

Commissione Scientifica Nazionale IV

Gruppo Teorico LNF

GENNARO CORCELLA

Coordinatore da 01/07/2022

- 1. Informazioni su gruppo ed anagrafica**
- 2. Attività sigle locali CSN4**

Anagrafica Gruppo IV 2022-23

Nome	Posiz.	Qual.	Aff.	ENP	TASP	TIME2QUEST	DOT4	CSNI	CSNII	CSNIII	CSNV	Tot
Bellucci Stefano	Dip.	I Ric.	CSN IV			100						100
Benfatto Maurizio	Dip.	I Ric.	CSN III			40				60		100
Corcella Gennaro	Dip.	I Ric.	CSN IV	100								100
Del Duca Vittorio	Dip.	I Ric.	CSN IV	100								100
Gionti Gabriele	Ass.	I Ric.	CSN IV				50					50
Nardi Enrico	Dip.	Dir.Ric.	CSN IV		100							100
Pancheri Giulia	Ass.	Ass.Sen.	CSN IV	0								0
Plascencia Alexis	Ass.Ric.	Ass.Ric.	CSN IV		100							100
Sengupta Shree	Ass.Ric.	Ass.Ric.	CSN IV	100								100

Assegnisti di ricerca 'Nicola Cabibbo':

G. Grilli di Cortona: LNF sino a Ottobre 2022, poi INFN Roma I

A. Plascencia: LNF sino a Ottobre 2023

D. Sengupta (Ph.D. Oklahoma, postdoc Taiwan) da Ottobre 2022 in ENP (2+1 anni)

Nuovo ricercatore III livello in arrivo a fine 2022

Totali FTE (ottobre 2022):

ENP (Exploring New Physics): FTE=3.0

Time2Quest (Theoretical methods for 2D materials): FTE=1.4

TAsP (Theoretical Astrophysics): FTE=2.0

Totale sigle: FTE=6.4 (7.4 con nuovo ricercatore nel 2023)

Dot. Gr. IV: FTE=0.5

Totale Sigle+Dot. Gr. IV: FTE=6.9 (7.9 nel 2023)

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

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 ETH Zurigo sino al 15/12/2022), D. Sengupta (FTE=1, assegnista 'Cabibbo', da ottobre 2022)

G. Pancheri (senior associate, FTE=0)

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 di carica $4/3$ o $5/3$.
- 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, frammentazione di quark pesanti a (N)NLO e modelli di adronizzazione, limite di Regge delle ampiezze di scattering, sezione d'urto totale non diffrattiva

Gennaro Corcella:

1. Fisica dei quark pesanti nel Modello Standard (top e bottom)

Frammentazione del bottom in $t \rightarrow bW + ng$ ($b \rightarrow B$, $B \rightarrow J/\psi X$) a NNLO+NNLL (risommazione soffice/collineare e tuning di modelli di adronizzazione a LEP/SLD)

In progress: codice MC per $pp \rightarrow t\bar{t} \rightarrow (bW^+)(\bar{b}W^-) \rightarrow (X_b \ell^+ \nu_\ell)(X_{\bar{b}} \ell^- \bar{\nu}_\ell)$ a NNLO

Funzioni di frammentazione NNLO per altri processi ed impatto su m_t

(G.C., M.Czakon, T.Generet, A.Mitov and R.Poncelet, in progress)

ACE per l'analisi di ATLAS sulla misura della massa del top da muoni soffici:

$t \rightarrow bW$, $W \rightarrow \ell\nu$, $b \rightarrow B \rightarrow X\mu \Rightarrow m_t = (174.48 \pm 0.78)$ GeV da $M_{\mu\ell}$

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

$pp \rightarrow Y^{++}Y^{--} \rightarrow (T\bar{b})(\bar{T}b) \rightarrow (b\bar{b}\mu^+\mu^+)(b\bar{b}\mu^-\mu^-)$ con $Q(T) = 5/3$ in 331 visibile a FCC- hh (100 TeV, $\mathcal{L} = 3000 \text{ fb}^{-1}$, $m_Y \simeq 1.3 \text{ TeV}$), ma statistica insufficiente a LHC

(G.C., C.Corianò, A.Costantini, P.H.Frampton, PLB'22)

In corso: ricerche di bileptoni da dati di run II di LHC (supporto ad ATLAS Bologna)

$pp \rightarrow Y^{++}Y^{--} \rightarrow (\ell^+\ell^+)(\ell^-\ell^-)$

Chairman of Spring/Summer School 'Bruno Touschek' (LNF) and Linear and Future Colliders 2022 (with G.Pancheri, ECT*)

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] rappresenta il primo conto esatto al NLO, che includa le masse dei quark top e bottom, e la dipendenza da una massa dinamica
- sviluppare uno schema per il calcolo di sezioni d'urto al NNLO in α_s e oltre in modo indipendente dal particolare processo [2], usando l'universalità delle divergenze infrarosse [3]
- potenziare il calcolo di ampiezze di scattering in teorie di gauge, mediante l'analisi nel limite di Regge [4]

[1] R. Bonciani, V. Del Duca, H. Frellesvig, M. Hidding, V. Hirschi, F. Moriello, G. Salvatori, G. Somogyi, F. Tramontano
"NLO QCD Corrections to Higgs Production in association with a Jet"
[arXiv:2206.10490 [hep-ph]], to appear on Phys.Rev.Lett.

[2] V. Del Duca, C. Duhr, F. Guadagni, P. Muckerjee, G. Somogyi, F. Tramontano
"Colour singlet production in hadron collisions in NNLO subtraction methods"
to appear soon

[3] V. Del Duca, C. Duhr, R. Haindl, Z. Liu
"Tree-level soft emission of a quark pair in association with a gluon"
[arXiv:2206.01584 [hep-ph]], to appear on JHEP

[4] E.P. Byrne, V. Del Duca, L.J. Dixon, E. Gardi, J.M. Smillie
"One-loop central-emission vertex for two gluons in N=4 super Yang-Mills theory"
[arXiv:2204.12459 [hep-ph]], to appear on JHEP

Giulia Pancheri 2022-23

Work in progress in particle physics

- **Touschek's Infrared Resummation** vs. Weinberg's approach to infrared gravitons, boundary conditions
- **Empirical model for elastic differential** cross-section at LHC
 - New fits to 13 TeV data

History of Physics and LNF

- **Book** *Bruno Touschek's extraordinary Journey from death rays to antimatter*
Springer Biographies (July 2022 publication)
- **Proceedings** *Bruno Touschek Hundred Years*, with L. Maiani and L. Bonolis,
Springer Open access 2022
- **Talks** about *Giorgio Salvini* U. Rome Memorial May 2022 and (remote) *Frascati electron Synchrotron* in Santo Domingo Conference, June 2022
- **Poster** about *Italy's road to particle accelerator*, HoP Dublin conference June 2022
- **Articles in progress** *Quaderni di Fisica*, Dec. 2022 and rivista *Prometeo* (outreach) Dec. 2022

Time2Quest

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)

CSN4 research line: statistical physics and field theory

Main research issues

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

Richiesta 2022 4.5 KE Missioni

Personnel associated in 2022, as of today,(100% where not indicated)

S. Bellucci, M. Benfatto (40%),

FTE 1.4

Time2Quest started 2021 evaluated AAA by 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 2022

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

Publications by the LNF unit in 2022

I7 papers su: Nanomaterials (3), Materials (2), Journal of Functional Biomaterials (2),
Bioinorganic Chemistry and Applications, Adsorption Science & Technology,
Journal of High Energy Physics, Advances in High Energy Physics,
Symmetry, Journal of Nanomaterials, Microchemical Journal, Condensed Matter,
Journal of Composites Science, Journal of Cosmology and Astroparticle Physics

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 2022

LNF 11 April 2022, U.Cassino@LNF Lectures

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

LNF 29 June 2022, U.Cassino SUMMER COURSE Nano and quantum technologies

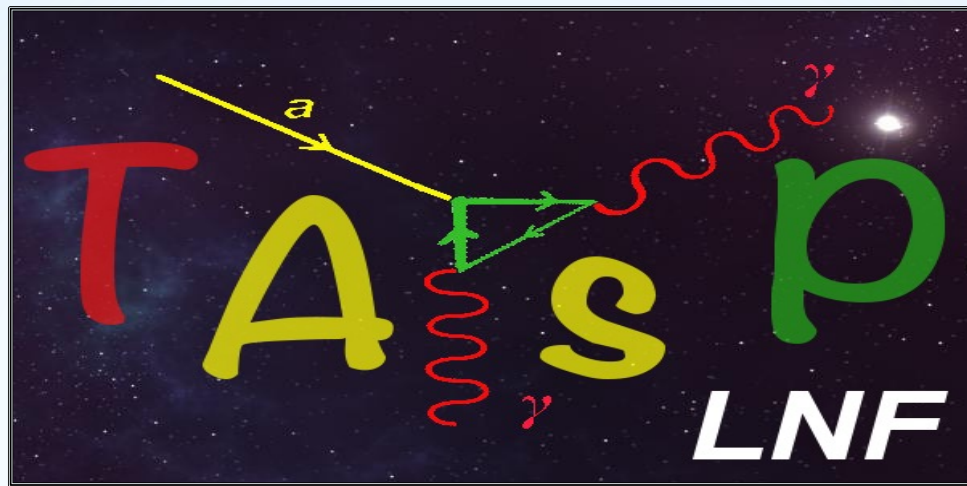
S. Bellucci: **Sensor devices based on nanomaterials**

LNF 12-14 October 2022, CAS 2022 International Semiconductor Conference,
Poiana Basov, Romania, 12-14 Oct.2022

S. Bellucci: **Sensors based on nanomaterials**

LNF 14-16 November 2022, V Internacional Congress of Nanoscience and Nanotechnology,
Universidad Yachay Tech, San Miguel de Urcuquí, Ecuador

S. Bellucci: **Advanced two-dimensional materials and artificial intelligence
for CBRN sensing devices**



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, until Oct. 2022)
- 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 2021-2022

- ➔ 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 38 (2021) 153001

In the realm of the Hubble tension—a review of solutions*

110 pages ~ **480 cit.**

E. Di Valentino, O. Mena, S. Pan, **L. Visinelli**, W. Yang, A. Melchiorri, D. Mota, A. Riess, J. Silk

AXIONS:

The problem of the origin of the Peccei-Quinn symmetry

Exact accidental U(1) symmetries for the axion

Luc Darmé* and Enrico Nardi[†]

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

PHYSICAL REVIEW D **104**, 055013 (2021)

Axion emission from celestial bodies: Hints and Constraints

*J*ournal of **C**osmology and **A**stroparticle **P**hysics Published February 21, 2022
An IOP and SISSA journal

Stellar evolution confronts axion models

Luca Di Luzio,^{a,b,c} Marco Fedele,^d Maurizio Giannotti,^e Federico Mescia^f and Enrico Nardi^g

Axion models: stability of astrophobic conditions vs. higher order corrections

Renormalization group effects in astrophobic axion models *To appear in PRD letters*

Luca Di Luzio^{a,b}, Federico Mescia^c, Enrico Nardi^d, Shohei Okawa^c

Approved long workshop for the GGI 2023 Spring/Summer Program:

Axions across boundaries between Particle Physics, Astrophysics, Cosmology and forefront Detection Technologies **April 24 to June 9, 2023**

24/4 - 28/4

1/5 - 5/5

8/5 - 12/5

15/5 - 19/5

22/5 - 26/5

29/5 - 2/6

5/6 - 9/6

Training week

Astro

Particle

Cosmo

Experiment

Conference week

Contact person:
enrico.nardi@lnf.infn.it

Phenomenology of Feebly Interacting Particles

Light dark matter searches with positrons

M. Battaglieri, ... L.Darmé ... E. Nardi + ... *Eur.Phys.J.A* 57 (2021) 8, 253

Invisible decays of axion-like particles: constraints and prospects

L. Darmé, F. Giacchino, E. Nardi, M. Raggi, *JHEP* 06 (2021) 009

Correlation between axion and Higgs phenomenology

Phenomenological study of a class of DFSZ QCD axion models that can address stellar cooling anomalies and their interplay with Higgs physics:

Badziak, Grilli di Cortona, Tabet, Ziegler **JHEP 10 (2021) 181**

Semi-visible jets studies

Use of the ability to tag semivisible jets to define new event-level variables that can increase the ability of hadron colliders to discover dark confining sectors:

Beauchesne, Grilli di Cortona, arXiv:2111.12156 **Contribution to Snowmass 2022;**

Albouy, ..., Grilli di Cortona et al., arXiv:2203.09503 **Contribution to Snowmass 2022;**

Dark Matter theory/phenomenology /Experiment

Study of twin stau as a Dark Matter candidate in Twin Higgs models:

Badziak, Grilli di Cortona, Harigaya, Lukowski arXiv:2202.10488, submitted to **JHEP**

Study of Dark Matter at directional direct detection experiments:

1. Proposal to measure the Migdal effect with the LIME Cygno prototype: Grilli di Cortona, Messina, Piacentini **J.Phys.Conf.Ser. 2156 (2021) 1** and **PoS PANIC2021 (2022) 051**
2. Amaro, ..., Grilli di Cortona et al. arXiv:2202.05480 **Instruments 6 (2022) 1, 6**
3. O'Hare, ..., Grilli di Cortona et al. arXiv:2203.05914 **Contribution to Snowmass 2022**

Theoretical constructions beyond the Standard Model

Possible solution to the $g-2$ anomalies

Show that the discrepancy between the experimental results by the FNAL $g-2$ Muon Experiment and by BNL, the data driven SM estimate (together with the crucial KLOE and BaBar disagreement) and the lattice estimate could be accounted by a new boson produced resonantly at 1 GeV: [Darmé](#), [Grilli di Cortona](#), [Nardi](#) arXiv:2112.09139, accepted by [JHEP](#)

Light mediator models

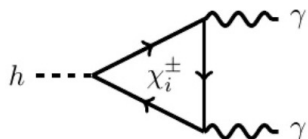
Study of generic light mediator models (kinetic mixing or gauged dark photons, ALPs, ...) as a possible connection to dark sectors or solution to existing problems:

1. Phenomenology of dark photon models in presence of additional heavy degrees of freedom: [Barducci](#), [Bertuzzo](#), [Grilli di Cortona](#), [Massoni Salla](#) **JHEP 12 (2021) 081**;
2. Phenomenology of dark photon models with universal couplings or gauged $B - L$ and $L_\mu - L_\tau$ symmetries at future neutrino experiments exploiting Coherent Nucleus Neutrino Scattering: [Bertuzzo](#), [Grilli di Cortona](#), [Magno Dantas Ramos](#) **JHEP 06 (2022) 075**;
3. Sensitivity of the [MUonE](#) experiment to light mediators (dark photons and ALPs): [Grilli di Cortona](#), [Nardi](#) as a Letter in [Phys.Rev.D 105 \(2022\) 11](#)

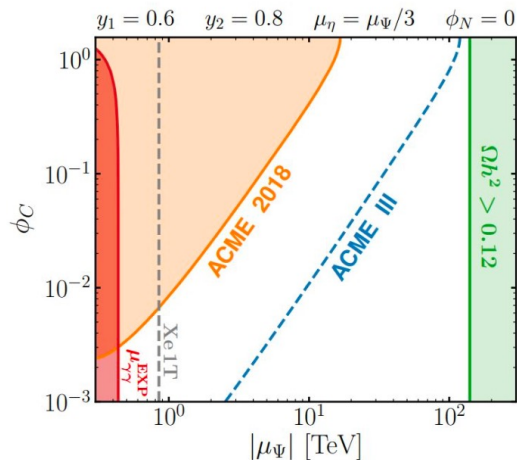
Theoretical constructions beyond the Standard Model

Minimal theory for gauged Baryon Number with 6 fermionic representations:

- Dirac dark matter phenomenology
- CP violation and Electric Dipole Moments
- Modified SM Higgs diphoton decay rate

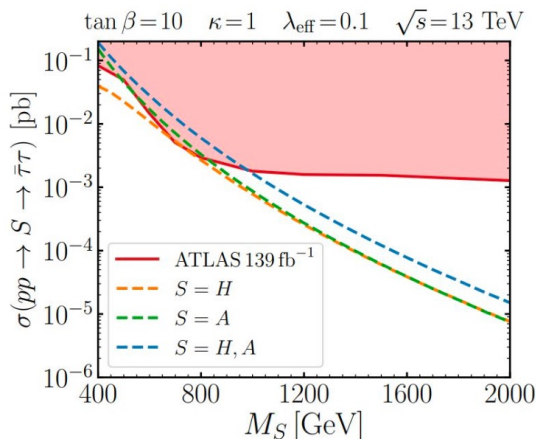


[P Fileviez Perez, AD Plascencia 2112.02103]



Phenomenology of the real scalar triplet extension of the Standard Model. This scenario provides the minimal explanation for the W -boson mass measurement recently reported by the CDF-II collaboration which has a 7σ deviation from the SM prediction.

[P Fileviez Perez, HH Patel, AD Plascencia 2204.07144]



Study on how to probe the Two-Higgs-Doublet-Model (2HDM) that arises from a theory of Pati-Salam quark-lepton unification at the LHC

[P Fileviez Perez, E Golias, AD Plascencia 2205.02235]

Conclusioni

Eccellente produzione scientifica del gruppo teorico dei LNF

Collaborazioni internazionali e locali con gruppi a LNF e dell'area romana

Continua interazione con gruppi sperimentali di Gruppo I e II in loco e non (ATLAS, PADME, DarkSide, JLAB)

Assegno di ricerca Cabibbo (collider o astroparticelle) ben consolidato

Grande attesa per il nuovo ricercatore teorico (ultima assunzione 2011)

Ulteriore rafforzamento del gruppo con ricercatori a tempo indeterminato necessario alla luce dei prossimi pensionamenti nel 2022/2023

Sperando in un definitivo superamento della pandemia, si prevede la ripresa di workshop (tipo JRW) e institutes, per i quali si chiederanno a Div.Ric. e Direzione qualche finanziamento e supporto di segreteria