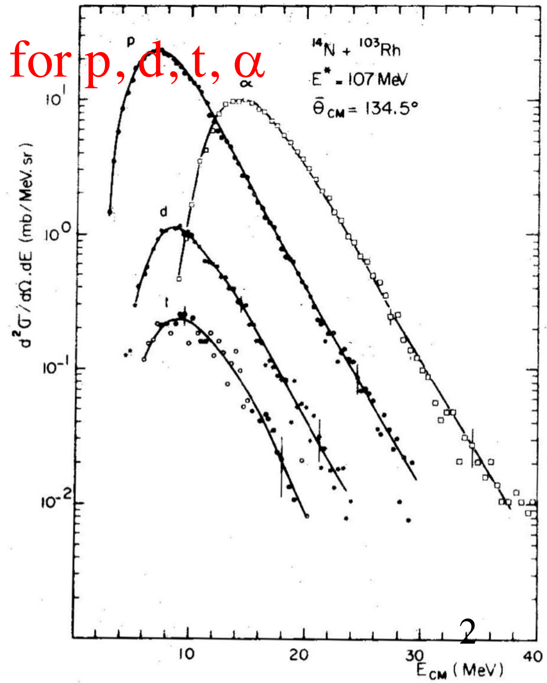
Reactions with light exotic beams at incident energies E/A = 10-15 MeV

- Fusion : N/Z dependence of level density parameter
- DIC : Isospin diffusion
- Fragmentation of the projectile: access to exotic excited states

1- Fusion of light systems : Validity of statistical theories

- Exotic beams produce a large variety of excited nuclei
- Their decay is described by means of statistical models
- Assumption : in microcanonical ensemble all available final states have the same probability to be populated
- The main ingredient : level density parameter

E spectra of light particles Maxwellian shape: same slope for p, d, t, α
Validity of the basic assumption of Statistical Theories



But :
•One body observable such as particle analysis provide limited information.
•Correlation between successive particles emitted in the same event is lost

Precise study of the decay of CN*

- Produced with Exotic and stable nuclei : SPIRAL, FRIB, RIKEN
- Powerful detectors (FAZIA + INDRA,…)
- Means of correlation techniques (invariant-mass method)

Offer opportunity to explore the N/Z dependence of decay process and test of the Statistical Theories

2 - DIC with Exotic nuclei

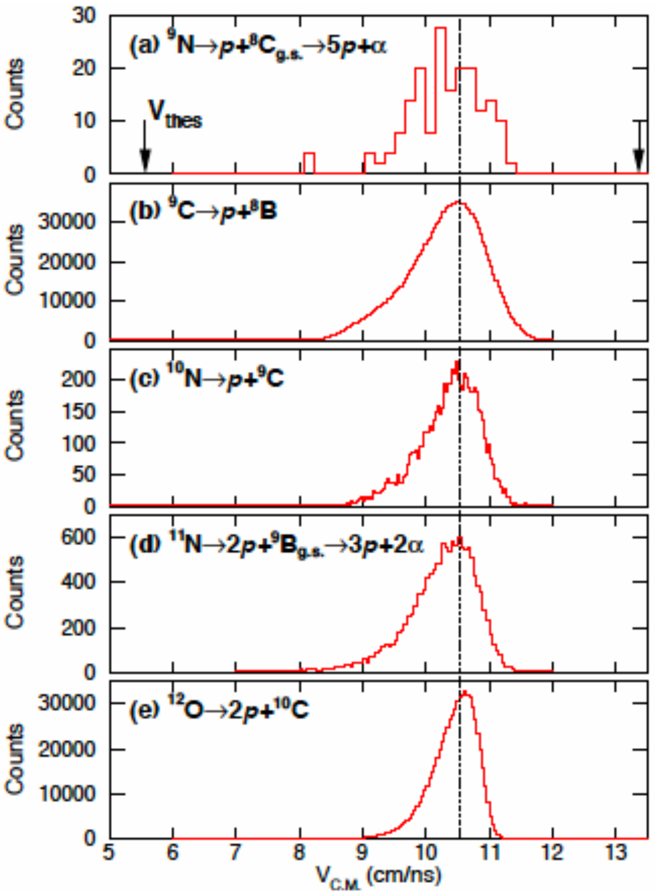
- Isotopic distributions of the QP
- Deduce the transport coefficients

Offer opportunity to explore the N/Z dependence of Isospin diffusion, and density dependence of symmetry energy

Exploring Isospin diffusion

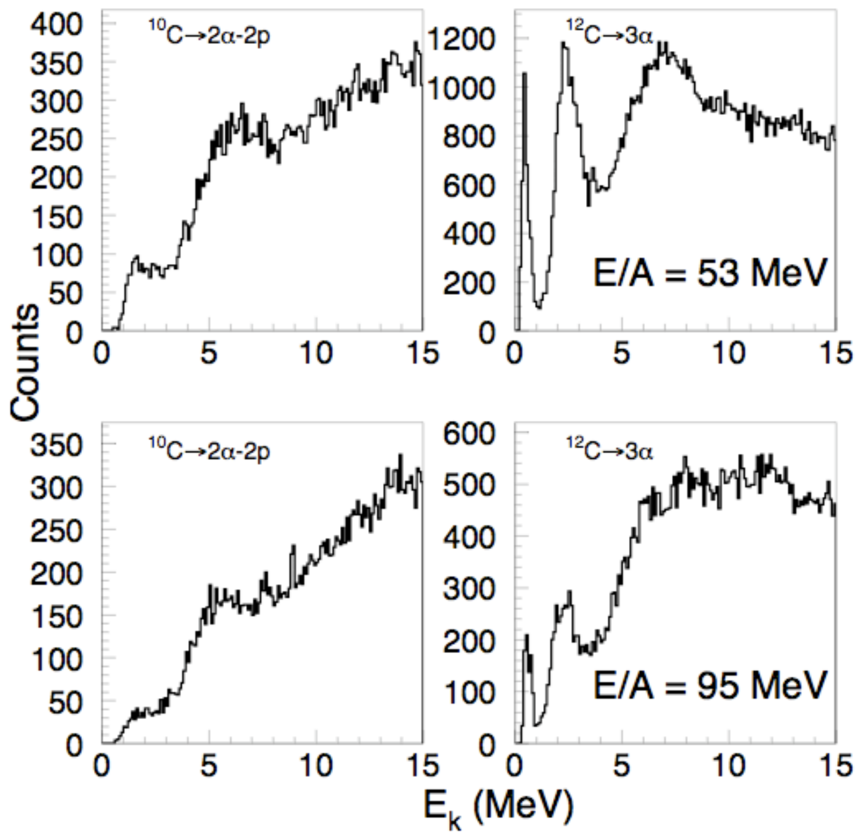
3 – fragmentation of exotic projectile

- Gives access to many resonances in different nuclei located beyond the p-drip line or at the edge of the n-drip line.
- Means of the Invariant-mass method applied to the emitted products.
- Recent example is the fragmentation of 13O (Charity & Sobotka)
- See also Diego presentation



Two or multi-particle correlations

Exotic phenomena : clustering, quasi-molecular states



Reaction $^{12}C+^{24}Mg$
INDRA

Not described by Weisscopf theory

F. Grenier et al.

GANIL/SPIRAL1 / FAZIA-INDRA

- E/A = 10-15 MeV, e*/A=2-4 MeV
- $^{14,16,18,19,20}O + ^{12}C \rightarrow ^{26-32}Si^*$
- typical intensity : 2. 10^5 pps for $^{14,15,19}O$ and 2. 10^4 pps for ^{20}O
- Other targets are possible: ^{24}Mg, ^{9}Be CN = $^{38-44}Ca$, $^{23-29}Mg$

OR

- $^{17-25}Ne + ^{12,13}C \rightarrow ^{29-38}S^*$

- Quality of the exotic beams at SPIRAL 1, low contaminants at this energies.

Observables to be measured

- Fusionlike residues (ER) : A, Z
- PLF : A, Z
- LCP and (partially) neutrons
- Fazia can help for detection of ER & PLF at forward angles : A, Z identification by means of ToF? and PSA, in coincidence with all evaporative particles.

Detector arrangements

- Fazia-INDRA configuration
  - Wall composed of 12*16 = 256 modules
  - Will cover : angular range : 2-10° at 120 cm distance from target

- Additional neutron detectors would be nice :
  - neutron Demon-like detectors

summary

- Fusion of exotic light systems, DIC of exotic systems, fragmentation of exotic projectiles,
- Allows the study of exotic excited states
- $^{14,16,18,19,20}O + ^{12}C \rightarrow ^{26\text{-}32}Si^*$ at GANIL
- Detector: Fazia + INDRA (isotopic resolution for all emitted charged reaction products) addition of n-detectors.
- Needs: simulations

REACTION 20O + 12C ---> 20O + 12C 15 MeV/nucleon

- ***** REACTION 20O + 12C ---> 20O + 12C ******
- E.LAB = 300 MEV QGG = 0 MEV
- E.EXC = 0 MEV ==> Q-REACTION = 0 MEV
- AVAILABLE ENERGY IN C.M. : ECM = 112.27 MEV (3.50845 MEV/A)
- PROJECTILE VELOCITY IN LAB 5.31616 CM/NS (0.177328 * C)
- VELOCITY OF C.M. 3.34279 CM/NS
- ENERGY - VELOCITY OF NUCLEUS 1 IN CM : 42.1473 MEV 2.01318 CM/NS (K=1.66045)
- ENERGY - VELOCITY OF NUCLEUS 2 IN CM : 70.1231 MEV 3.34279 CM/NS (K=1)
- ENERGY - VELOCITY OF NUCLEUS 3 IN CM : 42.1473 MEV 2.01318 CM/NS (K=1.66045)
- ENERGY - VELOCITY OF NUCLEUS 4 IN CM : 70.1231 MEV 3.34279 CM/NS (K=1)
- MAXIMUM SCATTERING ANGLE IN LABORATORY
- THETA #3# 36.8588 DEG.
- THETA #4# 90 DEG.
- GRAZING ANGLE IN LABORATORY : PROJECTILE 1.60817 DEG.
- GRAZING ANGLE IN LABORATORY : TARGET 87.8555 DEG.
- CN = 32Si

***** REACTION 20O + 24Mg ---> 20O + 24Mg ****** 15 MeV/nucleon

- ***** REACTION 20O + 24Mg ---> 20O + 24Mg ******
- E.LAB = 300 MEV QGG = 0 MEV
- E.EXC = 194.578 MEV ==> Q-REACTION = -194.578 MEV
- AVAILABLE ENERGY IN C.M. : ECM = 163.245 MEV (3.71012 MEV/A)
- PROJECTILE VELOCITY IN LAB 5.31616 CM/NS (0.177328 * C)
- VELOCITY OF C.M. 2.43867 CM/NS
- ENERGY - VELOCITY OF NUCLEUS 1 IN CM : 88.978 MEV 2.9196 CM/NS (K=0.835275)
- ENERGY - VELOCITY OF NUCLEUS 2 IN CM : 74.2675 MEV 2.43867 CM/NS (K=1)
- ENERGY - VELOCITY OF NUCLEUS 3 IN CM : -17.0847 MEV nan CM/NS (K=0)
- ENERGY - VELOCITY OF NUCLEUS 4 IN CM : -14.2478 MEV nan CM/NS (K=0)
- MAXIMUM SCATTERING ANGLE IN LABORATORY
- THETA #3# 180 DEG.
- THETA #4# 180 DEG.
- GRAZING ANGLE IN LABORATORY : PROJECTILE 3.02131 DEG.
- GRAZING ANGLE IN LABORATORY : TARGET 87.2306 DEG.
- CN = 44Ca