

TUM



LMU

# Science Day Research Area G

## Origin of the Elements

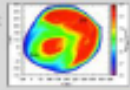
MPA, 23 July 2014

# THE LATE UNIVERSE

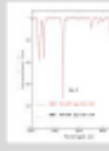
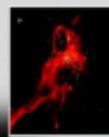
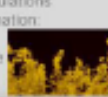
## Which Processes Drive the Evolving Visible Structures in the Universe?

Stars and Supernovae, Black Holes, ISM, Galaxy Evolution, Star and Planet Formation

Origin of  $^{60}\text{Fe}$  as seen in ocean crust and ISM:  
3D hydro simulation of local bubble



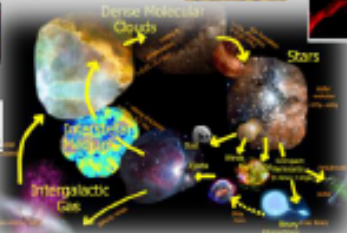
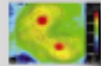
Hydrodynamical simulations of star & planet formation:  
Feedback from radiation, winds, SNe



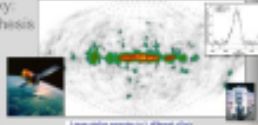
Spectra of first stars: r-process sources



Galactic magnetic fields



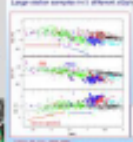
Radioactive isotopes in the Galaxy: Nucleosynthesis yields from Stars and SNe



Modeling supernovae and binary mergers: Progenitors of SNe, SN nucleosynthesis



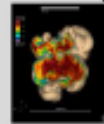
Elemental abundances in nearby galaxies: Archeology and galaxy evolution



Galaxy evolution: gas streams, star formation



GRB observations: Abundances in high-z universe



## A cross-disciplinary and inter-institutional collaboration in experiment and theory

### Junior Research Groups

- Stellar evolution and quantitative spectroscopy
- New algorithms for computational astrophysics



### Common Goals – Examples

- What drives the multi-phase, turbulent interstellar medium?
- How do stars and planets form?
- How do supernova explosions relate to properties of r-process nuclei?
- How do hadron properties impact the structure of dense cosmic objects?

## What is the Origin of Cosmic Elements and the Structure of Hadronic Matter

Nuclear Astrophysics and Hadron Physics in Dense Nuclear Matter

### Experimental Approaches:

- Beams of short-lived nuclei (GSI SIS/ESR, CERN-ISOLDE, RIKEN RIBF)
- Hadrons in the hot dense matter of relativistic heavy-ion collisions (GSI FAIR, FAIR)

### Past Cluster research

### Proposed extensions

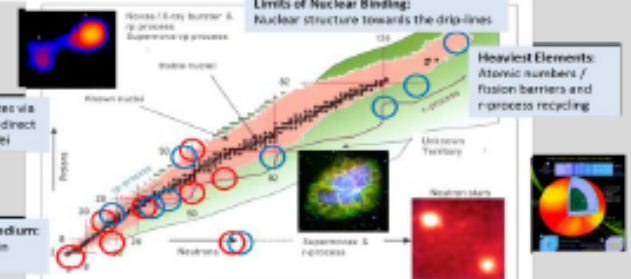
r<sub>p</sub>-Process: Proton capture-rates via femto-second Doppler-shift in direct reactions with short-lived nuclei

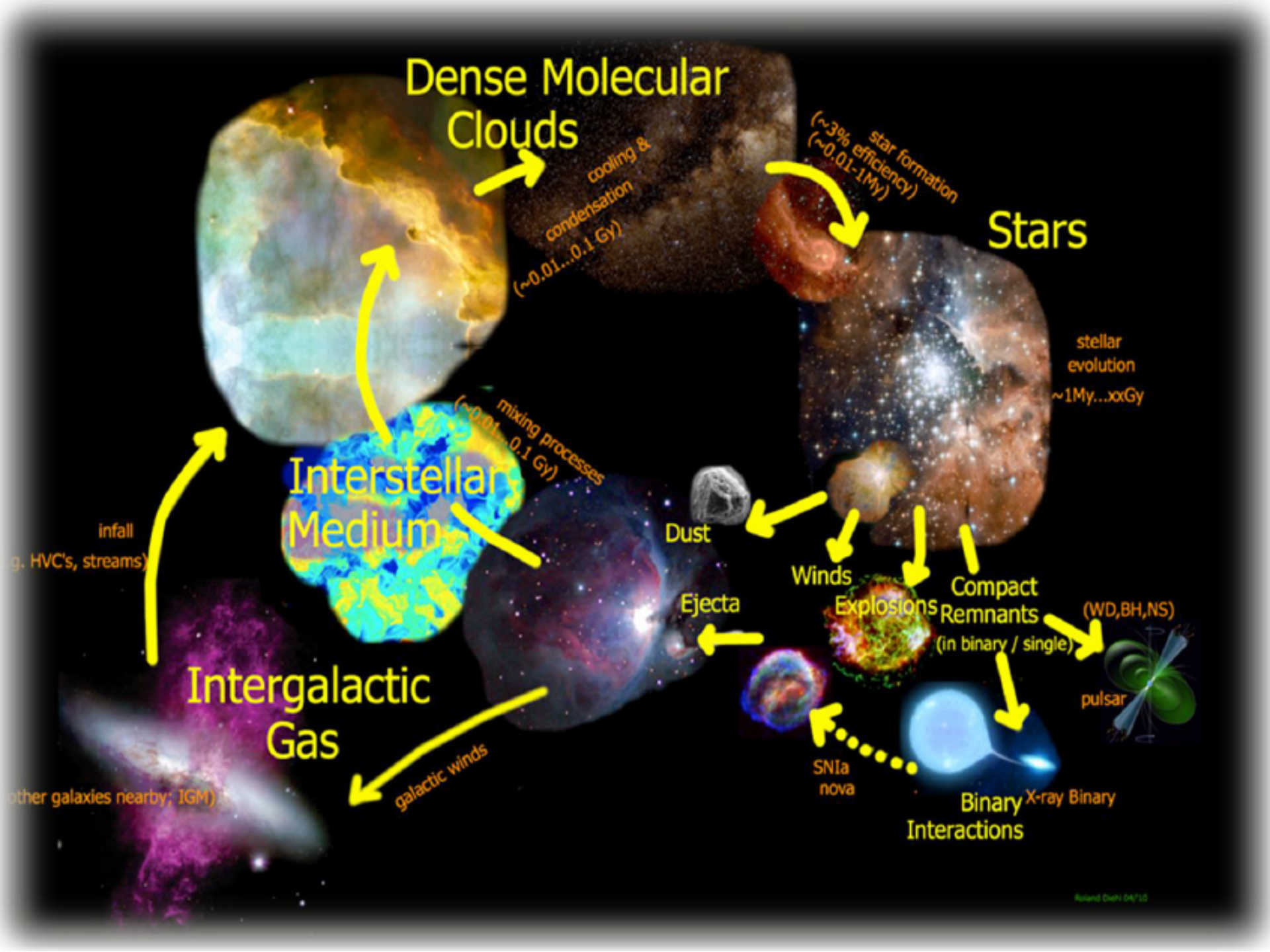
Hadrons in the nuclear medium: Light and strange mesons in nucleus-nucleus collisions

Supernova Remnants: Lifetime and trace analysis of SN-induced  $^{60}\text{Fe}$ ,  $^{244}\text{Pu}$ ,  $^{247}\text{Cm}$ ,  $^{235}\text{U}$  in terrestrial and lunar rock

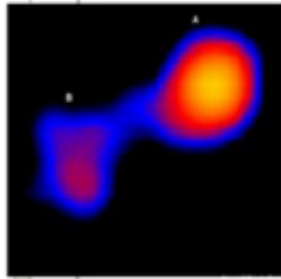
r-Process: Nuclear properties governing the r-process path

Kaon-Nucleon Interactions: Kaon-nucleon clusters, meson condensates and the interior of neutron stars





Matter of relativistic heavy-ion collisions



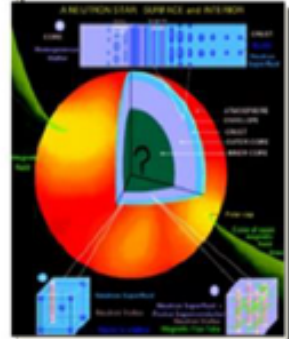
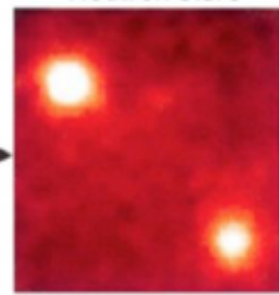
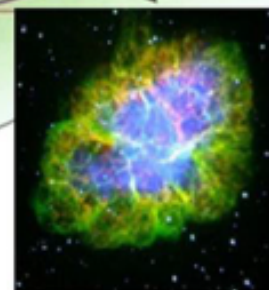
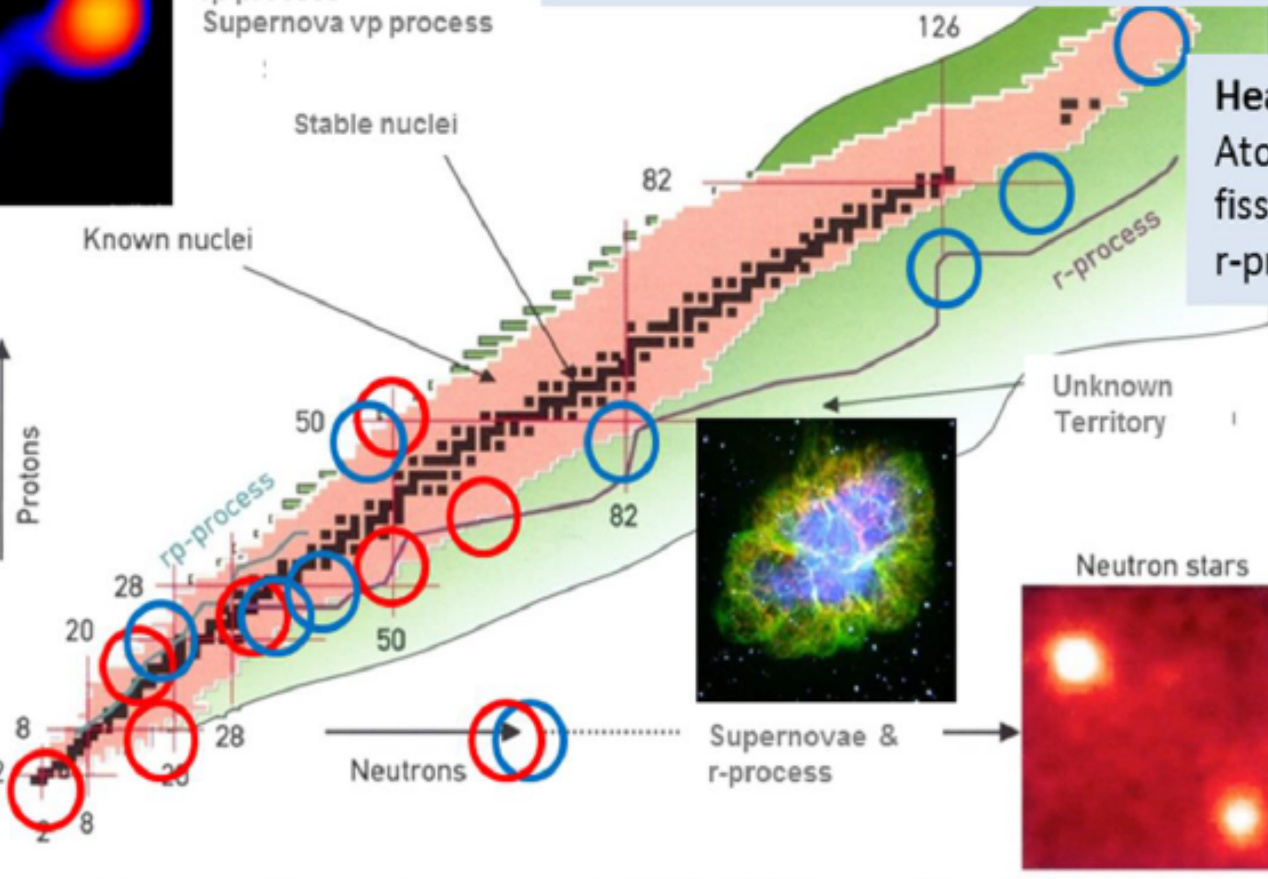
Novae / X-ray burster & rp process  
Supernova vp process

Limits of Nuclear Binding:  
Nuclear structure towards the drip-lines

Heaviest Elements:  
Atomic numbers / fission barriers and r-process recycling

... via direct  
... lei

medium:  
in



Supernova Remnants:  
... and trace analysis of  
... 244Pu ... 247Cm

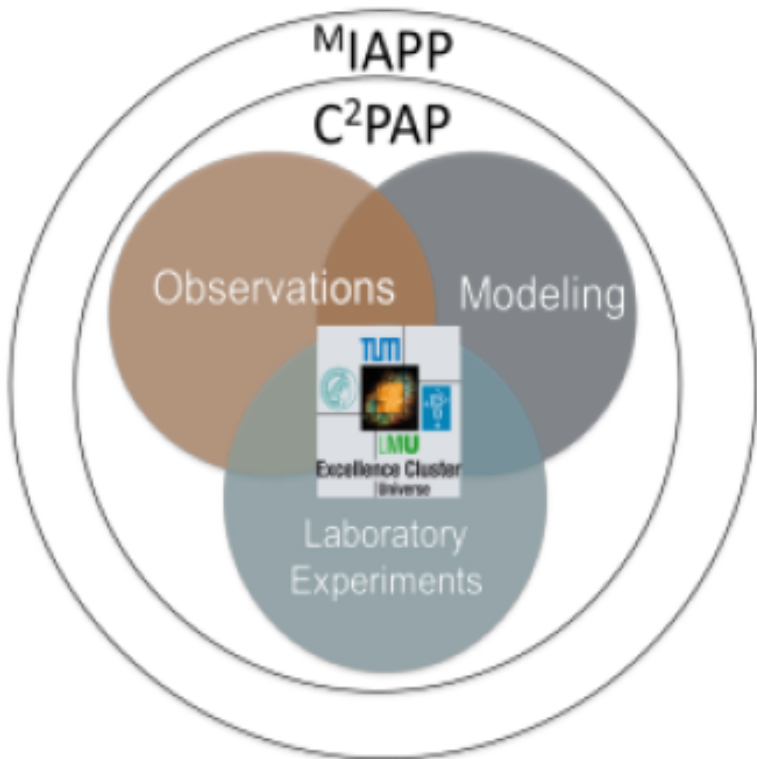
r-Process: Nuclear properties governing the r-process path

Kaon-Nucleon Interactions:  
Kaon-nucleon clusters, meson condensates and the interior

# Science Topics, RA-G

- Astronomical observations
  - of abundances of specific elements and nuclei
    - at various sites throughout the universe and in solar system
  - of sites of cosmic nucleosynthesis
- Physics experiments
  - of nuclear properties
  - of nuclear reactions
    - as relevant in cosmic sites
- Astrophysical models
  - of sources of new nuclei
  - of matter re-cycling in galaxies

# Methods of RA-G Work



## Common Goals -- Examples

- What drives the multi-phase, turbulent interstellar medium?
- How do stars and planets form?
- How do supernova explosions relate to properties of r-process nuclei?
- How do hadron properties impact the structure of dense cosmic objects?

# RA G: Scientists and Domains

- ~60 Members total - Senior Scientists, Post-Docs, Students; a.o.:

## Theory

A. Burkert (USM/LMU), B.Ercolano (TUM), W. Hillebrandt (MPA), Th. Janka (MPA), N. Kaiser (TUM), S. Khochfar (MPE), E. Müller (MPA), W. Müller (IPP), T. Naab (MPA), G. Raffelt (MPP), P. Ring (TUM), W. Weise (TUM), A. Weiss (MPA), H. Wolter (LMU), ...

## Observations

H. Böhringer (MPE), R. Diehl (MPE), M. Kissler-Patig (ESO), B. Leibundgut (ESO), W. Hillebrandt (MPA), W. Kudritzki (MPA), T. Preibisch (LMU), N. Patat (ESO) F. Primas (ESO), M. Rejkuba (ESO), M. Teshima (MPP), ...

## Experiment

S. Bishop (TUM), T. Faestermann (TUM), W. Henning (TUM), (R. Krücken (TUM)), G. Korschinek (TUM), P. Thirolf (TUM), D. Habs (LMU), ...

# RA G Science Projects & Reports

- Supernova Models
  - SNIa Progenitor Variety
- Supernova Observations
  - SN light curves and Opt/UV/IR spectral evolution
  - SN and massive star radioactivity gamma-rays
  - SN ejecta in terrestrial samples
- Nuclear properties experiments
  - rare isotopes towards r-process path in Sn/Cd region
  - nova nuclear reactions
  - fission barrier studies
- Nuclear theory
  - Nuclear potentials from nucleon-nucleon force and experiments
  - Nuclear symmetry energy and neutron star matter

# PROGRAM

Science Day RA-G

23 July 2014

9:30-9:45 R. Diehl: Introduction: RA-G Science activities, and Science Day  
9:45-10:30 M. Limongi: Massive Star Models and production of  $^{26}\text{Al}$  and  $^{60}\text{Fe}$   
10:30-11:00 M. Krause: 3D Hydro Simulations of the interstellar medium around massive-star groups

11:00-11:30 Coffee Break

11:30-12:15 L. Fimiani: Measurements of recent nearby supernova ejecta through search for  $^{60}\text{Fe}$  in lunar material  
12:15-12:35 G. Korschinek: Cosmic Ray Intensity History on Earth

12:35-14:00 Lunch Break with Bayerische Brotzeit

14:00-14:30 S. Dhawan: Supernova light curves in the Infrared  
14:30-15:00 T. Siegert: SN2014J Gamma-ray line measurements  
15:00-15:30 K. Maguire: Searching for progenitor signatures in Type Ia supernova spectra  
15:30-16:00 M. Klauser: Hubble constant determination with SNIIP  
16:00-16:30 D. Lubos: Nuclear Structure of the Doubly Magic  $^{100}\text{Sn}$  and its neighbours

16:30 End of meeting