

Recent progress at the AIST slow positron beam facility

National Institute of Advanced Industrial
Science and Technology (AIST)

Koji Michishio

AHIPS-2024, 16th December 2024

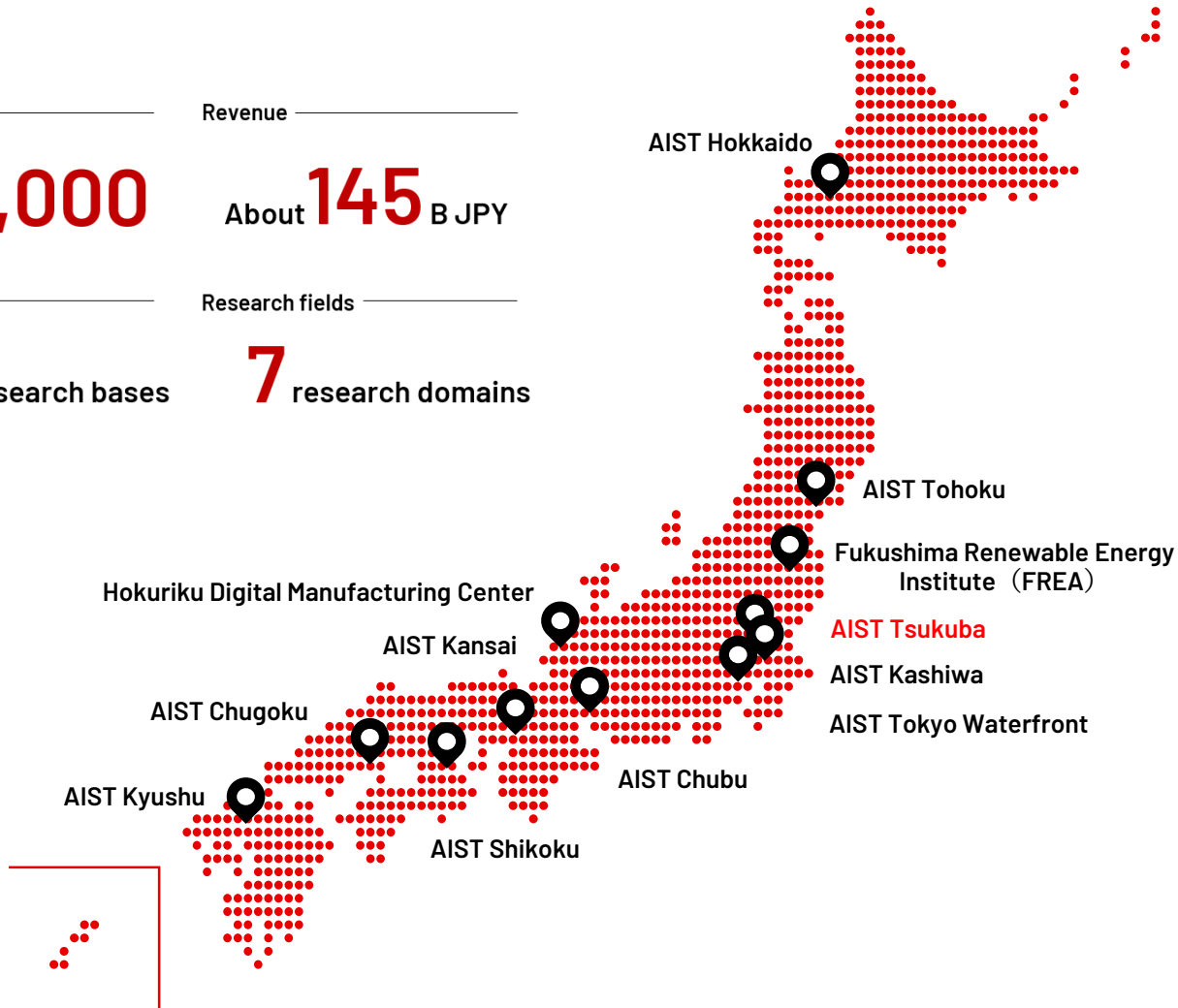
Outline

- Introduction
- LINAC-based slow positron facility
- Slow positron beam and its applications
- Summary

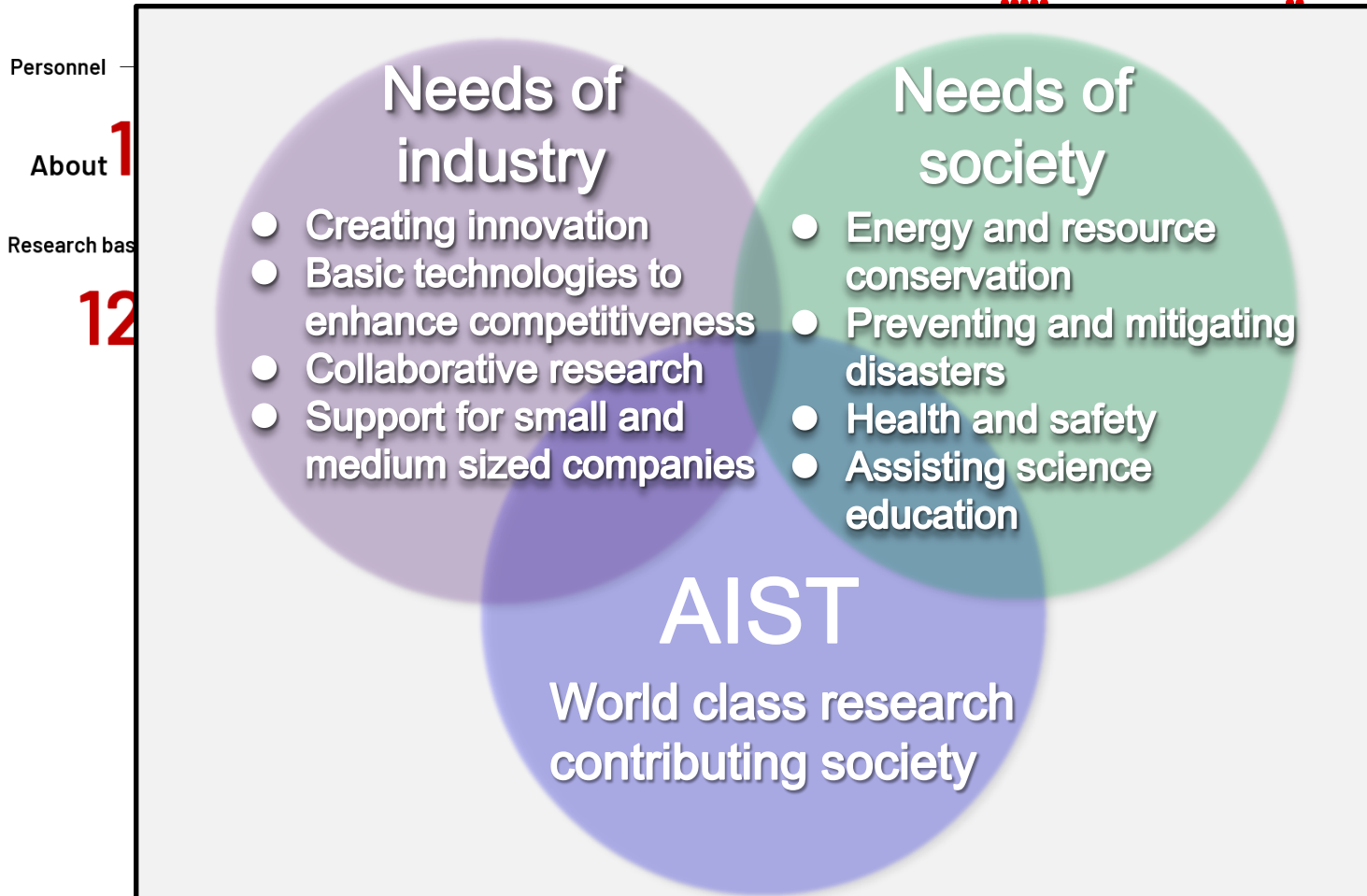
AIST : National Institute of Advanced Industrial Science and Technology



Personnel	Revenue
About 12,000	About 145 B JPY
Research base	Research fields
12 research bases	7 research domains

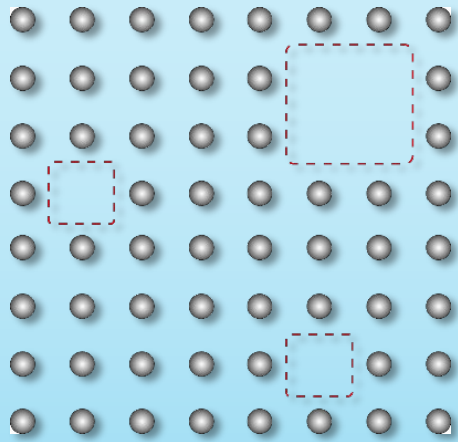


AIST : National Institute of Advanced Industrial Science and Technology



Defect and pore structures

Metal, semiconductor

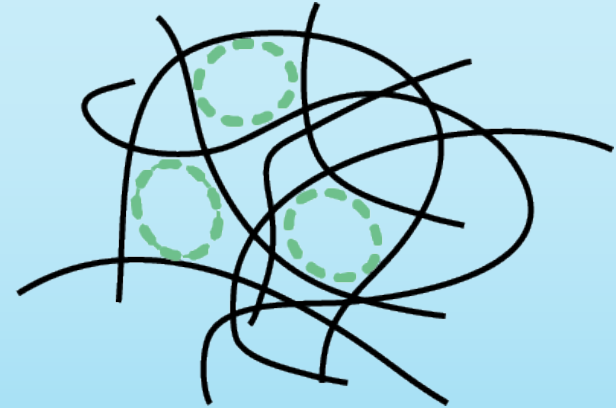


mechanical property, electrical conductivity, diffusion, occlusion



- structural materials
- ion irradiation semiconductors
- hydrogen storage alloys, etc...

Polymer, glass



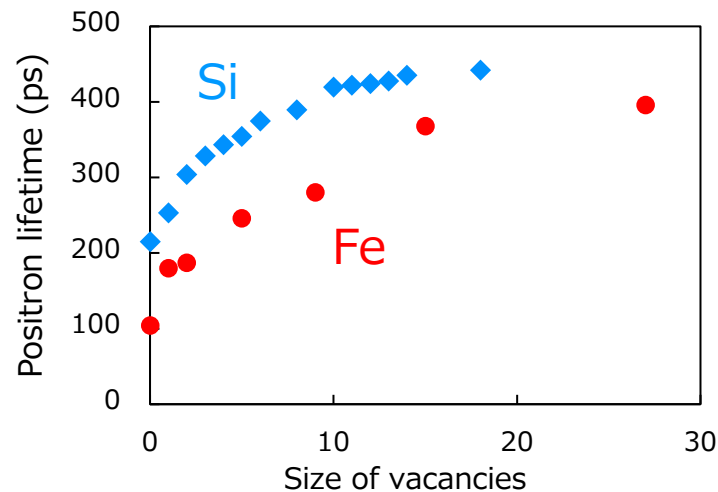
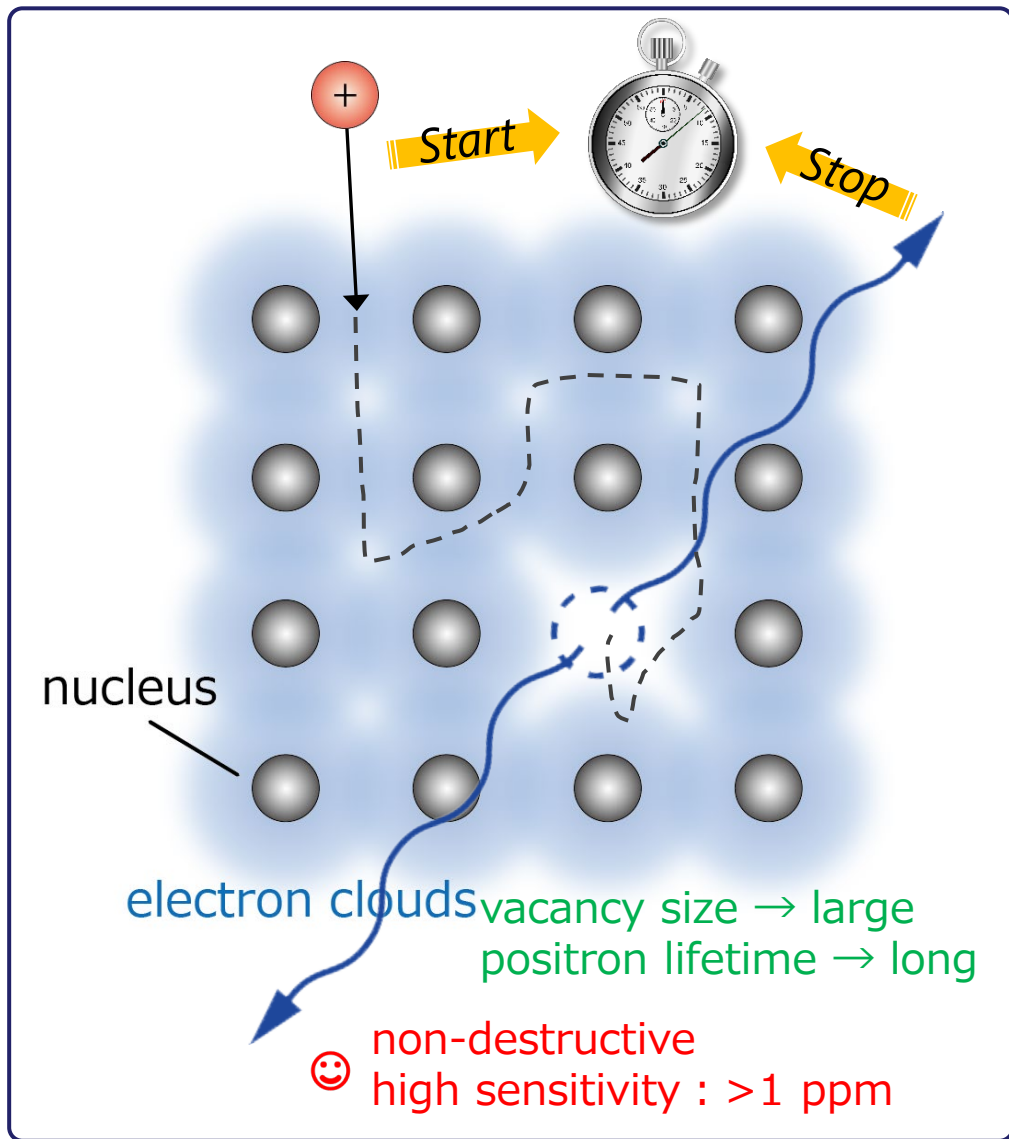
filtration, barrier performance, dielectric property



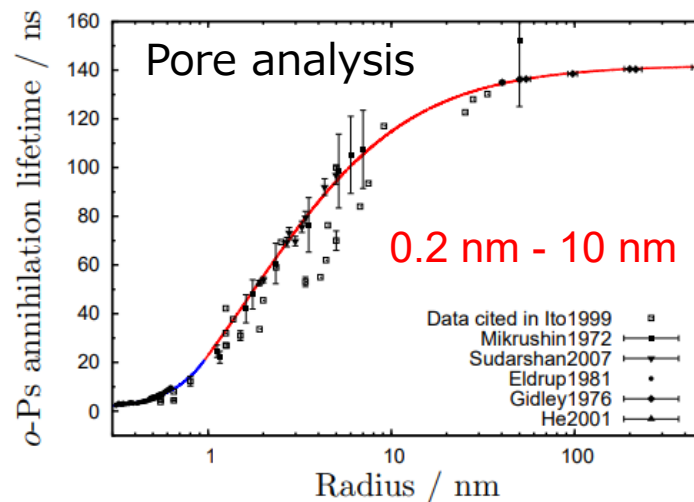
- reverse osmosis membranes
- gas barrier membranes
- electrolyte membranes, etc...

Extremely small voids affect the macroscopic properties of materials!

Positron Annihilation Lifetime Spectroscopy (PALS)



H. Ohkubo *et al.*, *Mat. Sci. Eng. A*, **350**, 95 (2003)

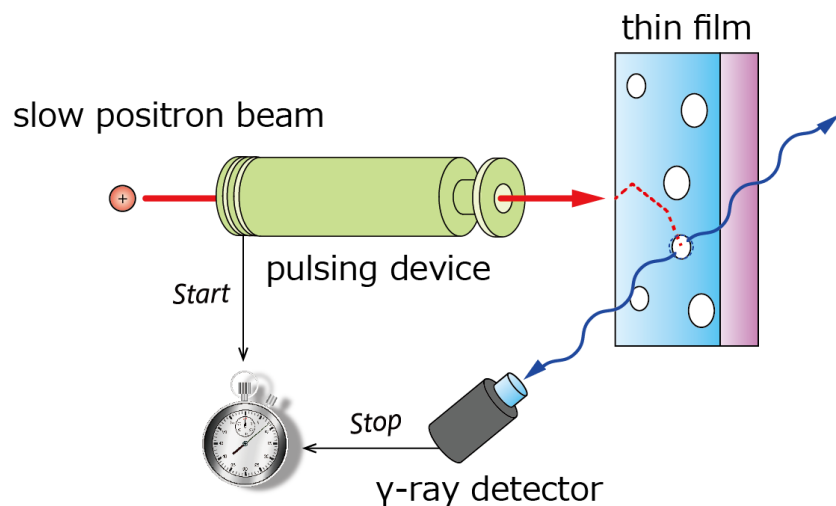


K. Wada, T. Hyodo, *J. Phys. Conf. Ser.* **443**, 012003 (2013)
 T. L. Dull, ..., D. W. Gidley *et al.*, *J. Phys. Chem. B* **105**, 4657 (2001)

Positron beam analysis (PALS)

Slow Positron Beam Method

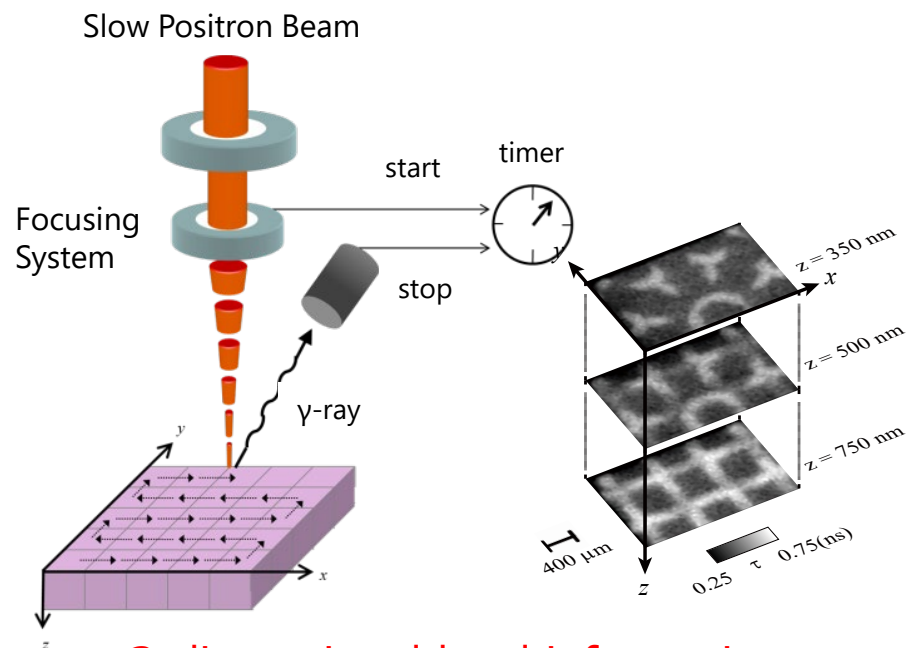
- Depth Res.: Surface $\sim 1 \mu\text{m}$ (1-30 keV)
- Spot Size : $\sim 10 \text{ mm}$



Depth-resolved information
(surface • thin film)

Positron Microscopy method

- Depth Res.: Surface - $\sim 1 \mu\text{m}$ (1-30 keV)
- Spot Size : $< 100 \mu\text{m}$



3-dimensional local information
(tinny sample • composite materials)

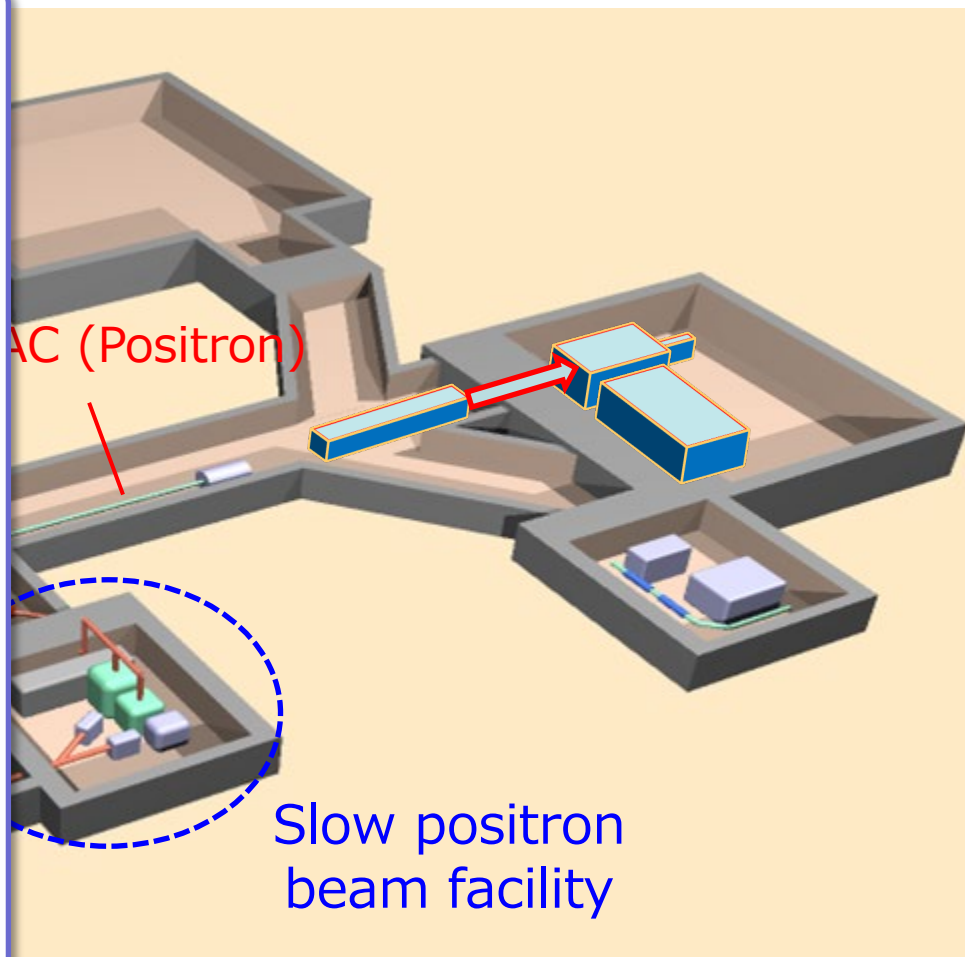
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AIST Slow Positron Facility

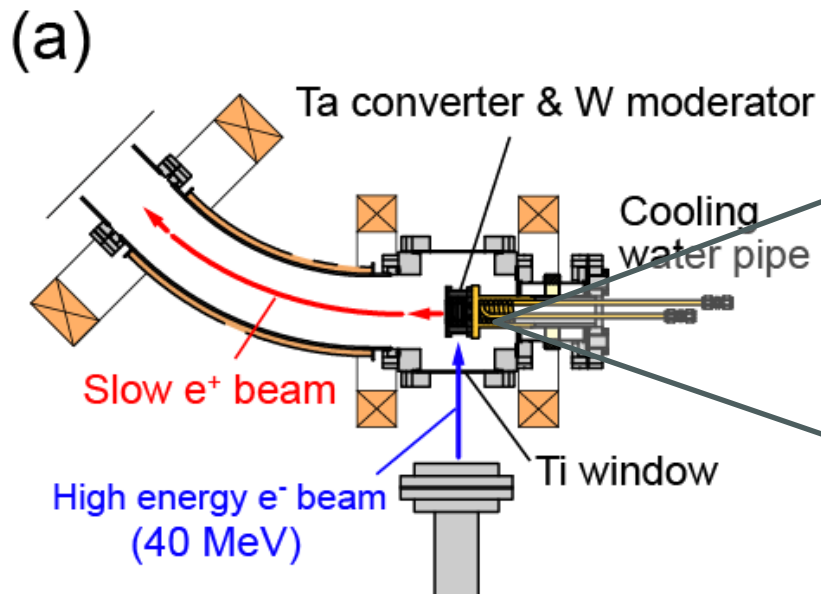


S-band Electron LINAC
dedicated for positron production

- Acceleration energy : 40 MeV
- Power : 300 - 400 W
- Pulse width : 2 μ s
- Repetition rate : 1-50 Hz



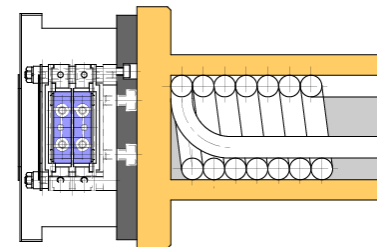
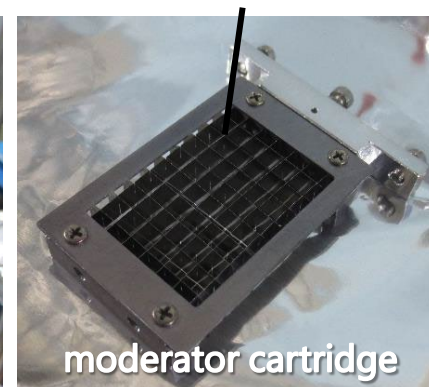
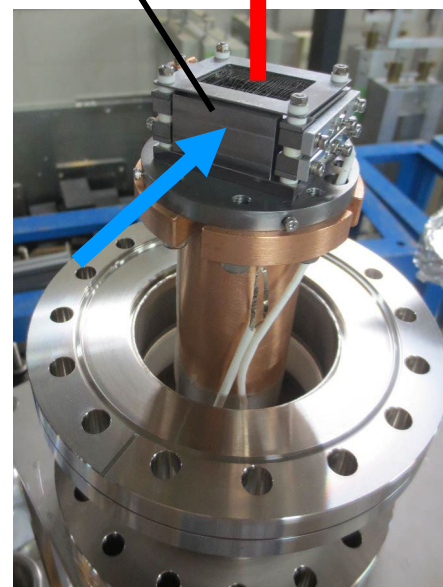
AIST Slow Positron Facility



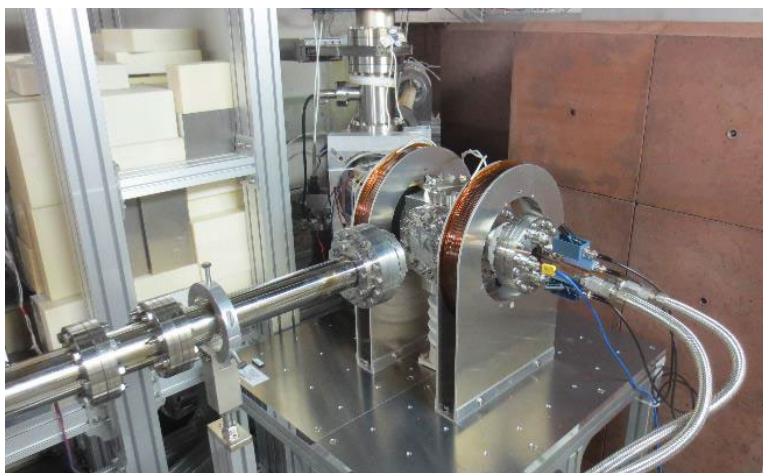
Slow e⁺ beam

Ta converter (t4 mm)

W moderator lattices (t25 μm, pitch 3 mm)

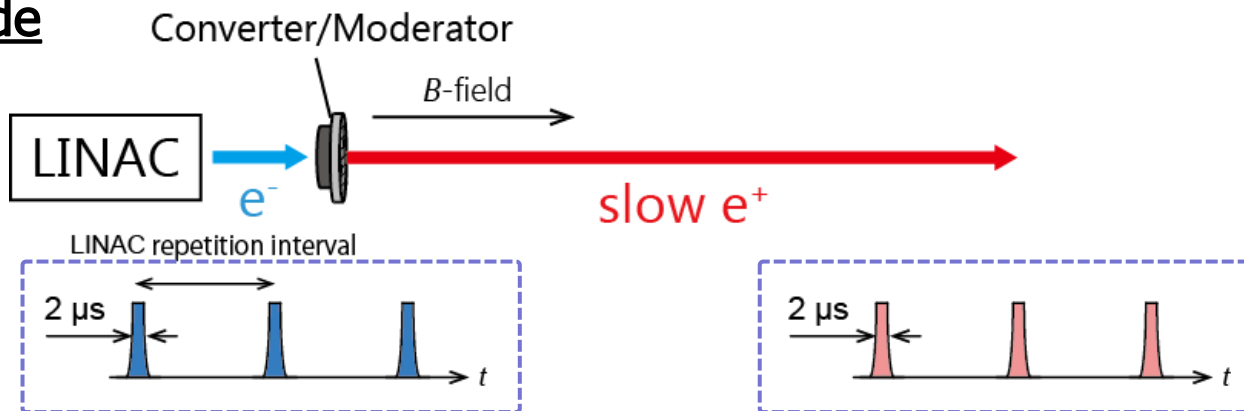


- Intensity : 2×10^7 slow e⁺/s
- diameter : ~15 mm
- transport energy : 5 - 100 eV

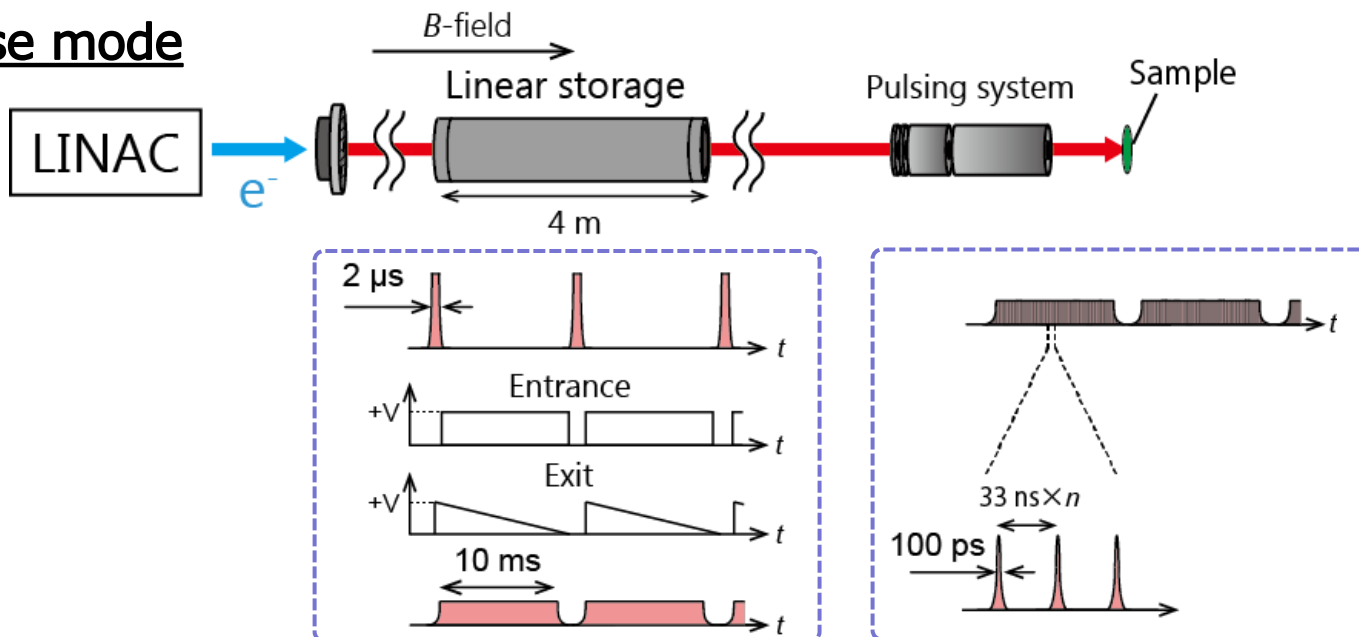


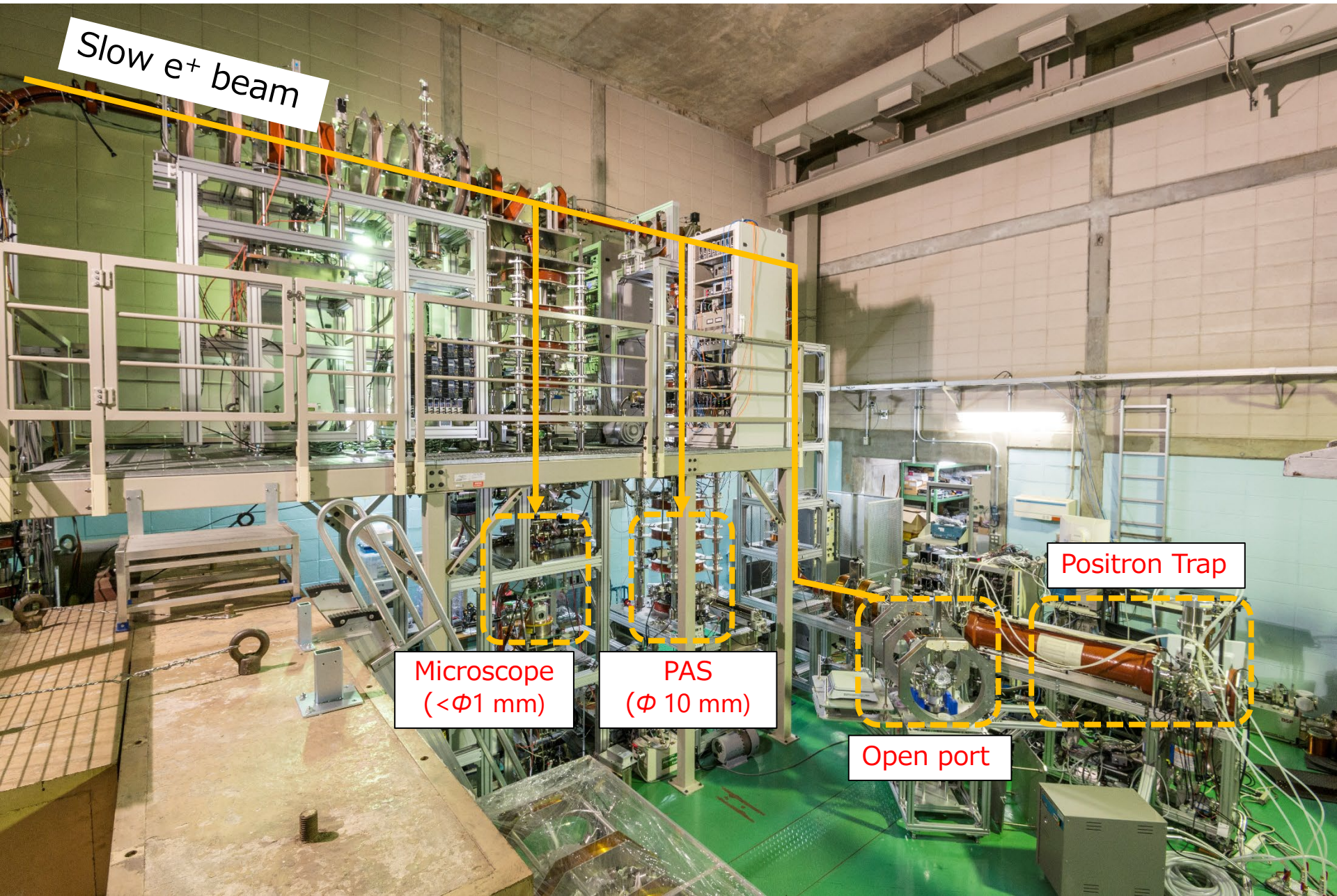
Operation mode

Pulse mode



Macropulse mode





Slow e^+ beam

Microscope
($\lt \phi 1 \text{ mm}$)

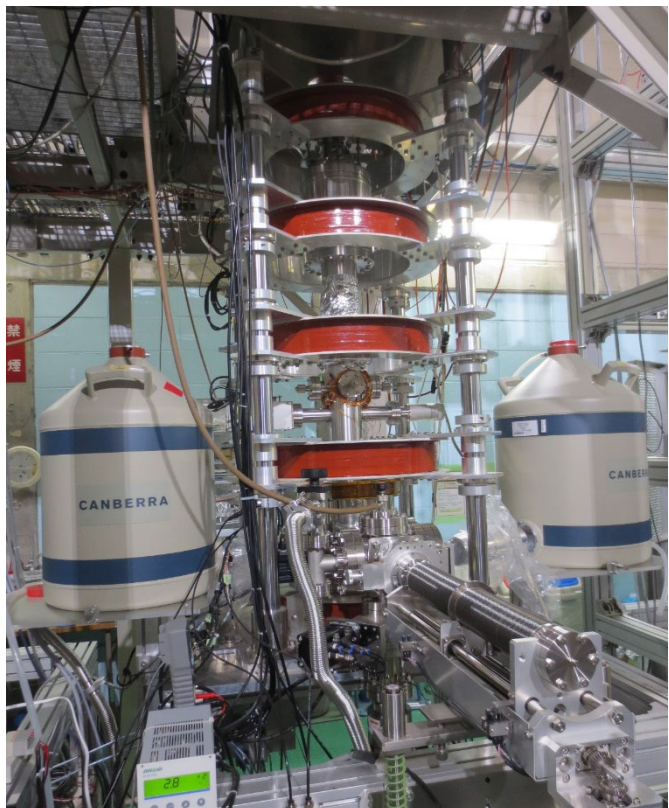
PAS
($\phi 10 \text{ mm}$)

Open port

Positron Trap

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Vertical positron beam analyzer



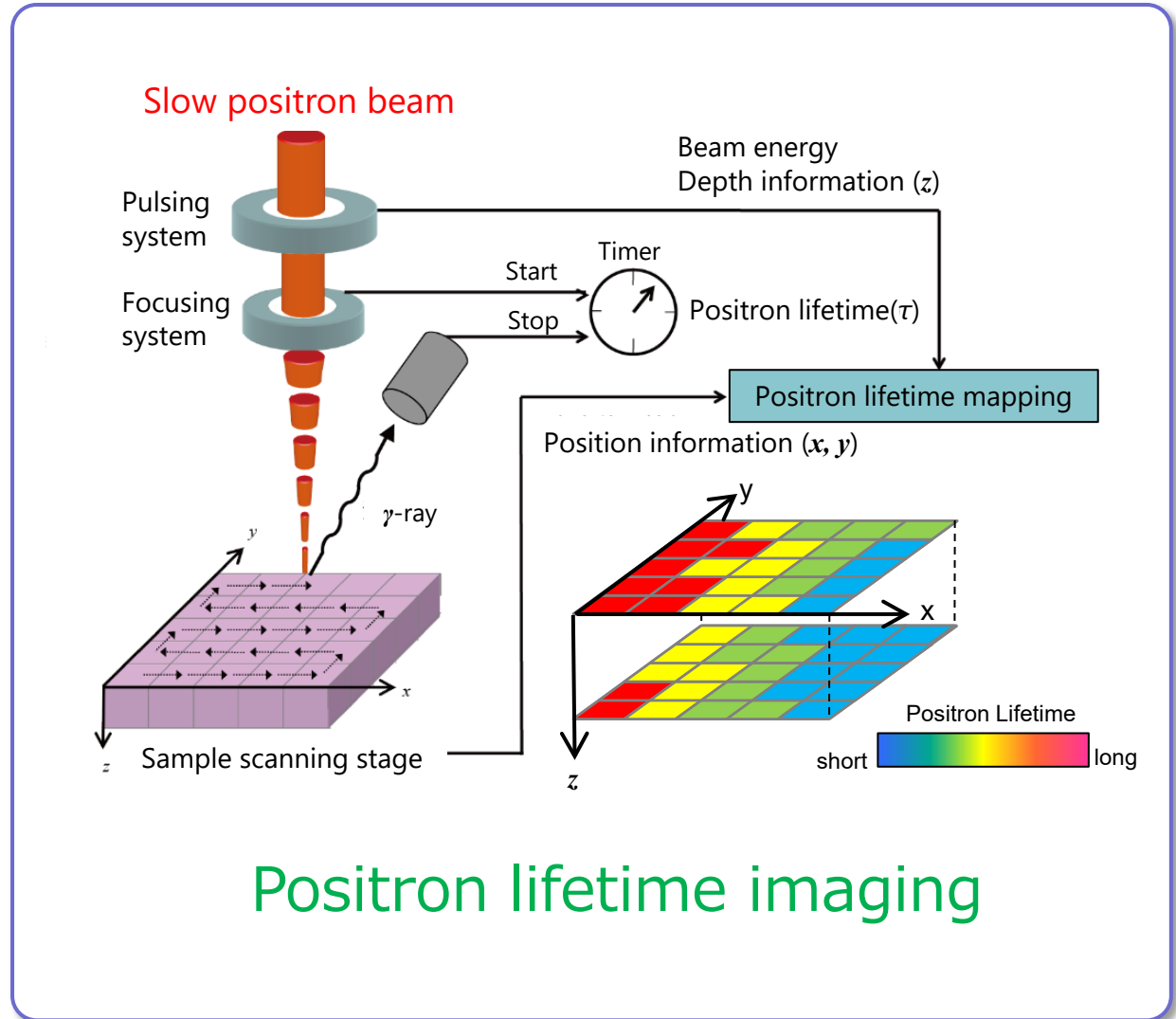
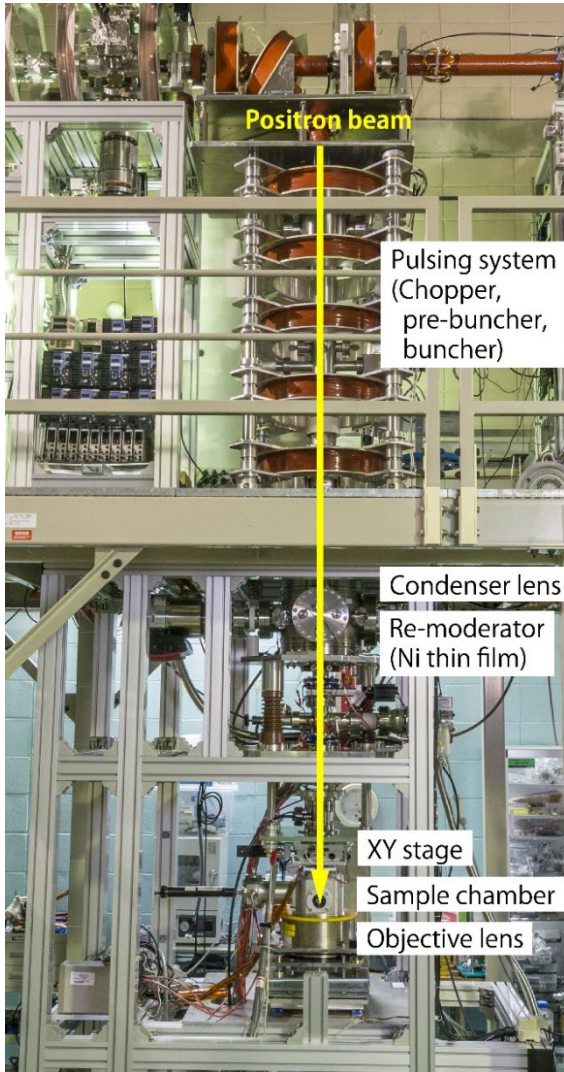
Pure Cu

Powder-PALS measurement
(K. Michishio, *in preparation*)

Coincidence Doppler Broadening

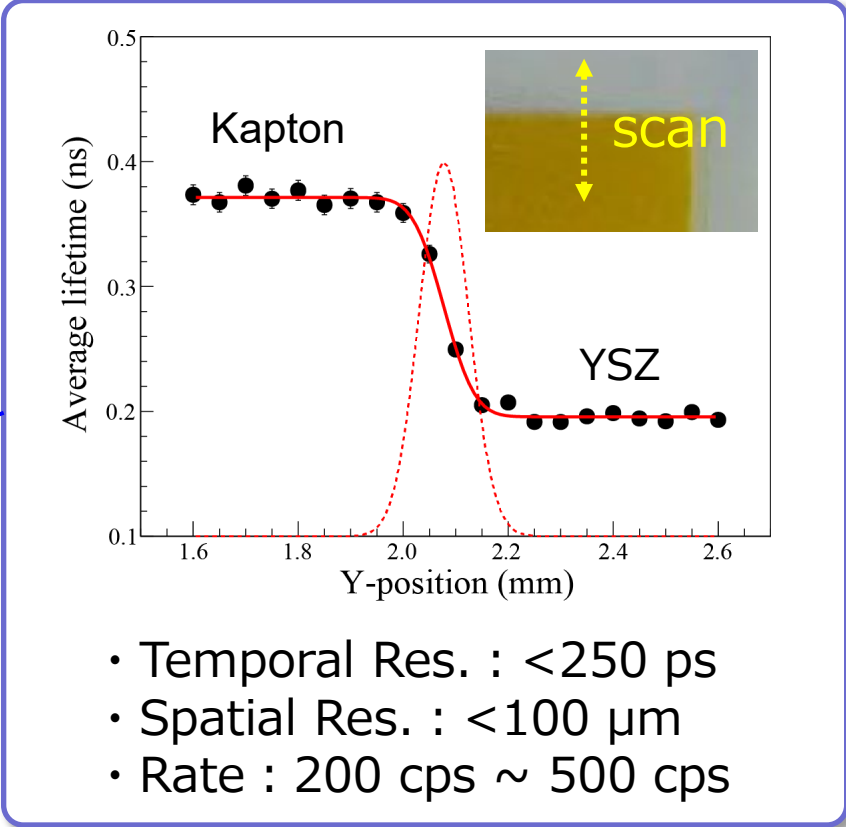
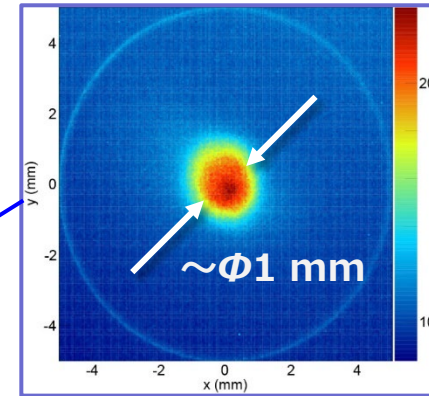
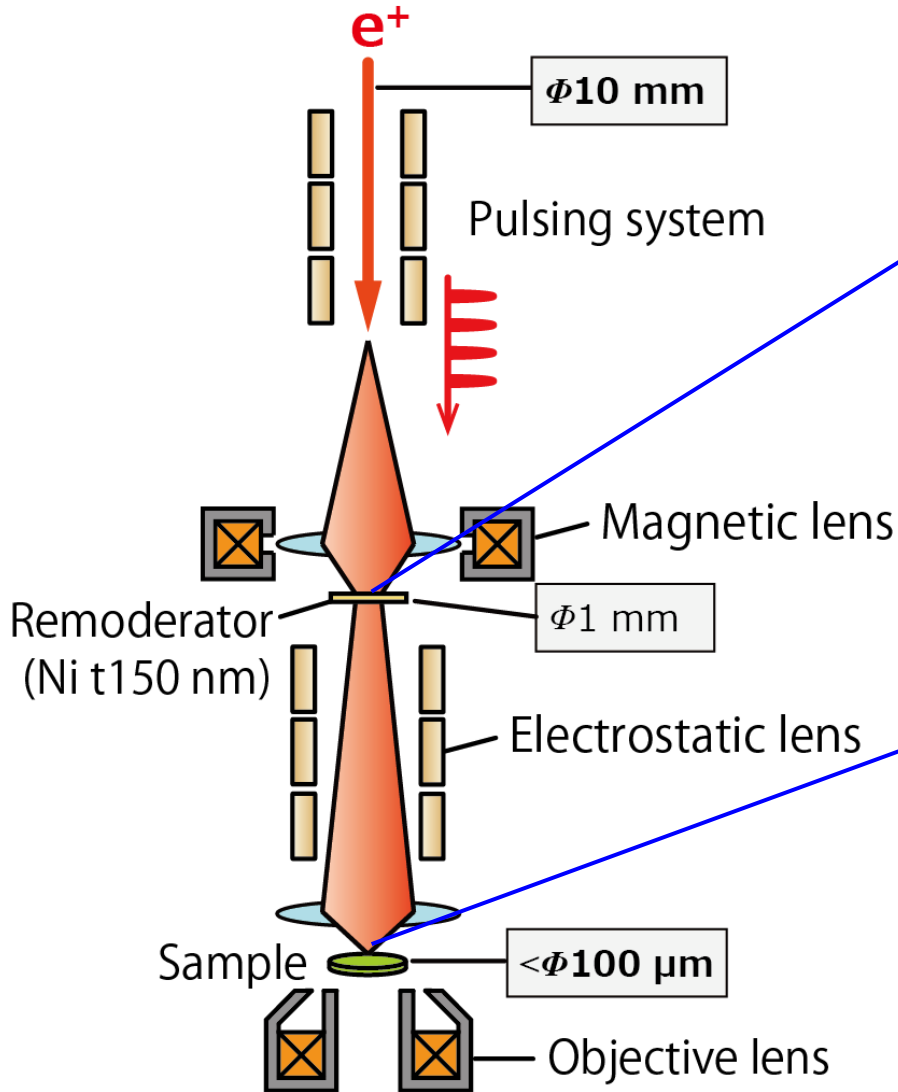
- Measurement : PALS, DB, CDB
- Acc. Energy : 1 – 25 keV
- Time resolution : <250 ps
- Beam spot size : 10 mm
- Sample : film, bulk, **powder...**

Positron microscope

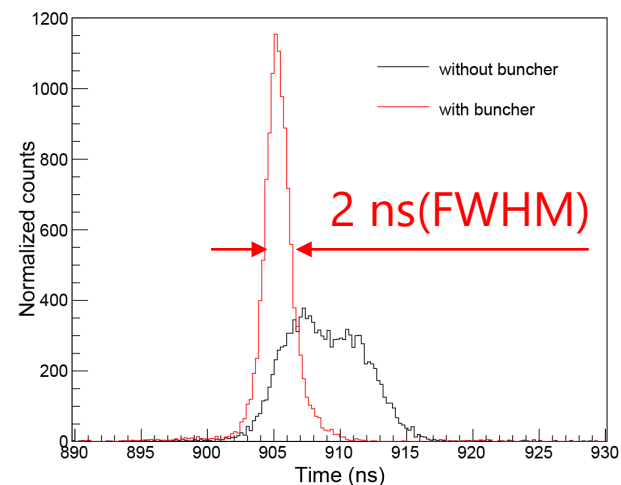
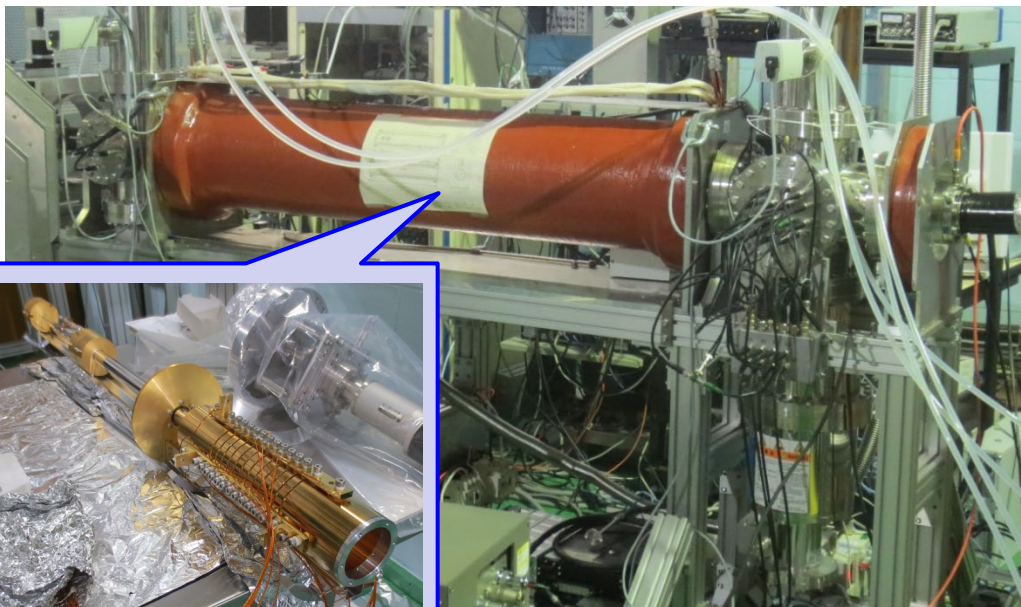


N. Oshima *et al.*, App. Phys. Lett. 101, 014102 (2012)

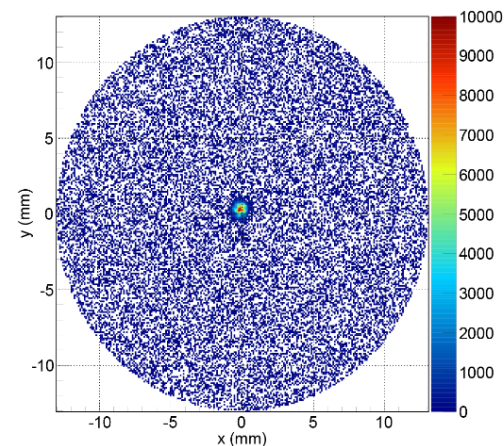
Positron microscope



Positron trap



Temporal profile



Spatial profile

Trapping technology of LINAC-based e^+ beam

- N_2 buffer-gas trap (trap eff. $\sim 5\%$)
- Center-hole SiC trap (trap eff. $\sim 30\%$)

**➔ High-quality positron burst beam
Positron plasma experiment**

H. Higaki *et al.*, Appl. Phys. Exp. **13**, 066003 (2020)

K. Michishio *et al.*, New J. Phys. **24**, 123039 (2022)

Summary

- Slow positron beams are crucial not only in basic science but also in **industrial applications**.
- There is a high demand for accelerator-based systems capable of generating **intense slow positron beams**.
- While high-intensity accelerators are being developed, a **simple and compact accelerator-based positron beam that can be used by amateurs** may accelerate industrial applications.

Thank you for your attention