

가스 기반의 하전입자 검출 시스템

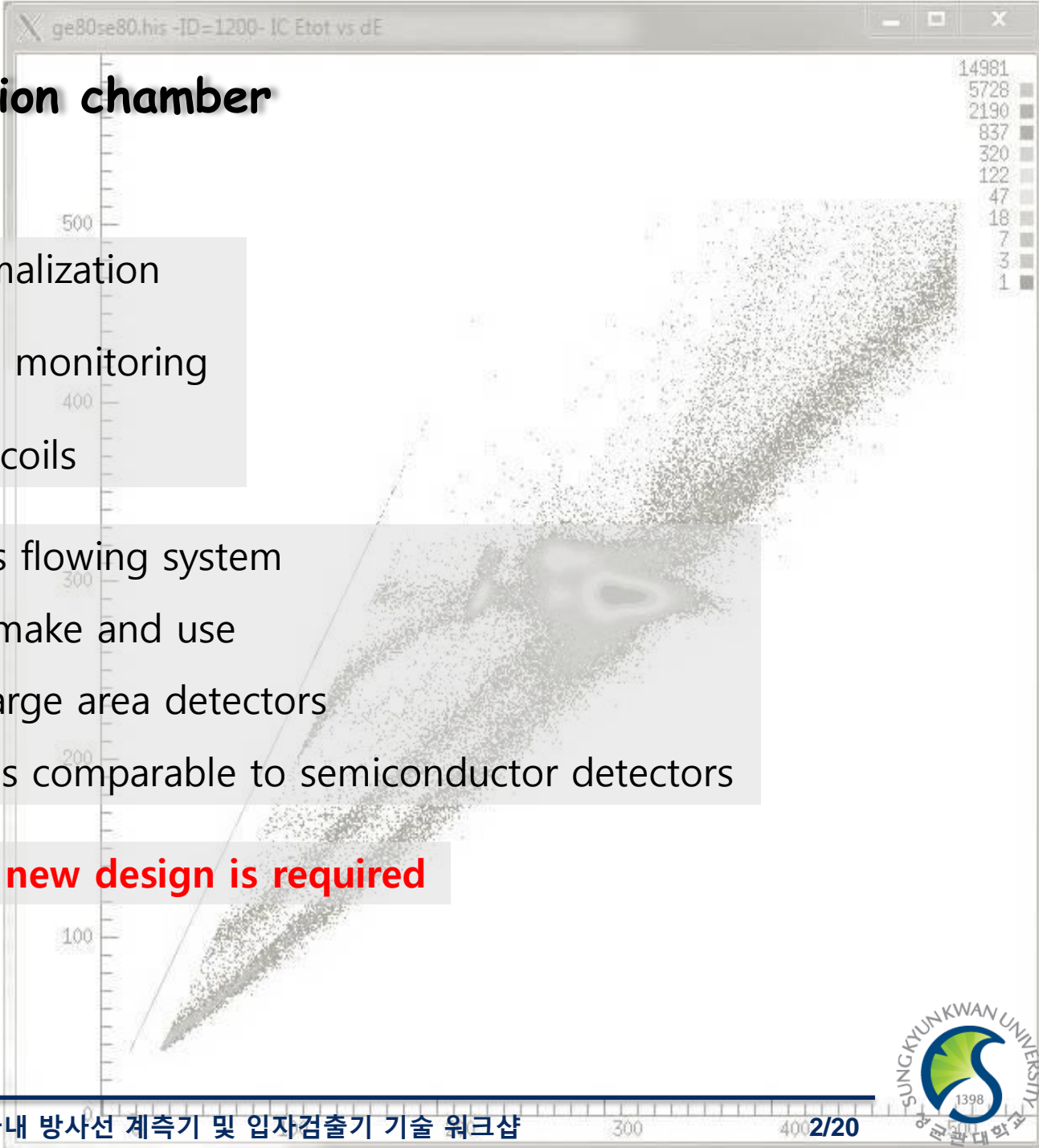
채경육

kchae@skku.edu

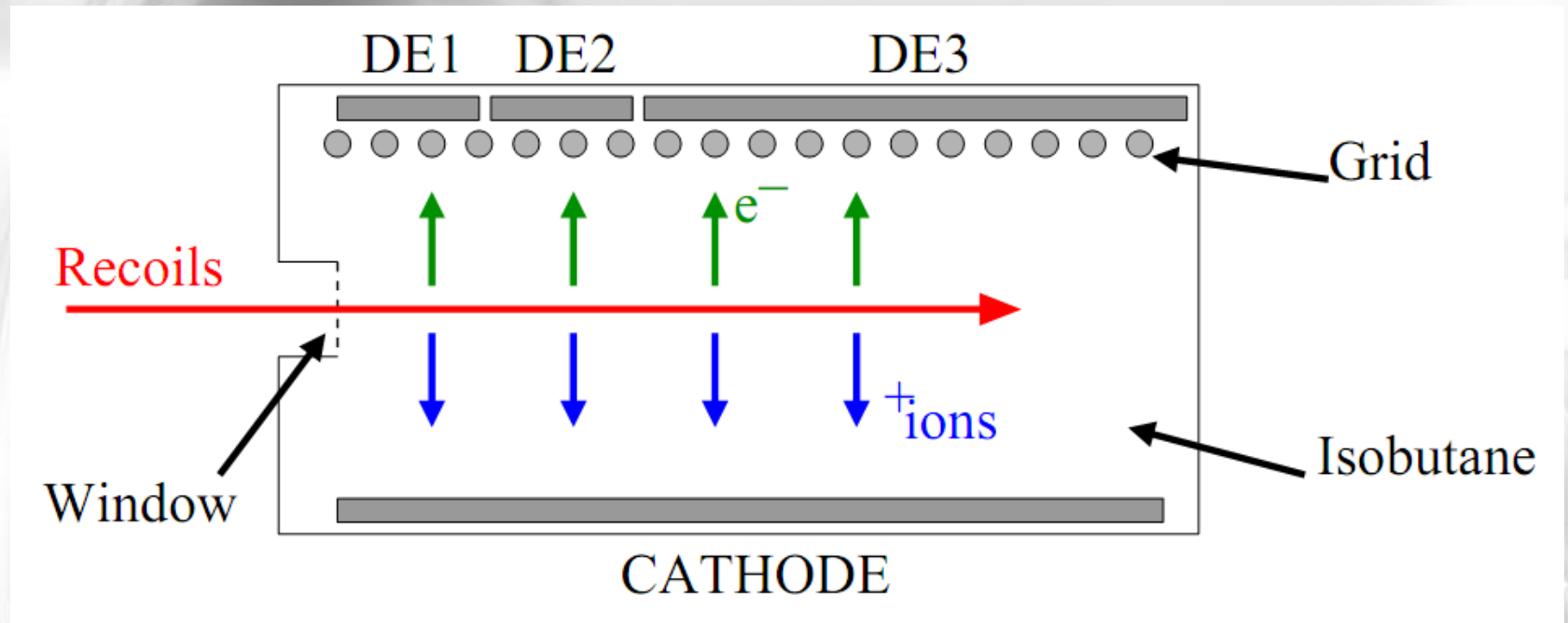
성균관대학교 물리학과

Gas-filled ionization chamber

- beam current normalization
- beam composition monitoring
- detecting heavy recoils
- Long life using gas flowing system
- Relatively easy to make and use
- Easy to fabricate large area detectors
- Energy resolution is comparable to semiconductor detectors
- **Slow response → new design is required**

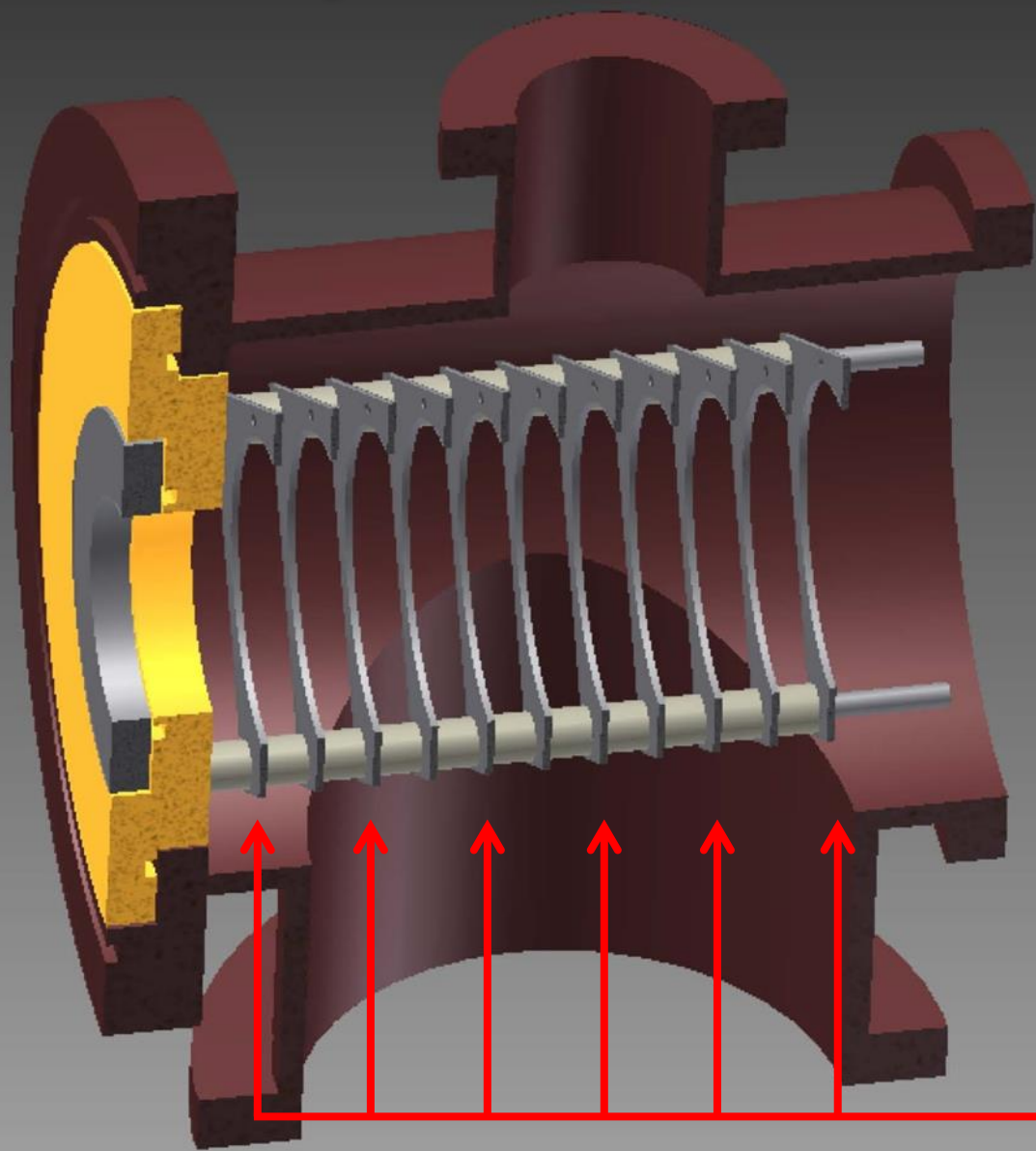


Conventional design



- Frisch grid: to get rid of the dependence of the pulse amplitude on position of formation of the ion pairs
- electrons (and positive ions) should travel relatively long distance
- maximum counting rate is limited to $\sim 100,000$ pps

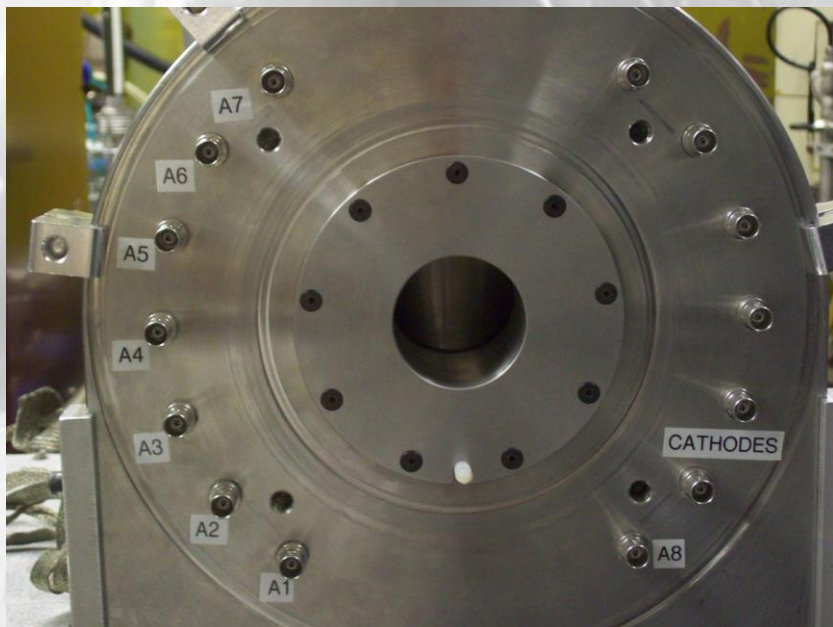
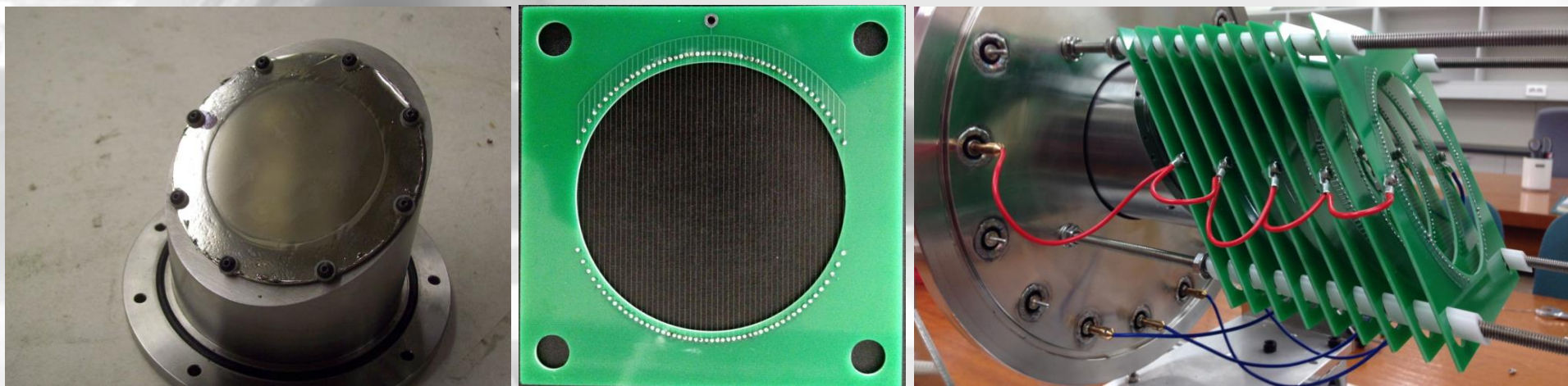
New design: multi-electrodes fast ionization chamber



- electrodes perpendicular to the beam axis
- alternative cathode-anode configuration
- cathodes are combined and grounded
- each anode is connected to a BNC feedthrough
- each section between cathodes acts as an separate I.C.
- 10 mm spacing between electrodes → **fast response**

Cathodes (grounded)

Window and Electrodes



- easy to replace window (window block)
- entrance window: gauge 20C Mylar
- electrodes: Cu frames or PCB boards+ 0.0007" gold coated tungsten wires
- wire pitch: 2 mm (transmission rate ~99%)
- **ΔE -E telescope**

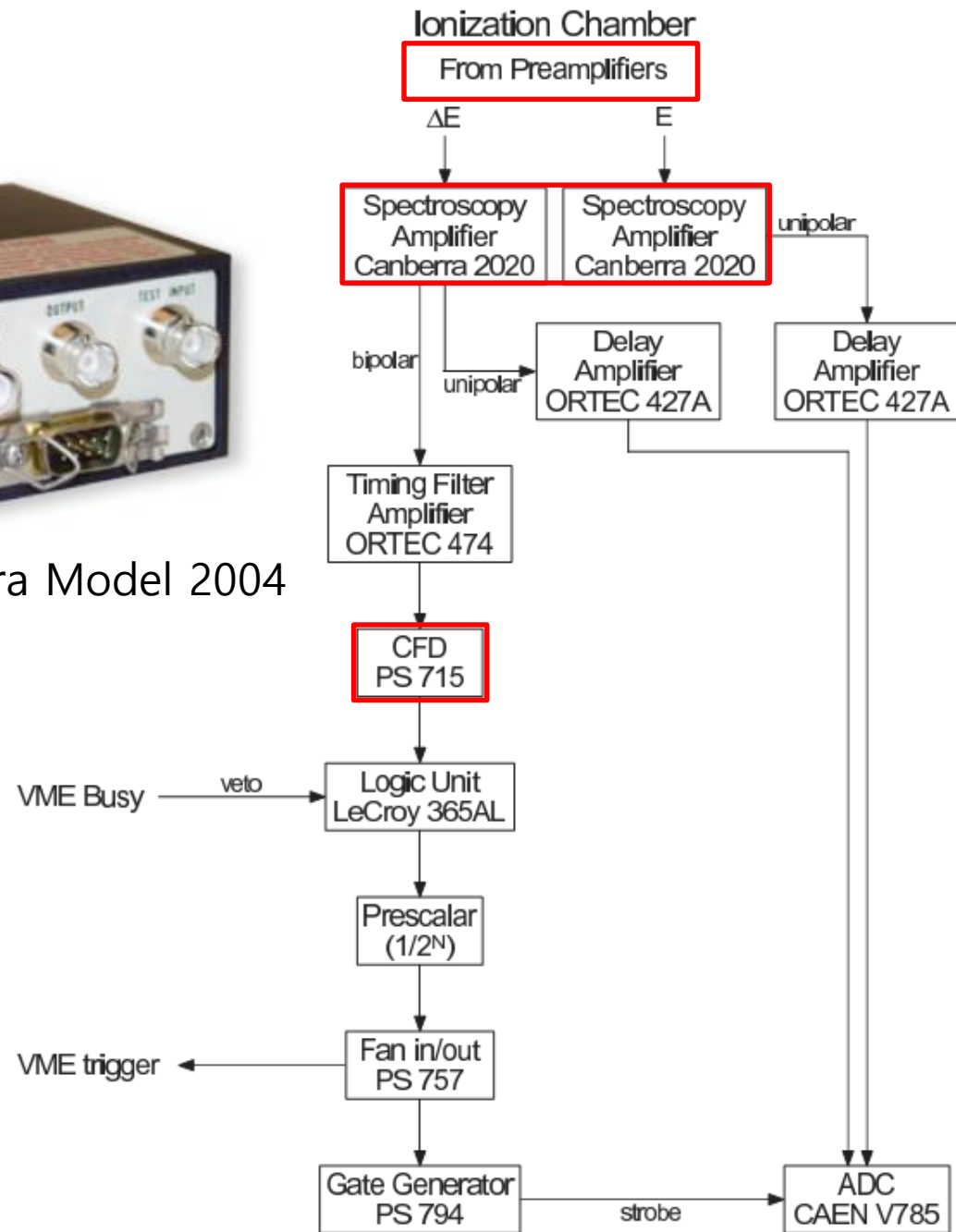
Electronics



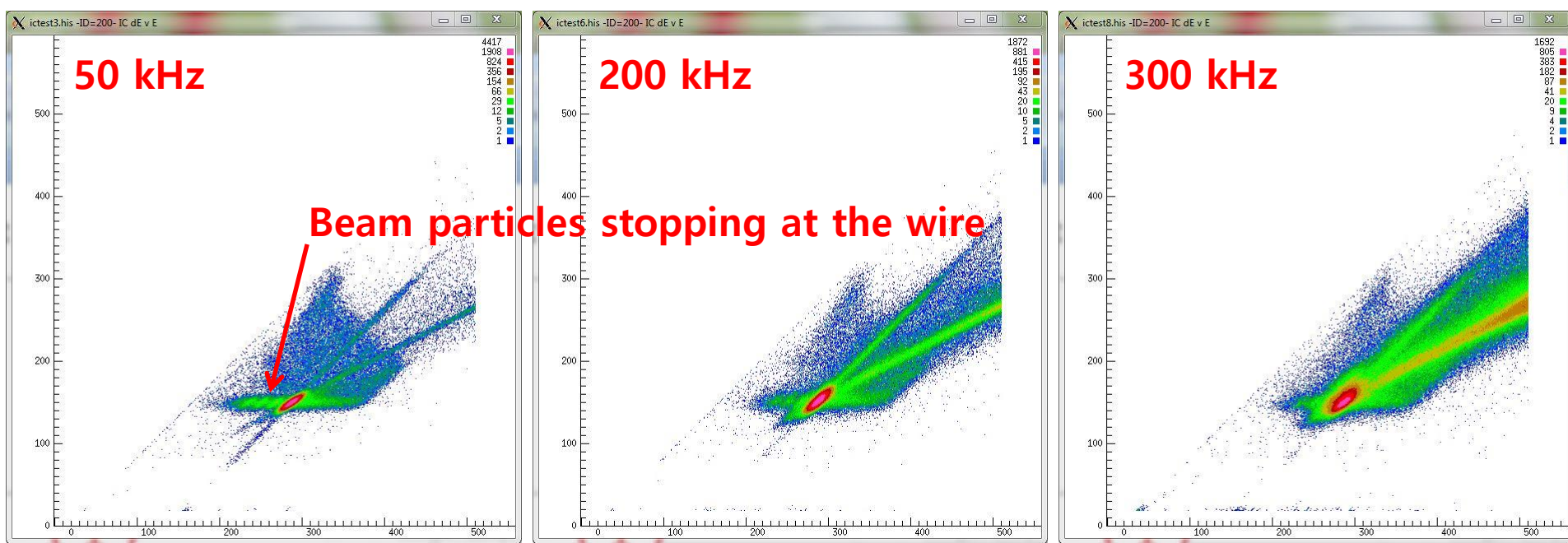
preamp: Canberra Model 2004



amp: Canberra Model 2020

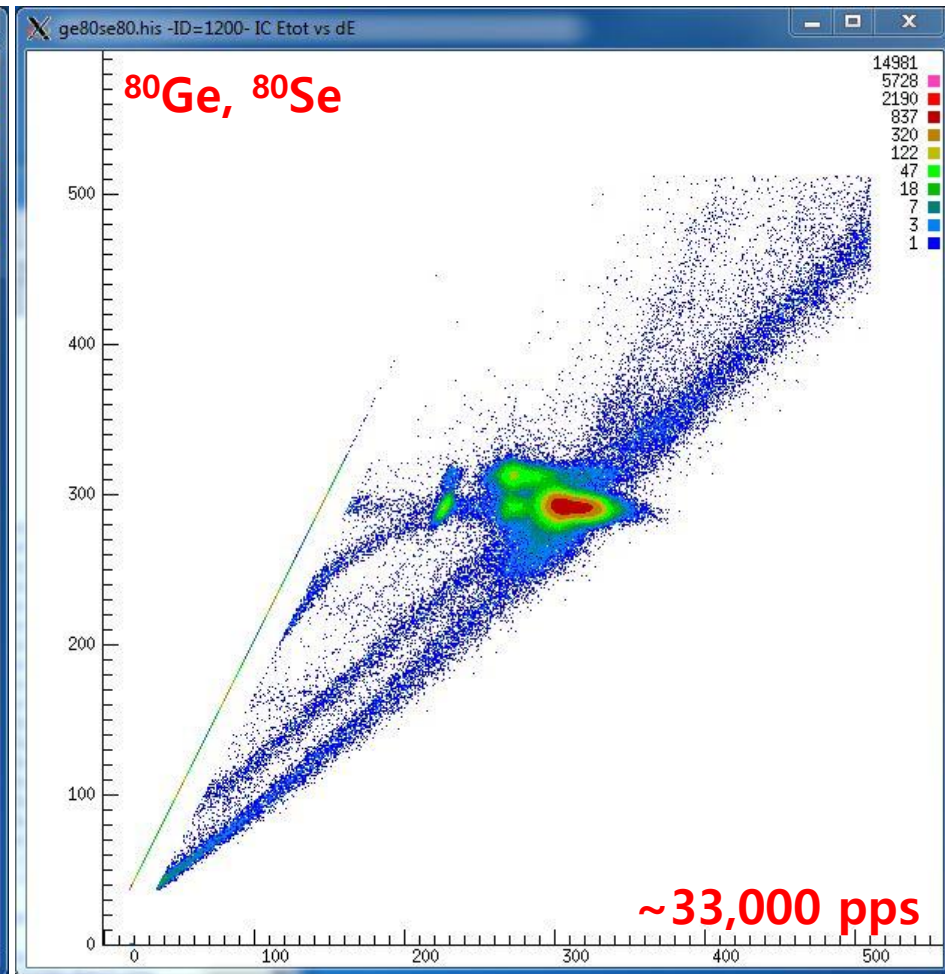
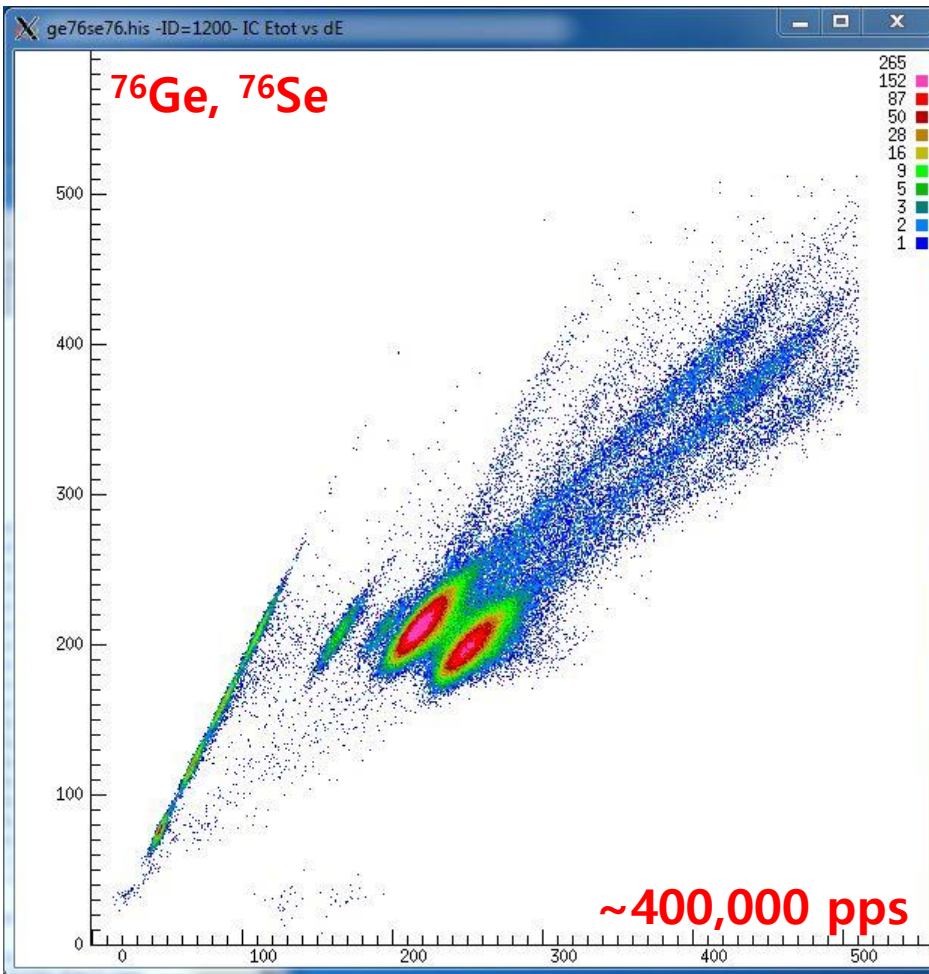


Results I - ^{10}B beam, $E_{\text{beam}} = 60 \text{ MeV}$



- new fast ion counter can reliably count up to 300,000 pps
- transmission rate through a plane of electrode is ~98% for 1 mm spacing
- a set of electrodes with 2 mm pitch was made

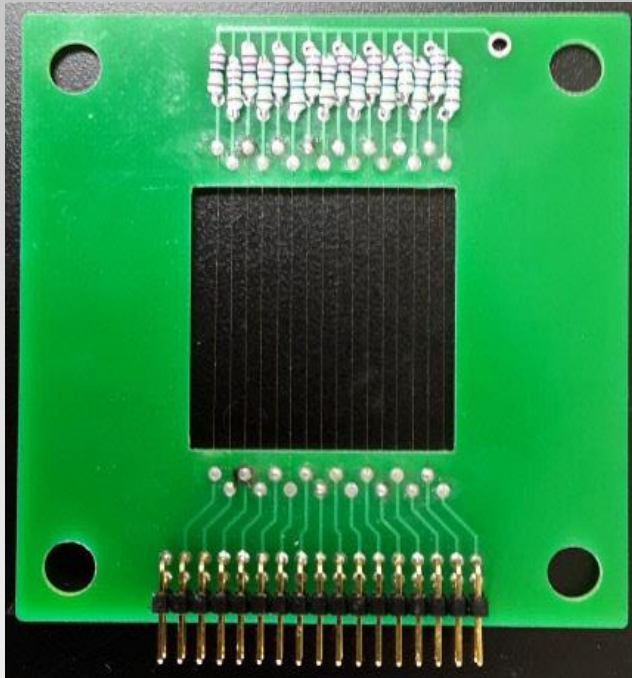
Results II - cocktail beams



Maximum count rate of $\sim 700,000$ pps was achieved!

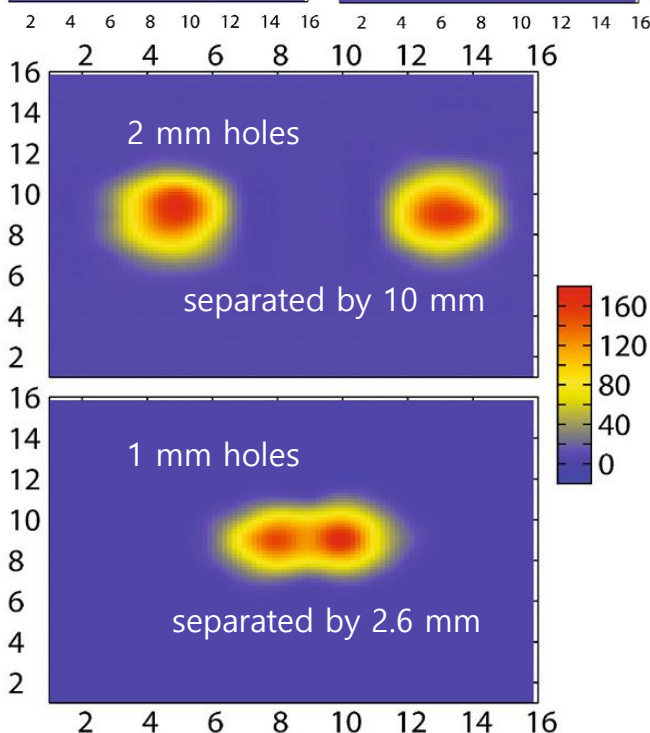
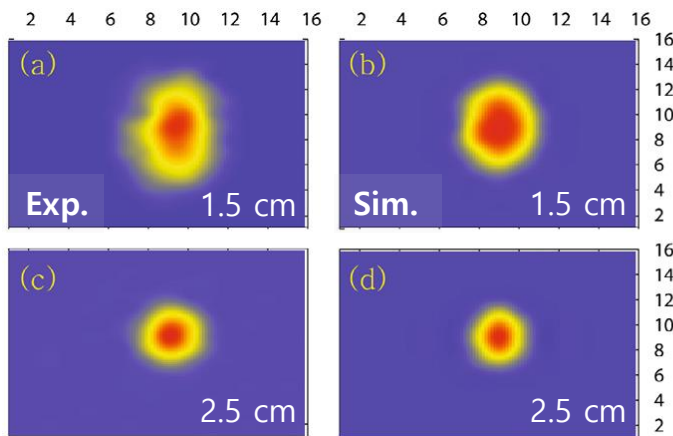
fast IC: NIM A **751**, 6 portable IC: JKPS **64**, 516

Next step: Position sensitive electrode

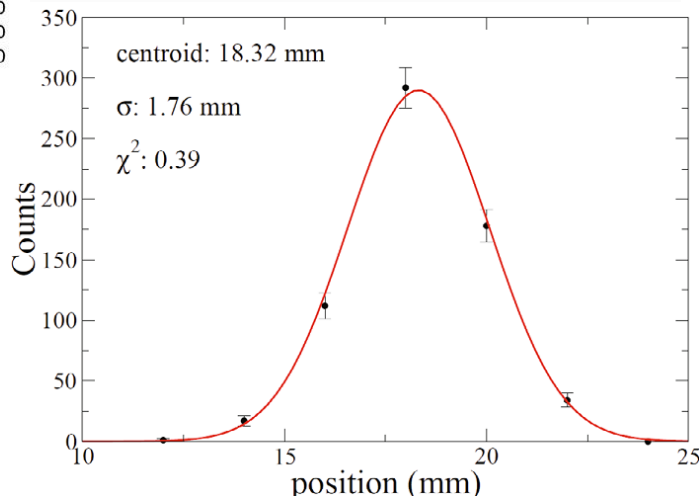


- position sensitive electrodes for the first two anodes
→ x and y position information
- 2 mm pitch → position resolution of 1 mm
- 16 channels per electrode

Position sensitive ionization chamber - results (off-line)

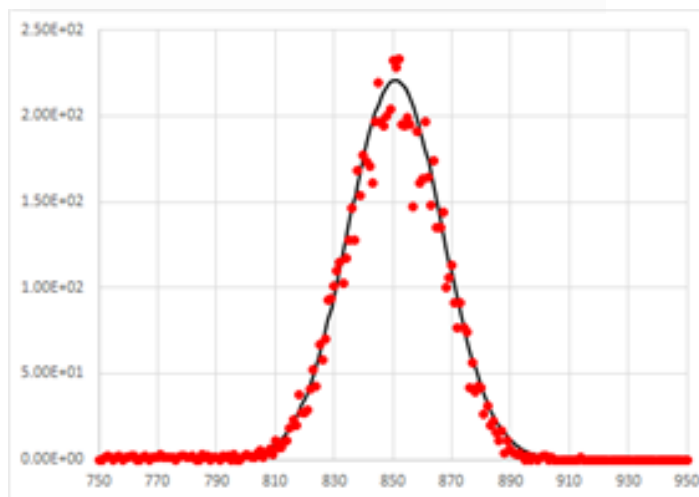


위치분해능: 2 mm collimator 사용



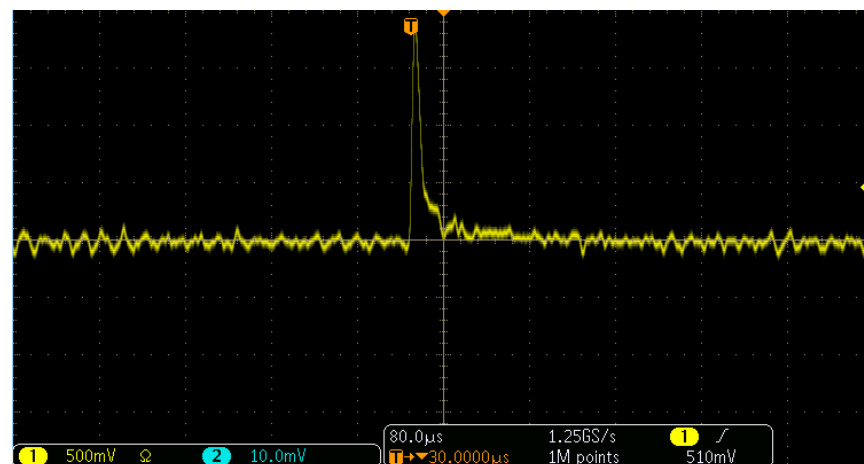
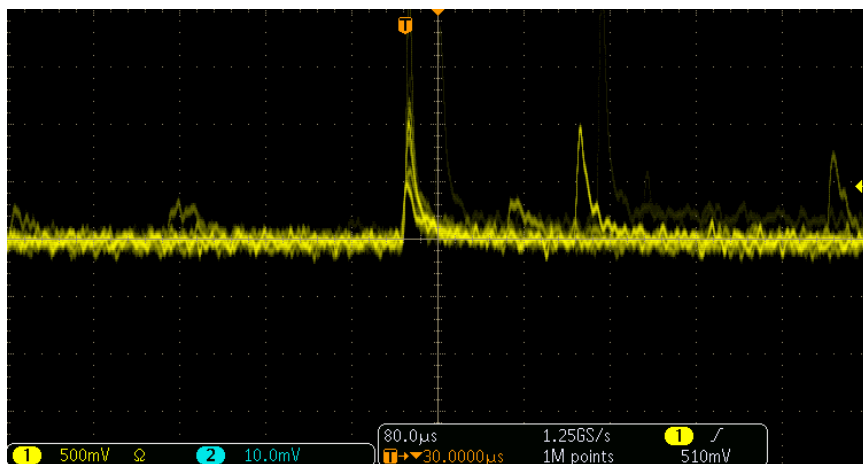
- 2 mm 간격의 wire
→ **1 mm 위치분해능**
- 빔 투과율 > **99.9%**

에너지분해능:



- 5.486 MeV α 입자
→ 851.5 Ch.
- FWHM: 37.4 Ch.
- **에너지 분해능 4.39%**

Position sensitive ionization chamber - results (on-line)



약 5×10^5 pps의 빔 전류에서도 안정적으로 작동

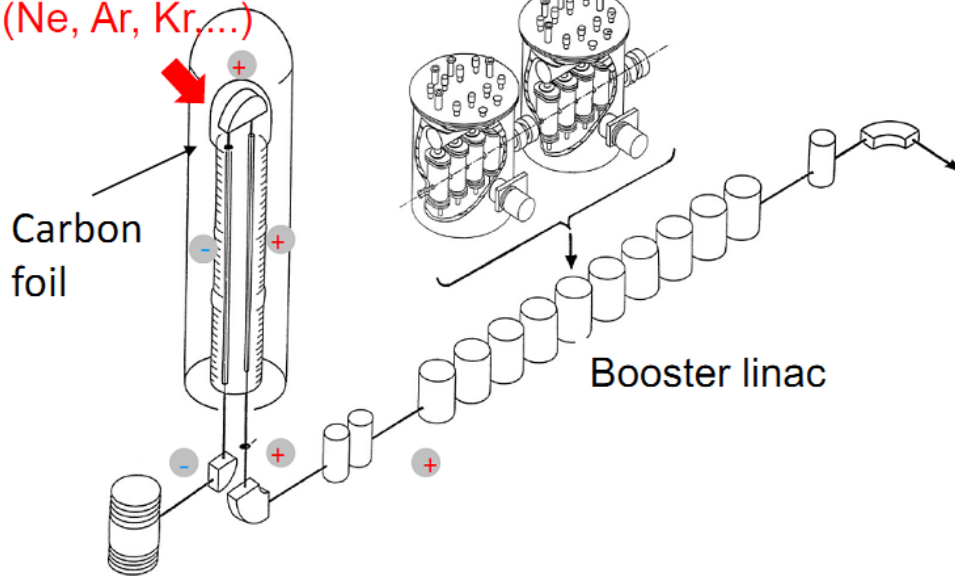


J-PARC

Tandem facility

JAEA tandem facility

ECR Ion Source
(Ne, Ar, Kr...)

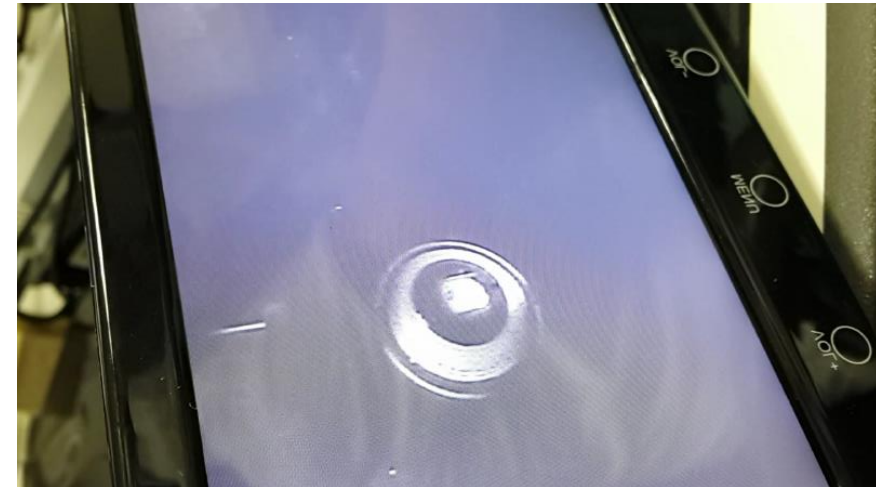


Negative Ion Source

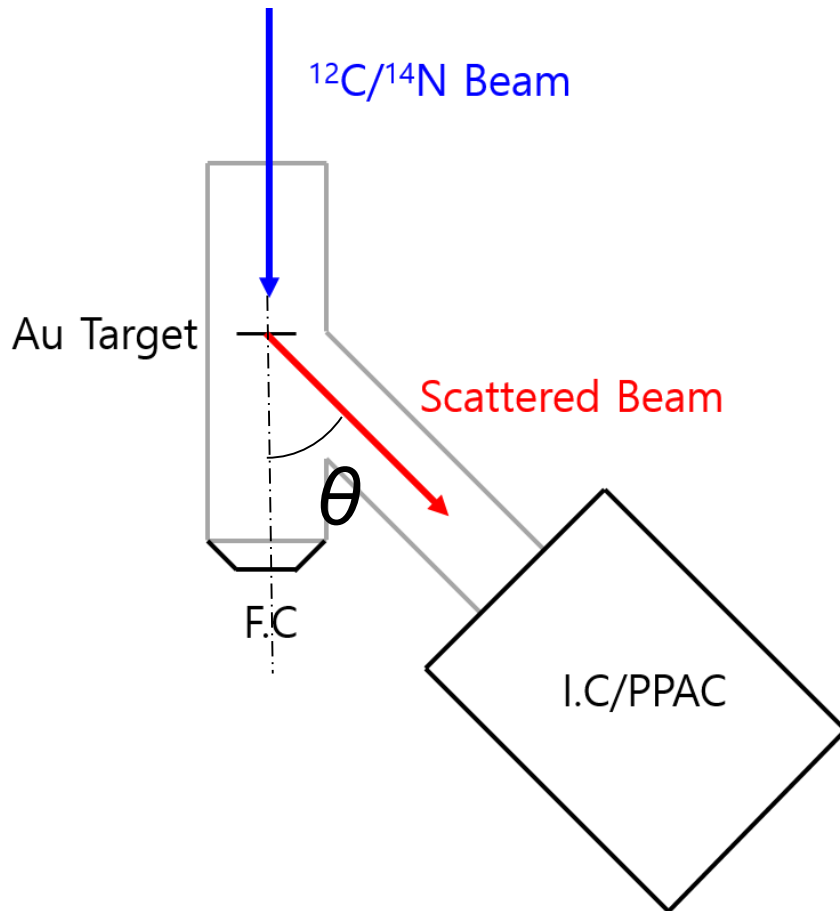
- 세계 최고 에너지의 정전 가속기
- maximum terminal voltage: 20 MV
- Ne, Ar, Kr 등의 빔을 위한 ECR Ion Source (terminal 에 위치) 및 Negative Ion Source
- 작은 빔 사이즈 (수 mm)
- 정확한 빔 위치
- 정확한 빔 에너지 ($\Delta E < 1\%$)

Blocker out

Blocker in



Experimental setup



- ^{12}C (24h) and ^{14}N (24h) beams at **60 MeV**
- isobutene and/or P-10 gas will be used to fill the detectors: PPAC ~10 Torr, I.C. ~100 Torr
- Using a ^{197}Au **solid target**, only scattered particles (not direct beam particles) will be detected by the detectors
- **Position resolution** and **energy resolution** will be measured with the beams
- Various intensities of incident charged particles ranging from 10^3 pps to 10^6 pps will be used to find the **maximum counting rate** that the detector can handle
- A Faraday cup will be used to monitor the beam intensity

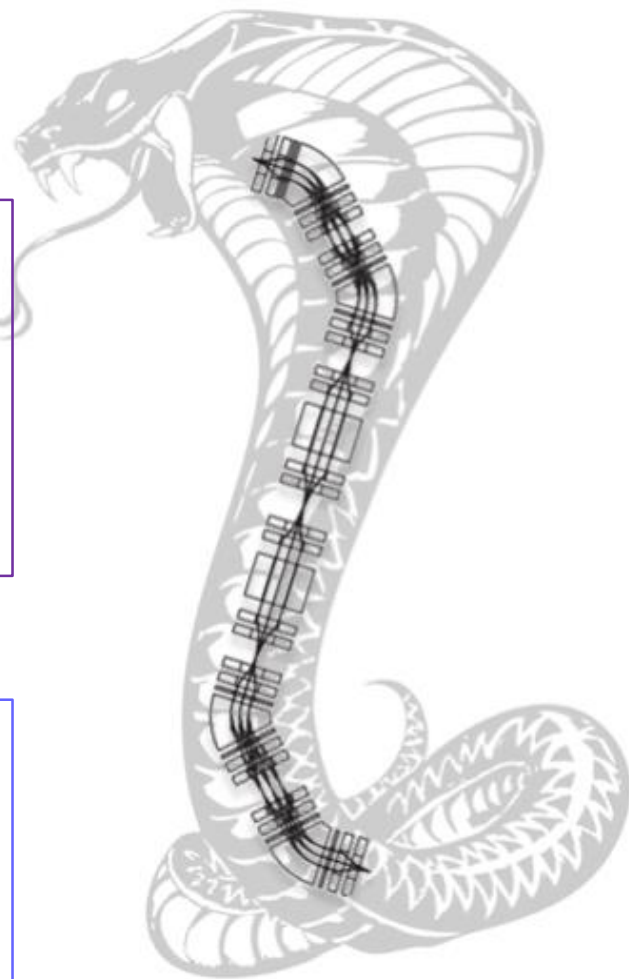
Raon의 저에너지 핵물리 실험을 담당할 중추 시설

활용 가능 분야 및 실험

- 핵구조
- 핵천체물리
- 대칭에너지
- 포획반응 및 전달반응
- 탄성 및 비탄성 산란반응
- Fusion/Fission spec.
- Decay spectroscopy

요구사항

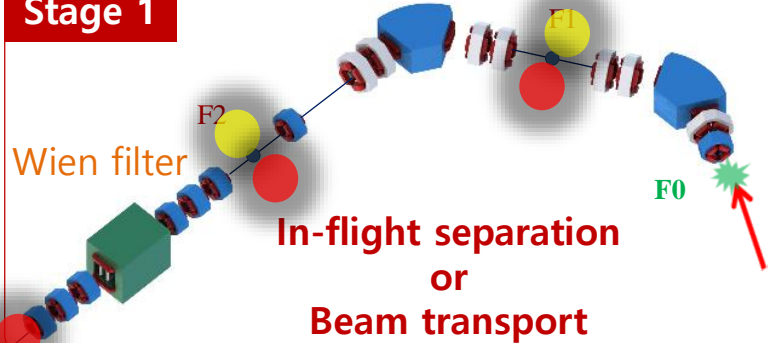
- SIB과 In-Flight 방식을 이용한 RIB 생성 ($> 10^6$ pps)
- 넓은 범위의 입사각 ($> \pm 100\text{mSr}$)
- 고분해능 ($p/\Delta p > 2000$)
- 편광 RIB 생성 ($> \text{수 } \%$)



KOBRA 설계 현황

- 이온챔버
- PPAC
- 실리콘 검출 시스템

Stage 1



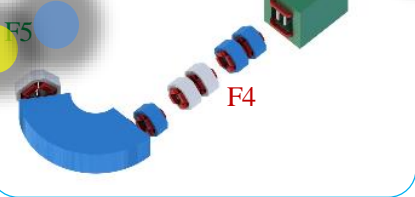
Main Specifications

Maximum magnetic rigidity (Tm)	~3
Mass resolution ($m/\Delta m$) @ stage 1	~700
Dispersion (cm/%) @ stage 1	4.2
Momentum acceptance (%) @ stage 1	± 4
Angular acceptance (mrad) @ stage 1	± 40 (H) and ± 100 (V)

Stage 2

Big-bite spectrometer

Wien filter



Design concept

- Stage 1 (F0-F3)

Production and separation of RIBs via In-Flight method with high intensity SIBs from SCL to produce both neutron- and proton-rich RIBs

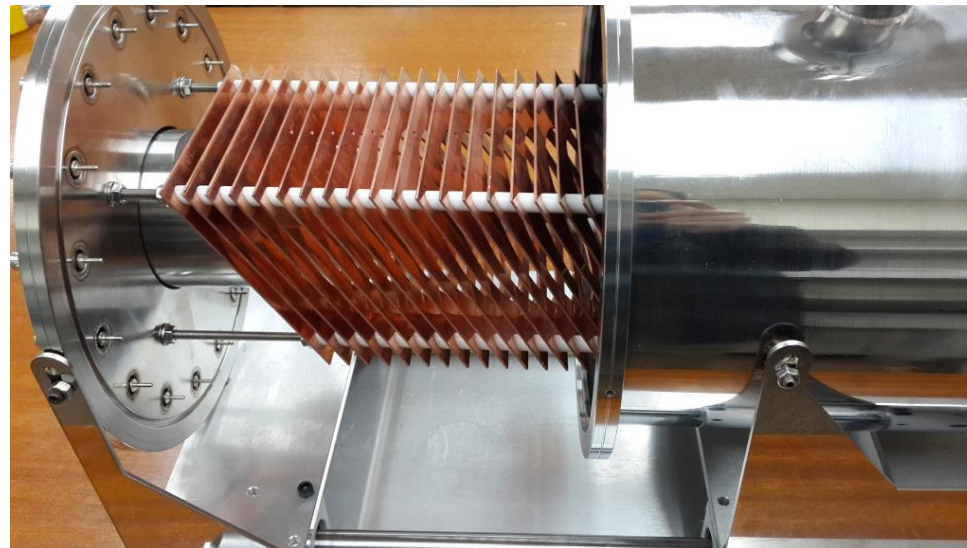
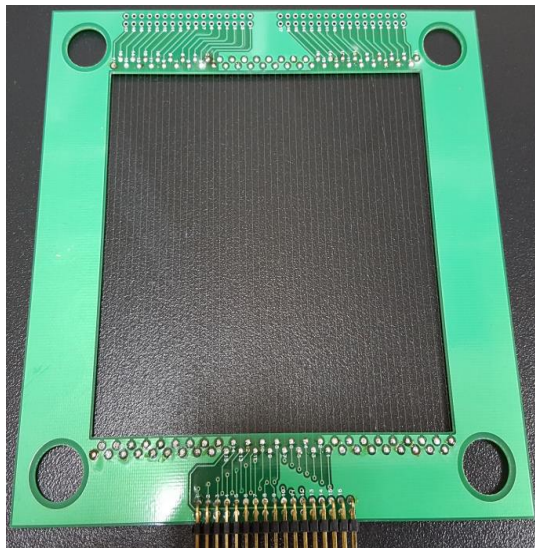
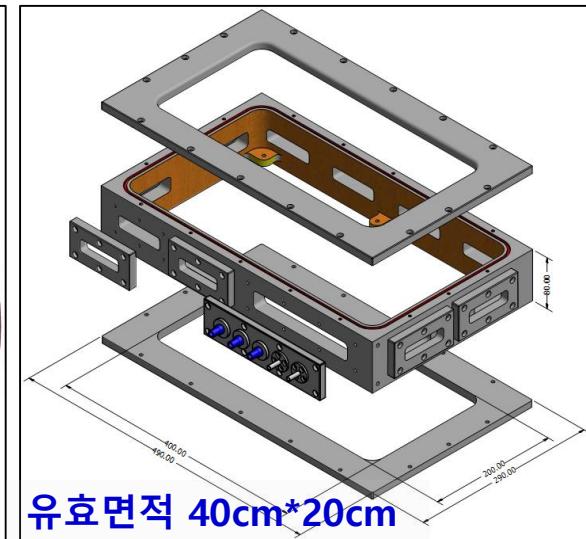
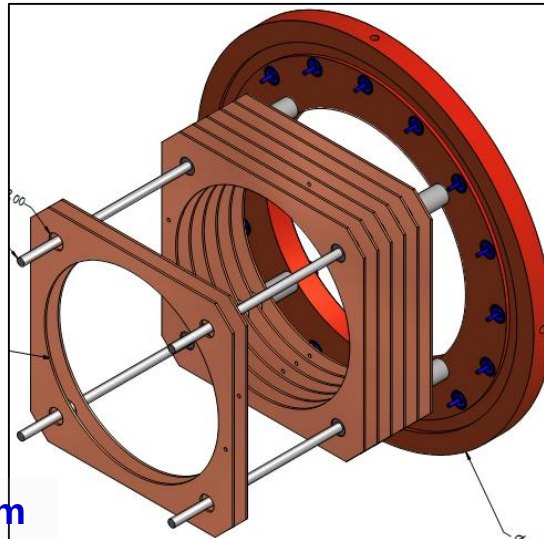
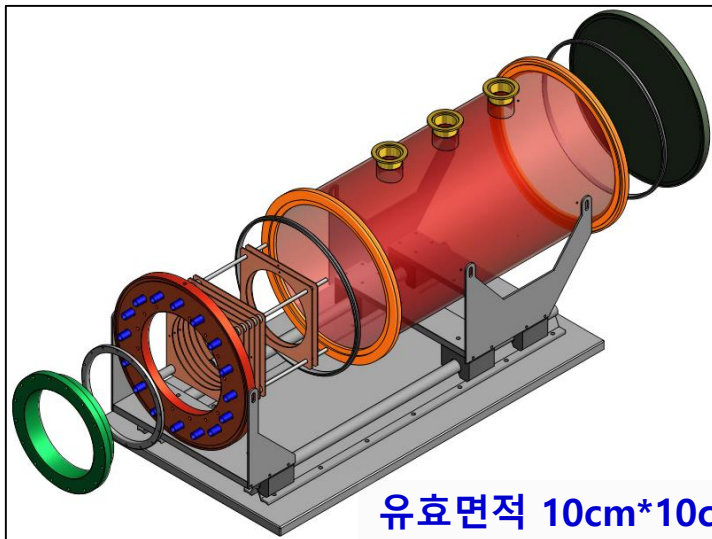
- Stage 2 (F3-F5)

Big-bite spectrometer with a Wien filter
Rotatable stage is under consideration
Large acceptance

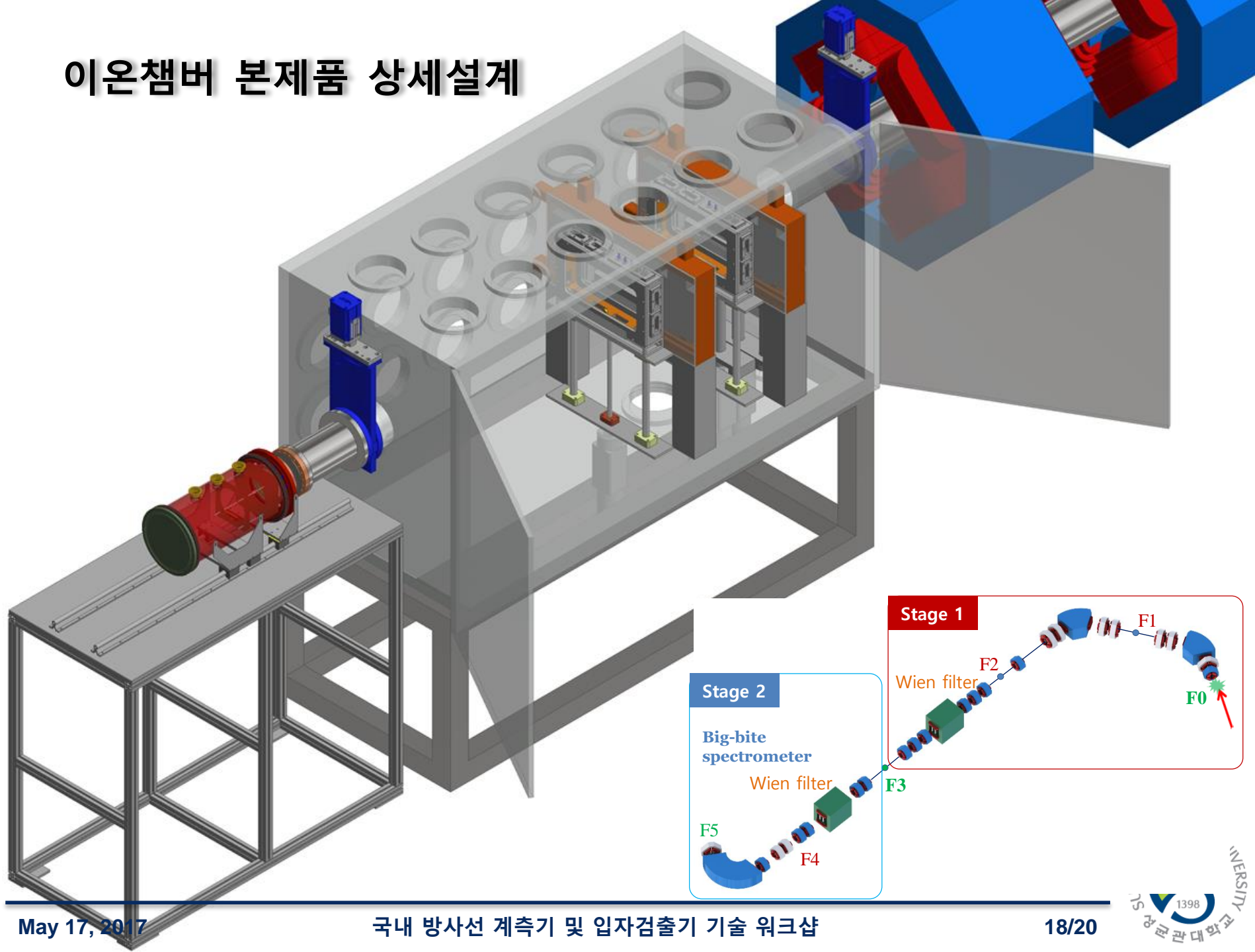
Associate devices

FP	Equipments
F0	RI production target
F3	gas-jet target, gamma-array, detection system
F5	Focal plane detection system

Ionization chambers at KOBRA



이온챔버 본제품 상세설계



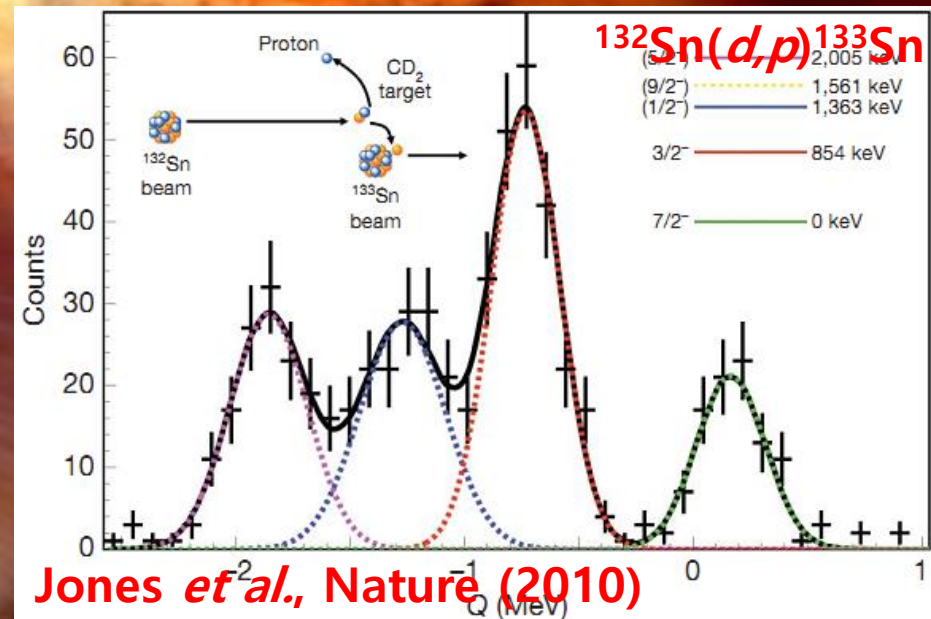
Future use

Will be used...

to monitor the beam intensity and

to detect heavy recoils in transfer reaction measurements

such as (d,p) , (d,t) , (p,d) , (p,t) , etc.



Thank you

K.Y. Chae, M.S. Kwag, S.M. Cha, M.J. Kim, D.H. Kim, Y.G. Kim, K.B. Lee, C. Akers, K. Nishio, K. Hirose, H. Makii, R. Orlandi

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