Nuclear octupole shapes in Actinides with Fayans functionals

G. Danneaux [1]

gauthier.j.danneaux@jyu.fi

[1] Department of Physics, University of Jyväskylä, Jyväskylä, Finland

PLATAN 2024, JUNE 11th 2024

JYVÄSKYLÄN YLIOPISTO
UNIVERSITY OF JYVÄSKYLÄ

ACADEMY OF FINLAND

1) At the heart of nuclei

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution
- Energy Density Functional

$$\epsilon_t^{even} = \left(C_{t0}^{\rho} + \rho_0^{\gamma} C_{tD}^{\rho}\right)\rho_t^2 + C_t^{\tau}\rho_t\tau_t + C_t^{\Delta\rho}\rho_t\Delta\rho_t + C_t^{\nabla J}\rho_t\nabla J_t + C_t^{J} J_t^2$$
$$\epsilon_t^{odd} = \left(C_{t0}^{s} + \rho_0^{\gamma} C_{tD}^{s}\right)s_t^2 + \cdots \qquad t = 0,1$$

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution
- Energy Density Functional

$$\epsilon_t^{even} = \left(C_{t0}^{\rho} + \rho_0^{\gamma} C_{tD}^{\rho}\right)\rho_t^2 + C_t^{\tau}\rho_t\tau_t + C_t^{\Delta\rho}\rho_t\Delta\rho_t + C_t^{\nabla J}\rho_t\nabla J_t + C_t^{J} J_t^2$$
$$\epsilon_t^{odd} = \left(C_{t0}^{s} + \rho_0^{\gamma} C_{tD}^{s}\right)s_t^2 + \cdots \qquad t = 0,1$$

- Variety of Skyrme-based EDFs, adjusted, strong results [1]

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution
- Energy Density Functional

$$\epsilon_t^{even} = \left(C_{t0}^{\rho} + \rho_0^{\gamma} C_{tD}^{\rho}\right)\rho_t^2 + C_t^{\tau}\rho_t\tau_t + C_t^{\Delta\rho}\rho_t\Delta\rho_t + C_t^{\nabla J}\rho_t\nabla J_t + C_t^J J_t^2$$
$$\epsilon_t^{odd} = \left(C_{t0}^{s} + \rho_0^{\gamma} C_{tD}^{s}\right)s_t^2 + \cdots \qquad t = 0{,}1$$

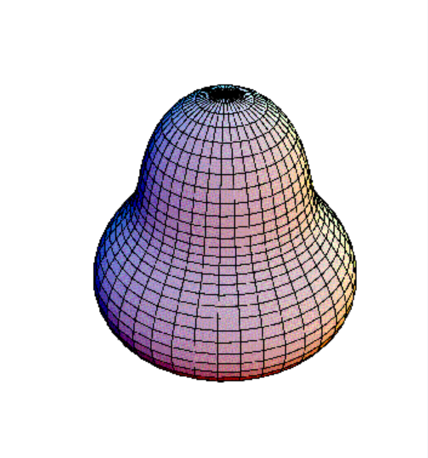
- Variety of Skyrme-based EDFs, adjusted, strong results [1]
- Still lacks in systematics, excitation spectra, etc.

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution
- Energy Density Functional

$$\epsilon_t^{even} = \left(C_{t0}^{\rho} + \rho_0^{\gamma} C_{tD}^{\rho}\right)\rho_t^2 + C_t^{\tau}\rho_t\tau_t + C_t^{\Delta\rho}\rho_t\Delta\rho_t + C_t^{\nabla J}\rho_t\nabla J_t + C_t^J J_t^2$$
$$\epsilon_t^{odd} = \left(C_{t0}^{s} + \rho_0^{\gamma} C_{tD}^{s}\right)s_t^2 + \cdots \qquad t = 0,1$$

- Variety of Skyrme-based EDFs, adjusted, strong results [1]
- Still lacks in systematics, excitation spectra, etc.

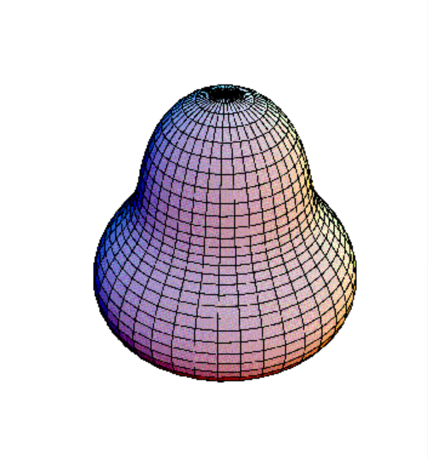


- Octupole deformation [2], lower impact in current gen EDFs

1) At the heart of nuclei

- Density Functional Theory -> iterative self-consistent operations -> stable solution
- Energy Density Functional

$$\epsilon_t^{even} = \left(C_{t0}^{\rho} + \rho_0^{\gamma} C_{tD}^{\rho}\right)\rho_t^2 + C_t^{\tau}\rho_t\tau_t + C_t^{\Delta\rho}\rho_t\Delta\rho_t + C_t^{\nabla J}\rho_t\nabla J_t + C_t^{J}J_t^2$$
$$\epsilon_t^{odd} = \left(C_{t0}^{s} + \rho_0^{\gamma} C_{tD}^{s}\right)s_t^2 + \cdots \qquad t = 0,1$$



- Variety of Skyrme-based EDFs, adjusted, strong results [1]
- Still lacks in systematics, excitation spectra, etc.

- Octupole deformation [2], lower impact in current gen EDFs
- Fayans Pairing Term [3] -> adjusted Next-gen Fayans Functionals [4] [5] [6]

1) At the heart of nuclei

Skyrme and Fayans EDFs

Skyrme

$$\mathcal{E}_{\text{pair},q} = \frac{1}{4}\underline{V_{\text{pair},q}}\left(1 - \frac{\rho_0}{\underline{\rho_{\text{pair}}}}\right)\breve{\rho}_q^2 \qquad (q = p, n)$$

$$\mathcal{E}_{\text{Sk},t} = C_t^{\rho\rho}(\rho_0)\rho_t^2 + C_t^{\rho\tau}\rho_t\tau_t + C_t^{\rho\Delta\rho}\rho_t\Delta\rho_t + C_t^{\rho\nabla J}\rho_t\nabla\cdot\boldsymbol{J}_t + C_t^{J^2}\boldsymbol{J}_t^2$$

$$E_C = e^2\int d^3r\, d^3r'\rho_p(\boldsymbol{r})\frac{1}{|\boldsymbol{r}-\boldsymbol{r}'|}\rho_p(\boldsymbol{r}')$$

$$\mathcal{E}_{\text{C,ex}} = -\tfrac{3}{4}e^2\left(\frac{3}{\pi}\right)^{1/3}\rho_p^{4/3}.$$

Fayans EDFs

$$\mathcal{E}_{\text{Fy},q}^{\text{pair}} = \frac{2\varepsilon_F}{3\rho_{\text{sat}}}\breve{\rho}_q^2\left[f_{\text{ex}}^{\xi} + h_+^{\xi}x_{\text{pair}}^{\gamma} + \underline{h_{\nabla}^{\xi}r_s^2(\nabla x_{\text{pair}})^2}\right]$$

$$x_t = \frac{\rho_t}{\rho_{\text{sat}}}, \quad x_{\text{pair}} = \frac{\rho_0}{\rho_{\text{pair}}}$$

$$\mathcal{E}_{\text{Fy}}^{\text{v}} = \tfrac{1}{3}\varepsilon_F\rho_{\text{sat}}\left[a_+^{\text{v}}\frac{1-h_{1+}^{\text{v}}x_0^{\sigma}}{1+h_{2+}^{\text{v}}x_0^{\sigma}}x_0^2 + a_-^{\text{v}}\frac{1-h_{1-}^{\text{v}}x_0}{1+h_{2-}^{\text{v}}x_0}x_1^2.\right]$$

$$\mathcal{E}_{\text{Fy}}^{\text{s}} = \tfrac{1}{3}\varepsilon_F\rho_{\text{sat}}\frac{a_+^{\text{s}}r_s^2(\nabla x_0)^2}{1 + h_+^{\text{s}}x_0^{\sigma} + h_{\nabla}^{\text{s}}r_s^2(\nabla x_0)^2}$$

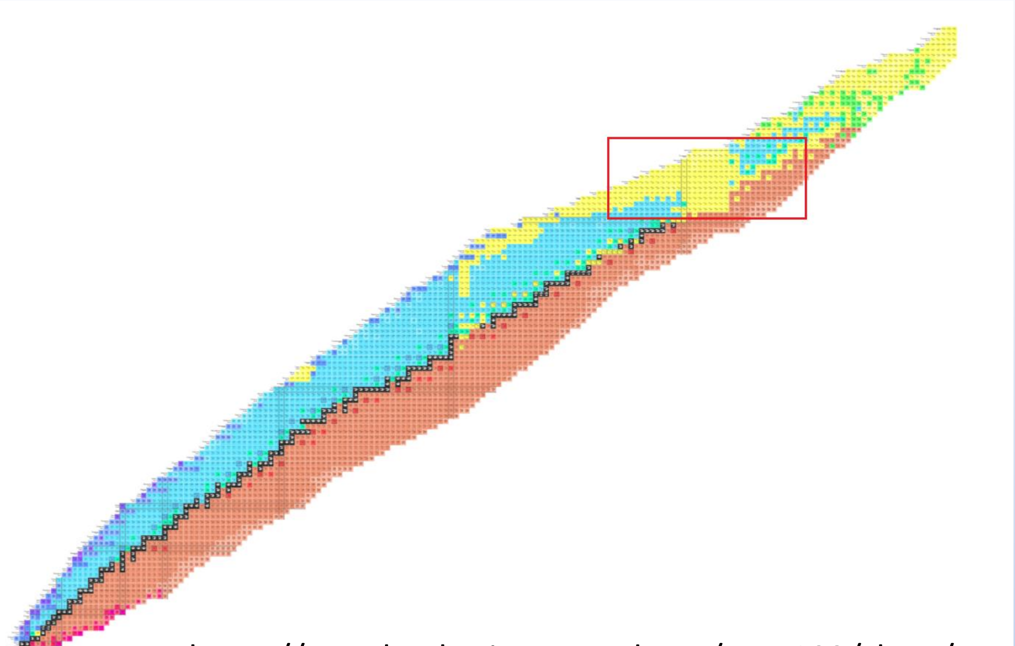
$$\mathcal{E}_{\text{Fy}}^{\text{ls}} = \frac{4\varepsilon_F r_s^2}{3\rho_{\text{sat}}}\left(\kappa\rho_0\nabla\cdot\boldsymbol{J}_0 + \kappa'\rho_1\nabla\cdot\boldsymbol{J}_1 + g\boldsymbol{J}_0^2 + g'\boldsymbol{J}_1^2\right)$$

$$\mathcal{E}_{\text{C,ex}} = -\tfrac{3}{4}e^2\left(\frac{3}{\pi}\right)^{1/3}\rho_p^{4/3}(1 - h_C x_0^{\sigma})$$

2) Actinides and octupoles

2) Actinides and octupoles

- Actinides and superheavy clusters expected to present β_3 [7] [8]



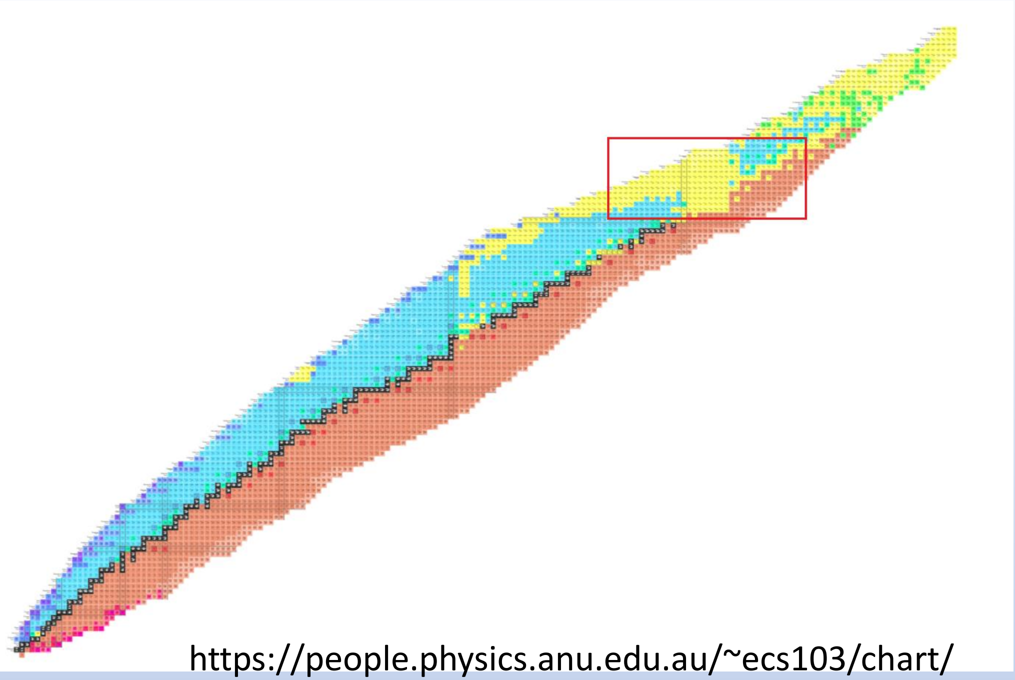
https://people.physics.anu.edu.au/~ecs103/chart/

2) Actinides and octupoles

- Actinides and superheavy clusters expected

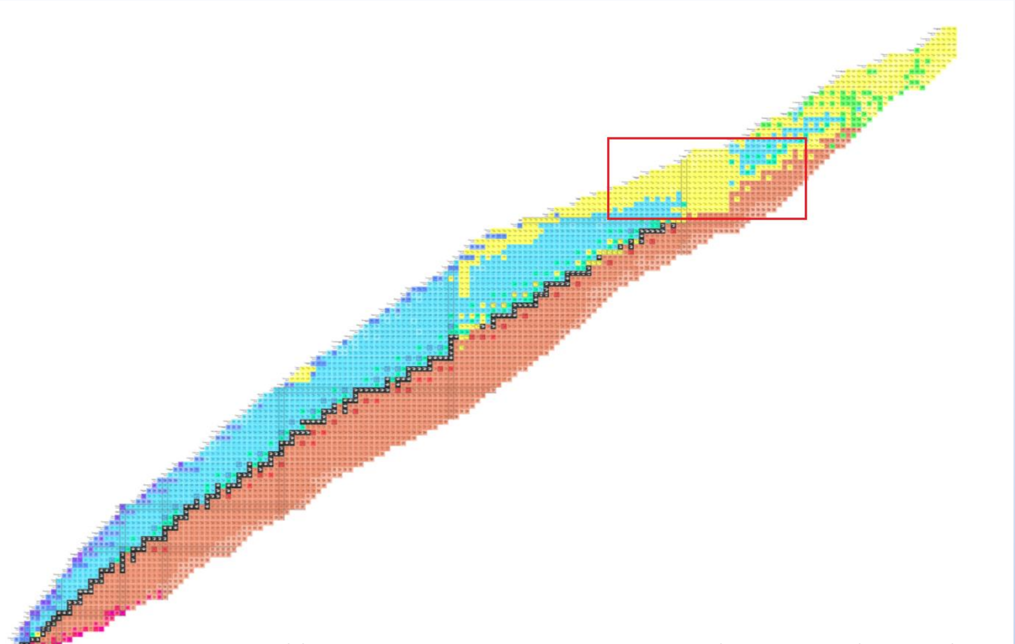
to present β_3 [7] [8]

- Systematic survey



https://people.physics.anu.edu.au/~ecs103/chart/

2) Actinides and octupoles


https://people.physics.anu.edu.au/~ecs103/chart/

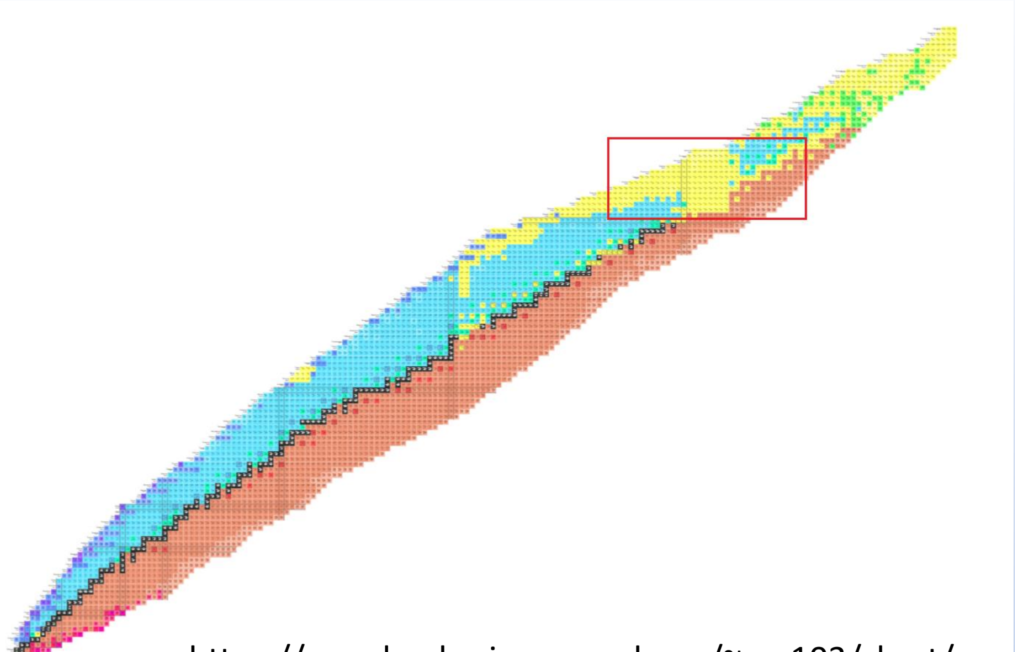
- Actinides and superheavy clusters expected

to present β_3 [7] [8]

- Systematic survey

- Spanned whole cluster 84 < Z < 108; 120 < N < 150

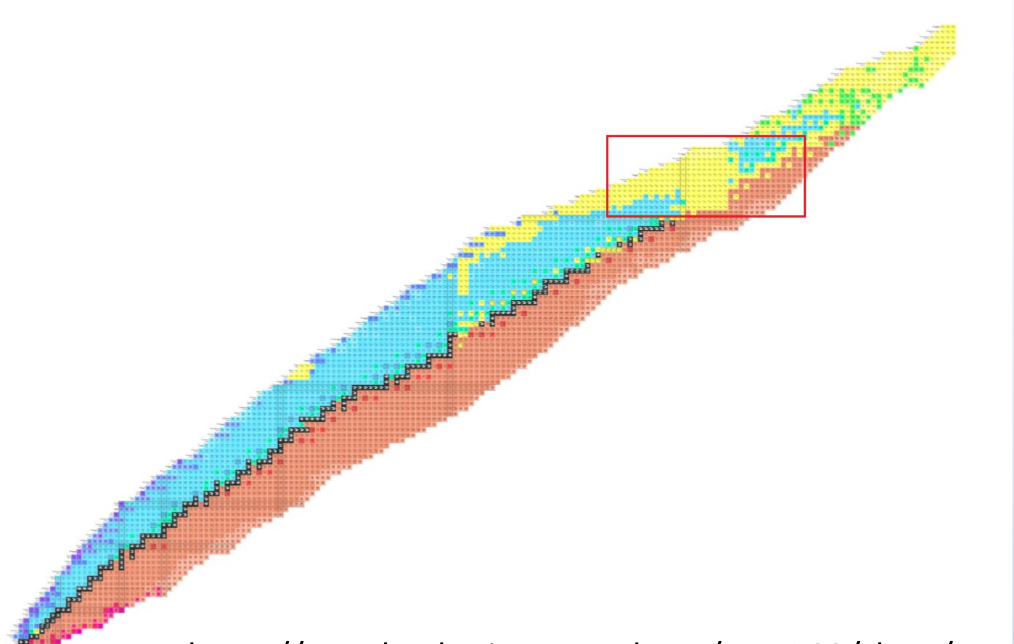
2) Actinides and octupoles



- Actinides and superheavy clusters expected to present β_3 [7] [8]
- Systematic survey

- Spanned whole cluster 84 < Z < 108; 120 < N < 150
- Ground state energy, β_2, β_3, $\Delta_{1;2n}$, rms radii, etc.

2) Actinides and octupoles

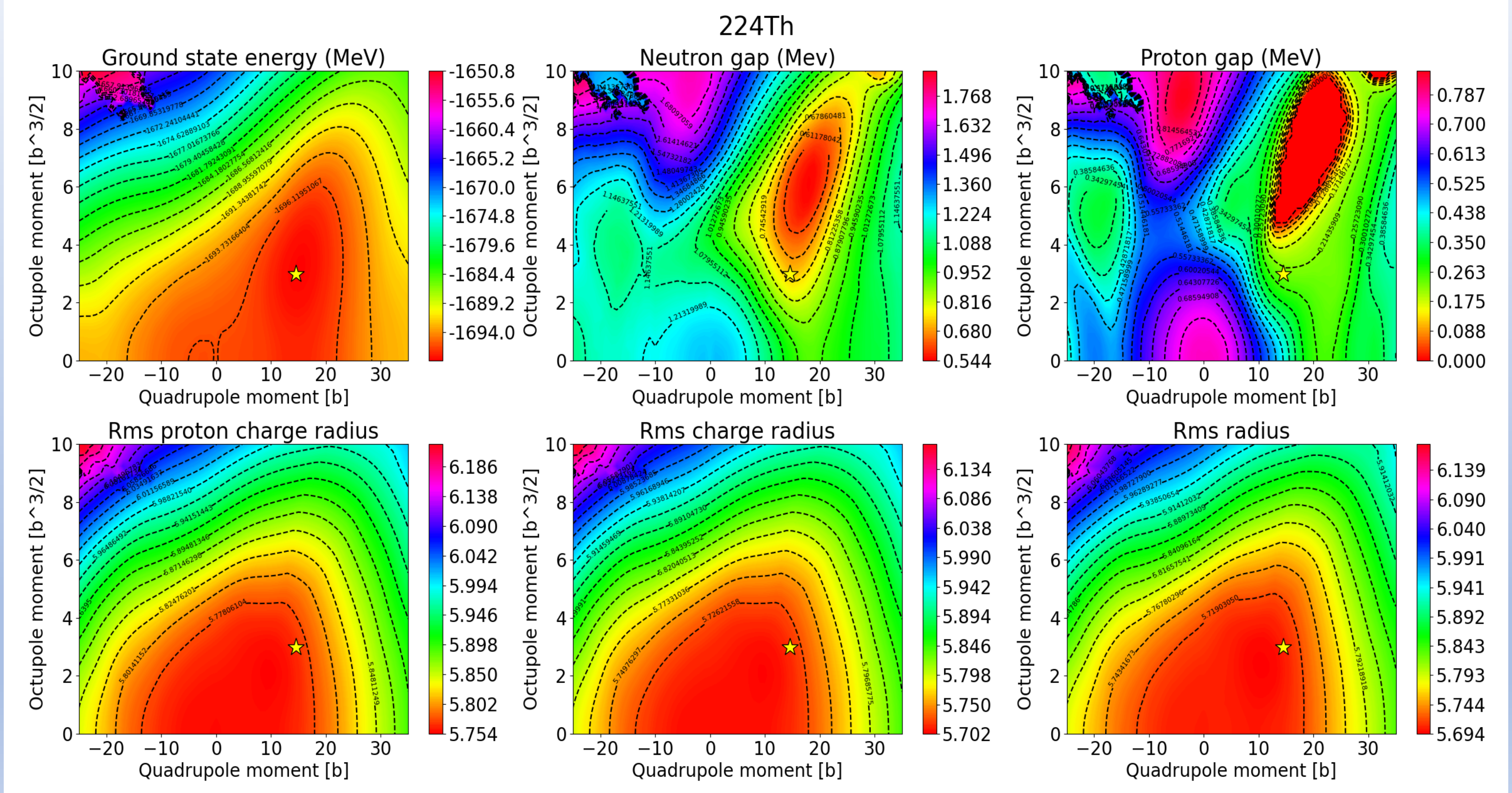

https://people.physics.anu.edu.au/~ecs103/chart/

- Actinides and superheavy clusters expected to present β_3 [7] [8]
- Systematic survey

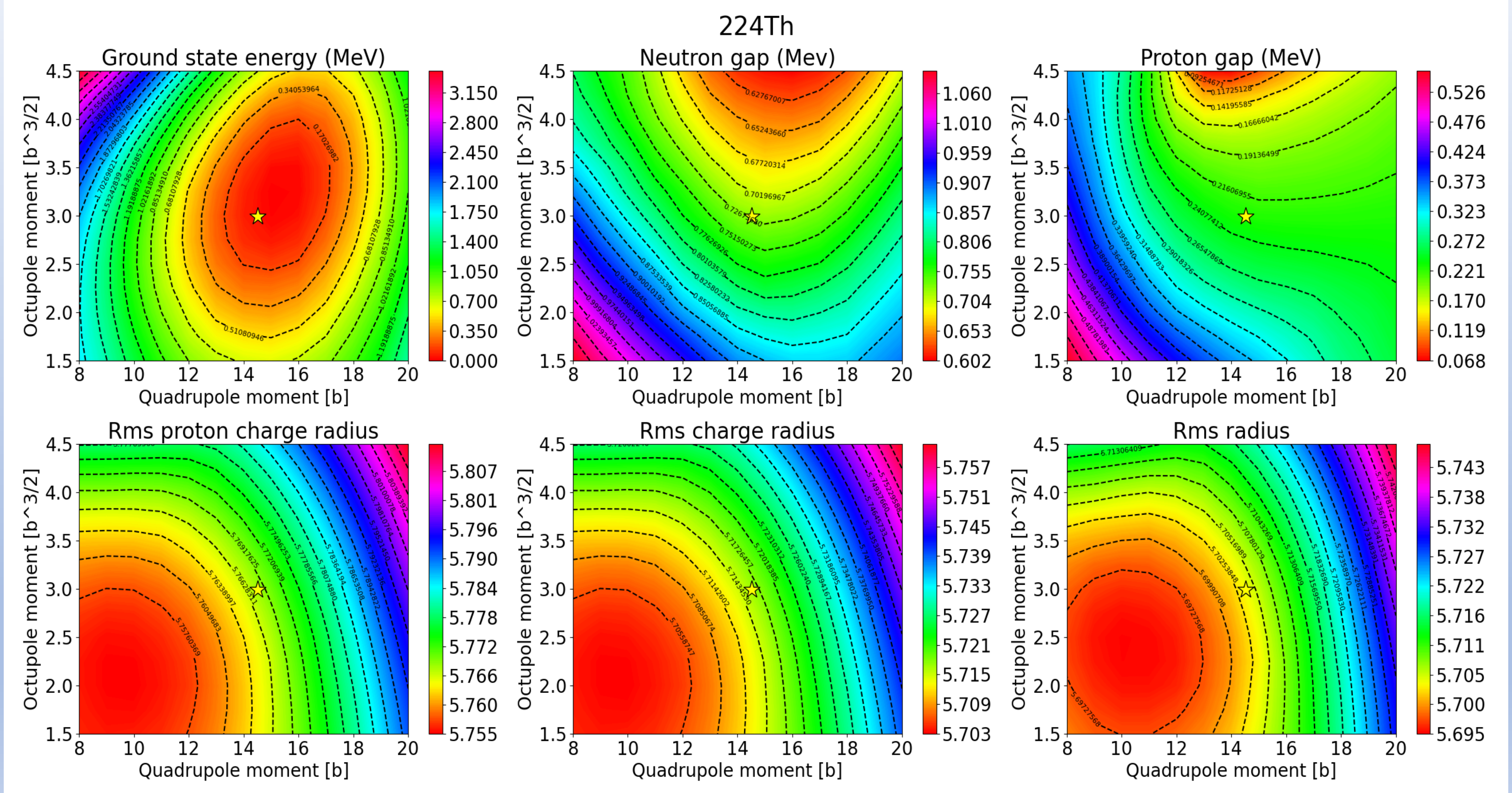
- Spanned whole cluster 84 < Z < 108; 120 < N < 150
- Ground state energy, β_2, β_3, $\Delta_{1;2n}$, rms radii, etc.
- Comparison to current-gen EDFs and studies on pear-shaped nuclei [9]

3) Fayans results in Actinides (FYdrHFB)

3) Fayans results in Actinides (FYdrHFB)

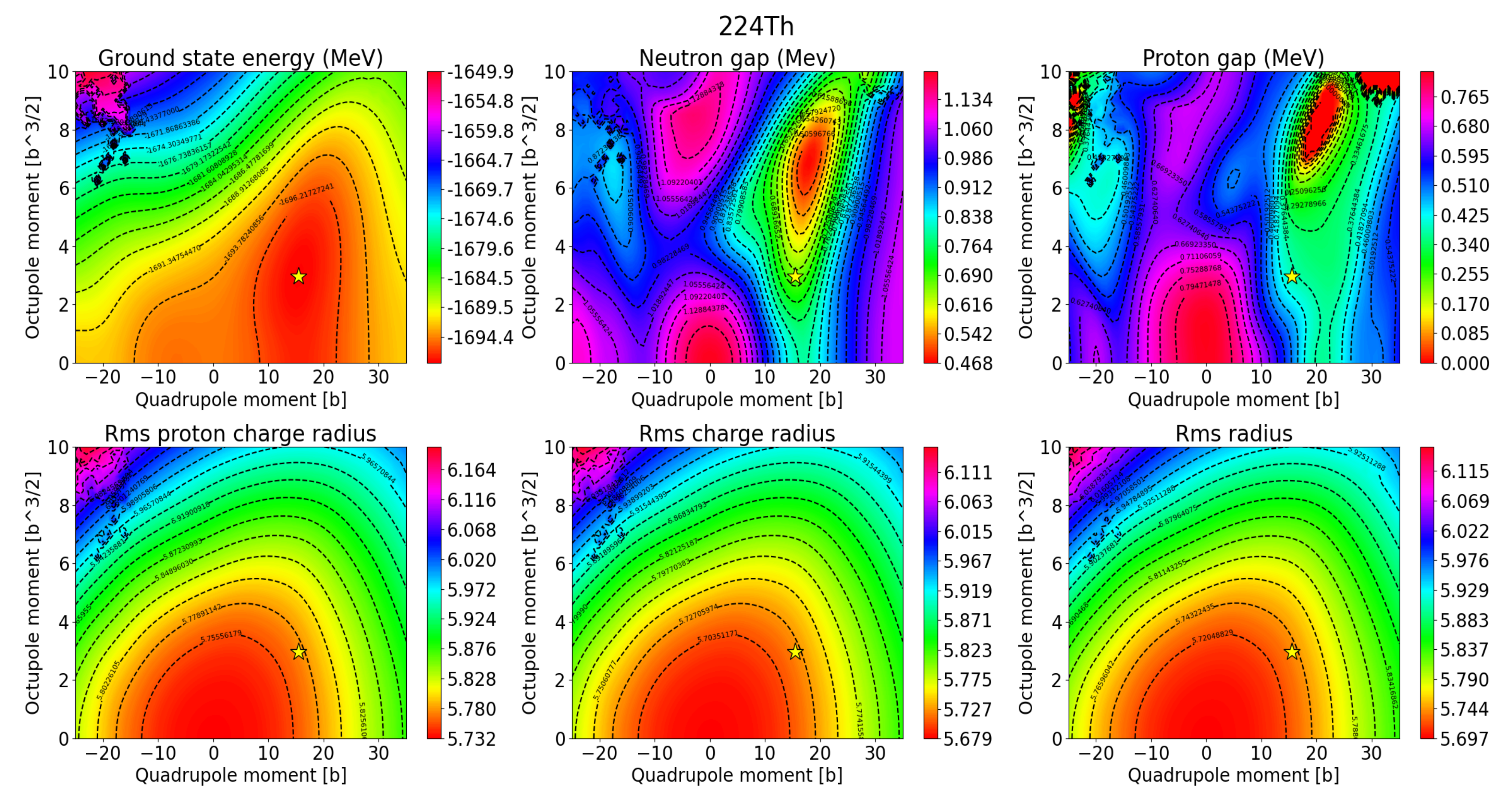


3) Fayans results in Actinides (FYdrHFB)

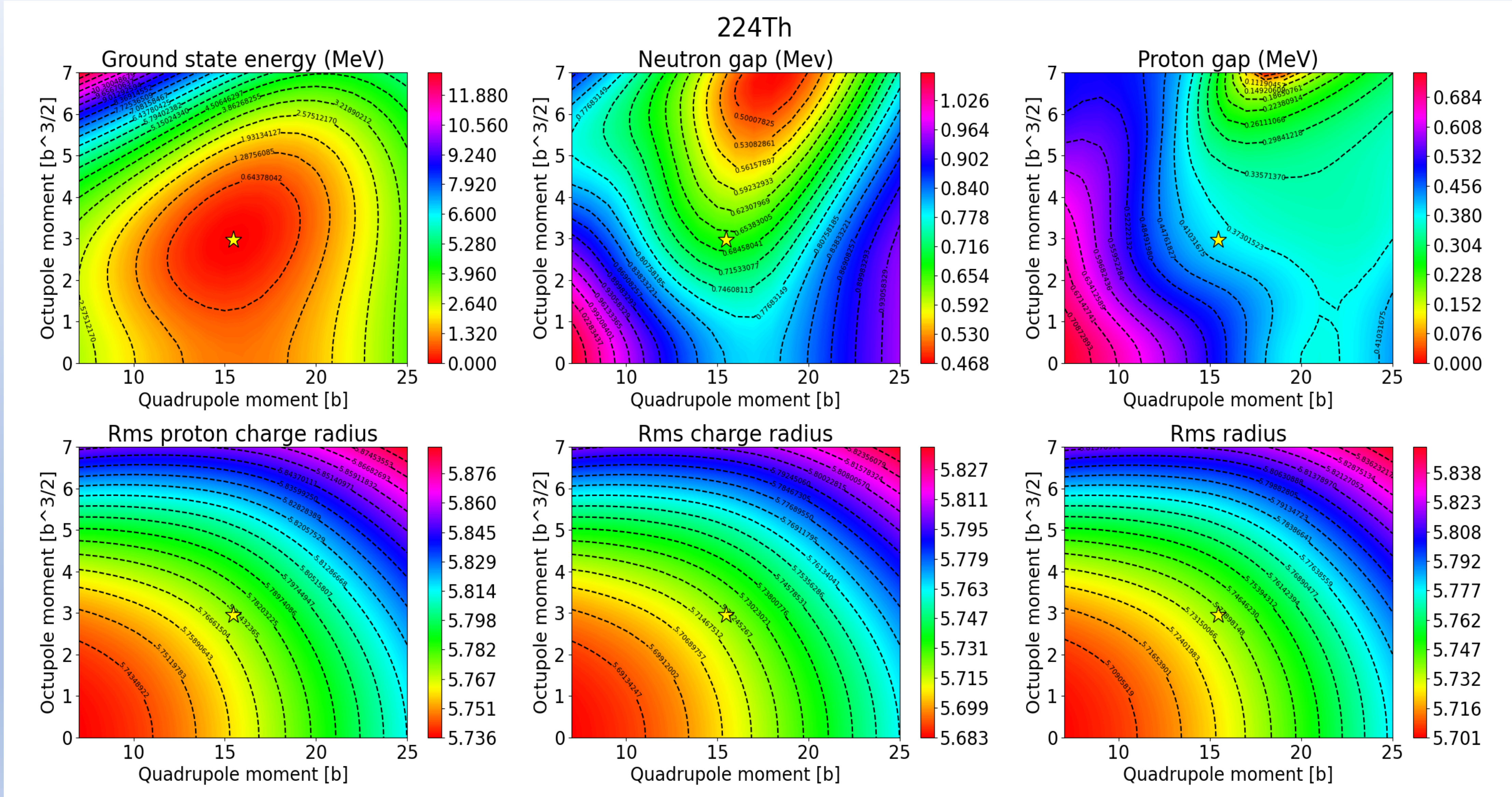


3) Fayans results in Actinides (FYstd)

3) Fayans results in Actinides (FYstd)



3) Fayans results in Actinides (FYstd)



3) Fayans results in Actinides

3) Fayans results in Actinides

1) Even-even computation around expected Q2-Q3 for min(E) of odd nucleus

3) Fayans results in Actinides

1) Even-even computation around expected Q2-Q3 for min(E) of odd nucleus
2) Select reasonable blocking orbitals candidates

90_Th_210_FYdrHFB neutron blocking

```
num=   1 block=   1 state=   1     1 Eqp=   0.98849777  (1-2N)E=  -0.43803999  Ovlp=   0.48581159  1-[ 5, 3, 0]
num=   2 block=   1 state=   2     2 Eqp=   1.03132448  (1-2N)E=  -0.79448565  Ovlp=   0.50056312  1+[ 6, 2, 0]
num=   3 block=   2 state=   1   154 Eqp=   1.03849441  (1-2N)E=   0.59329136  Ovlp=   0.66069727  3-[ 5, 4, 1]
num=   4 block=   1 state=   3     3 Eqp=   1.09072859  (1-2N)E=   0.31649926  Ovlp=   0.61462786  1-[ 5, 4, 1]
num=   5 block=   2 state=   2   155 Eqp=   1.12867326  (1-2N)E=  -0.92131424  Ovlp=   0.53585210  3+[ 6, 3, 1]
num=   6 block=   3 state=   1   290 Eqp=   1.33024372  (1-2N)E=  -1.16652448  Ovlp=   0.60205808  5+[ 6, 2, 2]
num=   7 block=   2 state=   3   156 Eqp=   1.33143102  (1-2N)E=  -1.08108058  Ovlp=   0.51947902  3-[ 5, 3, 2]
num=   8 block=   3 state=   2   291 Eqp=   1.36263221  (1-2N)E=  -1.21421565  Ovlp=   0.57512942  5-[ 5, 3, 2]
num=   9 block=   4 state=   1   410 Eqp=   1.65087848  (1-2N)E=  -1.53015780  Ovlp=   0.58929986  7+[ 6, 3, 3]
num=  10 block=   5 state=   1   515 Eqp=   2.11694535  (1-2N)E=  -2.00442036  Ovlp=   0.76908035  9+[ 6, 2, 4]
num=  11 block=   5 state=   2   516 Eqp=   2.62695340  (1-2N)E=   2.52311239  Ovlp=   0.83796064  9+[ 6, 0, 4]
num=  12 block=   1 state=   4     4 Eqp=   2.63183142  (1-2N)E=   1.52769455  Ovlp=   0.76577608  1-[ 5, 5, 0]
num=  13 block=   1 state=   5     5 Eqp=   2.67050206  (1-2N)E=  -1.69863083  Ovlp=   0.62843667  1-[ 5, 1, 0]
num=  14 block=   2 state=   4   157 Eqp=   2.74809493  (1-2N)E=  -2.68508005  Ovlp=   0.71099017  3-[ 5, 1, 2]
num=  15 block=   6 state=   1   606 Eqp=   2.76648130  (1-2N)E=  -2.57569794  Ovlp=   0.90042656 11+[ 6, 1, 5]
num=  16 block=   1 state=   6     6 Eqp=   2.78133078  (1-2N)E=  -2.70752540  Ovlp=   0.69568921  1-[ 5, 0, 1]
num=  17 block=   6 state=   2   607 Eqp=   2.95067683  (1-2N)E=   2.77257885  Ovlp=   0.91231534 11+[ 6, 0, 6]
```

3) Fayans results in Actinides

1) Even-even computation around expected Q2-Q3 for min(E) of odd nucleus

2) Select reasonable blocking orbitals candidates

90_Th_210_FYdrHFB neutron blocking

num=	1	block=	1	state=	1	1	Eqp=	0.98849777	(1-2N)E=	-0.43803999	Ovlp=	0.48581159	1-[5, 3, 0]
num=	2	block=	1	state=	2	2	Eqp=	1.03132448	(1-2N)E=	-0.79448565	Ovlp=	0.50056312	1+[6, 2, 0]
num=	3	block=	2	state=	1	154	Eqp=	1.03849441	(1-2N)E=	0.59329136	Ovlp=	0.66069727	3-[5, 4, 1]
num=	4	block=	1	state=	3	3	Eqp=	1.09072859	(1-2N)E=	0.31649926	Ovlp=	0.61462786	1-[5, 4, 1]
num=	5	block=	2	state=	2	155	Eqp=	1.12867326	(1-2N)E=	-0.92131424	Ovlp=	0.53585210	3+[6, 3, 1]
num=	6	block=	3	state=	1	290	Eqp=	1.33024372	(1-2N)E=	-1.16652448	Ovlp=	0.60205808	5+[6, 2, 2]
num=	7	block=	2	state=	3	156	Eqp=	1.33143102	(1-2N)E=	-1.08108058	Ovlp=	0.51947902	3-[5, 3, 2]
num=	8	block=	3	state=	2	291	Eqp=	1.36263221	(1-2N)E=	-1.21421565	Ovlp=	0.57512942	5-[5, 3, 2]
num=	9	block=	4	state=	1	410	Eqp=	1.65087848	(1-2N)E=	-1.53015780	Ovlp=	0.58929986	7+[6, 3, 3]
num=	10	block=	5	state=	1	515	Eqp=	2.11694535	(1-2N)E=	-2.00442036	Ovlp=	0.76908035	9+[6, 2, 4]
num=	11	block=	5	state=	2	516	Eqp=	2.62695340	(1-2N)E=	2.52311239	Ovlp=	0.83796064	9+[6, 0, 4]
num=	12	block=	1	state=	4	4	Eqp=	2.63183142	(1-2N)E=	1.52769455	Ovlp=	0.76577608	1-[5, 5, 0]
num=	13	block=	1	state=	5	5	Eqp=	2.67050206	(1-2N)E=	-1.69863083	Ovlp=	0.62843667	1-[5, 1, 0]
num=	14	block=	2	state=	4	157	Eqp=	2.74809493	(1-2N)E=	-2.68508005	Ovlp=	0.71099017	3-[5, 1, 2]
num=	15	block=	6	state=	1	606	Eqp=	2.76648130	(1-2N)E=	-2.57569794	Ovlp=	0.90042656	11+[6, 1, 5]
num=	16	block=	1	state=	6	6	Eqp=	2.78133078	(1-2N)E=	-2.70752540	Ovlp=	0.69568921	1-[5, 0, 1]
num=	17	block=	6	state=	2	607	Eqp=	2.95067683	(1-2N)E=	2.77257885	Ovlp=	0.91231534	11+[6, 0, 6]

3) Unconstrained calculation for each possible configuration

3) Fayans results in Actinides

1) Even-even computation around expected Q2-Q3 for min(E) of odd nucleus
2) Select reasonable blocking orbitals candidates

90_Th_210_FYdrHFB neutron blocking

```
num=   1 block=   1 state=   1     1 Eqp=   0.98849777  (1-2N)E=  -0.43803999  Ovlp=    0.48581159  1-[ 5, 3, 0]
num=   2 block=   1 state=   2     2 Eqp=   1.03132448  (1-2N)E=  -0.79448565  Ovlp=    0.50056312  1+[ 6, 2, 0]
num=   3 block=   2 state=   1   154 Eqp=   1.03849441  (1-2N)E=   0.59329136  Ovlp=    0.66069727  3-[ 5, 4, 1]
num=   4 block=   1 state=   3     3 Eqp=   1.09072859  (1-2N)E=   0.31649926  Ovlp=    0.61462786  1-[ 5, 4, 1]
num=   5 block=   2 state=   2   155 Eqp=   1.12867326  (1-2N)E=  -0.92131424  Ovlp=    0.53585210  3+[ 6, 3, 1]
num=   6 block=   3 state=   1   290 Eqp=   1.33024372  (1-2N)E=  -1.16652448  Ovlp=    0.60205808  5+[ 6, 2, 2]
num=   7 block=   2 state=   3   156 Eqp=   1.33143102  (1-2N)E=  -1.08108058  Ovlp=    0.51947902  3-[ 5, 3, 2]
num=   8 block=   3 state=   2   291 Eqp=   1.36263221  (1-2N)E=  -1.21421565  Ovlp=    0.57512942  5-[ 5, 3, 2]
num=   9 block=   4 state=   1   410 Eqp=   1.65087848  (1-2N)E=  -1.53015780  Ovlp=    0.58929986  7+[ 6, 3, 3]
num=  10 block=   5 state=   1   515 Eqp=   2.11694535  (1-2N)E=  -2.00442036  Ovlp=    0.76908035  9+[ 6, 2, 4]
num=  11 block=   5 state=   2   516 Eqp=   2.62695340  (1-2N)E=   2.52311239  Ovlp=    0.83796064  9+[ 6, 0, 4]
num=  12 block=   1 state=   4     4 Eqp=   2.63183142  (1-2N)E=   1.52769455  Ovlp=    0.76577608  1-[ 5, 5, 0]
num=  13 block=   1 state=   5     5 Eqp=   2.67050206  (1-2N)E=  -1.69863083  Ovlp=    0.62843667  1-[ 5, 1, 0]
num=  14 block=   2 state=   4   157 Eqp=   2.74809493  (1-2N)E=  -2.68508005  Ovlp=    0.71099017  3-[ 5, 1, 2]
num=  15 block=   6 state=   1   606 Eqp=   2.76648130  (1-2N)E=  -2.57569794  Ovlp=    0.90042656 11+[ 6, 1, 5]
num=  16 block=   1 state=   6     6 Eqp=   2.78133078  (1-2N)E=  -2.70752540  Ovlp=    0.69568921  1-[ 5, 0, 1]
num=  17 block=   6 state=   2   607 Eqp=   2.95067683  (1-2N)E=   2.77257885  Ovlp=    0.91231534 11+[ 6, 0, 6]
```

3) Unconstrained calculation for each possible configuration
4) Lowest E -> Ground state

3) Fayans results in Actinides

1) Even-even computation around expected Q2-Q3 for min(E) of odd nucleus
2) Select reasonable blocking orbitals candidates

90_Th_210_FYdrHFB neutron blocking

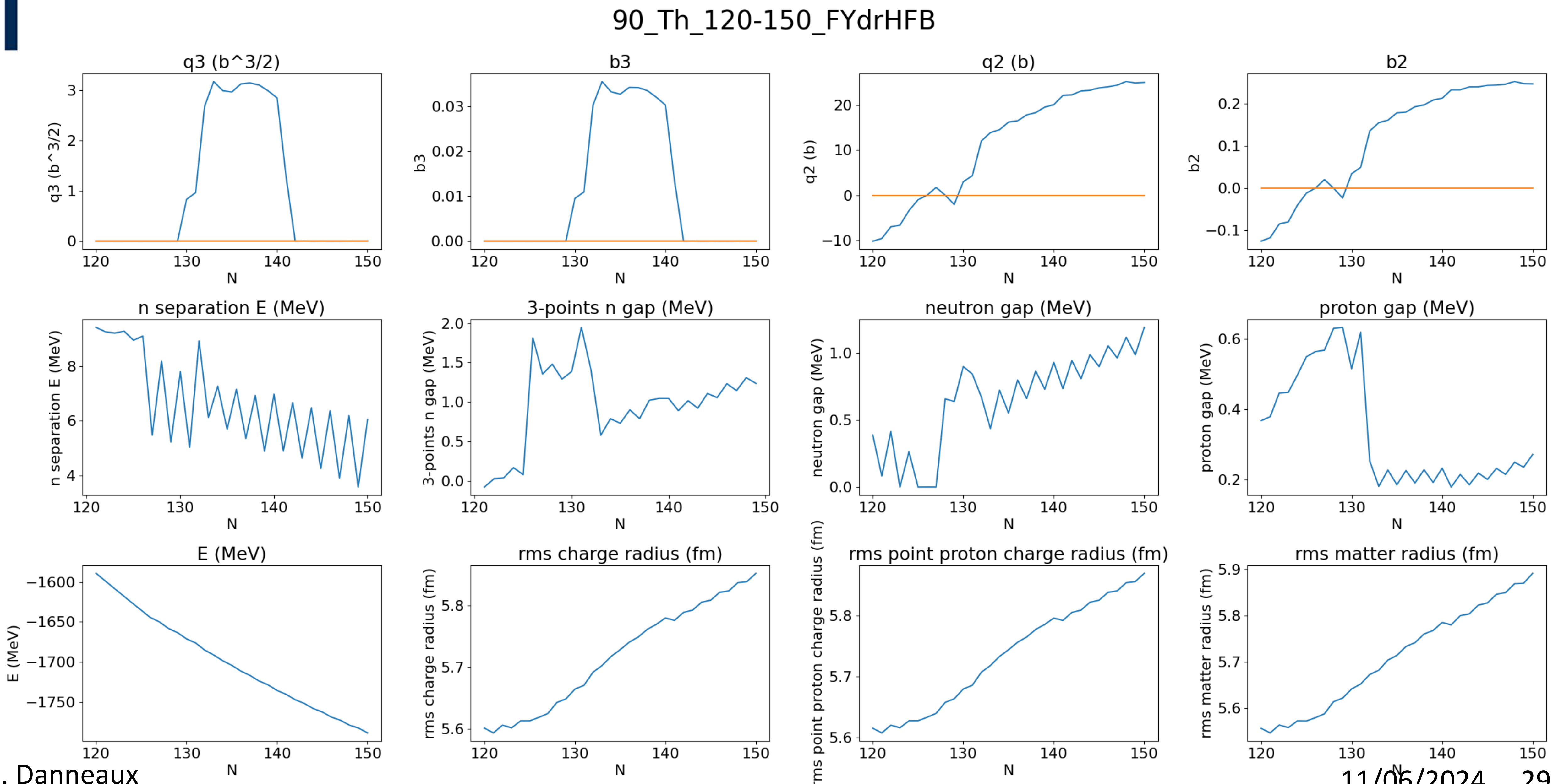
num=	1	block=	1	state=	1	1	Eqp=	0.98849777	(1-2N)E=	-0.43803999	Ovlp=	0.48581159	1-[5, 3, 0]
num=	2	block=	1	state=	2	2	Eqp=	1.03132448	(1-2N)E=	-0.79448565	Ovlp=	0.50056312	1+[6, 2, 0]
num=	3	block=	2	state=	1	154	Eqp=	1.03849441	(1-2N)E=	0.59329136	Ovlp=	0.66069727	3-[5, 4, 1]
num=	4	block=	1	state=	3	3	Eqp=	1.09072859	(1-2N)E=	0.31649926	Ovlp=	0.61462786	1-[5, 4, 1]
num=	5	block=	2	state=	2	155	Eqp=	1.12867326	(1-2N)E=	-0.92131424	Ovlp=	0.53585210	3+[6, 3, 1]
num=	6	block=	3	state=	1	290	Eqp=	1.33024372	(1-2N)E=	-1.16652448	Ovlp=	0.60205808	5+[6, 2, 2]
num=	7	block=	2	state=	3	156	Eqp=	1.33143102	(1-2N)E=	-1.08108058	Ovlp=	0.51947902	3-[5, 3, 2]
num=	8	block=	3	state=	2	291	Eqp=	1.36263221	(1-2N)E=	-1.21421565	Ovlp=	0.57512942	5-[5, 3, 2]
num=	9	block=	4	state=	1	410	Eqp=	1.65087848	(1-2N)E=	-1.53015780	Ovlp=	0.58929986	7+[6, 3, 3]
num=	10	block=	5	state=	1	515	Eqp=	2.11694535	(1-2N)E=	-2.00442036	Ovlp=	0.76908035	9+[6, 2, 4]
num=	11	block=	5	state=	2	516	Eqp=	2.62695340	(1-2N)E=	2.52311239	Ovlp=	0.83796064	9+[6, 0, 4]
num=	12	block=	1	state=	4	4	Eqp=	2.63183142	(1-2N)E=	1.52769455	Ovlp=	0.76577608	1-[5, 5, 0]
num=	13	block=	1	state=	5	5	Eqp=	2.67050206	(1-2N)E=	-1.69863083	Ovlp=	0.62843667	1-[5, 1, 0]
num=	14	block=	2	state=	4	157	Eqp=	2.74809493	(1-2N)E=	-2.68508005	Ovlp=	0.71099017	3-[5, 1, 2]
num=	15	block=	6	state=	1	606	Eqp=	2.76648130	(1-2N)E=	-2.57569794	Ovlp=	0.90042656	11+[6, 1, 5]
num=	16	block=	1	state=	6	6	Eqp=	2.78133078	(1-2N)E=	-2.70752540	Ovlp=	0.69568921	1-[5, 0, 1]
num=	17	block=	6	state=	2	607	Eqp=	2.95067683	(1-2N)E=	2.77257885	Ovlp=	0.91231534	11+[6, 0, 6]

3) Unconstrained calculation for each possible configuration
4) Lowest E -> Ground state

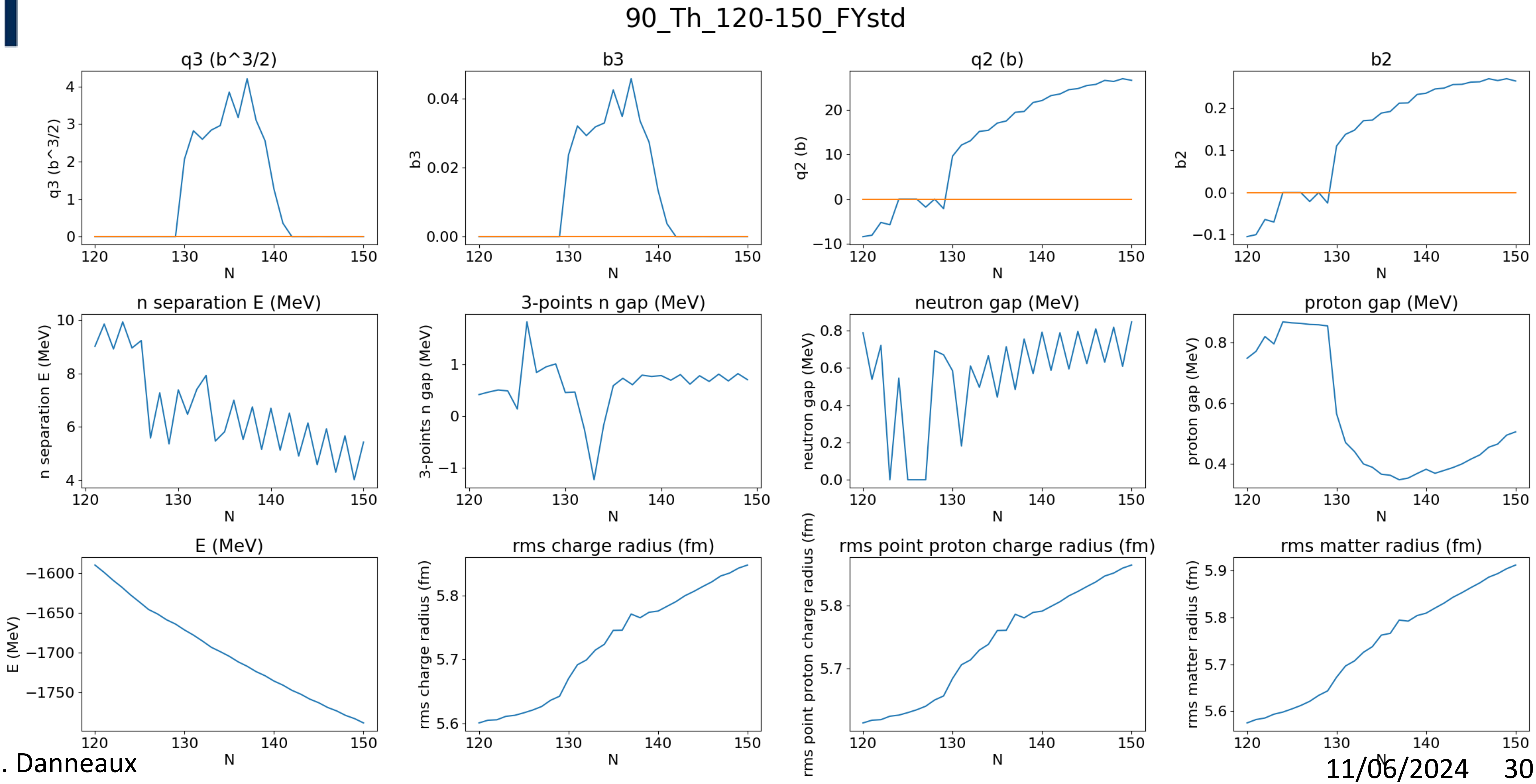
Whole Q2-Q3 landscape unreasonable for non-ee nuclei; but isotopic chains can be built

3) Fayans results in Actinides

3) Fayans results in Actinides



3) Fayans results in Actinides

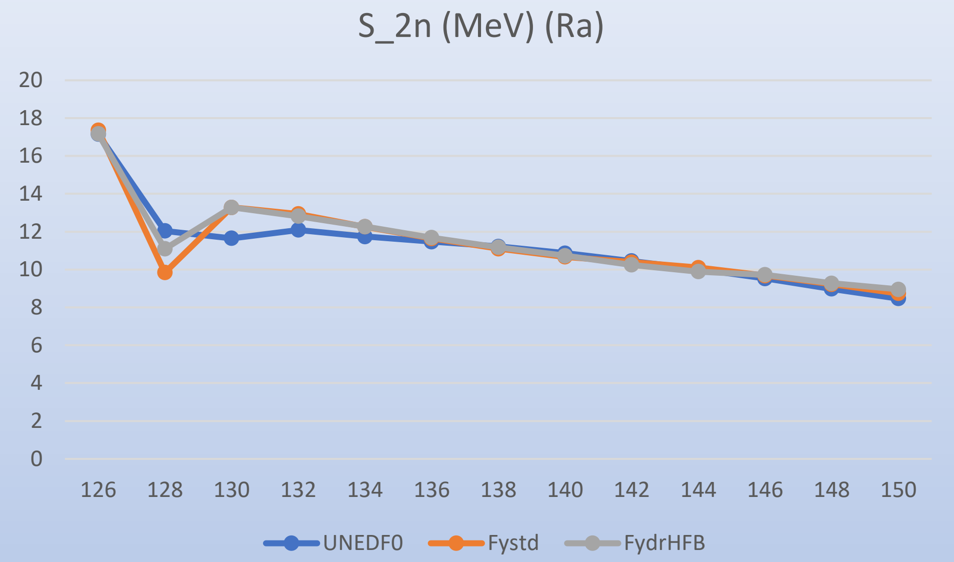


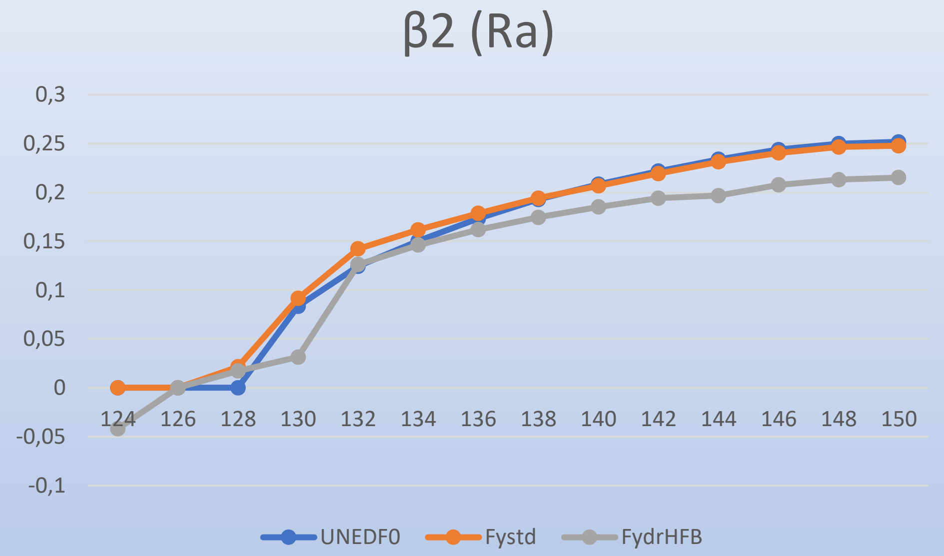
4) Comparisons

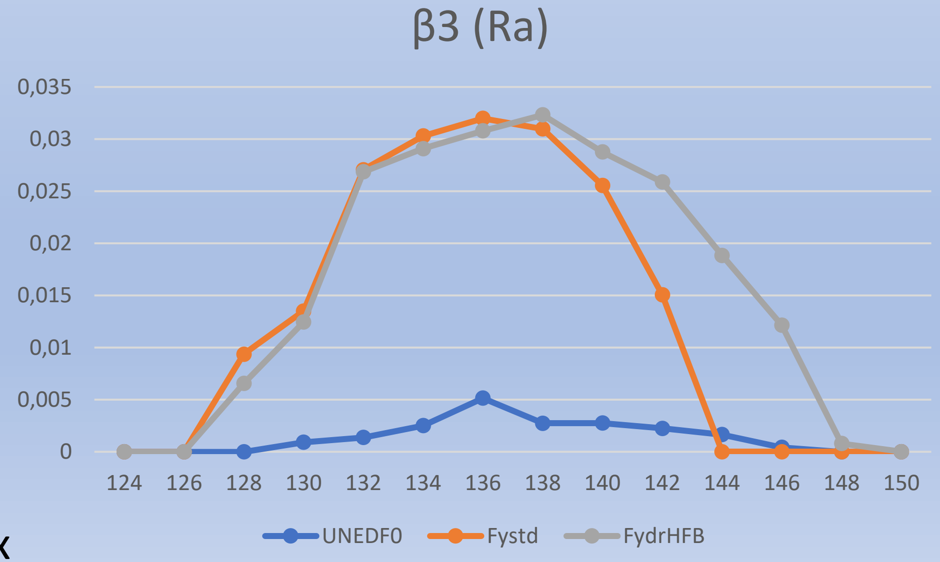
- Current-gen widely used EDFs: UNEDF(0;1;2), SLY4, etc

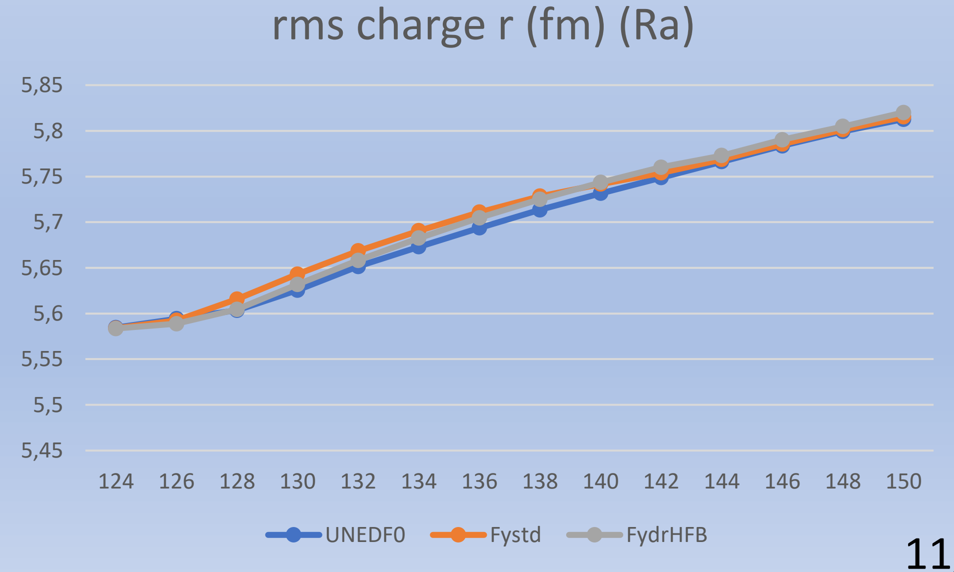
4) Comparisons

- Current-gen widely used EDFs: UNEDF(0;1;2), SLY4, etc



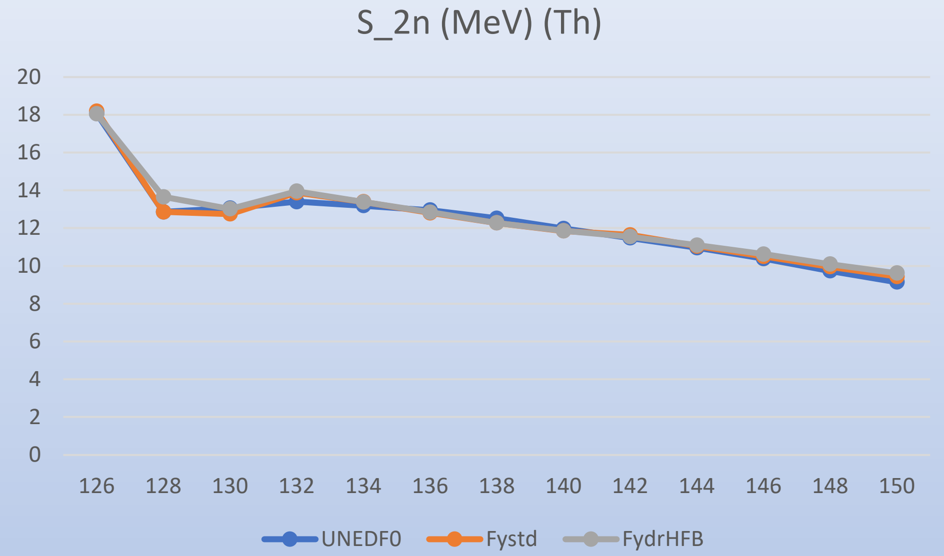


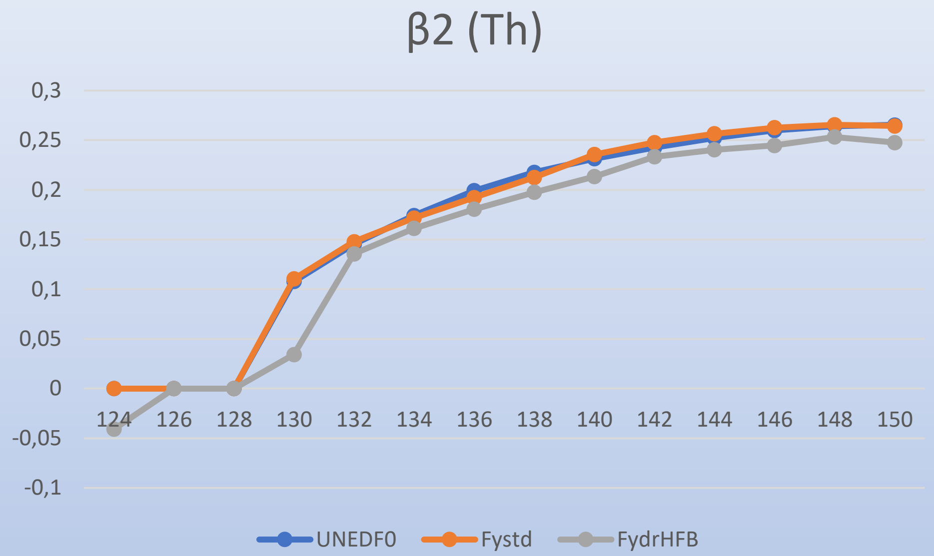


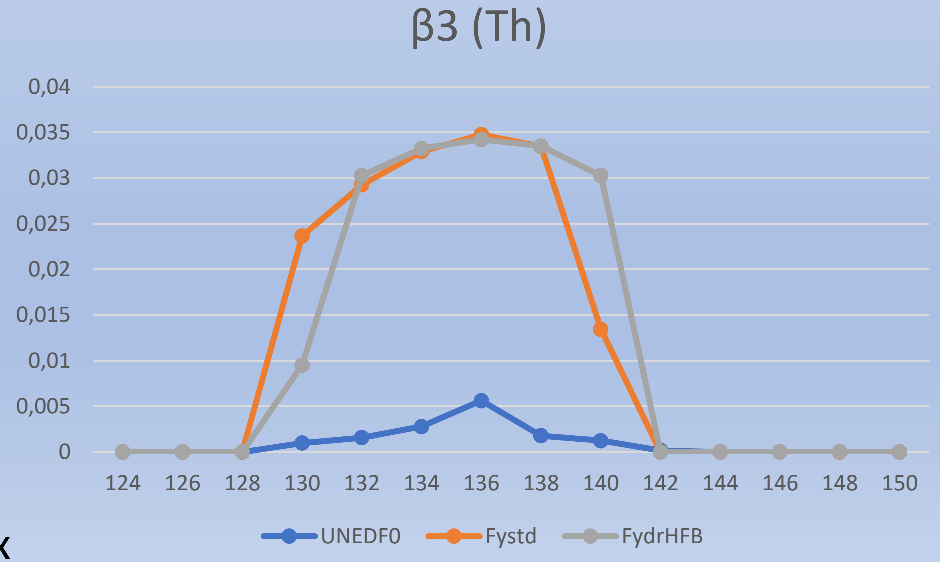


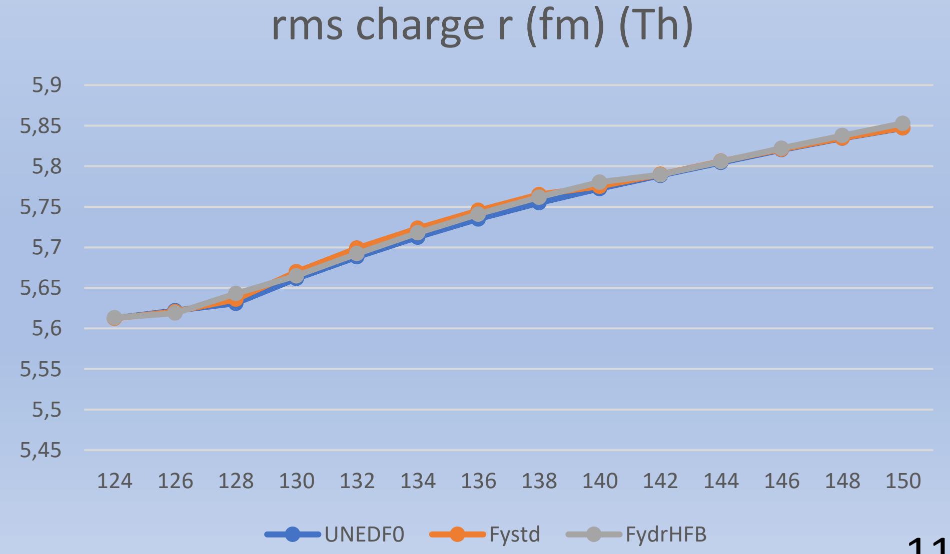
4) Comparisons

- Current-gen widely used EDFs: UNEDF(0;1;2), SLY4, etc



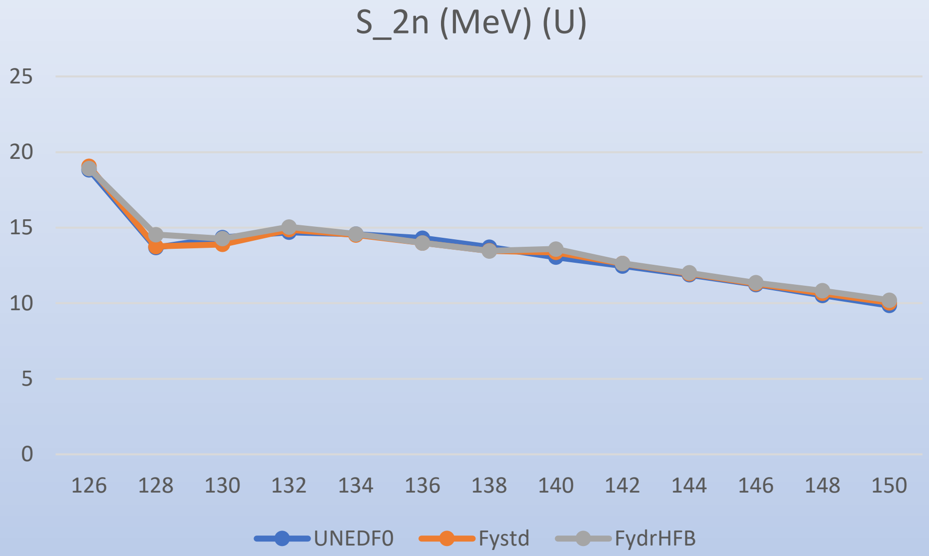


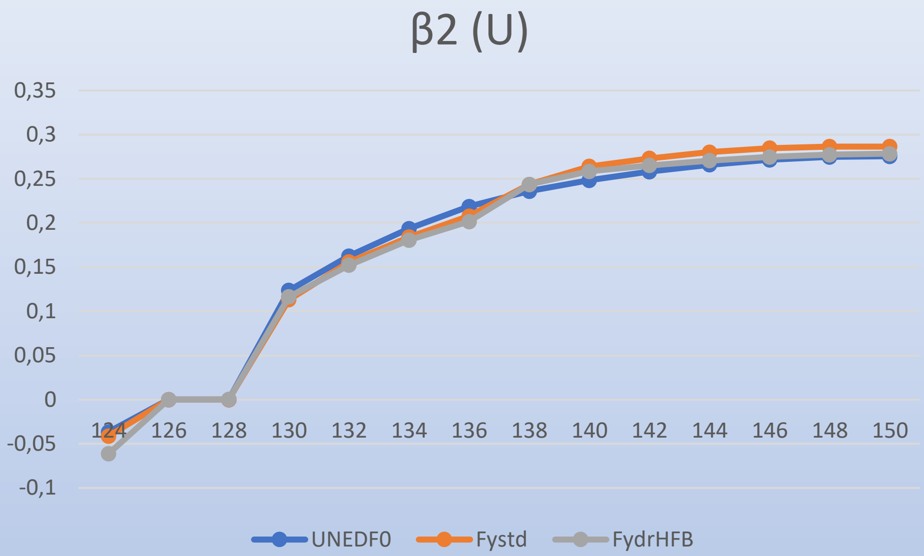


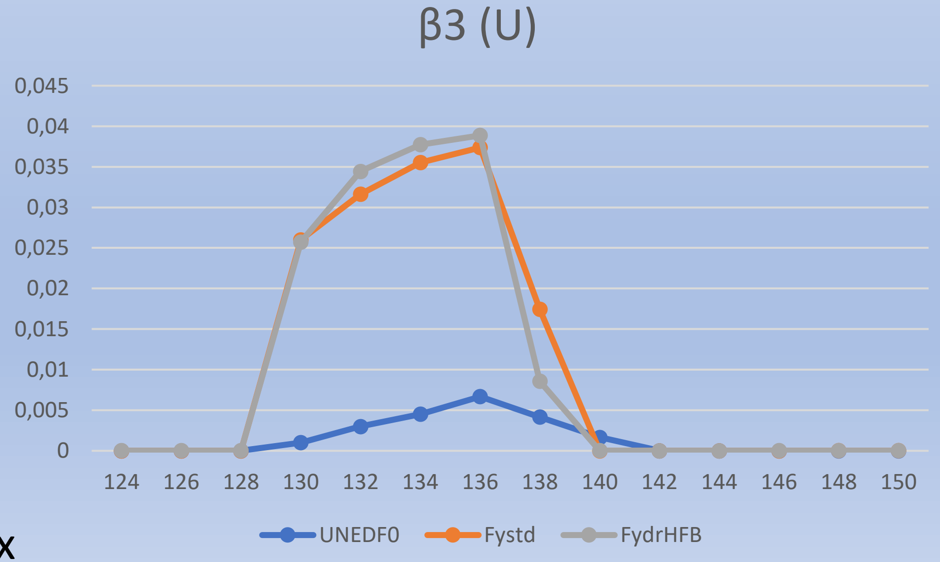


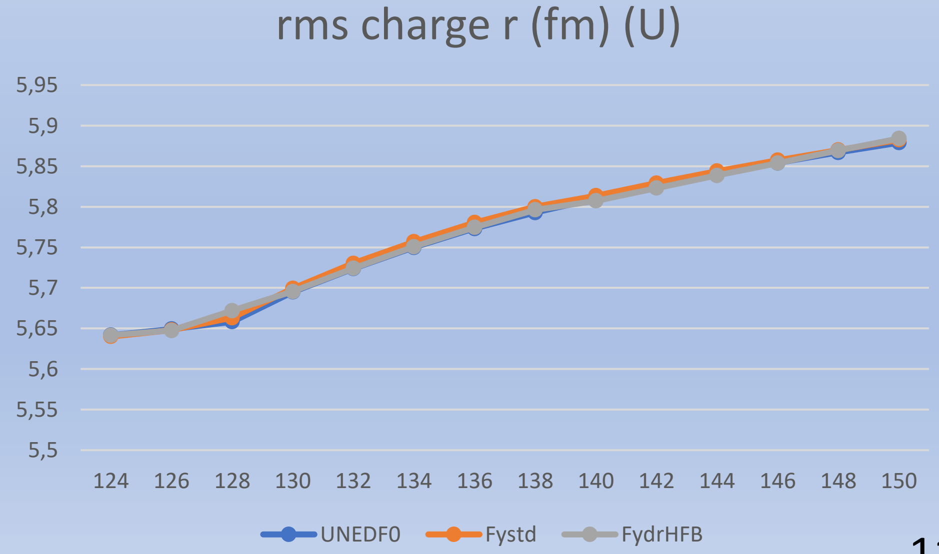
4) Comparisons

- Current-gen widely used EDFs: UNEDF(0;1;2), SLY4, etc



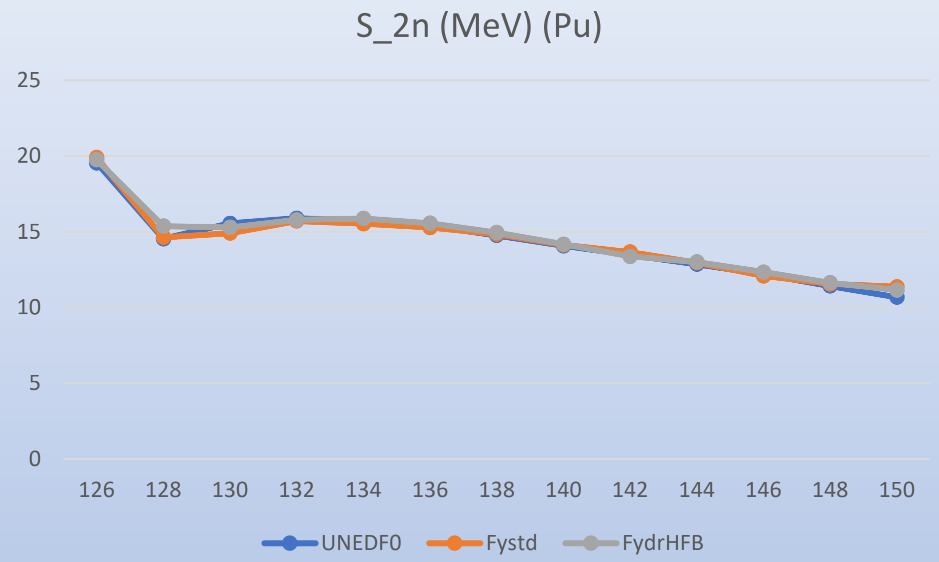


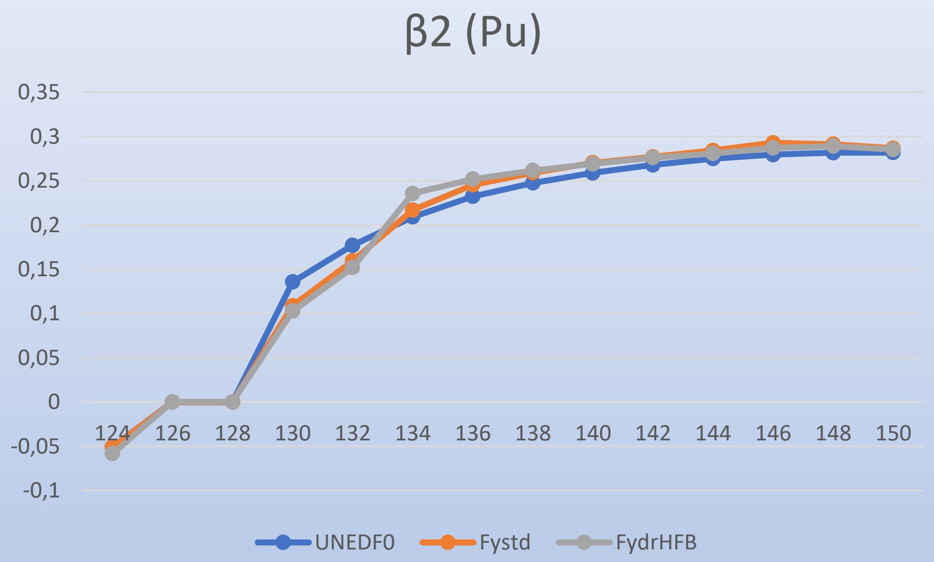


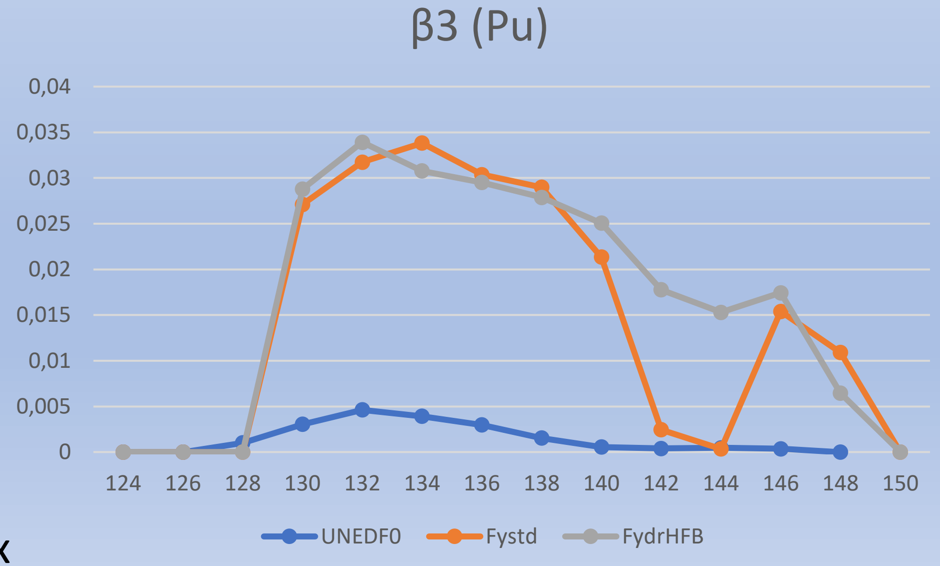


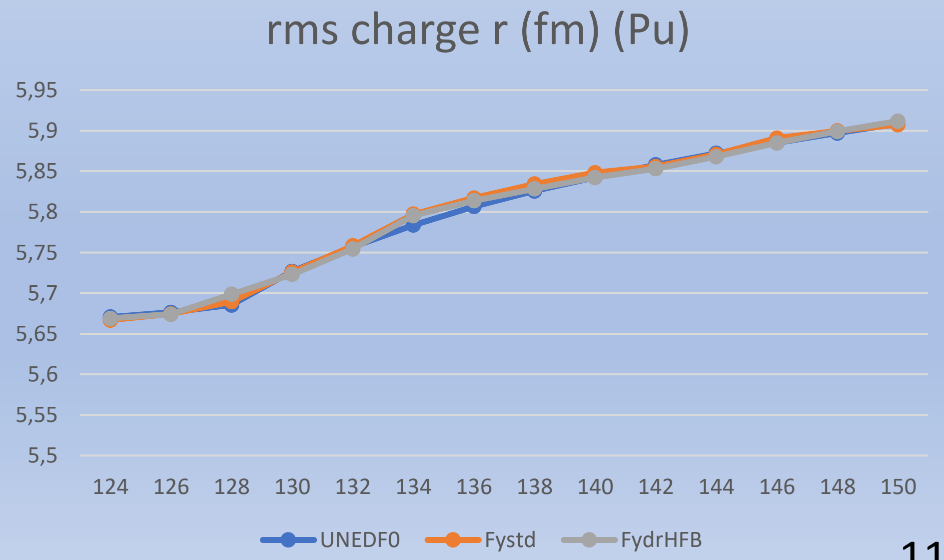
4) Comparisons

- Current-gen widely used EDFs: UNEDF(0;1;2), SLY4, etc





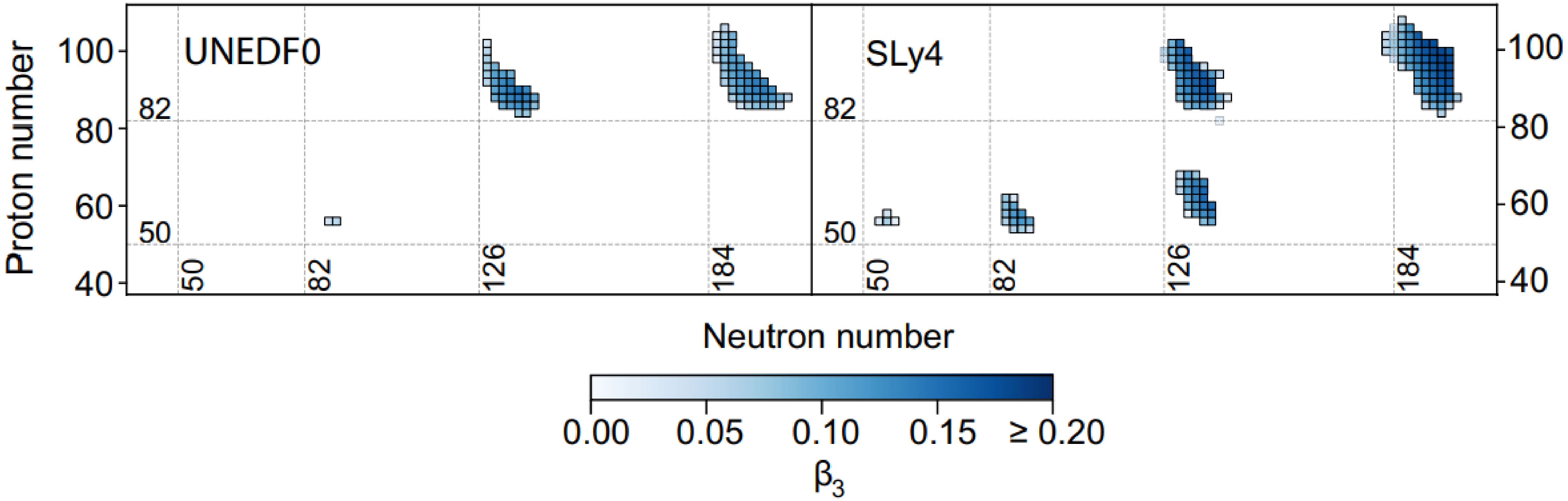




4) Comparisons

4) Comparisons

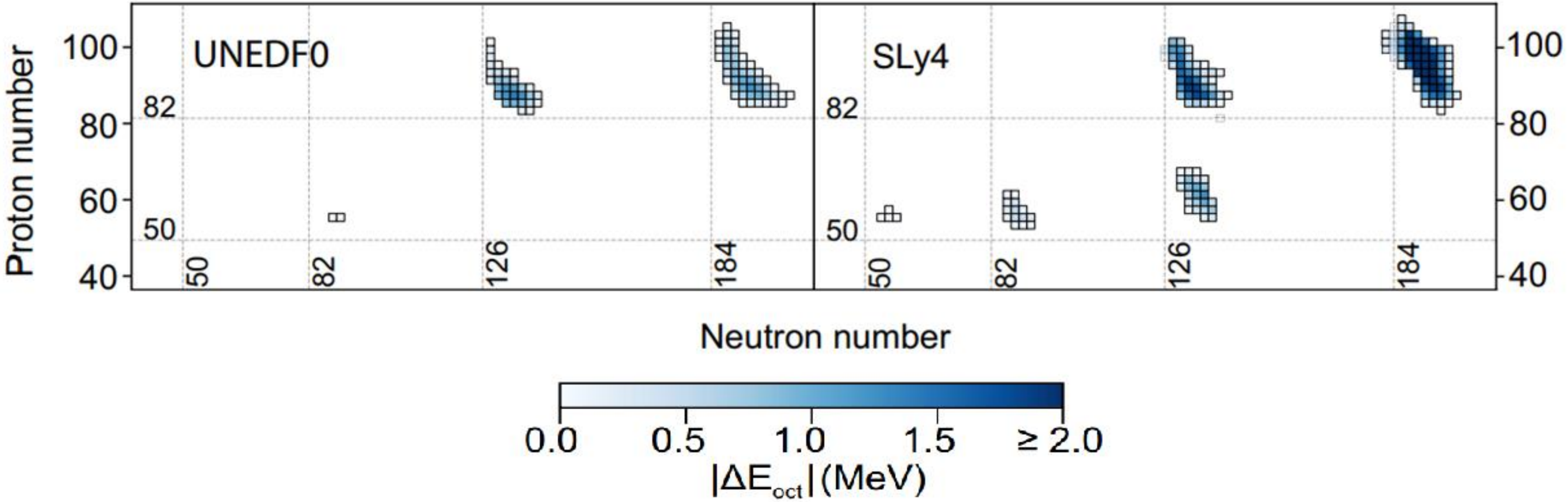
- Survey of pear-shaped landscapes with Skyrme-based EDFs [9]



[9] Y. Cao, S.E. Agbemava, A.V. Afanasjev et al., Phys. Rev. C, 102, 12 (2020)

4) Comparisons

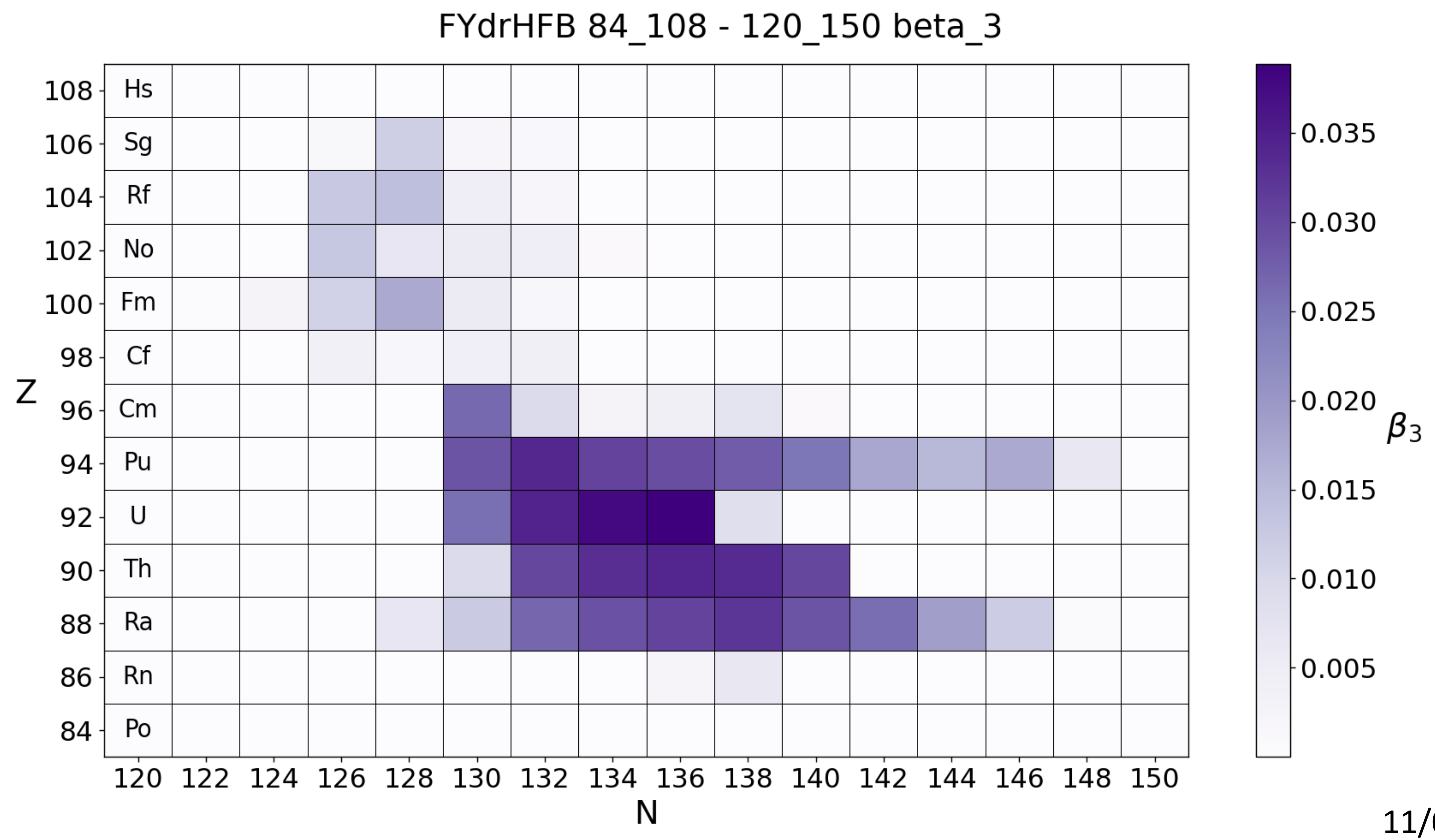
- Survey of pear-shaped landscapes with Skyrme-based EDFs [9]



[9] Y. Cao, S.E. Agbemava, A.V. Afanasjev et al., Phys. Rev. C, 102, 12 (2020)

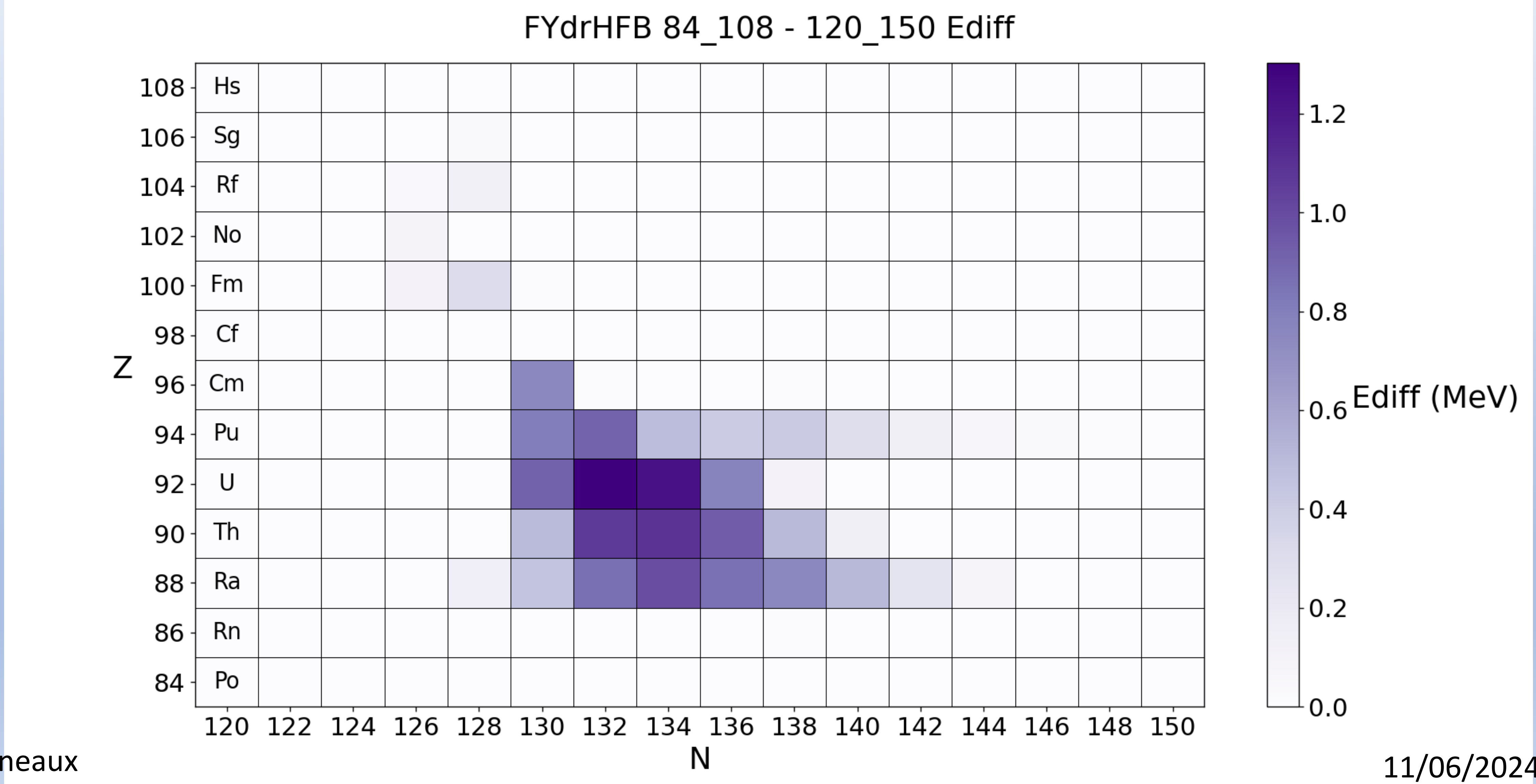
4) Comparisons

4) Comparisons



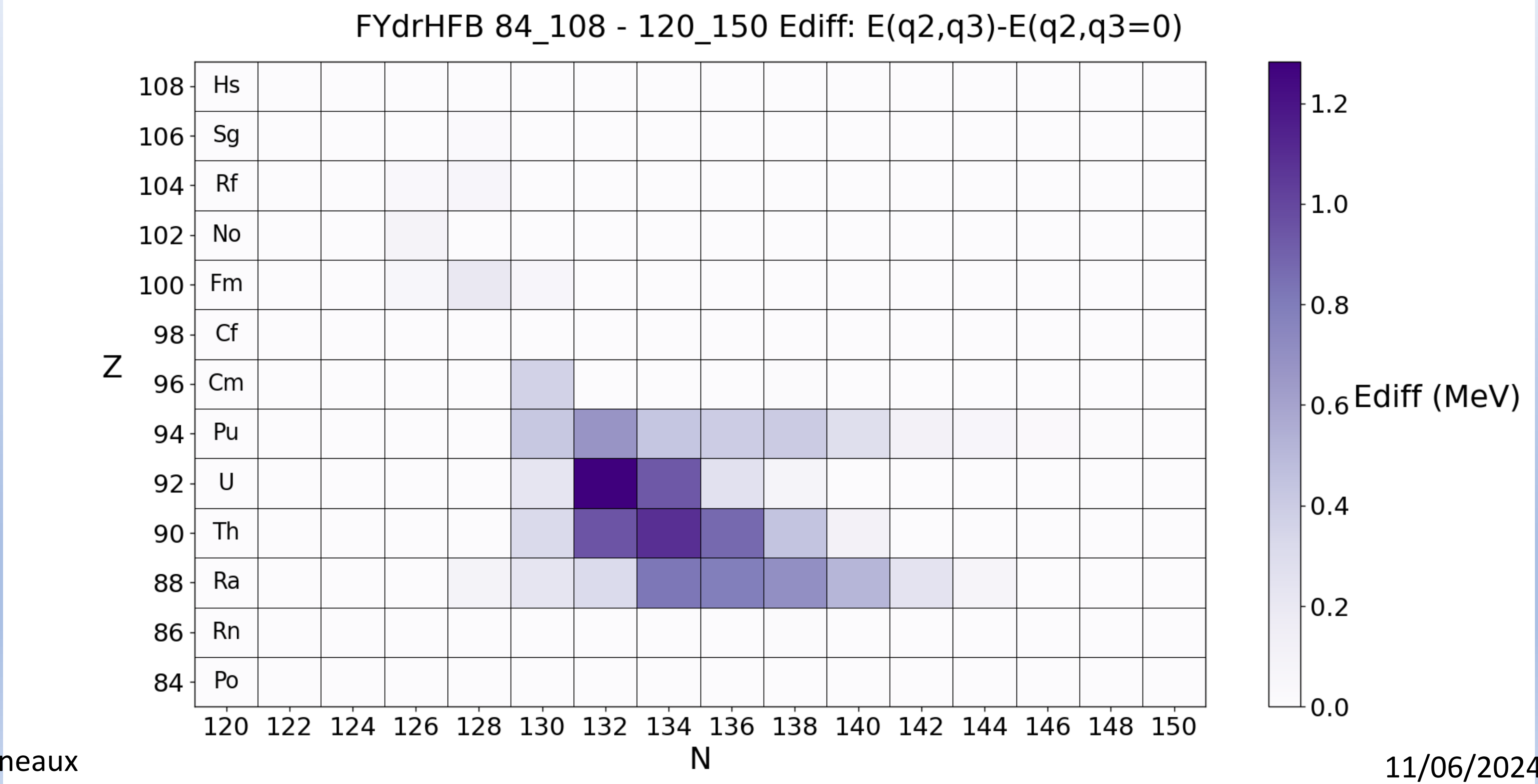
4) Comparisons

Difference in ground state energy gained from the inclusion of octupole deformation



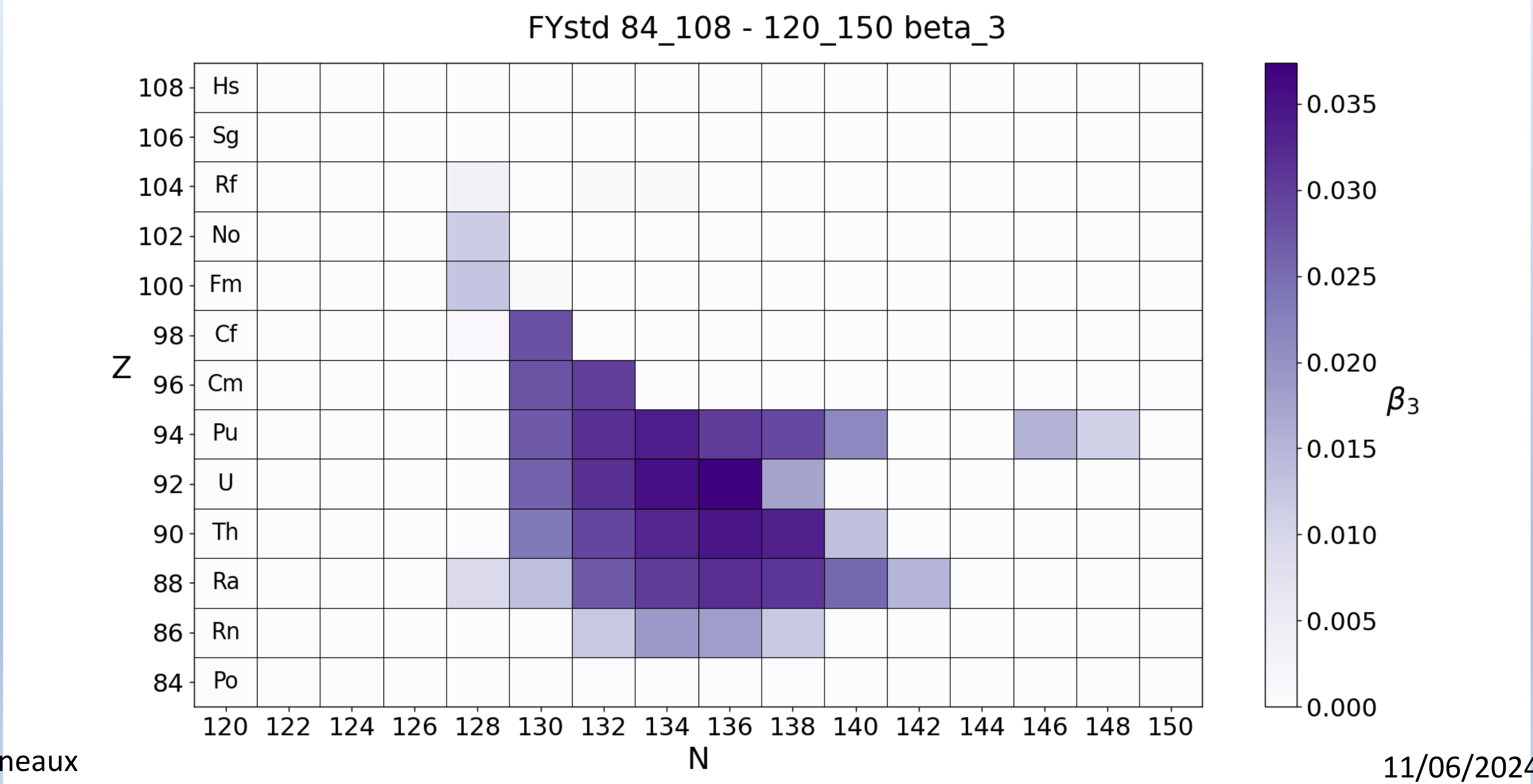
4) Comparisons

Difference in ground state energy gained from the inclusion of octupole deformation



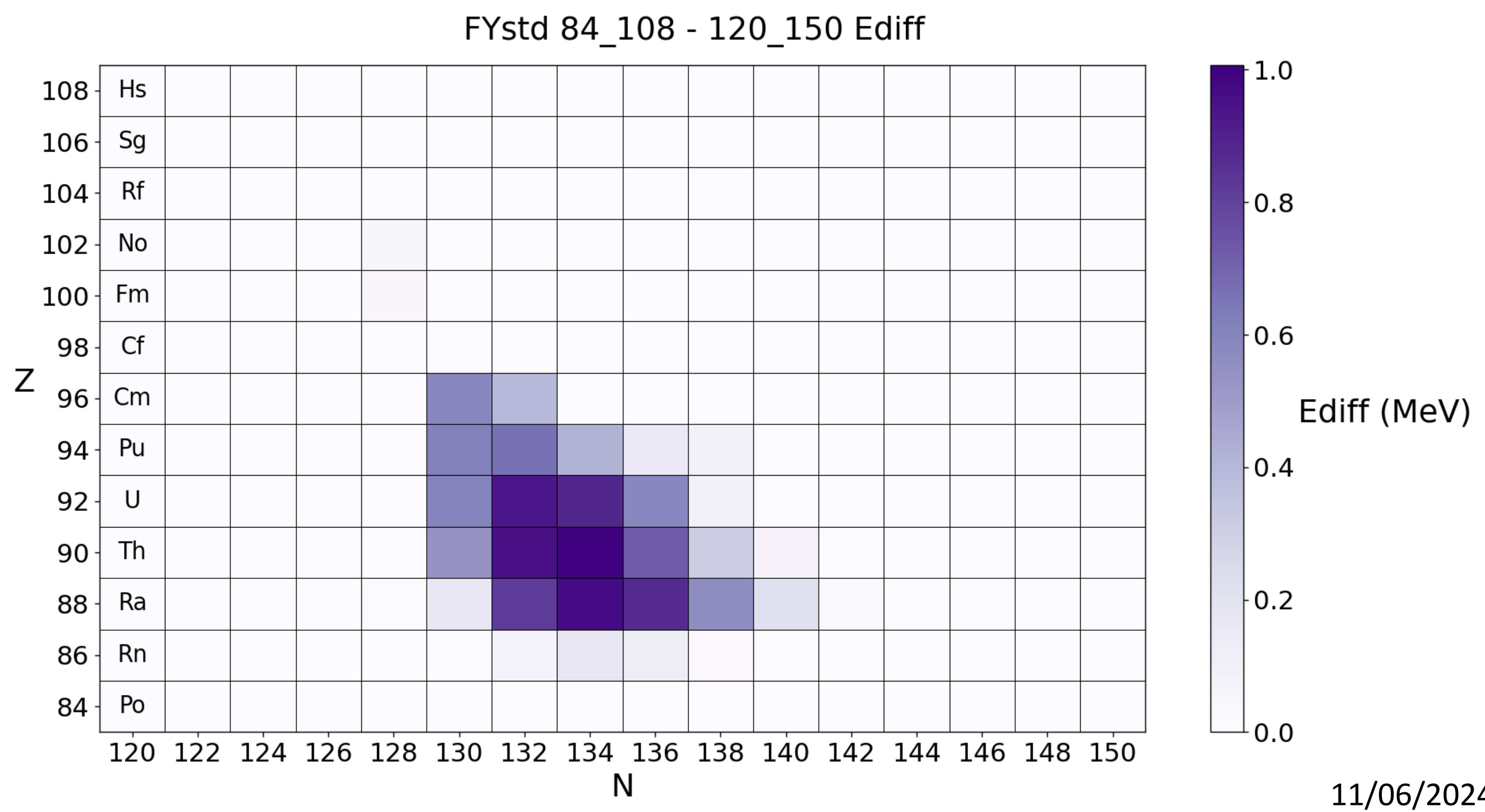
4) Comparisons

4) Comparisons



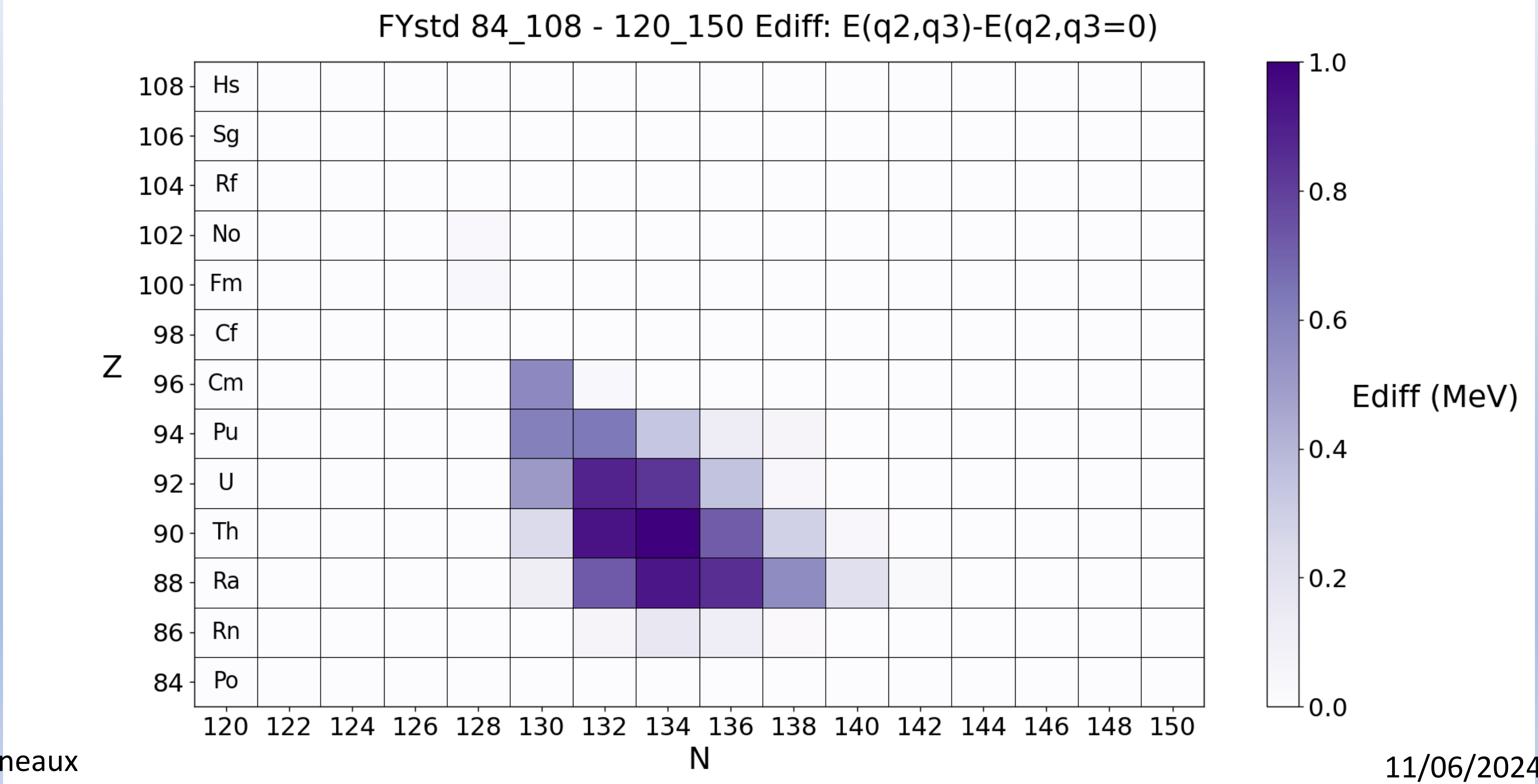
4) Comparisons

Difference in ground state energy gained from the inclusion of octupole deformation



4) Comparisons

Difference in ground state energy gained from the inclusion of octupole deformation



5) Conclusions

5) Conclusions

- Given minor revisions -> as good as current state-of-the art Skyrme EDFs

5) Conclusions

- Given minor revisions -> as good as current state-of-the art Skyrme EDFs

- Coherent results regarding $E, r_{rms}, \Delta_n, \beta_2$, odd-even effects, etc.

5) Conclusions

- Given minor revisions -> as good as current state-of-the art Skyrme EDFs

- Coherent results regarding $E, r_{rms}, \Delta_n, \beta_2$, odd-even effects, etc.

- Returned predicted octupole clusters in Actinides with stronger β_3

5) Conclusions

- Given minor revisions -> as good as current state-of-the art Skyrme EDFs
- Coherent results regarding $E, r_{rms}, \Delta_n, \beta_2$, odd-even effects, etc.
- Returned predicted octupole clusters in Actinides with stronger β_3
- Strong step towards better understanding of heavily-deformed nuclei complex processes s.a. systematics, spectra, nuclear Schiff moment, fission, etc.

Thanks to my colleagues:

M. Kortelainen, R. Han; University of Jyväskylä. J. Dobaczewski; University of York. K. Bennaceur; IPNL

References

[1] J. Bonnard, J. Dobaczewski, G. Danneaux et al., Phys. Lett. B, 843, (2023)

[2] P.A. Butler, Proc. R. Soc. A, 476 (2020)

[3] P.G. Reinhard, W. Nazarewicz, Phys. Rev. C, 95, 6 (2017)]

[4] A.J. Miller, K. Minamisono, A. Klose et al., Nature Physics, 15 (2019)

[5] A . Koszorus, X. Yang, W. Jiang, Nature Physics, 17 (2021)

[6] M. Reponen et al., Nature Commun., 12, 1 (2021)

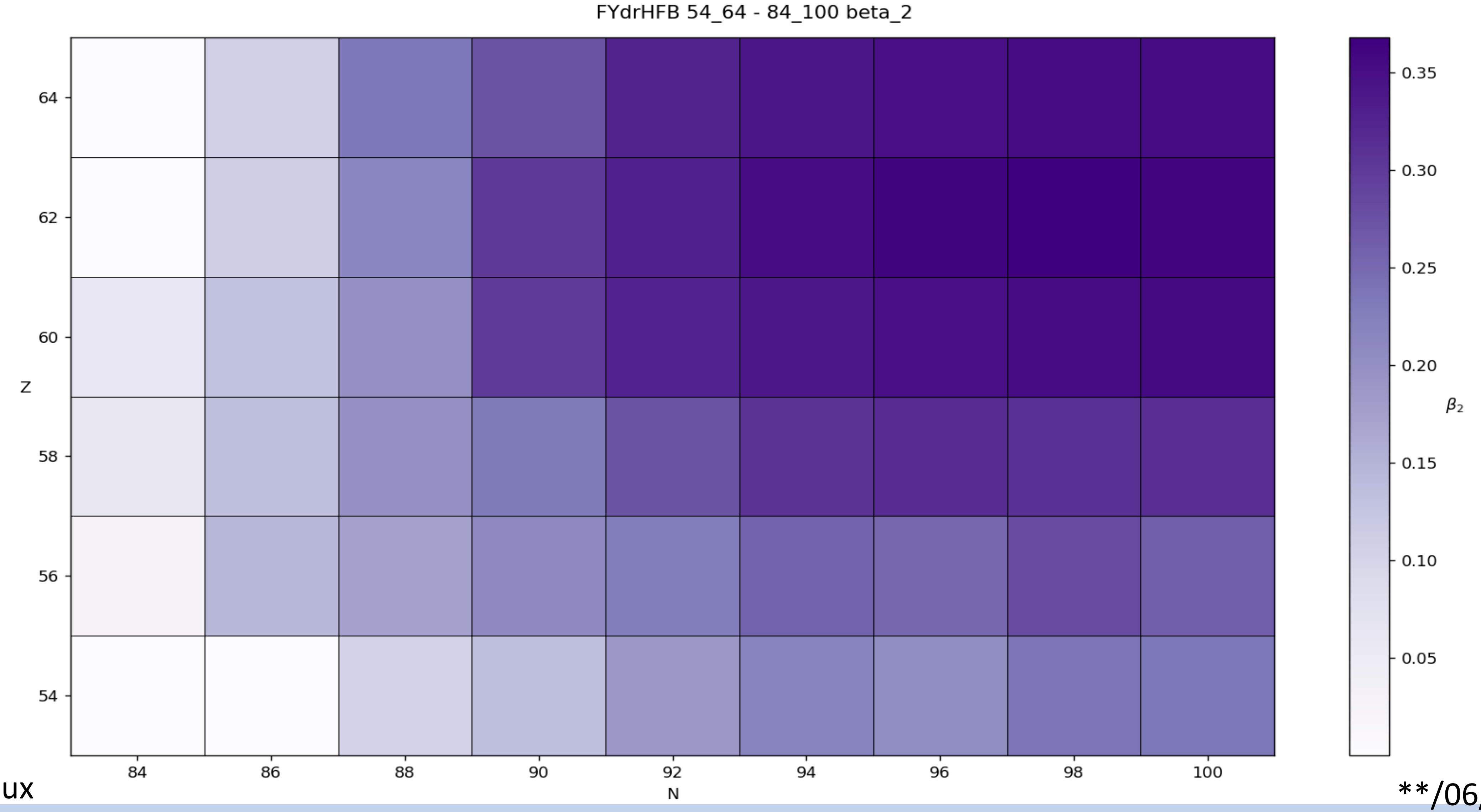
[7] J. Dobaczewski, J. Engel, M. Kortelainen et al., Phys. Rev. Lett., 121, 23 (2018)

[8] S. Ebata and T. Nakatsukasa, Physica Scripta, 92, 6 (2017)

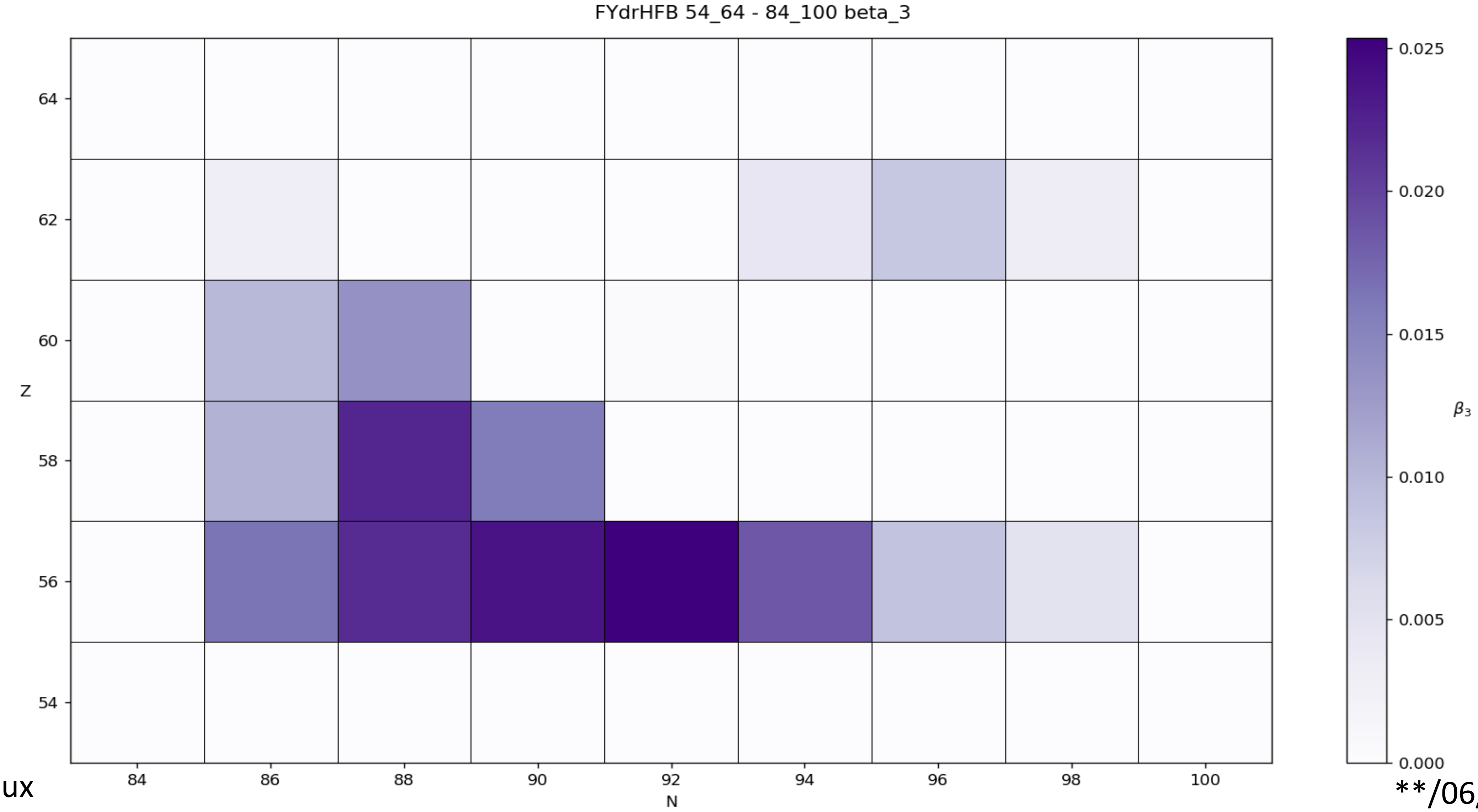
[9] Y. Cao, S.E. Agbemava, A.V. Afanasjev et al., Phys. Rev. C, 102, 12 (2020)

Cesium-centered cluster

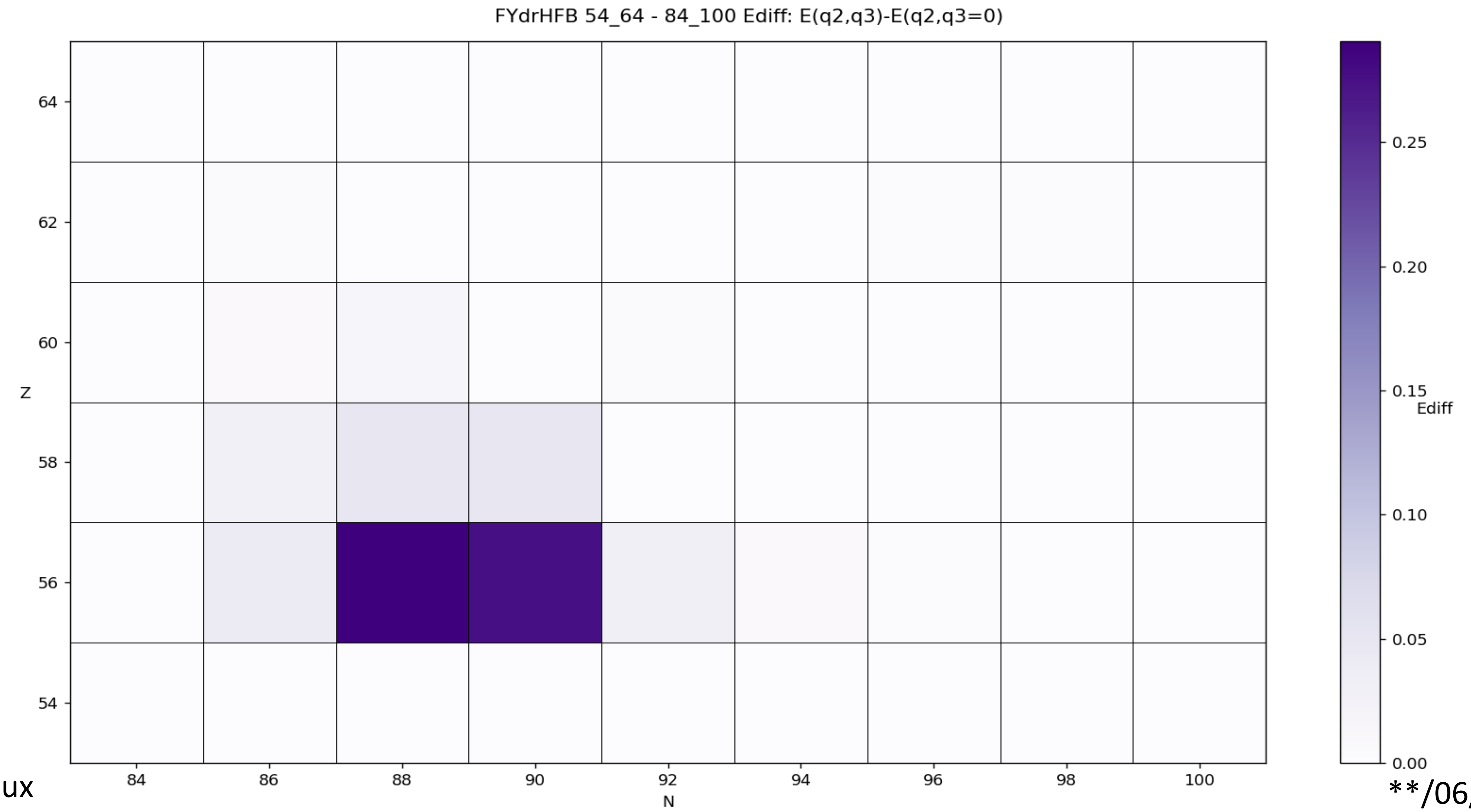
Cesium-centered cluster



Cesium-centered cluster

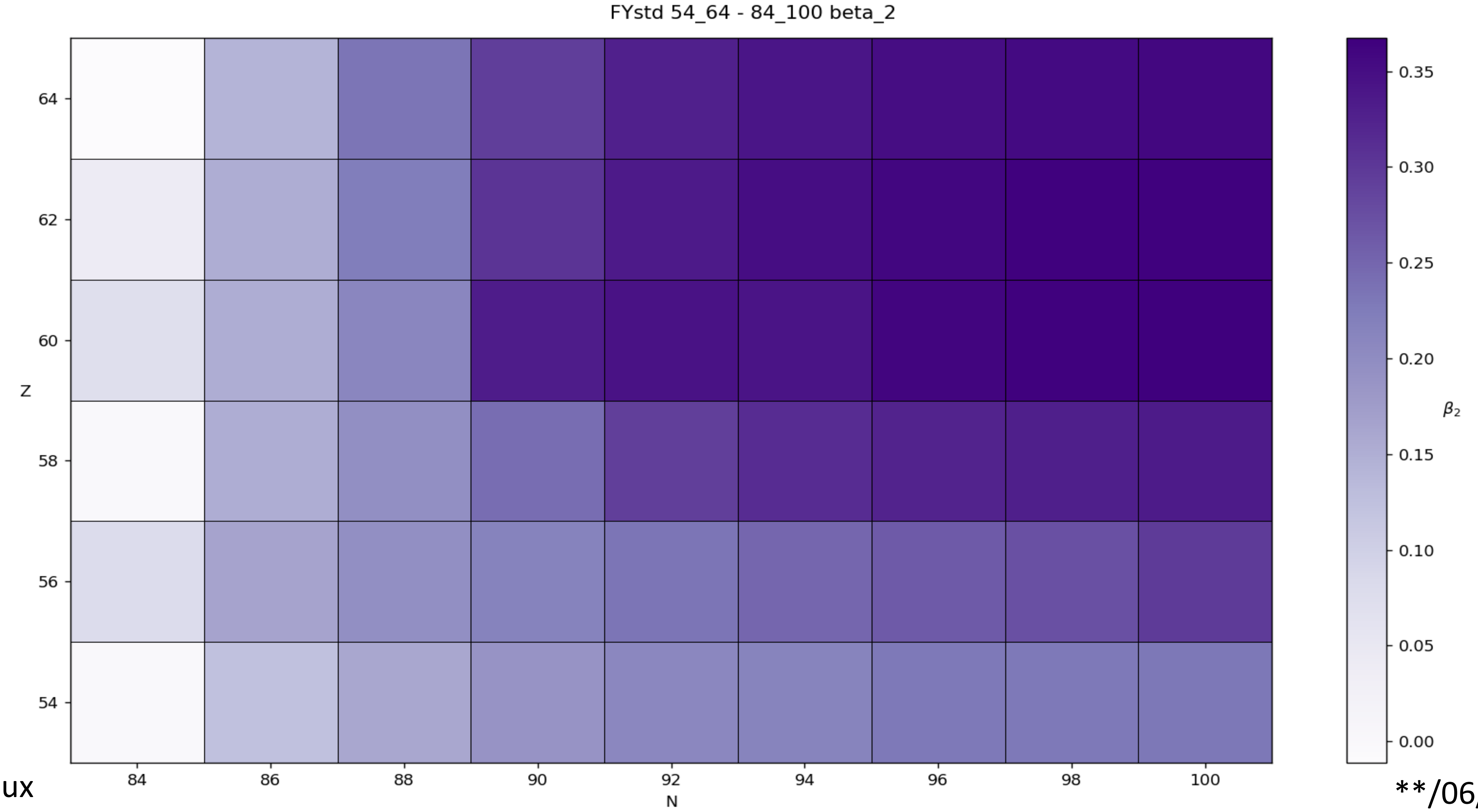


Cesium-centered cluster

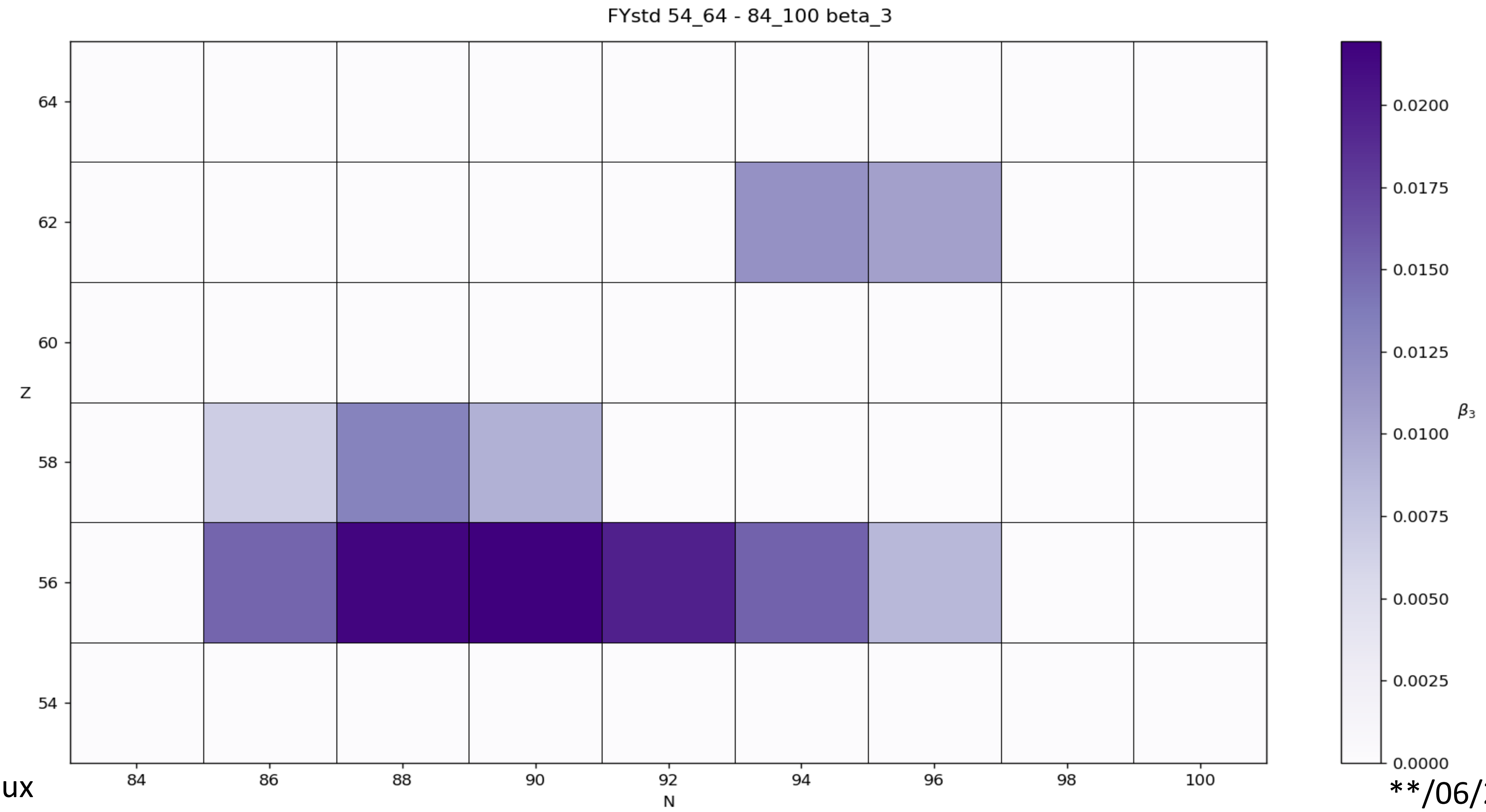


Cesium-centered cluster

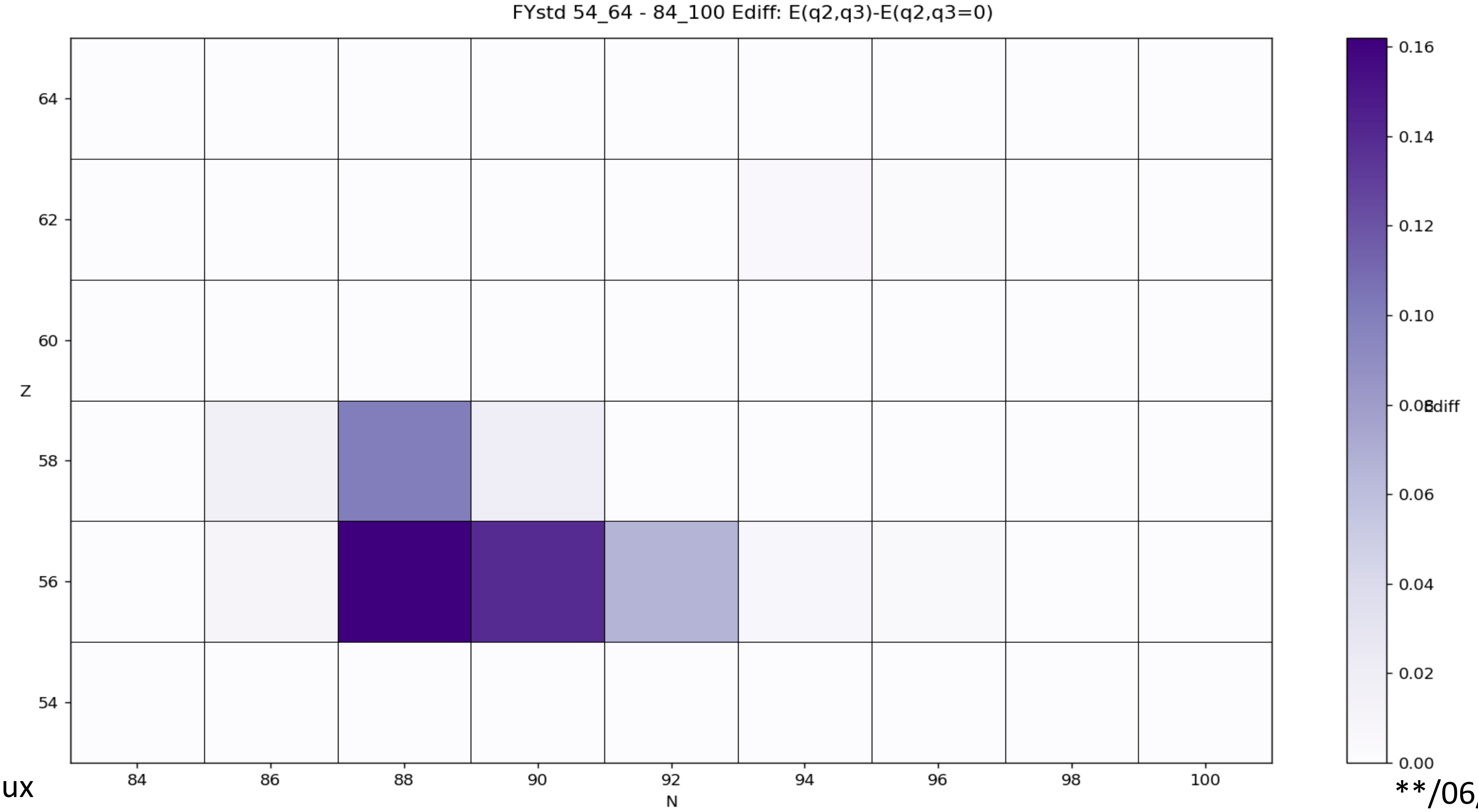
Cesium-centered cluster



Cesium-centered cluster

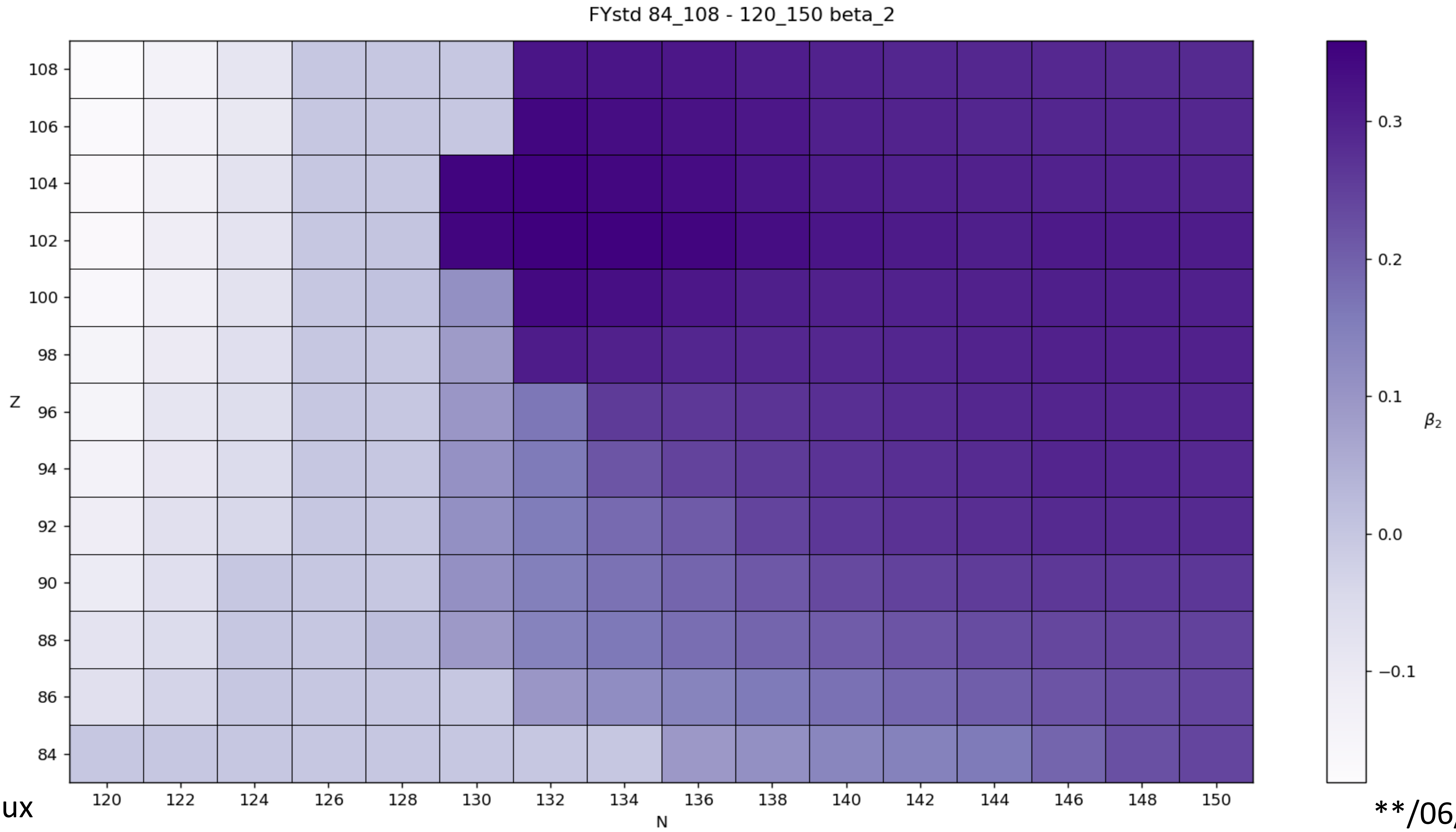


Cesium-centered cluster

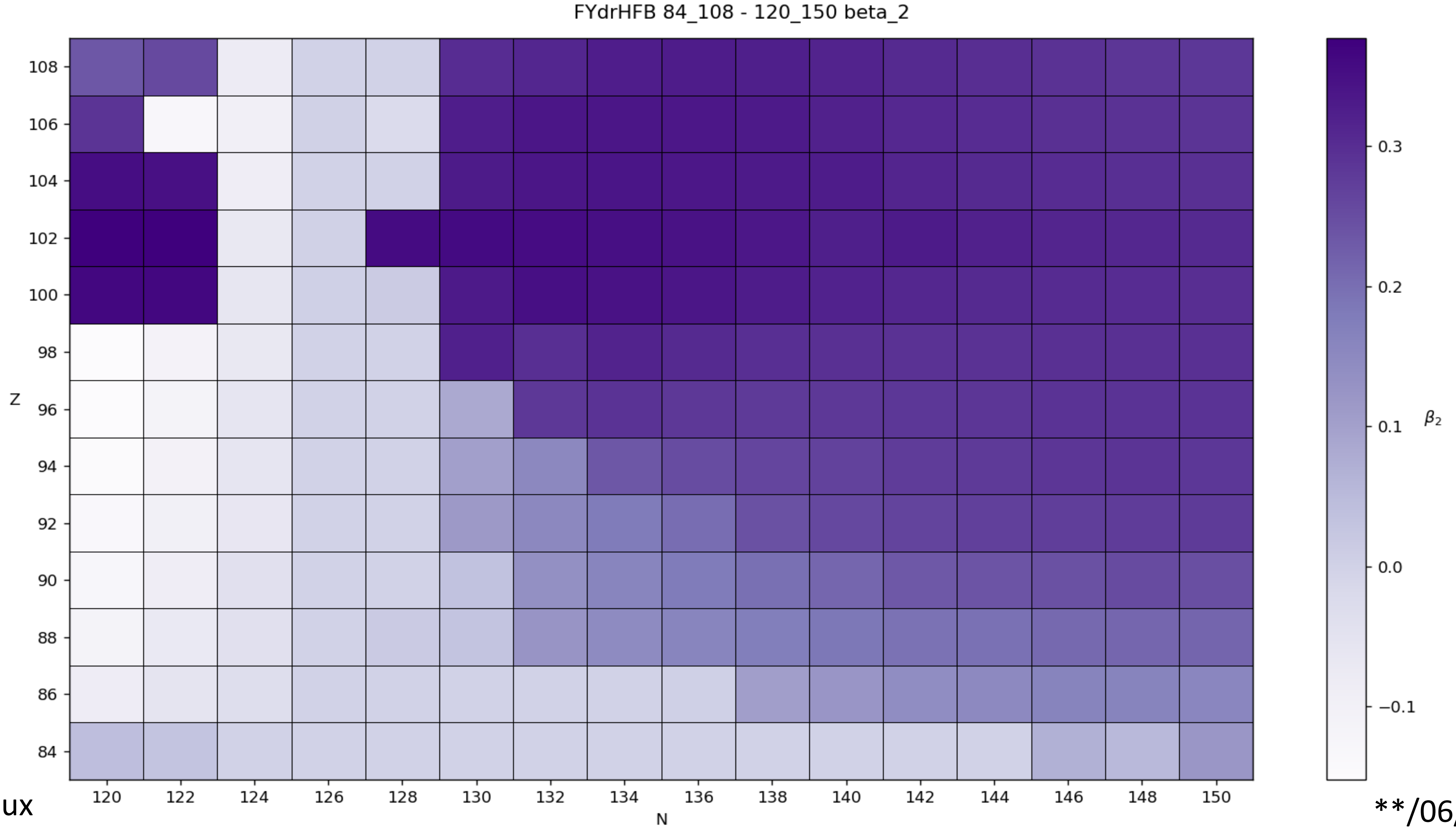


Quadrupole

Quadrupole


FYstd 84_108 - 120_150 beta_2
108
106
104
102
100
98
96
94
92
90
88
86
84
Z
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
N
0.3
0.2
0.1
0.0
−0.1
β_2

Quadrupole



FYdrHFB 84_108 - 120_150 beta_2
Z
N
108
106
104
102
100
98
96
94
92
90
88
86
84
120
122
124
126
128
130
132
134
136
138
140
142
144
146
148
150
β_2
0.3
0.2
0.1
0.0
−0.1