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Isospin influence on the decay modes of systems produced in the $^{78,86}Kr+^{40,48}Ca$ reactions at 10AMeV

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Outline

- The Physics Case

- The Experimental Method

- Experimental Results

  - IMF behavior
  - Global features

- Conclusions and Outlook

Physics case

Heavy-ion induced reactions with stable and radioactive beams are ideal to explore the response of nuclei under different stress conditions

Energy domain E < 15 MeV/A is dominated by fusion processes in competition with binary reactions

Both these processes are influenced by many parameters :

- angular momentum, dynamical effect -> quasi-fission
- structure and N/Z of the system

Decay modes populate the whole mass/charge domain from evaporated light particles up to the symmetric fission fragments, with the IMF in between

the decay mechanism are influenced by different parameters :

E*, J, N/Z, structure

Experimental method

ISODEC CHIMERA@LNS

E = 10 AMeV ^{78}Kr + ^{40}Ca -> ^{118}Ba and ^{86}Kr + ^{48}Ca -> ^{134}Ba

Formation of two composite systems that are different for 16 neutrons

	^{118}Ba	^{134}Ba
E*(MeV)	215	270
V_B(MeV)	90	87
$(N/Z)_{tot}$	1.11	1.39

-> possibility to explore the dependence of the formation and decay mechanisms of the composite system on the isospin (N/Z)

S. Pirrone et al.,*EPJ* 17 (2011) 16010; G. Politi et al., *EPJ* 21 (2012) 02003;S. Pirrone et al., *AIP Conf. Proc*. 1524 (2013) 7-10;
G. Politi et al., *JPS Conf. Proc.* to be published 2014; S. Pirrone et al., *Journal of Physics: Conference Series* 515 (2014) 012018;

ISODEC Experiment complements the experiment E457S (GANIL)
-> study of the reactions ^{78,82}Kr + ^{40}Ca at 5.5 AMeV with the INDRA device
same neutron-poor system -> influence of the energy of the entrance channel

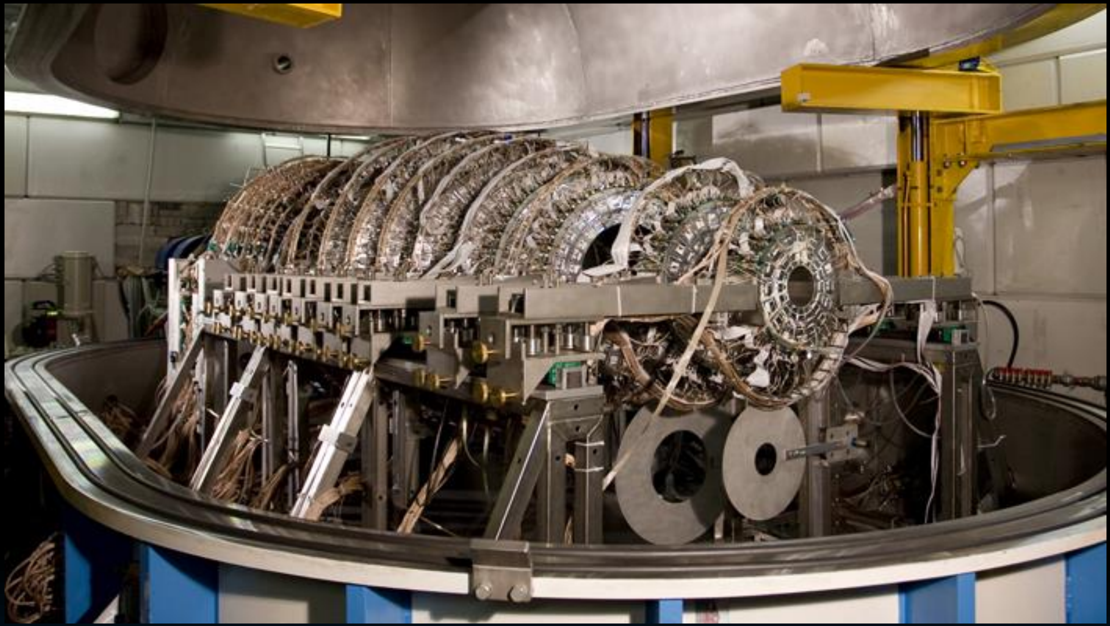
G. Ademard et al., PRC 83 (2011) 054619

CHIMERA device at INFN-LNS in Catania – ITALY

4π device

1192 Telescopes

Si (300μm) - CsI(Tl)



Forward part 1°<θ<30°

688 modules

9 Rings 100<d<350 cm

Backward part 30°<θ<176°

504 modules

Sphere R=40 cm

Precise measurement of E, TOF, Velocity, θ/φ

Different identification methods: PSD Si, E-ToF, DE/E, PSD CsI

CHIMERA device at INFN-LNS in Catania – ITALY

4π device

1192 Telescopes

Si (300μm) - CsI(Tl)

Forward part 1°<θ<30°

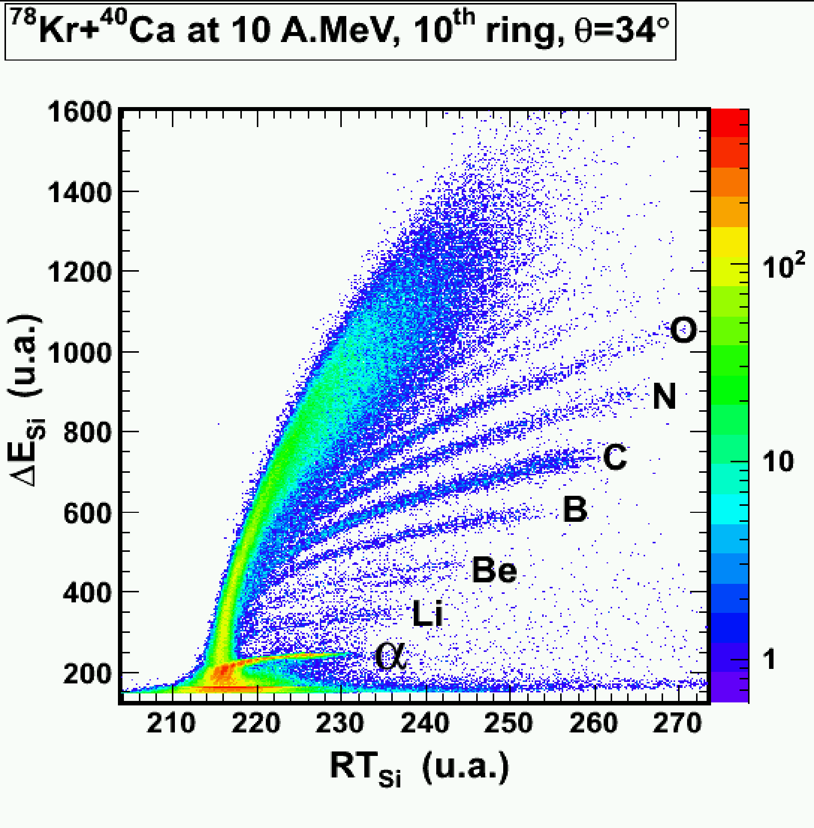
688 modules

9 Rings 100<d<350 cm

Backward part 30°<θ<76°

504 modules

Sphere R=40 cm



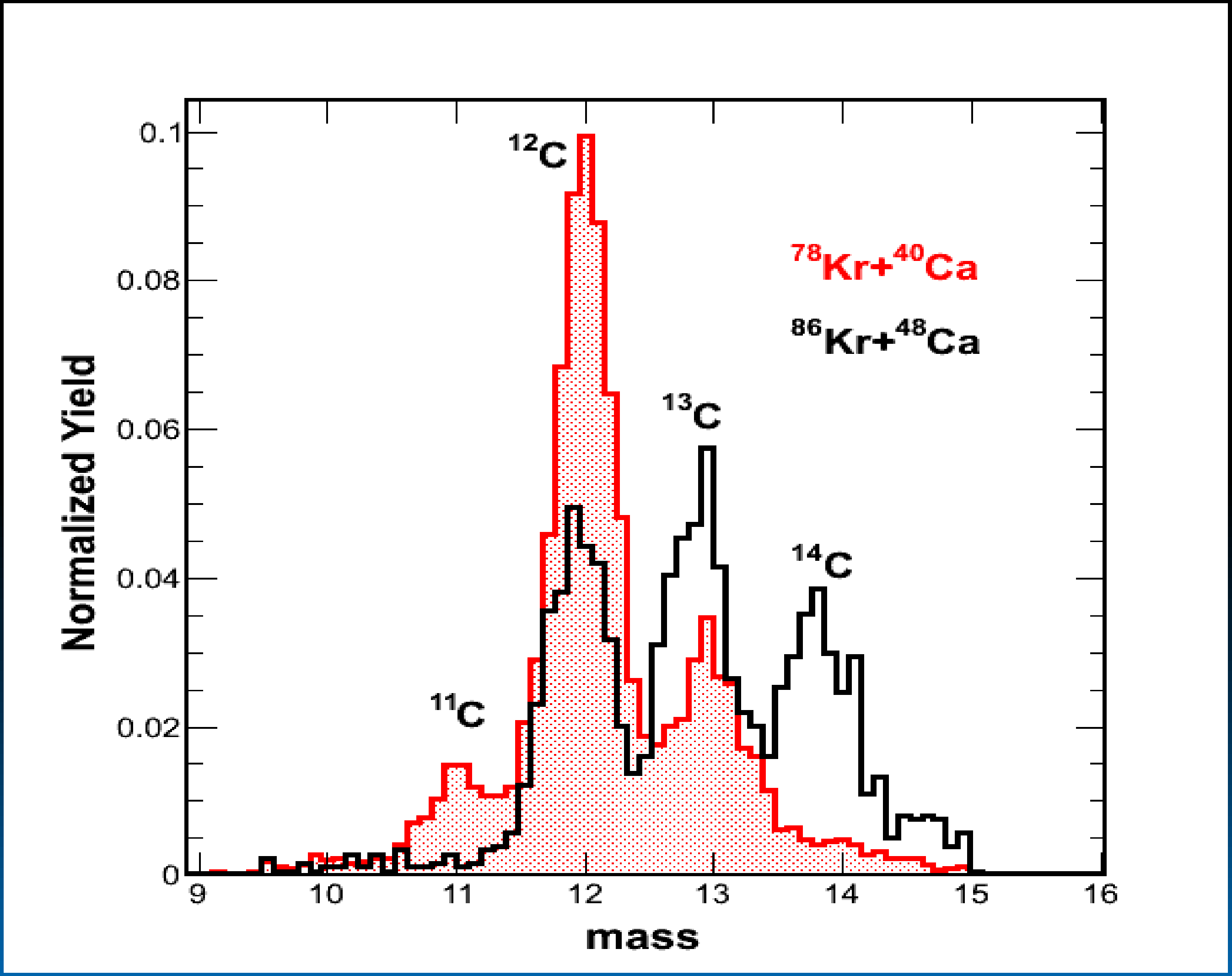
Precise measurement of E, TOF, Velocity, θ/φ

Different identification methods: PSD Si, E-ToF, DE/E, PSD CsI

Experimental results

IMF behavior

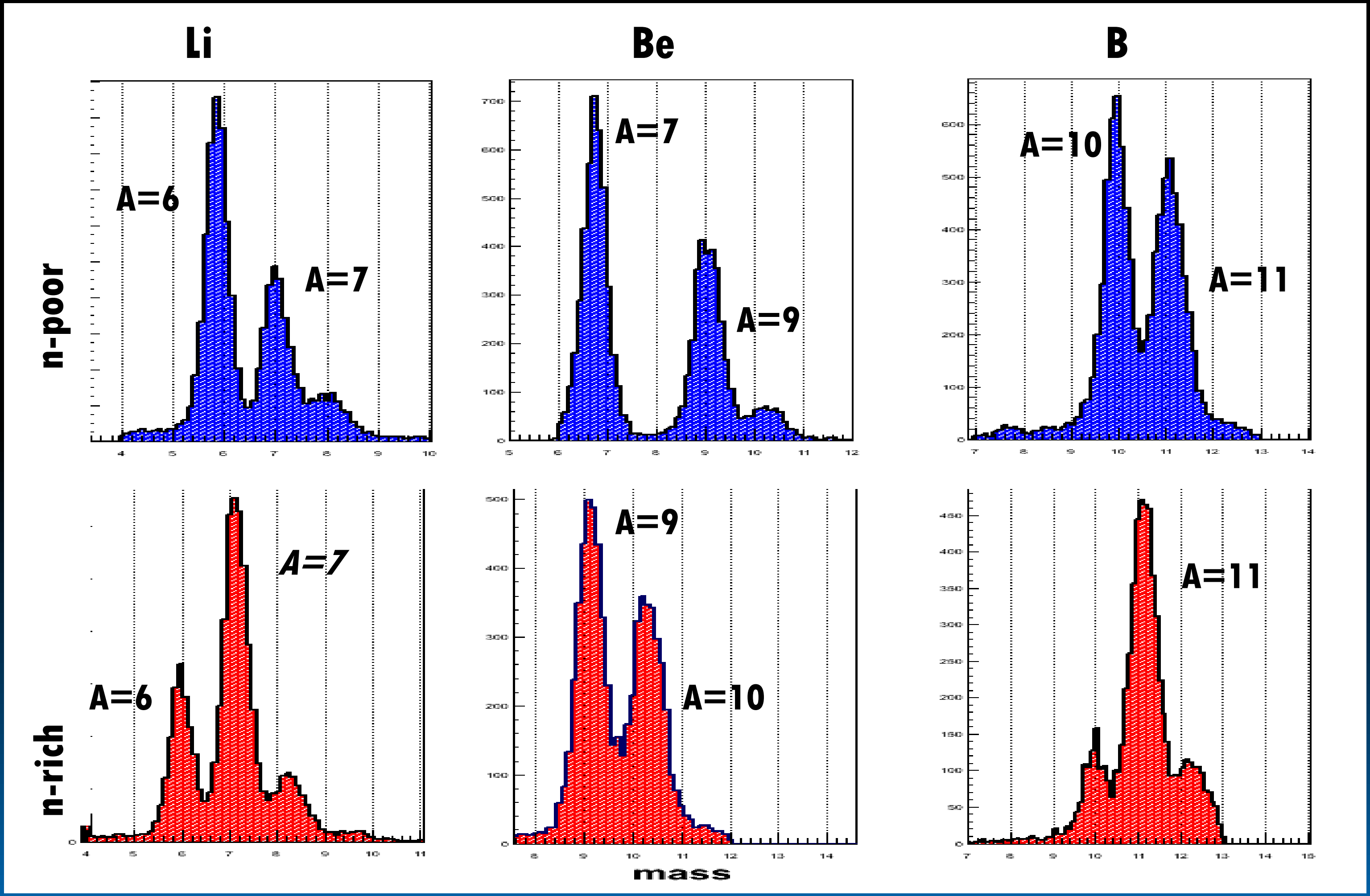
Different isotopic composition and relative richness of the Carbon for the two systems



Experimental results

IMF behavior

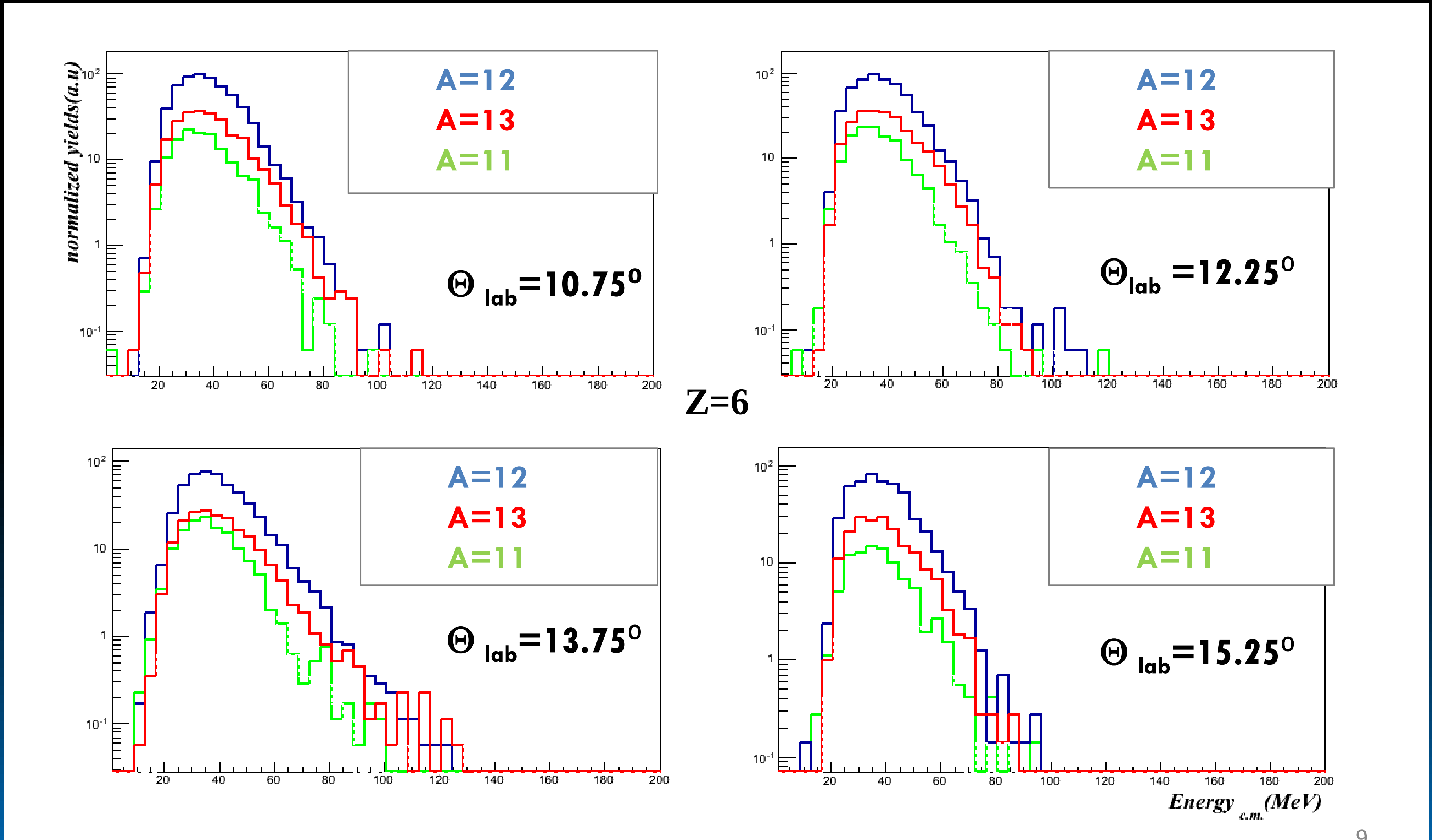
Mass distributions of different Z for the n-poor system $^{78}Kr + ^{40}Ca$ and for the n-rich system $^{86}Kr + ^{48}Ca$ at $\theta_{lab} = 21°$



Experimental results

IMF behavior

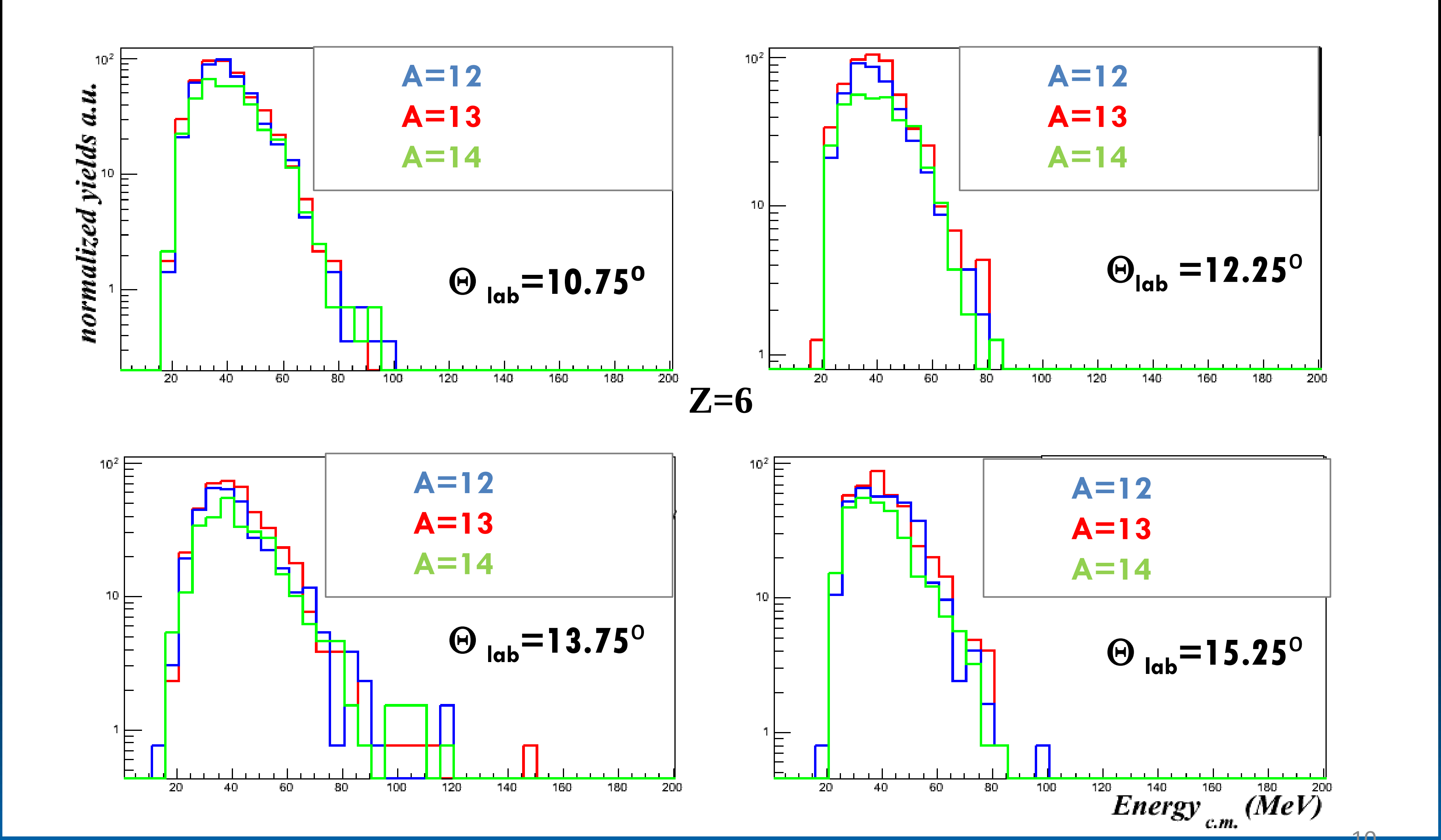
Energy spectra of the isotopes of the Carbon in the center of mass frame at different angles for $^{78}Kr + ^{40}Ca$



Experimental results

IMF features

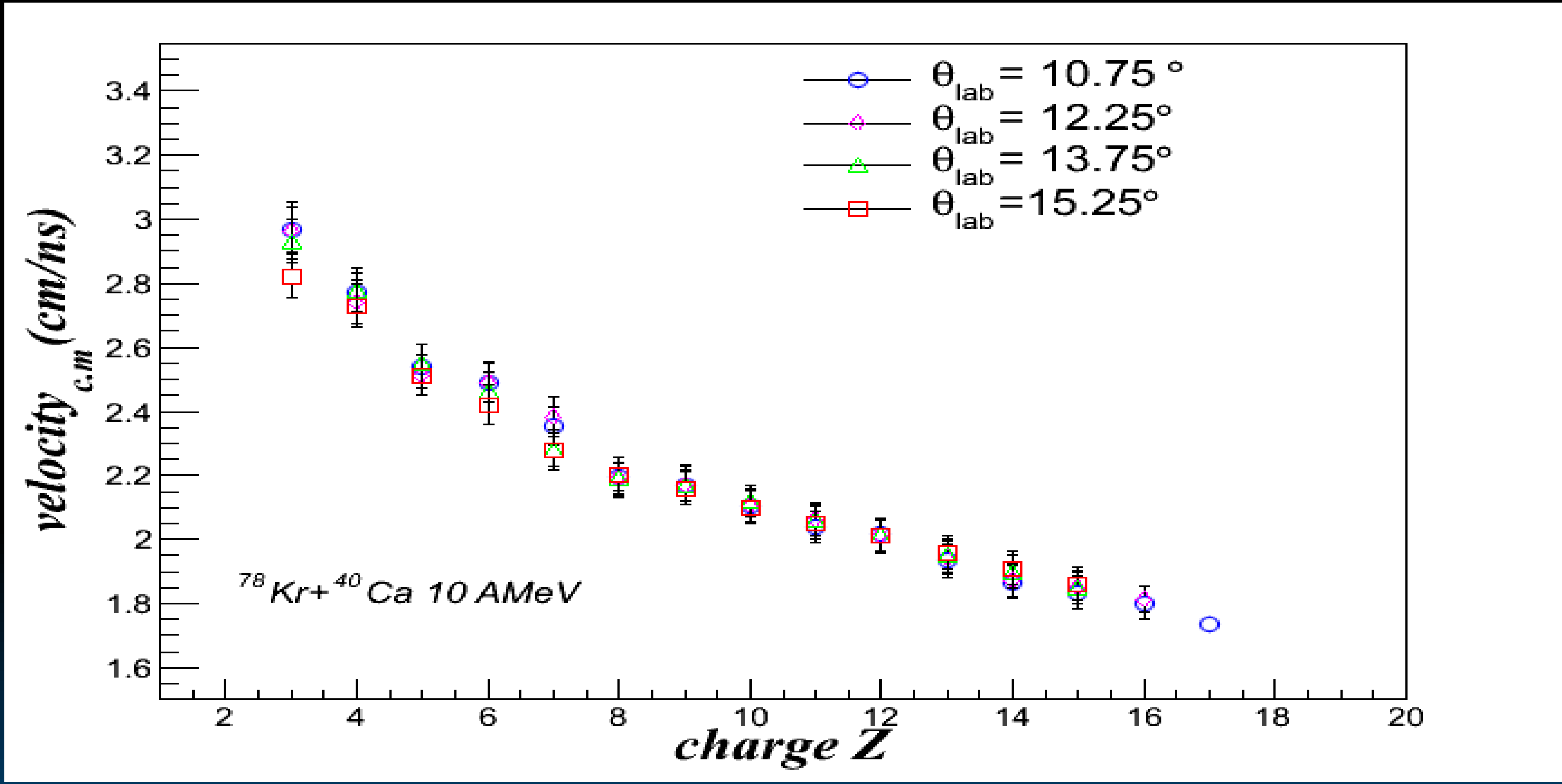
Energy spectra of the isotopes of the Carbon in the center of mass frame at different angles for $^{86}Kr + {}^{48}Ca$



Experimental results

IMF behavior

Average velocity for Z= 3-17 in the center of mass frame for different Z and at different θ_{lab}



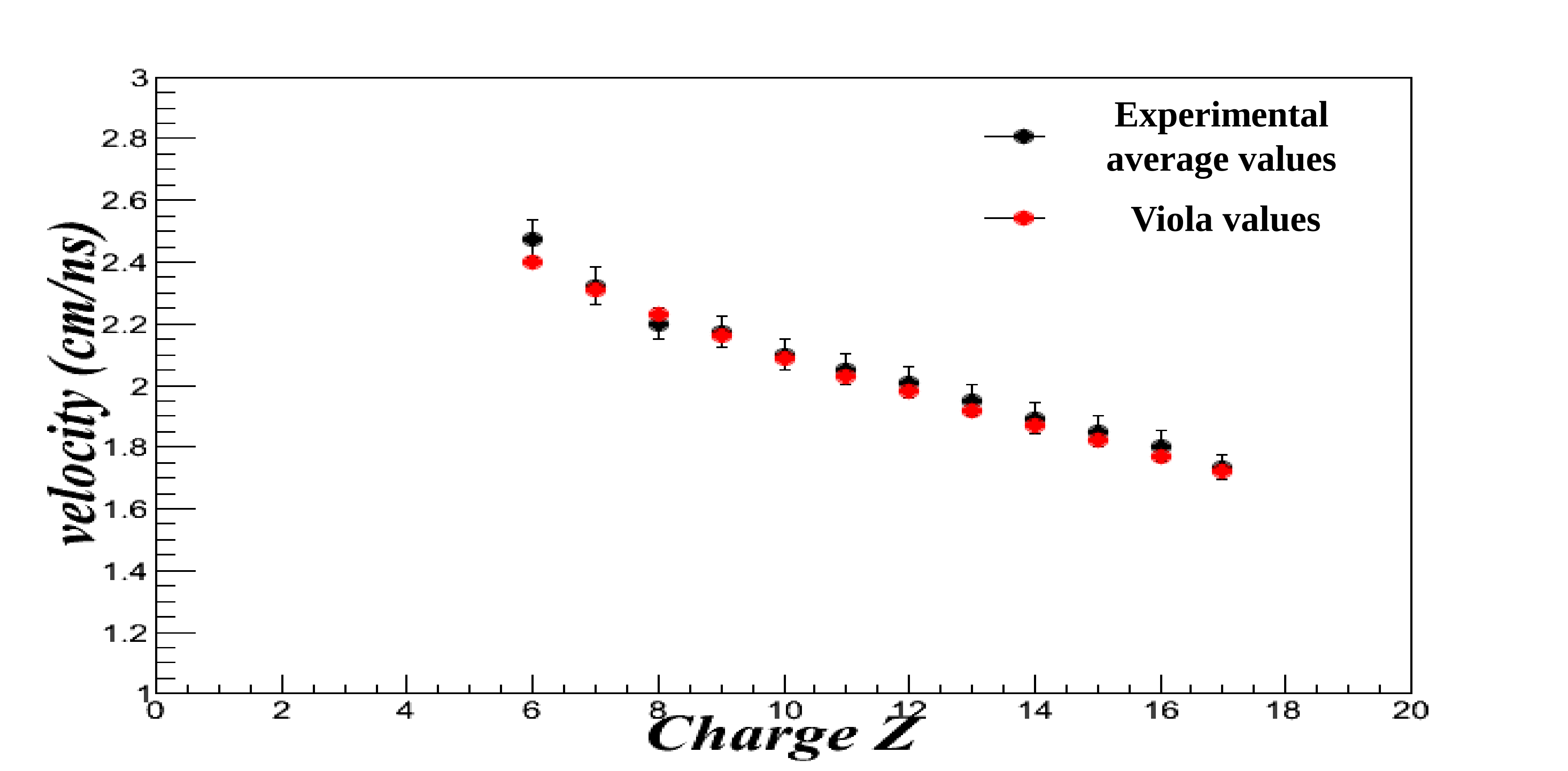
Velocity seems to be independent of the emission angle for all the fragments

-> high degree of relaxation of kinetic energy

Signature of a binary process dominated by the Coulomb interaction between the considered fragment and its complementary partner

Experimental results

IMF behavior

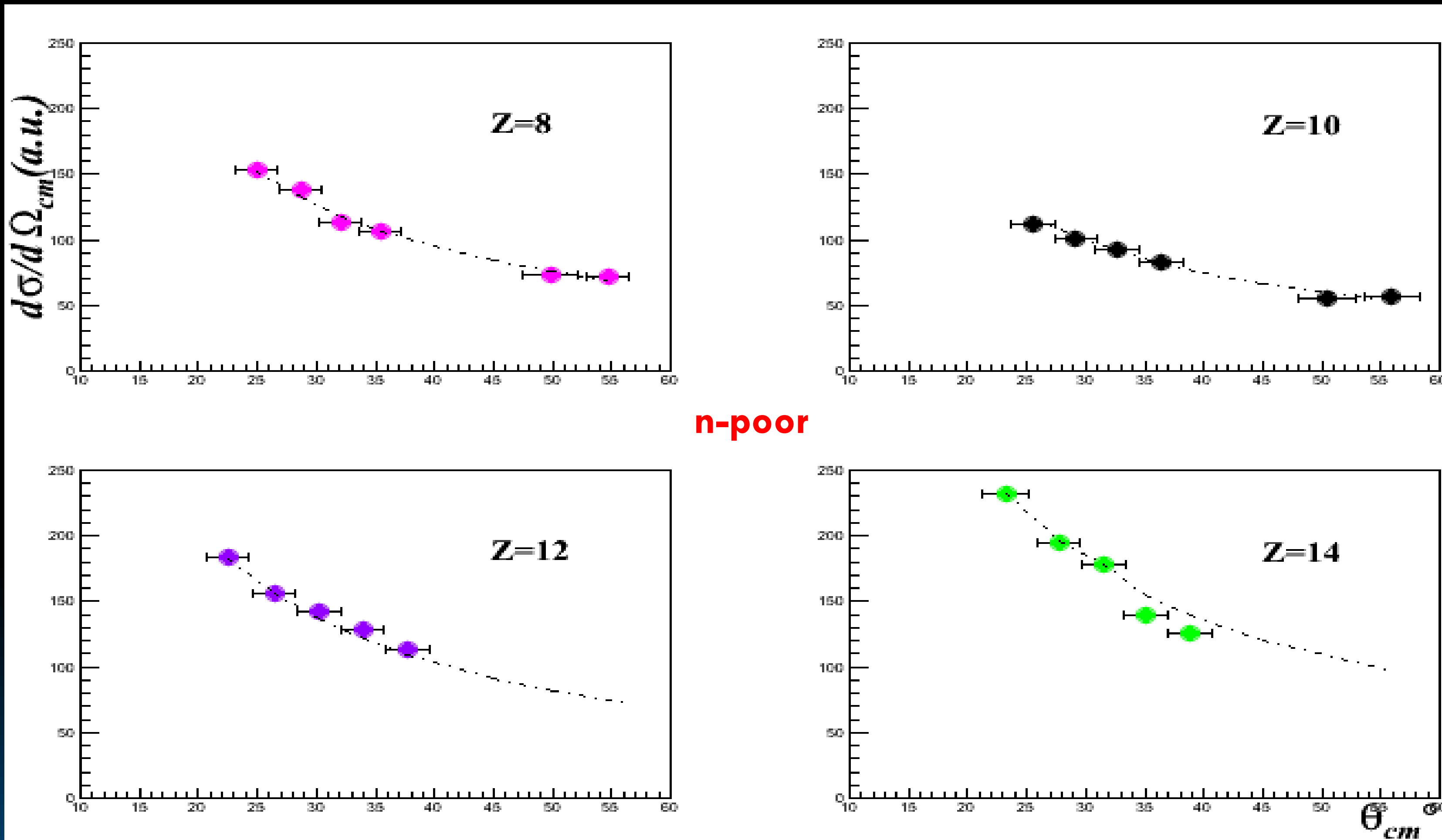


Average values of the experimental velocity (from Θ $_{lab}$=10.75^0 to Θ $_{lab}$=15.25^0)
in the center of mass frame compared to the values obtained with the systematic of Viola,
with the correction for the asymmetric fission (D.J. HINDE, *NP* A472 (1987) 318-332)

Experimental results

IMF behavior

Angular distributions in the center of mass frame

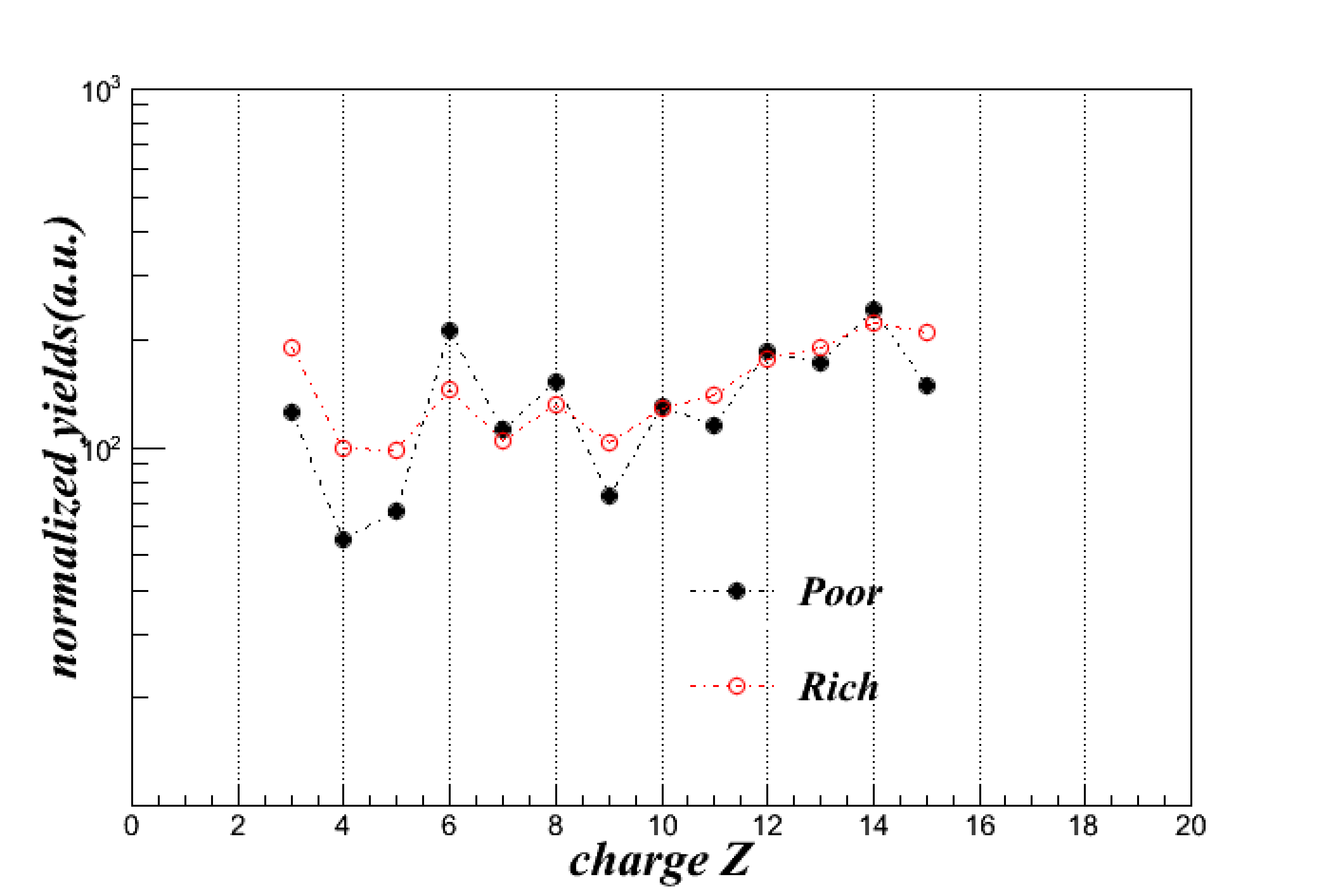


1/senθ fit->high degree of relaxation
Production via a long lived system
Similar results for the n-rich system

Experimental results

IMF behavior

Charge Yields for IMF of the reactions $^{78,86}Kr + ^{40,48}Ca$ in the range θ_{Lab} = 10°- 16°



The IMF yields exhibits an odd-even staggering, that is more pronounced for the n-poor system

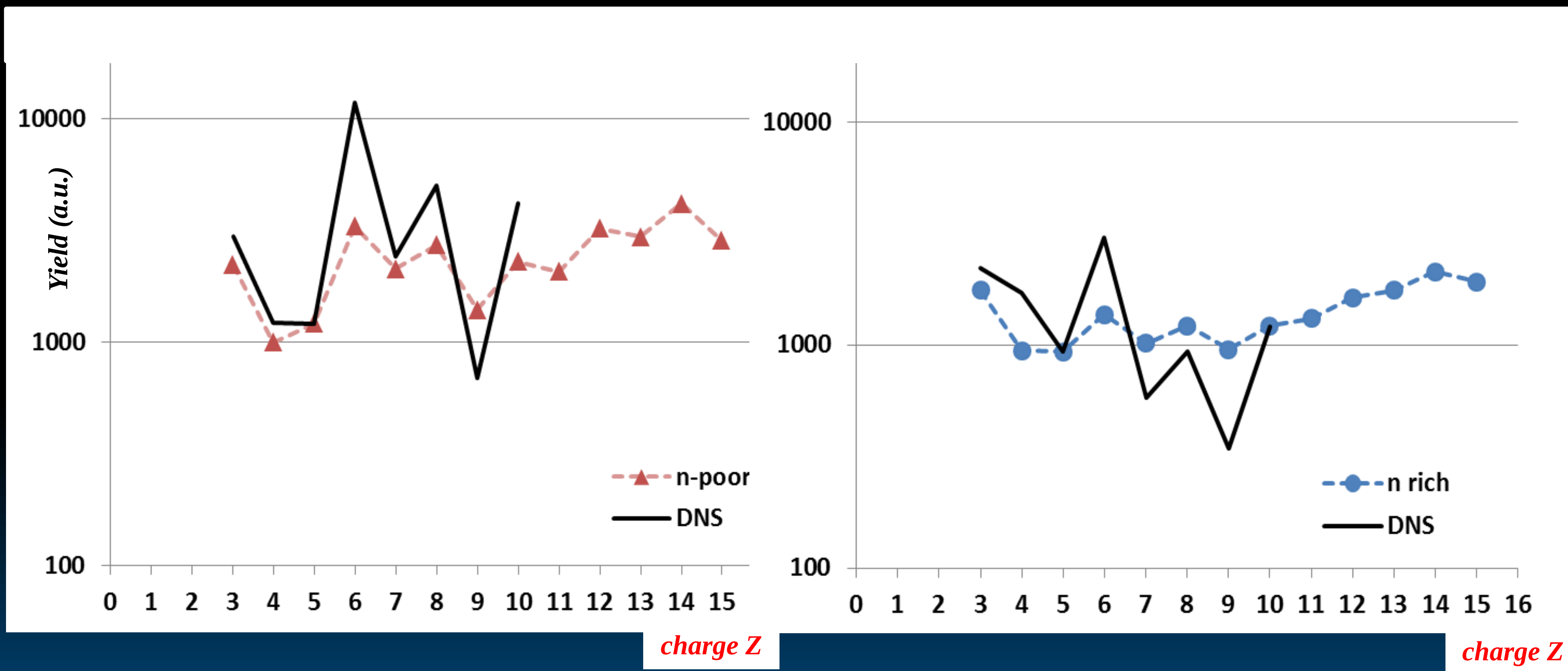
In agreement with : I. Lombardo et al., *PRC 84* ,(2011), 024613
G. Casini et al., *PRC* 86, (2012), 011602

Experimental results

IMF behavior

Preliminary comparison with DiNuclear System (DNS) code

S.A. Kalandarov et al. *PRC* 82 (2010) 044603



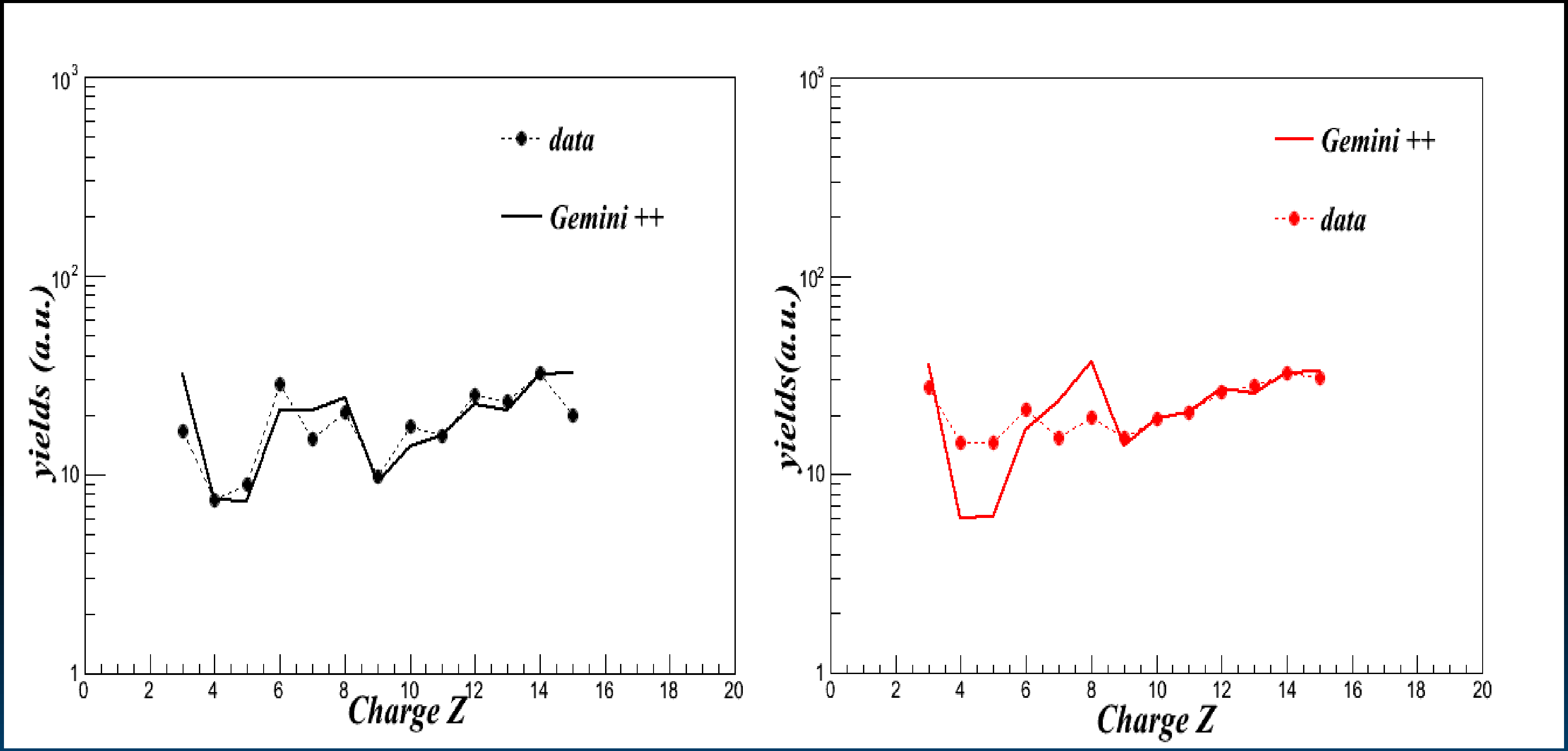
Simulation performed for the TOTAL cross section and normalized at Z=5

DNS seems to reproduce slightly better the n-poor system

Experimental results

IMF behavior

Preliminary comparison with Gemini ++ code



Simulation performed for the TOTAL cross section and normalized at Z=14

Gemini++ seems to reproduce slightly better the n-poor system

Experimental results

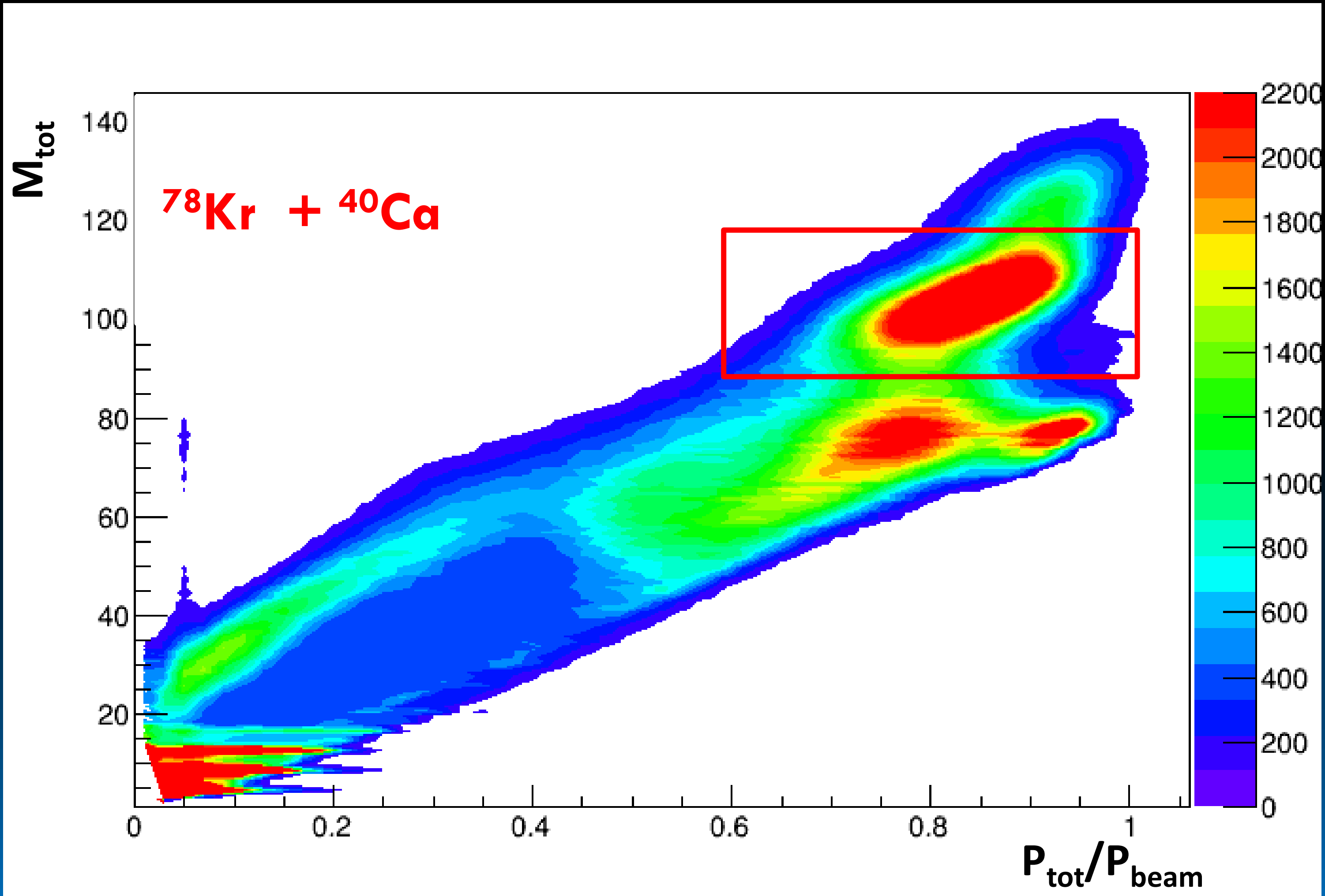
Global features

M_{tot} –P_{tot} plot for complete events selection:

Multiplicity≥2

$0.8\ M_{CN} \leq M_{tot} \leq 1.1\ M_{CN}$

$0.6 \leq p_{tot}/p_{beam} \leq 1$



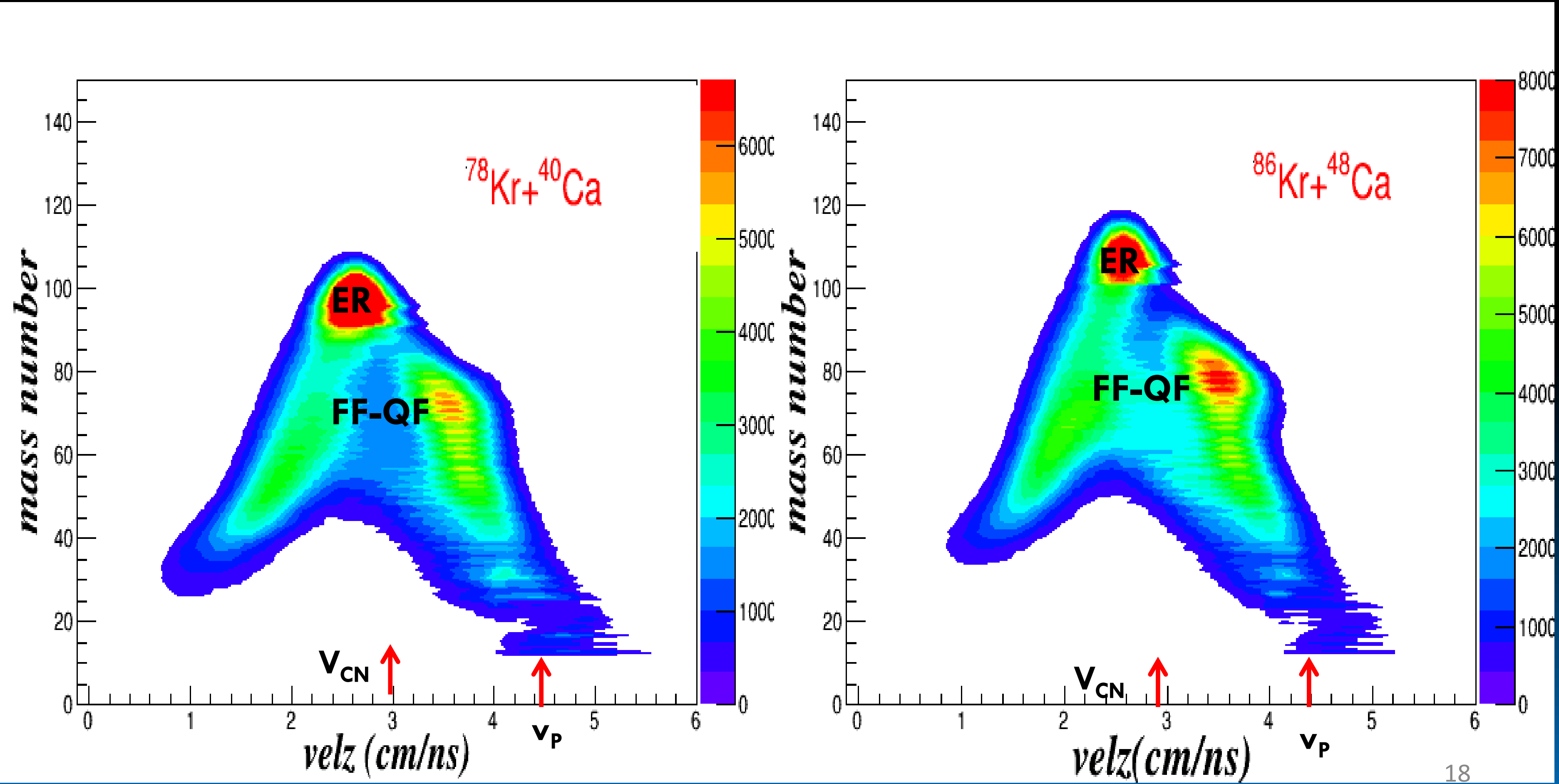
Experimental results

Global features

Plot mass-vparallel of the reaction products with complete events selection

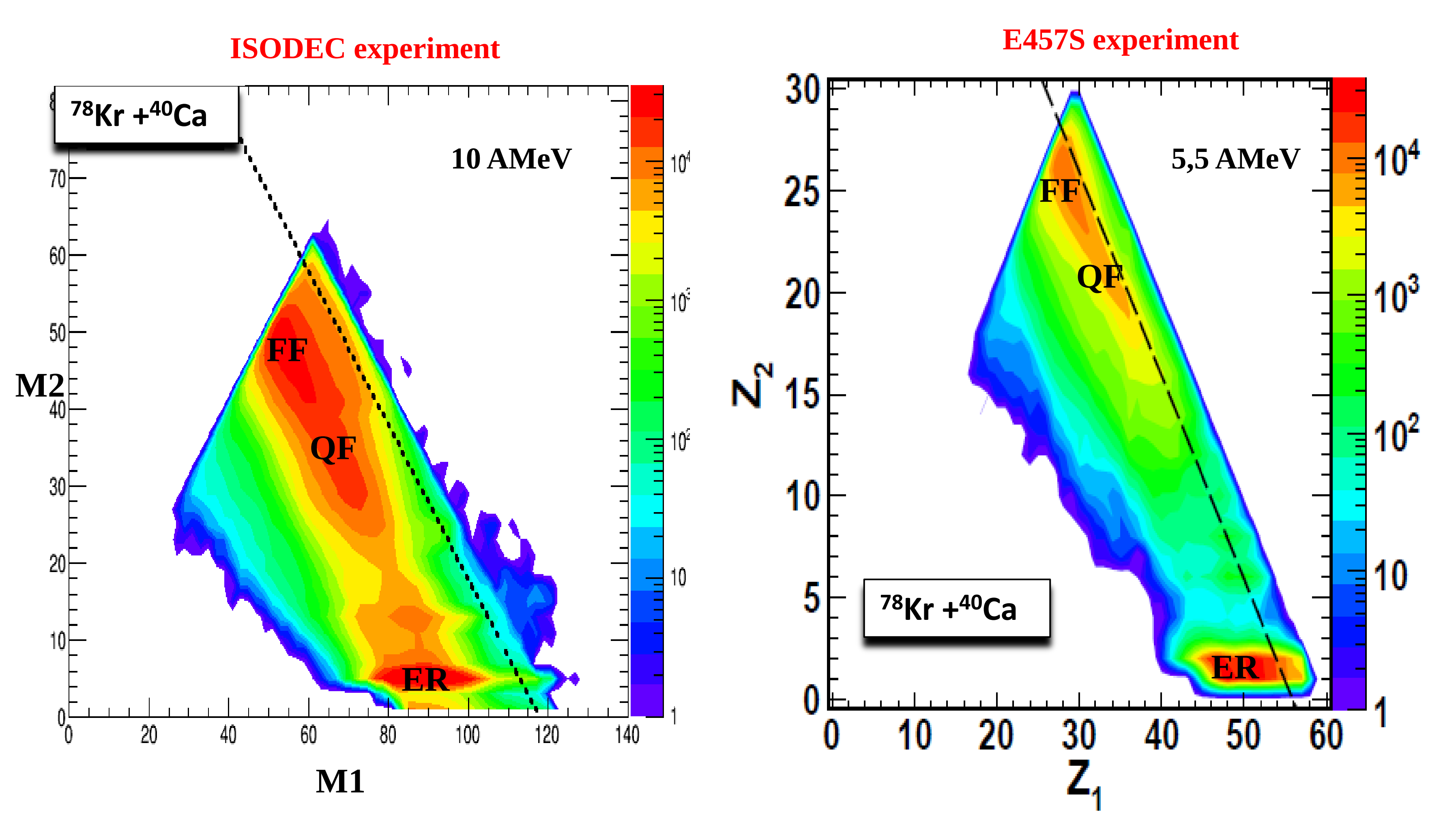
-> important information on the competition between the reaction mechanism

->very preliminary analysis seems to show that > there is a slightly higher ER/FF ratio for n-poor system compared to the n-rich



Experimental results

Global features



Preliminary comparison with the INDRA results of the reaction ^{78}Kr +^{40}Ca at 5.5 AMeV

(G. Ademard et al, *PRC* 83, (2011) 054619)

Conclusions

The results of the analysis of the reactions $^{78,86}Kr + ^{40,48}Ca$ at 10 AMeV are presented:

The kinematical characteristics and the angular distributions of the fragments detected seem to indicate for both reactions a high degree of relaxation of the composed system

The results put in evidence the influence of the neutron enrichment of the entrance channel on:

- Different isotopic composition and relative richness of the reaction products for the two systems.

- Odd- even effect , Staggering , in the IMF charge distributions
-->stronger for the n-poor system.

- Differences in the contribution arising from the various reaction mechanisms:
FF, QF and ER-> there is a slightly higher ER/FF ratio for n-poor system compared to the n-rich

Outlook

Data analysis are in progress :

Cross sections calculations for different mechanisms to confirm this first qualitative observation

Study of the Coincidence between LCP-FF, LCP-ER

More precise comparisons with theoretical predictions to provide indications on the isospin influence on the reaction mechanism and fragments production

Results suggest to extend the study at higher value of N/Z -> use of RIB

LOI presented at SPES2014 to use radioactive beams at INFN-LNL

Larger range of N/Z in entrance channel and compound nuclei:

^{92}Kr + ^{40,48}Ca 10 AMev ^{132,140} Ba* E* ~ 320 MeV

EXOCHIM – ISODEC collaboration

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