The Radon daughter implementation on the surface of the rare events detectors

Ali DASTGHEIBI FARD

CNRS/LPSC_LSM

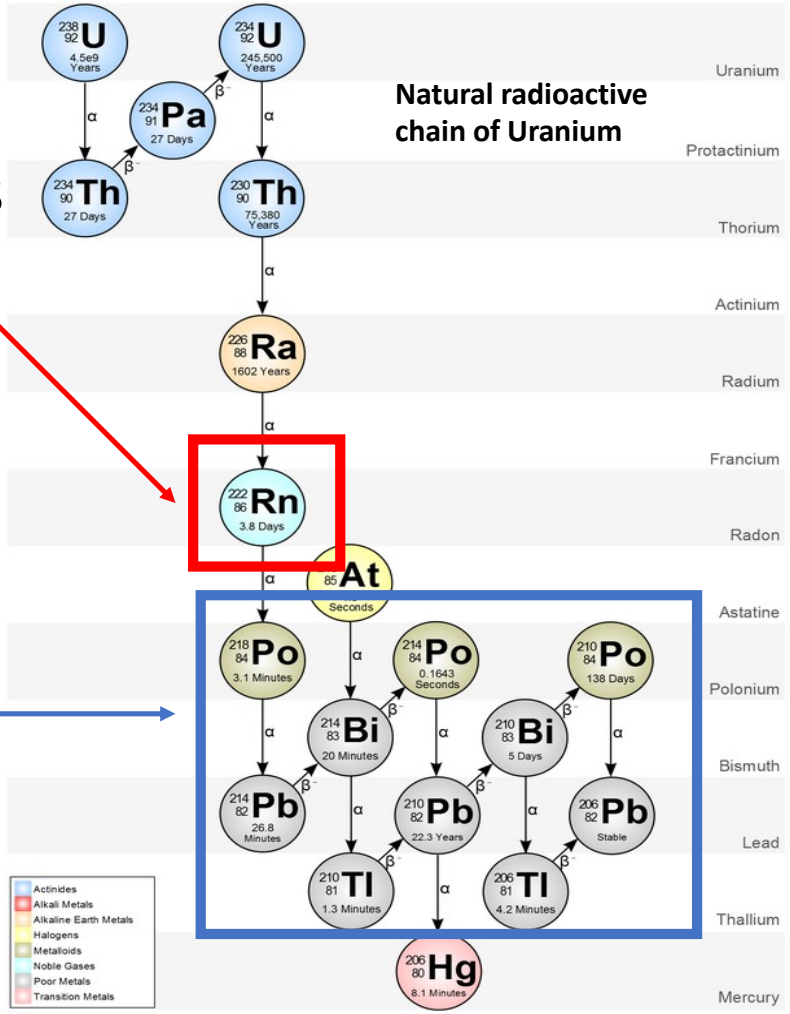
(Part of the results from Mounir OMRI internship @ LSM)

EDSU 2022 Nov 7-11

Laboratoire Souterrain de Modane

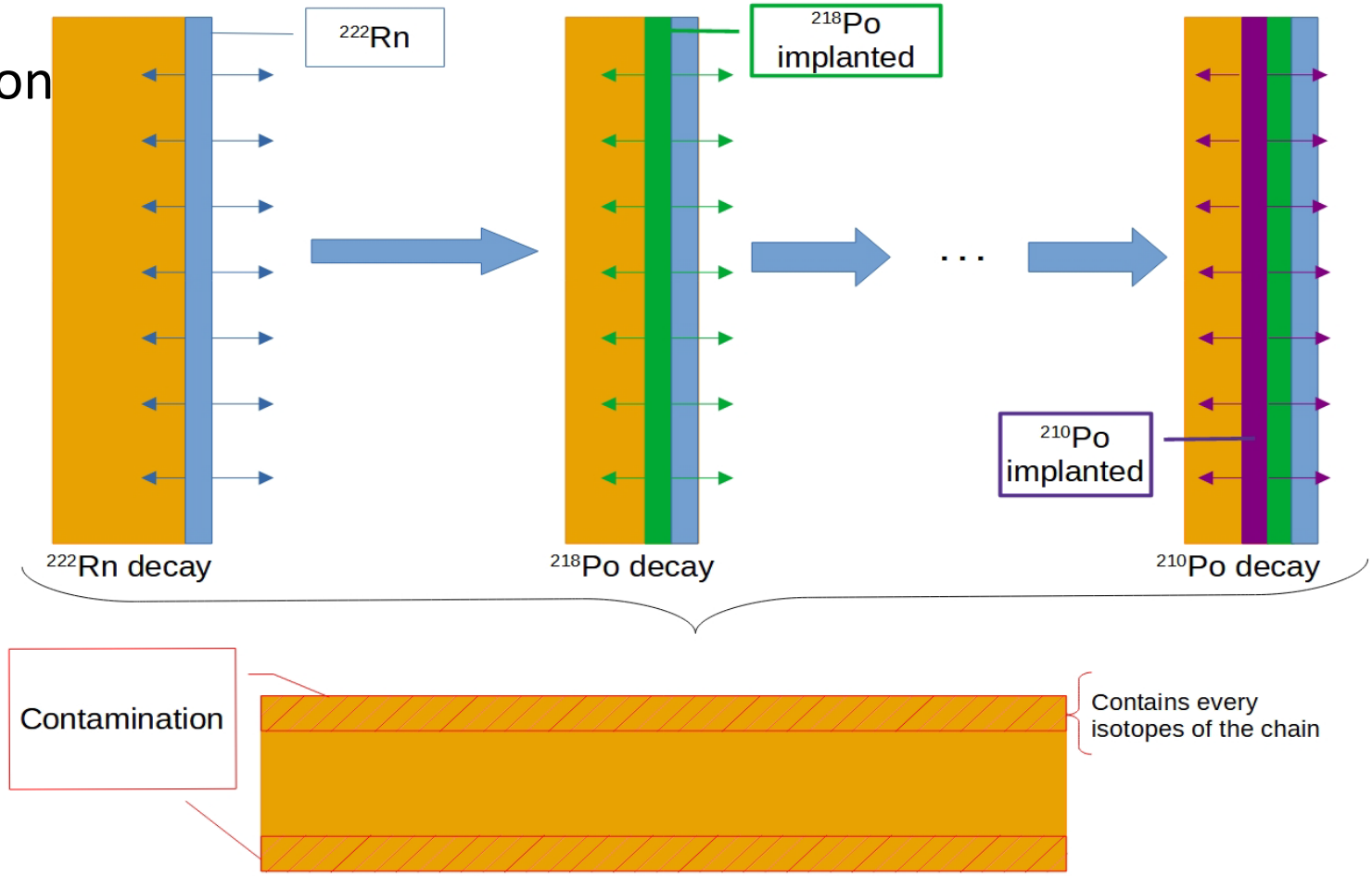
Motivation: Radon daughter like background source

- Radon comes from the soils and rocks emanation (contain U and Th)
- Radon (^{222}Rn) is a noble radioactive gas with $t_{1/2}$ = 3.8 d existing in air.
- Radon daughter can deposit on the surface of the detector components in contact with air
- Main issues come from the accumulation on the surface of:
  - ^{210}Pb -> $t_{1/2}$ = 22.3 y
  - ^{210}Po -> $t_{1/2}$ = 138 d
- Possible background source for rare events detection at low masses



Radon like source behaviour

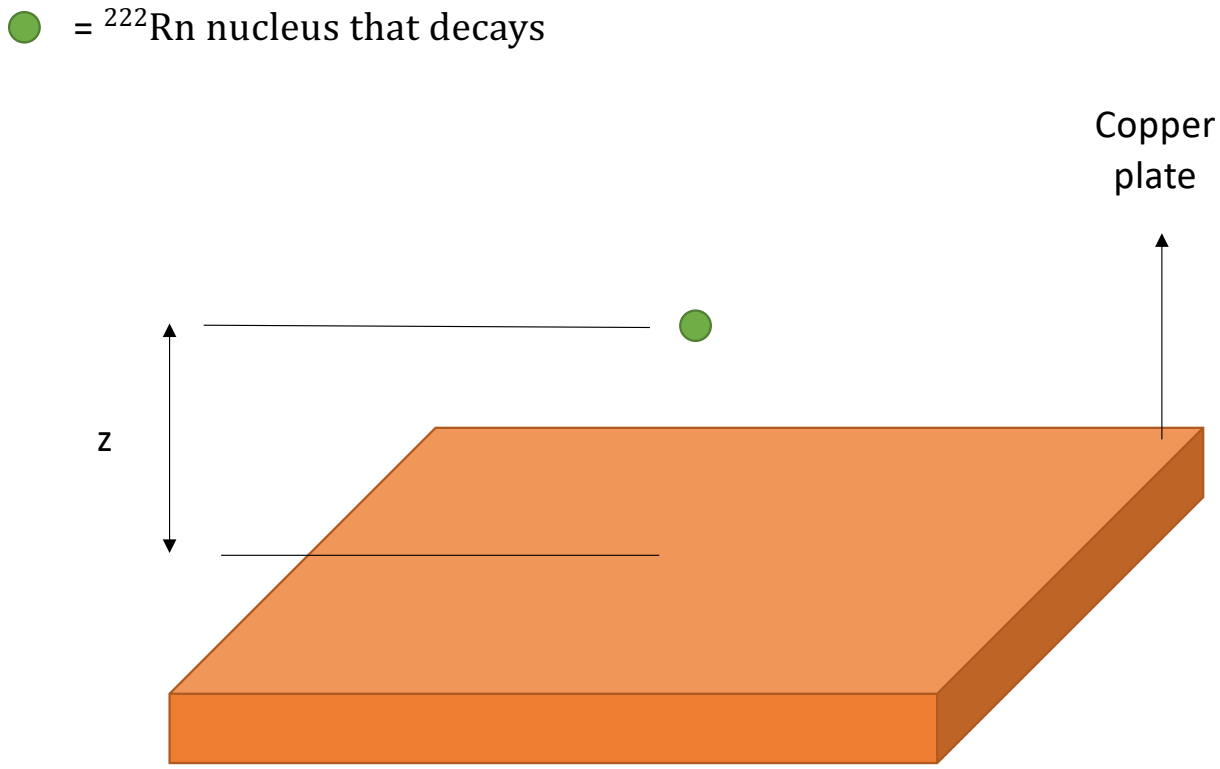
- First deposition of radon or radon daughter is triggered by chemical properties
- Study of implantation using Geant4 to probe nuclear recoil



Radon implementation schematic

Implementation processes

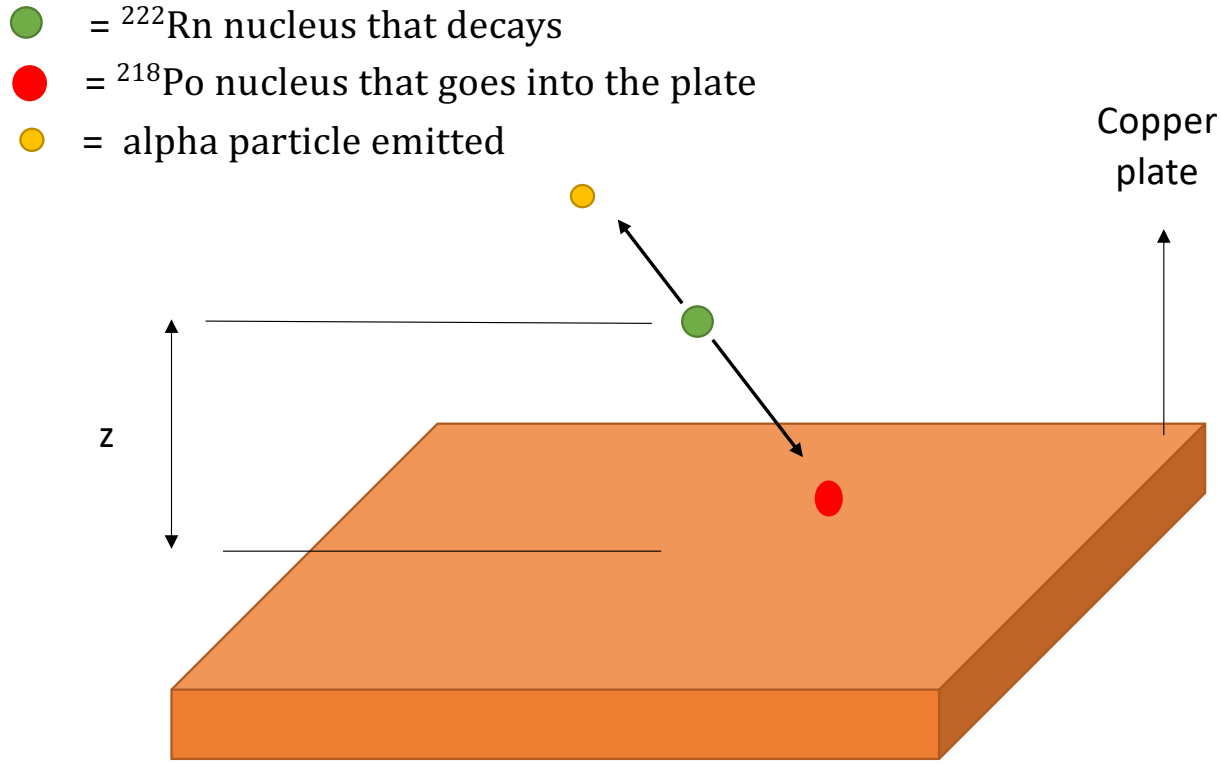
- It occurs on the surface and consists of the insertion of Radon daughters into solid surface.
- The implantation process occurs because of nuclear recoil of Radon and its daughters.
- Radon daughters can be extracted from the surface as they can be implanted further.



Radon implementation schematic

Implementation processes

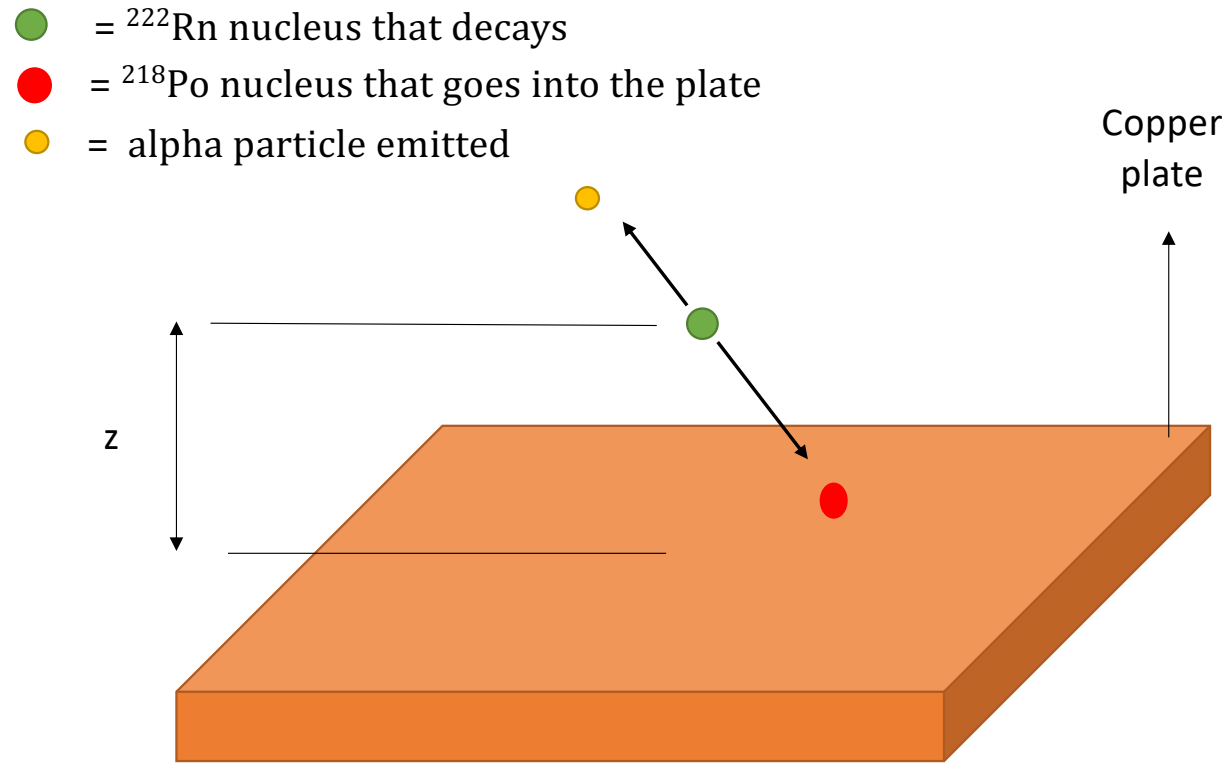
- It occurs on the surface and consists of the insertion of Radon daughters into solid surface.
- The implantation process occurs because of nuclear recoil of Radon and its daughters.
- Radon daughters can be extracted from the surface as they can be implanted further.



Radon implementation schematic

Implementation processes

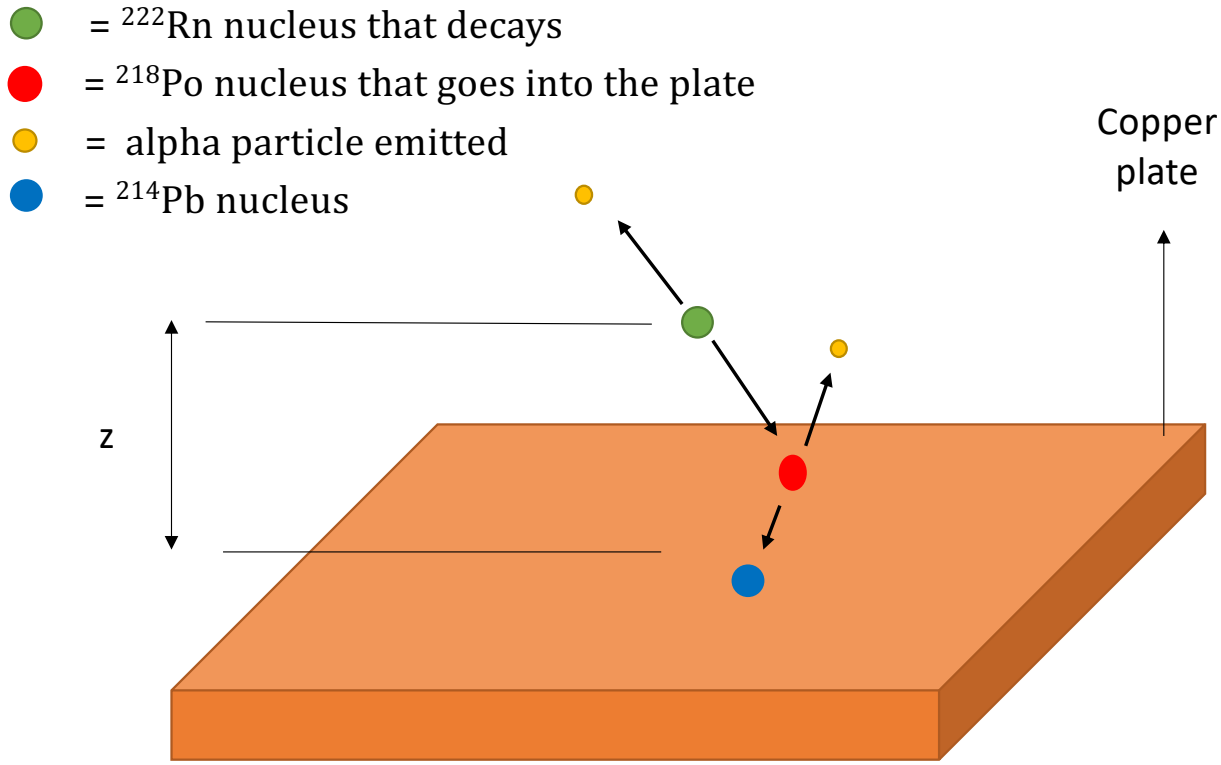
- It occurs on the surface and consists of the insertion of Radon daughters into solid surface.
- The implantation process occurs because of nuclear recoil of Radon and its daughters.
- Radon daughters can be extracted from the surface as they can be implanted further.



Radon implementation schematic

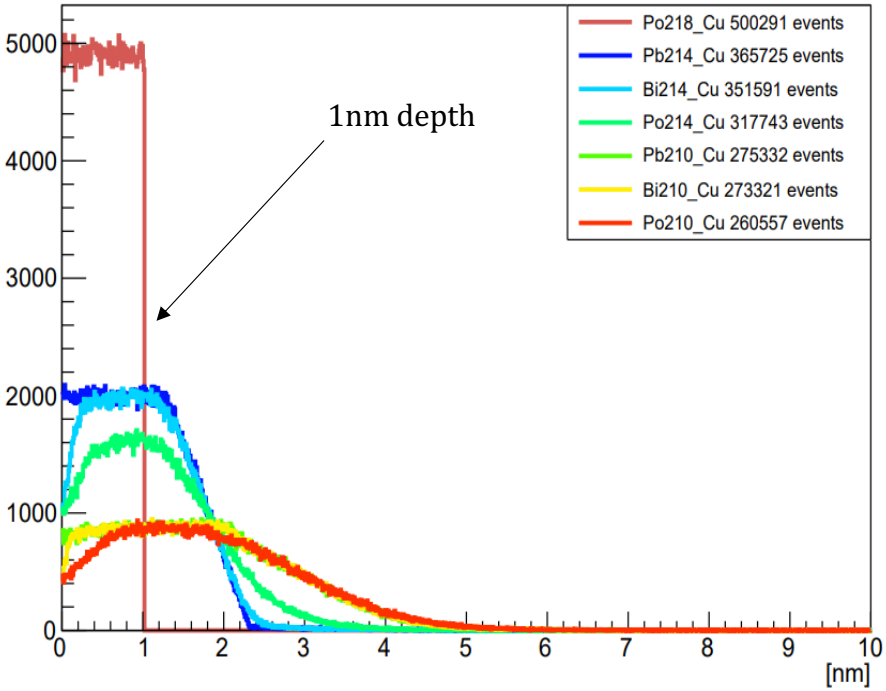
Implementation processes

- It occurs on the surface and consists of the insertion of Radon daughters into solid surface.
- The implantation process occurs because of nuclear recoil of Radon and its daughters.
- Radon daughters can be extracted from the surface as they can be implanted further.

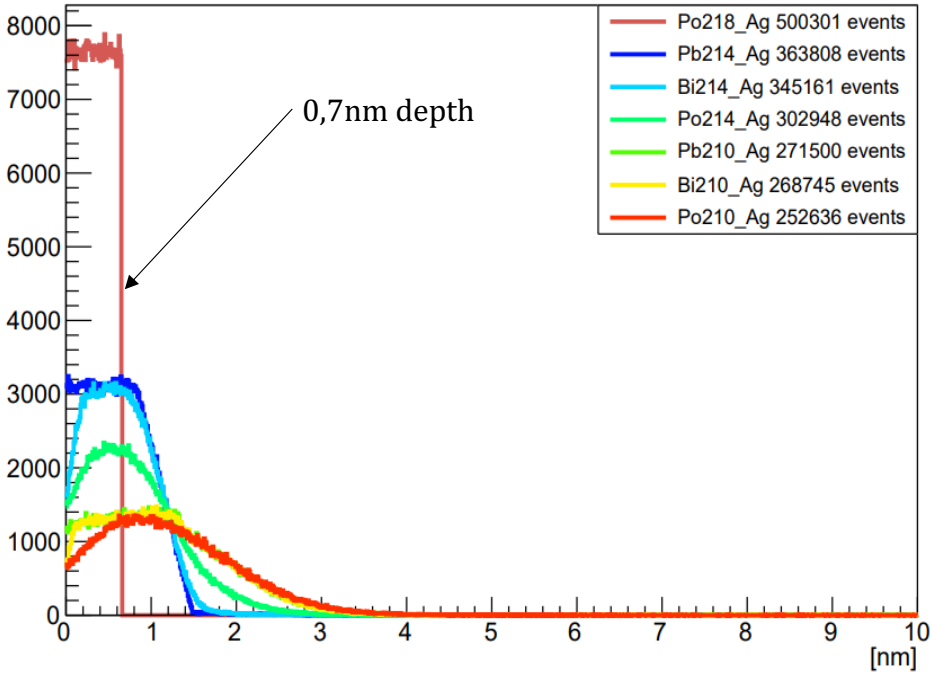


Simulation #1

Source placed on the surface of the plate at (0,0,0)



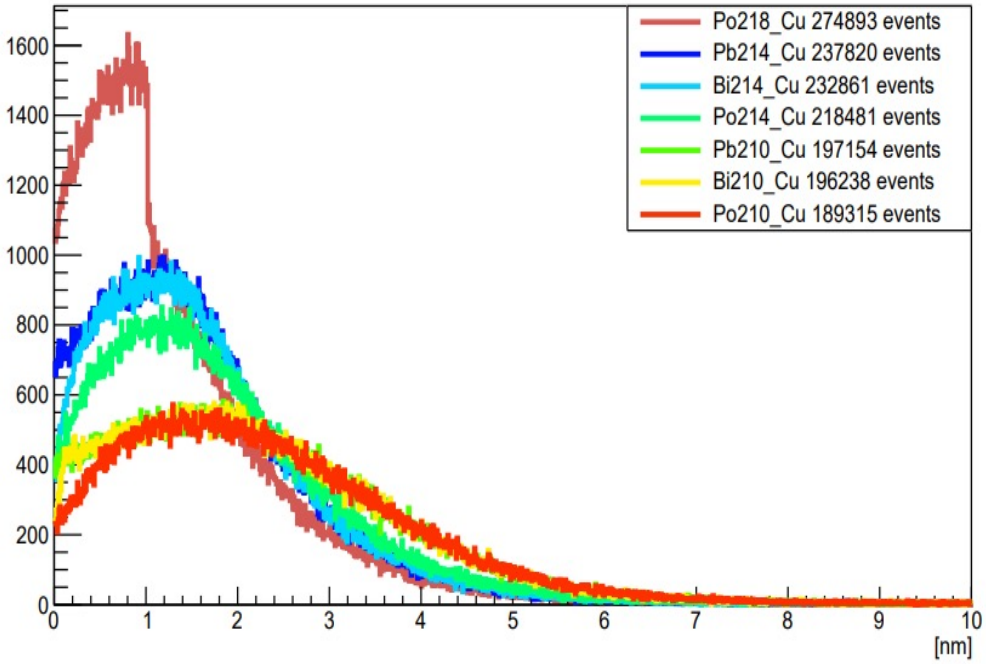
Implantation depth on ^{222}Rn daughters following 10^6 decays on a **copper** surface



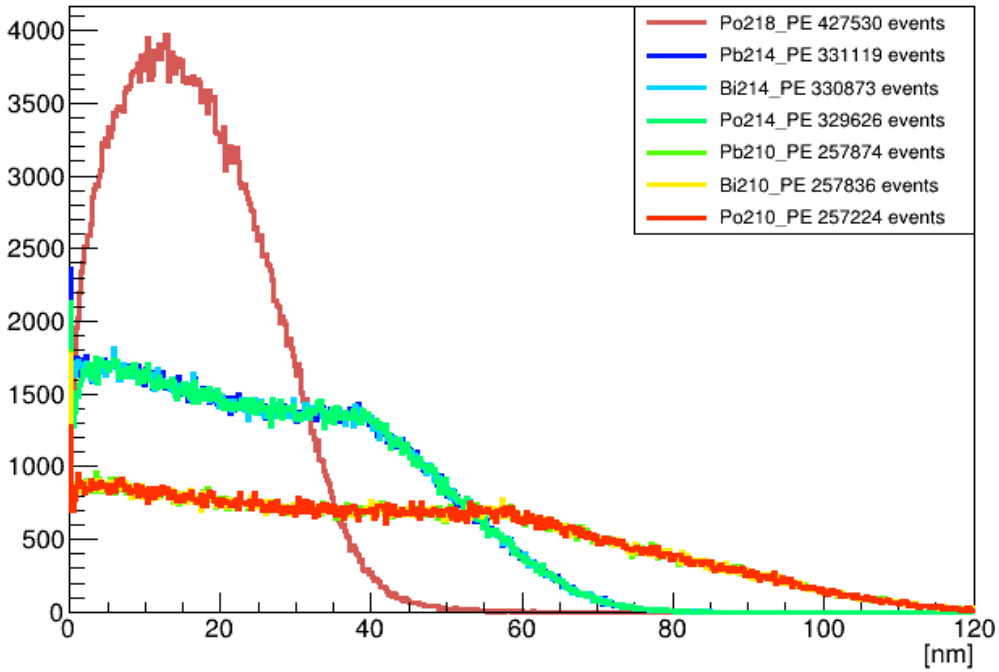
Implantation depth on ^{222}Rn daughters following 10^6 decays on a **silver** surface

Simulation #2

Source placed on the surface at 1nm over the plate



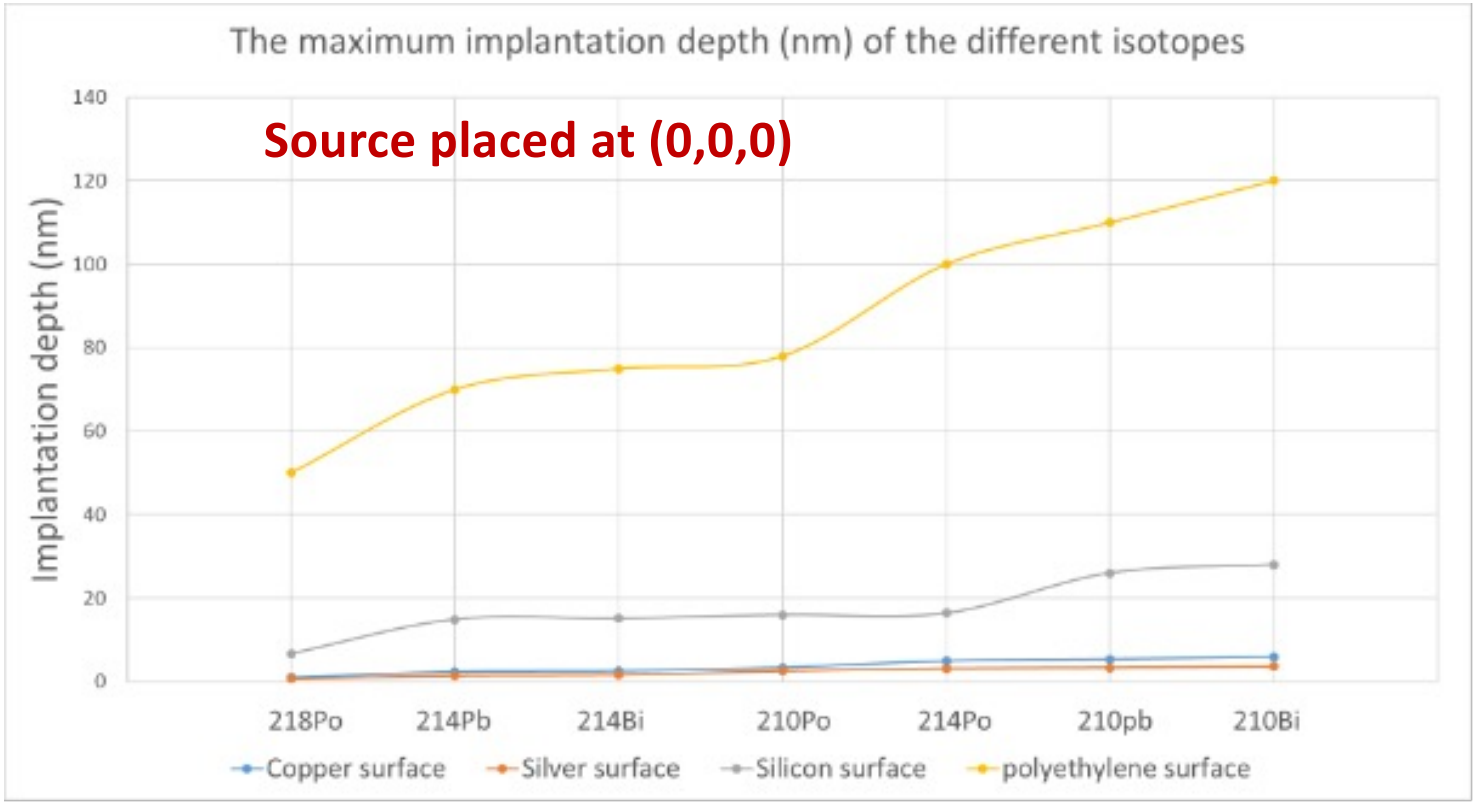
implantation depth of ^{222}Rn decay chain at a distance of 1 nm from the **copper** plate.



implantation depth of ^{222}Rn decay chain at a distance of 1 nm from the **Polyethylene** plate.

Simulation #3

Maximum implantation depth



Maximum implantation depth for each isotope from the ^{222}Rn decay chain

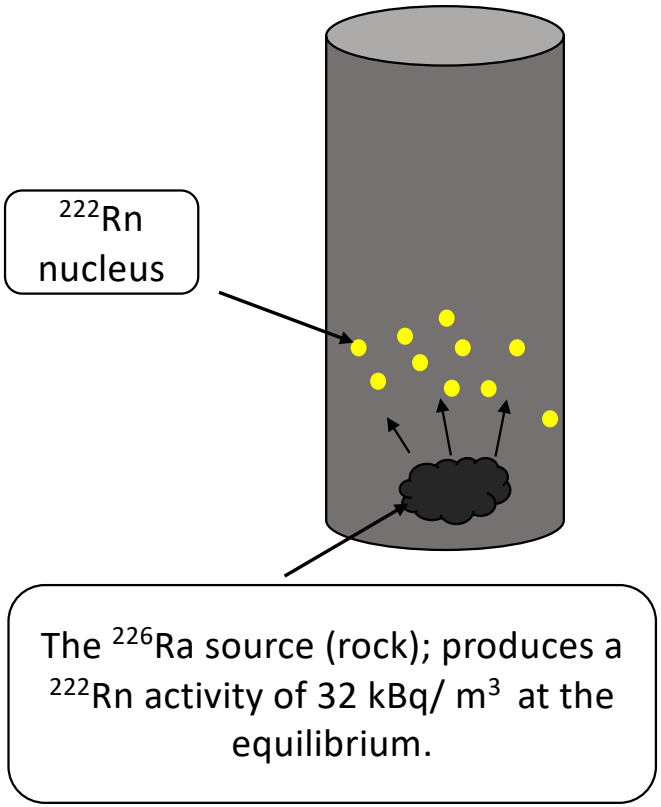
Further simulations were performed for other materials in order to compare the maximum implantation depth results for different densities.

$$\rho_{Ag} > \rho_{Cu} > \rho_{Si} > \rho_{PE}$$

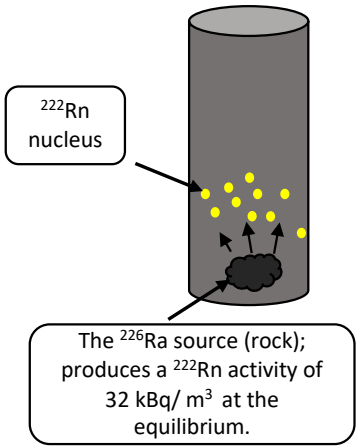
And

$$Z_{Ag} > Z_{Cu} > Z_{Si} > Z_{PE}$$

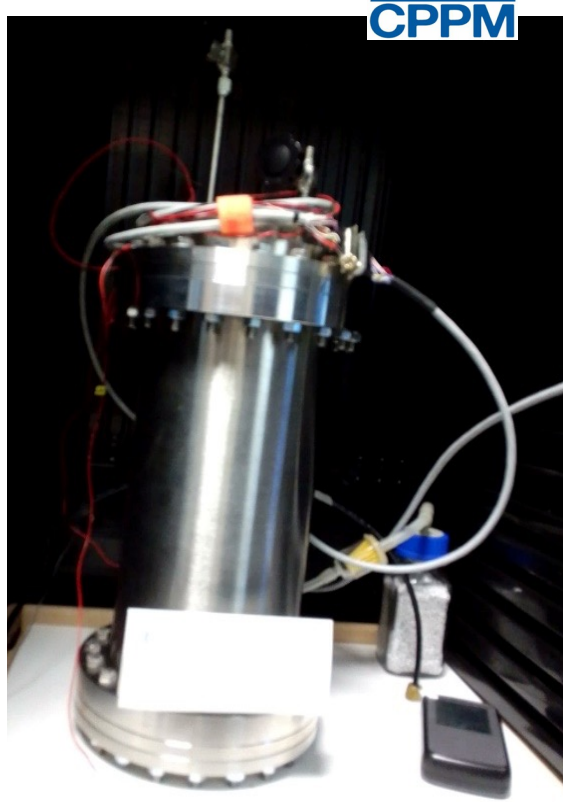
Experiment: Samples “radonisation” @ CPPM



Experiment: Samples “radonisation” @ CPPM



a) Support of the samples



b) Radonisation chamber

Experiment: Samples “radonisation” @ CPPM

The experiment is carried out at the particle physics center of the Marseille University (CPPM) with Pr. José Busto.

The samples used for the measurements with a size of 3x3 cm

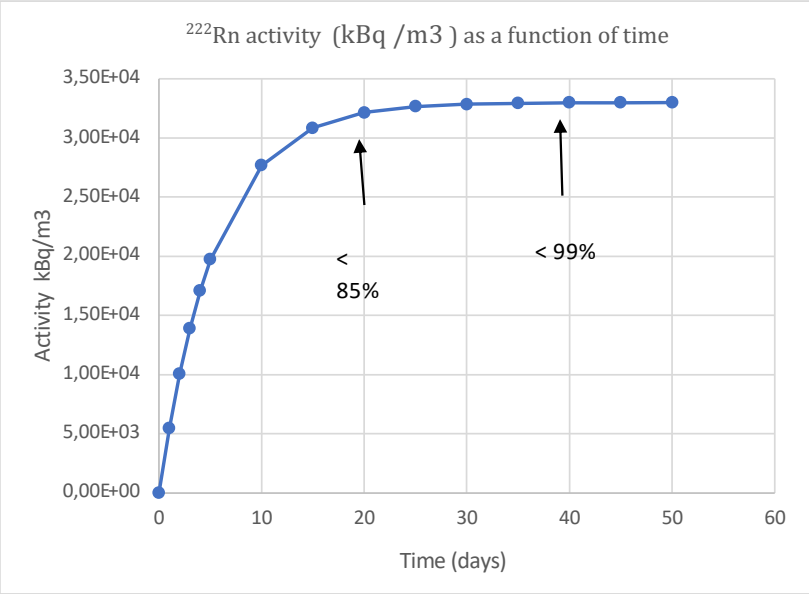
1) Covered Copper sample with 1 plastic bag.
2) Covered Copper sample with 2 plastic bags.
3) Covered Copper sample with 3 plastic bags.
4) Bare silver sample.
5) Bare copper sample.
6) Bare polyethylene sample.
7) Bare scintillator sample.

batch	Temperature °C	Humidity %
A	18	59
B	18	100
C	45	59
D	45	100

Temperature and humidity conditions during measurements

Experiment: Samples “radonisation” @ CPPM

^{222}Rn activity evolution over time



illustrates the evolution of ^{222}Rn activity as a function of time in the measurement chamber.

The results

- The results from our measurement are under analysis
- Other experiment was done for DARK SIDE. The results: using the several layers of plastic show:
  - 1 foil layer decrease by factor 3.6
  - 2 foil layers decrease by factor ≥ 160
  - 3 foil layers decrease by factor ≥ 160 (detection limit)

Summary

- The Radon is a noble radioactive gas, from soils and rocks out-gasing
- The Radon daughters deposition can become a source of background, mainly : ^{210}Pb and ^{210}Po
- The simulations are ongoing to modelized the Radon implementation
- The experimentation measurement are ongoing with variation of humidity and temperature

How to avoid

- Reducing the exposure time with air
- After production/cleaning, storge the detector component in the adapted plastic bag and/or under the inert gas (Or anti-radon tent)

سپاس

Mési

Merci

谢谢

Gracias

謝謝

Thanks

Danke

Grazie

धन्यवाद

Back up

Radon implantation model #1

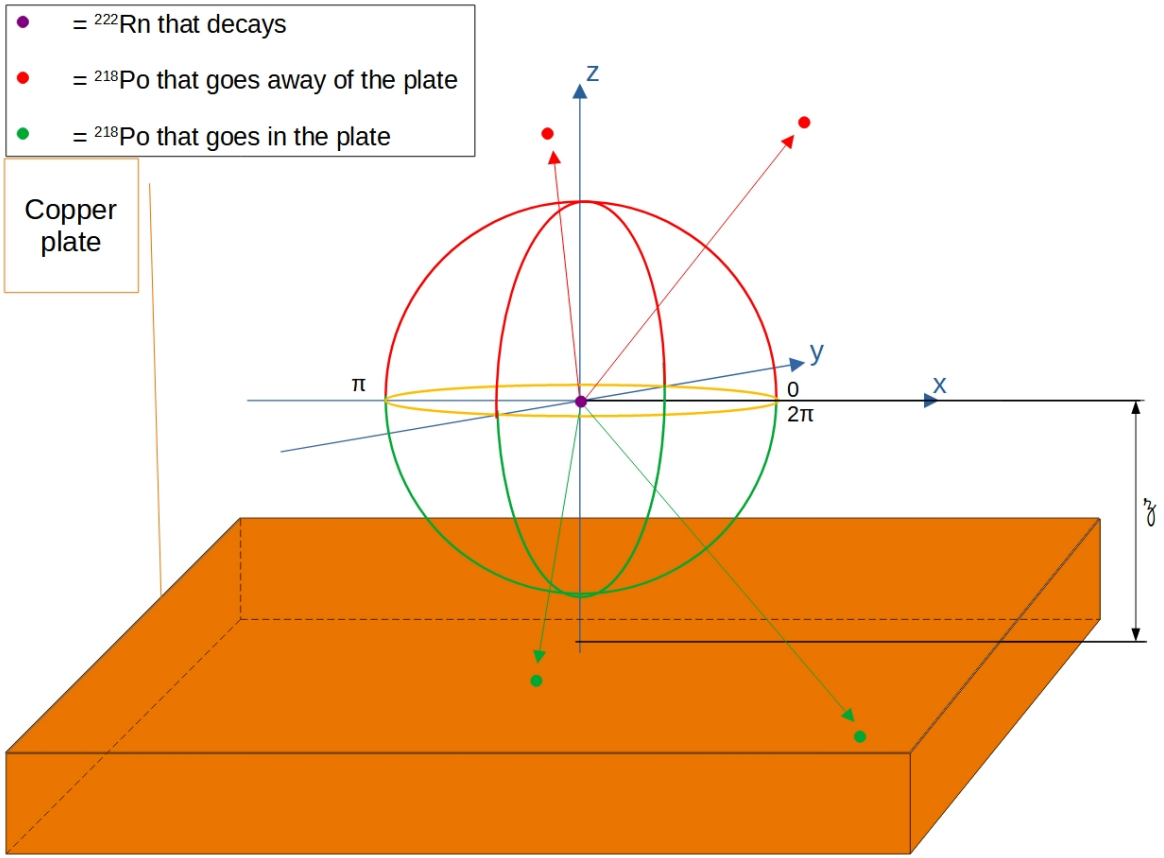
Modelisation Radon daughters:

- On the surface
- In the bulk (z tbd)
- Define a function for each isotope according the obtained curve

An internal new contamination

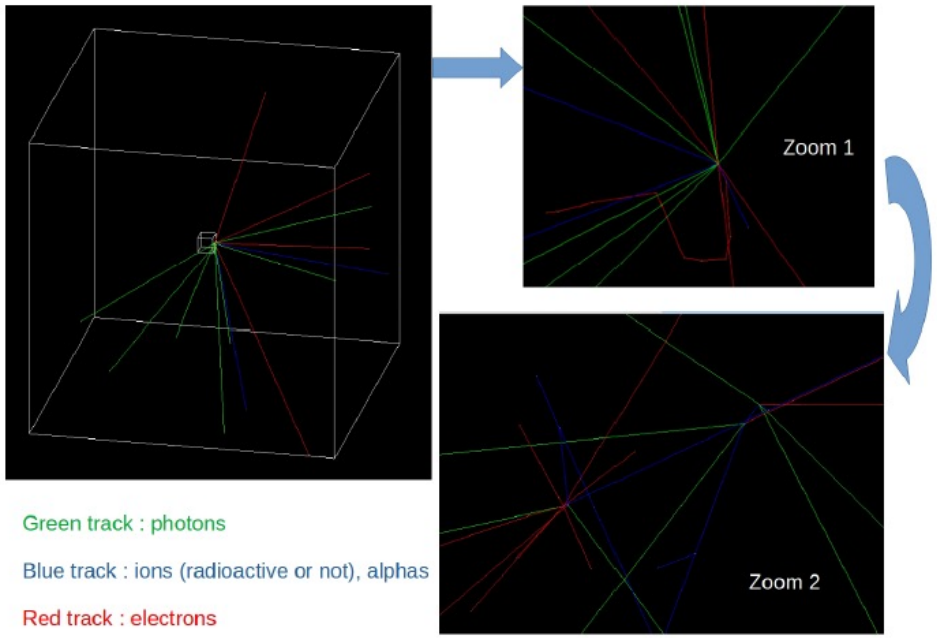
Which impact for detector ?

These information will be an input for DAMICM background simulation

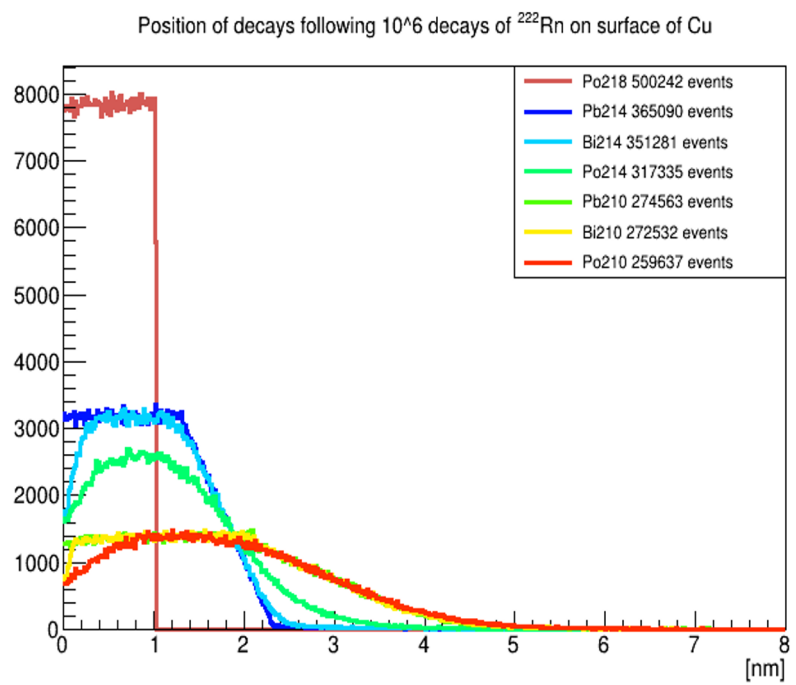


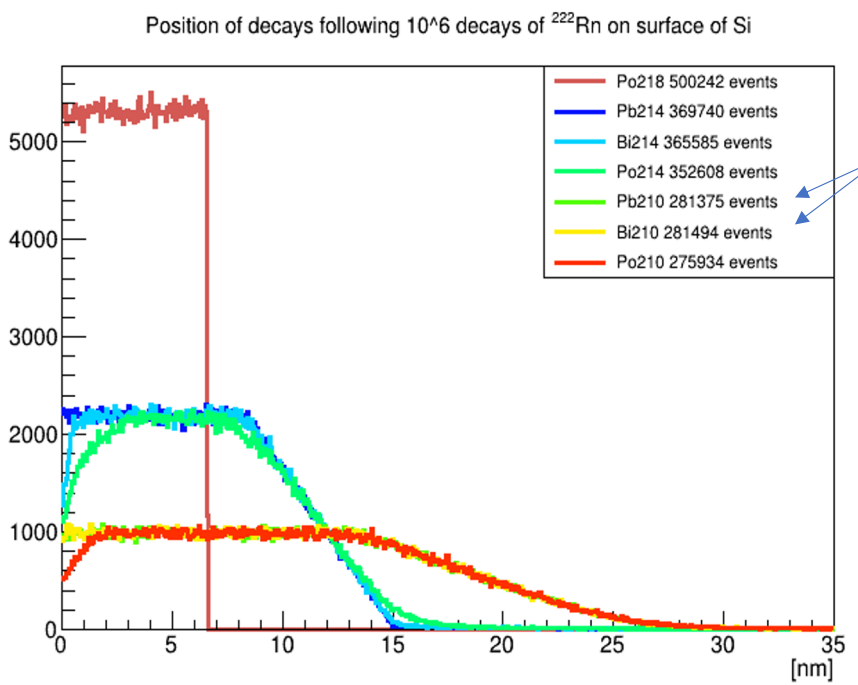
Simulation

- Geometry
- Deposition of an ion on the surface of material
- Position (0,0,0)on the surface and material below
- Full decay
- Record of the position of each nucleus daughter
- Plot projection on z axis
- Code Given by A Brossard on behalf of News-g collaboration



First results source on the surface





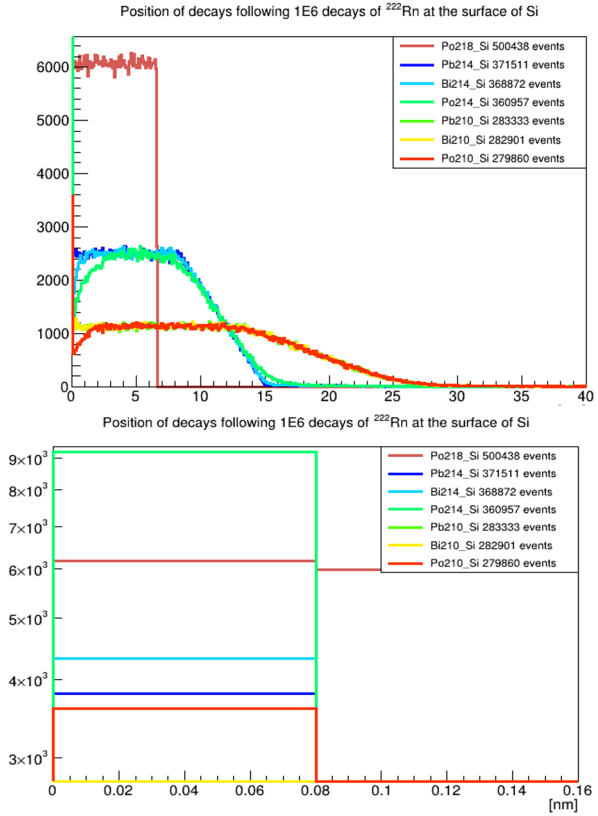
Augmentation of number of event theoreticaly impossible

Recoil penetration is Z and density dependent

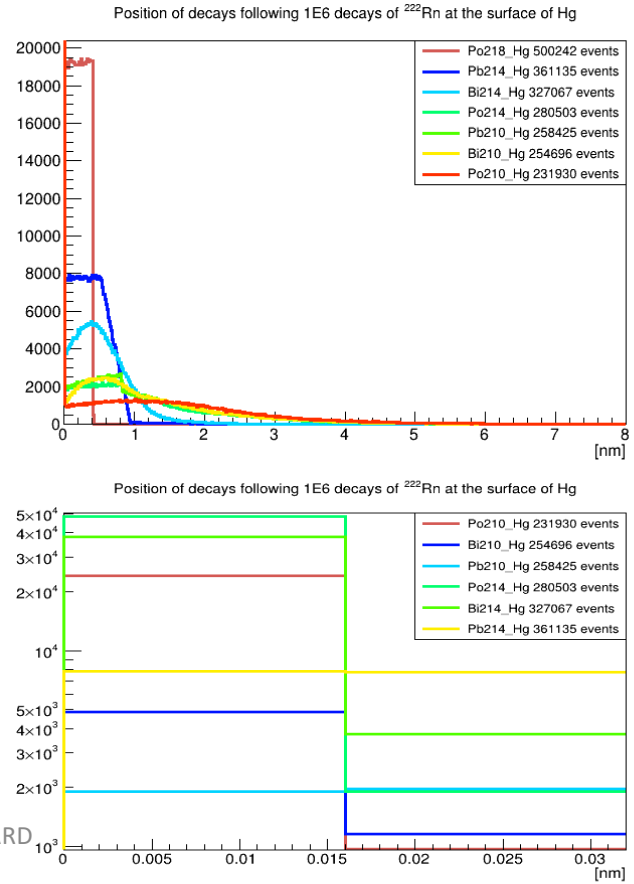
Depth improbably low

```
{
    if (Z > 1.e-6)  h_Amplitude->Fill(Z/10.);
}
```

Histograms of the implantation depth are drawn without the condition :
“if z > 1E-6 ” allowing to see unexpected surface event.

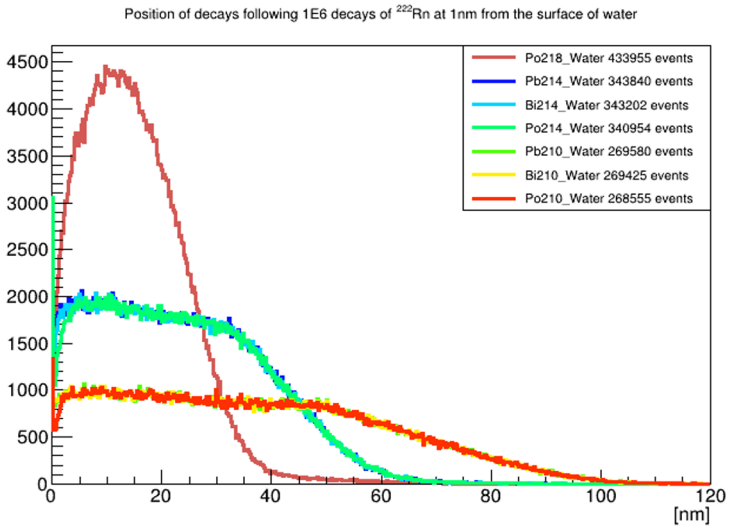


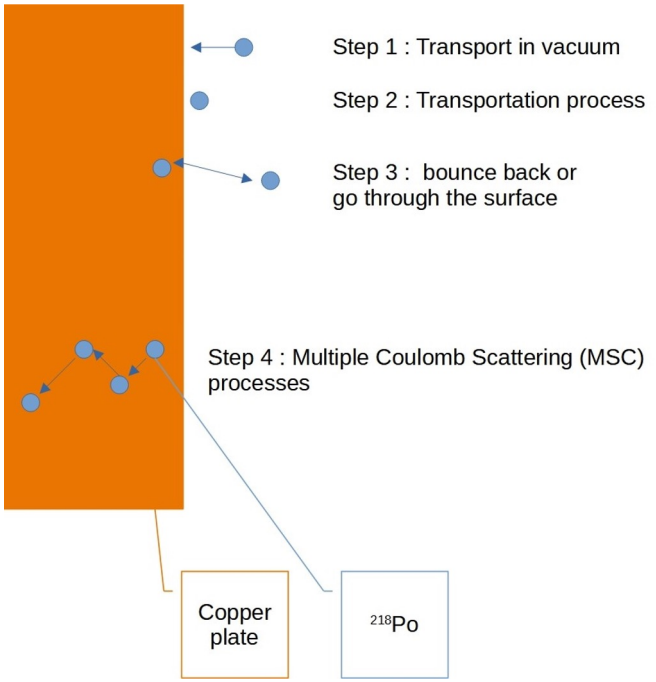
Phenomenon enhanced by using high Z material
First position of nuclei are improbable , below 0,1 nm meaning less than 1 atom



Interaction with surface

- Changing decay position to (0,0,1) nm
- New shape of the curve

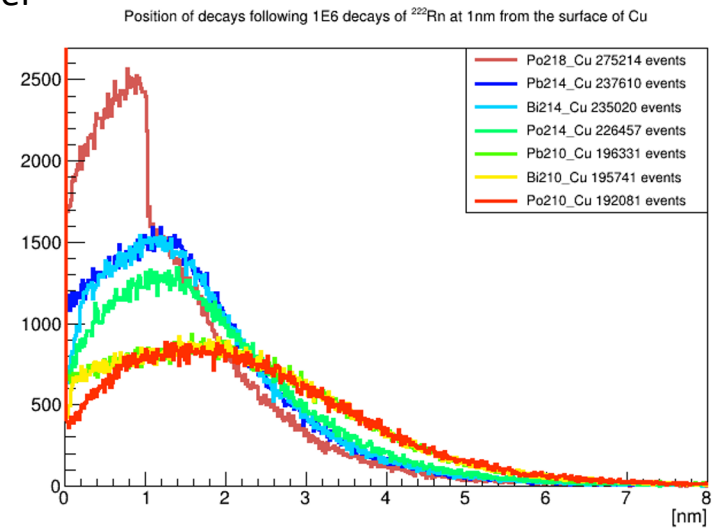




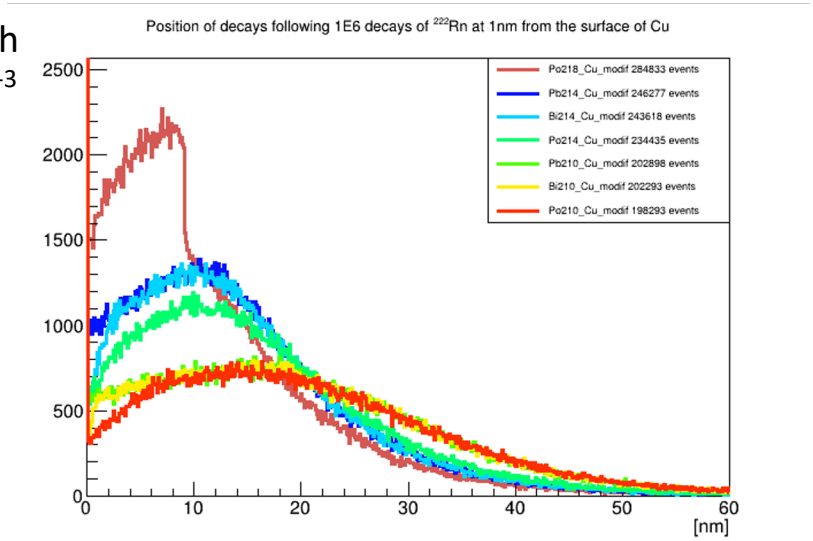
Imperfection in the shape

- Discontinuity for higher Z
- Independant from density

Copper

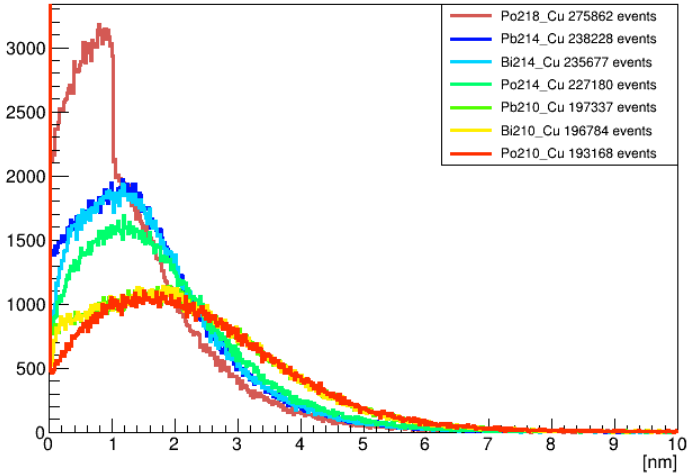


*Copper with $\rho = 1.0\ g.cm^{-3}$



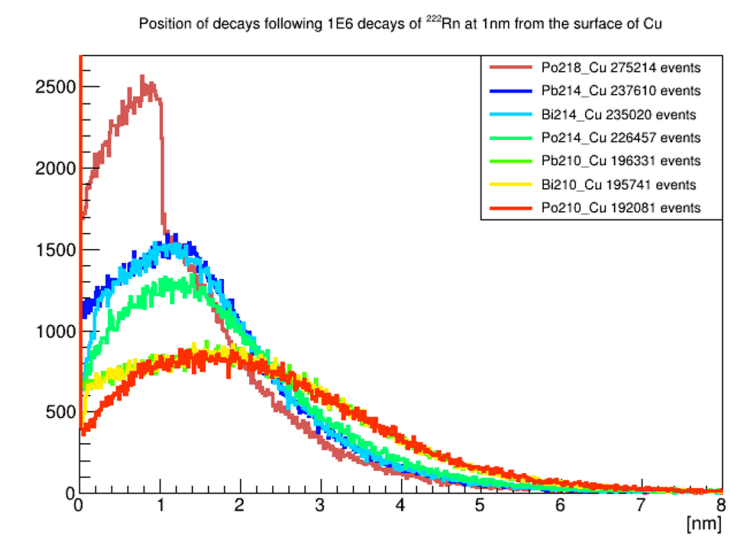
Forcing G4step

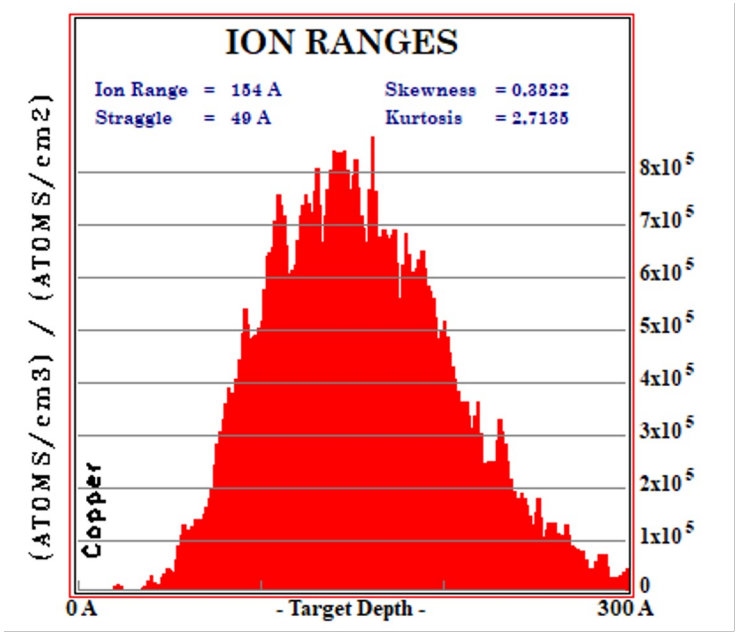
- Using a step max (any) will reproduce (0,0,z) decay point
- Console shows that Compton scatering process is used instead of MSC process producing smoother but not continuous curves



G4stepmax
forced to 1µm

Comparison GEANT4 vs Srim





^{218}Po depth range in copper – SRIM 2013