Nuclear Astrophysics Masterclasses

A journey through the elements

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What are we working on?

Development of **two Nuclear Astrophysics Masterclasses**

- **Masterclasses**
  - One-day outreach activities in which students are given an introduction to the field of research and analyze real data from experiments themselves
  - under the guidance of young scientists (Science Communicators)
  - At schools, universities or student labs
- **Learning Goals**
  - Teaching the basic principles of nuclear physics & astrophysics
    Nuclei structure, nucleosynthesis, stellar evolution
  - Conveying the basic idea of this science field
    What questions does nuclear astrophysics ask?
  - Insight into the work of nuclear astrophysicists

What are we working on?

Development of **two Nuclear Astrophysics Masterclasses**

- **First Masterclass: a journey through the elements**
  - 7 different languages & more coming:
    German, English, French, Italian, Czech, Bulgarian, Sorbian, *Spanish, Romanian, Swedish, Hungarian, Lithuanian, Hebrew, Catalan, Welsh*
  - 14 Masterclass Run Throughs in 2023, ~ 300 students
- **Second Masterclass: Fingerprints of the stars**
  - Available in German since this year, English coming soon
  - 5 Masterclass run throughs this year, ~ 70 students

General Design Aspects

1. Accessability

- For Students
  - Previous knowledge in astrophysics and nuclear physics not mandatory
  - Target group: age 15+
- For Teachers:
  - Masterclass available in both online and live formats
  - No software installations necessary
- For Facilitators
  - Complete materials & guides for educators open access online
  - Making it as easy as possible, to be a nuclear astrophysics facilitator

General Design Aspects

1. **Accessability**
2. **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

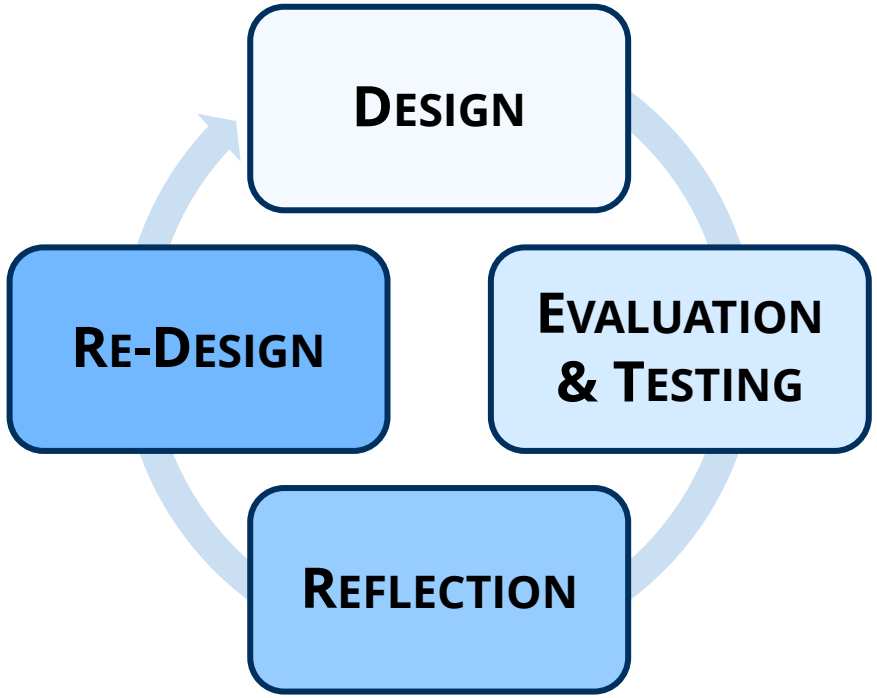
1. Masterclass
Nuclear Physics Experiments

Nuclear Astrophysics

2. Masterclass
Astronomical Observations

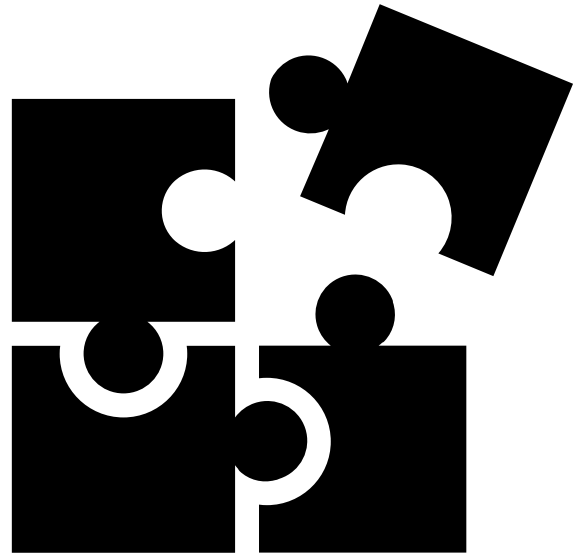
General Design Aspects

1. **Accessability**
2. **Two different Masterclasses**
3. **Design-based research as evaluation methodology**
   - Testing the teaching methods & activities with students
   - Multiple Iterations in designing the masterclasses



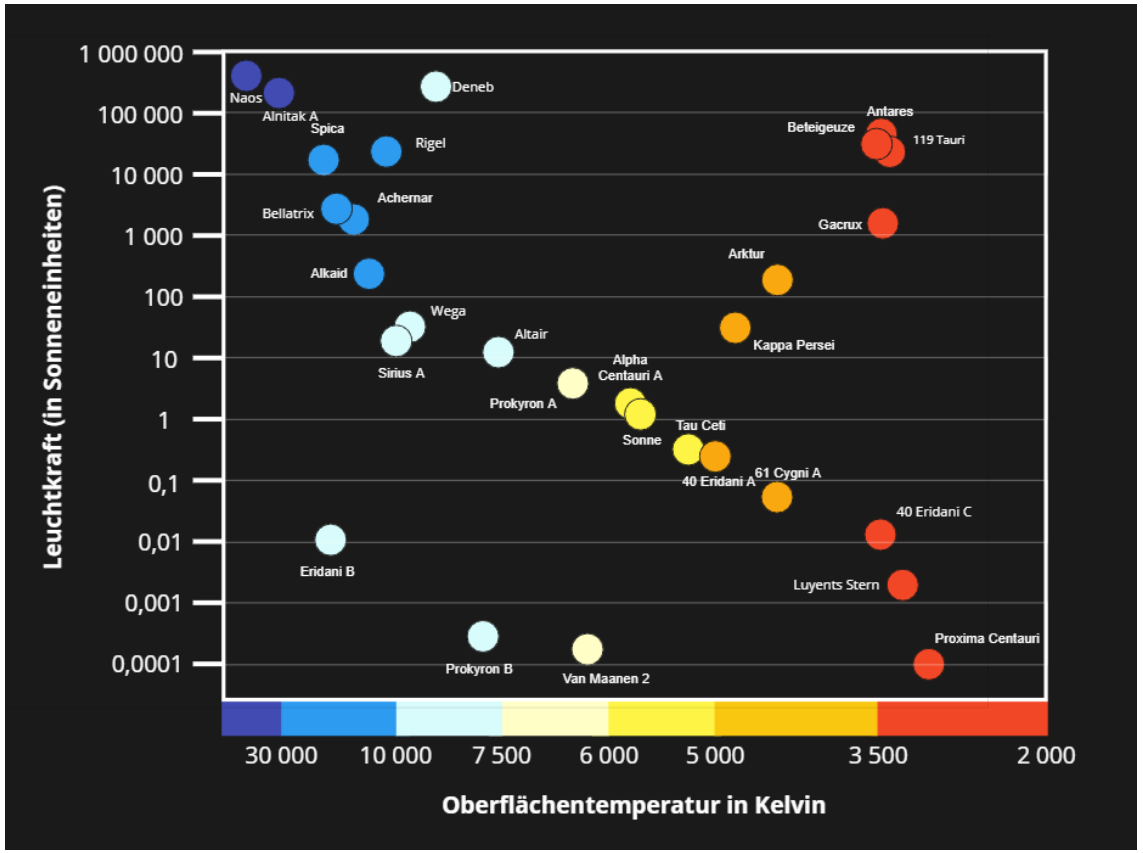
General Design Aspects

1. **Accessability**
2. **Two different Masterclasses**
3. **Design-based research as evaluation methodology**
4. **Focus on Gamification elements**
   - Game based Learning
   - Interactivity with a non-interactive learning object



Content & Materials

- Multiple activities with gamification elements, e.g. …
  - **Building a Hertzsprung–Russell diagram together**
  - Playful challenges
  - Primordial nucleosynthesis puzzle
  - Nuclei Race
- Videos & visualizations
- Various lectures linking the activities
- Data analysis: stellar spectroscopy & gamma spectroscopy of nuclear Reactions



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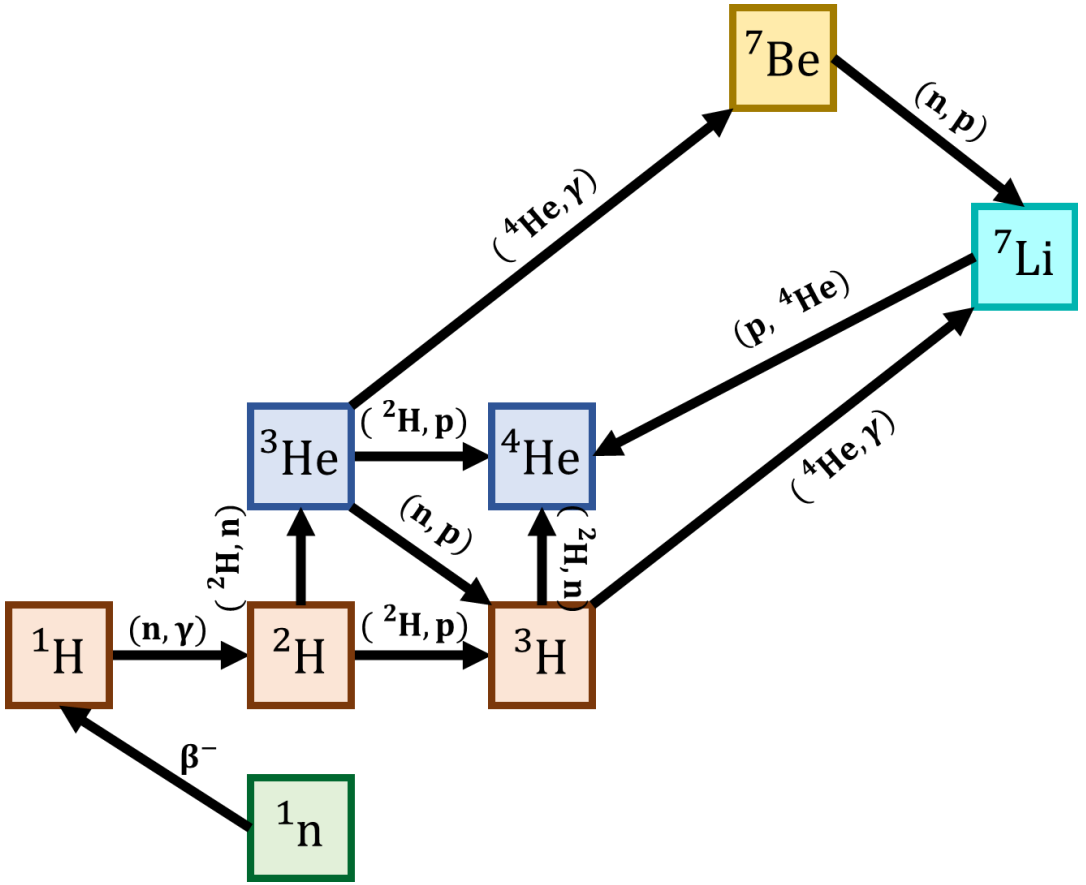

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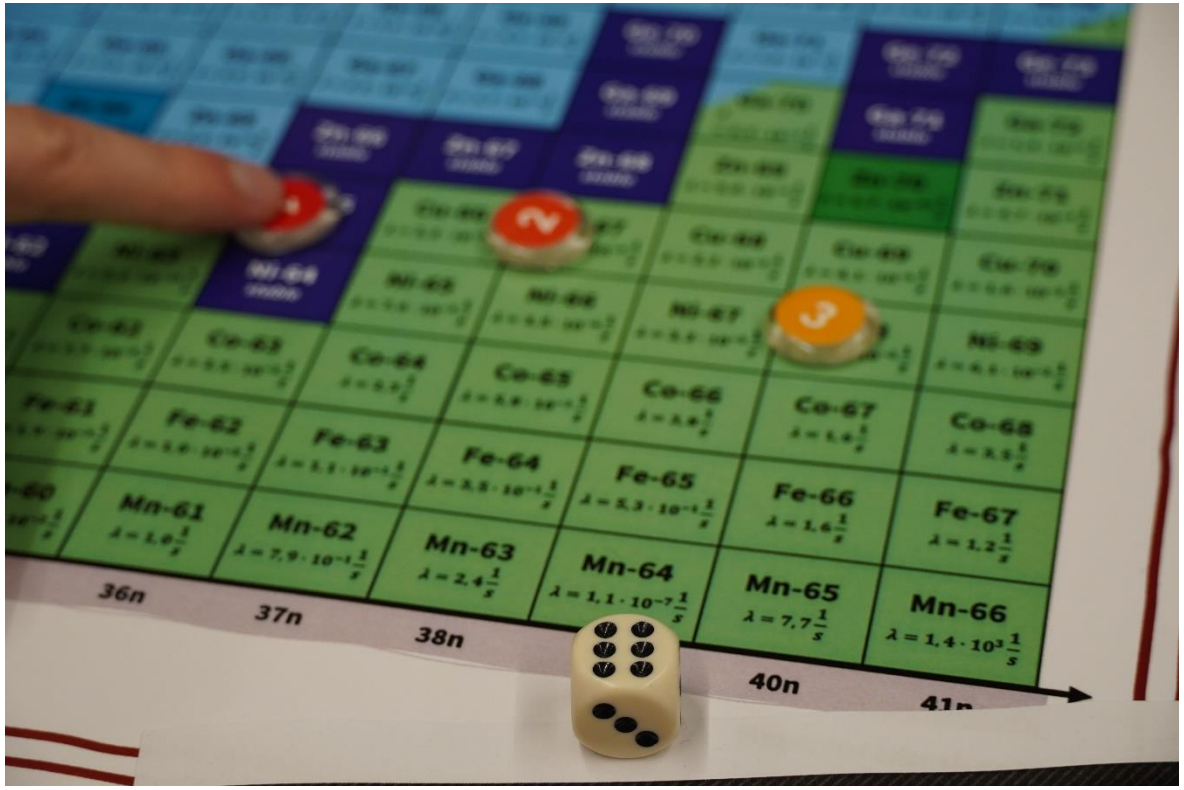

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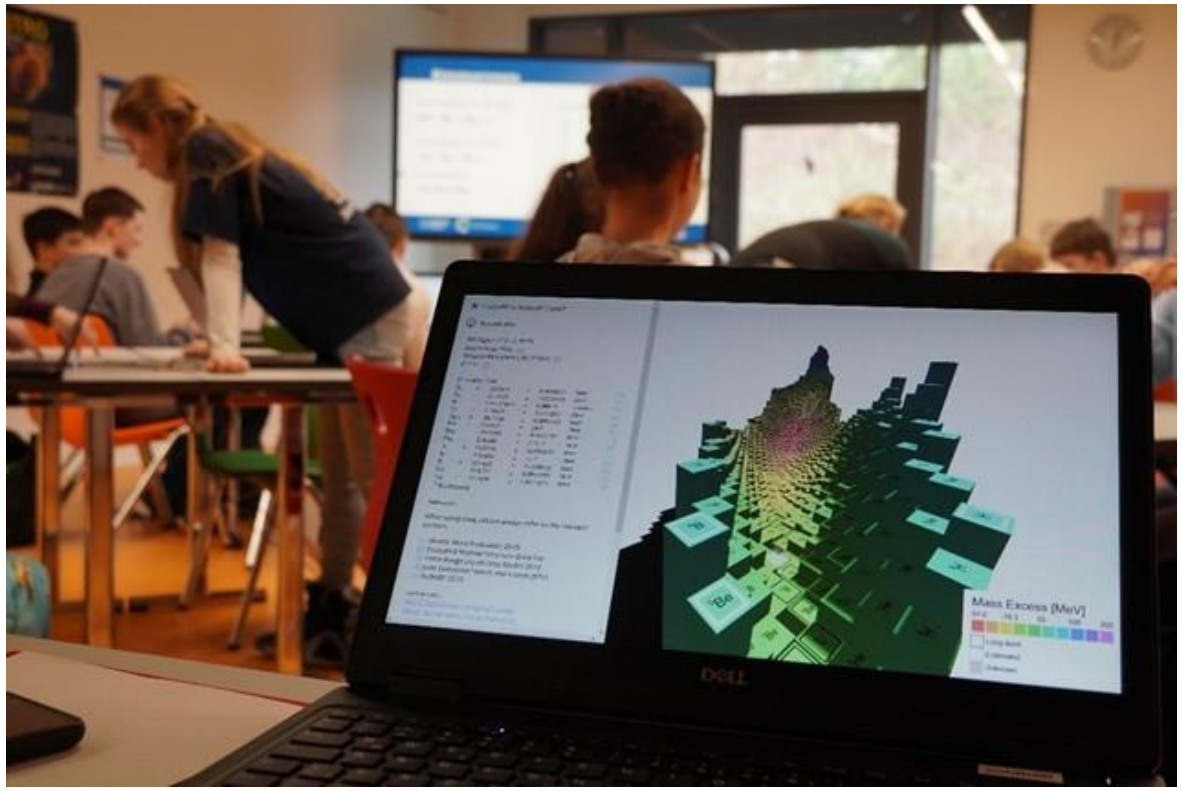

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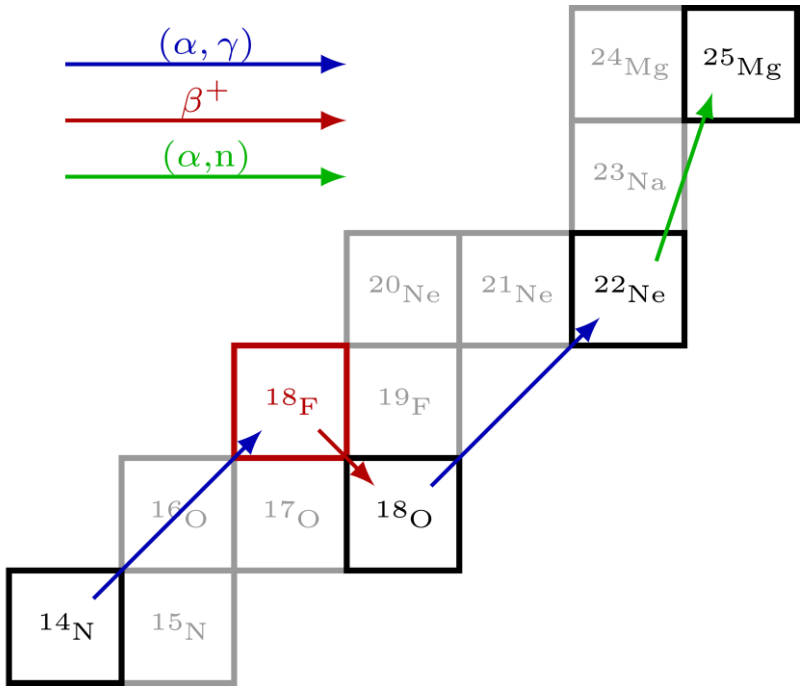
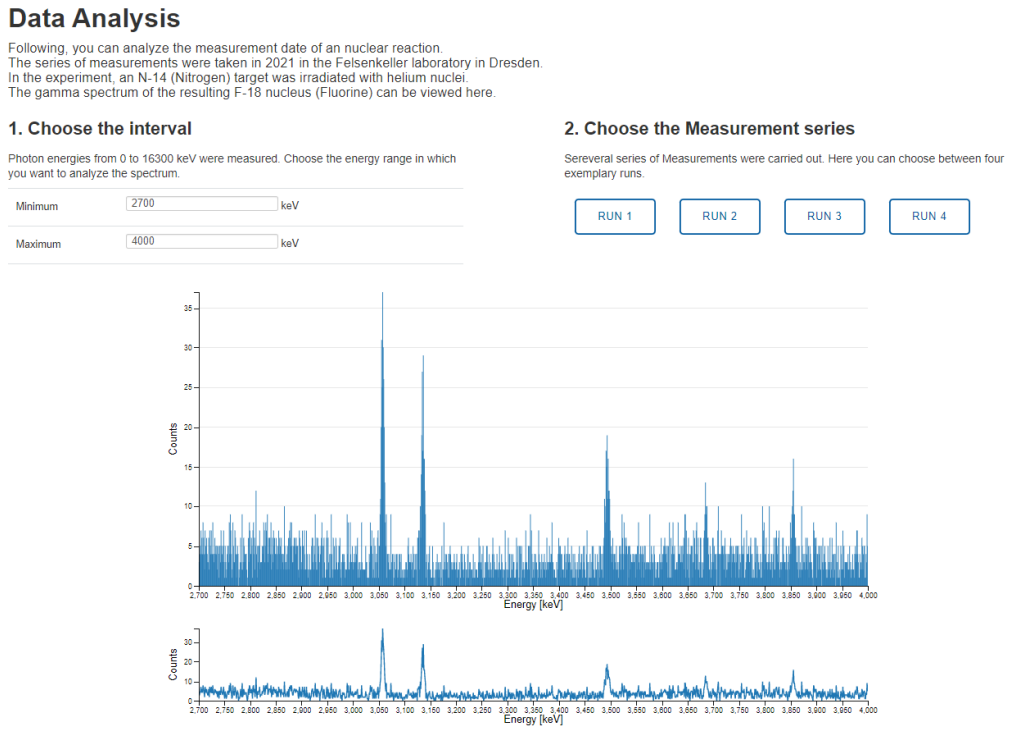
First Masterclass: a journey through the elements

- **Centerpiece** of the Masterclass:
  Analysis of a **nuclear reaction**
  - ➢ **Reaction rates**
- Measurement carried out at the
  Felsenkeller Laboratory
  Underground ion accelerator lab in Dresden, Germany
- Research question:
  Where do the neutrons come from?
- Data analysis of $^{14}\mathrm{N}(\alpha,\gamma)^{18}\mathrm{F}$
  - Start of a reaction chain taking place in
    red giant stars towards the end of helium burning
  - Important neutron source for s-processes



First Masterclass: a journey through the elements

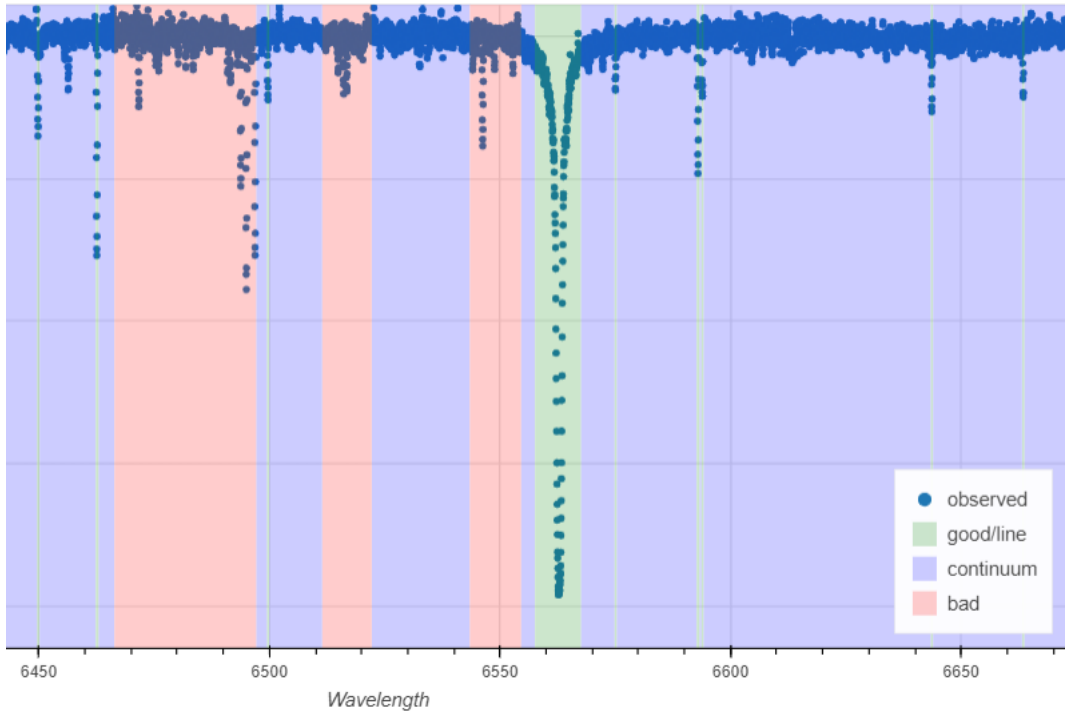
- **Centerpiece** of the Masterclass:
  Analysis of a **nuclear reaction**
  - ➢ **Reaction rates**
- **Tasks** of the learners:
  - Gamma spectroscopy & peak measurements
  - Usage of a term diagram
  - Consideration of the underground
  - Determination of the cross section & reaction rate
- **Goals**:
  - Working as a nuclear physicist for one day
  - Gain an insight into the laboratory and the working methods of a nuclear physicist



Data Analysis Webtool

Second Masterclass: Fingerprints of the stars

- **Centerpiece** of the Masterclass:
  Analysis of **stellar spectra**
  - ➢ **Element abundances in old stars**
- Observations with the **VLT, FLAMES Spectrograph**
  by Astronomers at Uppsala, Sweden
- Analysis with the **WebSME online tool**
  by Johannes Puschnig
- Research question:
  Why is there so less lithium in the universe?
- Data Analysis of **spectra of old RGB-stars**
  - Measuring chemical element abundances in early stages of the universe

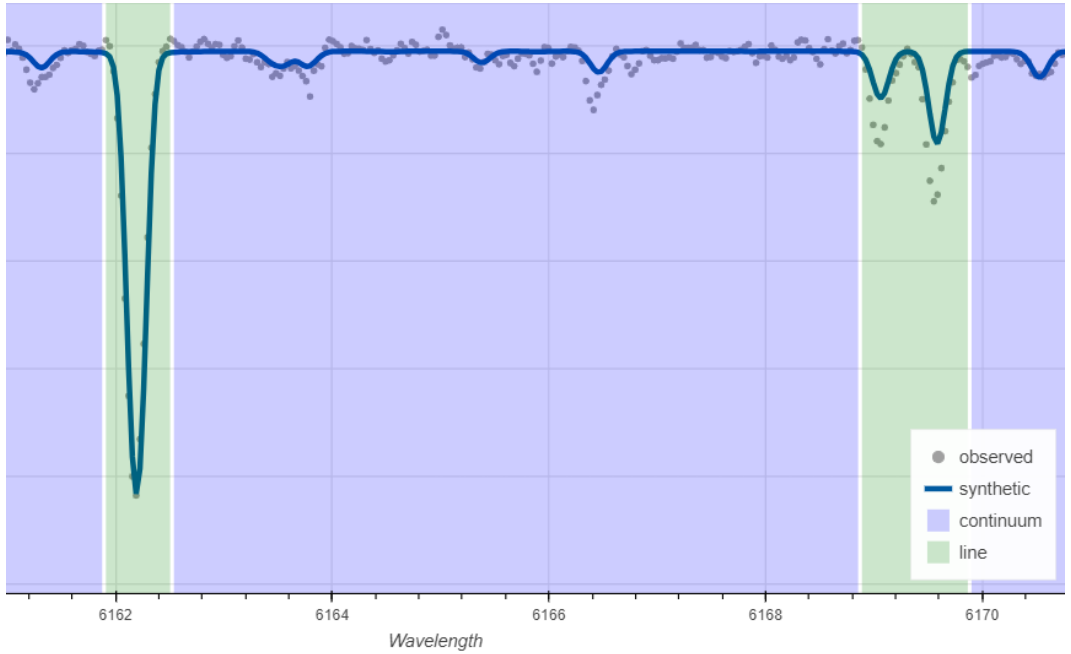


Input spectrum in WebSME

Second Masterclass: Fingerprints of the stars

- **Centerpiece** of the Masterclass:
  Analysis of **stellar spectra**
  - ➢ **Element abundances in old stars**

- **Tasks** of the students:
  - Analyse stellar spectra
  - Determine the meaning of stellar parameters
  - Element abundance measurements
  - Comparison of the measured lithium abundances with theoretical predictions



Synthetic spectrum in WebSME

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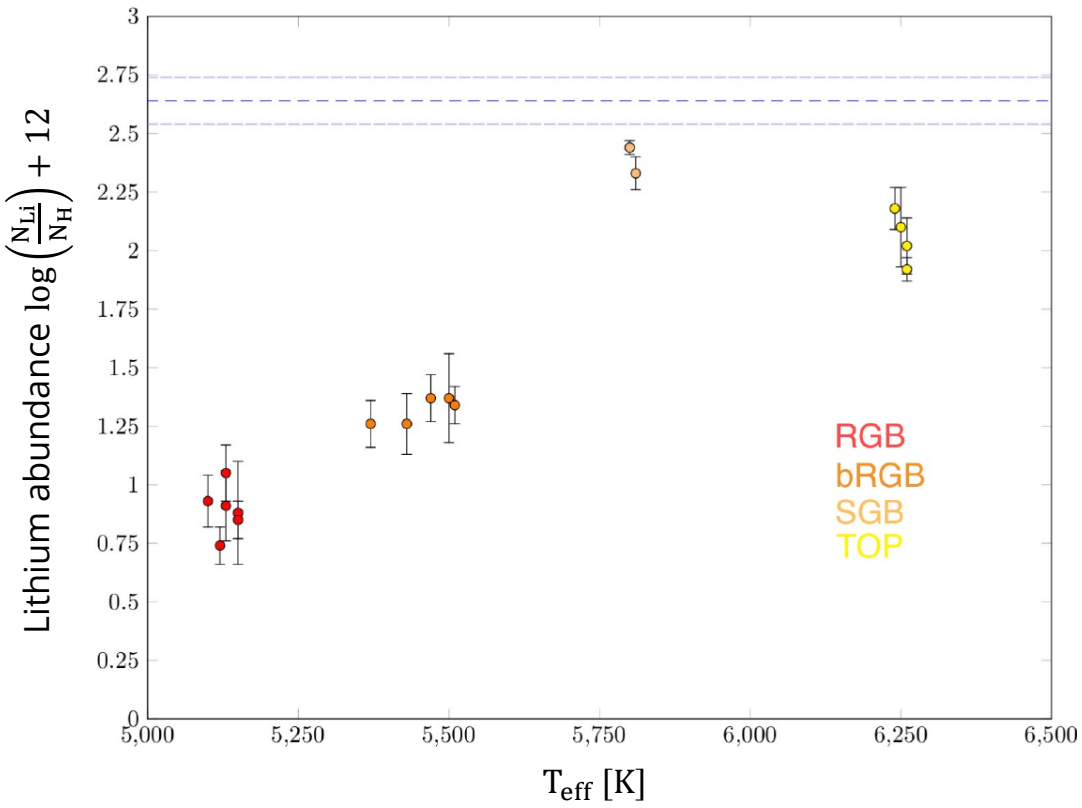

Recent Masterclass Events

- **Multiple Run Throughs with the first Masterclass**
  - Until now 14 sessions and more than 300 students
  - In Germany & Austria
- **First Run Throughs with the second Masterclass**
  - Until now 5 sessions this year and ~ 70 students
  - Masterclass @ Erkek Lisesi, Istanbul

Recent Masterclass Events

- **Masterclass Training Days**
  - @ the NPA-X Summer School
    - 1 week PhD School on nuclear astrophysics @ the CERN
    - 1 whole day for outreach activities
  - @ the Chinos PhD Summer School
    - Using activities from the masterclass for training PhDs
    - „Explain it for a student “ - Quiz
  - Discuss about how to communicate nuclear astrophysics
  - **Motivating PhD students for outreach & science communication**

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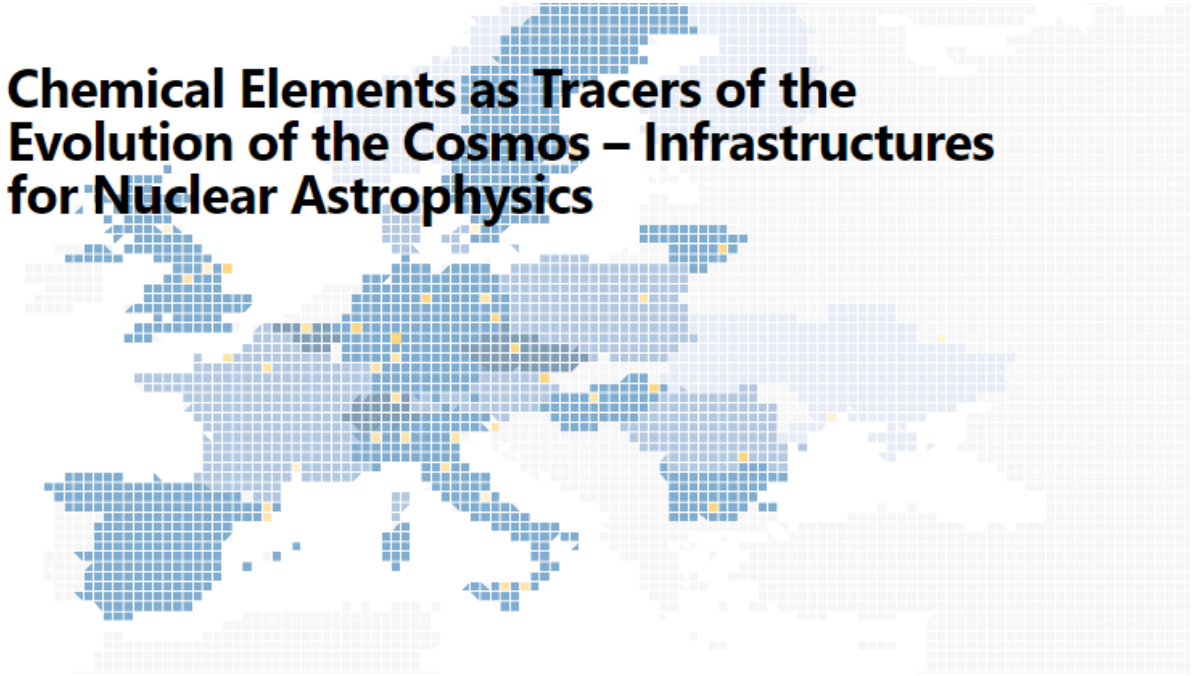
Outlook

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 @

http://mc.chetec-infra.eu

Thank you for your attention.