

# The Development of Proton ECRIS for Boron Neutron Capture Therapy

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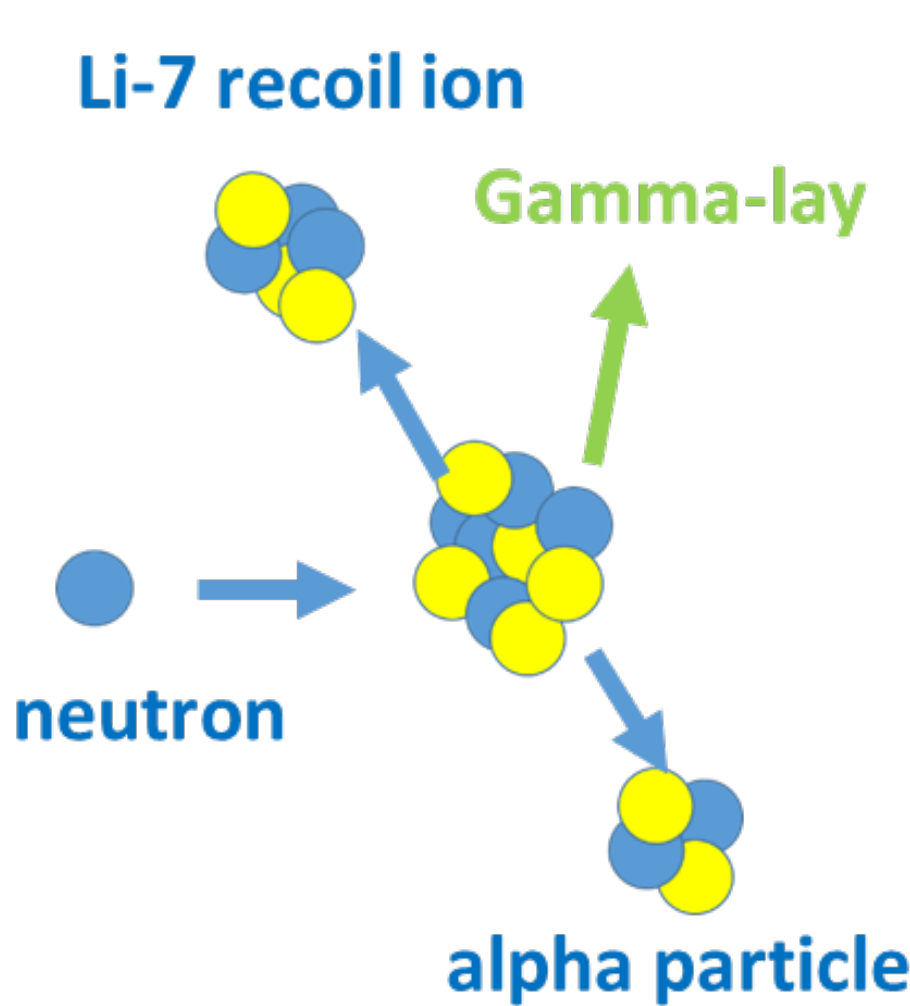
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## Abstract

For overcoming limitation of convectional particle therapy, the development of Accelerator-based Boron Neutron Capture Therapy (A-BNCT) is in progress by Dawonsys Co. Ltd. Dawonsys developed a duoplasmatron ion source for A-BNCT and KBSI (Korea Basic Science Institute) is developing an Electron Cyclotron Resonance Ion Source (ECRIS) as alternative candidate of duoplasmatron. The proton ion source of A-BNCT must satisfy some requirements such as high voltage platform over 50 kV, small emittance below  $0.2 \pi \text{mm.mrad}$ , and high current over 50 mA. In this paper, we will report results of design study and manufacturing issues.

## Needs & treatment effect of BNCT



### ❖ Treatment Effects

- ❑ Overcoming limitations of convectional particle therapy
  - Clarity of therapeutic principles
  - Treatment of unit cell size
  - Minimization of radiation exposures for normal tissues
  - Reduction of side effects
  - Treatment of malignant cancers which are not effective with conventional treatments (Brain Tumor, Head & Neck Cancer, Malignant Skin Cancer, Recurrent Cancers, Radiation Resistant Cancers)

### ❖ Cost Prospective

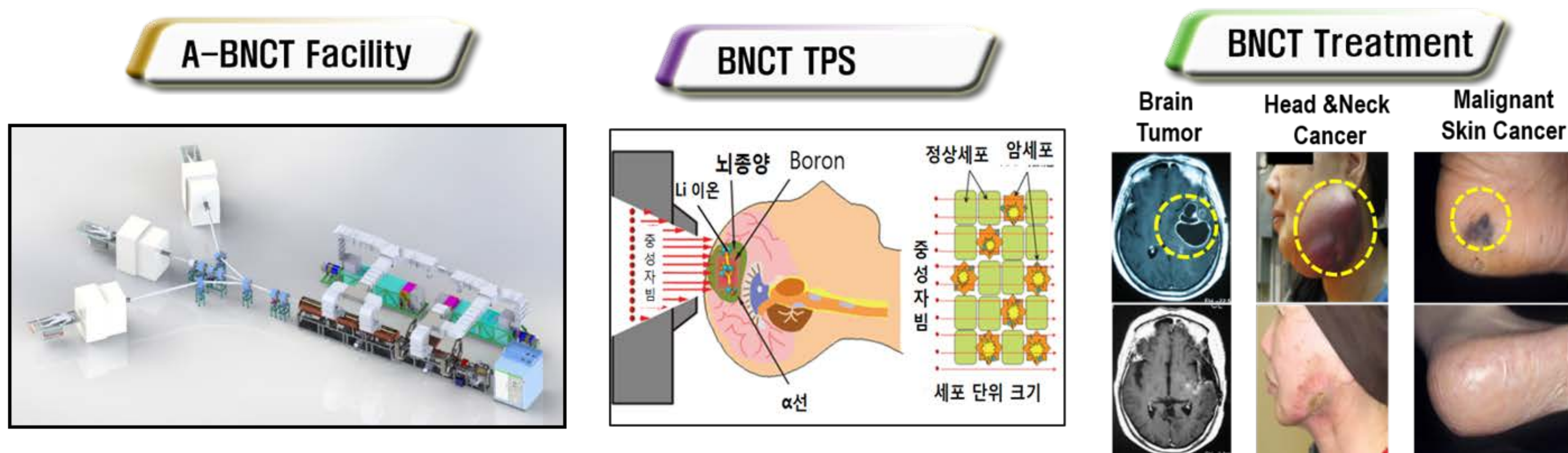
- Low construction cost (about 1/3 of proton therapy facility)
- Low fractional treatment (1-2 times)
- Low treatment cost (about 1/3 of proton therapy facility)

### ❖ Limitation of BNCT & Issues

- Increasing Treatment depth
- Improving the boron capture ratio of cancer cells / normal cells
- Improving boron drug delivery method

## Introduction of A-BNCT project

- ❑ **Project Name** : Development of the accelerator based Boron Neutron Capture Therapy system for the cancer treatment within 1 hour therapeutic time
- ❑ **Project Period** : 2016 . 4 ~ 2020 . 12
- ❑ **Leading Organization** : Dawonsys Inc.
- ❑ **Participating Organization** : Gil Hospital, Gachon Univ., PAL, KAERI and KBSI
- ❑ **Project Berget** : 14.1 B Won (excluding building & utility costs)
- ❑ **Development Items** : Proton Linac, Be Target Assembly, Dosimetry, Radiation Safety, Boron Compounds TPS(Treatment Planning System), Clinical Trials, Government Permission of B Drugs & BNCT Treatment



## Development of test bench and duoplasmatron

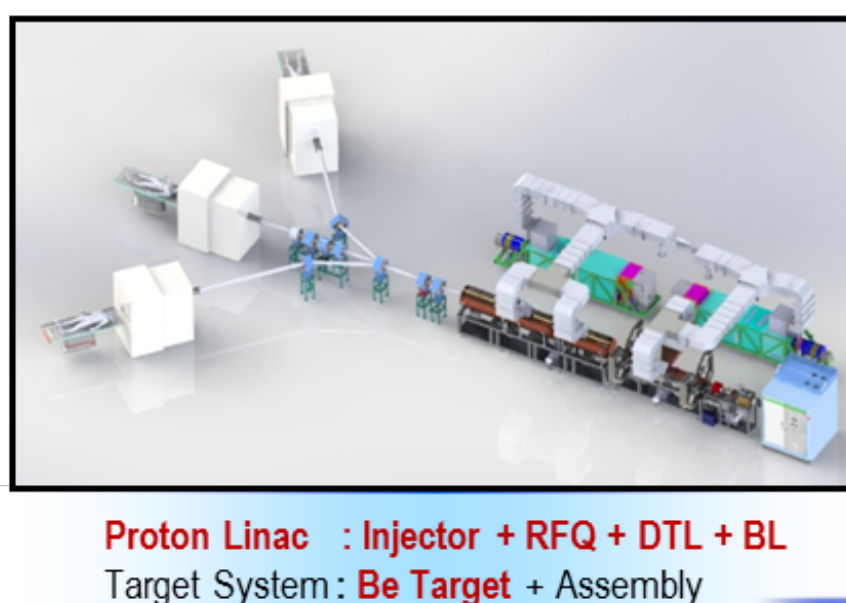
- The duoplasmatron and test bench for A-BNCT was developed by Dawonsys in last year. Also, plasma was ignited and beam extraction was performed. The duoplasmatron source will be modified to extract beam of 50mA and  $0.2 \pi \text{mm.mrad}$  during this year.



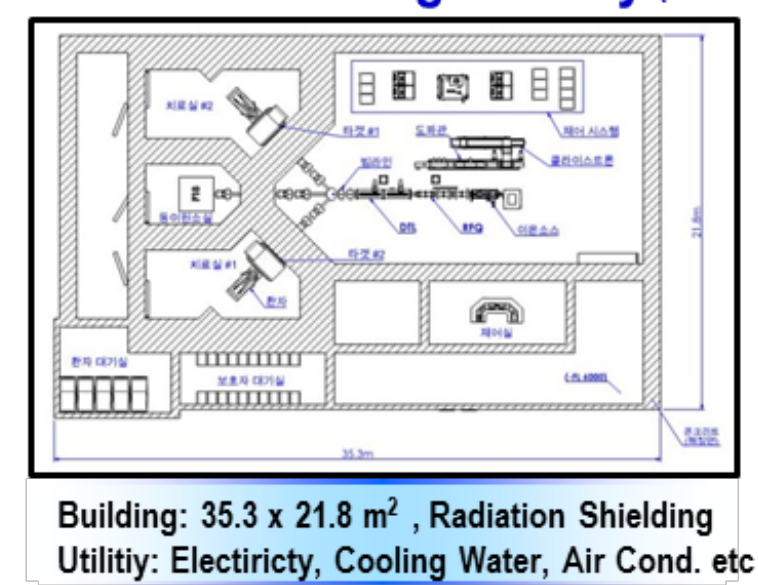
## Project Schedule and design issues

- We had plan to change proton ECR ion source instead of duoplasmatron at 2<sup>nd</sup> year (2018) but our plan was changed for installation schedule and development schedule of duoplasmatron. A proton ECR ion source will be developed at 3<sup>rd</sup> year with independent test bench.

### Fabrication of Components (1<sup>st</sup> -2<sup>nd</sup> yr.)

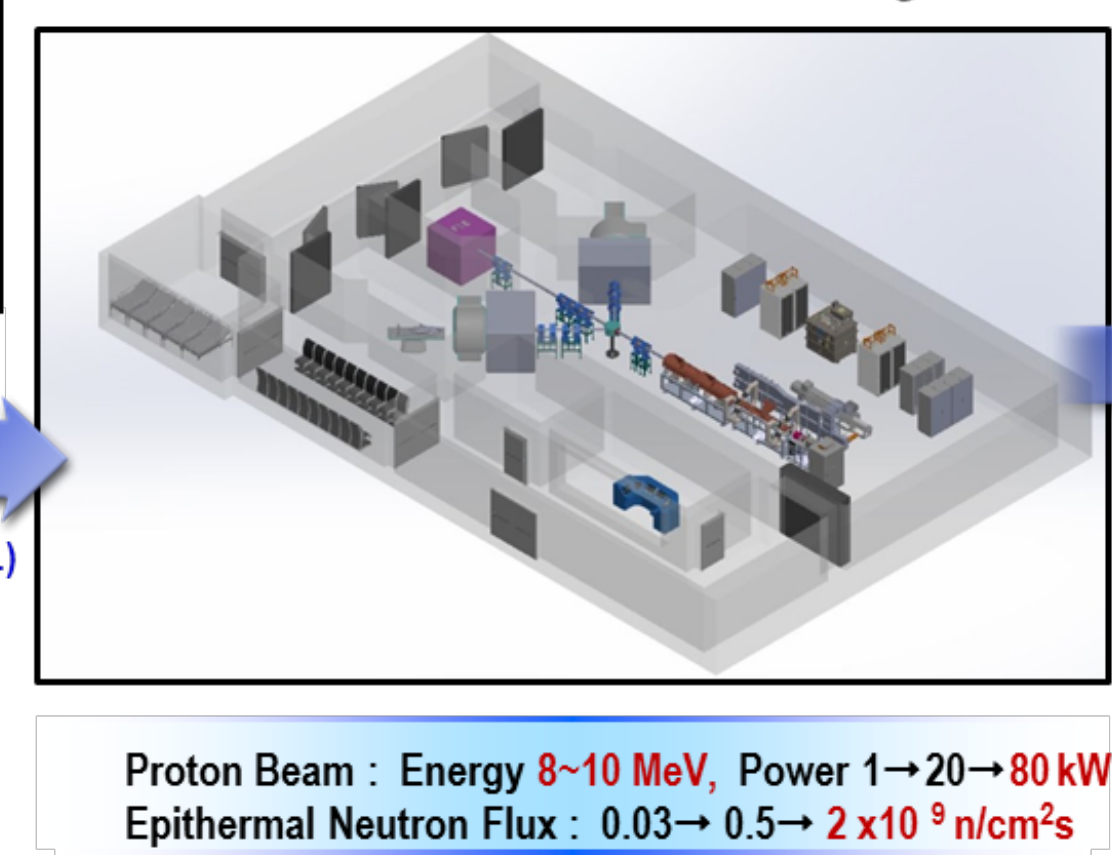


### Constr. of Building & Utility (1<sup>st</sup> -2<sup>nd</sup> yr.)



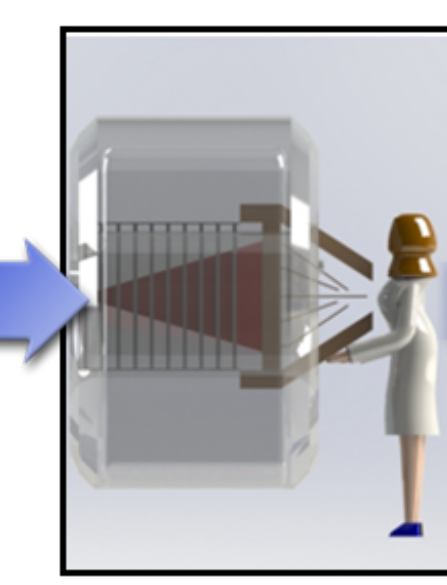
Building: 35.3 x 21.8 m<sup>2</sup>, Radiation Shielding  
Utility: Electricity, Cooling Water, Air Cond. etc

### Installation & Commissioning (3<sup>rd</sup> - 5<sup>th</sup> yr.)



Proton Beam : Energy 8~10 MeV, Power 1→20→80 kW  
Epithermal Neutron Flux : 0.03→0.5→ $2 \times 10^9 \text{ n/cm}^2\text{s}$

### Clinical Trial (3<sup>rd</sup> - 5<sup>th</sup> yr.)

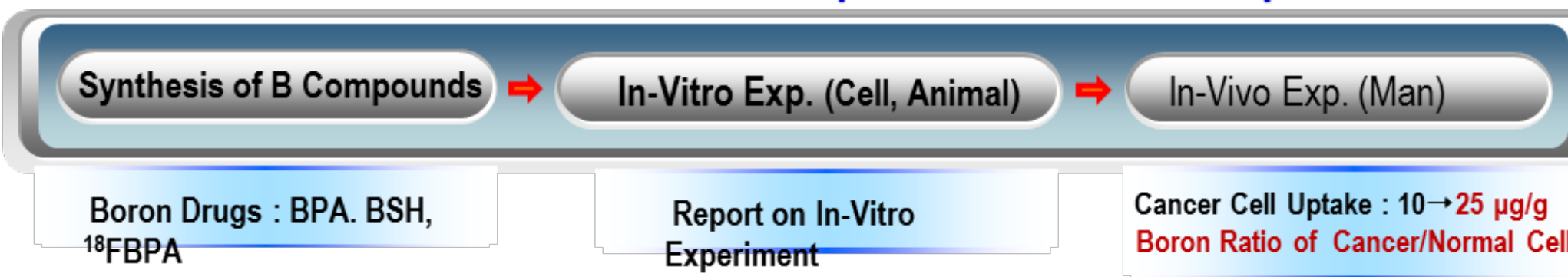


1<sup>st</sup> Stage Trial  
2<sup>nd</sup> Stage Trial

### Final Goal

- BNCT 3<sup>rd</sup> Stage
- Facility Transfer to the Hospital

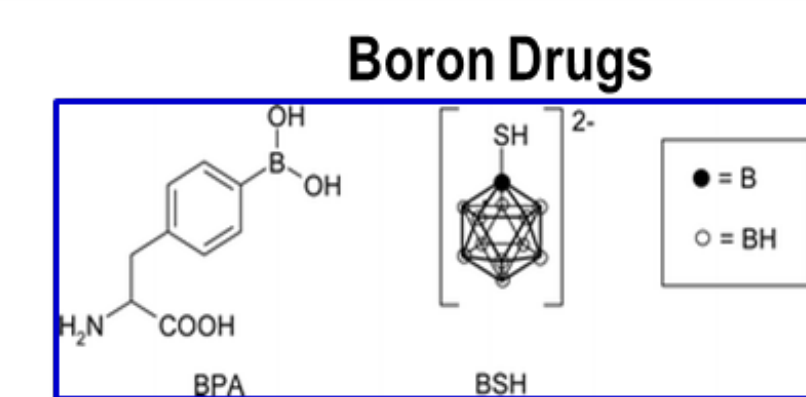
### Development of Boron Compounds (1<sup>st</sup> -3<sup>rd</sup> Yr.)



Boron Drugs : BPA, BSH, <sup>10</sup>BPA

Report on In-Vitro Experiment

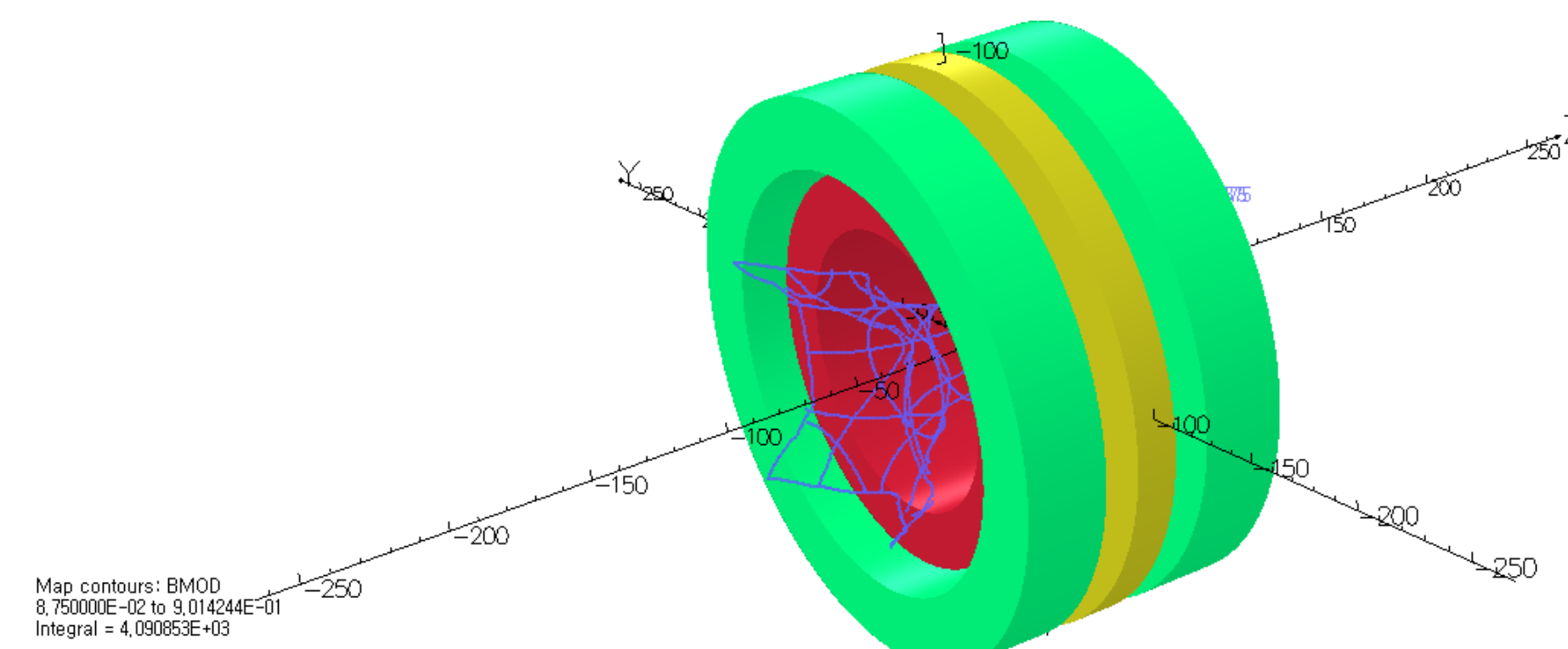
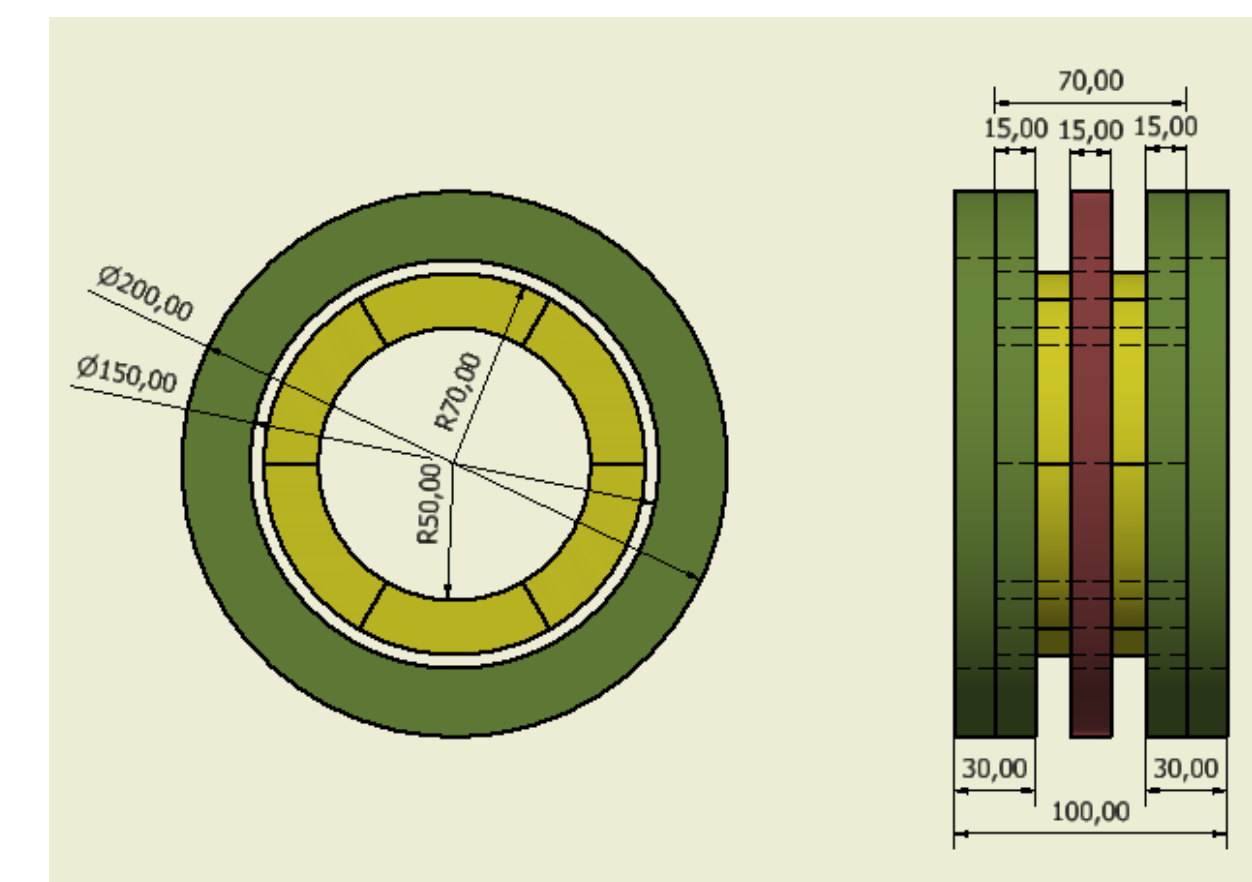
Cancer Cell Uptake : 10→25 µg/g  
Boron Ratio of Cancer/Normal Cell : 2→4



- In this year, new design issues generate space limitation related on high voltage platform and diagnostic system. The magnet design must be changed due to space problem

## Magnet design results

- We are designing compact type magnet in this year.
- Current design results have small ECR zone due to space problem. Also, another issues are generated related on microwave transfer. we need confirm about microwave transfer.



UNITS

Length	mm
Mean Flux Density	T
Magnetic Field	A/m
Magn. Scalar Pot.	V
Current Density	A/mm <sup>2</sup>
Power	W
Force	N

MODEL DATA

M2 993  
Magnetostatic (TOSCA)  
Linear materials  
Simulation No. 1 of 1  
127059 elements  
49388 nodes  
Nodally interpolated fields  
Activated in global coordinates

Field Point Local Coordinates

Local = Global

FIELD EVALUATIONS

Line	LINE (nodal)	101	Cartesian
x=0.0	y=0.0	z=250.0 to -250.0	
Cartesian (nodal)	40-40	Cartesian	
x=-100.0 to 100.0	y=-100.0 to 100.0	z=100.0 to z=-300.0	

opera