INNOWACYJNA GOSPODARKA
NARODOWA STRATEGIA SPÓJNOŚCI
UNIWERSYTET JAGIELLOŃSKI W KRAKOWIE
FNP Fundacja na rzecz Nauki Polskiej
UNIA EUROPEJSKA
EUROPEJSKI FUNDUSZ ROZWOJU REGIONALNEGO
INTERNATIONAL PHD PROJECTS IN APPLIED NUCLEAR PHYSICS AND INNOVATIVE TECHNOLOGIES
This project is supported by the Foundation for Polish Science – MPD program, co-financed by the European Union within the European Regional Development Fund

FAZIA detector system - motivation, first results and current status

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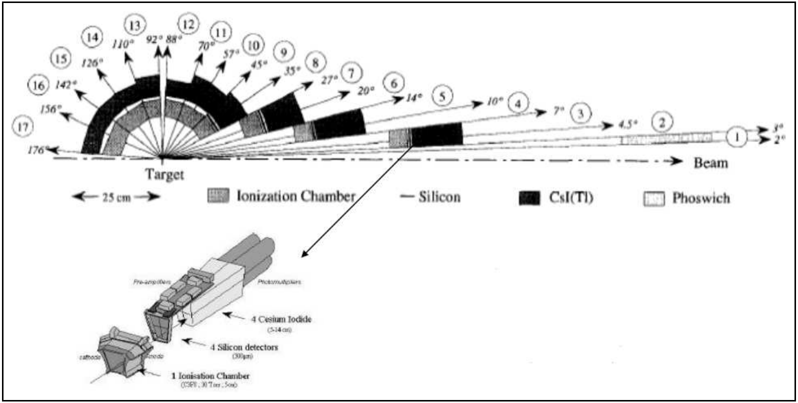
4.06.2013

INDRA = Identification des Noyaux et Detection a Resolution Accrue

Design:

- wide angular coverage: ~90% of 4π
- high granularity
- small detection thresholds of ~1MeV/A
- high charge resolution (up to Z~50)
- isotopic identification of light charged particles

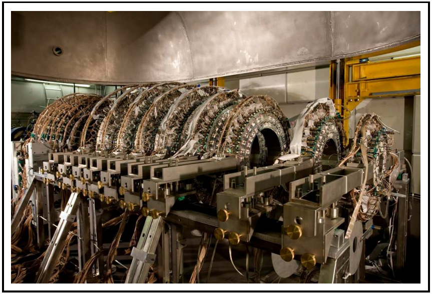
How it looks:


176°
156°
142°
126°
110°
92° 88°
70°
57°
45°
35°
27°
20°
14°
10°
7°
4.5°
3°
2°
Beam
Target
25 cm
Ionization Chamber
Silicon
CsI(Tl)
Phoswich
4 Cesium Iodide
4 Silicon detectors
1 Ionisation Chamber

Characteristics:

- composed of ionisation chamber - silicon -CsI(TI) telescopes
- ΔE-E and light shape analysis used to identify nuclei
- good identification of charged products up to Z~60 with a threshold of $\sim$ 1 AMeV
- problem: isotopic identification limited to $Z = 6$

CHIMERA = CHarged Ion Mass and Energy Resolving Array
4π detector for charged particles devoted to the study of nuclear reactions at intermediate energies (10-100 MeV/A) and operating at Laboratori Nazionali del Sud in Catania



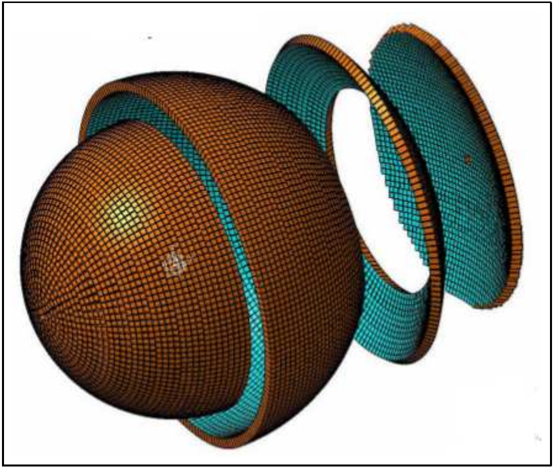
Characteristics:

- ensemble of silicon - CsI(TI) telescopes
- identification through ToF, ΔE-E and light shape analysis techniques
- very low thresholds for mass identification, but much higher ones for Z identification
- isotopic identification up to $Z = 13$ - still not satisfactory

Spectrometers:

- still unmatched nucleus identifiers
- A, Z, energy and velocity provided with high resolution
- problem: covering a very small solid angle, which makes it impossible to fully analyse many-body events, unless coupled to other detection array

FAZIA:



Interest: isospin dependence of the competition between multifragmentation and fission channels

What can be learnt/achieved:

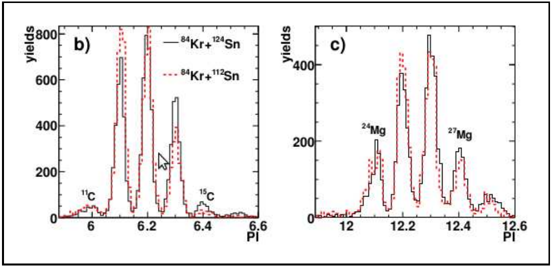
- discrimination of theoretical models - the ratio of the two channels still unknown
- isospin effect on energy:
  $E(N, Z) = -a_V A + a_S A^{2/3} + \mathbf{a}_{\mathrm{sym}} \frac{\mathbf{(N-Z)^2}}{\mathbf{A}} + a_C \frac{Z^2}{A^{1/3}}$
- symmetric nuclear matter extensively explored, but asymmetric ($N - Z \neq 0$) largely unknown
- systems very asymmetric in neutron and proton numbers need to be explored

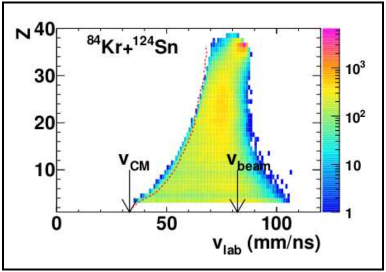
Motivation (continued):

- study of the de-excitation properties of isotopic chains of compound nuclei, with complete isotopic identification of the emitted nuclei and of the final residue, shall give unique information on the temperature dependence of E_{sym}
- pushing CN towards the drip lines will permit to explore decay modes that cannot be predicted by the Weisskopf theory (clustering, multifragmentation)
- at low energies, dissipative collisions induced by exotic projectiles should provide new information on the neck-instabilities, and on the achievement of isospin equilibration, both directly depending on E_{sym}

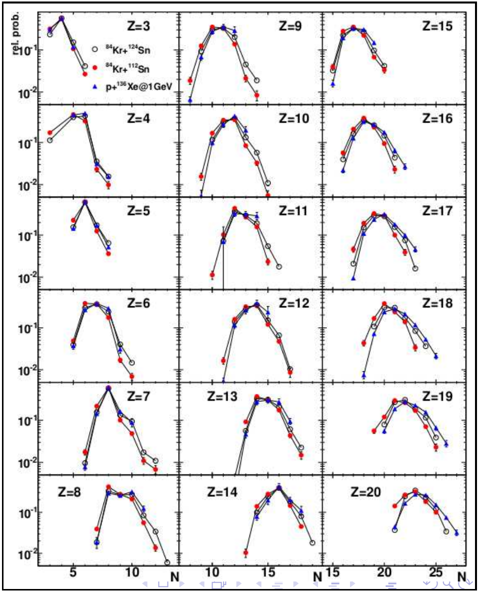
Recent results from FAZIA experiment:

- Kr beam impinging on neutron-rich and neutron-poor isotopes
- isospin diffusion between target and projectile



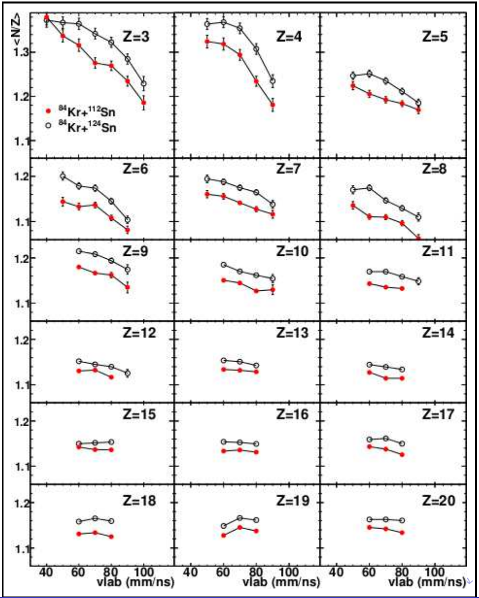


- good isotopic resolution of telescope allows to investigate isotopic composition of fragments
- similarity to C and Mg isotopes (shown above)
- good agreement with ^{136}Xe + p
- conclusion: final fragment isospin content does not depend on the dynamics, but original neutron content is "remembered"



Dependence of isospin content on the phase-space region?

- isospin diffusion seen again
- breakup of neck-like structure formed between QP and QT
- lighter fragments from the central part of the neck have small velocities
- very high values of $\langle N \rangle / Z$ indicate isospin drift

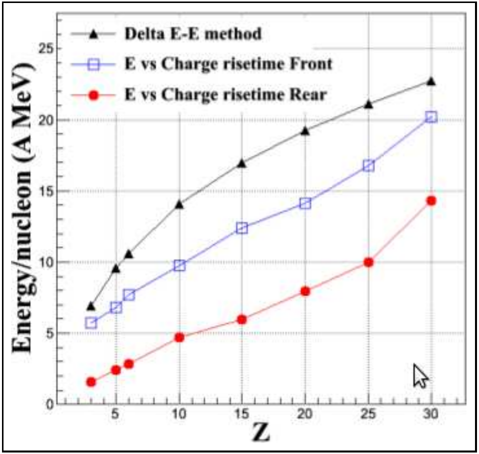


Possible improvements:

- replacing the FAZIA modules at backward angles with Single Chip Telescopes: reduction in the number of electronic channels (hence cost and complexity of the apparatus), as one Si detector can be used as a photodiode for the scintillator light readout
- even more advantages: less-crowded FEE, lower power dissipation
- SCTs already tested, not as good as regular telescopes for low-energetic fragments with $Z > 2$

Improvements (continued):

- pulse shape analysis used for identification
- threshold significantly reduced



- FAZIA project presently in the phase of building a demonstrator = an array of 192 telescopes
- final electronics and mechanical solutions are adopted
- FEE located inside the vacuum chamber to minimize detector-preamplifier-digitizer distances
- demonstrator expected to be ready in 2014

Thank you for your attention