Reactions with RIBs at RIBLL2-ETF

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Oct. 2025
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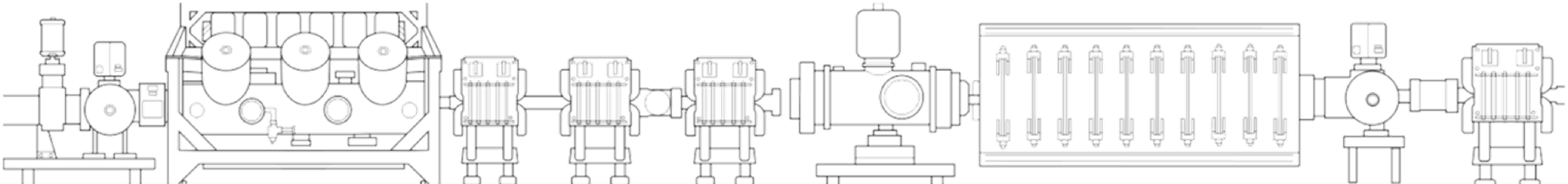
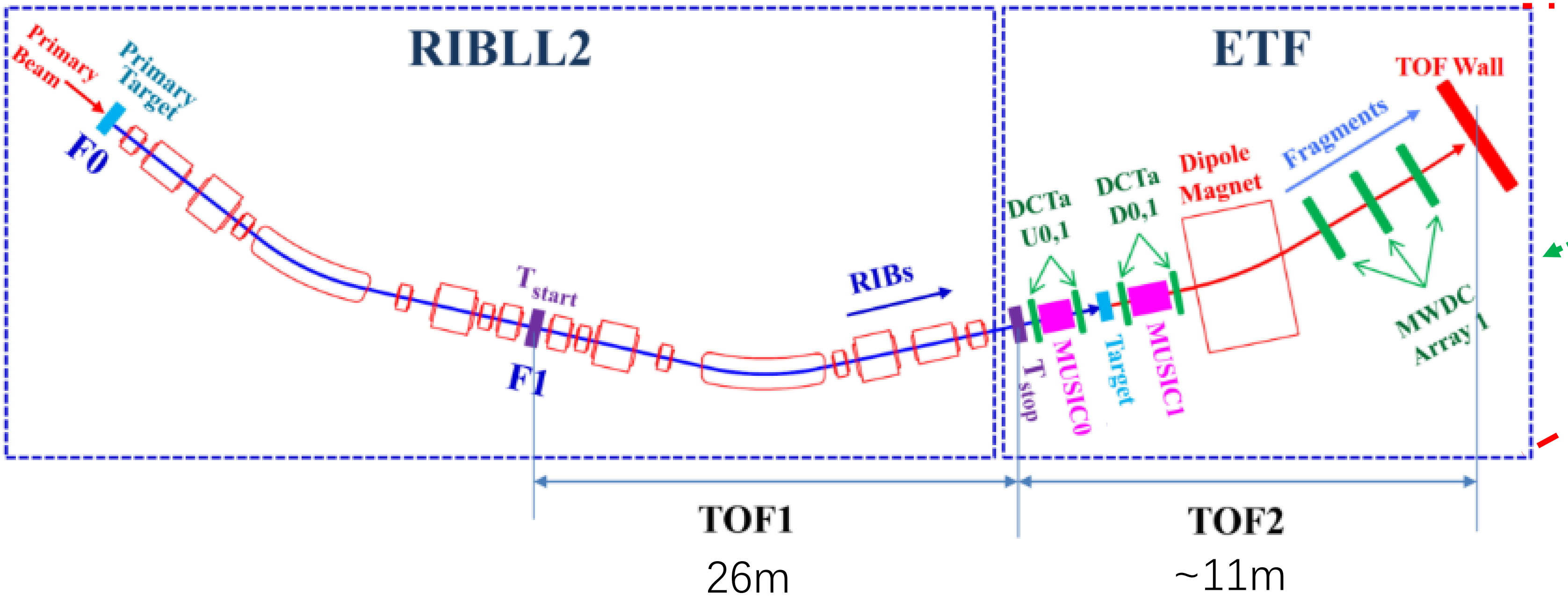


Introduction to RIBLL2-ETF

- RIBLL2: 2nd Radioactive Ion Beam Line in Lanzhou
- ETF: External Target Facility

- Beams: **~2800MeV proton to ~520 MeV/nucleon Uranium fed by CSRm**
- Secodary beams: **generated by projectile fragmentation at F0**
- Flight path in RIBLL2: **26m, from** Tstart **@F1 to** Tstop **@ETF (TOF1)**
- Flight path in ETF: **~11m, from** Tstop **to** TOF Wall **(TOF2)**
- **A position sensitive plastic scintillator array (width=2mm) is installed at the dispersive plane F1.**



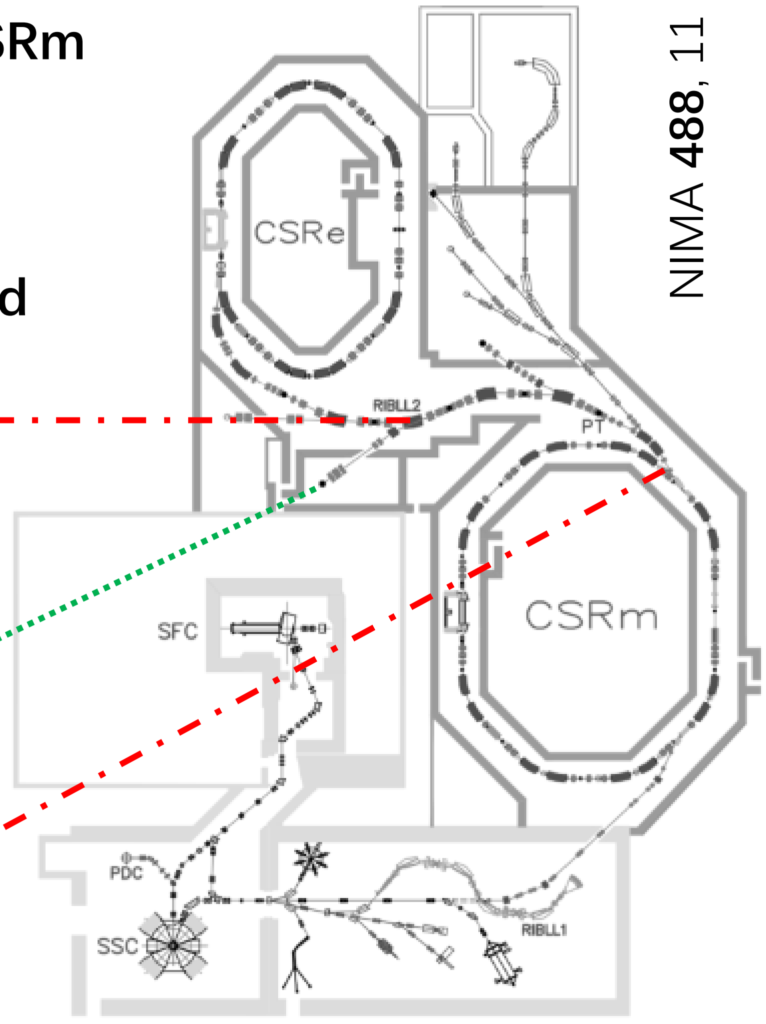
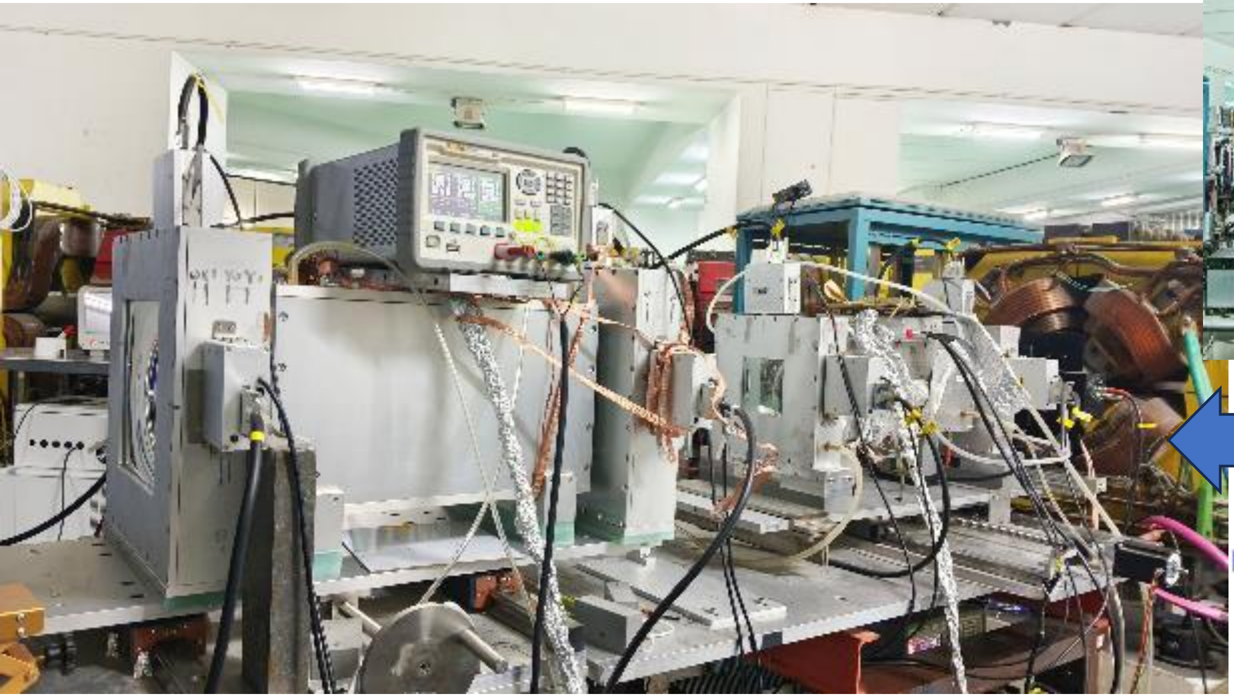


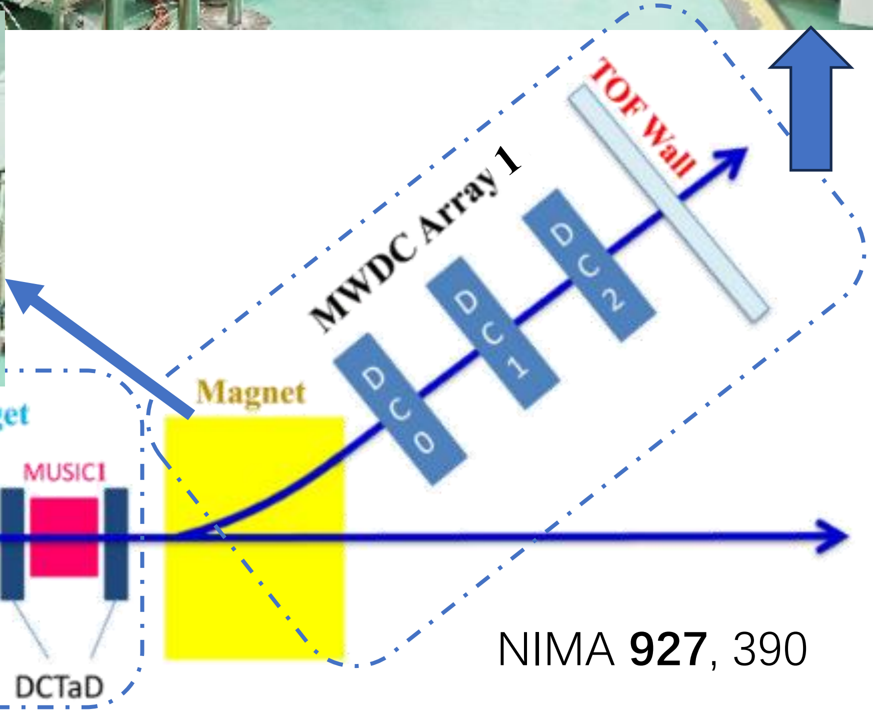
Fig. 1. Overall layout of the HIRFL-CSR complex.

NIMA 488, 11

Introduction to ETF

- Z detectors: **MUSIC0,1**
- Tracking detecotrs: **DCs around target (DCTaU,D) and after magnet (MWDC Array 1)**
- Max. magnetic intensity of the dipole magnet: **1.5Telsa @I=1500A**





NIMA **927**, 390

The TOF System

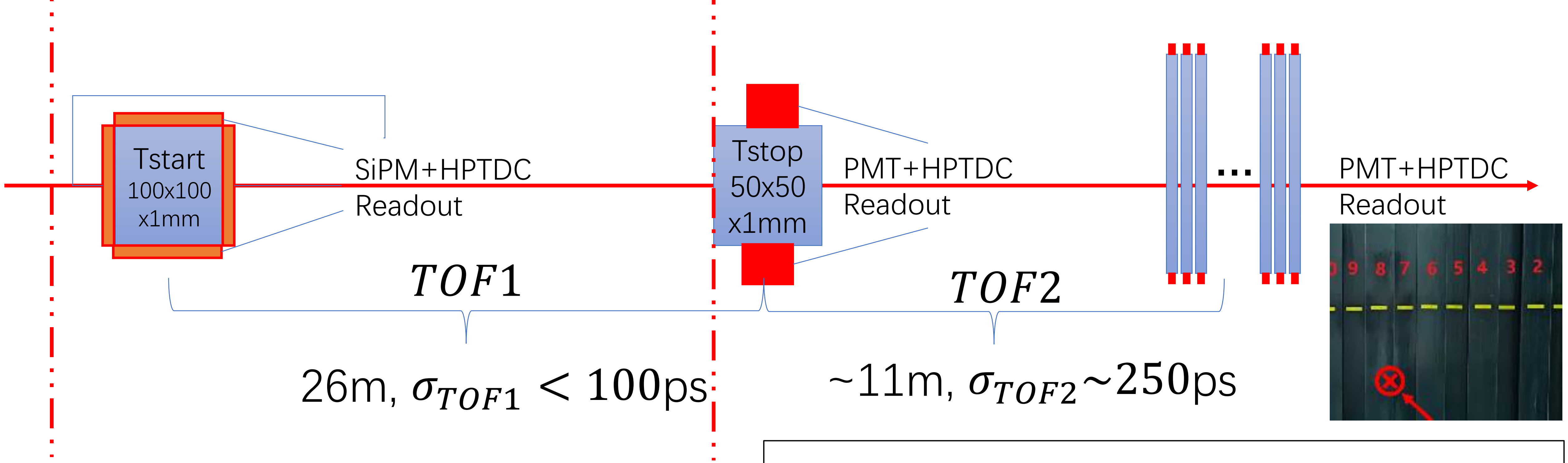
TOF Wall

15 strips

Each strip: **1200x100x10**mm

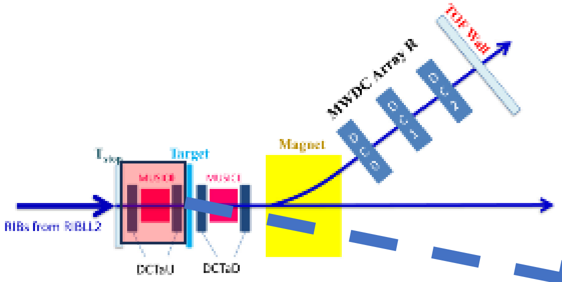
Adjacent strips **overlap** by **10**mm

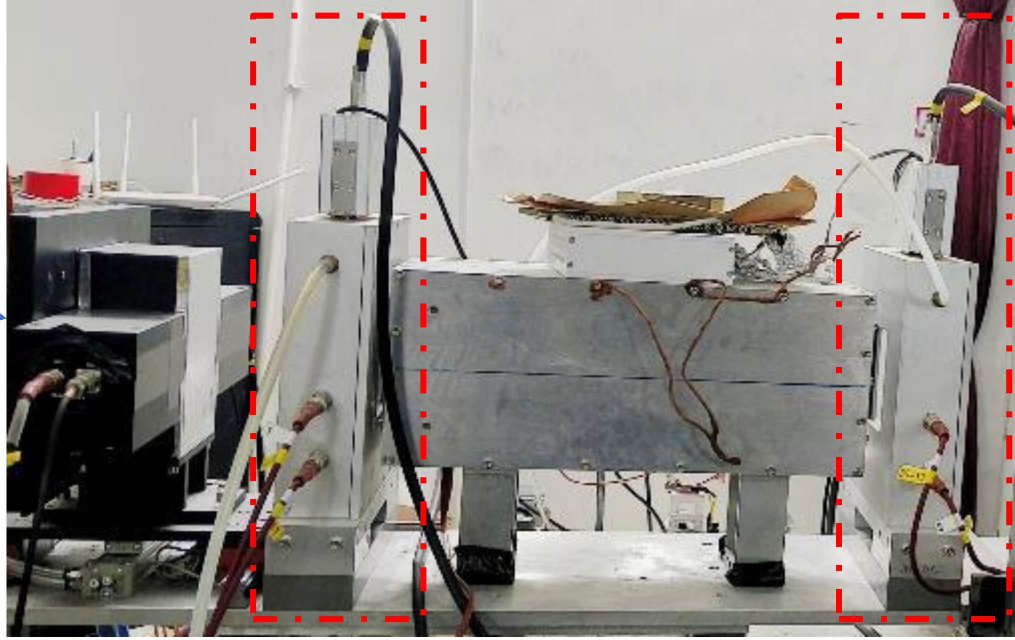
Sensitive Area: **1200x1360**mm



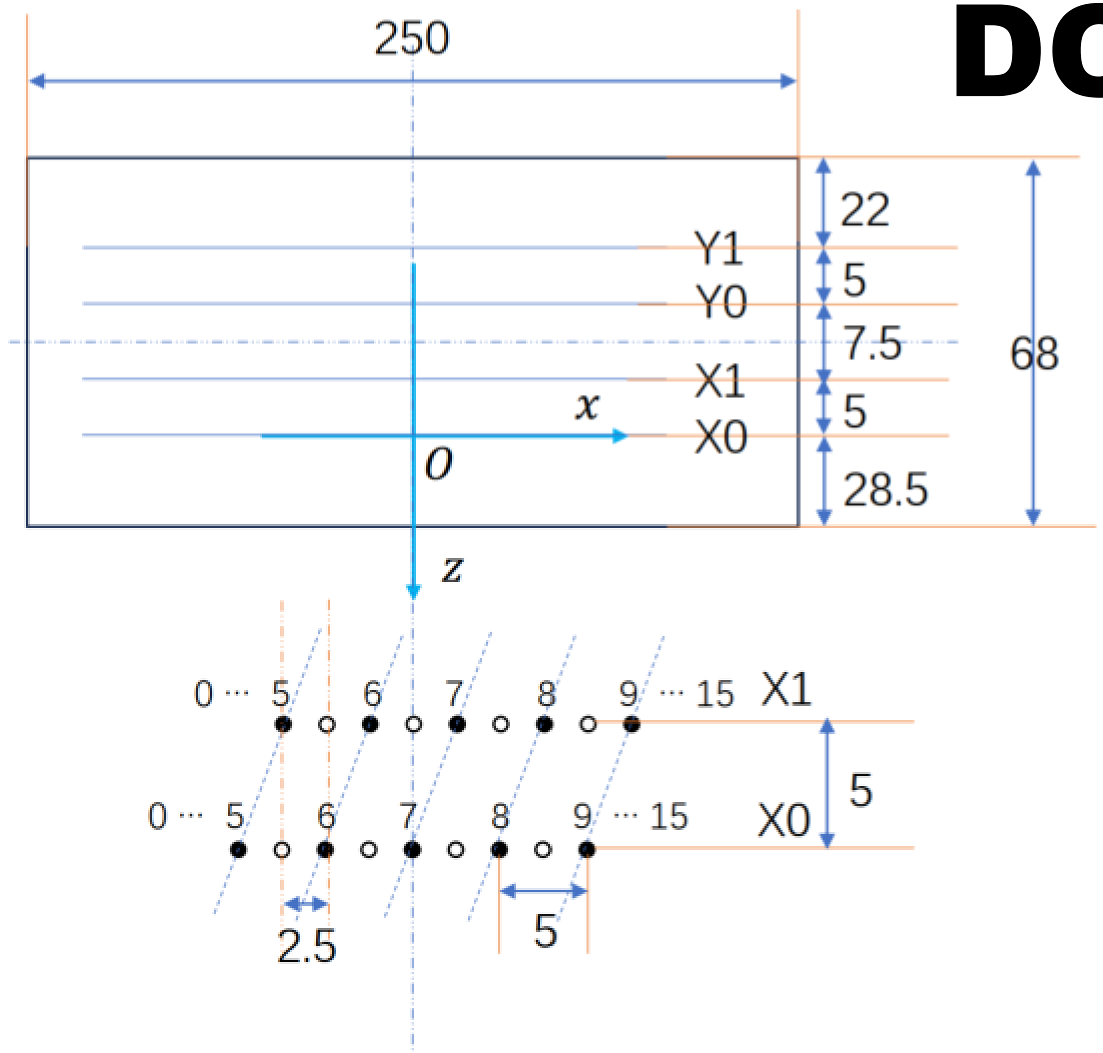
The new TOF Wall is tested in Kr beam test with improperly low supply HV. σ_{TOF2} could be better with higher HV.

The Drift Chambers





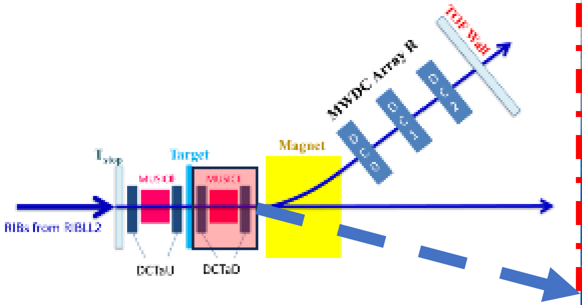
DCTaU

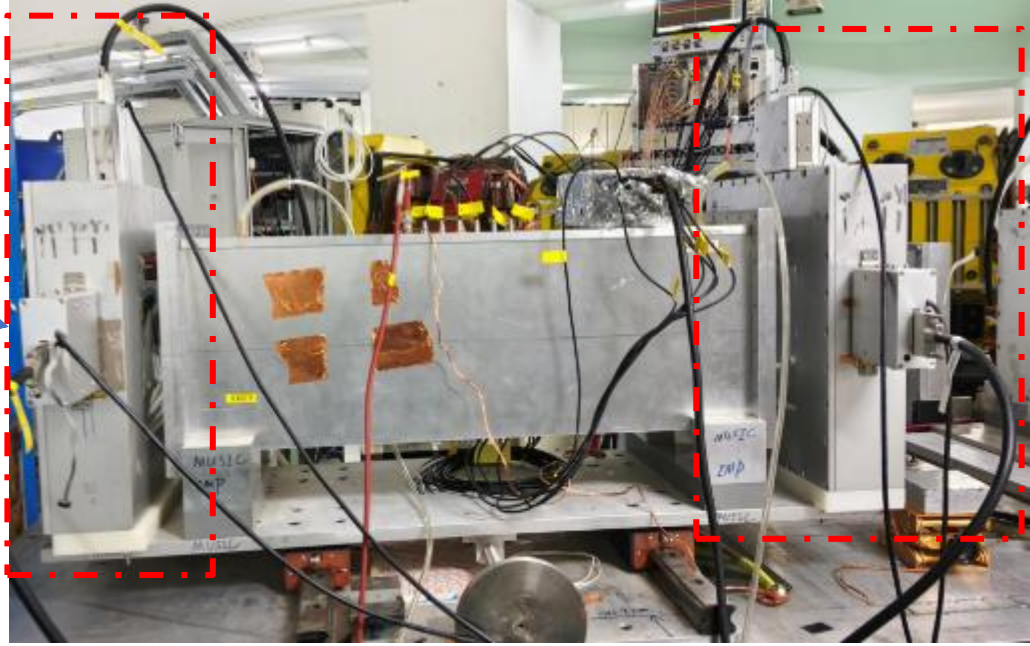


- Active Volume: **80(X)x80(Y)x68(Z)mm**
- Drift Length: **2.5mm**
- Sense wire configuration: **X0X1(0°), Y0Y1(90°)**
- Readout: **16x4=64ch**
- Operating gas: **80%Ar+20%CO_2 at atmospheric pressure**
- High voltage: **1300V (typical for cosmic rays)**
- Readout electronics: **SFE16 (ASD) + HPTDC**
- Typical spatial resolution: σ_χ**<50um (^{78}Kr@350MeV/u)**

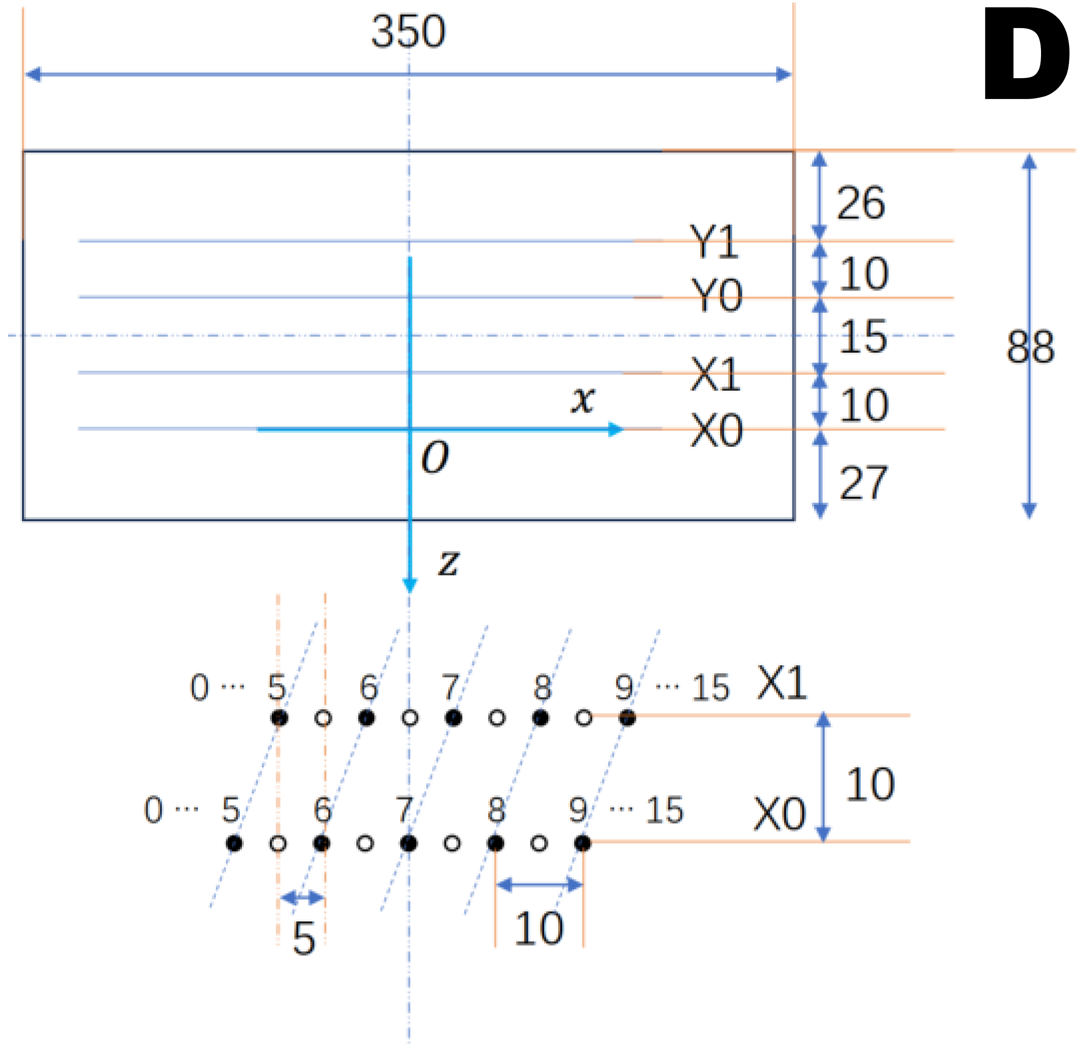
ASD: amplifier-shaper-discriminator

The Drift Chambers





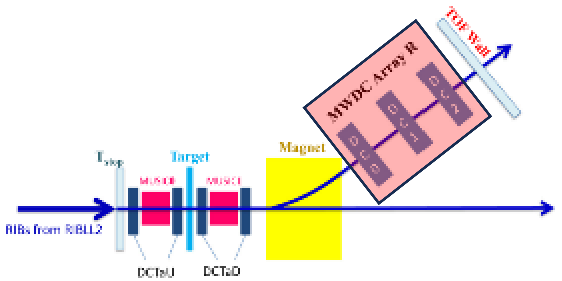
DCTaD

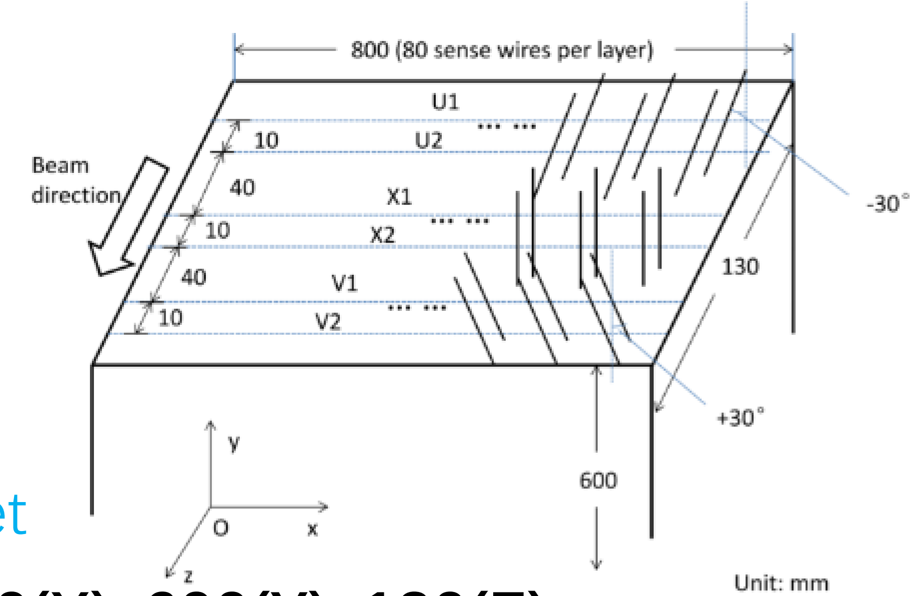


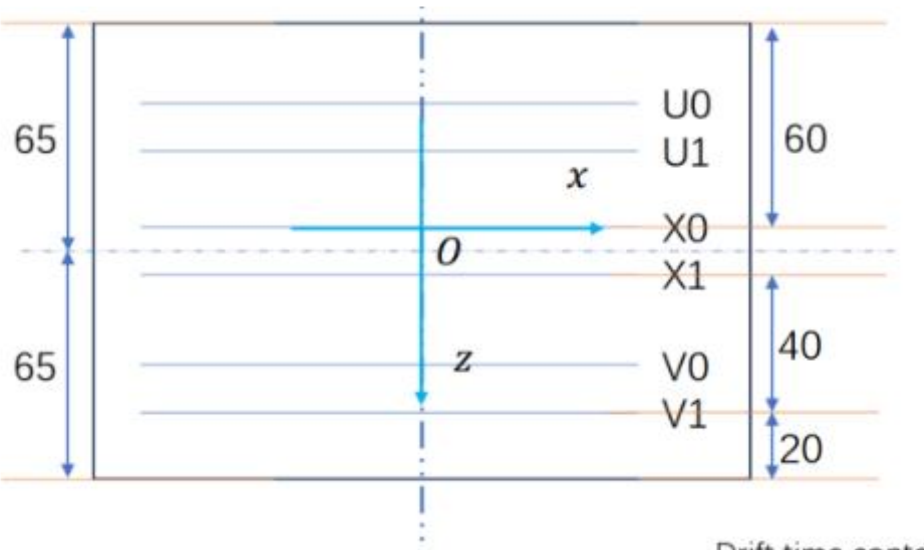
- Active Volume: **160(X)x160(Y)x88(Z)mm**
- Drift Length: **5mm**
- Sense wire configuration: **X0X1(0°), Y0Y1(90°)**
- Readout: **16x4=64ch**
- Operating gas: **80%Ar+20%CO_2 at atmospheric pressure**
- High voltage: **1300V (typical for cosmic rays)**
- Readout electronics: **SFE16 (ASD) + HPTDC**
- Typical spatial resolution: σ_χ**<100um (^{78}Kr@300MeV/u)**

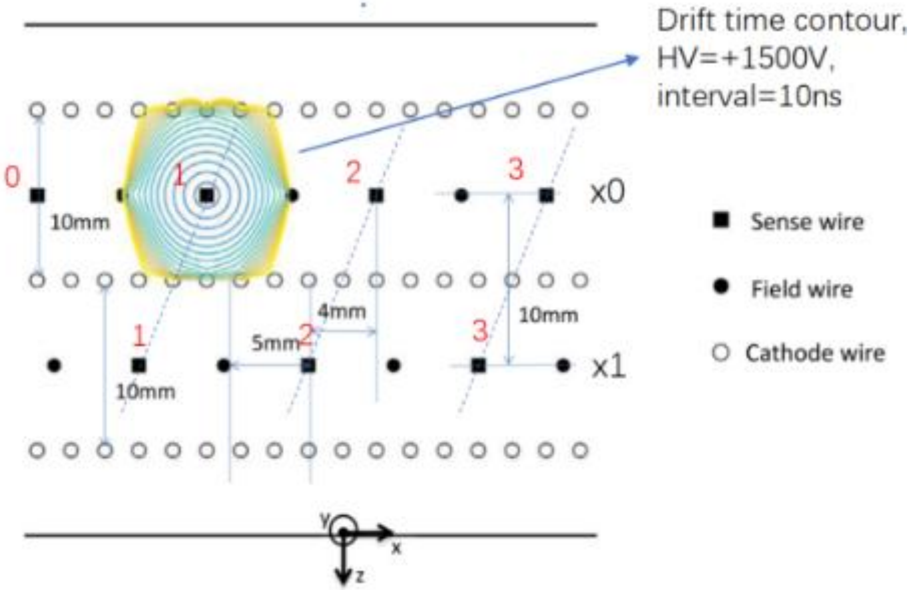
ASD: amplifier-shaper-discriminator

The Drift Chambers







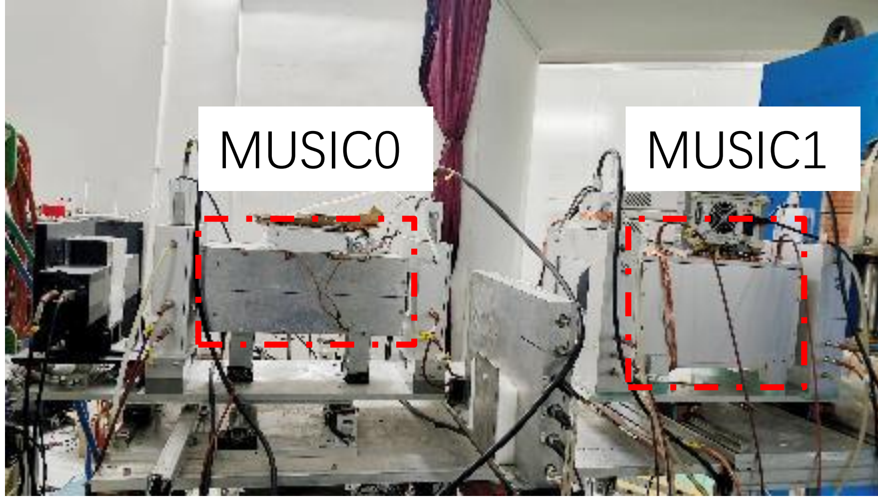


DC

– after dipole magnet

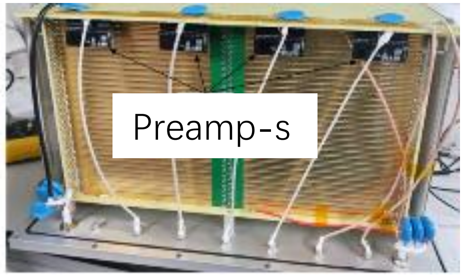
- Active Volume: **800(X)x600(Y)x130(Z)mm**
- Drift Length: **5mm**
- Sense wire configuration: **U0U1(-30°), X0X1(0°), V0V1(+30°)**
- Readout: **80x6=480ch**
- Operating gas: **80%Ar+20%CO_2 at atmospheric pressure**
- High voltage: **1500V (typical for cosmic rays)**
- Readout electronics: **SFE16 (ASD) + HPTDC**
- Typical spatial resolution: σ_χ~**230um ^{40}Ar@311MeV/nucleon**

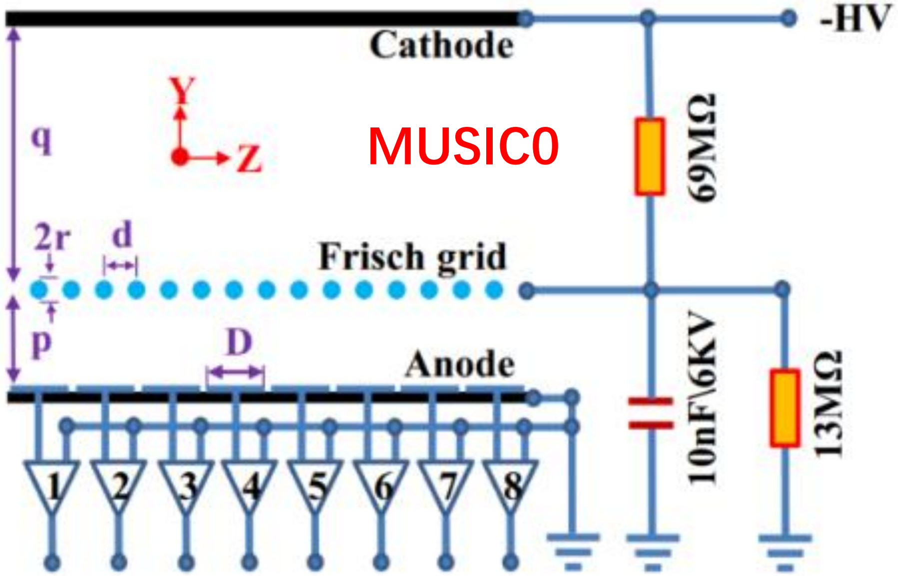
The MUSICs

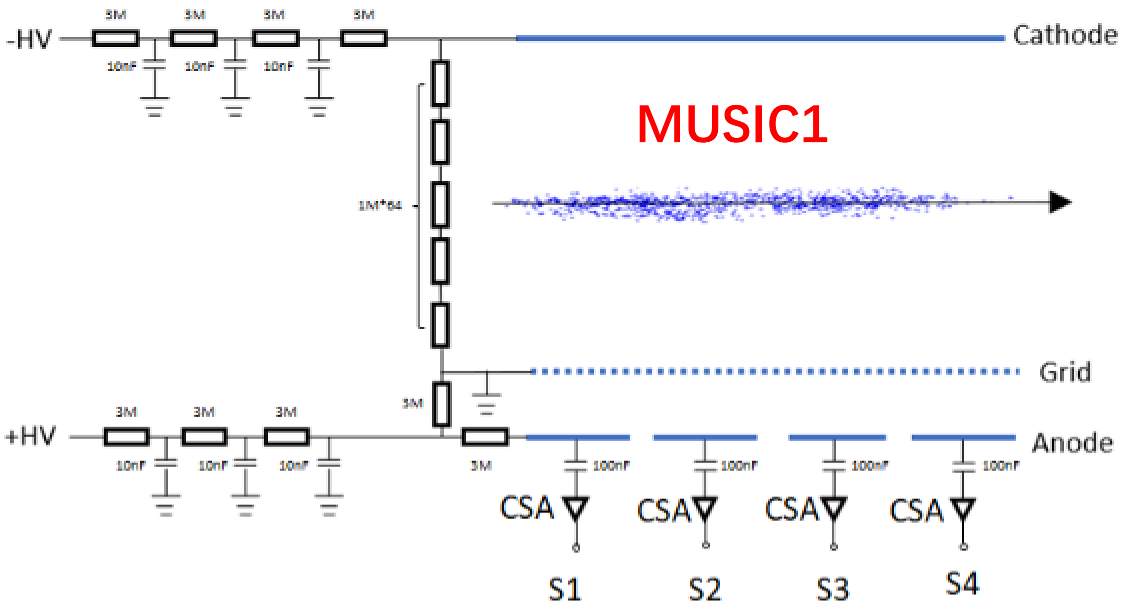


- MUSIC0 and MUSIC1 have similar structures.
  - ➢Readout: **self-R&D preamplifier** + **MSCF-16 spectroscopy amplifier+v785 ADC**
  - ➢Operating Gas: **P10**

	HV (V)	Active Volume (mm)
MUSIC0	**-1710**	**85(X)x85(Y)x380(Z)**
MUSIC1	**-3000**	**170(X)x170(Y)x320(Z)**

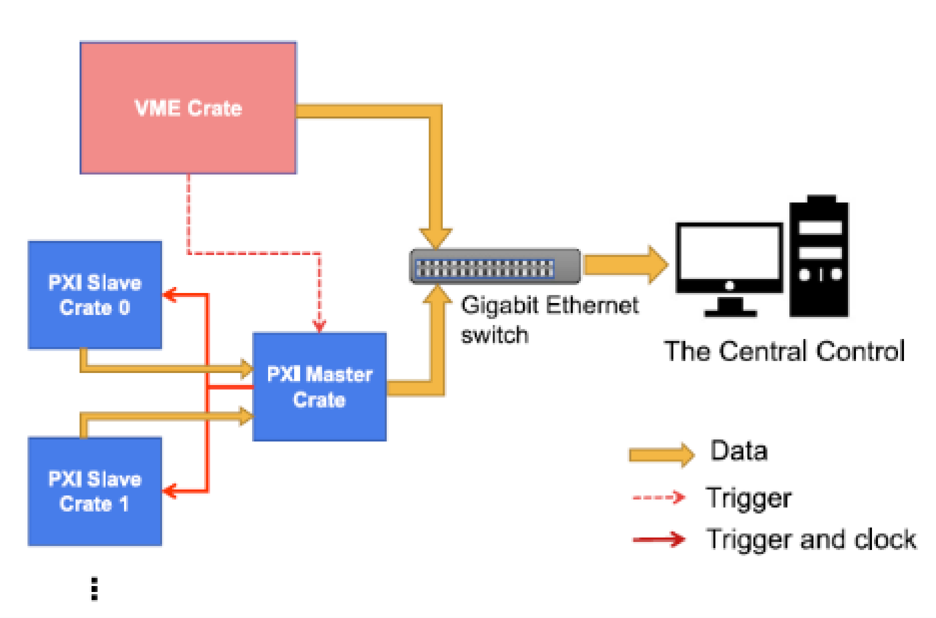


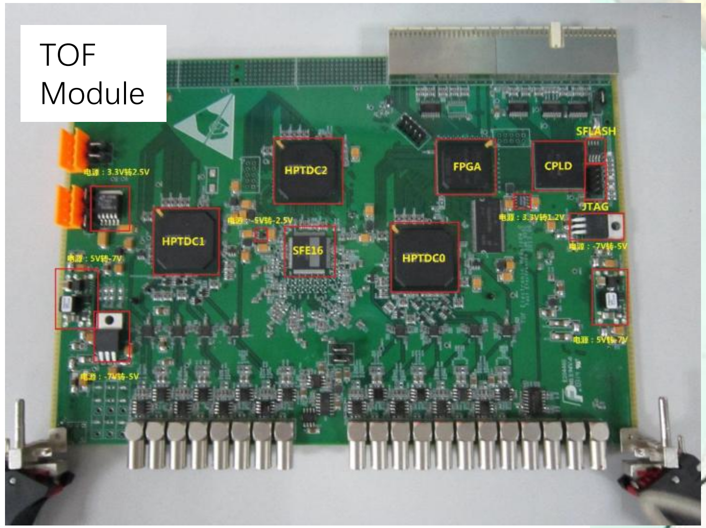


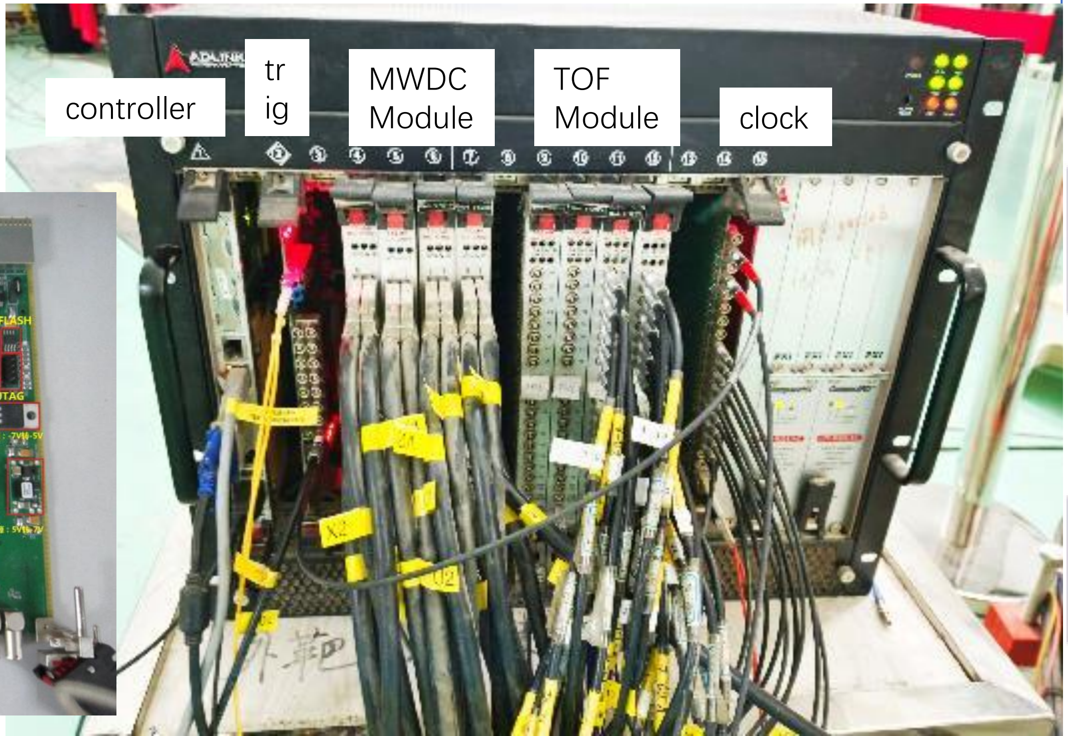


DAQ

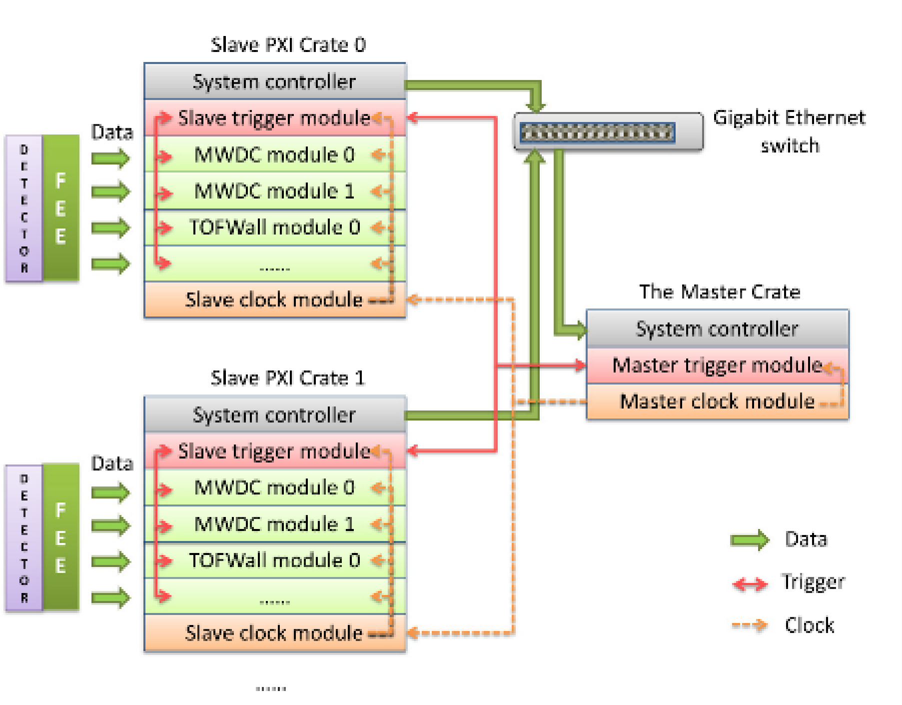
- Self-R&D PXI boards to drive HTPDC chips for DAQ of timing of TOF and MWDC detectors (by ***FELAB*** of USTC)
- Highly integrated
- Working in synchronization with a VME DAQ for MUSICs using global triggers
- Typical data rate: ~2500 events/s







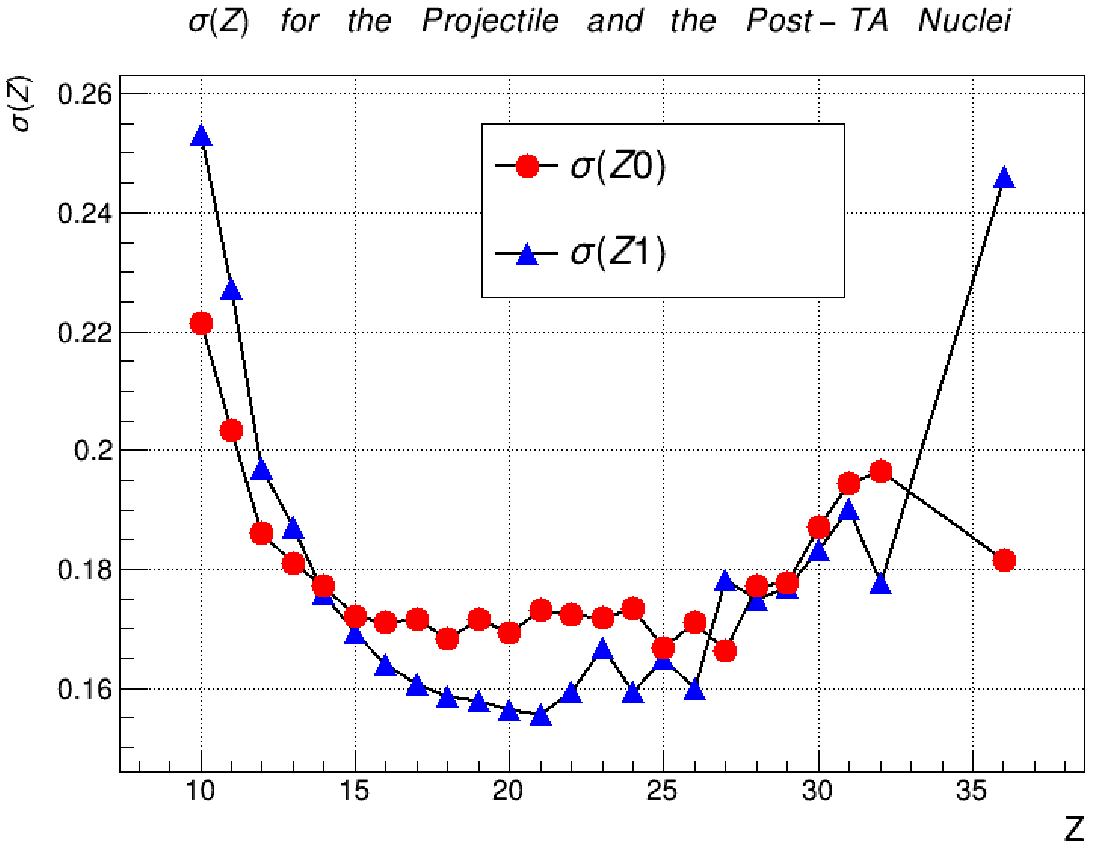
Nuclear Inst. and Methods in Physics Research, A 894 (2018) 72–80

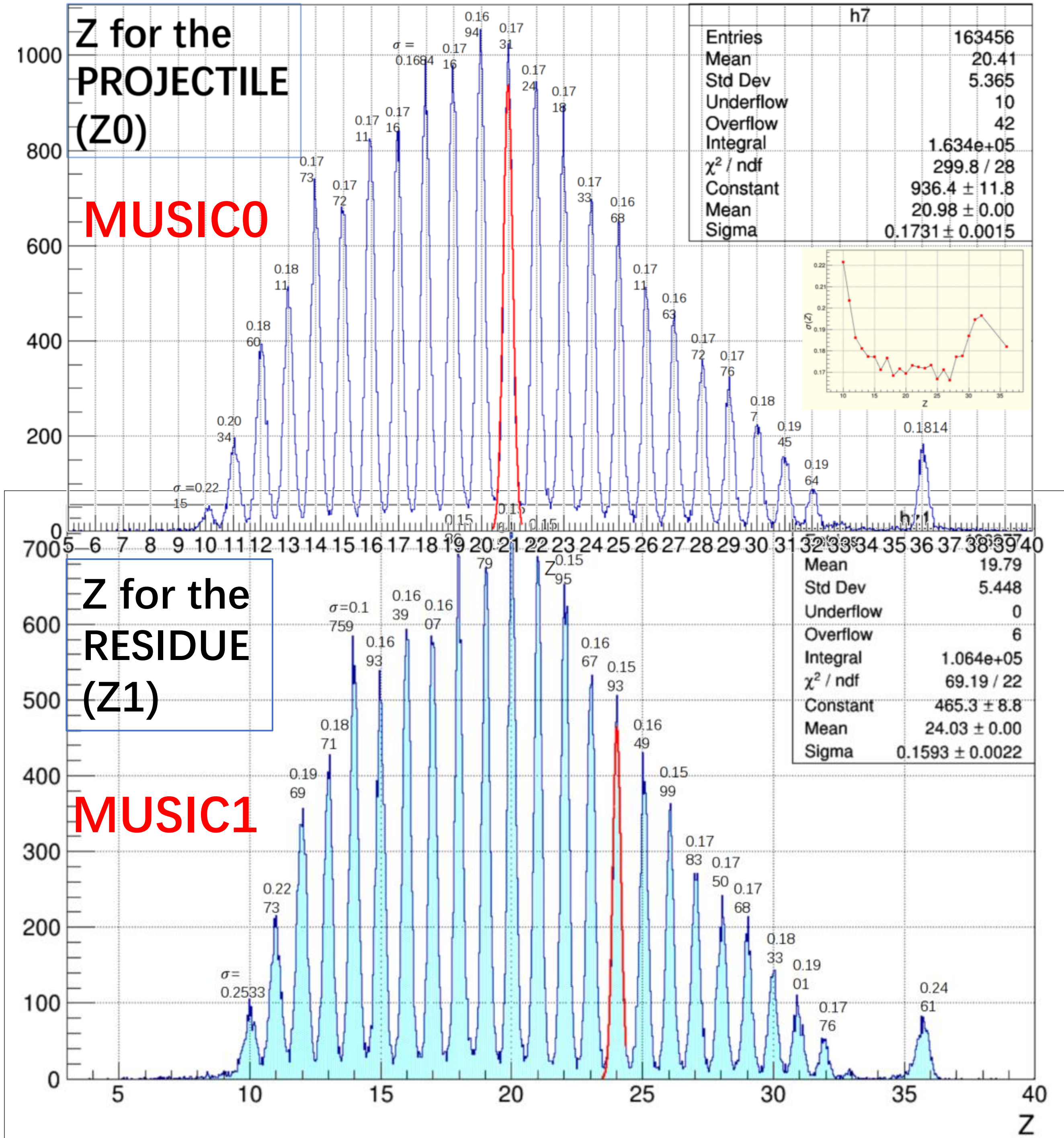


Z Resolution

With 2ndary beams from ^{78}Kr@350MeV/u -> 10mm Be

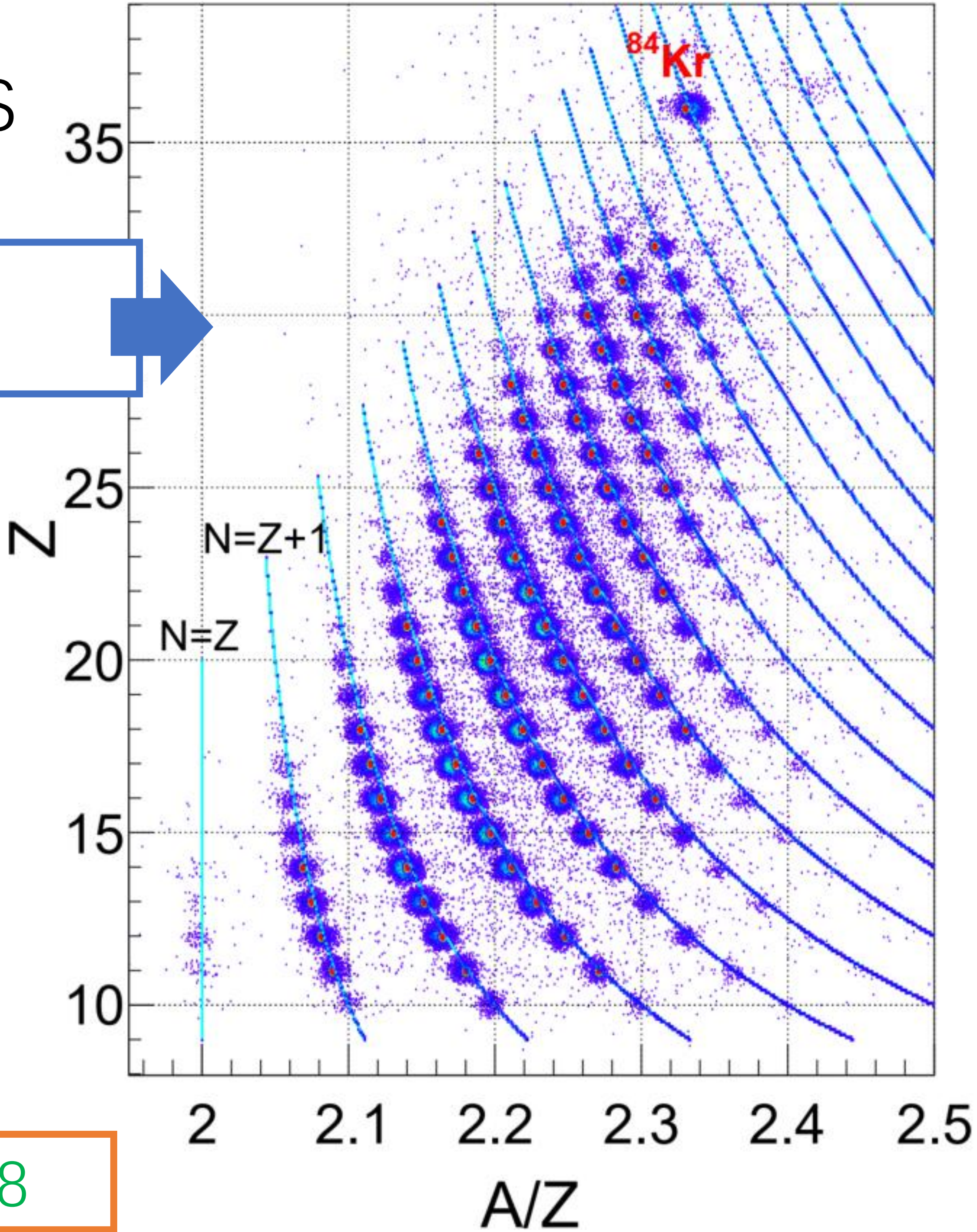
The Z resolution of the new MUSIC1 is slight better than the old MUSIC0.

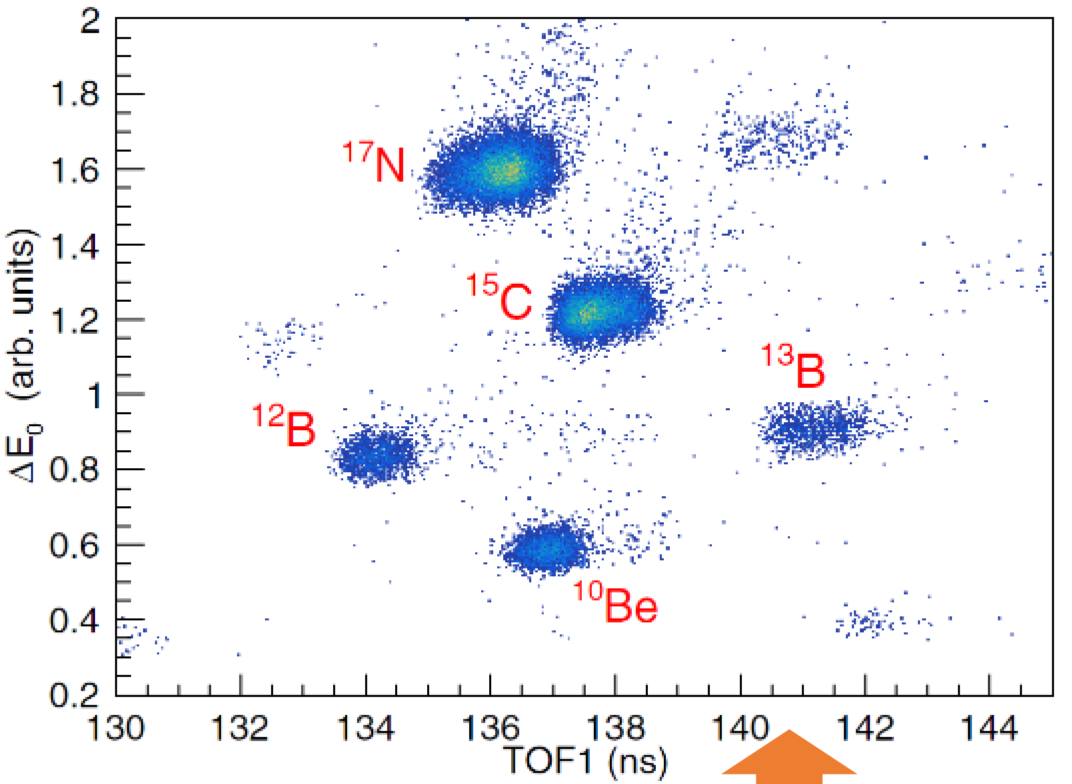




RIBLL2 PID of 2ndary Beams

- **350MeV/u ^{78}Kr** → 10mmBe @ Jun., 2024
  - *Position correction has been applied to Bρ in RIBLL2*

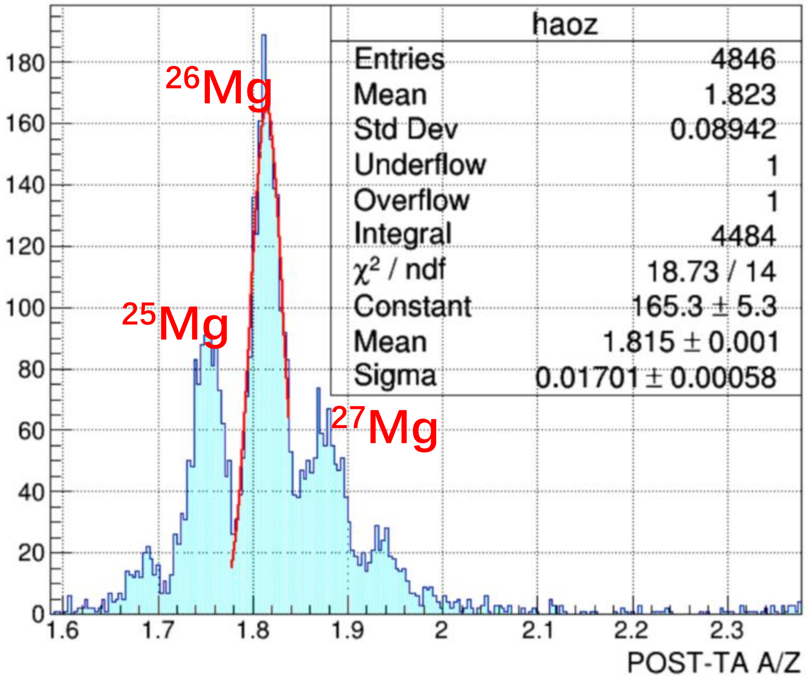




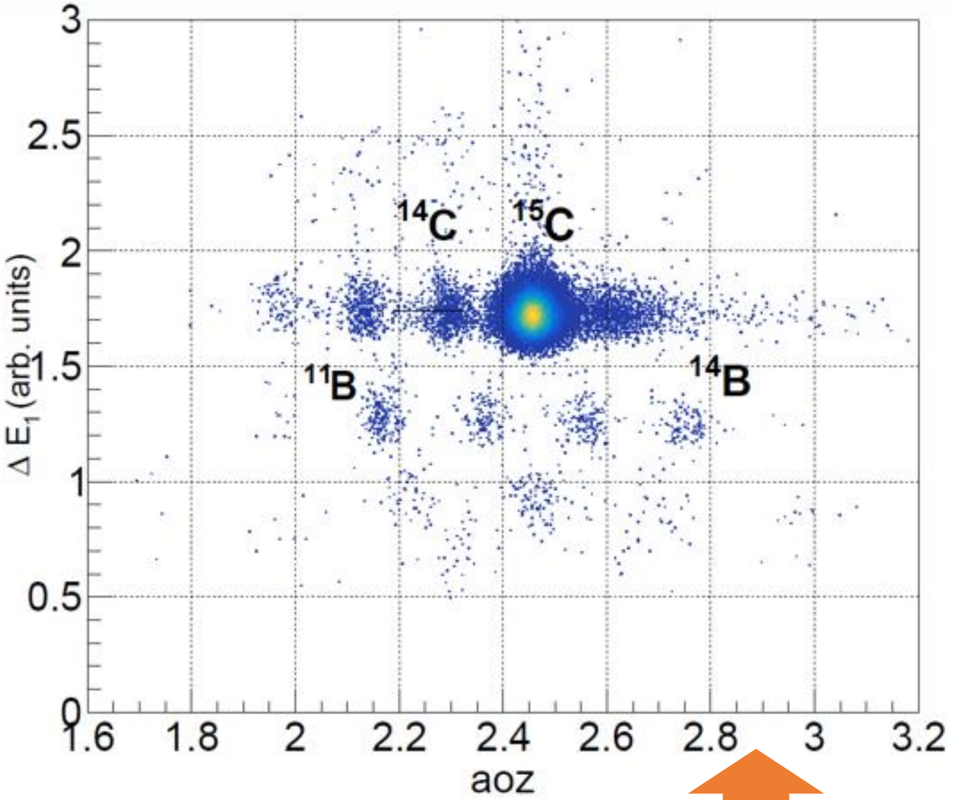
- **240MeV/u ^{18}O** → 15mmBe @ Jul., 2018

PID of ETF for reaction residues

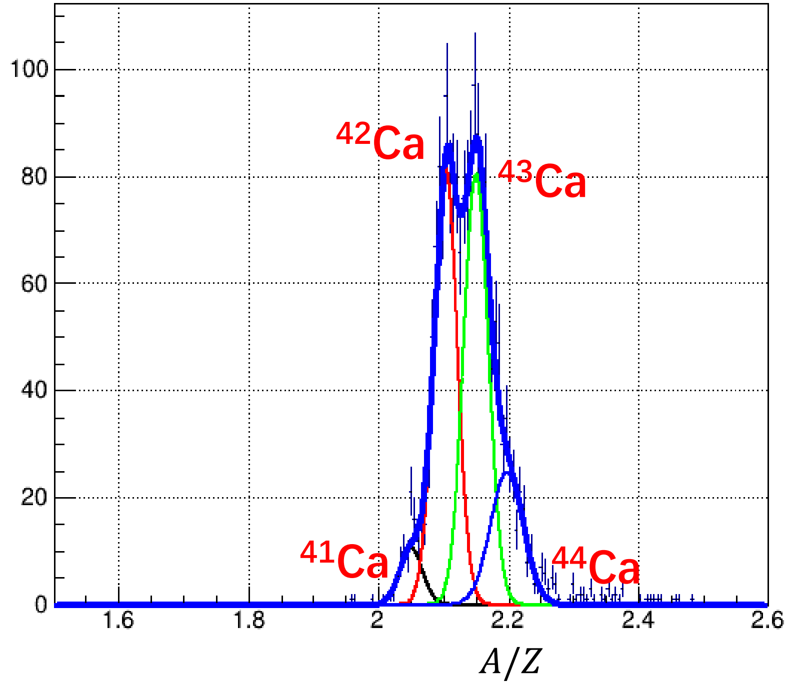
350MeV/u ^{78}Kr → 10mmBe @ Jun., 2024



$\sigma_{A/Z} \sim 0.02$



- Z~5: 😄
- Z~12: 😊
- Z~20: 😳

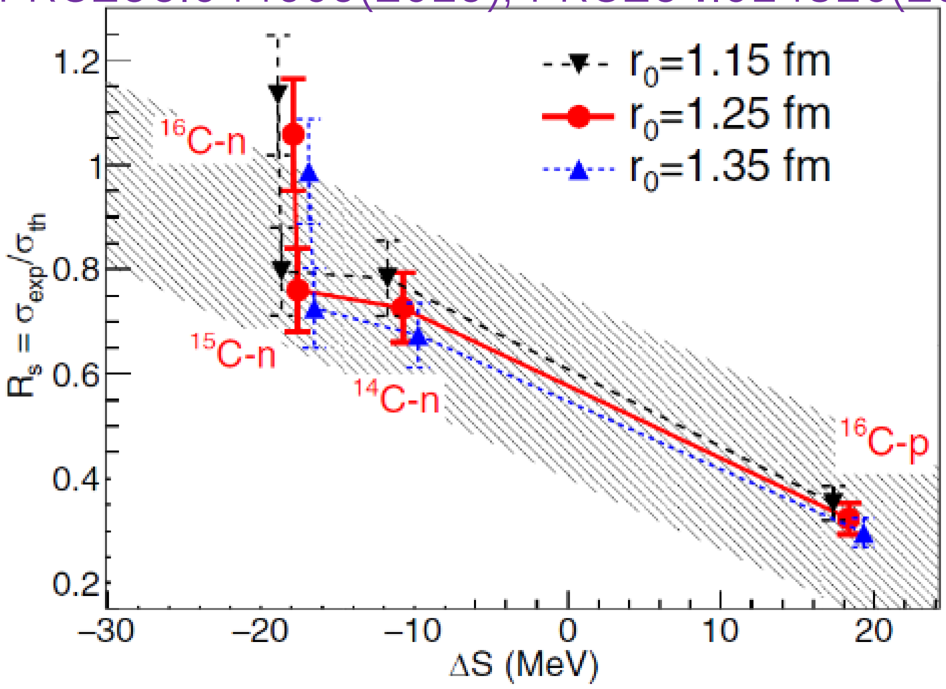


- **239MeV/u ^{16}C** → 5mmC @ Jul., 2018

Recently Developments in Physics Study

1. Confirming that the reduction R_s of spectroscopic factors still drops roughly linearly with regard to the binding depth ΔS of the removed nucleon at beam energies > **230 MeV/nucleon in one-nucleon removal reactions**.

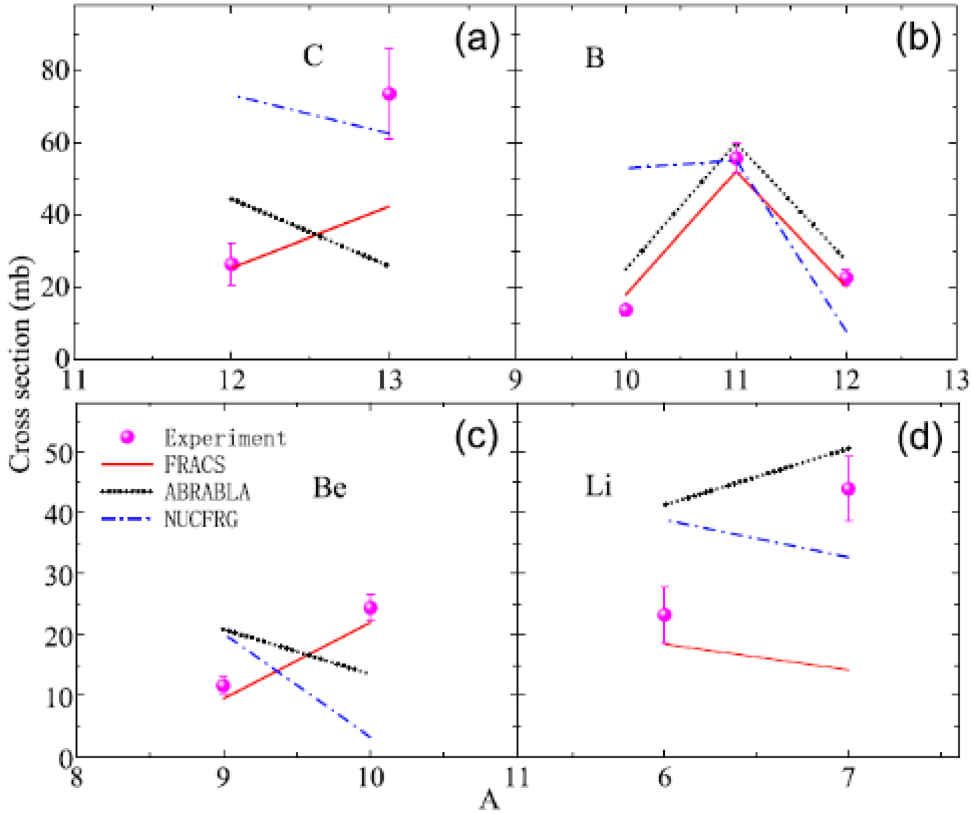
[PRC**100**.044609(2019), PRC**104**.014310(2021)]



Reduction of the Spectroscopic factor v.s. binding depth of the removed nucleon [PRC**104**.014310(2021)]

2. A myriad of **fragmentation cross sections** of stable and neutron-rich C,N and O beams at around 230 ~ 260MeV/nucleon are extracted systematically, which compare well with results from other labs in general, and provide useful benchmarking for fragmentation models.

[CPC**46**.014003(2022), CPC**46**.111001(2022), PRC**108**.034602(2023)] (CPC: Chin. Phys. C)

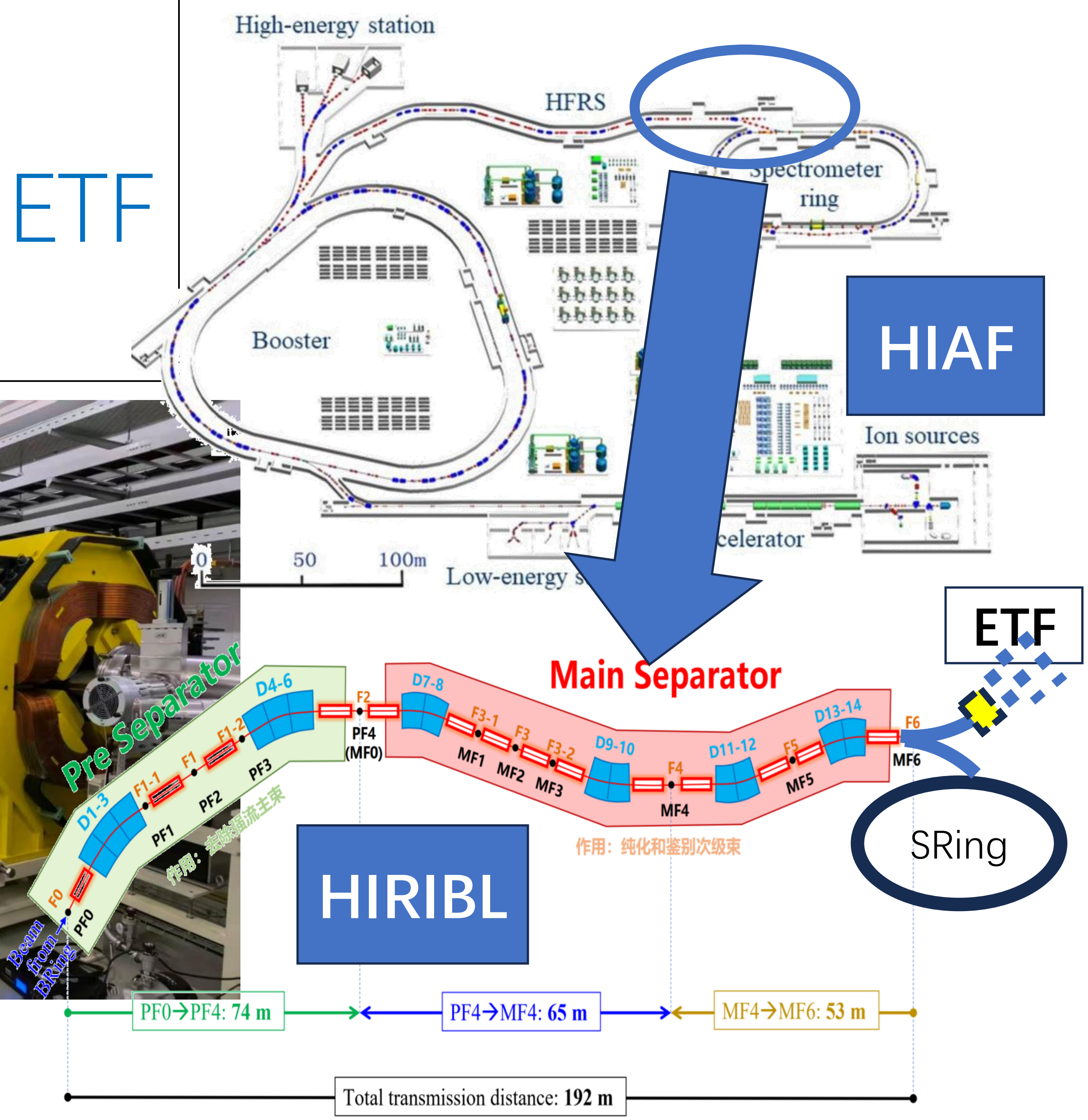


C.S. of ^{14}O fragmentation products at 240MeV/nucleon measured in ETF [PRC**108**.034602 (2023)]

Future plan:

limited exps at RIBLL2-ETF

More at HIRIBL



THANKS