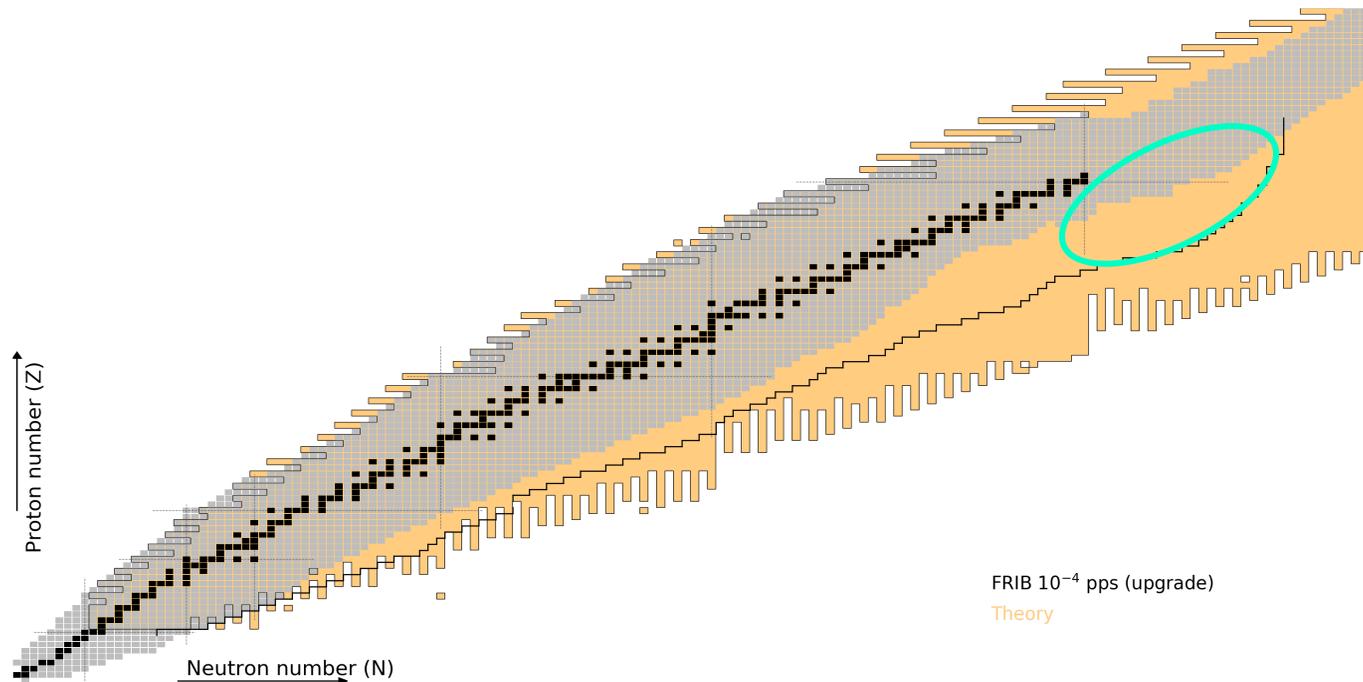


# INSIGHTS INTO THE $N = 126$ SHELL CLOSURE



LA-UR-19-25586

**MATTHEW MUMPOWER**

*Workshop on Nuclear Astrophysics  
Opportunities at ATLAS*

Saturday July 13<sup>th</sup> 2019



**FIRE Collaboration**

Fission In R-process Elements

# WHY IS THE $N = 126$ SHELL CLOSURE INTERESTING?

The evolution of nuclear structure throughout the chart of nuclides

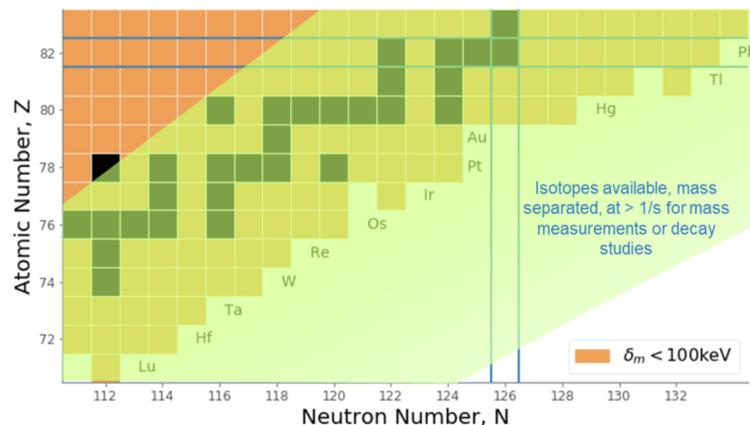
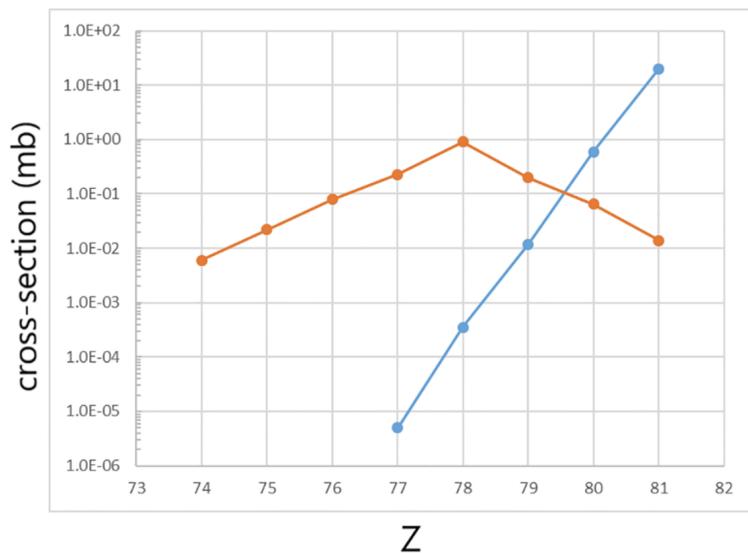
GT or FF contributions could dominate in this region for nuclear  $\beta$ -decay

For the study of reactions ( $\gamma$ -strength and nuclear level densities)

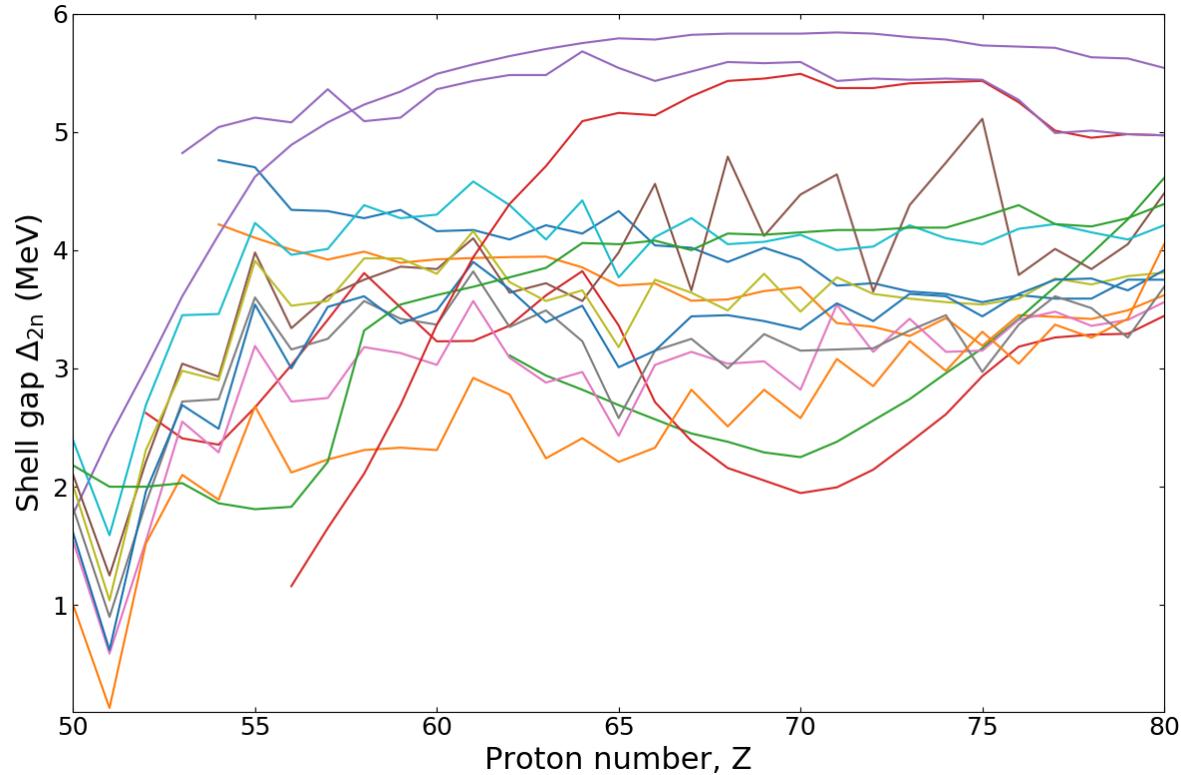
Formation of the elements in astrophysical environments ( $r$ -process)

How much actinides are produced in nature? What about superheavies?

Important for high opacity elements (both lanthanides & actinides) that can impact light curves



# THE $N = 126$ SHELL GAP



The **shell gap** can be used as a measure of the strength of a shell closure

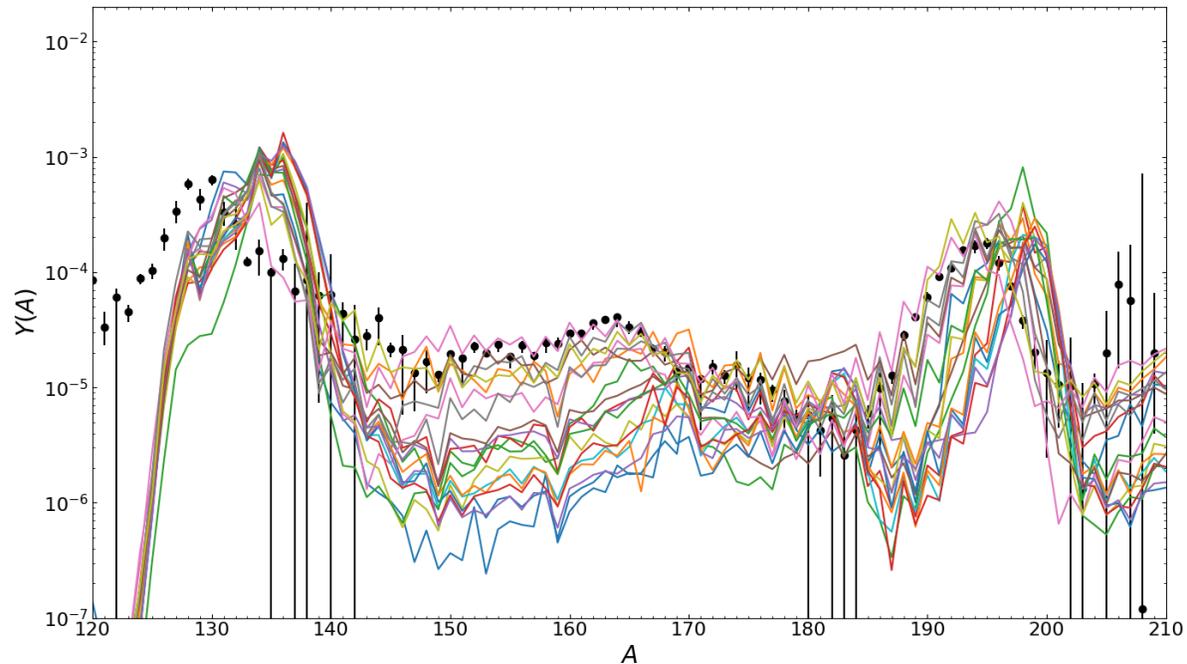
A **strong shell closure** is baked into present nuclear models ( $\Delta_{2n}$  rather flat and  $> 0$ )

For nucleosynthesis this means it takes awhile to get beyond this **hangup spot**



# IMPORTANCE FOR THE $r$ -PROCESS

A dirty secret: nucleosynthesis simulations have trouble reproducing  
(1) the peak height (2) peak height relative to  $A = 130$  and (3) the position of the  $A = 195$  peak



Final abundances using 20 mass models given the same astro. conditions

The  $N = 126$  shell closure acts as the **gatekeeper** to **actinide production**

If **fission recycling**: implications for lanthanide production and galactic chemical evolution







# THE $N = 126$ SHELL CLOSURE



YOU SHALL NOT PASS!







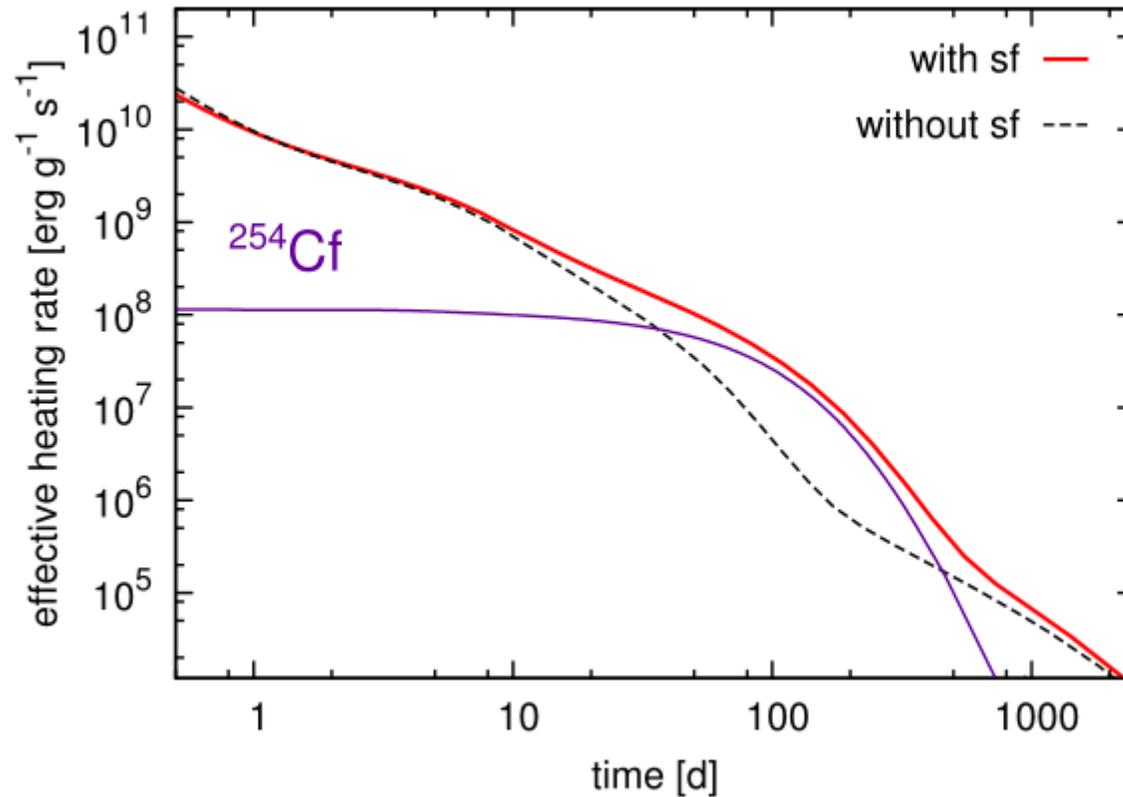








# CRITICAL FOR UNDERSTANDING ACTINIDE PRODUCTION



Is there any precursor to show that actinide nucleosynthesis has occurred in an event?... **YES!**

The spontaneous fission of  $^{254}\text{Cf}$  is the primary contributor to nuclear heating at late-time epochs

Producing actinides depends on the  $N = 126$  shell closure strength and hence impacts kilonova observations































# SUMMARY

The  $N = 126$  factory will give much needed insight to studies of nuclear structure

A strong  $N = 126$  shell closure is baked into current nuclear models

This has important implications for the  $r$ -process of nucleosynthesis...

The  $N = 126$  closure acts as the gatekeeper to actinide production

Astro. observations are influenced depending on production of high opacity elements

Even lanthanide production is influenced if fission recycling is active

This is important if we want to understand the history of element production in our galaxy

Results / Data / Papers @ [MatthewMumpower.com](http://MatthewMumpower.com)





























































