



CdL preventivi 6/7/2021

CSN IV

Gruppo Teorico: LNF-TH

Enrico Nardi

↳ Info su GR4 ed anagrafica 2021 - 2022

↳ Attività sigle locali di CSN4 (contributi)

Anagrafica 2021-22

Nome	Età	Posizione	Qualifica	Afferenza	ENP	TASP	TIME2QUEST	UE-CLEANHE	UE-FREYCAR_318	UE-FELLINI	UE-MSNANO_3175	ALTR0-EX_PRO_R	DOT4	CSN I	CSN II	CSN III	CSN V	P.S.	CCR	Servizi	UE	PUN	FOR	FIRB	PRIN	ALTR0	PP	TT	CSH	Tot.
1 Bellucci Stefano		Dipendente	I Ric.	CSN IV			100																							100
2 Benfatto Maurizio		Dipendente	I Ric.	CSN III			40									60														100
3 Corcella Gennaro		Dipendente	I Ric.	CSN IV	100																									100
4 Del Duca Vittorio		Dipendente	I Ric.	CSN IV	100																									100
5 Gionti Gabriele		Associato	Ricercatore straniero	CSN IV									50																	50
6 Nardi Enrico		Dipendente	Dir.Ric.	CSN IV		100																								100
7 Pancheri Giulia		[P] Associato	Ass.Senior	CSN IV	0																									0
8 Panella Orlando		Dipendente	Ricercatore	CSN IV	100																									100

Cabibbo Fellows

11 Grilli Di Cortona Giovanni		Assegno di Ricerca		CSN IV		100																								100
12 Plascencia Contreras Alexis		Assegno di Ricerca		CSN IV		100																								100

Fellini Fellow

10 Visinelli Luca		Dipendente	Ricercatore	CSN IV		0				100																				100
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ENP	(Exploring New Physics)	FTE	3.0
Time2Quest	(Theoretical methods for 2D materials)	FTE	1.4
TASP	(Theoretical Astroparticle Physics)	FTE	3.0
UE-FELLINI	(L. Visinelli)	FTE	1.0
TOT Sigle:		FTE	8.4
Dot.GR4	(+ G. Gionti - O. Panella)	FTE	0.5 - 1.0
TOT GR4-LNF:		FTE	7.9

ENP

Exploring New Physics

CSN4 **Linea 2** (*Phenomenology of elementary particles*)

R.L. Gennaro Corcella

- G. Corcella 100%
- V. Del Duca 100% (April 1st, 2021)
- G. Pancheri (senior associate)
- O. Panella 100% (Ric.3° livello a PG. DotGr4 PG, Sigla ENP-LNF)

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

Responsabile Nazionale: G. D'Ambrosio (NA); Responsabile LNF: G. Corcella

Nodo LNF:

G. Corcella (FTE=1, Ric. II Livello), V. Del Duca (FTE=1, Ric. II Livello, in congedo a Zurigo), O. Panella (Ric. III Livello, Perugia)

G. Pancheri (senior associate)

Attività di ricerca su vari aspetti di fenomenologia dei collider:

- Test di precisione del Modello Standard e ricerche di nuova fisica ai collider di alta e bassa energia, in particolare supersimmetria, produzione di Z' , modelli 331, Higgs carichi, quark esotici;
- Calcoli di precisione e simulazioni Monte Carlo per interazioni forti ed elettrodeboli a LHC e futuri collider (FCC, HL/HE-LHC): ampiezze di scattering ad alta energia a due loop, risommazione di gluoni e fotoni soffici, correzioni NLO elettrodeboli/forti alla produzione di Higgs, fisica del quark top, frammentazione di quark pesanti, sezione d'urto totale non diffrattiva

Gennaro Corcella:

1. Fisica del quark top

Contributo all'errore Δm_t della frammentazione del b in $t \rightarrow bW$ con $b \rightarrow B$

Stime $\Delta m_t(\text{frag}) \simeq 250 \text{ MeV}$ basate su generatori Monte Carlo LO e fit a dati di LEP

In progress: uso di calcoli NNLO per $t \rightarrow bW$ e $e^+e^- \rightarrow b\bar{b}$ e nuovi fit a LEP

ACE (Analysis Consultant and Expert) per l'analisi di ATLAS sulla misura della massa del top da muoni soffici ($t \rightarrow bW$, $W \rightarrow \ell\nu$, $b \rightarrow B \rightarrow X\mu$)

$m_t = (174.48 \pm 0.78) \text{ GeV}$ da $M_{\mu\ell}$, ATLAS-CONF-2019-046

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

Due scenari: $M_Y > M_Q$ (a) e $M_Q > M_Y$ (b) a LHC e collider futuri

Caso (a): $pp \rightarrow Y^{++}Y^{--} \rightarrow (T\bar{b})(\bar{T}b) \rightarrow (b\bar{b}\mu^+\mu^+)(b\bar{b}\mu^-\mu^-)$ con $Q(T) = 5/3$ in 331 separabile da fondo e visibile a FCC- hh (100 TeV, $\mathcal{L} = 3000 \text{ fb}^{-1}$), ma statistica insufficiente a LHC (G.C., C.Corianò, A.Costantini, P.H.Frampton, 2106.14748 [hep.ph])

Caso (b): $pp \rightarrow T\bar{T} \rightarrow (Y^{++}b)(Y^{--}\bar{b}) \rightarrow (\ell^+\ell^+b)(\ell^-\ell^-\bar{b})$ in progress analisi in modello semplificato e 331 (G.C., A.Costantini, M.Ghezzi, L.Panizzi, G.M.Pruna, J.Salko, in progress)

Relazione sull'attività di ricerca

Vittorio Del Duca

Linee di ricerca

- migliorare l'accuratezza teorica nella produzione di Higgs in associazione con 1 jet [1]
- sviluppare uno schema per il calcolo di sezioni d'urto al NNLO in α_s in modo indipendente dal particolare processo, usando l'universalità delle divergenze infrarosse [2]

[1] R. Bonciani, V. Del Duca, H. Frellesvig, M. Hidding, F. Moriello, G. Salvatori,
"Two-loop amplitudes for Higgs + three partons with full heavy-quark mass dependence"
to appear soon

[2] V. Del Duca, G. Somogyi, F. Tramontano
"Colour singlet production in hadron collisions through CoLoRFuNNLO"
to appear soon

Giulia Pancheri 2021-22

Research in particle physics

- **Soft Resummation** and boundary conditions, QCD vs in QED => discrete vs continuum
- **Elastic differential** cross-section at LHC
 - Role of color condensate in diffraction peak

GP & YSrivastava,
About soft photon resummation
[2011.05865](#)

History of physics

- Bruno Touschek Centennial:
 - New biography (English) submitted to Springer Nature
 - December 2021 Lincei Symposium (OC)
 - Italian Version under preparation
- TALKS about Touschek and AdA:
 - Dublin, IOP, June 2021
 - Santo Domingo, June 2021
 - SIF September 2021

L.Bonolis, F. Bossi & G.P.,
LNF : Past and Future,
Il Nuovo Saggiatore, in print

Bruno Touschek



– From death-rays to anti-matter–

Time2Quest

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

CSN4 Linea 6 (Statistical Physics and Applied Field Theory)

LNF (S. Bellucci R.N.), Unical (gruppo CS, A. Sindona)

RM2 (G. Stefanucci), UNIMI (G. Onida)

FTE LNF: 1.4 S. Bellucci (100%), M. Benfatto (40%)

Main research topics: Spectroscopies, Electron correlations, Density Functional Theory, Modeling-Simulations and low-dimensional systems

New IS, started in 2021 (Evaluated AAA by CNS4-L6 referees)

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

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

Collaborations in 2021

NATO Emerging Security Challenges Division, SPS Programme projects "Nanocomposite based photonic crystal sensors of biological and chemical agents" 2018-2021, directed by S. Bellucci, with Fraunhofer Institute Goelm, Germany and Ukraine Nat. Acad. Sciences, Kiev and Polytechnical Univ. Lviv.

HPSWFood, High Pressure Sanification of Water for Foodborne Virus removal Progetto Regione Lazio per Organismi di Ricerca, 2021-2023, directed by S. Bellucci, with Univ. Roma Tor Vergata and Istituto Superiore di Sanità

SFIDE, a Smart Framework for vIrus Detection, fondo integrativo speciale per la ricerca (FISR), Projects against COVID-19, 2021, S. Bellucci, with Univ. Roma Tor Vergata and Univ. Cassino

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

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

Talks in 2021

LNF 23 April 2021, U.Cassino@LNF Lectures

S. Bellucci: **Nanomaterials and Nanocomposites Realization and Characterization**

LNF 14 May 2021, U.Cassino@LNF Lectures

S. Bellucci: **Electromagnetic properties of nanocarbon based materials**

Publications by the LNF unit in 2021 (17 papers su Eur. Phys. J C, Phys. Rev.B, Nanomaterials, Symmetry, J. of Phys.: Cond. Matter, Appl. Surface Science, Entropy)

Research activity of M. Benfatto

Synchrotron Radiation activity

We have continued the development of the MXAN program in collaboration with professors N. Sanna and G. Chillemi (University of Tuscia). MXAN is a program able to obtain structural three-dimensional information from the low energy part of the XAS spectrum.

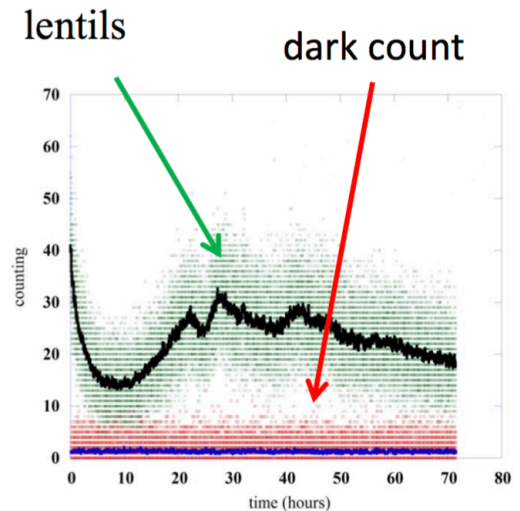
This new version has the possibility to analyze time-dependent XANES data and signals coming from disordered systems. In this new release several sources code have been optimized to have a fast access in RAM memory and an execution in parallel mode. Another important aspect is the choice we made to provide the full package on docker runtime-based containers. This new version has been published on Computer Physics Communication.

M. Benfatto et al. Com. Phys. Comm , **265**, 107992 (2021)

M. Benfatto et al. International Tables for Crystallography Vol. I (2020)

Bio-photon research

We have continued the experimental and theoretical activity to understand the bio-photon emission from living organism in collaboration with the C. Curceanu and her group. Outside we collaborate with Prof. I. Davoli and R. Francini (Tor Vergata University, Rome), Prof. P. Grigolini (University of North Texas, Denton), Prof M. Grandi (La Torre Institute, Turin)

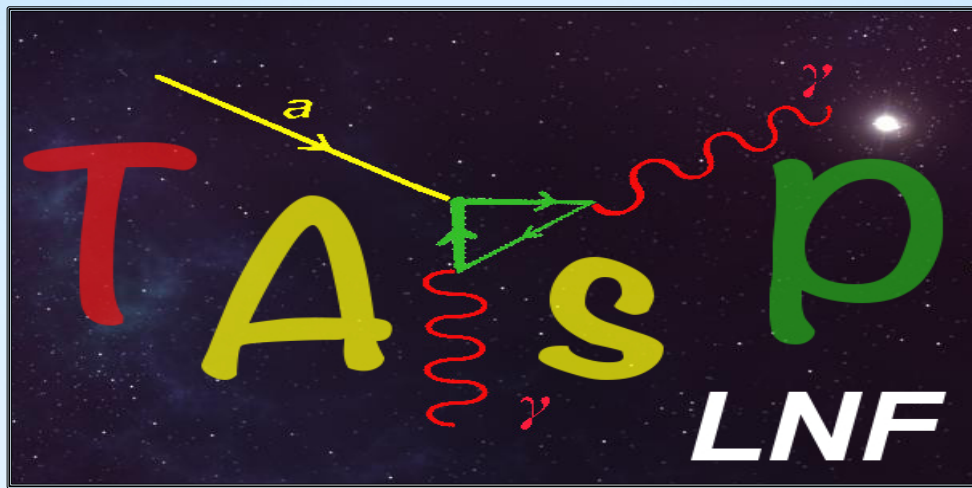


The time series of signal emission (counts/sec) has been analyzed on the basis of Diffusion Entropy Analysis approach which is based on the concept of Kolmogorov complexity. In this way it is possible to distinguish if the complexity of the signal is generated either by non-ergodic crucial events with a non-stationary correlation function or by the infinite memory of a stationary but non-integrable correlation function or by a mixture of both processes. In the presence of seeds (lentils) the anomalous scaling emerges as a mixture of both processes. With the progress of germination the non-ergodic component tends to vanish and complexity becomes dominated by the stationary infinite memory. The experiment and analysis has been published on Entropy.

M. Benfatto et al. Entropy **23**, 554 (2021)

he is also involved in teaching activities in schools of Anthropology (Turin), Counseling (Rome) and Synchrotron Radiation (Les Houches, next September).

Invited speaker at HPXM2020 conference



Theoretical Astroparticle Physics

CSN4 *Linea 5* (Astroparticle Physics)

R.L. Enrico Nardi

- L. Darmé 100% (Bors.P.Doc INFN, until Aug.2021)
- G. Grilli di Cortona 100% (Ass. Cabibbo)
- A. Plascencia Contreras 100% (Ass. Cabibbo, from Oct. 2021)
- L. Visinelli 0% (Fellini fellow, until Oct. 2021 ?)
- E. Nardi 100%

TAsP-LNF: Argomenti di Ricerca

- ➔ Physics of the Axions: theory and phenomenology
Theoretical models (generation of $U(1)_{PQ}$), Astrophysics, Cosmology
- ➔ Feebly Interacting Particles (FIPs) (dark photons, ALPS, LDM)
Connections with searches at PADME, Jlab, etc... Effects on $(g-2)_{\mu,e}$
- ➔ Dark Matter: studies of detection sensitivities
Connections with DarkSide, Cygno prototype (Migdal effect)
- ➔ Cosmology: Hubble tension, dark energy, gravitational waves
(mainly **UE-FELLINI** activities - L. Visinelli)

Classical and Quantum Gravity

ACCEPTED MANUSCRIPT • **OPEN ACCESS**

In the realm of the Hubble tension - a review of solutions

135 pages
~ 100 cit.

AXIONS:




Contents lists available at [ScienceDirect](https://www.sciencedirect.com)

Physics Reports

journal homepage: www.elsevier.com/locate/physrep




The landscape of QCD axion models

Luca Di Luzio^a, Maurizio Giannotti^b, Enrico Nardi^{c,*}, Luca Visinelli^d

Published:
25/07/2020


Solar Axions Cannot Explain the XENON1T Excess

Luca Di Luzio,^{1,*} Marco Fedele,^{2,†} Maurizio Giannotti,^{3,‡} Federico Mescia,^{2,§} and Enrico Nardi^{4,¶}



Dear Sir or Madam,

We are pleased to inform you that the Letter



has been highlighted by the editors as an Editors' Suggestion. Publication of a Letter is already a considerable achievement, as *Physical Review Letters* accepts fewer than 1% of submissions, and is ranked first among physics and mathematics journals by the Google Scholar five-year h-index. A highlighted Letter has additional significance, because only about one Letter in six is highlighted as a Suggestion due to its particular importance, innovation, and broad appeal. Suggestions are downloaded more than twice as often as the average Letter, and receive substantially more press coverage. Suggestions are cited at roughly twice the rate of nonhighlighted Letters. More information about our journal and its history can be found on our webpage prl.aps.org.

Yours sincerely,

Hugues Chaté
Editor
Physical Review Letters

Piero Mehta
Editor in Chief
Physical Review

Physical Review Letters, 1 Research Road, Ridge, NY 11961-0701



After the one obtained in 2017, we have received another Phys. Rev. Lett. award



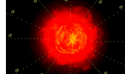
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Dear Sir or Madam,

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Solar axions cannot explain the XENON1T excess

Luca Di Luzio *et al.*
Phys. Rev. Lett. **125**, 131804 (2020)

Published 24 September 2020


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Yours sincerely,

Hugues Chaté
Editor
Physical Review Letters

Michael Thoennessen
Editor in Chief
American Physical Society

PHYSICAL REVIEW LETTERS




The last theoretical paper, also important

Exact accidental U(1) symmetries for the axion

Luc Darmé^{1,*} and Enrico Nardi^{1,†}

¹INFN, Laboratori Nazionali di Frascati, C.P. 13, 100044 Frascati, Italy

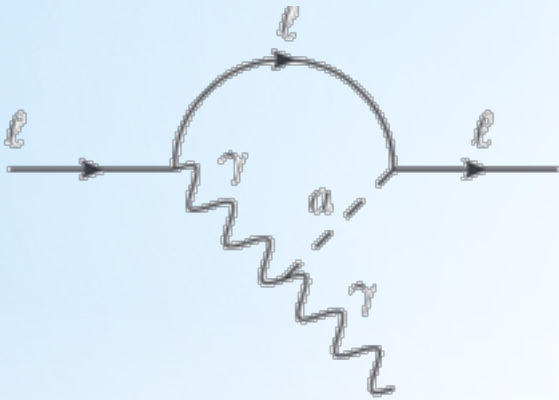
Online publication: expected 19 July 2021

Feebly Interacting Particles:

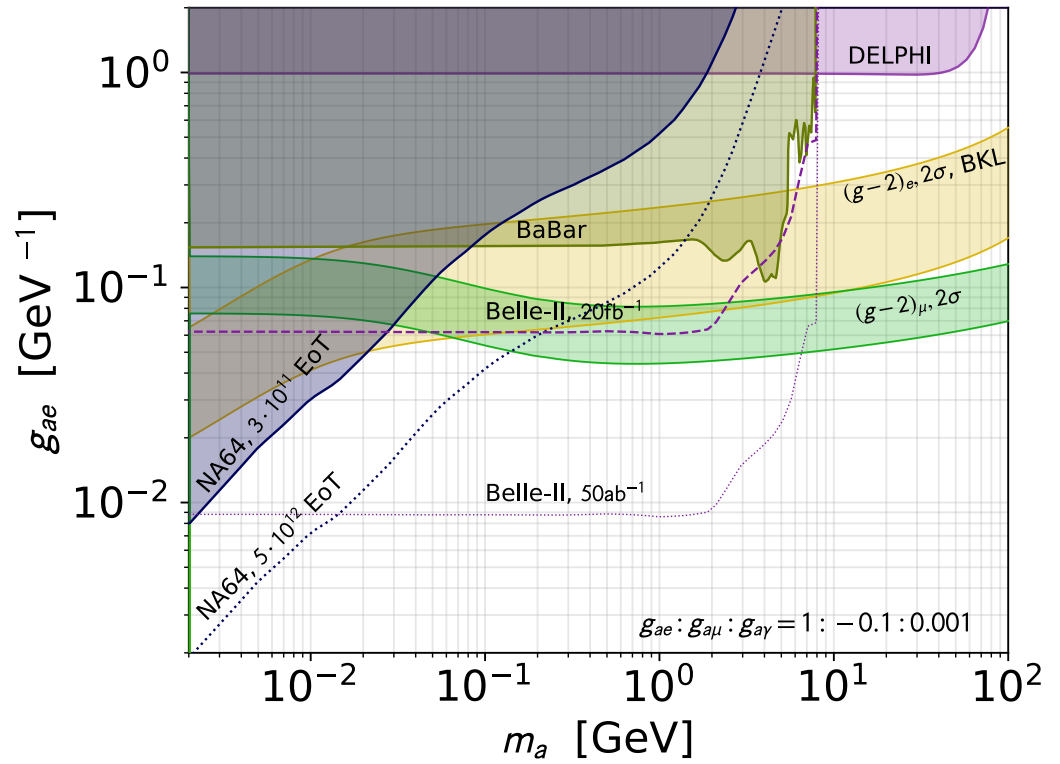
Searching for FIPs candidates with an eye to anomalous $(g-2)_{\mu,e}$

→ We considered Barr-Zee diagrams + various constraints:

Adapted from LD, F. Giacchino, E. Nardi, M. Raggi, 2012.07894



$$\propto g_{a\gamma} g_{a\ell}$$

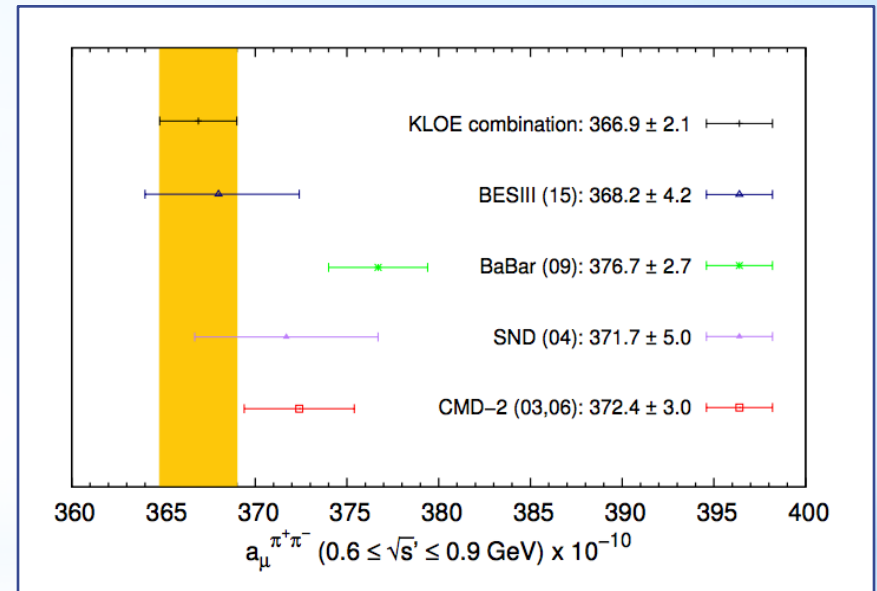
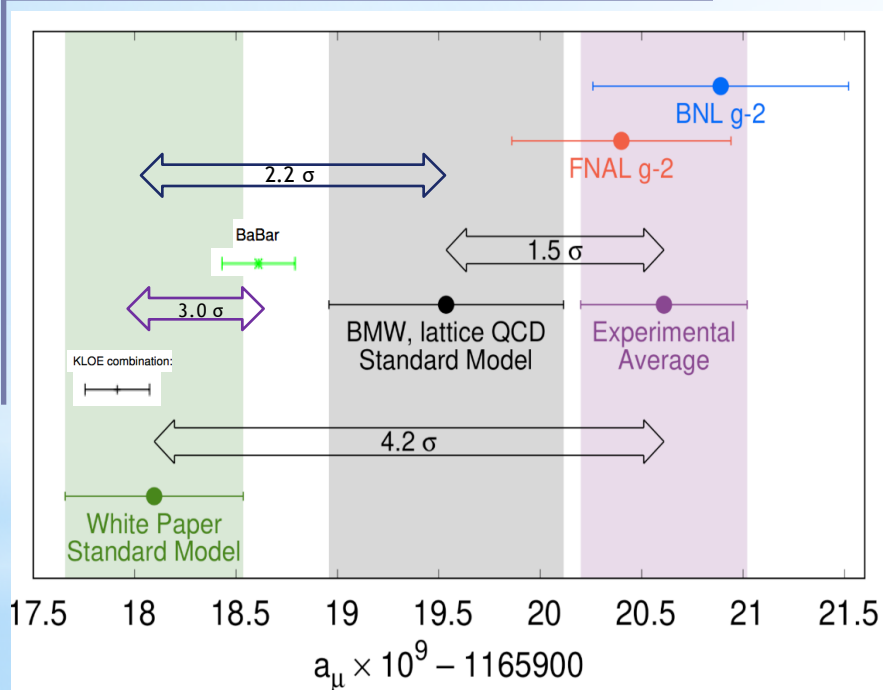


A combined explanation of Δa_μ and Δa_e via ALPs effects is possible, in parameter space regions that will be tested soon (mainly by Belle-II)

Anomalies in the μ anomalous magnetic moment

a_μ^{SM} vs. a_μ^{Exp} ($\sim 4.2\sigma$); σ_{had} : KLOE vs. BaBar ($\sim 3.0\sigma$); a_μ^{HVP} R-ratio vs. Lattice ($\sim 2.2\sigma$)

More anomalies in $(g - 2)_\mu$

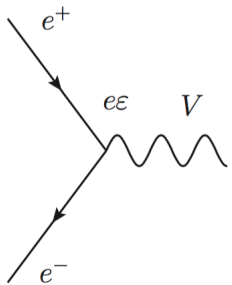


[A. Anastasi et al. (KLOE-2 Collab.), JHEP 03 (2018) 173]

We are trying to understand if a BSM contribution to Bhabha scattering, used to measure the luminosity, could affect differently BaBar and KLOE, and bring the data driven result closer to the lattice determination of a_μ^{HVP}

Future "resonant" experiments for FIPs

- Using "resonant" FIP production in new experiments



$$\sigma_{res} \sim \frac{\pi^2 \alpha \varepsilon^2}{m_e} \delta(E_+ - E_{res})$$

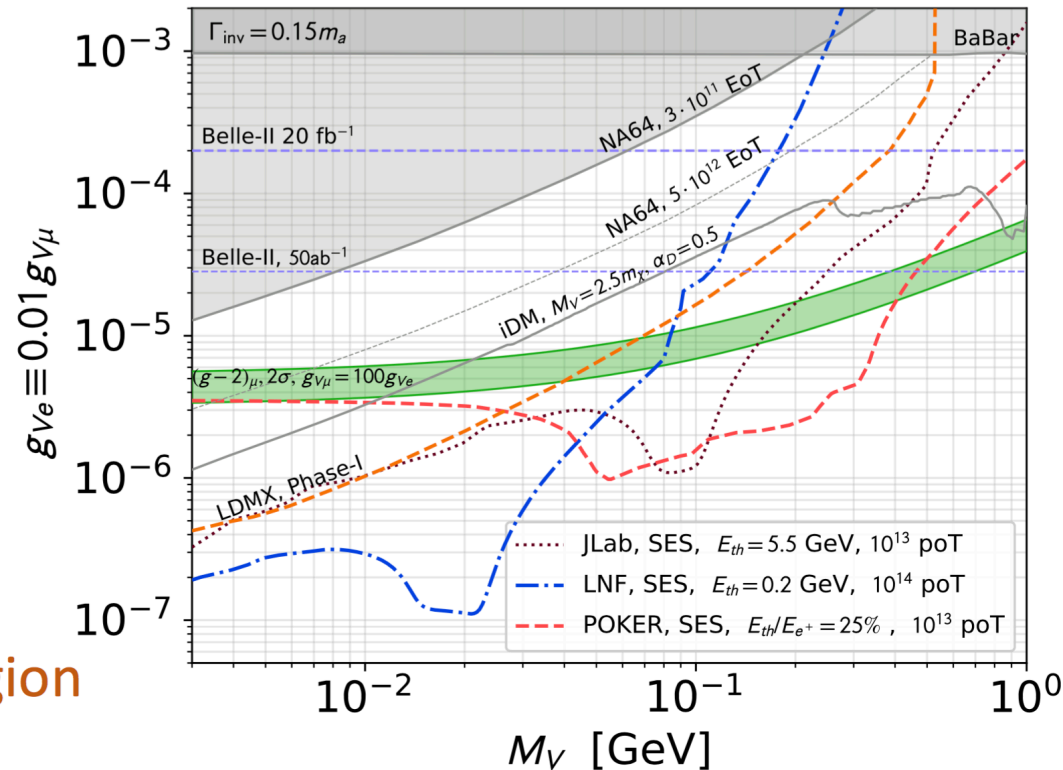
In the narrow width approximation

Extremely large cross-section!

- POKER proposal, SPS-based 100, 50, 25, 2 GeV e^+ beam
- JLab, 11 GeV e^+ beam
- LNF, 0.5 GeV e^+ beam

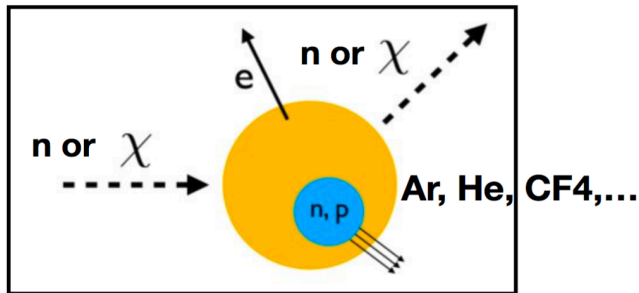
- Full light dark matter and Δa_μ region in reach for various FIP models!**

Adapted from LD, F. Giacchino, EN, M. Raggi, 2012.07894, and LD, EN, L. Marsicano, A. Celentano 2006.09419



Dark Matter:

Migdal effect:



in a nuclear recoil collision, due to the initial 'displacement' between the nucleus and the electron cloud, an atom can emit an electron.


[A. Migdal]

- Sensitivity studies of DM detection with the DarkSide-50 full data;
- Proposed to measure the Migdal effect with a Cygno prototype [Grilli di Cortona (LNF), Piacentini (Sapienza U.) & Messina (Sapienza U.)] exploiting neutron sources;
- Sensitivity studies for detecting sub-GeV DM exploiting the Migdal effect with CYGNO;

Twin Higgs models:

Study of twin charged particles (twin stau, twin stop, ...) as dark matter candidates.

RECAP and CONCLUSIONS:

- *Nel 2020/21 Collaborazioni, interazioni e cross-breeding con i colleghi sperimentali LNF e non solo (JLAB, DarkSide, LNGS) sono continuate ed ulteriormente sviluppate (importanti le sinergie generate da FFF).*
- *Collaborazioni nazionali ed internazionali del gruppo continuano a consolidarsi e svilupparsi nonostante le limitazioni imposte dalla pandemia.*
-  *Un primo rafforzamento del gruppo in termini di numero di TI (esigenza non più procrastinabile) speriamo possa avvenire già nel corso di quest'anno.*
- *Alla Div. Ric. chiediamo la disponibilità per supporto di segreteria anche per qualche Workshop organizzato con preavviso limitato (quando sarà nuovamente possibile)*

