*Enrico De Filippo (INFN Catania) for the **NEWCHIM** collaboration*

Dependence from the Isospin of the entrance channel in Projectile-like (PLF) break-up at Fermi energies

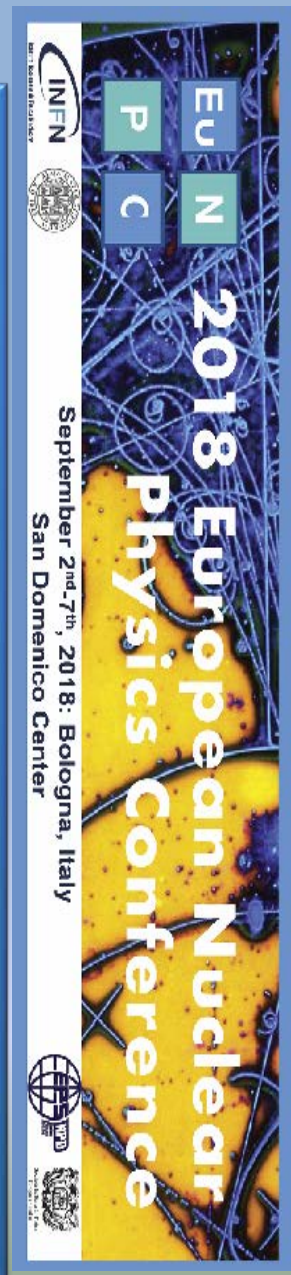
The Physics case: dynamical vs. statistical production of Intermediate Mass Fragments (IMF).

The Experiment: The **InKiIsSy** experiment (Inverse Kinematics Isobaric Systems), ^{124}**Xe**+^{64}**Zn**,^{64}**Ni** at 35 A.MeV as compared with previous studied reactions ^{124,112}**Sn**+^{64,58}**Ni**.

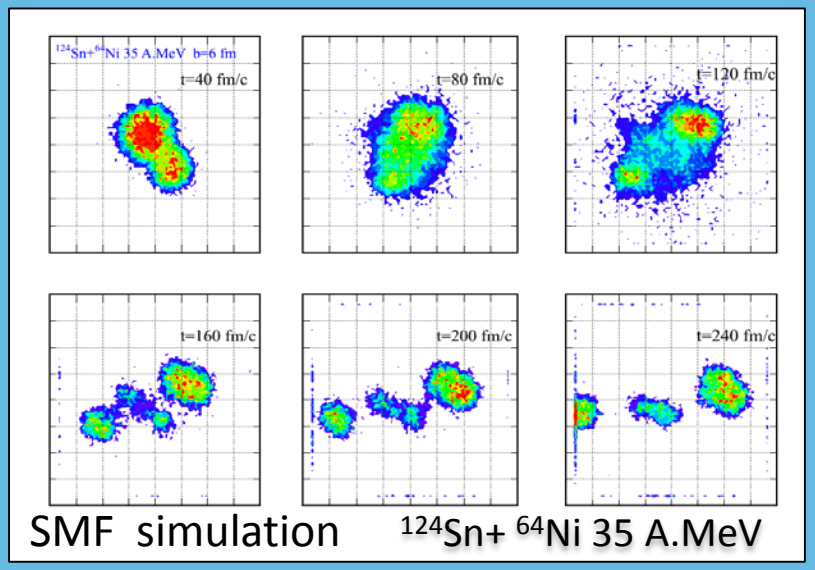
Main Results: the «dynamical» fission of the PLF* is mainly rules by the **N/Z** content of the projectile and target and not dependent by the sistem «size».

Constrained Molecular Dynamics (**CoMD-3**) simulations

CHIFAR: CHImera-FARcos : A new experiment to study projectile-like break-up and IMF production at 20 A.MeV with the CHIMERA and **FARCOS** devices

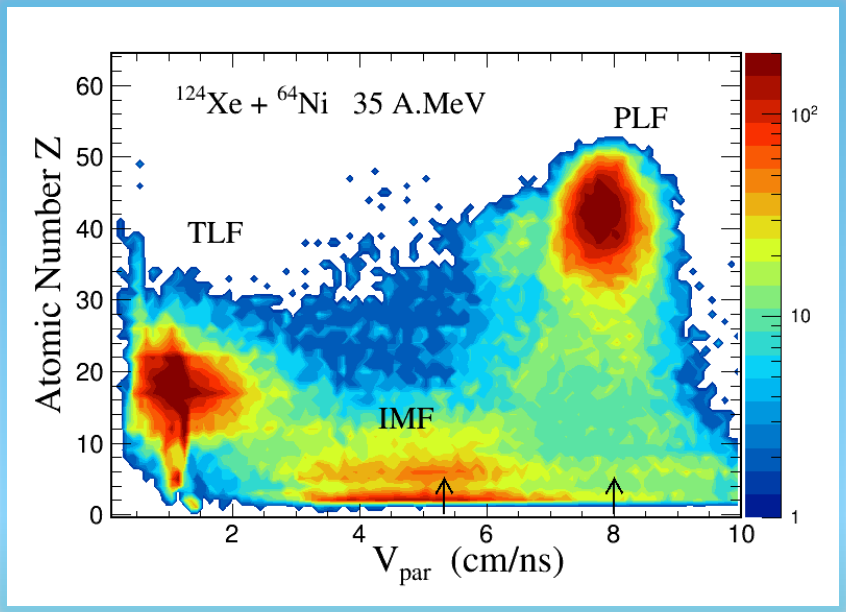


Physical case: sources of IMFs in semi-peripheral reactions



In the "**neck**" emission light IMFs (Z<≈9) are produced at midrapidity due to the rupture of a piece of nuclear matter a low density ("neck"). This is generally a **FAST** process (<100 fm/c)

Excitation of a primary Projectile-like PLF* (TLF*) followed by its **dynamical (non-equilibrated)** splitting (**dynamical fission**). In this case emission of the **lighter IMF** is preferentially backwards in the PLF reference system. This process is in competition with **statistical (equilibrated)** break-up



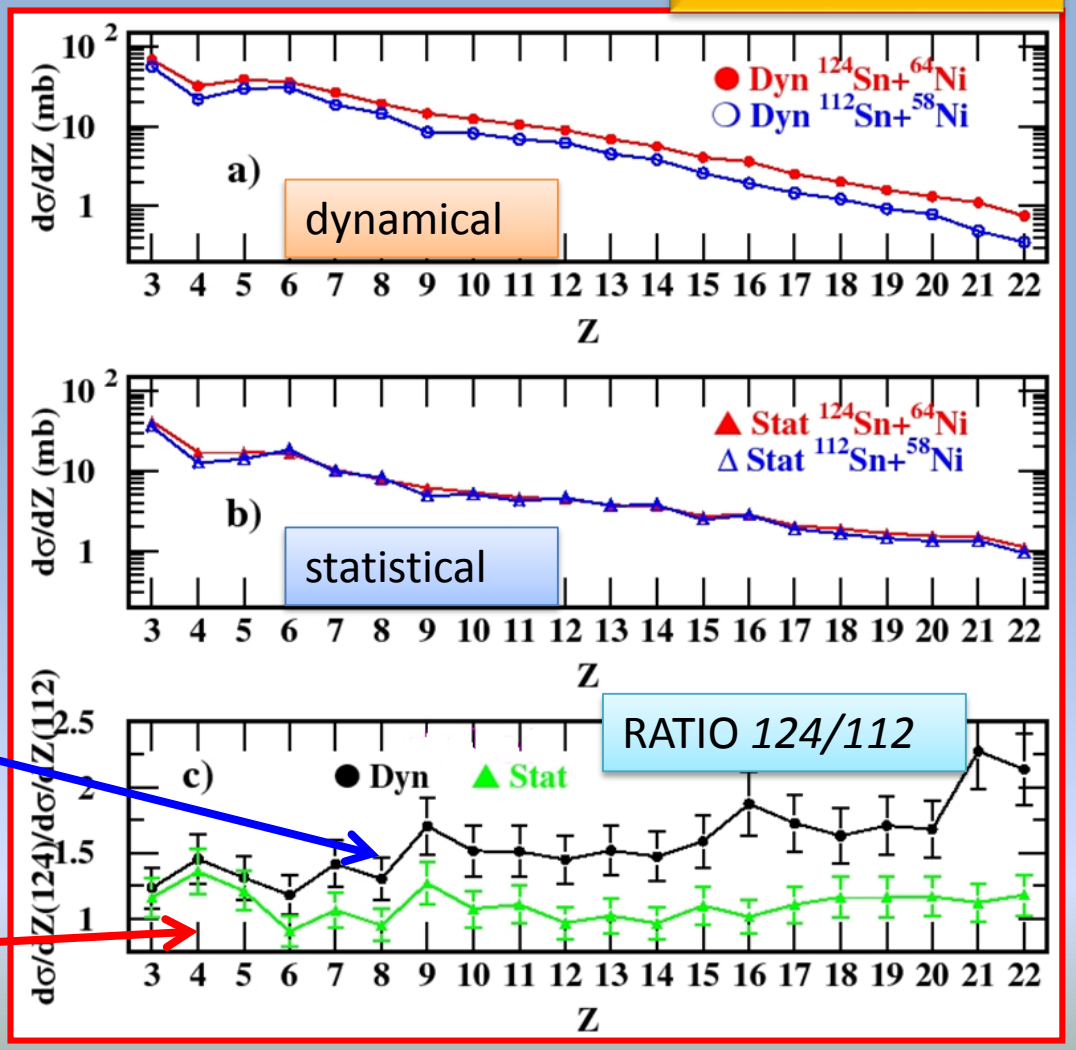
Our goal: **Study of Isospin influence on PLF dynamical break-up**

Previous results: comparison of IMFs cross sections for $^{124}Sn+^{64}Ni$ and $^{112}Sn+^{58}Ni$

P. Russotto et al. , Phys. Rev. C91, 014610 (2015)

Main experimental signature:
Enhanced contribution of dynamical component in binary projectile break-up (dynamical fission) for neutron rich system

Cross-sections

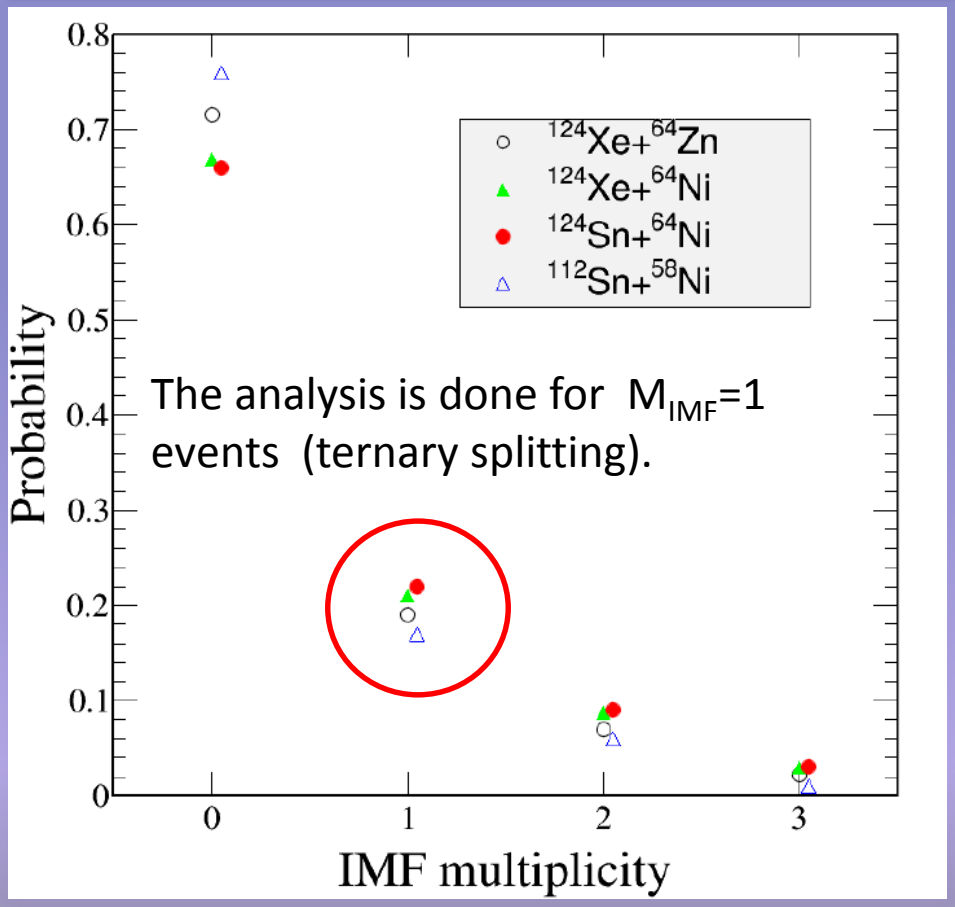


- **Dynamical component: enhanced for the neutron rich**
- **Statistical component: almost equal (A ratio: ~1.1 close to the mass ratio between the systems)**

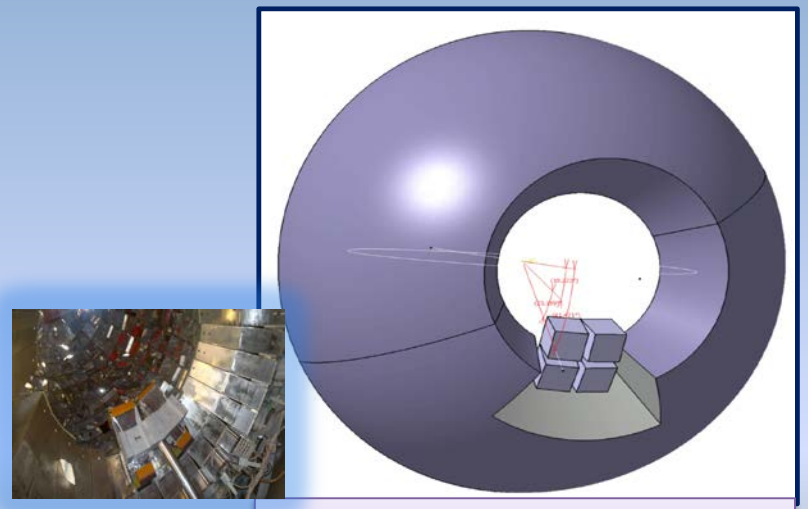
Isospin influence on dynamical production of IMFs in the InKiIsSy (Inverse Kinematics Isobaric Systems) experiment: ^{124}Xe + ^{64}Zn,^{64}Ni@35 A.MeV

The main goal of the experiment was to disentangle entrance channels Isospin effects from «size> effects by using isobaric systems

M_{proj}=124 : M_{targ} = 64



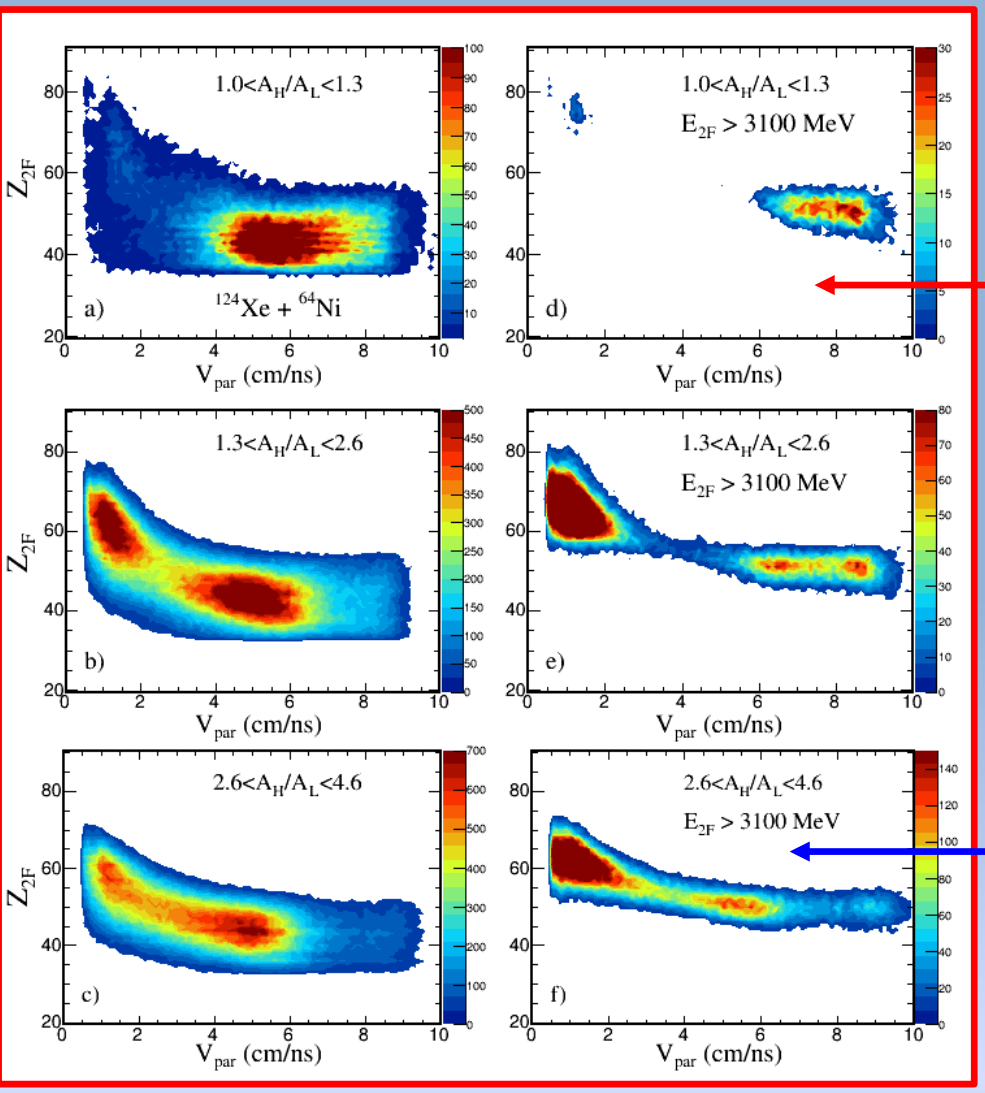
System	N/Z Projectile	N/Z target	N/Z compound
^{124}Sn+^{64}Ni	1.48	1.29	1.41
^{124}Xe+^{64}Ni	1.30	1.29	1.29
^{124}Xe+^{64}Zn	1.30	1.13	1.24
^{112}Sn+^{58}Ni	*1.24*	*1.07*	*1.18*



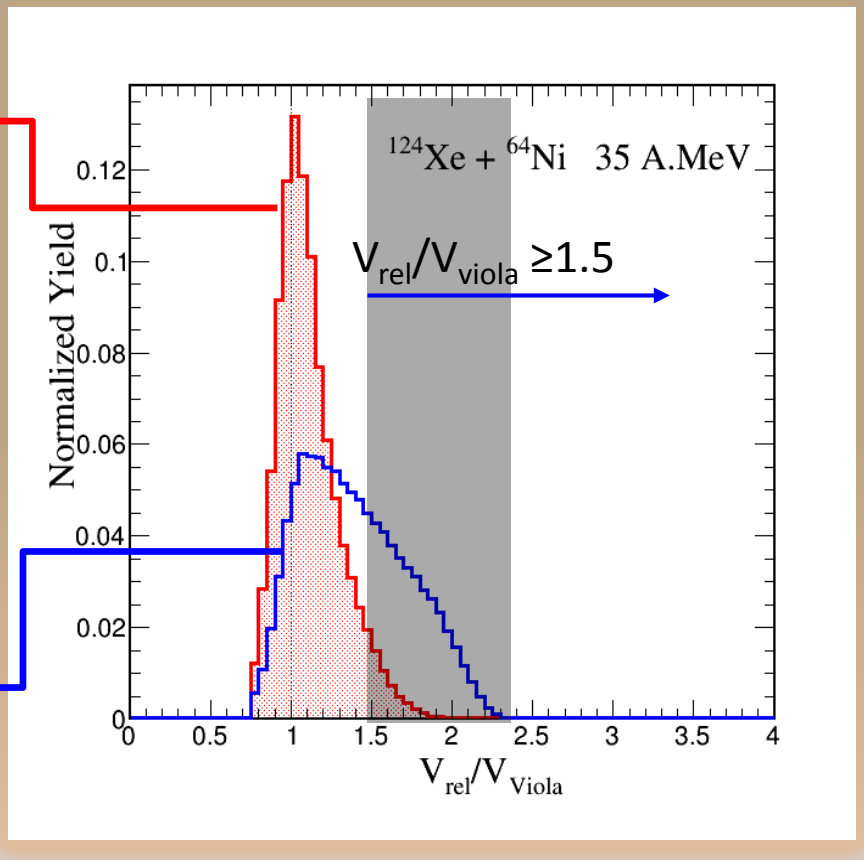
Farcos demonstrator 25 cm from the target θ_{lab} ~ 15-45 deg, $\Delta\phi$ ~ 75 deg

P. Russotto et al.: arXiv:1803.03046v1 (2018)

Analysis of the two largest fragments Z_1 - Z_2



$V_{rel} = V_{PLF} - V_{IMF}$



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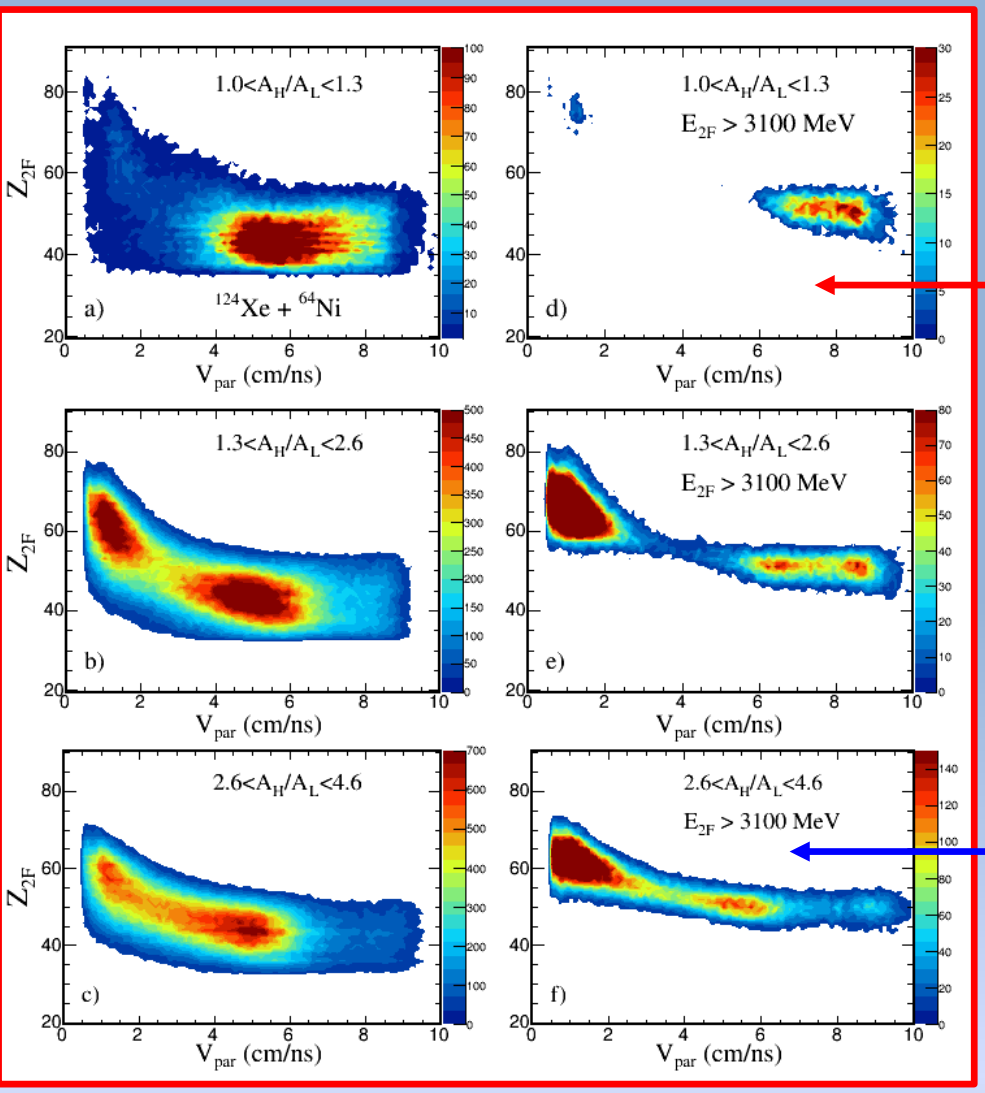
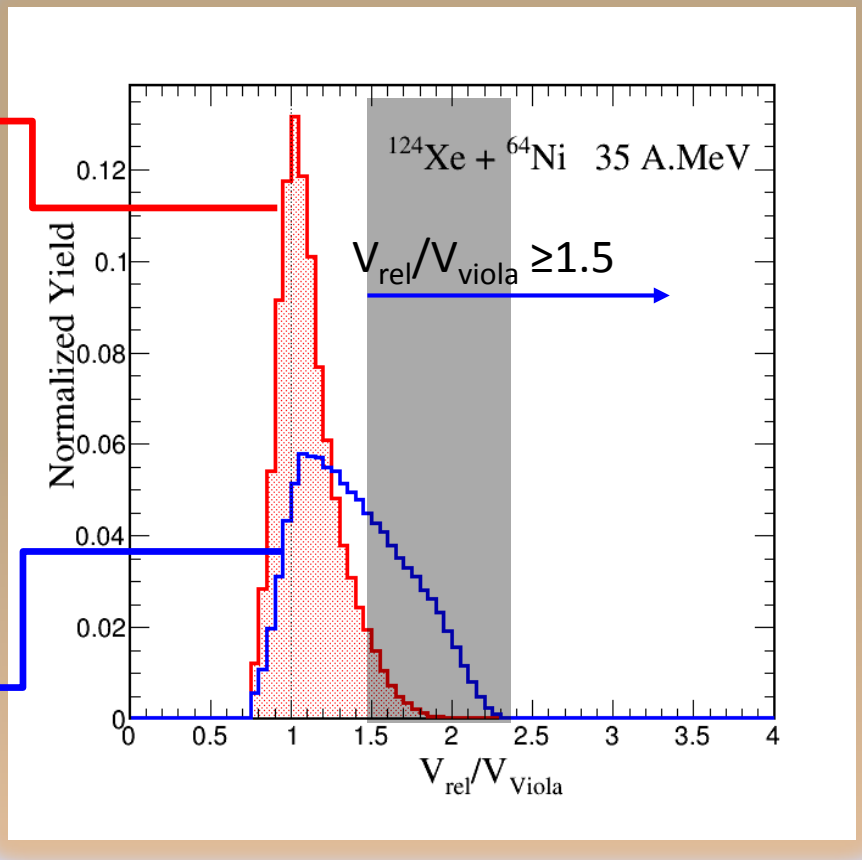
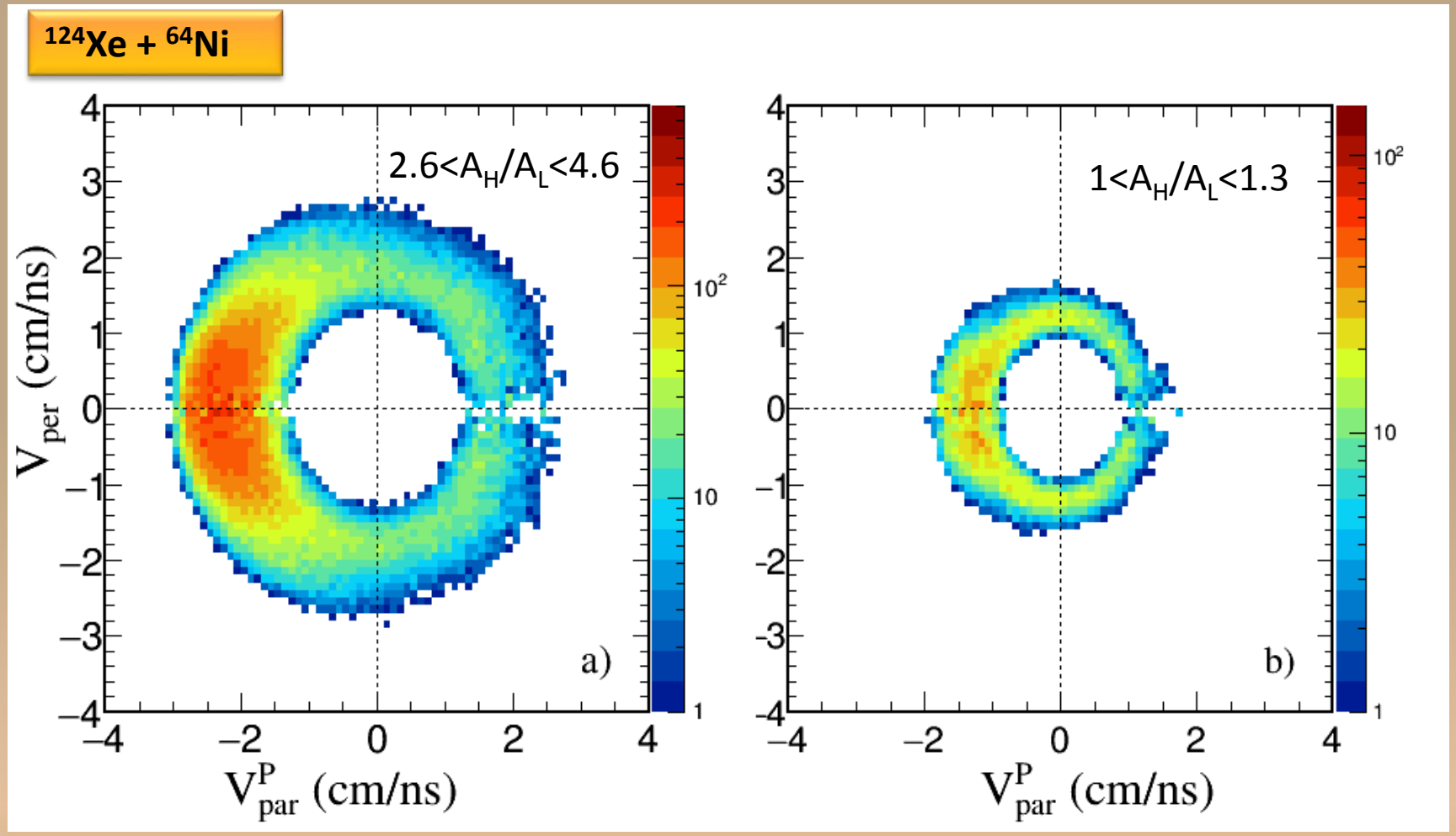


$V_{rel} = V_{PLF} - V_{IMF}$

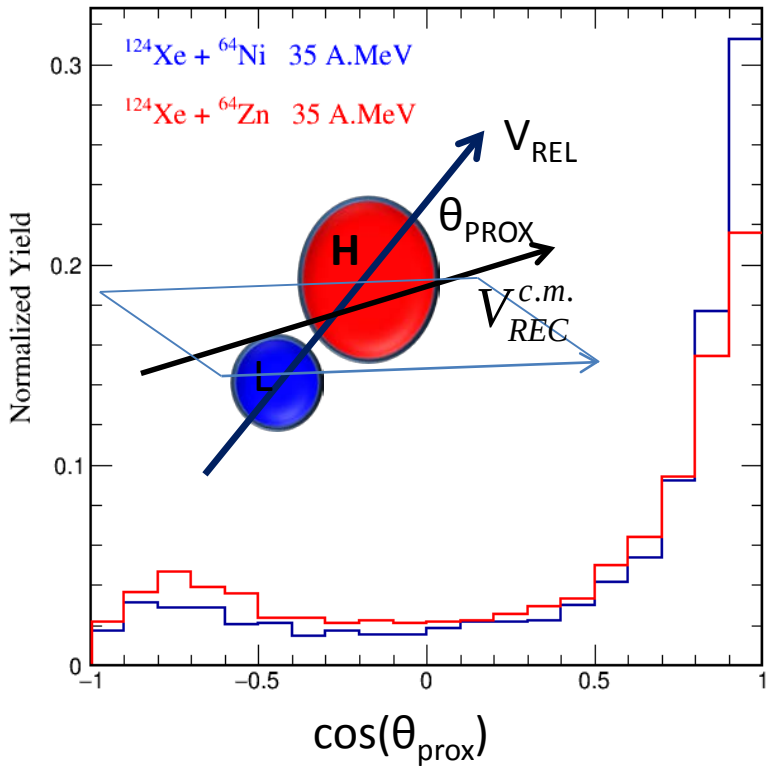


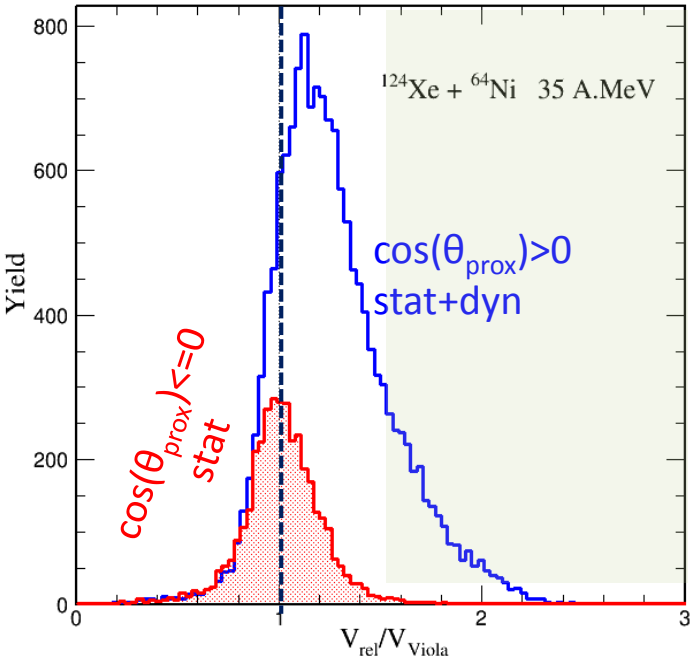
We select only data with **Vrel/Vviola <= 1.5** in order to reject IMFs emitted from TLF (see P. Russotto et al., PRC 91, 014610 2015.)

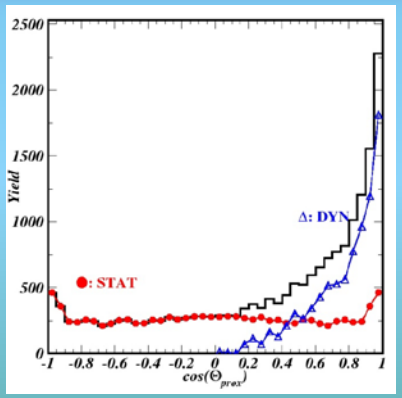
Galileian Invariant cross-sections for the lighter fragment A_L in the reference frame of the PLF source



Data analysis method: angular distributions

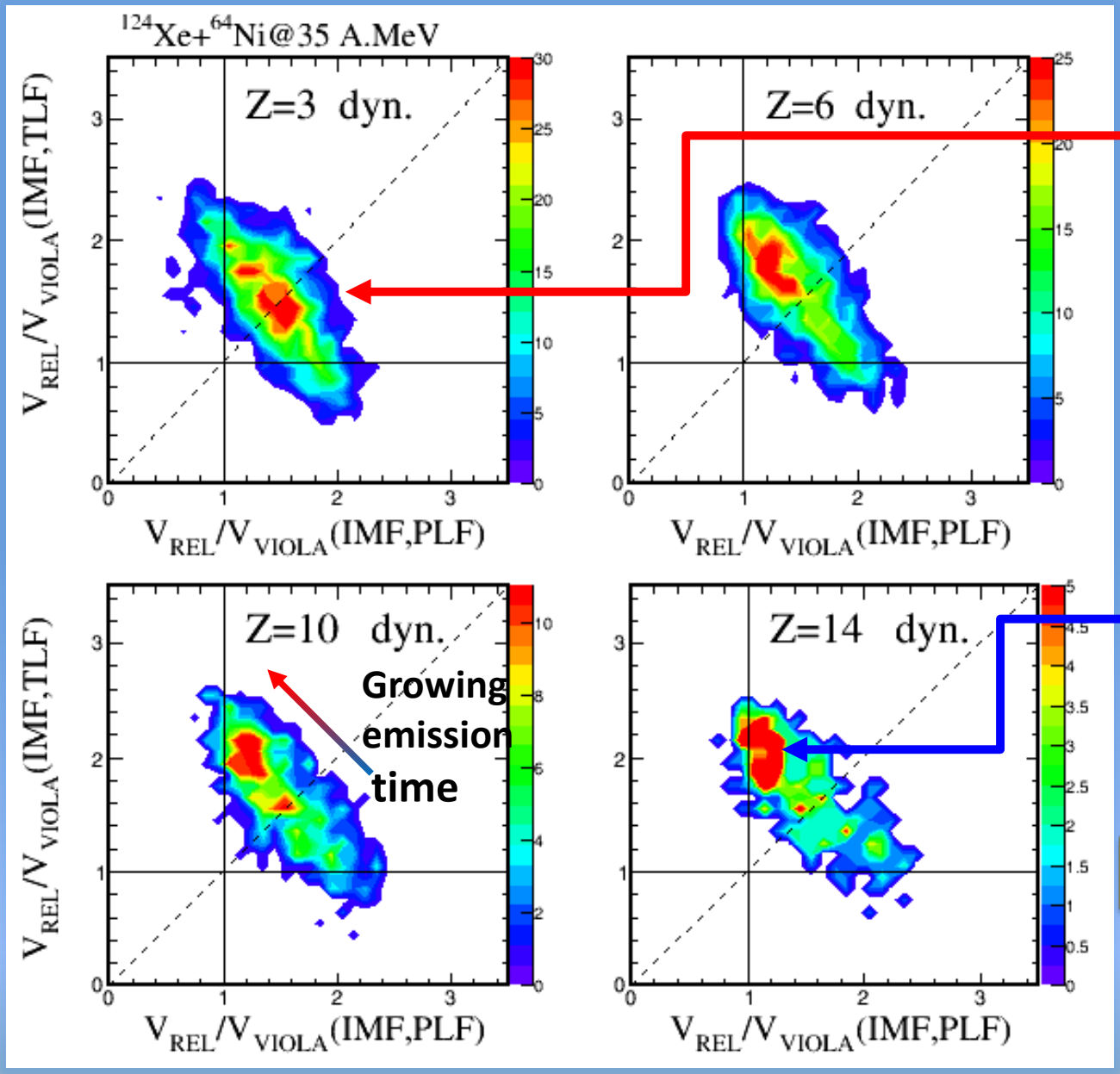






Disentangling statistical and dynamical emission

Three body analysis of fragments (neck dynamics) in INKIISSY



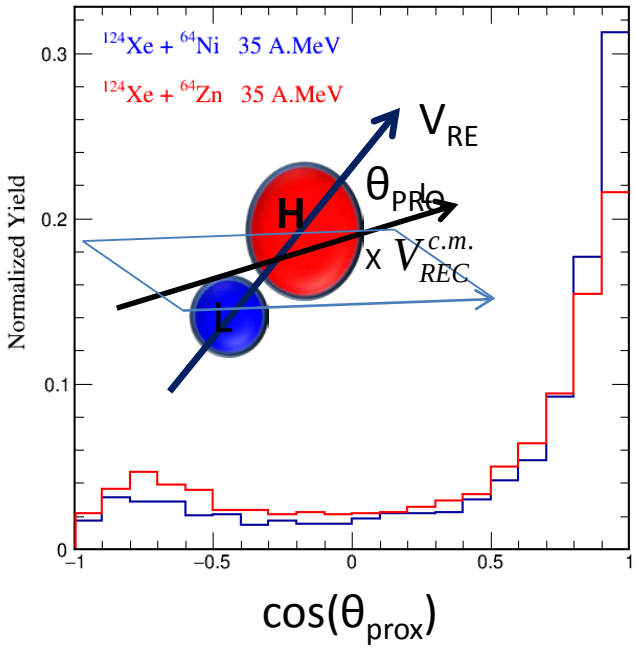
FROM neck emission

TO projectile-like asymmetric break-up

^{124}Xe + ^{64}Ni @35 A.MeV

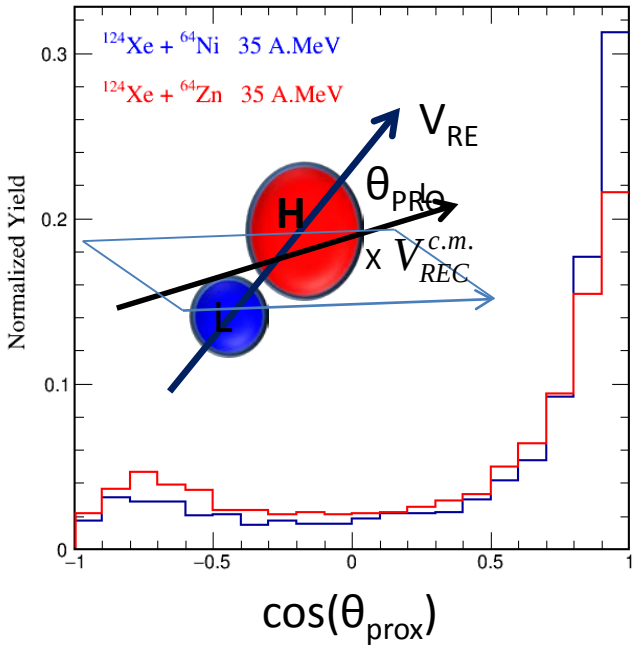
See also: E.d.F. et al. Phys. Rev. C**86** 014610 2012

PLF BREAK-UP ANGULAR DISTRIBUTIONS

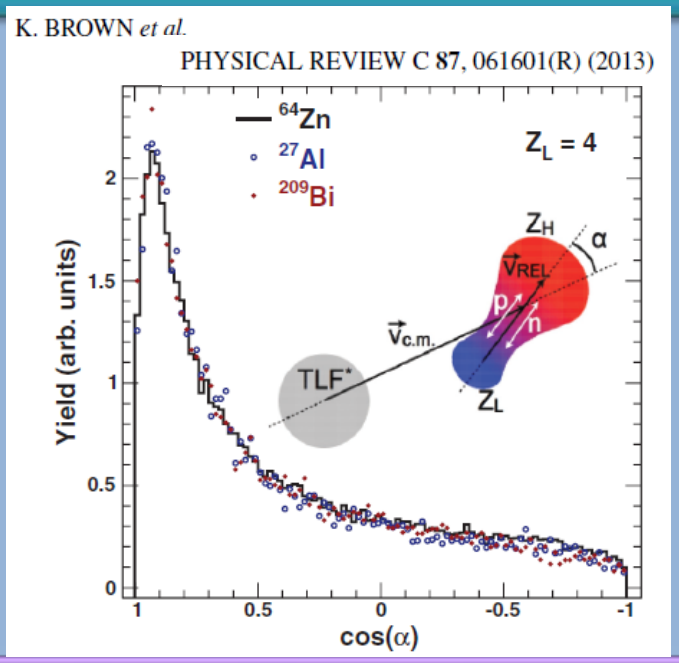


We use angular distribution of fragments in order to estimate the probabilities of dynamical vs. statistical emission as a function of IMFs charge

PLF BREAK-UP ANGULAR DISTRIBUTIONS



We use angular distribution of fragments in order to estimate the probabilities of dynamical vs. statistical emission as a function of IMFs charge

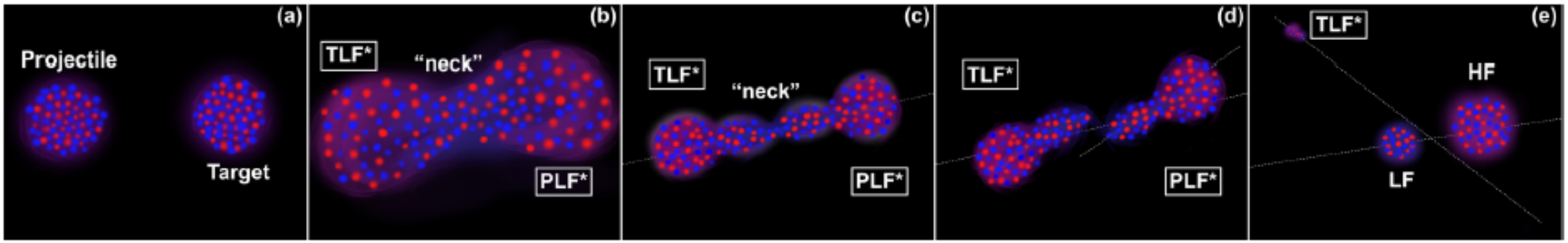


This is a different case where the relation between the N/Z of fragments is observed as a function of the break-up angular distributions, related to the time-scale of the process.

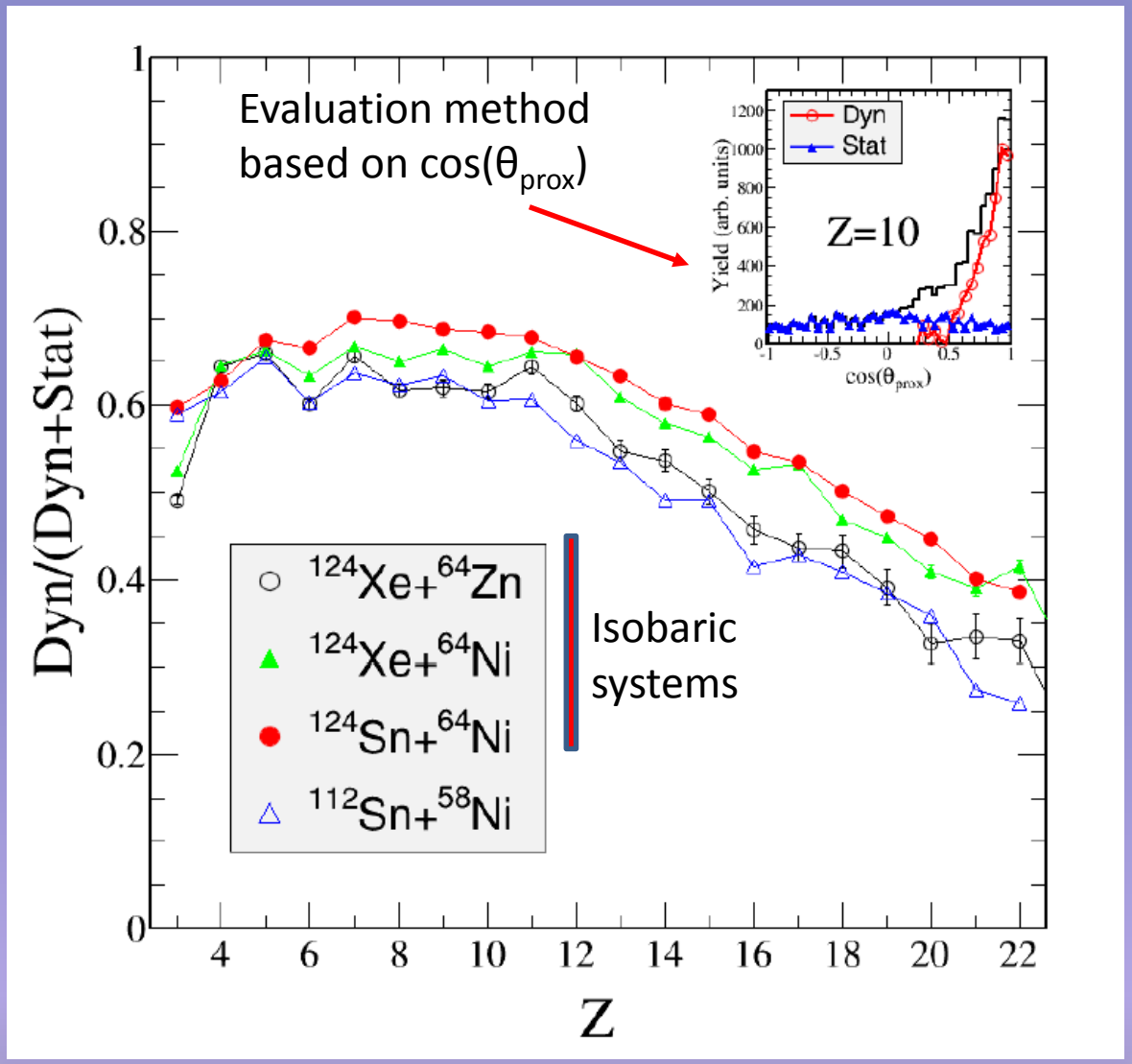
A. RODRIGUEZ MANSO *et al.*

- Extract time-scale from rotation

PHYSICAL REVIEW C **95**, 044604 (2017)

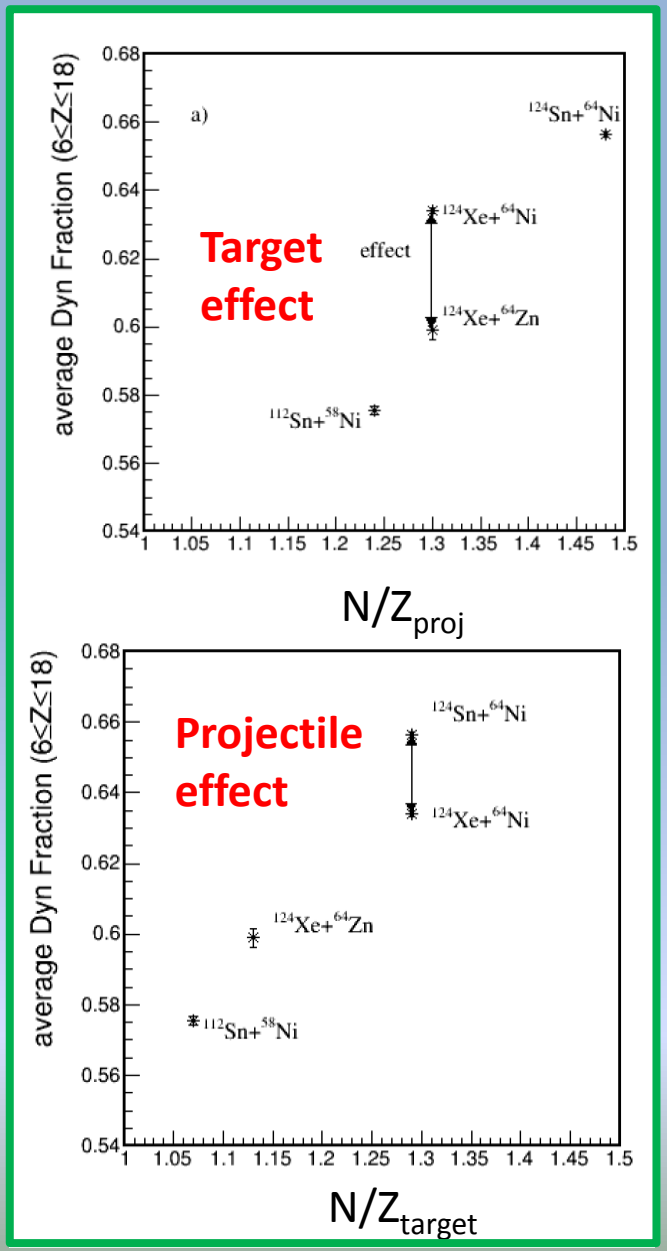


Main experimental Result: dynamical emission is favored by an increase of projectile and target Isospin and is independent by the system size

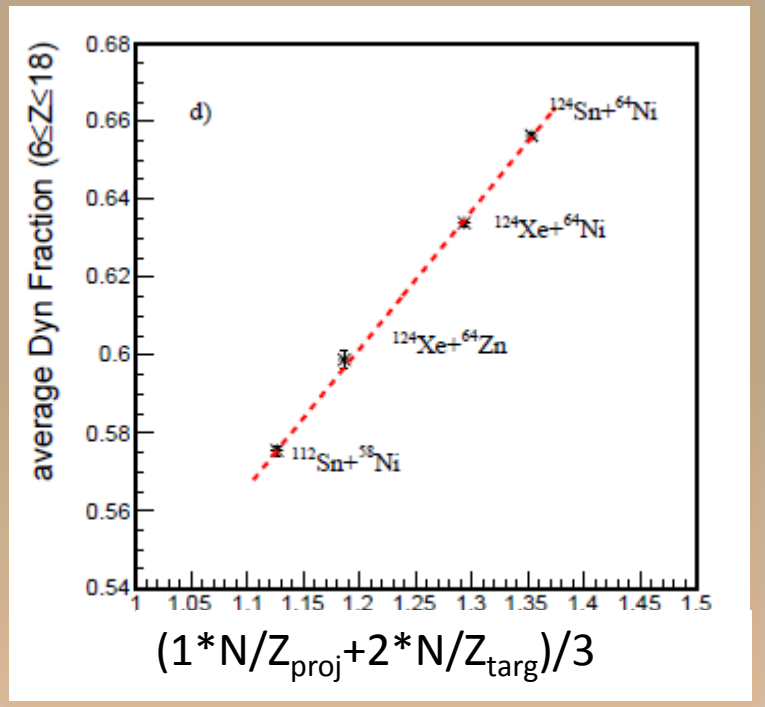


P. Russotto, E.d.F, E.V Pagano et al. arXiv:1803.03046v1 (2018)
To be submitted to EPJ-A

Main experimental Result: dynamical emission is favored by an increase of both Projectile and Target Isospin



Linear Scaling with a weighted N/Z content of projectile and target



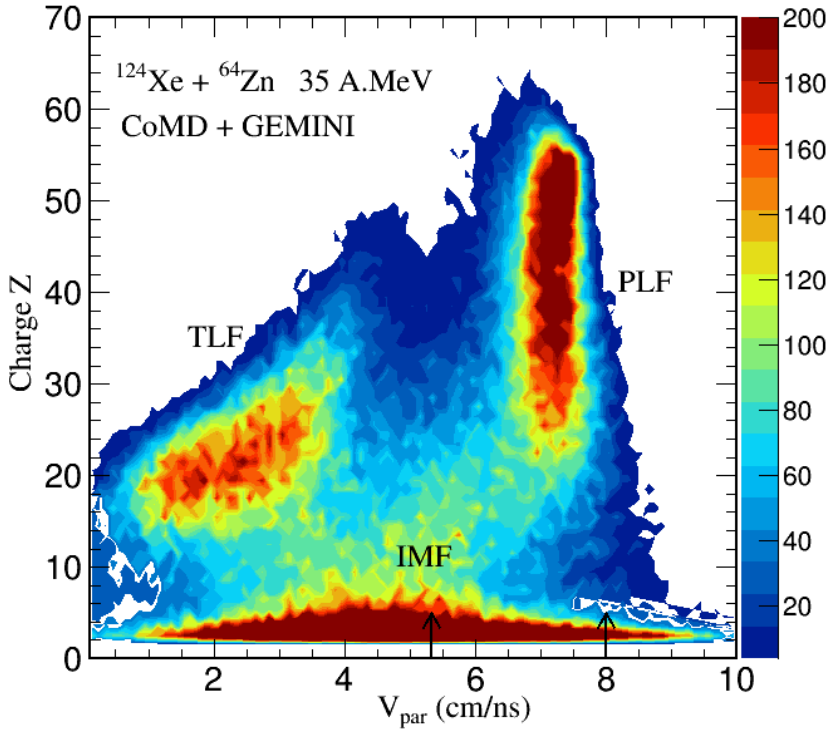
Dynamical emission is mainly ruled by The N/Z content of both projectile and target

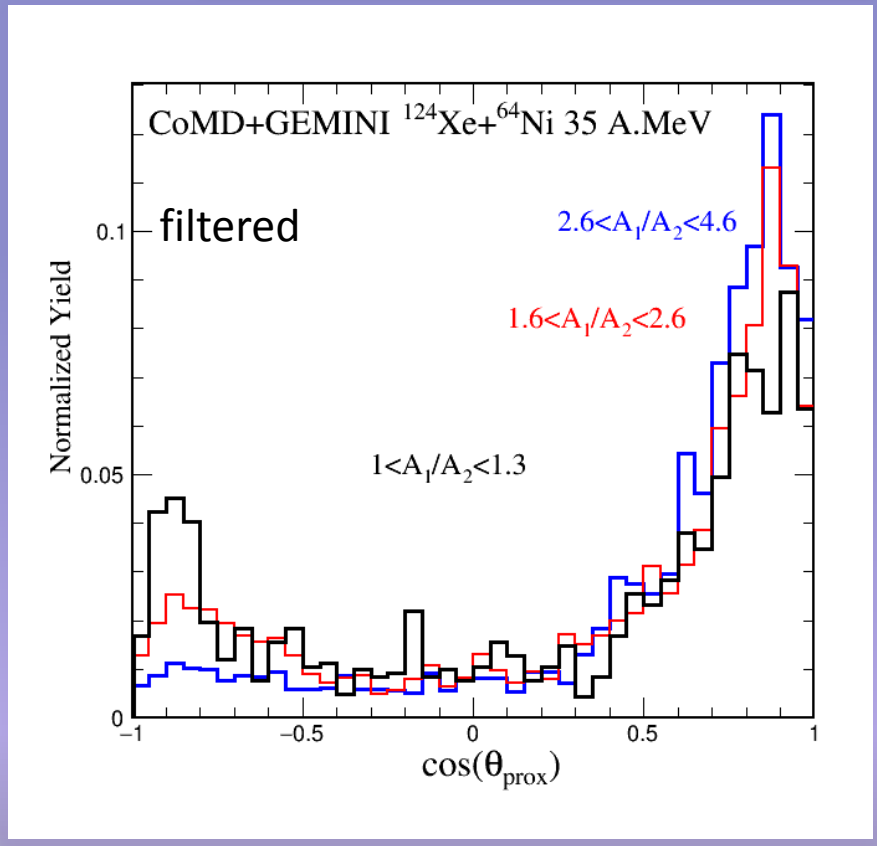
Constrained Molecular Dynamics simulation (CoMD-3)

- ✓ ^{124}Xe + ^{64}Ni and ^{124}Sn + ^{64}Ni @ 35 A.MeV
- ✓ **Preliminary** test at 650 fm/c and stiffness parameter on $E_{sym}(\rho)$, γ=1
- ✓ Checking for projectile break-up events

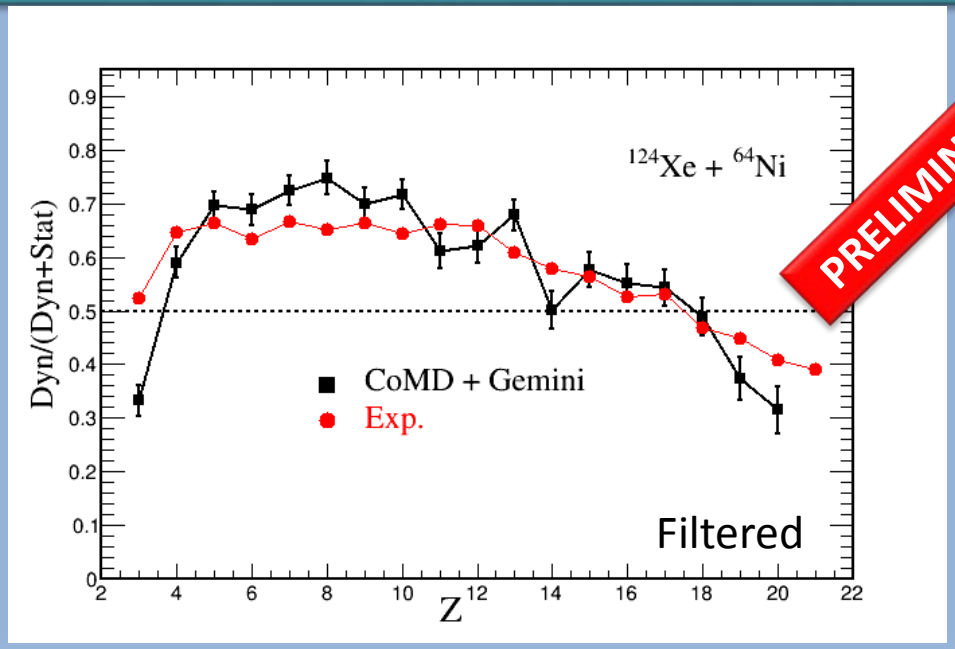
*Model → see M. Papa, Phys. Rev. **C87**, 014001 (2013) and refs therein*

Selection: data analysis as in the experiment





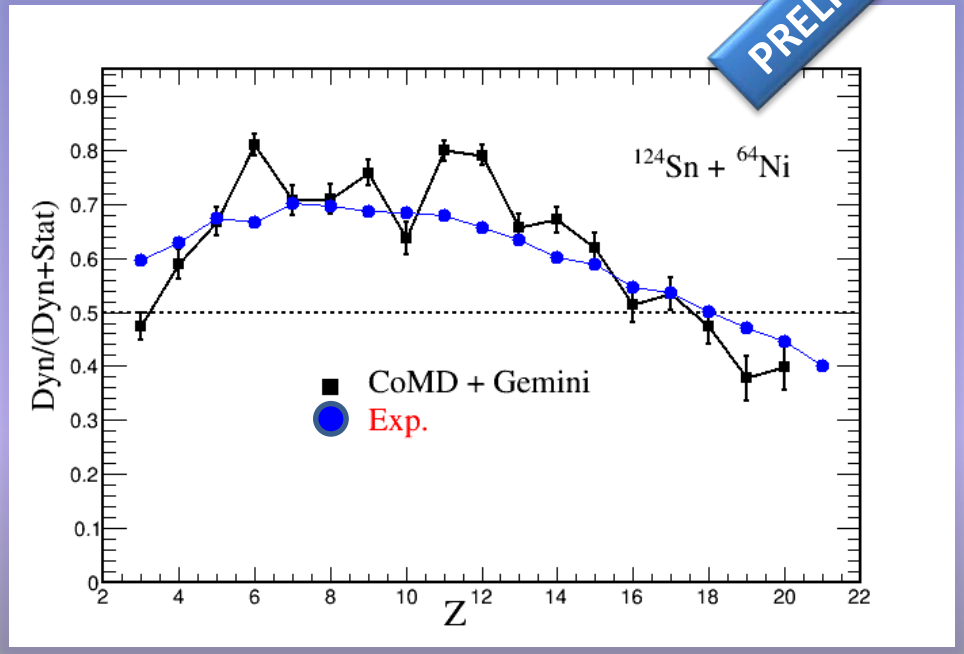
Simulation with Constrained Molecular Dynamics simulation (CoMD-3)



PRELIMINARY

650 fm/c and stiffness parameter on $E_{sym}(\rho)$, γ=1 (stiff). Data analysis as for the experimental data.

(work in progress…)



Dynamical processes in projectile break-up and IMF production at 20 A.MeV studied with the CHIMERA and FARCOS devices. CHIFAR: CHImera-FARcos

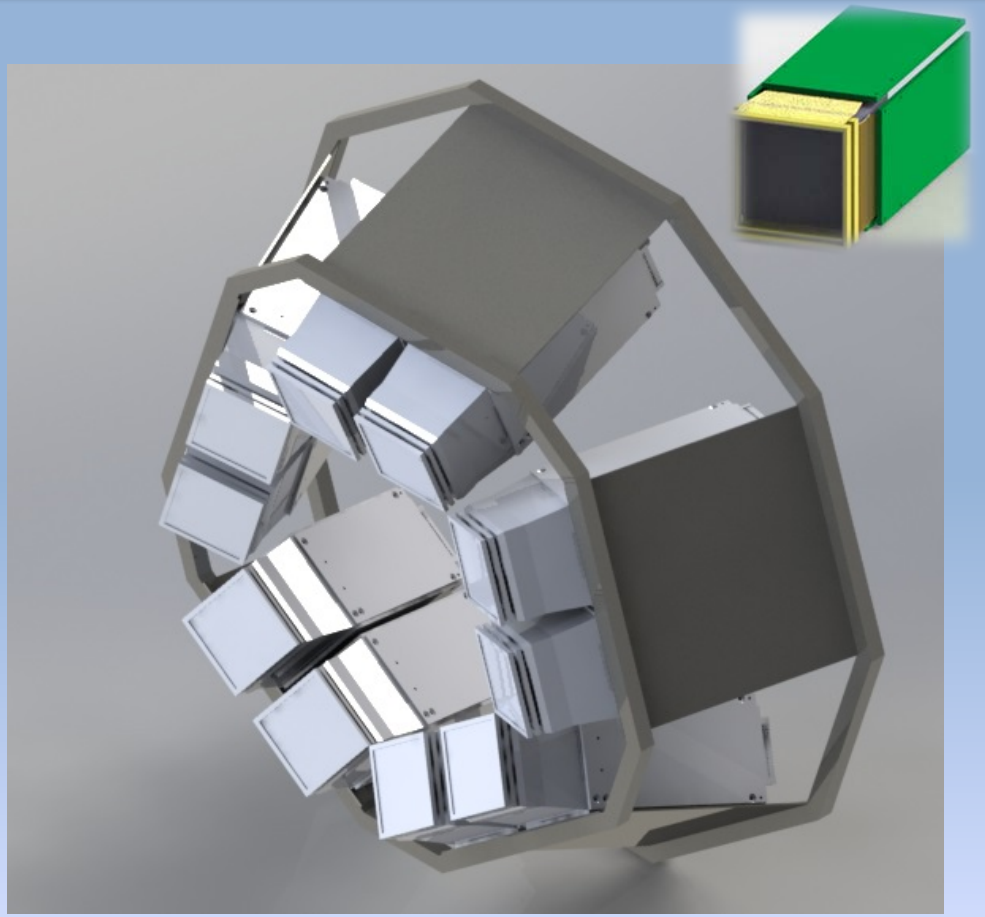
(approved LNS-PAC proposal) **spokes: E.V. Pagano, E.d.F., P. Russotto**

Dynamical processes in projectile break-up and Intermediate Mass Fragments production at **20 A.MeV** beam incident energy studied with the CHIMERA and **FARCOS** devices

CHIMERA + 10 FARCOS telescopes in a "quasi"-ring configuration

^{124}Xe, ^{124}Sn + ^{64}Ni, ^{64}Zn

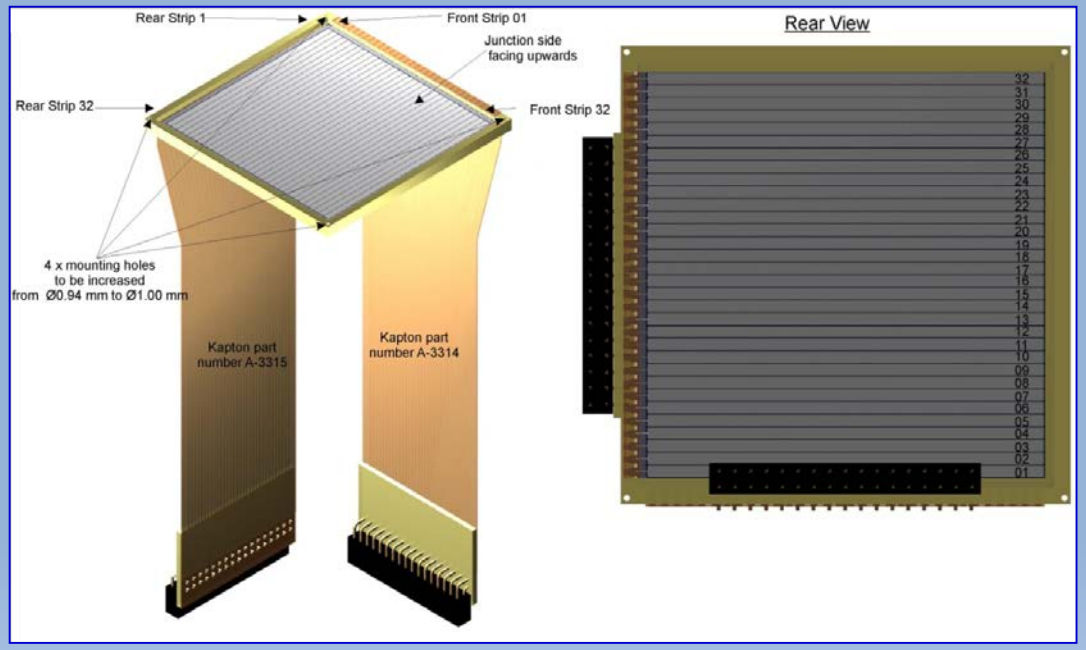
^{112}Sn+^{58}Ni @ 20A.MeV



Configuration CAD study for 10 FARCOS telescopes between the sphere and ring 9; *Luis Acosta group, Mexico*

FARCOS: Femtoscope Array for COrrelations and Spectroscopy

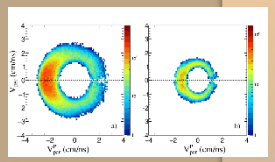
Technical Design Report (TDR): https://drive.google.com/file/d/0B5CgGWz8LpOOc3pGTWdOcDBoWFE/view



Highly homogeneous CsI(Tl) crystals produced by SCIONIX.
Wrapped with 0.12 mm thick white reflector +50 µm aluminized mylar.
Aluminized mylar window 2 µm thick (0.29 gr/cm^2). Read by Photodiode Hamamatsu 300 µm
ΔE/E=2-3% (α 5.48 MeV)

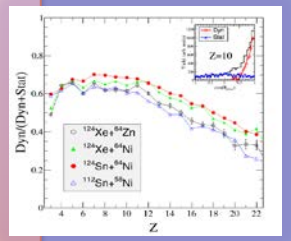
64 mm, 32 strips, Double-Sided Silicon Strip Detectors
produced by Micron Semiconductor.
(300 and 1500 µm / C= 25pF and 5pF)
Capton cable 2x32pin connectors
Minimum PCB
frame-area thick, 4 mm,
frame-thick 6.5 mm
ΔE= 20KeV (α 5.48 MeV) **ΔE/E (elastic)=0.2-0.3%**
Rise time<20ns

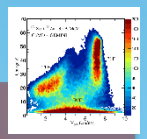
Summary

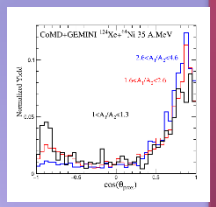


We have shown results of the **InKiIsSy** experiment, ^{124}**Xe+**^{64}**Zn,**^{64}**Ni** at 35 A.MeV using two systems that are isobaric with the ^{124}**Sn+**^{64}**Ni. All the system have the same size but differ in N/Z isospin**

Results show that in the binary break-up of the quasi-projectile there is an enhancement of the break-up probability for the neutron-rich system with respect to the neutron poor and this is due to the increase of the dynamical emission component, mainly ruled by the N/Z content of the projectile and target.

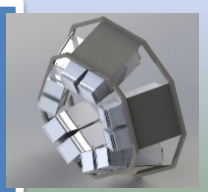






This effect could be related to the density dependence of symmetry energy but needs calculations that are able to follow the largest possible time-scales of IMF emission. We performed simulations using the CoMD3 model with promising results.

CHIFAR: A new experiment by using CHIMERA and FARCOS devices is programmed in order to study projectile break-up and IMF production and correlations at 20 MeV/A



Collaboration for the INKIISSY experiment

P. Russotto[1], E. De Filippo[2], E.V. Pagano[1,3], L. Acosta[1,4], L.Auditore[2,5], T. Cap[6], G.Cardella[2], S. De Luca[2,5], B.Gnoffo[2,3], G.Lanzalone[1,7], I.Lombardo[2], C.Maiolino[1], N.Martorana[1,3], T. Minniti[2], S. Norella[2,5], A. Pagano[2], M.Papa[2], E. Piasecki[8], S.Pirrone[2], G.Politi[2,3], F. Porto[1,3], L.Quattrocchi[2,3], F.Rizzo[1,3], E. Rosato[9], K. Siwek-Wilczynska[10], A.Trifirò[2,5], M.Trimarchì[2,5], G. Verde[2] and J. Wilczynski[6]

1-INFN-LNS Catania
2-INFN Sezione di Catania
3-Dipartimento di Fisica e Astronomia Università di Catania
4-Instituto de Física Universidad Nacional Autónoma de México, México
5-MITF, Università Messina
6-National Center for Nuclear Research Otwock-Swierk, Poland
7-Università Kore Enna
8-Heavy Ion Laboratory, University of Warsaw, Poland
9-INFN-Sez. di Napoli and Dipartimento di Fisica Università di Napoli Federico II
10- Faculty of Physics Universy of Warsaw, Poland