THE TECHNOLOGY PROGRAMME

TECHNOLOGY (SOMETIMES ONLY FICTIVELY) CONNECTED TO CERN EXPERIMENTS

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AIM OF THE TECHNOLGY PROGRAMME?

“The programme aims at integrating the projects that have significant technology development, transfer and pre-commercialization activities of HIP in the same programme”

“Synergies with other international big science initiatives are actively sought”

The programme consists of several thematic technology areas: systems, materials, radiation safety, “other”

- many many small projects (from the point of view of direct HIP resources)

MODULES, STRUCTURES AND MANUFACTURING FOR ACCELERATORS

- Markus Aicheler (HIP)
- High precision industrialized manufacturing and assembly of accelerator components
- CLIC module re-design
- Transfer of high gradient expertise to other accelerator based applications
- Engineering and manufacturing support to CompactLight
- Business Finland co-creation project: additive manufacturing and precision machining for physics detector lightweight structures
  - Co-innovation project (BF) in preparation

ROBOTICS AND AI FOR MONITORING AND INTERVENTION


CERN-bot

- Roel Pieters, Esa Rahtu (TUNI)
- Topics:
  - deep learning-based localization and detection techniques,
  - virtual reality techniques for tele-presence and interaction,
  - deep learning for robotics
- Considered environments: current tunnel infrastructure (LHC), future tunnels (FCC)
- Co-funding from CERN, Business Finland


Virtual Reality interaction


CERN tunnel environment

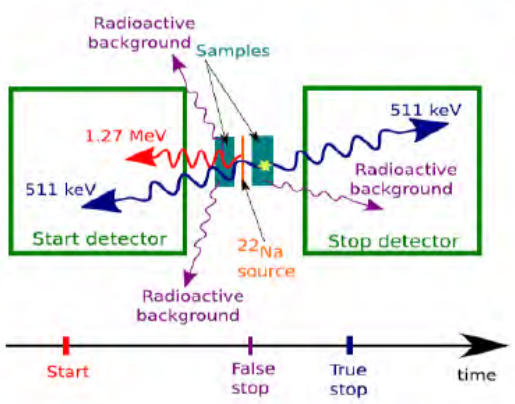
INSTRUMENTATION FOR RADIOACTIVE MATERIALS TESTING

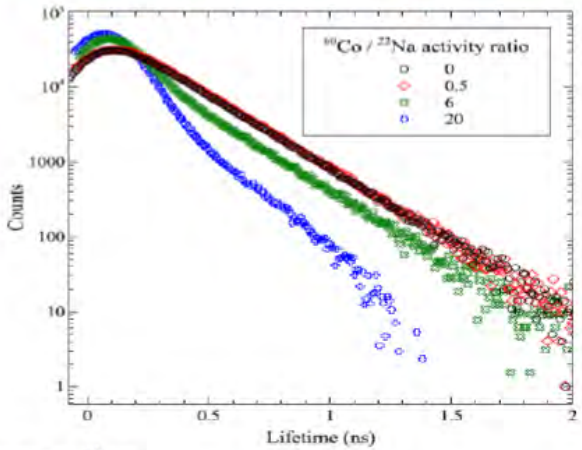
René Bès (UH)

➢ Positron annihilation spectroscopy

- ❖ Sensitive to dilute vacancy type defect concentration in materials
- ❖ Positron lifetime determination
  - ✓ Plastic scintillator: very fast timing
  - ✓ One lifetime per vacancy type
  - ✓ **Detection of 2γ in coincidence**

→ **Sensitive to radioactive background !**



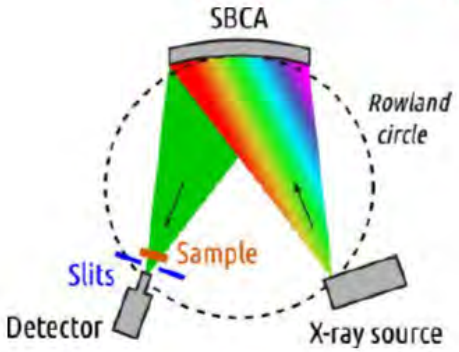


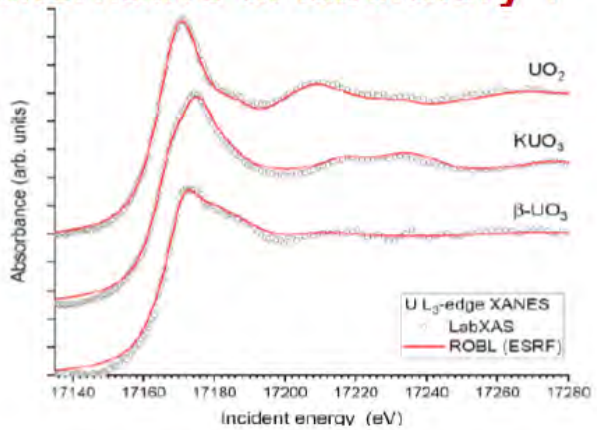
Heikinheimo et al., NST2016 proceeding

➢ X-ray absorption spectroscopy

- ❖ Local order and element sensitive in any kind of materials
- ❖ Mainly available at synchrotron facilities
  - ✓ **restricted access of radioactive matter**
  - ✓ high cost of transportation
  - ✓ delay between synthesis and characterization

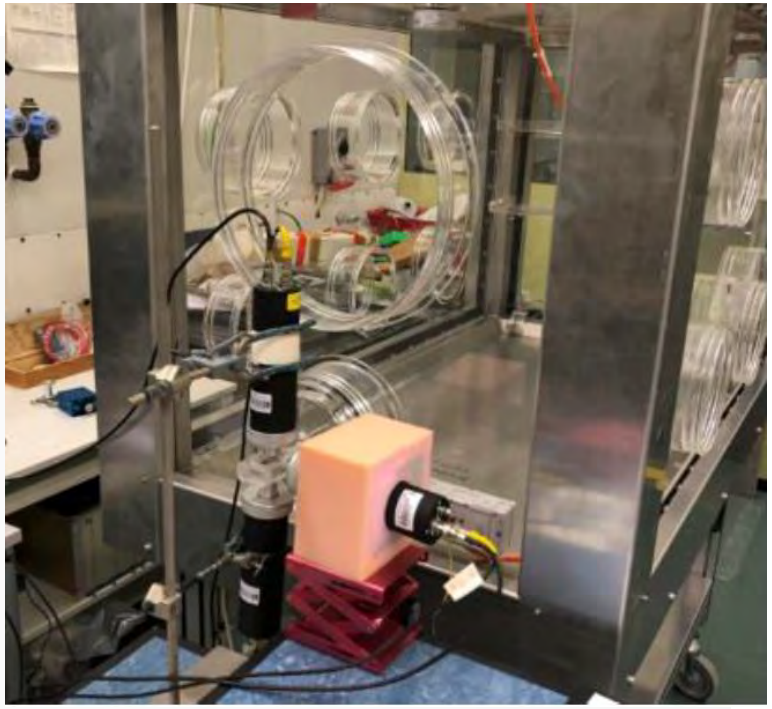
→ **Is there an alternative at laboratory ?**





Bes et al., JNM 507 (2018) 50.

PAS & XAS

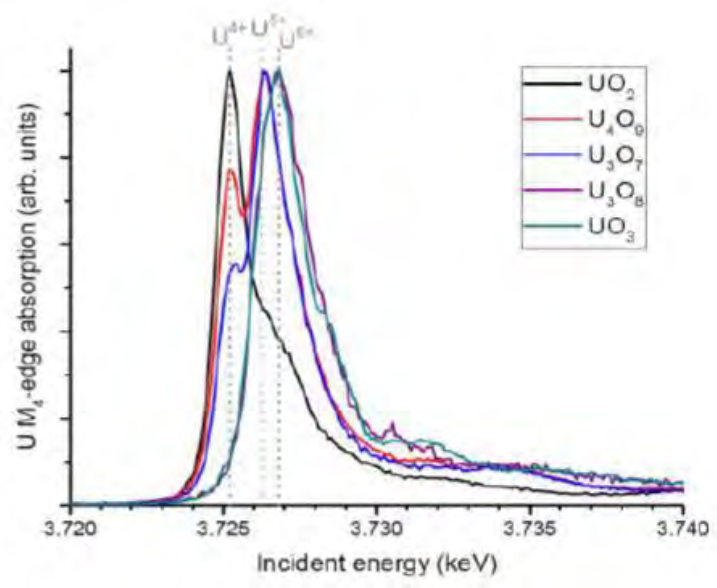


PAS device attracts interest from several laboratories dealing with radioactive materials

- JRC Karlsruhe (Germany) for study MOX nuclear fuels
  - Collaboration through H2020 European project INSPYRE
  - **Commissioning on-going, ready next month**
- CEA Atalante facility (France) is considering us for upgrading their existing device for nuclear waste/fuel studies

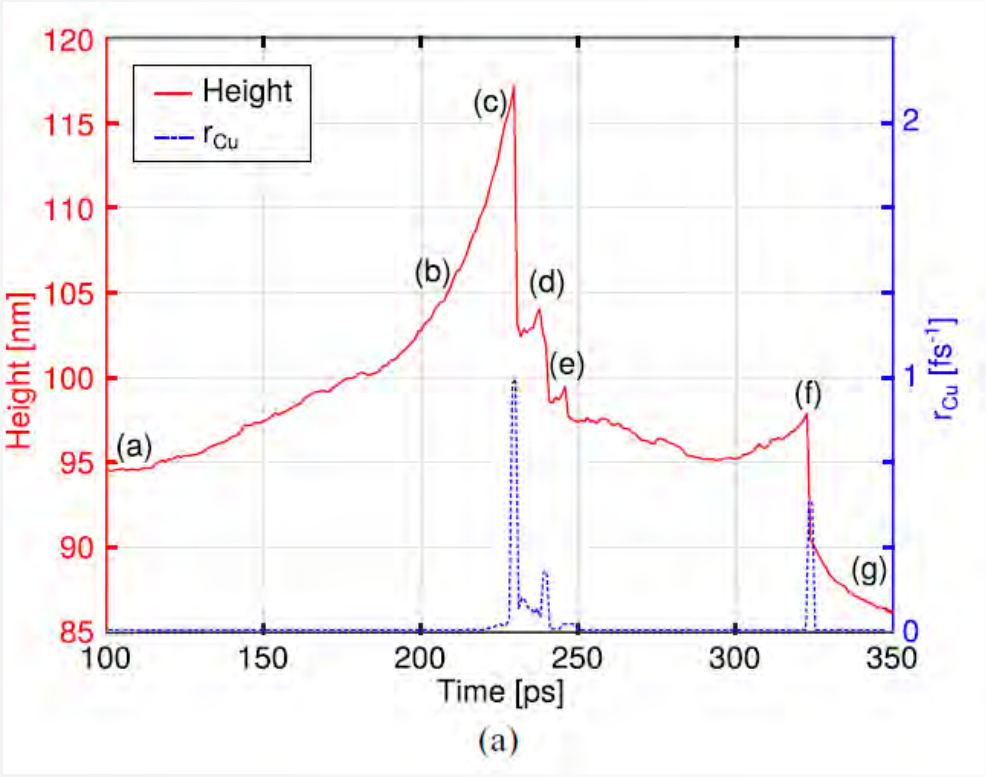
Laboratory scale XAS device development

- Specific design to allow in situ experiments coupled to accelerator
- Agreement with CEA Atalante to build a similar device in their facility for nuclear waste/fuel studies
  - HIP-CEA bilateral agreement under preparation, CEA funding
- Collab. with HZDR / ESRF Rossendorf Beamline (Germany)
- Strong interest from Studsvik (Sweden)

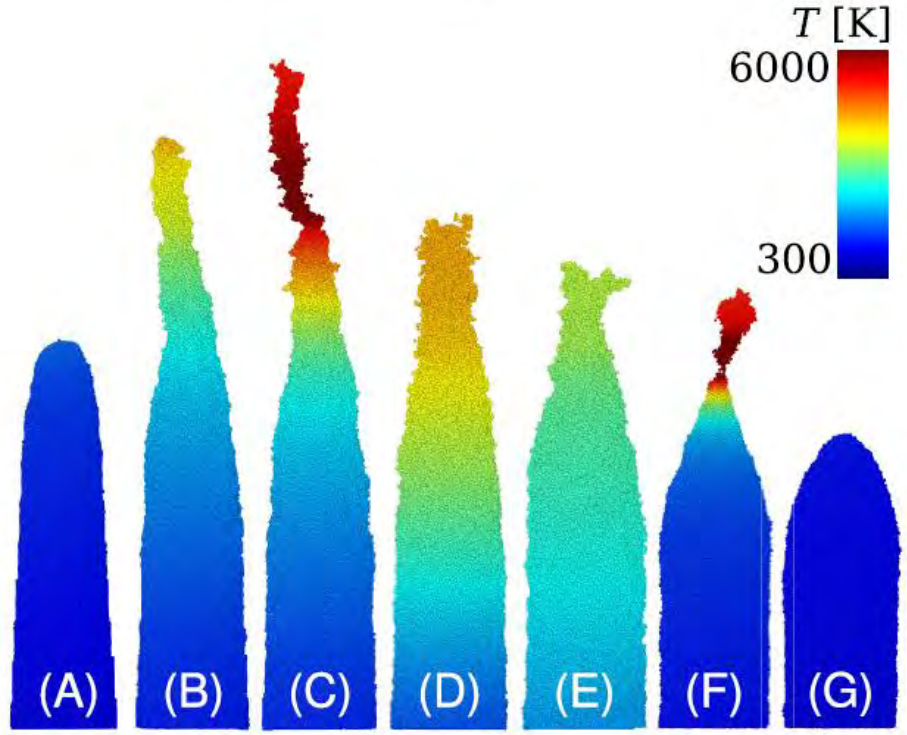


ACCELERATOR MATERIALS

- Flyura Djurabekova (UH/HIP)
- Focus on understanding the evolution of surfaces under high electric fields
- Code development: molecular dynamics (FEMOCS), kinetic Monte Carlo, machine learning algorithms
- Experiments: Large Electrodes System (LES), transferred from CERN to UH in 2017
- Future plans include proton radiation damage in FCC structures
- CERN K-contract, Academy of Finland funding (post-doc and regular projects), MATRENA graduate school
- Example: thermal runaway of metal nano-tips under during intense electron emission



(a)

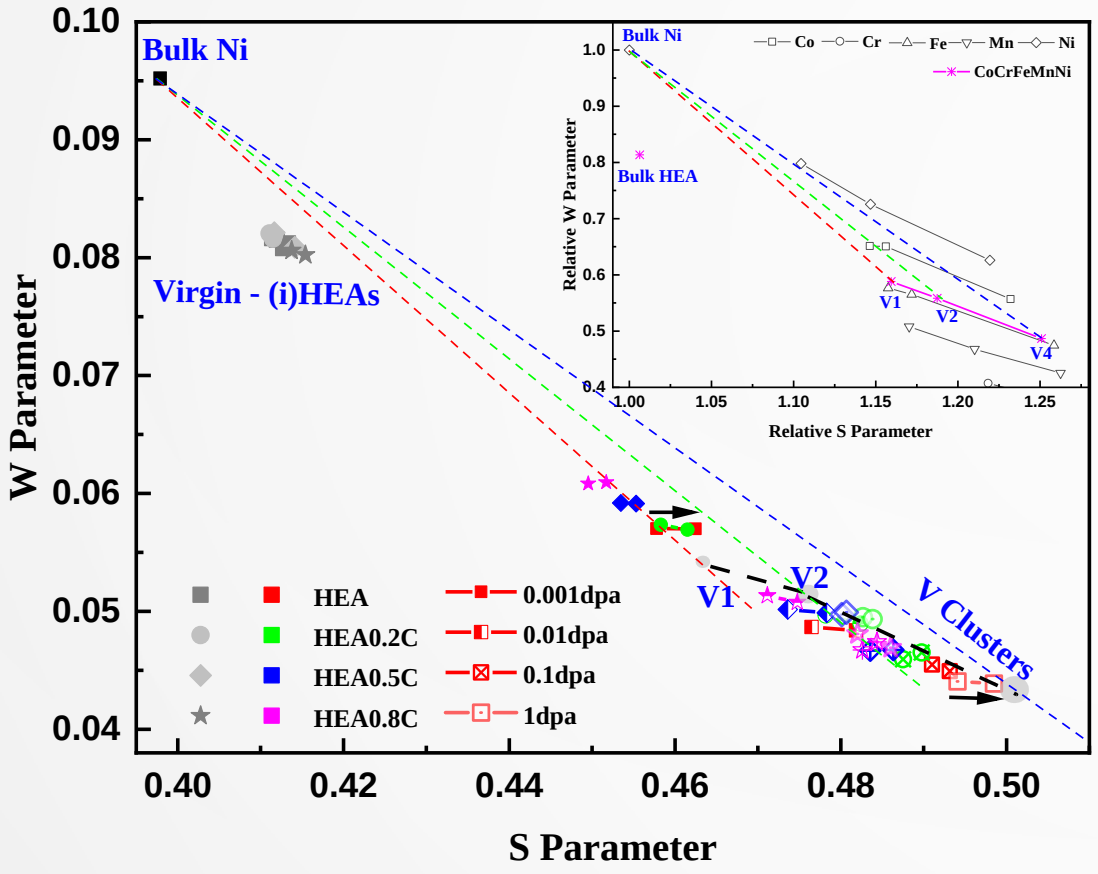


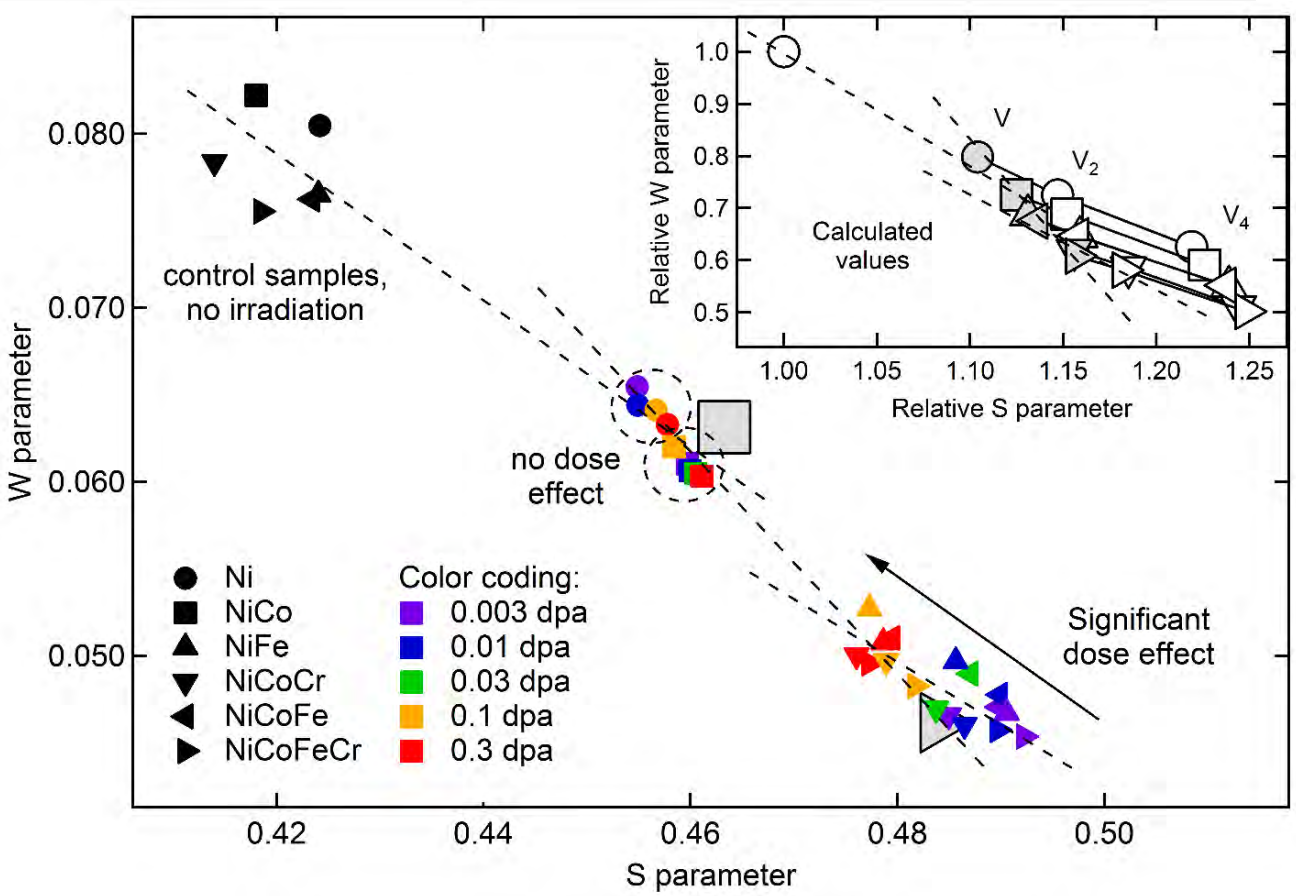
(b)

Figure 5. (a) Evolution of the height of the tip (red line, left axis) and the Cu atoms evaporation rate (blue dashed line, right axis). The designated points ((a)–(g)) correspond to the frames depicted in figure (b). The color coding of (b) corresponds to the local temperature. All evaporated atoms and nano-clusters have been removed. The full animation is available in the supplementary material.

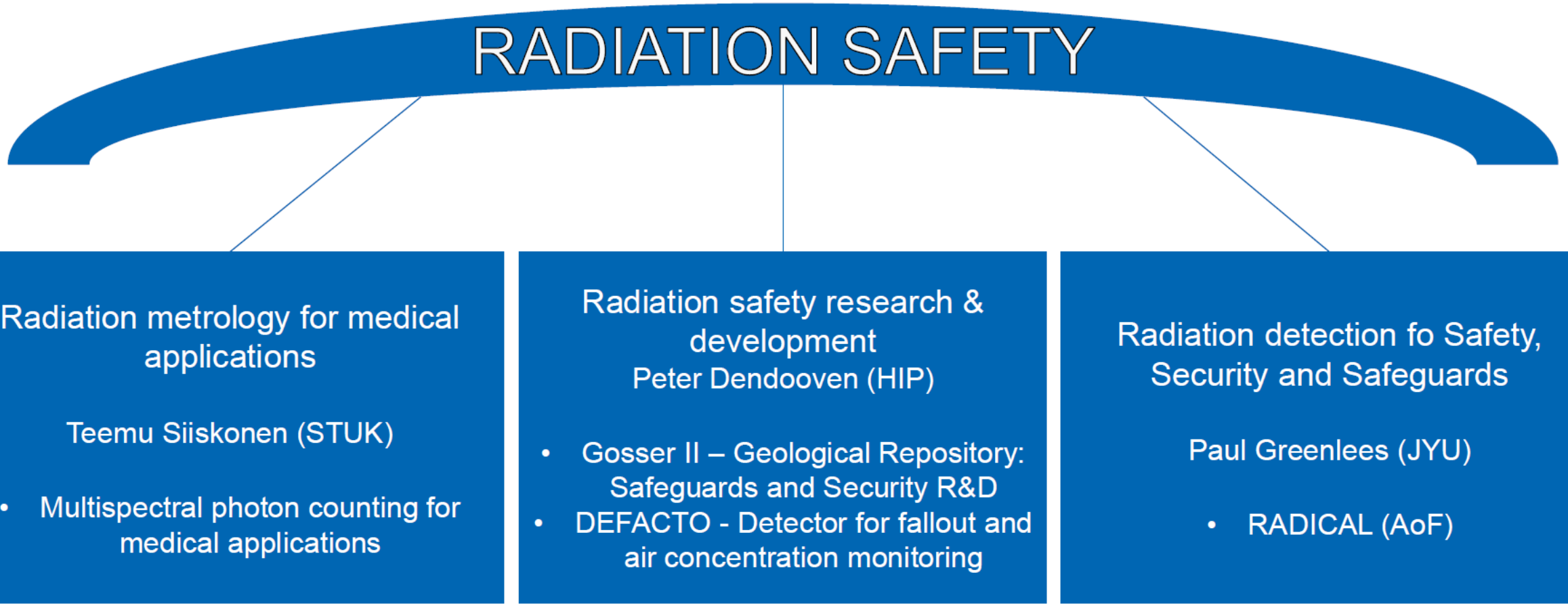
NEW MATERIALS FOR BIG SCIENCE INSTALLATIONS

- Ilja Makkonen (UH)
- Development and characterization of new materials for harsh environments
  - particle accelerators, fusion experiment devices, NPPs
- Radiation damage in High Entropy Alloys (HEAs)
  - metallic alloys that contain five or more elements in nearly equivalent ratios
- Also tungsten, copper
- Porosity in Nb superconductor coatings for FCC RF accelerating cavities
- Academy of Finland funding (Academy Research Fellow, post-doc)


Bulk Ni
Virgin - (i)HEAs
Bulk HEA
Co
Cr
Fe
Mn
Ni
CoCrFeMnNi
HEA
HEA0.2C
HEA0.5C
HEA0.8C
0.001dpa
0.01dpa
0.1dpa
1dpa
V1
V2
V4
V Clusters
Relative W Parameter
Relative S Parameter
W Parameter
S Parameter

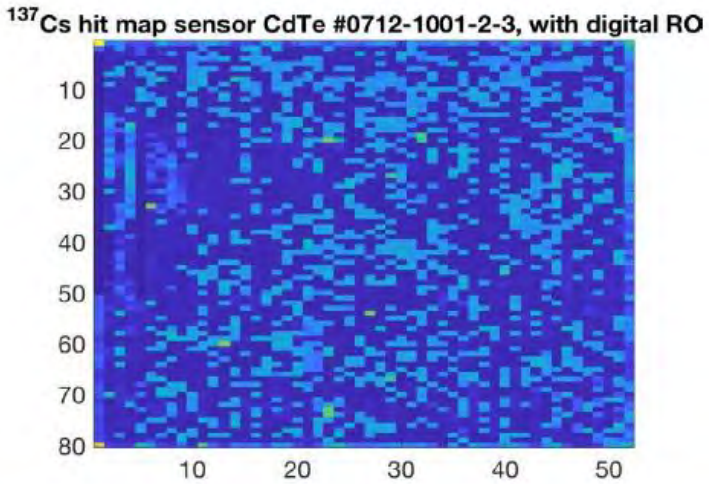

control samples,
no irradiation
no dose
effect
Significant
dose effect
Ni
NiCo
NiFe
NiCoCr
NiCoFe
NiCoFeCr
Color coding:
0.003 dpa
0.01 dpa
0.03 dpa
0.1 dpa
0.3 dpa
Calculated
values
V
V2
V4
Relative W parameter
Relative S parameter
W parameter
S parameter

STUK related projects in the HIP Technology Programme



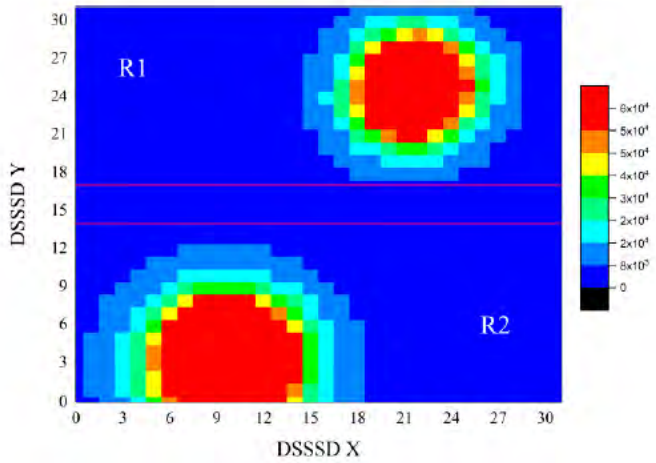
MULTISPECTRAL PHOTON COUNTING

- Aims
  - Develop novel detectors and signal processing for CT imaging and radiotherapy beam quality control
  - Improve safety and efficacy of patient imaging and radiotherapy treatment
- Technology
  - CdTe pixel detector
  - Scintillator array scanner
  - Scintillators on top of Si pixel detector
  - Acquire pulse height spectrum pixel by pixel
- Funding from Academy of Finland (2018-2021, HIP-AU-LUT-STUK consortium)
  - Project PI Panja-Riina Luukka (HIP)



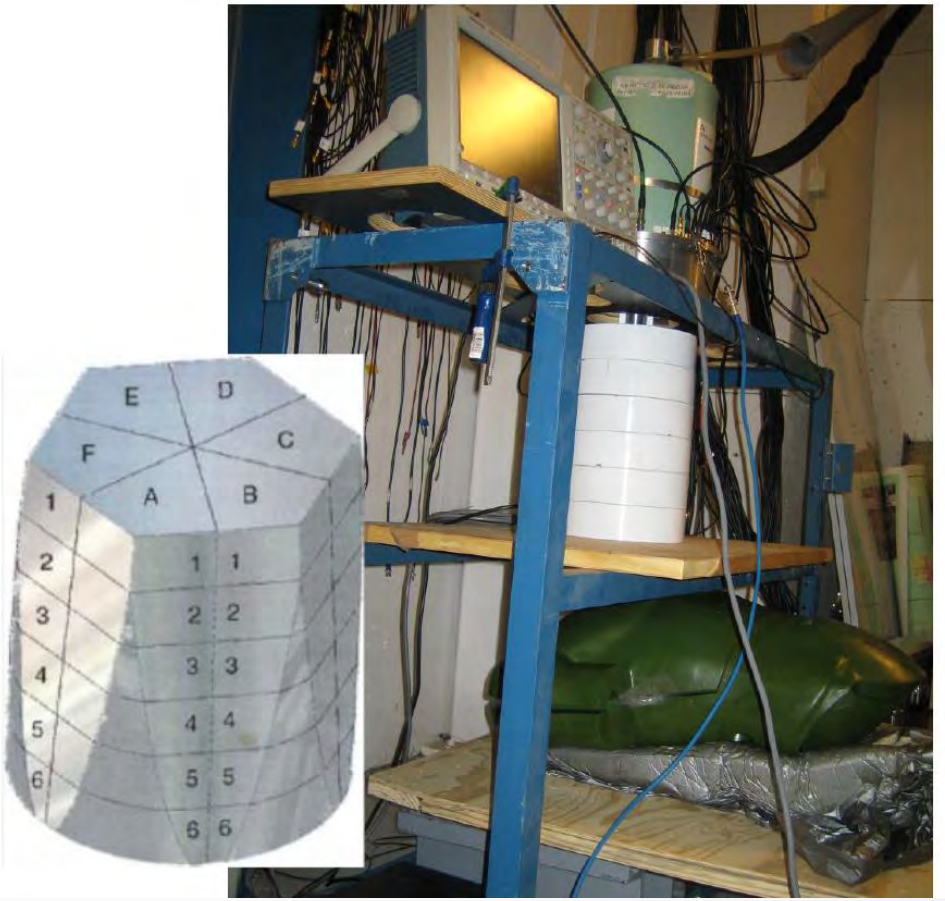
SAFETY, SECURITY AND SAFEGUARDS

- Aims to improve the sensitivity and reliability of laboratory radiation measurements carried out by STUK
  - Lower MDAs, shorter measurement times, more comprehensive analysis of samples
- Technology
  - Coincidence measurements with Si and Ge detectors (α-γ, β-γ)
  - List mode multiparameter data acquisition systems with digital electronics
  - New analysis and data sorting-software
  - Position- and radiation-type sensitive sample analysis (PANDA device at JYU)
  - Active suppression in low-background sample analysis (two setups at STUK)
- Funding: STUK's internal research funding (2018-2021)

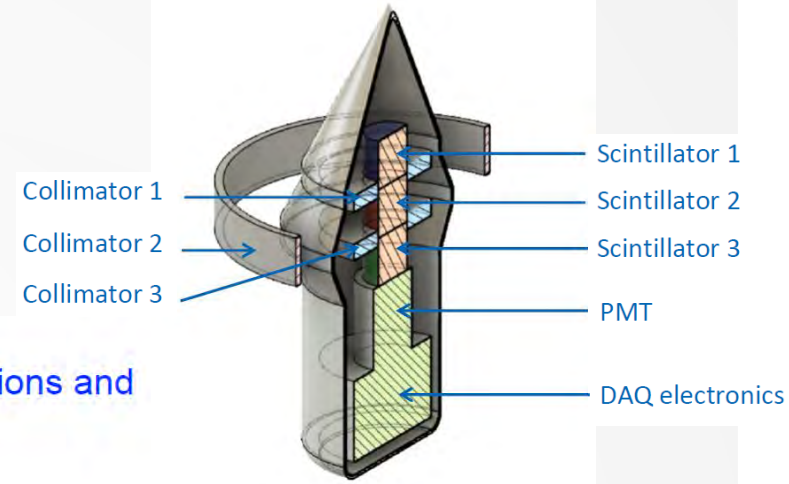


MORE 3S

- Full body counting (e.g. lungs)
- Measurement of low-energy (60 keV) gamma-rays from e.g. ingested Pu
- Hampered by Compton background from ^{40}K (1460 keV)
- Requires simulation and development of application-specific detector and coincidence counting
- Potential for collaborative project with HIP Detector Laboratory / JYFL / STUK
- Requires staff and detector development costs
- PhD student now employed at JYFL



RADIATION SAFETY R&D



Background:

- Current Finnish nationwide early warning network consists of about 250 dose-rate measurement stations and about 20 stations with a gamma-ray spectrometers
- An update for the network is currently under investigation

Main goal: Develop a new spectrometric sensor for the Finnish early warning network that can:

- Distinguish between airborne radioactivity and radioactive fallout
- Identify/prevent contamination of the detector instrument

DEFACTO

GOSSER II

motivation: Finnish spent nuclear fuel disposal in a geologic repository

main goal: spent fuel verification technology for a national approach for disposal safeguards

focus of HIP: continued development of PGET & PNAR devices for spent fuel verification
specific HIP expertise/resources: Monte Carlo simulations, Detector Laboratory

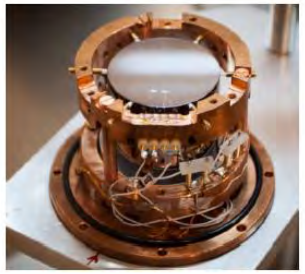
FINNISH CERN BIC

- Saku Mäkinen, Pietari Kauttu (TUNI, CERN)

- Facilitation of 4 Business Finland funded co-creation projects:
  - Augmented monitoring with intelligent machines at CERN (Pieters, Rahtu TUNI/HIP)
  - Ecosystem as stepping stone to a European superconductor cluster (Stenvall TUNI/HIP)
  - Data centers as active components of the energy system (Vilkko TUNI/SENECC)
  - Advanced Mechanics and Materials for Detectors and Accelerators (Österberg UH/HIP)

- Industrial activation and BIC: negotiations ongoing, HIP, TUNI, UH, Aalto (ESA-BIC), Tamlink Oy, Ruuti Oy, Maria 01?

NEW INITIATIVES



- Mechatronics, autonomous vehicles (related to remote operation, CERN)
- Cryogenics, COSINUS experiment (matter - dark matter interaction, confirmation or rejection of the DAMA/LIBRA experiment)
- Isotope-pure 1-tonne HPGe detector for LEGEND (follow-up to GERDA-MAJORANA 30-40kg), neutrinoless ββ-decay of ^{76}Ge (neutrino = anti-neutrino?)
- Cooperation with other Big Science programmes
  - in particular, the challenge of operating in harsh radiation environments, see, e.g., the recent CERN-ESA collaboration agreement
  - fusion research?
  - synchrotrons?