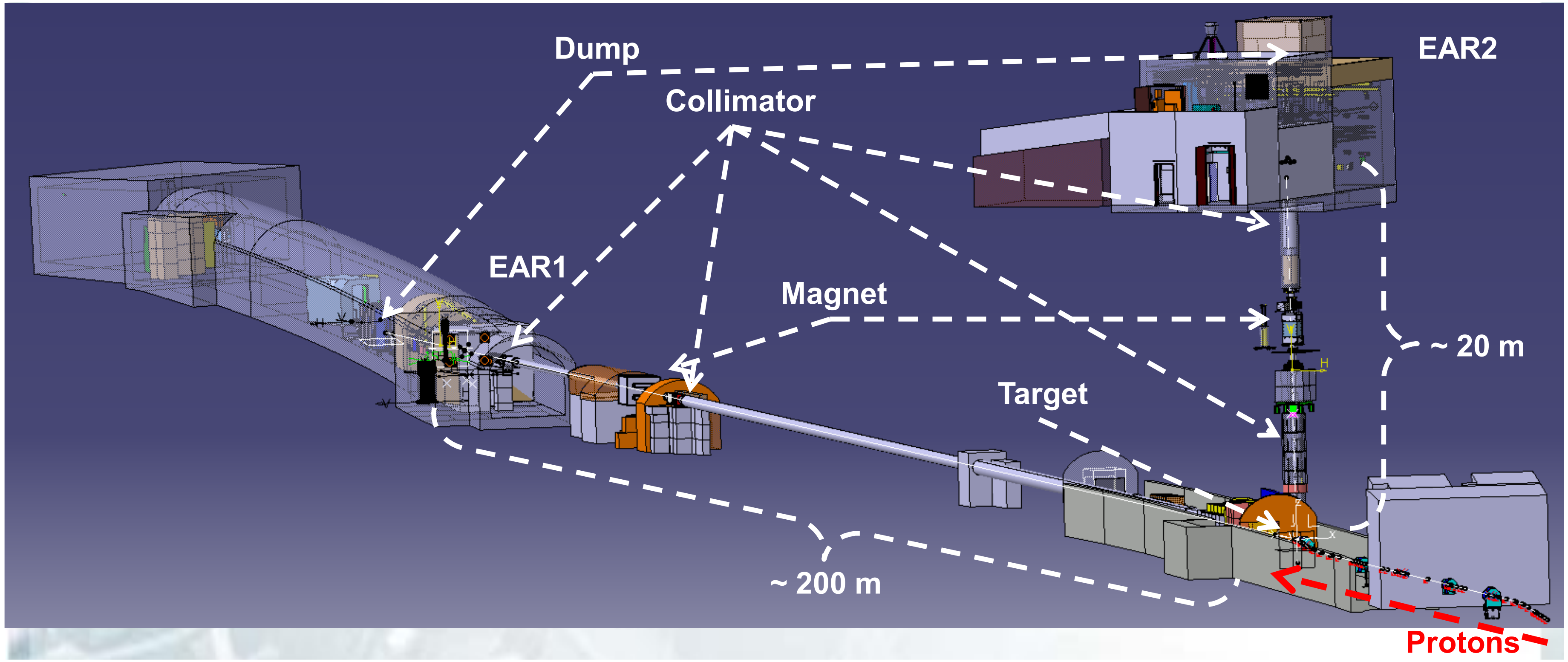
NSTAPP – Neutrons in Science, Technology and Applications

The n_TOF Collaboration

22 November 2021

n_TOF @ CERN



Conclusions and (a few) Perspectives

- Core business going on
- The NEAR Station
- Synergies with ISOLDE

Core business going on

reaction	field of interest	note
$^{94,95,96}Mo(n,\gamma)$	– s-process AGB stars, SiC grains – fp, fuel alloys	stable samples (*)
$^{94}Nb(n,\gamma)$	– anomalies in pre-solar grains – strong contributor to the long-term radiotoxicity among fp	radioactive sample $t_{1/2}$ = 20 ka
$^{79}Se(n,\gamma)$	– s-process thermometer – strong contributor to the long-term radiotoxicity among fp	radioactive sample $t_{1/2}$ = 300 ka
$^{50,53}Cr(n,\gamma)$	– criticality safety (major element in stainless steel)	stable samples
$^{40}K(n,p)$ $^{40}K(n,\alpha)$	– radiogenic heating in earth-like exoplanets (destruction vs production mechanisms)	~ stable samples

(*) part of a EU H2020 nuclear data project

continue…

Core business going on

reaction	field of interest	note
^{239}Pu(n,γ) and α-ratio	– advanced nuclear technologies	radioactive sample $t_{1/2}$ = 24.1 ka (*)
^{243}Am(n,f)	– contributes to production of ^{239}Pu (by α + β^- decays)	radioactive sample $t_{1/2}$ = 7364 a

…

(*) part of a EU H2020 nuclear data project

Basic science at n_TOF

Explored

Cosmochronology (nuclear clocks) : Re/Os clock

BBN : the cosmological lithium problem (CLiP)

Planned

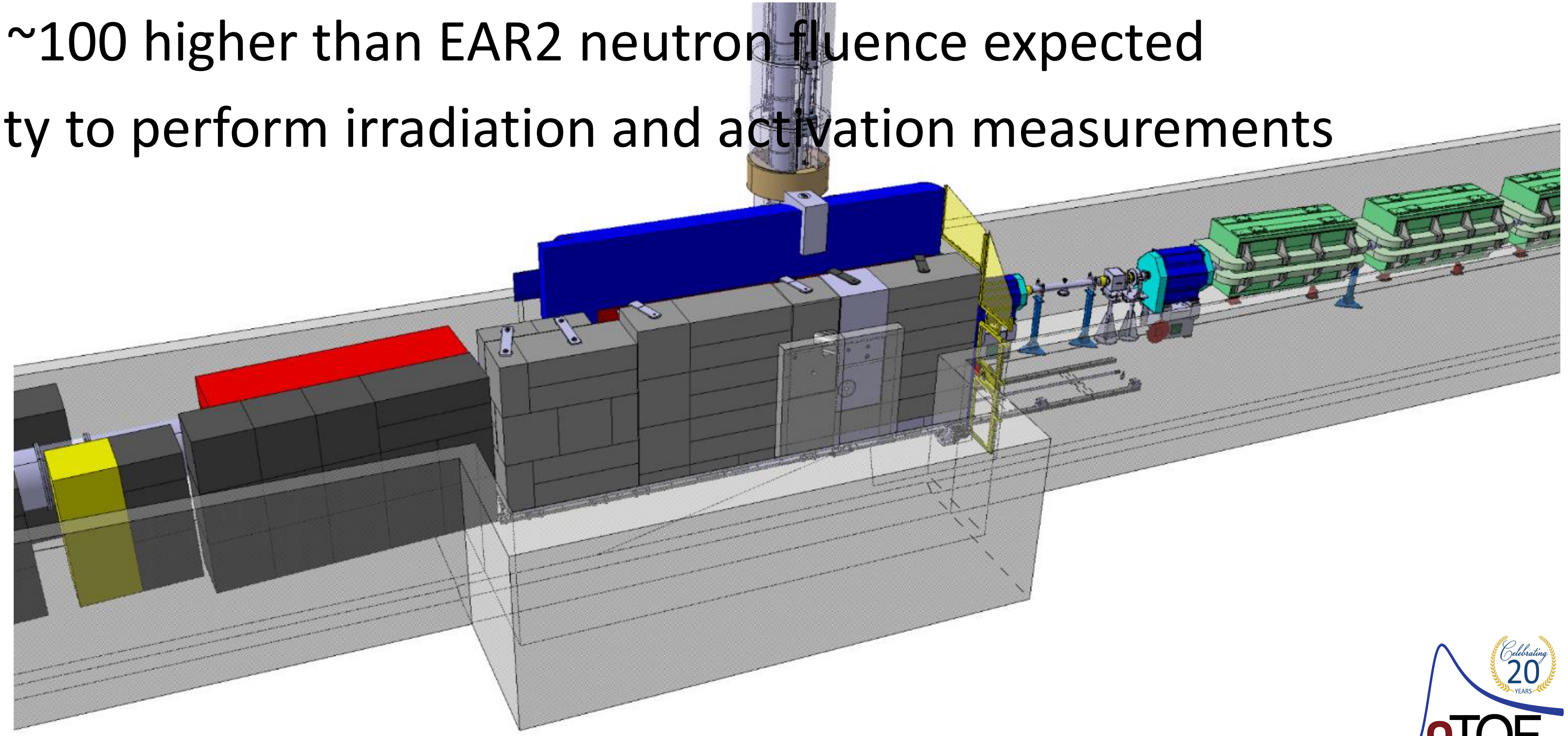
NN-scattering length : charge-symmetry breaking in QCD

To be explored

X17 (n+^{3}He, n+^{7}Be) : dark photons/fifth force (?)

The n_TOF NEAR Station

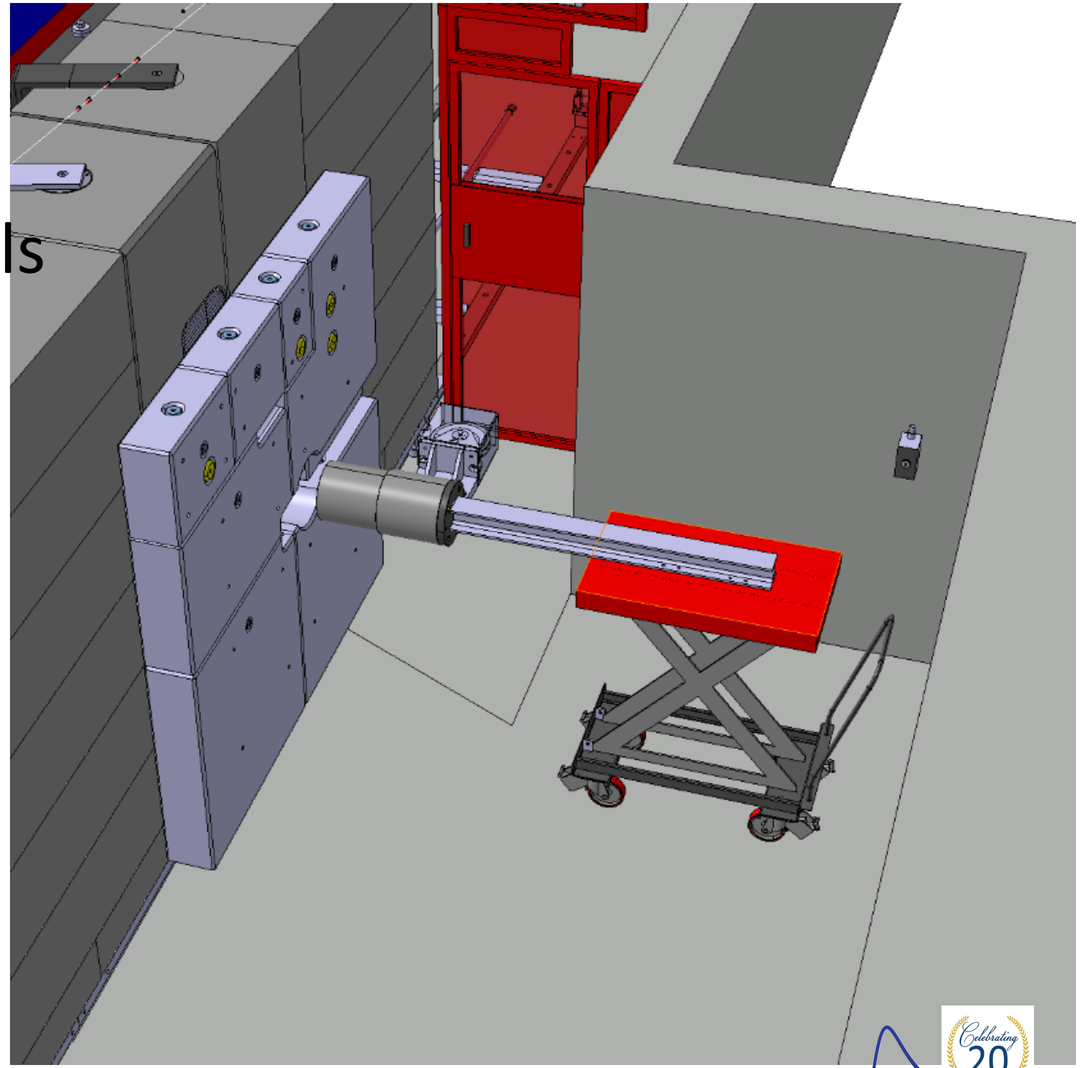
- 2-3 m from the target assembly
- a factor ~100 higher than EAR2 neutron fluence expected
- possibility to perform irradiation and activation measurements



The n_TOF NEAR Station

- irradiation of materials
  applications for Fusion research, SEE, behavior of non-metallic materials for accelerator and experiments in radiation fields

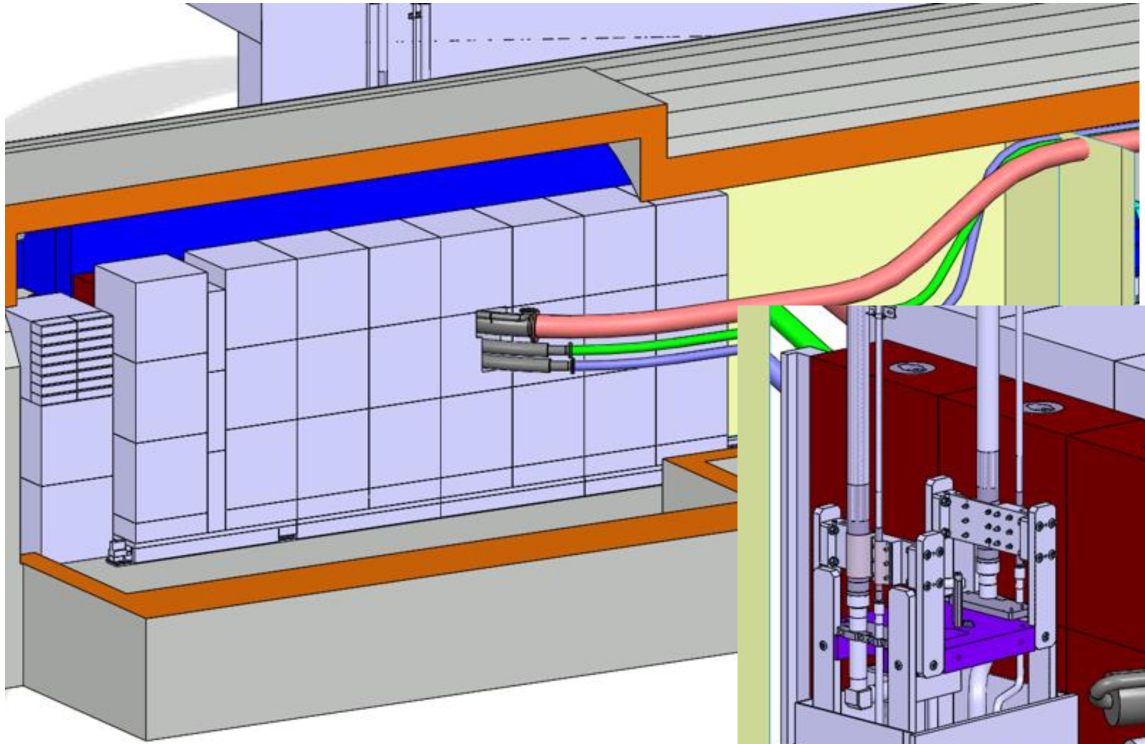
- activation measurements
  extremely small samples, short-lived nuclei for s-process branchings and other aspects of nucleosynthesis

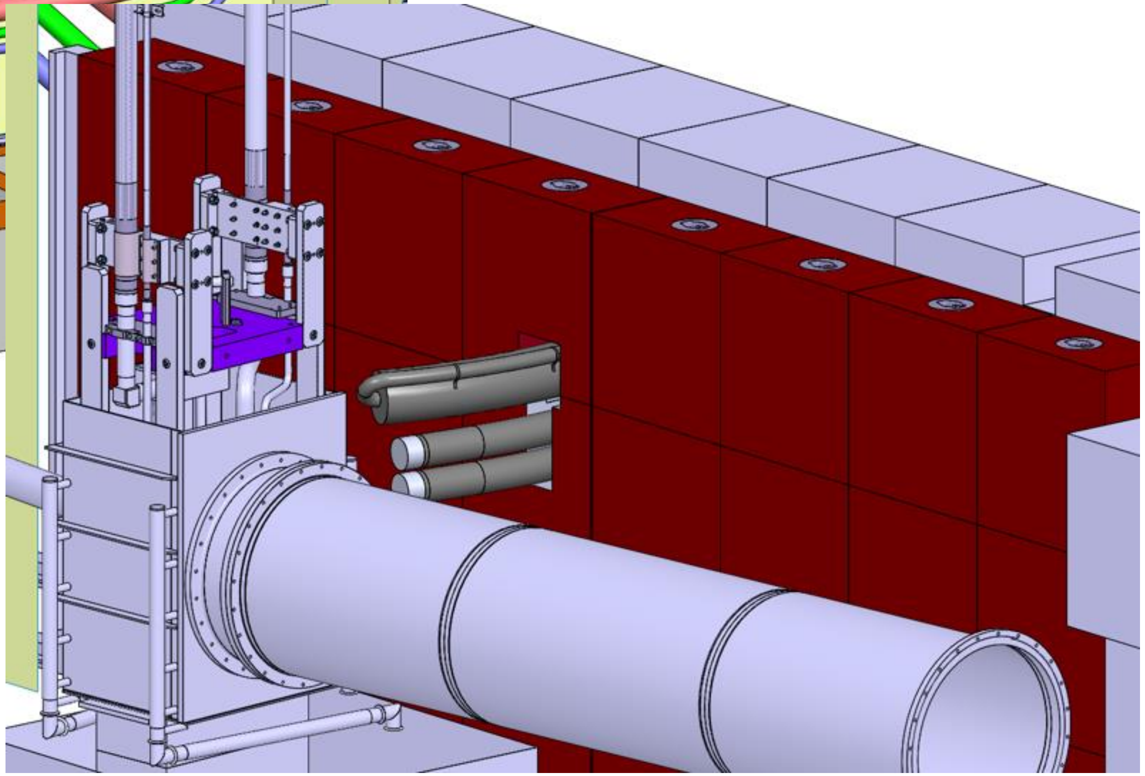


synergies with ISOLDE (present and future) being explored

The NEAR Station

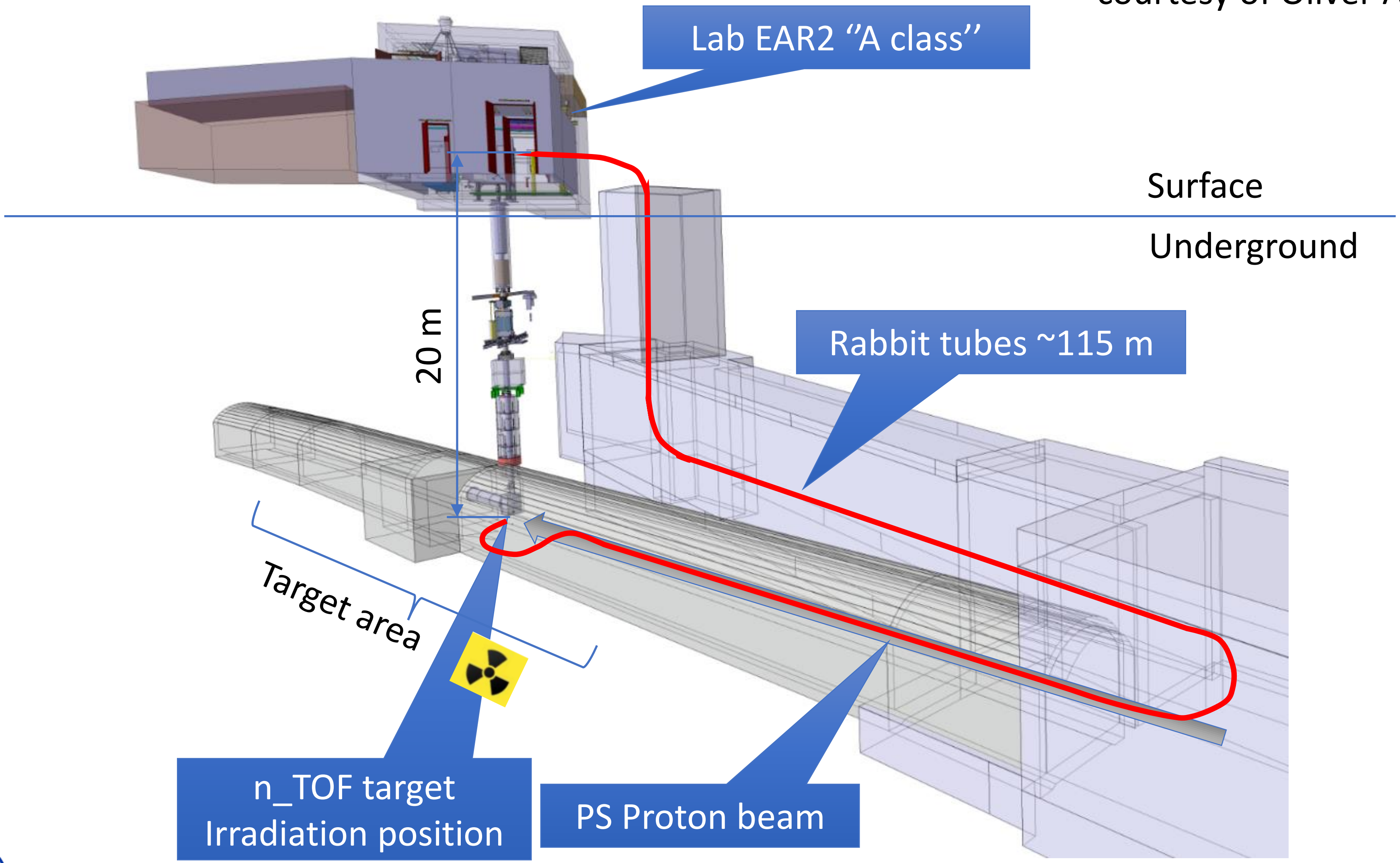
courtesy of Oliver Aberle (CERN)





The NEAR Station

courtesy of Oliver Aberle (CERN)



The NEAR Station

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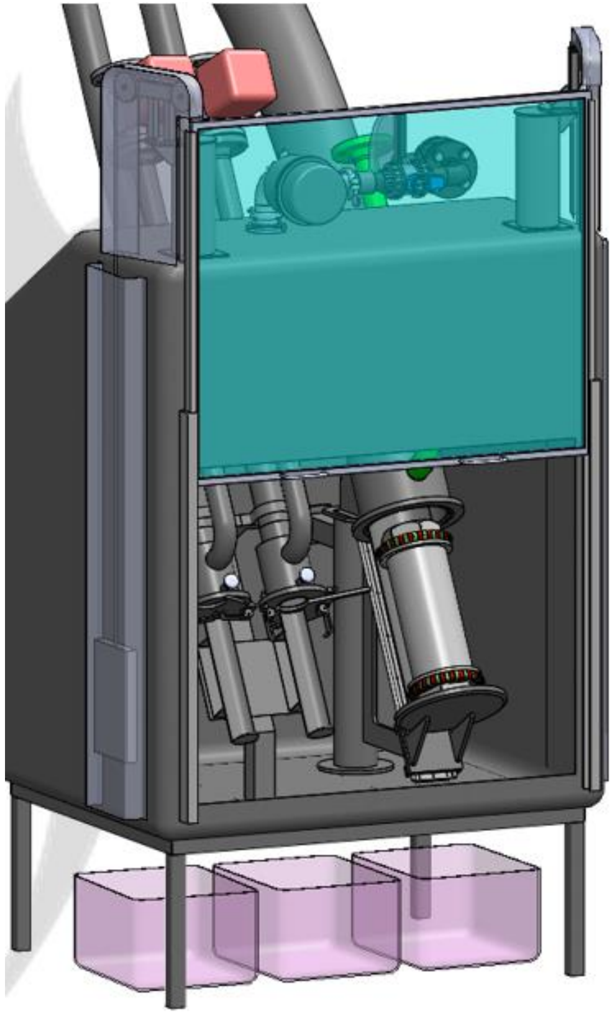
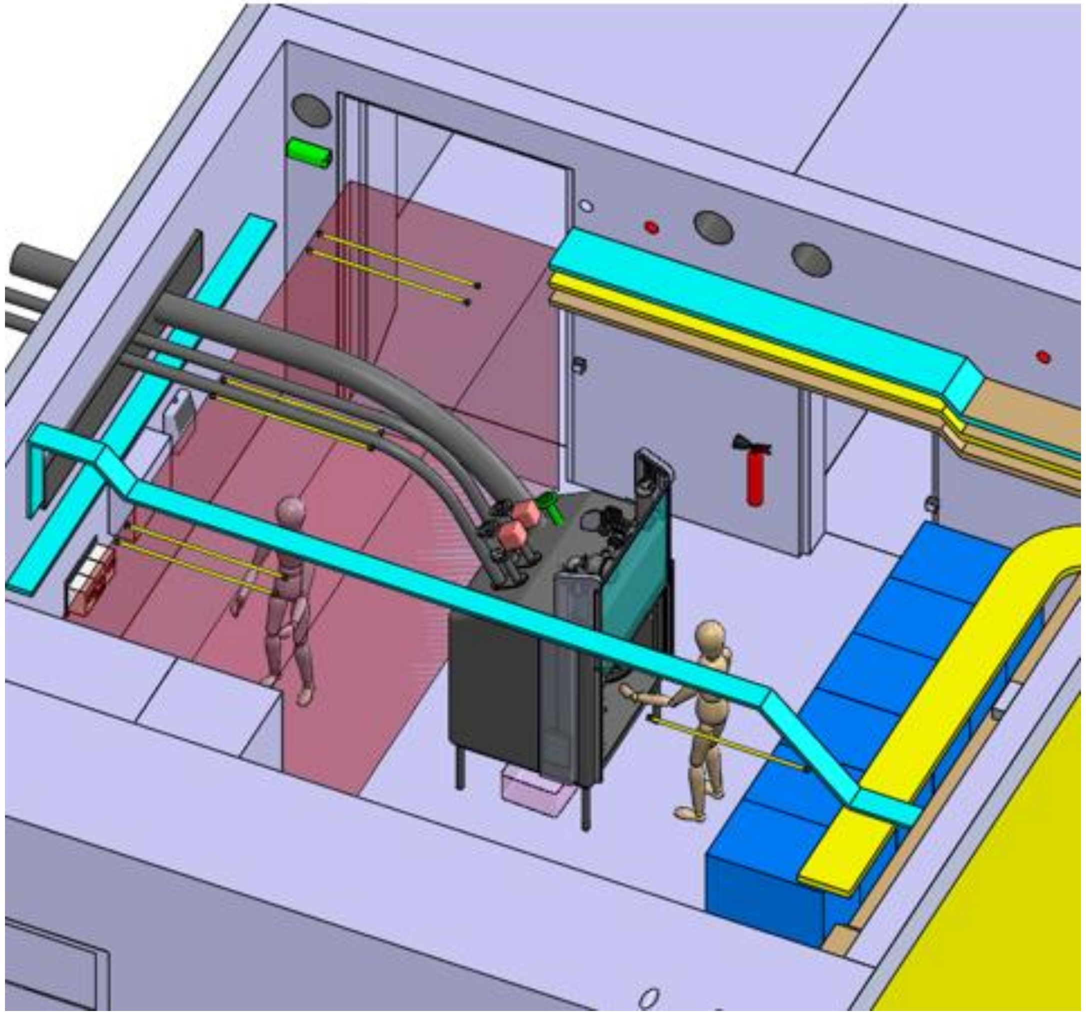




$^{7}Be(n,p)^{4}He$

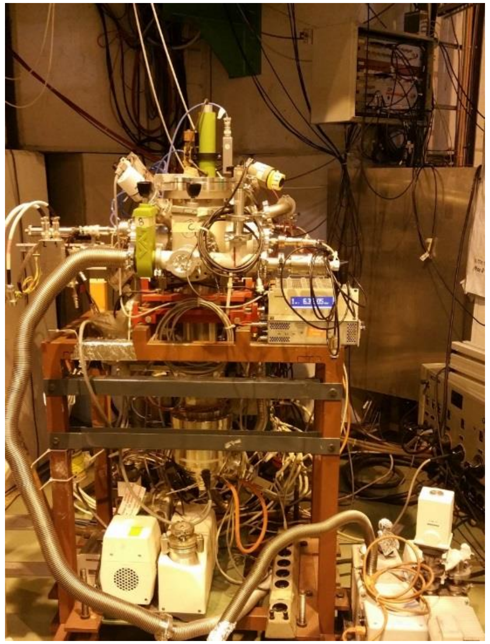
L A Damone et al. (The n_TOF Collaboration)
Phys. Rev. Lett. **121** (2018) 042701

A three-step experiment:

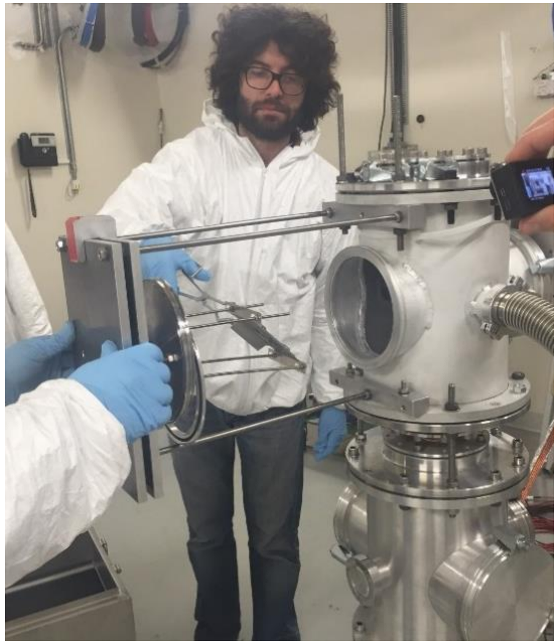
- Extraction of 200 GBq material from water cooling of SINQ spallation source at PSI
- Implantation of the 30 keV (~45 nA) ^{7}Be beam on suited backing using **ISOLDE-GPS separator and RILIS**
- Measurement at n_TOF-EAR2 using a silicon telescope (20 and 300 mm, 5x5 cm^{2} strip device)

PSI hot-cell

ISOLDE - GLM



n_TOF EAR2



E. Maugeri *et al.* (The n_TOF Collaboration), Nucl. Instr. and Meth. A **889** (2018) 138
M. Barbagallo *et al.* (The n_TOF Collaboration), Nucl. Instr. and Meth. A **887** (2018) 27-3

CERN PAUL SCHERRER INSTITUT PSI ISOLDE nTOF

Perspectives

n_TOF pushed feasibility of neutron cross section measurements to limits of half-life of a few years on sample materials with ~ $10^{17} – 10^{19}$ atoms

With the availability of the NEAR Station, these limits could be pushed to shorter half-lives and smaller sample masses (at least for activation measurements)

ISOLDE can provide
- mass separation & implantation on material provided from outside source
- direct production of separated ions with a variety of species & yields

Examples

^{7}Be (already done)
^{134,137}Cs
^{85}Kr
^{154}Eu
…

Big bang nucleosynthesis: Cosmological Lithium Problem (CLiP)

time: **0.5 s – 200 s**

thermal equilibrium $n_n/n_p = e^{-Q/kT}$ up to T ~ 10 GK

~ 1/7 at T ~ 1 GK

time: **200 s – a few min**

nucleosynthesis of d, ^{3}He, ^{4}He and ^{6,7}Li

^{7}Be(n,p)

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Phys. Rev. Lett. **121** (2018) 042701

^{7}Be(n,α)

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Phys. Rev. Lett. **117** (2016) 152701