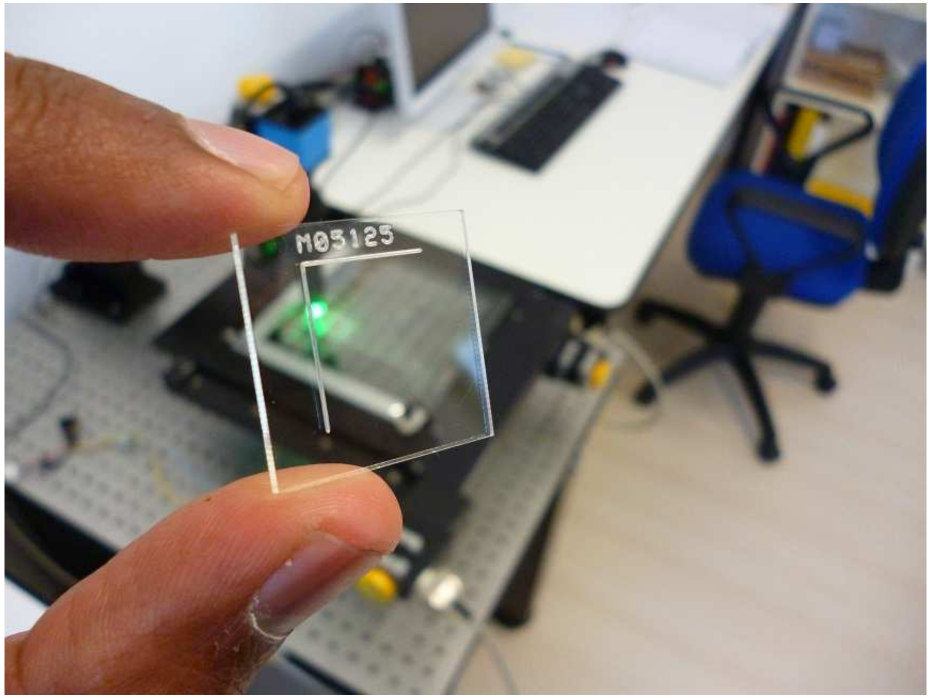
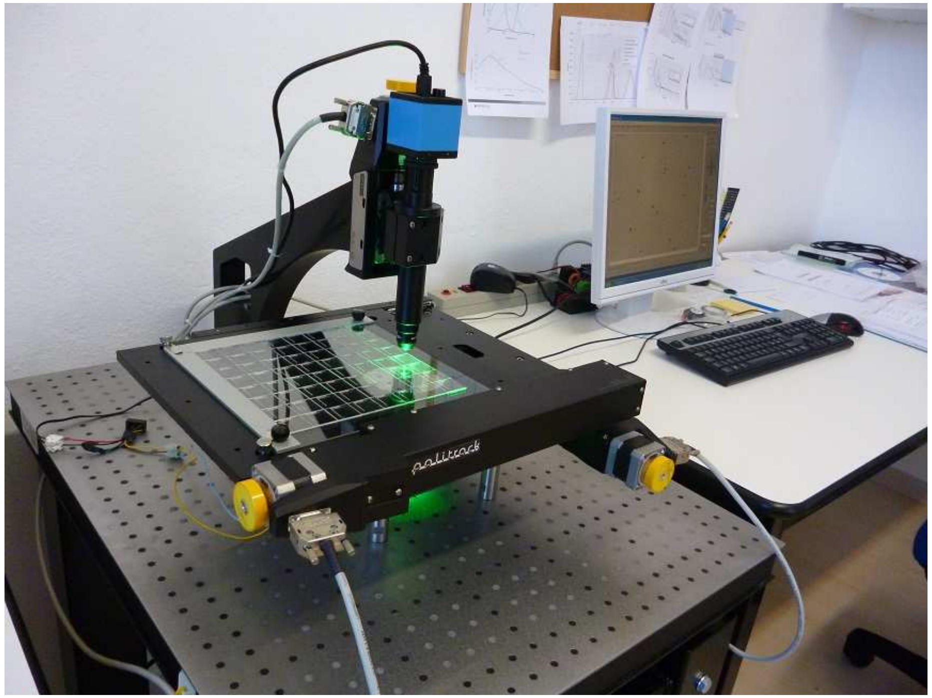
Course n° 3

CR-39 for Measuring Exposure to Radon (^{222}Rn)

Track Detectors for Radon

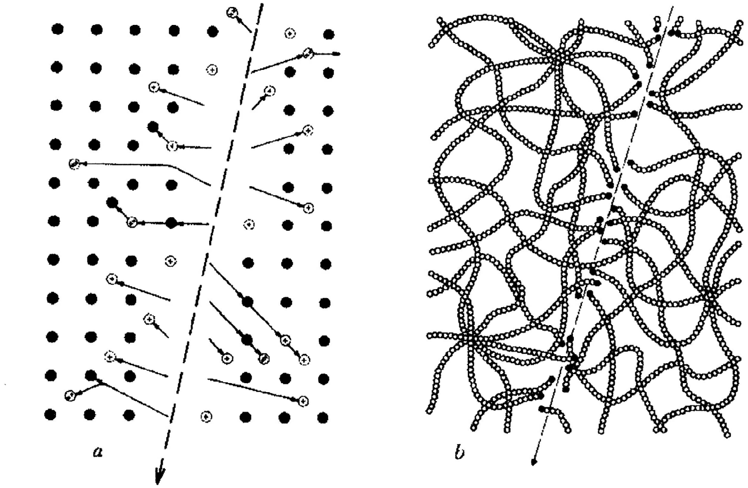


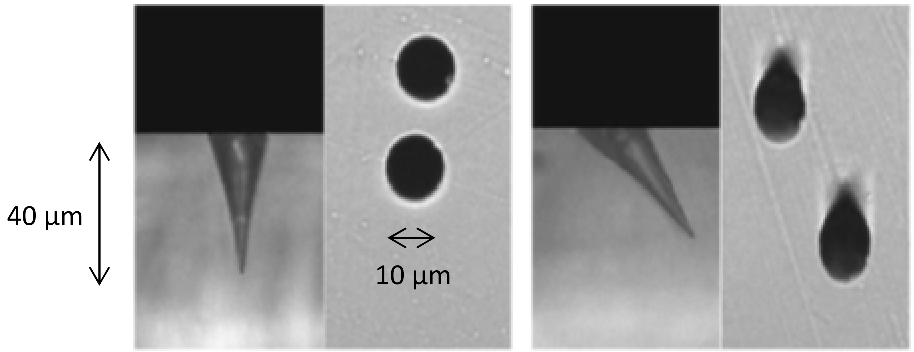
Intercast CR-39 detector



Politrack^{TM} instrument

Track Detectors





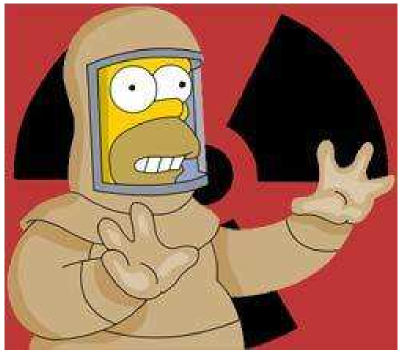
B. Dorschel et al. / Radiation Measurements 37 (2003) 563 – 571

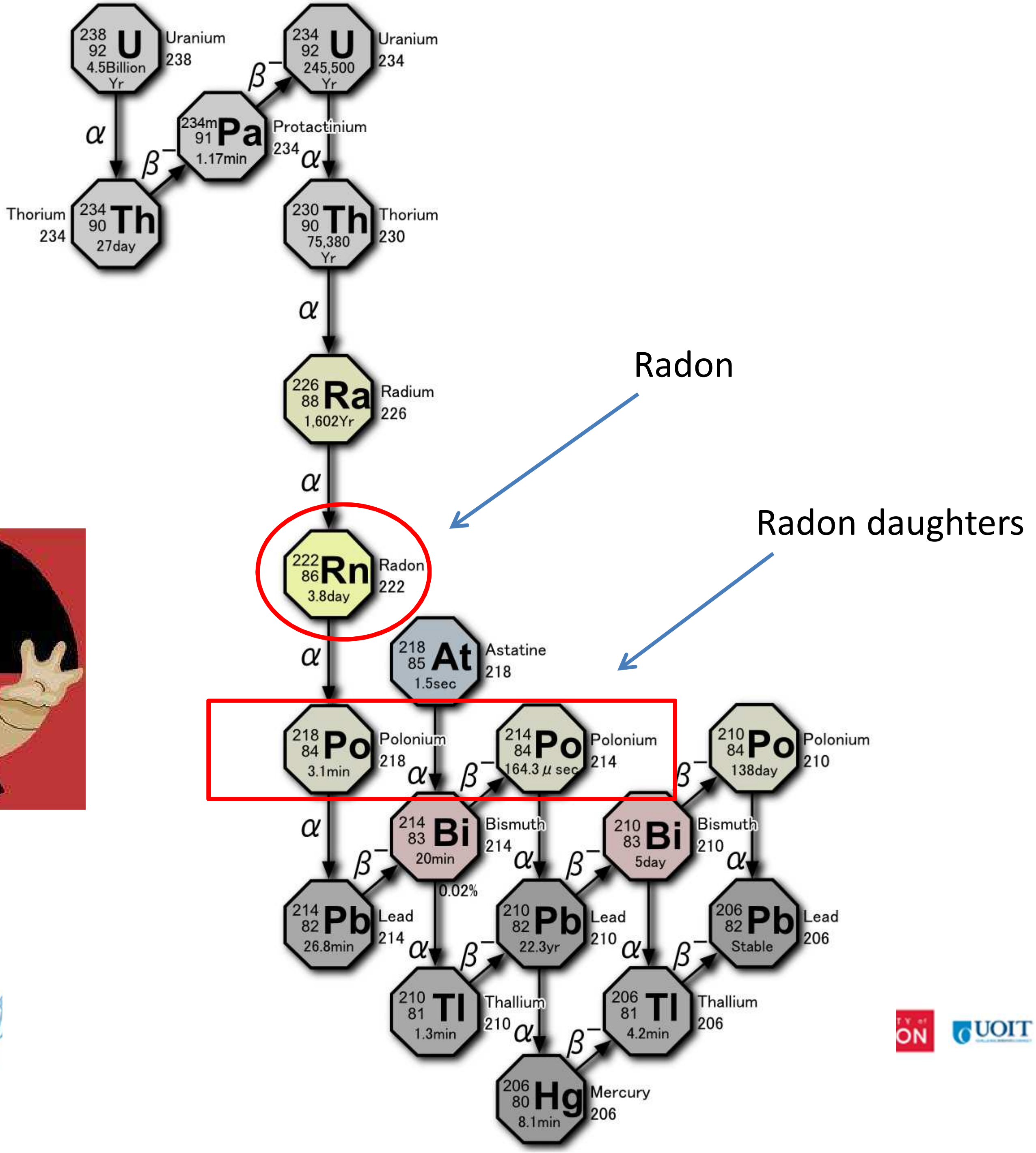
Physics of track detectors

When an <u>ionizing charged particle</u> passes through a dielectric material the <u>transfer of energy</u> to electrons results in a trail of <u>damaged molecules along the particle's track</u>.

Radiation Detection and Measurements, G. Knoll

The tracks can be made visible with a chemical treatment, called "<u>Etching</u>". The opening of the track is then of about 5-20 µm depending on the type and energy of the hadrons.

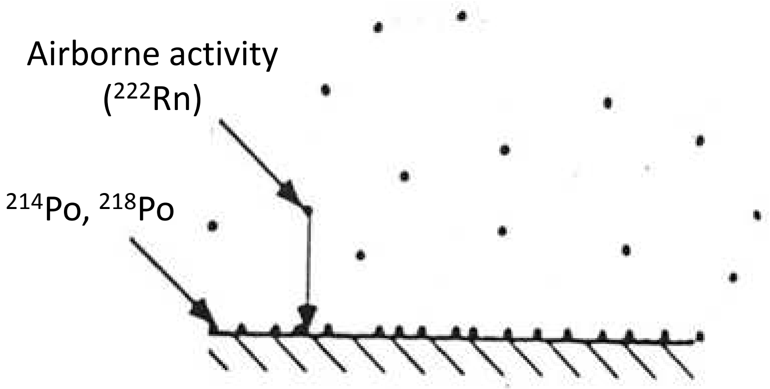




238 92 U 4.5Billion Yr
Uranium 238
234 92 U 245,500 Yr
Uranium 234
234m 91 Pa 1.17min
Protactinium 234
Thorium 234
234 90 Th 27day
230 90 Th 75,380 Yr
Thorium 230
226 88 Ra 1,602Yr
Radium 226
Radon
222 86 Rn 3.8day
Radon 222
Radon daughters
218 85 At 1.5sec
Astatine 218
218 84 Po 3.1min
Polonium 218
214 84 Po 164.3 μ sec
Polonium 214
210 84 Po 138day
Polonium 210
214 83 Bi 20min
Bismuth 214
210 83 Bi 5day
Bismuth 210
0.02%
214 82 Pb 26.8min
Lead 214
210 82 Pb 22.3yr
Lead 210
206 82 Pb Stable
Lead 206
210 81 Tl 1.3min
Thallium 210
206 81 Tl 4.2min
Thallium 206
206 80 Hg 8.1min
Mercury 206

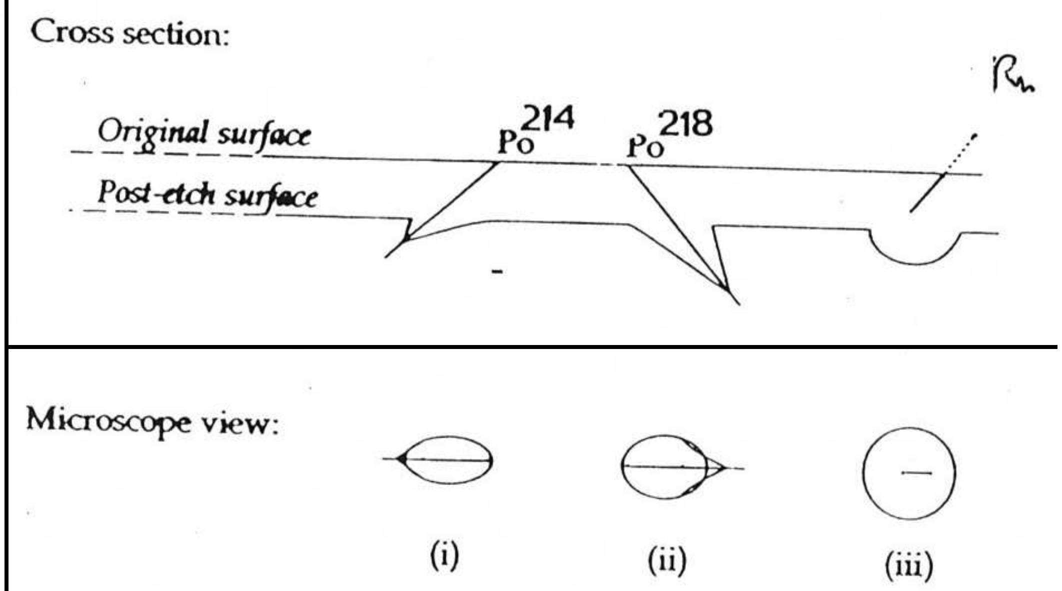
Detecting Radon

Alpha particles from ^{222}Rn, ^{214}Po & ^{218}Po

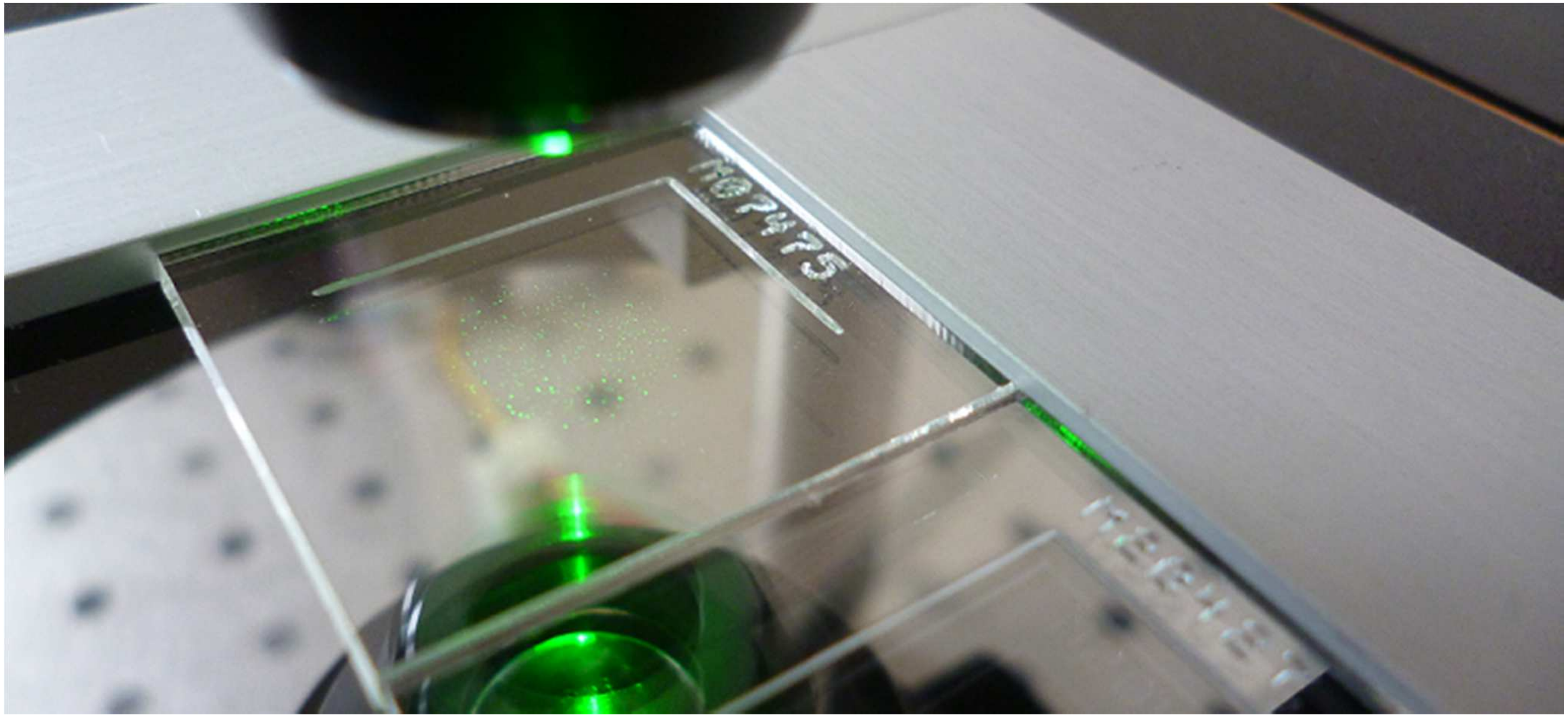


Surface of CR-39 detector

Different shape of tracks left by Radon and Radon daughters (Polonium)



Measuring Radon



Tracks left by alpha particles in CR-39, from Radon and Polonium, seen with the naked eye.

Measuring Radon

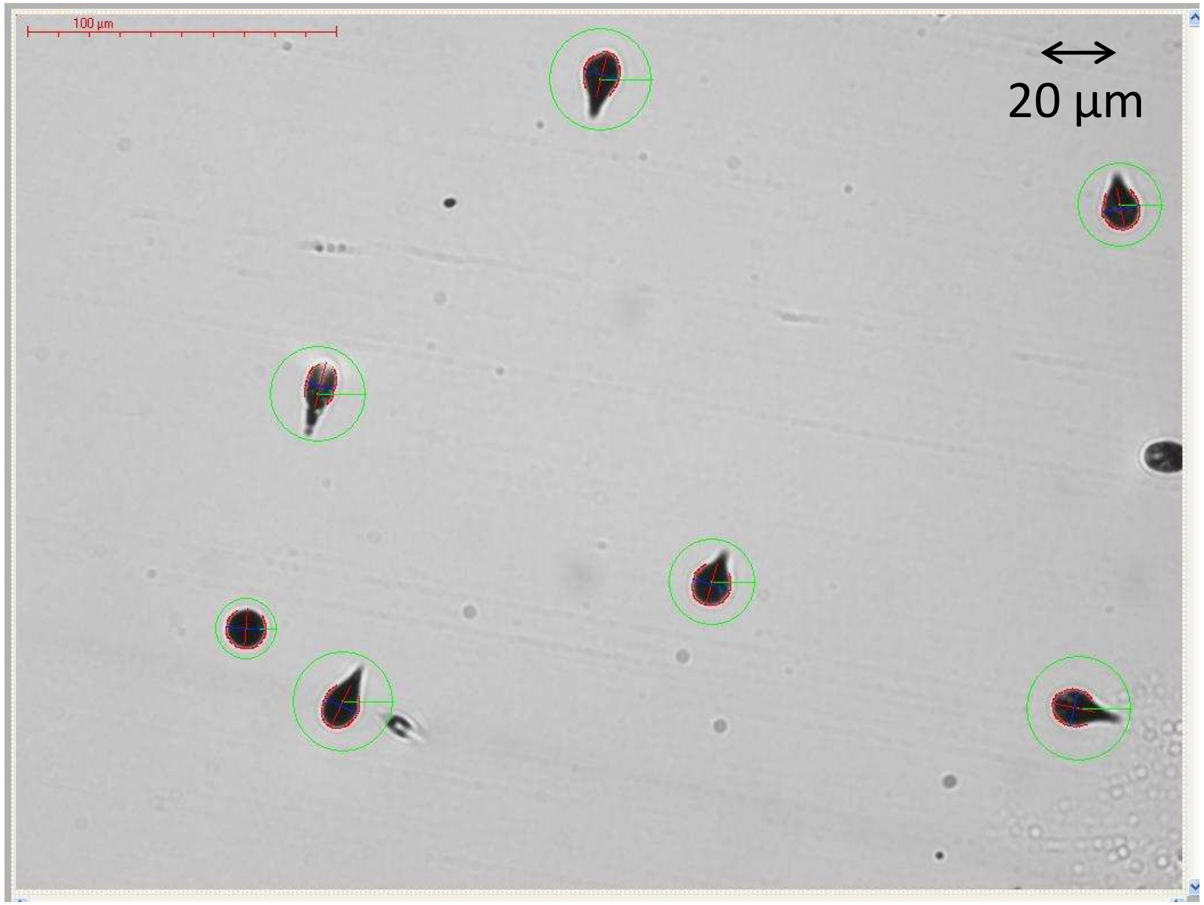
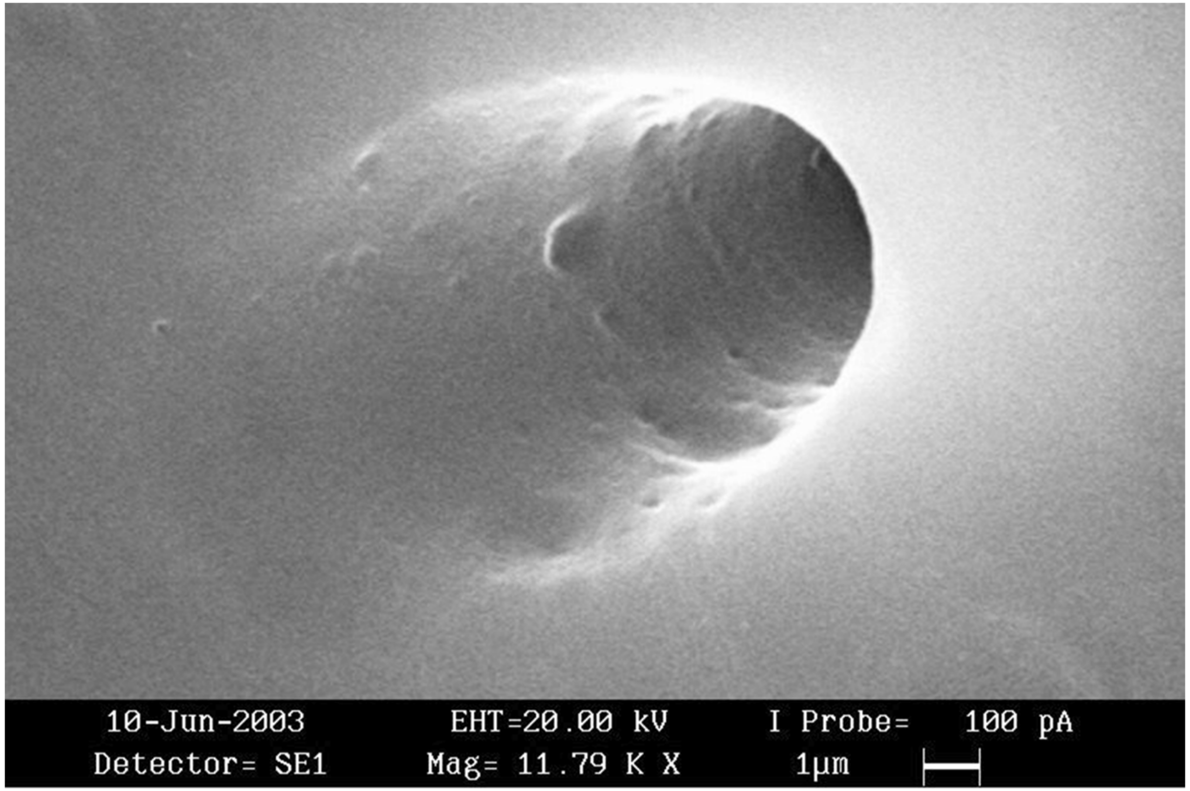


Image of tracks captured, after etching, with the POLITRACK microscope in a CR-39 detector exposed to Radon gas

Track left by alpha particle



Very close look at an alpha particle's track using an Scanning Electron Microscope (SEM)

QUIZ (a short one)

QUIZ (a short one)

a) Is Radon visible to our naked eye?

- ❑ YES of course
- ☐ NO this is impossible

b) Where could we find Radon in greatest proportions in our house?

- ❑ Cellar
- ☐ Terrace

c) What is the effect of Radon on your body?

- ❑ Provokes lung cancer
- ☐ Makes you more beautiful

d) What is the best technique to avoid accumulation of Radon in your house?

- ❑ Ask advice to an expert
- ☐ Ventilate regularly all rooms and cellar

e) If we <u>cannot</u> see, feel, smell or taste Radon gas, how do we detect it?

- ❑ Detect alpha particles from Rn & Po
- ☐ Call the Police

Answers…

a) Is Radon visible to our naked eye?

- ☐ YES of course
- ☒ NO this is impossible

b) Where could we find Radon in greatest proportions in our house?

- ☒ Cellar
- ☐ Terrace

c) What is the effect of Radon on your body?

- ☒ Provokes lung cancer
- ☐ Makes you more beautiful

d) What is the best technique to avoid accumulation of Radon in your house?

- ☒ Ask advice to an expert
- ☒ Ventilate regularly all rooms and cellar

e) If we <u>cannot</u> see, feel, smell or taste Radon gas, how do we detect it?

- ☒ Detect alpha particles from Rn & Po
- ☐ Call the Police

Experiments

Neil Patrick Harris,
Dr Horrible

Experiments

- Session 1
  - Calibrate CR-39 detectors

- Session 2
  - Measure the amount of radon in your house
  - Calculate the amount of Radon recorded by the CR-39 detector

Session 1 - Calibration

a) Using the optical microscope to count the number of track on the CR-39 detectors, left from Radon and Radon daughters for the known Exposure levels.

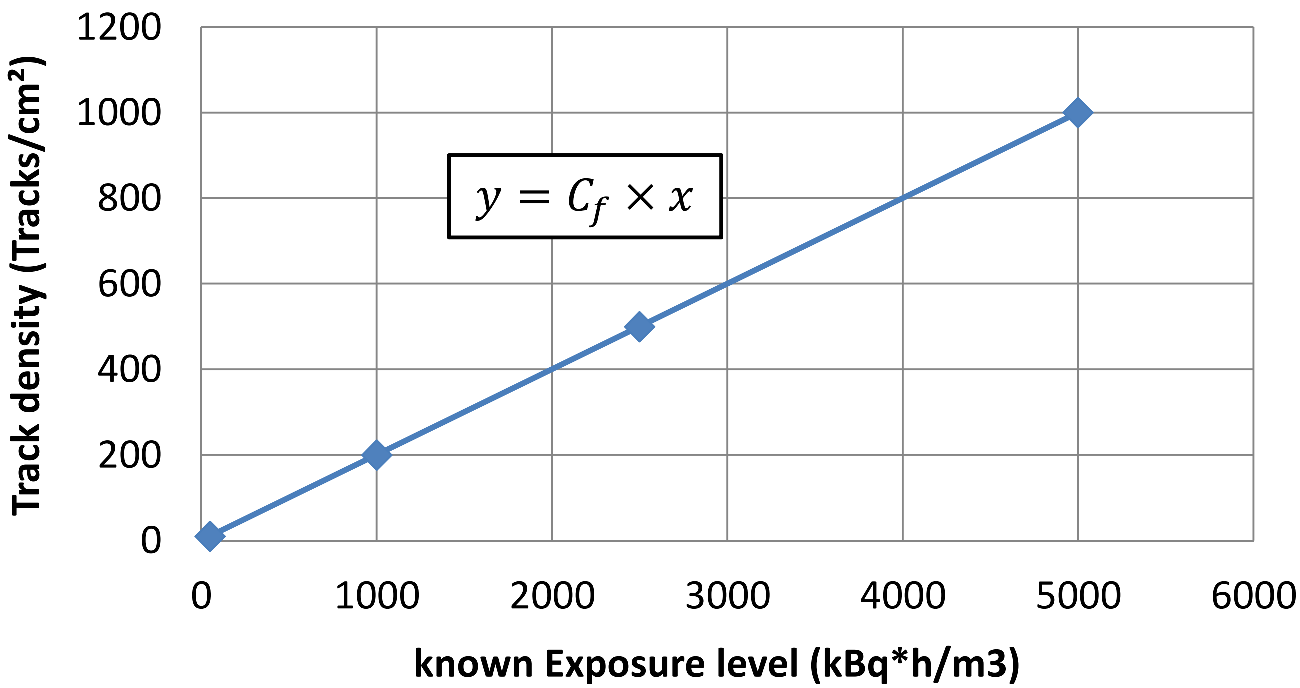
b) Calculate the area used for measurements

c) Calculate the track density (N° of tracks per cm^2)

d) Plot the graph of Track density (N° of tracks per cm^2) VS. Radon exposure ($Bq*h/m^3$)

e) Calculate the Calibration Factor (C_f) which is the gradient of the graph (see next slide)

Example of calibration curve



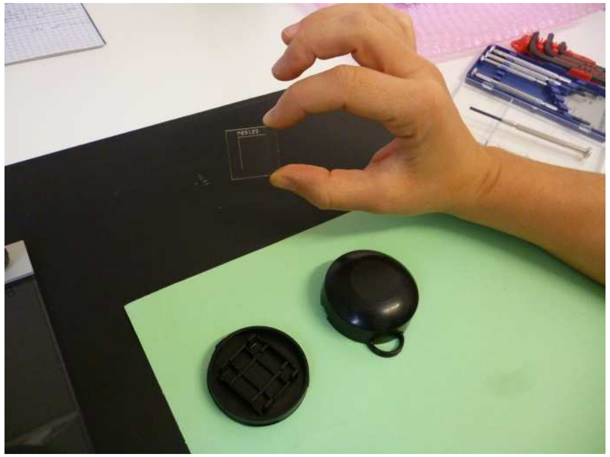
$$Track\ density = \boldsymbol{C_f} \times Exposure$$

Session 2 – Radon measurement

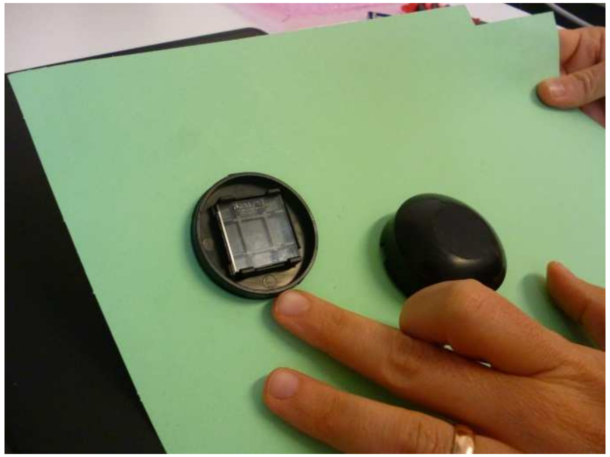
1. Assemble CR-39 detector and holder
2. Expose detectors in a “living space” during period of time T
3. After exposition, detector is etched in conc. NaOH for 60 mins at Mi.am SRL
4. Detectors are read with an optical microscope to count the track density (N° of tracks per cm^2)
5. Calculate Exposure using equation 1
6. Calculate Radon Concentration using equation 2
7. CONGRATULATIONS! You are a Radiation Protection Expert!!!

Step 1 – Detector assembly

Take the CR-39 detector | Put CR-39 in base of holder | Clip in the cover of the holder



(a)

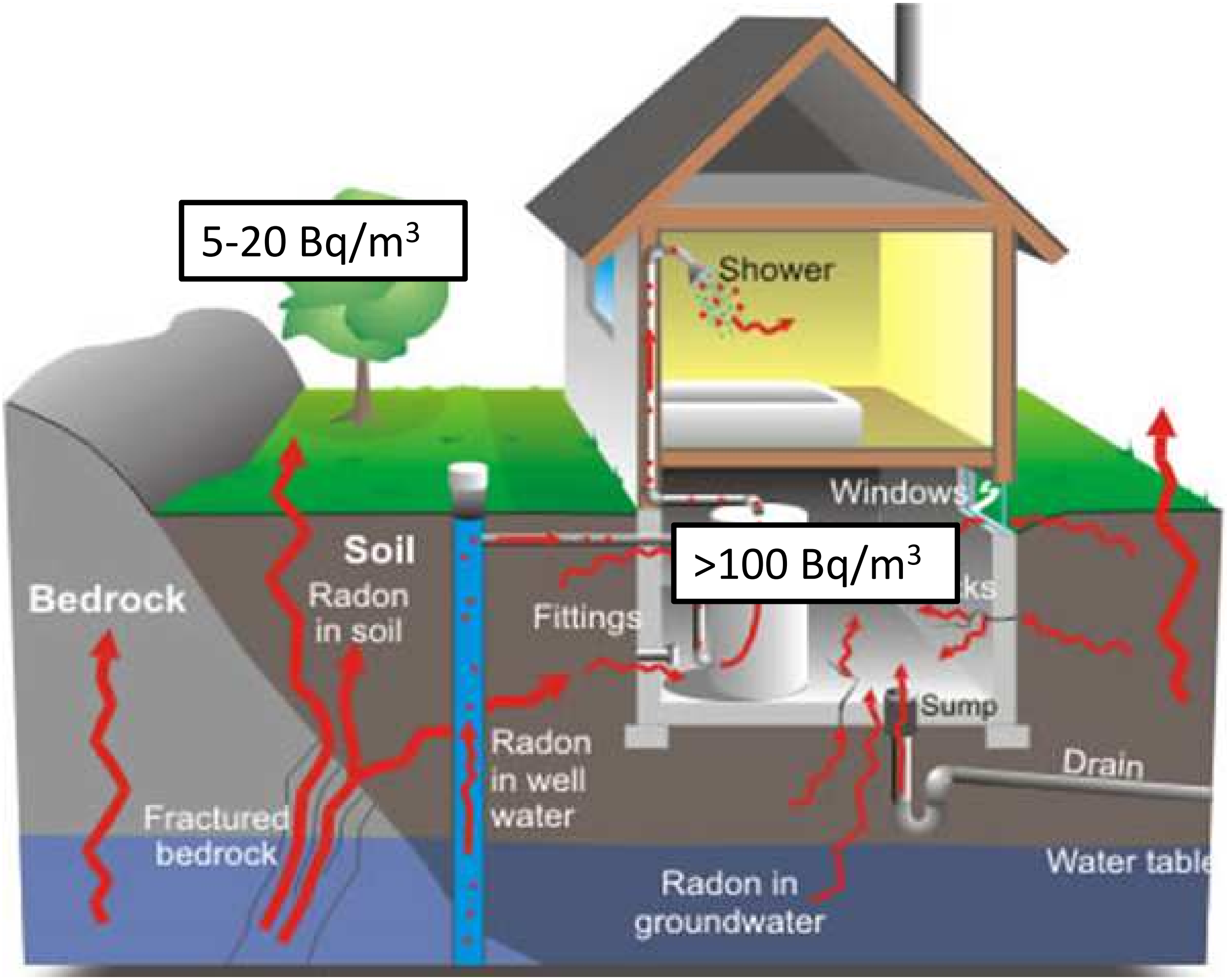


(b)

(c)

Special thanks to Barbara Rossi for lending her hands for this presentation

Recap: Where do we find ^{222}Rn?



- Radon is emanated from the Uranium rich soil or rocks
- Radon can also be found in water
- Radon escapes easily from the ground into air where it decays into its *progeny* ***^{214}Po, ^{218}Po***

World Health Organisation

Step 2 – Radon measurement

This is not my house, these pictures were taken randomly from the internet

Living room

Bedroom

Cellar

Bathroom

The detector should be exposed in a "living space" for several months:

- Bedroom
- Living room
- Study room
- Basement used as playroom
- Cellar (Wine)
- Bathroom

Choose one of those rooms in your house/apartment for the experiment

Step 3 - Etching

Etching is important in order to reveal the tracks formed at the surface of CR-39 after it has been exposed to Radon gas

60 mins in conc. aqu. solution of NaOH at 98 °C

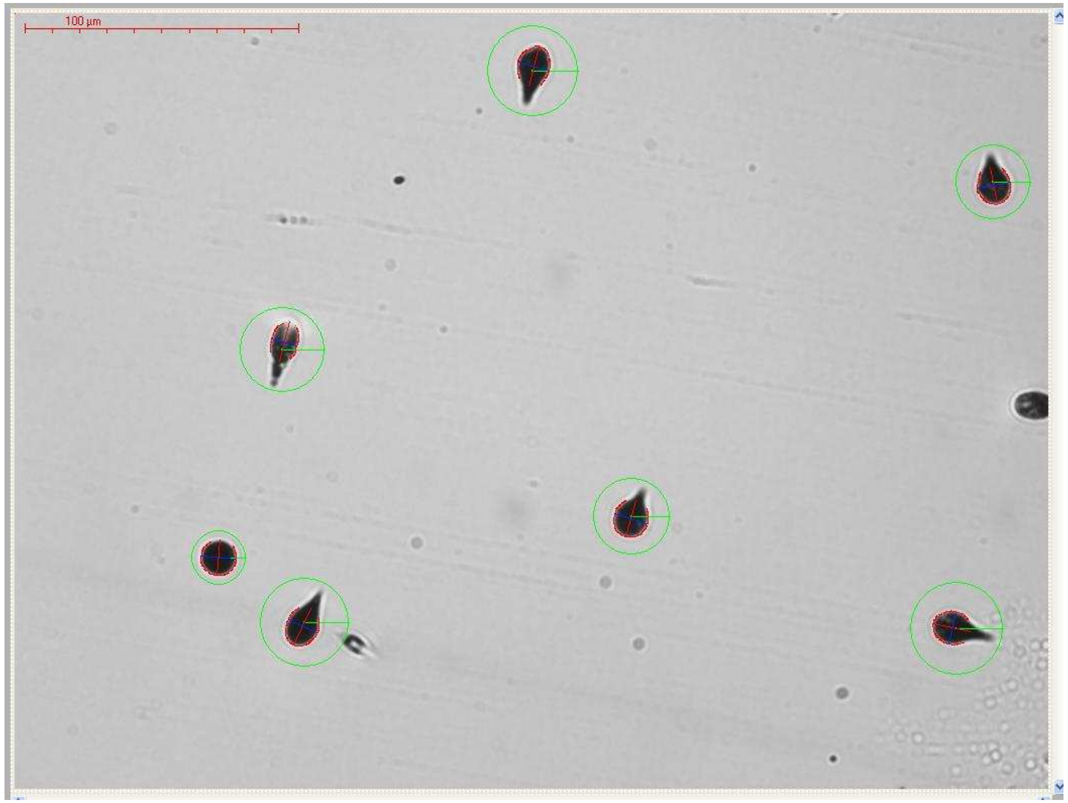
Step 4 – Track density (Tracks per cm²)

1. Look at the CR-39 detector under the microscope.

2. Count the total number of tracks you can find on a surface of 1 cm × 1 cm = 1 cm²

3. This number of tracks in 1 cm² is the track density

4. Note down this track density for step 5



Step 5 – Calculate Radon Exposure

$$\text{Exposure} = \frac{\rho_{tracks}}{C_f}$$

[Bq*h/m^3]

Where ρ_{tracks} is the track density expressed in cm^{-2} and C_f is the calibration factor calculated in Session 1.

Step 6 – Calculate Radon concentration

$$\text{Radon Conc.} = \text{Exposure} / \text{T} \qquad [\text{Bq/m}^3]$$

Where *Exposure* is the Radon exposure expressed in $Bq*h/m^3$ and *T* is the exposition time in hours.

NB: Remember to take note of the irradiation time, note the date you start and finish the experiment

Step 7 – Congratulations!!!

You are a

Radiation Protection Expert!!!!

I am joking :)

Applications of CR-39 detector

Widely used for several applications:

- Radon measurement – Environmental dosimetry ★
- Fast neutron dosimetry – Space, Aircrafts and Particle Accelerators
- Thermal neutron dosimetry – Nuclear Reactors
- Cosmic rays detection – Observatories
- High Energy Physics experiments – Nuclear Fusion, Military & Defense

Neutron detection

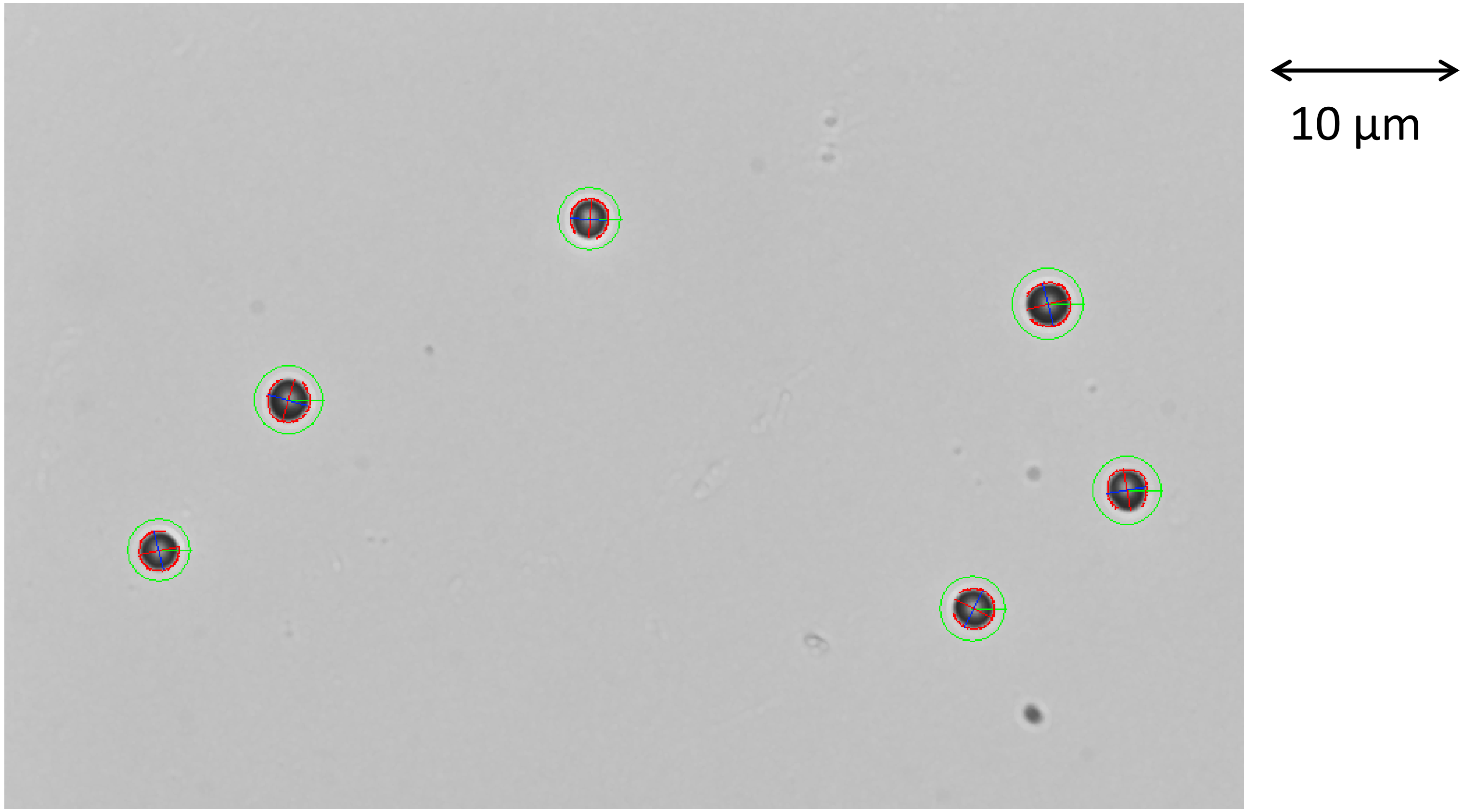


Image of tracks captured, after etching, by POLITRACK in a CR-39 detector (coupled to PMMA) exposed in a quasi-monoenergetic neutron beam.


www.nasa.gov


www.nasa.gov