The ^{11}Be and the evolution of the shell structure

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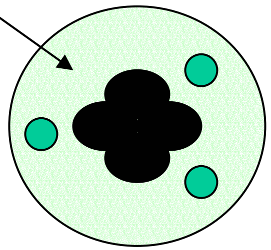
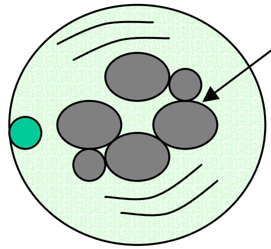
ECT* Trento, 30 Oct -3 Nov 2006

What exactly?

Stiff core



An important part of the phase space is represented by



Softer core

- N = 1 → ^{7}He
- N = 2 → ^{11}Be
- N = 3 → ^{15}C
- N = 4 → ^{19}O
- N = 5 → ^{23}Ne
- N = 6 → ^{27}Mg
- …

studied via (^{7}Li,^{7}Be) reaction

BSEC

(Bound States Embedded in the Continuum)

↓

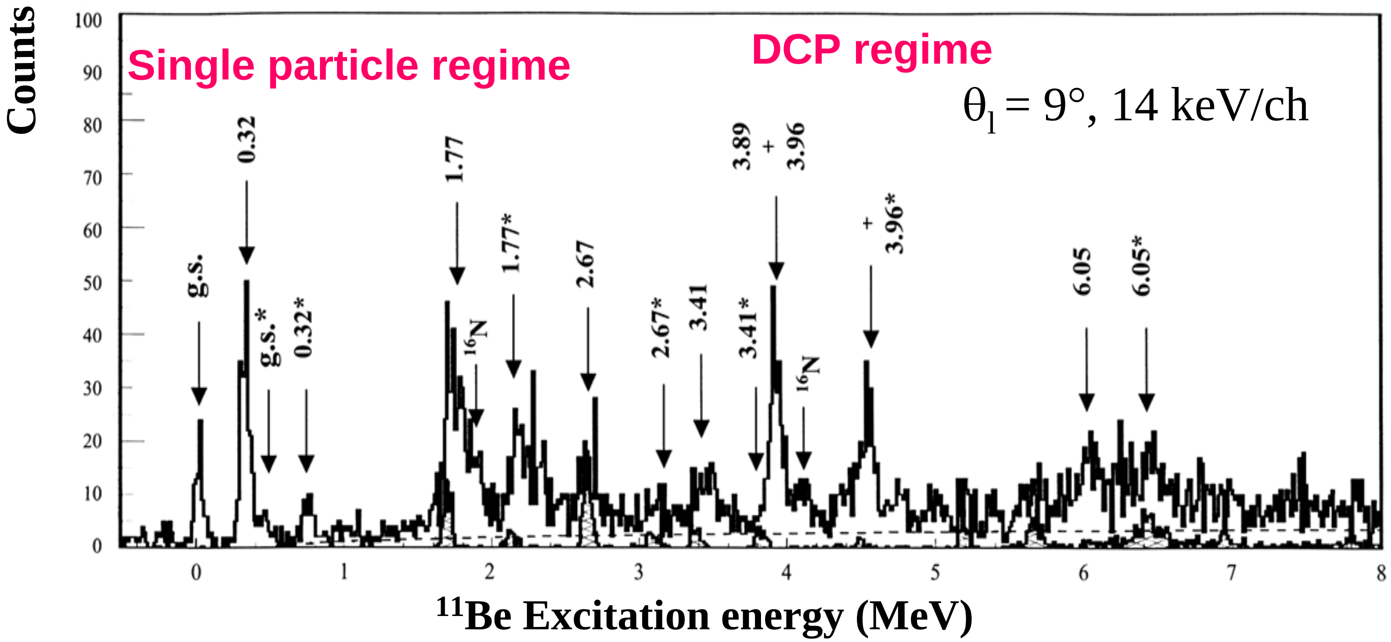
DCP

(Dynamical Core Polarization)

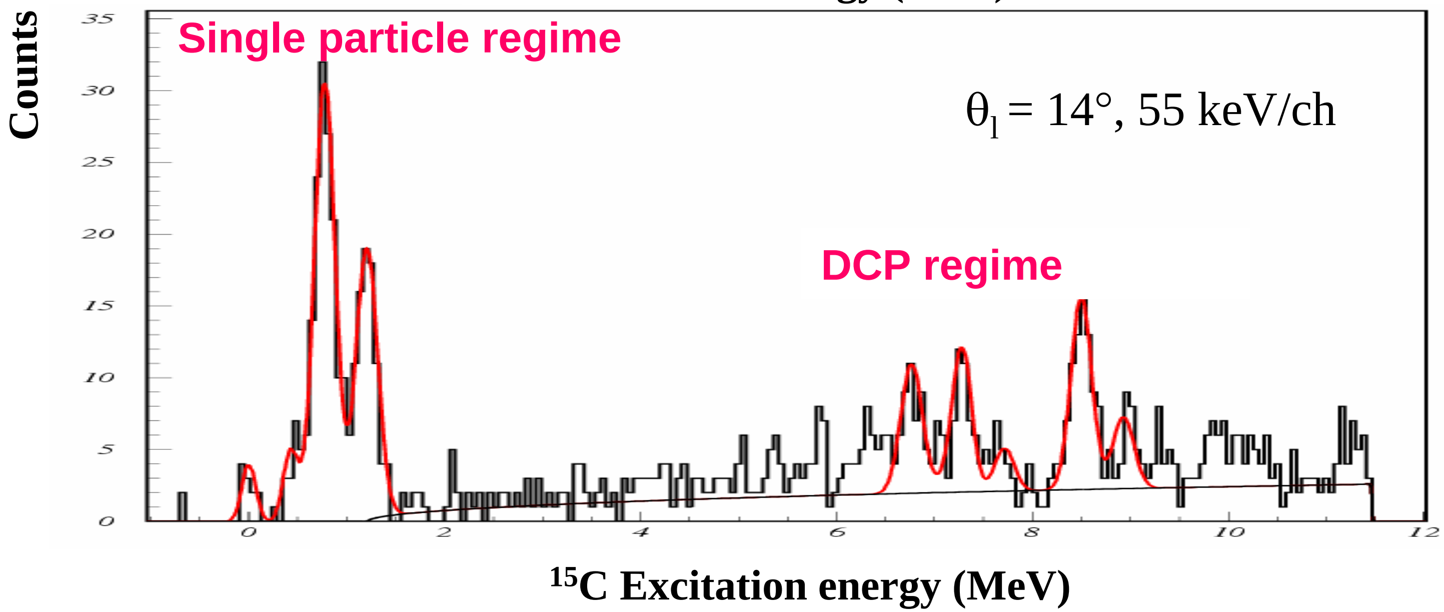
Examples:

^{7}Be detected with the IPN-Orsay Split Pole

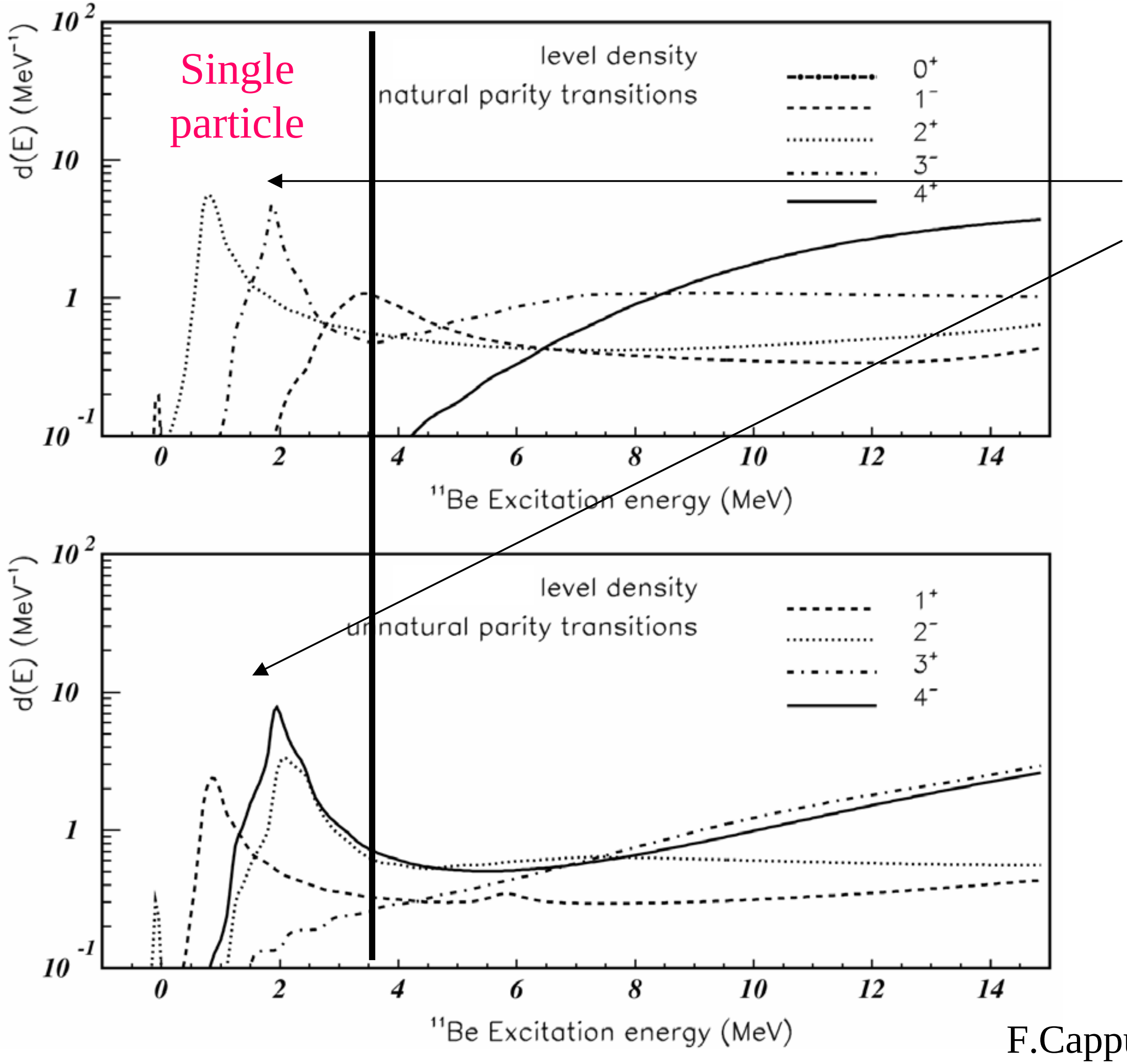
$^{11}B(^{7}Li,^{7}Be)^{11}Be$
at 57 MeV



$^{15}N(^{7}Li,^{7}Be)^{15}C$
at 55 MeV



Results of QRPA calculations



^{11}Be strength well reproduced for single particle transitions,

namely $1/2^+$ g.s. , $1/2^-$ excited state at 0.32 MeV and $5/2^+$ state at 1.77 MeV of ^{11}Be

The observed fragmentation beyond 2 MeV is **not reproduced**

F.Cappuzzello et al., *Phys. Lett. B 516(2001)21*

Nuclear structure model

Quasiparticle-core coupling model (QPC) (Bohr & Mottelson)

$$H = H_{11} + V_{22} + V_{13}$$

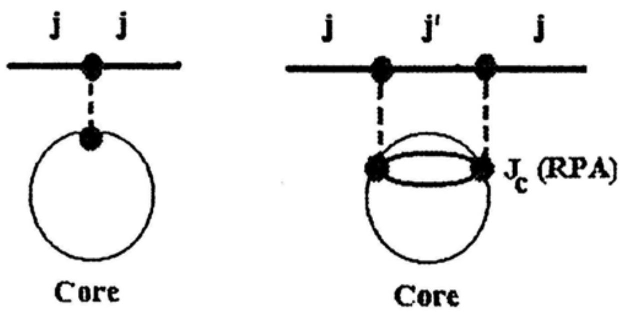
eff. Hamiltonian of the odd-mass system

Odd-mass system w. f. :

$$\left| jm,\lambda \right\rangle = \sum_n z_{nlj}(\lambda) \left| nlj \right\rangle + \sum_{j'J_C} z_{j'J_C}(\lambda) \left| (j'J_C)j \right\rangle$$

s.p. *mixing* **1*qp*** **3*qp***

V_{13} couples



state-dependent mass operator

Quasiparticle-RPA approach:

$$\left| nlj \right\rangle = \alpha^+_{jm} \left| 0 \right\rangle$$

where $\left| 0 \right\rangle$ is the g.s. correlated of the **even-mass core** and

$$\alpha^+_{jm} = u_j a^+_{jm} - (-1)^{j+m} \mathrm{v}_j a_{j-m}$$

by *Bogolyubov-Valatin transformation*

with $\mathrm{v}_j^2 + u_j^2 = 1$

H. Lenske, *Progr. in Part. and Nucl. Phys.* A693(2001)616

Nuclear structure calculations

Calculation of s.p. strength distributions of the odd-mass nucleus :

1. **Shell-model calculation**
   - s.p.energies and wave functions for *p* and *n*
   - (WS potential + HFB)
   - E = 100 MeV (L_{max}= 4), R = 35 fm

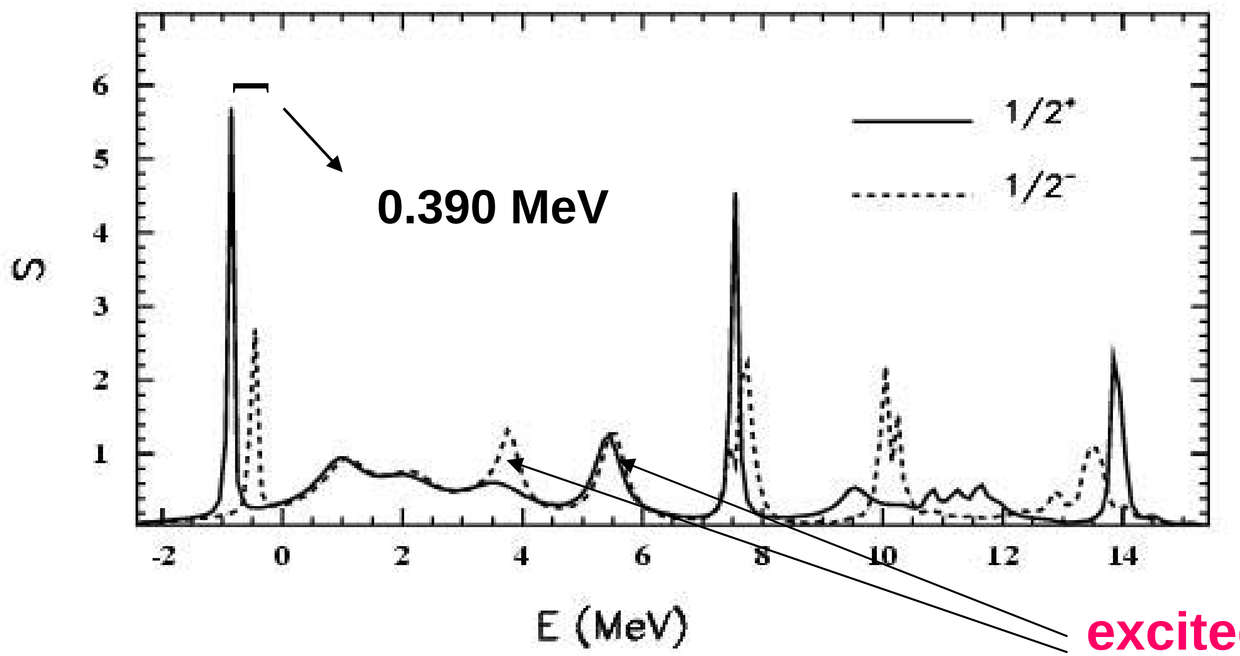
2. **QRPA on the even-mass core**
   - particle state probabilities for *p* and *n*
   - natural and unnatural parity states calculated up to E_x = 35 MeV

3. **DCP calculations**
   - RPA-Green function method
   - 1*qp* : contribution of 'major' shells up to 18 MeV
   - 3*qp* : QRPA Ex ≤ 20 MeV
   - state-dependent pairing, D3Y-G matrix inter.

2. and 3. with the same microscopic interaction

Results of DCP calculations

$s_{1/2}$ and $p_{1/2}$ strength distributions of ^{11}Be



g.s. configuration:

$s_{1/2} \otimes {}^{10}Be(0^+) \quad C^2S = 0.79$

$\boldsymbol{d_{5/2,3/2} \otimes {}^{10}Be(2^+)}$: 18%

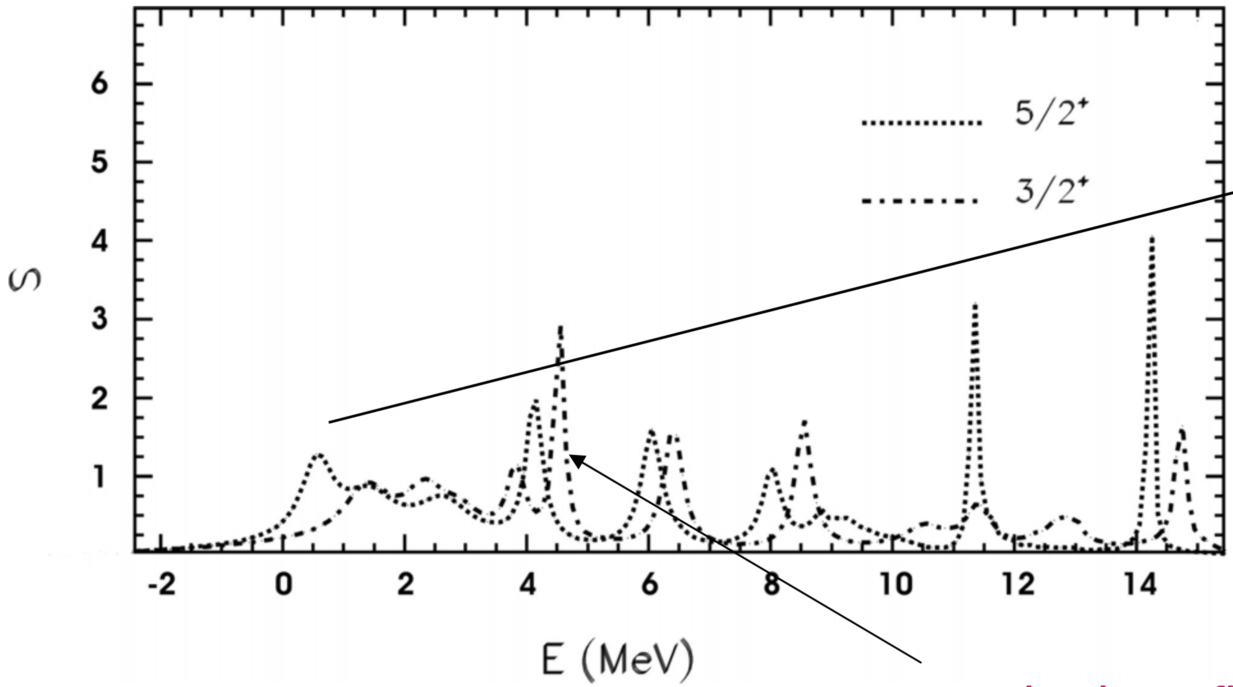
excited configuration: dominance of 2^+ core excitations

Strong fragmentation of the strength appears at 4< E_x <15 MeV

C. Nociforo et al., *Eur. Phys. J.*A27 (2006)287

Results of DCP calculations

$d_{5/2}$ and $d_{3/2}$ strength distributions of ^{11}Be



1.438 MeV configuration:

$$d_{5/2} \otimes {}^{10}Be(0^+) \quad C^2 S = 0.99$$

excited configuration: $s_{1/2} \otimes {}^{10}Be(2^+)$
dominance of core excitations 2^+

Conclusions

- Exploration of excited states of light neutron-rich nuclei like ^{11}Be is a rich source of information about nuclear structure

- High energy resolution is crucial to that purpose

- Use of refined microscopic theories is also fundamental

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