

Prologue

1985	XXIII	“Multi-Fragmentation Reactions Within the Nuclear Lattice Model”
1993	XXXI	“Pion Correlations in Proton-Induced Reactions ...”
1999	XXXVII	“Sub-Poissonian Fluctuations ...”
2007	XLV	“Fragment Size Rankings ...”
2008	XLVI	“Double Beta Decay”
2010	XLVIII	“The Physics and Astrophysics of FRIB”
2012	L	“The Nuclear Fragmentation Problem and Bormio’s contribution to its solution”
2016	LIV	... anything I want ...

Forgery Protection of Artwork with Rare Isotopes

Wolfgang Bauer
Michigan State University

25–29 January 2016, Bormio, Italy

54th

**International Winter
Meeting on Nuclear Physics**



HIM
Helmholtz-Institut Mainz



PRISMA
Cluster of Excellence



GRUPPO BANCARIO
Credito
Valtellinese



Art Market

- \$57.3 Billion in art sales last year (European Fine Art Foundation estimate)
- Nafea Faa Ipoipo (When Will You Marry?) sold for ~\$300 million in February 2015
- Increasing market for fakes/forgeries
 - March 2015: Spanish authorities busted a forgery ring, seizing nearly 300 fake Picassos, Warhols, and Mirós
- Authenticators experience increased litigation against them
 - Muzzling effect on art experts, scientists, and historians



Nafea Faa Ipoipo
(When Will You Marry?)
Paul Gauguin, 1892

Wolfgang Beltracchi Scandal

<http://www.vanityfair.com/unchanged/2012/10/wolfgang-beltracchi-helene-art-scam>

- Forged at least 58 and perhaps hundreds of pictures by ~50 artists

- Forgeries sold for up to \$3.6M

- Works by Max Ernst, Heinrich Compendonk, Fernand Léger, Kees van Dongen, ...

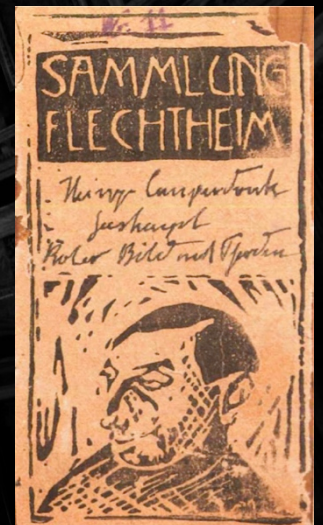
- Caught because he used a modern pigment in 'Flechtheim' collection logo



Red Picture with Horses, a painting supposedly by German Expressionist Heinrich Campendonk, forged by Beltracchi; it sold at auction for \$3.6 million in 2006



Helene Beltracchi, posing as her grandmother, in a pseudo-antique photo staged to lend credibility to the fictional provenances of Wolfgang Beltracchi's forgeries. Hanging on the wall at left is a fake Fernand Léger; at far right is a phony Max Ernst (from the 'Flechtheim Collection')



- *La Forêt (2)* by Max Ernst (not!)
- Sold for \$7M



New Authentication Technique

Signing with specks of
artificial DNA (?)

www.nytimes.com/2015/10/13/arts/design/dev...
The New York Times
ART & DESIGN
Art Forgers Beware: DNA Could Thwart Fakes
By TOM MASHBERG OCT. 12, 2015
Email
Share
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Pin
Save
More
HE NAMED ME MALALA



Eric Fischl, an artist, advocates DNA-based authentication. Danny Ghitis for The New York Times

The artist [Eric Fischl](#) remembers the time a friend waved a catalog at him to alert him that one of his paintings was up for auction for six figures in London. In reality, the work was a fake, but so convincing, [Mr. Fischl](#) said, "I thought I was losing my mind."

Brushes with forgery like that one two decades ago, and concerns about his legacy and estate, prompted Mr. Fischl to appear in London on Monday to vouch for a new authentication system that would let artists sign their works with specks of synthetic DNA.

The background of the slide is a reproduction of Michelangelo's famous fresco, "The Creation of Adam". It depicts Adam reclining on the left, reaching towards God who is reclining on the right, surrounded by other figures. The word "Idea" is written in large blue letters with an orange outline, and a small blue asterisk in parentheses is to its right.

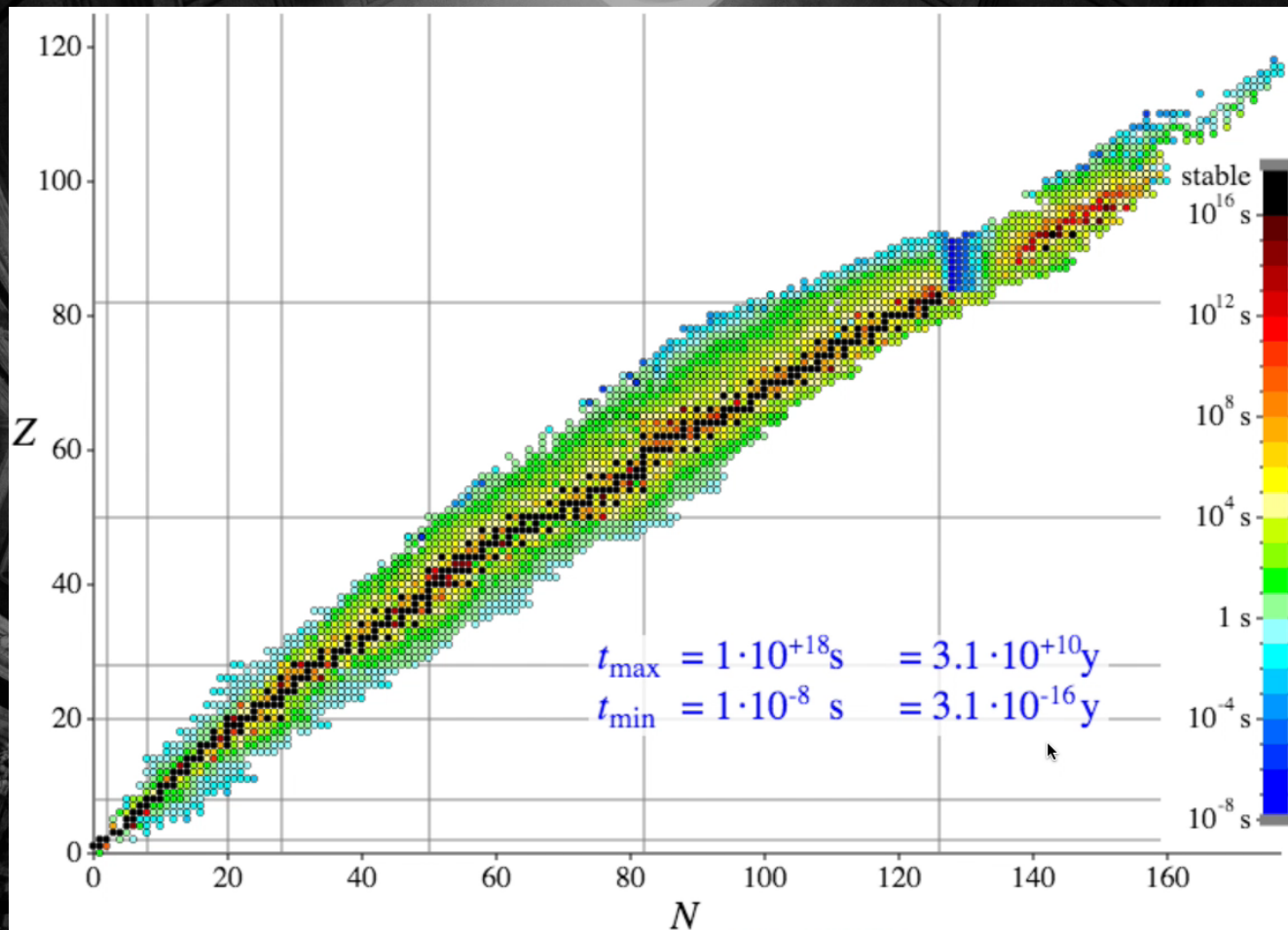
Idea (*)

(*) Patent Pending

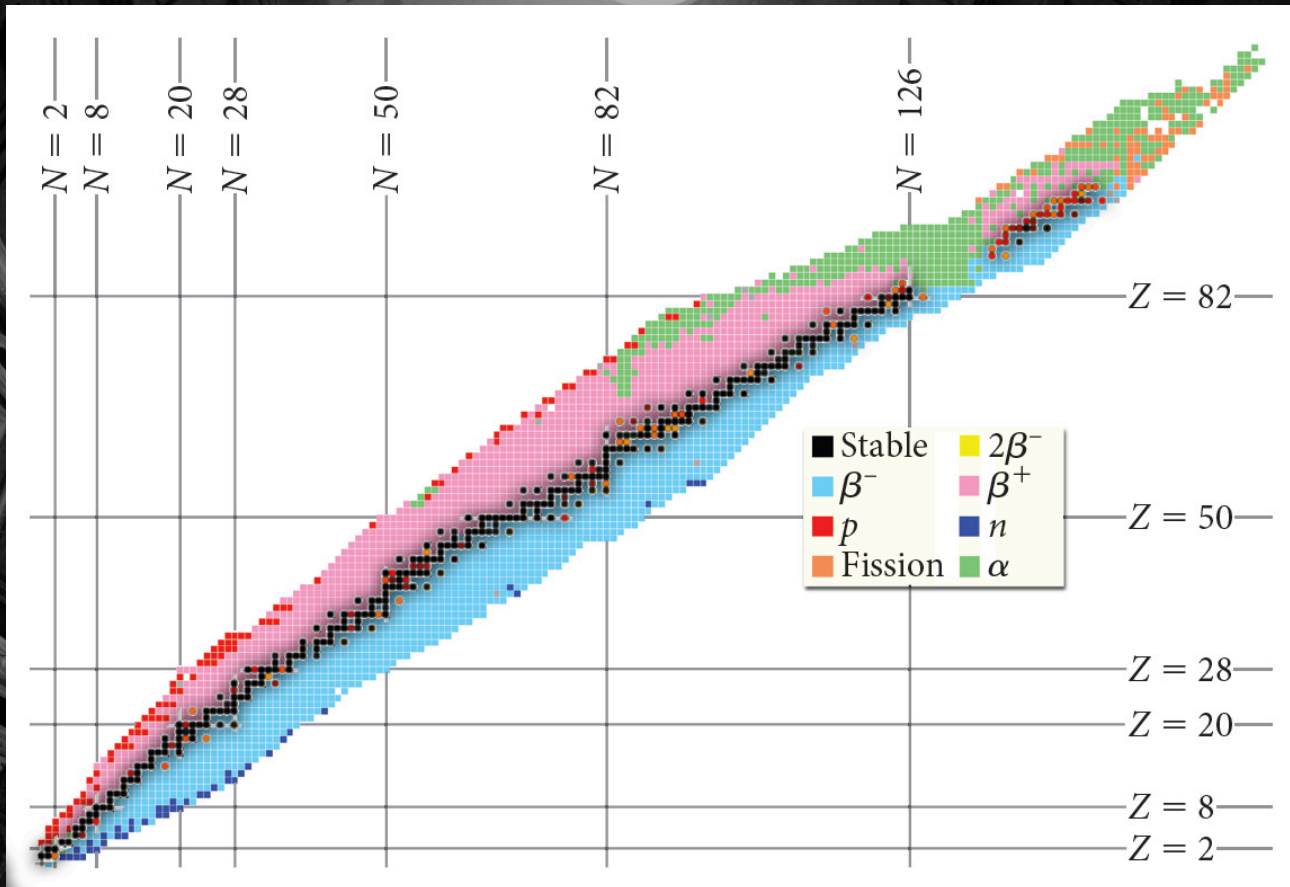
Rare Isotope Tagging of Artwork

- **Protect art by sub-surface implantation of rare isotopes**
- **Desired properties of isotope**
 - Must be easy to make in very expensive accelerators (FRIB, RIKEN, FAIR, ...)
 - Must be impossible to make in cheap accelerators
 - Must have lifetimes of a few months to centuries
 - Must have precise decay signature
 - Must have unique decay signature (not available from other isotopes)
 - Must be non-hazardous

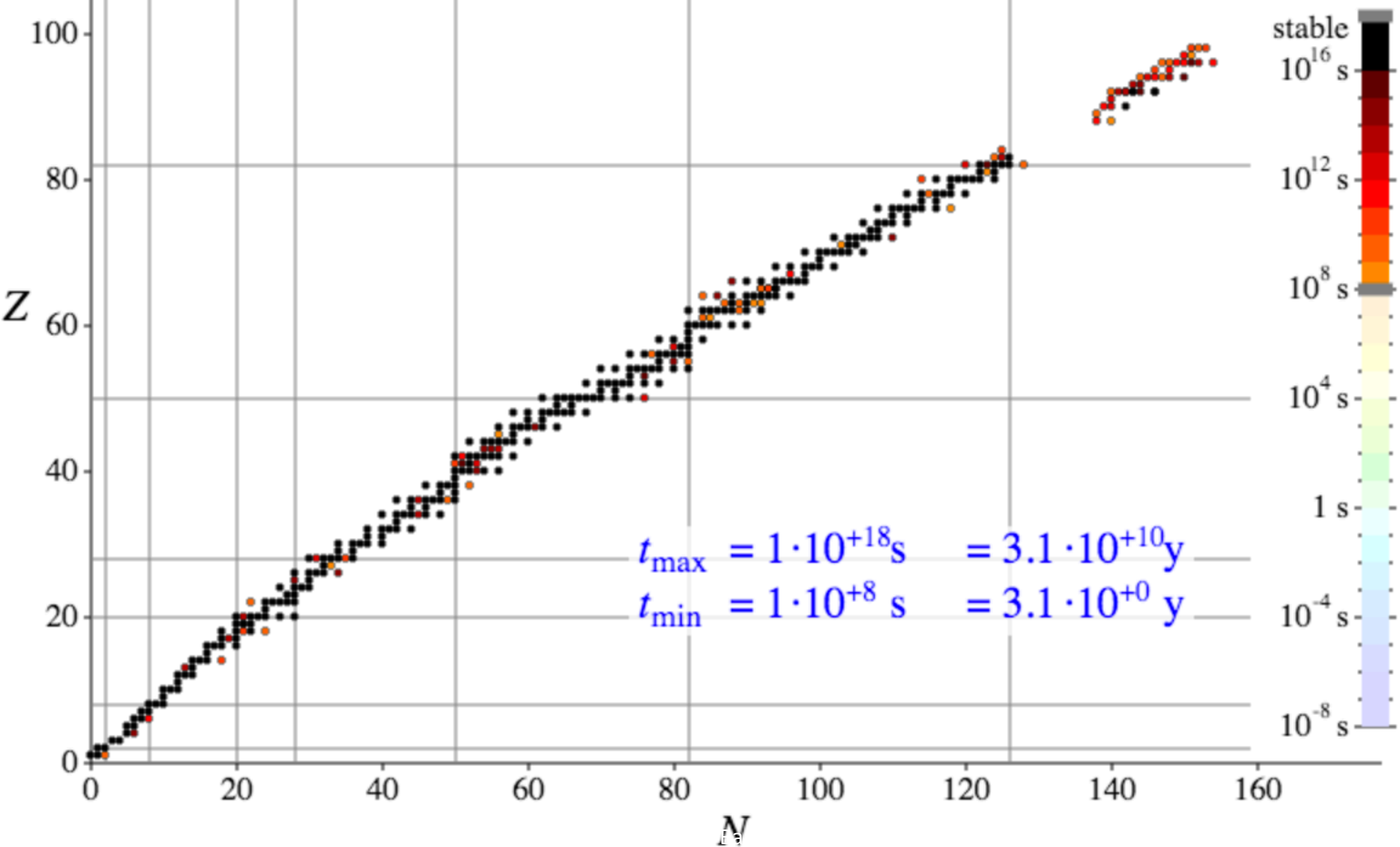
Isotope Half-lives

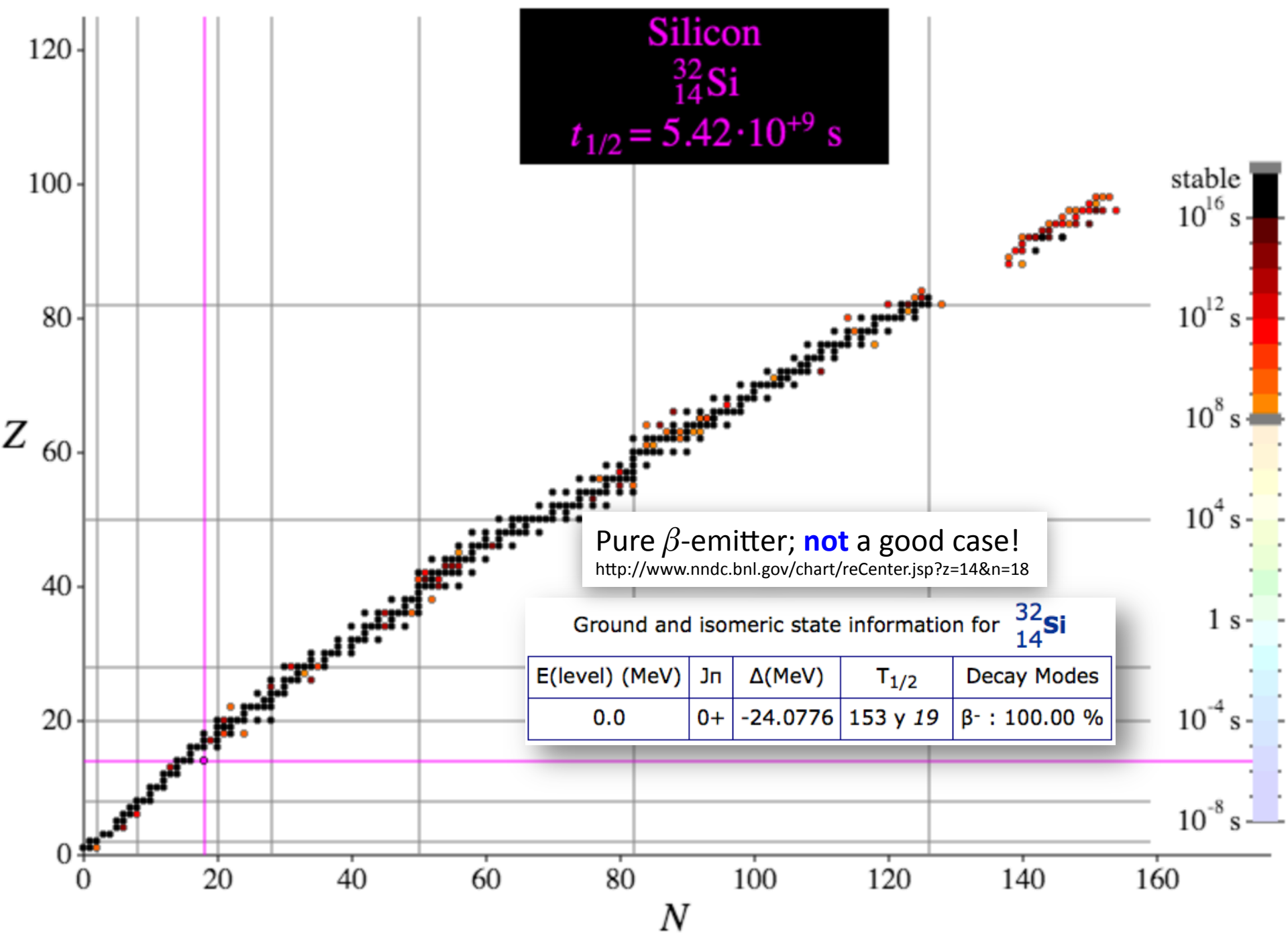


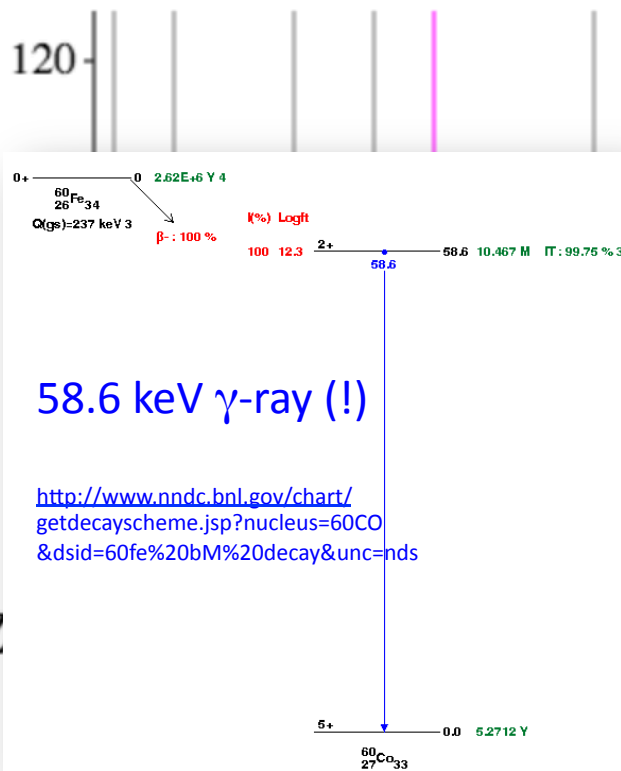
Isotope Decay Modes



Which are Usable Isotopes?



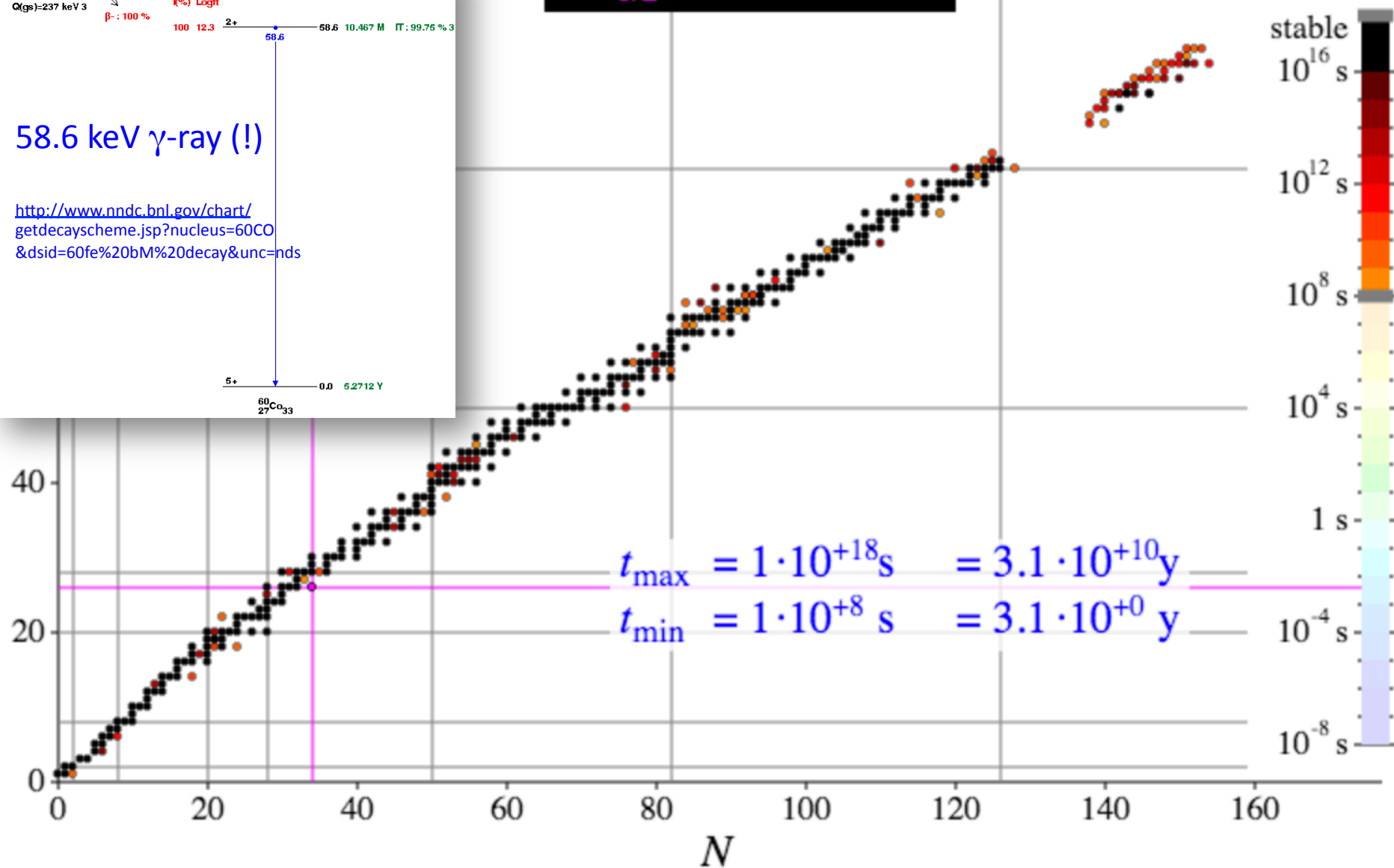




58.6 keV γ -ray (!)

<http://www.nndc.bnl.gov/chart/getdecayscheme.jsp?nucleus=60CO&dsid=60fe%20bM%20decay&unc=nds>

Iron
 $^{60}_{26}\text{Fe}$
 $t_{1/2} = 4.73 \cdot 10^{+13}\text{s}$



Gadolinium



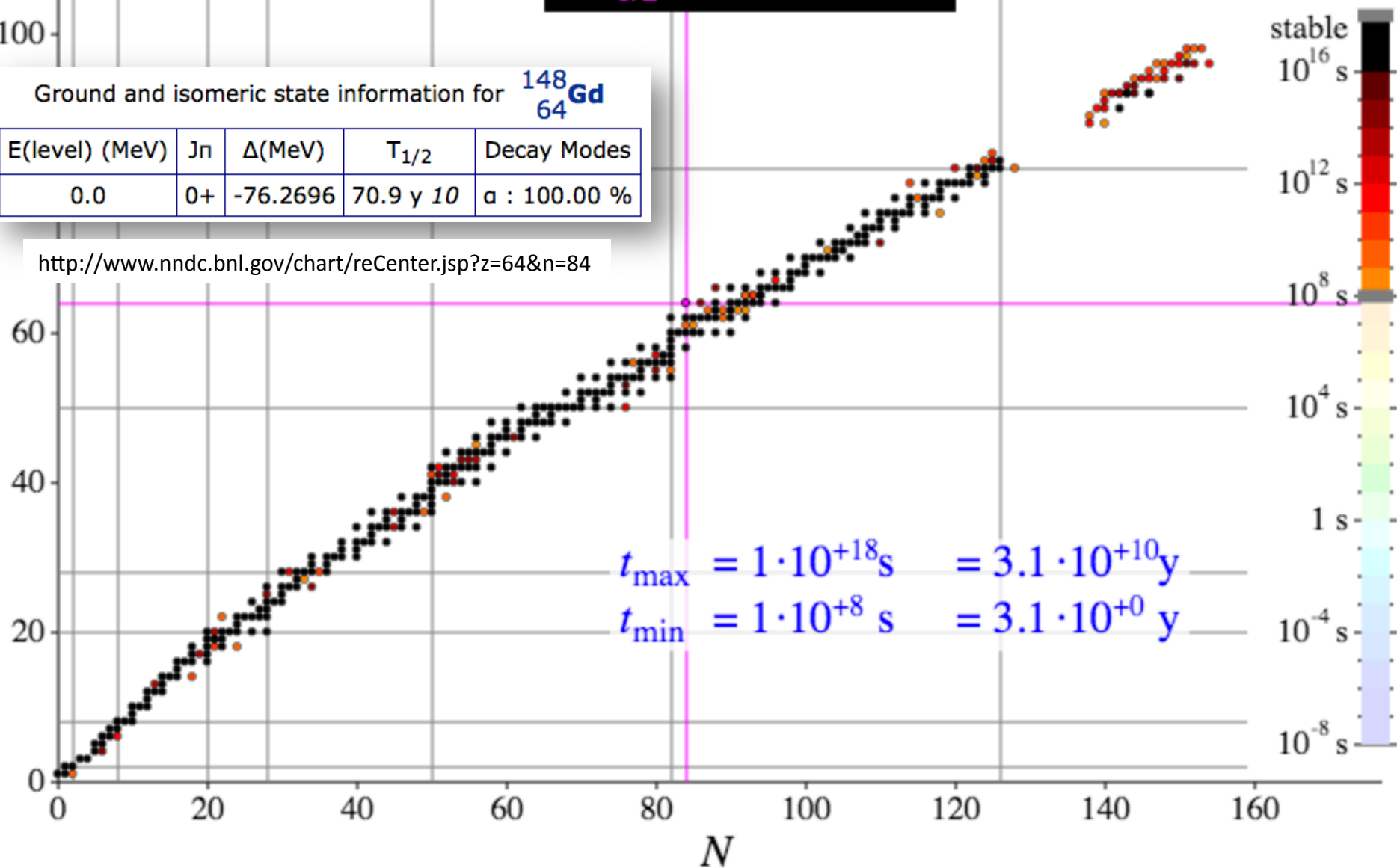
$$t_{1/2} = 2.35 \cdot 10^9 \text{ s}$$

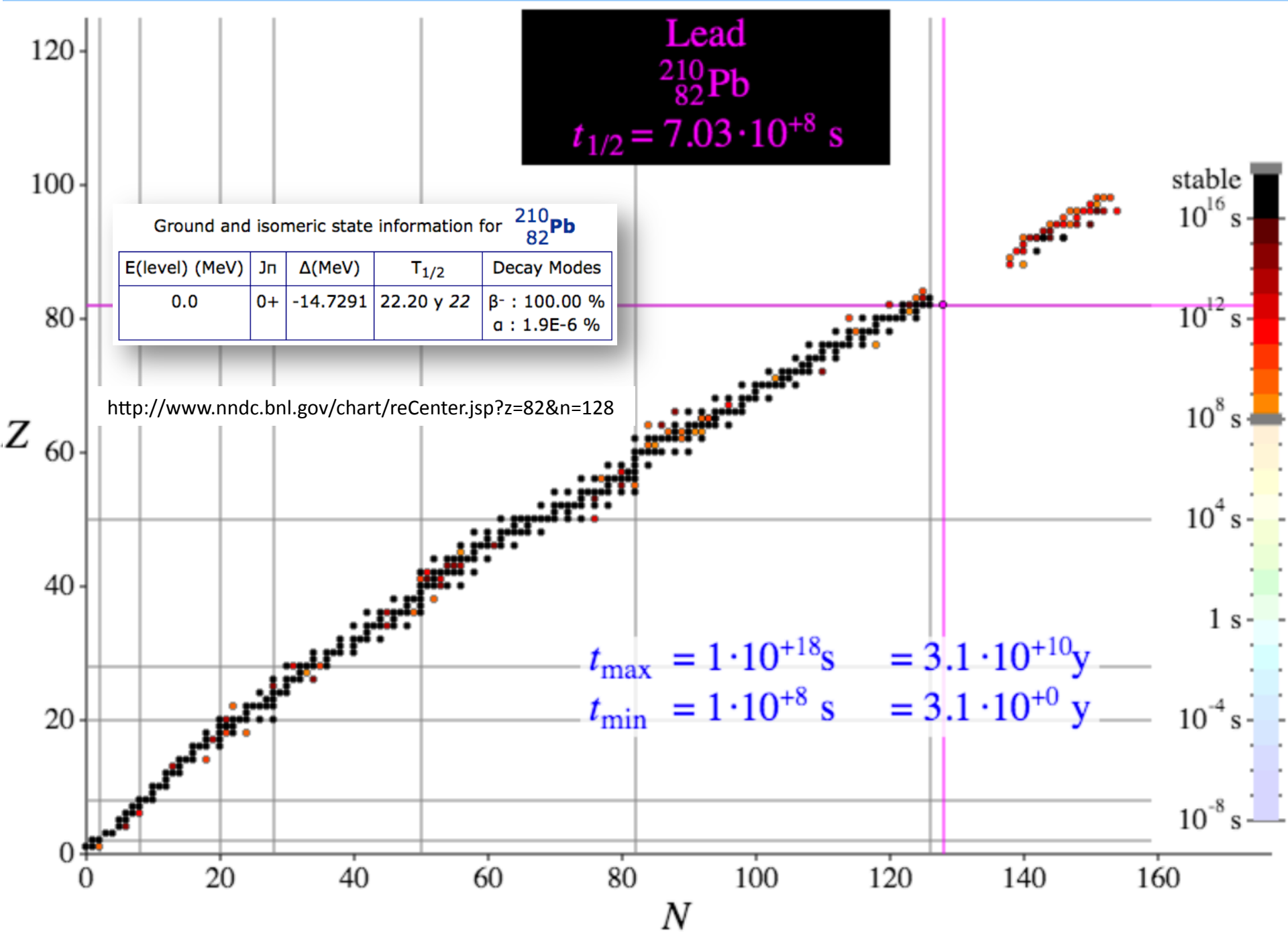
Ground and isomeric state information for $^{148}_{64}\text{Gd}$

E(level) (MeV)	J π	Δ (MeV)	T $_{1/2}$	Decay Modes
0.0	0+	-76.2696	70.9 y 10	α : 100.00 %

<http://www.nndc.bnl.gov/chart/reCenter.jsp?z=64&n=84>

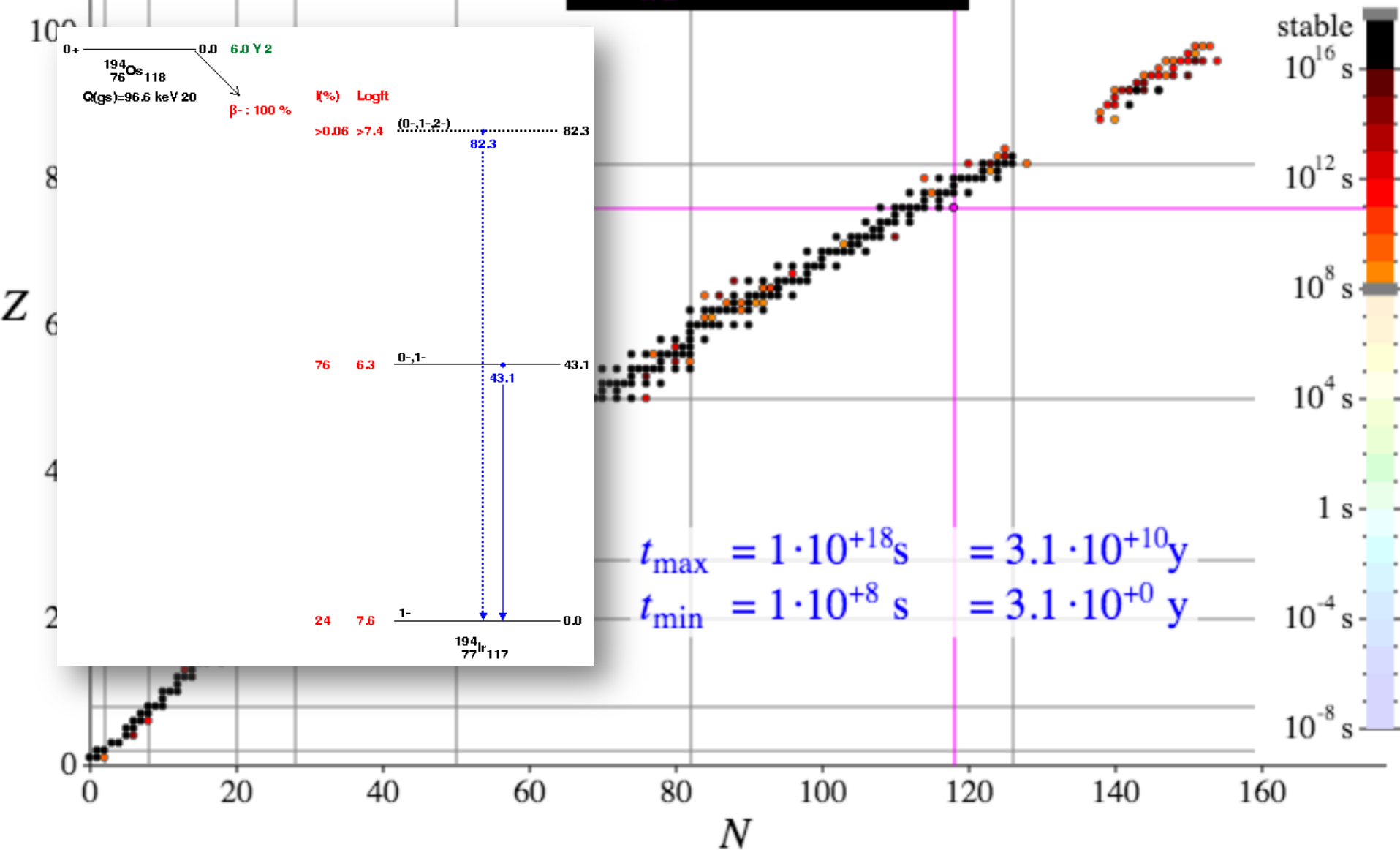
Z



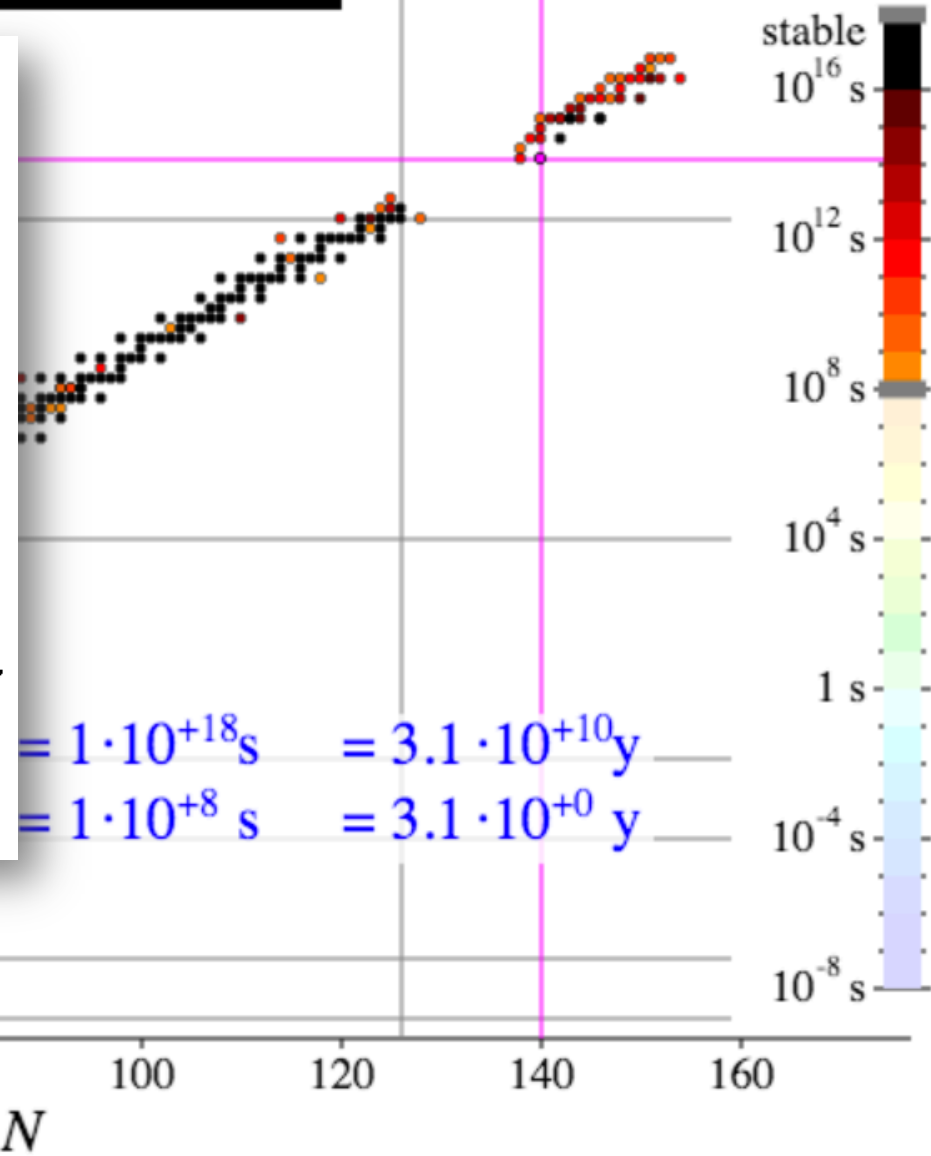
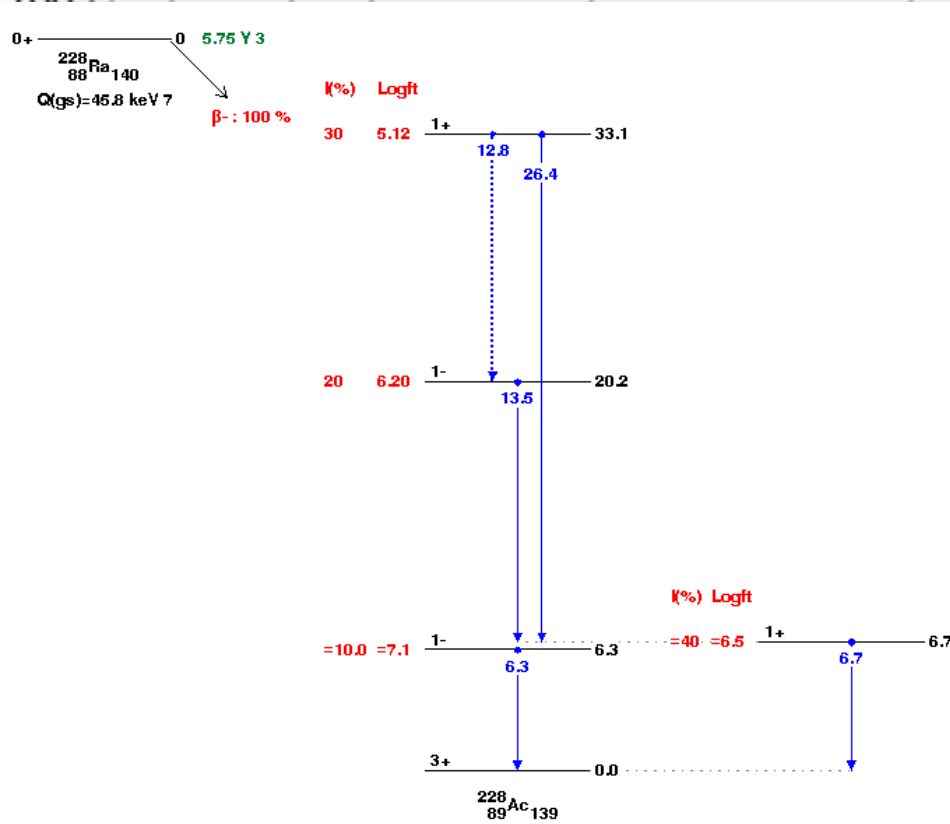


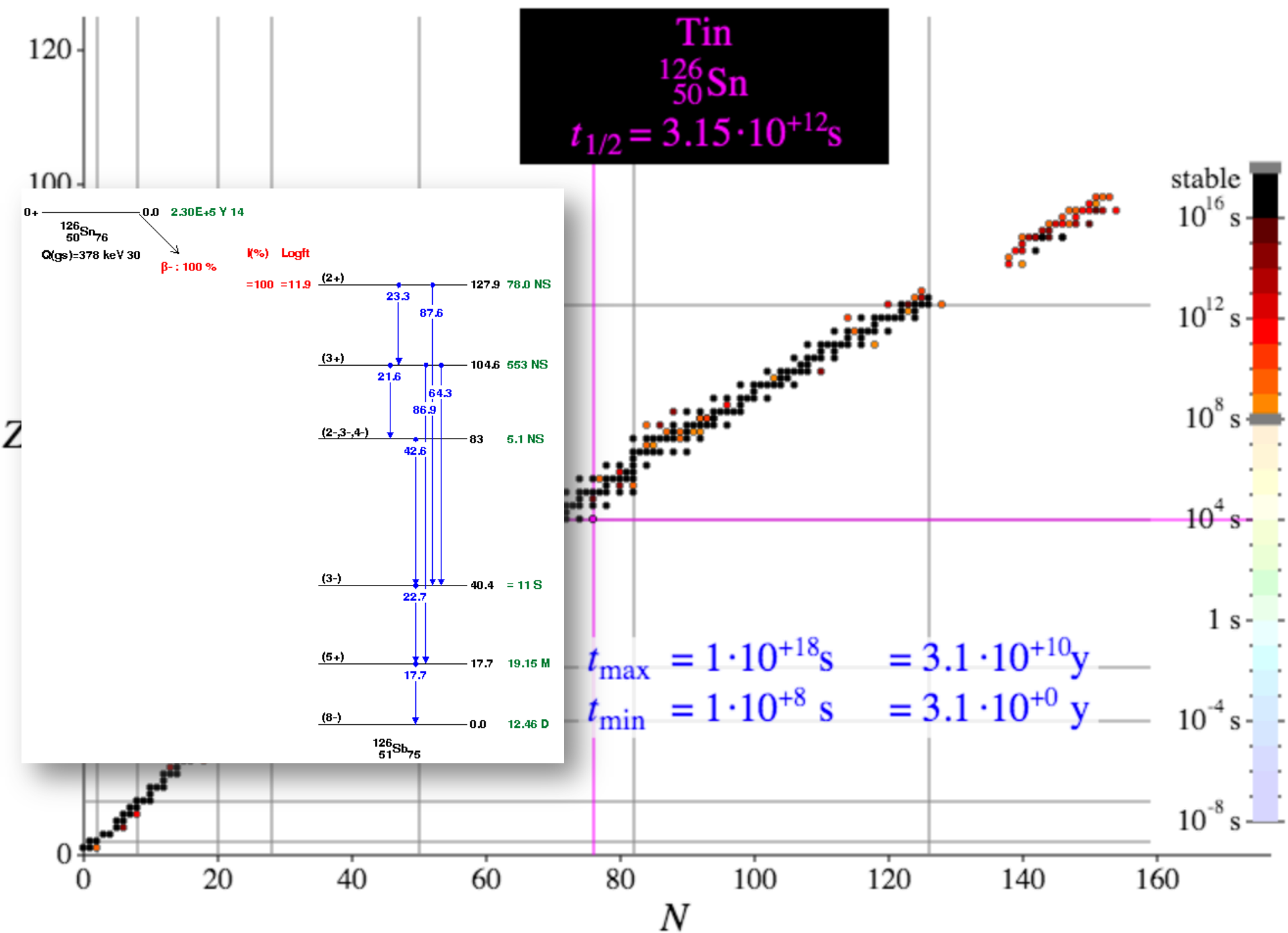
$^{194}_{76}\text{Os}$

$$t_{1/2} = 1.89 \cdot 10^8 \text{ s}$$



Radium
 $^{228}_{88}\text{Ra}$
 $t_{1/2} = 1.81 \cdot 10^{+8} \text{ s}$





Facility for Rare Isotope Beams

Scheduled completion 2022 on track for 2021



FRIB



Facility for Rare Isotope Beams

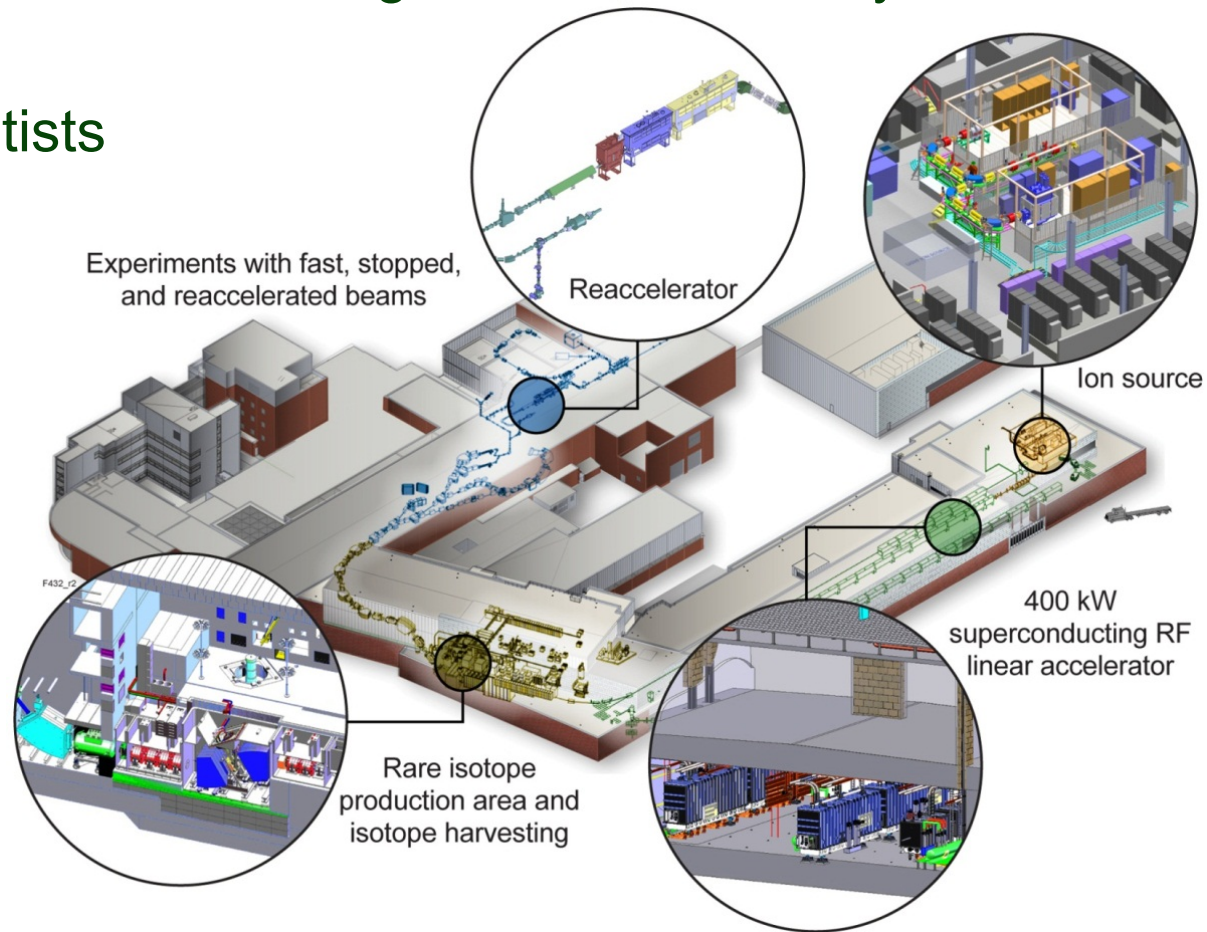
U.S. Department of Energy Office of Science
Michigan State University

B. Sherrill, October 2015, Broad Financial Markets Institute Board, Slide 19

Facility for Rare Isotope Beams

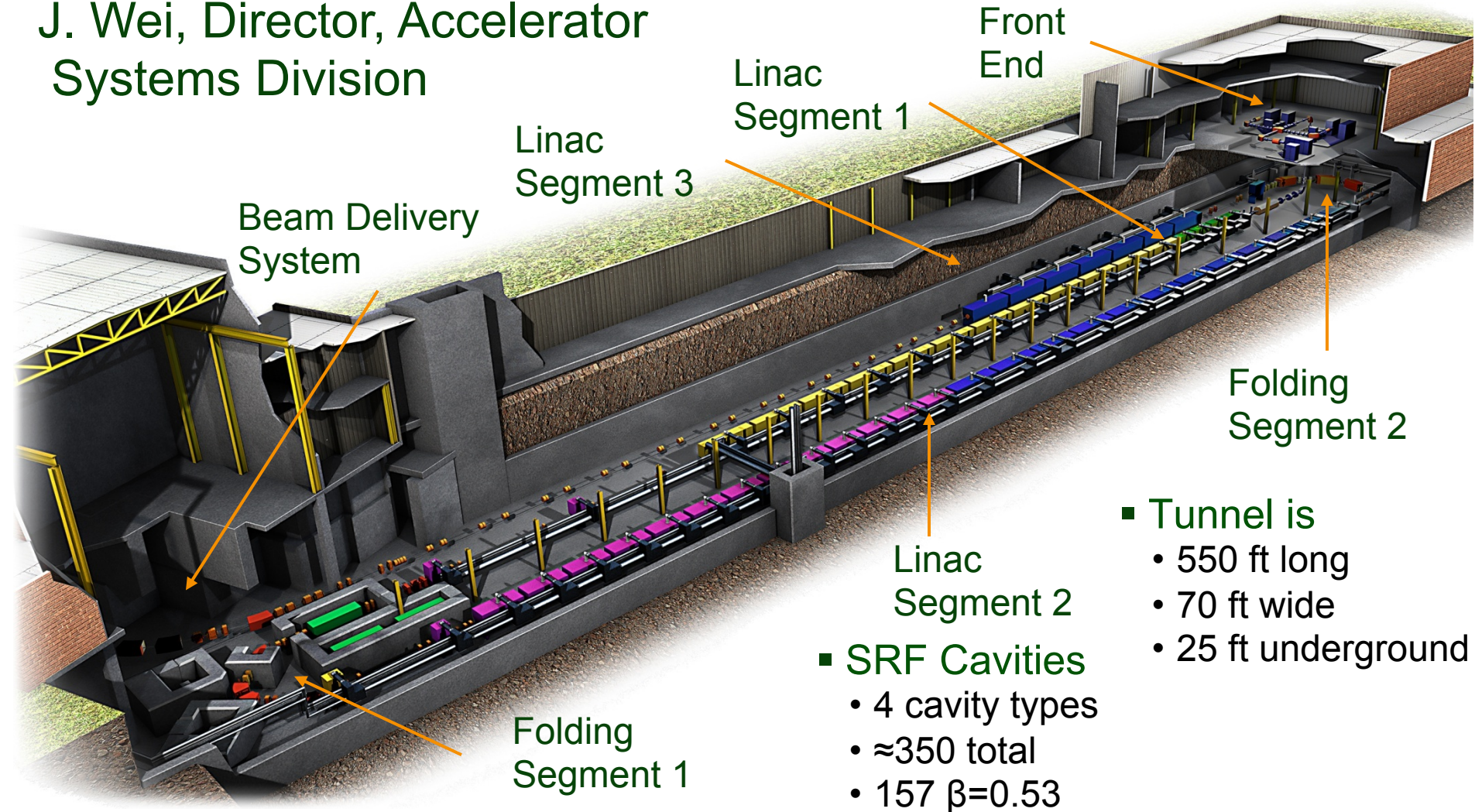
A Future DOE-SC Scientific User Facility for Nuclear Physics

- Funded by U.S. Department of Energy Office of Science with contributions and cost share from Michigan State University and State of Michigan
- Serving over 1,300 scientists
- Key feature is 400 kW beam power
- Separation of isotopes in-flight
 - Fast development time for any isotope
 - Suited for all elements and short half-lives



FRIB Driver Linear Accelerator

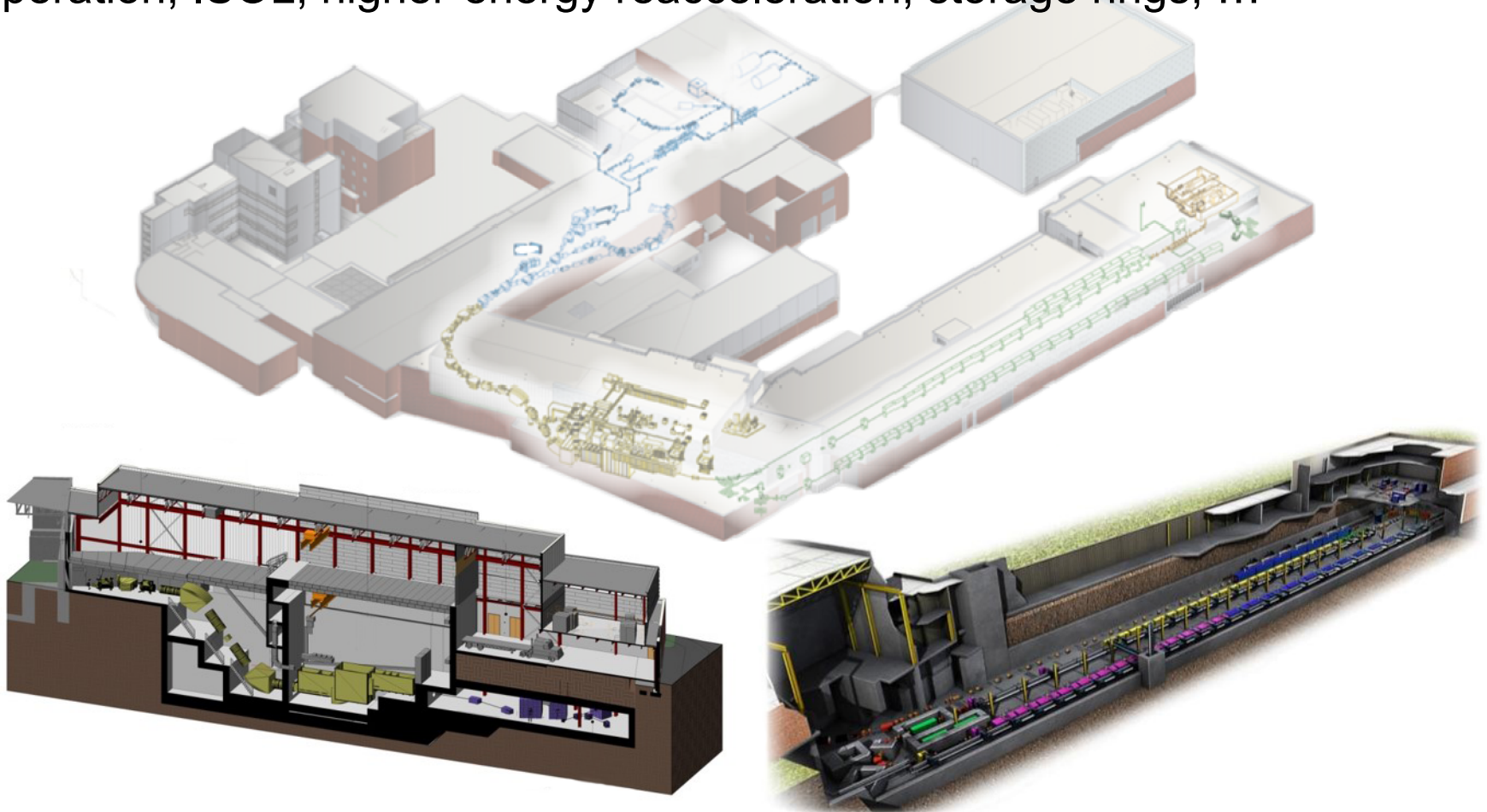
J. Wei, Director, Accelerator
Systems Division



- **Tunnel is**
 - 550 ft long
 - 70 ft wide
 - 25 ft underground
- **SRF Cavities**
 - 4 cavity types
 - ≈ 350 total
 - 157 $\beta=0.53$

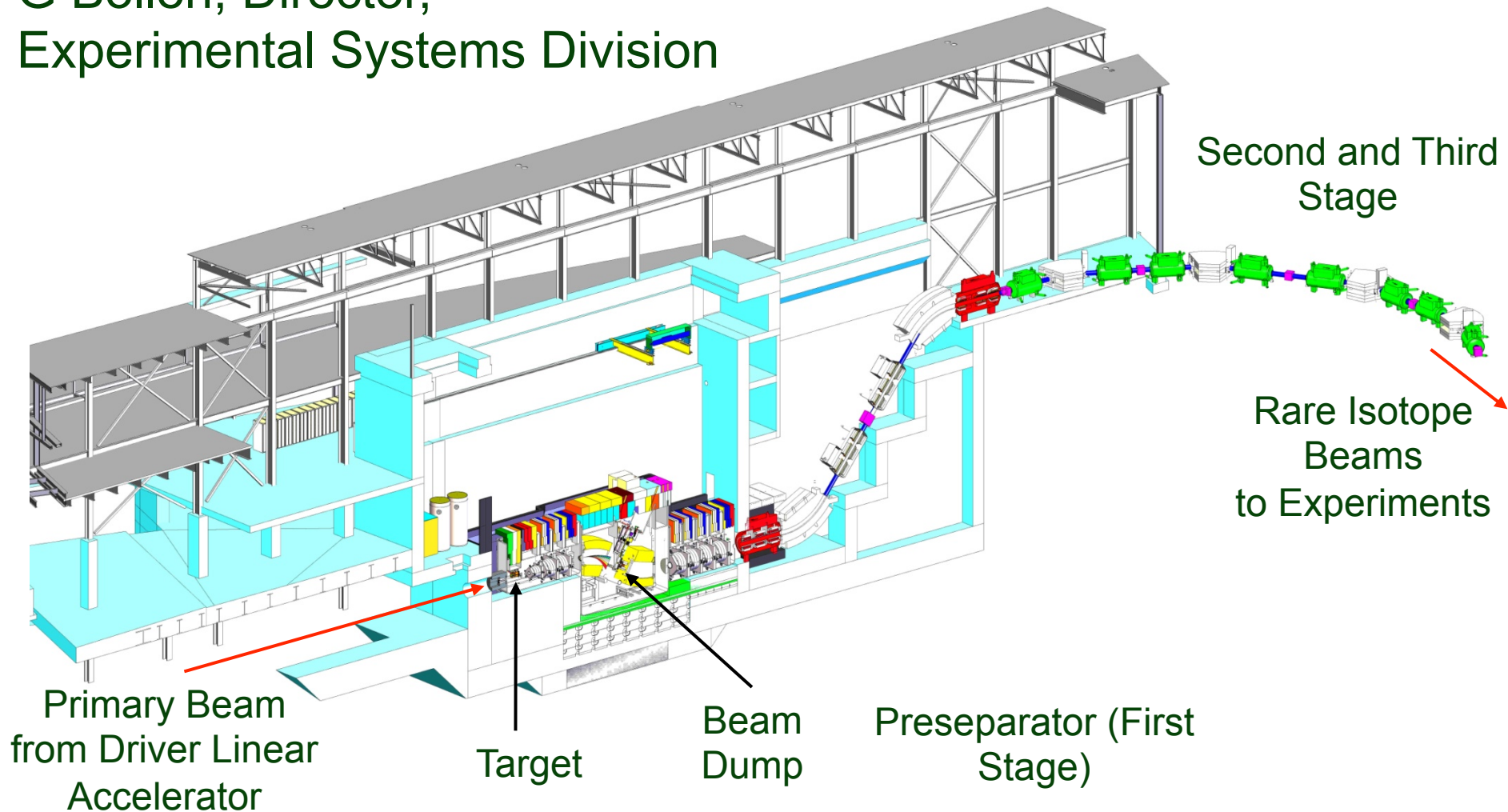
Integrated Design Includes Options for Science-Driven Upgrades

Possibilities include higher beam energy, isotope harvesting, multi-user operation, ISOL, higher-energy reacceleration, storage rings, ...



Isotope Production Area Target and Fragment Separator

G Bollen, Director,
Experimental Systems Division



FRIB Construction is Underway: Ground Breaking March 17, 2014



FRIB construction site 17 March 2014 – www.frib.msu.edu



Facility for Rare Isotope Beams
U.S. Department of Energy Office of Science
Michigan State University

Sherrill - Fundamental Symmetry Tests with Rare Isotopes 2014, Slide 24

Civil Construction Eight Weeks Ahead of Baseline Schedule



FRIB construction site – October 2015

Web cameras at www.frib.msu.edu



Facility for Rare Isotope Beams
U.S. Department of Energy Office of Science
Michigan State University

B. Sherrill, October 2015, Broad Financial Markets Institute Board, Slide 25

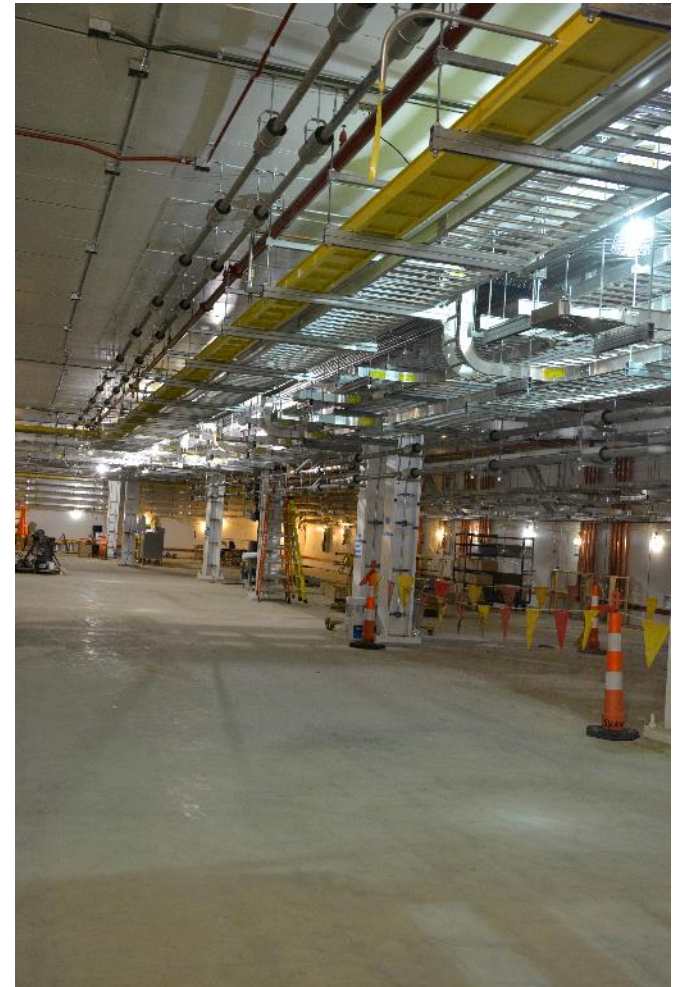
Conventional Facilities Progress



View of tunnel lid re-steel looking east

■ Tunnel is

- 570 feet long
- 70 feet wide
- 32 feet underground



Linac tunnel facing east

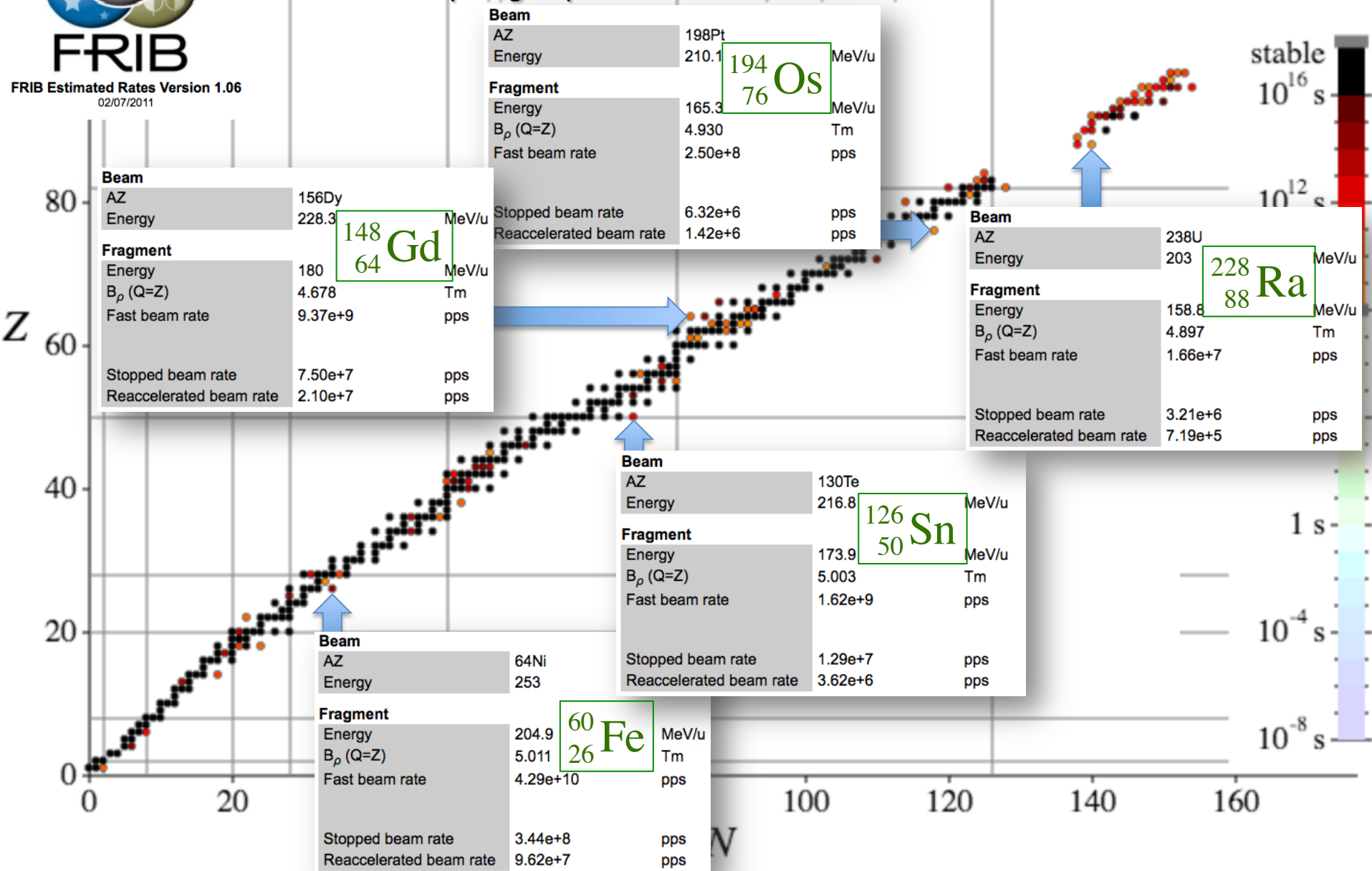


FRIB

FRIB Estimated Rates Version 1.06
02/07/2011

Predicted FRIB Rates

<https://groups.nsl.msu.edu/frib/rates/fribrates.html>



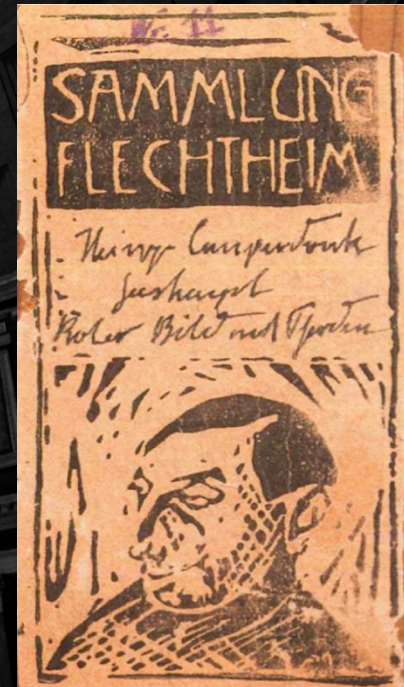
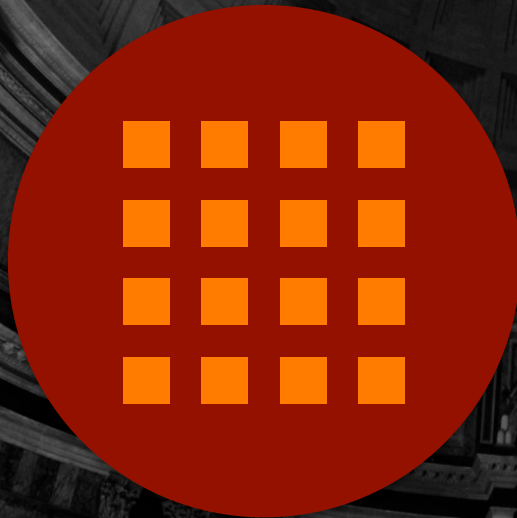
Detecting the Radiation

- Use commercially available radiation detectors
- Handheld, ~\$1k
- Isotope identification



Isotope Patches in Combination

- Use masks to apply isotopes in certain combinations to different parts of the tag allows unique identifiers for each piece of art (... or other rare and valuable items)





The Card Players, Paul Cézanne, 1892 (sold in 2011 for >\$259 to State of Qatar)



work with **Brad Sherrill**, MSU&NSCL

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