Inflation, Dark Matter And The Large Scale Structure Of The Universe (InDark)

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Consiglio di Sezione INFN

Ferrara, 1 luglio 2022

INDARK - OBIETTIVI

- L'IS **InDark** si propone di studiare aspetti del **modello cosmologico standard** e delle sue estensioni, in connessione alla **fisica delle particelle**

- Tre temi principali: **Inflazione e Universo primordiale**, **Materia Oscura e Specie Leggere**, **Energia Oscura e Gravità Modificata….**

- …e tre "probes" osservative: **Cosmic Microwave Background**, **Strutture a grande scala**, **Onde Gravitazionali**

- Novità rispetto al triennio 2017-2020: **onde gravitazionali**, approccio più marcatamente **multiprobe/multiscale**, attenzione alle **tensioni osservative** (es. H0 tension)

INDARK - OBIETTIVI

“Our goal is to advance in the path that goes from a simple phenomenological description of the Universe and of its evolution, to fully understanding the nature of its constituents, the behaviour of gravity on cosmological scales and the mechanisms generating the primordial cosmological perturbations. At the same time, this strategy will allow to constrain models of particle physics. Once paired with reliable theoretical predictions, present and forthcoming data provide a treasure trove that allows to test with increasing accuracy, and possibly rule out, various models of the Universe, its evolution and the structures within. “

INDARK - STRUTTURA

- Proposta per una **nuova IS** per il triennio 2021-2024

- **Sezioni INFN coinvolte**: BO, FE, GE (nuova!), LNGS, PD, PR, RM2, RM3, TO, TS

- **~ 65 FTE** e **80 partecipanti**

- **Responsabile nazionale**: M. Lattanzi (FE)

INDARK – ATTIVITÀ A FERRARA

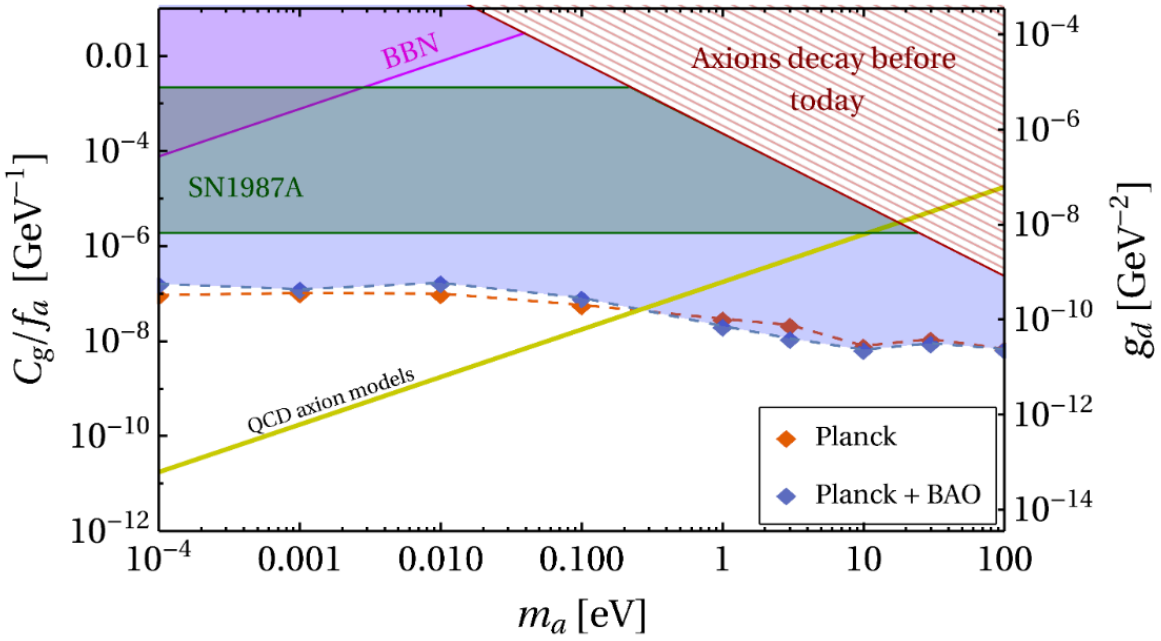
- **Particle cosmology:** neutrini, neutrini sterili, assioni, majoroni…
- **CMB e Fisica BSM** (es. violazione di simmetrie fondamentali)
- **Anomalie della CMB**
- **Metodi statistici per l'estrazione di informazione da osservabili cosmologiche**
- **Inflazione cosmica e "media" in cosmology**

Personale coinvolto: S. Arcari, M. Ballardini, N. Barbieri, M. Bortolami, T. Brinckmann, L. Caloni, D. Comelli, M. Gerbino, M. Lattanzi, M. Lembo, P. Natoli, L. Pagano

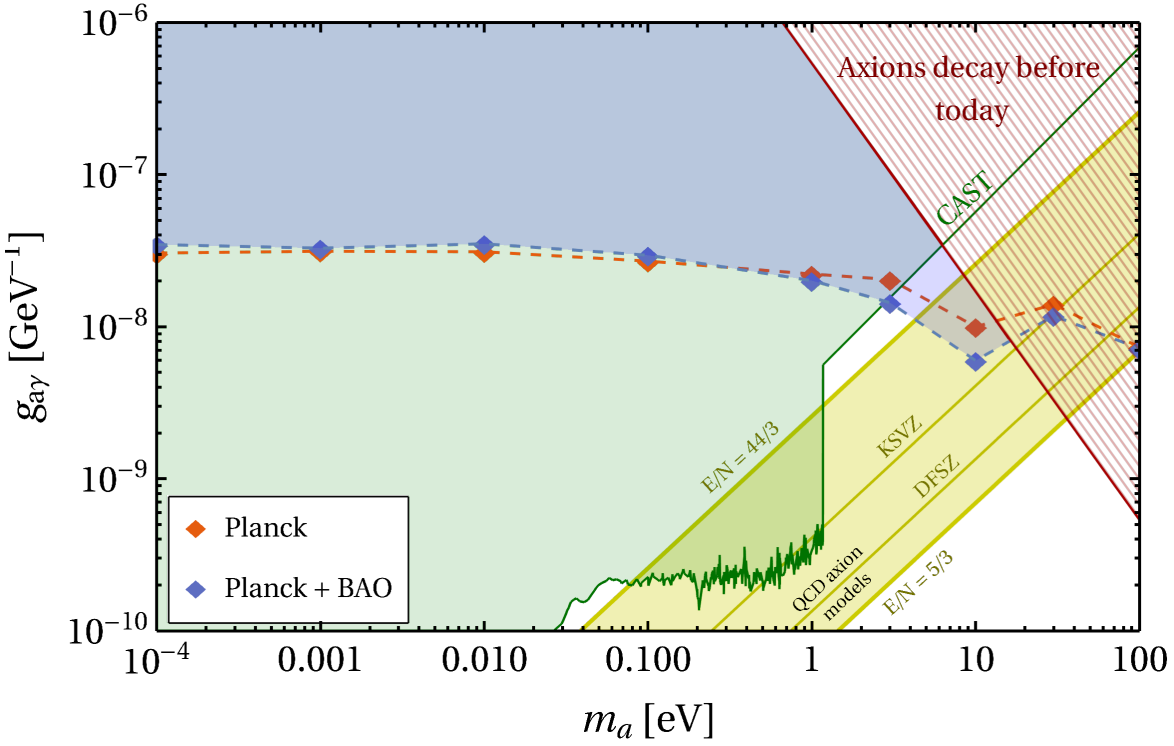
Principali collaborazioni: A. Gruppuso (INAF BO), L. Pilo, M. di Giambattista (L'Aquila), P. Ciafaloni (INFN Lecce), A. Urbano (La Sapienza), A. Mirizzi (Univ. Bari), L. Visinelli (Shanghai), S. Pastor (IFIC Valencia), ……

Cosmological constraints on thermal axions

Axions can be produced thermally in the early Universe through their coupling to **photons** or gluons



$$\mathcal{L}_{ag} = \frac{\alpha_s}{8\pi}\frac{C_g}{f_a}\, a G^i_{\mu\nu}\tilde{G}^{\mu\nu,i}$$



$$\mathcal{L}_{a\gamma} = \frac{1}{4} g^0_{a\gamma} a F_{\mu\nu}\tilde{F}^{\mu\nu}$$

Caloni, Lattanzi, Gerbino, Visinelli, 2022

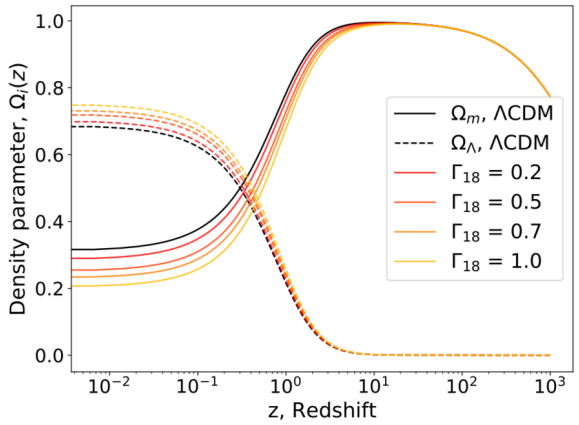
DM late invisible decays

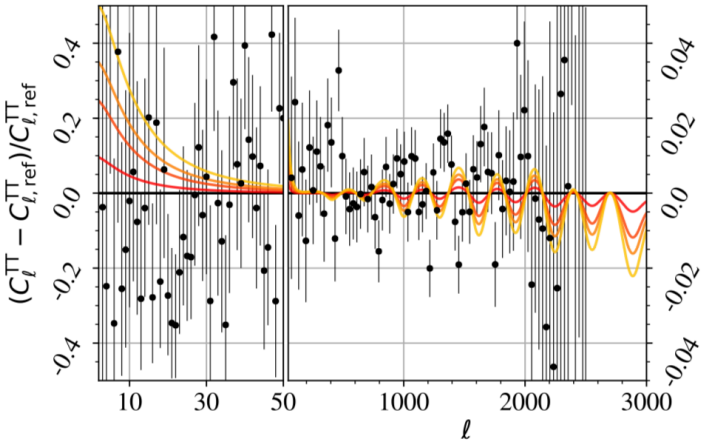
CMB anisotropies can probe invisible DM decays (e.g. to neutrinos)

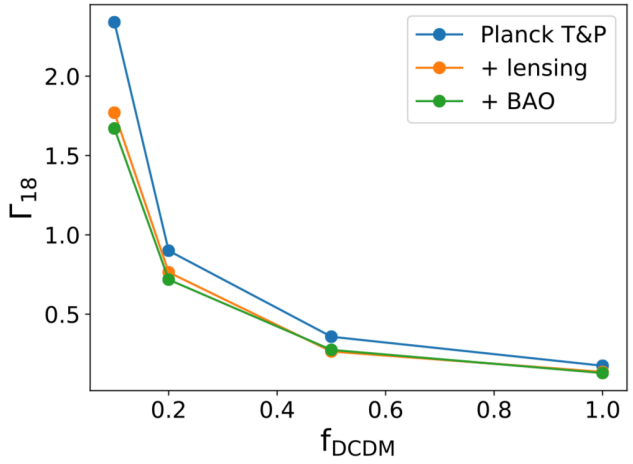
- Larger late ISW due to variation in gravitational potentials
- Smaller lensing due to suppression of fluctuations

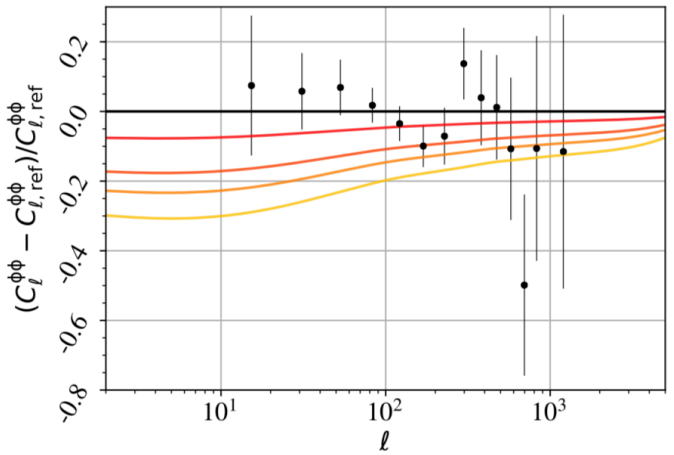
$\tau_{\rm CDM} > 246\,{\rm Gyr}$

from Planck+BAO





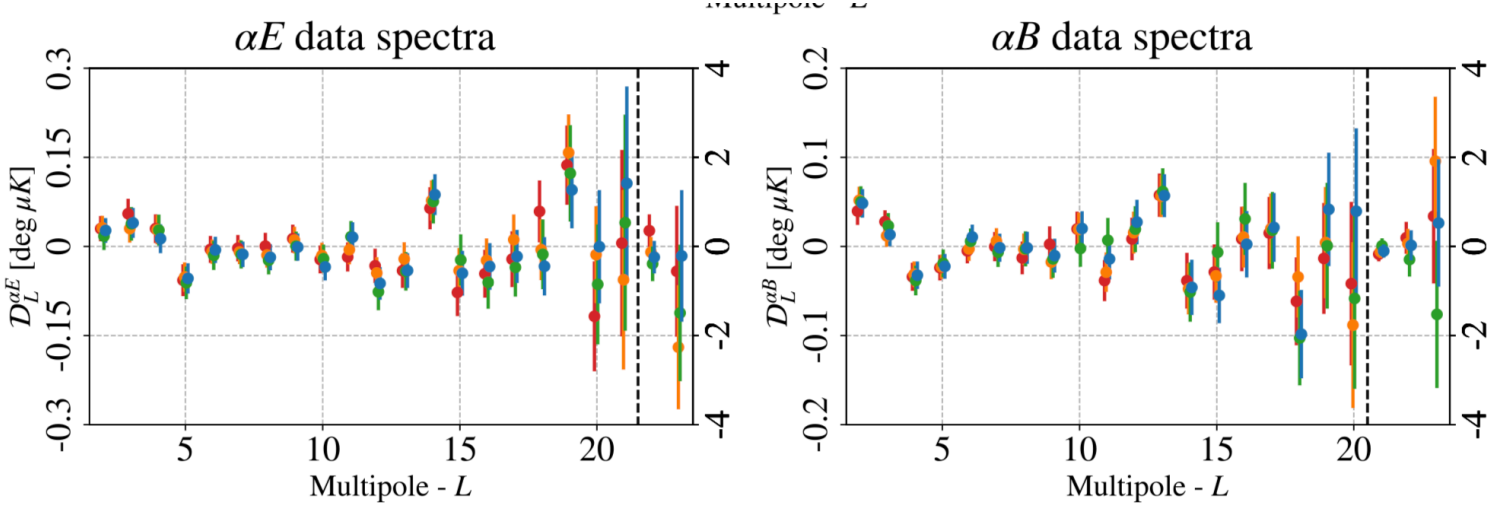




Alvi, Brinckmann, Gerbino, Lattanzi, Pagano, arXiv:2205.0563

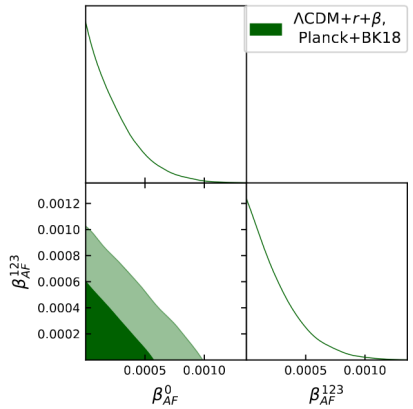
CMB polarization and violation of fundamental symmetries

Violation of fundamental symmetries (e.g. parity) can give rise to **cosmic birefringence** and other similar phenomena



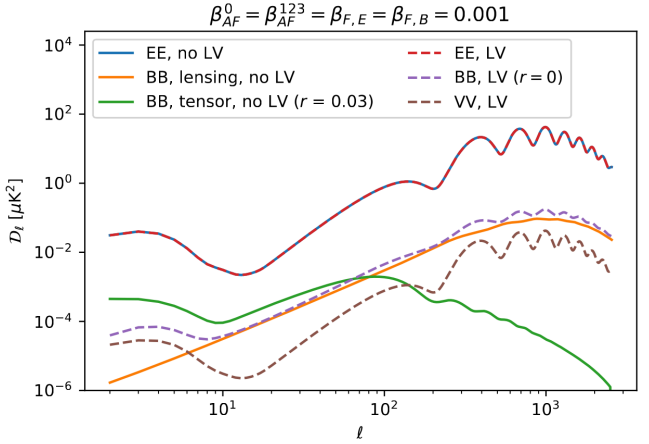
First estimate of the cross correlation between the birefringence angle and polarization

Bortolami, Billi, Gruppuso, Natoli, Pagano
arXiv:2206.01635



Lorentz-violating EM would also leave imprint in CMB polarization (including the generation of circular modes)

Caloni, Giardiello, Lembo, +
In preparation



Cosmology

- Stability and Quantization for Gyroscopic systems

$$\mathcal{L} = \underbrace{\frac{\dot{\phi}^t\,\dot{\phi}}{2}}_{kinetic} + \underbrace{\phi^t\,\mathcal{D}\,\dot{\phi}}_{gyroscopic} - \underbrace{\frac{1}{2}\phi^t\,\mathcal{M}\,\phi}_{mass}, \qquad \phi = \left| \begin{array}{c} \phi_1 \\ \phi_2 \end{array} \right|$$

- Primordial Gravitational waves generation

In collaboration with L.Pilo, M. diGiambattista (Univ. of L'Aquila)

High Energy Physics

- Loop corrections for very high energy cross sections in spontaneously broken gauge theories and cancellation of the Infrared divergences

In collaboration with P.Ciafaloni (INFN Lecce), A.Urbano (Univ. La Sapienza)

InDark – Anagrafica Preventivi 2022

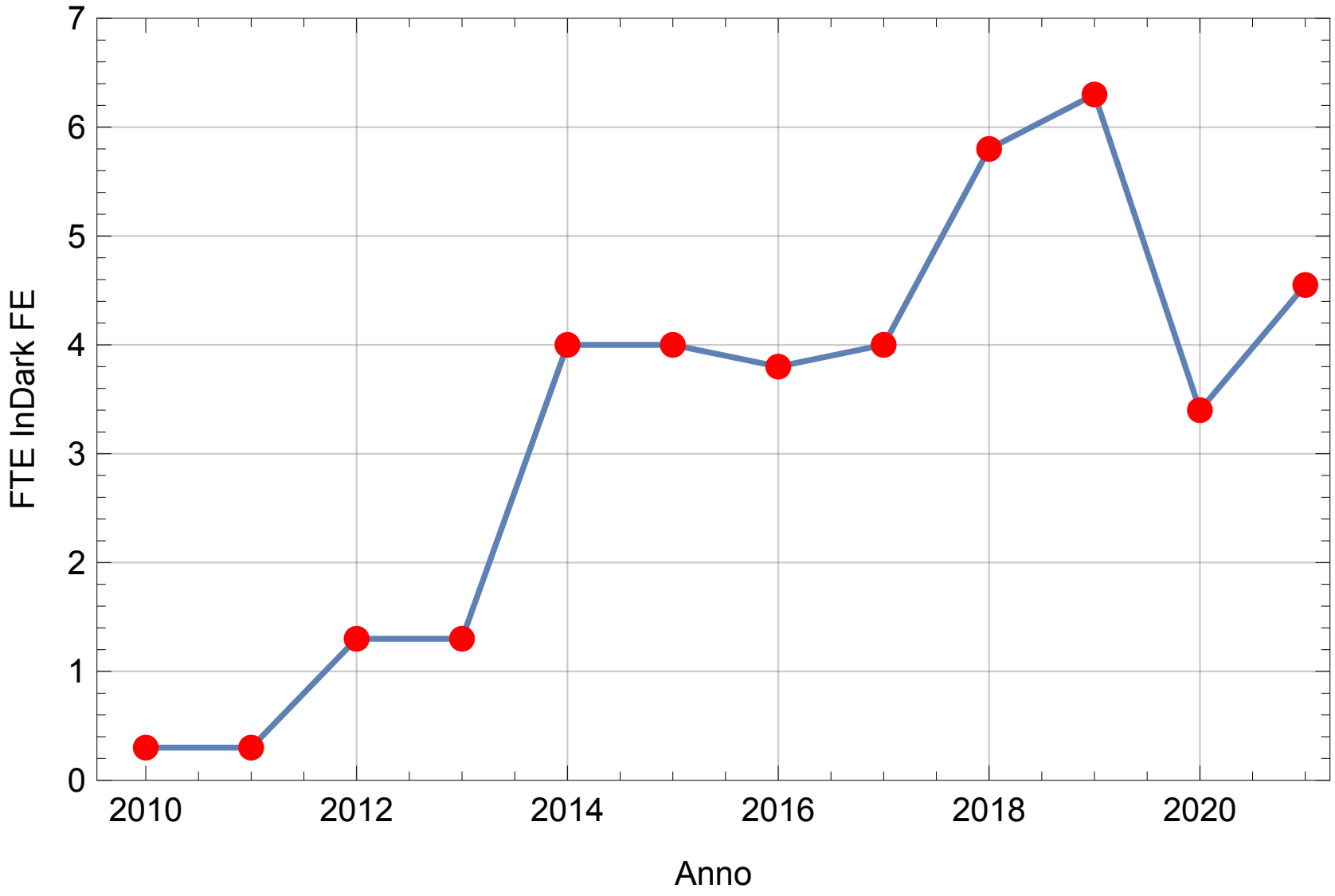
Nome	Contratto	Qualifica	Percentuale
Marco Bortolami	Associato	Dottorando UniFE	0.5
Luca Caloni	Associato	Dottorando UniFE	1
Denis Comelli	Dipendente	Pr Ric INFN	1
Martina Gerbino	Dipendente	Ricercatrice INFN	0.5
Massimiliano Lattanzi (RL,RN)	Dipendente	Ricercatore INFN	0.8
Luca Pagano	Associato	RTDB UniFE	0.25
Paolo Natoli	Associato	PA UniFE	0.5
Totale			**4,55**

InDark – Anagrafica e Richieste 2023

Nome	Contratto	Qualifica	Percentuale
Stefano Arcari	Associato	Dottorando UniFE	0.7
Nicola Barbieri	Associato	Dottorando UniFE	1
Thejs Brinckmann	Associato	Assegnista UniFE	1
Luca Caloni	Associato	Dottorando UniFE	1
Denis Comelli	Dipendente	Pr Ric INFN	1
Martina Gerbino	Dipendente	Ricercatrice INFN	0.5
Massimiliano Lattanzi (RL,RN)	Dipendente	Ricercatore INFN	0.8
Margherita Lembo	Associato	Assegnista UniFE	0.5
Paolo Natoli	Associato	PO UniFE	0.4
Totale			**6.90**

Richieste 2022: 15K per Missioni

FTE InDark-FE dal 2010



(fonte: sito preventivi INFN)