STUDIES OF MULTINUCLEON TRANSFER IN PERIPHERAL COLLISIONS OF ^{86}KR WITH ^{124}SN, ^{112}SN AT 15 MEV/NUCLEON

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6TH HELLENIC INSTITUTE OF NUCLEAR PHYSICS WORKSHOP

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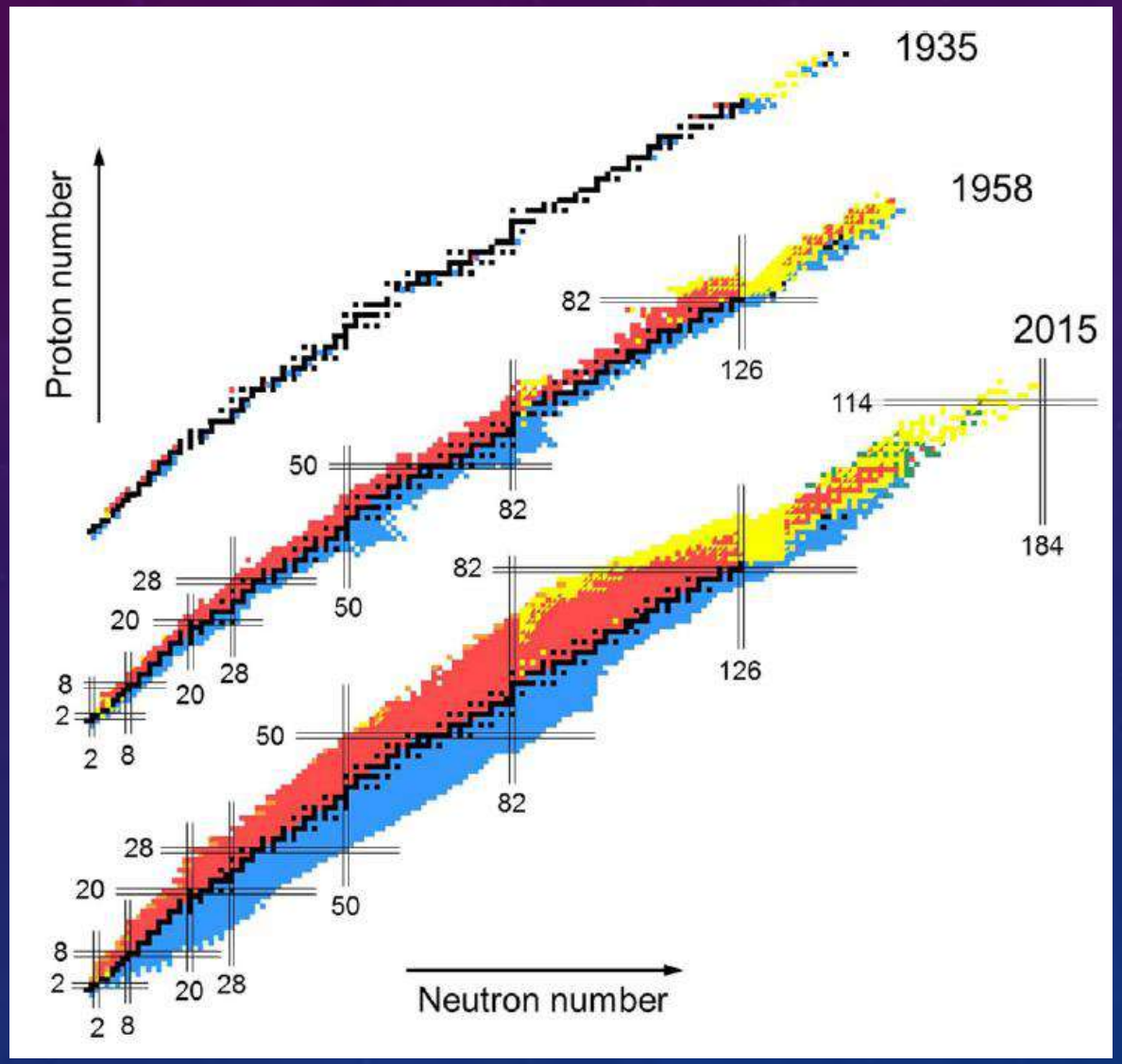
HINP ΕΙΠΦ

Overview

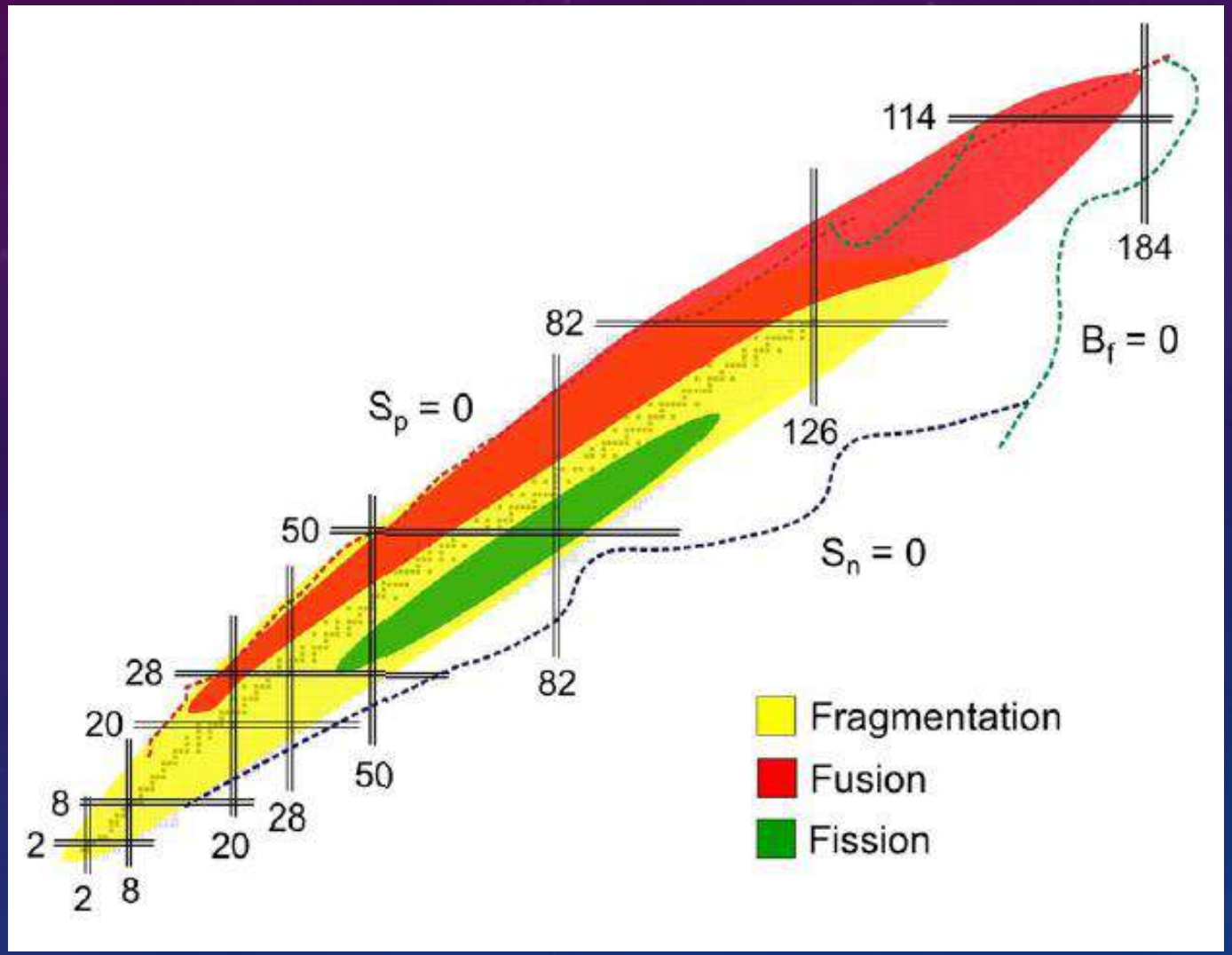
- Introduction
- Experimental Data 15 MeV/nucleon ^{86}Kr + $^{112/124}$Sn
  - Mass distributions
  - Momentum distributions
- Model Calculations 15 MeV/nucleon ^{86}Kr + $^{112/124}$Sn
  - Mass distributions
  - Momentum distributions
- Conclusions - Discussion

Isotope Discoveries



G. G. Adamian et. al, Eur. Phys. J. A 56:47 (2020).

Methods of Production



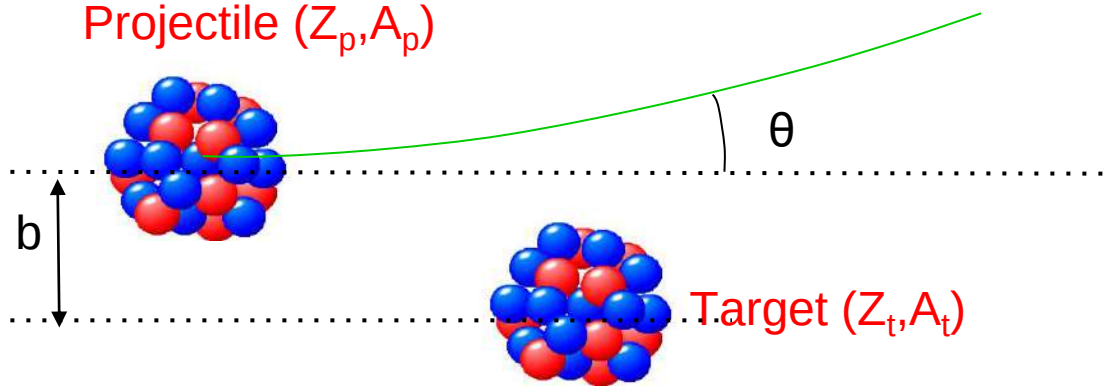
G. G. Adamian et. al, Eur. Phys. J. A 56:47 (2020).

Nuclear Reactions

- High Projectile Energies
  - Peripheral: Fragmentation Reactions
- Coulomb barrier
  - Peripheral and semi-peripheral reactions
  - Nucleon exchange
- Fermi Energy Regime
  - Reaction mechanism in between
  - Multinucleon Transfer
  - Our main focus
- Nuclear Fission
  - Production of neutron rich isotopes

Peripheral Reactions

Approaching phase:

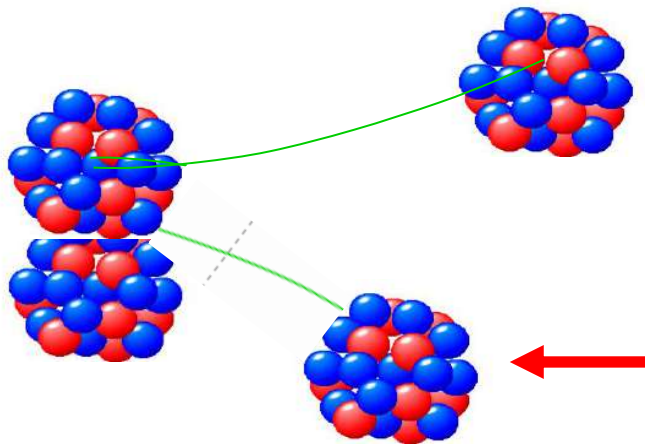


Neutrons
Protons

b: impact parameter
θ: scattering angle

Interaction phase:

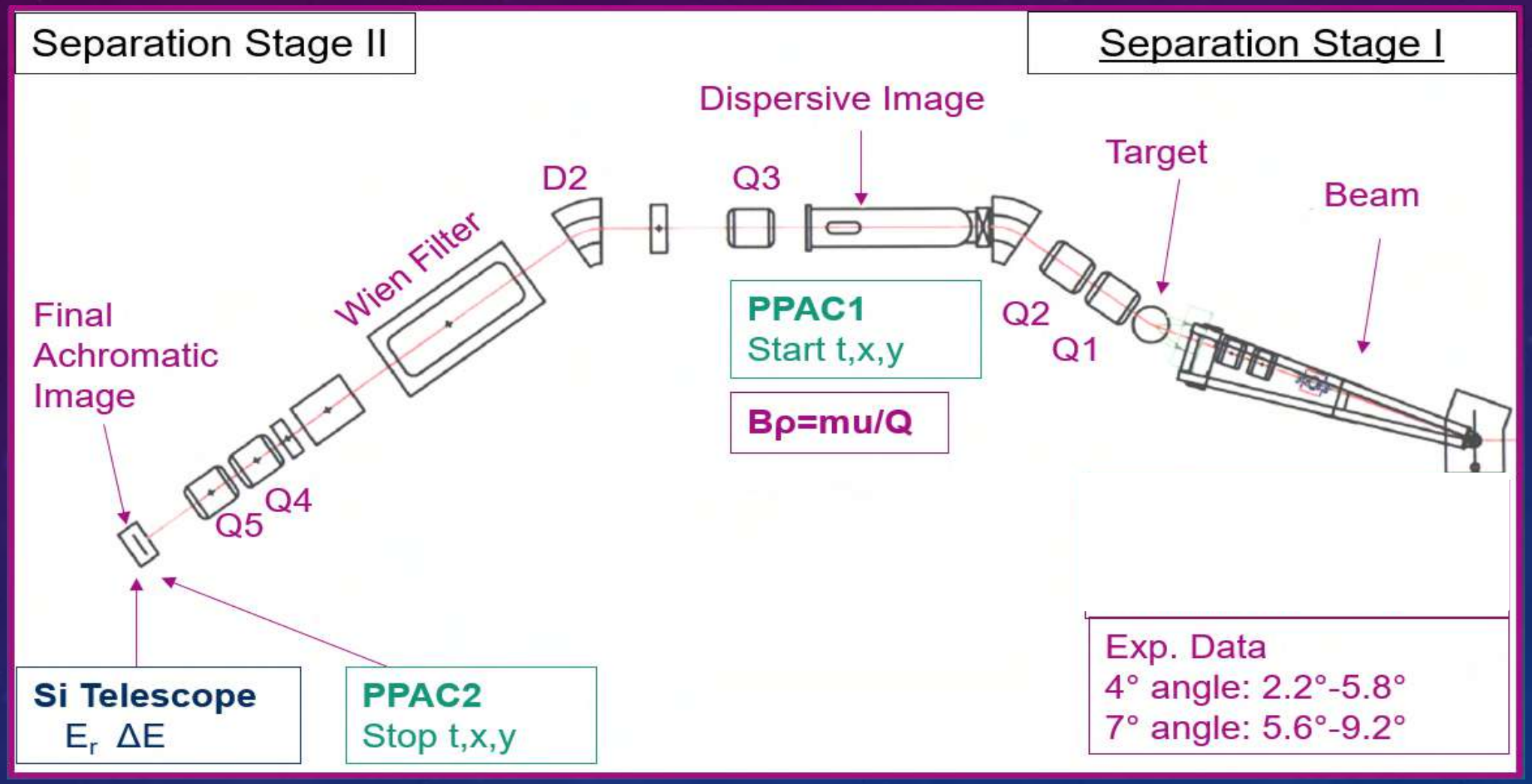
Exchange of nucleons:



excited projectile-like fragment (PLF) or quasi-projectile

excited target-like fragment (TLF) or quasi-target

Momentum Achromat Recoil Separator - MARS

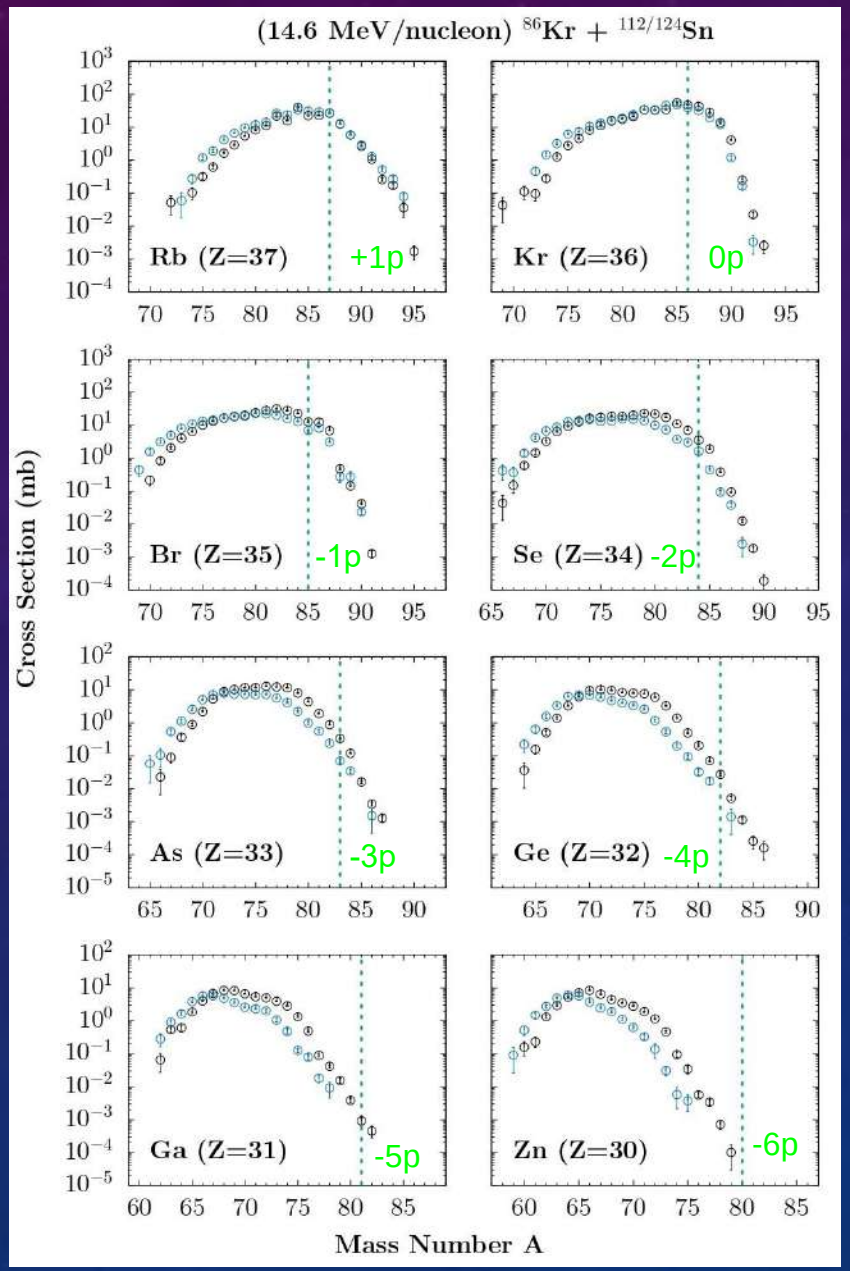


*G. A. Souliotis et al., Nucl. Instr. Methods B, 266, 4692 (2008) and references therein

Experimental Mass Distributions: ^{86}Kr + ^{112}Sn / ^{124}Sn

Mass Distributions of Projectile-like fragments

- ^{124}Sn higher than ^{112}Sn on neutron rich side
- Production of neutron rich
- Kr, Se: up to 6 n-pickup
- Br, As, Ge: up to 4 n-pickup



● : ^{86}Kr + ^{124}Sn (N/Z=1.48)
● : ^{86}Kr + ^{112}Sn (N/Z=1.24)
- - - : Neutron Pickup

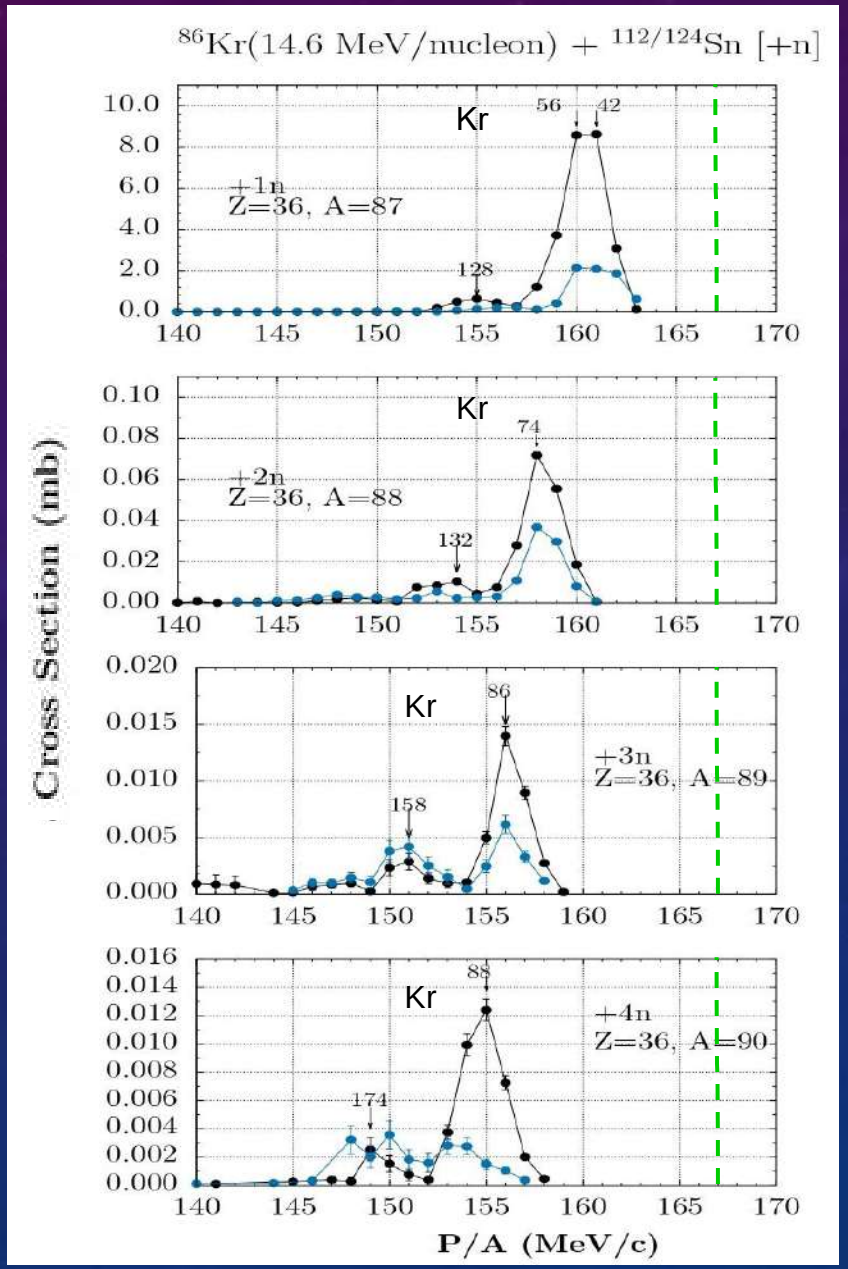
☆ **Experimental data:** G.A. Souliotis et al., Phys. Rev. C, 84, 064607, (2011).

Experimental Momentum Distributions: ^{86}Kr + ^{112}Sn / ^{124}Sn

Momentum Distributions Extracted from original data☆

Neutron Pickup Channels

- ☆ Measured Cross Sections at 7°
- ☆ ^{124}Sn higher than ^{112}Sn
- ☆ Two main regions



● : ^{86}Kr + ^{124}Sn (N/Z=1.48)

● : ^{86}Kr + ^{112}Sn (N/Z=1.24)

- - - : Beam Velocity: 167 MeV/c

Binary Kinematics (Peripheral)

$E^*_{tot} = Q_{gg} - Q_r$ | $E_{QP} \approx E^*_{tot}/2$

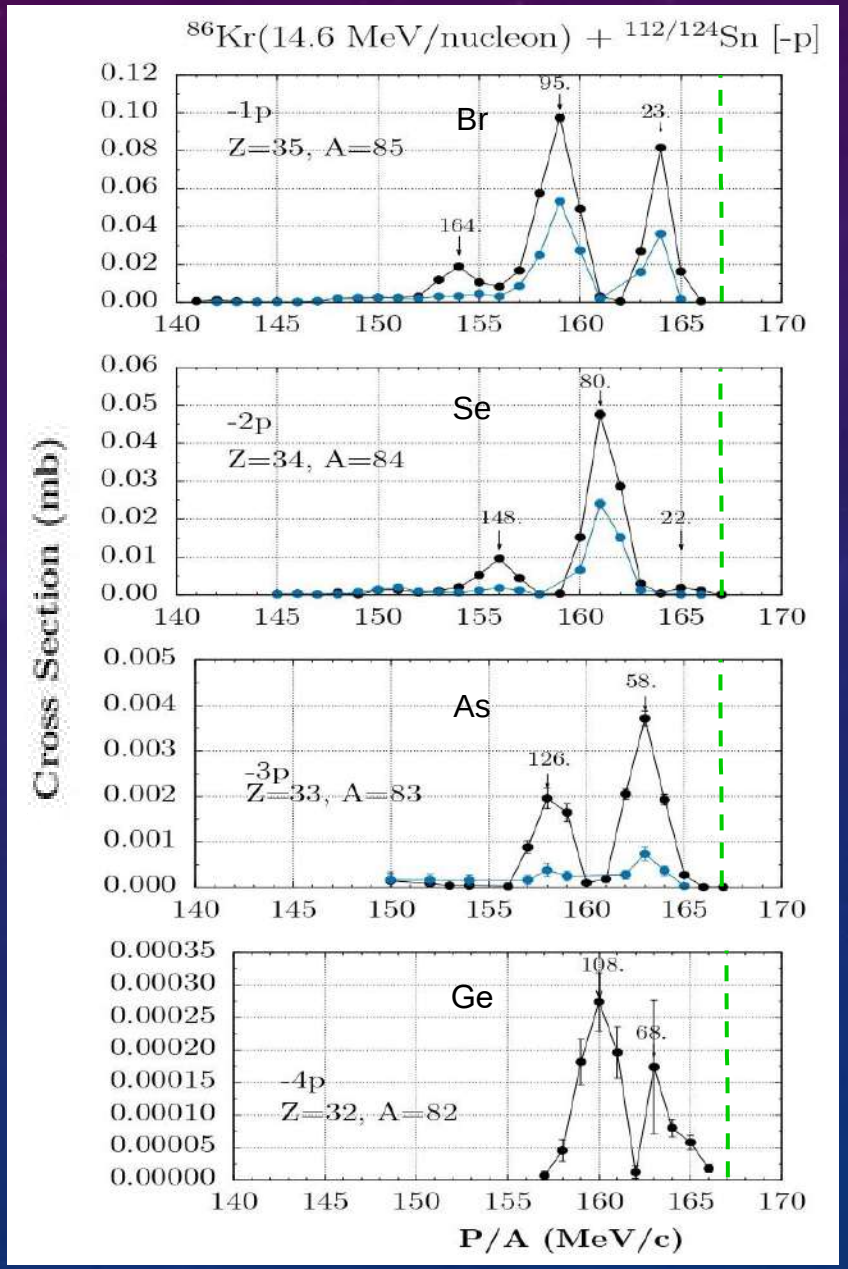
☆ **Original Experimental data:** G.A. Souliotis et al., Phys. Rev. C, 84, 064607, (2011).

Experimental Momentum Distributions: ^{86}Kr + ^{112}Sn / ^{124}Sn

Momentum Distributions Extracted from original data☆

Proton Removal Channels

- ☆ Measured Cross Sections at 7°
- ☆ ^{124}Sn higher than ^{112}Sn
- ☆ Two main regions



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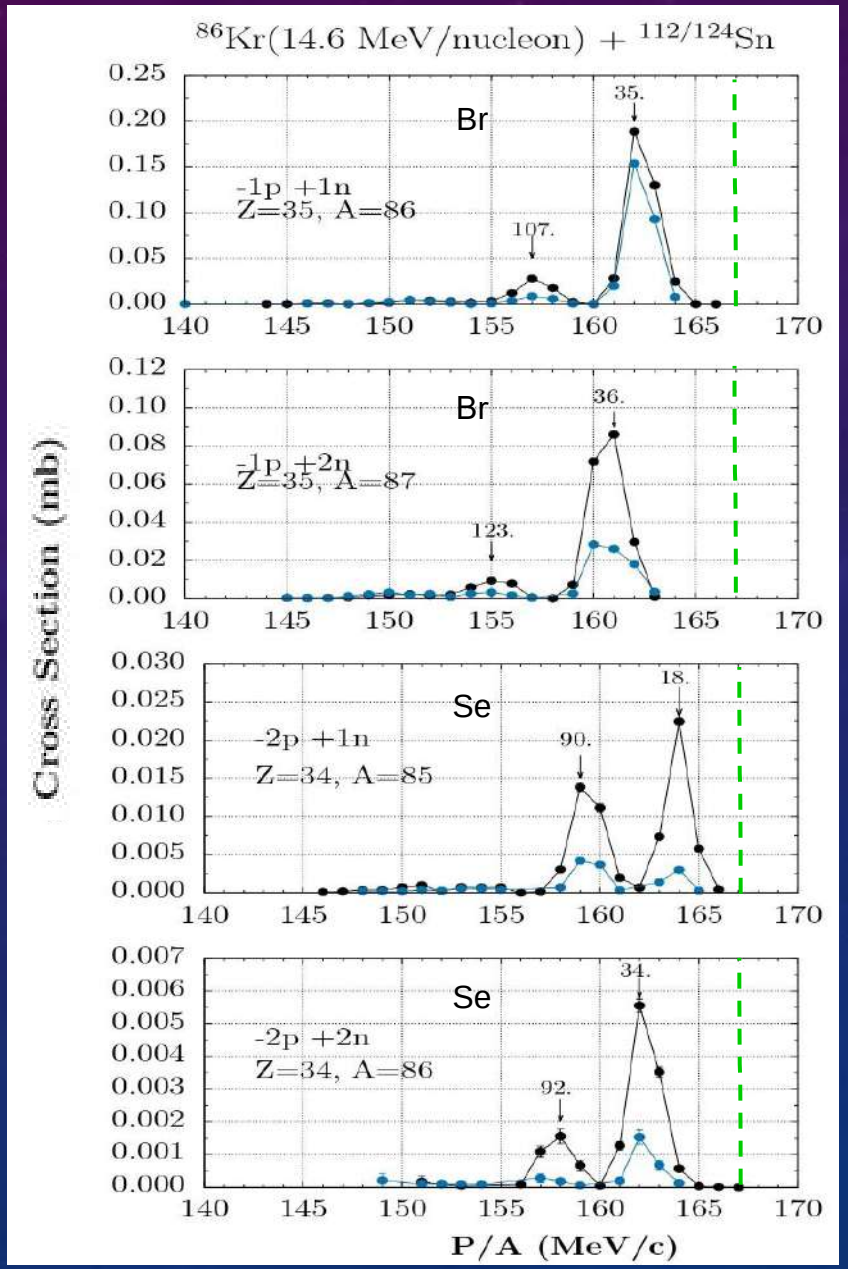
Experimental Momentum Distributions: ^{86}Kr + ^{112}Sn / ^{124}Sn

Momentum Distributions Extracted from original data☆

Channels -p +n

- ☆ Measured Cross Sections at 7°
- ☆ ^{124}Sn higher than ^{112}Sn
- ☆ Two main regions



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☆ **CoMD:** Constrained Molecular Dynamics,M. Papa et al., Phys. Rev. C, 64, 024612, (2001)

☆ **Gemini:** R. Charity et al., Nucl. Phys. A 483, 371 (1988). R. J. Charity, Phys. Rev. C 58, 1073 (1998).

Calculation Models

DIT - Deep Inelastic Transfer model (Phenomenological)

- Peripheral and semi-peripheral collisions
- Stochastic nucleon exchange

Deep Inelastic Transfer (DIT) Model, L. Tassan-Got and C. Stephan, Nucl. Phys. A 524, 121 (1991)

CoMD: Constrained Molecular Dynamics model (Semiclassical)

- Nucleons are considered as Gaussian wavepackets
- **N-N effective interaction** (Skyrme-type with K=254 MeV/fm^3)
- **Pauli principle** imposed via a phase-space constraint
- **Monte Carlo** implementation. Description of the dynamical stage for t = 0-600 fm/c

Constrained Molecular Dynamics, M. Papa et al., Phys. Rev. C, 64, 024612, (2001)

GEMINI - De-Excitation

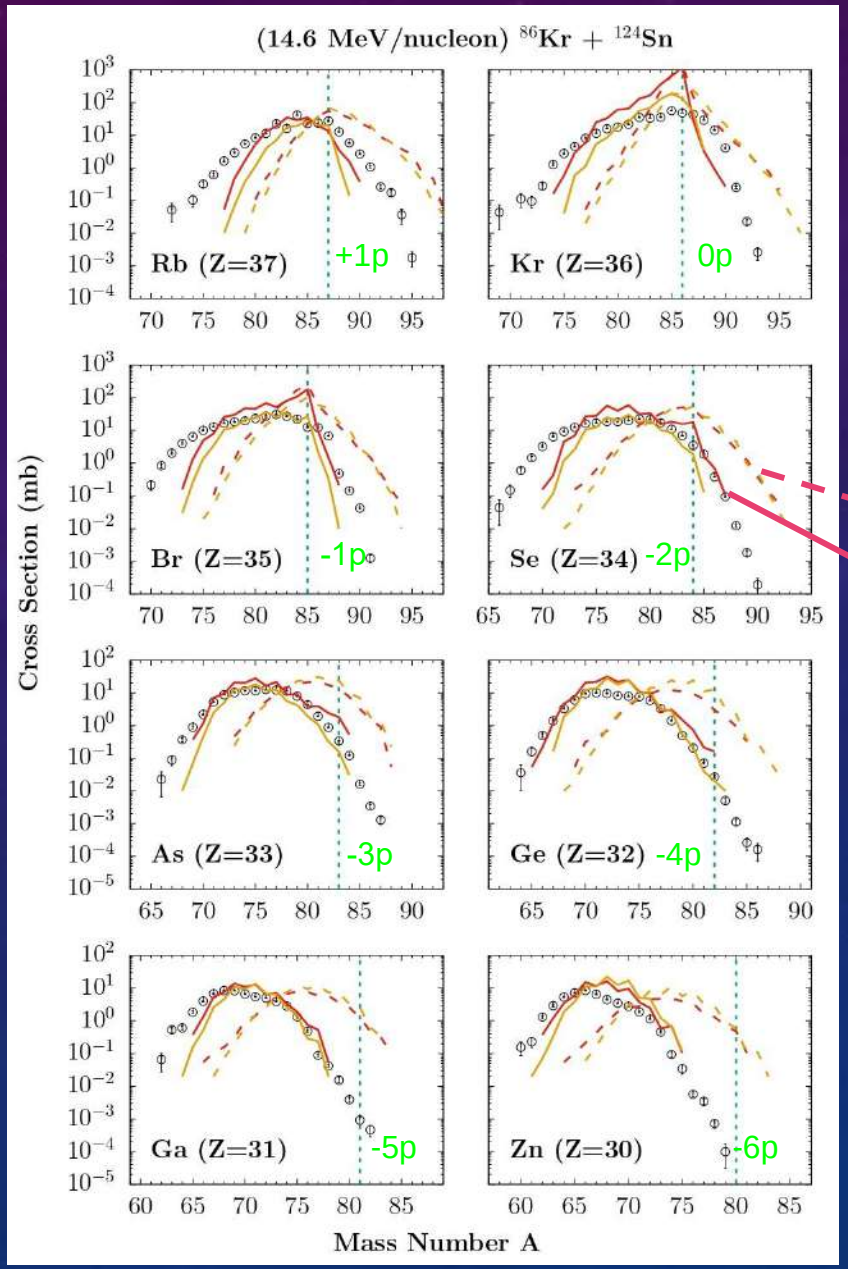
- Binary decay model

R. Charity et al., Nucl. Phys. A 483, 371 (1988). R. J. Charity, Phys. Rev. C 58, 1073 (1998).

Model Calculations - Mass Distributions: ^{86}Kr + ^{124}Sn

Mass Distributions of Projectile-like fragments

- ☆ Primary Fragments Same DIT/CoMD
- ☆ DIT lower than CoMD
- ☆ Overall good agreement on Z=34-32



● : ^{86}Kr + ^{124}Sn (N/Z=1.48)
- - -: Neutron Pickup
——: CoMD/Gemini
- - -: CoMD (Primary)/Gemini
——: DIT/Gemini
- - -: DIT (Primary)/Gemini

Primary fragments

De-excited fragments

☆ **Experimental data:** G.A. Souliotis et al., Phys. Rev. C, 84, 064607, (2011).
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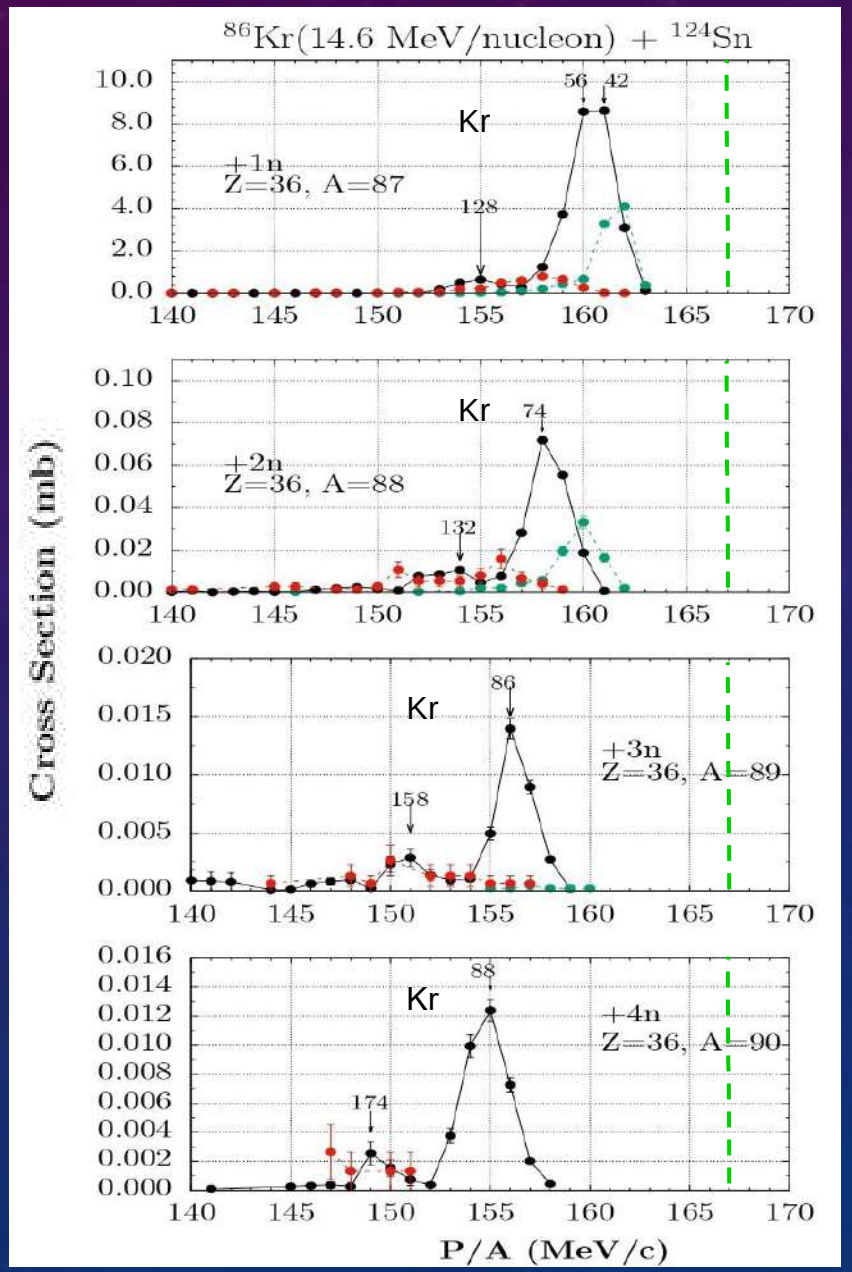
Model Calculations - Momentum Distributions: $^{86}Kr + ^{124}Sn$

Momentum Distributions Extracted from original data☆

Neutron Pickup Channels

☆ Preliminary calculations



● : $^{86}Kr + ^{124}Sn$ (N/Z=1.48)
—— : CoMD/Gemini
—— : DIT/Gemini
- - - : Beam Velocity=167 MeV/c

Binary Kinematics (Peripheral)

$E^*_{tot} = Q_{gg} - Q_r$ | $E_{QP} \approx E^*_{tot}/2$

☆ **Original Experimental data:** G.A. Souliotis et al., Phys. Rev. C, 84, 064607, (2011).
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Conclusions - Discussion

So far:

- Extracted and systematically studied experimental momentum distributions: ^{86}Kr beam with targets of ^{124}Sn and ^{112}Sn at 15 MeV/nucleon
- Kinematic analysis on the momentum distributions
- Preliminary calculations with DIT and CoMD models

Future plans:

- Study reactions with ^{86}Kr beam
  - Targets of ^{124}Sn and ^{112}Sn at 15 MeV/Nucleon
  - Targets of ^{64}Ni and ^{58}Ni at 15 MeV/Nucleon
  - Targets of ^{124}Sn and ^{112}Sn at 25 MeV/Nucleon
- Kinematic analysis on the momentum distributions
- Attempt to reconstruct the quasi-projectile
- Detailed calculations with the DIT and CoMD models with all the different parameters
- Explore the benefits of momentum distributions studies
  - Elucidate the reaction mechanisms
  - Reach neutron rich isotopes

THANK YOU!