The 10th China LHC Physics Conference
Summary of CLHCP2024

Jia Liu (刘佳)
Peking University

CLHCP from 2020-now

Year	Session	Mode	Organizer	Participants
2020	6th	Online	THU	451
2021	7th	Online	NJNU+THU	520
2022	8th	Online+Onsite	NJNU	400+Onsite
2023	9th	Onsite	SJTU/TDLI	467

CLHCP from 2020-now

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2020	6th	Online	THU	451
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2022				400+Onsite
2023				467

第十届中国LHC物理会议（CLHCP2024 青岛）

Nov 13 – 17, 2024
山东省青岛市鳌山湾 (Aoshan Bay, Qingdao, Shandong)
Asia/Shanghai timezone

Enter your search term

- 419 participants
- 272 abstracts
- 1 public lecture
- 30 plenary talks
- 160 parallel talks
- 15 posters

第十届中国 LHC 物理会议
（CLHCP2024 青岛）

Wednesday, November 13, 2024 - Sunday, November 17, 2024
山东省青岛市鳌山湾 (Aoshan Bay, Qingdao, Shandong)

Book of Abstracts

Changes compared to the previous CLHCP

- Change of the name

第八届中国LHC物理研讨会 The 8th China LHC Physics Workshop (CLHCP2022)

第九届中国LHC物理年会 The 9th China LHC Physics Workshop (CLHCP2023)

第十届中国LHC物理会议（CLHCP2024 青岛）

尊敬的各位专家学者：

2024年第十届中国LHC物理会议 The 10th China LHC Physics Conference (CLHCP2024)由中国物理学会高能物理分会主办，山东大学承办，中国高等科学技术中心（CCAST）与北京大学高能物理研究中心协办，会议日期为2024年11月14日至11月17日 (11月13日报到)，会议地点为山东省青岛市蓝谷国际酒店。

Changes compared to the previous CLHCP

- Integration of theory and experimental talks
- Customized 12 theory parallel talks to join experimental talks

Thursday			
Parallel 2	14:00 - ~16:00		
HIGGS (1)	#talks:	8	Lianliang MA (convener)
	Speaker	Institute	Title
15' + 5'	Jian Wang	SDU	Improved constraint on Higgs boson self-couplings with quartic and cubic power dependence in the cross section
12' + 3'	Junquan Tao	IHEP	Measurements of Higgs boson properties and search for new resonances in gamma gamma final state at CMS
12' + 3'	Yuji Li	FDU/BUAA/IHEP	Measurements of Higgs boson production cross sections in the four-lepton final state at 13.6 TeV in CMS
12' + 3'	Han Li	SDU	Simplified template cross sections for Higgs boson decays in H to ZZ* to 4l channel
12' + 3'	Chengguang Zhang	IHEP	Measurements of Higgs boson mass and width at CMS
12' + 3'	Ehsan Musajan	USTC	Measurement of the Higgs boson cross section and Width with the ATLAS detector
12' + 3'	Chengyang Pan	PKU	Measurements of Higgs boson production cross sections in the di-photon final state at 13.6 TeV in CMS
12' + 3'	Antonio De Maria	Nanjing University	Differential cross-section measurement of the Higgs boson decaying into two taus at the ATLAS experiment

A fruitful year of physics study

一些数据和说明 ATLAS/ Z.J. Liang (梁志均)

通过官方数据库索引：https://atlas-glance.cern.ch/atlas/

CLHCP2023以来，ATLAS中国组成员以主要作者身份（Primary Author）

发表 36 篇期刊文章 （包括已投稿）

总的国际会议报告数 45个（不包含poster）

后面仅高亮部分物理成果作展示

* 选择的结果中，中国组均起主导（分析组负责人、文章通讯作者等）或主要作用（主要完成人、各类审核报告等）

* 数家单位协作时，按拼音顺序排列

CMS中国组物理分析结果 CMS/ Zhen Hu (胡震)

2023.11至今公开的物理结果（22个）

- 希格斯性质测量： 2篇文章，2篇arXiv，2篇PAS
- 标准模型精确测量： 3篇文章，1篇arXiv，2篇PAS
- 新物理直接寻找： 5篇文章（2篇刚accepted），1篇arXiv
- B物理： 1篇文章，1篇PAS
- 重离子对撞： 2篇PAS

总计：11篇文章，4篇arXiv，7篇PAS

2022.11 ~ 2023.10的公开结果（16个）： 7篇文章，5篇arXiv，4篇PAS

5

年度研究进展 ALICE/X.M. Zhang (张晓明)

2023年12月 – 2024年11月： ALICE发表文章47篇

- 中国组主导发表文章9篇（其中*Phys. Rev. Lett.* 2篇）
  ➡ 占比：19%（人数占比5%，M&OA占比3%）
- 投稿文章12篇、内部审阅文章3篇

作HP、SQM、ICHEP等国际学术会议报告约30人次

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2024年度中国组主导的物理成果汇总 LHCb/Y.X. Zhang (张艳席)

已投稿9篇（其中5篇已发表），5篇即将投稿

另外9篇去年投稿今年发表

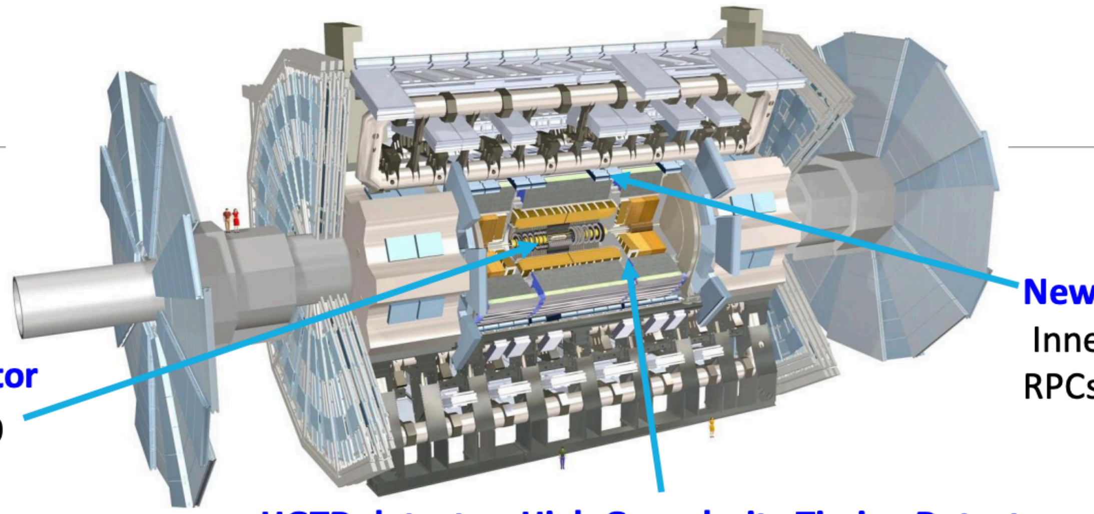
CP破坏稀有衰变	Λ_b^0, Λ_c^+和Λ衰变参数和CP破坏精确测量	arXiv:2409.02759, 已投稿至PRL	
	首次发现$B^+ \to J/\psi\pi^+$CP破坏迹象	LHCb-PAPER-2024-031, 将投稿至PRL	
	首次发现重子衰变$\Lambda_b^0 \to \Lambda K^+K^-$CP破坏迹象	LHCb-PAPER-2024-043, 将投稿至PRL	CERN seminar
	$B_s^0 \to \mu^+\mu^-\gamma$稀有衰变研究	JHEP 07 (2024) 101	
强子物理	$B^+ \to D^{*\pm}D^{\mp}K^+$中观测到(类)粲偶素新强子态	PRL 133 (2024) 131902	Editors' suggestion
	首次发现$\Lambda_b^0 \to \Sigma_c^{(*)++}D^{(*)-}K^-$衰变	PRD 110 (2024) L031104	
	首次发现$\Lambda_b^0 \to D^+D^-\Lambda$衰变	JHEP 07 (2024) 140	
	$\Xi_c(3055)^{+/0}$ 自旋量子数测量	arXiv:2409.05440，已投稿至PRL	
	$D_{s1}(2460)^+$衰变中发现新四夸克态 $T_{cs0}^*(2327)^{++/0}$信号	arXiv:2411.03399, 已投稿至Science Bulletin	
	发现$T_{cs0}^*(2870)^0$新衰变模式，检验同位旋对称性	LHCb-PAPER-2024-040, 将投稿至PRL	
重离子物理	pp 对撞$\psi(2S)$截面随带电多重数增加而降低	JHEP 05 (2024) 243	
	PbPb对撞 $\psi(2S)$与J/ψ相对截面测量	LHCb-PAPER-2024-041, 将投稿至JHEP	
	pp 对撞 $\Upsilon(2S)$和$\Upsilon(3S)$截面随多重数增加而降低	LHCb-PAPER-2024-038, 将投稿至JHEP	
电弱物理	电弱混合角精确测量	arXiv:2410.02502，JHEP已接受	

2024/11/14 张艳席，北京大学物理学院 12

Detector upgrade and performance

ATLAS/ Mei Zhao

ATLAS Phase-2 Upgrade



New Muon system
Inner barrel region with new RPCs, sMDTs, and TGCs

ITK: Inner Tracking Detector
- All silicon with at least 9 layers up to |η| = 4
- Less material, finer segmentation

HGTD detector: High Granularity Timing Detector
LGAD detector, high granularity and precise timing information

Upgraded Trigger and Data Acquisition System
- Single Level Trigger with 1 MHz output
- Improved 10 kHz Event Farm

Electronics Upgrades
- On-/off-detector electronics upgrades of LAr Calorimeter, Tile Calorimeter & Muon Detectors
- 40 MHz continuous readout with finer segmentation to trigger

Other upgrades
- Luminosity detectors (1% precision)
- HL-ZDC (Heavy Ion physics)

CMS/ Yong Ban

CMS Phase II upgrade

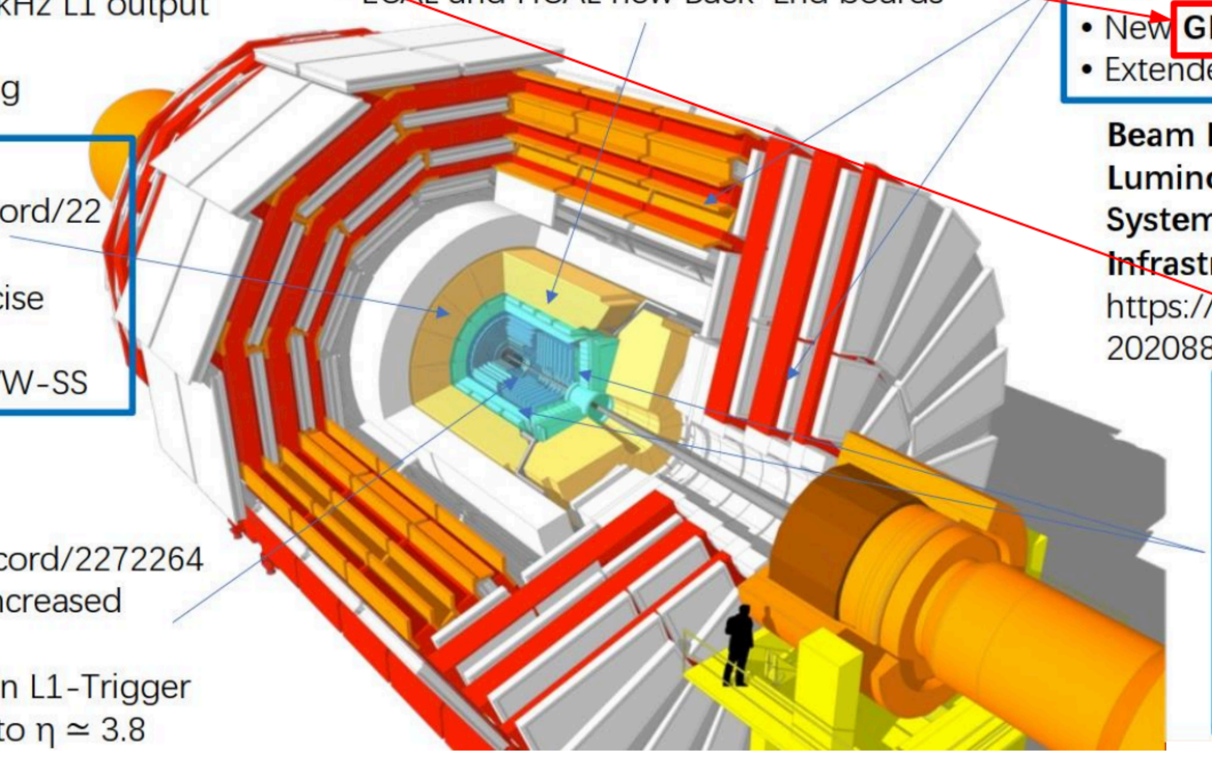
Tasks of China group

L1-Trigger HLT/DAQ
https://cds.cern.ch/record/2714892
https://cds.cern.ch/record/2759072
- Tracks in L1-Trigger at 40 MHz
- PFlow selection 750 kHz L1 output
- HLT output 7.5 kHz
- 40 MHz data scouting

Barrel Calorimeters
https://cds.cern.ch/record/2283187
- ECAL crystal granularity readout at 40 MHz with precise timing for e/γ at 30 GeV
- ECAL and HCAL new Back-End boards

Muon systems
https://cds.cern.ch/record/2283189
- DT & CSC new FE/BE readout
- RPC **Link**-board
- New **GEM/iRPC** 1.6 < η < 2.4
- Extended coverage to η ≃ 3

Calorimeter Endcap
https://cds.cern.ch/record/2293646
- 3D showers and precise timing **HGCAL**
- Si, Scint+SiPM in Pb/W-SS



Beam Radiation Instr. and Luminosity, and Common Systems and Infrastructure
https://cds.cern.ch/record/2020886

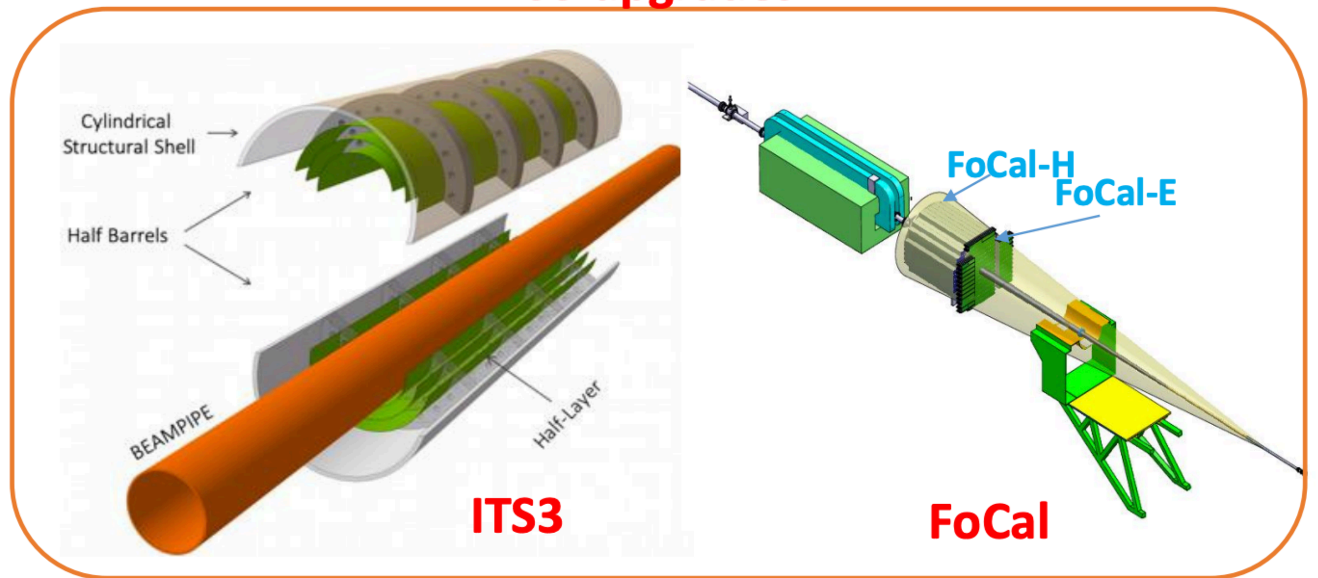
MIP Timing Detector
https://cds.cern.ch/record/2296612
Precision timing with:
- Barrel layer: Crystals + SiPMs
- Endcap layer: Low Gain Avalanche Diodes

Tracker
https://cds.cern.ch/record/2272264
- Si-Strip and Pixels increased granularity
- Design for tracking in L1-Trigger
- Extended coverage to η ≃ 3.8

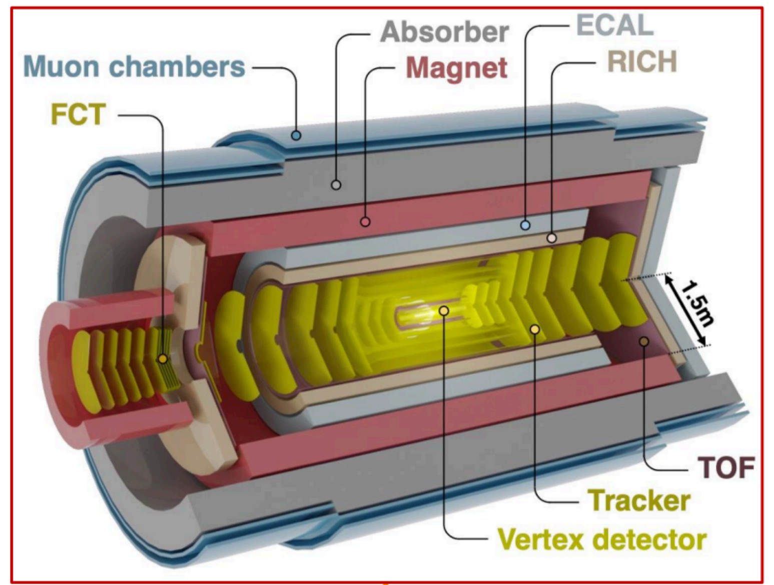
ALICE/Xuhao Yuan

ALICE upgrade programs

LS3 upgrades



LS4: ALICE3



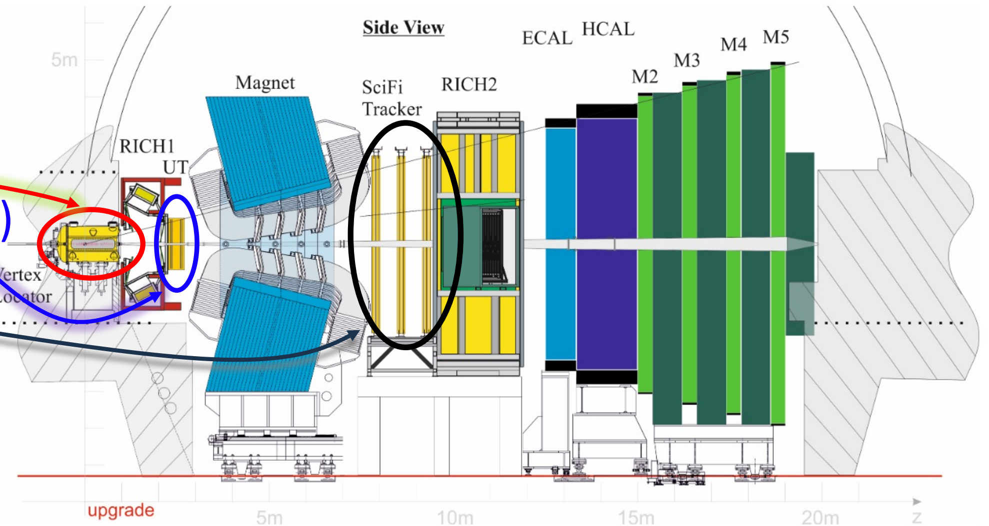
LHCb/ Xuhao Yuan

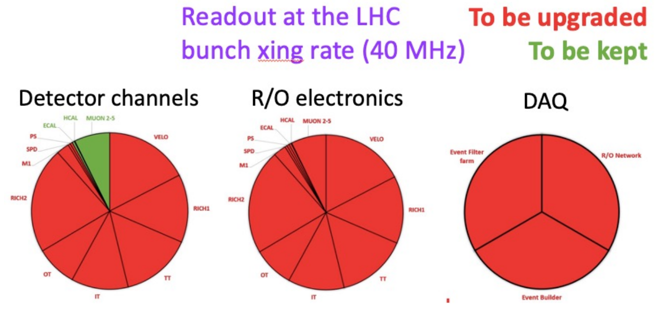
Upgrade I: a brand new detector

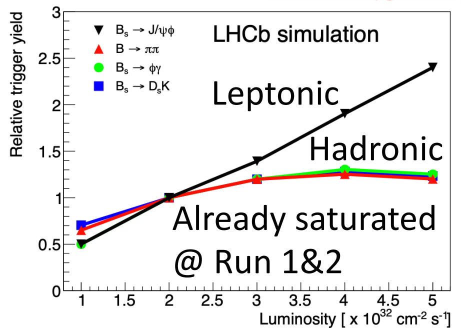
Higher luminosity (5x$\mathcal{L}_{Run1\&2}$) results in
➢ Higher rate, pile up, occupancy, fluence

New tracking system
➢ **VE**rtex**LO**cator (VELO), **U**pstream **T**racker (UT) and **Sci**ntillating **Fi**ber Tracker (SciFi)

RICHs: New optics + photon detectors
Calos: Reduce PMT gain + new electronics
MUON: new electronics







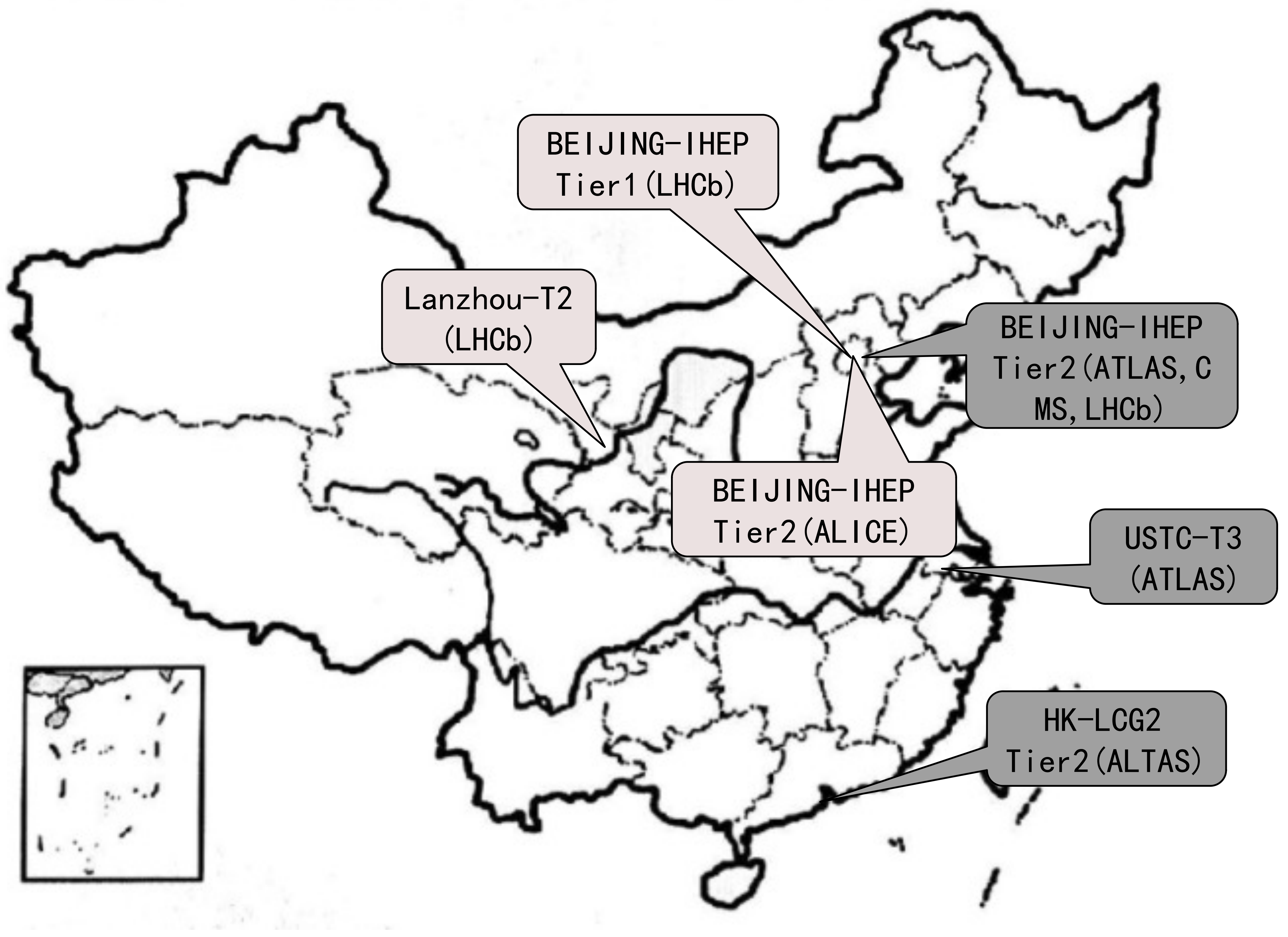
No hardware trigger
➢ 1st GPU trigger in a HEP experiment

LHC computing in China

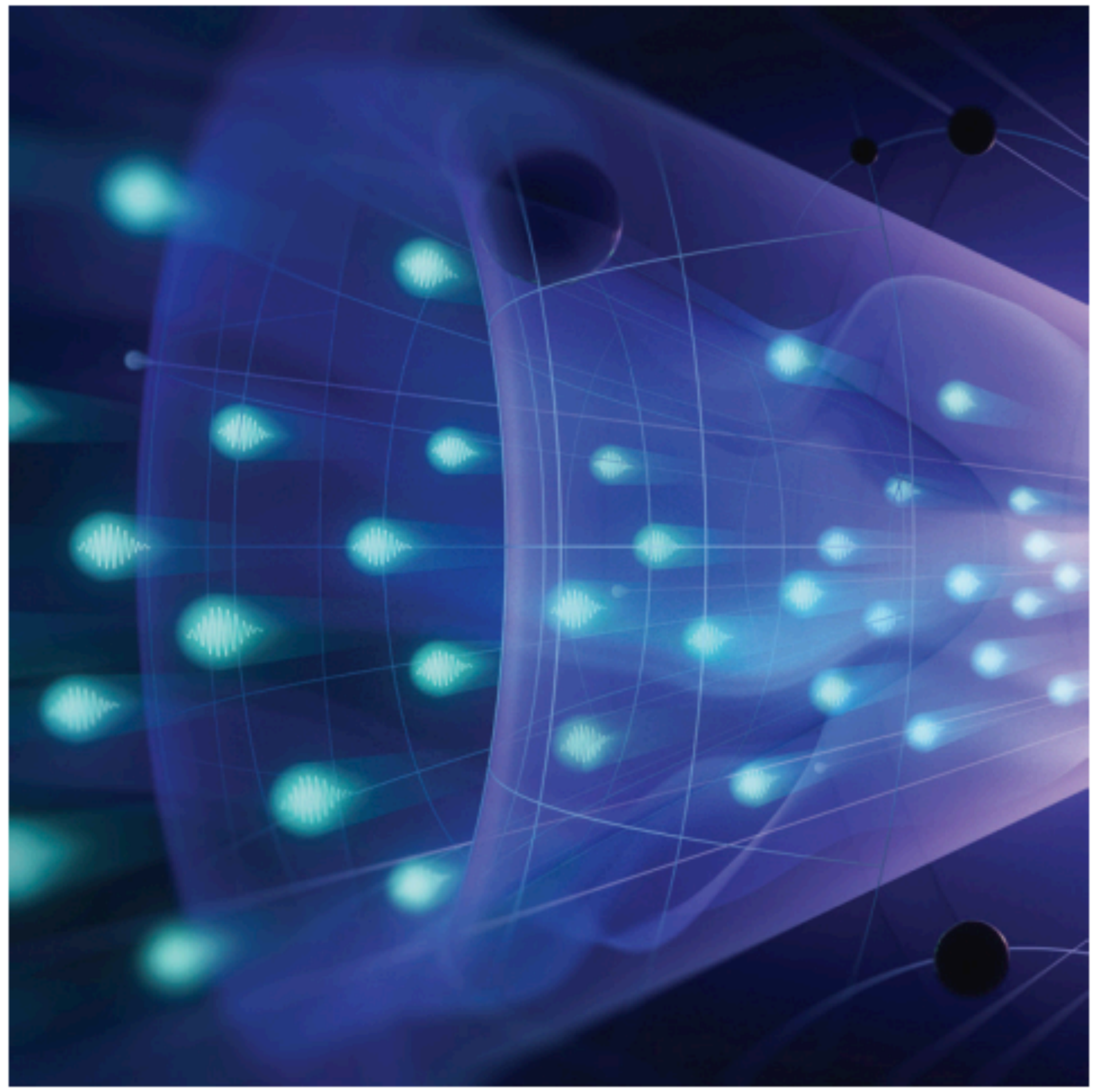
WLCG Sites in China mainland

IHEP/ Fazhi Qi

- Tier-2 sites
  - BEIJING-IHEP (ATLAS, CMS, LHCb)
  - HK-CUHK(ATLAS)
- New sites in these two years
  - Tier-1: BEIJING-IHEP (LHCb)
  - Tier-2: LZU-T2 (LHCb)
  - Tier-2: BEIJING-IHEP (ALICE)



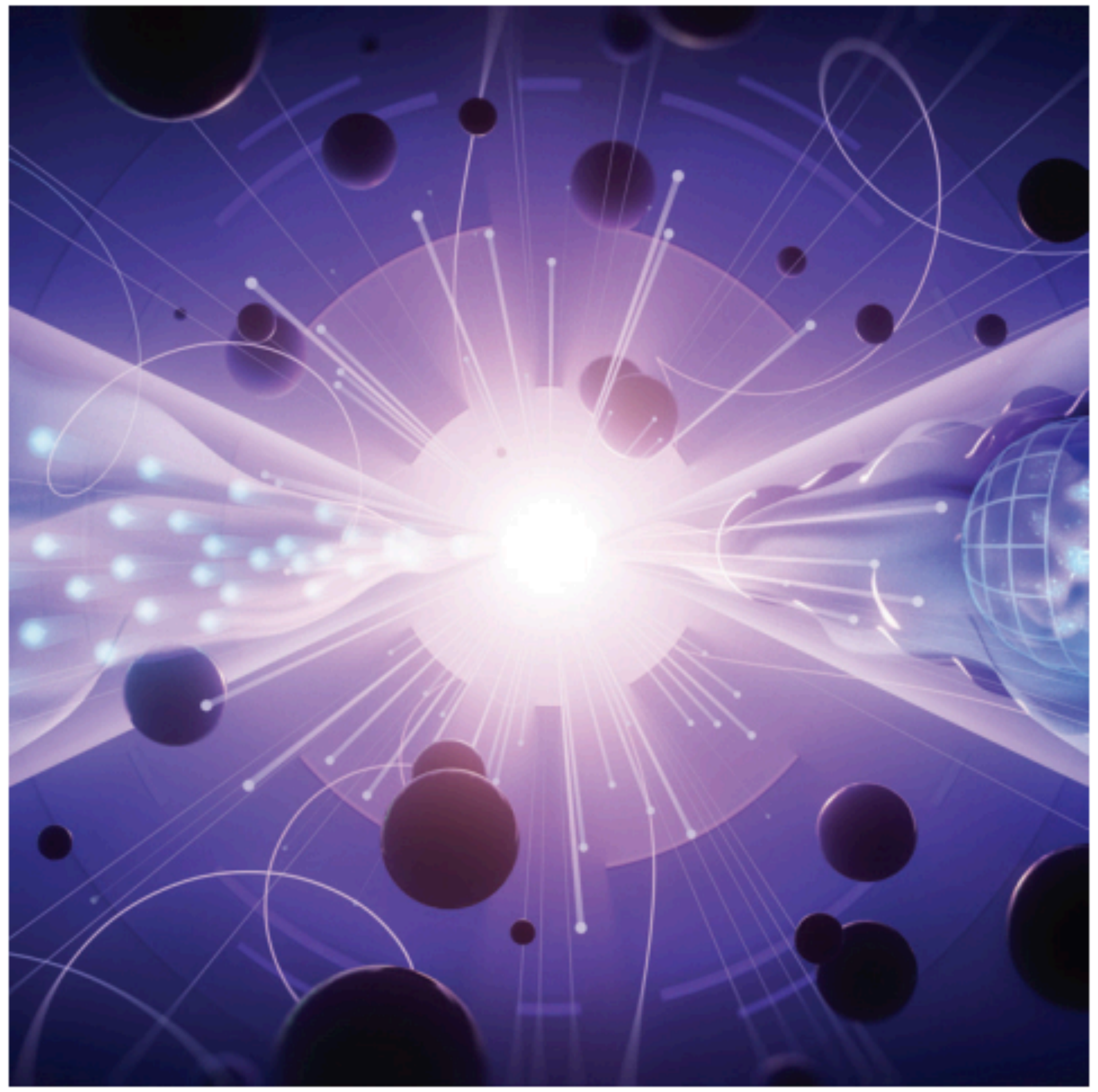
Collider physics as energy frontier



Decipher the Quantum Realm

Elucidate the Mysteries of Neutrinos

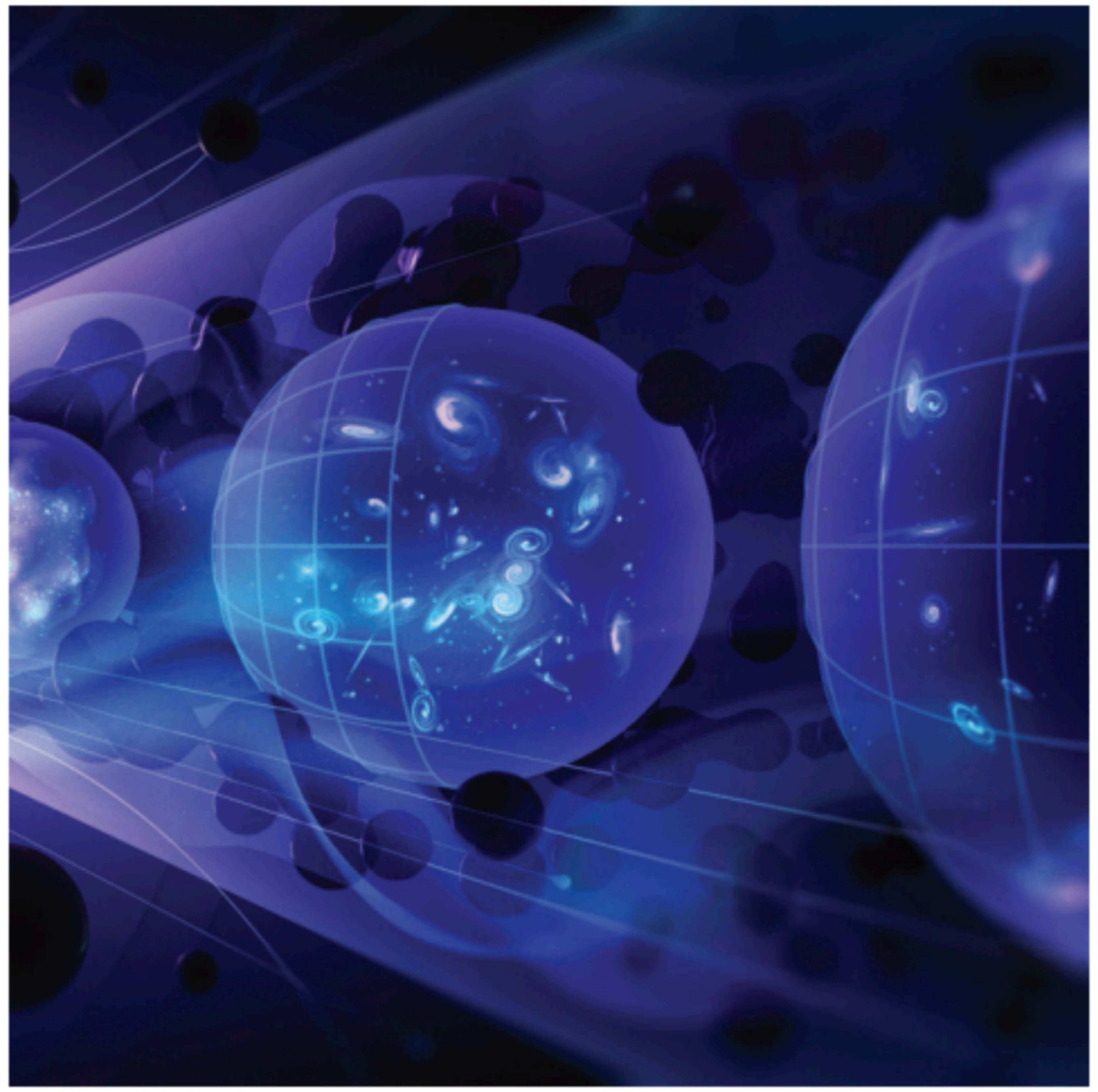
Reveal the Secrets of the Higgs Boson



Explore New Paradigms in Physics

Search for Direct Evidence of New Particles

Pursue Quantum Imprints of New Phenomena



Illuminate the Hidden Universe

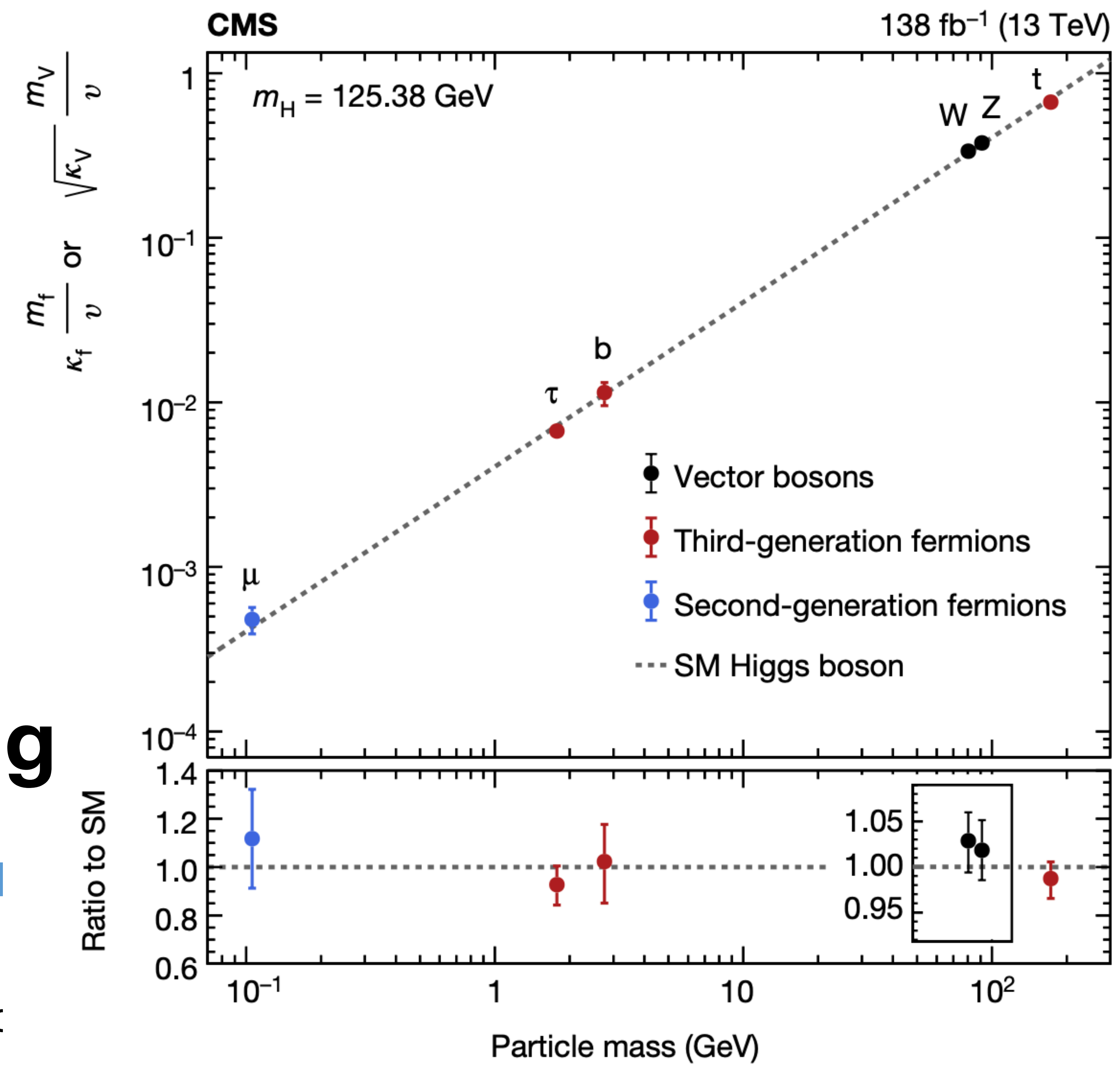
Determine the Nature of Dark Matter

Understand What Drives Cosmic Evolution

US P5 report 2023

Higgs physics

- Early hints to charm couplings



TDLI/ Kun Liu

IHEP/ Jin Wang

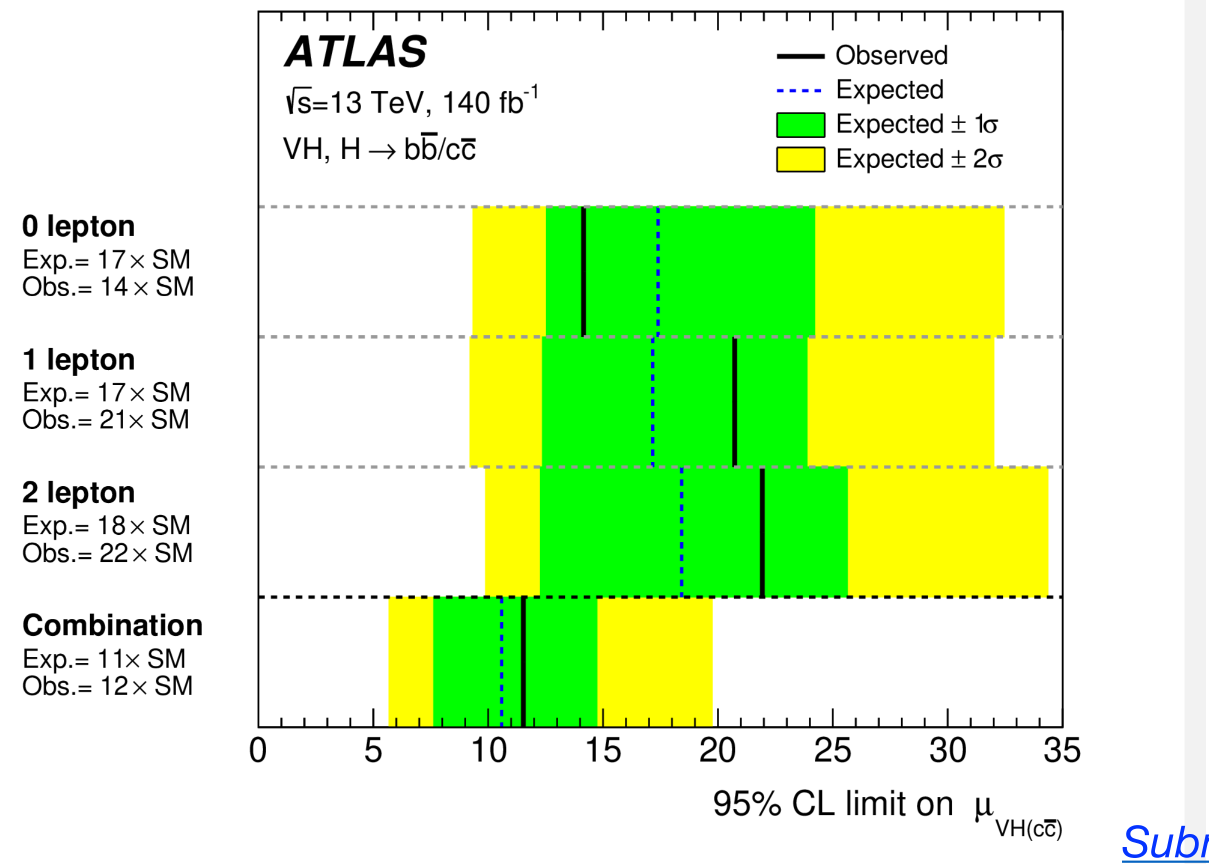
VH, H→cc direct constraints on the charm Yukawa coupling

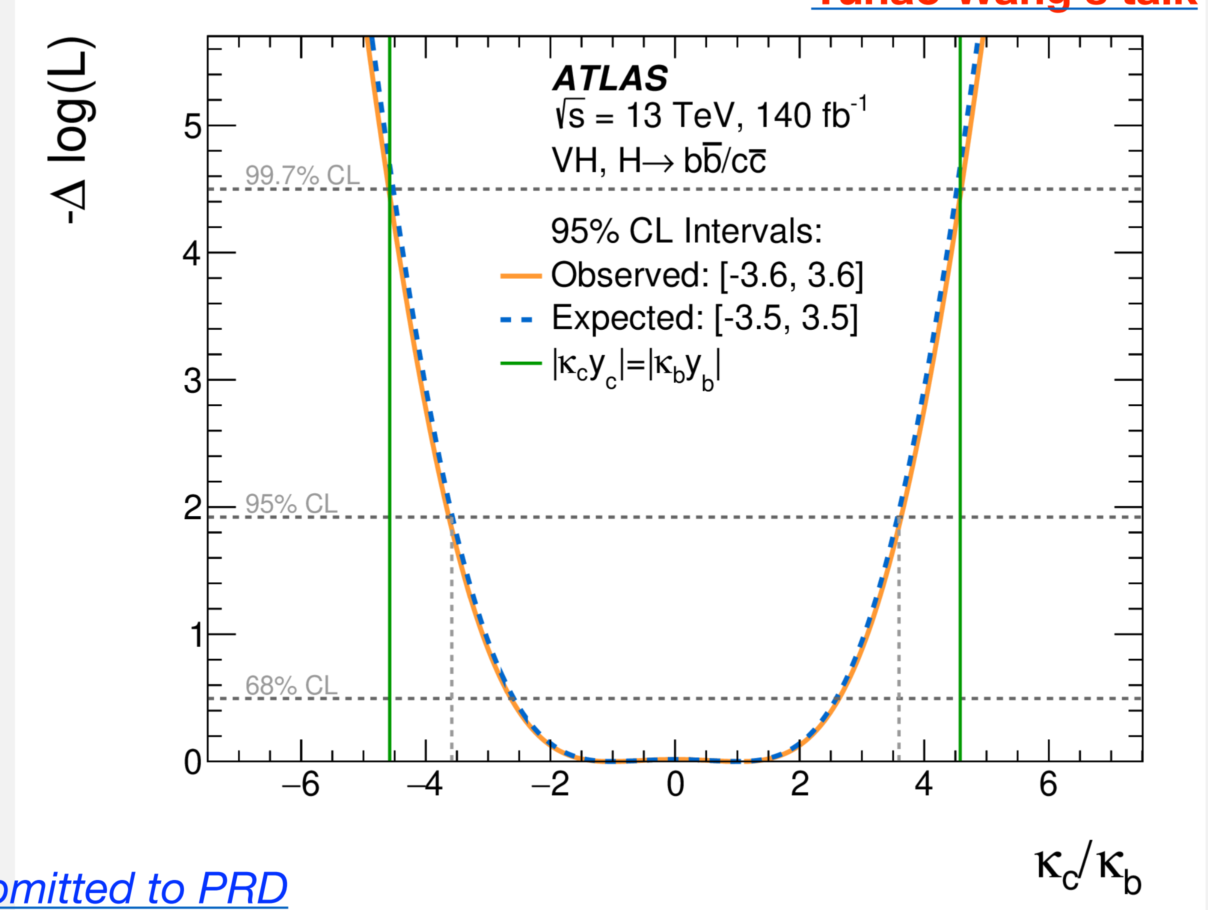
李政道研究所 Tsung-Dao Lee Institute

- 95% CL upper limit on signal strength 11.5 and on coupling modifier $|\kappa_c| < 4.2$.
- Combination of H→bb and H→cc, setting 95% CL upper limit on: $|\kappa_c/\kappa_b| < 3.6$. → less than b- and c-quark mass ratio 4.578, confirming Higgs coupling to charm is weaker than coupling to bottom.

Yuhao Wang's talk

Stat. and sys. effect at a similar level !

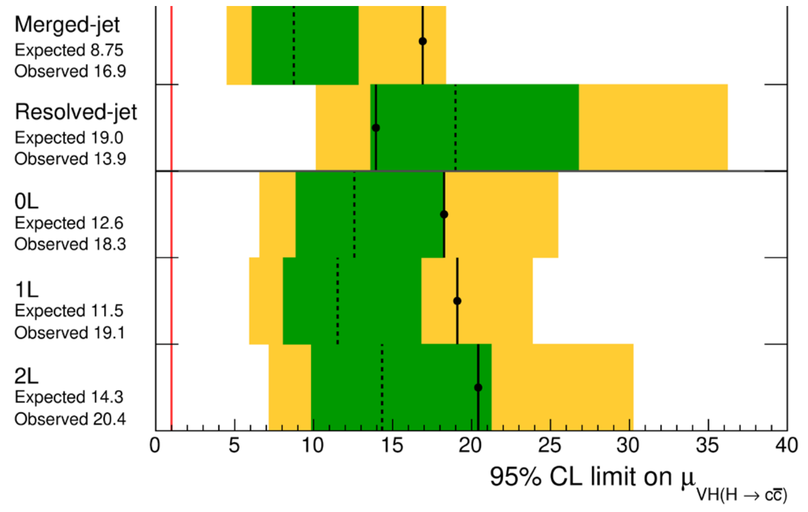




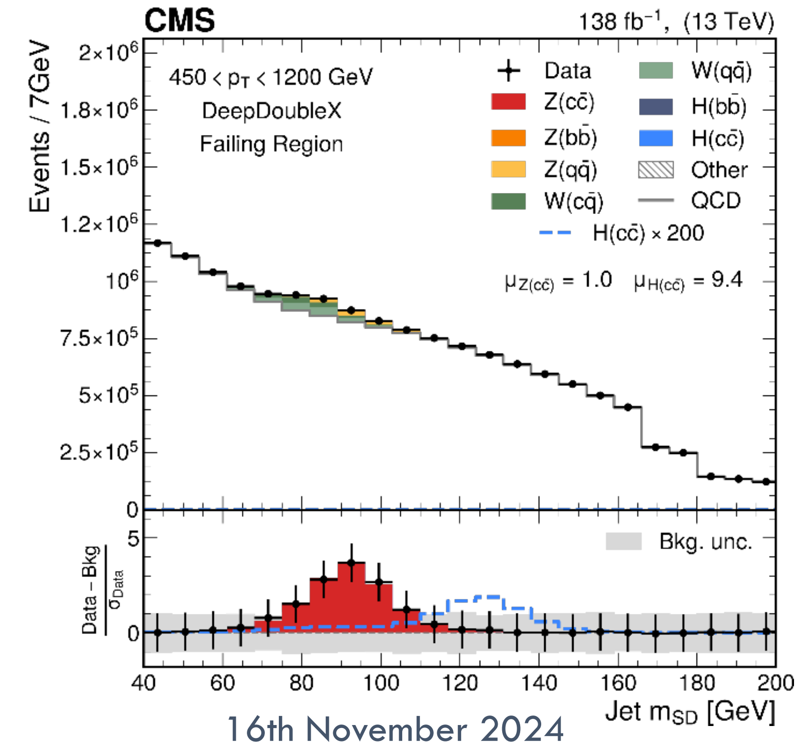
Submitted to PRD

5

- CMS $VH \to cc$
  - Leptonic decays
  - With both resolved and boosted jet analyses
  - Used GNN based c-tagging



- $\mu_{VH\to cc} < 14$ @ 95% CL (7.6 exp.)
  - Best sensitivity
- $|k_c| < 3.4$ @ 95% CL
  - Most stringent constraint to date
- Boosted $H \to cc$ ($p_T{}^H > 300$ GeV)
  - Boosted fat jets identified with DNN c-tagging
  - First observation of $Z \to cc$ in hadronic collisions



Phys. Rev. Lett. 131 (2023) 041801

Higgs physics

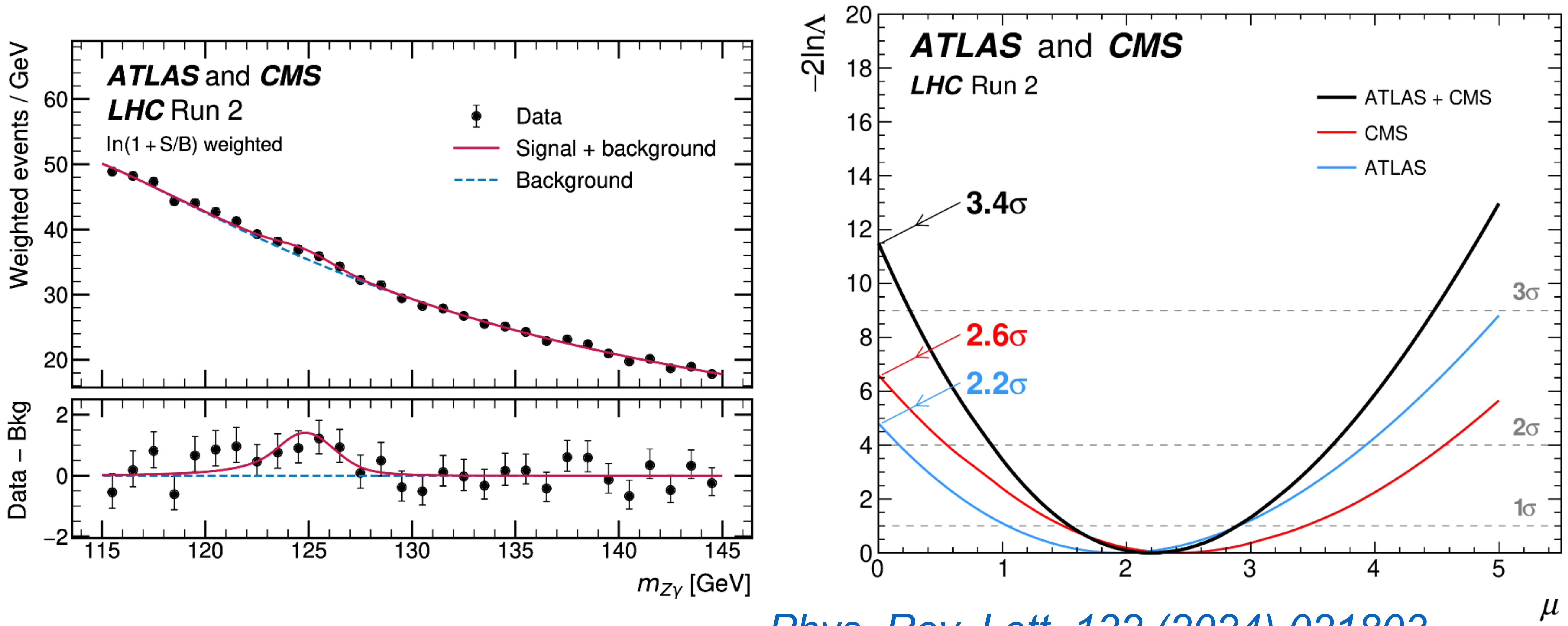
- New evidence to loop decay: $h \to Z\gamma$

IHEP/ Jin Wang

$H \to Z\gamma$ (ATLAS+CMS)

7

- Statistical combination of ATLAS and CMS results



Phys. Rev. Lett. 132 (2024) 021803

- Best fit signal strength at 2.2 ± 0.7 times the SM prediction
- The observed (expected) $H \to Z\gamma$ significance is 3.4 (1.6) σ
  - First evidence of the $H \to Z\gamma$ decay

Di-Higgs searches

- Path towards understanding Higgs potential and BSM

Higgs portal : $H^\dagger H$

SDU/ Yanlin Liu

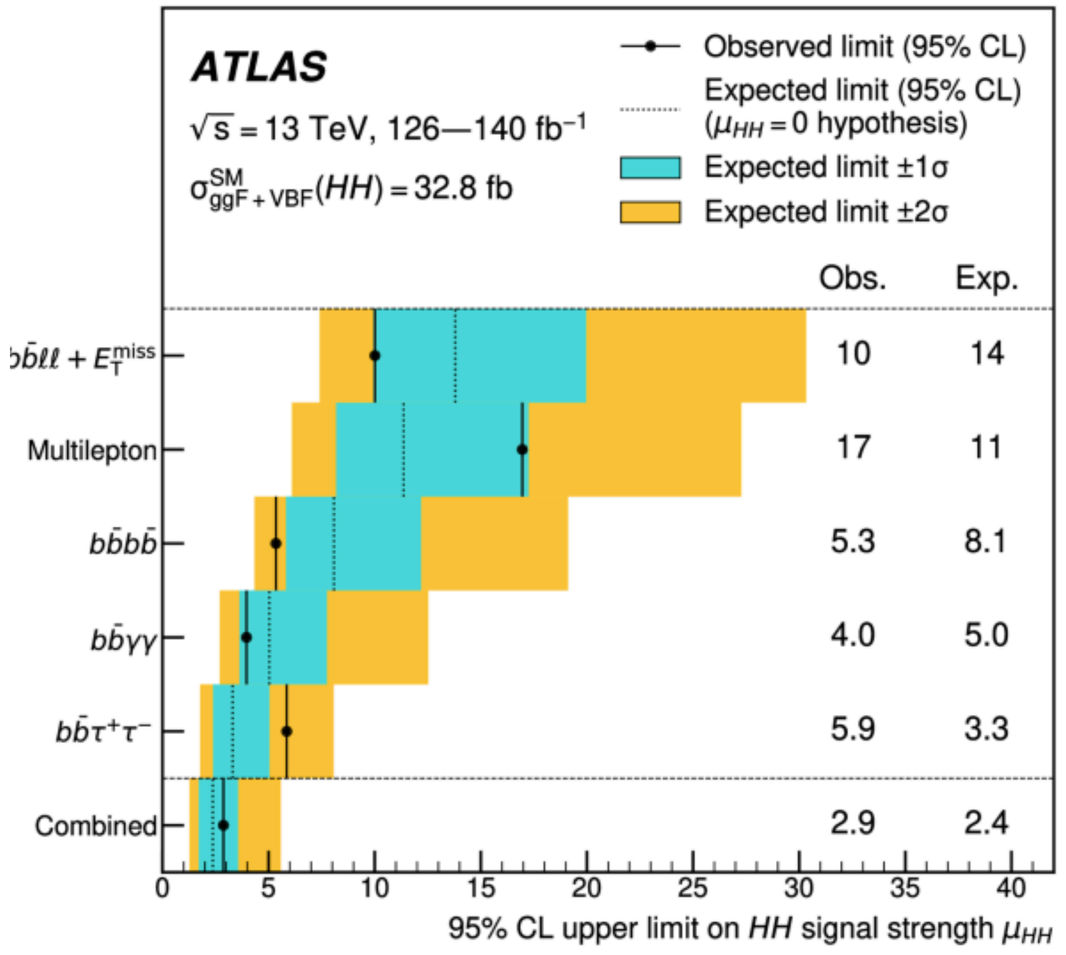
希格斯自耦合作用的研究：Combination

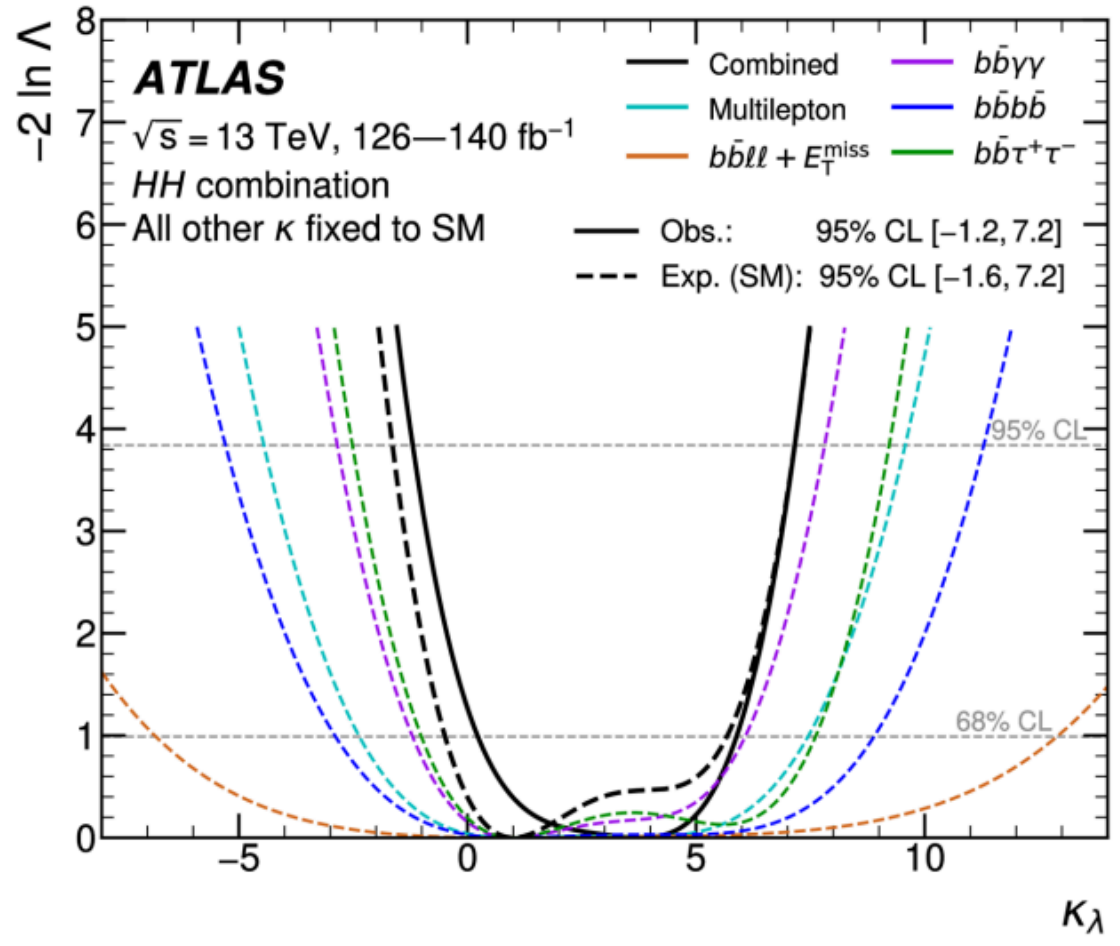
HH non-resonant combination

高能所、南大

ATLAS实验目前对希格斯自耦合最强限制

Phys. Rev. Lett. 133 (2024) 101801





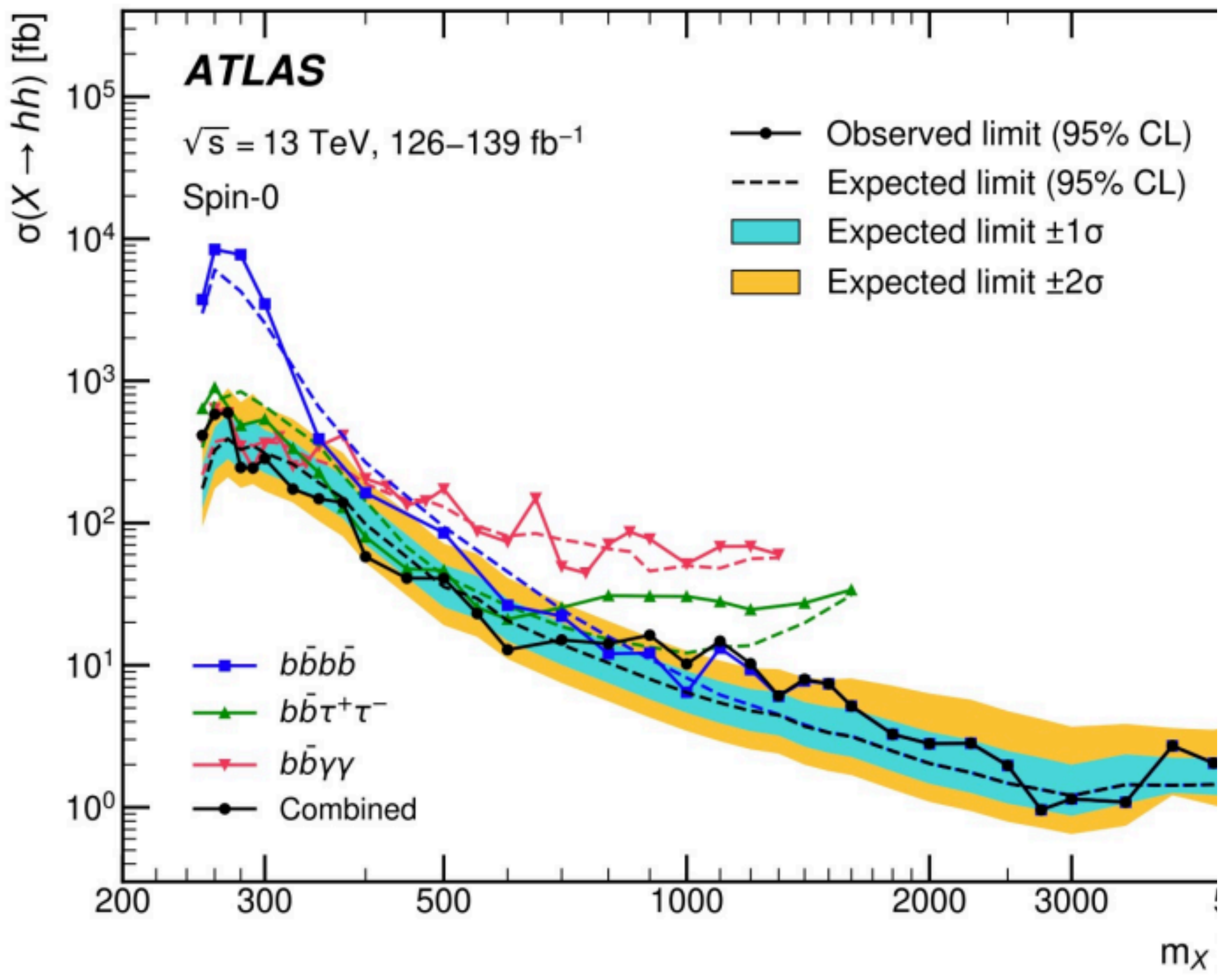
IHEP/ Zhijun Liang

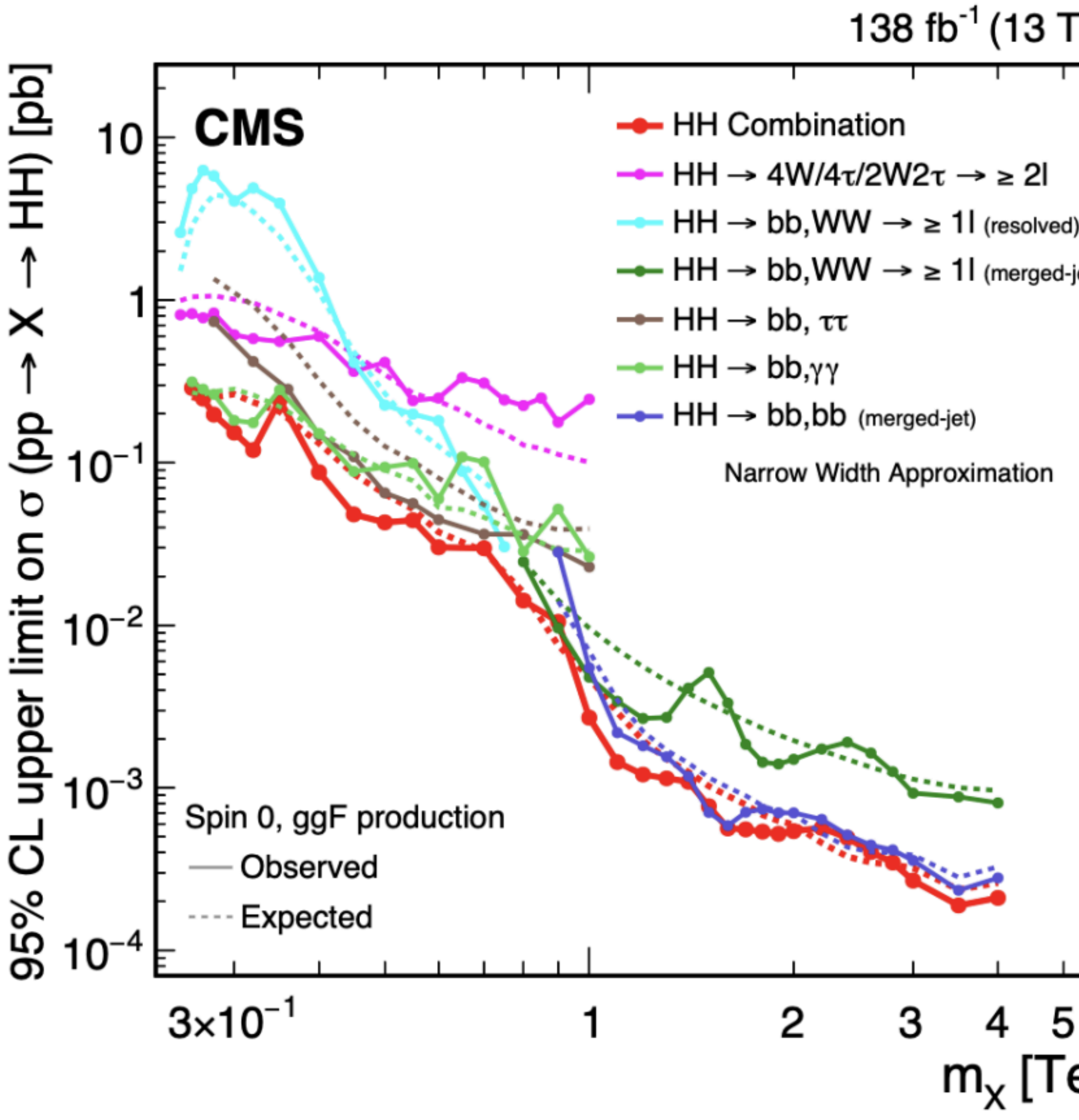
HH resonant combination

南大、山大

暂无新共振态的迹象

Phys. Rev. Lett. 132 (2024) 231801





Phys. Rev. Lett. 132 (2024) 231801

Di-boson measurement

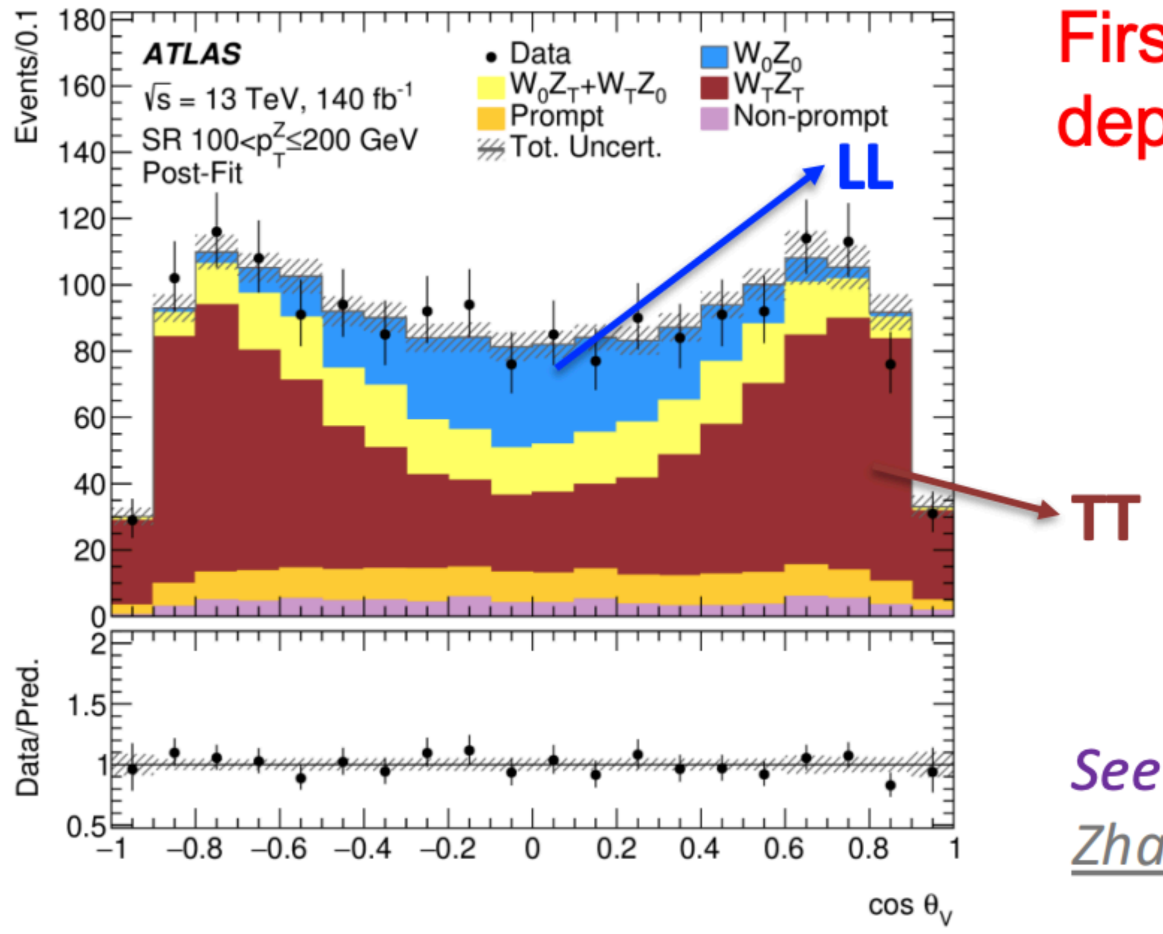
- Observation of WZ polarization and RAZ effect

USTC/Lailin Xu

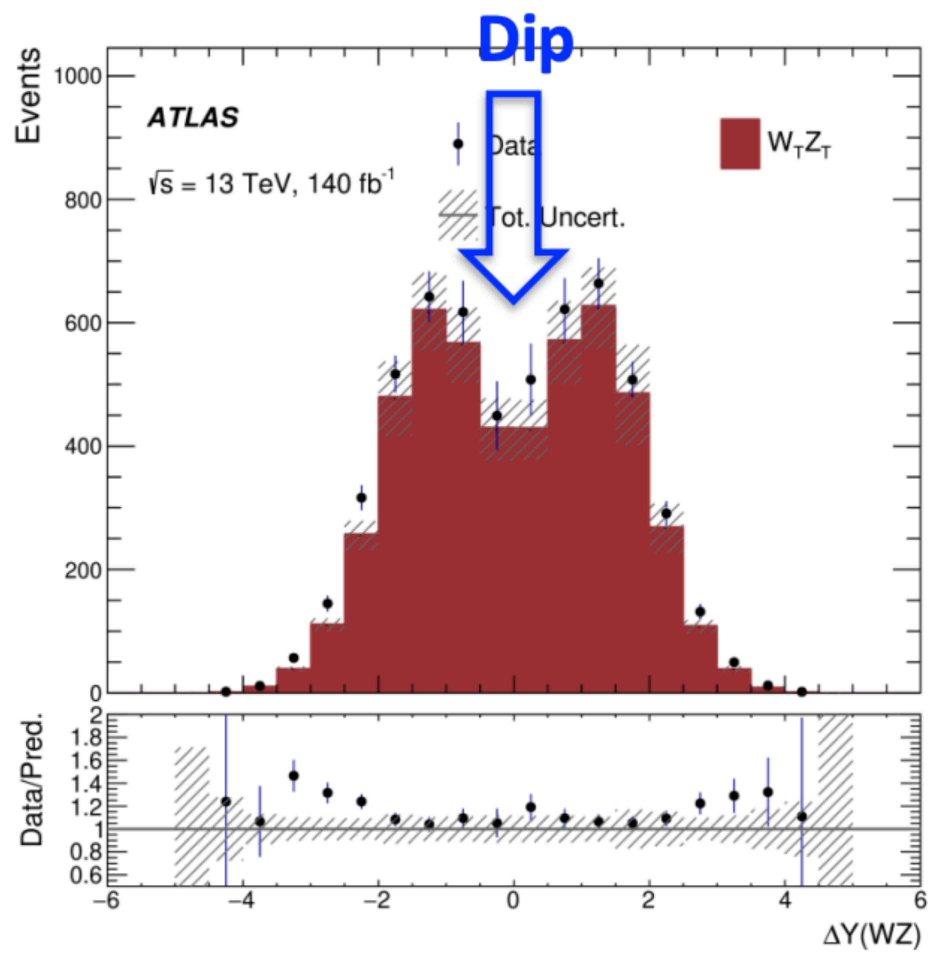
Observation of WZ pol. and the Radiation Amplitude Zero effect

	Measurement	
	$100 < p_T^Z \leq 200$ GeV	$p_T^Z > 200$ GeV
f_{00}	$0.19 \pm^{0.03}_{0.03}$ (stat) $\pm^{0.02}_{0.02}$ (syst)	$0.13 \pm^{0.09}_{0.08}$ (stat) $\pm^{0.02}_{0.02}$ (syst)
f_{0T+T0}	$0.18 \pm^{0.07}_{0.08}$ (stat) $\pm^{0.05}_{0.06}$ (syst)	$0.23 \pm^{0.17}_{0.18}$ (stat) $\pm^{0.06}_{0.10}$ (syst)
f_{TT}	$0.63 \pm^{0.05}_{0.05}$ (stat) $\pm^{0.04}_{0.04}$ (syst)	$0.64 \pm^{0.12}_{0.12}$ (stat) $\pm^{0.06}_{0.06}$ (syst)
f_{00} obs (exp) sig.	5.2 (4.3) σ	1.6 (2.5) σ

ATLAS, PRL133 (2024) 101802



First measurement of energy dependence of diboson polarization



See more details in Zhenyu Zhao's talk (Friday afternoon)

- RAZ effect leads to a dip around 0 in the $\Delta Y(WZ)$ and $\Delta Y(l_W Z)$ distributions
- Significant dips are observed
- Unfolded distributions also measured

Hadron physics

- New particles found related with charm

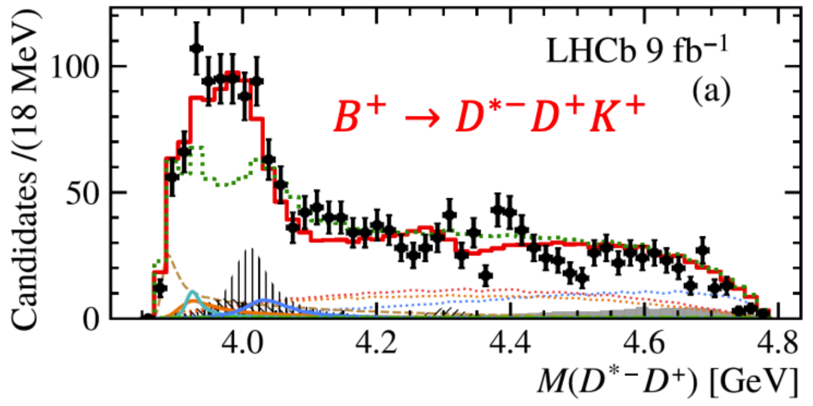
$B^+ \to D^{*\pm}D^{\mp}K^+$中发现新(类)粲偶素

国科大
清华

PRL 133 (2024) 131902

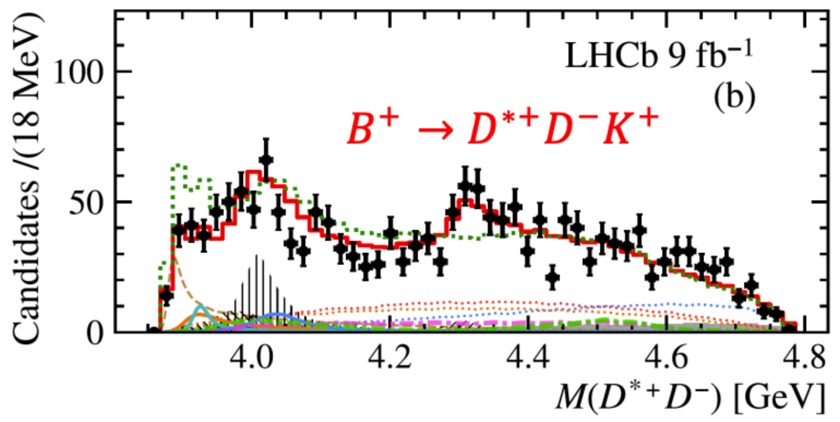
➢首次利用C宇称关联，联合分析$B^+ \to D^{*\pm}D^{\mp}K^+$两个衰变

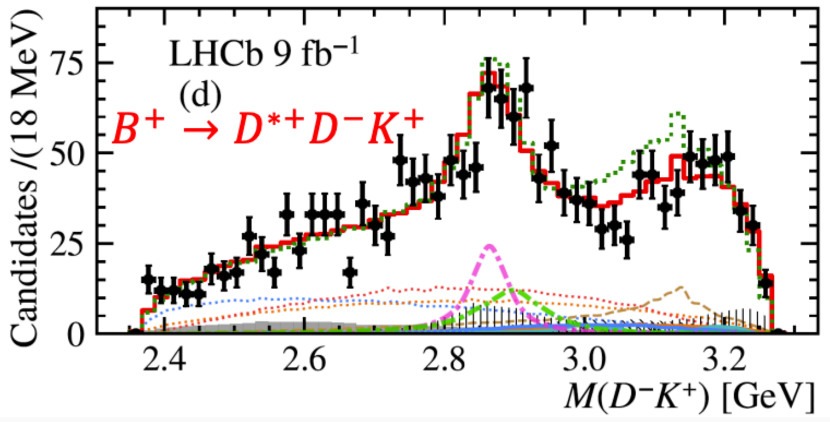
➢发现了至少三个新(类)粲偶素：$h_c(4000)$，$\chi_{c1}(4010)$，$h_c(4300)$



	$h_c(4000)$	$\chi_{c1}(4010)$	$h_c(4300)$
J^{PC}	1^{+-}	1^{++}	1^{+-}
m_0/MeV	4000^{+17+29}_{-14-22}	$4012.5^{+3.6+4.1}_{-3.9-3.7}$	$4307.3^{+6.4+3.3}_{-6.6-4.1}$
Γ_0/MeV	184^{+71+97}_{-45-61}	$62.7^{+7.0+6.4}_{-6.4-6.6}$	58^{+28+28}_{-16-25}

➢在新产生过程重现奇特态$T^*_{cs0}(2870)^0$, $T^*_{cs1}(2900)^0$





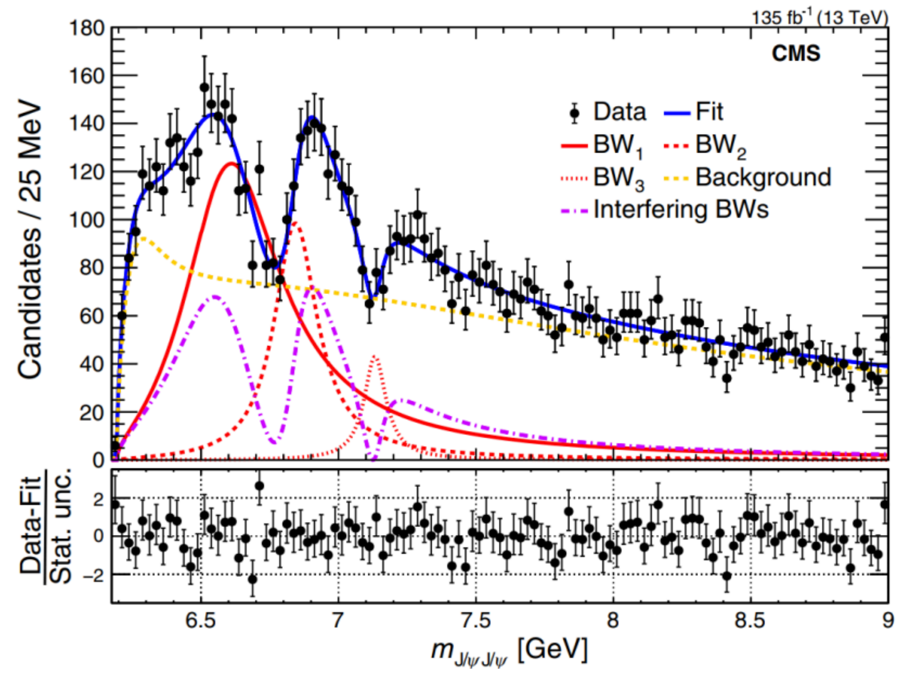
2024/11/14 张艳席，北京大学物理学院 21

J/ψ J/ψ 质量谱发现新粒子

Phys. Rev. Lett. 132 (2024) 111901
PRL编辑推荐

南师、清华、复旦

- 观测到3个可能的全粲四夸克态
  - X(6600) （>5σ）：新共振态（等待其他实验的检验）
  - X(7300) （>3σ）：Evidence
  - X(6900)：确认了LHCb实验2020年发现
- 3个峰干涉后更好地符合实验数据：可能具有相同的“自旋宇称”量子数，来自于同一家族
- 中国团队的原创主导贡献
  - 南师易凯分析联络人、张敬庆做预审核和审核报告、清华博士后Muhammad Ahmad做审核报告
  - 陈和生院士“......30年以来，这是第一次由一个中国CMS团队主导发现新粒子，而且是意料之外的粒子。”



		BW₁	BW₂	BW₃
No interference	m (MeV)	$6552 \pm 10 \pm 12$	$6927 \pm 9 \pm 4$	$7287^{+20}_{-18} \pm 5$
	Γ (MeV)	$124^{+32}_{-26} \pm 33$	$122^{+24}_{-21} \pm 18$	$95^{+59}_{-40} \pm 19$
	N	470^{+120}_{-110}	492^{+78}_{-73}	156^{+64}_{-51}
Interference	m (MeV)	6638^{+43+16}_{-38-31}	6847^{+44+48}_{-28-20}	7134^{+48+41}_{-25-15}
	Γ (MeV)	$440^{+230+110}_{-200-240}$	191^{+66+25}_{-49-17}	97^{+40+29}_{-29-26}

正在进行自旋、宇称、截面测量

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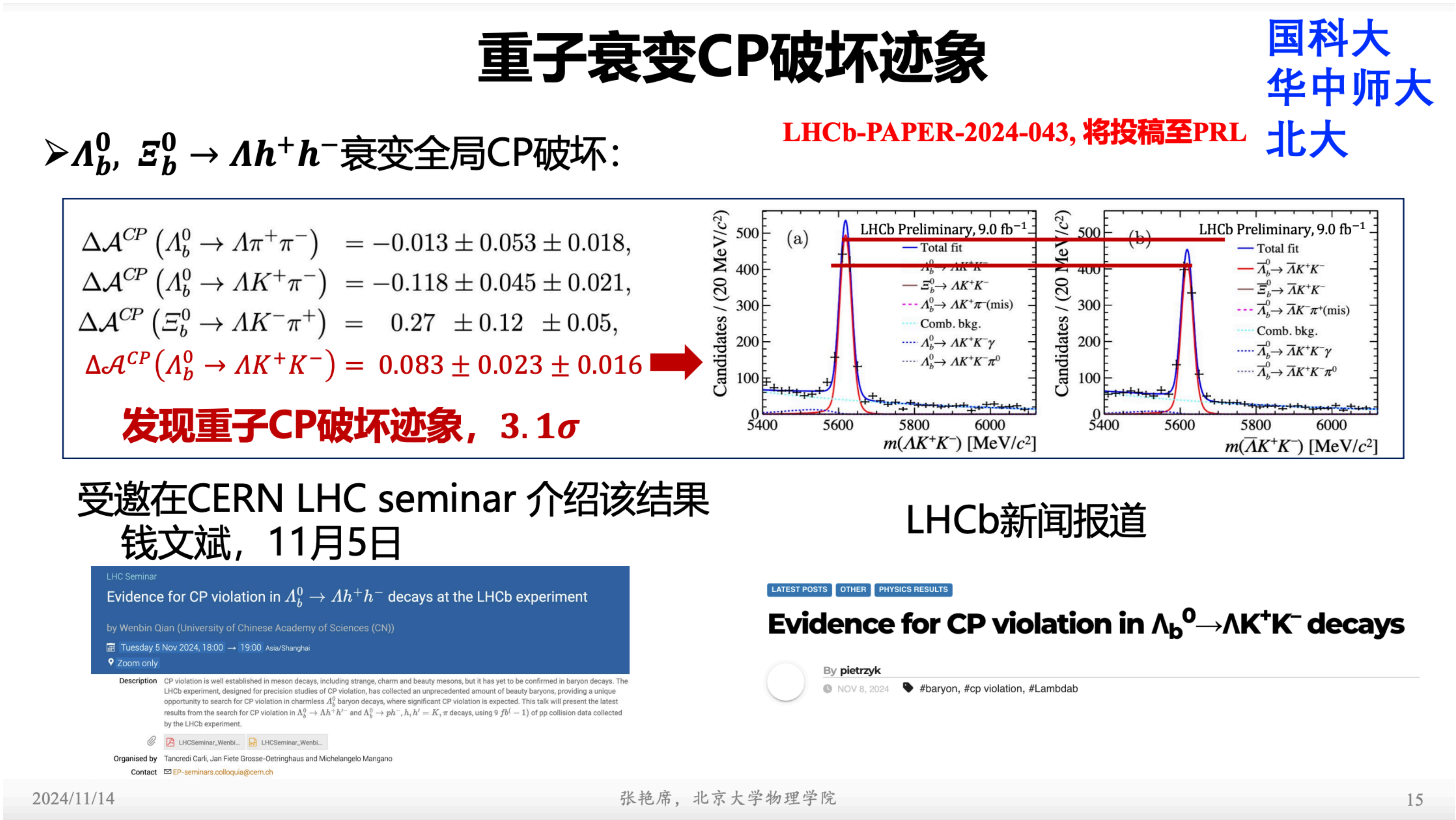
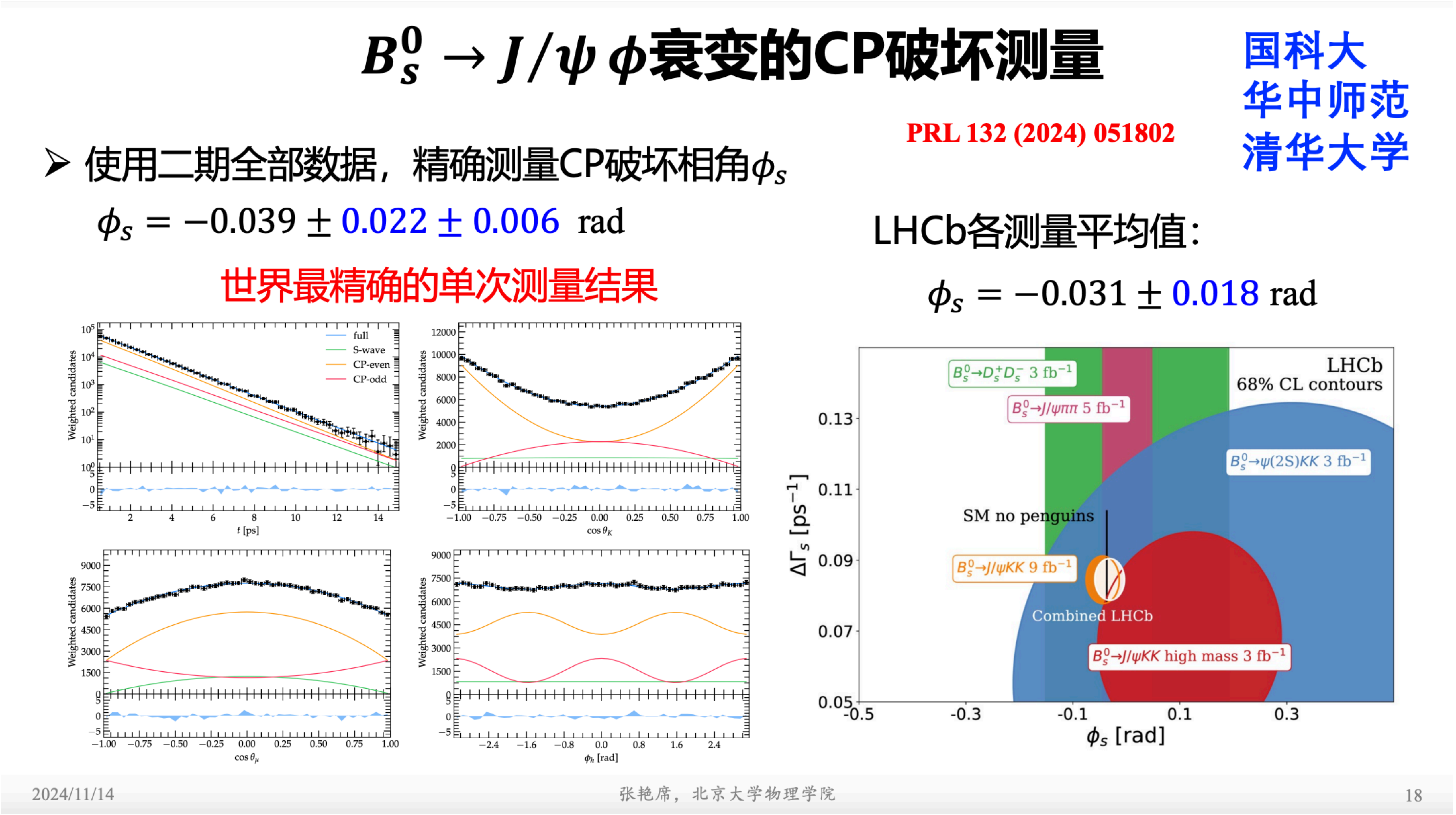
PKU/Yanxi Zhang

Flavor physics

- Better CP measurements in baryon and B mesons





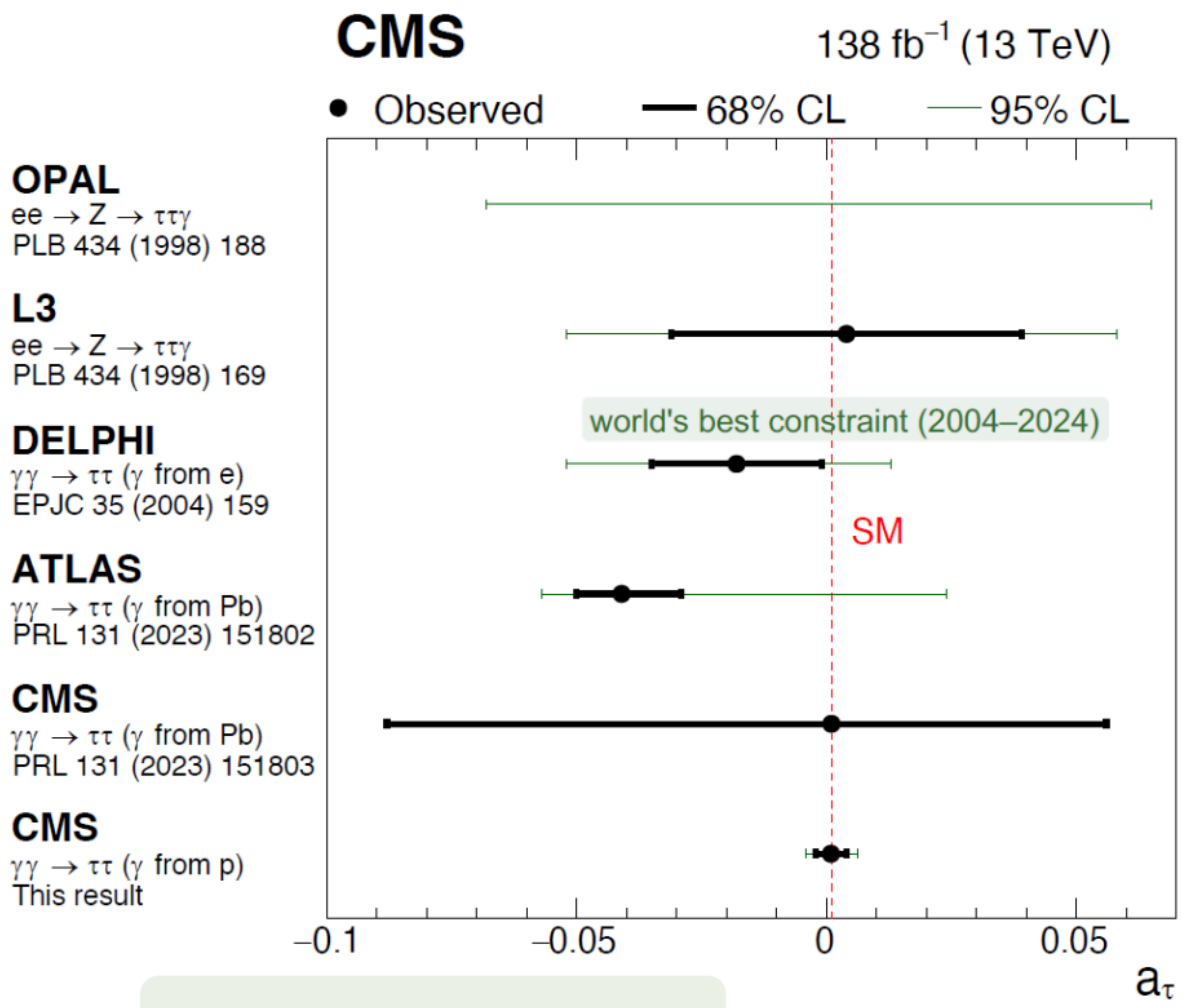
PKU/Yanxi Zhang

Tau g-2

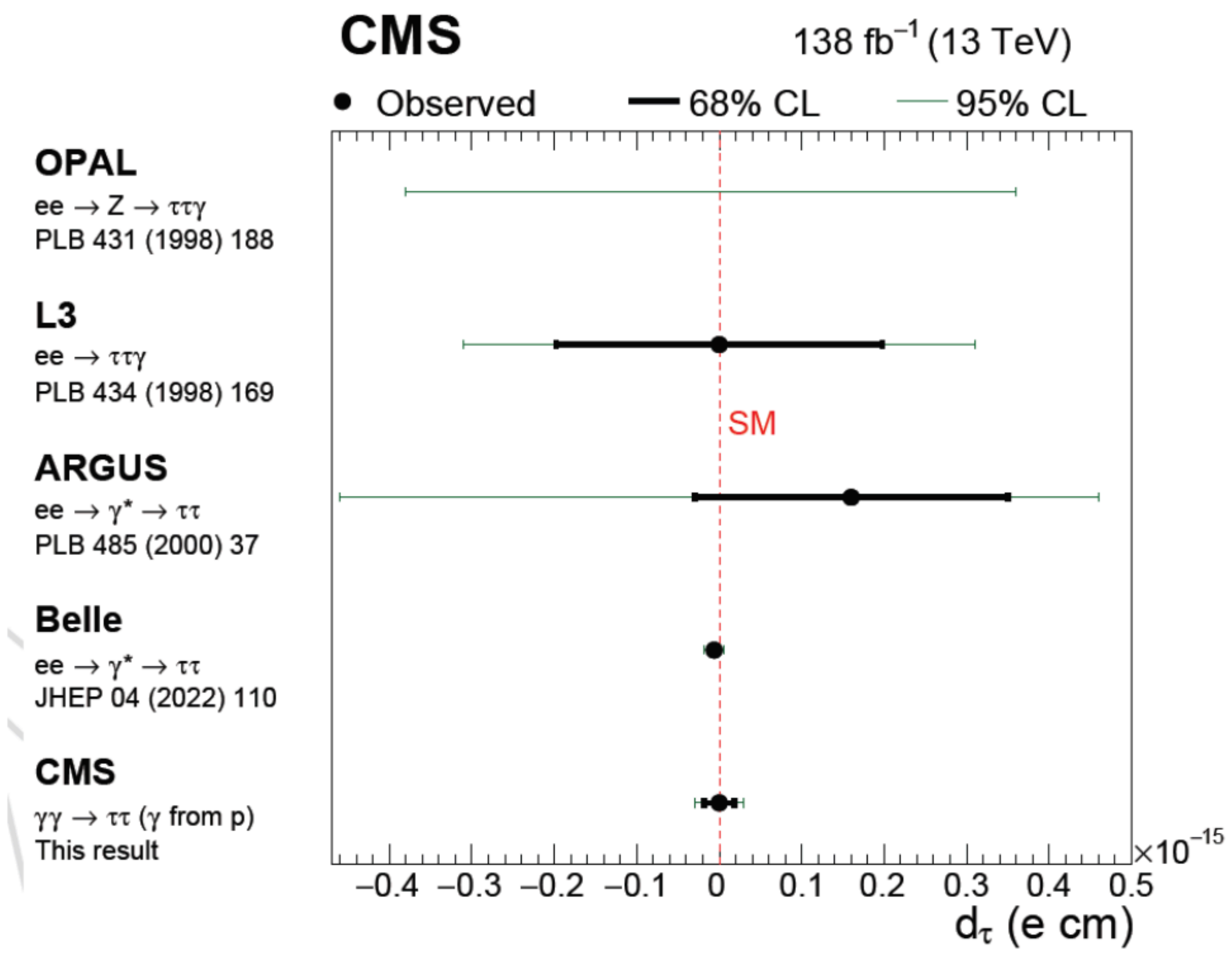
- Best measurement for tau g-2 and EDM

PKU/Dayong Wang

Constraints on a_τ and d_τ



>5x better than LEP !



approaching Belle !

ROPP 87 (2024) 107801

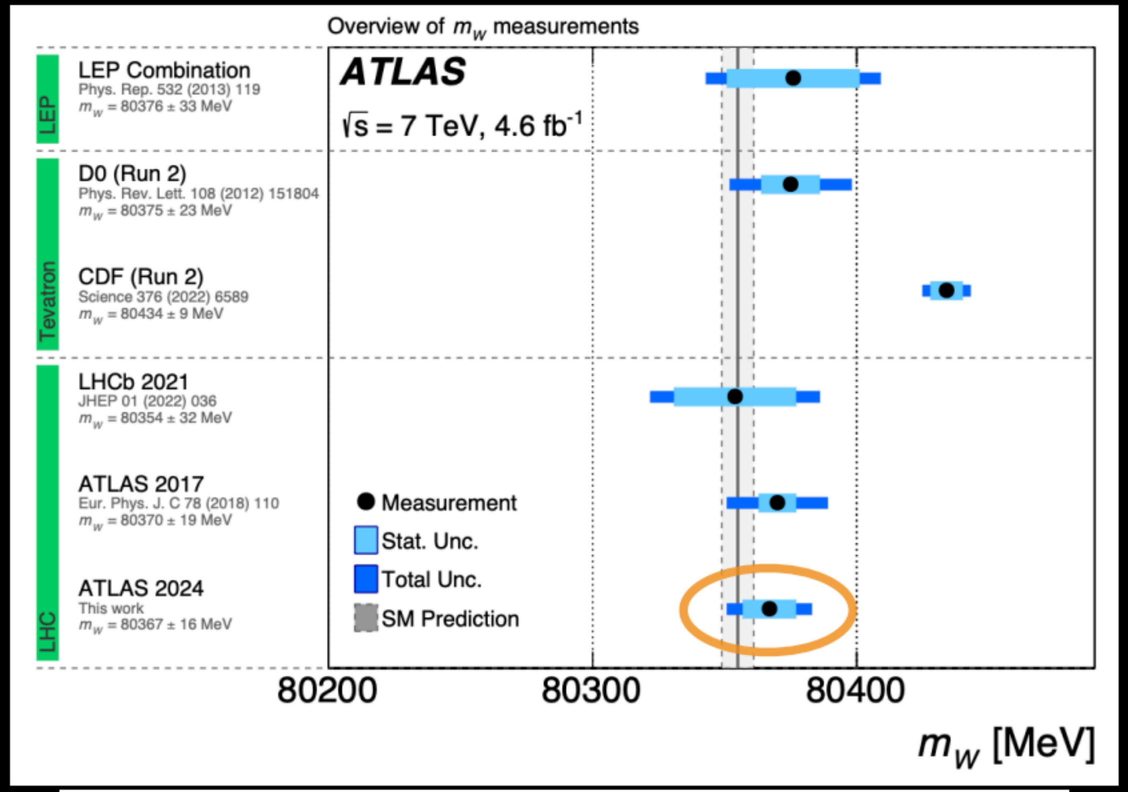
Precision EW physics: W mass

- Back to the norm

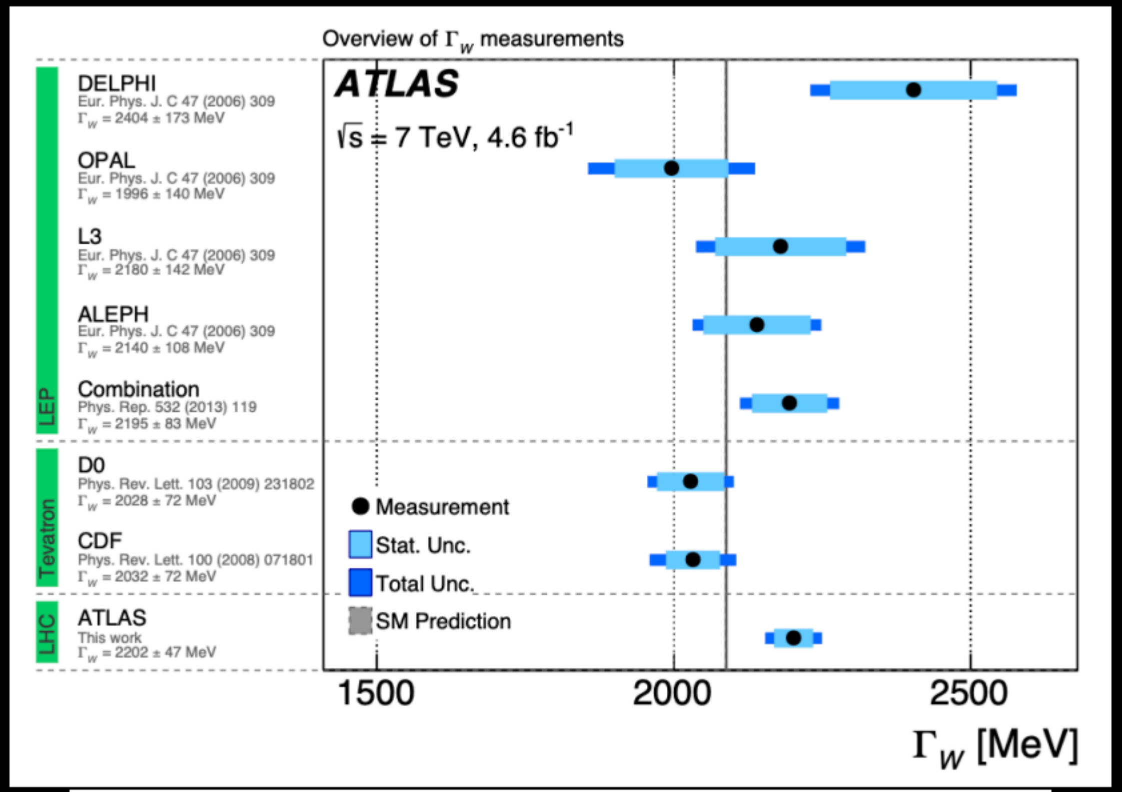
IHEP/ João Costa

W mass and width measurements from ATLAS

arXiv:2403.15085



Unc. [MeV]	Total	Stat.	Syst.	PDF	A_i	Backg.	EW	e	μ	u_T	Lumi	Γ_W	PS
p_T^ℓ	16.2	11.1	11.8	4.9	3.5	1.7	5.6	5.9	5.4	0.9	1.1	0.1	1.5
m_T	24.4	11.4	21.6	11.7	4.7	4.1	4.9	6.7	6.0	11.4	2.5	0.2	7.0
Combined	15.9	9.8	12.5	5.7	3.7	2.0	5.4	6.0	5.4	2.3	1.3	0.1	2.3

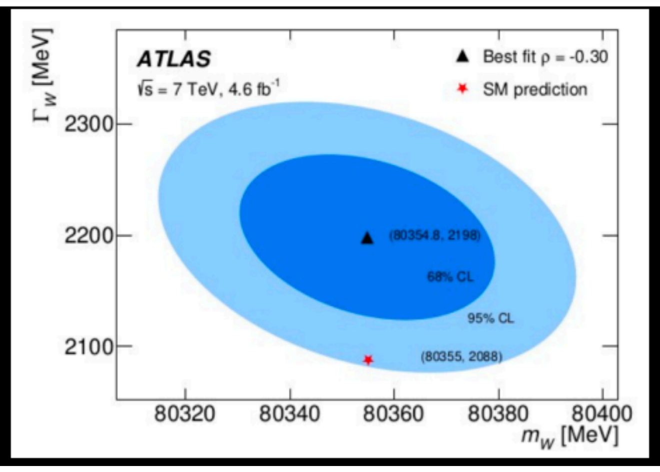


Unc. [MeV]	Total	Stat.	Syst.	PDF	A_i	Backg.	EW	e	μ	u_T	Lumi	m_W	PS
p_T^ℓ	72	27	66	21	14	10	5	13	12	12	10	6	55
m_T	48	36	32	5	7	10	3	13	9	18	9	6	12
Combined	47	32	34	7	8	9	3	13	9	17	9	6	18

m_W = 80366.5 ± 15.9 MeV (0.02% uncertainty)

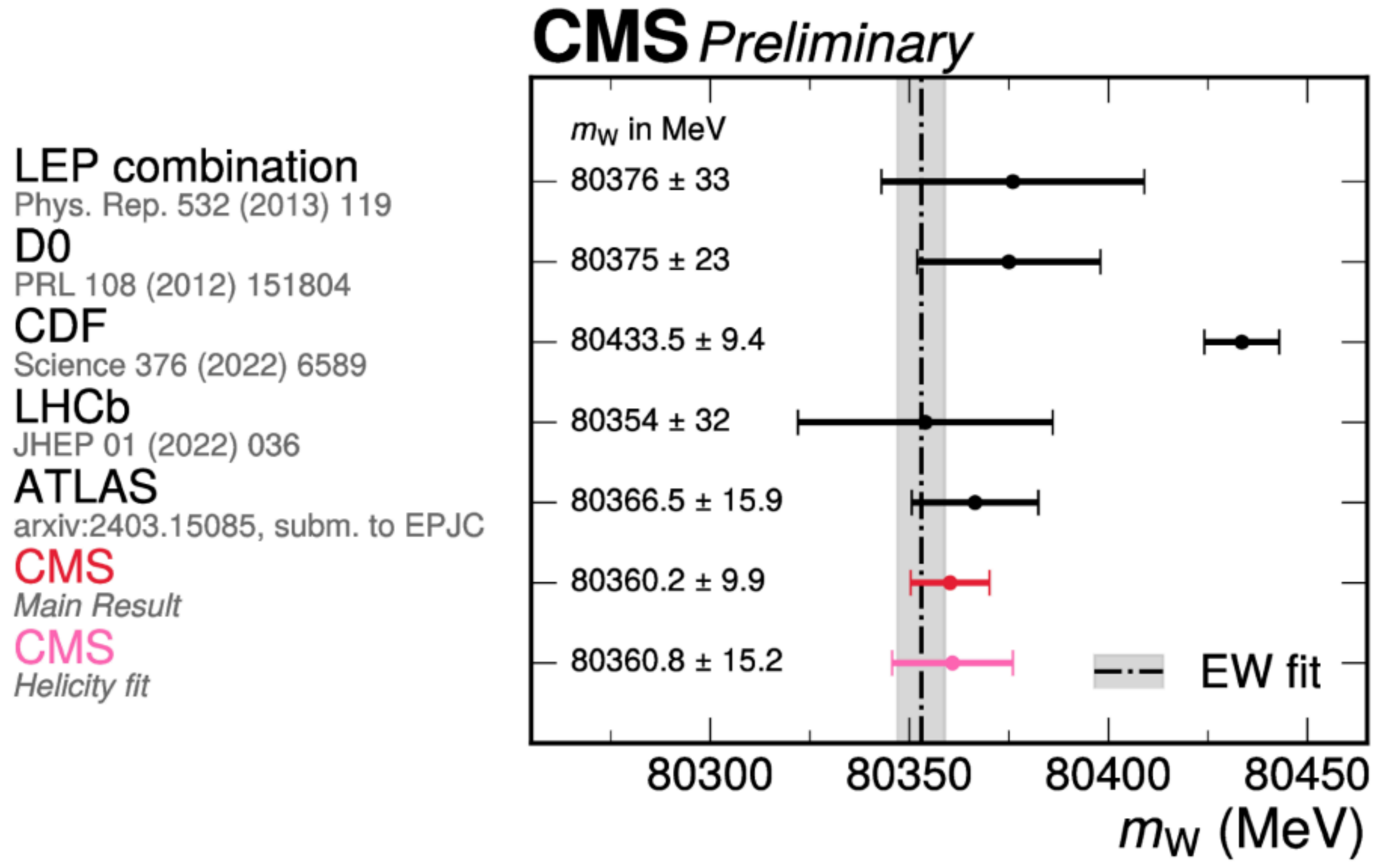
Γ_W = 2202 ± 47 MeV

Most precise single-experiment measurement of Γ_W



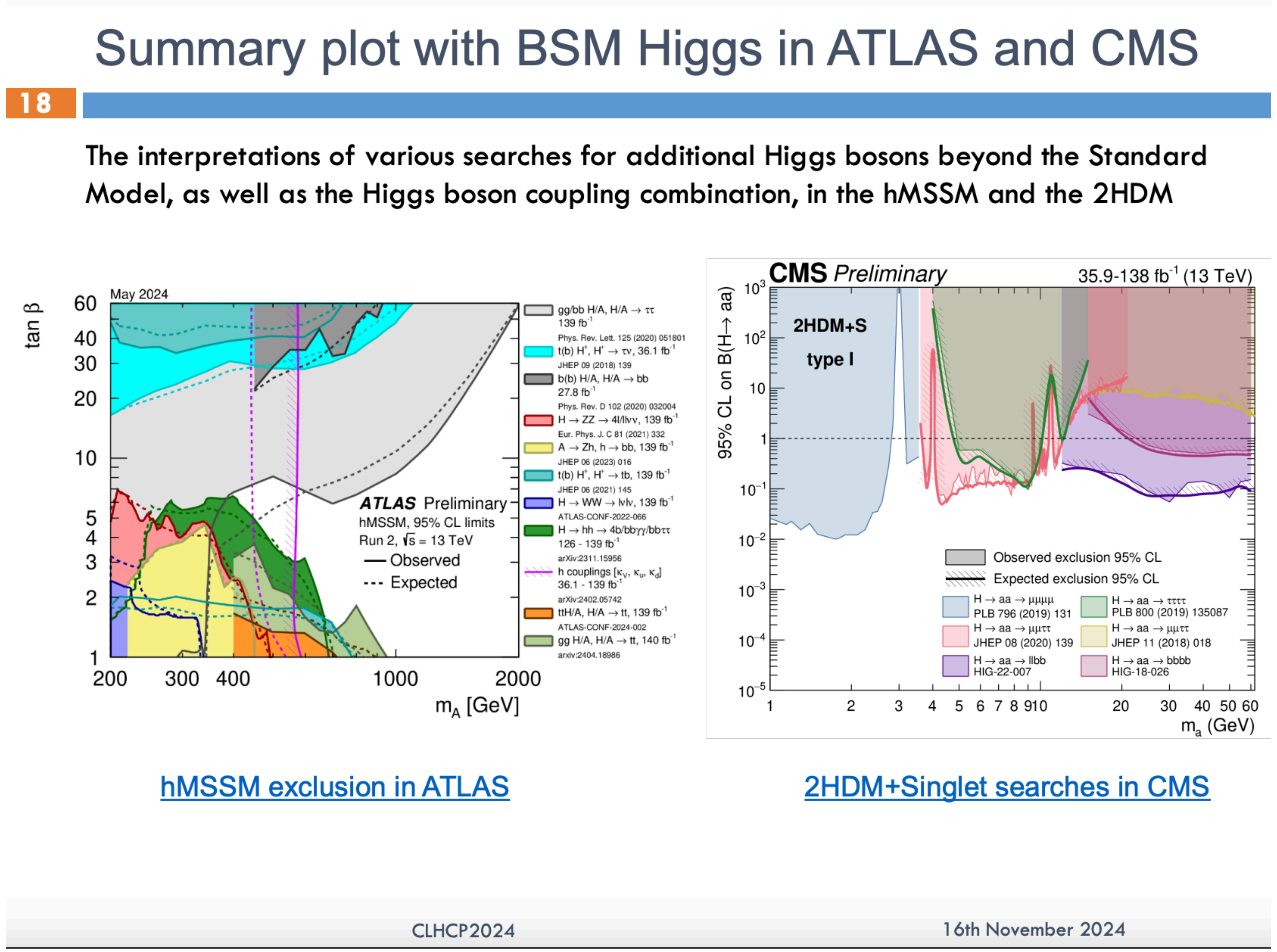
Previous measurement from 2017: m= 80370 ± 19 MeV

20

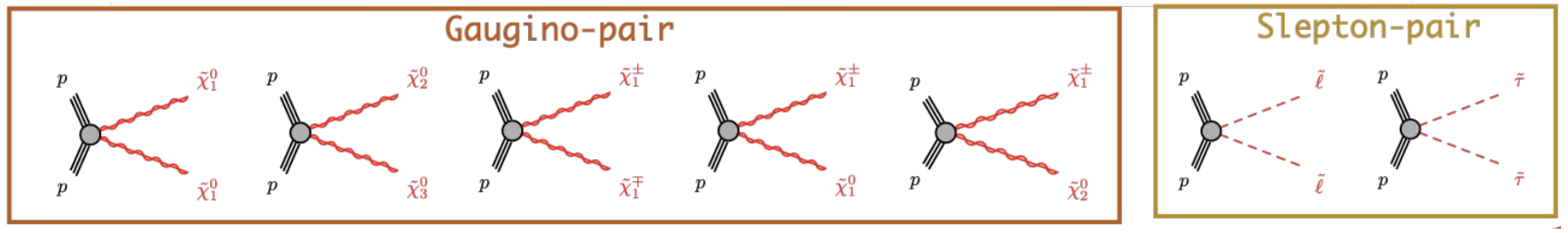


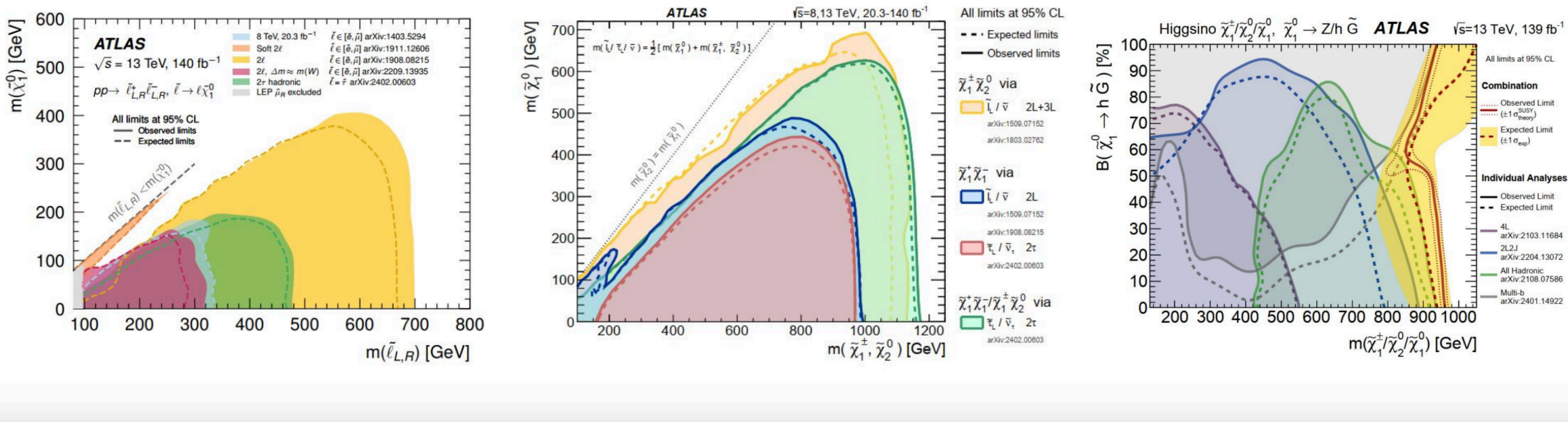
BSM searches

- BSM searches with extra Higgs and SUSY



EWKly produced SUSY:





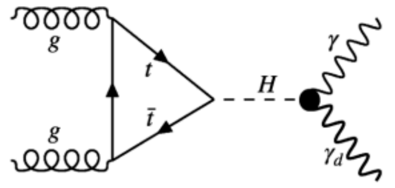
SYSU/Yang Liu

BSM searches

- Dark matter/dark sector searches

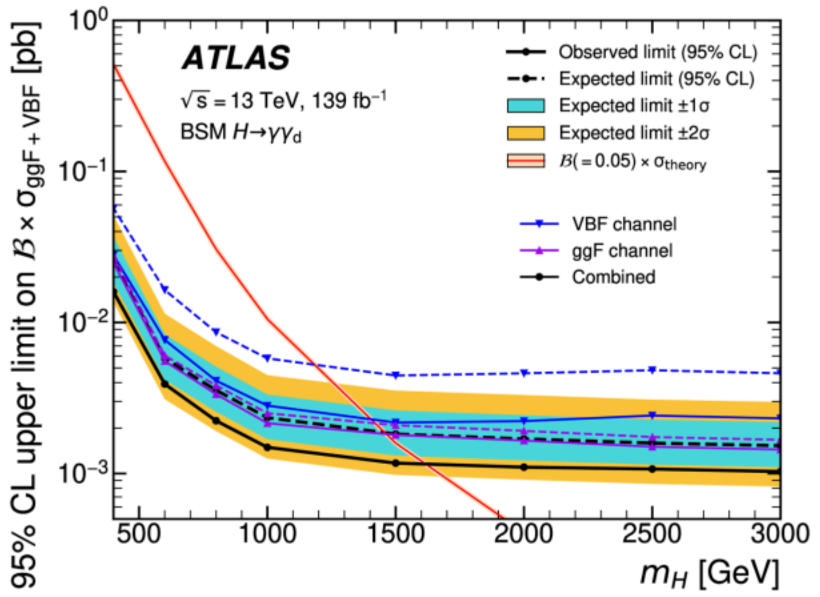
新物理研究 –暗物质寻找

ATLAS暗光子寻找联合统计测量
$H \rightarrow \gamma\gamma_d$
交大、李所

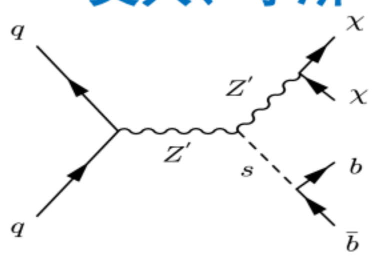


JHEP 08 (2024) 153

给出SM Higgs和BSM Higgs的$H \rightarrow \gamma\gamma d$分支比最严格上限

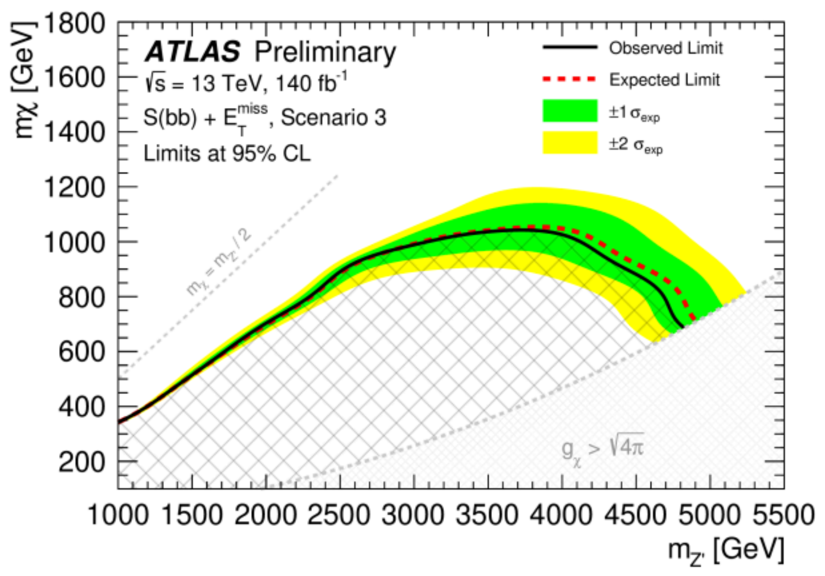


暗希格斯粒子寻找:
mono-S(bb)
交大、李所

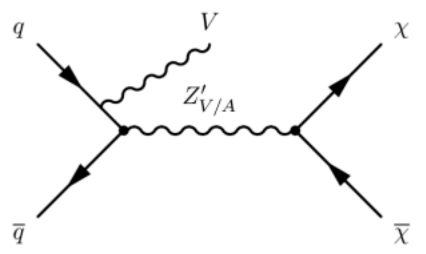


arXiv:2407.10549

LHC首个基于Cosmology Coherent Context的暗希格斯粒子寻找物理结果

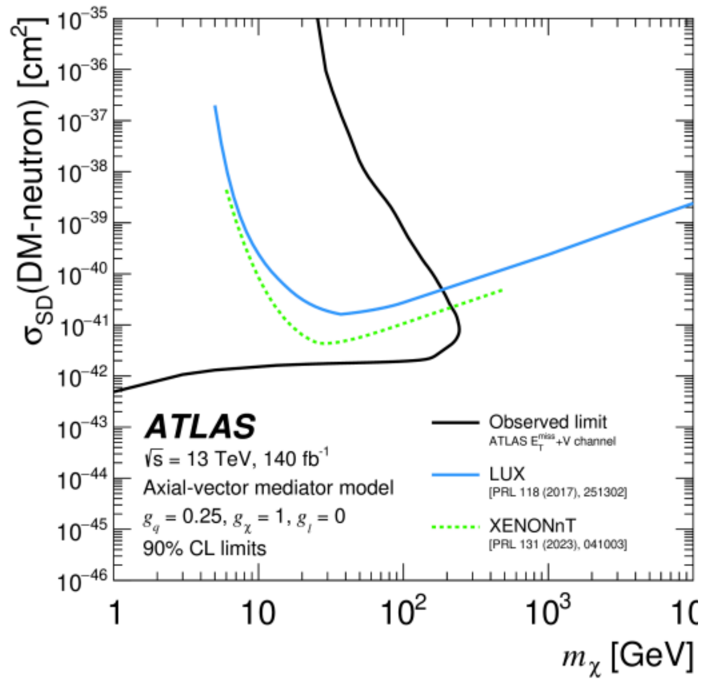


暗物质和矢量玻色子共同产生
mono-V(jj)
交大、李所



arXiv:2407.

多种与矢量玻色子强耦合的暗物



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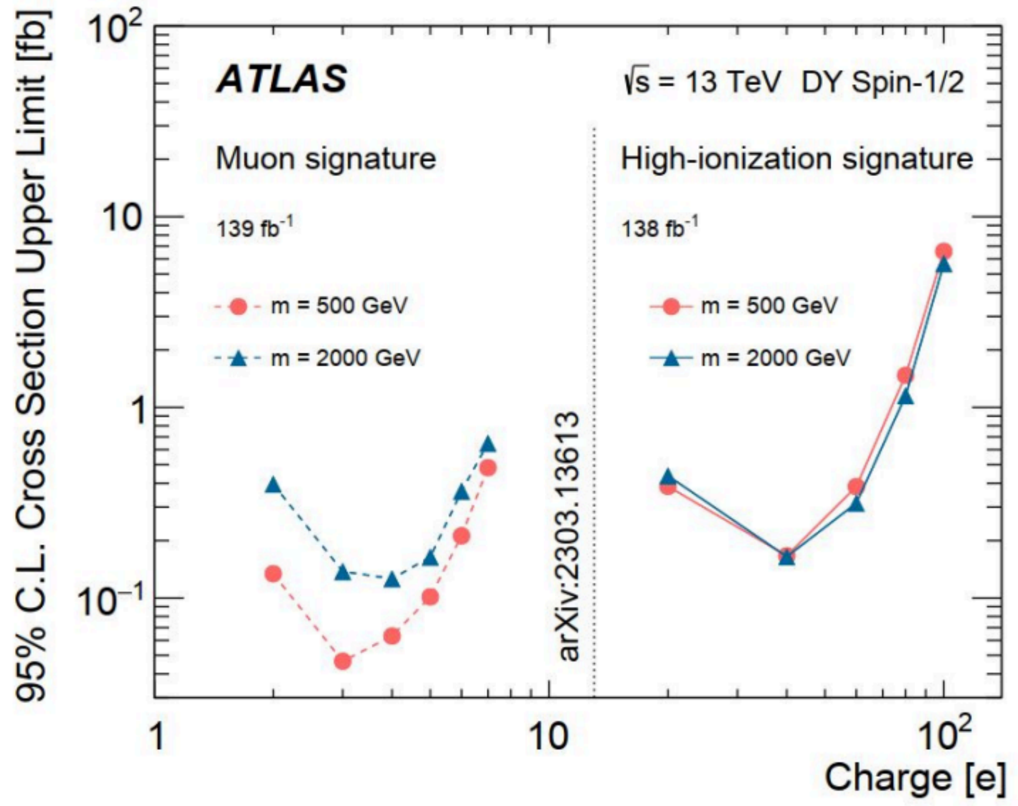
Charged LLPs:

- Motivated from many BSM theories
- Can have varied charge multiplicity |z|:
  - Multi-charged particles (MCPs): 2<|z|<7:
    - Two doubly charged fermions, table multi-charged technibaryons, long-lived doubly charged Higgs bosons
    - Like heavy muons with a higher specific energy loss dE/dx in the pixel, TRT and MDT
  - Highly ionizing particles (HIPs): 20<|z|<100
    - Strange matter, Q-ball, Dirac magnetic monopoles
    - HI hit in TRT and custom HIP trigger together with specific reco alg



- For MCP:
  - Models with 500 GeV masse are strongly excluded
  - At 2 TeV, none of the MCP models are excluded

THU/Zhen Hu

SYSU/Yang Liu

Ion Physics

- New structure and behavior in nucleus matter

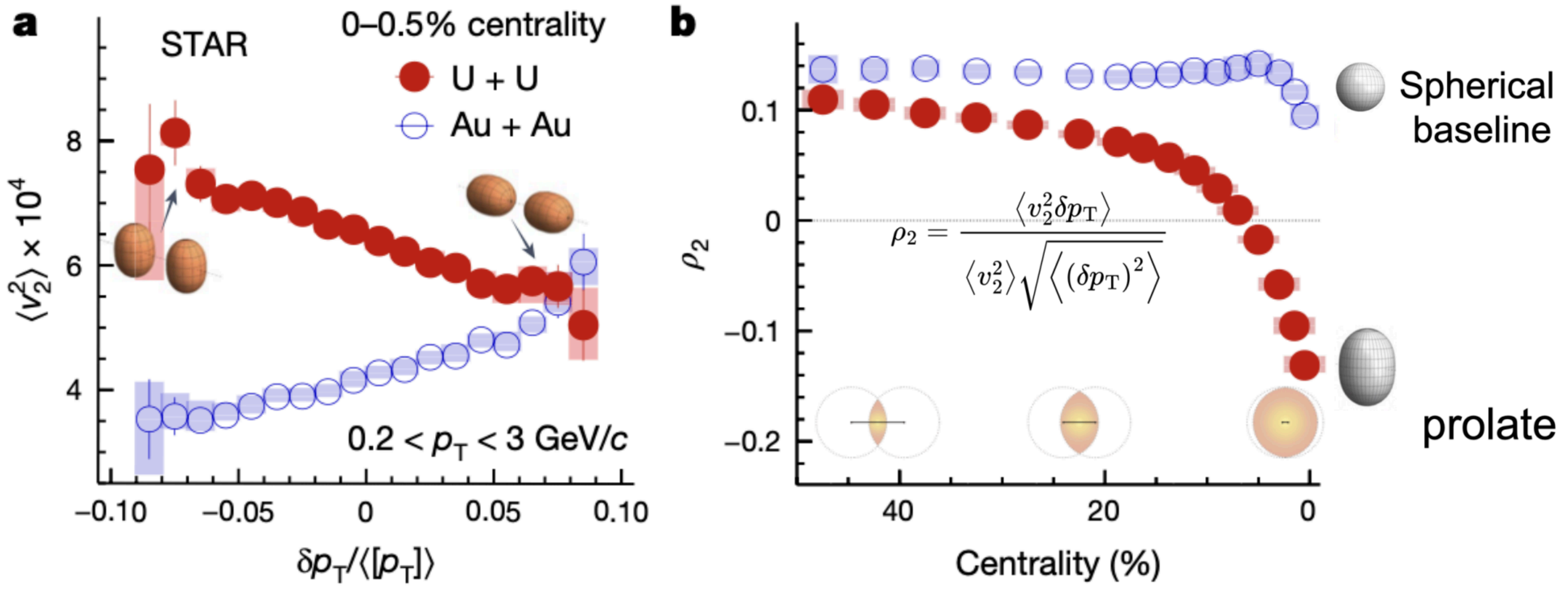
Plenary talks:

Xiaozhi Bai, Zaochen Ye， Chunjian Zhang, Xiaoming Zhang, Jianhui Zhu

Impact of quadrupole deformation

11

Seen directly by comparing $^{238}U+^{238}U$ with near-spherical $^{197}Au+^{197}Au$



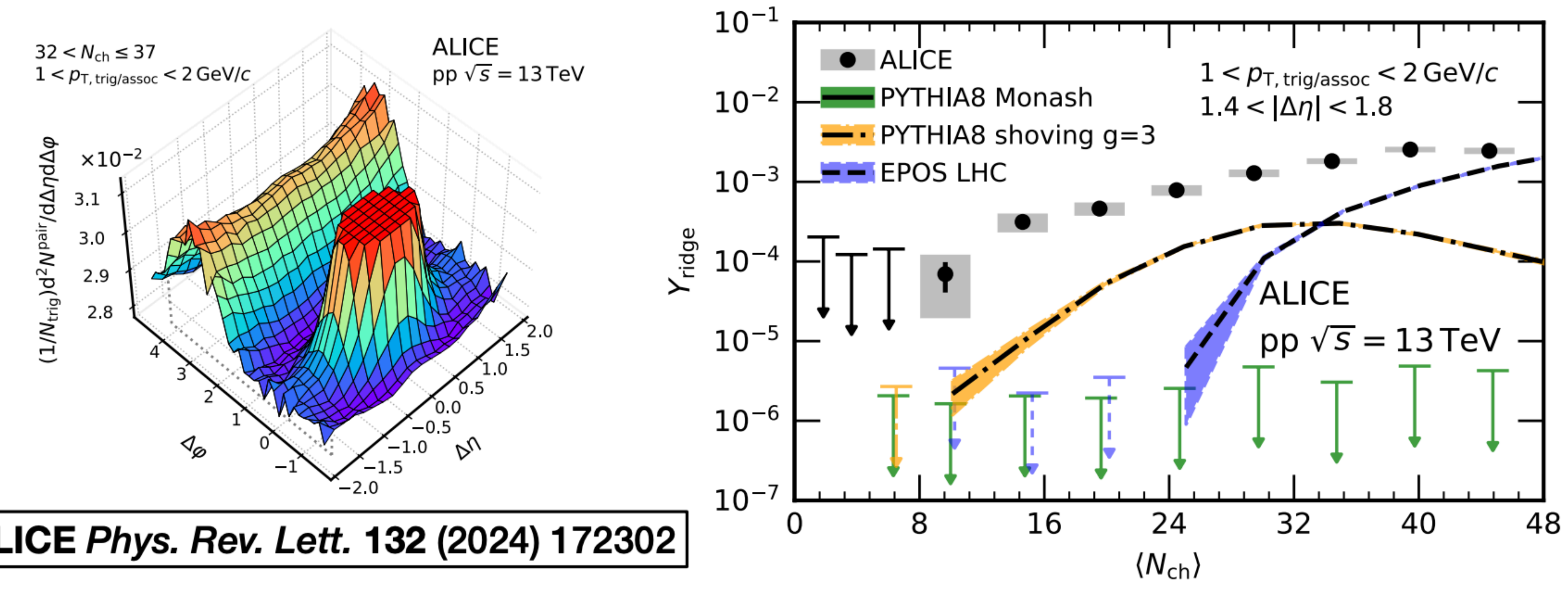
Nature, 635, 67-72 (2024)
https://doi.org/10.1038/s41586-024-08097-2

Near-spherical → flat ρ_2 vs centrality
Strongly prolate → decreasing ρ_2 vs centrality

11

FDU/Chunjian Zhang

低多重数质子–质子碰撞中的长程关联



ALICE *Phys. Rev. Lett.* 132 (2024) 172302

- 发现相同事件多重数下强子型小系统碰撞中的长程关联相较于正–负电子对撞的显著增强
- 两类碰撞系统末态粒子的产生行为具有本质差异

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ALICE/X.M. Zhang

Quantum entanglement in colliders

- Why quantum entanglement?

- Starting from entangled wave function, but did not use entanglement information previously

$$|\psi_f\rangle \simeq \sum_{p_3 s_3; p_4 s_4} \mathscr{M}(i \to p_3 s_3; p_4 s_4) \, |p_3 s_3\rangle \otimes |p_4 s_4\rangle$$

$$\sigma = \frac{(2\pi)^{-2}}{2E_1 2E_2 (v_1 + v_2)} \int |M_{fi}|^2 \delta(E_1 + E_2 - E_3 - E_4) \delta^3(\vec{p}_1 + \vec{p}_2 - \vec{p}_3 - \vec{p}_4) \frac{\mathrm{d}^3 \vec{p}_3}{2E_3} \frac{\mathrm{d}^3 \vec{p}_4}{2E_4}$$

- Decoherence and spin correlation

- Provide new observable/perspective from entanglement entropy

Quantum entanglement in top pair

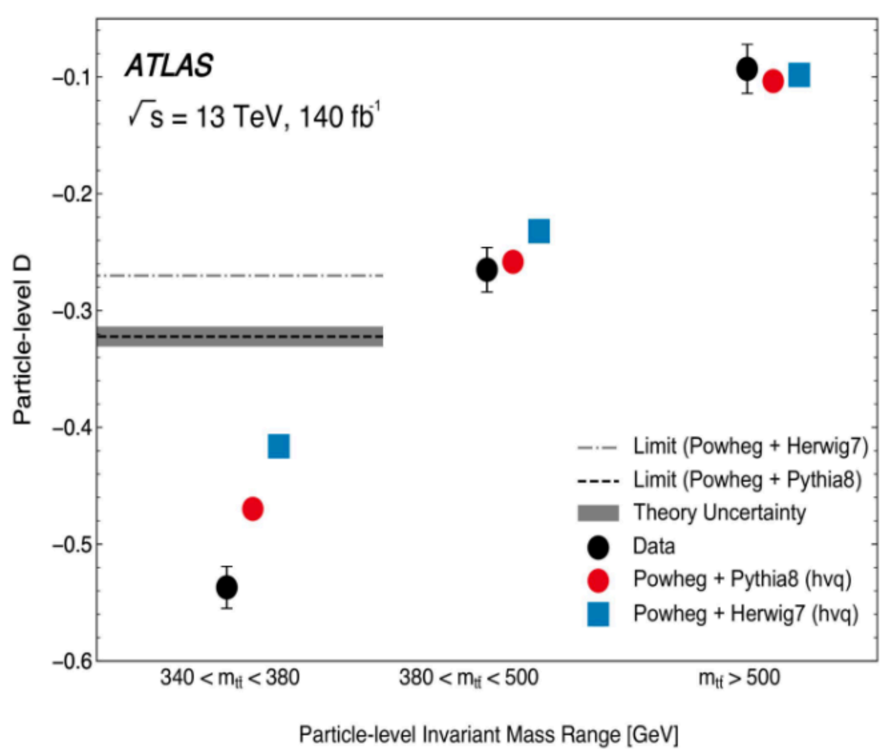
- Quantum entanglement in top spins

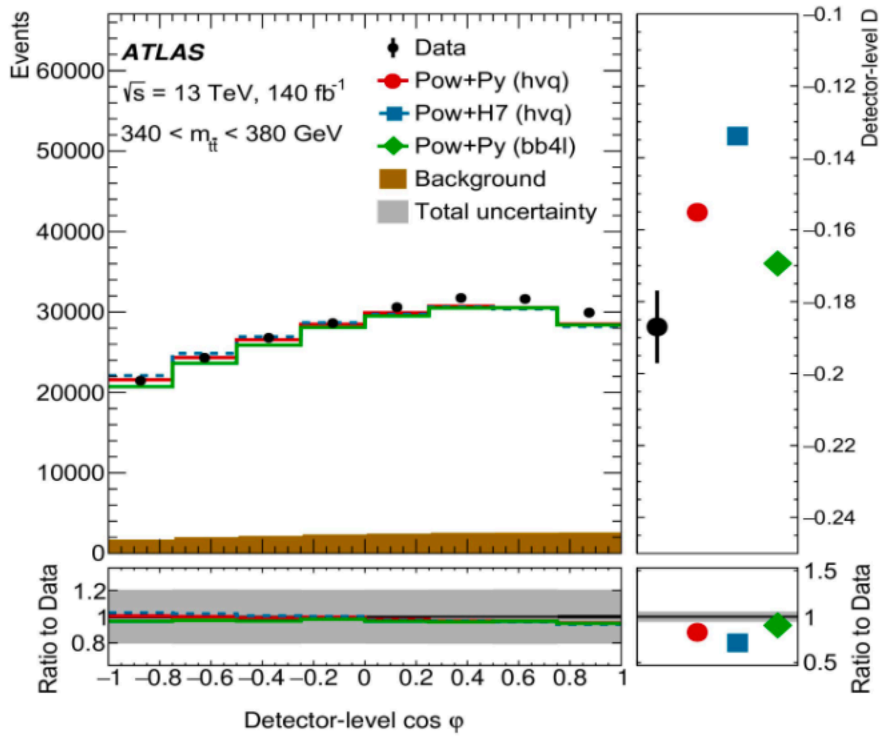
IHEP/ Hongbo Liao

Observation of Entanglement -ATLAS

Nature 633 (2024) 542

- ***eμ*** channel
- Entanglement marker ***D*** = *−tr[C]/3* = *−(*C_{nn}*+*C_{rr}*+*C_{kk}*)/3*
  - obtained from angle btw. leptons in top rest frames
  - ***D* < ⅓** ⇒ entangled system
- Measurement in narrow **low-m_{tt} region**:
  - to enhance entanglement effect



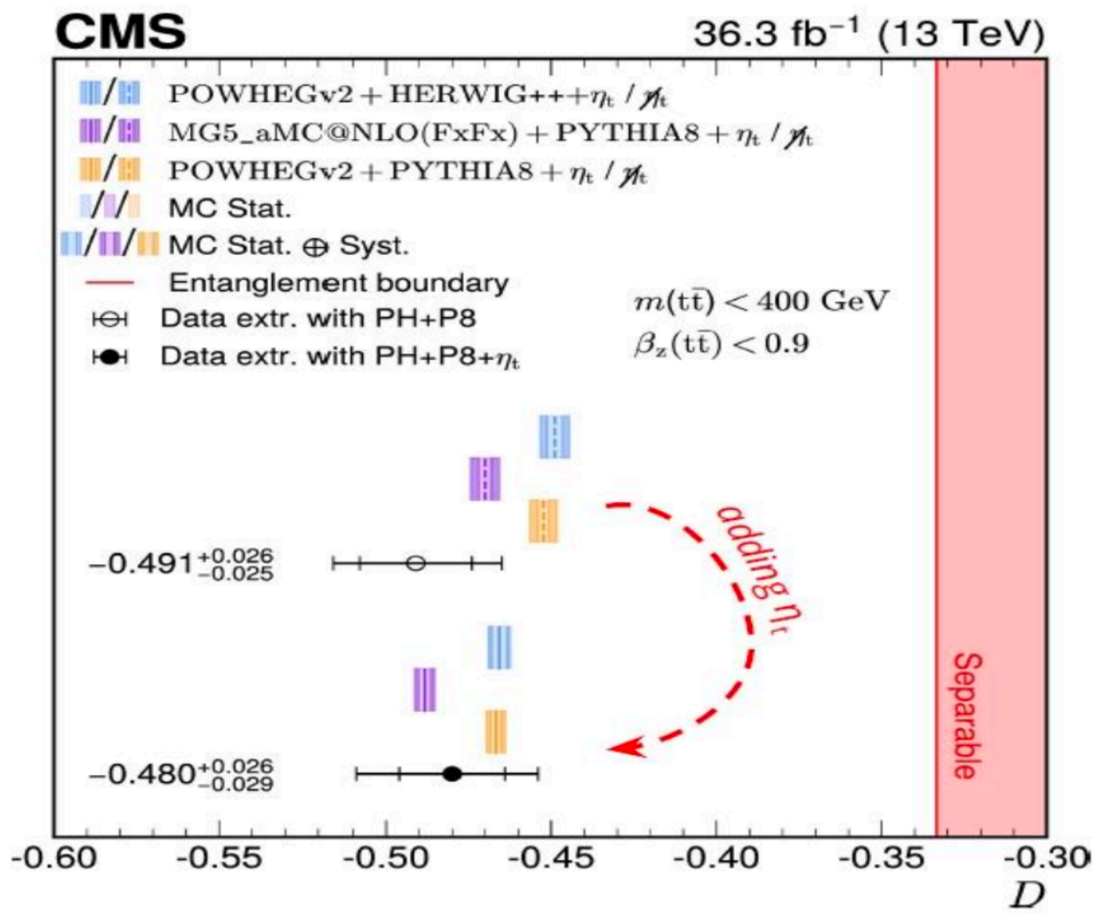


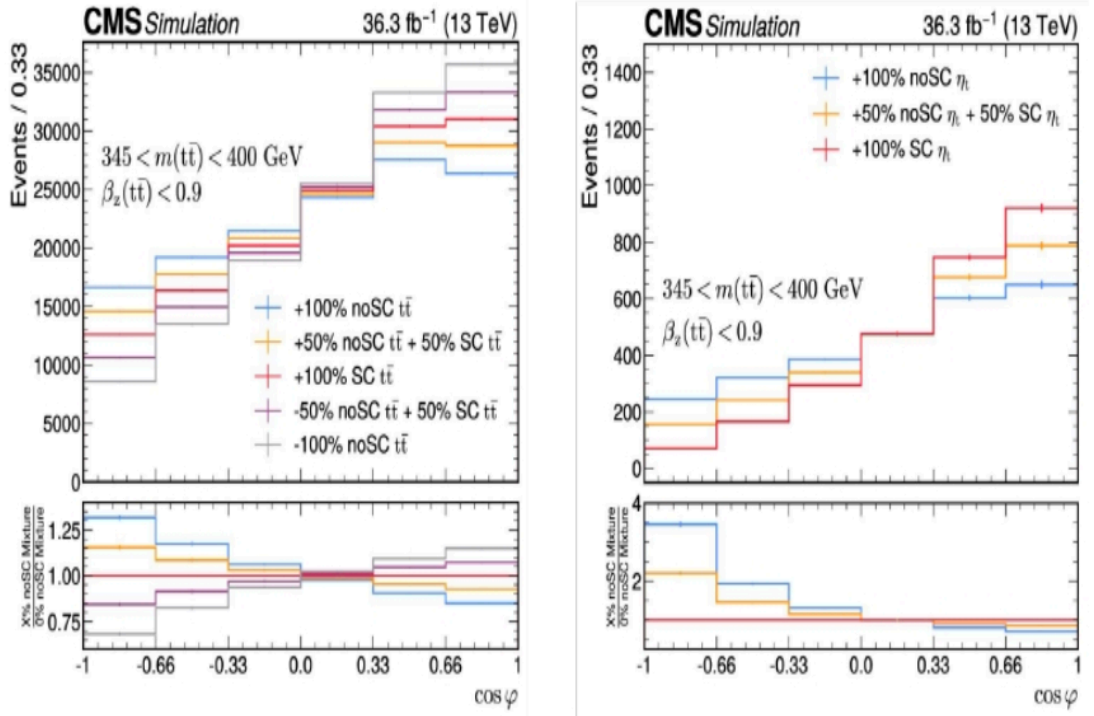
- ✓ **> 5σ over no-entanglement hypothesis**
- ✓ **Discrepancy** observed btw. data and predictions from NLO+PS simulation:
  - data "more entangled" than MC (!!)

Observation of Entanglement - CMS

arXiv:2406.03976

- ***eμ/ee/μμ*** channels, **kinematic reconstruction** of *tt* system
- Same observable ***D*** extracted from *cosφ*:
  - **low-m_{tt}** selection
  - *D* measured with **binned likelihood fit**





- Inclusion of **"toponium" effect (η_t)** at LO
  (σ(η_t) = 6.43 ± 0.90 pb - arXiv:2102.11281 [hep-ph])
- **Entanglement observed** with > 5σ significance
  - **both** with and without η_t inclusion in the model

New arrangements in theory talks

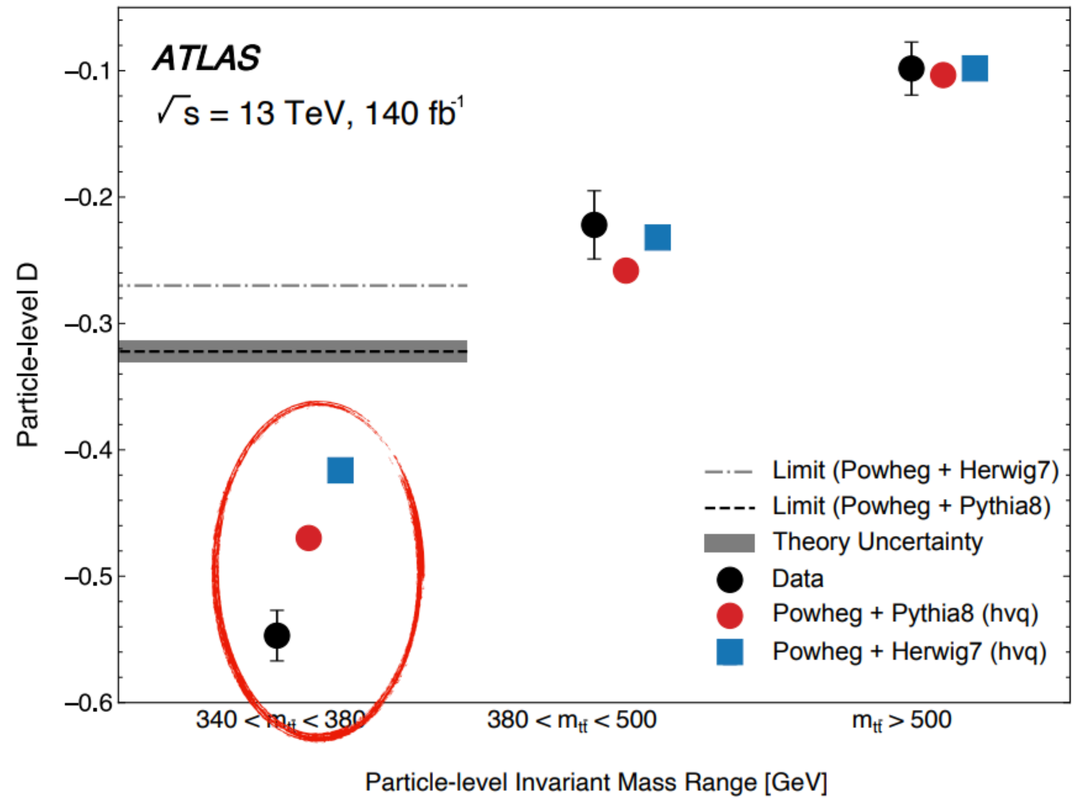
EWPT/Kepan Xie, ION/Chunjian Zhang, EFT/Minglei Xiao, Flavor&Precision QCD/ Shan Chen

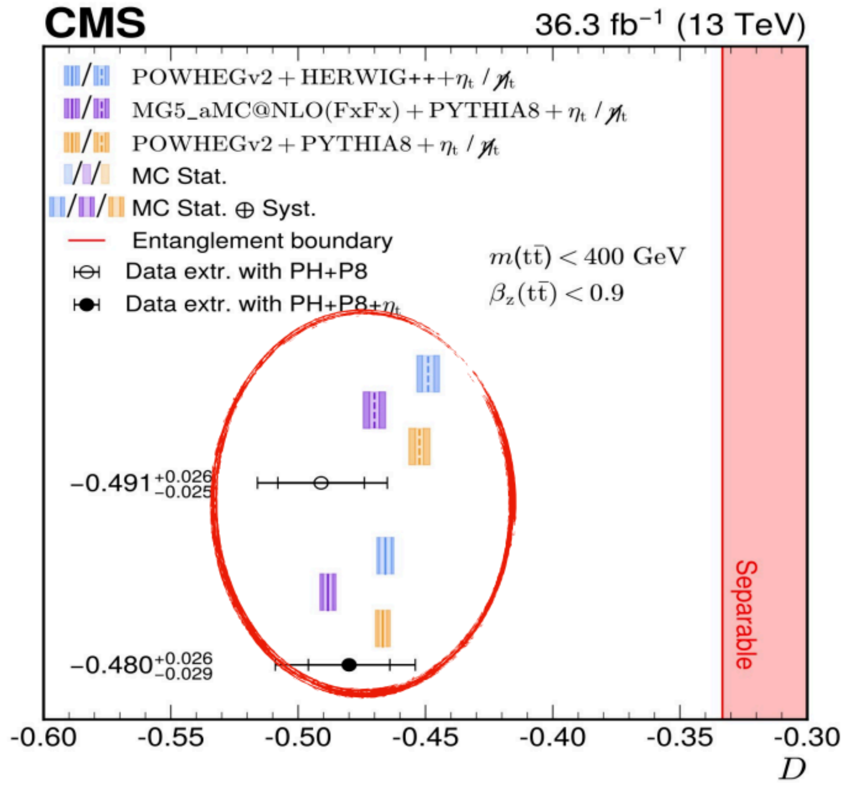
- In addition to traditional topics, try to cover recent developments

Higgs&Quantum Entanglement
IHEP/ Hao Zhang

Quantum Entanglement

- Testing quantum entanglement at TeV scale (for more details, see Prof. Hongbo Liao's talk).

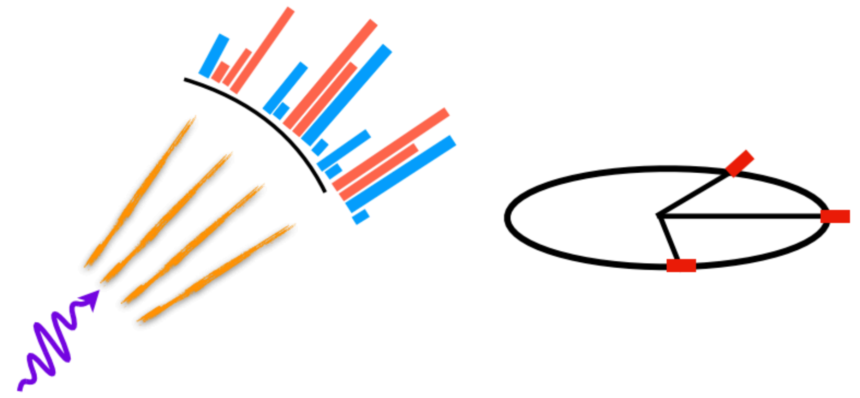


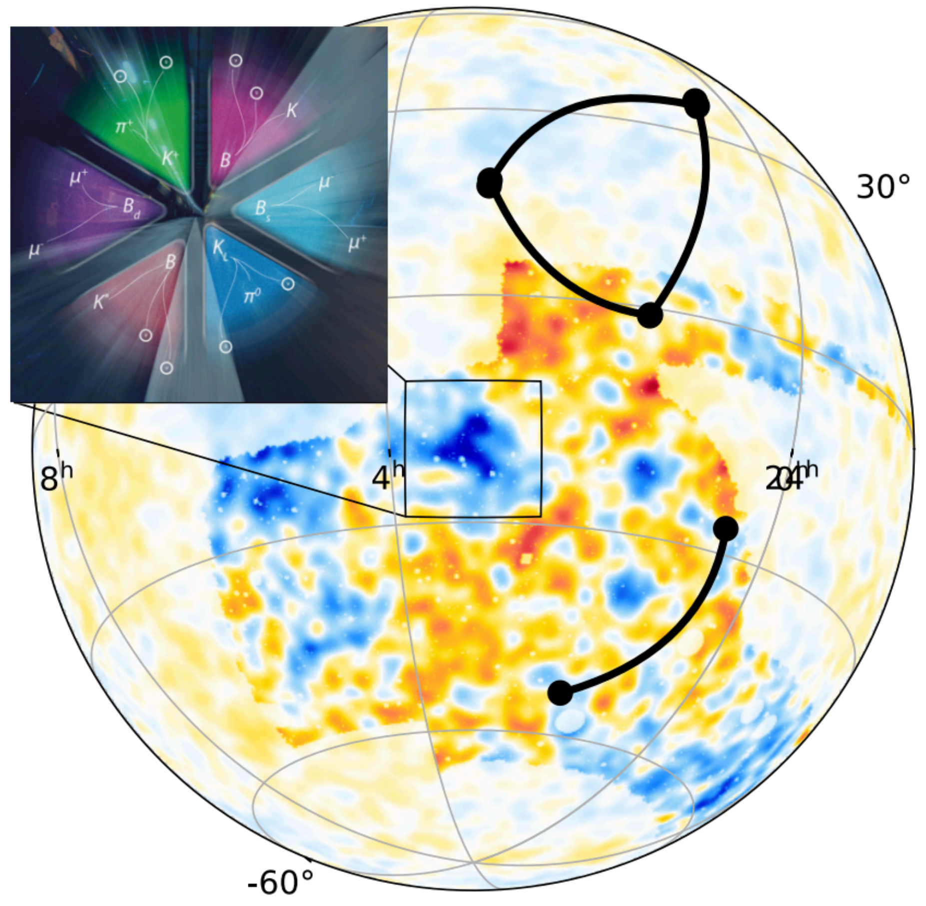


Energy Energy Correlator
BNU/ Xiaohui Liu

Energy Correlators

Energy-Correlators (ENC)





$$\mathrm{ENC} = \frac{1}{\sigma}\int d\sigma \sum \frac{E_1 E_2 \ldots E_N}{Q^N} \mathcal{M}(\{\theta_{ij}\})$$

- Can be generalized to multiple pt correlation, **a Collider CMB**
  - Long/short wave physics ⟺ smaller/larger angular separations

5

Work for the future: CEPC

- Moving to Engineering Design Report

IHEP/CAS Jianchun Wang

From CEPC Accelerator TDR to EDR

2012.09	2015.03	2018.11	2023.12	2025	2027	15^{th} FYP
CEPC proposed	Pre-CDR	CDR	TDR	CEPC Proposal	EDR	Start of construction

Ref-Detector TDR by June 2025

Accelerator EDR by 2027

Construction starts during the 15^{th} FYP

The **goal, scope and plan** of the CEPC accelerator EDR were reviewed by the IARC on Sept 18-20, 2024

International Accelerator Review Committee

- Phillip Bambade, IJCLab
- Maria Enrica Biagini (chair), INFN
- Brian Foster, Oxford/DESY
- Kazuro Furukawa, KEK
- Xiaoye He, USTC
- Roberto Kersevan, CERN
- In-Soo Ko, Postech
- Michael Koratzinos, CERN
- Gero Kube, DESY
- Eugene Levichev, BINP
- Hiroyuki Nakayama, KEK
- Norihito Ohuchi, KEK
- Katsunobu Oide, KEK/CERN
- Carlo Pagani, INFN-Milano
- Paolo Pierini, ESS
- Anatoly Sidorin, JINR
- Steinar Stapnes, CERN
- Makoto Tobiyama, KEK
- Akira Yamamoto, KEK
- Zhentang Zhao, SINAP

Many thanks to

- CLHCP2024 program committee
- CLHCP2024 local committee
- Supporting staffs/volunteers