Impact Of The First-forbidden Beta Decay On The Production Of The A~195 r-process Peak

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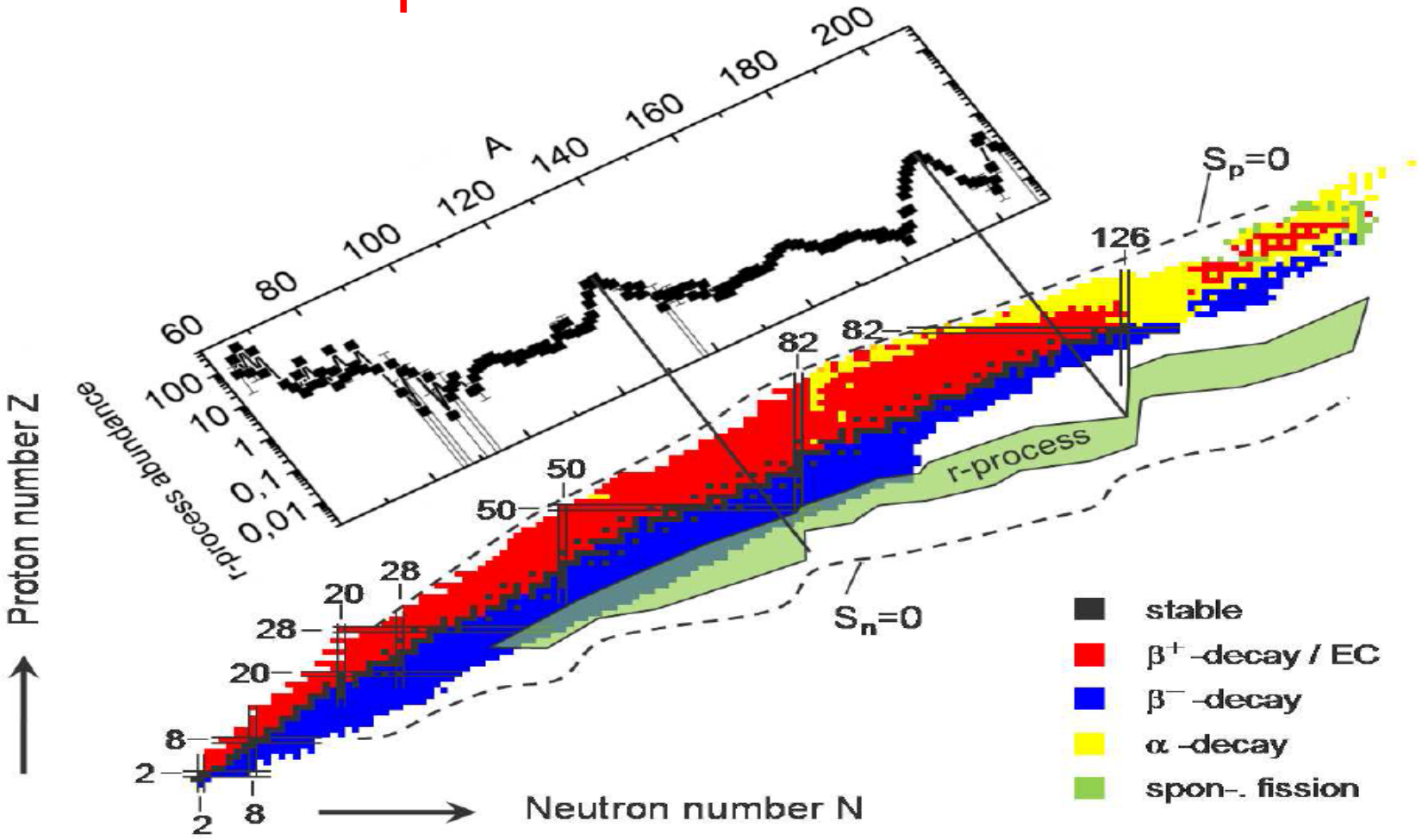
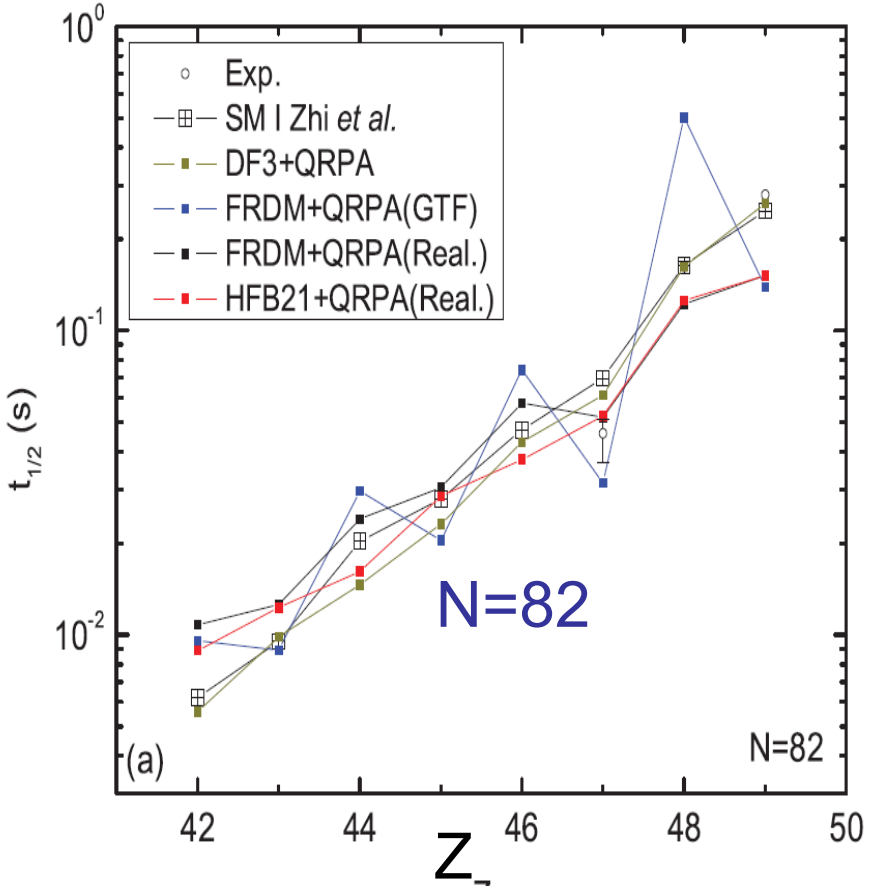
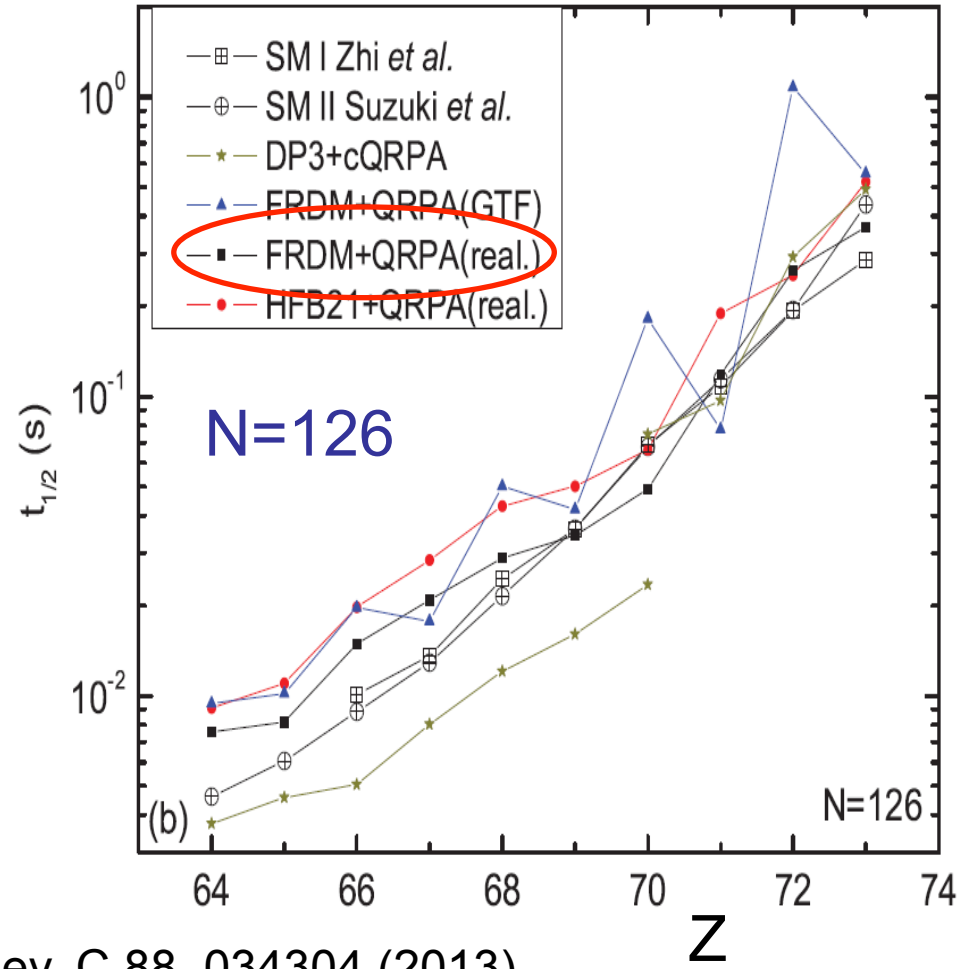
The r process and neutron-rich nuclei



Halflives





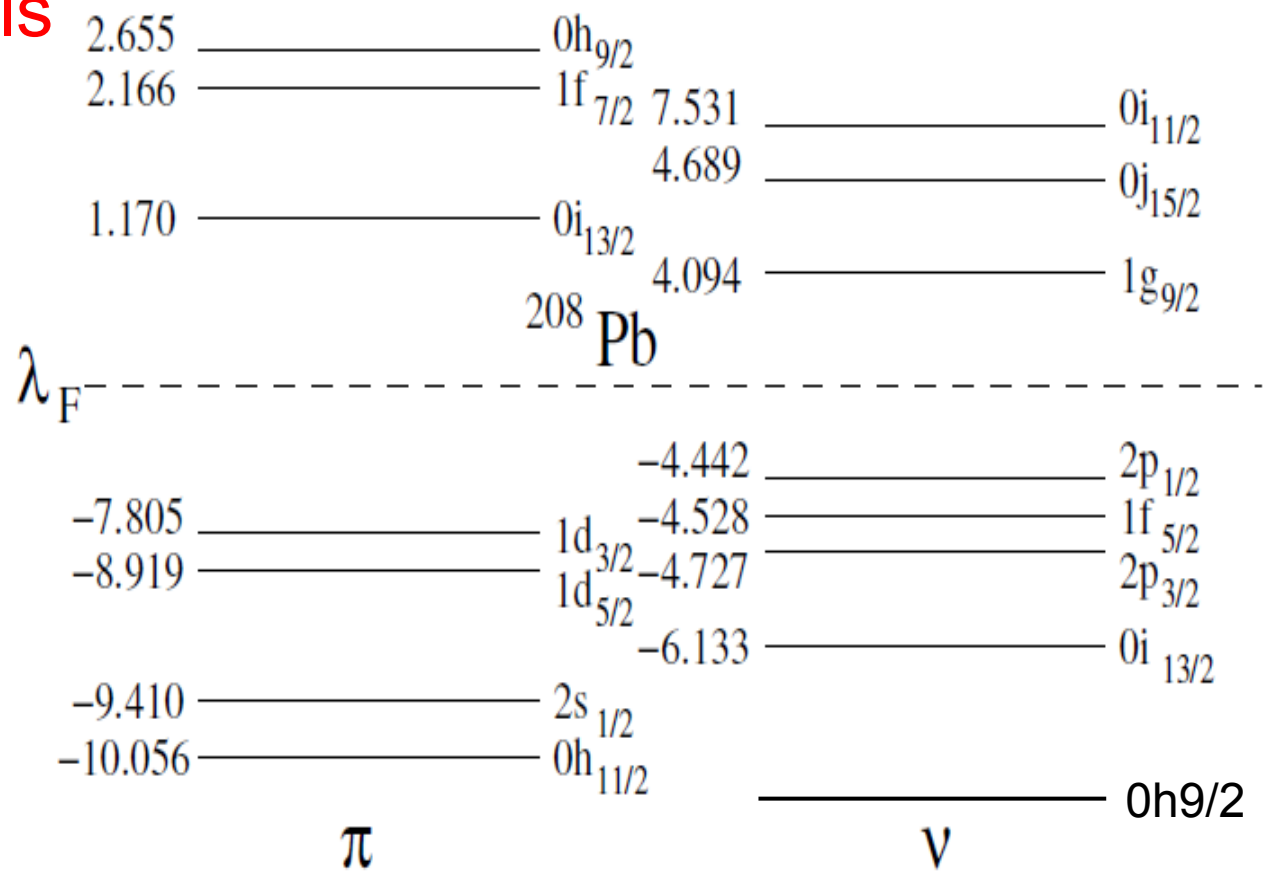
D.-L. Fang, B.A. Brown, T. Suzuki, Phys. Rev. C 88, 034304 (2013)

Shell model orbitals

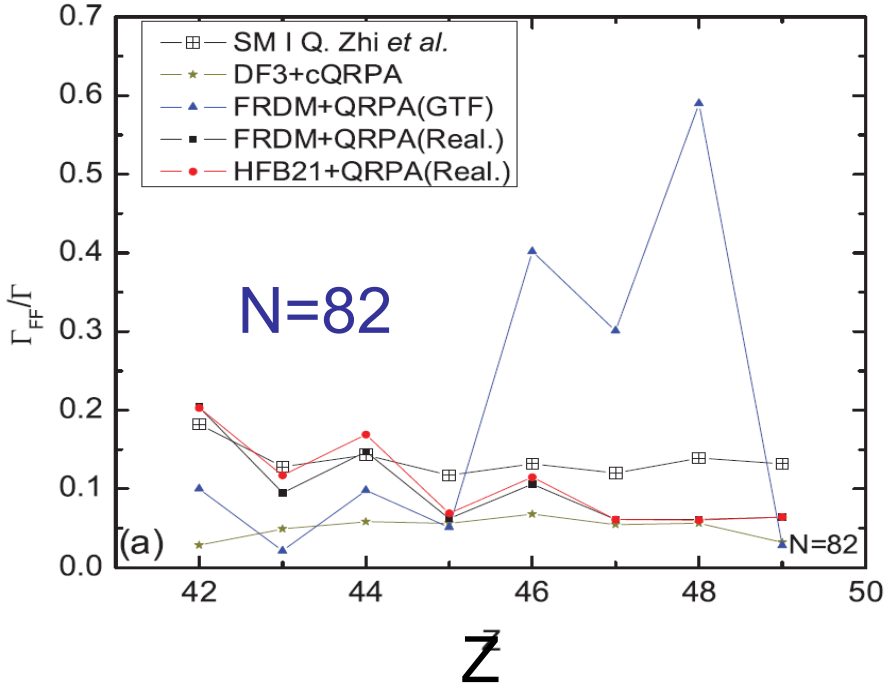
Allowed GT:
νh9/2 -> πh11/2

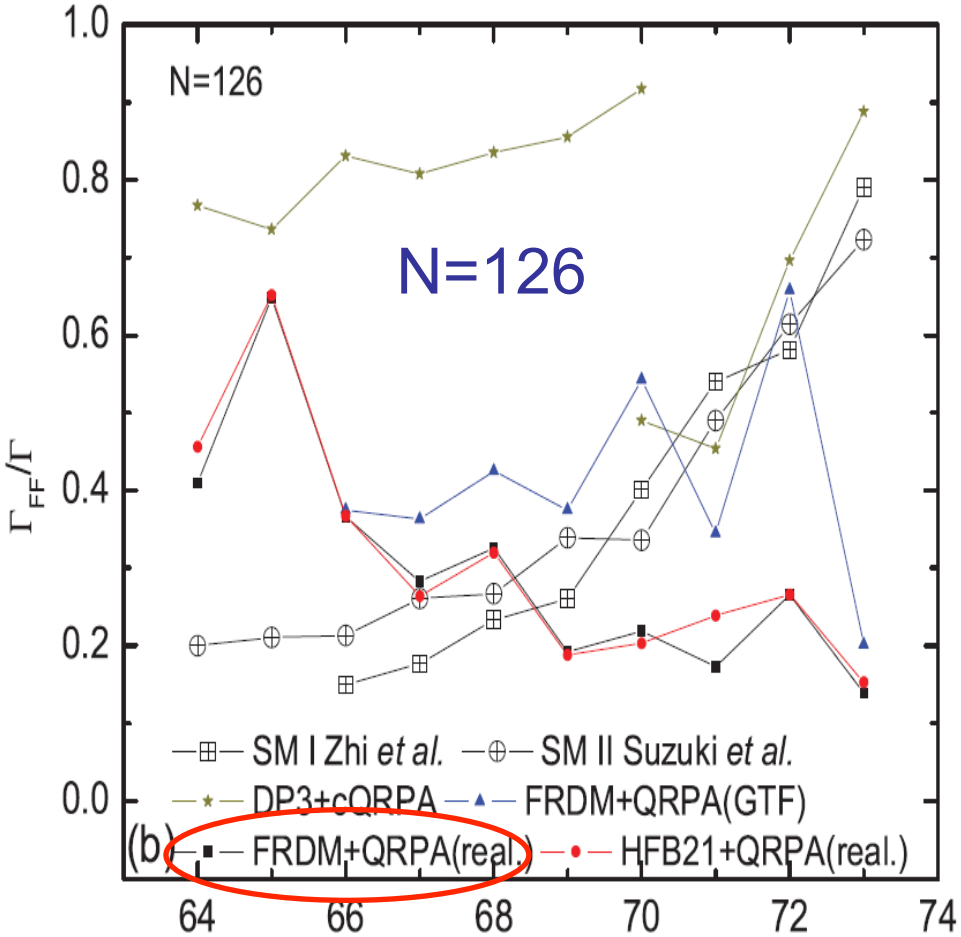
First-forbidden:
νi13/2 -> πh11/2
νp1/2->πd3/2

FF Energetically favoured



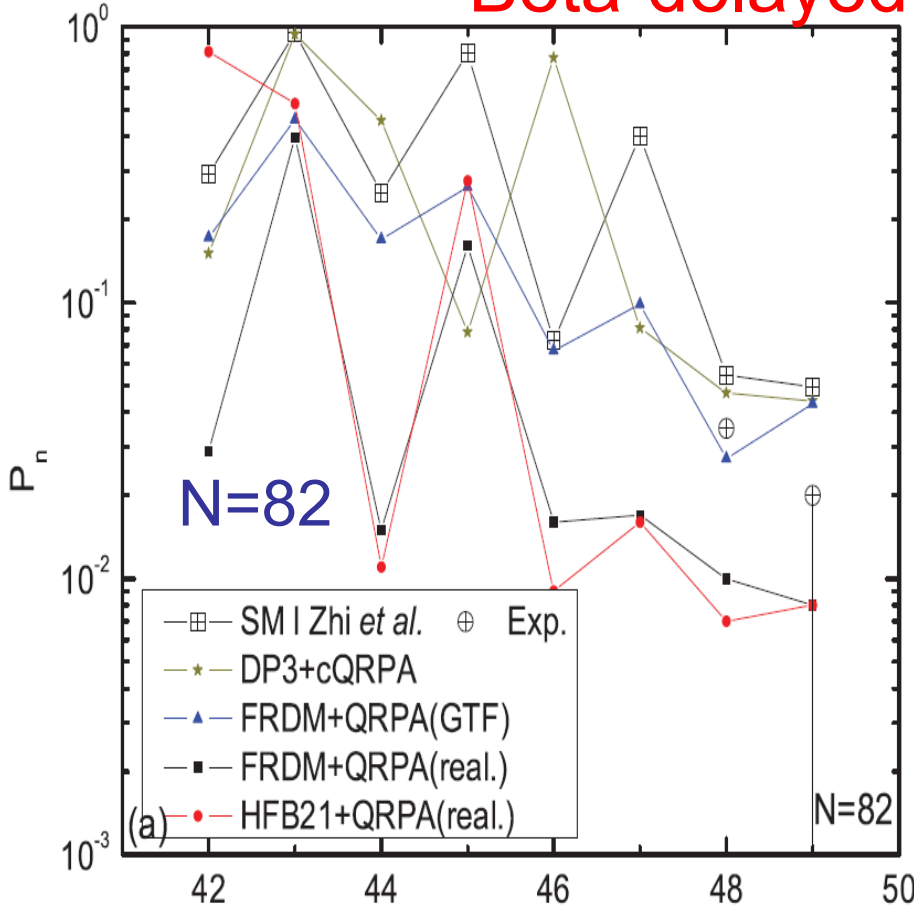
First-forbidden β decay

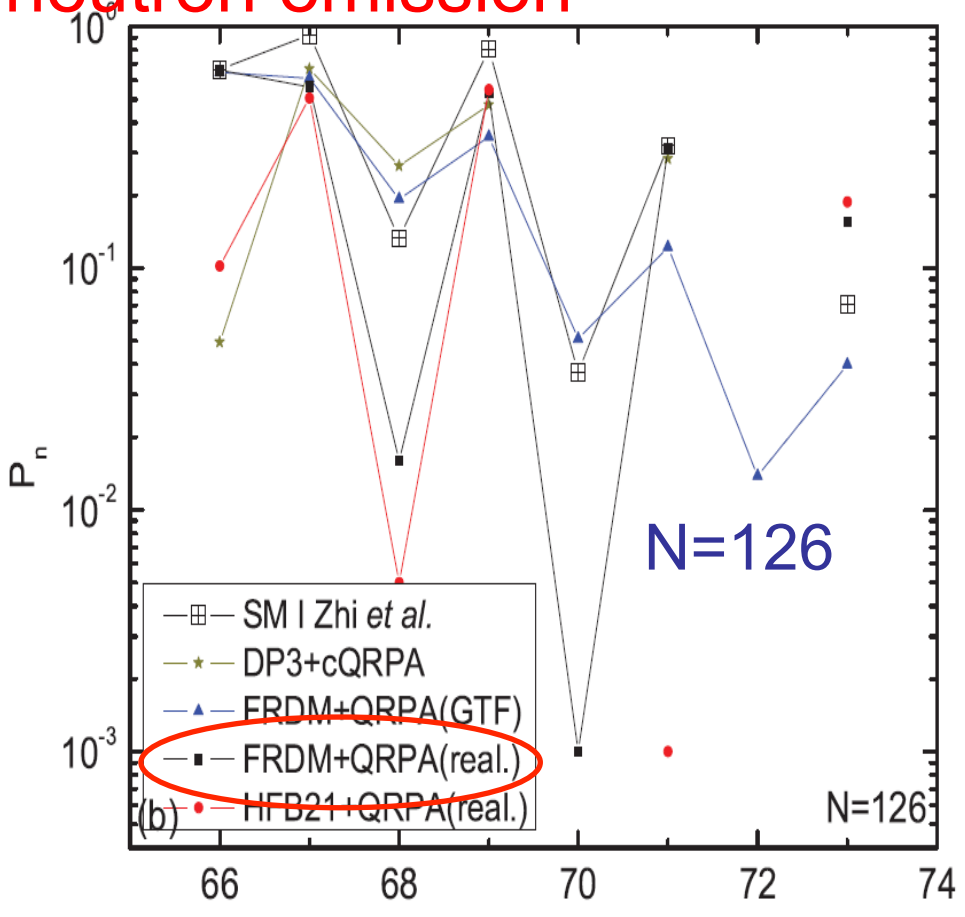




D.-L. Fang, B.A. Brown, T. Suzuki, Phys. Rev. C 88, 034304 (2013)

Beta-delayed neutron emission



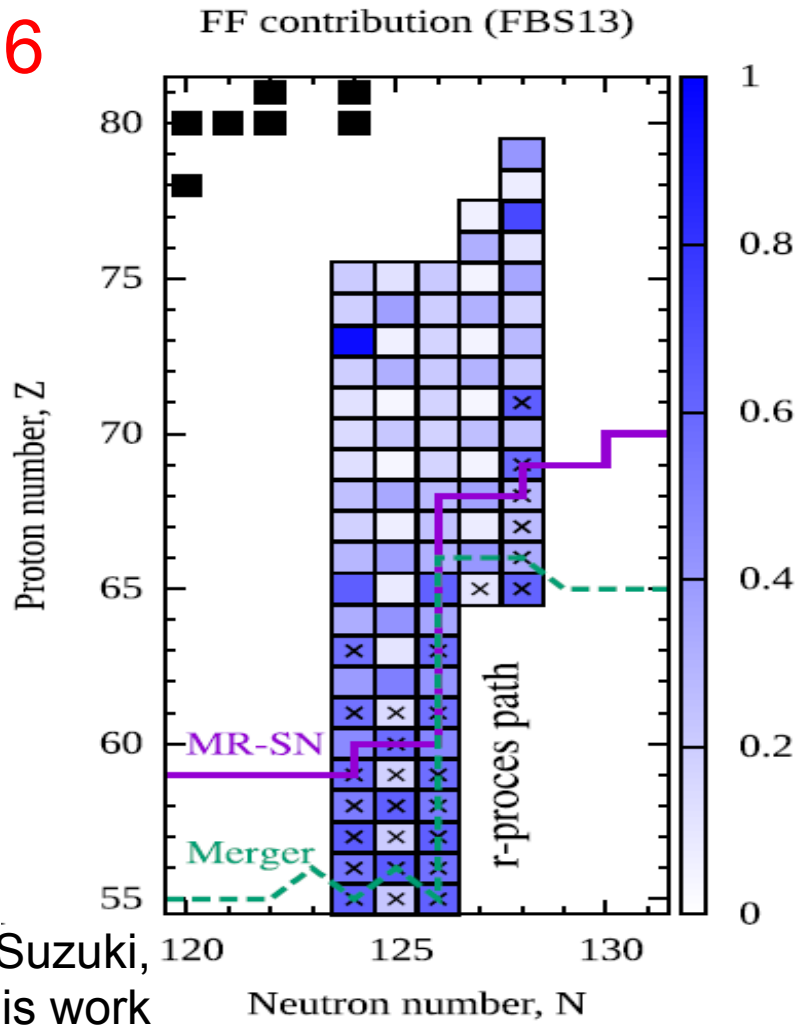


D.-L. Fang, B.A. Brown, T. Suzuki, Phys. Rev. C 88, 034304 (2013)

FF contribution for N~126

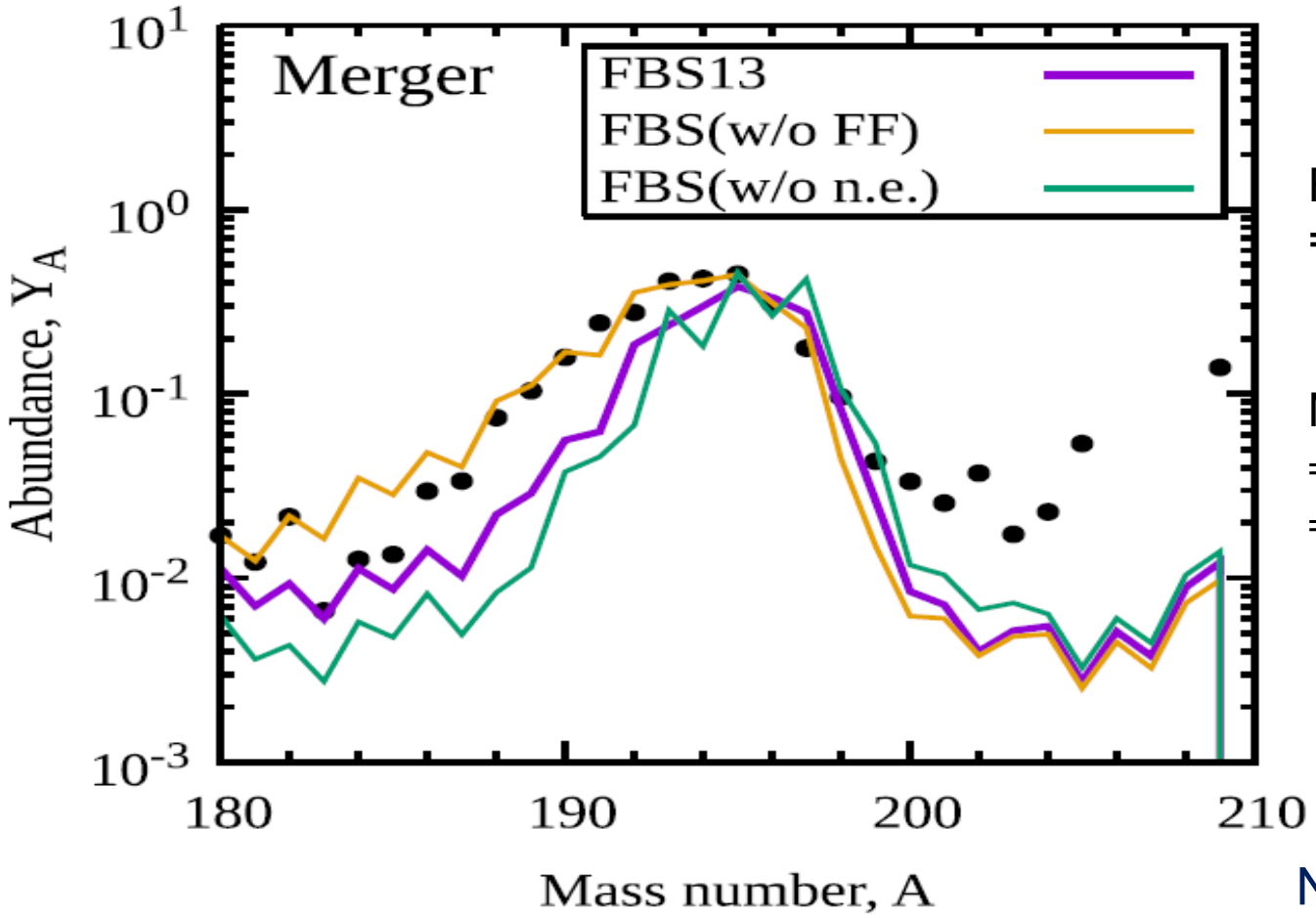
X if

$$\sum_{n=1}^{3} n P_n > 1$$



Structure from D.-L. Fang, B.A. Brown, T. Suzuki, Phys. Rev. C 88, 034304 (2013); astro: this work

Impact of the first-forbidden β decay on the A~195 r-process peak

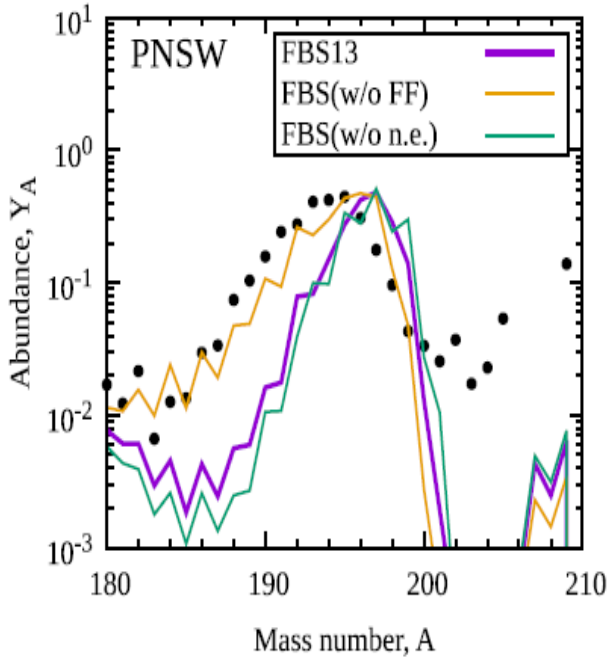


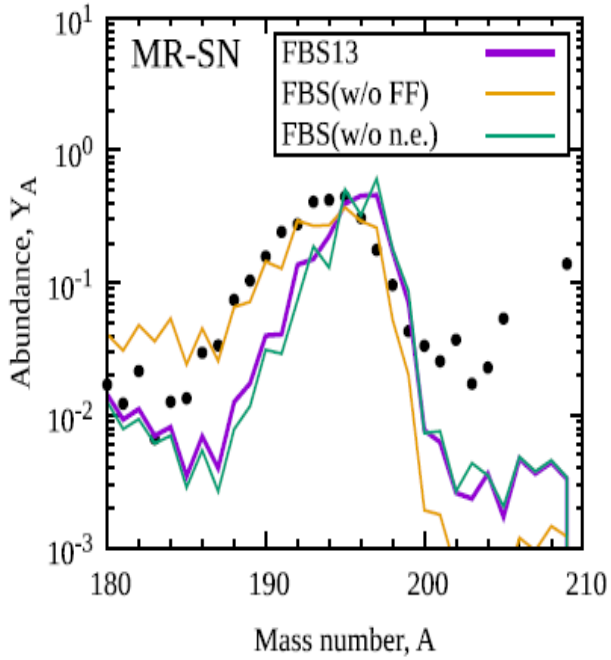
FF transitions:
=>peak moves →

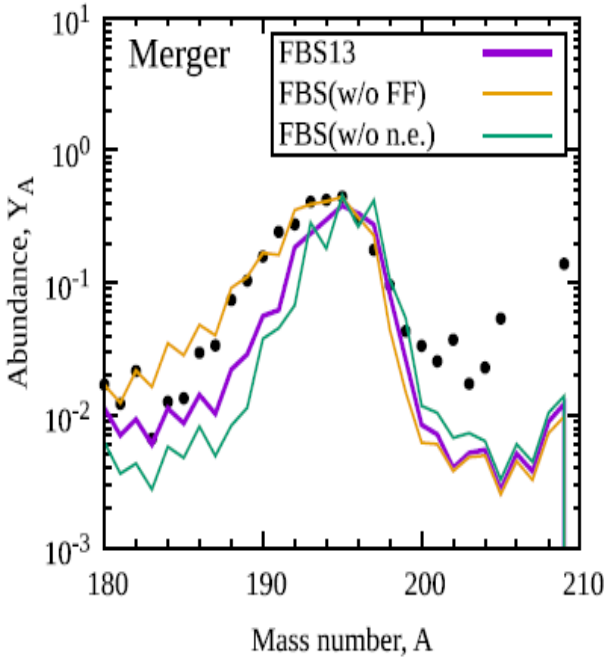
Neutron decay:
⇒ Peak moves ←
⇒ Peak smoother

Neutron-star merger

Three different astrophysical scenarios







neutron richness →

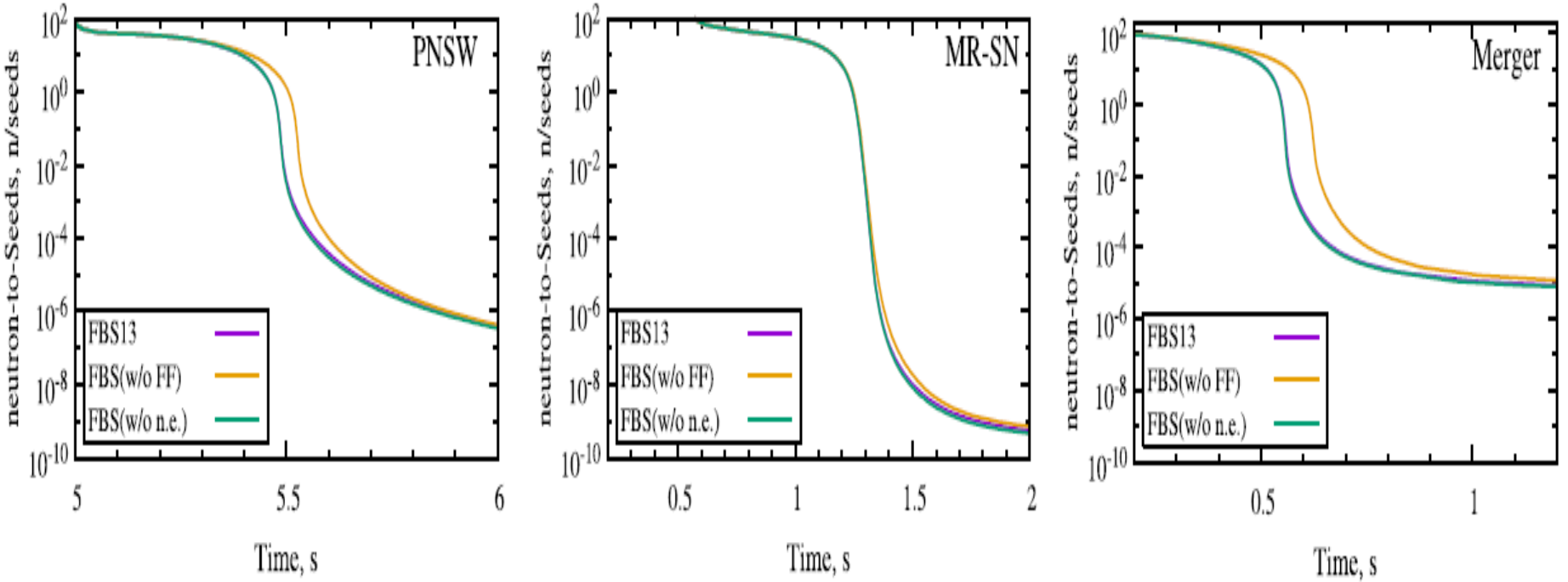
entropy ←

Proto-neutron star wind

Magneto-rotational supernovae

Neutron-star merger

Neutron-to-seed ratio



FF=> shorter $T_{1/2}$ => shorter neutron capture phase

β-delayed neutrons have small effect on neutron density

Proto-neutron star wind | Magneto-rotational supernovae | Neutron-star merger

Conclusions

-the first-forbidden beta decay shorten lifetimes
=> abundance peak shifts to higher masses

-β-delayed neutron emission smooths the abundance distribution, shifts peak to lower masses and broadens it

Qualitative differences, depending on astrophysical site

Impact of the first-forbidden β decay on the production of $A \sim 195$ r-process peak

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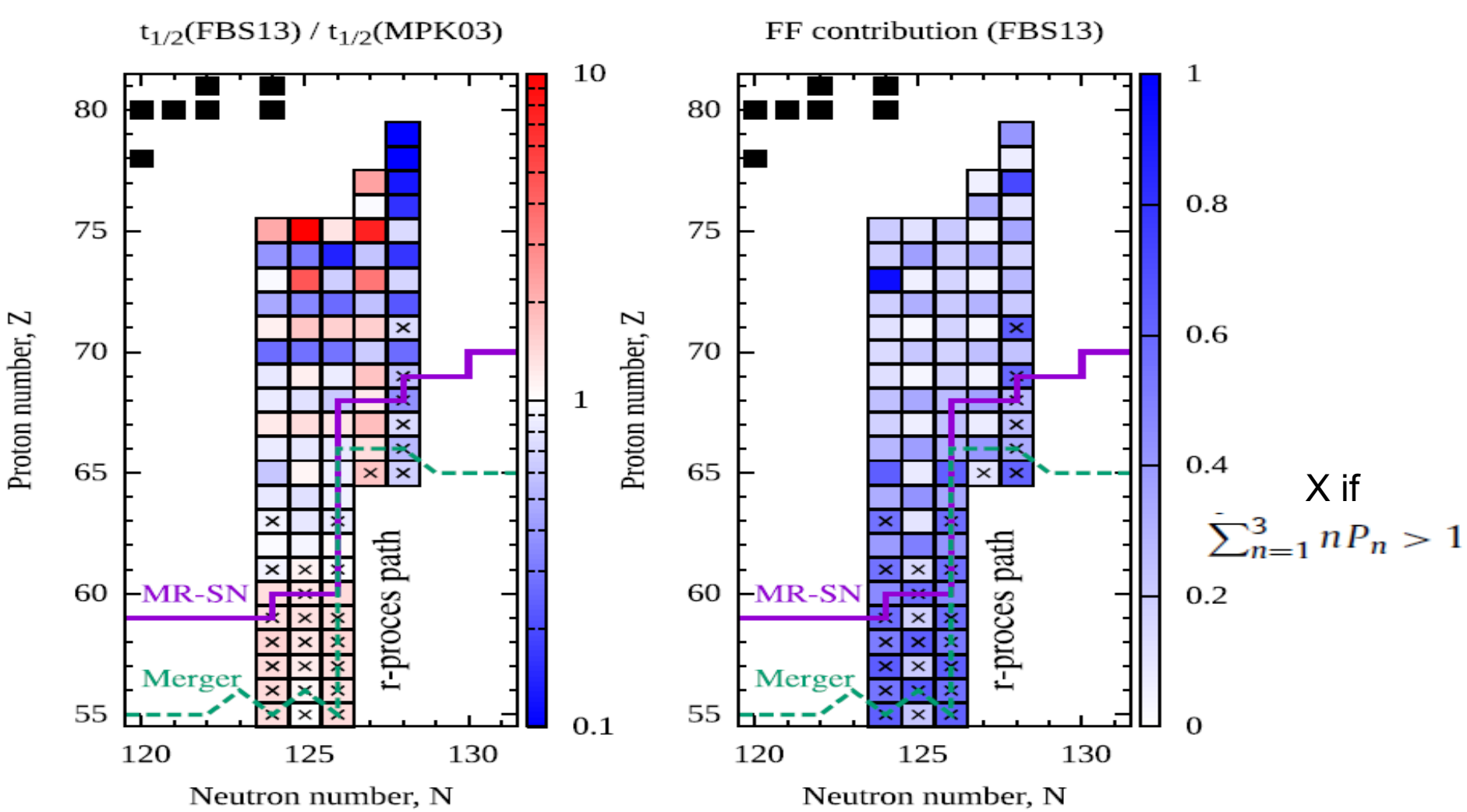
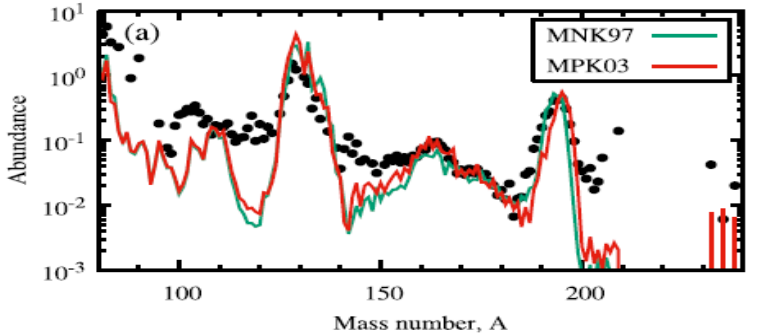
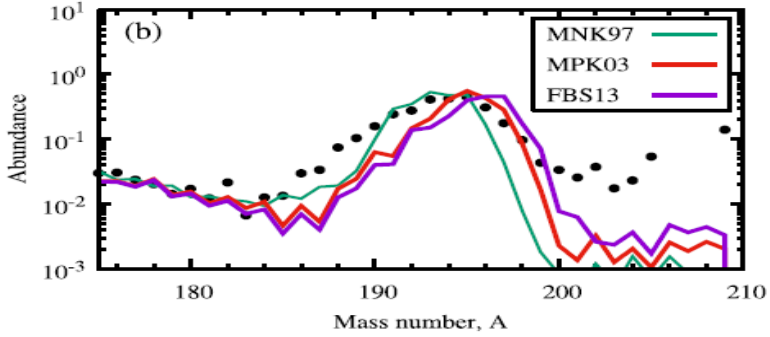
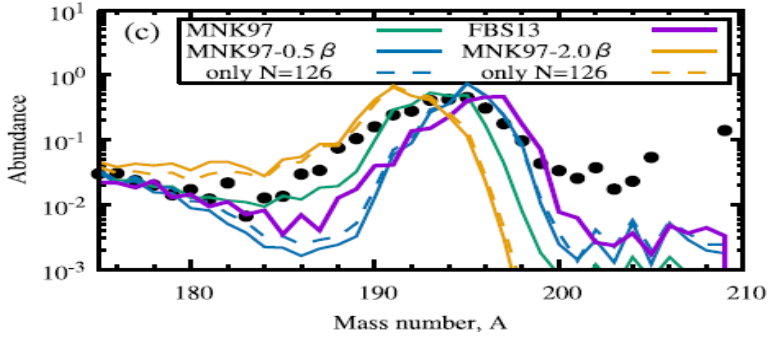
END


$t_{1/2}$(FBS13) / $t_{1/2}$(MPK03)
FF contribution (FBS13)
Proton number, Z
Neutron number, N
MR-SN
Merger
r-proces path
X if
$\sum_{n=1}^{3} nP_n > 1$


(a)
MNK97
MPK03
Abundance
Mass number, A


(b)
MNK97
MPK03
FBS13
Abundance
Mass number, A


(c)
MNK97
MNK97-0.5 β
only N=126
FBS13
MNK97-2.0 β
only N=126
Abundance
Mass number, A

forces as introduced in [17,18]. The advantage of this method is that with the G matrix obtained from the Bethe equations with realistic potentials fitted from the nucleon-nucleon scattering data, one can obtain the full spectrum for the ground as well as excited states of the odd-odd daughter nuclei. The full spectrum provides an exact treatment for the excitation energies which are missing in most other QRPA methods. The inclusion of states with more spin-parities also means that we can deal with the negative-parity FF transitions which are missing in some calculations [11,12].