

Parallel 4A : Hadronic Models: Development & Validation Part II

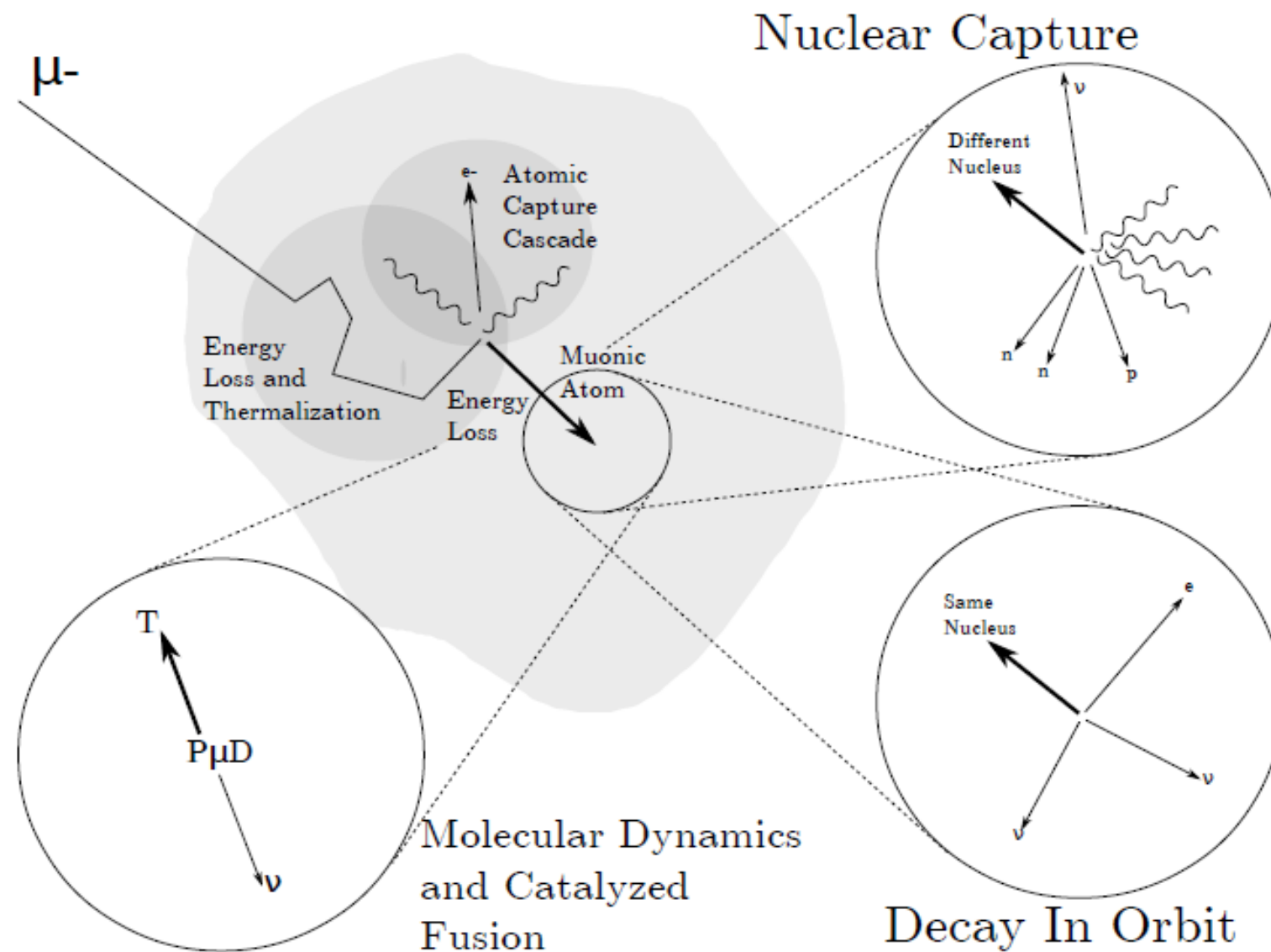
- Kevin Lynch
“*Developments in muon-nuclear models*”
- Laurent Desorgher
“*Progress on Radioactive Decay and Photon Evaporation database*”
- Vladimir Ivanchenko
“*Angular correlations in Photon Evaporation*”
- Michael Taylor
“*Requests for development in low-energy hadronics*”

A proposal for improving muon capture in Geant4

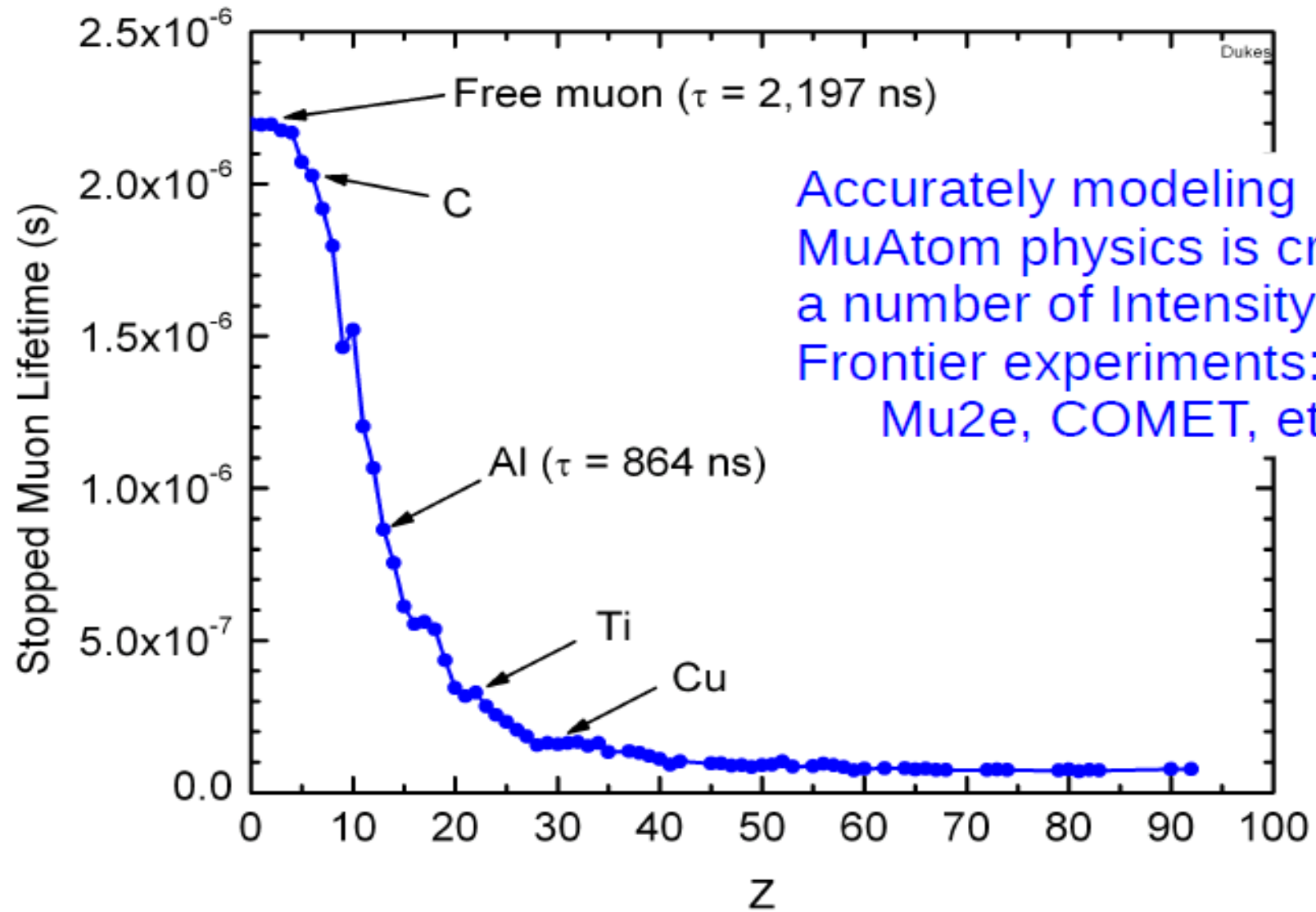
Kevin Lynch

20th Geant4 Collaboration Meeting
Fermilab
September 27-October 2, 2015

The atomic, nuclear, and particle physics of the μ^- in matter is quite varied



MuAtom physics varies widely with Z



Accurately modeling
MuAtom physics is critical to
a number of Intensity
Frontier experiments:
Mu2e, COMET, etc

The current implementation of capture at rest works well within its design limits

- class G4MuonMinusCapture:
 - A subclass of G4HadronStoppingProcess, which performs all steps of the physics:
 - Element selection
 - Atomic capture cascade
 - Nuclear capture or bound decay
 - Attached to G4MuonMinus

The current implementation has a few shortcomings that we propose to remedy

- Make the muonic atom a first class particle type
 - Allows transportable muonic atoms
 - Allows to special case the light atoms naturally
 - Muonic molecules are a natural extension
- Factorize the process model
 - Separate atomic cascade, capture, and DIO physics into separate processes that can be customized on a per species basis
 - Radiative extensions can be added as for free radiative muon decays
 - Spin dependent physics can be supported
 - Impurity transfer and catalyzed fusion
 - Provides customization points: add specific model or data driven processes per species

Schedule

- Fermilab and York/CUNY have proposals to DOE that support work on this
- Assuming you're happy with us pursuing some variant of this...
 - 2016: introduce MuAtoms and factorize the physics processes
 - 2017: introduce light atom physics
 - 2018: radiative corrections (assuming existence of theory calculations)
 - perhaps the molecular physics...

Additional possibilities

- There are other exotic atoms that may benefit from a similar approach
 - Pionic and kaonic atoms
 - Muonium
 - Positronium

Laurent Desorgher

Radiophysics institute, Lausanne

RadioactiveDecay and Photon-Evaporation database

Presented by Dennis Wright

General changes in the databases

- § New updates of the databases based on ENSDF datafiles from February 2015
- § Levels of excited states are consistent in ENSDFDATA, RadioactiveDecay and PhotonEvaporation
- § Some redundant information through the different databases : $t_{1/2}$, J, ...
- § Remove from g4radecay and photoevaporation database ?
- § Suppress the need of ENSDFSTATE data file? Back to g4.9.6?

Simulation of correlated gamma emission

. Ivanchenko, CERN & Geant4 Associates International

20th Geant4 Collaboration Workshop

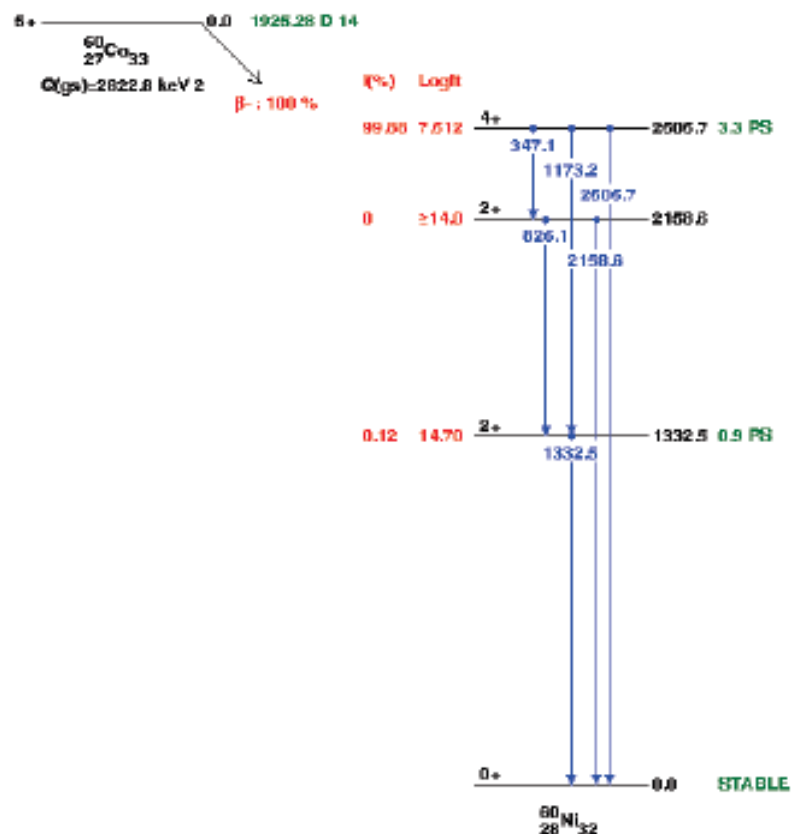
30 September 2015

FNAL, Batavia (Illinois, USA)

*From the original slides prepared by **Jason Detwiler**
at the Radioactive Decay mini-workshop at CERN, March 2015*

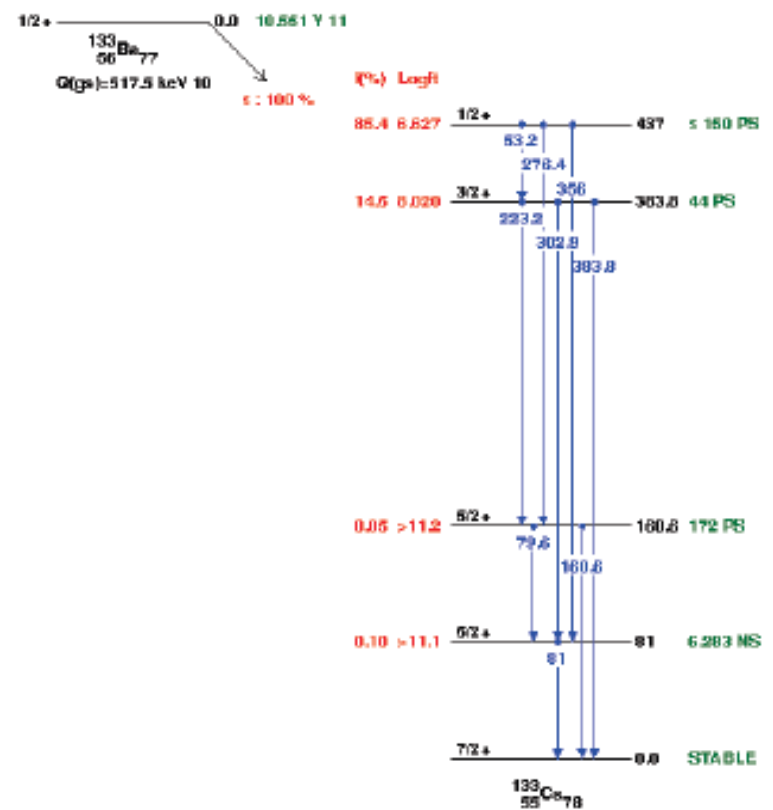
Motivation: ^{60}Co Decay

- ▶ An important source of background in my experiment (MAJORANA neutrinoless double beta decay search)
- ▶ Background rate depends on both gammas hitting one detector: angle between the gammas matter
- ▶ Well-known angular dependence, used for thermometry (“nuclear orientation thermometry”)



Motivation: ^{133}Ba

- ▶ A common calibration source for radiation detectors
- ▶ Jason experiment: spectral fit useful for determining dead layers, active volume
- ▶ Gamma summing depends on angular correlations in the cascade



Geant4 implementation

- ▶ 4 classes were provided by Jason are already integrated :
 - ▶ **hadronic/util:**
 - ▶ G4NuclearPolarization - keep polarization tensor
 - ▶ **hadronic/model/util:**
 - ▶ G4Clebsch - extended class
 - ▶ G4LegandrePolynomial
 - ▶ G4PolynomialPDF
 - ▶ G4Fragment - is updated - instead of vector of polarisation is keeping now a pointer to G4NuclearPolarization
- ▶ **What is left to do:**
 - ▶ We need to get one extra utility class to handle polarization tensor and to add a way optionally enable enable sampling of gamma emission using these classes
 - ▶ New G4PromptPhotonEvaporation model should be capable to include these
 - ▶ New evaporation data from Laurent

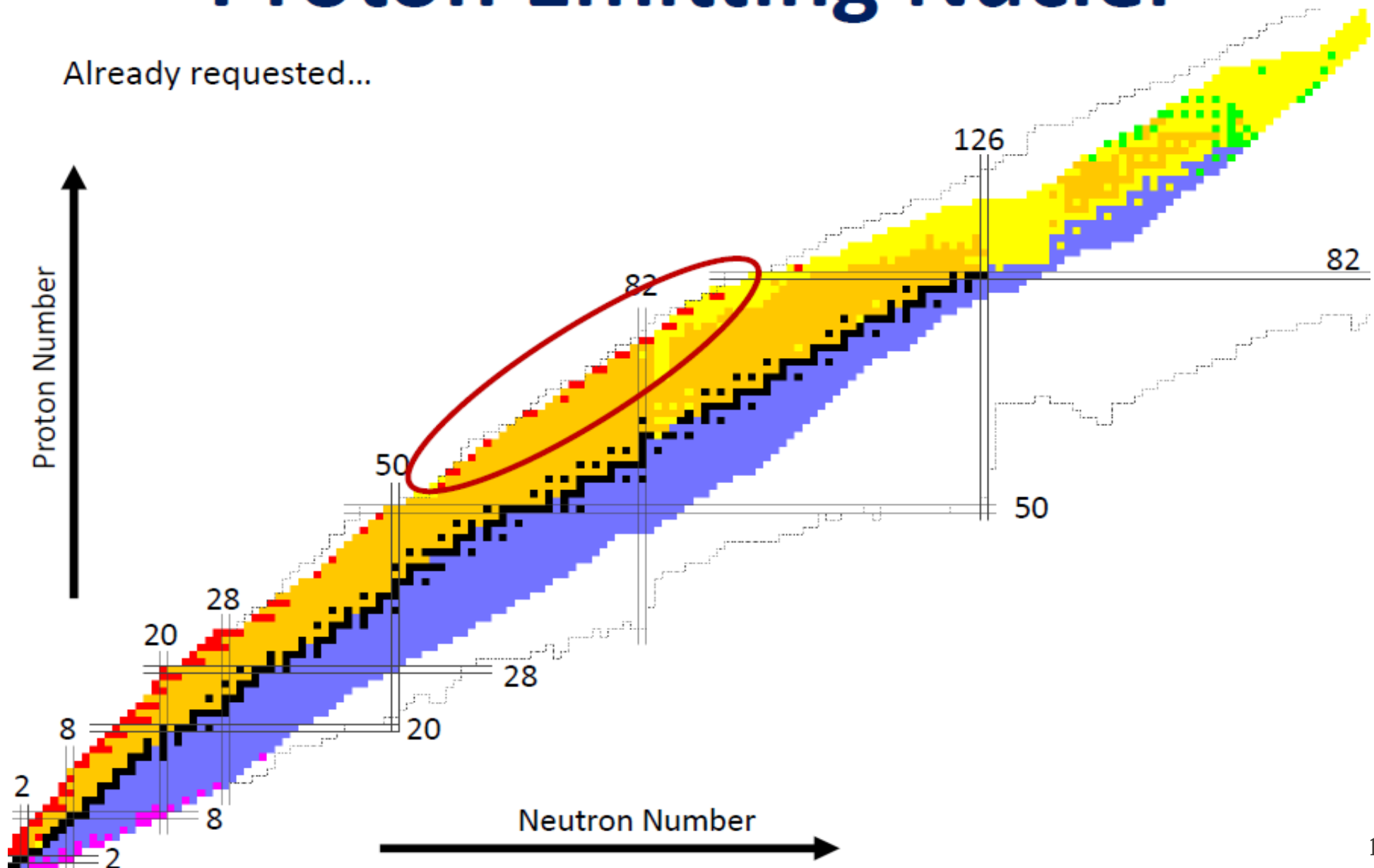
Requests for development in low-energy hadronics

Dr Michael Taylor

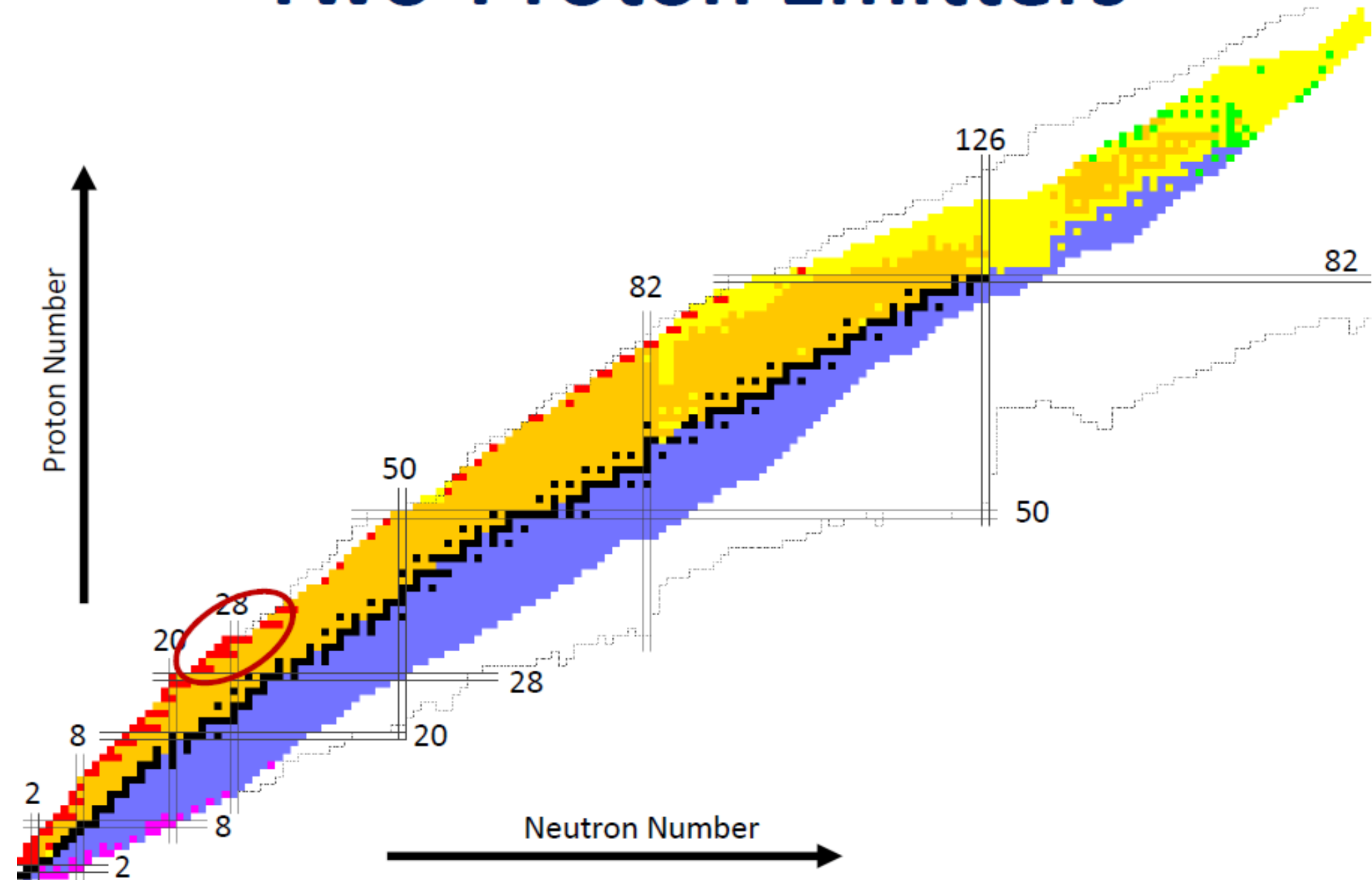
The University of Manchester and the Christie NHS Foundation Trust

Proton Emitting Nuclei

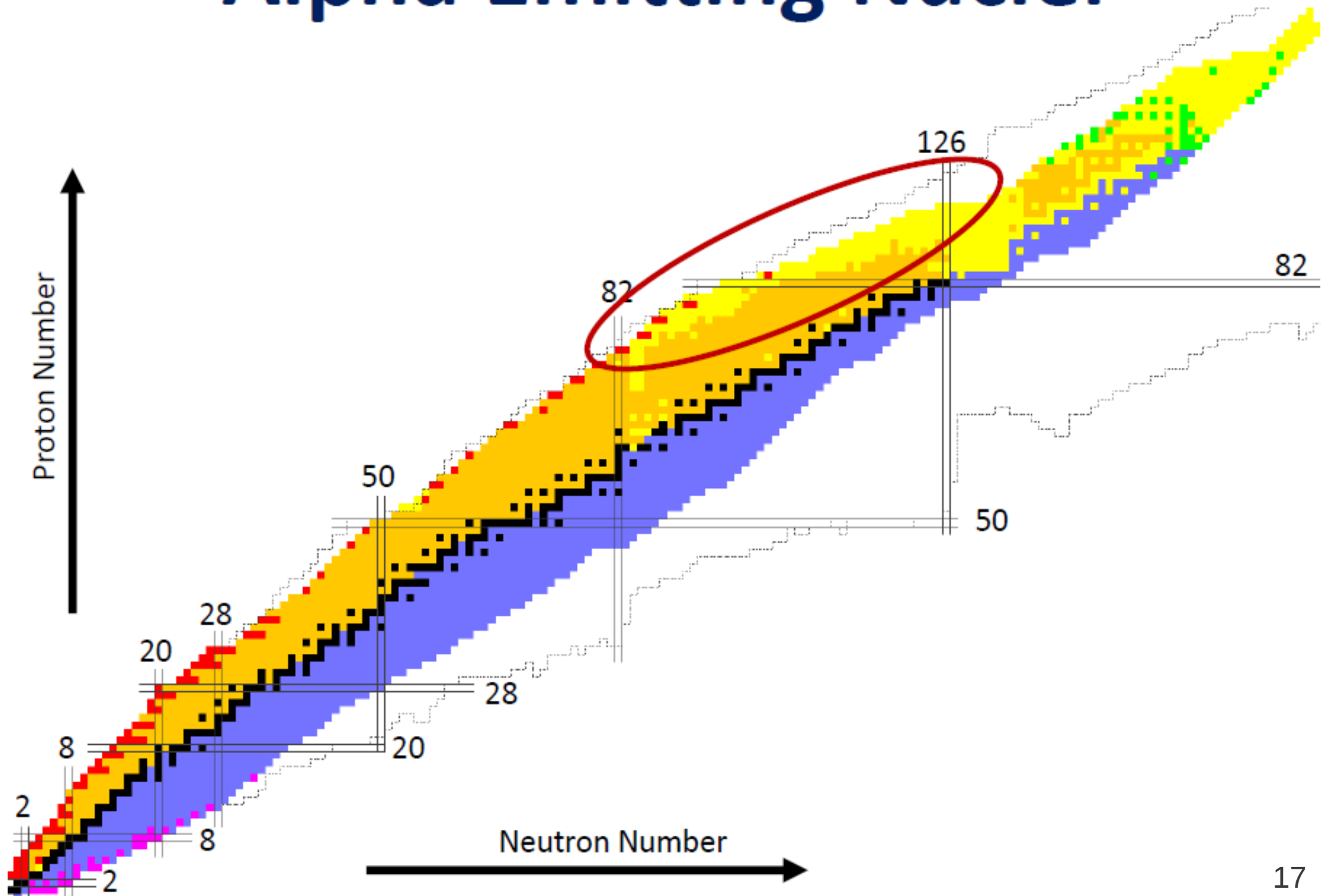
Already requested...



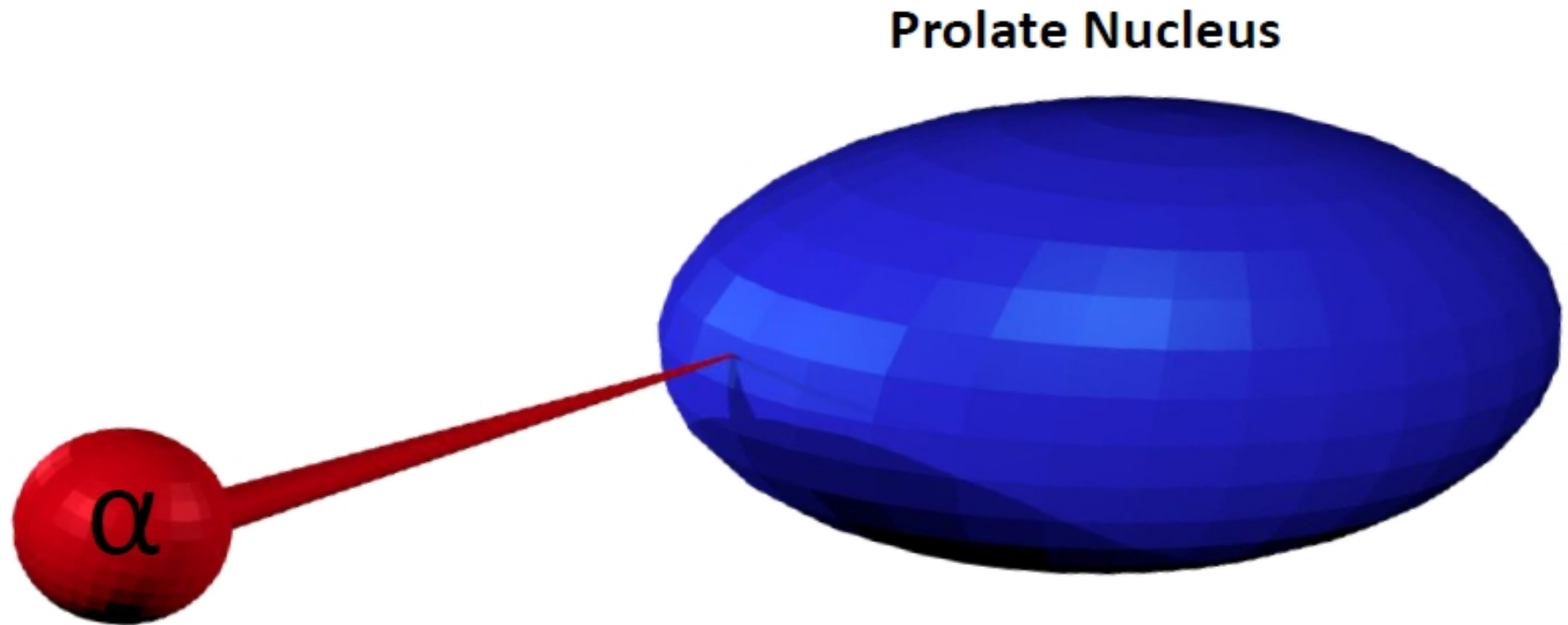
Two-Proton Emitters



Alpha Emitting Nuclei

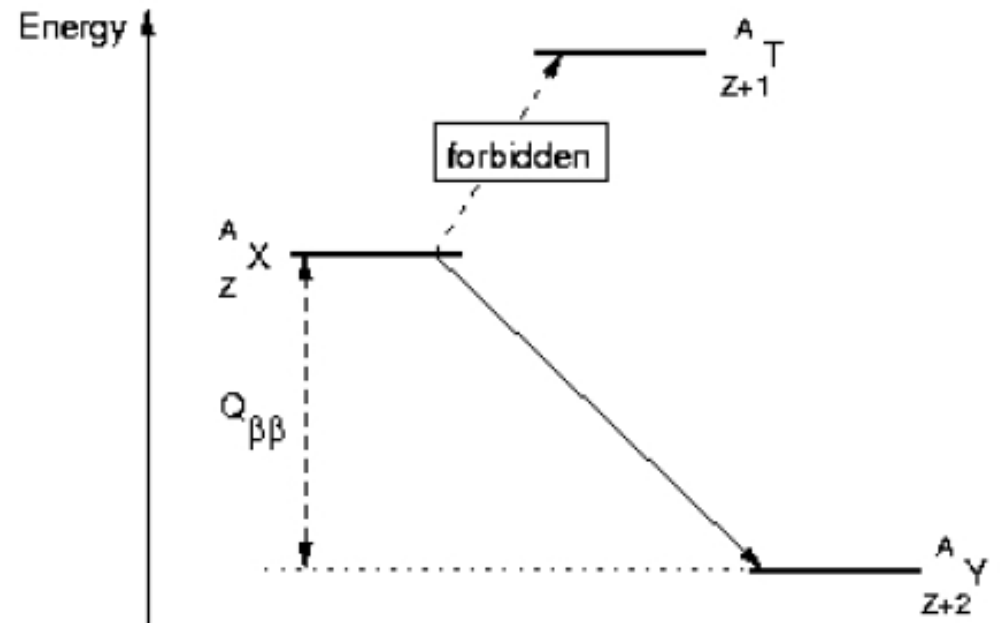
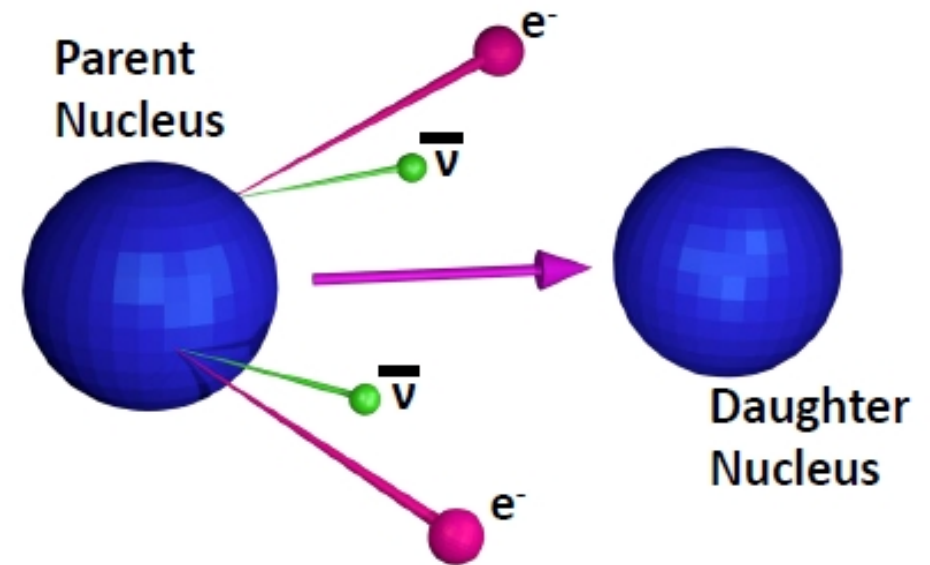
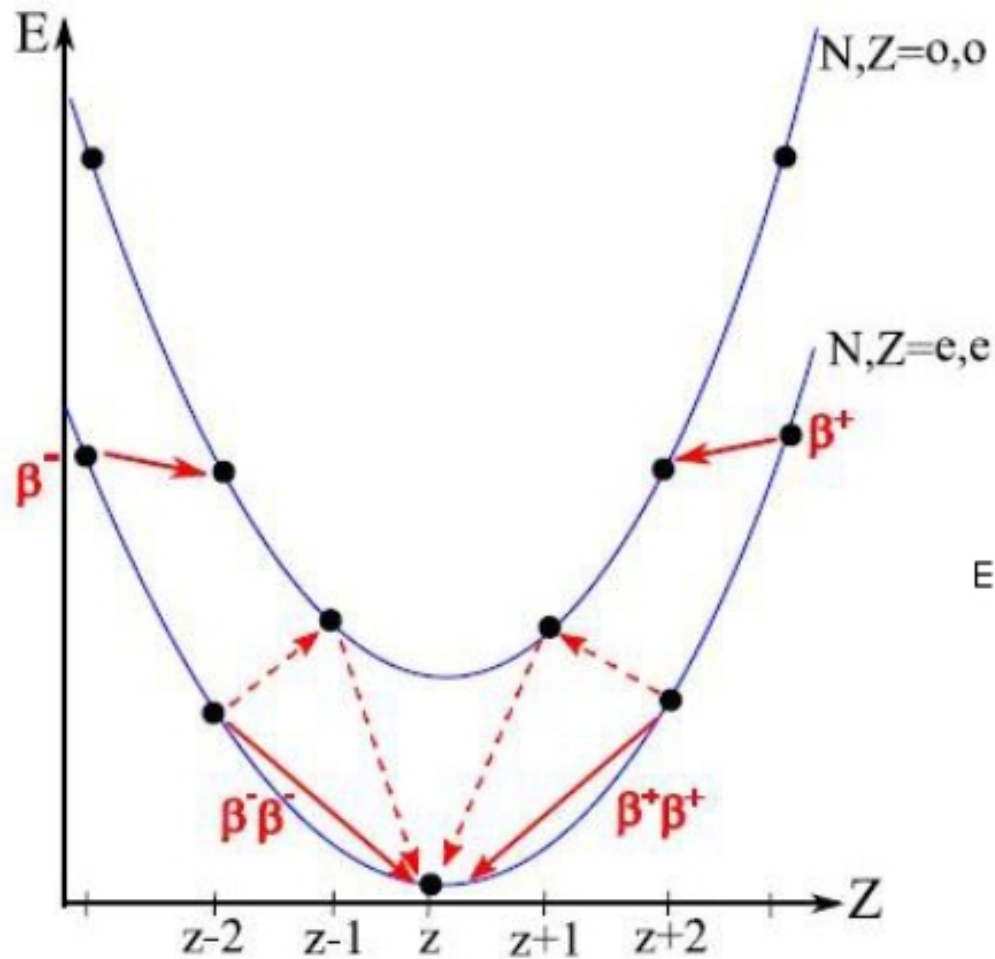


Alpha Decay: Deformation

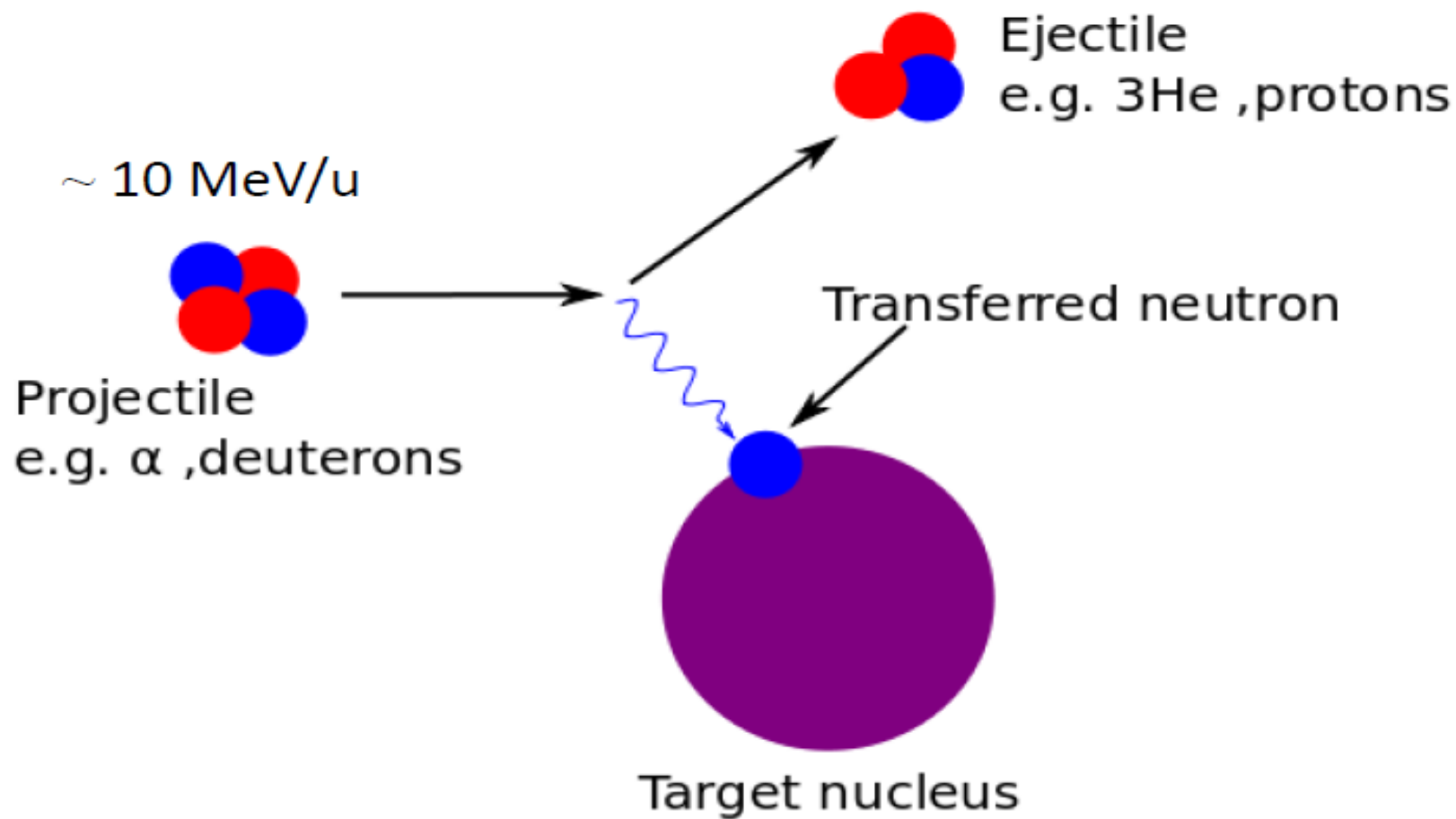


Anisotropic Emission = f (Quadrupole Deformation)

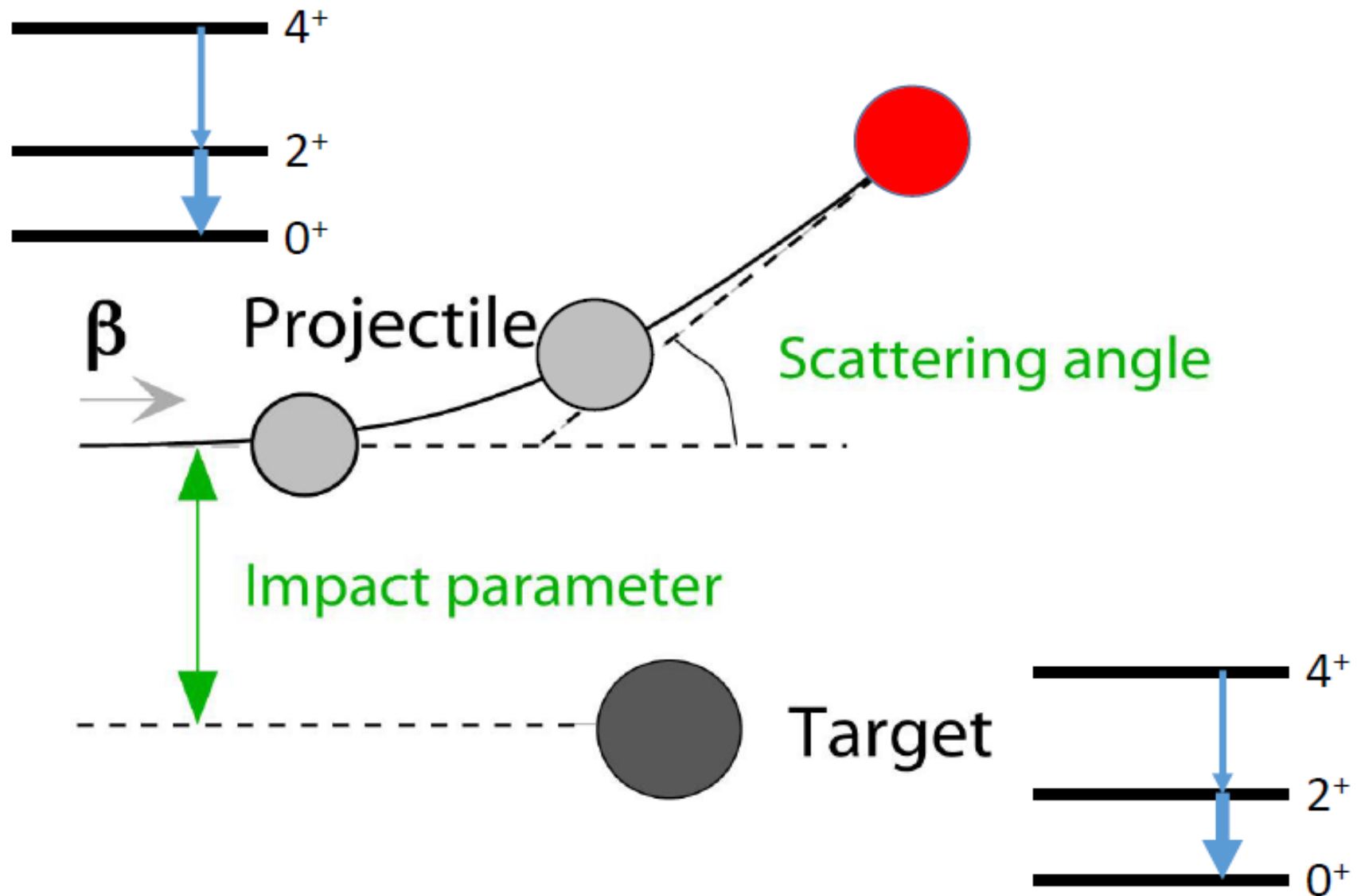
Double Beta Decay



Transfer Reactions



Coulomb Excitation



My take-home message from this session

- Lot of interesting ideas – and concrete projects – in low-energy hadronics of Geant4
- New people joining, motivated by the needs of experimental communities that are either not present at all in Geant4 or not well described
- ...an healthy trend that, I believe, will keep thriving !