Electroexcitation of the first $1/2^+$ state in ^{9}Be *

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- Motivation
- Experiments
- Results
- Summary and outlook

* Supported by the DFG within SFB 634

Motivation

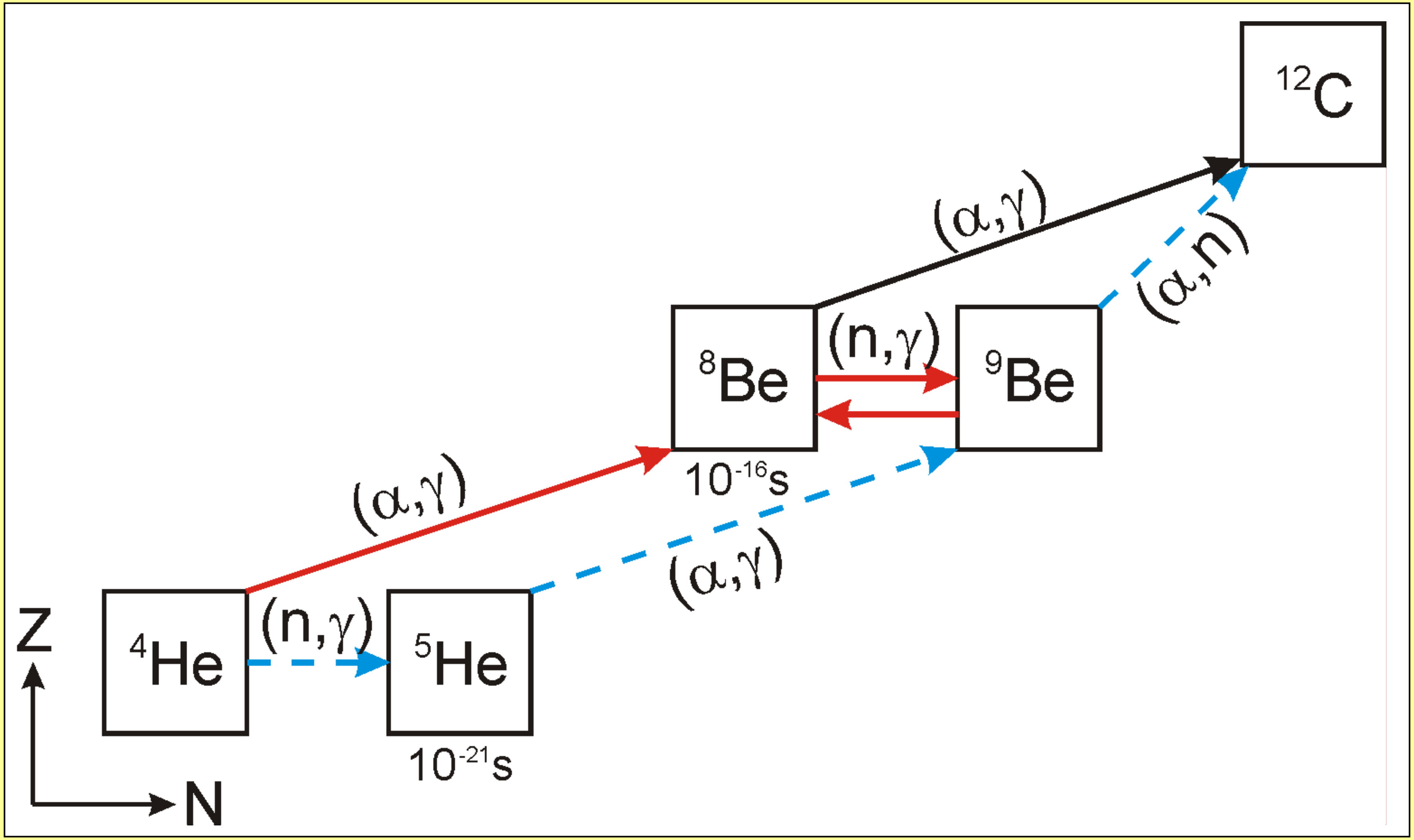
- ^{9}Be is a loosely bound nuclear system consisting of 2α and a neutron

- ^{9}Be has the lowest neutron threshold (S_n= 1.665 MeV) of all stable nuclei

  → first excited state lies some tens of keV above S_n

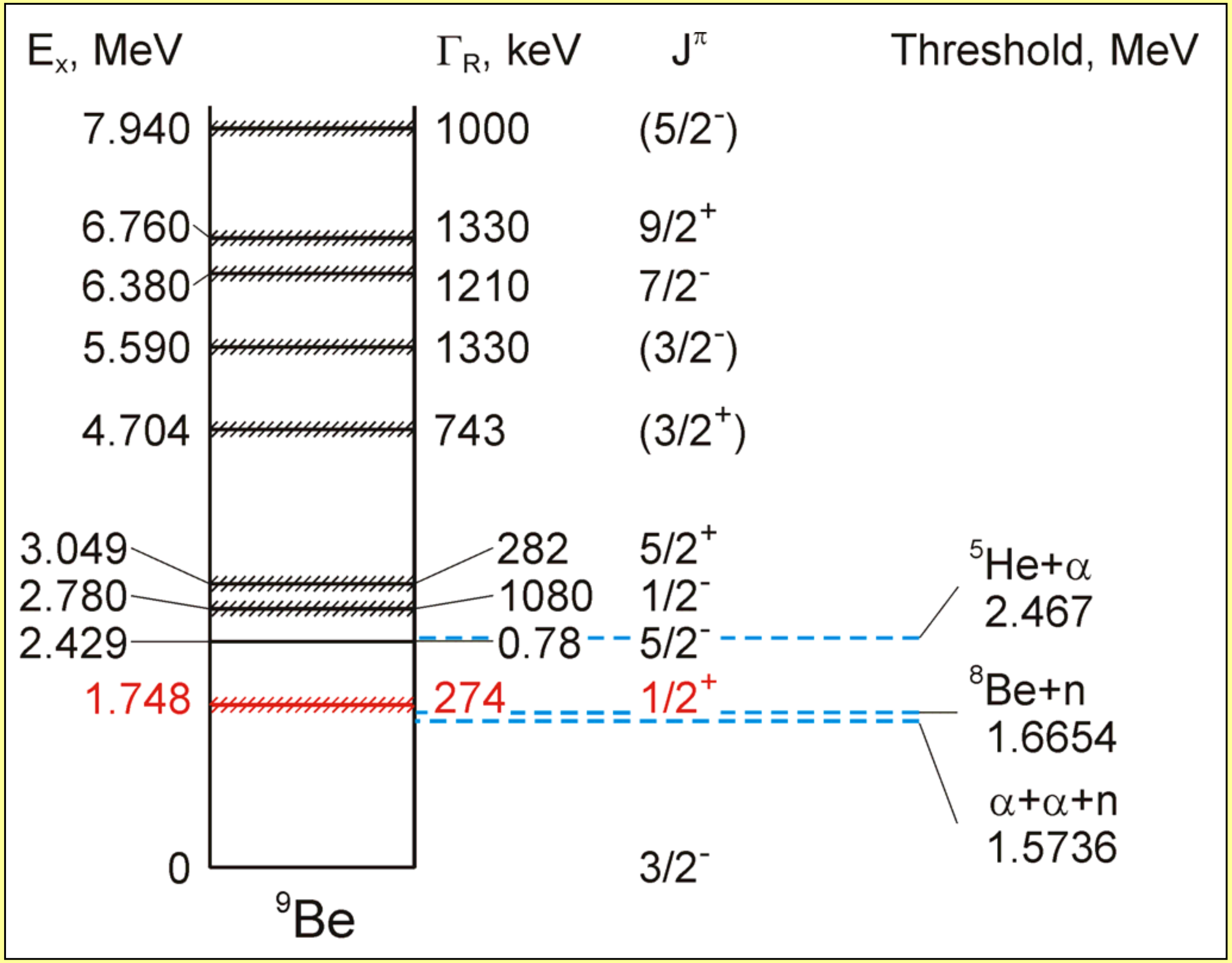
  → all excited states are unstable with respect to neutron decay

Possible role of ^{9}Be in the production of ^{12}C



- In *n*-rich environment (core-collapse supernovae) this reaction path may provide an alternative route for building up the heavy elements and triggering the *r* process

J^{π} = 1/2$^+$ state at threshold



- The photodisintegration cross section at low energies is given by the properties of 1/2$^+$ resonance
- Strongly asymmetric line shape

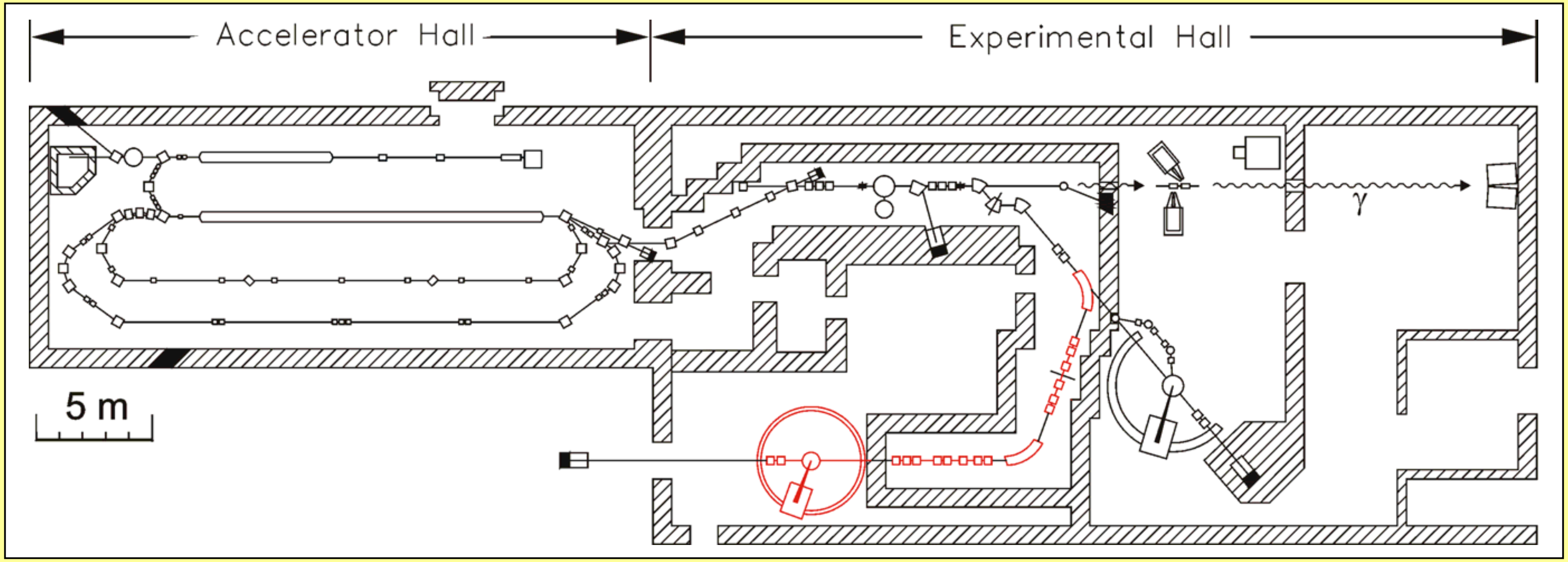
Parameters of the first $J^\pi = 1/2^+$ state in ^{9}Be

	(γ, n) [1]	(e,e′) [2]	(e,e′) [3]	Reanalysis of [2] by Barker [4]
E_R, MeV	1.75(1)	1.684(7)	1.68(15)	1.7316
Γ_R, keV	283(42)	217(10)	200(20)	280
$B(E1)\uparrow$, e^2fm^2	0.0535(35)	0.027(2)	0.034(3)	0.0685

[1] H. Utsunomiya et al., Phys. Rev. C63 (2001) 018801
[2] G. Küchler et al., Z. Phys. A326 (1987) 447
[3] J. P. Glickman et al., Phys. Rev. C43 (1991) 1740
[4] F. C. Barker, Aust. J. Phys. 53 (2000) 247

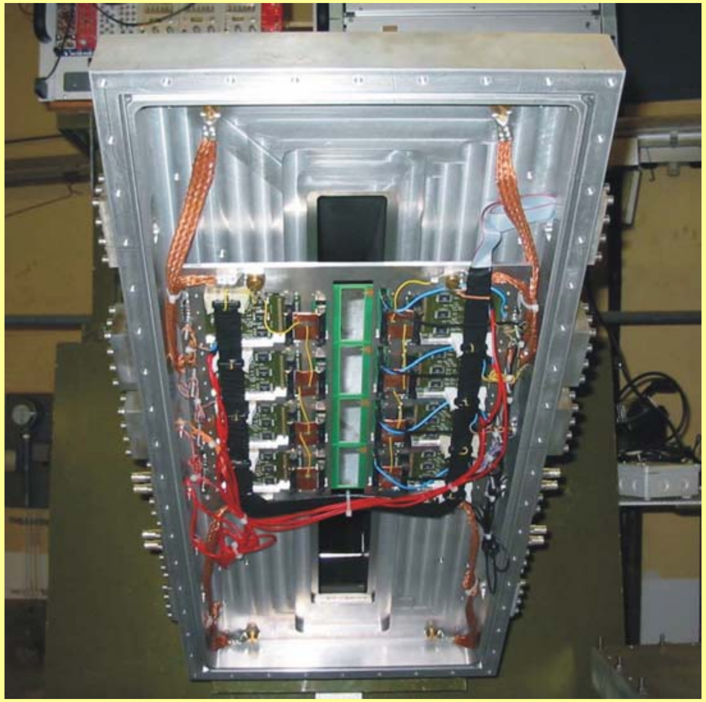
- Resonance parameters from different experiments and analysis are not in mutual agreement

S-DALINAC and its Experimental Facilities



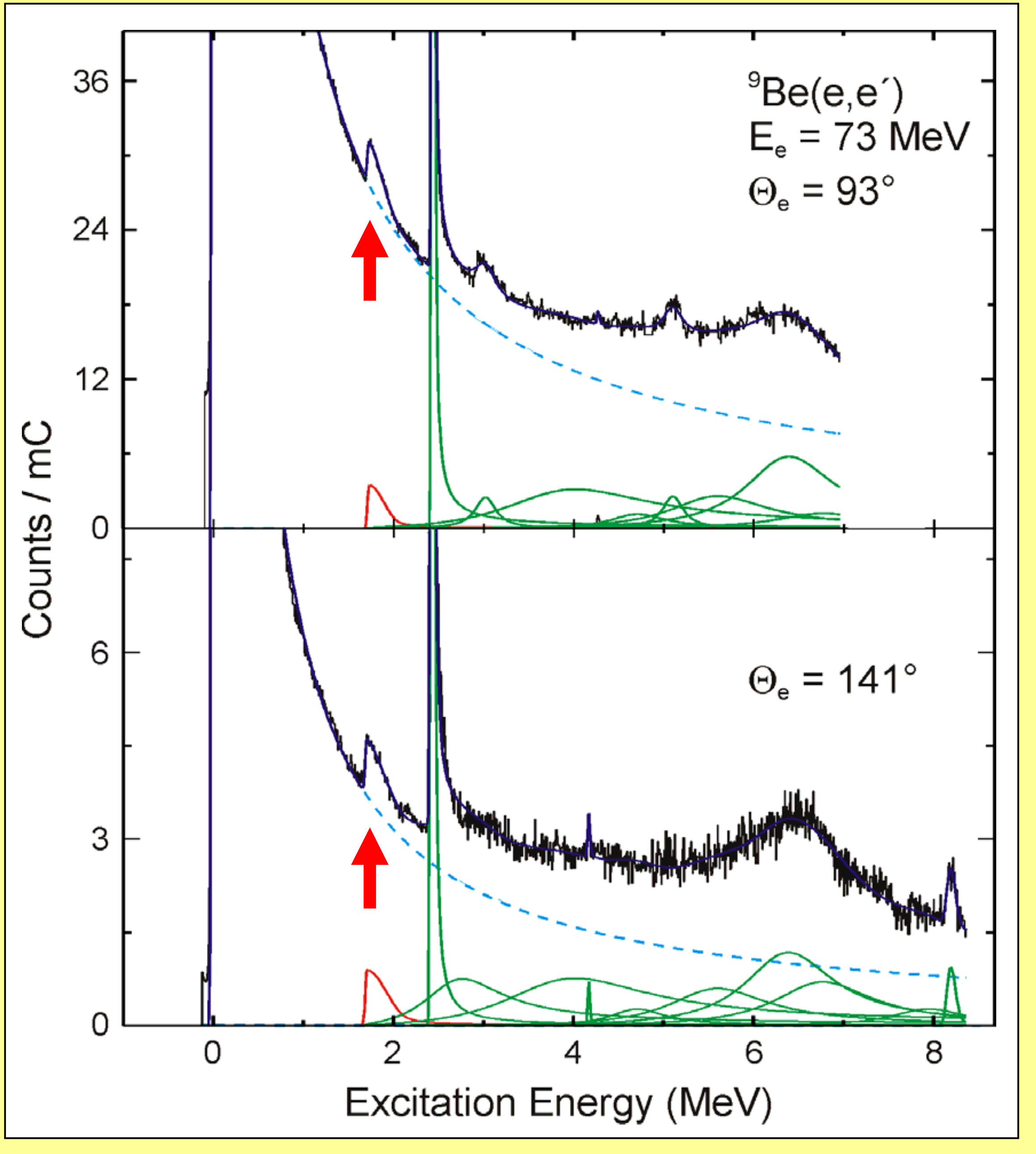
- High-resolution (e,e´) experiments at 169° spectrometer

169° Spectrometer and Focal Plane Detector System

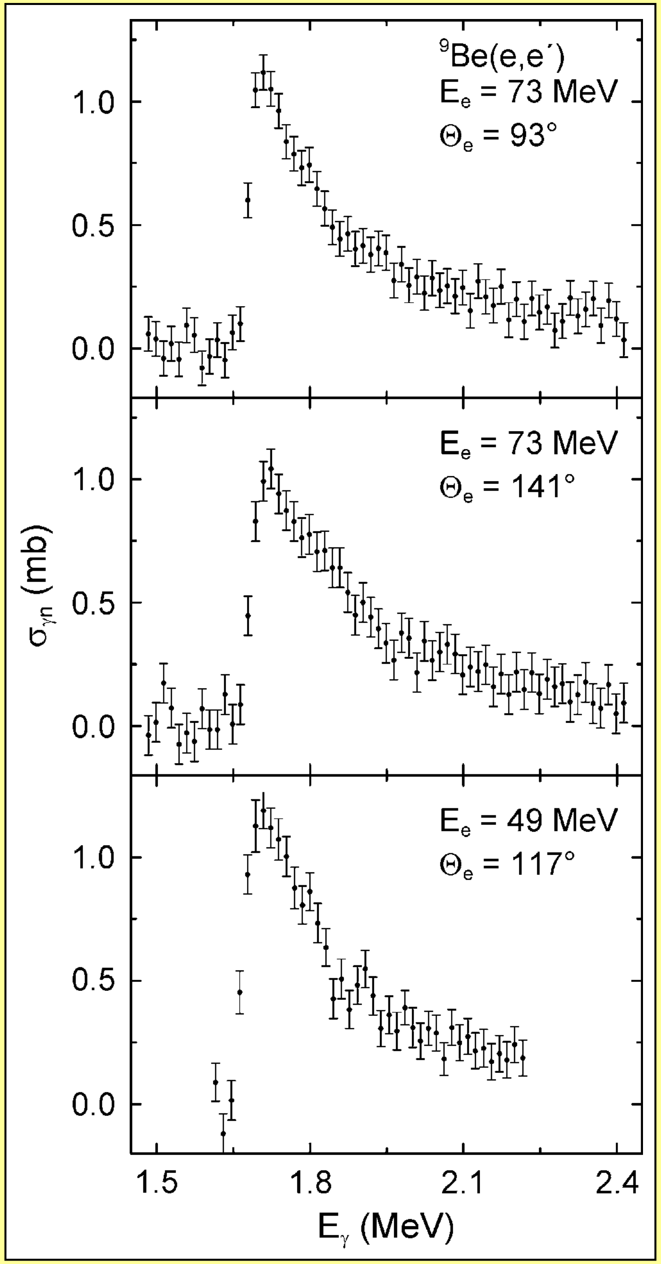


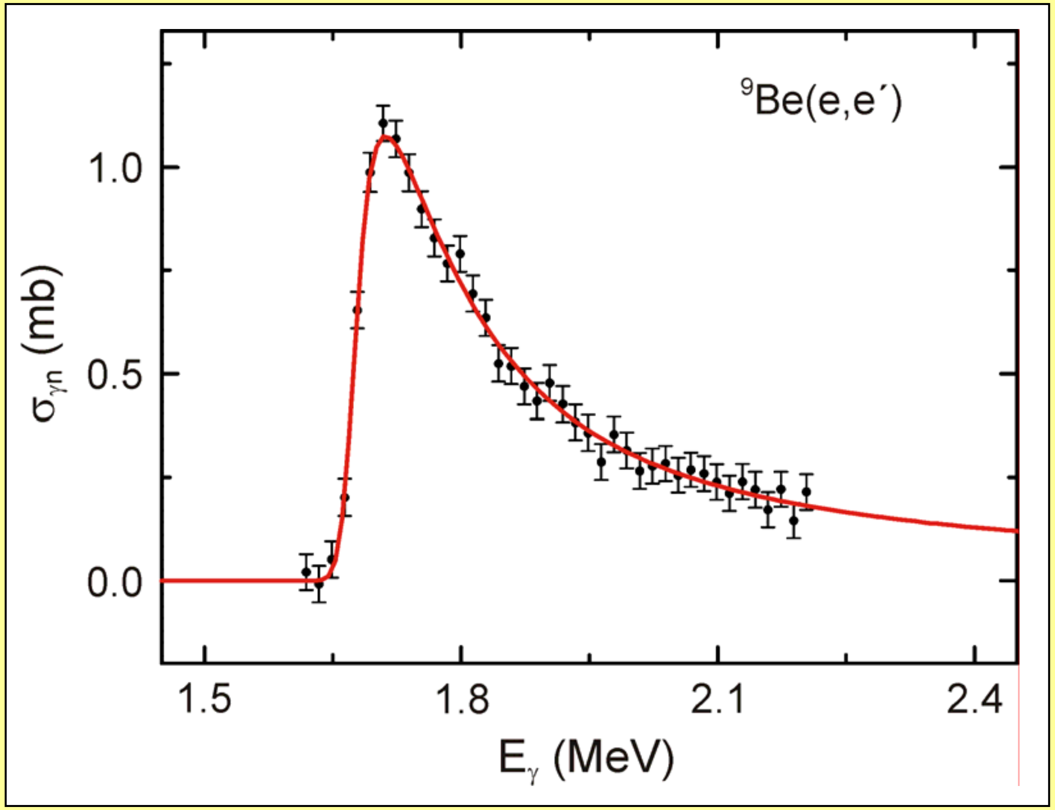
- Si microstrip detector system: 4 modules, each 96 strips with pitch of 650 μm
- Count rate up to 100 kHz
- High spatial resolution 1.5×10^{-4}

Deconvolution of the spectrum



$^9Be(\gamma,n)$ extracted from $^9Be(e,e')$

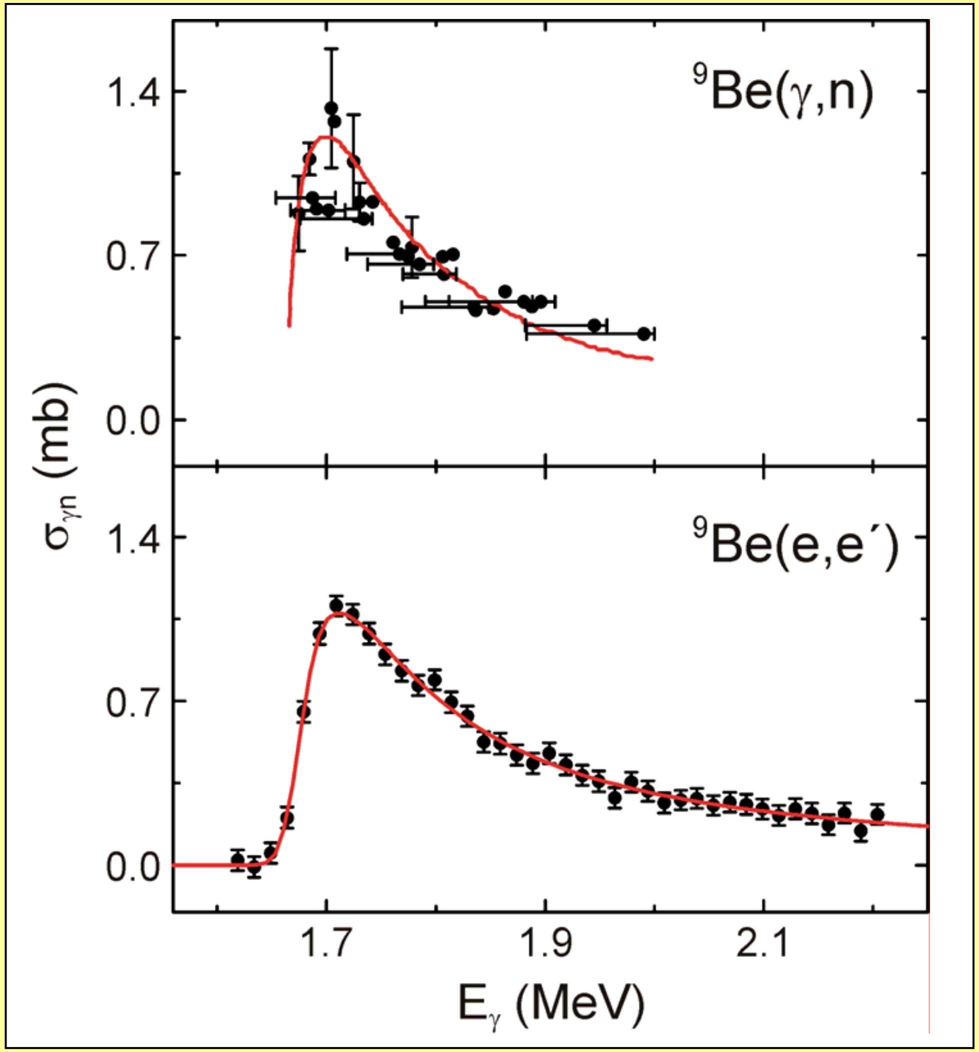




E_R = 1.737(10) MeV

Γ_R = 275(14) keV

Comparison: ^{9}Be(γ,n) and ^{9}Be(e,e´)



H. Utsonomiya et al.,
PRC 63, 018801

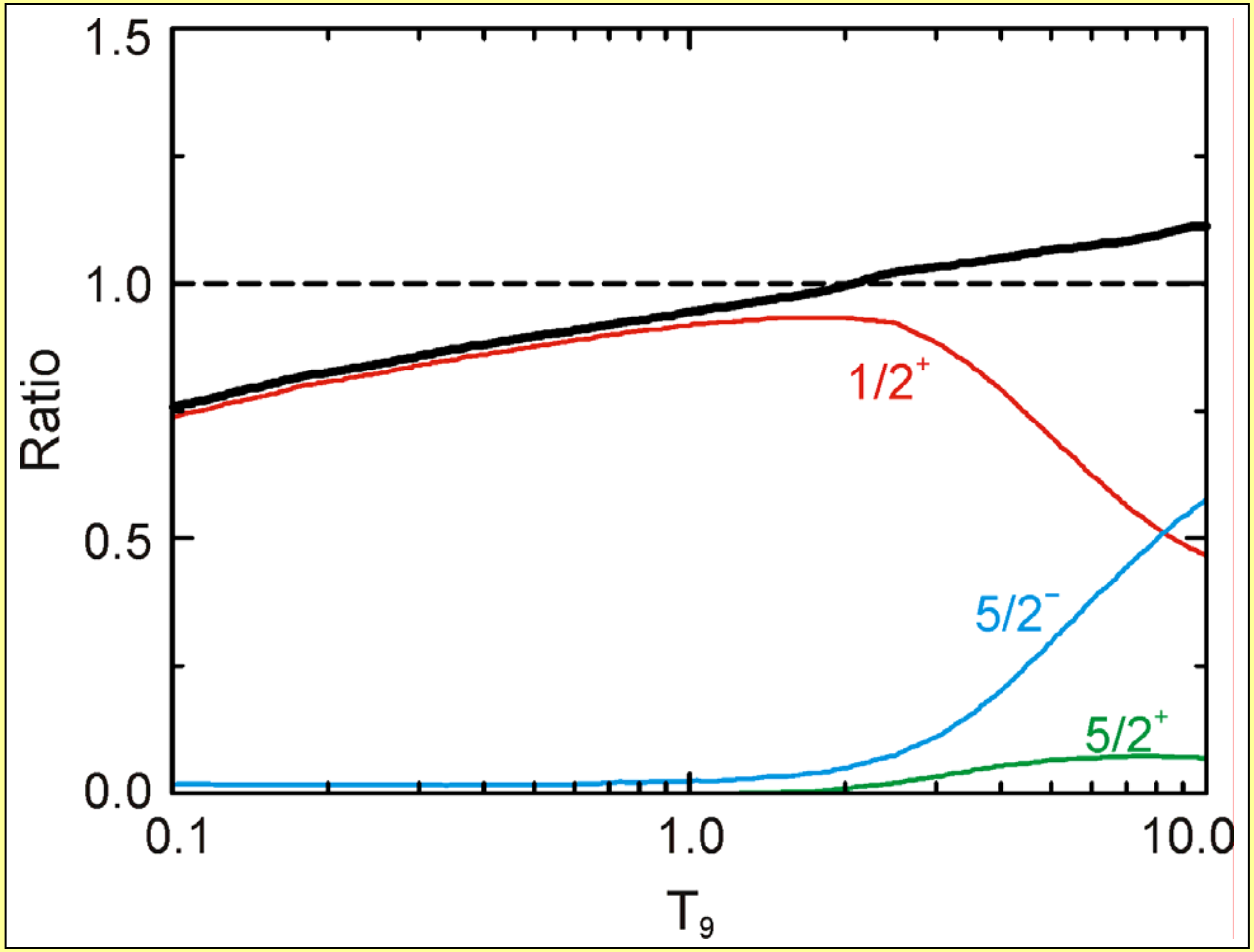
E_R = 1.75(1) MeV
Γ_R = 283(42) keV

Present

E_R = 1.737(10) MeV
Γ_R = 275(14) keV

- Resonance parameters agree well

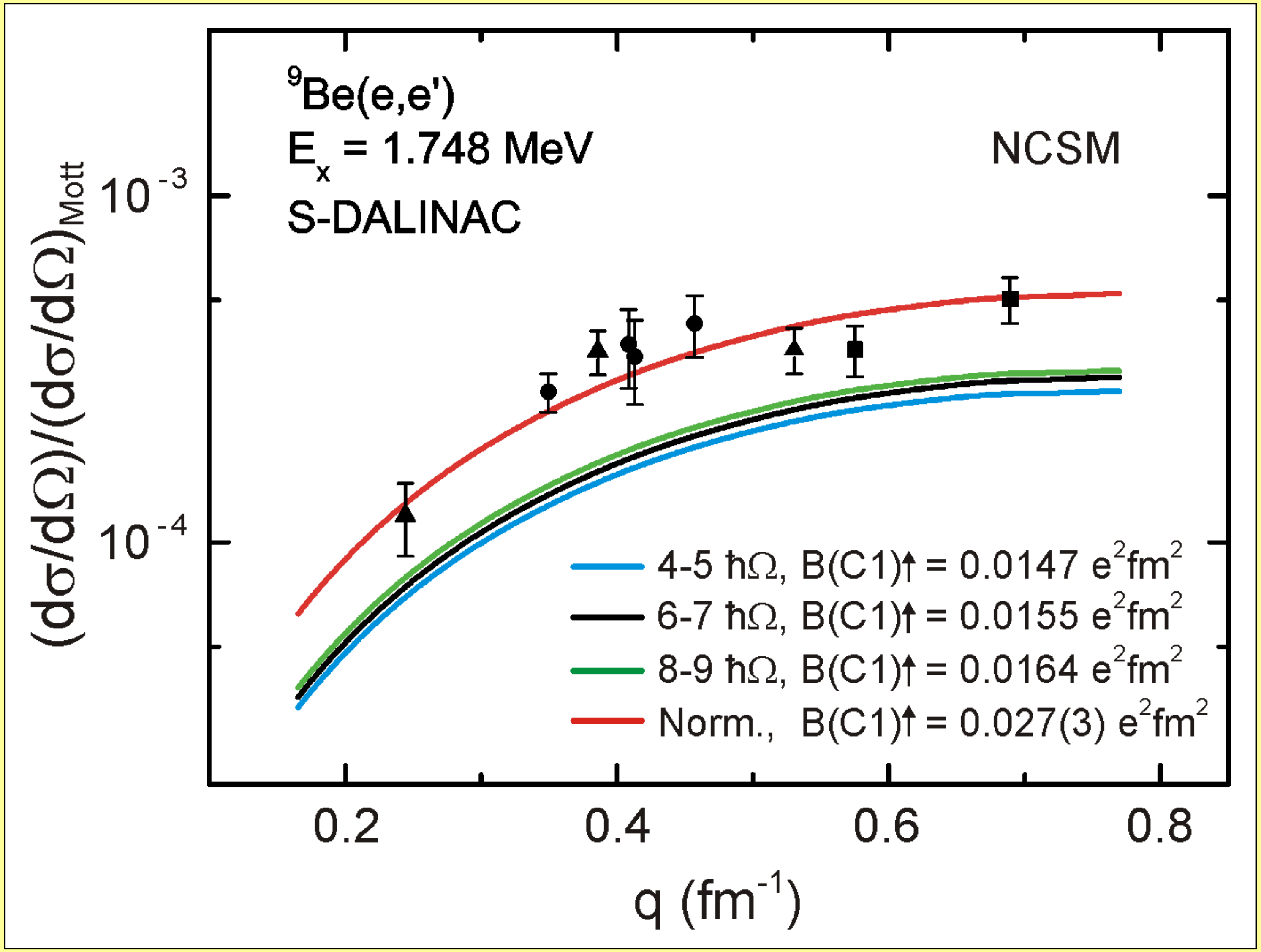
Reaction rate of $\alpha\alpha n \rightarrow {}^{9}Be$



1999 compilation:
C. Angulo et al.,
NPA 656 (1999) 3

- Deviation ranges from -25% to +11% from adopted values
- For T_9 = 0.1 – 3 the $1/2^+$ resonance determines exclusively ${}^{4}He(\alpha,\gamma){}^{8}Be(n,\gamma){}^{9}Be$ chain

Form factor of the $J^{\pi} = 1/2^{+}$ state



- NCSM: correct *q* dependence but difference in magnitude compared to the data (C. Forssén)

B(E1,k) strength

Siegert´s theorem: $B(E1,q) = (k/q)^2\, B(C1,q)$

at photon point $(q = k = E_x/\hbar c)$ $B(E1,k) = B(C1,k)$

(e,e´) $B(C1,k) = 0.027(3)\ e^2fm^2 = B(E1,k)$

(γ,n) $B(E1,k) = 0.0535(35)\ e^2fm^2$

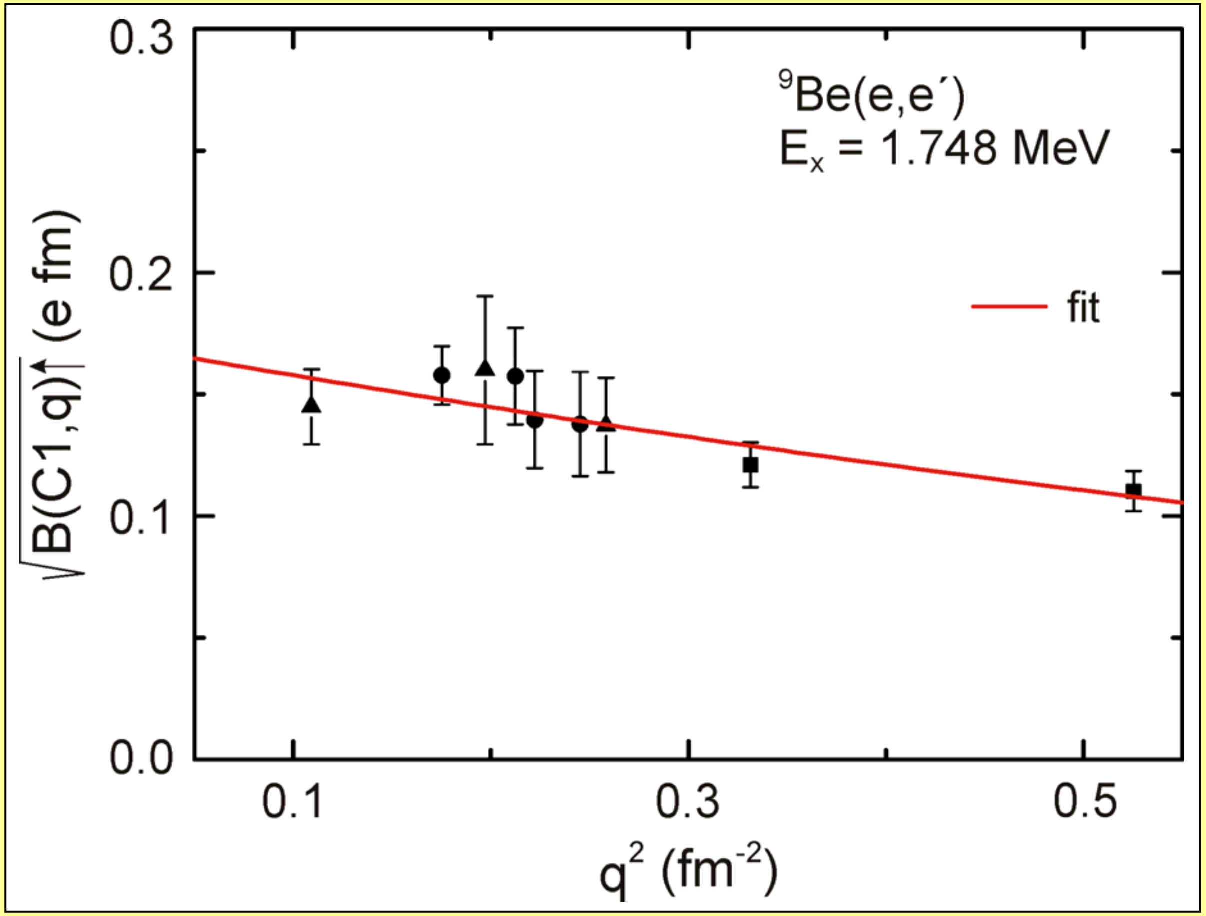
- $B(C1) \neq B(E1)$ at photon point $k = q \rightarrow$ violation of Siegert´s theorem ?

Summary and outlook

- Final values of line shape parameters of $J^{\pi} = 1/2^{+}$ resonance:
  $E_R = 1.748(6)$ MeV and $\Gamma_R = 274(8)$ keV
- B(*C*1) ≠ B(*E*1) at photon point $k = q$
  → violation of Siegert´s theorem ?
- Theoretical calculations in NCSM and FMD
- E1 operator needs to be renormalized → effective charges
- Investigate also the transverse E1 response to search for possible sources of the violation of Siegert´s theorem

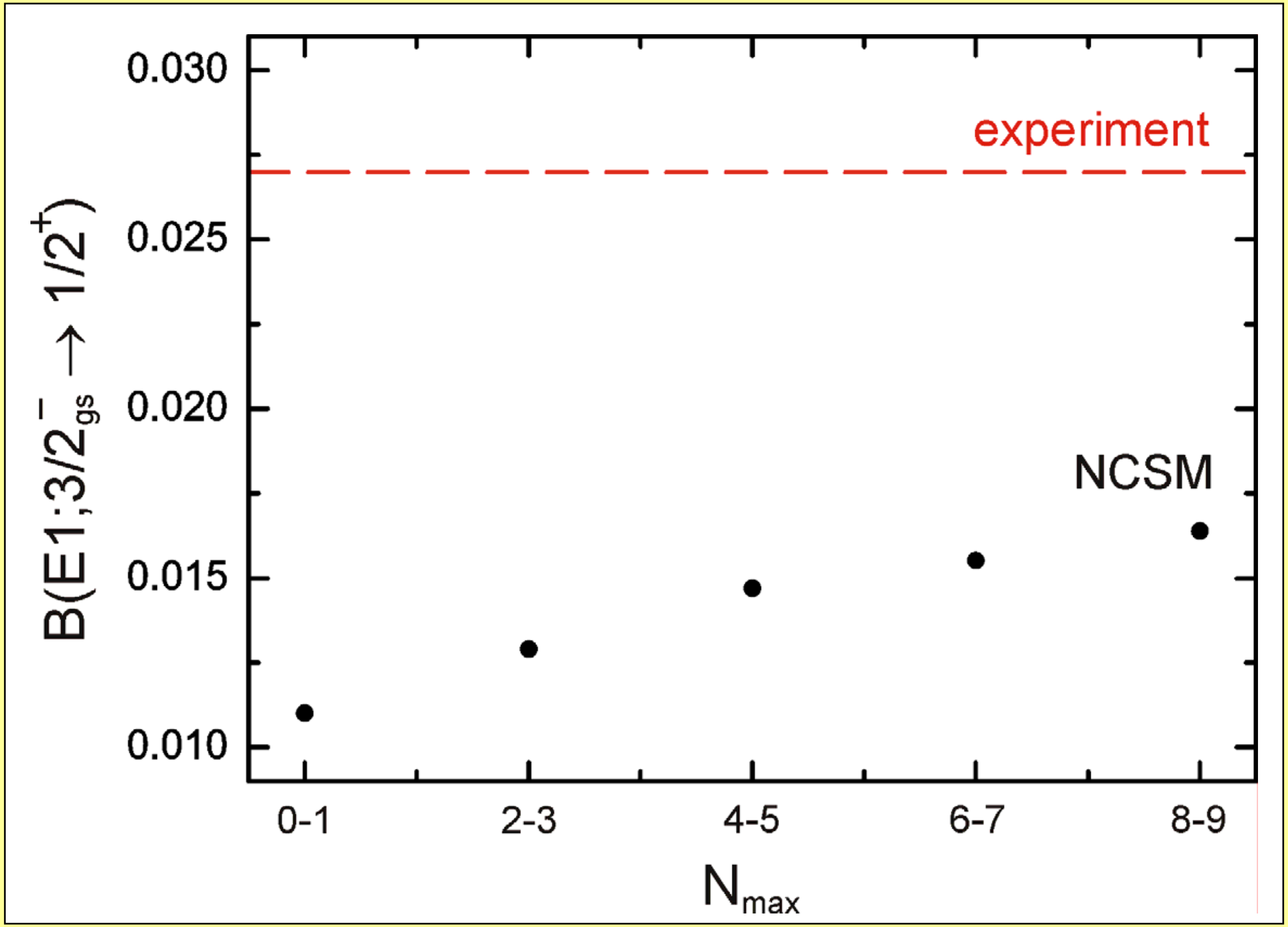
PWBA model independent analysis: B(C1,k)

$$\sqrt{B(C1,q)} = \sqrt{B(C1,0)}\left(1 - q^2\frac{R_{tr}^2}{10} + q^4\frac{R_{tr}^4}{280} - \ldots\right)$$

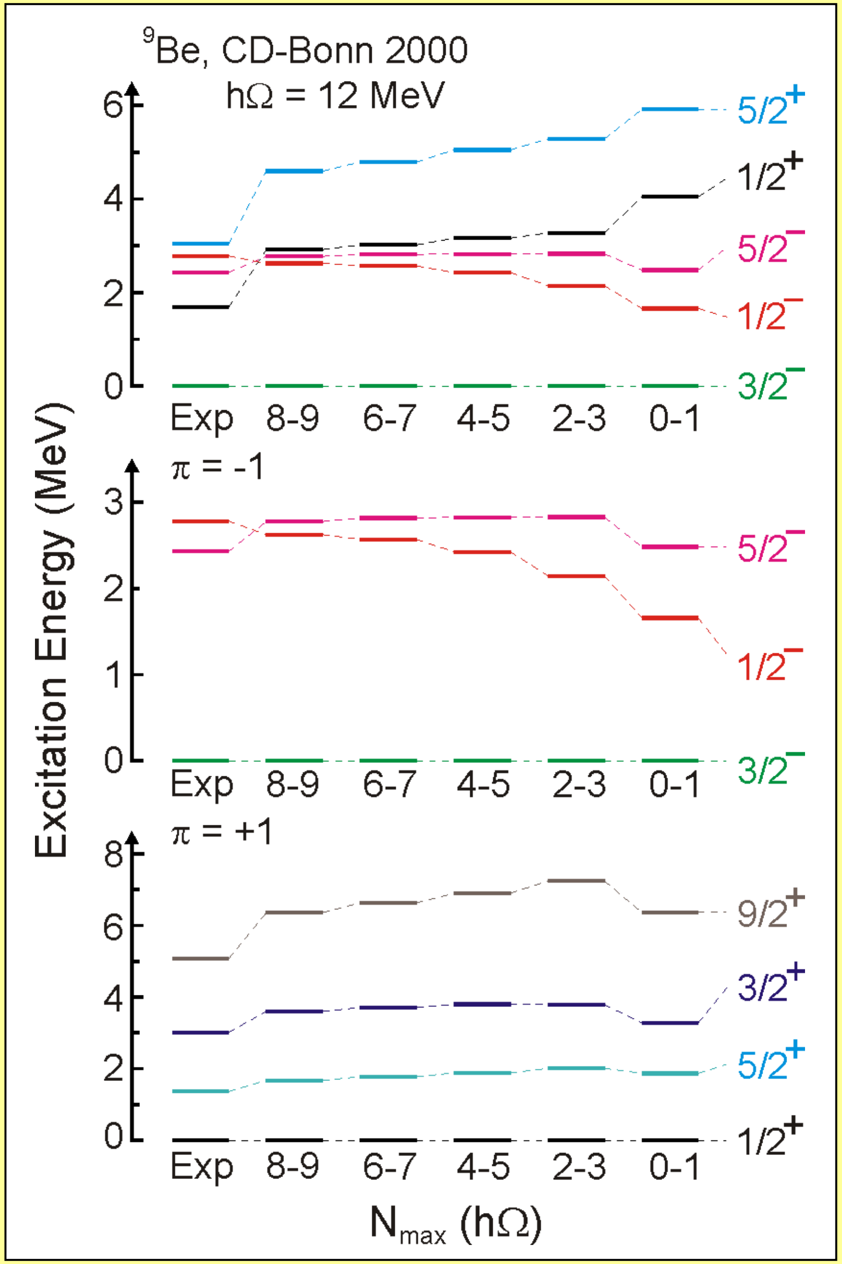


B(C1,k = E_x/hc) = 0.027(4) e^2fm^2

Convergence behavior of NCSM results



Convergence behavior of NCSM results



Radial transition densities from NCSM