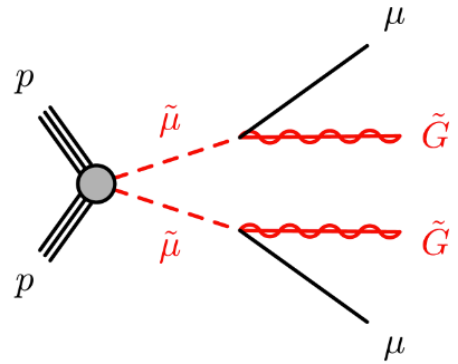
首次观测到四顶夸克产生过程
6.1σ (双同号轻子或三轻子+X末态)

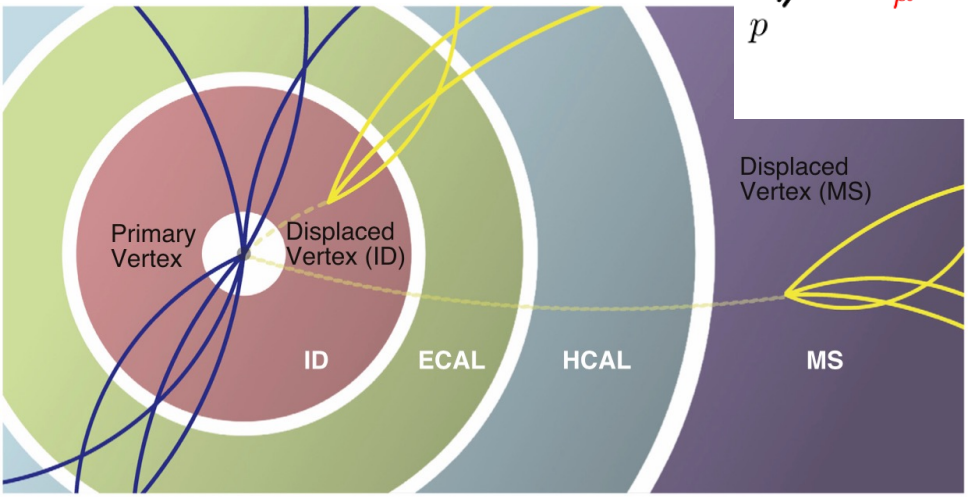
Supersymmetry

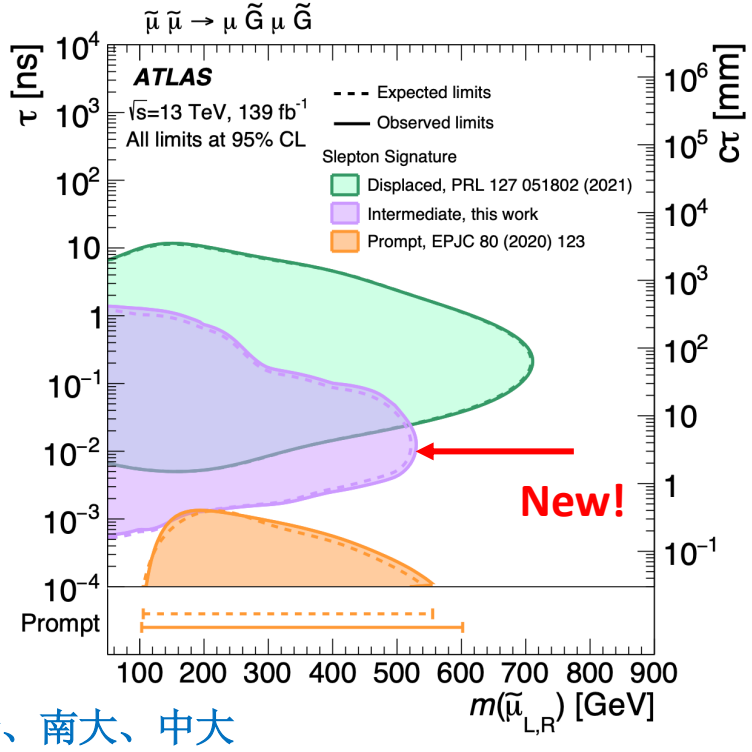
Displace muon

arXiv: 2305.02005

- **Pair produced smuons that live for short time before decay to μ + Gravitino.**
- **Muon with impact parameters in the *millimetre* range, targeting the medium displacement leptons:**
- **complementary to previous searches of large displacement and prompt smuons**







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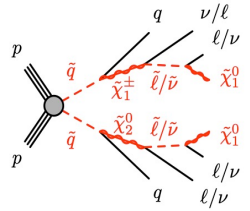
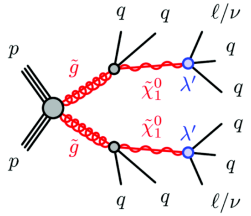
Supersymmetry: strong and weak production

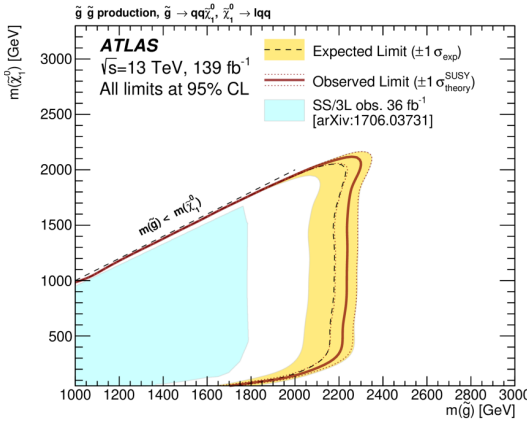
Strong production, same sign di-lepton tri-lepton

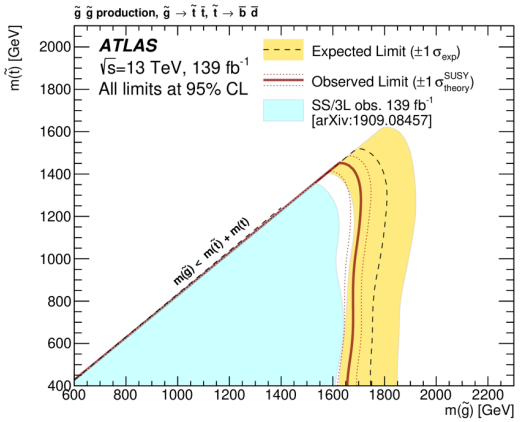
(Gluino ~ 2.2 TeV, Squark ~ 1.7 GeV)





arXiv:2307.01094， submitted to JHEP





利用强产生过程+双同号轻子或三轻子末态

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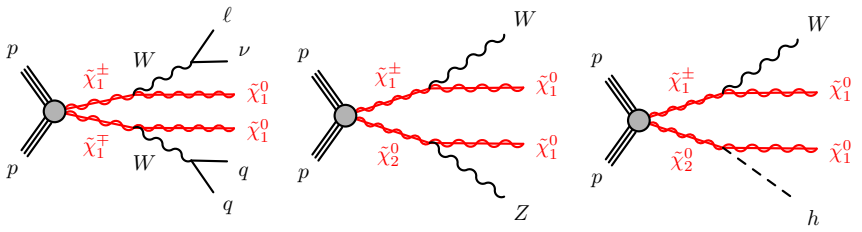
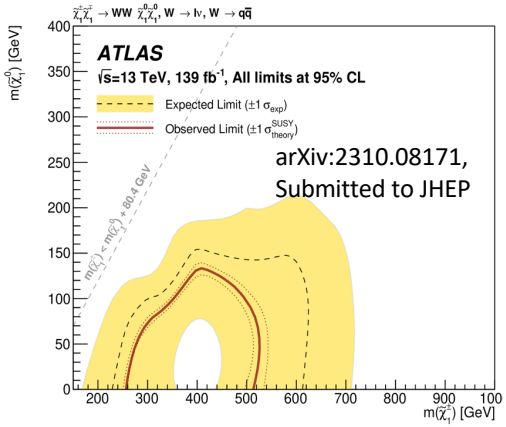
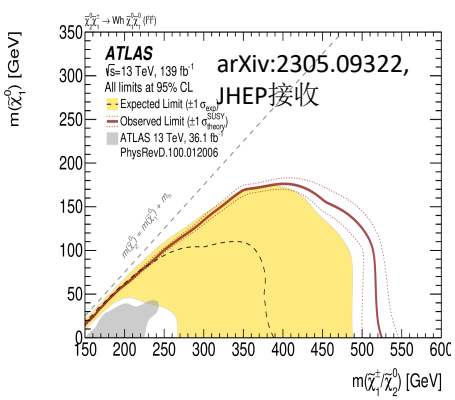
Weak production+ boson leptonic decay

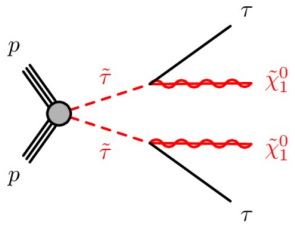






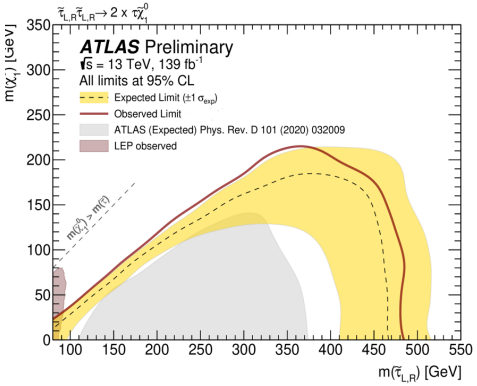
利用弱产生过程+玻色子轻子衰变末态
→ 获得紧致的对Gaugino统计限制，
显著提高对gap区间的灵敏度

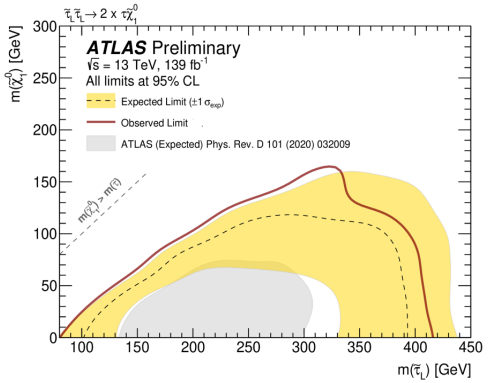
Supersymmetry: stau, SUSY combination



First search for stau in di-tau final state

ATLAS-CONF-2023-029



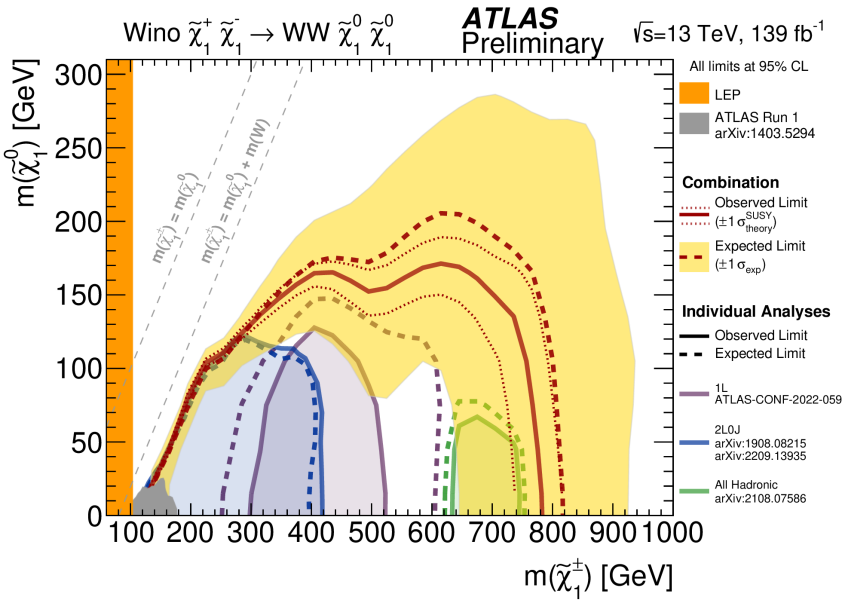


首次利用双陶轻子过程寻找stau，得到最紧致排除限，首次研究右手stau排除限

高能所

SUSY combination on EWK, pMSSM, long-lived smuon

ATLAS-CONF-2023-046



完成多项SUSY统计联合研究，EWK, pMSSM, long-lived smuon等

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Summary

- *ATLAS continue data taking in run3*
  - *Large amount for Run 3/HL-LHC data can provide us* more sensitivity to new physics
  - *Stay tuned!*
- New Trend:
  - *Quantum Entanglement study in high energy physics*
  - *Long-Live particle search with new experimental signature*
  - *More analyses using Higgs as a probe to search for new physics*