EURISOL targetry challenges

EURISOL shall deliver beams of 3 orders of magnitude higher intensity than 1999 yields.

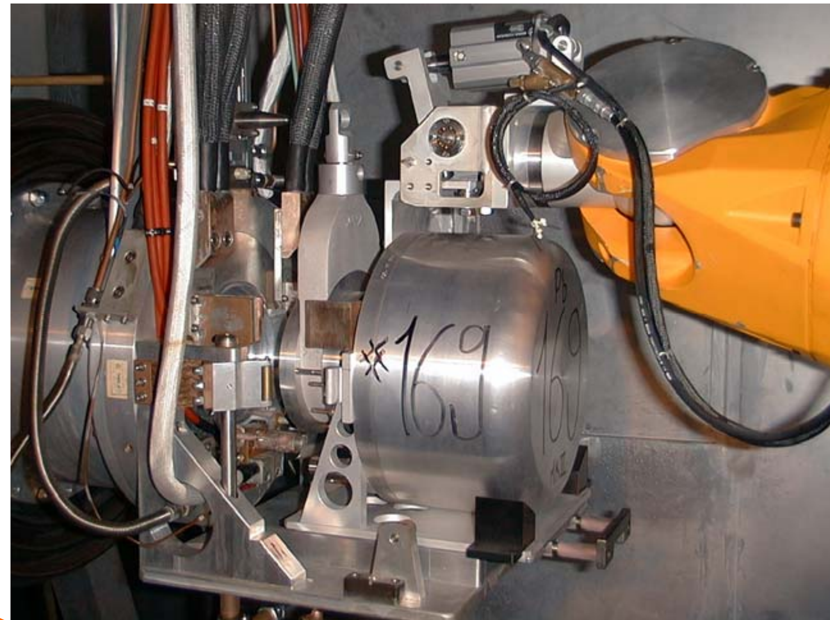
- Design of "oven + heat-transport system" target containers dissipating a direct GeV p-beam dc-power of > 100 kW to produce spallation generated RIBs.
- Computational optimization of the wall material and target geometry of a chosen element from a "*target vessel, transfer line & ion-source*" system to improve the release efficiency.
- Improve ion-source efficiencies and beam purity.
- Design high power density spallation n-sources (10 MW/l)
- Design actinide targets intercepting efficiently the neutrons generated by high power density n- sources.

Introduction to ISOL RIB facilities

Isotope **S**eparation **O**n **L**ine

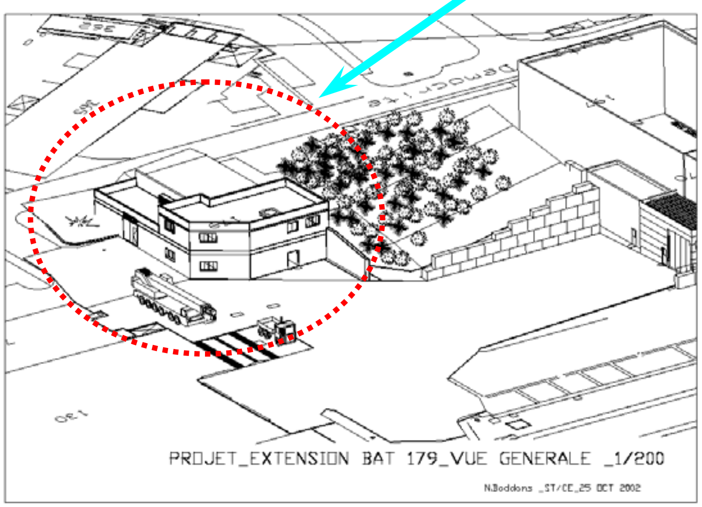
- ISOLDE
- TRIUMF

ISOLDE target handling.

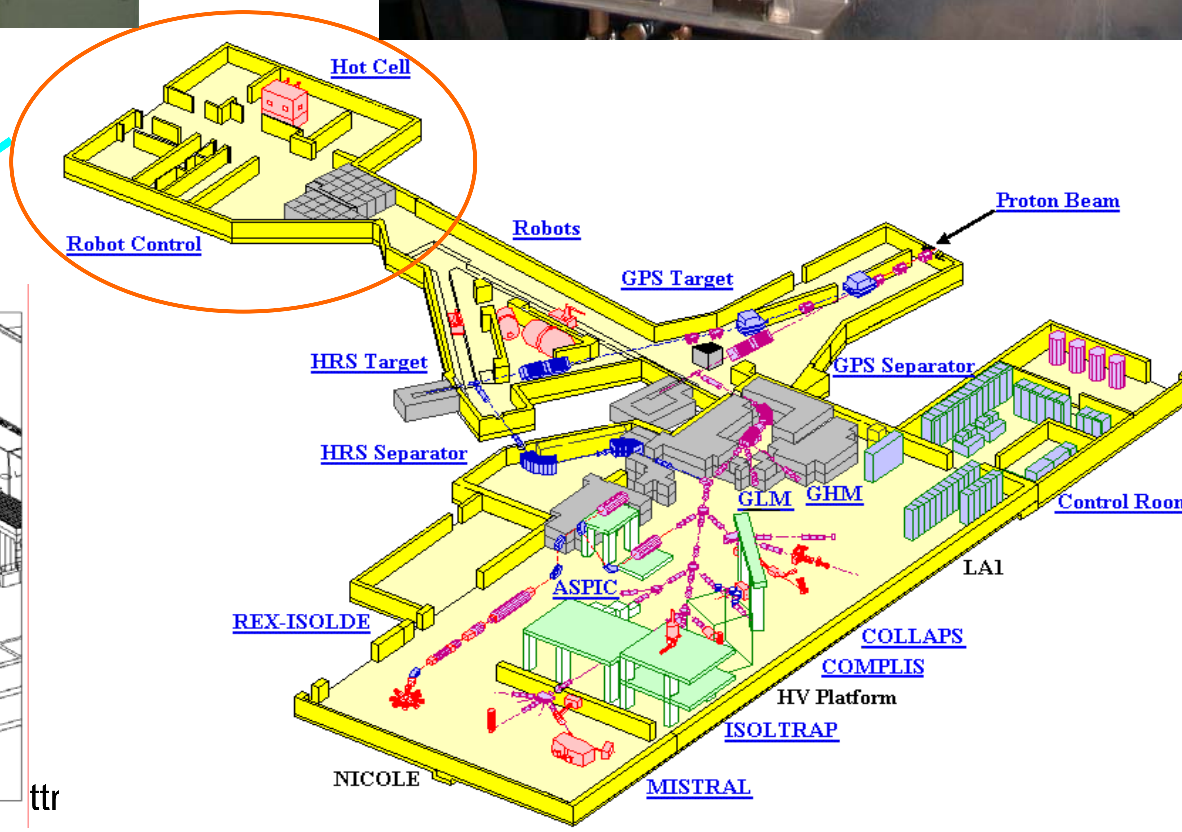


Class A laboratory

$\Sigma_{Isotopes}$ $(Activity/LA) > 10'000$



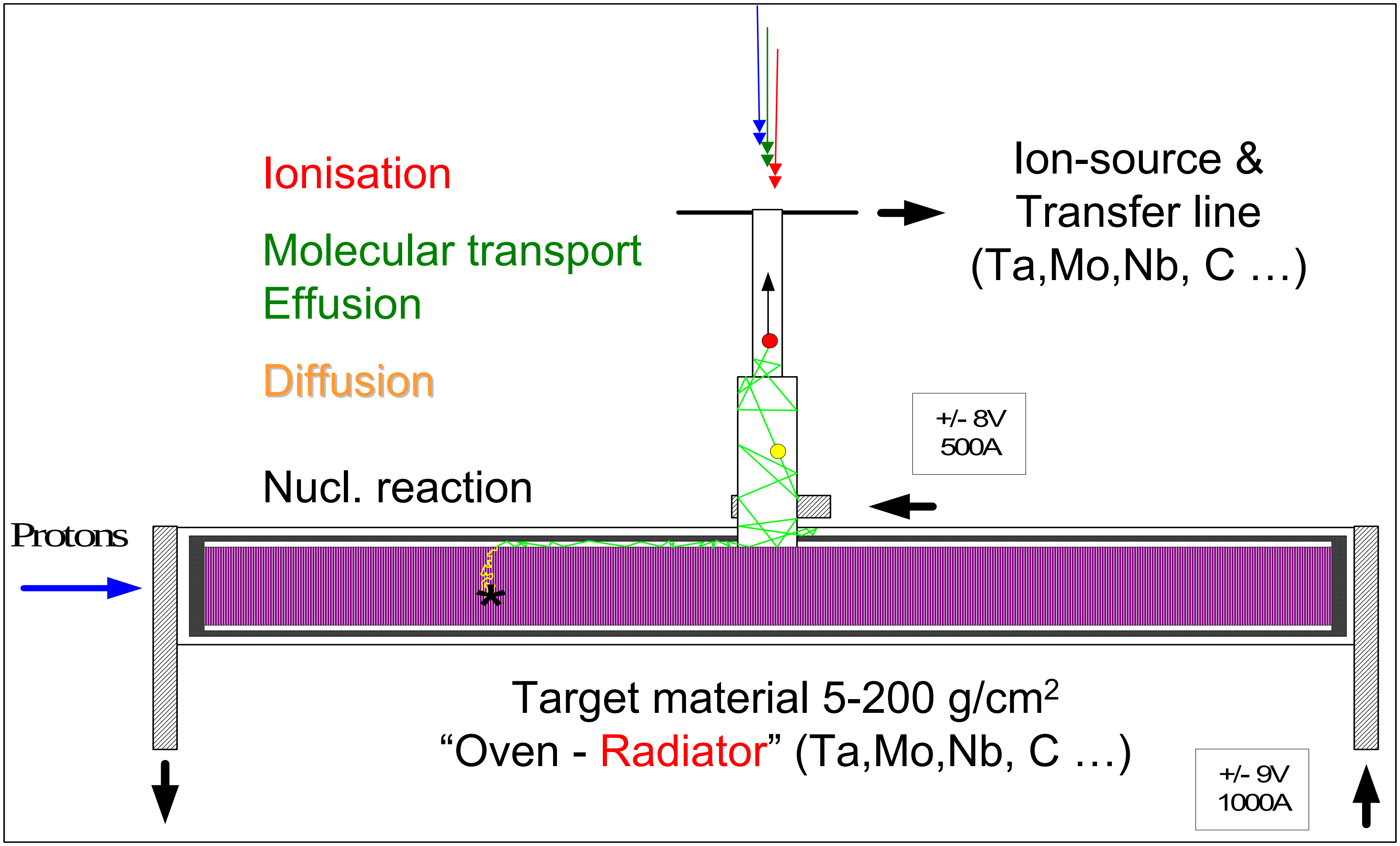
ttr



ISOL "Thick" targets

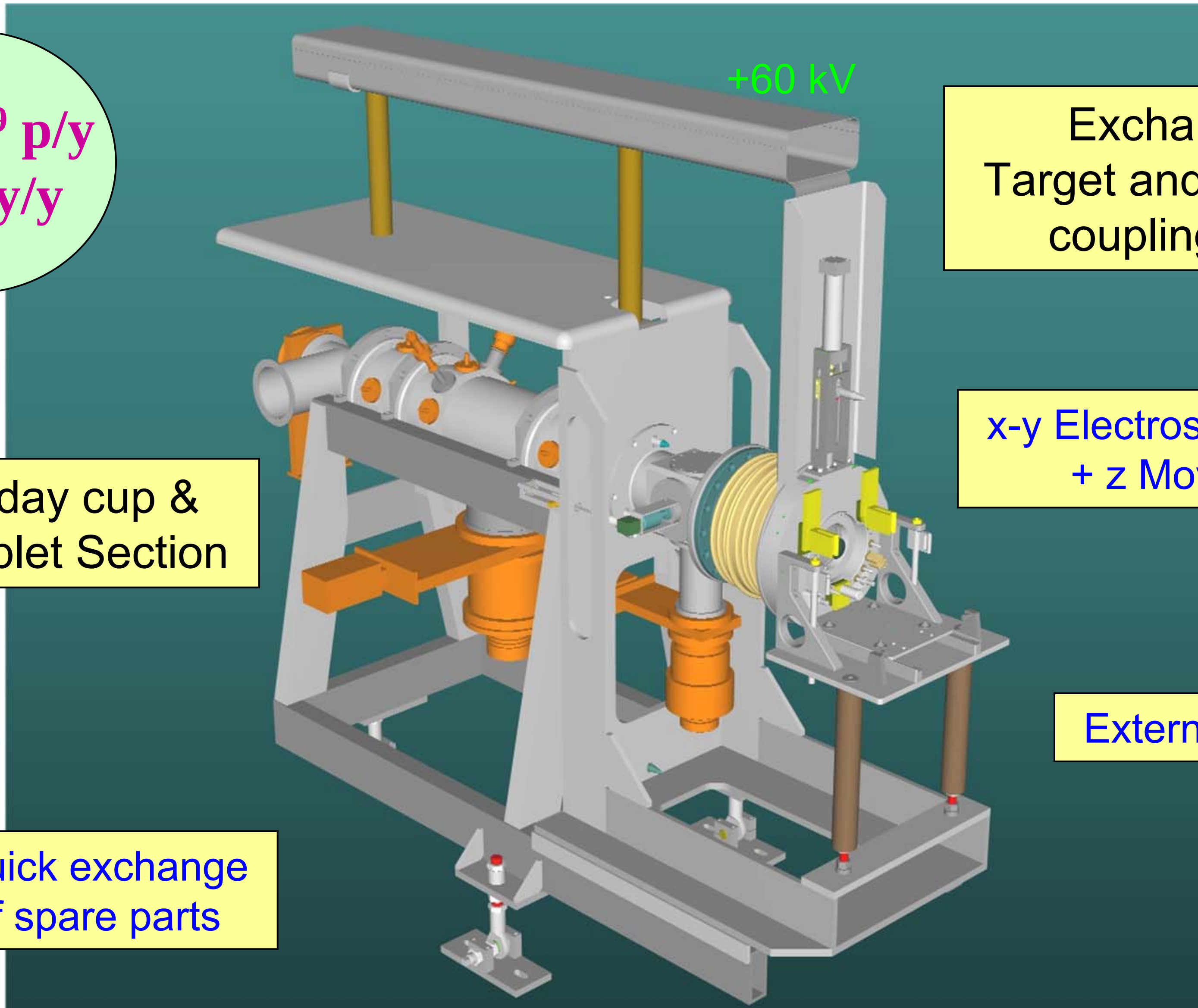
Pre-Separation, Separation
Extraction, beam optics

(1 GeV ~ 200 g/cm²)



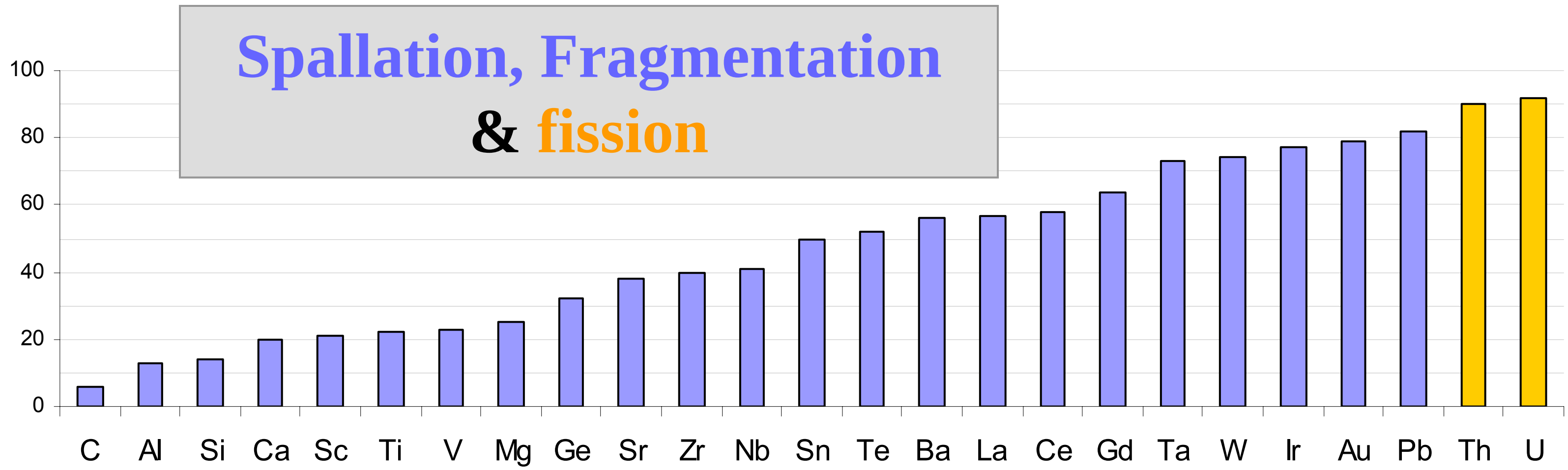
ISOLDE Front-End
Technical design

Strategy: 2 FE + 1spare
Production needs: 1 FE/3years
"Minor" repair after 1 year of cooling



S. Marzari
& ATB-IF

$6 \leq Z \leq 92$ Target materials



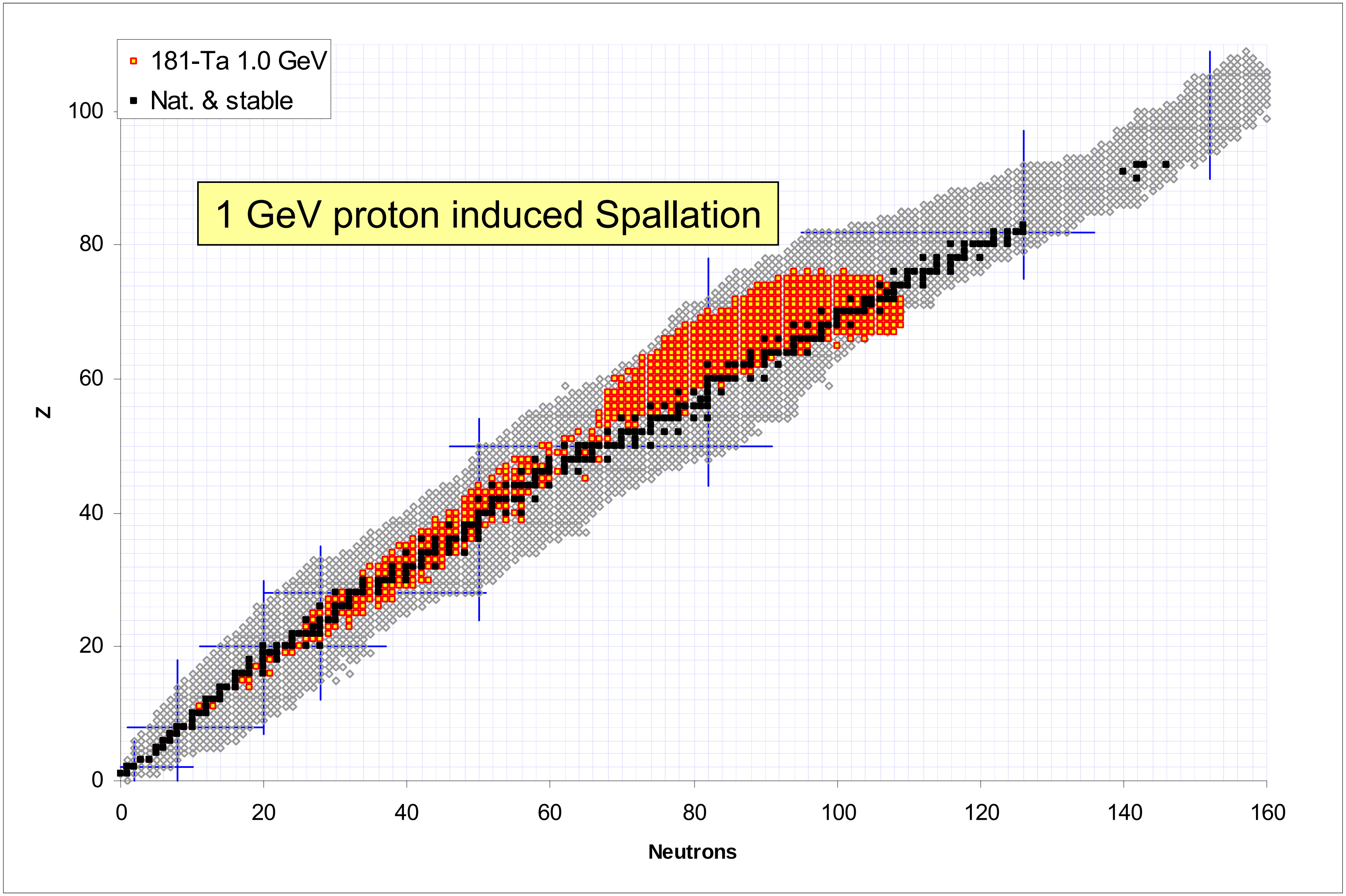
25 Elements,
~ 40 compounds:

Oxides, Carbides
Molten metals, - salts
Thin foils, Powders

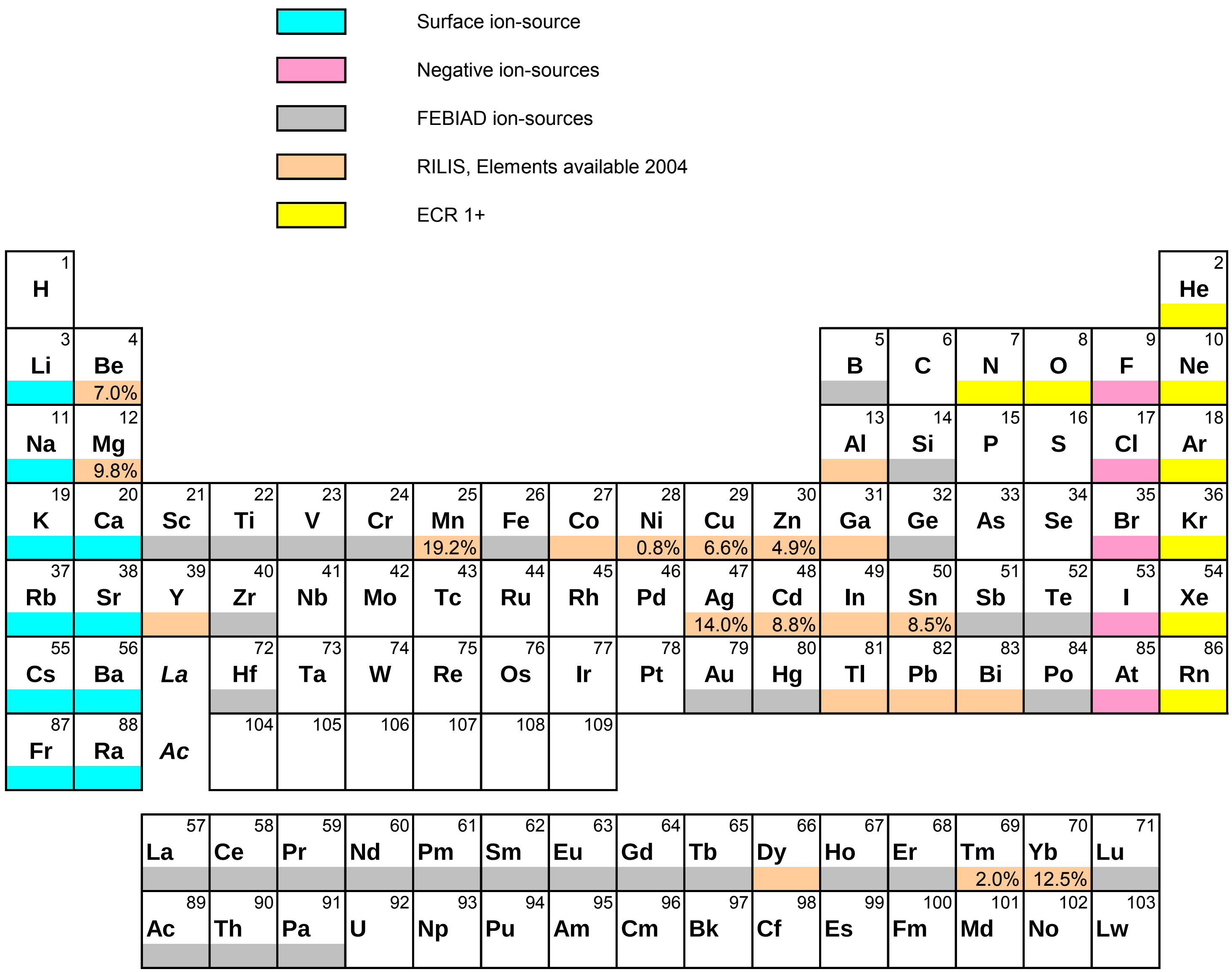
Target thickness: 4-220 g/cm^2
Cross section $\sigma(E_{proton})$

Beam power for ISOL-RIB production:
Liquids (1-2 kW), Solids (5 kW),
Ta, Nb, SiC (20-30 kW @ TRIUMF)

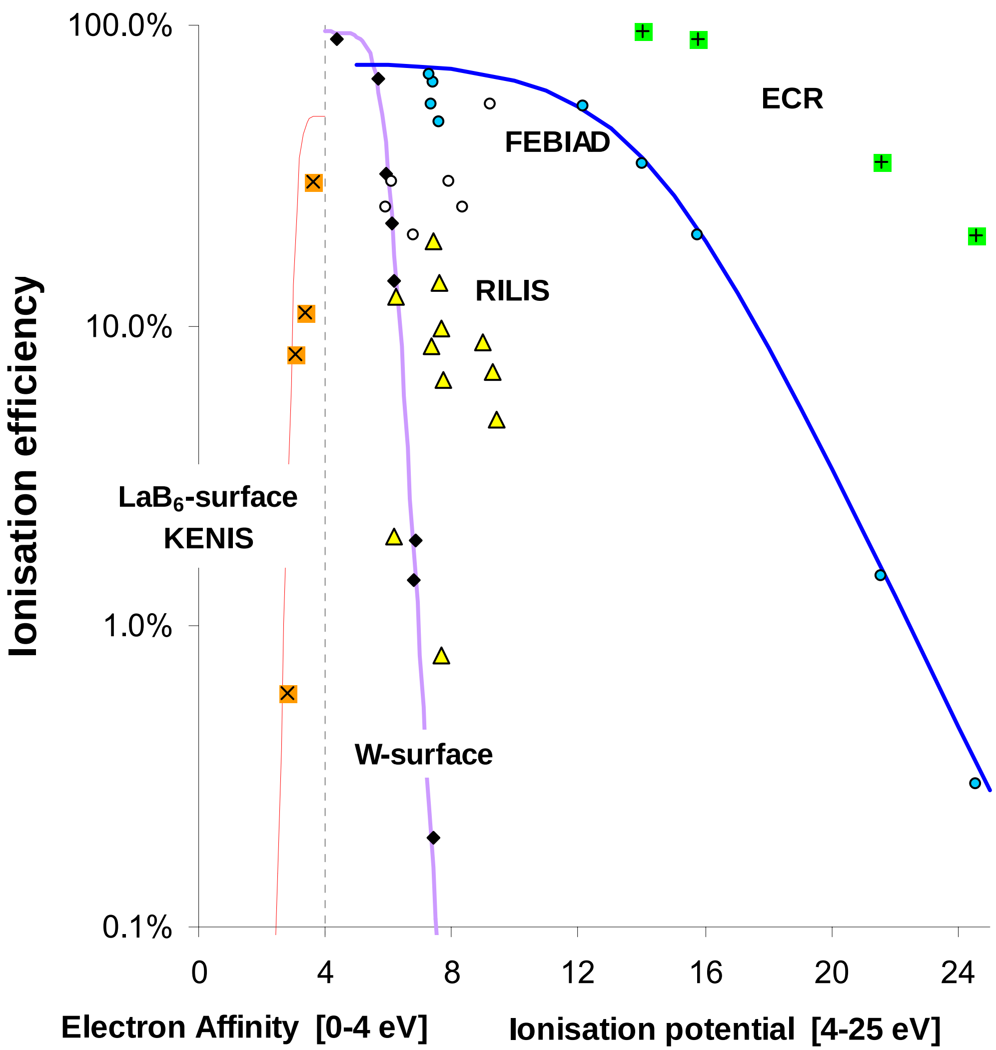
Ta + 1 GeV p, CASCABLA, A. Junghans

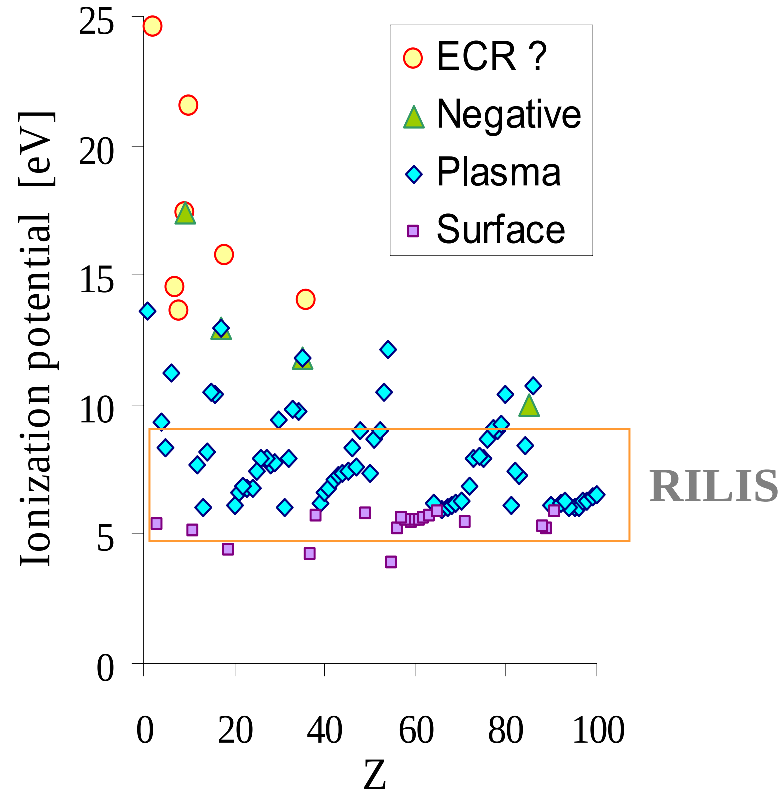


Chemically selective RIB Ion-sources



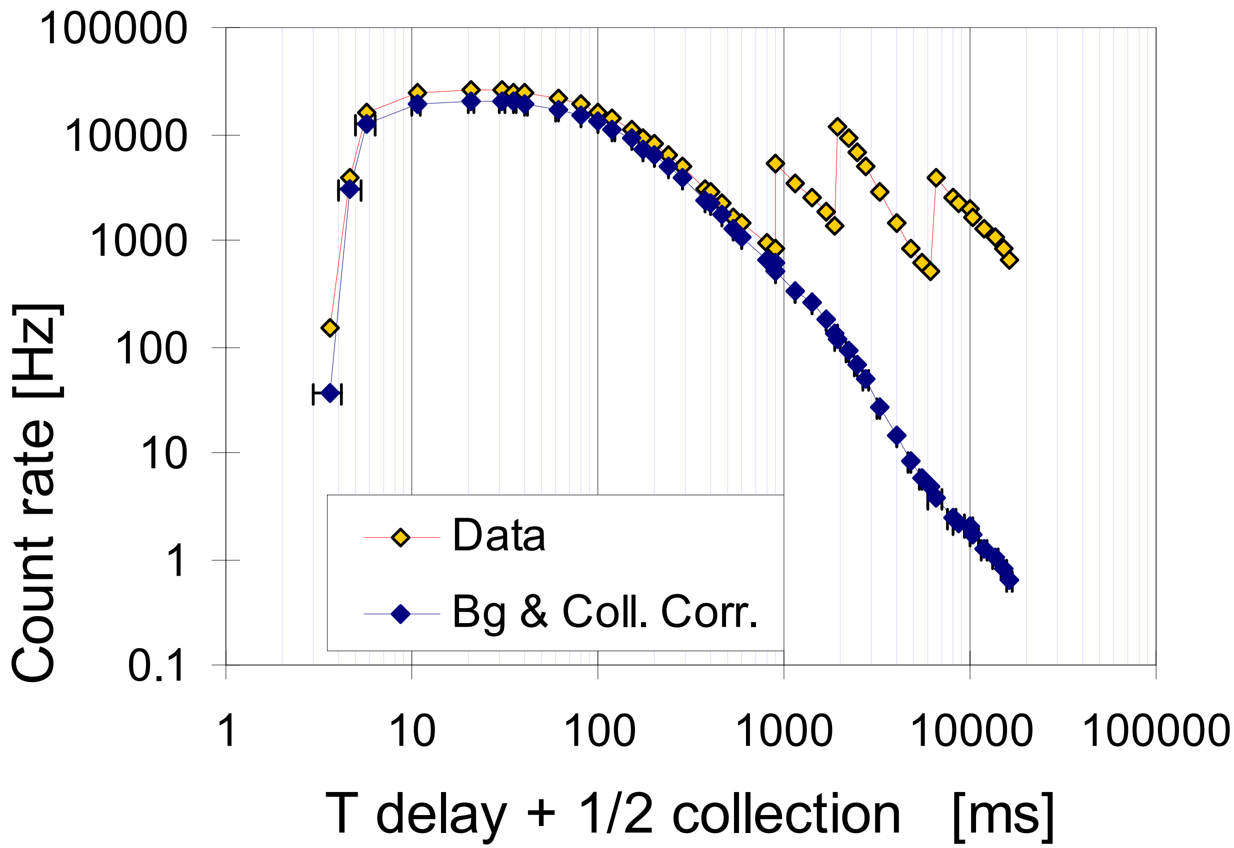
Ion-sources efficiencies





Release efficiency

effusion, diffusion



^{25}Na (59.6s)

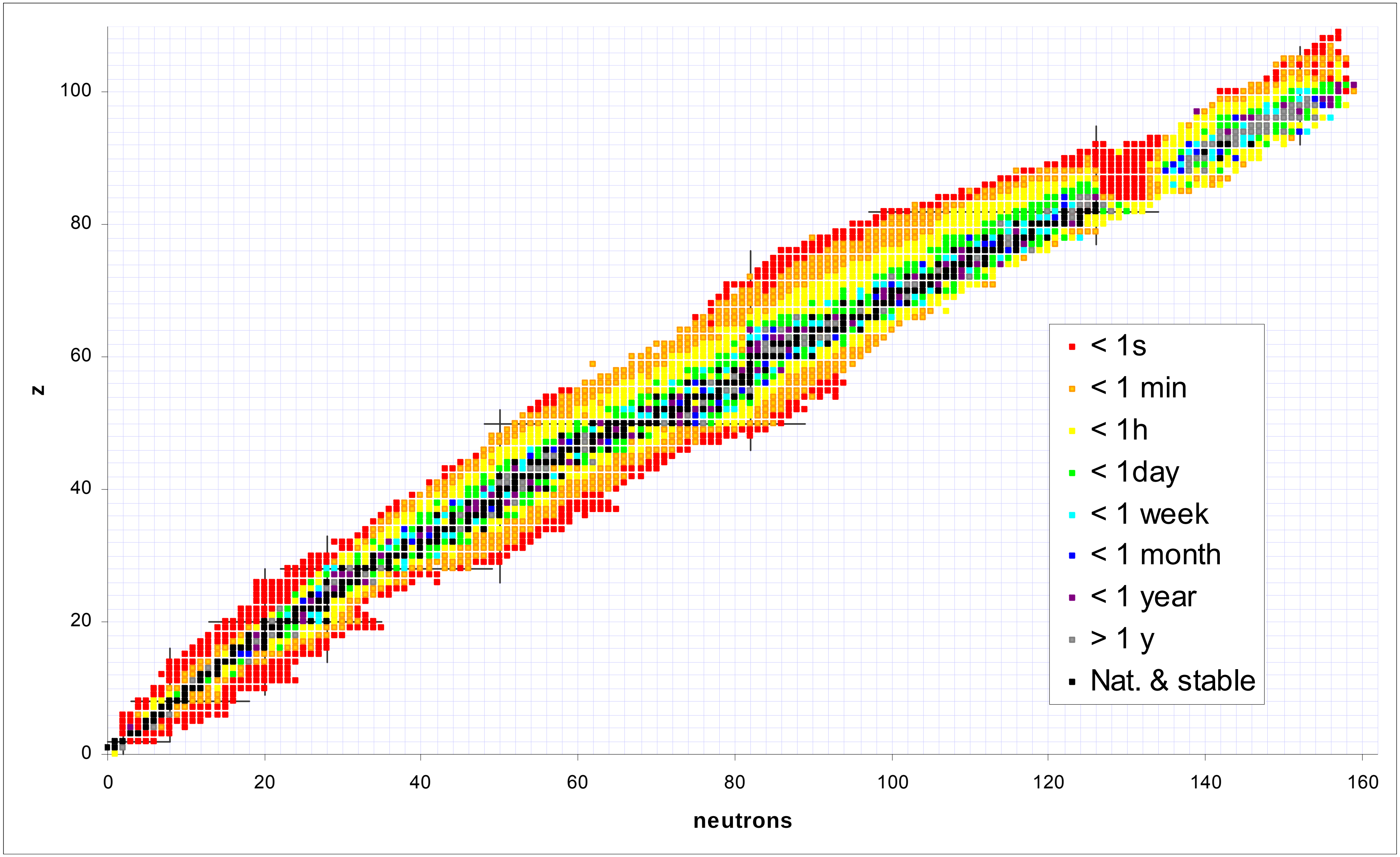
UC-118 2100°C

^{32}Na (13.5 ms)

^{33}Na (8.2 ms)

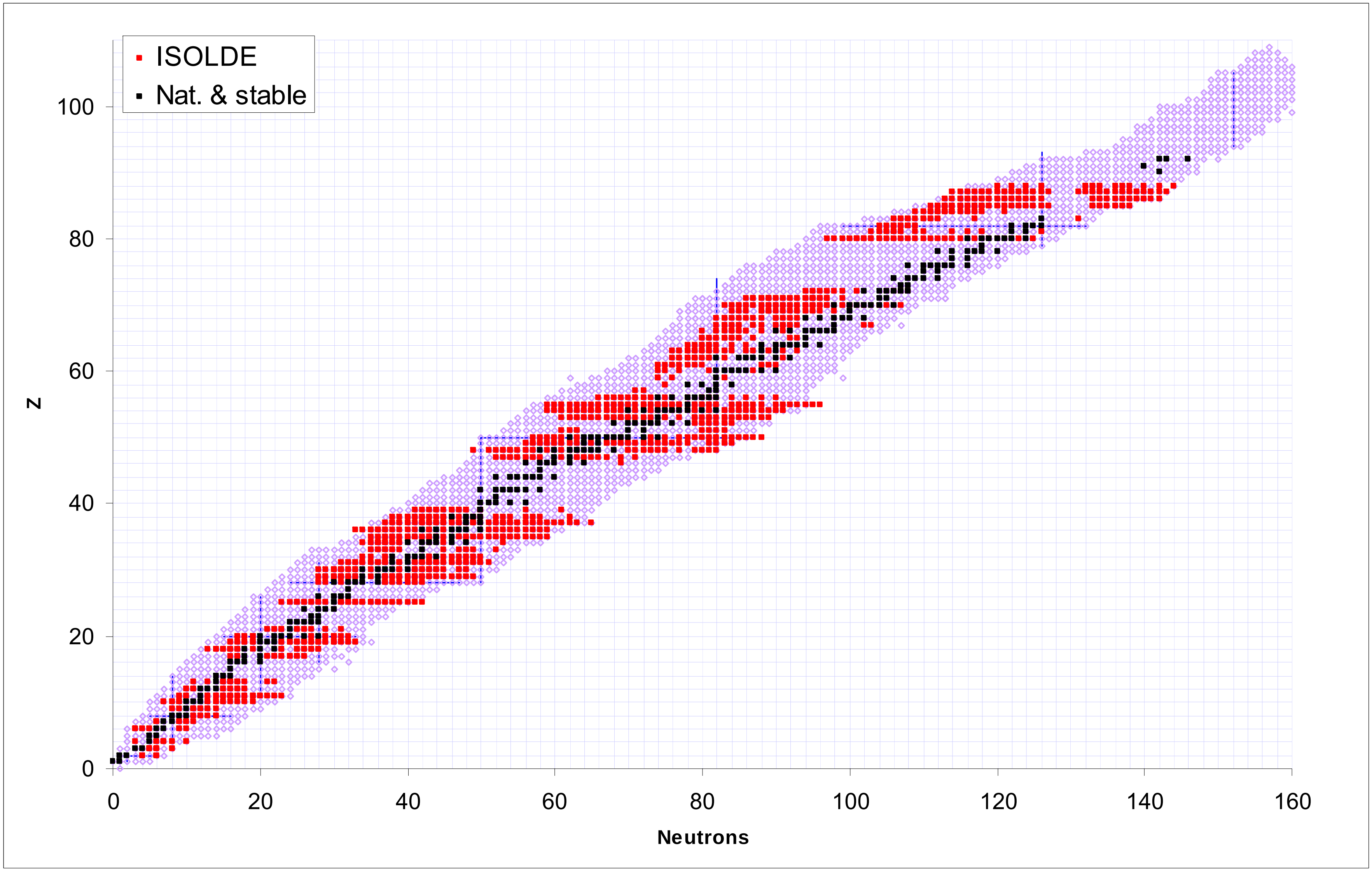
…..

Half lives



100
80
60
40
20
0
z
0
20
40
60
80
100
120
140
160
neutrons
< 1s
< 1 min
< 1h
< 1day
< 1 week
< 1 month
< 1 year
> 1 y
Nat. & stable

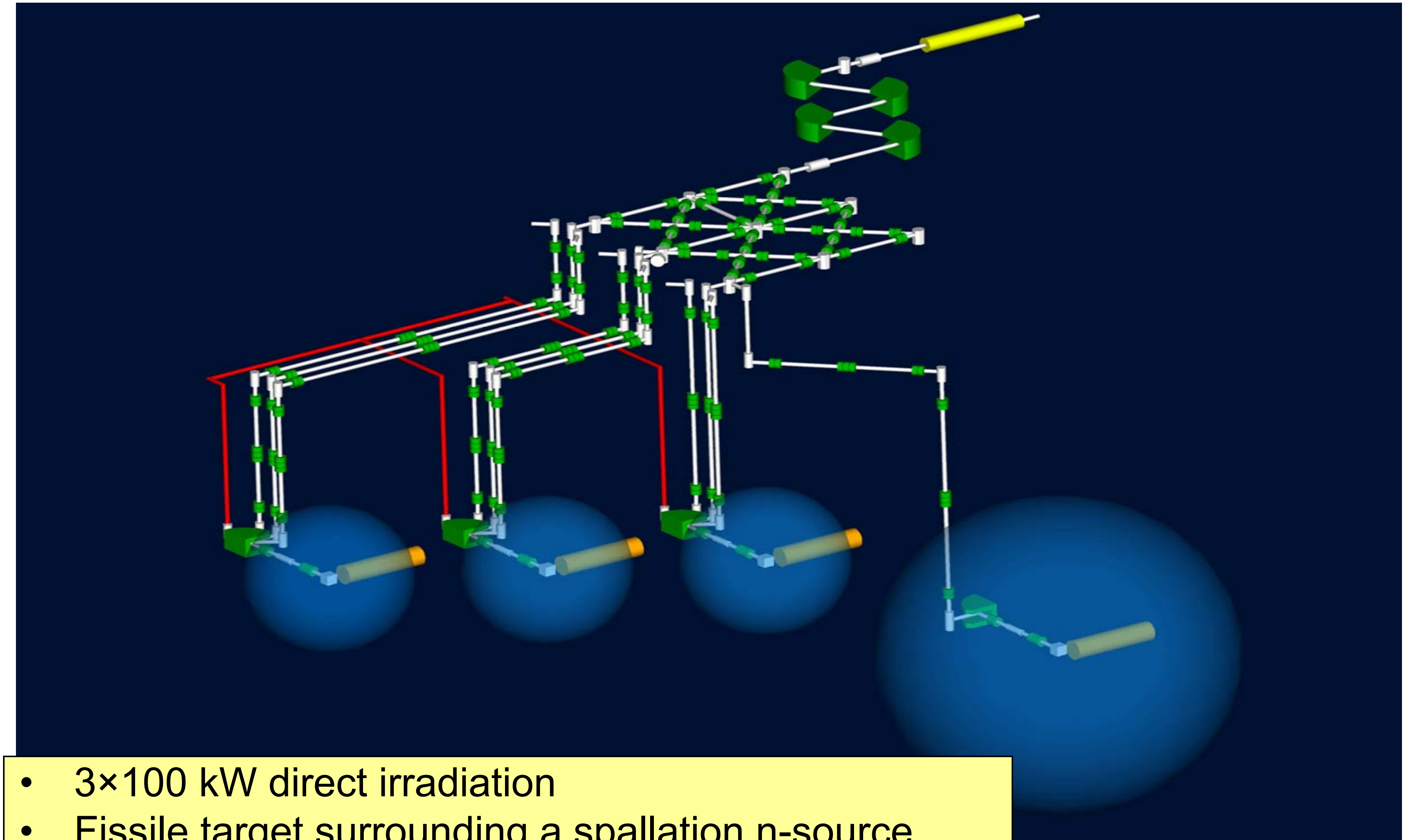
ISOLDE yields: ~750 RIBs produced (1963-2004)



EURISOL -- EURISOL DS

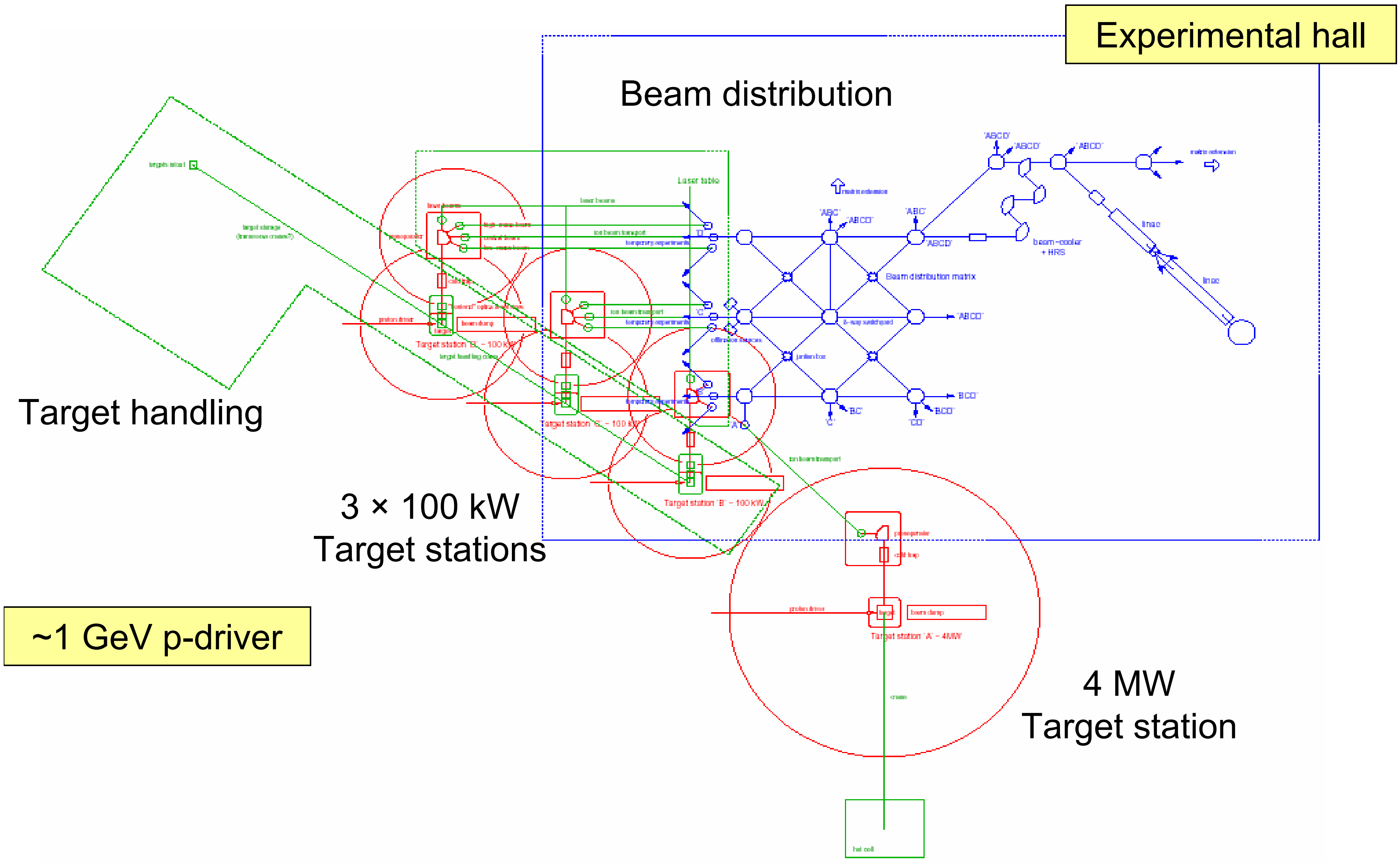
- 4 years EU project published end 2003;
- Conclusion: RIB yields enhancement predicted (vs. 1999 data) by factors of 2 to 4 orders of magnitude !
- 2005 EURISOL-DS to address the remaining technological challenges

EURISOL target stations



- 3×100 kW direct irradiation
- Fissile target surrounding a spallation n-source
  - >100 kW Solid converters (RAL 800 kW operational)
  - 4 MW Hg-jet

Top view



Experimental hall
Beam distribution
Target handling
3 × 100 kW
Target stations
~1 GeV p-driver
4 MW
Target station
Laser table
Beam distribution matrix
beam-cooler
+ HRS
linac
Target station 'A' ~ 4MW

100 kw direct irradiation

EURISOL Design Study

- Target Materials: > **25**
  - Thickness, Heat transport, dose rate
  - Diffusion and Effusion delays
- Chemical nature of the target: **6**
- Oven Materials: **4**
- Elements to be produced: > **70**
- Transfer line: **4**
  - Drift fields
- Ion source: **5**
  - Stabilisation of the production (Std. eff., life time, reproduce on-line the best off-line results).
  - Radiation Hardness.
  - Selectivity vs. isobars.
- Maintenance, vacuum vessel, pumps, radioactive Waste handling.

100
Target and Ion-source systems

One
Standard Front-end *?*

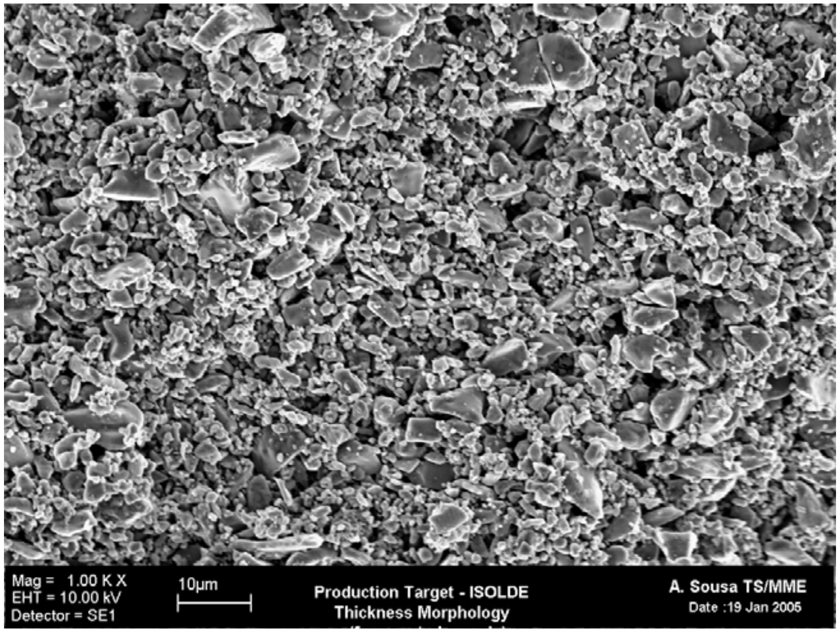
TEST cases 100 kW direct

- *Targets*
  - Actinide target (carbide)
    - UC_2+C, ThC_2+C
    - W-converter, Moderator & Reflector
  - Metal foil target (solid)
    - Ta, Nb
  - Oxide powder of fiber
    - BeO + converter
    - Insulating materials low dE/dx
    - Low density
  - Molten metal (Liquid)
    - Vapor condensation
- *Ion-sources*
  - Mono ECR
  - RILIS, Surface
  - FEBIAD
- *Elements*
  - He, Li, Be, Hg …

4 Targets
4 Ion-sources
1 Front-end

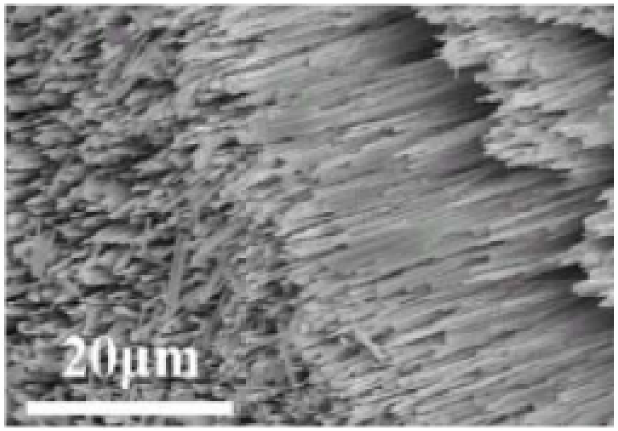
Synergy with β-beam

Spin off is expected on:
- Similar target materials
- Elements from the same chemical group

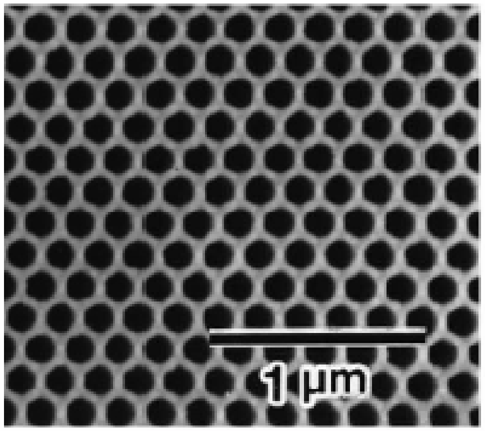


SiC Triumf

Nanowires

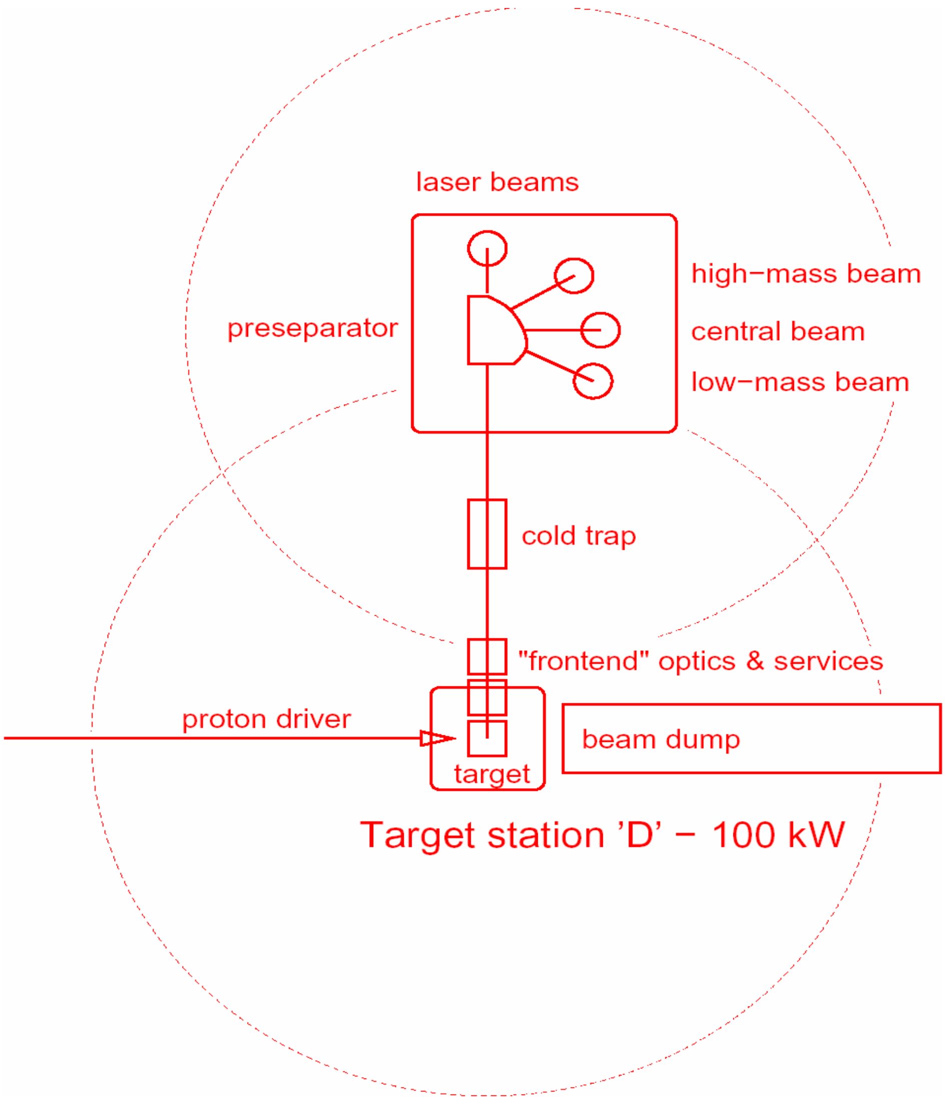


Nanoholes



ISOLDE Physics Seminar, 15 Feb. 2005 Thomas AGNE (CERN/UdS)

Confinement of the activity, RIB-selection

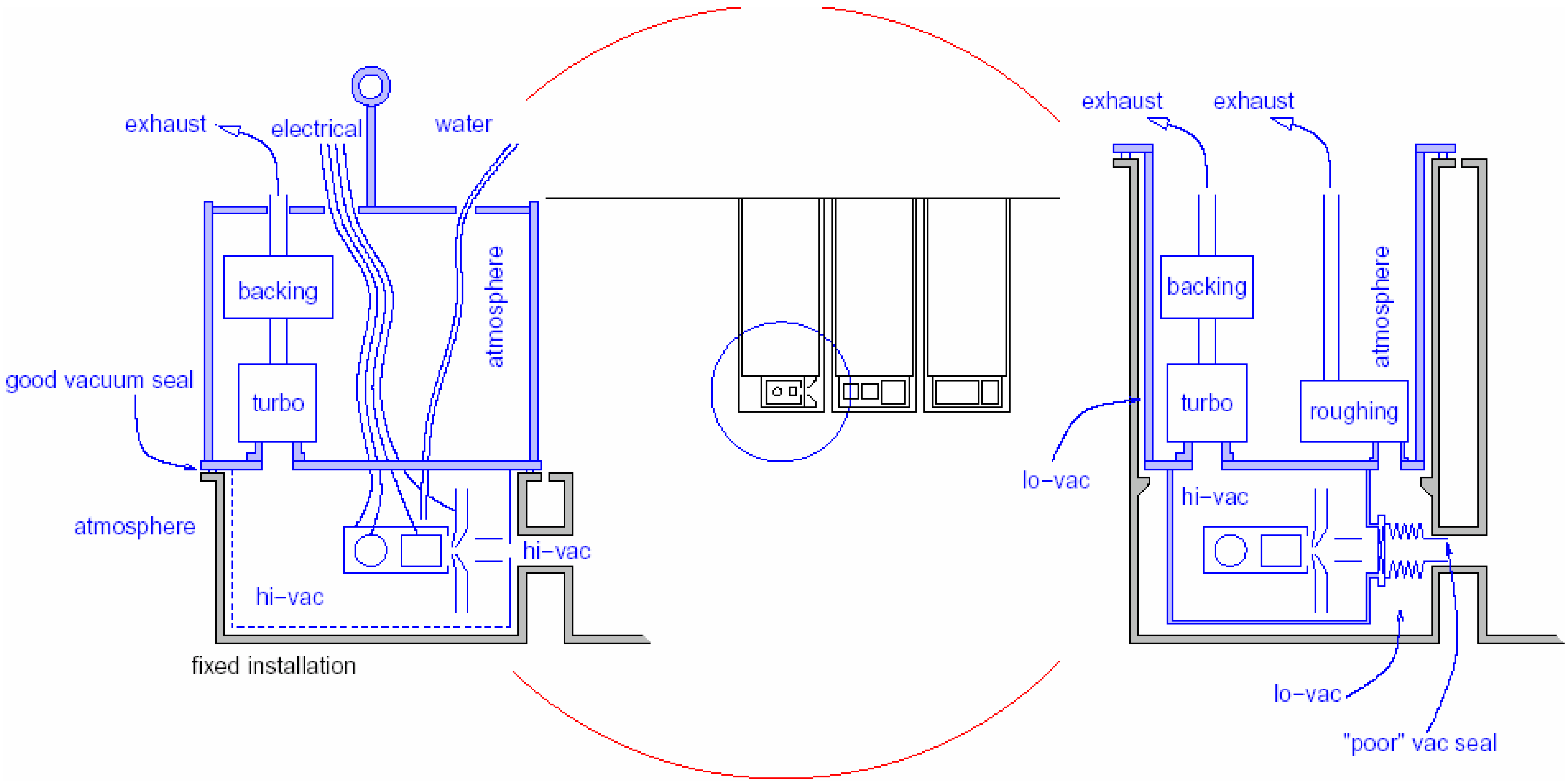


Mass separator

Confinement of radioactve gases (cold trap)

Target station Chemically selective ion-source (RILIS)

Target plugs



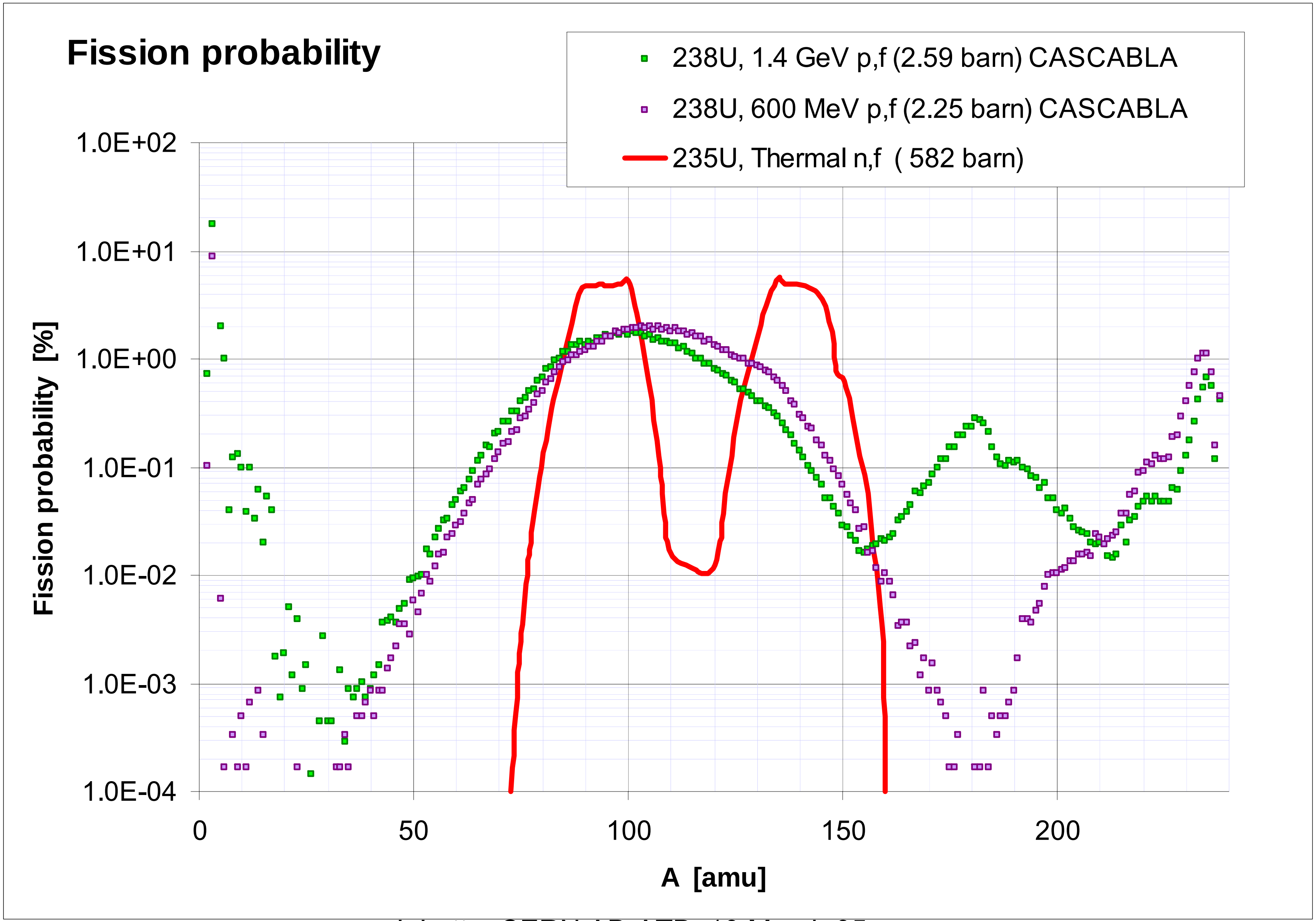
Actinide target

- Cylindrical, donut or C-shaped optimized vs. n-flux … and target exchange.
- Target material: Test of the release properties of high density UC_2 vs. UC_2+C powder
- Thermal equilibrium issue: the target is kept at 2200ºC while its inner or close by placed Hg-n-spallation source Has to evacuate ~1 MW.

Synergy with SNS, SPIRAL II and SPES
Competitive method: high flux reactors
^{235}U-fission at MAAF

1 Target **?**
5 Ion-sources
1 Front-end

p- or n-induced fission

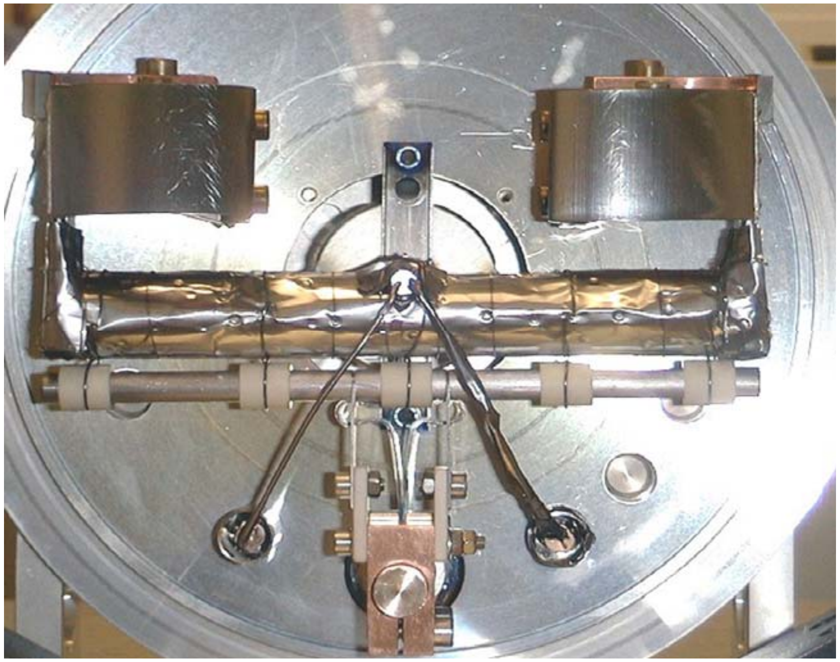


Spallation n-sources

- Cooled Ta or W-rods
- Hg stream or confined Hg-jet

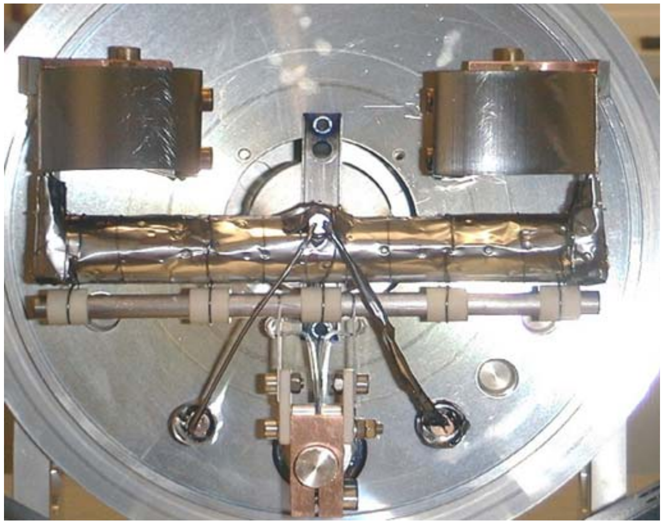
ISOLDE n-spallation source:
Ta(W)-rod mounted below
the UC target
(before irradiation)

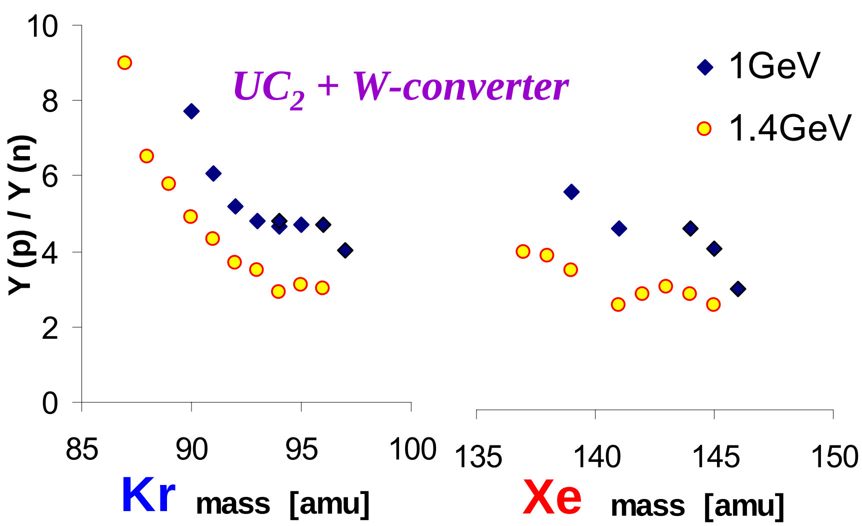
- Engineering study of the thermal hydraulics, fluid dynamics and construction materials of a window free liquid-metal converter.
- Study of an innovative waste management in the liquid Hg-loop e.g. by means of Hg distillation.
- Engineering design and construction of a functional Hg-loop.
- Off-line testing and validation of the thermal hydraulics and fluid dynamics.
- Detailed planning and proposal for subsequent in-beam test in collaboration with other Hg target users.
- Engineering design of the entire target station and its handling method

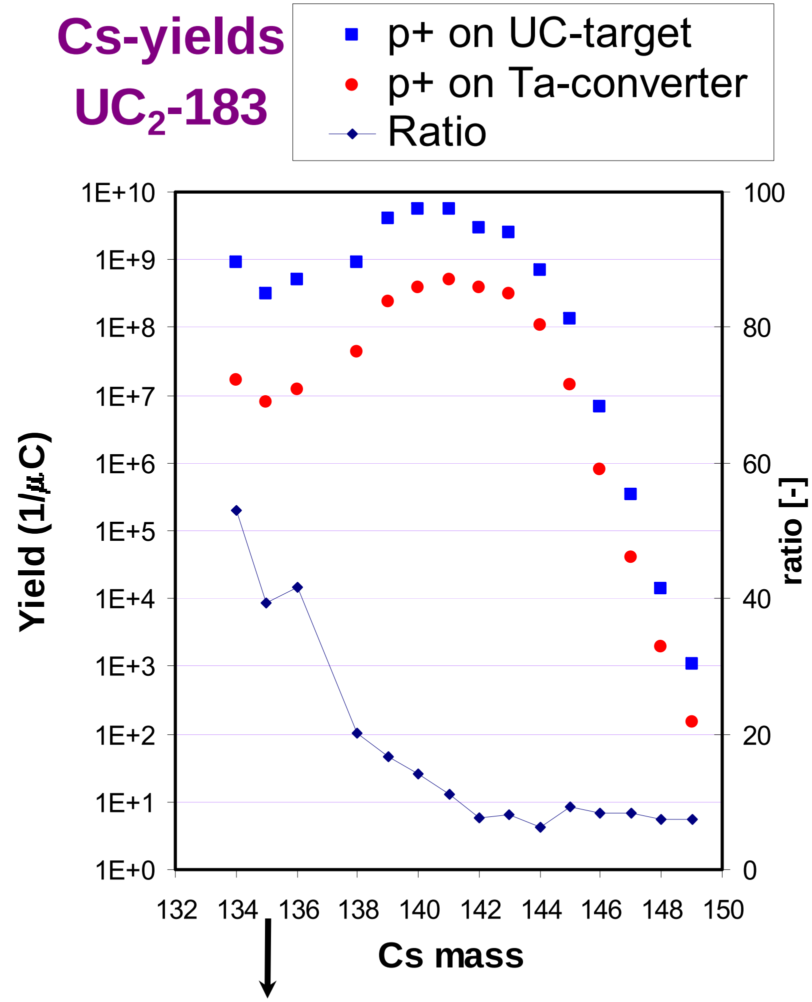


Kr, Xe and Cs yields, Ta-W converter

EURISOL Design Study







Spallation Fission

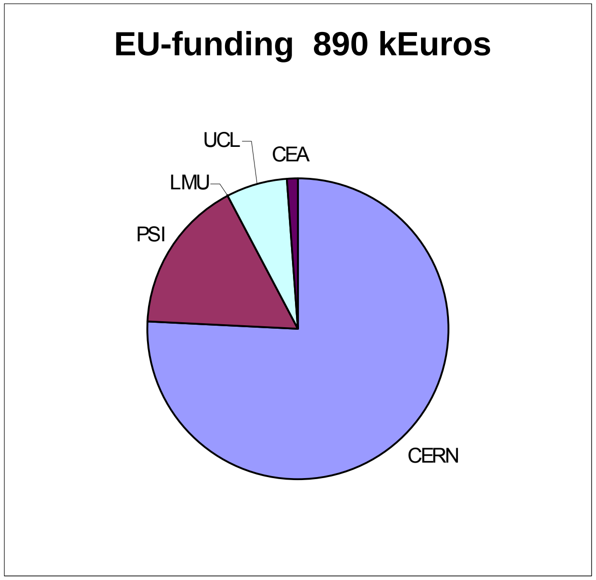
The yields of very n-rich isotopes obtained via neutron induced fission of Th or U are close to those of high energy protons.

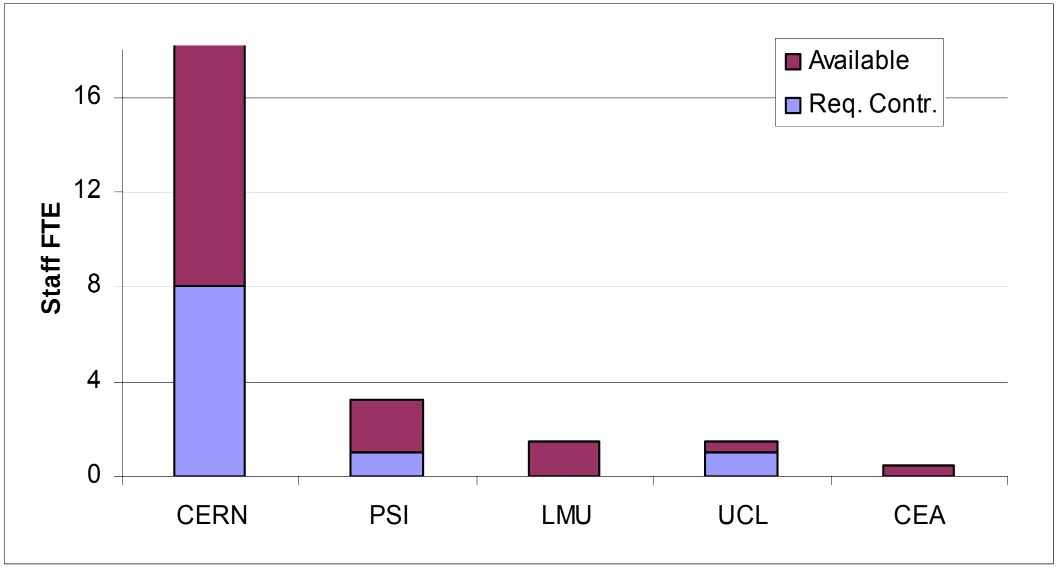
Further developments:
Geometrical optimum and n-reflectors

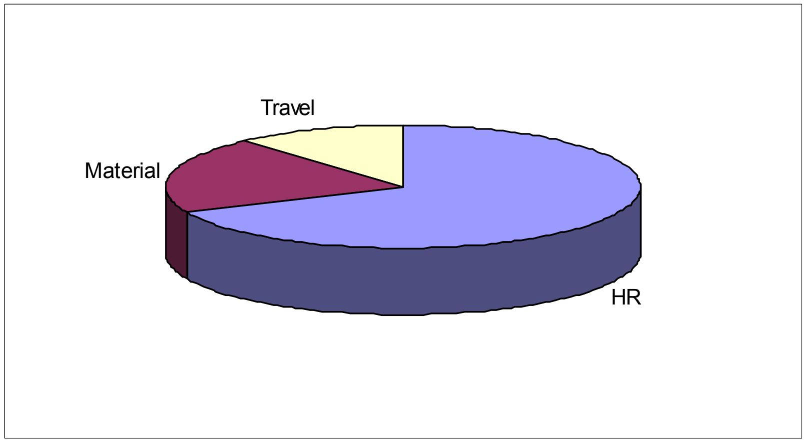
Conclusion

- The EURISOL-DS-targetry group proposes:
  - 4 test cases to define the front-end of the 100 kW target stations (T3).
  - Investigation of a spallation n-source based on Hg loop (4 MW) (T2) and cooled solids (<1 MW) (T4).
  - Compare yields of high-density and powder of actinide carbides (T4).
- Decision on EU-funding of the EURISOL-DS project in June 2004

T3 – direct target







Total estimated Cost (k€): 2439
Contribution from UE (k€): 890