

## Origin of the Elements and Nuclear History of the Universe (EuroGENESIS)

### MASCHE Mid-term Report

#### Part A. General information on the CRP and personnel

##### A.1. Overview of the CRP

<b>CRP Number:</b>	09-EuroGENESIS-FP-003
<b>CRP Title and Acronym:</b>	Massive Stars as Agents of Chemical Evolution (MASCHE)
<b>Project Leader (PI 1):</b>	Prof. Friedrich-Karl Thielemann, Switzerland
<b>Co-Project Leader (PI 2):</b>	Prof. Roland Diehl, Germany
<b>Principal Investigator 3:</b>	Prof. Klaus Blaum, Germany
<b>Principal Investigator 4:</b>	Dr. Zsolt Fülöp, Hungary
<b>Principal Investigator 5:</b>	Prof. Recep Taygun Güray, Turkey
<b>Associated Partner 1:</b>	Dr. Daniel Bemmerer, Germany
<b>Associated Partner 2:</b>	Dr. Alessandro Chieffi, Italy
<b>Associated Partner 3:</b>	Prof. Claes Fransson, Sweden
<b>Associated Partner 4:</b>	Dr. Raphael Hirschi, United Kingdom
<b>Associated Partner 5:</b>	Dr. Gabriel Martinez-Pinedo, Germany
<b>Associated Partner 6:</b>	Prof. Francesca Matteucci, Italy
<b>Associated Partner 7:</b>	Dr. Nikolas Prantzos, France
<b>Associated Partner 8:</b>	Dr. Anton Wallner, Austria
<b>Associated Partner 9:</b>	Prof. Kai Zuber, Germany
<b>CRP start and end dates:</b>	<b>01 Sep 2010 / 30 Aug 2013</b>
<b>CRP website:</b>	<a href="http://www.mpe.mpg.de/gamma/science/lines/eurogenesis/MASCHE_home.html">http://www.mpe.mpg.de/gamma/science/lines/eurogenesis/MASCHE_home.html</a>

##### Topics of the Call for Proposals addressed by the CRP

**A2. Individual Projects (IPs) / Associated Projects (APs)****Principal Investigator:****Prof. Friedrich-Karl Thielemann**

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 Switzerland  
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**Amount of funding granted:**      **networking funds**

**IP start and end date:**      **01 Sep 2010 / 30 Aug 2013**

**IP website:**                      <http://www.physik.unibas.ch/dept/pages/de/personnel/thielemann.htm>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Massive-Star and Supernova Models, including nuclear reaction treatment**

**Scientific & technical personnel involved in the Individual Project (IP)****Personnel directly funded under the CRP budget****Personnel funded through sources other than the CRP budget**

F.-K. Thielemann, prof, nuclear astrophysics  
 M. Liebendörfer, SNF-prof., computational astrophysics, supernova core collapse  
 M. Pignatari, SNF Ambizione Fellow, stellar evolution and s-process  
 T. Rauscher, lecturer, nuclear astrophysics and nuclear reactions  
 A. Arcones, Feodor-Lynen postdoc, nucleosynthesis, r-process  
 R. Cabezón, HP2C (High performance and high productivity computing) postdoc, 3D hydrodynamics  
 M. Hempel, SNF postdoc, high density equation of state of compact objects/neutron stars  
 N. Nishimura, SNF postdoc, nucleosynthesis, r-process  
 N. Vassetz, HP2C postdoc, general relativity, neutron stars and black holes  
 U. Battoni, SNF graduate student, stellar evolution and accretion onto white dwarfs  
 S. Fehlmann, SNF graduate student, accretion onto neutron stars and X-ray bursts  
 U. Frischknecht, SNF graduate student, stellar evolution with rotation and s-process  
 R. Käppeli, SNF graduate student, magnetohydrodynamics, core collapse with rotation/magn. fields  
 A. Perego, department graduate student, neutrino transport in supernovae, neutron star mergers,  
 C. Winteler, SNF graduate student, big bang nucleosynthesis, nucleosynthesis in supernovae with polar jets

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Principal Investigator:

#### Prof. Roland Diehl

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 85741 Garching  
 Germany  
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**Amount of funding granted:**      networking funds

**IP start and end date:**      01 Sep 2010 / 30 Aug 2013

**IP website:**    <http://www.mpe.mpg.de/~rod/rod.html>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Observations in X-rays and gamma-rays on massive stars and supernovae and their afterglows (radioactivities, SNR); modeling massive star group impacts on their surrounding ISM**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

#### Personnel funded through sources other than the CRP budget

Roland Diehl, Senior Staff Scientist, PI of INTEGRAL/SPI telescope, PI in Excellence Cluster Universe; analysis of XMM-Newton and INTEGRAL data on galactic SNR and massive-star groups  
 Pierrick Martin, PostDoc (until Feb 2011), analysis of SPI data on  $^{26}\text{Al}$  regions and positron annihilation  
 Rasmus Voss, PostDoc (until Oct 2010), modeling of massive star groups  
 Martin Krause, PostDoc (Aug 2011 - Jun 2012), simulations of ISM around massive stars and supernovae  
 Karsten Kretschmer, PhD student (till Sep 2011), PostDoc (Oct 2011 - May 2012), data analysis SPI/ $^{26}\text{Al}$   
 Michael Lang, PhD student (till Dec 2010), INTEGRAL data analysis and  $^{60}\text{Fe}$  study  
 Frauke Alexander, PhD (since Feb 2012), data analysis and modelling of Sco-Cen massive-star groups  
 Daniel Lubos, grad.stud. (Dipl.) (Sep 2011 - Oct 2012), data analysis XMM/SPI Orion-Eridanus region  
 Xiaoling Zhang, PostDoc, INTEGRAL Science Data and Software Archive Maintenance

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Principal Investigator:

#### Prof. Klaus Blaum

Gentner lab, room 132  
 Max-Planck-Institut für Kernphysik  
 Saupfercheckweg 1  
 69117 Heidelberg  
 Germany  
 Email: klaus.blaum@mpi-hd.mpg.de

**Amount of funding granted:**      **networking funds**

**IP start and end date:**              **01 Mar 2011 / 30 Aug 2013**

**IP website:**                              <http://www.mpi-hd.mpg.de/blaum/members/blaum.en.html>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**High-precision mass spectrometry, Collinear laser spectroscopy, short-lived nuclides far from stability**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Prof. Klaus Blaum  
 Plus division members, see:  
<http://www.mpi-hd.mpg.de/blaum/members/index.en.html>

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Principal Investigator:

#### Dr. Zsolt Fülöp

Hungarian Academy of Sciences  
 Institute of Nuclear Research (ATOMKI)  
 POB. 51  
 4001 Debrecen  
 Hungary  
 Tel: +36 52 509200  
 Email: fulop@atomki.hu

**Amount of funding granted:** 21,998,000 HUF + networking funds

**IP start and end date:** 01 May 2010 / 30 May 2013

**IP website:** [http://www.atomki.hu/atomki/IonBeam/nag/staff\\_en.html](http://www.atomki.hu/atomki/IonBeam/nag/staff_en.html)

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Nuclear reaction experiments: Low energy cross section determination, p-process, elastic scattering, optical potential, half-lives**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

#### Personnel funded through sources other than the CRP budget

Zs. Fülöp (staff)  
 J. Farkas (grad. student)  
 Gy. Gyürky (staff)  
 Z. Halász (grad. student)  
 G.G. Kiss (post.doc),  
 P. Mohr (collaborating scientist)  
 E. Somorjai (professor emeritus)  
 T. Szücs (grad. student)

**A2. Individual Projects (IPs) / Associated Projects (APs)****Principal Investigator:****Assoc Prof. Recep Taygun Güray**

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 Faculty of Science and Art  
 Kocaeli University  
 Umuttepe  
 41380 Kocaeli  
 Turkey  
 Tel: +90 535 4731494  
 Email: tguray@kocaeli.edu.tr

**Amount of funding granted:** 175,175 TL + networking funds

**IP start and end date:** 01 Sep 2010 / 30 Aug 2013

**IP website:** <http://akademikpersonel.kocaeli.edu.tr/tguray/>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Nuclear reaction experiments and theory: Explosive-nucleosynthesis reactions, Nuclear reactions and their specifics in cosmic nucleosynthesis environments, Nuclear reaction studies as relevant for p-process, Radiative capture experiments, Statistical model calculations for the astrophysical processes**

**Scientific & technical personnel involved in the Individual Project (IP)****Personnel directly funded under the CRP budget**

Z. Korkulu (Ph. D. Student),	01 Oct. 2010 - 15 May 2013, 100%
E. Dikme (Ph. D. Student),	01 April 2011- 15 May 2013, 100 %

**Personnel funded through sources other than the CRP budget**

Assoc. Prof. R. T. Güray, Department of Physics, Kocaeli University  
 Assoc. Prof. N. Özkan, Department of Physics, Kocaeli University  
 Dr. C. Yalçın, Research assistant, Department of Physics, Kocaeli University

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Dr. Daniel Bemmerer

Institute for Radiation Physics  
Bautzner Landstr. 400  
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Germany  
Email: d.bemmerer@fzd.de

**Amount of funding granted:** |

**IP start and end date:** **01 Mar 2011 / 30 Aug 2013**

**IP website:** <http://www.hzdr.de/db/ContMan.Visi.Card?pUser=3802&pNid=no>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Nuclear reaction experiments for astrophysics**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Dr. Daniel Bemmerer

Dr. Zoltán Elekes

Dr. Arnd Junghans

Dipl.-Phys. Michael Anders (PhD student on  $^2\text{H}(\alpha,\gamma)^6\text{Li}$  at LUNA)

Dipl.-Phys. Konrad Schmidt (PhD student on  $^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$  at HZDR)

cand. phys. Marie-Luise Menzel (Diploma student on  $^{22}\text{Ne}(p,\gamma)^{23}\text{Na}$  at LUNA)

Mirco Dietz (Bachelor student on  $^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$  at HZDR)

**A2. Individual Projects (IPs) / Associated Projects (APs)****Associated Partner:****Dr. Alessandro Chieffi**

Istituto Nazionale di Astrofisica  
 NAF-Istituto di Astrofisica Spaziale e Fisica cosmica  
 Via del Fosso del Cavaliere 100  
 00133 Roma  
 Italy  
 Email: alessandro.chieffi@iasf-roma.inf.it

**Amount of funding granted:**

**IP start and end date:**                   **01 Sep 2010 / 30 Aug 2013**

**IP website:**                   <http://www.oa-roma.inaf.it/localinfo/staff/viewstaffdetail.php>  
 lang=en&username=chieffi (and username=limongi)

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Modeling of massive star structure and evolution, including nucleosynthesis**

**Scientific & technical personnel involved in the Individual Project (IP)****Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

Dr. Alessandro Chieffi, staff researcher, stellar evolution and nucleosynthesis  
 Dr. Marco Limongi, staff researcher, stellar evolution and nucleosynthesis



## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Prof. Claes Fransson

Stockholm University  
 Universitetsvägen 10A  
 10691 Stockholm  
 Sweden  
 Email: claes@astro.su.se

### Amount of funding granted:

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### IP start and end date:

01 Sep 2010 / 30 Aug 2013

### IP website:

<http://tft.astro.su.se/~claes/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

Observations of supernovae, modeling of supernova light curves and spectra

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Prof. Claes Fransson, supernova observations  
 Prof. Peter Lundqvist, supernova observations

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Dr. Raphael Hirschi

Astrophysics Group, EPSAM  
 Keele University  
 LJ 2.09  
 Keele ST5 5BG  
 United Kingdom  
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### Amount of funding granted: █

**IP start and end date:** 01 Sep 2010 / 30 Aug 2013

**IP website:** <http://www.astro.keele.ac.uk/~hirschi>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Modeling of stellar structure and evolution, including nucleosynthesis**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Dr. Raphael Hirschi, Lecturer in Astrophysics, Evolution of massive stars with rotation and comprehensive nucleosynthesis

M. E. Bennett, Ph D student, late evolution stages of massive stars

S. W. Jones, PhD student, progenitors of electron-capture supernovae

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Dr. Gabriel Martinez-Pinedo

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 Germany  
 Email : g.martinez@gsi.de

### Amount of funding granted:

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**IP start and end date:** 01 Sep 2010 / 30 Aug 2013

**IP website:** [http://www.gsi.de/employees/1163009815/index\\_e.html](http://www.gsi.de/employees/1163009815/index_e.html)

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Nuclear reaction theory and experiment, nucleosynthesis**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Prof. Gabriel Martinez-Pinedo, nuclear structure and reaction theory, nucleosynthesis  
 Dr. Almudena Arcones, postdoc until fall 2010, supernova neutrino wind, r-process, LEPP  
 Dr. Tobias Fischer, postdoc, supernova core collapse, neutrino transport, equation of state  
 Prof. René Reifarth, nuclear reaction experiments, s-process, p-process  
 Dr. Michael Heil, nuclear reaction experiments, s-process, p-process  
 Dr. Iris Dillmann, Helmholtz Young Investigator, nuclear reaction experiments, p-process  
 Lutz Huther, Ph D student, nuclear reaction rates, nucleosynthesis

**A2. Individual Projects (IPs) / Associated Projects (APs)****Associated Partner:****Prof. Francesca Matteucci**

Astronomy Department  
 Trieste University  
 Piazzale Europa  
 34127 Trieste  
 Italy  
 Email: matteucc@oats.inaf.it

**Amount of funding granted:**

|

**IP start and end date:** 01 Sep 2010 / 30 Aug 2013**IP website:** [http://www.gsi.de/employees/1163009815/index\\_e.html](http://www.gsi.de/employees/1163009815/index_e.html)**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

Chemical evolution modeling and data interpretations

**Scientific & technical personnel involved in the Individual Project (IP)****Personnel directly funded under the CRP budget**

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

**Personnel funded through sources other than the CRP budget**

(Name, position, nature of involvement)

Prof. Francesca Matteucci, chemical and dynamical evolution of galaxies  
 L. Vincoletto, Ph D student  
 Dr. L. Silva, staff astronomer  
 Dr. G. Granato, staff astronomer

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Dr. Nikos Prantzos

Institute Astrophysique de Paris IAP  
 98 bis Blvd Arago  
 75014 Paris  
 France  
 Email: prantzos@iap.fr

### Amount of funding granted:

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### IP start and end date:

01 Sep 2010 / 30 Aug 2013

### IP website:

<http://www2.iap.fr/users/prantzos/>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

Chemical evolution modeling and data interpretations

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Dr. Nikos Prantzos, directeur de recherche, chemical evolution of galaxies, galactic cosmic rays  
 Maxime Kubryk, PhD student, Dynamical and chemical evolution of the Milky Way

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Dr. Anton Wallner

University of Vienna  
 Wilhelm Exner Gasse 2/8  
 1090 Vienna  
 Austria  
 Email: anton.wallner@univie.ac.at

### Amount of funding granted:

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**IP start and end date:** 01 Sep 2010 / 30 Aug 2013

**IP website:** <http://physik.univie.ac.at/index.php?id=1039>  
<http://physik.univie.ac.at/index.php?id=1039>

### Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)

**Nuclear reaction experiments, neutron activation analysis, long-lived radioactivities from stellar explosions**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Dr. Anton Wallner, group leader  
 Claudia Lederer, Ph D student  
 Jenny Feige, Ph D student  
 Stefan Pavetich, master student

## A2. Individual Projects (IPs) / Associated Projects (APs)

### Associated Partner:

#### Prof. Kai Zuber

Institut für Kern- und Teilchenphysik  
 Zellescher Weg 19  
 01069 Dresden  
 Germany  
 Tel: +49 351 463 42250  
 Email: zuber@physik.tu-dresden.de

**Amount of funding granted:** █

**IP start and end date:** **01 Mar 2011 / 30 Aug 2013**

**IP website:** <http://iktp.tu-dresden.de/IKTP/mitarbeiter/Mithome.php?id=100>

**Expertise contained in the IP which is relevant to the CRP objectives and topics of the Call for Proposals (keywords)**

**Nuclear reaction experiments, underground accelerators**

### Scientific & technical personnel involved in the Individual Project (IP)

#### Personnel directly funded under the CRP budget

(Name, position, contract start/end dates; estimated percentage of work time dedicated to the programme)

#### Personnel funded through sources other than the CRP budget

(Name, position, nature of involvement)

Prof. Kai Zuber  
 Prof. Thomas Cowan

## Part B. Progress report

### B1. CRP progress and scientific highlights (max. 1500 words)

#### 1. The collaborative work (c.400-750 words)

- a. With reference to the CRP objectives and work plan, describe the work undertaken by the CRP to date and the contribution of each Individual Project to the collaboration in terms of its specific expertise and tasks/responsibilities. How closely are the partners working together?

The collaboration has been formed in summer 2010, with task distribution and collaboration setups settled during the first 7 months (including new APs Heidelberg, Dresden/Rosendorf). Annual progress meetings have been held (July 2010 Darmstadt, November 2010 Dubrovnik, Nov 2011 Basel).

Cross-CRP Miniworkshops, where members of our CRP participated or which were organized with a strong involvement of our CRP, include workshops on nuclear reaction rates, nucleosynthesis, chemical evolution issues, and dust formation in stellar winds and stellar explosions:

Madrid April 2011 (nuclear reaction rates) <http://161.111.23.207/MaKaC/internalPage.py?pagelId=0&confId=4>  
<http://161.111.23.207/MaKaC/internalPage.py?pagelId=0&confId=4>

Kocaeli May 2011 (p-process)

<http://pprocess.kocaeli.edu.tr/sponsors.html>

Basel November 2011 (chemical evolution of galaxies and nucleosynthesis input)

<http://phys-merger.physik.unibas.ch/users/group/eurogenesis>

Vienna November 2011 (cosmic dust grains as diagnostics for massive stars)

[http://www.codustmas.eu/docs/First%20circular%20-%20workshop%20Vienna%2021\\_22%20Nov.pdf](http://www.codustmas.eu/docs/First%20circular%20-%20workshop%20Vienna%2021_22%20Nov.pdf)

Research visits of individual CRP scientists to other EuroGenesis sites have been arranged (Arcones, with CRP EXNUC Barcelona, implementation of hydrocode FLASH for neutrino wind simulations in supernovae; Krause with CRP FirstStars Geneva, chemical evolution of globular clusters).

Stellar models of structure and evolution have been compared in detail among the Rome/Keele/Basel groups, test cases simulated, and comparison criteria identified; report and publication is being prepared. Underground nuclear reaction experiments for reactions in early stellar evolution have been pursued by the Debrecen and Dresden groups. Nuclear reaction rate experiments and involved theory have led to discussions and collaborations among Basel/Kocaeli/Debrecen/Darmstadt/Heidelberg groups (workshops Kocaeli, Darmstadt, Basel) with respect to s-, p- and r-process studies. Supernova core collapse simulations, nuclear equation of state tests and predictions of nucleosynthesis ejecta have been performed in collaboration of the Basel and Darmstadt groups. Chemical-evolution processes and building blocks were simulated and discussed among the Paris/Trieste/Garching groups and at the Basel Workshop.



## 2. Scientific highlights (c.400-750 words)

- a. Describe the scientific highlights and main achievements of the CRP to date. What has been the most significant/valuable contribution to knowledge so far (e.g. results, breakthroughs)?

A detailed overview of achievements, highlights and priorities for future directions is given in the summary of the joint Masche/First Stars workshop (<http://phys-merger.physik.unibas.ch/users/group/eurogenesis>) in Basel. Here we want to give a shortened summary

### **Chemical evolution issues:**

1. In order to obtain a correct understanding of chemical evolution it is important to have dense grids of stellar models in the mass ranges  $18-22M_{\text{sol}}$  and  $8-10M_{\text{sol}}$ , where strong transition in stellar structure occur, and present investigations of our stellar modelers implemented this strategy.
2. For applications tracing feedback on time scales  $<10^7\text{y}$  (e.g. interaction with ISM), the time-resolved specification of ejected matter and its composition is needed from stellar models. This means that e.g. wind ejecta need to be given with their ejection time during stellar evolution, before the final explosion.
3. Massive-star groups ionize and sweep up their surrounding interstellar clouds more rapidly than thought before; this explains why some energy is lost to cooling, and explains ISM cavity sizes. These studies and their refinements have been stimulated by EuroGenesis and Masche and will lead to a more global understanding of chemical *and dynamical* evolution of galaxies (and involved mixing processes).

### **Globular clusters:**

1. The origin of second-generation stars ( $<1 M_{\text{sol}}$ ) requires either a special IMF for the first generation stars, or a total initial stellar mass of the cluster 10 to 20 times larger than the present mass. GCs have strongly contributed to the stellar population of the Galactic halo.
2. There are indications of homogeneous metallicities within each GC, but also of self-enrichment and second generation stars with different ages and metallicities. GCs appear to be a special star formation mode early in a galaxy's evolution, and are found in all galaxy types.
2. Hydrodynamical ISM simulations which treat  $1000 M_{\text{sol}}$  within a 2 pc scale, see their evolution and the formation of second generation stars can lead to an understanding of these issues and are related to 3. In the previous section (chemical evolution).
4. The data gathered by Korn and collaborators (from First Stars) on GC stars can be used to constrain stellar models of Pop II stars, including atomic diffusion and transport processes (rotation-induced mixing, internal gravity waves).

### **Stellar evolution models:**

1. A major effort has been undertaken in comparisons of different stellar evolution codes (mainly Rome/Keele). This includes a critical examination of the implementation of mixing, such as rotation-induced mixing, semiconvection, or overshoot and mass loss prescriptions.
2. As the evolution during H- and He-burning is affected tremendously by mass loss, initial progenitor masses can lead to quite different advanced stages of stellar evolution. Therefore the size of the C/O-core is the best indicator for the final evolutionary stages and explosion properties.
3. Besides convergence on the way to utilize mixing and mass loss prescriptions, emphasis will be put on a best choice set of key nuclear reaction inputs, such as in  $^{14}\text{N}(p,\gamma)$ ,  $^{12}\text{C}(\alpha,\gamma)$ ,  $^{22}\text{Ne}(\alpha,n)$ ,... supported by input from our experimental groups,  $^{12}\text{C}+^{12}\text{C}$  (where a major study has been undertaken), and reactions for heavy nuclei, based on theoretical investigations (see below).

### **Supernovae:**

1. A major aim for our modelers of massive star evolution is to follow the evolution up to the very late stages of Si-burning, when contraction and collapse are initiated already, in order to make the best possible transition to core collapse studies.
2. There are good comparison tests between the Garching and Basel, as well as the Tokyo and Oak Ridge groups. Key issues at present are:
  - The equation of state during collapse
  - (a) improved equations of state at high densities (quark-hadron phase transition)

(b) the treatment of an NSE distribution of heavy nuclei

- full 3D neutrino transport and/or simplifications/approximations
  - full 3D general relativity or effective Newtonian potentials
  - the role of instabilities, e.g. standing accretion shock instability, magnetic instabilities
  - the role of rotation and magnetic fields, possibly leading to jet explosions
  - the p/n ratio in neutrino winds, role of sterile neutrinos, effect of collective neutrino oscillations.
3. Observations, radioactivities from lightcurve/remnant observations ( $^{56/57}\text{Ni,Co,Fe}$ ,  $^{44}\text{Ti}$ , and  $^{26}\text{Al}$ )

#### **Nuclear reactions:**

These are directly related to stellar evolution (and explosions, see above)

1. A new  $^{22}\text{Ne}(p,\gamma)$  measurement is planned
2. Given the importance of  $^{22}\text{Ne}(a,\gamma)$ , the feasibility of an experiment is will be checked
3. Dresden will investigate  $^{14}\text{N}(p,\gamma)$  (H-burning in stellar evolution) and  $^{40}\text{Ca}(\alpha,\gamma)^{44}\text{Ti}$  (explosive Si-burning in supernovae)
4. GSI/Frankfurt n-capture rates are already incorporated in Basel/Keele s-process studies
5. Close collaboration Debrecen/Basel/GSI/Giessen on KADONIS data base for p-process studies
6. Basel provides consultation/collaboration on theoretical rate investigations and comparison with experiments (Dresden/Debrecen/GSI/Kocaeli)

#### **Heavy element synthesis (key open questions and achievements):**

1. Site of the (main) r-process (neutron star mergers, polar jets in explosions with rotation and strong magnetic fields, accretion disks around black holes, ways out with sterile neutrinos in neutrino winds)? Investigations on several of these scenarios are underway.
2. What is the origin of the weak r-process?
3. Which processes contribute to the so-called LEPP region (lighter (heavy) elements primary process), (weak) r-process, vp-process, s-process (s-process uncertainties due to convective-boundary mixing and  $^{13}\text{C}$  pocket, vp-process dependence on strength of neutrino wind and neutrino spectra, r-process source?)
4. Observations (direct link to chemical evolution) play a key issue. How are element features correlated (e.g. Fe-group, LEPP or weak r-process, heavy or main r-process)?

b. List up to five of your CRP's most significant joint publications (i.e. involving co-authors from at least two IPs in your CRP or co-authors from other CRPs in the programme).

1. Diehl, Hartmann, Prantzos (editors): Astronomy with Radioactivities, Springer LNP 812 (2011), with articles by Busso, Chieffi, Diehl, Hirschi, Liebendörfer, Limongi, Prantzos, Rauscher, Thielemann (Peruga, Rome, Garching, Keele, Basel, Paris; MASCHE, CoDustMas)
2. Chiappini, C., Frischknecht, U., Meynet, G., Hirschi, R., Barbuy, B., Pignatari, M., Decressin, T., Maeder, A., Imprints of fast-rotating massive stars in the Galactic Bulge, Nature 474, 666 (2011) (Geneva, Keele, Basel; First Stars, MASCHE)
3. Bennett, M.E. , Hirschi, R., Pignatari, M. et al, The effect of  $^{12}\text{C} + ^{12}\text{C}$  rate uncertainties on the evolution and nucleosynthesis of massive stars. MNRAS 420, 3047 (2012) (Keele, Basel)
4. Szücs, T., Bemmerer, D., Cowan, T., Degering, D., Elekes, Z., Fülöp, Z., Gyürky, G. Junghans, A., Köhler, M., Marta, M. Schwengner, R., Wagner, A., Zuber, K., 2012, Eur. Phys. J. A, 48, 8 (2012) (Debrecen, Dresden)
5. Kiss G. G., P. Mohr, Zs. Fülöp, Gy. Gyürky, Z. Elekes, J. Farkas, E. Somorjai, C. Yalcin, D. Galaviz, R. T. Güray, N. Özkan, and J. Görres,  $^{110,116}\text{Cd}(\alpha,\alpha)^{110,116}\text{Cd}$  elastic scattering and systematic investigation of elastic  $\alpha$  cross sections along the  $Z = 48$  isotopic and  $N = 62$  isotonic chains", Phys. Rev. C 83, 065807 (2011) (Debrecen, Kocaeli)
6. Fischer, T., Martinez-Pinedo, G., Hempel, M., & Liebendörfer, M.: Neutrino spectra evolution during proto-neutron star deleptonization, arXiv:1112.3842, Phys. Rev. D, submitted (2012) (GSI, Basel)

## B.2. Integration of the CRP in the programme (300-600 words)

1. Describe the contribution of your CRP to the EUROCORES programme. What is the place and role of the CRP in the framework of the programme? From a scientific perspective, how well integrated is your CRP in the programme? How would you describe the intensity of interaction between your CRP and other CRPs in the programme?

MASCHE addresses all issues related to massive stars and their core-collapse supernovae, contributing to EuroGenesis' goal of cosmic nucleosynthesis investigations, aiming at a better understanding of the origins of the elements and isotopes we are made of. MASCHE contributes with respect to theories, models, and simulations of massive stars in their structure and evolution, and of core-collapse supernovae. In both these objects, characteristic nuclear reactions are addressed, the requirements for determinations of reaction rates are converted into activities in theoretical nuclear physics investigations and in experimental efforts to measure specific nuclear reaction properties in laboratory experiments. The Debrecen and Dresden groups are involved in underground accelerator activities to determine stellar reaction rates at low energies (at lowest possible background). The Kocaeli, Debrecen, and GSI/Giessen groups are strongly involved in determining reactions for explosive burning phases, with a special emphasis on the p-process. The GSI/Frankfurt group is actively pursuing neutron capture cross section measurements for s-process studies. GSI/Theory and Basel provide theoretical cross section predictions and comparisons with the experimental group. All of these results enter into stellar evolution calculations (Keele, Rome, Basel). Core collapse supernova calculations are performed at Basel and GSI, requiring weak interaction reactions and a nuclear equation of state at high densities. This leads (after successful explosions) to explosive nucleosynthesis, exploration of the role of neutrinos and weak and main r-process calculations. Such explosions can be observed in lightcurve observations (Stockholm) and in supernova remnants, the latter and their mixing of matter with the interstellar medium being modeled with simulations (Garching). [The dust formation in such objects is the topic of the CoDustMas CRP.] Finally, the results of stellar winds and explosive nucleosynthesis are the ingredients to understand the chemical evolution of galaxies (Paris, Trieste, and Garching). This closes the full circle to low metallicity stellar abundance observations (undertaken by the First Stars CRP). The ExNuc CRP focuses on the evolution of binary systems (with one compact object), where there exists overlap with the neutron star equation of state or explosive nucleosynthesis in novae, X-ray bursts and type Ia supernovae (in terms of nuclear reactions as well as nucleosynthesis input to chemical evolution).

The overall interpretation within the chemical and dynamical evolution of galaxies is relying heavily on astronomical observations, their interpretation with respect to constraints on the input of massive stars and supernovae. This permits a description of the cosmic evolution of abundances of elements and their isotopes, based on the processes how massive stars and supernovae feed the interstellar gas, which can be studied through astronomical observations and also hydrodynamical simulations. MASCHE has on the one hand direct contact to all other CRPs as described above and the chemical evolution part combines input or observations from all other CRPs.

2. Describe the benefit to your CRP of being part of the EUROCORES programme (e.g. achieving critical mass of expertise, scale and scope, visibility, collaborative opportunities, ideas, etc.).

Within EuroGenesis, the astrophysical processes discussed above also play a role in other CRPs, which is why we organize and support cross-CRP activities. Specifically, nuclear reaction rates under various astrophysical conditions are a major overlap, but also hydrodynamical modeling of stars and explosions. MASCHE emphasizes massive stars and core-collapse supernovae, which are characterized by a variety of observational constraints, as these objects are frequent and have been observed in abundance. They also are short-lived, and present a current view of cosmic nucleosynthesis, which ties in with the delayed explosions of SNe Ia addressed in EXNUC, and the metal-poor star observations in FIRSTSTARS. CoDustMas supports MASCHE through its focus on the complex role of dust grain formations from massive stars and supernovae, which is one of the astronomical, more indirect constraints which we wish to exploit for our understanding of massive stars and their supernovae.

### B.3. Cross-CRP networking, training and dissemination (max. 750 words)

1. Which networking/training/dissemination activities have you or your CRP members participated in? Indicate how many team members participated in each activity.

Networking activities in which MASCHE members participated:  
 Madrid April 2011 (nuclear reaction rate workshop), participation of 1 MASCHE member  
 Kocaeli May 2011 (p-process workshop), 9 MASCHE members  
 Basel November 2011 (chemical evolution of galaxies and nucleosynthesis input), 18 MASCHE members  
 Vienna November 2011 (cosmic dust grains as diagnostics for massive stars), 6 MASCHE members.  
 Research visits of individual CRP scientists to other EuroGenesis sites have been arranged (A. Arcones, with CRP EXNUC Barcelona, implementation of hydrocode FLASH for neutrino wind simulations in supernovae; M. Krause with CRP FirstStars Geneva, chemical evolution of globular clusters)

2. **Networking activities.** Describe *the most important networking activity* for your CRP to date (in terms of impact, outcome, creation of synergy and cooperation within or outside the programme).

All of the above, probably most important the chemical evolution workshop in Basel and the p-process workshop in Istanbul

3. **Training activities.** Describe *the most useful training activity* to date (workshop, course, school, etc.) undertaken by senior or junior researchers of your CRP.

Outside of Eurogenesis, MASCHE members participated in training events which address similar topics and are especially tuned to training PhD students:  
 Thermonuclear Reaction Rates for Astrophysics Applications, Demokritos Institute Athens (Greece), November 24-25, 2011  
 JINA/Universe Cluster workshop/school on nuclear reaction rates, Frauenwörth (D), organizers S. Bishop (MASCHE), H. Schatz (JINA), April 10-17, 2011  
 Helmholtz International Summer School "Nuclear Theory and Astrophysical Application" Dubna (Russia), July 24 - August 2, 2011, organizer David Blaschke (COMPSTAR, cross connection to an ESF research network)

4. **Dissemination activities.** Describe the *most valuable dissemination activity (or activities)* your team has undertaken so far, with respect to (i) the scientific community and (ii) the wider public. Describe the outcome and impact of these activities in terms of promoting your field of research and the EUROCORES programme.

Astrobiology Exhibition, organized by N. Mason (OPEN University, UK), with Exhibits of CompStar and EuroGenesis programmes of EuroCores/ESF, Museum of National Science, Brussels, 23-25 Jun 2011, as part of the International Year of Chemistry (YC 2011), a UN approved initiative of the International Union of Pure and Applied Chemistry (IUPAC) and the United Nations Educational and Cultural Organisation (UNESCO).

5. List the cross-CRP activities your CRP has organised or co-organised. If your CRP has not been involved in organising any cross-CRP activity to date, what activities do you intend to propose and organise in the future?

Nucleosynthesis reactions and the p-process, EuroGenesis workshop May 25-27, 2011, Istanbul (Turkey), Organizers Taygun Güray

Chemical Evolution of Galaxies, EuroGenesis workshop, Nov. 13-15, 2011, Basel (CH), Organizers F.-K. Thielemann, R. Diehl and A. Korn/C. Charbonnel (First Stars)

Dust in Massive Stars, EuroGenesis workshop, Nov 21-23 2011, Vienna (A), Organizers I. Cherchneff (CoDustMas) and A. Wallner (CoDustMas/MASCHE)

There exist additional activities which were organized by MASCHE members and led to cross-CRP interactions, but were funded by other means:

Nucleosynthesis beyond iron and the lighter element primary process, workshop supported by the Extreme Matter Institute, October 10-12, 2011, GSI Darmstadt, Germany, organizers from MASCHE: A. Arcones, M. Pignatari

Astrophysics with Modern Small-Scale Accelerators, workshop supported by the Heraeus Foundation, February 6-10, 2012, Bad Honnef, Germany, organizers from MASCHE: R. Reifarth, D. Bemmerer

2nd workshop on Exotic Radionuclides from Accelerator Waste for Science and Technology (ERAWAST II), workshop supported by PSI, August 29- September 02, 2011, Villigen, Switzerland, organizers from MASCHE: R. Reifarth, D. Bemmerer

The Origin of the Elements: A Modern Perspective, workshop supported by ECT\*, Trento, Italy, May 16-20 (2011), organizers from MASCHE: G. Martinez-Pinedo, F.-K. Thielemann

## B.4. Publications, dissemination and outreach

**Important:** *In your lists, include only those publications which resulted to a significant extent from work undertaken in the framework of the CRP or from collaboration with other CRPs. Note that all such publications should bear an acknowledgement of the EuroGENESIS programme.*

### In addition:

- List all authors.
- Identify with an asterisk (\*) publications which acknowledge the EUROCORES programme.
- Underline publications/presentations involving co-authors from at least two IPs within your CRP.
- **Mark in bold publications/presentations involving co-authors from other CRPs in the programme.**

### Publications

- Articles

*Peer-reviewed articles in journals (published, in press or submitted)*

Only publications are listed which acknowledge EuroGenesis

Arcones, A., Fröhlich, C., Martinez-Pinedo, G.: Impact of supernova dynamics on the vp-process, [arXiv:1112.4651](https://arxiv.org/abs/1112.4651), Ap. J., in press (2012)

Bennett, M.E., Hirschi, R., Pignatari, M. et al: The effect of  $^{12}\text{C}$  +  $^{12}\text{C}$  rate uncertainties on the evolution and nucleosynthesis of massive stars. MNRAS 420, 3047 (2012)

**Chiappini, C., Frischknecht, U., Meynet, G., Hirschi, R., Barbuy, B., Pignatari, M., Decressin, T., Maeder, A.: Imprints of fast-rotating massive stars in the Galactic Bulge, Nature, 474, 666 (2011)**

Diehl, R., Lang, M. G., Martin, P., Ohlendorf, H., Preibisch, T., Voss, R., Jean, P., Roques, J.-P., von Ballmoos, P., Wang, W.: Radioactive  $^{26}\text{Al}$  from the Scorpius-Centaurus association. A&A 522 A51 (2010)

Diehl, R.: Massive-Star Nucleosynthesis and INTEGRAL, ArXiv e-prints [arXiv:1107.4894](https://arxiv.org/abs/1107.4894) (2011)

**Ekström, S., Georgy, C., Eggenberger, P., Meynet, G., Mowlavi, N., Wyttenbach, A., Granada, A., Decressin, T., Hirschi, R., Frischknecht, U., Charbonnel, C., Maeder, A.: Grids of stellar models with rotation. I. Models from 0.8 to 120 Msun at solar metallicity (Z = 0.014) A&A, 537, A146 (2012)**

Farkas J., Gyürky Gy., Halász Z., Szücs T., Fülöp Zs., Somorjai E.: Half-life measurement of  $^{133\text{m}}\text{Ce}$  with gamma-spectrometry. Eur. Phys. J. A 47, 7 (2011)

Fischer, T., Martinez-Pinedo, G., Hempel, M., & Liebendörfer, M.: Neutrino spectra evolution during proto-neutron star deleptonization, [arXiv:1112.3842](https://arxiv.org/abs/1112.3842), Phys. Rev. D, submitted (2012)

Frischknecht, U., Hirschi, R., and Thielemann, F.-K.: Non-standard s-process in low metallicity massive rotating stars, A&A, 538, L2 (2012)

Fröhlich C., T. Rauscher, X. Tang, J. Truran: Critical Nuclear Reactions in the vp-Process, Phys. Rev. C, submitted (2012)

Fröhlich C., T. Rauscher: Reaction rate uncertainties and the vp-process. AIP Conf. Proc. OMEG11, in press. (2012)

Gyürky Gy., Elekes Z., Farkas J., Fülöp Zs., Halsz Z., Kiss G.G., Somorjai E., Szücs T., Güray R.T., Özkan N., Yalcin C., Rauscher T.: Alpha-induced reaction cross section measurements on  $^{151}\text{Eu}$  for the astrophysical gamma-process. J. Phys. G 37 115201 (2010)

Hempel, M., Fischer, T., Schaffner-Bielich, J., Liebendörfer, M.: New equations of state in core-collapse



- supernova simulations, arXiv:1108.0848, Ap. J., in press (2012)
- Hempel, M., Schaffner-Bielich, J., Typel, S., Röpke, G.: Light clusters in nuclear matter: Excluded volume versus quantum many-body approaches, Phys. Rev. C, 84, 055804 (2011)
- Isern, J., Jean, P., Bravo, E., Knodlseder, J., Diehl, R., Hirschmann, A., Elias-Rosa, N., Hernanz, M., Badenes, C., Dominguez, I., Kulebi, B., Garcia, D., Jordi, C., Lichti, G., Vedrenne, G., von Ballmoos, P.: Bounds to the gamma-ray flux emitted by SN 2011fe before the maximum of light as obtained by INTEGRAL/SPI, The Astronomer's Telegram 3683, 1 (2011)**
- Kiss G.G., Mohr P., Fülöp Zs., Gyürky Gy., Elekes Z., Farkas J., Somorjai E., Yalcin C., Galaviz D., Güray R.T., Özkan N., Görres J.,  $^{110,116}\text{Cd}(\alpha,\alpha)^{110,116}\text{Cd}$  elastic scattering and systematic investigation of elastic alpha scattering cross sections along the  $Z = 48$  isotopic and  $N = 62$  isotonic chains. Phys. Rev. C 83 065807 (2011)
- Kiss G.G., Rauscher T., Szücs T., Kertész Zs., Fülöp Zs., Gyürky Gy., Fröhlich C., Farkas J., Elekes Z., Somorjai E.: Determining reaction cross sections via characteristic X-ray detection: Alpha-induced reactions on  $^{169}\text{Tm}$  for the astrophysical gamma-process. Physics Letters B 695 419 (2011)
- Kiss G.G., Szücs T., Gyürky Gy., Fülöp Zs., Farkas J., Kertész Zs., Somorjai E., Laubenstein M., Fröhlich C., Rauscher T.: Activation method combined with characteristic X-ray counting: A possibility to measure (alpha, gamma) cross sections. Nucl. Phys. A 867, 52 (2011)
- Kreim, S., Measurements of ground-state properties of  $^{82}\text{Zn}$  by precision mass and laser spectroscopy, Phys. Rev. C, in preparation
- Mohr P., Galaviz D., Fülöp Zs., Gyürky Gy., Kiss G.G., Somorjai E.: Total reaction cross sections from elastic alpha-nucleus scattering angular distributions around the Coulomb barrier. Phys. Rev. C 82, 047601 (2010)
- Muñoz-Mateos, J. C., Boissier, S., Gil de Paz, A., Zamorano, J., Kennicutt, R. C., Jr., Moustakas, J., Prantzos, N., Gallego, J., Radial Distribution of Stars, Gas, and Dust in SINGS Galaxies. III. Modeling the Evolution of the Stellar Component in Galaxy Disks, Ap. J. 731, 10 (2011)
- Nishimura, N., Fischer, T., Thielemann, F.-K., et al.: Nucleosynthesis in core-collapse supernova explosions triggered by a quark-hadron phase transition, arXiv:1112.5684, Ap. J., submitted (2012)
- Prantzos, N., On the origin and composition of Galactic cosmic rays, A&A 538, A80 (2012)
- Prantzos, N., Production and Evolution of Li, Be, and B in the Galaxy, A&A, in press (2012)
- Prantzos, N., Boehm, C., Bykov, A. M., Diehl, R., Ferrière, K., Guessoum, N., Jean, P., Knodlseder, J., Marcowith, A., Moskalenko, I. V., Strong, A., Weidenspointner, G.: The 511 keV emission from positron annihilation in the Galaxy. Reviews of Modern Physics 83, 1001 (2011)
- Rauscher T., C. Fröhlich, Proton-rich abundances and nuclear physics, AIP Conf Proc. OMEG11, in press (2012)
- Reifarh, R., Dababneh, S., Heil, M., Käppeler, F., Plag, R., Sonnabend, K., Uberseder, E., Neutron activation of natural zinc samples at  $kT=25\text{keV}$ , Phys. Rev. C, in press (2012)
- Sagert, I., Fischer, T., Hempel, M., et al.: Strange matter in core-collapse supernovae, arXiv:1112.6328, in Strangeness in Quark Matter, in press (2012)
- Szücs, T., Dillmann, I., Plag, R., Fülöp, Z., The KADoNiS databases - progress and future plans, J. Phys. Conf. Ser., 337, 012033 (2012)
- Szücs, T., Bemmerer, D., Cowan, T., Degering, D., Elekes, Z., Fülöp, Z., Gyürky, G., Junghans, A., Köhler, M., Marta, M., Schwengner, R., Wagner, A., Zuber, K., Shallow-underground accelerator sites for nuclear astrophysics: Is the background low enough? Eur. Phys. J. A, 48, 8 (2012)
- Thielemann, F.-K., Arcones, A., Käppeli, R., et al.: What are the astrophysical sites for the r-process and the production of heavy elements?, Progr. Part. Nucl. Phys. 66, 346 (2011)
- Voss, R., Diehl, R., Vink, J. S., Hartmann, D. H., Probing the evolving massive star population in Orion with kinematic and radioactive tracers, A&A 520 A51 (2010)
- Voss, R., Martin, P., Diehl, R., Vink, J. S., Hartmann, D. H., Preibisch, T., Energetic feedback and  $^{26}\text{Al}$  from massive stars and their supernovae in the Carina region, A&A 539, A66 (2012)
- Winkler, C., Diehl, R., Ubertini, P., Wilms, J., INTEGRAL: Science Highlights and Future Prospects, Space Sci. Rev. 161, 149 (2011)
- Winteler, C., Käppeli, R., Perego, A., Arcones, A., Vasset, N., Nishimura, N., Liebendörfer, M., Thielemann, F.-K., Magneto-rotationally driven Supernovae as the origin of early galaxy r-process elements? arXiv:1203.0616, Ap. J. Lett., submitted (2012)

*Published contributions to international conferences*



Many, not listed here

#### *News & Views-type articles*

News and Views articles about research undertaken by MASCHE members:  
 A new spin on the first stars, by [Jason Tumlinson](#), Nature 472, 42 (2011)  
 Precise mass measurement aids the hunt for heavy elements that decay slowly, by Geoff Brumfield, Nature doi:10.1038/news.2010.58 (2010)

#### *Other articles (please define)*

#### - Books

##### *As editor(s)*

Diehl, R., Hartmann D.H., Prantzos N.: Astronomy with Radioactivities. Springer Lecture Notes in Physics, Vol. 812 (2011)  
 F. Matteucci: Chemical Evolution of Galaxies, Springer (2011)

##### *As author(s) or author(s) of chapters*

Diehl R.: Introduction to Astronomy with Radioactivities. Springer LNP Vol. 812, 3-23 (2011)  
 Lugaro M., Chieffi A.: Radioactivities in low- and intermediate-mass stars. Springer LNP Vol. 812, 83-151 (2011)  
 Thielemann, Hirschi, Liebendörfer, Diehl: Massive Stars and their Supernovae, Springer LNP 812, 153-231 (2011)  
 Diehl, Hartmann, Prantzos: Diffuse Radioactivities, Springer LNP 812, 345-436 (2011)  
 M. Liebendörfer: Computer-Modeling of Stars, Springer LNP 812, 439-460 (2011)  
 M. Wiescher, T. Rauscher: Nuclear Reactions, Springer LNP 812, 461-490 (2011)

#### - Other

##### *Please define (data products, video, etc.)*

Weltenreise, <http://www.weltenreise.unibas.ch/>

### **Presentations in scientific meetings**

#### - Oral presentations (indicate invited / keynote talks)

Only invited talks  
 A. Arcones: Explosive nucleosynthesis: nuclear physics impact using neutrino-driven wind simulations, NUSTAR annual meeting Darmstadt, Germany (2011)  
 A. Arcones: Nucleosynthesis of heavy elements in core-collapse supernovae, 8th Russbach Workshop on Nuclear Astrophysics, Russbach, Austria (2011)  
 A. Arcones: Heavy elements produced in neutrino-driven winds, Nuclear Physics in Astrophysics V, Eilat, Israel (2011)  
 A. Arcones: Nucleosynthesis in Neutrino-Driven Winds, The Origin of the Elements: A Modern Perspective, Trento, Italy (2011)  
 A. Arcones: Nucleosynthesis of heavy elements in neutrino-driven winds and neutron star mergers, Microphysics in Computational Relativistic Astrophysics, Waterloo, Canada (2011)  
 A. Arcones: Neutrino-driven winds and nucleosynthesis of heavy elements, HANSE: Hamburg neutrinos from Supernova Explosions, Hamburg, Germany (2011)  
 A. Arcones: The r-process as a source of new elements, energy and optical transients, Heavy elements in galactic chemical evolution and NLTE effects, Odessa, Ukraine (2011)

- A. Arcones: Nucleosynthesis beyond iron in core-collapse supernovae, EMMI Physics Days, Darmstadt, Germany (2011)
- A. Arcones: Impact of nuclear physics input on the r-process, Thermonuclear Reaction Rates for Astrophysics Applications, Athens, Greece (2011)
- A. Arcones: Core-collapse supernovae and r-process, The Chemical Evolution of Galaxies, Basel, Switzerland (2011)
- U. Battino: The p-process in SNe Ia: Different production channels and main abundance dependences, Thermonuclear Reaction Rates for Astrophysics Applications, Athens, Greece (2011)
- D. Bemmerer: Nuclear astrophysics at underground Laboratories, Astrophysics with modern small-scale accelerators, Bad Honnef, Germany (2011)
- D. Bemmerer: LUNA: Underground nuclear astrophysics, Helmholtz International Summer School "Nuclear Theory and Astrophysical Applications", Dubna, Russia (2011)
- D. Bemmerer: Data needs for underground accelerators Workshop on Data Requirements in Nuclear Astrophysics, Darmstadt, Germany (2010)
- D. Bemmerer: Underground accelerators in Europe, Origins of the elements and nuclear history of the universe, Eurogenesis Meeting, Dubrovnik, Croatia (2010)
- K. Blaum: High-precision mass measurements for nuclear astrophysics, The 11th International Symposium on Origin of Matter and Evolution of Galaxies (OMEG11), Wako, Japan (2011)
- K. Blaum: High-Precision Mass Measurements in Penning Traps and Storage Rings, International Workshop on Physics of Rare-RI Ring, RIKEN, Tokyo, Japan (2011)
- K. Blaum: Precision Penning Trap Experiments with Exotic Ions, EMMI Physics Days 2011, GSI Darmstadt, Germany (2011)
- K. Blaum: g-factor of hydrogenlike silicon  $^{28}\text{Si}^{13+}$  - The most stringent test of bound-state quantum electrodynamics, 8th International Topical SPARC Workshop, Moscow, Russia (2011)
- K. Blaum: Precision Penning trap experiment with stored and cooled exotic ions, SPARC Lecture Days, Moscow, Russia (2011)
- K. Blaum: High-precision mass measurements with storage rings and Penning traps, lecture at the International Summer School on Subatomic Physics 2011, Beijing, China (2011)
- K. Blaum: Precision Measurement of Ground-state Properties with Stored Ions for Nuclear Structure Studies, Rutherford Centennial Conference 2011, Manchester, England (2011)
- K. Blaum: High-Precision Measurements of Nuclear Masses for Astrophysics, ECT\* workshop on "The Origin of the Elements", Trento, Italy (2011)
- K. Blaum: A Storage Ring Facility at HIE-ISOLDE, CERN INTC-Meeting, Geneva (2011)
- A. Chieffi: The influence of mass loss and rotation on the stellar yields from massive stars, NIC XI, Heidelberg, Germany (2010)
- Diehl, R.: Cosmic Radio-Isotopes Radioactivity in Astrophysics Workshop, York, United Kingdom (2010)
- Diehl, R.: Cosmic Radioactivities. NUSTAR Workshop, Darmstadt, Germany (2012)
- Diehl, R.: Measuring gamma-ray lines from cosmic sources. 6th European Summer School on Experimental Nuclear Astrophysics. Catania, Italy (2011)
- Diehl, R.: Nucleosynthesis and Gamma-Ray Line Spectroscopy with INTEGRAL. Workshop "The Extreme and High-Energy Sky: 9 years INTEGRAL", Chia Laguna, Italy (2011)
- Diehl, R.: Nucleosynthesis in Massive Stars and Supernovae. Workshop on Opportunities for Nuclear Astrophysics in Space, Darmstadt, Germany (2011)
- Diehl, R.: Radioactive Isotopes in our Nearby Galactic Environment. Workshop on Isotopes in Astrochemistry, Lorentz Center, Leiden, Netherlands (2011)
- Diehl, R.: Radioactivities and Massive Star Feedback, Int. Workshop "Astronomy with Radioactivities VII", Phillip Island, Australia (2011)
- Diehl, R.: Radioactivities as a Tool: Massive Stars and Supernovae. Research Day RA-G of the Excellence Cluster on Origins and Evolution of the Universe, Garching, Germany (2011)
- C. Fransson: Observational constraints on structure and nucleosynthesis from supernova light curves and spectra, EuroGenesis Workshop, Dubrovnik (2010)
- C. Fransson: Late time observations of core collapse SNe, Supernovae and their Host Galaxies, Sydney, Australia (2011)
- C. Fransson: Surveys now and in future: Progress and prospects, Explosive Ideas about Massive Stars - From Observations to Modeling, Stockholm (2011)
- U. Frischknecht: Sr, Y and Zr from rotation induced s process in massive stars, Nucleosynthesis beyond iron and the lighter element primary process (LEPP), Darmstadt, Germany (2011)
- U. Frischknecht: s-Process in massive rotating stars, The Chemical Evolution of Galaxies, Basel, Switzerland (2011)

Fülöp Zs.: The Atomki p-process program. 6th European Summer School on Experimental Nuclear Astrophysics. Catania, Italy (2011)

Güray R. T.: Measurements of charged particle induced reaction cross sections relevant to the astrophysical p-process: Activation Method, First EuroGENESIS Workshop: Origins of the elements and nuclear history of the universe, Dubrovnik, Croatia (2010)

Gyürky Gy.: Cross section measurement of alpha-induced reactions for the astrophysical p-process. Nuclear Physics in Astrophysics. NPA 5. Eilat, Israel, 3-8 April, (2011)

M. Hempel: New Equations of State in Simulations of Core-Collapse Supernovae, Gravitational Waves and Electromagnetic Radiation from Compact Stars, Catania, Italy (2011)

M. Hempel: New equations of state in simulations of core-collapse supernova, Nuclear Fragmentation 2011, Kemer, Turkey (2011)

M. Hempel: Light clusters and new equations of state in simulations of core-collapse supernovae, Clusters in Nuclei and Nuclear Matter: Nuclear Structure, Heavy Ion Collisions, and Astrophysics, Trento, Italy (2011)

M. Hempel: Exotic nuclei and the equation of state in core-collapse supernovae, The shell model, Trento, Italy (2011)

M. Liebendörfer: Neutrino-radiation-hydrodynamics: General relativistic versus multidimensional supernova simulations, New Frontiers in QCD, NFQCD10, Kyoto, Japan (2010)

M. Liebendörfer: Neutrino emission in core collapse supernovae, Neutrino emission in core-collapse supernovae, The Origin of the Elements: A Modern Perspective, Trento, Italy (2011)

M. Liebendörfer: 3D Supernova Models, Microphysics in Computational Relativistic Astrophysics, Waterloo, Canada (2011)

M. Liebendörfer: Microphysics of the Supernova Core, HANSE: HAMBURG neutrinos from Supernova Explosions, Hamburg, Germany (2011)

M. Liebendörfer: Core-collapse supernovae and their explosion mechanisms, The Chemical Evolution of Galaxies, Basel, Switzerland (2011)

M. Limongi: Evolutionary path toward core collapse supernova explosion, Supernovae and their Host Galaxies, Sydney, Australia (2011)

M. Limongi and A. Chieffi: Presupernova evolution and explosion of massive stars, Nuclear Physics in Astrophysics IV, Frascati, Italy (2010)

M. Limongi and A. Chieffi: Explosive nucleosynthesis in massive stars, Origin of Matter and Evolution of Galaxies (OMEG10), Osaka, Japan (2010)

M. Limongi and A. Chieffi: Evolutionary path toward the core collapse supernova explosion and explosive yields, Chemical Evolution of GRB Host Galaxies, Sexten, Italy (2011)

M. Limongi and A. Chieffi:  $^{12}\text{C}+^{12}\text{C}$  reaction and astrophysical implications, 6th European Summer School on Experimental Nuclear Astrophysics, Santa Tecla, Italy (2011)

P. Lundqvist: Circumstellar gas around SN 1987A, Explosive Ideas about Massive Stars - From Observations to Modeling, Stockholm (2011)

G. Martinez-Pinedo: Explosive Nucleosynthesis of Heavy Elements, Workshop on Reactions of Astrophysical Interest, Madrid, Spain (2011)

G. Martinez-Pinedo: Explosive Nucleosynthesis in neutrino-driven winds, Workshop on Advanced Topics in Astrophysics, Llafranc, Spain (2011)

G. Martinez-Pinedo: Nuclear Physics for r-process nucleosynthesis, ECT\* Workshop The Origin of the Elements: A Modern Perspective, Trento, Italy (2011)

G. Martinez-Pinedo: Neutrinos and explosive nucleosynthesis, Workshop on Microphysics in Computational Relativistic Astrophysics, Perimeter Institute, Waterloo, Canada (2011)

G. Martinez-Pinedo, Exotic Nuclei and Explosive Nucleosynthesis, Frontiers Issues in Physics of Exotic Nuclei, Kyoto, Japan (2011)

Matteucci, F.: Chemical evolution of galaxies hosting GRBs, Workshop Chemical evolution of GRB host galaxies, Sexten, Italy (2011)

N. Nishimura: New Supernova Scenarios for r-process Nucleosynthesis, Heavy elements in galactic chemical evolution and NLTE effects, Odessa, Ukraine (2011)

N. Nishimura: Heavy Element Nucleosynthesis in Supernova triggered by a quark-hadron phase transition, Supernova Conference 2011, Kyoto, Japan (2011)

Özkan N., "Towards low energy p and  $\alpha$  capture measurements in the heavier mass region for the astrophysical p process", NUFRA2011 (Third International Conference on Nuclear Fragmentation: From Basic Research to Applications), Kemer, Turkey. (2011)

Pignatari M.: Production of copper, gallium and germanium in massive stars, The Origin of the Elements: A Modern Perspective, ECT\* Trento, Italy (2011)

Pignatari M.: Production of Mn in stars, SCOPES workshop: Heavy elements in galactic chemical evolution and NLTE effects, Odessa, Ukraine (2011)

Pignatari M.: Slow neutron capture process in massive stars, 8th Russbach Workshop on Nuclear Astrophysics, Russbach, Austria (2011)

N. Prantzos: Composition and acceleration of Galactic Cosmic Rays, Cosmic Rays and their InterStellar Medium environment: CRISM, Montpellier, France (2011)

N. Prantzos: Nucleosynthesis and gamma-ray lines, 8th INTEGRAL Workshop "The Restless Gamma-ray Universe", Dublin, Ireland (2010)

N. Prantzos: Topics on Galactic Chemical Evolution, 11th Symposium on Nuclei in the Cosmos, Heidelberg, Germany (2010)

T. Rauscher: Astrophysical reaction rates for proton- and neutron-rich nucleosynthesis (and connections to experiments), The Origin of the Elements: A Modern Perspective, Trento, Italy (2011)

T. Rauscher: Origin of the p-Nuclides and Relevant Astrophysical Reaction Rates, The p-Process: Present Status and Outlook, Istanbul, Turkey (2011)

T. Rauscher: Complications in Determining Stellar Reaction Rates for Explosive Nucleosynthesis, 10th Int. Symp. on Origin of Matter and Evolution of the Galaxies (OMEG11), Osaka, Japan (2011)

T. Rauscher: Reaction Rates between the Driplines for Astrophysics, The shell evolution and the role of correlations in very neutron rich nuclei, Trento, Italy (2011)

R. Reifarth: Current experimental aspects of the s-process research, Workshop on Nuclear Physics in Hot Dense Plasmas, London, UK (2011)

R. Reifarth: Measurements of proton-induced reaction at the Experimental Storage Ring at GSI, p-process workshop, Istanbul, Turkey (2011)

R. Reifarth: Nuclear astrophysics at FRANZ (neutron-induced reactions for nuclear astrophysics), International Summer School "Nuclear Theory and Astrophysical Applications", Dubna, Russia (2011)

R. Reifarth: Current experimental developments for s-process nucleosynthesis, 14th International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics (CGS14), Guelph, Canada (2011)

R. Reifarth: Approaches to LEPP measuring nuclear reactions, EMMI-JINA Workshop "Nucleosynthesis beyond iron and lighter element primary process", Darmstadt, Germany (2011)

R. Reifarth: Astrophysics with unstable nuclei at FAIR and FRANZ, ISPUN 2011 "The International Symposium on Physics of Unstable Nuclei", Hanoi, Vietnam (2011)

R. Reifarth: The Stellar neutron capture of  $^{60}\text{Fe}$ , 2nd workshop on Exotic Radionuclides from Accelerator Waste for Science and Technology (ERAWAST II), Villigen, Switzerland (2011)

Thielemann F.-K.: Did Nature produce superheavy elements? TAN 11, Physics and Chemistry of Transactinide Nuclei, Sochi, Russia (2011)

Thielemann F.-K.: Nucleosynthesis in Astrophysical Explosions and the Origin of Heavy Elements, Advanced Topics in Astrophysics Llafranc, Spain (2011)

Thielemann F.-K.: Radioactivity and Nucleosynthesis as Probes of (core collapse) Explosion Models, Explosive Ideas about Massive Stars - from Observations to Modeling, Stockholm, Sweden (2011)

Thielemann F.-K.: Stellar Nucleosynthesis: the key to galactic evolution, Symmetries and Phases in the Universe, Kloster Irsee, Germany (2012)

Thielemann F.-K.: The Astrophysical Site(s) for Producing the Heavy Elements: Hints for solving the puzzle, Nuclear and Particle Astrophysics, Erice, Italy (2010)

Thielemann F.-K.: The Interplay of Nuclear Properties and Astrophysical Conditions in Stellar Evolution and Explosive Nucleosynthesis, Merging Particle Physics, Nuclear Physics and Astrophysics, From Quarks to Supernovae, Atagawa, Japan (2010)

A. Wallner: SUPRATEAMS: Supernova-produced radionuclides and trace elements studied by AMS, EuroGenesis Workshop, Dubrovnik (2010)

Wallner, A.: Accelerator Mass Spectrometry - Applications within CoDustMas, Cosmic Dust as Diagnostics of Massive Stars, Vienna, Austria (2011)

- Posters

Farkas J., Gyürky Gy., Halász Z., Szücs T., Fülöp Zs., Somorjai E.: Half-life determination of  $^{133\text{m}}\text{Ce}$  for activation cross section measurements (Abstr.: p. 233). 11th International Symposium on Nuclei in the Cosmos. NIC XI. Heidelberg, Germany, 19-23 July, 2010

- Güray R. T.: EuroGENESIS (Origin of the Elements and Nuclear History of the Universe): Massive Stars as Agents of Chemical Evolution, NUFRA2011 (Third International Conference on Nuclear Fragmentation From Basic Research to Applications), October 2 - 9, 2011, Kemer (Antalya), Turkey. (invited / talk)
- Gyürky Gy., Halász Z., Farkas J., Fülöp Zs., Somorjai E., Szücs T.: Target characterization for the  $^{130}\text{Ba}(\alpha,\alpha)^{134}\text{Ce}$  gamma-process experiment. 11th International Symposium on Nuclei in the Cosmos. NIC XI. Heidelberg, Germany, 19-23 July, 2010
- Halász Z., Gyürky Gy., Somorjai E., Szücs T., Farkas J., Takács M.P., Fülöp Zs.: In-beam  $(\alpha,\gamma)$  cross section measurement for the astrophysical p-process. Nuclear Physics in Astrophysics. NPA 5. Eilat, Israel, 3-8 April, 2011
- Halász Z., Gyürky Gy., Szücs T., Farkas J., Fülöp Zs., Somorjai E.: Alpha-induced activation reaction cross section measurement  $^{130}\text{Ba}$  relevant for the astrophysical p-process (Abstr.: p. 238), 11th International Symposium on Nuclei in the Cosmos. NIC XI. Heidelberg, Germany, 19-23 July, 2010
- Kiss G.G., Fülöp Zs., Gyürky Gy., Elekes Z., Farkas J., Somorjai E., et al.: Experimental investigation of alpha nucleus potential parameterizations along the Cd isotopic chain. Nuclear Physics in Astrophysics. NPA 5. Eilat, Israel, 3-8 April, 2011
- Kiss G.G., Gyürky Gy., Szücs T., Kertész Zs., Farkas J., Fülöp Zs., Somorjai E., et al.: Measuring alpha-induced cross sections in the region of heavy p-nuclei: The case of  $^{169}\text{Tm}+\alpha$  (Abstr.: p. 237). 11th International Symposium on Nuclei in the Cosmos. NIC XI. Heidelberg, Germany, 19-23 July, 2010
- Kiss G.G., Mohr P., Fülöp Zs., Gyürky Gy., Elekes Z., Farkas J., Somorjai E., et al.: Investigating the variation of elastic alpha scattering cross sections in the  $A \sim 100$  region. Nuclear Physics in Astrophysics. NPA 5. Eilat, Israel, 3-8 April, 2011
- Özkan N.: Proton and alpha capture measurements on higher masses related to the p-process, First EuroGENESIS Workshop: Origins of the elements and nuclear history of the universe, Grand Hotel Park, Dubrovnik, Croatia, 24-26 November 2010

And many more

- Other (*please define*)

## Public outreach

### - Press releases

Fülöp Zs.: Interview, and election as "researcher of the month", see OTKA (Hungarian Funding Agency) web page (Oct 2010)

### - National / international newspaper articles (presenting your CRP or part of your work)

### - TV appearance

### - Radio appearance

Thielemann F.-K.: Element formation in the Universe, Deutschlandfunk  
<http://www.dradio.de/dlf/sendungen/forschak/1689284/>

### - Other (please define)

Weltenreise, a public theater event in Basel, University of Basel, <http://www.weltenreise.unibas.ch/>

## Other activities / outputs

### - Patents

### - Websites

[http://www.mpe.mpg.de/gamma/science/lines/eurogenesis/MASCHE\\_home.html](http://www.mpe.mpg.de/gamma/science/lines/eurogenesis/MASCHE_home.html)

### - Other (please define)

## **B.5. Feedback on the EUROCORES programme and EUROCORES scheme**

Any other comments on the EUROCORES programme in particular or the EUROCORES scheme in general.

The EuroGenesis program in general plus our MASCHÉ CRP made it possible not only to meet at international conferences and discuss interesting issues of joint interest, it actually initiated joint planning, coordination and collaboration.