

Tritiated graphene - stability

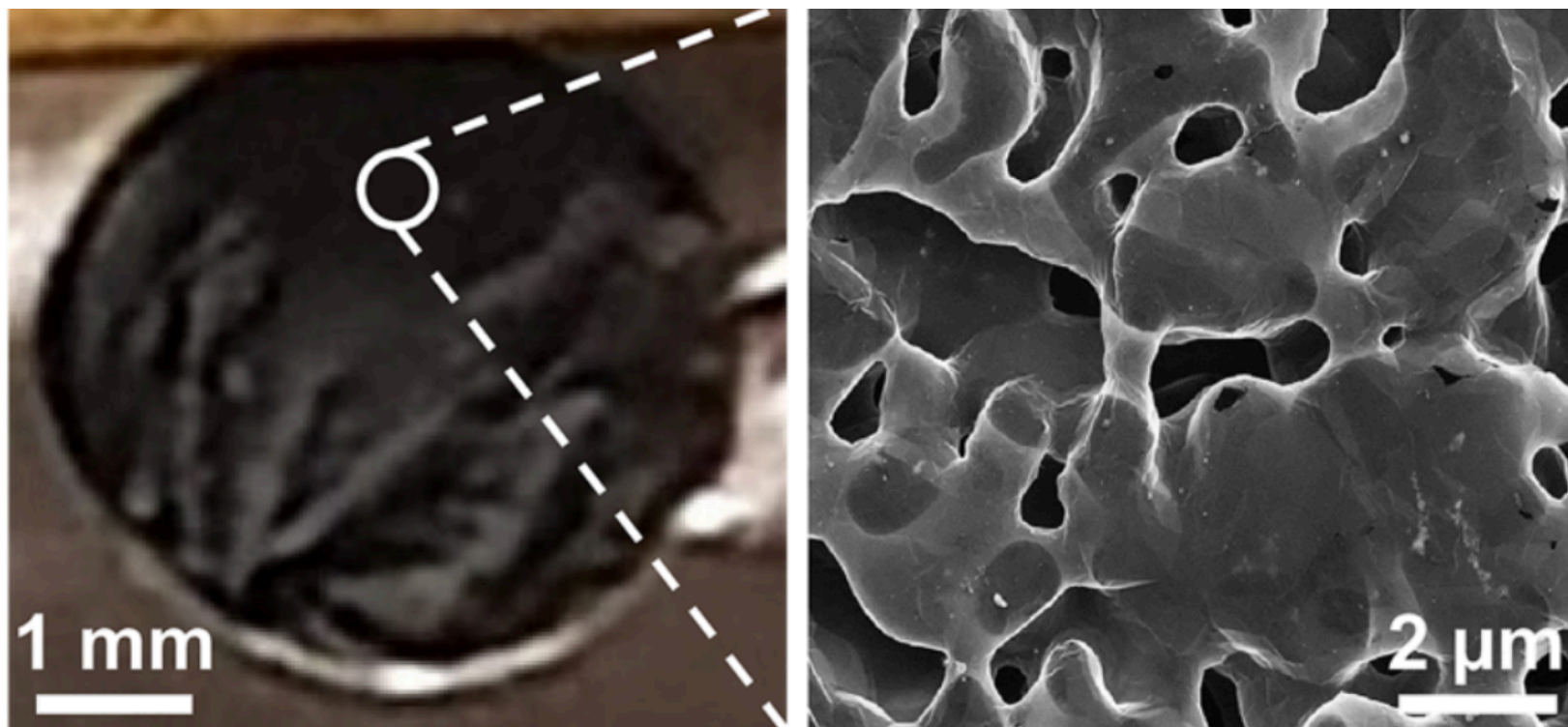
Gianluca Cavoto - Sapienza Univ and INFN Roma

6 nov 2022

Ptolemy Coll meeting - Amsterdam

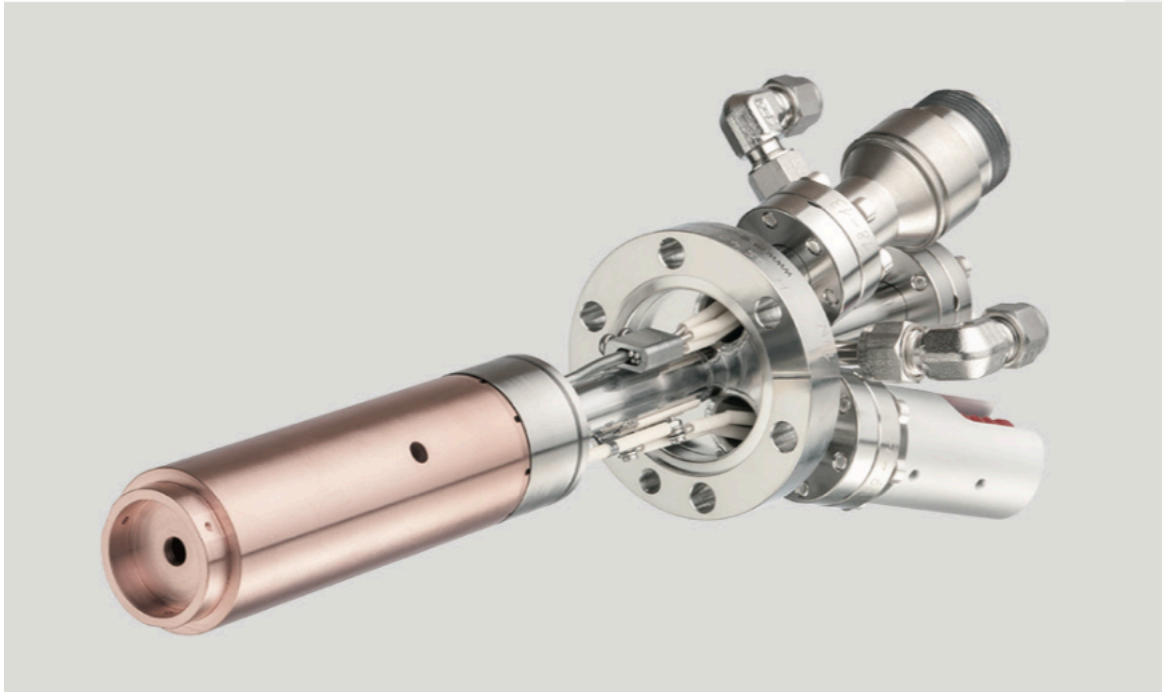
Nanoporous graphene (NPG)

- ▶ We have successfully tested various techniques to “*implant*” hydrogen (deuterium) to **Nano-Porous Graphene**
- ▶ See tomorrow’s C.Mariani talk. [Nano Lett. 2022, 22, 7, 2971–2977](#)

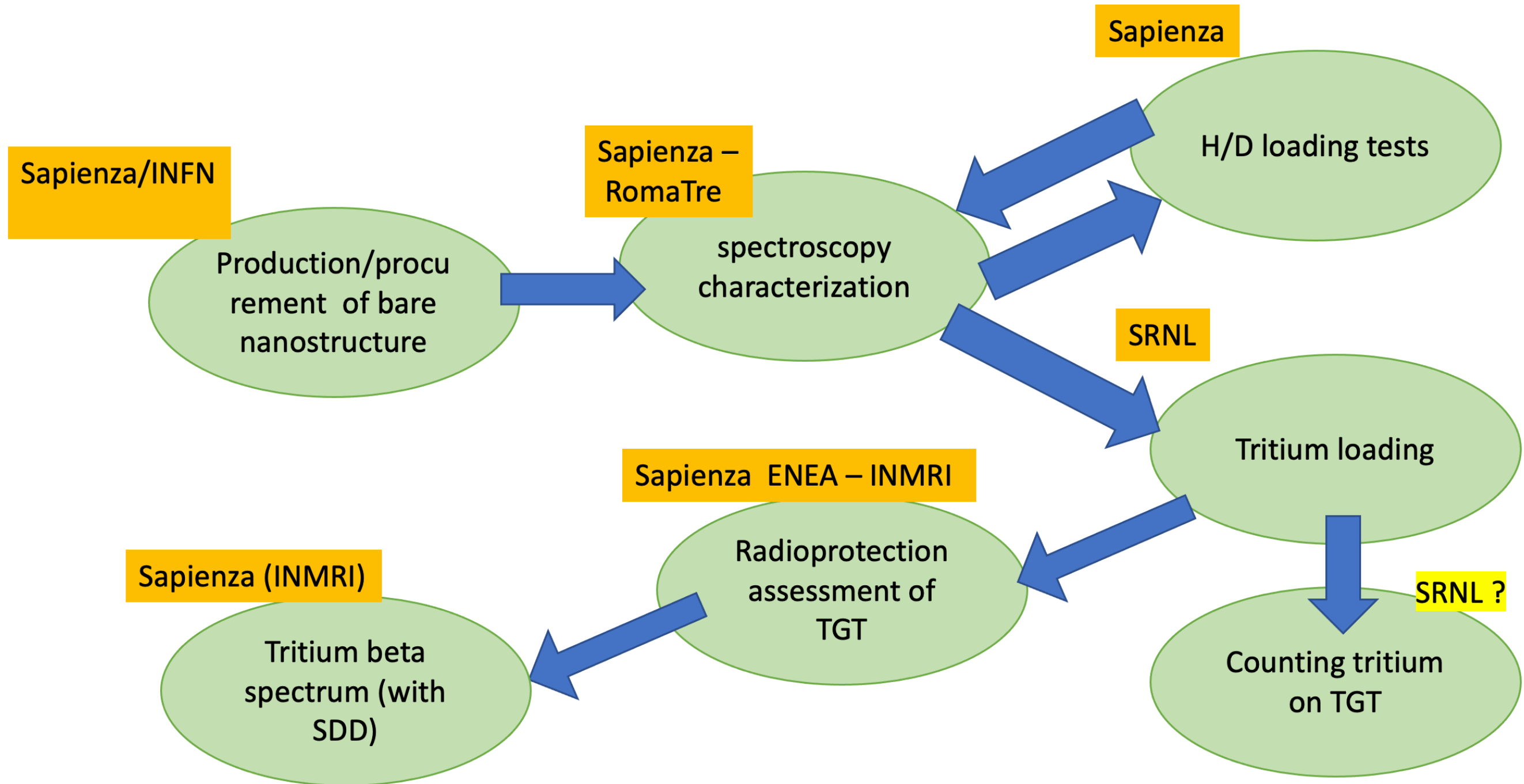


- ▶ Hydrogen chemi-sorbed on NPG
(NPG provided by Tsukuba Univ.)

NPG hydrogenation

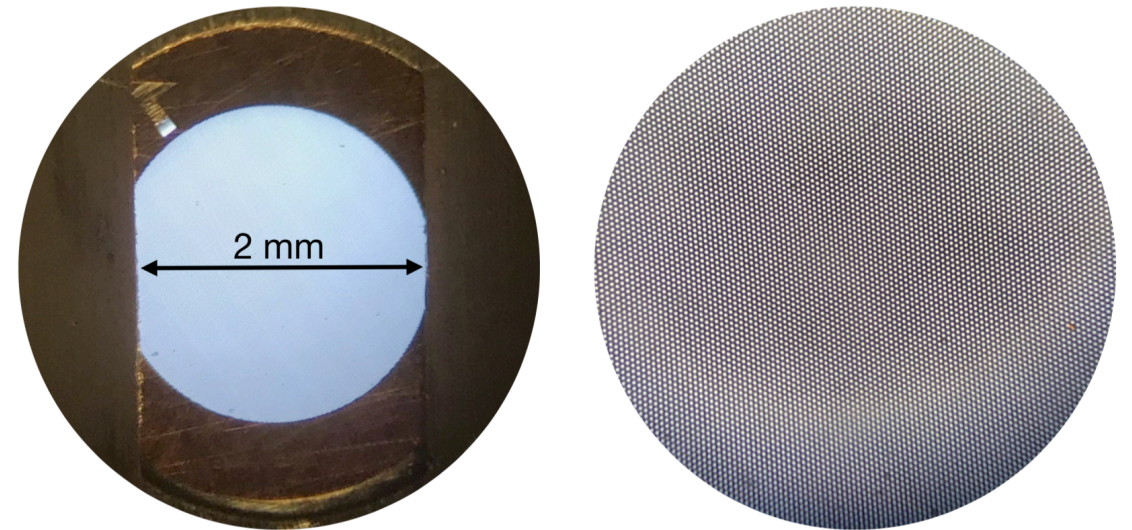
- ▶ Best choice:
 - ▶ High quality NPG (many convexity points)
 - ▶ In UHV
 - ▶ Hydrogen thermally cracked (2100 °C)
 - ▶ Capillary source of **atomic H**
 - ▶ Done at Roma Sapienza and at SOLEIL (Antares)
 - ▶ >90% coverage (*graphane*) obtained
 - ▶ Tungsten capillary
 - ▶ Atomic H flux $10^{16} \text{ cm}^{-2} \text{ s}^{-1}$
 - ▶ 80-99% atomic flux
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- ▶ Willing to port this technique to a **tritium lab** (Savannah River Nat. Lab)

Ptolemy target TGT



Tritium loading

- ▶ **Different carbon nanostructure**
 - ▶ Single layer graphene on TEM-grid (see Apponi's talk)
 - ▶ NPG
 - ▶ Aligned Carbon nanotubes (see Rago's talk)
- ▶ Need to **demonstrate the tritium-loaded graphene is radio-safe**
 - ▶ *Administrative*: can handle TGT as a **solid** source (can be easily moved, no tritium recycling installations, no special license)
 - ▶ *Substantial*: do not want to contaminate instruments (vacuum)



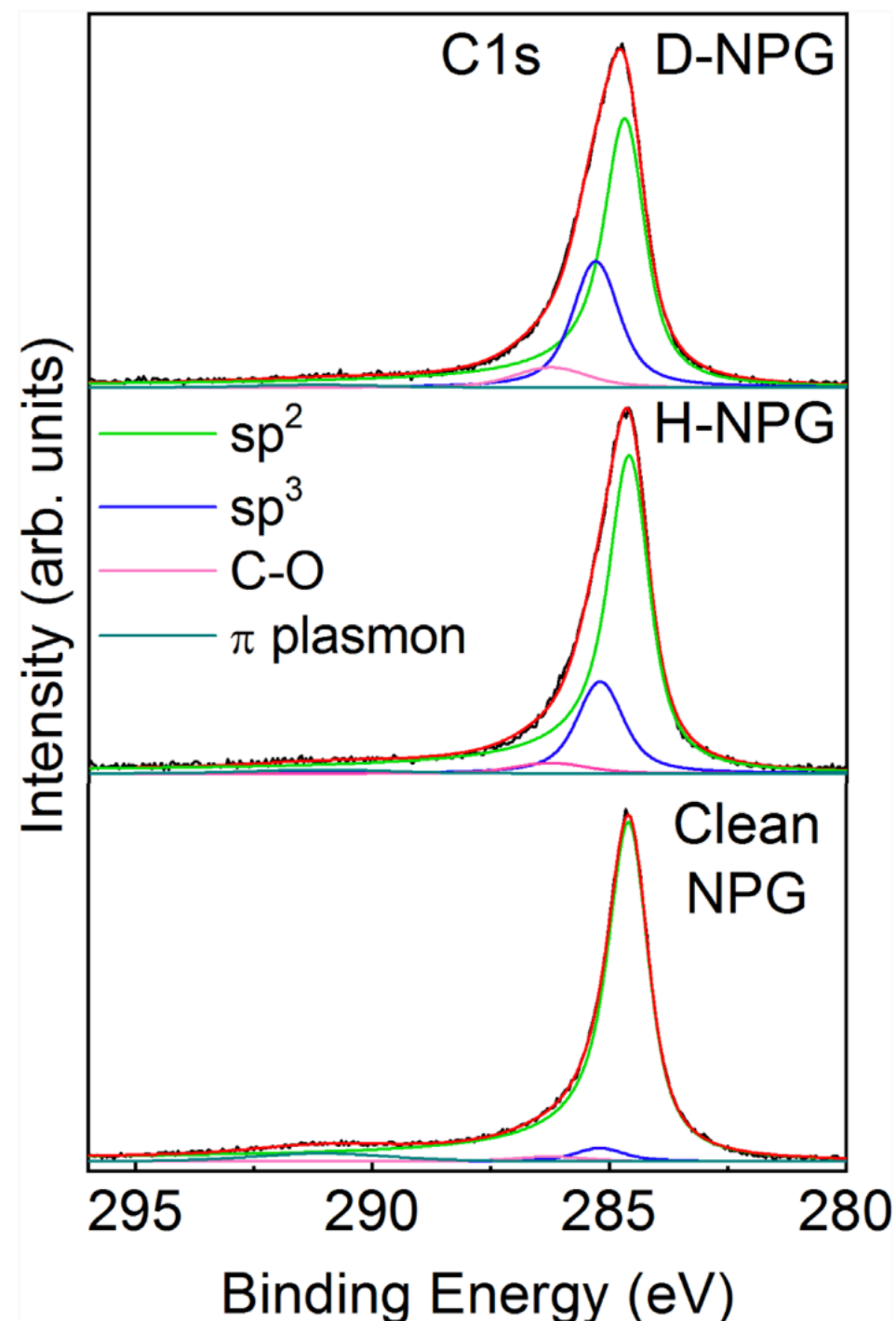
Limits

- ▶ Legal limit to hold a T source is **1 GBq**
 - ▶ Above this limit need a real tritium lab.
- ▶ For an ideally fully loaded sample:
 - ▶ 10 cm² planar graphene : ~0.5 GBq (2 µg)
 - ▶ 1 NPG sample (5x5x0.1mm²): 36.5 GBq (140 µg)
 - ▶ 1 graphene on TEM grid : 4 MBq
- ▶ Need to start with a lower activity: **0.1-10 MBq**

**Collaboration being formally setup with ENEA INMRI
(NATIONAL INSTITUTE OF IONIZING RADIATION METROLOGY)
M.Capogni and M.Capone**

Test of thermal stability

Mahmoud Mohamed Saad Abdelnabi et al 2021 Nanotechnology 32 035707

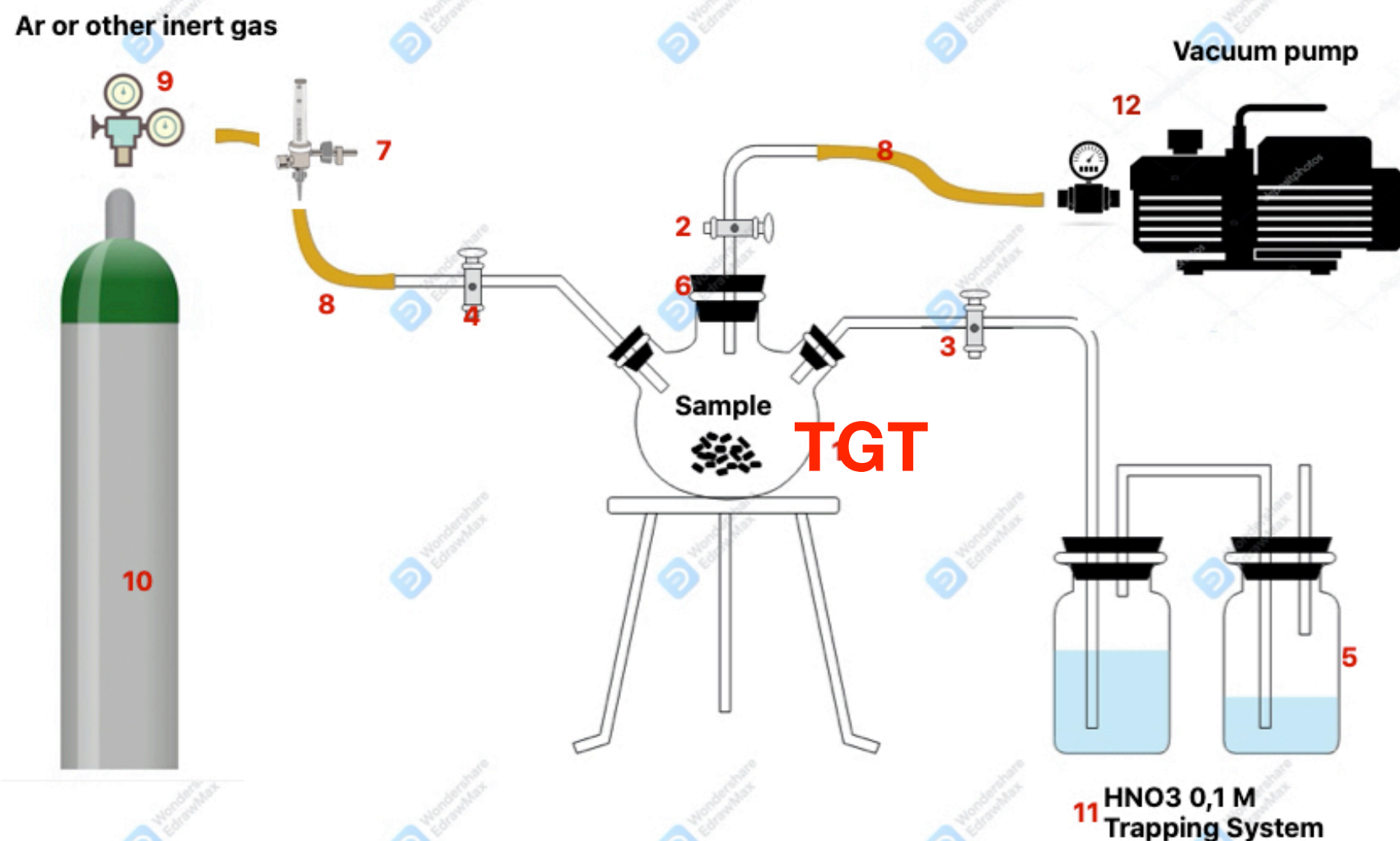


- ▶ Test of hydrogenation and deuteration done in UHV
- ▶ Fraction of sp^3 in $C1s$ line (coordination of a H/D atom with C)
- ▶ **Starts to disappear at 800 K**
- ▶ **totally removed > 920 K**

Radiochemical TGT at ENEA

M.Capogni, M.Capone

Schema apparecchiatura per desorbimento H-3 da matrice carboniosa

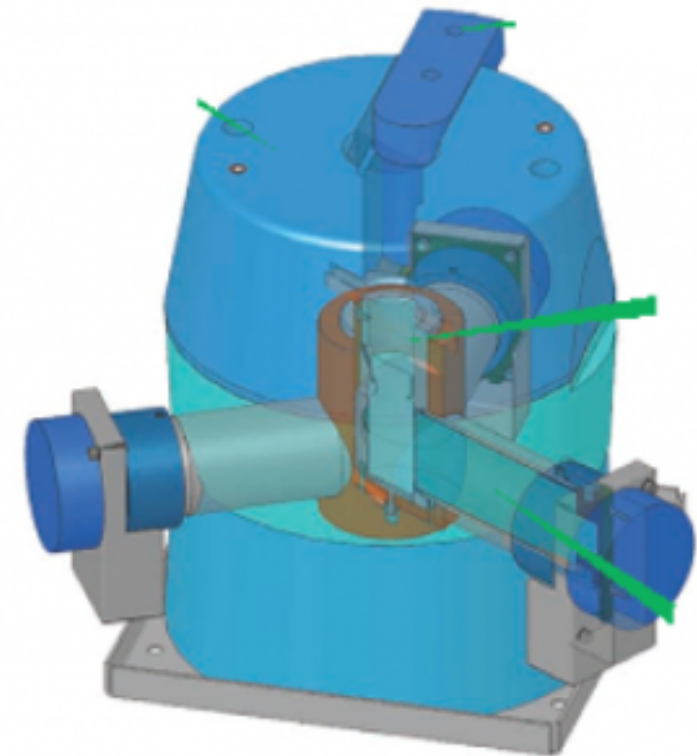


TGT in vacuum (scroll pump only) at room temperature
Count T by trapping it in a nitric acid solution

Detection of desorbed tritium

M.Capogni, M.Capone

- ▶ If T detaches from NPG can be trapped in the HNO_3 solution
 - ▶ Ar (or N_2) flow takes the T to the solution
- ▶ Solution is then analysed by mixing it with a liquid scintillator
- ▶ TDCR technique to detect tritium beta decay
 - ▶ Can have 1 Hz background count, **100 Bq sensitivity** easily possible.



Capogni M., Anthoe A., *Construction and implementation of a TDCR system at ENEA*, Appl. Radiat. Isot. 87 (2014), 260-264, DOI: [10.1016/j.apradiso.2013.11.014](https://doi.org/10.1016/j.apradiso.2013.11.014)

- ▶ INFN CNS5 **financed** the radiochemical setup
 - ▶ Parts being purchased now.
 - ▶ Agreement between ENEA and INFN/Sapienza being signed.
 - ▶ Ready for a first measurement in early 2023.
 - ▶ NPG sample to be **shipped** to US.
 - ▶ Hot capillary system **being setup** at SRNL
 - ▶ Shipping details of TGT to Italy to be sorted out
 - ▶ Might be expensive
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Next

- ▶ We should aim at measuring the **beta spectrum** with a lower resolution detector
- ▶ Understand how to deal with the TGT in vacuum
- ▶ One possibility is using **SSD** (150 eV resolution)
- ▶ Other detectors might do the job