



# **SCIENCE COMMUNICATION & NUCLEAR ASTROPHYSICS MASTERCLASSES**





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*Hannes Nitsche (TU Dresden)* hannes.nitsche@tu-dresden.de Masterclasses online @ http://mc.chetec-infra.eu

### WHO AM I?

- **2021**: State examination for Teaching (Computer Science & Physics)
- **PhD Student** @ Technische Universität Dresden, Germany
  - Chair of Didactics of Physics
  - Outreach Group of the Institute for Nuclear & Particle Physics
- I'm doing ...
  - Educational Research regarding Nuclear Astrophysics
  - Giving Masterclasses around Germany
  - Teaching as much as possible







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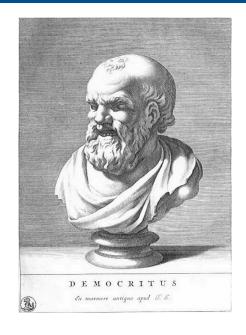


# **OUTREACH**WHY AND HOW?









- Where do we come from?
- What are we made of (and the things around us?)
- What are the rules behind all this?

#### **Explanation**







**Taxpayer** 

**Fundamental research** 

A price worth paying R. Heuer (2020) <a href="https://cerncourier.com/a/a-price-worth-paying/">https://cerncourier.com/a/a-price-worth-paying/</a>

Explanation

Legitimation

# Scientific research at CERN ... (n=1,005) Agree Disagree ...is important for everybody in the world ...is important for scientists only

... is important only for the region where the CERN is located

... is dangerous for the environment



From: Scientific Research at CERN as a Public Good: A Survey to French Citizens M. Florio et al. (2018) <a href="http://cds.cern.ch/record/2635861">http://cds.cern.ch/record/2635861</a>







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#### **Horizon Europe Programme**

#### **MISSION**

Strengthen scientific & technological bases

Boost innovation capacity, competitiveness & jobs

Deliver on citizens' priorities & sustain our socioeconomic model & values

**1** €25.8B

EXCELLENT SCIENCE

European Research Council

Marie Sklodowska-Curie actions

Research Infrastructures

**€52.7B** 

GLOBAL CHALLENGES & EUROPEA

Health

Culture, creativity & inclusive society

Civil security for society Digital, industry & space

Climate, energy & mobility

Food, bioeconomy, natural resources, agriculture & environment

**3** €13.5B

**INNOVATIVE EUROPE** 

European innovation council

European innovation ecosystem

European institute of Innovation & Technology

**( €2.1B** 

WIDENING PARTICIPATION & STRENGTHENING
THE EUROPEAN RESEARCH AREA

Spreading excellence

Reforming the European R&I system

**∜**ttopstart

European Commission proposal budget 2021-2027

**Explanation** 

Legitimation

**Visibilty** 







Leon Lederman, 1980ies

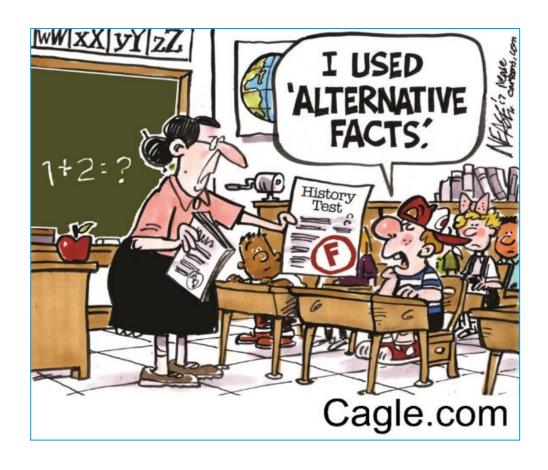
Explanation

Legitimation

Visibilty

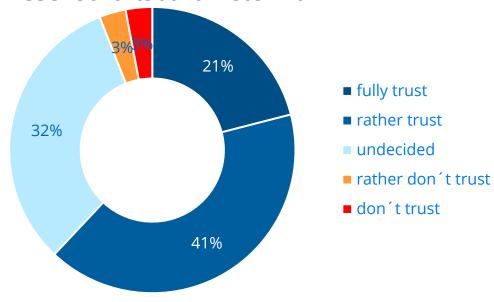
**Next generation** 





"How much do you trust science and research?"

Wissenschaftsbarometer 2021



Source: Wissenschaft im Dialog/Kantar

Explanation

Legitimation

Visibilty

Next generation

**Trust in science** 







QAA Podcast on Twitter: "Tonight's epi... twitter.com



CERN AND THE GATES OF HELL | BKOHTAKTE vk.com



Pin on For the Home pinterest.com



CERN Concern News - Home | Facebook facebook.com



LHC pinterest.com



JULY 5, 2022. WILL A PORTAL TO HELL WILL ... theworldhour.com

V

Explanation

Legitimation

Visibilty

Next generation

**Trust in science** 



#### **CONCEPT OF MASTERCLASSES**

- High school students (15 19) are "scientists for one day"
- Lectures & Hands-on activities
- Held by (young) physicists, e.g. PhD students
- At a research institute or university or classroom







#### THE IDEA BEHIND MASTERCLASSES

#### Act as a "scientist for a day"

- Close to current research
- Own "hands-on" activities (listen = forget, see = remember, do = understand)

#### **Authentic experiences**

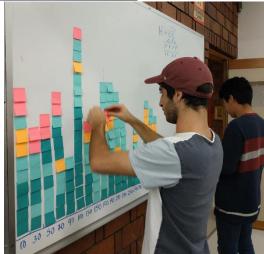
- Analysis of real scientific data
- Meeting and discussion with scientists

#### **Get insight into the research process**

- Use of relevant methods and tools
- Comparisons between experiment and theory











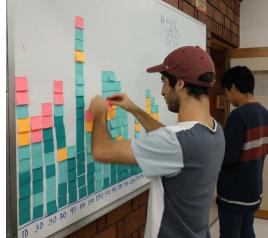
#### THE IDEA BEHIND MASTERCLASSES

Existing programs and structures create **multiple benefit** 

- win for **high school students**:
   ´experience modern research first-hand
- win for facilitators/PhD students:
   train their communication skills,
   participate in a rewarding activity,
   learn more about their own science
- win for **physicists**: get young talents for the research groups











# Nuclear Astrophysics Masterclasses





# What are we working on?

- Development of two Nuclear Astrophysics Masterclasses
  - First Masterclass available
     mc.chetec-infra.eu
  - Second Masterclass coming End of 2023
- Languages
  - German, English, French, Italian,
     Czech, Bulgarian, Sorbian
  - Spanish, Romanian, Swedish, Hungarian, Lithuanian, Hebrew, *Hindi, Catalan, Welsh*







# What are we working on?

- 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
    Education is that which remains when one has forgotten everything he learned in school.



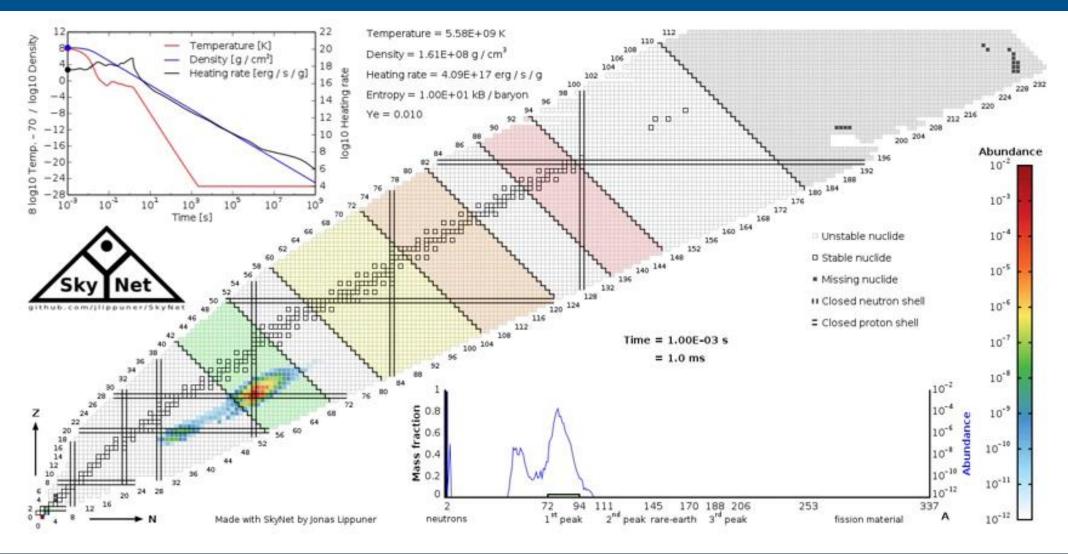


# INSIGHT INTO THE CONTENT AND MATERIALS





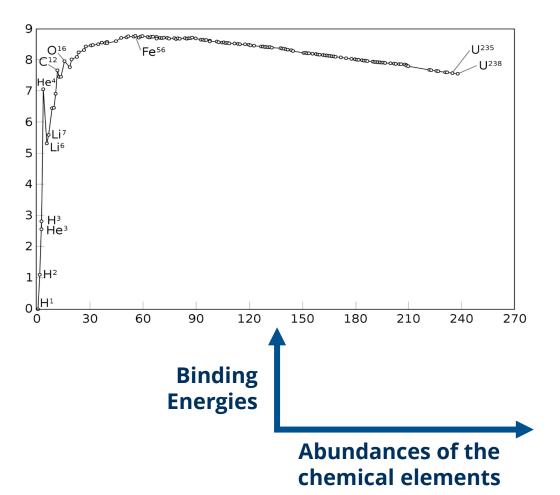
# **R-Process in Action**

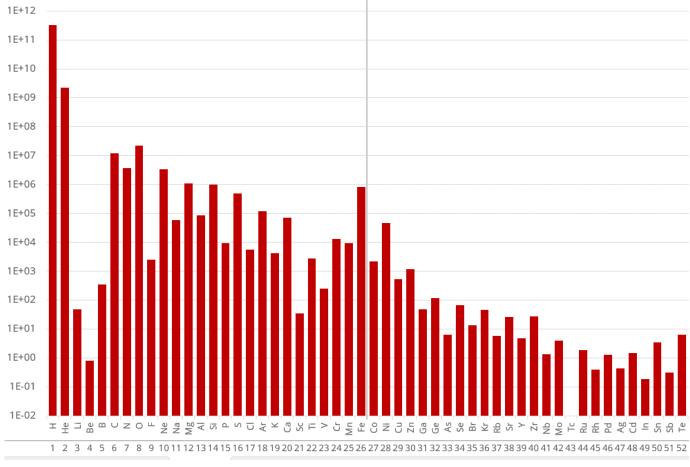






# S- & R-PROCESS







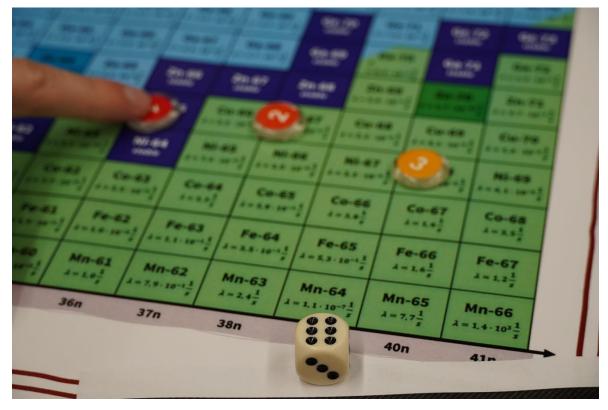


# S- & R-PROCESS

#### > 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 map
- Clarify the difference between the s- & r-process as well as the stochastic character







### S- & R-PROCESS

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	stabil	stabil	stabil	$\lambda = 1.8 \cdot 10^{-7} \frac{1}{s}$	$\lambda = 8.4 \cdot 10^{-15} \frac{1}{s}$	$\lambda = 1,9 \cdot 10^{-3} \frac{1}{s}$	$\lambda = 1, 0 \cdot 10^{-2} \frac{1}{s}$	$\lambda = 1, 1 \cdot 10^{-1} \frac{1}{s}$	$\lambda = 3.5 \cdot 10^{-1} \frac{1}{s}$	$\lambda = 5, 3 \cdot 10^{-1} \frac{1}{s}$	$\lambda = 1, 6\frac{1}{s}$	$\lambda = 1, 2\frac{1}{s}$
26р	Fe-56	Fe-57	Fe-58	Fe-59	Fe-60	Fe-61	Fe-62	Fe-63	Fe-64	Fe-65	Fe-66	Fe-67
27р	Co-57 $\lambda = 2, 9 \cdot 10^{-8} \frac{1}{s}$	Co-58 $\lambda = 1.1 \cdot 10^{-7} \frac{1}{s}$	Co-59 stabil	Co-60 $\lambda = 4.2 \cdot 10^{-9} \frac{1}{s}$	Co-61 $\lambda = 1.2 \cdot 10^{-4} \frac{1}{s}$	Co-62 $\lambda = 7, 7 \cdot 10^{-3} \frac{1}{s}$	Co-63 $\lambda = 2, 5 \cdot 10^{-2} \frac{1}{s}$	$\mathbf{Co-64}$ $\lambda = 2, 3\frac{1}{s}$	Co-65 $\lambda = 5.8 \cdot 10^{-1} \frac{1}{s}$	$Co-66$ $\lambda = 3, 8\frac{1}{s}$	$Co-67$ $\lambda = 1, 6\frac{1}{s}$	$\mathbf{Co-68}$ $\lambda = 3, 5\frac{1}{s}$
28р	Ni-58 $\lambda = 5, 5 \cdot 10^{-23} \frac{1}{s}$	Ni-59 $\lambda = 2, 9 \cdot 10^{-13} \frac{1}{s}$	Ni-60 stabil	Ni-61 stabil	Ni-62 stabil	Ni-63 $\lambda = 2, 2 \cdot 10^{-10} \frac{1}{s}$	Ni-64 stabil	Ni-65 $\lambda = 7, 6 \cdot 10^{-5} \frac{1}{s}$	Ni-66 $\lambda = 3.5 \cdot 10^{-6} \frac{1}{s}$	Ni-67 $\lambda = 3, 3 \cdot 10^{-2} \frac{1}{s}$	Ni-68 $\lambda = 2.4 \cdot 10^{-2} \frac{1}{s}$	Ni-69 $\lambda = 6, 1 \cdot 10^{-2} \frac{1}{s}$
29р	$Cu-59$ $\lambda = 8, 5 \cdot 10^{-3} \frac{1}{s}$	Cu-60 $\lambda = 4.9 \cdot 10^{-4} \frac{1}{s}$	Cu-61 $\lambda = 5.8 \cdot 10^{-5} \frac{1}{s}$	Cu-62 $\lambda = 1.2 \cdot 10^{-3} \frac{1}{s}$	Cu-63 stabil	Cu-64 $\lambda = 1.5 \cdot 10^{-5} \frac{1}{s}$	Cu-65 stabil	Cu-66 $\lambda = 2, 3 \cdot 10^{-3} \frac{1}{s}$	$Cu-67$ $\lambda = 3, 1 \cdot 10^{-6} \frac{1}{s}$	$Cu-68$ $\lambda = 2, 2 \cdot 10^{-2} \frac{1}{s}$	Cu-69 $\lambda = 4.1 \cdot 10^{-3} \frac{1}{s}$	Cu-70 $\lambda = 1.6 \cdot 10^{-2} \frac{1}{s}$
30р	$Zn-60$ $\lambda = 4.8 \cdot 10^{-3} \frac{1}{s}$	$ Zn-61 $ $ \lambda = 7.8 \cdot 10^{-3} \frac{1}{s} $	$ Zn-62 $ $ \lambda = 2, 1 \cdot 10^{-5} \frac{1}{s} $	$ Zn-63 $ $ \lambda = 3, 0 \cdot 10^{-4} \frac{1}{s} $	$ Zn-64 $ $ \lambda = 7.8 \cdot 10^{-25} \frac{1}{s} $	$ Zn-65 $ $ \lambda = 3, 3 \cdot 10^{-8} \frac{1}{s} $	Zn-66 stabil	Zn-67 stabil	Zn-68 stabil	$Zn-69$ $\lambda = 2, 0 \cdot 10^{-4} \frac{1}{s}$	$ Zn-70  \lambda = 1.7 \cdot 10^{-24} \frac{1}{s} $	$ \mathbf{Zn-71} $ $ \lambda = 4, 7 \cdot 10^{-3} \frac{1}{s} $
31р	$Ga-61$ $\lambda = 4, 1\frac{1}{s}$	$Ga-62$ $\lambda = 6, 0\frac{1}{s}$	Ga-63 $\lambda = 2.1 \cdot 10^{-2} \frac{1}{s}$	Ga-64 $\lambda = 4.4 \cdot 10^{-3} \frac{1}{s}$	$Ga-65$ $\lambda = 7, 6 \cdot 10^{-4} \frac{1}{s}$	Ga-66 $\lambda = 2, 0 \cdot 10^{-5} \frac{1}{s}$	Ga-67 $\lambda = 2.5 \cdot 10^{-6} \frac{1}{s}$	Ga-68 $\lambda = 1.7 \cdot 10^{-4} \frac{1}{s}$	Ga-69 stabil	$Ga-70$ $\lambda = 5, 5 \cdot 10^{-4} \frac{1}{s}$	Ga-71 stabil	<b>Ga-72</b> $\lambda = 1.4 \cdot 10^{-5} \frac{1}{s}$
32p	Ge-62 unbekannt	$Ge-63$ $\lambda = 4, 9\frac{1}{s}$	Ge-64 $\lambda = 1.1 \cdot 10^{-2} \frac{1}{s}$	Ge-65 $\lambda = 2, 2 \cdot 10^{-2} \frac{1}{s}$	$Ge-66$ $\lambda = 8, 5 \cdot 10^{-5} \frac{1}{s}$	Ge-67 $\lambda = 6, 1 \cdot 10^{-4} \frac{1}{s}$	Ge-68 $\lambda = 3, 0 \cdot 10^{-8} \frac{1}{s}$	Ge-69 $\lambda = 4.9 \cdot 10^{-6} \frac{1}{s}$	Ge-70 stabil	Ge-71 $\lambda = 7.0 \cdot 10^{-7} \frac{1}{s}$	Ge-72 stabil	Ge-73 stabil
33р	As-63 unbekannt	As-64 $\lambda = 3.8 \frac{1}{s}$	$As-65$ $\lambda = 5, 4\frac{1}{s}$	As-66 $\lambda = 7, 2\frac{1}{s}$	As-67 $\lambda = 1.6 \cdot 10^{-2} \frac{1}{s}$	As-68 $\lambda = 4.6 \cdot 10^{-3} \frac{1}{s}$	As-69 $\lambda = 7.6 \cdot 10^{-4} \frac{1}{s}$	As-70 $\lambda = 2, 2 \cdot 10^{-4} \frac{1}{s}$	As-71 $\lambda = 2.9 \cdot 10^{-6} \frac{1}{s}$	As-72 $\lambda = 7.4 \cdot 10^{-6} \frac{1}{s}$	As-73 $\lambda = 1.0 \cdot 10^{-7} \frac{1}{s}$	As-74 $\lambda$ = 4,5 · 10 <sup>-7</sup> $\frac{1}{s}$





- Various Lectures linking the activities
- Videos & Visualizations
- Multiple Activities with Gamification Elements, e.g. ...
  - Nuclei Race
  - Primordial nucleosynthesis puzzle
  - Playful Challenges
  - Building a Hertzsprung–Russell diagram together

Nuclides	Stars	Galaxies	Universe
\$ 100	\$ 100	<b>\$ 100</b>	<b>\$ 100</b>
\$ 200	\$ 200	\$ 200	\$ 200
\$ 300	\$ 300	\$ 300	\$ 300
\$ 500	\$ 500	\$ 500	\$ 500





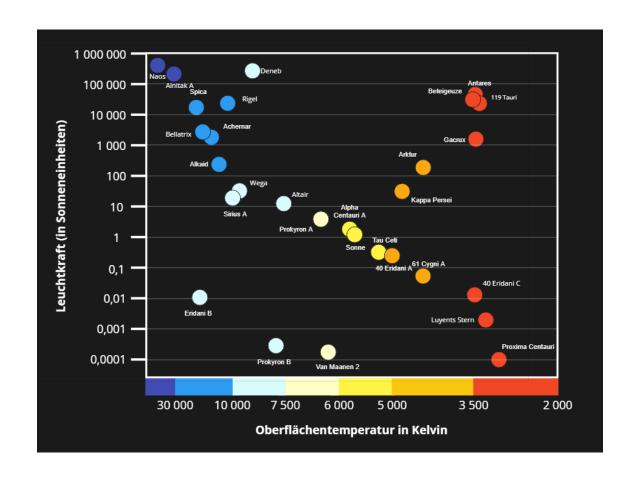
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\$ 300	\$ 300	\$ 300





**Nuclides** Stars Universe Why are Why is the earth's How do we know core composed mainly of Iron & Nickel? how old the stars universe is? spinning? Why are Lithium and Beryllium so Why do stellar How does the spectra have expansion of the absorption lines? universe work? rare? Why is there What was What is a radioactivity before the star? at all? **Big Bang?** 





#### **Centerpiece** of the Masterclass:

Analysis & evaluation of a nuclear astrophysics experiment

#### 1. Masterclass

- Nuclear Reaction Measurements carried out at the Felsenkeller Laboratory
- Data analysis of  $^{14}N(\alpha, \gamma)^{18}F$ 
  - Gamma spectroscopy & peak measurements
  - usage of a term diagram
  - Consideration of the underground
  - Determination of the cross section & reaction rate

#### 2. Masterclass

- Stellar Spectra provided by Andreas
- Analysis of Lithium Abundances
  - Astronomical Spectroscopy
  - Deriving stellar parameters
  - Calculating Abundances with WebSME
  - Reconstructing the cosmological lithium problem

#### Goals:

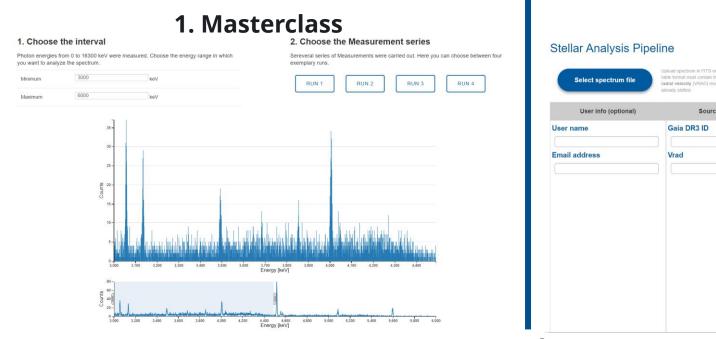
- Working as a Physicist for one day
- Gain an Insight into the Laboratory and the working methods of Nuclear & Astrophysicists



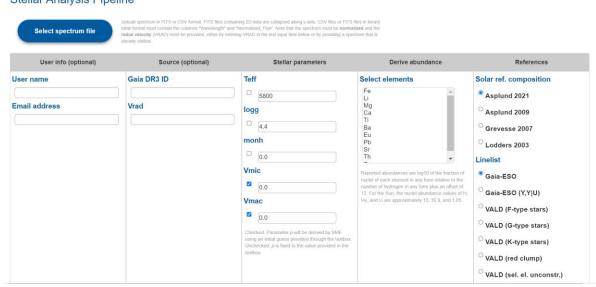


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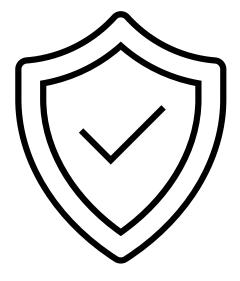
# GENERAL **DESIGN ASPECTS**OF THE MASTERCLASSES





#### 1. Low Threshold

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







#### 1. Low Threshold

#### 2. Accessability

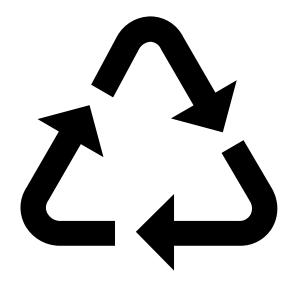
- Masterclass available in both online and live formats
- Open Access to all materials online
- No software installations necessary
- Analog materials can be recreated easily







- 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







- 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





# How can you contribute?



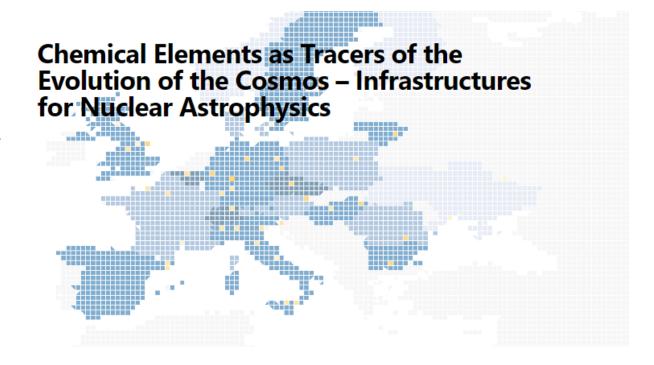


#### How can you Contribute?

#### 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









# How can you Contribute?

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





#### How can you Contribute?

#### **Connecting with Schools & Students**

- Talk to your supervisor
- Masterclass contacts at your institute?
   Outreach / public engagement officer at your institute or faculty?
- Check out NuPECC, PANS (Public Awareness of Nuclear Science)
- School contact office, Newsletter, mailing, social media, Contact your former school
- Cooperation with a school lab, or networks, e.g.
   STEM schools
- Contact Hannes!

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.



