T-chamber at AGHS for Ptolemy

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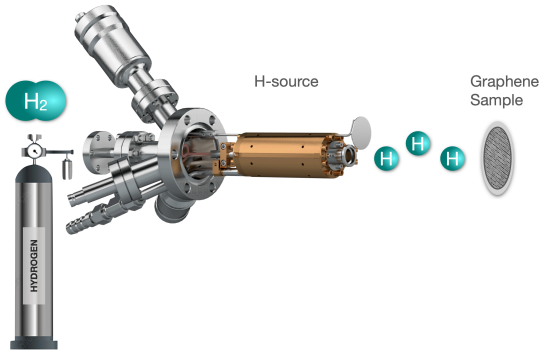
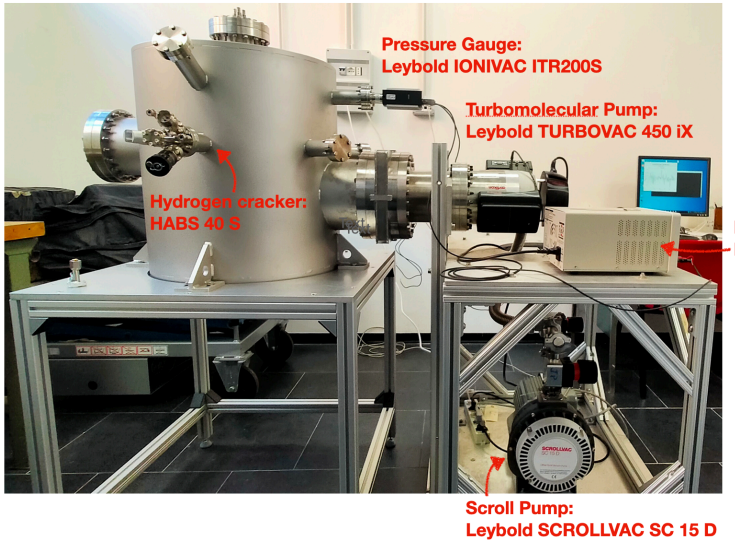
19th Feb 2025

Solid atomic tritium target

M.G.Betti et al. Nano Lett. 2022, 22, 7, 2971–2977

- Exploit expertise in graphene hydrogenation
  - *thermal H_2 cracking*
- **Atomic tritium *chemisorbed* on graphene monolayer**
  - Well defined electric potential, stable at room T in vacuum.
- Contact with UKAEA's Active Gas Handling System (tritium for JET, EU Tokamak) for a **feasibility study for reaction chamber project**
- First contacts promising

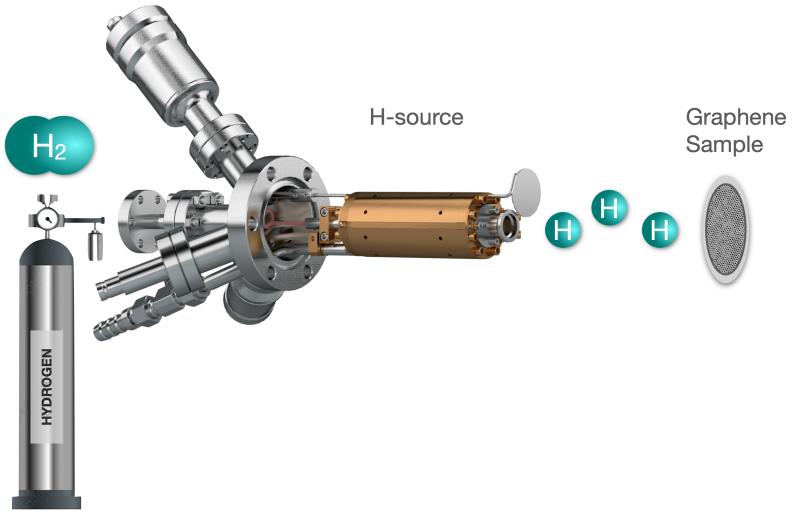




Concept for graphene target production

- Use **thermal cracking** (2400 K) of hydrogen molecule
  - Atomic thermal hydrogen flowing onto the sample with a thermal kinetic energy

Atomic Hydrogen source
Hot tungsten capillary



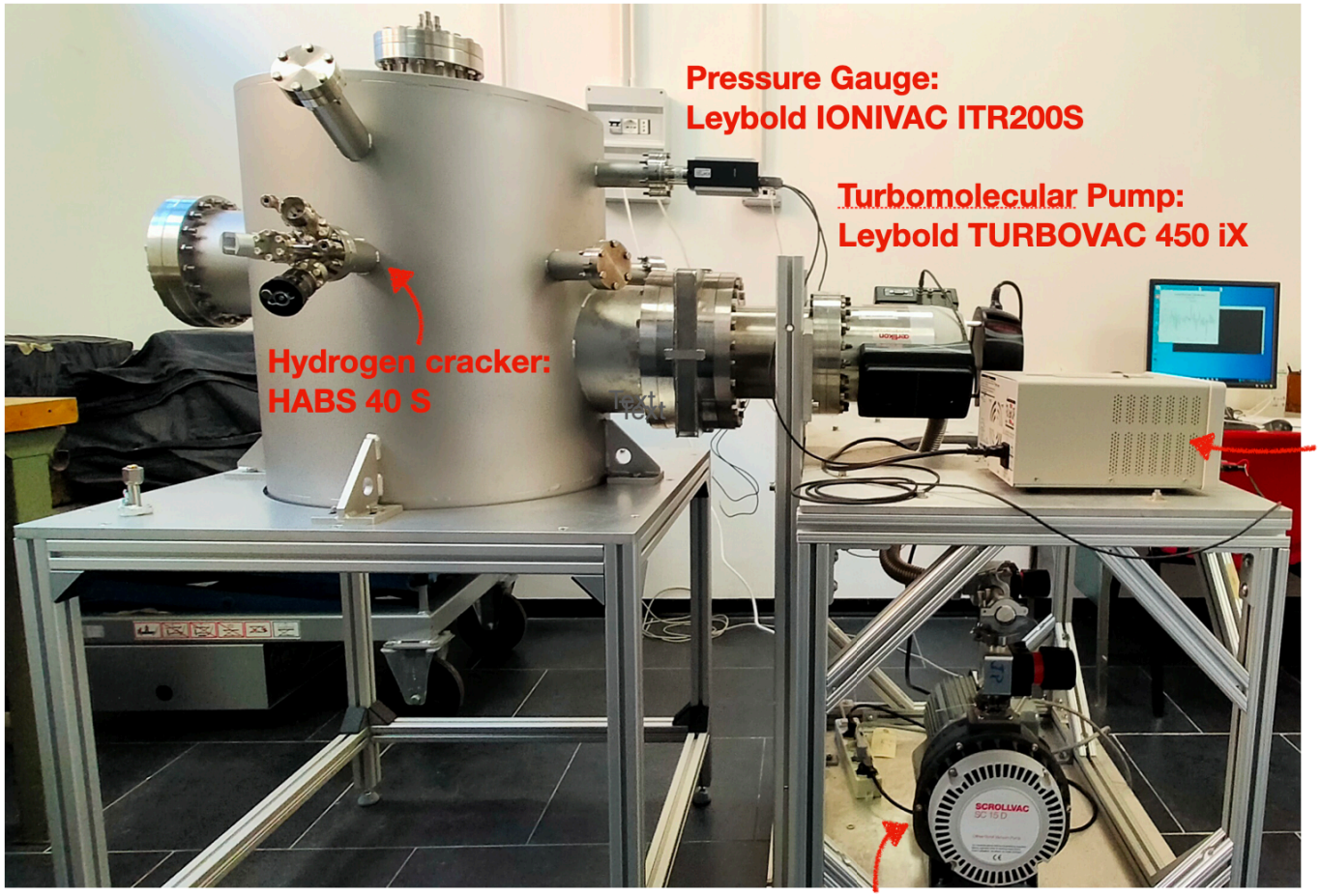
Mass Spectrometer
In order to measure H_2 flux
And to control possible contaminations

pressure goal: 10^{-10} - 10^{-9} mbar

Using **commercial components** (reproduced in several experiments now in Roma and RomaTre)

T-chamber at Sapienza

Financed by Princeton U



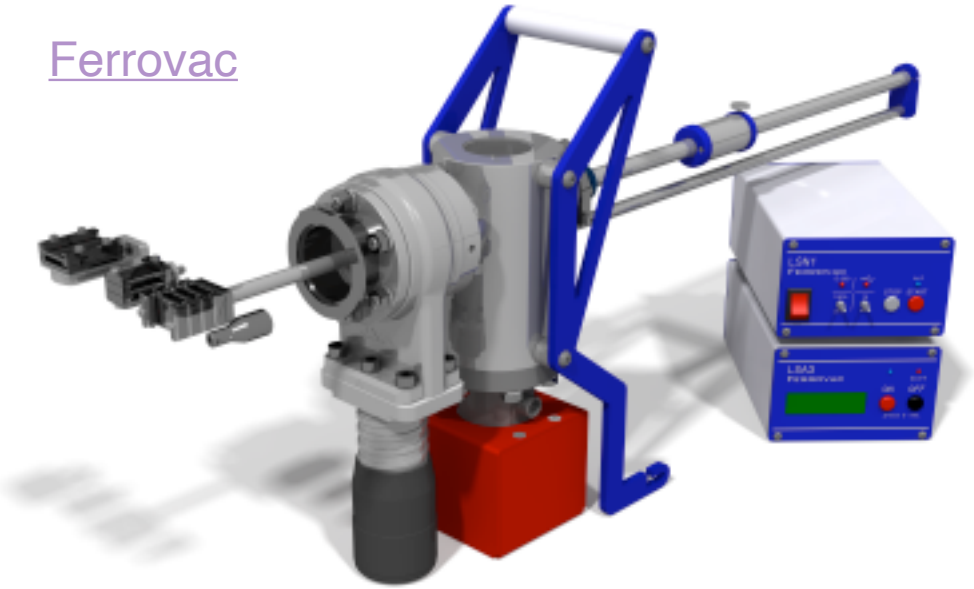
What we think we might do

- Need to comply with the multiple containment principle
  - **Redesign T-chamber** (smaller volume, less gas "consumption") - minimal setup: fixed holder? thermal cracker
  - It must be tritium compatible
  - T-chamber must go into a "**glove box**"
    - Can we reuse something at AGHS ? Should be design a new one ?
      - **Important**: tritiated graphene cannot exposed to air, must stay in vacuum (we know hydrogen is substituted by oxygen)
      - **Manipulation of the sample though the glove box in vacuum**

Shipping of the sample

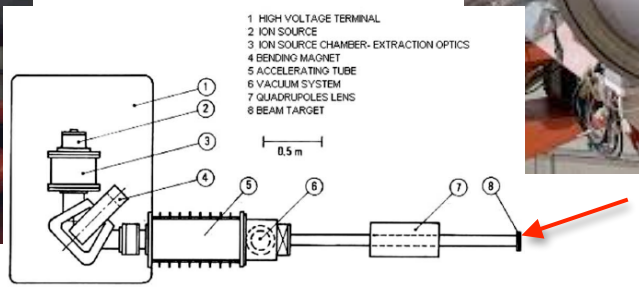
- Legal issues
- we need a special suitcase to ship a sample to be kept in vacuum
  Commercial “vacuum” suitcase available

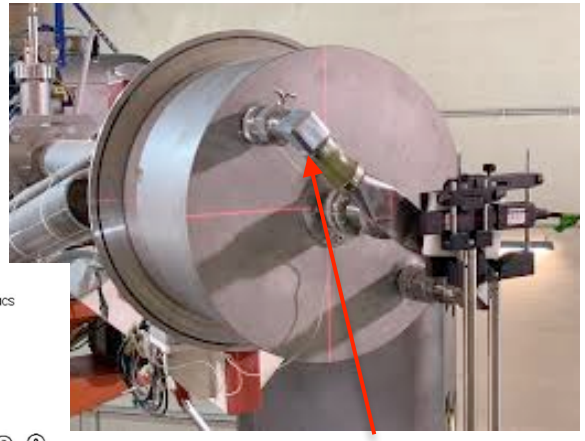
Ferrovac



Where “solid” tritium is used in Italy

- ENEA FNG (**F**rascati **N**eutron **G**enerator)
  - ENEA Frascati where the ITER DTT (*divertor* demonstrator) will be built
  - Tritium **beam target** (D +T reaction to yield neutrons)
  - Bought from a French company (metal “tritide”)
- Tritiated graphene will be like tritium absorbed in a metal





The whole vacuum chamber of the FNG is connected to a tritium detection system
Beam target kept in a glove box
Exhaust sent to atmosphere

Outlook

- Accessing tritium is vital for our Ptolemy experiment
- We believe we need various steps
  - 1) design of a new smaller T-chamber to be located into a glove box (optimise gas flow, reduce contaminants, check parts are compliant with tritium usage…)
    - **Need AGHS expertise**
  - 2) manipulation of the sample in vacuum
  - 3) shipping (in vacuum) according to regulations
  - 4) assessment of the level of radioactivity with standard metrology
  - 5) first test in a vacuum chamber (beta spectrum, …)

We expect it can be a few years project
We currently have some funding to start (in the process to ask more to INFN)

During 2025-2026 commissioning of the Ptolemy demonstrator (magnet)

We can wait end of 2026 at the earliest to have tritiated graphene in the demonstrator

Possible schedule

			months	0-3	3 - 6	6 - 9	9 - 12	12 - 15	15 - 18	18 - 21	21 - 24	24 - 27	27 - 30	30 - 33	33 - 36
TASK															
feasibility study (interaction Ptolemy - AGHS)															
	month 3				* Ptolemy - AGHS workshop to discuss feasibility study										
	Month 6				green light from feasibility study										
design of the T-AGHS-chamber + AGHS glove box;															
evaluate the legal issues connected to shipping to LNGS,															
LNGS evaluates feasibility of tritiated graphene storage and design															
	month 12							green light on desing Tchamber							
	month 15							green light on LNGS storage for tritium							
procurement of T-chamber for AGHS and glove box															
	month 27										installation of T chamber at AGHS				
• construction tritiated graphene storage at LNGS															
commissioning of T-AGHS-chamber + AGHS glove box															
	month 33													first tritiated graphene sample at AGHS	
	month 36														graphene sample at LNGS

- Feasibility study
- Design and procurement T-chamber for AGHS
- Design and construction tritium lab at LNGS
- Operation at AGHS and delivery to LNGS

Feasibility study

1. The tritium compatibility of the design of the Ptolemy sample preparation system (including the primary vacuum chamber and cracker)

2. Viability of integrating into our tritium subsystems in the vacuum conditions and timeframe required by the Ptolemy Project.

3. Investigating the regulatory landscape and export possibilities to ensure tritium is appropriately handled and shipped in accordance with international requirements.

1. 4 months

2. Wants to meet us at the beginning

3. They want requirements from us well spelled.

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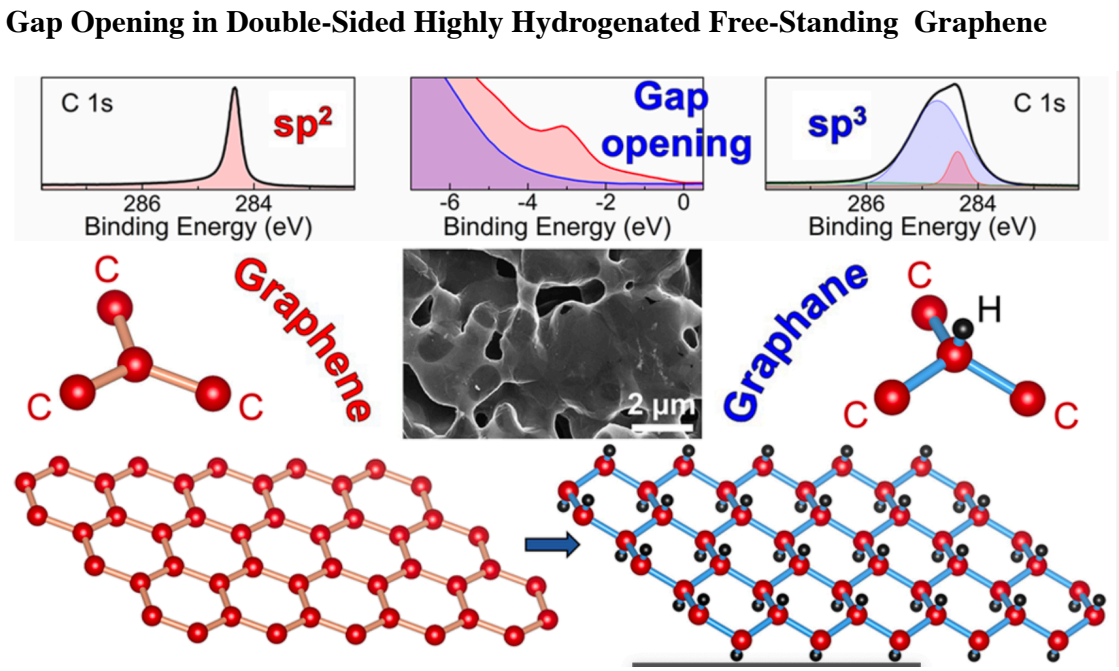
Demonstration of graphene hydrogenation

- Use thermal cracking in vacuum



- Nanoporous graphene (NPG) as substrate
- X-ray spectroscopy to see **sp³** bonds to measure hydrogen uptake

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