# Summary of EPS 2025

Monika Wielers (STFC – Rutherford Appleton Laboratory)

EUROPEAN PHYSICAL SOCIETY
EPS
HEP2025
MARSEILLE
07 11 JULY 2025

EPS-HEP CONFERENCE
**07-11 JULY, 2025**
PALAIS DU PHARO
**MARSEILLE, FRANCE**

# Overview

- Full 5-day programme with
  - 102 posters
  - 526 parallel talks
  - 38 plenary talks
  - 7 prizes
  - Lot of chats
  - Nice views
- Website
  - https://www.eps-hep2025.eu/
- Will show some of my personal highlights
  - A bit LHC heavy….
  - Emphasis on new physics results

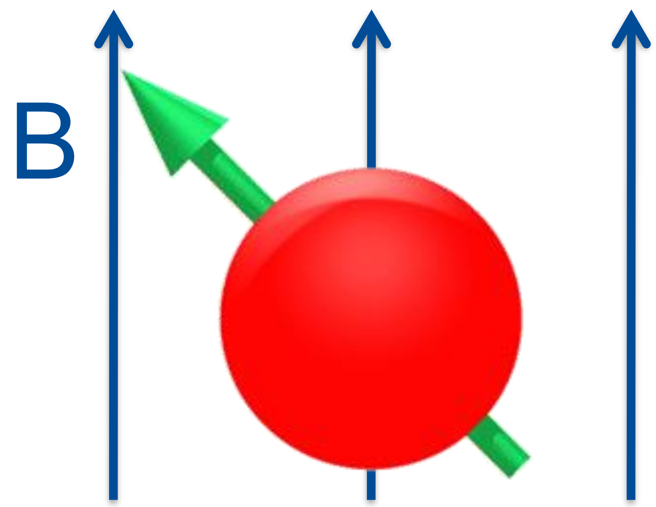


# Ultimate Precision

Saskia Charity

# Final result from Fermilab Muon g–2 experiment

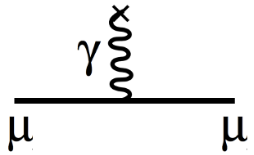
- Goal: Measure muon anomalous magnetic moment $a_\mu$ to 140 parts per billion
  - Muon sector “convenient” place to test the Standard Model
- 6 runs between 2018 (Run-1) and 2023 (Run-6) now analysed
  - > 300 billion analysed positrons
- What is $a_\mu$?



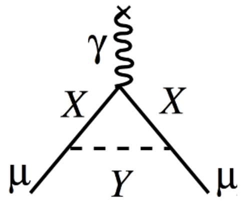

*g* determines spin precession frequency in a magnetic field

| Torque in B-field | Magnetic Moment |
| --- | --- |
| $\vec{\mu} \times \vec{B}$ | $\vec{\mu} = g \frac{e}{2m} \vec{S}$ |

$g = 2$




$g > 2$



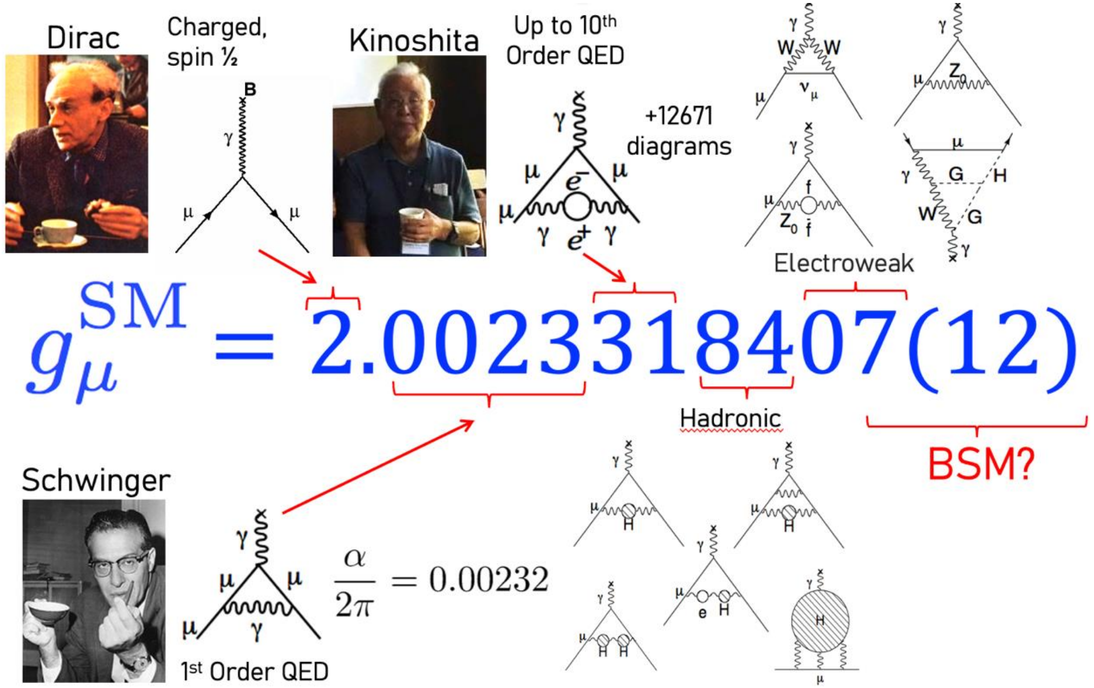

$$a_\mu = \frac{g_\mu - 2}{2}$$

- For a pure Dirac spin-½ charged fermion, g is exactly 2
- Interactions between the muon and virtual particles alter the value
- X & Y particles could be SM or new physics

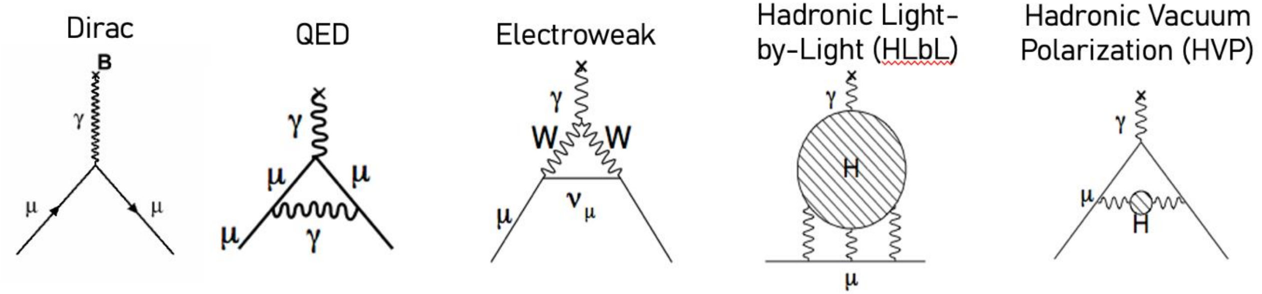
Saskia Charity

# Final result from Fermilab Muon g–2 experiment

- Standard Model components of $g_\mu$



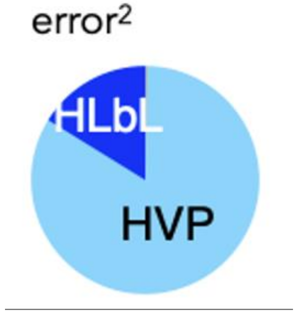

- Expressed as $a_\mu$




$a_\mu^{SM}$ portion ~99.99% ~1 ppm ~59 ppm ~1 ppm

$$a_\mu^{SM} = a_\mu^{QED} + a_\mu^{EW} + a_\mu^{HVP} + a_\mu^{HLbL}$$

- $a_\mu^{SM}$ provided by g-2 Theory Initiative (TI)
- Uncertainty dominated by hadronic terms – in particular HVP



Saskia Charity

# Final result from Fermilab Muon g–2 experiment

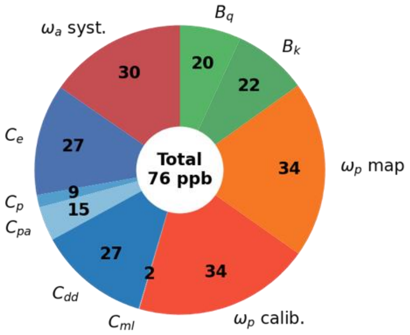
## Results from Run1-6

- Run-2/3 (2023) halved the uncertainty of the Run-1 (2021) result
- Run-4/5/6 (2025) data reduced uncertainty by a further factor of 1.8
- $a_\mu(\text{FNAL}) = 116\,592\,0705\,(148) \times 10^{-12}\,(127\,\text{ppb})$
- $a_\mu(\text{EXP}) \quad = 116\,592\,0715\,(145) \times 10^{-12}\,(124\,\text{ppb})$

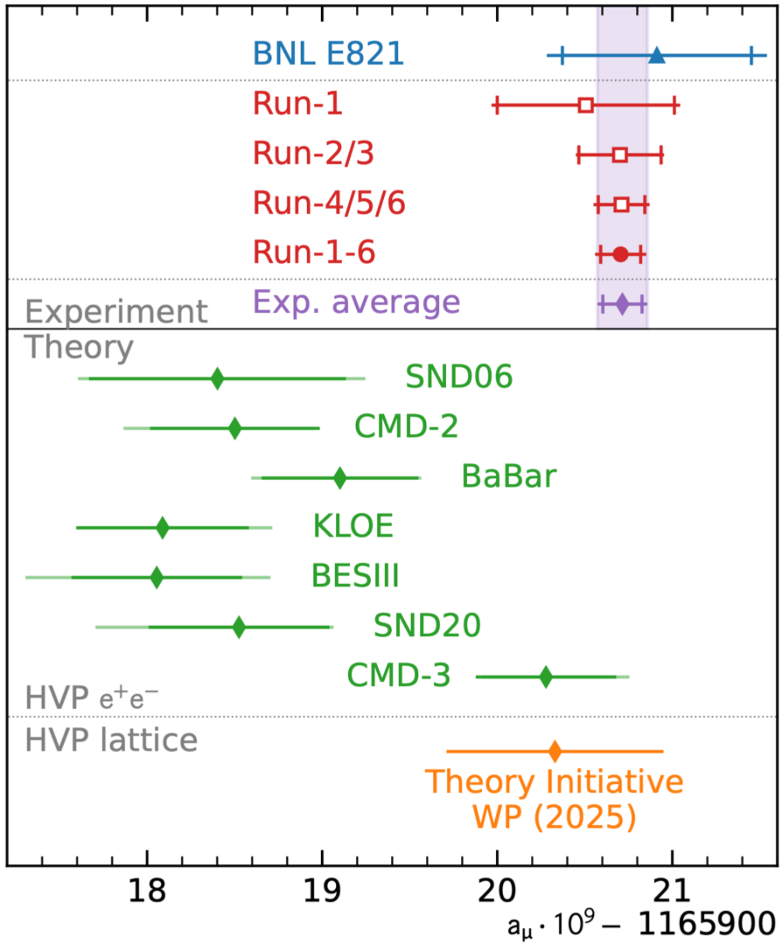
## Uncertainties

$$a_\mu \propto \frac{f_{clock}\,\omega_a^m\,(1 + C_e + C_p + C_{pa} + C_{dd} + C_{ml})}{f_{calib}\,\langle\omega_p'(T_r) \times M\rangle\,(1 + B_k + B_q)}$$

Clock blinding frequency ($f_{clock}$); Anomalous precession frequency ($\omega_a^m$); Beam dynamics corrections ($C_e + C_p + C_{pa} + C_{dd} + C_{ml}$); Absolute calibration ($f_{calib}$); Magnetic field map ($\omega_p'(T_r)$); Muon beam distribution ($M$); Transient magnetic field corrections ($B_k + B_q$)




- TDR goal of 100 ppb systematic reached
- No dominant source of systematic
- Further improving would require reduction in many categories




## WP25 (based on lattice QCD) agrees with the experiment

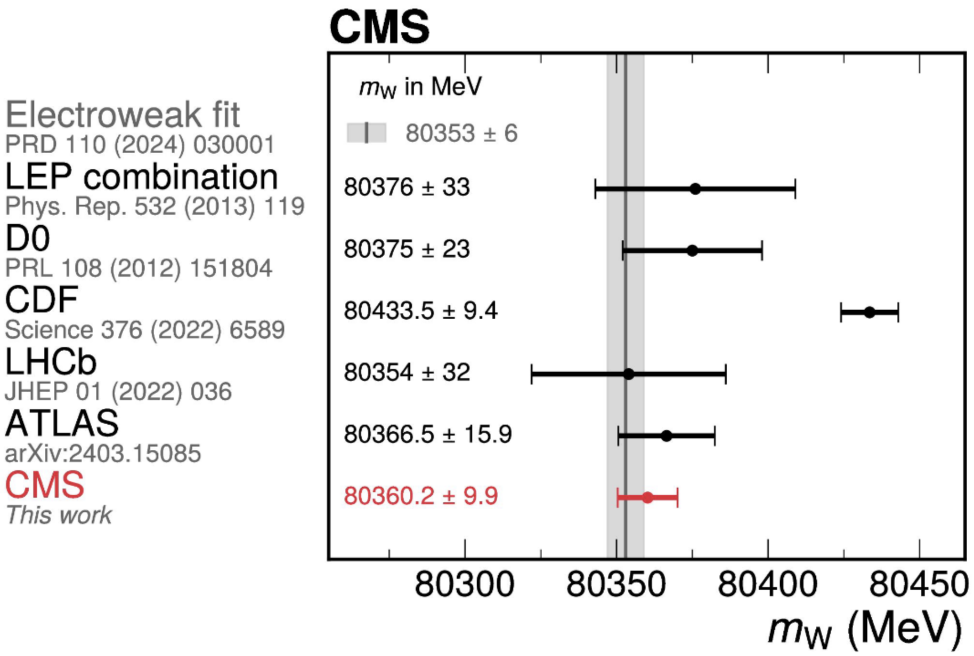
- Hadronic Vacuum Polarisation $e^+e^-$ (data-driven approach) not included for the WP25
- Tensions still to be understood, large discrepancies in low-energy cross section data

# LHC Physics:

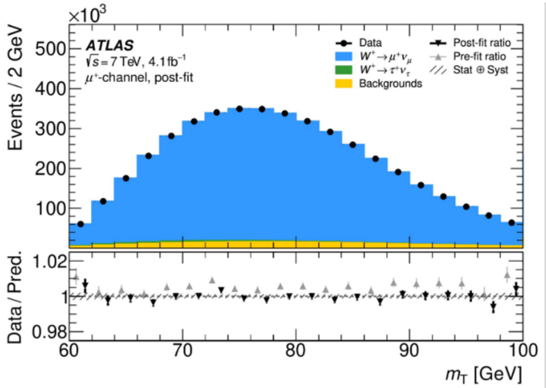
# SM and top

Josh Bendavid

# W mass



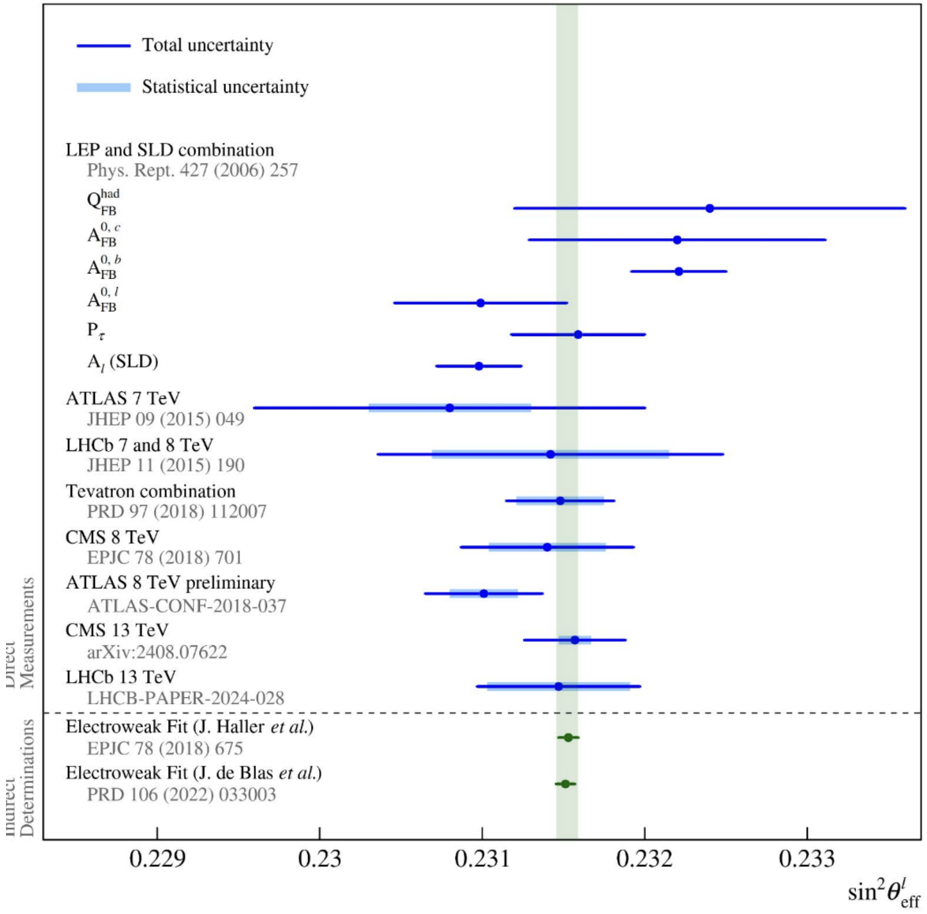

| Source of uncertainty | Impact (MeV) Nominal | Impact (MeV) Global |
|---|---|---|
| Muon momentum scale | 4.8 | 4.4 |
| Muon reco. efficiency | 3.0 | 2.3 |
| W and Z angular coeffs. | 3.3 | 3.0 |
| Higher-order EW | 2.0 | 1.9 |
| $p_T^V$ modeling | 2.0 | 0.8 |
| PDF | 4.4 | 2.8 |
| Nonprompt background | 3.2 | 1.7 |
| Integrated luminosity | 0.1 | 0.1 |
| MC sample size | 1.5 | 3.8 |
| Data sample size | 2.4 | 6.0 |
| Total uncertainty | 9.9 | 9.9 |

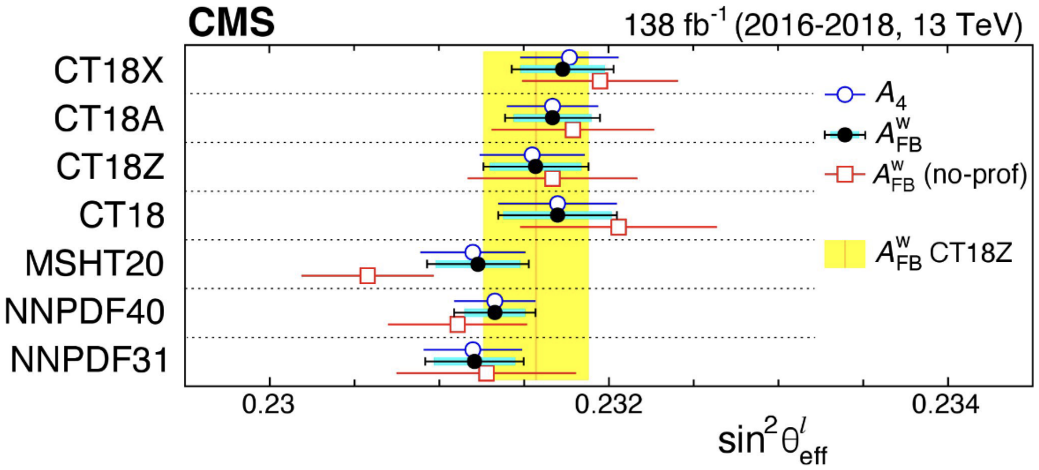



- Recent CMS measurement is the most precise at the LHC, approaching quoted CDF precision, compatible with SM prediction and other measurements
- Exploits strong in-situ constraints to reduce PDF/QCD uncertainties
- Clear tension with CDF measurement

# Weak mixing angle

- $\sin^2\theta_W$ measured from forward-backward asymmetry in $Z/\gamma^* \rightarrow \ell\ell$ events near Z peak



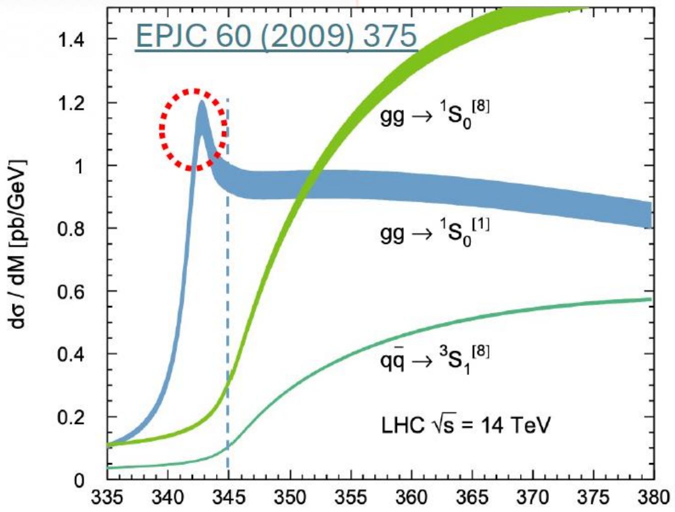



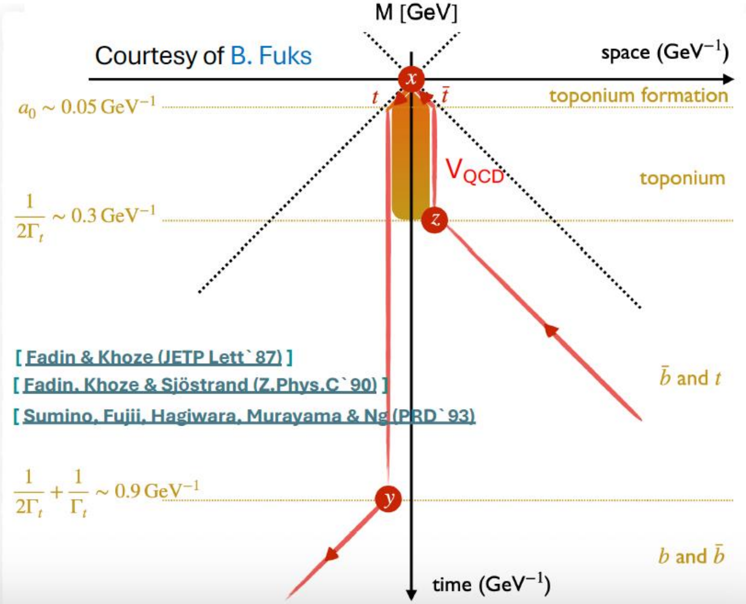

- LHC measurements now competitive with LEP/SLD
- For recent CMS measurement PDFs are largest uncertainty
- Non-negligible PDF dependence for result (though reduced by profiling)
- LHCb measurement is statistically dominated

Fabio Cerutti

# Observation of ttbar cross-section enhancement at threshold

- Non-Relativistic QCD predicts the formation at threshold ($m_{tt}$~$2m_t$~345 GeV) of **quasi-bound-state** (*Toponium*): spin-singlet - color-singlet **$^1S_0^{[1]}$**
- Our baseline tt modeling - PS-matched pQCD predictions reweighted to NNLO-QCD+NLO-EW – is missing these NRQCD states
- Experimentally extremely challenging: small effect (1% of total xs) in a $m_{tt}$ region much smaller than experimental resolution
- **New modeling** of NRQCD effects via the re-weighting of the tt production MEs through the non-relativistic QCD Green's function and projection to color singlet (Fuks et al. EPJC 85 (2025) 157) used as "signal"
- CMS measurement based on simplified model (pseudo-scalar resonance $\eta_t$)
  - $\sigma(\eta_t)=8.8^{+1.2}_{-1.4}$ pb >5 $\sigma$ observation arXiv:2503.22382




13.33 x 7.50 in

Screenshot

F. Cerutti LBNL - ATLAS Highlights

# Observation of ttbar cross-section enhancement at threshold

Andreas Hoecker
Fabio Cerrutti
Roberto Saviano

## CMS observed enhancement near tt production threshold — observation confirmed by ATLAS

### ATLAS

- Use tt→ℓνb ℓνb leptonic decay:
  - Reconstruction of $m_{tt}$ → mass resolution **~20%** at threshold
  - Enhance sensitivity using lepton angular variables sensitive to tt spin correlation ($c_{hel}$ and $c_{han}$) signal behaves as "*pseudo-scalar*"
- Fit to the data in 9 SR with $m_{tt}$ bins (300-500 GeV)
  - Background Model: baseline pQCD
  - Signal Model: NRQCD (from Fuks et al.)
- Bkg.-only hypothesis rejected at **7.7σ**

$\sigma(tt_{NRQCD})$ = 9.0 ±1.3 pb (expected 6.4pb, 5.7σ)

ATLAS **observed** this *elusive* NRQCD phenomena

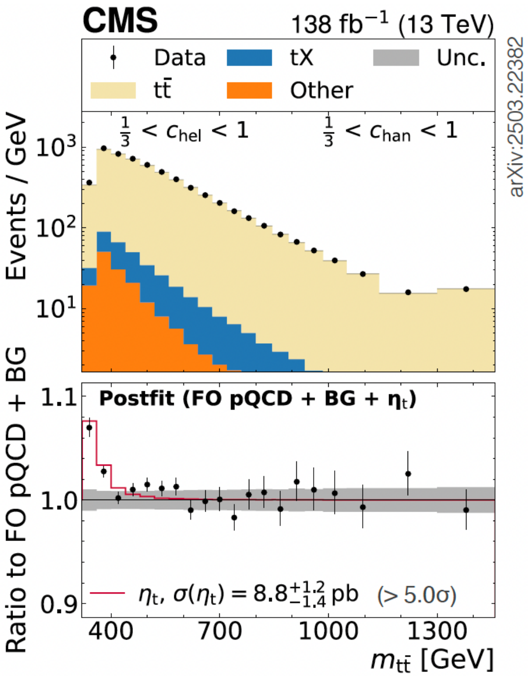
more work is needed on theory side (off-shell effects, matching pQCD and NRQCD, other NRQCD effects, ...) to better establish the properties of the observed signal

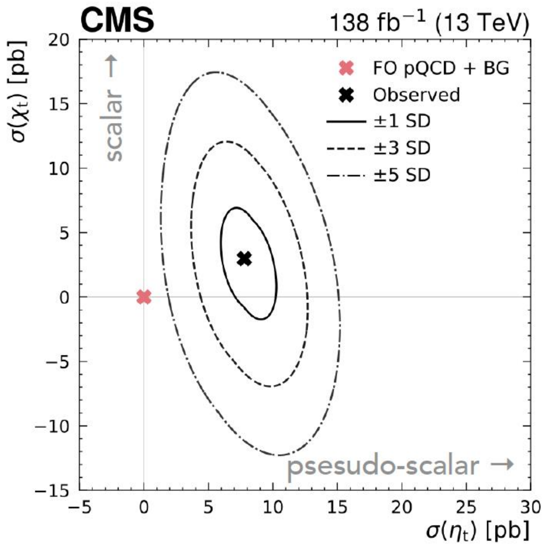
### CMS

In the search for H/A resonances into $t\bar{t}$ observed an excess of data at threshold

Measured cross section of a quasi-bound
$$\sigma(\eta_t) = 8.8^{+1.2}_{-1.4}\ \text{pb}$$

Compatible with NRQCD prediction $\sigma(\eta_t) = 6.4$ pb
*arXiv:2102.11281 arXiv:2401.08751*



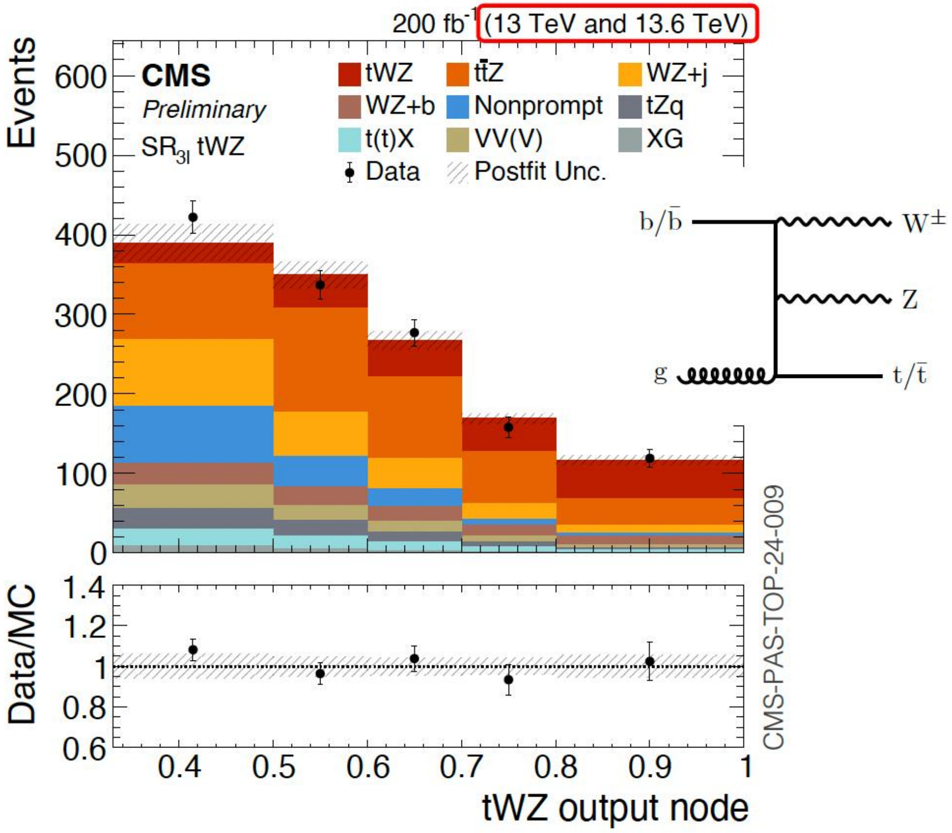




Excess compatible with pseudo-scalar hypothesis

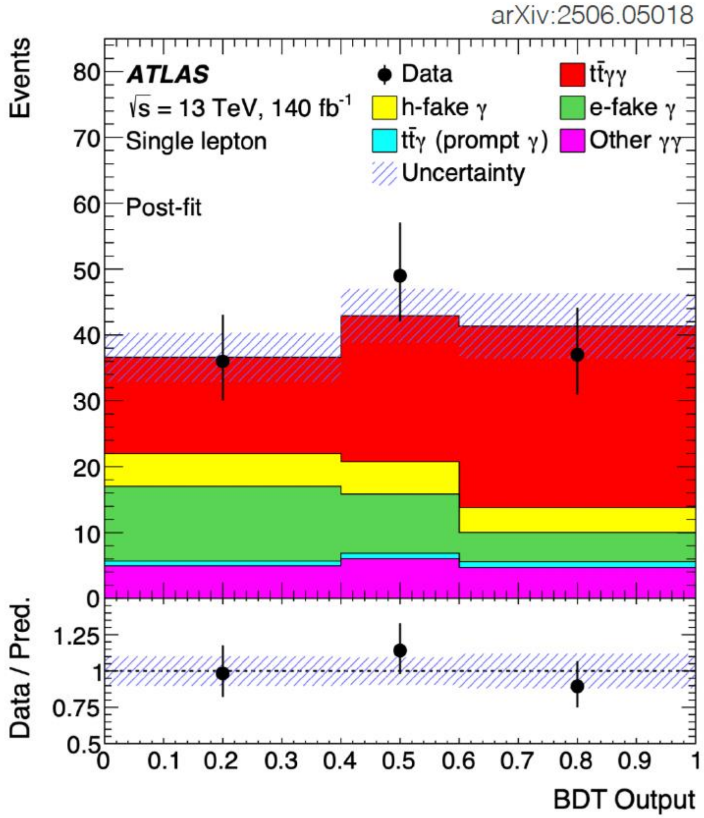
# Rare processes

**LHC experiments push intensity frontier to ever rarer processes — with help from machine learning**

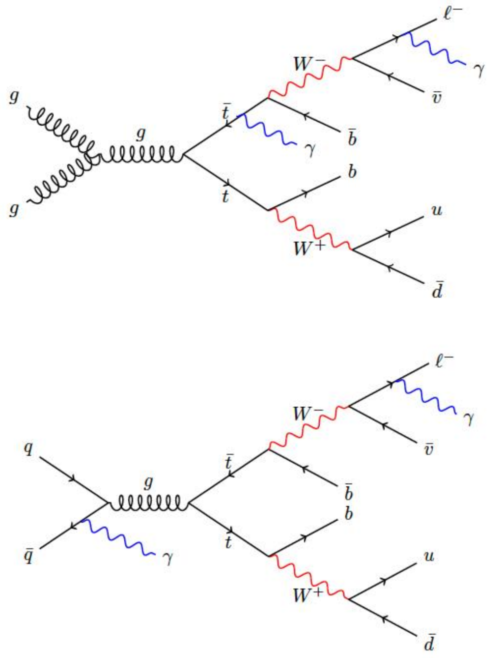
Each of them probes new, often deep facets of the SM. Here: first observation of tWZ (left) and tt$\gamma\gamma$ (right)




σ(tWZ) = 248 ± 52 fb (5.8σ significance)




$\sigma_{fid}$(tt$\gamma\gamma$) = 2.4 ± 0.5 fb (5.2σ significance)



# LHC Physics:
# Hadron and Flavour

Andreas Hoecker,
Tim Gershon

# First observation of *CP* violation in baryon decays

## First observation of CP violation in baryon decay by LHCb

Direct CPV requires interference of diagrams with non-zero differences of weak *and* strong phases

Use $\Lambda_b^0 \to \Lambda_c^+(pK^-\pi^+)\pi^-$ as reference channel

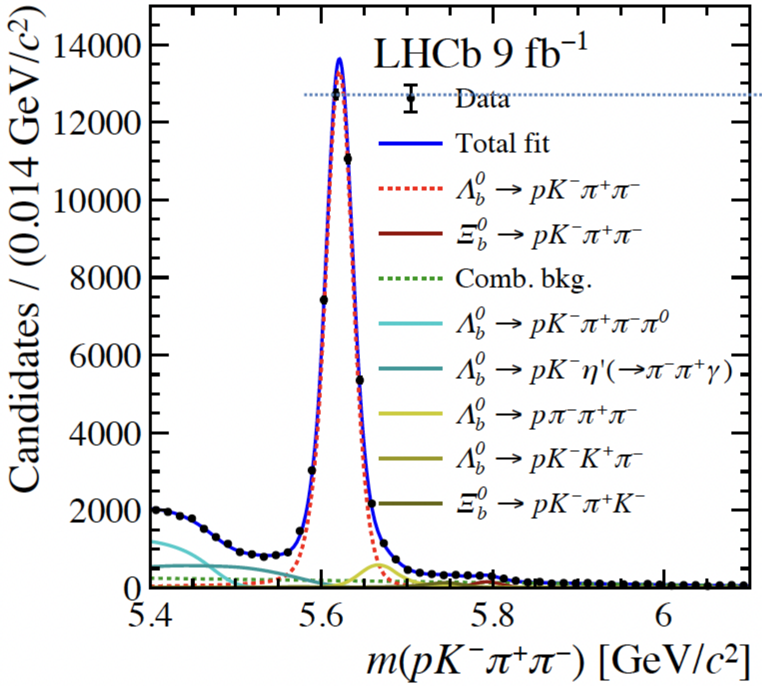
$$\mathcal{A}_{CP} \equiv \frac{\Gamma(\Lambda_b^0 \to pK^-\pi^+\pi^-) - \Gamma(\overline{\Lambda}_b^0 \to \overline{p}K^+\pi^-\pi^+)}{\Gamma(\Lambda_b^0 \to pK^-\pi^+\pi^-) + \Gamma(\overline{\Lambda}_b^0 \to \overline{p}K^+\pi^-\pi^+)} = (2.45 \pm 0.46 \pm 0.10)\%$$

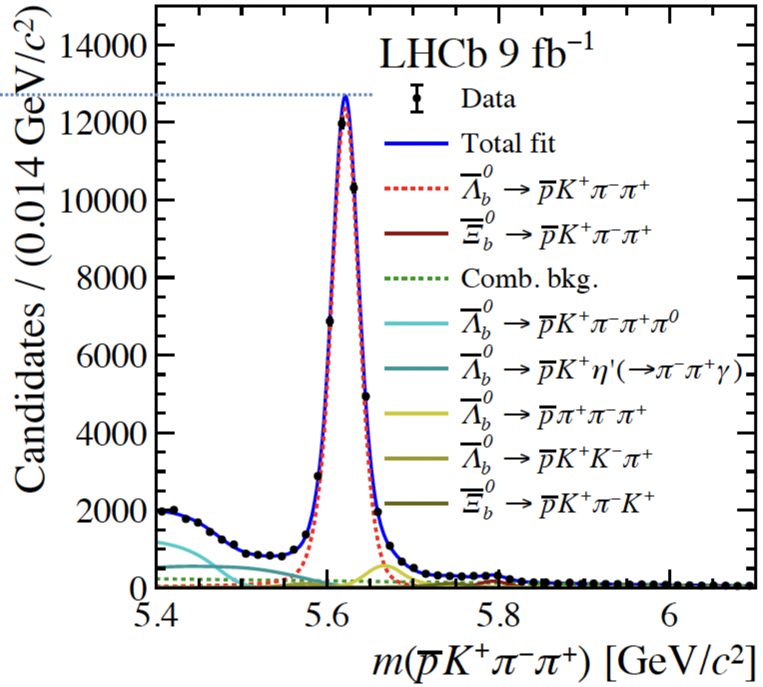
5.2σ from zero

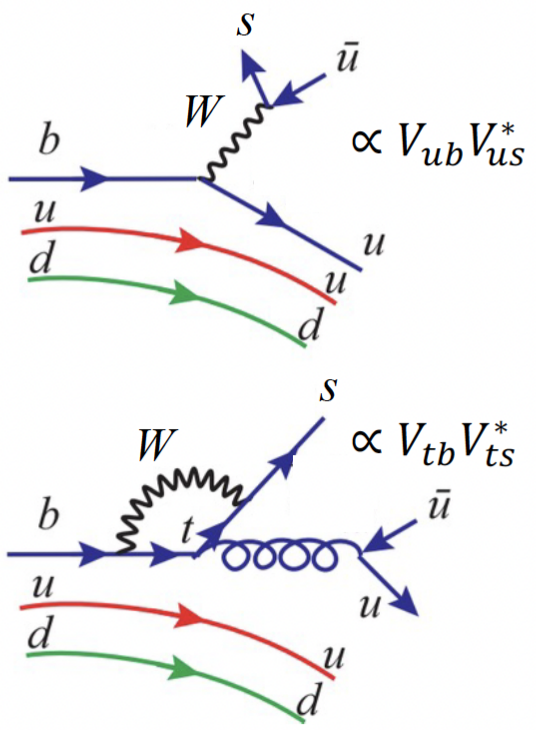
Decay proceeds mostly through intermediate resonances (showing different amount of $A_{CP}$)

Derived from uncorrected yield difference: $A_N = 3.71 \pm 0.39$ %

arXiv:2503.16954




CP violation due to interference between tree and penguin diagrams

Precise amount of CPV very hard to predict, but interestingly smaller in baryon than similar meson systems

Note that baryogenesis requires proton decay and CPV, but not necessarily in the baryon sector

# CP violation in charm

Andreas Hoecker
Vladimir Gligorov

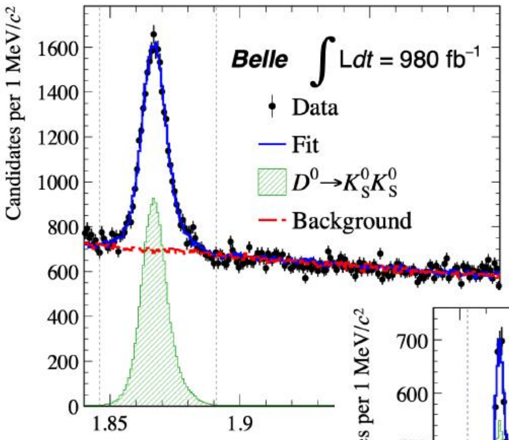
**CP violation in charm sector (up-type quarks)** is mostly expected to be very small (< $O(10^{-3})$) in SM

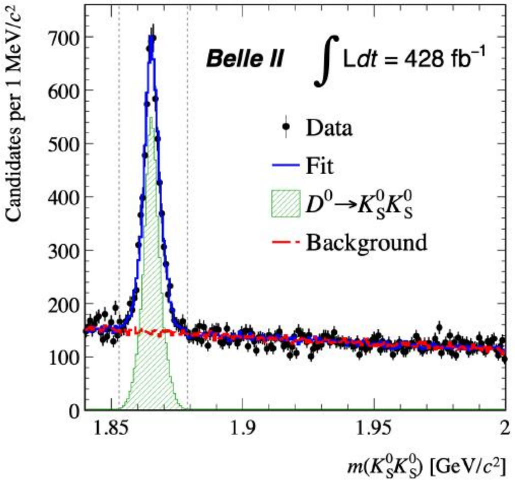
First observation by LHCb in 2019 from $\Delta A_{CP}$ between $D^0 \to K^+K^-$ and $D^0 \to \pi^-\pi^+$ decays = $(-15.4 \pm 2.9)\times10^{-4}$ [arXiv:1903.08726] which is about six times larger than theoretical bounds (but difficult calculations)

**New measurements by Belle II and LHCb**

$$\mathcal{A}^{CP}(K^0_S K^0_S) \equiv \frac{\Gamma(D^0 \to K^0_S K^0_S) - \Gamma(\overline{D}^0 \to K^0_S K^0_S)}{\Gamma(D^0 \to K^0_S K^0_S) + \Gamma(\overline{D}^0 \to K^0_S K^0_S)}$$

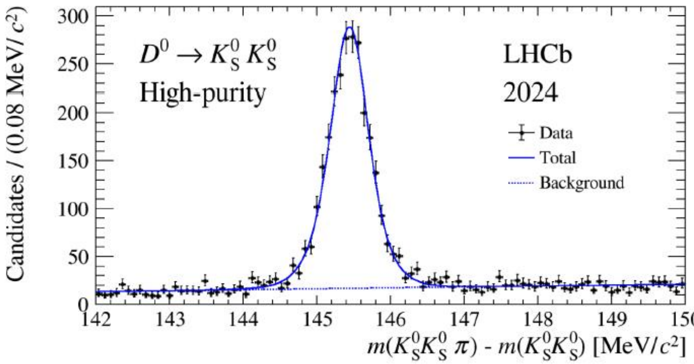
Echange & loop diagrams only, may enhance CPV to ~1% [Link]

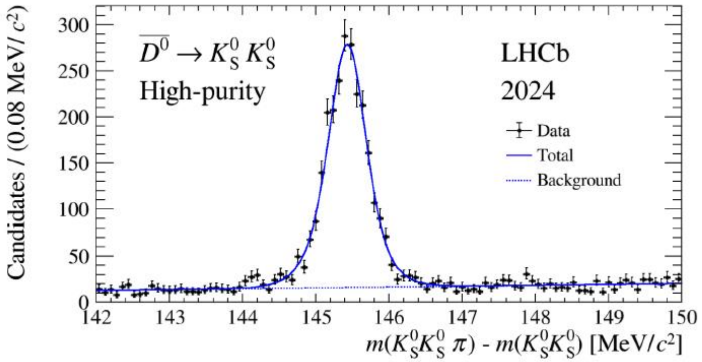


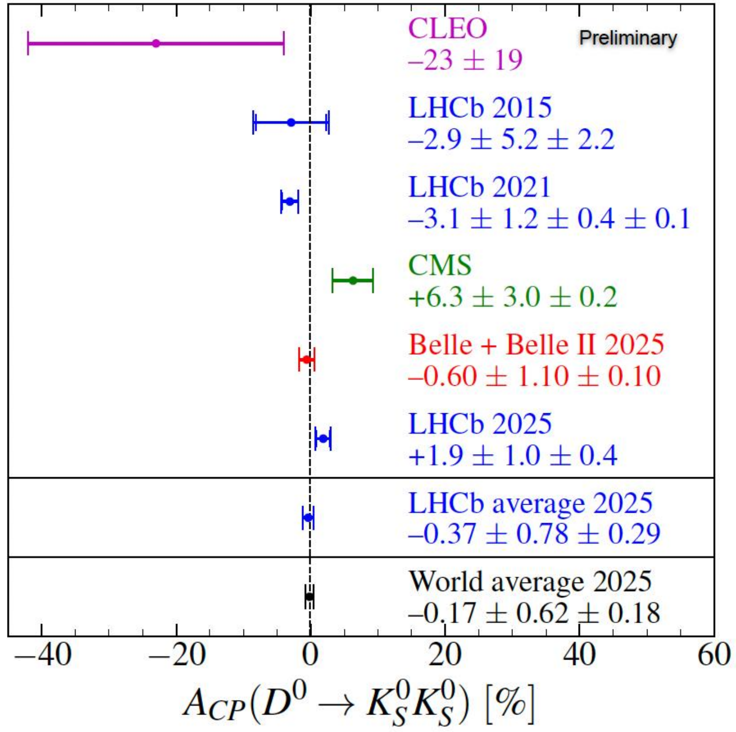




**Combination of Belle and Belle II data**

**LHCb 2024 dataset →**



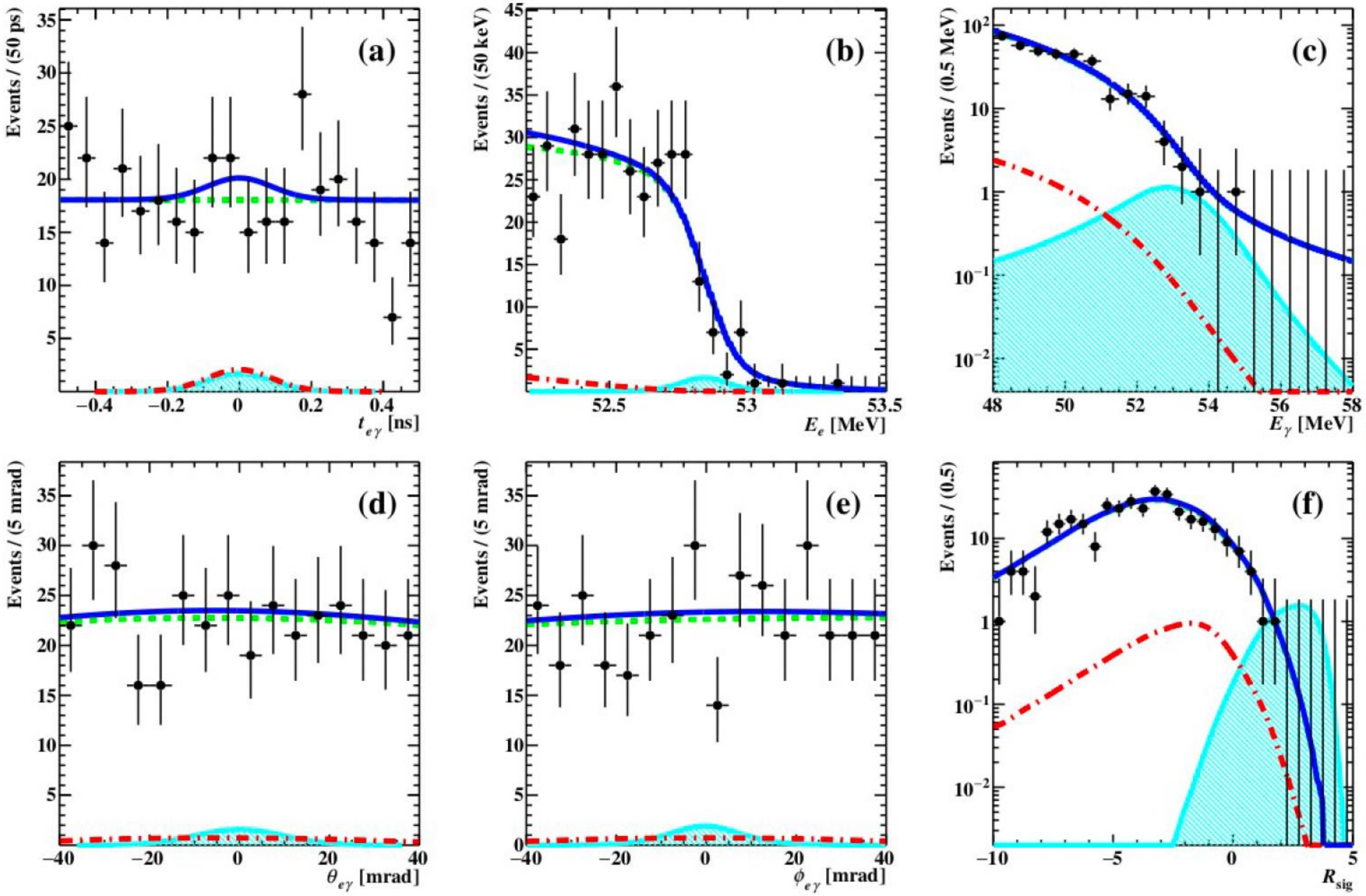




**World average and LHCb internal average compatible with zero and statistically limited.**

# MEG II result on B(μ→eγ)

## Crucial to be background-free




arXiv:2504.15711

Eight discriminating variables (5 shown) combined into fitted likelihood function (transformed to $R_{sig}$ for illustration)

No signal excess observed

$B(\mu^+ \rightarrow e^+\gamma) < 1.5 \times 10^{-13}$ at 90% CL

[×2.4 higher sensitivity c.f. MEG]

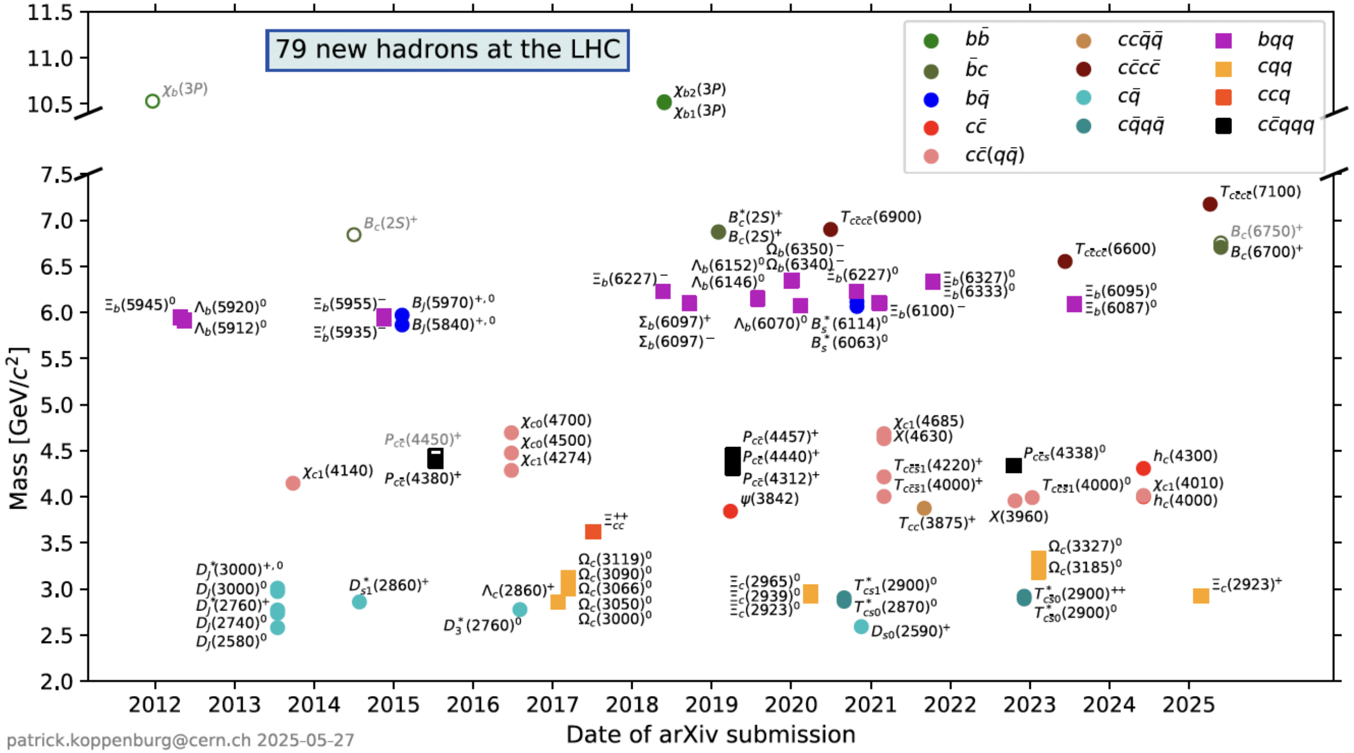
Uses 2021-22 data; ×2 more data collected in 23-24 & more anticipated 25-26

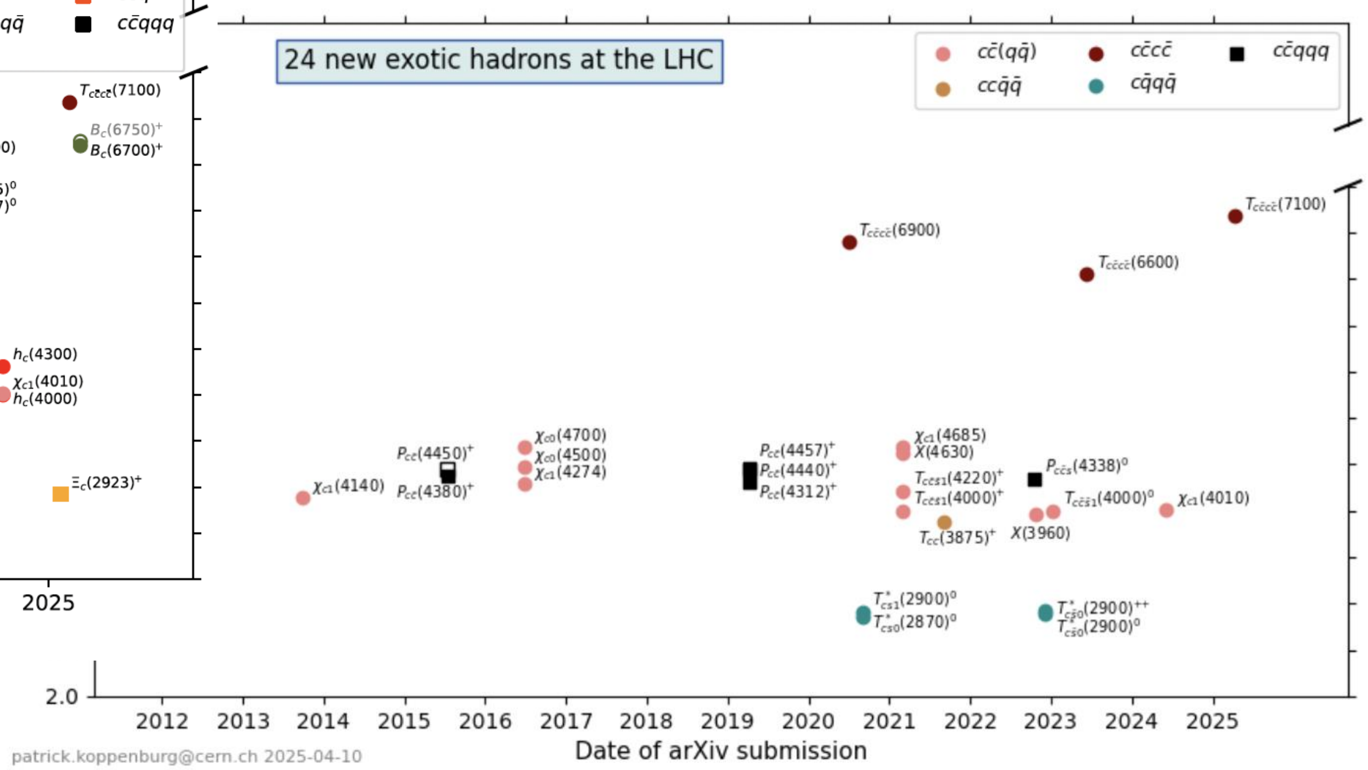
Target sensitivity $6 \times 10^{-14}$

Andreas Hoecker
Vladimir Gligorov

# Hadron spectroscopy at LHC

- Several 4- and 5-valence quark states found, majority by LHCb, and certainly not the end of the story…
  - Resonances with heavy quarks reduce the amount of open decay channels and thus have smaller width → easier to discover if enough energy, luminosity, and momentum resolution



# LHC Physics:
# Higgs

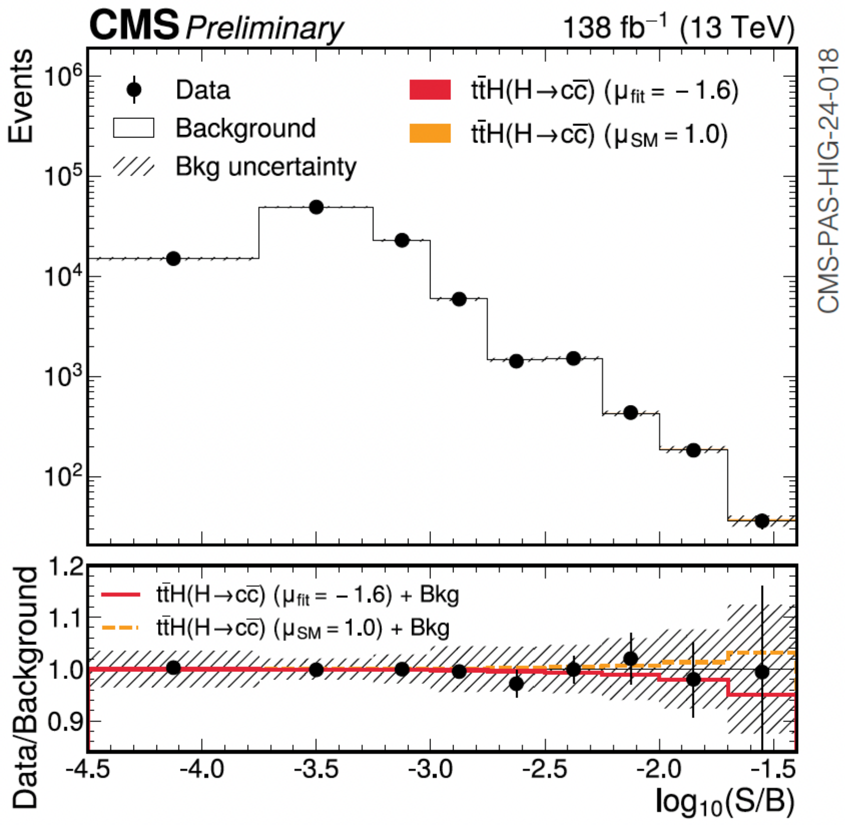
Andreas Hoecker

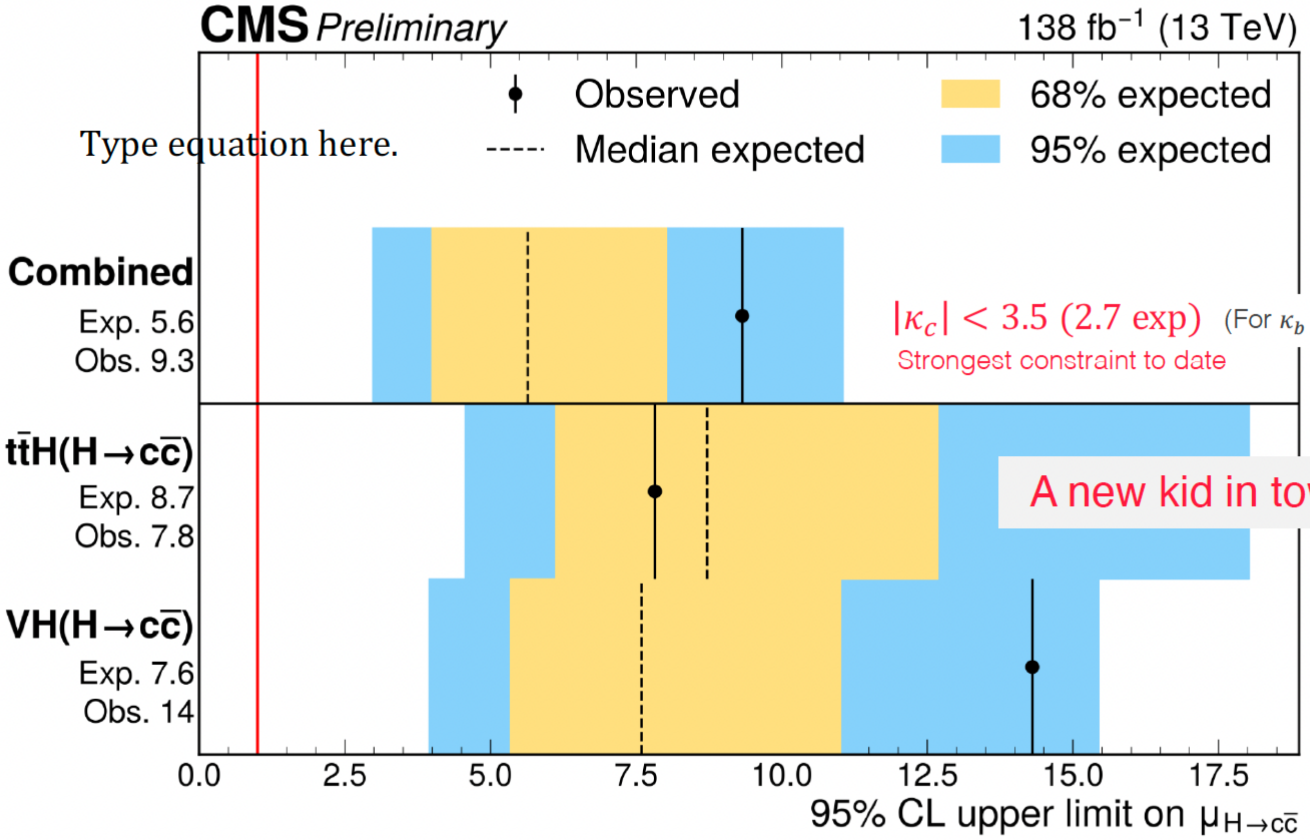
# Higgs coupling to charm quarks

**BR(H → cc) 20 × smaller than H → bb due to lighter charm quark, challenging to isolate experimentally**

Best constraints so far from VH production: $\mu_{VH \times H \to cc} < 11.5_{obs}$ $(10.6_{exp})$ / $14_{obs}$ $(7.6_{exp})$ (ATLAS / CMS) [arXiv:2410.19611 / 1912.01662 ]

Strong new result from CMS using ttH production and simultaneously measuring H → bb / cc (as also done in VH)



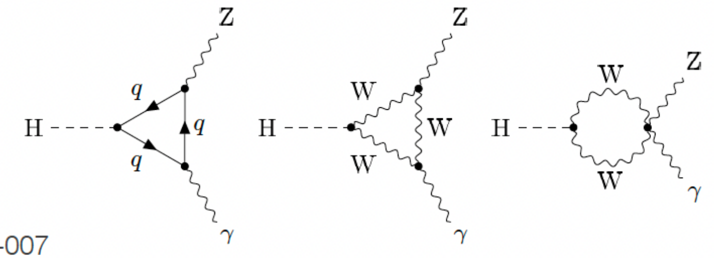

$|\kappa_c| < 3.5$ (2.7 exp) (For $\kappa_b = 1$)

Strongest constraint to date

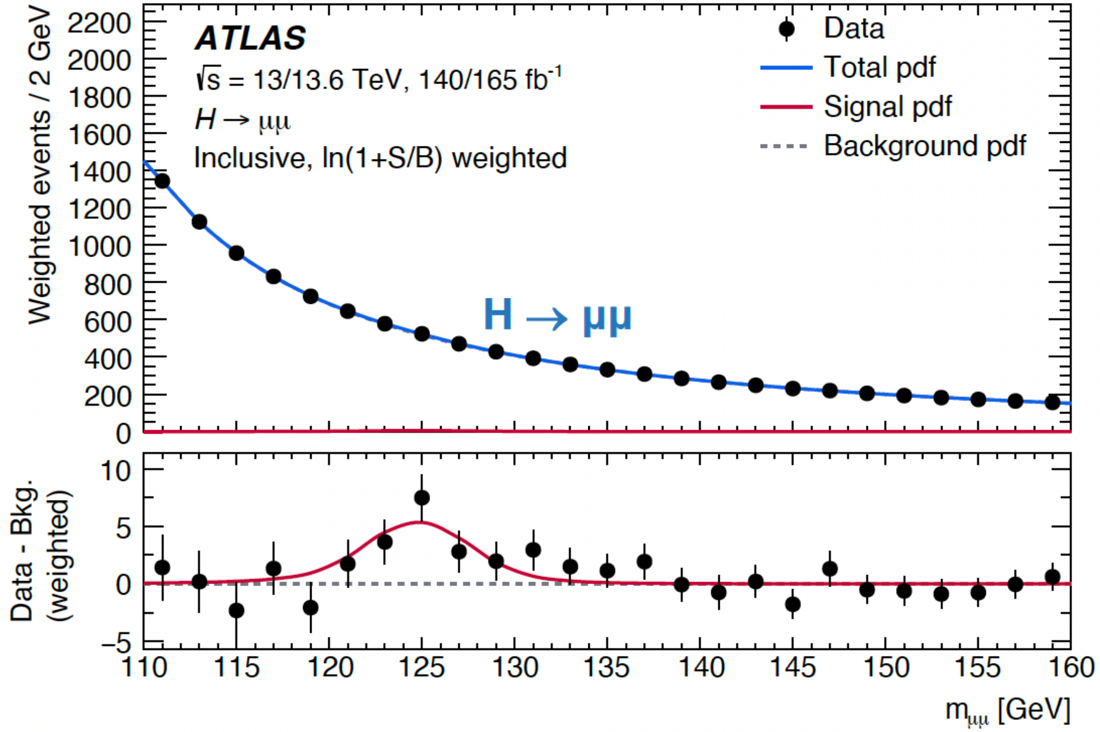
A new kid in town

# $H \to \mu\mu$ and $H \to Z\gamma$

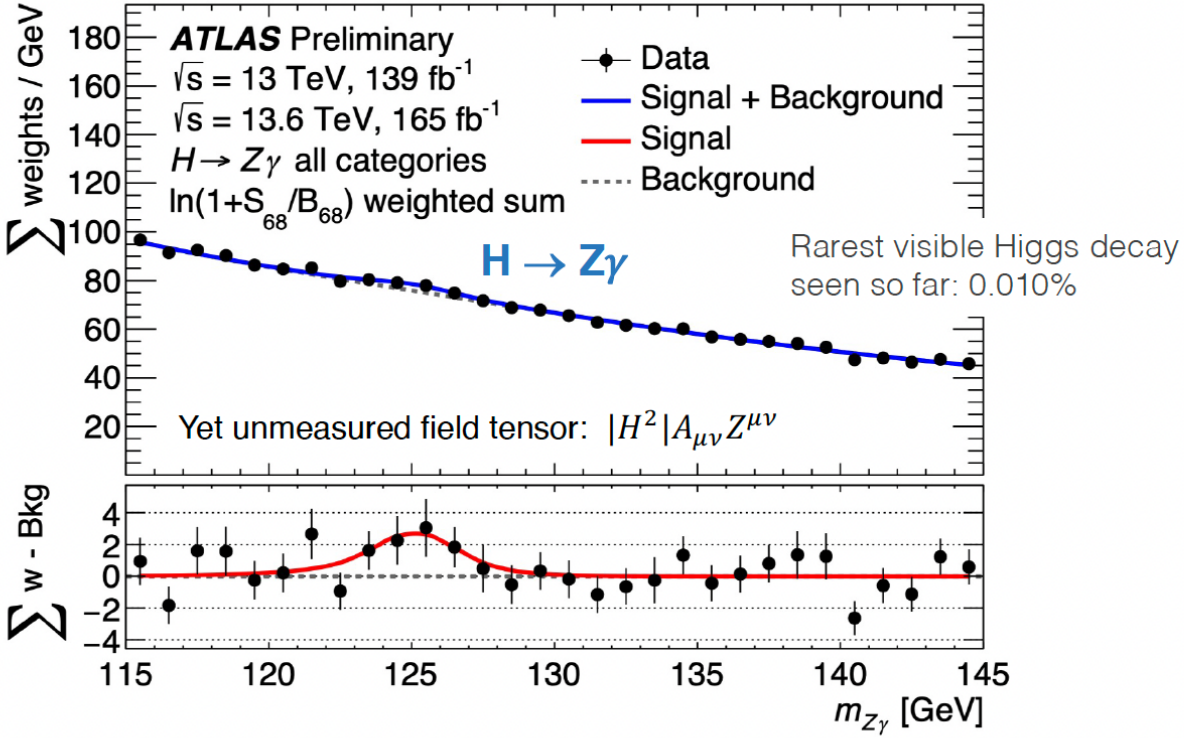
**Using 305 fb$^{-1}$ of Run-2 + 3 data, ATLAS reports evidence for rare 2$^{nd}$ generation H → μμ, and released new result on loop decay H → Zγ**




arXiv:2507.03595




ATLAS-CONF-2025-007




Significance: 3.4σ (2.5σ exp), μ = 1.4 ± 0.4

Reminder: CMS (Run 2): μ = 1.19 ± 0.43 (3.0σ) [arXiv:2009.04363]

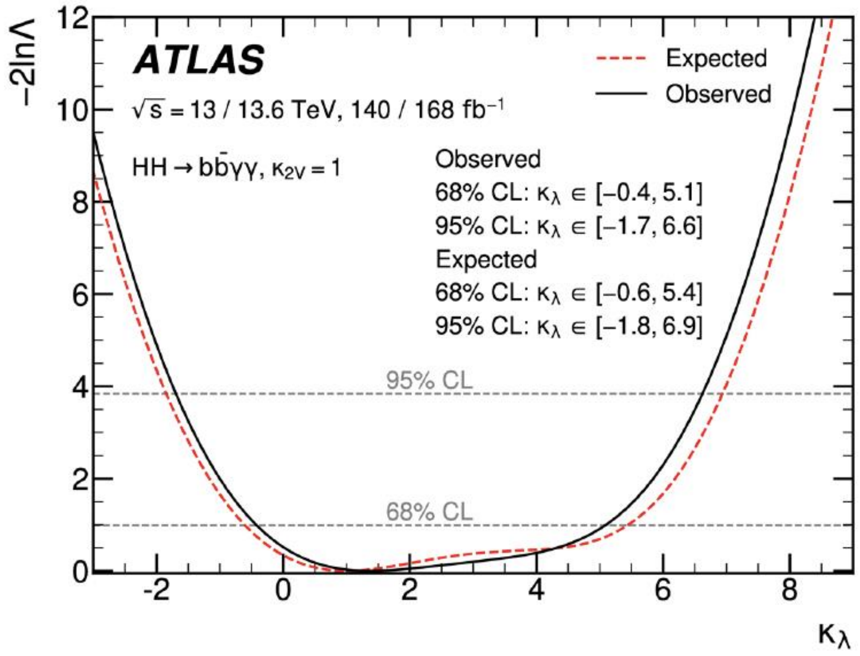
Significance: 2.5σ (1.9σ exp), μ = 1.3 $^{+0.6}_{-0.5}$

Reminder: ATLAS & CMS (Run 2): μ = 2.2 ± 0.7 (3.4σ) [arXiv:2309.03501]

# Search for HH → $bb\gamma\gamma$

Fabio Cerutti,
Emmanuele di Marco

- New measurement using reprocessed Run 2 + Run 3 (2022-2024!) → Total **308 fb$^{-1}$**
- **Timely calibration of physics objects** for Run 3 (up to 2024!)
- Improvements on HH sensitivity relative to Run 2 legacy analysis:
  - Additional data: **50%**
  - New flavor tag algorithm **GN2**: **20%**
  - Analysis preoptimization: **10%**
  - $m_{bb}$ kinematic fit : **5%**
- Signal extracted by a fit to $m_{\gamma\gamma}$ in 7 BDT categories
  - Observed $\mu(\sigma/\sigma_{SM})_{HH} = 0.9^{+1.4}_{-1.1}$
  - 0.8 σ significance (1.0 expected)
  - Similar sensitivity of Legacy Run 2 combination (5 chan.)
- Higgs boson self-coupling modifier (coupling normalized to its SM prediction) $\kappa_\lambda \in [-1.7, 6.6]$ @95% CL




Higgs self-coupling (Run2 legacy) (using more final states)

most stringent 95% CLs on Higgs boson self-coupling from HH:

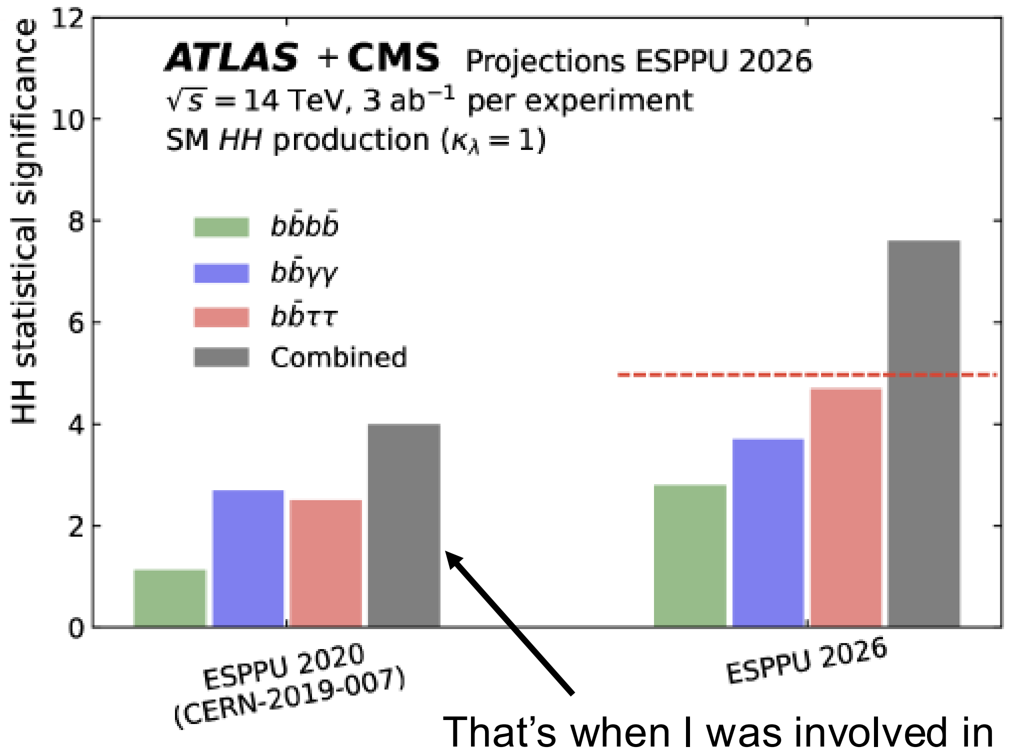
$-1.2 < \kappa_\lambda < 7.2$ (ATLAS)

$-1.39 < \kappa_\lambda < 7.02$ (CMS)

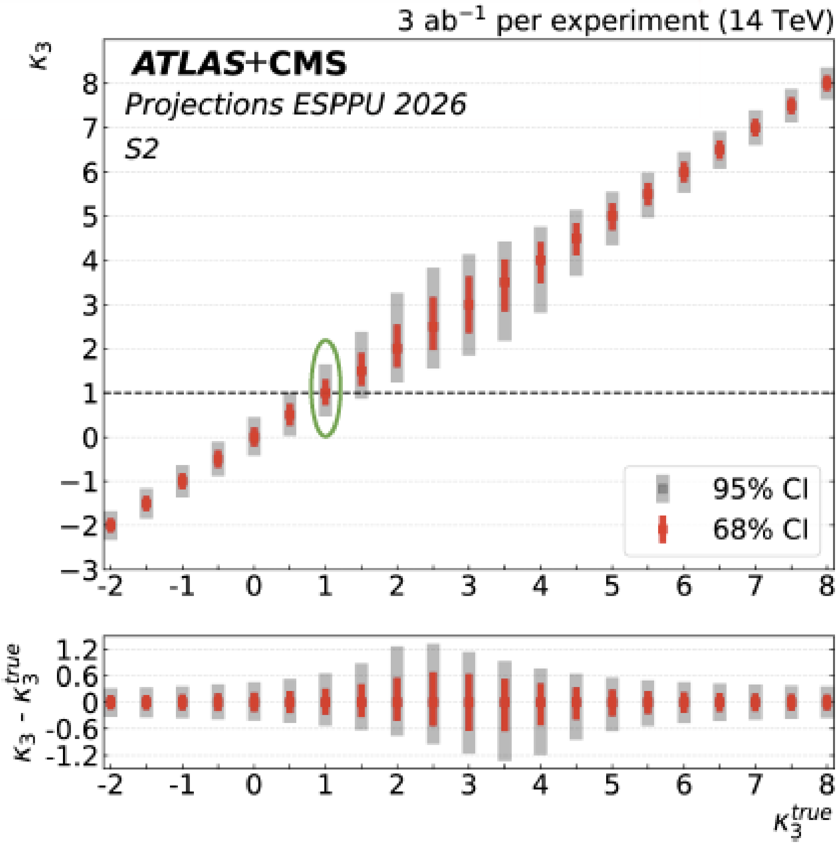
Fabio Cerutti

# HL LHC HH combination

ATL-PHYS-PUB-2025-018/




That's when I was involved in HH @ HL LHC




Among the main physics goals of the HL-LHC program one is the Observation of the HH process and measurement of the Higgs boson self-coupling with a 30% accuracy → we need 3ab$^{-1}$ good for physics to achieve them

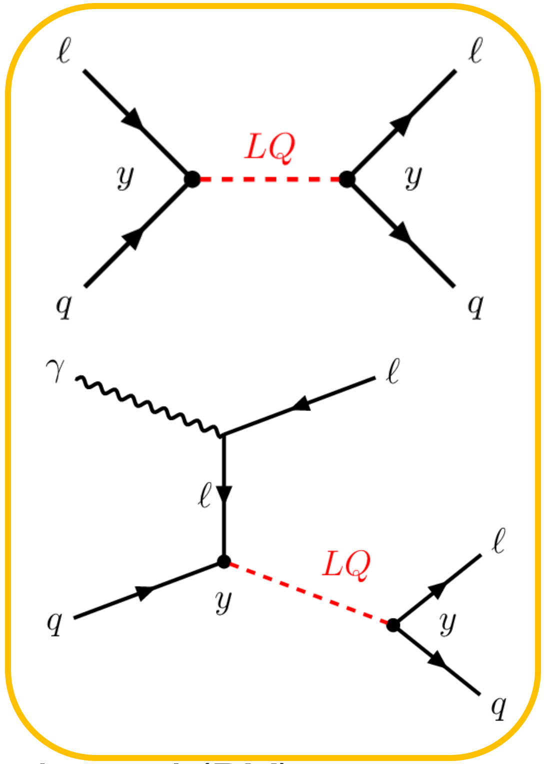
# LHC Physics:
# BSM

# Resonant 1st and 2nd generation LQ production

New

arXiv:2507.03650

- Search for resonant single LQ production in new production mode using Run-2 and 58 fb$^{-1}$ Run-3 data
  - 1st ATLAS analysis for LQ production exploiting lepton+photon PDFs
    - Possible now due to advancements in understanding of lepton content of protons
    - Photon PDF less suppressed than lepton PDF → contributions roughly on “equal footing”
  - Use scalar $\tilde{S}_1$ LQ with q=-4/3e as benchmark signal
- Search in final states with 1 or 2 leptons and a jet
  - 1e or 1$\mu$ + 1 light jet; 1e or 1$\mu$ + 1 b-jet
  - 2e or 2$\mu$ + 1 light jet; 2e or 2$\mu$ + 1 b-jet
    - LQ sensitivity also from non-resonant production to dilepton production via t-channel (DY)
- Main SM backgrounds
  - W+jets, Z+jets, $t\bar{t}$ (in b-jet channels)
  - Jets mis-identified as leptons or non-prompt leptons



Monika Wielers

# Resonant 1st and 2nd generation LQ production

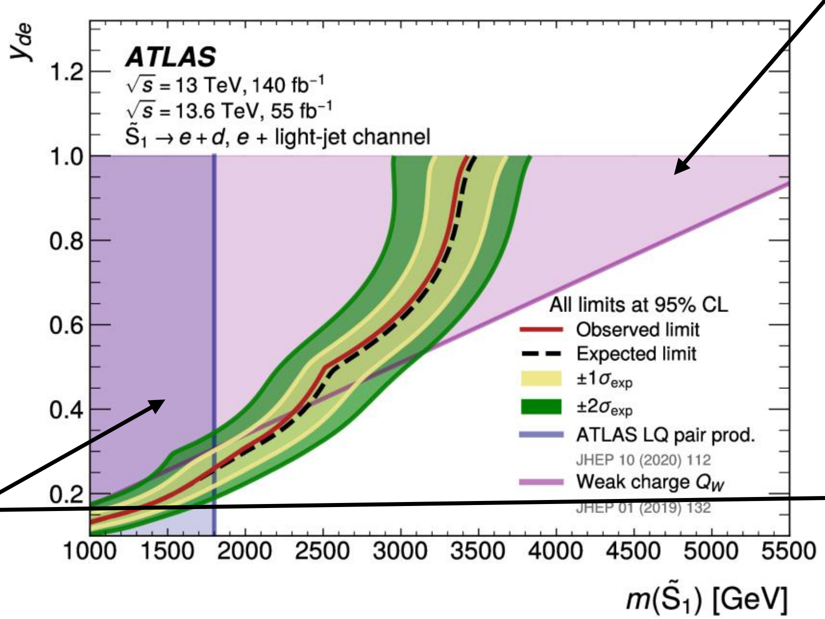
New

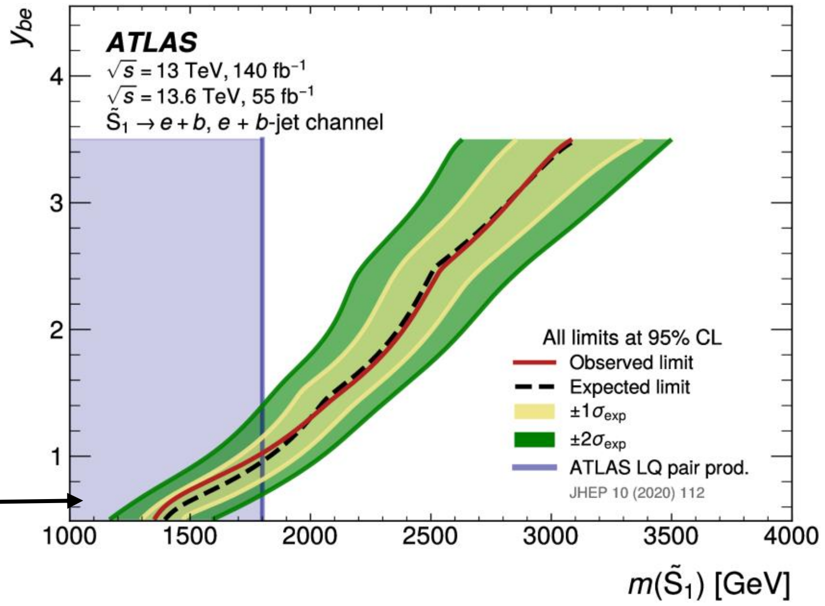
arXiv:2507.03650

- 95% CL exclusion limits

Constraints from low energy experiments on $y_{de}$ couplings (weak charge measurements) JHEP 01(2019) 132

Constraints from ATLAS LQ pair production JHEP 10(2020) 112

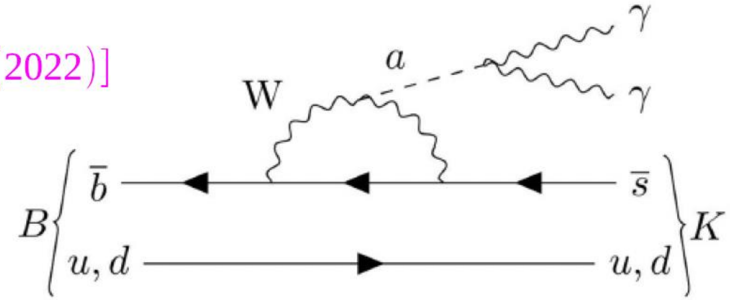


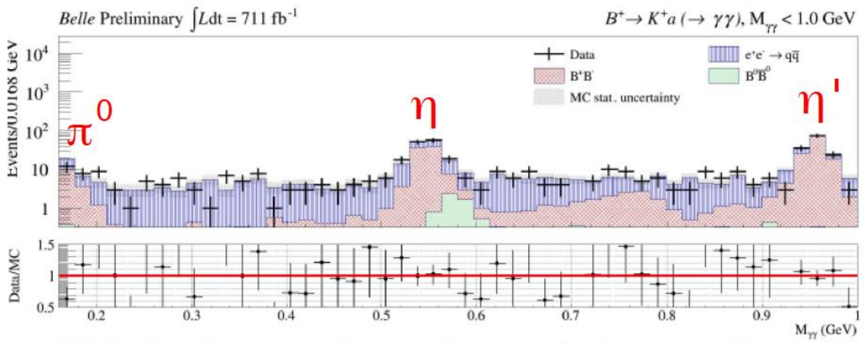

- e+light-jet channel: $m_{LQ}$ < 3.4 TeV with $y_{de}$=1.0
- e+b-jet channel: $m_{LQ}$ < 3.1 TeV with $y_{be}$=3.5
- $\mu$+light-jet channel: $m_{LQ}$ < 4.3 TeV with $y_{s\mu}$=3.5
- $\mu$+b-jet channel: $m_{LQ}$ < 2.8 TeV with $y_{b\mu}$=3.5
- Access new phase space (high coupling+high mass)

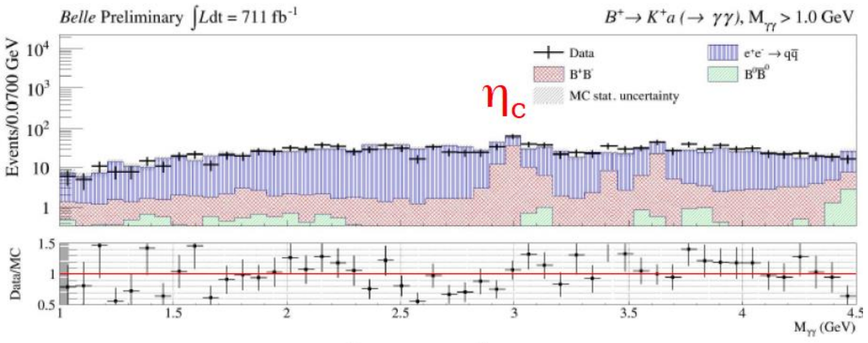
# Search for Alps: B→K$^{(*)}$ a(→$\gamma\gamma$) with Belle

- Search for an ALP in the MeV-GeV scale
- Previous result on $B^+ \to K^+ a$ [BaBar, PRL 128, 131802 (2022)]




- using Belle sample (711 fb$^{-1}$)
- four kaon modes included: $K_S^0$, $K^+$, $K^{*+}$, $K^{*0}$
- $\mathcal{B}(a \to \gamma\gamma) \sim 100\%$ when $m_a \ll m_{W^+}$
- $m_a$ investigated from 160 MeV/$c^2$ to the kinematic end-point

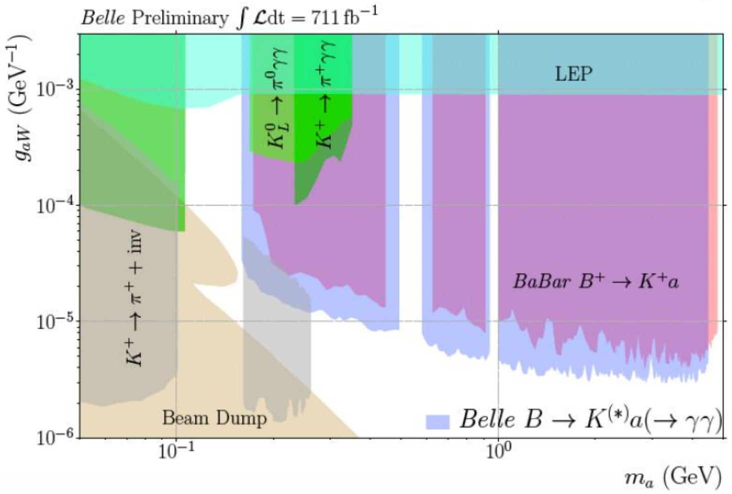



- Main background is continuum ($e^+e^- \to q\bar{q}$) rejected with BDTs based on kinematics and topology variables
- fit di-photon invariant mass to extract signal yield
- Peaking background regions vetoes ($\pi^0$, $\eta$, $\eta'$)
- $B \to K\eta, K\eta'$ as validation modes

For each ALP mass hypothesis, simultaneous fit performed on four kaon modes to obtain the coupling constant $g_{aW}$

**⇒ improved at least by factor 2 from BaBar**




"Searches for dark sector particles at Belle II"
(L. Salutari)

16

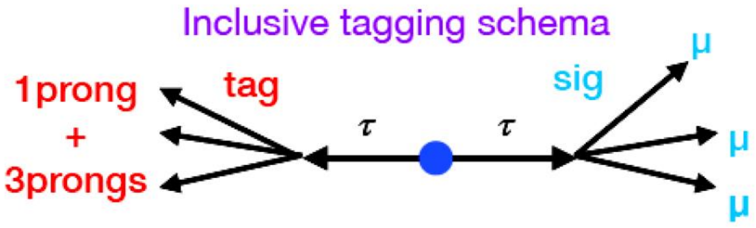
# Lepton flavour violating decay of $\tau \to 3\mu$ at Belle II

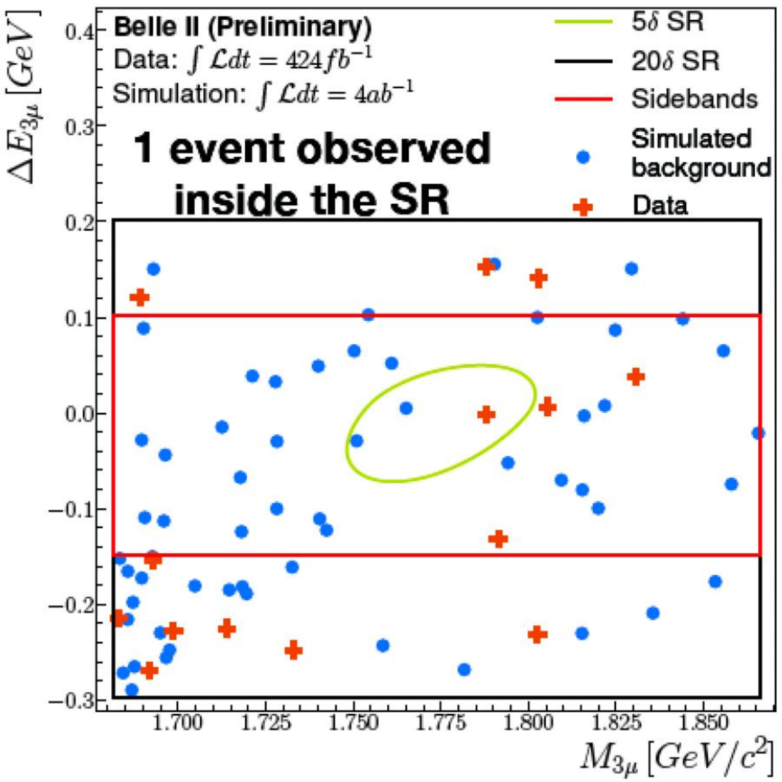
## Analysis selection and results: inclusive approach

BDT trained on 32 variables:
inputs from signal $\tau^-$, event tag side, event shape and kinematics

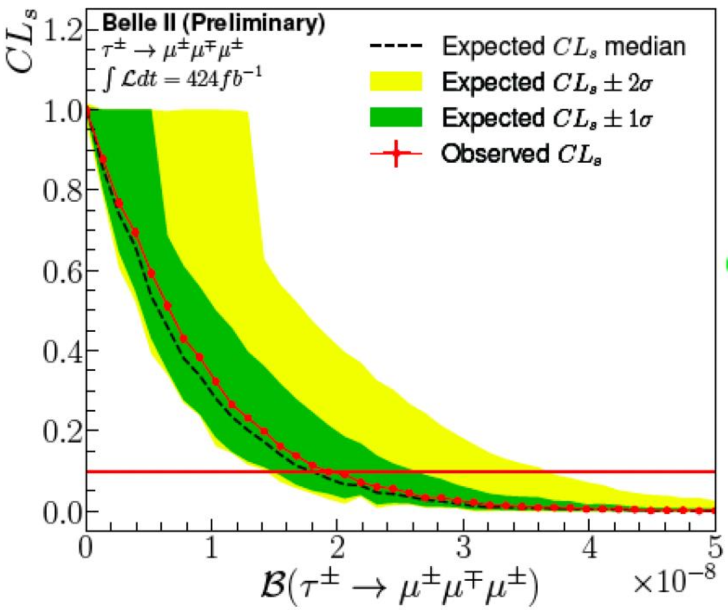
$\epsilon_{sig} = (20.42 \pm 0.06)\%$ (3 × larger than Belle)

Expected BKG: $0.5^{+1.4}_{-0.5}$ evts




No significant excess in 424 $fb^{-1}$ of data




**Obtained most stringent limit**
**$1.9 \times 10^{-8}$**

[2405.07386, JHEP 2024 (2024) 62]

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ATLAS 13 TeV result: B($\tau \to 3\mu$) < 3.1 (2.7) × $10^{-8}$ expected (observed)

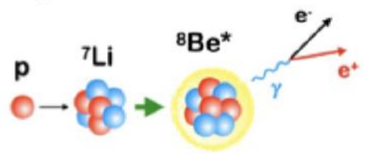
CMS: B($\tau \to 3\mu$) < 2.4 (2.9) × $10^{-8}$

Andreas Hoecker

# X17

## Puzzle from measurements of internal pair conversion process $^7$Li + p → $^8$Be*(18.1) → $^8$Be + $\gamma$*(→ e$^+$e$^-$)

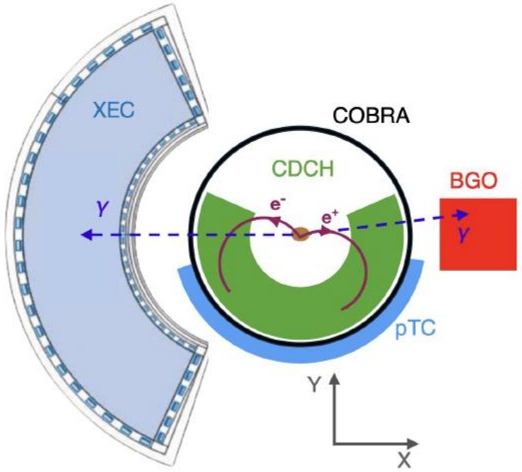
Since 2016, ATOMKI data show a persistent excess in e$^+$e$^-$ angular distributions consistent with a ~17 MeV particle at rate vs. $\gamma$ of ~ 6×10$^{-6}$ (challenging measurement due to low energy of emerging e$^+$ / e$^-$). Follow-up studies with refined analyses and other nuclei confirm the anomaly. No SM explanation exists for such a phenomenon.

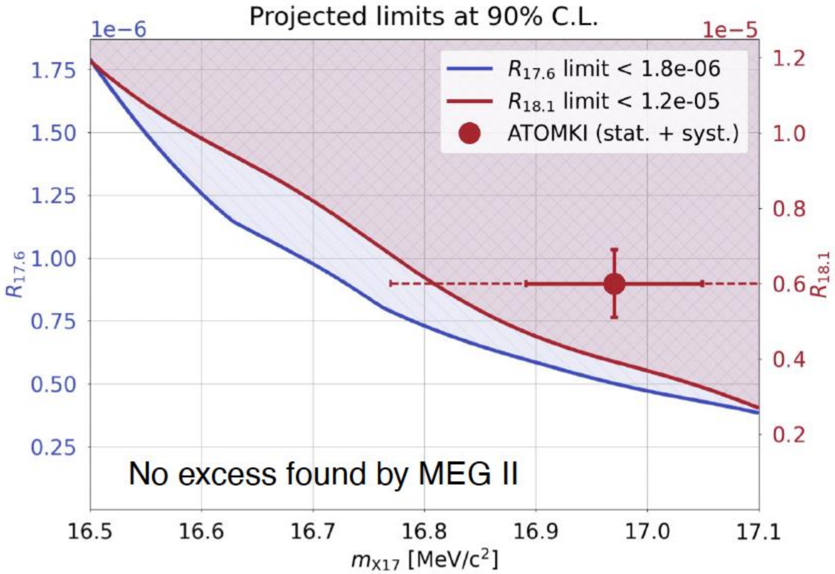



Many groups looking at this anomaly. Two reports this week:

### MEG II (PSI) [arXiv:2411.07994]

Dedicated 4-week run in Feb 2023 with 1.08 MeV proton on Li target, measuring outgoing $^8$Be* de-excitation photons and e$^+$, e$^-$

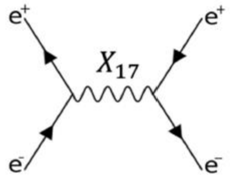


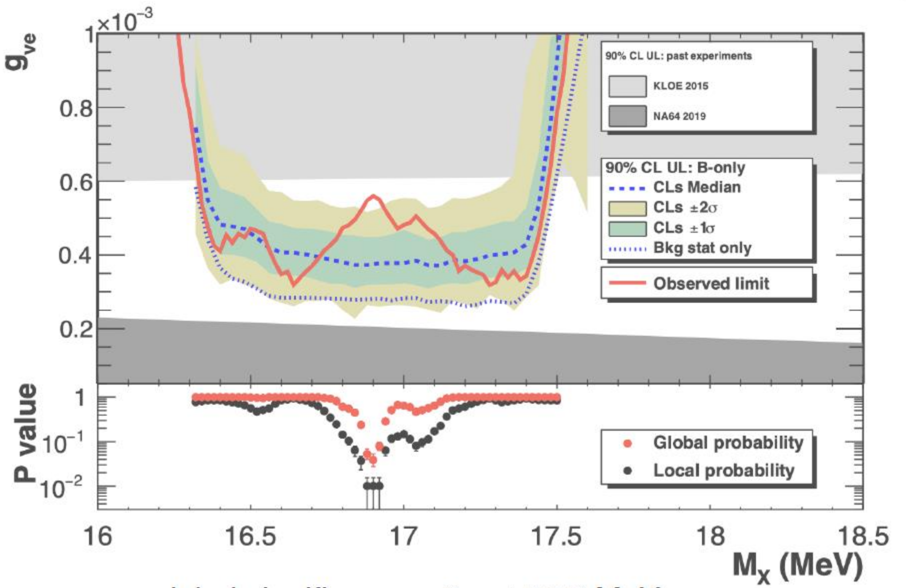




$$R_{\mathrm{IPC}Q} = \frac{\mathscr{B}(^8\mathrm{Be}^*(Q) \to {}^8\mathrm{Be} + \mathrm{X17})}{\mathscr{B}(^8\mathrm{Be}^*(Q) \to {}^8\mathrm{Be} + e^+e^-)}$$

### PADME (Frascati) [arXiv:2505.24797]

Try to directly produce X17 by hitting thin (0.1 mm) diamond target with 283 MeV e$^+$ beam and measure outgoing e$^+$, e$^-$




Small excess seen, global significance ~2σ at 16.9 MeV

# LHC Physics:

# Heavy Ion

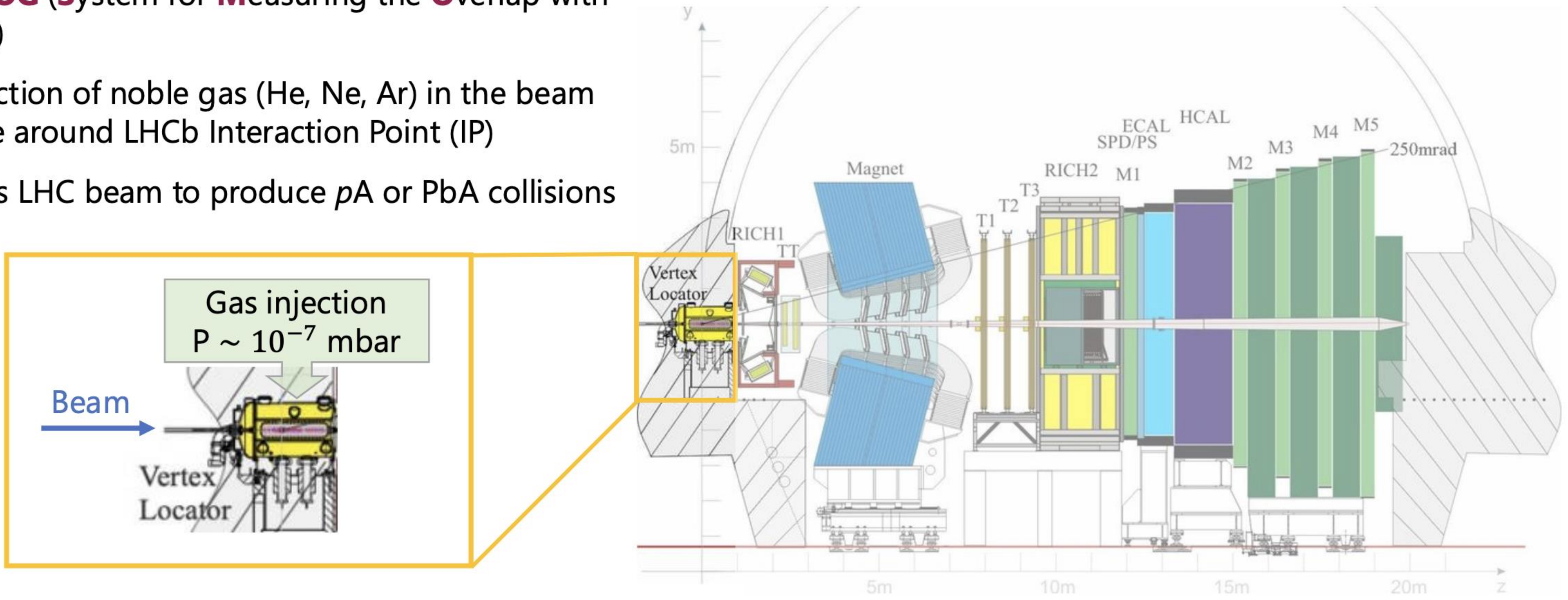
Juliette Authier

# LHCb: Fixed-target configuration in Run 2

**Highest-energy fixed target experiment, the only one at LHC!**

JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

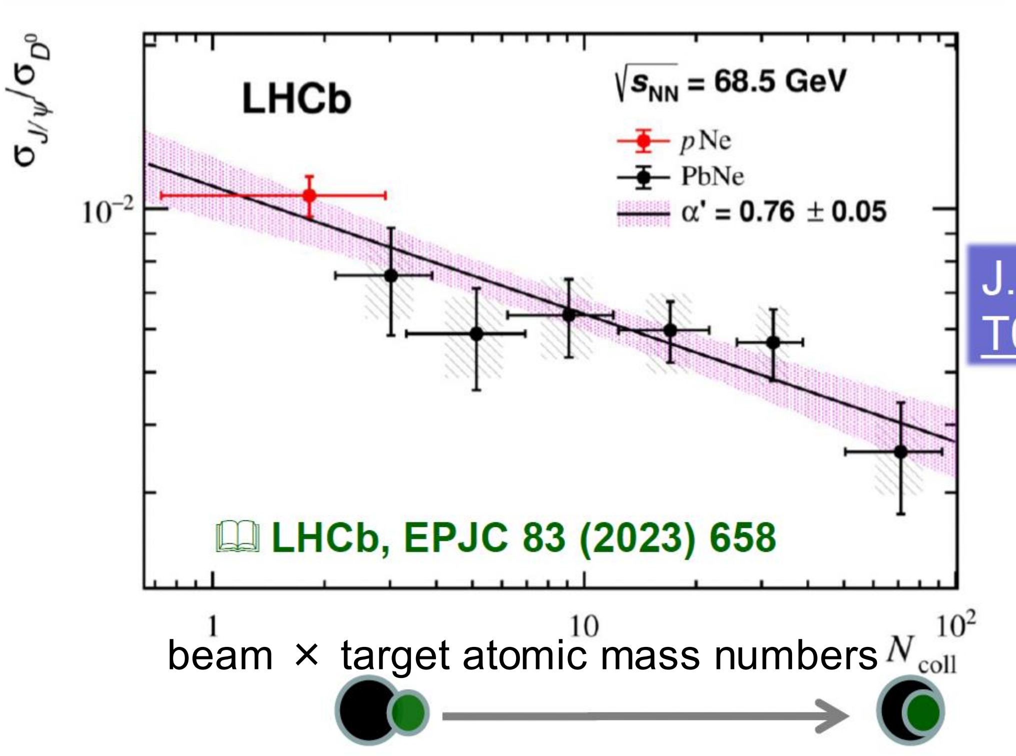
- **SMOG** (**S**ystem for **M**easuring the **O**verlap with **G**as)
- Injection of noble gas (He, Ne, Ar) in the beam pipe around LHCb Interaction Point (IP)
- Uses LHC beam to produce *p*A or PbA collisions



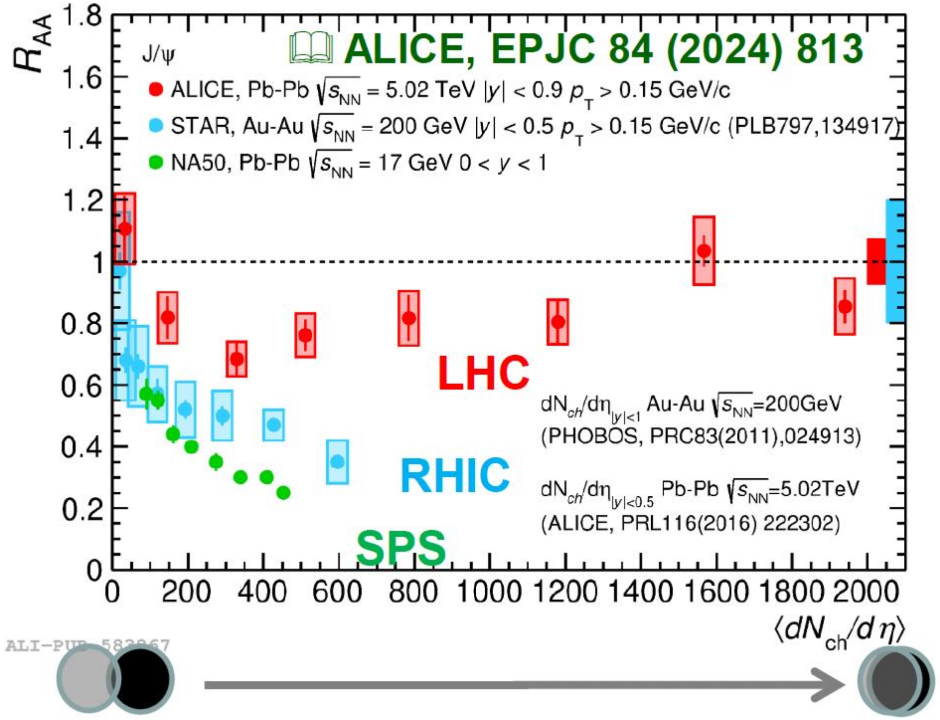

**Perfect to study charm hadronisation!**

# Enriching the J/Psi picture with SMOG@LHCb

- J/ψ / $D^0$ ratio in p-Ne and Pb-Ne using fixed-target configuration (SMOG) of LHCb
  - ⇨ $\sqrt{s_{NN}}$ = 68.5 GeV, in between SPS and RHIC
  - ⇨ J/ψ yield suppressed relative to $D^0$ → J/ψ affected by additional nuclear effects compared to $D^0$
  - ⇨ Continuous trend from p-Ne to central Pb-Ne collisions within current uncertainties




J. Auhtier
T04 Wed 16.00

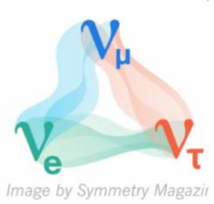


# Neutrinos

Katarzyna Kowalik,
Kate Scholberg
Andreas Hoecker

# Neutrino mixing

flavour eigenstates




LBL experiments sensitive to these parameters

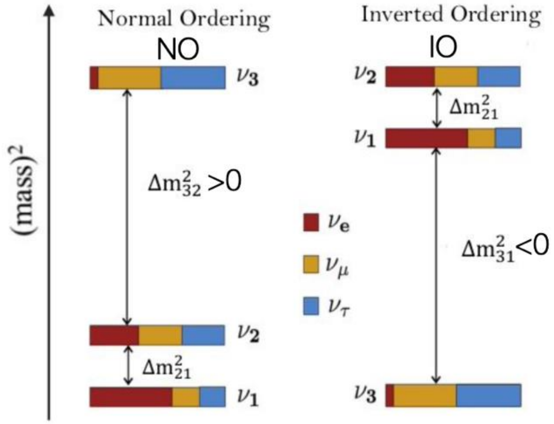
$$\begin{pmatrix}\nu_e\\ \nu_\mu\\ \nu_\tau\end{pmatrix} = \begin{pmatrix}1 & 0 & 0\\ 0 & \cos\theta_{23} & \sin\theta_{23}\\ 0 & -\sin\theta_{23} & \cos\theta_{23}\end{pmatrix}\begin{pmatrix}\cos\theta_{13} & 0 & \sin\theta_{13}e^{-i\delta_{CP}}\\ 0 & 1 & 0\\ -\sin\theta_{13}e^{i\delta_{CP}} & 0 & \cos\theta_{13}\end{pmatrix}\begin{pmatrix}\cos\theta_{12} & \sin\theta_{12} & 0\\ -\sin\theta_{12} & \cos\theta_{12} & 0\\ 0 & 0 & 1\end{pmatrix}\begin{pmatrix}\nu_1\\ \nu_2\\ \nu_3\end{pmatrix}$$

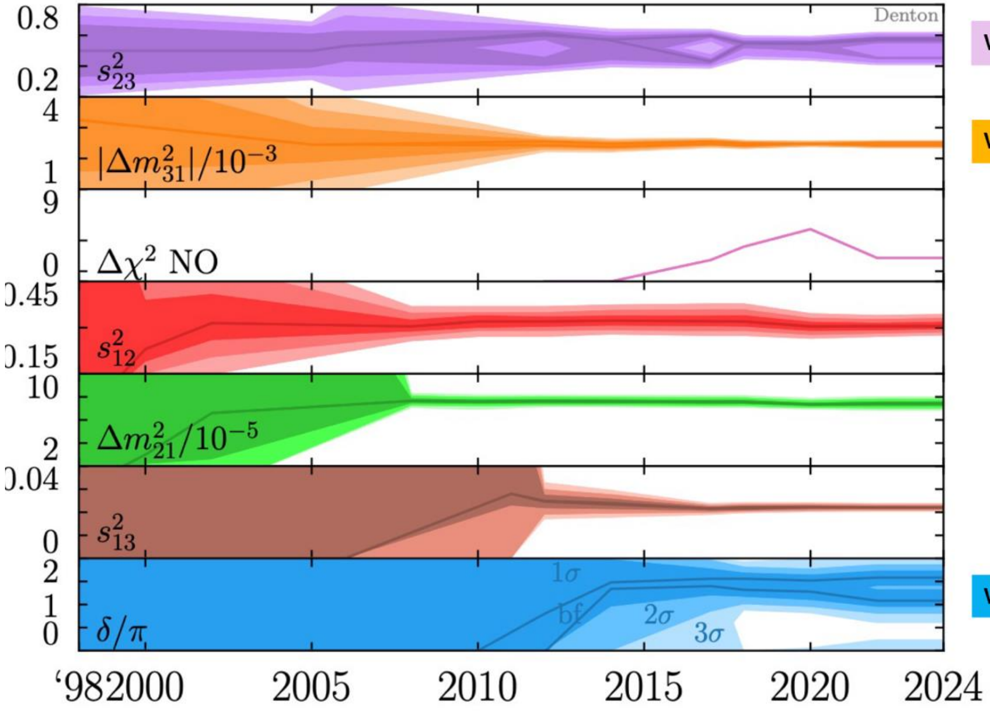
Atmospherics and LBL
$\theta_{23} \sim 45^\circ$
$|\Delta m^2_{32}| \sim 2.5\times10^{-3}\mathrm{eV}^2$

Reactors
$\theta_{13} \sim 10^\circ$
$\delta_{CP}$ unknown

Solar and Reactors
$\theta_{12} \sim 35^\circ$
$\Delta m^2_{21} \sim 7.5\times10^{-5}\mathrm{eV}^2$

mass eigenstates




Peter Denton, CIPANP 2025 2212.00809 2501.08374

which side?

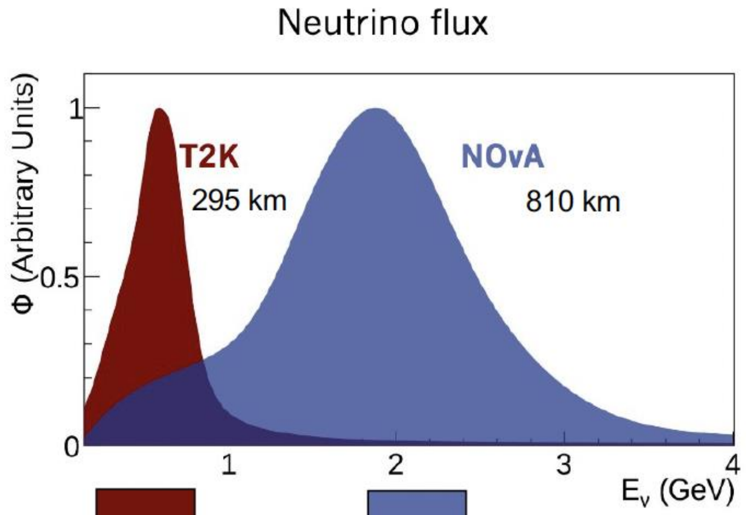
which sign?

which sine?

Huge progress during the last 25 years since the discovery of neutrino oscillation — precise measurements of PMNS matrix elements (2.1 / 3.1 / 1.3% for $\theta_{12\,/\,13\,/\,23}$) and mass-squared differences (2.5 / 0.8% for $\Delta m^2_{21/3\ell}$)

# T2K-NOvA joint analysis

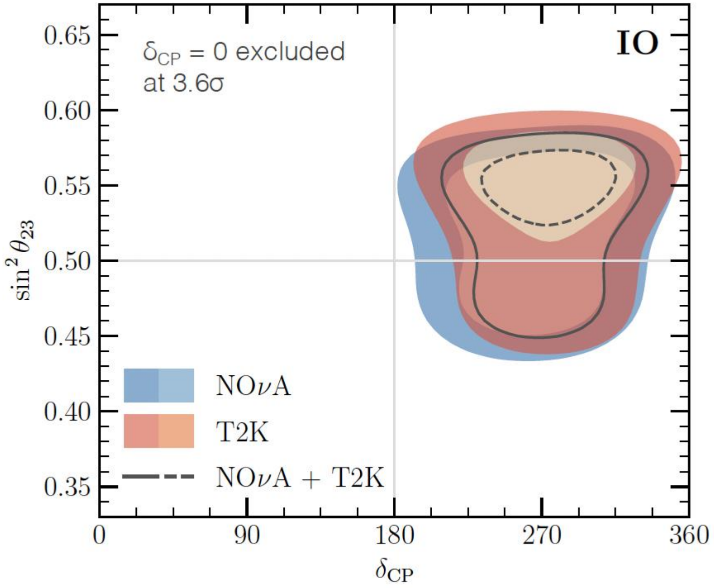
Kate Scholberg
Andreas Hoecker

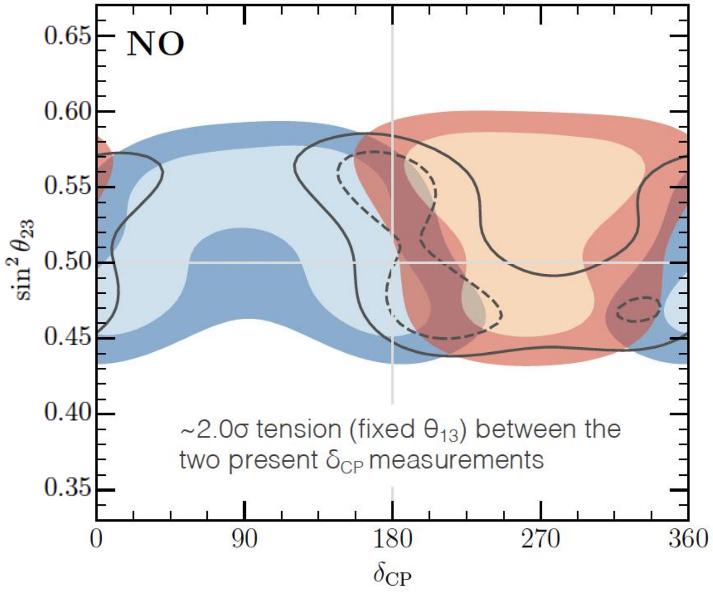



Shorter baseline, cleaner CPV effect

Longer baseline, more matter effect, more MO sensitivity

- ~Uncorrelated detector & flux systematics
- Analysis with and without Daya Bay reactor constraint




- both individually favor NO
- *mild* CP δ tension

Both experiments have more data under analysis and continue running until end of 2026 (NOvA) and 2028 (T2K)

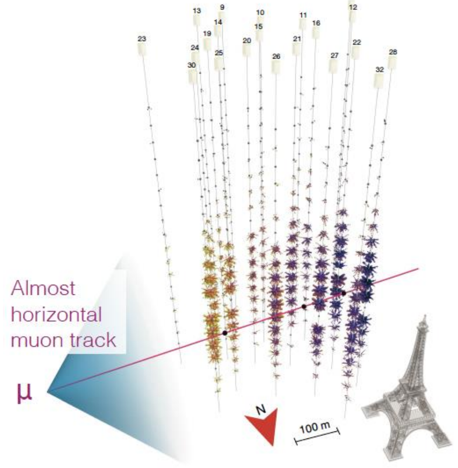
# High energy neutrinos

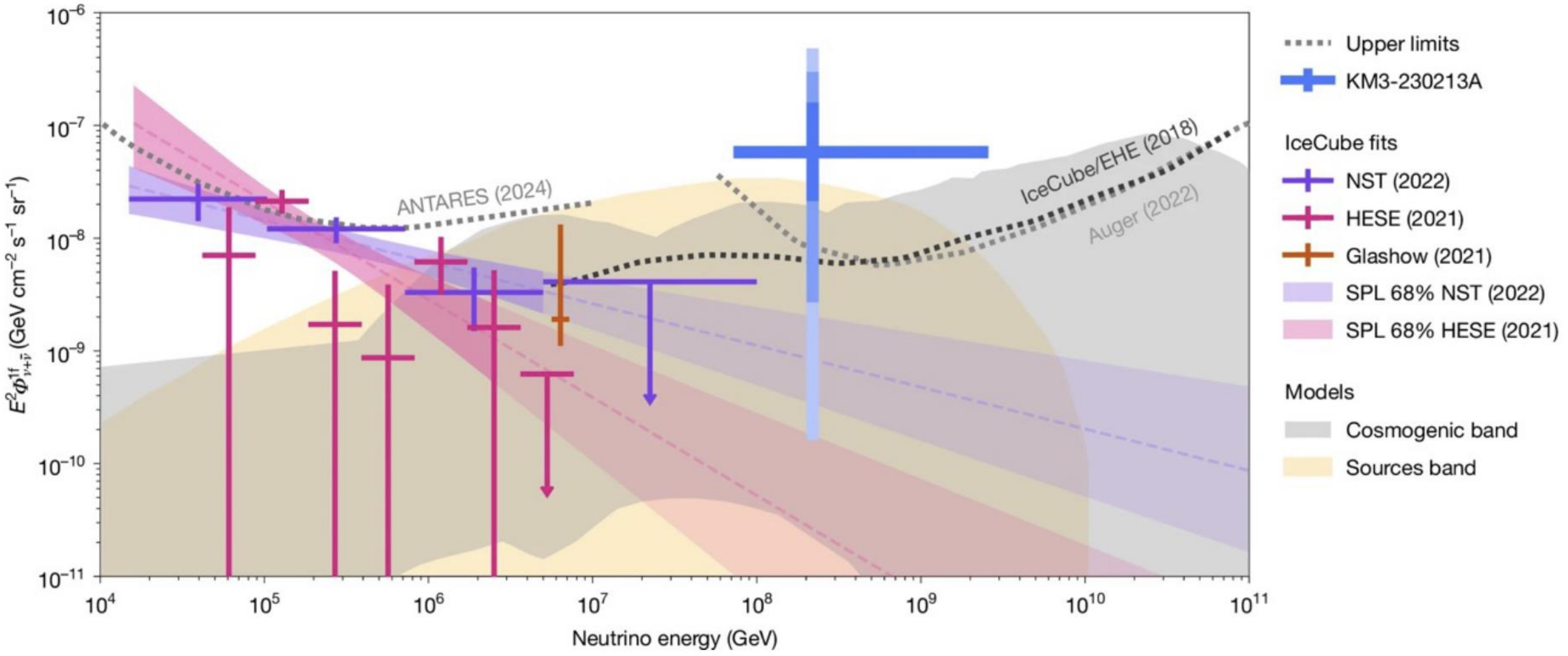
**KM3Net – ARCA** (high-E $\nu$'s): south-east of Sicily 3,450 m depth, 33 DUs (14%), big campaign to install ~20 additional DUs

**Detected highest-energy neutrino ever measured**

Hypotheses about origin:

- Galactic origin unlikely (no potential accelerators)
- Possibly Blazar (AGN with relativistic jets
- Cosmogenic origin not excluded



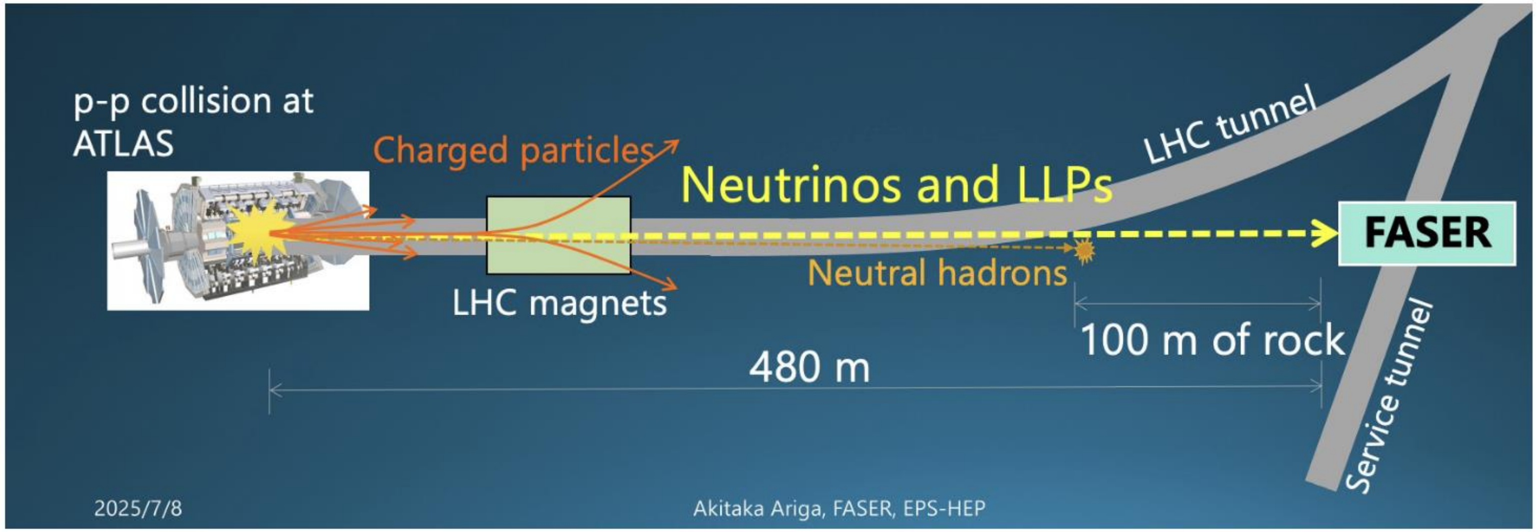




$P(\mu) = 120^{+110}_{-60}$ PeV

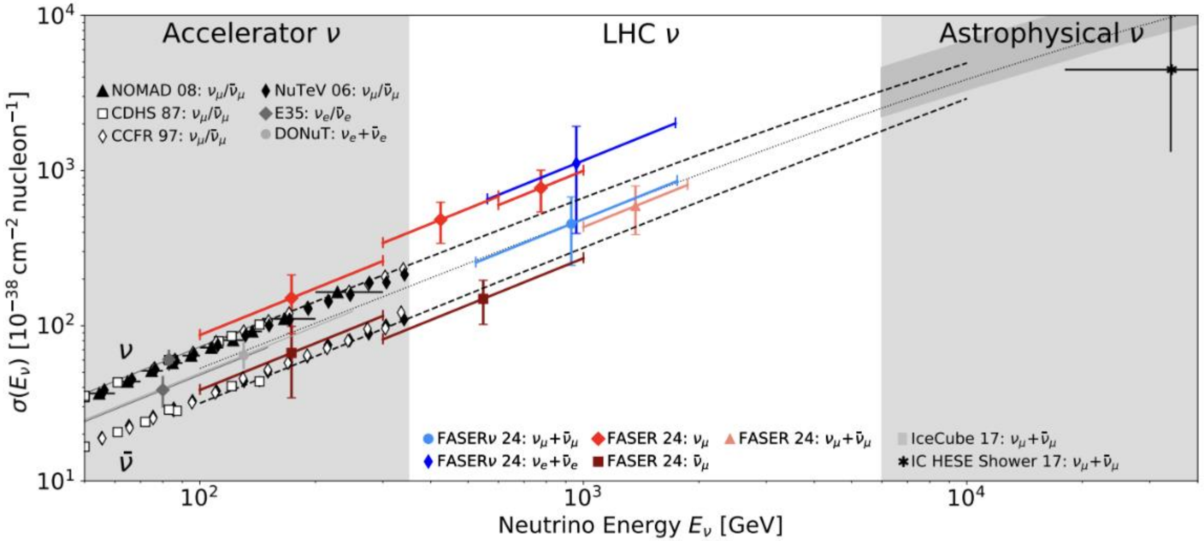
$P(\nu) \approx 220^{+560}_{-110}$ PeV

Kate Scholberg
Andreas Hoecker

# New results from FASER




Above TeV energies, cosmic-ray neutrino backgrounds for astrophysical neutrino searches arise mainly from charm decays, whose flux and cross section can be measured at the LHC by FASER and SND




**Measure flux-averaged cross section → interpret as cross-section *or* flux measurement**

# Cosmology

# $\Lambda$CDM (Lambda cold dark matter)

- ΛCDM is a remarkable six-parameter model describing 13.8 B years of cosmic evolution: from inflation over CMB anisotropies to large-scale structure formation, Super Novae Ia observations, and today's energy density
- It achieves this without a clue about the nature of DM and dark energy, and the mechanism for inflation. ΛCDM assumes a cosmological constant dark energy (Λ) with energy density that is constant in space and time
- But there are some troubling signs
  - Is dark energy weakening?
- DESI (Dark Energy Spectroscopic Instrument) DR2 (3 years) results on Baryon Acoustic Oscillation (BAO)
  - standard cosmological ruler (~ 150 Mpc today)
  - ~14 million redshifts analysed (~40 million to come)

Cosmological constant Λ

$w = -1$

Evolving dark energy

$w = w_0 + (1-a)w_a$

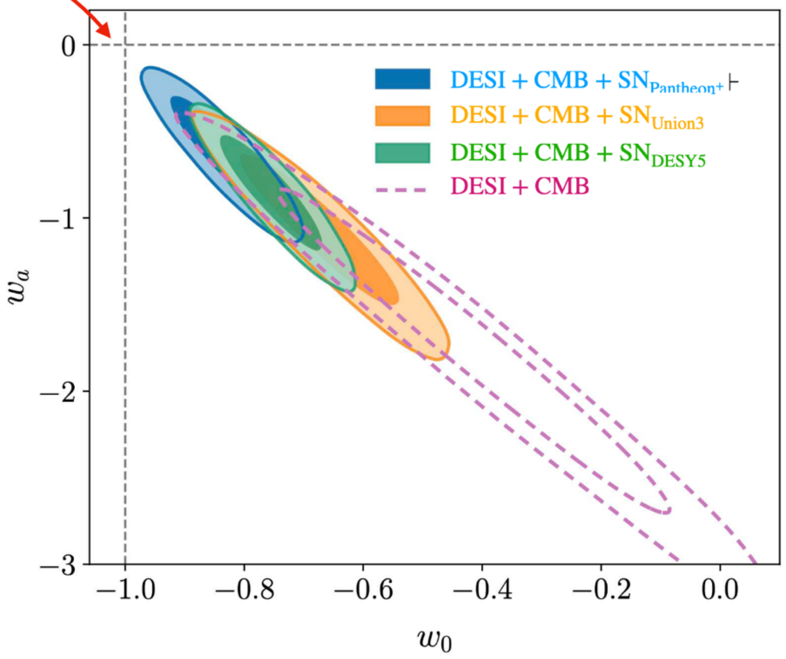
**Tension with the cosmological constant:**

$\mathrm{DESI} + \mathrm{CMB} \Rightarrow 3.1\sigma$

$\mathrm{DESI} + \mathrm{CMB} + \mathrm{SN}_{\mathrm{Pantheon+}} \Rightarrow 2.8\sigma$

$\mathrm{DESI} + \mathrm{CMB} + \mathrm{SN}_{\mathrm{Union3}} \Rightarrow 3.8\sigma$

$\mathrm{DESI} + \mathrm{CMB} + \mathrm{SN}_{\mathrm{DESY5}} \Rightarrow 4.2\sigma$



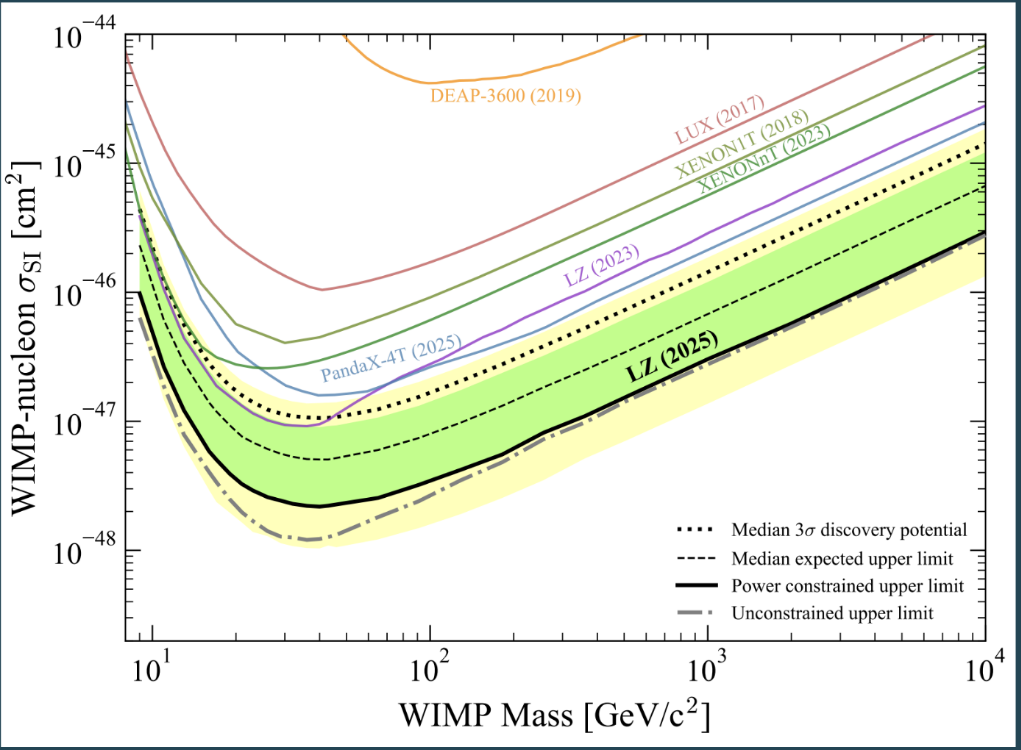
# Dark Matter

Andreas Hoecker
Amy Cottle

# Wimp searches at LZ

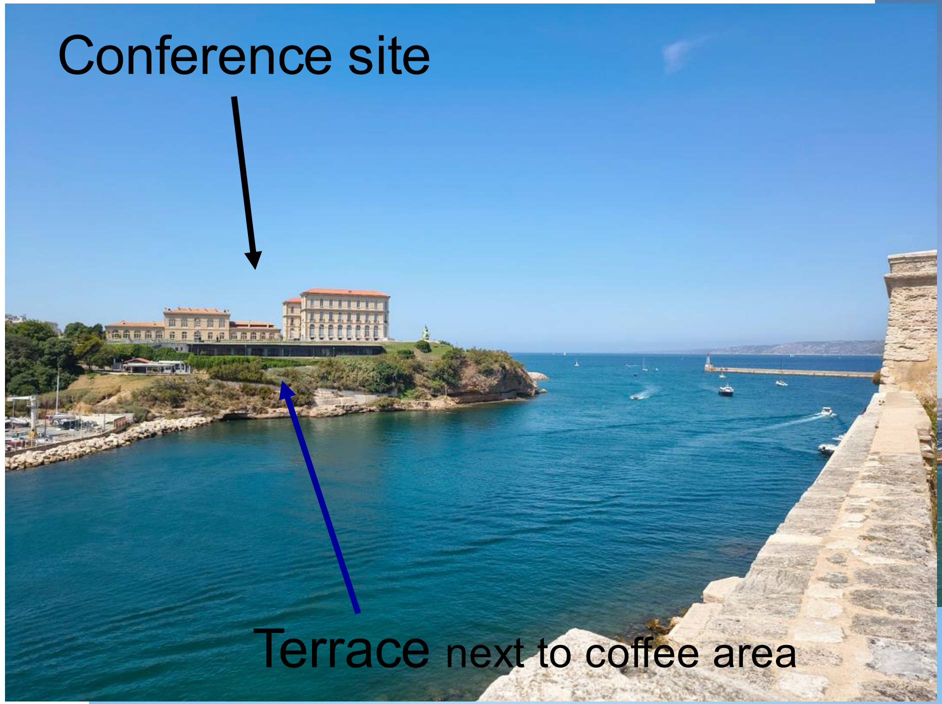
- Looking for nuclear recoil of target from elastic collision from DM particles
- LZ: world's largest 7t active dual-phase xenon TPC
- Results based on 4.2 Tonne-Years of Exposure

## WS2024+WS2022 SPIN-INDEPENDENT LIMIT




- Combining 60 days of WS2022 with 220 days of WS2024
- Two-sided profile likelihood ratio test statistic
- Power constrained at -1σ as per recommended conventions
  EPJC 81, 907 (2021)
- Best limit from combined analysis of $\sigma_{SI}$= 2.2 × $10^{-48}$ cm$^2$ for 40 GeV/c$^2$
- **Results & analysis in paper**
  *PRL 135, 011802 (2025)*

# The End

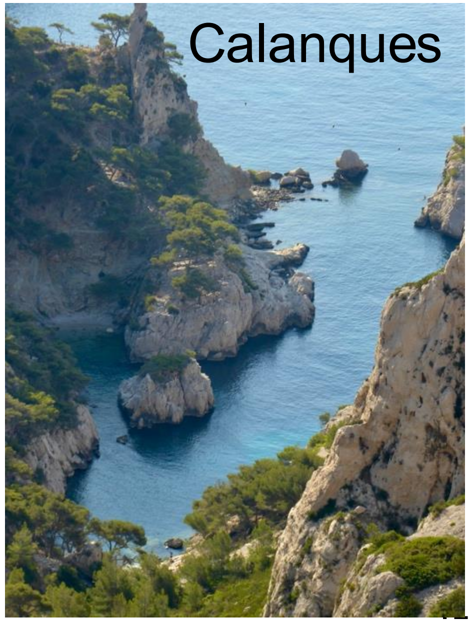

Conference site
Terrace next to coffee area


Fire near Estaques
seen from conference site

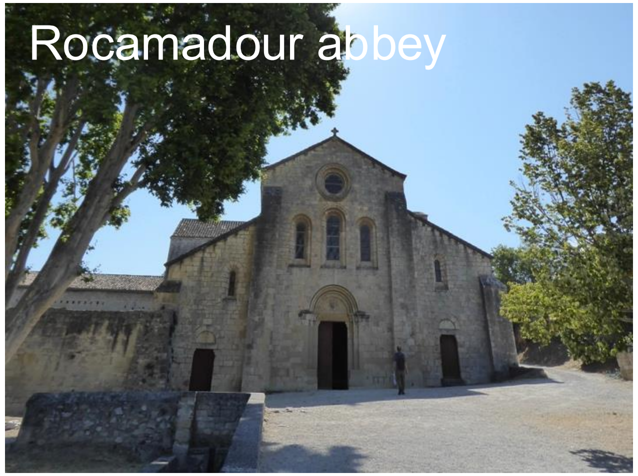

Corniche


Vieux port with
Notre Dame


Calanques

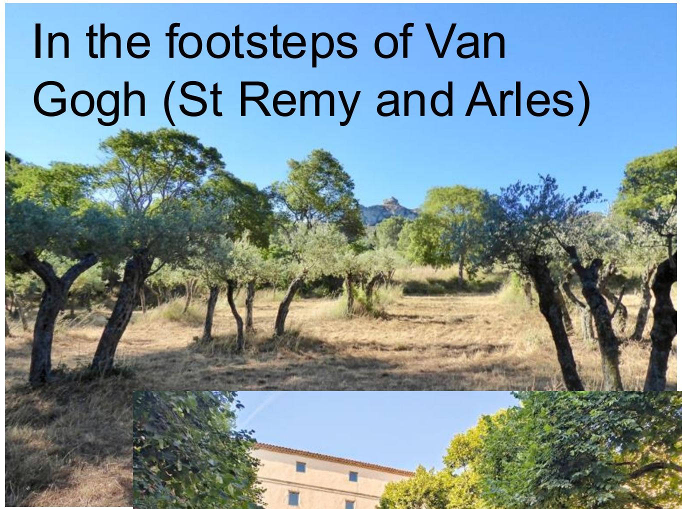

Calanques

# Around Marseille

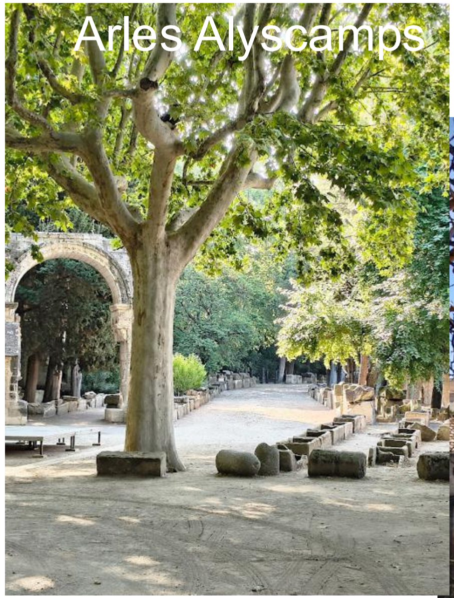


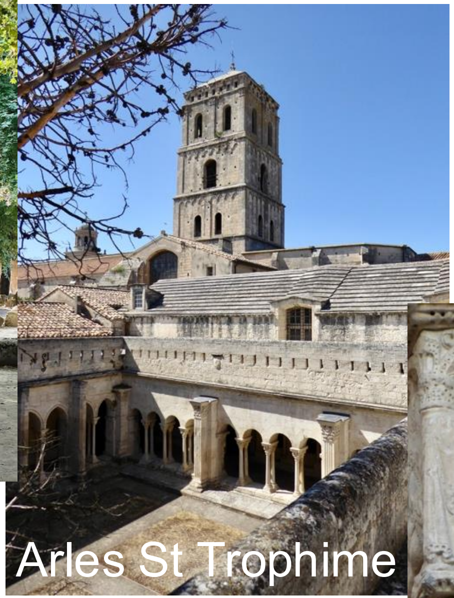










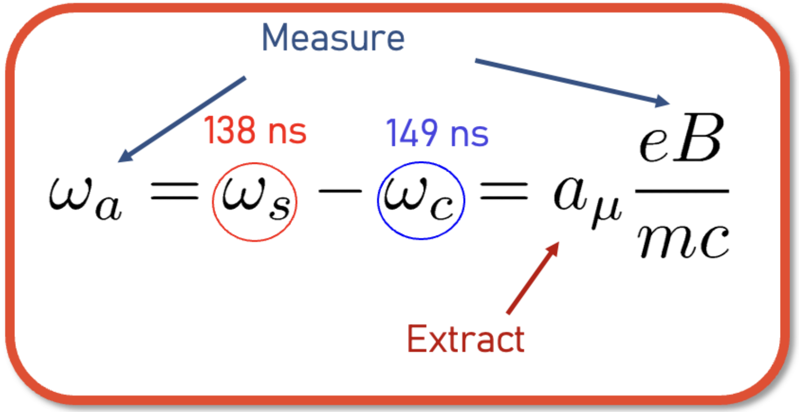

# BACKUP

Saskia Charity

# Final result from Fermilab Muon g–2 experiment

## Measurement principle

- Muons orbit the ring with cyclotron frequency $\omega_c$
- Spin precesses with frequency $\omega_s$
- Both spin and cyclotron frequencies are proportional to B
- Spin rotates ahead of momentum as the muon orbits the ring
- Difference frequency $\omega_a$ is proportional to $a_\mu$ and B




$$\omega_a = \omega_s - \omega_c = a_\mu \frac{eB}{mc}$$

- If g were exactly 2, $\omega_s = \omega_c$ and $\omega_a = 0$ → no precession

## Positive muons, 3.09 GeV/c, injected into Storage Ring in 125 ns bunches