A NEW NUCLEAR ASTROPHYSICS MASTERCLASS

A Journey through the Elements

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What are we working on?

- Development of two Nuclear Astrophysics Masterclasses
  - First Masterclass available in German & English since last year @mc.chetec-infra.eu/de
  - Second Masterclass coming End of 2023
- Languages
  - German, English, Spanish, French, Italian, Romanian, Swedish, Hungarian, Lithuanian, Catalan, Hebrew, Czech, Bulgarian, Welsh and **Sorbian**
- Unusual Masterclass for Netzwerk Teilchenwelt
  - Hadron Physics, hardly contact with particle physics
  - Hands-on Data Analysis comparatively small part

Insight into the **Content** and **Materials**

Content & Materials

- **Centerpiece** of the Masterclasses: Analysis & evaluation of a **physical experiment**
  - ➢ Current Measurements carried out by nuclear physicists / Astrophysicists
- **Learning Goals**
  - Teaching the basic principles of nuclear physics & astrophysics
    Nuclei Structure, Nuclear Reactions, Nucleosynthesis, Stellar Evolution, Cross Sections etc.
  - Conveying the basic idea of this science field
    What questions does nuclear astrophysics ask itself and how does it work to answer them?
  - Depicting how physical knowledge develops
    Dynamics, evolution & open questions of nuclear astrophyiscs
  - Insight into the work of nuclear astrophysicists
  - ➢ Create interest in Nuclear Astrophysics

Content & Materials

Lectures

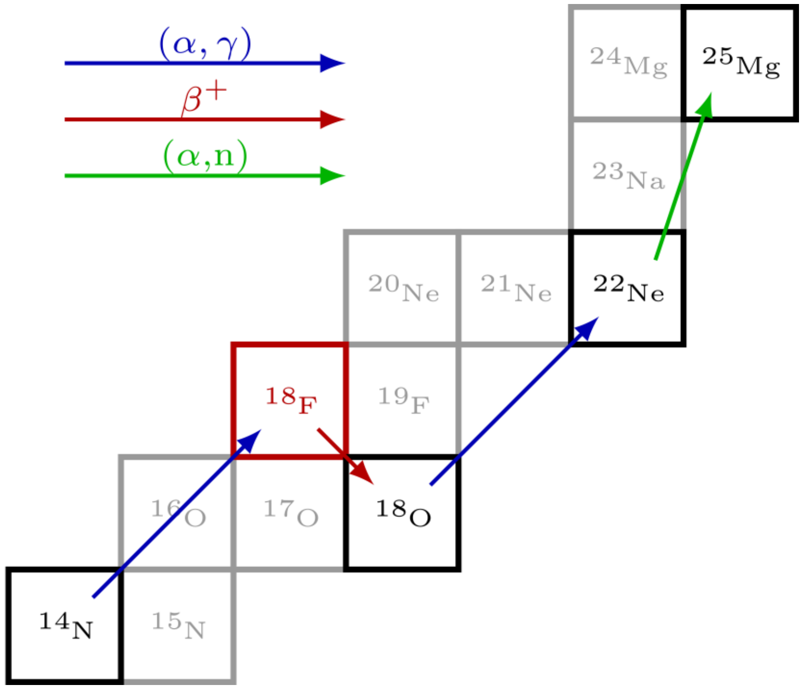
Activities !

More Details: **Guide**

Phase	Content	Method
Part I Ancient & Modern Research	Historical Insight: The Development of the Periodic Table	Lecture
	Insight in Modern Research	Short Video
Part II Atomic nuclei and their peculiarities	Basics of Nuclear Reactions	Group Puzzle
	Binding Energy & (In)stability	Lecture
Part III The Evolution of a Star	Building a Hertzsprung-Russell-Diagram	Group project
	The Story of the evolution of a Star	Lecture
Part IV On To Higher Elements!	Neutron sources and their Meaning	Lecture
	S- and R-Processes: Nuclei Race	Game
Part V Stars in the Lab	What does the photon tell us? Basics of Gamma spectroscopy	Partner work
	Data Analysis: The Search for Neutrons	

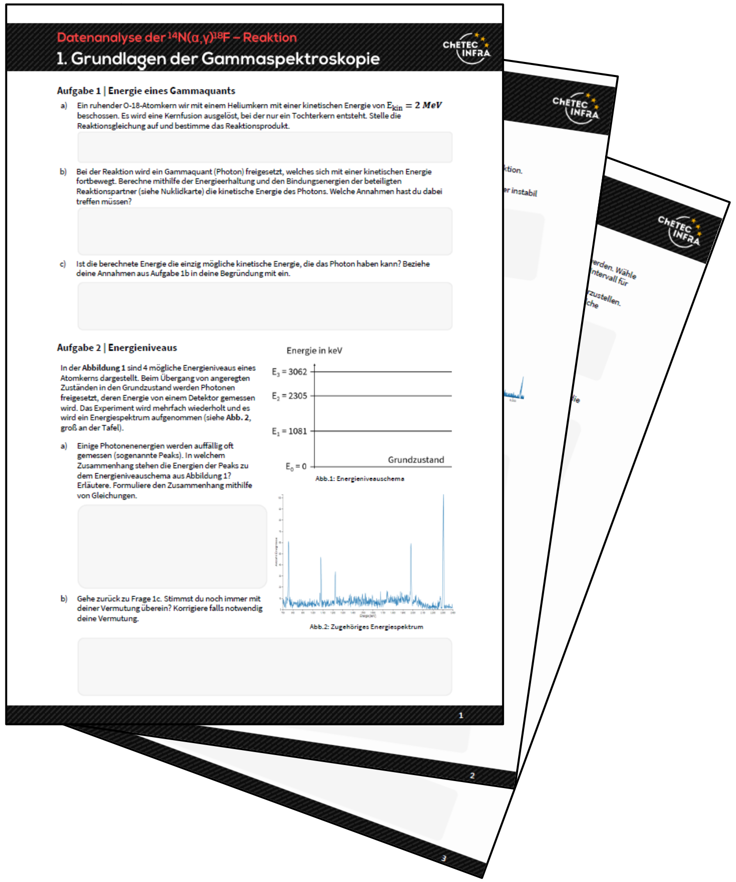
Content & Materials

- **Centerpiece** of the Masterclass:
  Analysis & evaluation of a **nuclear physics experiment**
- Measurement carried out at the
  Felsenkeller Laboratory
  Underground ion accelerator lab in Dresden
- Research Question:
  Where do the Neutrons come from?
- Data Analysis of $\mathbf{^{14}N(\alpha,\gamma)^{18}F}$
  - Start of a Reaction Chain taking place in red giant stars towards the end of helium burning
  - One of the main neutron sources for s-processes



Content & Materials

- **Centerpiece** of the Masterclass:
  Analysis & evaluation of a **nuclear physics experiment**
- **Tasks** of the Learners:
  - Gamma Spectroscopy & Peak Measurements
  - Usage of a Term Diagram
  - Consideration of the underground
  - Determination of the cross section & reaction rate
- **Goals**:
  - Working as a Nuclear Physicist for one day
  - Gain an Insight into the Laboratory and the working methods of a Nuclear Physicist



Data Analysis Work Sheets

Content & Materials

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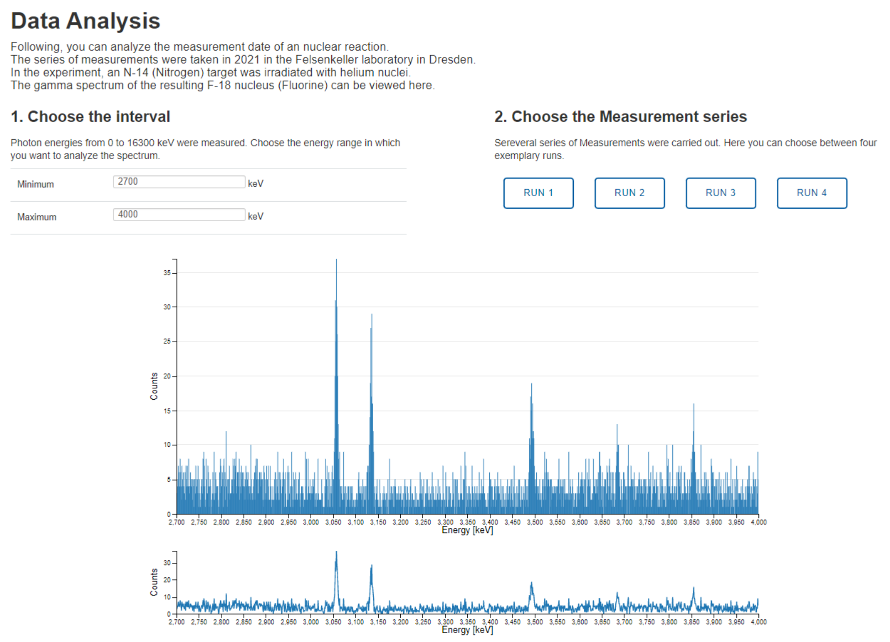
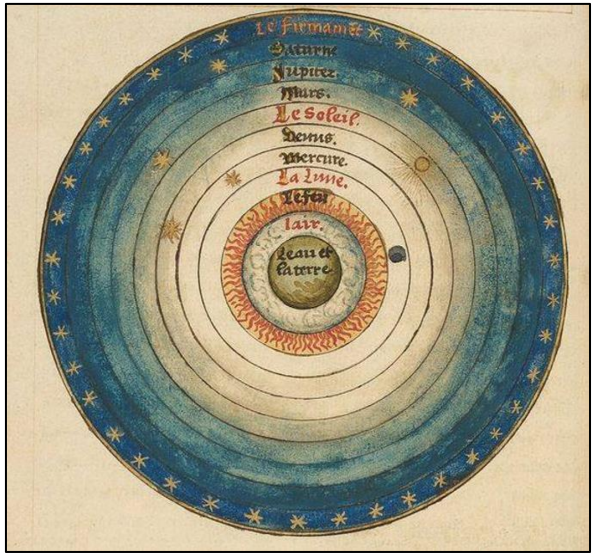


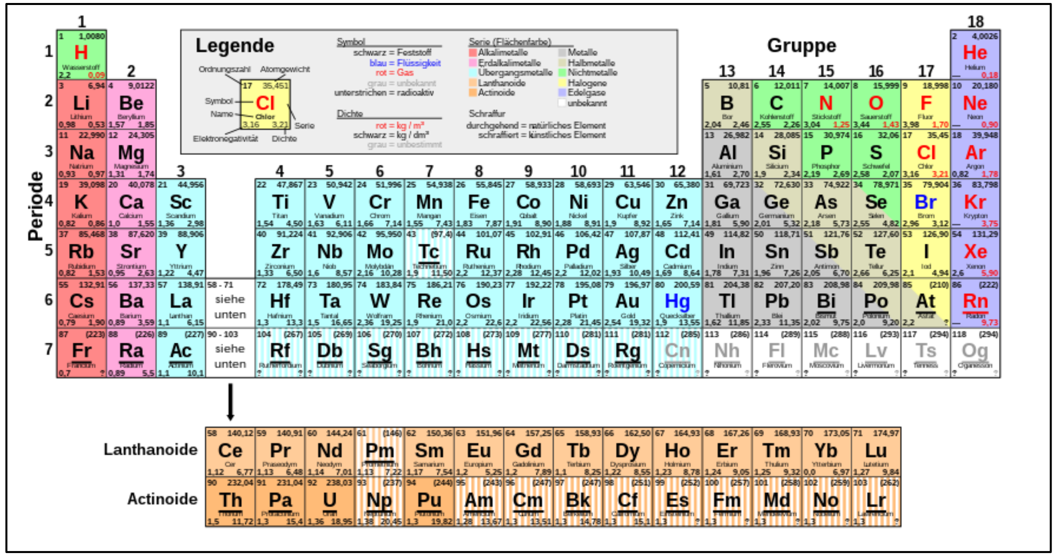
Data Analysis Webtool

Additional Content

- **Various Lectures** linking the activities e.g. …
  - Development of the understanding of chemical elements over history



The Aristotelian Cosmos



The modern Periodic Table

Additional Content

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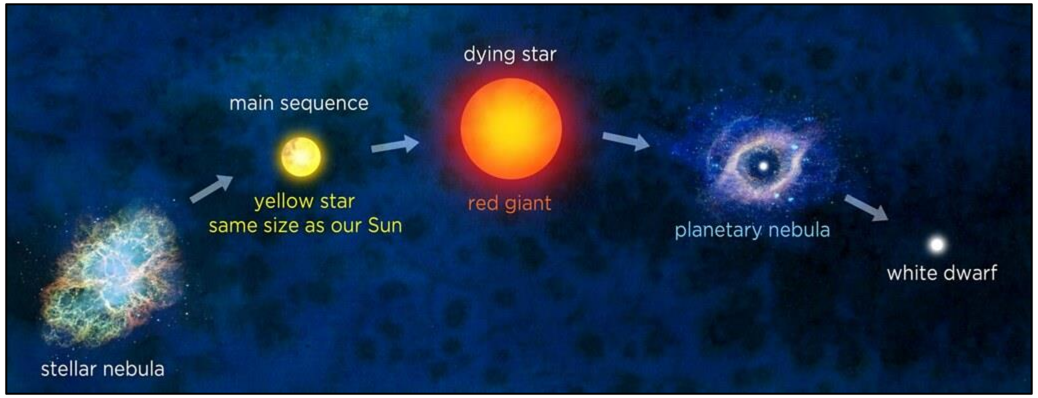
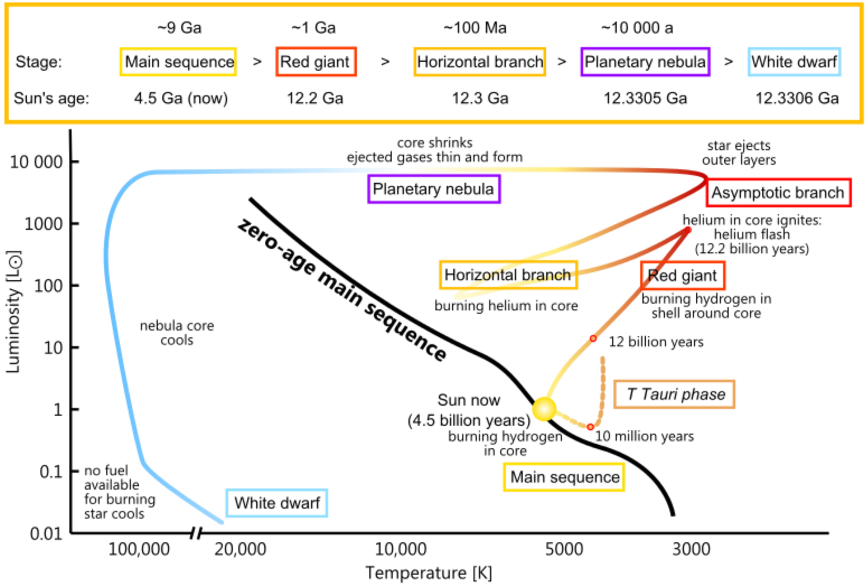
  - Development of the understanding of chemical elements over history
  - The life story of our sun - from protostar to white dwarf





Additional Content

- **Various Lectures** linking the activities
- **Videos & Visualizations**
  - Camera tour through the Felsenkeller underground laboratory
  - Astronuclear Nibbles – Video series

Felsenkeller Laboratory

Astronuclear Nibbles:
https://youtu.be/L6NMurf64-4

Additional Content

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- **Multiple Activities** with Gamification Elements, e.g. …
  - Building a Hertzsprung–Russell diagram together

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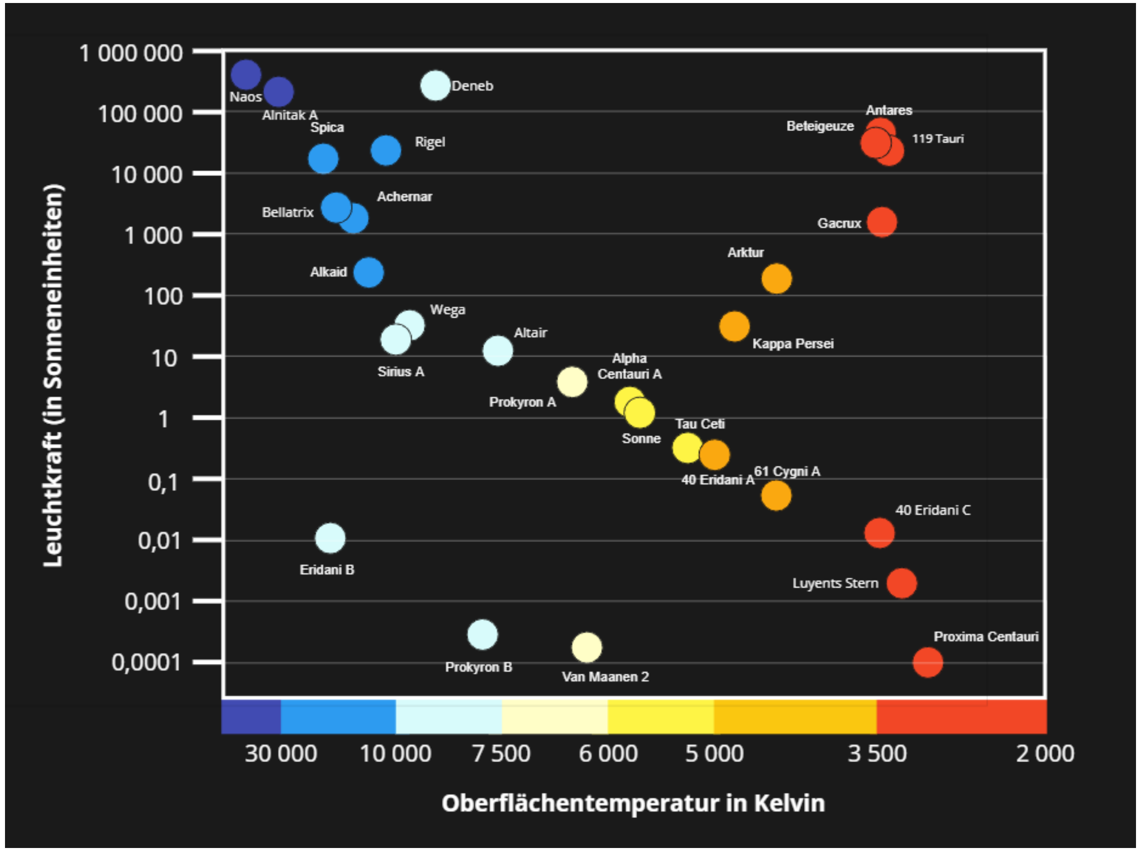

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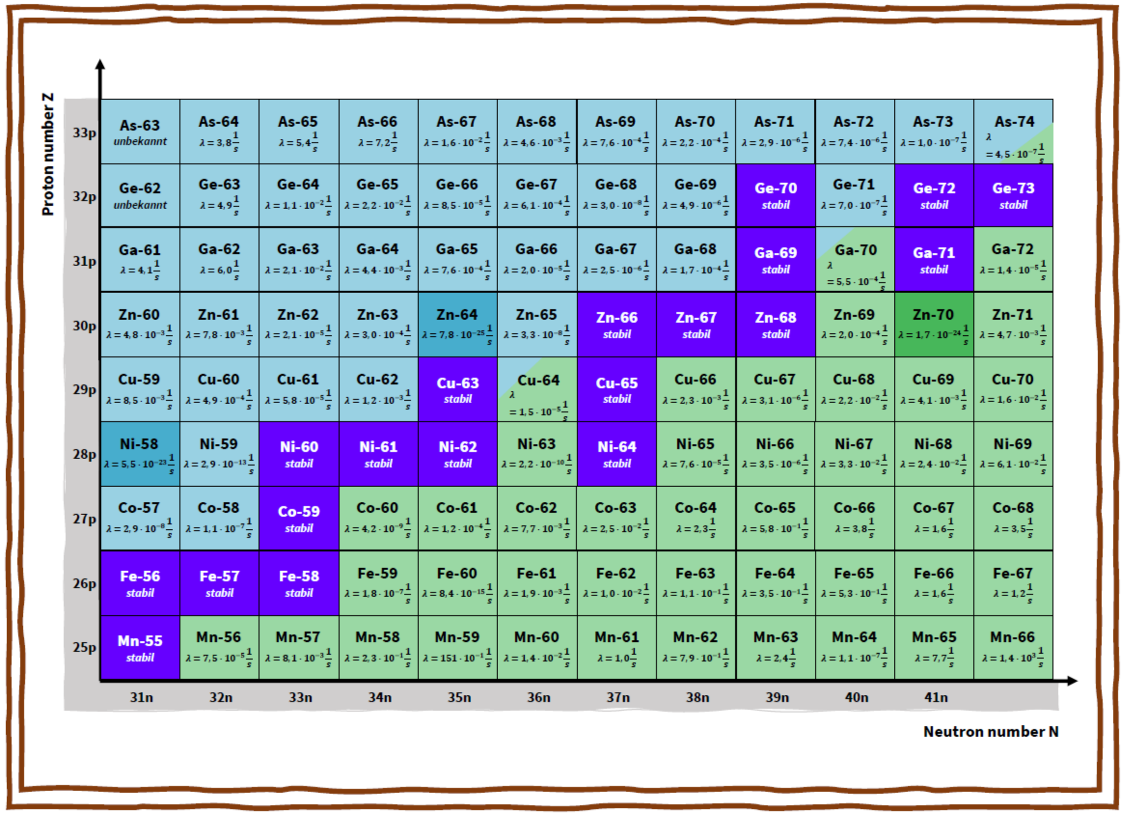
- **Videos & Visualizations**
- **Multiple Activities** with Gamification Elements, e.g. …
  - Building a Hertzsprung–Russell diagram together
  - The Nuclei Race:
    Recreating s- and r-processes in a board game



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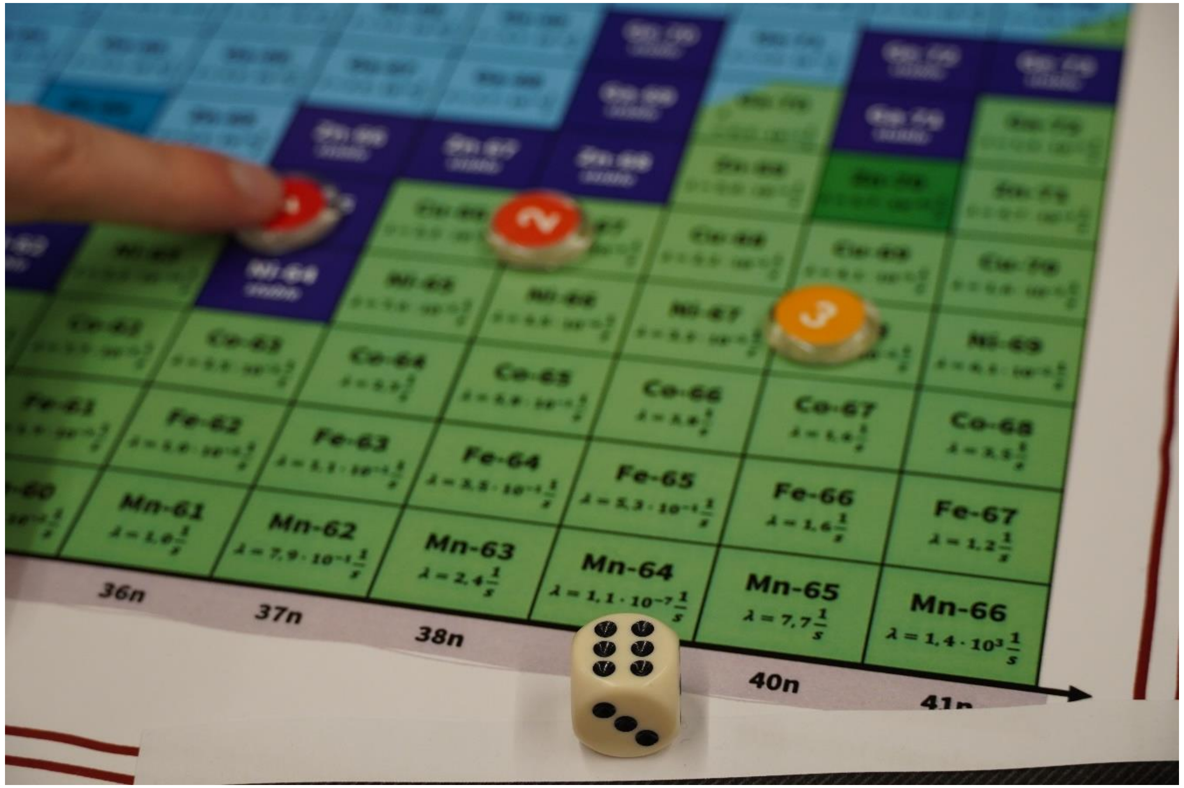
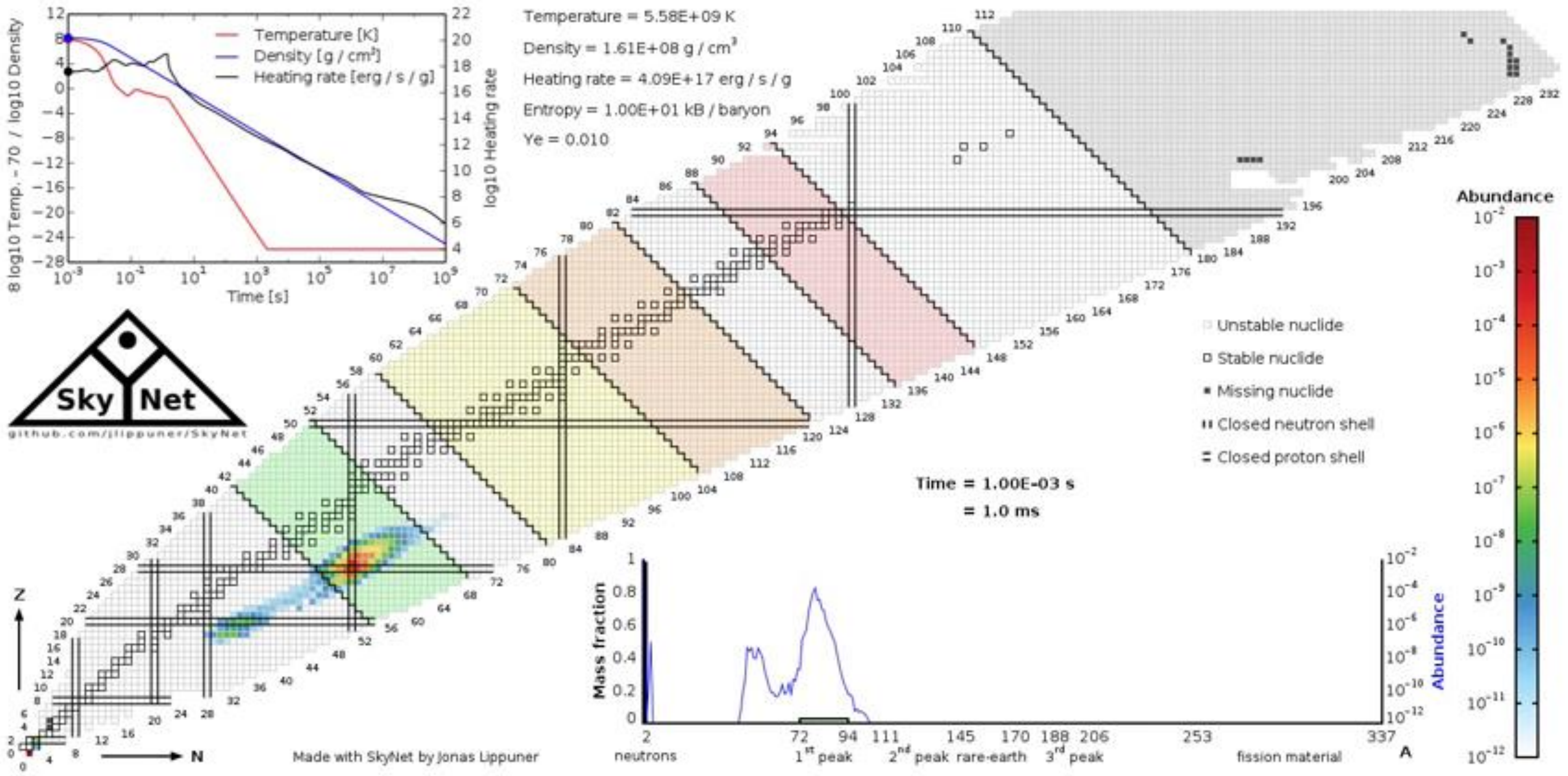


R-Process in Action

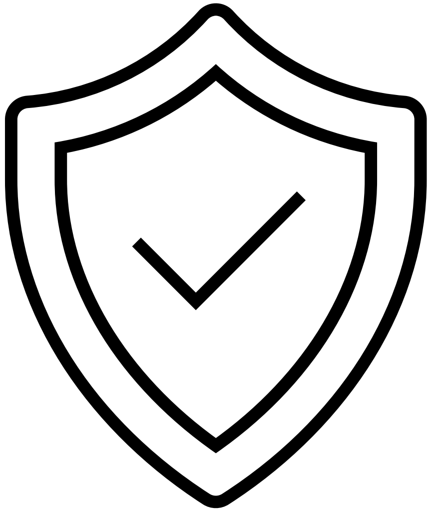


General **Design Aspects** of the Masterclasses

General Design Aspects

1. **Low Threshold**

- Previous knowledge in astrophysics and nuclear physics not mandatory
- Target Group: Age 15+



General Design Aspects

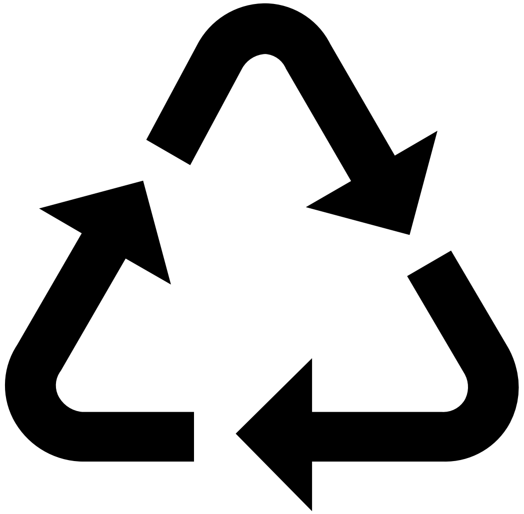
1. **Low Threshold**
2. **Accessability**

- Masterclass available in both online and live formats
- Open Access to all materials online
- No software installations necessary
- Analog materials can be recreated easily

General Design Aspects

1. **Low Threshold**
2. **Accessability**
3. **Reproducibility**

- Complete materials & instructions for educators open access
- Making it as easy as possible, to be a Nuclear Astrophysics Facilitator



General Design Aspects

1. **Low Threshold**
2. **Accessability**
3. **Reproducibility**
4. **Two different Masterclasses**

- Access to nuclear astrophysics with different Points of View
- No Necessity to visit the first Masterclass to understand the second
- Two independent Masterclasses
    - Each Scientist can choose their preferred topic

1. Masterclass
Nuclear Physics Experiments

Nuclear Astrophysics

2. Masterclass
Astronomical Observations

Recent Masterclass **Events**

Recent Masterclass Events

- **First Masterclass Run Through**
  - @ the Delta-X Student Lab
    (Helmholz-Zentrum Dresden Rossendorf)
  - with 13 students (14-16 Yrs o.)

Recent Masterclass Events

- **First Masterclass Run Through**
- **Masterclass Training Day**
  - @ the NPA-X Summer School
  - 1 week PhD School on Nuclear Astrophysics @ the CERN

NPA-X SCHOOL

Recent Masterclass Events

- **First Masterclass Run Through**
- **Masterclass Training Day**
  - @ the NPA-X Summer School
  - 1 week PhD School on Nuclear Astrophysics @ the CERN
  - 1 whole Day for Outreach Activities
  - Using the Masterclass to
    - Train Facilitators
    - Discuss about how to communicate Nuclear Astrophysics

Recent Masterclass Events

- **First Masterclass Run Through**
- **Masterclass Training Day**
- **Second Masterclass Run Through**
  - School in Spremberg
  - With 20 Students 11th & 12th Grade
- **Third Masterclass Run Through in February 2023**
  - School in Berlin
  - With 16 Students 10th Grade

Outlook

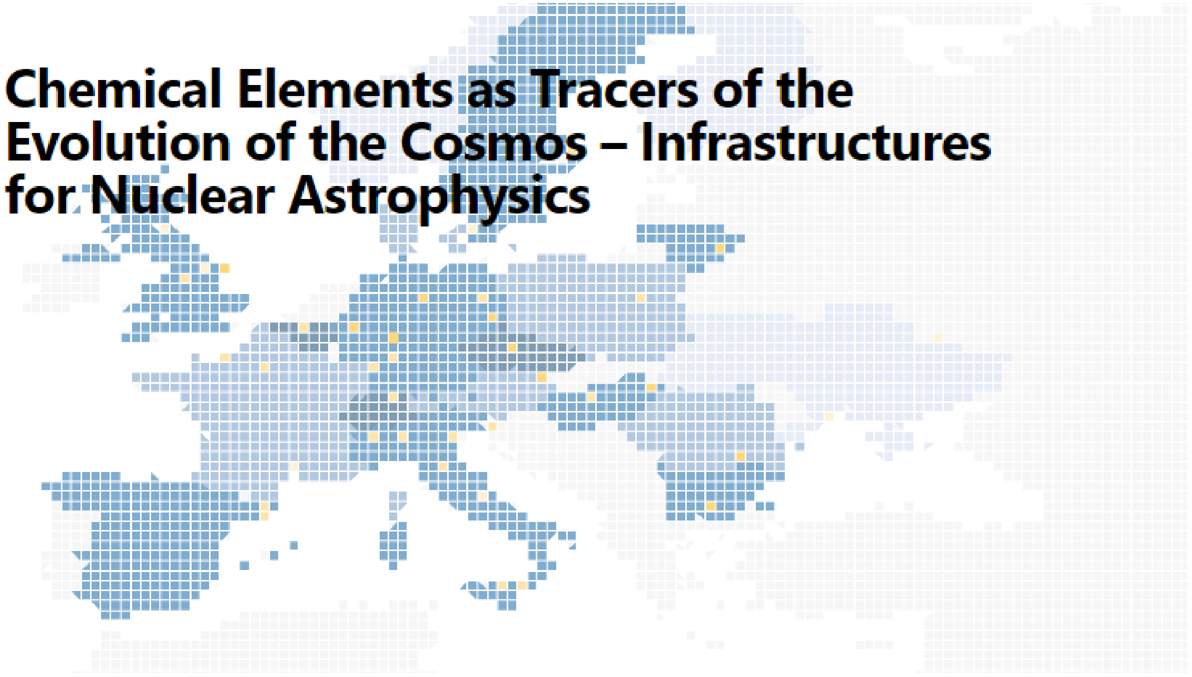
OUTLOOK

We are aiming for…

- Creating a Network of Nuclear Astrophysics **Facilitators**
- Giving every Physicist the opportunity to be a Educator
- Mediate Nuclear Astrophysics around the Globe

ChETEC-INFRA Network

https://www.chetec-infra.eu/



Outlook

We are looking for…

Science Communicators who want to give Nuclear Astrophysics Masterclasses

- Anyone who works in this field, can be an **Educator & Facilitator**
- **Open Access Teaching Materials** including
  - Presentation
  - Guide for the whole Masterclass
  - Guided Masterclass Run Through

If you're interested, get in touch:

hannes.nitsche@tu-dresden.de

Masterclass can be found online @

[*mc.chetec-infra.eu/masterclass/*]

Thank you for your attention.