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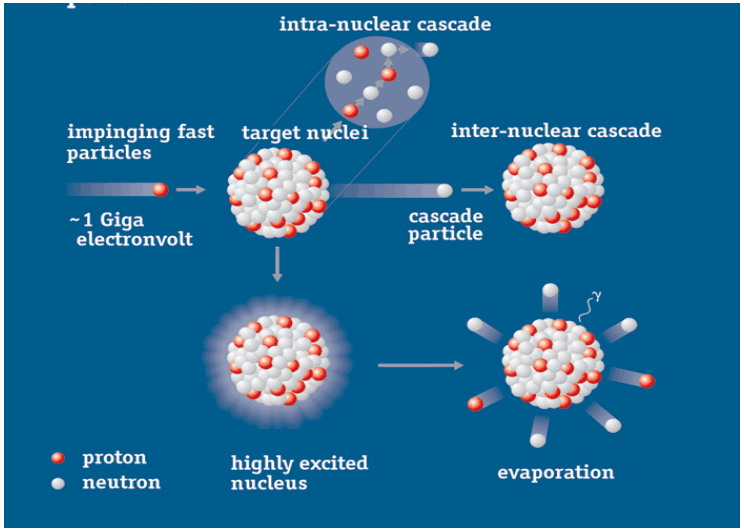
PSI

Rugard Dressler & Dorothea Schumann :: Laboratory of Radiochemistry :: Paul Scherrer Institut

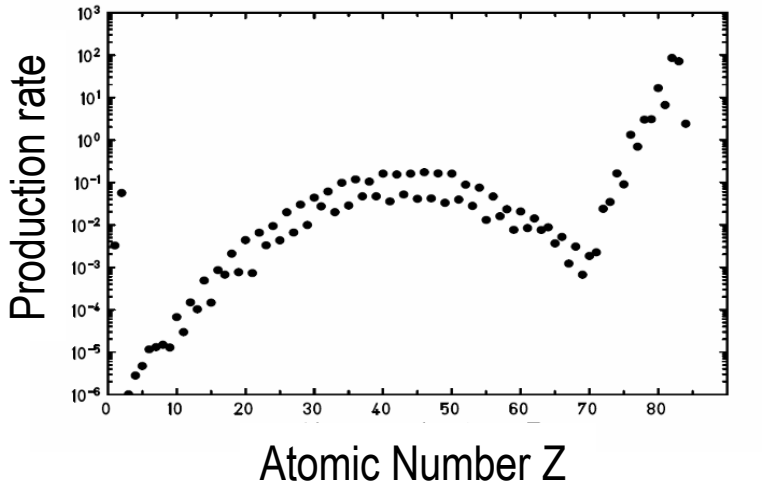
Isotope Production at PSI

30th Conference of the INTDS, 25 – 30 September 2022, PSI, Switzerland

Spallation Reactions
a source for exotic isotopes

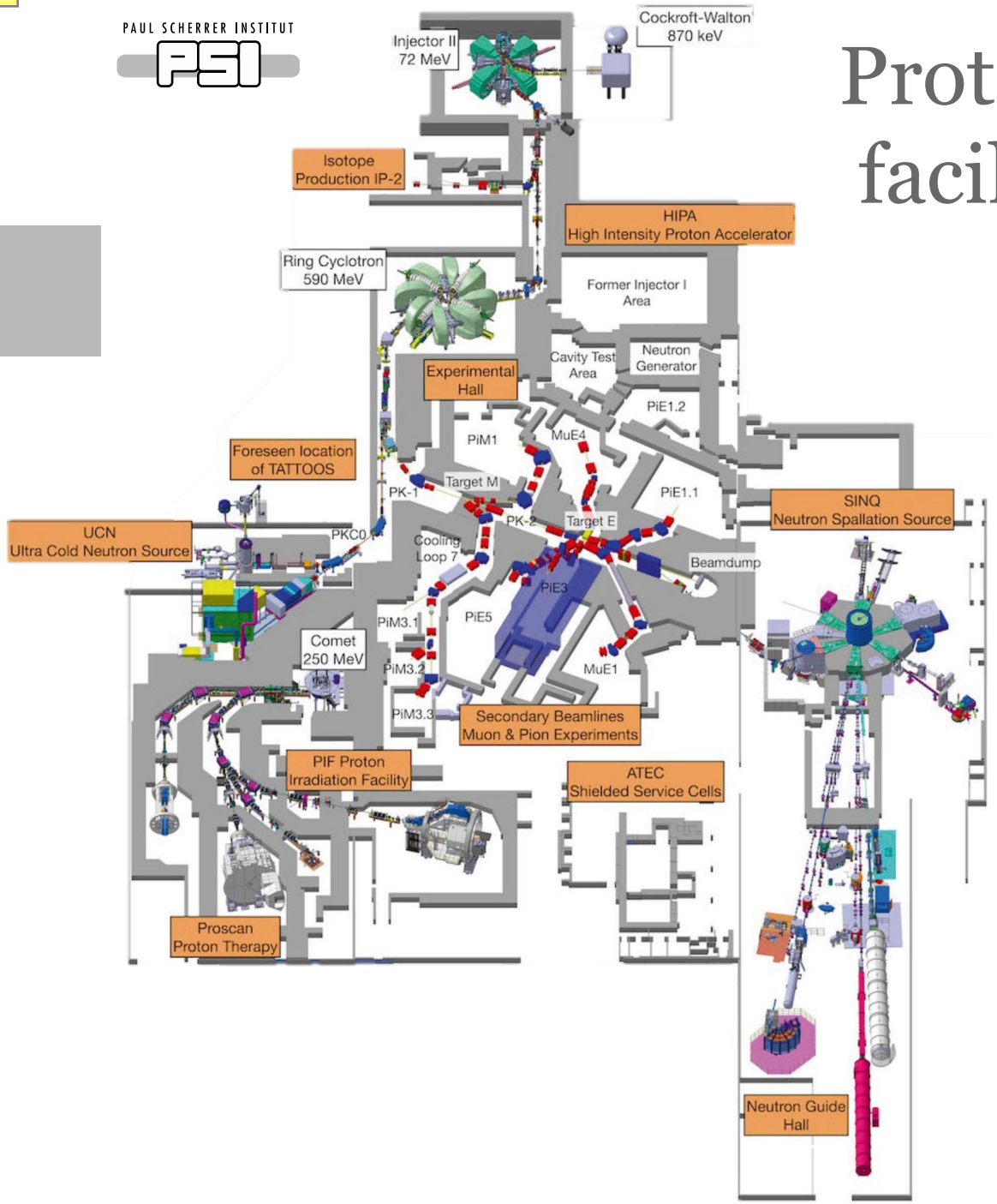


all elements with $Z \leq Z_{target} + 1$ produced



PSI at night

Proton accelerator facilities at PSI



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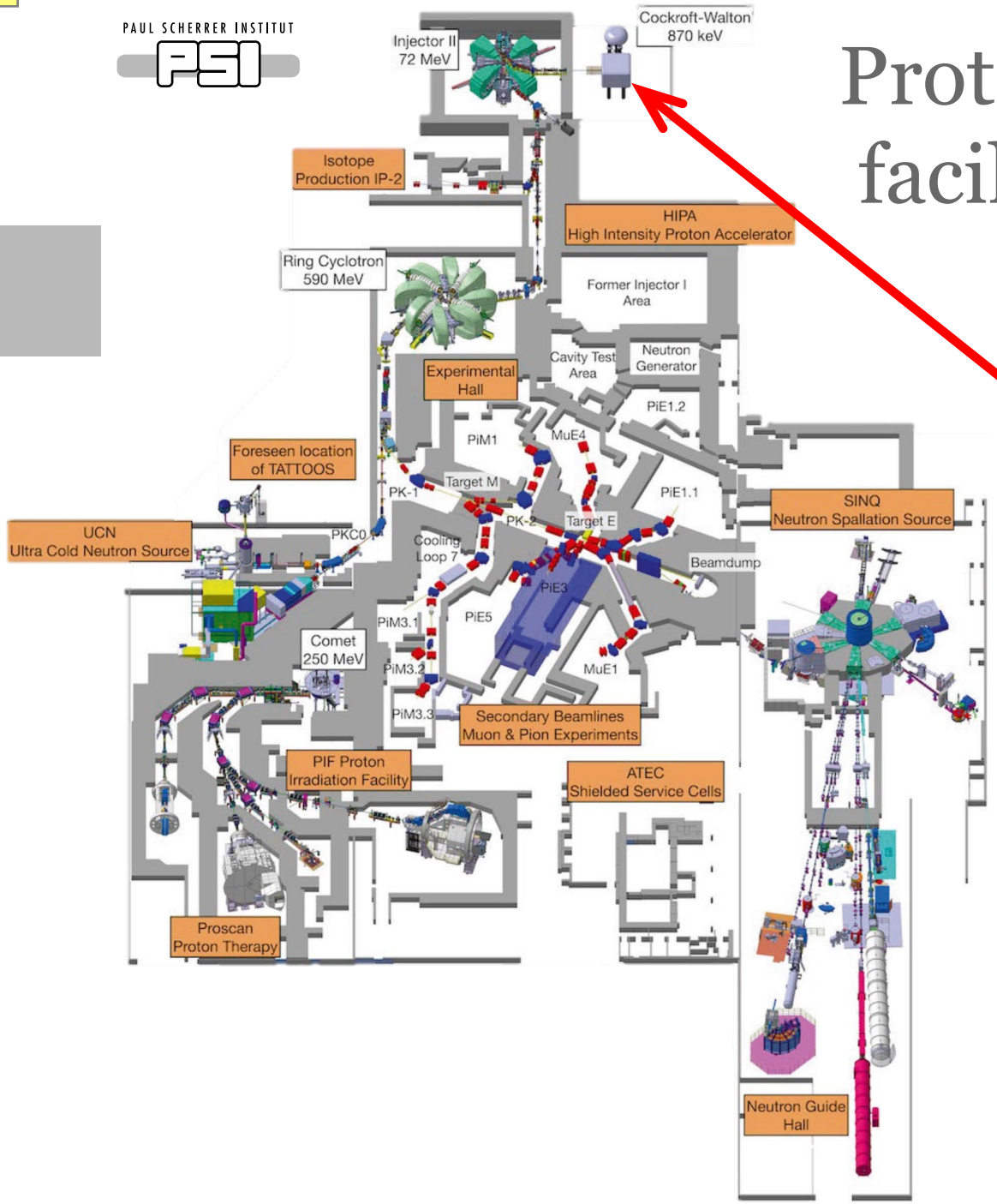
Proton accelerator facilities at PSI



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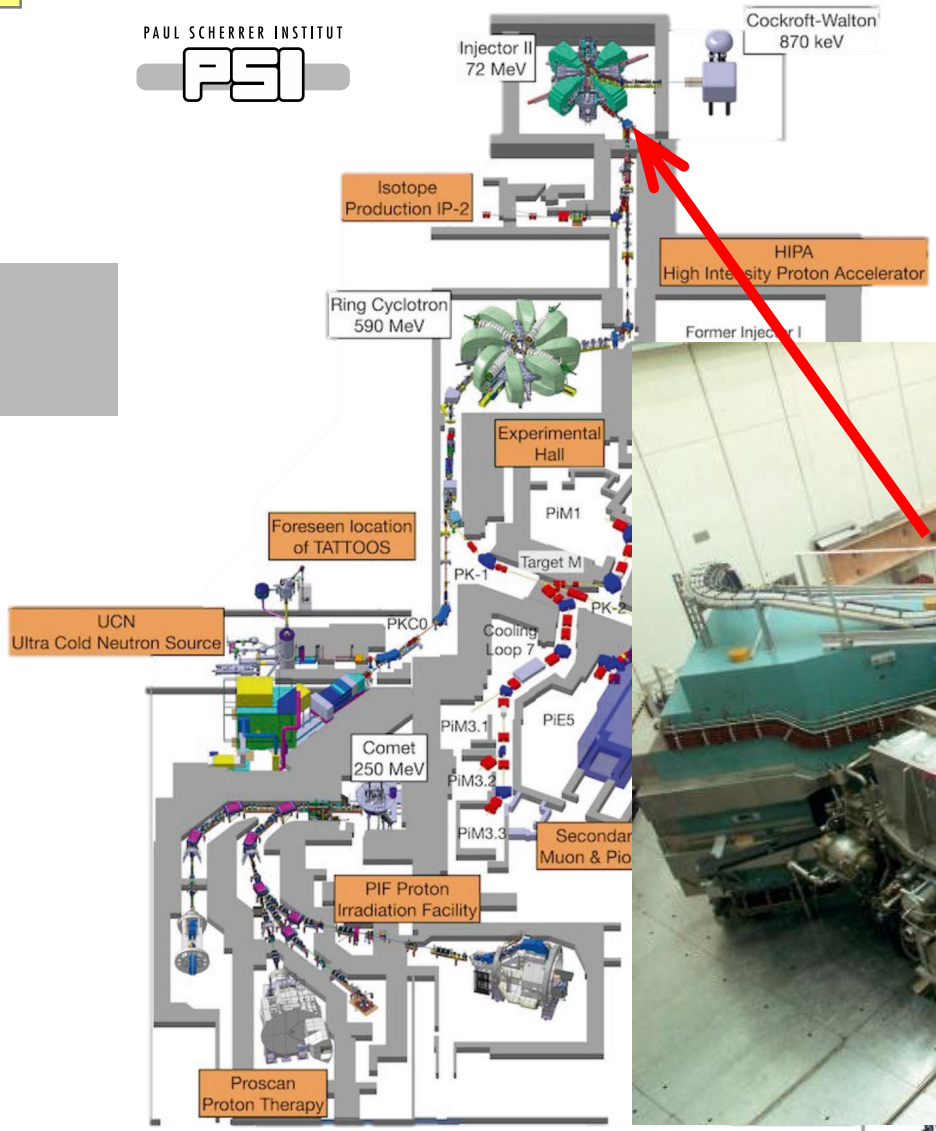
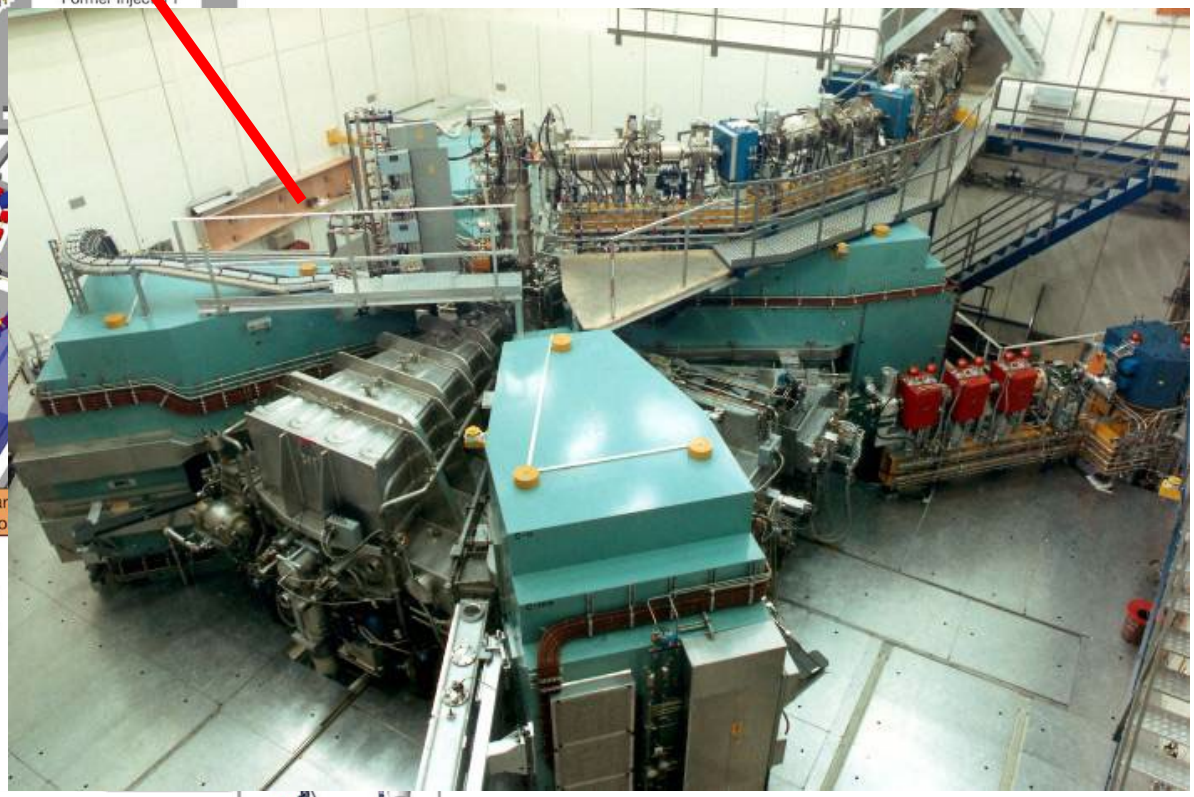
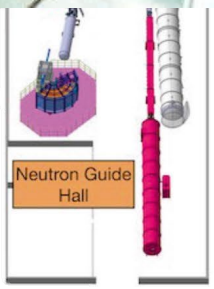
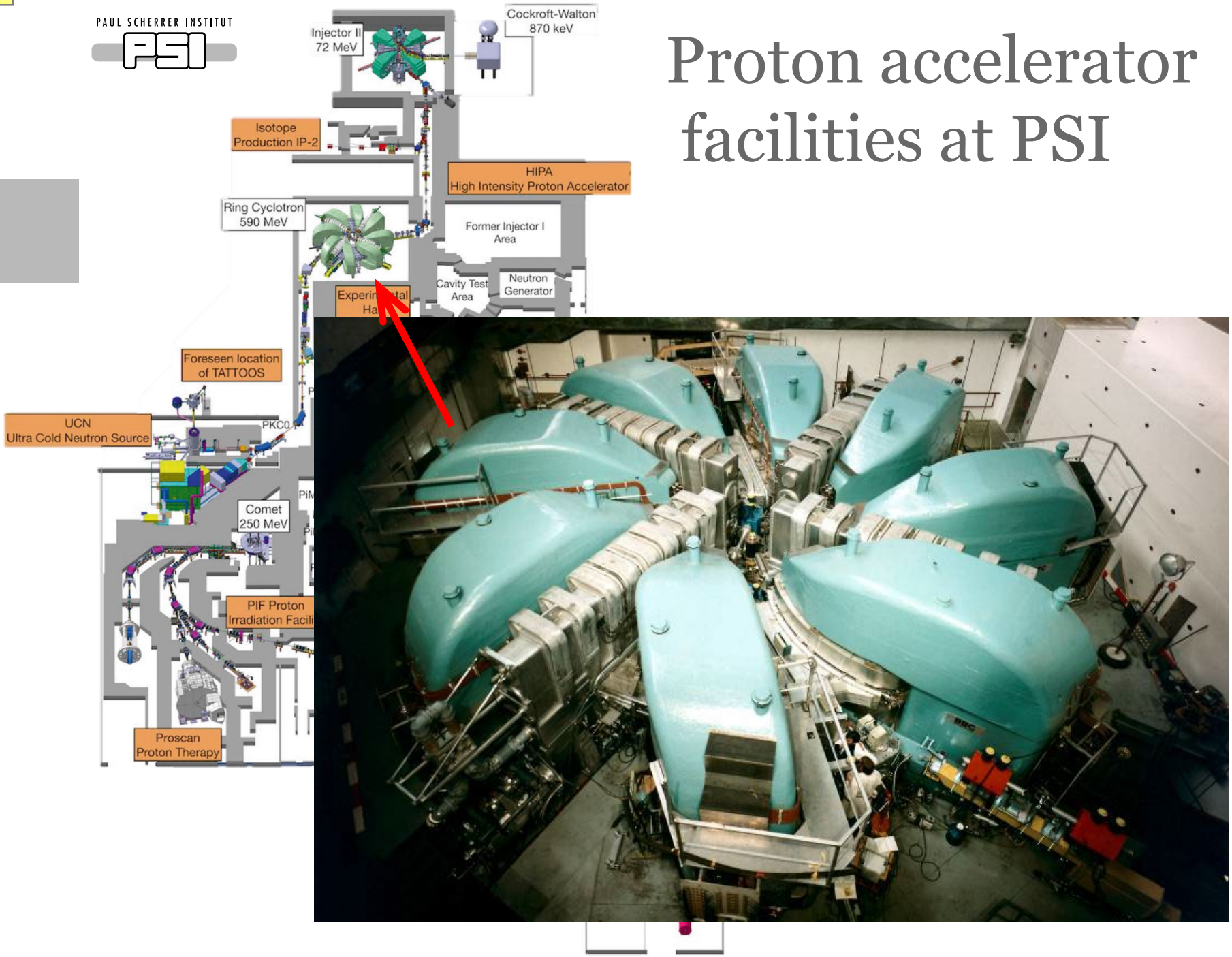
Proton accelerator facilities at PSI



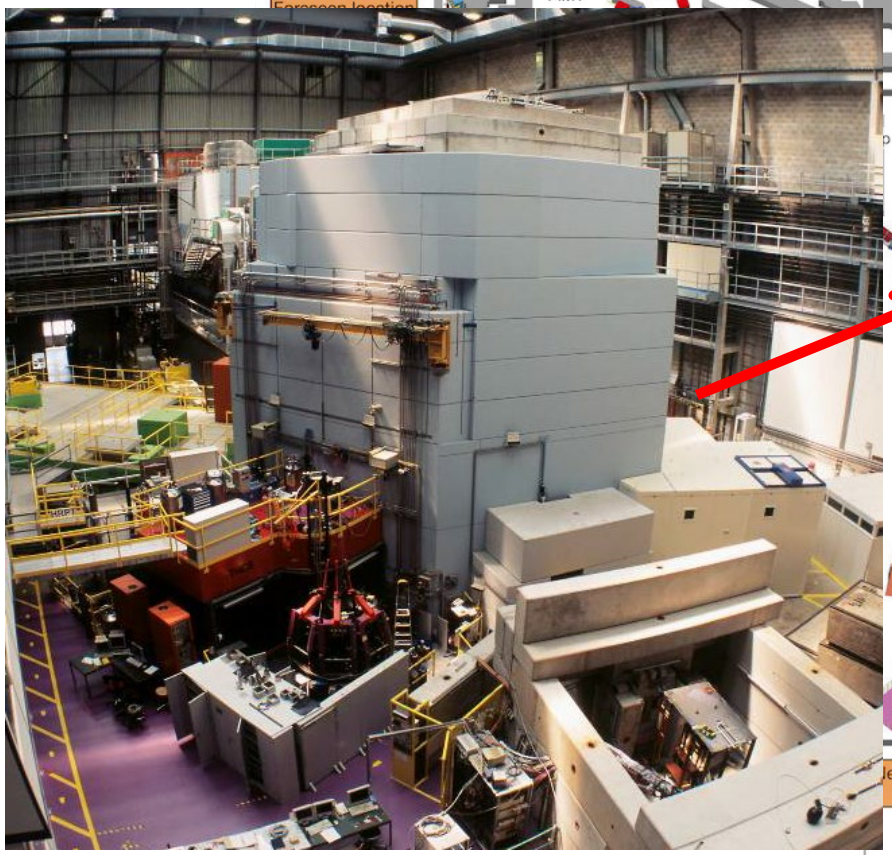


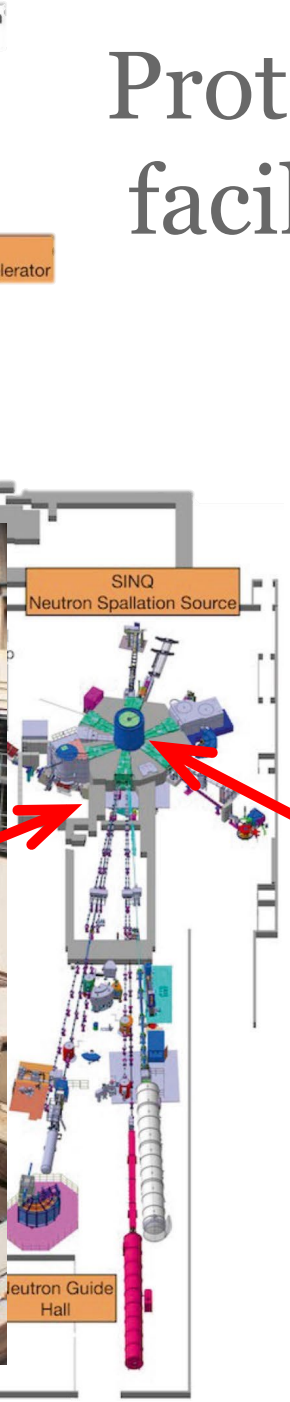


Proton accelerator facilities at PSI



Proton accelerator facilities at PSI





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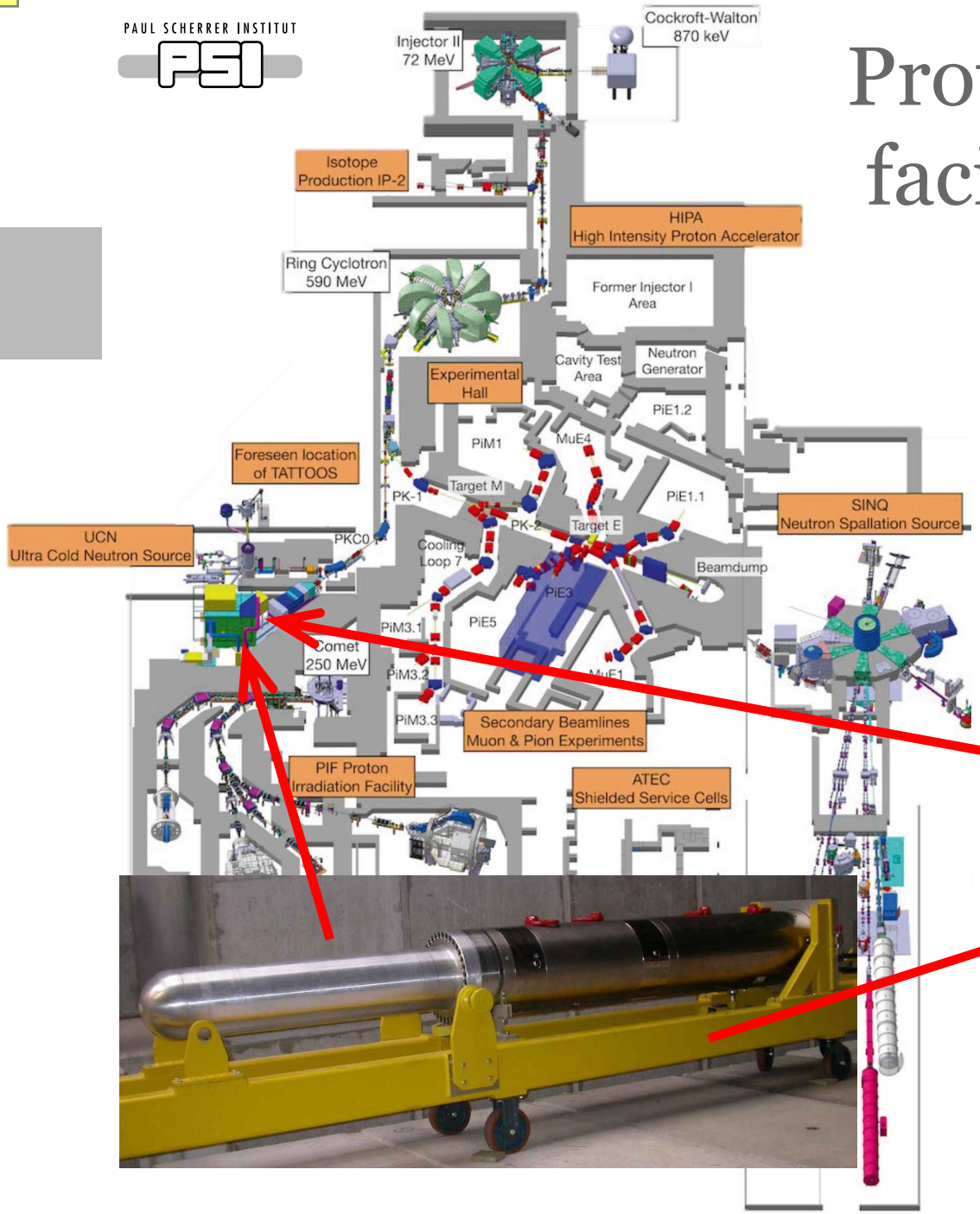
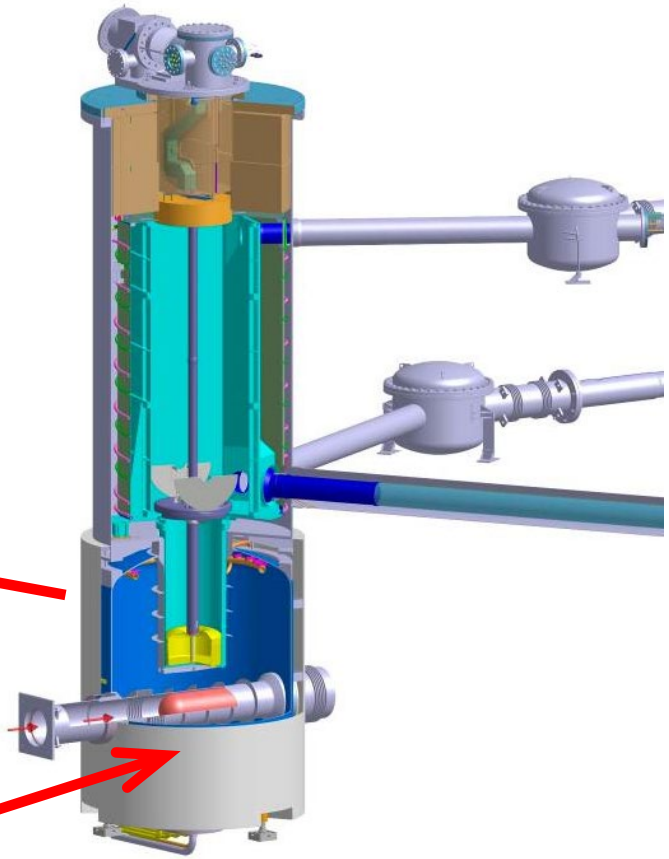
Proton accelerator facilities at PSI





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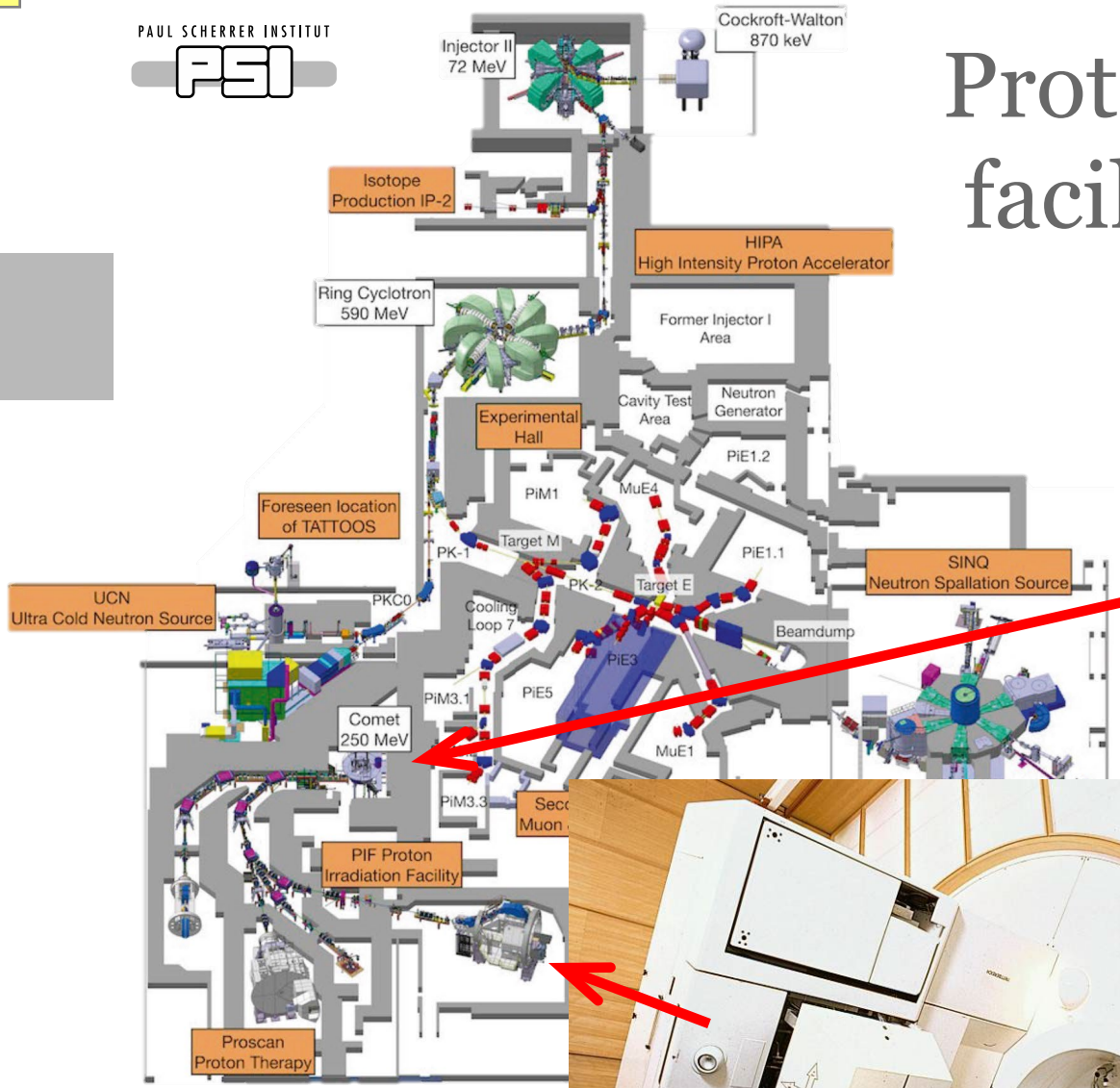
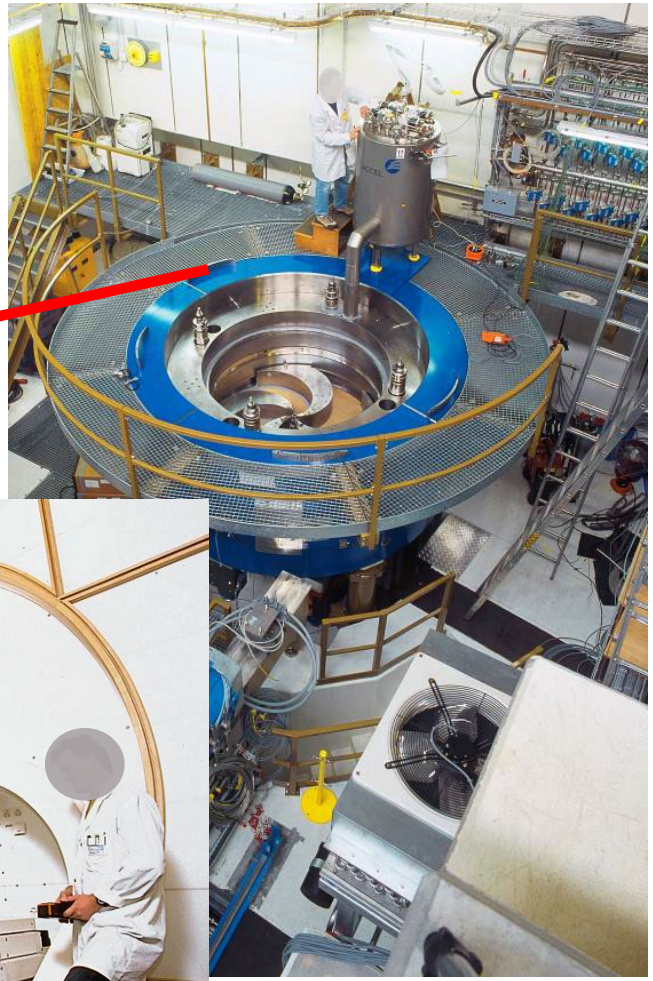
Proton accelerator facilities at PSI

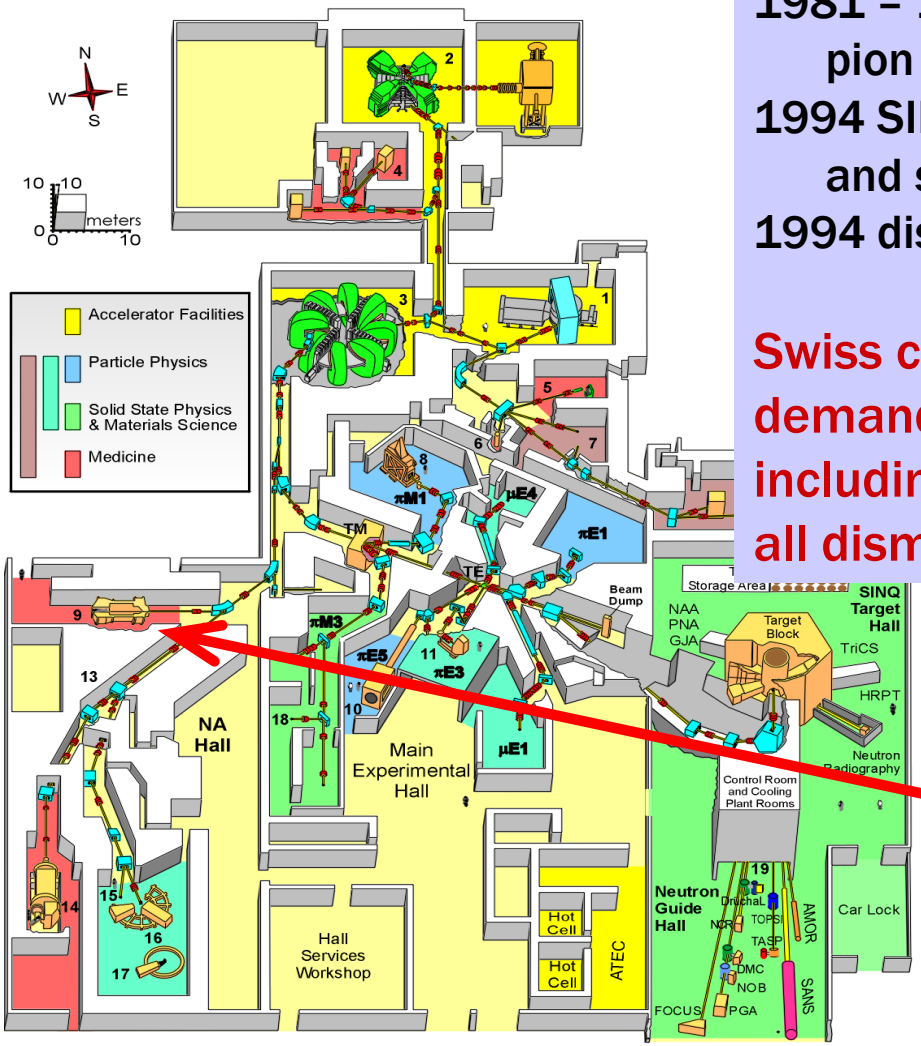




How its began

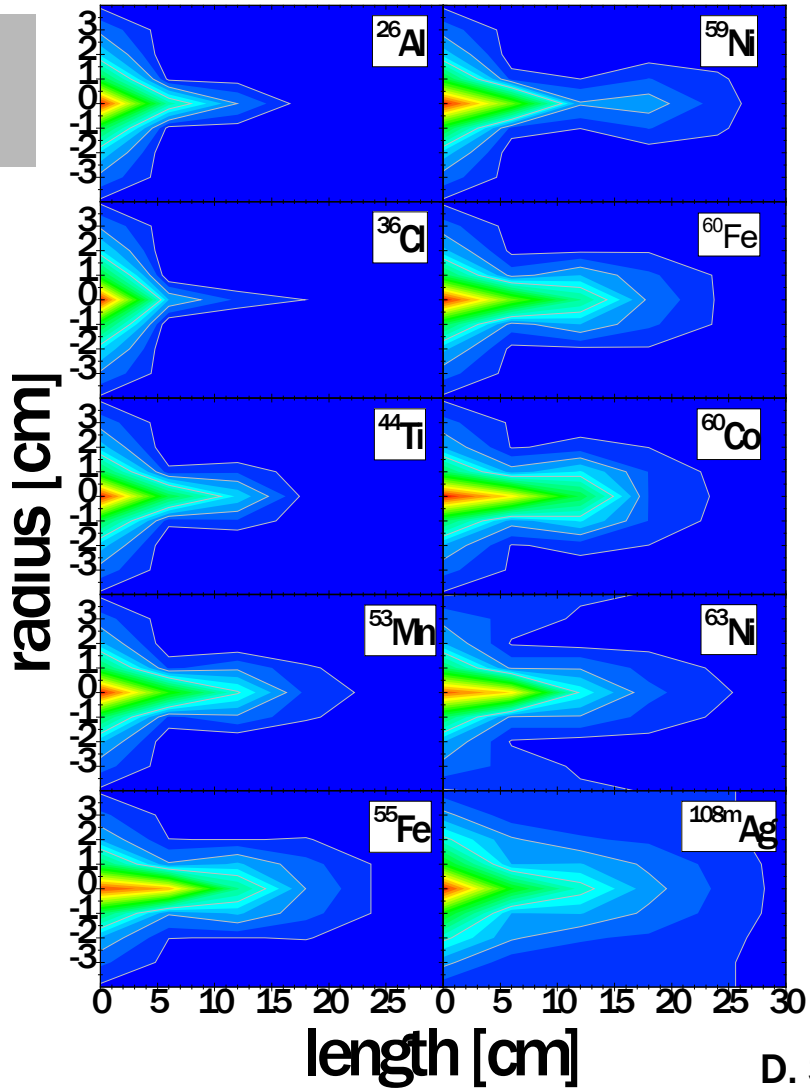
1981 – 1992
pion tumor-therapy at SIN/PSI
1994 SINQ was operational
and serves as a total beam-dump
1994 dismantling of the bio-medical setup

Swiss control and licensing authority demanded a characterization including the nuclide-vector of all dismantled parts for final disposal.



D. Schumann, J. Neuhausen: J Phys. **G 35** (2008) 014046

Nuclide distribution in Copper beam dump



total stored material
about 500 g copper

radio nuclides inventory

^{26}Al	7 kBq	≈ 2.3×10^{17} atoms
^{32}Si	10 MBq	≈ 7.8×10^{16} atoms
^{44}Ti	100 MBq	≈ 2.8×10^{17} atoms
^{53}Mn	500 kBq	≈ 8.4×10^{19} atoms
^{59}Ni	8 MBq	≈ 2.7×10^{19} atoms
^{60}Fe	5 kBq	≈ 5.9×10^{17} atoms

D. Schumann, et al.: Radiochim. Acta **97** (2009) 123

Experiments with ^{60}Fe

Half-life measurements

old adopted value

$t_{1/2}$ = 1.5 My

W.Kutschera, et al.:

NIM B 5 (1984) 430

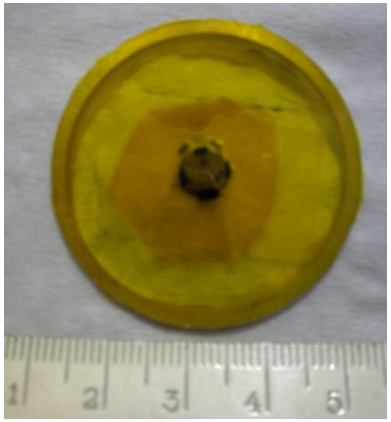
new value

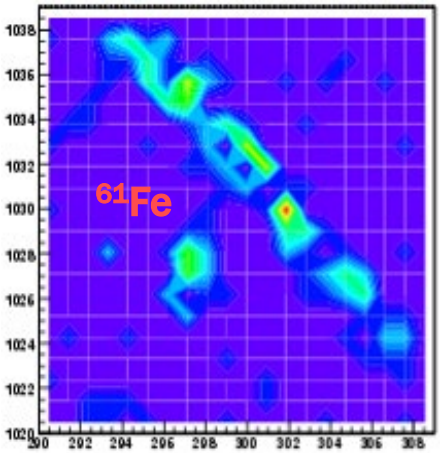
$t_{1/2}$ = 2.62 My

- G.Rugel, et al.:
  Phys. Rev. Lett. **103** (2009) 072502
- A.Wallner et al.:
  Phys. Rev. Lett. **114** (2015) 041101
- K.M.Ostdiek, et al.:
  Phys. Rev. C **95** (2017) 055809

neutron capture cross section

- ^{60}Fe(n,γ)^{61}Fe at stellar neutron temperatures kT = 25 keV
  ‹σ› = 5.6 mbarn
  E.Uberseder, et al.:
  Phys. Rev. Lett. **102** (2009) 151101





- thermal neutrons capture
  T.Heftricht, et al.:
  Phys. Rev. C **92** (2015), 015806

The ERAWAST-project

(Exotic Radionuclides from Accelerator WAste for Science and Technology)

Objective:

Exploitation of accelerator waste for isolating rare exotic radionuclides

History:

- Radiochemical analytics of activated components for disposal
- Results showed high content of several rare isotopes
- Looking for potential users of these isotopes: I. ERAWAST workshop 2006 (PSI), funded by ESF
- Five-years working program
- II. ERAWAST workshop 2011 at PSI: first results and future program
- CHANDA-workshop in 2015
- ~ 20 Partners
- Member of n_TOF

Collaboration between

Nuclide production facilities

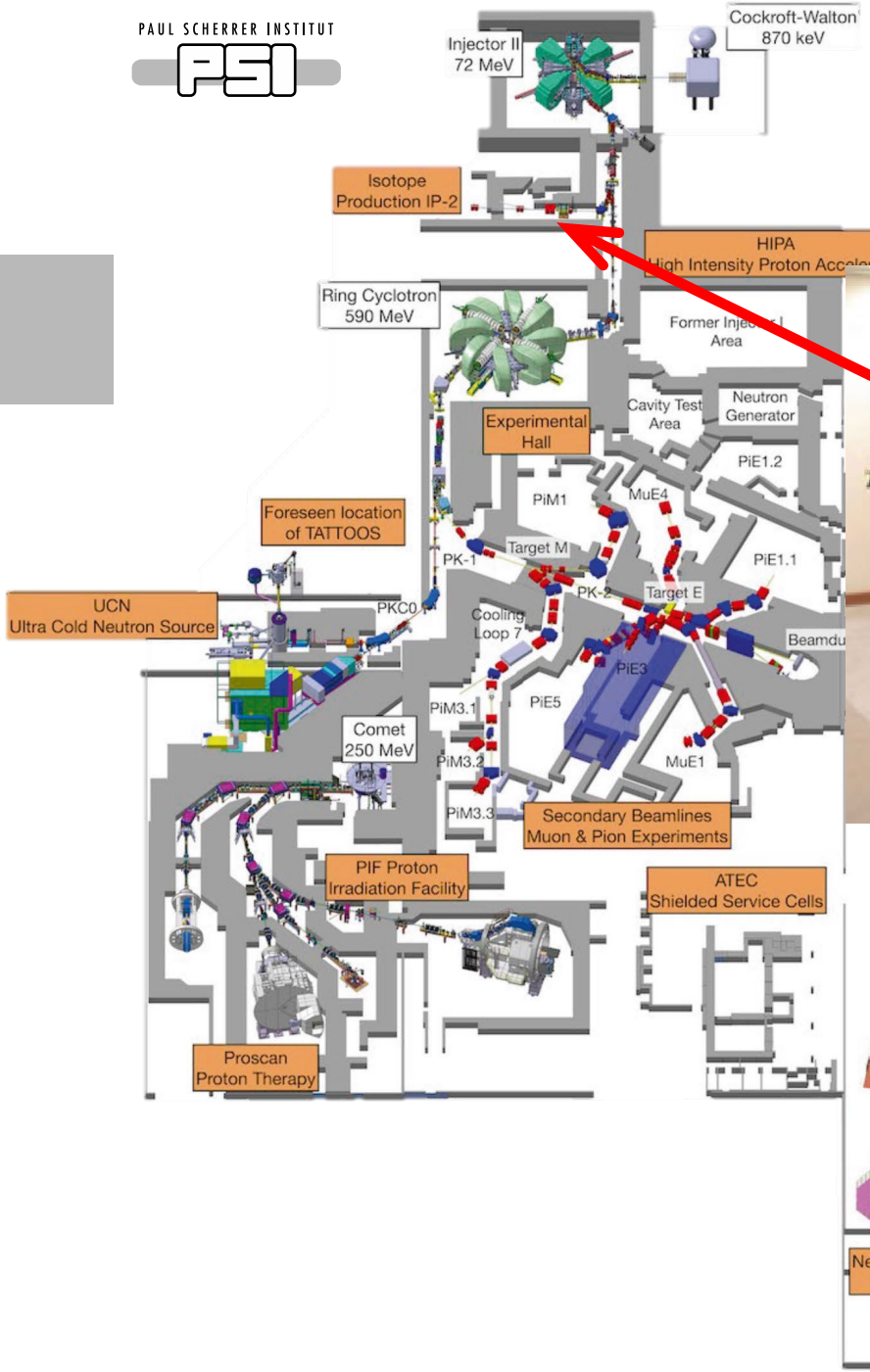
Basic nuclear physics research

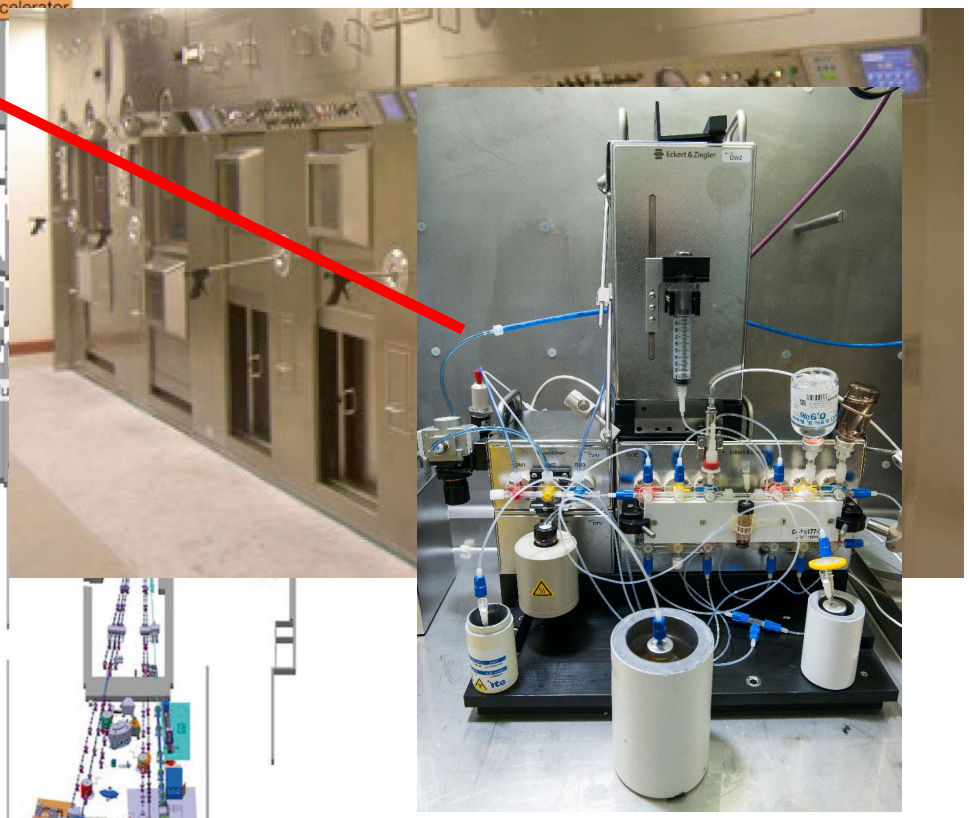
Nuclear astrophysics

AMS measurement groups

Environmental chemistry

„Useful“ Installations at PSI

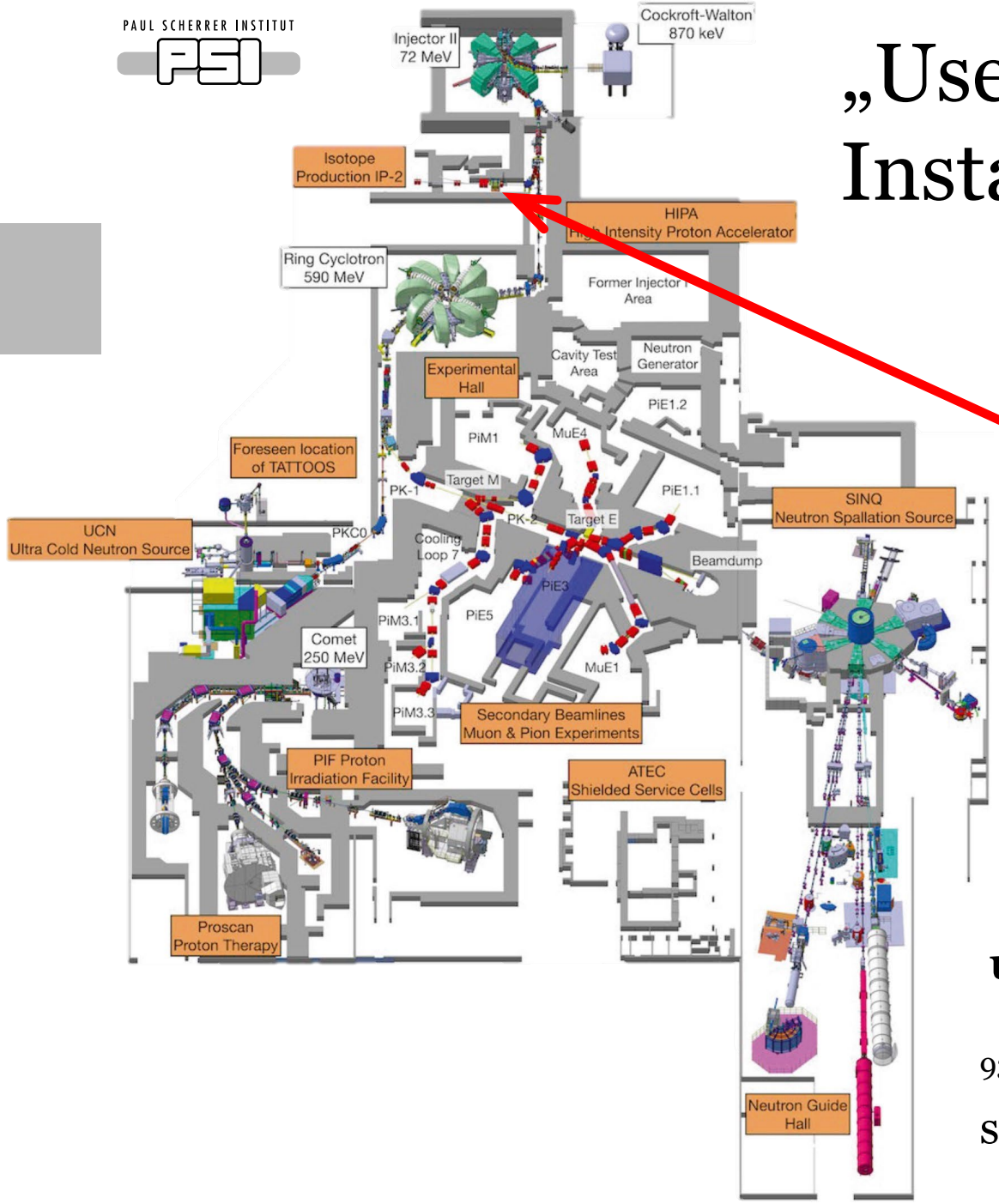




Isotope production

^{64}Cu, ^{68}Ga, ^{44}Sc, ^{43}Sc,
^{155}Tb, ^{167}Tm

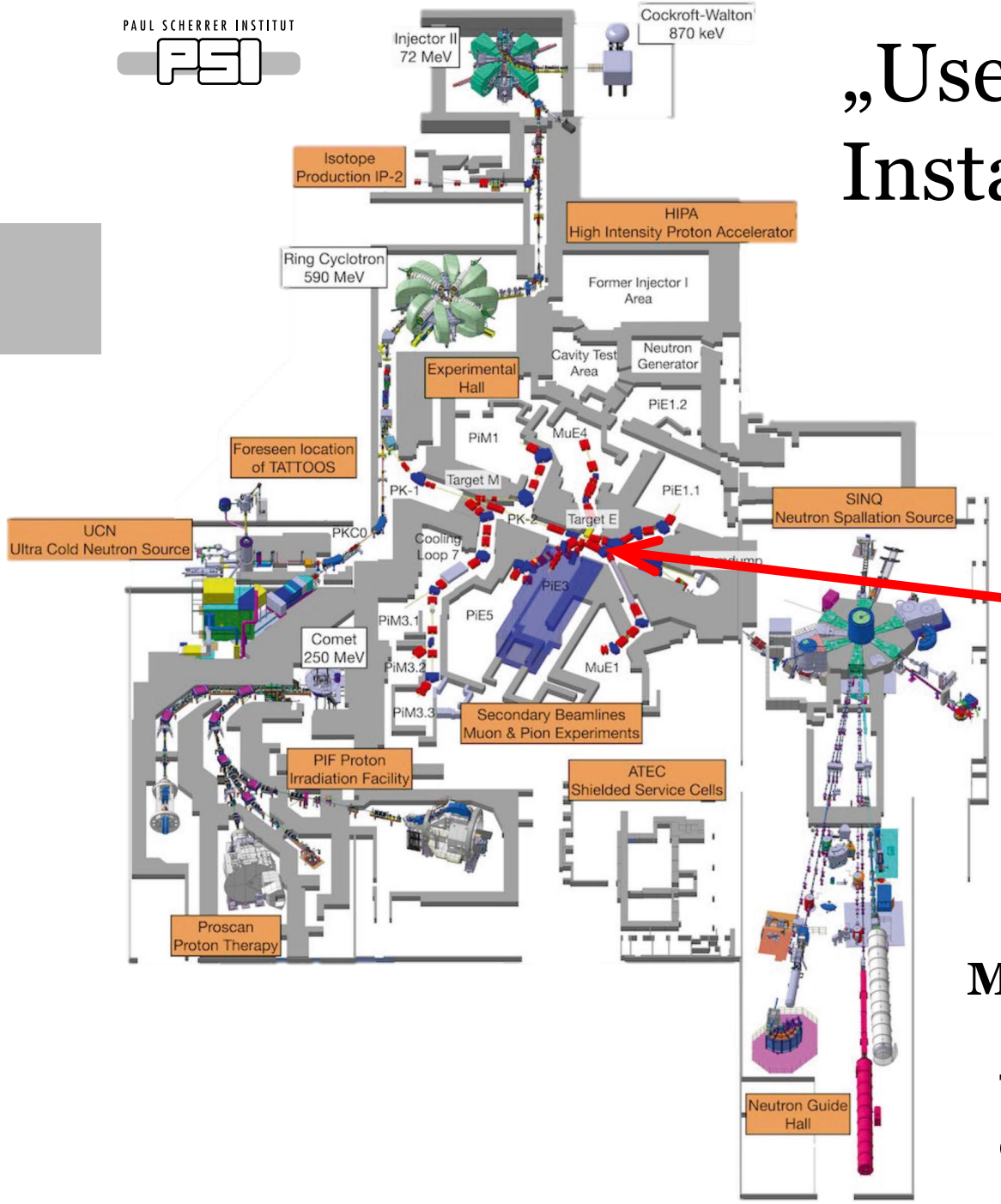
„Useful“ Installations at PSI

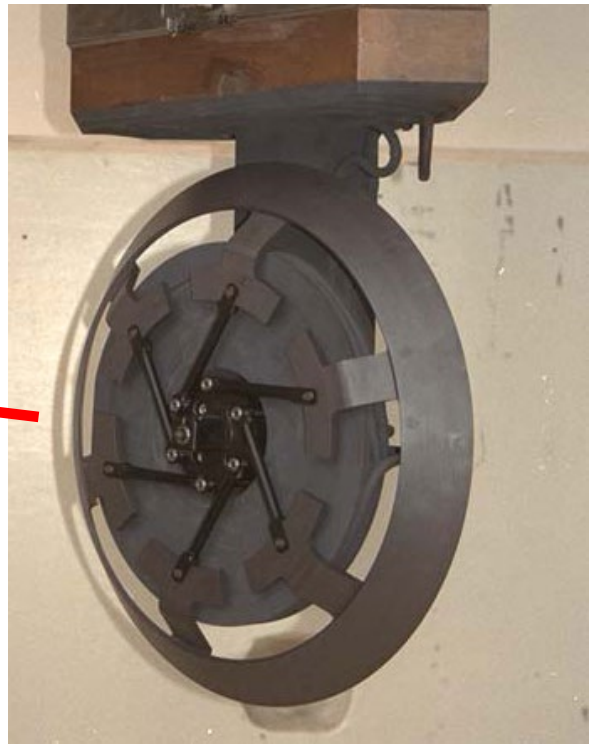


Niobium disc
used as energy degrader

^{93}Mo
separation factor of Nb >10^{12}

„Useful“ Installations at PSI

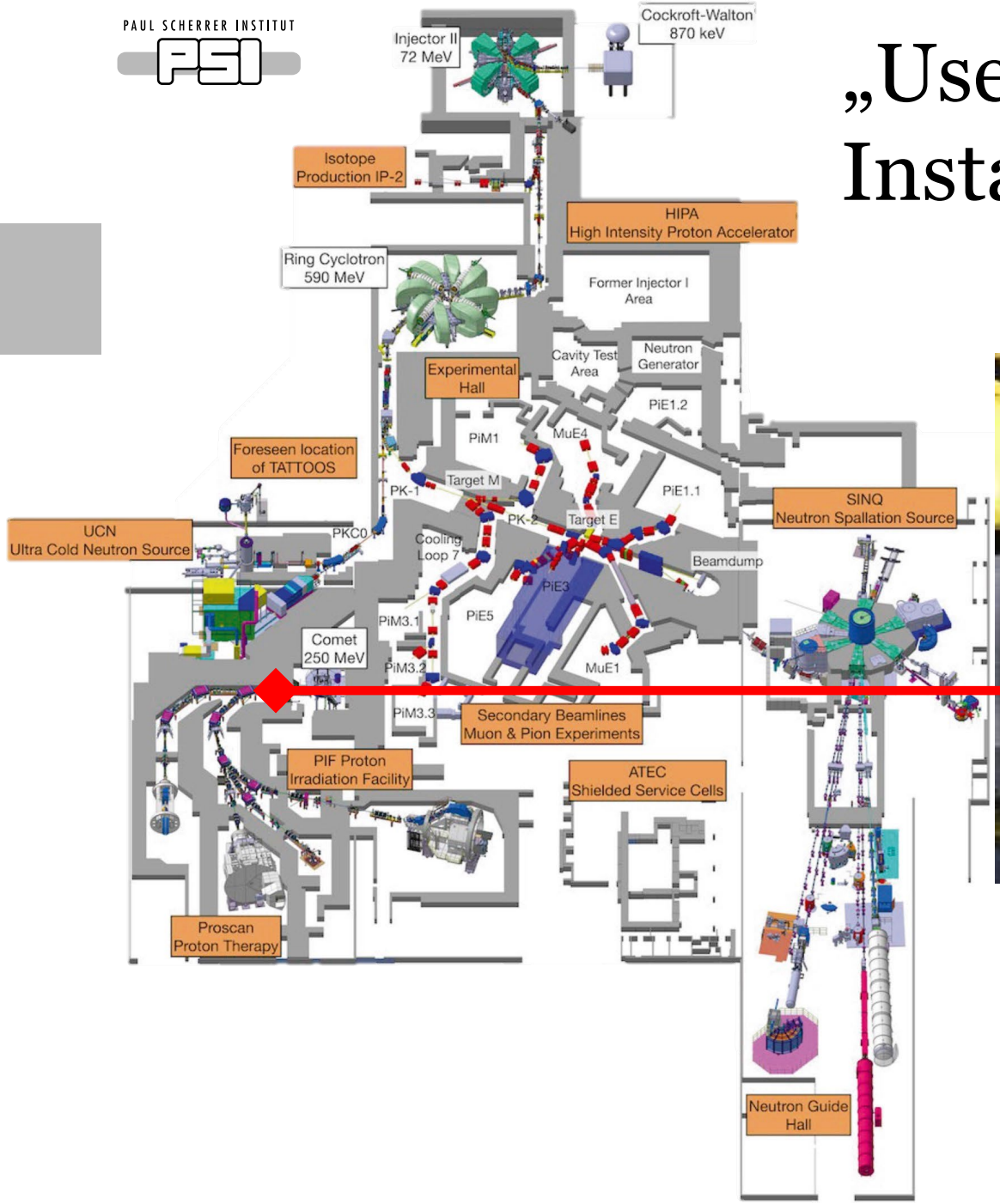




Myon production target

^{7}Be, ^{10}Be
operation 1-3 years

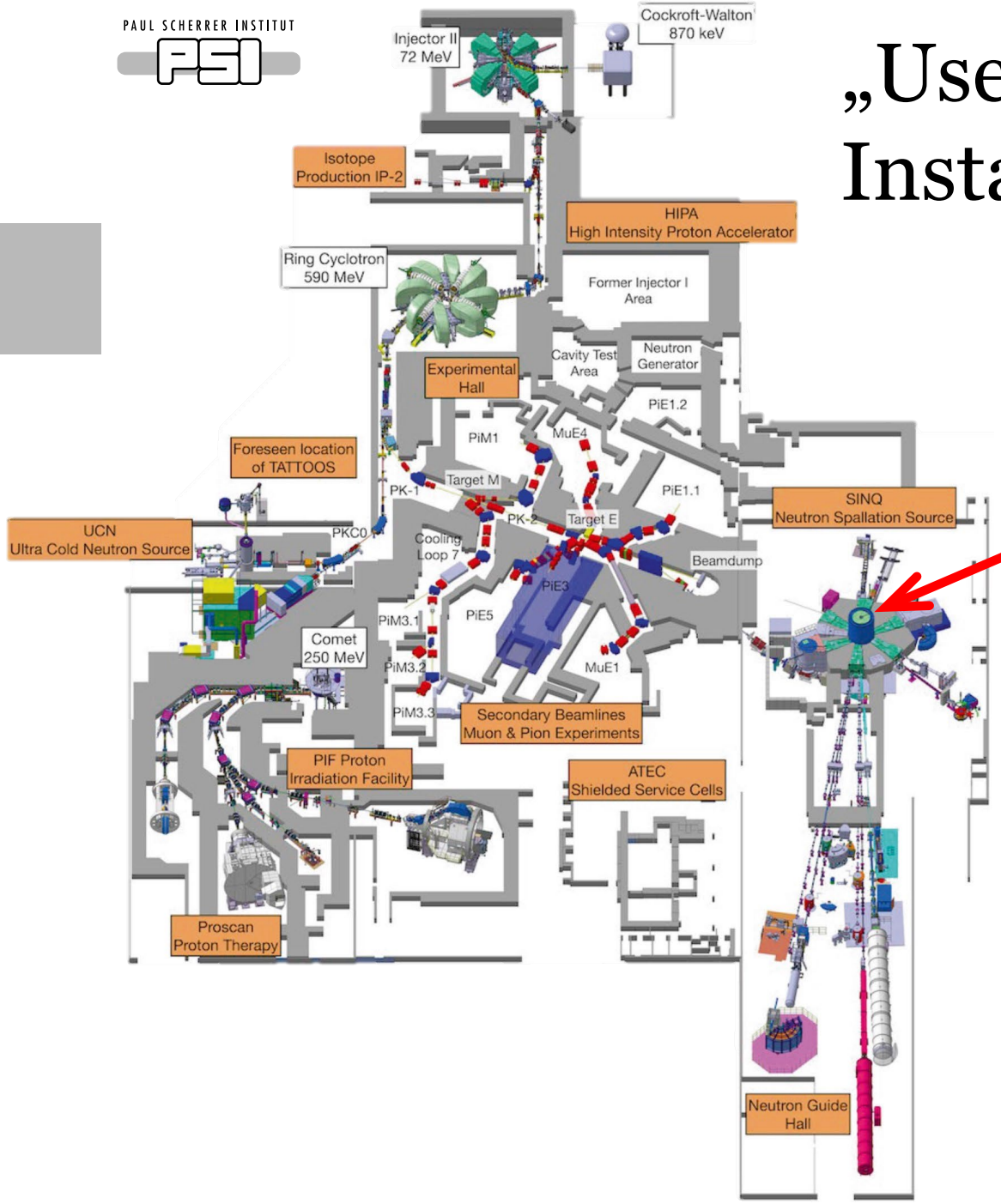
„Useful“ Installations at PSI

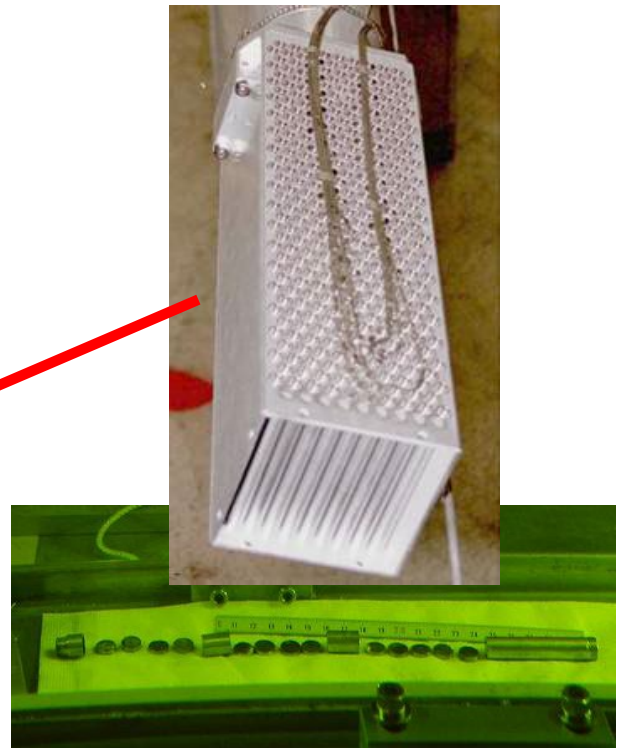


Copper beam dump

^{26}Al, , ^{32}Si, ^{44}Ti,
^{53}Mn, ^{60}Fe, ^{59}Ni

„Useful“ Installations at PSI

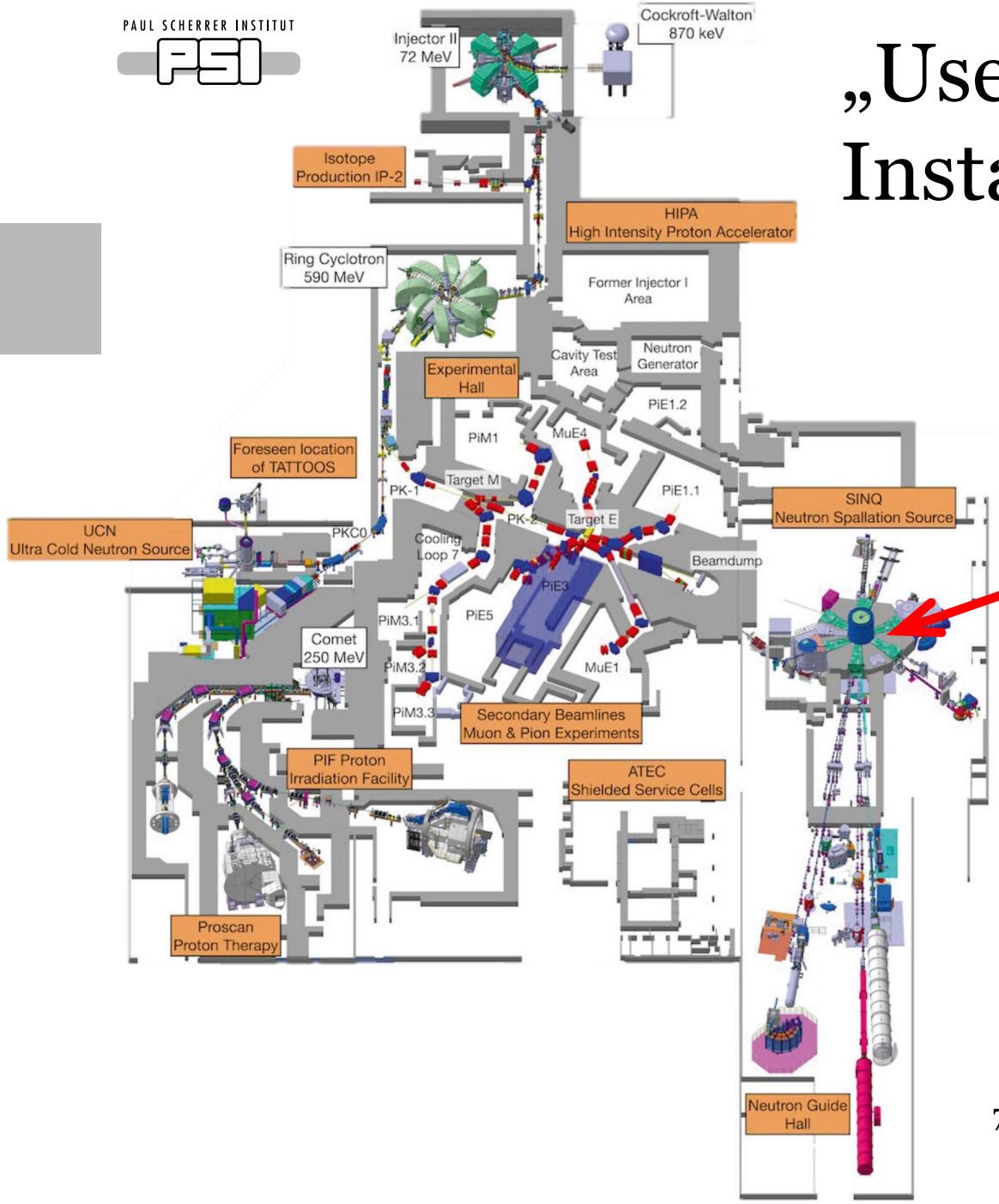


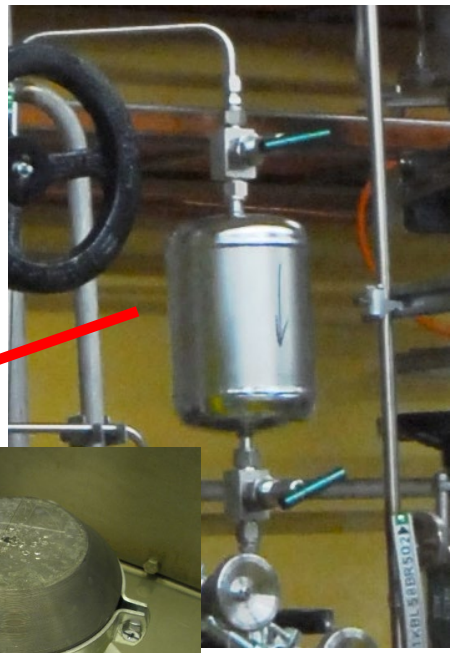


SINQ target

^{207}Bi, ^{202}Pb, ^{194}Hg,
^{172}Hf, ^{173}Lu, ^{125}Sb,
^{106}Ru, ^{44}Ti

„Useful“ Installations at PSI

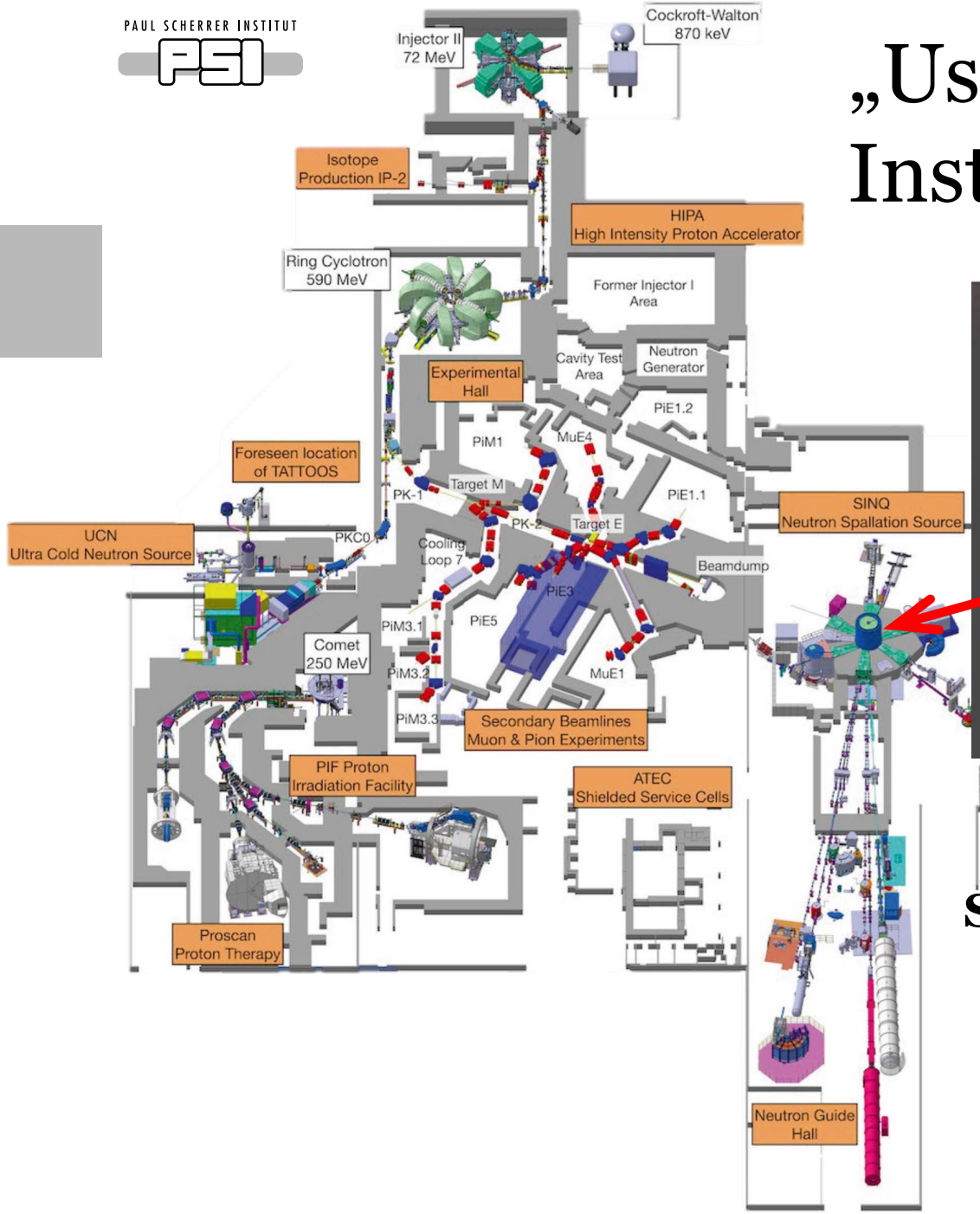




SINQ cooling water

^{7}Be, (^{22}Na, ^{54}Mn, ^{88}Y ...)

„Useful“ Installations at PSI



SINQ Target Irradiation Program-STIP

^{26}Al, ^{44}Ti, ^{53}Mn
many Lanthanides

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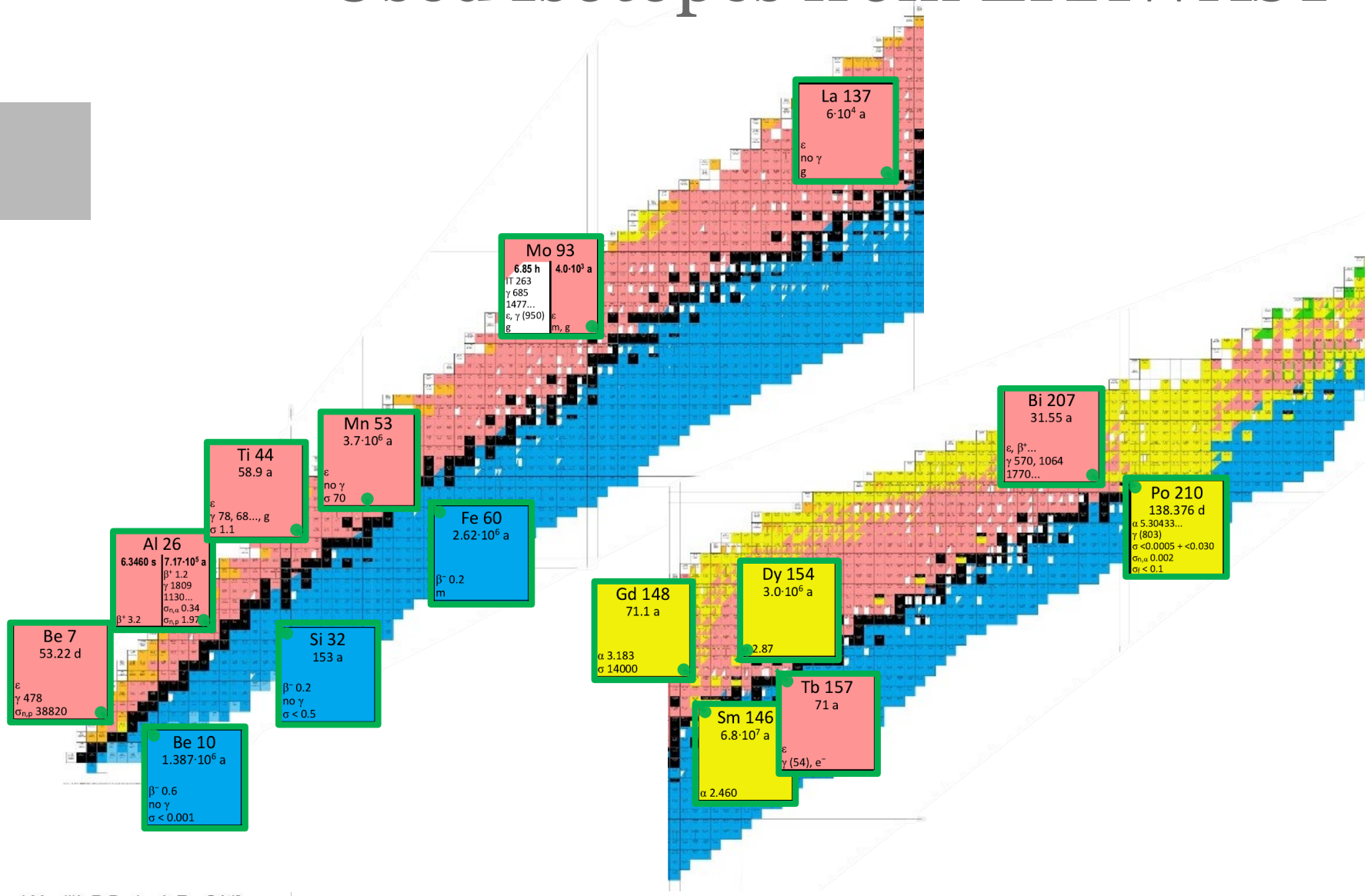
Used Isotopes from ERAWAST



J.Magill[1], R.Dreher[1], Zs. Sóti[2]

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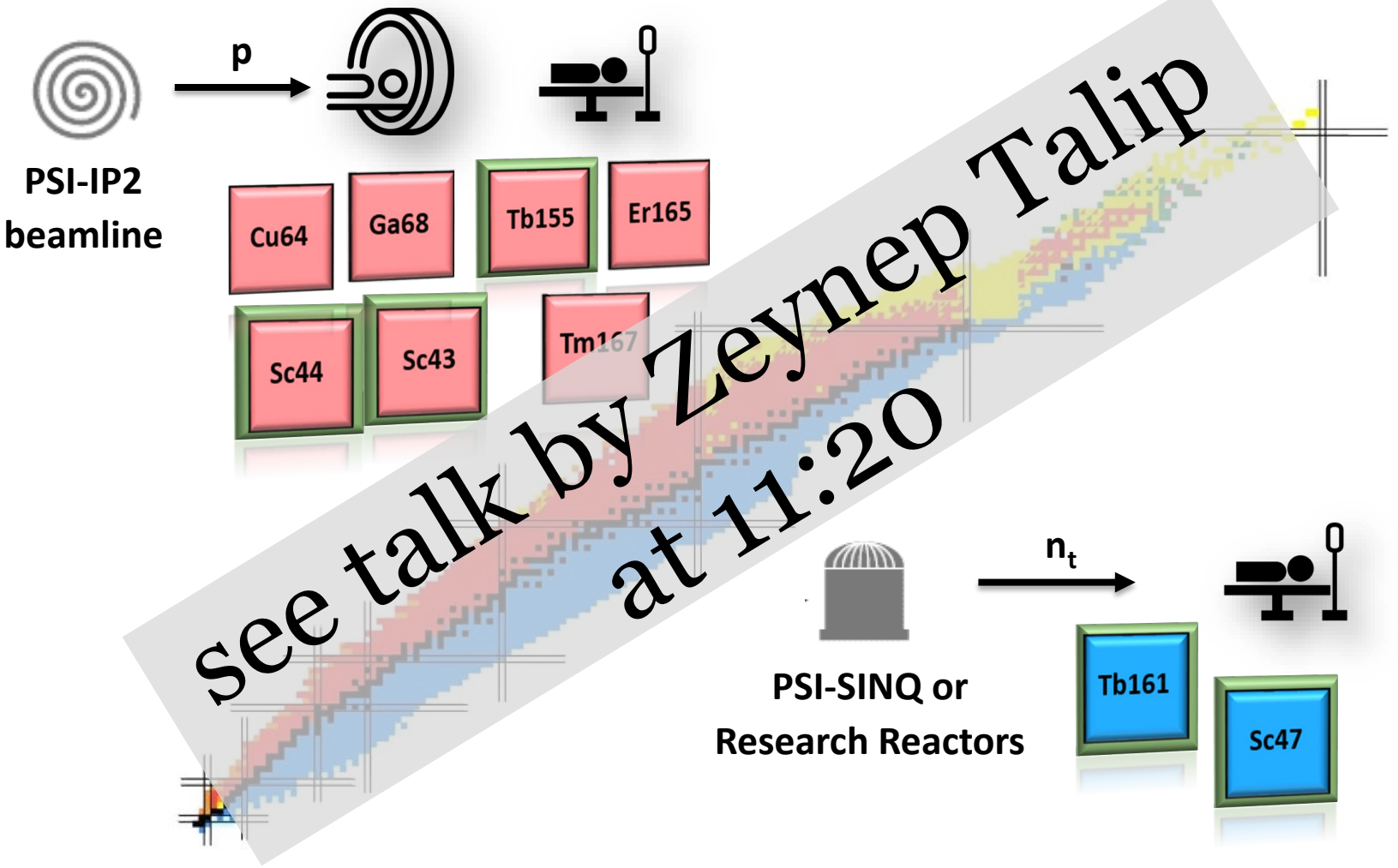
76139 Karlsruhe, Germany

[2]European Commision, Joint Research Centre
Directorate G – Nuclear Safety and Security
P.O. Box 2340, 76125 Karlsruhe, Germany

Medical Radionuclide Production at PSI



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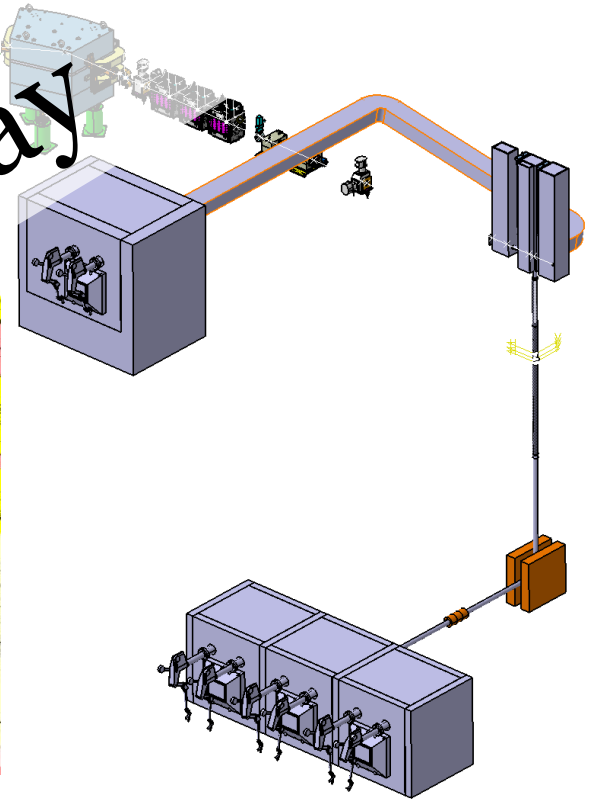
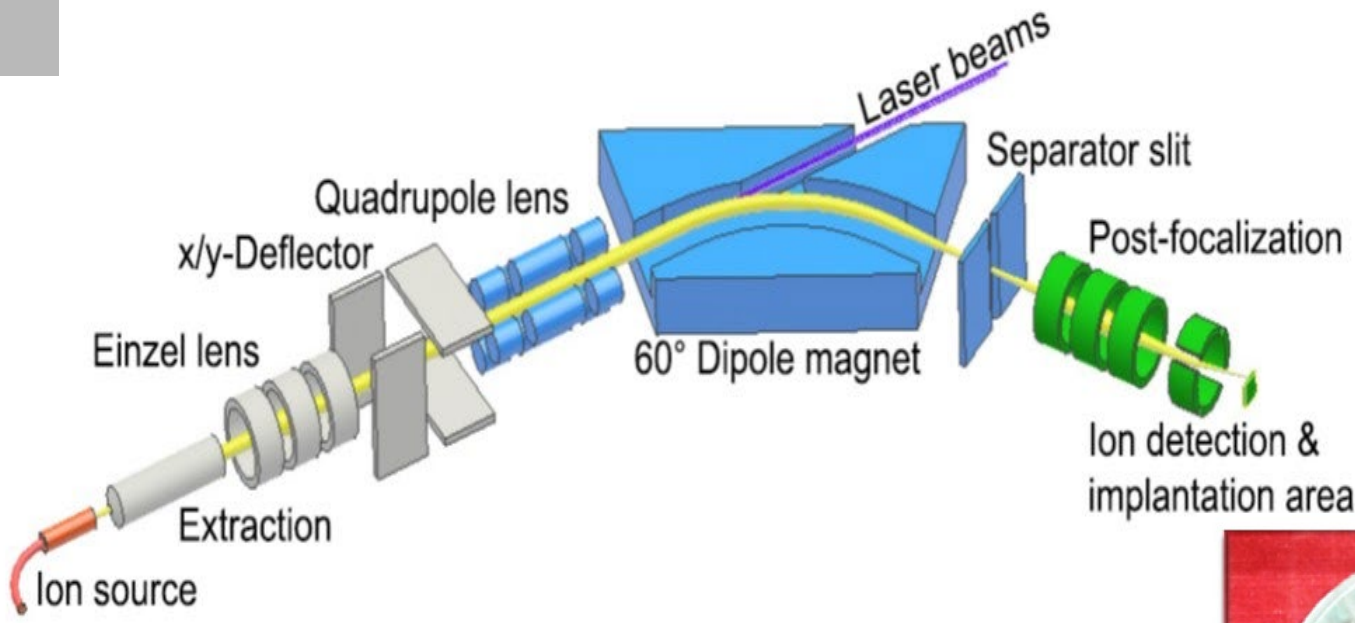
^{149}Tb Production @ PSI-HIPA with the IMPACT Project

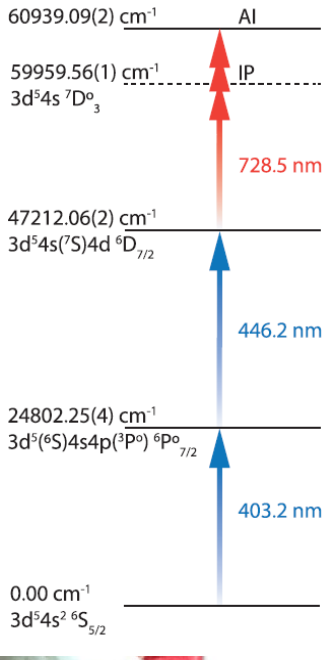
^{181}Ta(p,10p & 20/23 n)^{149,152}Tb



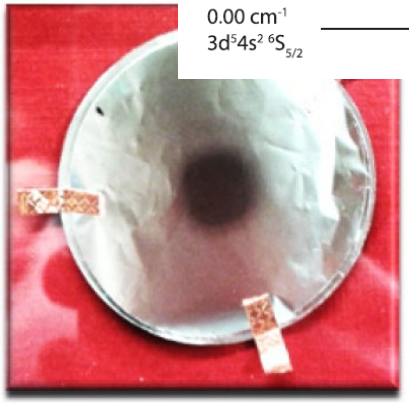
remember talk of Robert Eichler at Wednesday

Actinide Isotope Separator
Laser resonance ionization





RISIKO @ JGU Mainz used for ^{53}Mn



N. Kneip, et al:
Eur. Phys. J. Appl. Phys. **97** (2022) 19

Summary and outlook

- **Exotic radionuclides are produced in components of the 590 MeV proton accelerator at PSI**
- **After chemical separation, these isotopes are available for scientific applications**
  - Nuclear astrophysics
  - Geoscience
  - Basic nuclear physics
- **PSI owns a store house of several very rare isotopes, some of them being unique world-wide in quality and quantity ($^{7/10}$Be, ^{32}Si , ^{53}Mn, ^{60}Fe and others)**
- **Examples for front-end experiments using our material**
  - ^{60}Fe half-life and neutron capture cross section measurements
  - ^{7}Be in Big Bang Theory
- **Half-life (^{53}Mn, ^{146}Sm, ^{32}Si, ^{148}Gd, ^{154}Dy, ^{157}Tb, ^{137}La, ^{93}Mo) and cross section (^{44}Ti,^{53}Mn) measurements, most of them under the leadership of PSI completed, ongoing or planned**
- **We need a dedicated mass separation device for exotic radionuclides!**

My thanks go to

- The Isotope and Target Chemistry research group and all members of LRC
- The PSI Hotlab crew
- The PSI ATEC group
- Colleagues from the Radioprotection Division
- all colleagues using samples and targets from PSI:
  - n_TOF and ISOLDE at CERN
  - SARAF
  - Uni Frankfurt/KIT Karlsruhe
  - ILL Grenoble
  - ANU Canberra
  - and many others

You for your attention