IV LEA Colliga Meeting

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Measurements of Dynamical Dipole in N/Z asymmetric reactions with Garfield at LNL

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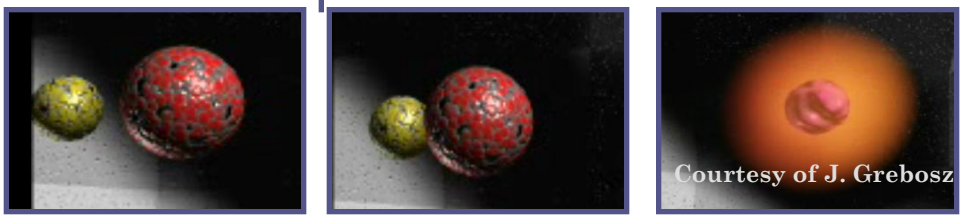
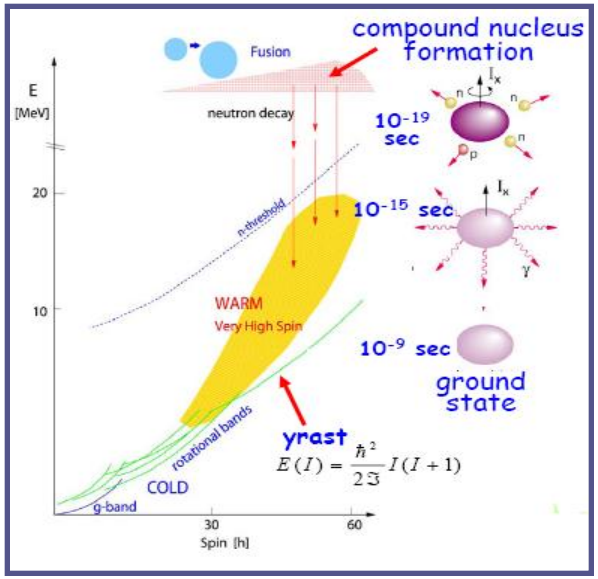
DYNAMICAL DIPOLE γ DECAY IN N/Z ASYMMETRIC REACTIONS

t=0s → t=10^{-24}s CN formation → t=10^{-21}s CN statistical decay



10^{-24}< t <10^{-21}s CN formation: pre-equilibrium phase - energy and momentum equilibration

t >10^{-21}s CN statistical decay (GDR decay)



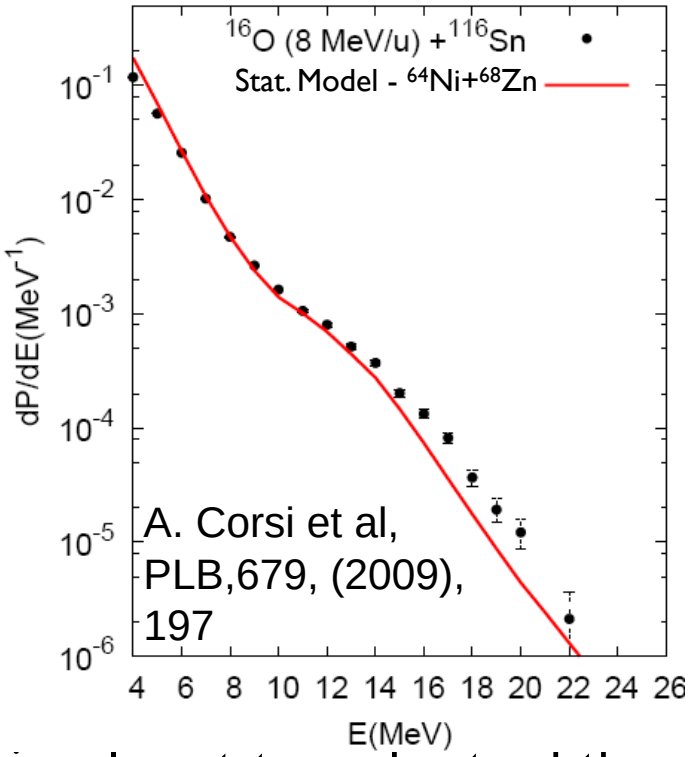
In a fusion reaction, if the colliding nuclei have a different N/Z ratio, a charge equilibration process takes place. The related neutron-proton motion has the features of a collective oscillation and it is associated to a γ emission, the so called **Dynamical Dipole (DD)** emission.

GIANT DIPOLE RESONANCE AND DYNAMICAL DIPOLE γ EMISSION

The **DD γ emission** and the **GDR** have the same dipolar nature and the same energy.

The experimental signature of pre-equilibrium emission is an **excess of counts** in energy range of 10-20MeV with respect to the statistical decay.

To identify the DD contribution from the GDR the emitted γ-rays spectrum of the **N/Z asymmetric reaction** ($^{16}O+^{116}Sn$) is compared by the spectrum obtained from a **N/Z symmetric reaction** ($^{64}Ni+^{68}Zn$).



The study of the pre-equilibrium γ emission is relevant to understand the fusion process dynamics and gives information about:

- The **symmetry term** of the equation of state
- **Nucleon-Nucleon** collision **cross** section inside a medium

THEORY: BNV MODEL

Dynamical model:

BNV Bolzman Nordheim Vlasov

The BNV model is based on nuclear EOS (Equation Of State) as function of ρ + n-n cross section in medium

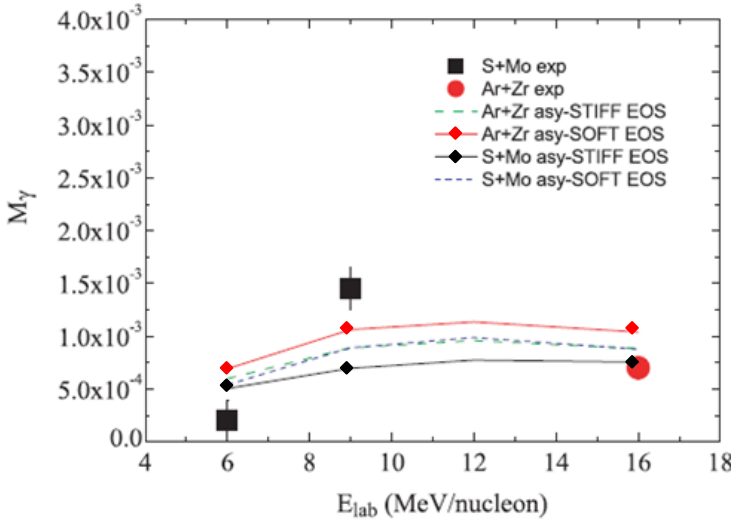
Microscopic dynamics in fusion process and time evolution of Dynamical Dipole

DD emission from bremsstrahlung formula: $\frac{dP}{dE_\gamma} = \frac{2e^2}{3\pi\hbar c^3 E_\gamma}\left|D''(\omega)\right|^2$

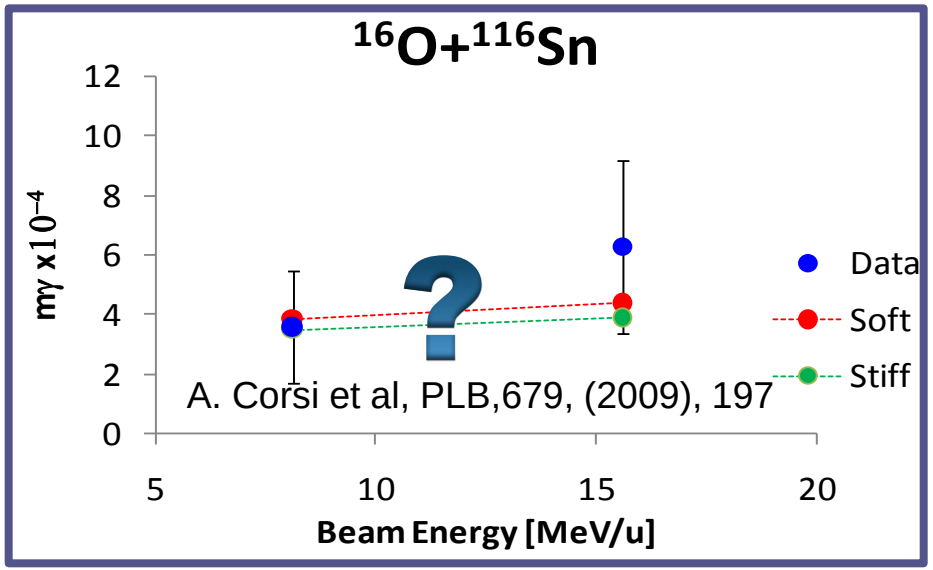
PHYSICAL MOTIVATIONS:
DD DEPENDENCE ON BEAM ENERGY

The existing experimental data are still rather scarce. Some systematic exists in A=132 mass region.

D. Pierroutsakou et al. , PRC, 80, 024612 (2009)



- Verify rise and fall trend in a similar system
- Refine theoretical calculations
- More exclusive experiment

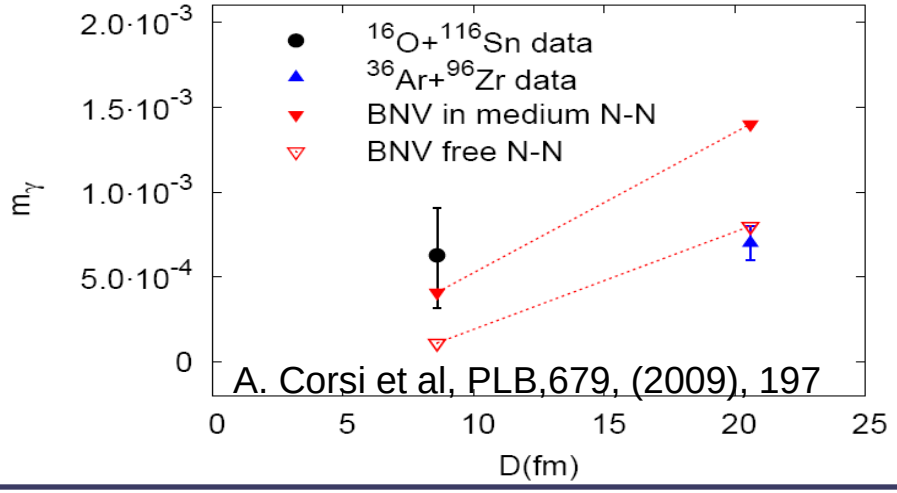


My work

DD dependence on beam energy per nucleon in the $^{16}O+^{116}Sn$ system.

PHYSICAL MOTIVATIONS:

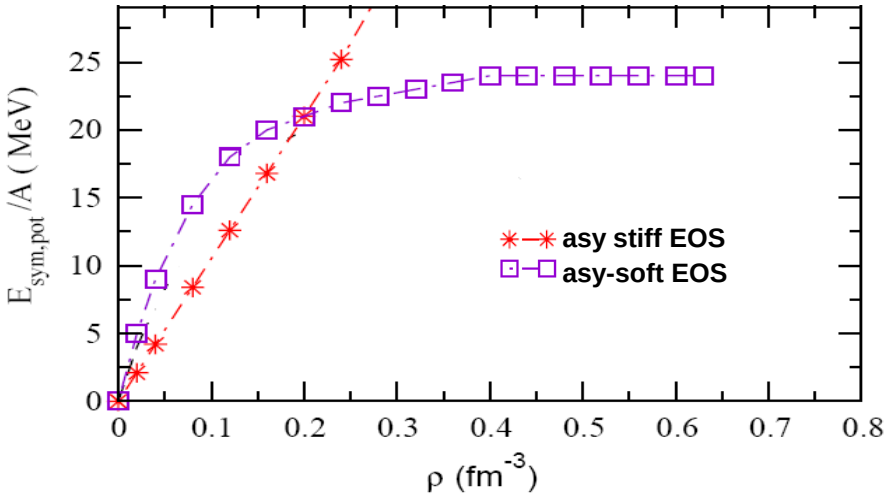
DD DEPENDENCE ON N/Z



DD dependence on N/Z asymmetry at fixed beam energy per nucleon (15MeV/u)
The experimental data don't seem to confirm the theoretical model

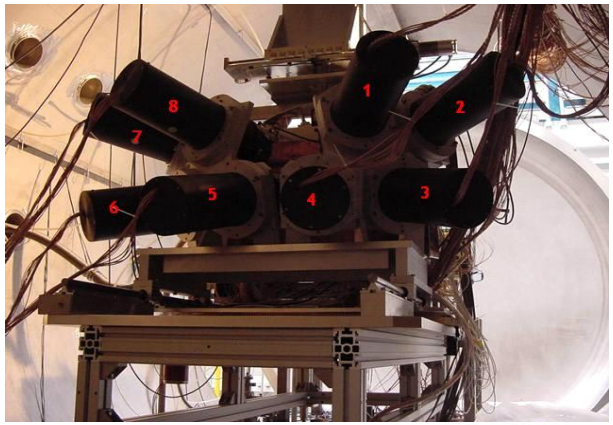
The DD emission is related to the **Nuclear Equation of State** (EOS), in particular to the **symmetry term** and to its density dependence.

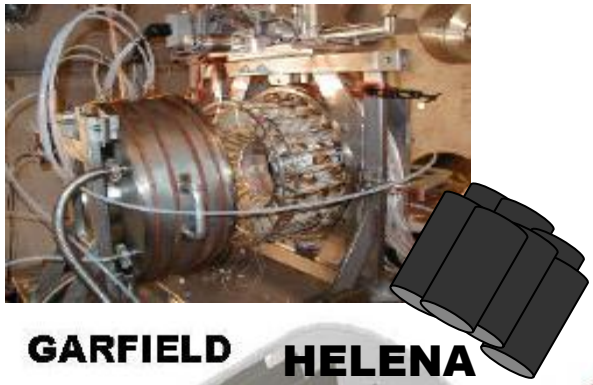
Nuclear EOS as a function of ρ plus n-n cross section in medium.

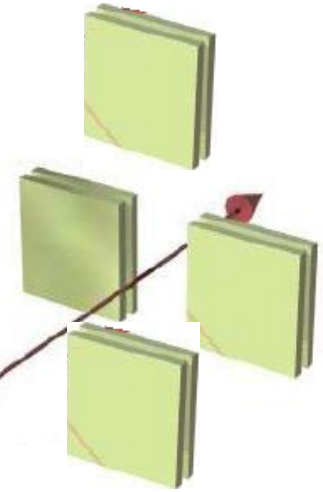


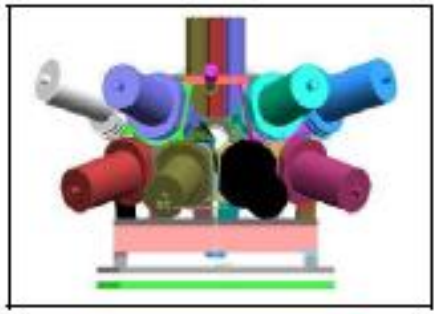
EXPERIMENTAL SET UP

- **Garfield array** for light charge particle (LCP)
- **Phoswich detectors** for evaporation residues
- **Hector detectors** for high energy γ-rays
- **Helena detectors** as time reference and for pre-equilibrium neutrons





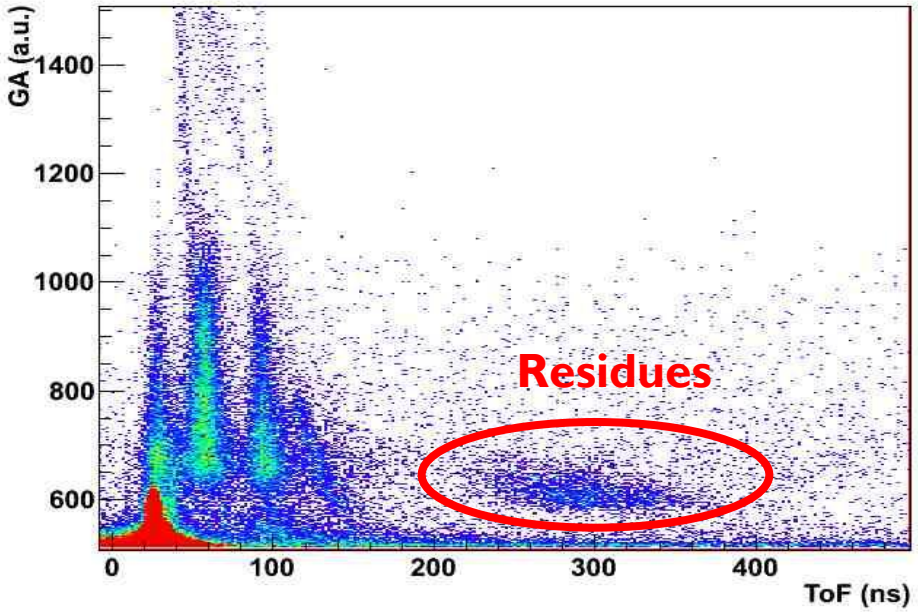




$^{16}O+^{116}Sn$ at 12MeV/u

PRELIMINARY RESULTS: Phoswich

To select the fusion reactions → Energy vs ToF spectra of phoswich

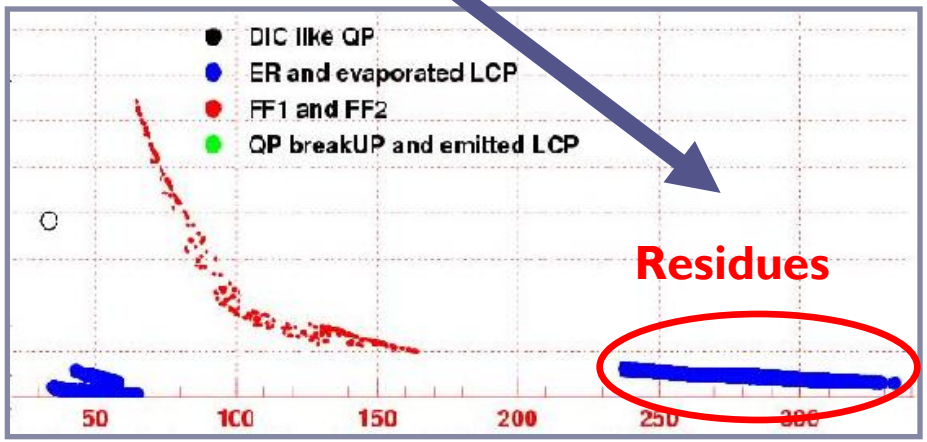


The event identification is obtained by ToF-Energy

In particular the evaporation residues are selected to have the coincidence with high energy γ rays

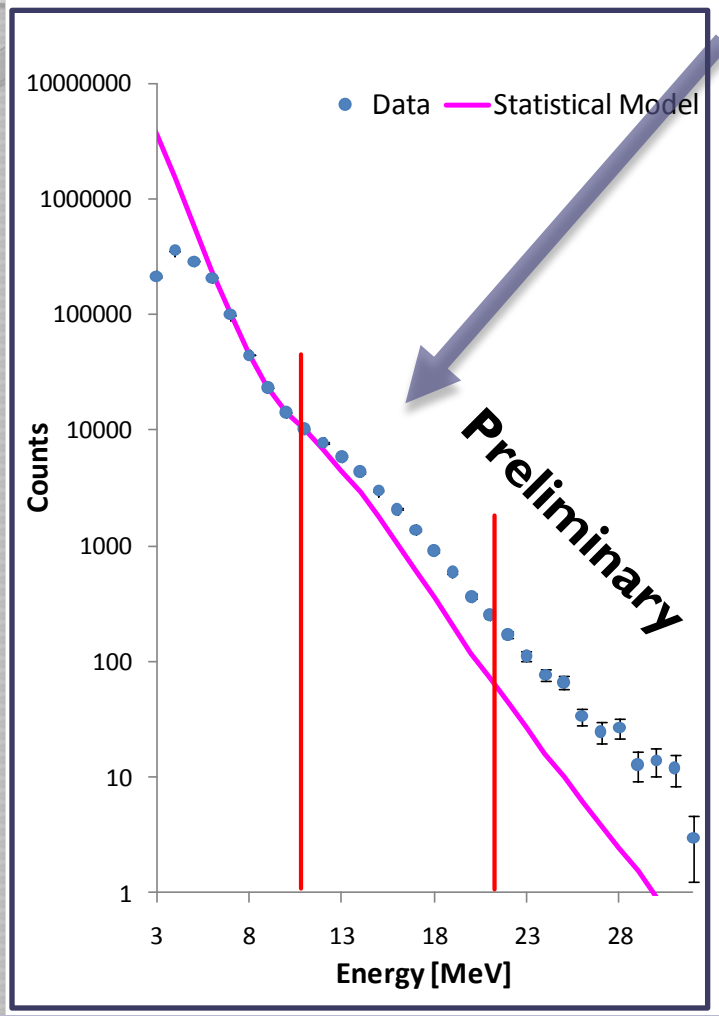
Comparison with Monte Carlo simulation

The evaporation residues have the expected time structure



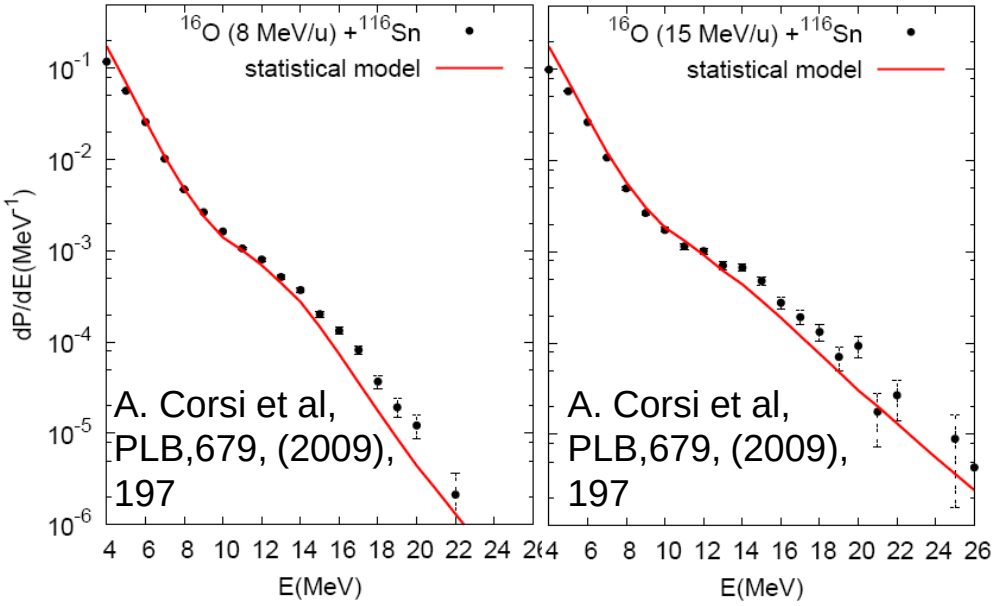
PRELIMINARY RESULTS: Hector

The γ energy spectra obtained by the coincidence between the high energy γ rays and the evaporation residues



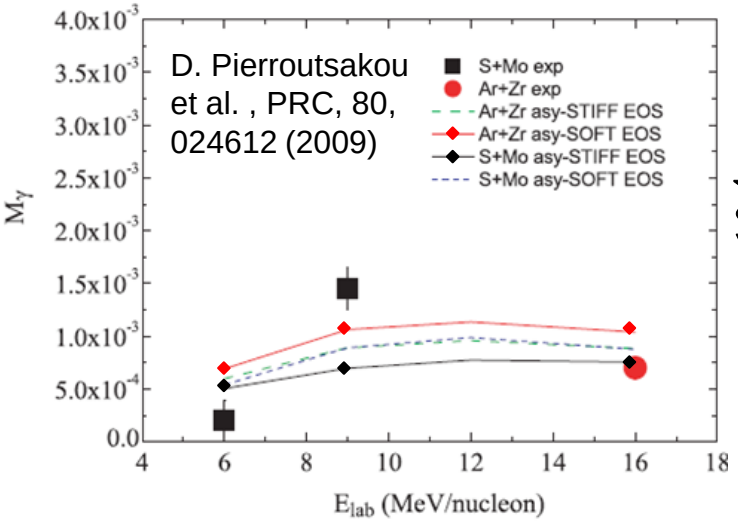
Excess of counts (10-20MeV) **attributed to Dynamical Dipole** at 12MeV/u

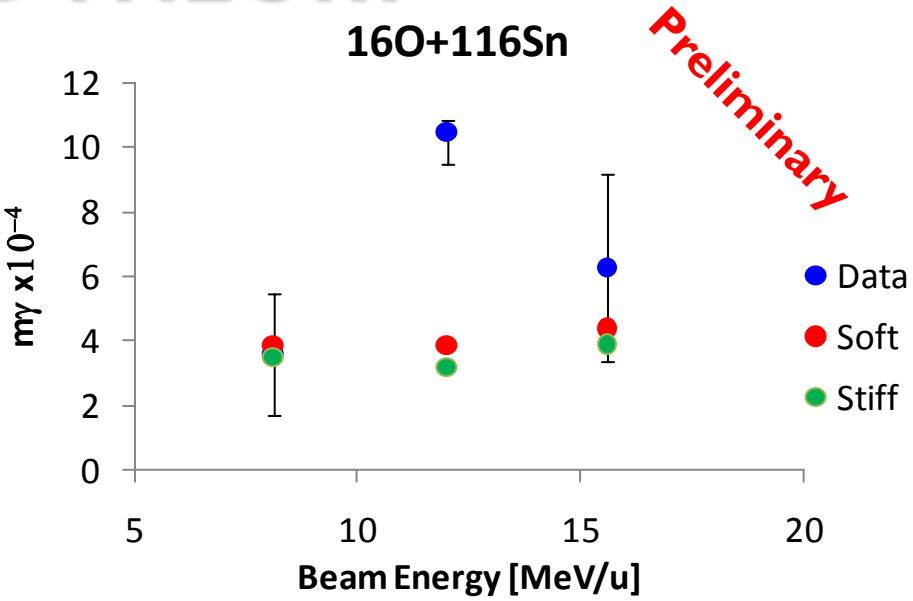
This excess has to be compared with the values obtained at different beam energies



DD excess of counts at 8.1 and 15.6MeV/u

COMPARISON BETWEEN RESULTS AND THEORY





The extra yield obtained from our data displays a rise and fall behavior similar to the one of D. Pierroutsakou et al. measured for the same compound but with very different entrance channel.

The comparison of data with theoretical predictions of this multiplicity shows that such rise and fall behavior isn't predicted

CONCLUSION AND PRESPECTIVES

- Acquired approximately **20000 high energy γ-rays** (10-20MeV) in coincidence with evaporation residues $^{16}O+^{116}Sn$ for the measurement of the DD yield emission
- The measured γ-ray spectra has been compared with the **statistical γ decay** of $^{132}Ce^{*}$ and the measured pre-equilibrium Dynamical Dipole emission yield has been compared with that given by the **BNV-model**.

- Angular distribution
- BNV calculation (in collaboration with Catania)
- Pre-equilibrium neutron multiplicity (in collaboration with Bologna and Firenze)

High energy γ-rays from hot compound nuclei are an important tool to understand reaction dynamics, nuclear structure and symmetries

GARFIELD HECTOR COLLABORATION

A.Giaz[1], A.Corsi[1], F.Camera[1], S.Barlini[6], V.L.Kravchuk[3], R.Alba[8], P.Bednarczyk[4], A.Bracco[1], G.Baiocco[5], L.Bardelli[6], G.Benzoni[2], M.Bini[6], N.Blasi[2], S. Brambilla[2], M.Bruno[5], S.Carboni[6], G.Casini[6] , M.Ciemala[4], M.Cinausero[3], M.Chiari[6], M.Colonna[9], F.C.L. Crespi[1], M.D'Agostino[5], M.Degerlier[3], M.Di Toro[9], F.Gramegna[3], M.Kmiecik[4], S.Leoni[1], C.Maiolino[8], A.Maj[4], T.Marchi[3], K.Mazurek[4], W. Meczynski[4], B.Million[2], D.Montanari[1], L.Morelli[5], A.Nannini[6], R.Nicolini[1], G.Pasquali[6], S.Piantelli[6], A.Ordine[7], G.Poggi[6], V.Rizzi[3], C.Rizzo[9] , D.Santonocito[8], V.Vandone[1], G.Vannini[5], O.Wieland[2]

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Thank you for the attention