EDEN

(*Excited and DEformed Nuclei*)

Dynamics in heavy-ion collisions

Heavy-ions of energy up to 20 AMeV
(*Tandem-ALPI accelerator, LNL, Italy*)

Heavy-ions and 4He beams of energy higher than 20 AMeV
(*K500 Superconductive Cyclotron, Texas A&M University, USA*)

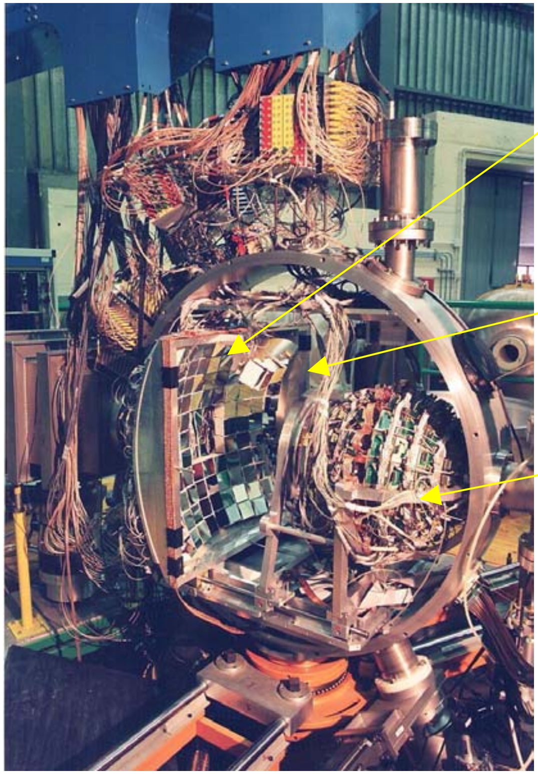
INFN - Laboratori Nazionali di Legnaro, Università and INFN - Napoli,
Università and INFN - Padova, Università and INFN - Firenze, Università and INFN - Bari,
Texas A&M University - College Station (USA), BARC - Bombay INDIA

31 physicists are involved : 23 from Italy
Experiment coordinator : D. Fabris

Main research topics:

- Study of the hot nuclei decay
- Study of the pre-fission emission
- Study of the nuclear level density
- Nuclear astrophysics

Experimental set-up

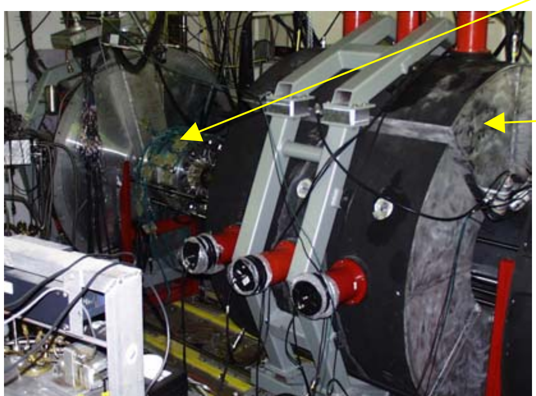


At the LNL a 4π charged light particle detector is fully operational (8πLP). It consists of 262 ΔE-E telescopes organized as follows:

the WALL : 116 telescopes (a matrix of 11x11 modules)
300 μm Si + 15 mm CsI(Tl)
target distance: 60 cm
angular coverage: 2° - 24° (angular resolution 4°)

the RING : 20 telescopes
300 μm Si + 15 mm CsI(Tl)
target distance: 40 cm
angular coverage: 24° - 34° (angular resolution 7°)

the BALL : 126 telescopes (30 cm diameter, 7 rings of 18 modules)
300 μm Si + 5 mm CsI(Tl)
target distance: 15 cm
angular coverage: 34° - 177° (angular resolution 18°)
Ball silicon detectors can be used as trigger for fission fragments (FF).
Evaporation Residue (ER) trigger detectors can be mounted at forward angles.



At the Cyclotron Institute of the Texas A&M University the NIMROD array is installed. It is a new 4π charged particle apparatus placed in a cavity inside the TAMU Neutron Ball and composed of:

168 CsI(Tl) organized in:

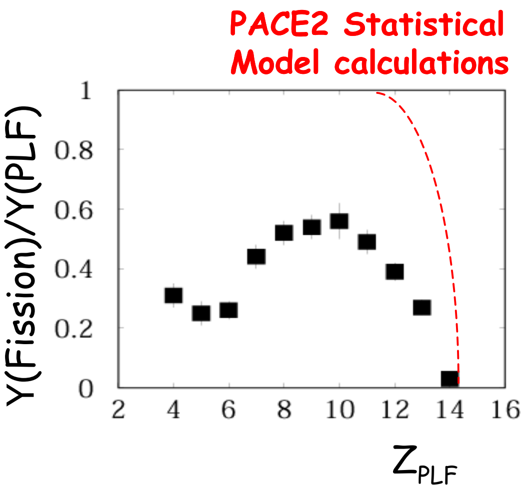
- 6 rings of 12 detectors covering angles between 3° and 35°
- 2 rings of 24 detectors covering angles between 30° and 45°
- 2 rings of 16 detectors covering angles between 45° and 100°
- 2 rings of 8 detectors covering angles between 100° and 140°

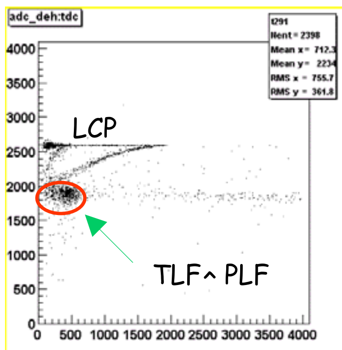
10 silicon-silicon telescopes placed in front of 10 CsI(Tl) scintillators in each ring
96 ionization chambers

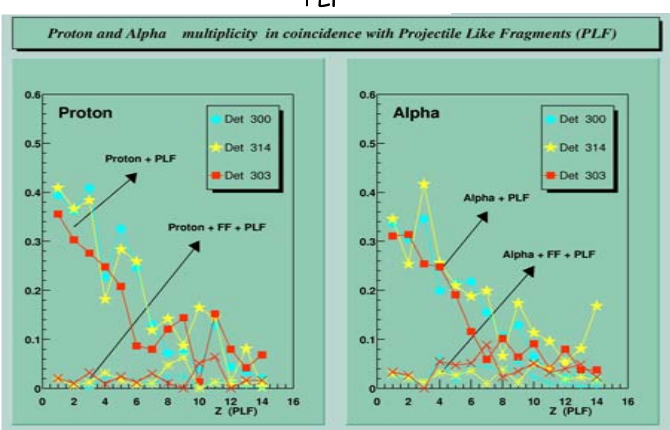
Experimental results

Starting December 1998 the following experiments have been performed at LNL :

- $^{28}Si + ^{232}Th$ at E_{lab} = 340 MeV
- $^{32}S + ^{100}Mo$ at E_{lab} = 240 MeV
- $^{32}S + ^{58}Ni$ at E_{lab} = 350 MeV
- $^{19}F + ^{209}Bi$ at E_{lab} = 130, 137 MeV
- $^{6}Li + ^{208}Pb$ at E_{lab} = 35 MeV

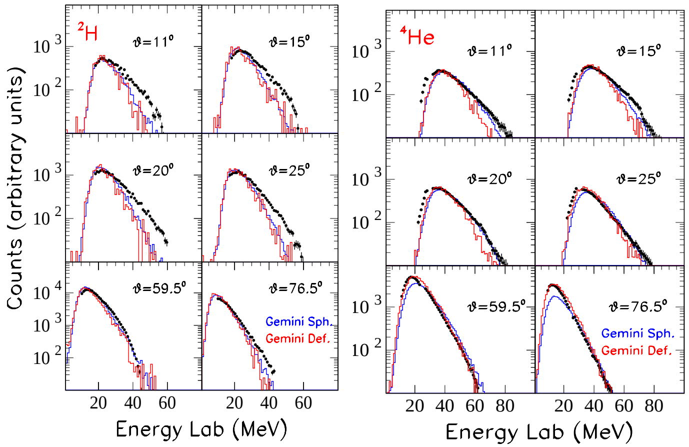




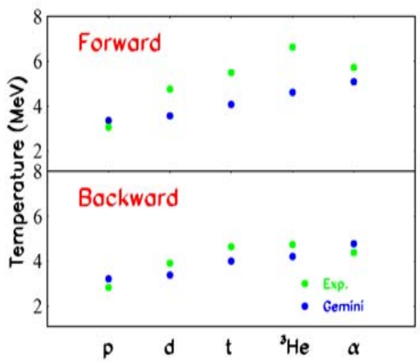


The ratio of transfer induced fission yield to PLF singles yield has been measured in $^{28}Si + ^{232}Th$ at 340 MeV as a function of the projectile-like fragments (PLF) charge and total kinetic energy loss. The measured ratio shows an increase to about 0.6 with increasing the net charge transfer ΔZ, up to $\Delta Z = 4$, then shows a plateau around the value 0.5 followed by a decrease for higher Z-transfers.This indicates a significant survival against fission of the populated primary target-like fragments (TLF), which have been experimentally detected for smaller values of ΔZ in coincidence with PLF, and it is in disagreement with standard Statistical Model calculations which predict values of 1 of fission probability for almost all TLF fragments.

Proton and alpha multiplicities in coincidence with PLF have been measured as a function of Z_{plf} . Generally an increase of particle multiplicities is evidenced in increasing the net charge transfer. For $\Delta Z > 4$ the multiplicities are much larger when compared with that in coincidence with fission fragments, this difference can be due in large part to the particle decay from the excited TLF fragment.



Laboratory energy spectra for p, d, t, ^{3}He and α in coincidence with ER have been measured for the $^{32}S + {}^{58}Ni$ reaction. The spectra have been compared with Statistical Model Calculations performed with GEMINI code, considering the emission from a Spherical emitter (blue lines) or from a Deformed one (red lines) with an axis ratio of 1.6 (here are reported, as an example, d and α spectra). The comparison between calculated and experimental spectra indicate the presence of different deexcitation mechanisms , which have to be investigate in more details.



The effective nuclear temperature from experimental and calculated energy spectra has been extracted for all light particles at all laboratory angles. The comparison between the experimental (green) and calculated (blue) average temperature, at forward and backward angles, indicates the presence of an emission source that is not accounted for in the compound nucleus decay at forward angles. Further analysis is in progress.

Laboratory energy spectra and multiplicity of α particles in coincidence with Fission Fragments (FF) have been measured in the reaction $^{32}S + {}^{100}Mo$ and compared with statistical model calculations performed with GANES code. In the figure are reported the GANES predictions for three emitting sources. The pre-scission α multiplicities, extracted from the fit, are in agreement with statistical model calculations. While it was not necessary to introduce any fission delay to fit the experimental energy spectra. This seems to indicate that the particle emission time is comparable with fission time.