

# 50 years from the foundation of Department of Nuclear Physics

## Production of intense beta neutrino emitters at CERN-ISOLDE for Beta beams

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The Beta beams were proposed by Piero Zucchelli in 2002 [1]. This is a concept of a large scale facility, based on existing CERN accelerators, aiming to provide pure and collimated ultra-relativistic beams of electron (anti)neutrinos with help of accelerated  $\beta$ -decaying radioactive ions circulating in a storage decay ring [see Fig.1] [2].

### Physical applications:

- ❖ **High energy**  $\rightarrow$  Neutrino oscillation physics (mixing angle  $\theta_{13}$  and CP violation phase).
- ❖ **Low energy**  $\rightarrow$  Cross-sections of neutrino-nucleus interaction.

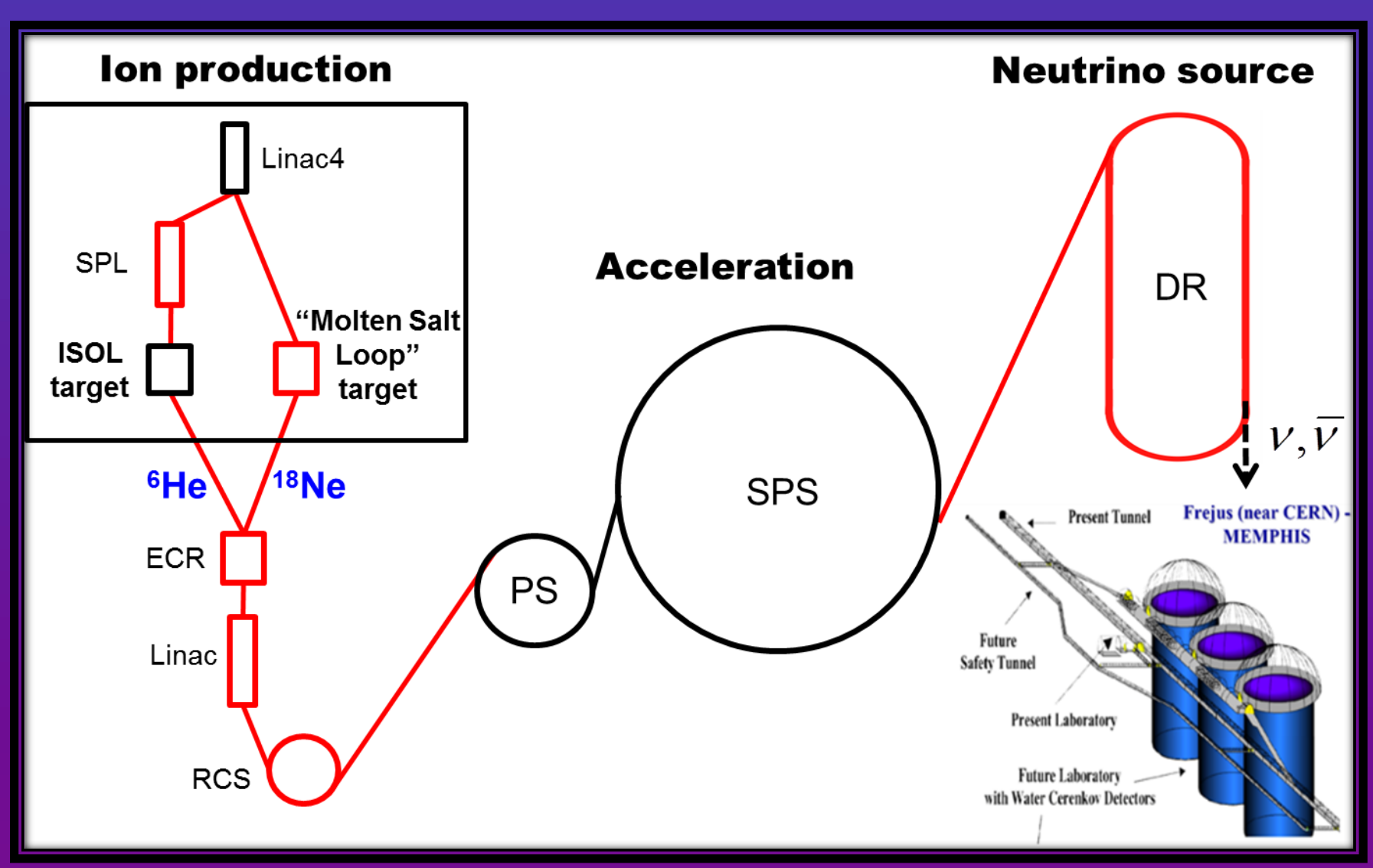
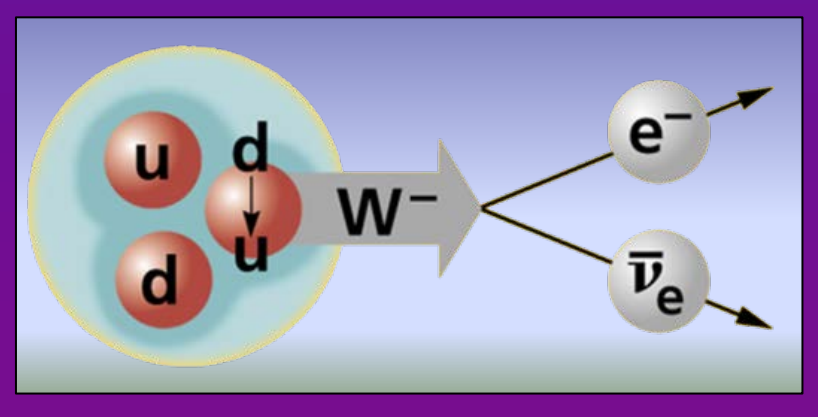
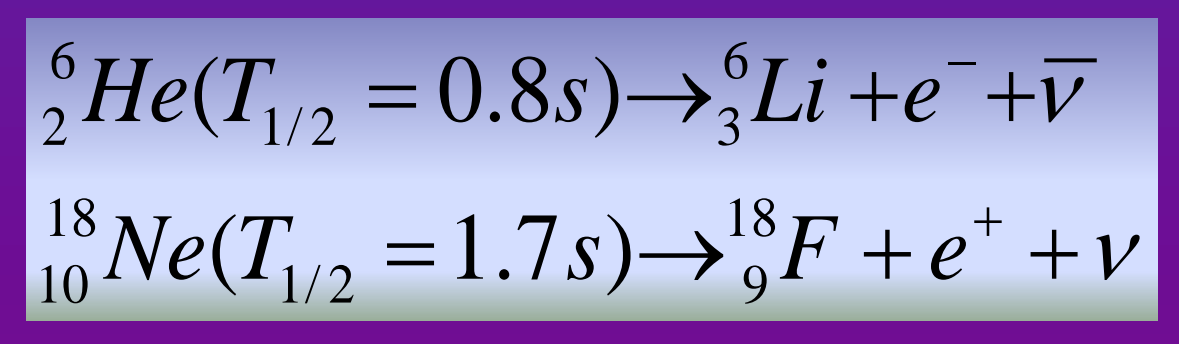


Fig.1.: Schematic layout of a possible Beta beams facility proposed at CERN

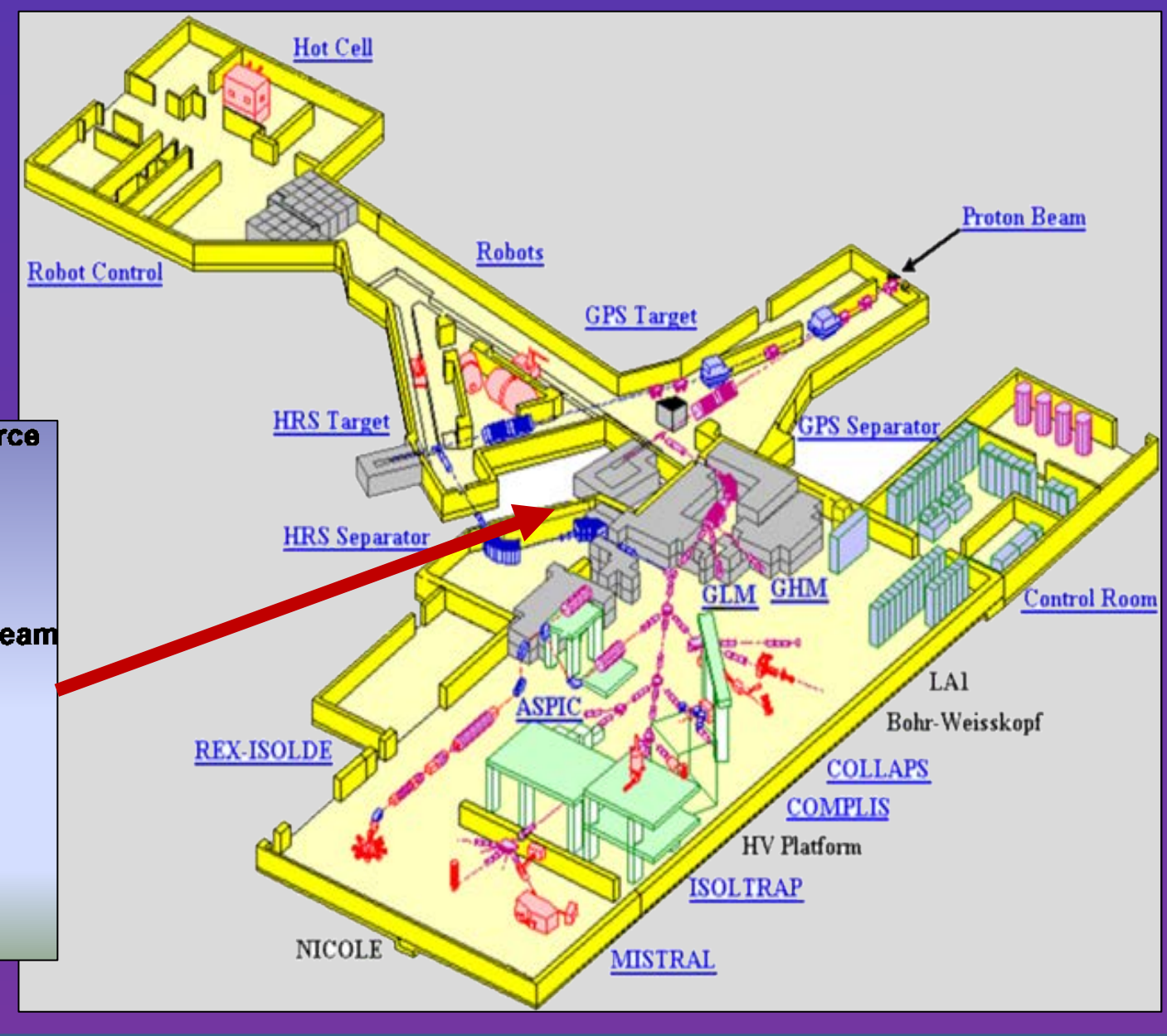
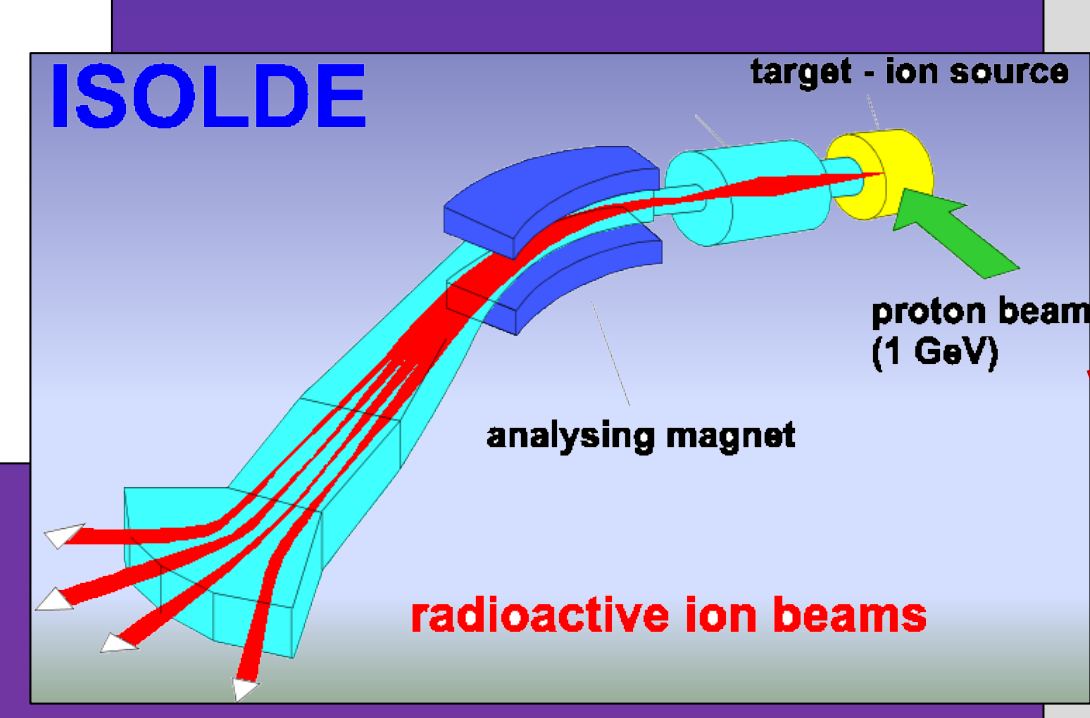
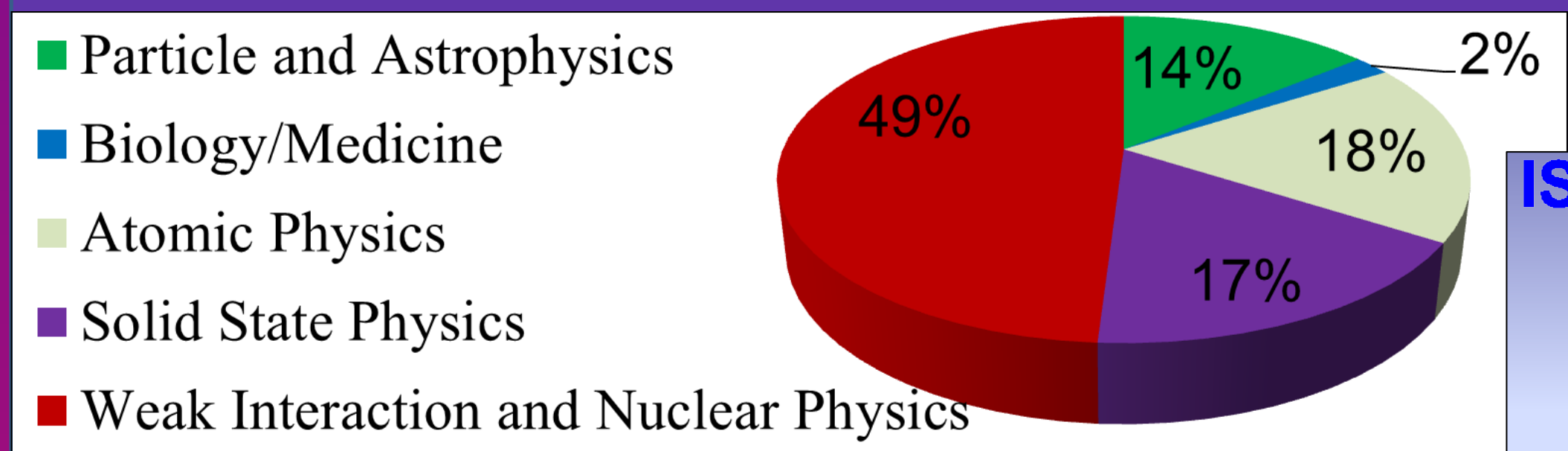
### Production goal over 10 years

- ❖  $2.9 \times 10^{19}$  anti- $\nu_e$  ( $3.3 \times 10^{13}$   ${}^6\text{He/s}$ )
- ❖  $1.1 \times 10^{19}$   $\nu_e$  ( $2.1 \times 10^{13}$   ${}^{18}\text{Ne/s}$ )



### ISOLDE (Isotope mass Separator On-Line DEvice) facility

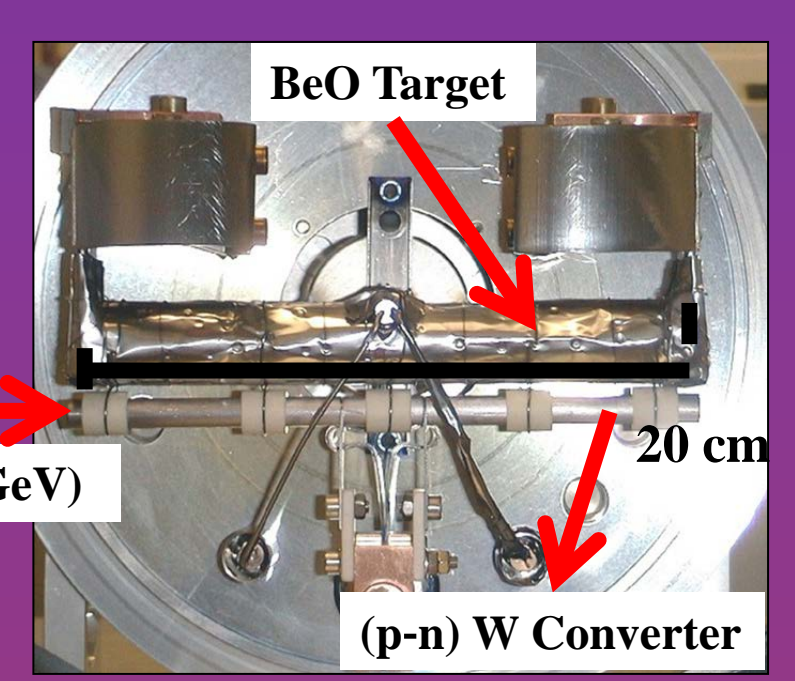
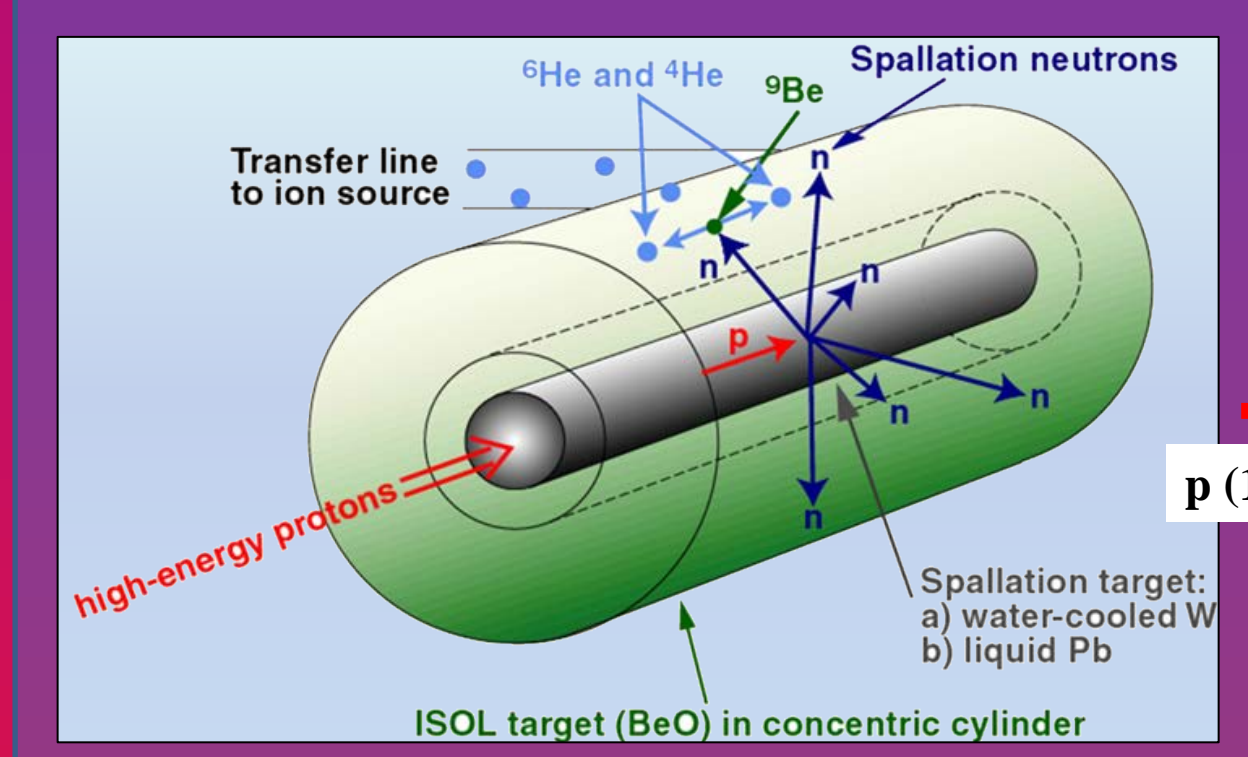
World-leading laboratory for production and studies of radioactive nuclei  
ISOL as injector to post accelerators



**EURISOL**  
Design Study <http://isolde.web.cern.ch/ISOLDE/>

### ${}^6\text{He}$ production

Production of the baseline  $\beta^-$  emitter  ${}^6\text{He}$  with fast neutrons on a thick **beryllium oxide** target with the  ${}^9\text{Be}(n,\alpha){}^6\text{He}$  reaction.

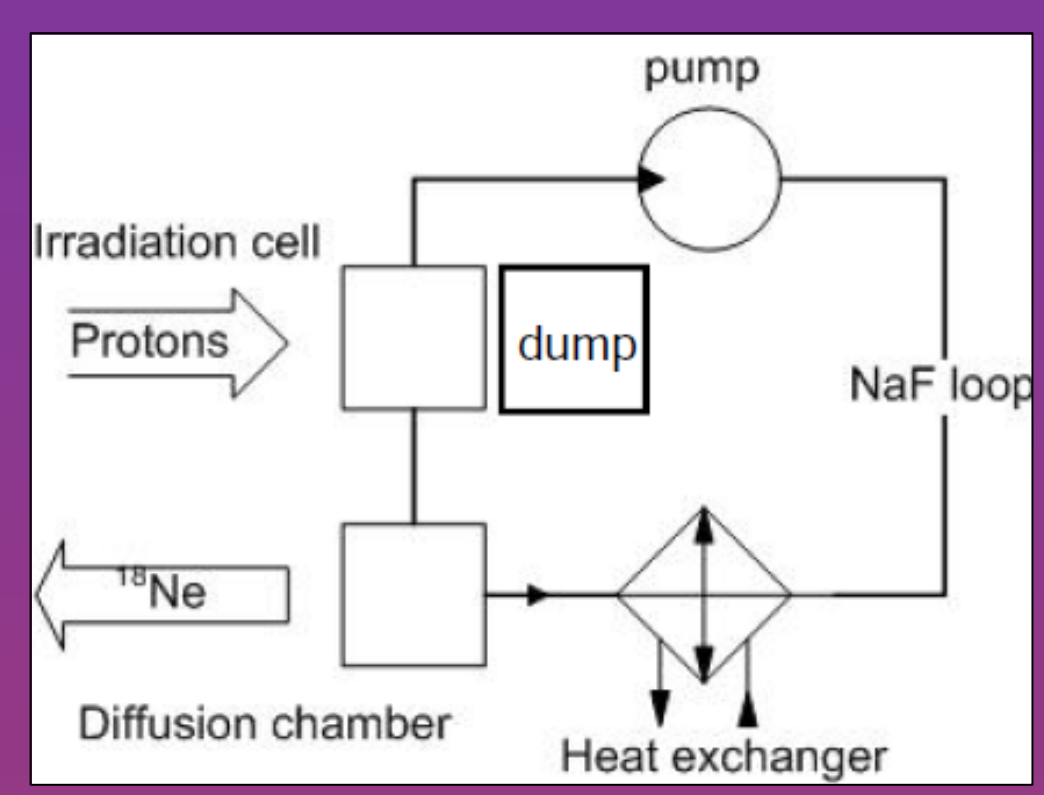


Configuration used for the online tests at CERN-ISOLDE (2009) [3].

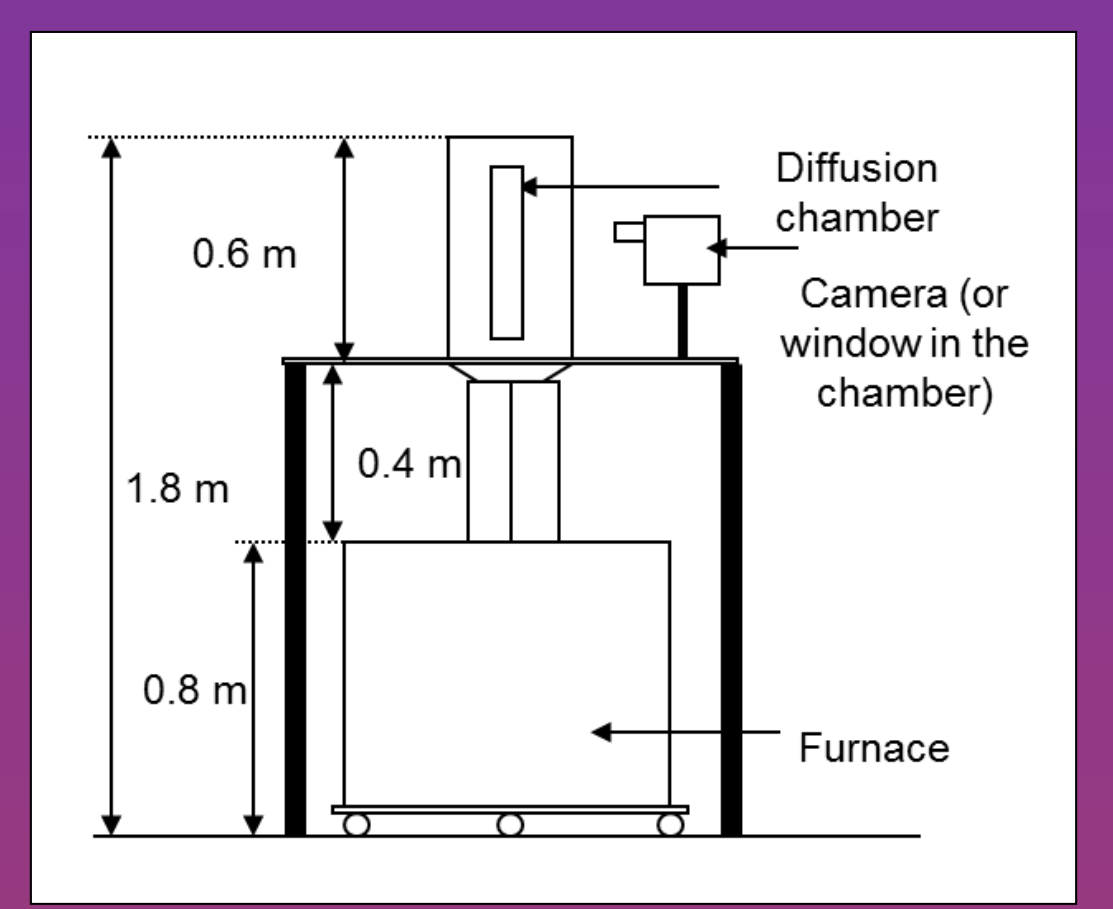
Conceptual configuration of the dual W converter- BeO assembly for 1 GeV proton beam.

### ${}^{18}\text{Ne}$ production

Production of the baseline  $\beta^+$  emitter  ${}^{18}\text{Ne}$  with protons based on a circulating loop of molten salt ( $\text{NaF-ZrF}_4$ ) with the  ${}^{19}\text{F}(p, 2\alpha){}^{18}\text{Ne}$  and  ${}^{23}\text{Na}(p, X){}^{18}\text{Ne}$  reaction.



Conceptual layout of a molten salt circulating target.



Diffusion chamber layout.

Isotope	Accelerator	Beam	$I_{\text{beam}}$ [mA]	$E_{\text{beam}}$ [MeV]	$P_{\text{beam}}$ [kW]	Target	Extract. Isotope rate [ $\text{s}^{-1}$ ]
${}^6\text{He}$	SPL	${}^1\text{H}$	0.2	1000	200	Solid W/BeO	$2.10^{13}$ Experimentally validated [3]
${}^{18}\text{Ne}$	Linac 4	${}^1\text{H}$	6	160	1000	Molten salt NaF-ZrF <sub>4</sub> loop	$1.10^{13}$ Need experimental confirmation (2012)

### References

- [1] P. Zucchelli, Phys. Lett. B 532 (2002) pp. 166–172.
- [2] Final Report of the EURISOL Design Study, J. Cornell Ed., GANIL (2009).
- [3] T. Stora, R. Hodák et al., to be published in EPL.