2022 Low Energy RI Research Workshop

Optical model potential studies at KoBRA

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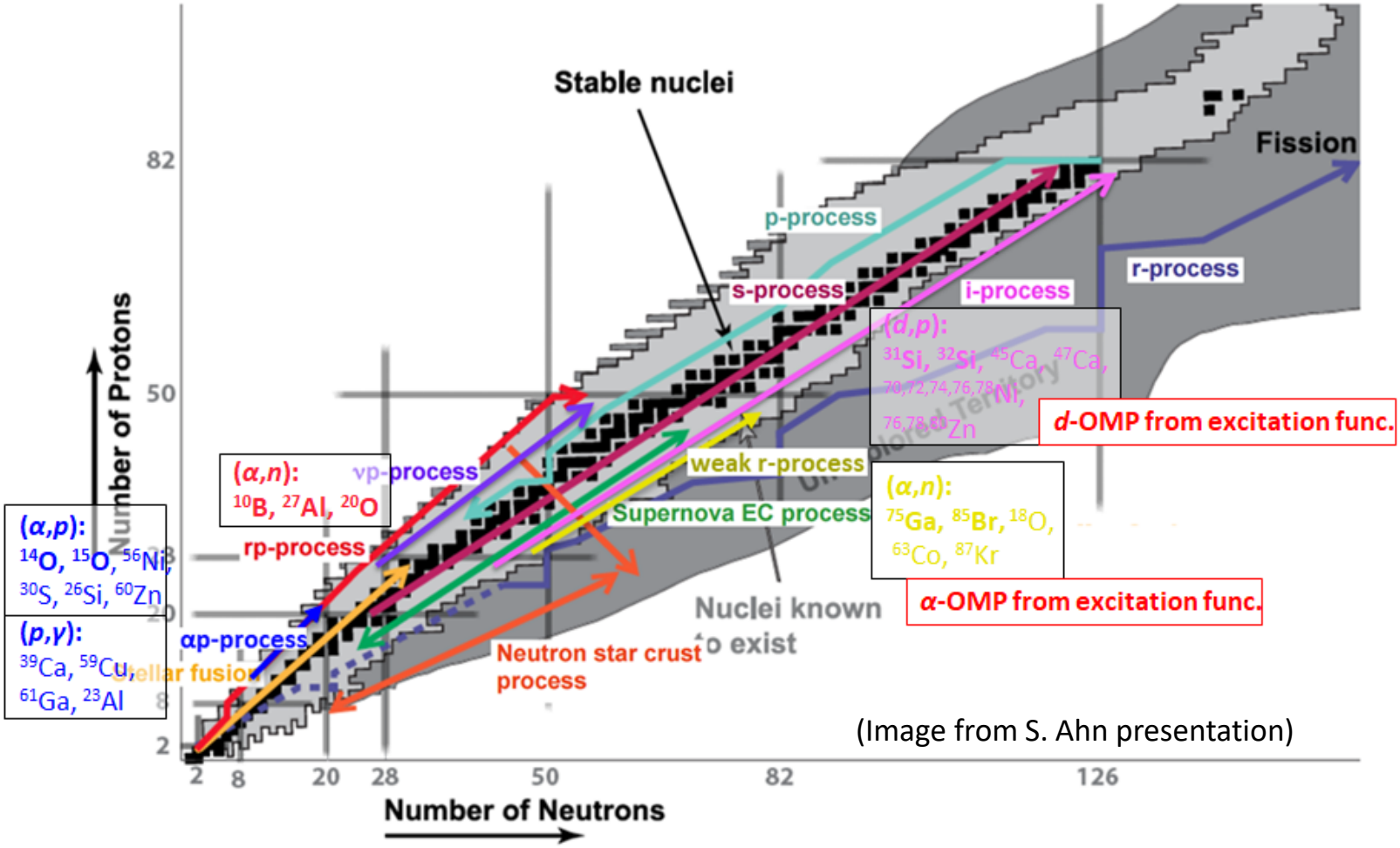
Collaboration: CENS and SKKU

Nucleosynthesis processes

Optical model potential(OMP) is related to the nucleosynthesis processes

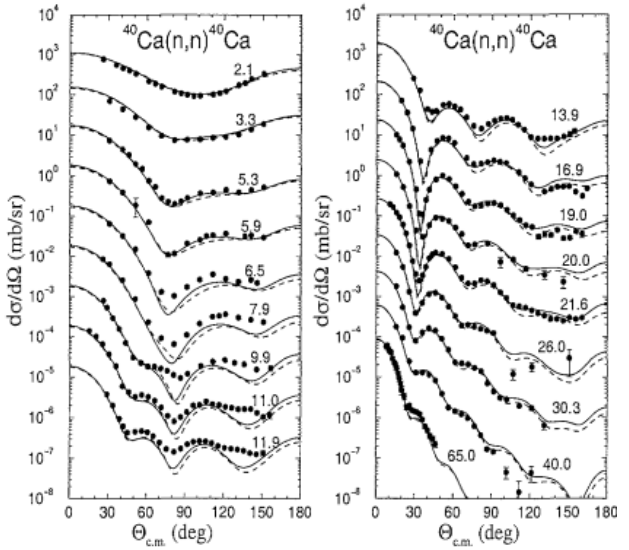


(Image from S. Ahn presentation)

Optical Model Potential for stable nuclei

(Phenomenological) Global Optical Model Potential — Phenomenological approach

- Comes from the stable elastic scattering data base
- Stable nuclei with 24 < A < 209 up to projectile energy of E ~ 200 MeV



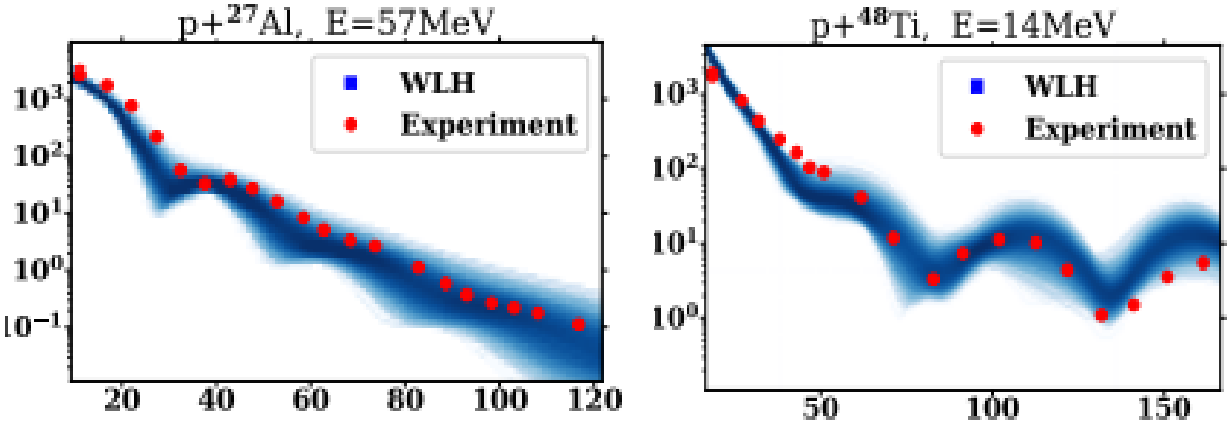
(Microscopic) Global Optical Model Potential — Theoretical approach

- The function of microscopic global optical model potential comes from theoretical calculation for describing rare isotopes

Experiment plan for OMP

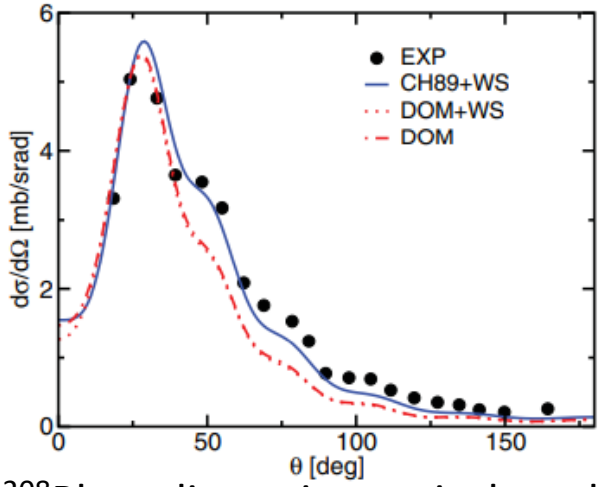
[Main Goal] Compare the calculation results of OMP and experimental data

Examine whether the dOMP and EFT results for predicting rare isotopes are valid even in stable nuclei!



Optical model potential from chiral effective field theory

T. R. Whitehead et al., arXiv:2009.08436v3

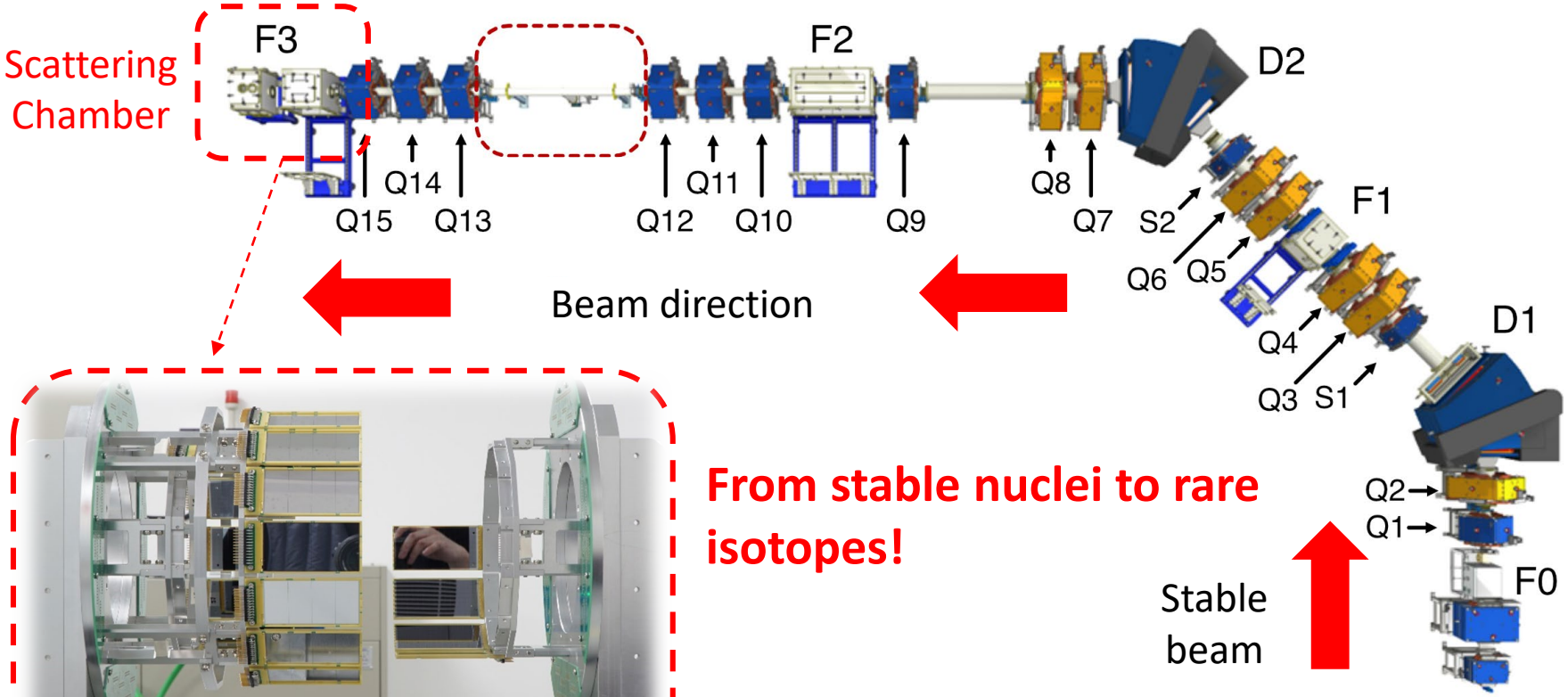


208Pb+p dispersive optical model

J. Phys. G: Nucl. Part. Phys. 44, 033001 (2017)

Experimental set-up

[KoBRA(Korea Broad acceptance Recoil spectrometer and Apparatus)]



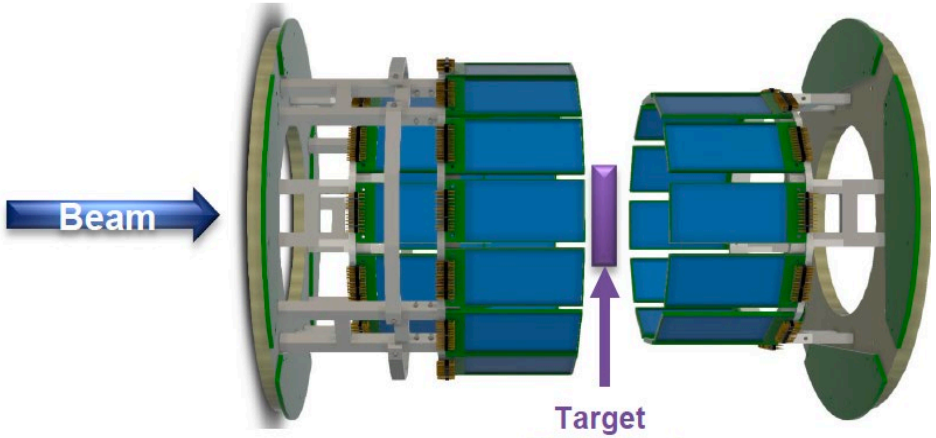
Good opportunity to perform the OMP experiment using stable beams

Experimental set-up

[Possible experimental set-up at KoBRA]

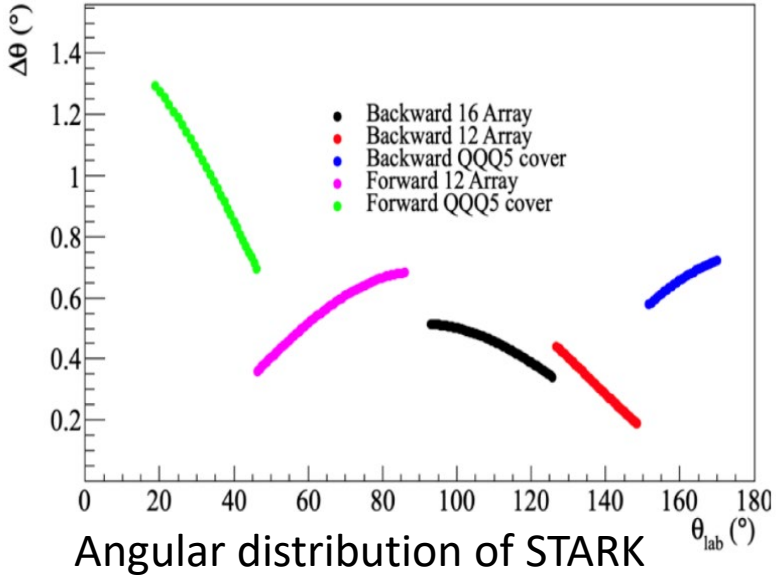
- Solid target + STARK combination
- Wide angle coverage (20˚ ~ 170˚) for one energy
- $\Delta\theta_{lab} < 1^{\circ}$ expected

  => Comparable or better than state-of-the-art detectors (Super ORRUBA (<1˚))



(Image from S. H. Bae presentation)

Conceptual design of STARK



Angular distribution of STARK

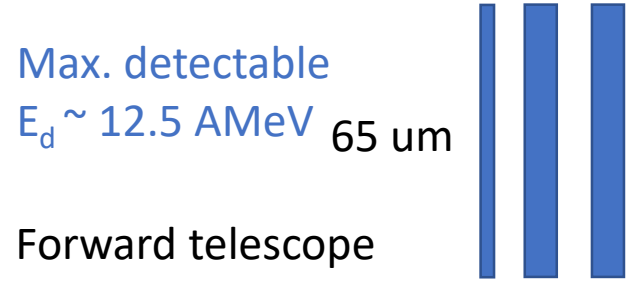
^{22}Ne+d/p experiments for OMP

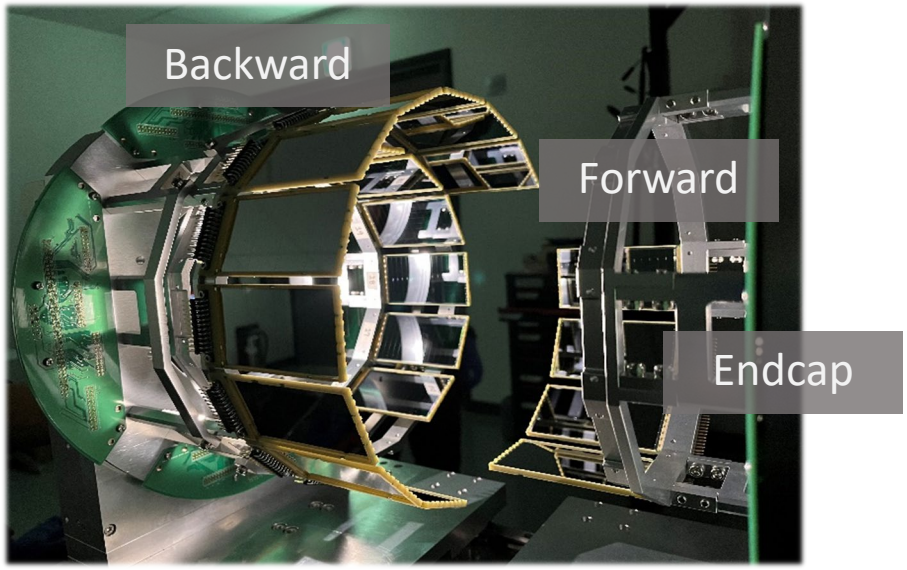
[Experiment] ^{22}Ne+d/p elastic scattering experiments

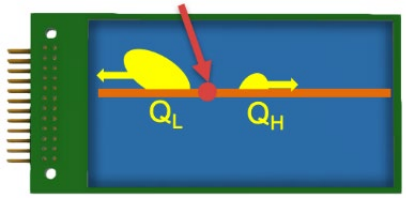
- Previous OMP(Optical Model Potential) studies for neutron transfer reaction
- Using STARK detector with changing target
- Forward and Endcap telescopes will be used to detect deuterons and protons.

Max. detectable E_d ~ 12.5 AMeV

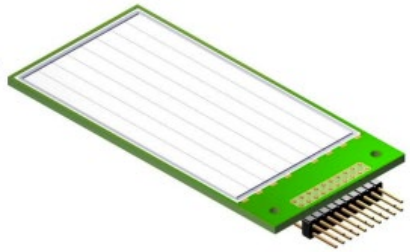
Forward telescope (BB10+X6+X6)







X6 detector

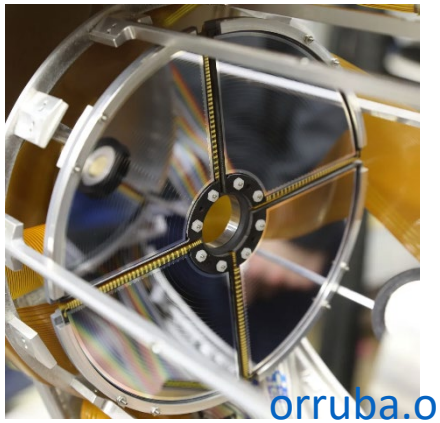


BB10 detector

^{22}Ne+p/d experiments for OMP

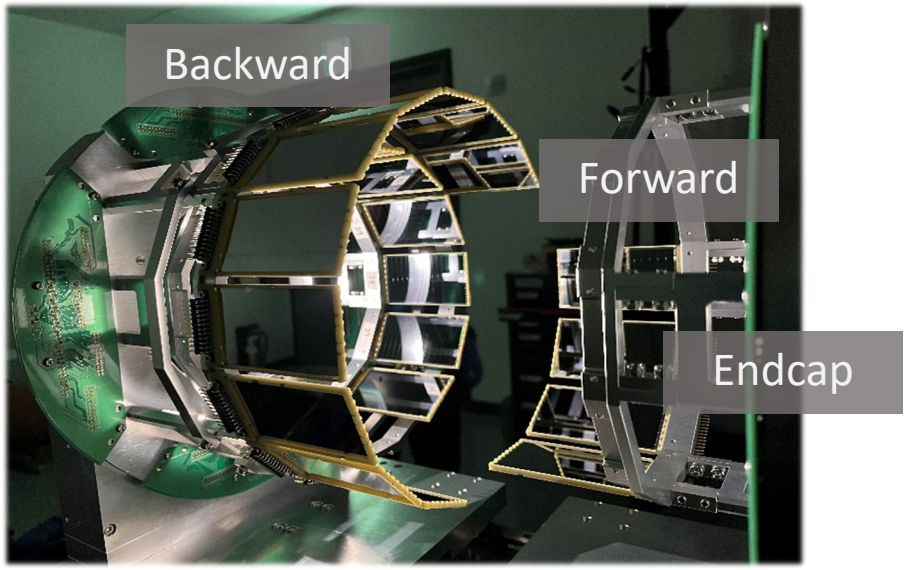
[Experiment] ^{22}Ne(d,d) /(p,p) elastic scattering experiment

- Previous OMP(Optical Model Potential) studies for neutron transfer reaction
- Using STARK detector with changing target
- Forward and Endcap telescope arrays will be used to detect deuterons and protons.



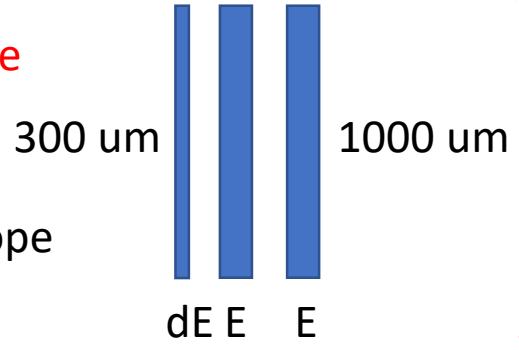
orruba.org

QQQ5



Max. detectable
E_d ~ 13 AMeV

Endcap telescope
(All QQQ5)

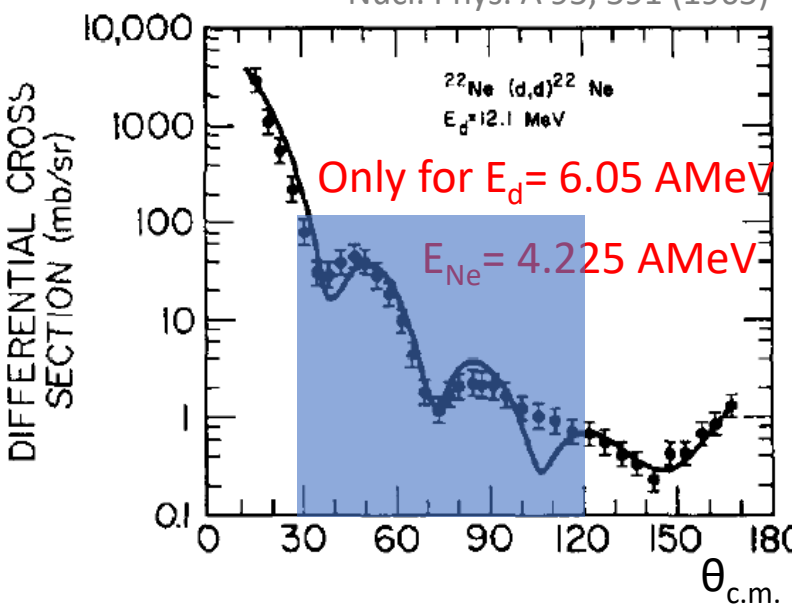


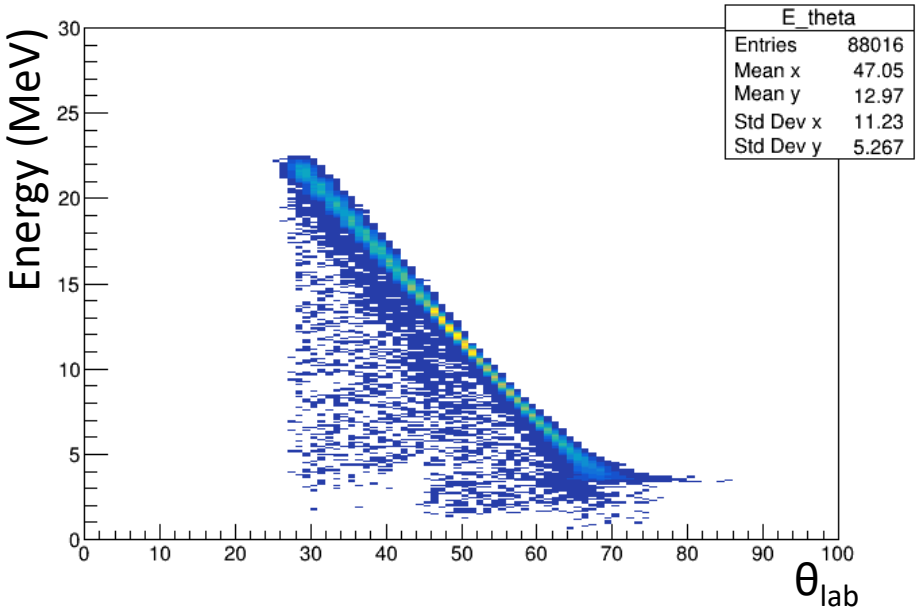
Vikar simulation for STARK detector

[Vikar simulation for ^{22}Ne+d elastic scattering]

- Detection efficiency: ~69%
- Simulated number: 100000
- Secondary beam: $^{22}Ne^{10+}$ 4.225 AMeV @ target
- Secondary target: CD_2 (polyethylene) 2 um thickness

Nucl. Phys. A 95, 591 (1965)

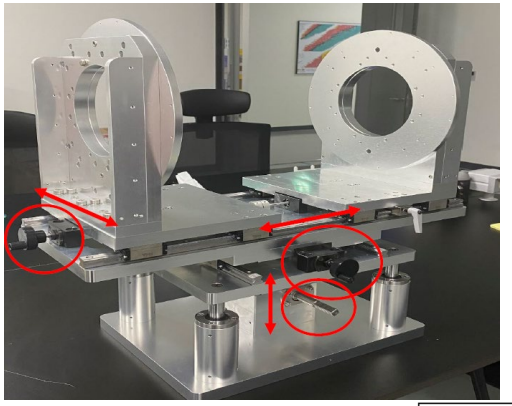




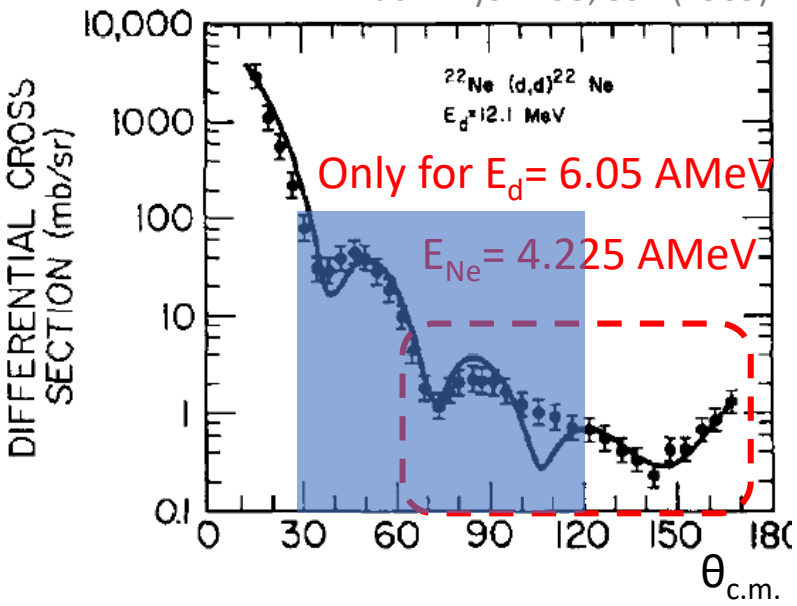
Vikar simulation for STARK detector

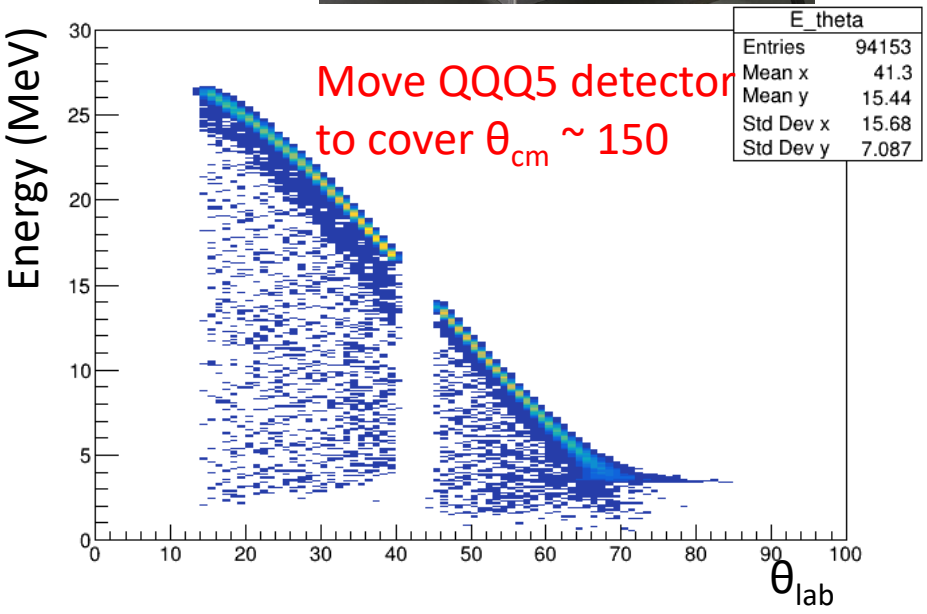
[Vikar simulation for ^{22}Ne+d elastic scattering]

- Detection efficiency: ~60%
- Simulated number: 100000
- Secondary beam: $^{22}Ne^{10+}$ 4.225 AMeV @ target
- Secondary target: CD_2 (polyethylene) 2 um thickness



Nucl. Phys. A 95, 591 (1965)

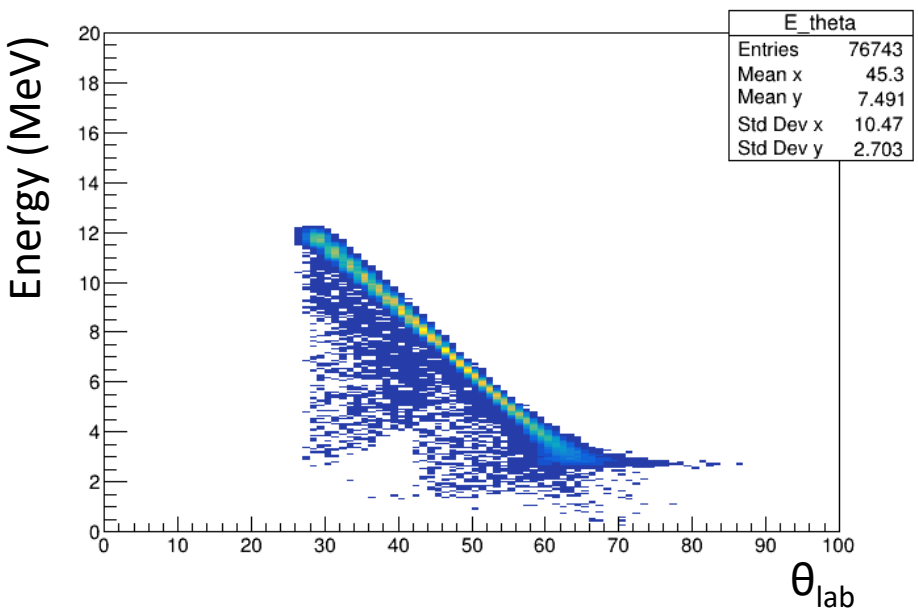


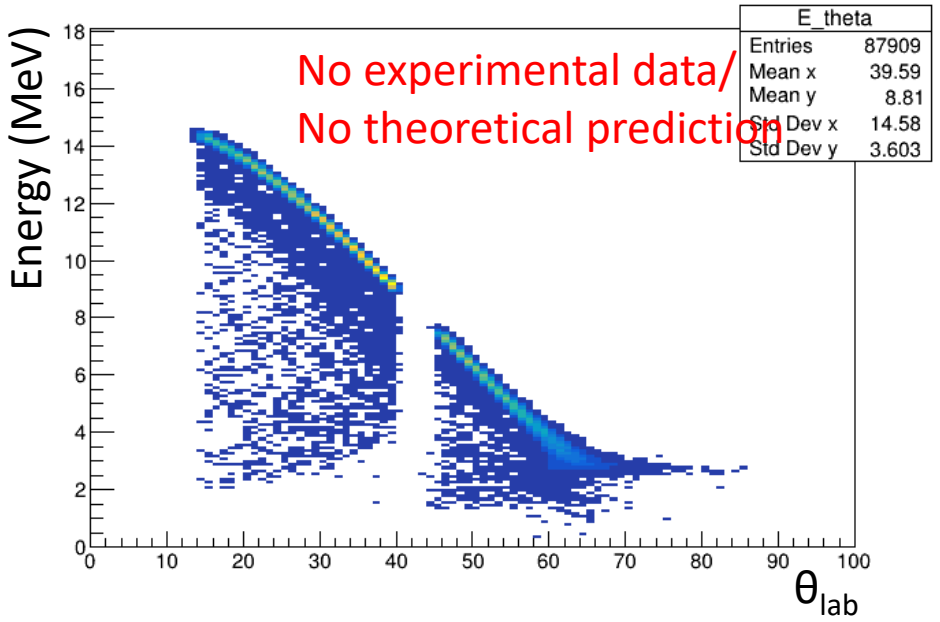


Vikar simulation for STARK detector

[Vikar simulation for ^{22}Ne+p elastic scattering]

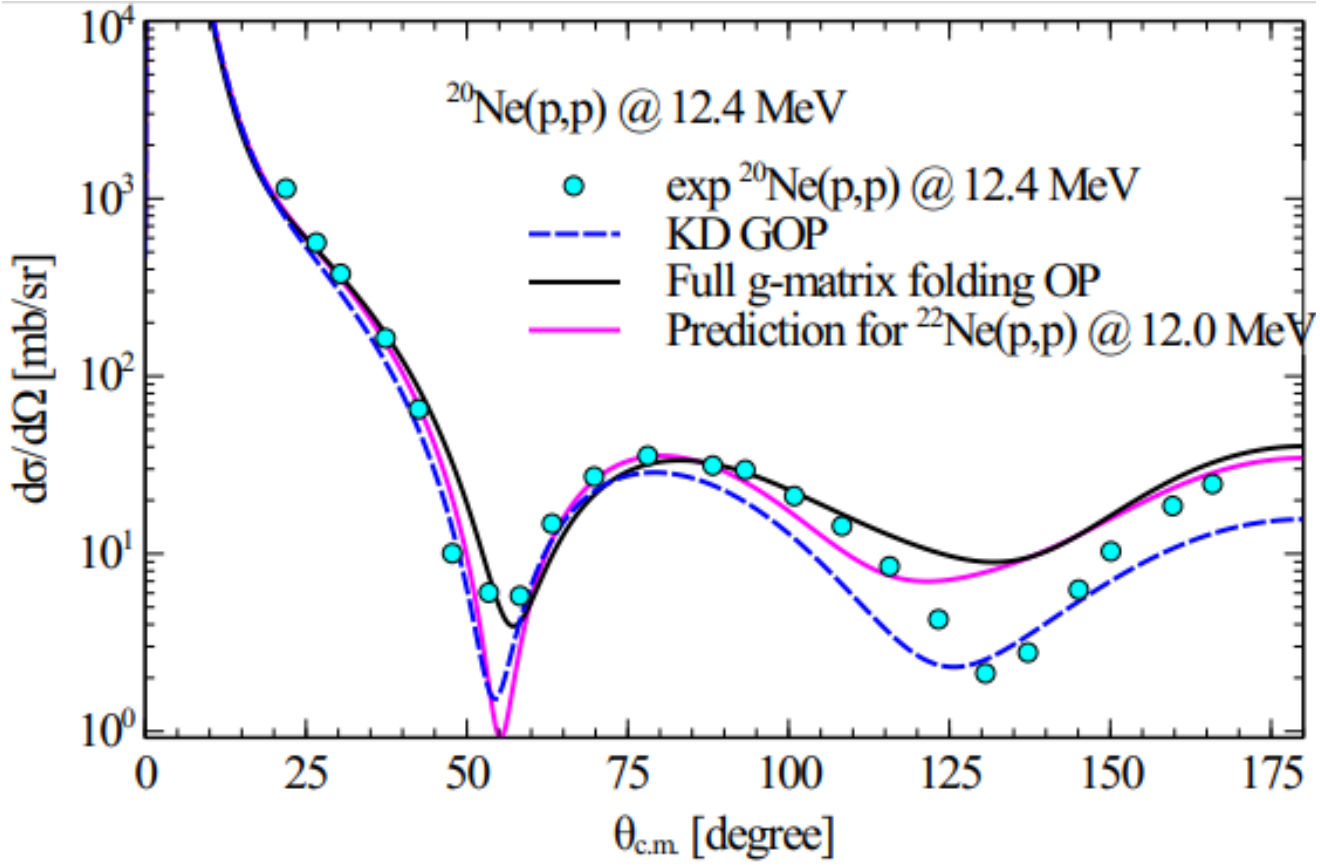
- Detection efficiency: ~69%/60%
- Simulated number: 100000
- Secondary beam: $^{22}Ne^{10+}$ 4.225 AMeV @ target
- Secondary target: CH_2 (polyethylene) 2 um thickness





Feasibility: Theoretical OMP calculation result

◈ OMP calculation result by Dr. Bui



microscopic OMP

^{22}Ne beam production

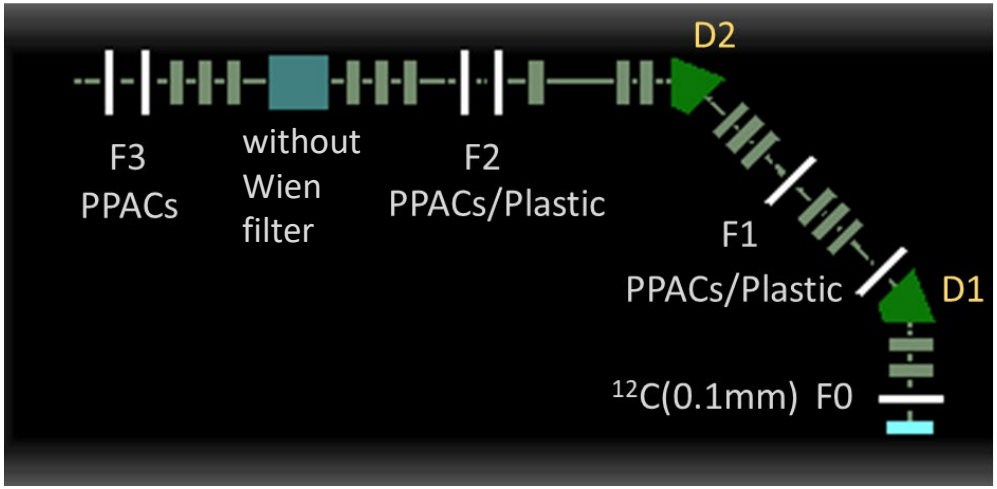
[KoBRA LISE++ beam production simulation]

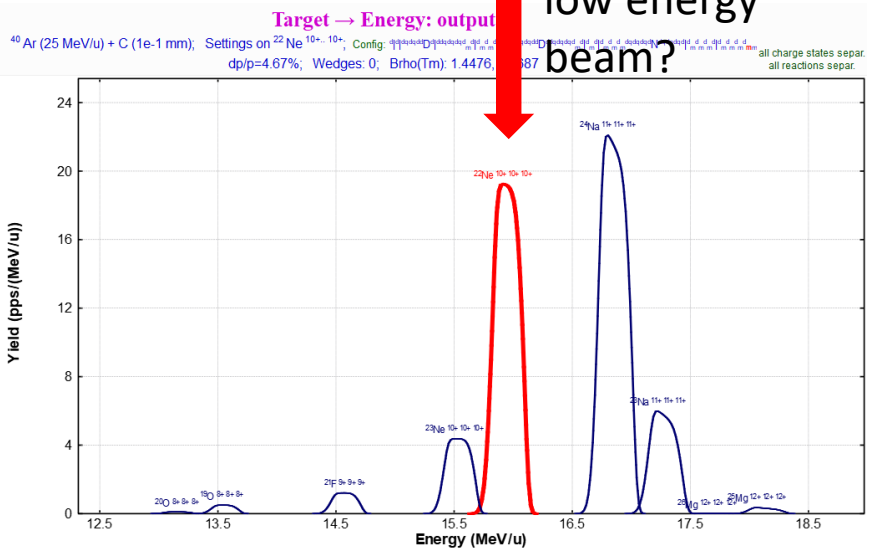
- Primary beam: $^{40}Ar^{9+}$ 25 AMeV
- Target: Graphite(^{12}C) 0.1 mm
- Secondary beam: $^{22}Ne^{10+}$ 16 AMeV @ target
- Secondary target: CD_2 (polyethylene) 10 um thickness

$^{22}Ne^{10+}$ 4.225 AMeV

16 AMeV is too high

Can we get low energy beam?





Summary

- Examine microscopic optical model potential for rare isotopes are valid even in many stable nuclei
- Compare different kind of the optical model potential to confirm the validity for the rare isotopes
- The candidate experiments to study the optical model potential are ^{22}Ne+d/p elastic scattering using the stable beam at KoBRA facility
- We confirmed the feasibility of the ^{22}Ne+d/p elastic scattering using STARK detector
- For the OMP experiments, low energy ^{22}Ne beam(< 5 AMeV) is required

Thank you for your attention!

[Collaboration list]

CENS

Deuksoon AHN, Sunghoon(Tony) AHN , Sunghan BAE, Soomi CHA, Kevin Insik HAHN, Dahee KIM, Byul MOON, Chaeyeon PARK, Xesus PEREIRA-LÓPEZ, Minh-Loc BUI

SKKU

Minju KIM, Kyungyuk CHAE