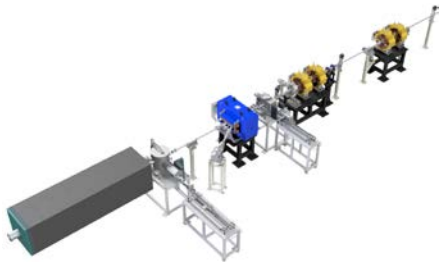
Current status and future plans of KoBRA

추경호, 편성재, 이광복, 곽민식, Charles Akers, 김미정, 김재천, 김동건, 이청수, 함철민, 신택수
Experimental System Team, RISP (2023.5.17)

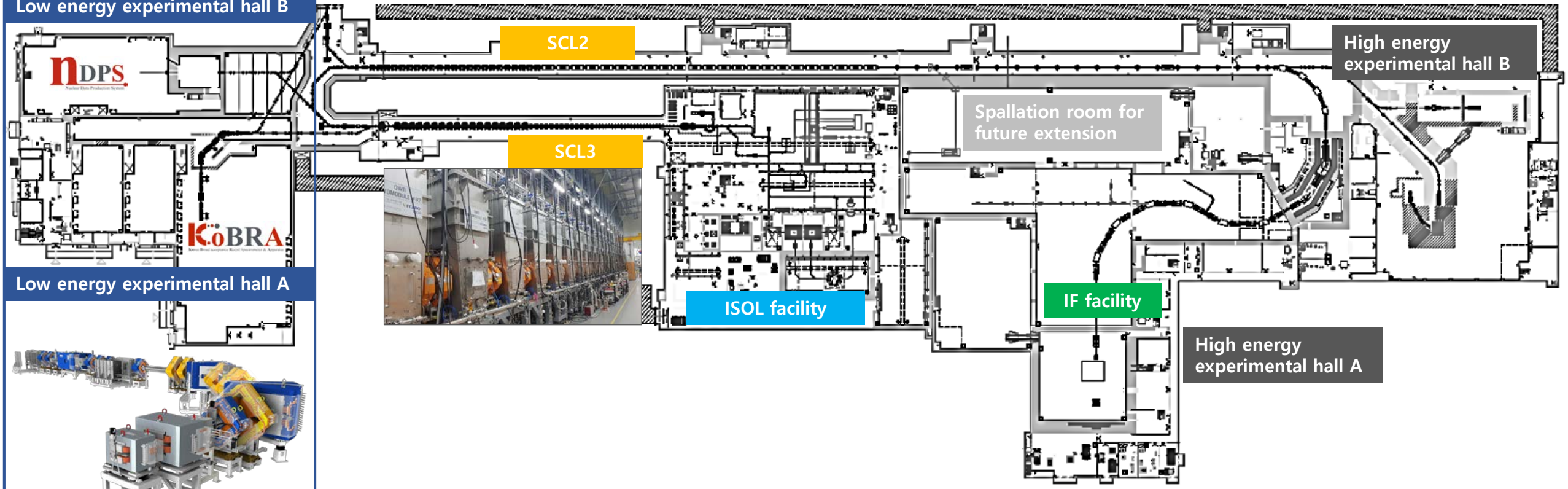
RAON Rare isotope Accelerator complex for ON-line experiments

Low Energy Experimental Facilities at RAON



Low energy experimental hall B

Low energy experimental hall A

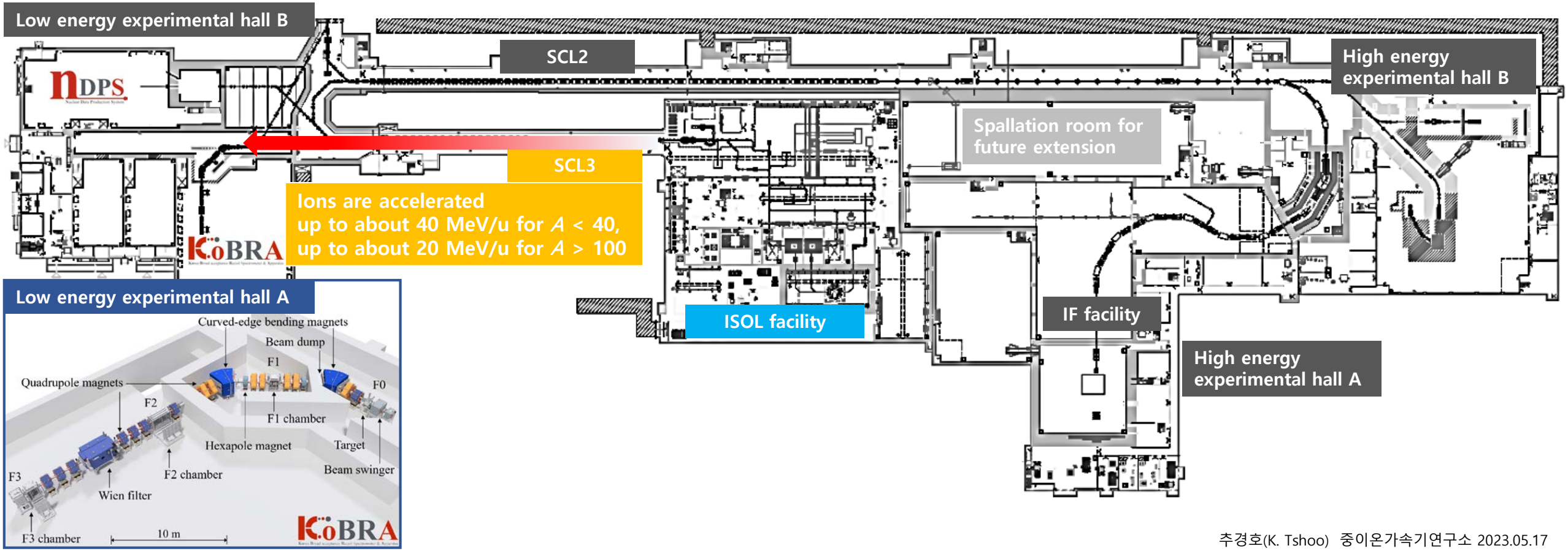


KoBRA

Korea Broad acceptance Recoil Spectrometer & Apparatus

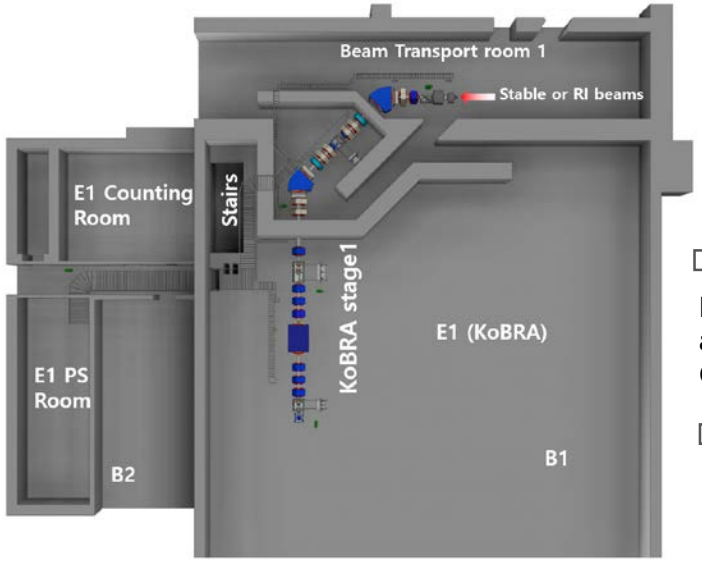
Goal: Construction of **multi-purpose experimental instrument** using stable or RI beams for studies of the **nuclear structure** and **nuclear astrophysics**, in the energy range of about 1 – 40 MeV/u

- ❖ **RI beam productions at a few MeV/u and at about 20 – 40 MeV/u using a stable ions from ECR ion source**
- ❖ **Recoil mass separator at less than few MeV/u for direct measurements of radiative-capture cross, using a RI from ISOL facility (future plan)**



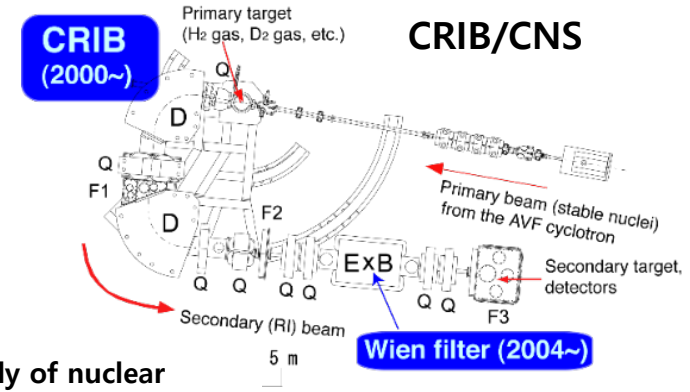
KoBRA

Korea Broad acceptance Recoil Spectrometer & Apparatus

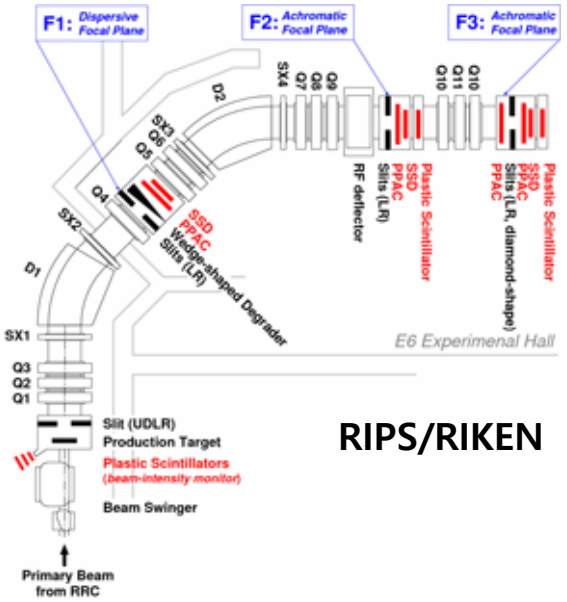


Magnetic rigidity	0.25 – 3.0 Tm
Angular acceptance	80 mrad (H) 200 mrad (V)
Momentum acceptance	8%
Momentum resolving power at F1	2100 at 2 mm beam size
Mass resolving power (with Wien filter)	750 at 2 mm beam size
Beam swinger	up to 12 degree for 3 Tm
High order correction	up to 4th order
Degrader at F1	Homogeneous

RI beam production for study of nuclear astrophysics in the energy of few MeV/u like CRIB.

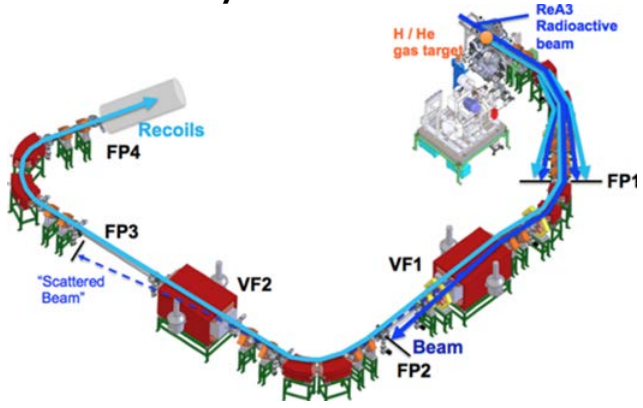


RI beam production for studies of nuclear structure & nuclear reaction in the energy of 20 – 40 MeV/u for A < about 40 like RIPS.

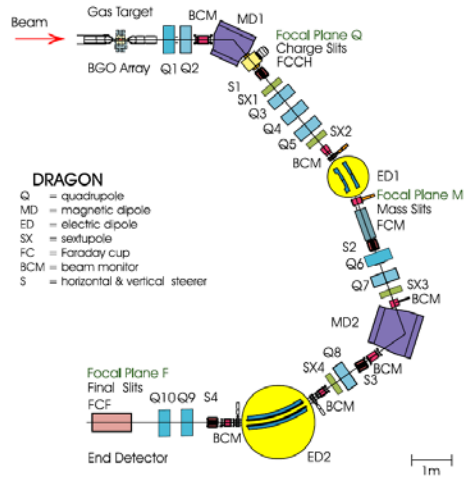


After adding Stage2,
RI Beams from ISOL facility

SECAR/MSU



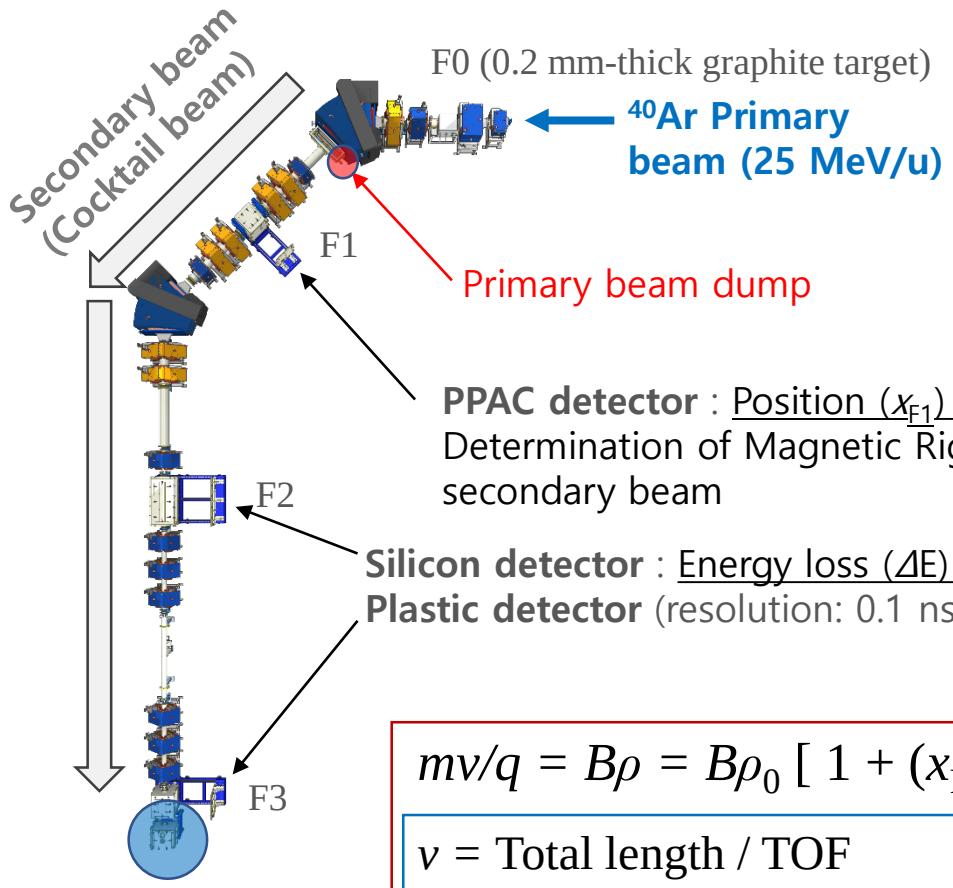
DRAGON/TRIUMF



Recoil spectrometer for study of nuclear astrophysics in the energy of < few MeV/u like SECAR or DRAGON.

RI beam production experiment

KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



Experiments using secondary beam

PPAC detector : Position (x_{F1}) measurement
Determination of Magnetic Rigidity ($B\rho$) of secondary beam

Silicon detector : Energy loss (ΔE) measurement
Plastic detector (resolution: 0.1 nsec) : Time of flight (TOF) measurement

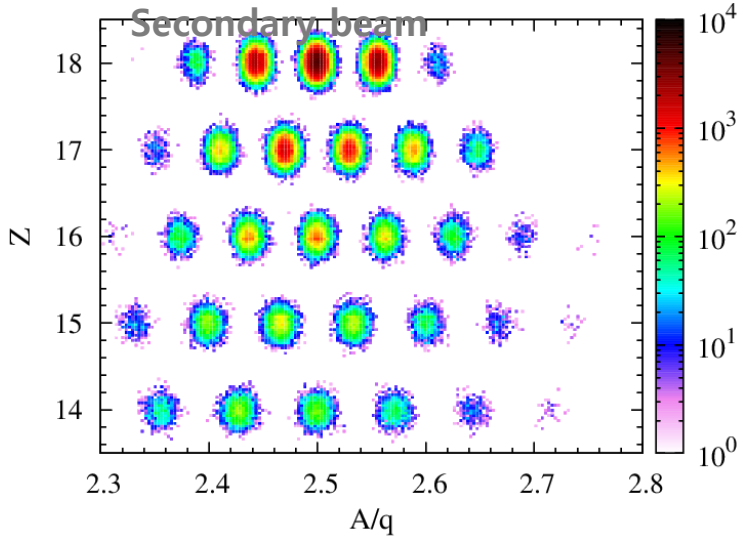
$$mv/q = B\rho = B\rho_0 [\ 1 + (x_{F1} - M\, x_0)/D\ ]$$

v = Total length / TOF

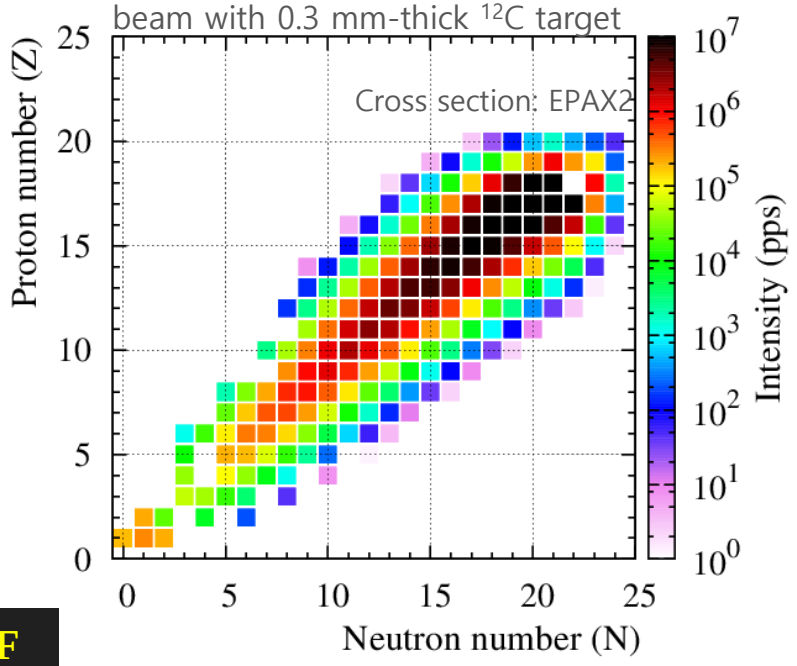
Nuclear charge: $Z \sim \Delta E^{1/2}\, v$

Z is determined by measuring ΔE and TOF

m/q is determined by measuring x_{F1} and TOF



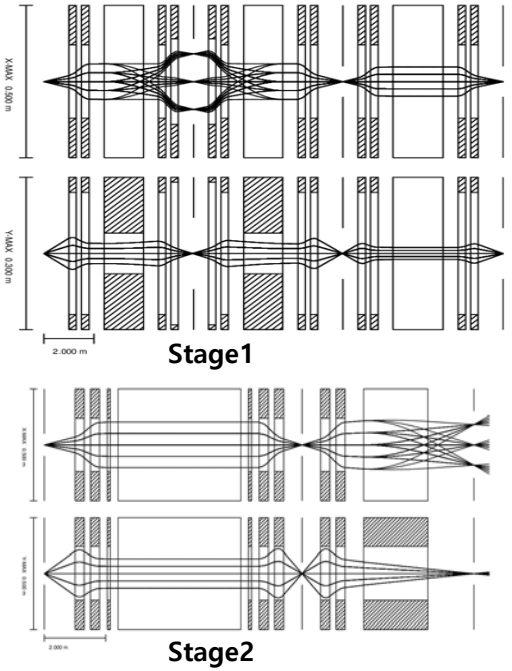
RI beam intensity for 100 pnA ^{40}Ar beam with 0.3 mm-thick ^{12}C target



KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

❖ 2013 – April 2014

- Primitive optics design



J. Park (student), Y.K. Kwon

- International collaborators

  S. Kubono (RIKEN)

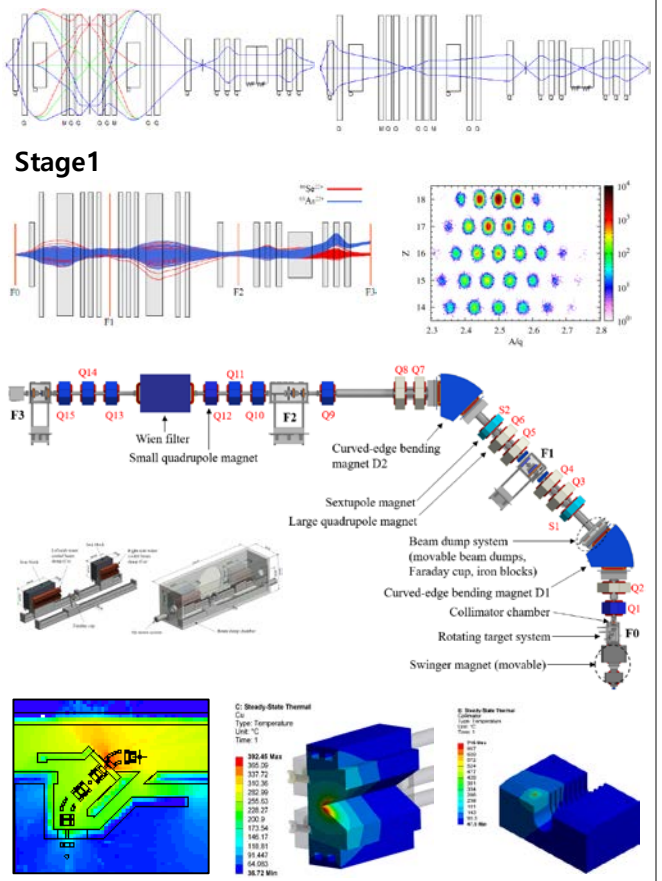
  S. Kato (Yamagata Univ.)

  G.P.A. Berg (Notre Dame Univ.)

  G.A. Souliotis (Athens Univ.)

❖ April 2014 – October 2016

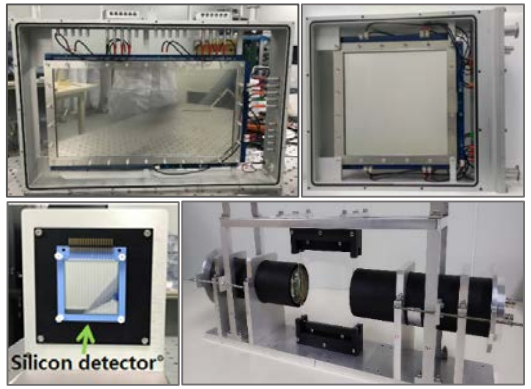
- Optics design was finalized
- Magnet designs were finalized
- Beam dump design was finalized
- Radiation shielding structure was finalized
- Conceptual design of vacuum was done



K. Tshoo, J. Park (student), M.S. Kwag (student)

❖ Mar 2014 – Aug 2017

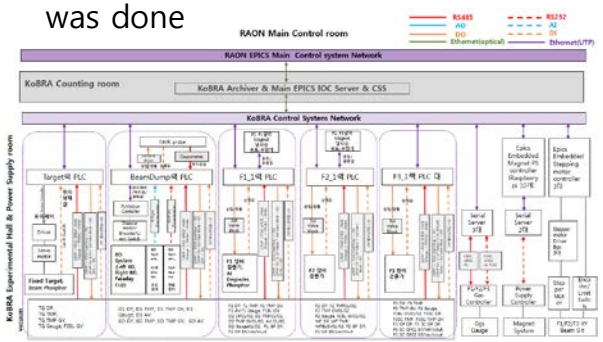
- Beam diagnostic detectors were developed and tested:
  - PPACs, Plastic & silicon detectors
- Detector DAQ system were developed



K.B. Lee, Charles Akers, J.H. Park, E.H. Kim

❖ February 2017 – March 2019

- Basic design of KoBRA control system was done



M. Kim

❖ May 2017 – December 2018

- Purchasing procedure
  (Contracted on December 2018)

HANMAC (Korea)
Project management

DANFYSIK (Danmark)
Project management
Designs of all magnets
Productions of bending magnets and swinger

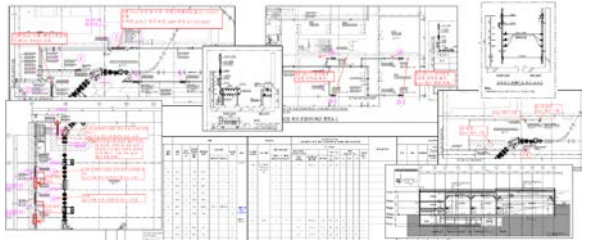
KR TECH (Korea)
Productions of quadrupole and sextupole magnets

VITZRO TECH (Korea)
Designs and productions of diagnostic chambers, beam pipe, beam dump, and etc

K. Tshoo

❖ 2015 – December 2019

- All the detailed requirements of Experimental Hall A/B were discussed with the Facility Construction & Infrastructure Division



K. Tshoo

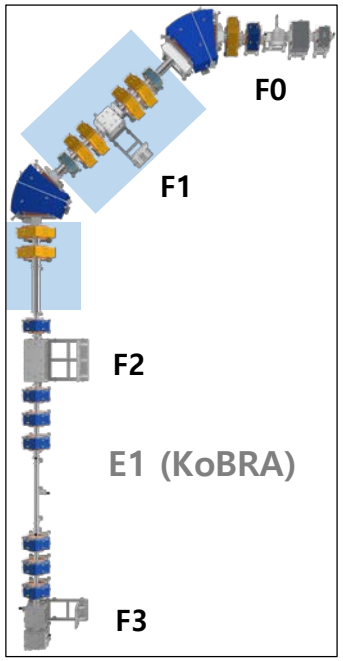
KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

Installation TEST of radiation shielding blocks (Low Energy Experimental Hall A)

FAT (Factory Acceptance Testing) finished

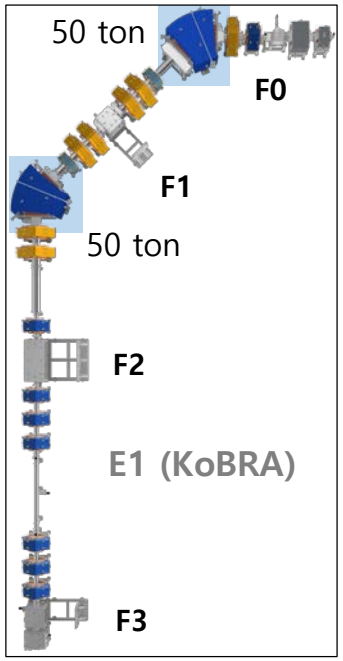
Delivering started at July 2020

KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



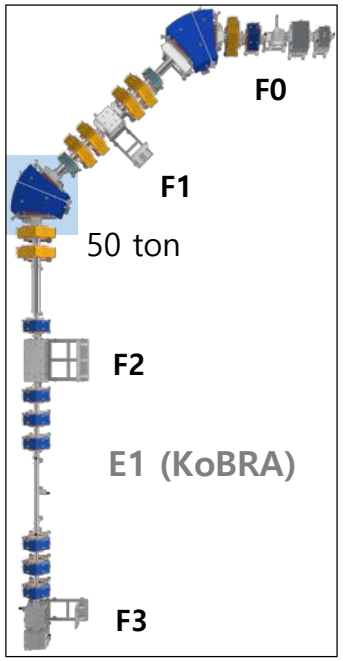
KoBRA Installation

KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

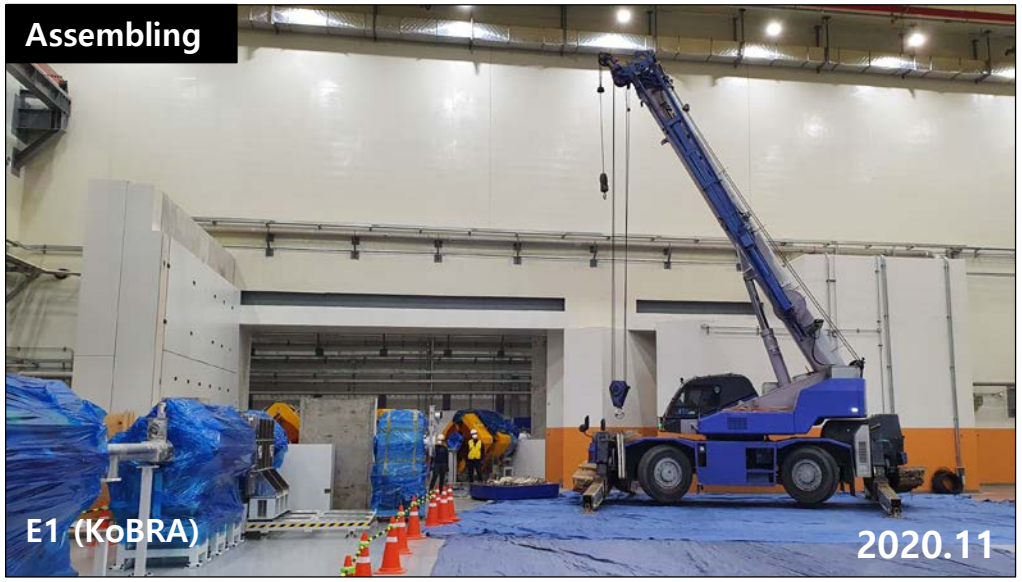


KoBRA Installation

KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



KoBRA Installation



KoBRA
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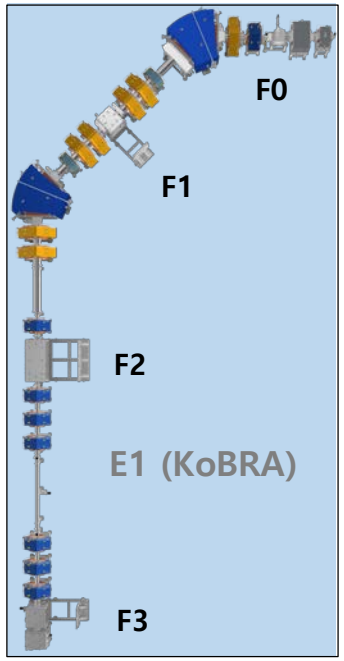
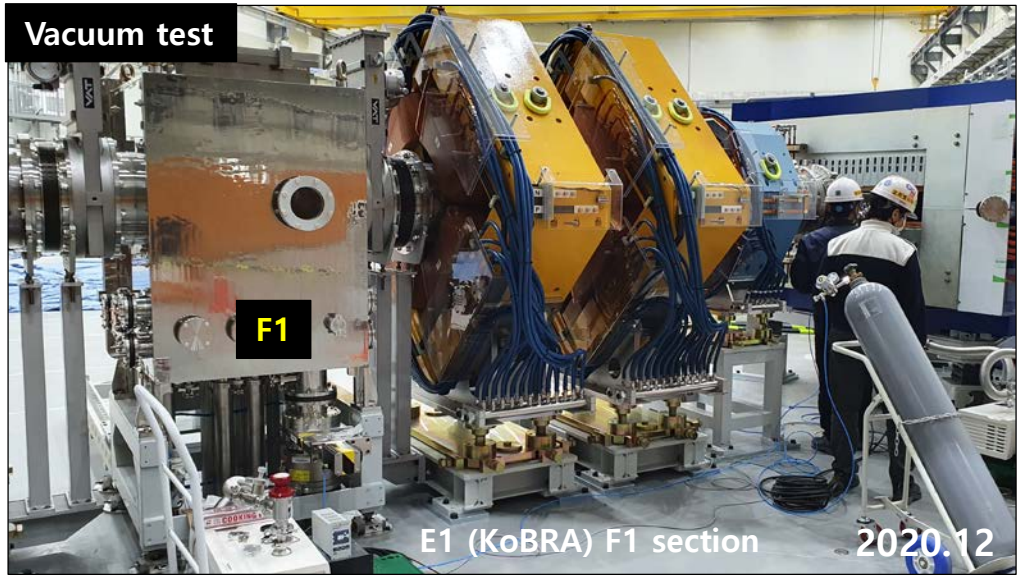
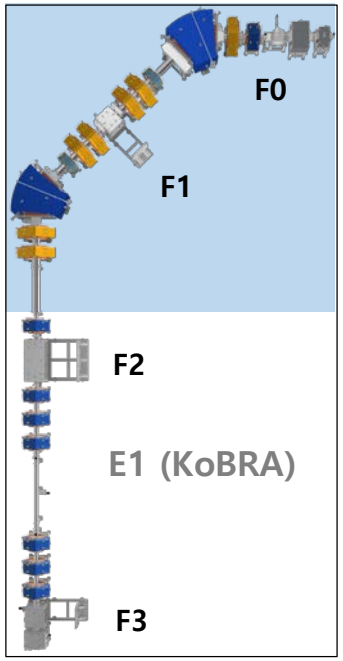


KoBRA Installation



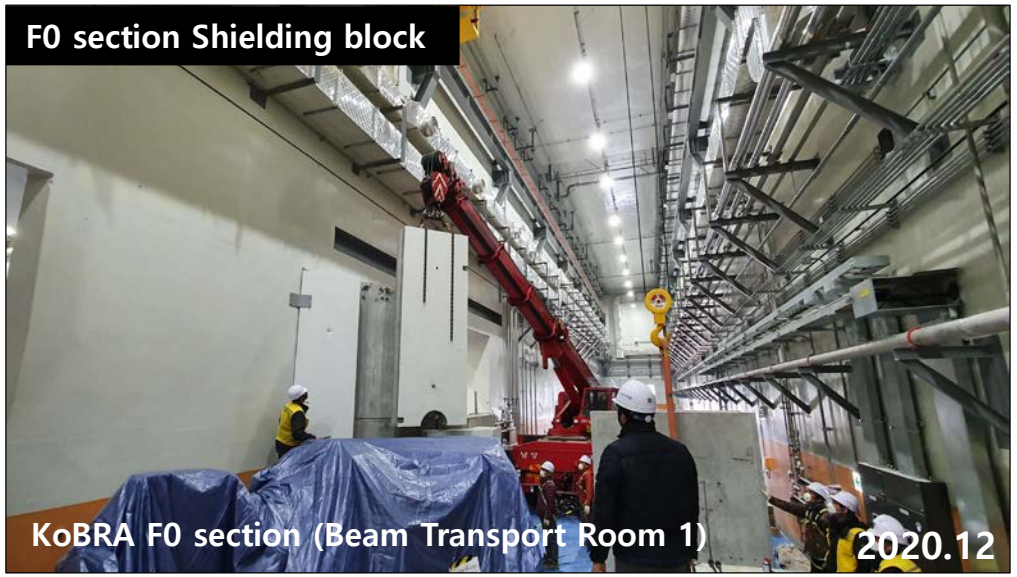
KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



Radiation Shielding Block installation

F0 section Shielding block

F0 section Shielding block



F1 section Shielding block

F1 section Shielding block

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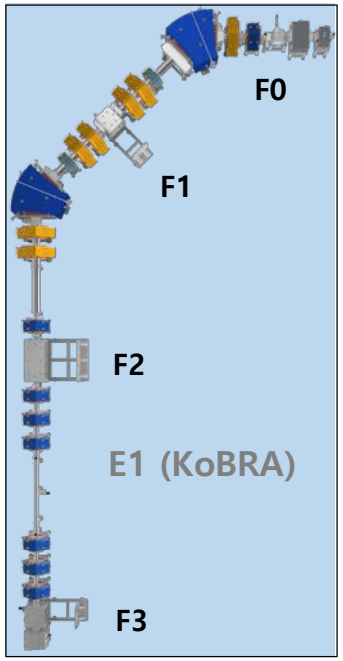
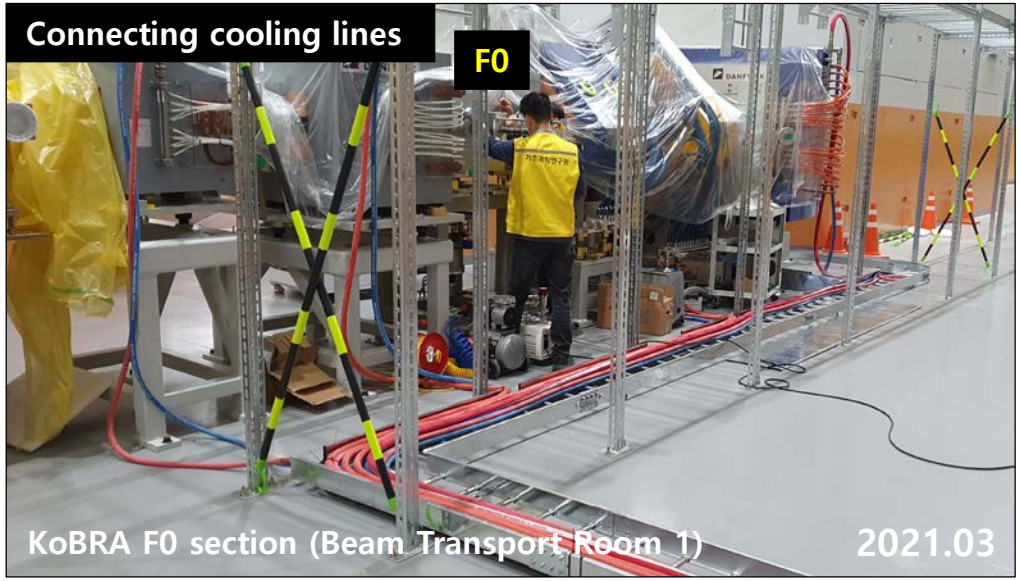
Korea Broad acceptance Recoil Spectrometer & Apparatus



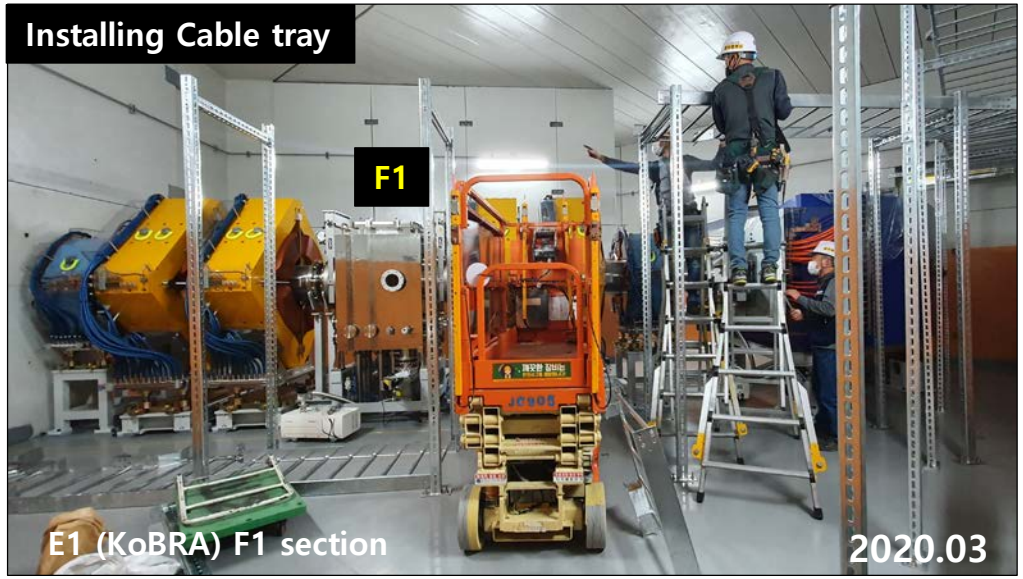
Cable tray & Cable installation

Cables & Cable tray delivering

Connecting cooling lines



Installing Cable tray



Power cable Wiring

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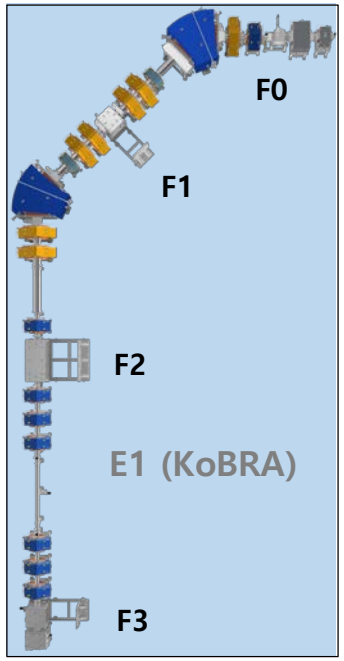
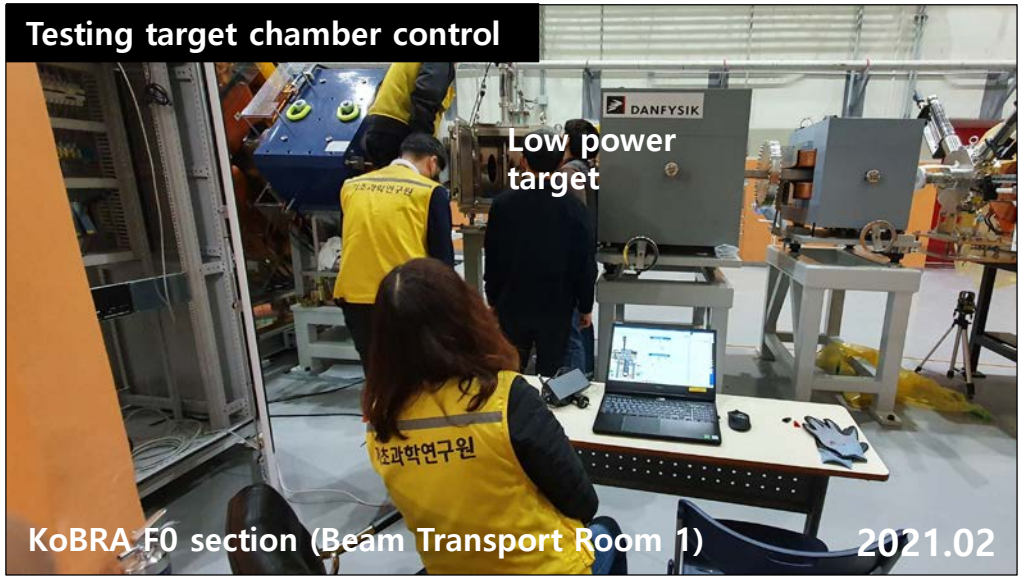
Korea Broad acceptance Recoil Spectrometer & Apparatus



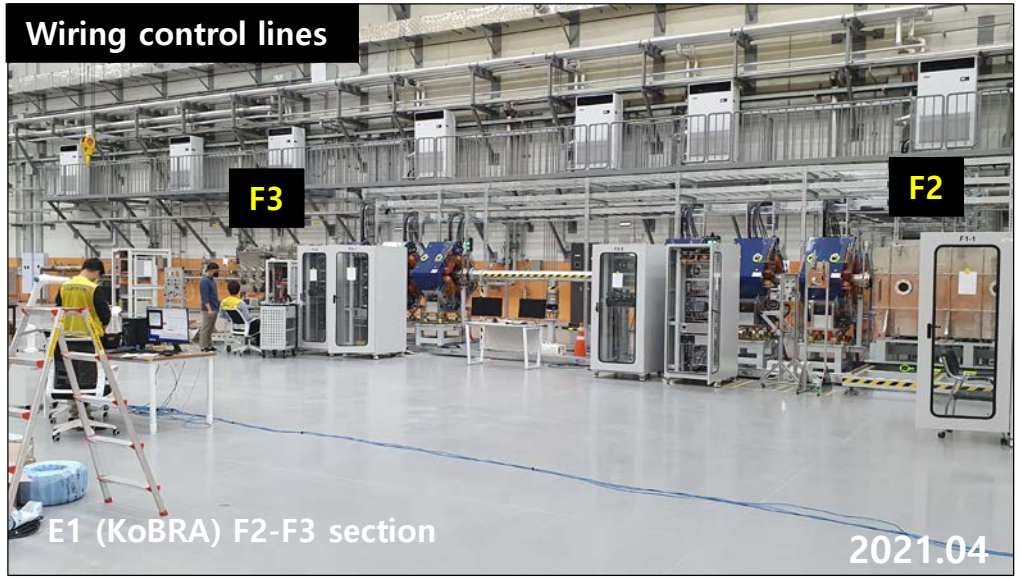
Control system installation

Delivering Control Racks

Testing target chamber control



Wiring control lines



Testing remote control

KoBRA
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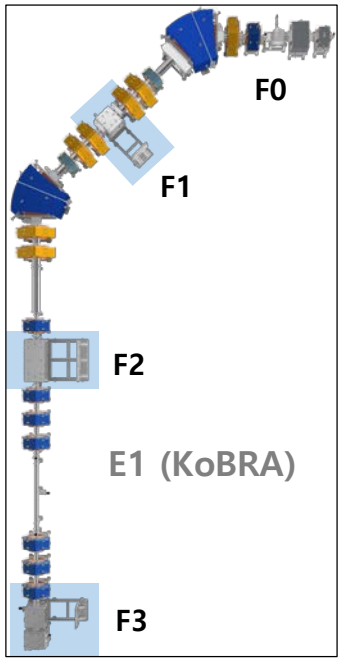
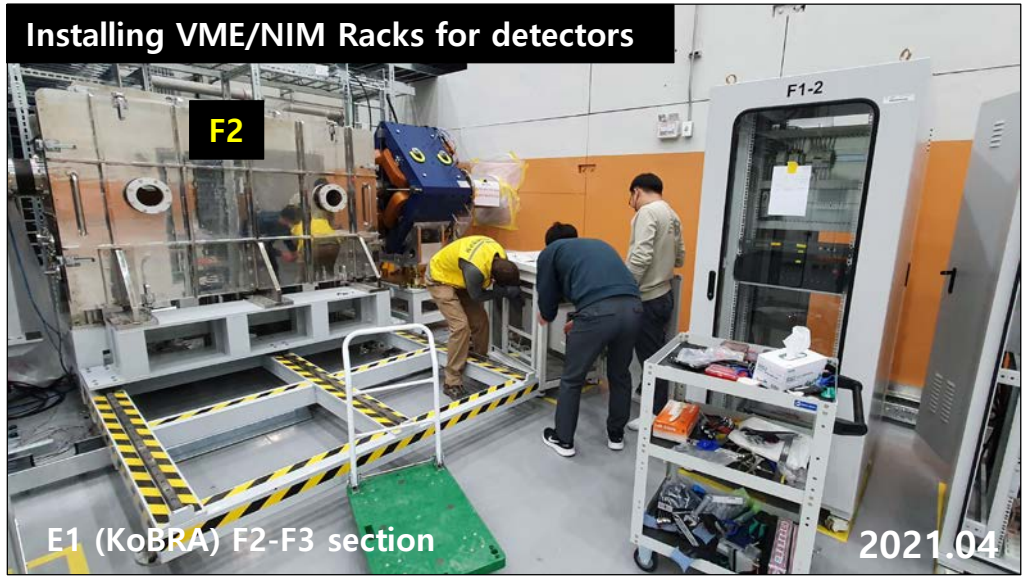


Detector & DAQ system installation

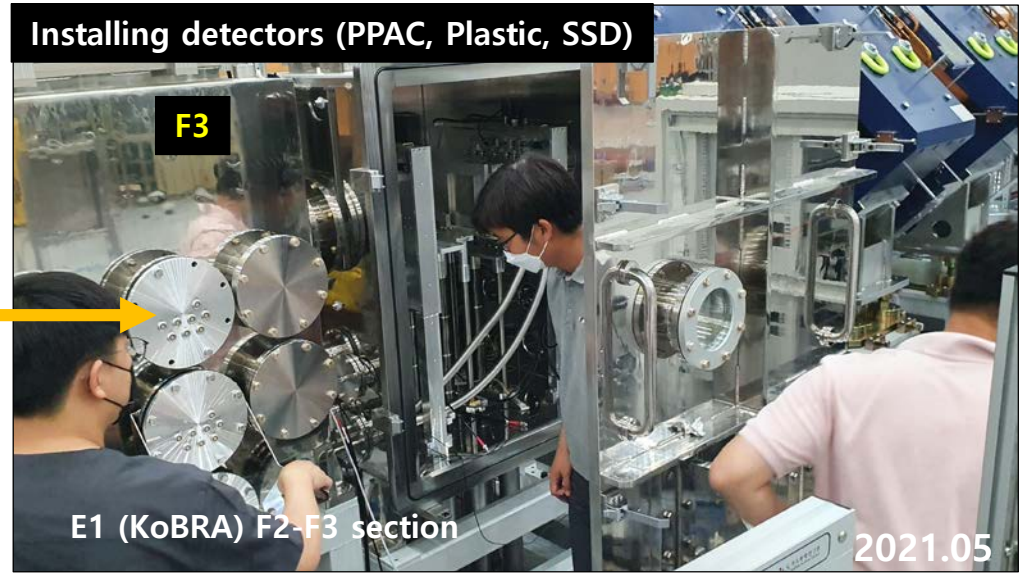
Silicon detector array for **N**uclear **A**strophysi**C**s study at **K**oBRA (SNACK)

Installing VME/NIM Racks for detectors

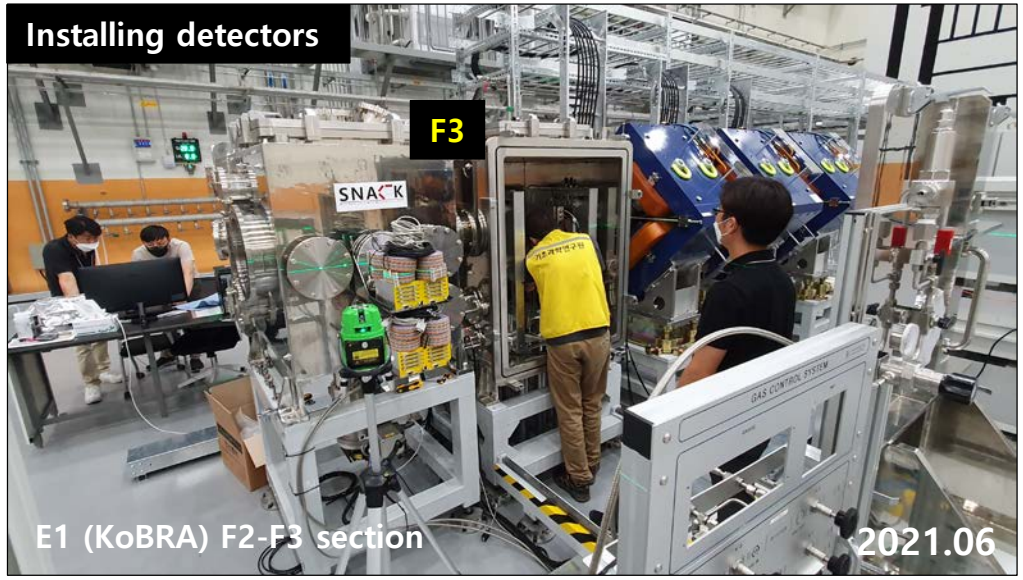


Installing detectors (PPAC, Plastic, SSD)

Installing detectors (PPAC, Plastic, SSD)



Installing detectors



KoBRA
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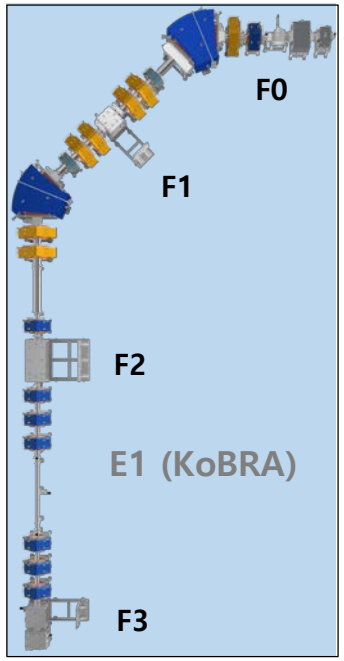
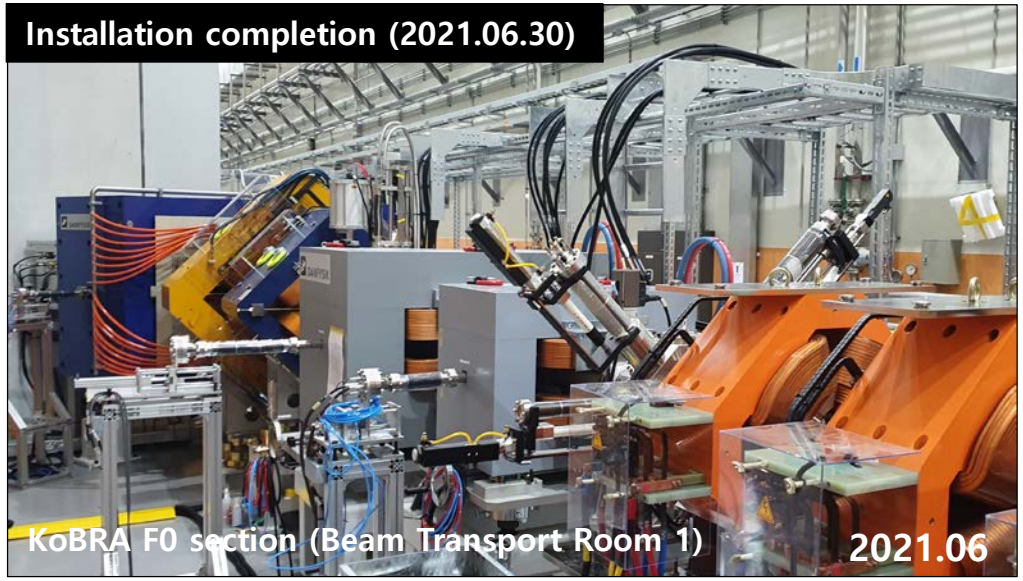


Completion of Installation: 30 June, 2021

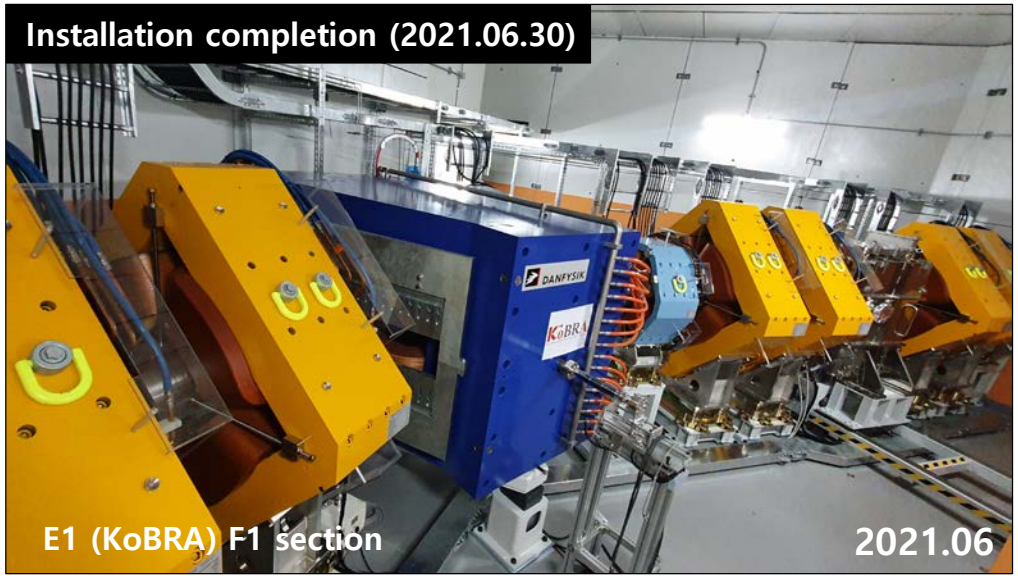
Magnet power supply Room

KoBRA Control Room

Installation completion (2021.06.30)



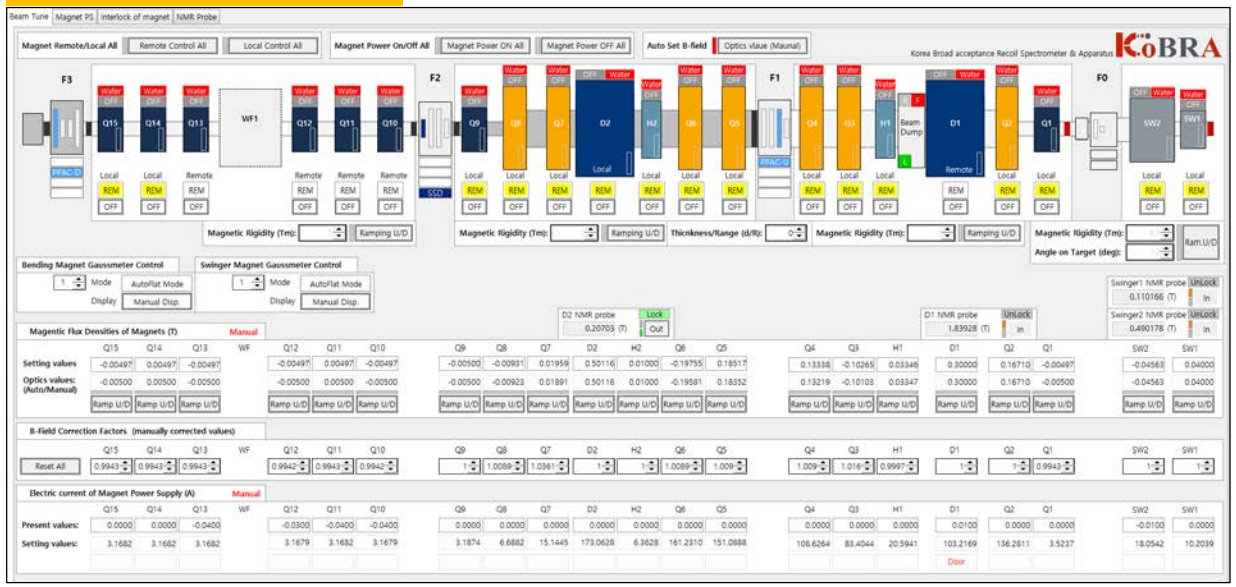
Installation completion (2021.06.30)



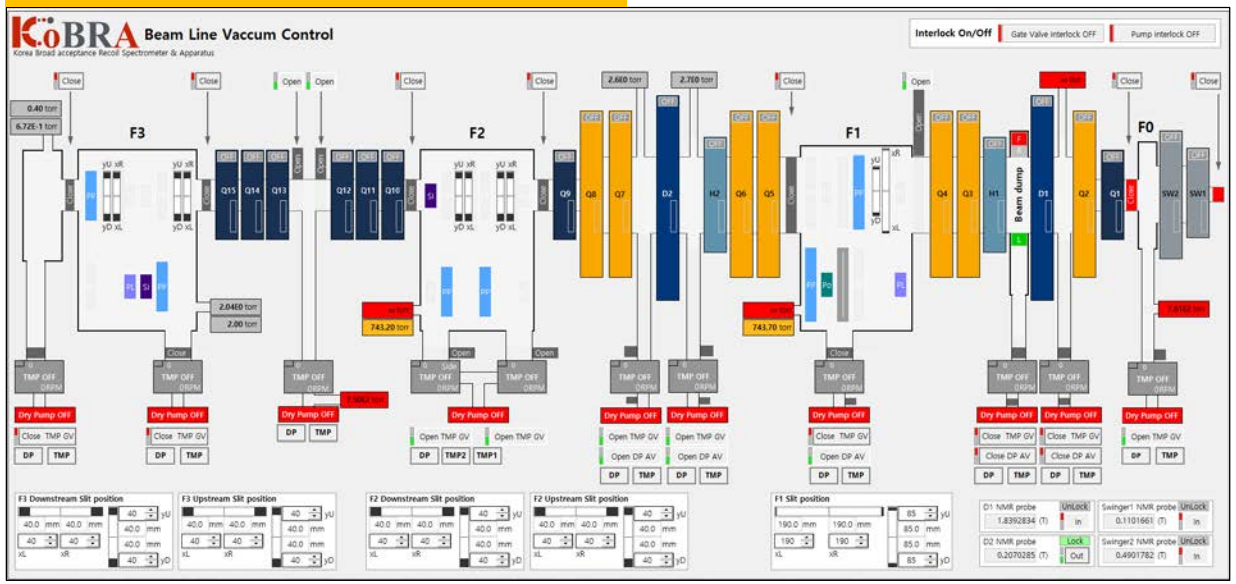
KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

Remote Control Panels

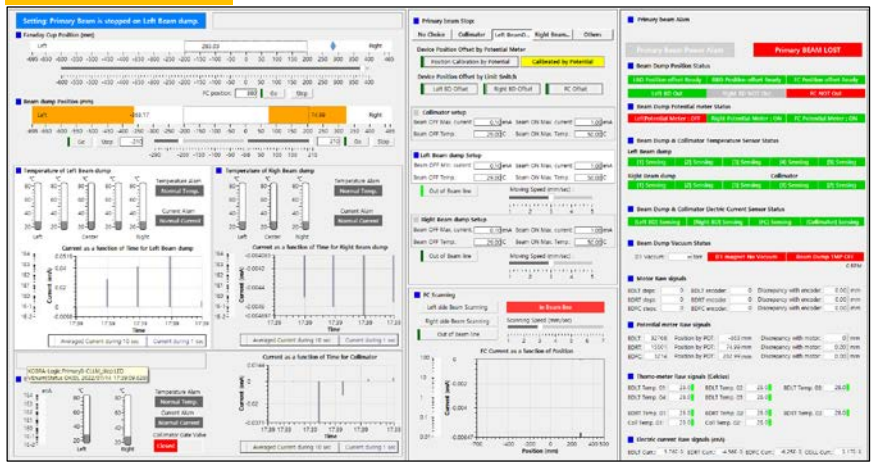
Magnets & Beam tune



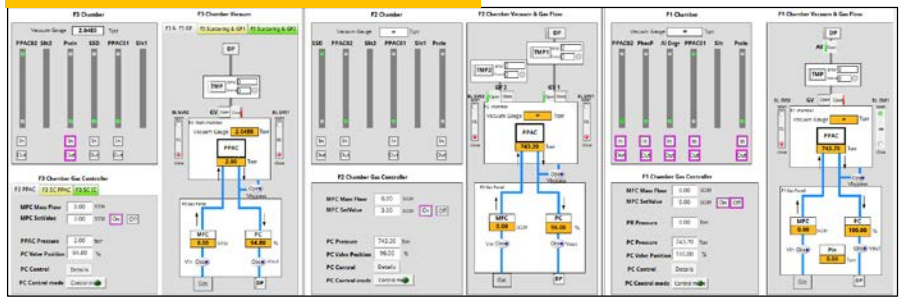
Vacuum (gate valves, gages, pumps)



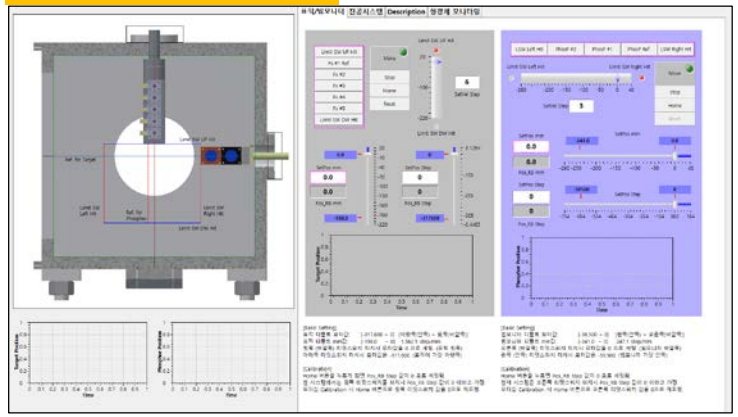
Beam dump



Detector Gas control (PPAC)

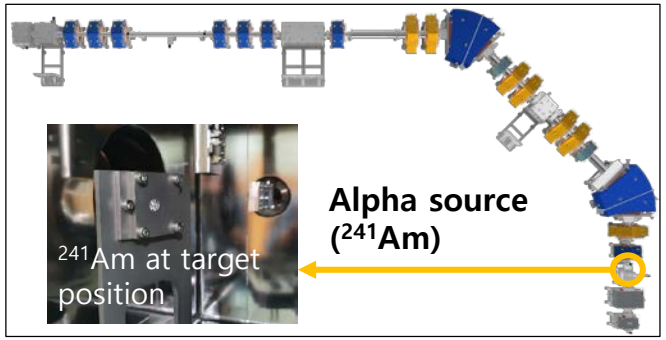


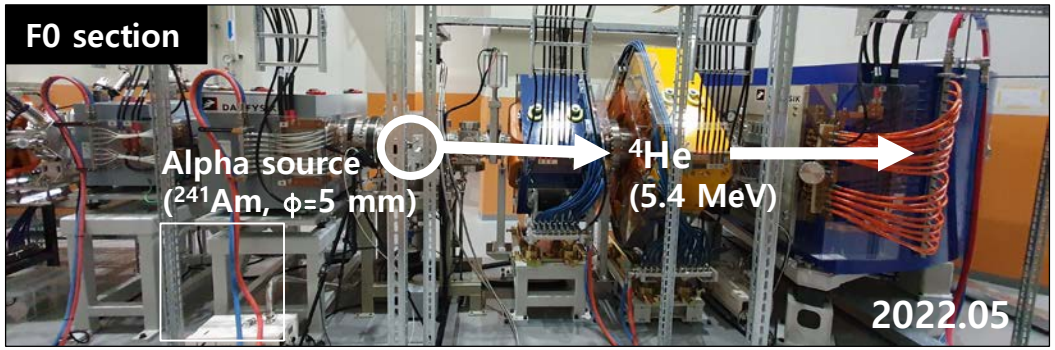
Production target

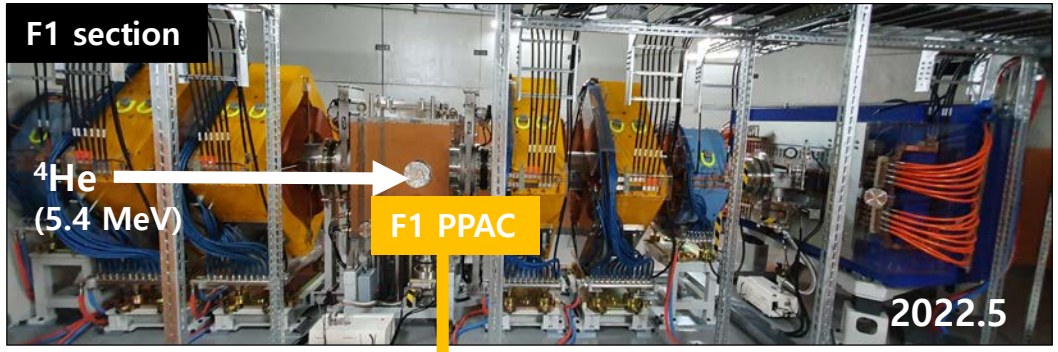


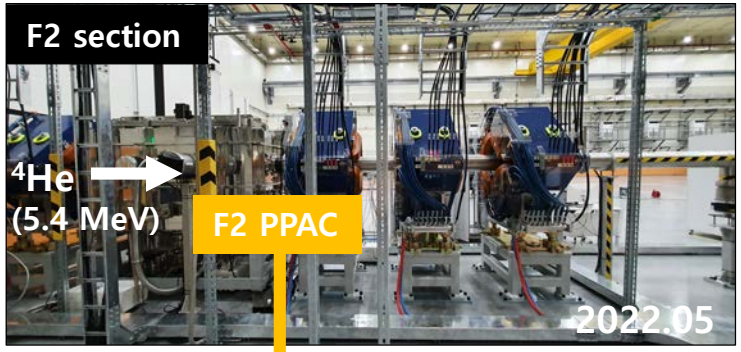
Test using α-source

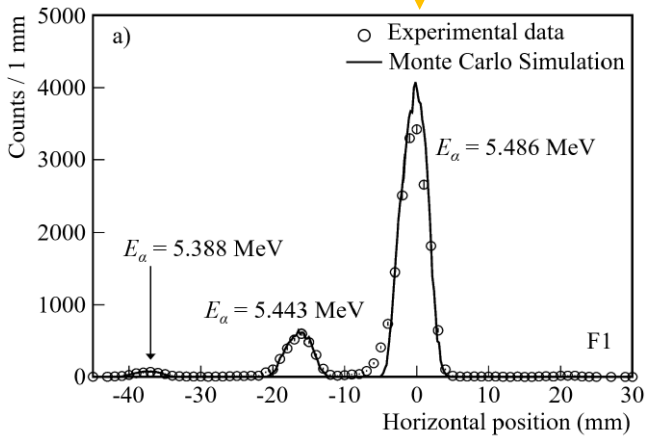
KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

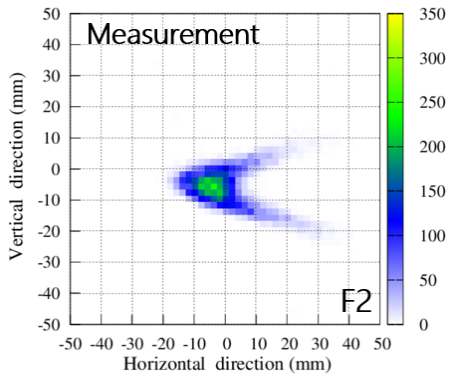


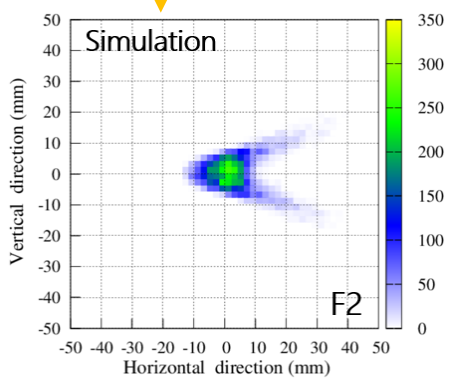


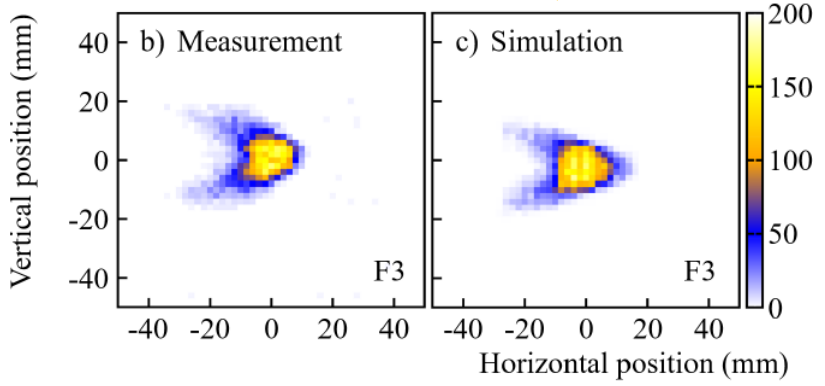






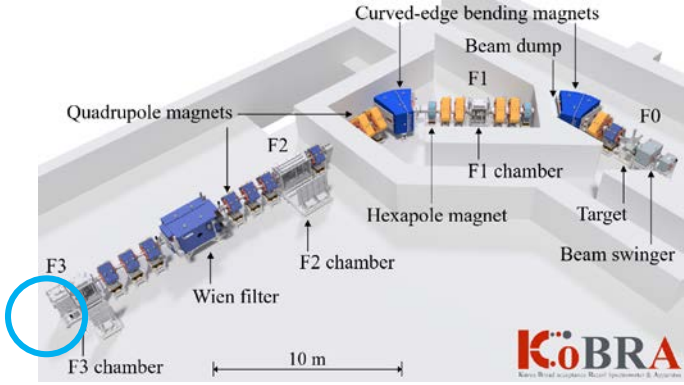




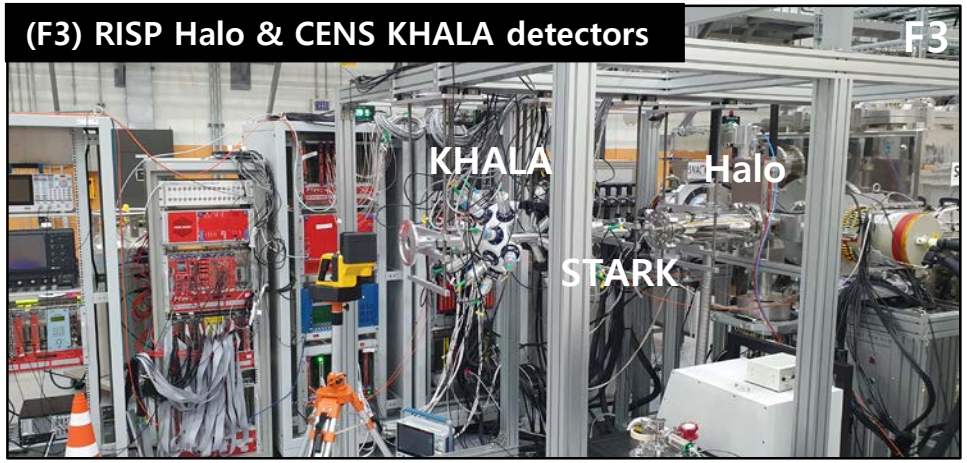


KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus

Beam Commissioning Experiments Plan



	Beam Time	$^{40}Ar^{9+}$ Beam	Att.	purpose	Detector	Priority
1	24×3 h	100 μsec, 1 Hz	-	KoBRA tune(1.95 Tm), Detector/electronics tune, detector calibration with ^{40}Ar and very low intensity of light RI beams	Halo	1
2	24×0.5 h	100 μsec, 1 Hz	-	KoBRA tune (1.75 Tm) for production of heavy RI beam	Halo	1
3	24×2 h	100 μsec, 1 Hz	-	**RI beam production for 1.75 Tm**	Halo	1
4	24×4 h	100 μsec, 1 Hz	-	**Magnetic rigidity scanning for RI production cross section measurement**	Halo	1
5	24×0.5 h	100 μsec, 1 Hz	-	KoBRA tune with Swinger for 1.75 Tm	Halo	2
6	24×0.5 h	100 μsec, 1 Hz	-	RI beam production for 1.75 Tm with Swinger	Halo	2
7	24×3 h	100 μsec, 1 Hz	-	RI beam fast timing γ–ray spectroscopy for 1.75 Tm (CENS)	KHALA+Halo	-
8	24×1 h	100 μsec, 10 Hz	10^{-2}	KoBRA tune for ^{40}Ar beam transport		1
9	24×1 h	100 μsec, 10 Hz	10^{-2}	CENS detector tune		1
10	24×2 h	100 μsec, 10 Hz	10^{-2}	$^{40}Ar(d,p\gamma)$ reaction experiment (KoBRA Team)	Halo	1
				$^{40}Ar(p,2p)$, Fast time measurement of ^{39}Cl (CENS)	KHALA	1
11	24×2 h	100 μsec, 10 Hz	10^{-2}	Activation method in inverse kinematics for astrophysical studies (CENS)	HPGe/CH_2 Al foil	1
12	24×3 h	100 μsec, 10 Hz	10^{-5}	$^{40}Ar+p$ and $^{40}Ar+d$ elastic scattering studies (CENS)	STARK	2



중이온가속기건설구축사업단(RISP) & IBS 희귀핵 연구단(CENS) 공동 수행

Plan	2022				2023			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
SCL3	Beam commissioning (0.7 – 20 MeV/u)					^{40}Ar Beam	maintenance	ISOL Beam
KoBRA	Tests, Improvements, Preparing to commissioning experiment					**^{40}Ar beam Commissioning**	maintenance	**ISOL Beam Commissioning**
NDPS	Installation & Test				Tests, Improvements, Preparing to commissioning experiment			

	2024			
	Q1	Q2	Q3	Q4
SCL3	ISOL Beam	Proton beam	maintenance	**Beam service to Users & experiments**
KoBRA	**ISOL Beam Commissioning**		maintenance	
NDPS		**Proton beam Commissioning**	maintenance	

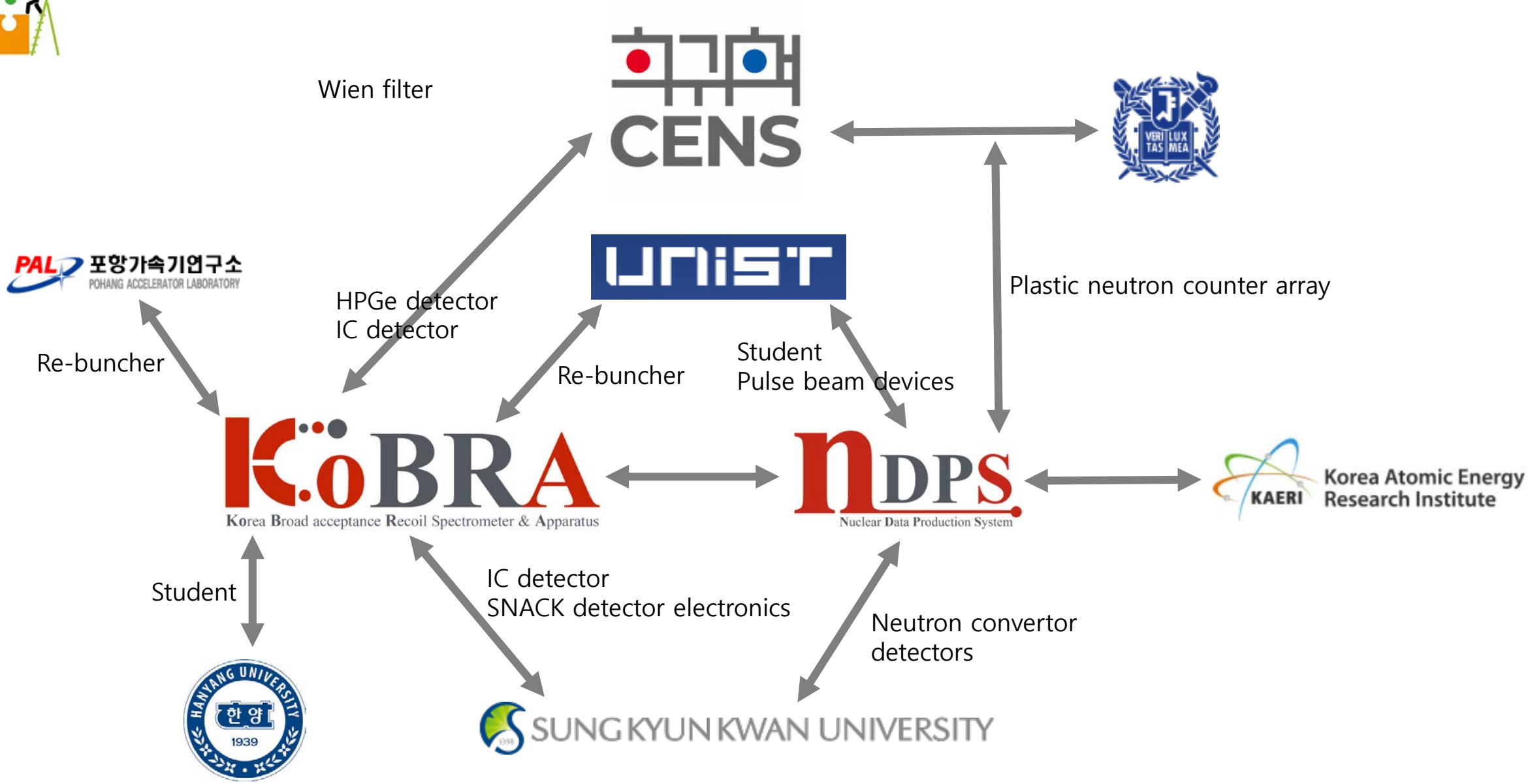
❖ We finished installing KoBRA at the end of June 2021, and tested a beam transportation using 5.4 MeV α source.

❖ All of devices consisting of KoBRA are being still improved by reflecting the issues obtained from the α source test.

❖ We are now preparing to the beam commissioning experiments together with IBS CENS.

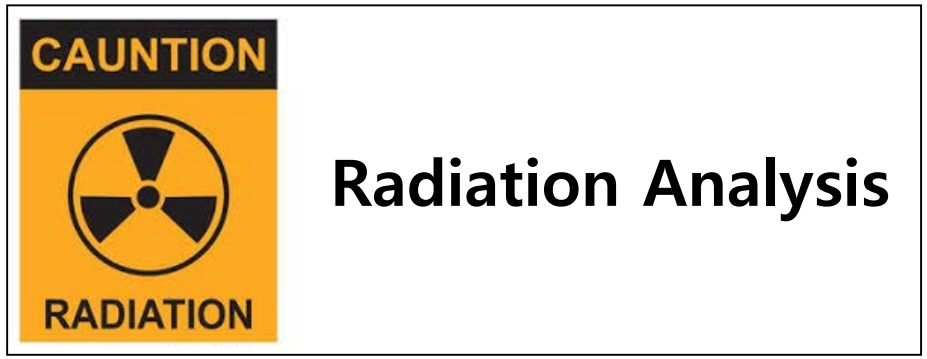
❖ We have a plan to perform several experiments using stable ion beams from SCL3 in 2023, and will provide Rare Isotopes Beams for users in 2024.

Collaboration (2022)



Thank you for your attention!

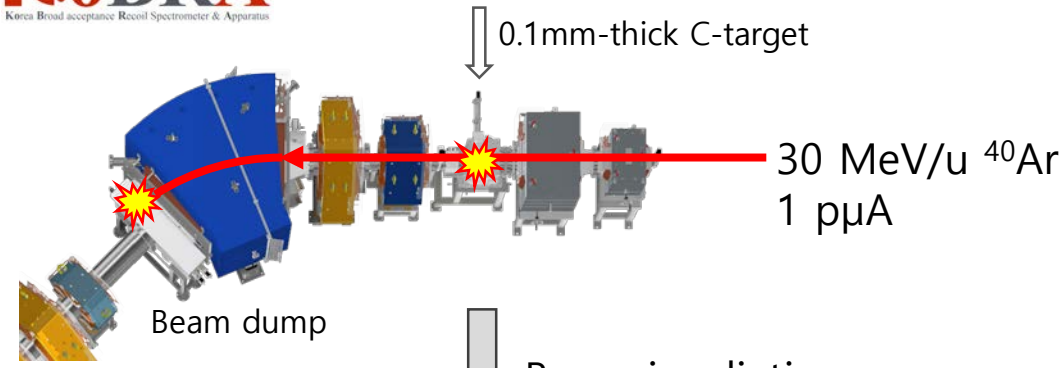
추경호(K. Tshoo) 중이온가속기연구소 2023.05.17



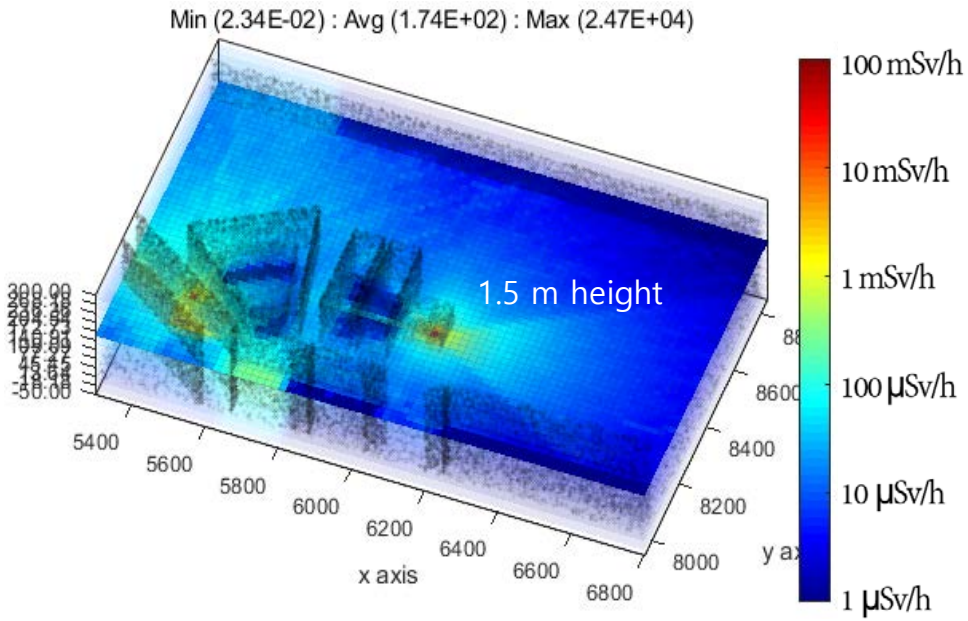
Radiation Analysis

Radiation analysis

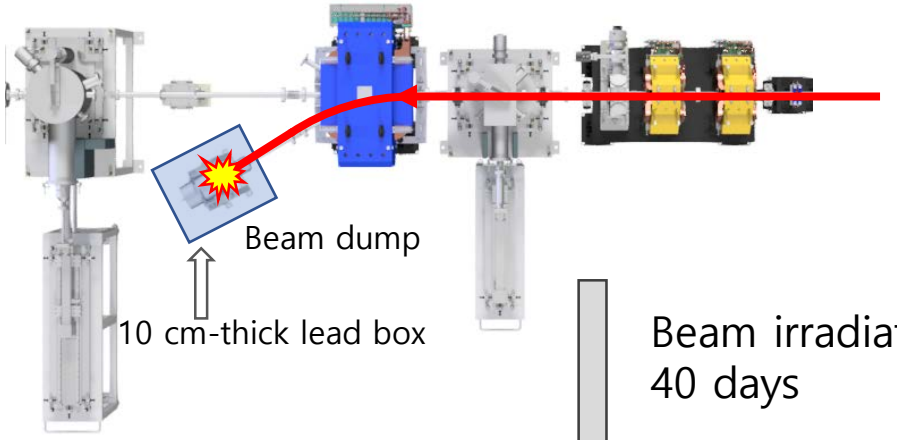
KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



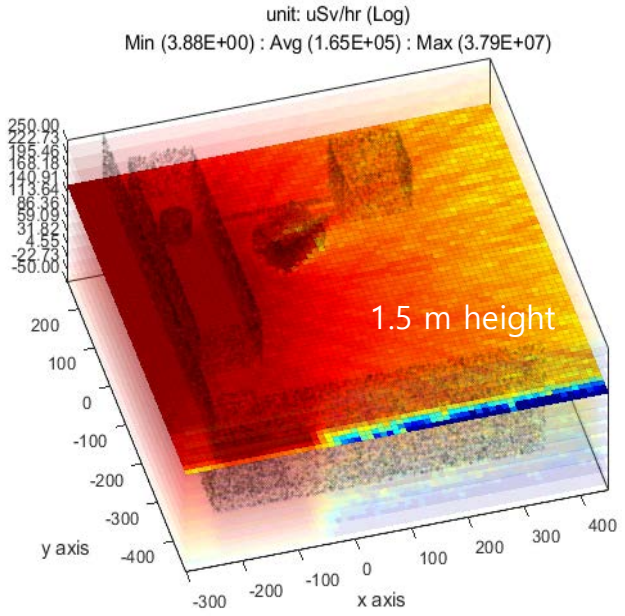
Beam irradiation:
4 days

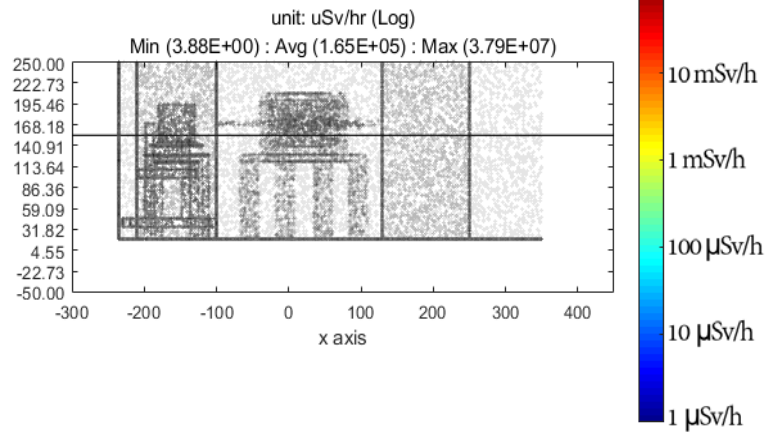


nDPS
Nuclear Data Production System



Beam irradiation:
40 days

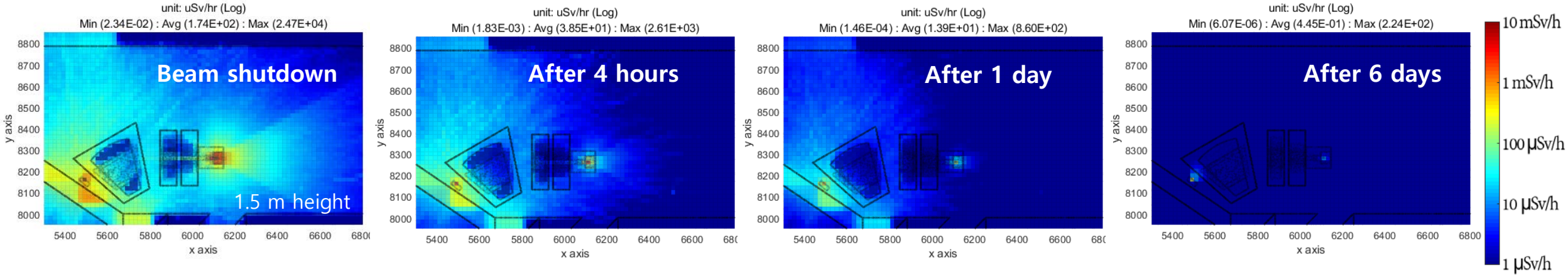




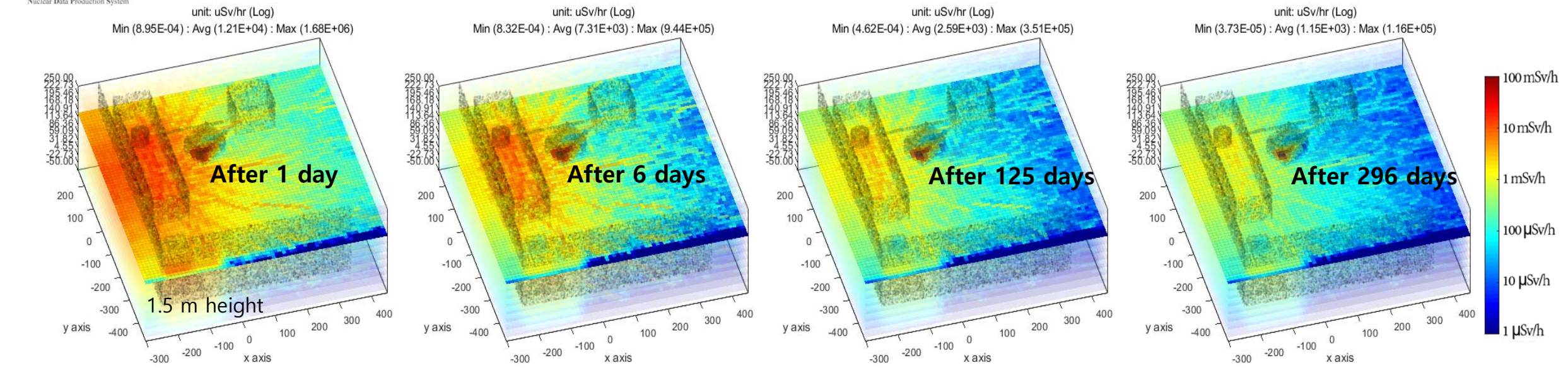
From 김재천 (J.C. Kim)

Radiation analysis

KoBRA
Korea Broad acceptance Recoil Spectrometer & Apparatus



nDPS
Nuclear Data Production System



From 김재천 (J.C. Kim)