# Report of MHEP-EXP Group

2024 IOP Retreat

December 29th, 2024

https://indico.phys.sinica.edu.tw/event/135/

# MHEP-EXP
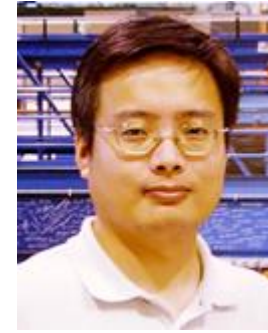


Yuan-Hann Chang
張元翰

Henry Tsz-King Wong
王子敬

Suen Hou
侯書雲

Wen-Chen Chang
章文箴

Song-Ming Wang
王嵩銘

Sadakazu Haino
灰野禎一

Yi Yang
楊毅

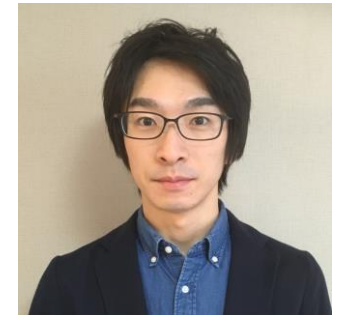Ming-Lee Chu
朱明禮

Chih-Hsun Lin
林志勳

Eric Yen
嚴漢偉

Yuki Inoue
井上優貴
(Adjunct)

# MHEP-EXP



**Collider**
**ATLAS, EIC, CEPC**
**Fixed-target (Hadron)**

**TEXONO.$\nu$@KSNL**
**Dark Matter**
**(AMS, TEXONO.DM@CDEX, TASEH)**

**Gravi. Wave**
**KAGRA**
**TEXONO.GR@LIGO**

**Instrumentation**
**ASGC**
**TIDC**

# Schools/Workshops

- Jan 21, TQCD meeting
- Mar 24-29, International Symposium on Grids & Clouds (ISGC) 2024
- Jun 17 – 19, CHiP Cross-Strait Workshop on Advanced Detectors and Technologies
- Jun 24 – 29, TIDC Summer School Of Experimental High Energy Physics
- Sep 9-10, J-PARC E16 workshop @ Taiwan
- Nov 20-22, 2024 CHiP and TIDC Annual Meetings

# Our Contributions in ATLAS Data Taking

- LHC/ATLAS just finished a successful 2024 data taking
  - LHC delivered ~125 fb$^{-1}$, ATLAS collected ~118 fb$^{-1}$
  - Achived ~95% data qualoty efficiency
- Doubled ATLAS data (L(Run2)=140 fb$^{-1}$, L(Run3)=160 fb$^{-1}$)
- **Run3 will end on June 2026**
- Academia Sinica plays significant role in Data Qulaity (DQ) monitoring in ATLAS control room since 2015
  - Responsible for monitoring tools, provides 24/7 on-call DQ service
  - AS members served as Online-DQ coordinator for several years (2017, 2018, 2023, 2025)





(AS online DQ team)



HCal        ECal
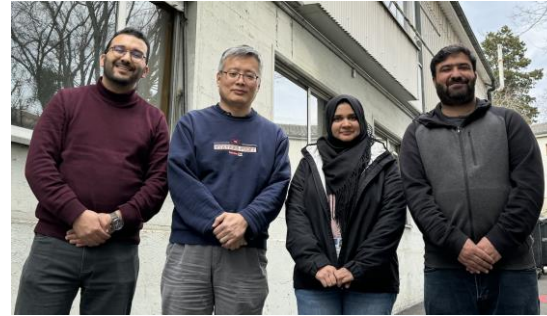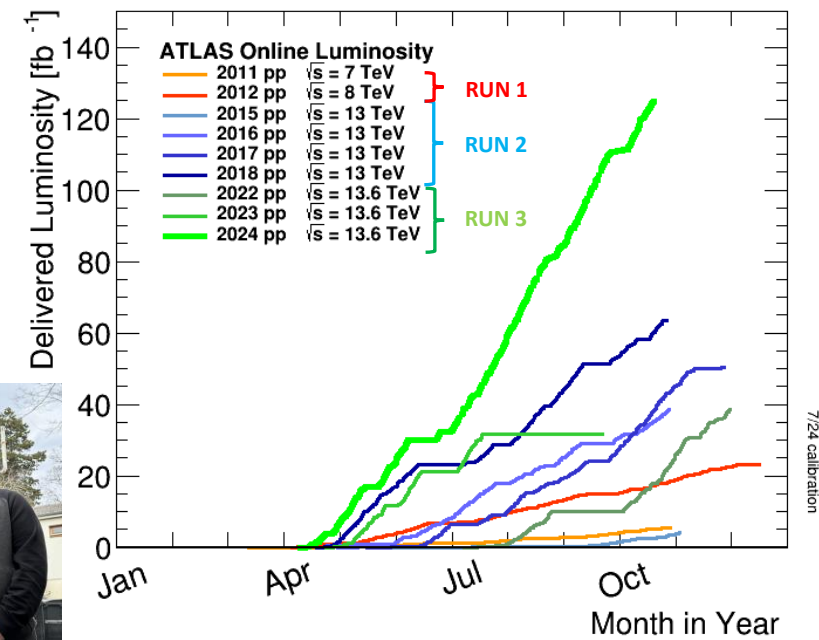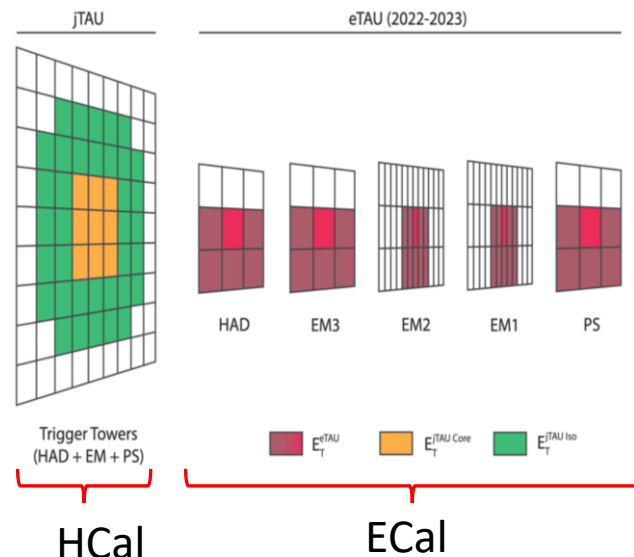
Use finer granularity calorimeter information
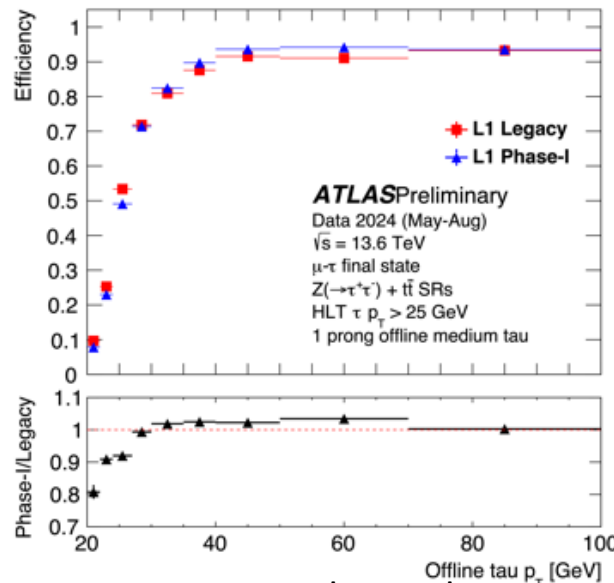


Measurement by student Kiran Farman

## TAU Trigger Coordination (2023-2025)

- Convening the group in developing and operating the triggers that select events with tau leptons,
- Work with physics groups to improve or implement new tau related triggers.
- In 2024 we commissioned the new Phase-1 tau triggers, whicb are based on the ATLAS upgraded Level-1 trigger electronics that uses finer granularity information of the ATLAS calorimeter to improve the energy resolution.
  - Achieve sharper turn-on in trigger efficiency

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# Higgs measurements in H->WW decay  (NTHU + AS)

- **Differential Kinematic Measurements in HH->WW*->lvlv**
  - Reanalyzing Run2 dataset, results are approved by ATLAS
  - Improvements/additions to the previous publication  (Phys. Rev. D 108 (2023) 032005)
    - Use more advanced analysis method (Deep neural network to separate the background from signal)
    - Adding final states of two same flavor leptons(two electrons or two muons)
    - An overall 20% improvements across different kinematic regions
  - Now also exploring H->WW*->lvqq channel
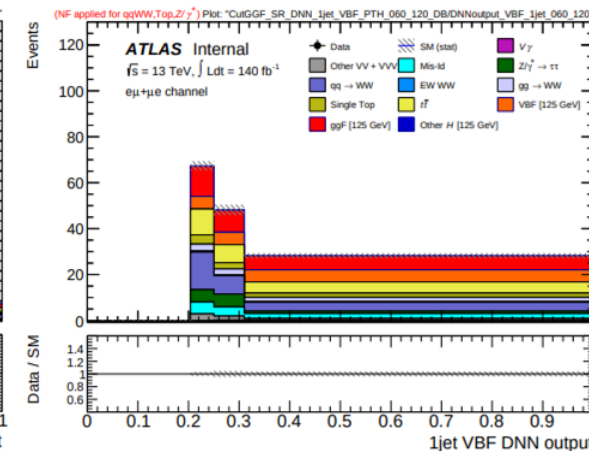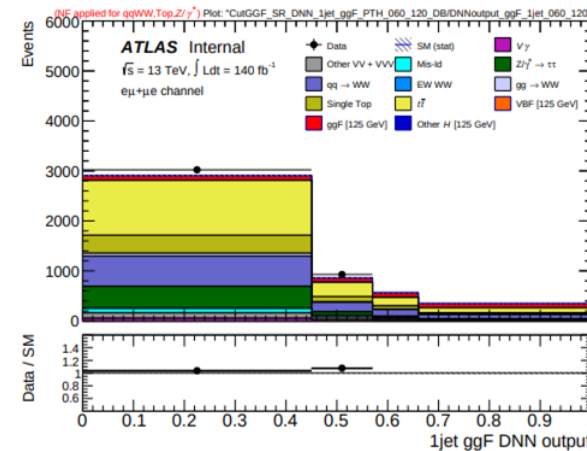


GGF and VBF DNN in the 1 jet category

- **Quantum Entanglement**
  - ATLAS recently achieves highest energy detection of QE in the measurements of the angular separation of the top-quarks' decay products
  - **We are probing quantum entanglement (QE) using H->WW*->lvlv events with Run2+Run3 data**
  - Higgs(spin 0), W(spin 1) :  states of the two decayed W boson are non-separable
  - Measurement of lepton kinematics to probe the QE : W+(-) boson decay preferentially emits a charged lepton moving along (against) its spin direction





Expectation value of the Bell observable in the YZ plane

6
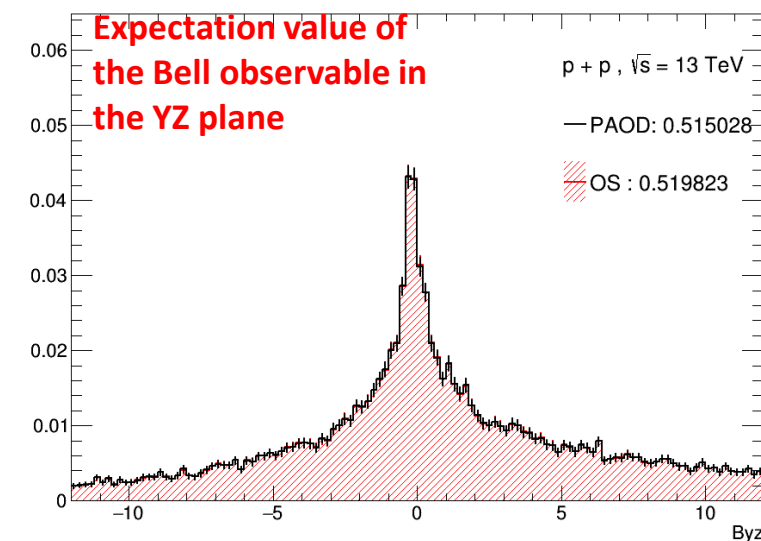
# Search for Double Higgs boson in $HH \to bb\tau\tau$ decay (AS)

- To measure the Higgs self coupling ($\lambda_{HHH}$), which determines the shape of the Higgs potential.
- ATLAS conducts search in many decay channels, $bb\tau\tau$ is one of the most sensitive channel
- Latest results with Run2 data set observed (expected) limits on the HH production cross section at 5.9 (3.3) times the Standard Model prediction => **world best expected sensitivity for single channel.**
  - Phys. Rev. D 110 (2024) 032012

- Our work in tau trigger group is helping to improve HH signal trigger acceptance in Run3
- Expect new results with Run3 data in 2026



HH trigger acceptance improvement
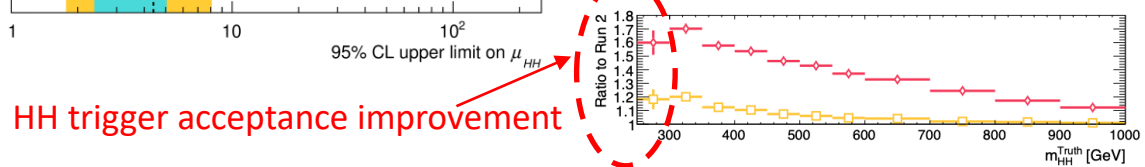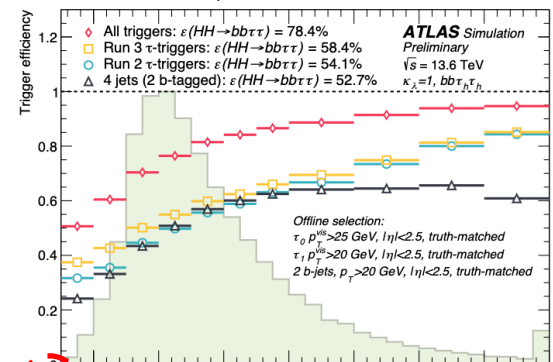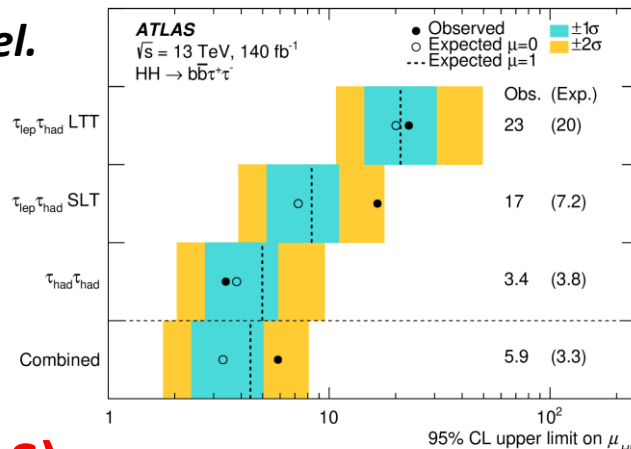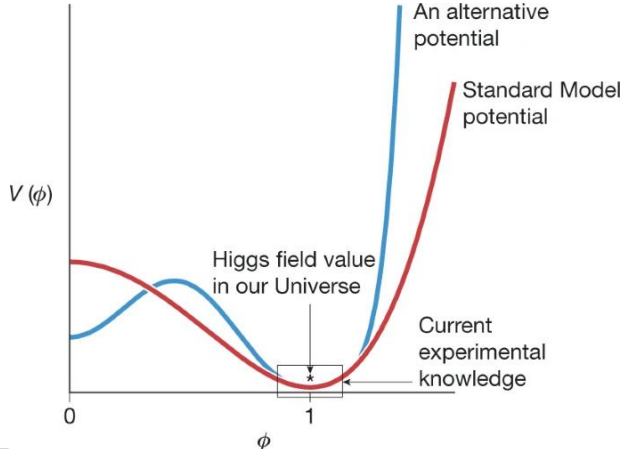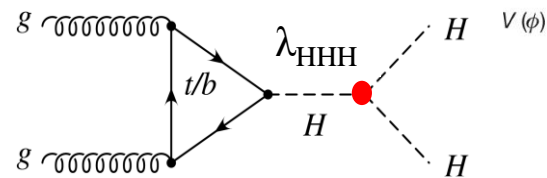
# Search CP-odd Higgs boson in $A \to ZH \to llbb$ (AS)

- Baryogenesis favours a heavy A with large mass splitting between A and H mass (H, CP-even Higgs (non SM))
- Previous search assume high H mass (> 125 GeV)
- New analysis (Run2+Run3 data):
  - Will include lower H mass (<125 GeV) in search
  - Have sensitivity in 2HDM+a Type-I at low M mass (arXiv:2404.05704)
- Targeting results in 2026



above $m_H = 800$ GeV and $m_A = 1200$ GeV the A width becomes too large

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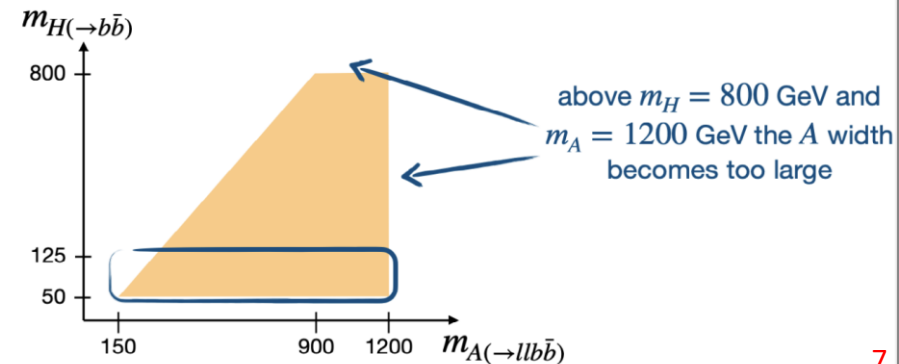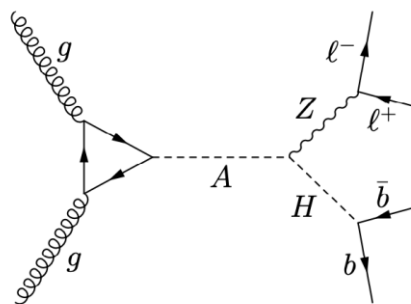
# Heavy Ion Physics @ STAR



o Yi Yang 's group is heavily involved in the operation and
performance of Muon Telescope Detector, and forward upgrade.

o Main physics results are the production of J/$\psi$ , $\psi$(2S), and $\Upsilon$ in
p+p, p+A, and A+A collisions
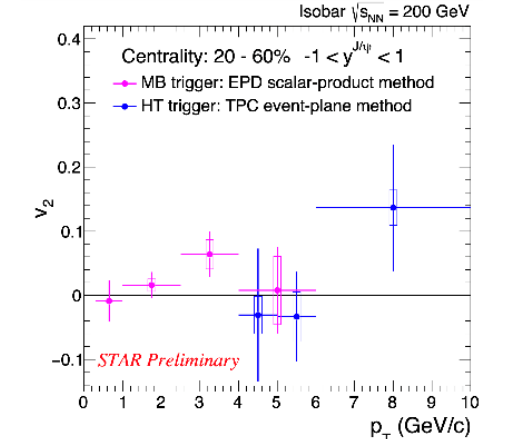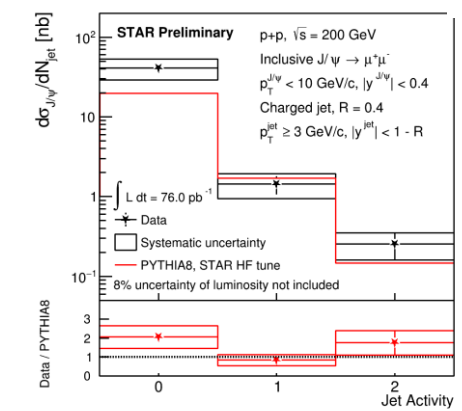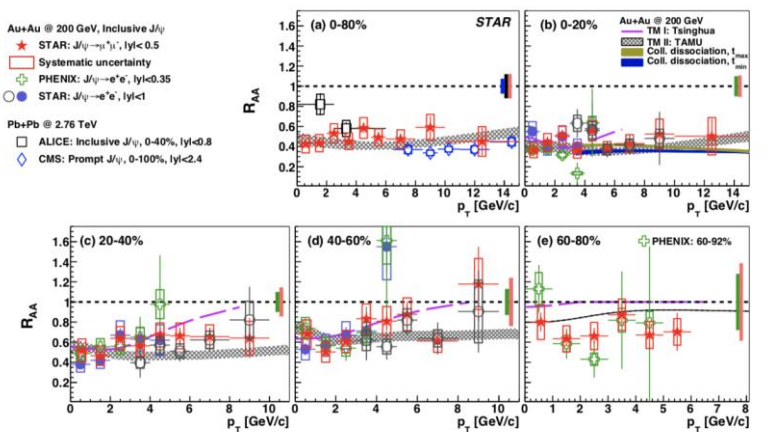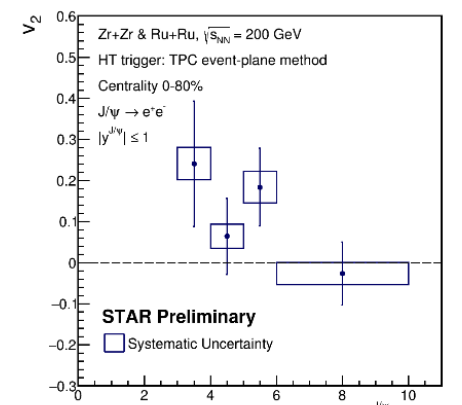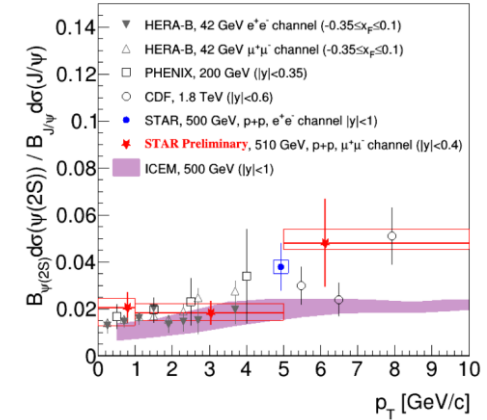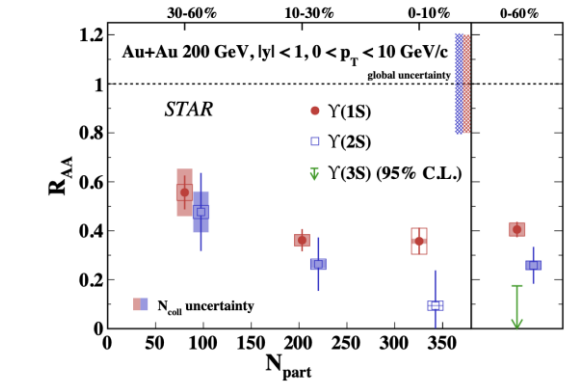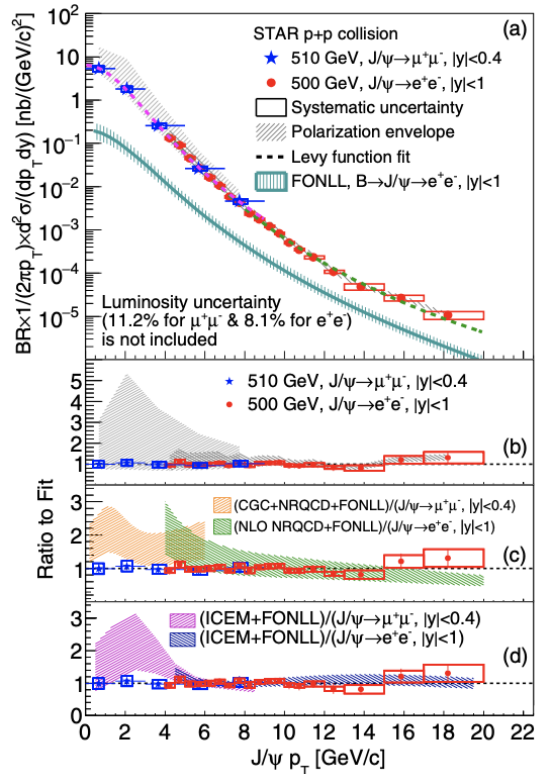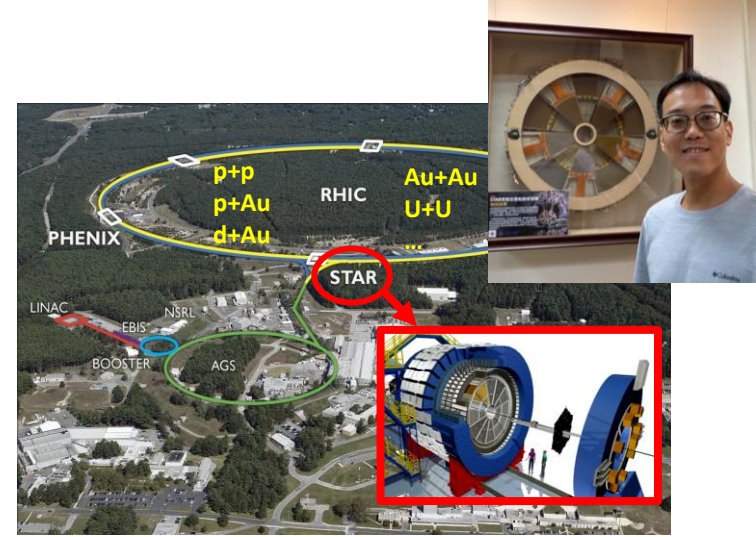
# High Granularity Timing Detector (HGTD) for ATLAS in HL-LHC (AS + NTHU)

- Pileup can reach ~200 at High Luminosity LHC (HL-LHC),
- HGTD can help to medicate high pileup effect in the detector forward region using its high precision timing measurement (~30ps per charge track)
- **Taiwan-ATLAS responsible for producing electrical and optical fiber cables (Suen), and implementing a production database**
- Production database:
  - To record all the components produced to construct the HGTD (e.g. wafers, sensors, ASICs, hybrids, modules,…)
  - Record all the quality control test measurements of the components during production
  - To be used throughout the HL-LHC program (until 2040)

- Collaborates with NCP to setup the database
  - Main structure and functionality are implemented
  - Passed the ATLAS Final Design Review (FDR)
  - Started recording data of few component types
  - To be ready for HGTD pre-production in 2025

2m

2m
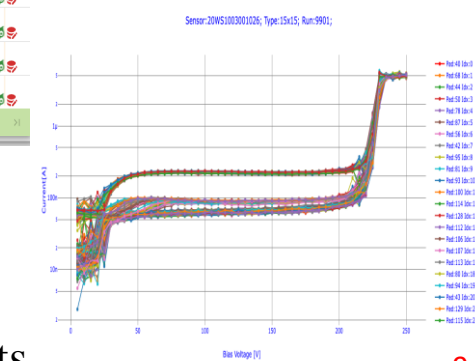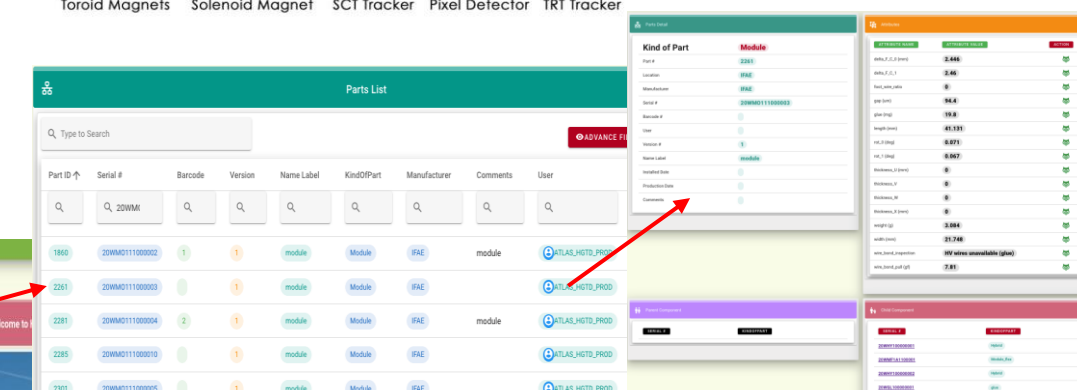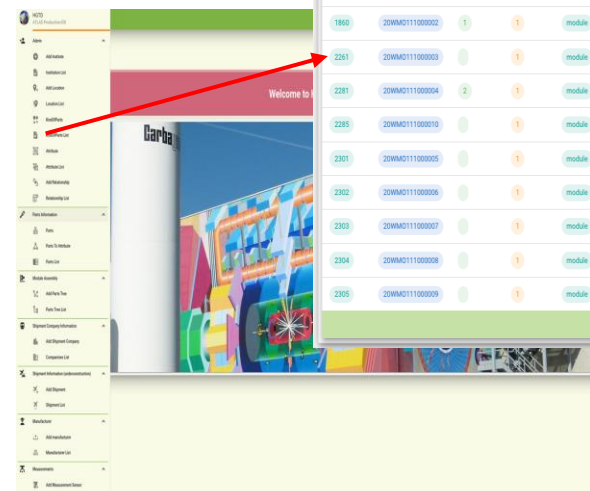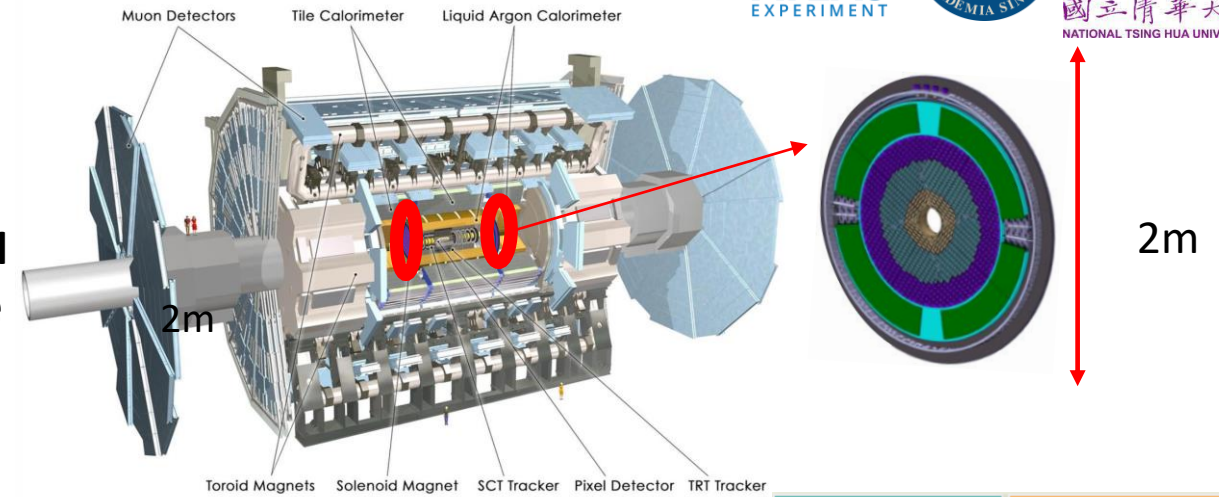
Plot test measurements

# AMS experiment latest results by ASIoP
# "Antiprotons and elementary particles over a solar cycle"
# PRL Accepted, Editor's suggestion

- First measurement of cosmic ray antiproton flux time-dependence over a full solar cycle.
- AMS completed the time dependence of proton, antiproton, electron, and positron.
- **Their correlation between these particles show intriguing hysteresis behavior.**
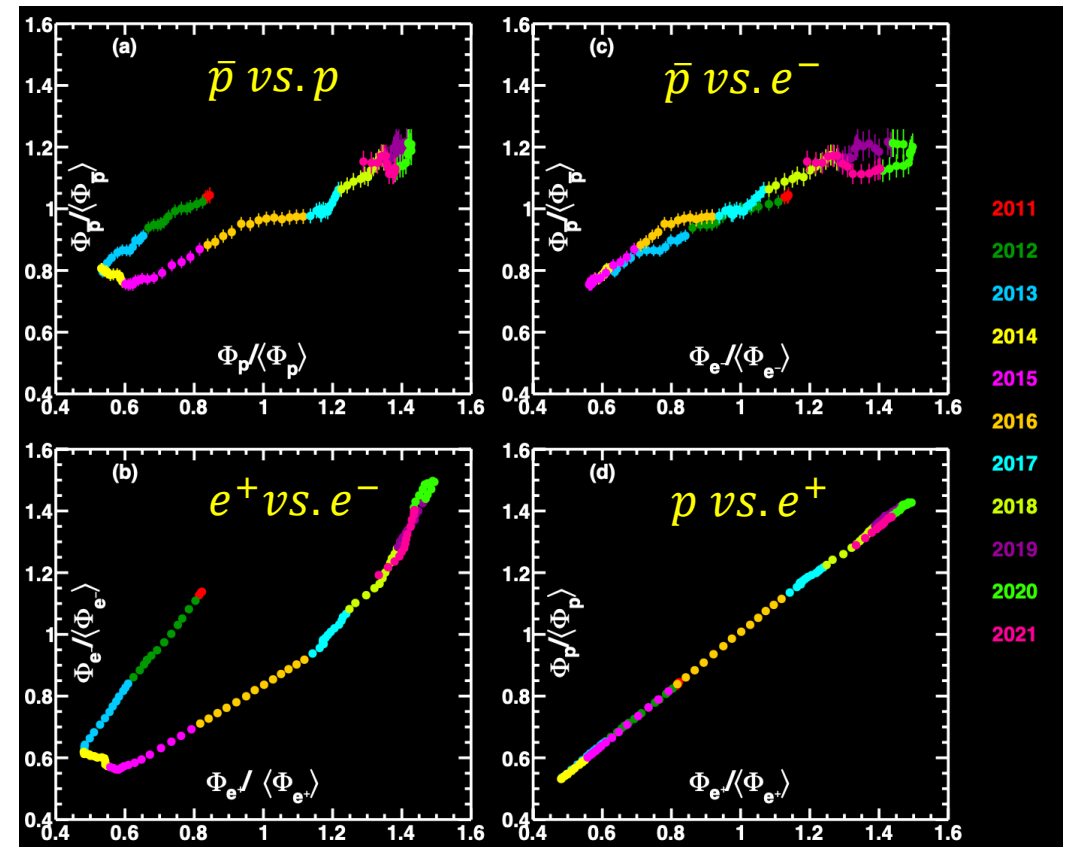
# AMS Upgrade

1.PDS radiator: extend the lifetime of AMS

2.Layer-0 tracker: expand our physics understanding



AIDC

PDS Radiator

Layer-0 Tracker

⚑ **Low Background Germanium Detectors with sub-keV sensitivities**

⚑ **Low Energy Neutrino Properties and Interactions at Kuo-Sheng Reactor Neutrino Laboratory (KSNL), Taiwan** *[+ teams from China, India, Turkey]*

→ **New Sanmen Reactor Laboratory at Zhejiang, China**
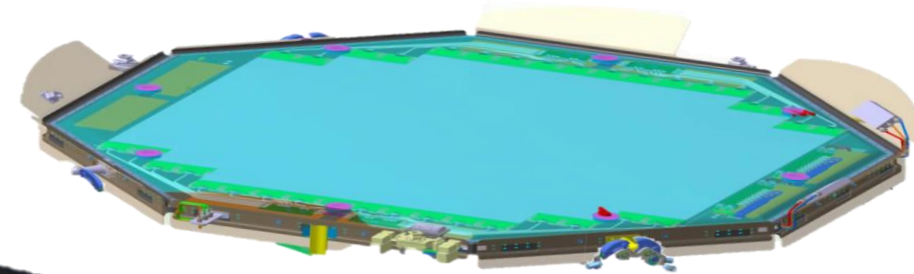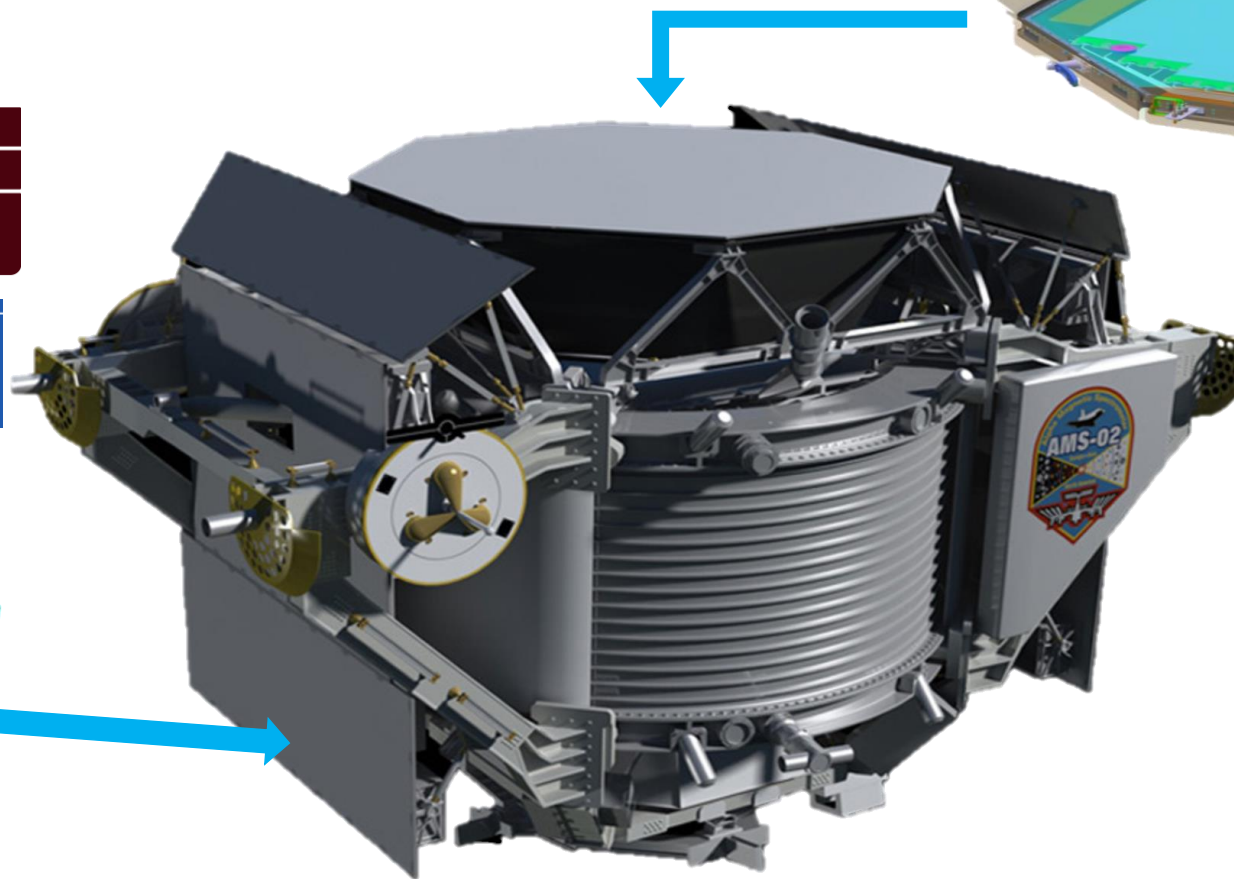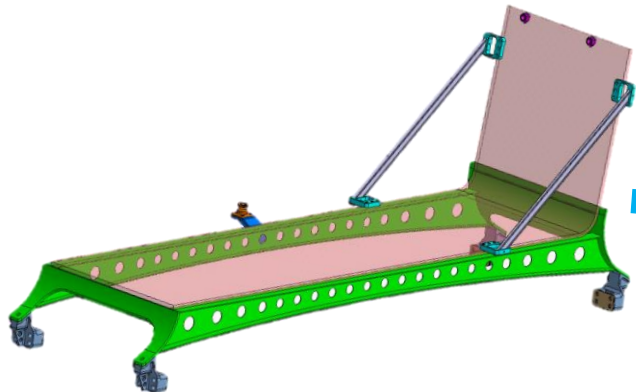
⚑ **Founding partner of CDEX Light Dark Matter Searches** *[+ Tsinghua U, Sichuan U et al, China]* **at China Jinping Underground Laboratory (CJPL)**

  ■ **Future evolution to Neutrinoless Double Beta Decay Program with $^{76}$Ge**

⚑ **Theory Research** *[+ theory teams from Taiwan, India, Turkey]*

  ■ **Low energy $\nu/\chi$ interactions with matter, Quantum-Mechanical Coherency in $\nu N$ elastic scattering, Time-of-Flight Signatures in Dark Matter Searches …..**

⚑ **Gravitational Wave Physics**

  ■ **One of Taiwan groups in LIGO Observatory** *[+Nat. Central U., Nat. Tsing-Hua U, Taiwan]*

  ■ **Next Generation Mirror Coating & Characterization, Cryogenic techniques for GW, Instrument Response & Calibration, Stochastic GW Background, BSM@GW**

**Selected Advances in 2024 ....**

**DM χN+χe Annual Modulation Combined Analysis**

arXiv:2412.04916
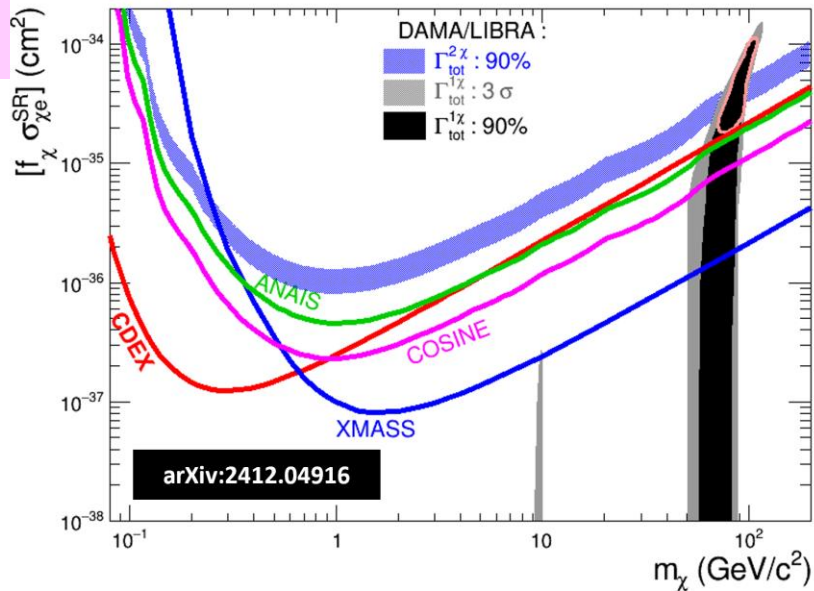
**New νA_el results at KSNL**

arXiv:2411.18812 [nucl-ex]
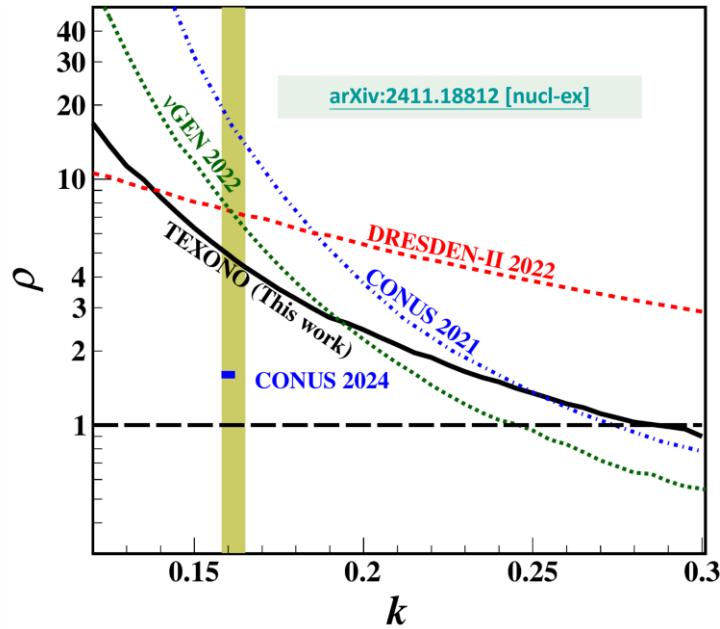
**Commissioning of TSRI-LPCVD N2O Gas Line**

Oct 2023
Feb 2024
Commissioned: April 2024
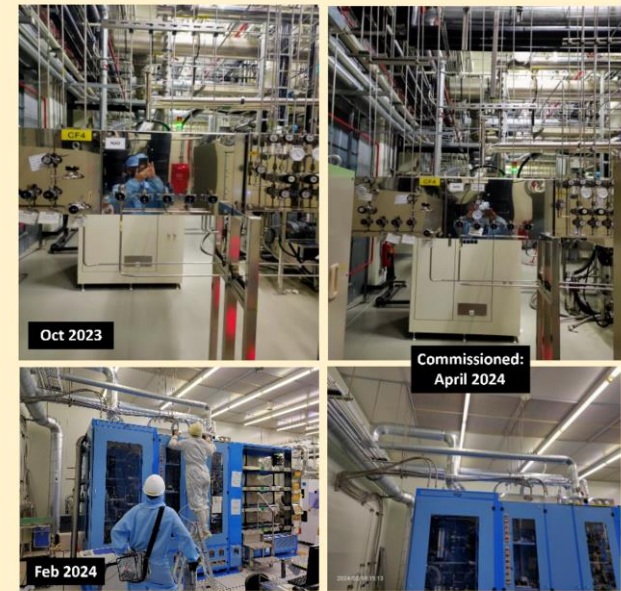
**Construction of ASGRAF @ IoP-B1**

Original NTHU Mirror Lab
2023/7
2023/8
Lab Move – 2024/11
2024/5/7
2024/11

**Construction of Sanmen Laboratory**

近点 (~11m)
超近点 (~7m)
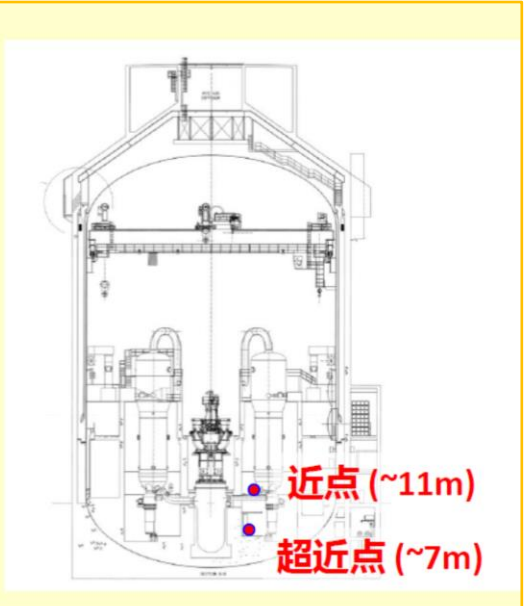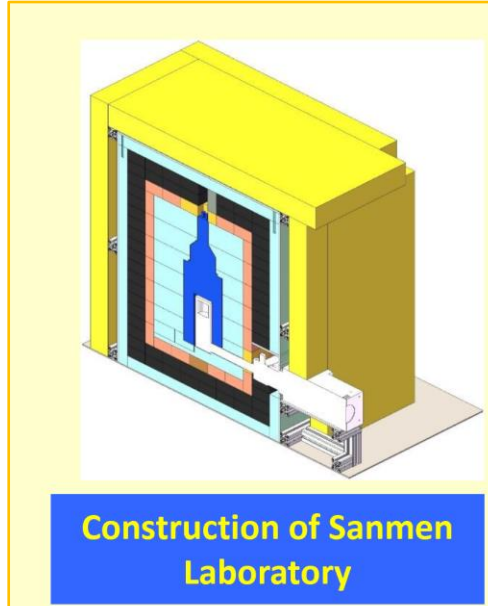
# E16 at J-PARC: evidence of chiral symmetry restoration at finite baryon densities

E16 Workshop @ Taiwan
September 9-10th, 2024
Institute of Physics, Academia Sinica

| JFY | 2023 | | | 2024 | | | 2025 | | | 2026 | | | 2027 | | | 2028 | | | 2029 | | | 2030 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 4- | 7- | 101- | 4- | 7- | 101- | 4-6 | 7-9 | 10-1-3 | 4-6 | 7-9 | 10-1-3 | 4-6 | 7-9 | 10-1-3 | 4-6 | 7-101- | 4-6 | 7-101- | 4- | 7-101- | 1- |
| | | | | | | | | | | | | | | | | | | | | | | |
| Grant-in-Aid(S) | | | | | | | | | | | | | | | | | | | | | | |
| E16 plan (24 Dec. | study | | | study | | | Run-1 | | | | | | | | E88 | | | Run-2 | | | | |

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# Sivers Asymmetry in Polarized Drell-Yan

Statistics:
2015: 35K
2018: 37K



**PRL 133, 071902 (2024)**
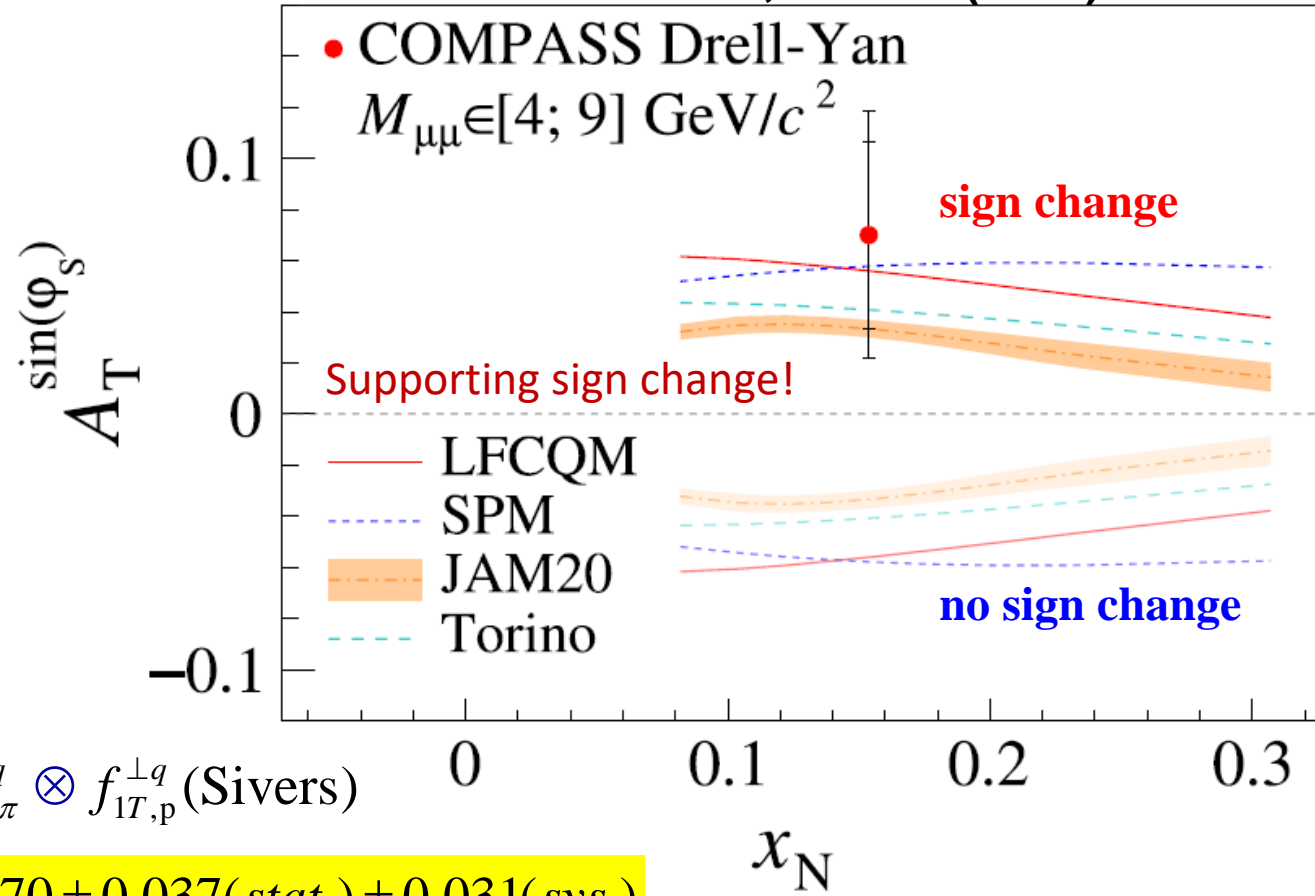
$$A_T^{\sin\varphi_S} \propto f_{1,\pi}^q \otimes f_{1T,\mathrm{p}}^{\perp q} (\text{Sivers})$$

$$A_T^{\sin\varphi_s} = 0.070 \pm 0.037(stat.) \pm 0.031(sys.)$$

Agreeing with the sign-change of Sivers function!

# ASGC - Accelerating Discovery & Innovation Your Computational Research Partner

- WLCG Tier Centre - building capacity by participating the development & deployment of the world largest and advanced distributed cloud research infrastructure
  - WLCG is moving towards O(1000)PB scale in RUN4
- Core Facility - computing arms of HEP experiment, research facility and research communities, based on WLCG core technologies
- IOP (26.3%) and Structural Biology (23.9%) are the two largest user communities, in terms of computing (CPU+GPU) usage

# Reliability & Efficiency are the keystones

- 173 PI Groups, 588 users from 25 Institutes in Taiwan
  - 23+ supported research publications
  - Finished 4.9M CPU jobs, and 52K GPU Jobs, with 98%+ reliability in 2024
- Demands of advanced GPU keeps growing in 2024 - 20% utilization growth in high usage situation
- CPU usage has increase of 333% in 2024
- Power consumption reduced 20% in two years straight from 2023
- Intelligent monitoring & control is the key task for efficiency progression
- **Resource: 5,120 CPU Cores, 216 GPU Boards, 13PB Disk, 4PB Tape**
  - Additional 2,208 CPUCores, 5PB Disk for WLCG (ATLAS)
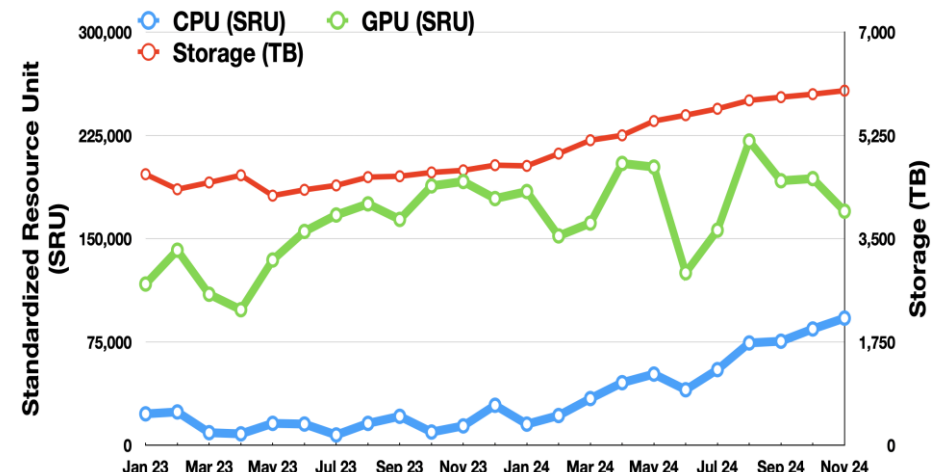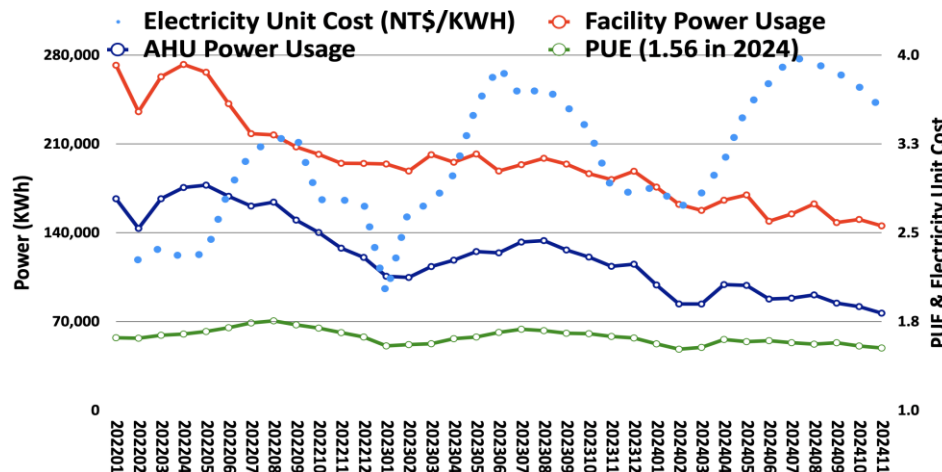
# ISGC 2025

## AI and Hybrid Quantum - Shaping Tomorrow's Scientific Breakthroughs

- **16-21 March 2025, Academia Sinica, Taipei, Taiwan**

- **ISGC is a collaboration platform for e-Science hosted by ASGC from 2002**

- **Keynote & Plenary Speakers**
  - **Ilkay Altintas (SDSC, US)**
  - **Daniele Bonacorsi (UniBol, IT)**
  - **Simone Campana (CERN, CH)**
  - **Michael Dowling (U. Regensburg, DE)**
  - **David Groep (NIKHEF, NL)**
  - **Danny Hsu (AS, TW)**
  - **Yeu-Hwang Hwu (AS, TW)**
  - **Dieter Kranzlmueller (LRZ, DE)**
  - **Yusuke Oda (NII, JP)**
  - **Ping Yeh (Google)**
  - **(NVIDIA)**
  - **Gergely Sipos (EGI)**

- Workshops
  - 17 March - Security Workshop (Nikhef, EGI-CSIRT)
  - 18 March - Hybrid Quantum Computing Workshop (LRZ/DE, ASGC)
  - 19 March - AI Masterclass (U. Bologna/IT)
  - 20 - 21 March - Environmental Computing Workshop (LRZ/DE and ASGC)
- Asia Country Updates (AU, CN, ID, JP, TH, TW, + KR, SG, PH)
- Sessions (based on submitted abstracts)
  - AI, Physics Applications, Life Science Applications, Earth Science Applications, Humanities & Social Sciences, Infrastructure Cloud & Virtualization, Converging HPC Infrastructure, Data Management, Networking & Security
- https://indico4.twgrid.org/event/51/