EMIS 2022
October 3 - 7, 2022 | Science Culture Center, IBS

Proof of Principle of Newly Installed Second Arm at VAMOS++ Spectrometer

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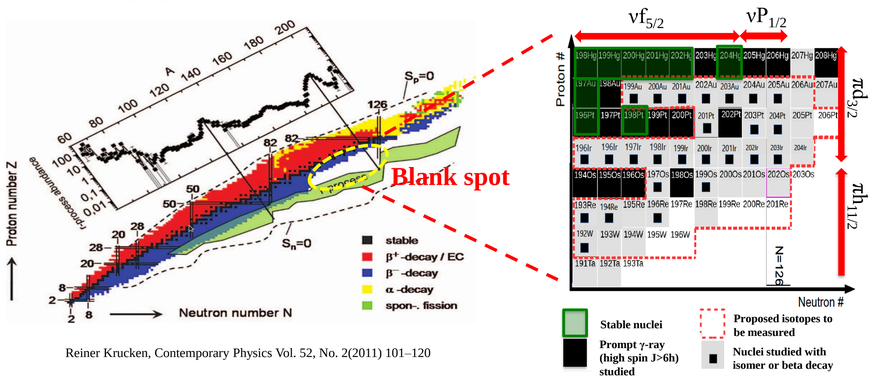
Motivation

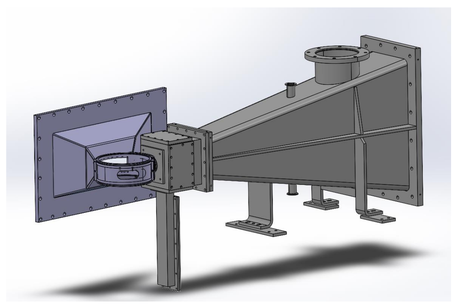


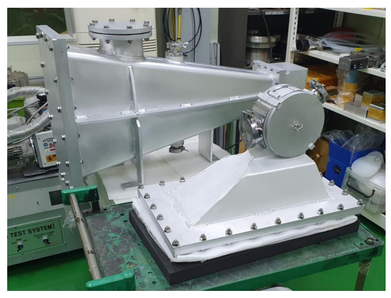
Reiner Krucken, Contemporary Physics Vol. 52, No. 2(2011) 101–120

Accessing "Blank Spot" below ^{208}Pb

- Study Evolution of nuclear structure N~126 shell closured neutron rich nuclei, relevant to nuclear-astrophysical r-process
- Difficult to access by conventional reaction mechanism methods (fragmentation, fission, fusion)
- Approach using multi-nucleon transfer reaction between 7MeV/u ^{136}Xe beam on ^{198}Pt target

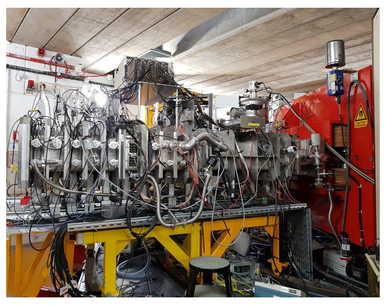
Necessity of the Second Arm





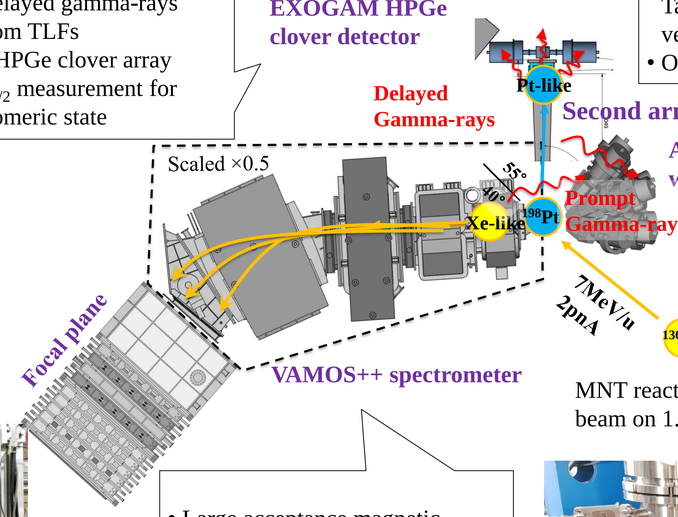
- Projectile-like fragments (PLFs) are fully identified by VAMOS++ spectrometer
- The nuclides of interested are on target-like fragments (TLFs) difficult to identify directly
- Many isomeric states in TLF nuclides exists
- Additional setup for TLFs→ **Second arm!**
- Velocity and TOF of TLFs are measured by second arm to calculate excitation energy and mass before neutron evaporation
- Measurement can help TLFs identification and reaction mechanism study

Experimental Setup



Focal plane of the VAMOS++ spectrometer

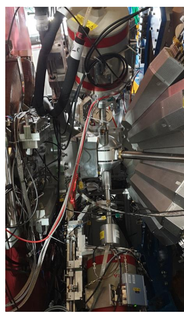
- Delayed gamma-rays from TLFs
- 4 HPGe clover array
- $T_{1/2}$ measurement for isomeric state



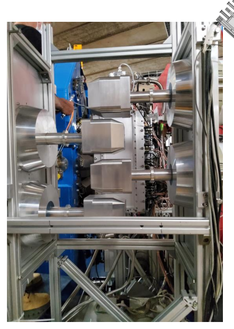
- Direct measurement of Target-like fragments (TLFs) velocity
- One MWPC (TOF, X&Y)

- Prompt gamma-rays form PLFs and TLFs
- 39 crystals with nominal configuration

MNT reaction of 7MeV/u ^{136}Xe beam on 1.3mg/cm^2 ^{198}Pt target

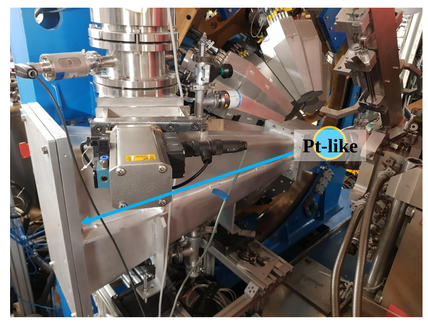


AGATA tracking array



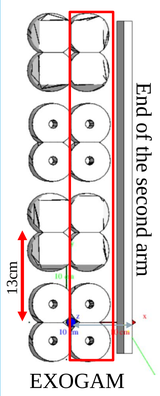
EXOGAM clover detector

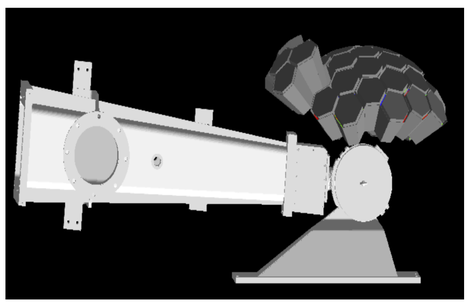
- Large acceptance magnetic spectrometer
- Direct detection of Projectile-like fragments(PLFs)
- Two MWPCs (TOF, X&Y)
- Segmented IC (IC[0]~IC[6])
- Ion track reconstruction (Bρ, Path)

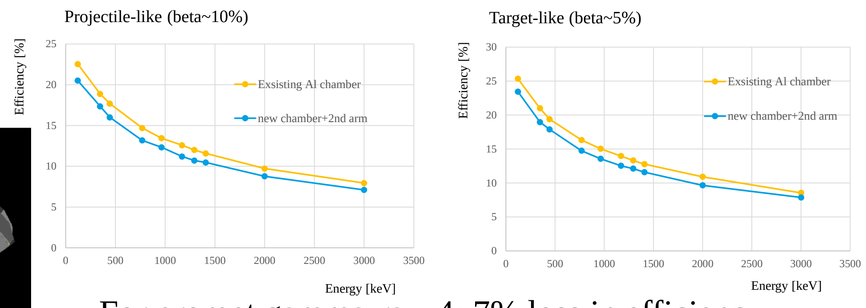


Second arm and AGATA

Second Arm Simulation

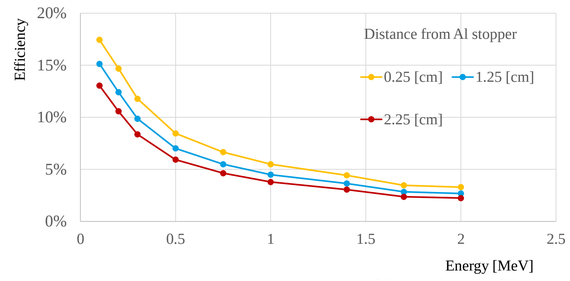






- A new setup developed in SNU, for TLFs detection
- Composed of vacuum chamber with multi-wire proportional counter
- GEANT4 simulation verifying second arm can be used for this experiment

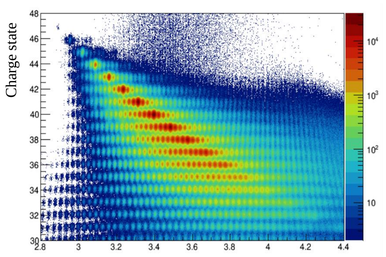
For prompt gamma-ray, 4~7% loss in efficiency compared to original setup, and it is not crucial loss

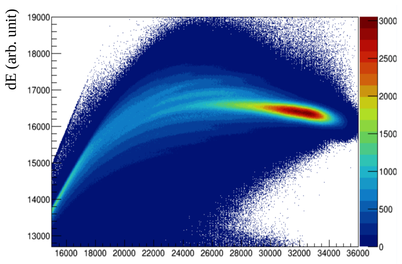


For delayed gamma-ray, sufficient efficiency for the experiment

Experimental Result

1) Ion distribution



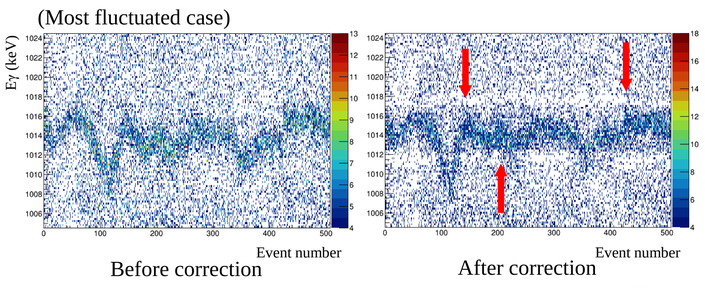


Projectile-like fragments are well identified for preliminary result (Q/ΔQ ~ 80, M/ ΔM ~ 210)

- Charge states and mass numbers are identified using machine learning (Y. Cho)

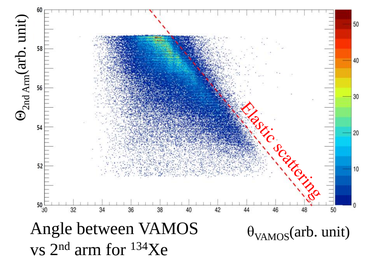
2) Energy Calibration & Time correction

(Most fluctuated case)



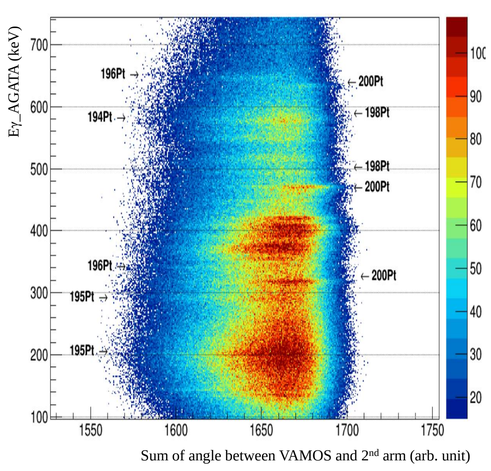
- The gain of EXOGAM crystal changes slightly over time
- Event-by-event correction using reference energy E_{ref}, change gain slowly using weight w as $w\cdot(E_{ref}/E)$ if event counts near E_{ref}

3) Second arm angular correlation



- Clear angular correlation between PLF and TLF
- MNT-(Quasi-elastic vs deep inelastic) observed

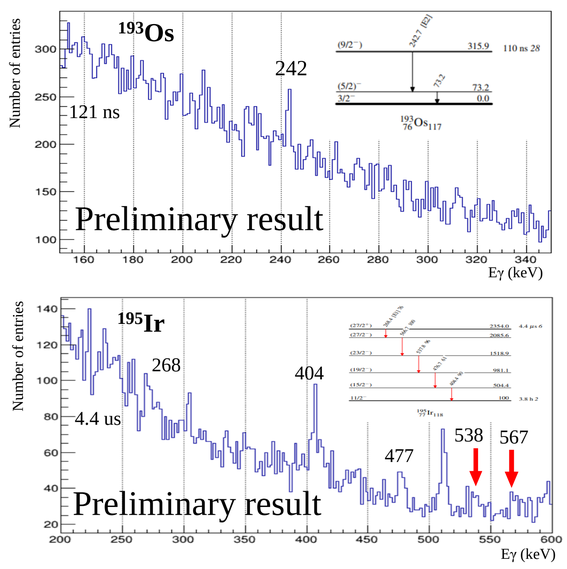
4) E* Selection



Preliminary result

- Prompt gamma-rays from TLFs when PLF is selected as ^{134}Xe, detected by AGATA
- By neutron evaporation, other TLF peaks beside ^{200}Pt are observed
- Angle sum of PLF and TLF is proportional to E*, and different isotopes are separated according to angle sum

5) Isomer results less exotic side



- Delayed gamma-rays from the decay of isomeric states of TLFs stopped at the end of the second arm, detected by EXOGAM
- Peaks from **^{195}Ir** and **^{193}Os** decay scheme was observed at n-evaporation channels (2n,3n respectively)

Summary

- Second arm was developed to detect target-like fragment difficult to identify directly
- By GEANT4 simulation, it is verified that second arm is available for experiment
- Proof of principle demonstrated by preliminary result with ion detection at MWPC and prompt and delayed gamma rays from target-like fragment