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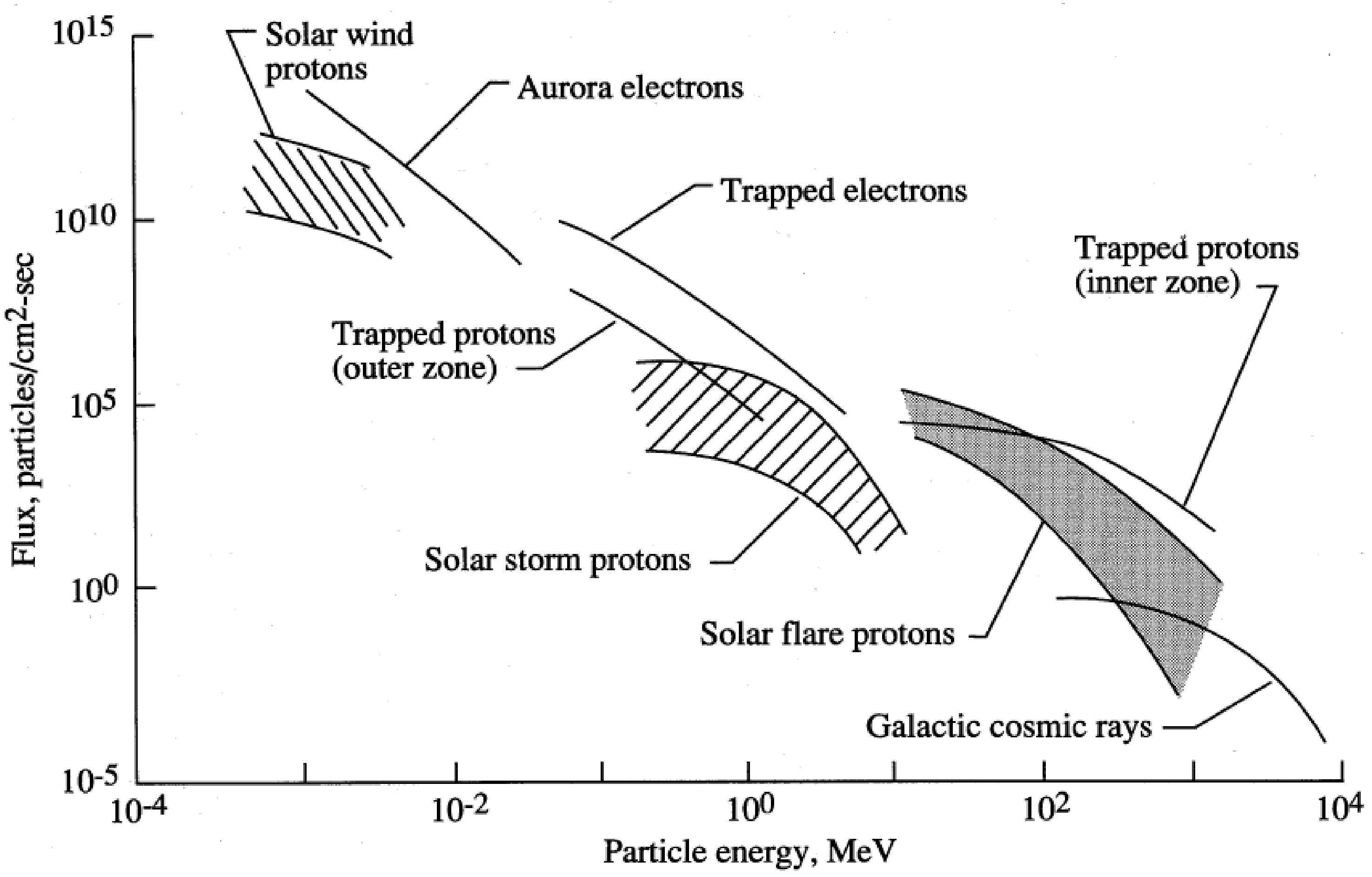
Theoretical study of isotopic production cross-sections in proton-nucleus reactions at 200MeV

Mohammad S Sabra
USRA Space Science Department
NASA Marshall Space Center
Huntsville, AL 35805

Introduction

- As NASA's future plans include extended human missions in deep space, protection from space radiation takes on increased importance.
- When galactic cosmic rays, mainly protons, interacts with spacecraft materials, secondary fragments are produced, which contribute substantially to the dose and dose equivalent received by the crew inside.
- A detailed understanding of the reaction mechanism, as well as a knowledge of cross sections are needed.

Space radiation spectra



- From Wilson *et al.*, NASA Reference Publications 1257 (1991)

Scattering And Production Theory Of Nuclei (SAPTON)

- SAPTON is a modified version of the standard statistical model.
- It has a final-state interaction between the emitted fragments
- It distinguishes itself from other models in at least one important aspect:

It includes the possibility that the fragments are being emitted the ground states, excited states, as well as in the continuum.

SAPTON

- Double differential cross-section for the production of a pair of fragments $\boldsymbol{A}_1$ and $\boldsymbol{A}_2$ is given by

$$\frac{d^2\sigma}{d\Omega dE} \propto \int \frac{T_l(\varepsilon)\rho_1(U_1)\rho_2(U_2)}{\rho_c(U_c)} dU_1 dU_2$$

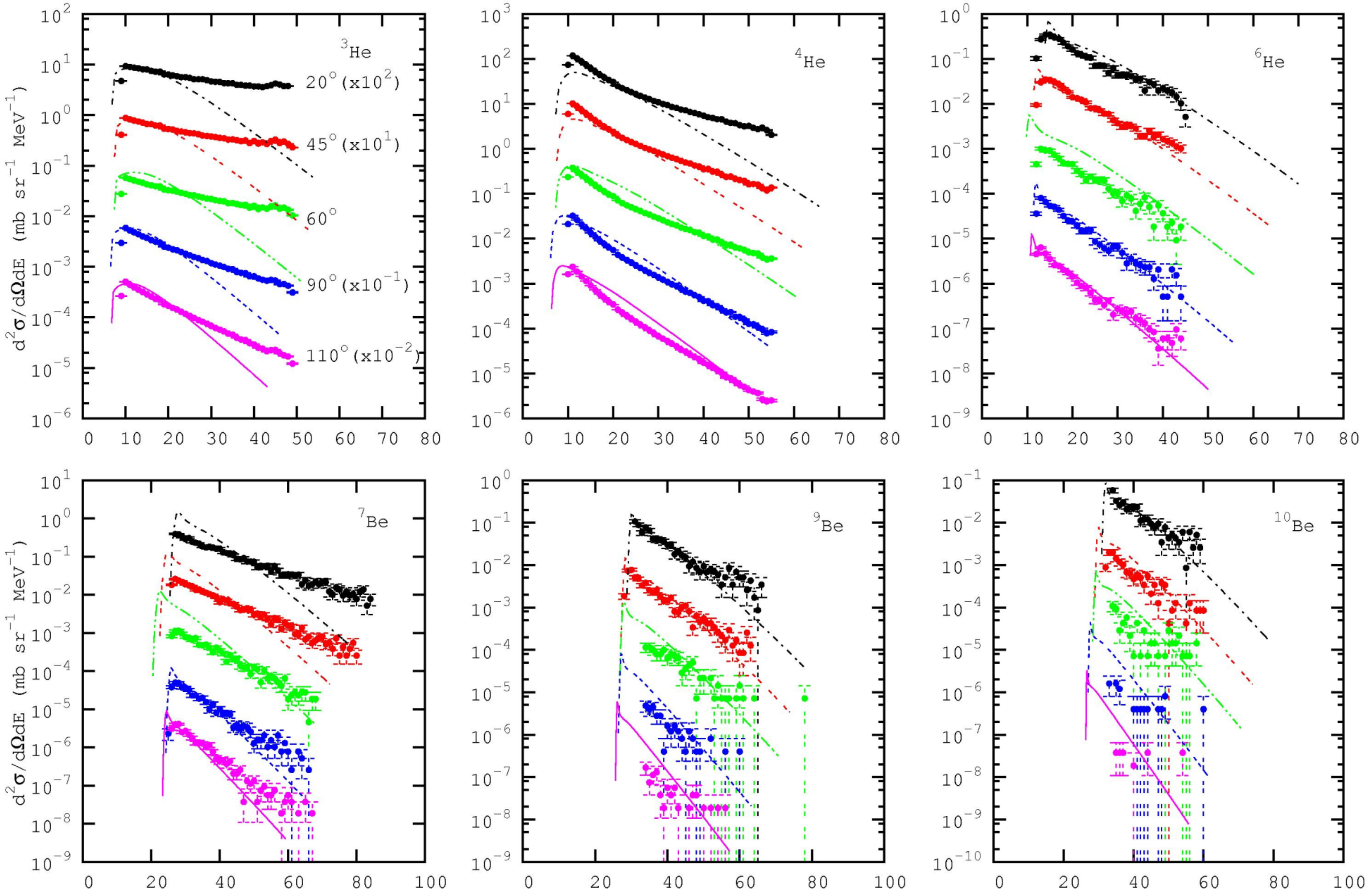
where

- $T_l(\varepsilon)$ is the transmission Coefficient between the pair with relative energy ε
- ρ_1, ρ_2 are their level densities
- U_1, U_2 are their excitation energies
- ρ_c, U_c are the level density and excitation energy of the composite system

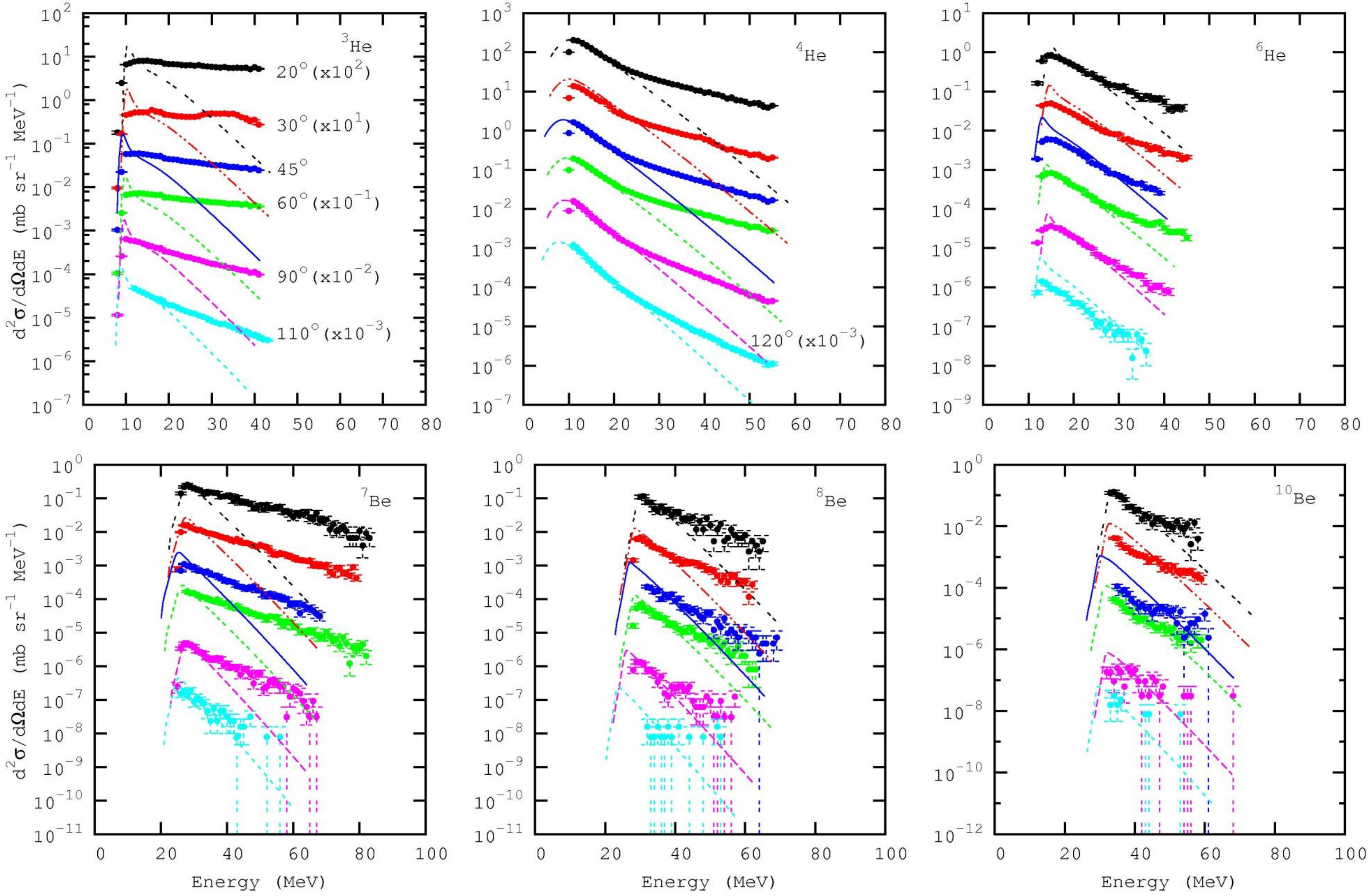
Theory vs Experiment

- Machner et. al. measured intermediate-mass fragments from the interaction of ^{27}Al, ^{59}Co, and ^{197}Au with 200 MeV protons in an angular range 20^o to 120^o.
- Double-differential cross-sections were extracted.
- Using SAPTON, with L = 0 (i.e. evaporation stage) → we have calculated energy spectra for fragments produced in proton incident on Al and Co.

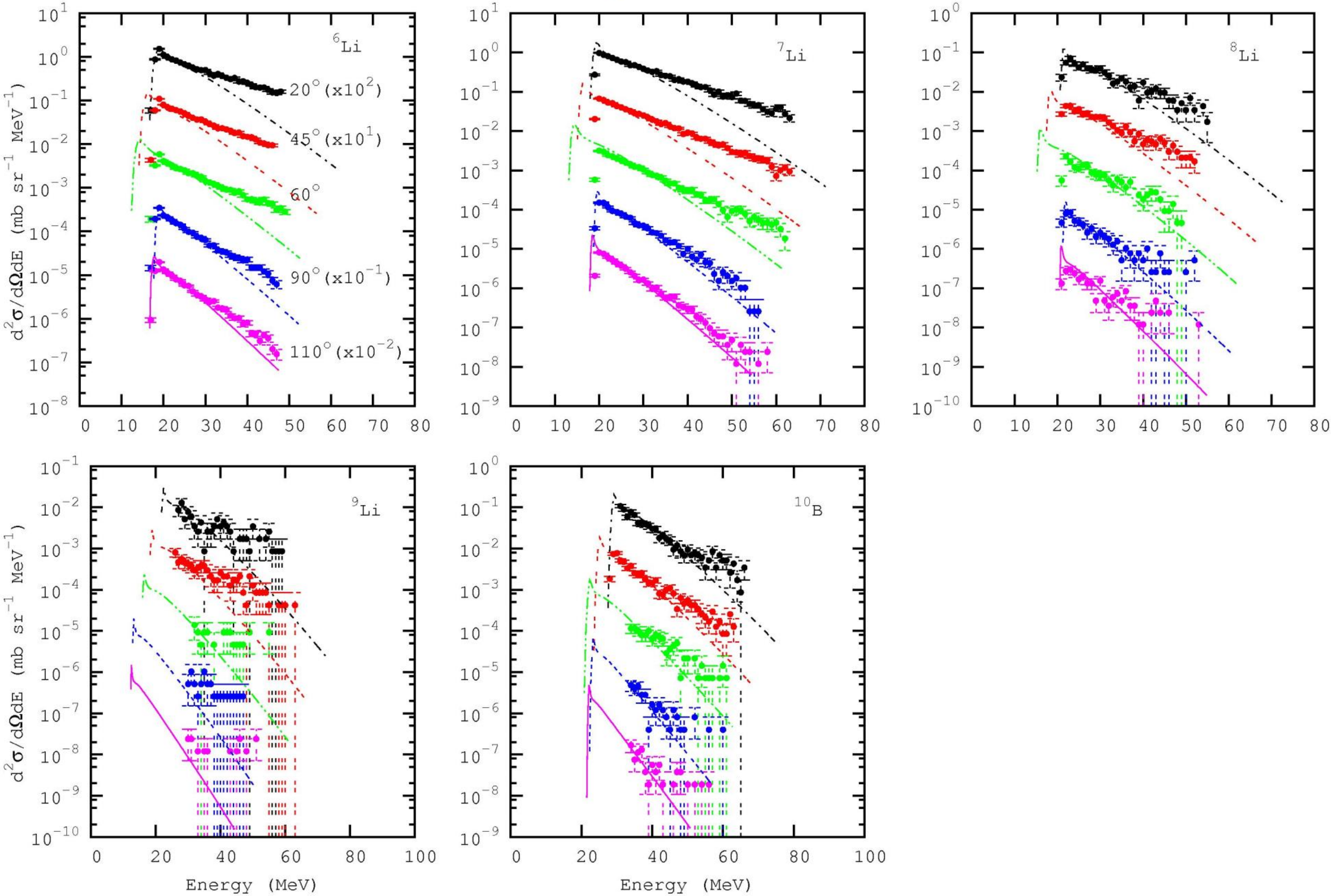
200 MeV p + Al → Fragment (A,Z)



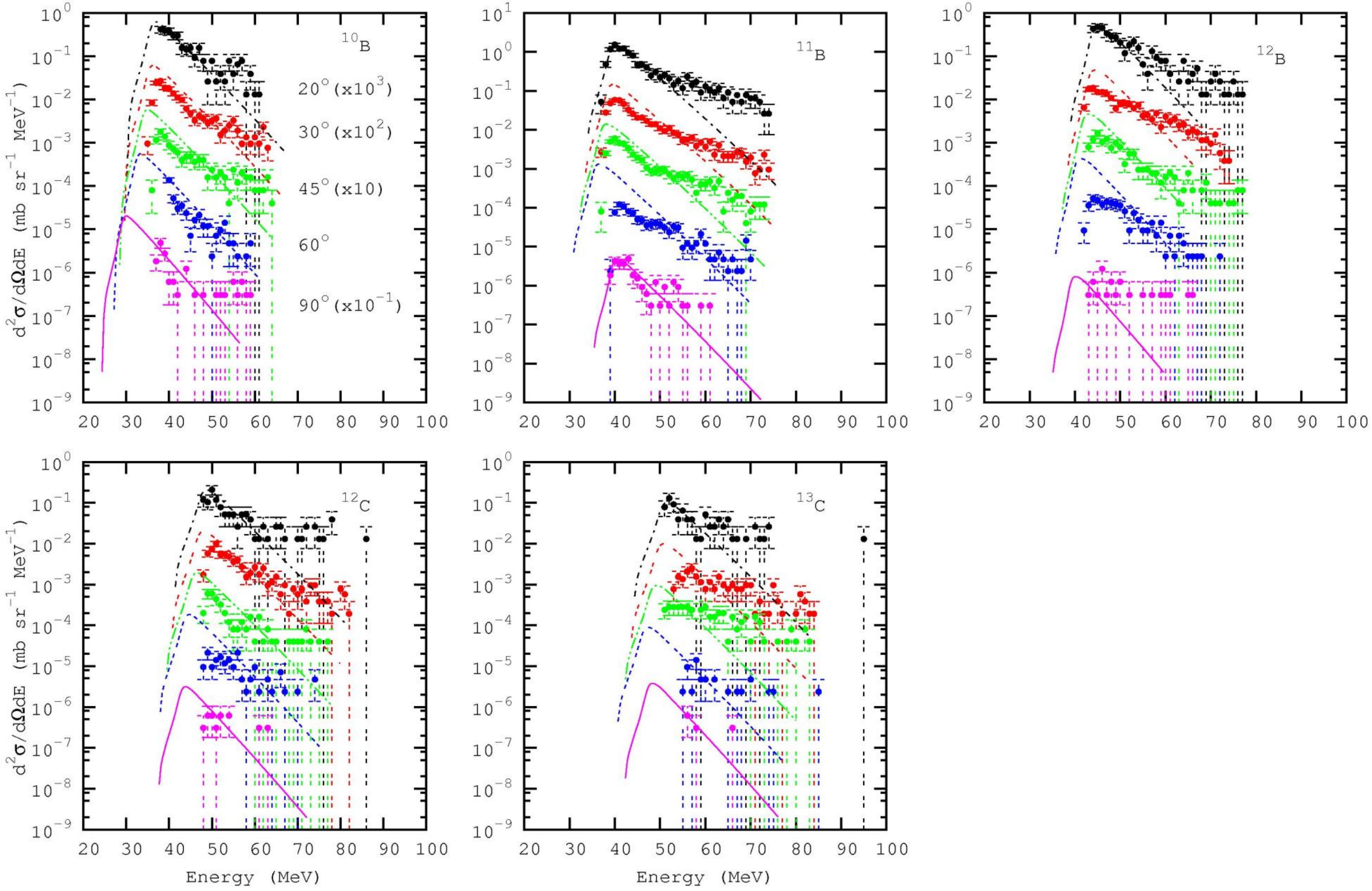
200MeV p + Co → Fragment (A,Z)



200MeV p + Al → Li + X



200MeV p + Co → Fragment (A,Z)



Remarks

- Using SAPTON → we have calculated intermediate mass fragments (He – C) emissions from ^{27}Al and ^{59}Co at 200MeV proton, which is near the maximal abundance in the proton energy cosmic rays
- Productions of ^{6}He, ^{8}Li, and ^{9,10}Be are dominated by the evaporation stage compared to other fragments, where evaporation stage dominates in the backward direction
- Production of ^{3}He is dominated by the equilibrium stage, even in the backward direction at higher energies → all tritium decays into ^{3}He

Future work

- Study the emission of intermediate mass fragments (IMFs) in 200MeV p + ^{197}Au

THANK YOU

QUESTIONS ?