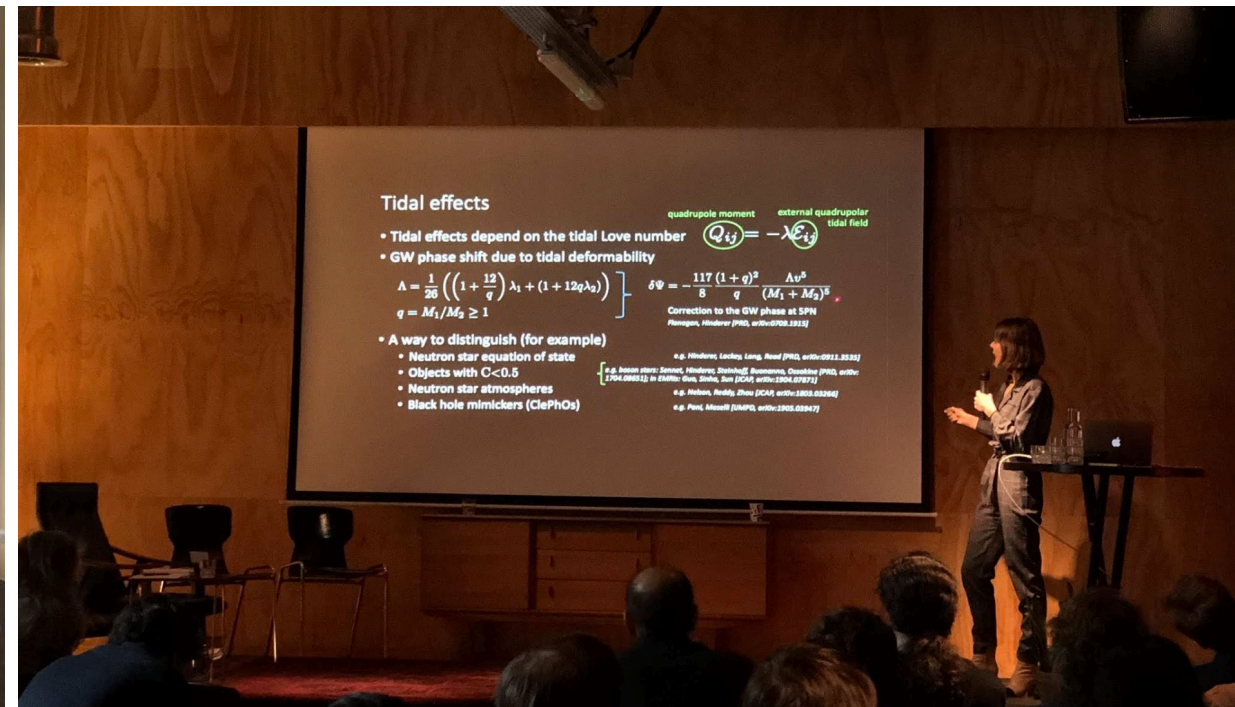




EuCAPT

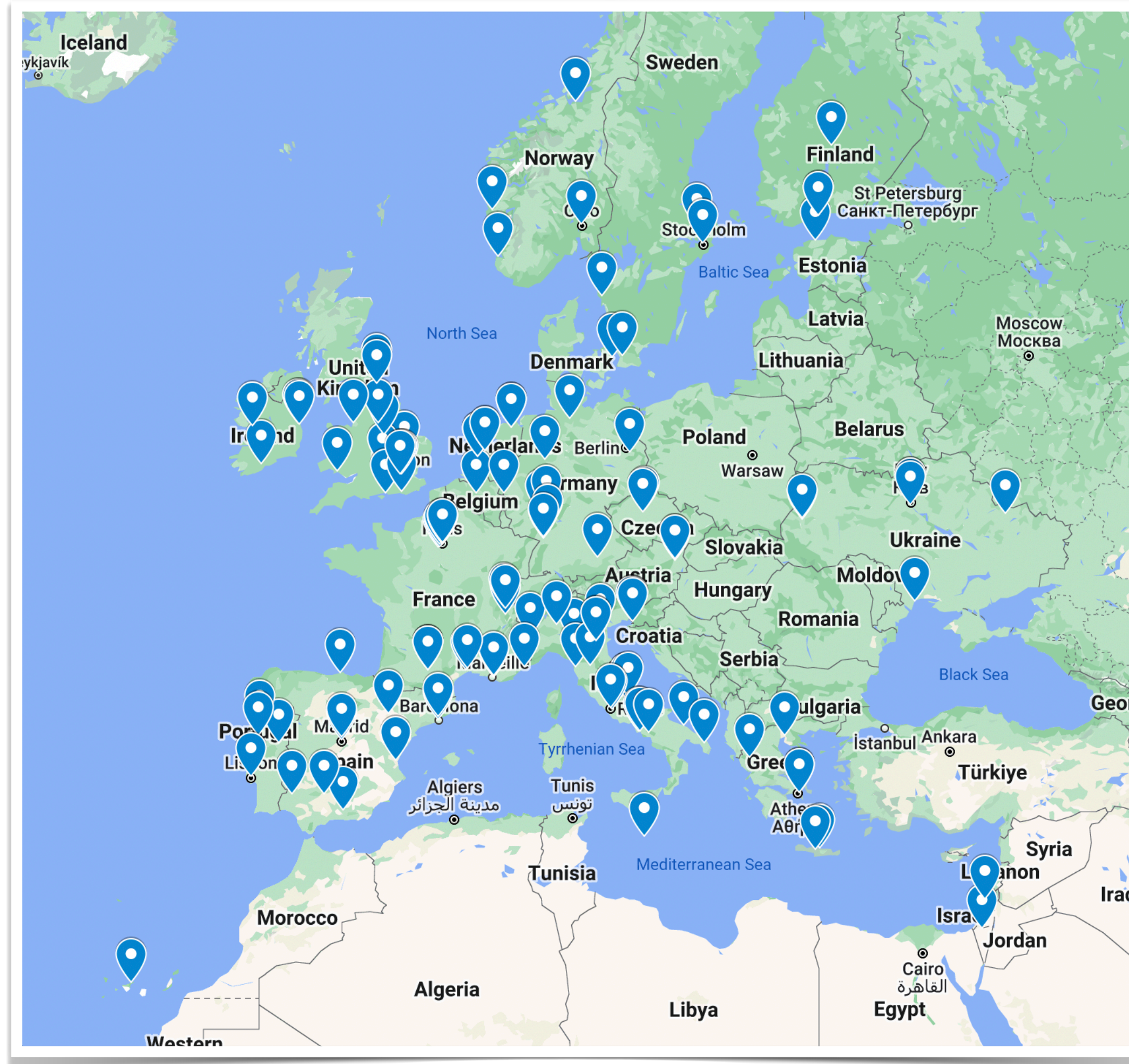
EuCAPT

European Consortium for Astroparticle Theory



Gianfranco Bertone, 7/12/2023

EuCAPT in 2023



- Launched in 2019
- Central hub at CERN
- Grown in 4 years to:
 - **133** Institutions
 - **1688** individual members
- Represented by:
 - **70** Council Members
 - **11** Steering Committee members

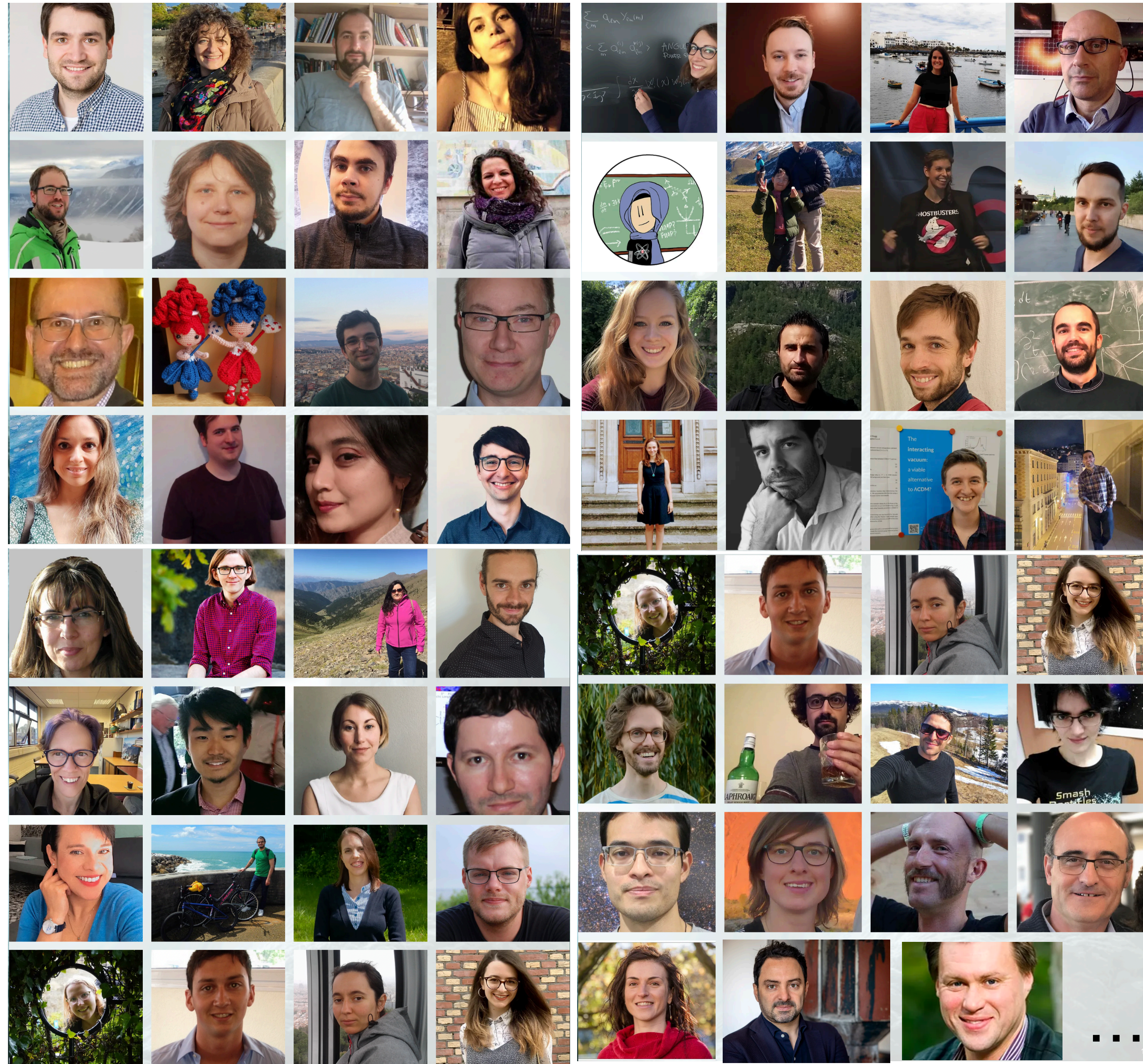


..and it keeps growing: in 2023, 7 new Institutes, 120 members

EuCAPT

No	DE	MPIK	Max Planck Institute for Nuclear Physics	Saupfercheckweg 1, 69117 Heidelberg	http://www.mpi-hd.mpg.de/	45	Manfred Lindner	lindner@mpi-hd.mpg.de	NEW
No	BG	"St. Kl. Ohridski" U. of Sofia	"St. Kl. Ohridski" University of Sofia, Faculty of Physics	5 James Bourchier Boulevard, Sofia 1164, Bulgaria (Faculty of Physics)	https://www.uni-sofia.bg/index.php/eng	7	Stoytcho Yazadjiev	yazad@phys.uni-sofia.bg	NEW
No	UK	U. of Manchester and Jodrell Bank Centre for Astrophysics and the Particle Physics Group	Department of Physics and Astronomy, University of Manchester (incl. the Jodrell Bank Centre for Astrophysics and the Particle Physics Group)	University of Manchester, Oxford Road, Manchester M13 9PL, United Kingdom	https://www.jodrellbank.manchester.ac.uk and https://www.hep.manchester.ac.uk	22	Peter Millington	peter.millington@manchester.ac.uk	NEW
Yes	CZ	Institute of Physics in Opava, Silesian University	Institute of Physics in Opava, Silesian University	Institute of Physics in Opava, Silesian University Bezručovo náměstí 1150/13, 746 01 Opava, Czech Republic	https://www.slu.cz/phys/en/				NEW
	CZ	Institute of Particle and Nuclear Physics, Faculty of Mathematics and Physics, Charles University	Institute of Particle and Nuclear Physics, Faculty of Mathematics and Physics, Charles University	Institute of Particle and Nuclear Physics, Faculty of Mathematics and Physics, Charles University V Holešovičkách 2, 180 00 Prague 8, Czech Republic	https://ipnp.cz/	21	Adam Smetana	adam.smetana@cvut.cz	NEW
	CZ	Institute of Experimental and Applied Physics, Czech Technical University in Prague	Institute of Experimental and Applied Physics, Czech Technical University in Prague	Institute of Experimental and Applied Physics, Czech Technical University in Prague Husova 240/5, 110 00 Prague 1, Czech Republic	http://www.utef.cvut.cz/				NEW
No	IL	Ariel University	Ariel University	Ariel University Physics Department, Ariel University, Ramat Hagolan Street, Ariel 40700, Israel	https://www.ariel.ac.il/wp/en/	23	Ido Ben-Dayan	idobd@ariel.ac.il	NEW
No	PT	CFisUC	Centre for Physics of the University of Coimbra (CFisUC)	Centre for Physics of the University of Coimbra (CFisUC) Department of Physics, University of Coimbra, 3004-516 Coimbra, Portugal	https://cfisuc.fis.uc.pt/research.php?oid=8103799	22	João G. Rosa	jgrosa@uc.pt	NEW

Who are we?



- 1688 individual members
- A vibrant, diverse community:
 - **Video profile series:** recorded Zoom interviews with members of the community, covering research and life in academia
 - **Blog profiles series:** short, written interviews with members of the community

EuCAPT Council








- First meeting 4 Oct 2022
- Second meeting 30 May 2023
- Third meeting 10 October 2024

António Pestana Morais
Enrico Pajer
Jackson Levi Said
Pedro G. Ferreira
Alberto Mariotti
Francesca Calore
Alejandro Ibarra
Paul Saffin
Irene Tamborra
Valerie Domcke
Volodymyr Pelykh
Silvia Pascoli
Gert Hütsi
Pedro Schwaller
Ely Kovetz
Giuseppe Fannizza
Jorge Martin Camalich
Riotto Antonio
Katy Clough
Laura Sagunski
Pierre Vanhove
José Ignacio Illana
Paolo PANCI
Foteini Oikonomou
Carmelo Evoli
Harry Desmond
David J. E. Marsh (Doddy)
Laura Bernard
David Langlois
Jose Alberto Ruiz Cembranos
Gabriela Barenboim
Riccardo Catena
Ivonne Zavala
Alessio Notari

Alvise Raccanelli
Bradley J Kavanagh
Sami Nurmi
Jessica Turner
John Antoniadis
José Manuel Carmona
Masina Isabella
Isabella Masina
Alessandra Silvestri
Marco Taoso
Federico Urban
Isabella Masina
Walter Winter
Christoph Weniger
Isabella Masina
Sébastien Renaux-Petel
Philipp Mertsch
Ricardo Z. Ferreira
Matteo R. Fasiello
Masha Chernyakova
Arttu Rajantie
Marina Migliaccio
Ilidio Lopes
Tim Linden
Paolo Pani
Fabio Iocco
Davide Gerosa
Emanuela Dimastrogiovanni
Alain Blanchard
Josef Pradler
Gabrijela Zaharijas
Željka Marija Bošnjak
Julia Becker Tjus
Stefano Liberati
Geraint Pratten

Steering Committee



 Ema Dimastrogiovanni Training	 Silvia Pascoli Outreach	 Anne Green Colloquia	 Matteo Fasiello Workshops	 Francesca Calore Governance/ Elections	 Gabriela Barenboim Funding Opportunities
 Andrew Taylor Newsletter	 David Marsh Website	 Valerie Domcke Symposium	 Jessica Turner EDI/ Community building	 Alvise Raccanelli Collaborative Projects	 Gianfranco Bertone Director

Junior Contributor:



Niko Šarčević

Former members:



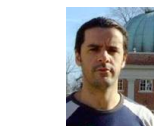
Piero Ullio



Philippe Brax



Licia Verde



Vitor Cardoso



Gian Giudice



Toni Riotto



David Langlois



Subir Sarkar

Selected highlights

- Community-wide **White Paper** “Opportunities and Challenges for Theoretical Astroparticle Physics in the Next Decade” (arXiv:2110.10074) 135 authors, 400 endorsers
- **Community building:**
 - Website
 - Monthly Newsletter
 - Mailing list (1655 colleagues)
 - Code repository HEP + Astro + Cosmo
- Funded **exchange program** in 2022 and 2023:
 - 6 small-scale collaboration meetings at CERN
 - 15 individual visits to other EuCAPT institutions
- **Events** organised:
 - 3 Annual Symposia
 - 6 Thematic Workshops
 - 15 Virtual Colloquia
 - This year: 1st EuCAPT BIP Erasmus+ School

What's next?

- How can we enable/accelerate new discoveries?
- How can we attract new resources?
- How can we best serve our growing and increasingly diverse community?
- How can we improve the public understanding of Cosmology and Astroparticle Physics?
- What are the questions that we are not even asking yet?

Funding Opportunities and Training Task Forces

Funding Opportunities

Gabriela Barenboim (chair) gabriela.barenboim@uv.es

Gabrijela Zaharijas gzaharijas@ung.si

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Ivonne Zavala e.i.zavalacarrasco@swansea.ac.uk

Davide Gerosa davide.gerosa@gmail.com

Paolo Panci paolo.panci@cern.ch

Training



Marina Migliaccio
Department of Physics
University of Roma Tor
Vergata/INFN

Harry Desmond
Institute of Cosmology and
Gravitation
University of Portsmouth



Christoph Weniger
GRAPPA
University of Amsterdam

Ema Dimastrogiovanni
Van Swinderen Institute
University of Groningen



- 1st **EuCAPT BIP Erasmus+ School:**
 - Blended Intensive Program (in person+virtual)
 - Aimed to Master and PhD Students
 - Combined scientific programme with “soft skills” training
 - Lecturers = world experts from different European institutions
 - Worth 3 ECTS credits
 - No registration fee + travel support from Erasmus

Symposium Task Force

3rd EuCAPT Symposium at CERN, May 31 to June 2, 2023



3rd EuCAPT Symposium at CERN, May 31 to June 2, 2023

Lightning Talks

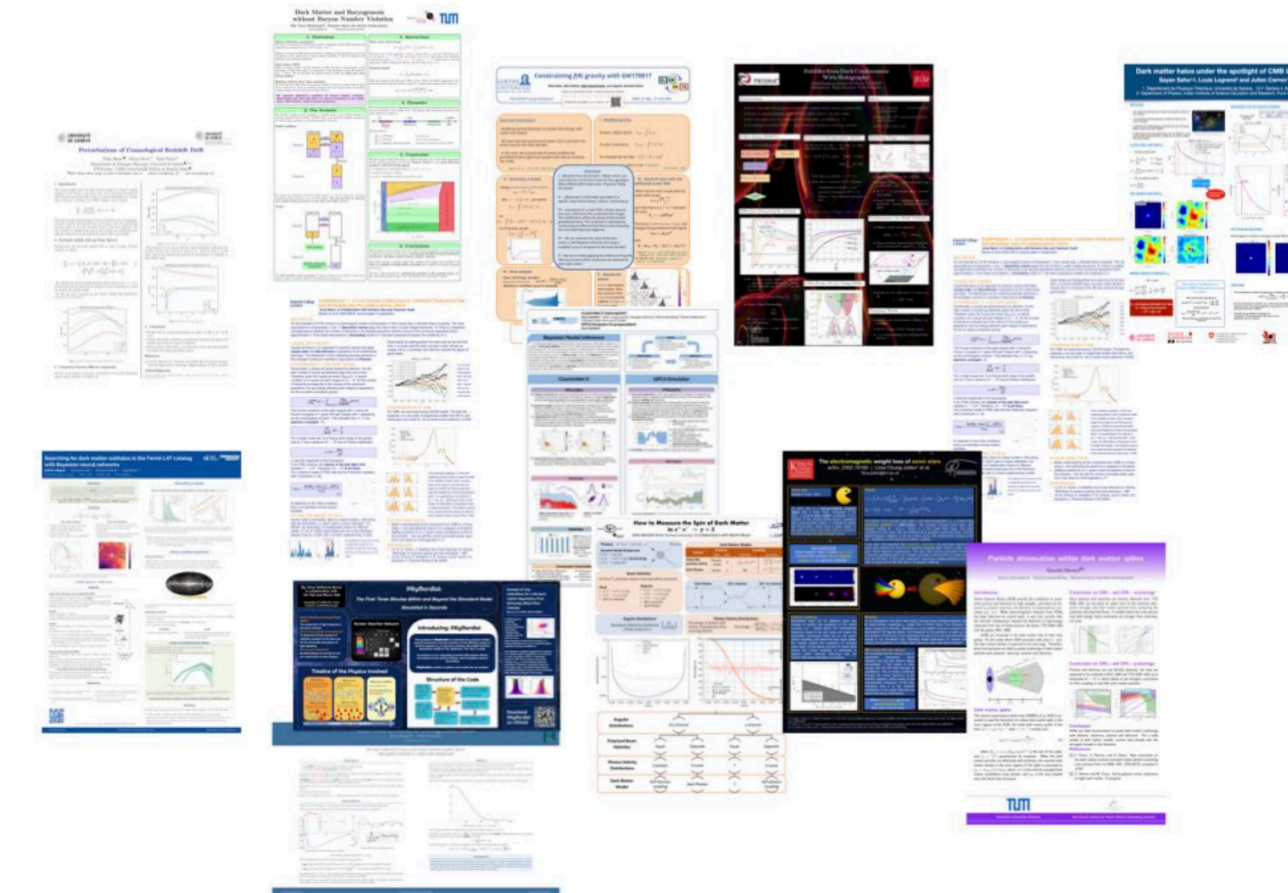
 30 Lightning Talks presented

Robust constraints on the primordial spectrum from DM mini halos and the CMB anisotropies Guillermo Franco Abellán	Impact of Neutrino Decay on the Cosmic Neutrino Background Leonardo Jose Ferreira Leite
Gravity as a Portal to Reheating, Leptogenesis and Dark Matter Basabendu Barman	A First Look at Sky Anisotropies of High-Energy Neutrino Flavours Bernarda Telalovic
The Cosmological Flow : a Systematic Approach to Primordial Correlators Denis Werth	Dark Sectors and MiniBooNE Low Energy Excess Jaime Hoelken Zink
Real scalar phase transitions: bubble nucleation, nonperturbatively Anna Kormu	Space Plasma Instabilities Resolve GeV-TeV Tension and Constrain Light Axions Oindrila Ghosh
Dissipative effects during inflation Alejandro Perez Rodriguez	The origin of ANITA-IV events from the synergies with IceCube Antoni Bertólez-Martínez
Reheating dynamics of dark sectors Helena Kolesova	CR antineutrino predictions and their detectability in the next years Pedro De la Torre Luque
Gamma-ray flux limits from nearby brown dwarfs: implications for dark matter annihilating into long-lived mediators. Pooja BHATTACHARJEE	Probing Axions through Tomography of Anisotropic Cosmic Birefringence Alessandro Greco
Neural simulation-based inference of dark matter substructure in JVAS B1938+666 strong gravitational lensing system Noemi Anzu Montiel	Extracting Cluster Information from small-scale CMB Sayan Saha
Dark Matter Pollution in the Diffuse Supernova Neutrino Background Sandra Robles	Modelling of Astrophysical Systematics for Cosmology with LSST Ms Nikolina Šarčević
Cosmic Web Studies in Fuzzy Dark Matter Cosmologies Tabor Dome	Reliable and resource preserving emulation for Bayesian model inference Sven Günther
A Bayesian Estimation of the Milky Way's Circular Velocity Curve using Gaia DR3 Sven Pödder	Antisymmetric galaxy cross-correlations Eleonora Vanzan
Smoking-Gun Signatures for Indirect Detection from Bound State Formation of Electroweak Multiplets Giovanni Armando	The Dipole of the Pantheon+SH0ES Data Francesco Sorrenti
Testing Grand Unified Theories with gravitational waves and proton decay LUCA MARSILI	
A new universal property of cosmological gravitational wave anisotropies Ameek Malhotra	
Searching for Primordial Black Holes with the Einstein Telescope Mr Francesco Iacovelli	
The impact of gravitational wave memory in constraining binary black holes parameters Silvia Gasparotto	
ECQHOs in the dark: Gravitational Wave backgrounds from colliding ECOs at atom interferometers Hannah Banks	
Cosmological history of the HEFT MIA,ROBIN,BYRON WEST	



Posters

 45 posters presented, online + in person



(a subset taken from mattermost)



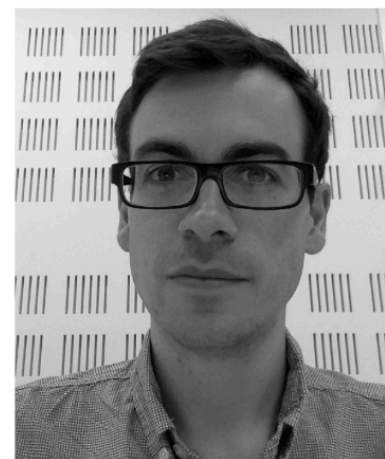
<https://indico.cern.ch/event/1218730/>

Website Task Force



Katy Clough //
QMUL
k.clough@qmul.ac.uk

David Marsh //
Stockholm University
david.marsh@fysik.su.se



Bradley Kavanagh //
IFCA
kavanagh@ifca.unican.es

Niko Šarčević //
Newcastle University
n.sarcevic2@newcastle.ac.uk



In progress or done:

- General info
- Joining EuCAPT
- Resources
- Events/News
- Blog
- Video profiles
- Events

Plans:

- Evolve with the organization
- Synchronize with other task forces
- Increase social media presence
- Community insight and suggestions

Outreach Task Force

Silvia Pascoli, University of Bologna, INFN

Jorge Martin Camalich, IAC,
University of La Laguna

Jose Ignacio Illana Calero, U. of Granada

Pierre Vanhove, IPT CEA-Saclay

Isabella Masina, U. of Ferrara, INFN

Alessio Notari, U. of Barcelona

Jose Manuel Carmona, U. of Zaragoza



- **Phase I: collect information about what the community does and needs emerge.**
 - We will send out a survey to capture a picture of the activities carried out by the community, especially to highlight innovative initiatives.
- **Phase II: proactively initiate new outreach activities of broad scope in theoretical astroparticle physics**
 - (e.g. Twitter further developing current activity, Instagram, youtube channel for talks, prizes for outreach)..

Cosmos Prize

- **2 prizes** for best pop science book awarded every year: 1 from scientists, 1 from high school students
- **Very successful** in Italy
 - Top scientists & communicators involved (Jim Al Khalili, Brian Greene, Sean Carroll, David Spiegelhalter)
 - Thousands of students involved
- Open to all, focus on youth from **disadvantaged backgrounds**
- In **collaboration** with Education Ministry, Publishers, Schools, National agencies

Already established in Italy and NL, ongoing discussions with colleagues in France, UK, Sweden, Spain...

EuCAPT White Paper



arXiv:2110.10074v1 [astro-ph.HE] 19 Oct 2021

EuCAPT White Paper

Opportunities and Challenges for Theoretical Astroparticle Physics in the Next Decade



Abstract

Astroparticle physics is undergoing a profound transformation, due to a series of extraordinary new results, such as the discovery of high-energy cosmic neutrinos with IceCube, the direct detection of gravitational waves with LIGO and Virgo, and many others. This white paper is the result of a collaborative effort that involved hundreds of theoretical astroparticle physicists and cosmologists, under the coordination of the European Consortium for Astroparticle Theory (EuCAPT). Addressed to the whole astroparticle physics community, it explores upcoming theoretical opportunities and challenges for our field of research, with particular emphasis on the possible synergies among different subfields, and the prospects for solving the most fundamental open questions with multi-messenger observations.

<https://arxiv.org/abs/2110.10074>

- **Early universe:** Daniel Baumann and Laura Covi;
- **Dynamical spacetimes:** Rafael Porto and Philipp Moesta;
- **Nuclear Astrophysics:** Tetyana Galatyuk and Tanja Hinderer;
- **Cosmic accelerators:** Sera Markoff, James Matthews, and Enrico Ramirez Ruiz;
- **Traveling Messengers:** Daniele Gaggero and Kumiko Kotera;
- **Neutrino Properties:** Thomas Schwetz and Olga Mena;
- **Particles from stars:** Aldo Serenelli and Irene Tamborra;
- **Dark Matter:** Francesca Calore, David J. E. Marsh, and Christian Byrnes;
- **Dark Energy:** Alessandra Silvestri, and Julien Lesgourgues;
- **Astrostatistics:** Christoph Weniger and Roberto Trotta.

- 135 authors
- 400 endorsers
- 133 pages
- 1382 references

- I cannot possibly make justice in 20 mins
- high-level summary of key challenges/opportunities

Early Universe

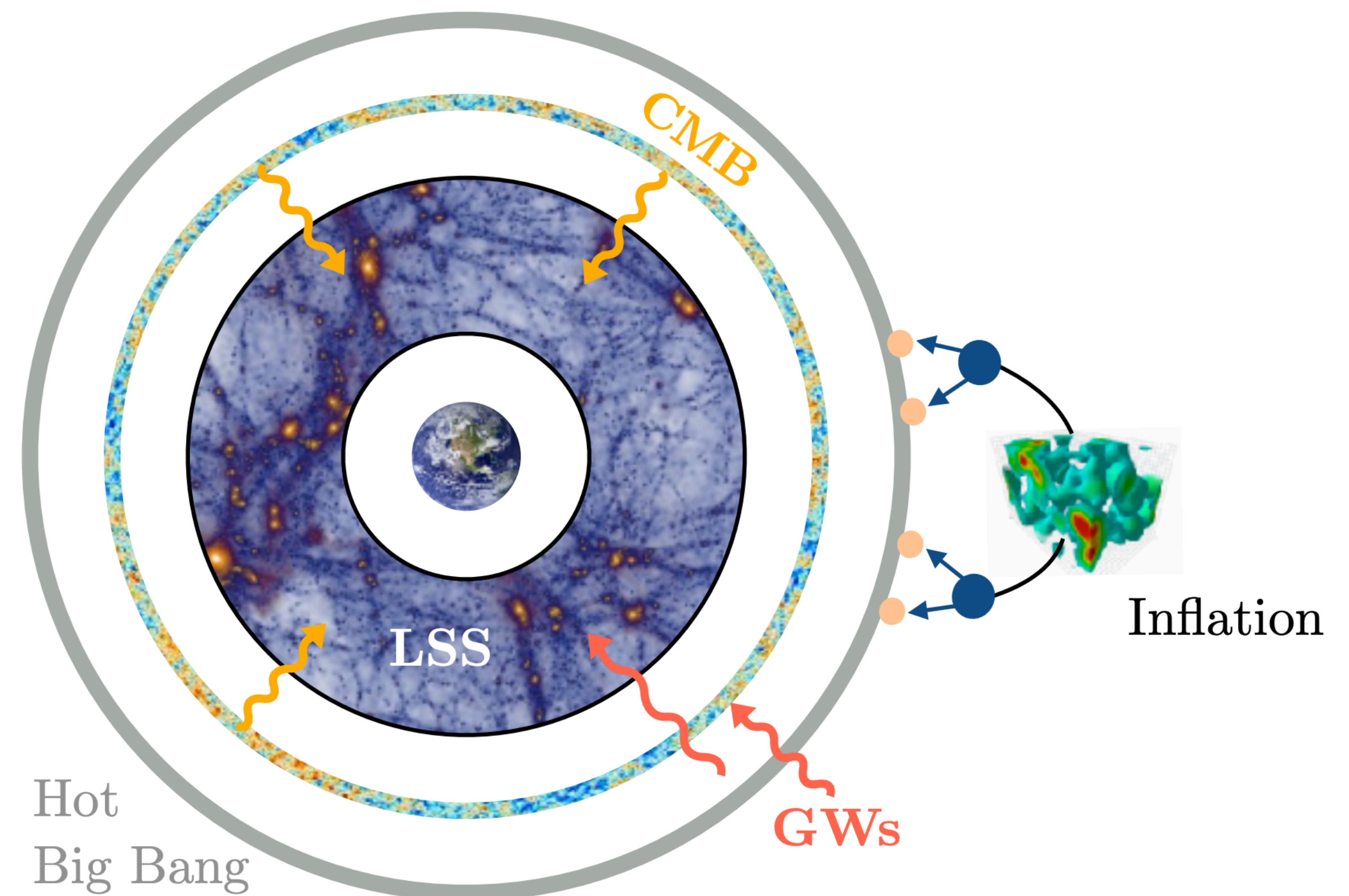
Λ CDM model phenomenologically very successful, but raises many important questions, in particular about the physics of the early universe

- **Key questions:**

- What happened in the 1st second?
- What matter / what physical processes?
- What created the initial fluctuations?
- What created the baryon asymmetry?

- **Key challenges:**

- systematic classification of inflationary predictions
- calculations of non-Gaussian correlations
- calculations of other probes of the early universe, including reheating, thermal relics, baryogenesis and phase transitions



Data: Photons (MWL), Neutrinos, GWs

Dynamical Spacetimes

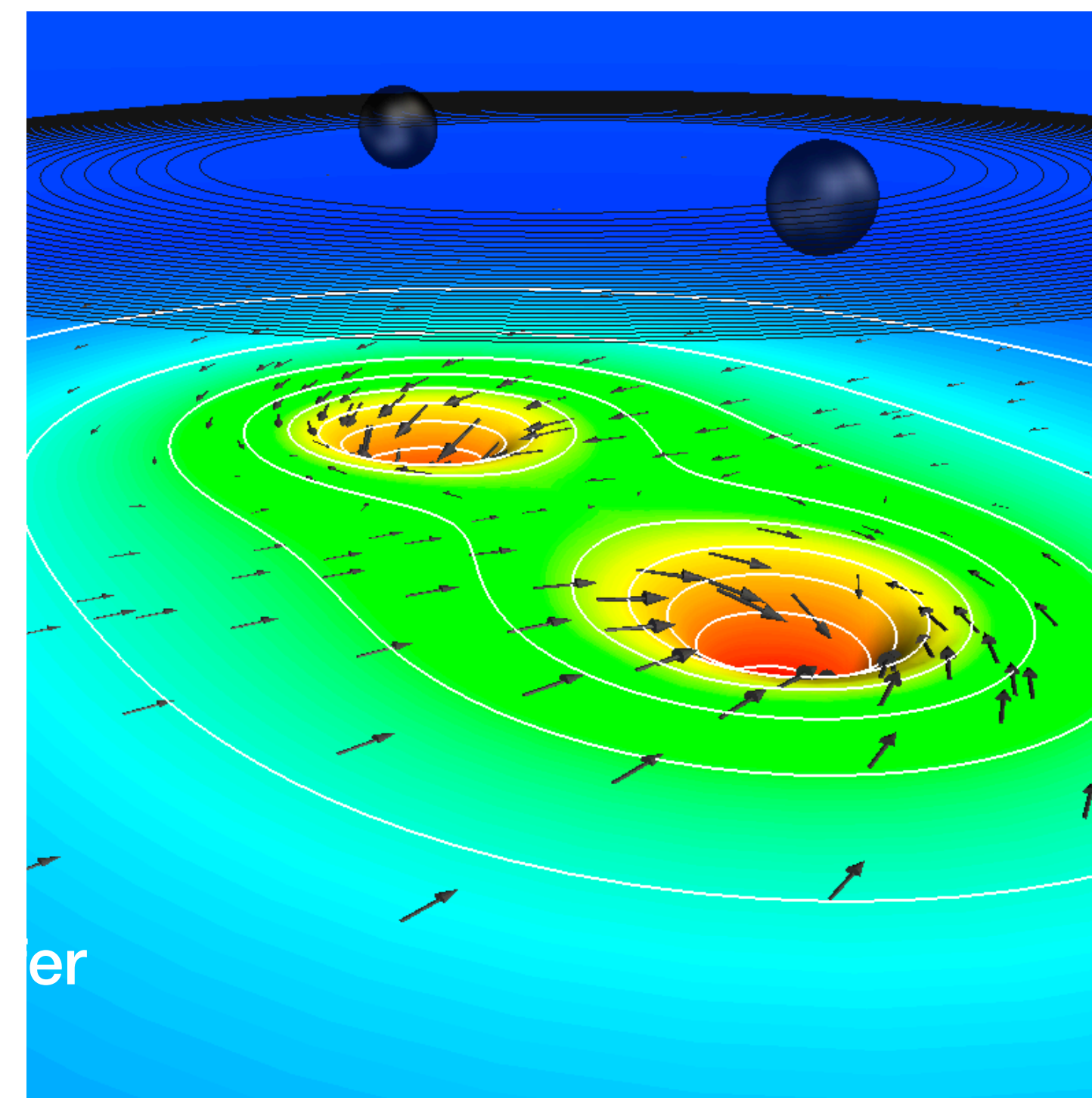
Future interferometers promise to solve long-standing problems in cosmology, astrophysics, and particle physics. High-precision theoretical predictions are crucial to enable new discoveries

- **Key questions:**

- What is the nature of compact objects in binary systems?
- Can we discover new physics in BH environments?
- Does GR hold in the strong field regime?

- **Key challenges:**

- reaching accuracy needed to properly interpret GW signals in future detectors
- NR simulations computationally expensive/ significantly slower than perturbative approaches
- implementing neutrino transport, B fields in full relativistic MHD simulations, to connect with multimessenger observations



Data: Photons (MWL), Neutrinos, GWs

Nuclear Astrophysics

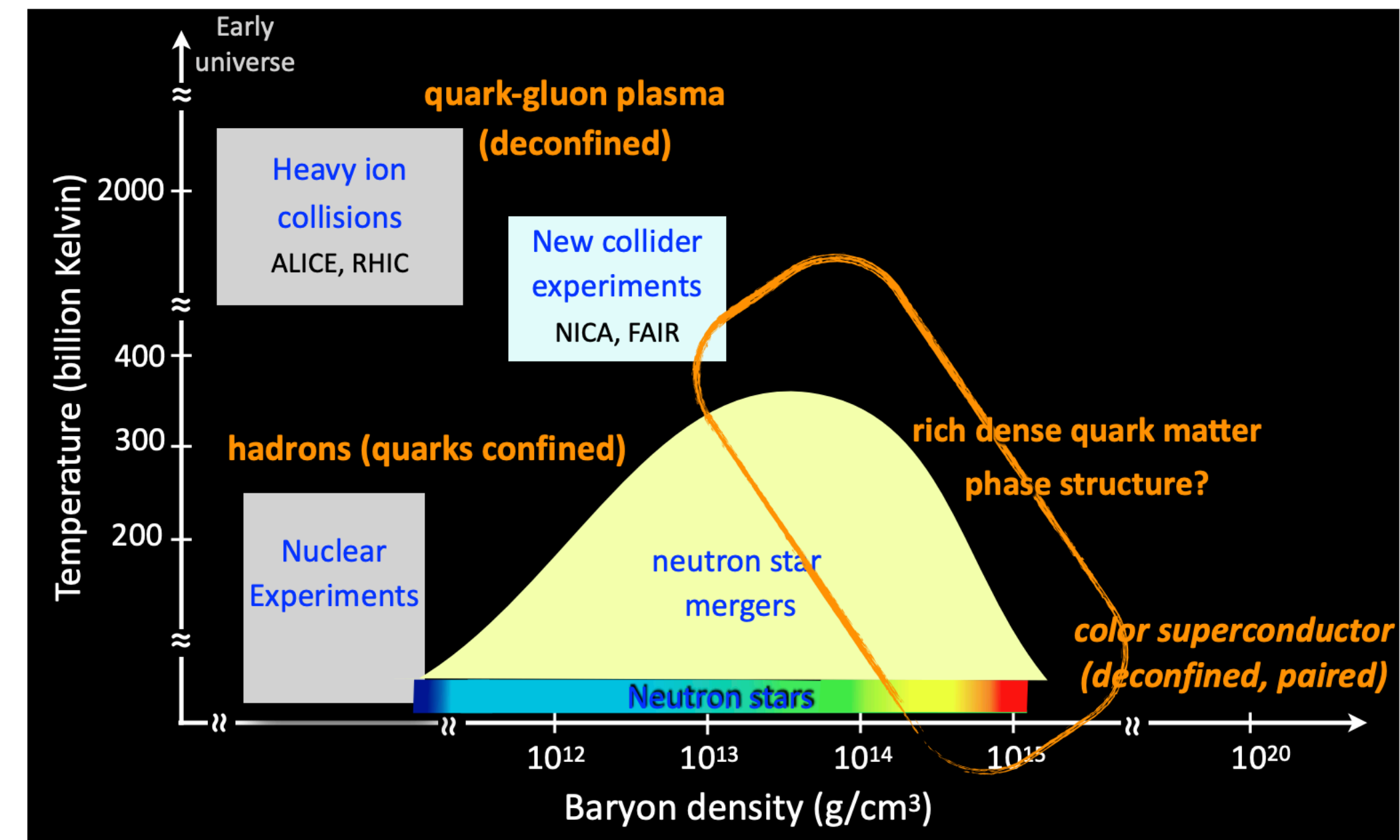
Nuclear astrophysics aims to understand the role of nuclear processes in astrophysical environments, and to probe nuclear astrophysics beyond the reach of terrestrial labs

- **Key questions:**

- How does nuclear structure emerge from fundamental constituents?
- What are the properties of nuclear matter in astrophysical environments?
- What can we learn about QCD?
- How are heavy elements formed?

- **Key challenges:**

- Complexity/multi-scale/nonlinear dependence of observables
- reduce uncertainties on properties of nuclides in unexplored regimes
- dependence of lightcurves on physical processes and progenitor parameters



Data: Photons (MWL), Neutrinos, GWs

Cosmic Accelerators

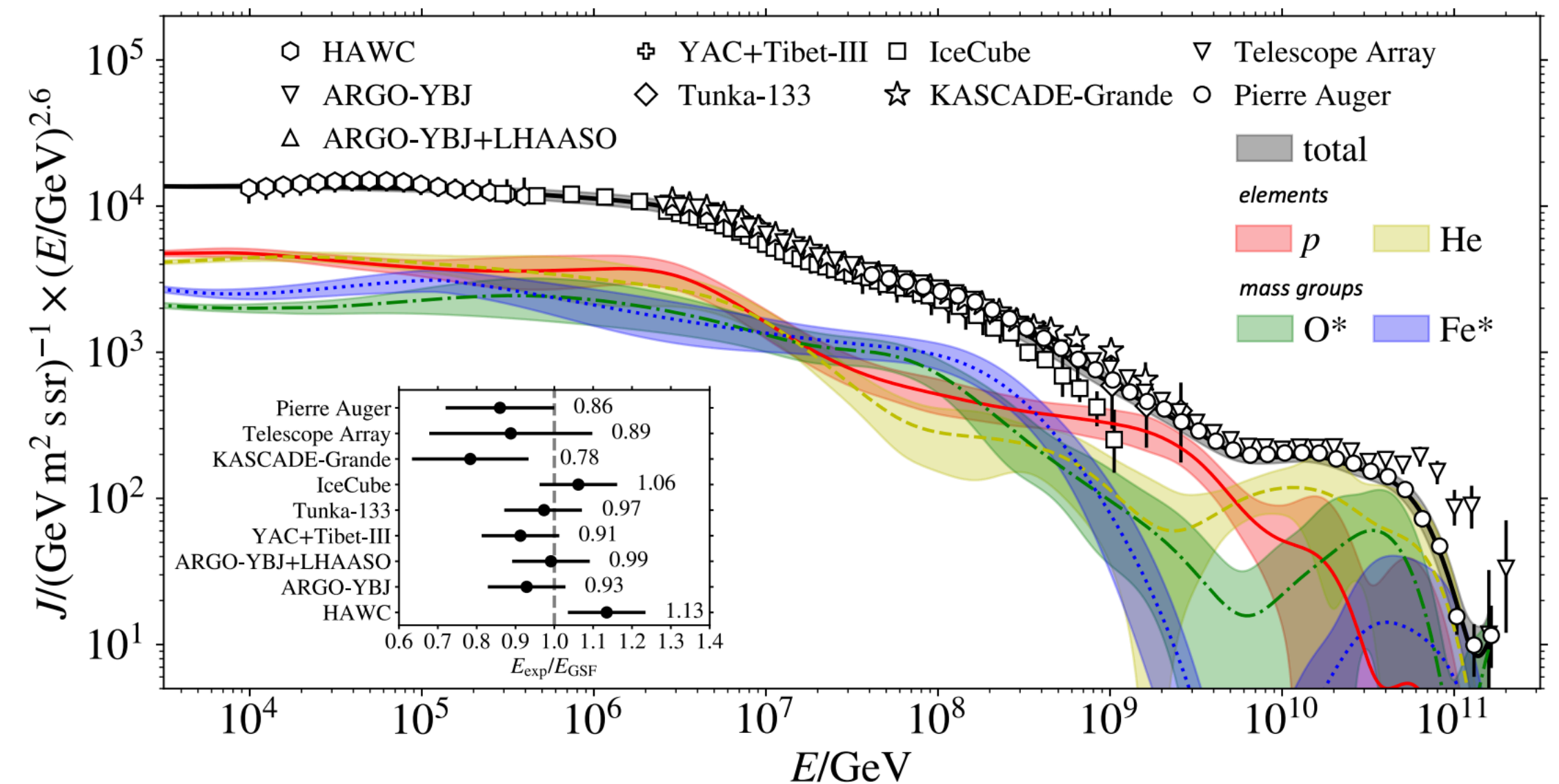
Unambiguously identifying cosmic accelerators remains the perennial challenge, as well as understanding particle acceleration, and sources accounting for total diffuse fluxes in all species

• Key questions:

- What are PeVatrons?
- Where and how CRs get accelerated to UHE?
- How do BHs launch jets?
- What are the sources of diffuse fluxes?

• Key challenges/opportunities:

- predictions of MM and multi-wavelength (MWL) spectra require complex plasma physics
- multi-scale simulations computationally prohibitive
- community building is key, facilitating collaboration between scientists and institutions with different specialisations and crosspollination of ideas and methods



Data: Photons (MWL), CRs, Neutrinos, GWs

Traveling and Interacting Messengers

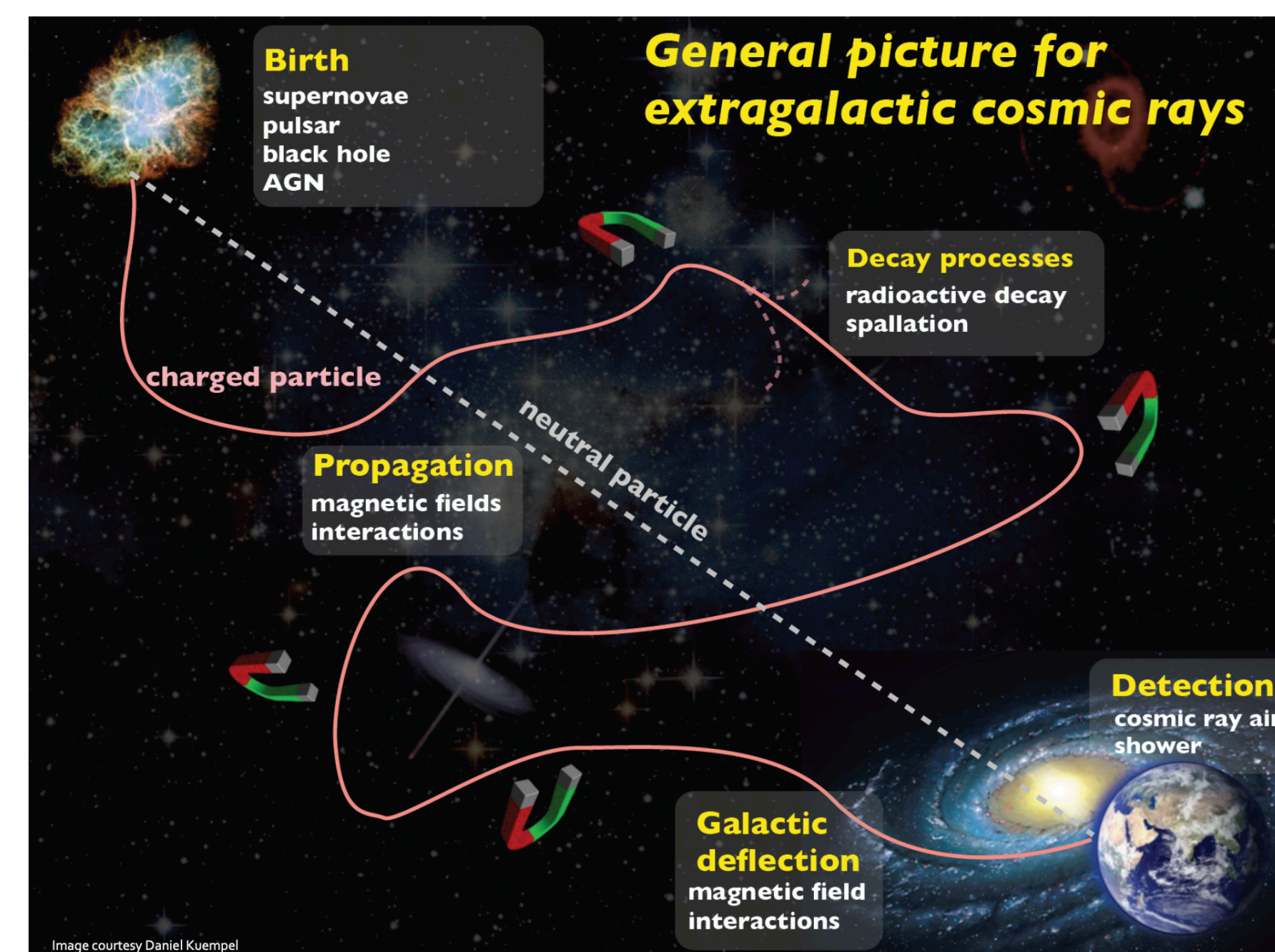
CRs travel from acceleration sites to us, interacting with the traversed media at various scales via micro-physics processes. These interactions leave imprints on astrophysical environments, and multi-messenger hints on their sources

• Key questions:

- How do energetic charged particles interact with/ feedback onto with EM fields?
- What are the plasma processes regulating propagation through turbulent media?
- What is the impact of cosmic rays on their environment?

• Key challenges:

- Can we derive describe diffusion from first-principles?
- Photodisintegration cross sections of nuclei poorly known
- Capturing energy cascades/MM aspects in numerical simulations



Data: Photons (MWL), Neutrinos, CRs

Neutrino Properties

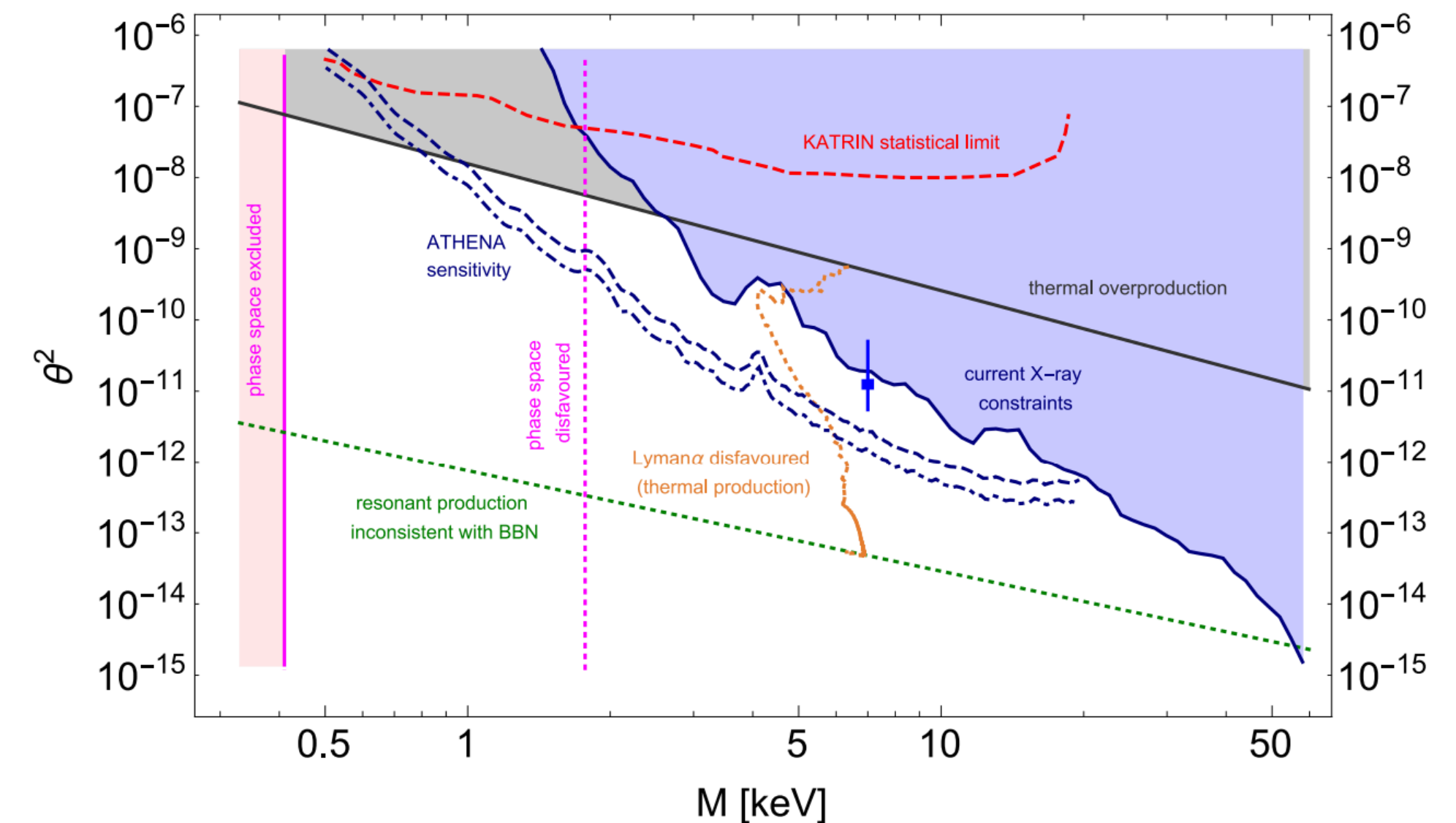
Cosmological surveys and other (astro)particle experiments aim to precisely measure the neutrino mass scale/ connect CP and L violation with the origin of matter / discover new physics

- **Key questions:**

- Dirac or Majorana?
- Are there sterile neutrinos?
- Connections with dark matter? Dark energy? Leptogenesis?
- Can we use HE astro neutrinos to test neutrino properties?

- **Key challenges/opportunities:**

- Particle physicists are skeptical about cosmological neutrino mass determinations..
- Can non-standard neutrino properties explain the H_0/σ_8 tensions?



Data: Photons (MWL), Neutrinos, GWs

Particles from stars

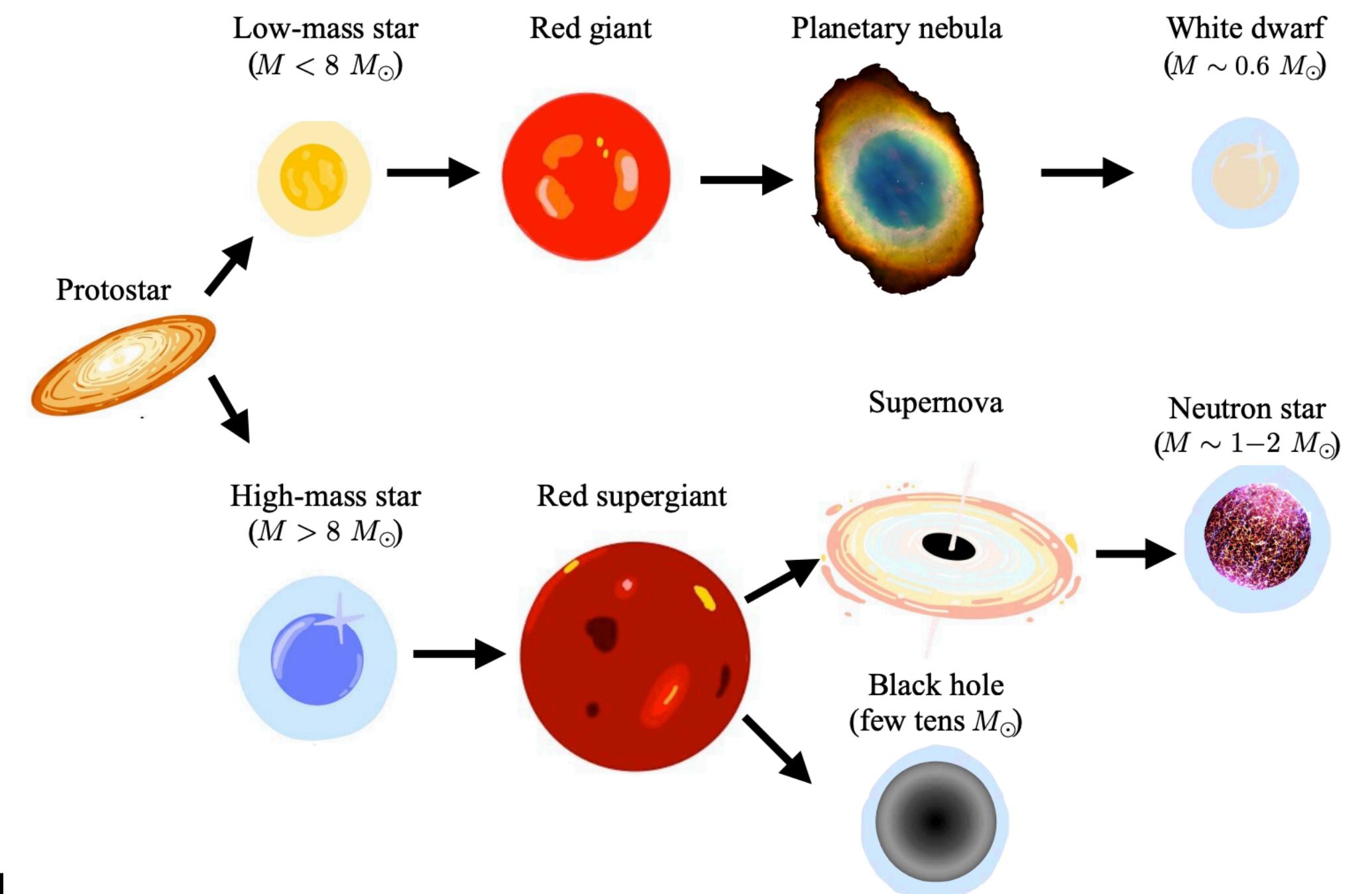
The sheer size of stars and the extreme conditions in stellar interiors make them excellent laboratories for particle physics, complementary in many cases to dedicated Earth-based experiments.

- **Key questions:**

- What can be learned about new particles from stellar structure and evolution?
- Can we probe dark matter with stellar physics?
- Can we detect axions from the Sun?

- **Key challenges:**

- Improved stellar evolution models throughout evolutionary phases and stellar masses are needed
- ‘Holistic’ methods to capitalize on the upcoming wealth of multi-messenger data should be developed
- including (neutrino/radiation/magneto) hydrodynamic + modeling of exotic physics needed to interpret data



Data: Photons (MWL), Neutrinos, CRs

Dark matter

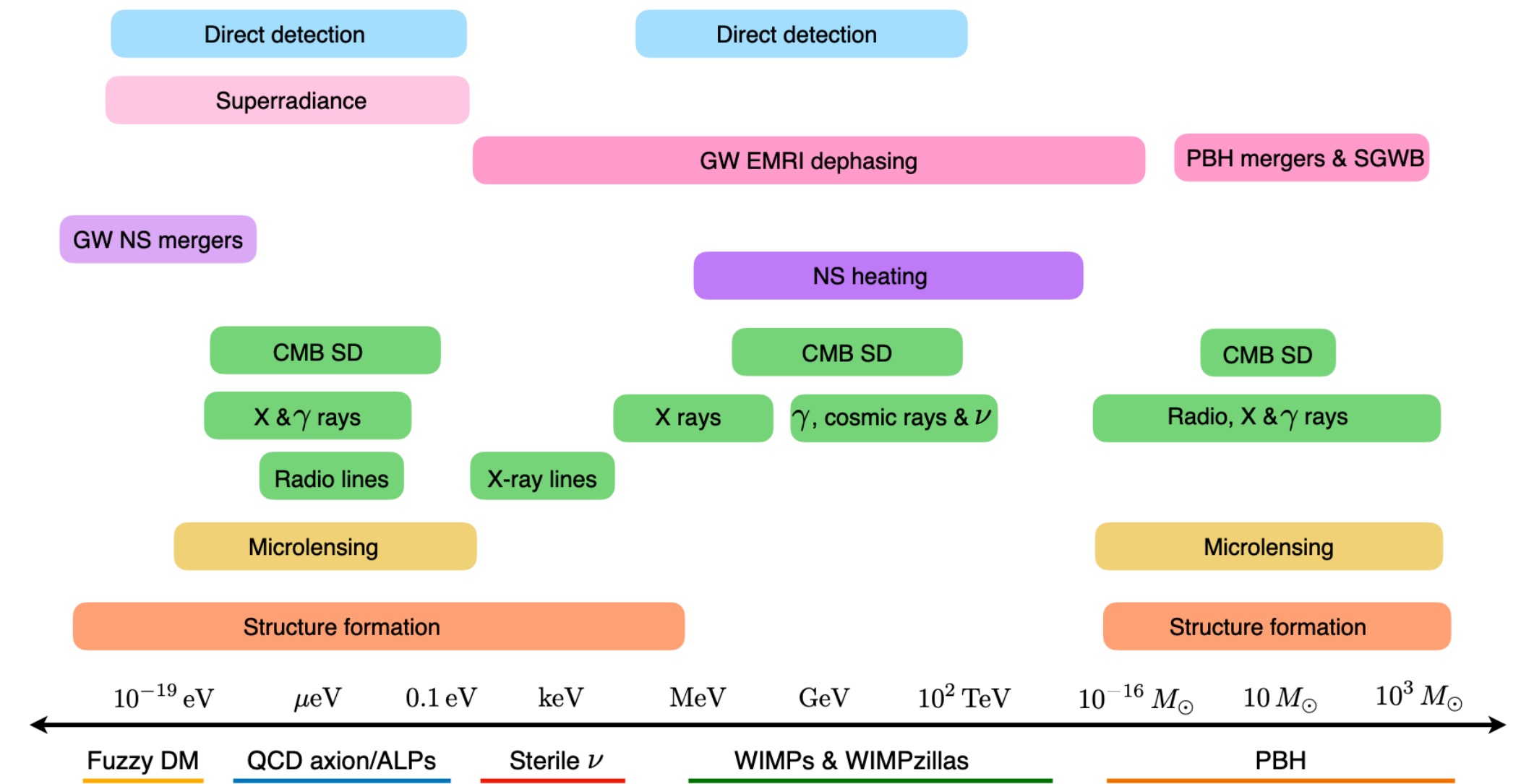
The physical nature of dark matter remains a mystery. Crucial to extend current searches to wide range of DM models, as well as to map out combinations of strategies yielding best chance of identifying DM.

• Key questions:

- Is there astrophysical evidence to go beyond the cold and collisionless hypothesis?
- If DM is multi-component, how would we know?
- How is DM produced in the Early Universe/ connected to late Universe observables?

• Key challenges:

- Can we find smoking-gun evidence from MM data?
- Can we break degeneracies with baryons?
- Vast DM theory parameter space. How to probe it?
- What can we learn from GWs?



Data: Photons (MWL), Neutrinos, CRs, GWs

Dark energy

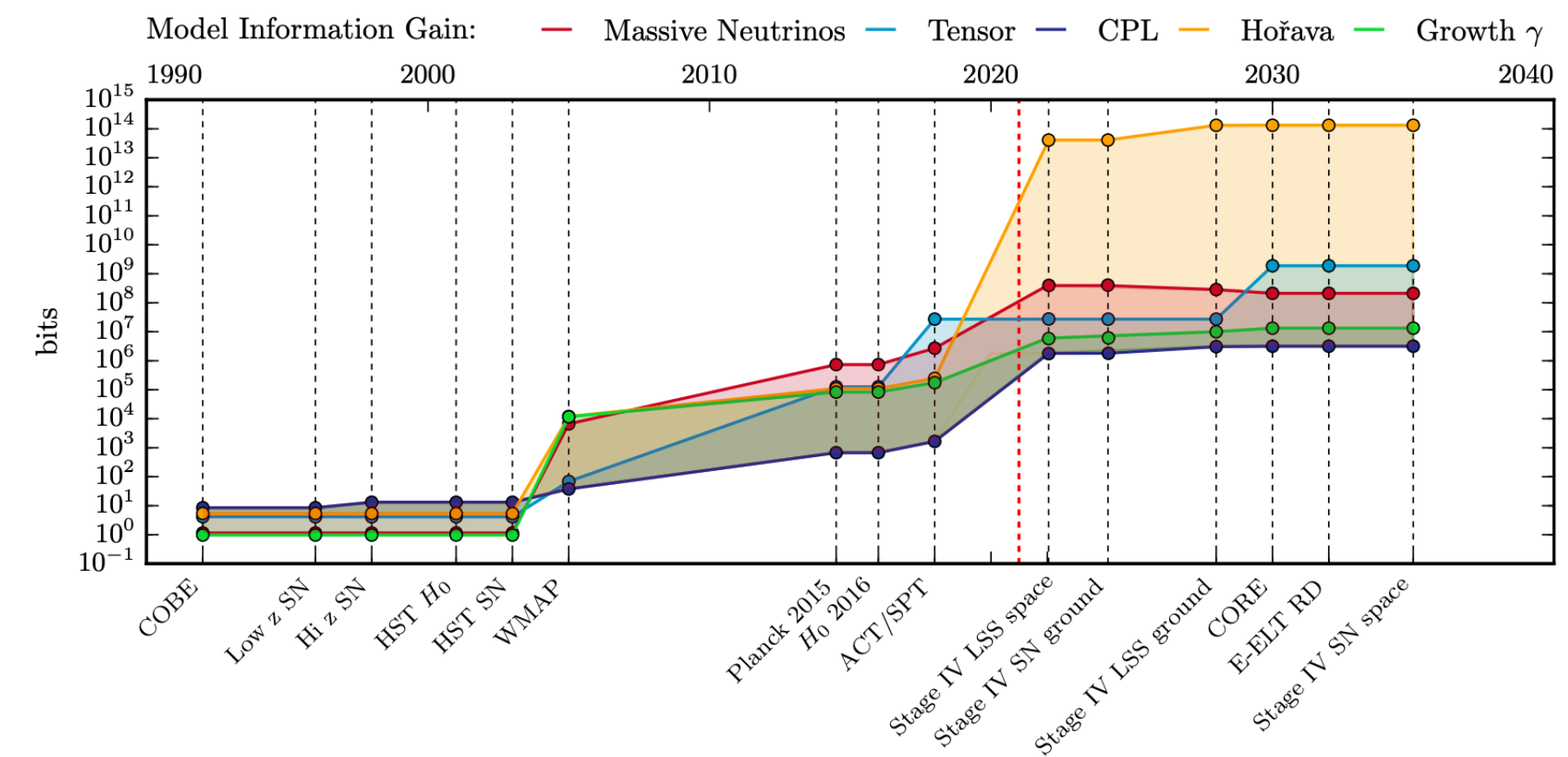
Past decade: constrained parameters of the standard cosmological model, and unveiled some tensions. Next decade: discerning among various extensions of standard cosmology

- **Key questions:**

- Do we need to go beyond GR on large scales?
- Are there screening mechanisms protecting modified gravity theories from small-scale constraints
- What should we try to constrain with observations?

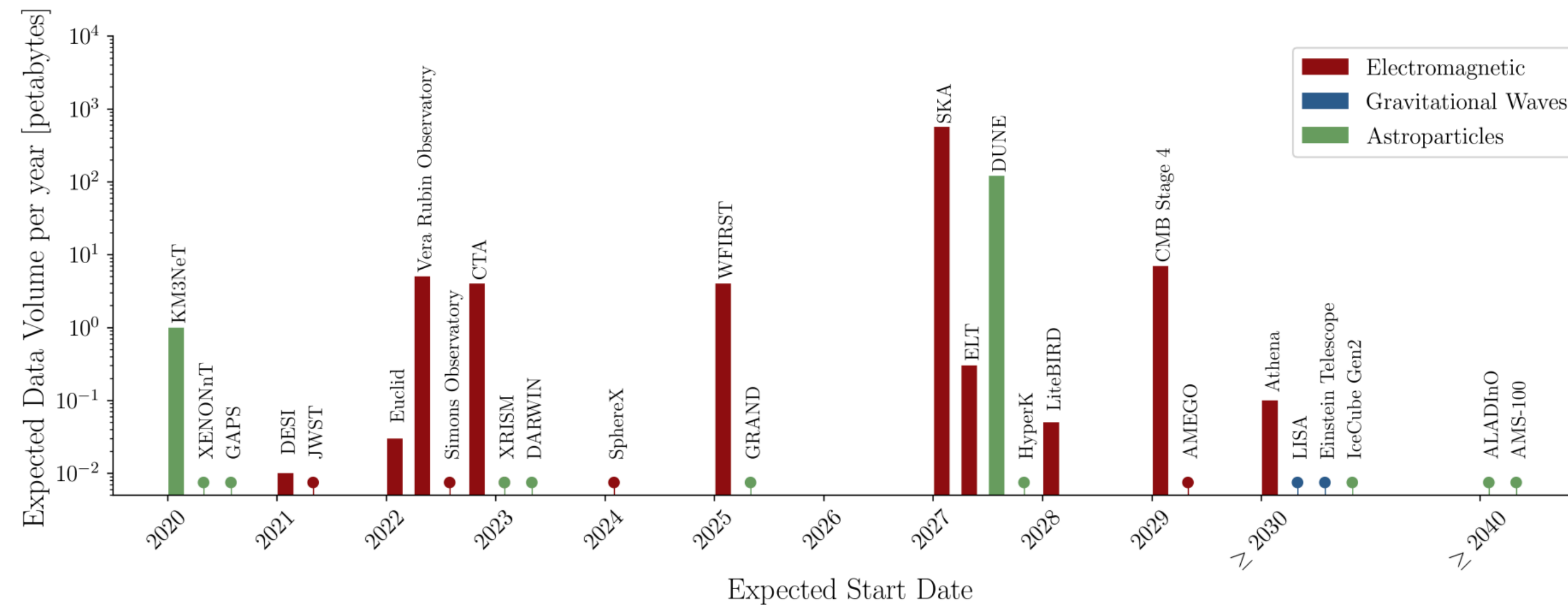
- **Key challenges:**

- What if Λ CDM remains consistent with all data?
- Is a parametrised approach sufficient to detect/characterise cracks in Λ CDM?
- Running/post-processing N-body simulations for a large number of modified gravity scenarios



Data: Photons (MWL), Neutrinos, CRs, GWs

Astroparticle physics data rapidly increasing in volume and precision. Scientific return of upcoming observations is expected to be limited by efficiency and sophistication of statistical inference tools



• Recommendations for theorists:

- Shift towards simulation-based inference + computational and educational infrastructure
- Modern ML methods (e.g. variational inference) require differentiable physical simulators
- Share simulation results in a way that allows simulation reuse

• Recommendations for observers:

- release instrumental forward simulations together with data
- provide detailed information about systematic uncertainties and all relevant correlations
- jointly organise data and simulation challenges

Recommendations

- We hope white paper will increase the awareness of theoretical challenges and opportunities, and help prepare for **interpretation** of upcoming data/**inform design** of future experimental probes
- Addressing fundamental questions will require **collaboration** of theorists with different backgrounds and skills, as well as with experimentalists, observers, data scientists, and computer scientists.
- Recommendations:
 - Support positions **beyond** geographic, thematic, or experimental **boundaries**
 - Provide adequate **computational resources** in Europe, avoid relying solely on infrastructure overseas
 - Build extensive **open-access repositories** for software, and services to enable open science
 - Explore **potential synergies** in technology, physics, organization and/or applications (e.g. JENAS, ESCAPE)
 - Support education and training in **machine learning** methods and astrostatistics
 - Ensure **diversity** in all initiatives + equal opportunities and access to scientific resources and funding

The next director

- After an election procedure that involved the community through:
 - Institutional representatives in the Council (expressed their preferences for candidates)
 - A selection committee = EuCAPT Steering Committee + APPEC GA representatives (A. Haungs)
- EuCAPT elected as its new director:

The next director

- After an election procedure that involved the community through:
 - Institutional representatives in the Council (expressed their preferences for candidates)
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- EuCAPT elected as its new director:



Prof. Silvia Pascoli
University of Bologna

Stay tuned and..

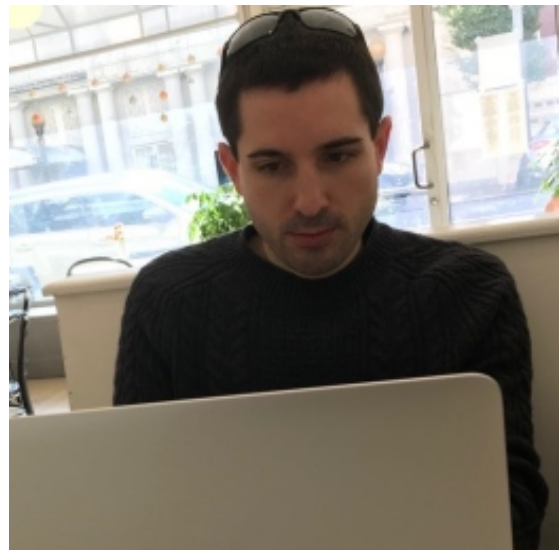
Thank You APPEC!

Back up slides

Community Building Task Force



- Jessica Turner (University of Durham) :
jessica.turner@durham.ac.uk



- Tim Linden (Stockholm University):
linden@fysik.su.se



- Laura Bernard (Paris Observatory) :
laura.bernard@obspm.fr



- Irene Tamborra (Niels Bohr Institute)
: tamborra@nbi.ku.dk

- **In progress or done :**
 - update the **EuCAPT Code of Conduct** (<https://www.eucapt.org/coc>)
 - suggest speakers on **EDI** for the EuCAPT colloquium, workshops and schools
- **Planned :**
 - analyse the census data about the diversity of the EuCAPT community
 - act as ombudsperson for EuCAPT - contact (to be set up)

Governance Task Force

- **Francesca Calore,**
 - Laboratoire d'Annecy de Physique Théorique (FR)
 - calore@lapth.cnrs.fr
- **Ricardo Z. Ferreira,**
 - Institut de Física d'Altes Energies (ES)
 - rzambujal@ifae.es
- **David Langlois**
 - Laboratoire Astroparticules & Cosmologie (FR)
 - langlois@APC.UNIV-PARIS7.FR
- **Arttu K. Rajantie**
 - Imperial College London (UK)
 - a.rajantie@imperial.ac.uk

Top priorities:

- Prepare elections for new EuCAPT director [Done]
- Prepare next Council Chair election [Done]
- Maintain official EuCAPT governance document updated [In progress]
- Revise membership and representation rules [In progress]
- Invite missing institutions to join + reopen membership applications [In progress]