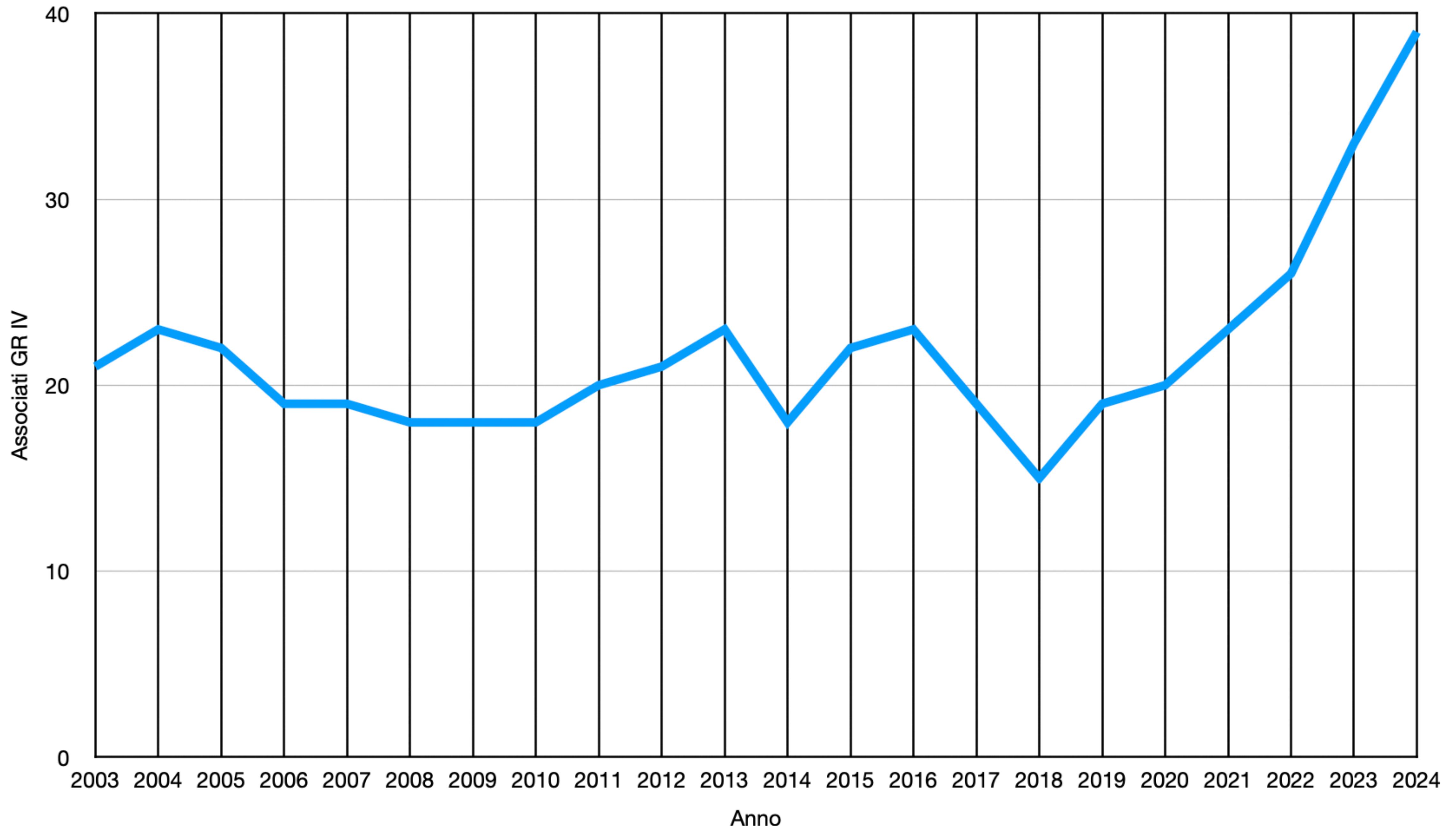


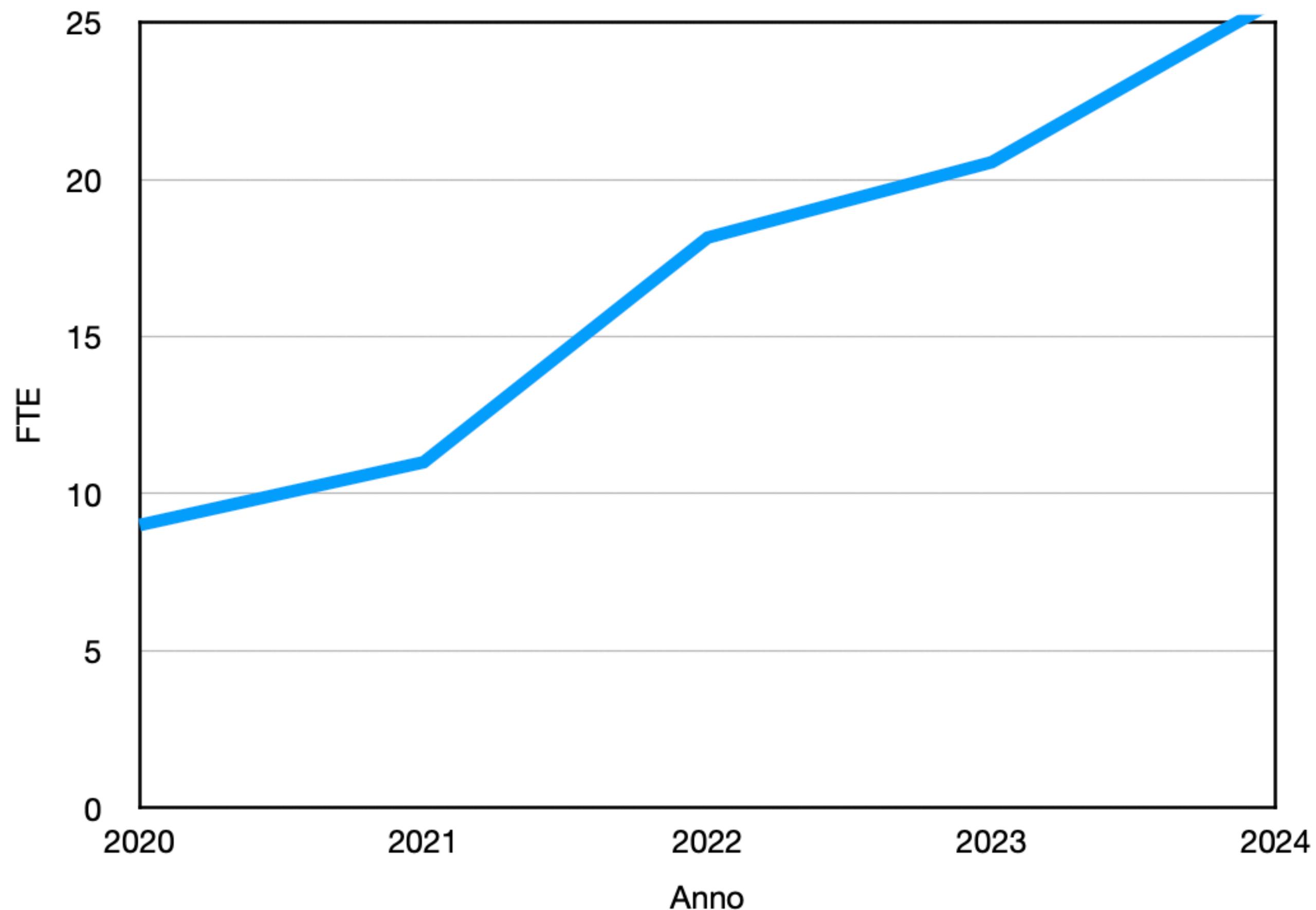
Il Gruppo Collegato INFN di Parma

Massimo Pietroni 9/7/2024

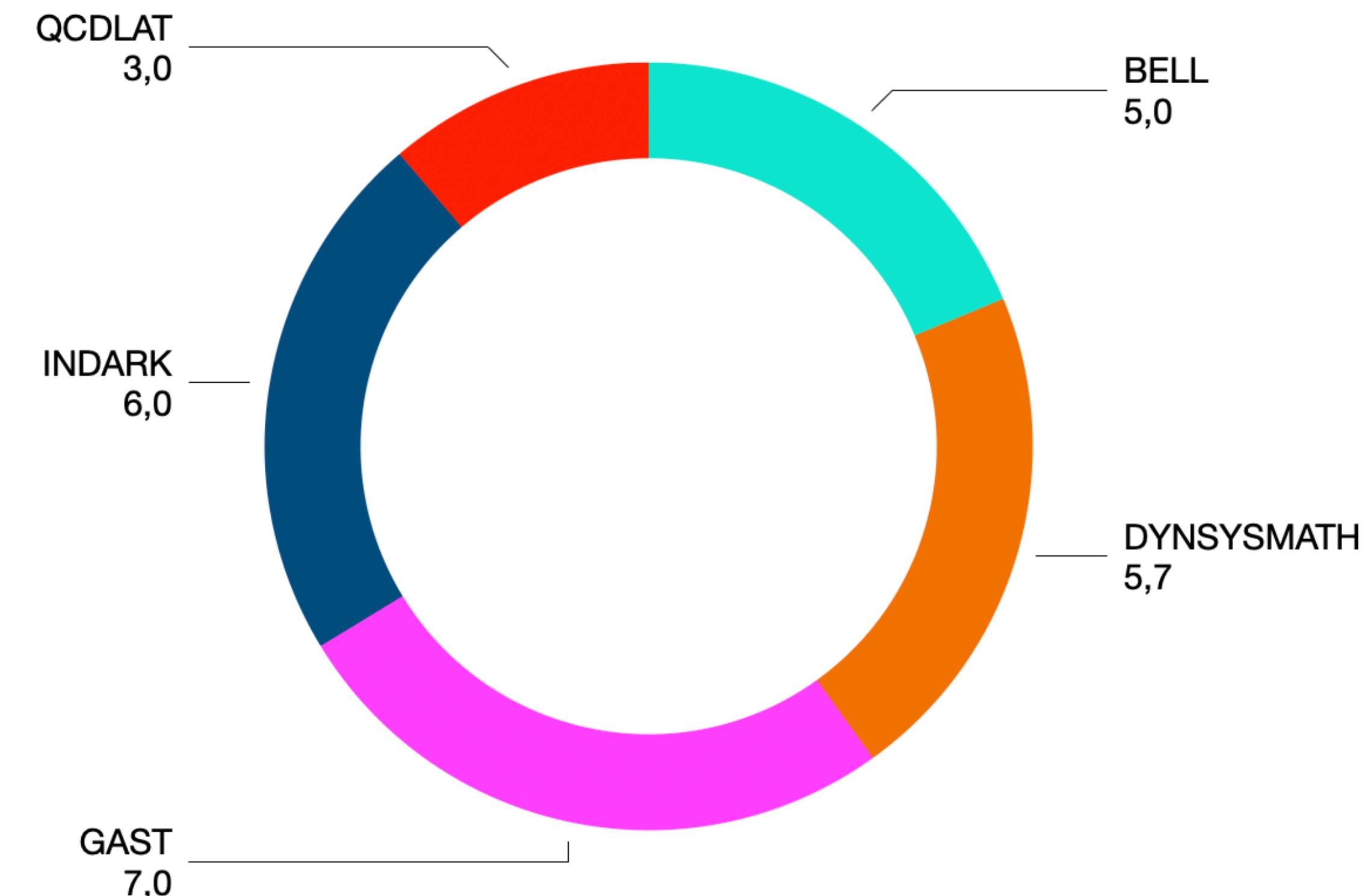
Parma: Associati GR IV



Gruppo Collegato di Parma (FTE)



$$\text{FTE(2024)}/\text{FTE(2020)} = 2.86$$



FTE per iniziativa specifica

- 6 incarichi di ricerca
- 11 universitari staff
- 3 RTD
- 1 dipendente CNR
- 14 dottorandi
- 2 affiliati
- 1 borsista post doc INFN
- 1 tecnologica borse E.P.
- 1 Ass. Senior

Convenzione INFN-UNIPR

- rinnovata a gennaio 2024
- durata 7 anni
- contributo INFN per servizi e utenze, borsa di dottorato, (co)finanziamento assegni...
- modifiche minori rispetto alla precedente

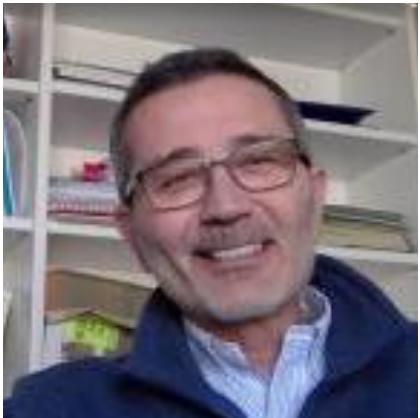
Le iniziative specifiche

Group

BELL : Fundamental Problems in Quantum Physics (Commissione IV, Linea 4)



S. CARRETTA



P. SANTINI



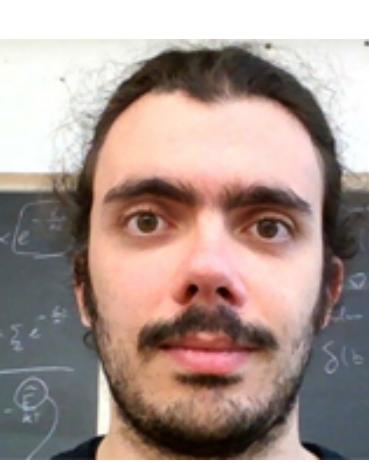
A. CHIESA



E. GARLATTI



L. LEPORI



E. MACALUSO



L. RATINI

- Stefano Carretta (PO)
- Paolo Santini (PO)

- Alessandro Chiesa (RTD)
- Elena Garlatti (RTD)
- Luca Lepori (RTD)
- Emilio Macaluso (RTD)
- Leonardo Ratini (assegnista)



A. CANTARELLA



S. MACEDONIO



M. MEZZADRI



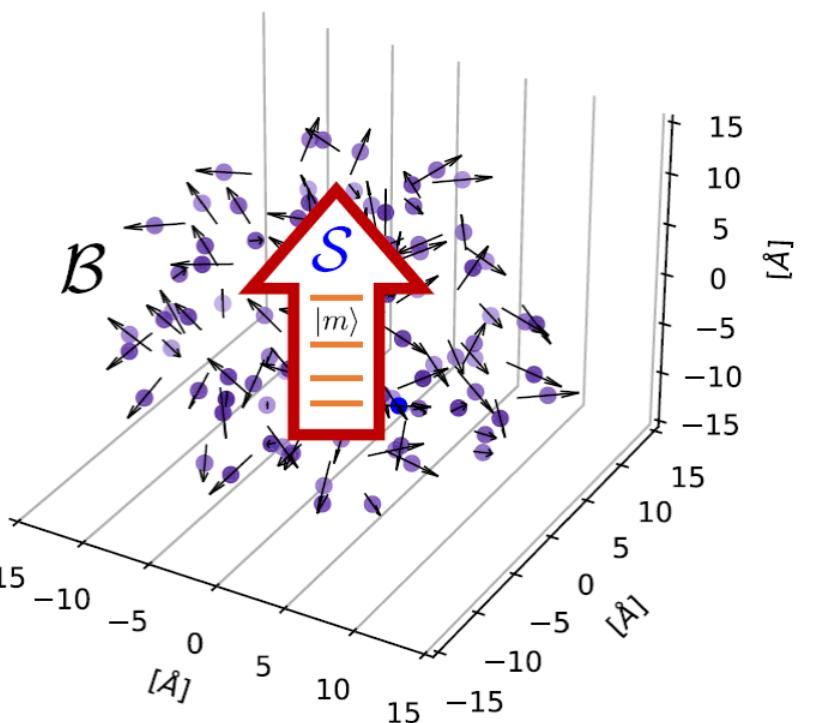
G. SANSONE

- Arianna Cantarella (phD student)
- Silvia Macedonio (phD student)
- Matteo Mezzadri (phD student)
- Giacomo Sansone (phD student)

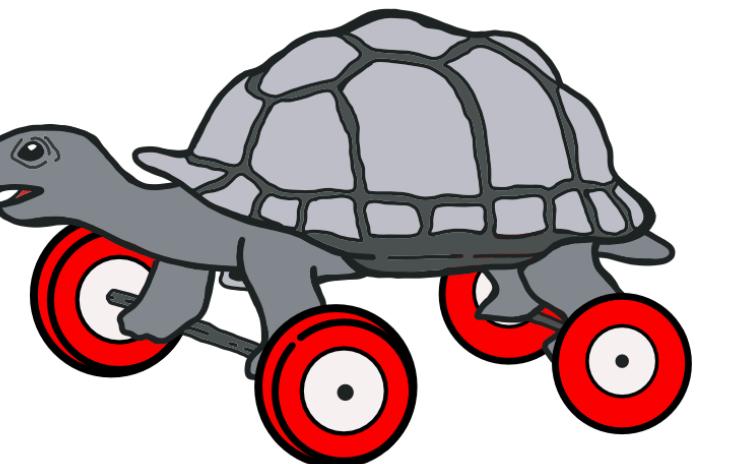
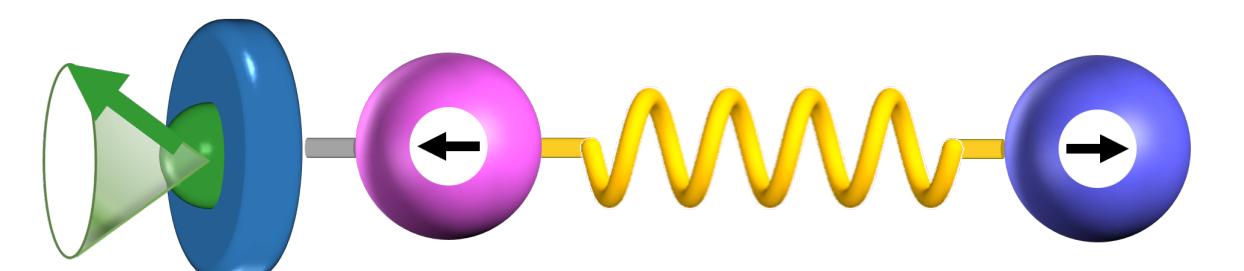
Research Lines

Theoretical modelling, schemes and algorithms for Quantum Information Processing

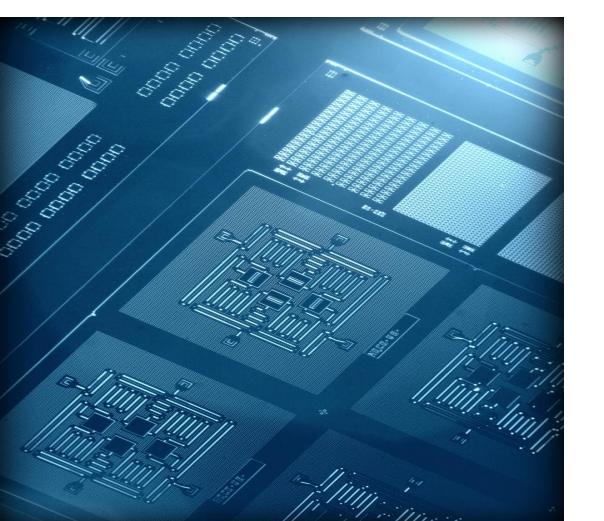
- Modelling of **decoherence** in molecular qubits



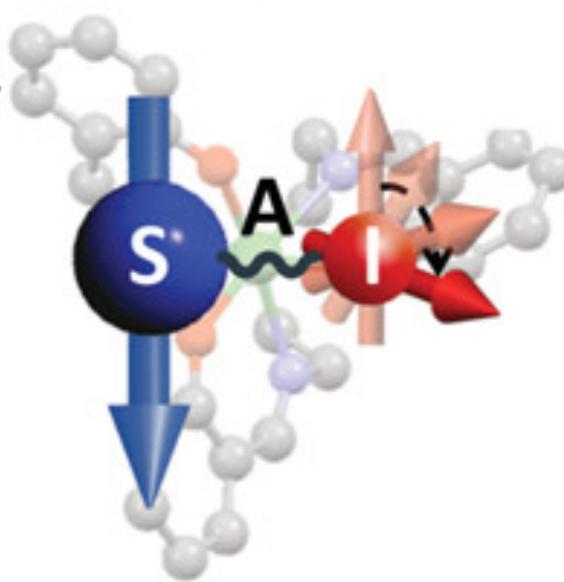
- Chirality as a tool for quantum technologies



- Preparation of quantum states with optimized adiabatic techniques

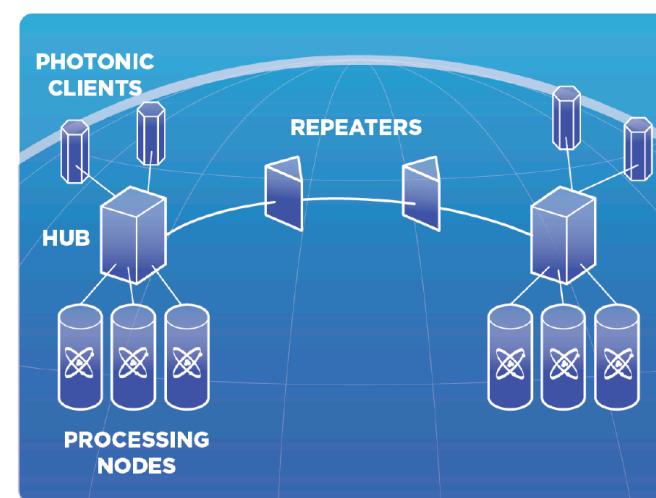
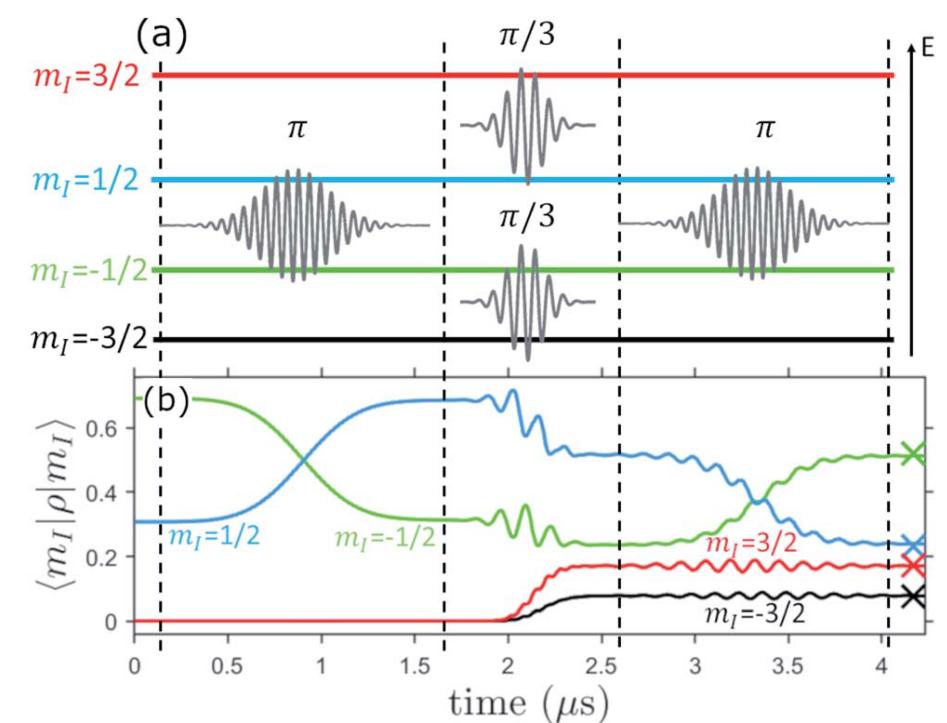


- Schemes for using **transmons** as qudits



- Qudit encoding:
 - **Quantum Error Correction** algorithms for qudits
 - **Quantum simulation** of fermionic problems

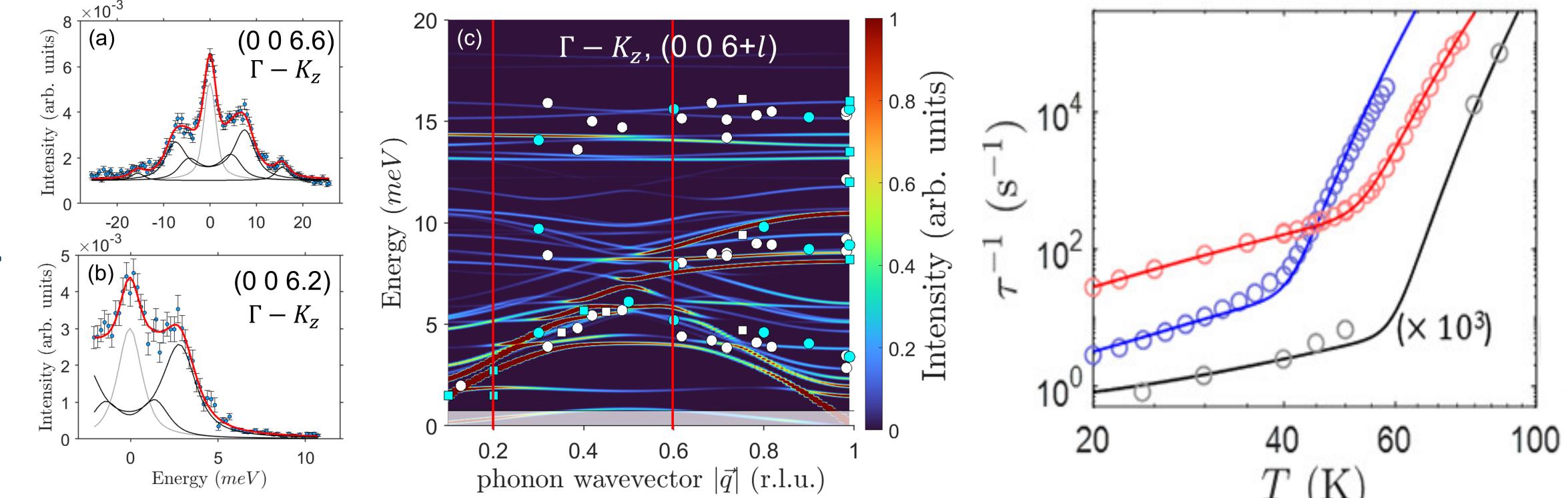
- Design of pulse sequences to **implement** quantum algorithms



- Quantum internet

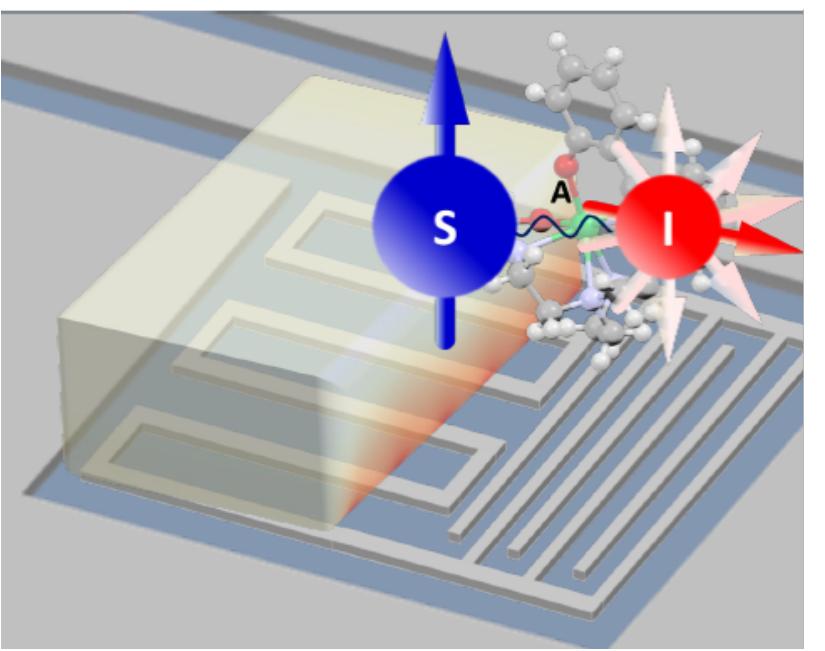
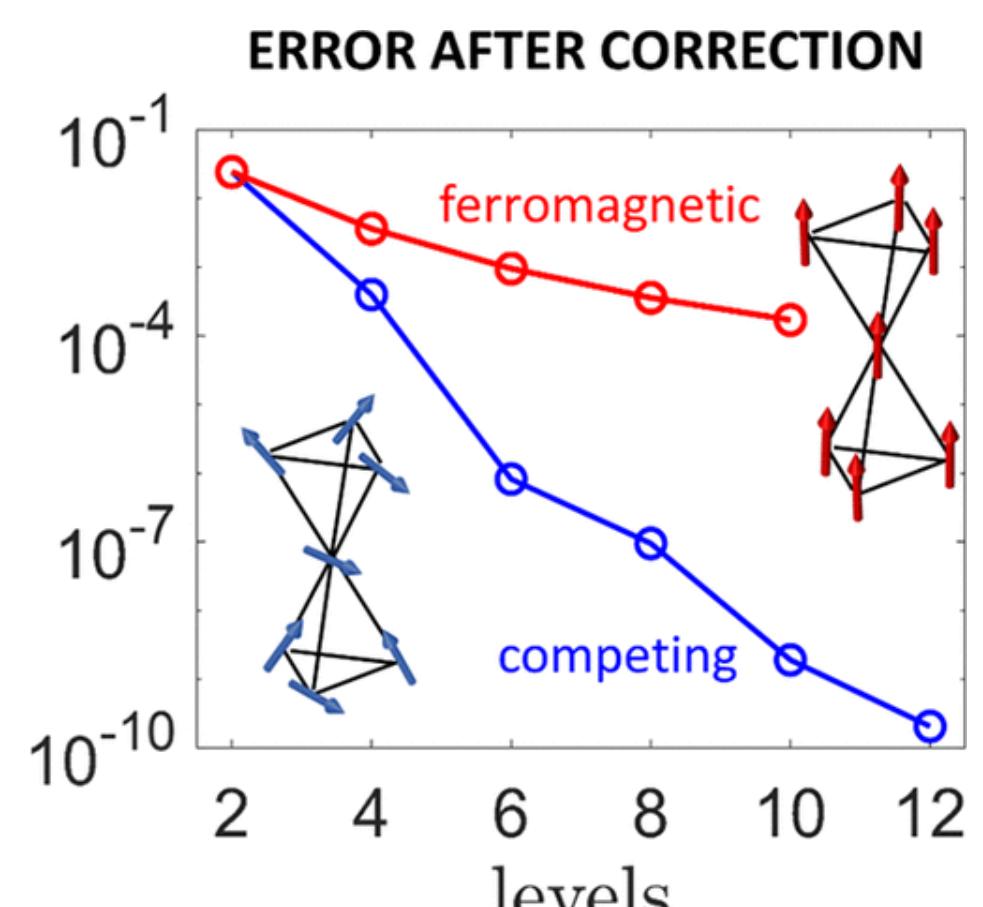
Highlights

- Investigation of **phonon-induced relaxation** in molecular qubits by modelling the first INS and IXS experiments
- Design of qudit-based QC schemes based: multi-level logic to enhance computing power and **embed quantum error correction**



Nature Commun. **14**, 1653 (2023)

J. Phys. Chem. Lett. **12**, 8826–8832 (2021)

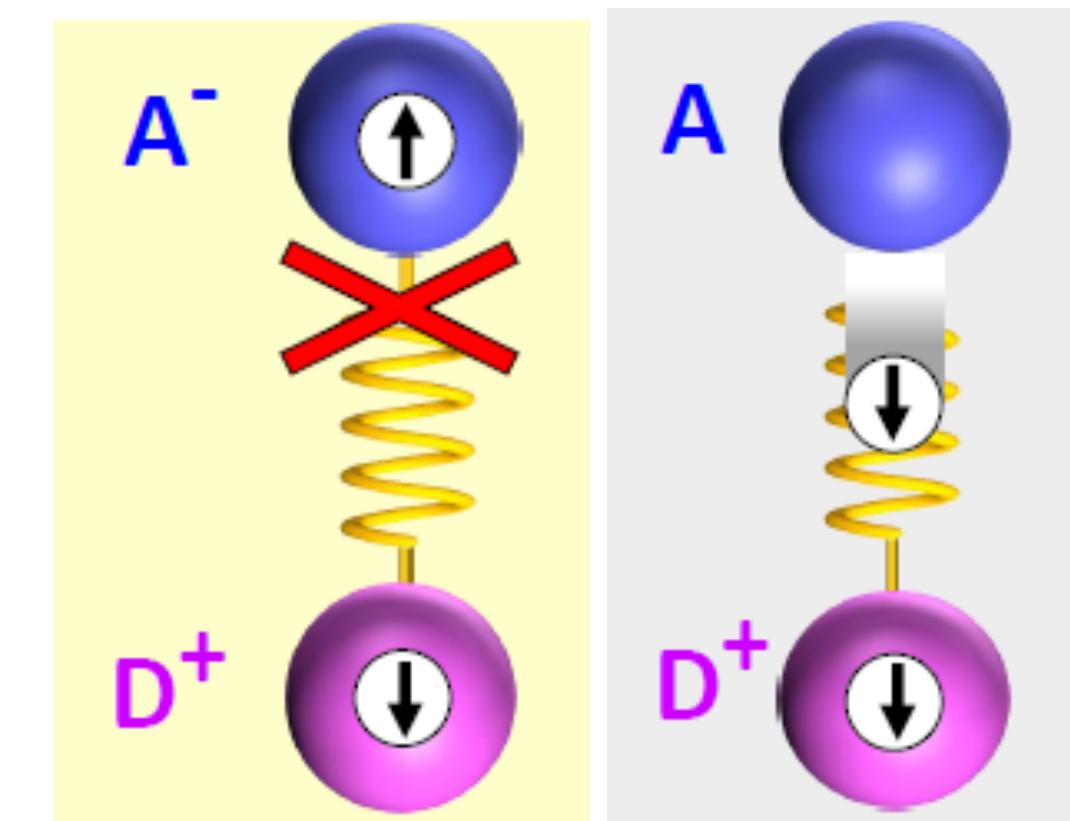


Appl. Phys. Lett. **118**,
240501 (2021)

npj Quantum Inf. **7**, 133 (2021).

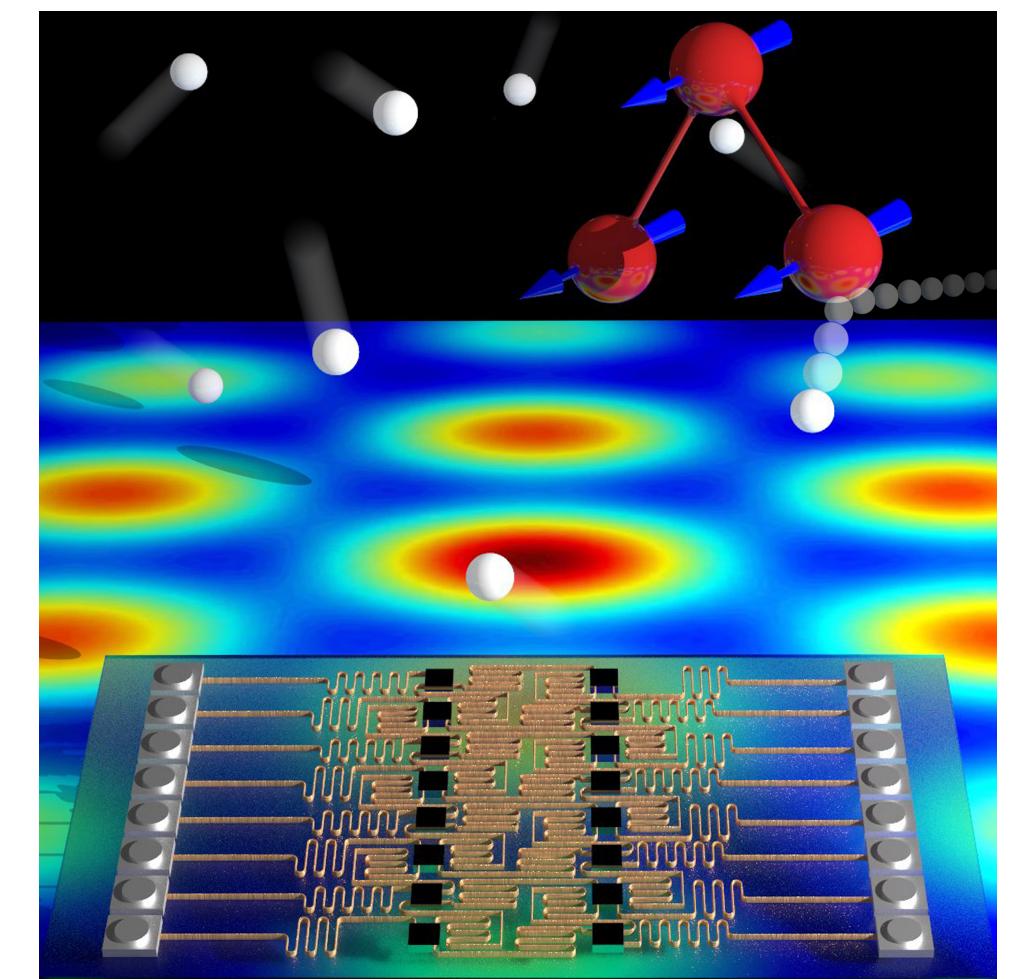
J. Phys. Chem. Lett. **13**, 6468 (2022)

- Schemes for **spin to charge conversion** based on chirality induced spin selectivity



Adv. Mater. (2023), in press

- **Quantum simulations** on prototype quantum chips



Nat. Phys. **15**, 455-459 (2019)

Projects



project n. 101071533



European Research Council
Established by the European Commission

PNRR MUR project PE0000023-NQSTI

National Quantum Science and Technology Institute



Finanziato
dall'Unione europea
NextGenerationEU



Ministero dell'Università e
della Ricerca



PRIN 2022 “CROQUET”

novo nordisk
foundation

Coherent addressing of isotopically pure lanthanide complexes by photons and efficient quantum error correction for Quantum Information Technologies



**QUANTUM
INTERNET
ALLIANCE**



BELL - Fundamental Problems in Quantum Physics

**UNIVERSITÀ
DI PARMA**



DYNSYSMATH

DYNamics and non equilibrium states of complex SYStems: MATHematical methods and physical concepts

Nodi:

- Parma (national coordinator: R. Burioni)
- Roma Sapienza
- Milano Statale (+ Brescia and Como)
- Catania
- Firenze

Parma: R. Burioni, D. Cassi, S. Wimberger,

M Bellingeri, P. Rotondo

A. Vezzani (CNR)

+ A Bassanoni, L. Guglielmi (Ph.D.)

+ 2 studenti in tesi magistrale

Principali expertise del gruppo di Parma:

Equilibrium and out of equilibrium statistical physics,

Statistical Physics and dynamical models on graphs and networks

Classical and quantum transport, quantum control

Research Topics

- ⌚ Sincronizzazione e transizioni di fase dinamiche su networks: applicazioni a neural networks, a processi epidemici e di trasporto e a misure di resilienza delle reti
- ⌚ Inferenza statistica da dati neural, Statistical Physics of Machine Learning, Bayesian Inference. Analisi di grandi fluttuazioni e large deviations
- ⌚ Trasporto coerente e effetti quantistici, quantum walks, quantum control, classical to quantum parallels in Synchronization and Entanglement

Collaborazioni principali

Parigi IV, ENS Paris, Friburgo, Zurigo, Boston Northeastern, Bar Ilan University, Vietnam National University, Erlangen-Norimberga, Heidelberg, Oklahoma State University, Granada University , Leiden, Cardiff, Sapienza Roma, Roma Tor Vergata, CNRS Marsiglia, Los Alamos, Washington, Università di Bologna, Università di Firenze, Università di Pisa, Istituto dei Sistemi Complessi CNR-ISC Roma e Firenze, Università di Salerno

Highlights

- Presenti in 2 partenariati Estesi e 2 Centri Nazionali PNRR, 1 progetto internazionale, 2 progetti regionali, 2 PRIN (di cui uno su INFN Mib)
- 10 tesi di dottorato svolte all'interno del gruppo negli ultimi 5 anni, di cui 3 in cotutela con Università Straniere
- 1 tesi di Dottorato premiata con Menzione Speciale del Premio Fubini 2023 (Marco Mancastropfa)
- 1 tesi di Dottorato premiata con il Premio "Giovanni Paladin" della Società Italiana di Fisica Statistica per la miglior tesi di dottorato in Fisica Statistica 2022 (Marco Mancastropfa).
- Organizzazione del Convegno della Società Italiana di Fisica Statistica (SIFS) 2019-2024 (Finanziamento INFN nel 2024)
- Gruppo coinvolto nell'organizzazione di Statphys29 (Firenze 2025)

★ GAST- Nonperturbative dynamics in gauge and string theories (Linea 1)

Marisa Bonini (Prof. Ass)

Luca Griguolo (Prof. Ass)

Carlo Meneghelli (RTDB)

Dottorandi: Sophie Mueller (II anno), Leonardo Bossi (I anno),
Alessandro Testa (I anno)

Collaborazioni principali

Humboldt University, Uppsala University, Oxford University, King' s College, ICTP-SAIFR

Stony Brook and Simons Center, Iceland University, Università di Torino, Università di Firenze,

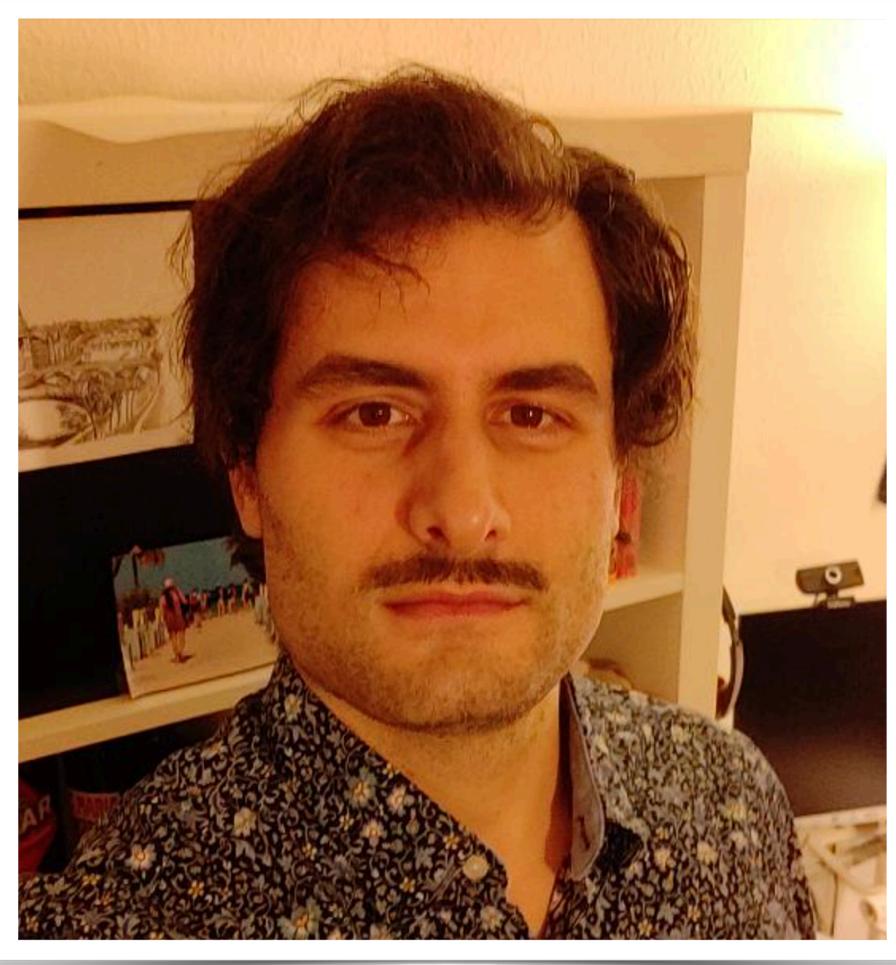
Università di Milano Bicocca, GGI Firenze

★ GAST-Nonperturbative dynamics in gauge and string theory (Linea 1)

Linee di ricerca: aspetti nonperturbativi in teoria quantistica dei campi, teorie di campo supersimmetriche e superconformi, calcoli semiclassici in teoria di stringa, path-integral localization, bootstrap, CFT, gravita' quantistica in due e tre dimensioni

- Wilson loops, correlations functions e difetti in teorie (super)conformi
- Gravita' quantistica e buchi neri in dimensioni minori di quattro
- Bootstrap e localizzazione in teorie supersimmetriche
- AdS/CFT and gauge/gravity duality
- 11 Dottorandi, 16 studenti Master, 1 post-doc INFN

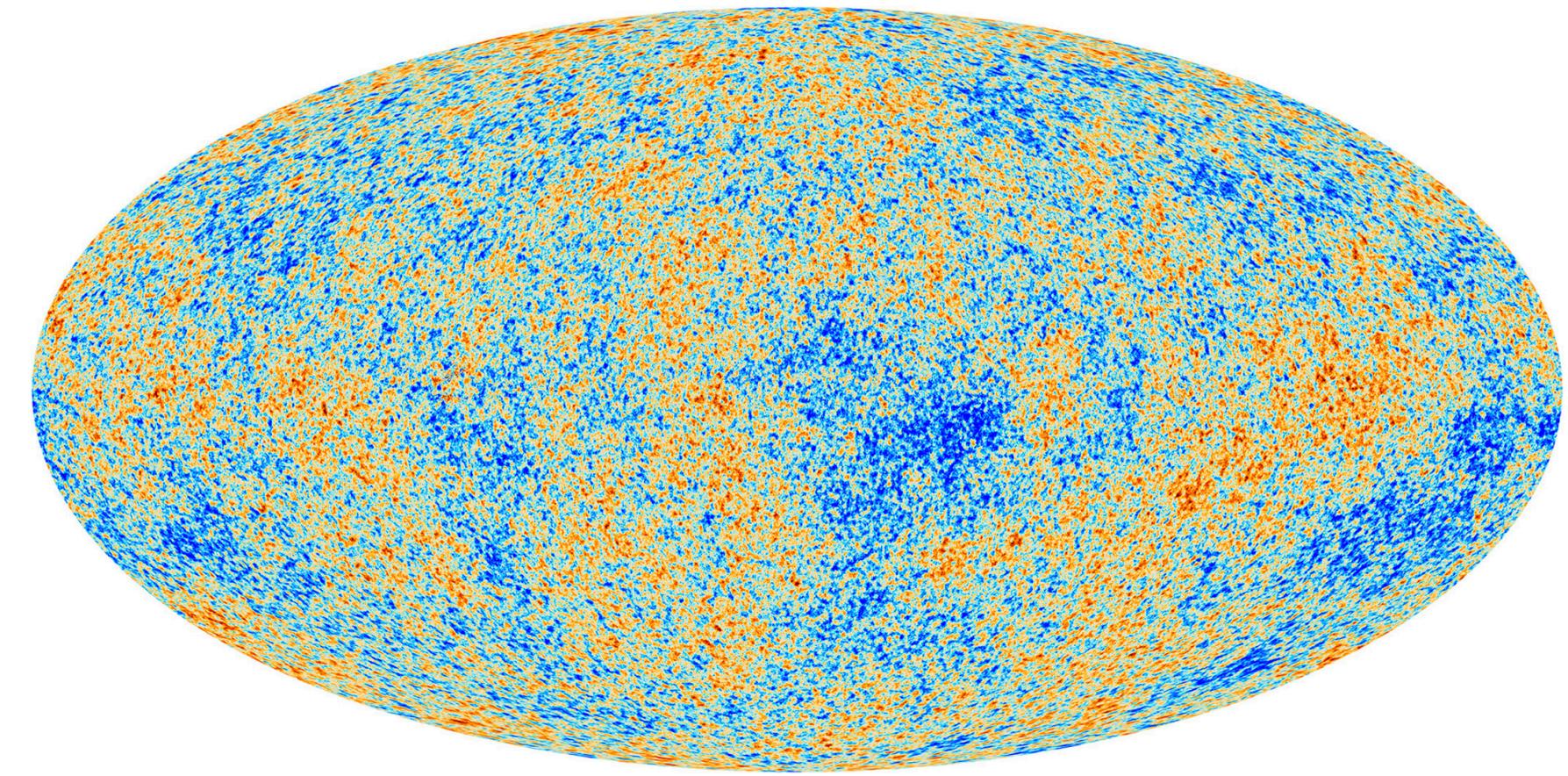
INDARK a Parma



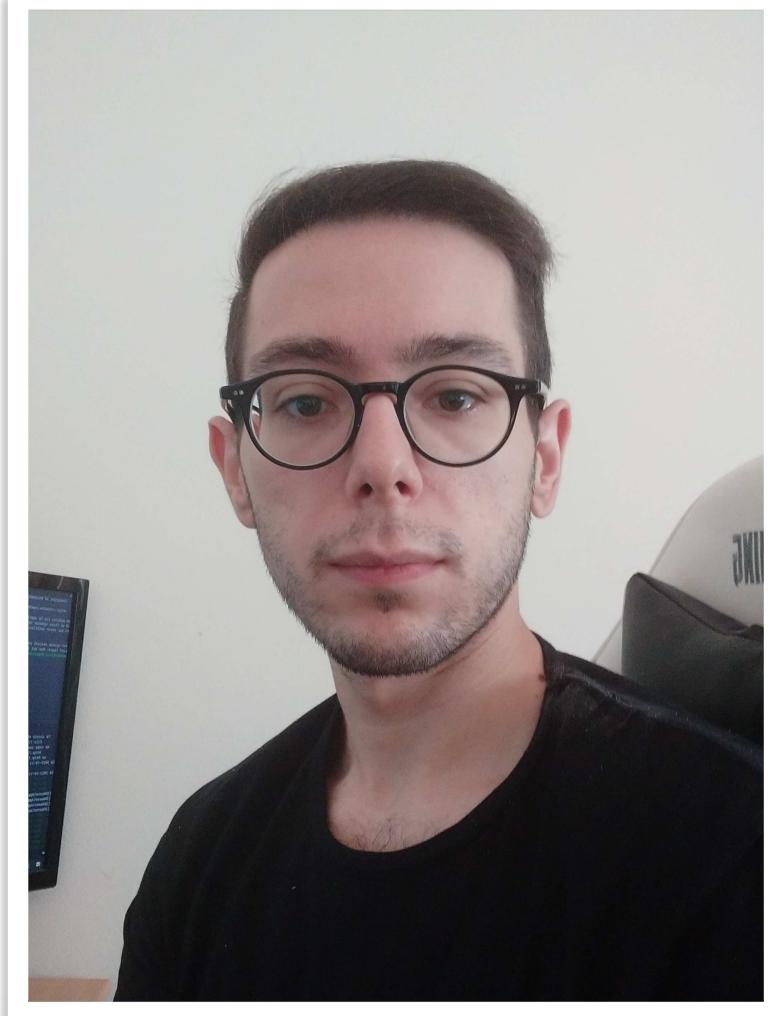
Guido D'Amico



Massimo Pietroni



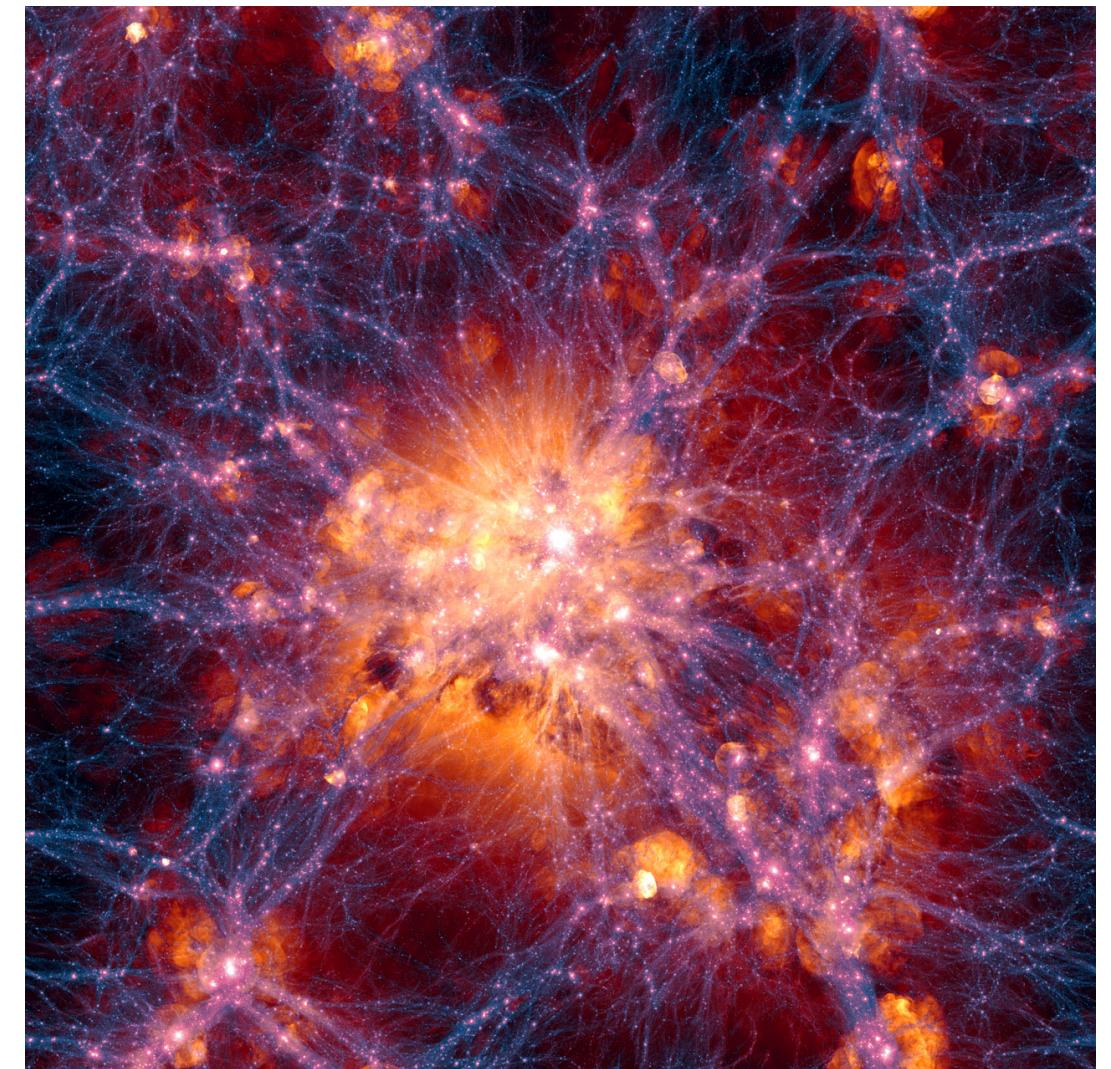
Dennis Linde



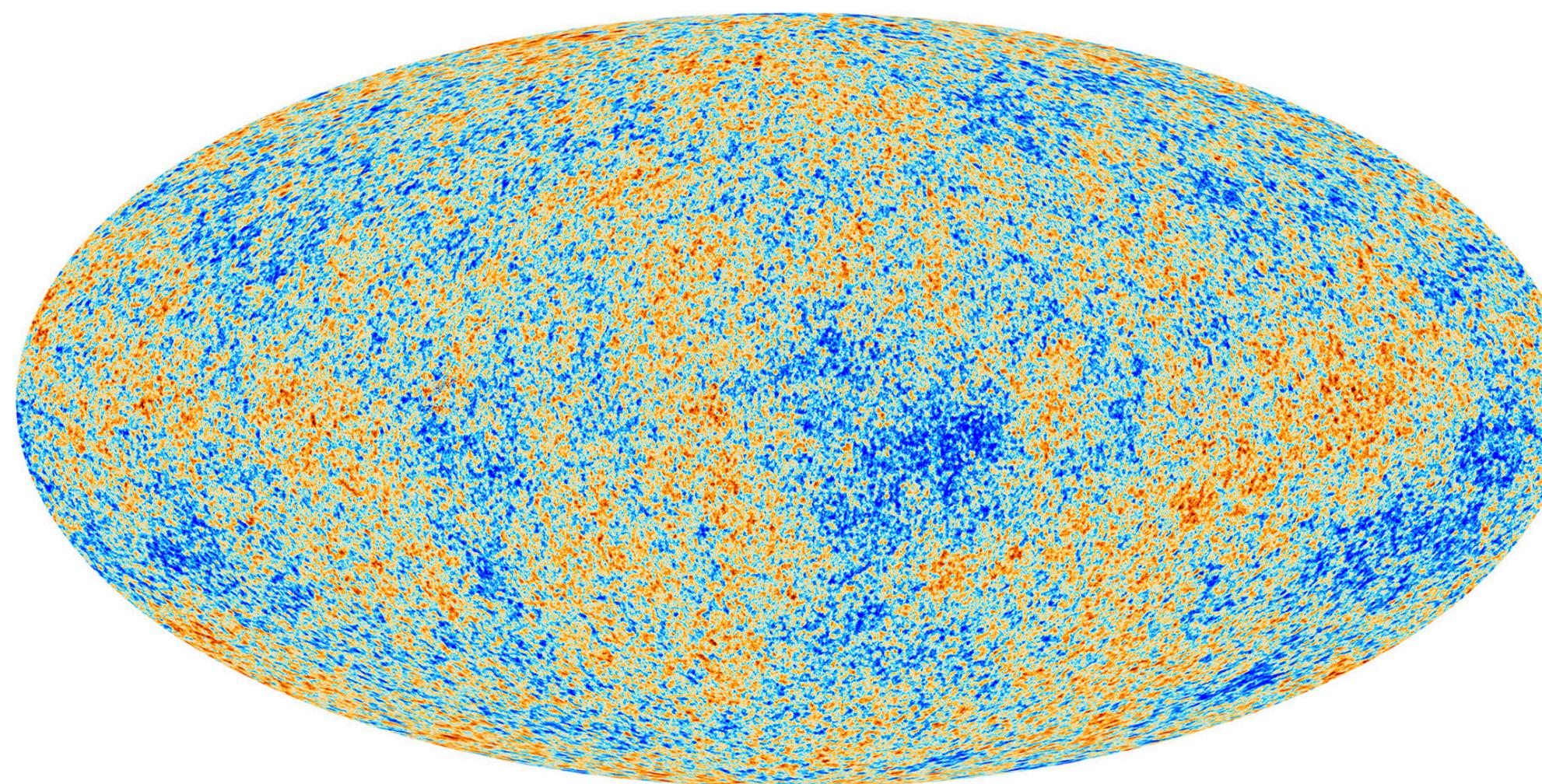
Matteo Peron



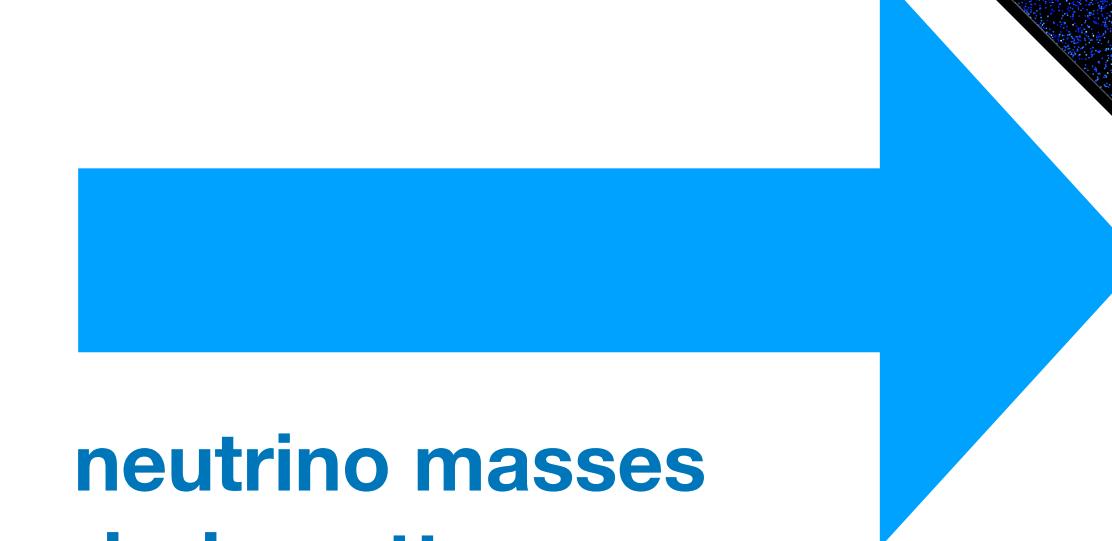
Kevin Paredede (post doc INFN)



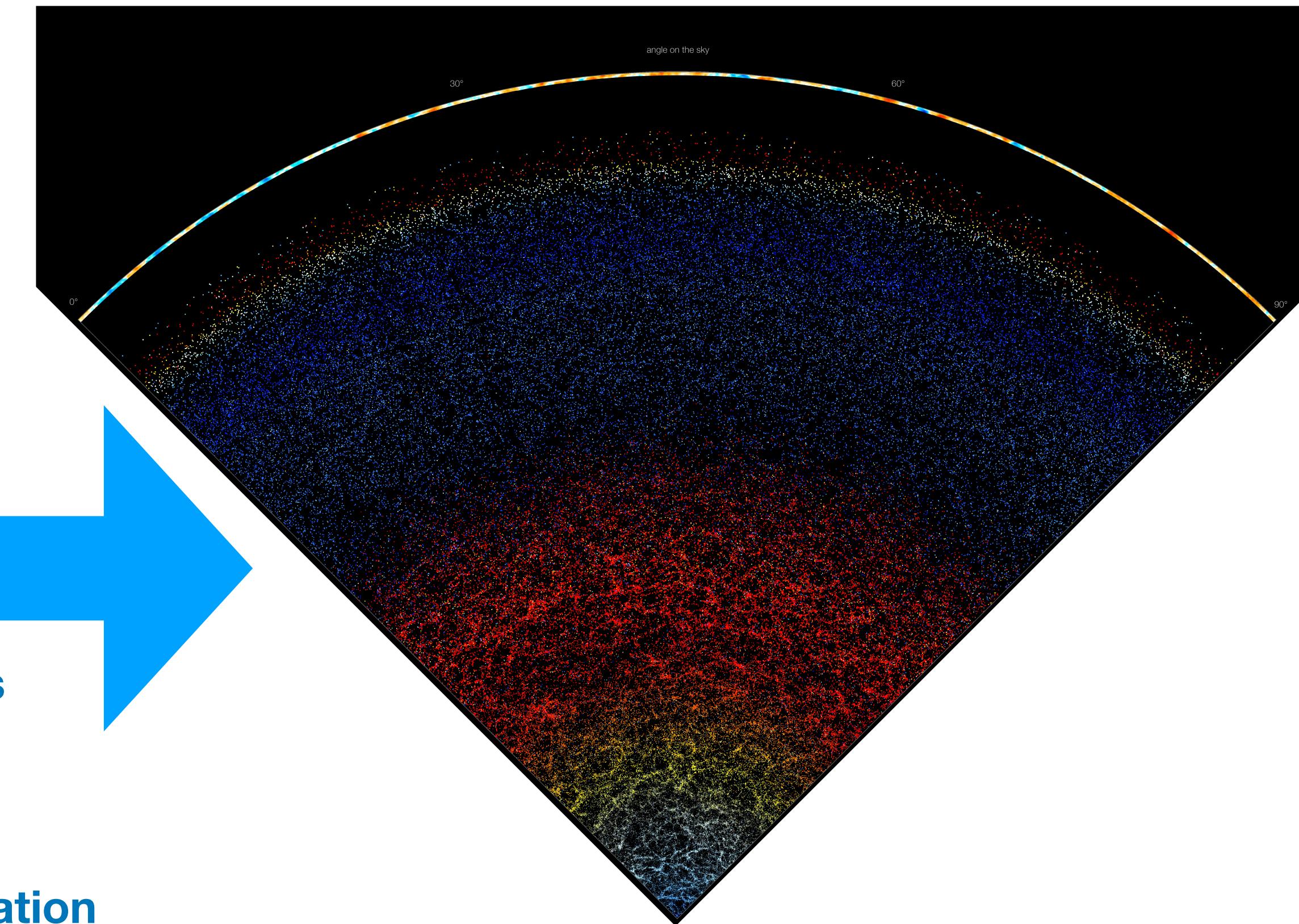
Extract information on Fundamental Physics from Cosmological Observations



CMB: “Initial conditions”



neutrino masses
dark matter
dark energy
tests of gravity
dynamics of inflation



Large Scale Structure: “Late Time Universe”

Euclid Consortium (ESA)



Scientific goals:

Dark Energy

Dark Matter

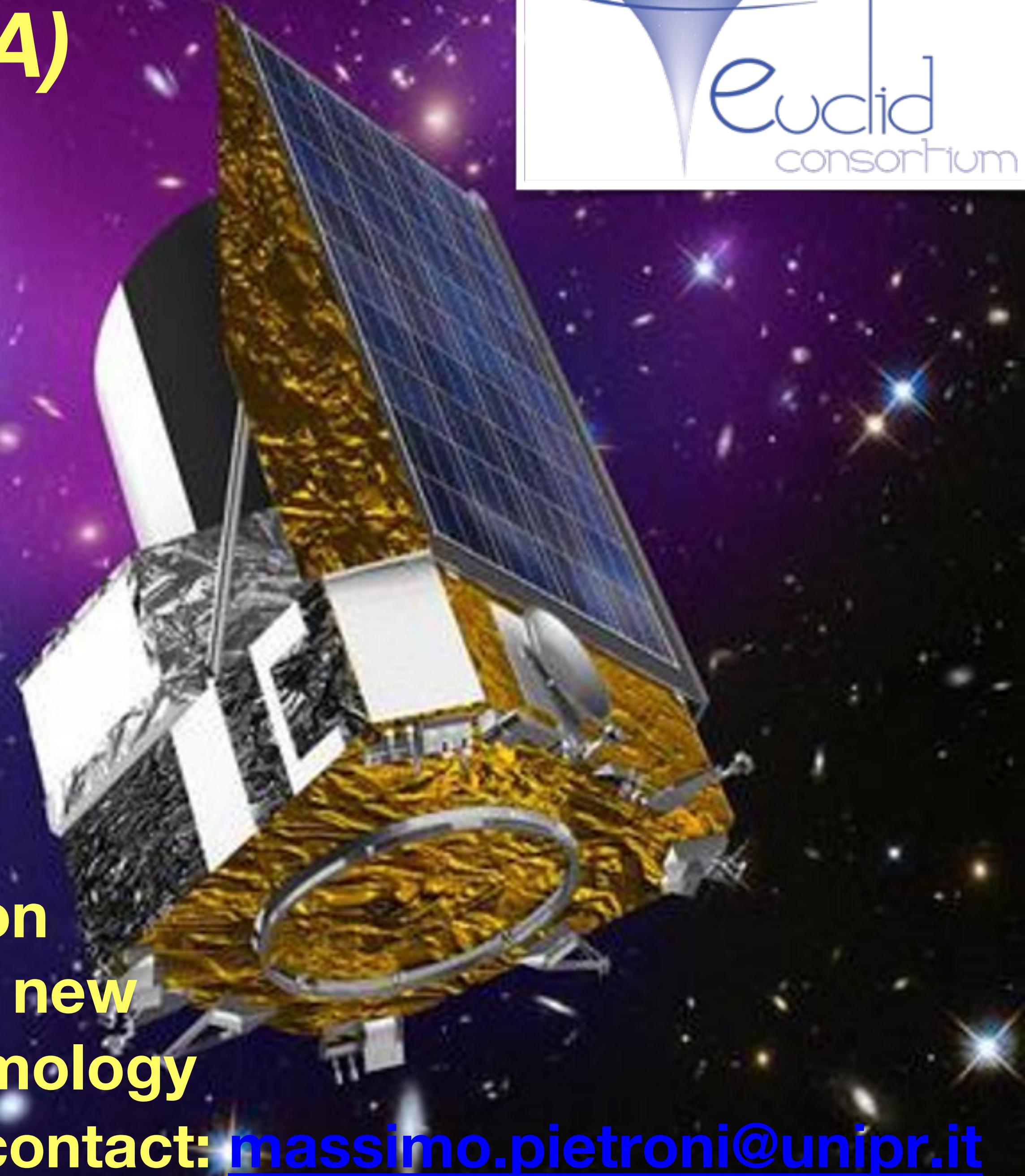
Testing Gravity on cosmological Scales

Measuring neutrino masses

Launch in July 2023 (Space X)

Parma Cosmology Group:

**Galaxy clustering data analysis, extraction
of cosmological parameters and tests of new
physics beyond standard models of cosmology
and particle physics**

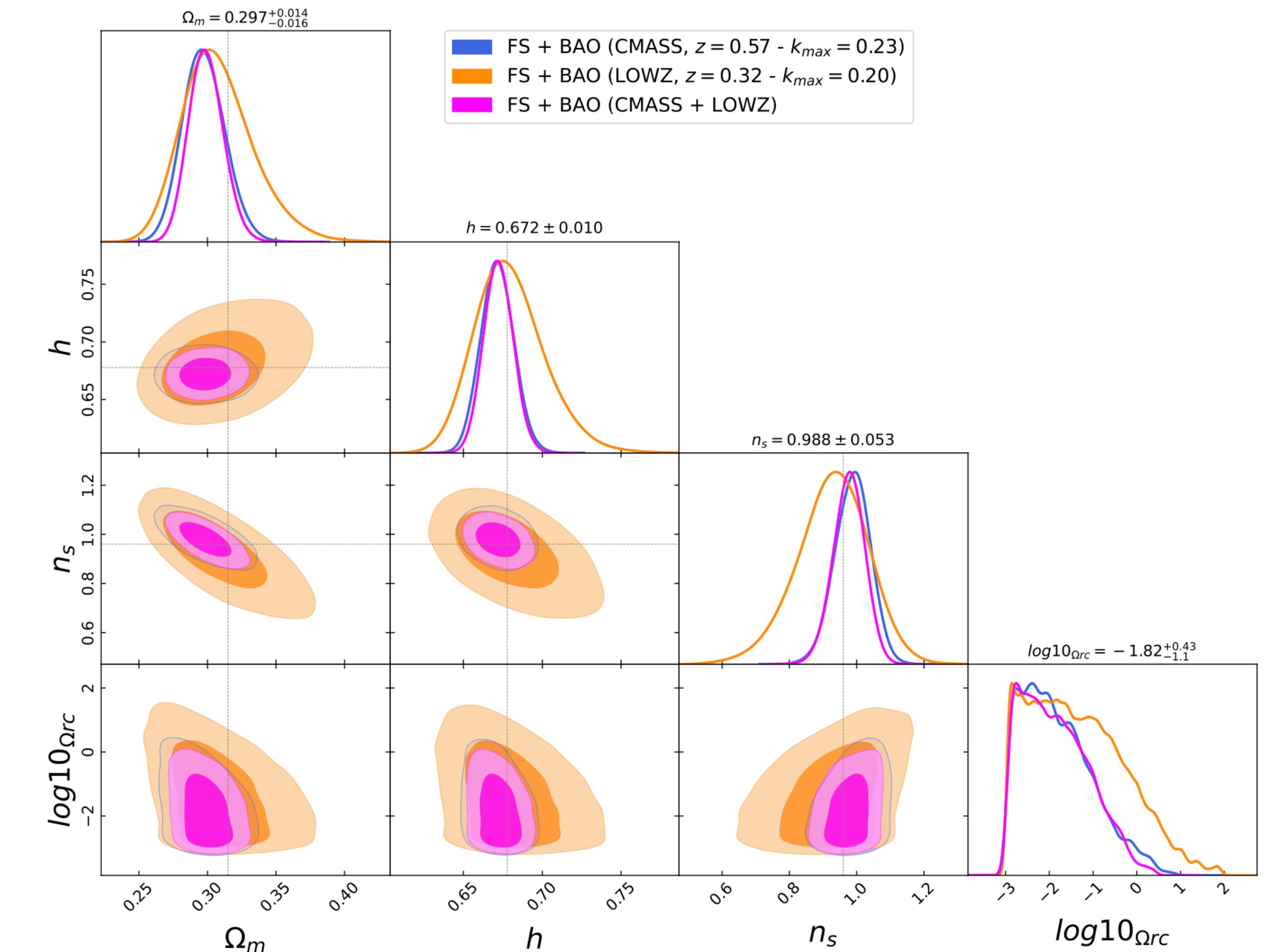


contact: massimo.pietroni@unipr.it

- The Universe as a laboratory for Fundamental Physics
- Neutrino Masses and properties
- Dynamics of Inflation
- Precision tests of the Standard Cosmological Model
- Tools from our (INFN) common background:
Effective Field Theory, Resummations, Symmetries, Bootstrap...

In Euclid:
MP: Co-lead of Work Package on “*Analytical Approaches to Non-Linearities*”

GdA: Lead of Key Project Paper on: “Cosmological constraints on non-standard cosmologies”



Example: bounds on modifications of GR on cosmological scales

Linea scientifica 2 (*Phenomenology of elementary particles*)

“The main objective of this project is to search for new fundamental phenomena in Nature by advancing the theoretical knowledge on strongly interacting theories in the Standard Model (SM) and beyond.”

LAT stands for **LATTICE**

A Parma

- **QCD a TEMPERATURA e DENSITÀ FINITE** (*diagramma di fase della QCD*)

Critical End Point
candidate !!!

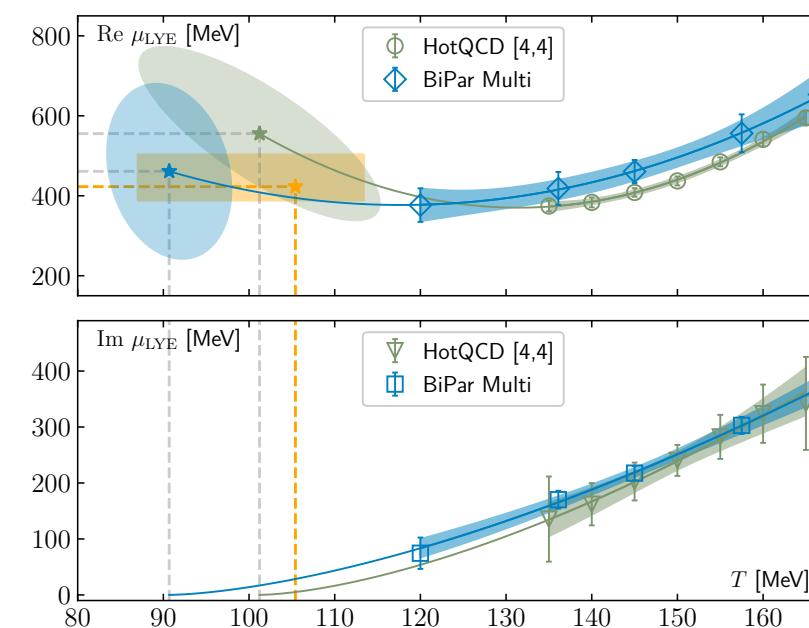


FIG. 4. Scaling fits for the LYE singularities related to the CEP. Green data come from a [4,4] Padé from Ref. [7]. Blue data come from the multi-point Padé. *Top:* Scaling of the real part. *Bottom:* Scaling of the imaginary part. The ellipses shown in the top panel represent the 68% confidence region deduced from the covariance matrix of the fit. The orange box indicates the AIC weighted estimate (6).

- **Sviluppi teorici** (*regolarizzazione di teorie di campo su Lefschetz thimbles; alti ordini perturbativi, rinormaloni, resurgence theory*)
- **Sviluppo di strategie computazionali** (*Numerical Stochastic Perturbation Theory; implementazione algoritmica della regolarizzazione su L. Thimbles; approssimanti di Padè multi-point per lo studio della struttura di singolarità del diagramma di fase della QCD; applicazioni di Intelligenza Artificiale*)

In anni recenti membri di reti europee

- **STRONG2020** (*NA6 lattice hadrons*)
- **EuroPLEX** (*MCSA Initial Training Network - H2020*)



- **Grant di calcolo** (*PRACE, ISCRA B, EuroHPC, ...*)



- **ILDG** (*responsabilità per l'INFN entro l'International Lattice Data Grid*)



Principali collaborazioni scientifiche

- Bielefeld (*C. Schmidt*)
- Swansea (*B. Lucini*)
- ETMC, FLAG (*via P. Dimopoulos*)

P.S.

- M. Aliberti è un dottorando con borsa INFN
- un PostDoc INFN per QCDLAT prenderà servizio in autunno

Richieste 2025 (preliminary!)

Dotazioni GR IV	36 K€
BELL	11 K€
DYNSYSMATH	10 K€
GAST	9 K€
INDARK	9 K€
QCDLAT	5 K€