Monte Carlo simulations to investigate the alpha absorption in the fibers of radioactive aerosol filters

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Plan

- Introduction
- Difficulties for accurate nuclear measurements
- Quantitative study of the α energy degradation in different filter types and determination of experimental correction factors of the activity measurements inside fiber filters
- MCNPX simulation for α-particles
- Preliminary study with MCNPX of a simple solid source
- Fiber filter simulation studies with MCNPX
- Determination of simulated correction factors of the activity in fiber filters
- Comparison MCNPX Vs experimental spectroscopy
- Conclusion and perspectives

Introduction

Determination of the deposited activity inside fiber filters upon environmental contamination monitoring near nuclear facilities

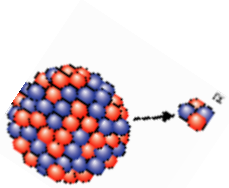
Industry

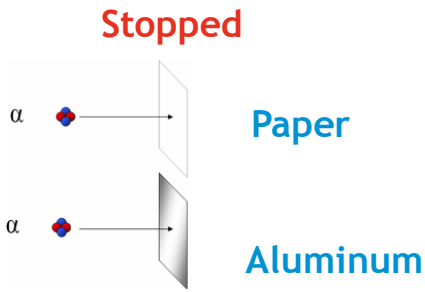
Natural atmospheric contamination or industrial contamination

Health risks

Contamination by inhalation of radioactive aerosols

Fast and non-destructive measurements of the α activity deposited as radioactive aerosols in fiber filters which are usually used in French nuclear industry





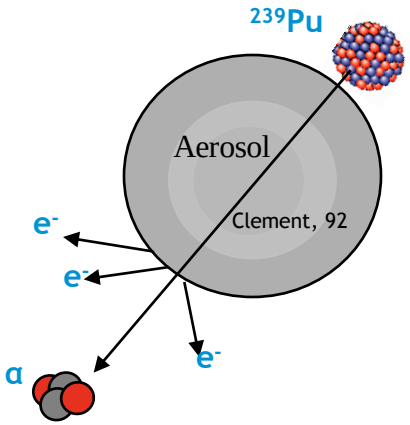
Influent parameters to be evaluated in order to have accurate nuclear measurements

Incidence on the radioactivity measurement into a filter

α energy attenuating Factors

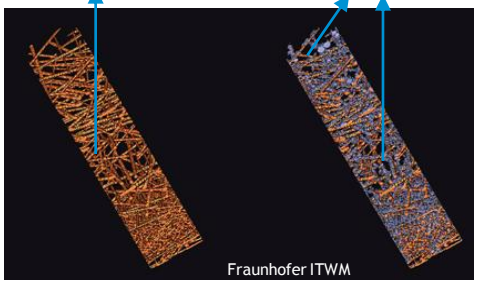
Under-estimation of the radioactivity in the filter up to a factor of 2

Examples of α energy attenuators

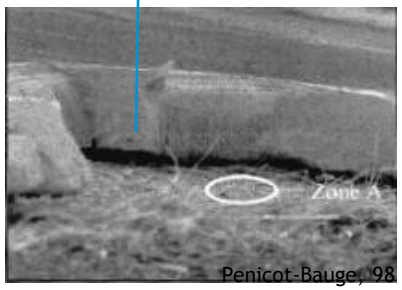


Fibers

Aerosols



Aerosol cake on the surface of the filter



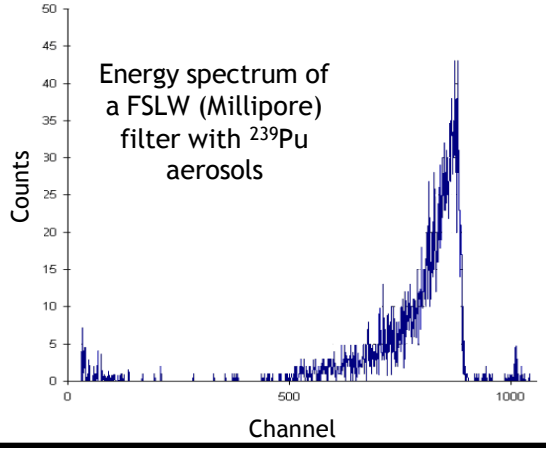
Distance and air between source/detector

Experiments and Monte Carlo simulations to find Correction factors

Experimental study of the α energy degradation in different filters

FSLW fluoropore filter → α-particles are deposited on the filter surface

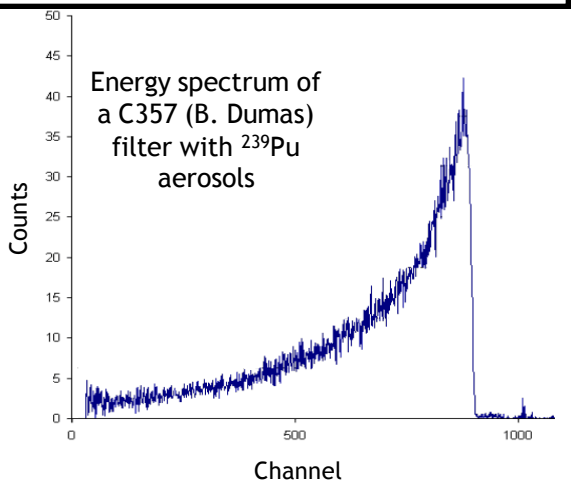
Porous membrane



C357 fiberglass filter → α-particles are deposited inside the filter

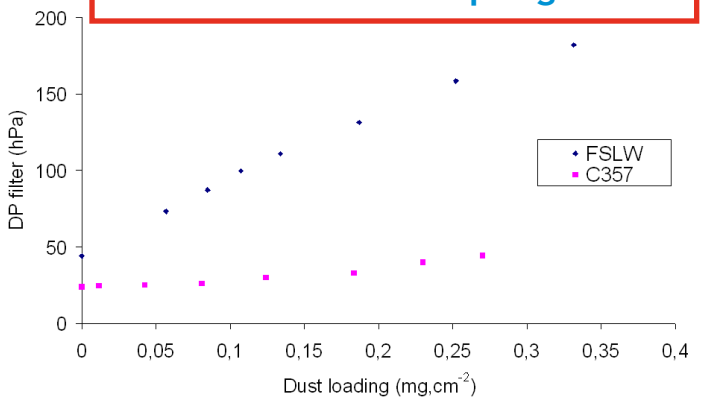
Thickness of the filter

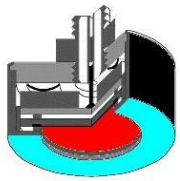
Fiberglass filter



example of inconvenient

High ΔP for FSLW filter → Short life time for the sampling





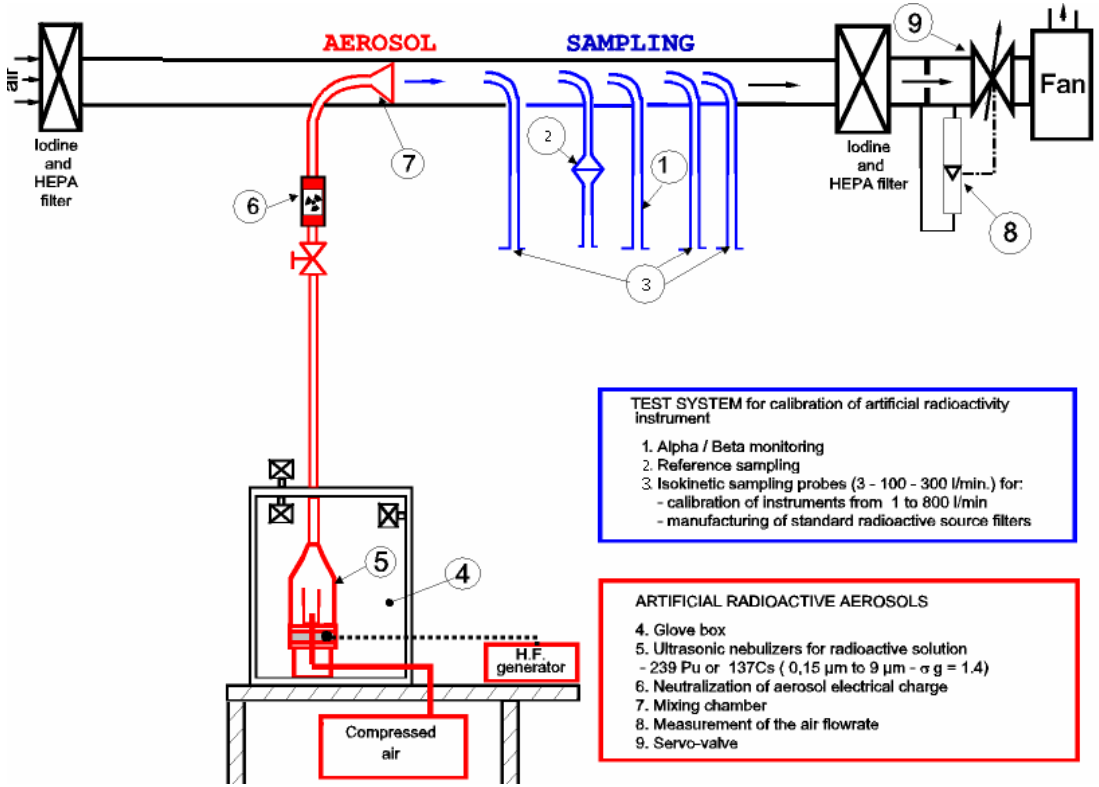
PIPS

Larger tail of the α energy peak → underestimation of α activity inside the selected α channel

↓

Need activity correction factors

Determination of experimental correction factors of the activity inside fiber filters



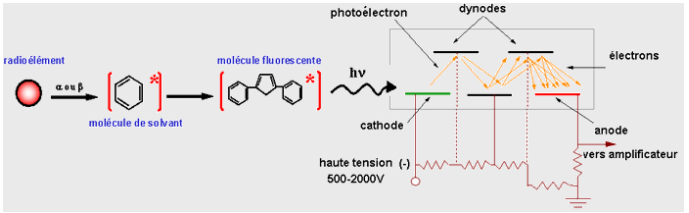
TEST SYSTEM for calibration of artificial radioactivity instrument

1. Alpha / Beta monitoring
2. Reference sampling
3. Isokinetic sampling probes (3 - 100 - 300 l/min.) for:
   - calibration of instruments from 1 to 800 l/min
   - manufacturing of standard radioactive source filters

ARTIFICIAL RADIOACTIVE AEROSOLS

4. Glove box
5. Ultrasonic nebulizers for radioactive solution
   - 239 Pu or 137Cs (0,15 µm to 9 µm - σ g = 1.4)
6. Neutralization of aerosol electrical charge
7. Mixing chamber
8. Measurement of the air flowrate
9. Servo-valve

Experiments with fiber filters usually used in nuclear industry (ex: B. DUMAS réf. C357, B132, …)



Principle of L.S. technique

The activity in the filter is measured successively with PIPS detector, proportional counter and liquid scintillation (L.S.) technique → Correction factors Fc

$$F_c = \frac{A_{L.S.}}{A_{mesured}}$$

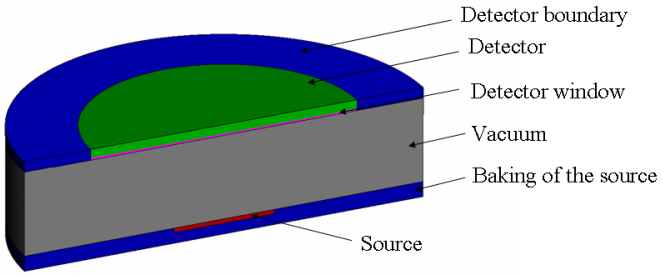
Long, non-exhaustive experiments and destructive way to measure the correction factors of absorbed α-particles in filter fibers

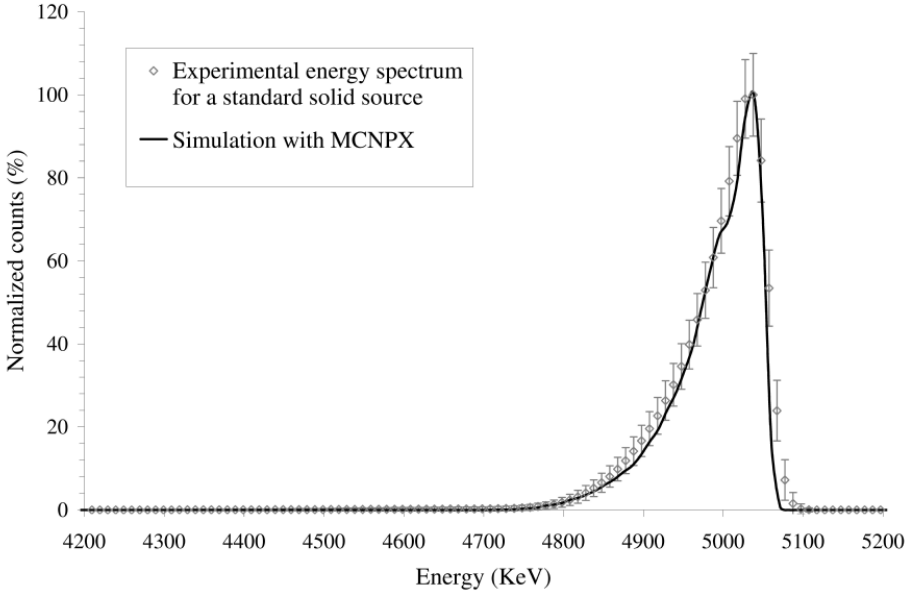
Simulation of α-particles in fiber filters $\rightarrow$ calculated correction factors with MCNPX

Preliminary study with MCNPX of the detection efficiency of a PIPS detector for a simple source – simulation *Vs* experiment comparisons

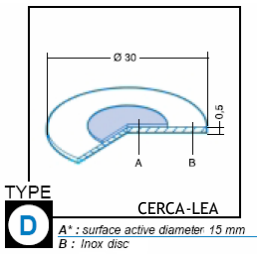
Validation of α-particle simulation

- Verification of the model feasibility with a solid source
- Calculation of the detection efficiency for a PIPS detector geometry
- Comparison between experimental and simulated detection efficiencies





Solid source



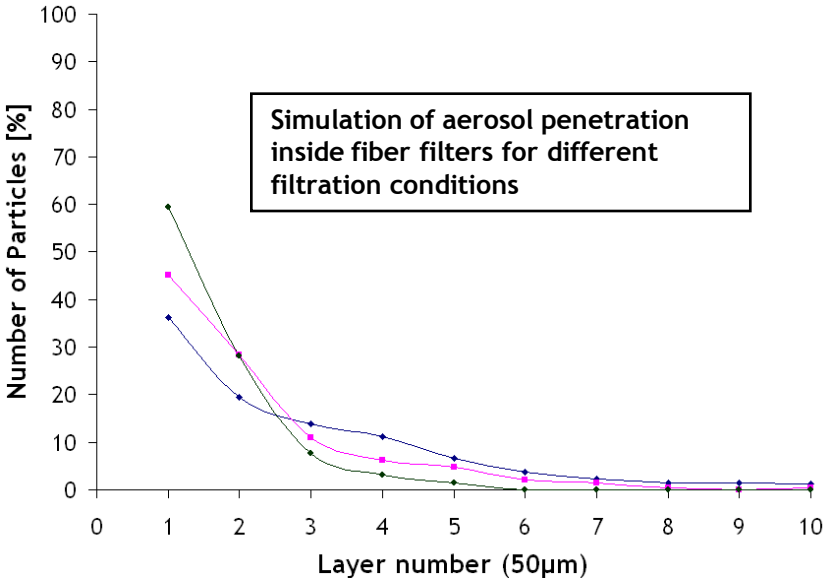
^{239}Pu radioactive source : 213 α/2πsr

Measured activity (ORTEC PIPS) = 151.53 0.11 Bq → R_{exp} = 24.7 ± 0.89 %

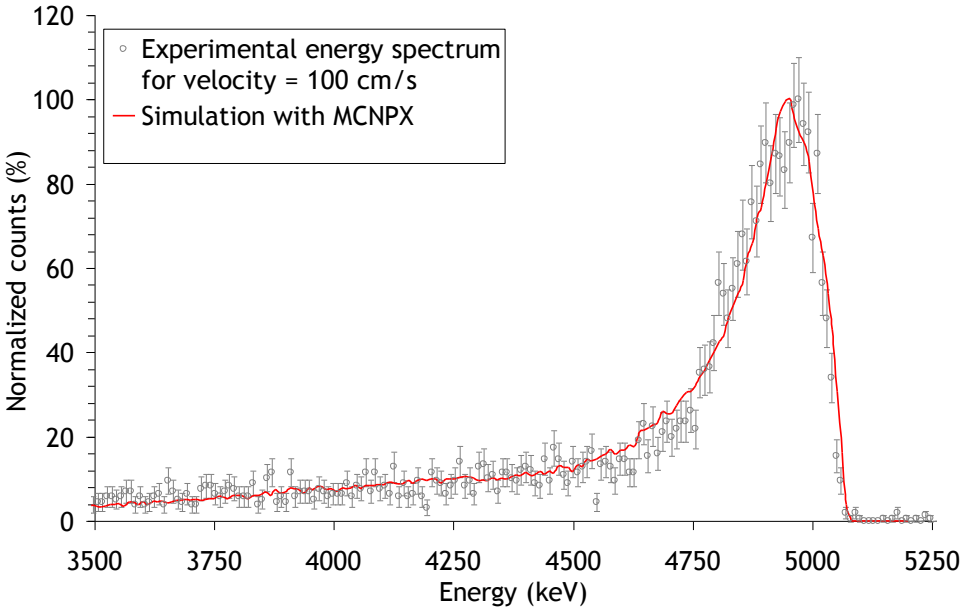
Simulated activity (MCNPX) = 153.09 ± 0.35 Bq → R_{th} = 24.5 ± 0.21 %

MCNPX simulations of a C357 fiber filter

Simulation of a filter with ^{239}Pu aerosols as an heterogeneous activity distribution in the filter described as the following curves found with a filtration software

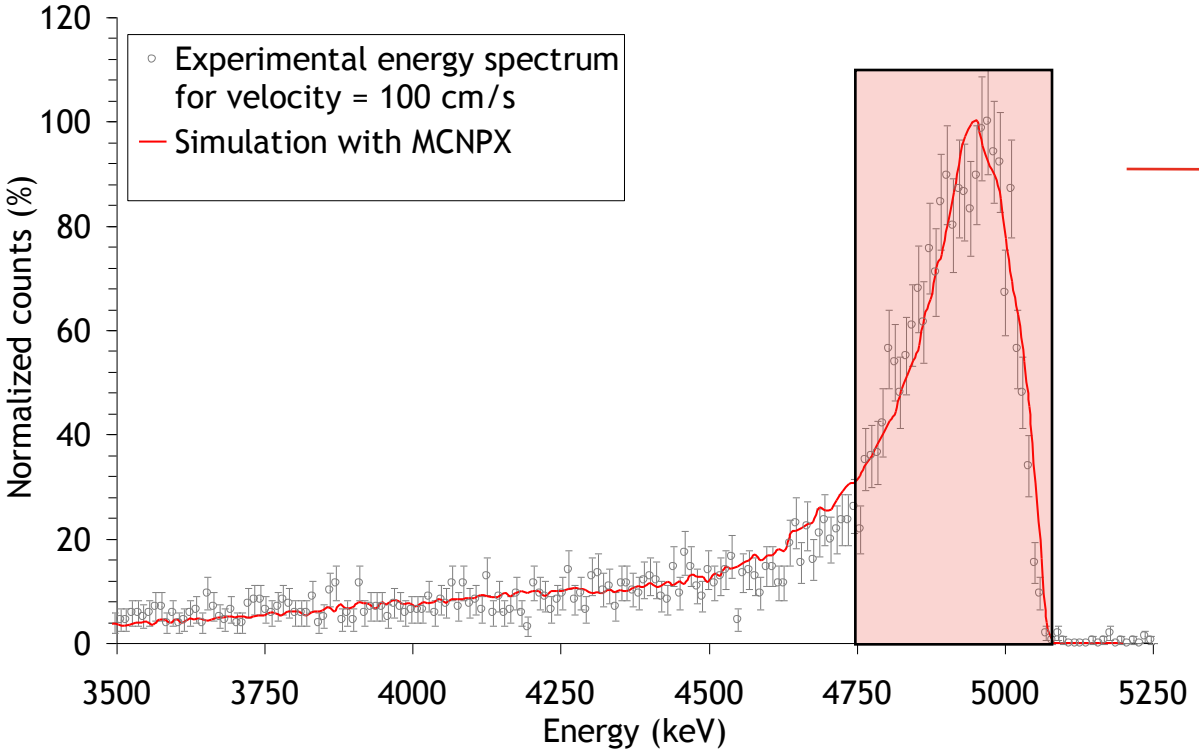


Penetration function of radioactive aerosols in C357 filter estimated with a filtration software and implemented in MCNPX simulation



Determination of the correction factor of activity measurements inside a fiber filter

Number of total events = reference activity measurement over 4π total measurement in the L.S.



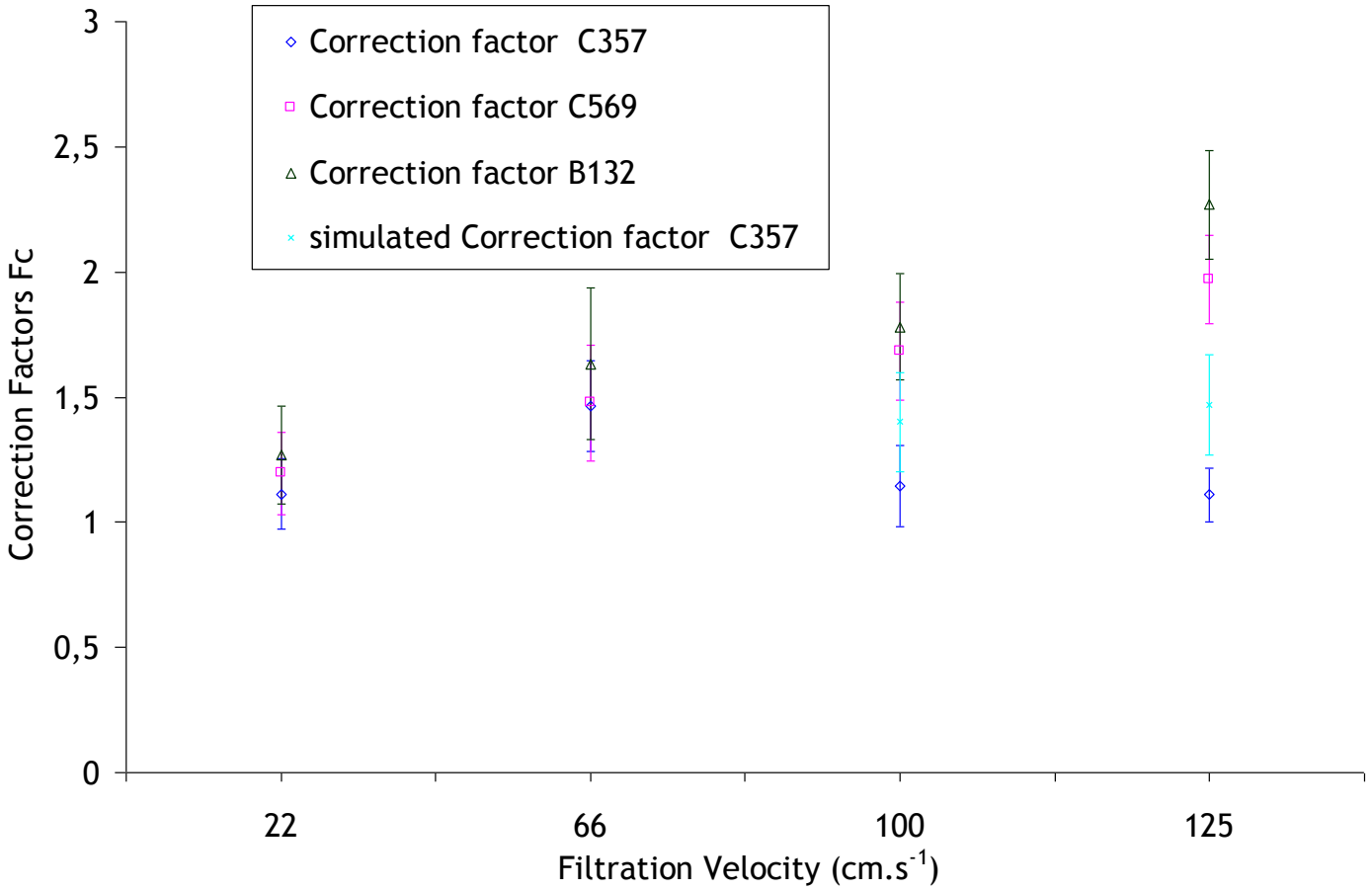
Representation of a classical artificial channel for ^{239}Pu measurement → detected counts inside this channel

α-particles degradation → bigger tail → detected activity reduced

+

L.S. reference activity → correction factors for this type of detector

Experimental and simulated determination of the correction factors of the activity in different fiber filters



Conclusion

- Quantitative experimental study of the α energy degradation in fiber filters
- Determination of experimental correction factors of the activity in a fiberglass filter
- Validation of α-particle physic models
- Simulation of a C357 fiber filter with aerosol penetration found in filtration software
- Calculated correction factors of the activity in a fiber filter

Perspectives

- Pursuit of experiments and simulations in order to study the effect of accumulated masses on the filter and then the clogging of filters on the measurement of radioactivity inside filters
- Global simulation of the aerosol penetration and the α energy degradation in fiber filters with models of filtration and Monte Carlo software

Thank you for your attention…

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