Radioactive aerosols produced in AP0 target station

Feb. 2010 – Sep. 2011

1. Correlation between the particle size distribution of radioactive aerosols and their half-lives

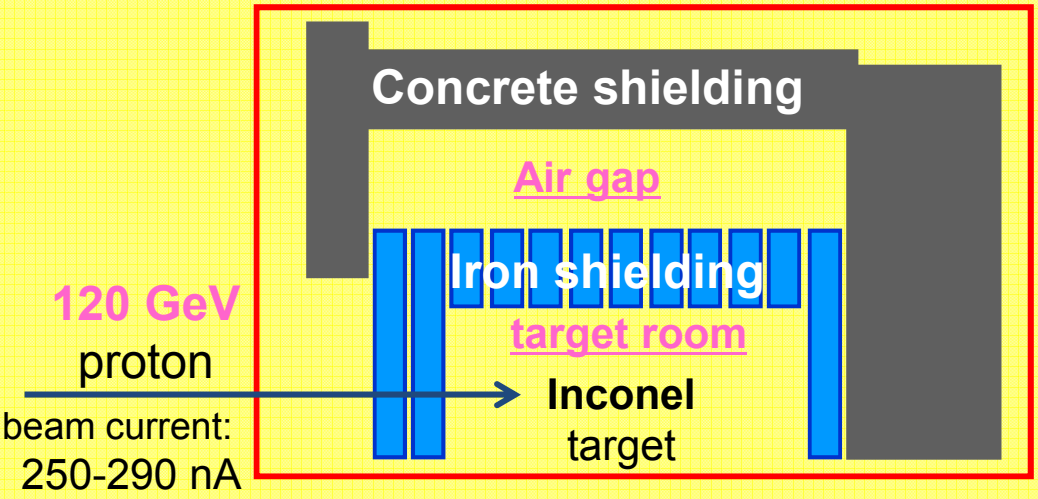
2. Activity of P-32

Shun Sekimoto
(Kyoto University Research Reactor Institute)

JASMIN collaboration meeting, February 16, 2012

Introduction

In target area of accelerator facility,
"**High-energy proton beams**
traveling in air and
beam sprays
from the interaction of the beam
with the target
and related target
station components
produce **radioactive aerosols**."



Anti-proton target station (AP0) @Fermilab

Motivation

To investigate those radio-nuclides **composition** and their **amount**
→The shielding in an accelerator facility
(by evaluating a residual radioactivity)
→Cosmo- and geo- science
(by simulating high-energy nuclear (spallation) reaction

To know **particle size** of those radioactive aerosols
→For the radiation control purposes, especially for evaluating the internal exposure of the workers.

Introduction

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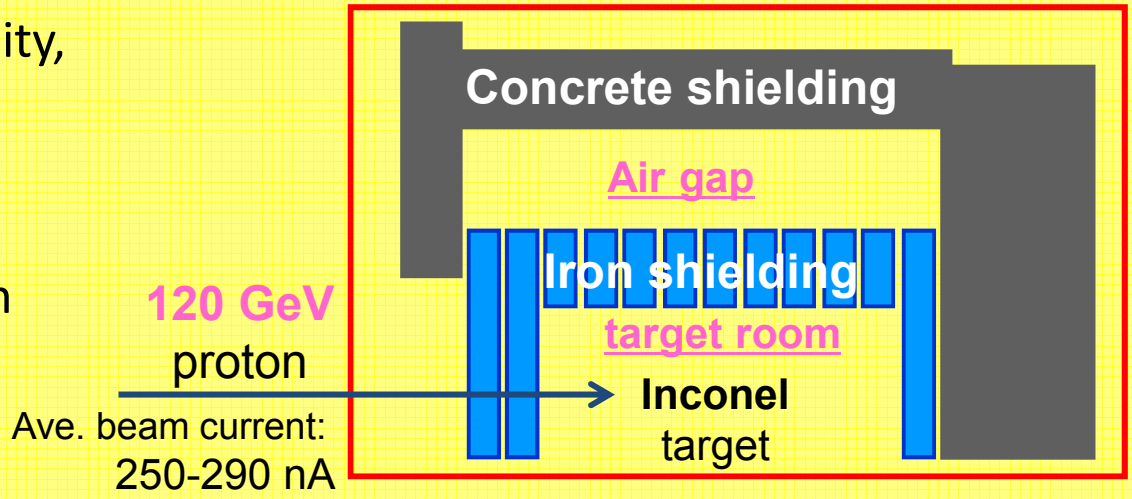


Anti-proton target station (AP0) @Fermilab

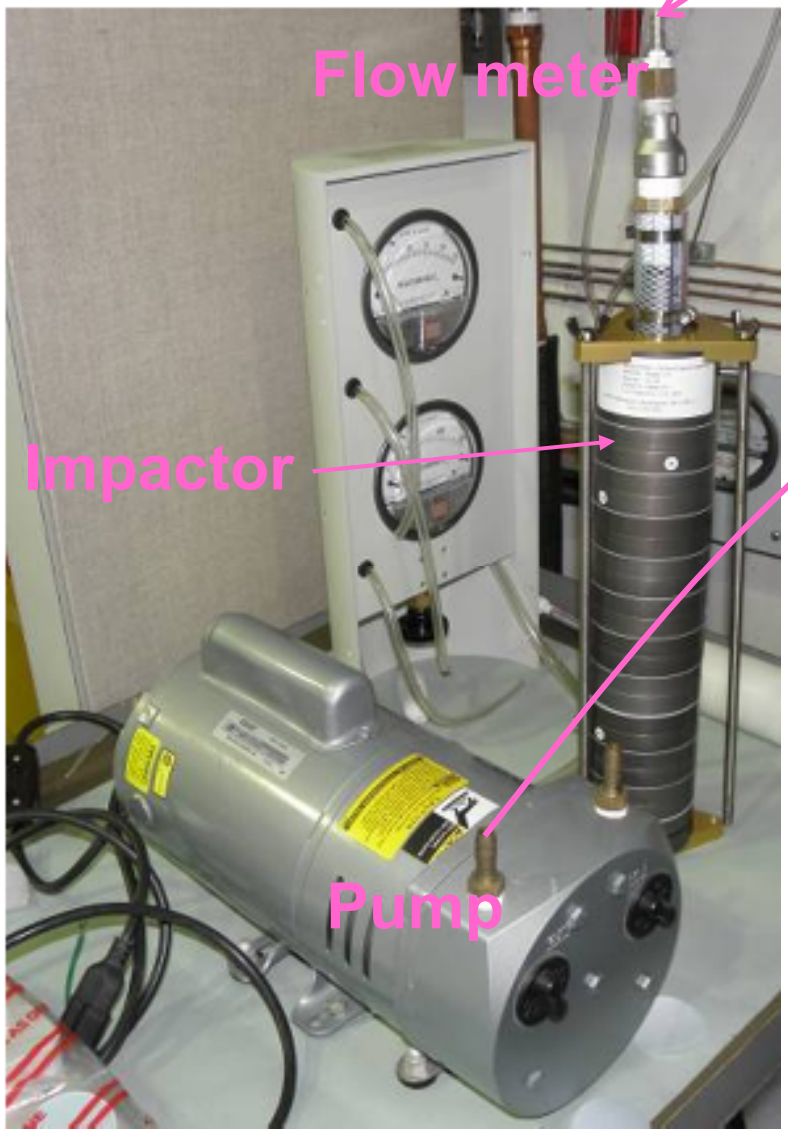
This work

Collection of **radioactive aerosols**
from the AP0 target vault

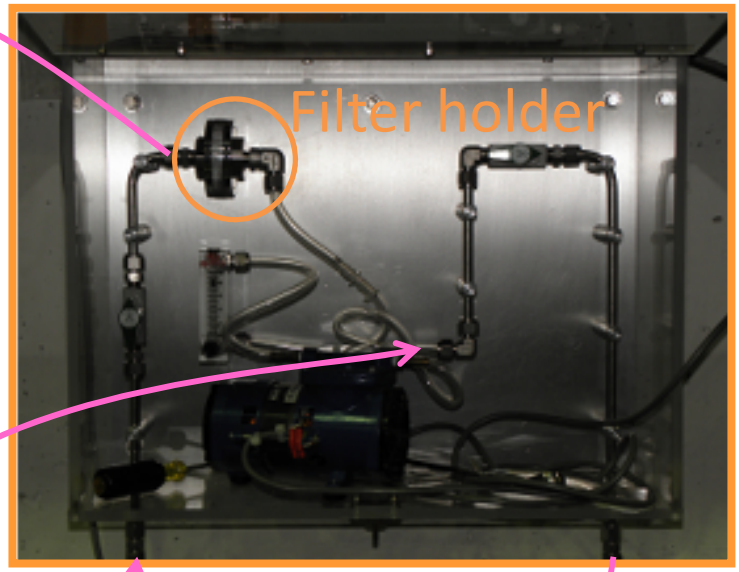
Separation of **radioactive aerosols** into several samples according to particulate size ranging from 0.056 to 10 μm

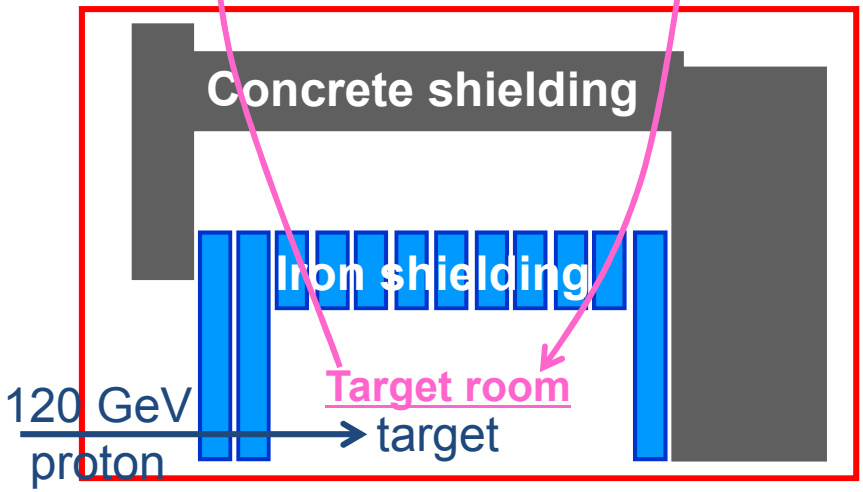
Impactor method

Experimental (Aerosol-sampling) (2/15, 10:20- 3h sampling)

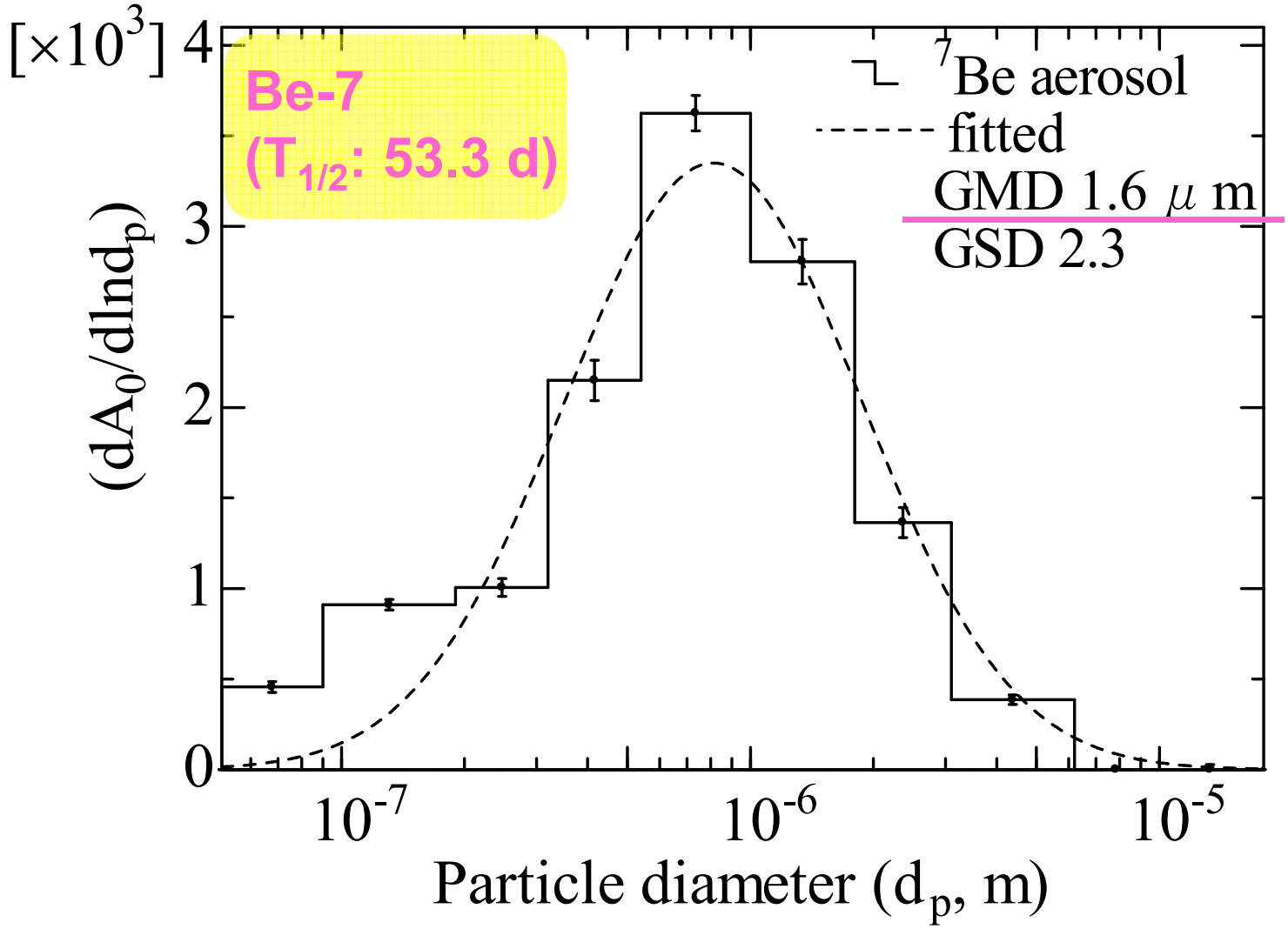


Gas/ aerosol-sampling device↓



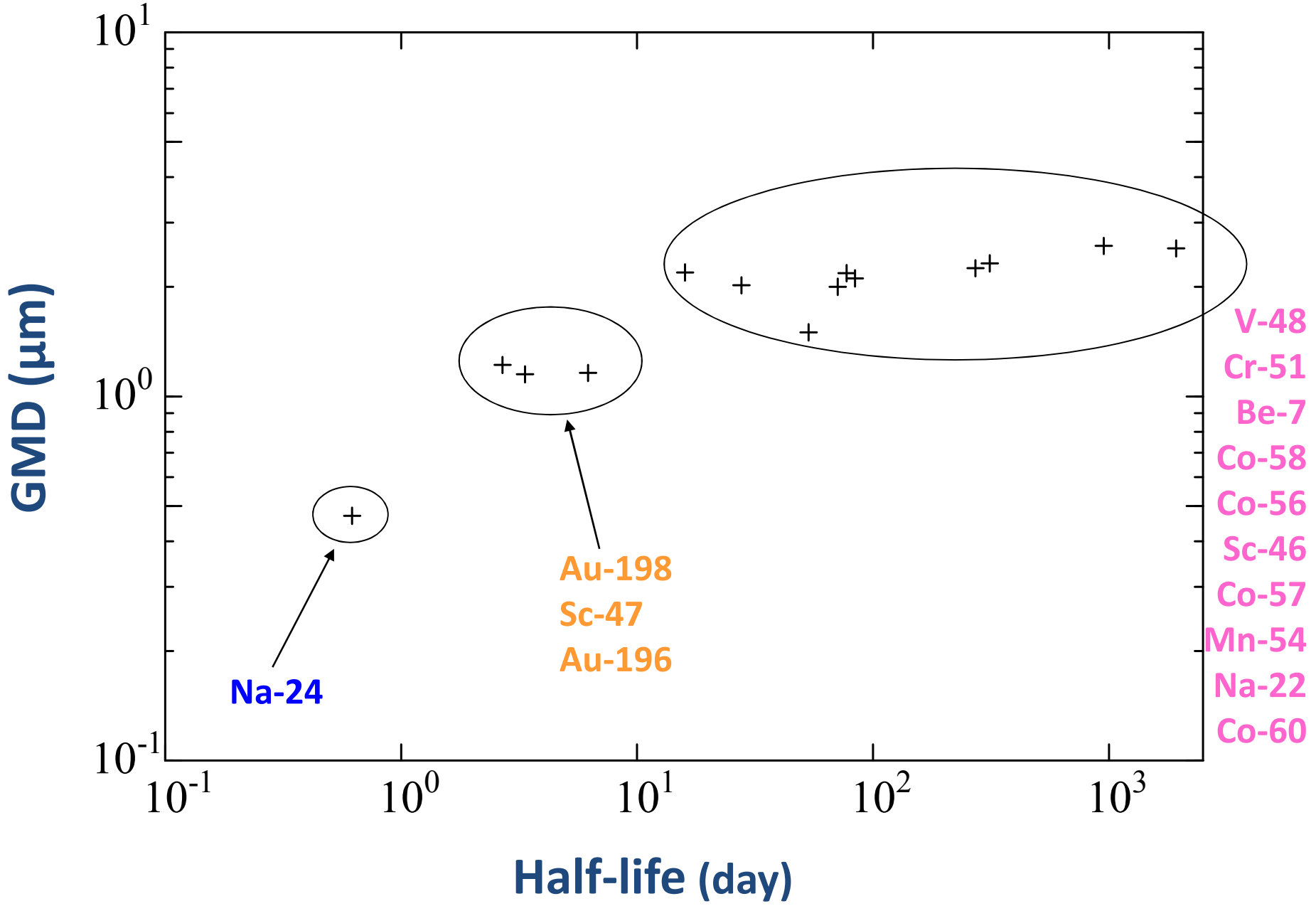


Results: Particle size distribution



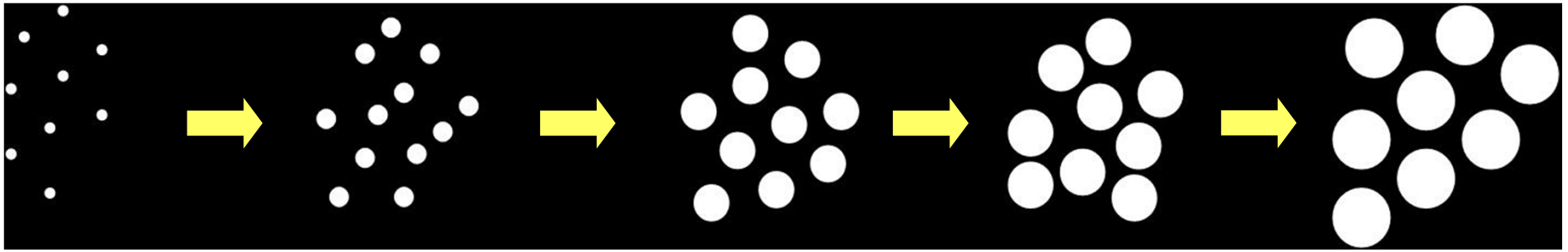
GMD: Geometric mean diameter

Discussion: Half life *vs.* particle size distribution



Discussion: Half life *vs.* particle size distribution

Restart of AP0-operation →**6 month**→ **Aerosol-sampling**



Growing up of aerosols

Na-24	Na-24			
Au-198	Au-198	**Au-198**	Au-198	
Sc-47	Sc-47	**Sc-47**	Sc-47	
Au-196	Au-196	**Au-196**	Au-196	
V-48	V-48	V-48	V-48	**V-48**
Cr-51	Cr-51	Cr-51	Cr-51	**Cr-51**
Be-7	Be-7	Be-7	Be-7	**Be-7**
Co-58	Co-58	Co-58	Co-58	**Co-58**
Co-56	Co-56	Co-56	Co-56	**Co-56**
Sc-46	Sc-46	Sc-46	Sc-46	**Sc-46**
Co-57	Co-57	Co-57	Co-57	**Co-57**
Mn-54	Mn-54	Mn-54	Mn-54	**Mn-54**
Na-22	Na-22	Na-22	Na-22	**Na-22**
Co-60	Co-60	Co-60	Co-60	**Co-60**

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Motivation (Why we focus on P-32)

The pure beta emitters such as **P-32** as well as **gamma rays emitting nuclides** are also important.

^{32}P ($T_{1/2}$ = 14.26 d, no-γ)

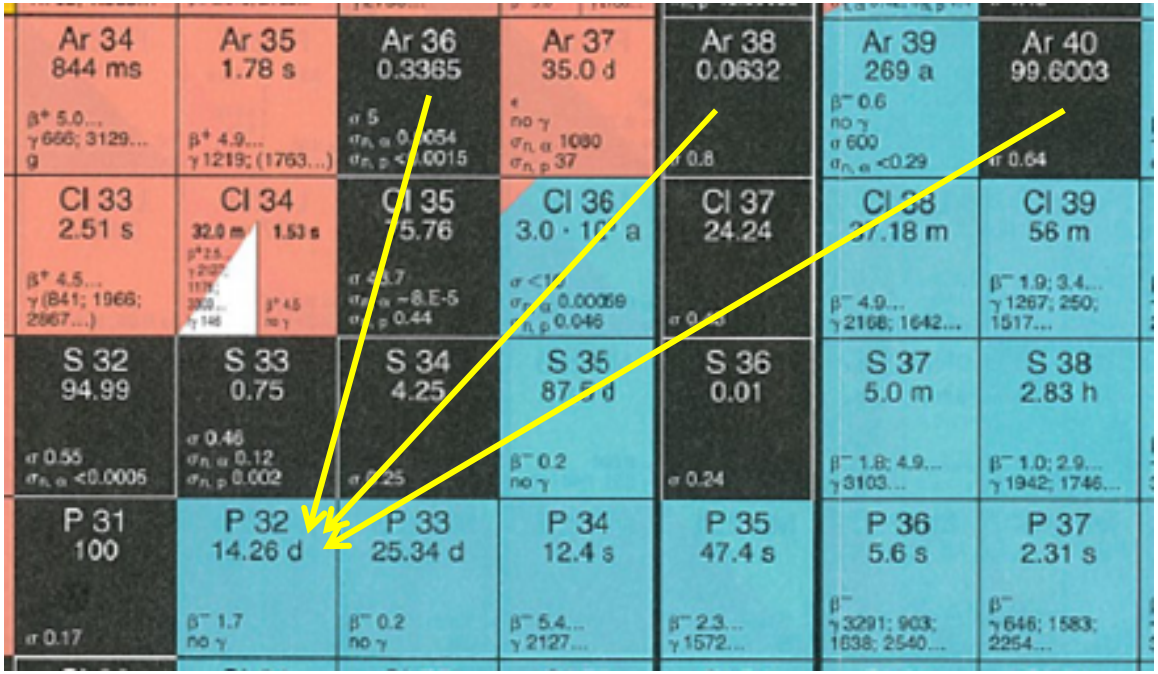
-**pure beta emitter**

→cannot be determined by **conventional method** used in radiation control

-from argon (Ar) in air

→ close to Ar

→ P-32 from Ar >> trace



In spite of **target materials**, it is essential to determine **activity levels of ^{32}P** for the radiation control purposes, especially for evaluating the internal exposure of the workers.

Production of ^{32}P in target area have not been studied previously,
because of difficulties in detecting and characterizing pure beta-emitters compared to gamma-ray emitters.

Motivation (Why we focus on P-32)

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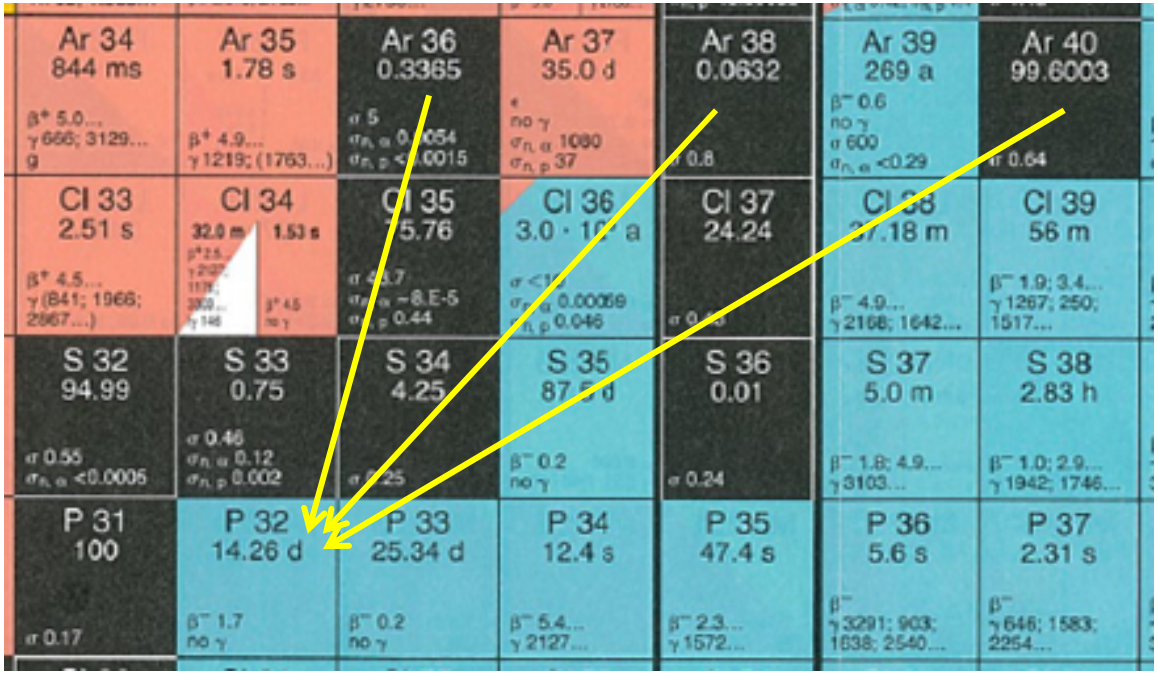


This work

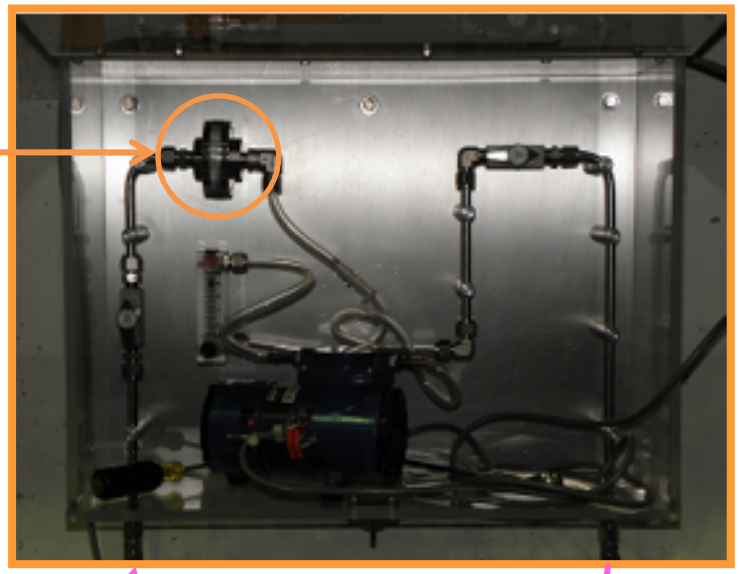
Determination of **the activity levels** of the beta emitting radio-nuclide **^{32}P** in the radioactive aerosols produced in Anti-proton target station.

Is **^{32}P** mainly produced from **Ar** in air, **target**, or **the instruments** around the target?

Experimental (Aerosol-sampling)

Gas/ aerosol-sampling device →

Filter holder

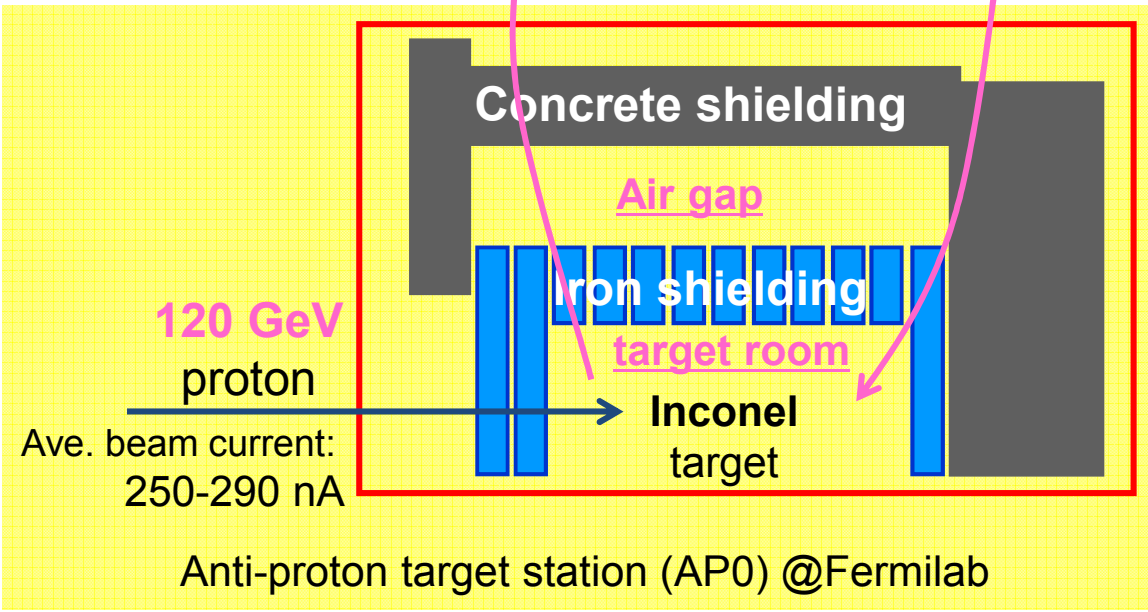


The radioactive aerosols,
(which were produced from Ar in air, target, or the other instruments,)
were withdrawn by a pump and collected on **filter paper**.

gamma-ray spectrometry

chemical treatment
(to separate P)

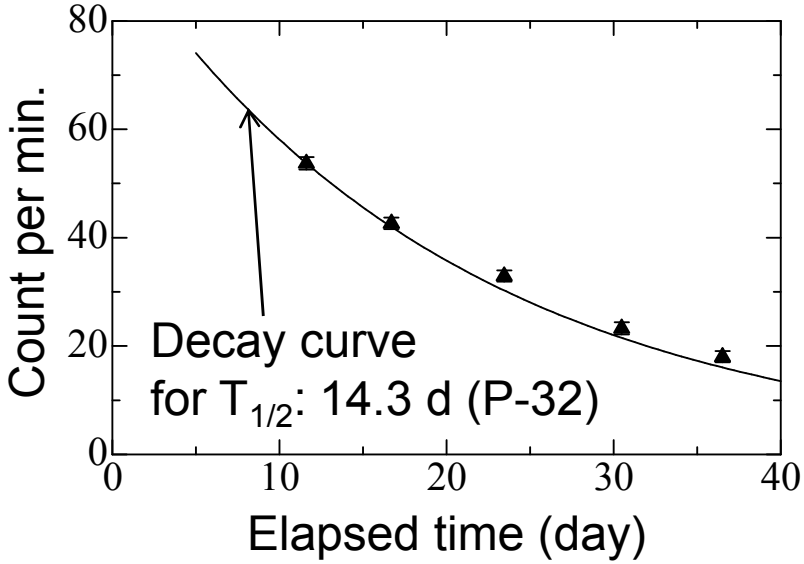
Sampling condition:
9.5 L of air / min
26 h-sampling
(≈ 15 m^3 of air in total)



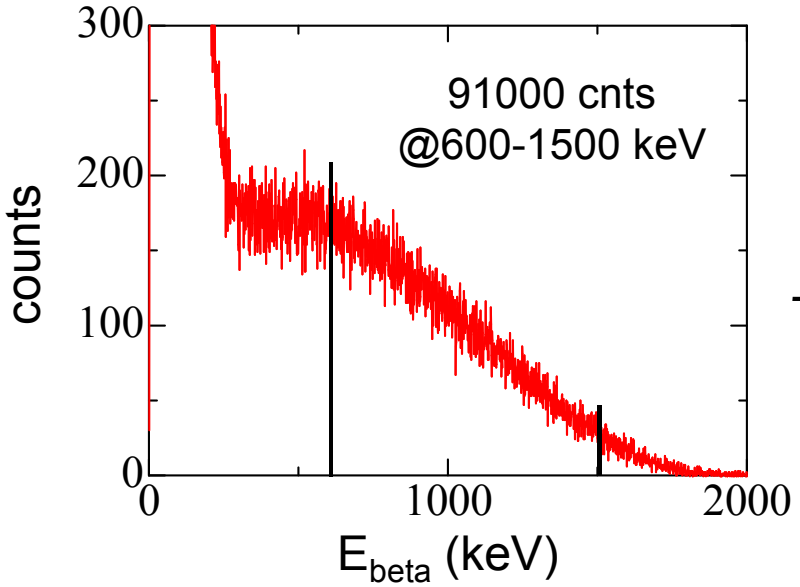
Results “Beta-ray counting and spectrum”

$MgNH_4PO_4 \bullet 6H_2O$

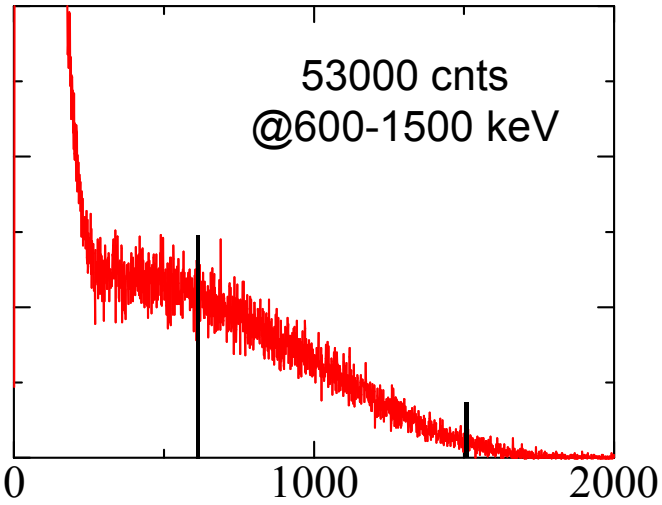
Beta-ray counting
by Geiger-Mueller counter



Beta-ray spectra from liquid scintillation counter

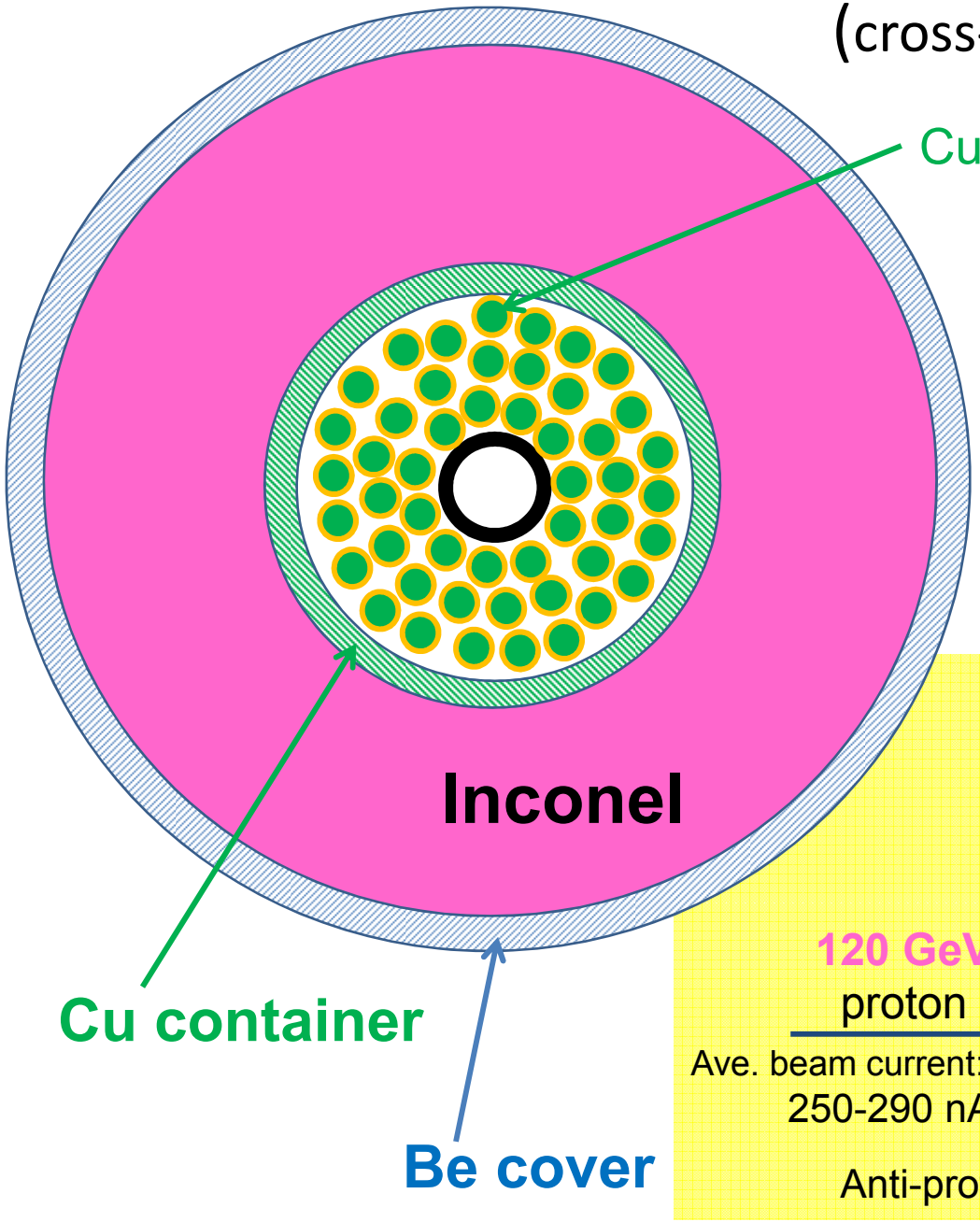


10 days



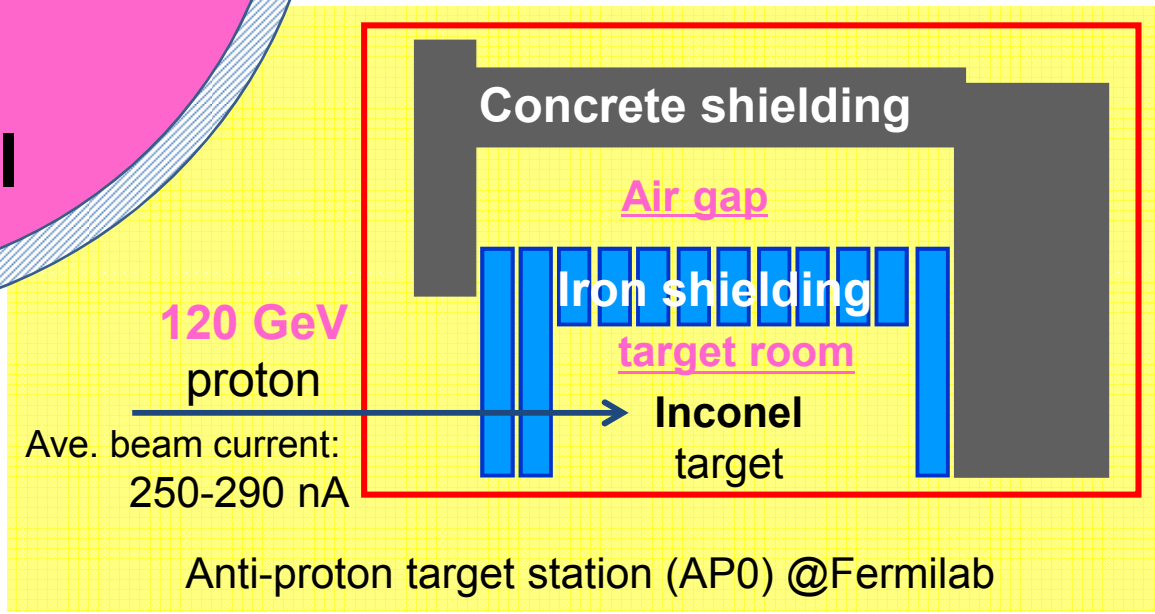
Discussion “Target materials in detail”

(cross-section drawing of target parts)

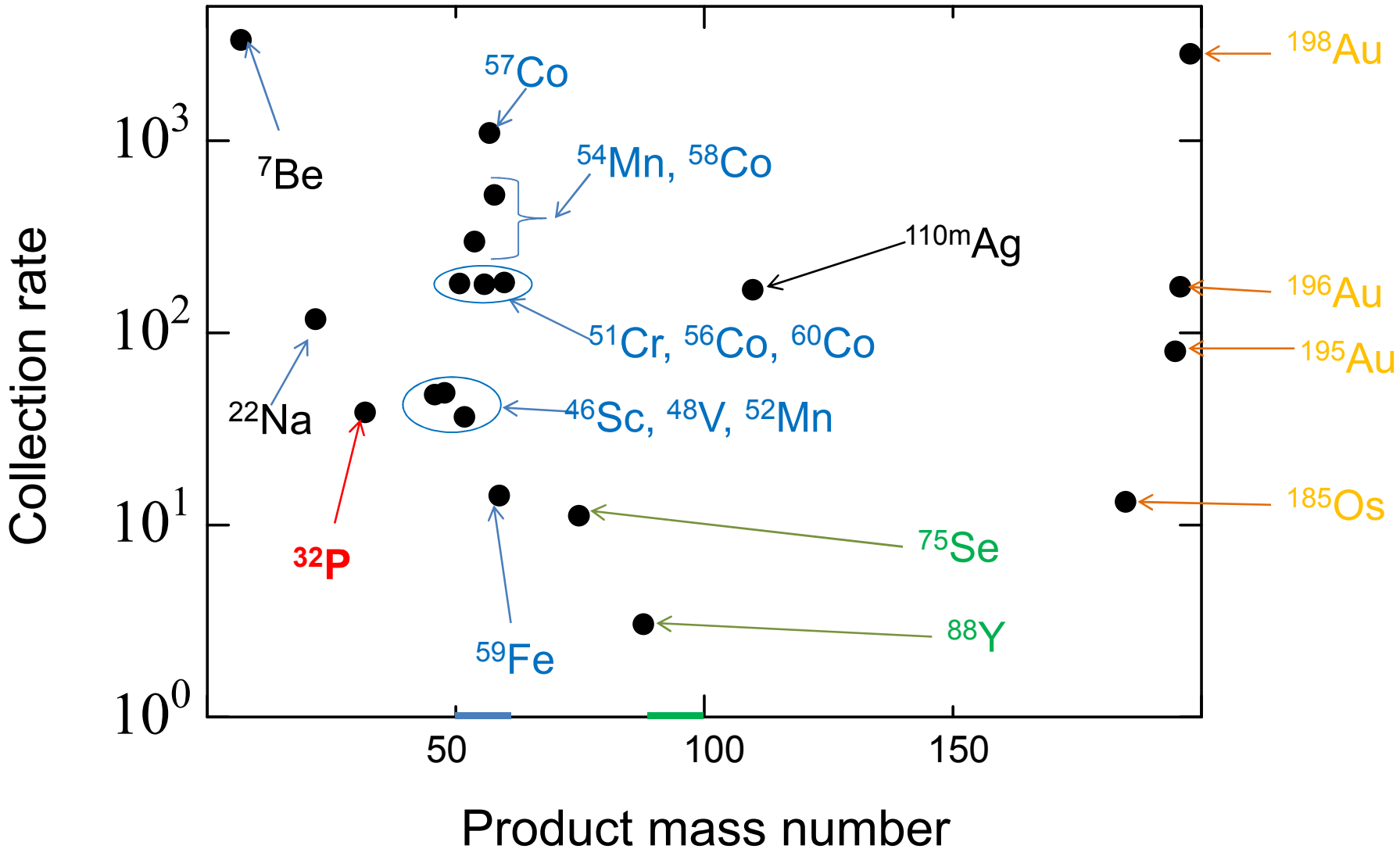


To cool down the Inconel target, Cu container and Cu balls are installed in the Inconel-target-hole.

Inconel: Ni, Fe, Cr, Nb, Mo etc.,



Discussion "Which contribute to P-32 production, air, target, etc.?"



^{32}P: < ^{22}Na, ≈ ^{46}Sc, ^{48}V, ^{52}Mn

→mainly produced from target materials or Ar in air ?

Summary

Determination of **the activity levels** of the beta emitting radionuclide ^{32}**P** in the radioactive aerosols produced in Anti-proton target station.

→Aerosol-sampling, chemical separation, LSC

Discussion about source material of ^{32}**P**, air or target components.

→Comparing other nuclides obtained by gamma-ray spectrometry