Proton beam from the RCNP Ring Cyclotron

Kichiji Hatanaka, RCNP, Osaka University

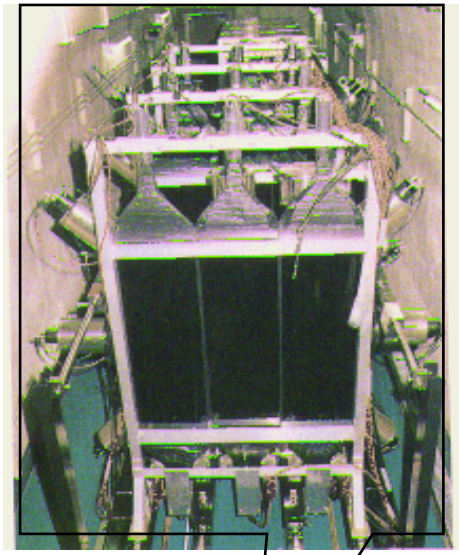
- RCNP-KEK workshop on fundamental neutron physics and related fields -
Physics with Spallation Ultracold Neutrons

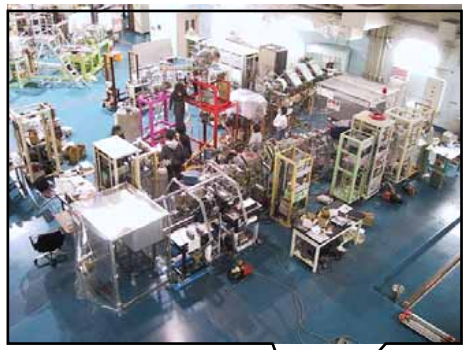
March 17 to 18, 2005
Meeting room on 4th floor, Main Building,
RCNP, Osaka University

Neutron Course

East experimental hall

Ring Cyclotron



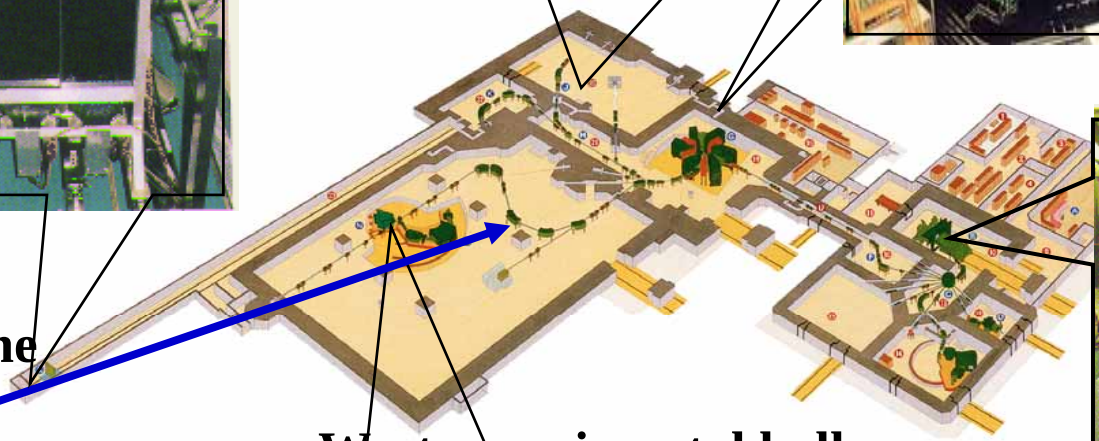


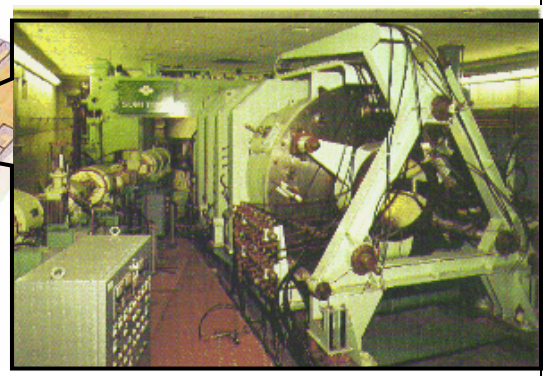
K400

← 1991

1973

K140 ↓





WS beam line

2000

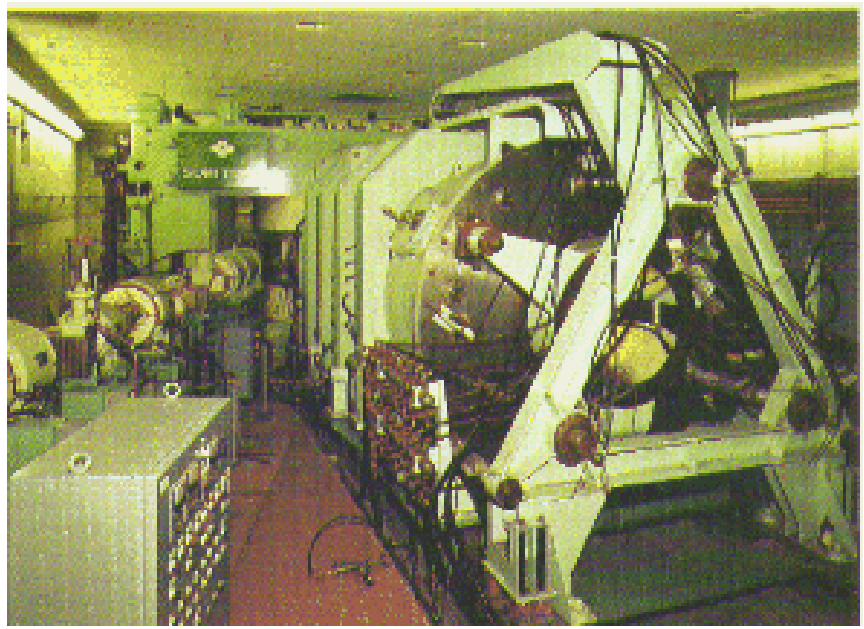
West experimental hall

Focal Plane Polarimeter

AVF Cyclotron

- Polarized p/d beams
- Ultra precise beam
- Two arm spectrometers
- Polarimeters
- Projectile fragment separator
- Ultracold neutron source
- Spallation neutron source

AVF Cyclotrons



Magnet

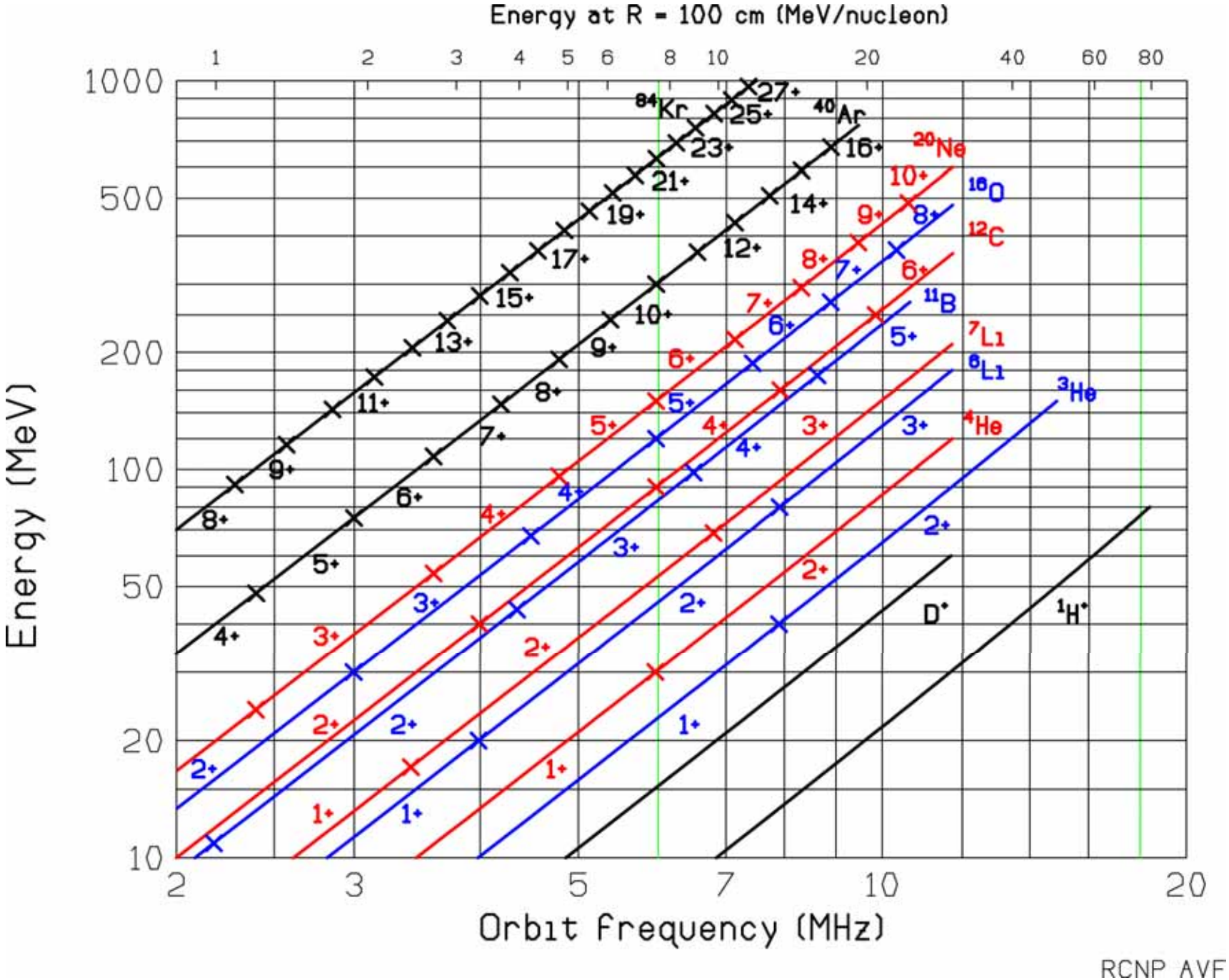
- **Pole diameter : 3.3 m**
- **Pole gap : 20.6 cm ~ 34.7 cm**
- **Averaged field : 1.6 T**
- **Trim coils : 16 sets**
- **Valley coils : 3 ~ 5 sets**
- **Weight : 400 tons**

Acceleration system

- **Dee : Single 180 degrees type**
- **Resonator : Moving short**
- **Frequency : 6 ~ 19 MHz**
- **Max. accel. voltage : 80 kV**
- **Extraction system : Electrostatic deflector**

Ion Sources

- **External ion source : Atomic beam type polarized ion source**
  : ECR ion source


Energy at R = 100 cm (MeV/nucleon)
1
2
3
4
5
6
8
10
20
40
60
80
1000
500
200
100
50
20
10
Energy (MeV)
2
3
5
7
10
20
Orbit Frequency (MHz)
84Kr
40Ar
20Ne
16O
12C
11B
7Li
6Li
3He
4He
D+
1H+
RCNP AVF

Ring Cyclotron

Magnet

- Sector magnets : 6 sets
- Pole gap : 6 cm
- Max. magnetic field : 1.75 T
- Trim coils : 36 sets
- Injection radius : 2 m
- Extraction radius : 4 m
- Weight : 2200 tons

Acceleration system

- Single gap type : 3 sets
- Frequency : 30 ~ 52 MHz
- Max. accel. voltage : 500 kV
- RF power : 250 kW/cavity
-

Flat-topping cavity

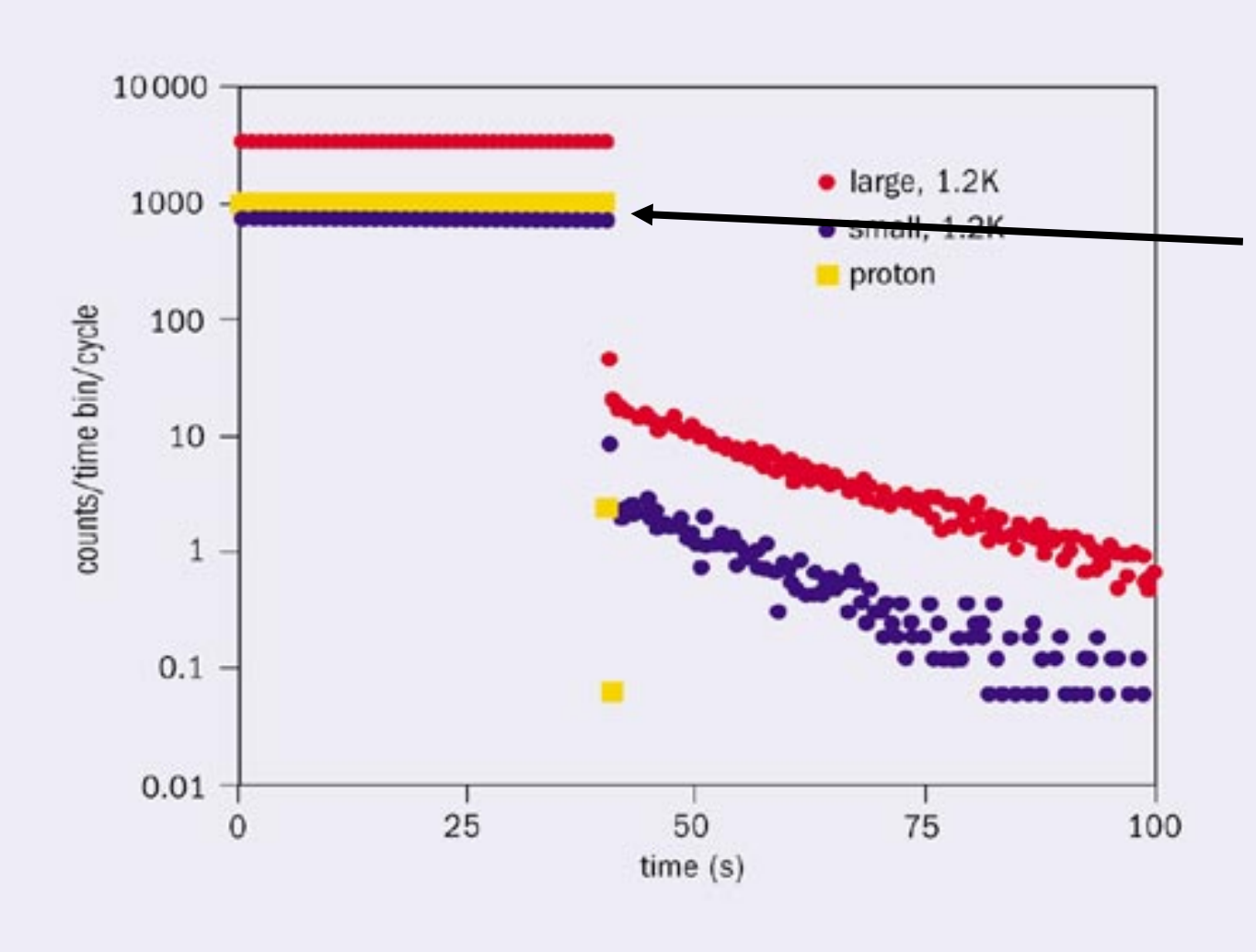
- Single gap type : 1 set
- Frequency : 90 ~ 156 MHz

Accelerated Ions and Energies

Proton	**: 100 - 420 MeV**	**Deuteron**	**: 150 - 200 MeV**
$^{3}He^{2+}$	**: 400 - 450 MeV**	$^{4}He^{2+}$	**: 180 - 400 MeV**
$^{6}Li^{3+}$	**: 600 MeV**	$^{7}Li^{3+}$	**: 455 MeV**
$^{14}N^{7+}$	**: 560 - 980 MeV**	$^{18}O^{8+}$	**: 1,062 MeV**

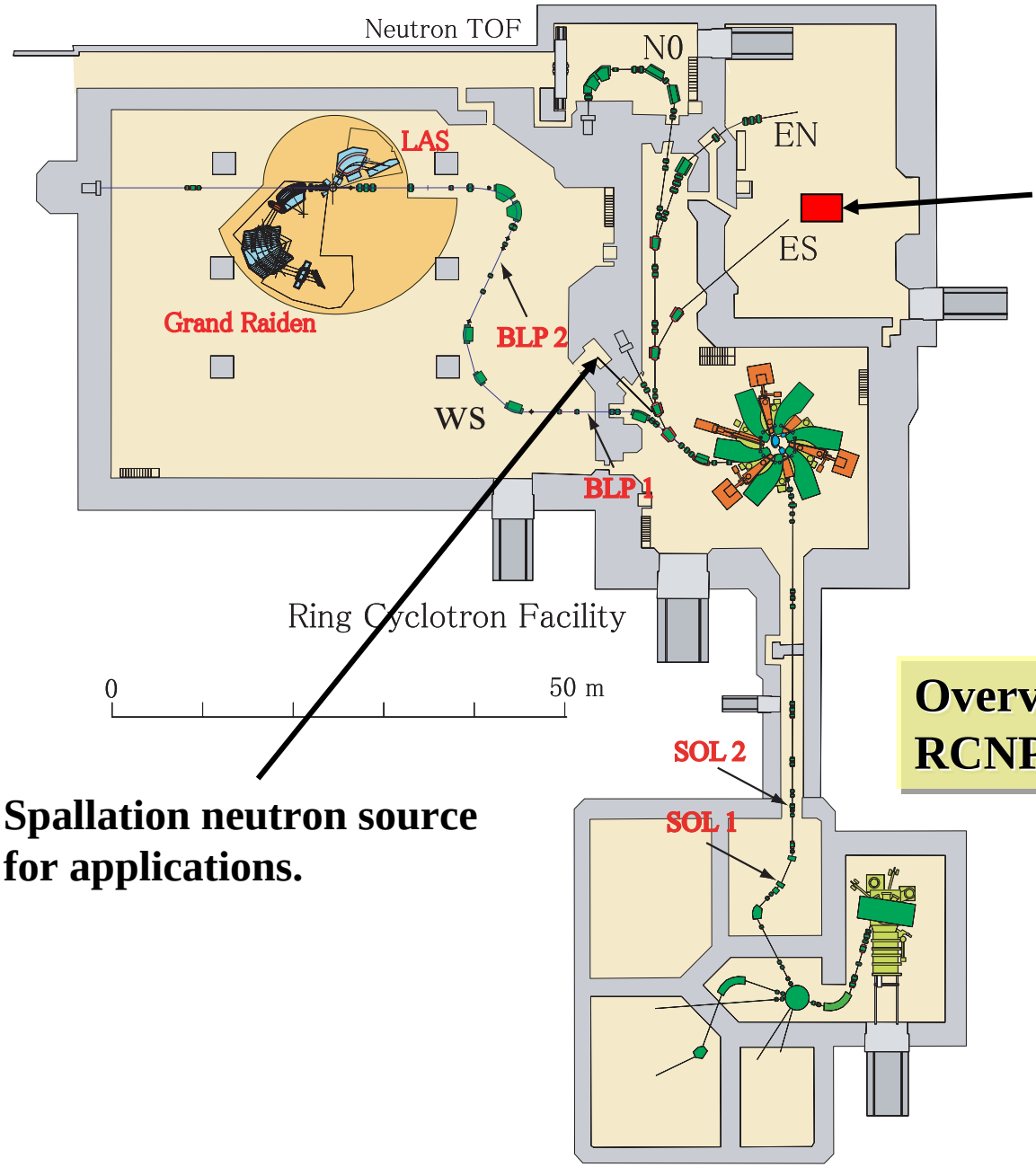
Max. integrated beam current on the production target

1.1 μA✕168 hrs/week @400 MeV



Neutron counts for a 40 s proton beam pulse, with 1.5 cm and 2.4 cm diameter ultracold neutron detectors at 1.2 K.

0.7 neutrons/cm^3 for a proton-beam power of 78 W and He-II temperature of 1.2 K



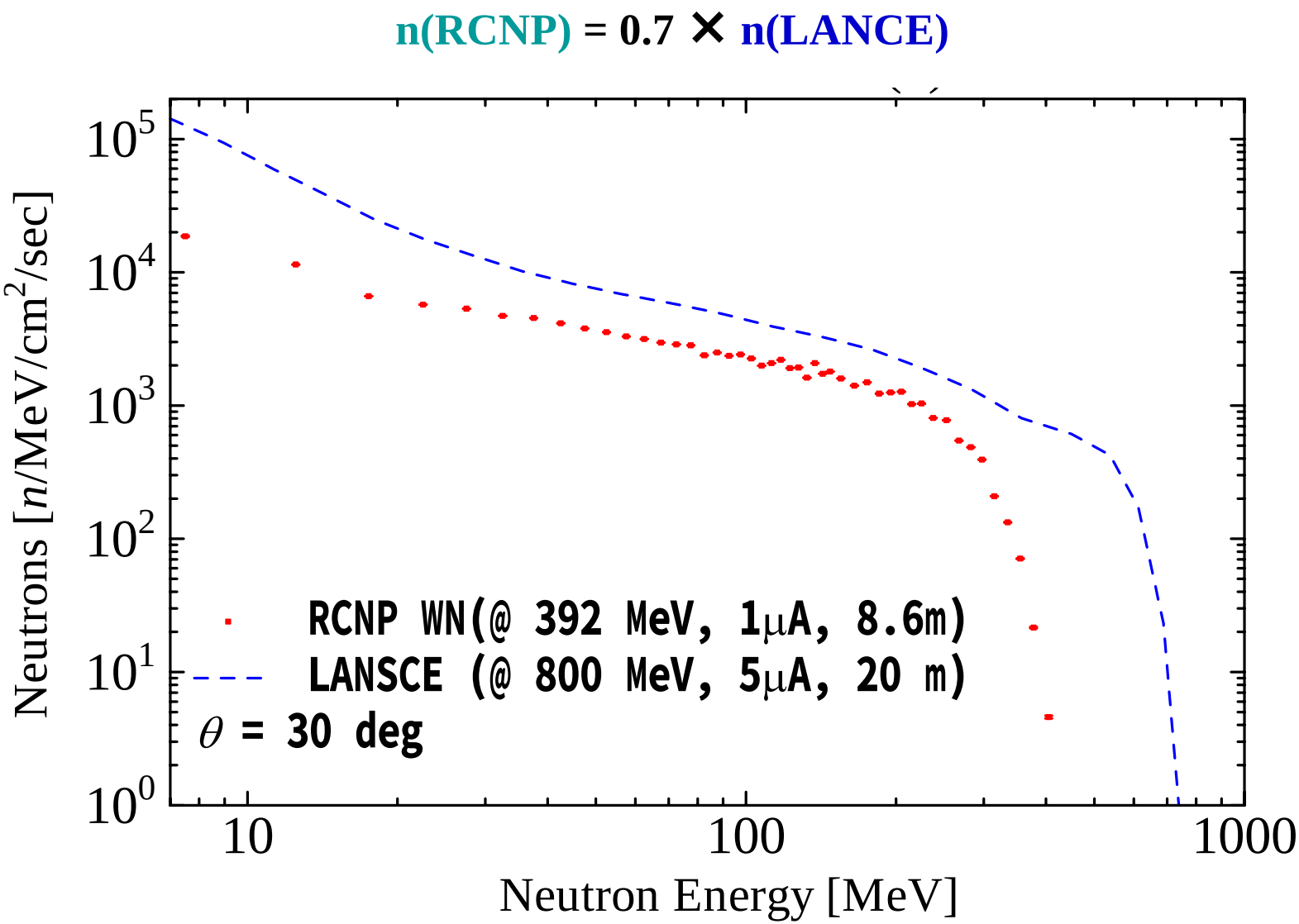
UCN source

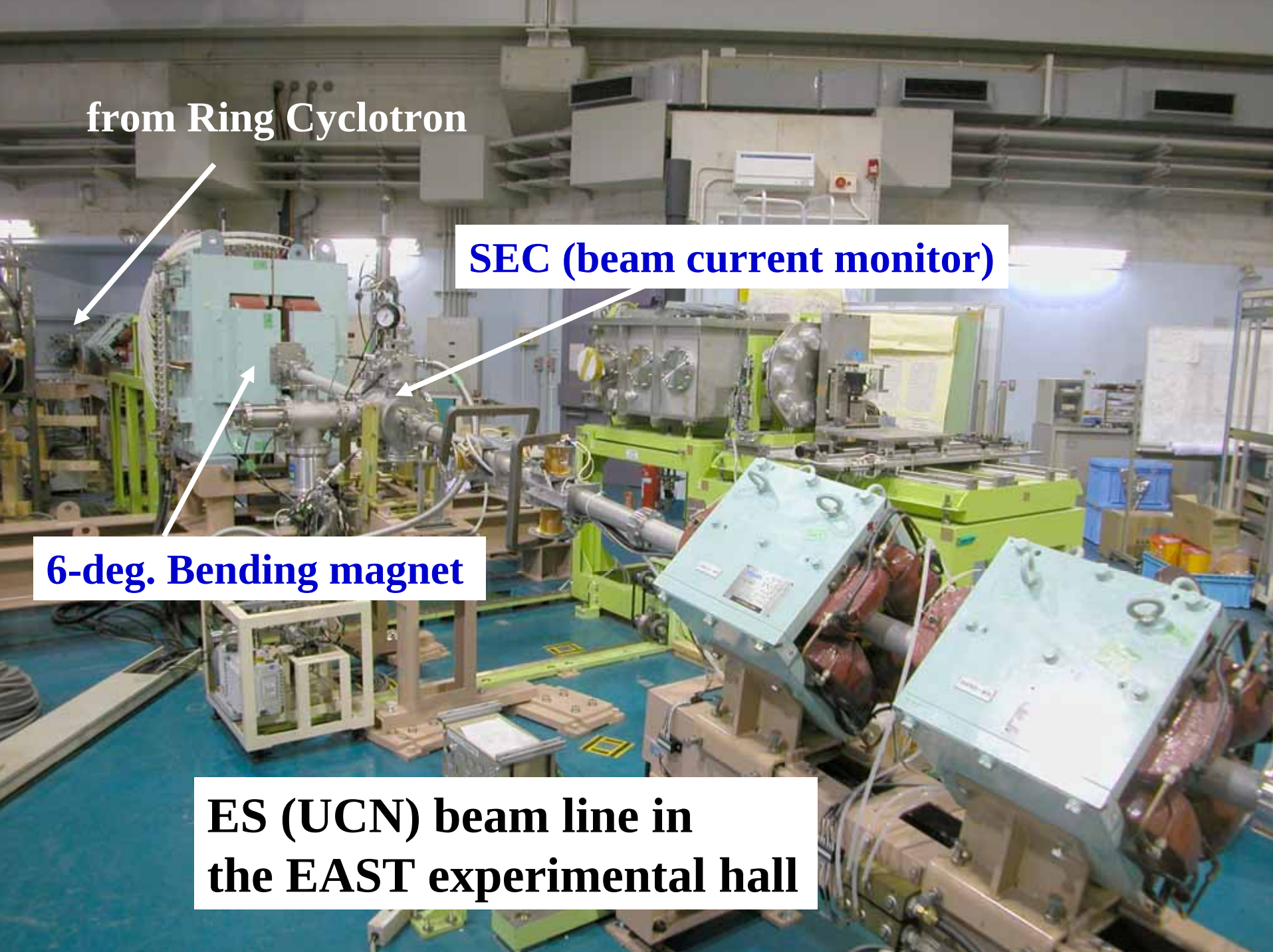
in the EAST experimental hall

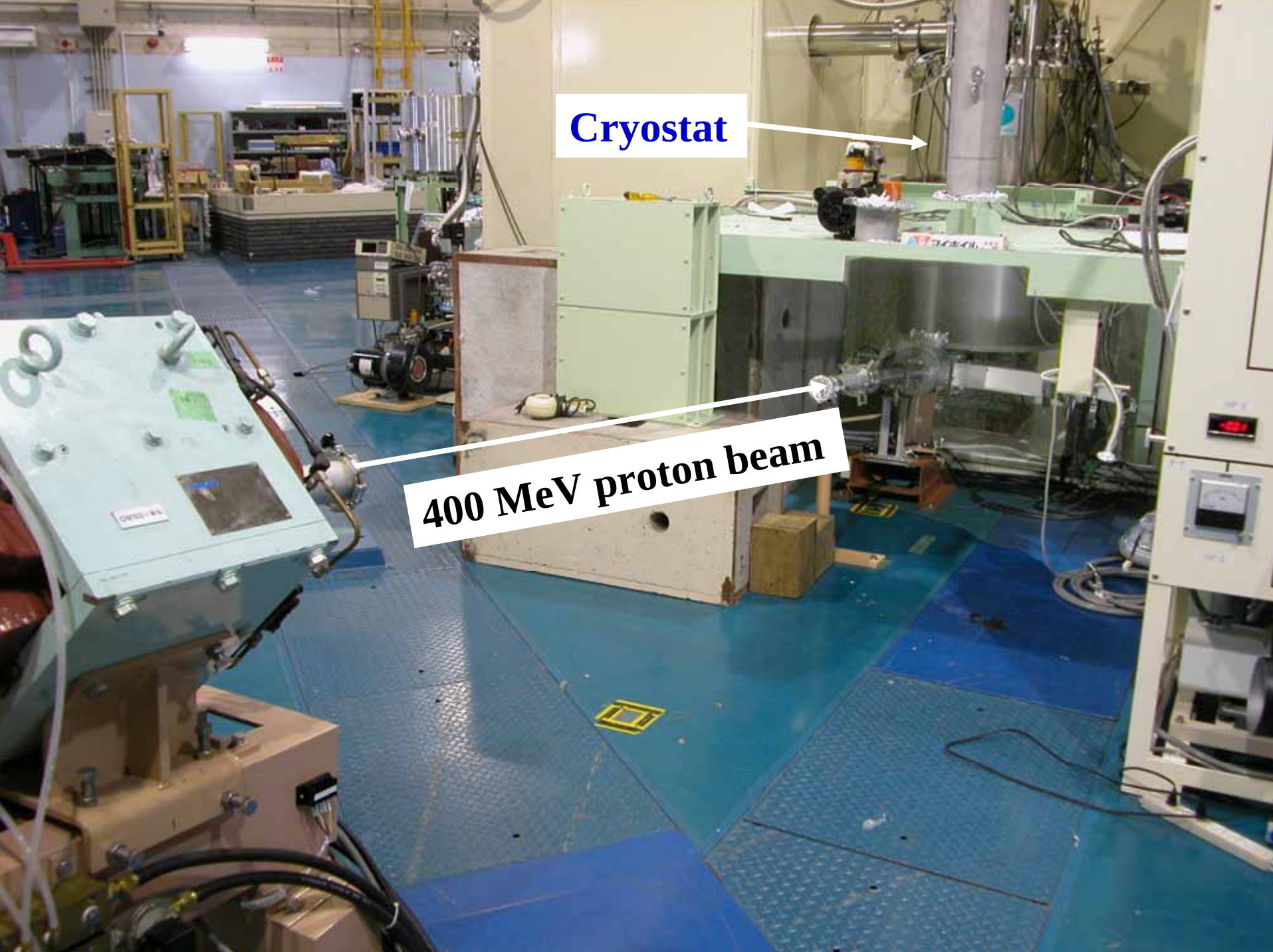
Overview of the RCNP Ring Cyclotron Facility

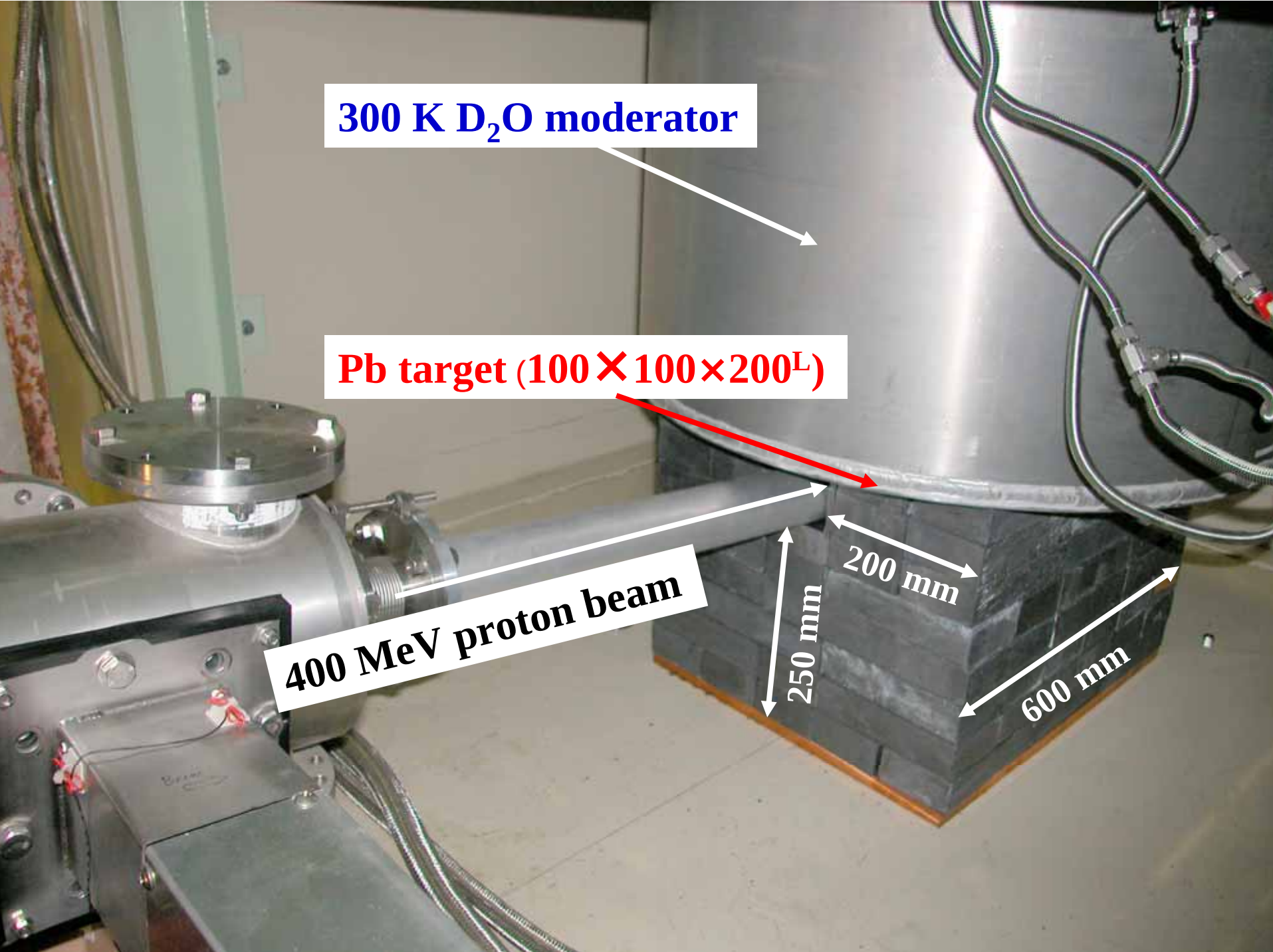
Spallation neutron source for applications.

Spectra of spallation neutrons




from Ring Cyclotron
SEC (beam current monitor)
6-deg. Bending magnet
ES (UCN) beam line in
the EAST experimental hall


Cryostat
400 MeV proton beam

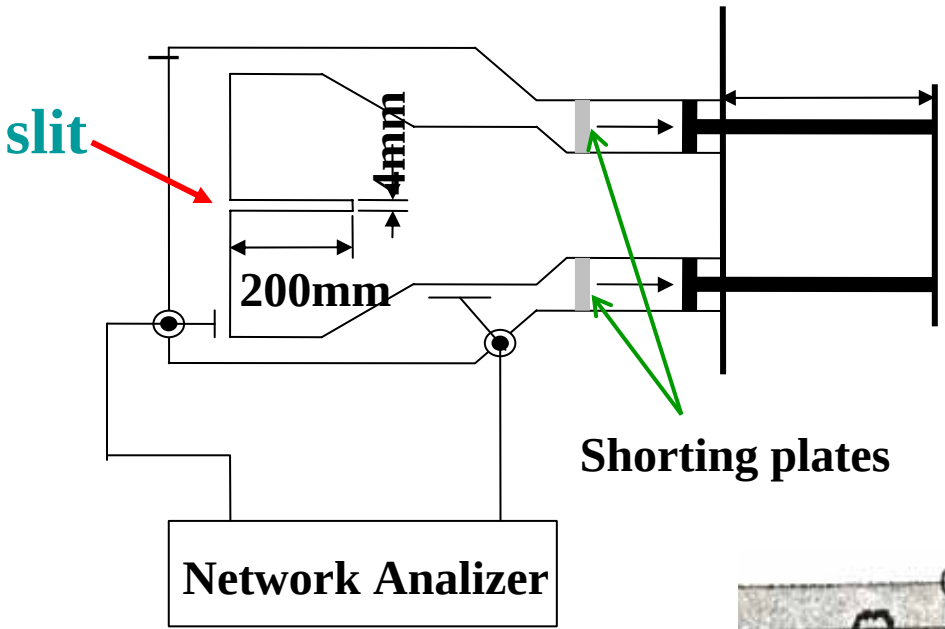

300 K D_2O moderator
Pb target (100×100×200^L)
400 MeV proton beam
200 mm
250 mm
600 mm


Shielding room (1000t Fe + 500t concrete)

Upgrade of the AVF cyclotron facility

- **Beam quality (single turn extractions for all the beams)**
  - **Higher accelerating voltage (50 → 100 kV)**
  - **Flat-topping voltage (5^{th}, 7^{th}, 9^{th} harmonics)**
- **Beam quantity (high intensity)**
  - **Superconducting ECRIS (18 GHz)**
- **New instruments**
  - **Polarized ^{6}Li ion source**
  - **Beam line from AVF to ring cyclotron experimental halls**
- **Replacements**
  - **Trim coil power supplies**
  - **Control system**

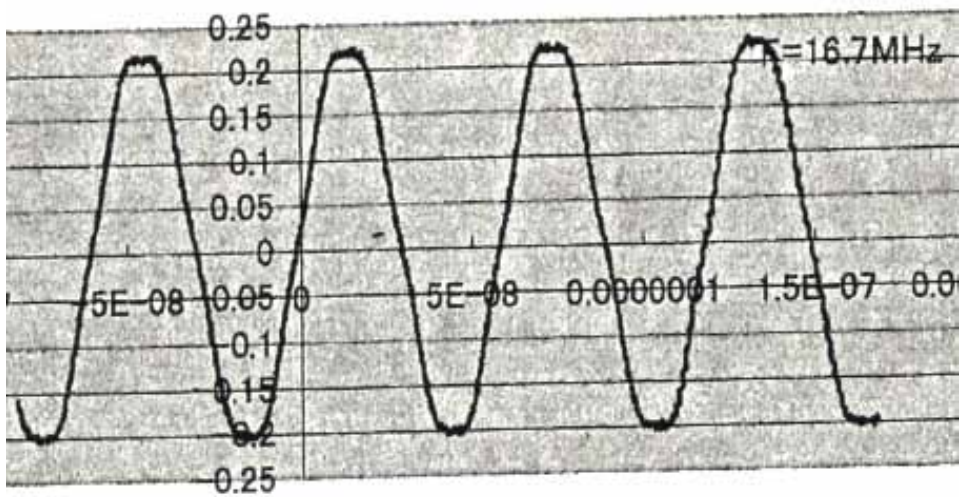
Modification of the dee electrode to avoid parasitic resonances.



20P18: T. Saito

Studies with a 1/5 model

$$V = V_0\left[\cos(\omega t) - \frac{1}{25}\cos(5\omega t)\right]$$

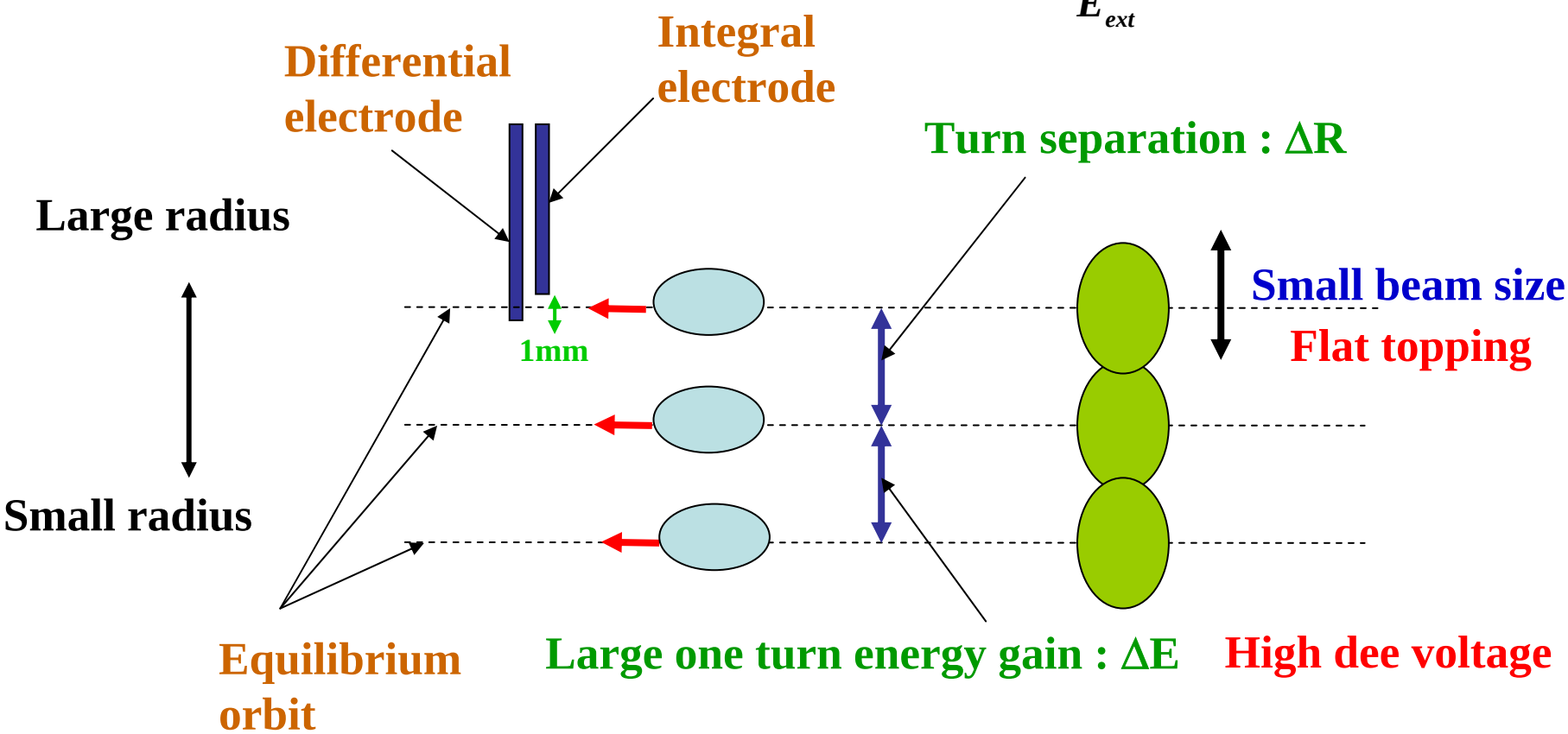


Superposition of the 5th harmonic voltage on the present dee electrode.

Single turn extraction from AVF cyclotron

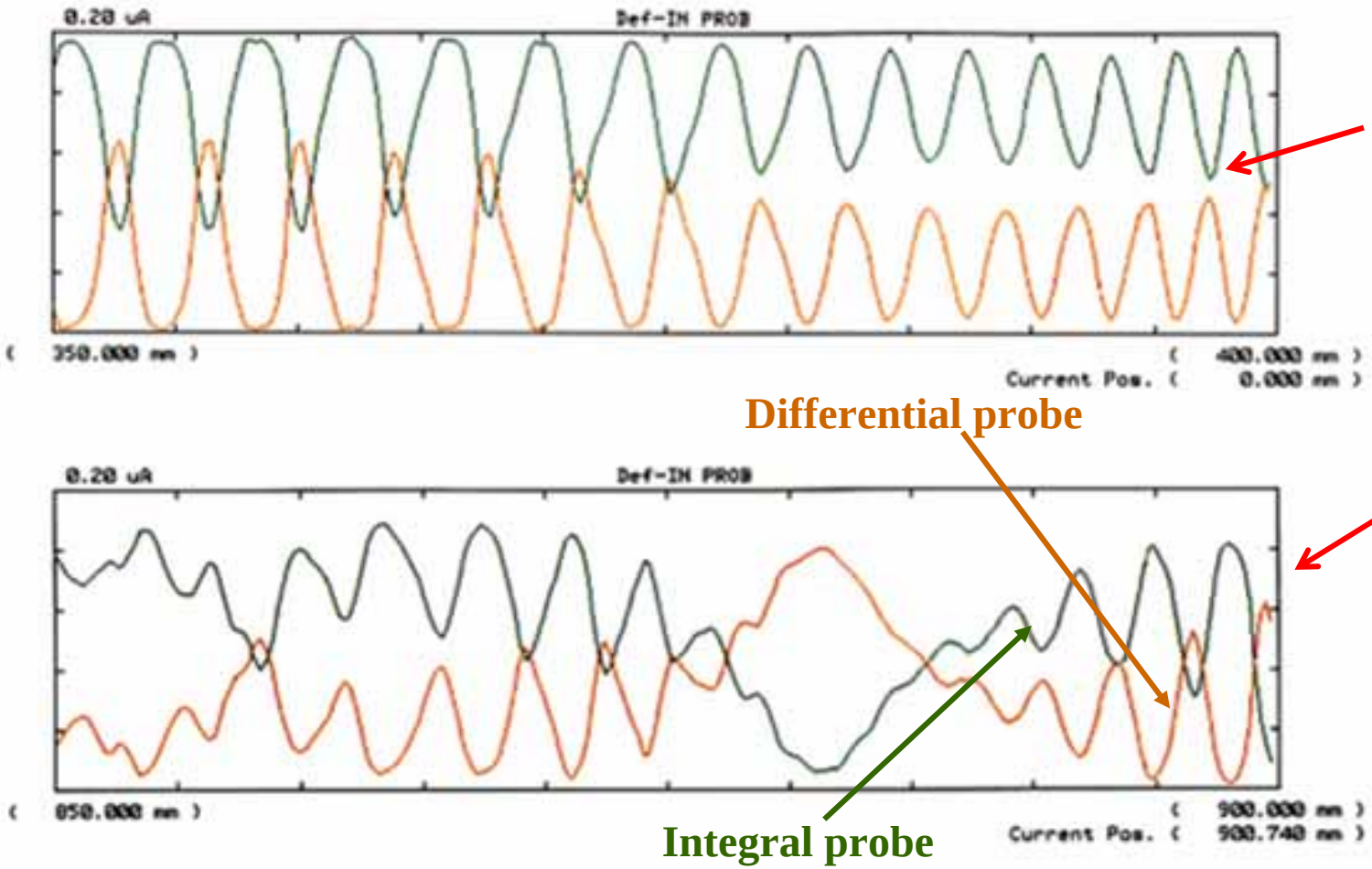
$$\Delta R = R_{ext} \cdot \frac{\Delta E}{2E_{ext}} = \frac{1}{2}\frac{R_{ext}}{N}$$

$$N = \frac{\Delta E}{E_{ext}}$$



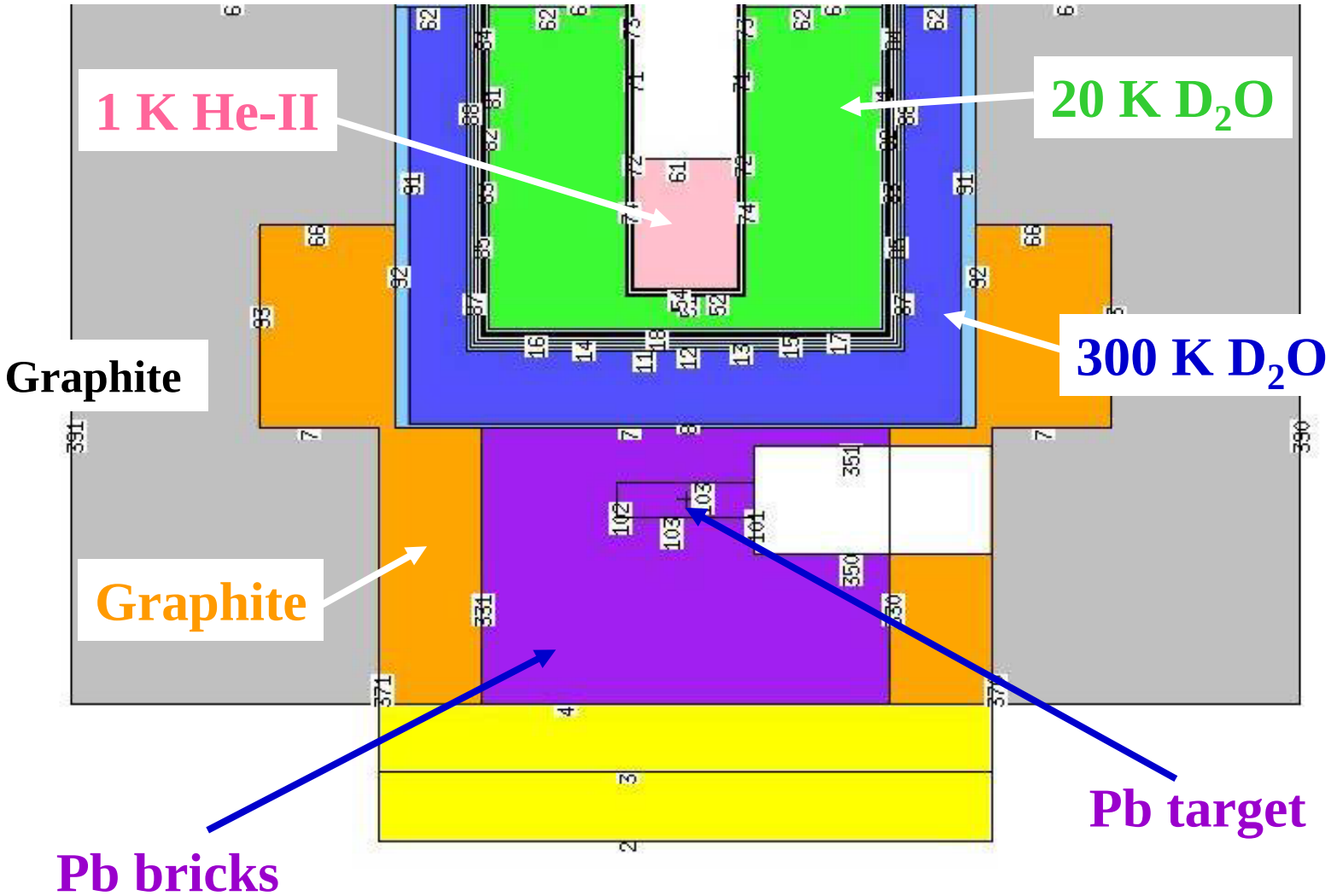
Tetrode: RCA4648 → RS2042SK(Siemens)

^{3}He 88 MeV



By restricting the beam phase spread, a single turn extraction is nearly achieved.

Dec. 02, 2003



MCNPX modeling

MCNPX results