



HOW PHYSICS MASTERCLASSES CAN BENEFIT FROM GAMIFICATION ELEMENTS

*Gamification Elements in Nuclear Astrophysics
Masterclasses*

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*This project has received funding
from the European Union's Horizon
2020 research and innovation
programme under grant agreement
No 101008324*

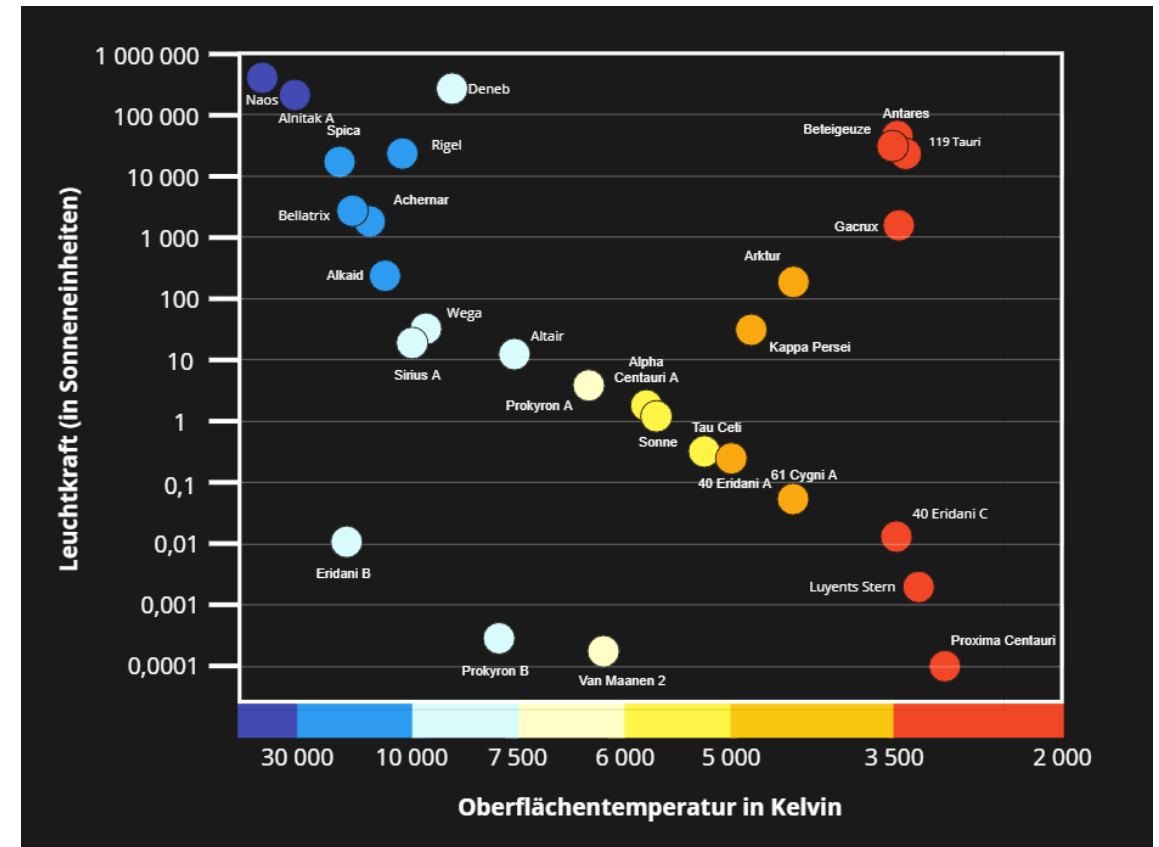
WHAT ARE WE WORKING ON?

- Development of two Nuclear Astrophysics Masterclasses
 - First masterclass available @ mc.chetec-infra.eu
 - Second masterclass coming January 2024 in German & English
- **First Masterclass**
 - 7 different languages, more coming next year:
German, English, French, Italian, Czech, Bulgarian, Sorbian, Spanish, Romanian, Swedish, Hungarian, Lithuanian, Hebrew, Catalan, Welsh
 - Approx. 300 students
- **Learning Goals**
 - Teaching the basic principles of nuclear physics & astrophysics
Nuclei structure, nuclear reactions, nucleosynthesis, stellar evolution
 - Conveying the basic idea of this science field
What questions does nuclear astrophysics?
 - Insight into the work of nuclear astrophysicists



CONTENT & MATERIALS

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



CONTENT & MATERIALS

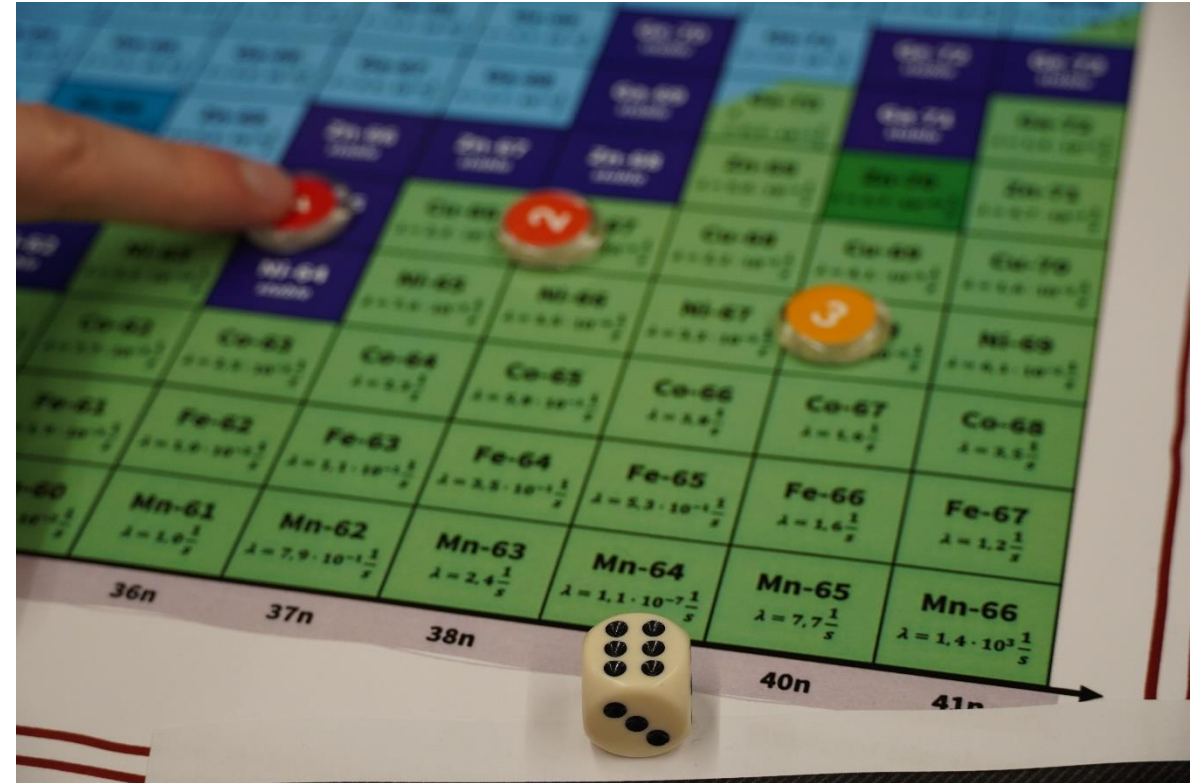
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Nuclides	Stars	Galaxies	Universe
\$ 100	\$ 100	\$ 100	\$ 100
\$ 200	\$ 200	\$ 200	\$ 200
\$ 300	\$ 300	\$ 300	\$ 300
\$ 500	\$ 500	\$ 500	\$ 500



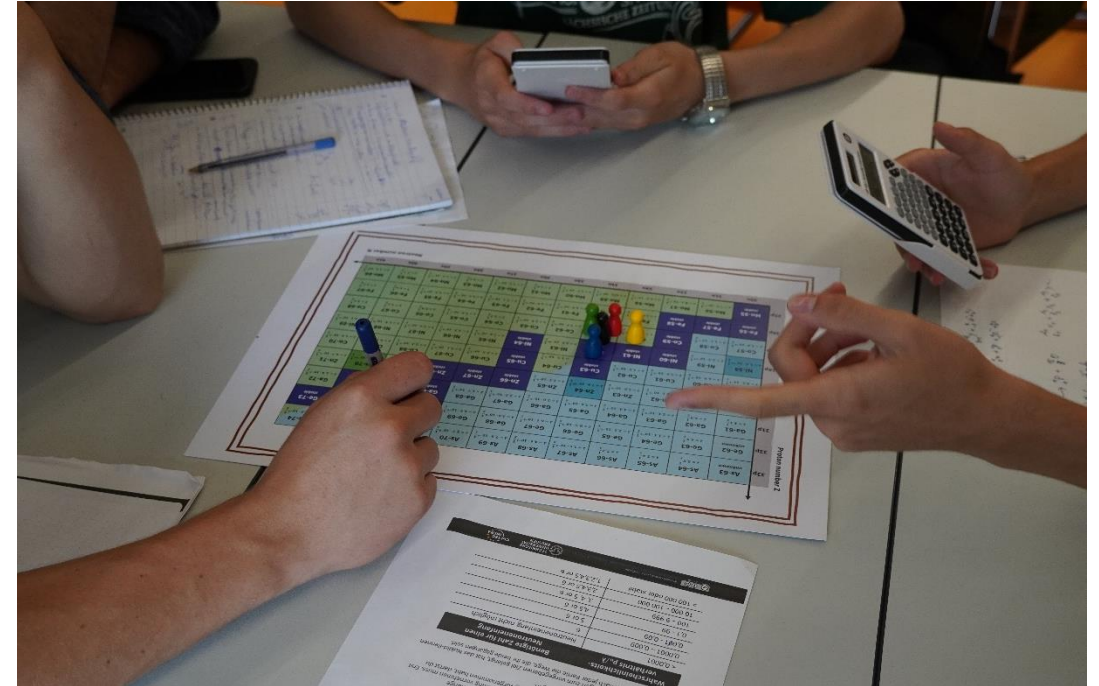
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NUCLEOSYNTHESIS OF HEAVY ELEMENTS

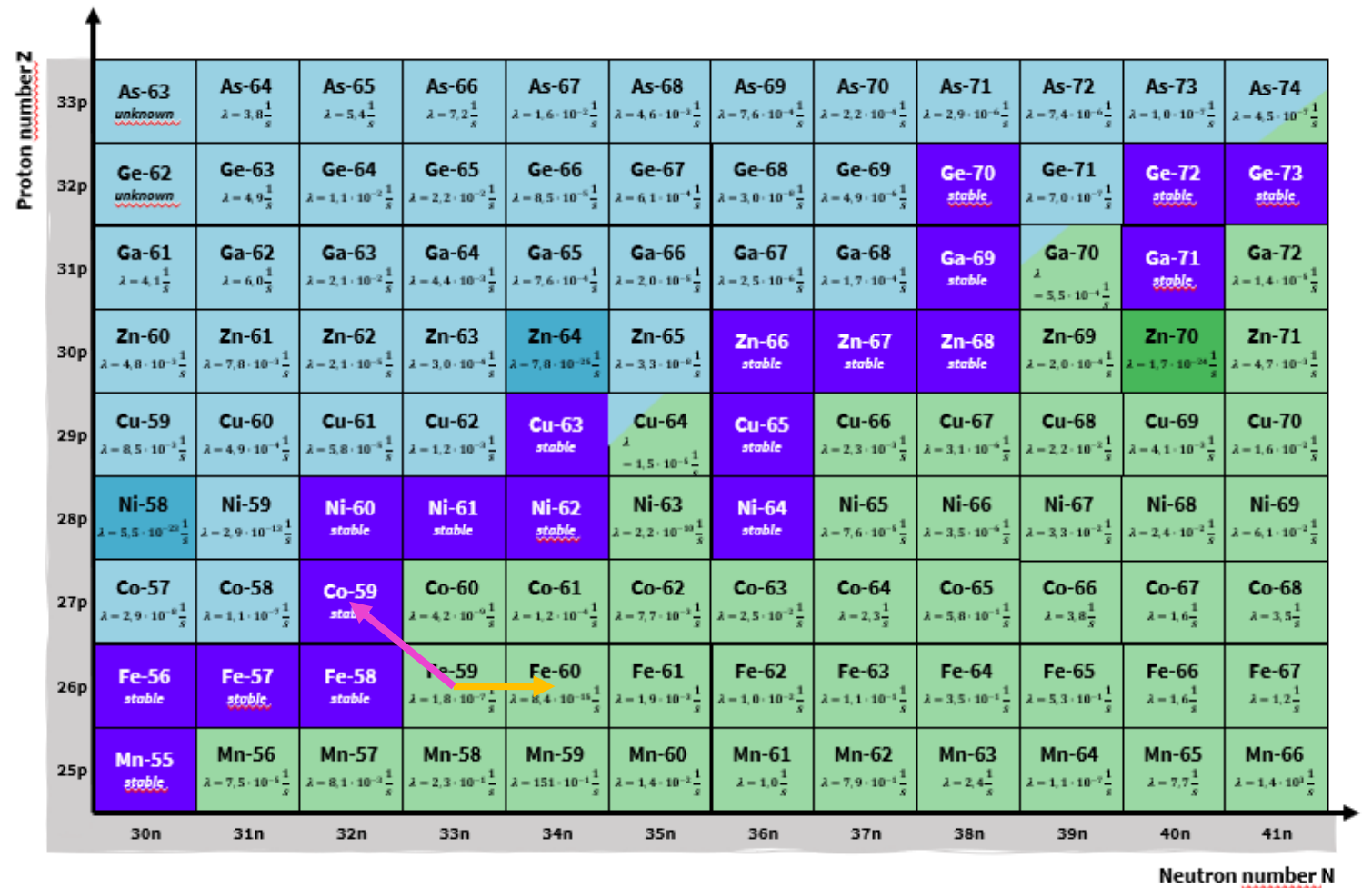
- **The Nuclei Race:**
Recreating s- and r-processes in a board game
 - Calculate the probability ratio between neutron capture and beta conversion
 - Tracing the steps on a nuclide chart
 - Clarify the difference between the s- & r-process as well as the stochastic character
- **Physical laws are simulated using Game Rules**



NUCLEOSYNTHESIS OF HEAVY ELEMENTS

➤ The Nuclide Race Principles

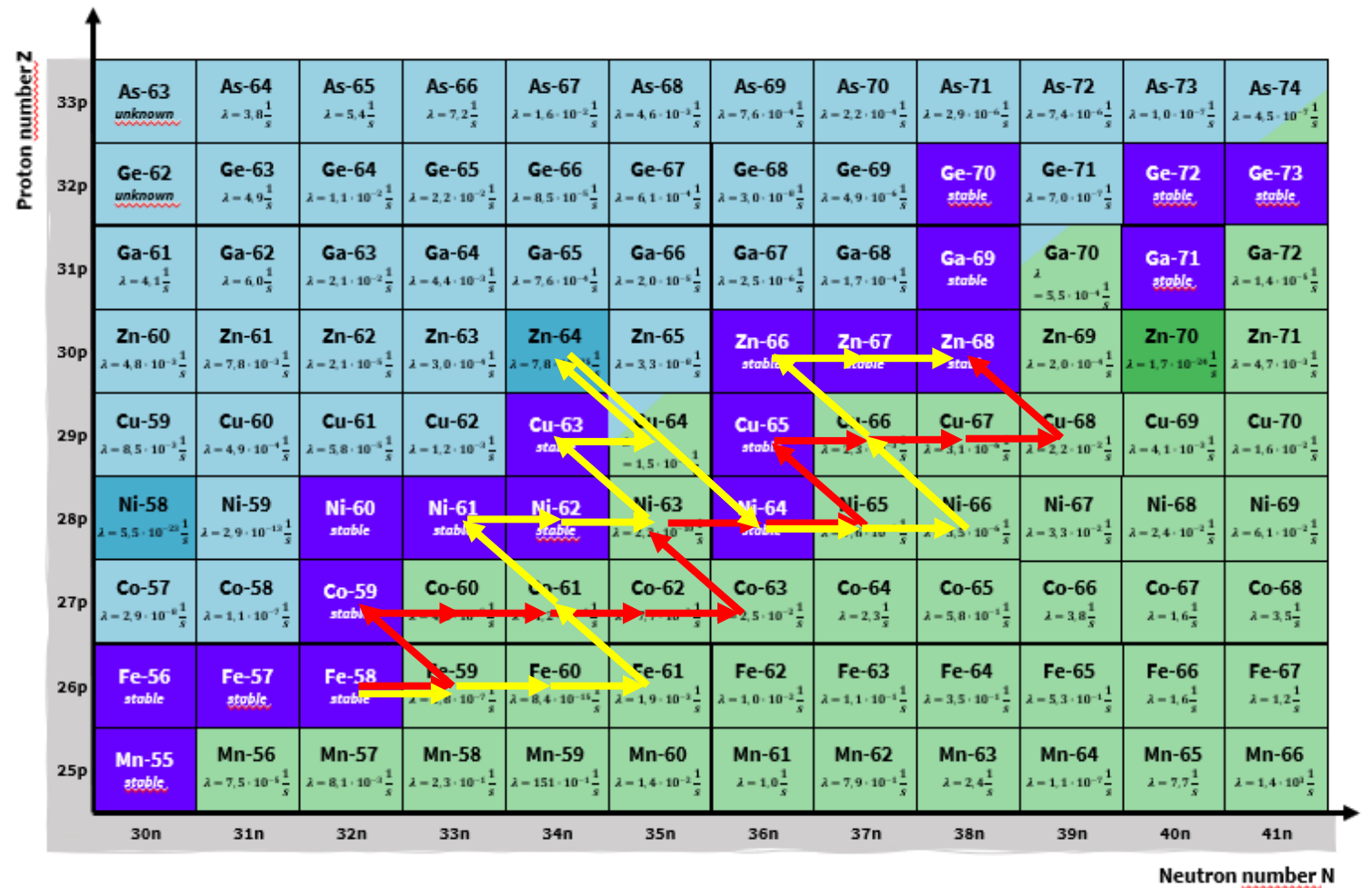
- Calculating the probability ratio between neutron capture and beta conversion
- Rolling a dice
- The number decides if the players nuclide makes a beta conversion or a neutron capture
- The players get different goals with different neutron capture rates and have to synthesize nuclides as fast as possible
- **Race in a game of dice**



NUCLEOSYNTHESIS OF HEAVY ELEMENTS

➤ Non-deterministic processes

- Every player will “roll” a different path
- Quantum mechanical properties lead to probabilities, simulated by rolling the dice



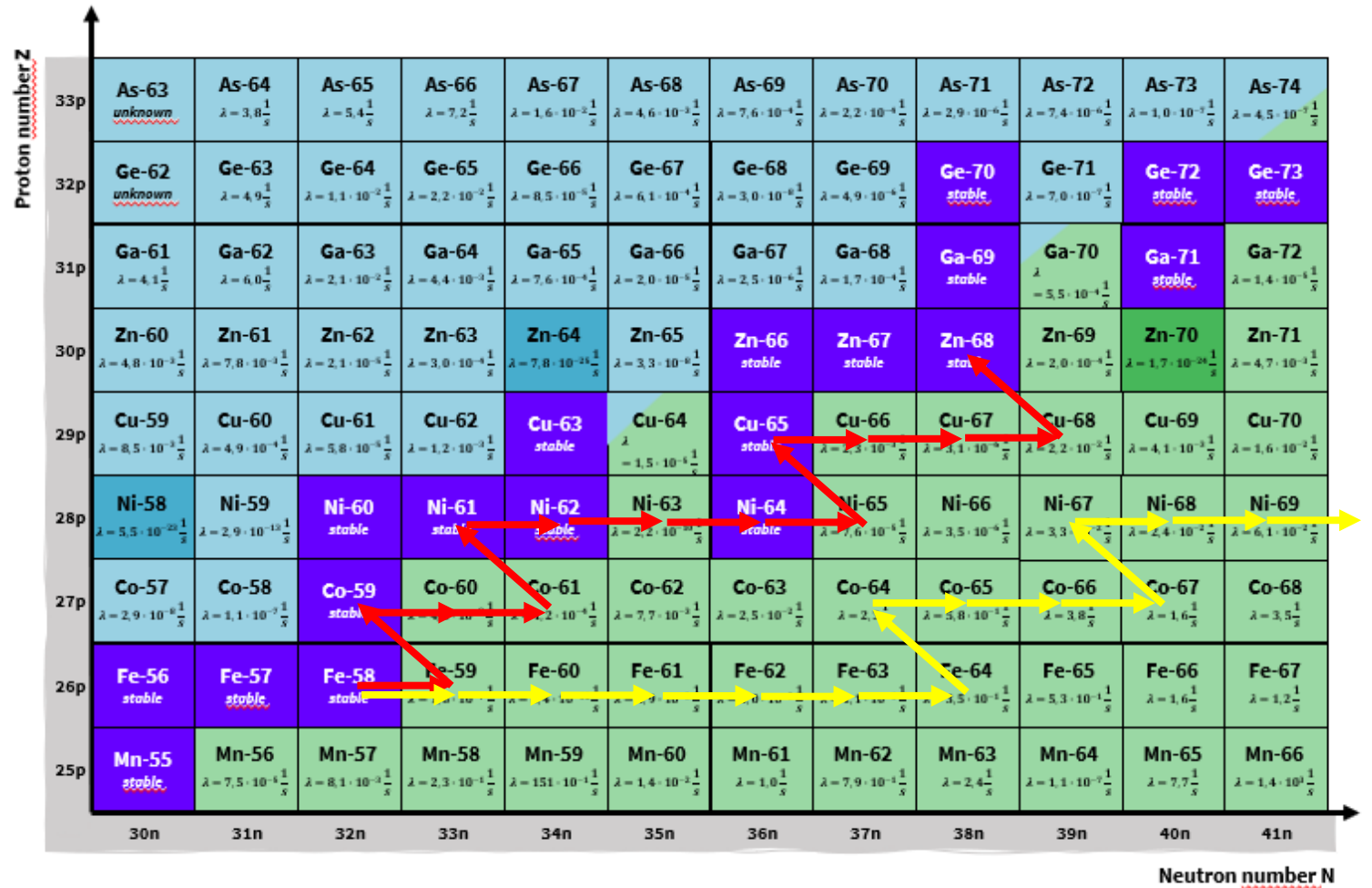
NUCLEOSYNTHESIS OF HEAVY ELEMENTS

➤ Non-deterministic processes

- Every player will “roll” a different path
- Quantum mechanical properties lead to probabilities, simulated by rolling the dice

➤ Difference between s- & r-processes

- **S-process** with low neutron capture rates (e.g. in AGB-stars during helium burning)
- **R-processes** with high neutron capture rates (supernovae-like conditions)



NUCLEOSYNTHESIS OF HEAVY ELEMENTS

- **Physical laws are simulated using Game Rules**
 - The principles illustrated by the rules of the game are the most memorable for students
 - Amazing feedback from students
 - Greater learning effect for content conveyed with gamification elements
- ***What associations do I want to build up with the game?***



PARTICLE CARDS

- Netzwerk Teilchenwelt [Particle Cards](#) with different [Game Ideas](#)



NUCLEAR ASTROPHYSICS JEOPARDY

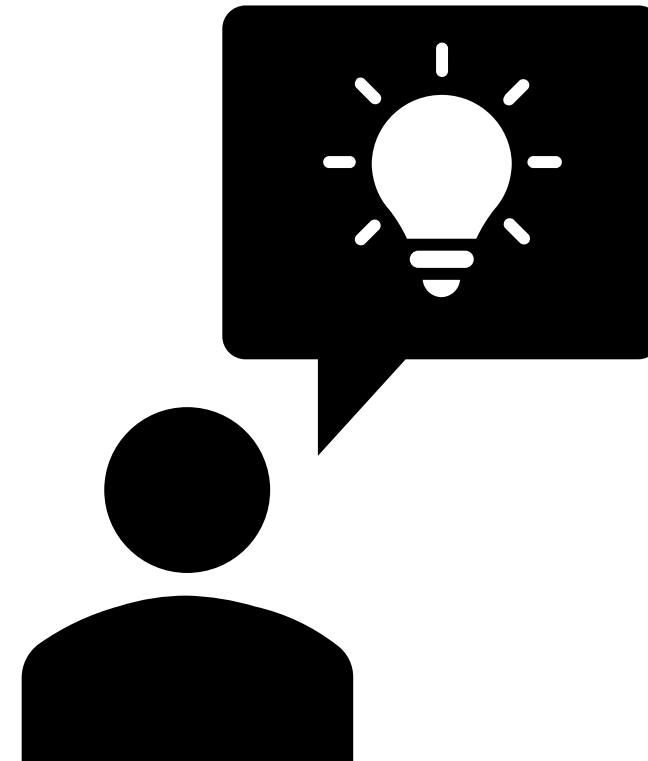
- **„Explain it for a student “ - Quiz**
Masterclass Training for PhD Students
 - Discussing physical questions
 - Evaluate the comprehensibility of the explanation
 - Motivation through competition and points system
- **Motivating PhD students for outreach & science communication**

Nuclides	Stars	Universe
Why is the earth's core composed mainly of Iron & Nickel?	Why are stars spinning?	\$ 100
\$ 200	\$ 200	How does the expansion of the universe work?
\$ 300	What is a star?	\$ 300



WHY GAMIFICATION?

- Build strong associations through fun activities
- Motivate by shifting an external learning purpose to the game objective
- Conveying a sense of autonomy
- Social integration
- ...





Masterclass can be found online @

<http://mc.chetec-infra.eu>

Thank you for your attention.

