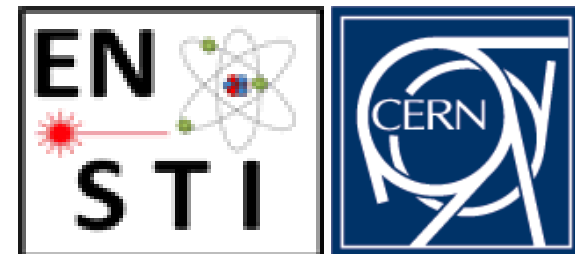


Prototype target tests with the ISOLDE Tape Station

Tania M. Mendonca



Beam development at ISOLDE

Group for the Upgrade of ISOLDE (GUI)

<https://isolde-upgrade.web.cern.ch/isolde-upgrade/>

Identification of programme driven priorities for beam developments:

1. Needs of approved experiments
2. Beam improvement
3. Research and development

Evaluation of technical feasibility of proposals at INTC

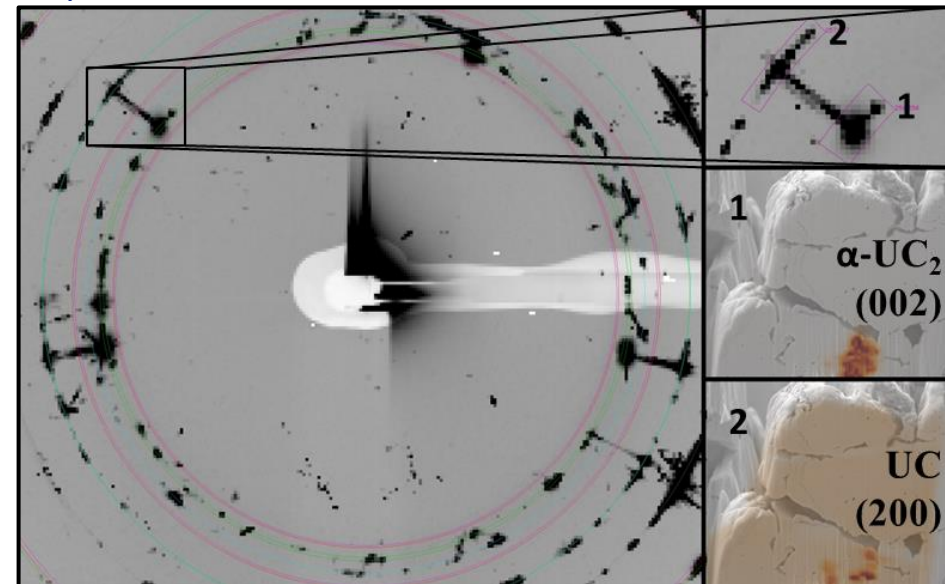
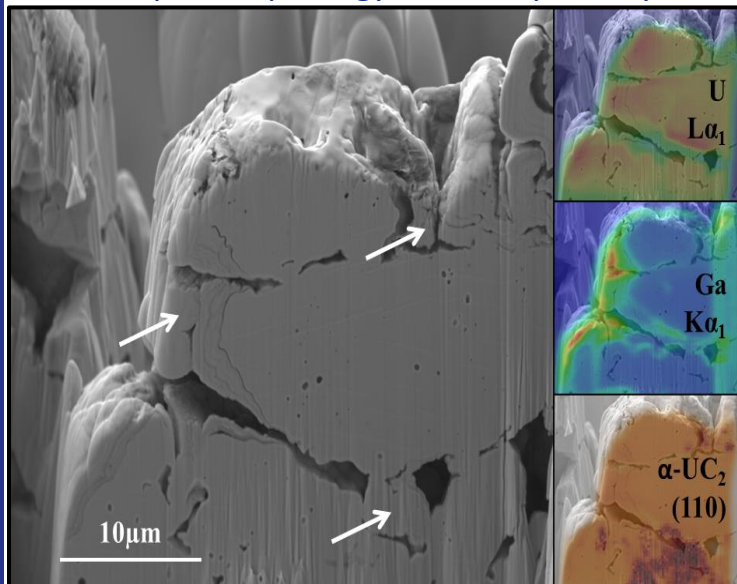
IS509/IS540: Target R&D experiments related to larger projects
(Beta Beams/ActILab-ENSAR, respectively)

IS540 - UC_x prototype target tests for ActILab-ENSAR



Characterization of conventional UC_x using synchrotron-based micro-beam analysis:

Microscopic morphology – buried porosity & chemistry



- Grain size of material is smaller than previously estimated; global phase transition observed at 2100°C
- Phase competition between UC and α -UC₂ as yet missing explanation of performance and durability of this material

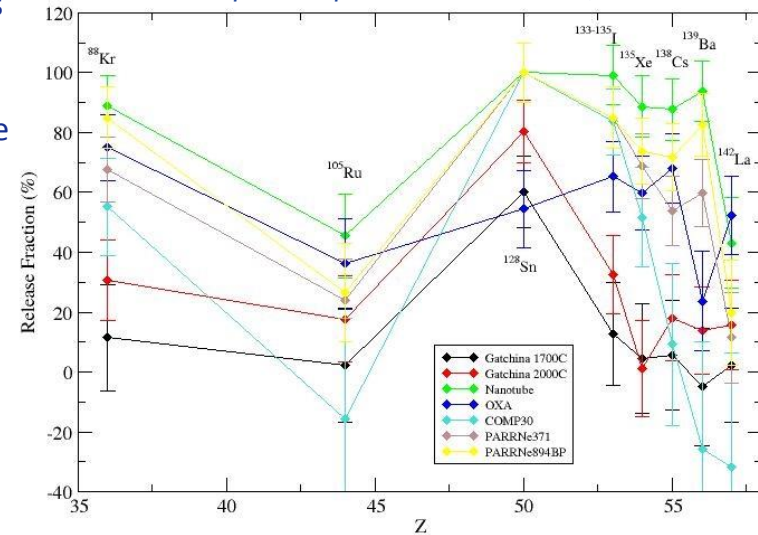
IS540 - UC_x prototype target tests for ActILab-ENSAR

Online tests and synthesis of de-novo designed uranium carbide matrixes:

Different microstructures, densities, grain sizes, crystal structures tested → tailor-made matrix:

- Suspension grinding of UO₂ powder to 160 nm average particle size
- Wet-mixing with multi-walled carbon nanotubes
- Ultrasound drying of mixture and pressing to 1.6 g/cm³ pellets
- Fast reactive sintering to mixed uranium carbide in carbon nanotube matrix

Release fractions from RaBIT irradiations, ALTO 2013



Ch. Lau, et al., in preparation

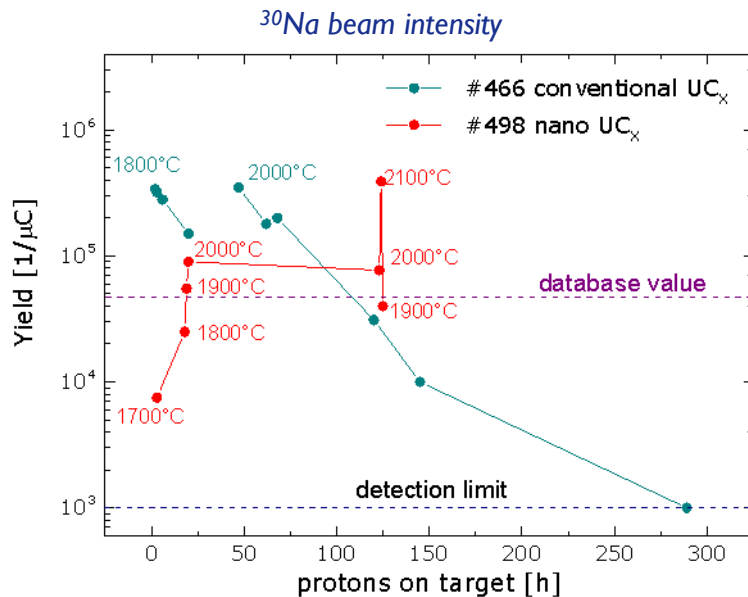
IS540:

Despite major technical difficulties (RFQ, tape station, separator):

- record yield of ¹¹Be: 6.0x10⁷ /μC, database: 7x10⁶ /μC (confirmed)
- Structure appears to be widely conserved over time and temperature (see ³⁰Na evolution)
- Yields of Rb, Cs, Fr remain to be confirmed

Repeat tests at ISOLDE (as TISD run) and at ALTO within ActILab in 2014

If results are promising we propose to use this material for selected beams in order to gain experience.



IS540 - UC_x prototype target tests for ActILab-ENSAR

First analysis of an irradiated UC_x target in the history of ISOLDE

(important to understand ageing processes and for upcoming waste campaign)

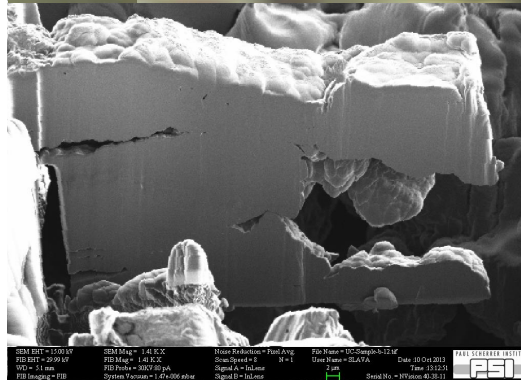
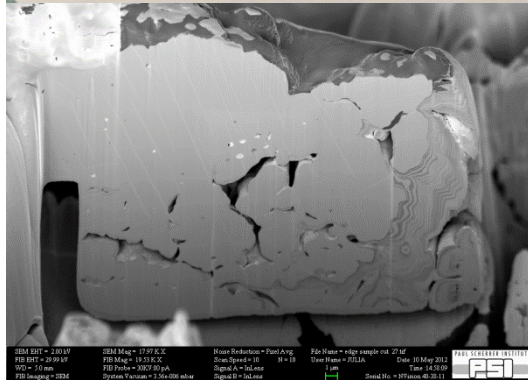
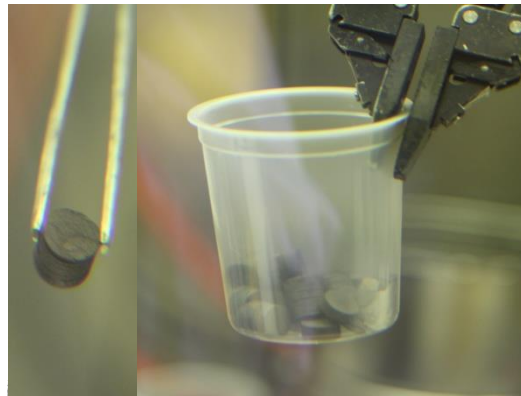
Opening target unit #466 ($8.8 \cdot 10^{18}$ protons in 2011) in inert-gas hot-cell at PSI,

19 mSv/h on contact with Ta beam window

before irradiation



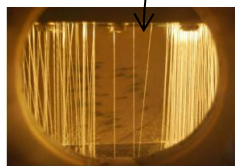
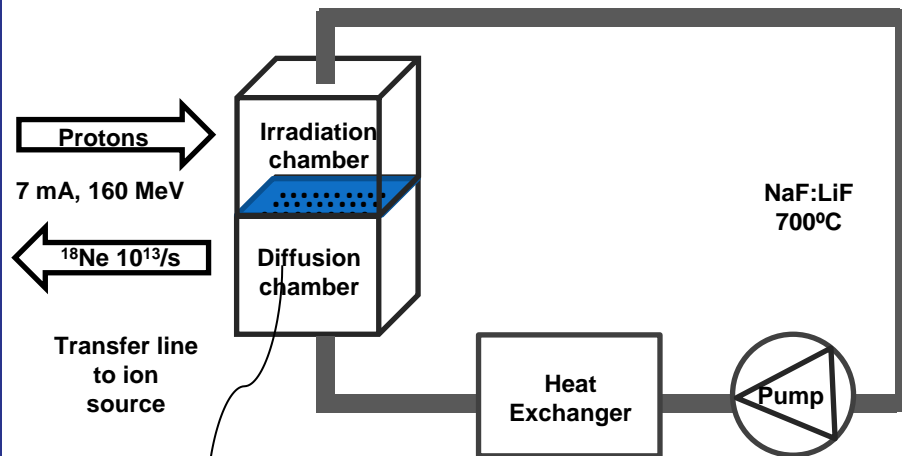
after irradiation



- Pellets appear macroscopically unchanged
- Microscopic evolution of pore distribution and grain size under irradiation observable
- 500 μ Sv/h on contact with single pellet
- Results of synchrotron investigations under analysis
- Ceramography and electron microprobe analysis scheduled for April
- Perform full suite of investigations on nano UC

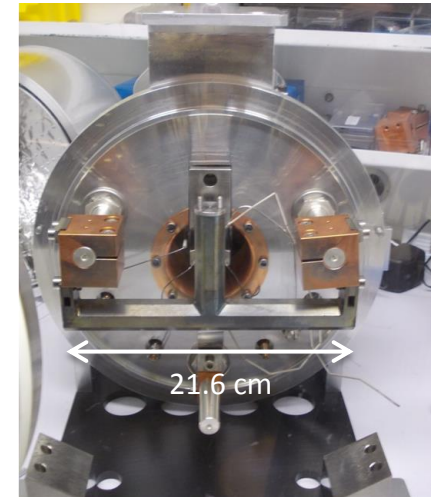
IS509: Production and release of gas and volatile elements from sodium-based targets

- Sodium or sodium-based alloys as targets or coolants for MW proton beams for Neutron Spallation Sources or Neutrino Oscillation Physics
- Proposal of molten salt target loop for production of $10^{13}/s$ rates of baseline isotope ^{18}Ne for the Beta Beams
- Conceptual design inspired from Pb/Bi loop developed at IPUL during EURISOL Design Study
- Validation of target material with prototype static NaF:LiF target (1^{st} proposal with NaF:ZrF₄)



Pb/Bi shower at diffusion chamber
(at the exit of interchangeable grid)

@IPUL, Latvia
Molten Pb/Bi loop



•Static unit

•Target material: NaF:LiF (39:61% mol.)

• Containment: Haynes 242

•VADIS ion source with controlled temperature transfer line

•Target unit #478 irradiated in June 2012

P. Zuchelli, Phys. Lett B 532 (2002) 166

Final Report of the EURISOL Design Study 2009, J. Cornell Ed., GANIL

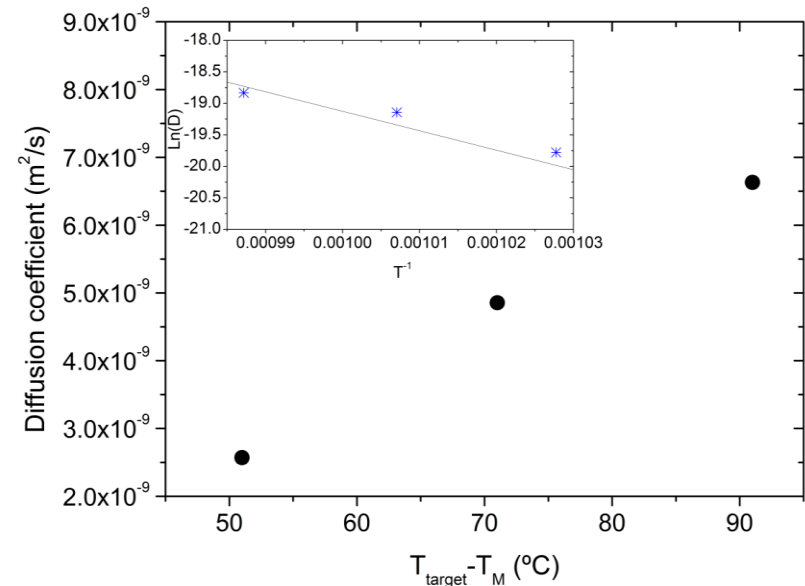
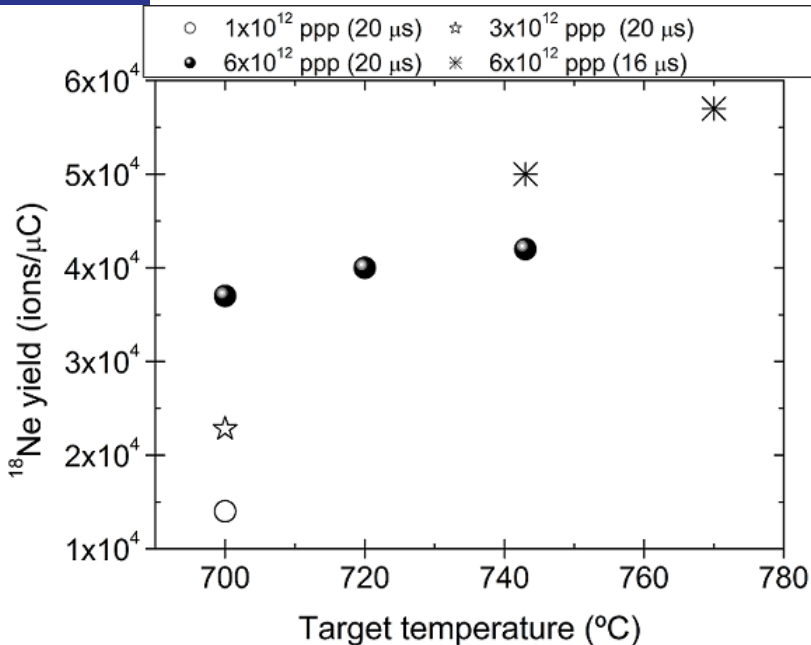
T. Stora, CERN Yellow Report, CERN-2010-003

T.M. Mendonca et al., CERN-ACC-NOTE-2013-0009

IS509: Study of production and release of ^{18}Ne

Determination of diffusion coefficient of Neon

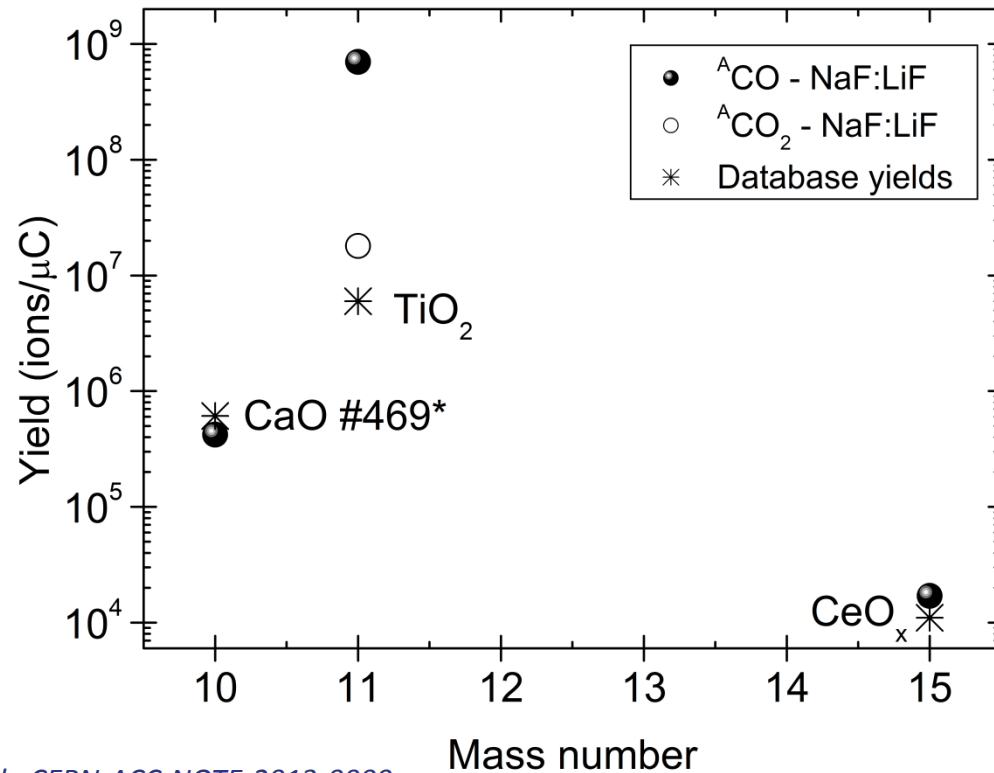
- Systematic study as a function of the target temperature and proton beam intensity
- Increase of ^{18}Ne yield with both temperature and proton beam intensity
- Maximum yield of 5.7×10^4 / μC at 770°C
- First determination of diffusion coefficient of neon in molten fluoride salts .
- $D_{\text{Ne in NaF:LiF}} \sim 10^{-9} \text{ m}^2/\text{s}$, 8 orders of magnitude higher than oxide targets (CaO, Al_2O_3 with $D \sim 10^{-17} \text{ m}^2/\text{s}$).



IS509: Experimental results

Study of production of carbon beams

- Increase of ^{11}C yields in both monoxide and dioxide form in comparison with presently reported in the ISOLDE database
- Record yield for $^{11}\text{C}+\text{O}$ with 2 orders of magnitude improvement – possible use as production unit
- Small improvement of ^{15}C yield in the monoxide form by a factor of 1.5
- ^{11}C yields relevant for production of radiotracers for PET



Future plans for available shifts

Complementary data on carbon production

- Best operation conditions for high intensity beams
- Feasibility of use of such targets in production of medical isotopes

Complementary studies of release parameters of neon isotopes

- Model of diffusion of neon in molten fluoride salts

Test of different salt compositions NaF:ZrF₄

- Performance in ¹⁸Ne production
- Study of production in medium mass elements
(improvement in ⁷²Kr yield by a factor of 10 expected)

| Isotope | yield (/uC) | target – ion source | Shifts (8h) |
|------------------------------------|-------------|----------------------------|-------------|
| ¹¹ C | - | NaF:LiF – VD7 | 2 |
| ¹⁵ C | - | NaF:LiF – VD7 | 0.5 |
| ¹⁸ Ne | - | NaF:LiF – VD7 | 1 |
| ¹⁹ Ne | - | NaF:LiF – VD7 | 1 |
| ⁷² Kr, ¹⁸ Ne | - | NaF:ZrF ₄ – VD7 | 2.5 |

Total shifts: 6

Publication List

1. T.M. Mendonca, R. Hodak, T. Stora, Journal of Physics: Conference Series 408, 012068 (2013)
2. T.M. Mendonca, et al., CERN-ACC-NOTE-2013-0009
3. T.M. Mendonca, et al., Submitted
4. T.M. Mendonca, et al., in preparation

Thank you for the attention!