Dynamics of Inclomplete Fusion reaction - first experiment on EAGLE array

Jan Mierzejewski
Heavy Ion Laboratory
University of Warsaw

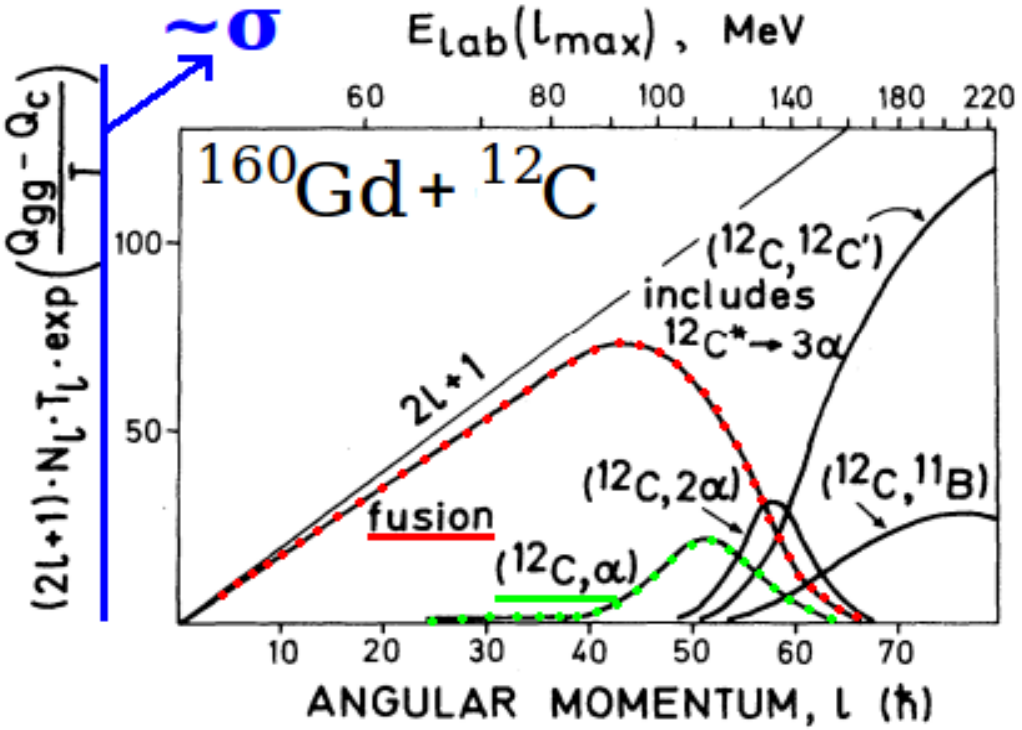
- What is Incomplete Fusion?
- Experiment
- Interpretation
- Conclusions

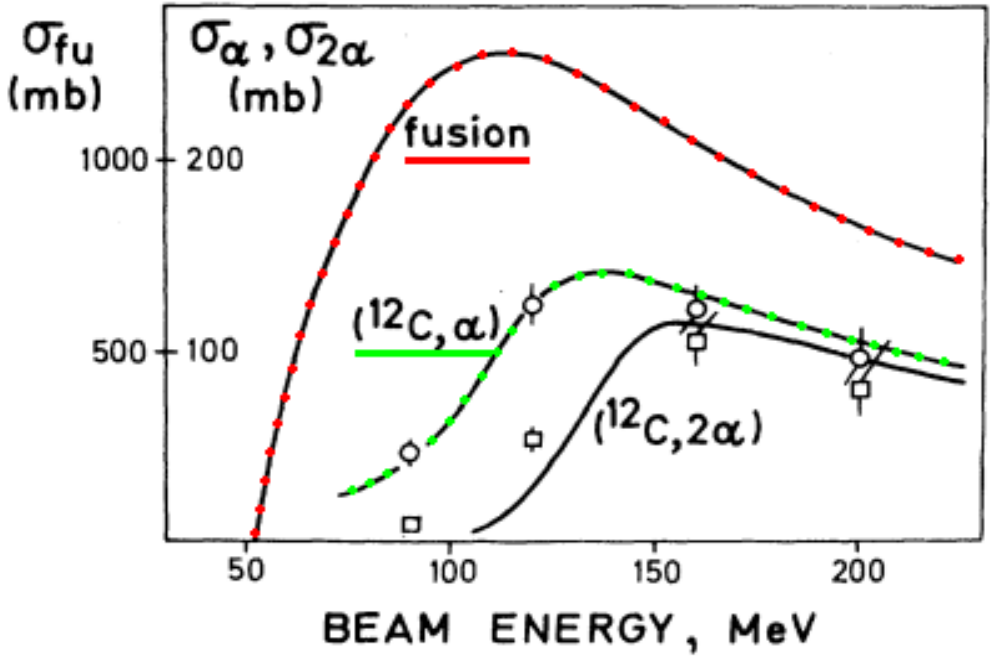
WHY INCOMPLETE FUSION ?

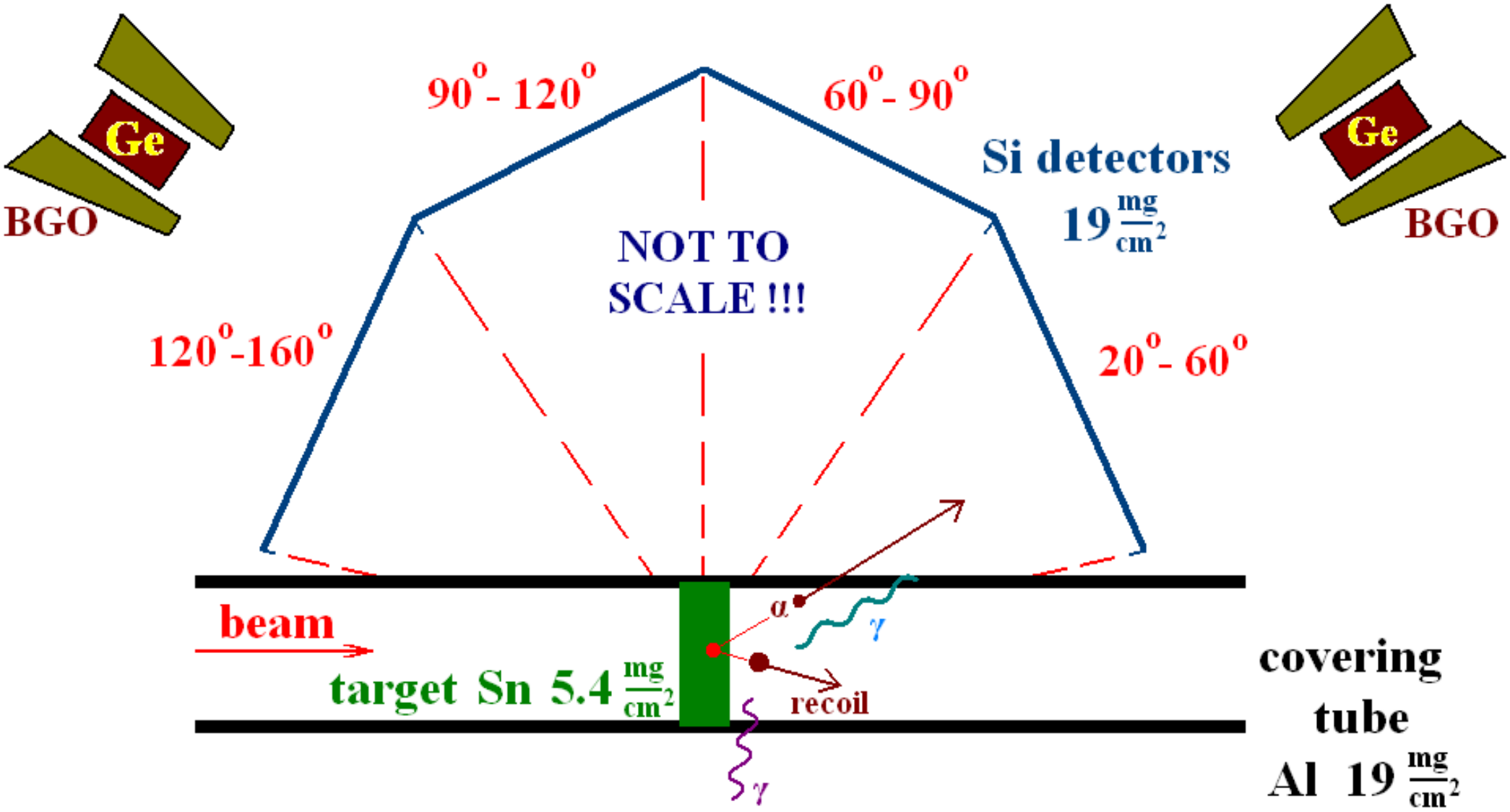
1. **Generalised concept of Critical Angular Momentu**
   K. Siwek-Wilczyńska et al. (PR
2. **Sum Rule Model**
   J. Wilczyński et al. (PRL 1980)

Both models describe entrance angular momentum leading to CF and ICF

1980's 1990's 2000's
Cross sections
&
particle spectra measurements
No theoretical approach describing the dynamics:
1. Fragment escape
2. Compound nucleus formation after the fragment escape





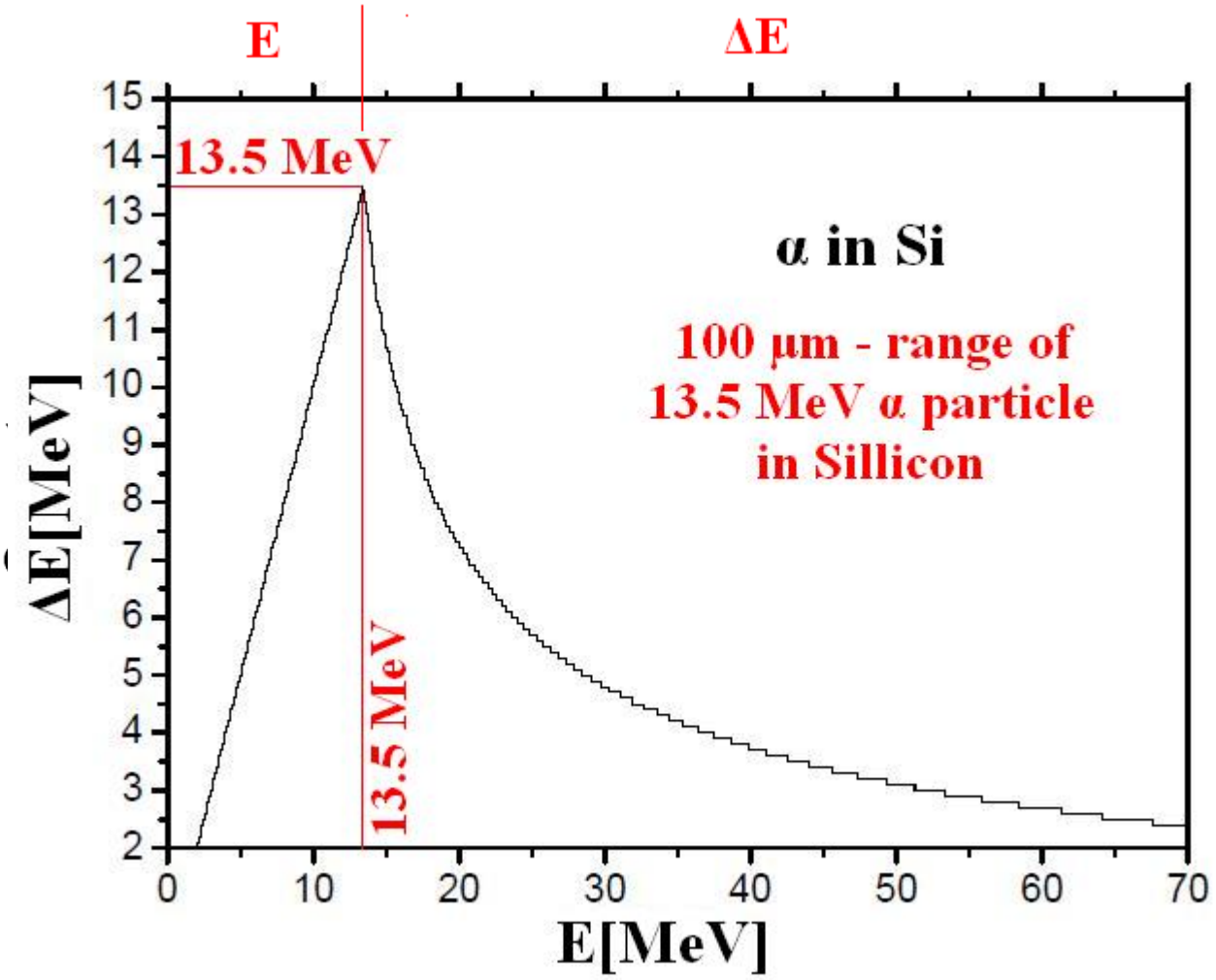


12 Ge detectors of 20-35% photopeak efficiency.
Total array efficiency ~ 0.5% (1.3 MeV)

Si-ball consisting of 30 thin (100 μm) Si detectors

Two ^{20}Ne beam energies – 141 MeV and 150 MeV

Particle-gamma coincidences



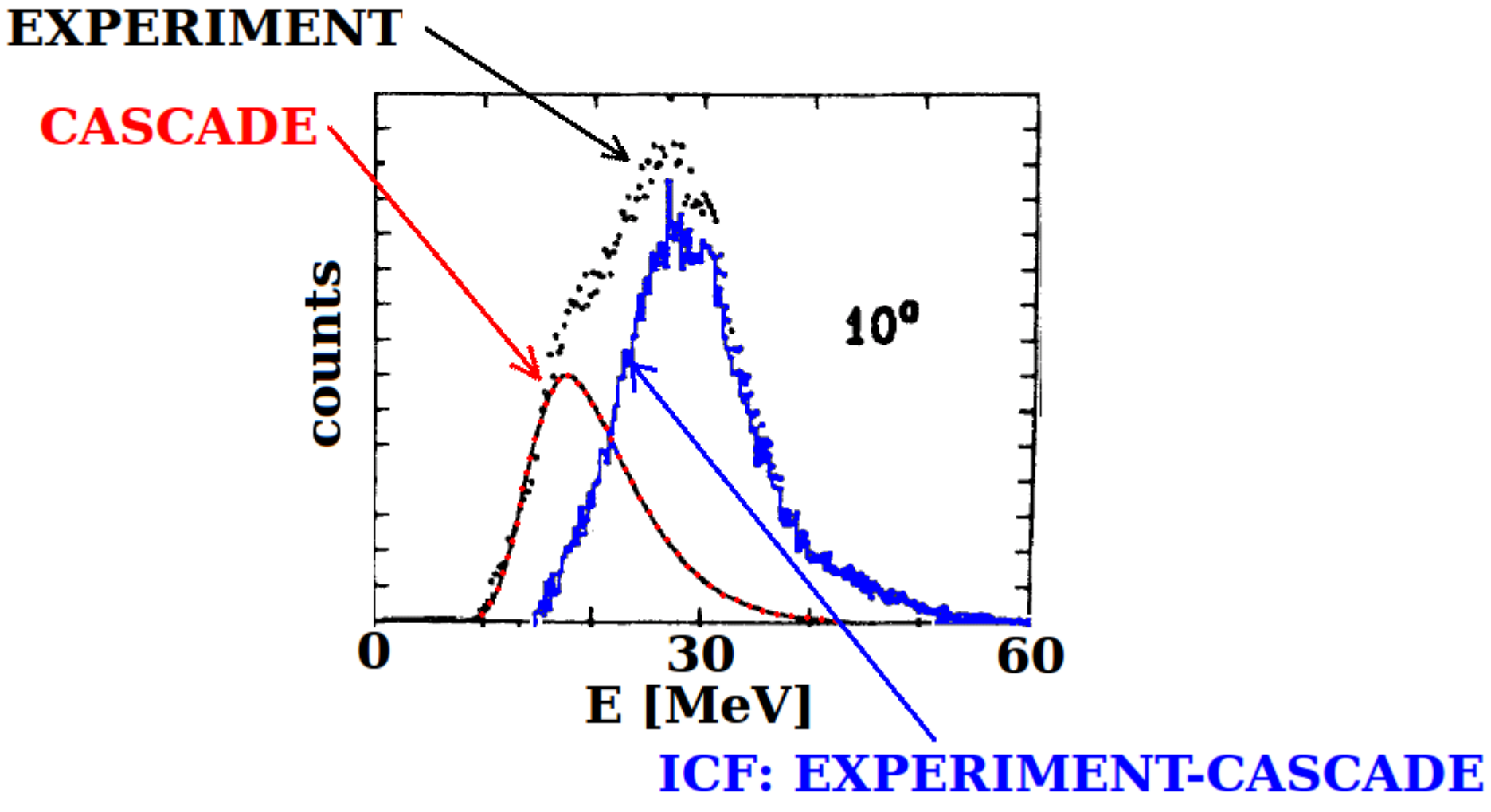
MC simulations with COMPA code.

1. Spin and excitation energy of the residue,
2. Directions and velocities of the recoil and emitted light particles (n,p,α),
3. Reaction point coordinates,
4. Stopping in passive elements of the setup (target & tube), stopping powers taken from SRIM,
5. Protons and α particles detection in 100 μm Si detector .

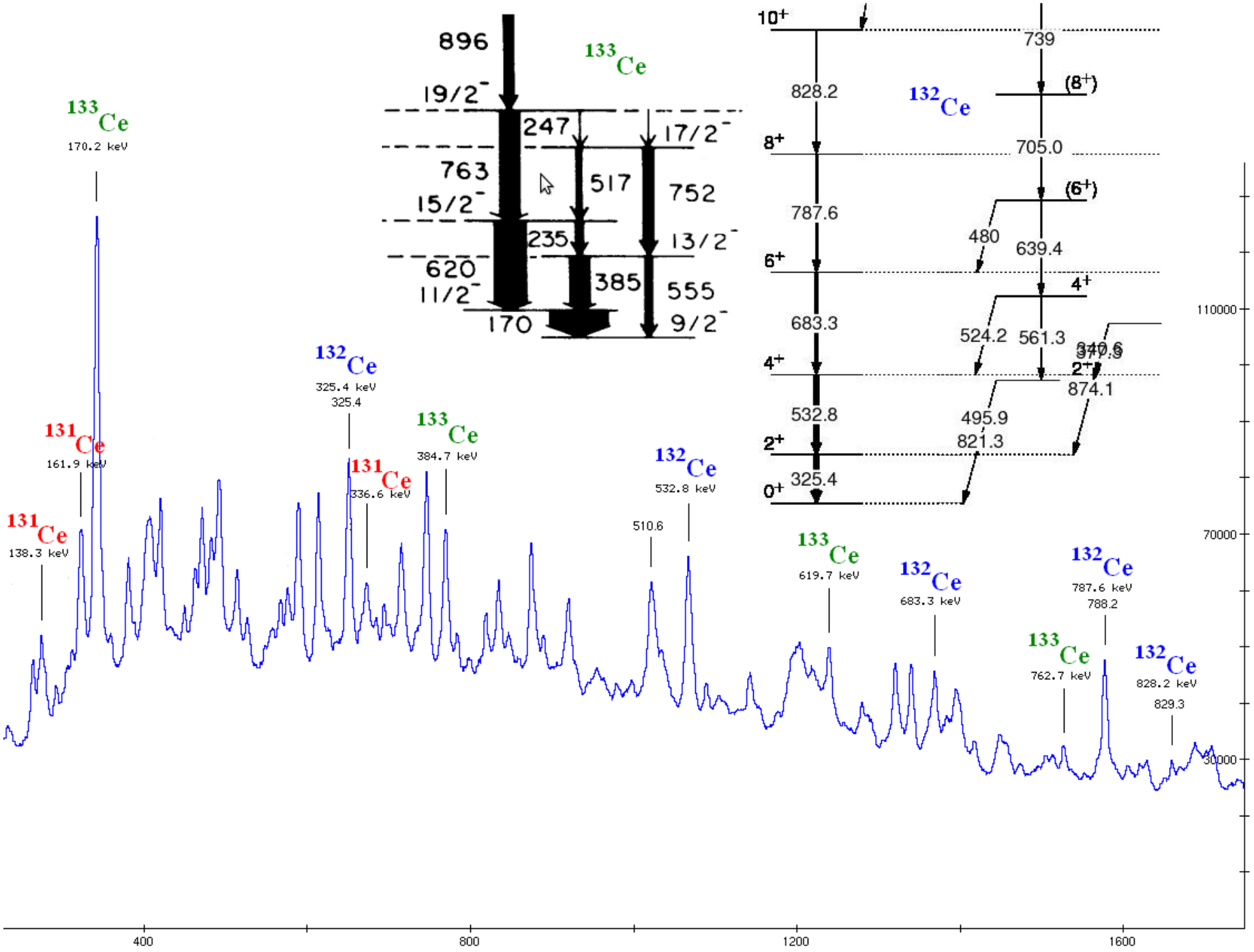
PHYSICAL REVIEW C VOLUME 30, NUMBER 1 JULY 1984

Complete and incomplete fusion in $^{12}C+^{51}V$ at $E(^{12}C)=36-100$ MeV from analysis of recoil range and light particle measurements

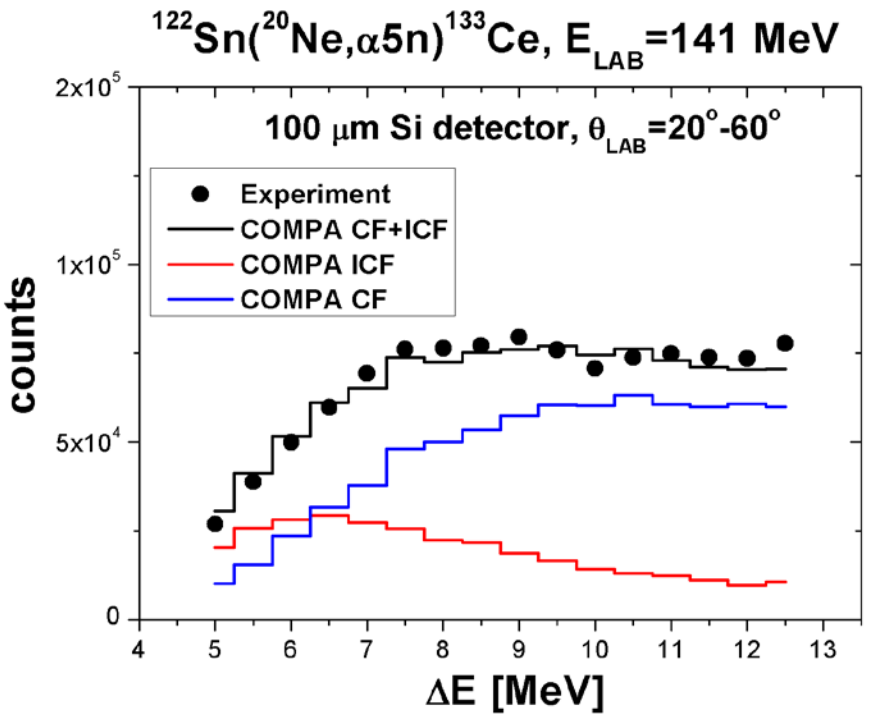
D. J. Parker, J. Asher, T. W. Conlon, and I. Naqib*
Nuclear Physics Division, Atomic Energy Research Establishment Harwell, Oxfordshire, OX11 ORA, United Kingdom
(Received 2 March 1984)

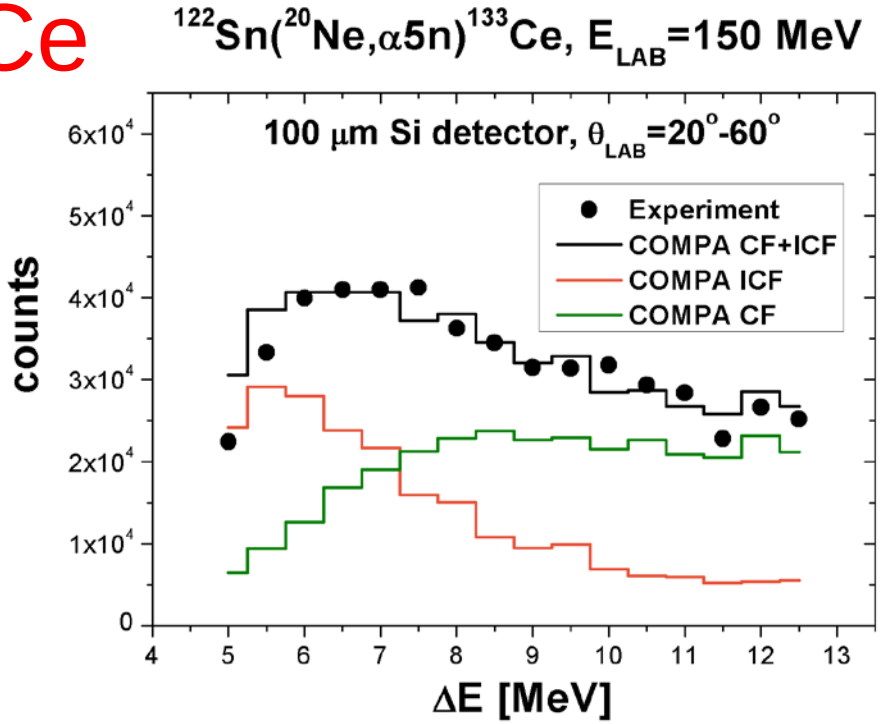


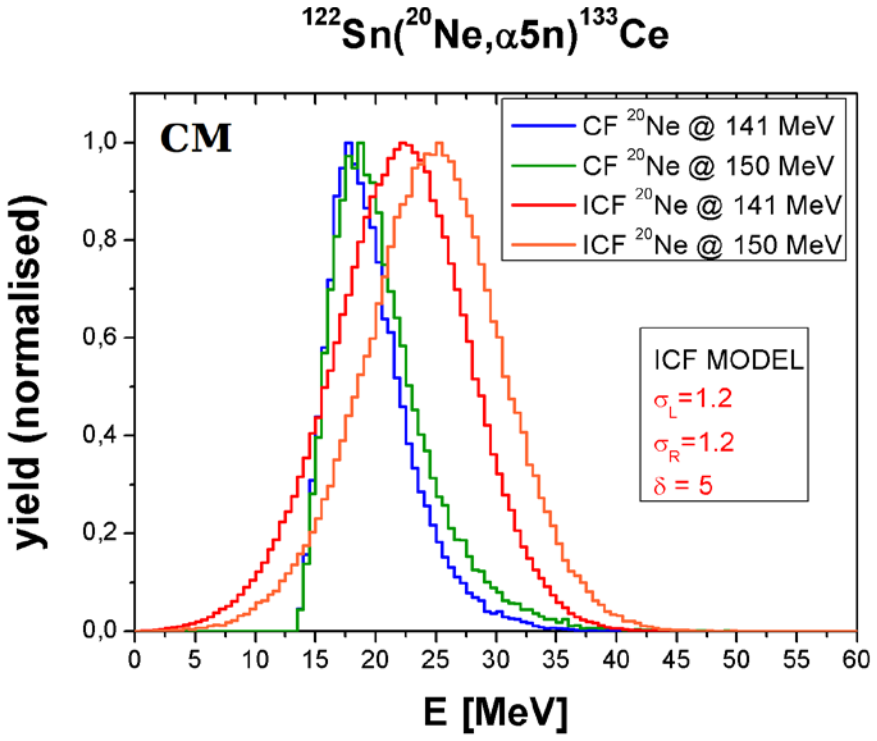
particle-γ coincidence spectrum



^{133}Ce

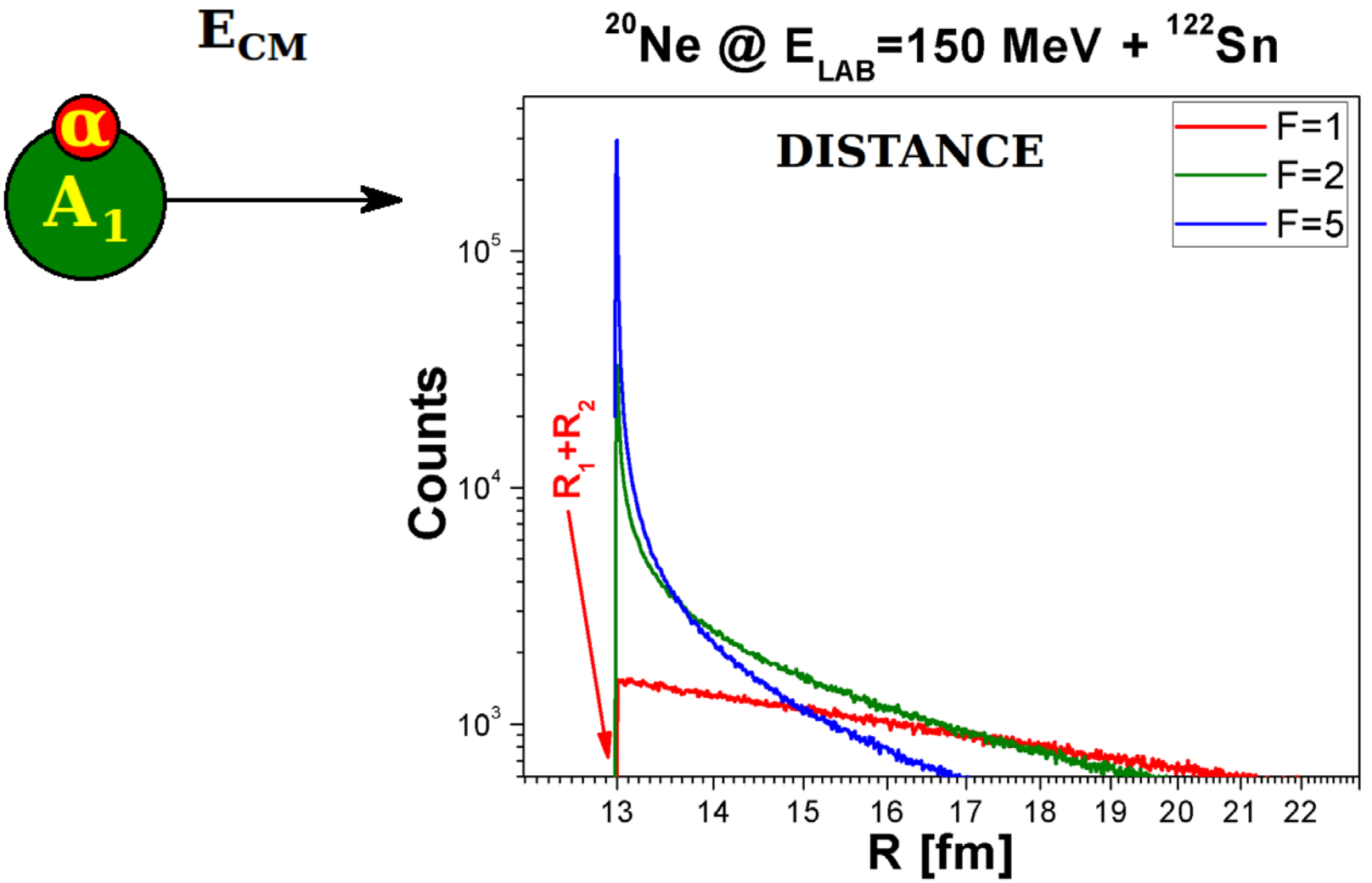




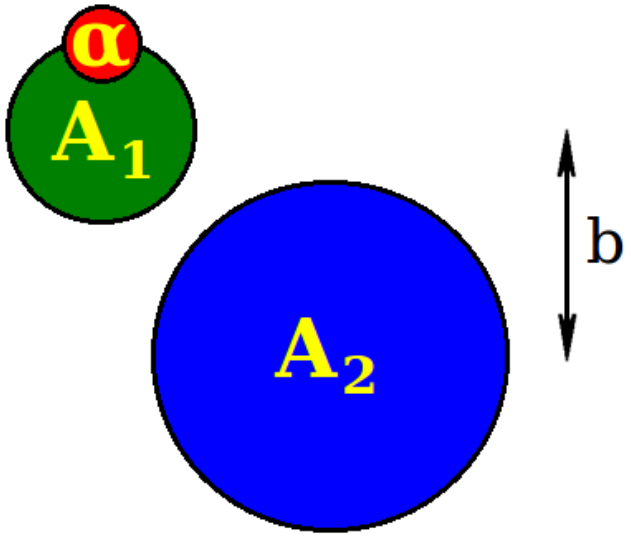


The CF spectra are almost equal
While the ICF spectra are energy dependent

ICF MODEL


E_CM
α
A_1
20Ne @ E_LAB=150 MeV + 122Sn
DISTANCE
F=1
F=2
F=5
Counts
10^5
10^4
10^3
R_1+R_2
13
14
15
16
17
18
19
20
21
22
R [fm]

ICF MODEL



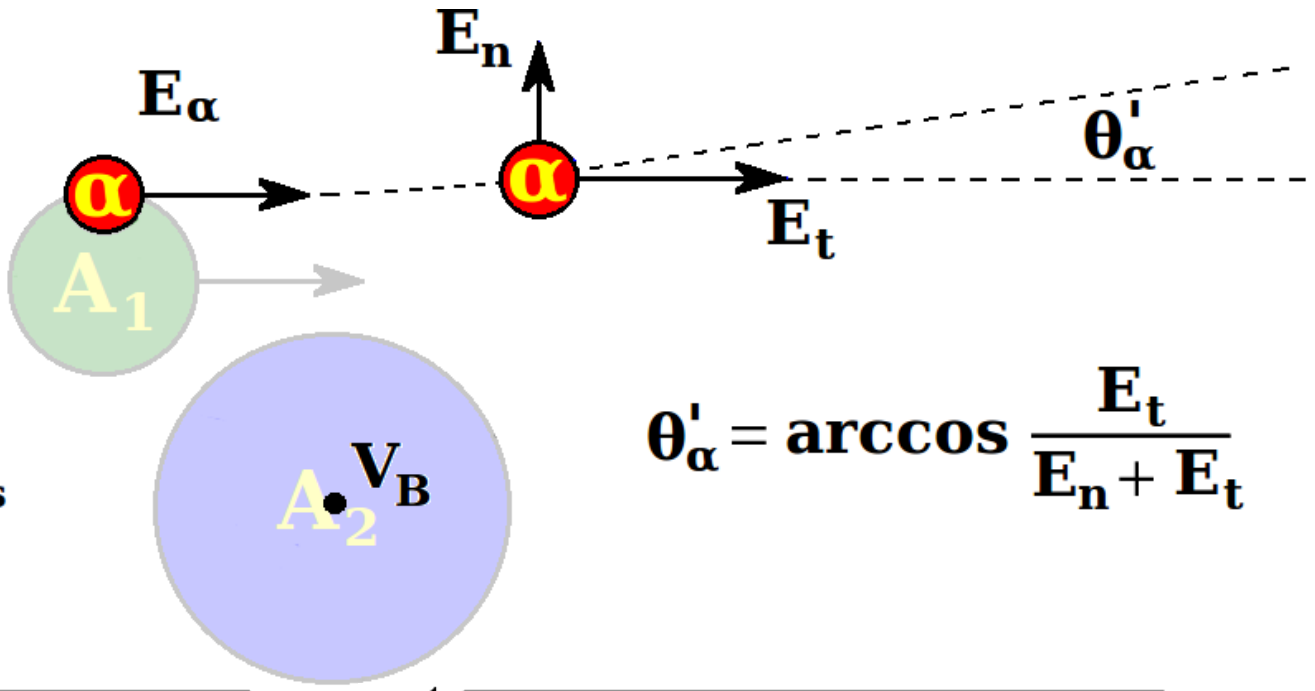
ICF MODEL

$$E'_\alpha = E_t + E_n + V_B$$

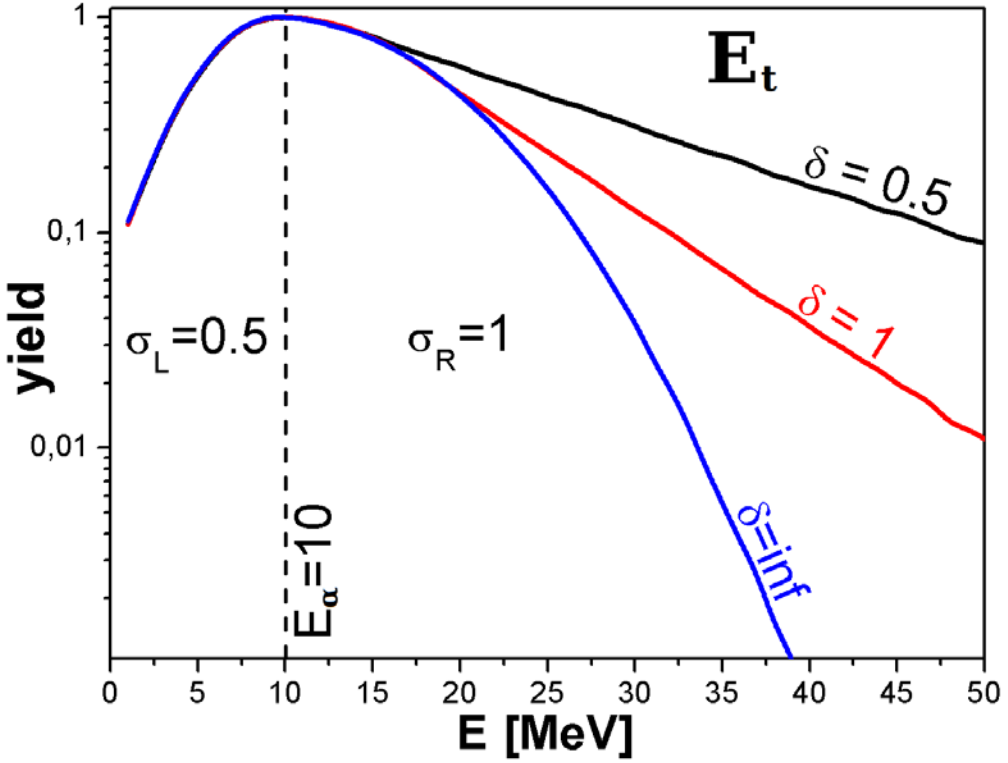
E_t - transversal component

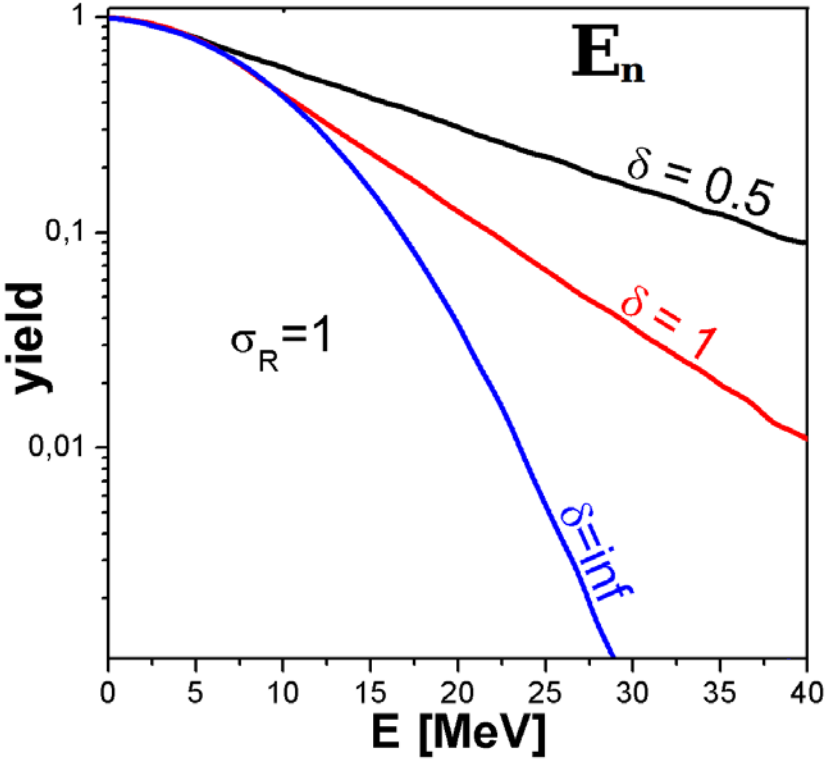
E_n - normal component

V_B - sum of coulomb potentials

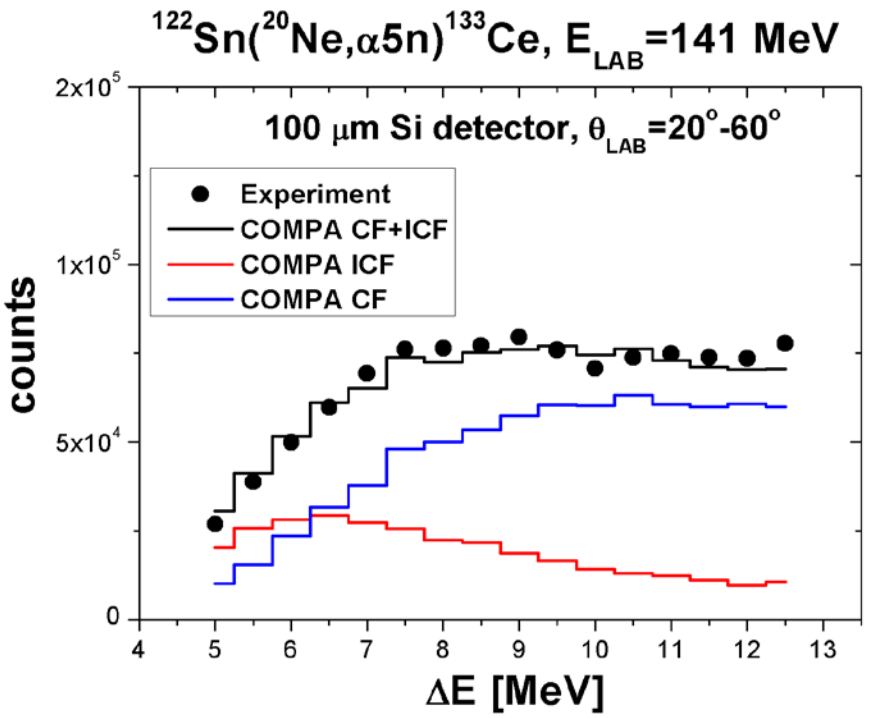


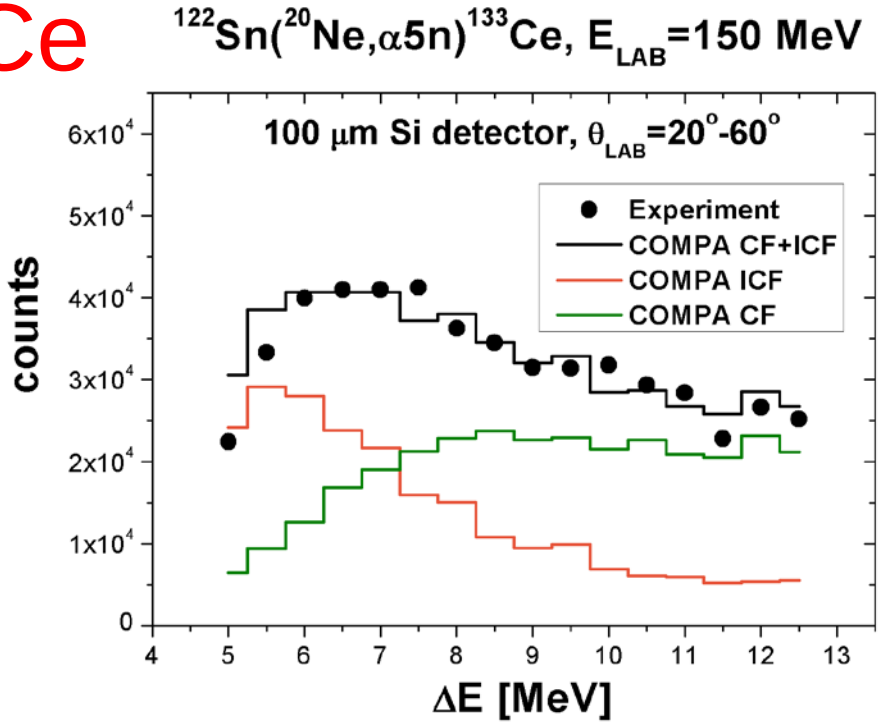
$$\theta'_\alpha = \arccos \frac{E_t}{E_n + E_t}$$

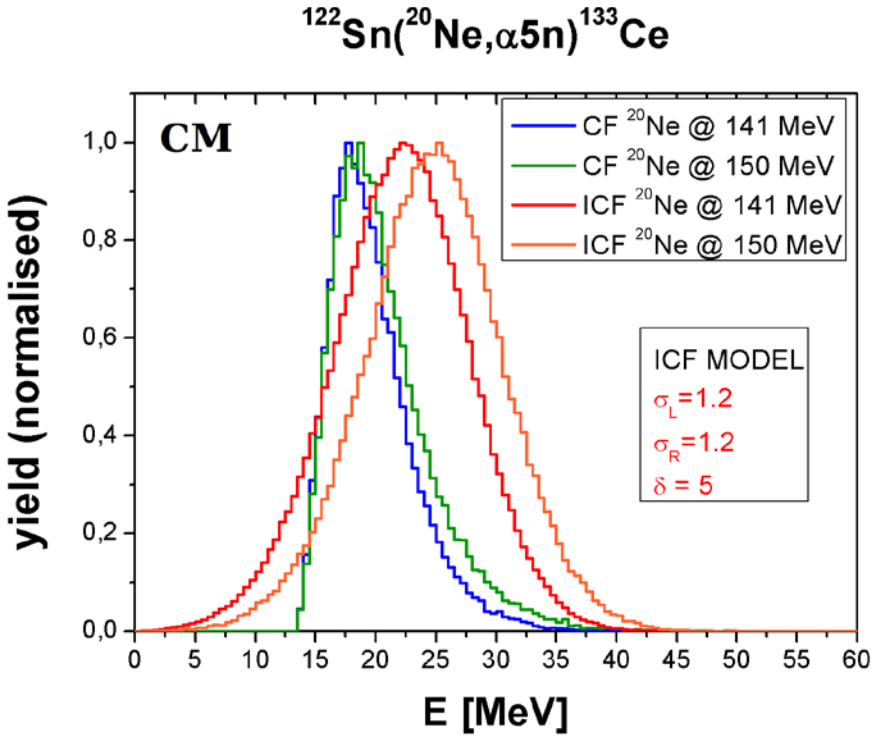




^{133}Ce







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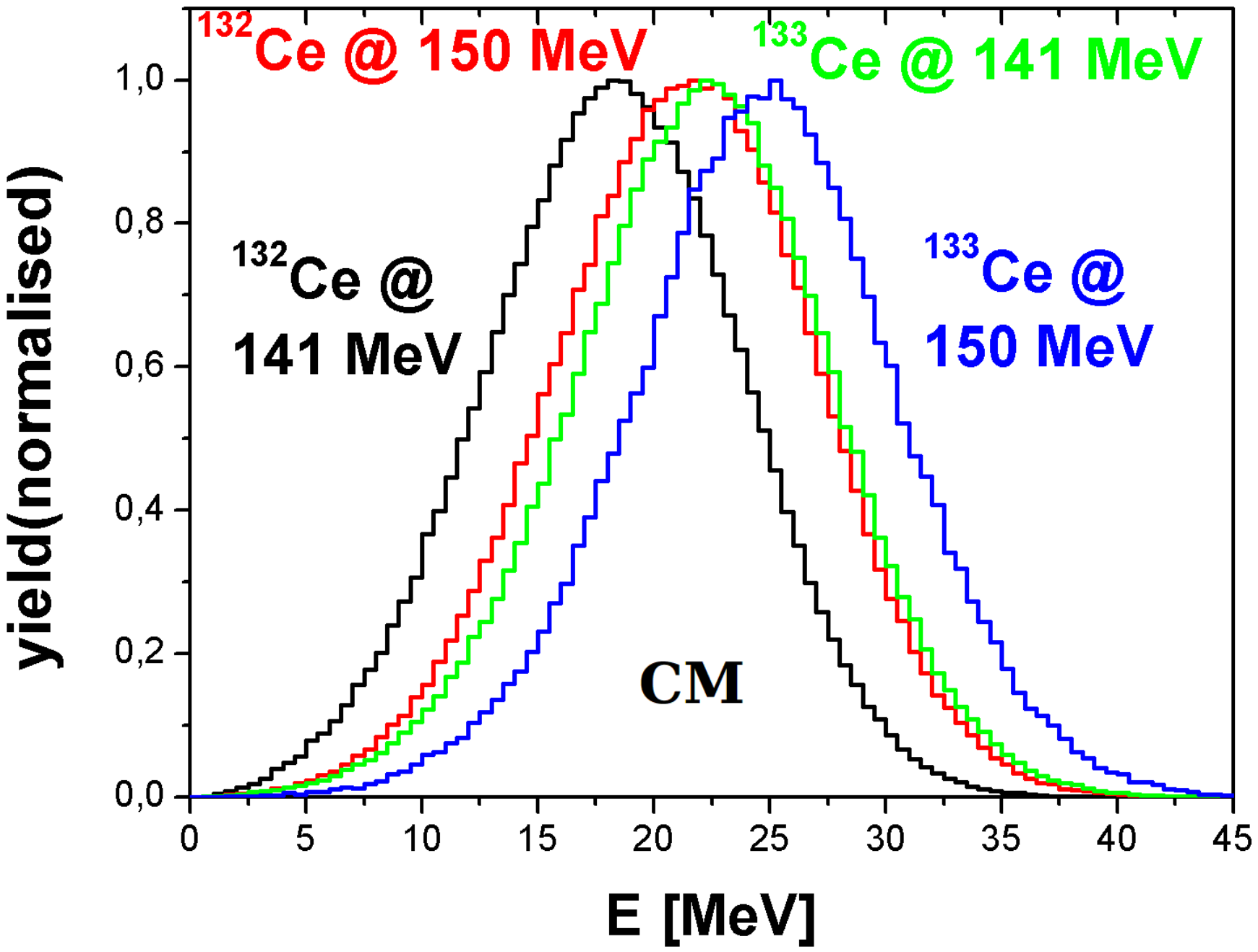
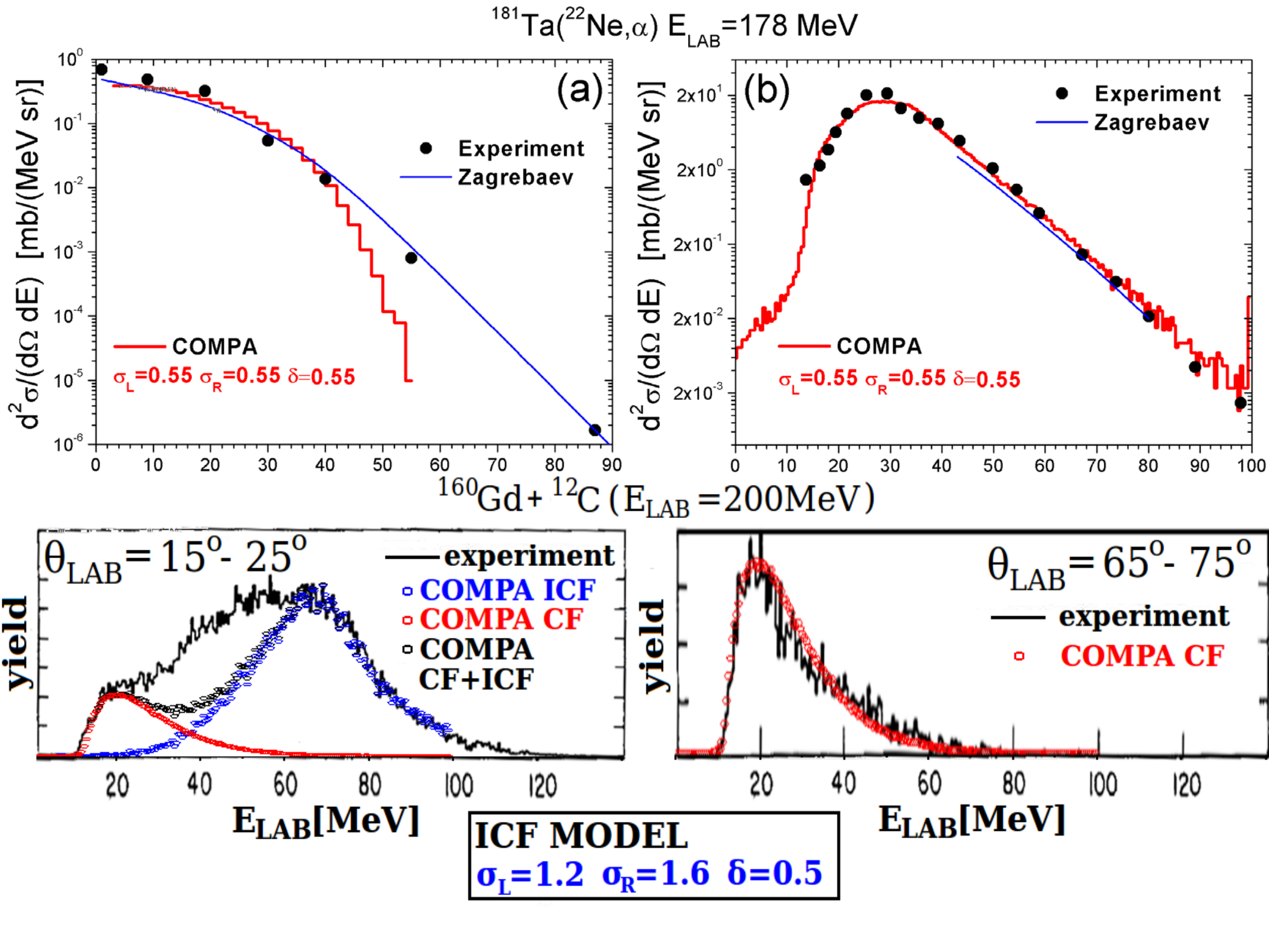

132Ce @ 150 MeV
133Ce @ 141 MeV
132Ce @
141 MeV
133Ce @
150 MeV
CM
yield(normalised)
E [MeV]
1,0
0,8
0,6
0,4
0,2
0,0
0
5
10
15
20
25
30
35
40
45


^{181}Ta(^{22}Ne,α) E_{LAB}=178 MeV
(a)
Experiment
Zagrebaev
COMPA
σ_L=0.55 σ_R=0.55 δ=0.55
$d^2\sigma/(d\Omega\, dE)$ [mb/(MeV sr)]
(b)
Experiment
Zagrebaev
COMPA
σ_L=0.55 σ_R=0.55 δ=0.55
$d^2\sigma/(d\Omega\, dE)$ [mb/(MeV sr)]
^{160}Gd+ ^{12}C (E_{LAB} =200MeV)
θ_{LAB}= 15°- 25°
experiment
COMPA ICF
COMPA CF
COMPA CF+ICF
yield
E_{LAB}[MeV]
θ_{LAB}= 65°- 75°
experiment
COMPA CF
yield
E_{LAB}[MeV]
ICF MODEL
σ_L=1.2 σ_R=1.6 δ=0.5

Conclusions
The EAGLE works !

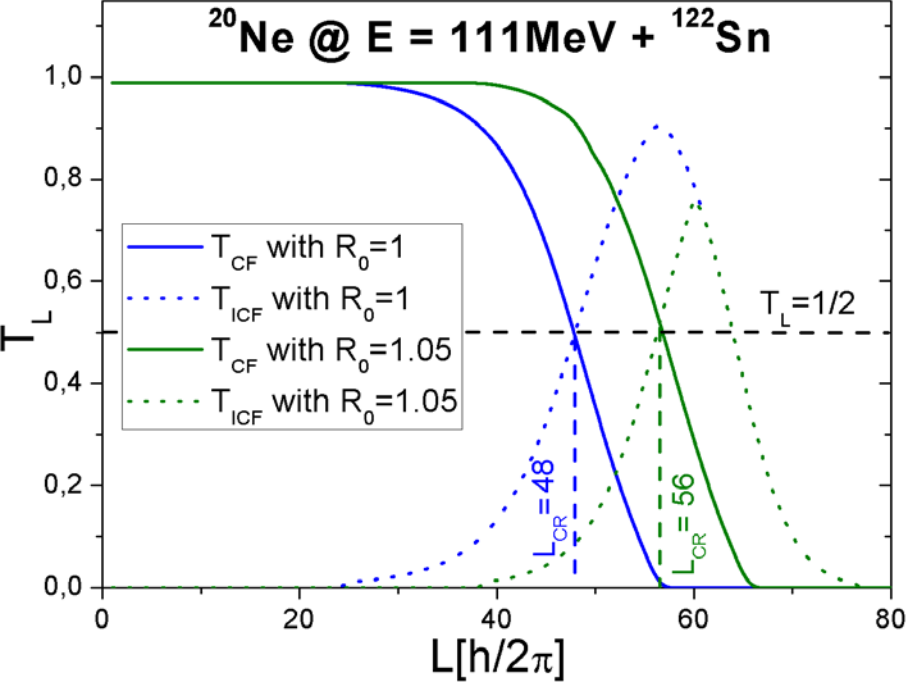
1. α5n (133Ce) and α6n (132Ce) measured for 141MeV and 150MeV,
2. ΔE spectra analysed almost as (E,ΔE) spectra,
3. Angular correlation measured,
4. CF and ICF coexistence shown,
5. New model describing α particle escape in ICF mechanism was compared to the experiment.

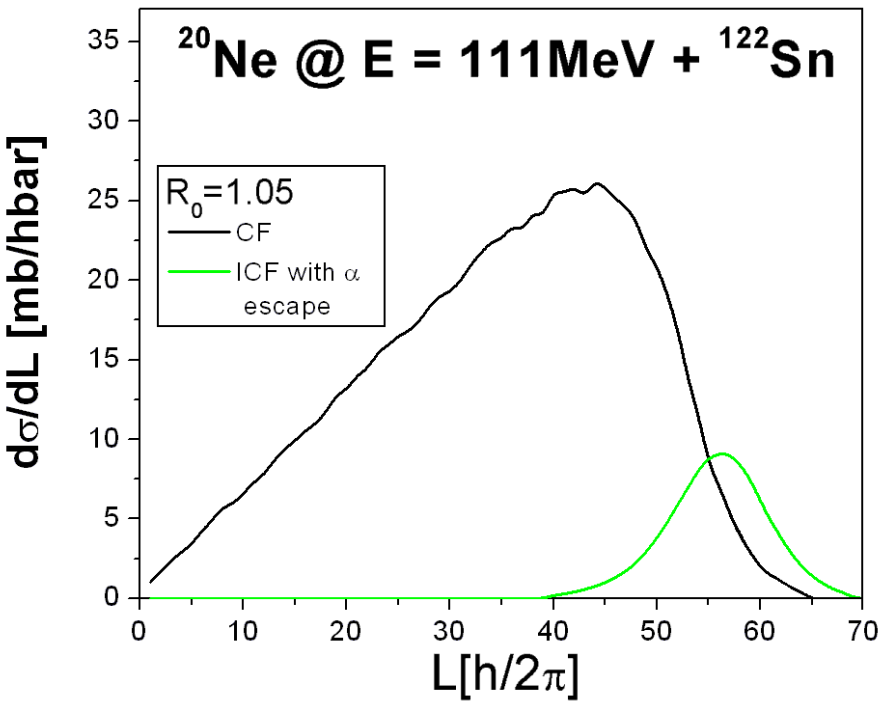
The model also describes creation of the compound nucleus after α particle escape (spin and excitation energy). γ-multiplicity and energy sum measurements allow to check this part of the model.

(**R.M. Lieder et al. submitted to EPJA**)

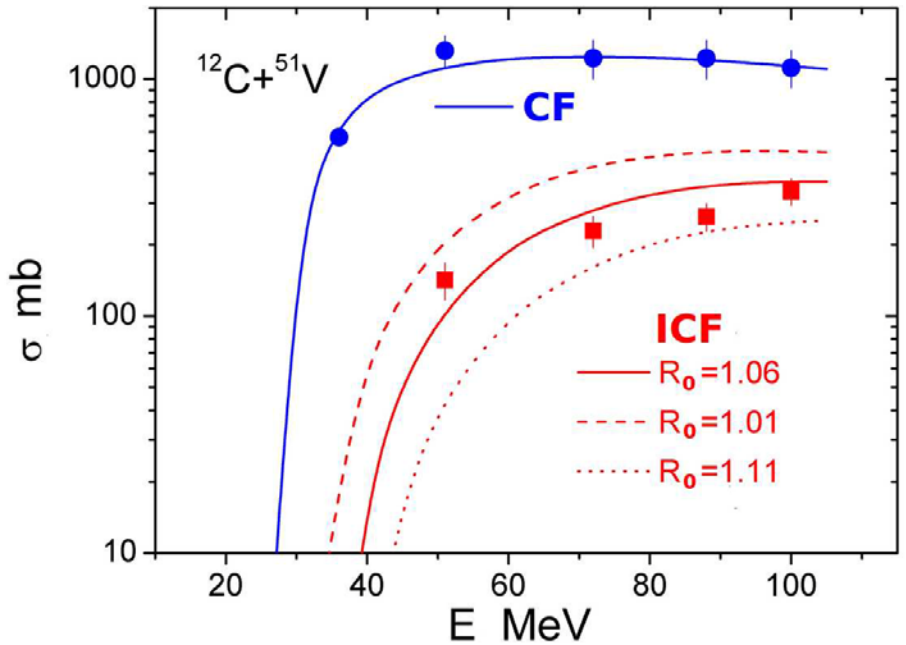
6. Experiment with efficient Ge array, multiplicity filter and (E,ΔE) telescopes is the best way to check the whole model.

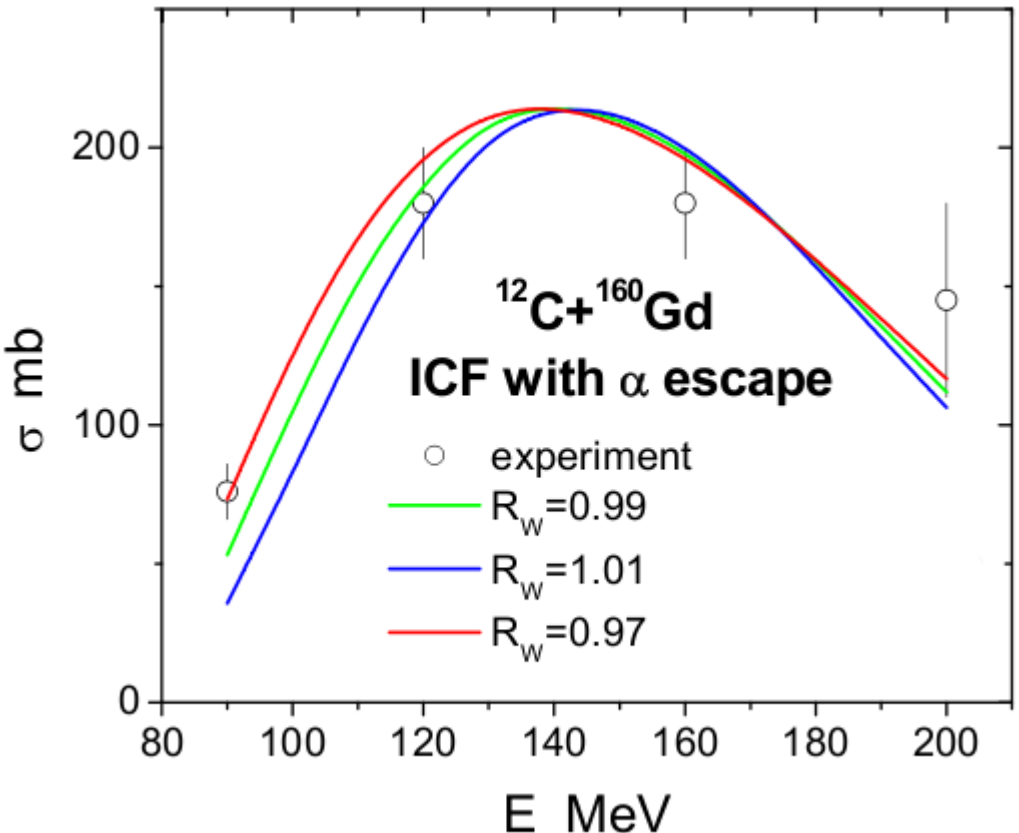
THANK YOU !!!

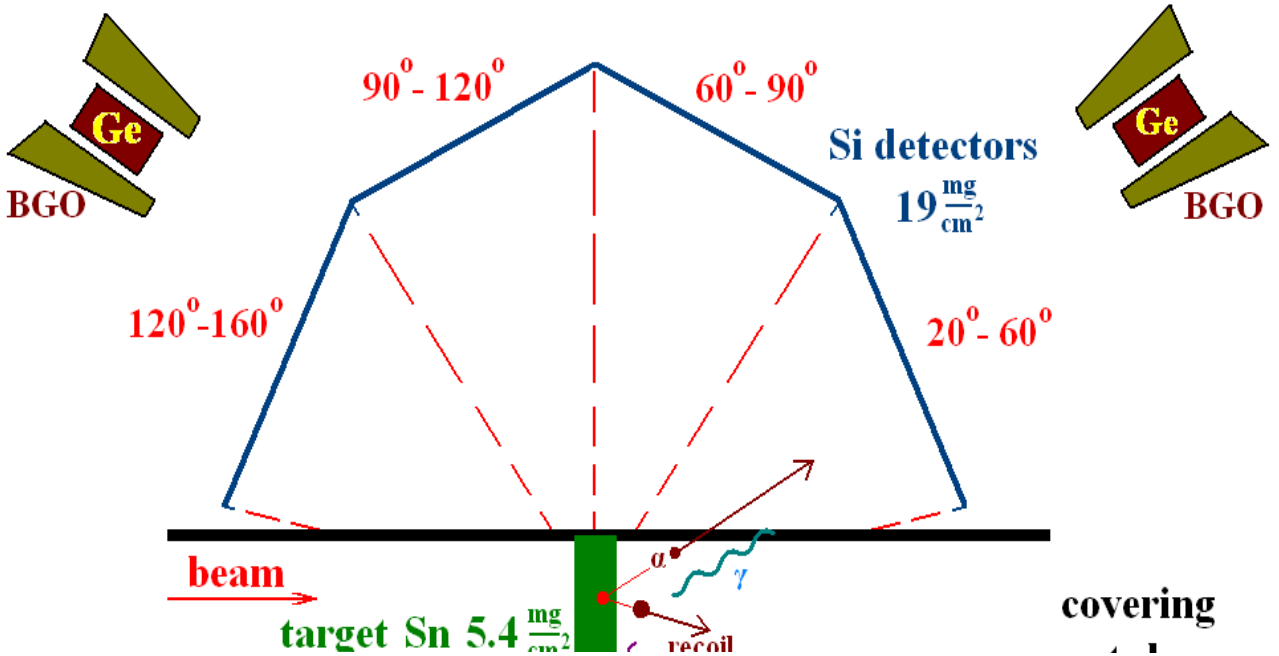




$$\sigma(L) = \pi \lambda^2 T_L(L) \cdot (2L+1)$$







covering

evaporation

α particles at θ = 21°-63°