Commissione Scientifica Nazionale IV
Gruppo Teorico LNF

Gennaro Corcella

1. **Informazioni su gruppo ed anagrafica**

2. **Attività sigle locali CSN4**

Anagrafica Provvisoria 2025-26 – dipendenti e associati senior

Nome	Pos	Qual.	AMPLITUDES	ENP	PML4HEP	TASP	TIME2QUEST(CS)	DOT	Tot
Bagnaschi Emanuele	Dip	Ric.		10	90				100
Bellucci Stefano	Ass	Ass.Sen.					100		100
Corcella Gennaro	Dip	I Ric.		100					100
Del Duca Vittorio	Dip	I Ric.	100						100
Gionti Gabriele	Ass	I Ric.						50	50
Mescia Federico	Dip	Dir.Ric.				100			100
Nardi Enrico	Ass	Ass.Sen.				100			100

Assegnisti di ricerca

F. Arias Aragón (Cabibbo fellow, TAsP): LNF sino a Ottobre 2025 ($\rightarrow$ Madrid)

A. Lind (Cabibbo fellow, ENP): LNF sino a Settembre 2026 ($\rightarrow$ Roma)

F. Alessio (Amplitudes) sino a Ottobre 2026

V. Susic (PRIN 'Axion Origins', TAsP) sino ad Aprile 2026

K. Müürsepp (Estonian Research Council, ENP) da Gennaio 2025

G. Landini (Cabibbo fellow, TAsP) da Ottobre 2025

Ming-Ming Long (Amplitudes) da Ottobre 2025

Dottorandi di ricerca: V. Fiorentino (Roma III, TAsP), E. Rosi (Sapienza, Amplitudes)

Affiliati over 72: C. Natoli, G. Pancheri, F. Palumbo, A. Tenore

IS Exploring New Physics (ENP) – Nodi: LNF, RM1, RM2, NA, PG

Responsabile Nazionale: G.Corcella (2024-26)

ENP valutata in prima fascia da referee esterni

Nodo LNF:

G. Corcella (100%, Ric. II Livello), E.A. Bagnaschi (10%, Ric. III Livello),
K.Müürsepp and A.Lind (100%, assegnisti di ricerca)

Attività di ricerca su vari aspetti di fenomenologia dei collider:

- Test di precisione del Modello Standard: fenomenologia dei quark pesanti e Higgs, QCD perturbativa e non, implementazione Monte Carlo, ioni pesanti

- Fisica BSM: modelli e scenari non ancora esclusi, e.g., 331 (bileptoni)

Intensa attività nei gruppi di lavoro sulla strategia europea per i futuri collider

Gennaro Corcella:

1. Fisica del top e QCD

Top a FCC-ee: $e^+e^- \to t\bar{t}$, $t \to jjb$, $\bar{t} \to XY$, $\bar{t}$ non passa selezione del top $\Rightarrow$ limiti model-independent su decadimenti BSM $\mathrm{BR}_{\mathrm{exo}} \simeq 10^{-3}$ (prel.) (G.C., D.Sengupta, B.Mele)

Interpretazione massa del top (m_{MC} vs. m_{pole}) mediante mesoni $T^{\pm,0}$ fittizi grazie a $m_T = m_{\mathrm{pole}} + \Delta$ (HQET) $\Rightarrow m_{\mathrm{MC}} \simeq m_{\mathrm{pole}} + \mathcal{O}(\Lambda)$ (G.C., A.Lind)

Costante di accoppiamento forte efficace $\tilde{\alpha}_S(Q^2)$ priva del polo di Landau per includere effetti non perturbativi (broadening, EEC in e^+e^-) in luogo di modelli fenomenologici con parametri liberi, e.g. $\tilde{\alpha}_S(Q^2) = \frac{1}{\beta_0}\left[\frac{1}{\ln(Q^2/\Lambda^2)} - \frac{\Lambda^2}{Q^2-\Lambda^2}\right]$ (G.C., U.Aglietti and G.Ferrera)

2. Fisica BSM

Bileptoni $Y^{\pm\pm}$ ($L = \pm 2$) e quark esotici Q di massa $\mathcal{O}(\mathrm{TeV})$ e carica $5/3$ o $4/3$ da vari modelli, come il 331, basato sulla simmetria $SU(3)_C \times SU(3)_L \times U(1)_X$

Produzione di quark pesanti nel 331: $pp \to T\bar{T} \to (Y^{++}b)(Y^{--}\bar{b}) \to (b\mu^+\mu^+)(\bar{b}\mu^-\mu^-)$

(G.C.,C.Corianò, P.H.Frampton, D.Melle)

Chairman di Spring School 'Bruno Touschek' (LNF, Maggio 2026), possibile coordinamento con Scuola INFN Monopoli (ex Otranto)

Research projects of Alexander Lind

Research interests:

- Collider phenomenology and precision predictions
- Monte Carlo event generators
- QCD, Higgs physics, and BSM extensions

Current research projects:

- Monte Carlo study of top quark mass systematics using fictitious top hadrons in Pythia 8 and Herwig 7

  with Gennaro Corcella
- Constraints on new physics using Higgs p_T STXS measurements with H1jet and HiggsSignals

  with Emanuele Bagnaschi and collaborators in Germany and Spain

Research projects of Alexander Lind

Current research projects (continued):

- BSM extensions for $pp \to h \to t\bar{t}$ and $pp \to hh$ including tree-loop interference terms at NLO QCD
  with collaborators in the UK
- Simulation of jet energy loss in heavy-ion collisions with SUBA-Jet and implementations in EPOS4 and Pythia 8
  with collaborators in France and Prague
- Four-point energy correlators from collinear QCD splitting amplitudes
  with Vittorio Del Duca and collaborators in Zurich and the US
- Unitarity violation in the PMNS matrix for $e^+e^- \to W^+W^-$ at future lepton colliders
  with Kristjan Müürsepp, Enrico Nardi, Gennaro Corcella, Emanuele Bagnaschi, and collaborators in Estonia and Trieste

CP violation from production at bubble collisions

Together with Miguel Vanvlasselaer (Brussels U) and Martina Cataldi (DESY), **arXiv:2506.12123 [hep-ph]**

Including **BOTH on- and off-shell proccesses:**

The rate of production of asymmetry is given by:

$$\left(\Gamma^{\epsilon}_{\phi^\star\to HL\chi}\right)_{\alpha I} = \frac{1}{(2\pi)^3}\frac{1}{32p^3}\int_{s_{12}^{\min}}^{s_{12}^{\max}}\int_{s_{23}^{\min}}^{s_{23}^{\max}} \left|\mathcal{M}_0^{\alpha I}(s_{12},s_{23})\right|^2 \epsilon_{\alpha I}(s_{12})\mathrm{d}s_{12}\,\mathrm{d}s_{23}$$

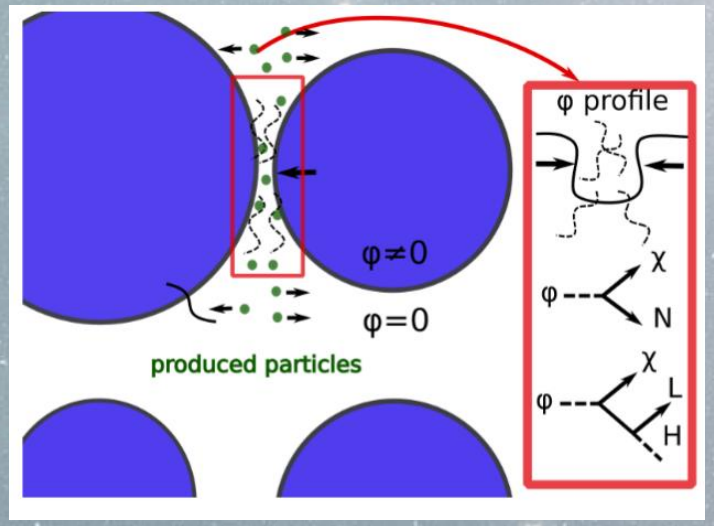
From which we can compute the lepton asymmetry:

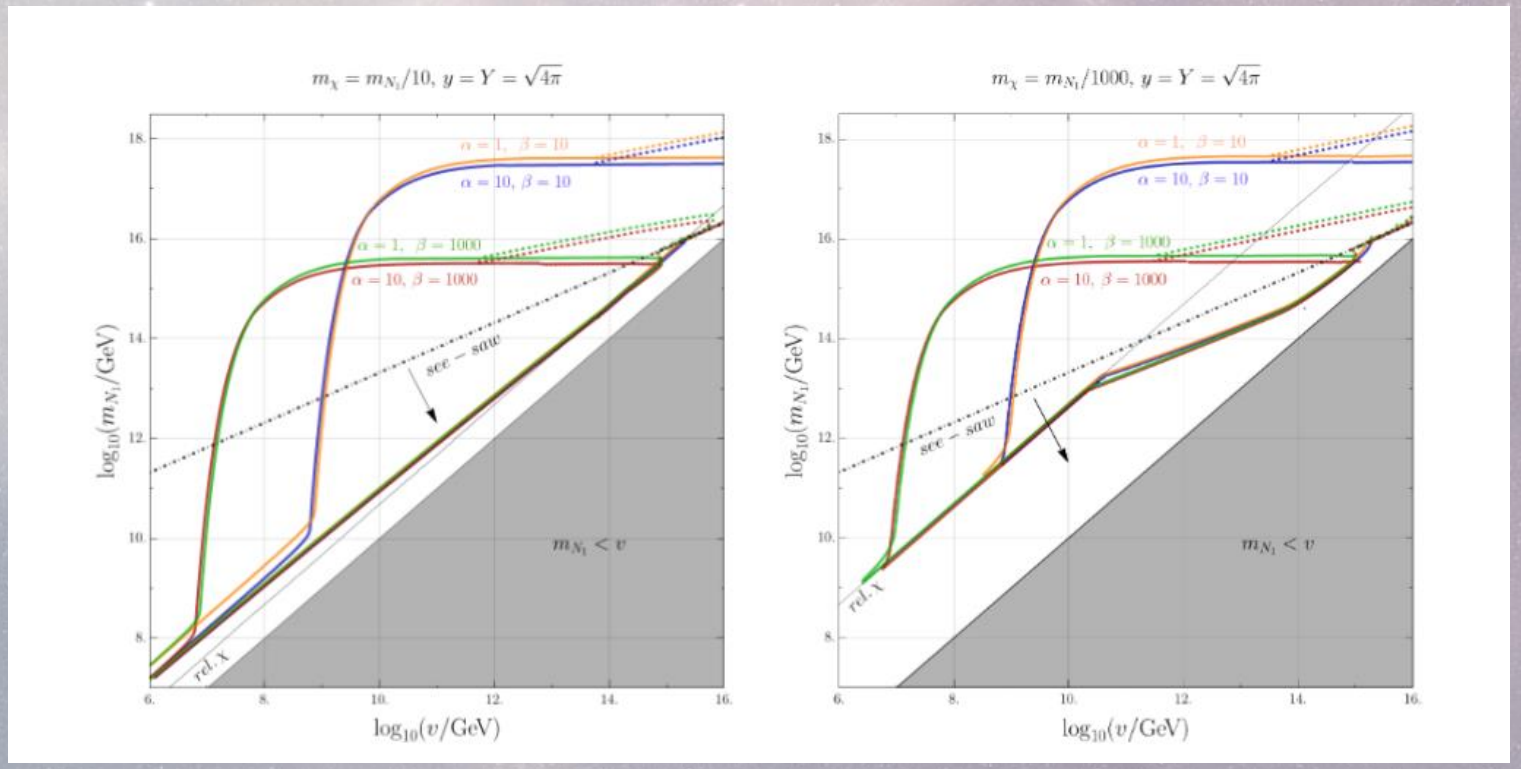
$$\left.\frac{N_{\Delta L}}{A}\right|_{\phi^\star\to\chi HL} \approx \int \frac{dp_z d\omega}{(2\pi)^2}\Gamma_{\phi^\star\to\chi HL}(p)\left|\phi(p^2)\right|^2 \qquad \Rightarrow n_{\Delta L} \approx \frac{3\beta H}{2}\times\left.\frac{N_{\Delta L}}{A}\right|_{\phi^\star\to\chi HL}$$

Available parameter space

FEATURES ALSO GW SIGNALS for ET!

Schematic description of the mechanism





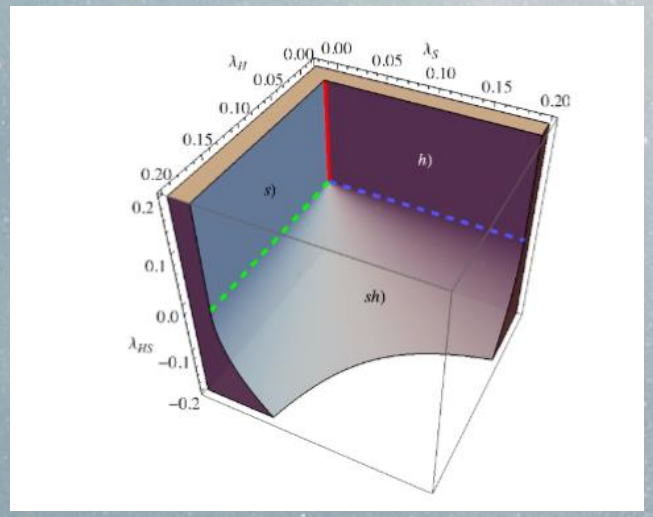
RG-improvement of models of multiphase criticality

Together with K.Kannike (NICPB, Tallinn) and L.Marzola (NICPB, Tallinn)

MOTIVATION: The lightness of the Higgs could hint to criticality of two phases!

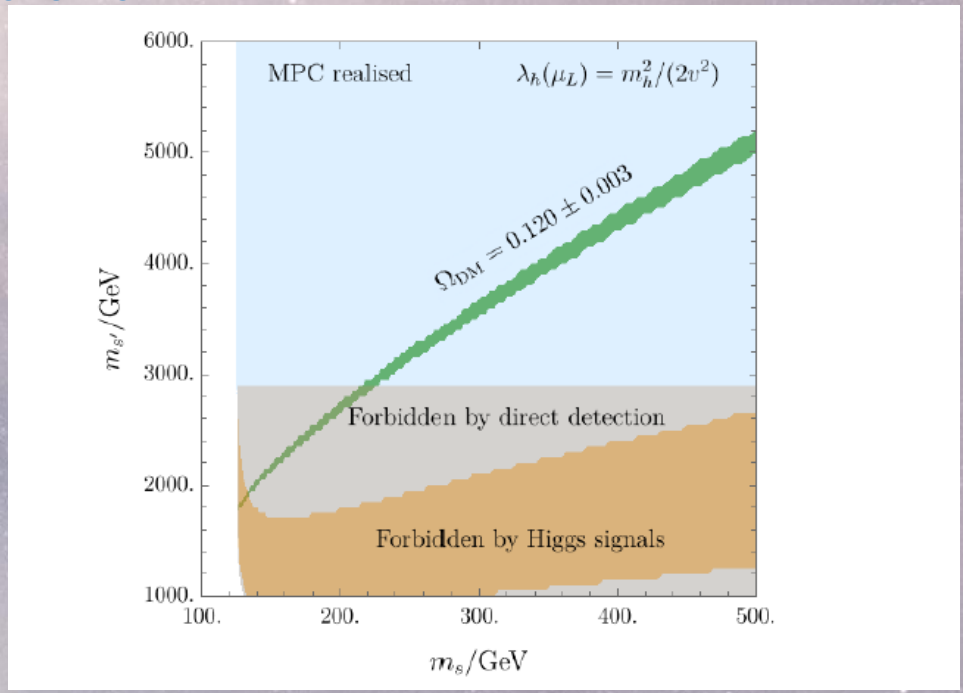
1. Criticality requires small values of dilaton and portal couplings
2. Then the s) and sh) phases are smoothly connected: Higgs mass flips sign between the phases-> Higgs naturally light

$$V = \frac{\lambda}{4}h^4 + \frac{\lambda_s}{4}s^4 + \frac{\lambda_{s'}}{4}s'^4 + \frac{\lambda_{hs}}{4}h^2s^2 + \frac{\lambda_{hs'}}{4}h^2s^2 + \frac{\lambda_{SS'}}{4}s^2s'^2$$



We include the full SM (neglected before) and consider different hierarchies with full multi-scale RG- improvement.

1. Higgs and dilaton are approximately degenerate in mass
2. Higgs is lighter tan the dilaton
3. Higgs is heavier than the dilaton



Kannike, Marzola, Raidal, Strumia, Phys. Lett. B., 816, 2021

Relazione sull'attività di ricerca

Vittorio Del Duca

Gruppo

- al momento, il gruppo consta di
  — Francesco Alessio (AR junior ai LNF da ottobre 2024 a settembre 2026)
  — Emanuele Rosi (dottorando della Sapienza da ottobre 2024)

- ne hanno fatto parte
  — Damiano Barcaro (primo semestre 2024, come tesista di Magistrale della Sapienza)
  — Andrea De Simone (primo semestre 2024, come tesista di Magistrale della Sapienza)

- al gruppo si unirà
  — Ming-Ming Long (AR senior dell'IS Amplitudes, ai LNF da ottobre 2025)

- del gruppo fa informalmente parte
  — Riccardo Gonzo (postdoc fellow a Queen Mary U.)
  che è stato co-relatore di Barcaro e De Simone, e attualmente nostro collaboratore

Linee di ricerca

- sviluppare uno schema per il calcolo di sezioni d'urto al NNLO in α_s e oltre in modo indipendente dal particolare processo [1], usando l'universalità delle divergenze infrarosse
- potenziare il calcolo di ampiezze di scattering in teorie di gauge, mediante l'analisi nel limite di Regge [2, 3]
- calcolare l'emissione di onde gravitazionali da un sistema binario di oggetti massivi compatti [4, 5, 6]

[1] V. Del Duca, C. Duhr, L. Fekeshazi, F. Guadagni, P. Muckerjee, G. Somogyi, F. Tramontano, S.van Thuerenhout
``NNLOCAL: completely local subtractions for colour-singlet production in hadron collisions"
JHEP 05 (2025) 151 [arXiv:2412.21028 [hep-ph]]

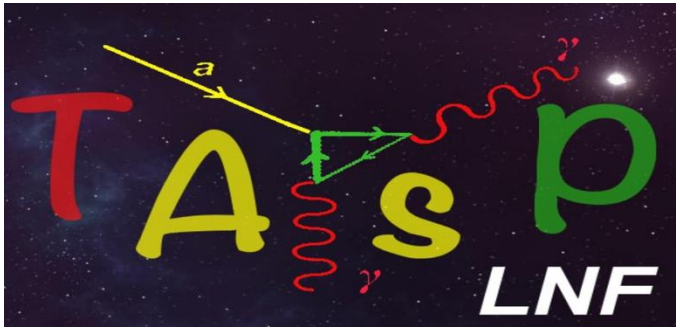
[2] V. Del Duca, G. Falcioni
''The two-loop Higgs impact factor", arXiv:2504.06184 [hep-ph]

[3] E.P. Byrne, V. Del Duca, E. Gardi, Y. Mo, J.M. Smillie
''Regge factorisation of tree-level QCD amplitudes using a minimal set of light cone variables",
arXiv:2506.10644 [hep-ph]

[4] D. Akpinar, V. Del Duca, R. Gonzo
''The spinning self-force EFT: 1SF waveform recursion relation and Compton scattering",
arXiv:2504.02025 [hep-th]

[5] F. Alessio, R. Gonzo, C. Shi
''Dirac brackets for classical radiative observables", arXiv:2506.03249 [hep-th]

[6] D. Barcaro, V. Del Duca
''The Central-Emission Vertex of two gravitons", arXiv:2506.11822 [hep-th]



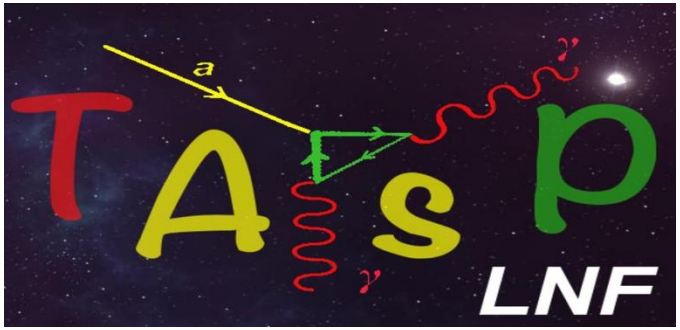
Theoretical Astroparticle Physics
CSN4: linea 5

R.L *Federico Mescia*

2025-26 Team@LNF

❖ F. Aragon Arias	0%	(Ass. Cabibbo, **until Sept. 2025** → IFT)
❖ **V. Susic**	100%	(Ass. PRIN, until April 2026)
❖ **G. Landini**	100%	(Ass. Cabibbo, **from Oct. '25** ← U.V)
❖ **V. Fiorentino**	100%	(Dott. U. Roma Tre, until Oct. '27)
❖ **Ji-Heng Guo**	0%	(PhD Beihang U., until July '26, CSC-grant)
❖ **E. Nardi**	100%	(Ass. Senior)
❖ **F. Mescia**	100%	

Frascati, July 14th, 2025



Theoretical Astroparticle Physics
CSN4: linea 5

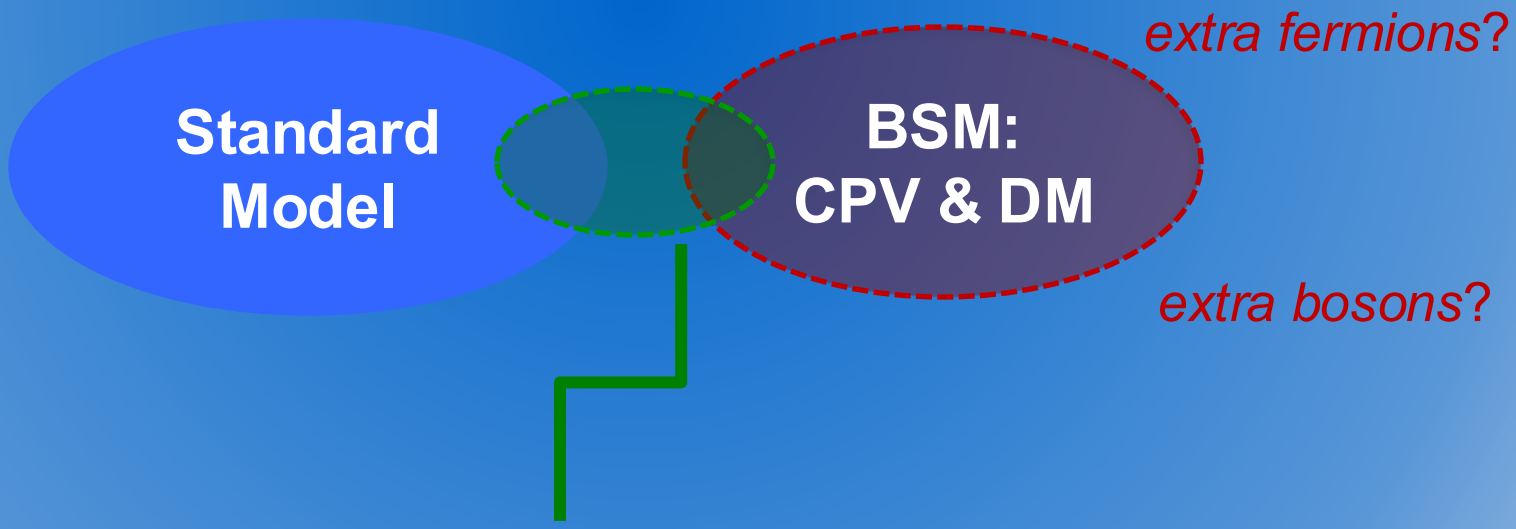
R.L *Federico Mescia*

Collaborations

- **L. Di Luzio** — **INFN-PD** → Axion and Flavour
- **L. Darme** — **U. Lyon** → Light Dark Matter and X_{17}
- **G. Grilli di Cortona** — **LNGS** → Light Dark Matte and X_{17}
- **L. Visinelli** — **U. Salerno** → GW for Flash theory WG
- **R. Franceschini** — **U. Roma TRE** → DM at collider
- **L. Vittorio** — **U. RM1** → Flavour Physics and LDM
- **M. Giannotti** — **U. Zaragoza** → Axion Astrophysics
- **D. Becirevic** — **U. Paris-Saclay** → Flavour Physics
- **Claire Chevalier** — **U. Paris-Saclay (PhD, visitor)** → Flavour Phys.
- **C. Toni** — **Annecy** → X_{17} and Flavour Physics

TAsP-LNF: research priorities (2025-26)

"Establishing Physics Beyond the Standard Model in the light of Data"



TAsP-LNF: Research Priorities (2025-26)

"New production and detection mechanisms of dark sector in colliders and in astrophysics."

1. Physics of the Axions: theory and phenomenology:
   linked to searches at FLASH → strengthened by G. Landini
   (background on axion and GW)

2. Feebly Interacting Particles (LDM, Alps, dark photon, …)
   linked to searches at PADME, LHCb and NA62

3. Minimal Flavour Violations and Dark sectors
   linked to searches at NA62 and Belle II

TAsP-LNF: 2024-25 Publications

1. F. Arias-Aragon, L. Darme, G. G. di Cortona and E. Nardi, ``Production of Dark Sector Particles via Resonant Positron Annihilation on Atomic Electrons," Phys. Rev. Lett. 132 (2024) no.26, 261801, [arXiv:2403.15387 [hep-ph]].

2. S. Babu, B. Bajc and V. Susic,``A realistic theory of E6 unification through novel intermediate symmetries, JHEP06 (2024), 018, [arXiv:2403.20278 [hep-ph]].

3. K. Müürsepp, E. Nardi and C. Smarra, ``Accelerated cosmic expansion, mass creation, and the QCD axion," [arXiv:2405.00090 [hep-ph]].

4. F. Arias-Aragon, L. Darme, G. G. di Cortona and E. Nardi, ``Atoms as Electron Accelerators for Measuring the Cross Section of e+e-->Hadrons," Phys. Rev. Lett. 134 (2025) no.6, 061802, [arXiv:2407.15941 [hep-ph]].

5. F. Mescia, S. Okawa and K. Wu, ``Multi-component dark matter from Minimal Flavor Violation," JHEP 11 (2024), 114, [arXiv:2408.16812 [hep-ph]].

TAsP-LNF: 2024-25 Publications

6. L. Di Luzio, V. Fiorentino, M. Giannotti, F. Mescia and E. Nardi, ``Do finite density effects jeopardize axion nucleophobia in supernovae?,'' Phys. Rev. D 111 (2025) no.1, 015018, [arXiv:2410.04613 [hep-ph]].

7. F. Arias-Aragon, M. Giannotti, G. G. di Cortona and F. Mescia, ``Axion-induced pair production: A new strategy for axion detection,'' Phys. Rev. D 111 (2025) no.4, 043021, [arXiv:2411.19327 [hep-ph]].

8. F. Arias-Aragon, L. Darme, R. Gargiulo, G. G. di Cortona, V. Kozhuharov, E. Nardi, M. Raggi, T. Spadaro and P. Valente, ``NA62e+: dark sector searches with h. intensity positron beams in ECN3,'' [arXiv:2502.10346 [hep-ph]].

9. D. Barducci, D. Buttazzo, A. Dondarini, R. Franceschini, G. Marino, F. Mescia and P. Panci, ``Scalar Rayleigh Dark Matter: current bounds and future prospects,'' JHEP 06 (2025), 171, [arXiv:2501.09073 [hep-ph]].

10. S. Bertelli et al. [PADME], ``Blind unblinding procedure for the PADME X17 data sample,'', JHEP06 (2025), 040, [arXiv:2503.05650 [hep-ex]].

TAsP-LNF: 2024-25 Publications

11. L. Di Luzio, G. Landini, F. Mescia and V. Susic, ``High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries, [arXiv:2503.16648 [hep-ph]].

12. L. Di Luzio, G. Landini, F. Mescia and V. Susic, ``High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries, [arXiv:2503.16648 [hep-ph]].

13. F. Arias Aragon, G. G. di Cortona, E. Nardi and L. Veissiere, ``Atoms as electron accelerators for new physics searches," JHEP06 (2025), 199doi:10.1007/JHEP06(2025)199, [arXiv:2504.00100 [hep-ph]].

14. F. R. Candon, S. Ganguly, M. Giannotti, T. Kumar, A. Lella and F. Mescia, ``A Fresh Look at the Diffuse ALP Background from Supernova,"[arXiv:2505.05567 [hep-ph]].

TAsP-LNF: Workshop Organizations 2025

1. GAMBIT XVI @ LNF (16-20 September 2024):
   Sept. 16-20, 2024 (loc: F. Mescia and E. Nardi)
2. Low Energy Tests of Fundamental Physics,
   Feb. 10-12, 2025 @LNF (co-chair: F. Mescia)
3. LDMA' 25; Light Dark Matter @ Accelerators,
   April 8-11 @ Genoa (loc: E. Nardi)
4. CLFV Searches with the MU2E Experiment @LNF
   June 6-13, 2025 @LNF (loc: F. Mescia)
5. FLASY 2025, "11th Workshop on Flavour Symmetries and Consequences in Accelerators and Cosmology".
   June 30th - July 4, 2025, (loc: F. Mescia)
6. LDS (Light Dark Sector) @LNF
   Nov. 22-2, 2025 (loc: F. Mescia and E. Nardi)

TAsP-LNF: Visitors and Mentoring Activities

Several invited speakers and visitors:

→ resulting in several fruitful publications following their visits

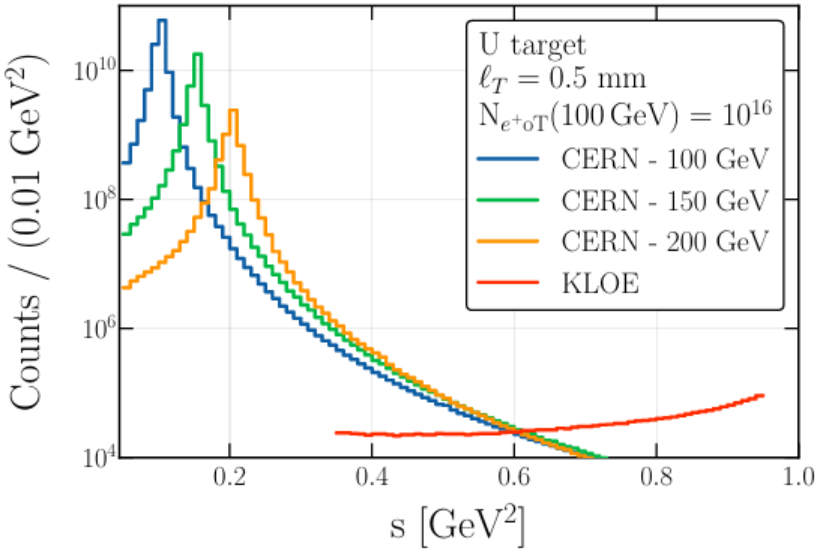
K. Wu, S, Okawa (2408.16812), M. Giannotti (2411.19327),
G. Marino/D. Barducci (2501.09073), G. Landini (2503.16648),
G. Sougata/K. Tanmoy (2505.05567), C. Toni (2504.11439),
R. Plestid, O. Zapata, …

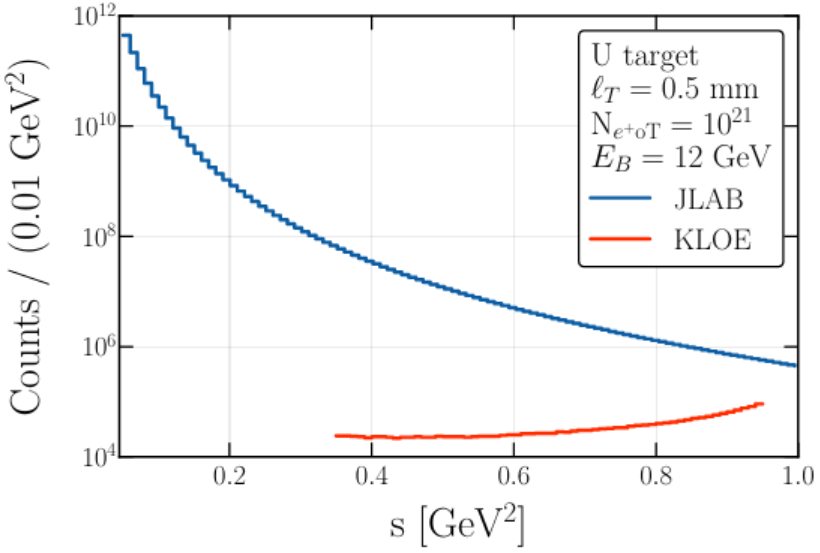
Supervisions of Students:

1. Leo Veissiere (internship, U. Lyon), summer '24
   → 2504.00100 with F. Arias-Aragon and E. Nardi.
2. Marco Olivieri (internship, U. Perugia), spring '25
   → work in progress on EW@GUT with V. Susic.
3. Claire Chevallier (guest, Orsay), march '25
   → work in progress on 2HDM with F. Mescia.
4. Miriam Bulliri (tesi magistrale, RM1), July – December 2024
   → work in progress on top decays with F. Mescia.
5. Francesco Valle (tesi triennale, RM1), July – December 2024
   → millicharged studies for FLASH with F. Mescia.
6. **M. Graciani (tesi magistrale, RM1), June – January 2026**
   → work in progress on LDM with F. Mescia

TAsP-LNF: Highlight of some publications

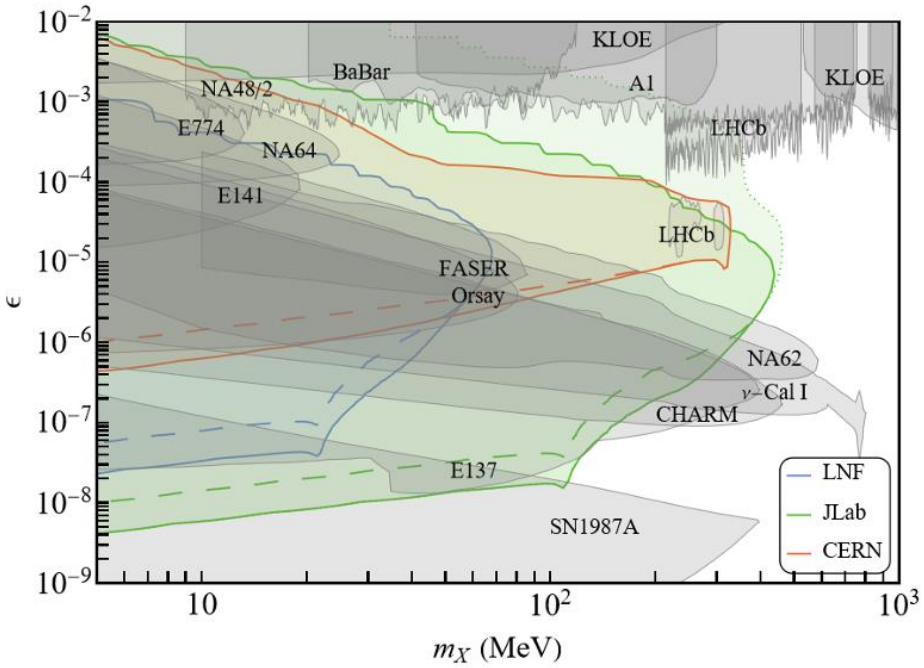
F. Arias Aragon, L. Darmé, G. Grilli di Cortona, E. Nardi
Phys. Rev. Lett 134 (2025) 6, 061802

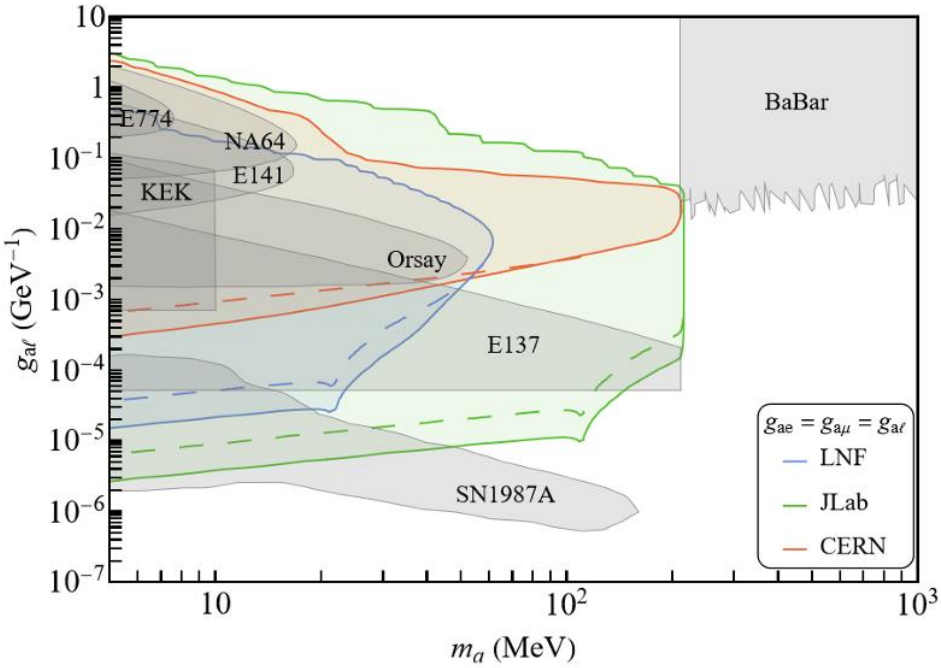




Atomic electron motion can be used as a new energy scan method. This, in experiments using very intense beams, can allow for the measurement of the di-muon cross section with very high statistics in all of the centre-of-mass energy range relevant for the determination of the hadronic vacuum polarization contribution to the anomalous magnetic moment of the muon.

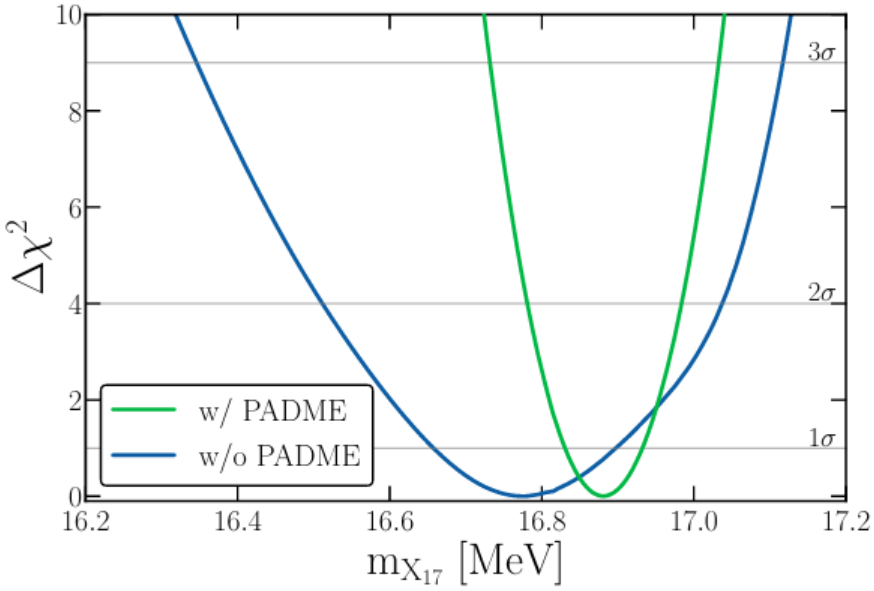
F. Arias Aragon, G. Grilli di Cortona, E. Nardi and L. Veissière
JHEP 06 (2025) 199

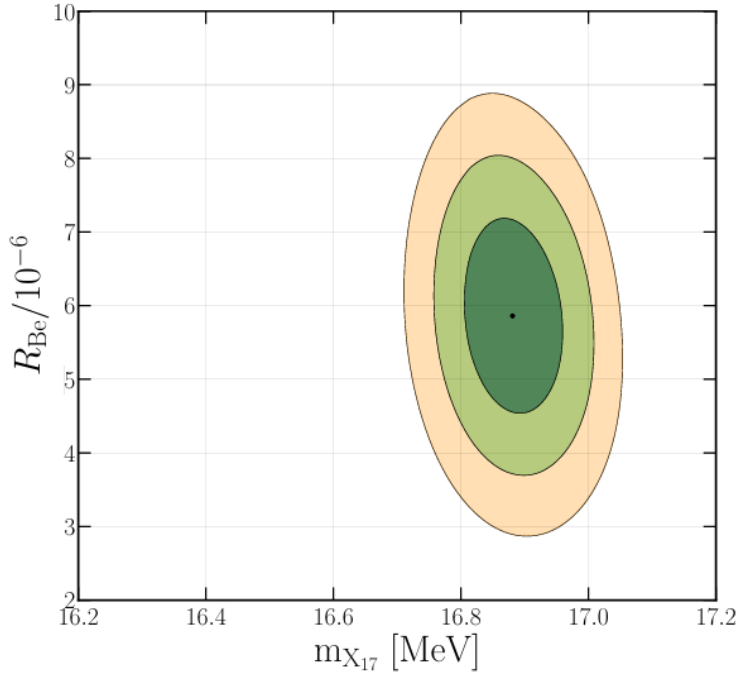




We study the power of using high-Z targets together with very intense positron beams and show their reach for pseudoscalar and vector boson searches, considering the accelerators at LNF, JLab and CERN

F. Arias Aragon, G. Grilli di Cortona, E. Nardi and C. Toni
2504.11439

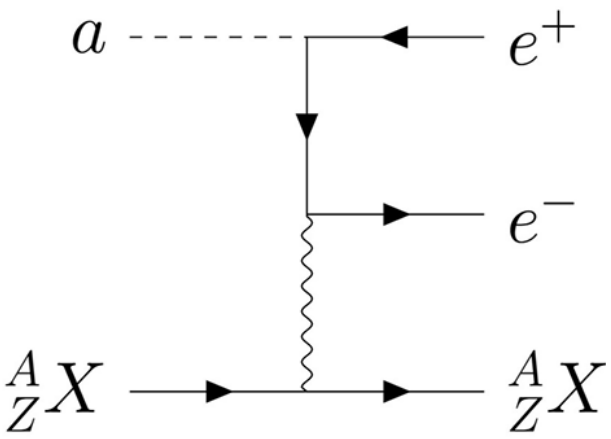


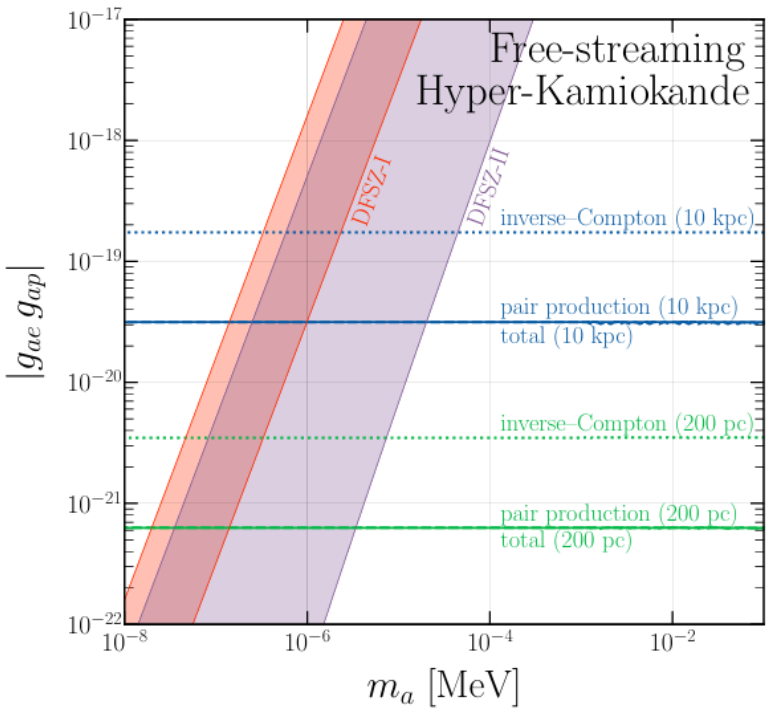


We show that the recent excess measured by the PADME collaboration greatly sharpens the global expected mass for the X17 particle when including at the same time all measurements existing for it.

F. Arias Aragon, M. Giannotti, G. Grilli di Cortona, F. Mescia
Phys.Rev.D 111 (2025) 4, 043021

New detection mechanism





The inclusion of axion-induced external electron-positron pair production increases the limits that can be set by existing and future experiments due to axion emission in the sun or within supernovae.

F. Mescia, S. Okawa and K. Wu, "**DM and Flavour Physics**"
JHEP 11 (2024), 114, [arXiv:2408.16812 [hep-ph]]

Dark matter can naturally be stabilized within MFV

Minimal Flavor Violation hypothesis (MFV): *all flavor violation is caused solely by the Yukawa matrices*

$$Y_u \sim (\mathbf{3}, \overline{\mathbf{3}}, \mathbf{1}, \mathbf{1}, \mathbf{1}), \quad Y_d \sim (\mathbf{3}, \mathbf{1}, \overline{\mathbf{3}}, \mathbf{1}, \mathbf{1}),$$

under $\mathrm{U}(3)_{q_L} \times \mathrm{U}(3)_{u_R} \times \mathrm{U}(3)_{d_R} \times \mathrm{U}(3)_{\ell_L} \times \mathrm{U}(3)_{e_R}$

- For new physics interactions, e.g. $\mathcal{L}_{\rm NP} = C_{ij}(\overline{u}_{Ri}\gamma^\mu u_{Rj})\mathcal{O}_\mu$

→ $C_{ij} = c_0\,\delta_{ij} + \epsilon\, c_1 (Y_u^\dagger Y_u)_{ij} + \epsilon^2 \left[c_2 (Y_u^\dagger Y_u Y_u^\dagger Y_u)_{ij} + c_2' (Y_u^\dagger Y_d Y_d^\dagger Y_u)_{ij} \right] +$

F. Mescia, S. Okawa and K. Wu, "**DM and Flavour Physics**"
JHEP 11 (2024), 114, [arXiv:2408.16812 [hep-ph]]

Dark matter can naturally be stabilized within MFV

Add a new field to the SM, χ, that has no color but a flavor charge under MFV: Flavored DM candidates

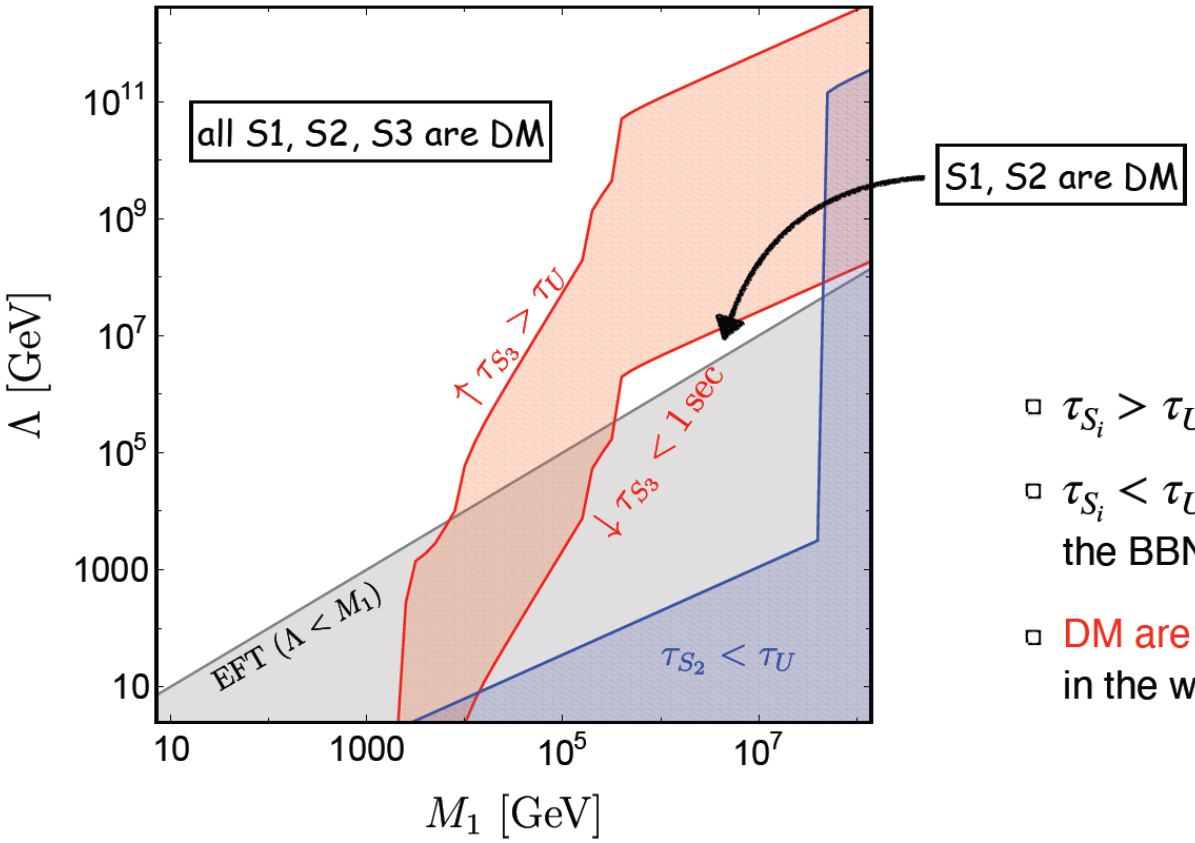
(n,m)	$SU(3)_Q \times SU(3)_{u_R} \times SU(3)_{d_R}$	Stable?
$(0,0)$	$(\mathbf{1},\mathbf{1},\mathbf{1})$	
$(1,0)$	$(\mathbf{3},\mathbf{1},\mathbf{1})$, $(\mathbf{1},\mathbf{3},\mathbf{1})$, $(\mathbf{1},\mathbf{1},\mathbf{3})$	Yes
$(0,1)$	$(\bar{\mathbf{3}},\mathbf{1},\mathbf{1})$, $(\mathbf{1},\bar{\mathbf{3}},\mathbf{1})$, $(\mathbf{1},\mathbf{1},\bar{\mathbf{3}})$	Yes
(2,0)	$(\mathbf{6},\mathbf{1},\mathbf{1})$, $(\mathbf{1},\mathbf{6},\mathbf{1})$, $(\mathbf{1},\mathbf{1},\mathbf{6})$ $(\mathbf{3},\mathbf{3},\mathbf{1})$, $(\mathbf{3},\mathbf{1},\mathbf{3})$, $(\mathbf{1},\mathbf{3},\mathbf{3})$	Yes
(0,2)	$(\bar{\mathbf{6}},\mathbf{1},\mathbf{1})$, $(\mathbf{1},\bar{\mathbf{6}},\mathbf{1})$, $(\mathbf{1},\mathbf{1},\bar{\mathbf{6}})$ $(\bar{\mathbf{3}},\bar{\mathbf{3}},\mathbf{1})$, $(\bar{\mathbf{3}},\mathbf{1},\bar{\mathbf{3}})$, $(\mathbf{1},\bar{\mathbf{3}},\bar{\mathbf{3}})$	Yes
(1,1)	$(\mathbf{8},\mathbf{1},\mathbf{1})$, $(\mathbf{1},\mathbf{8},\mathbf{1})$, $(\mathbf{1},\mathbf{1},\mathbf{8})$ $(\mathbf{3},\bar{\mathbf{3}},\mathbf{1})$, $(\mathbf{3},\mathbf{1},\bar{\mathbf{3}})$, $(\mathbf{1},\mathbf{3},\bar{\mathbf{3}})$ $(\bar{\mathbf{3}},\mathbf{3},\mathbf{1})$, $(\bar{\mathbf{3}},\mathbf{1},\mathbf{3})$, $(\mathbf{1},\bar{\mathbf{3}},\mathbf{3})$	

- Applied for any spin and EW representation of χ.
- Only the lightest flavored state is stable due to MFV.
  - All heavy flavors quickly decay, and only the lightest flavor is DM.
  - some heavy flavors are decaying but long-lived enough to serve as DM → **multi-component DM.**

F. Mescia, S. Okawa and K. Wu, "**DM and Flavour Physics**"
JHEP 11 (2024), 114, [arXiv:2408.16812 [hep-ph]]

Dark matter can naturally be stabilized within MFV

Multi-component flavored DM



$$\epsilon = 10^{-3} \simeq \frac{M_3 - M_1}{y_t^2\, M_1}$$

$\lambda = 0$ (i.e. no Higgs portal coupling)

- $\tau_{S_i} > \tau_U \rightarrow$ DM
- $\tau_{S_i} < \tau_U \rightarrow$ not DM and have to decay prior to the BBN (we require $\tau_{S_i} < 1\,\mathrm{sec}$ in that case)
- DM are composed of two or three components in the white region

➢ Future directions

- Phenomenological
  - indirect search: $S_j \to S_i \gamma\gamma,\ S_i q\bar{q},\ \ldots$
  - inelastic scattering: $S_j N \to S_i N$
  - flavor physics: $b \to s\, S_3\, S_2^\dagger$ and $s \to d\, S_2\, S_1^\dagger$ **Belle II and NA62**

- Theoretical
  - other spin and EW representation
  - extension to lepton sector
  - connection to UV theory

L. Di Luzio, G. Landini, F. Mescia and V. Susic, “High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries”, [arXiv:2503.16648 [hep-ph]].

- **Axion → best solution of the strong CP problem**

BUT the PQ solution suffers from some TH issues

- *What is the origin of* U(1)*?* U(1) is broken, why not ϕ, ϕ^2, ϕ^3**?**
- *Quantum Gravity is at odds with global symmetries*

U(1) ***must be an extremely good symmetry up to the Planck scale***

Peccei Quinn Quality Problem: UV completion of axion needed!

L. Di Luzio, G. Landini, F. Mescia and V. Susic, “High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries”, [arXiv:2503.16648 [hep-ph]].

Our goal:

→ the **PQ symmetry** arises **accidentally by a new gauge symmetry group, *G*?**

- A suitable model with **Pati-Salam vertical symmetry** and **$SU(3)_R$ for horizontal (flavour) symmetry** has been found! ☺

→ Our ***G*** = Pati-Salam with gauged + $SU(3)_R$ flavour

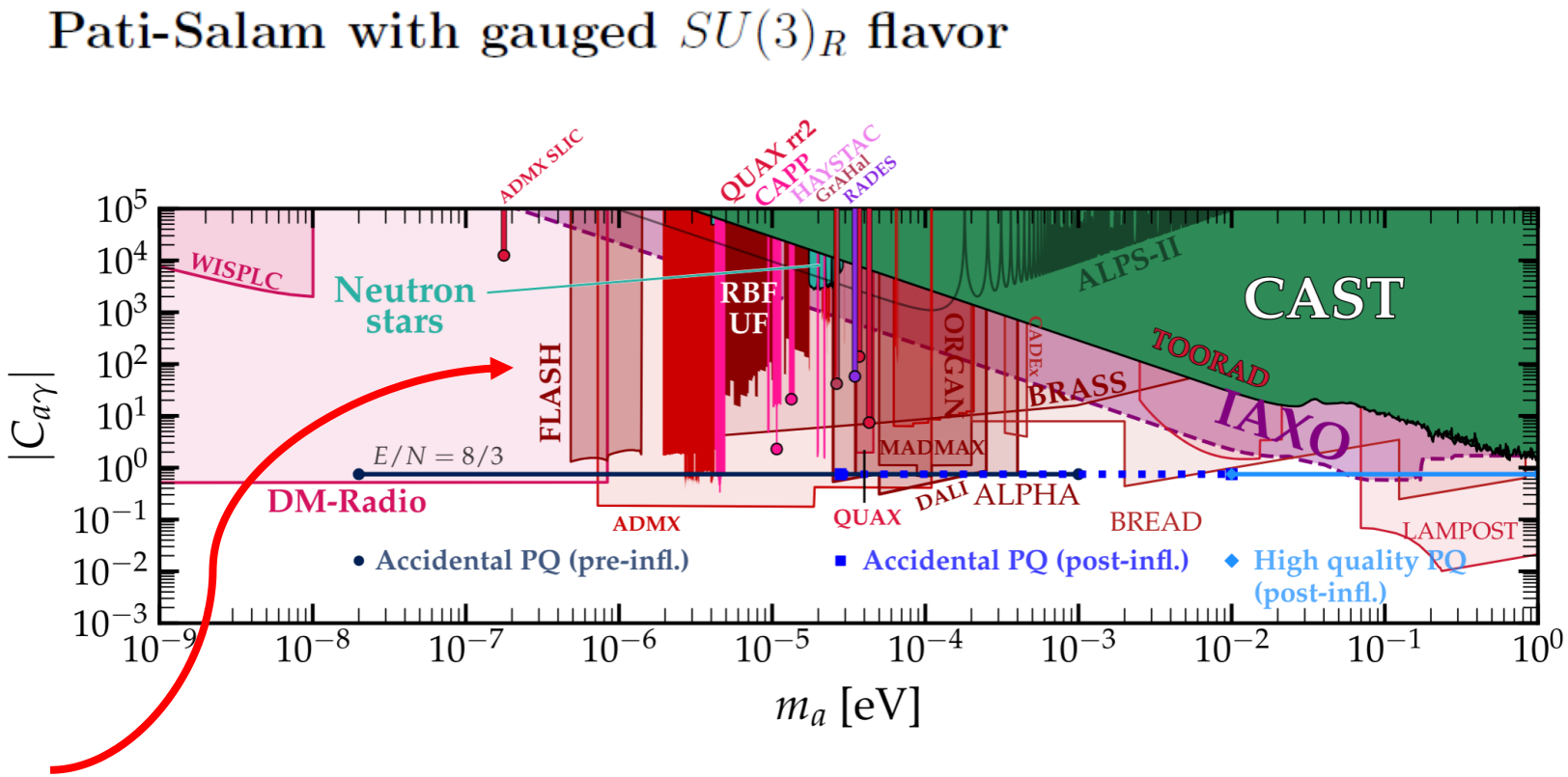
$$SU(4)_{PS} \times SU(2)_L \times SU(2)_R \times SU(3)_R$$

L. Di Luzio, G. Landini, F. Mescia and V. Susic, “High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries”, [arXiv:2503.16648 [hep-ph]].

	$SU(4)_c$	$SU(2)_L$	$SU(2)_R$	$SU(3)_R$	Generations	$U(1)_{\rm PQ}$
$\mathcal{Q}_L$	4	2	1	1	3	$+3/2$
$\mathcal{Q}_R$	4	1	2	3	1	$+1/2$
Ψ_R	1	1	1	$\bar{3}$	8	check!
Φ	1	2	2	$\bar{3}$	≥ 1	$+1$
Σ	15	2	2	$\bar{3}$	≥ 2	$+1$
Δ_R	10	1	3	6	1	$+1$
χ_R	4	1	2	$\bar{3}$	1	$-1/2$
χ_L	4	2	1	1	1	$-3/2$

- A suitable model with **Pati-Salam vertical symmetry** and **$SU(3)_R$ for horizontal (flavour) symmetry** has been found! ☺
- The PQ symmetry arises accidentally and highly protected!
- **Interested features**: new extra **light** fields needed to cancel the $SU(3)_R$ gauge anomalies
- Very strong contribution from S. Vasja, assegnista PRIN

L. Di Luzio, G. Landini, F. Mescia and V. Susic, “High-quality Peccei-Quinn symmetry from the interplay of vertical and horizontal gauge symmetries”, [arXiv:2503.16648 [hep-ph]].



- In the range of FLASH searches
- Very strong contribution from S. Vasja, assegnista PRIN

Accelerated Expansion, Mass Creation, and the QCD Axion

K. Müürsepp, C. Smarra, E. Nardi

Accelerated Cosmic Expansion:

Requires a new energy component (DE) beyond usual matter and radiation (cosmo constant Λ, quintessence: $|V(\varphi)| \gg \dot{\varphi}^2$). It is also possible with <u>energy density creation:</u> $\rho_\varphi = m_\varphi n_\varphi \sim \text{const}$

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Introduce a 4-vector $C_\mu=(\rho_b,0,0,0)$ with ρ_b, a certain (pressurless) `substance'. Define $C_{\mu\nu}=(C_\mu)_{;\nu}$

<u>Modified Einstein equations:</u>

Add a C-tensor to Einstein equations with η a new fundamental constant

Geometry — Stress-Eng Tensor — Cov. deriv. of "b" energy density

$$\mathcal{R}_{\mu\nu} - \frac{1}{2} g_{\mu\nu} \mathcal{R} = \frac{1}{m_P^2} T_{\mu\nu} + \frac{1}{\eta} C_{\mu\nu}$$

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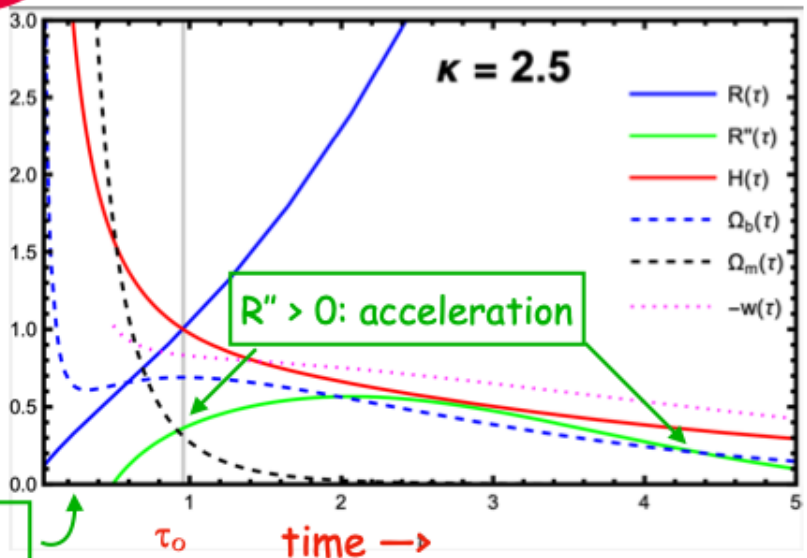
Add a **C**-tensor to Einstein equations with η a new fundamental constant

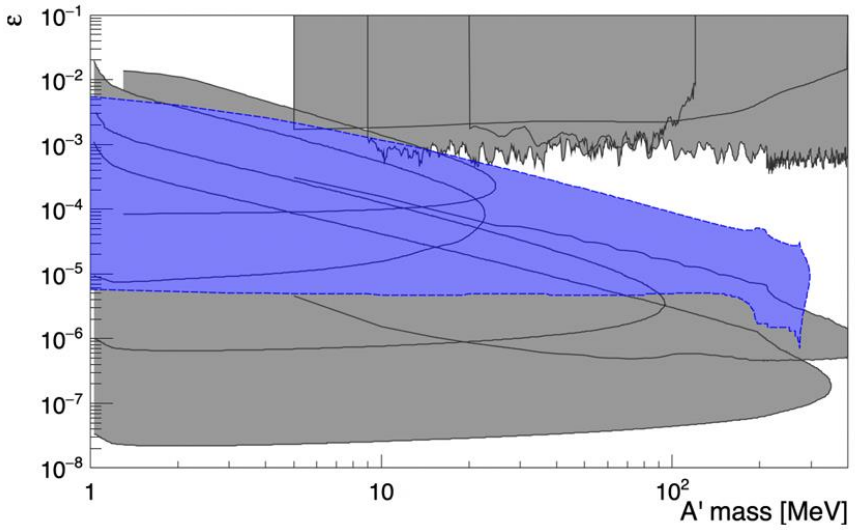
"b-substance" is identified with a dark sector axion φ_b. An initial $\rho_b \neq 0$ arises from partial conversion of QCD axion DM into φ_b at redshift $z \sim 2$-4 via the dynamics of a Level Crossing

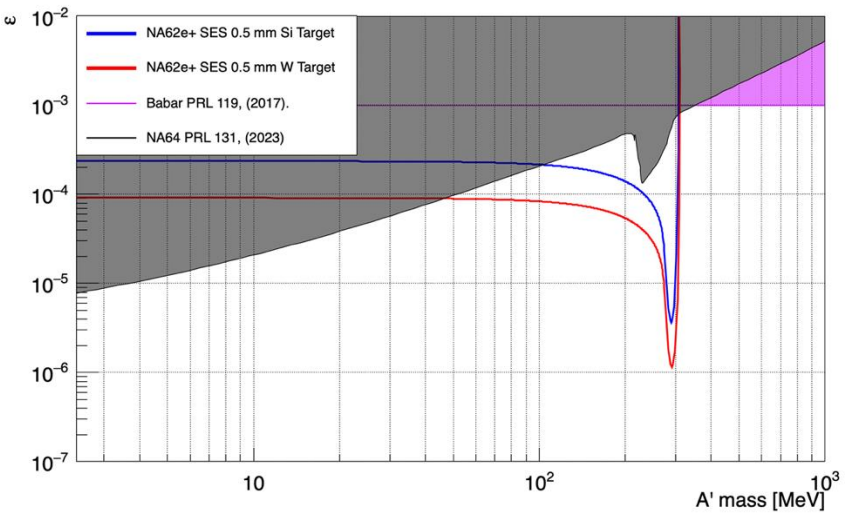


TAsP-LNF: Research Priorities (2025-26)

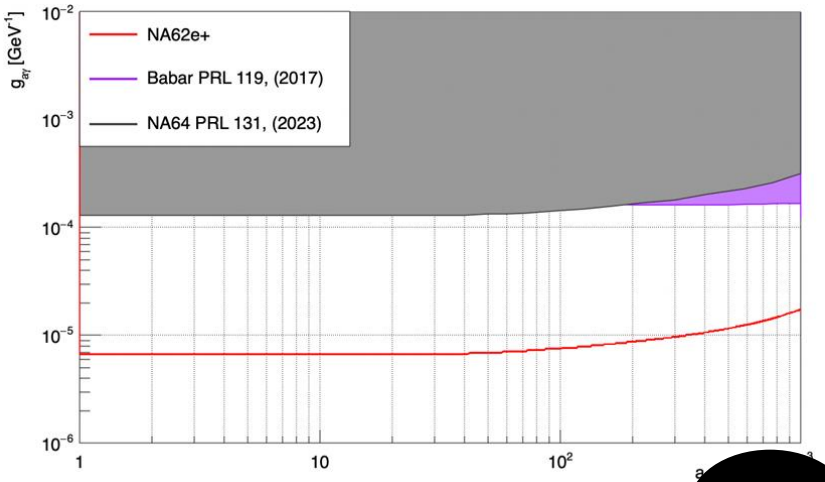
Activities linked to searches at PADME

F. Arias Aragon, L. Darmé, R. Gargiulo, G. Grilli di Cortona, V. Kozhuharov, E. Nardi, M. Raggi, T. Spadaro, P. Valente, 2502.10346



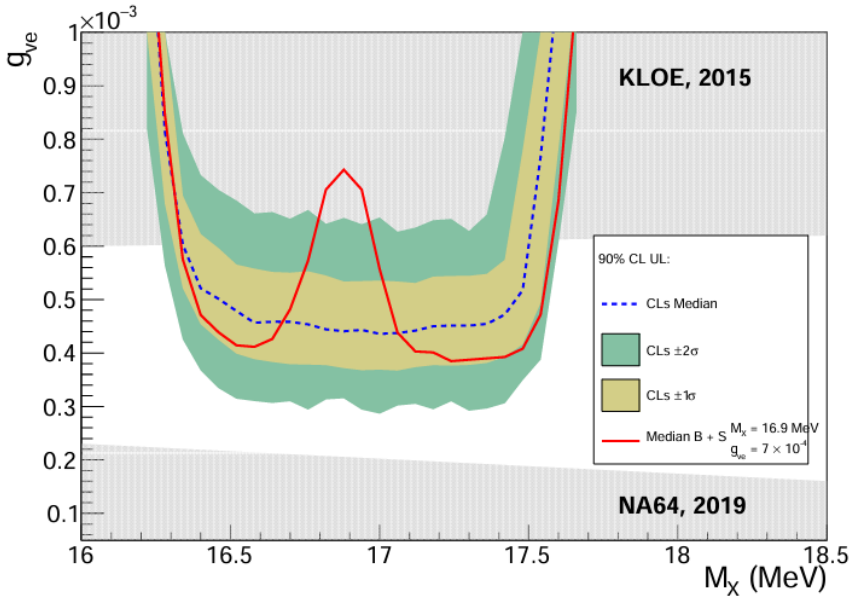


The NA62 experiment could employ intense positron beams that, as we show, could produce bounds stronger than the present ones in both visible and invisible searches of dark vectors and axions.



The PADME Collaboration +
F. Arias Aragon, L. Darmé, G. Grilli di Cortona and E. Nardi
JHEP 06 (2025) 040

The PADME experiment at Frascati performed a search for the X_{17} particle. This paper presents the data analysis strategy needed to allow for quality checks. For this analysis, we provided the collaboration with the correct signal shape expected in the event of the X_{17} particle existing, accounting for the atomic electron motion as required given the expected narrow width.



TAsP-LNF: Research Priorities (2025-26)

Activities linked to searches at FLASH

See Claudio Gatti slides at CL

Advanced Theoretical methods for emerging 2D materials in Quantum Information Technology Studies: Time2Quest

- *S. Bellucci, Unical (gruppo CS, A. Sindona), RM2 (G. Stefanucci), UNIMI (G. Onida)*

CSN4 research line: statistical physics and field theory

Main research issues

Spectroscopies, Electron correlations, Density Functional Theory, Modeling-Simulations and low-dimensional systems

Richiesta 2026 7.5 KE Missioni

Personnel associated in 2025, as of today

S. Bellucci (100%), M. Benfatto (30%), Iaroslav Gnilitskyi (AR, 100%),

Antonio Maffucci (PO, 100%), Cristian Vacacela (AR, 100%), Matteo La Pietra

and Federico Micciulla (guests)

FTE 2.3

Time2Quest started 2021 evaluated AAA by referees.

Advanced Theoretical methods for emerging 2D materials in Quantum Information Technology Studies: Time2Quest

- *S. Bellucci Unical (gruppo CS, A. Sindona), RM2 (G. Stefanucci), UNIMI (G. Onida), continued*

Collaborations in 2025

African Union-EU Collaborative Research and Innovation projects on renewable energy, "RCLIB: Recycling of the cathodes, based on carbon nanotubes and conducting polymers, from spent rechargeable Li batteries", 2023-2025, S. Bellucci, and Catalina Curceanu

Publications by the LNF unit in 2025

23 papers su rivista: Journal of Superconductivity and Novel Magnetism, RSC advances, Heliyon, Journal of Adhesion Science and Technology, Applied Physics A, Optical Materials, Journal of Alloys and Compounds Scientific Reports, Frontiers in Physics, Polymers, Catalysts, Journal of Functional Biomaterials, Emerging Science, Frontiers in Earth Science, Frontiers in Digital Health, AIP Advances, Sensors

Advanced Theoretical methods for emerging 2D materials in Quantum Information Technology Studies: Time2Quest

- *S. Bellucci Unical (gruppo CS, A. Sindona), RM2 (G. Stefanucci), UNIMI (G. Onida), continued*

Talks in 2025

Baku, Azerbaijan 3 June 2025, International UFAZ Conference, CPM's 2025 Edition, Chemistry Process Materials
S. Bellucci: **Advanced Carbon Nanomaterials for Environmental Restoration**

Ankara, TURKEY 16 May 2025, 5th INTERNATIONAL CONFERENCE ON LIGHT AND LIGHT BASED TECHNOLOGIES
S. Bellucci: **Tuning the Optical and Semiconducting Properties of Graphene Oxide Derivatives through Eco-Friendly Reduction Strategies**

Baku, Azerbaijan (online) 24 April 2025 II International Conference on Modern Problems of Macromolecular Compounds MPMC-2025
S. Bellucci: **Advanced Carbon Nanomaterials for Environmental Cleanup and Sustainable Energy Applications**

PHYSICAL REVIEW D **110,** 094511 (2024)

Modified Abelian and SU(2) Wilson theories on a lattice from a noncompact regularization

D. Babusci and F. Palumbo*
INFN, Laboratori Nazionali di Frascati, 00044 Frascati, Italy

Multiflavour gauge theories of matter systems on a three-dimensional lattice have recently been widely investigated especially in connection with a possible symmetry enlargement at a continuous phase transition. Abelian models were studied both with compact gauge fields and in a mixed formulation in which the coupling with matter fields is in compact form while the gauge fields Lagrangian is written in terms of non-compact gauge fields, getting quite different phase diagrams. It is therefore worth while to compare with a totally noncompact regularization which is derived in the present work. It contains only one auxiliary field, as in the already known case of SU(2) theories. In both cases for a large mass the auxiliary field can be integrated out providing a negative definite correction to the energy.

Time scaling with temperature in noncompact gauge theories on a lattice

(preliminary results)

F. Palumbo

There are several hypotheses and models in which spacetime is discrete, there being a minimal scale under which it looses its classical meaning, as for instance non-commutative geometry, doubly special relativity and loop quantum gravity. Such discreteness can have measurable effects on early universe cosmology or black hole entropy. I investigate what might happen of a minimal spacetime length at high temperature assuming as a simple model a gauge theory on a lattice whose spacing is assumed as a fundamental constant. Because such a theory is renormalizable, at higher scales effects of the cutoff can be absorbed in physical constants and are not observable. I study an SU(2) noncompact regularization restring myself to the temporal direction. I find that the minimal temporal length increases and diverges at very high temperatures at which time has wild fluctuations and looses its classical meaning.

G. Pancheri: **History** of e+e- and Touschek **resummation** for pp

Particle Physics

- **2024 Ukr.J.Phys**. 69 (2024) 11, 879 G Pancheri con O. Shekhovstova e Y.N. Srivastava, *Ansatz about a Zero Momentum Mode in QCD and the Forward Slope in pp Elastic Scattering*
- **2025-26 in progress :** *The origin of the forward peak in pp scattering*

History of Physics

• **2024 Eur.Phys.J. H.** *Eur.Phys.J.H* 49 (2024) 1, 24
G. Pancheri con L. Bonolis e F. Buccella, *Raoul Gatto and Bruno Touschek's legacy in the rise of electron positron physics*

• **2025 Proceedings of Science**, Scilight Vol.1, Issue 1, con L. Bonolis e F. Buccella, *Raoul Gatto and Bruno Touschek: the rise of electron positron physics*

• **2025-26 in progress** : *Birth and development of electron positron colliders between Frascati and Orsay*

Recent talks and poster presentation

May 20th 2025 IJCLab-Orsay Haissinski Colloque: G.Pancheri for *The birth of electron positron colliders*

Colloque Jacques Haïssinski
Particle Accelerators

May 29-30 2025 University of Coimbra, International Conference on the History of Physics, poster *A Laboratory on the Hills: Frascati and the Italian Road to Particle Colliders*

Conclusioni

Espansione del gruppo teorico (fondi esterni, dottorandi di ricerca), sperabilmente ulteriori membri TD e TI

Eccellente produzione scientifica del gruppo teorico dei LNF

Collaborazioni internazionali e locali con gruppi ai LNF e dell'area romana (PRIN, Assegni Cabibbo, didattica, relatori tesi)

Responsabili nazionali di Iniziative Specifiche ai LNF, osservatore CSN4 in CSN1

Continua interazione con gruppi sperimentali in loco e non (ATLAS, CMS, LHCb, PADME, JLAB, FLASH, NA62)

Intenso programma ospiti, workshop ed attività seminariale

Assegno 'Cabibbo' ben consolidato nella comunità internazionale con alternanza su profilo (nuove forme contrattuali)

Richieste: spazi (nuovi membri, collaborazioni, workshops), incarico/contratto di ricerca, fondi missione