UNIVERSIDAD TECNICA FEDERICO SANTA MARIA

Double Target system for the Run Group E experiment in CLAS12

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Main Physics Focus

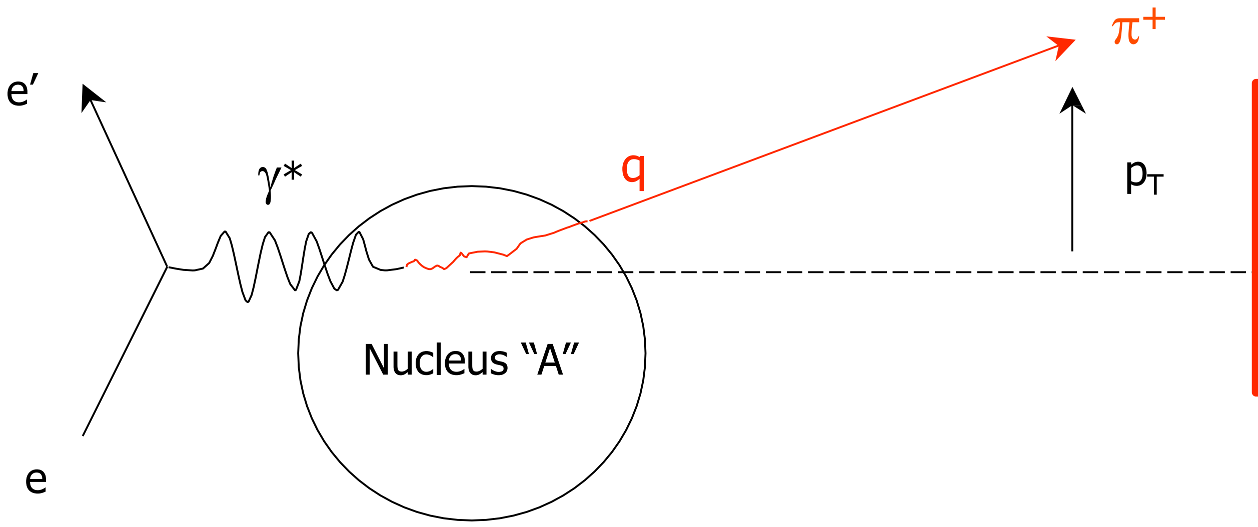
QCD in the space-time domain:

- How long can a light quark remain deconfined?
  - The production time τ_p measures this
  - Deconfined quarks lose energy via gluon emission
  - Measure τ_p (and dE/dx?) via *transverse momentum broadening* that arises due to partonic elastic scattering and medium-stimulated gluon emission

- How long does it take to form the full color field of a hadron?
  - The formation time τ_f^h measures this
  - Measure τ_f^h via *hadron attenuation in nuclei* together with the understanding of the production time τ_p

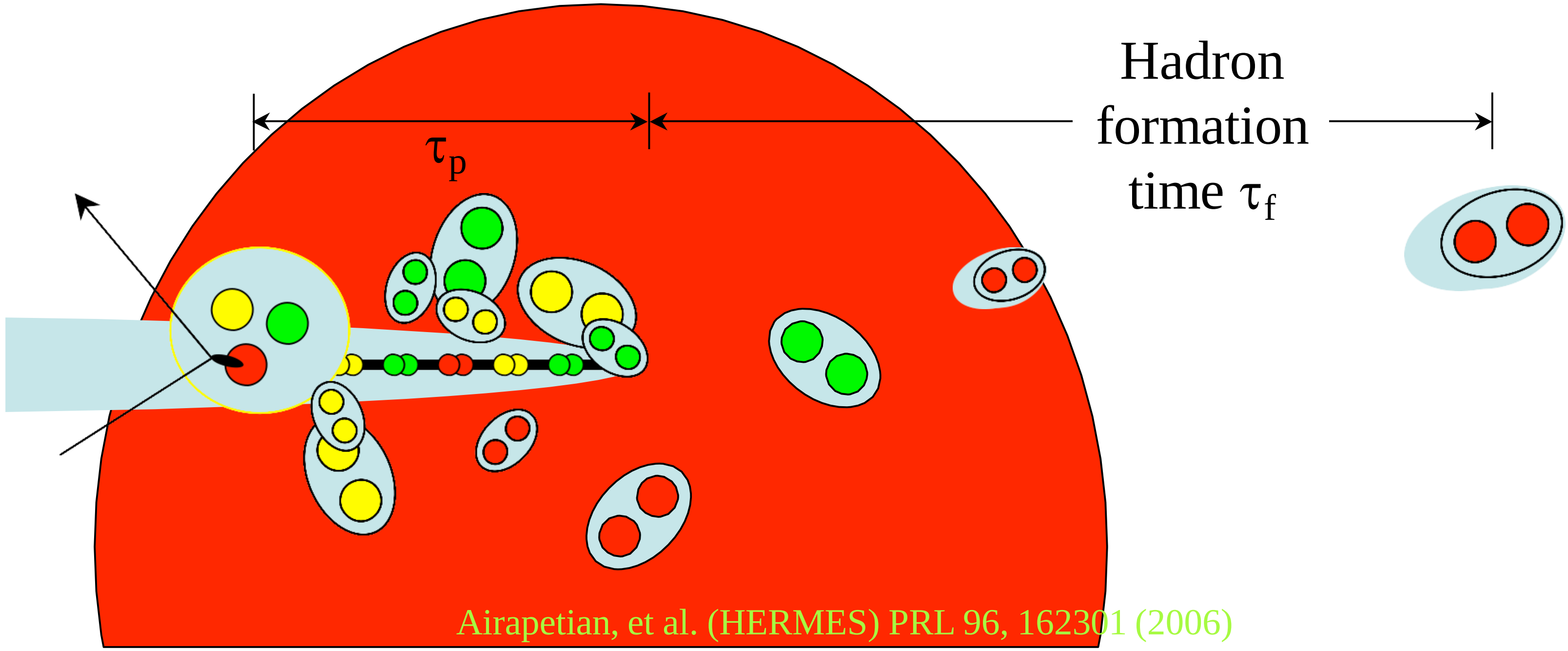
Definitions

p_T *broadening*: $\Delta p_T^2 = \langle p_T^2 \rangle_A^{DIS} - \langle p_T^2 \rangle_D^{DIS}$



Hadronic multiplicity ratio

$$R_M^h(z,\nu,p_T^2,Q^2,\phi) = \frac{\left\{ \frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_A}{\left\{ \frac{N_h^{DIS}(z,\nu,p_T^2,Q^2,\phi)}{N_e^{DIS}(\nu,Q^2)} \right\}_D}$$

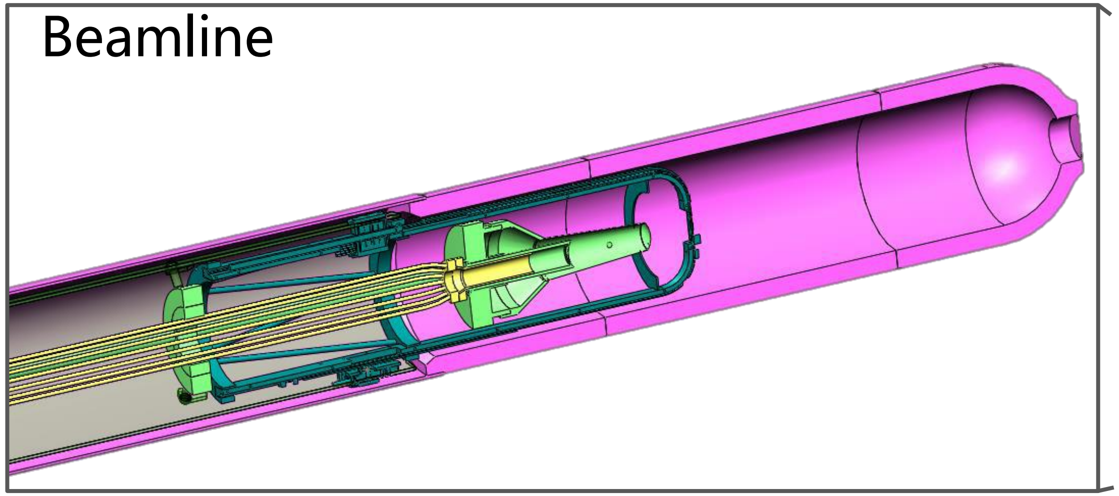


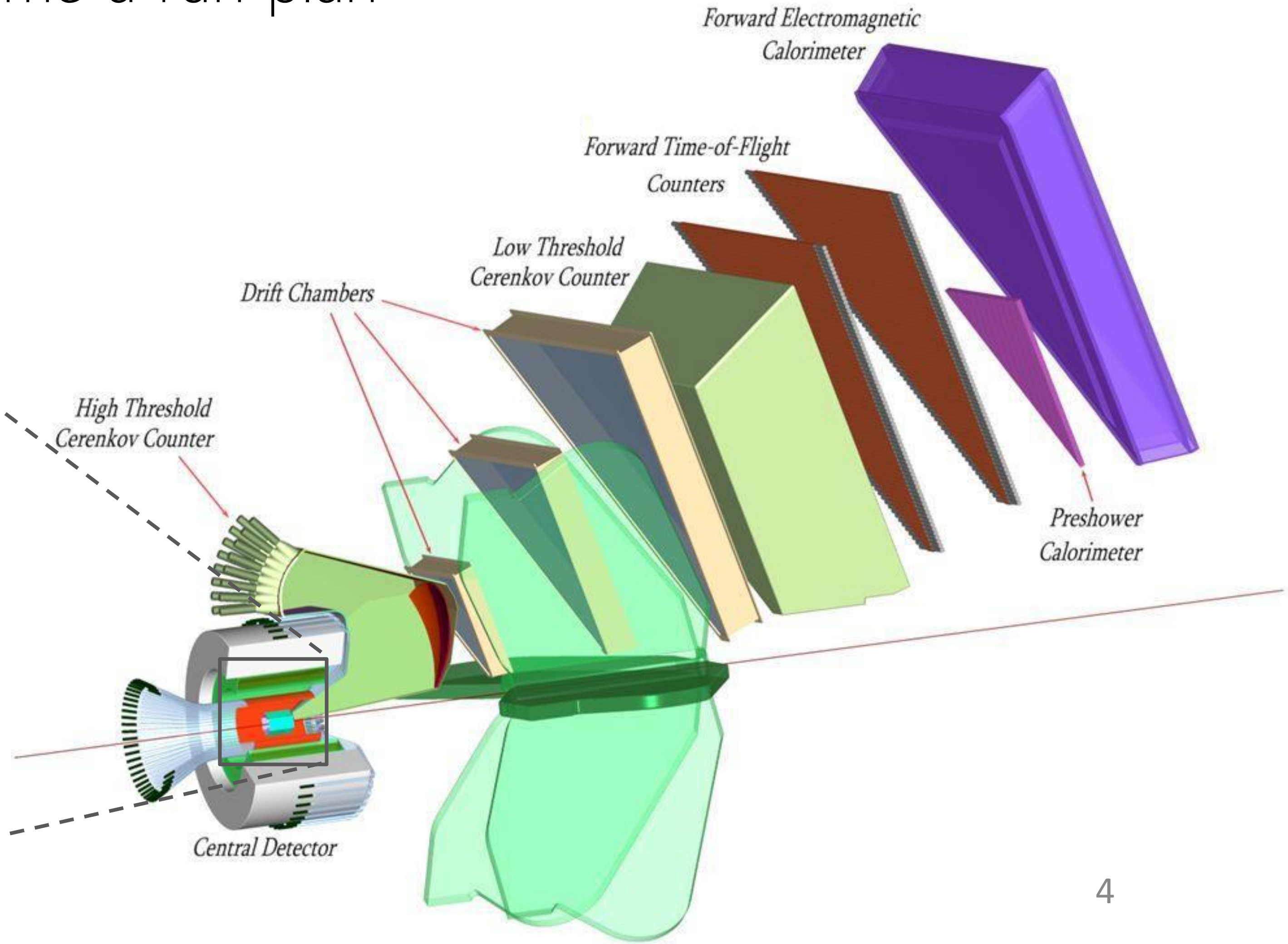
Airapetian, et al. (HERMES) PRL 96, 162301 (2006)

Motivation – CLAS12

In order to be scheduled for beam time a run plan must be provided by each run group.

- RG-E
- RG-D & M





Motivation

Place different **nuclear targets** in the beamline of CLAS12 to study the effect on the **hadronization** for nuclei of different sizes.

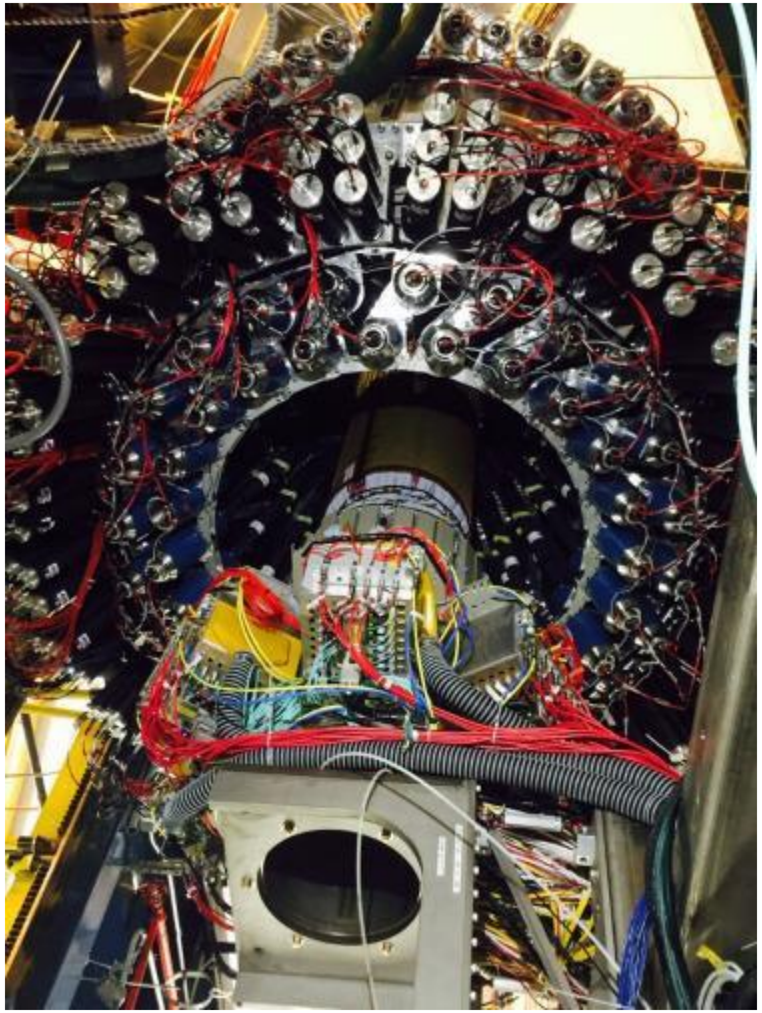
How we can do that in an efficient way?

- 2 targets **simultaneously** on the beamline
- One made of **liquid light nucleus** (cryocell) and the other of a **solid** material
- Possibility to interchange the different targets remotely
- Experimental time is reduced at least by half
- Time-dependent systematic effects are cancelled

Challenge

Extreme environmental conditions for the hardware:

- High vacuum: 6×10^{-6} [mbar]
- High magnetic field: $5\ [T]$
- Extreme temperatures: $30\ [K]$ from cryocell and ~ $950\ [K]$ from solid target
- Ionizing radiation: ~ 3800 [rem] from neutrons
- Limited space for installation: ~ $85\ [mm]$ beam pipe diameter



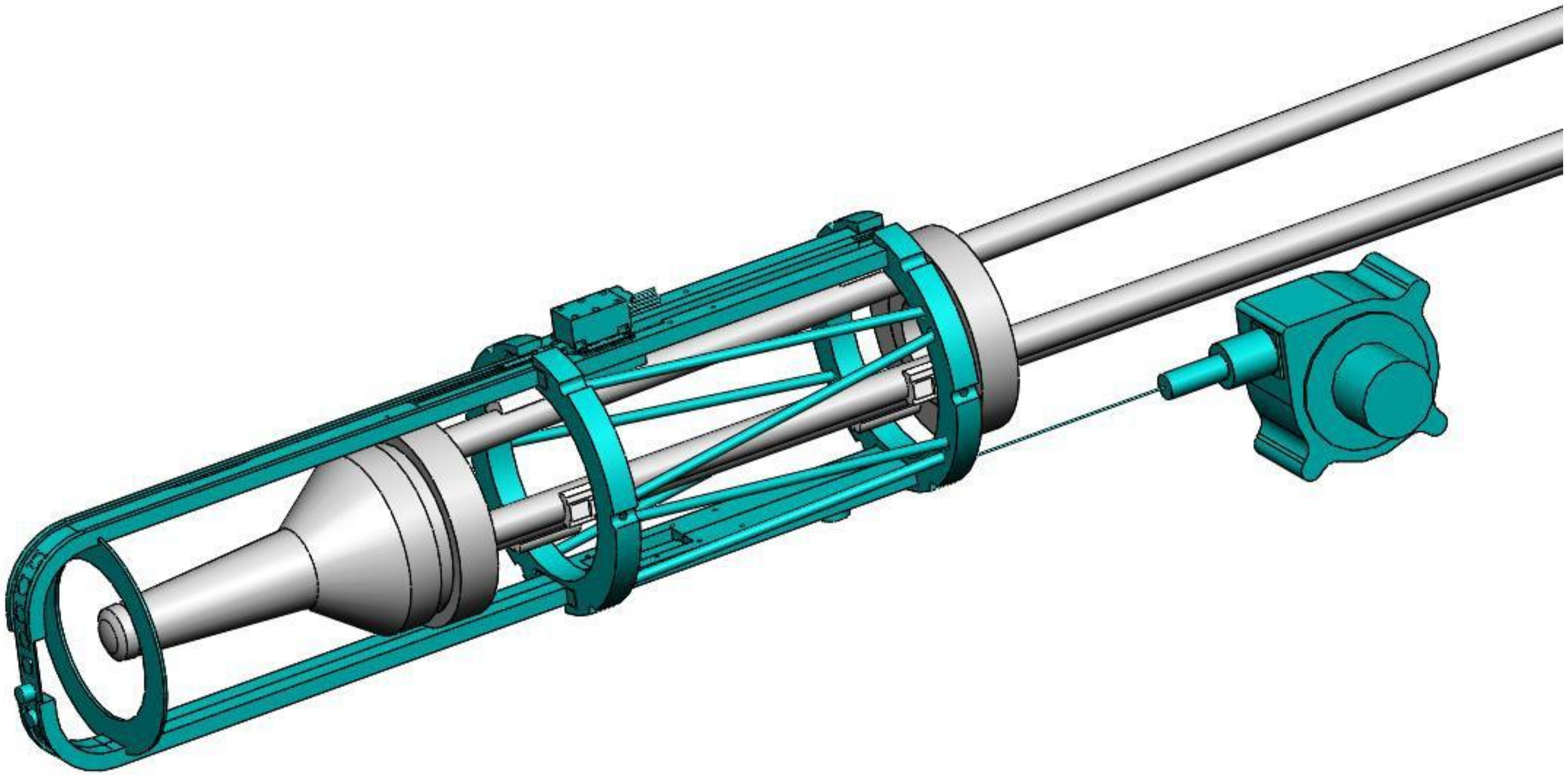
Proposal

Every challenge needs to be tackled:

- High vacuum: Compatible hardware and low gassing materials
- High magnetic field: Nonmagnetic materials and mechanisms
- Extreme temperatures: Insulate, conduct and radiate the heat
- Ionizing radiation: Shielding and radiation hardness
- Limited space for installation: Design considerations

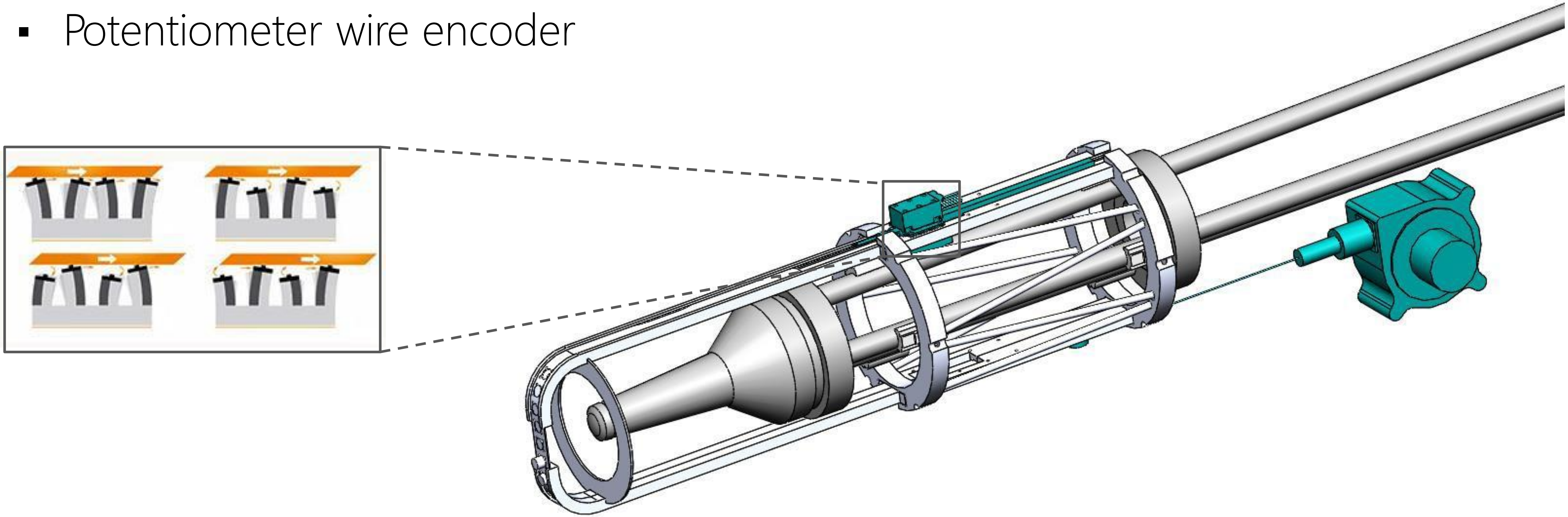
Double-target system

- Deuterium cryocell
- USM solid target system
  - Position control system
  - Support structure
  - Target holder ribbon



Position control system

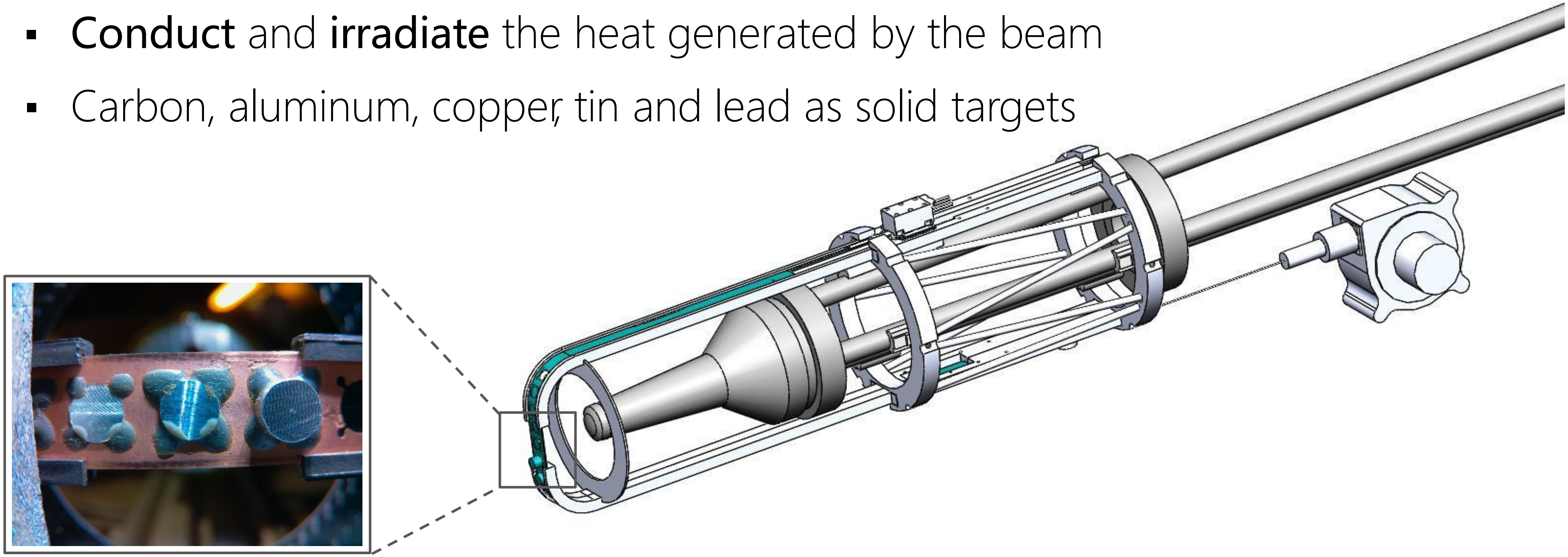
- **Piezoelectric** motor
- Potentiometer wire encoder



Nonmagnetic and vacuum resistant!

Target holder ribbon

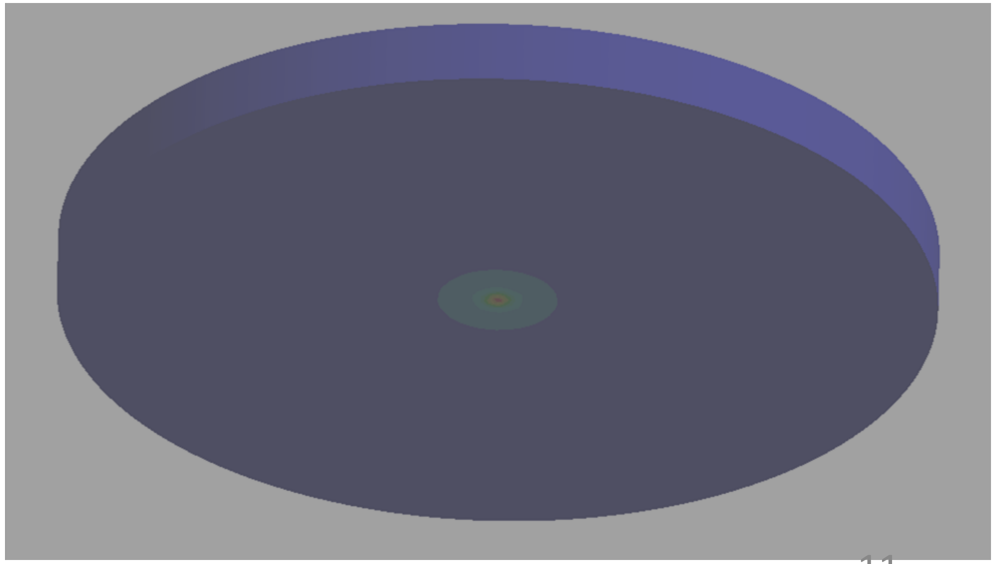
- Transfer the movement from the Piezomotor to the solid targets
- **Conduct** and **irradiate** the heat generated by the beam
- Carbon, aluminum, copper, tin and lead as solid targets



Thermal study

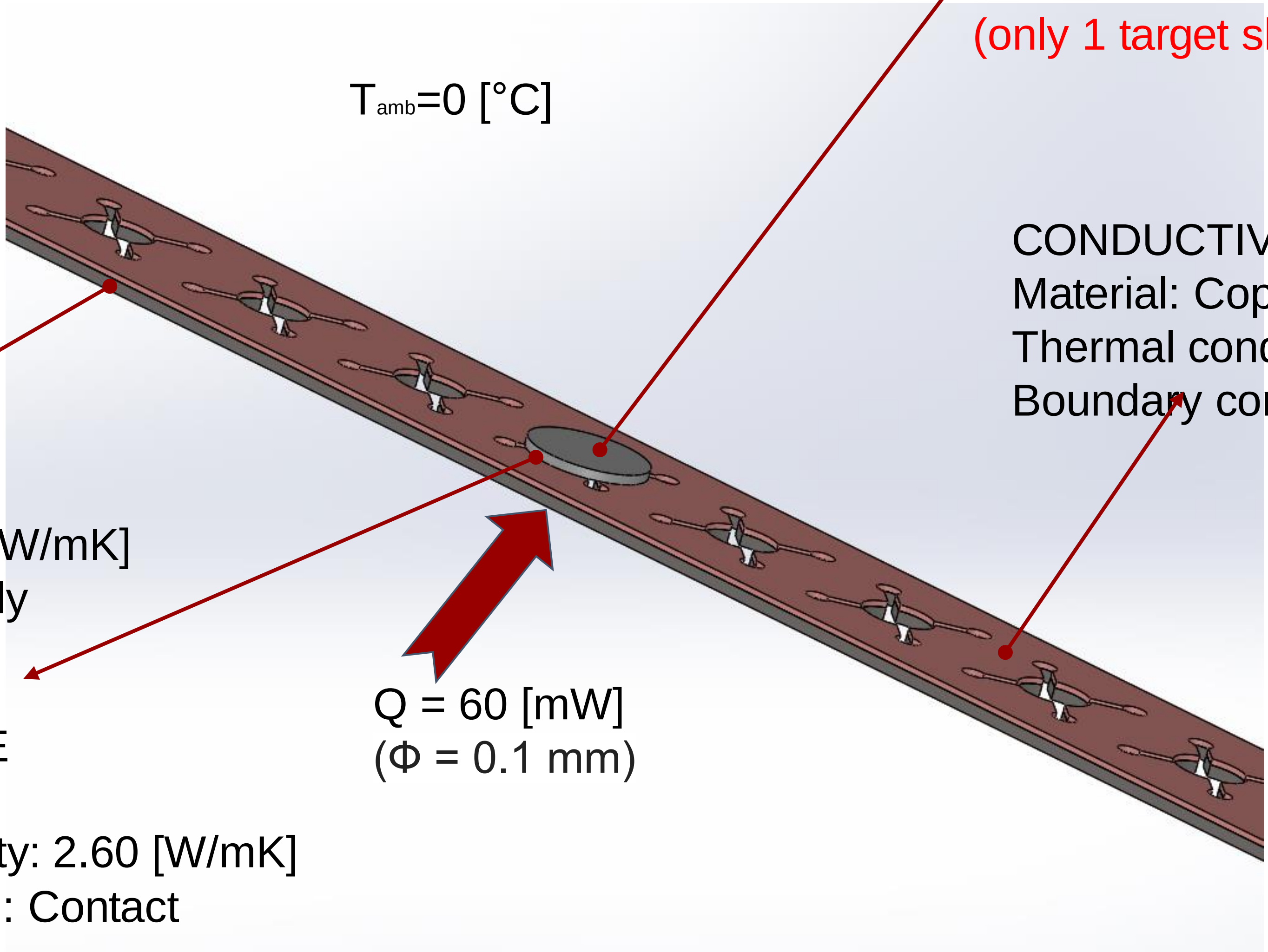
Estimate the heat removal capability of the system.

- Simulate the **maximum temperature** reached by the targets **without ribbon**
- Simulate the **maximum temperature** reached by the targets with the expected ribbon properties
- Compare both results



Thermal analysis

TARGETS
Materials: Carbon, aluminum, lead, tin
(only 1 target shown in the picture)

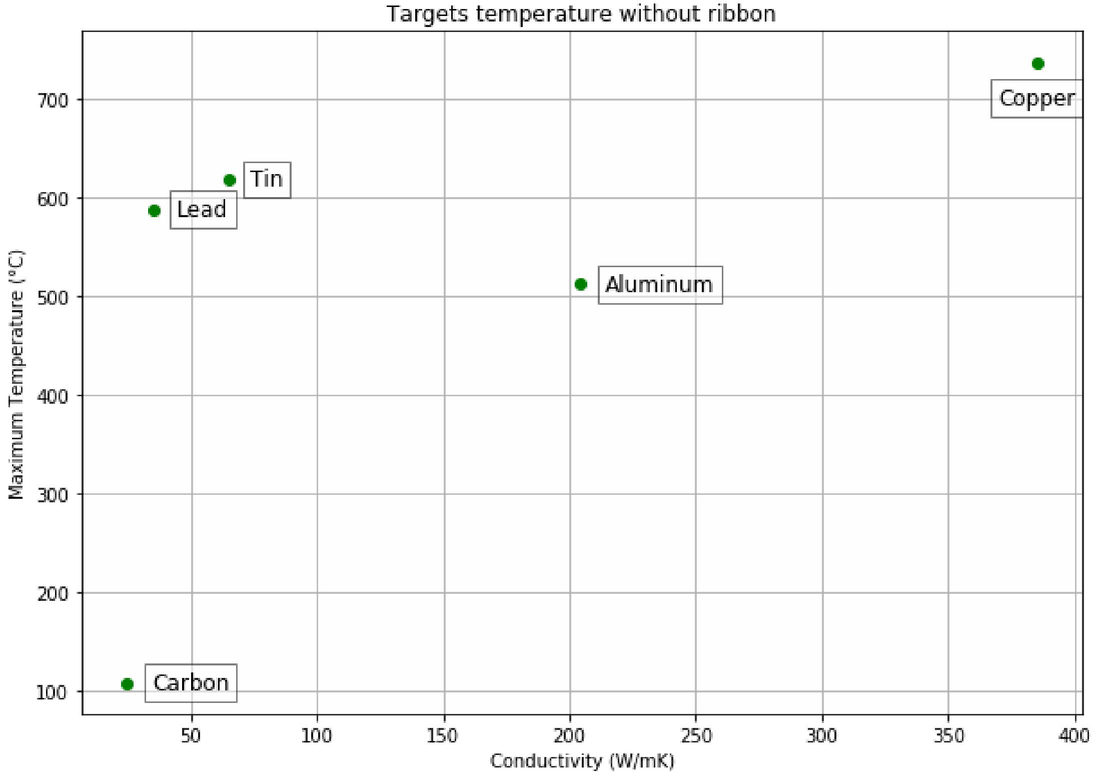


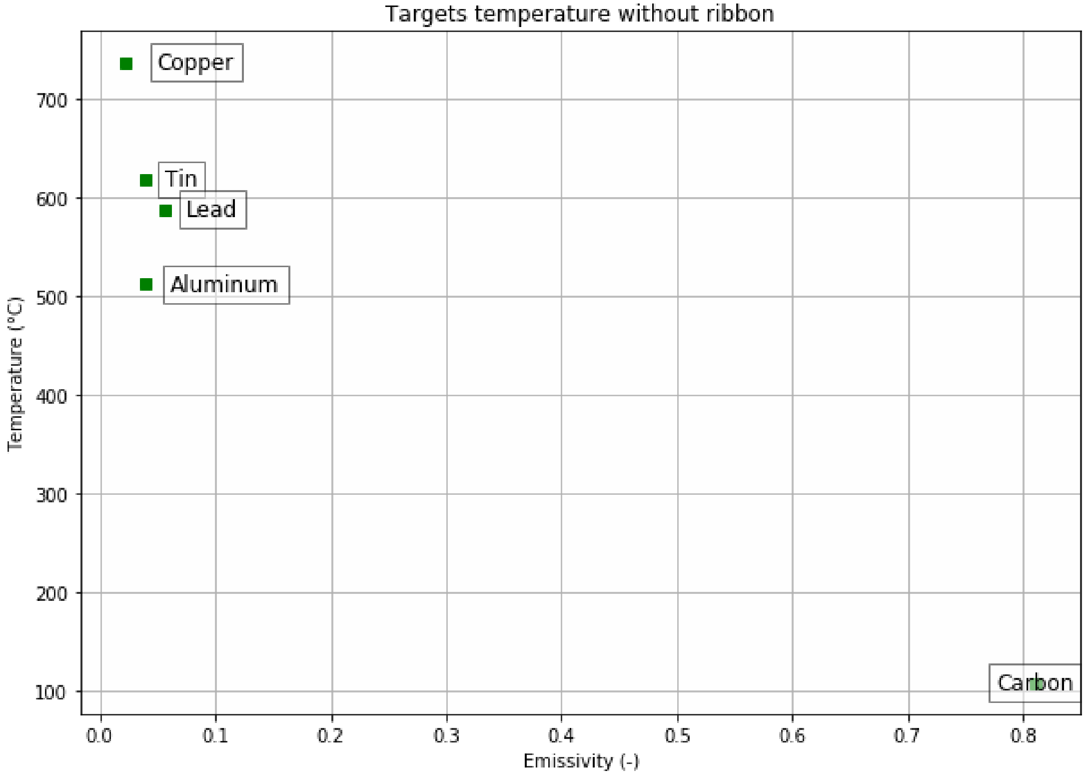
CONDUCTIVE FILM
Material: Copper
Thermal conductivity: 386 [W/mK]
Boundary condition: Radiation

RIBBON
Material: Kapton
Thermal conductivity: 0.12 [W/mK]
Boundary condition: Perfectly Insulated

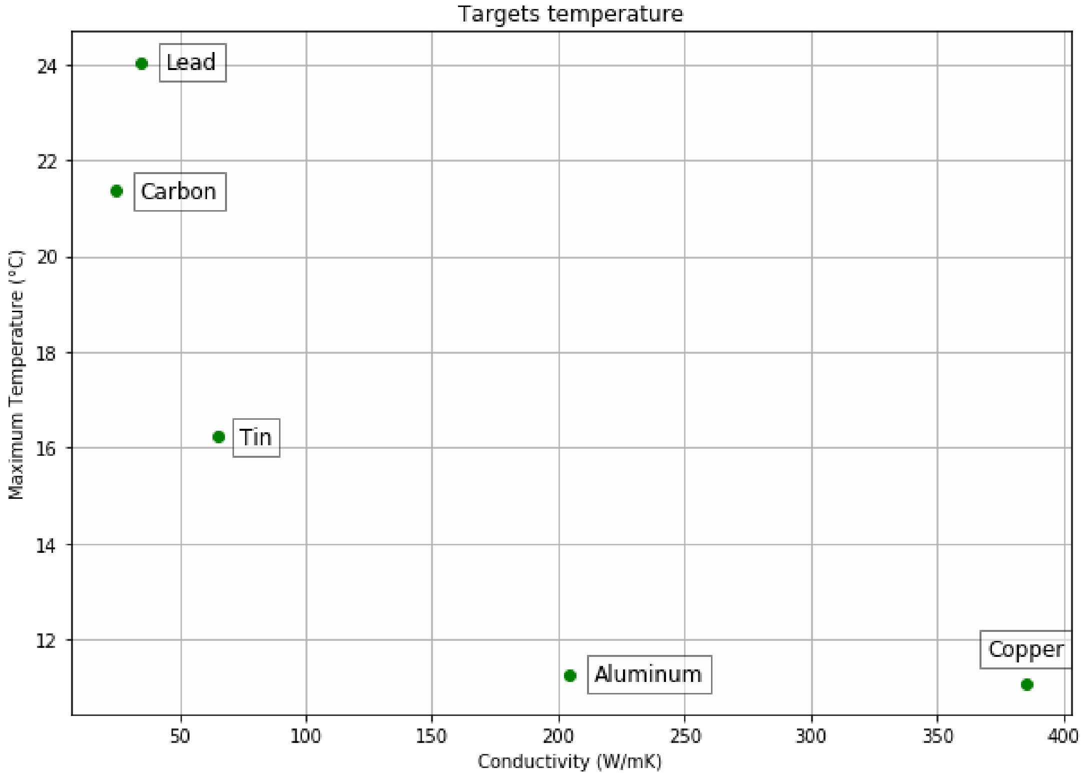
EPOXY ADHESIVE
Material: EP30TC
Thermal conductivity: 2.60 [W/mK]
Boundary condition: Contact

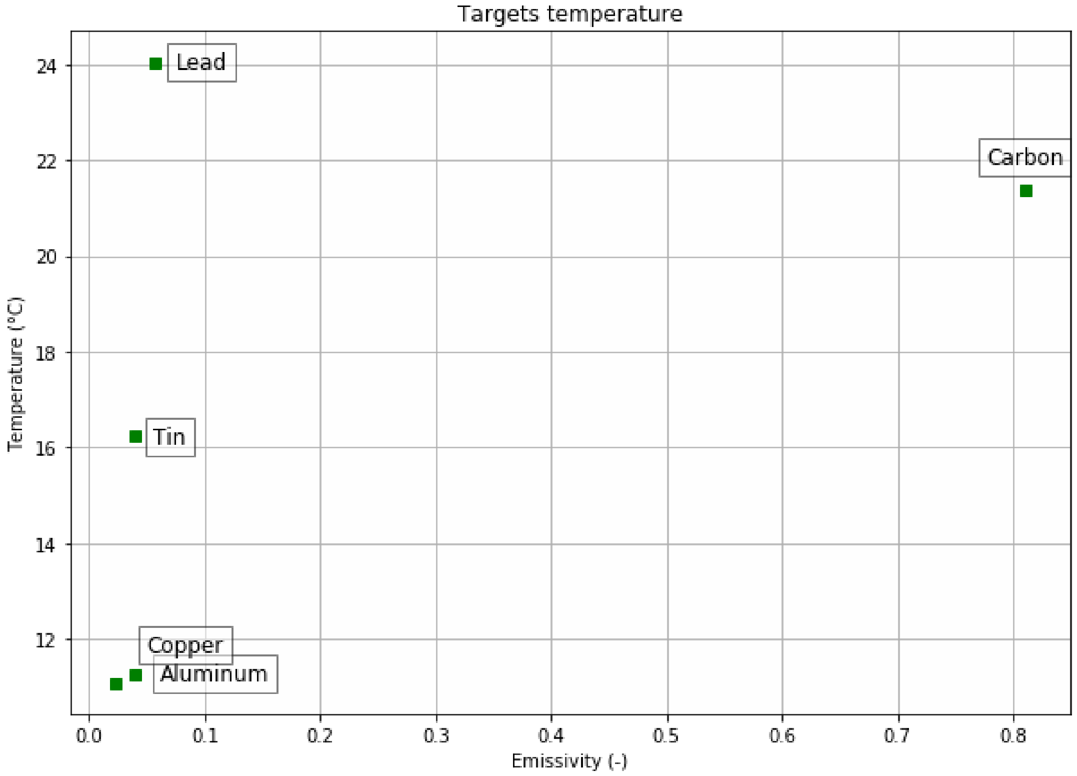
Thermal study – Results without ribbon





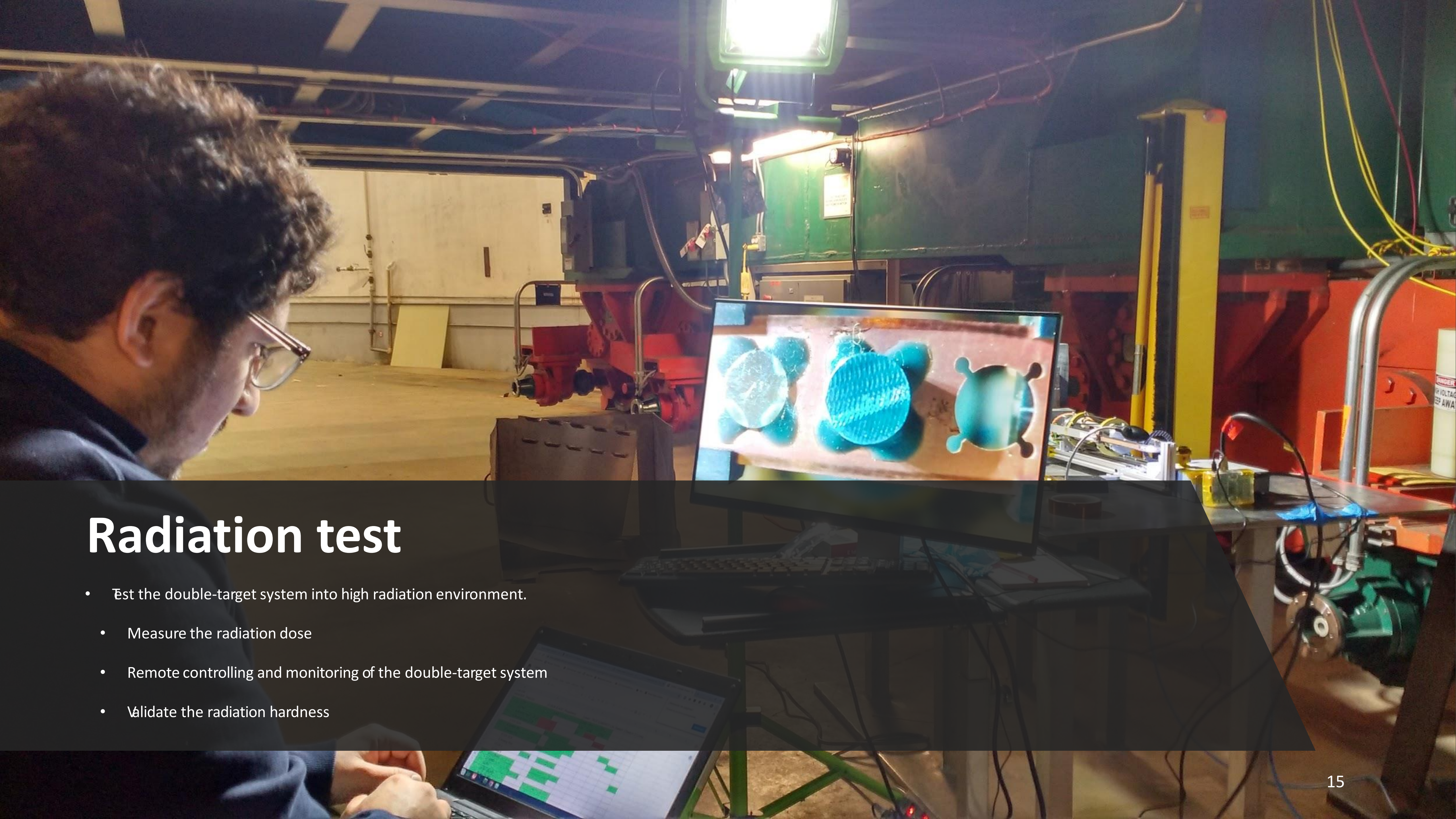
Thermal study – Results with ribbon





Temperature reduction

- Carbon: **80%**
- Aluminum: **98%**
- Copper : **99%**
- Tin: **97%**
- Lead: **96%**



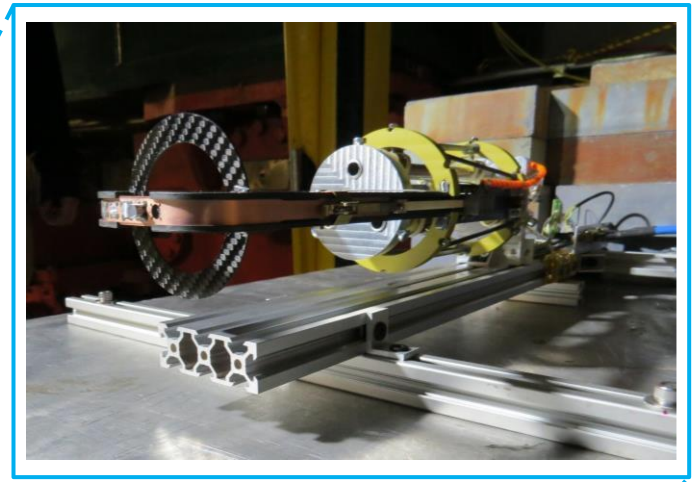
Radiation test

- Test the double-target system into high radiation environment.
  - Measure the radiation dose
  - Remote controlling and monitoring of the double-target system
  - Validate the radiation hardness

Radiation test – Experimental setup

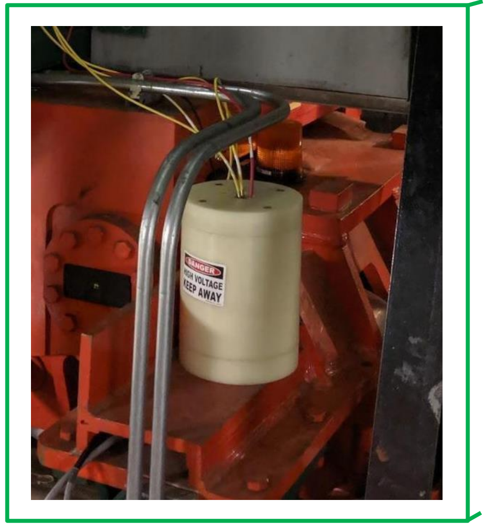
Hall A creates an ideal environment for the test:

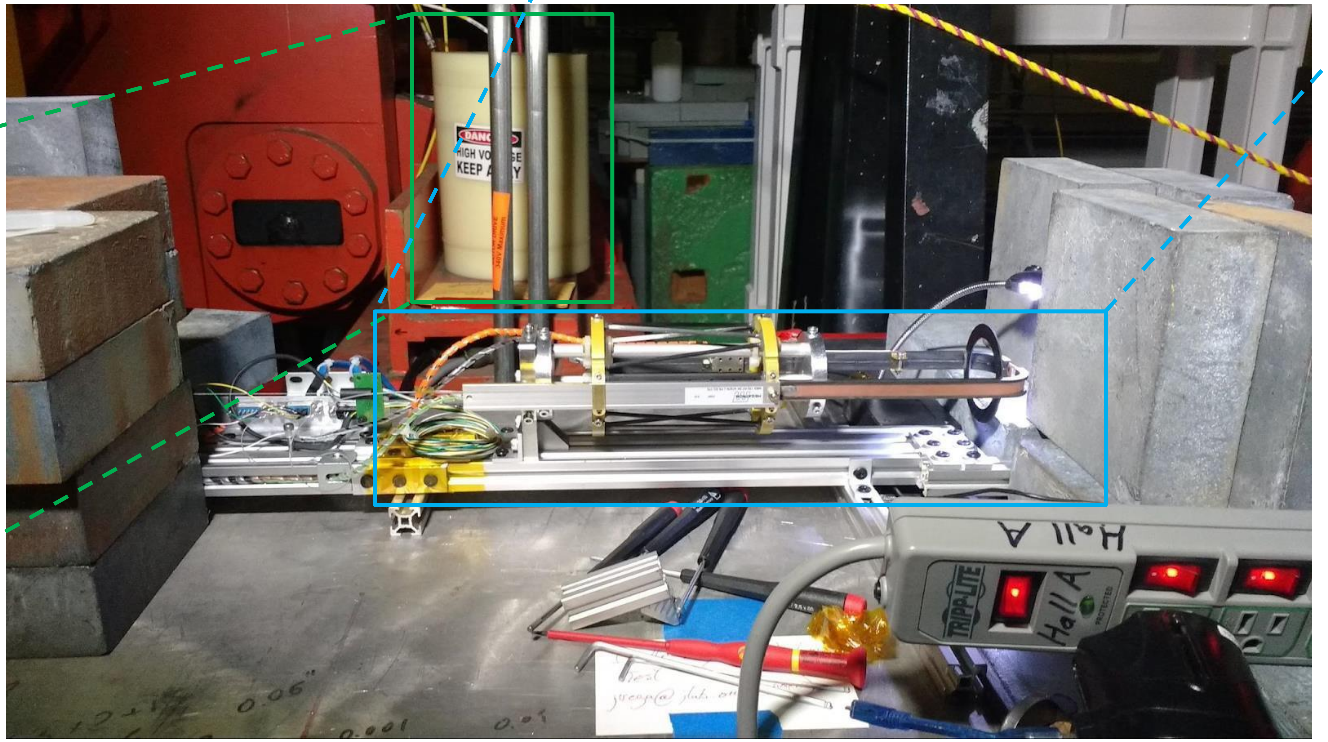
- Accessible **high radiation** areas
- **Monitored** radiation rates



USM target prototype

NDX02

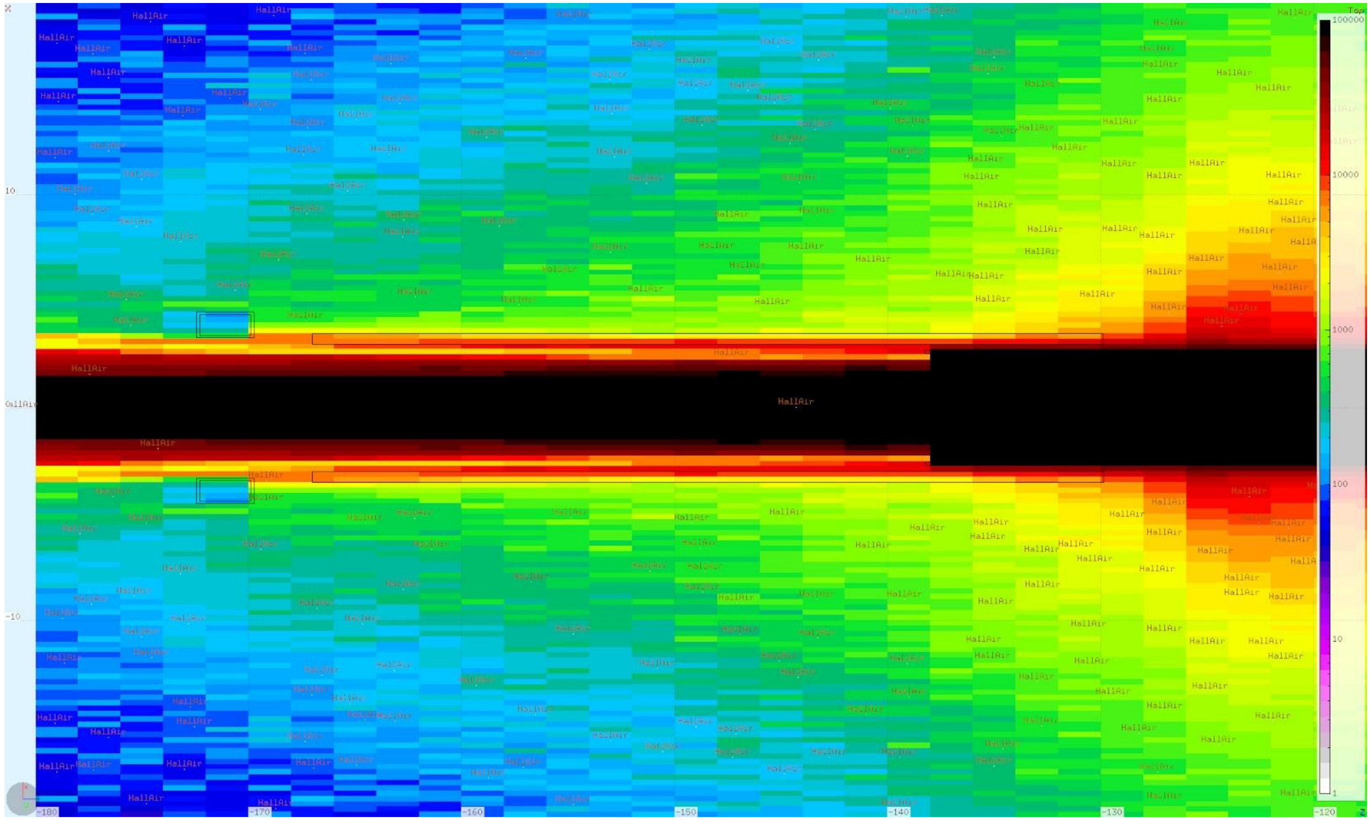




Radiation test – Radiation dose

Simulation of the estimated radiation dose for RG-M experimental time:

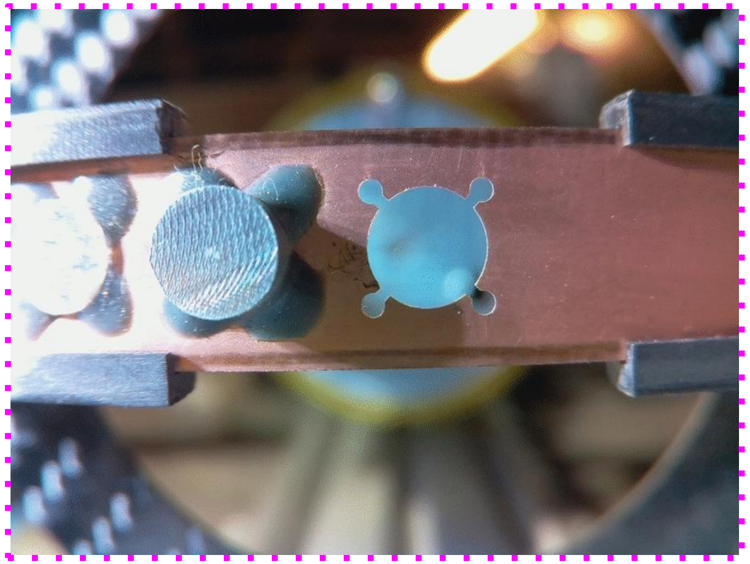
- **Neutron: 3,780 [rem]**
- **Photon: 367 [rem]**
- Proton: 92 [rem]
- Electron: 3,958 [rem]



Color map in [rad] units

Radiation test – Routine

Exchange the targets **each 40 seconds** by moving the ribbon with the motor. When ribbon arrives to the end, it goes back with the same routine, but in the opposite direction.

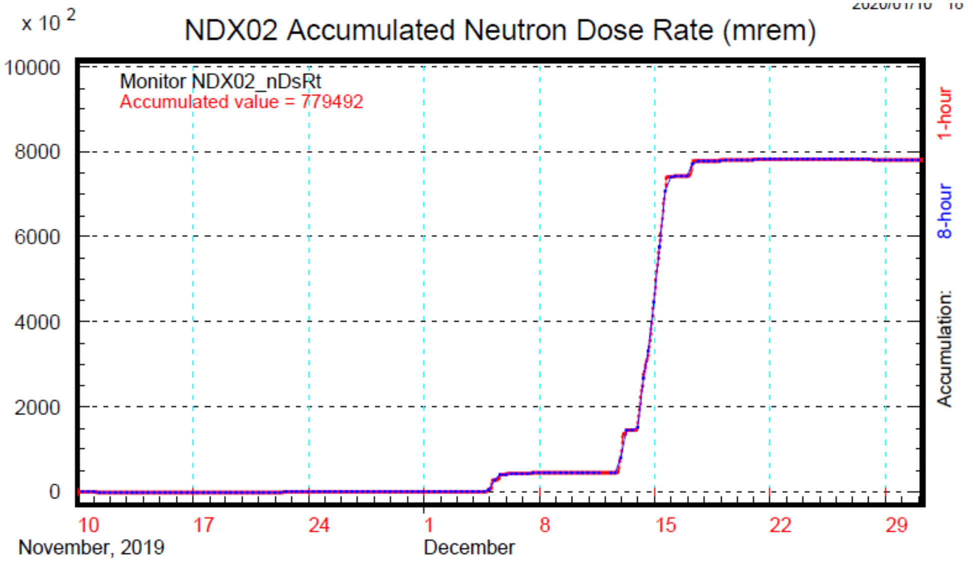


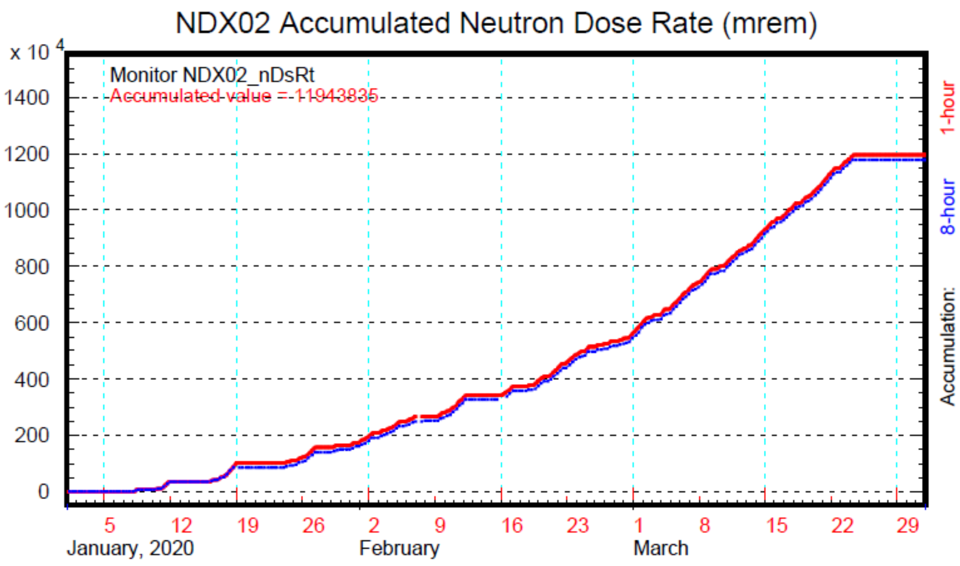
Radiation test - Results

Neutron dose

12,723 [rem]

337%!

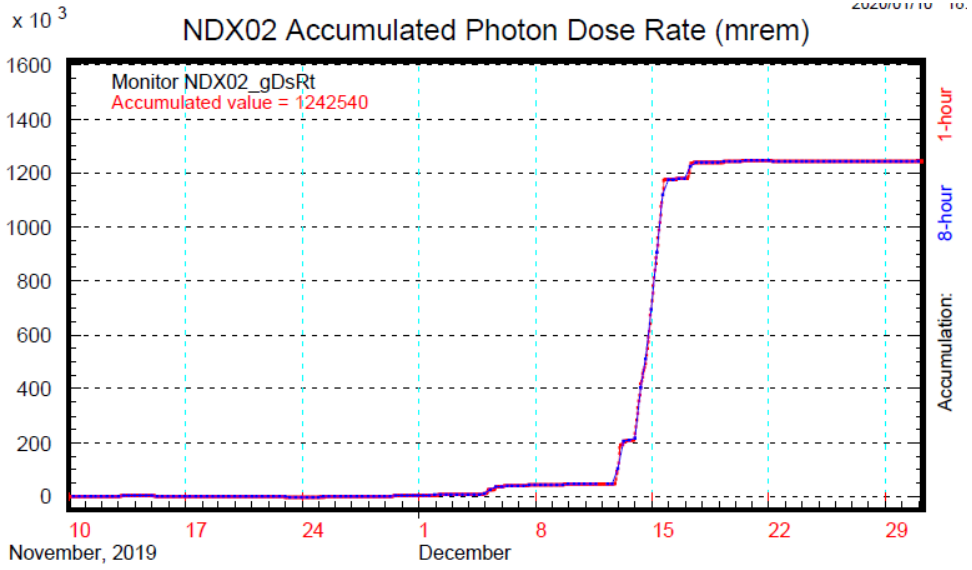


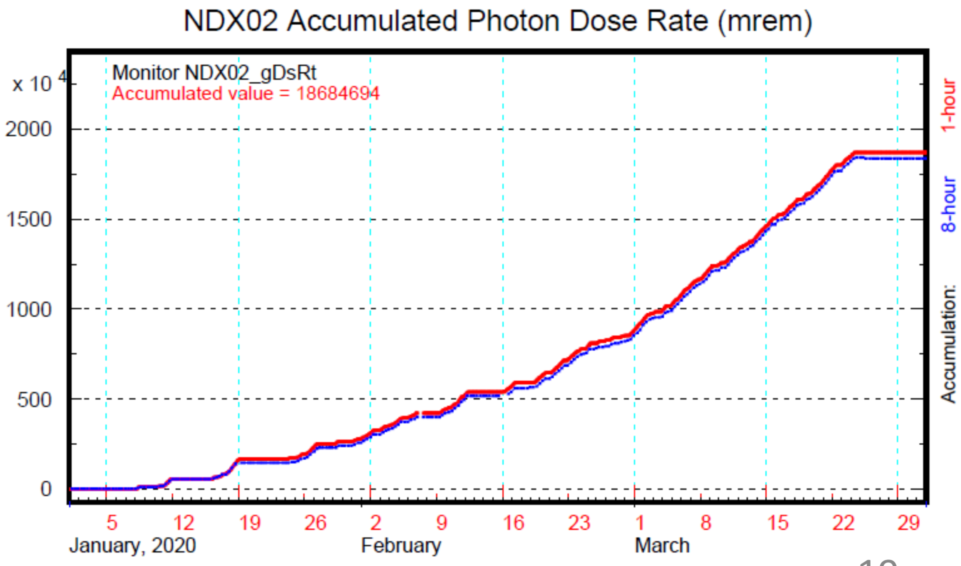


Photon dose

19,927 [rem]

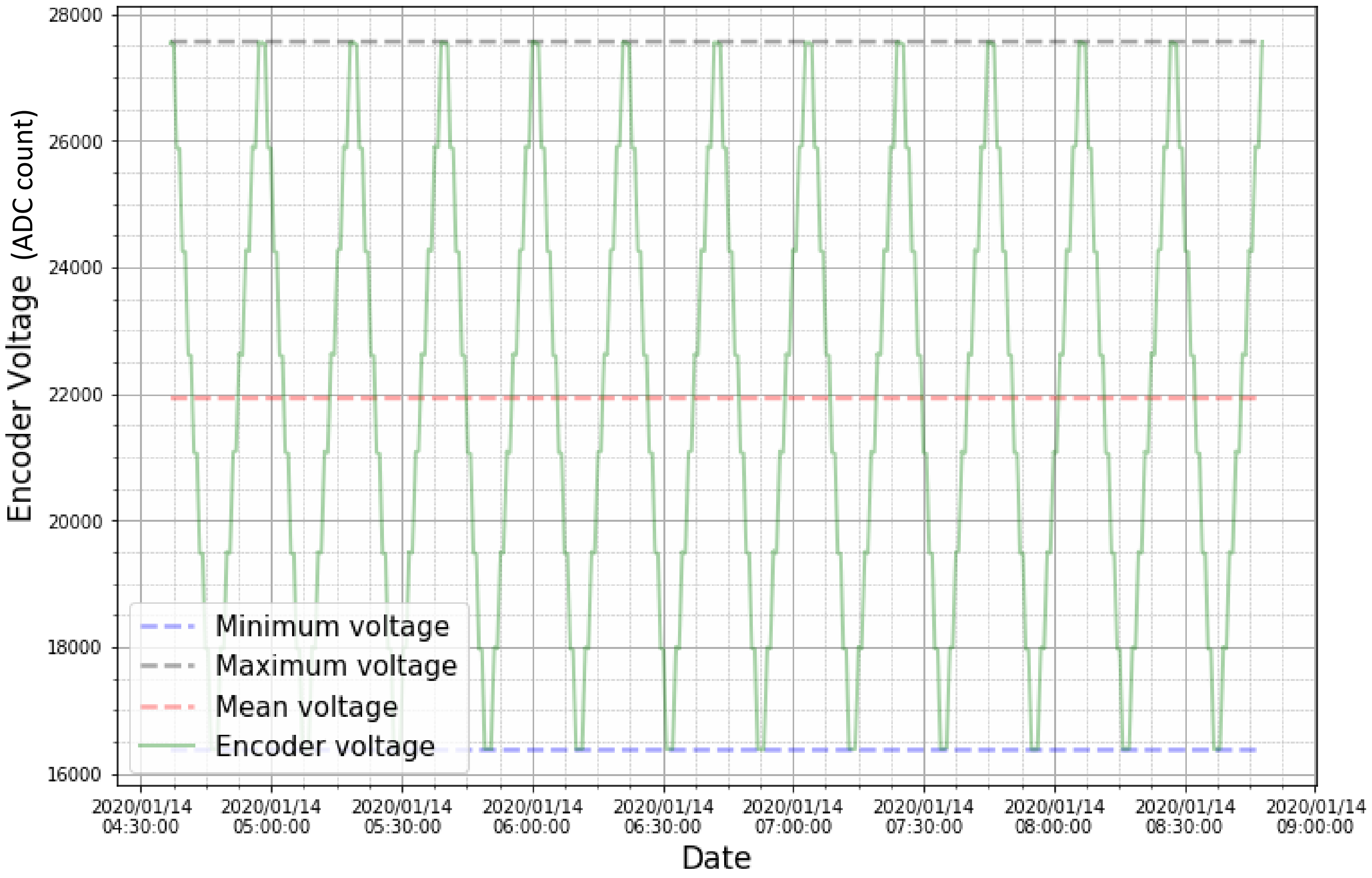
5,432%!





Radiation test - Results

125 days of continuum operation with **no difference** in the encoder voltage routine!



Conclusions

- The **design** proposal is capable to **solve the technical challenges**
- From the thermal simulation It was achieved a **temperature reduction** of more than **95%** for most of the targets
- The **double-target** system was capable to resist 125 days in a high radiation environment achieving **337%** of the estimated **neutron radiation dose**.

Thanks!