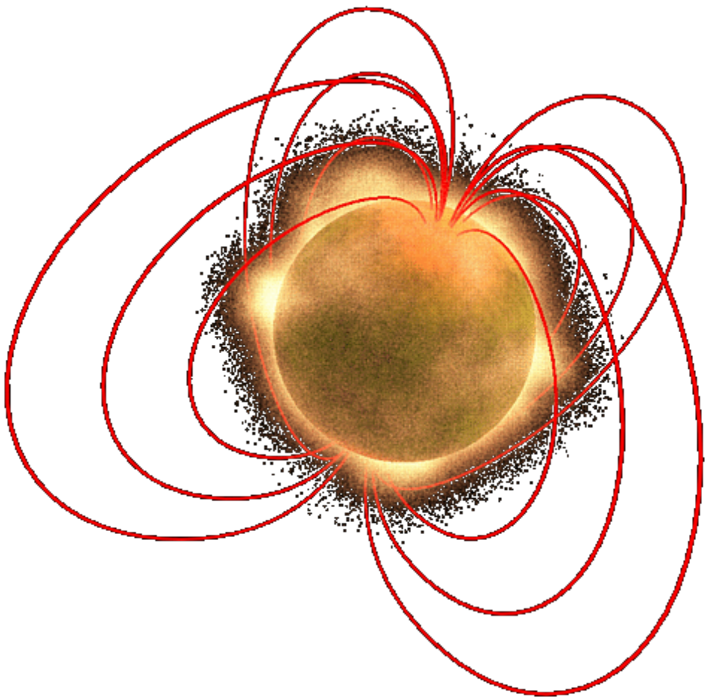
The multi-messenger PHysics and Astrophysics of NeutROn Stars

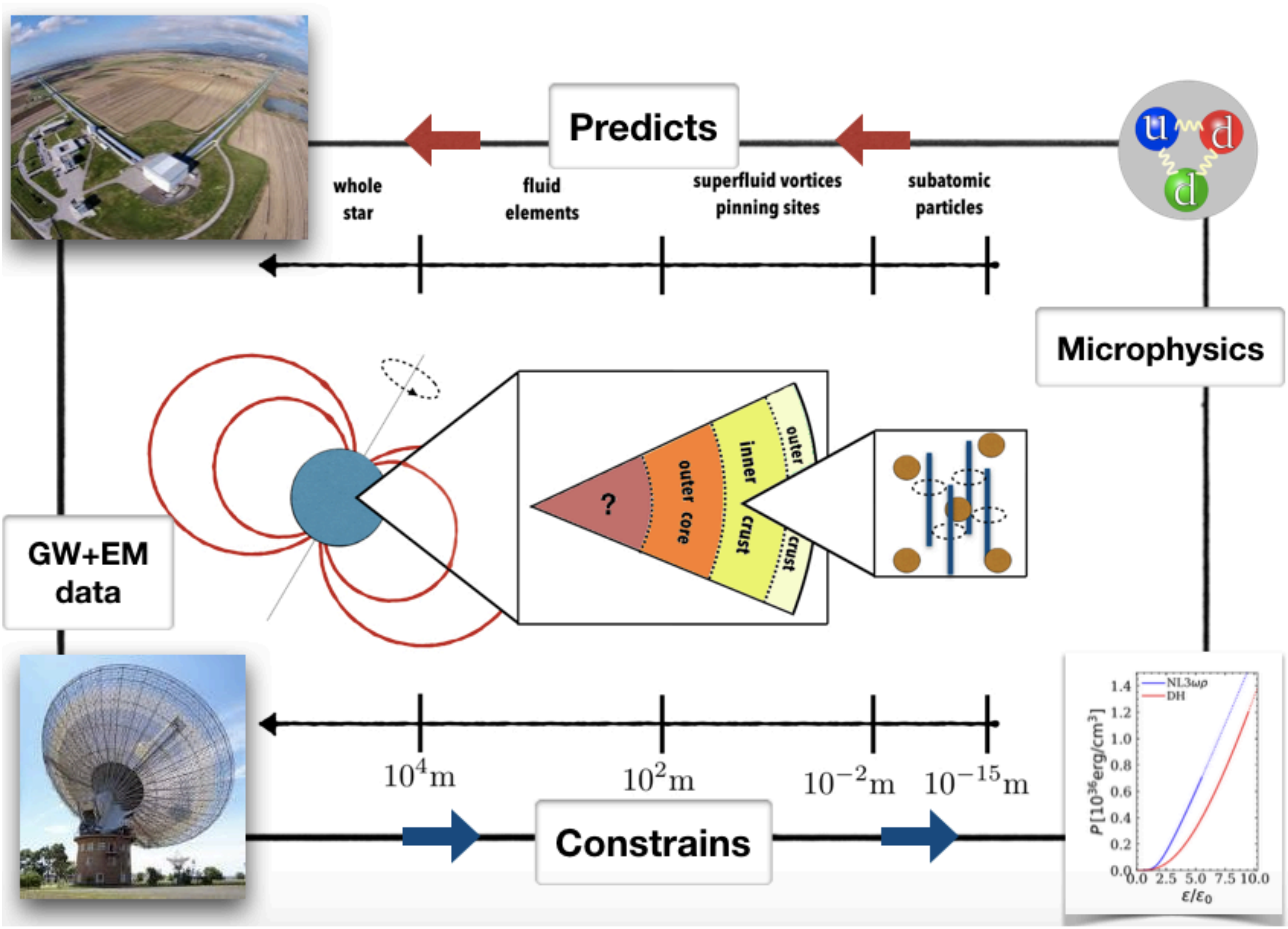
Nanda Rea and Bryn Haskell

http://www.pharos.ice.csic.es/

1. PHAROS Motivation



PHAROS
THE MULTI-MESSENGER
PHYSICS AND ASTROPHYSICS
OF NEUTRON STARS



PHAROS
THE MULTI-MESSENGER PHYSICS AND ASTROPHYSICS OF NEUTRON STARS

2. PHAROS Action Objectives

1. PHAROS will aim at answering how can the neutron star **Equation of State (EoS)** be investigated with different astrophysical and gravitational observations. Answering this question requires the communities to interact with nuclear physicists to set standard parameters for different EoS species to be implemented in astrophysical and gravitational simulations.
WG1 plus the others

2. PHAROS will aim at answering how can **transport phenomena** in neutron stars be modelled after or during their formation, also accounting for superfluidity and superconductivity, consistently with the EoS.
WG2 plus the others

3. PHAROS will aim at answering which different **gravitational signals** are expected from different neutron star systems, and how can they be characterized with real observables, and distinguished from other gravitational wave emitters.
WG3 plus the others

4. PHAROS will aim at answering how does the **magnetic field** evolve in isolated and accreting systems, how do turbulence and instabilities affect field formation and evolution and how does this affect the neutron star populations that we observe today.
WG4 plus the others

5. PHAROS will aim at answering how can the physics of neutron stars be tested by studying their interaction with the **local environment**, how can jets be launched in different neutron star systems or progenitors, as well as how can plasma physics in high-field regimes be modelled.
WG5 plus the others

…and all activities should:

6. Promote the interaction, and deliver common tools, between close communities interested in the same astrophysical objects from very different but complementary research approaches.

7. Train a young generation of students to a multi-disciplinary approach in their research activity, and help them grow and develop a shared language among close communities.

8. Encourage young women and early career researchers to take leadership roles in PHAROS, and provide young science students with young and senior women as role models. This has an extreme importance especially given the extremely low gender balance currently present in European scientific environments.

3. PHAROS Core Team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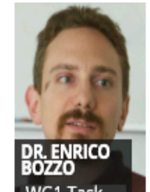
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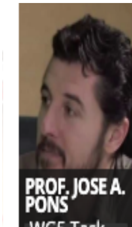
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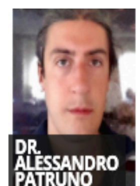
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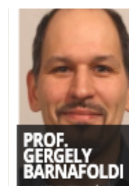
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4. PHAROS: Network

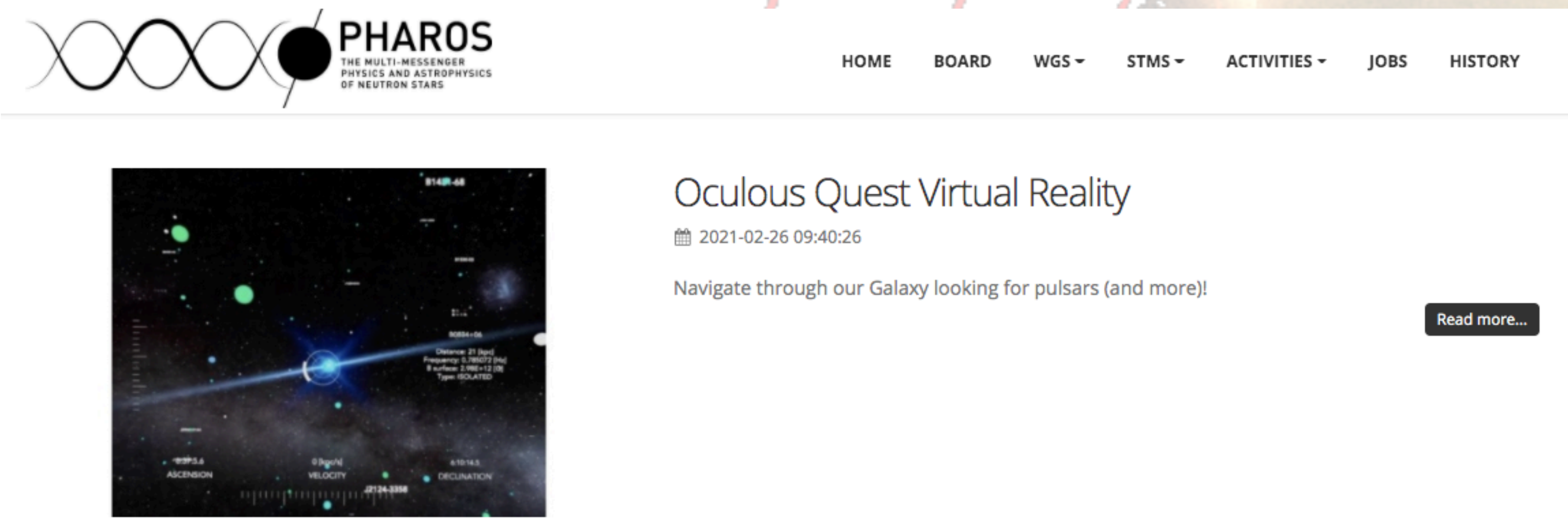
- 453 researchers from 30 different countries (45% of ITCountries)
- 57.4% Female and 42.6% Male scientists
- Average number of years since PhD graduation of proposers: 14.5
- Early Career Investigators (<8 years from PhD): 34

5. PHAROS Action Activities

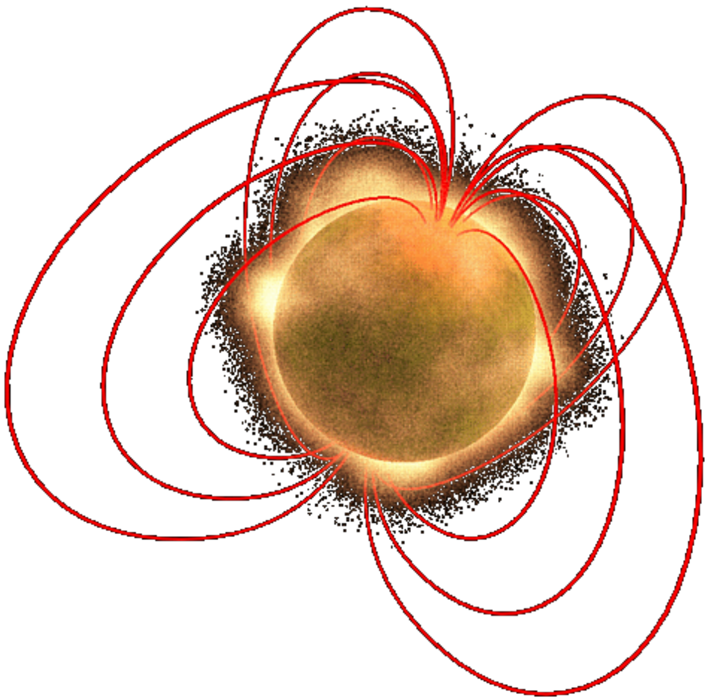
Meetings and STSMs affected by the pandemic…

Many STSMs still carried out pre 2020, many online meetings carried out after

Focus on Dissemination



Thanks for coming!!



PHAROS Working Groups

1. Equation of State of dense matter

Objectives:

- Collaboration between communities to determine standards.
- Provide benchmarks to test the correct implementation/functioning.
- Provide unified and consistent EoSs.
- Collaboration with WG2 to determine consistent transport parameters.

2. Superconductivity/Superfluidity in dense matter and transport coefficients

Objectives:

- Determine micro-physical inputs for glitch and gravitational wave modeling.
- Provide consistent transport coefficients and superfluid gaps for EoSs from WG1.
- Provide fitting formulae for numerical use.
- Determine standards for glitch observables, in preparation for SKA data.

3. Gravitational Wave signals in Neutron Stars

Objectives:

- Determine micro-physical and observational inputs required for models.
- Determine standards to allow gravitational wave observers to use models effectively.
- Closer collaboration between theorists and observers to develop models.

4. Magnetic field formation, evolution, (in)stability and neutron star population study

Objectives:

• Compare different magnetic evolution/formation/oscillations codes.
• Determine systematic differences, verify assumptions and validity in different communities.
• Closer collaboration between observers and theorists to set up observational tests.

5. Neutron star magnetospheres, acceleration mechanisms, environment and jets

Objectives:

- Compare analytical, radiative and numerical models for pulsar magnetospheres and wind nebulae.
- Determine systematic differences, and verify assumptions and validity