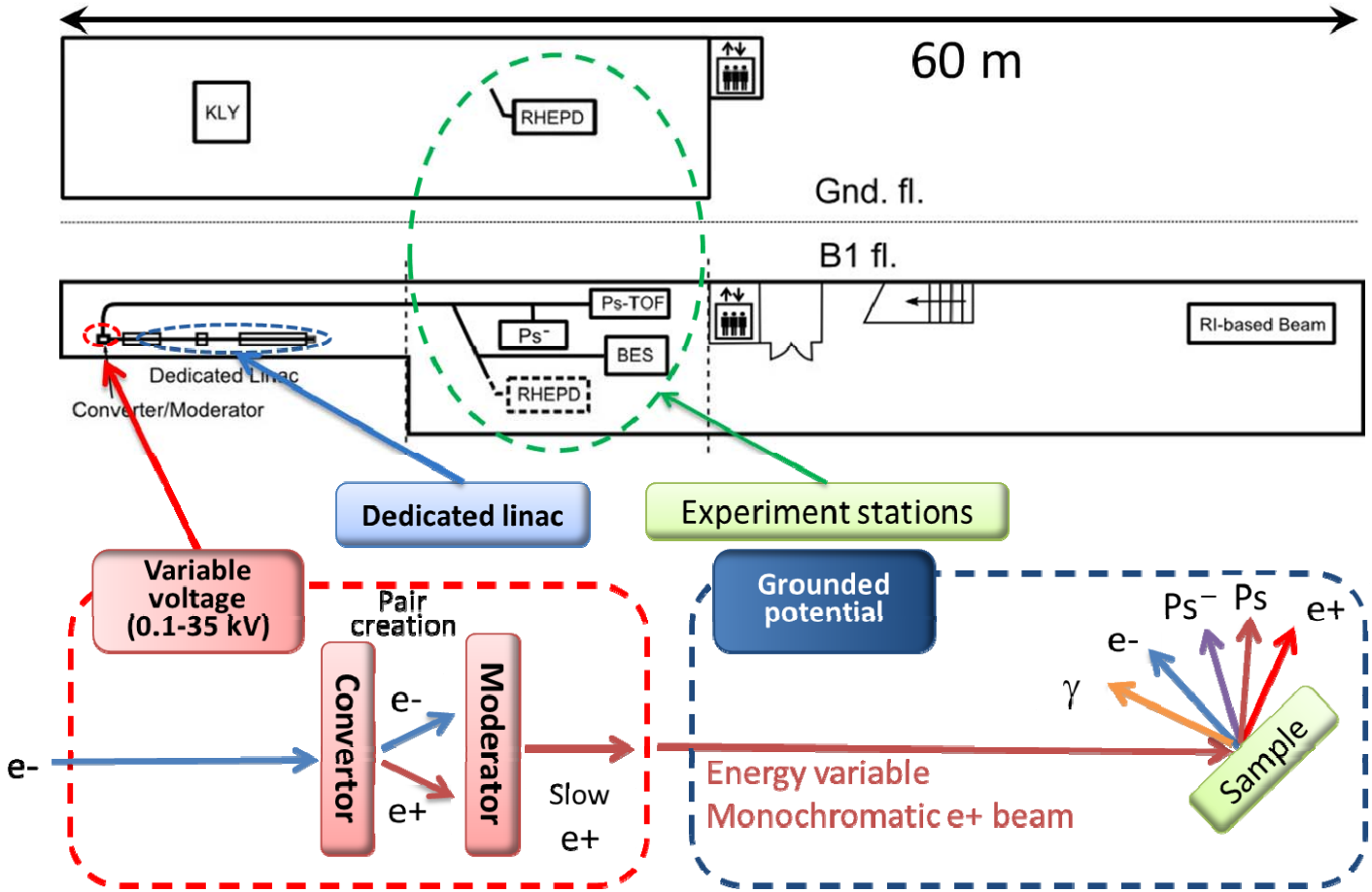
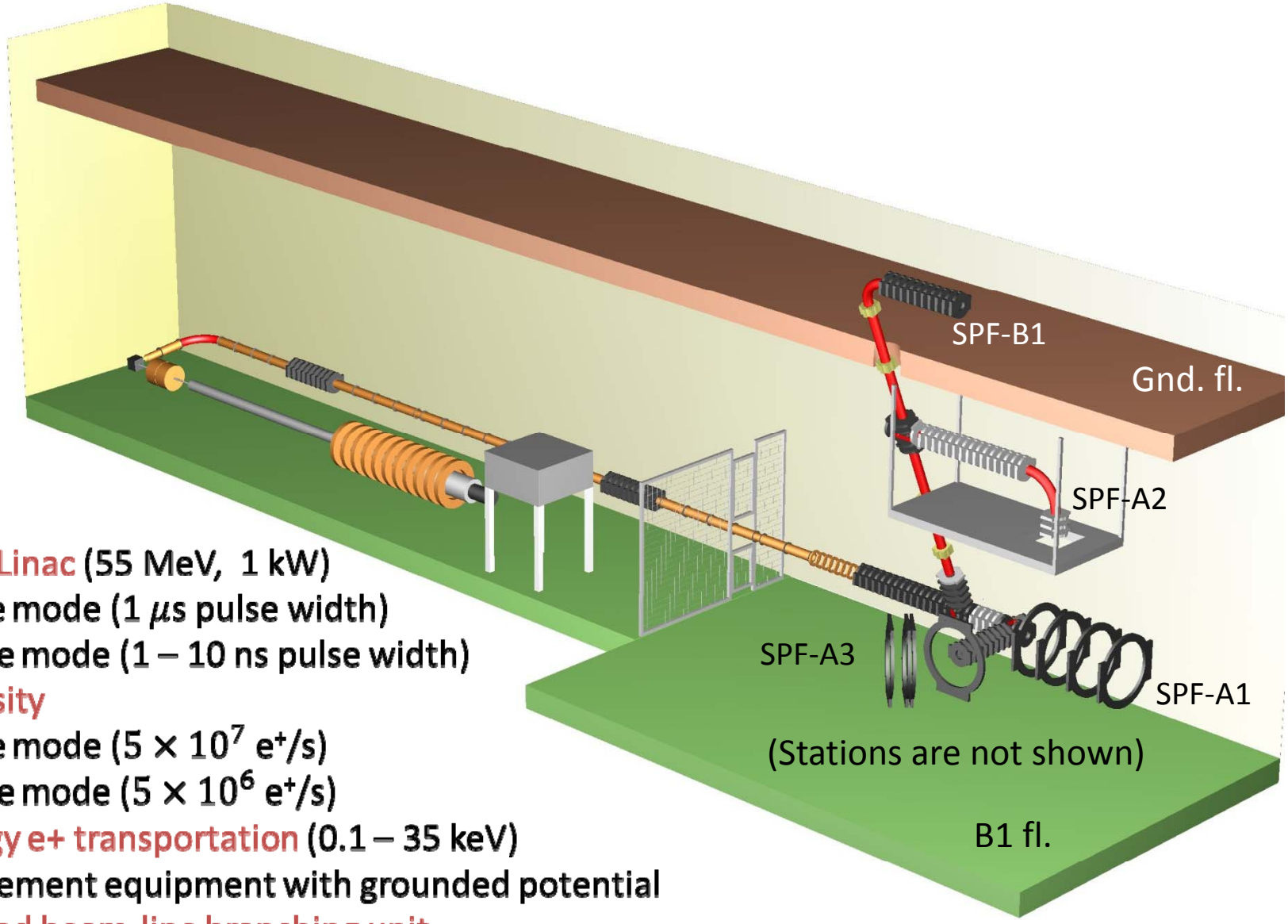
KEK-SPF experiment hall



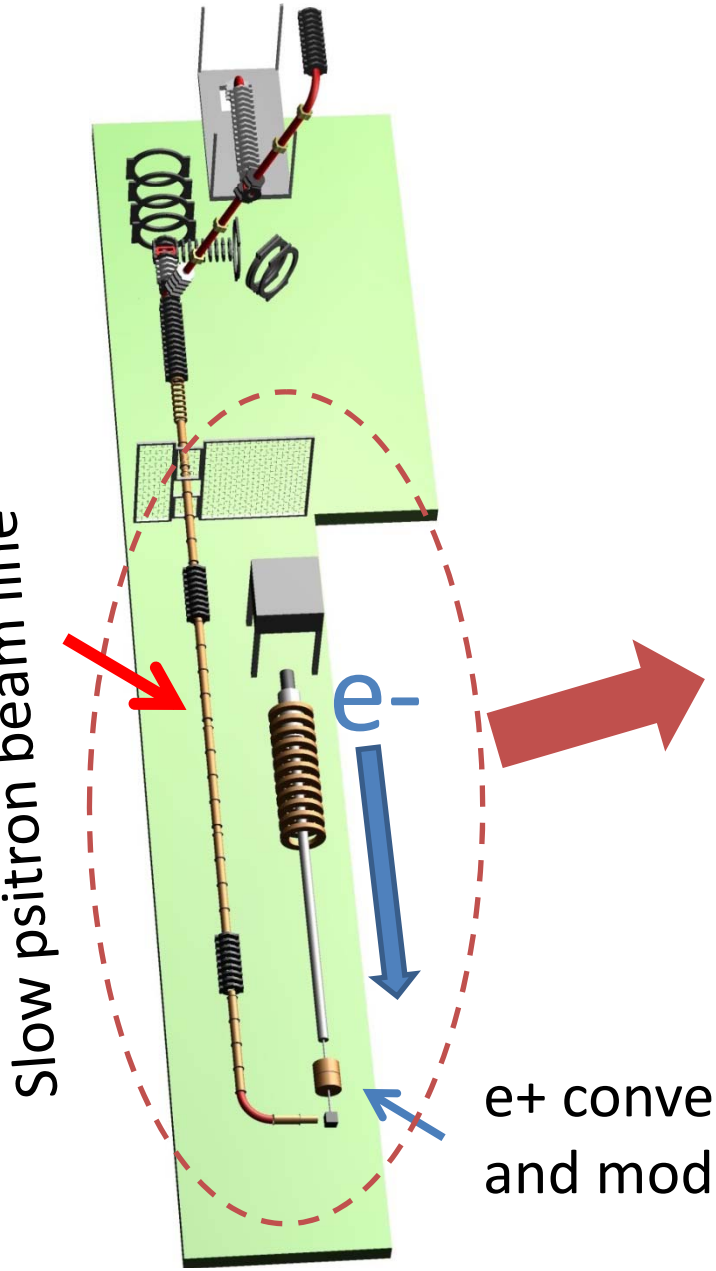
A high-intensity, pulsed slow positron beam is created by using a dedicated linac.
A positron convertor and moderator assembly is at high tension up to 35 kV.
And thus entire slow positron beam line is grounded.

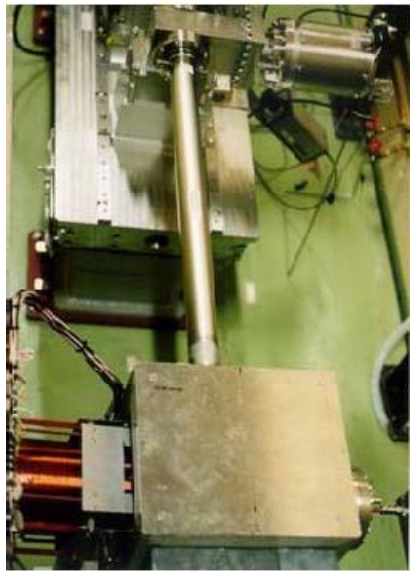
Schematic view of the Beam lines

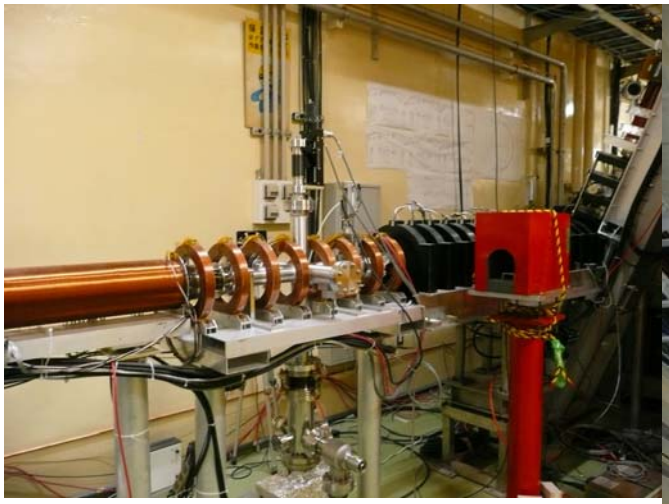


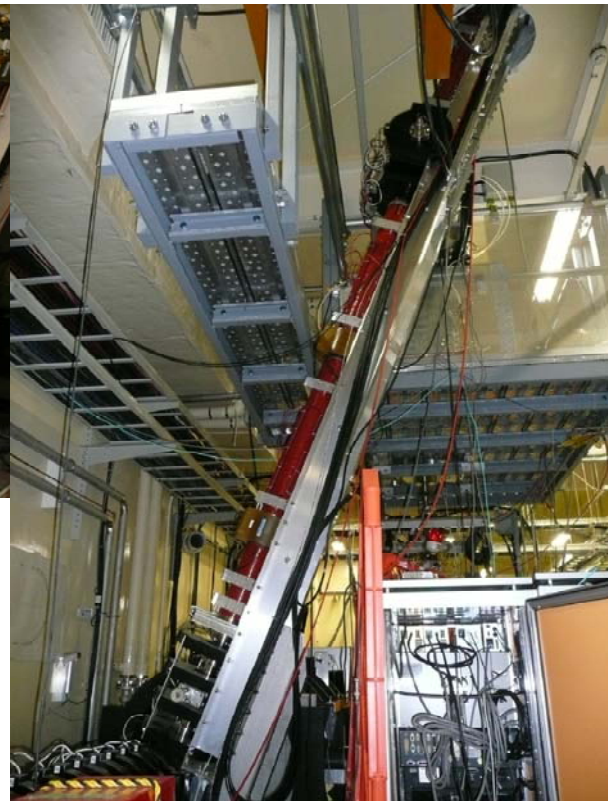
- Dedicated Linac (55 MeV, 1 kW)
  - Long-pulse mode (1 μs pulse width)
  - Short-pulse mode (1 – 10 ns pulse width)
- High intensity
  - Long-pulse mode (5×10^7 e^+/s)
  - Short-pulse mode (5×10^6 e^+/s)
- High-energy e+ transportation (0.1 – 35 keV)
  - ⇒ Measurement equipment with grounded potential
- Standardized beam-line branching unit
  - ⇒ Flexibility of beam-line arrangement

The Dedicated Linac with radiation shields off

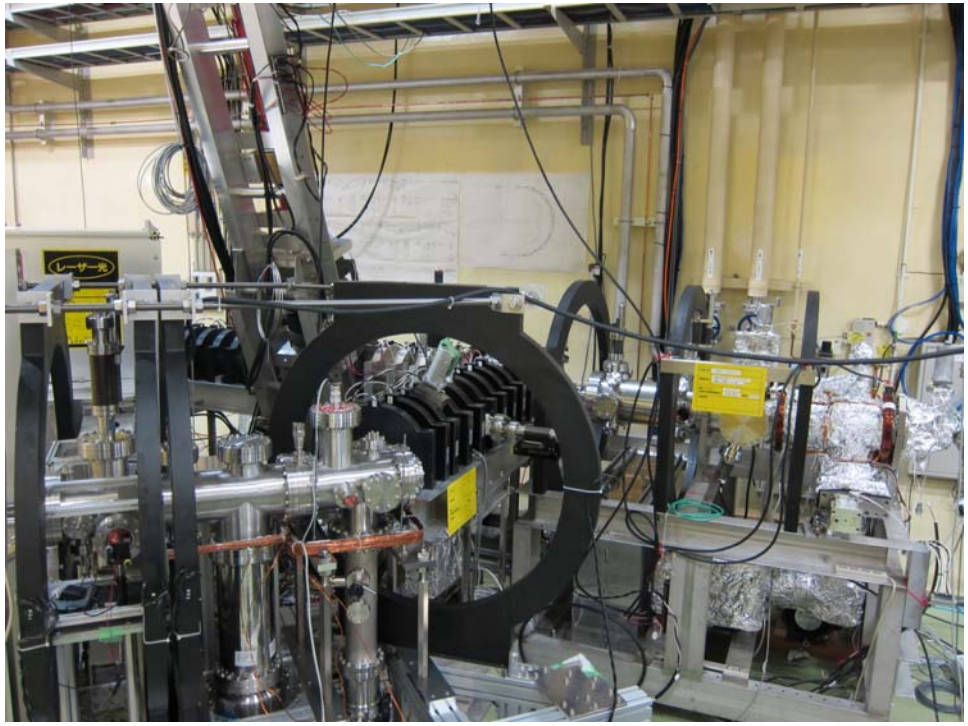


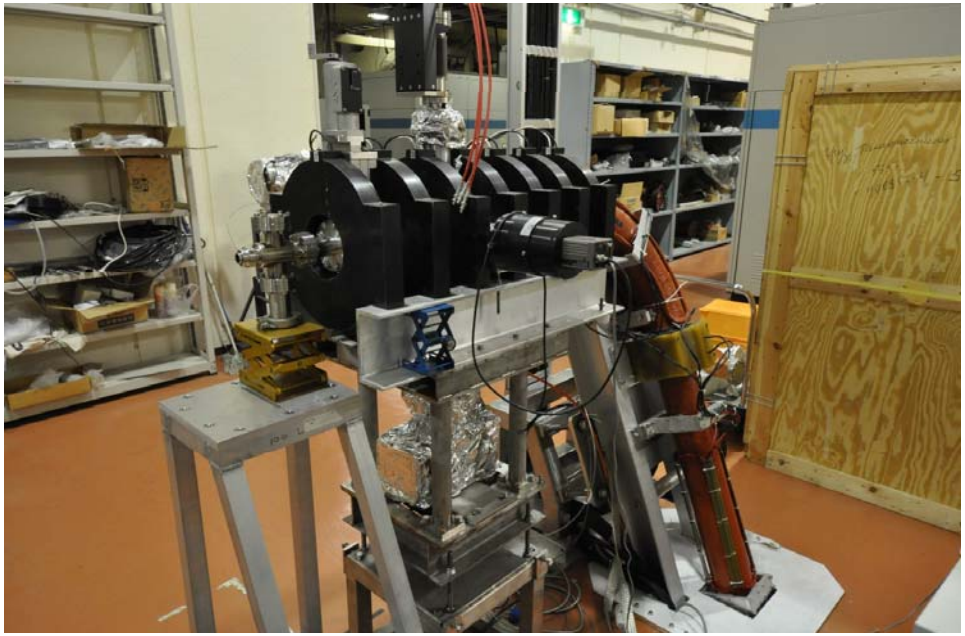






The slow-positron-beam lines and experiment stations



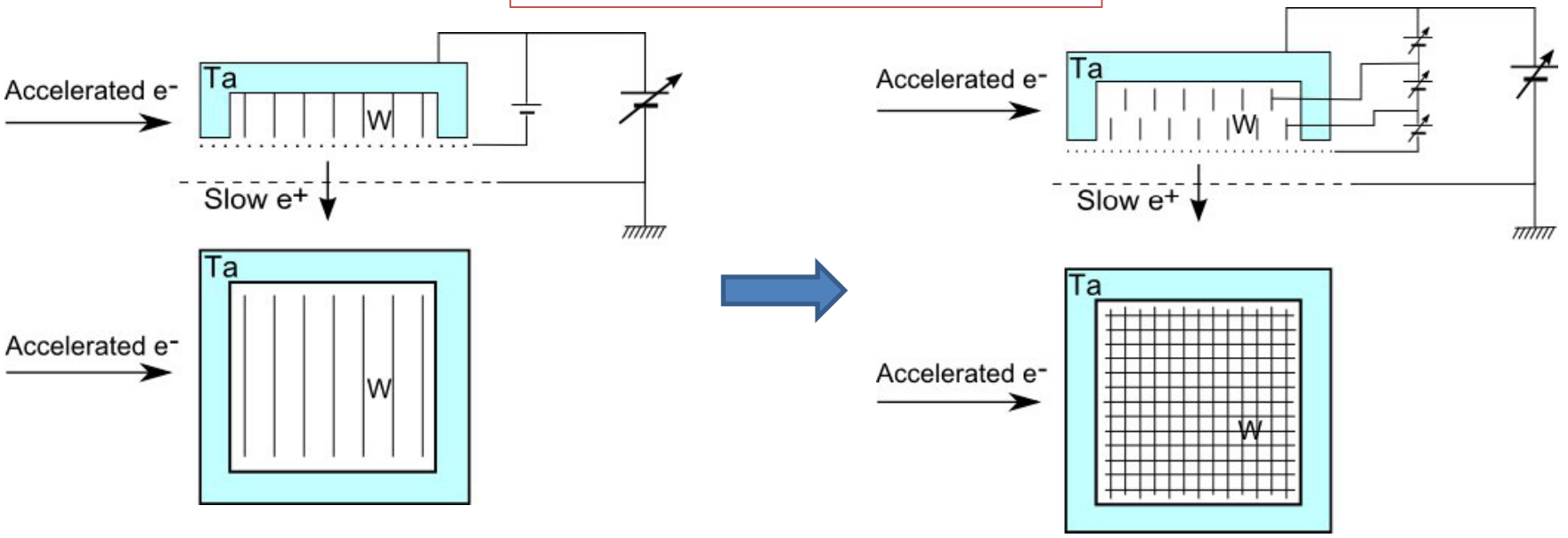


A new positron convertor / moderator

(Old)

An order of magnitude increase in the beam intensity

(New)

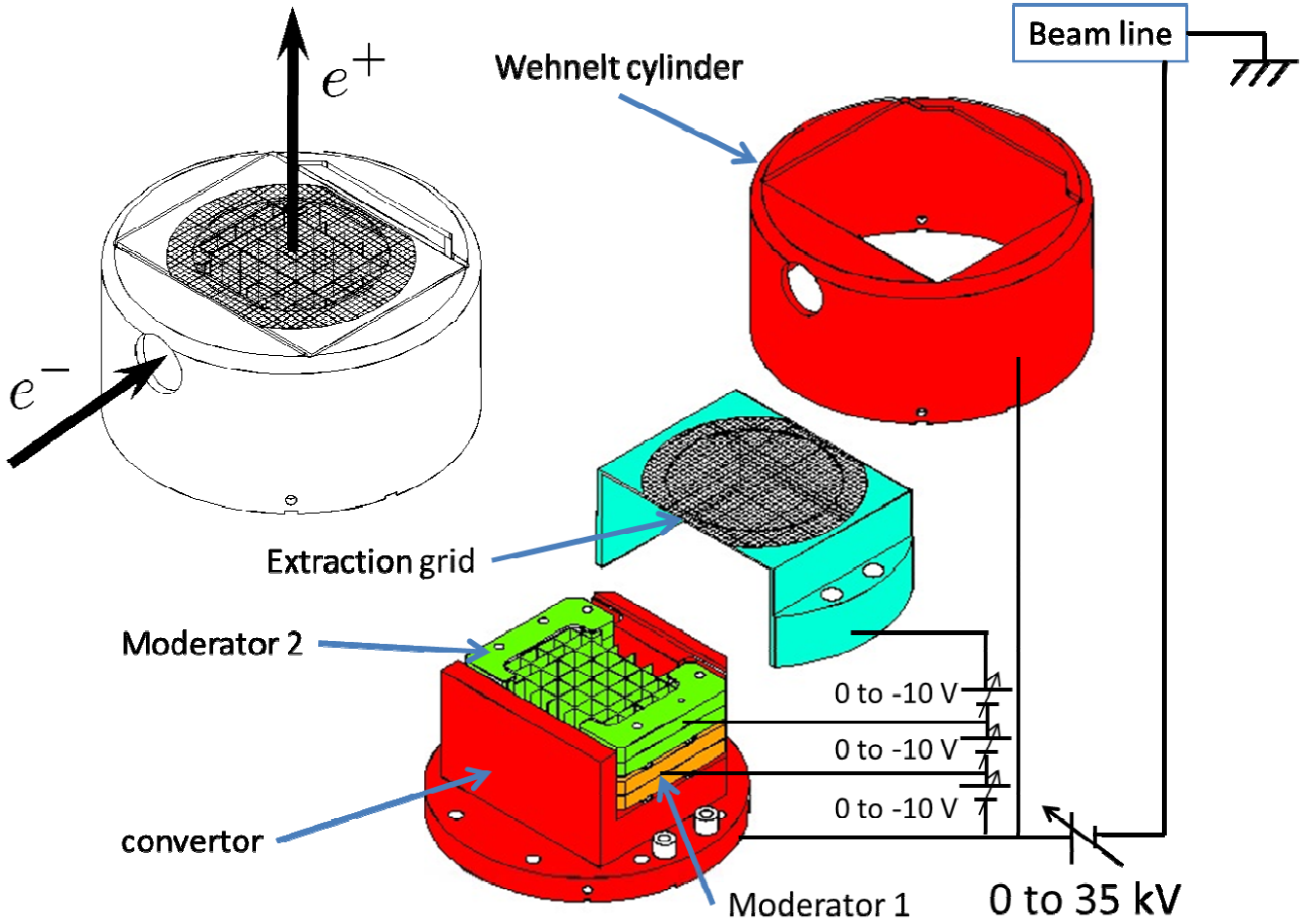


25 μm thick W foil array
Perpendicular to the e- incident direction

Two sets of W foil (25 μm thick) lattices
A cascade voltage supply to set voltages between the converter, the lattice 1, the lattice 2, and an extraction grid.

K. Wada *et al.*: Eur. J. Phys. D, 66: 37 (2012)

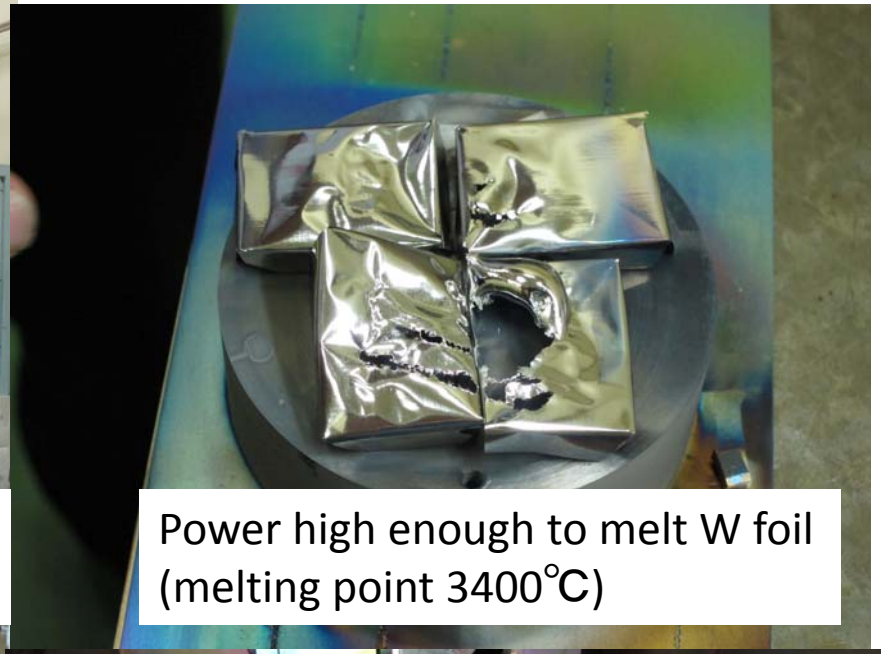
New e^+ convertor and moderator



The parts with different colors are electrically isolated from each other.
Bottom red: convertor Orange and green: moderators
Blue: extraction grid
Top red: wehnelt cylinder, same potential as the convertor

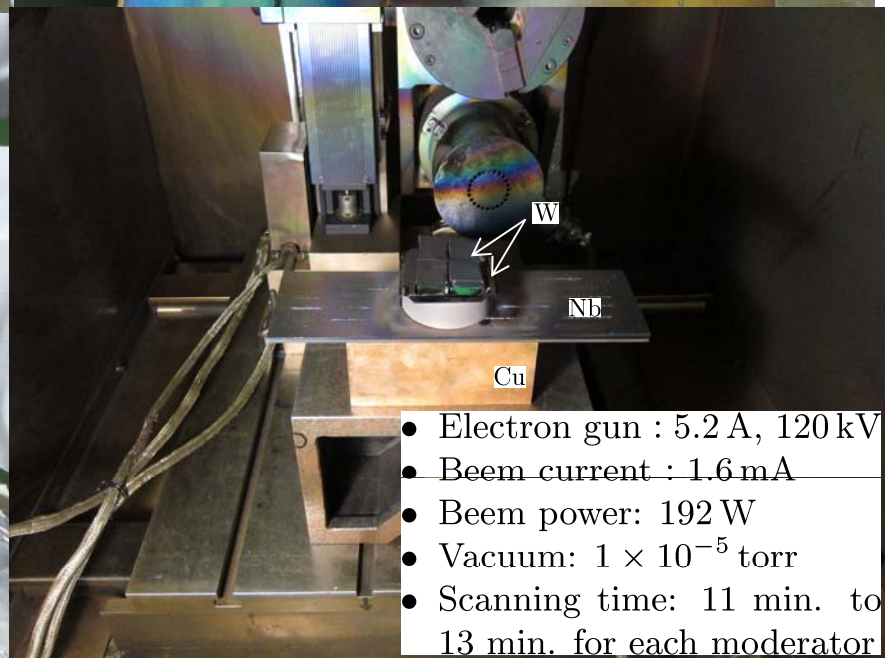
Annealing of W moderator with an electron-beam welder

The electron-beam welding machine used for annealing of the moderator



Power high enough to melt W foil (melting point 3400℃)

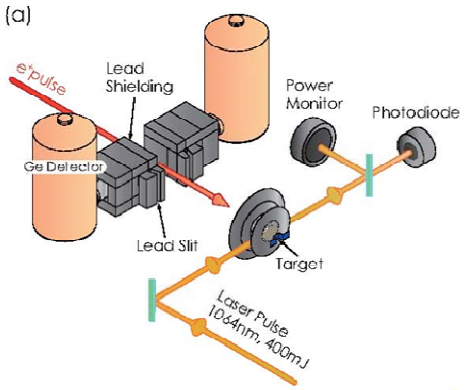
Each moderator was placed in a box with a cover made of 50 μm thick W foil.



- Electron gun : 5.2 A, 120 kV
- Beem current : 1.6 mA
- Beem power: 192 W
- Vacuum: 1×10^{-5} torr
- Scanning time: 11 min. to 13 min. for each moderator

(SPF-A1) Photo detachment of Positronium negative ion (Ps^-)

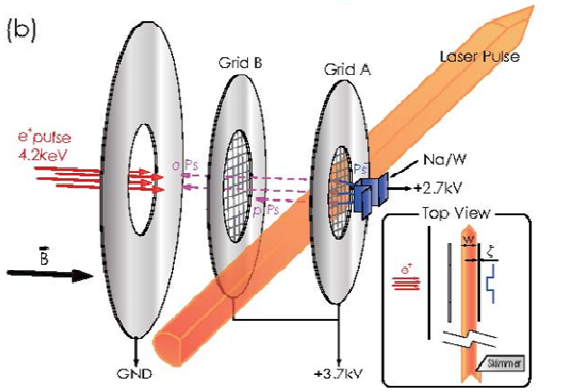
Experimental setup (Schematic)



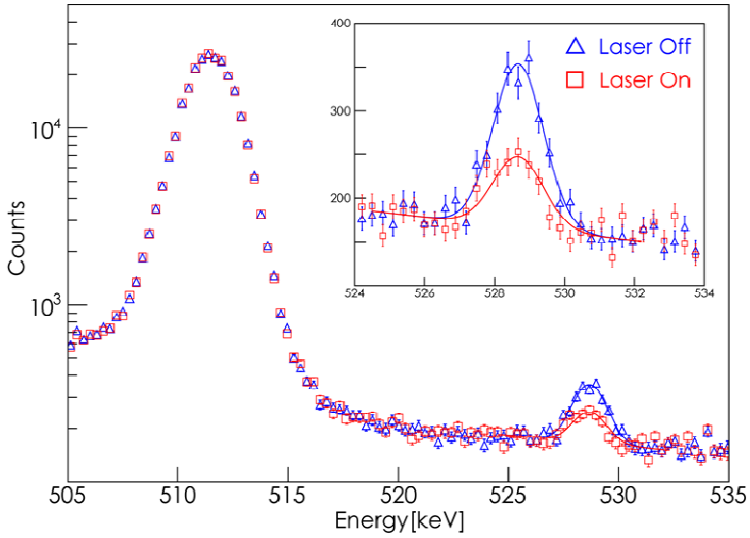
Photodetachment raction

$$Ps^- + h\nu \rightarrow Ps + e^-$$
$$(e^- e^+ e^-) \qquad (e^+ e^-)$$

Crossing of Ps^- and a laser beam



Reduction of Doppler-shifted γ-ray from Ps^-



Michishio, *et al.*, Phy. Rev. Lett., 106, 153401 (2011).

Positronium-negative-ion station built by the group of Prof. Nagashima
The photo detachment of the Ps^- ion with a pulsed 25 Hz Nd:YAG laser
Signals with and without laser irradiation of the 50 Hz slow-positron beam
Doppler-shifted annihilation γ from the accelerated Ps^- detected by Ge ditectors

Energy variable Ps beam

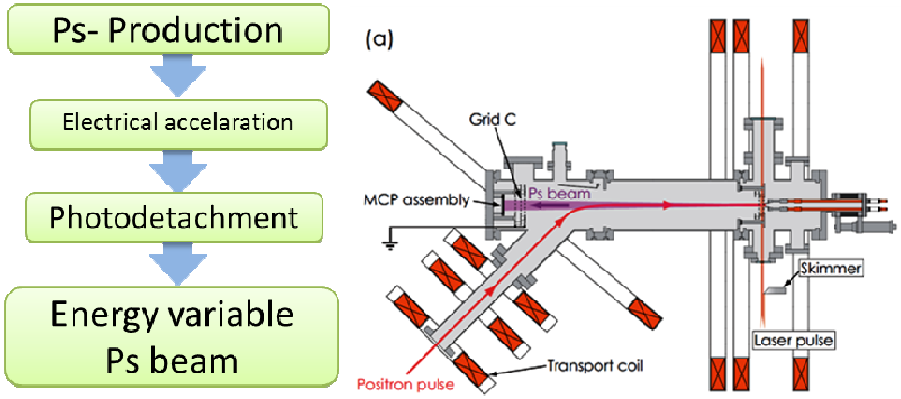
Setup for the production of energy-tunable Ps beam

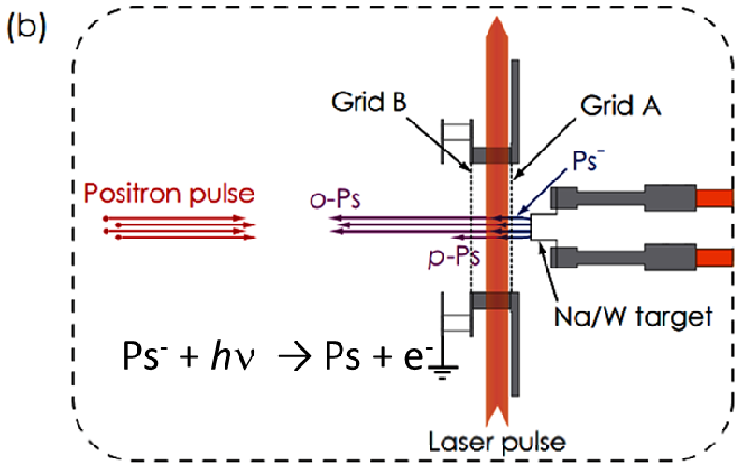
Ps- Production

Electrical accelaration

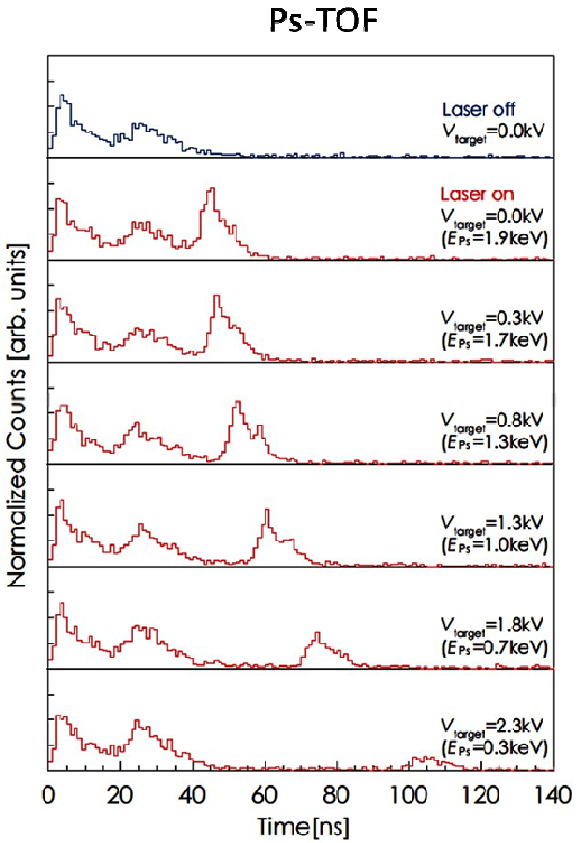
Photodetachment

Energy variable Ps beam





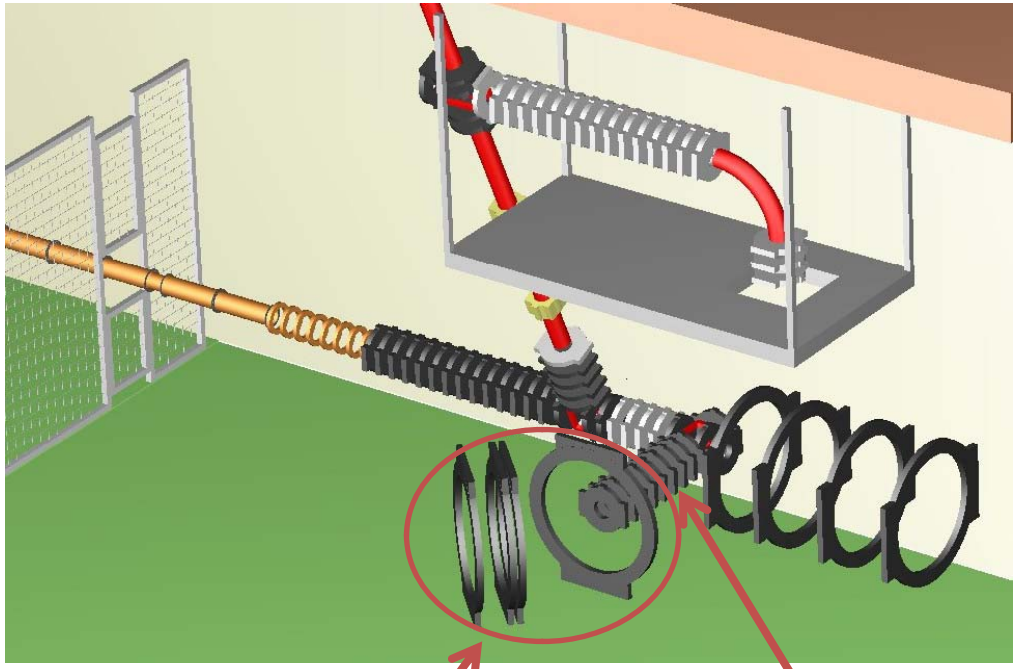
Time-of–flight spectrum for energy tunable Ps beam

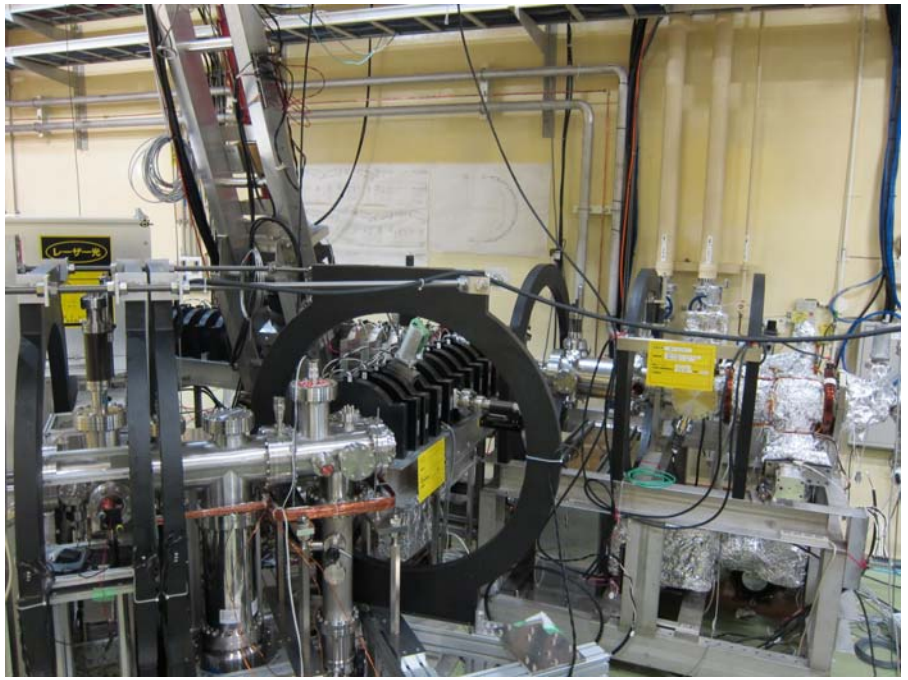


Michishio, *et al.*, Appl. Phy. Lett. 100, 254102 (2012).

Revised chamber for detecting photo-detached Ps directly with an MCP array.
The incident positron beam was magnetically bent by 45 degrees and led to the target.
Ps^- were accelerated by an electrostatic field, and then irradiated by the laser.
TOF of the Ps shows the acceleration before the photodetachment.

A new BL branch (SPF-A3) for Ps-beam detection



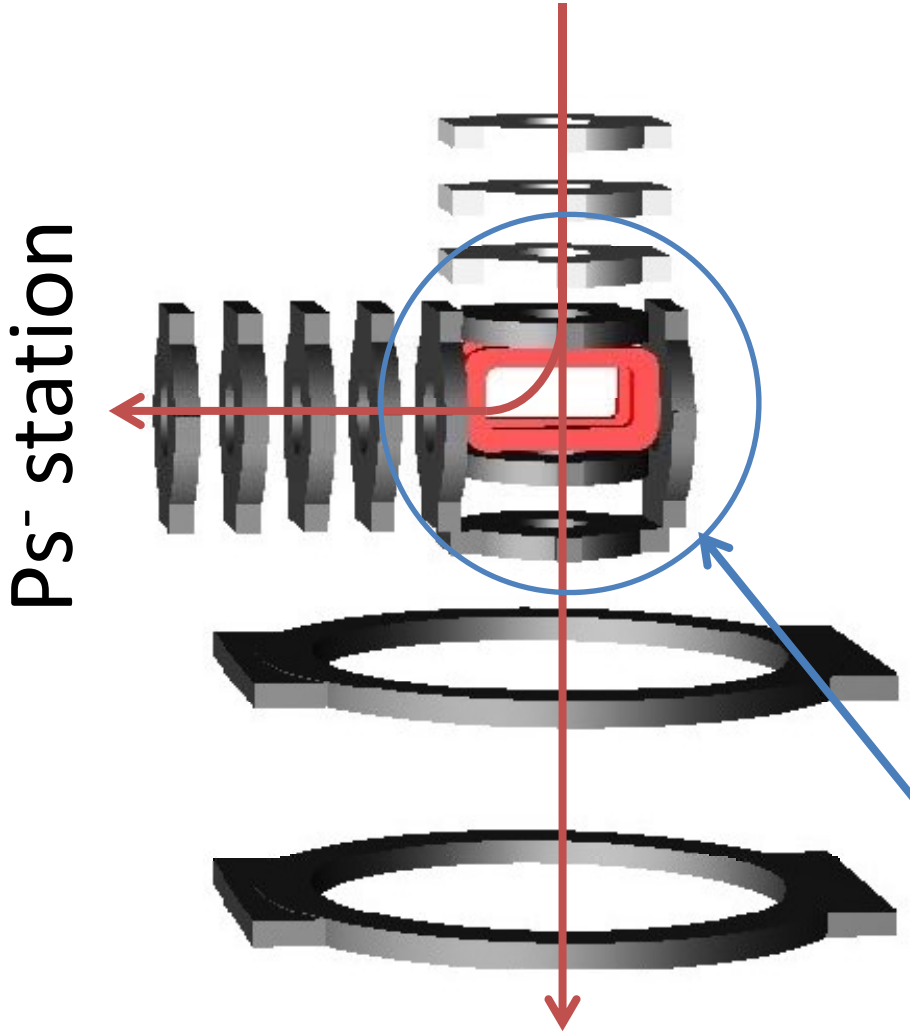


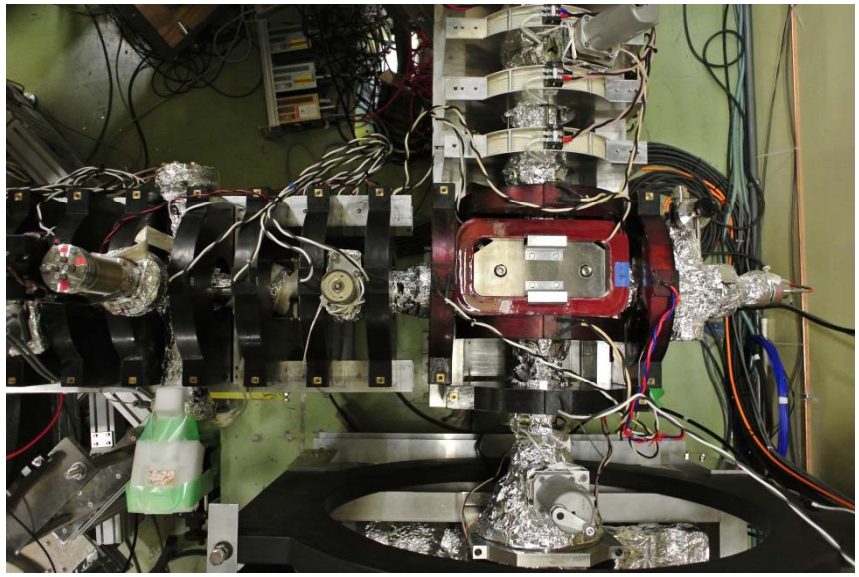
The new beam-line branch for Ps-beam station

Large magnetic coils for the Ps-beam station

Vacuum degree: ~ 2×10^{-8} Pa

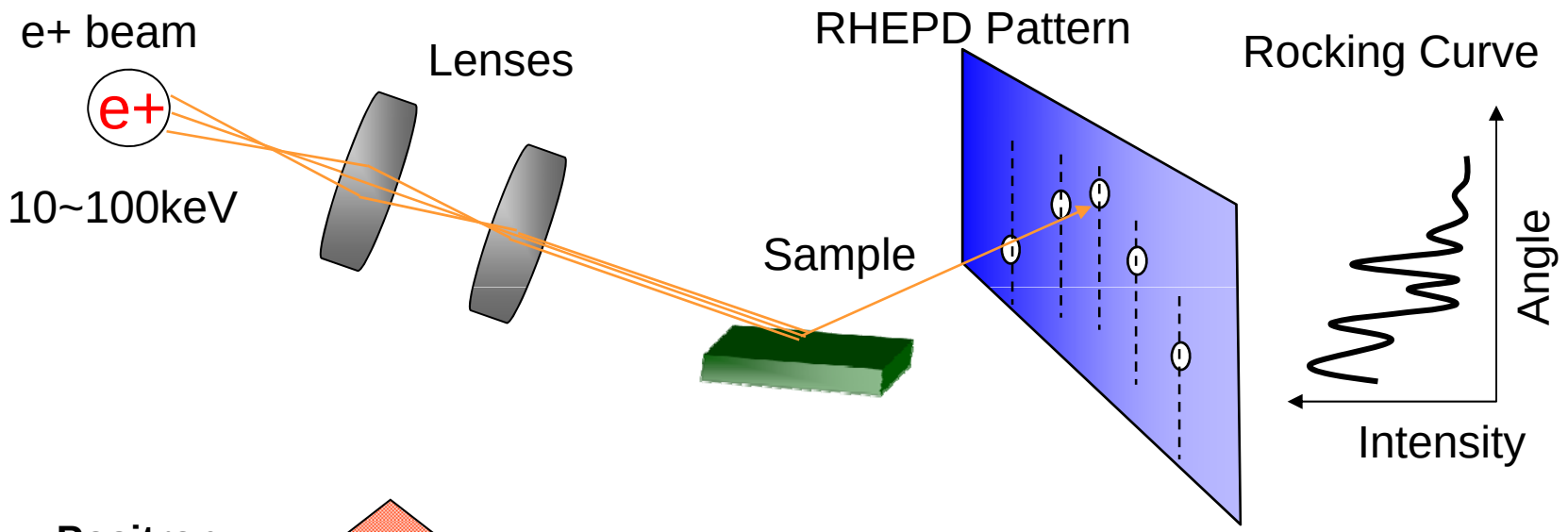
The beam-line branching unit

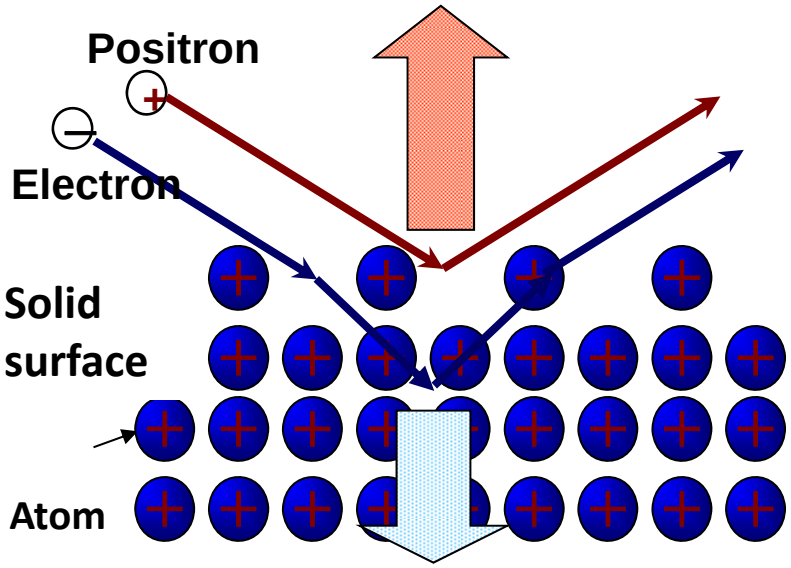




Standardized beam-line branching unit
for up to 35 keV positron beam

(SPF-B1) Reflection high-energy positron diffraction (RHEPD)

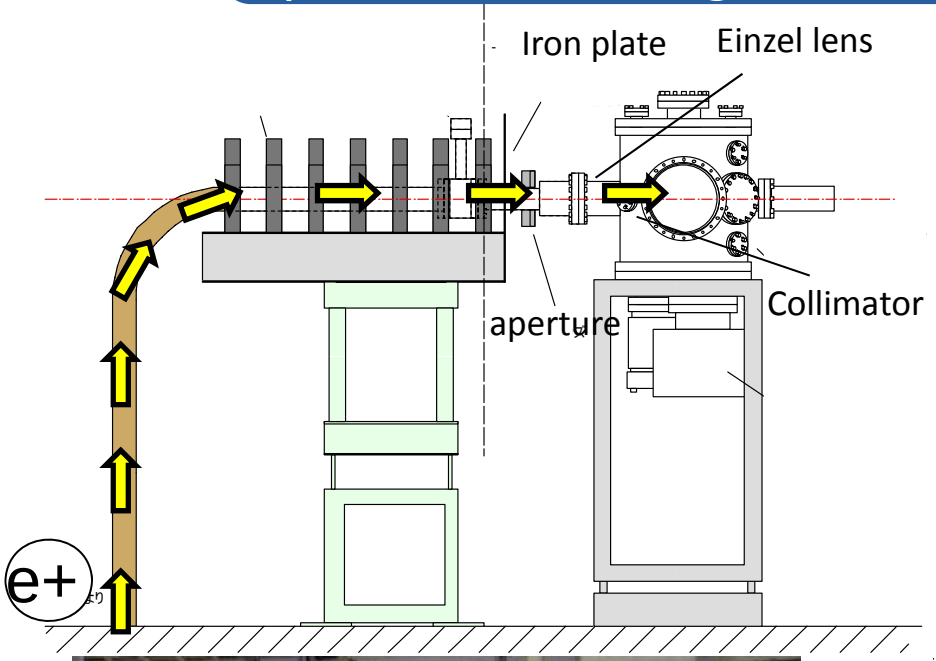




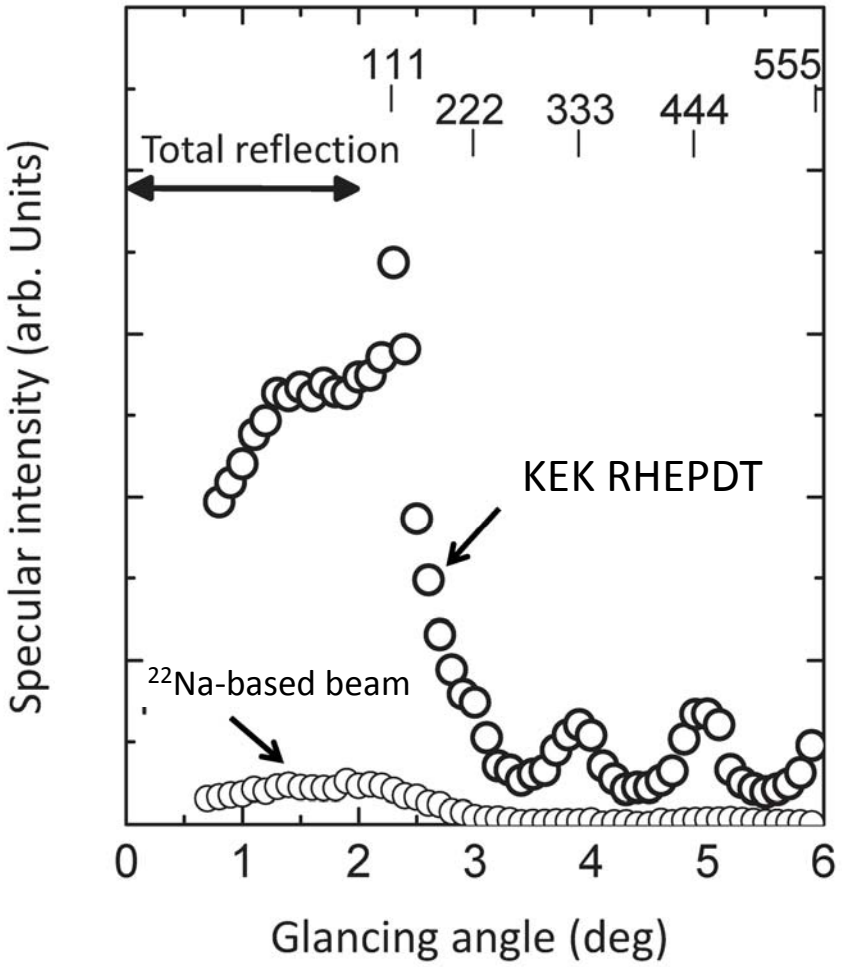
Positrons are totally reflected because of positive crystal potential.

Sensitive to the atomic arrangement and the effects of electrons and phonons.

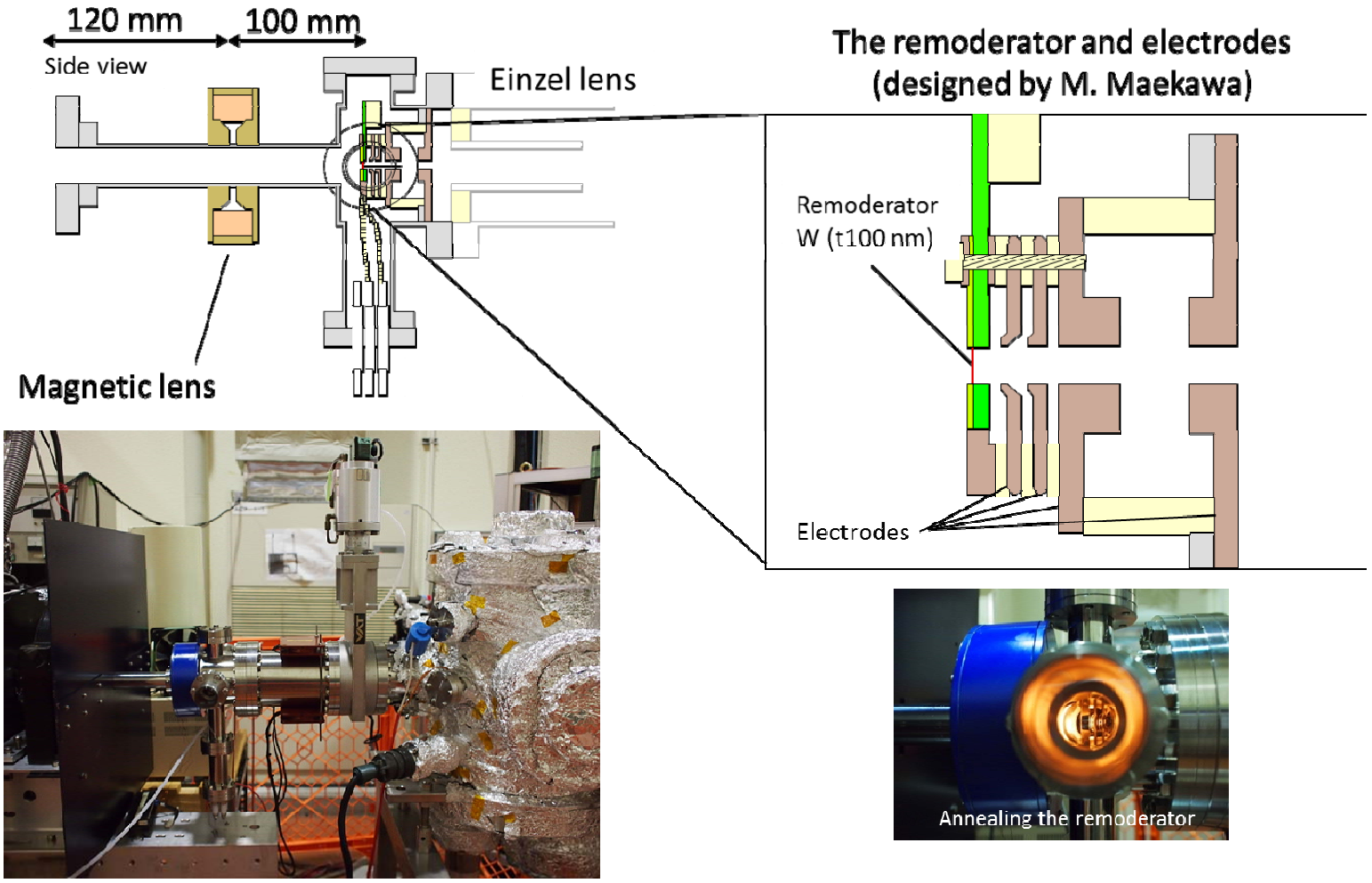
(SPF-B1) RHEPD station (without a brightness-enhancement unit)



RHEPD rocking curve



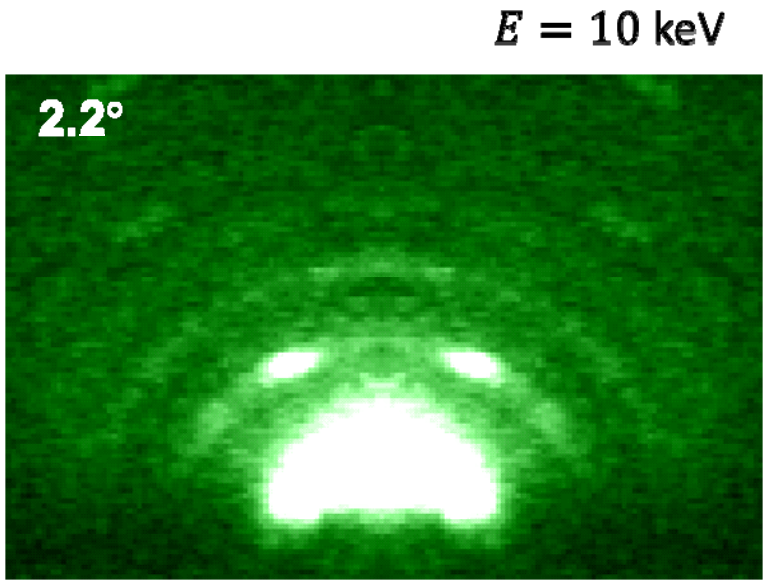
The brightness-enhancement unit (BER) for RHEPD



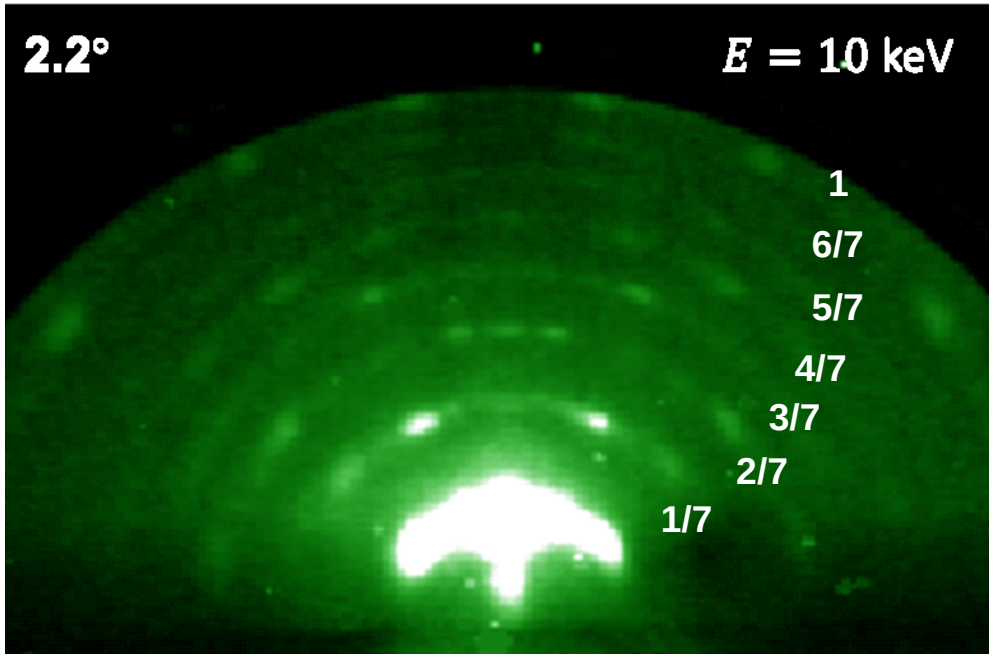
Schematics and pictures of the brightness-enhancement unit for RHEPD
Consisting of a transmission remoderator with 100 nm W crystal, and electrodes.
The W remoderator was annealed by the passage of electron current.

RHEPD pattern for the Si(111)-7x7 surface using the brightness-enhancement unit (BEU)

Before the BEU installation

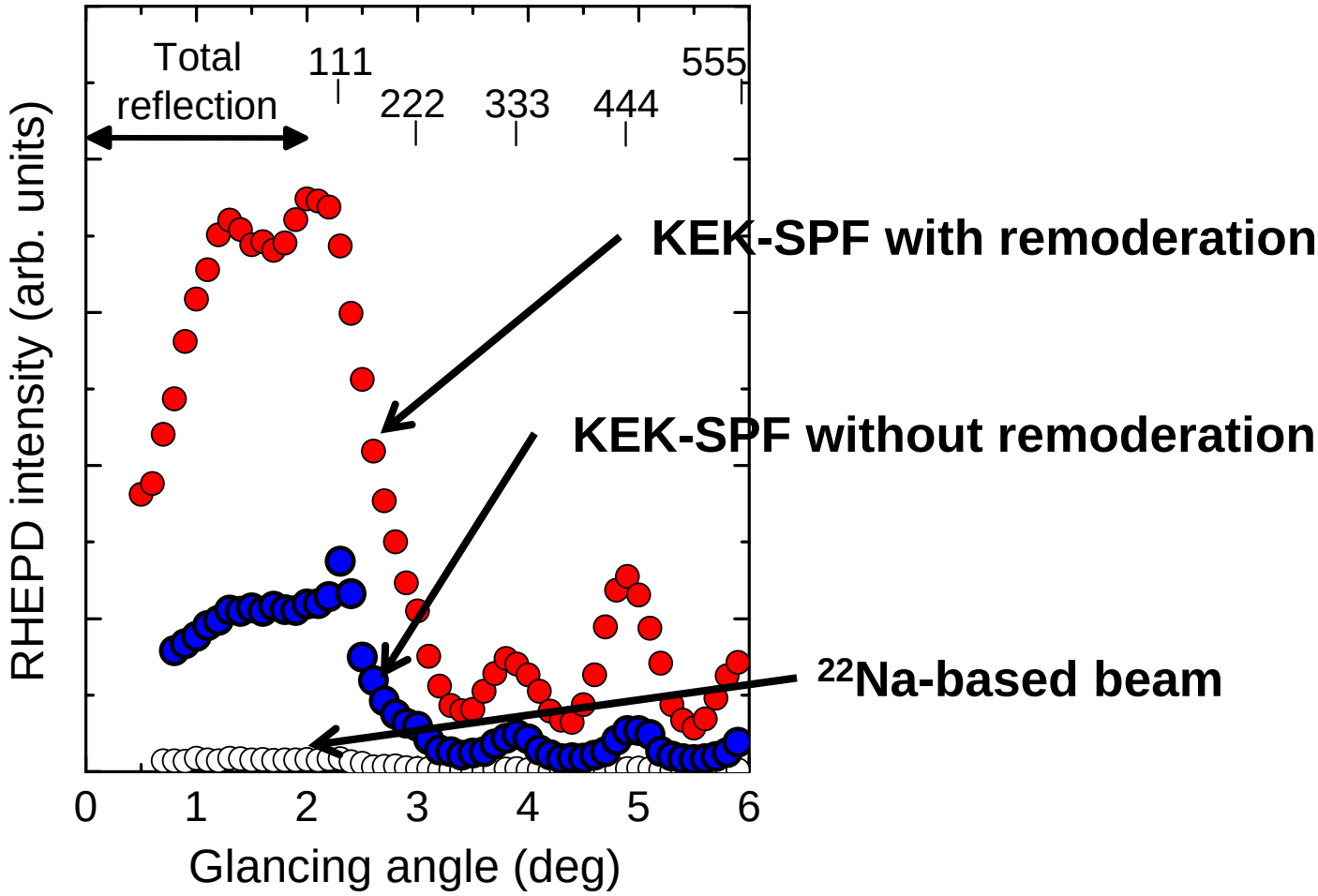


After the BEU installation

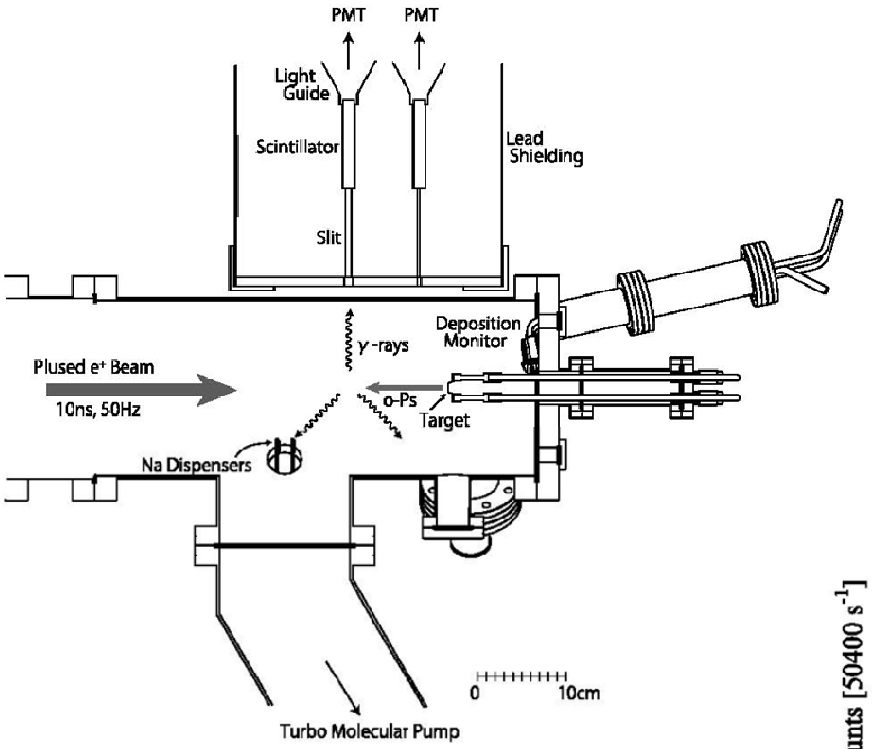


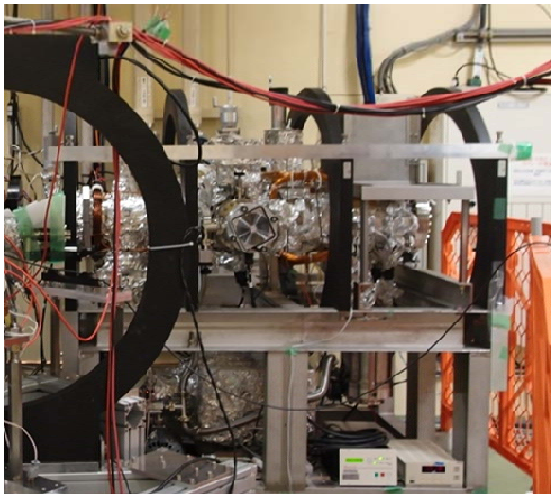
The fractional spots have been observed with the brightness-enhanced beam

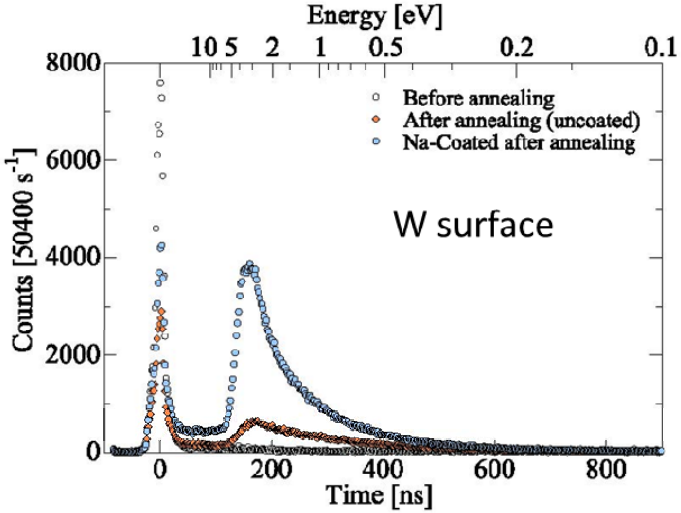
RHEPD rocking curve from Si(111)-7x7 surface



Renewed Ps time-of-flight (Ps-TOF) station







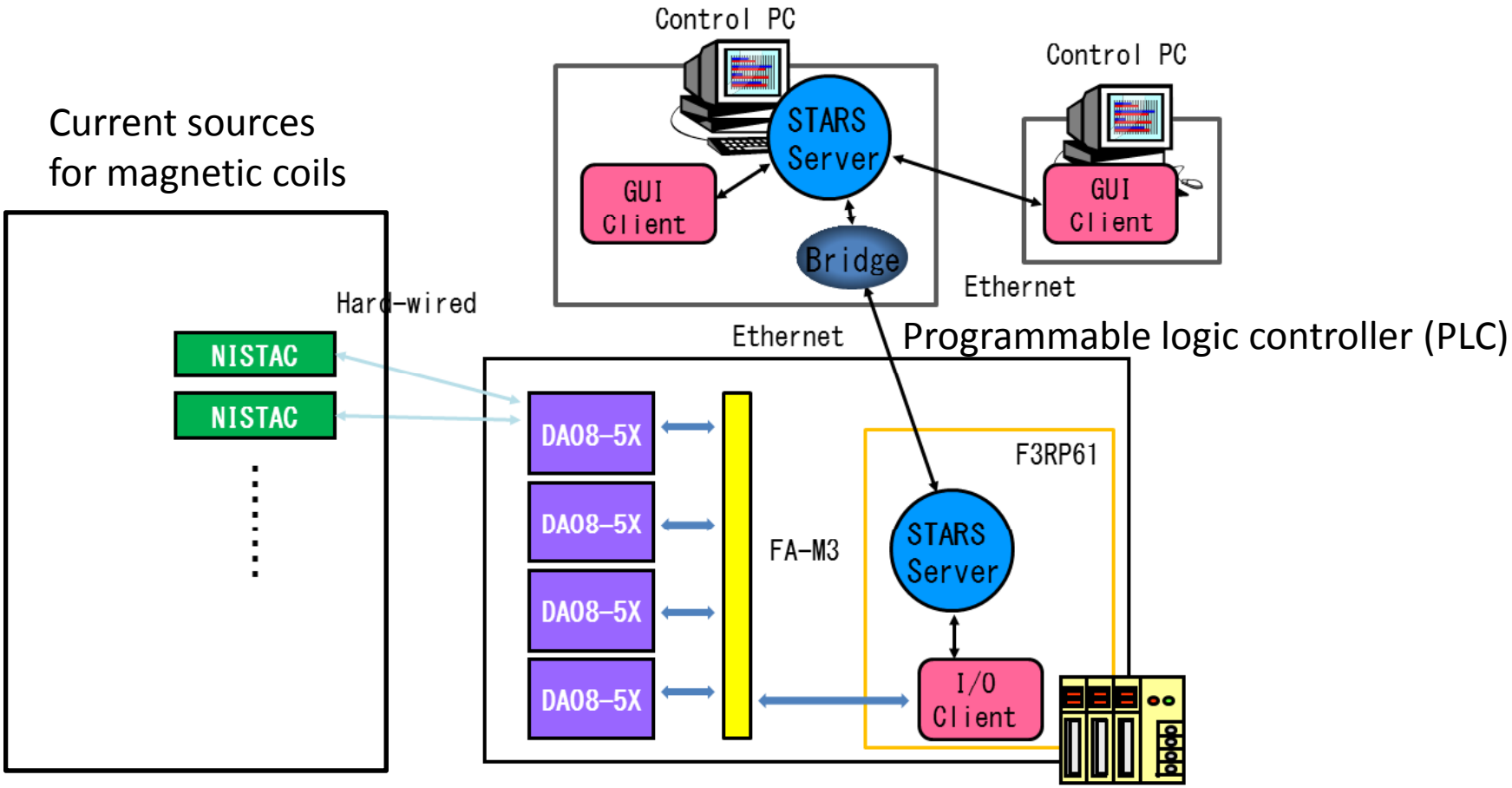
Renewed positronium time-of-flight (Ps-TOF) station

Smaller plastic scintillators deliver a better time resolution

TOF from the tungsten surface performed by Prof. Nagashima's group

Enhancement of the Ps-emission efficiency observed for Na-coated sample

A client-server system to control magnetic-coil current remotely



About 100 current sources for about 200 magnet coils will become to be controlled by STARS system

Beam time and experiments in KEK-SPF

- 2010: beam time 181-days
  - Ps^- experiment (Y. Nagashima et al.)
  - RHEPD experiment (Y. Fukaya et al.)
- 2011: beam time 180-days
  - Ps^- experiment
  - RHEPD experiment
- 2012
  - Ps^- experiment
  - RHEPD experiment
  - Ps-TOF experiment 1 (T. Tachibana et al.)
  - Ps-TOF experiment 2 (Wada et al.)
  - Positron-impact-induced ion-desorption experiment (Hirayama et al.)

Any researcher can use our beam line

through approval of research proposals

⇒ Contact us to get further information

Outlook for next a few years

- Reflection high-energy positron diffraction (RHEPD)

  2012: RHEPD experiment with brightness-enhanced beam

- Low-energy positron diffraction (LEPD)

  2012: designing

  2013: installation

- DC beam experiment

  2013: installation of DC-beam section

  2014: Doppler and coincidence Doppler experiment

Staff and current users of KEK-SPF

- KEK-SPF staff
  - Slow-positron beam line
    - T. Hyodo, K. Wada (April 2010 —), and I. Mochizuki (October 2012 —)
  - Dedicated linac of SPF
    - T. Shidara, S. Ohsawa, M. Ikeda, and other members of KEK linac group

- Current users of KEK-SPF
  - Ps negative ion and Ps-TOF experiment
    - Y. Nagashima and his students (Tokyo University of Science)
    - T. Tachibana (Rikkyo University)
  - RHEPD experiment
    - A. Kawasuso, Y. Fukaya, M. Maekawa (Japan Atomic Energy Agency)
    - I. Mochizuki (KEK)
  - Positron impact induced ion-desorption experiment
    - T. Hirayama and T. Tachibana (Rikkyo University)
  - LEPD experiment
    - T. Takahashi and T. Shirasawa (The University of Tokyo)
    - M. Fujinami (Chiba University)