



# IFAE Theory Division

李政道研究所  
TSUNG-DAO LEE INSTITUTE

**Tsung-Dao Lee Institute visit**  
**May 18th 2026**

**Oriol Pujolàs, IFAE**

# TH Division Members

Faculty: 12

Postdocs: 8

PhD students: 12

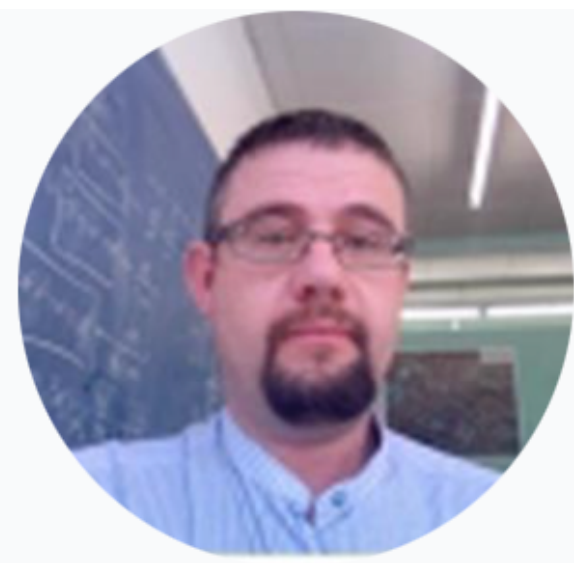
Visitors: >> 1

# Faculty



Diego Blas

**ICREA**  
**IFAE**



Rafel Escribano

**UAB**



Pere Masjuan

**UAB**



Eduard Masso

**UAB**



Joaquim Matias

**UAB**



Santi Peris

**UAB**



Toni Pineda

**UAB**



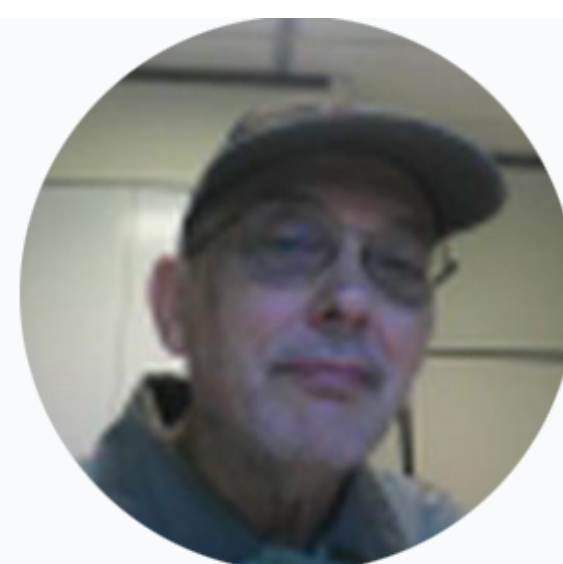
Àlex Pomarol

**UAB**



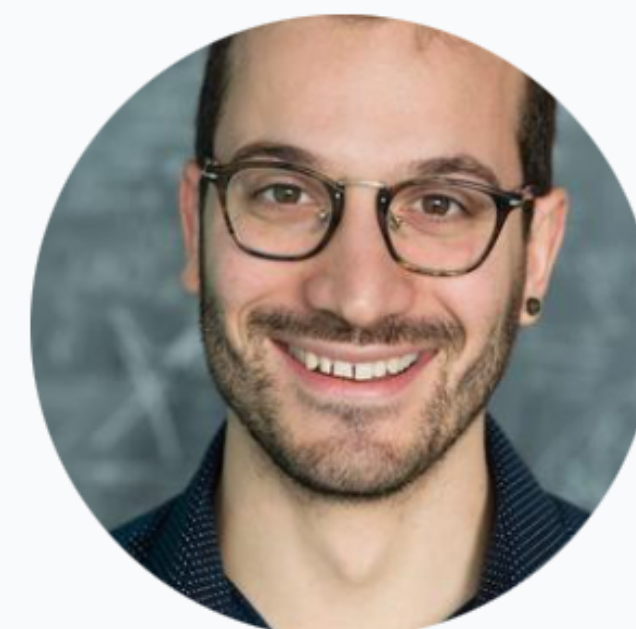
Oriol Pujolàs

**IFAE**



Mariano Quirós

**IFAE**



Fabrizio Rompineve

**UAB**



Andrea Wulzer

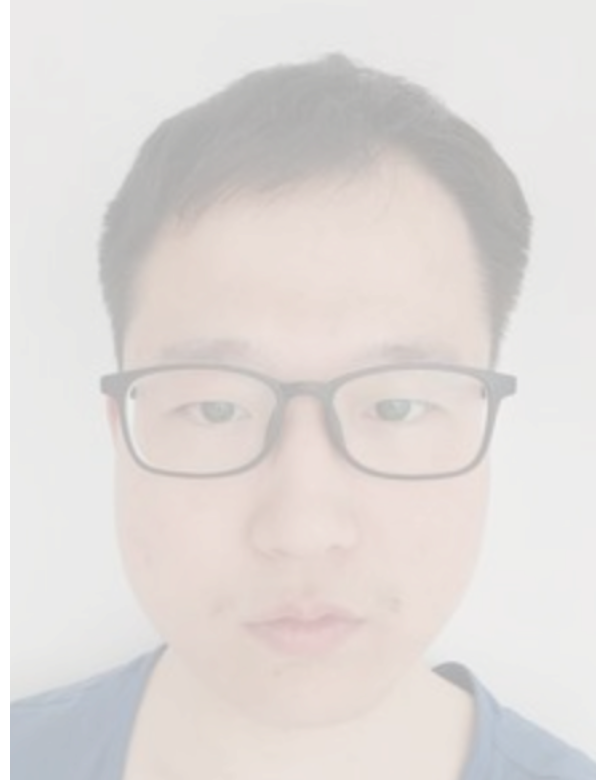
**ICREA IFAE**



Ennio Salvioni

**UAB**

# Postdocs 2025-2026



**Ziyu Dong**



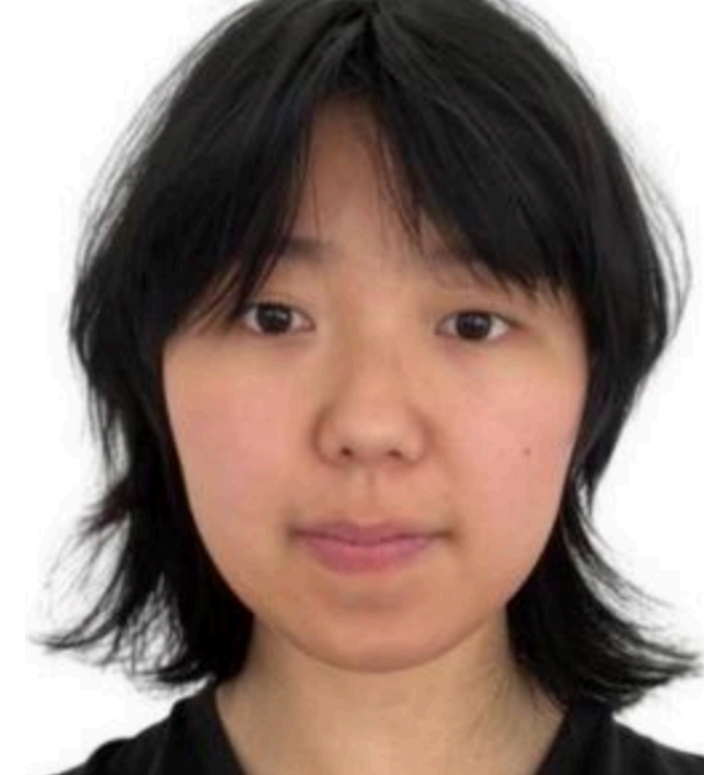
**Jordan Gué**



**Andreas Maier**



**J.S. Valbuena**  
JdC2024



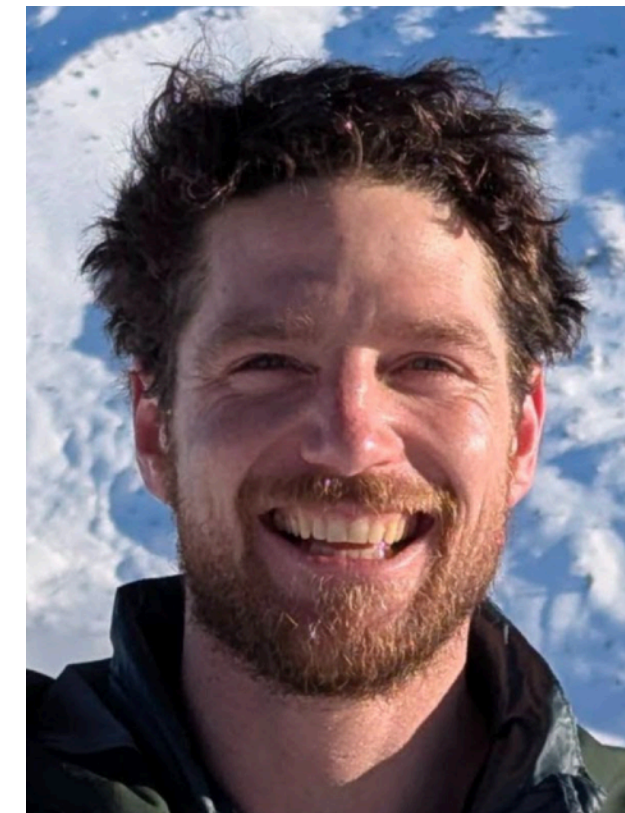
**Xiao Xue**



**Dorian Amaral**  
ERC



**Saarik Kalia**  
ERC



**Stefan Stelzl**



**Pablo Sesma**

# Predocs 2025-2026



**G Baltà**



**D Barbini**

FPI2024



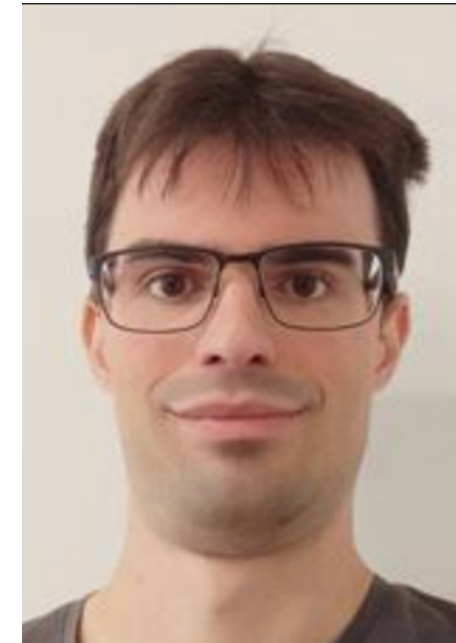
**Y Borysenkova**

ERC



**B Duch**

FI2024

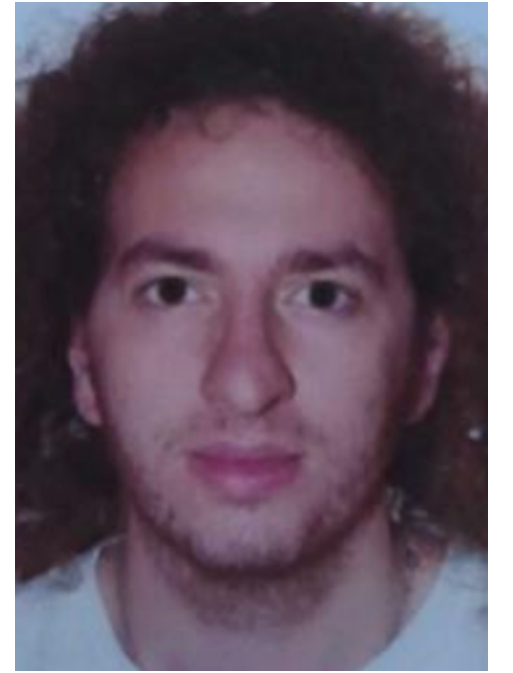


**H Cancio**



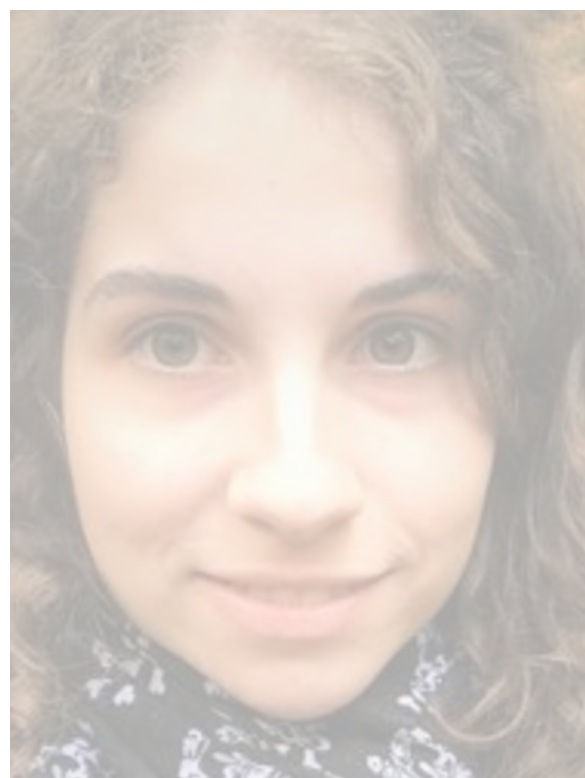
**N Duarte**

FPU2024



**F Montagno**

FI2023



**C Fernandez**



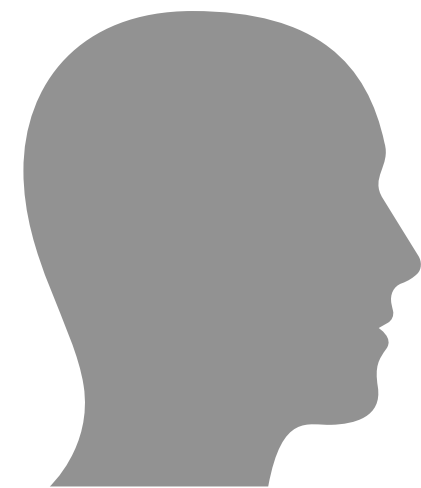
**S Gasparotto**

FI-SDUR22



**T Rivera**

FPI SO24



**E Diaz**

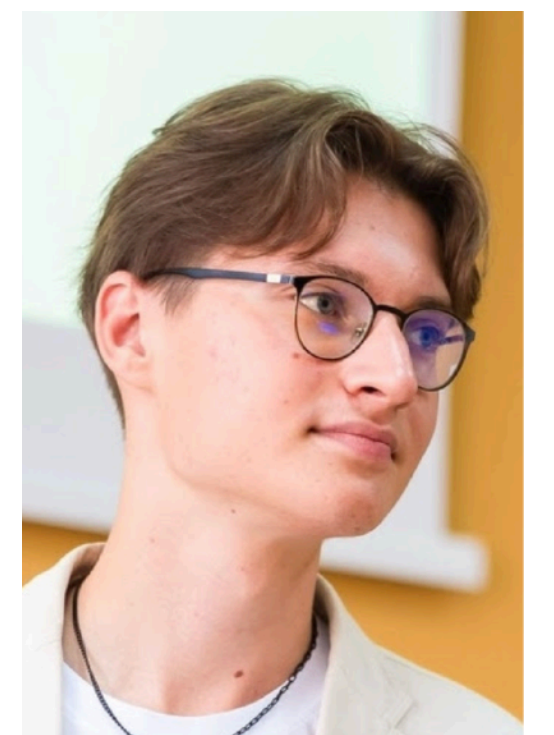


**F Sciotti**



**E Dallari**

RyC@UAB



**T Kvietkauskas**

ERC

# Visitors 2025-2026



**Maarten Golterman**  
San Francisco State U

**1 yr sabbatical**



**Mark Hertzberg**  
Tufts University, Boston

**1 month**

# Visitors 2025-2026

**Jaehoon Jeong**, Korea Inst. Advanced Study, Seoul

visiting **postdoc** – **1 yr**

**Yue-Hui Yao**, ICTP-AP, Beijing, CSC Scholarship

visiting **PhD student** – **6 month**

**Giulio Marino**, U. Pisa

visiting **PhD student** – **3 month**

**Matteo Borrello**, INFN Florence U

visiting **PhD student** – **3 month**

**+ seminar speaker program**

# Research topics

We are among the largest european TH groups

with **overall coherent goal: physics Beyond the SM**

**Close to experiment, phenomenology, not purely formal**

**Tuned to EXP:** GWs, gal. surveys, CMB, DM, colliders, precision, lattice

**Challenges & oportunities:** future colliders, GW concepts, theory developments, AI/ML for HEP, synergies across fields.

Strong connection with **CERN** among other european institutions

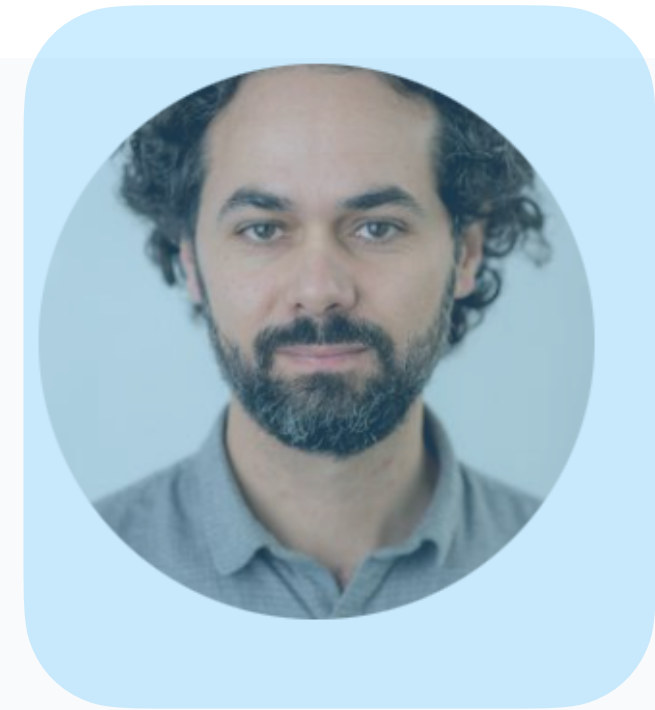
## **Topic**

- **GW physics**
- **Early Universe frontier**
- **DM searches**
- **Collider physics, future colliders**
- **Formal aspects, AdS/CFT**
- **Non-perturbative QCD**
- **Meson & hadronic physics**
- **Flavor anomalies**

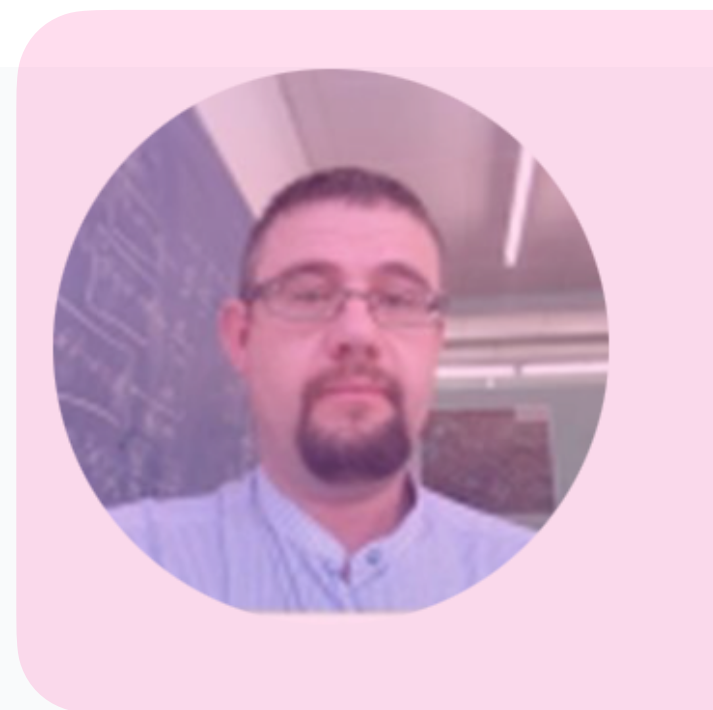
## **Seniors**

- **Blas, Pujolas, Rompineve**
- **Pujolas, Quiros, Rompineve**
- **Blas, Salvioni, Masso**
- **Salvioni, Wulzer**
- **Pomarol, Wulzer, Pujolas**
- **Pineda, Peris**
- **Escribano, Matias, Peris, Masjuan**
- **Matias, Masjuan**

# SM BSM



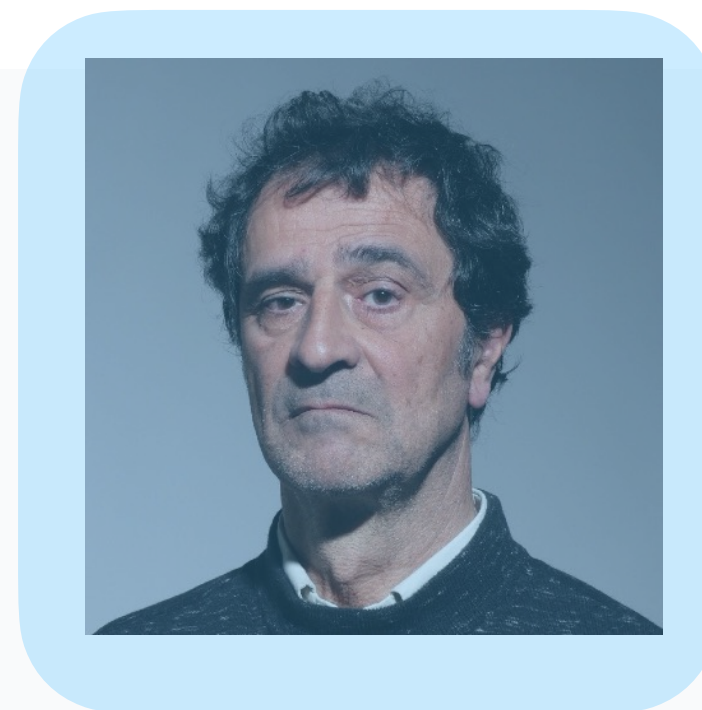
Diego Blas



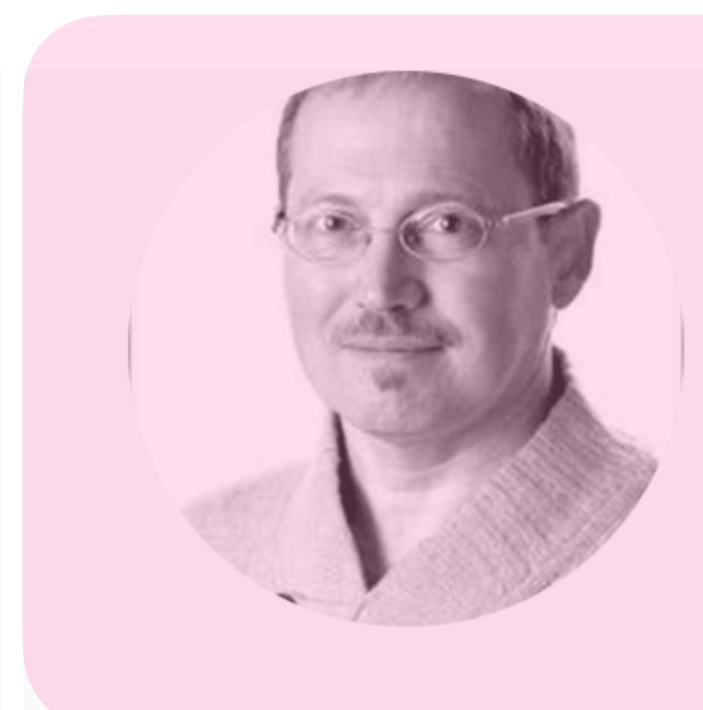
Rafel Escribano



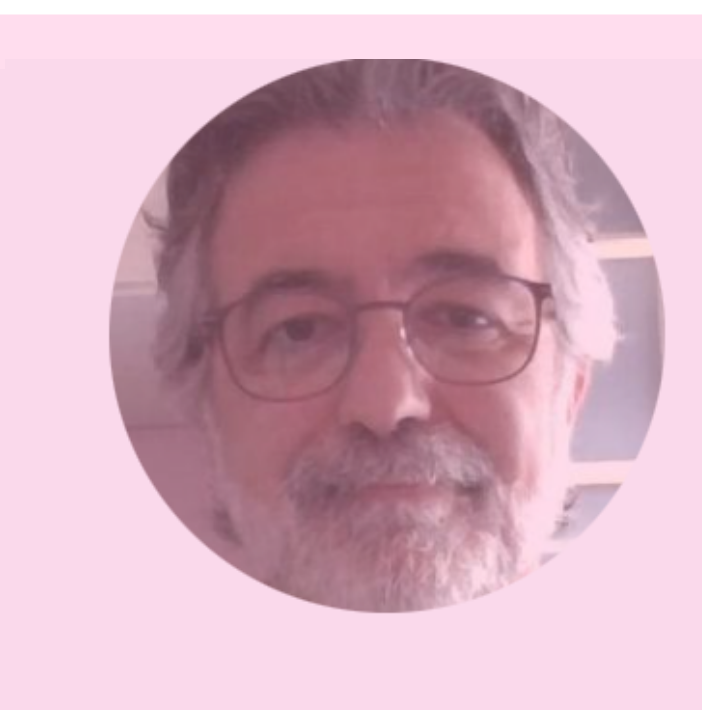
Pere Masjuan



Eduard Masso



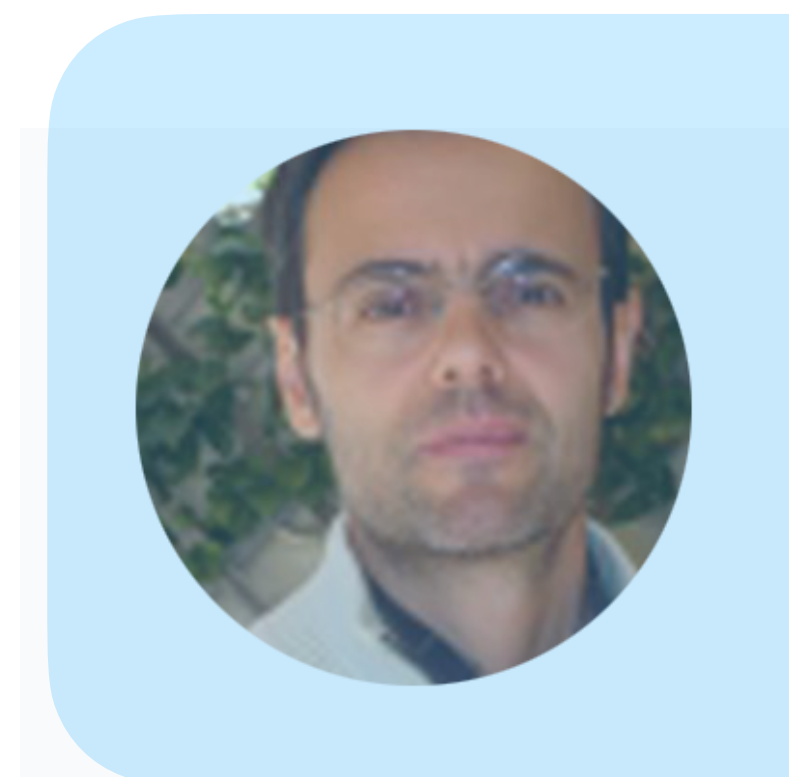
Joaquim Matias



Santi Peris



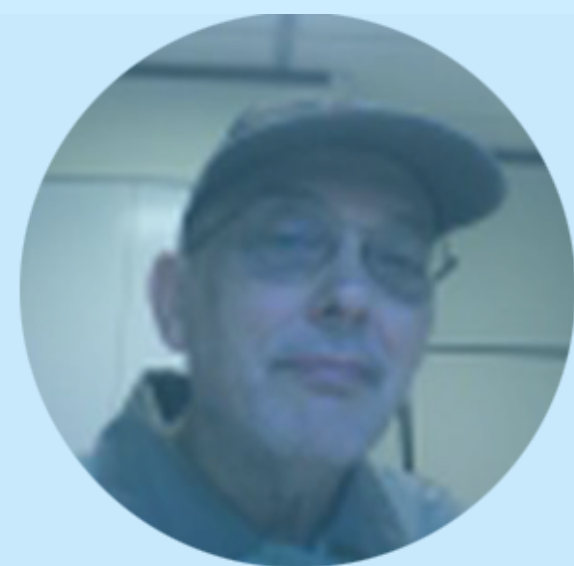
Toni Pineda



Àlex Pomarol



Oriol Pujolàs



Mariano Quirós



Fabrizio Rompineve



Andrea Wulzer



Ennio Salvioni

# Rafel Escribano

**Low energies strong interactions phenomenology**, especially eta and eta' mesons.

- 1) EFT and phenomenological models based on chiral symmetry
- 2) the study of (scalar, pseudoscalar and vector mesons)-mediated strong processes
- 3) decays of D and B mesons and of tau leptons.

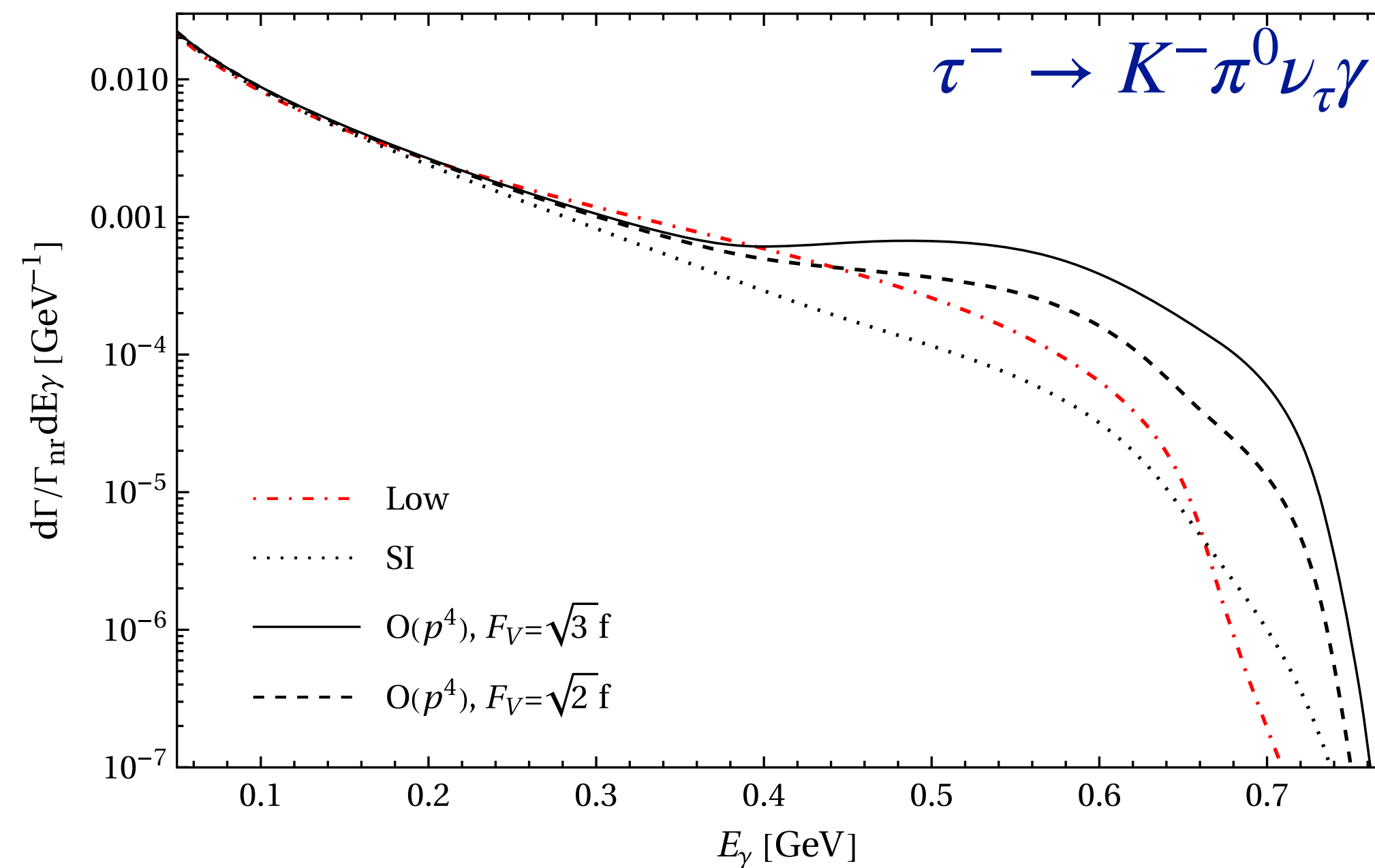
Team: S. González-Solís, P. Masjuan, P. Roig, E. Royo and P. Sánchez-Puertas.

## Radiative corrections to $\tau^- \rightarrow (P_1 P_2)^- \nu_\tau$ ( $P_{1,2} = \pi, K$ ) decays

R. Escribano, J. A. Miranda and P. Roig, Phys. Rev. D109 (2024) 053003

**Structure-dependent real photon** corrections calculated for the first time using Resonance Chiral Theory

These results allow for precise tests of **CKM unitarity**, **lepton flavor universality** and **non-standard interactions**



$$\Gamma_{PP(\gamma)} = \frac{G_F^2 S_{EW} m_\tau^5}{96\pi^3} |V_{uD} F_+(0)|^2 I_{PP}^\tau (1 + \delta_{EM}^{PP})^2$$

$$\delta_{EM}^{K^-\pi^0} = -(0.009_{-0.118}^{+0.010}), \quad \delta_{EM}^{\bar{K}^0\pi^-} = -(0.166_{-0.157}^{+0.100})$$

$$\delta_{EM}^{K^-K^0} = -(0.030_{-0.180}^{+0.032}), \quad \delta_{EM}^{\pi^-\pi^0} = -(0.186_{-0.203}^{+0.114})$$

$$\delta_{EM}^{K^-\eta} = -(0.026_{-0.163}^{+0.029}), \quad \delta_{EM}^{K^-\eta'} = -(0.304_{-0.185}^{+0.422})$$

# Rafel Escribano

The summary of my research in the last 5 years:

eta and eta' meson physics: theoretical analysis of the doubly radiative decays of the eta and eta' mesons; determination of the pi0-eta-eta' mixing from the radiative decays of the lightest vector mesons; theoretical analysis of the eta and eta' charge-conjugation conserving semileptonic decays; investigation of the prospect of observing such signatures via CP-violation using the former decays into muons at the REDTOP experiment; and analysis of the sensitivity of the eta and eta' doubly radiative decays to signatures of a leptophobic B boson in the MeV-GeV mass range.

D-meson and tau-lepton decays: combined study of multihadronic D and Ds decays by means of the analysis of semileptonic D decays; and computation of the radiative corrections of tau lepton decays into two pseudoscalar mesons (pi, K).

In beyond the SM physics, the computation of the pole mass and pole width of the Kaluza-Klein gluon and the prediction for proton-proton cross-sections.

Combined study of hadronic  $D^+ \rightarrow K^- \pi^+ \pi^+$  and  $D_s^+ \rightarrow K^+ K^+ \pi^-$  decays by means of the analysis of semileptonic

$D^+ \rightarrow K^- \pi^+ \ell^+ \nu_\ell$  decays

R. Escribano, P. Masjuan and P. Sánchez-Puertas, Phys. Rev. D108 (2023) 094006

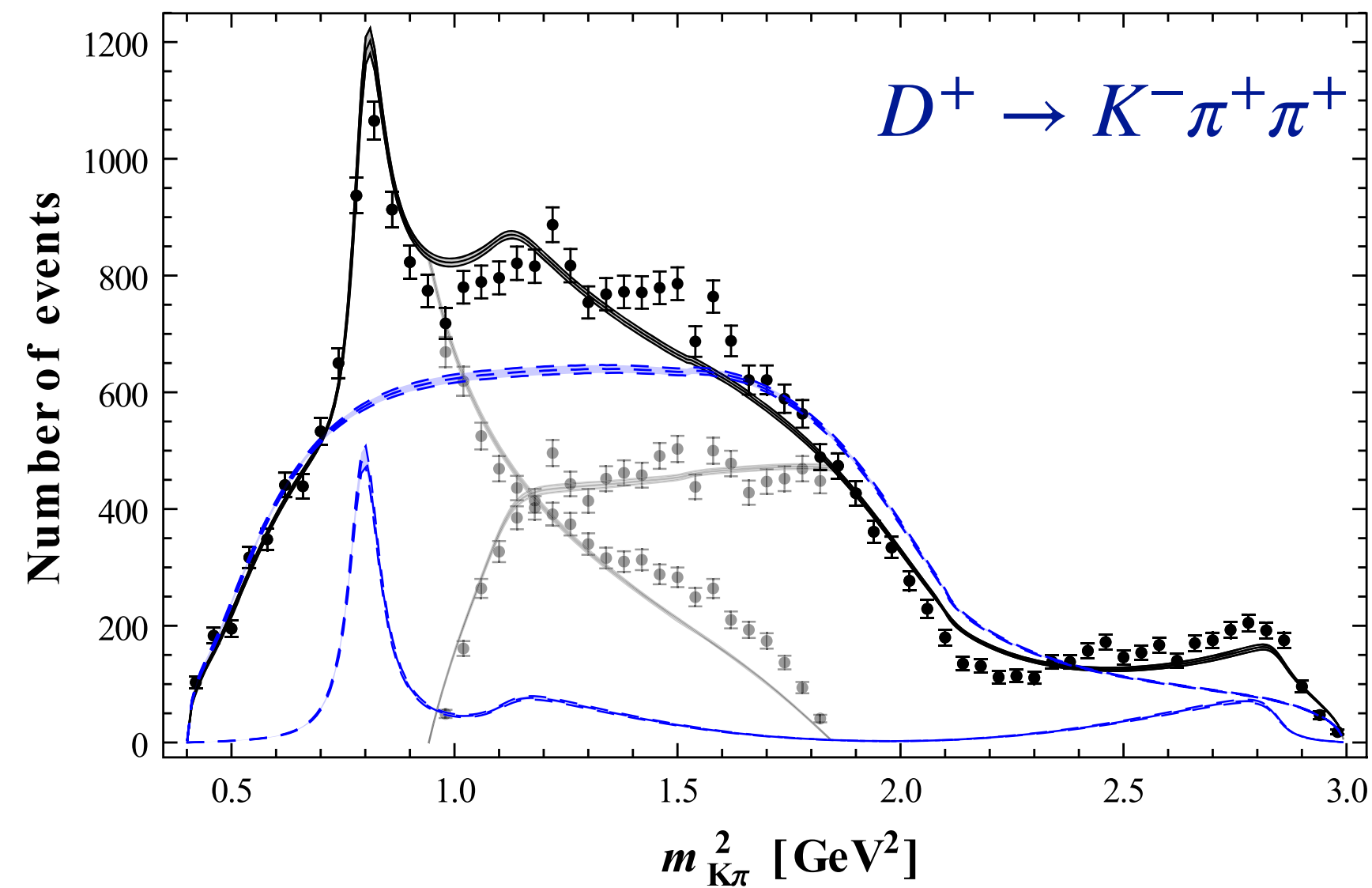
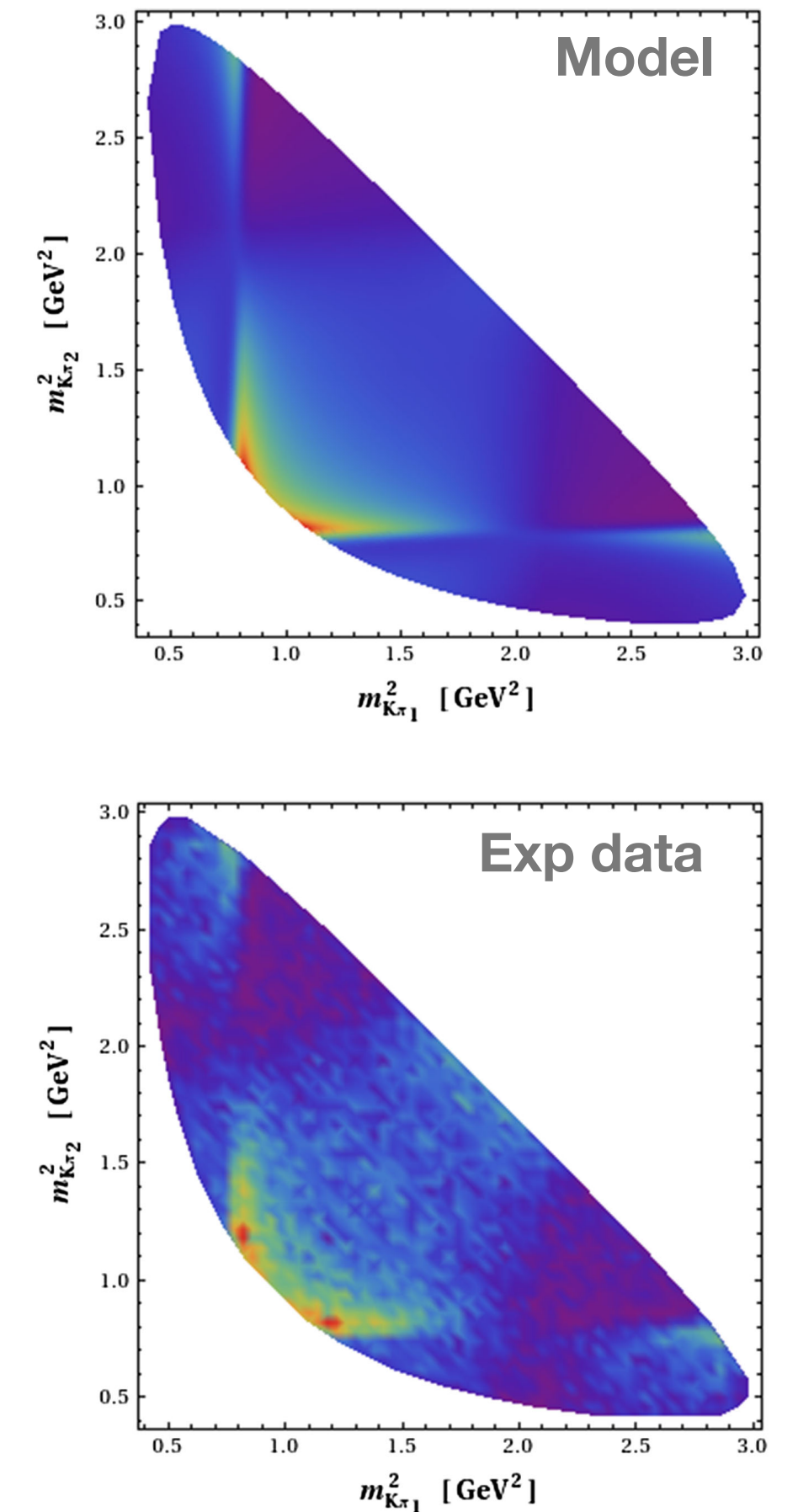


FIG. 4. Differential decay width for  $D^+ \rightarrow K^- \pi^+ \pi^+$  compared to E791 data [37]. The dark gray band represents our model, while the light gray bands represent the low- and high-mass parts of the spectra. The dashed blue lines represent the scalar and vector components in our model. The bands are dominated by our MC fit uncertainties but do not contain inherent uncertainties from the naïve-factorization hypothesis.



# Pere Masjuan

## Hadronic Physics for the $(g-2)_\mu$

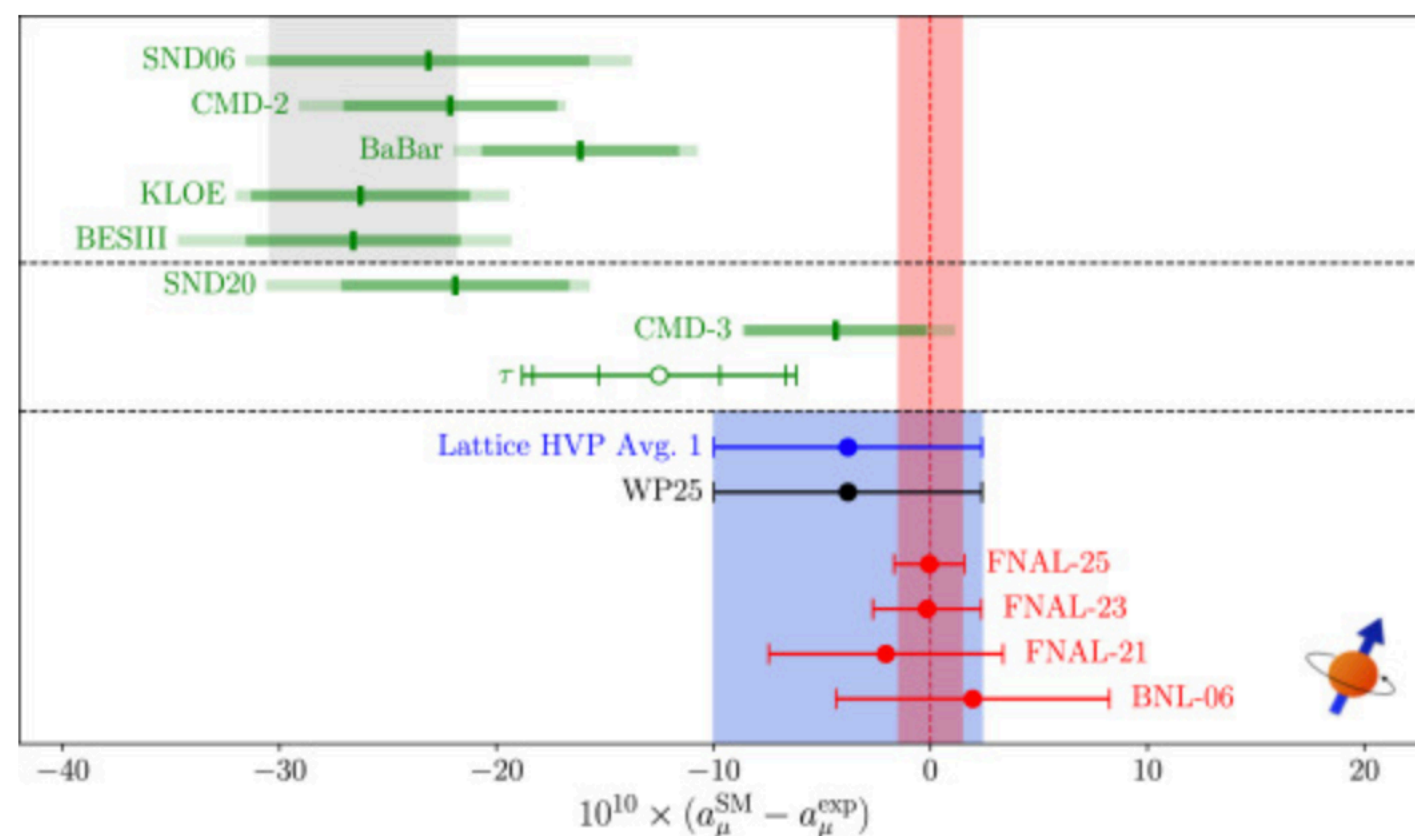
### A) New Theory White Paper: Is the anomaly still anomalous?

Review article

#### The anomalous magnetic moment of the muon in the Standard Model: an update

We dedicate this paper to the memory of Simon Eidelman.

R. Aliberti<sup>1,2</sup>, T. Aoyama<sup>3</sup>, E. Balzani<sup>4,5</sup>, A. Bashir<sup>6,7</sup>, G. Benton<sup>8,9</sup>, J. Bijnens<sup>10</sup>, V. Biloshytskiy<sup>1,2</sup>, T. Blum<sup>11,12</sup>, D. Boito<sup>13</sup>, M. Bruno<sup>14,15</sup>, E. Budassi<sup>16,17</sup>, S. Burri<sup>18</sup>, L. Cappiello<sup>19</sup>, C.M. Carloni Calame<sup>17</sup>, M. Cè<sup>14,15</sup>, V. Cirigliano<sup>20,21</sup>, D.A. Clarke<sup>22</sup>, G. Colangelo<sup>18</sup> ✉, L. Cotrozzi<sup>23</sup>, M. Cottini<sup>18</sup>, I. Danilkin<sup>1,2</sup>, M. Davier<sup>24</sup> ✉, M. Della Morte<sup>25</sup>, A. Denig<sup>1,2,26,27</sup>, C. DeTar<sup>22</sup>, V. Druzhinin<sup>28</sup>, G. Eichmann<sup>29</sup>, A.X. El-Khadra<sup>8,9</sup> ✉, E. Estrada<sup>30</sup>, X. Feng<sup>31,32,33</sup>, C.S. Fischer<sup>34,35</sup>, R. Frezzotti<sup>36</sup>, G. Gagliardi<sup>37</sup>, A. Gérardin<sup>38</sup>, M. Ghilardi<sup>16,17</sup>, D. Giusti<sup>39,40</sup>, M. Golterman<sup>41</sup>, S. González-Solís<sup>42,43</sup>, S. Gottlieb<sup>44</sup>, R. Gruber<sup>45</sup>, A. Guevara<sup>46</sup>, V. Gülpers<sup>47</sup>, A. Gurgone<sup>48,49</sup>, F. Hagelstein<sup>1,2</sup>, M. Hayakawa<sup>50,51</sup>, N. Hermansson-Truedsson<sup>10,47</sup>, A. Hoecker<sup>52</sup>, M. Hoferichter<sup>18</sup> ✉, B.-L. Hoid<sup>1,2</sup>, S. Holz<sup>18</sup>, R.J. Hudspith<sup>53</sup>, F. Ignatov<sup>23</sup>, L. Jin<sup>11</sup>, N. Kalntis<sup>18</sup>, G. Kanwar<sup>47</sup>, A. Keshavarzi<sup>54</sup>, J. Komijani<sup>45</sup>, J. Koponen<sup>1,2</sup>, S. Kuberski<sup>55</sup>, B. Kubis<sup>56</sup>, A. Kupich<sup>28</sup>, A. Kupść<sup>57,58</sup>, S. Lahert<sup>22</sup>, S. Laporta<sup>4,5</sup>, C. Lehner<sup>40</sup> ✉, M. Lellmann<sup>1</sup>, L. Lellouch<sup>38</sup> ✉, T. Leplumey<sup>59,60</sup>, J. Leutgeb<sup>61</sup>, T. Lin<sup>31</sup>, Q. Liu<sup>62</sup>, I. Logashenko<sup>28</sup>, C.Y. London<sup>13</sup>, G. López Castro<sup>30</sup>, J. Lüdtkke<sup>63</sup>, A. Lusiani<sup>49,64</sup>, A. Lutz<sup>24</sup>, J. Mager<sup>61</sup>, B. Malaescu<sup>65</sup>, K. Maltman<sup>66,67</sup>, M.K. Marinković<sup>45</sup>, J. Márquez<sup>30</sup>, P. Masjuan<sup>68,69</sup> ✉, H.B. Meyer<sup>1,2,26,27</sup>



### B) Hadronic corrections to MUonE experiment

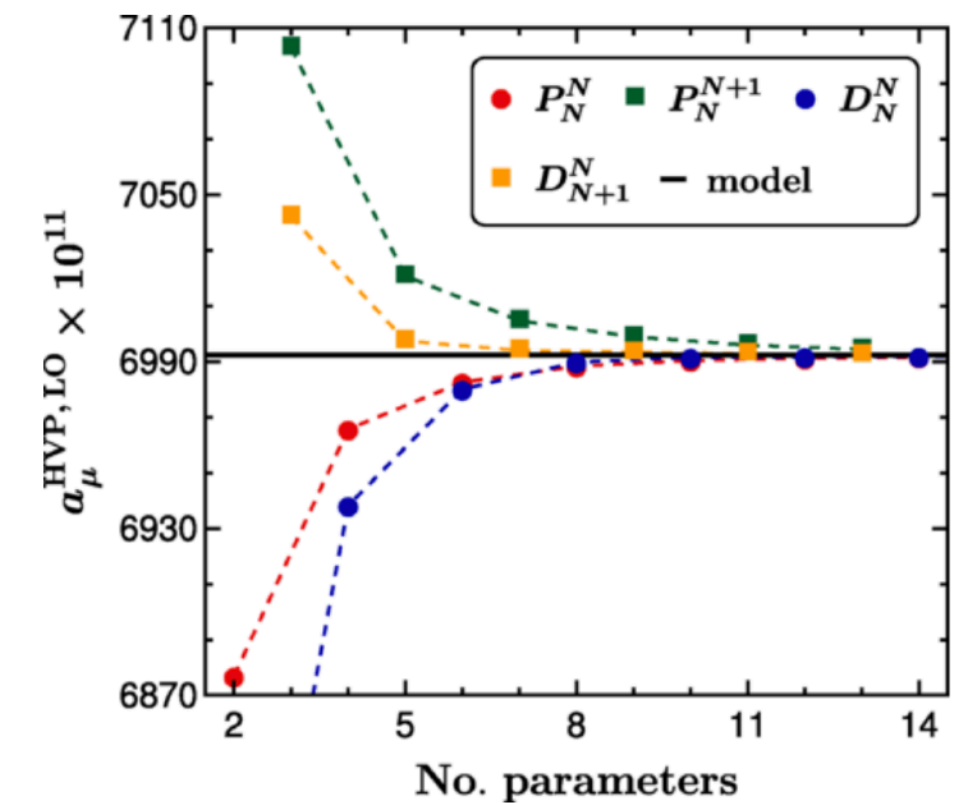
#### Model-independent extrapolation of MUonE data with Padé and D-Log approximants

Diogo Boito<sup>1</sup> ✉, Cristiane Y. London<sup>1,2</sup> ✉, Pere Masjuan<sup>1,2</sup> ✉, and Camilo Rojas<sup>1,2</sup> ✉

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Phys. Rev. D **110**, 074012 – Published 10 October, 2024

DOI: <https://doi.org/10.1103/PhysRevD.110.074012>



### C) New QCD running coupling constant

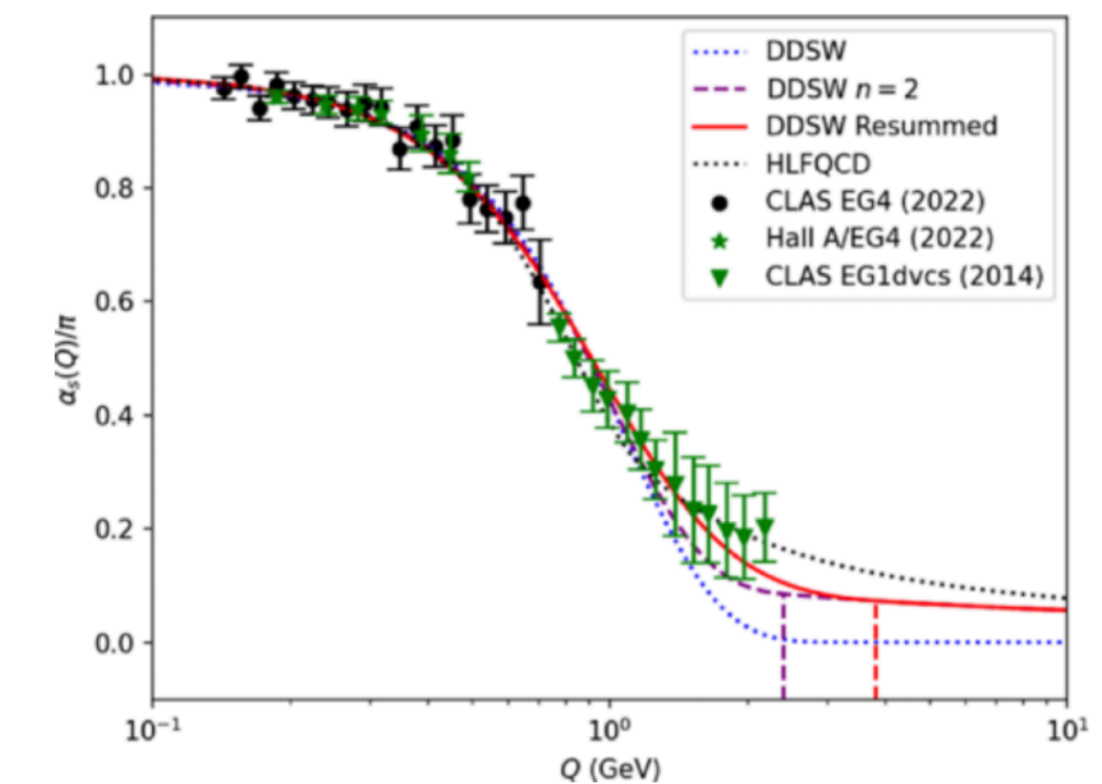
#### Holographic QCD running coupling constant from the Ricci flow

Héctor Cancio<sup>1</sup> ✉ and Pere Masjuan<sup>1,2</sup> ✉

Show more

Phys. Rev. D **111**, 094020 – Published 13 May, 2025

DOI: <https://doi.org/10.1103/PhysRevD.111.094020>



# Quim Matias

## 1) Semileptonic transitions: $b \rightarrow s \ell \ell^+$ with $\ell = e, \mu, \tau$

**New Physics shows a clear preference for Lepton Flavour Universality, i.e, same large New Physics for  $b \rightarrow s \mu \mu$  and  $b \rightarrow s e e$  channels.**

Developed new strategies to quantitatively understand and disentangle all possible sources of hadronic effects (form factors, charm loops, resonances, etc.).

Improved theoretical predictions for over 250 observables used in our global analyses, incorporating new form factor computations and long-distance charm contributions.

Evaluated the global significance of observed deviations to identify the relevant Wilson coefficients. Current results suggest that Lepton Flavour Universal (LFU) New Physics scenarios dominate, with the semileptonic Wilson coefficient  $C_9$  receiving the main New Physics contribution. Both model-independent and model-dependent analyses were performed.

Prospects:

Extending the analysis from binned to unbinned observables in  $B \rightarrow K^* \ell \ell^+ \ell^-$  decays to extract more detailed information from the shape of distributions (e.g., zero crossings). Collaboration with LHCb is ongoing.

Expanding the analysis beyond P-wave observables and including previously neglected corrections such as lepton mass effects and scalar contributions.

Investigating  $b \rightarrow s \tau^+ \tau^-$  decays and their connection to LFUV contributions in the charged sector, particularly in observables like  $R(D)$  and  $R(D^*)$ .

Published in: *Eur.Phys.J.C* 83 (2023) 7, 648. Cit: 119.

Scenario	Best fit	$1\sigma$	Pull <sub>SM</sub>	p-value
$(C_{9\mu}^V = -C_{10\mu}^V, C_9^U)$	(-0.11, -0.78)	([-0.17, -0.05], [-0.90, -0.66])	6.3	35.4%

Table 10: Full update. Outcome of the fit under Scenario 8 including  $R_{D^{(*)}}$ .

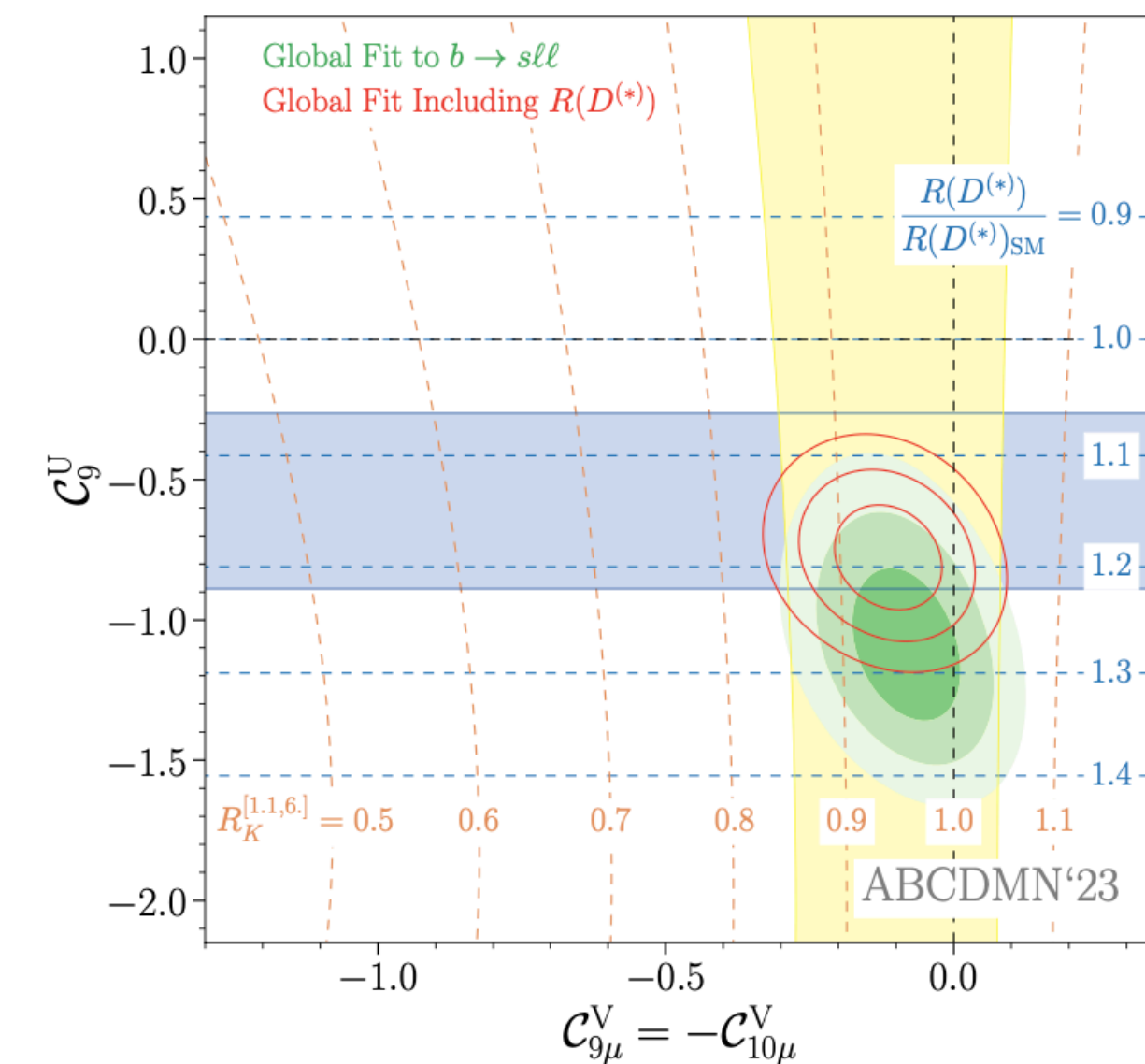


Figure 4: Full update. Preferred regions at the 1, 2 and  $3\sigma$  level (green) in the  $(C_{9\mu}^V = -C_{10\mu}^V, C_9^U)$  plane from  $b \rightarrow s \ell^+ \ell^-$  data. The red contour lines show the corresponding regions once  $R_{D^{(*)}}$  is included (for a NP scale  $\Lambda = 2$  TeV). The horizontal blue (vertical yellow) band is consistent with  $R_{D^{(*)}}$  ( $R_K$ ) at the  $2\sigma$  level and the contour lines show the predicted values for these ratios.

# Quim Matias

## 2) A new class of non-leptonic observables:

### New Physics in QCD-Penguins and/or Chromomagnetic Operators required to explain these anomalies.

Published in: JHEP 06 (2023) 108. JHEP 08 (2024) 030

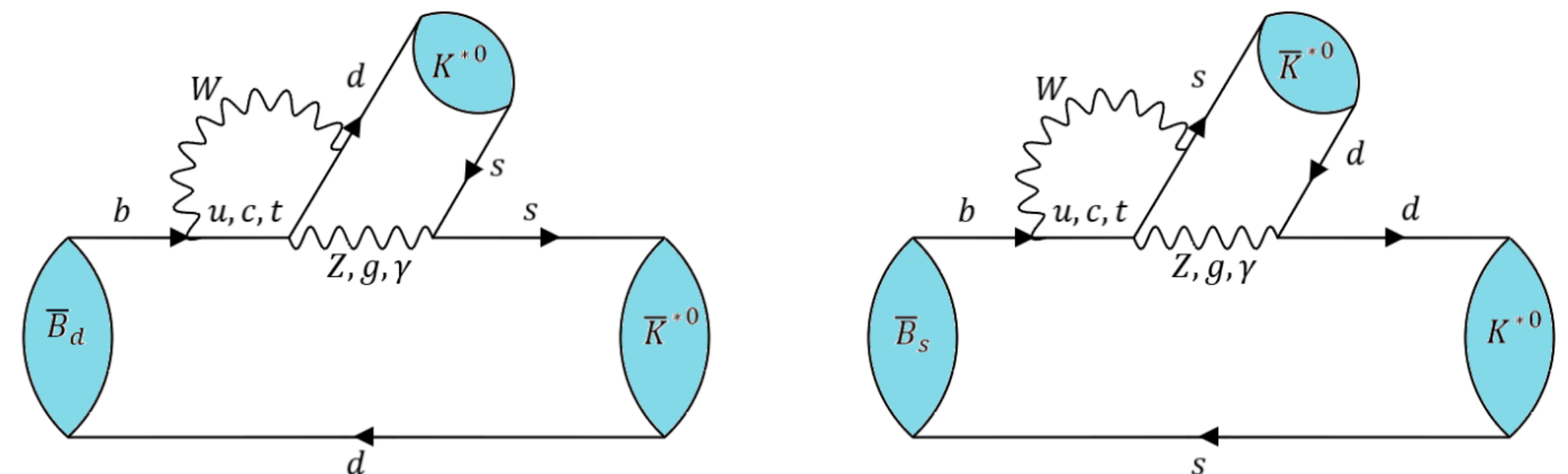
$$L_{K^* \bar{K}^*} = \rho(m_{K^{*0}}, m_{\bar{K}^{*0}}) \frac{\mathcal{B}(\bar{B}_s \rightarrow K^{*0} \bar{K}^{*0}) f_L^{B_s}}{\mathcal{B}(\bar{B}_d \rightarrow K^{*0} \bar{K}^{*0}) f_L^{B_d}} = \frac{|A_0^s|^2 + |\bar{A}_0^s|^2}{|A_0^d|^2 + |\bar{A}_0^d|^2},$$

$$L_{K^* \bar{K}^*}^{\text{SM}} = 19.53_{-6.64}^{+9.14}$$

while the experimental measurement is taken as

$$L_{K^* \bar{K}^*}^{\text{exp}} = 4.43 \pm 0.92$$

- **2.6 sigma for B->K\*K\* and similarly 2.4 sigma for B->KK.**
- **Same NP explanation for both anomalies.**



Main contributions:

Constructed new observables based on ratios of  $\mathcal{B}(\bar{B}_d \rightarrow K^* \bar{K}^*)$  and  $\mathcal{B}(\bar{B}_s \rightarrow K^* \bar{K}^*)$ , as well as  $\mathcal{B}(\bar{B}_d \rightarrow KK)$  and  $\mathcal{B}(\bar{B}_s \rightarrow KK)$ , which reduce the sensitivity to infrared divergences. These are referred to as L observables.

Analyzed their sensitivity to form factors obtained via LCSR (Light-Cone Sum Rules), with and without lattice QCD inputs, and their potential to reveal New Physics.

Proposed a scalar leptoquark model to address the newly observed non-leptonic anomaly.

Prospects:

Identified a new mechanism highly sensitive to New Physics that enhances or suppresses two partner decays:  $\mathcal{B}_{\{(d,s)\}}(\bar{B}_{\{(d,s)\}} \rightarrow KK^*)$  and  $\mathcal{B}_{\{(d,s)\}}(\bar{B}_{\{(d,s)\}} \rightarrow K^* K)$ , depending on whether the spectator quark ends up in the pseudoscalar or vector meson.

Experimental studies with LHCb are ongoing.

Initiated a systematic study of other related non-leptonic decay modes.

# Santi Peris

## Determination of $\alpha_s$ from hadronic $\tau$ decays

Non-perturbative effects have a small but non-trivial impact on the determination of the strong coupling from hadronic  $\tau$  decay data. We have recently been able to show that the value for  $\alpha_s$  determined in what used to be the traditional approach followed by Davier, Pich and collaborators turns out to derive purely from perturbation theory, with no role played by the non-perturbative condensates determined in the rest of the analysis. This leads to the conclusion that a revision of the conventional understanding of what is learned from truncated OPE analyses is necessary.

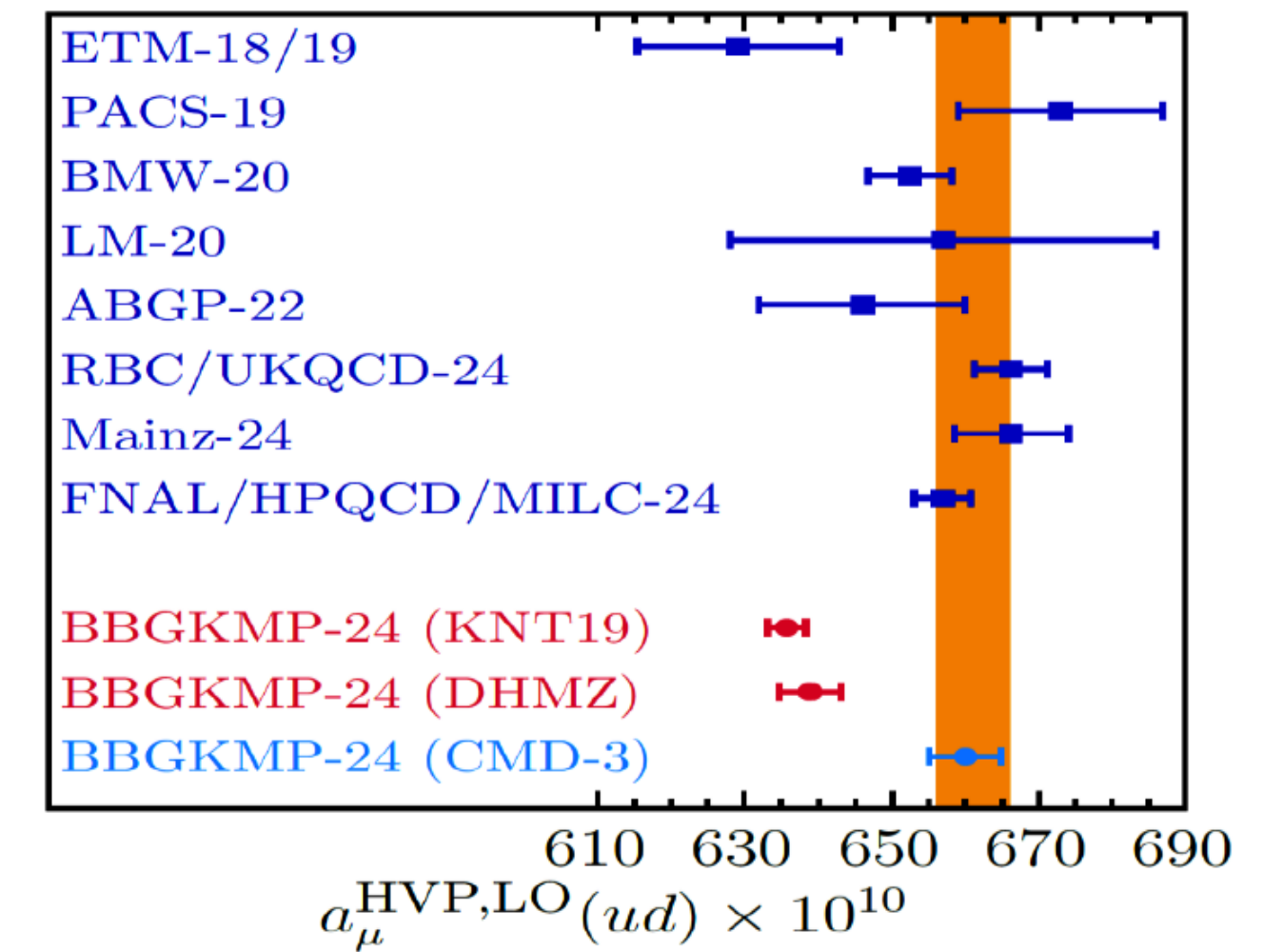
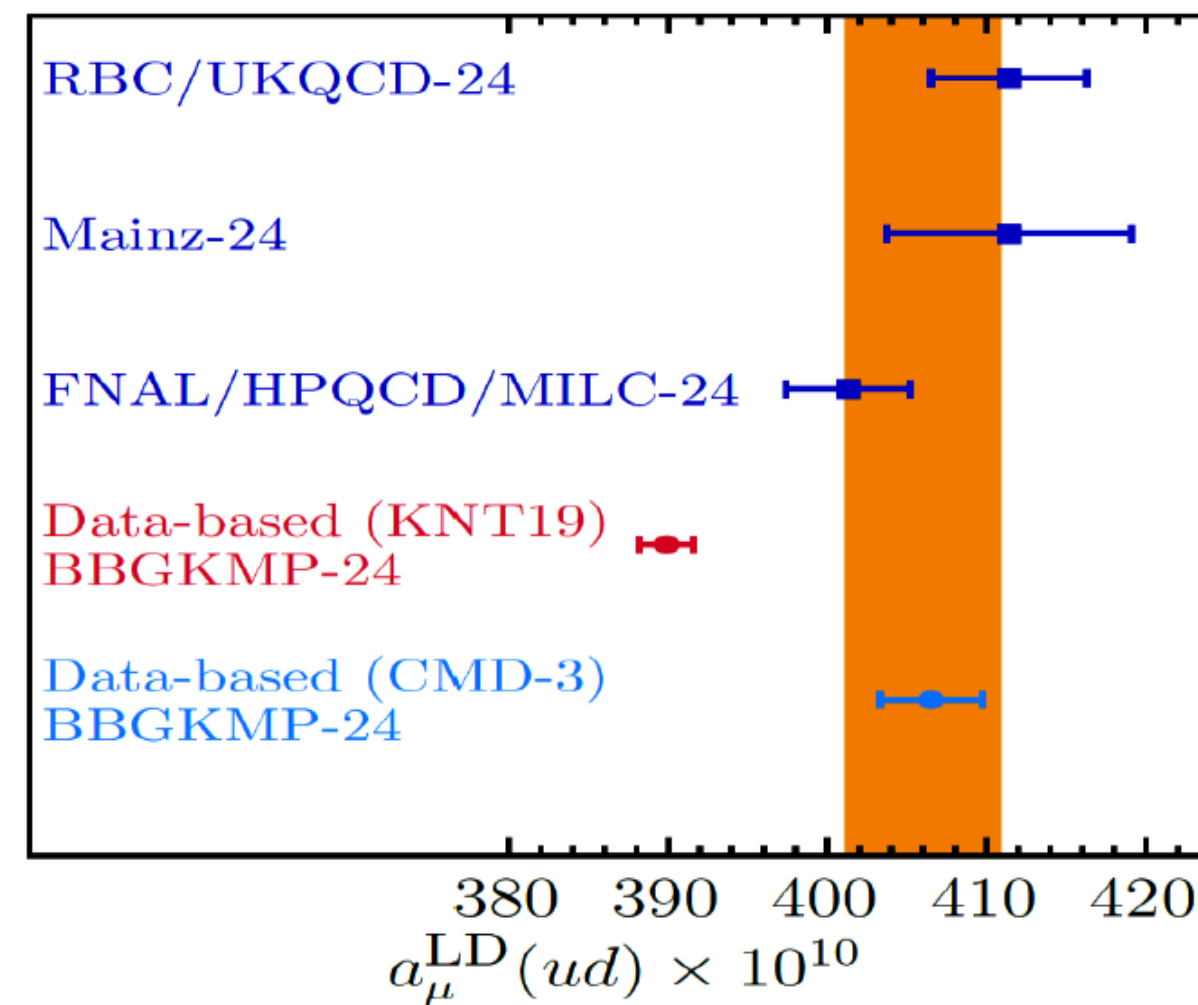
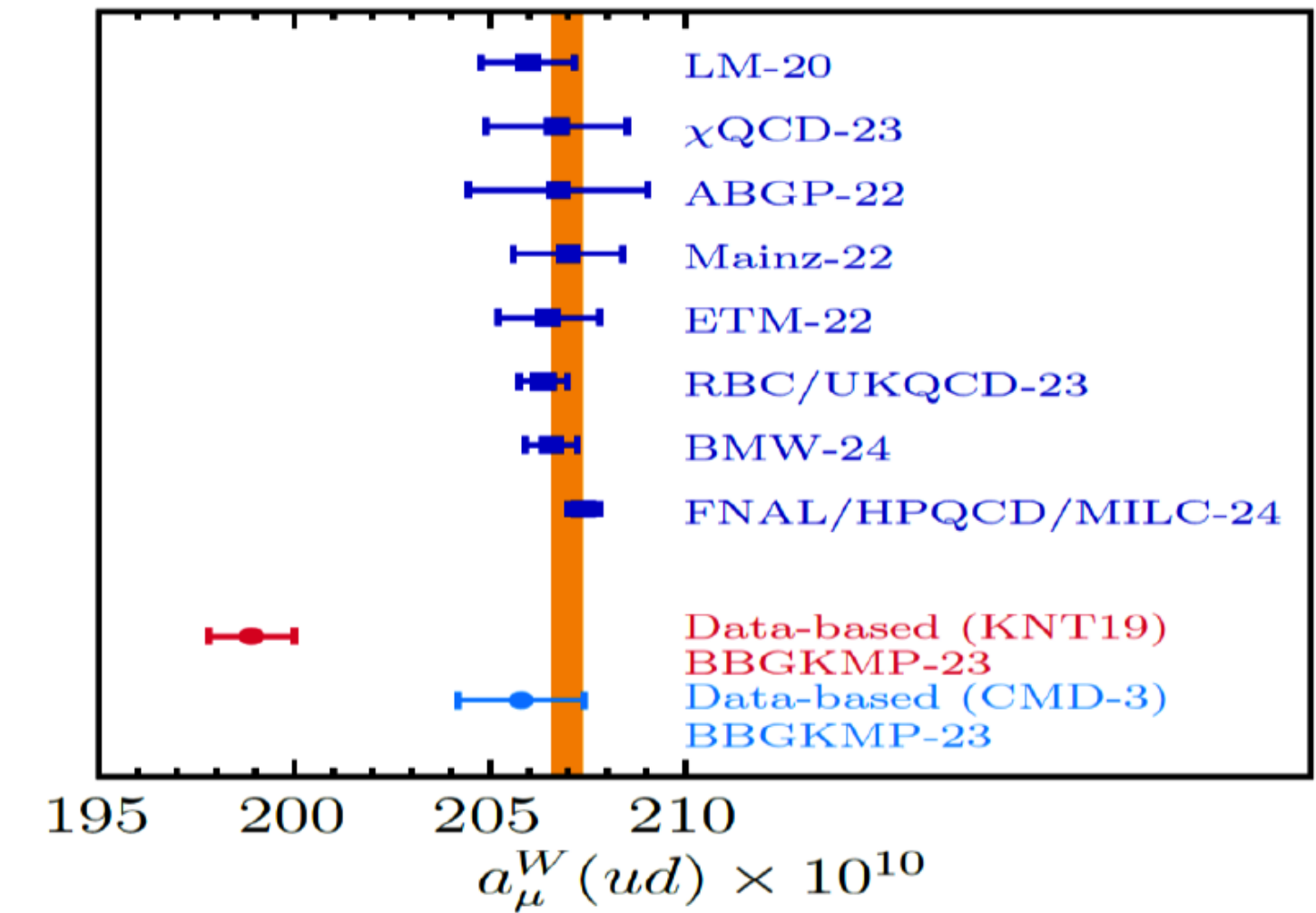
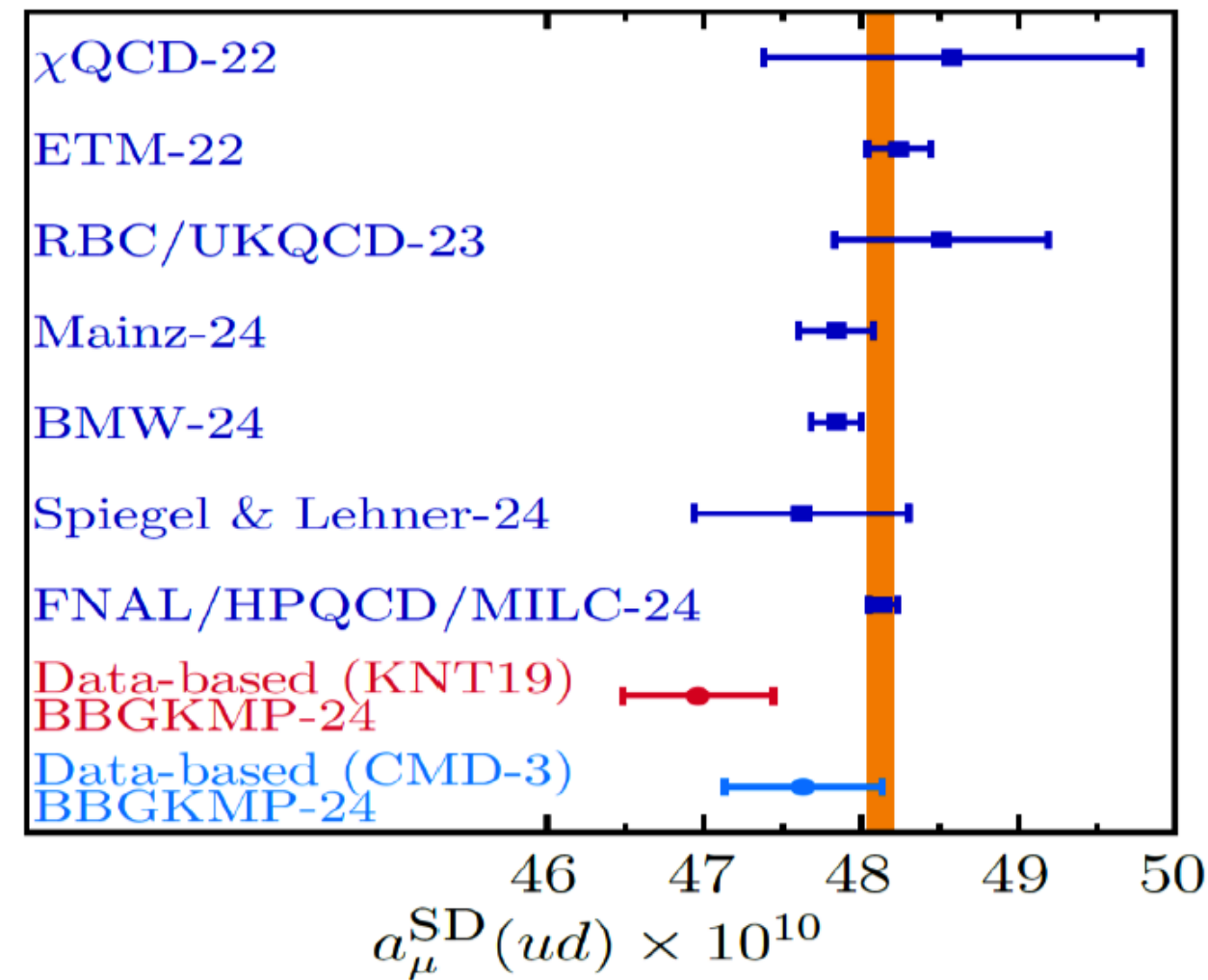
## Lattice QCD

The lattice is a nonperturbative method for studying QCD from first principles. However, it is formulated in the Euclidean which means that, up to now, spectral functions (such as, e.g.,  $R(e^+e^- \rightarrow \text{hadrons})$ ) have been beyond reach. Recently, there have been important theoretical developments which allow for a partial solution to this problem. We plan to apply several interesting ideas which could help improve our current understanding of this problem.

# Santi Peris

The discrepancy between the lattice and the data-based dispersive calculation of the the **muon g-2** has been studied with the help of a "windowed" analysis, in which a window in the integrand of the light-quark contribution to the hadronic vacuum polarization selects a limited range in energies. In this way, 3 windows, corresponding to three ranges of energies, have been selected: short, intermediate and long distances (resp. SD,W,LD). We have shown that the e+e- experimental data prior to CMD3 is in disagreement with all current lattice determinations of the intermediate distance window contribution while for the other windows the discrepancy is less severe. CMD3 data is, however, in agreement with the lattice. This disagreement between non-CMD3 data-based determination of the muon g-2 and the FERMILAB experimental result originates in this discrepancy of the intermediate window contribution, and disappears if the lattice or the CMD3 data is used.

## CMD-3 impact on lattice-dispersive HVP, SD, W1, LD lqc comparisons



**BBGKMP-24 our work**

# Toni Pineda

**Hyperasymptotic expansion techniques**

**Heavy-quark effective field theories**

**Prospects:**

- **Hyperasymptotic expansion techniques in observables**

where one can apply **the operator product expansion**

- **Compute heavy quarkonium observables with higher degree of accuracy.**

- **Explore the feasibility of applying potential non-relativistic effective field theories to binary systems.**

# Toni Pineda

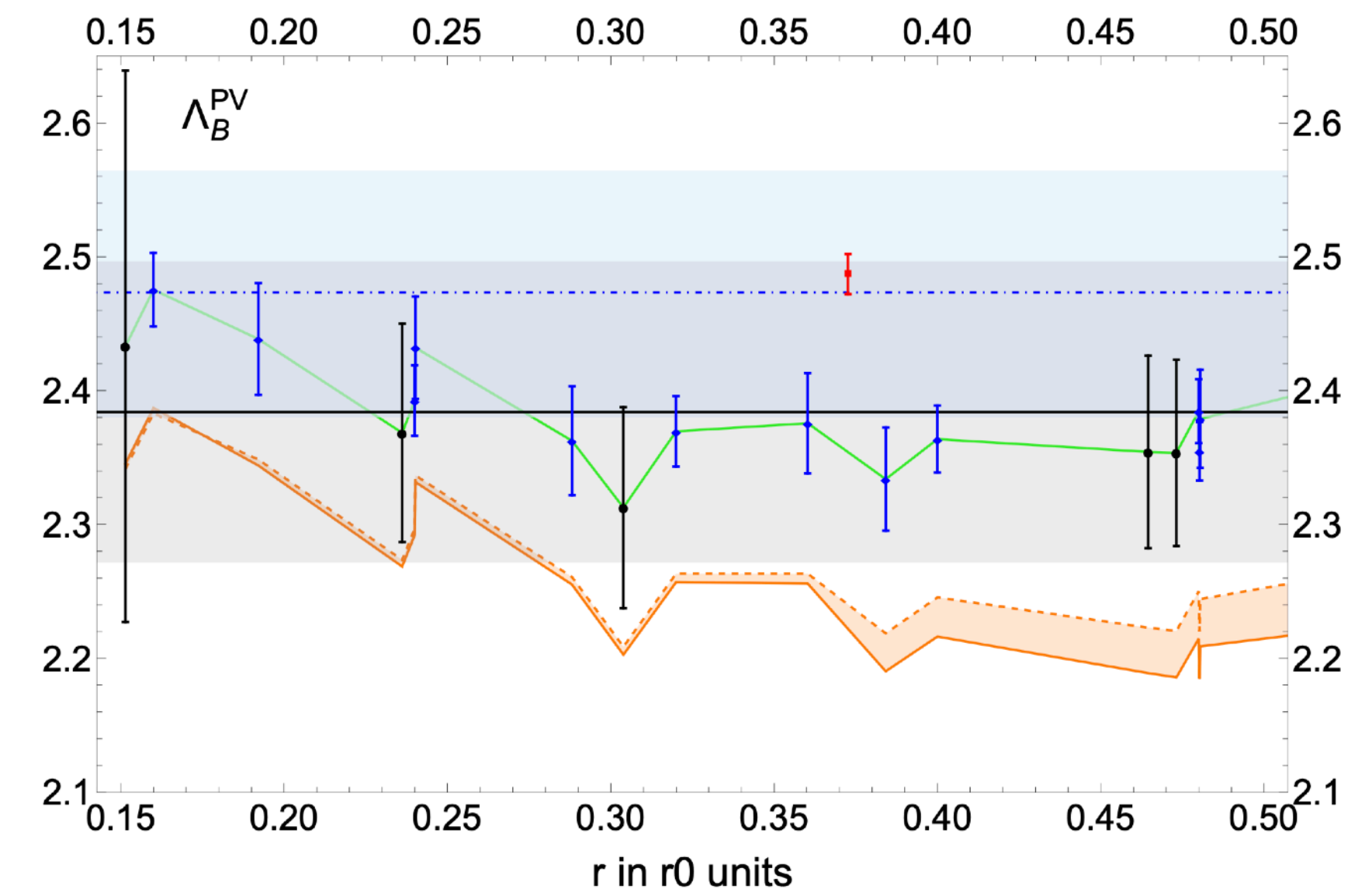
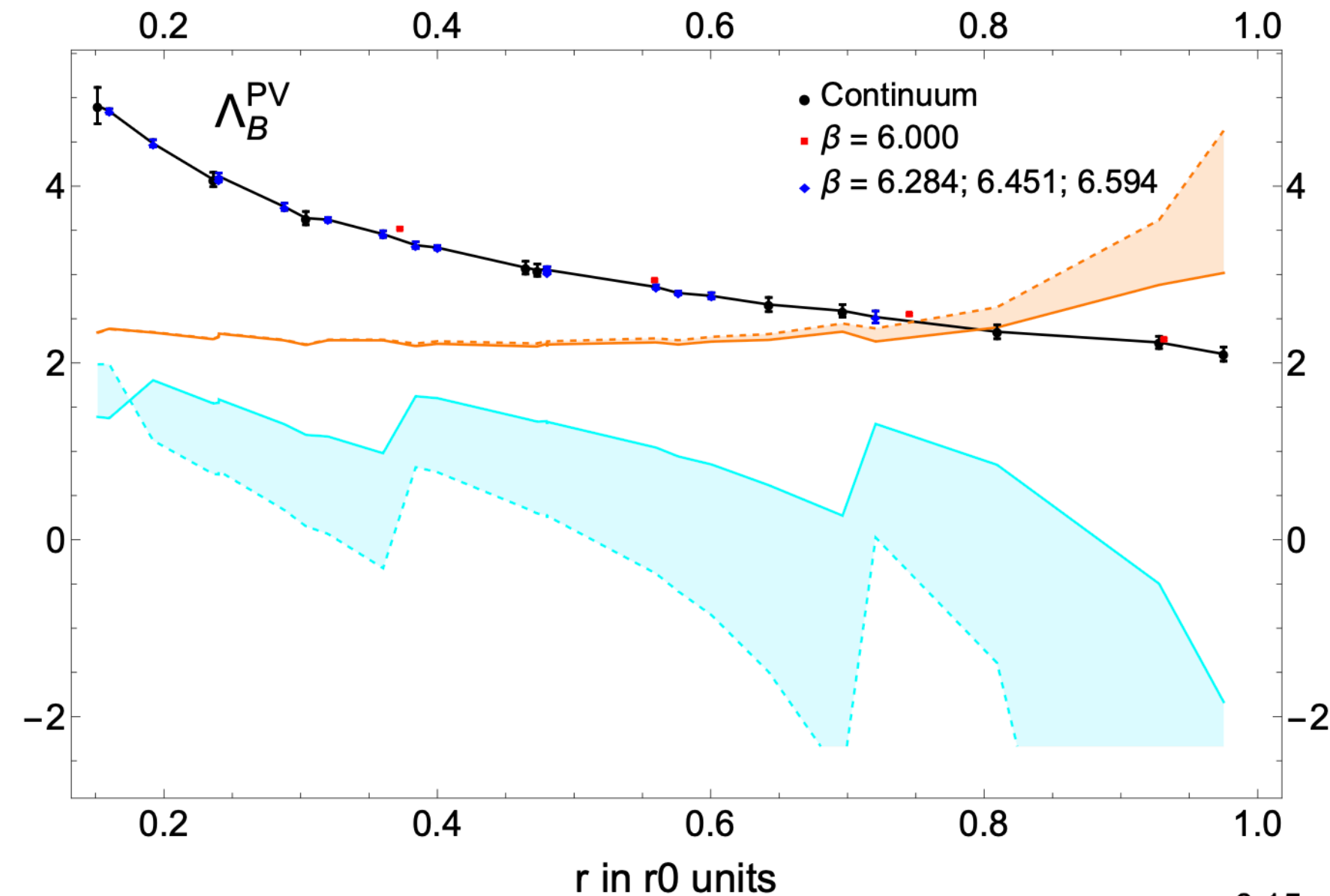
We have obtained the mass of lightest gluelump in the principal value summation scheme using hyperasymptotic expansions techniques. This number is renormalization scale and scheme independent.

"**Gluelump** states are created by a static source in the octet (adjoint) representation attached to some gluonic content (H) such that the state becomes a singlet under gauge transformations. This is what would happen to heavy gluinos in the static approximation."

The mass of the lightest gluelump

Cesar Ayala<sup>1</sup> and Antonio Pineda<sup>2,3</sup>

arXiv:2505.18827



**BSM**

# Diego Blas

- current **status** of research line
  - **Line 1. Gravitational waves searches in the  $\mu\text{Hz}$  band**
    - Preprints showing power of Lunar laser ranging, Satellite ranging and binary pulsars
    - First data analysis under way (collaboration with LLR and pulsar experts)
      - Organization of dedicated workshop
    - ESA proposal (125 M€) for dedicated mission (GUEST)
    - Other ideas under investigation (Moon's libration, asteroids, voids, star binaries...)
  - **Line 2. Quantum sensing for fundamental physics**
    - 2 collaborations: **AION** atom interferometry. & **GravNet** (gravitational waves in the lab)
      - Work towards Spanish Site      ERC-Synergy grant (10 M€): leading group of 6.
    - ERC-Synergy grant for GravNet: leading the group of 6.
    - New preprint for uses of ion interferometry.
    - On-going discussions with local quantum experts and 2 groups at ICFO.
- prospects of your research line in the **coming few years**
  - **Line 1. Towards data analysis and dedicated mission**
    - Early 2026: first data analysis of Lunar data/first steps towards pulsar data analyst
    - Dedicated proposal: if selected, great. If not selected, search other funds
  - **Line 2. Progress in collaborations + new ideas**
    - AION 100 & Operational GravNet (we need a better modeling of the signal)
    - New developments in the frontier of quantum sensing and fundamental physics

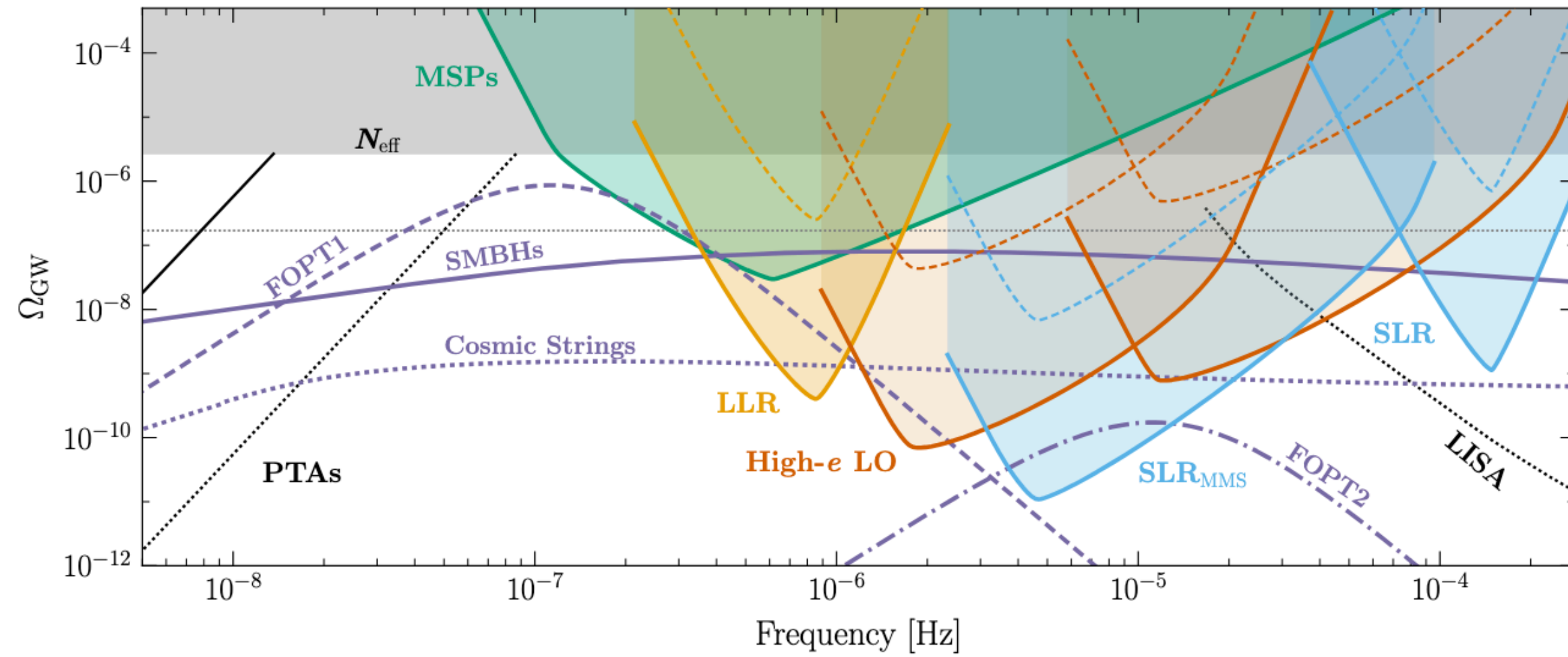
# Diego Blas

highlights from 2023 - now



## GWs searches in the $\mu\text{Hz}$ band

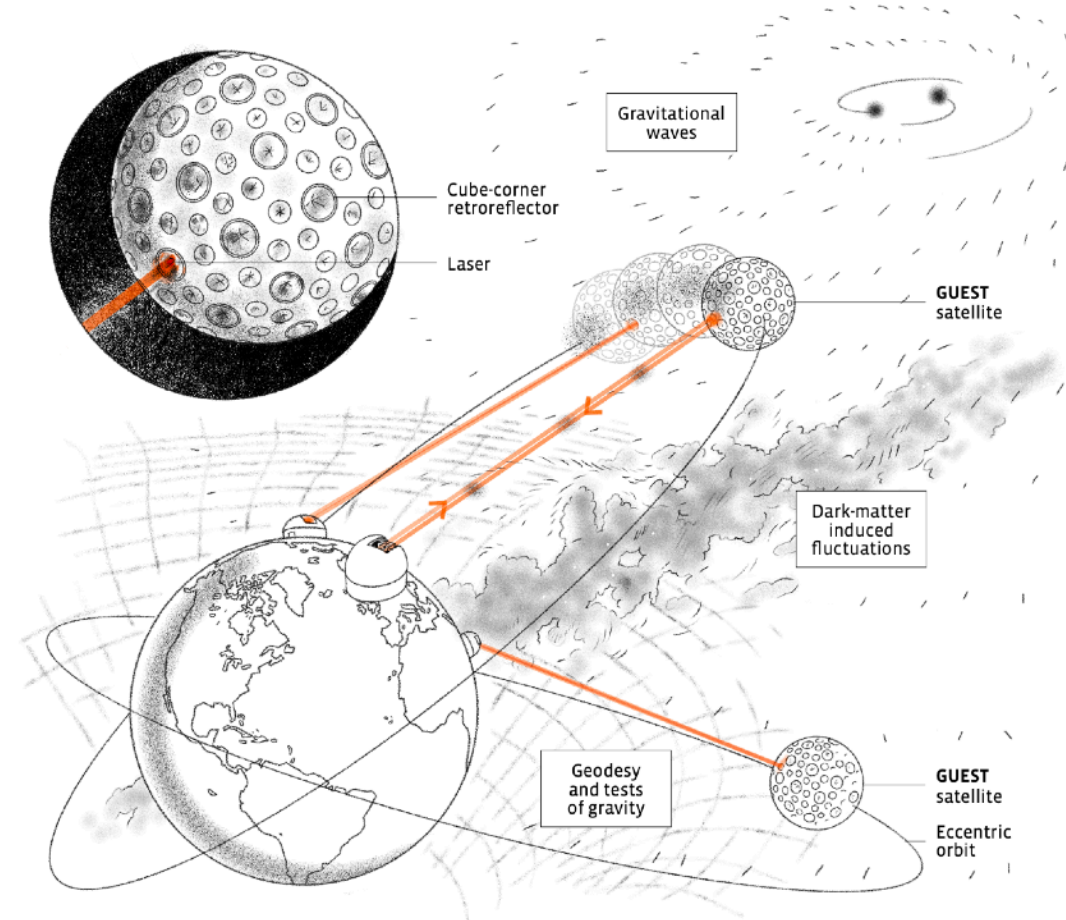
2504.15334



## Proposal for F-class ESA mission (2025)

Gravitational Universe Exploration with Satellite Tracking

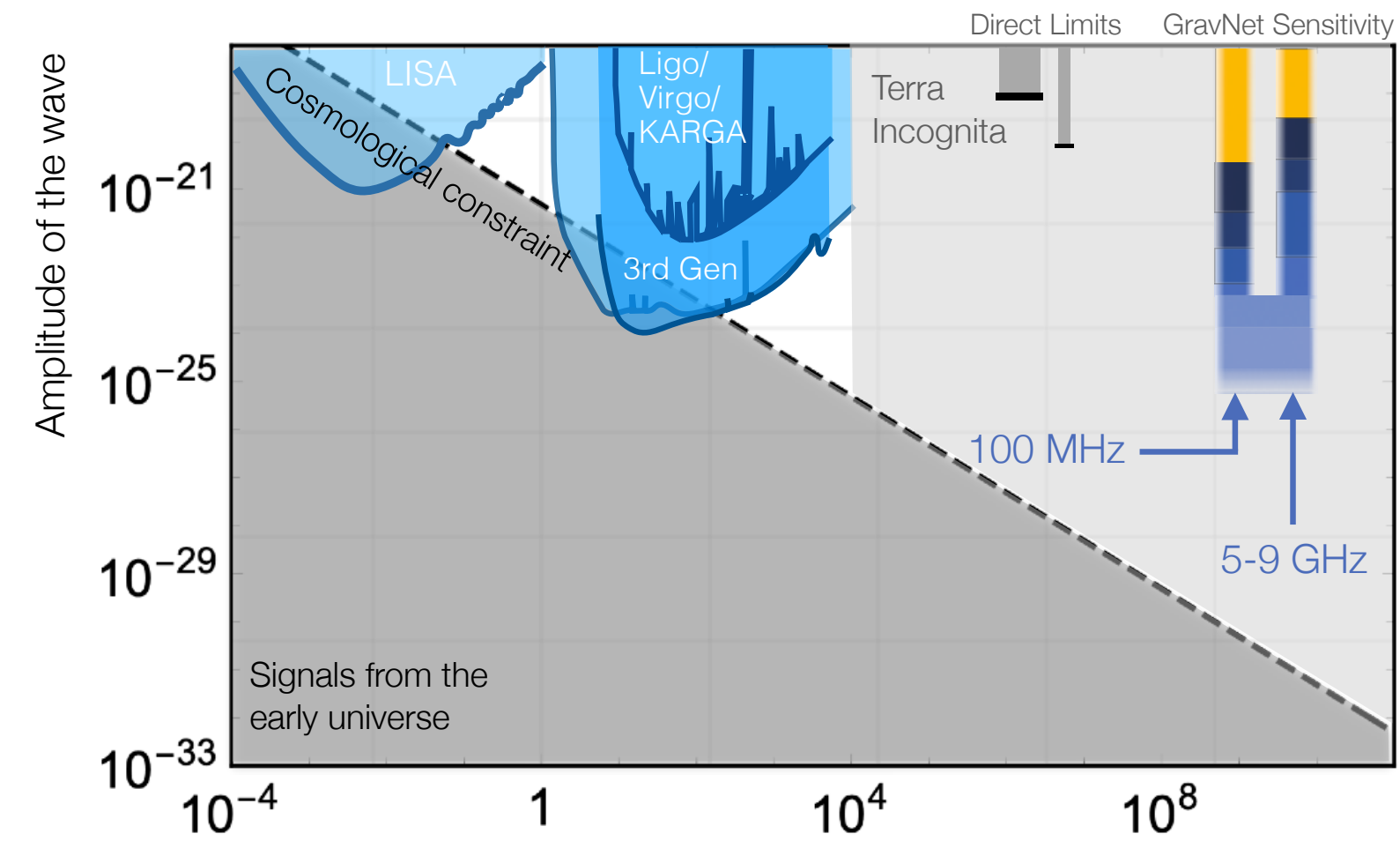
GUEST



## GravNet grant and project (2025)

### 8 High frequency GWs

GravNet in 2031



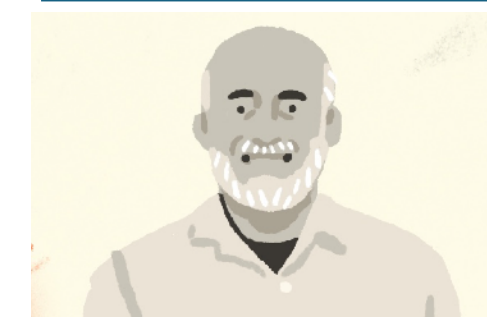
- ▶ GravNet Baseline
- ▶ Modelling and Data Analysis
- ▶ Cavity Design & Construction
- ▶ Quantum Amplifiers and Sensors
- ▶ Network Operation
- ▶ Combination of different frequencies
- ▶ Adding further detectors to network

Source Modeling and Data Analysis

Resonant Cavities

Quantum Sensing

Network Operation



# Alex Pomarol

We have used bootstrap methods to corner EFTs such as:

- Large-N QCD (proving for the first time Vector Meson Dominance)
- 5D holographic (putting constraints on CS-terms)
- Theories with axions (showing that have a cutoff smaller than naively expected)

Future:

By bootstrap methods:

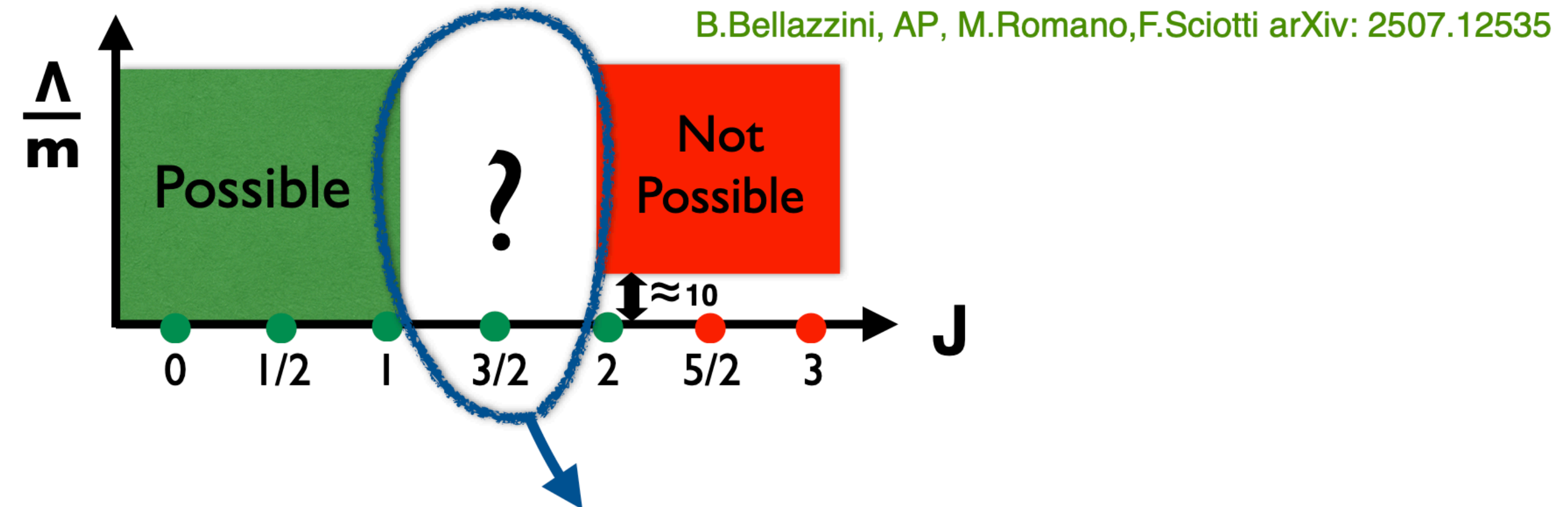
- Aim to put the strongest constraint on the SM 3-Higgs coupling
- Extract the full properties of strongly-coupled large-N theories

## Bootstrapping EFTs

Demanding “good” properties of the UV completion:

- **Lorentz, Positivity**
- **Locality (analyticity)**
- **Crossing, ...**

**Closing the gap:**



We showed that an **EFT** for a **massive spin-3/2** particle  
(the last unexplored possibility)  
is **only possible** in the presence of **gravity!**  
For **two spin-3/2**, one needs also the presence of a **photon**

# Oriol Pujolàs

**Primordial GW Backgrounds offer enormous opportunity for HEP**

LVK  $\rightarrow 10^8$  GeV

## Theory

- **topological defects, domain walls, strong phase transitions**
  - DWs well motivated case, yet poorly understood (computational challenge)
  - source characterization (templates)
  - new synergies with international groups (Tufts U Boston, Bilbao)
- **Primordial Black Holes**
  - we have pioneered computation of PBH fraction from non-inflationary mechanism
  - 1) Domain Wall collapse 2) First order Phase transitions

## Searches

- **PBHs, phase transitions, top. defects**
- **in LIGO/Virgo/Kagra, in PTAs**

# Oriol Pujolàs

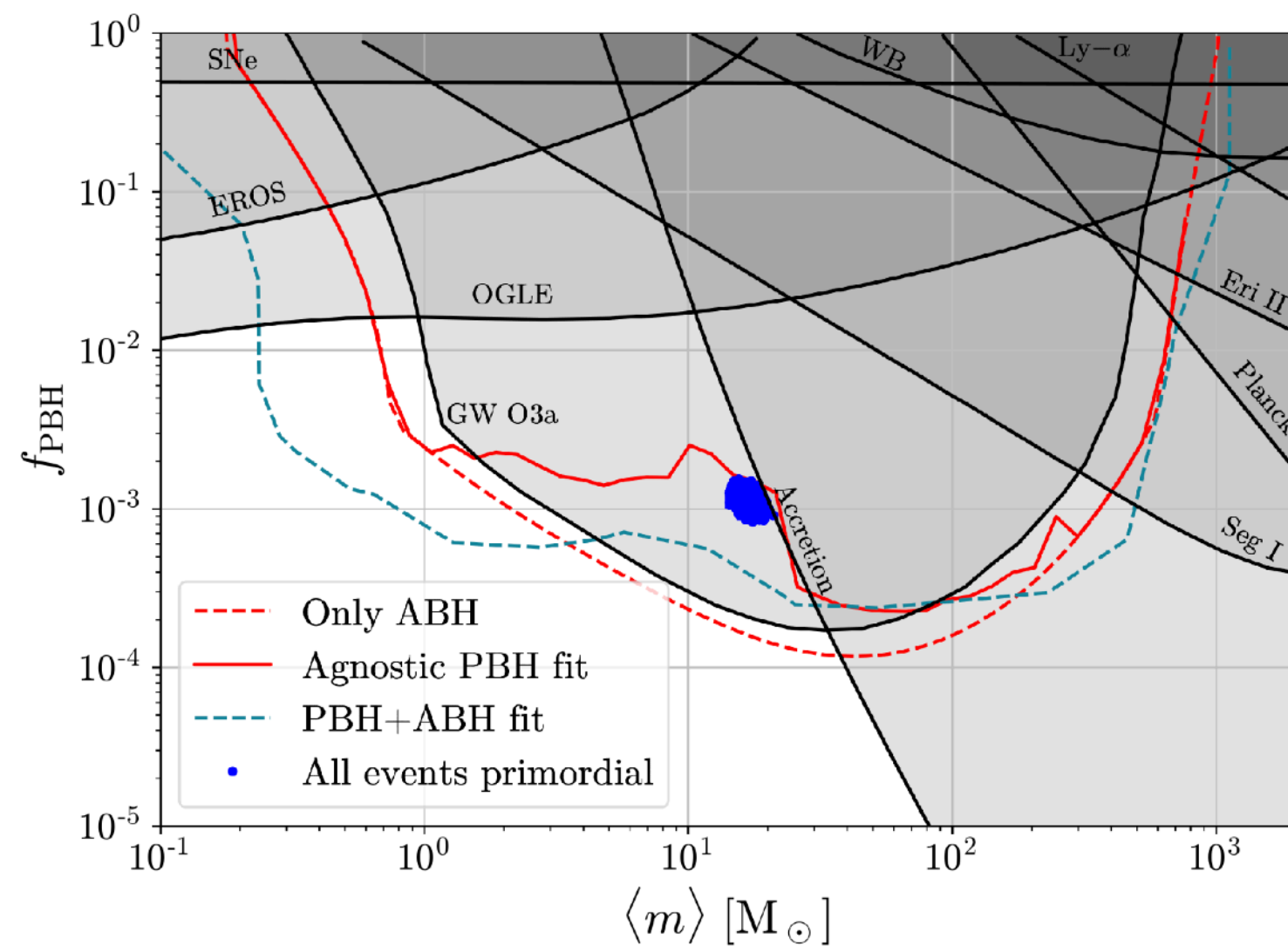
## Updated constraints on PBH from GW merger data (with IFAE GW group)

PHYSICAL REVIEW D **110**, 023040 (2024)

Editors' Suggestion

### Constraints on primordial black holes from LIGO-Virgo-KAGRA O3 events

M. Andrés-Carcasona<sup>1,\*</sup>, A. J. Iovino<sup>2,3,4,†</sup>, V. Vaskonen<sup>5,6,7,‡</sup>, H. Veermäe<sup>5,§</sup>,  
M. Martínez<sup>1,8</sup>, O. Pujolàs<sup>1</sup> and Ll. M. Mir<sup>1</sup>



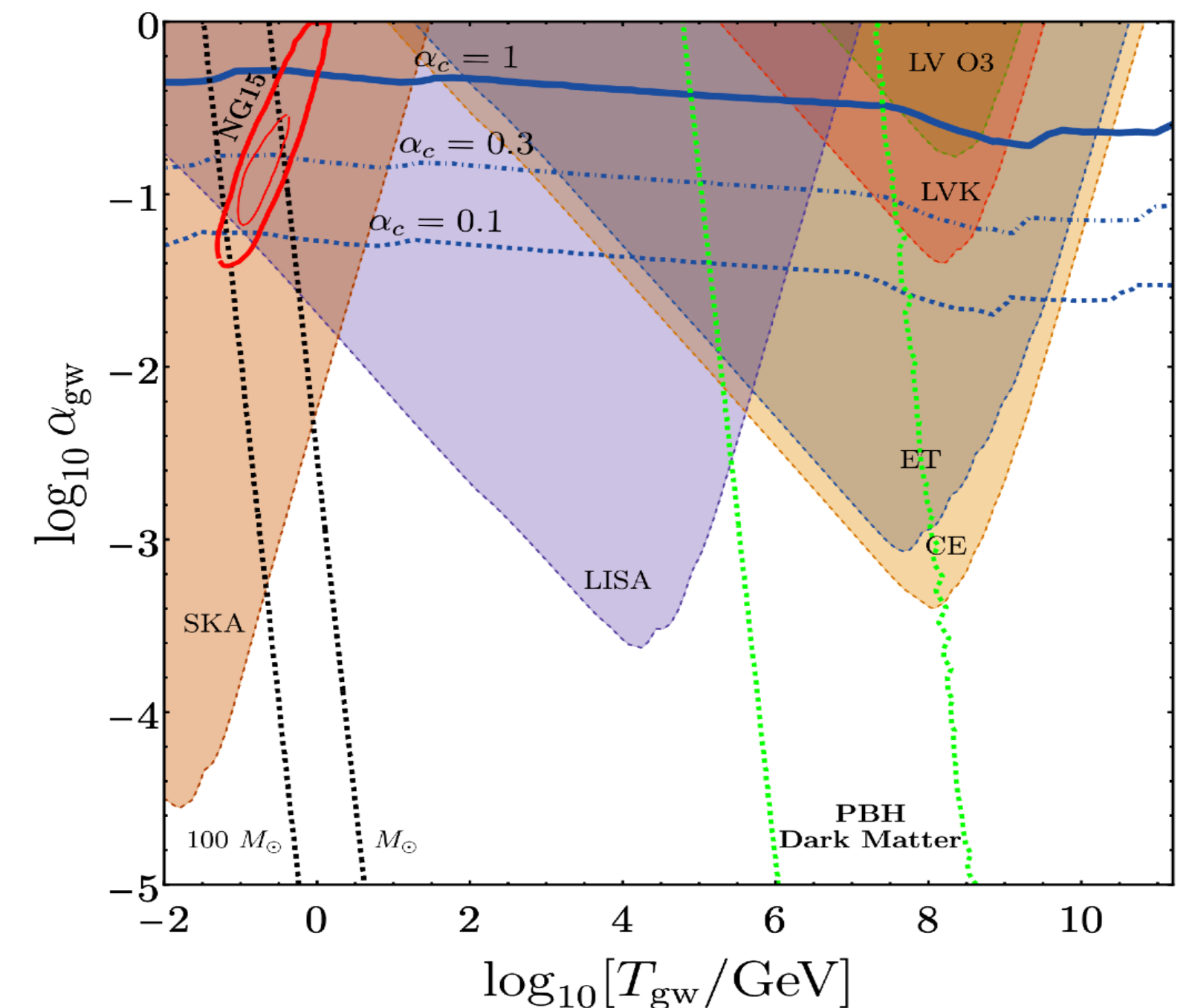
+ contributions to  
*The Science of the  
Einstein Telescope*,  
2503.12263

## First computation of both PBH and GW production from (decaying) domain walls PBH fraction crucial for DW interpretation

JCAP06(2024)020 *Journal of Cosmology and Astroparticle Physics*  
An IOP and SISSA journal

### Collapsing domain wall networks: impact on pulsar timing arrays and primordial black holes

Ricardo Z. Ferreira,<sup>a</sup> Alessio Notari,<sup>b,c</sup> Oriol Pujolàs<sup>d</sup> and Fabrizio Rompineve<sup>d,e,f</sup>



# Mariano Quirós

- My current research lines deal with the predictions and experimental signatures of the **confinement/deconfinement first order phase transition** produced in theories with **a warped extra dimension**. In particular with the production and detection of Primordial Black Holes and **Stochastic Gravitational Waves Background**, as well as the direct detection of **Kaluza-Klein gravitons at colliders**
- The prospects of my future research lines deal with studying the properties of the Black Hole (dark) fluids for **non-AdS metrics** and their influence in the cosmological evolution of the universe as well as in thermal phase transitions and the entanglement entropy. Even the possibility of identifying the dark fluid with the dark matter of the universe.

# Mariano Quirós

## Pulsar Timing Array Stochastic Background from light Kaluza-Klein resonances

Eugenio Megías,<sup>1,\*</sup> Germano Nardini,<sup>2,†</sup> and Mariano Quirós<sup>3,‡</sup>

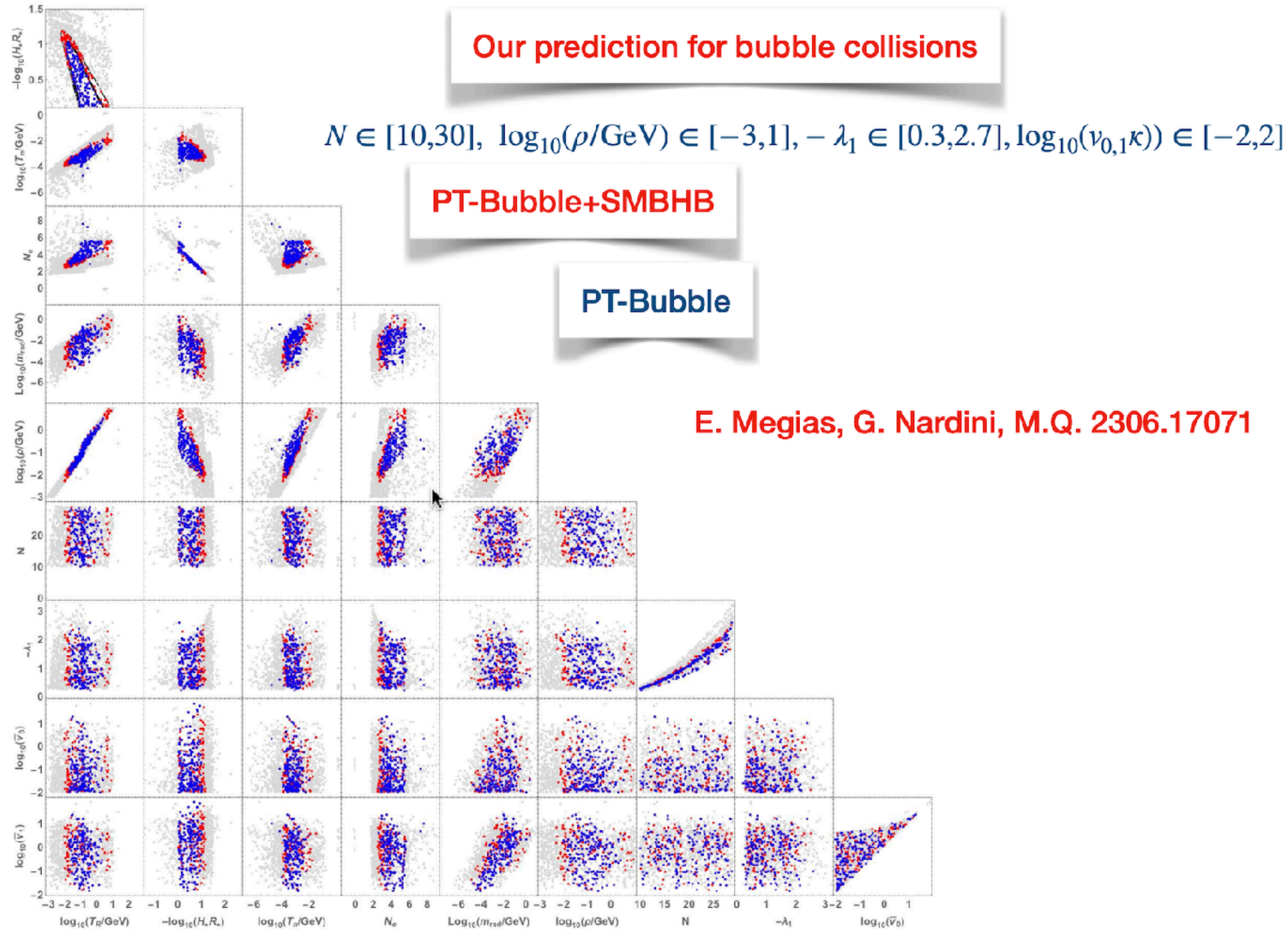
<sup>1</sup>Departamento de Física Atómica, Molecular y Nuclear and Instituto Carlos I de Física Teórica y Computacional, Universidad de Granada, Avenida de Fuente Nueva s/n, 18071 Granada, Spain

<sup>2</sup>Faculty of Science and Technology, University of Stavanger, 4036 Stavanger, Norway

<sup>3</sup>Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology (BIST), Campus UAB, 08193 Bellaterra (Barcelona) Spain

(Dated: August 7, 2023)

We investigate the potential of the warped-extra-dimension framework as an explanation for the recently observed stochastic gravitational background at nHz frequencies in pulsar timing arrays (PTA). Our analysis reveals that the PTA data can be effectively accommodated by a first-order phase transition triggered by a radion at the MeV-GeV scale feebly coupled to the Standard Model.



## COMPLEMENTARY PROBES OF WARPED EXTRA DIMENSION: Colliders, Gravitational Waves and Primordial Black Holes from Phase Transitions

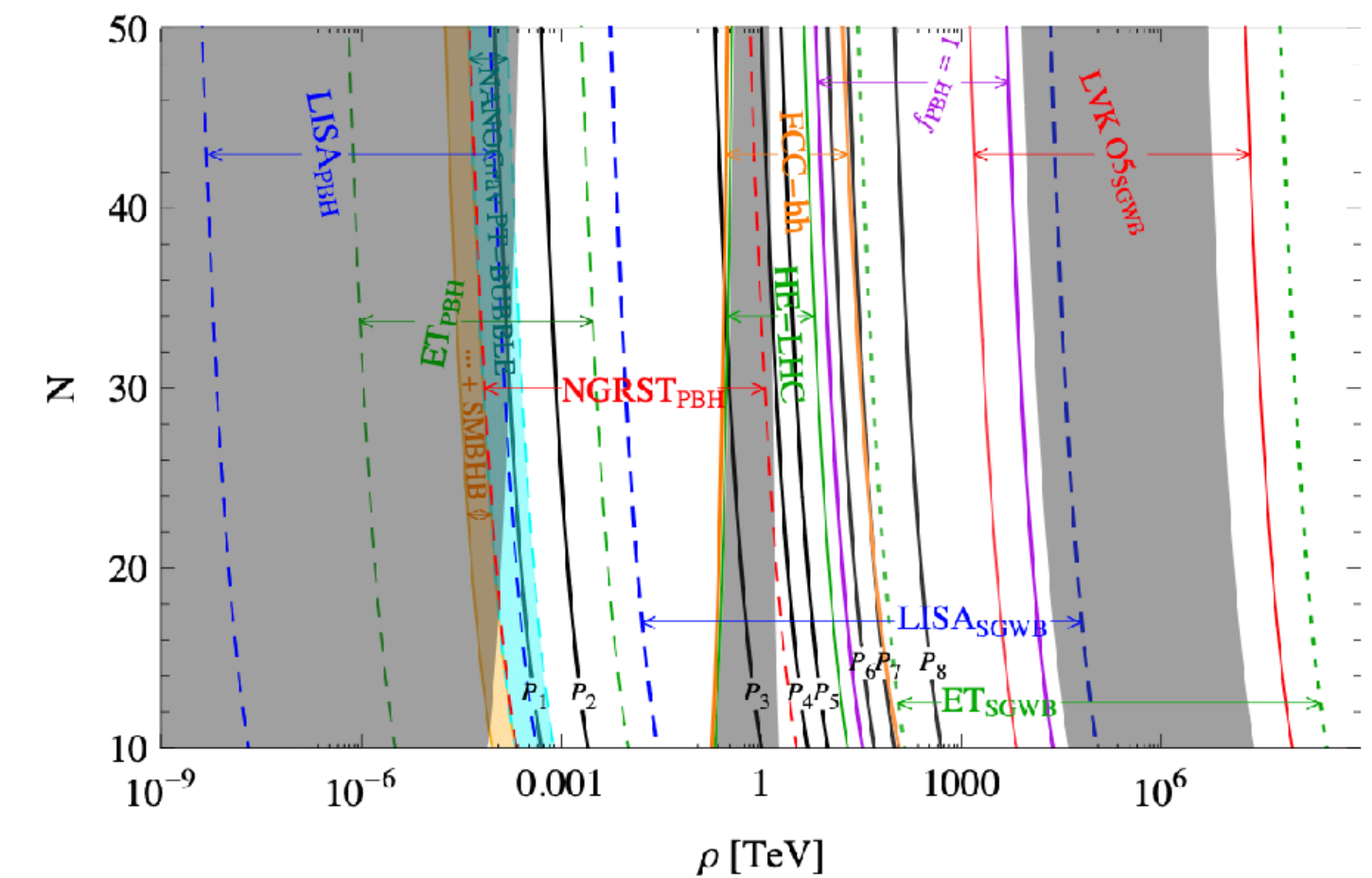
Anish Ghoshal<sup>a</sup>, Eugenio Megías<sup>b</sup>, Germano Nardini<sup>c</sup>, Mariano Quirós<sup>d</sup>

<sup>a</sup>Institute of Theoretical Physics, Faculty of Physics, University of Warsaw, Pasteura 5, PL 02-093, Warsaw, Poland

<sup>b</sup>Departamento de Física Atómica, Molecular y Nuclear and Instituto Carlos I de Física Teórica y Computacional, Universidad de Granada, Avenida de Fuente Nueva s/n, 18071 Granada, Spain

<sup>c</sup>Faculty of Science and Technology, University of Stavanger, 4036 Stavanger, Norway

<sup>d</sup>Institut de Física d'Altes Energies (IFAE), The Barcelona Institute of Science and Technology (BIST), Campus UAB, 08193 Bellaterra (Barcelona) Spain



**Figure 9.** Parameter regions probed by GW interferometers via the PBH SGWB ( $LISA_{PBH}$ ,  $ET_{PBH}$ ) and FOPT SGWB ( $LISA_{SGWB}$ ,  $ET_{SGWB}$ ,  $LVK O5_{SGWB}$ ), by microlensing observations ( $NGRST_{PBH}$ ), and collider searches ( $HL-LHC$ ,  $FCC-hh$ ). Dark areas are forbidden according to Fig. 8. PBH abundance matches the observed DM abundance in the region  $f_{PBH} = 1$ .

# Fabrizio Rompineve

## Cosmology of physics beyond the Standard Model

**Present:** recently released cosmological datasets (DESI, ACT, SPT), in addition to Planck data, provide the opportunity to probe BSM physics to an unprecedented extent, in particular as it concerns the existence of additional light degrees of freedom (dark radiation, such as axions) and properties of dark matter and dark energy. This motivates additional theoretical investigations especially on the compatibility of BSM scenario with data.

**Future:** Euclid is expected to release new LSS data in the next few years, which should clarify on recently reported deviations from  $\Lambda$ CDM (e.g. DESI on dark energy). Similarly, upcoming CMB surveys (Simons Observatory) provide the opportunity to test discover or constrain new physics scenarios. Meanwhile, efforts for the detection of the nature of the dark matter continue, and motivate theoretical studies of specific dark matter models (e.g. the QCD axion).

## Gravitational Waves

**Present:** the reported evidence for a stochastic GW background at nHz frequencies (by PTAs) provides a strong theoretical motivation for theoretical research, to the aim of extracting reliable predictions of GW spectra from BSM sources active in the early Universe, as well as understanding possible complementary signatures in cosmological datasets.

**Future:** the third data release of the International PTA consortium will be released in the next few years, possibly providing detection of the stochastic background. Other data releases from PTAs are also expected in the next five years. This, together with the longer-term outlook with LISA and possibly ET, motivates further studies in the characterization of early Universe sources of GWs (e.g. phase transitions, topological defects).

## Footprints of the QCD Crossover on Cosmological Gravitational Waves at Pulsar Timing Arrays

Gabriele Franciolini<sup>1,\*</sup>, Davide Racco<sup>2,†</sup> and Fabrizio Rompineve<sup>3,4,5,‡</sup>

<sup>1</sup>Dipartimento di Fisica, Sapienza Università di Roma and INFN, Sezione di Roma, Piazzale Aldo Moro 5, 00185, Rome, Italy

<sup>2</sup>Stanford Institute for Theoretical Physics, Stanford University, 382 Via Pueblo Mall, Stanford, California 94305, USA

<sup>3</sup>CERN, Theoretical Physics Department, Esplanade des Particules 1, Geneva 1211, Switzerland

<sup>4</sup>Departament de Física, Universitat Autònoma de Barcelona, 08193 Bellaterra, Barcelona, Spain

<sup>5</sup>Institut de Física d'Altes Energies (IFAE) and The Barcelona Institute of Science and Technology (BIST), Campus UAB, 08193 Bellaterra (Barcelona), Spain

(Received 19 July 2023; revised 1 December 2023; accepted 24 January 2024; published 20 February 2024)

Pulsar timing arrays (PTAs) have reported evidence for a stochastic gravitational wave (GW) background at nanohertz frequencies, possibly originating in the early Universe. We show that the spectral shape of the low-frequency (causality) tail of GW signals sourced at temperatures around  $T \gtrsim 1$  GeV is distinctively affected by confinement of strong interactions (QCD), due to the corresponding sharp decrease in the number of relativistic species, and significantly deviates from  $\sim f^3$  commonly adopted in the literature. Bayesian analyses in the NANOGrav 15 years and the previous international PTA datasets reveal a significant improvement in the fit with respect to cubic power-law spectra, previously employed for the causality tail. While no conclusion on the nature of the signal can be drawn at the moment, our results show that the inclusion of standard model effects on cosmological GWs can have a decisive impact on model selection.

**2024 Buchalter Cosmology Prize (Third Prize)**

## The spectrum of gravitational waves from annihilating domain walls

Alessio Notari<sup>a</sup>, Fabrizio Rompineve<sup>b,c</sup> and Francisco Torrenti<sup>a</sup>

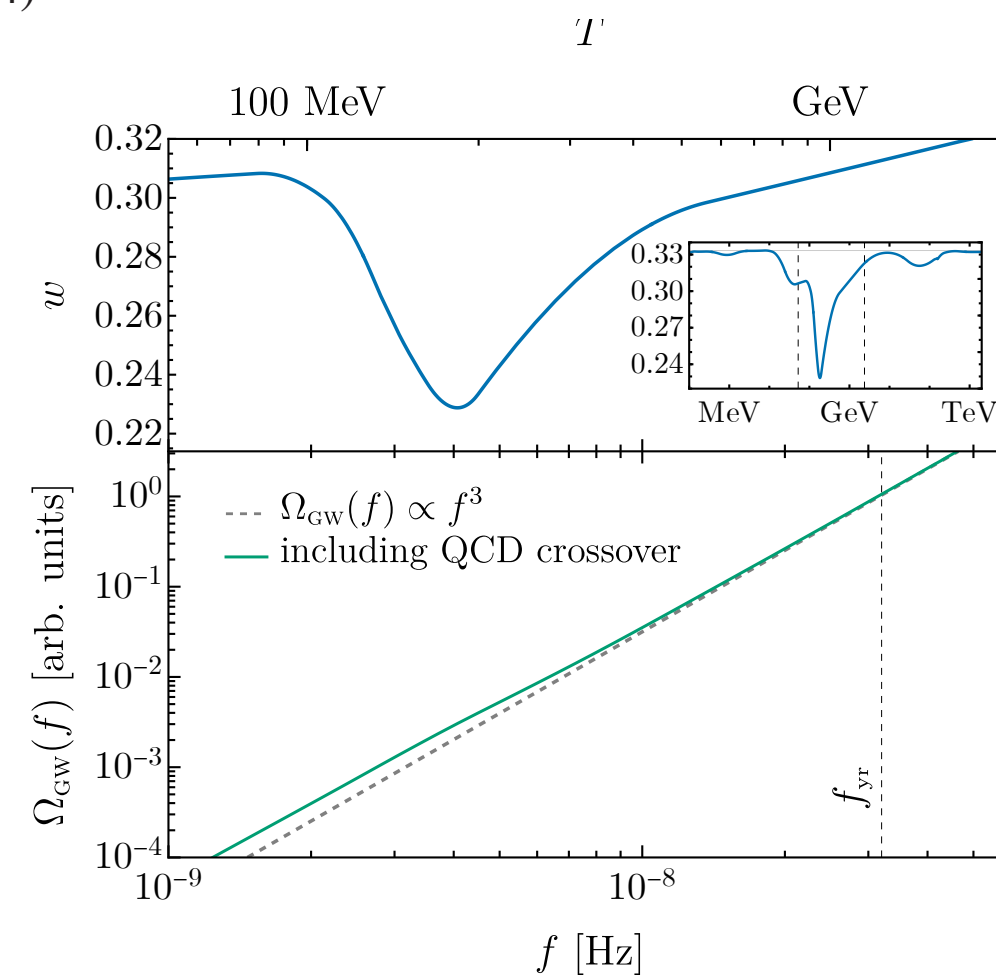
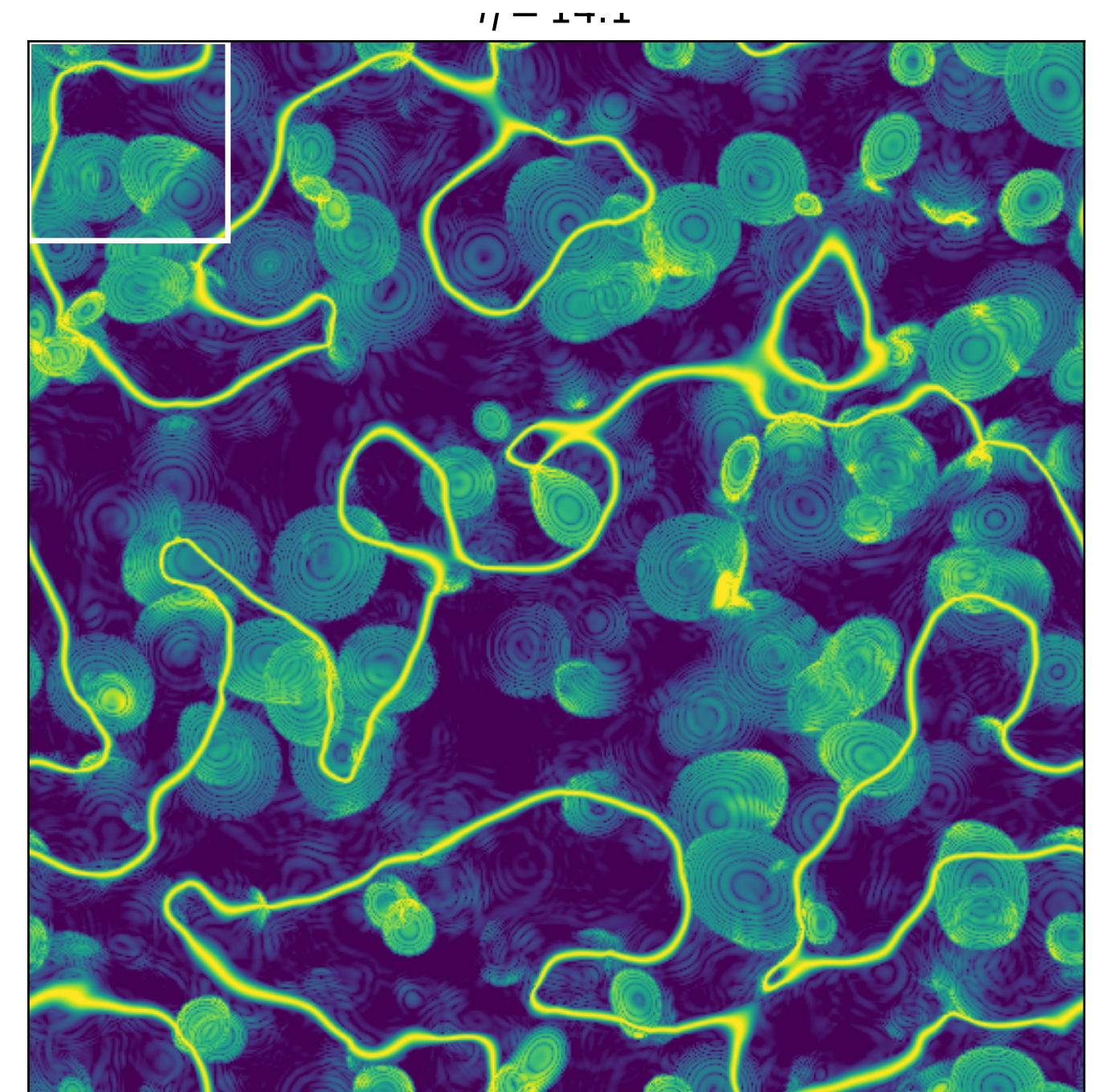


FIG. 1: *Top*: EoS during the QCD crossover. The inset shows  $w$  in an expanded range of temperatures. *Bottom*: Impact of the variation of  $w(T)$ ,  $g_*(T)$  on the CT of a primordial SGWB (plotted with an arbitrary amplitude). The dashed line shows the  $f^3$  scaling obtained in a pure radiation-dominated universe.



# Ennio Salvioni

## Expand exploration of portals to Dark Sector:

- **Test BSM physics with galaxy survey data**

**New calculations in the EFT of Large Scale Structure, new observables (e.g. multi-tracer bispectra)**

- **Light thermal Dark Matter**

**Production from strongly interacting Dark Sectors and interplay with LHC signals (“dark shower” topologies, improve modeling + input to searches at Runs 3-5)**

- **The Higgs boson as a portal**

**BSM Higgs physics @ LHC (Member of Steering Committee of LHC Higgs Working Group) and @ future colliders (muons, protons)**

# Ennio Salvioni

- Test new physics in the Dark Sector with data from ongoing galaxy surveys (DESI, Euclid, Rubin, ...)
- Improve on CMB sensitivity for broad range of microscopic models beyond  $\Lambda$ CDM
- Theory: develop EFT of Large Scale Structure for BSM dynamics



PHYSICAL REVIEW D **112**, 023525 (2025)

From 100 kpc to 10 Gpc: Dark matter self-interactions before and after DESI observations

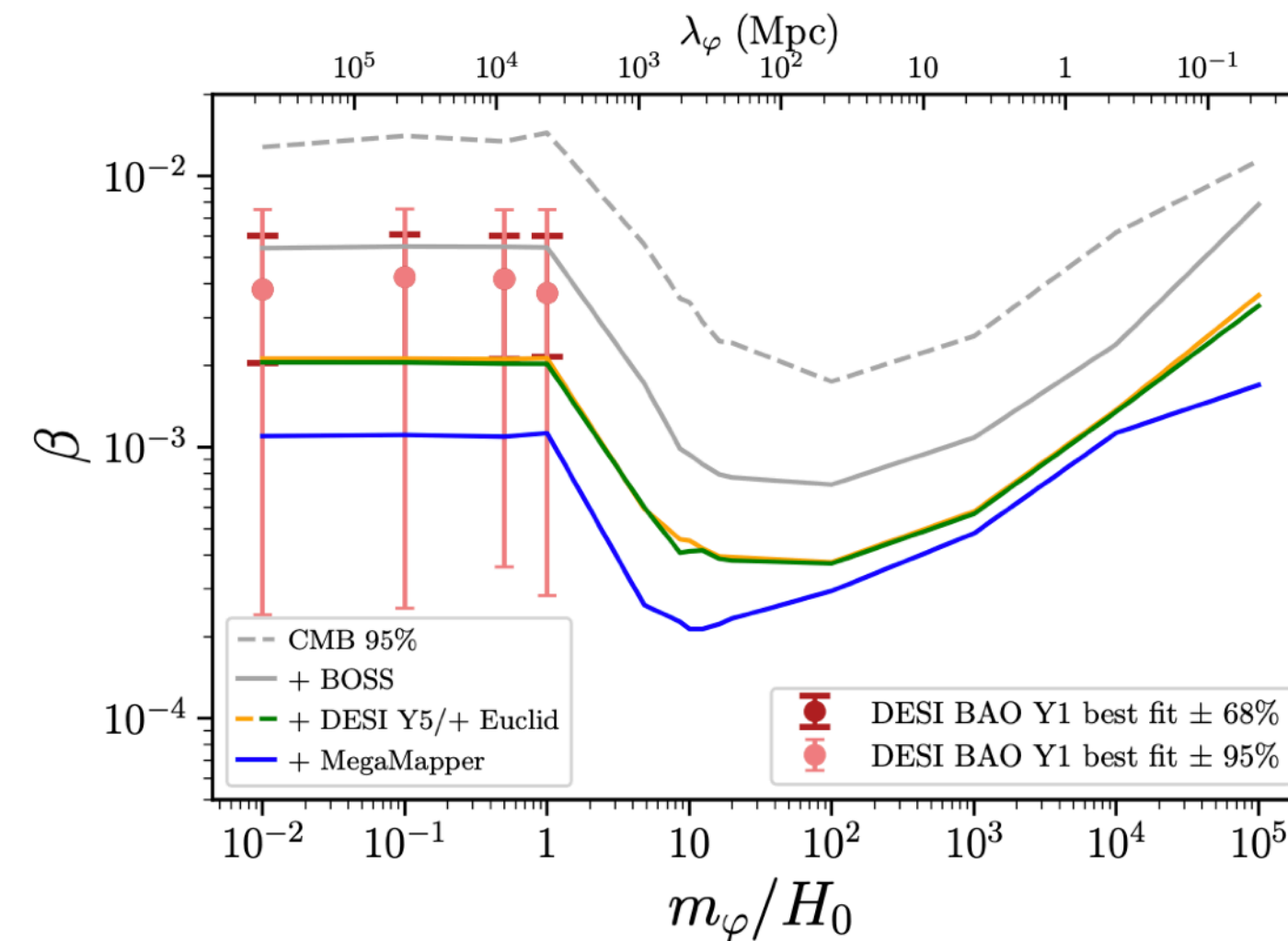
2204.08484  
2309.11496  
2407.18252

PHYSICAL REVIEW LETTERS **132**, 201002 (2024)

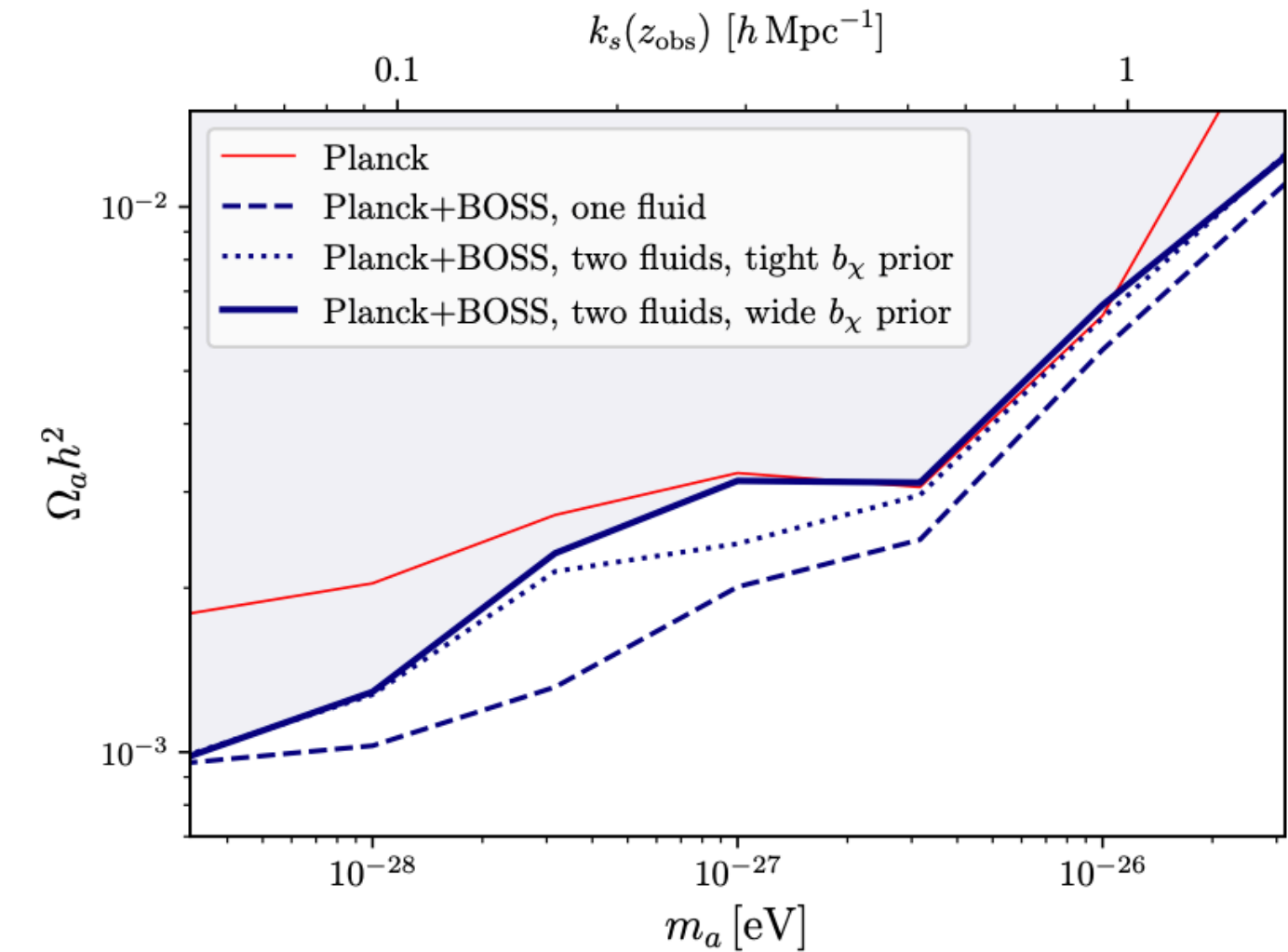
Unveiling Dark Forces with Measurements of the Large Scale Structure of the Universe

Salvatore Bottaro<sup>1</sup>, Emanuele Castorina<sup>2</sup>, Marco Costa<sup>3</sup>, Diego Redigolo<sup>4</sup>, and Ennio Salvioni<sup>5</sup>

Dark Matter self-interactions



New relativistic species (e.g. axions)



The Effective Field Theory of Large Scale Structure for Mixed Dark Matter Scenarios

Francesco Verdiani,<sup>a,b,c,d</sup> Emanuele Castorina,<sup>e,f</sup> Ennio Salvioni,<sup>g</sup>  
Emiliano Sefusatti<sup>b,c,d</sup>

2507.08792 @JCAP

# Andrea Wulzer

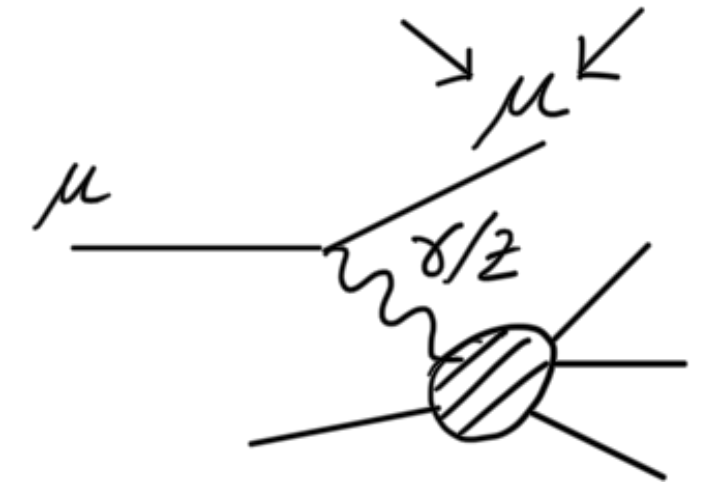
## Future colliders

The recent scientific achievements:

- consolidating of my previous studies on the physics opportunities of a very forward muon detector that uniquely exploits the penetrating nature of high-energy muons;
- opening a new avenue in flavor physics exploration by the direct study of flavor transitions in high-energy muon collisions, with a broad sensitivity to new physics effects that in many cases surpasses the future perspectives of low-energy probes;
- initiating the assessment of the opportunities of a neutrino Deep Inelastic Scattering experiment performed with the neutrinos from the decay of the high-energy muon collider beam, which offers extraordinary perspectives to improve the current knowledge of the CKM matrix elements and to advance the determination of the Parton Distribution Functions.

## Non-muon collider Research

Recent work not directly related to the muon collider include the development of a novel methodology to assess the systematic uncertainties associated with the truncation of an Effective Field Theory in LHC studies, and a new proof at tree level of factorization and the calculation of the associated splitting amplitudes that simultaneously accounts for the soft and for the collinear region extending previous work (including mine) on the subject.



# Andrea Wulzer

## Towards a muon collider - Science

Why detect forward muons at a muon collider

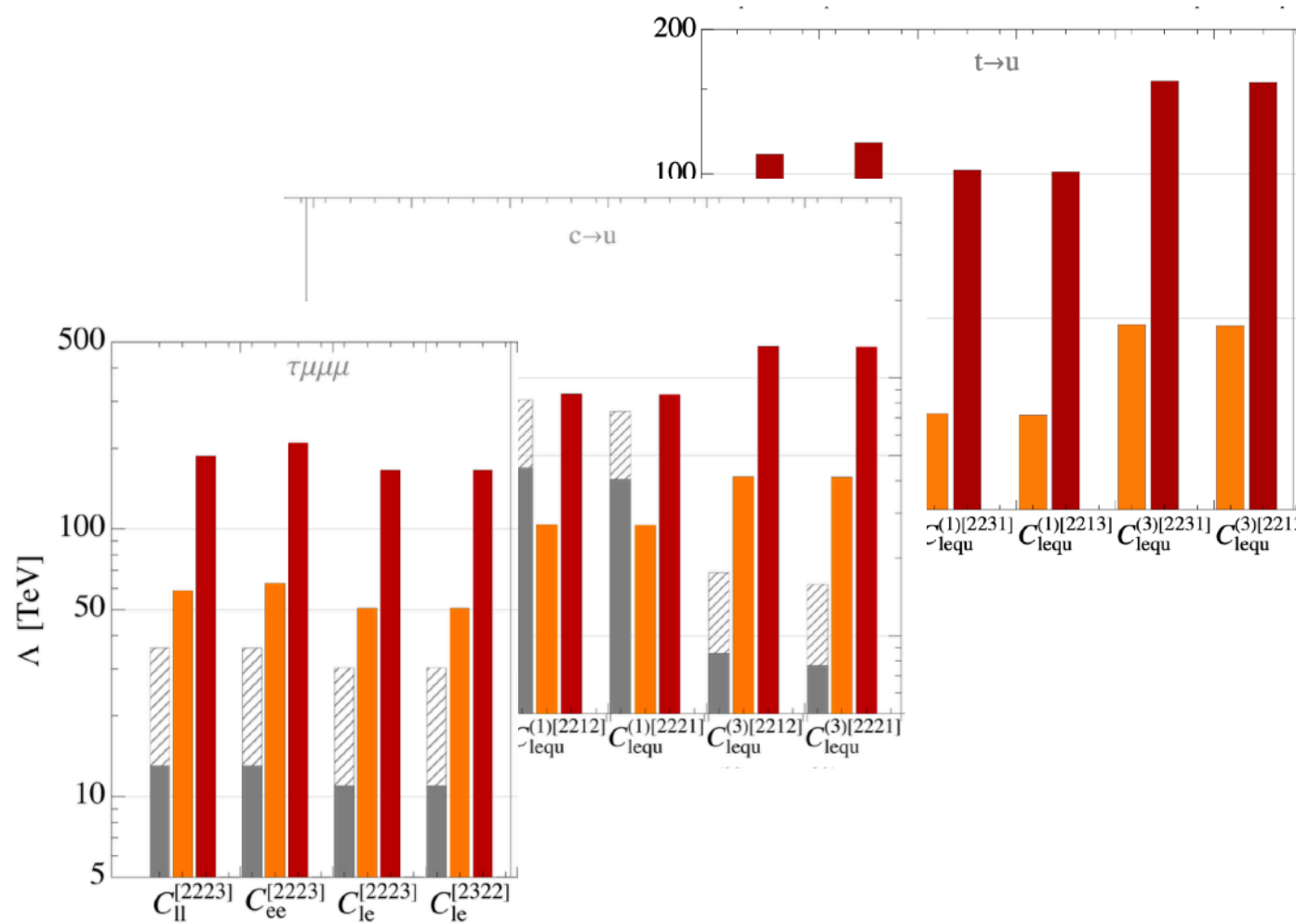
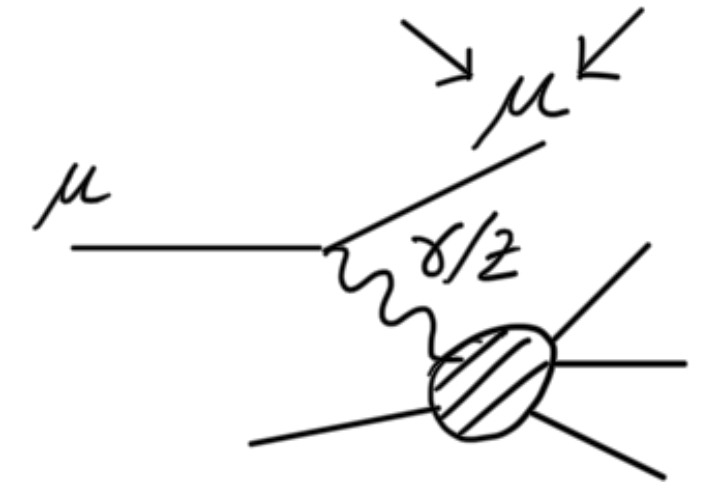
Opportunities of very forward detector that uniquely leverages muons as penetrating particles.  
[Phys.Rev.D 111 (2025) 5, 053010]

Flavor physics at high-energy muon colliders

Flavor transitions at high energy probes flavor physics systematically, and better than mesons/lepton low energy studies. [2509.08132, under review]

A new DIS experiment with muon collider neutrinos

Striking perspectives for PDF determination and CKM measurement. In progress. Preliminary results in IMCC ESPPU submission [2504.21417]



## Towards a muon collider - Coordination

Deputy Study Leader and Physics WG coordinator of IMCC

Major recent effort: IMCC ESPPU submission [2504.21417]

## Towards a muon collider - Impact

The National Academy of Sciences panel report:

[Spiropulu, Turner, Arkani-Hamed, Barish, Beacom, Bucksbaum, Carena, Fleming, Gianotti, Gross, Habib, Kim, Oddone, Patterson, Pilat, Prescod-Weinstein, Roe, Tait]

***Recommendation 1: The United States should host the world's highest-energy elementary particle collider around the middle of the century. This requires the immediate creation of a national muon collider research and ...***



Relative Precision [%]	CC+NC (Stat)	CC+NC	CC	PDG
$\delta V_{ud} $	0.00215	0.00788	0.0327	0.0329
$\delta V_{us} $	0.0269	0.0558	0.145	0.379
$\delta V_{ub} $	1.43	1.51	1.66	5.24
$\delta V_{cd} $	0.00967	0.250	0.463	1.81
$\delta V_{cs} $	0.00371	0.0134	0.207	0.615
$\delta V_{cb} $	0.191	0.220	0.625	2.92
$\delta s_W$	0.0110	0.0171	0.0173	0.0173

## Towards a muon collider - Perspectives

Pretty good. Shouldn't IFAE join IMCC?

## Non-muon collider Research

Low-virtuality splitting in the Standard Model [JHEP 10 (2024) 215]

Quantifying EFT Uncertainties in LHC Searches [2507.15954, under review]

# Leadership & exp collaboration

**Blas – LISA, AION, RADES, AEDGE**

**Escribano – REDTOP**

**Masjuan – Muon Anomalous  
Magnetic Moment Theory Initiative,  
REDTOP**

**Matias – close contact with CMS and  
LHCb**

**Pomarol – RPP, KIAS Scholar (KIAS  
Korea)**

**Pujolàs – Einstein Telescope**

**Rompineve – EPTA, EUCaPT**

**Wulzer – Muon Collider**

**Quiros – IAC of several intl  
conferences: Planck, SUSY,...**

**Salvioni – LHC Higgs Working  
Group, Muon Collider**

# TDLI – IFAE Synergies

- **IFAE physics interests highly overlapping with TDLI research:**
  - **GW physics, searches**
  - **Axion physics**
  - **Early Univ cosmology**
  - **DM searches**
  - **Future colliders**
  - **Formal developments**
  - **ML for HEP**
  - **BSM, model buildg.**
  - **low energy QCD**
  - **collider phys.**
  - **hadron EXP**
  - **Flavor**

# TDLI – IFAE Synergies

## Cavity Multimodes as an Array for High-Frequency Gravitational Waves

Diego Blas (Barcelona, IFAE), Yifan Chen (Tsung-Dao Lee Inst., Shanghai and Shanghai Jiao Tong U.), Yuxin Liu (Beijing, GUCAS and ICTP-AP, Beijing), Yanfei Shang (Peking U., SKLNPT and Peking U., CHEP), Jing Shu (Peking U., SKLNPT and Peking U., CHEP and BIMSA, Beijing) (Jan 6, 2026)

e-Print: [2601.03341](#) [hep-ph]

## Probing Axions via Spectroscopic Measurements of S-stars at the Galactic Center

Zhaoyu Bai (Weizmann Inst.), Vitor Cardoso (Bohr Inst. and Lisbon, CENTRA and Lisbon, CFTP), Yifan Chen (Bohr Inst.), Tuan Do (UCLA), Aurélien Hees (LTE, Paris), Huangyu Xiao (Chicago U., KICP and Fermilab), Xiao Xue (Barcelona, IFAE)

e-Print: [2507.07482](#) [hep-ph]

# TDLI – IFAE Synergies

## Holographic Lifshitz flows

Matteo Baggioli (Shanghai Jiaotong U. and SRCQS, Shanghai), Oriol Pujolas (Barcelona, IFAE), Xin-Meng Wu (Shanghai Jiaotong U. and SRCQS, Shanghai) (Jul 16, 2024)

Published in: *JHEP* 09 (2024) 175 • e-Print: [2407.11552](https://arxiv.org/abs/2407.11552) [hep-th]

# TDLI – IFAE Synergies

## Holographic Lifshitz flows

Matteo Baggioli (Shanghai Jiaotong U. and SRCQS, Shanghai), Oriol Pujolas (Barcelona, IFAE), Xin-Meng Wu (Shanghai Jiaotong U. and SRCQS, Shanghai) (Jul 16, 2024)

Published in: *JHEP* 09 (2024) 175 • e-Print: [2407.11552](#) [hep-th]



**Baggioli Matteo** Associate Professor



Wilczek Quantum Center



Theoretical High Energy Physics, Soft Matter Theory

**Matteo Baggioli** Jiao-Tong U., Shanghai (2020-present)

**PhD: 2013-2017, IFAE, supervisor: O Pujolàs**

**Time to establish TDLI – IFAE bridges !**



# Barcelona Shanghai Bridge

14 October  
18 November 2021