Lecture notes

Fusion products measurements of the D+D reactions at very low energies

Dr Rakesh Dubey, University of Szczecin, Poland
CleanHME Consortium
www.cleanhme.eu
https://twitter.com/cleanhme

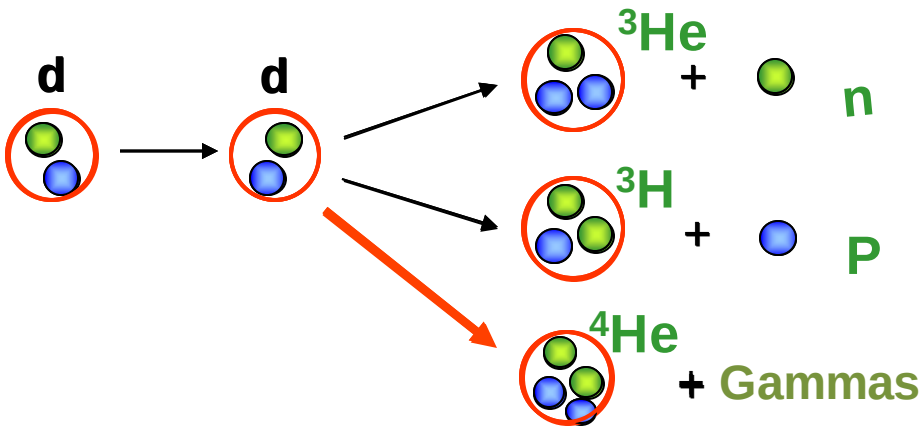
Outline

- D-D reactions at very low energies
- Fusion products measurements
- Experimental set up
- Results

Pic courtesy: www.oilprice. com

D-D fusion in metallic or gaseous environment

D-D reactions at very low energies



D-D Fusion Products;

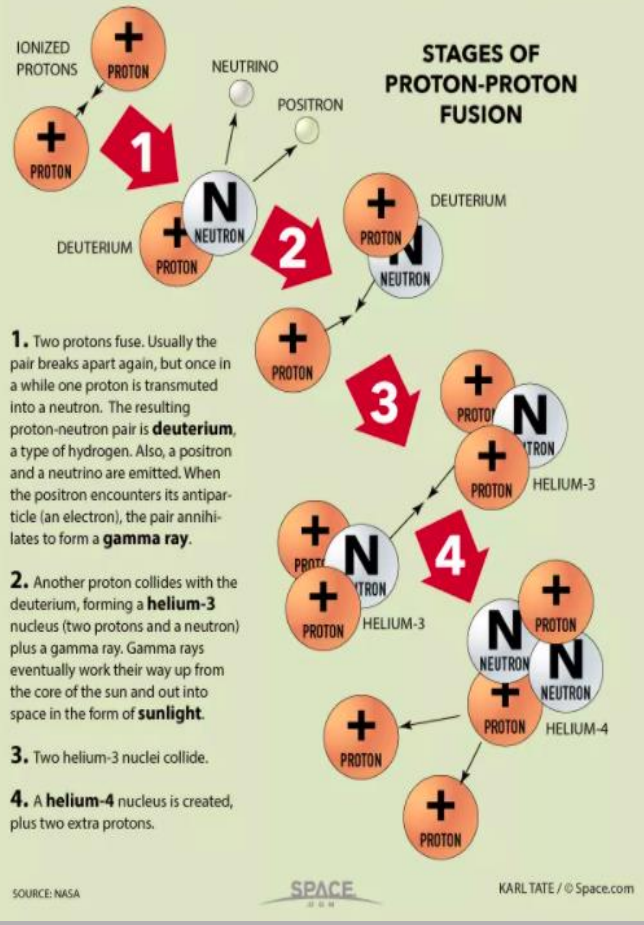
Charge particles : Helium-3(^{3}He), Helium-4 (^{4}He), Tritons (^{3}H), Protons (P);

Neutral particles : Neutrons (n), Gammas

How we can measure these particles and Gammas !!

"Nuclear measurements techniques"

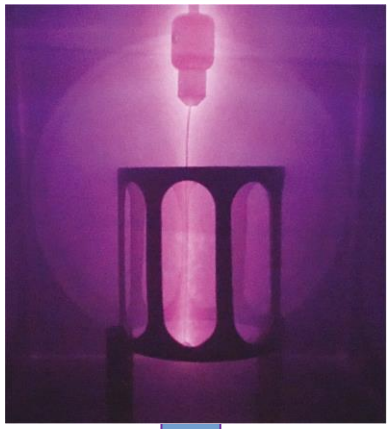
Inside stars like the sun, the extreme temperature rips atoms into their components: protons, neutrons and electrons. Under normal conditions, the mutual repulsion of individual protons ought to force them apart. Quantum-tunneling effects in the sun allow hot, high-speed protons to fuse into helium nuclei. This fusion reaction drives the sun's radiance.

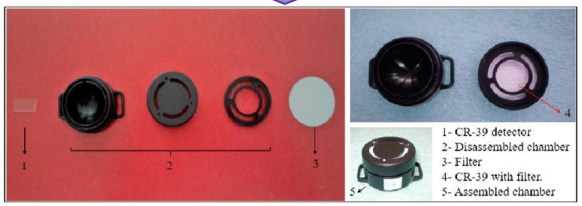


Nuclear measurements technique for D-D fusion products at very low energies

Charge particles Detections

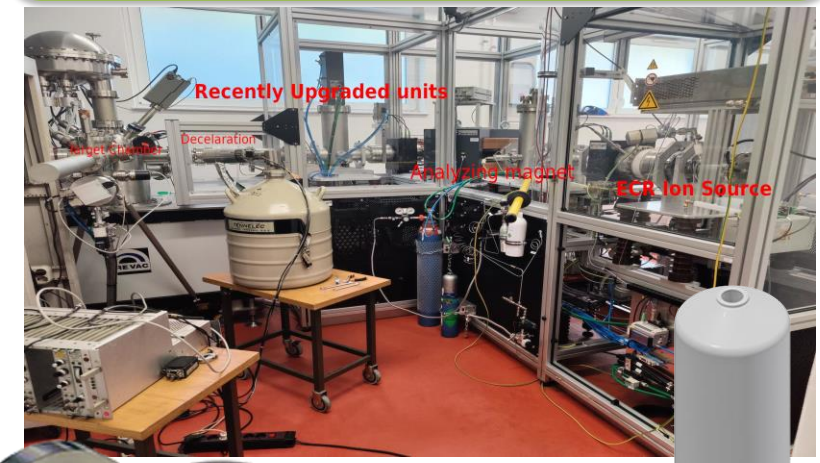
Plasma/Electrolysis/Diffusion[1]





Detectors : CR39 etc

Low energy Accelerator Facility



Pics courtesy: ORTEC, MIRION tech.

Detectors: PIPS, SiLi, SiGe etc.

Reference: 1)*Nature* **570**, 45–51 (2019)..

Nuclear measurements technique for D-D fusion products at very low energies

Neutral particles and Gammas Detections

Neutrons

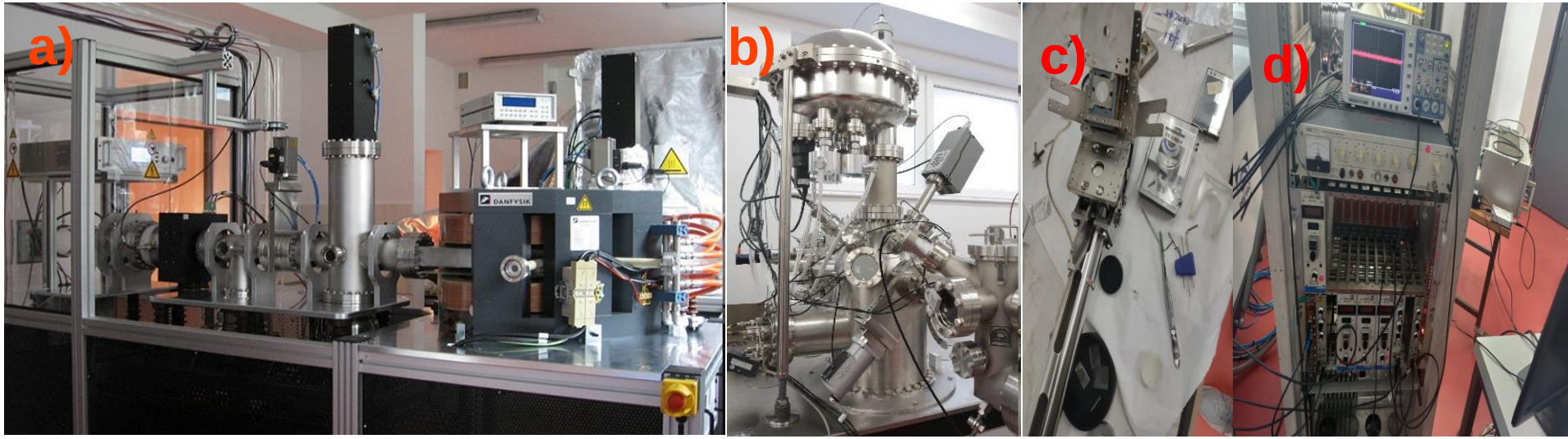
Scintillators Detectors and Neutron Counters

Gammas and X rays

Detectors: NaI, HPGe etc.

Pics courtesy: ORTEC, MIRION, KROMEK

Experimental Accelerator facility for Low energy nuclear reactions



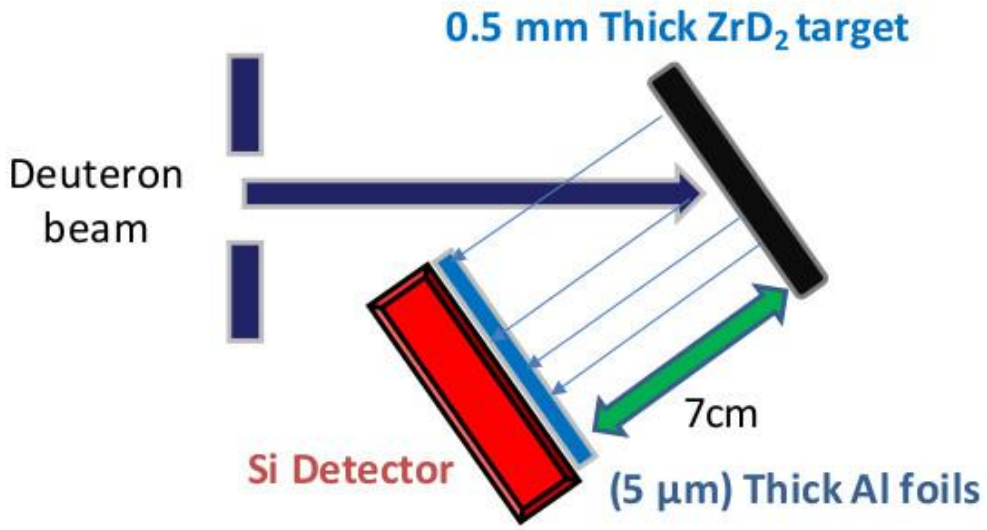
a) Accelerator with Ultra High Vacuum, b) Target Chamber c) Detector holder with Al foils d) Electronics set up

a)Prototype ECR ion source, low emittance , high current, light ions – a few mA

eLBRUS
LABORATORIA BADAWCZO-ROZWOJOWE UNIWERSYTETU SZCZECIŃSKIEGO

[a,b]Ref : M. Kaczmarski, et al., Acta Phys. Pol. B 45, 509 (2014).

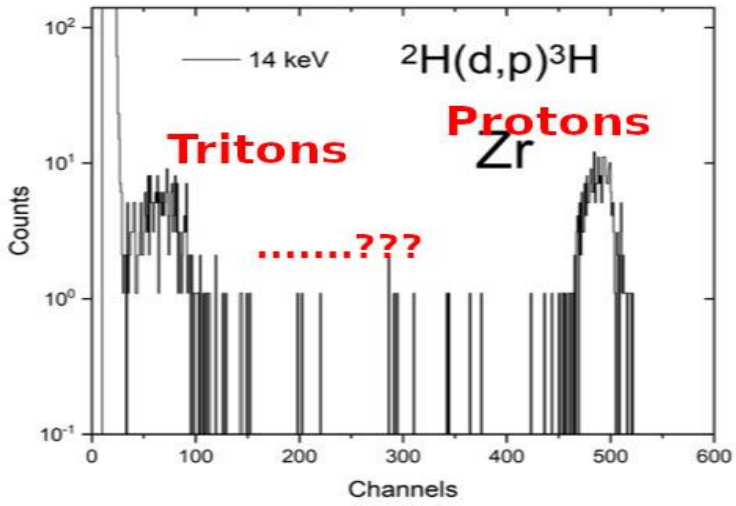
Experimental set up for fusion products measurements from D-D reactions at very low energies

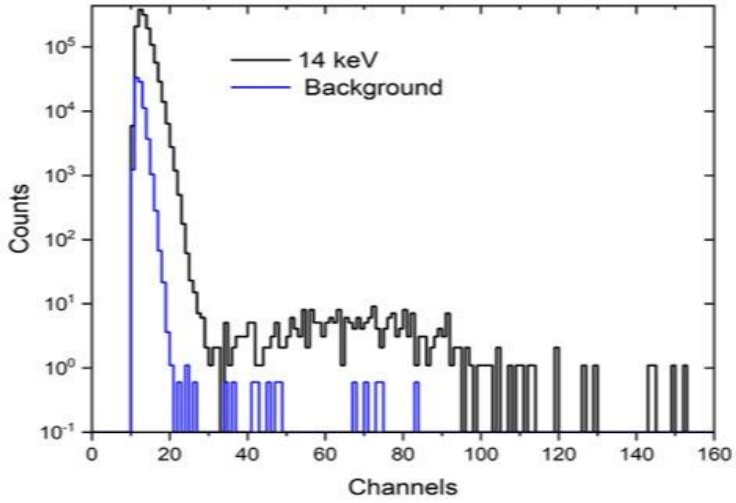


D2-beam Energy : 6-16 keV
EG ORTEC Silicon detector : 1000 µm thickness and Surface area 100 mm^2 ,

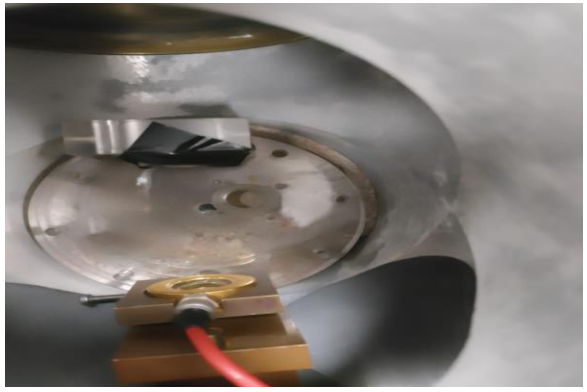
Thick ZrD 2 target that was tilted at 45° to the beam, resulting in the beam spot size of 7x12 mm.

Results : Charge Particles Spectra

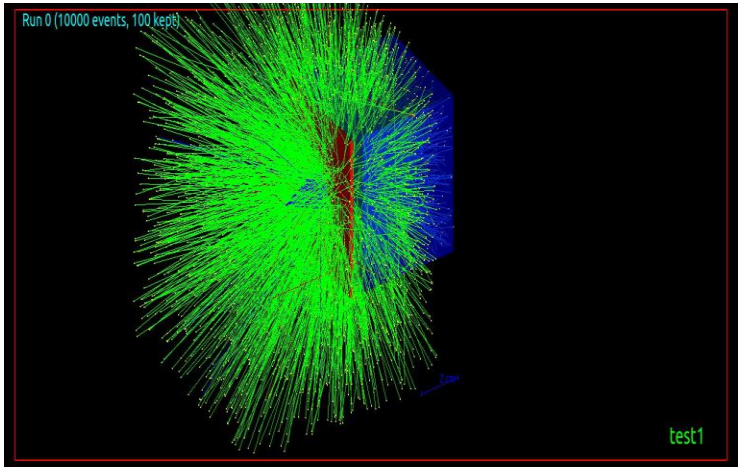


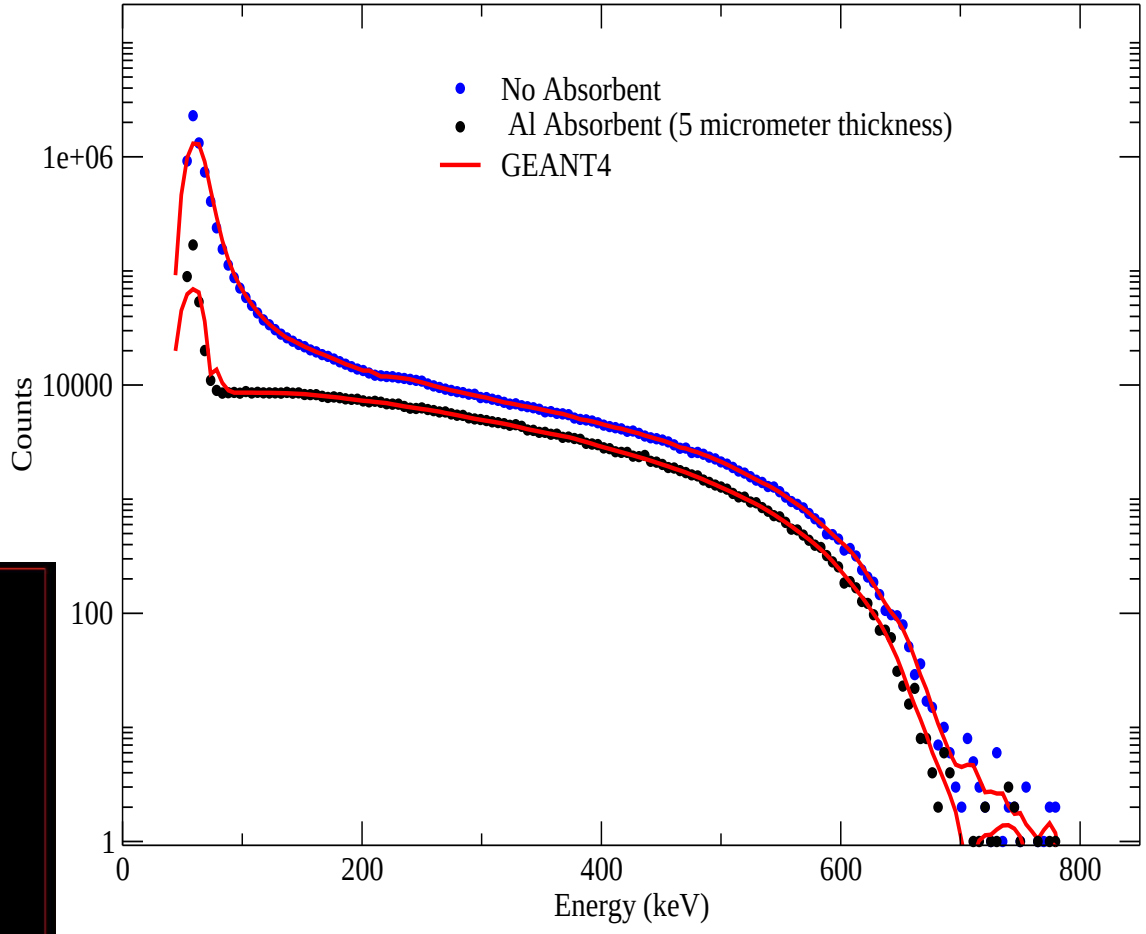


Si Detector Calibration set up with radioactive sources



Geant 4 simulations





^{204}Tl – Beta decay energy spectrum

Thank you!
Any questions?

This project has received funding from the European Union's Horizon2020 research and innovation programme under grant agreement no 951974