ERAWAST
Exotic Radionuclides from Accelerator WAste for Science and Technology

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Outline

- Objectives of ERAWAST
- What do we have?
  - PSI accelerator facility
  - Irradiated material
- What can we do?
  - Separation techniques
  - Equipment
- Who needs exotic radionuclides? And for what?
  - Future plans – short term
  - Future plans – long-term
  - First works – overview
- ESF workshop ERAWAST

Objectives of ERAWAST

Application of exotic long-lived isotopes from accelerator waste for several purposes

Examples:

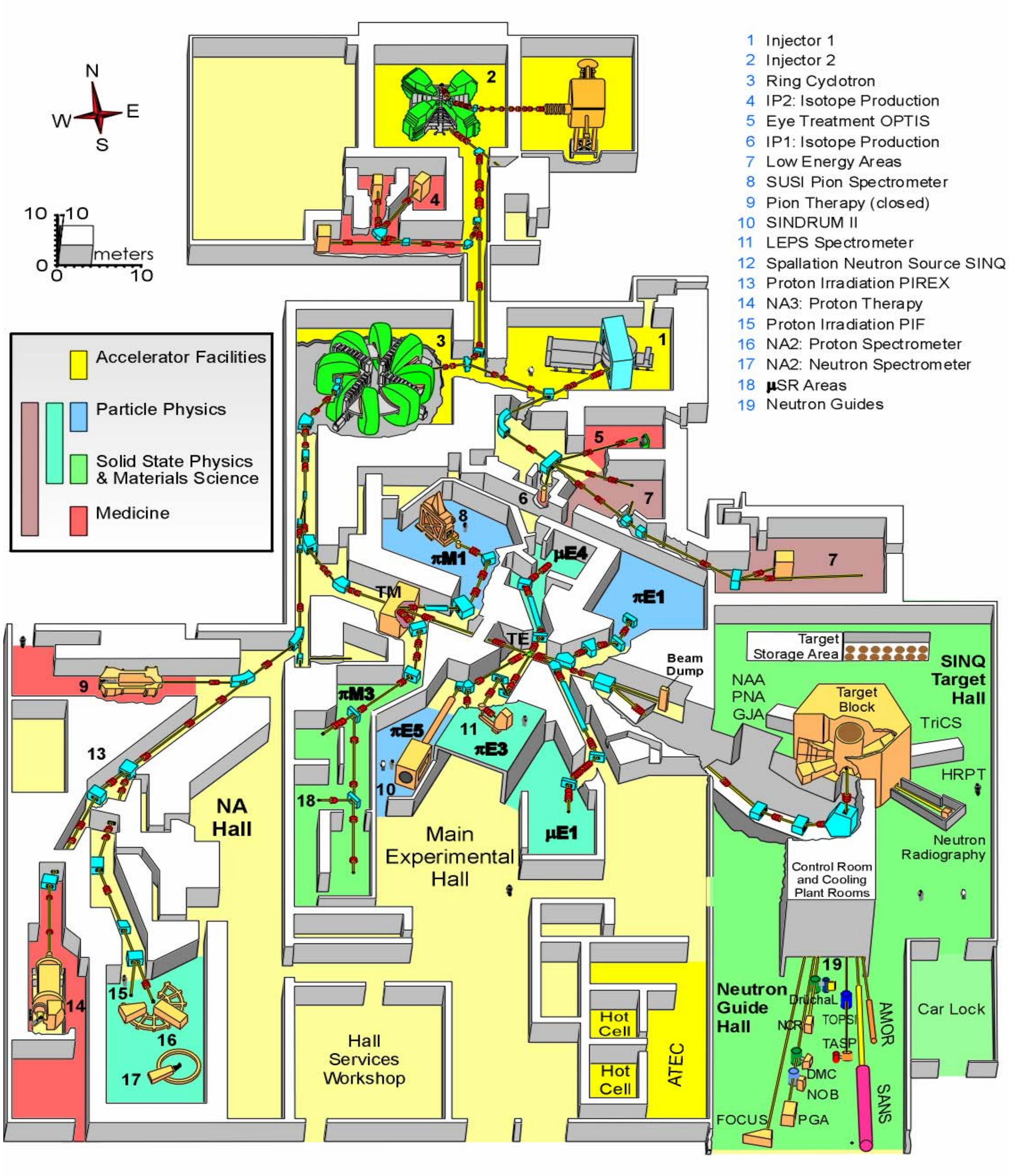
^{7}Be (50.8d), ^{10}Be ($1.6 \cdot 10^{6}$y), ^{26}Al ($7.2 \cdot 10^{5}$y), ^{44}Ti (60.4y), ^{53}Mn ($3.7 \cdot 10^{6}$y), ^{60}Fe ($1.5 \cdot 10^{6}$y), ^{146}Sm ($1.03 \cdot 10^{8}$y), ^{182}Hf ($9 \cdot 10^{6}$y)

Development of a long-term international collaboration between

- Nuclide production facilities
- Basic physics research
- Astrophysics
- AMS measurement groups
- Life science and pharmaceutical chemistry
- ?

What does PSI have?

- Most powerful proton accelerator in Europe, (590 MeV proton energy, beam current >1mA)
- Neutron spallation target (lead; >1 MW power)
- Highly activated materials from cooling water, beam dumps, shieldings, targets



Activated parts:

BX2-Target, Beam dump and shielding
(Beam Control, 71 MeV protons)

BMA-Target, Beam dump and shielding
(Pion therapy station, 590 MeV protons)

Target E, beam dump and shielding
(590 MeV protons)

Lead and Zirkalloy from the SINQ facility

Materials:
Copper
Beryllium
Tungsten
Aluminium
Cast iron
Stainless steel
Graphite
Lead
Concrete

Chemical separation techniques and equipment

- Aqueous chemistry
  - Ion exchange (Be, Al, Ti, Ln)
  - Extraction (Fe)
  - Precipitation (Ni, Mn)
- Gas phase chemistry
  - Thermochromatography (Po, Hg)
  - Destillation (I, Cl)
- Class B and C laboratories, 2 Hotcells, manipulators, measurement techniques (HPGe`s, LSC, α-detectors; AMS)

Overall project programme

- Short-term
- Long-term

Short -term

1. **Existing accelerator waste material**
   Copper beam dump irradiated at the 590-MeV proton beam station at PSI, dismounted about 10 years ago
   ^{26}Al, ^{59}Ni, ^{53}Mn, ^{60}Fe, ^{44}Ti or others can be separated
   other irradiated materials like carbon (^{10}Be), stainless steel or concrete are also available
2. **Target material from the SINQ facility**
   Two irradiated lead targets from the spallation source are available. Heavier isotopes like ^{182}Hf or several rare earth elements (e.g. ^{146}Sm, several Dy isotopes) can be obtained. In principle, targets from the SINQ will be available every second year.

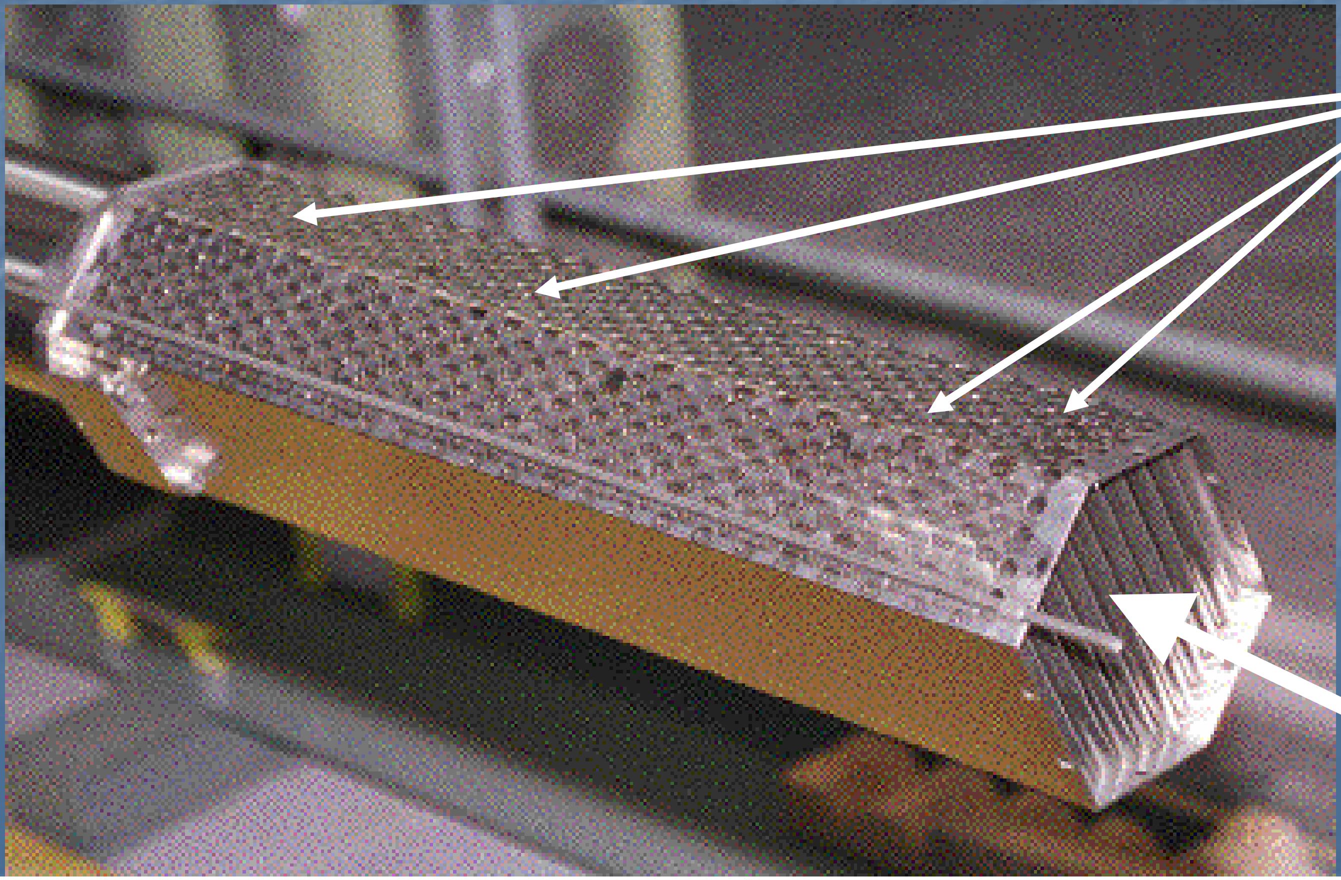
Long-term

3. **Nuclide extraction from Hg rods**
   In the frame of the EURISOL program studies for isotope separation from irradiated Hg targets are foreseen. Two already irradiated Hg rods are available for preparing small samples of interesting isotopes. Extended scale is expected with a working EURISOL facility.
4. **Special irradiations**
   The SINQ facility offers the possibility to irradiate materials with 590 MeV protons at special positions. Tended experiments for isotope production can be offered.

Photograph of the SINQ-Target

Occupation of several sample positions with selected materials is possible

Operation regime: target change every second year



Sample positions

Proton beam

First applications

- Research fields
- Chemical separation

1. Measurement of the $^7Be(p,\gamma)^8B$ cross section with an implanted ^7Be-Target

- Key reaction for the evaluation of solar neutrino fluxes (knowledge of the fusion reactions in the Sun)
- ^7Be-source: graphite-target for π-meson-production (PSI)
- Implantation into a copper substrate with ISOLDE technique at CERN (10^{16} atoms implanted)
- Collaboration with the Weizmann Institute of Science, Rehovot, Israel

2. Preparation of a ^{60}Fe-sample

- Chemical separation of the iron fraction from a sample from an irradiated beam-dump (590 MeV protons, beam dosis ca. 0.1Ah); $\sim 10^{14}$ atoms
- Basic research: Determination of the half-life of ^{60}Fe
- Applied research: Preparation of standard solutions for accelerator mass spectrometry, biomedical investigations, astrophysics
- Collaboration with TU Munich, Germany

3. Preparation of a ^{44}Ti-sample

- Chemical separation of the carrier-free titanium fraction from a sample from an irradiated beam-dump (590 MeV protons, beam dosis ca. 0.1Ah); ~1 MBq
- Generator nuclide pair $^{44}Ti/^{44}Sc$; ^{44}Sc being a potential PET nuclide for medical investigations
- Collaboration with the University of Mainz, Germany

4. Preparation of a ^{26}Al-sample

- Chemical separation of the aluminum fraction from a sample of an irradiated beam-dump (590 MeV protons, beam dosis ca. 0.1Ah); $\sim 10^{14}$ atoms
- AMS-Standard for calibration purposes
- Basic research: Radioactive beam, nuclear physics
- Collaboration with ETH Zürich, Switzerland
- Problem: γ-measurement with an accuracy <3% with a „Well"-detector is difficult

5. Preparation of a ^{10}Be-sample

- Chemical separation of the carrier-free beryllium fraction from a sample from an irradiated graphite target (Target E, 590 MeV protons, beam dosis ca. 11 Ah); ~ 20 μg ^{10}Be
- Foreseen for a ^{10}Be-beam, studies of halo states in drip line nuclei (nuclear structure)
- Collaboration with UCL, Belgium

ESF (European Science Foundation) workshop on ERAWAST

- 15.-17.11.2006 at PSI
- Topics:
  - Accelerator waste analytics, radionuclide production possibilities, separation techniques
  - Astrophysics, nuclear and basic physics
  - Medical applications and applied research
  - others
- Search for interested partners
- Result: 5-year-working-programme (ESF network or programme support, EU-projects or fellowships, bilaterale collaborations)