

PLANS FOR SAPIENZA HIGH ENERGY GROUP

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PTOLEMY theory meeting, December 2025

WHO ARE WE?

The Sapienza(-ish) HEP “armata Brancaleone” is currently composed of the following people:

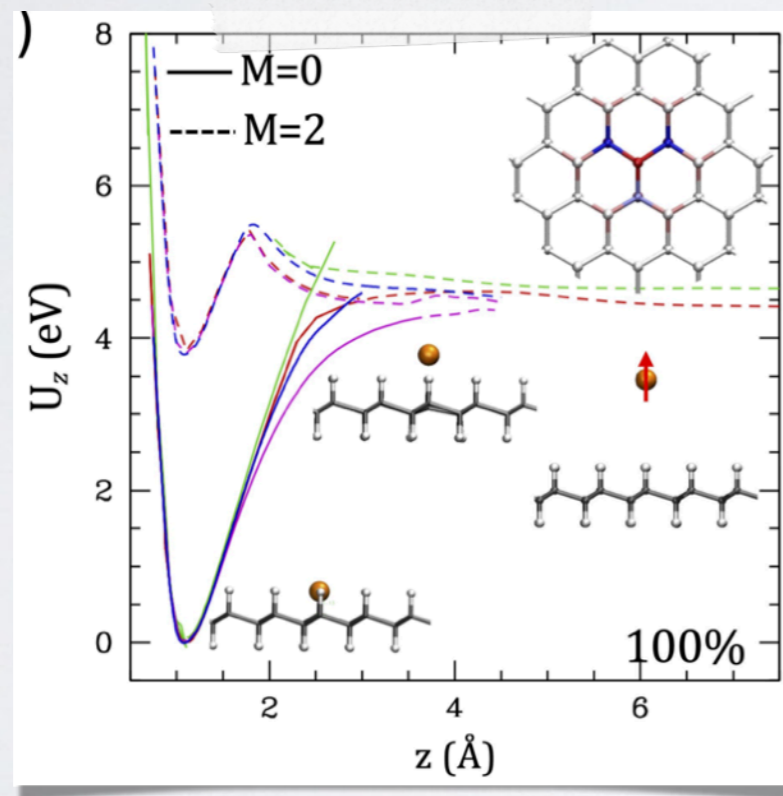
- Angelo Esposito (Sapienza)
- Andrea Casale (Columbia)
- Martina Chirico (Sapienza)
- (Possible) unknown Master’s student (I’d say, 30% chances)

No well defined role. We roll with the flow.

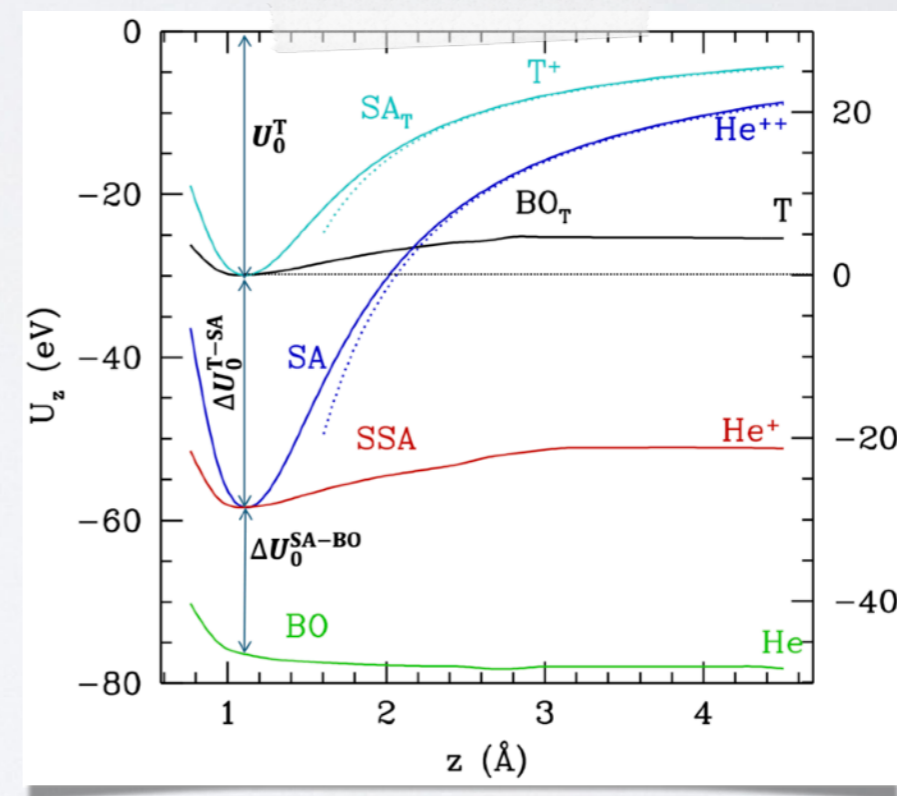
STATE-OF-THE-ART

Currently, the Tritium initial state and possible Helium final states are included in the β -decay rate with **explicit wave functions**

Initial state and final state binding potentials are therefore needed:



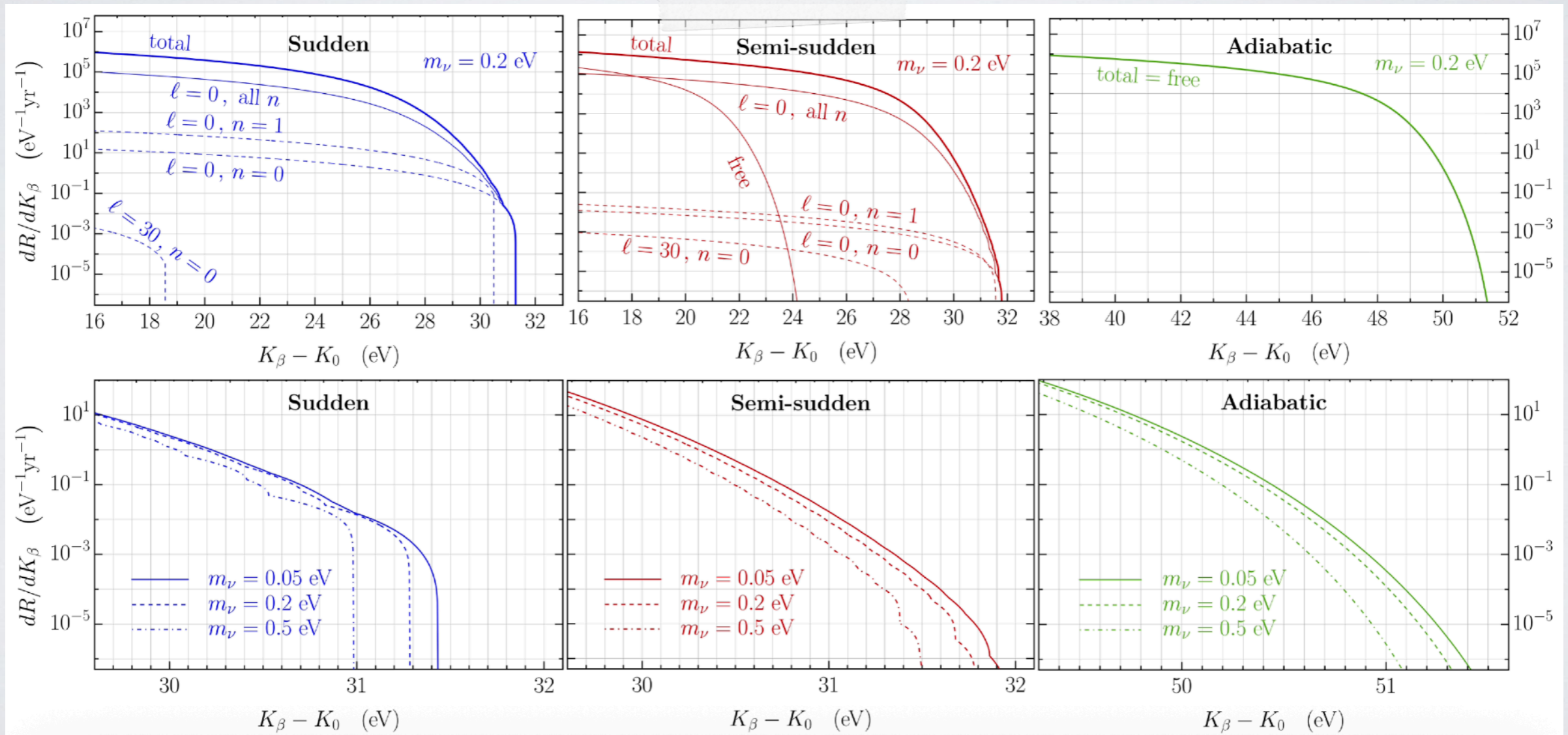
initial Tritium



final Helium (**essentially, ill defined**)

SPECTRA

Because of the issues with the final state potentials, the β -decay spectrum has **large theory uncertainties**



DESIDERATA

To improve on this state of affairs we cannot do anything but being systematic

Desiderata for a proper prediction:

- Free from ambiguities
- Practically calculable and/or measurable
- Come with an estimate of the theory uncertainties

I'd love to find a “master formula” with approximations under control. And, if needed, start modeling from there.

OUR (VERY VAGUE) IDEA

Our system features a large separation of scales:

$$E_e \sim 10 \text{ keV} \gg E_{\text{graphene}} \lesssim 10 \text{ eV}$$

Following an effective theory ideology, this typically implies factorization:

soft / long distance / slow “response”.
Essentially graphene Green’s function. Hard.

$$\frac{d\Gamma_{\text{PTOLEMY}}}{dE} \simeq \int d\omega d\mathbf{q} d\mathbf{k} \frac{d\Gamma_{\beta}}{d\omega d\mathbf{q}} G_{\text{graphene}}(\omega - E, \mathbf{q} - \mathbf{k})$$

hard / short distance / fast “source”.
Essentially nuclear β -decay. Easy.

OUR (VERY VAGUE) IDEA

There could be other systems featuring a similar separation of scale

$$E_{\text{detected}} \gg E_{\text{graphene}}$$

For example, X-ray scattering also involves energies $E_{\gamma} \sim 1 \text{ keV}$.

A similar factorization should hold:

$$\frac{d\Gamma_{\text{other system}}}{dE} \simeq \int d\omega d\mathbf{q} d\mathbf{k} \frac{d\Gamma_{\text{source}}}{d\omega d\mathbf{q}} G_{\text{graphene}}(\omega - E, \mathbf{q} - \mathbf{k})$$

OUR (VERY VAGUE) IDEA

The previous relation can be easily inverted by Fourier transform.

$$\frac{d\Gamma_{\text{PTOLEMY}}}{dE} \simeq \int d\omega d\mathbf{q} d\mathbf{k} \left(\frac{d\Gamma_{\beta}}{d\omega d\mathbf{q}} / \frac{d\Gamma_{\text{source}}}{d\omega d\mathbf{q}} \right) \frac{d\Gamma_{\text{othersystem}}}{d(\omega - E)d(\mathbf{q} - \mathbf{k})}$$

Questions we are trying to address:

- Which parameters control the factorization?
- What are the leading corrections to it?
- What's the most suitable "other system" for our needs?
- Can we compute it? Can we measure it?

Thank you!