ICHEP 2022
XLI
International Conference
on High Energy Physics
Bologna (Italy)

6
13 07 2022

Summary and Outlook

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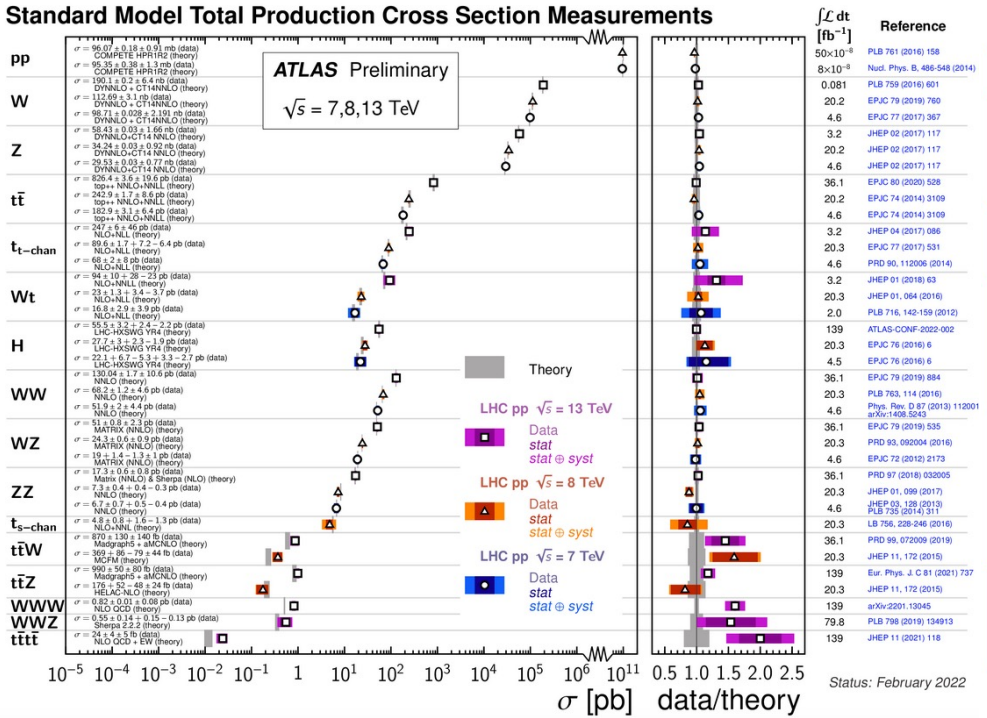
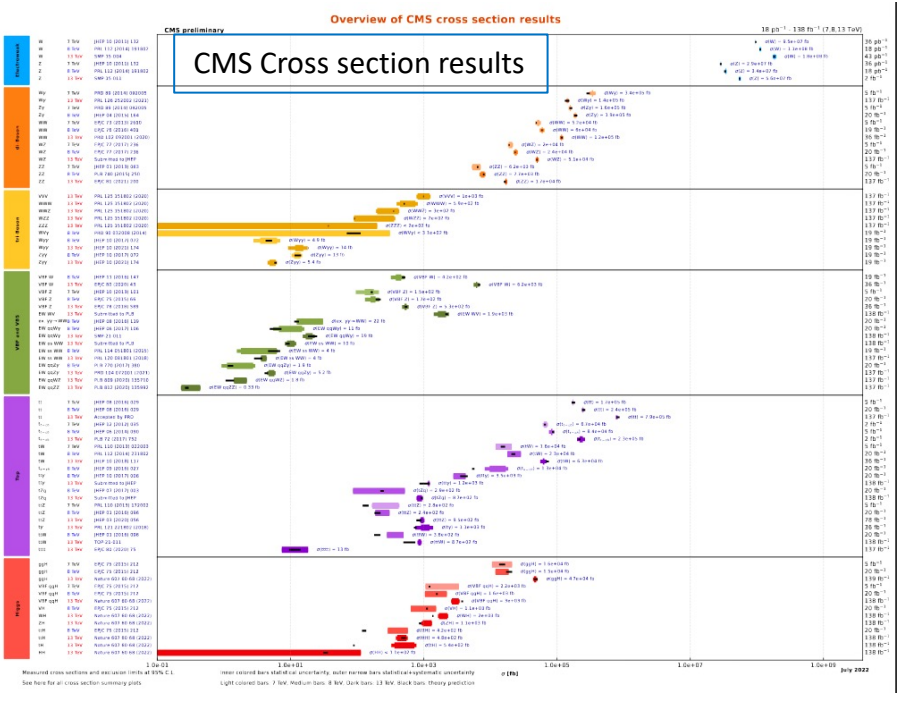
SEZIONE DI PISA


ICHEP 2022
BOLOGNA
About 900 talks in parallel sessions
1533 Participants
I will mostly focus on NEW results shown at THIS conference
Bononia
189 BC
17 parallel sessions
250 posters
Higgs Physics, Neutrino Physics, Beyond the Standard Model, Top quark and EW Physics, Quark and Lepton Flavour Physics, Strong interactions and Hadron Physics, Heavy Ions, Astroparticle Physics and Cosmology, Dark Matter, Formal Theory, Accelerators: Physics, Performance and R&D for future facilities, Operation Performance and Upgrade (Incl. HL-LHC) of Present Detectors, Detectors for Future Facilities - R&D - novel techniques, Computing and Data handling, Education and Outreach, Equality - Diversity and Inclusion, Technology Applications and Industrial Applications
You are here

First observation: it is since 10 years ago (ICHEP 2012 Melbourne) that we do not have a session called “Standard Model” … the Standard Theory is so successful that permeates most sessions, including ”Beyond …”

Example: at cross sections of single and associated production LHC tested over 14 orders of magnitudes !



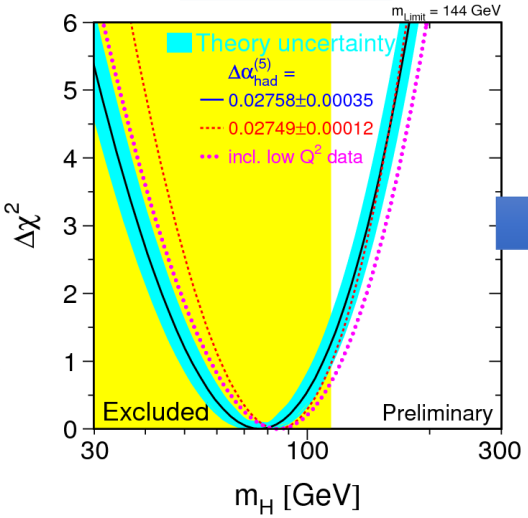


10 years since discovery and 40 years of work !

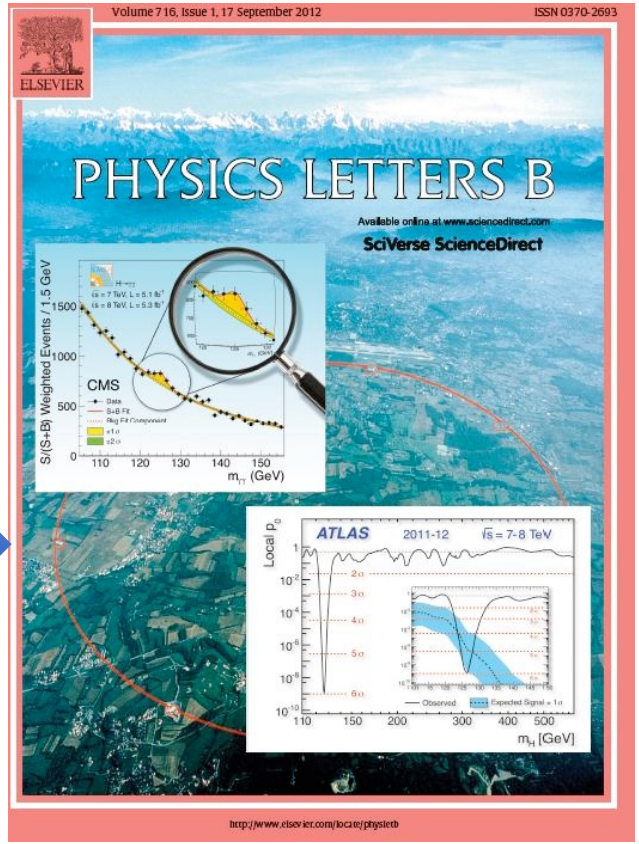
CERN 10 years HIGGS boson discovery

The quest for the Higgs boson started in the '80. The first "Higgstrahlung" beam dump experiment excluded $1\ \text{MeV} < M_H < 52\ \text{MeV}$

Status 2007



LHC

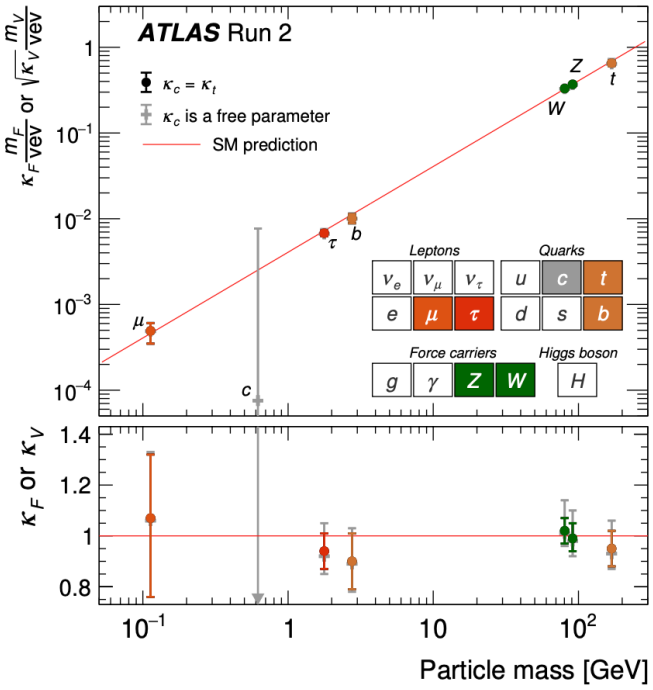


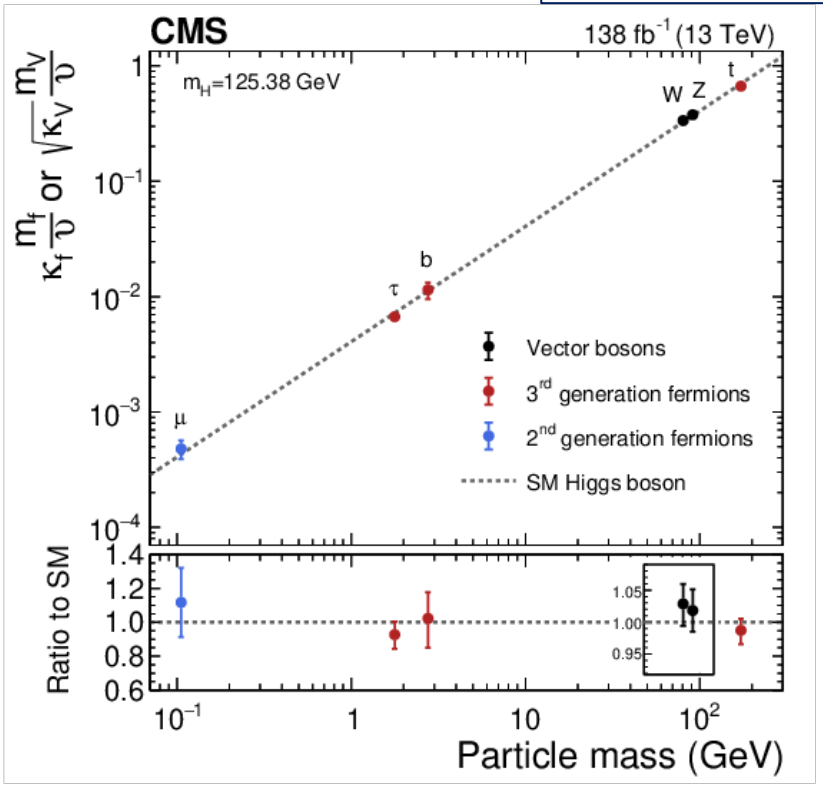
Higgs and electroweak

Nature 607 (2022) 52

Legacy Higgs Boson results with full Run 2 Statistics,
Two beautiful papers submitted to Nature last week

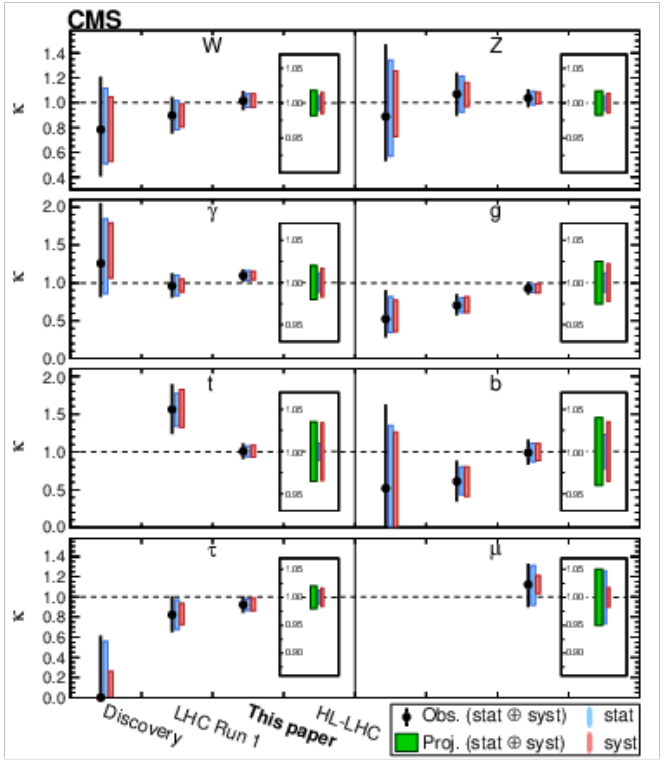
Nature 607 (2022) 60

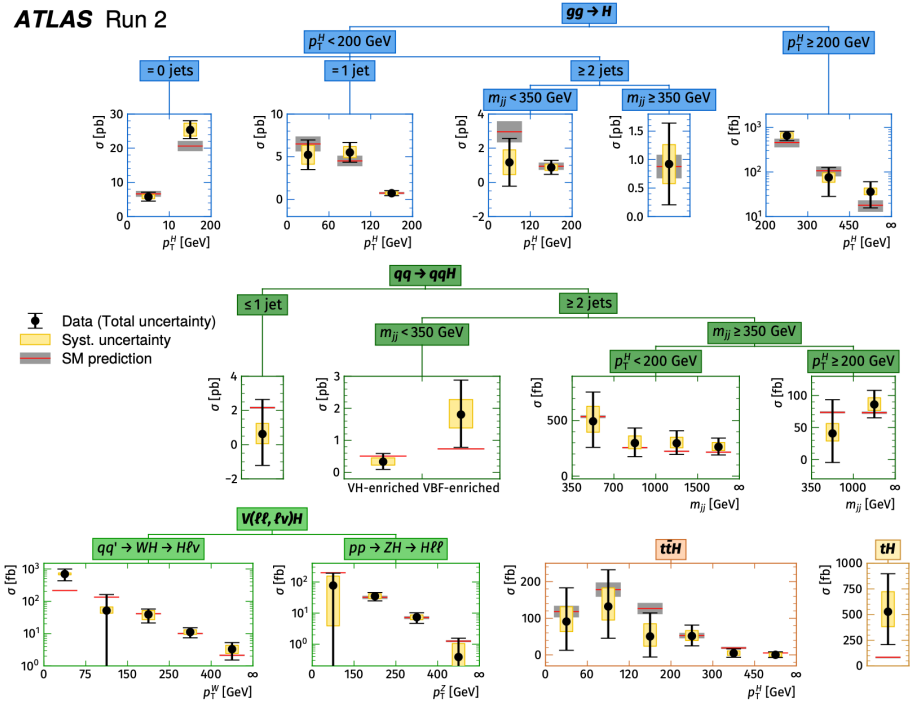




The couplings, past present and future

The Higgs boson, measured in various space phase regions

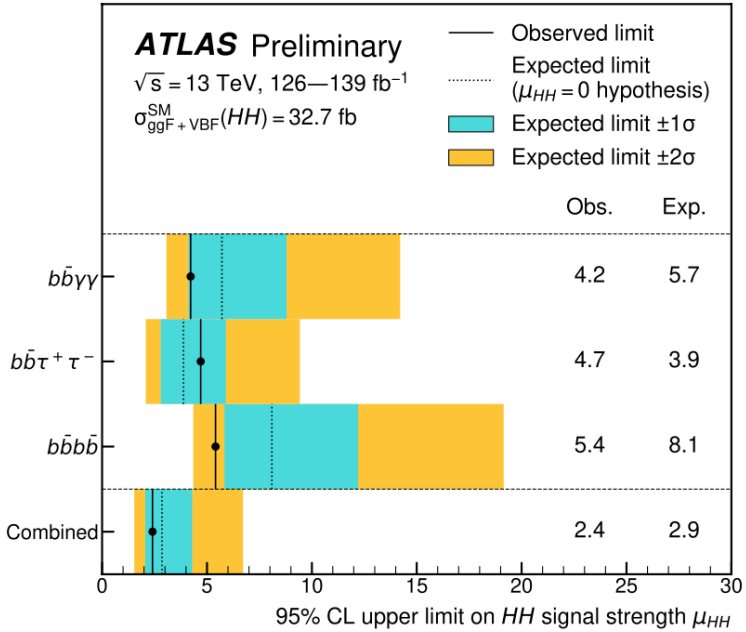




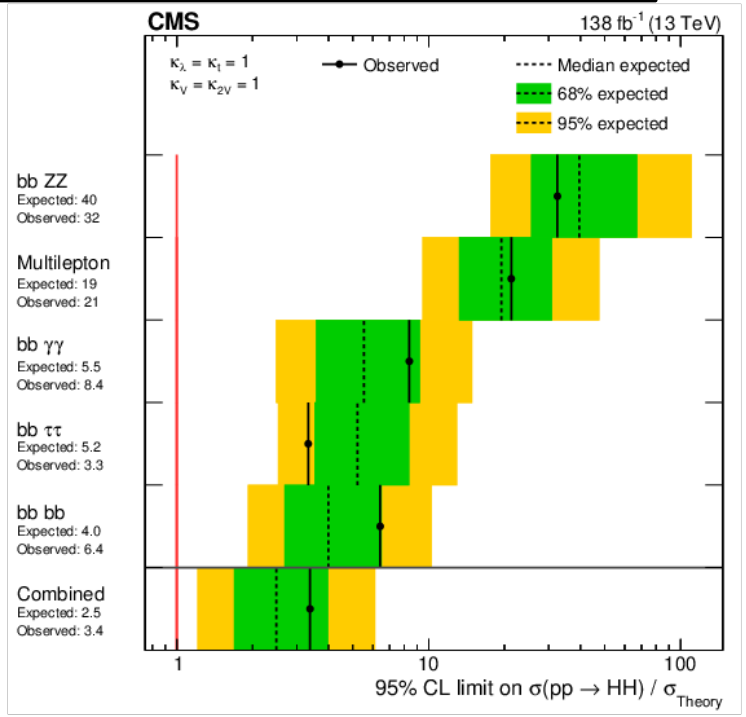
Heading to a few percent for HL-LHC

Search for Double Higgs production after RUN 2

Starting to get into a very interesting region 95% CL limits @ 2 – 3 times SM expectations !
Exciting in view of RUN 3 (… and HL-LHC of course)



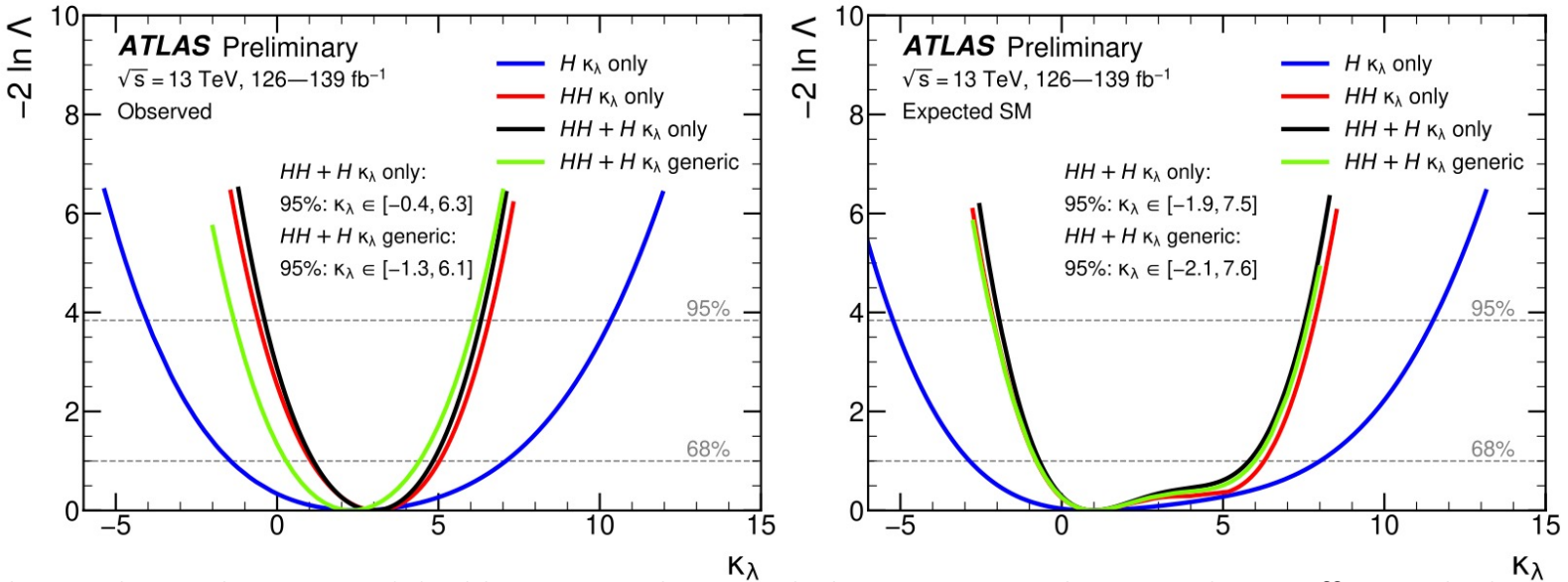
ATLAS-CONF-2022-050



Nature 607 (2022) 60

CMS Projection for HL-LHC below 1 …

Constraining the Higgs boson self-coupling from single- and double-Higgs production



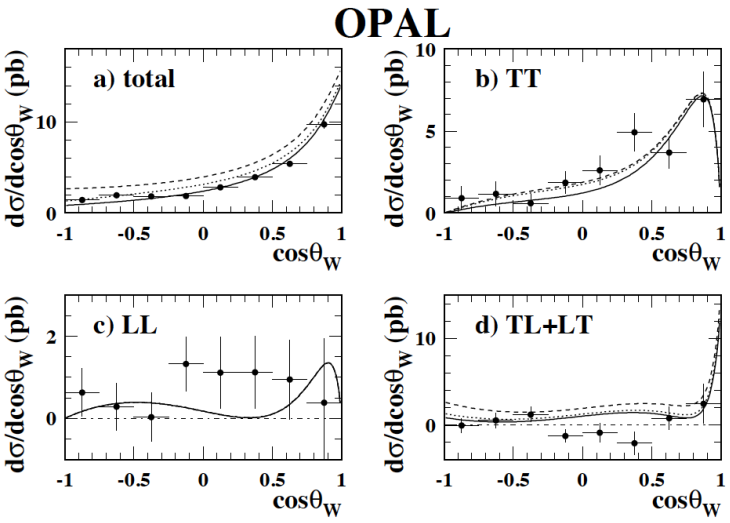
Combining the single-Higgs and double-Higgs analyses, with the assumption that new physics affects only the Higgs boson self-coupling (λ), values outside the interval $-0.4 < \kappa = (\lambda / \lambda \mathrm{SM}) < 6.3$ are excluded at 95% confidence level.

ATLAS-CONF-2022-050

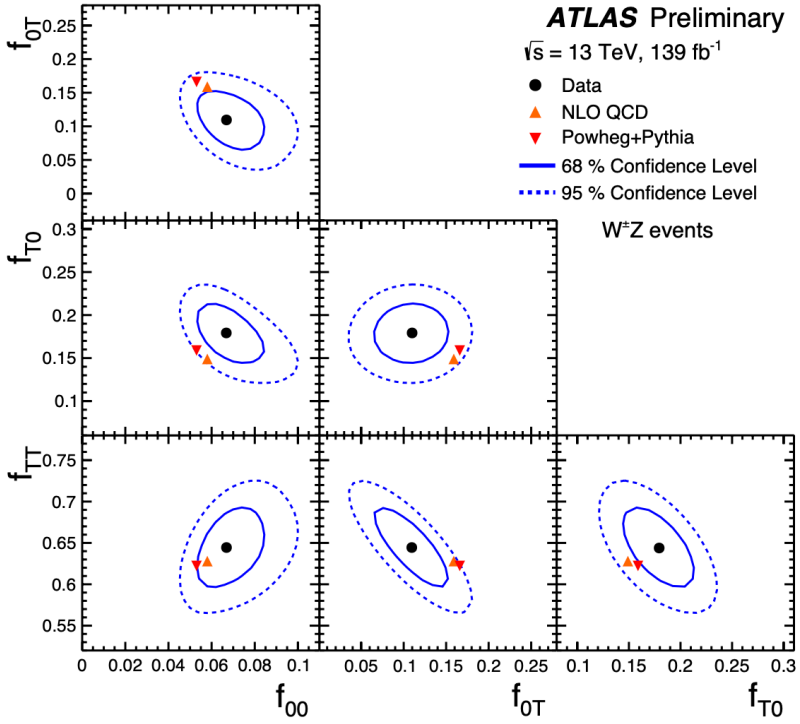
ATLAS-CONF-2022-053

Observation of gauge boson joint-polarisation states in $W^{\pm}Z$ production from pp collisions

Longitudinal component intimately related to EWSB mechanism



LEP: measurement of WW polarization states

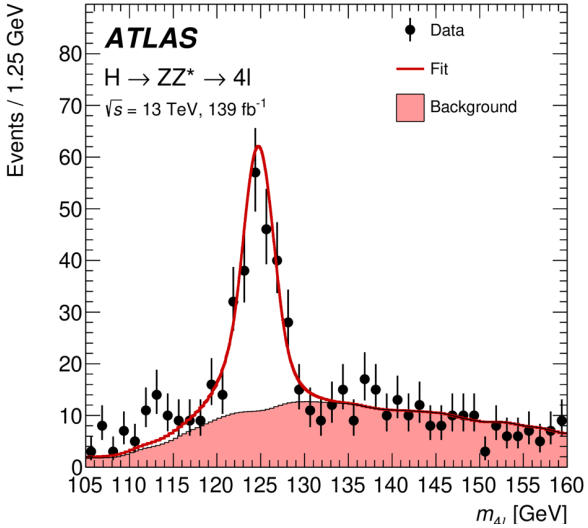


Measurement of the Higgs boson mass

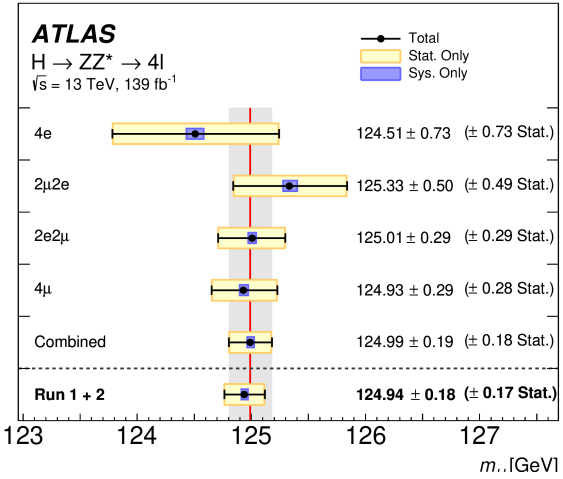
arXiv:2207.00320

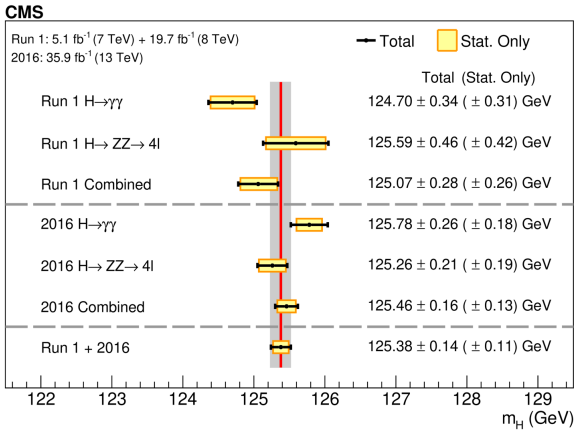
New ATLAS: first measurement with full Run 2 Statistics
Precision better than 1.5 permil on individual channel !!

mH =124.94±0.17(stat.)±0.03(syst.)GeV

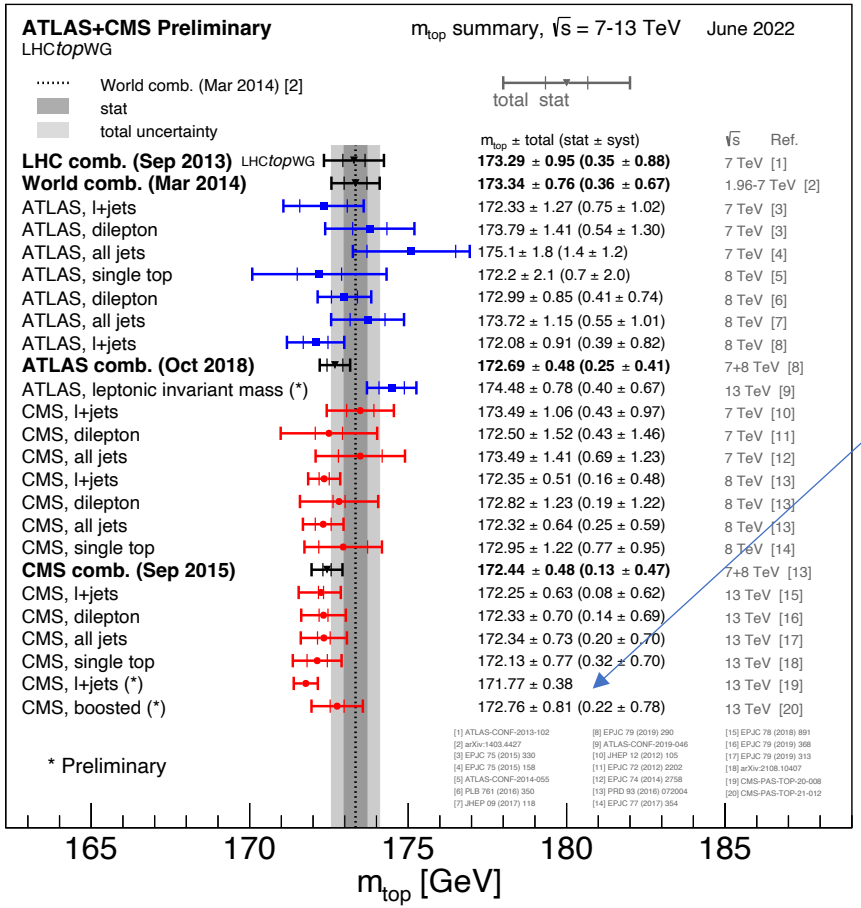


Systematic Uncertainty	Contribution (MeV)
Muon momentum scale	±20
Electron energy scale	±16
Signal Theory	±13



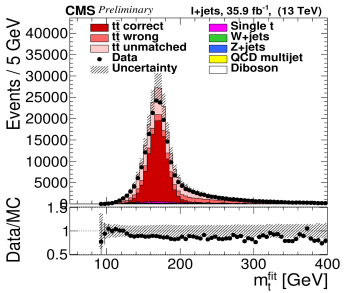


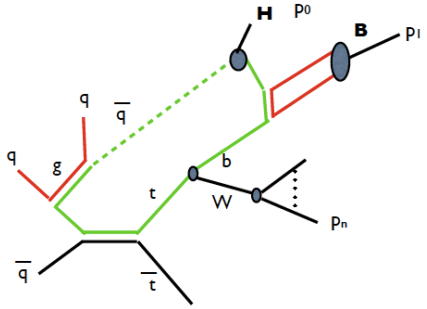
Top mass at the LHC top



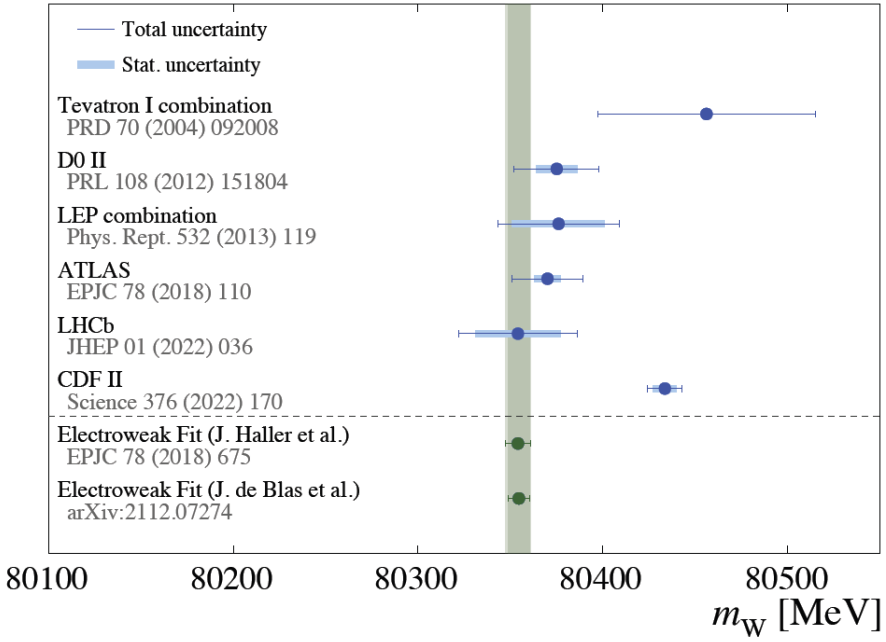
- **Top is a coloured fermion**, it decays before hadronizing, but the b quark from its decay must hadronize
  - **there is no way to assign final state particles only to the original top**, the concept is ill-defined as it is the use of a pole mass for a coloured particle
  - the effect is expected to be of the order of $\Lambda_{QCD} \approx 0.2$ GeV but the actual impact depends on the experimental method
  - **Reached ≈ 2 permil with individual measurement !**

1. **important to test the variables sensitive to the final state definition**
2. **continue to measure the mass with alternative techniques**





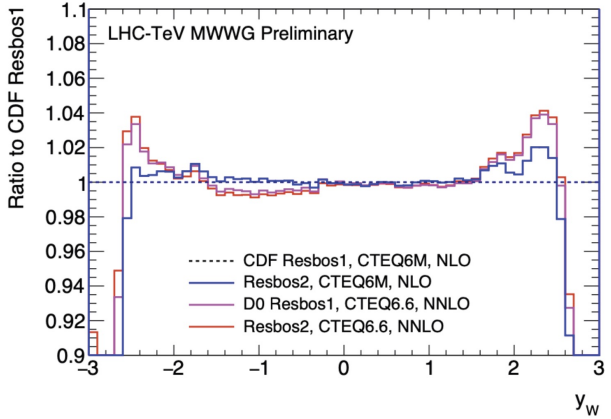
W mass: there is great confusion under heaven, the situation is excellent



CDF (8.8 fb^{-1}) [*Science* ***376*** *(2022) 170*]

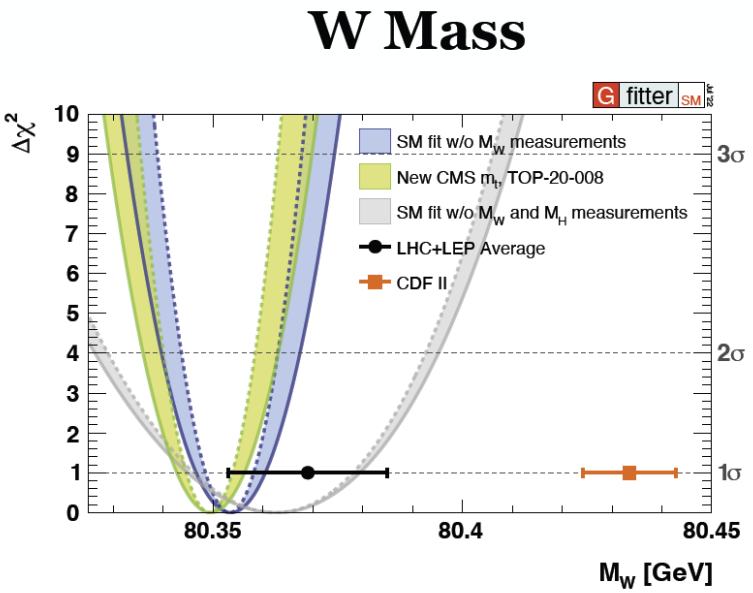
$m_W = 80433.5 \pm 6.4$ (stat.) ± 6.9 (sys.) MeV

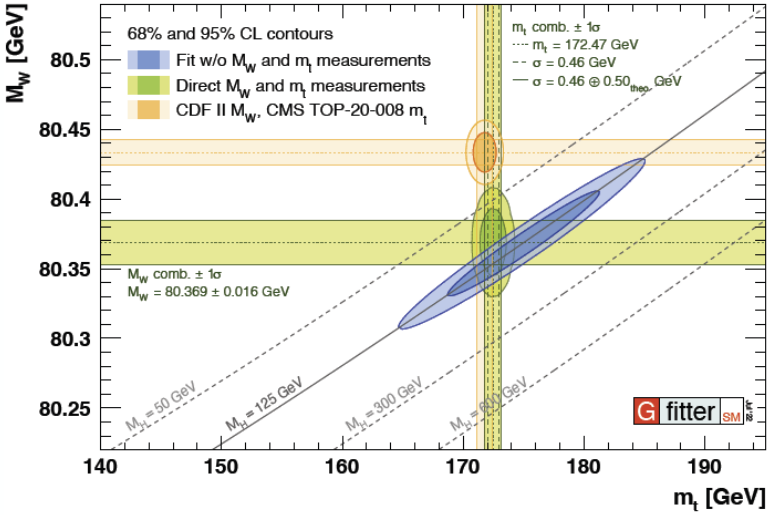
PDF are a key input, important to understand differences and harmonize PDF+generators before combining the measurements



https://agenda.infn.it/event/28874/sessions/21485/#20220707

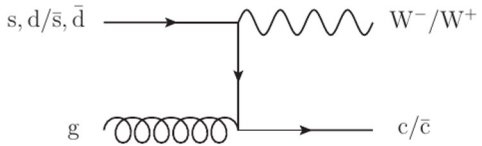
Life becoming difficult for EW global fits

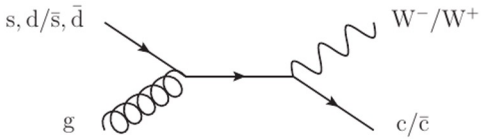




https://agenda.infn.it/event/28874/contributions/168907/

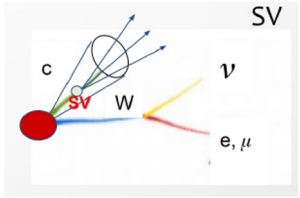
New measurement of W+charm production

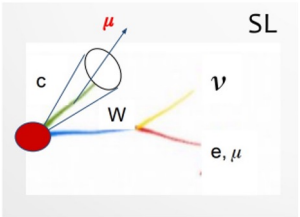


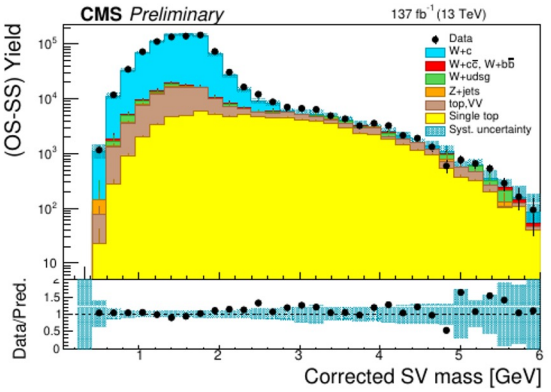


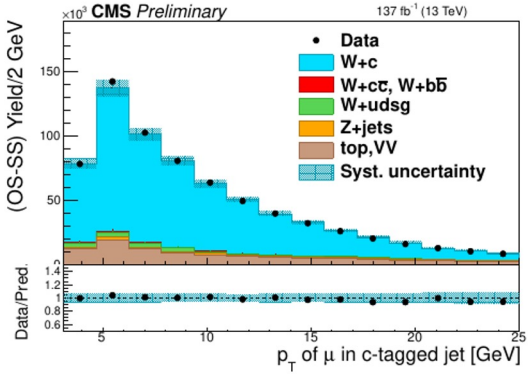
Channel	$N_{\text{sel}}(1-f_{\text{bkg}})$	$\mathcal{C}(\%)$	$\sigma(\text{W}+\text{c})$ [pb]
$\text{W} \to e\nu$, SL	$341\,316 \pm 1294$	$1.419 \pm 0.025 \pm 0.066$	$175.3 \pm 0.7 \pm 9.1$
$\text{W} \to \mu\nu$, SL	$194\,299 \pm 934$	$0.856 \pm 0.019 \pm 0.033$	$165.4 \pm 0.8 \pm 8.8$
$\text{W} \to e\nu$, SV	$276\,167 \pm 1717$	$1.261 \pm 0.024 \pm 0.062$	$159.6 \pm 1.0 \pm 8.6$
$\text{W} \to \mu\nu$, SV	$397\,555 \pm 1876$	$1.786 \pm 0.028 \pm 0.081$	$162.3 \pm 0.8 \pm 8.2$

Expect significant improvement in the s-quark PDF







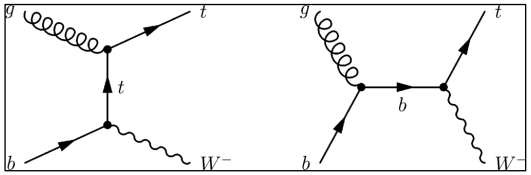


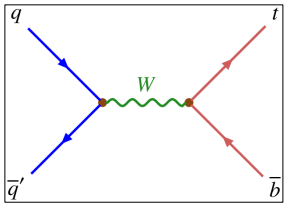
CMS-PAS-SMP-21-005

CMS-PAS-TOP-21-010

ATLAS-CONF-2022-030

Single top production in Wt and s channels

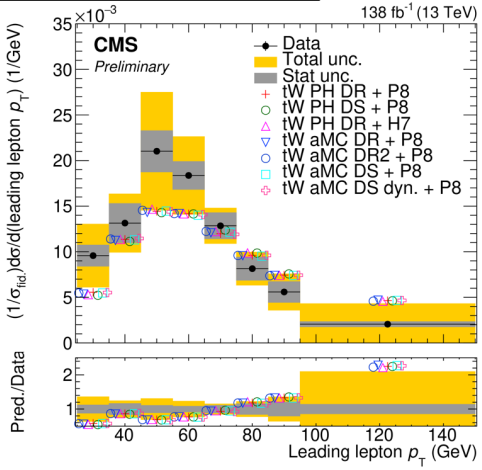


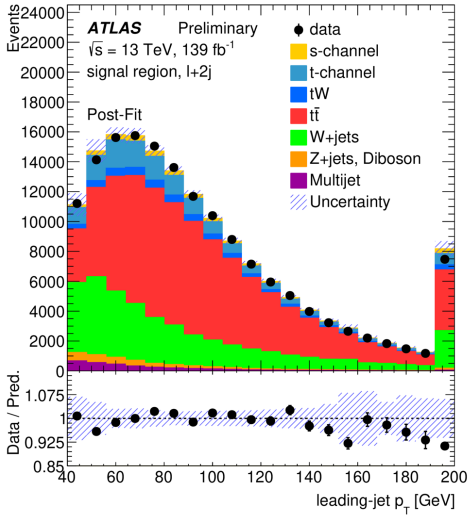


measured σ=
79.2 ± 0.8 (stat) $^{+7.0}_{-7.2}$ (syst) ± 1.1 (lumi) pb
Interferes with ttbar (same final state at NLO)

measured $\sigma = 8.2^{+3.5}_{-2.9}$ pb
(3.3 sigma observed
3.9 expected)

Difficult channel at LHC !





Flavour

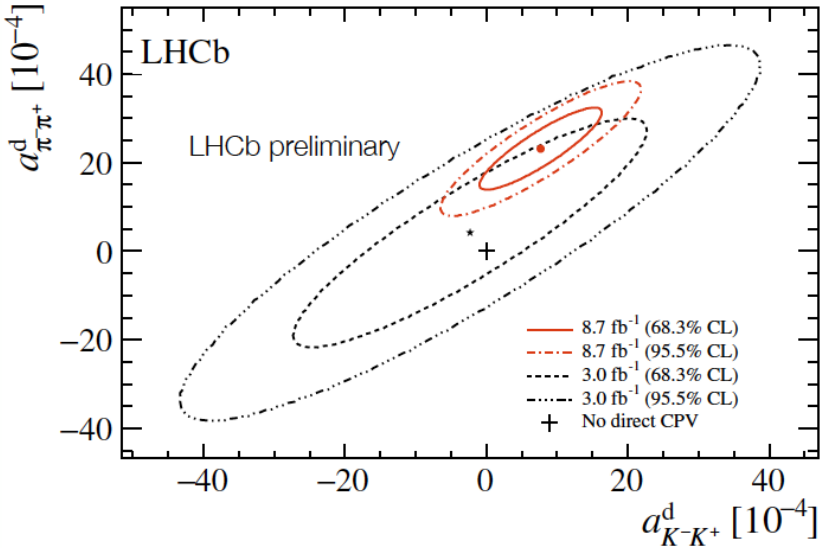
https://agenda.infn.it/event/28874/contributions/169315/

Evidence of *direct* CP violation in charm decays

- CPV in charm observed by LHCb in 2019

$$\Delta A_{CP} = A_{CP}(D^0 \to K^-K^+) - A_{CP}(D^0 \to \pi^-\pi^+) = (-15.4 \pm 2.9)\times 10^{-4}$$

- Now the $D^0 \to K^+K^-$ and $D^0 \to \pi^+\pi^-$ components separated for the first time to investigate the nature of CPV in the two decay modes



- They report the first evidence for **direct *CP* violation** in $D^0 \to \pi^-\pi^+$ decays at the level of **3.8σ**.

https://agenda.infn.it/event/28874/contributions/169355/

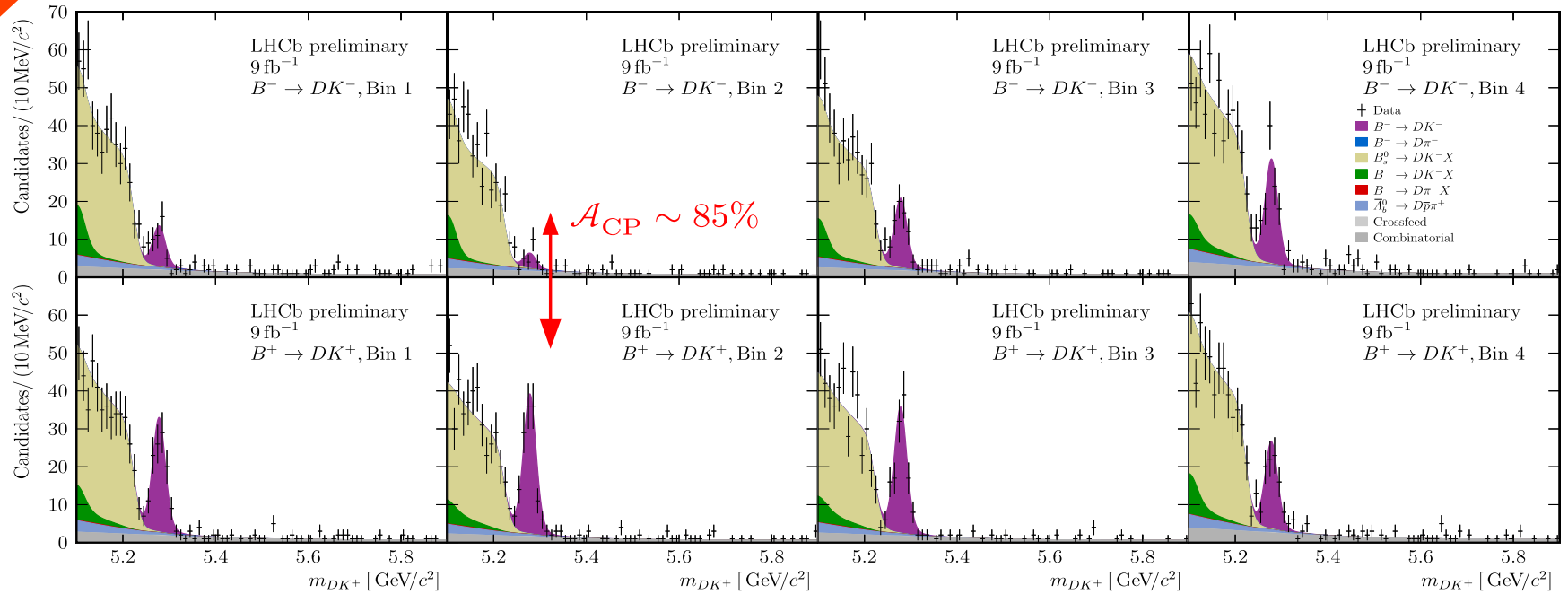
CP Asymmetries can be large in specific bins !

LHCb In preparation

γ from $B^{\pm} \to D\,[K^-\pi^+\pi^+\pi^-]\,h^{\pm}$ decays

$R_{K3\pi} \sim 0.4 \implies$ potentially large benefits from binned analysis

$\therefore$ Measure observables in 4 bins of D-decay phase-space [arXiv:1909.10196]

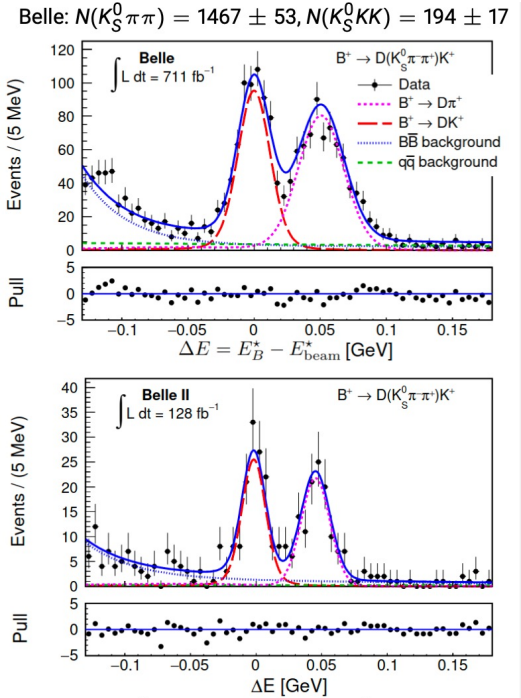


Full Run 1&2 Data set

Belle II : recorded ≈ 424 fb−1 and entering the game !

First joint Belle + Belle II measurement

Belle: $N(K^0_S\pi\pi) = 1467 \pm 53, N(K^0_S KK) = 194 \pm 17$



Belle II: $N(K^0_S\pi\pi) = 280 \pm 21,\ N(K^0_S KK) = 34 \pm 7$

$\gamma = (78.4 \pm 11.4\ (\text{stat.}) \pm 0.5\ (\text{syst.}) \pm 1.0\ (\text{ext.}))^\circ$

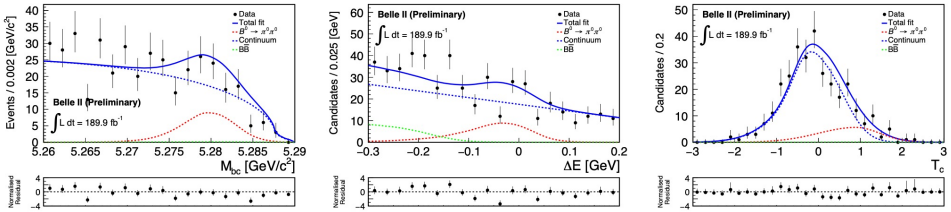
$B^0 \to \pi^0\pi^0$ Result

New for ICHEP

Results competitive with Belle with a data set of less than one third!

$$\mathcal{A}^{CP} = 0.14 \pm 0.46\ (\text{stat}) \pm 0.07\ (\text{syst})$$
$$\mathcal{B} = (1.27 \pm 0.25\ (\text{stat}) \pm 0.17\ (\text{syst})) \cdot 10^{-6}$$

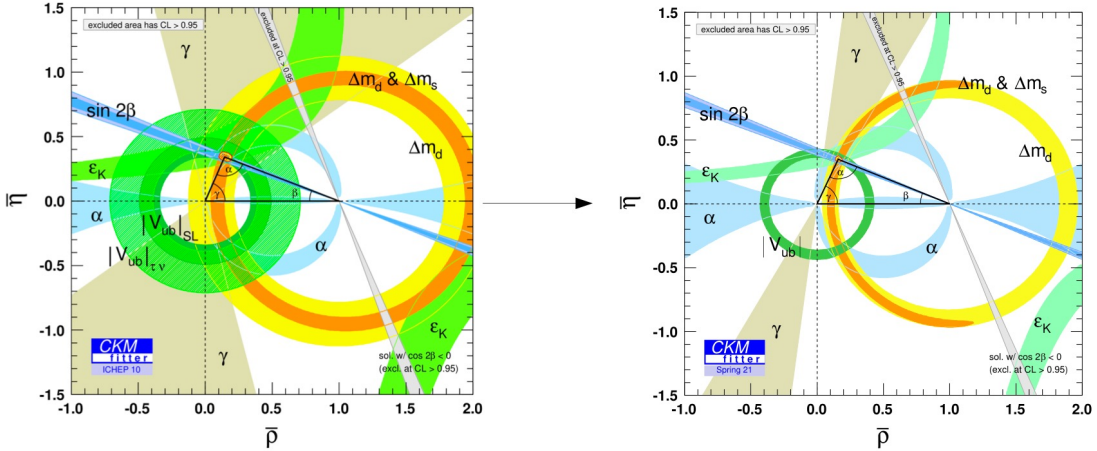
WA: $\mathcal{A}^{CP} = 0.33 \pm 0.22, \mathcal{B} = (1.59 \pm 0.26) \cdot 10^{-6}$

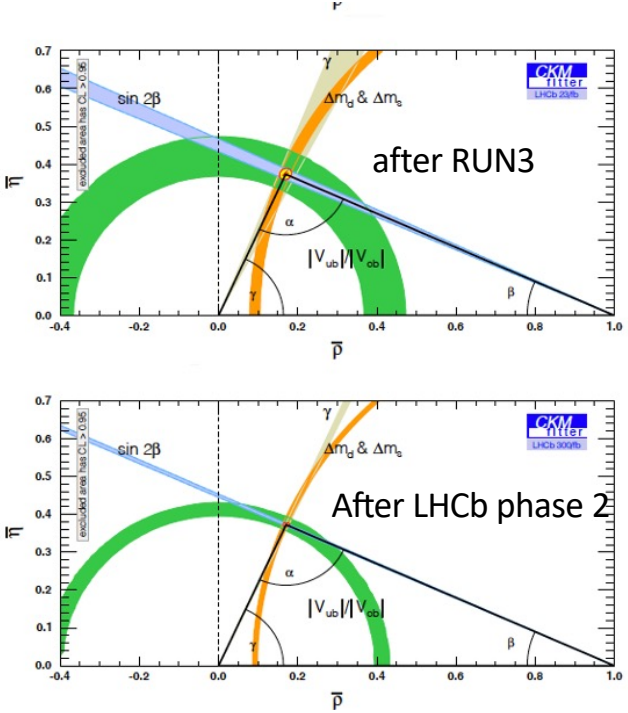


$N(\text{sig}) = 93 \pm 18$

- Results demonstrate Belle II's capability to measure decays with neutrals
  ⇒ Belle II is ready to offer key contributions

Status of the unitarity triangle

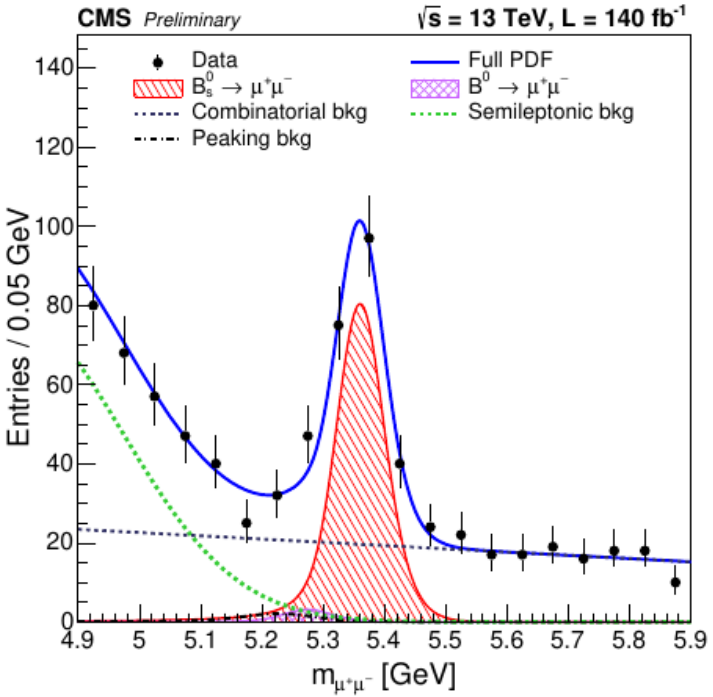


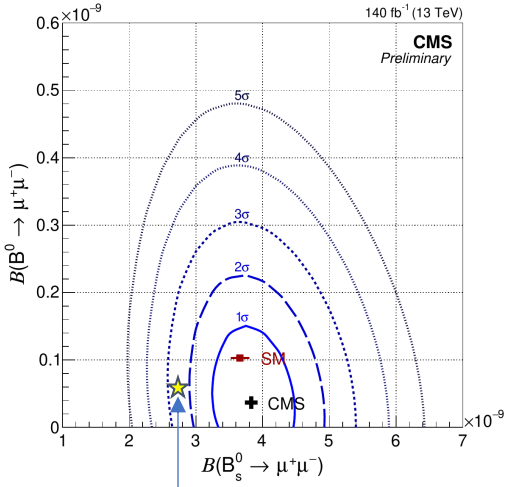


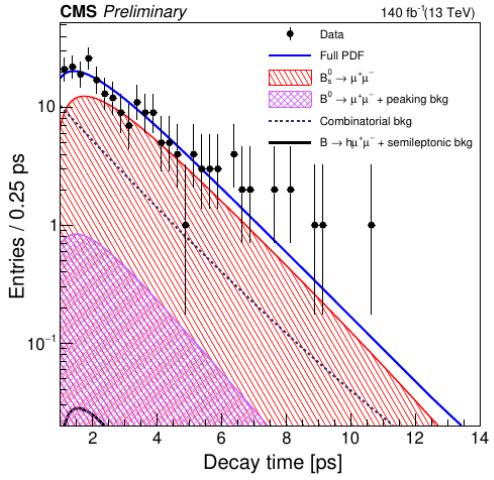
- 10 years of measurements have been game changing for flavour physics.

CMS Full Run 2 result on $B_s \to \mu\mu$

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \left[3.95^{+0.39}_{-0.37}\,(\text{stat})\,^{+0.29}_{-0.24}\,(\text{syst})\right] \times 10^{-9}$$







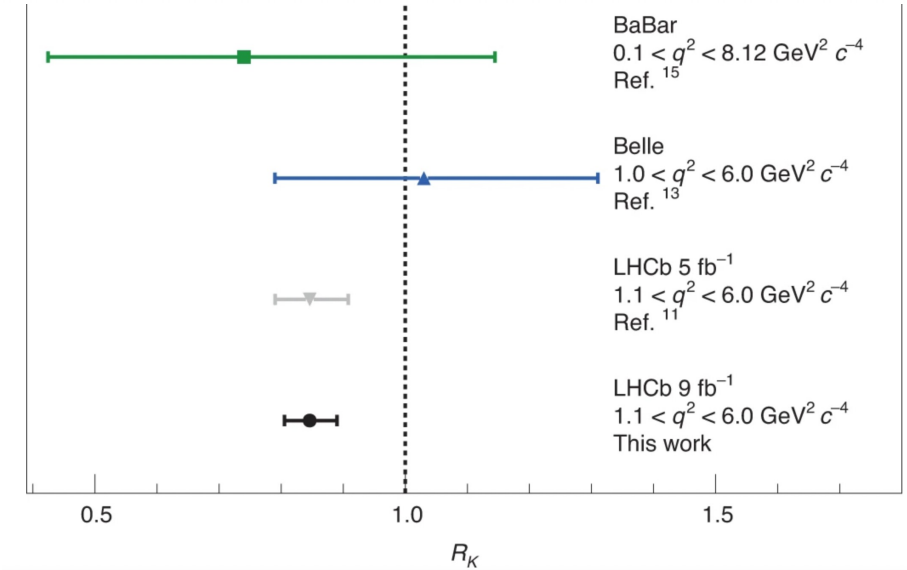
$$\tau = 1.83\,^{+0.23}_{-0.20}\,(\text{stat})\,^{+0.03}_{-0.03}\,(\text{syst})\ \text{ps}$$

ATLAS-CMS-LHCb combination summer 2020:
$B^0{}_s \to \mu^+\mu^-$ branching fraction $(2.69^{+0.37}_{-0.35}) \times 10^{-9}$
effective lifetime $\tau_{B0s \to \mu+\mu-} = 1.91^{+0.37}_{-0.35}$ ps.

Test of Lepton Flavour Universality in B decays

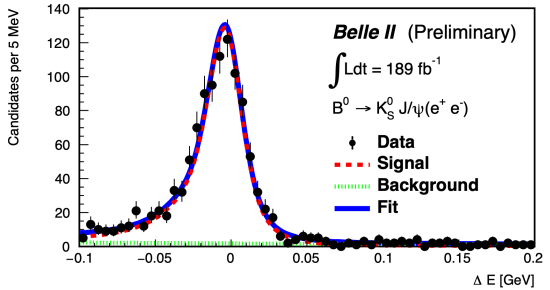
$$R_K = \frac{\mathcal{B}\ (B^+ \to K^+\mu^+\mu^-)}{\mathcal{B}\ (B^+ \to J/\psi(\to \mu^+\mu^-)K^+)} \Big/ \frac{\mathcal{B}\ (B^+ \to K^+e^+e^-)}{\mathcal{B}\ (B^+ \to J/\psi(\to e^+e^-)K^+)}$$

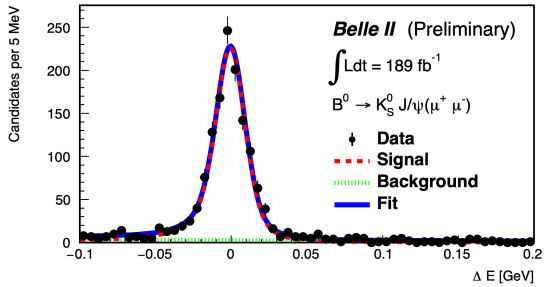
.



Nature Physics, **18**, 277-282 (2022)

Belle 2 presented new results on the control channel, preparing for R_K

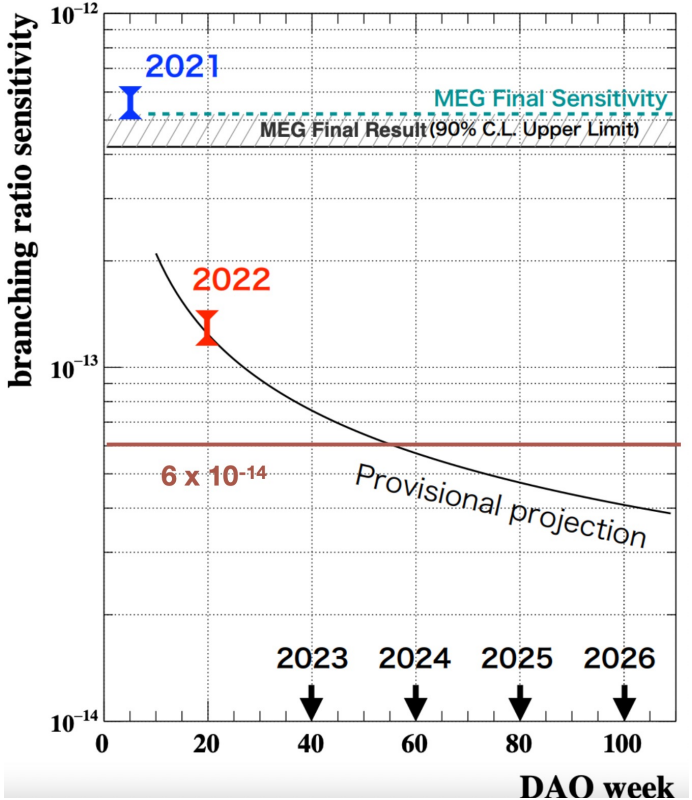




Observable	Belle II	Belle (2021)
$R_{K^+}(J/\psi)$	$1.009 \pm 0.022 \pm 0.008$	$0.994 \pm 0.011 \pm 0.010$
$R_{K^0_S}(J/\psi)$	$1.042 \pm 0.042 \pm 0.008$	$0.993 \pm 0.015 \pm 0.010$

Charged Leptons

- The MEG II $\mu \rightarrow e\gamma$ experiment started taking data at the PSI
- Data taking of G-2 progressing toward completion, collected ~19 x BNL over the last 5 years, factor ≈ 4 improvement on final uncertainty
- M2E construction progressing
- MUonE progressing as well, will measure directly the leading hadronic contribution to g-2
- Next years going to be exciting for charged lepton physics



Neutrino physics

Neutrini, their oscillations and masses

$$U = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{-i\delta_{\mathrm{CP}}} \\ 0 & 1 & 0 \\ -s_{13}e^{i\delta_{\mathrm{CP}}} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} e^{i\alpha_1} & 0 & 0 \\ 0 & e^{i\alpha_2} & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

θ_{23} & ΔM^2_{32}

Accel. LBL (ν_μ, $\bar{\nu}_\mu$) disapp. (K2K, MINOS, T2K, NOvA)
Accel. LBL (ν_e, $\bar{\nu}_e$) appearance (MINOS, T2K, NOvA)
Atmospheric Experiments (SK, IC-DC)

CP phase δ & θ_{13}

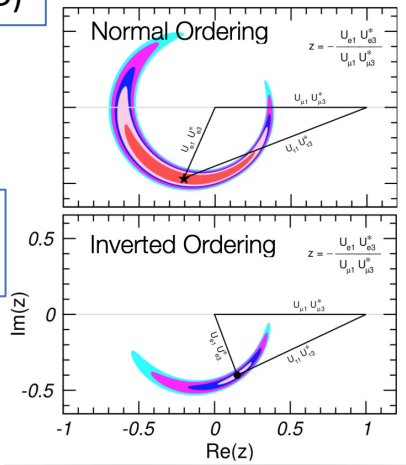
Reactor LBL (KamLAND)
Reactor MBL (Daya Bay, RENO, Double Chooz)
Accel. LBL (ν_e, $\bar{\nu}_e$) appearance (MINOS, T2K, NOvA)

θ_{12} & ΔM^2_{21}

Solar Experiments
Reactor LBL (KamLAND)

Majorana phase

Double beta decays

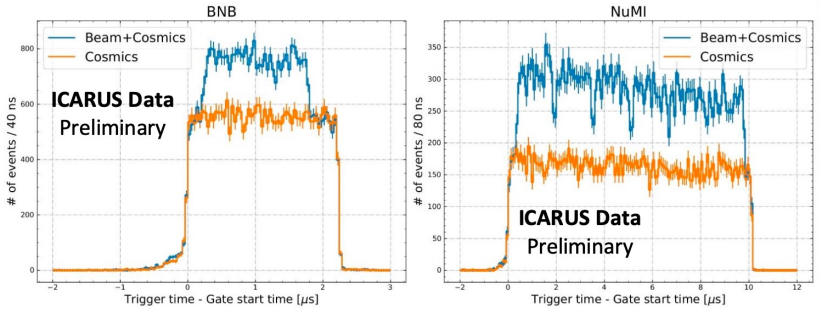


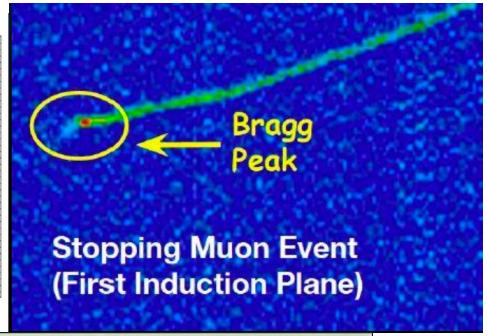
Important projects in preparation:
e.g., DUNE, HyperK, JUNO, KM3net, SNB Program
→ Status reports at this conference

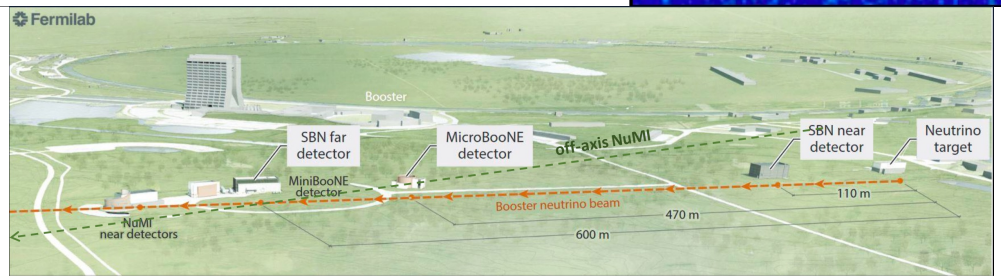
Leptonic mixing matrix (PNMS matrix) still poorly known including mass ordering

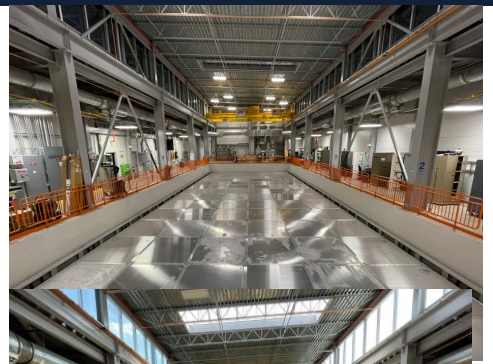
A project recently completed : Icarus 600 T @ SNB

August 2018	August 2020	March 2021	June 2021	December 2021	May 2022	June 2022
start of installation at FNAL	detector activation	First BNB and NuMI detected neutrinos	Run-0 taking data 24/7 with beam	Installation of CRT system completed	End of overburden installation	Beginning of Run-1

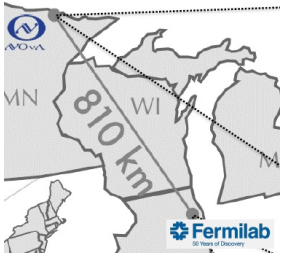








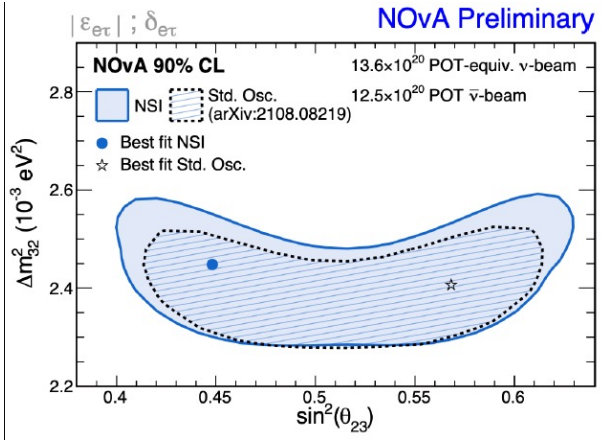
New result from NOvA including Non Standard Interactions in data analysis

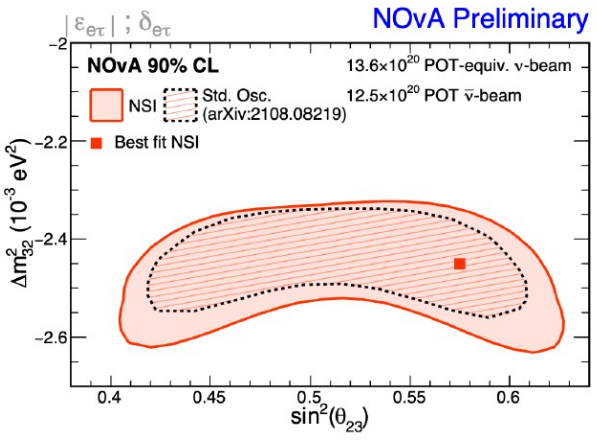


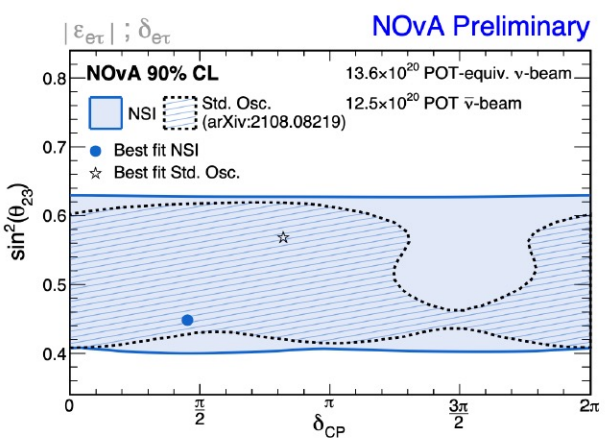
- NSI: anomalous interactions between neutrinos and matter

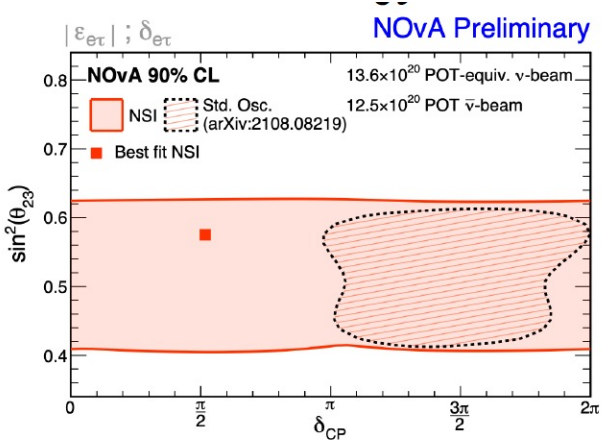
$$\mathcal{H} = \frac{1}{2E}\left[U_{PMNS}\begin{pmatrix}0 & & \\ & \Delta m^2_{21} & \\ & & \Delta m^2_{31}\end{pmatrix}U^{\dagger}_{PMNS} + a\begin{pmatrix}1+\varepsilon_{ee} & \varepsilon_{e\mu} & \varepsilon_{e\tau} \\ \varepsilon^*_{e\mu} & \varepsilon_{\mu\mu} & \varepsilon_{\mu\tau} \\ \varepsilon^*_{e\tau} & \varepsilon^*_{\mu\tau} & \varepsilon_{\tau\tau}\end{pmatrix}\right]$$

- <u>NSI effect could be large and significant in δ_{CP}</u>
- Mixing angle and mass difference are less affected





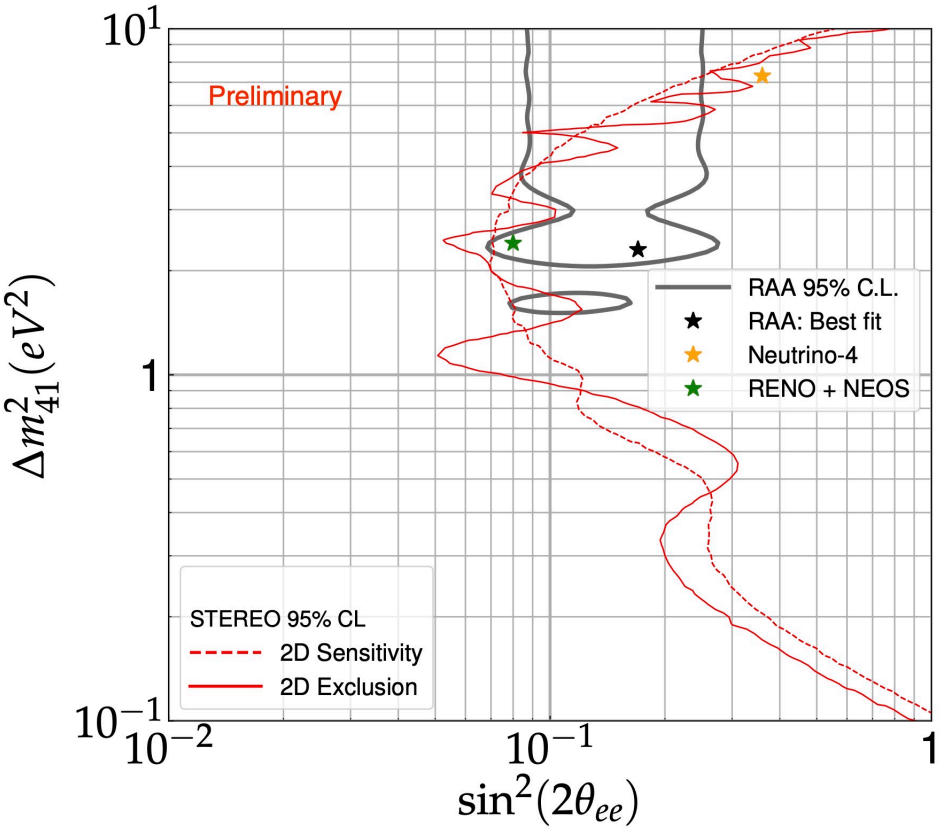




New: final results from STEREO on Reactor Antineutrino Anomaly (RAA)

- Reactor Antineutrino Anomaly : ~6% deficit observed in measured reactor antineutrino fluxes.
- Sterile neutrino with $\sin2(2\theta_{ee})=0.17$, $\Delta m^2_{41}=2.3$ eV^2 would explain RAA and Gallium anomalies
- The Stereo dectector is positioned 10 m away from the research reactor in Grenoble. The neutrino interaction occurs in 1800 liters of gadolinium (Gd) loaded liquid scintillator.

- Exclude most RAA allowed param space at > 95% CL for $\Delta m^2_{41} < 4$ eV^2
  - No oscillation ***not*** excluded (p-value=0.54)
  - RAA best fit excluded at $\gtrsim 4\ \sigma$
  - Neutrino-4 best fit excluded at $3.1\ \sigma$
  - Neos-RENO best fit excluded at $2.8\ \sigma$

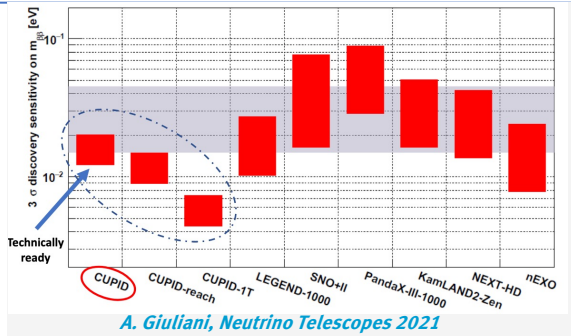


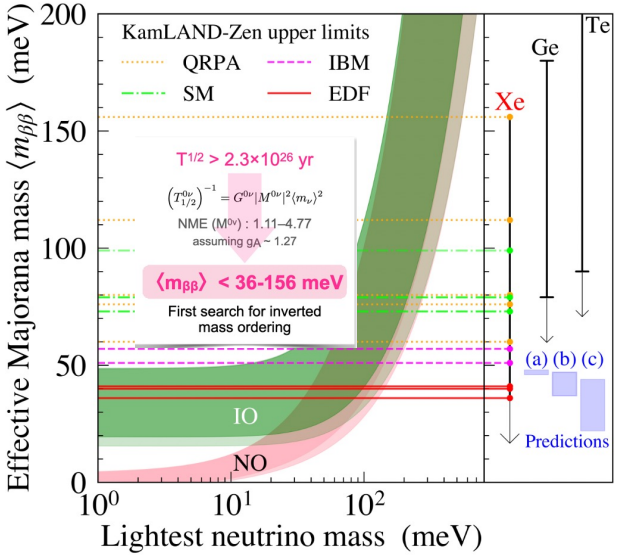
Search for Double Beta decays 0νββ

Decay rate $\Gamma = G|M|^2 m_{\beta\beta}{}^2$

$$m_{\beta\beta} = \sum_{i=1}^{3} m_i U_{ei}^2$$

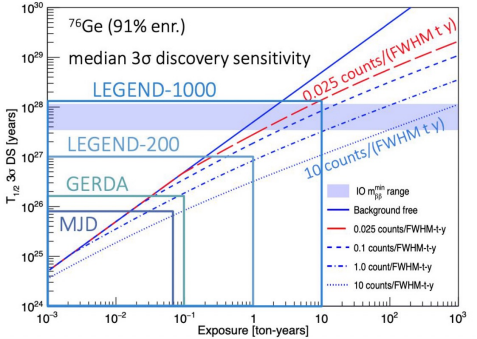
- Observation of **0νββ** would indicate lepton flavour violation and Majorana neutrinos
- Non observation sets limits on neutrino mass scale





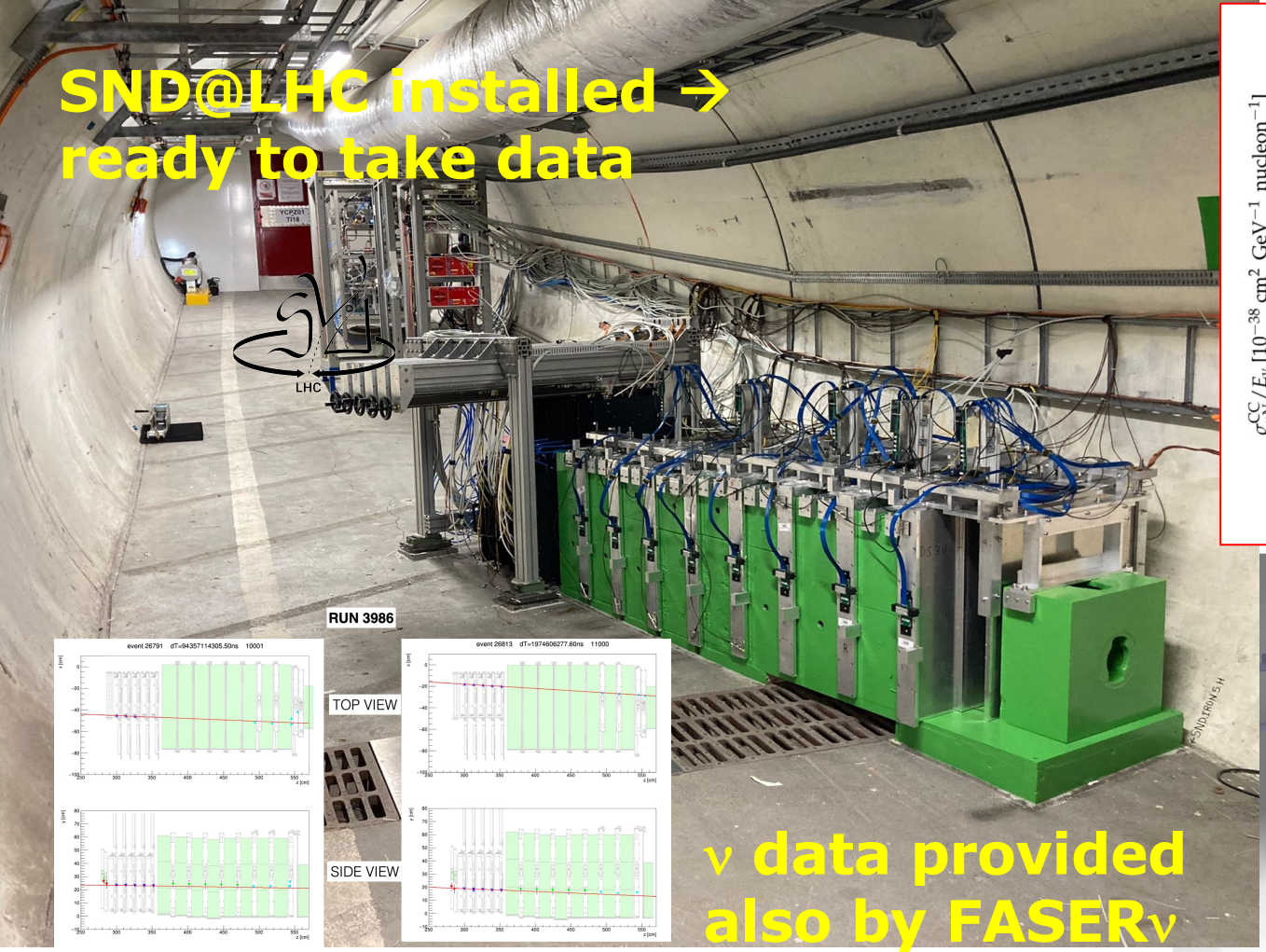
Future projects should reach $m_{\beta\beta} \approx 1$ meV

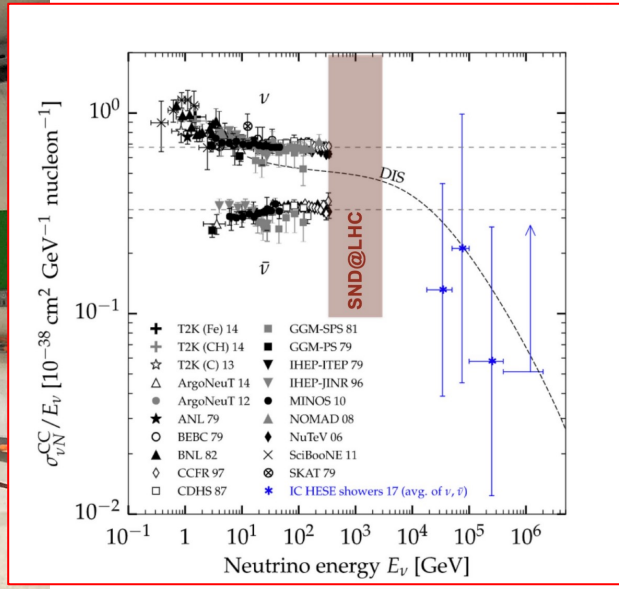
Legend at LNGS

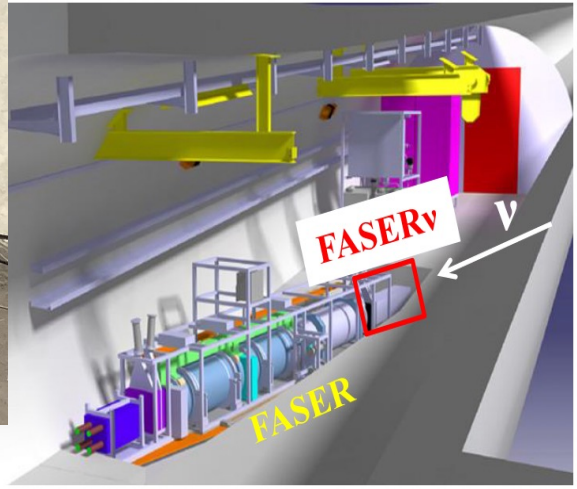


- LEGEND-200 is in commissioning, with data-taking beginning later this year
- LEGEND-1000 pre conceptual design available, with R&D and conceptual design

SND@LHC installed → ready to take data





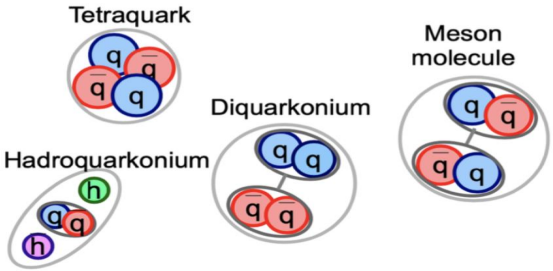


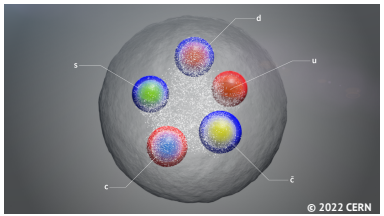
ν data provided also by FASERν

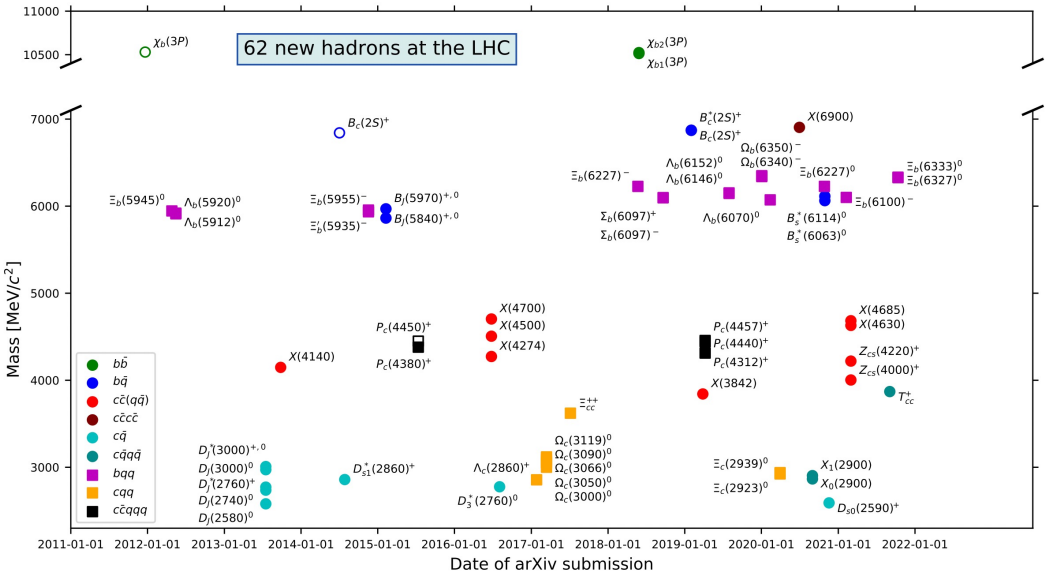
Spectroscopy

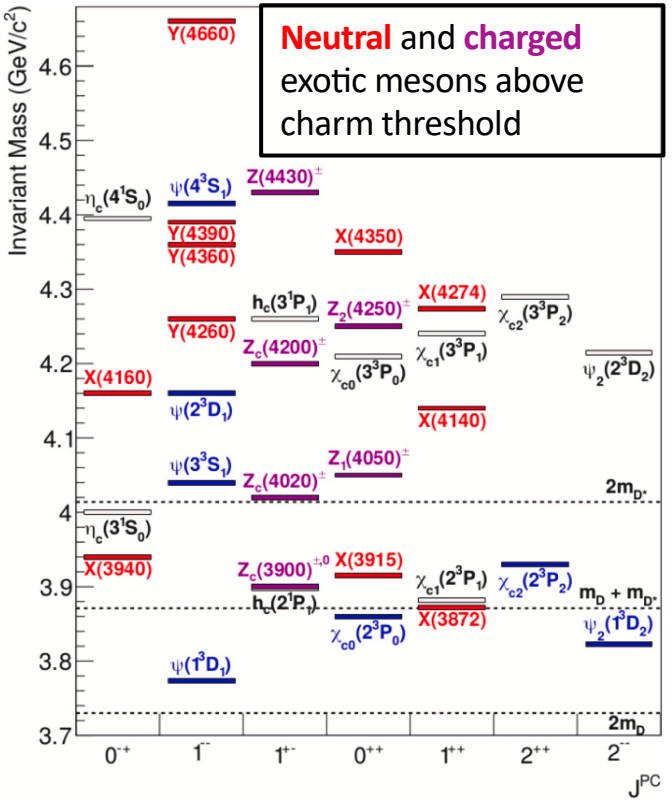
Spectroscopy: many new exotic states discovered in the past 10 years

Includes e+e-, e.g. BES III, Belle







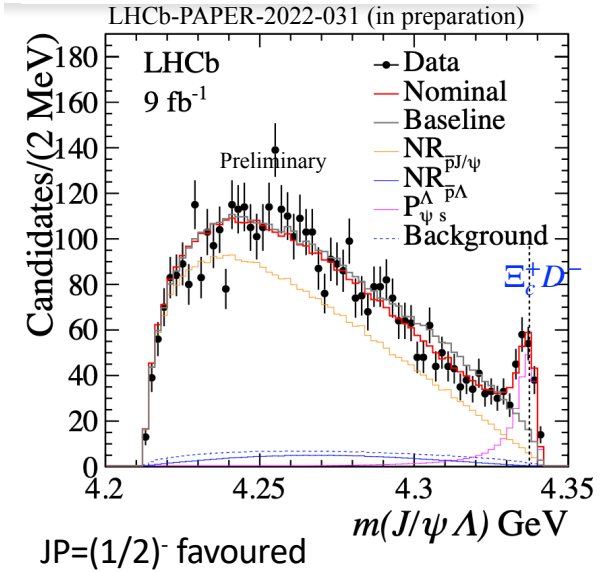


New pentaquark and tetraquarks candidates (LHCb)

Observation of $P_{\psi s}^{\Lambda}(J/\psi\Lambda)$ with strange quark content $c\bar{c}uds$ close to $\Xi_c^+ D^-$ threshold ($> 10\sigma$ significance)

$m(P_{\psi s}^{\Lambda}) = 4338.2 \pm 0.7 \pm 0.4$ MeV

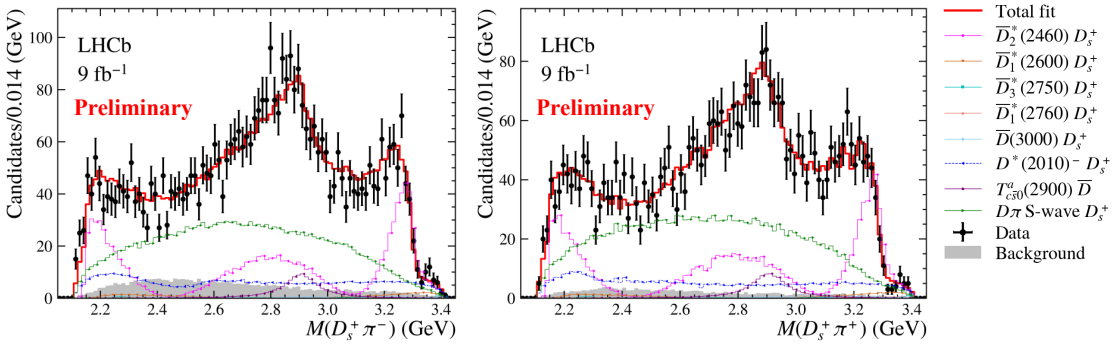
$\Gamma(P_{\psi s}^{\Lambda}) = 7.0 \pm 1.2 \pm 1.3$ MeV



JP=(1/2)⁻ favoured

✓ **First observation of a doubly charged mesonic exotic state, together with its neutral partner.**

- ✓ **Belong to the same isospin triplet.**
- ✓ **Spin-parity: 0^+**
- ✓ **Minimum quark content: $T_{c\bar{s}0}^{a}(2900)^{++}$: $[c\bar{s}u\bar{d}]$; $T_{c\bar{s}0}^{a}(2900)^{0}$: $[c\bar{s}\bar{u}d]$**
- ✓ **Similar mass with $X_0(2900)$ $(cs\bar{u}\bar{d})$, but width and flavor contents are different.**

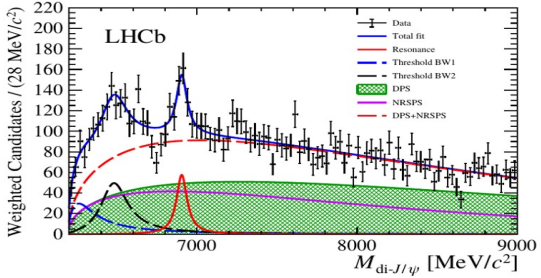


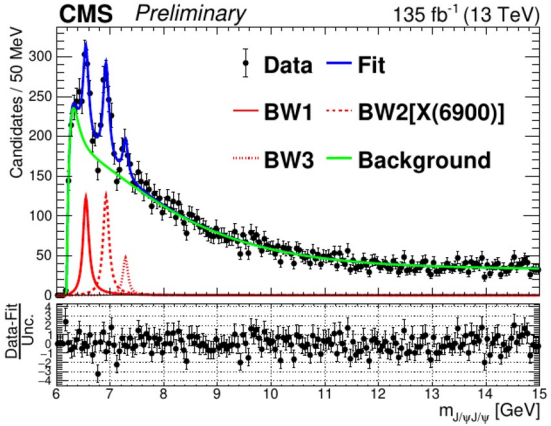
$T_{c\bar{s}0}^{a0}$ in $B^0 \to \bar{D}^0 D_s^+ \pi^-$ $\quad T_{c\bar{s}0}^{a++}$ in $B^+ \to D^- D_s^+ \pi^+$

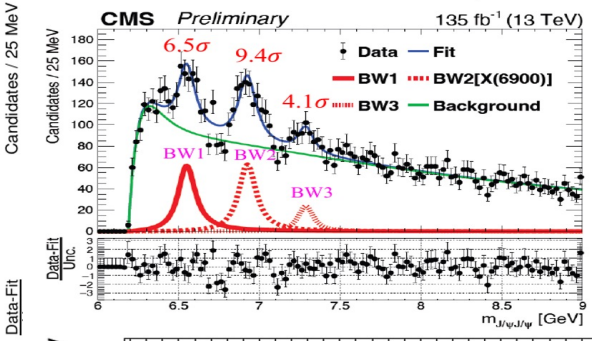
https://agenda.infn.it/event/28874/contributions/169025/
https://agenda.infn.it/event/28874/contributions/169018/

News about the X(6900) structure

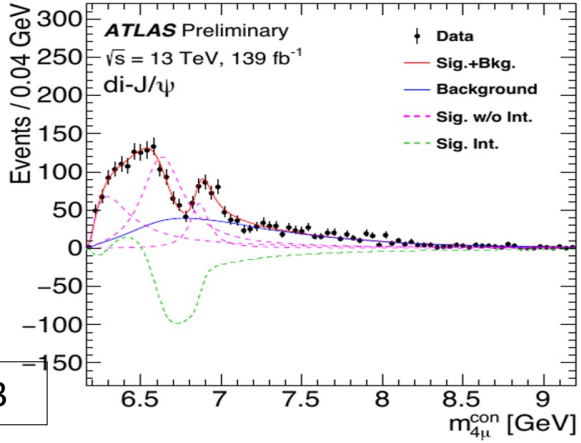
CMS observed three J/ψ J/ψ resonances compatible with predictions of **cccc tetraquarks** states around the **X(6900)** observed by LHCb
ATLAS confirmed structure in the same region







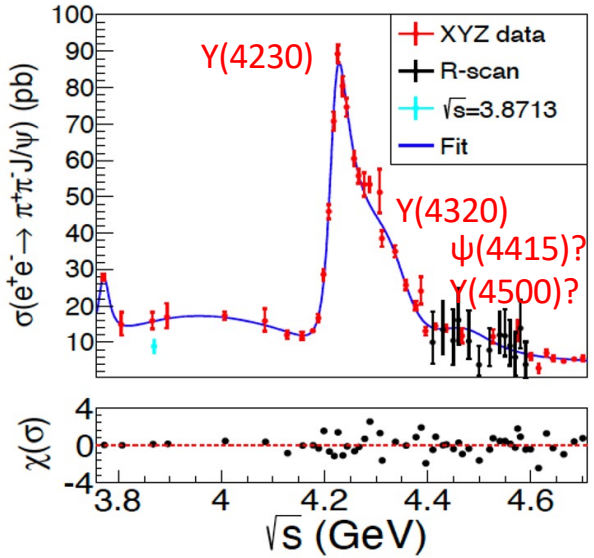
	BW1	BW2	BW3
m	$6552 \pm 10 \pm 12$	$6927 \pm 9 \pm 5$	$7287 \pm 19 \pm 5$
Γ	$124 \pm 29 \pm 34$	$122 \pm 22 \pm 19$	$95 \pm 46 \pm 20$
N	474 ± 113	492 ± 75	156 ± 56



ATLAS-CONF-2022-040 | CMS-PAS-BPH-021-003 | LHCb Science Bulletin 65 (2020) 1983

BESIII: new states observed in e+e- collisions

Resonance structures in $e^+e^- \to \pi^+\pi^-\psi_2(3823)$

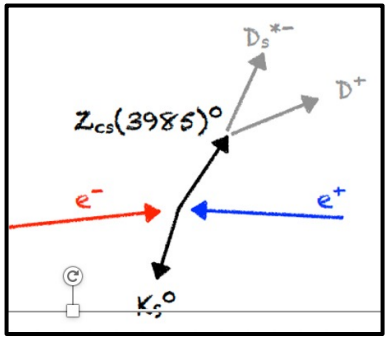


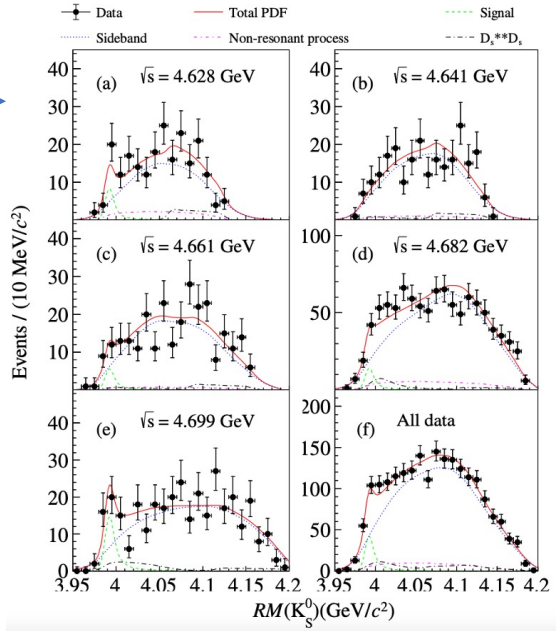
- Y(4230) and Y(4320) observed with > 10σ
- Evidence ~3σ of a structure at higher energies →ψ(4415)? The new Y(4500)?

arXiv:2206.08554

A neutral $Z_{cs}(3985)$ state

Minimal quark content $c\bar{c}s\bar{d}$?





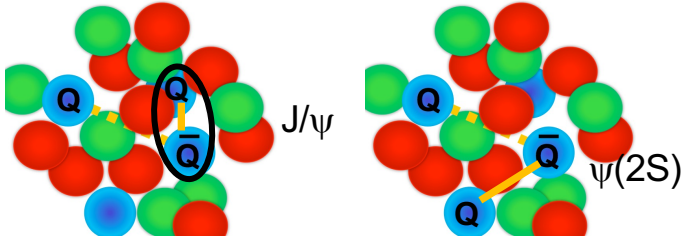
State	Mass (MeV/c^2)	Width (MeV)	Significance
$Z_{cs}(3985)^+$	$3985.2^{+2.1}_{-2.0} \pm 1.7$	$13.8^{+8.1}_{-5.2} \pm 4.9$	5.3σ
$Z_{cs}(3985)^0$	$3992.2 \pm 1.7 \pm 1.6$	$7.7^{+4.1}_{-3.8} \pm 4.3$	4.6σ

arXiv:2204.13703

Heavy Ions, but also pPb and pp

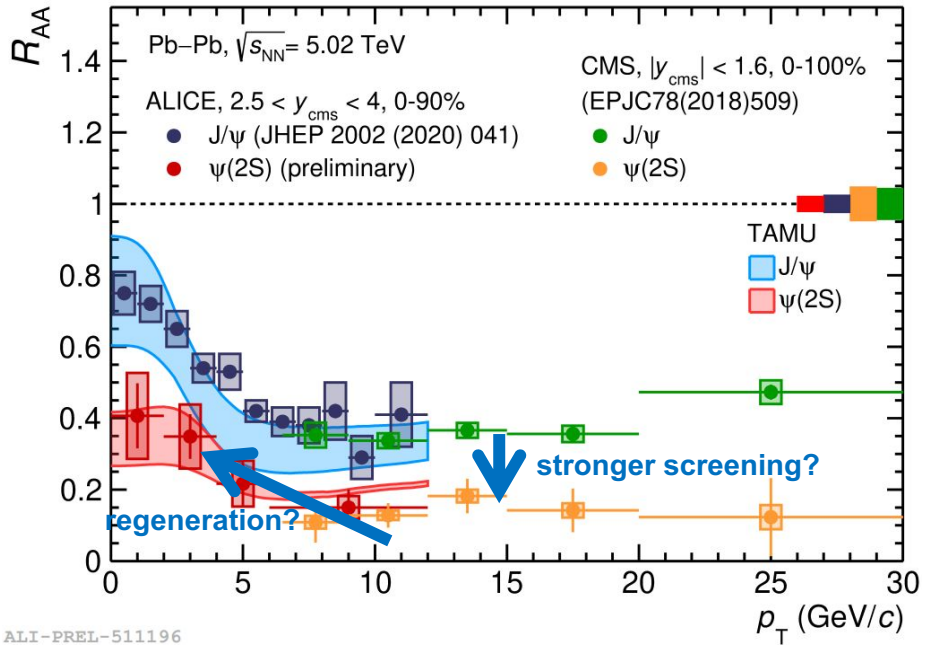
Charmonium melting and regeneration

- Reminder: J/ψ suppression due to colour screening in the QGP reduced at low p_T and at central rapidity by cc regeneration
  - ~100 cc pairs per central Pb-Pb



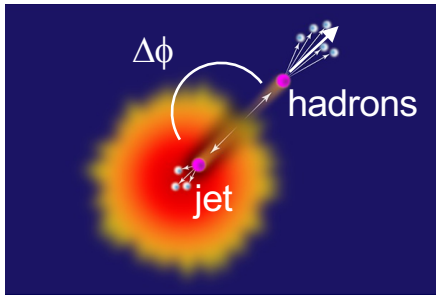
- New result: used ψ(2S) – 10x lower binding energy! - to pin down the role of these two mechanisms
- **ψ(2S) ~2x more suppressed than J/ψ**
- **Hint of regeneration at low p_T**

$$R_{AA} = \frac{1}{\langle N_{coll} \rangle} \frac{dN/dp_T|_{PbPb}}{dN/dp_T|_{pp}}$$



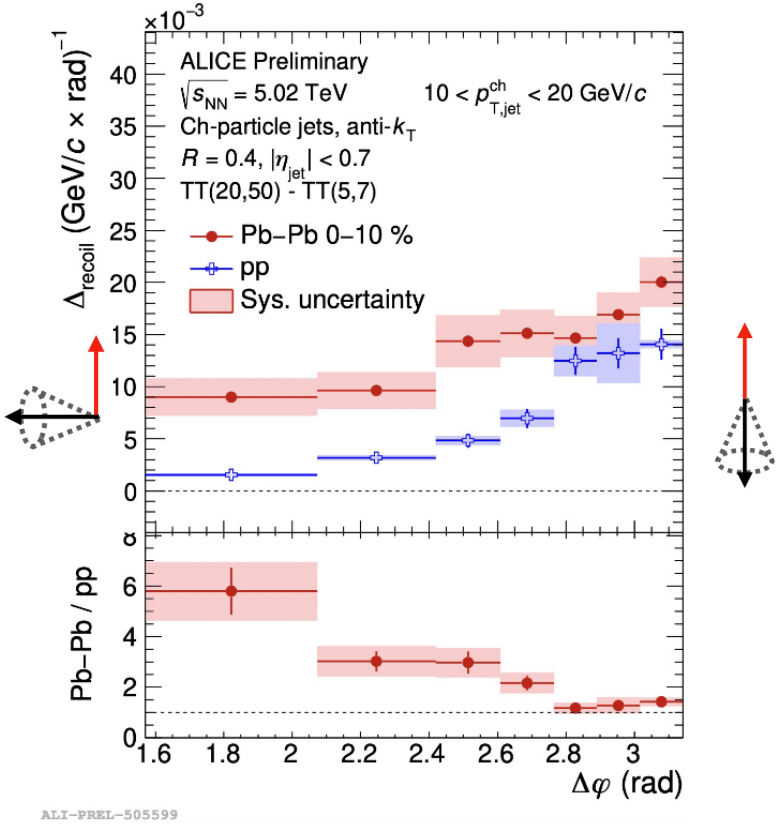
Semi-inclusive “soft” jets deflected

- Jets recoiling against a high-p_T hadron → down to jet p_T ~ 5 GeV/c



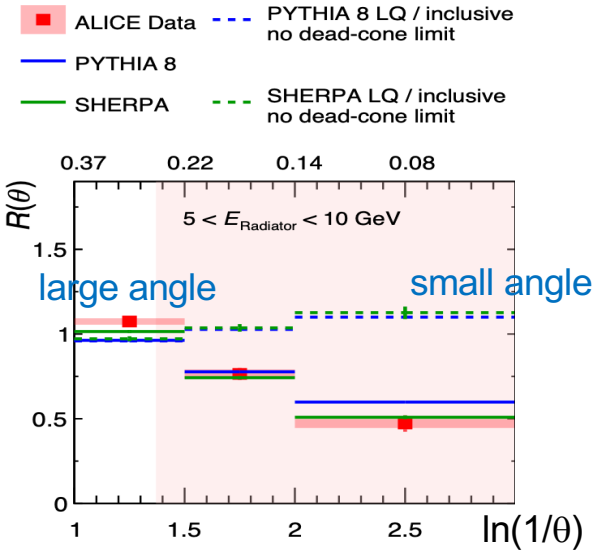
Δ_{recoil} vs $\Delta\phi$ broader in Pb-Pb than in pp

<u>Angular deflection of soft large-R jets:
Large-angle scattering on QGP constituents?</u>



Quark-mass dependence of energy loss

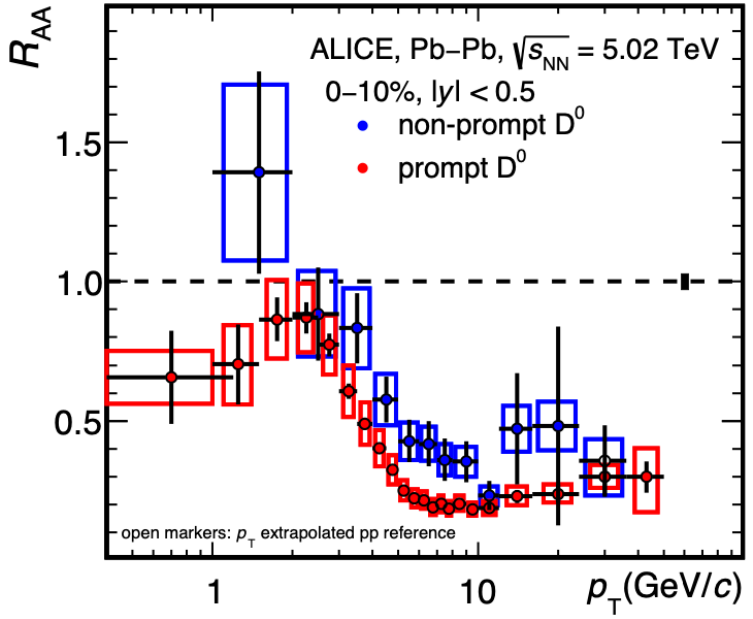
- Energy loss predicted to depend on QGP density, but also on quark mass
- "Dead cone" effect reduces small-angle gluon radiation for high-mass quarks



Recently observed by ALICE in pp collisions

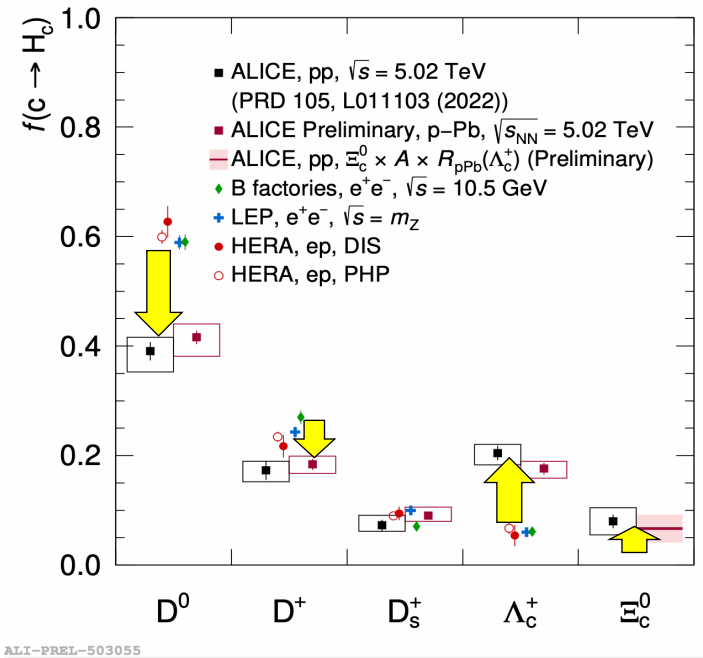
Nature 605 (2022) 7910, 440

In Pb-Pb less suppression for (non-prompt) D mesons from B decays than prompt D mesons

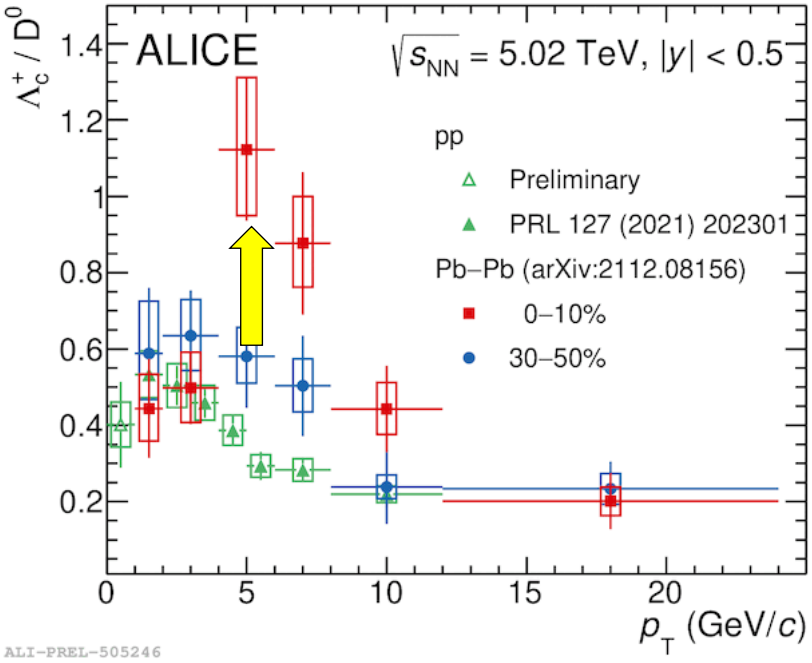


arXiv:2202.00815

Hadronization of charm quarks from pp to Pb-Pb (breakdown of jet universality in charm)

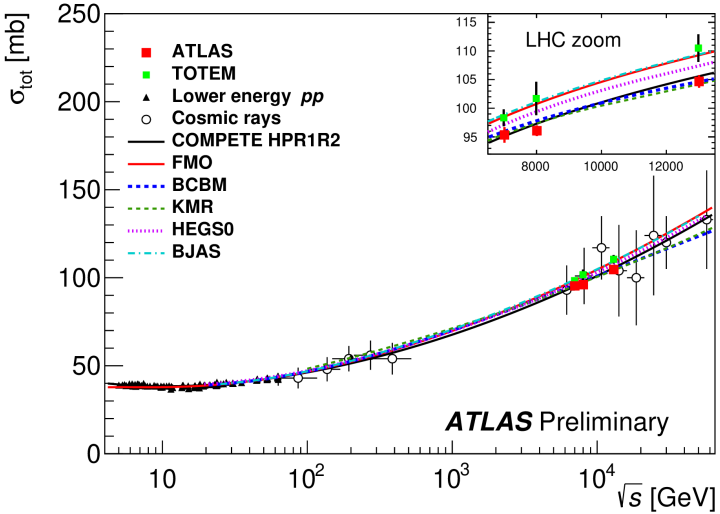


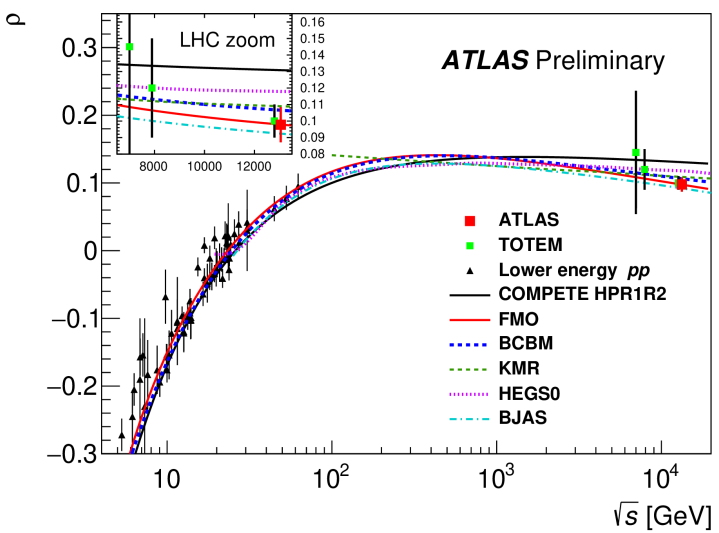
Charm quarks hadronize to baryons with much larger probability in hadronic collisions than in ee and ep collisions



Additional dynamics in central Pb-Pb collisions: Λ_c/D^0 enhancement at intermediate p_T

Measurement of the total cross section and ρ-parameter from elastic scattering in $p\,p$ collisions



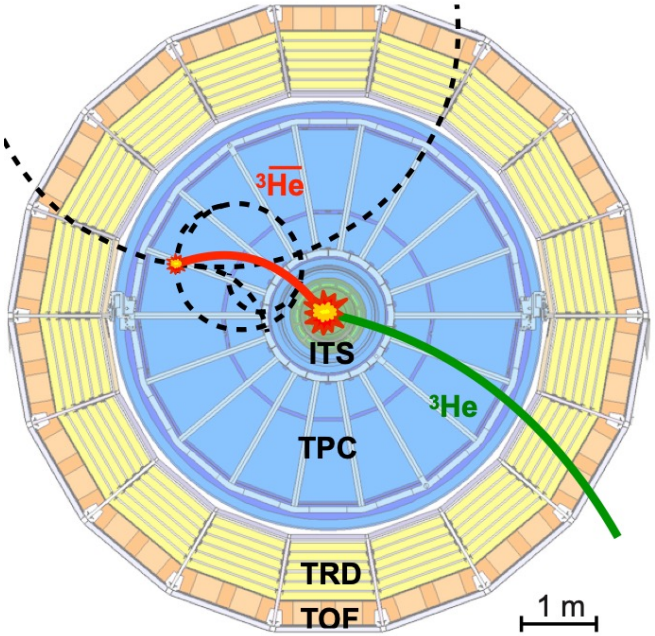


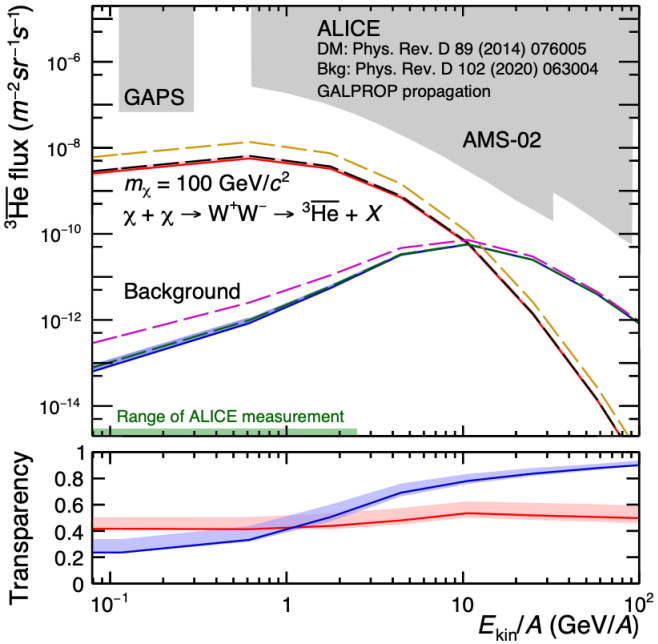
The measurements rely upon the luminosity determination that ATLAS provides for all cross section measurements. TOTEM is using a luminosity independent method for the normalization of the differential cross section.

Real-to-imaginary ratio of the elastic scattering amplitudes (ρ-parameter) Odderon component required !

https://agenda.infn.it/event/28874/contributions/169014/

Light nuclei absorption in ALICE and Galaxy transparency





- Novel technique to use detector material as d and ^{3}He absorber: constrain σ_{inel}
  - First measurement below 10 GeV/c

- Experiment-driven estimate of absorption probability of anti-nuclei from DM decays and from cosmic-ray background in the Galaxy

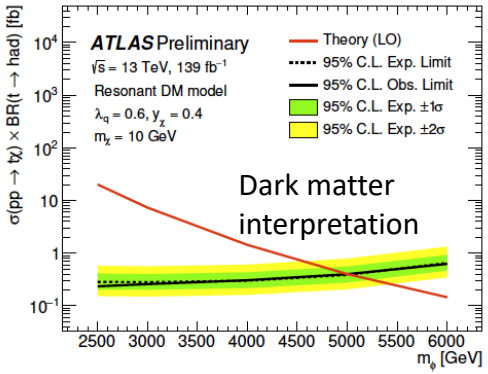
Beyond the Standard Model

https://agenda.infn.it/event/28874/contributions/169410/

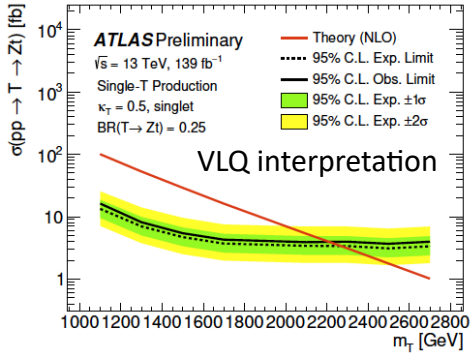
https://agenda.infn.it/event/28874/contributions/169444/

BSM searches with top in ATLAS

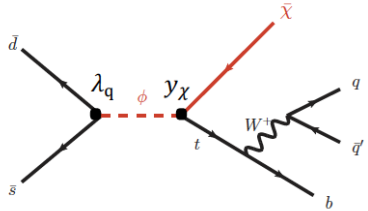
Single top plus invisible particles

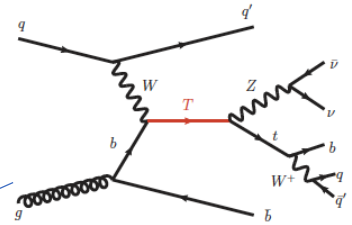


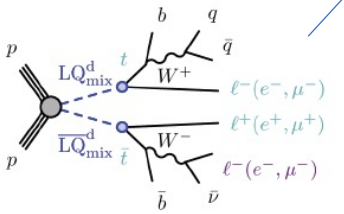
Dark matter interpretation



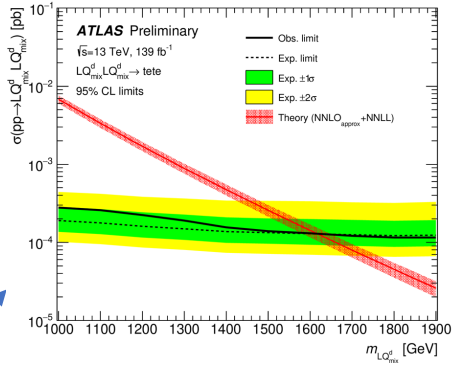
VLQ interpretation

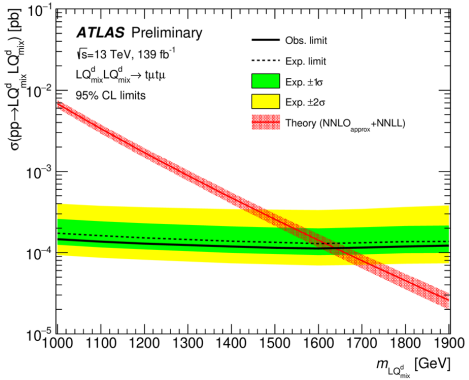






Search for leptoquark pair production decaying to tltl in multilepton





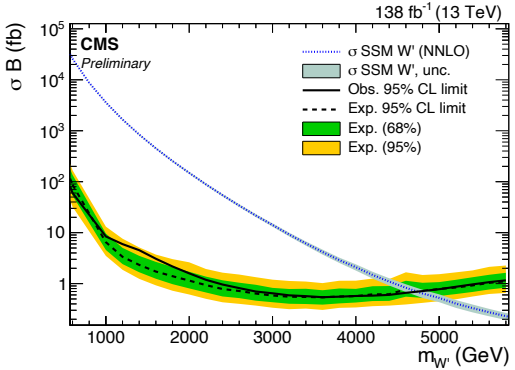
CMS-PAS-EXO-21-009

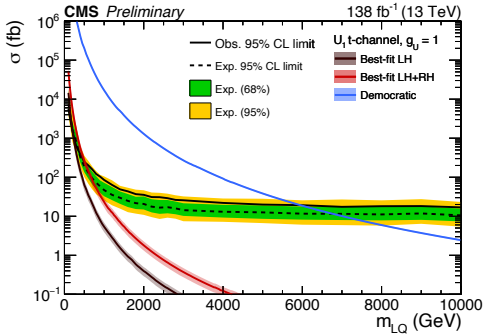
CMS-PAS-EXO-19-016

CMS-PAS-B2G-21-007

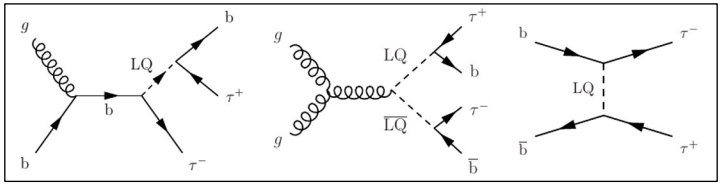
BSM searches at CMS

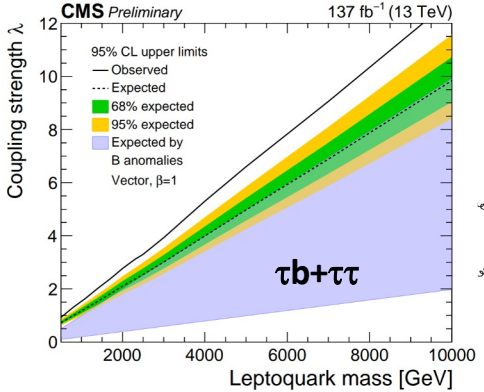
Leptoquarks or W' (τ+ν channel)



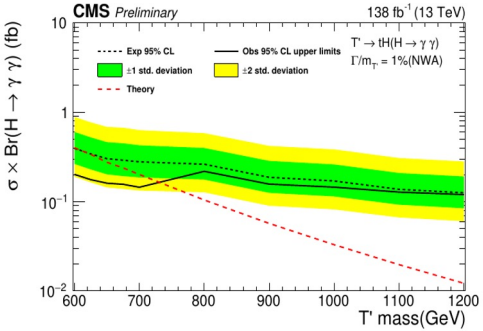


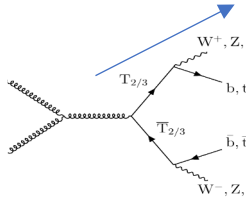
Leptoquarks ττ channel

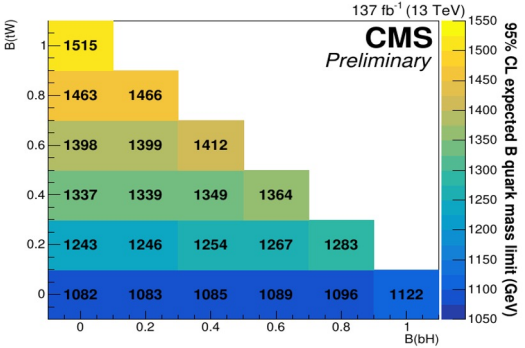




Vector-like quarks 3rd generation





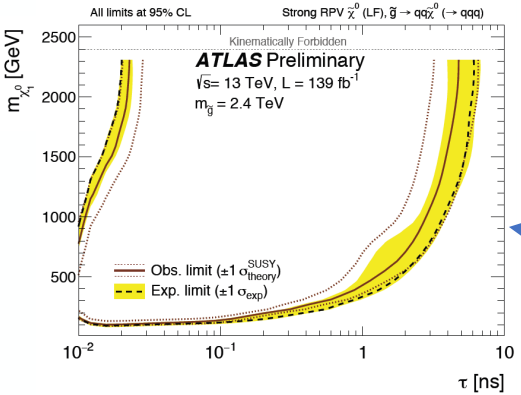


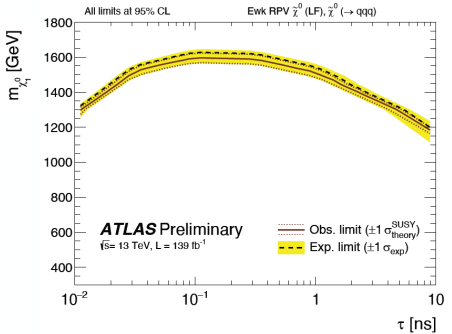
https://agenda.infn.it/event/28874/contributions/169435/

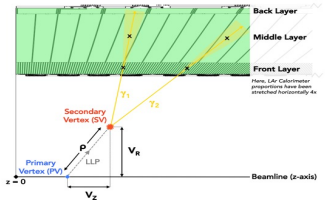
BSM searches with displaced vertices in ATLAS

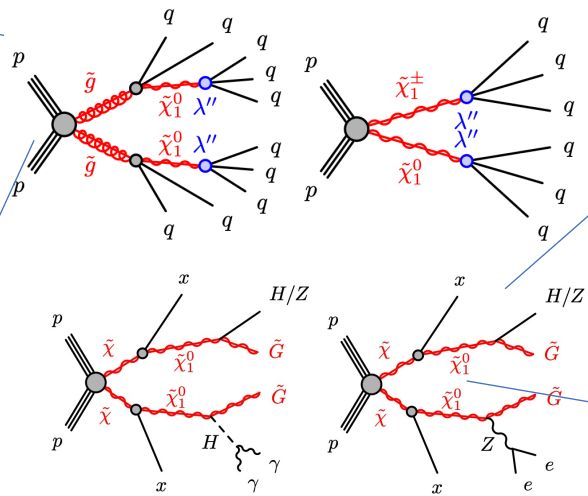
Search for long-lived, massive particles in events with **displaced vertices and multiple jets** in pp collisions

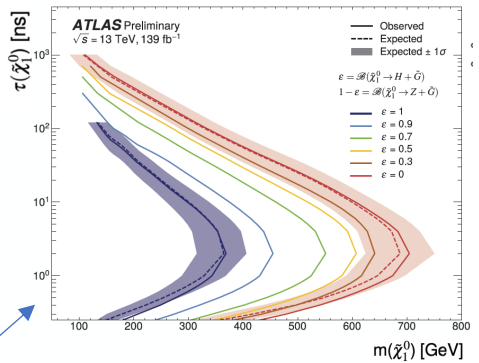
Search in **diphoton and dielectron** final states for **displaced** production of Higgs or Z bosons

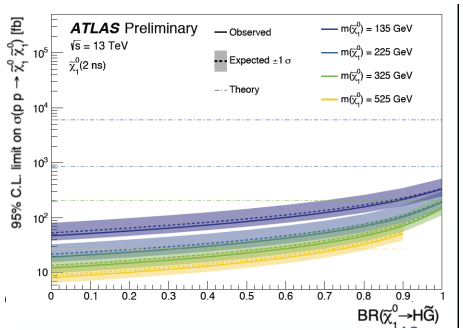








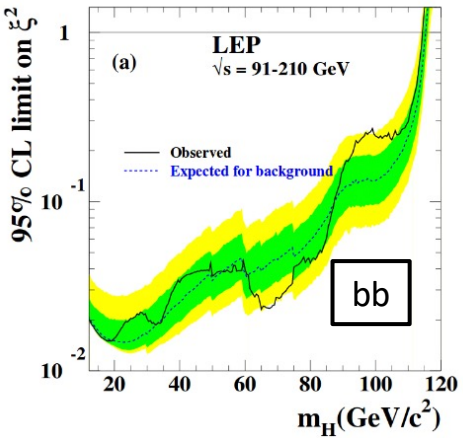


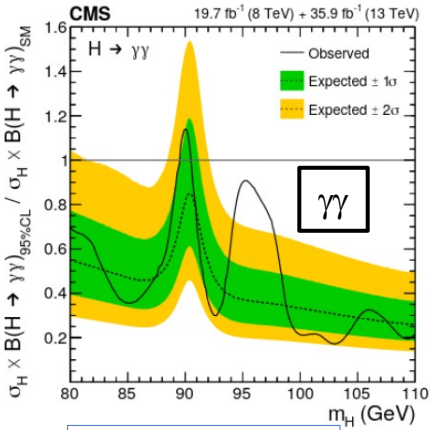


CMS-PAS-HIG-21-011

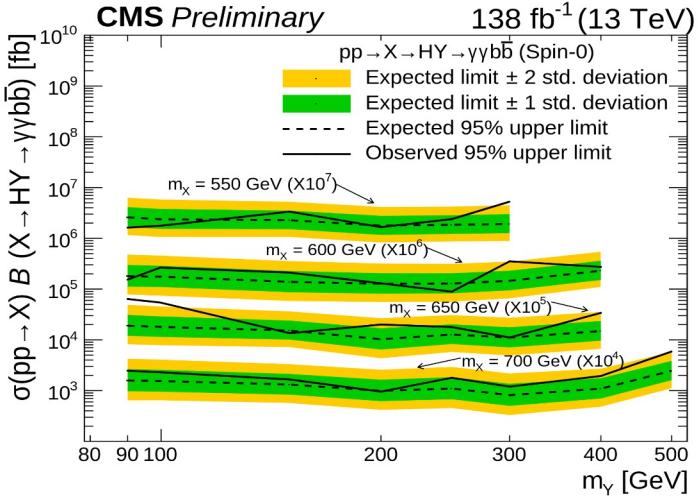
Search for resonances (X) decaying to H/Y(bb)H(γγ)

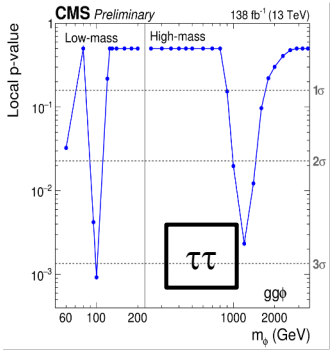
- Excess at (bb=125 GeV,γγ≈90 GeV) with ≈650 GeV heavy resonance mass
  - 3.8**σ** local, 2.8**σ** global
- Raising some discussion because of some old excesses at 95 GeV in scalar boson searches
- … and also at ≈650 GeV in resonances searches
- "**Se son rose fioriranno**"



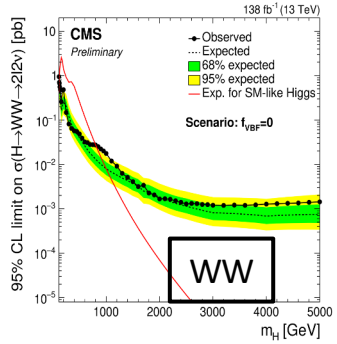


PLB 793 (2019) 320





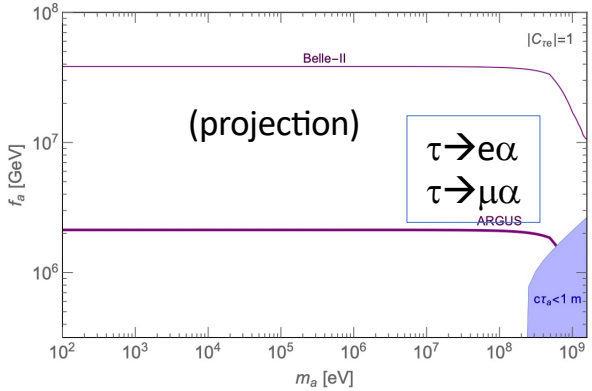
CMS-PAS-HIG-21-001

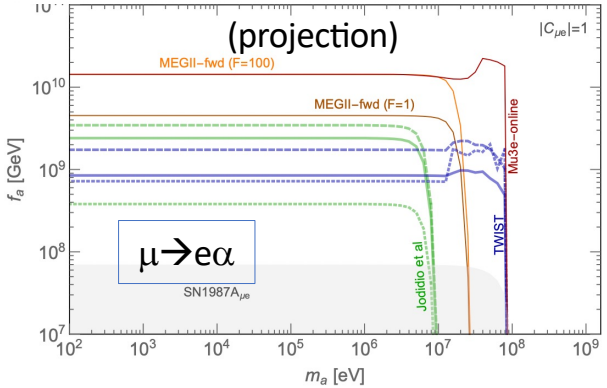


CMS-PAS-HIG-20-016

https://agenda.infn.it/event/28874/contributions/169331/

Search for Lepton Flavour Violating axions (Belle 2)

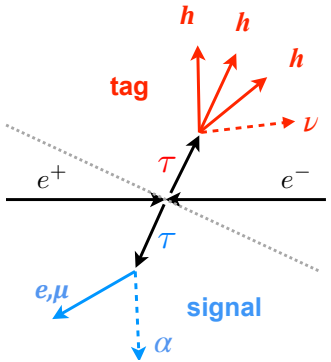


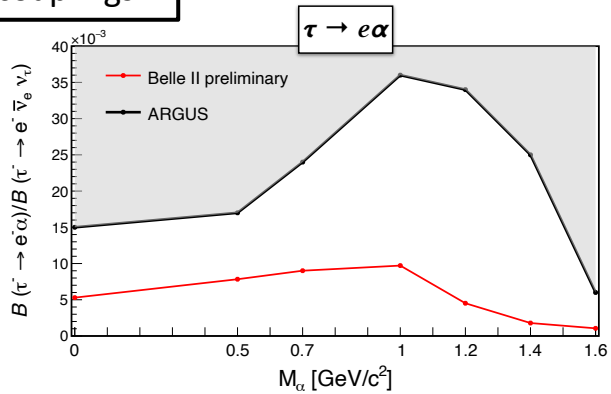


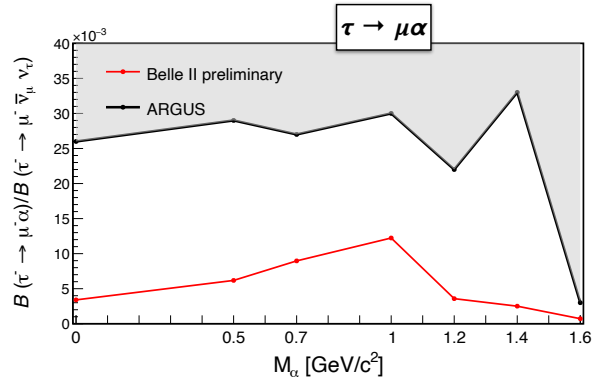
(Cabibbi, Redigolo, Ziegler, Zupan 2021)

MEG-II, Mu3e uniques for $C_{eμ}$ couplings
Belle 2 unique for for $C_{τμ}$ and $C_τe$ couplings

First preliminary results from Belle 2 on these channels

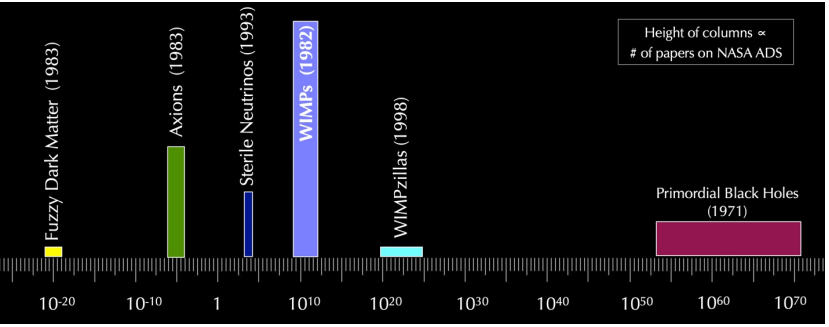






Some of these already discussed before in the context of searches at accelerators or reactors (e.g. χ , ALP, sterile neutrinos)

Dark Matter



New result from LUX-ZEPLIN (LZ) 7th July

https://lz.lbl.gov/wp-content/uploads/sites/6/2022/07/LZ_SR1_Paper_7July2022-1.pdf

Status of Direct detection searches for WIMP Dark Matter

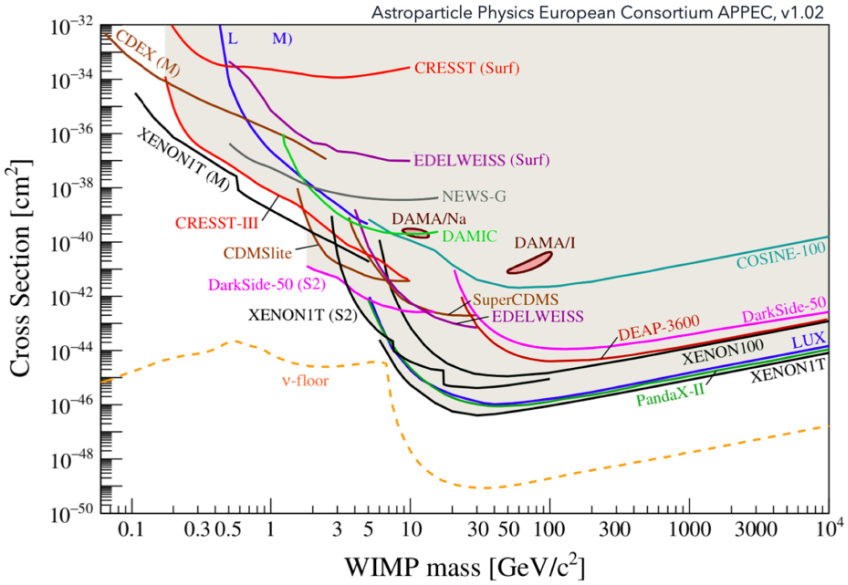
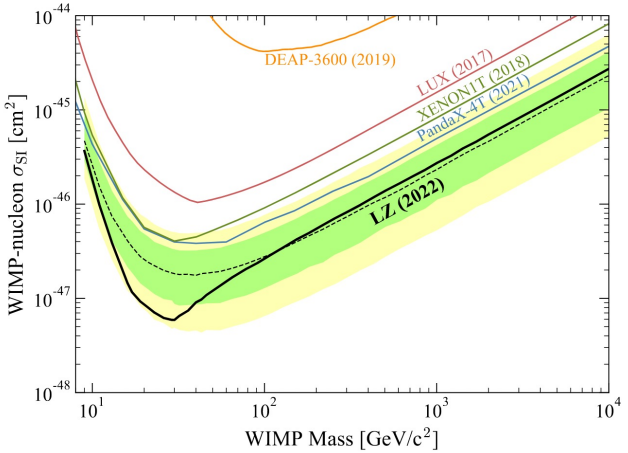
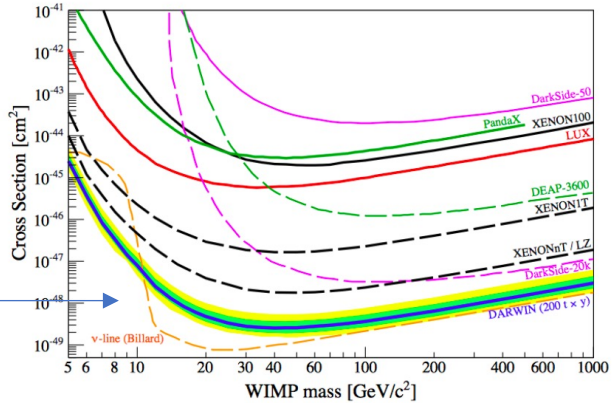


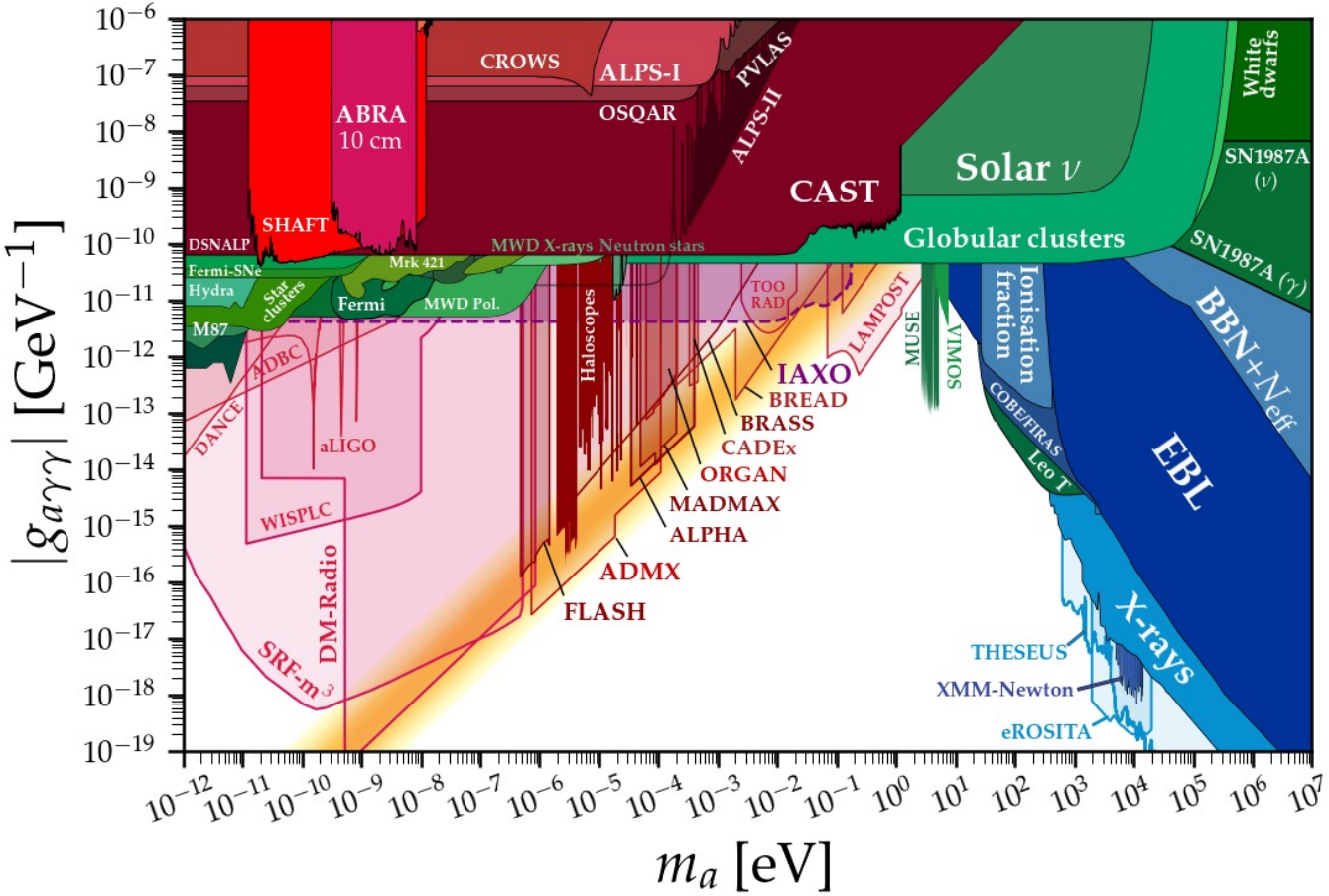
Figure modified from Rept. Prog. Phys. 85 (2022) 5, 056201



Future projects: reaching the ν-floor



Status of Direct detection searches for Axions



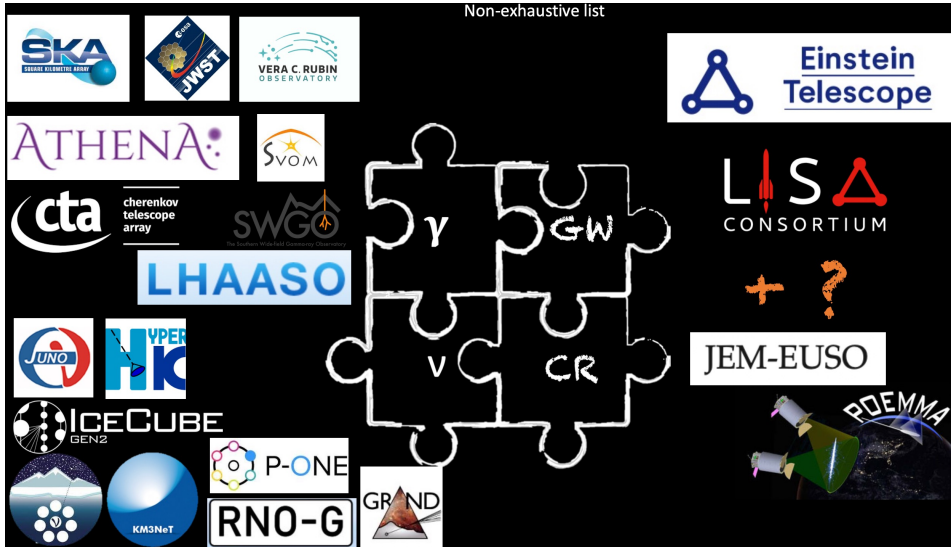
First photo from NASA's James Webb Space Telescope (July 11th)

Astroparticle, Gravitational Waves

γ, ν, cosmic rays, gravitational waves

The present

The future



https://agenda.infn.it/event/28874/contributions/171911/
https://agenda.infn.it/event/28874/contributions/171912/
https://agenda.infn.it/event/28874/contributions/171914/

Accelerators, Detectors, Theory

Three essential components, see the excellent reviews of today and Monday:

https://agenda.infn.it/event/28874/contributions/171927/

https://agenda.infn.it/event/28874/contributions/171940/

https://agenda.infn.it/event/28874/contributions/171906/
https://agenda.infn.it/event/28874/contributions/171907/

… and since I am the last speaker

On behalf of all participants I would like to THANK the organizers for the excellent organization of ICHEP 2022 in Bologna, the applause is for them !

Have a safe return home