

ASAMBLEA GENERAL DEL IFIC

Proyecto Severo Ochoa

L3 Flavour and quark matter

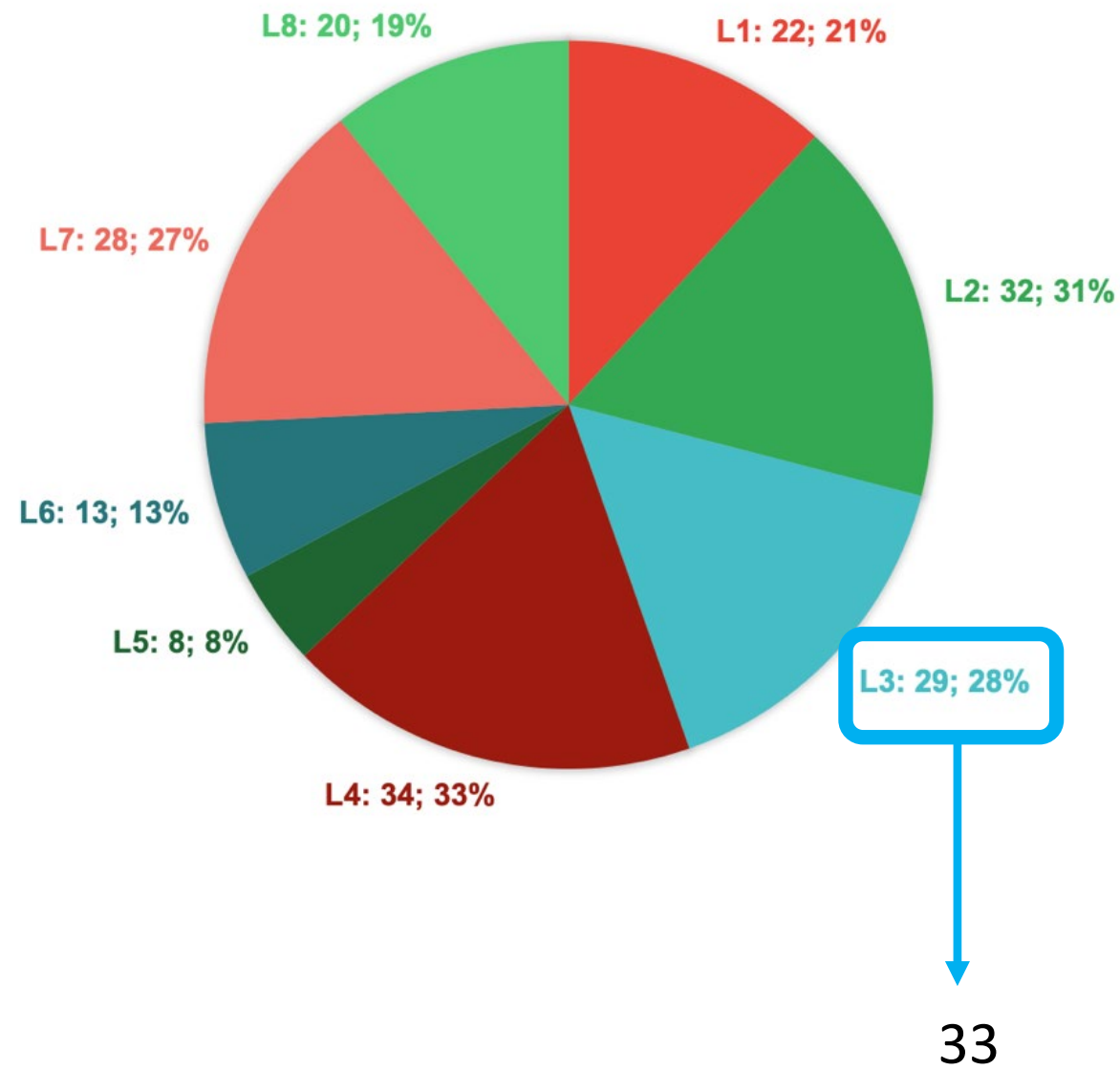


Francisco Botella
Fernando Martínez Vidal
Juan M Nieves
Antonio Pich

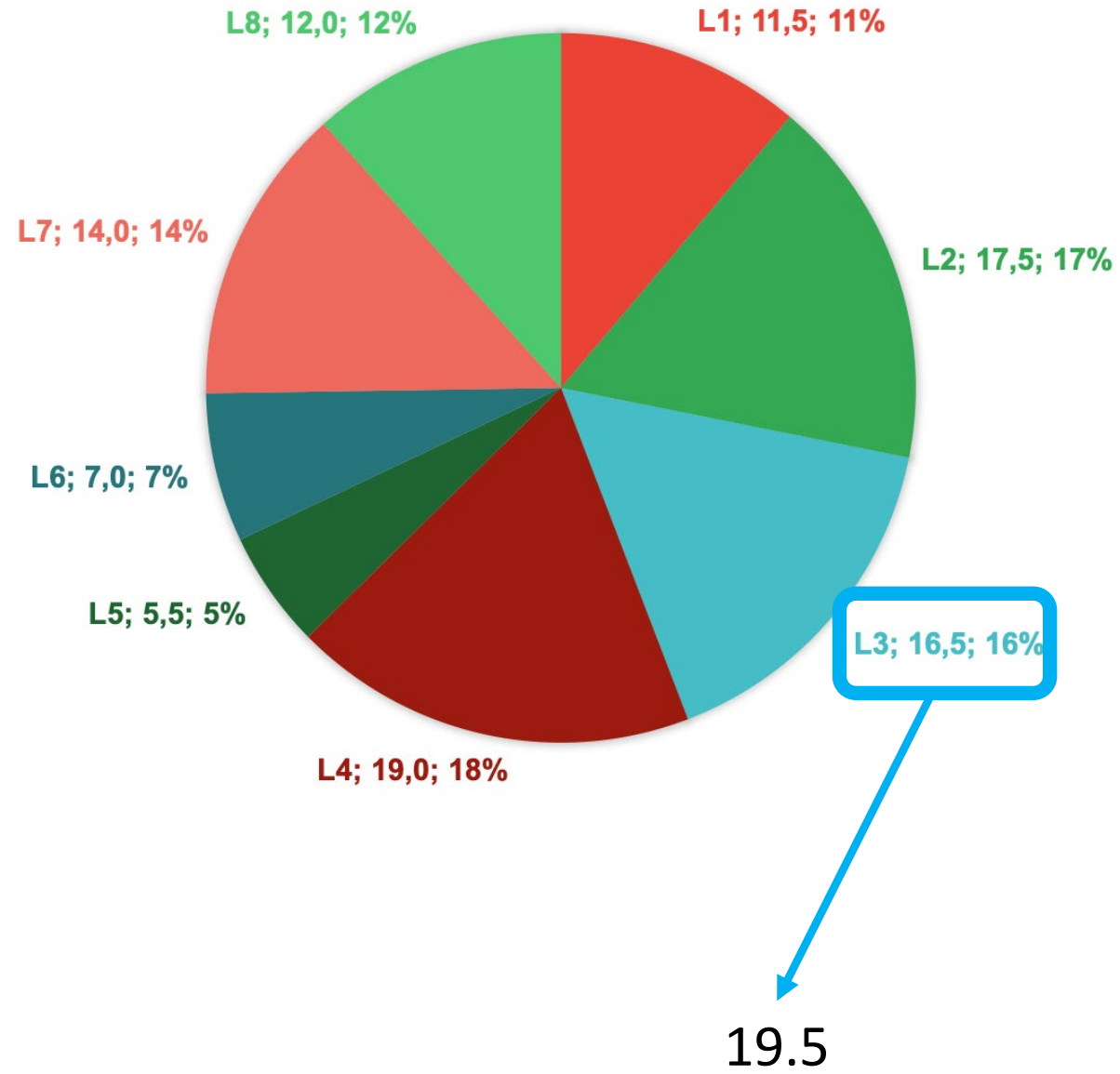
Flavour puzzle in SM (threefold repetition of family structures only distinguished by their interactions with the Higgs boson, leading to a "capricious" hierarchy of particle masses)

- ✓ Rare processes (forbidden or almost forbidden in the SM) very sensitive to new particles and/or interactions beyond direct reach of any conceivable particle accelerator. Searching for new physics with a flavour perspective is therefore **complementary to exploring the high energy frontier**
- ✓ Experimental viewpoint: pushing the intensity frontier to observe rarer processes and perform higher precision measurements
- ✓ Theoretical viewpoint. Predictions of many of these observables involve the strong interactions: **theoretical challenge** that requires sophisticated methods: EFTs & LQCD
- ✓ A number of experimental measurements have been shown to deviate from the SM theoretical expectations with moderately high significance (anomalous magnetic moment of the muon, flavour anomalies, including possible breaking of lepton universality and the unitarity of the quark mixing matrix). Understanding of these anomalies, either via new physics models or from improved measurements and SM predictions, is an area of intense research.
- ✓ Data of LHC and B factories: exotic states of quark matter in the form of **tetraquarks** or **pentaquarks** have been proposed to explain some newly observed states.

PERSONAS POR LÍNEA




FTE POR LÍNEA




IFIC Scientific Day (Enero 2024)

9:45 → 10:10 **SMEFT and (light quarks) flavor**
Ponente: Martín González-Alonso (IFIC/UV-CSIC)

 L3 talk MGA.pdf


10:10 → 10:35 **Flavor & dark matter**
Ponente: Oscar Vives (IFIC/UV-CSIC)

 Dark24.pdf

10:35 → 11:00 **Status of Belle II**
Ponente: Vidya Sagar Vobbiliseti

 IFIC Slides 08 Jan 2...

11:00 → 11:25 **Exotic spectroscopy and femtoscopy**
Ponente: Miguel Albaladejo (IFIC/UV-CSIC)


 Albaladejo_IFIC_Tal...

11:25 → 11:55 **Coffee break**


11:55 → 12:20 **BSM searches with ATLAS In scenarios of flavour anomalies**
Ponente: Luca Fiorini (IFIC/UV-CSIC)


 fiorini-Ifv-08_01_202...

12:20 → 12:45 **Meson and glueball spectroscopy within the graviton soft wall model**
Ponente: Vicente Vento (IFIC/UV-CSIC)


 AdS2024.pdf

12:45 → 13:10 **Electroweak structure of the nucleons**
Ponente: Fernando Alvarado (IFIC/UV-CSIC)


 F_EM_pres_IFIC_20...

 F_EM_pres_IFIC_20...

9:15 → 9:40 **Selected results from LHCb**
Ponente: Arantza Oyanguren (IFIC/UV-CSIC)

 Arantza_LHCb.pdf

9:40 → 10:05 **Schwinger mechanism In QCD**
Ponente: Joannis Papavassiliou (IFIC/UV-CSIC)

 Joannis-IFIC-2024.p...

10:05 → 10:30 **Lattice QCD activities at IFIC (computers, hadrons and the QCD coupling)**
Ponente: Alberto Ramos (IFIC/UV-CSIC)


 ific_L3.pdf

10:30 → 10:55 **Present and future of LLP searches at LHCb**
Ponente: Izaak Sanderswood (IFIC)

 jomadaL32024_LH...

10:55 → 11:25 **Coffee break**


11:25 → 11:50 **CP violation in charm-meson two-body hadronic decays**
Ponente: Luiz Vale-Silva (IFIC/UV-CSIC)

 DCPV_Vale_Silva_v...


11:50 → 12:15 **Polarization and decay of charm baryons at LHCb**
Ponente: Sergio Jaimes Elles (IFIC/UV-CSIC)

 IFICL3_CharmBaryo...

12:15 → 12:40 **Flavour, Higgs and g-2**
Ponente: Miguel Nebot (IFIC/UV-CSIC)

 Nebot_IFIC-L3_2024...

12:40 → 13:05 **Radiative b-hadron decays at LHCb**
Ponente: Jiahui Zhuo (IFIC/UV-CSIC)

 Radiative_b-hadron_...

13:05 → 13:15 **Closing**

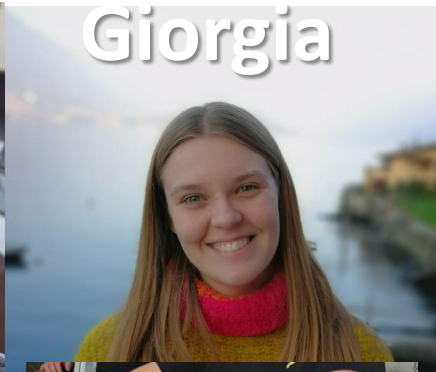
LHCb @ IFIC [Detector, Physics, Software/Computing]



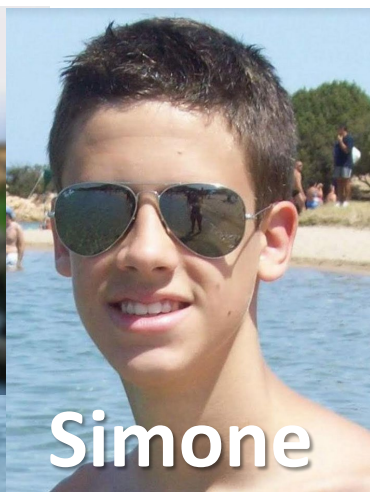
Jose



Volodymyr



Giorgia



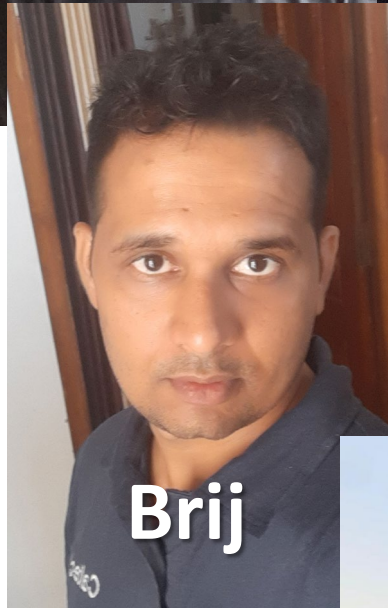
Simone



Jiahui



Jorge



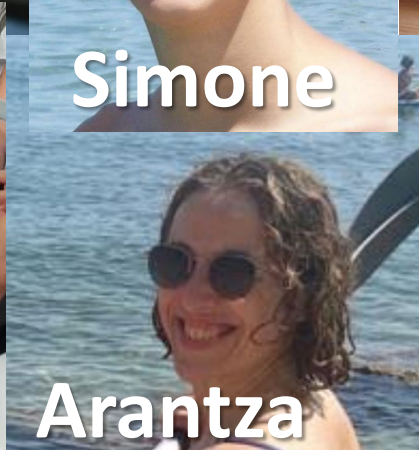
Brij



Izaac



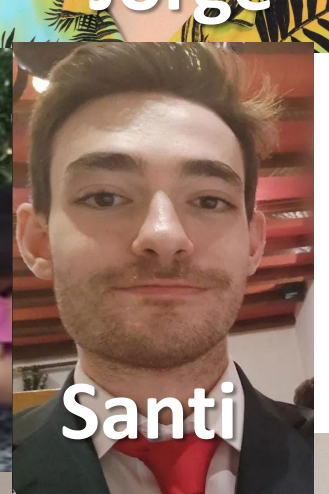
Fernando



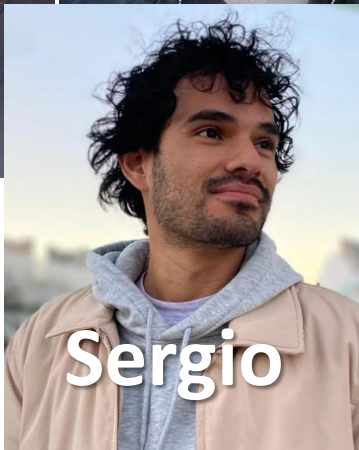
Arantza



Valerii



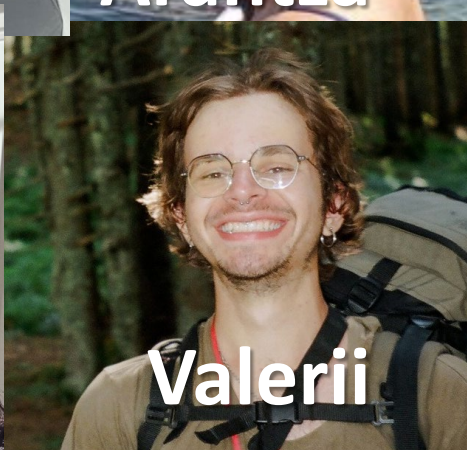
Santi



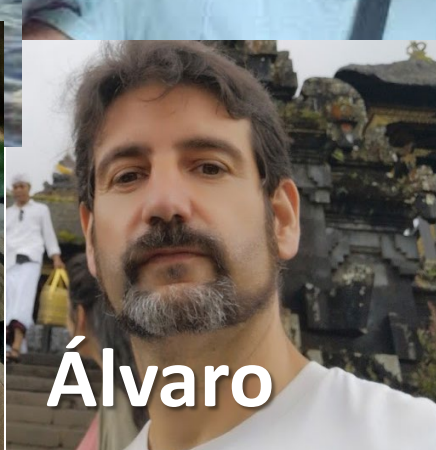
Sergio



Miriam



Valerii

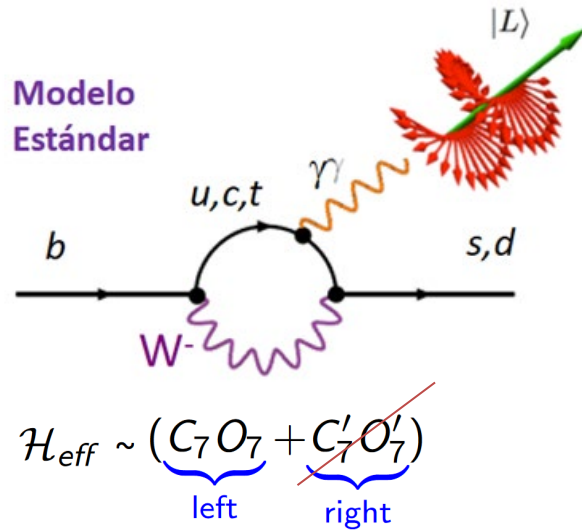


Álvaro

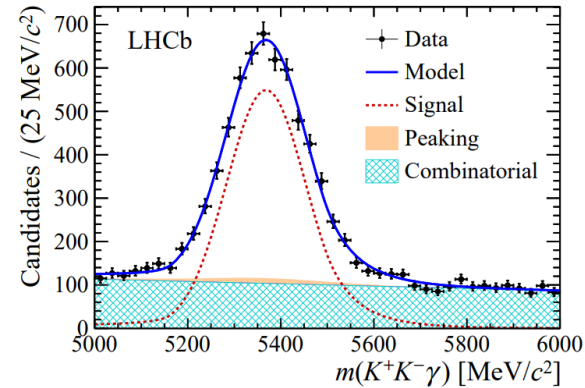


Javier

Rare decays

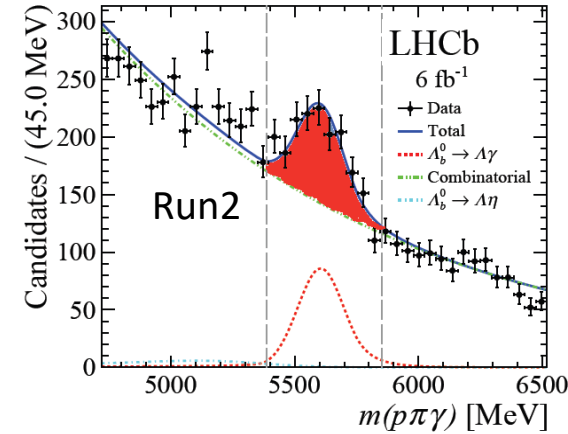


$B_s \rightarrow \phi \gamma$



PRL 123, (19) 081802

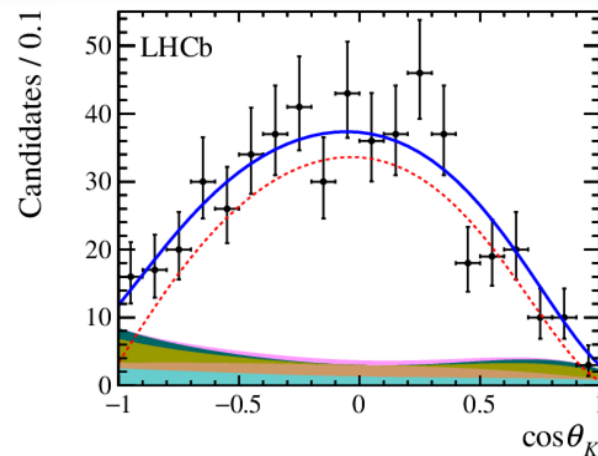
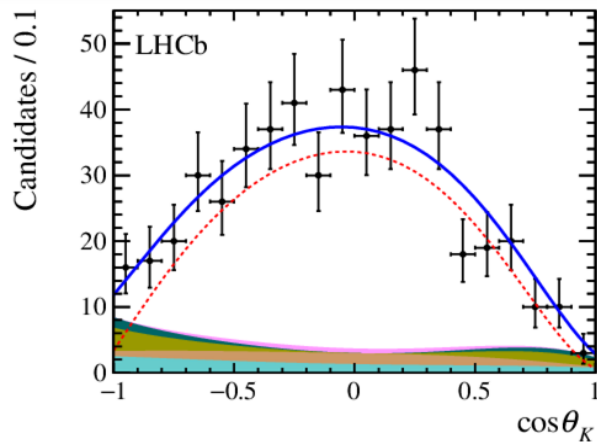
$\Lambda_b \rightarrow \Lambda \gamma$



PRD 105 (22) 5, L051104

Measurements of photon polarization, BRs, and CP with Run2 and Run3 data for Λ_b , Ξ_b , Ω_b

$B^0 \rightarrow K^* e e$ angular analysis



Angular observables sensitive to BSM contributions
Electrons in the final state lead to *bremstrahlung radiation*
Run 1 + 2 analysis (with Nikhef, UZH, IJCLAB, U. Milano)

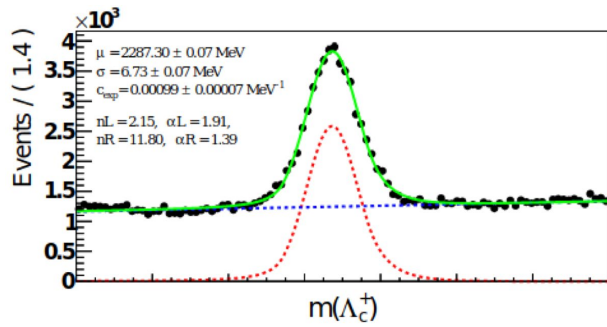
LHCb @ IFIC [Physics]



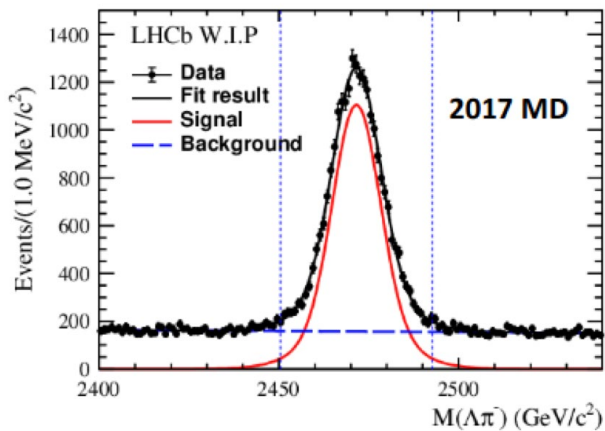
QCD, Spin Physics, g-2/EDM Λ baryon

Decay dynamics and (QCD & weak) polarization of multibody charm decays

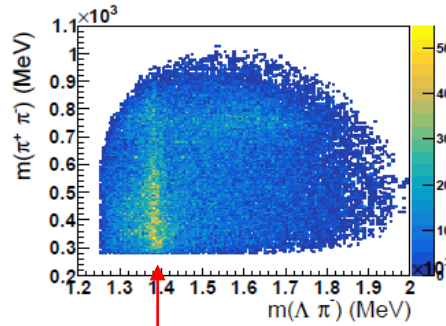
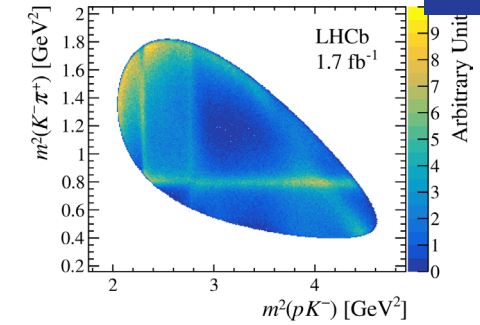
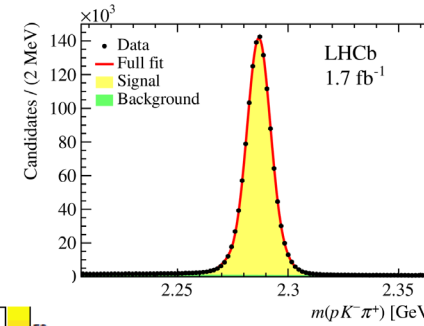
$\Lambda_c^+ \rightarrow \Lambda \pi^- 2\pi^+$ (pp, prompt)



$\Xi_c^{0(+)} \rightarrow \Xi^- \pi^+ (\pi^+)$ (pp, prompt)

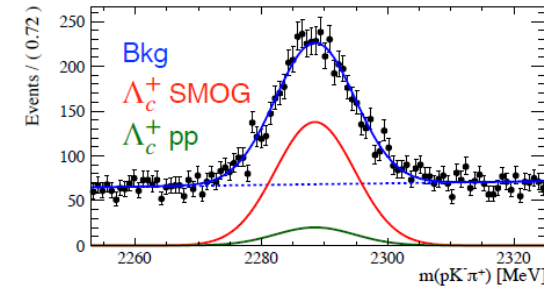


$\Lambda_c^+ / \Xi_c^+ \rightarrow pK^- \pi^+$ (pp, secondary & prompt)



$\Sigma^-(1385) +$ possible $\frac{1}{2}^-$ light pentaquark

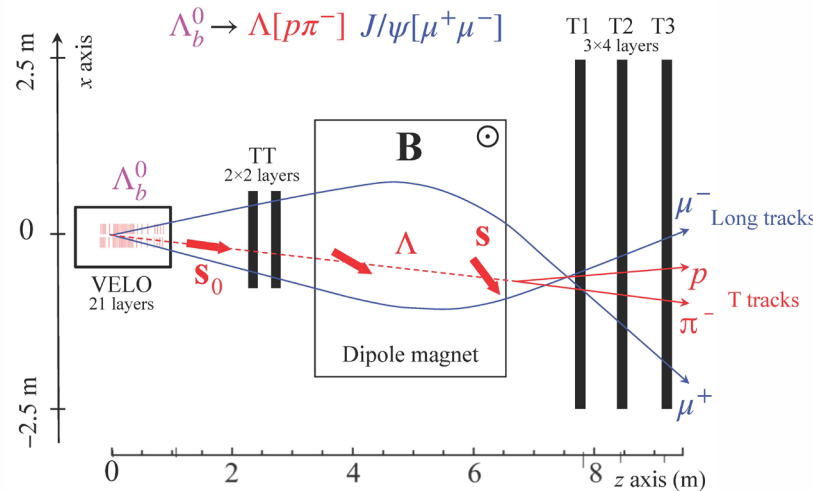
$\Lambda_c^+ \rightarrow pK^- \pi^+$ (SMOG pNe)



Phys.Rev.D 108 (2023) 1, 012023

Eur. Phys. J. C (2024),

arXiv:2211.10920

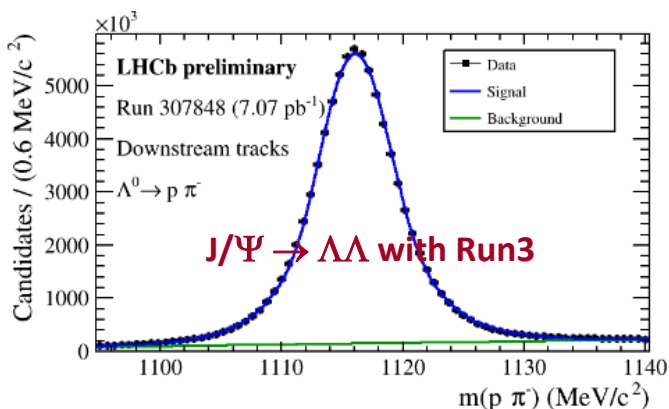


Polarization transfer to strange baryons

g-2/CPT test and EDM of polarized Λ baryons from charm baryons

LLPs and FIPs: Real Time Analysis (RTA) with GPUs (HLT1) and CPUs (HLT2)

In the SM, using *downstream tracks* (originated between 0.5- 2 m from IP):

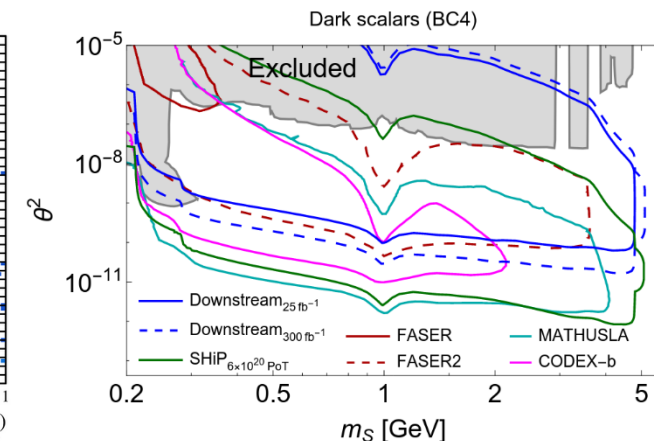
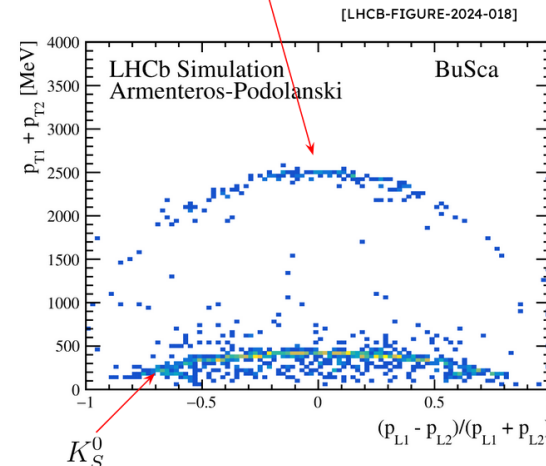
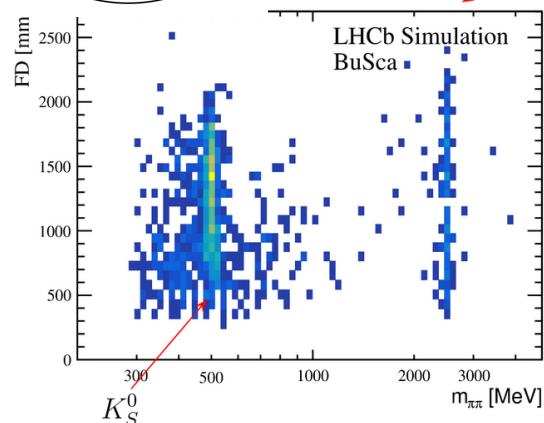


And beyond:

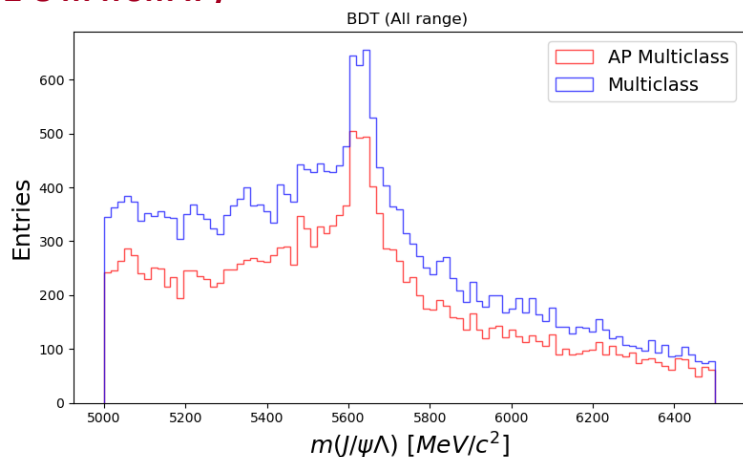
[CHEP'24]

hypothetical BSM particle

[Eur.Phys.J.C 84 (2024)6, 608]



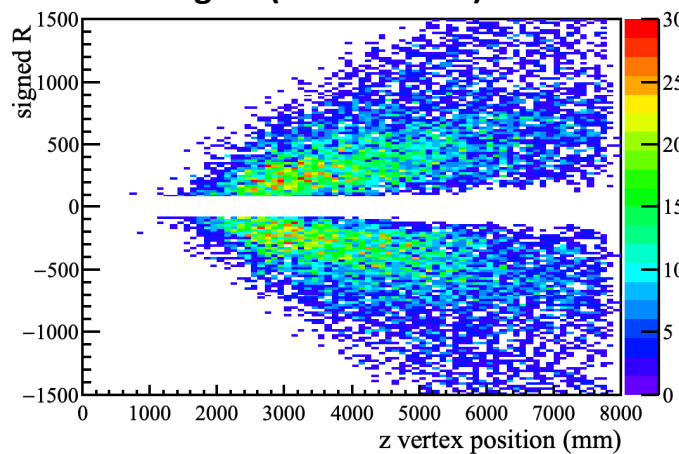
In the SM, using *T tracks* (originated between 2-8 m from IP)



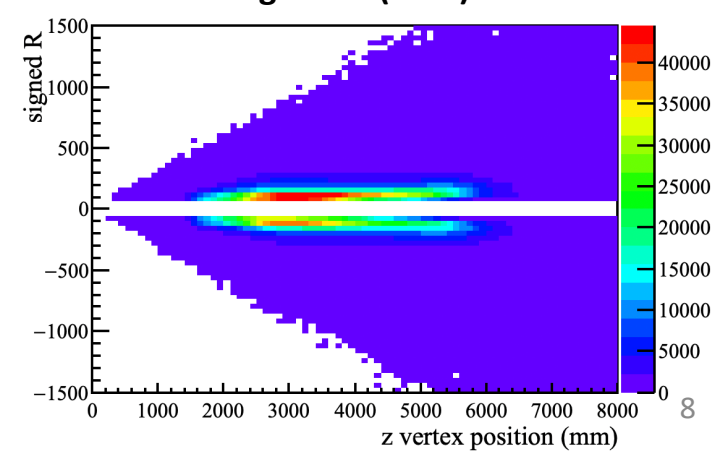
$\Lambda_b \rightarrow J/\Psi\Lambda$ with Run3

And beyond, eg. Dark H $\rightarrow \mu\mu$:

Signal (Monte Carlo)

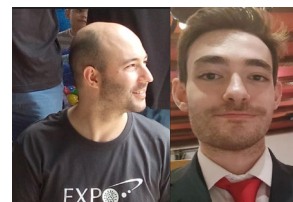
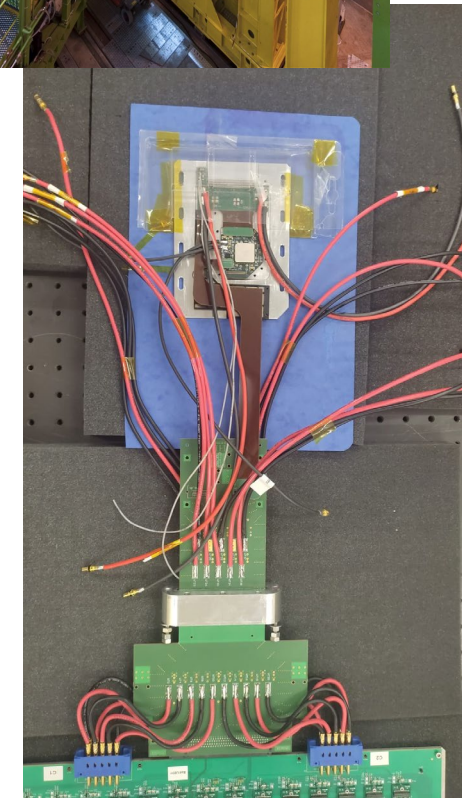
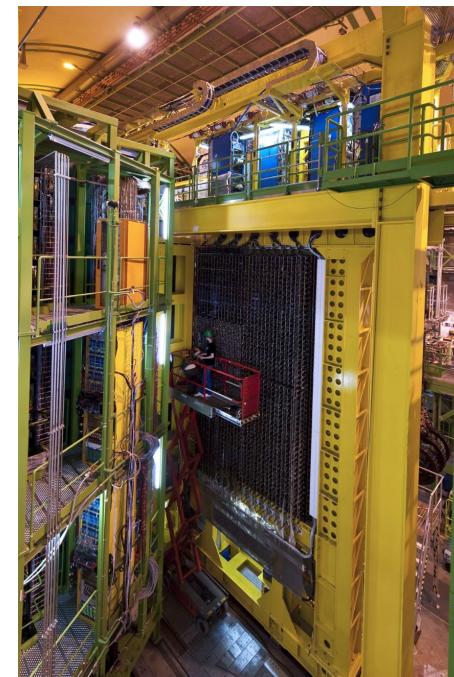


Background (data)



LHCb @ IFIC [Detector electronics]

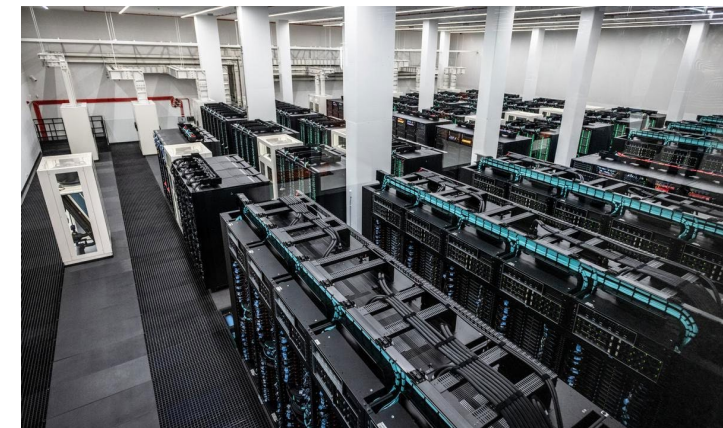
- **Upgrade Ib/2 Electromagnetic Calorimeter (PicoCal) readout electronics**
 - ASIC/chipset in TSMC 65nm with separate energy and timing processing
 - Amplifier + Shaper circuit included on the PMT base or FEB to compensate cable attenuation, improve SNR, if necessary, and reduce spill-over effort
 - Energy ASIC (ICECAL65) designed by IFIC, UPC and UB
- **PACIFIC++ chip for downstream tracker Upgrade 2 (Mighty Tracker)**
 - Analog processing chain, Multi-channel, Complex digital (digitization/clustering/timing), IpGBT control/direct connection
- **TWOCRIST proof-of-principle for ALADDIN Project (), recently approved by LHC Committee to move to Technical Proposal**
 - Flexes & integration with hybrid inside Roman Pot
 - Monitoring system (temp. & humidity inside RP)
 - HV/LV powering & distribution in LHC tunnel: power supplies, patch panels, ~300 m cabling



LHCb @ IFIC [Central Offline Computing]

- **Contributions to LHCb computing**

- Tier-1 Spain LHCb contact
- LHCb computing development and operations



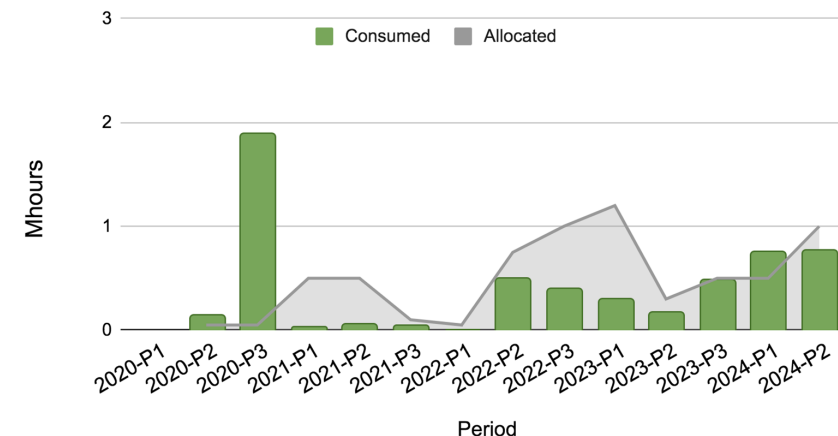
- **Finished tender to upgrade HLT2 CERN cluster in 2025**

- 56 Computing Nodes (x86_64) with 29k SPECrate2017_int power.

- **Usage of non-pledged resources at BSC MareNostrum 5**

- MN5: ~17 times previous MN4 => ~200 petaflops
- 730k CPU cores - 112 cores/node - 250 PB GPFS disk storage
- 3 Calls per year for Resources requested by (X. Vilasis-Ramon Lull)
~750k CPU Hours per call.
- IFIC contribution to LHCb services operation.

LHCb



- **Contributions to Grid Interware (LHCb + used by other experiments)**



- Using modern standards and tools



- **Usage of CERN resources + Testbed at IFIC**



Track reconstruction:

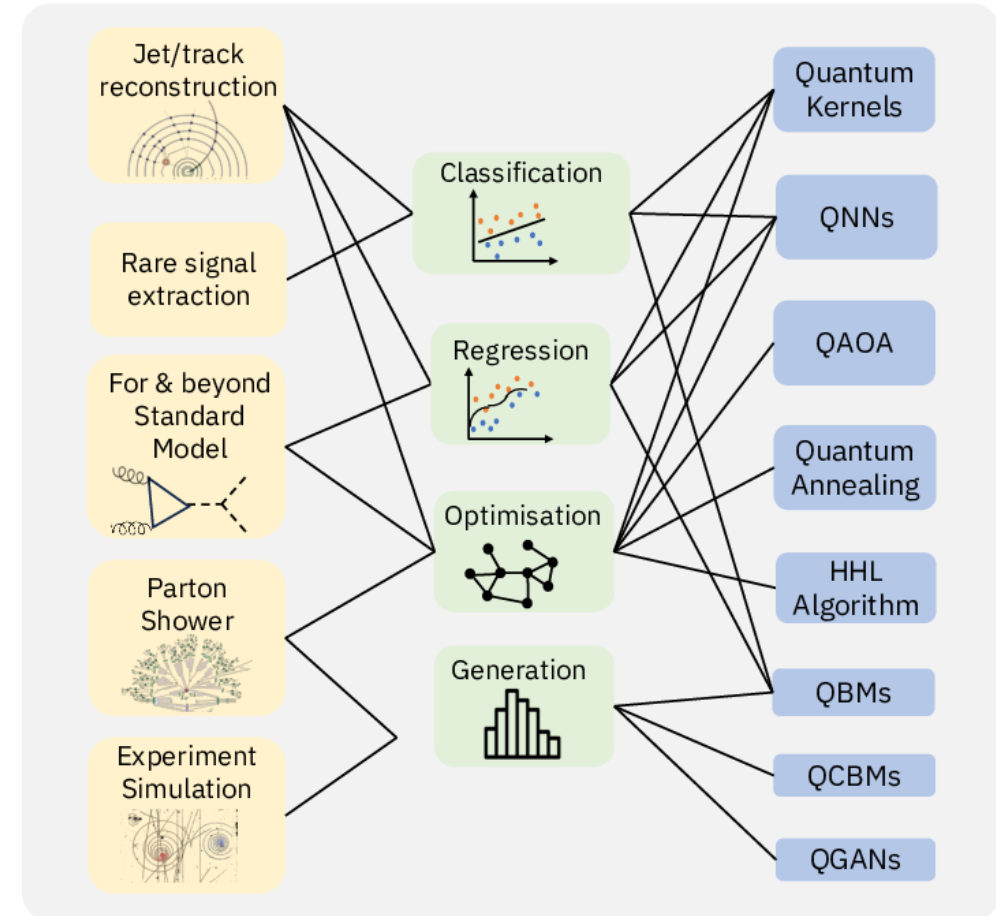
- Mostly global methods → *clustering algorithms*
 - Minimization of Ising-like Hamiltonian
- Good results with [HHL](#) for LHCb, working on improving performance on hardware [[JINST 18 \(2023\) 11, P11028](#)]
- Quantum variational algorithms also investigated at [DESY](#) [[Comput.Soft.Big Sci 7 \(2023\) 1, 14](#)]
- Work ongoing using [QAOA](#) [[arXiv:1411.4028](#)] and **Quantum annealers**

Experiment simulation:

- Using [qGANS](#) [[arXiv:1804.08641](#)] for calorimeter simulation at LHCb

b-jet tagging at LHCb:

- Currently studying the entropy to enhance performance of [initial results](#) [[JHEP 08 \(2022\) 014](#)]



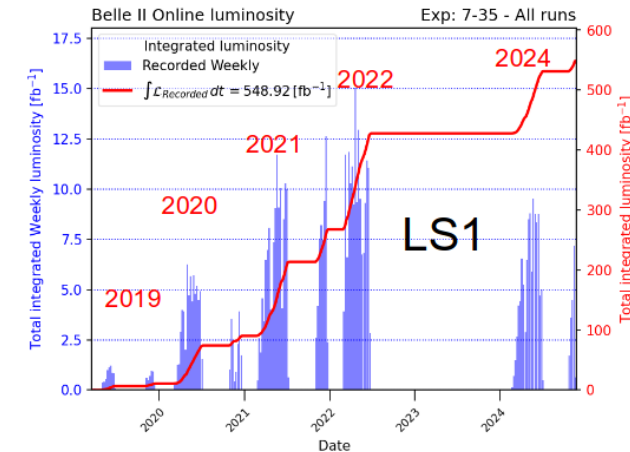
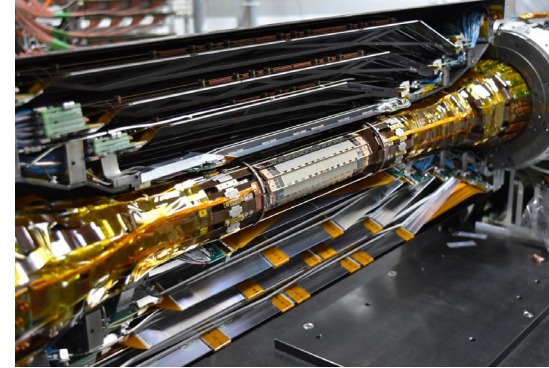
[Summary of the QC4HEP WG](#)
[[PRX Quantum 5 \(2024\) 3, 037001](#)]

Belle II @ IFIC in 2024 [Detector and Physics]

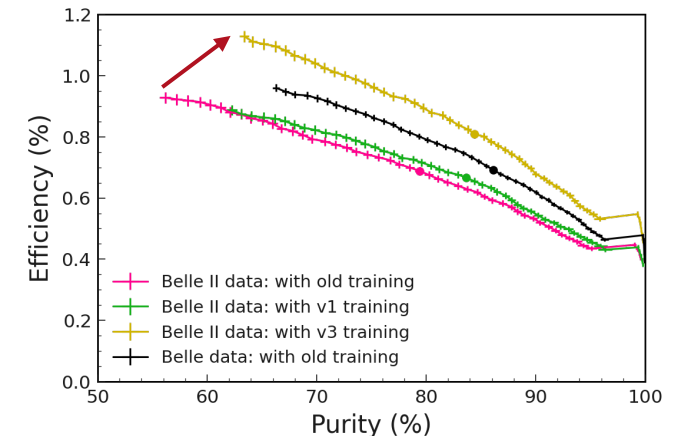
Group leaders: Carlos Mariñas (Technical Coordinator)

Vidya Sagar Vobbiliseti (Analysis tools convener and Software trigger librarian)

- Responsible for all detector systems and data taking performance.
 - Completion of detector upgrade in LS1
 - Peak luminosity: $4.71 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ (world record)
- Software maintenance for faster trigger and efficient data analysis
- Physics in L3 flavor and quark matter:
 - Search for rare $B^+ \rightarrow K^+ \tau \tau$ decay, sensitive to new physics enhancement → Targeting Moriond 2025.
 - Improving the B-tagging technique to search for more missing energy decays



Higher efficiency of B-tagging at same purity!



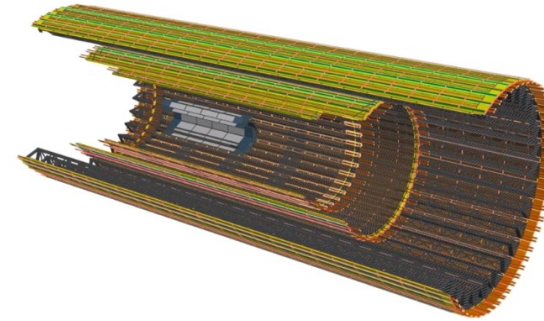
Belle II @ IFIC in 2024 [Upgrade and Performance]

Group leaders: Carlos Mariñas (Upgrade Coordinator)

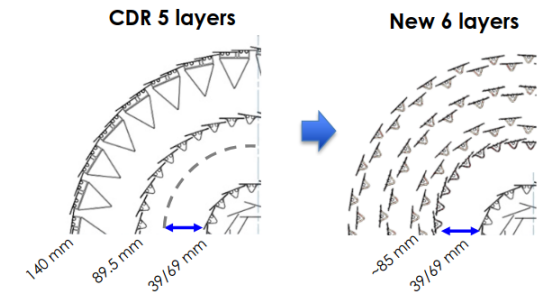
Vidya Sagar Vobbiliseti (Vertex upgrade performance leader)

Connected to L7: Advanced instrumentation and computing in fundamental physics

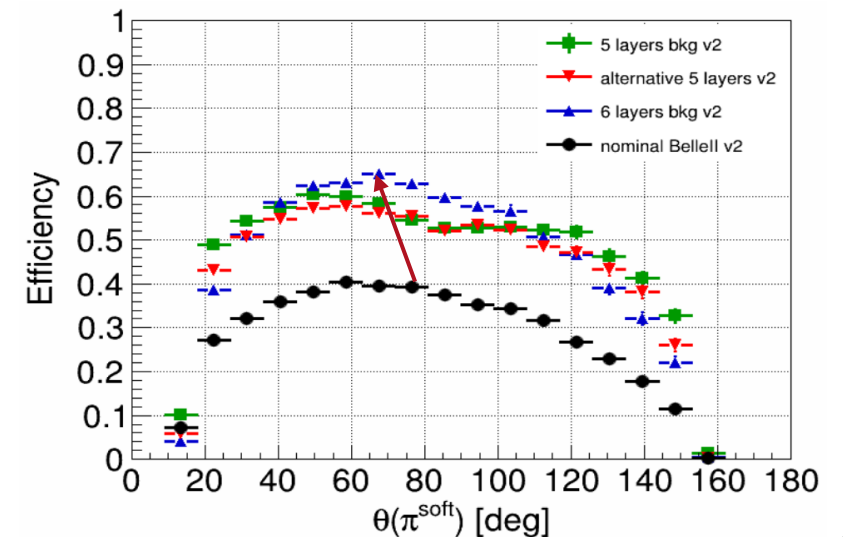
- Leading the Belle's upgrade program with special focus on the vertex detector.
- Expected to significantly improve vertex resolution, tracking precision, and particle identification capabilities
 - Enabling more sensitive measurements of rare decays and CP violation processes.
- Also, in charge of the vertex detector upgrade demonstrator for e^+e^- environments, linked to our SO initiative.



Optimizing the geometry



Higher efficiency of slow pions (< 250 MeV/c)

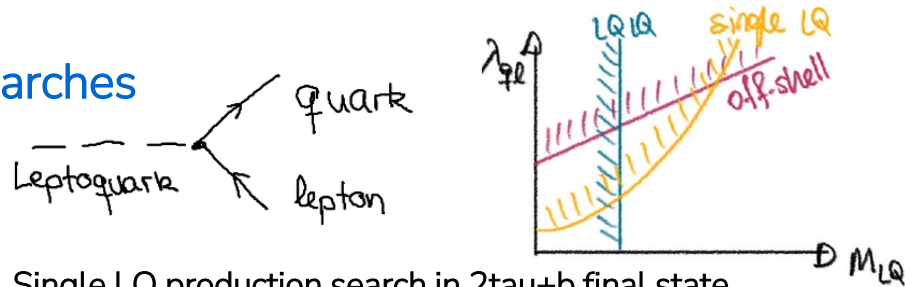


Leptoquarks and LFU in Higgs

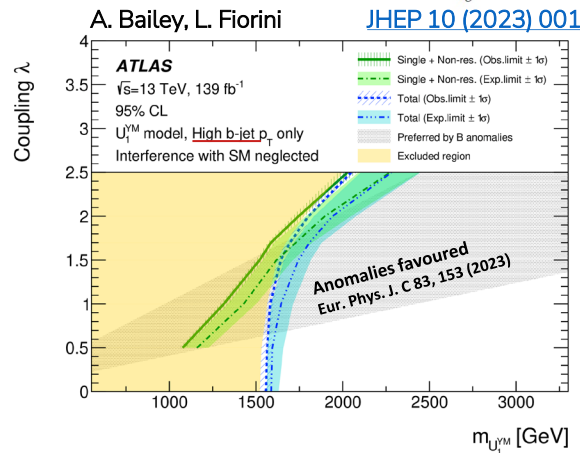
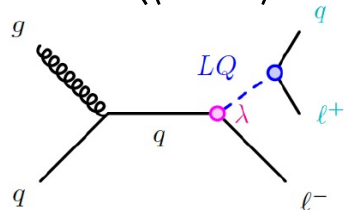
Contributors: K. Amos, L. Fiorini, A. Gomez, T. Zarareishvili



Leptoquark searches



Single LQ production search in 2tau+b final state
tauLQ(->btau)



Vec LQ (Q=2/3e, YM, BR=0.5)
95% UL:
 $m_{LQ} > 2.05 \text{ TeV}$ for $\lambda_{LQ} = 2.5$

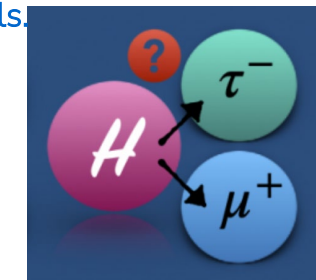
Lepton Flavour Violation in Higgs

$$\mathcal{L}_Y = -m_i \bar{f}_L^i f_R^i - Y_{ij} (\bar{f}_L^i f_R^j) h + h.c. + \dots,$$

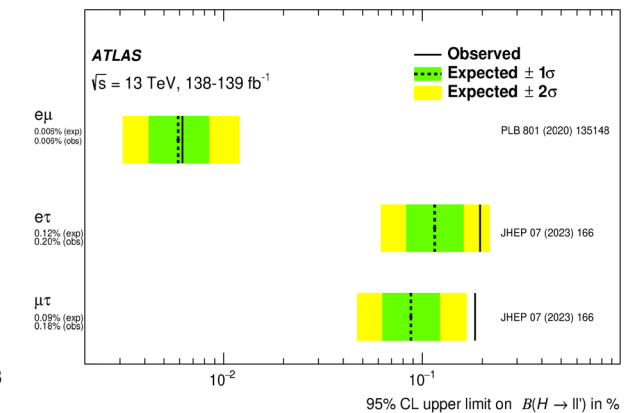
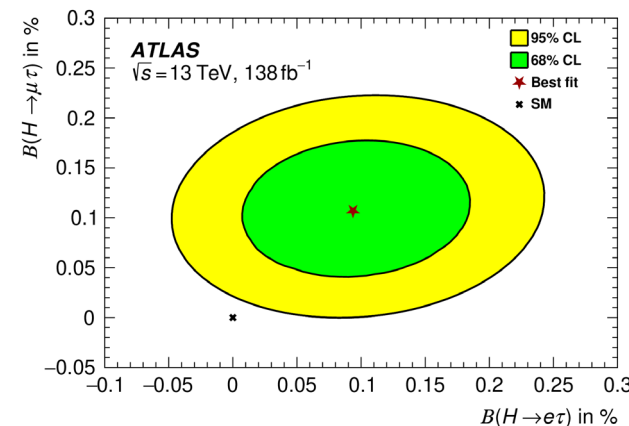
Accidental symmetry in SM: $Y_{ij} = (m_i/v)\delta_{ij}$

but broken in many BSM models.

Search for Higgs decay into $H \rightarrow e\tau$ and $H \rightarrow \mu\tau$ with Run 2 data. Now working on Run2+Run3 analysis.



JHEP 07 (2023) 166

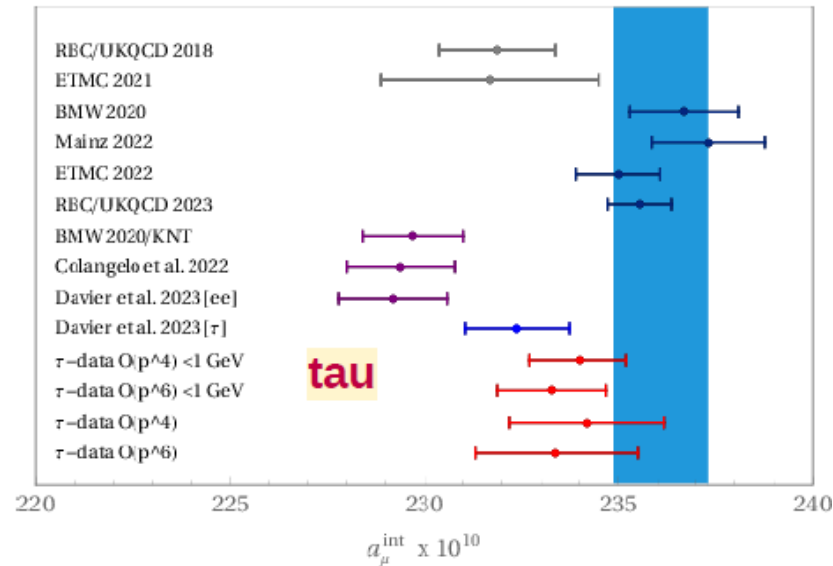
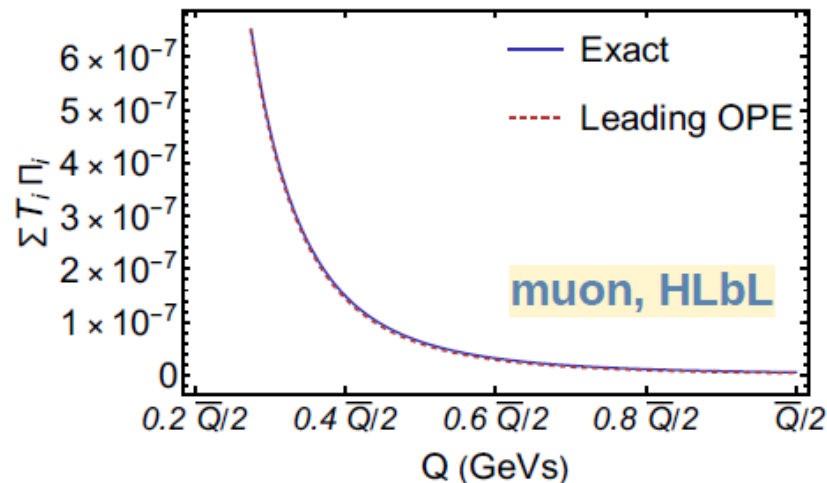
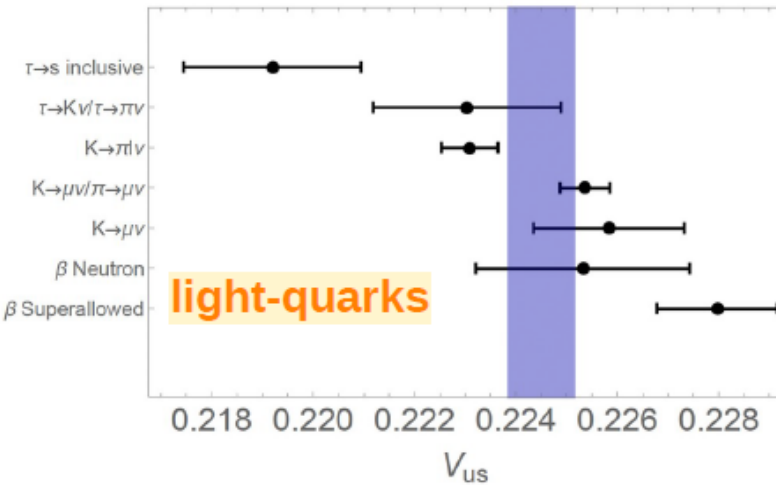


Flavor @

LHCPHENO Theory Group

Our group is active on the study of:

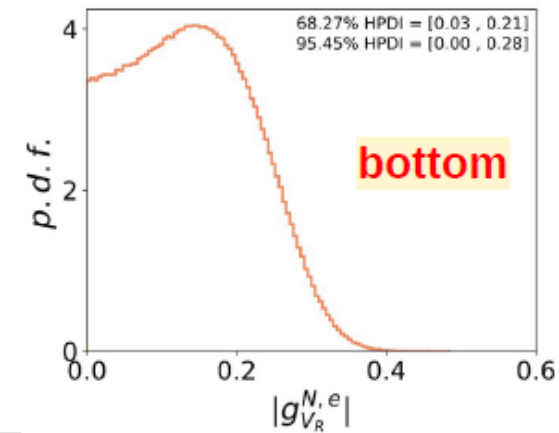
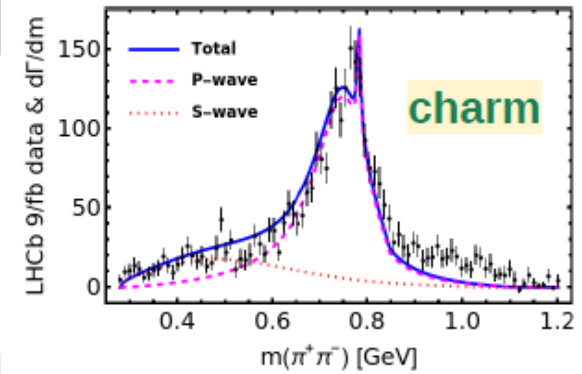
- **light-quark** semileptonic decays (V_{ud} , V_{us}), where several tensions are currently present [David Díaz-Calderón's PhD thesis (2024)]
- contributions of the HLbL integral involving large loop momenta, thus improving the SM **muon** $g-2$ prediction [Rodríguez-Sánchez et al. 2411.09578]
- several hadronic contributions to a_μ , reviving the use of **tau** data for the leading one [Roig et al. PLB 850 (2024) 138492]



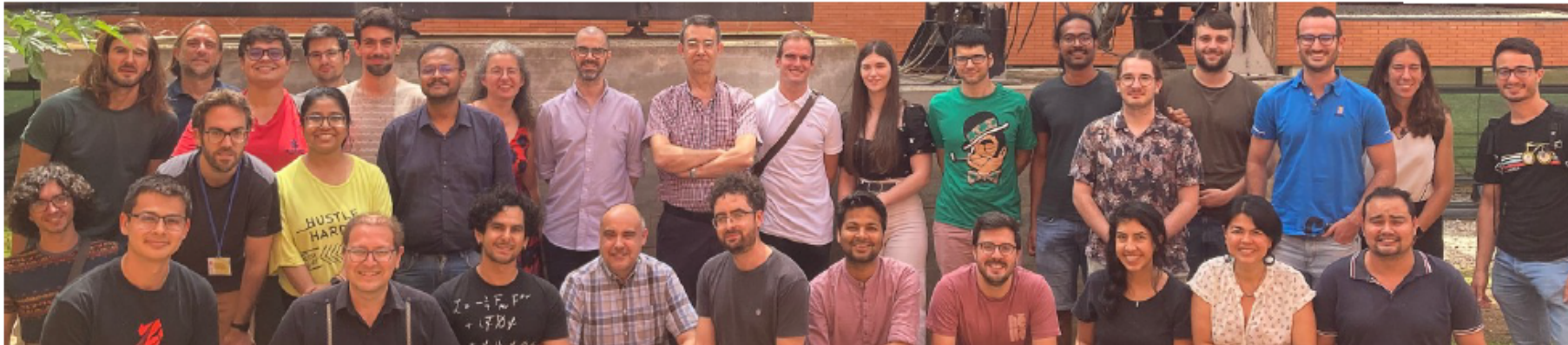
Flavor @

LHCPHENO Theory Group

- non-perturbative QCD dynamics in measurements of CP violation and rare decays in the **charm** sector [Eleftheria Solomonidi's PhD thesis (2024)]
- bounds on NP couplings to heavy sterile neutrinos inferred from the recent Belle angular analysis of **bottom** meson decays ($B \rightarrow D^* \ell \nu$, $\ell = e, \mu$) [Fedele et al. 2410.11945 (JHEP)]
- baryon number violation mediated by higher dimensional operators carrying the **top** flavor [Gisbert, Rodríguez-Sánchez, Vale Silva 2409.00218]



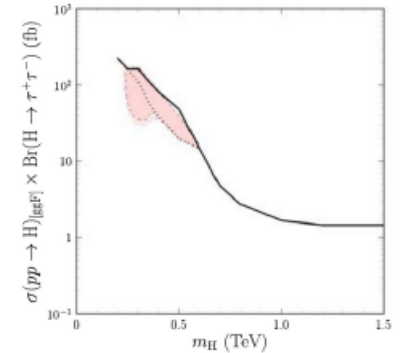
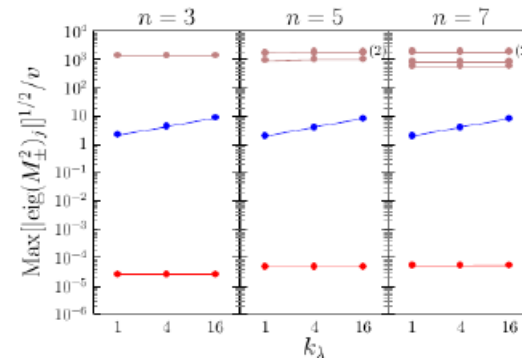
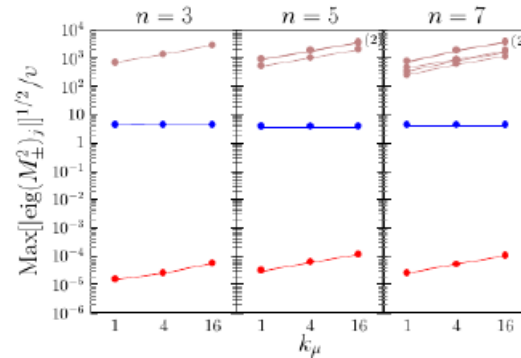
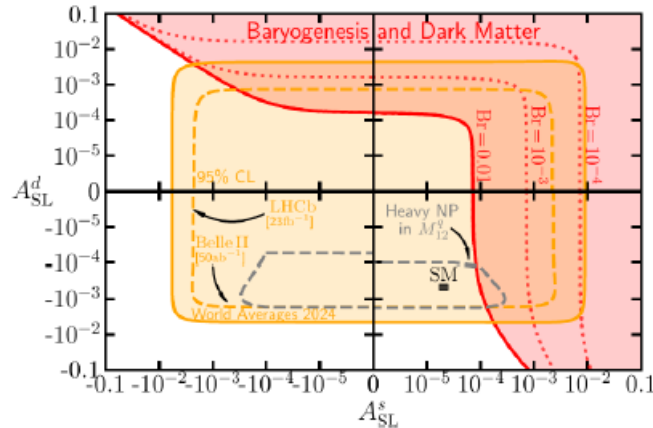
LHCpheno
summer '24
meeting



Elementary particles: the Standard Model and beyond

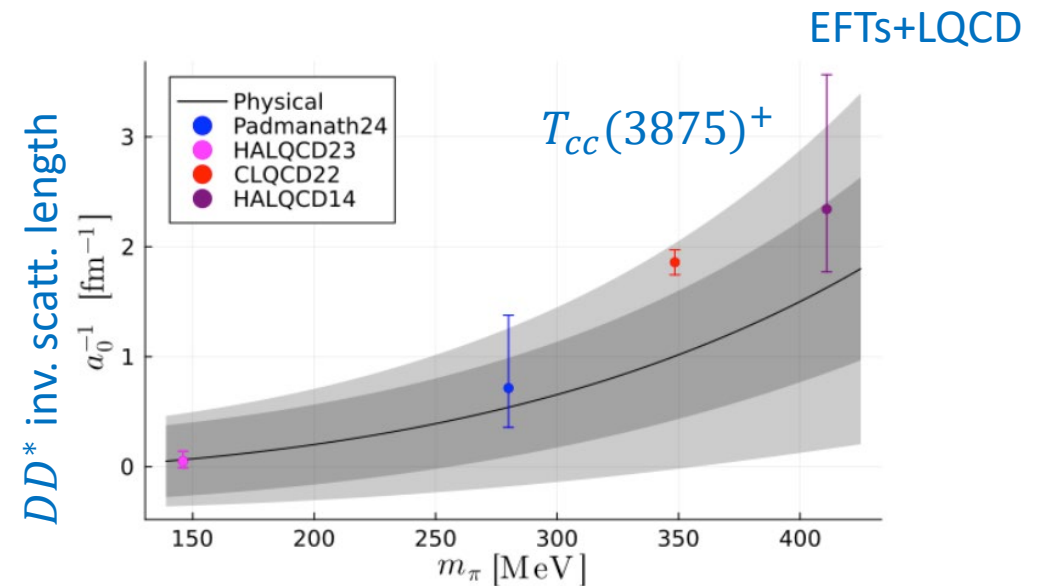
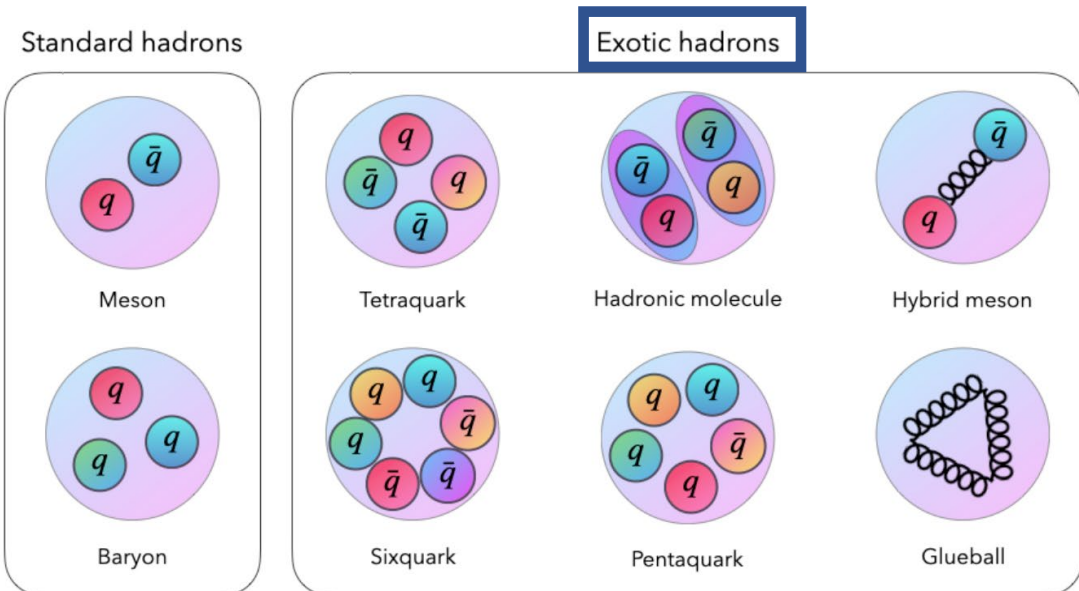
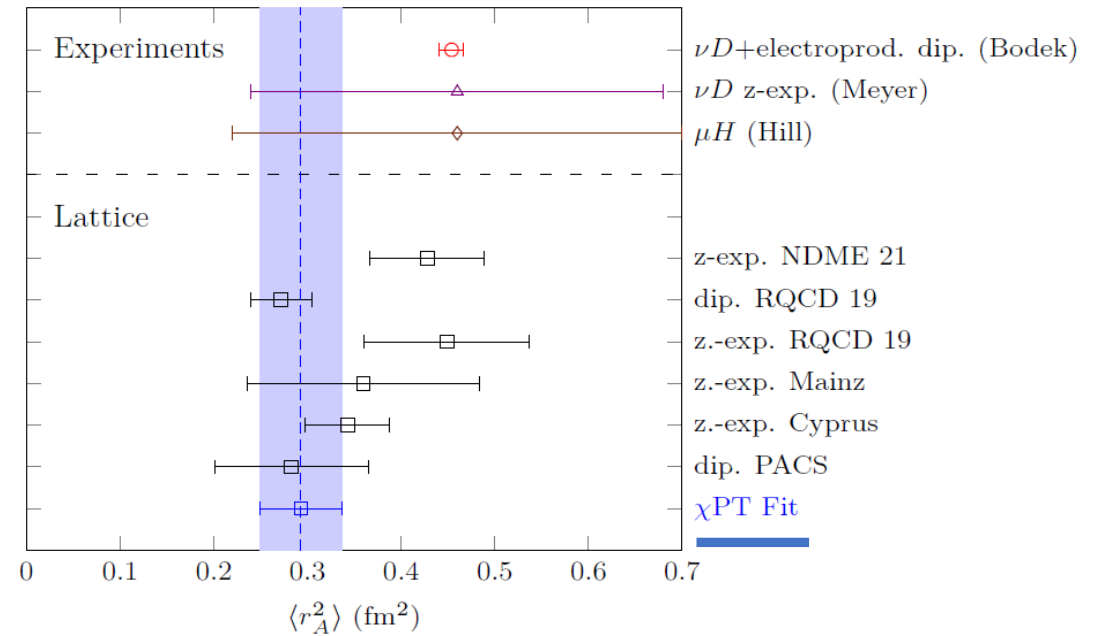
Activities

- *Flavon vacuum alignment beyond SUSY* (Phys.Rev.D 110 (2024) 1, 015009)
C. Hagedorn, M.L. López-Ibáñez, M. Jay Perez, M. Hossain, **O. Vives**
- *CP violation in neutral B mixings, implications for baryogenesis* (arXiv:2410.13936)
C. Miró, M. Escudero, **M. Nebot**
- *Light states in real multi-Higgs models with spontaneous CP violation* (arXiv:2411.00084)
C. Miró, **M. Nebot**, **D. Queiroz**
- *New physics hints from τ scalar interactions and $(g - 2)_e, \mu$* (J.Phys.G 51 (2024) 2, 025001)
F.J. Botella, **F. Cornet-Gómez**, **C. Miró**, **M. Nebot**



Effective field theories in hadron and nuclear physics

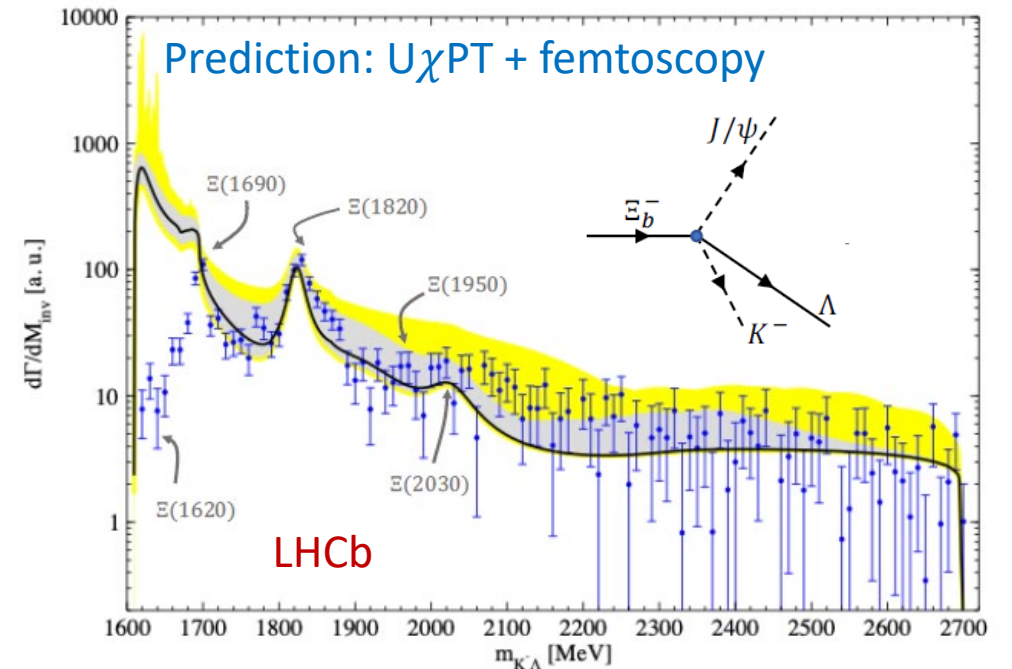
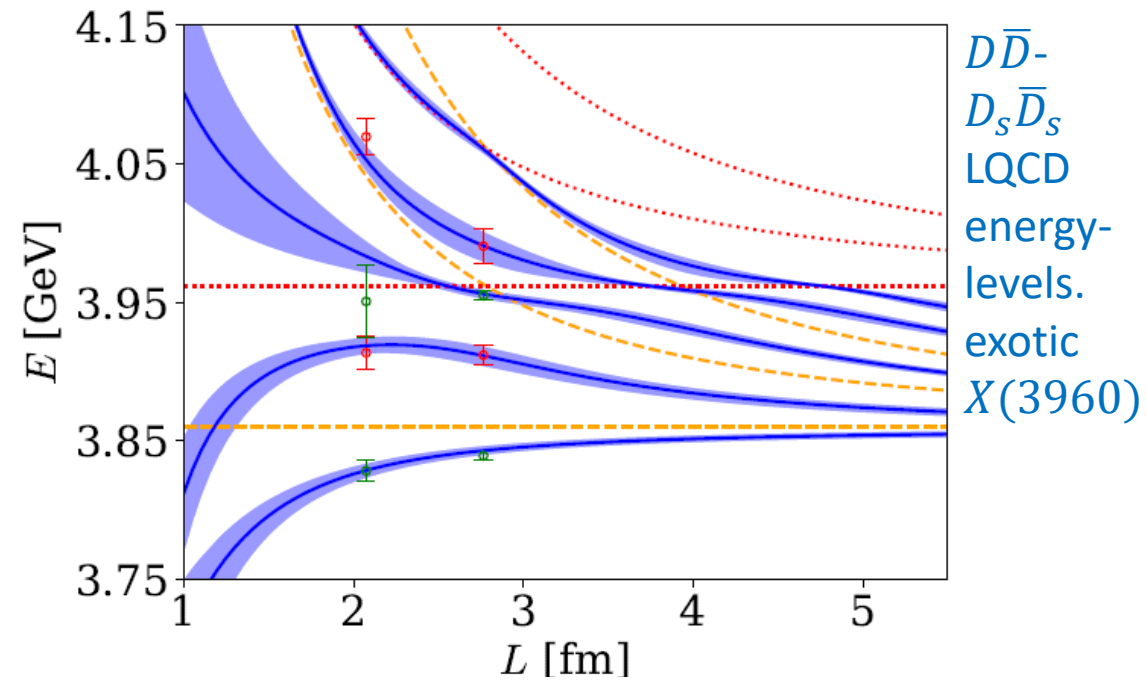
- Nucleon axial and electromagnetic form-factors [Fernando Alvarado's PhD thesis (2024), supervised by L. Álvarez-Ruso]
- Quark mass dependence of hadron resonances [Fernando Gil's PhD thesis (2024), supervised by R. Molina]



- P-wave charmonium contribution to hidden-charm states from lattice QCD [Shi et al., 2410.19563]
- Bridging correlation and spectroscopy measurements to access the hadron interaction behind molecular states: the case of the $\Xi(1620)$ and $\Xi(1690)$ in the $K\Lambda$ system [Feijoo et al, 2411.10245]

Co-organized Workshops

- [Excited QCD 2024](#)
- [2nd @FlipPhysics](#)



*Feliz Navidad
y próspero año
nuevo*

