THE THEORY OF PTOLEMY

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TWO AVENUES

PTOLEMY will study the spectrum of the electrons emitted by the β-processes of Tritium

Measure the neutrino mass

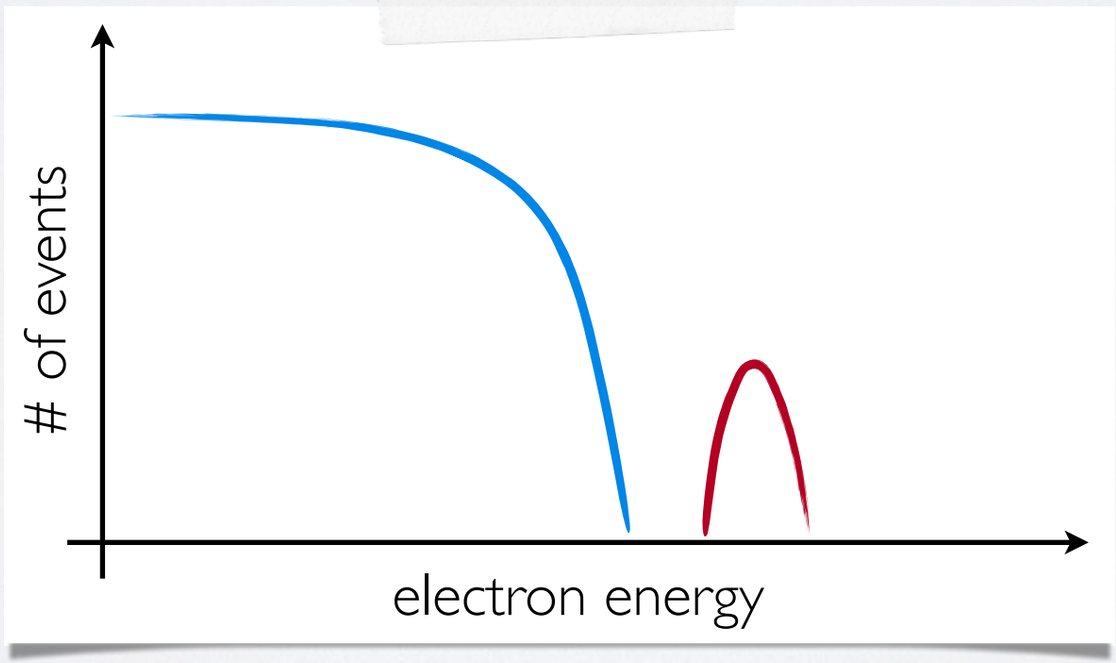
β-decay part of the spectrum

$^3\mathrm{H} \rightarrow {}^3\mathrm{He} + e^- + \bar{\nu}_e$

Observe relic neutrinos

Absorption part of the spectrum

$\nu_e + {}^3\mathrm{H} \rightarrow {}^3\mathrm{He} + e^-$

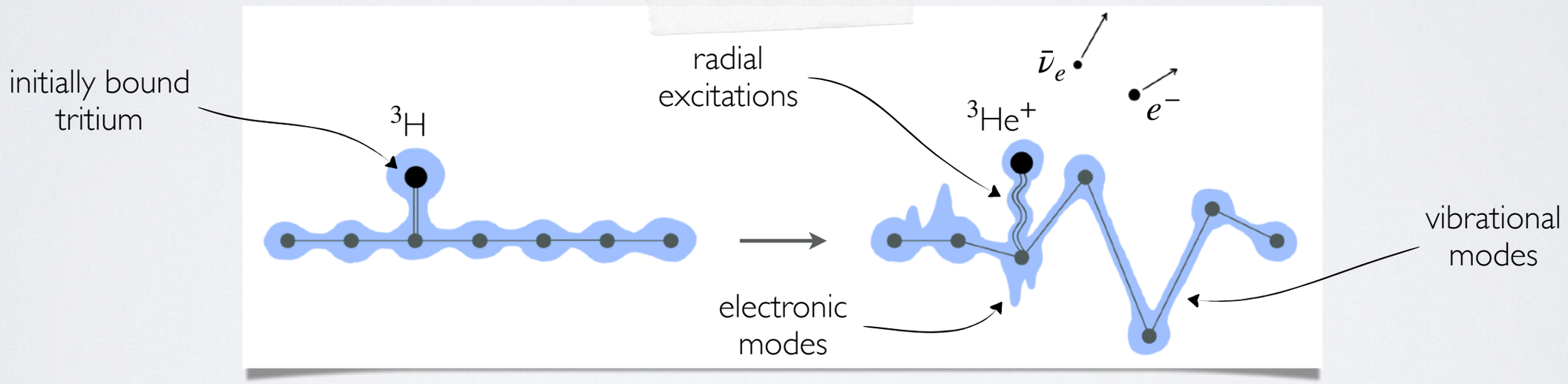


CONDENSED MATTER

The key to the success of the project is graphene:

store large quantities of tritium in a small volume and achieve small energy resolutions

But the condensed matter d.o.f. participate to the reactions



These excitations distort the electron spectrum

NEUTRINO MASS

To extract the neutrino mass we need a reliable model for the event rate, including all relevant effects

$$\frac{d\Gamma_\beta}{d\mathbf{k}} = 2\pi \sum_{f,\mathbf{p}} \left| {}_e\langle \mathbf{k} |\, {}_\nu\langle \mathbf{p} |\, {}_{\mathrm{G}}\langle f |\, H_w \,| i \rangle_{\mathrm{G}} \right|^2 \delta\left(E_i - E_f\right)$$

Many degrees of freedom participate:

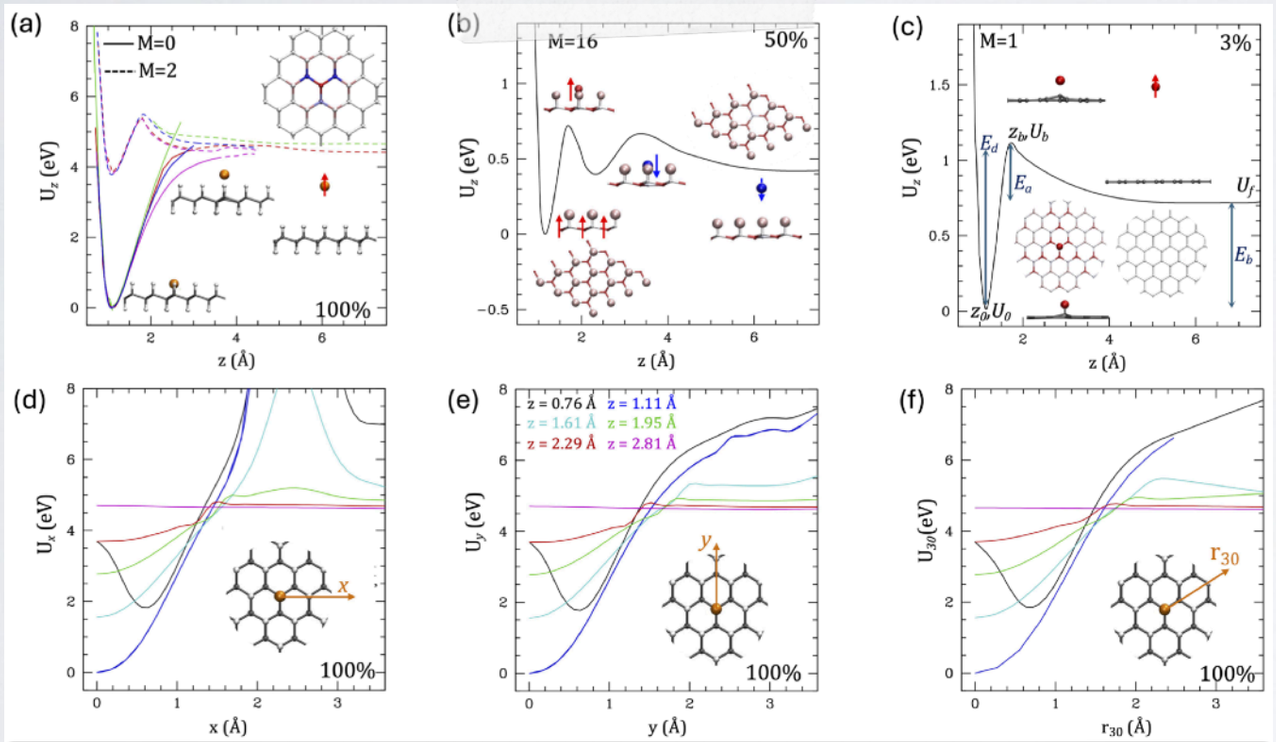
- vibrational
- electronic
- …

We started accounting for the ground state of the initial ^{3}H and for all possible excitations of the final ^{3}He

POTENTIALS

We used DFT to study initial and final interaction potentials

[Casale, **AE**, Menichetti, Tozzi 2504.13259 – submitted to PRC]



Initial ^3H

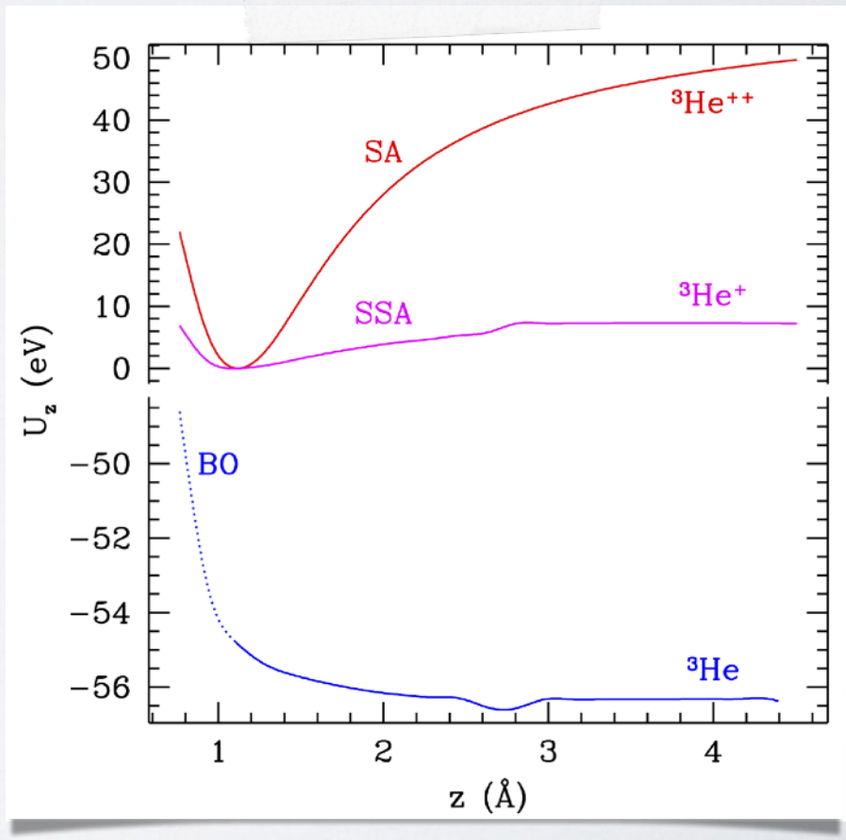
Very standard

Important for material optimization

Final ^3He

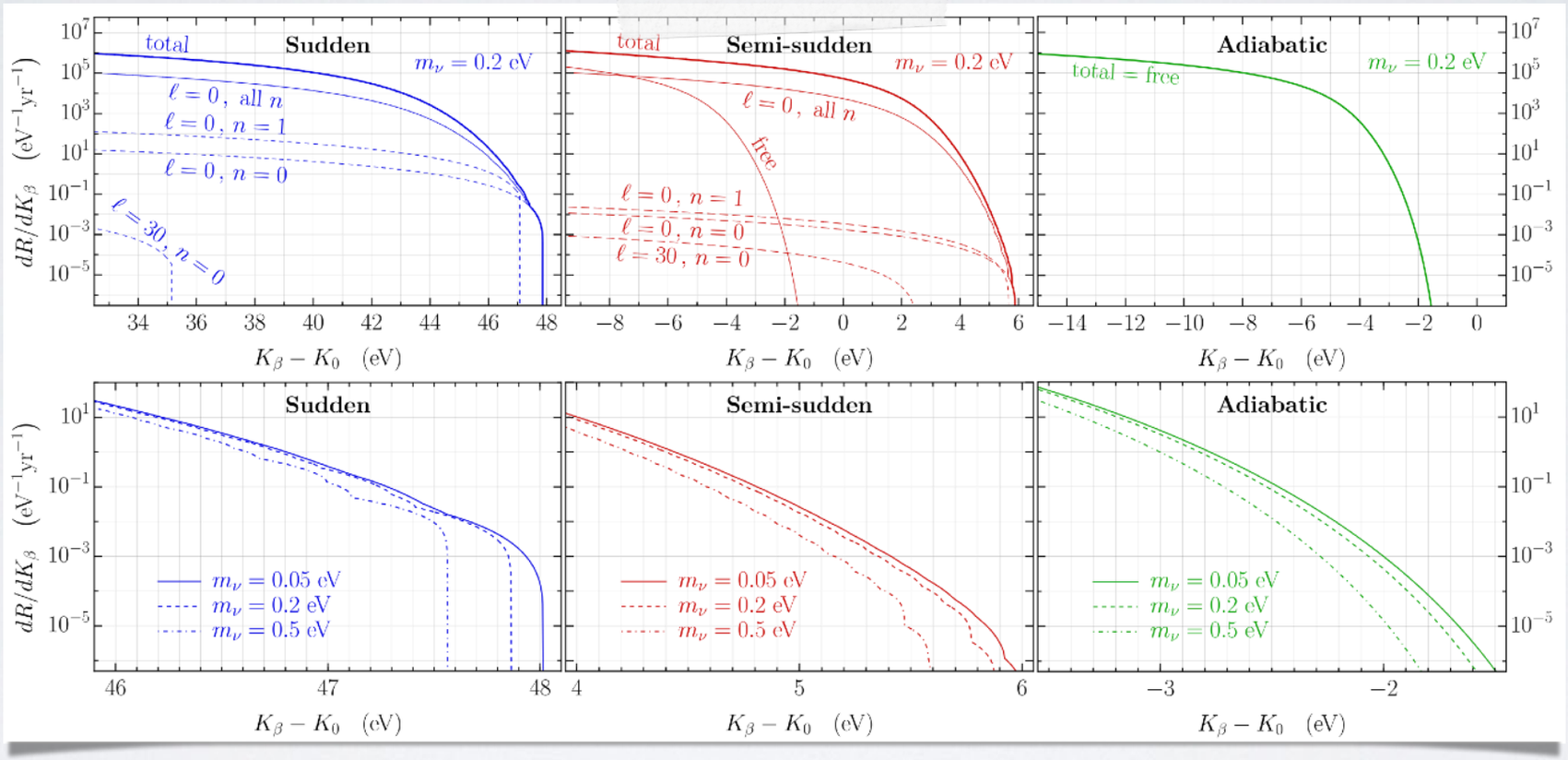
Unconventional

Large modeling uncertainties



DECAY SPECTRA

Different ^{3}He potentials reflect into different spectra

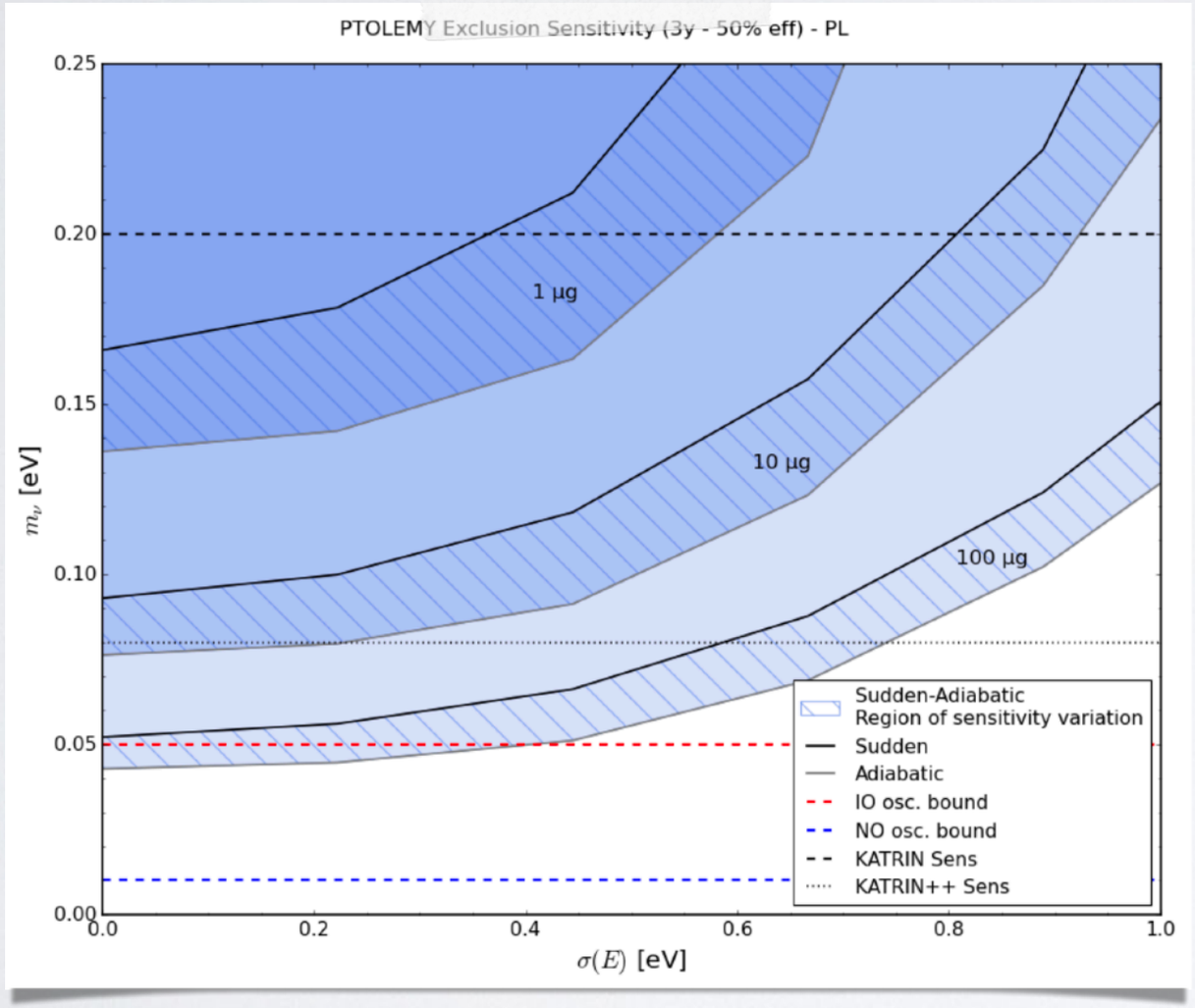


Features due to condensed matter effects are clearly visible

Difference in spectra are the main source of theory uncertainty

PRELIMINARY SENSITIVITY

Sensitivity projections are very promising



Theory uncertainty due to ^{3}He potential modeling

Our current understanding of the final state is limited

The theory error is very conservative ⟶ the truth is likely in the shaded band

DISCUSSION

PTOLEMY is a unique crossover between high and low energies

It can potentially lead to world leading results on the neutrino mass (… and the CνB)

Extensive theory efforts are being undertaken:

Casale (PhD)
Esposito (faculty)
Mangano (faculty)
Marcucci (faculty)
Menichetti (postdoc)
Pisanti (faculty)
Polosa (faculty)
Viviani (faculty)

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General formalism

Structure factors

Ab initio calculations

Material optimization and long time response

Thank you!