



UHV chamber for tritium graphene target

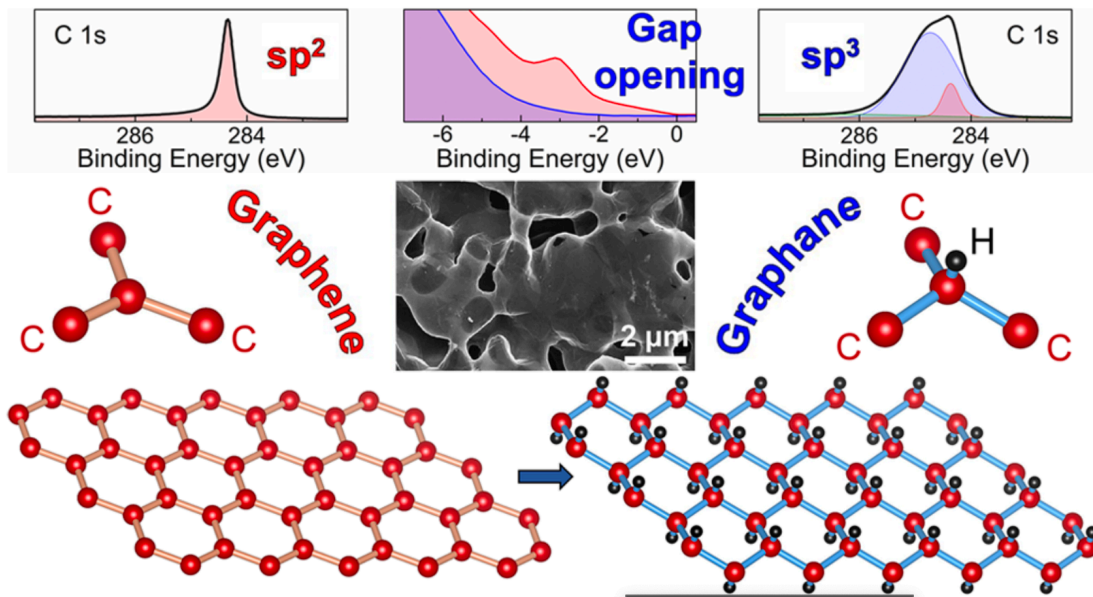
GC, C.Mariani, M.Messina, A.Tan, C.Tully
Ptolemy meeting in Princeton
Nov 2023

Demonstration of graphene hydrogenation

- ▶ Several attempts in the last years
 - ▶ (Cold) plasma, low energy ions, **<0.2 eV atoms**

- ▶ Use thermal cracking in vacuum
- ▶ Nanoporous graphene
- ▶ X-ray spectroscopy to see sp^3 bonds
 - ▶ Energy gap and hydrogen uptake

Gap Opening in Double-Sided Highly Hydrogenated Free-Standing Graphene



Tritium on graphene

Hydrogen and deuterium share the **same chemistry** with tritium
(Still interesting in future do some spectroscopy on graphene-
tritium system)

Port the graphene hydrogenation technique
to **tritium storage on graphene**
(and other carbon nanostructure in future)

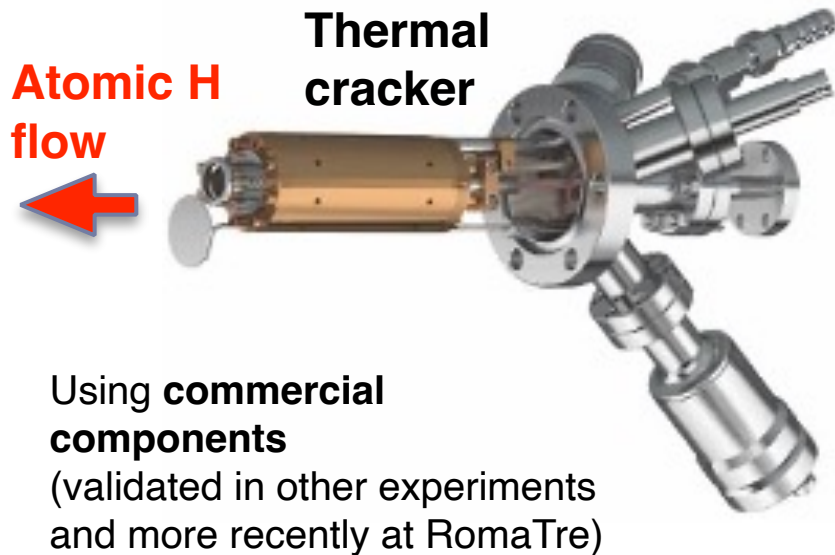
Start with **NPG** since self-standing and
proved to allow large uptake

Goals

- ▶ Have a **< 1 GBq solid atomic tritium** target
 - ▶ Less troubles with radio safety regulations
- ▶ Use carbon nanostructure as support
 - ▶ Well defined **position** in the apparatus, well defined **potential**
- ▶ Demonstrate the solid target is **stable** (i.e. no tritium release in air) at **room temperature**
 - ▶ To be certified according to radio-protection standards
- ▶ **Measure**
 - ▶ Radioactivity **activity**
 - ▶ band gap, resistivity
- ▶ First **beta spectrum** measurement
 - ▶ With solid state sensors ? relatively poor energy resolution ~ 100 eV
 - ▶ With electron analyser ? With retarding potential to select the end point of the spectrum

Plans for graphene target production

- ▶ Based on the work of C.Mariani et al. on NPG hydrogenation
 - ▶ Use **thermal cracking** (2400 K) of hydrogen molecule
 - ▶ Atomic thermal hydrogen flowing onto the sample



Funded by Princeton University



Being **commissioned** in Roma

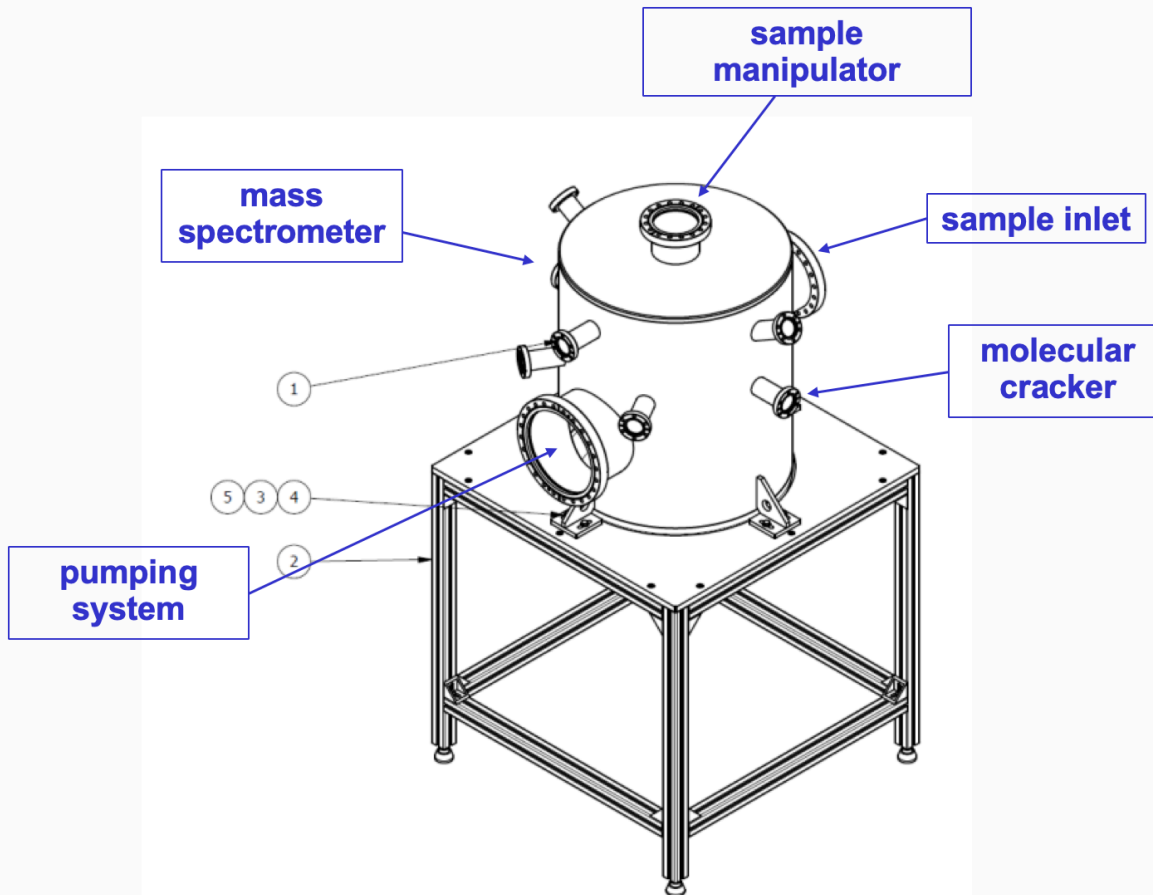


Shipped to US (Princeton and then **SRNL**)



Back to Italy for radio-safety and beta spectrum measurements

UHV chamber



Custom UHV chamber

Designed in collaboration to with SAER_RIAL (Parma, IT)

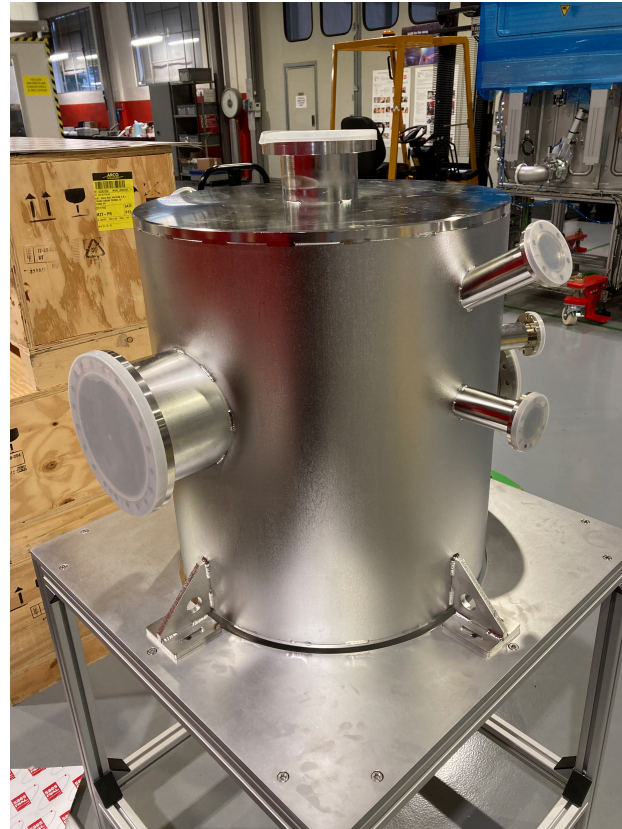
To be **shipped** to next week to Roma

Other parts being procured separately

UHV custom chamber ready



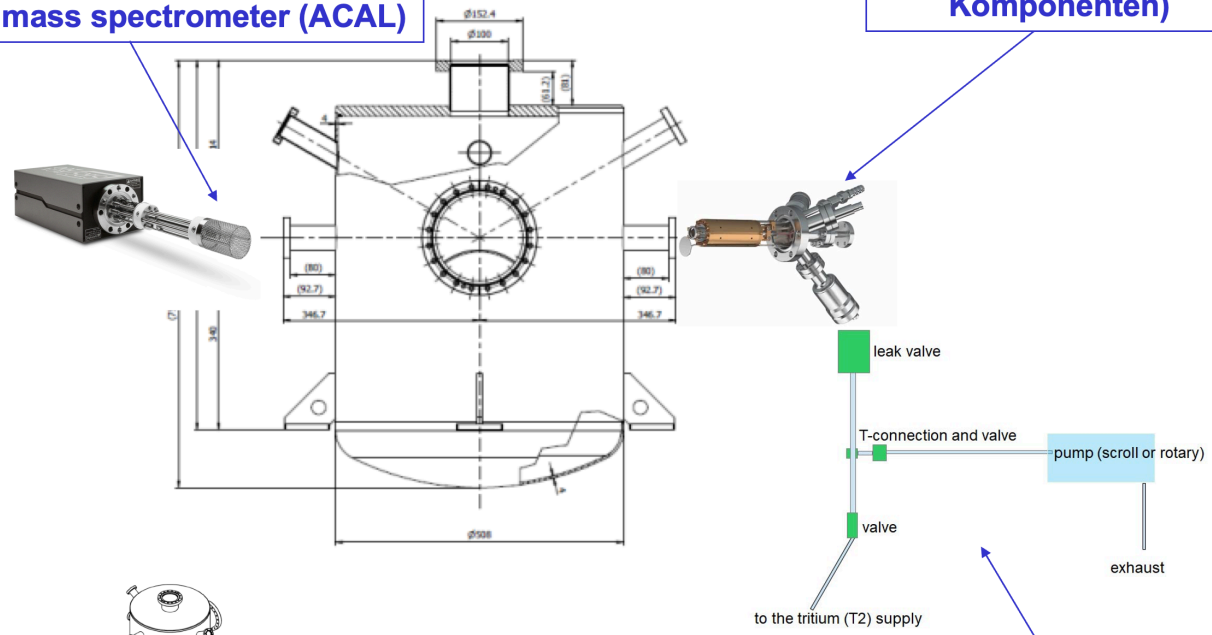
UHV custom chamber ready 2



Components of the chamber

0-100 a.m.u. quadrupole mass spectrometer (ACAL)

thermal (up to 2400 K) molecular cracker (MBE Komponenten)



► Pump system at LNGS



► Being moved to Roma

Parts produced

- ▶ Delivered to Roma Sapienza



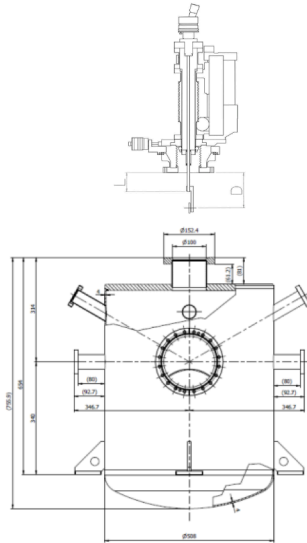
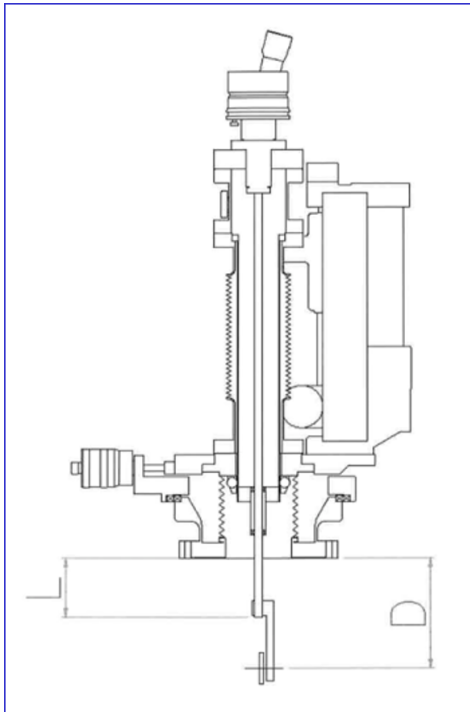
Therma cracker



Mass spectrometer



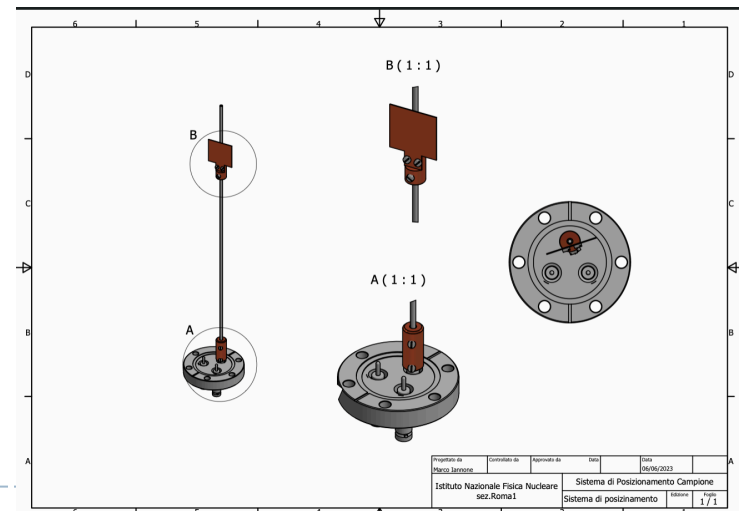
Manipulator for the samples



▶ VG HPT

- ▶ X - Y range ± 1.25 cm
- ▶ Z range ± 5.0 cm
- ▶ Heating system with e-bombardment (1300 K for sample annealing)
- ▶ Standard sample holder

- ▶ Long procurement time (end of Feb)
- ▶ Currently a **static holder** has been designed and built in Roma INFN (with a heating system)



Schedule

- ▶ Serious delays due to procurements (availability of companies, stainless steel markets, ...)
- ▶ Brand new lab equipped in Sapienza-INFN for flammable gases, available for testing the chamber (since **Sep 2023**)
- ▶ Without waiting the manipulator, we will do a **commissioning** using NPG substrates with **hydrogen starting Dec 2023**
 - ▶ Some standard test (XPS) in our lab's in Roma
- ▶ Ship everything by **Apr 2024** to Princeton.

ENEA INMRI collaboration



- ▶ Sapienza-ENEA **framework agreement** already in place, a specific memorandum being prepared (to be approved by early 2024)
 - ▶ Next year (starting mid 2024) they can
 - ▶ measure the **activity**
 - ▶ Very standard techniques, important for us to understand the **actual deposited mass of tritium**
 - ▶ demonstrate the tritiated graphene is not releasing tritium
 - ▶ Again using commercial tritium sensors
 - ▶ Possible extension of the collaboration to the use of **TES** for **metrology** of beta spectra
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Conclusion

- ▶ A general goal for the collaboration is to have a atomic **tritium sample** at our disposal
 - ▶ This would enable us to do **measurement of the beta** spectrum in different forms (albeit preliminary)
- ▶ Goal is to have a sample that can be easily handled
- ▶ Project of having a UHV chamber is **now at a critical point**
 - ▶ Slow, due to difficulties in parts procurement
 - ▶ Now parts are almost all at Sapienza
- ▶ We will start with **NPG as a first substrate** but in future we will also do planar graphene and CNT
 - ▶ Planar graphene and CNT hydrogenation being studies at RomaTre and Sapienza

**Assuming a mass density of NPG \sim 1/100 graphite with 100% T uptake
15 μ g tritium can be stored in NPG flake equivalent to 4 GBq activity**

Parts procurement schedule

		<i>Delivery (in Roma)</i>
Chamber	Completed	Nov 16th 2023
Manipulator	Ordered	End of Feb 2024
H-cracker		Sep 2023
Mass spectrometer		Sep 2023
Chiller	To be ordered	Dec 2023 (we can start without it)
Gas lines	To be installed	Nov 2023
Pumping system	In LNGS	Nov 2023
Static holding support	Completed	Oct 2023