

High Power Cyclotrons

**Sumitomo Heavy Industries, Ltd.
Industrial Equipment Div.**

Company Profile

Sumitomo Heavy Industries, Ltd.

Opened for Business in 1888, Incorporated in 1934

A Heavy Industries in Sumitomo Business Group

(Group Companies)

**Sumitomo Corporation
Sumitomo Mitsui Bank
Sumitomo Metal Mining
Sumitomo Chemical
NEC Corporation
Asahi Breweries, etc.**

7 Factories in Japan

47 Foreign Units

Employees: ~18,000



Head Office (Tokyo, Japan)

Sumitomo products



Double-hull tanker



Plant & Engineering



Plastic machinery



Construction Machines



Cryocoolers



Power transmission & control



Ring Cyclotron (540MeV)



Synchrotron & Storage Ring AURORA (700MeV)



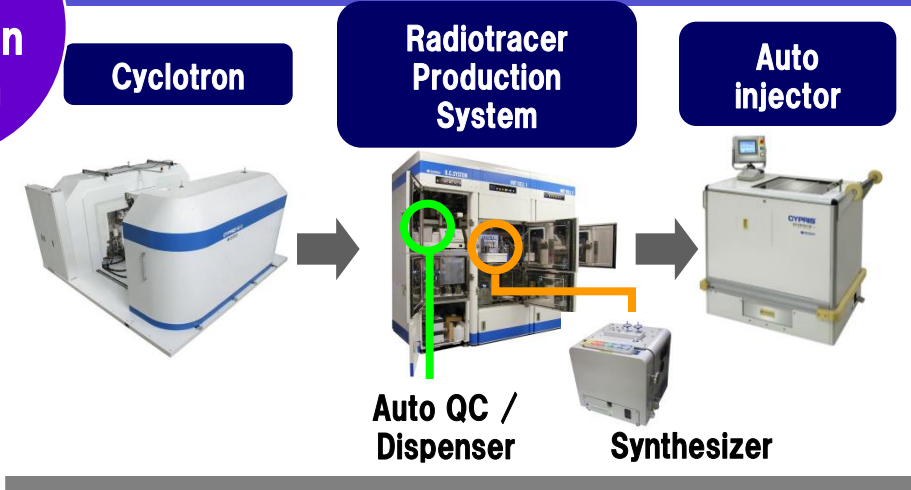
110MeV Cyclotron



70MeV Cyclotron

Diagnosis

**PET
Cyclotron
System**



**Semi-
conductor
Animal
PET**



Treatment

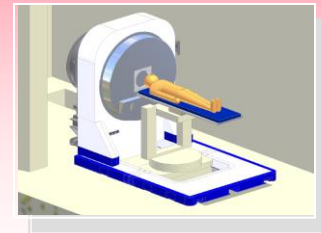
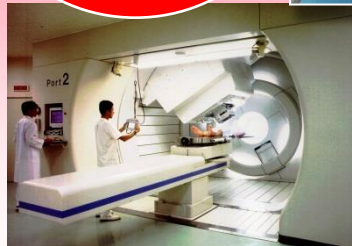
**Proton
Therapy
System**



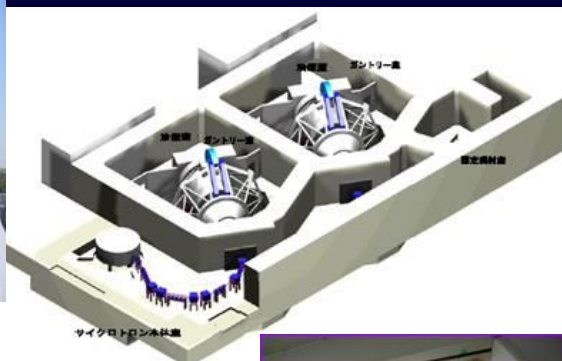
**BNCT
System**



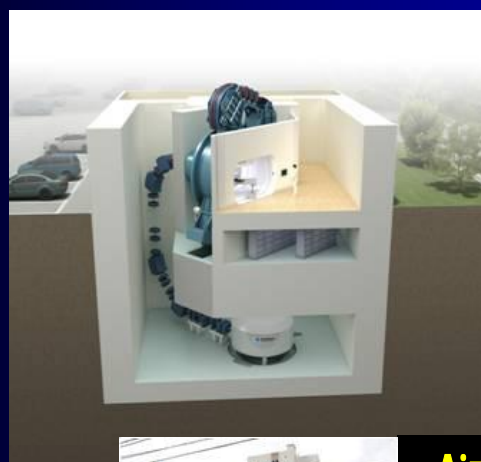
**Heavy Ion
Therapy
System**



References of Sumitomo PTS



National Cancer Center Hospital (Japan)

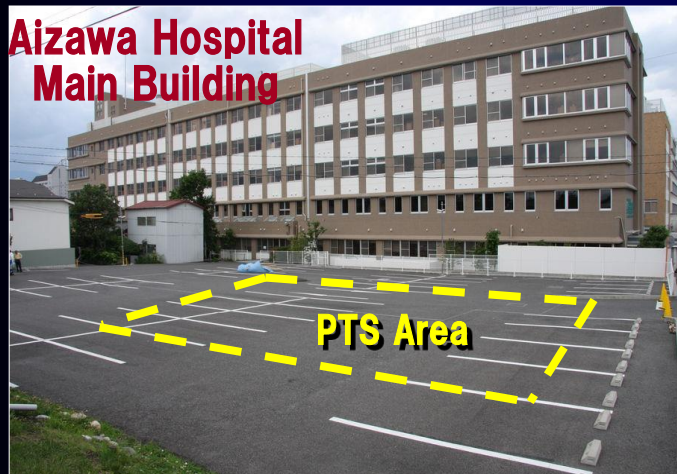


Aizawa Hosp. (Japan)



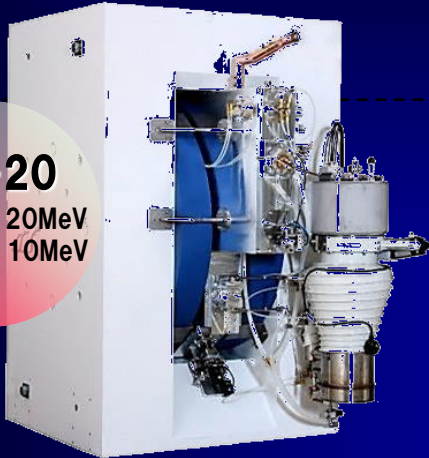
Samsung Medical Center (Korea)

Aizawa Hospital Vertically arranged PTS

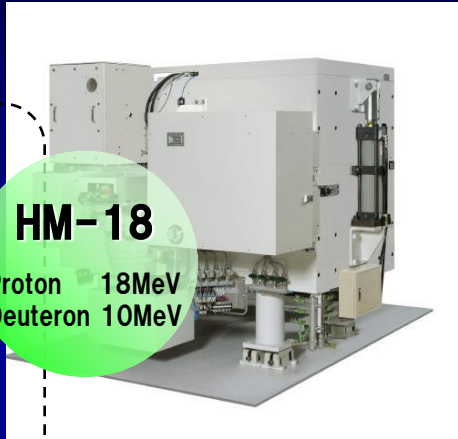


Cyclotrons for PET RI production

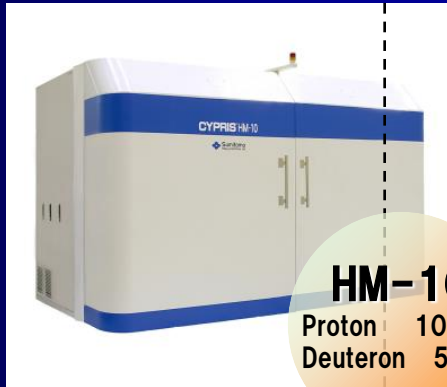
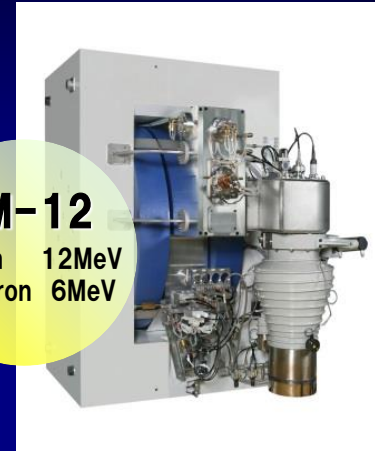
HM-20
Proton 20MeV
Deuteron 10MeV



HM-18
Proton 18MeV
Deuteron 10MeV



HM-12
Proton 12MeV
Deuteron 6MeV



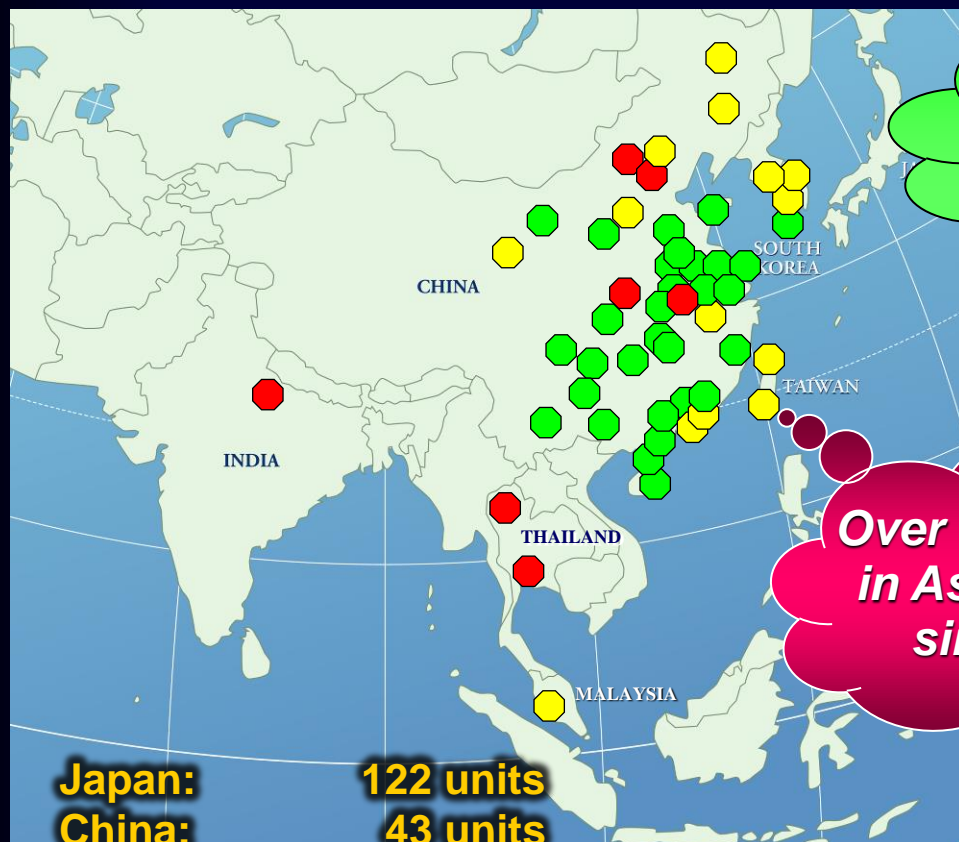
HM-10
Proton 10MeV
Deuteron 5MeV



HM-7
Proton 7.5MeV
Deuteron 4MeV

Proton beam current is $\sim 150\mu\text{A}$

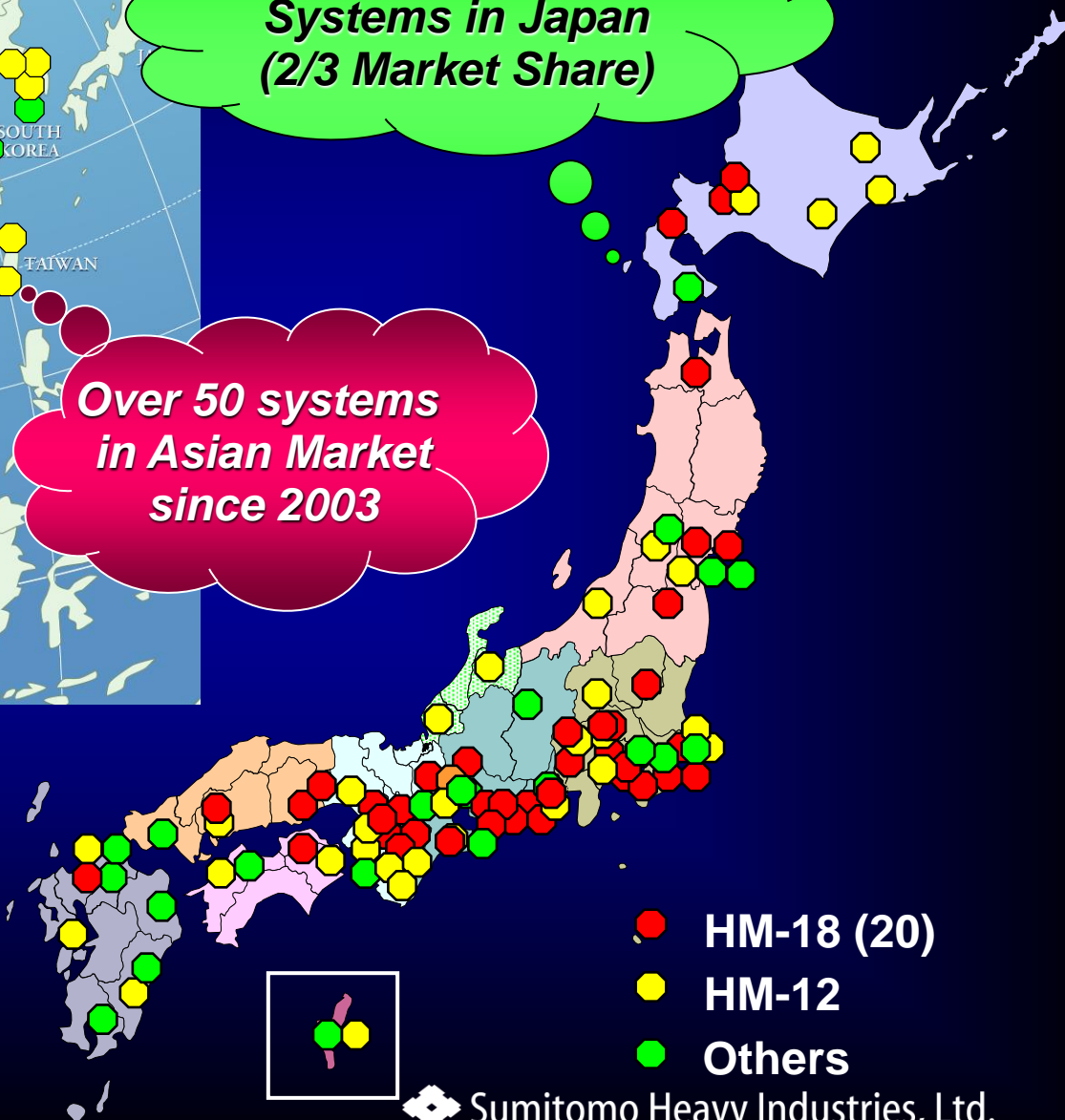
PET cyclotrons in Asia



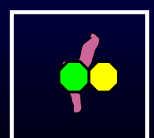
Over 120 Sumitomo Systems in Japan (2/3 Market Share)

Over 50 systems in Asian Market since 2003

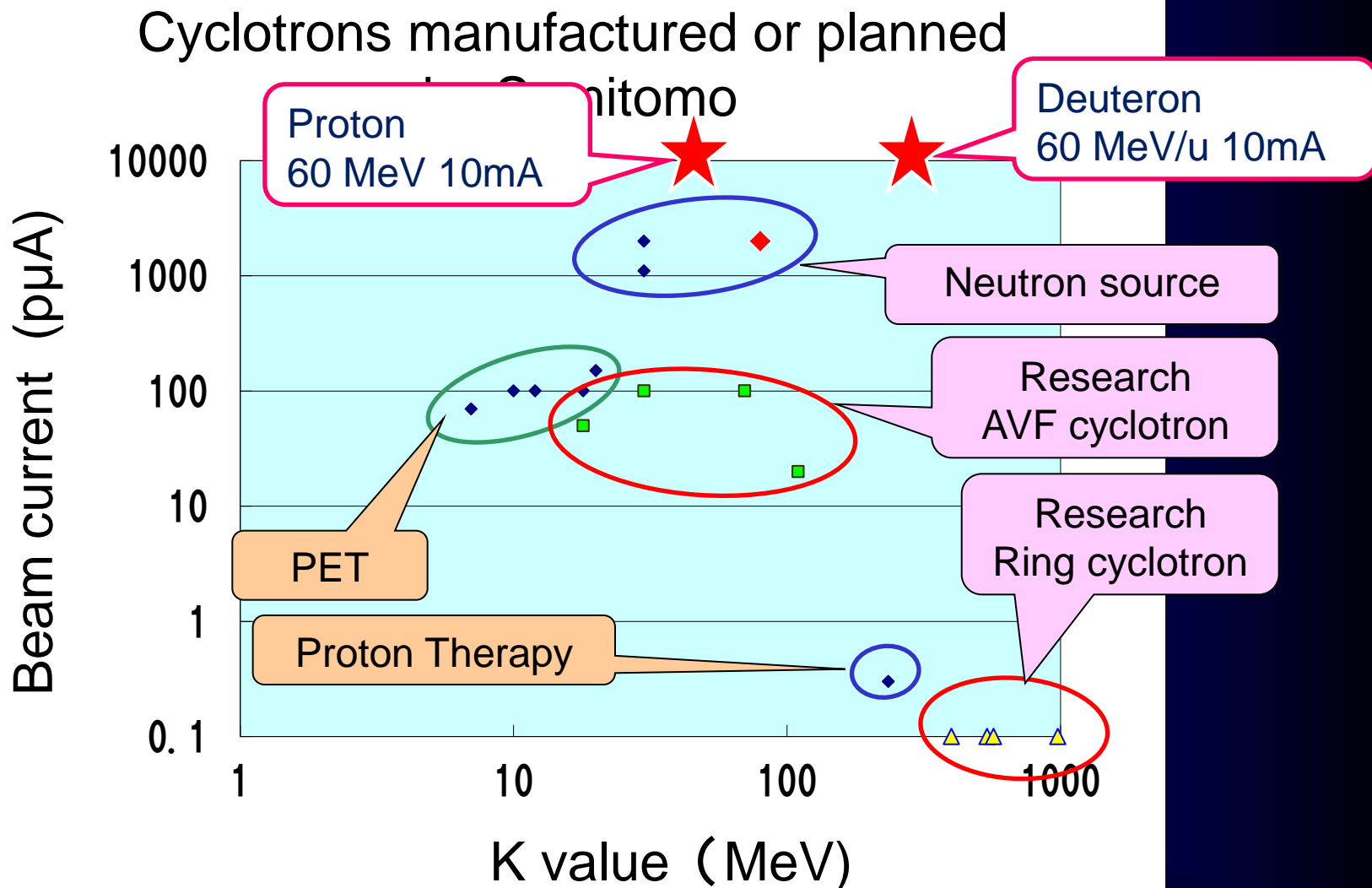
Japan:	122 units
China:	43 units
Hong Kong:	3 units
Korea:	4 units
Taiwan:	2 units
Malaysia:	1 unit
Thailand:	2 units
India:	1 unit
<u>Iraq:</u>	<u>1 unit</u>
Total:	179 units



- HM-18 (20)
- HM-12
- Others



Map of the cyclotrons by Sumitomo



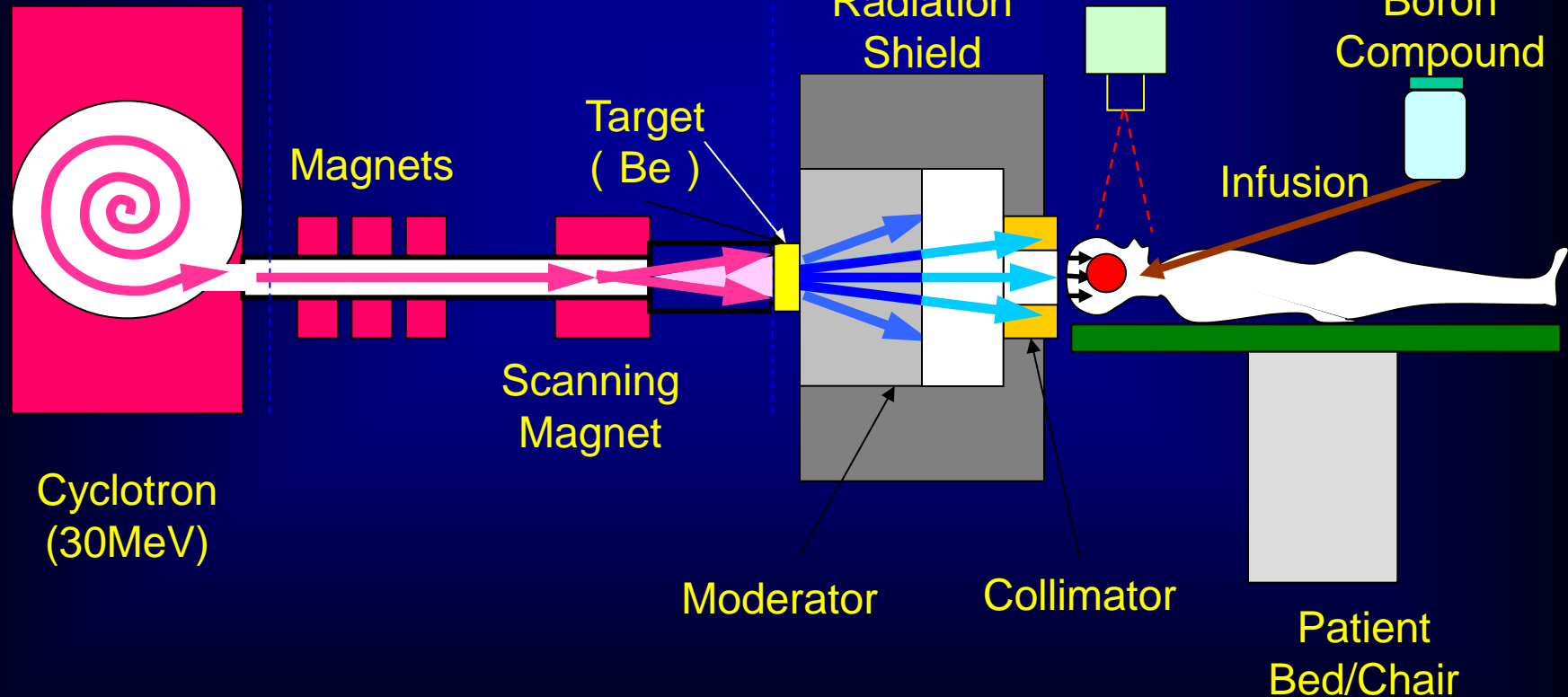
Neutron Source for Boron Neutron Capture Therapy

Basic Configuration of Accelerator Based BNCT

Proton Accelerator

Beam Transport

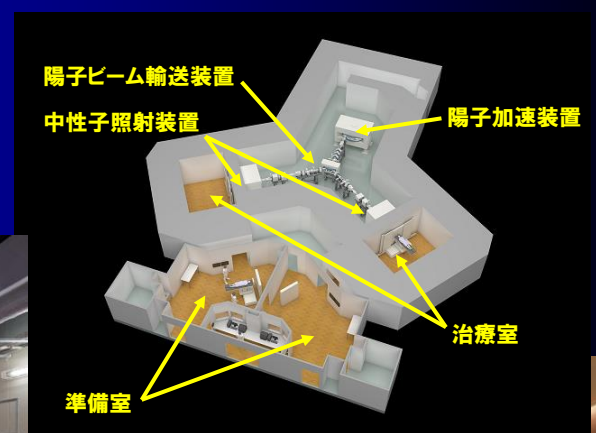
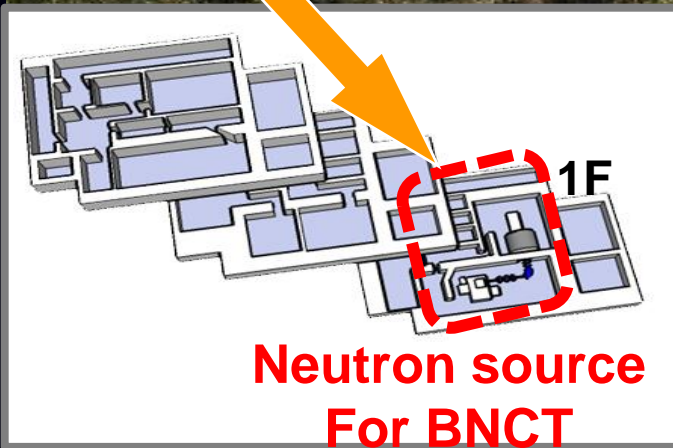
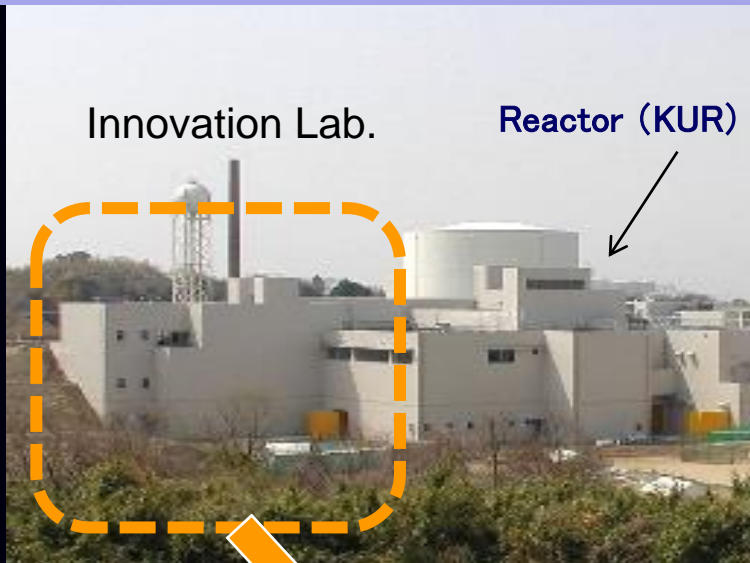
Target and Irradiation



Neutron source for BNCT

Kyoto University Research Reactor Institute

Southern Tohoku Hospital



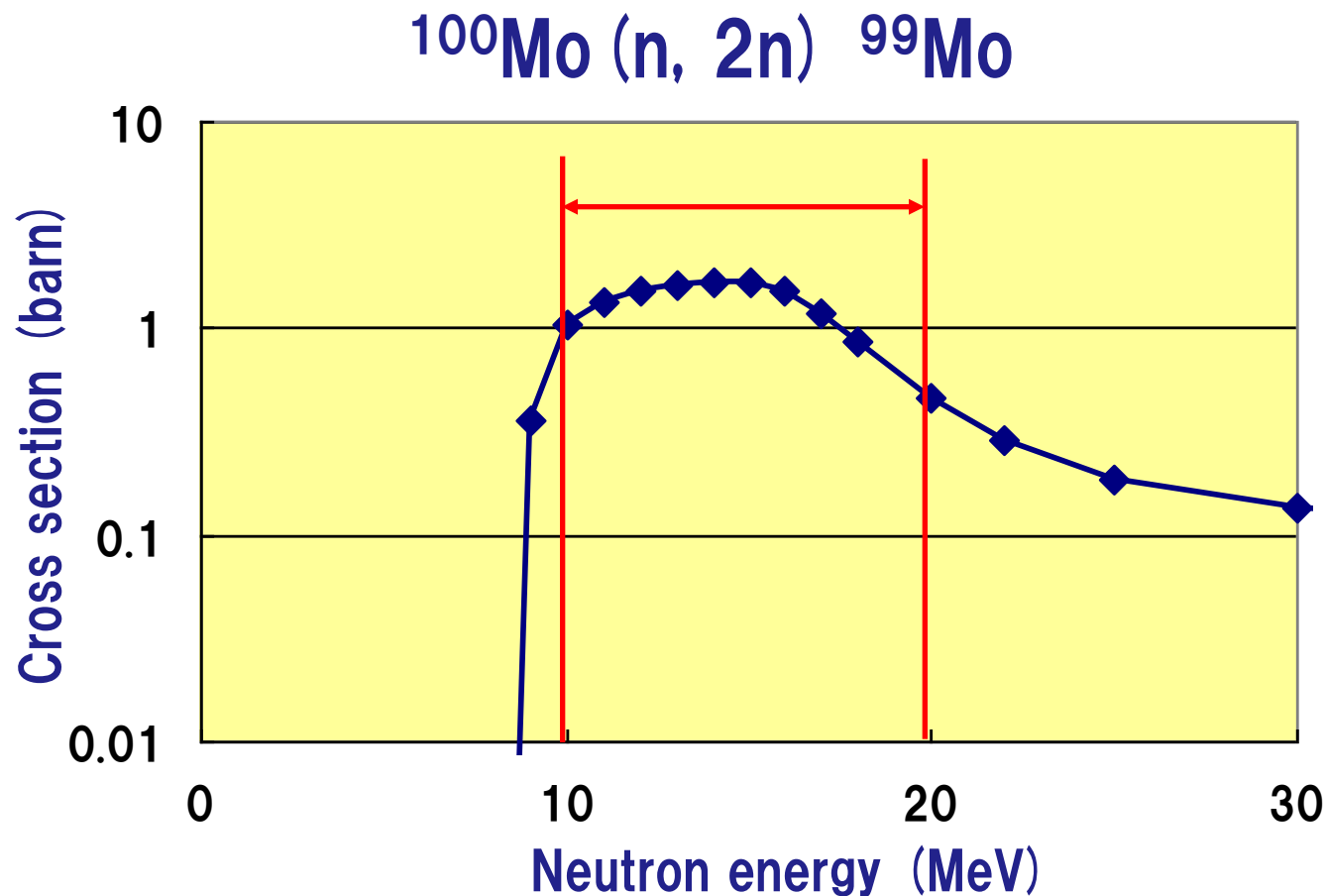


Type AVF Cyclotron

External Ion source	Negative Hydrogen source
Injection Energy	30 keV
Extraction Energy	30 MeV
RF	73.1 MHz
Mean Extraction Radius	645 mm
Mean Magnetic Field	1.2 T
Total Weight	60 Ton
Footprint	3.0 m × 1.6 m
Beam current: Nominal	1.0 mA
Proved	1.5 mA
Target	2.0 mA
Dream	3.0 mA

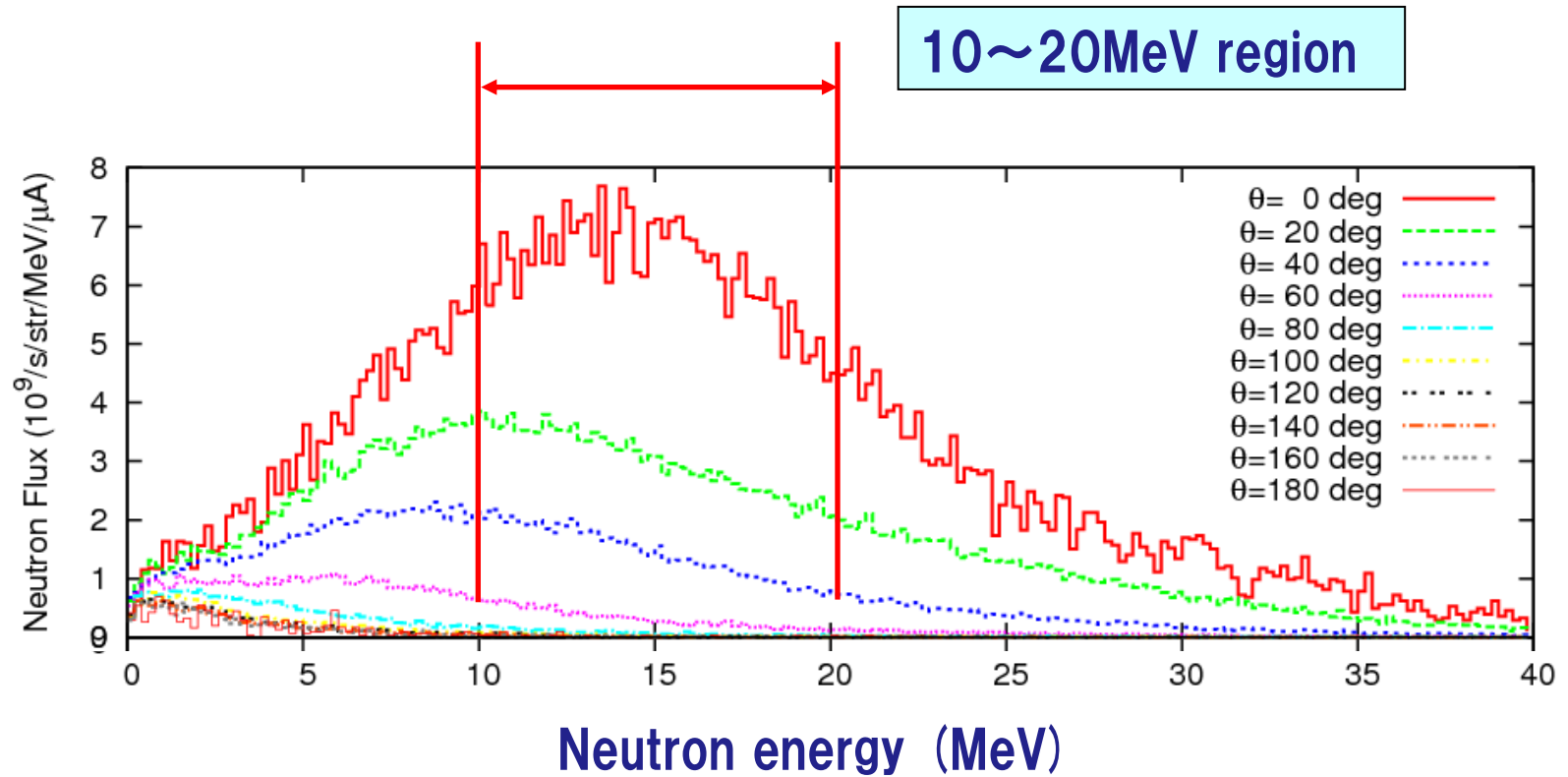
Neutron Source for ⁹⁹Mo Productions

Production of ^{99}Mo by neutrons



Production of neutrons

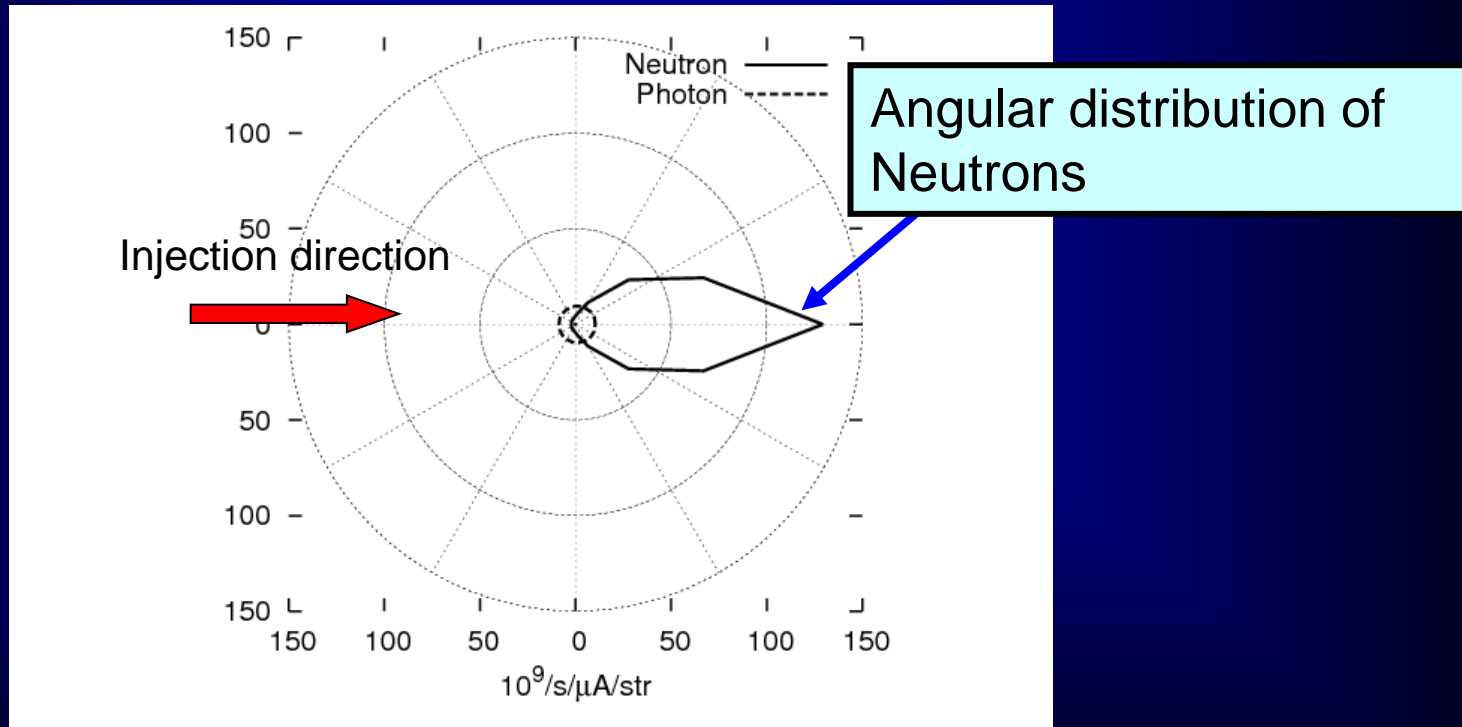
40MeV Deuteron + Carbon target



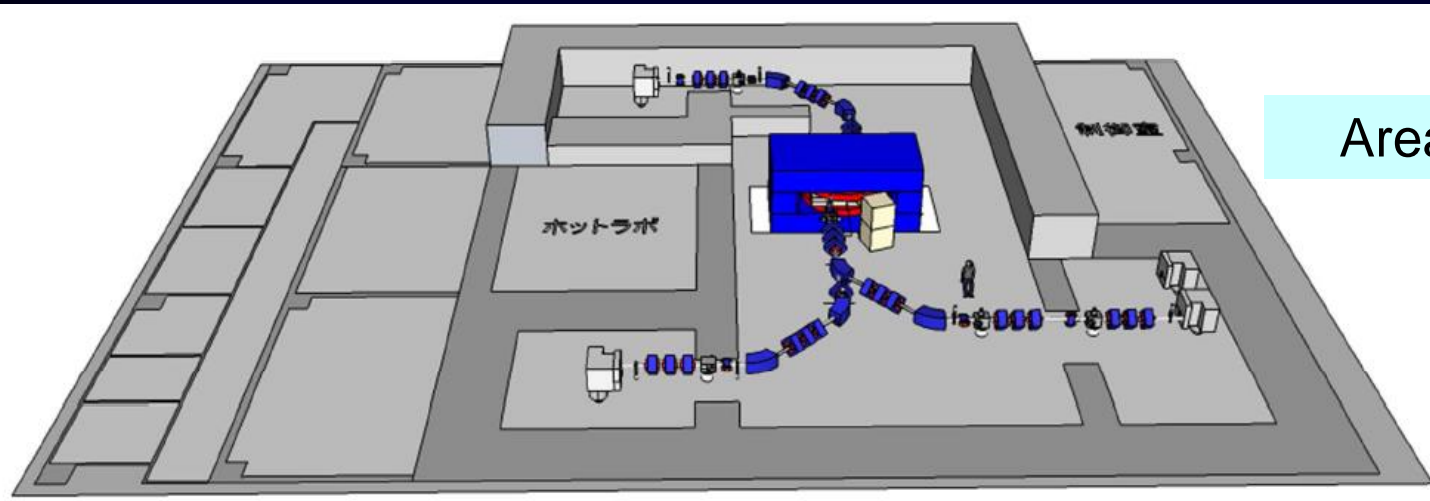
Neutron Production rate

40MeV Deuteron + Carbon target

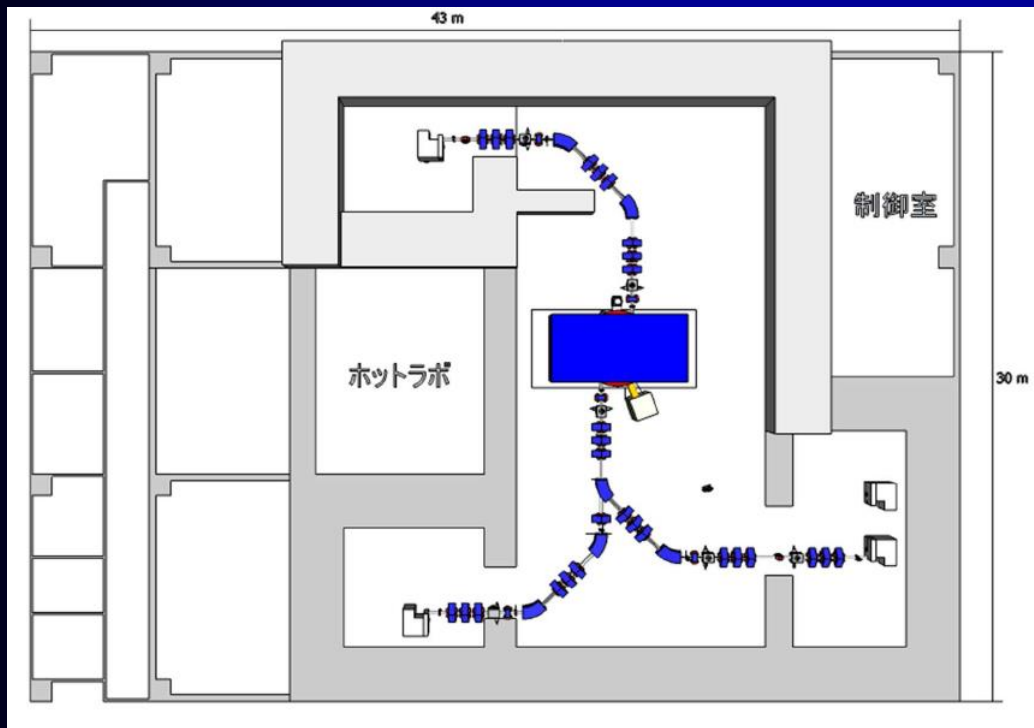
- Neutron production rate 1.7×10^{14} neutrons/sec/mA
- In the case of 40MeV 2mA
→ 3.4×10^{14} neutrons/sec/mA



Facility Layout Plan



Area: 30 m × 43 m



AVF Cyclotron
Ions: Deuteron
Energy: 40MeV
Beam current: 2mA

Specification of 40MeV Deuteron Cyclotron

Type AVF Cyclotron

External Ion source (Negative Ion)

Injection Energy 40 keV

Extraction Energy 40 MeV

Cyclotron Frequency 9.7 MHz

RF 38.8 MHz

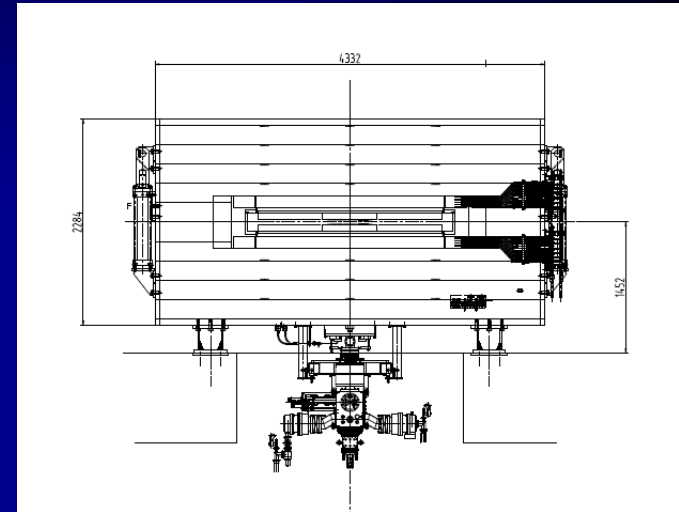
Mean Extraction Radius 930 mm

Mean Magnetic field 1.4 T

Total Weight 160 Ton

Foot print 4.5m X 2.5m

Beam current: Initial target 1mA
Final target 2mA



***Next Step
To Higher Power***

What is the limit?

Ion source

- Internal or External ?
- Positive or Negative ?
- Emittance ?

Acceleration

- RF loading
- Space charge?
- Activation, High dose
- Vacuum (In case of negative ions)

Extraction

- Negative: Stripper foil ?
- Positive: Deflector ?
- Or other method?

Thank you for your attention !