This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008324 (ChETEC-INFRA).

ChETEC-INFRA

Chemical **E**lements as **T**racers for the **E**volution of the **C**osmos – **Infra**structures for Nuclear Astrophysics

Achievements and way forward

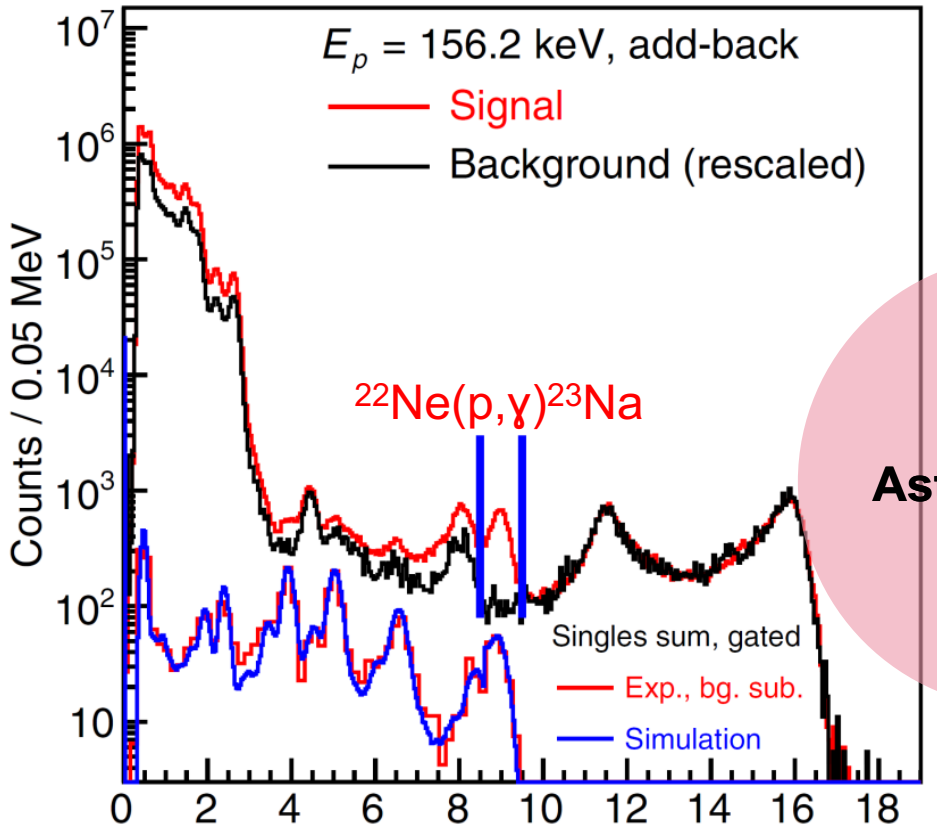
06/06/2023 Daniel Bemmerer, Helmholtz-Zentrum Dresden-Rossendorf d.bemmerer@hzdr.de chetec-infra.eu

ChETEC-INFRA – key facts at a glance [ketek-infra]

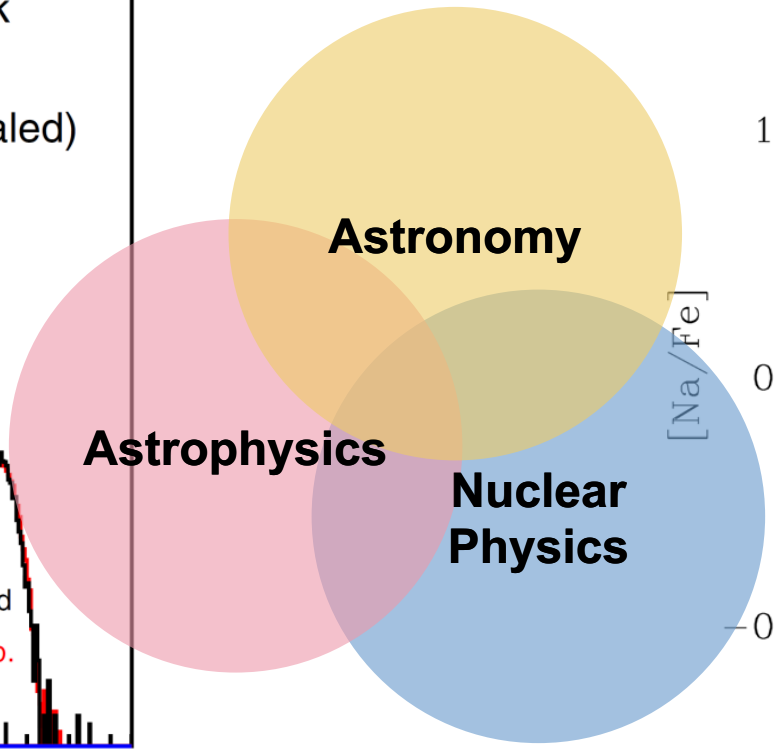
- EU Horizon 2020 **Starting Community** of research infrastructures to serve nuclear astrophysics
- H2020-INFRAIA-2020-1
- **32 partners** in 17 EU+ countries
- 1 May 2021 – 30 April 2025
- 5.0 M€ support by EU
- **13 research infrastructures** offer EU-supported transnational access, selection based on scientific merit

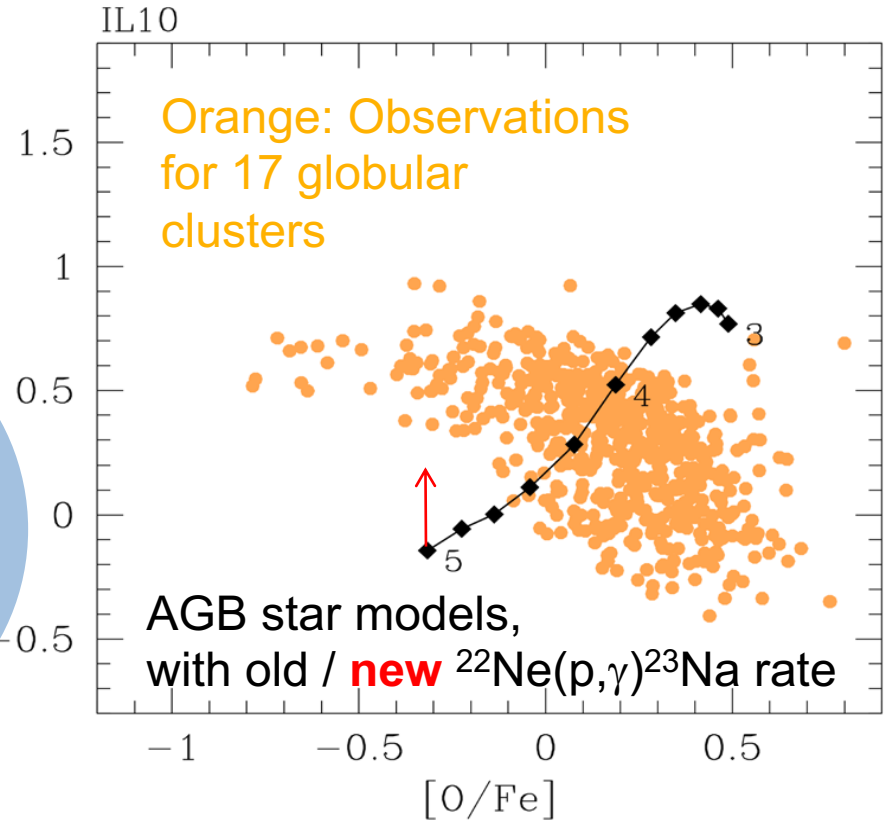
https://www.chetec-infra.eu

Nuclear astrophysics at the intersection of three disciplines



Ferraro *et al.* (2018)





Slemer *et al.* (2017)

Nuclear astrophysics as an emerging field in Europe

COST Action ChETEC

- Chemical Elements as Tracers of the Evolution of the Cosmos
- 30 European countries represented
- April 2017 – October 2021
- **Precursor of ChETEC-INFRA**

Nuclear Physics in Astrophysics Conference series, since 2002

- Sponsored by the Nuclear Physics Division of the European Physical Society
- 200+ participants
- NPA X: CERN, Geneva, Switzerland (2022)
- NPA XI: Dresden, Germany (15.-20.09.2024)
- **Partner with ChETEC-INFRA to support NPA conference schools**

Nuclei in the Cosmos conference series, every 2 years since 1990

- International conference alternates between Europe and rest of the world
- 200+ participants
- NIC XVII: Daejeon, South Korea (18. – 22.09.2023)

13 research infrastructures made accessible in ChETEC-INFRA


HZDR Felsenkeller
underground / DE


HZDR DREAMS
AMS / DE


Vienna University VERA
AMS / AT

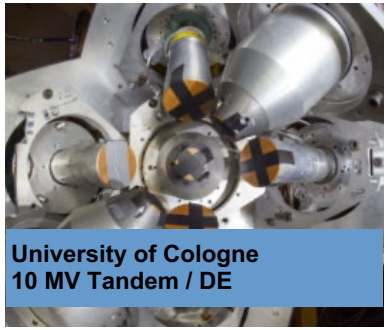

IANAO National Astronomical
Observatory / BG


ASU Perek
Telescope / CZ


Nordic Optical Telescope
La Palma / ES (Arhus / DK)


Frankfurt University
van de Graaf n-source / DE


PTB Ion Accelerator Facility /
DE


University of Cologne
10 MV Tandem / DE


ATOMKI
Cyclotron / HU

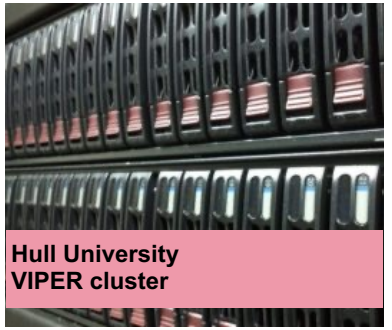
laboratories

supercomputers

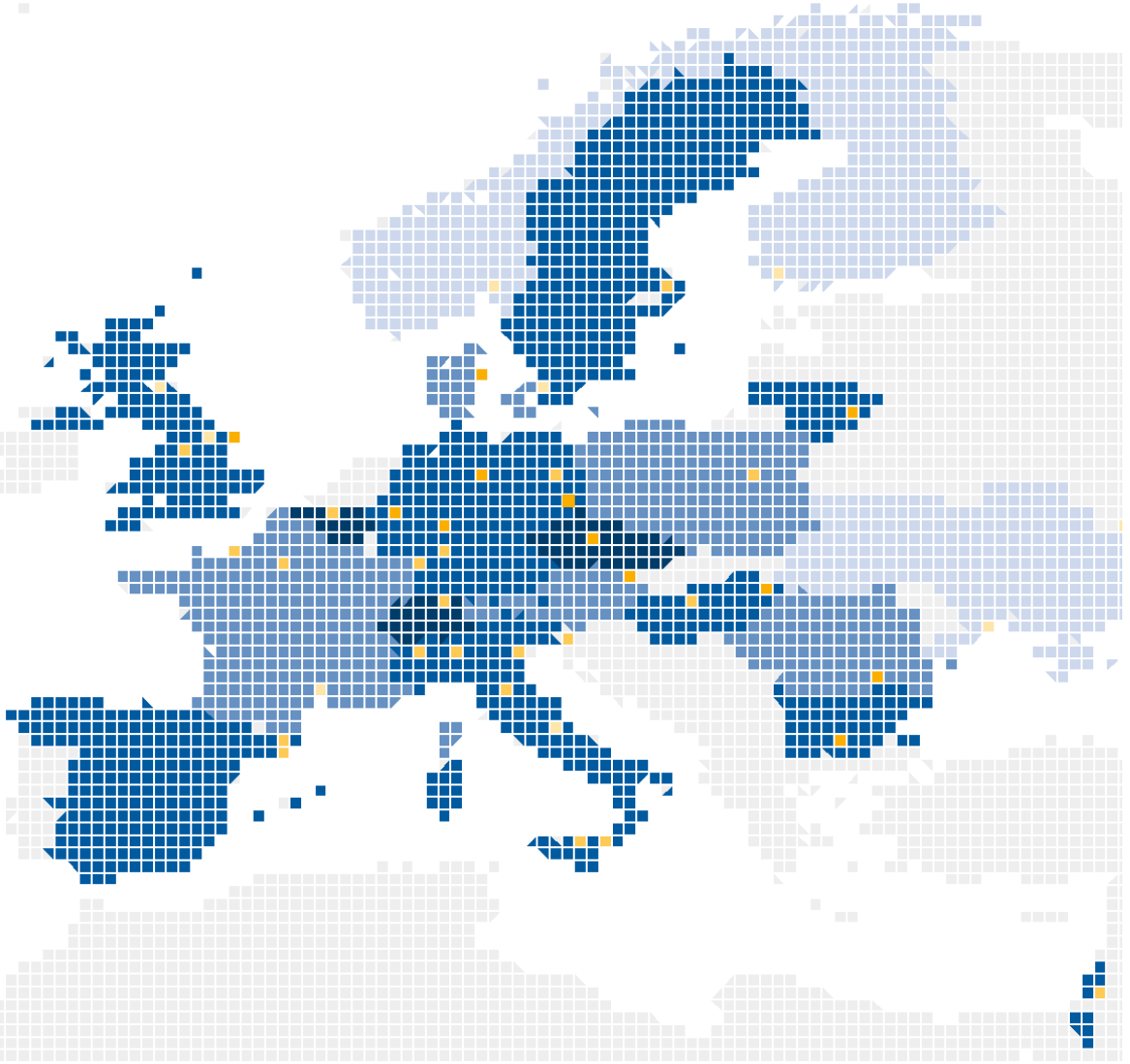
telescopes


Vilnius University Moletai
Astronical Observatory / LT


IFIN-HH 3 MV Tandetron
accelerator / RO

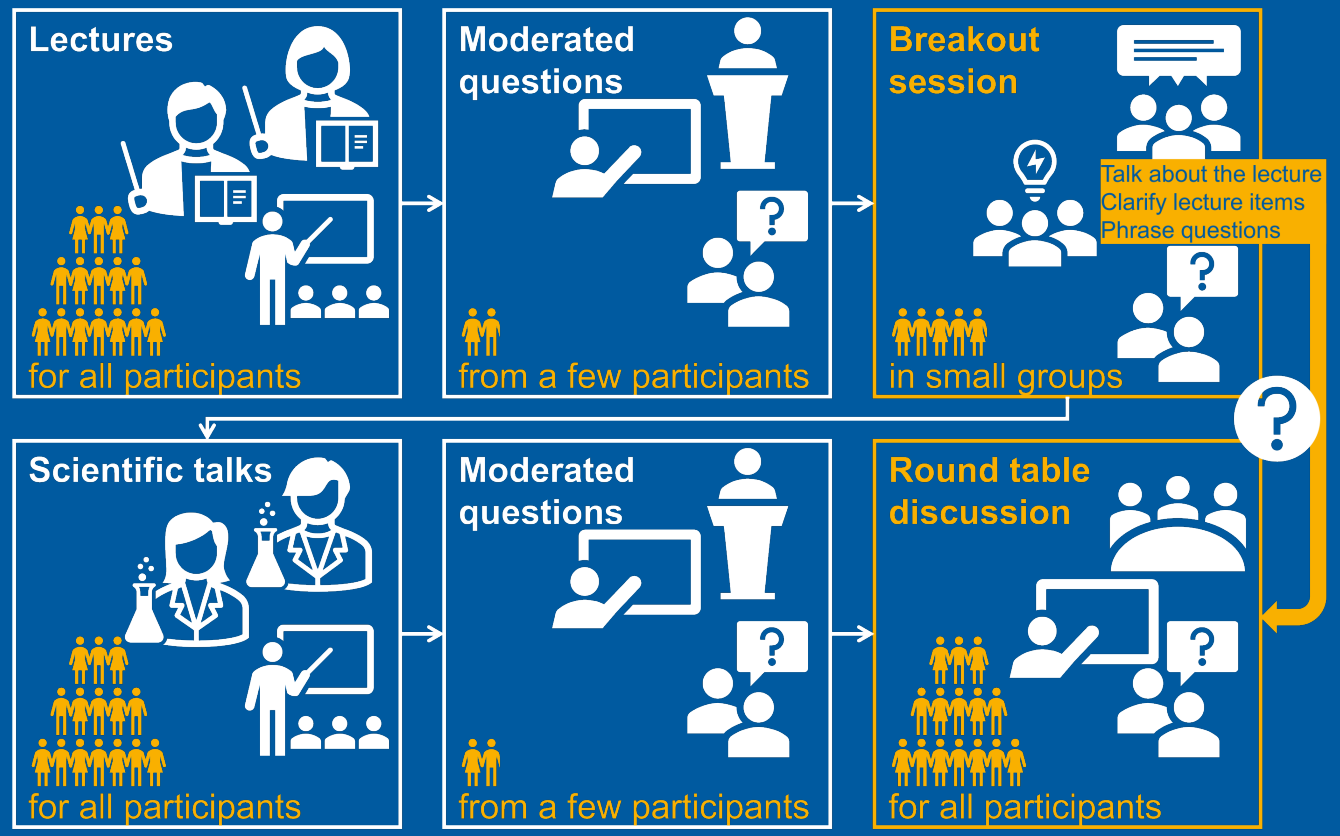

Hull University
VIPER cluster

32 partners …. plus NSF-funded IReNA network in the US



ChETEC-INFRA SNAQs [snacks]
Schools on Nuclear Astrophysics Questions

- ★ Response to Covid-19 travel restrictions
- ★ Provide the same interdisciplinary background for nuclear astrophysicists
- ★ 1000+ scientists reached
- ★ See Axel Boeltzig's and Olivier Sorlin's talks (WP7)



2nd General Assembly, Padova, 31.05. – 01.06.2022

Highlight talks on selected topics of interest for nuclear astrophysics

- Neutron stars and nucleosynthesis (G. Martinez Pinedo, Darmstadt/DE)
- Big Bang Nucleosynthesis (B. Fields, Illinois/US)
- Elemental Abundances in the Sun (E. Caffau, Paris/FR)
- Thermonuclear supernovae (F. Röpke, Heidelberg/DE)
- Nuclear astrophysics in Italy overview (E. Naselli, INFN/IT)

Presentations from neighboring networks

- EUROPLANET2024 RI (N. Mason, Kent/UK)
- EURO-LABS (M. Colonna, Catania/IT)
- IReNA (Z. Meisel, Ohio/US)
- Nuclear Astrophysics in Asia (W. Liu, CIAE/CN)

Ongoing work in ChETEC-INFRA

- Presentations on WP highlights
- Presentations on transnational access projects

Statistics

- 87 registered participants, most of them in-presence

3rd General Assembly, Debrecen, 06.- 07.06.2023

Presentations from neighboring networks and from regional laboratories

- ATOMKI Lab and Science (Z. Dombradi, Debrecen/HU)
- EUROPLANET2024 RI (N. Mason, Kent/UK)
- ATRI MTF ion beam laboratory (P. Noga, Bratislava/SK)
- Gas Targets from Transparent Materials (V. Tomkus, Vilnius/LT)

Highlight talks on selected science and outreach work in ChETEC-INFRA

- Live radioactive nuclei in the galaxy (B. Wehmeyer, Konkoly/HU)
- S-process abundances and meteorites (M. Ek, Zürich/CH)
- Galactic chemical evolution course (K. Womack, Hull/UK)
- Nuclear astrophysics masterclasses (H. Nitsche, Dresden/DE)
- Nucleosynthesis signatures in subdwarfs (J. Krticka, Brno/CZ)
- Abundance corrections 3D-NLTE (A. Gallagher, Potsdam/DE)
- ^{26}Al nucleosynthesis (U. Battino, Hull/UK)
- Tool for interactive stellar abundance work (J. Puschnig, Uppsala/SE)

Tomorrow: Ongoing work in ChETEC-INFRA

- Presentations on the Joint Research Activities and Networking Activities
- Transnational Access User's meeting

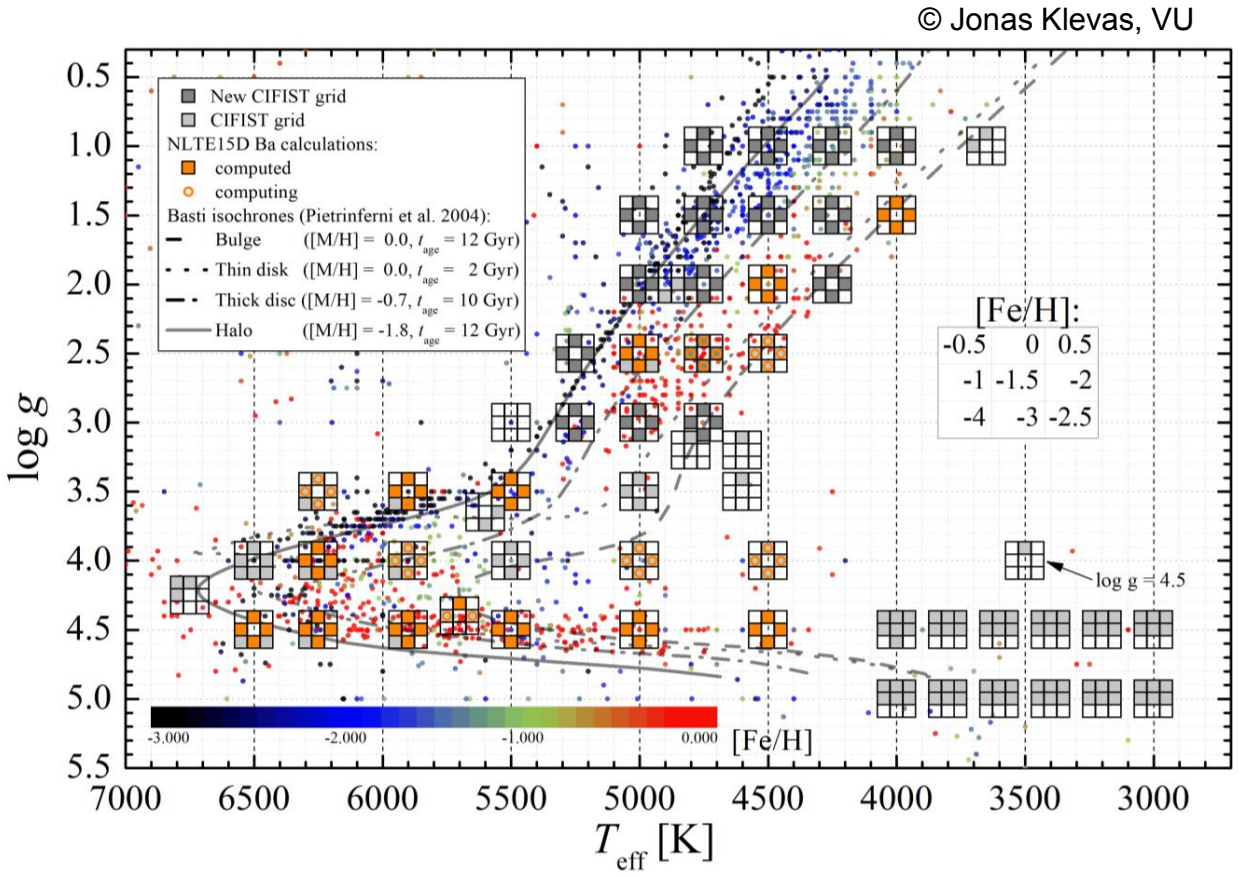
Statistics

- 78 registered participants, majority in-presence

Calculated abundance corrections (courtesy A. Kucinskas)

3D NLTE ABUNDANCE CORRECTIONS DATABASE & ABUNDANCE PIPELINE

- New grid of 3D hydrodynamical model atmospheres:
  - 60 3D model atmospheres of red giants
  - >5 million CPU hours used
- New tools for 1.5D NLTE abundance analysis:
  - massive parallelized computations of 1.5D NLTE abundance corrections using 3D hydrodynamical model atmospheres
- Grid of 1.5D NLTE abundance corrections for Ba:
  - 1.5D NLTE corrections for 56 3D models
  - part of computations done on the VIPER HPC cluster at Hull University, via the ChETEC-INFRA TNA
  - >4 million CPU hours used
  - first public release: April 2023

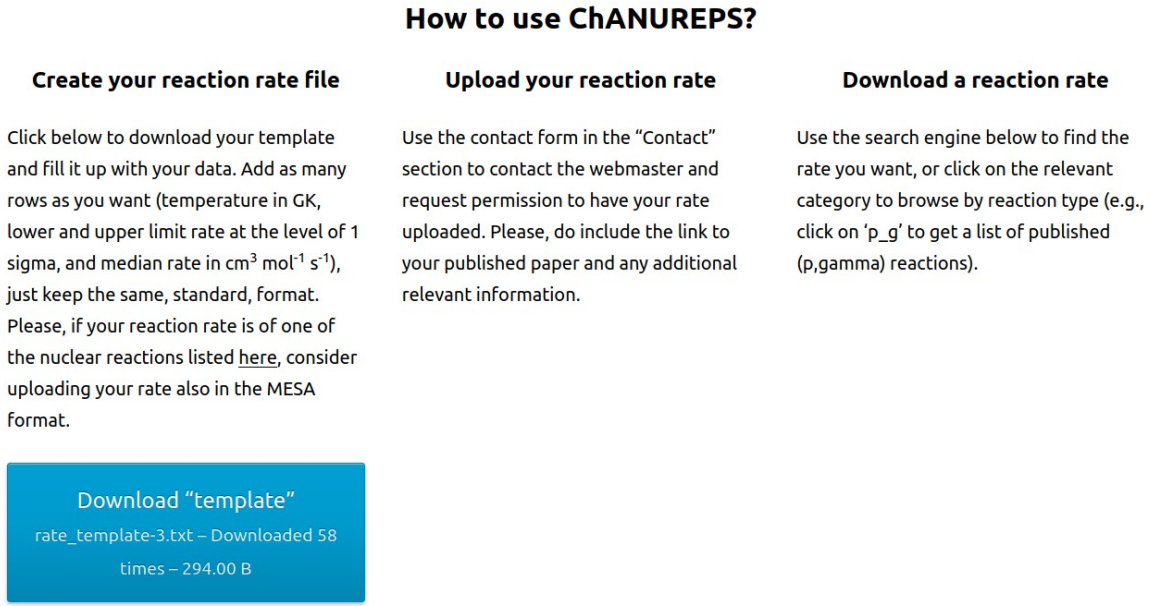


Data exchange platform (courtesy M. Pignatari)

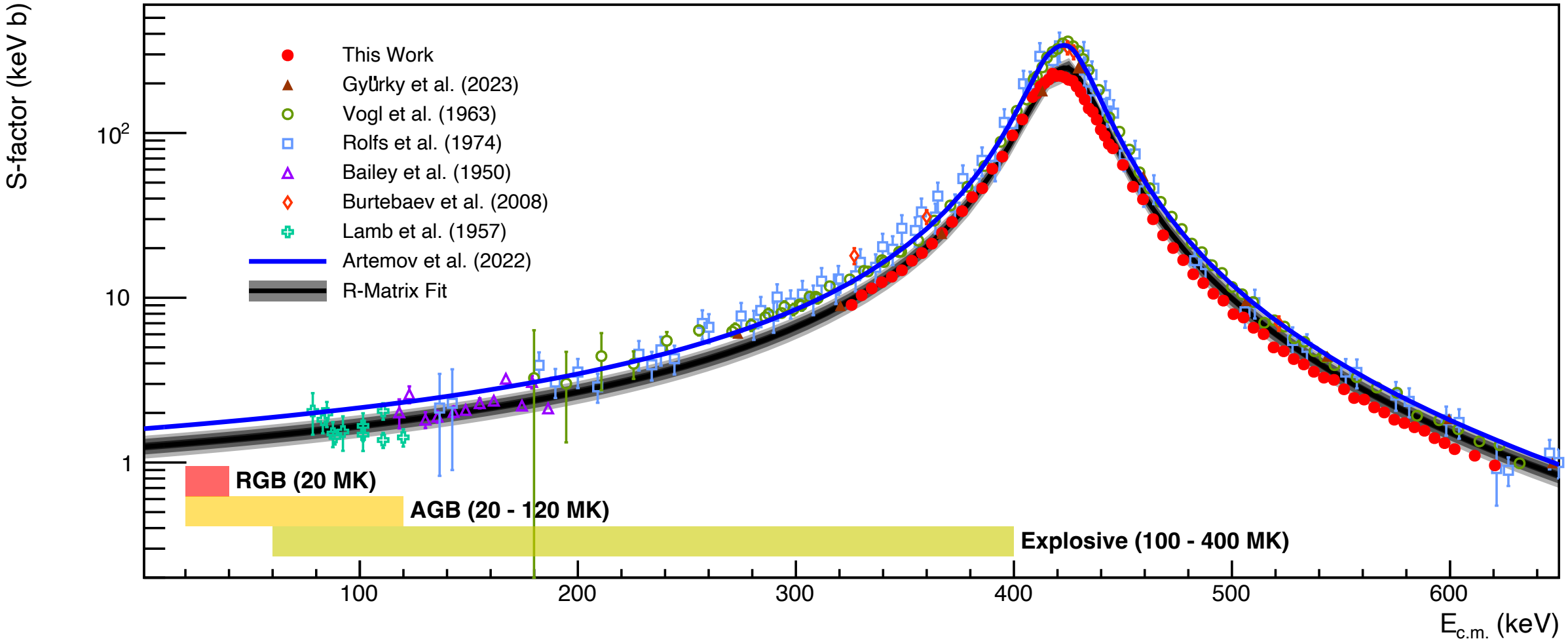
Platform for the Exchange of Nuclear Astrophysics Data - ChANUREPS

GOAL: share and distribute new published nuclear reaction rates as open source and with the same simple format.

Activity:
- New nuclear rates available: 24+
- Link to major nuclear reaction libraries
- Portal: http://chanureps.chetec-infra.eu/



TNA experiment: $^{12}C(p,\gamma)^{13}N$ at Felsenkeller (courtesy D. Piatti)



Scientific achievements, first two years of ChETEC-INFRA

Already >50 peer-reviewed publications, cited 190+ times, with explicit ChETEC-INFRA acknowledgment

- So far, mainly science papers benefiting from JRA and NA work
- TNA based papers are starting to arrive

Scientific legacy achieved already in the first two years of the project

- Previously non-existing interdisciplinary network between astronomers, astrophysicists, nuclear physicists
- Previously national-only facilities successfully opened up for TA
- Community-based decadal evaluation of Solar Fusion Cross Sections III
- Strong bridge to meteoritic and planetary science communities

General aspects of ChETEC-INFRA

- Strong educational aspect for PhD students and also secondary school students
- Inclusiveness across many dimensions (countries, gender, ages, …), extraordinary for a MINT-based network
- Active and thriving industry contacts

ChETEC-INFRA sustainability

Transnational access sustainability

- Continued provision of transnational access – applied for (SpaceSciRI)
- Sustainable accessibility to existing transnational access and consortium data – point for discussion

ChETEC-INFRA.EU web site as central data hub

- Sustainable domain name registration @ HZDR, well beyond the end of the project
- WordPress infrastructure for main web site @ HZDR
- Links from main web site to hardware and specialized scripts @ Uni Frankfurt - point for discussion

ChETEC-INFRA, summary and upcoming next steps

ChETEC-INFRA has transistioned from warm-up to full-running phase

- Staff onboarding completed everywhere
- Transnational access provision has ramped up, further acceleration in preparation

New focus points in new phase

- Ease and sustainability of access to ChETEC-INFRA results (e.g. webpage, data repositories)
- Strengthen network across the disciplines
- Make ChETEC-INFRA results visible (e.g. TNA slide, acknowledgments in publications)
- Dissemination of science enthusiasm to secondary school students, funding agencies, etc.

Much exciting science to come!

- New astronomical data, new laboratories, new computational tools

Make full use of ChETEC-INFRA tools and capabilities!

- Transnational access
- Travel for scientific work, conferences
- Support for scientific schools for PhD students
- Use the network!