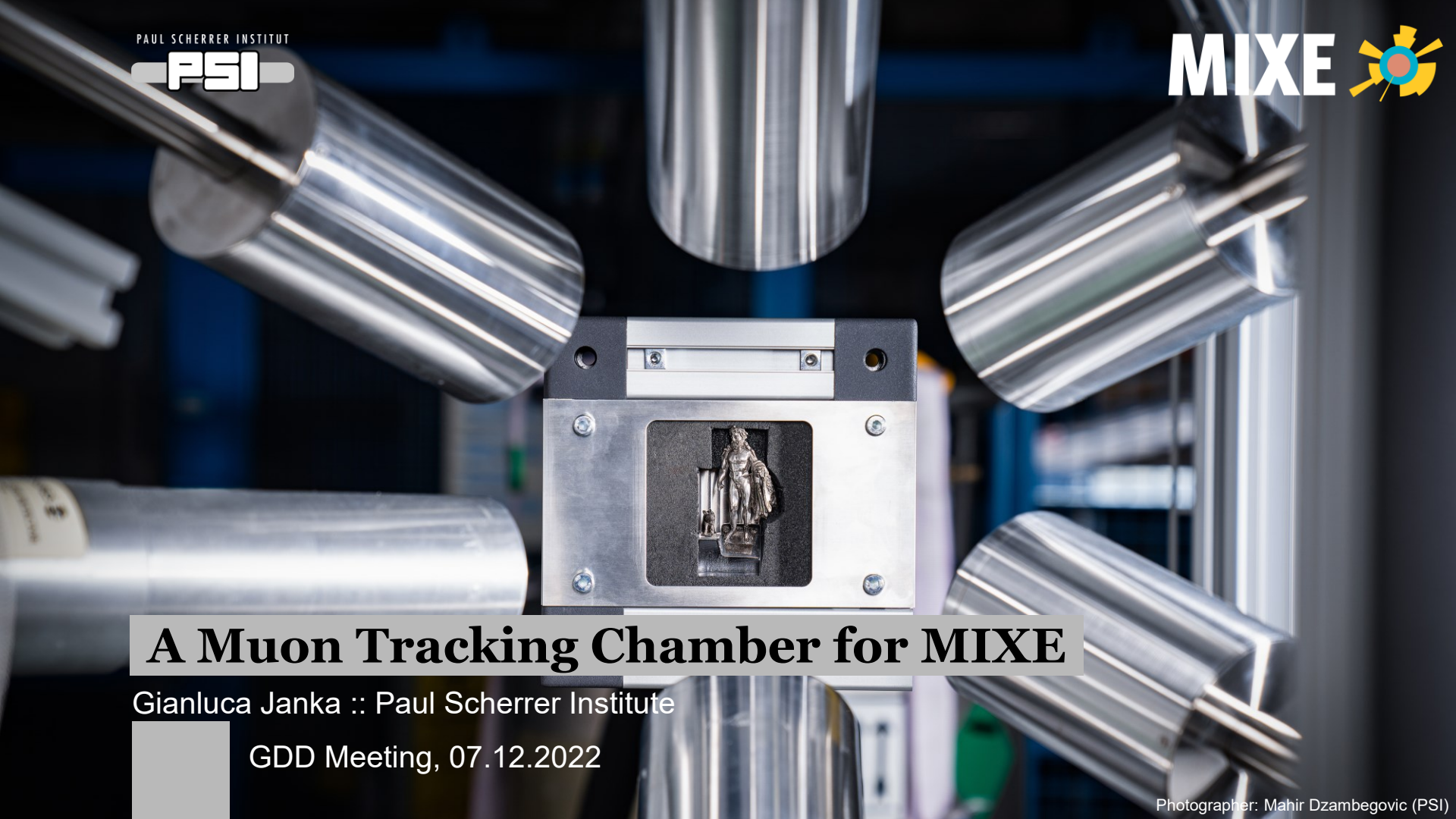


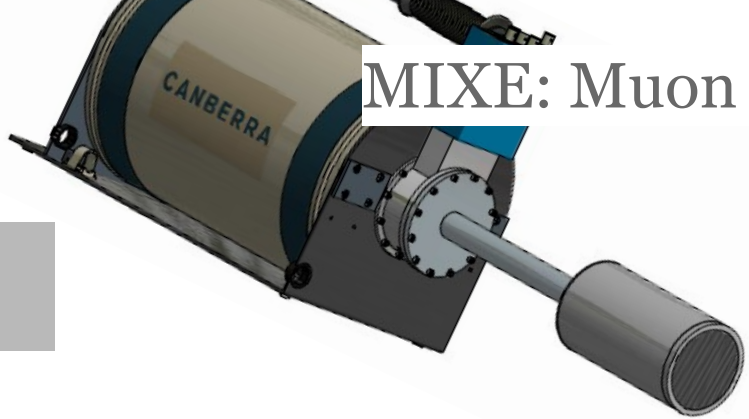
A Muon Tracking Chamber for MIXE

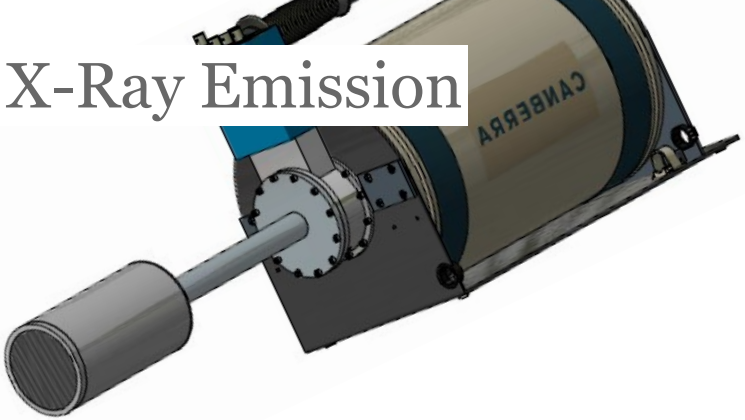
Gianluca Janka :: Paul Scherrer Institute

GDD Meeting, 07.12.2022

Photographer: Mahir Dzambegovic (PSI)

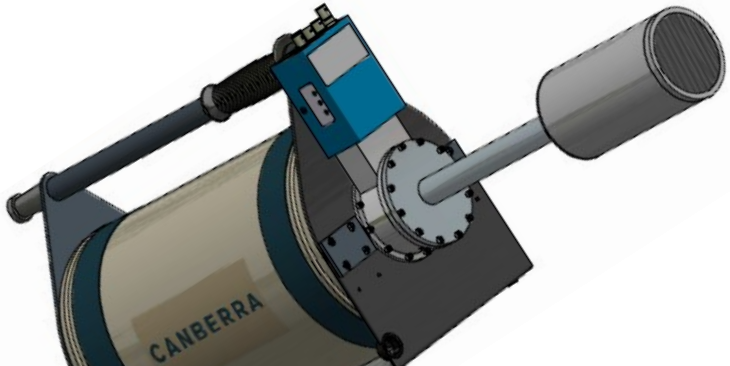
MIXE: Muon Induced X-Ray Emission

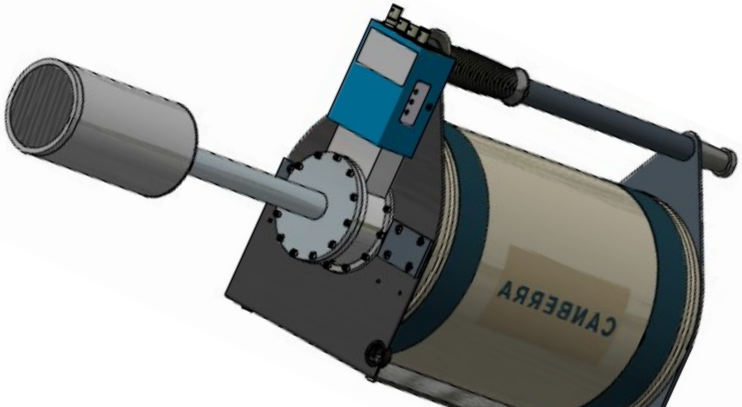




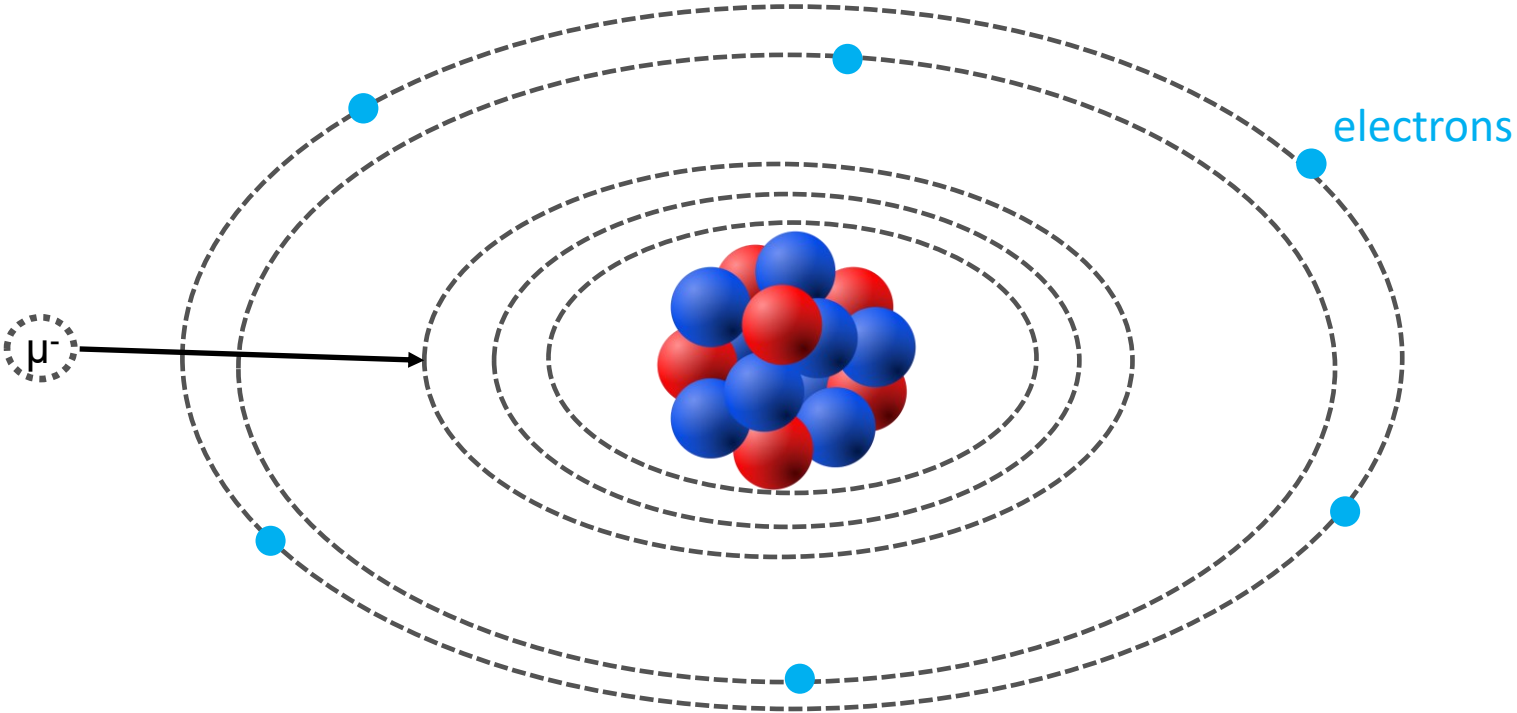
μ^- $p = 20 - 45$ MeV/c → Sample

- Implantation depth = μm – mm
- 5 – 50 kHz rate
- ~ 2cm sigma beam spot



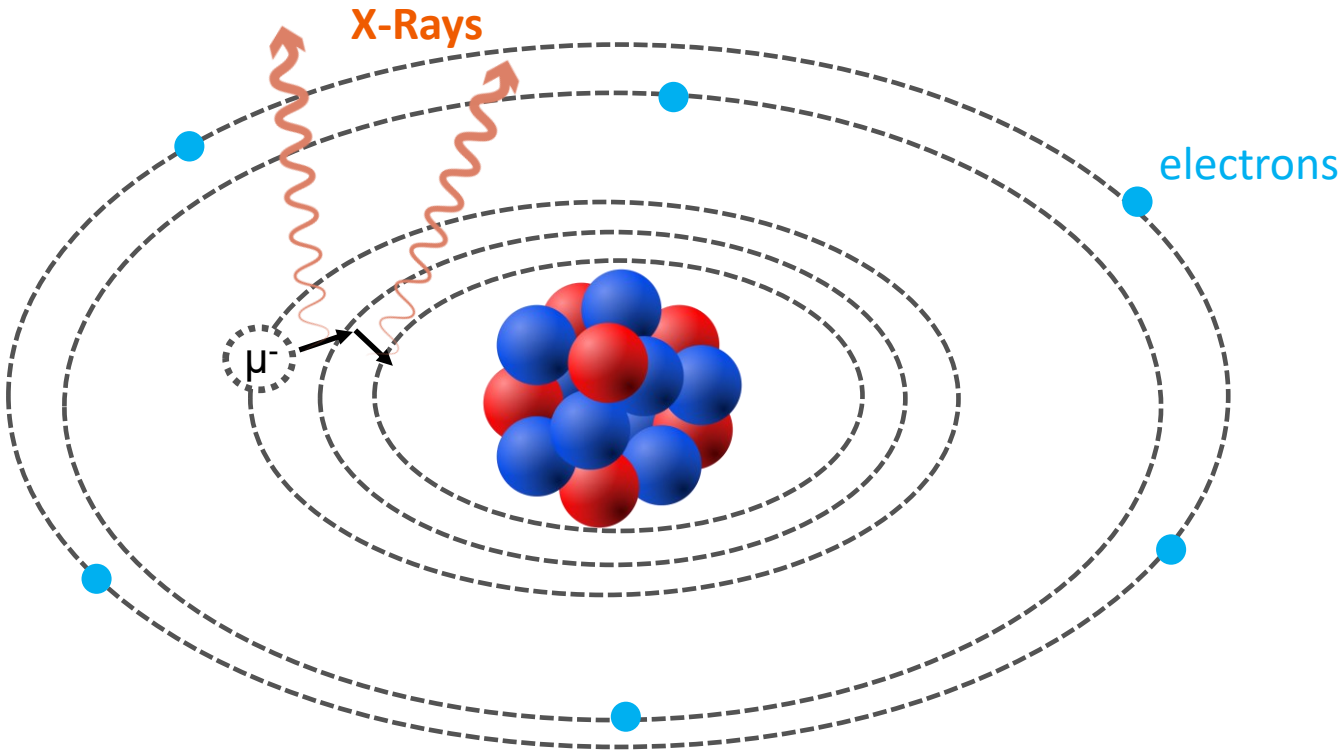


MIXE: Muon Induced X-Ray Emission



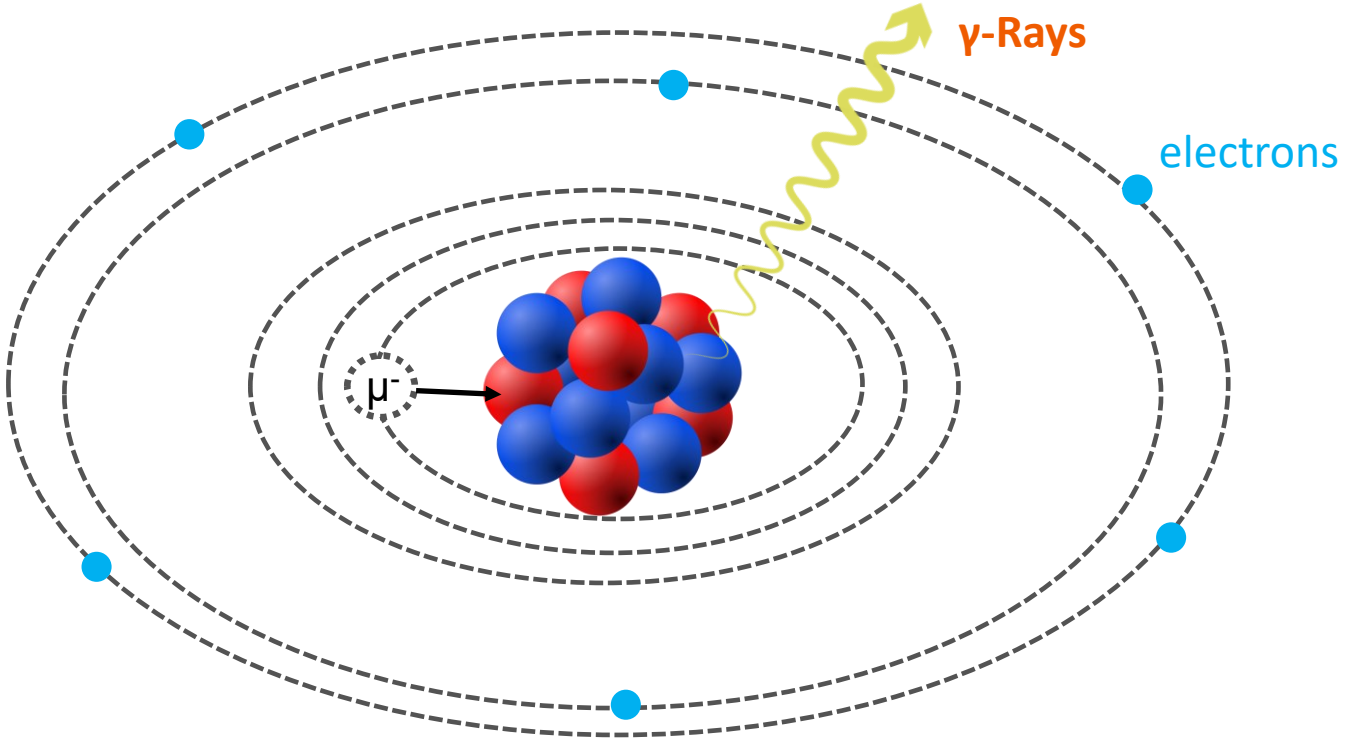
Muon capture into excited electric state

MIXE: Muon Induced X-Ray Emission



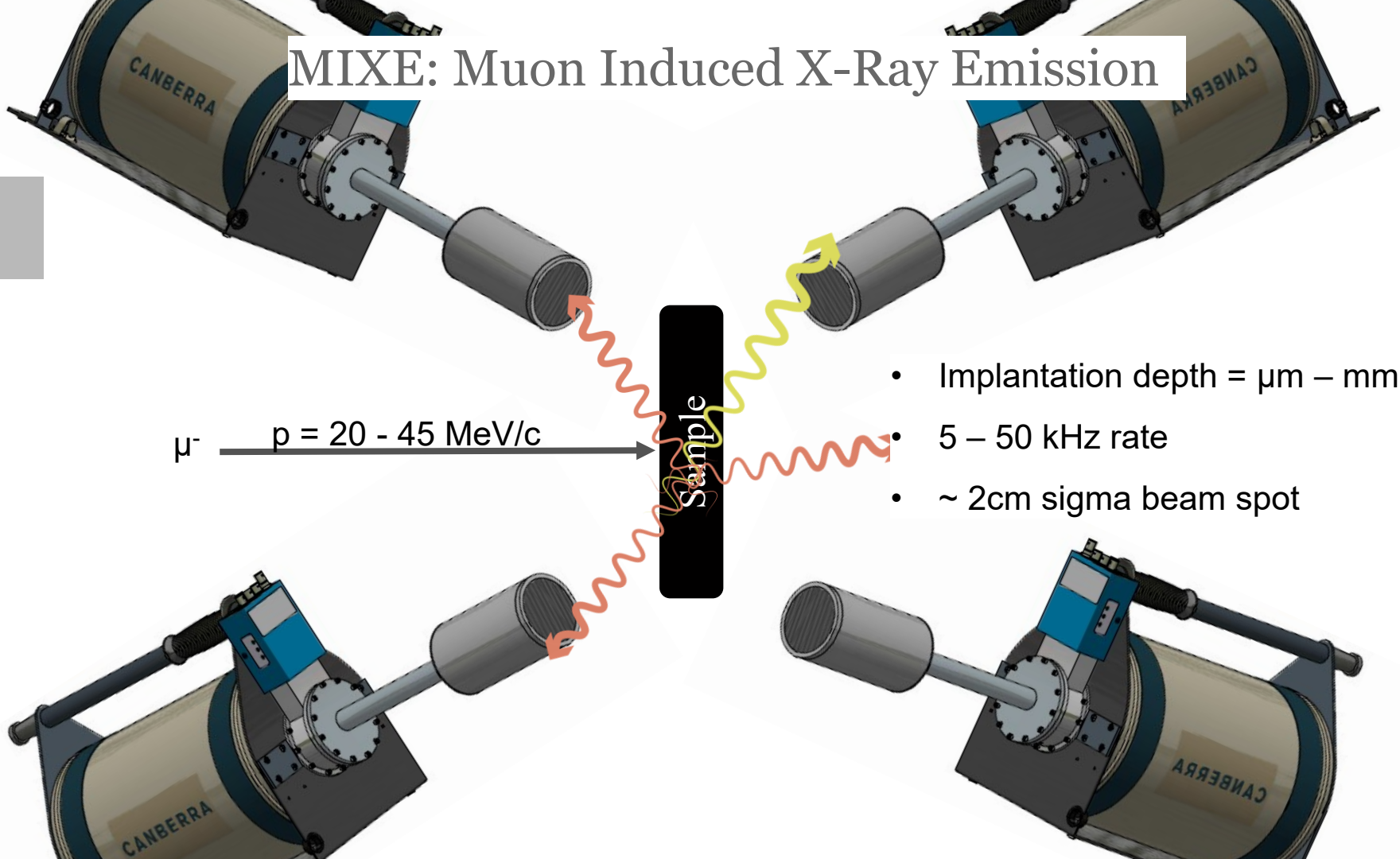
Muon relaxation to ground state via relaxation of X-Rays

MIXE: Muon Induced X-Ray Emission



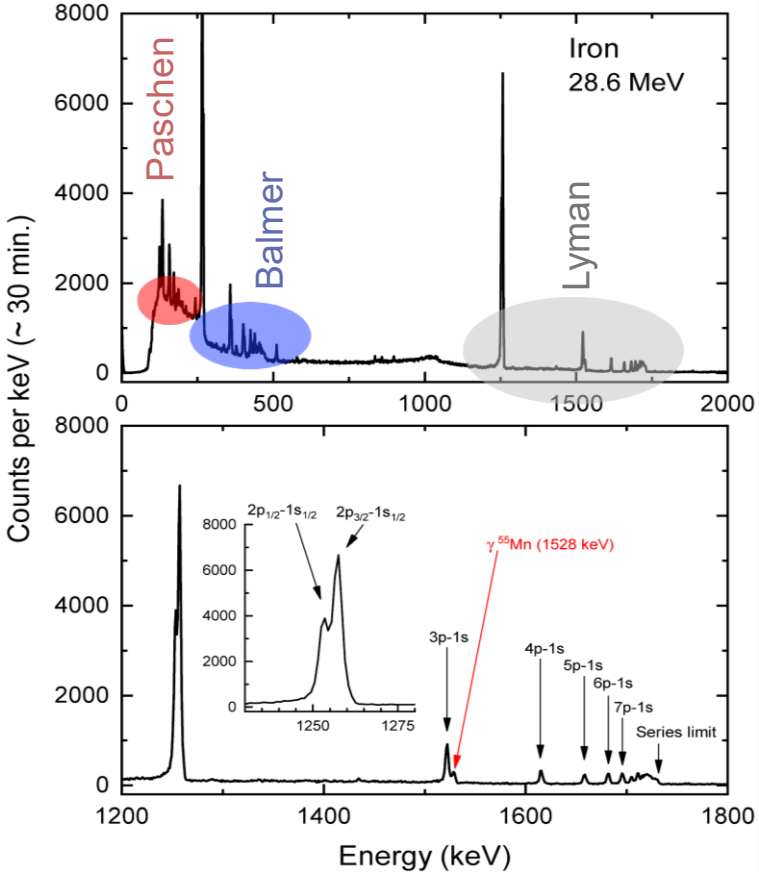
Muon captured into nucleus, inducing decay of nucleus under emission of gamma ray

MIXE: Muon Induced X-Ray Emission



- Implantation depth = μm – mm
- 5 – 50 kHz rate
- ~ 2cm sigma beam spot

MIXE: Muon Induced X-Ray Emission



Elemental Analysis with MIXE

Archeological artifacts

- Elemental composition
- Isotopic ratios
- Depth profiles
- Metallurgy
- Origin
- Source of ores

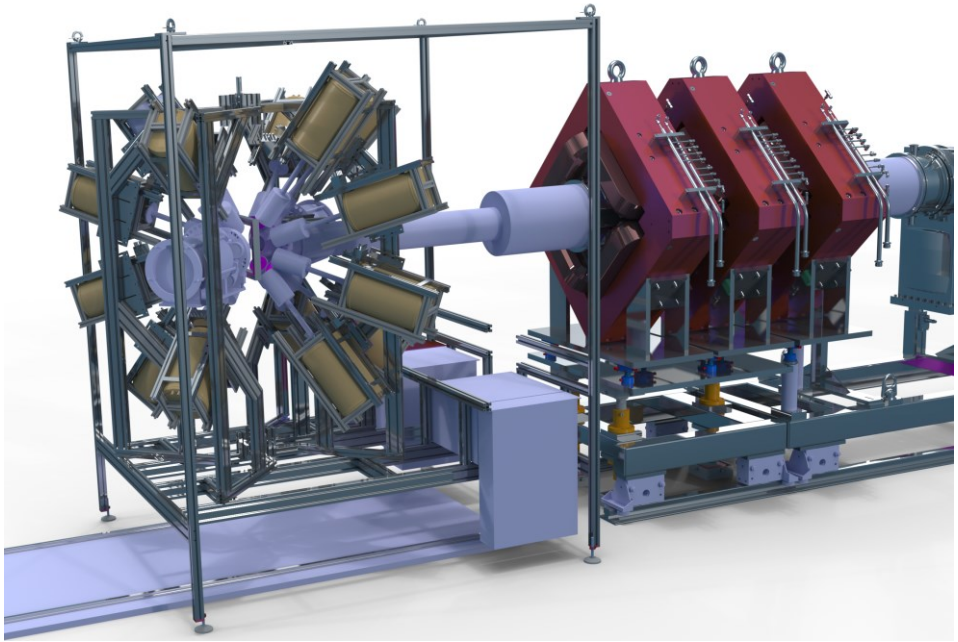
Layered structures
e.g. Li-batteries

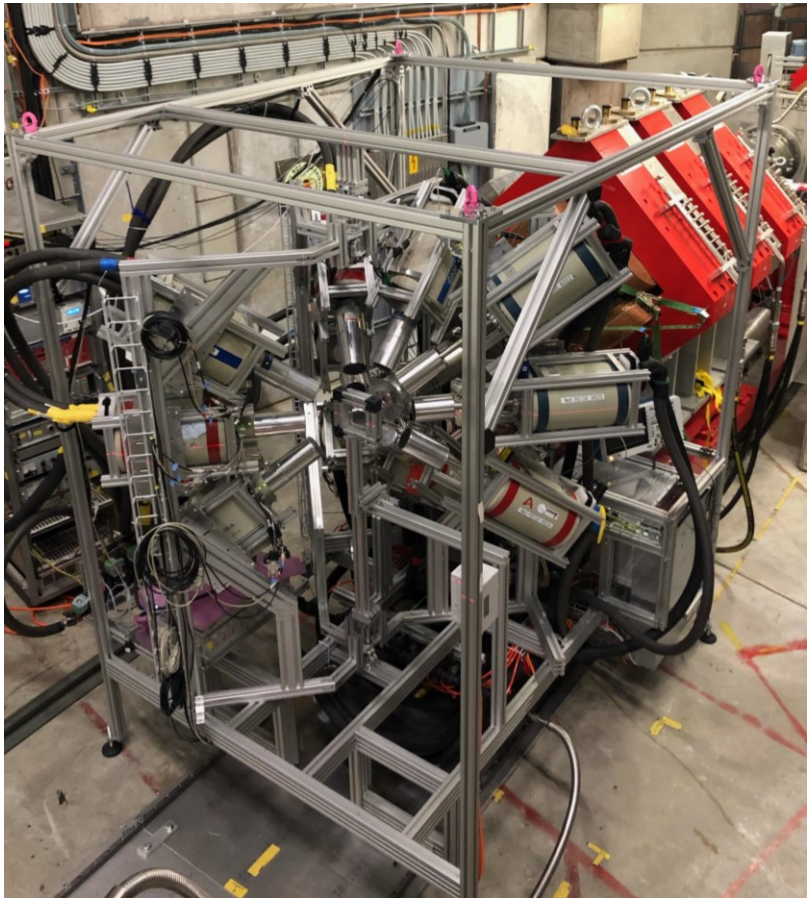
- Elemental distribution
- Depth profiles
- In-situ degradation

Extraterrestrial objects

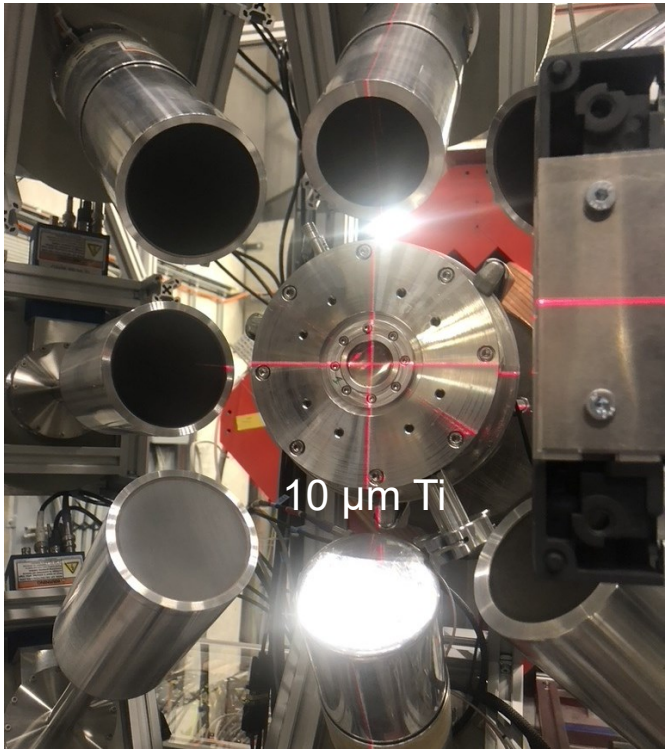
- Elemental composition
- Isotopic ratios
- Depth profiles
- Formation of crust, core and mantel of planets
- Ancient usage
- Origin of life

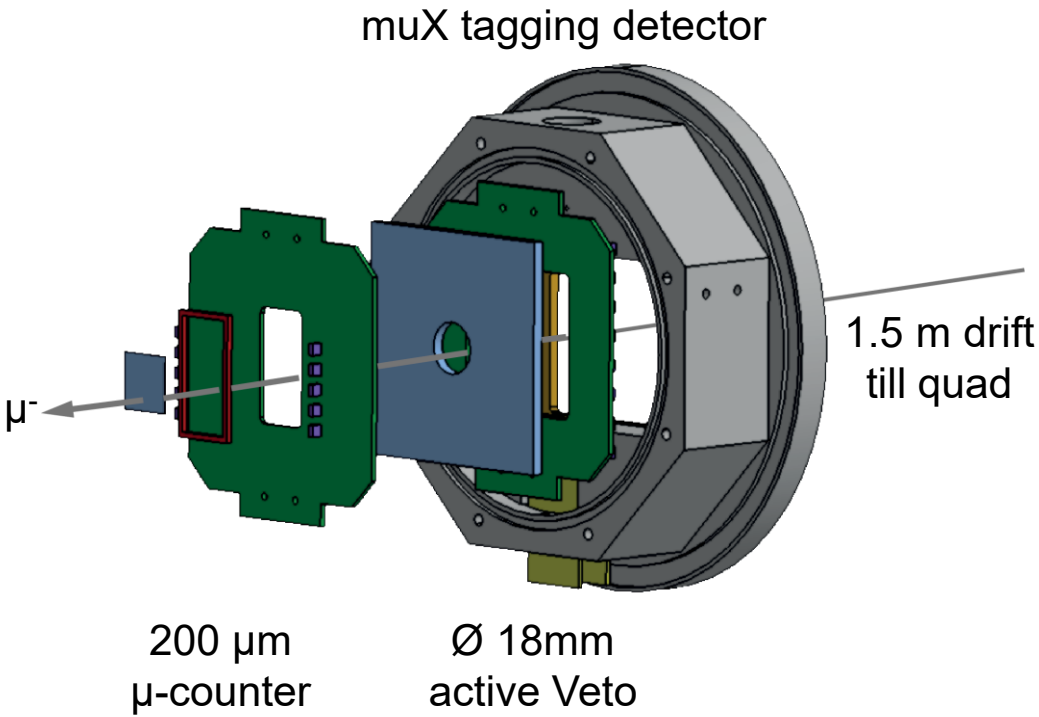
GIANT Setup





Tagging of muons

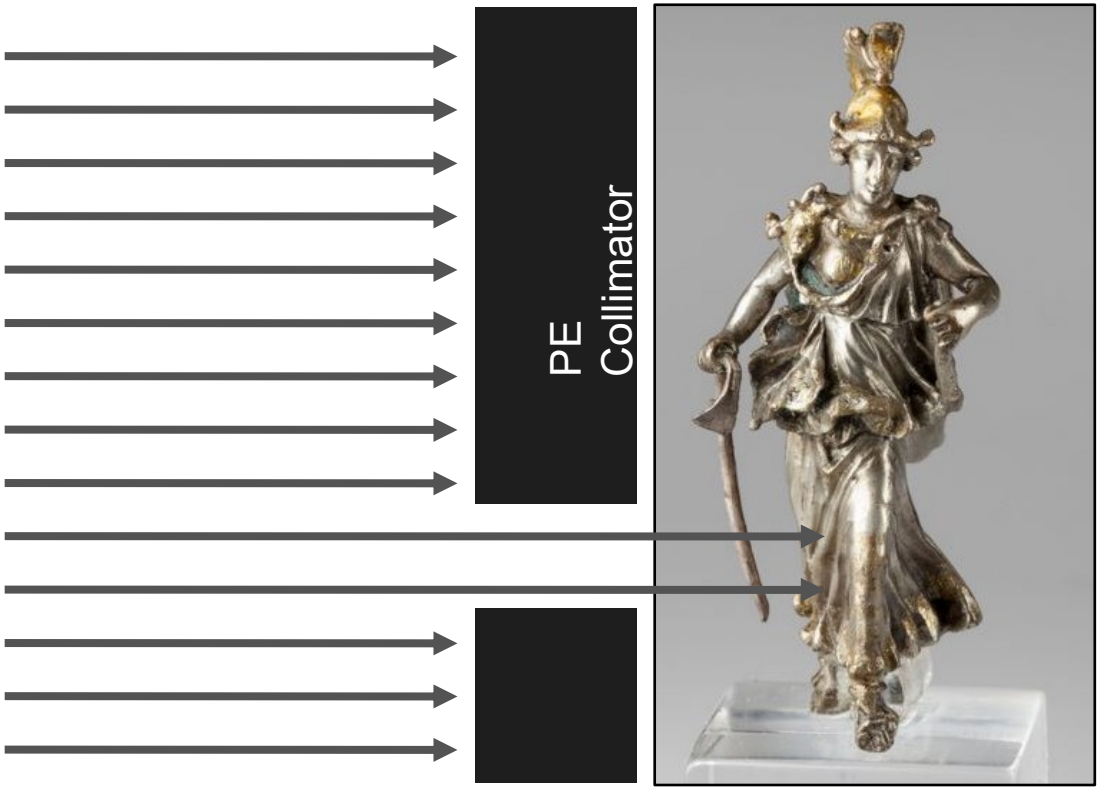




Distance from Ti window to sample: around 15cm

Motivation for Muon Tracking Chamber

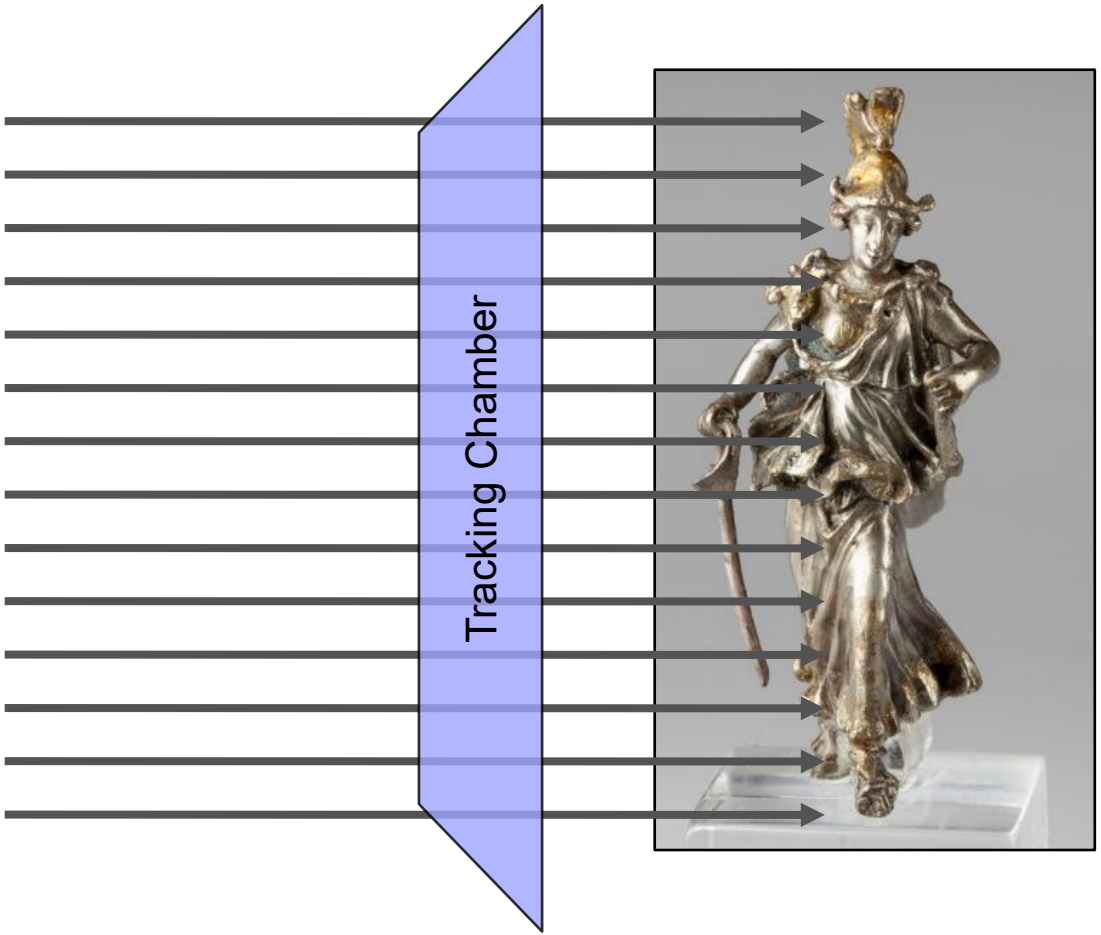
μ^-



1cm PE or 5mm Al blocks 100% of 45 MeV/c muon beam

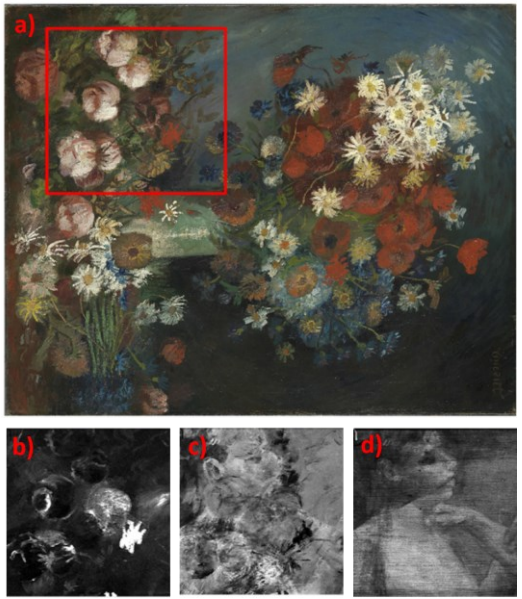
Motivation for Muon Tracking Chamber

μ^-



Motivation for Muon Tracking Chamber

- Collimation can be done offline → no muons get lost, no collimation background
- Background coming from other material than sample (frame, detectors) can be rejected
- Opens possibility to perform MIXE in 3D:



a) Vincent van Gogh's Flower Still Life with Meadow Flowers and Roses, summer 1886 (Kröller–Müller Museum, Otterlo, the Netherlands), rotated for illustration purposes.

b) Hg fluorescence signal of the area in the red box, flowers are visible.

c) Zn fluorescence signal of the same area, hints of a human face visible.

d) Zn fluorescence measured from the back of the painting with less absorption, revealing the human face as part of an overpainted wrestling scene..

M. Alfeld and J. A. C. Broekaert, Spectrochimica Acta Part B 88, 211- 230 (2013)

Summary slides & requirements

- CW beam with rates of **5 – 50 kHz tagged negative muons**
- Beam spot currently of around **2cm in sigma** (might be improved during next beamtime)
  - Samples typically also a few cm (for now)
  - **Active area** therefore also of this order of magnitude **(a few cm)**

- Tracking resolutions to be achieved (or dreamed of):
  - **A few mm** for replacing collimator / background suppression sufficient
  - **1mm and better** for art applications

- Choice of gas if necessary: also flammable an option
- Budget: There is money, but not >> 100k CHF for R&D of negative muons

PAUL SCHERRER INSTITUT

Thank you for your attention!

We are happy to receive feedback and suggestions on what type of detector would be most suitable, including also readout system etc.