Second SPES International Workshop

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INFN Laboratori Nazionali di Legnaro

SPES Letter Of Intent

Isospin dependence of compound nucleus formation and decay

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OUTLINE

Isospin dependence on compound nucleus formation and decay (ISODEC program)

Influence of the isospin on the competition between Statistical and Dynamical Fission (Time Scale and InKiIsSy experiments)

Letter Of Intent at SPES

ISODEC program

Neutron richness of a compound nucleus is expected to play a crucial role in the competition between various de-excitation channels

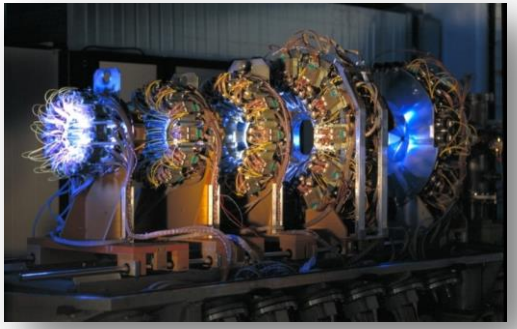
-> Information about level density, fission barrier, viscosity

Two experiments at GANIL and INFN-LNS using stable Kr beams:

$^{78,82}Kr + ^{40}Ca \rightarrow ^{118,122}Ba$

E/A=5.5 MeV/A E* ≈ 100 MeV

INDRA at GANIL



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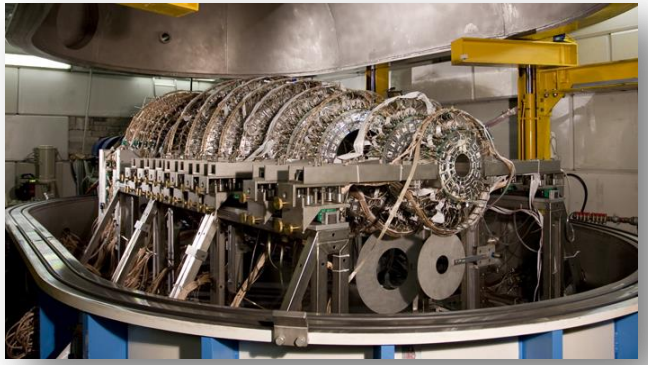
CHIMERA at INFN-LNS

LEA COLLIGA agreement



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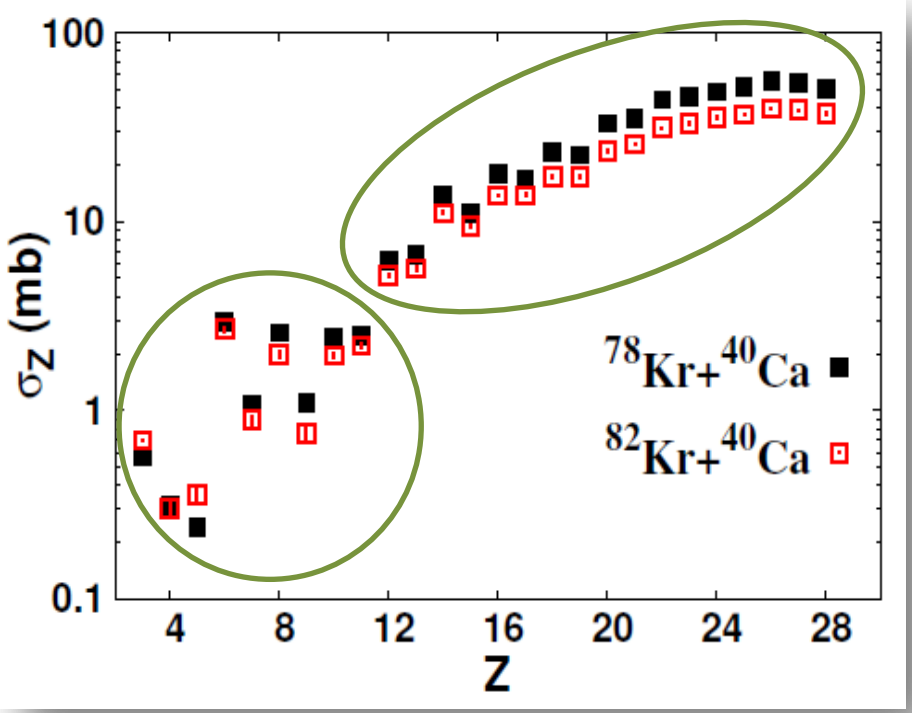
Production of fragments and heavy residues

Kinematical analysis and angular distributions -> high relaxation

Binary process dominant
-> CN/Fission or Quasi Fission

ER and Fission Like cross sections higher for neutron poor system

Strong odd-even staggering in fragment yields, lower for n-rich



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

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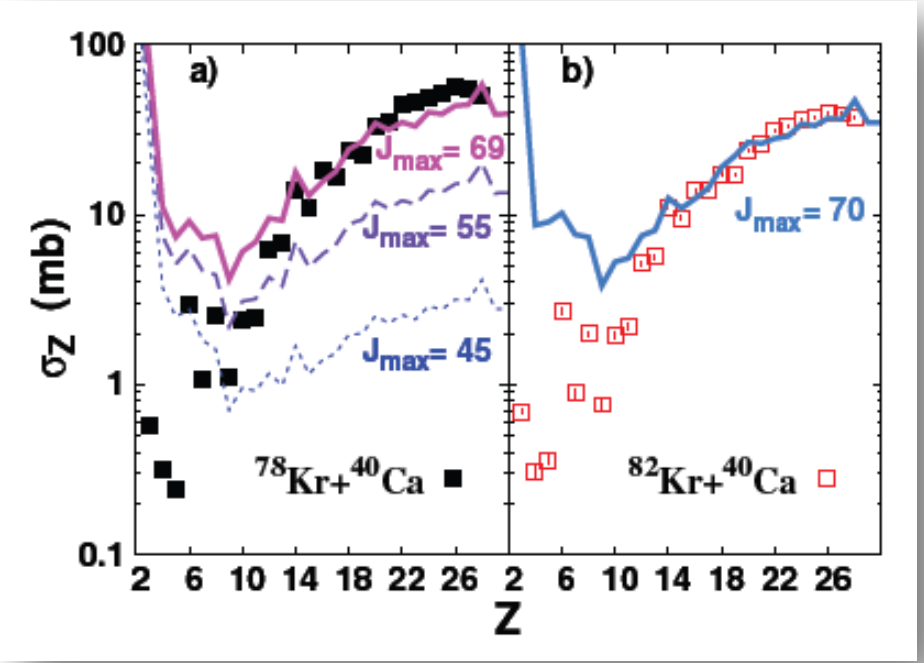

R. J. Charity et al, Nucl.Phys.A483 (1988)
D. Mancusi et al, PhysRev C 82 (2010)

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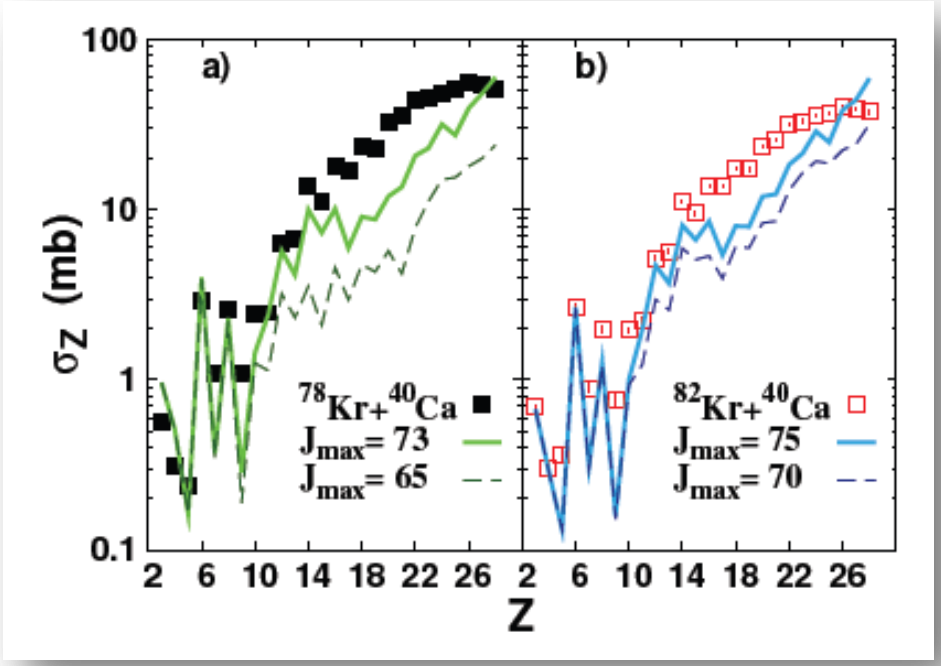


Comparison with DiNuclear System (DNS) - Entrance channel model with competition CN-QF processes works a bit better

Sh. A. Kalandarov et al. PRC82 (2010)

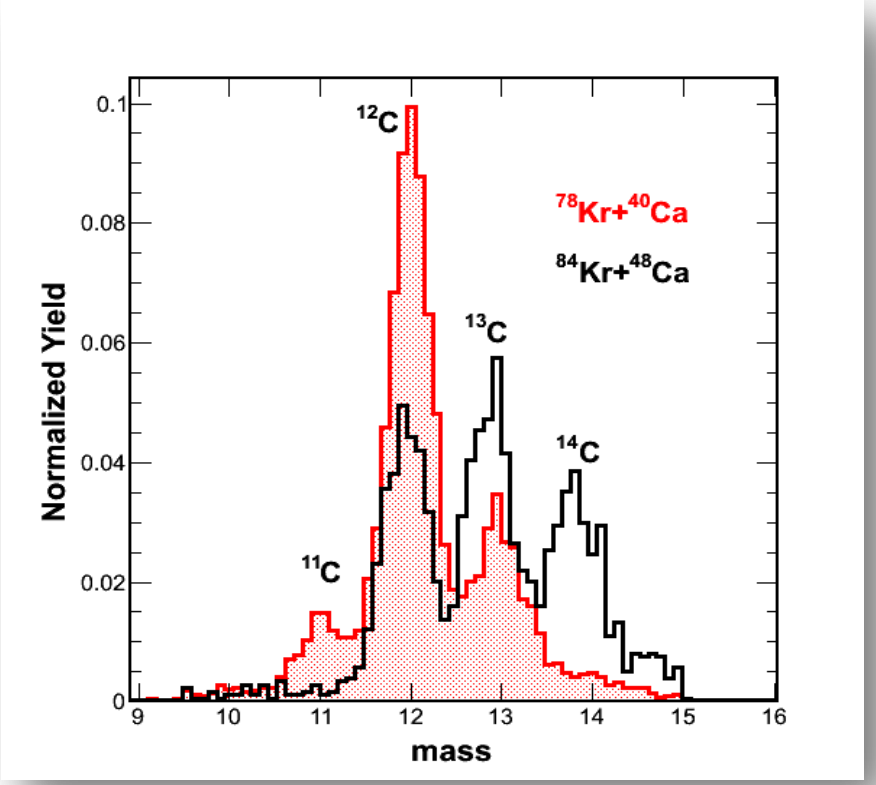
^{78,86}Kr + ^{40,48}Ca -> ^{118,134}Ba @ E/A=10 MeV/A E* ≈ 250 MeV CHIMERA

Composite systems with higher E and T -> effects on decay

Larger domain of N/Z (max with stable beam)

Analysis of IMF characteristics

Relative abundance of isotopes with 2 < Z < 9 is very different for the two systems



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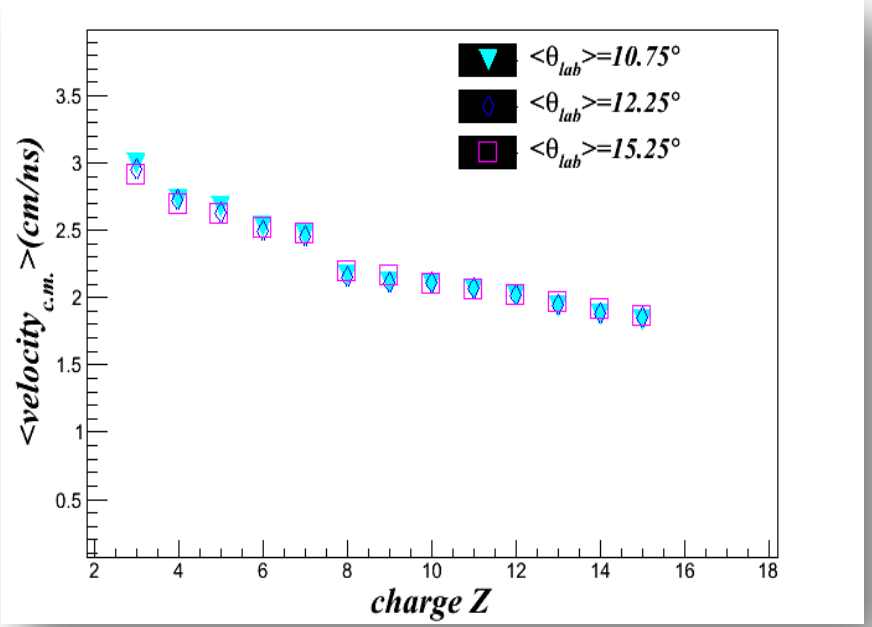
Energy and velocity spectra in CM frame slightly change with detection angle

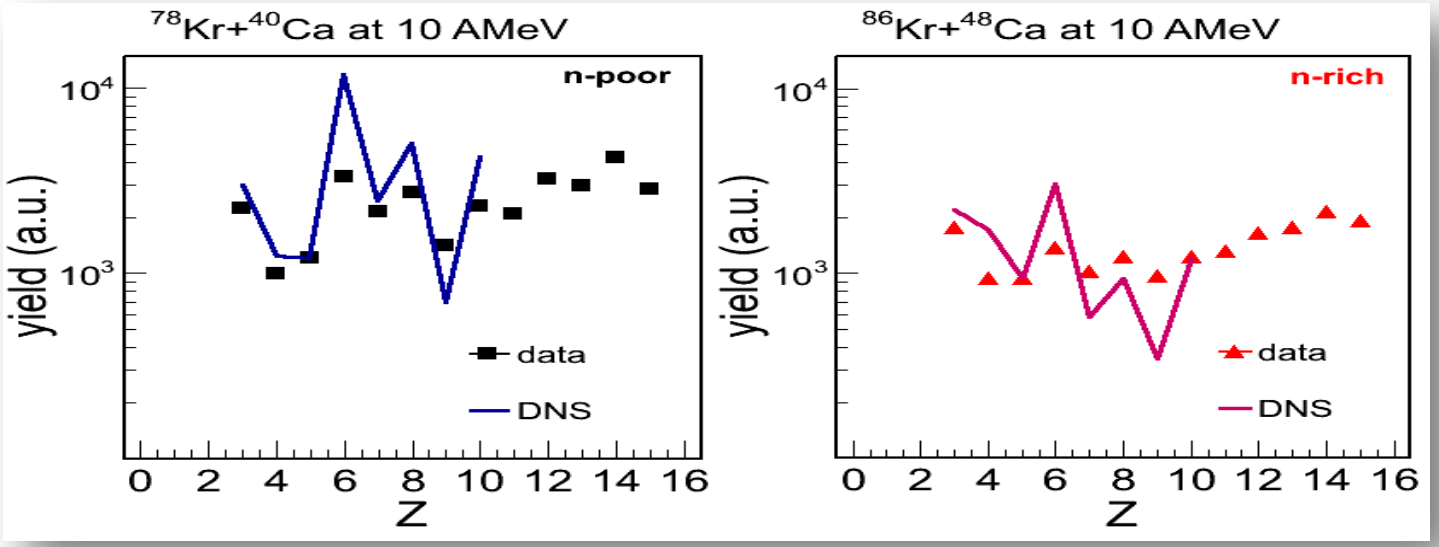


-> high degree of relaxation of kinetic energy

S. Pirrone et al., EPJ 17 (2011) 16010; G. Politi et al., EPJ 21 (2012) 02003
M. La Commara et al., EPJ 11 (2012); M. La Commara et al., Proc. of INPC2013, Florence, Italy, (in press) 2013
S. Pirrone et al., AIP Conf. Proc. 1524 (2013) 7-10

$^{78,86}Kr + ^{40,48}Ca \rightarrow ^{118,134}Ba$ @ E/A=10 MeV/A E* ≈ 250 MeV CHIMERA

Staggering effect still present and stronger for n-poor



Very preliminary comparison with DiNuclearSystem (DNS) code

DNS works a bit better for the n-poor system Sh. A. Kalandarov et al. PRC82 (2010)

Needs for more accurate comparisons

Starting work on Heavy Residues - Fission Fragments

Time Scale and InKilsSy experiments

Binary splitting of PLF vs energy dissipation, mass asymmetry, N/Z

$^{124}Sn+^{64}Ni$ and $^{112}Sn+^{58}Ni$ E/A=35 MeV/A CHIMERA

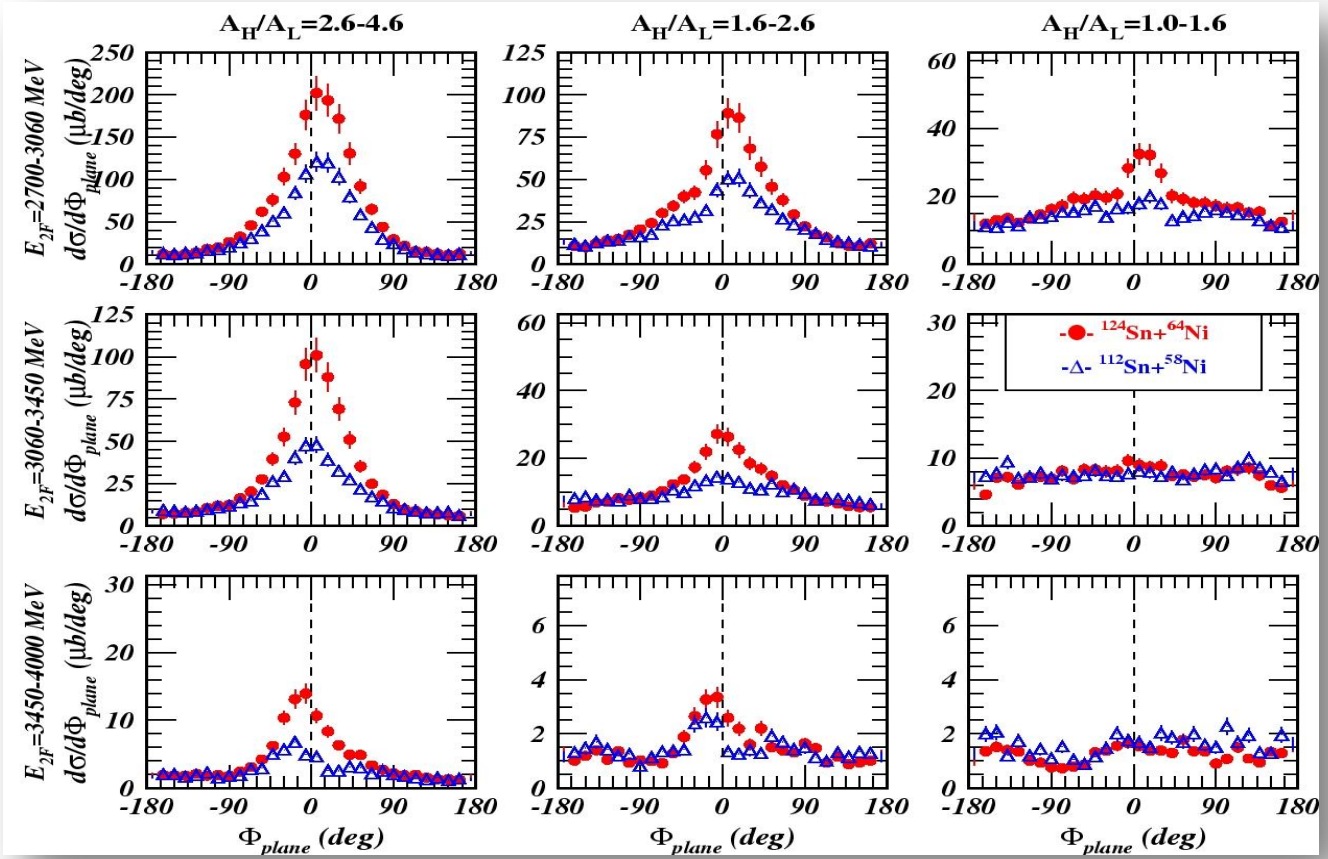
Observed two PLF break-up components for heavier IMF (Z>8):

- equilibrium statistical fission -> isotropic angular distribution
- fast not-equilibrated fission process (dynamical fission)
  -> emission preferentially backwards in the PLF reference system

E. De Filippo et al., Phys. Rev. C71 064604 (2005)
P. Russotto et al., Int. J. Mod. Physics E15 410 (2006)
P. Russotto et al., Phys. Rev. C81, 064605 (2010)
P. Russotto et al., Proc. Of "Int. Symp on Entrance Channel Effect on the Reaction Mechanism in HIC" Messina (Italy) 2013, in press on Journal of Physics: Conf. series

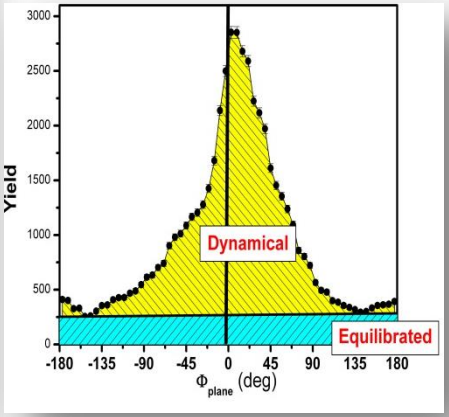
In plane angular distribution for different asymmetries and energy

-> separation of the two components



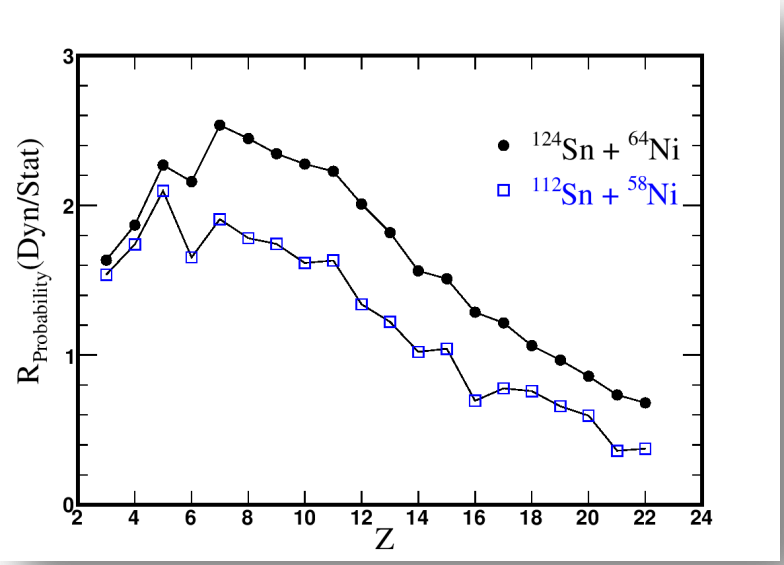
● $^{124}Sn+^{64}Ni$

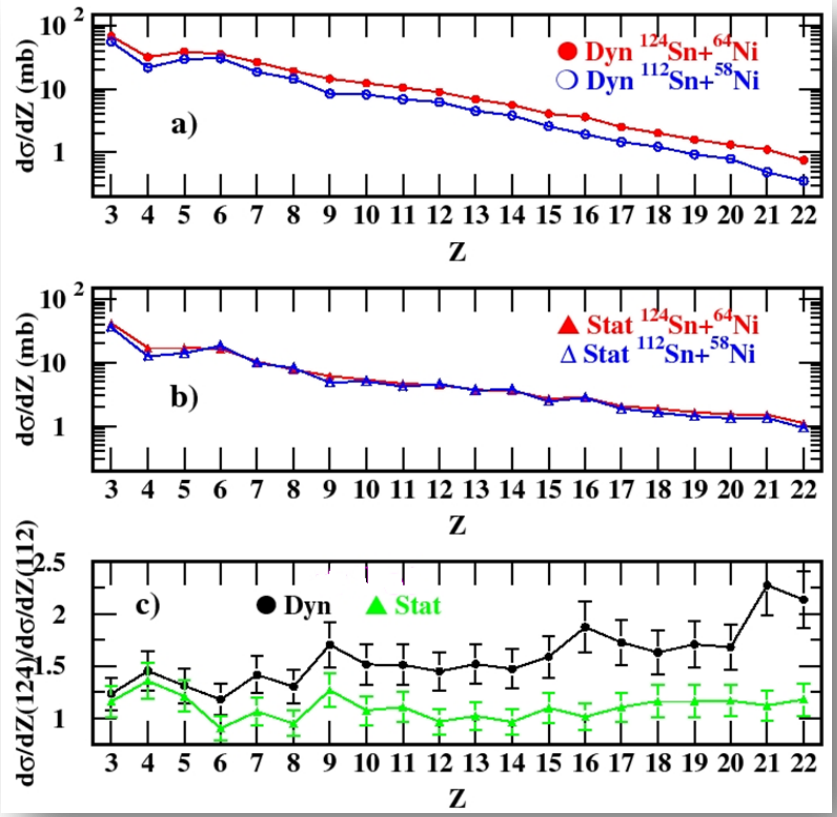
△ $^{112}Sn+^{58}Ni$



Dynamical component enhanced by a factor 1.5-2 in the neutron rich especially for heavier IMF

Statistical component almost equal in both system





Not equilibrated PLF fission for ^{84}Kr+^{166}Er ^{129}Xe+^{122}Sn @12.5 MeV/A

New fast fission mechanism for Au+Au @15 MeV/A with CHIMERA

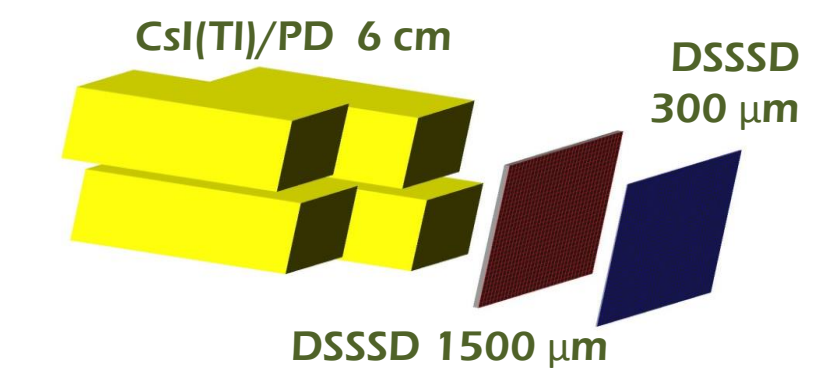
Mass or N/Z effect?

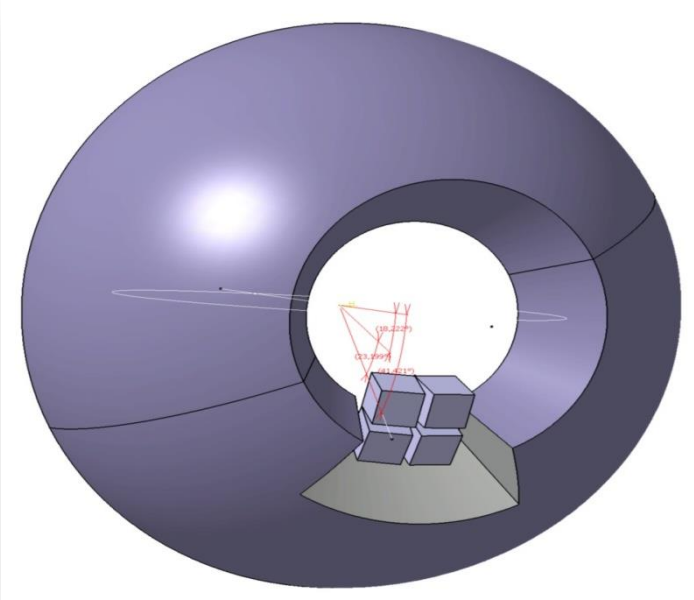
Study of a system with same mass of n-rich and N/Z near to the n-poor, at 35 A.MeV

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

4π CHIMERA and a FARCOS module at 25 cm from target

θ_{lab} = 16 °- 44 ° $\Delta\phi$ = 45 °





Letter Of Intent at SPES

Study of isospin effects on the reaction mechanisms and on IMF production

- compound nucleus formation and decay

- competition between Statistical and Dynamical Fission processes

Interest in intermediate mass region: Kr, Sr, Sn, Cs beams on Ca, Ni, Sn
-> broad domain in n/p ratio in entrance and compound system

In particular

- $^{88\text{-}94}$Kr with 10^5 - 10^7 pps @ E/A = 10 - 12 MeV/A
  on ^{40,48}Ca can extend the study at higher N/Z looking also
  for particular shape effects for n-rich CN -> see A. May's talk

- $^{126\text{-}132}$Sn and $^{132\text{-}144}$Cs beams at SPES energy can extend the studies
  of dynamical break-up where deformations or Coulomb proximity
  effects of the target play a crucial role in the fission process

Key observables: cross-sections, multiplicities, angular, energy and velocity distributions for the IMFs, LCPs, fission fragments, LCPs-HRs correlations

Requirements: isotopic resolution, low energy thresholds for LCPs and IMFs, high granularity and broad angular acceptance -> 4π

Reverse kinematics can be advantageous

Existing detector in LNL could be complemented by coupling other devices, like parts (or full configuration)of the CHIMERA detector

New incoming devices as FAZIA and FARCOS could be used
Good angular and energy resolution of FARCOS could be useful for particle-particle correlations -> space-time properties of CN and PLF

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This LOI is strongly related to other proposals for SPES and other European RIB facilities

- G.Casini et al. LOI for SPES2010, LOI for SPES2014
- F.Gulminelli et al. LOI for Spiral2; Dynamics and Isospin, November 2006

Participants

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J. Wilczynski (NCNR Otwock-Swierk)

ISODEC program

Neutron richness of a compound nucleus is expected to play a crucial role in the competition between various de-excitation channels

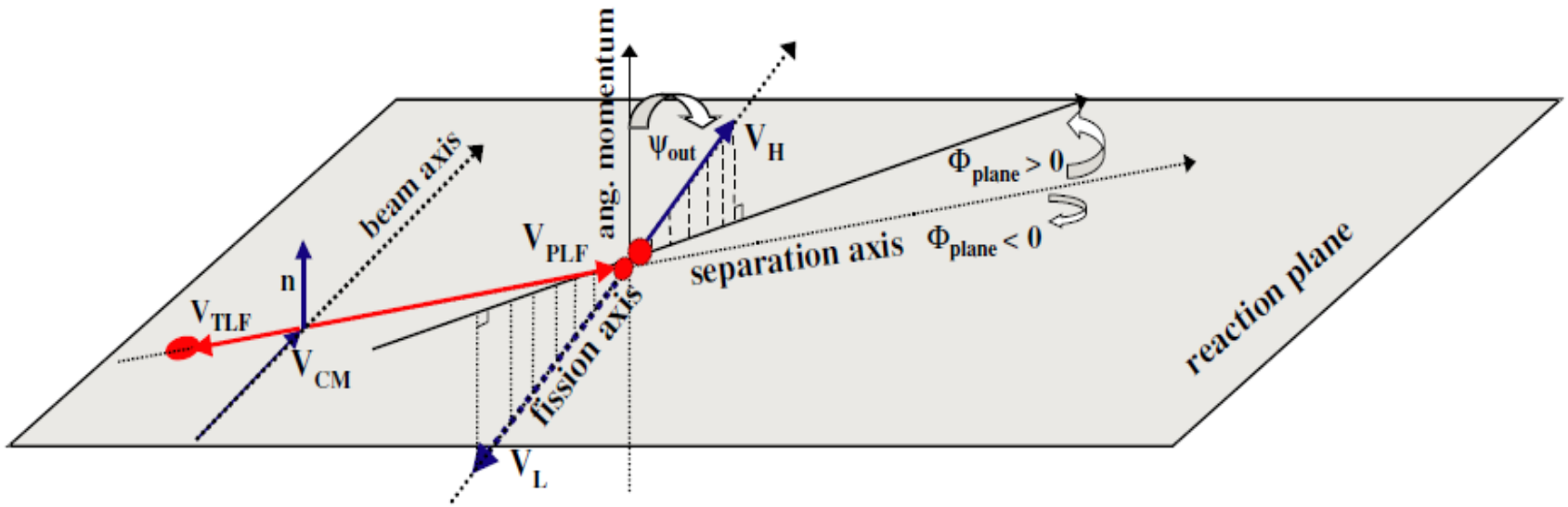
-> Information about level density, fission barrier, viscosity

The Level density parameter is related to the effective mass of nucleons in the nuclear medium that is sensitive to the n/p of nuclei

The fission barriers depend clearly on the symmetry energy that is weakly constrained by existing data

The viscosity reflects a coupling between collective modes and intrinsic DoF -> related to the Fermi energy level and to ratio n/p

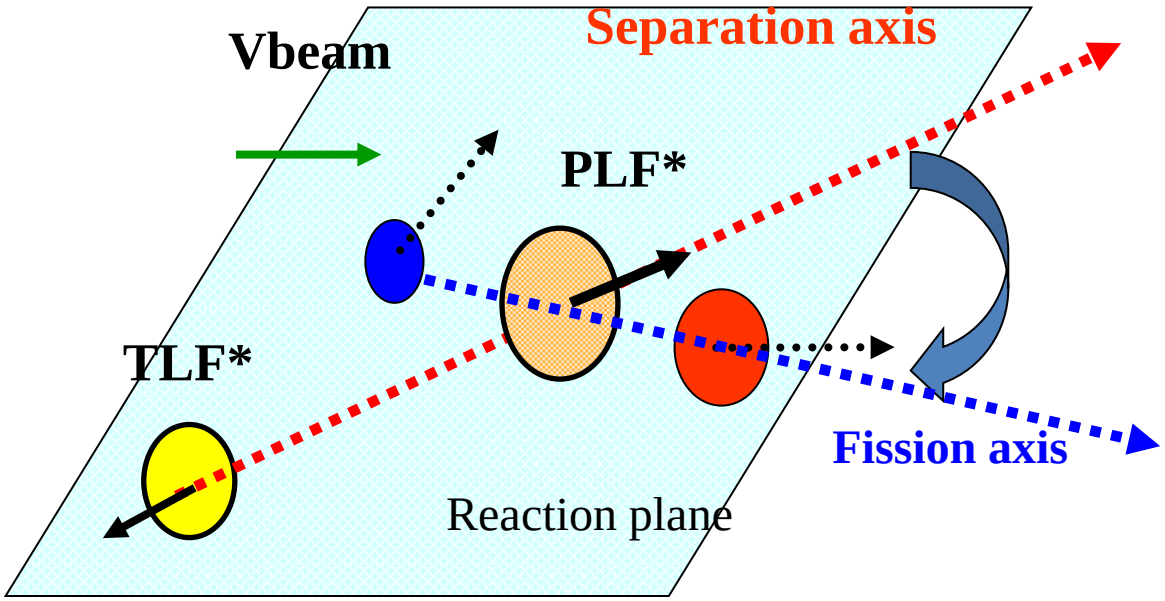
Novel information can be obtained by the study of the fission cross section across long isotopic chains of compound nuclei, extending from the neutron-rich to neutron-poor side



Statistical fission is characterized by isotropic fission fragment angular distribution,

Dynamical Fission is characterized by fast AL fragment emission preferentially backwards in the PLF reference system, i.e., towards the target nucleus

AP=AH+AL



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