Development of the STARK detector for nuclear reaction studies

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Motivation

▪ **Transfer reactions in nuclear physics**

In center of mass frame

target — beam → recoil, ejectile θ

Ex) (d,p), (d,n), (^{6}Li,d) …
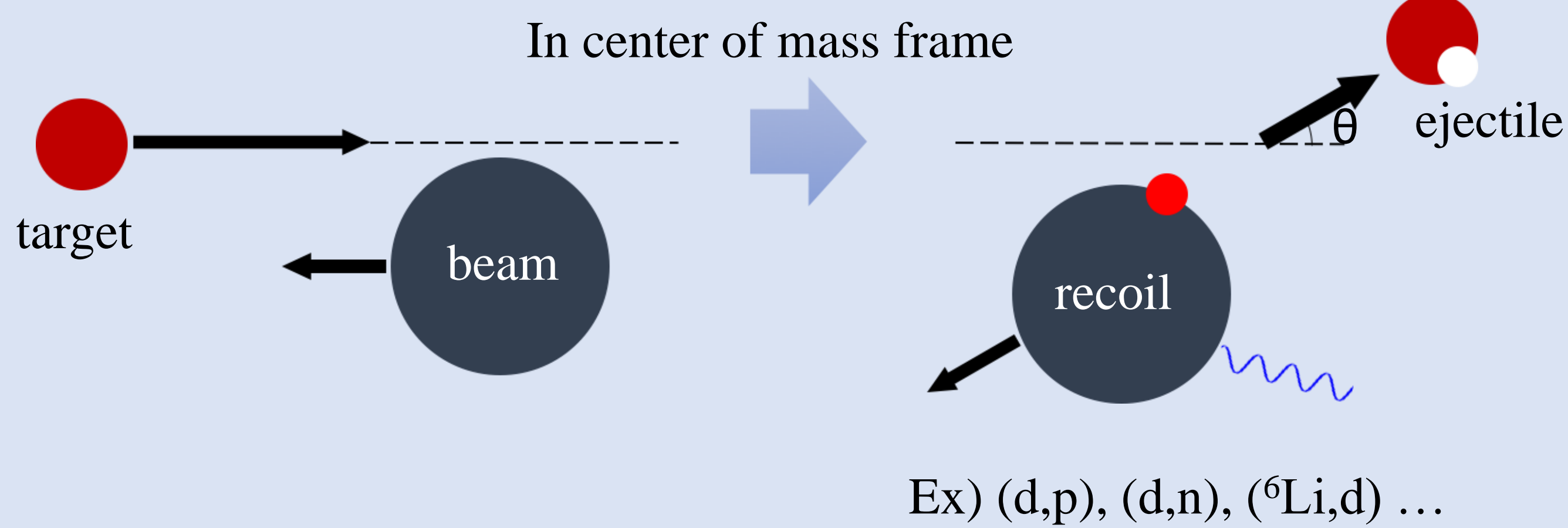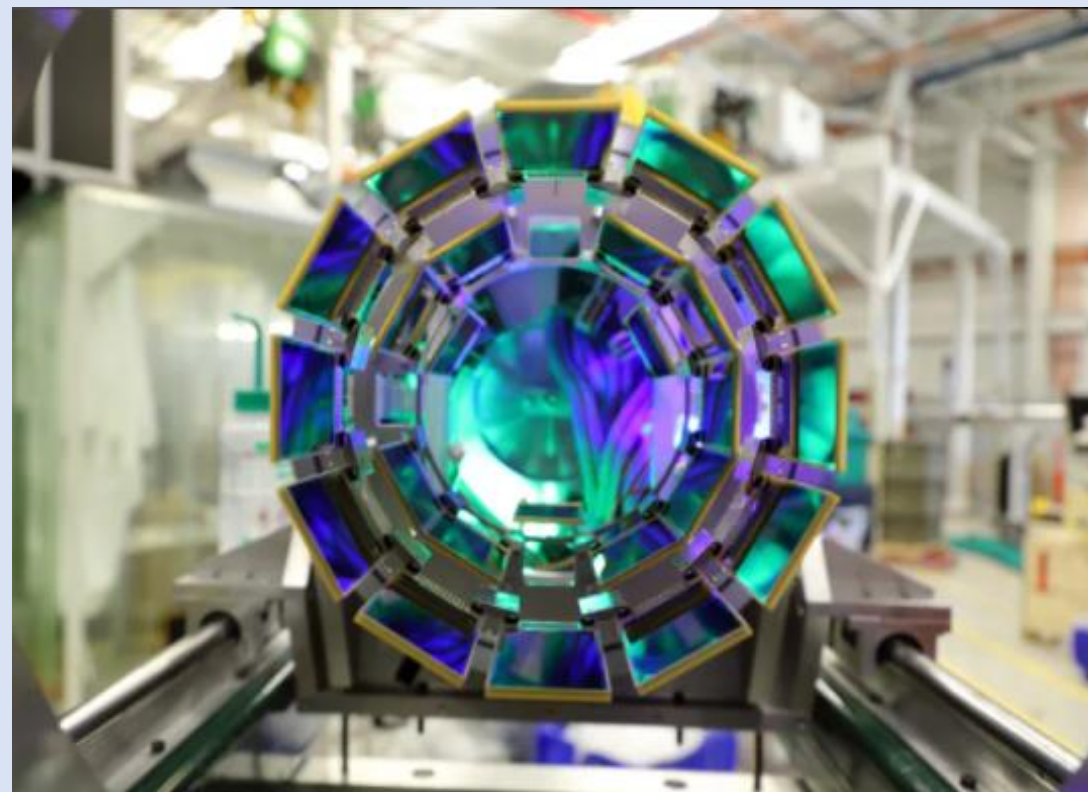
- One of the powerful experimental method to study nuclear reactions
- An ejectile reflects the properties of residual nucleus
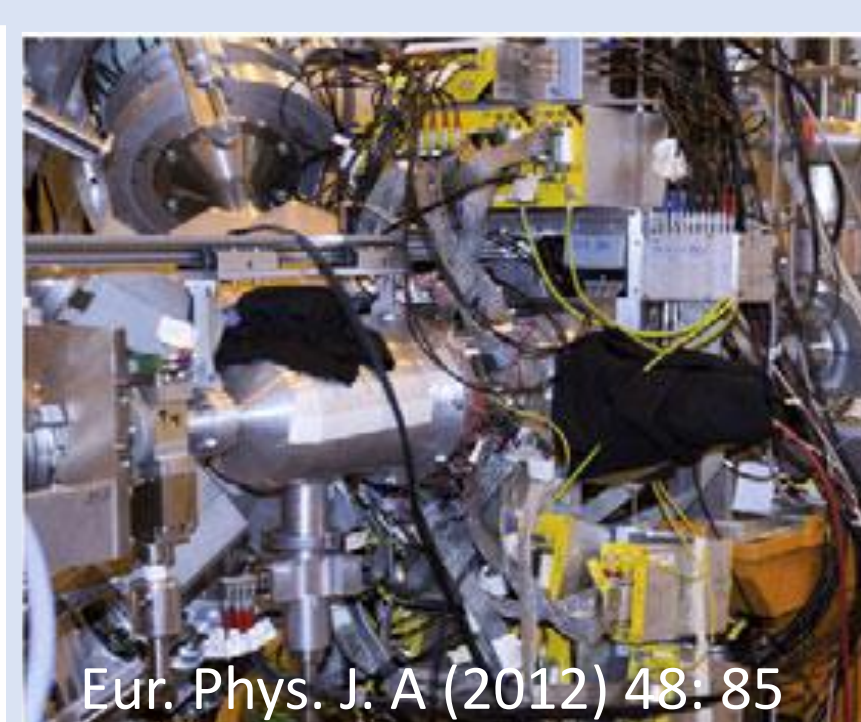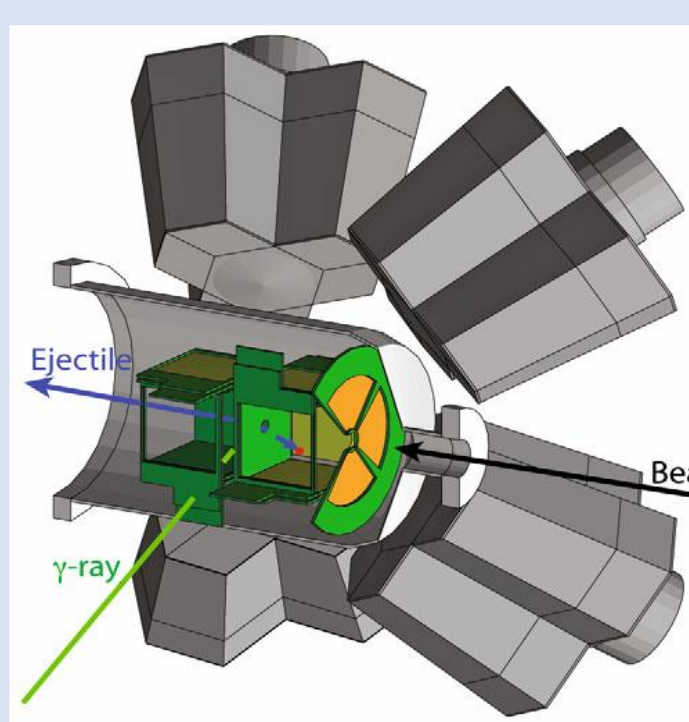- Measure energy, angular momentum, cross-section, spectroscopic factor

▪ **Silicon telescope array for reaction studies in the world**
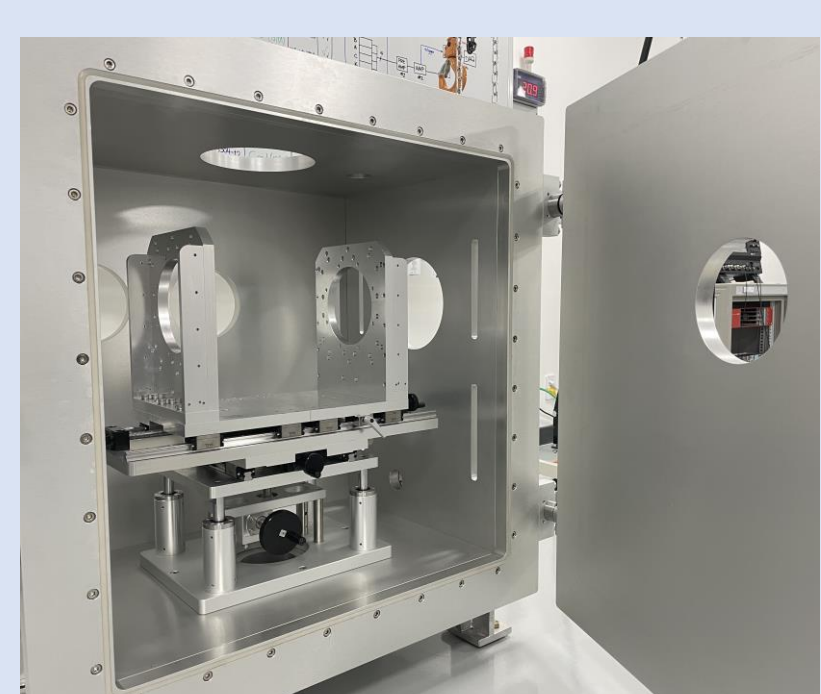
ORRUBA (+ GRETINA), ORNL

https://orruba.org/orruba/
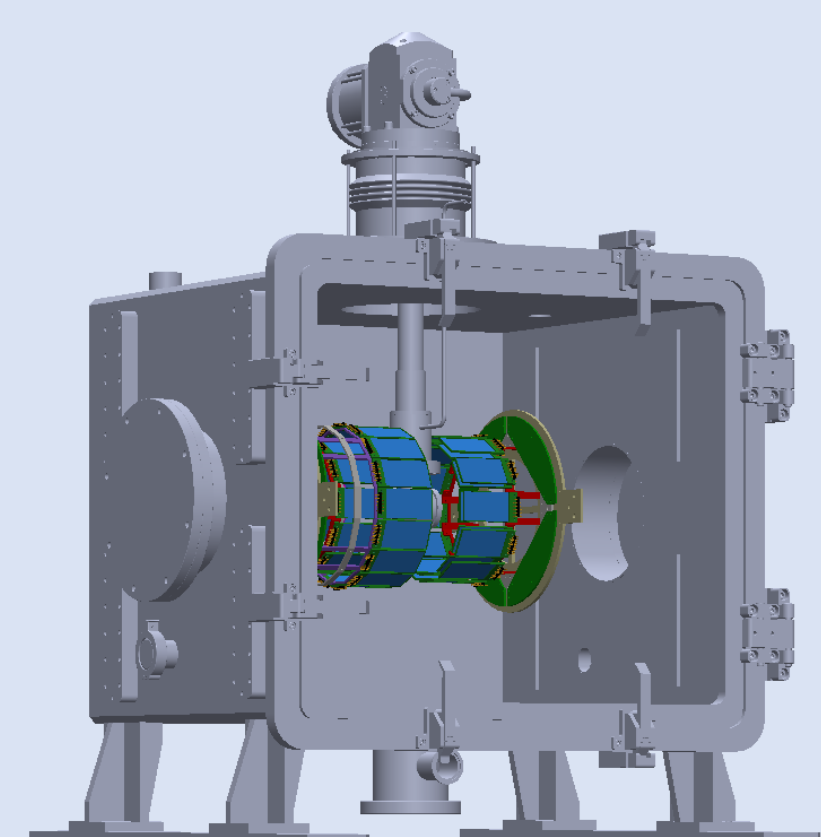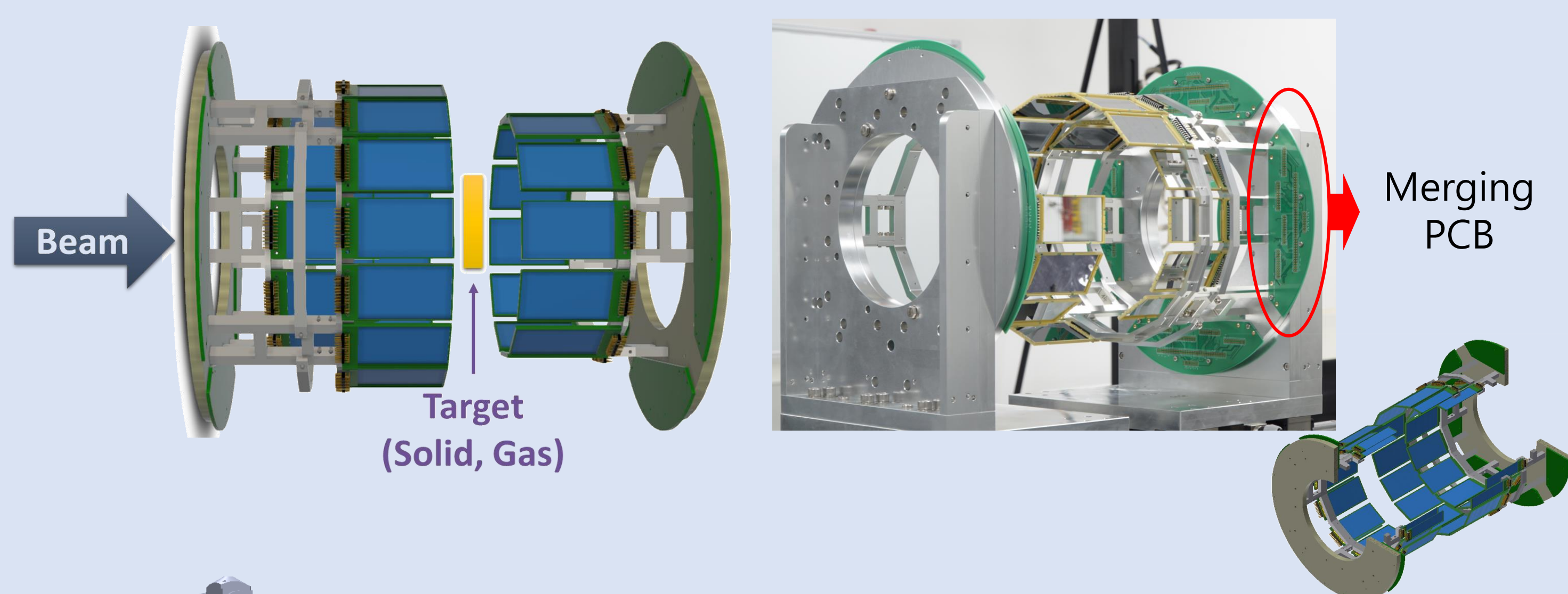
SHARC (+ TIGRESS), TRIUMF   T-REX (+ Miniball), ISOLDE

https://www.physics.uoguelph.ca/tigress
JINST 6, P02005

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Detector design

STARK
(**S**ilicon **T**elescope **A**rray for **R**eaction in inverse **K**inematics)

Beam → Target (Solid, Gas)   Merging PCB

- Charged particle detection from collision $(E, \vec{p})$
- Barrel type array, 12(12) + 16 + 12 sided ring
- Φ = 92.5, 118.8, 107 mm, 28.4 mm gap for target
- $\Delta\theta_{lab} < 1°$ expected with wide coverage
 (43˚ ~ 78˚, 105˚ ~ 150˚)
  Newly designed resistive silicon strip detector, **X6**
- **New merging PCB was designed for simple cabling**
- Useful for many rare isotope facilities (ex. RIKEN, FRIB and RAON)

Designed STARK chamber

Detector Assembly & Simulation

- STARK supporting frame was designed for barrel shape positioning
- Solid target will be installed at the center of supporting frame
- STARK frames can be moved to forward and backward direction for changing detector angle coverage
- NP-tool is a Monte-Carlo simulation package for low-energy nuclear physics experiment based on GEANT4
- NP-tool simulation was performed for predicting energy deposition, detector geometrical efficiency and particle identification
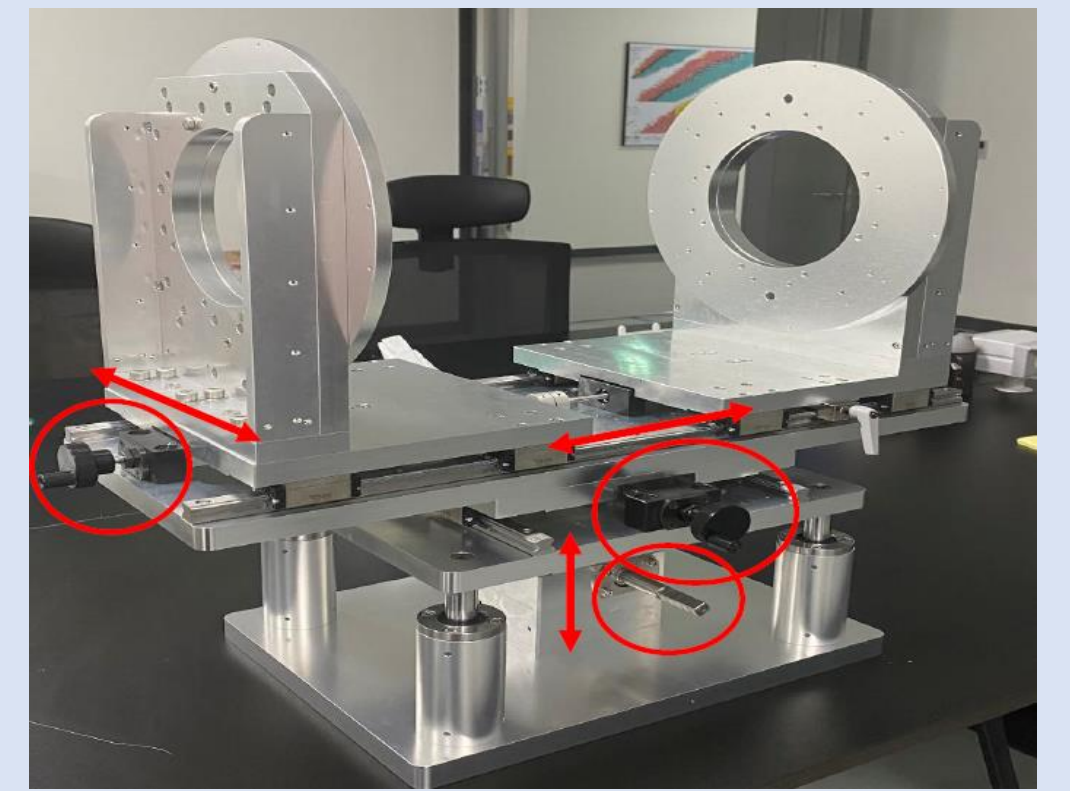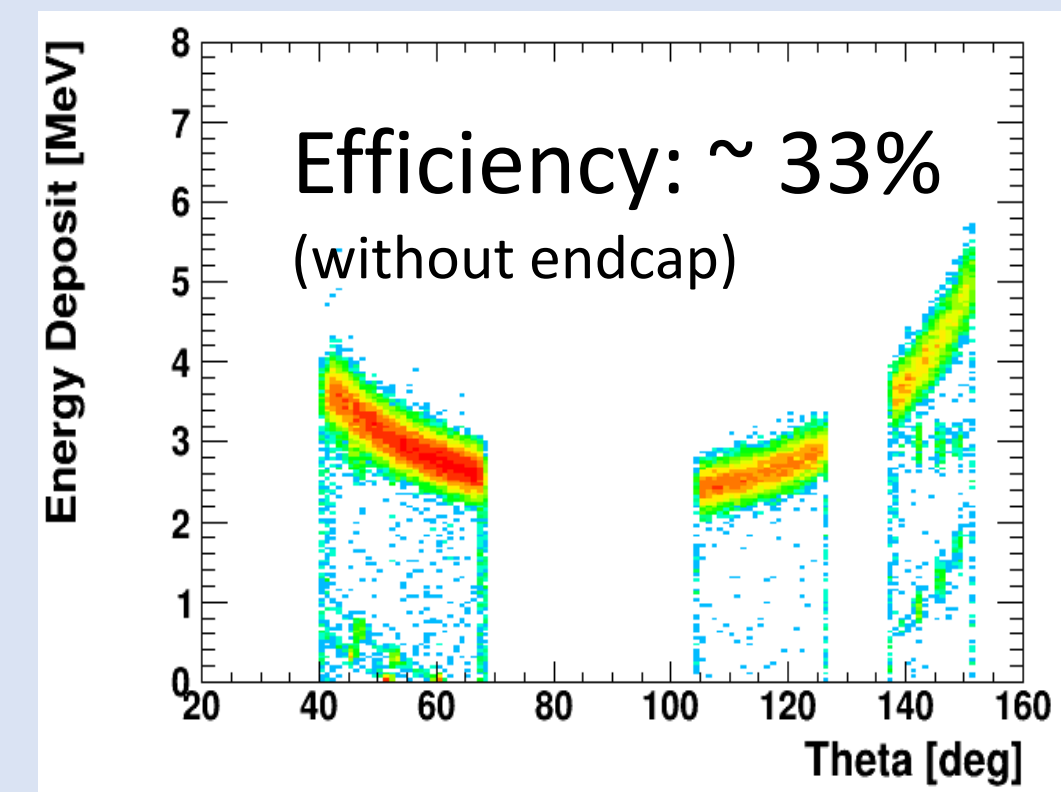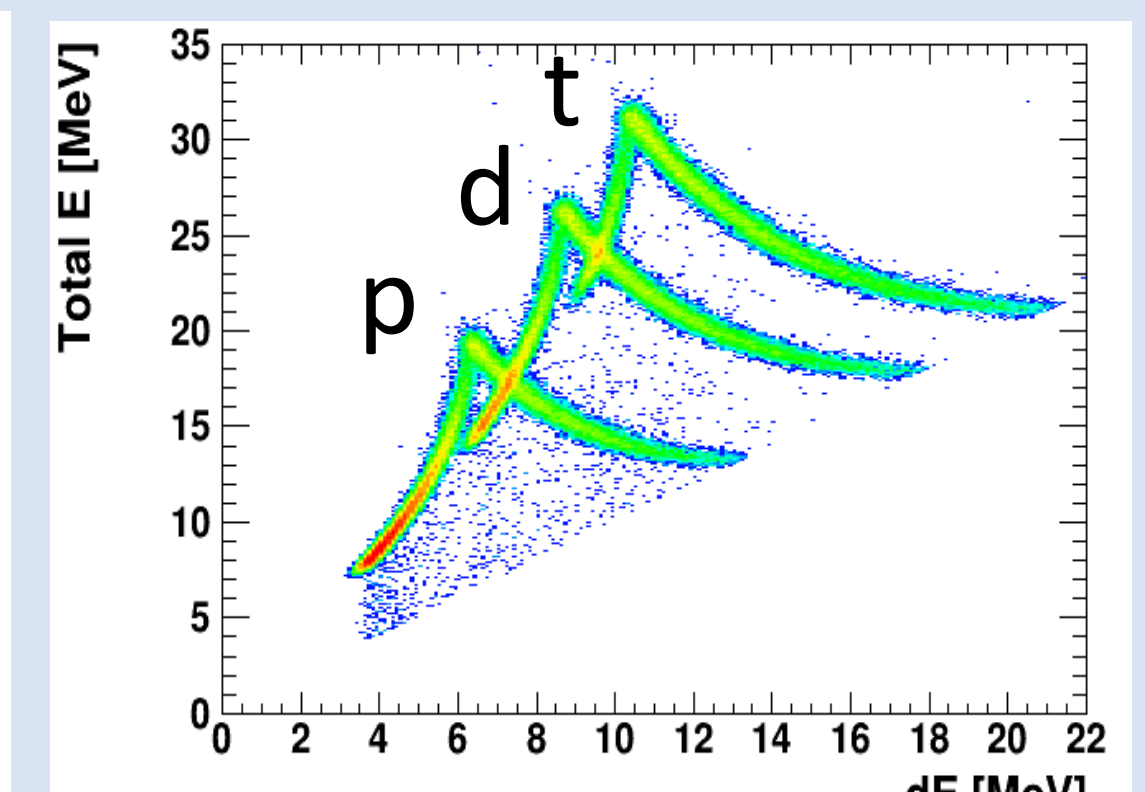

STARK supporting frame
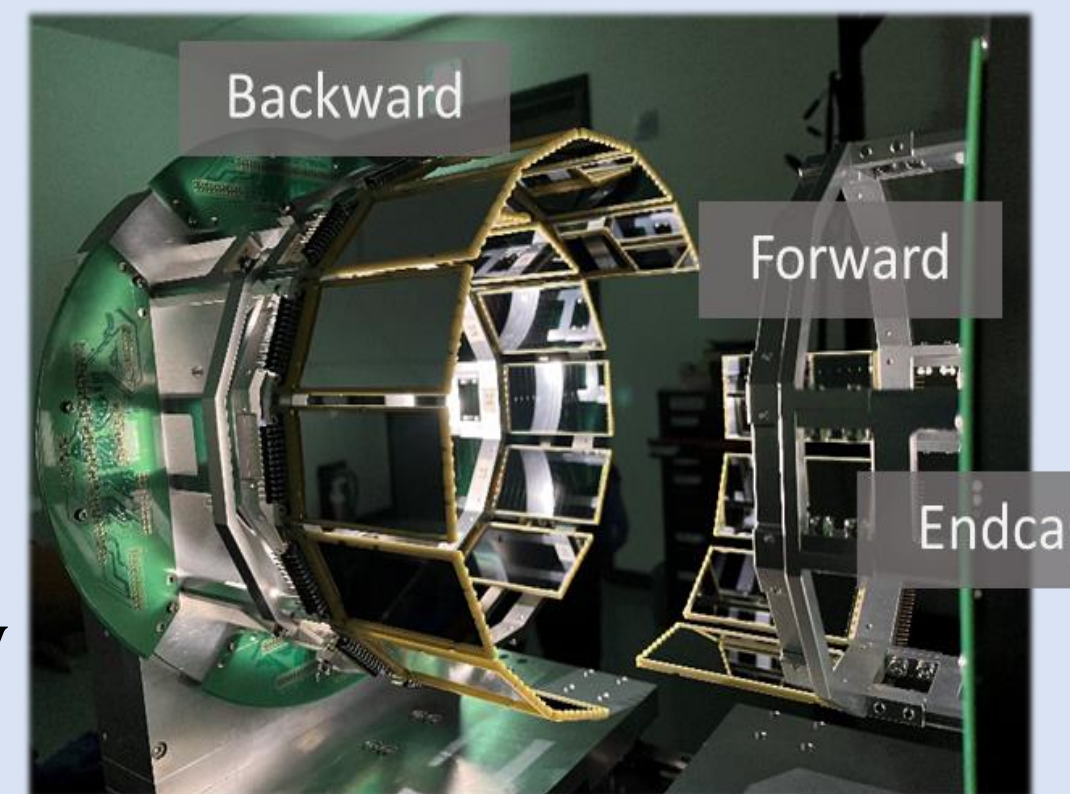
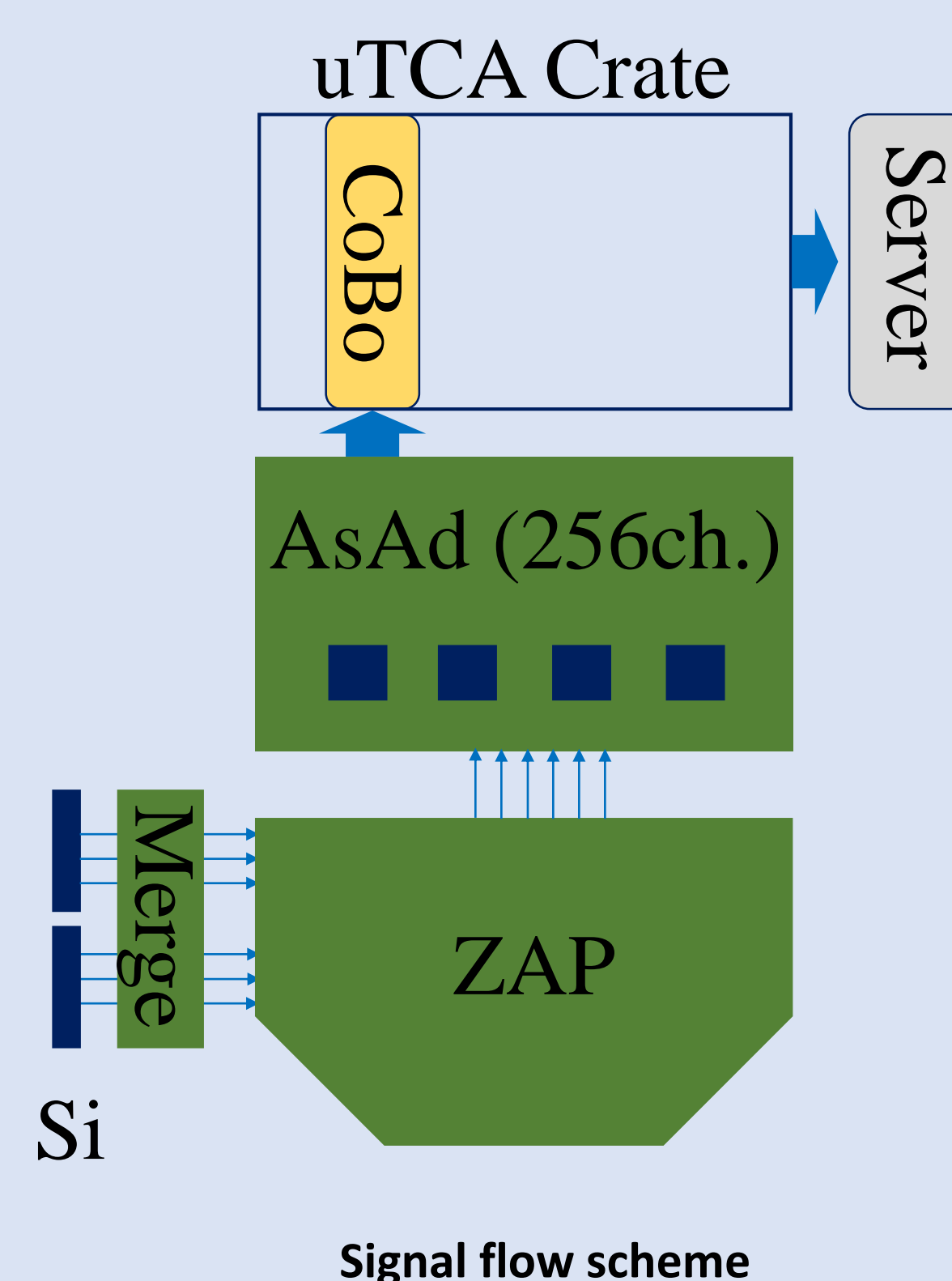STARK assembly
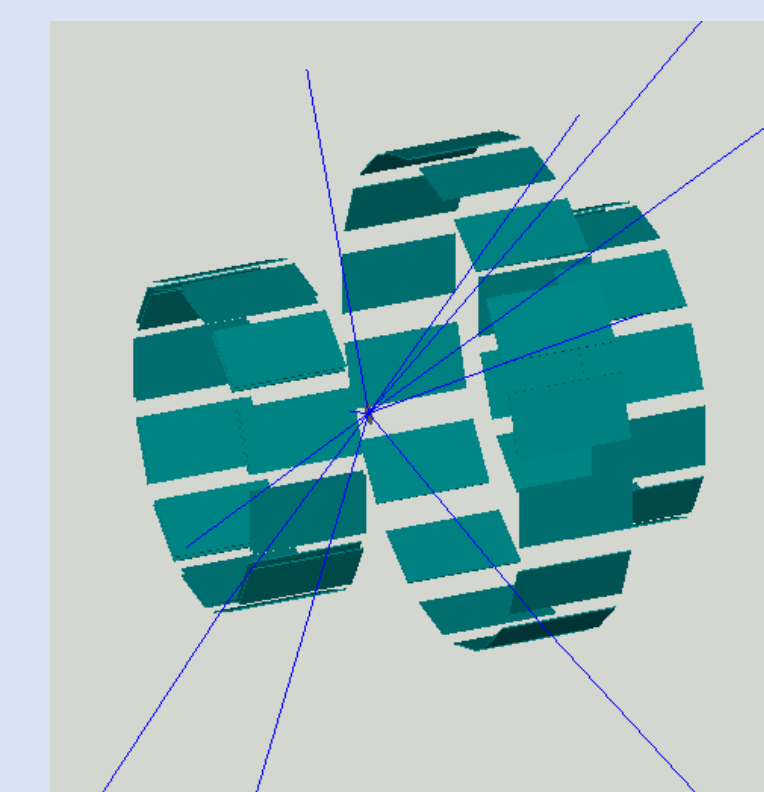
STARK geometry with NP-tool

Simulation result for angle coverage

Efficiency: ~ 33%
(without endcap)

Simulation result for the PID plot

DAQ system

uTCA Crate — CoBo — Server

AsAd (256ch.)

ZAP

Merge — Si

Signal flow scheme

- Electronics: GET system based on ASIC
- Merging board is designed for combining silicon detector signals
- ZAP is a multi-purpose board which is designed by CENS (biasing & bridging)
- The AsAd board is composed of four AGET chips
- Single AGET chip handles 64 channels of the silicon detector
- One CoBo module covers 4 AsAd boards (1024 channels for the silicon detector)
- 2 CoBo modules & 8 AsAd boards will be used for the STARK DAQ system

ZAP board & AsAd board assembly

uTCA & CoBo module
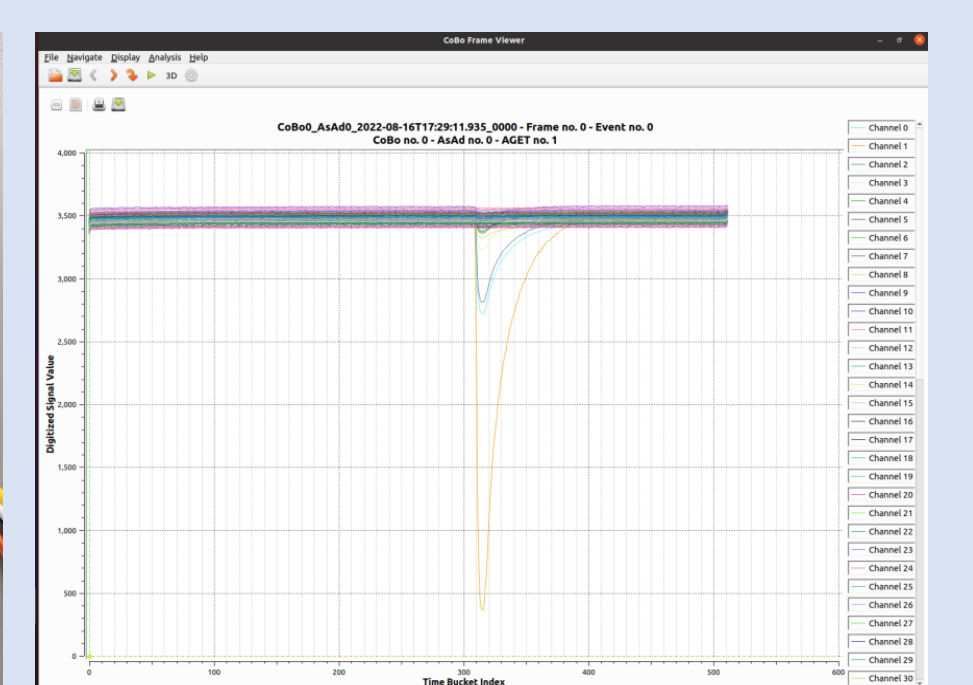
Signal test with CoBo

Current status & Future plan

- X6 detectors were prepared and the performance test is on going.
- Geant4 simulation with np-tool is ongoing.
- Detector and DAQ test are on going.
- ZAP and Merging board will be upgraded.
- System commissioning is planned on 2023.
- Single side silicon detector will be developed by CENS until 2023.

Acknowledgement