Radiation Damage in the neutron converter Spiral 2

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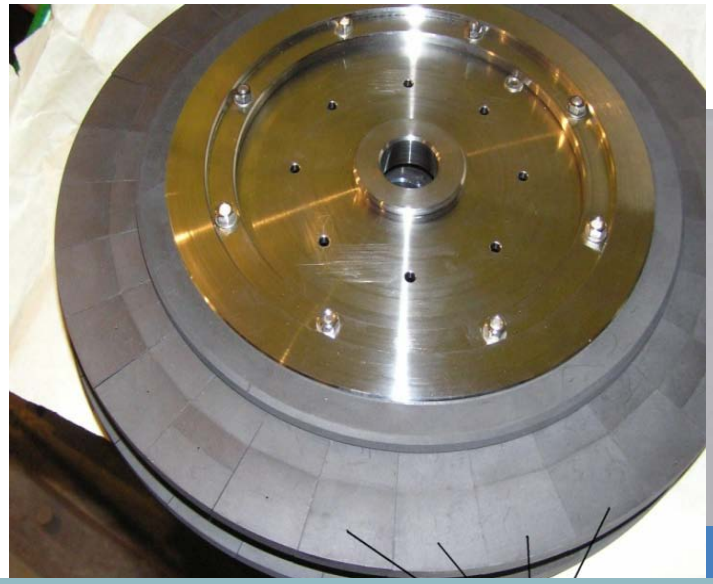
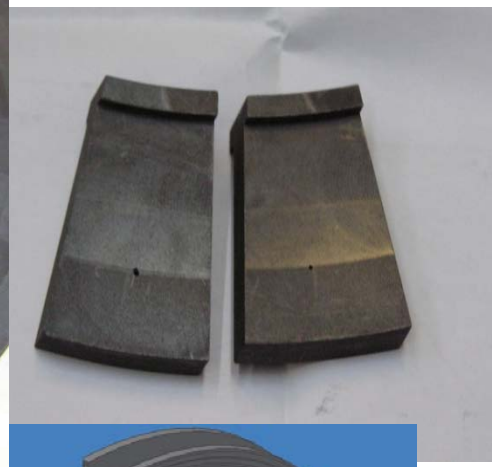




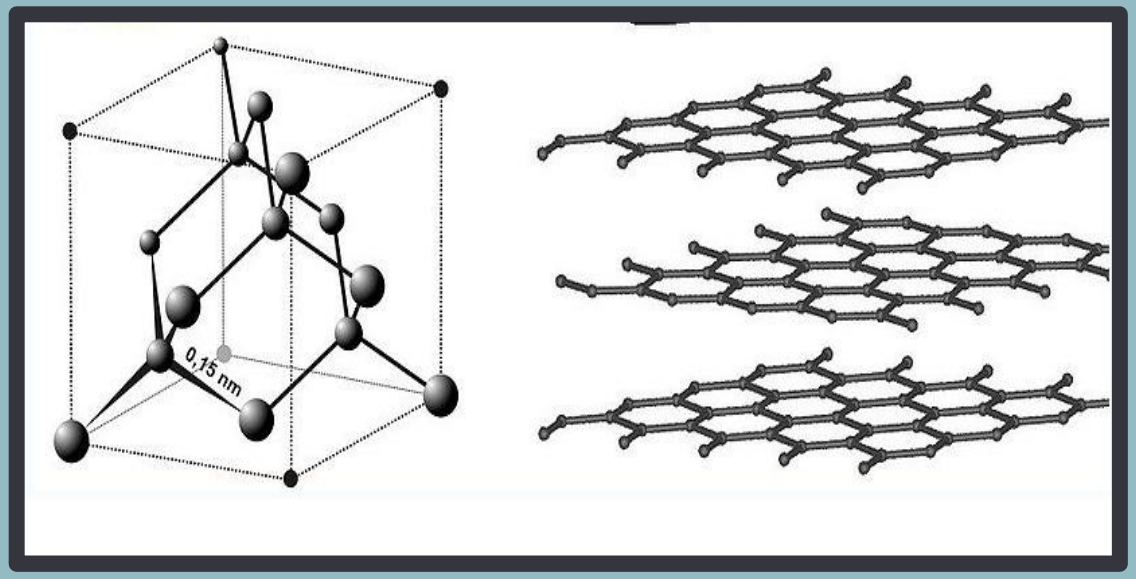
PROTOTYPE:

→**Primary Beam**: 40 MeV deuterons

→**Current** 1-5 mA,

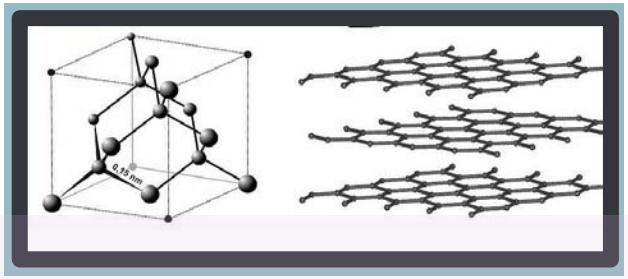
→**Thermal power** dissipated only by thermal radiation. **(200 kW)**

→**Temperature** on converter can arise to 1850°C

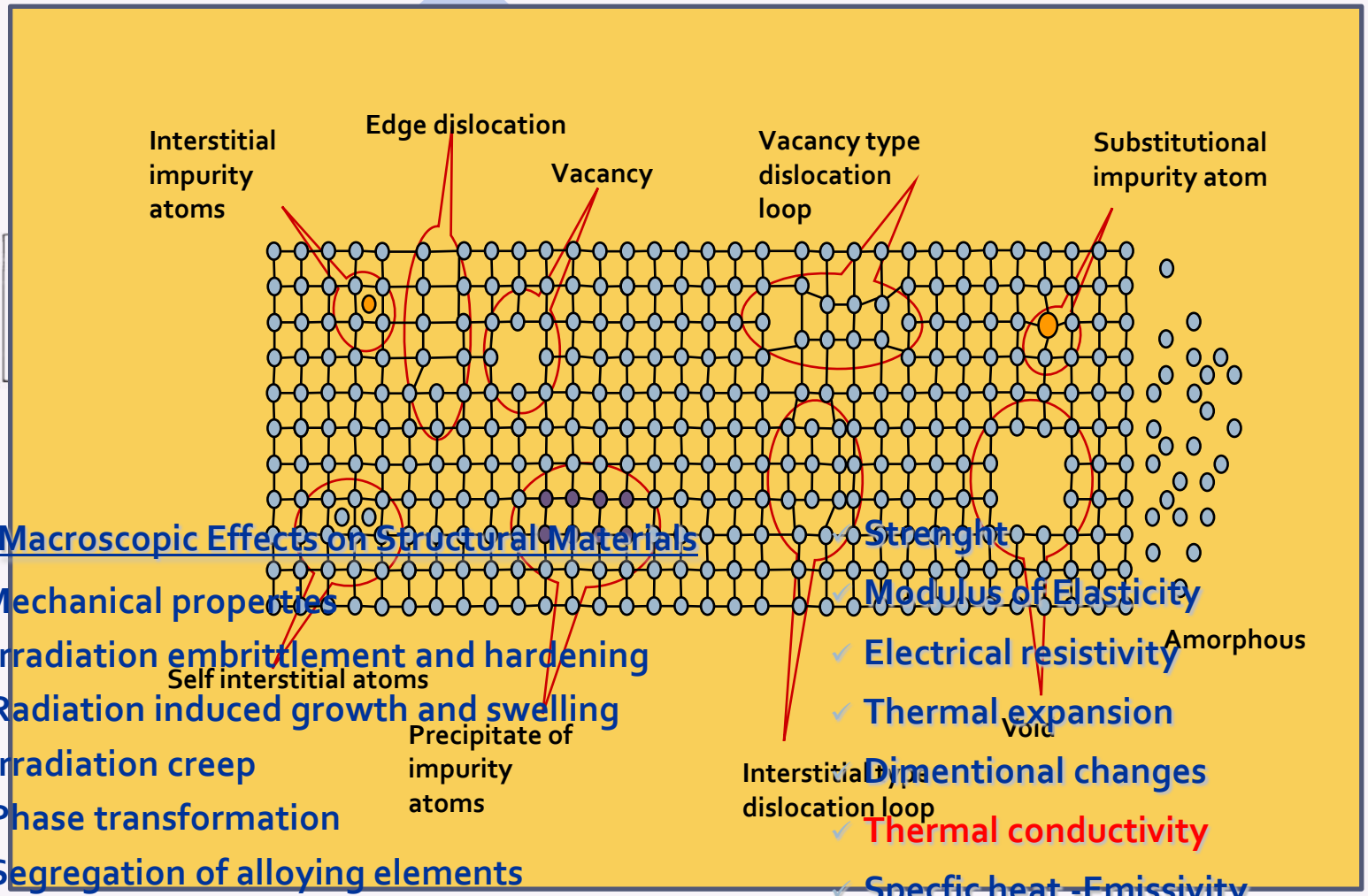


Spiral 2 **Request:**

•Evaluate changes on the structure during One cycle of operation (3 months)



Graphite characteristics and material properties

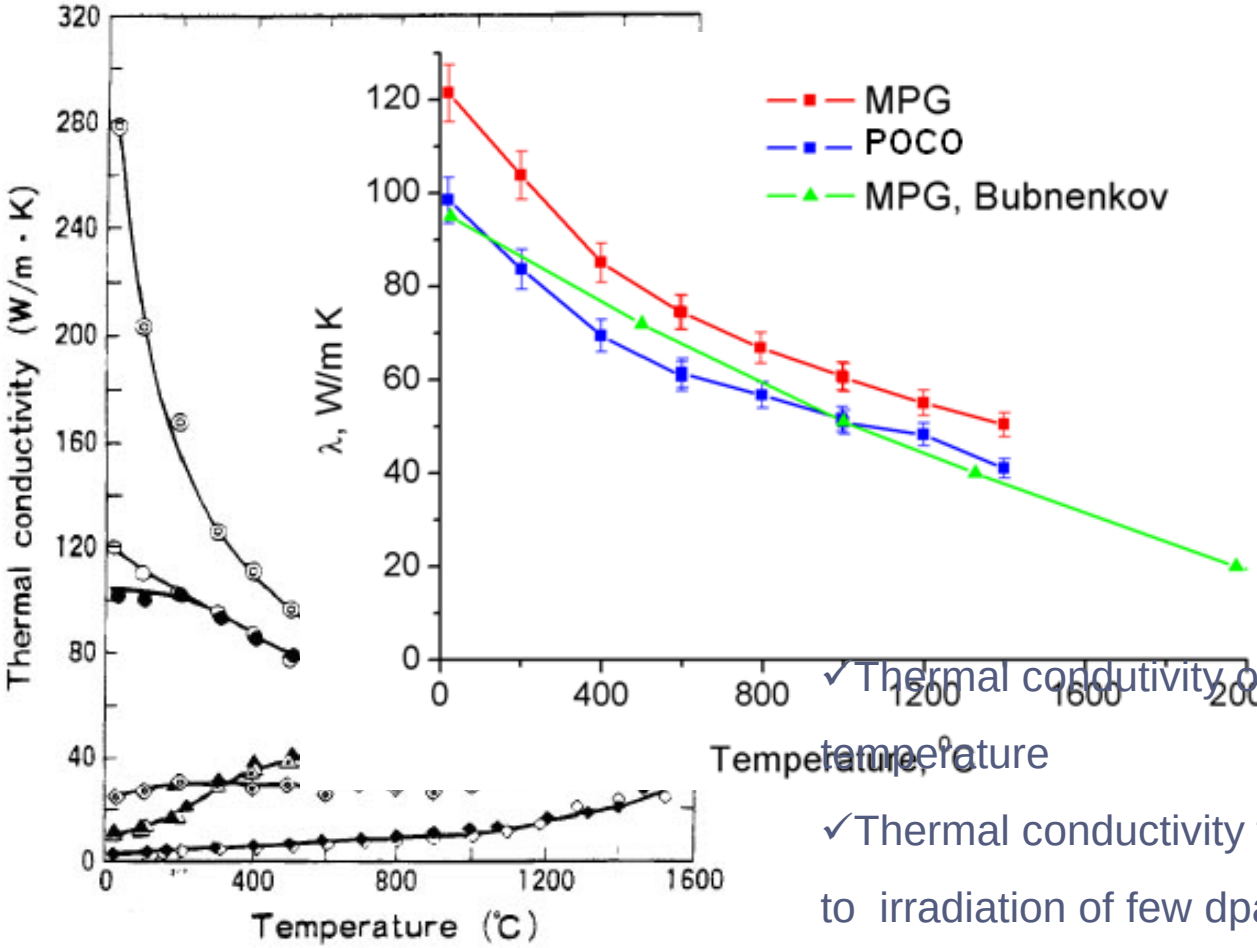


Macroscopic Effects on Structural Materials

- Mechanical properties
- Irradiation embrittlement and hardening
- Radiation induced growth and swelling
- Irradiation creep
- Phase transformation
- Segregation of alloying elements

- ✓ Strenght
- ✓ Modulus of Elasticity
- ✓ Electrical resistivity
- ✓ Thermal expansion
- ✓ Dimentional changes
- ✓ Thermal conductivity
- ✓ Specfic heat -Emissivity

Thermal conductivity



✓Thermal conductivity of graphite at high temperature

✓Thermal conductivity for graphite exposed to irradiation of few dpa.

Thermal conductivity at high target temperature and exposed to irradiation is matter of interest and **must be studied**

Factor controling Radiation Damage

Radiation damage dependence on:

- Irradiated particles
- Flux of irradiated particles
- Number of displacement per atom DPA
- Energy required to produce the displaced atom
- Maximal energy that can be transferred to atoms by the incident particle with energy E
- Number of the displacements due to a knock-on primary displacement (radiation damage function)
- Cross section of a particle of energy E to produce the DPA with the energy T

First Approach- Theoretical -calculations

I.L. Svyatov, V.V. Plokhoi, V.V. Sagaradze, D.V. Khmelnitsky

Use of PRIZMA and ATOCAS codes to correlate dpa and neutron fluence induced atom displacements.

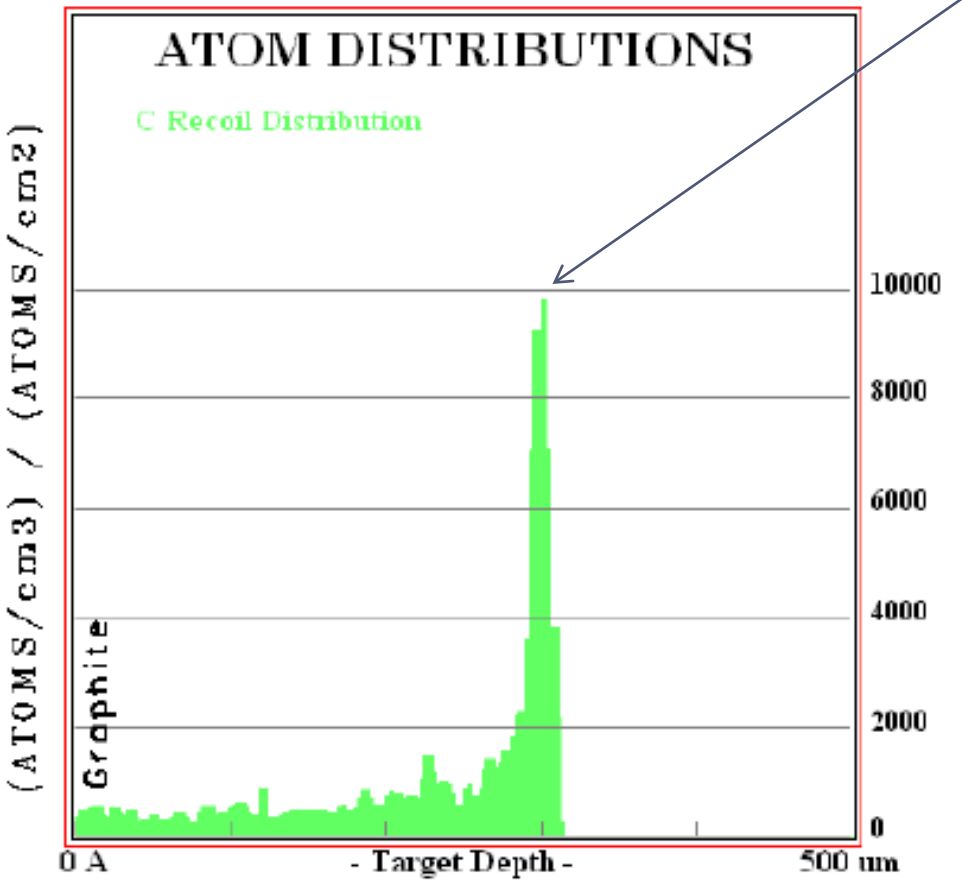
Considering relatively low neutron yield from $^{12}C(d,n)^{13}N$ reaction (~4%), the major radiation damages caused by the primary beam can be expected (high energy deuterons beam).

For 10.000 hours of target operation the maximum number of displacements in graphite will be ~50 dpa, without considering temperature effect.

This results push us to an evaluation of graphite charateristics with an experimental approach

Was proposed an experiment at CN Accelerator at LNL:

SRIM -Not considering Temperature effects



The energy is deposited in the bragg peak where the beam is stoped.

In this case at 300 μm deph

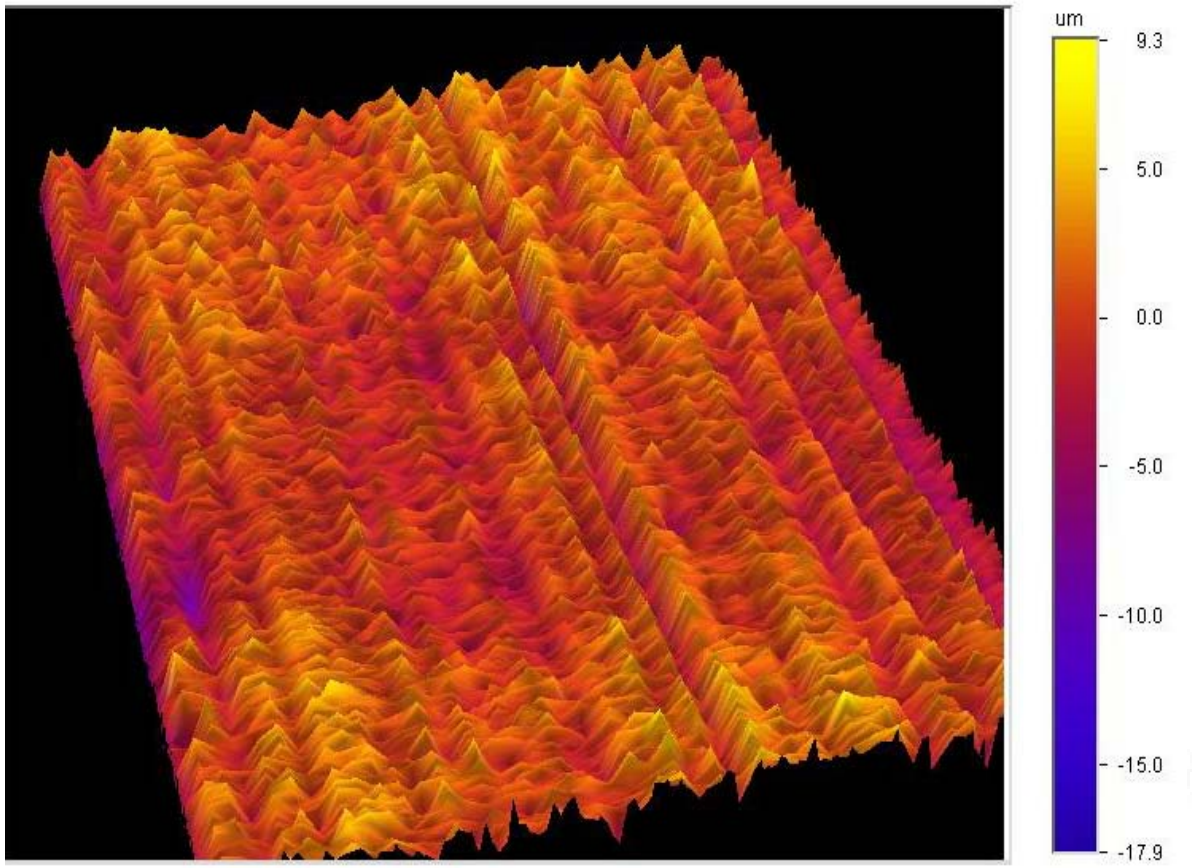
Beam characteristics:
protons 5 MeV, 4**μA**
beam spot 0,2 cm^2
current density 20 $\mu A/cm^2$

$7{,}7 \times 10^{18}$ p/cm^2 = 1 dpa
We could obtain 1 dpa after
20 hours of irradiation

Surface analysis before irradiation

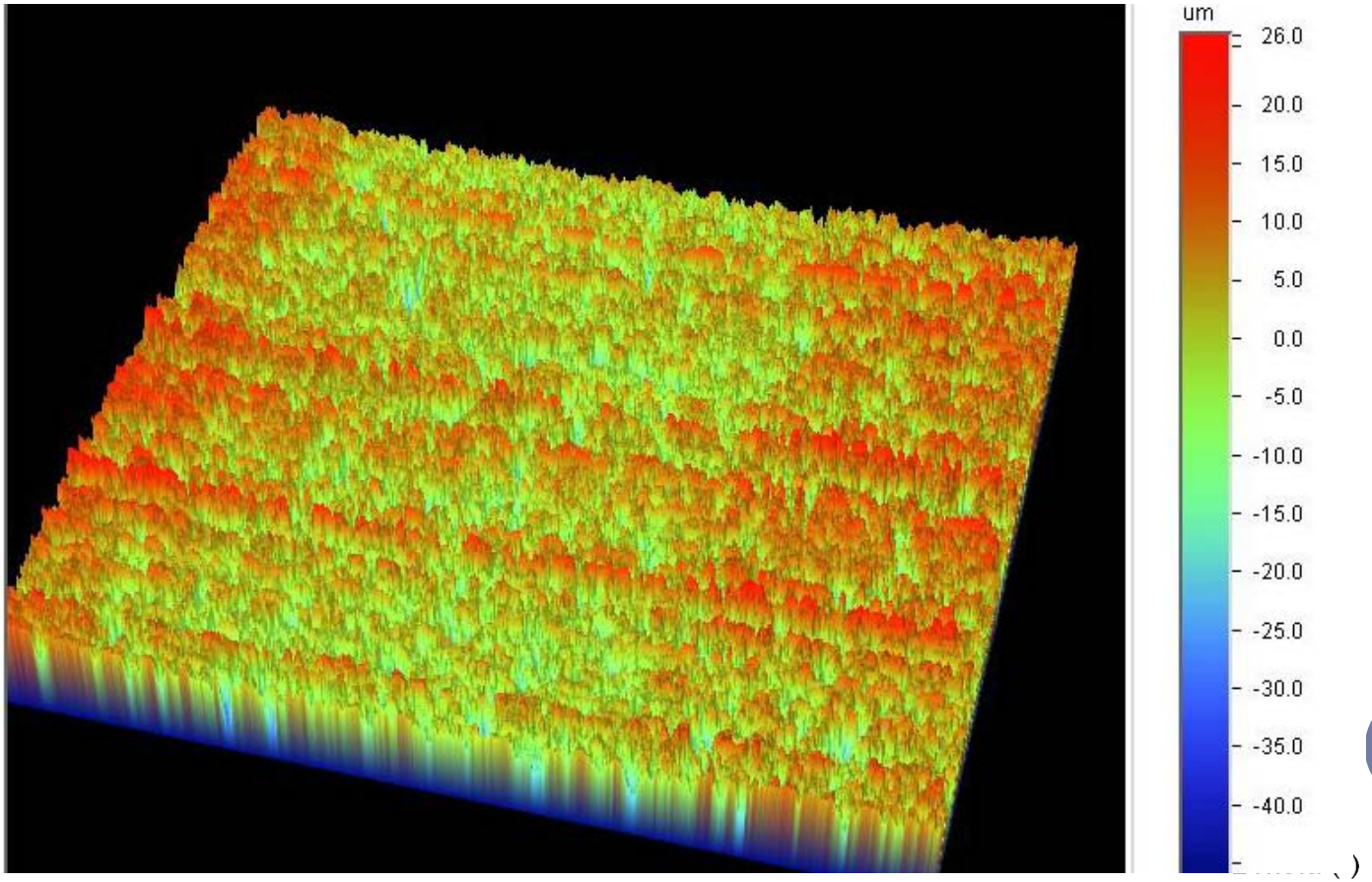
Sample: POCO graphite

Profile-map.
Dektak Profilmeter.
Stylus scaning.
Force applied by the scaning tip: 0.3 N



Results: Analysis after Protons irradiation at LNL-INFN

- Protons 5 MeV, 4**μA**
- Current density 20 μA/cm^2
- Temperature during irrad 300 °C

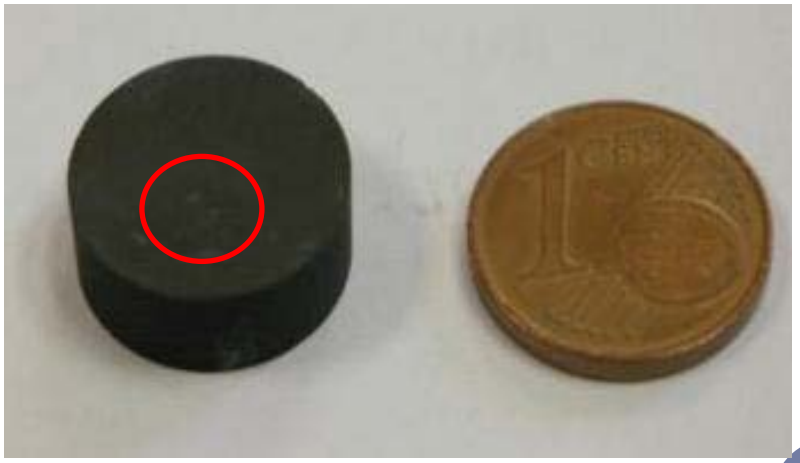


Results: Analysis after 26MeV Deuterons irradiation at TANDEM- IPNO

Sample: POCO graphite

Radiation spot diameter: 2mm.
current planned: 1.5 mA.

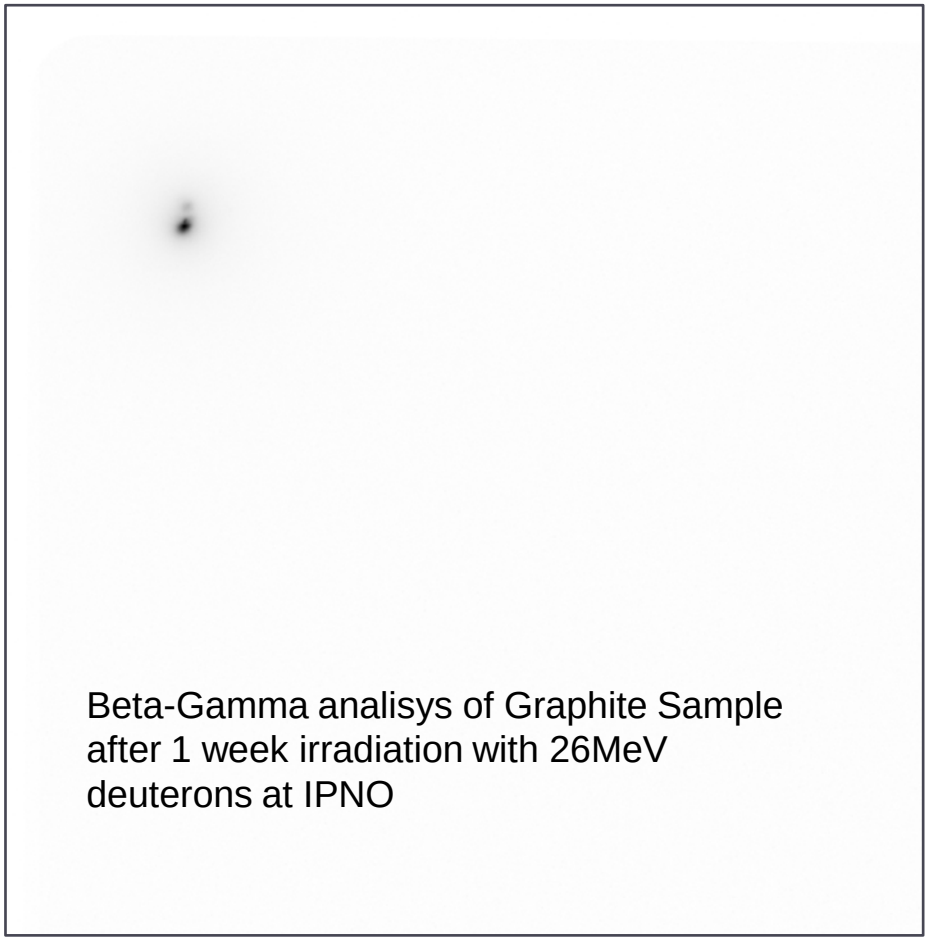
Total number of particles deposited during 1 week of irrdiation: **9,67E+17 ions** corresponding to 1dpa



*Coutersy of Mr. Marc and Alan

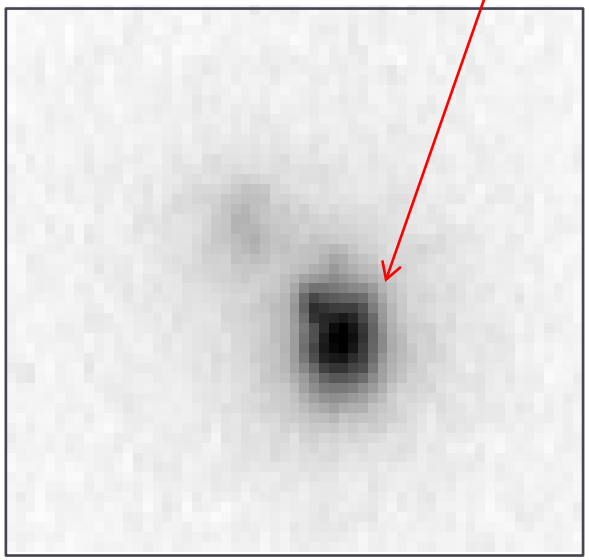
Graphite Sample after 1 week irradiation with 26MeV deutons at IPNO

Results: Analysis after 26MeV Deuterons irradiation at TANDEM- IPNO



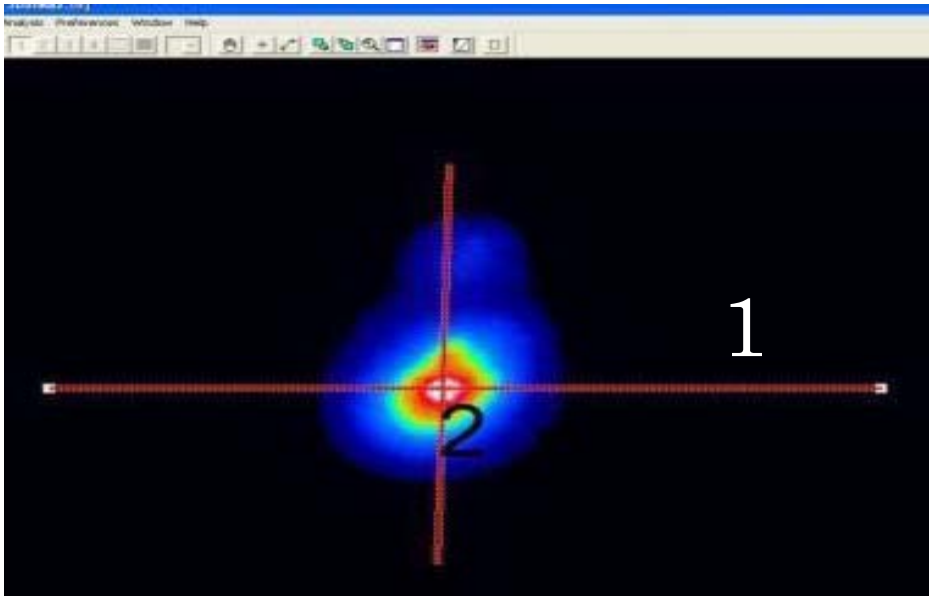
Beta-Gamma analisys of Graphite Sample after 1 week irradiation with 26MeV deuterons at IPNO

SPOT

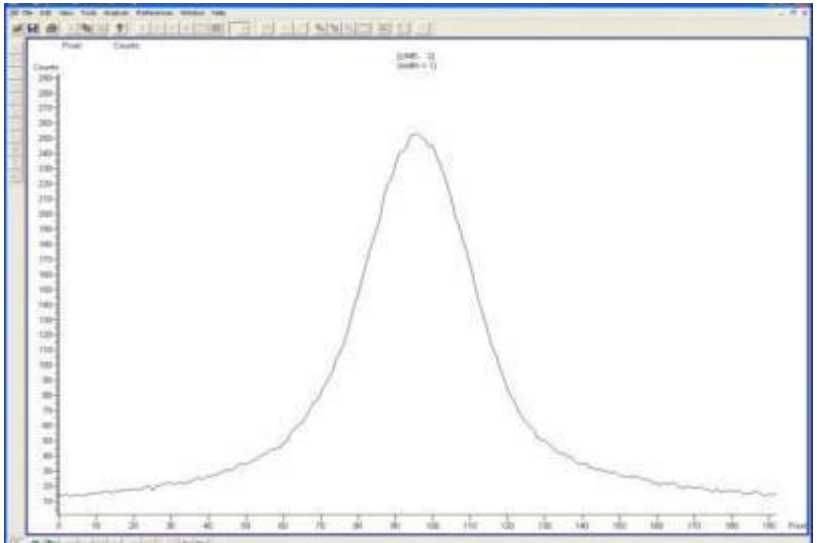


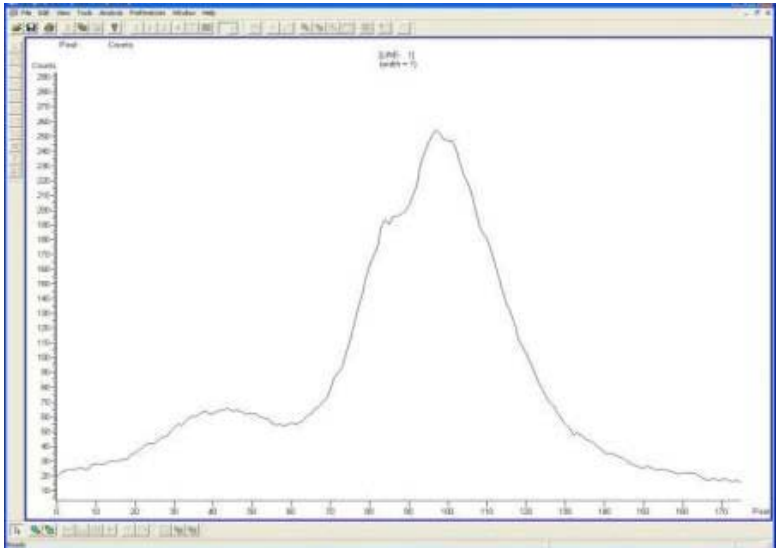
*Coutersy of Mr. Mottier & Mr. Lefort

Results: Analysis after 26MeV Deuterons irradiation at TANDEM- IPNO



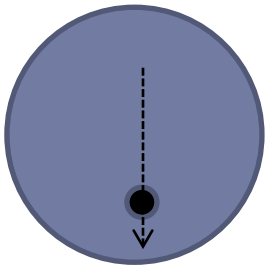
BETA-Gamma plaque analysis of Graphite Sample after 1 week irradiation with 26MeV deuterons at IPNO.

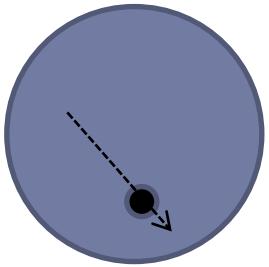


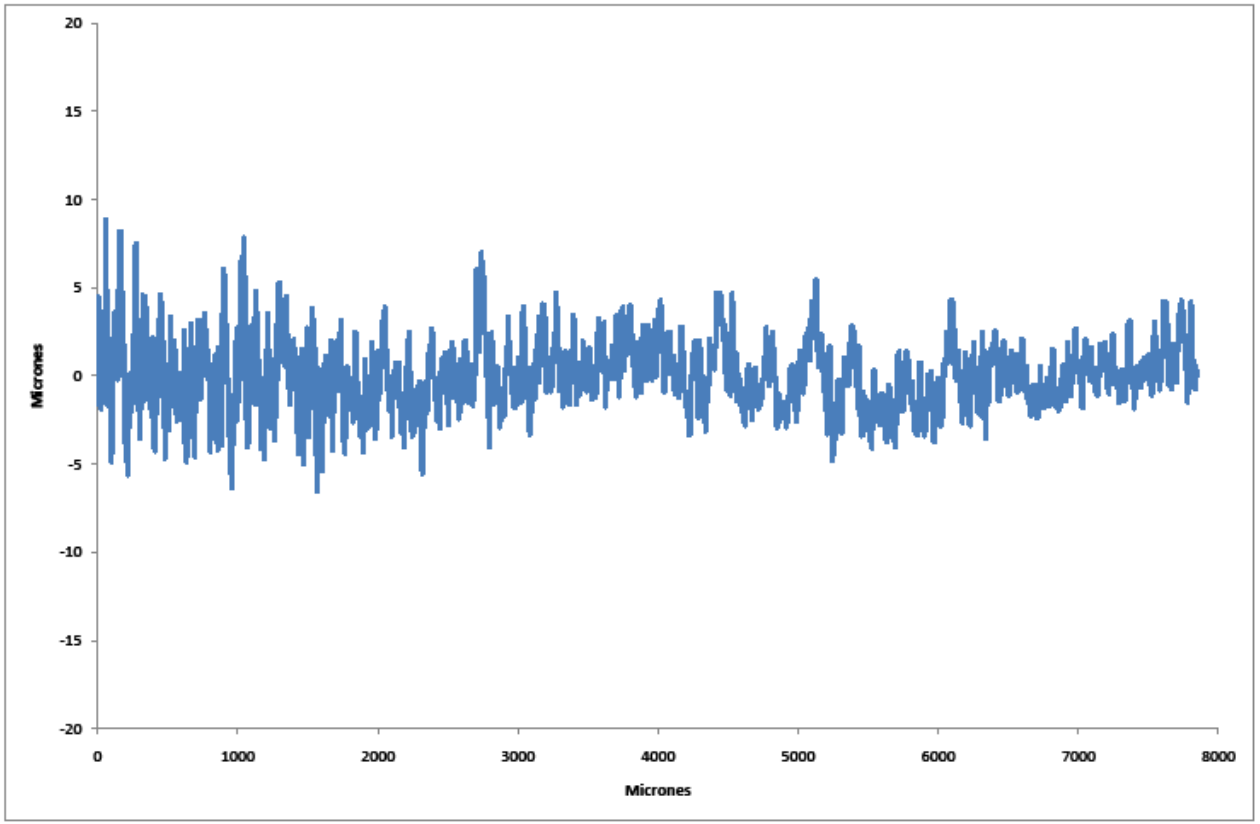


Results: Analysis after 26MeV Deuterons irradiation at TANDEM- IPNO

Profile analisys of Graphite Sample after 1 week irradiation with 26MeV deutons at IPNO

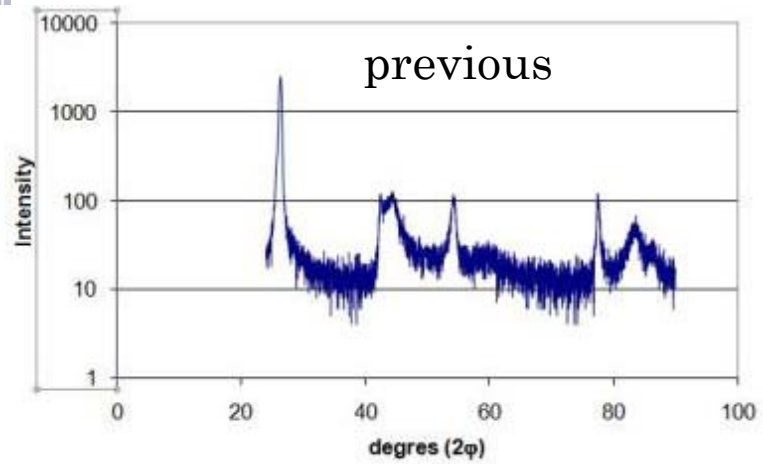


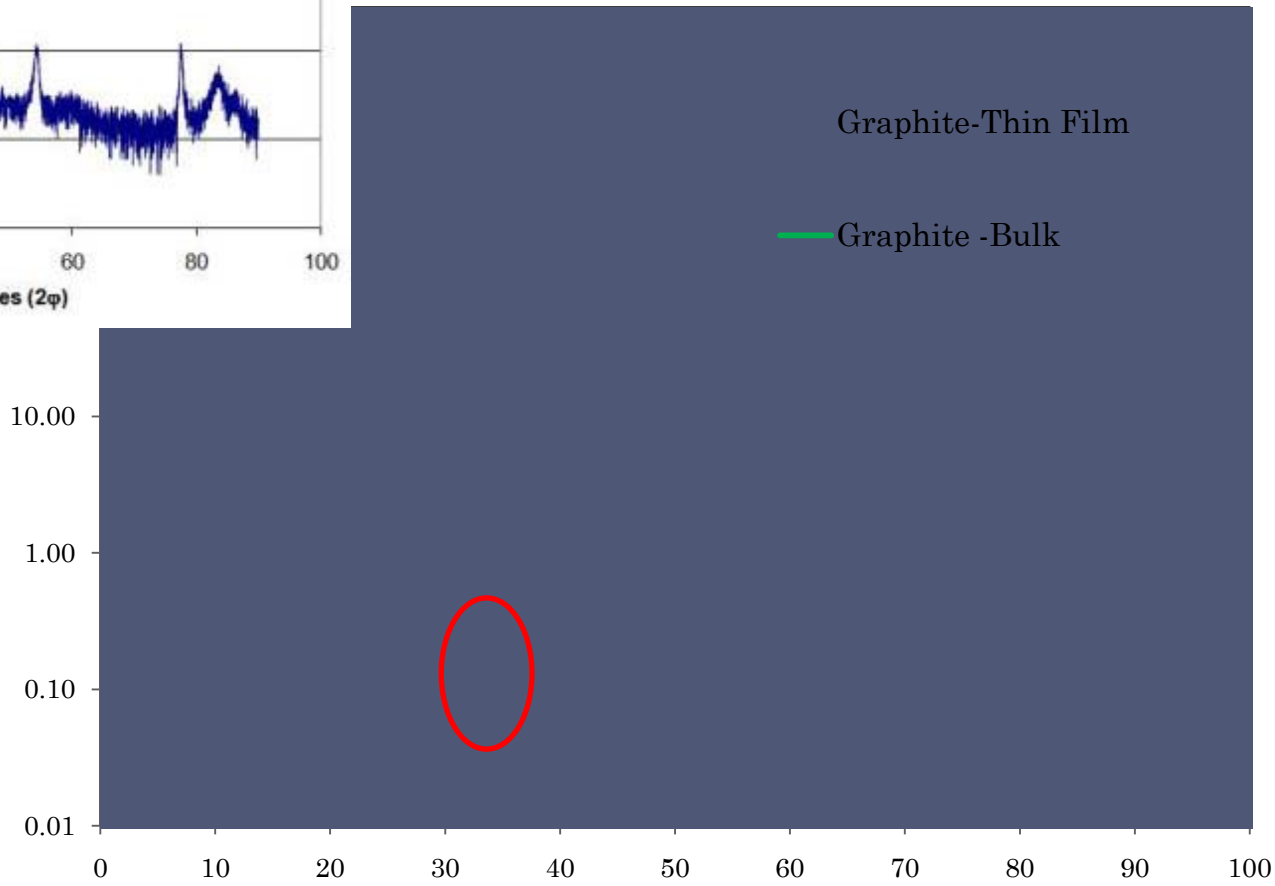




*Coutersy of Mr. J Mottier & Mr. Christoph Lau

Results: Analysis after 26MeV Deuterons irradiation at TANDEM- IPNO





*Coutersy of Mr. Walid

XRD analisys of Graphite Sample after 1 week irradiation with 26MeV deutons at IPNO

FUTURE -

- Next week will be irradiated at IPNO the sample one week more, in order to reach damage of 3-5 dpa.

- After the decay time required, XRD and profiles analysis will be carried out, to asses the effect of deuteron radiation on POCO graphite.

Thank’s for your attention…