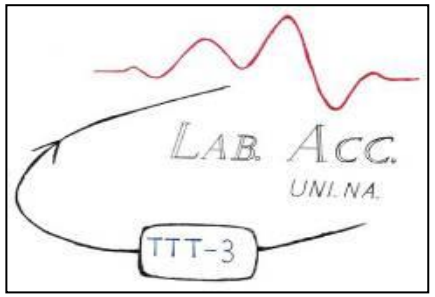
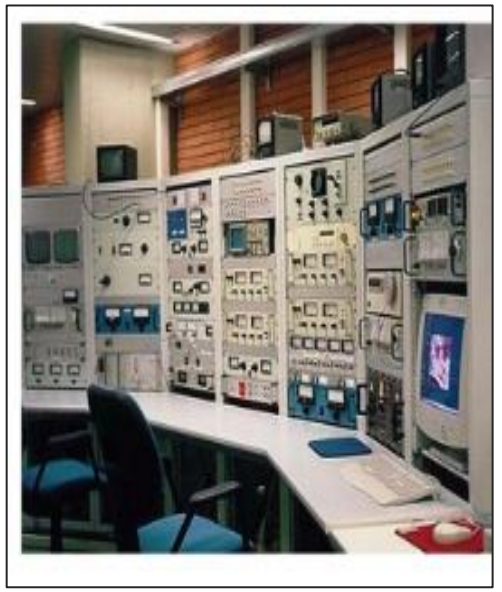
Opportunities of studying clustering in nuclei with the TTT3 tandem accelerator in Naples

Istituto Nazionale di Fisica Nucleare

The table-top TTT-3 van de Graaf tandem accelerator in Naples

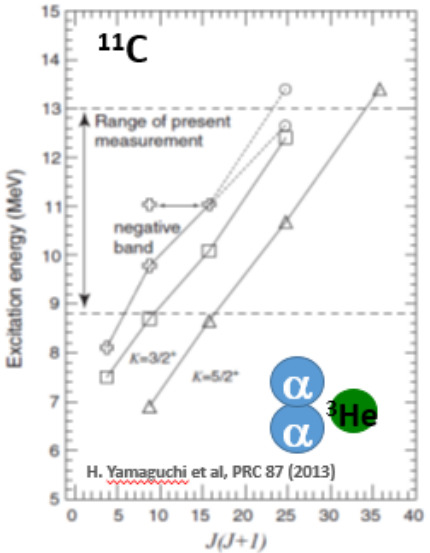
- A van de Graaf tandem accelerator is operative in Naples since **1977**. It was manufactured by HVEC. Maximum terminal voltage: **3.34 MV** (march 2012).
- It uses two sources: a **RF source** (^{1}H, ^{2}H, ^{4}He, ^{15}N, ^{16}O, ^{19}F beams) and a Kingston **sputtering source** (e.g. ^{1}H, ^{2}H, $^{6,7}Li$, ^{9}Be, $^{10,11}B$, ^{12}C … beams). 100 eV ripple.
- **Three reaction chambers** and five channels for the beam transportation (also **in air**). A dedicated **FAIR-VME** acquisition system.
- It was the first accelerator for **radioactive beams** (^{7}Be, in batch mode) operative in Italy.





^{11}C structure from ^{10}B(p,α_0)^{7}Be reaction

^{11}C is a proton-rich nucleus (1-n hole) → existence of α+α+^{3}He cluster structure

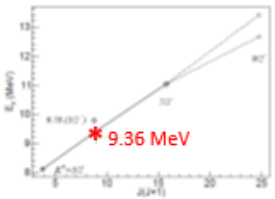


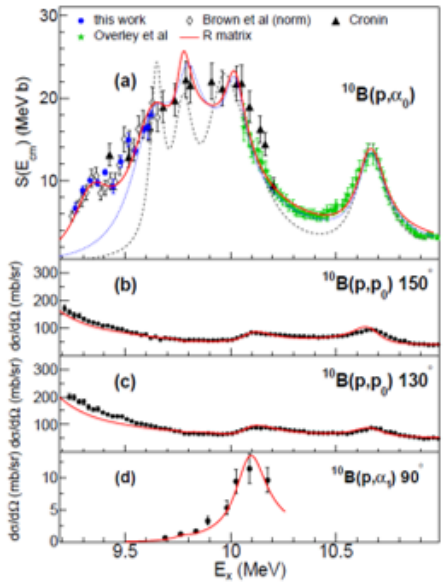
^{11}C spectroscopy → not well understood above the alpha threshold

Yamaguchi → negative parity cluster band

New experiment in Naples: p + ^{10}B to populate high energy states in ^{11}C compound nucleus

^{7}Be+α decay channel: high sensitivity to cluster states, but unfavorable kinematics



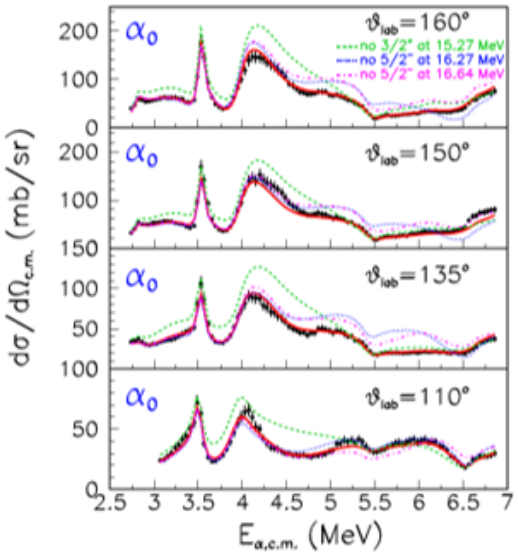


Inverse absorber technique → overcome the experimental difficulties and estimate integrated cross sections and S-factors …

… that were fitted with the R-matrix code AZURE2 to refine the spectroscopy of ^{11}C.

A new 5/2$^-$ state at 9.36 MeV with large Γ_α is candidate to belong to the negative parity band.

^{13}C structure from α+^{9}Be resonant scattering



^{13}C is the simplest system that can be built starting from a 3α structure coupled with a valence neutron.

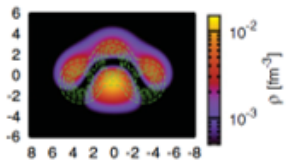
Its structure and spectroscopy is a benchmark for all the models trying to describe clustering in neutron rich nuclei, but …

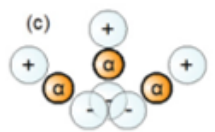
… above the α threshold (10.65 MeV), the spectroscopy is highly uncertain! (see also I. Lombardo poster)

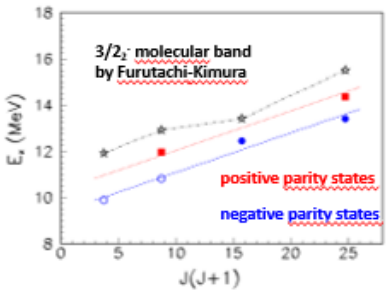
New measurement of a+9Be resonant elastic and inelastic scattering in Naples (≈150 energy changes).

The R-matrix analysis of excitation functions at several angles, coupled with ^{9}Be(α,n) reaction data → revision of ^{13}C spectroscopy

Analysis of level scheme → naïve indication of a negative parity band with molecular-like nature, as suggested by Furutachi and Kimura, PRC 81 (2010).

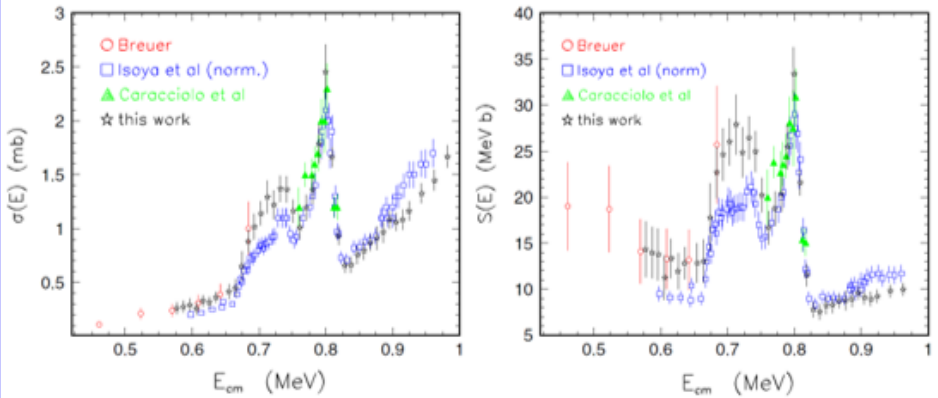






^{20}Ne spectroscopy and the ^{19}F(p,α)^{16}O reaction

A new measurement of the ^{19}F(p,α)^{16}O reaction → nuclear structure (^{20}Ne) and astrophysics (fluorine destruction in stars).

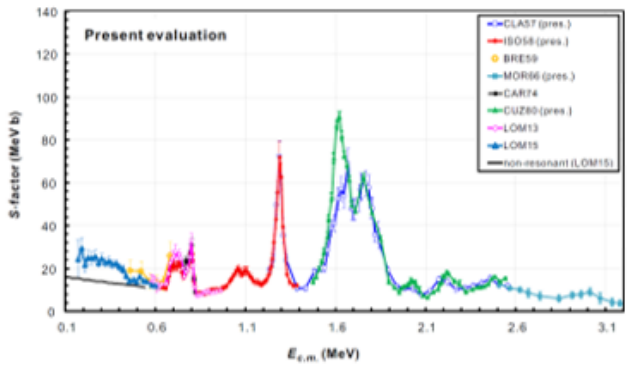


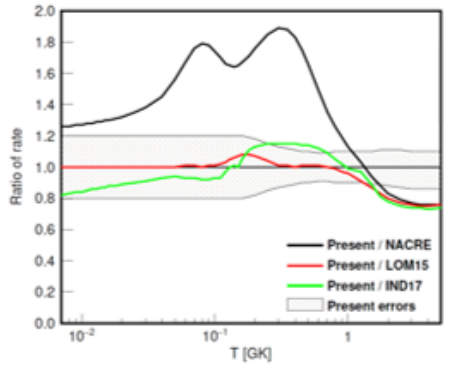
Low energy: broad states.

New exp. at LNL: low energy data

New react. rate

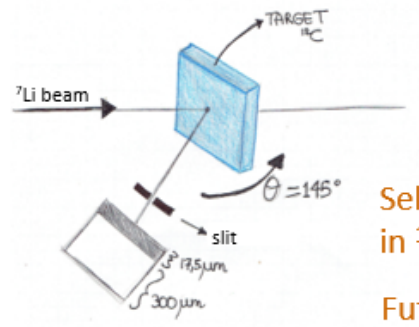
In 2017 → collaboration with JUNA people (J.J. He et al) for a general revision of the ^{19}F(p,α)^{16}O integrated cross sections and reaction rate.





^{18}O* via sub-barrier α-transfer induced by ^{7}Li

Good quality low energy ^{7}Li beams were used for α-transfer reactions on light targets. A test example was constituted by the ^{7}Li+^{12}C → p+^{18}O at 8.08 MeV



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Selection of protons: region of high level density in ^{18}O; nevertheless some structure is seen.

Future: ^{7}Li+^{9}Be → p+^{15}C to study clustering in ^{15}C