WP5.4 : New technology for radon-free environments

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Introduction
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Deliverables

cnrs IN2P3 Les deux infinis

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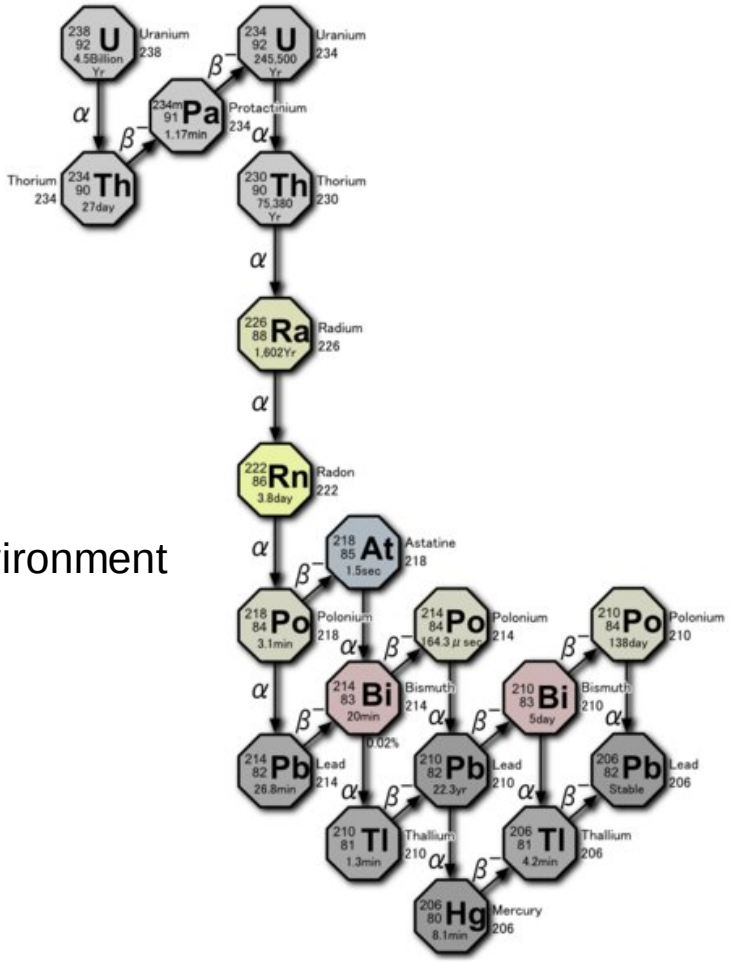
LPSC PLATEFORME NATIONALE LSM

Introduction

- As other WP, this WP is very low on equipment costs
  - Focus on what can be done with existing facilities
- Coordination of efforts
  - Rn experts (detection, transport, trapping)
  - Underground lab facilities
- Increase expertise
  - DUL facilities
  - Experiments

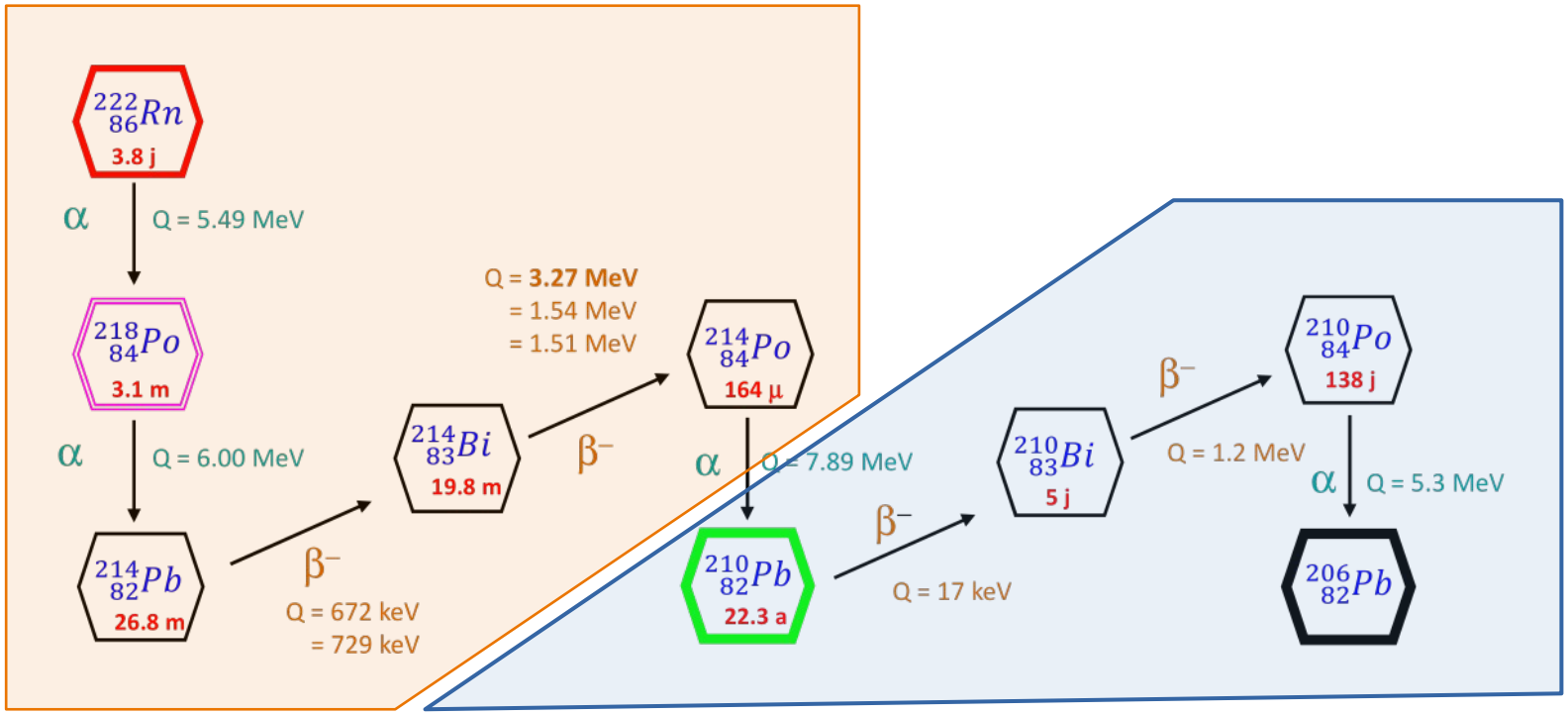
The Radon Problem

- Radon (Rn) is a ***radioactive***, noble gas
- Most stable isotope is ^{222}Rn (3.8 day)
  - ^{238}U decay chain
  - Some annoying daughters :
    - ^{210}Pb (22.3 year) → ^{210}Bi → ^{210}Po
- Radon mitigation is critical in low background environment
  - Radon emanation
  - Radon transport
  - Radon daughter deposition



Radon background sources

- Two mains background sources



Direct Background
(direct presence of radon)

Uncorrelated Background
(material deposition)

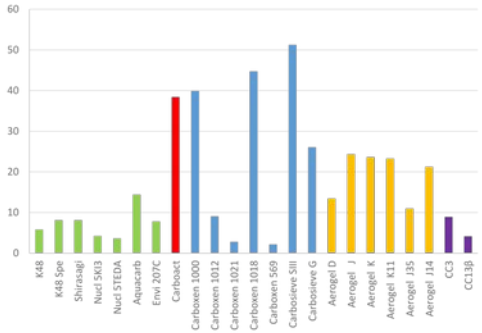
Goal 1 : Radon-free air

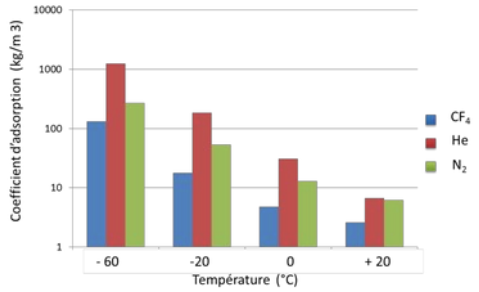
- Radon abatement systems are in operation in DUL since 2005 (LSM/ATEKO)
- Principle : Rn adsorption on an activated charcoal bed
  - Trap Rn in charcoal (adsorption) long enough for it to decay
  - Adsorption efficiency : material choice, material quantity (adsorption surface), temperature
  - compressed air → dryer → cooler → charcoal tower → radon-free air
- Needs for higher and higher radon-free air flow rates (up to 1000 m^3/hr)
  - Radon-free clean rooms
  - Scaling of existing systems is an issue :
    - Dimensions
    - Power consumption : ~ 70kW for 300m^3/hr

Cuore Rn abatement system (150 m^3/hr)

Goal 1 : Radon-free air

- Improving Radon trapping
  - Studies on new adsorption materials
  - Lower operating temperatures





- Improving power consumption
  - Systematic studies on system operation points (temp/pressure)
    - Influence of pressure on efficiency is not well documented
  - Replacement of air compressors by air turbines
    - 90% of power consumption is due to air compressors
    - Air turbine can efficiently provide high flow rate if low pressure operation

Goal 2 : Radon in pure gases

- Ar, Xe, He are intensively used in underground physics experiment detectors
- Cost and radiopurity issues
  - Liquefaction, Purification, Recycling
- Studies on transport and emanation of Rn in those gases
  - Temperature dependency
  - In liquid-gas phase
- Radon trapping in Xe
  - Rn and Xe have very close atomic radius
  - Development of innovative adsorbents with high Rn/Xe selectivity
- Rn transport and emanation in other detectors materials
  - Soft materials (eg. gaskets), liquid scintillators, organic vapors (alcohol)

Goal 3 : Radon Monitoring

- Detectors for ultra-low Rn activities
  - Detection of leaks, emanation, diffusion, along Rn-free air distribution system
  - continuous monitoring of radon concentrations
    - mBq/m^3 sensitivity
    - Multi-point (from Rn abatement system to users)
    - Cost effective
    - Easy Implementation
- Detectors for ultra-high Rn activities
  - Manipulation of strong Rn sources
  - Rapid detection of high Rn concentration
  - Hazard mitigation (health and environmental)

Partners

- LSM/LPSC (CNRS/IN2P3 France)
- CPPM (CNRS/IN2P3 France)

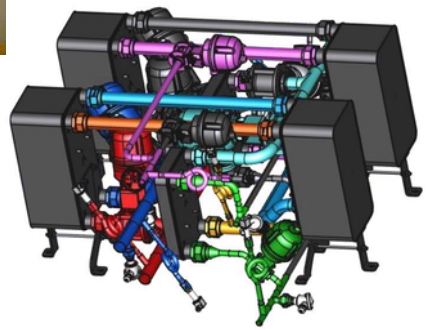
- LNGS (INFN Italy)
- Jagiellonian University (Poland)

- IEAP (CTU Prague / Czech Republic)
- SURO (Czech Republic)

- Industrial partners : ATEKO, TESLA, Carbio12

Facilities and equipment

- Radon abatement systems
  - Old system in operation @ LSM (2005-2020)
  - LSM is contracting a new system for 2022
    - In house developments for lower temp operations
  - Smaller system in operation in SURO for testing



- Radon adsorption test benches
  - Two systems in operation @ CPPM and CTU

- System for Rn transport and emanation studies
  - One system in operation @ CPPM

Facilities and equipment

- Rn-free clean rooms
  - LNGS
  - LSM (small, 20 m^3)
  - SURO (small, 13 m^3)

- Rn detectors
  - JAGU/LNGS :
    - Construction of a new detector with 1 mBq/m^3 sensitivity
    - High pressure operation to improve sensitivity
  - 10 mBq/m^3 detectors available at LSM, CTU, SURO

Deliverables

- Hire of new personal
  - 2 FTE.Yr share LSM/CPPM
  - 2 FTE.Yr share CTU/SURO
  - 1 FTE JAGU
- Commisionning of new LSM radon abatement system
  - Intensive testing
  - Operation points (temp/pressure)
  - Adsorption material tests
- Prototypes of new Rn detector
  - Both ultra-low and ultra-high concentration
- Dissemination and publications
  - Rn adsorption materials tests
  - Rn emanation and transport studies
  - Rn detectors
  - Rn-free environments