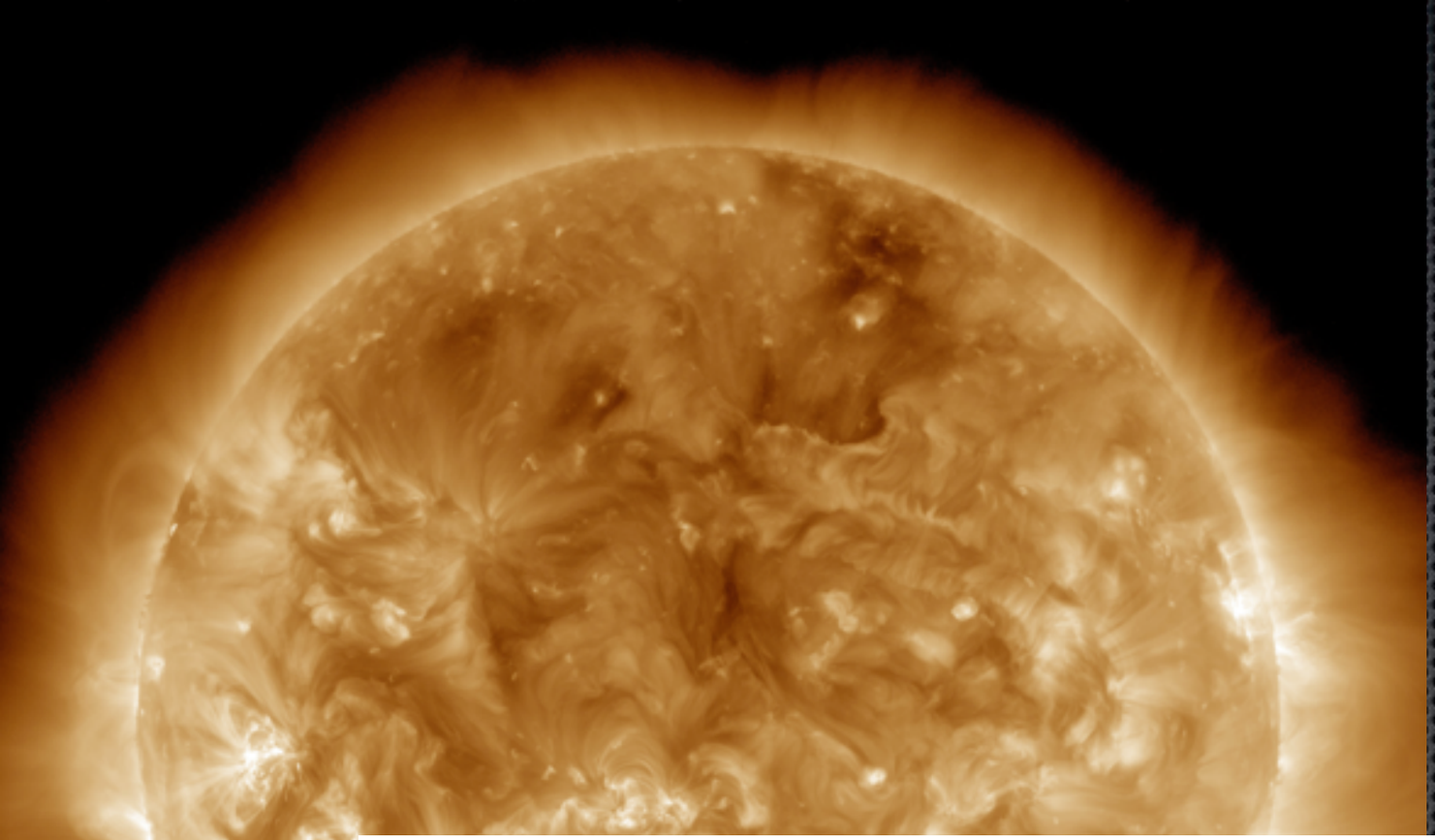
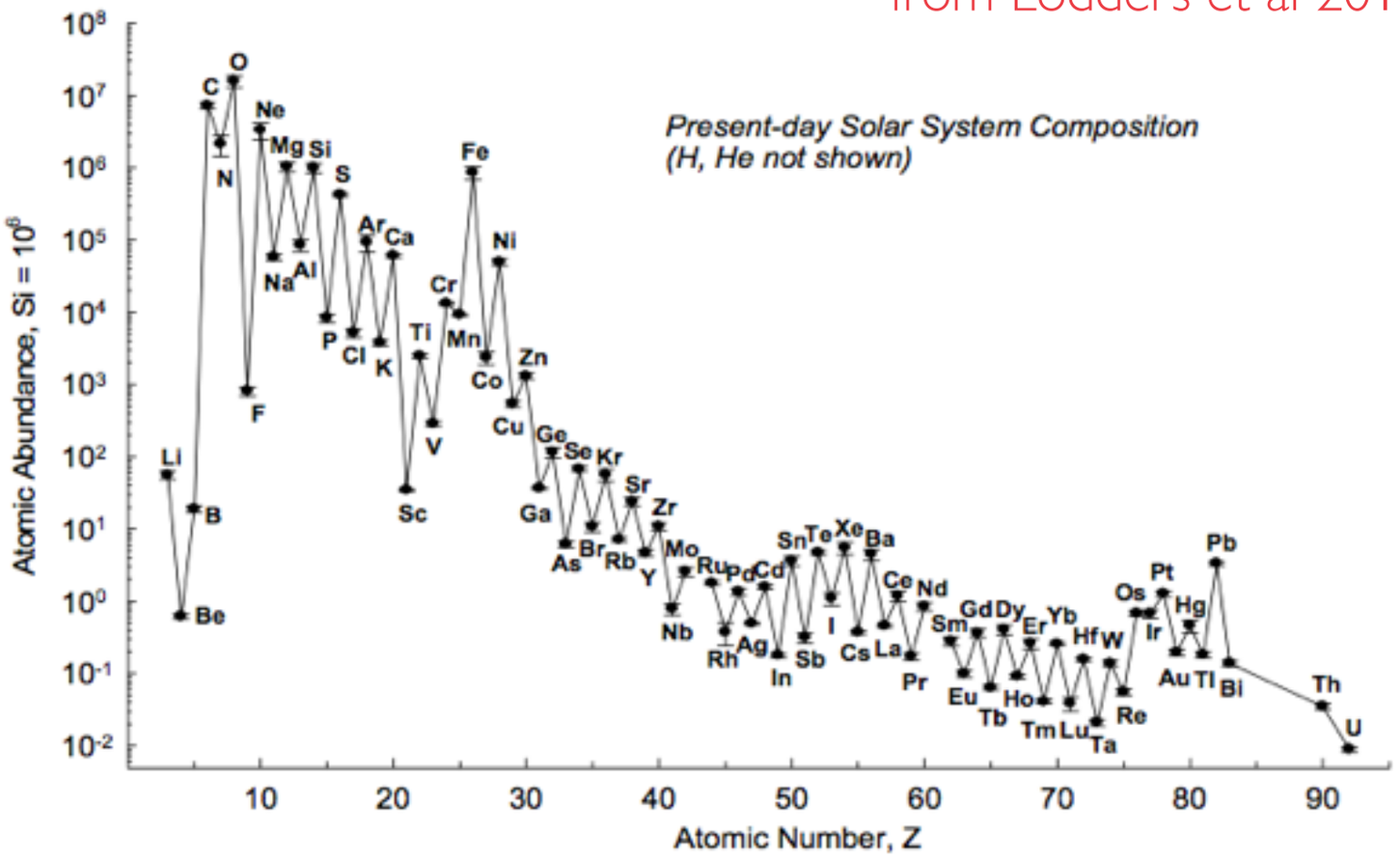
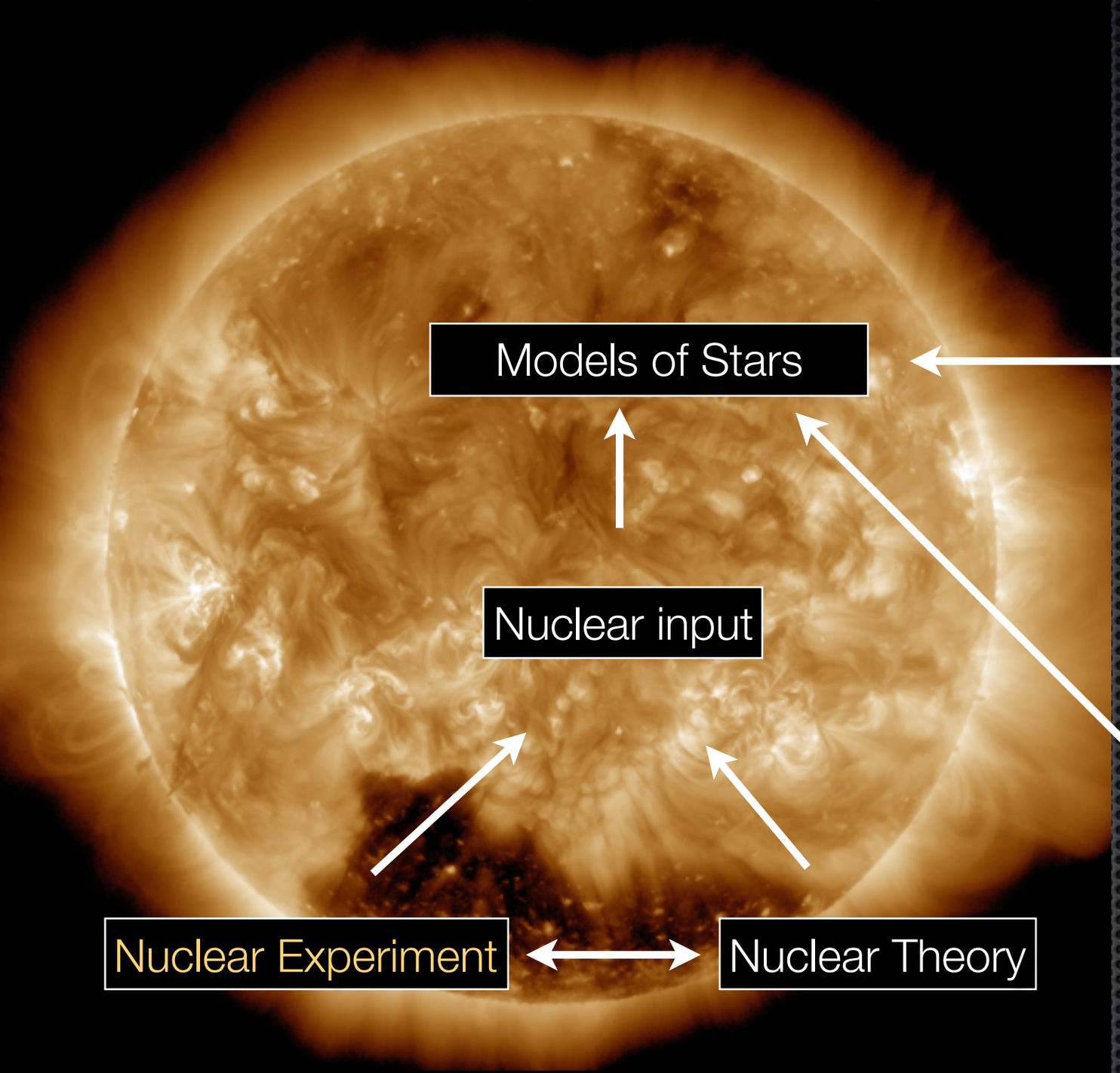
How uncertain are global optical potentials away from stability?

Georgios Perdikakis, Central Michigan University
ICNT workshop on “Deuteron-induced reactions and beyond: Inclusive breakup fragment cross sections”,
East Lansing, July 18-22, 2016



from Lodders et al 2010





Models of Stars

Nuclear input

Nuclear Experiment ⟷ Nuclear Theory

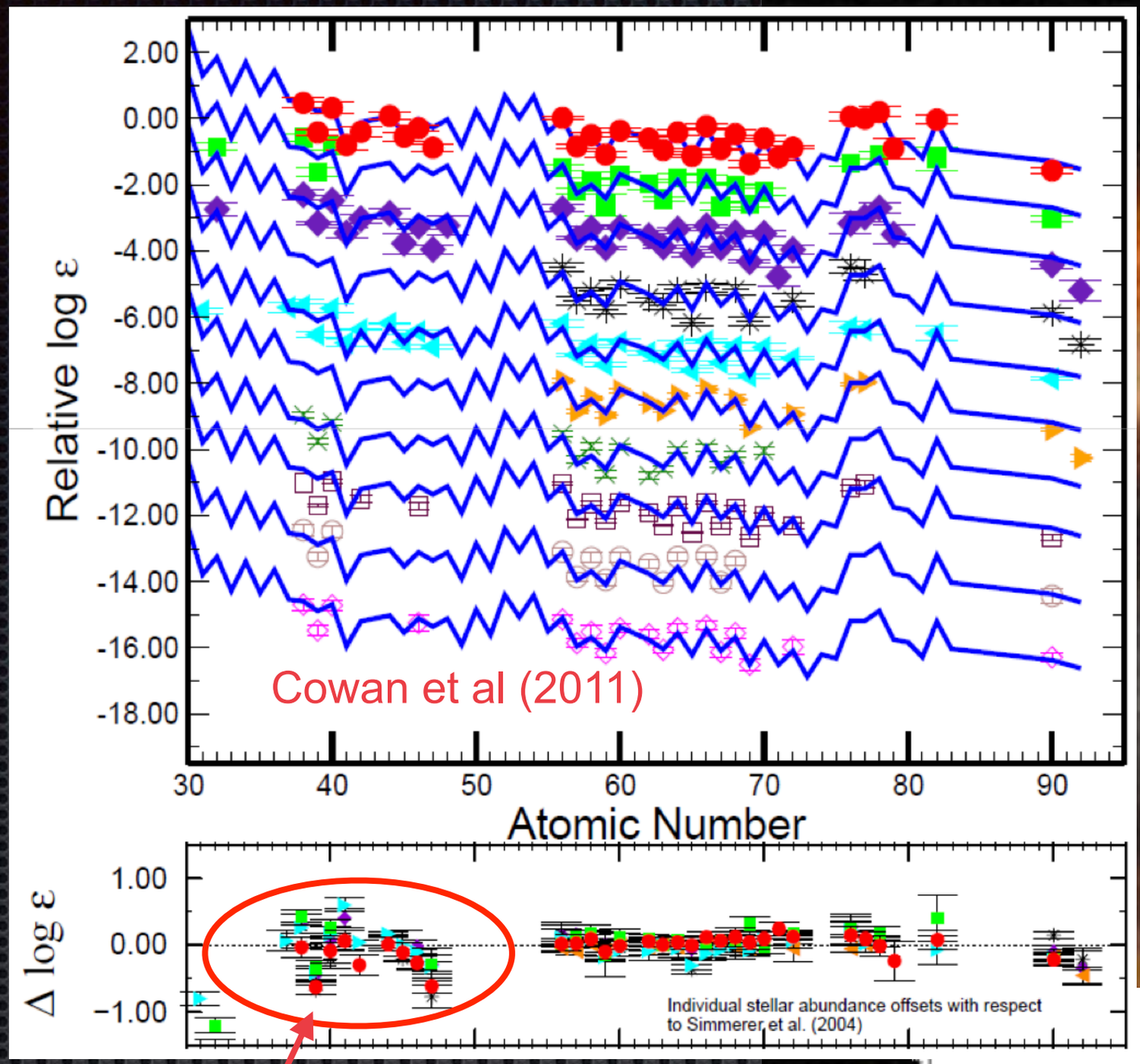
- Cross sections
- Nuclear Structure
- Masses

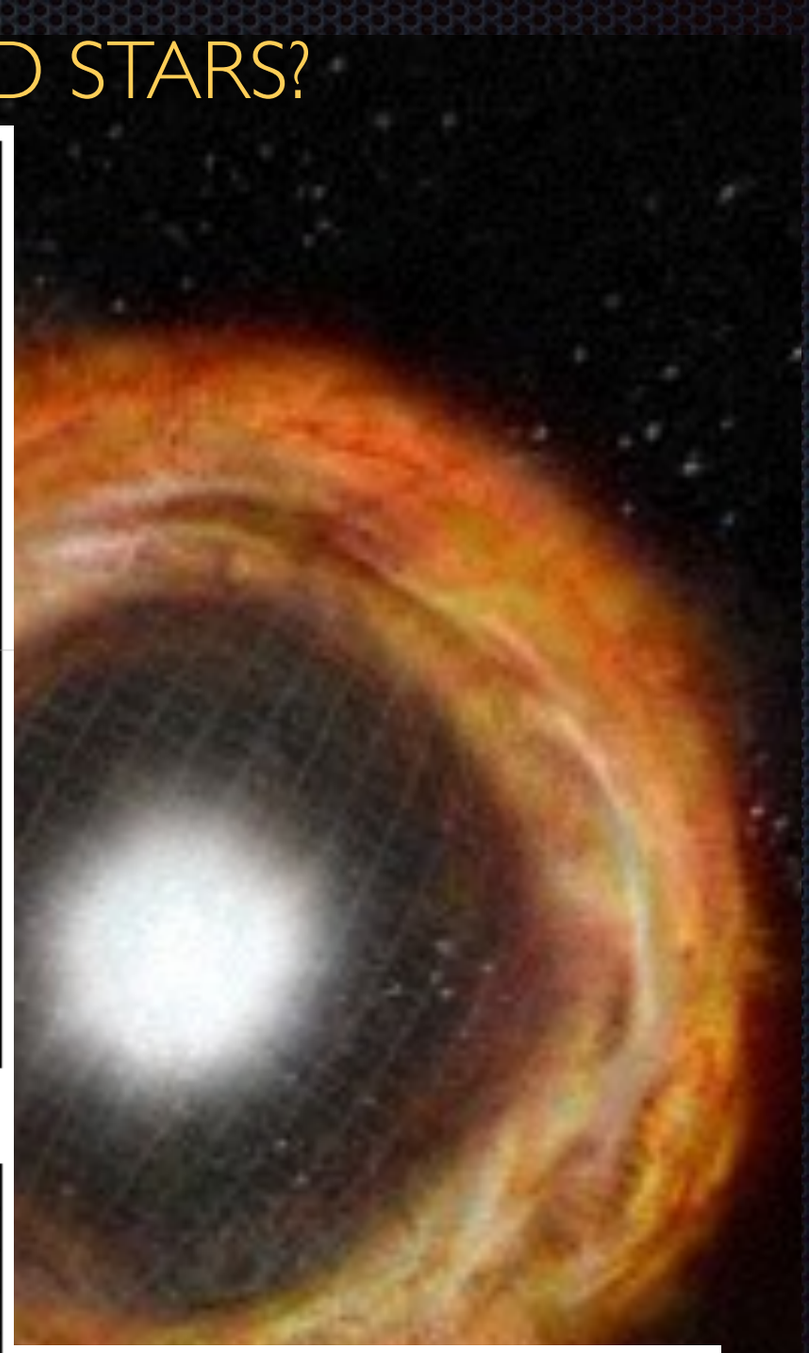
Observations

- Spectra (Large telescopes)
- Planetary (earth) matter, Meteorites
- Interstellar medium (space missions)

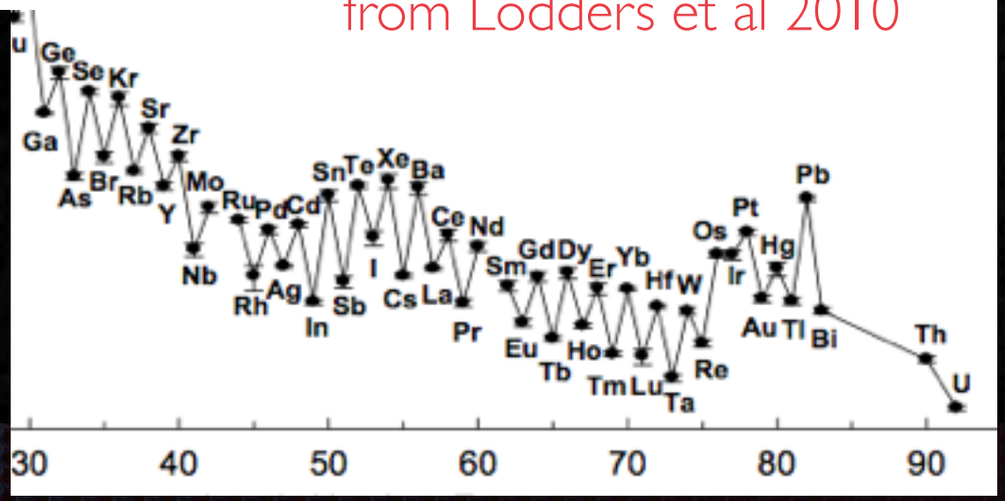
Galactic Chemical Evolution

WHAT CAN WE LEARN FROM OLD STARS?





from Lodders et al 2010

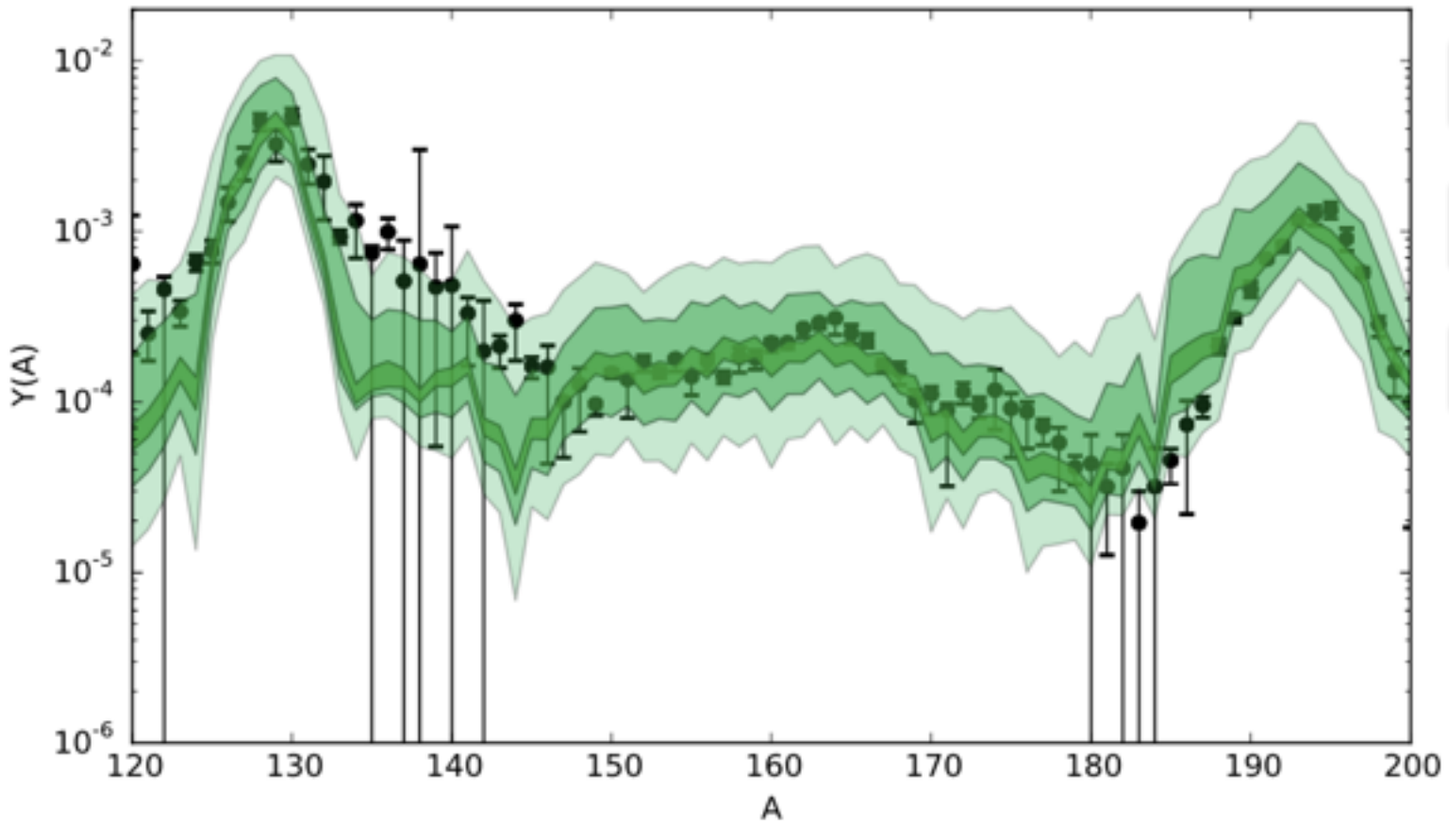


Lighter Element Primary Process (Mechanism unknown)

Qian and Wasserburg, 2007

Montes et al., 2007

How much reaction rate uncertainty is good enough for the r-process?

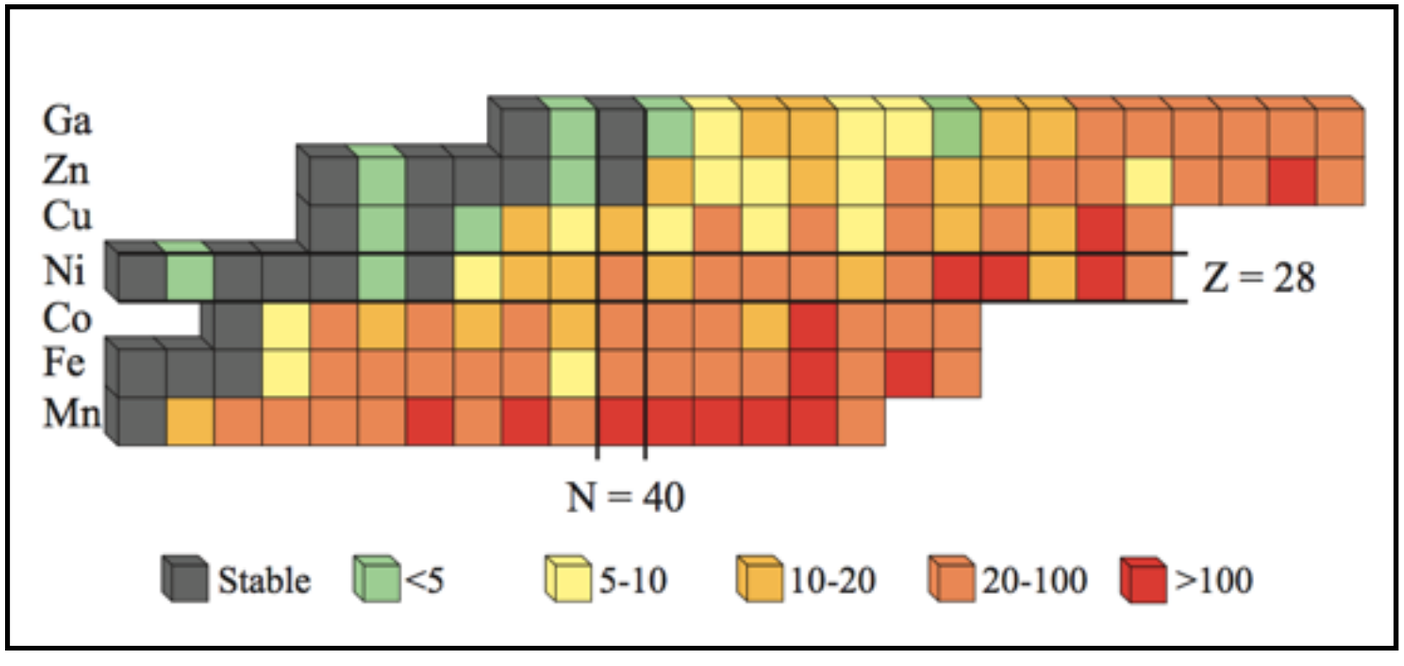


x2

x10

x100

How much uncertainty to expect?



Liddick,…,Perdikakis,…,Nikas,…, et al., Phys. Rev. Lett. 116, 242502, (2016)

Physics Letters B

Volume 653, Issues 2–4, 20 September 2007, Pages 178–183

Open Access

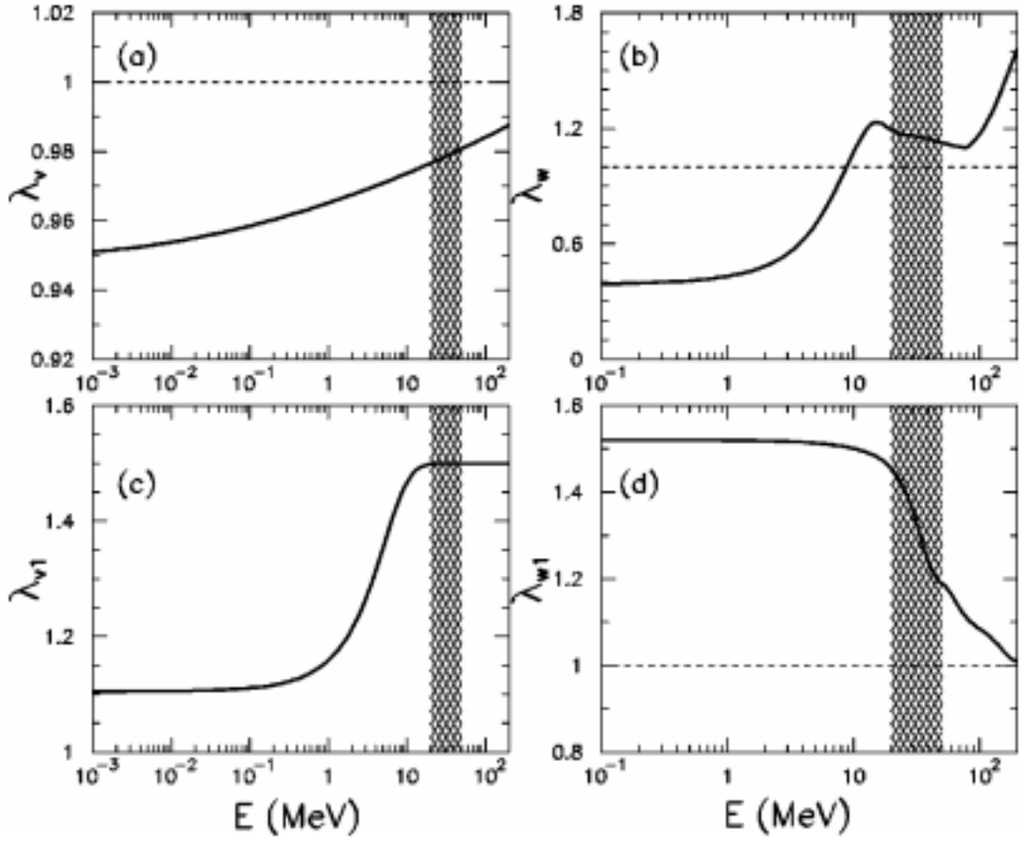
The isovector imaginary neutron potential: A key ingredient for the r-process nucleosynthesis

S. Goriely[a], J.-P. Delaroche[b]

[a] Institut d'Astronomie et d'Astrophysique, Université Libre de Bruxelles, Campus de la Plaine, CP 226, 1050 Brussels, Belgium

[b] DPTA/Service de Physique Nucléaire, CEA/DAM Ile de France, BP 12, 91680 Bruyères-le-Châtel, France

JLM semi-microscopic Optical Potential,



For n+ X(A,Z,N):

$$U(E) = \lambda_V(E)\left[V_0(E) + \lambda_{V_1}(E)\alpha V_1(E)\right] + i\lambda_W(E)\left[W_0(E) + \lambda_{W_1}(E)\alpha W_1(E)\right]$$

gray region: thorough checks with (p,p), (n,n) and (p,n) data, 1.5-10% uncertainty

(Bauge, Delaroche, Girod, PRC63, (2001), 024607)

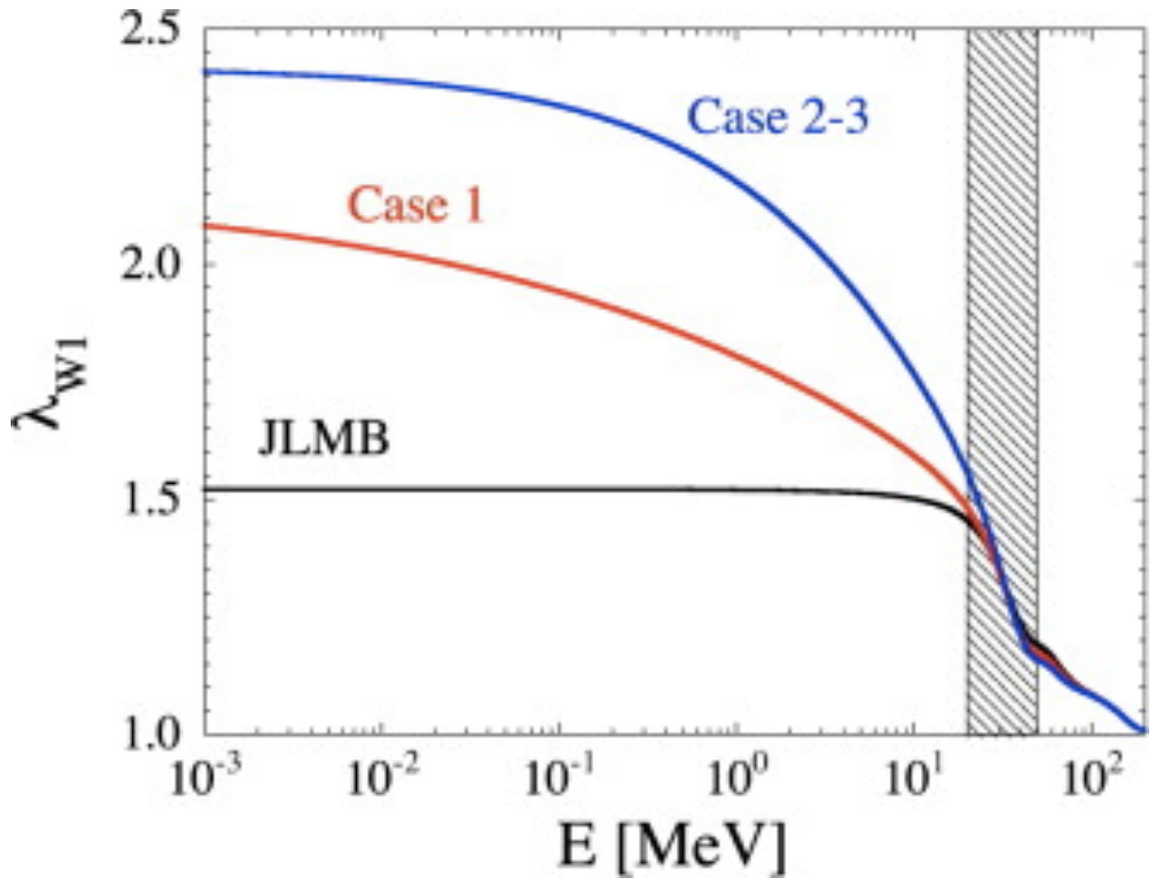
Why not add an energy dependence at low energies by hand?

$$U(E) = \lambda_V(E)\left[V_0(E) + \lambda_{V_1}(E)\alpha V_1(E)\right] + i\lambda_W(E)\left[W_0(E) + \lambda_{W_1}(E)\alpha W_1(E)\right]$$

Case 1: 30% higher $\boldsymbol{\lambda_{w1}}$ @ 100keV

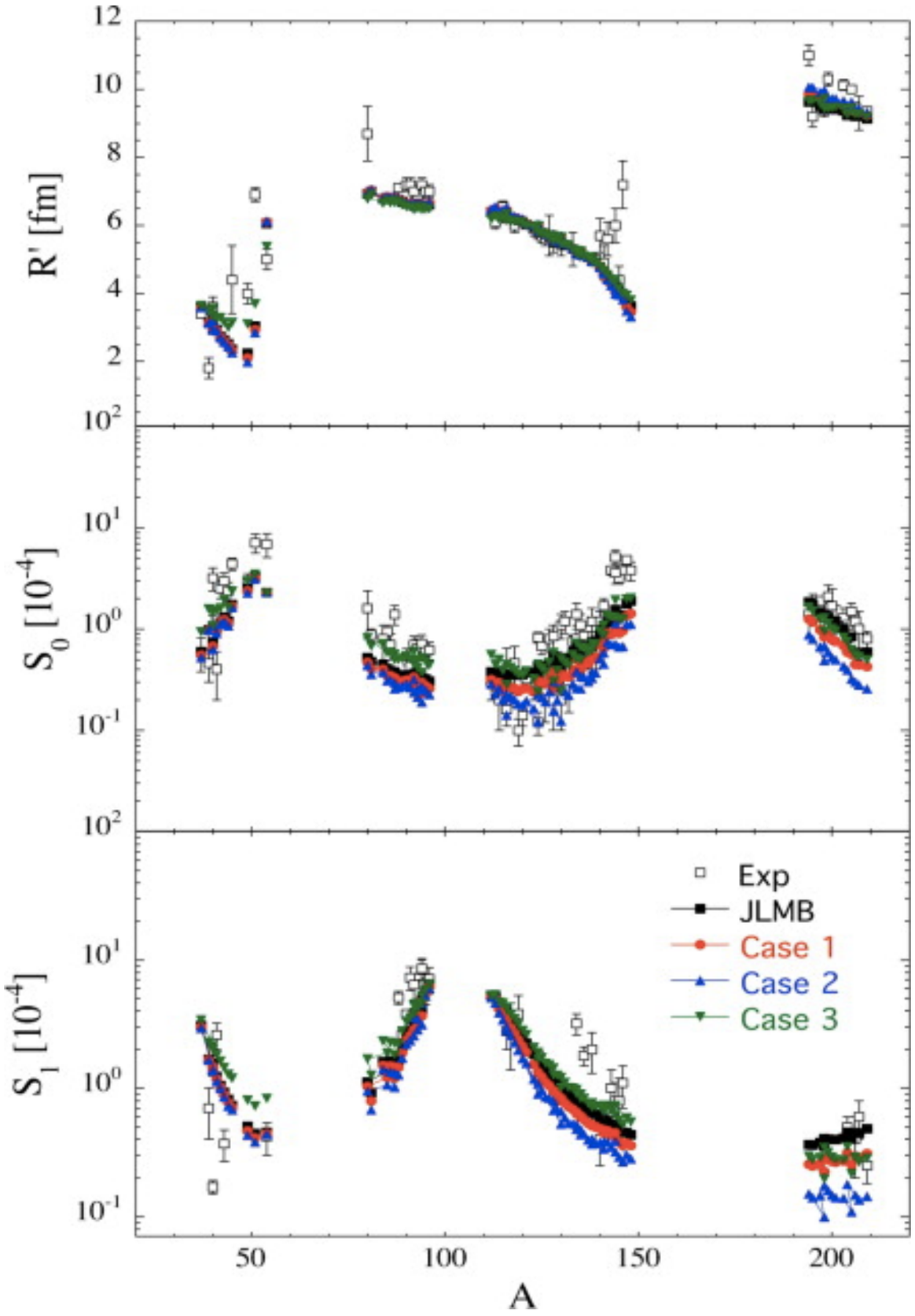
Case 2: 50% higher $\boldsymbol{\lambda_{w1}}$ @ 100keV

Case 3: 50% higher $\boldsymbol{\lambda_{w}}$ @ 100keV



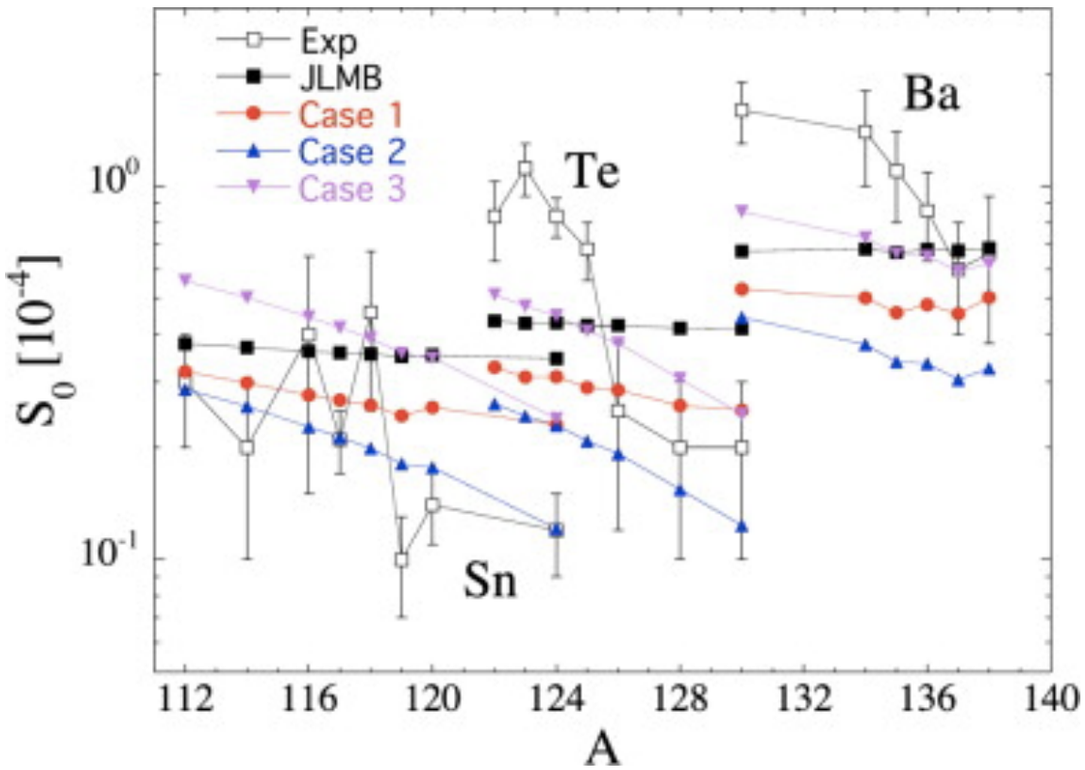
(Goriely and Delaroche, PLB653, (2007), 178)

How well does it perform? Neutron strength function as benchmark



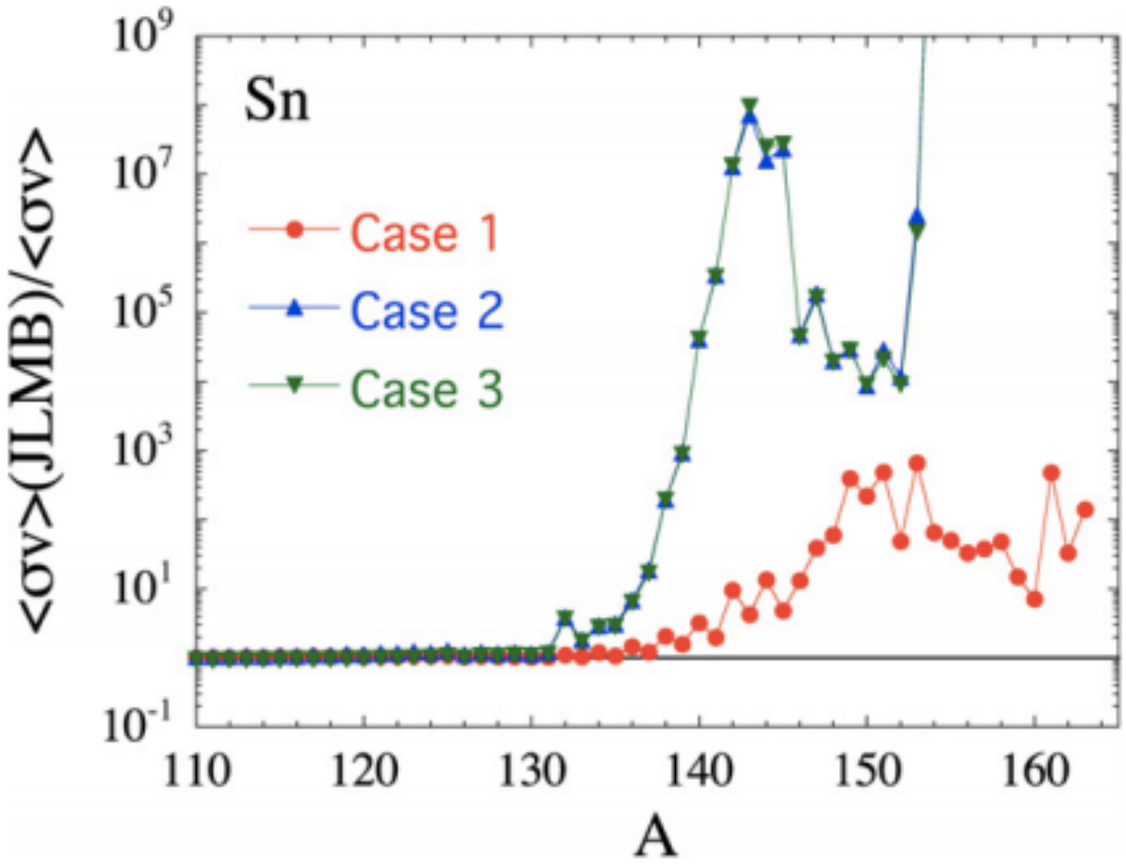
(Goriely and Delaroche, PLB653, (2007), 178)

How well does it perform? Neutron strength function as benchmark

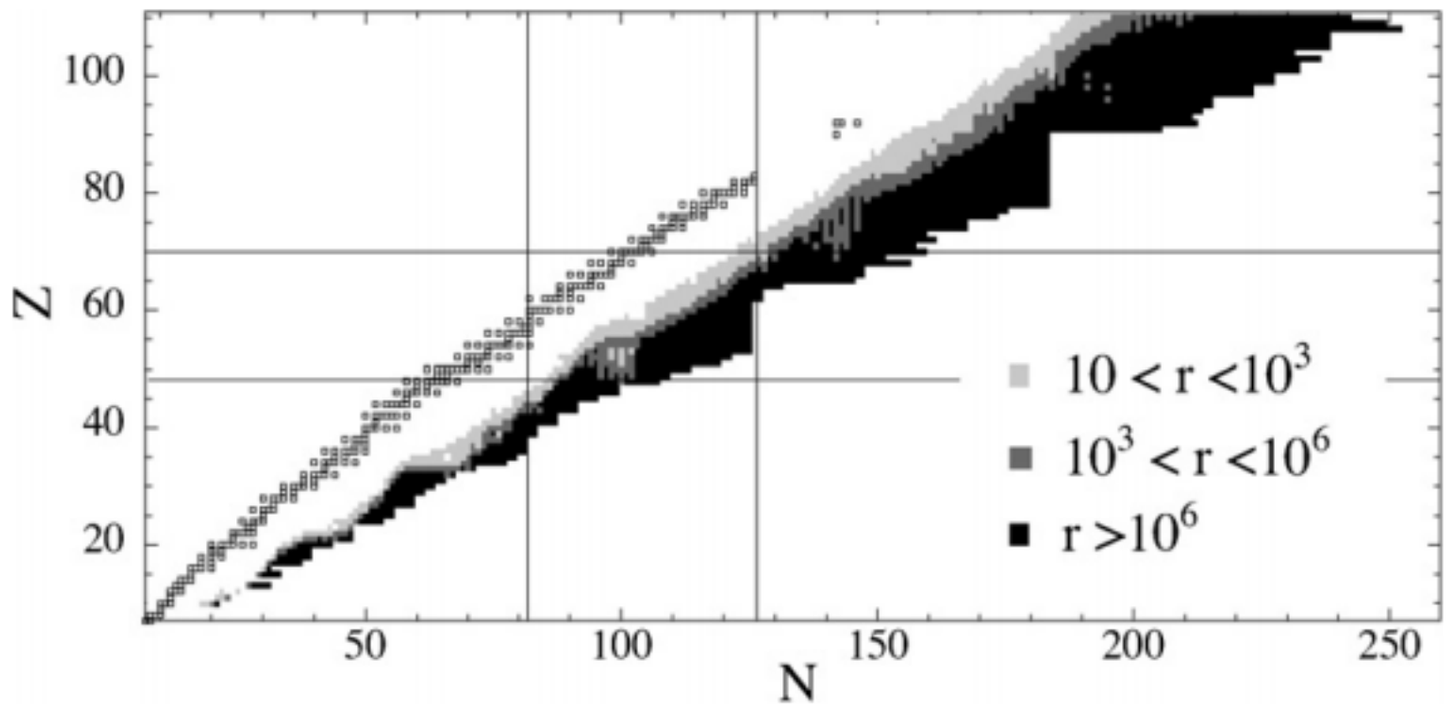


(Goriely and Delaroche, PLB653, (2007), 178)

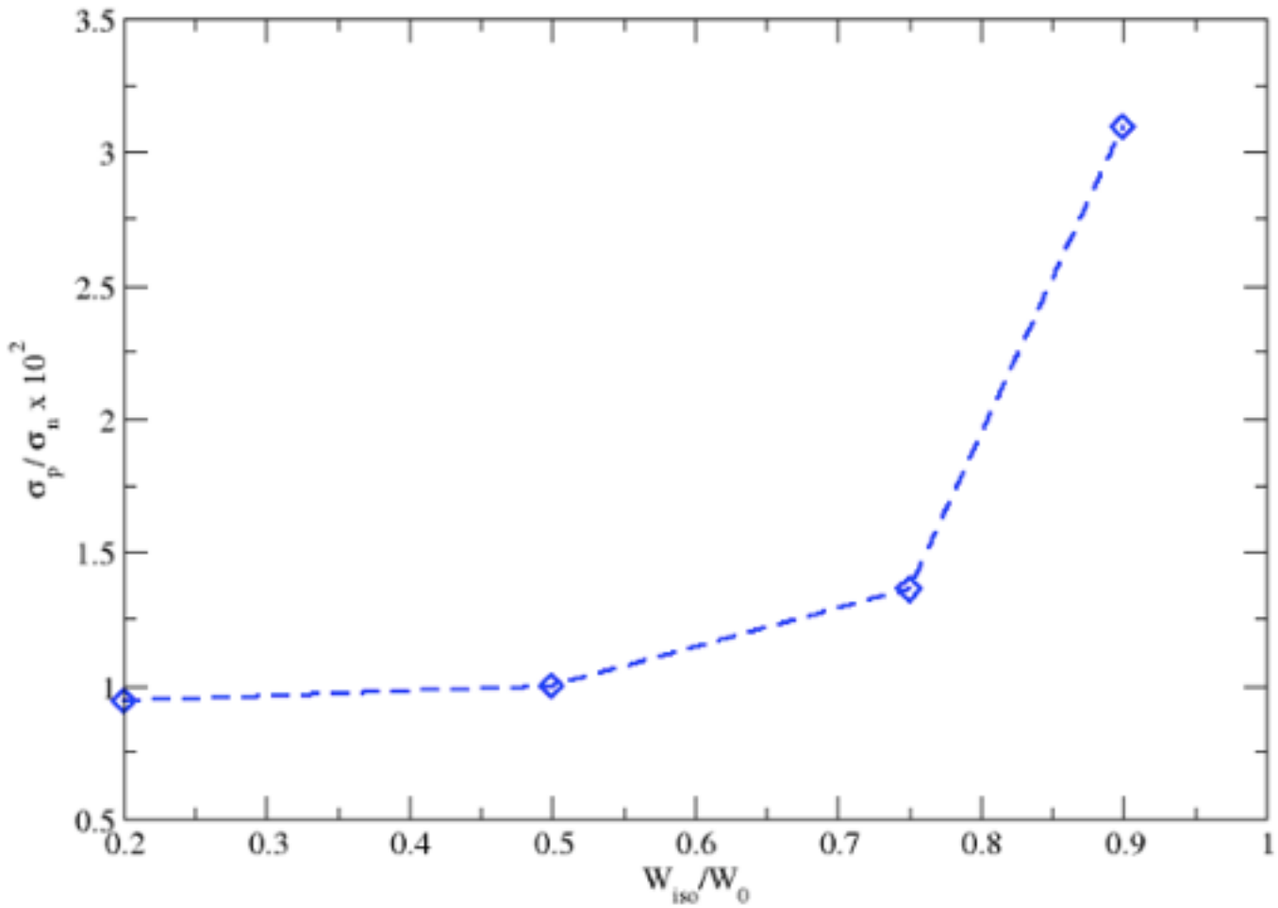
Is it important for astrophysics?



Yes, terrifying!

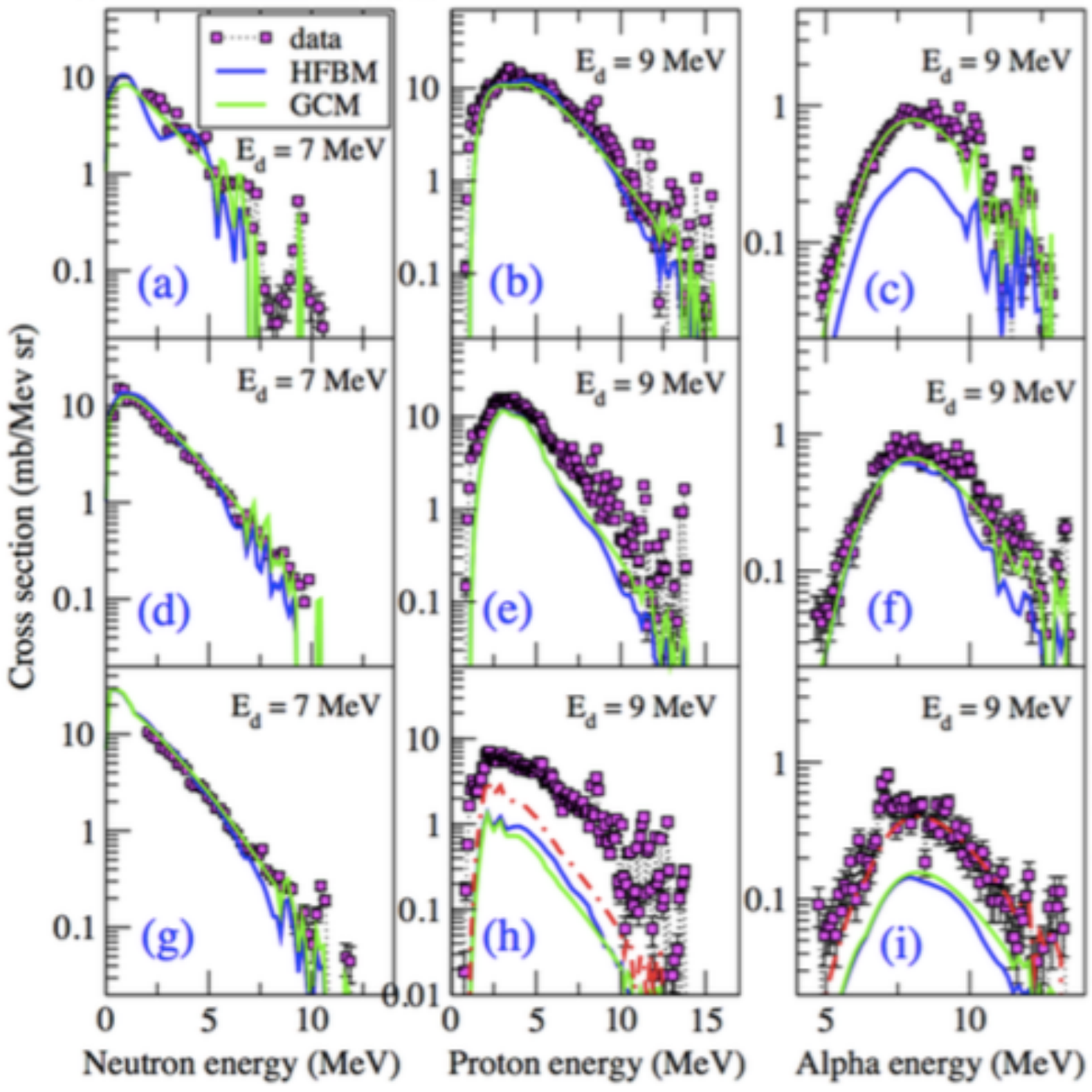


Tweaking the imaginary part and looking at particle production



Hauser Feshbach calculation by A. Voinov

Are there any corroborating experimental hints for such a discrepancy?

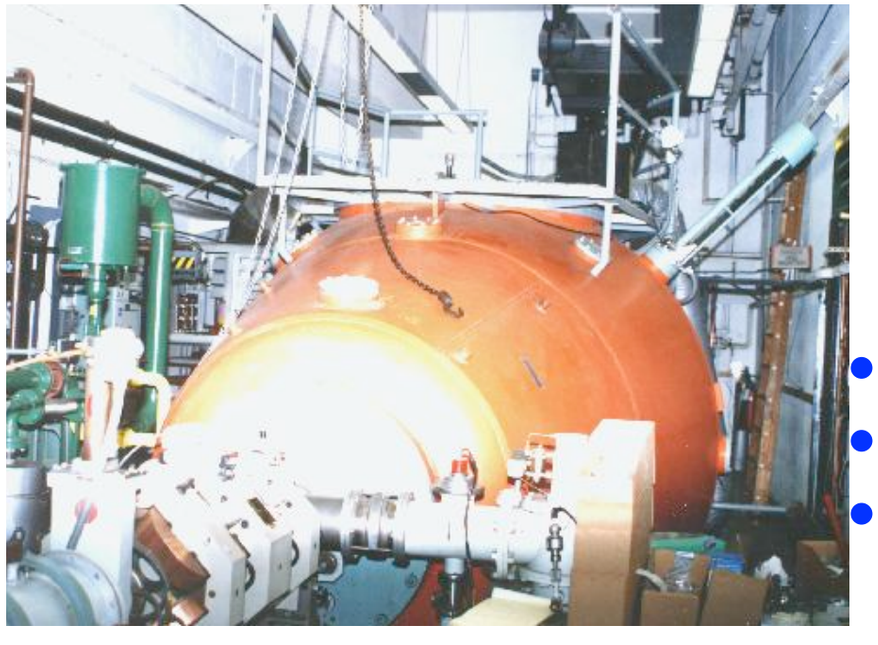


d+^{54}Fe

d+^{56}Fe

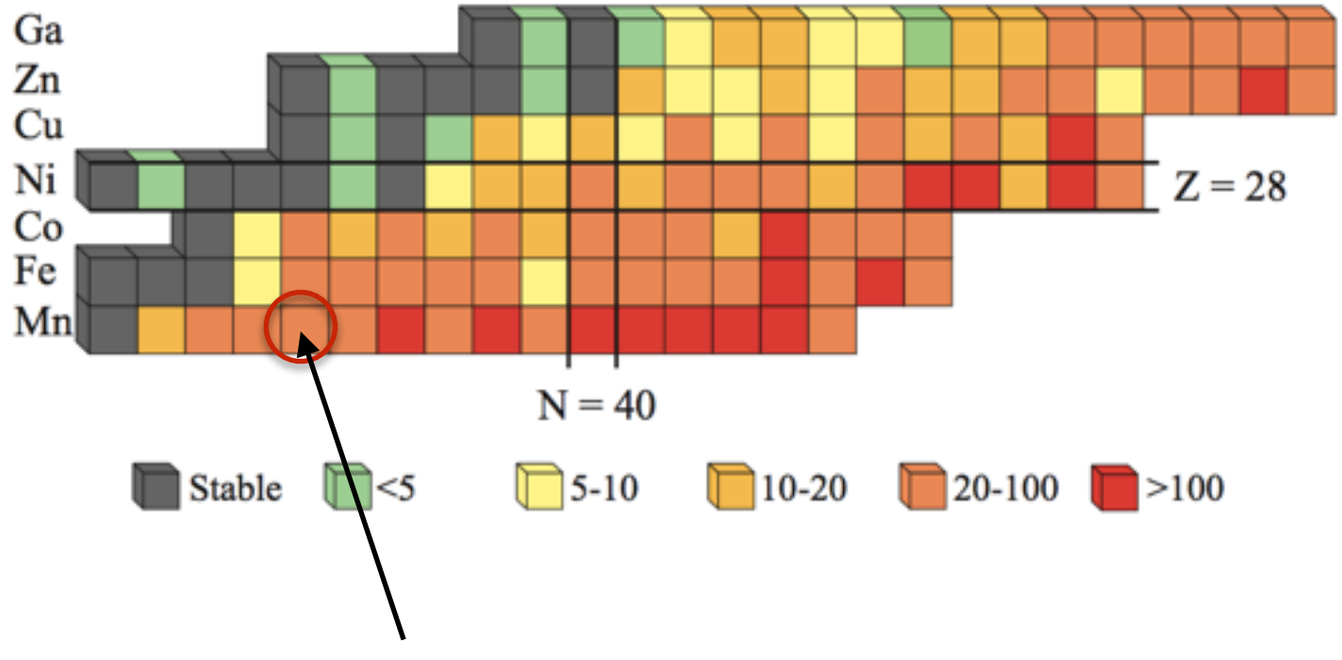
d+^{58}Fe

Ramirez, **Voinov**, Grimes et al., Phys. Rev. C 92, 014303, (2015)



Proposed experiment @ Ohio U accelerator

- E_{beam} < 5MeV/u
- Experimental setup for particle evaporation measurements
- Region with experimentally constrained level densities



$^{11}B+^{48}Ca \rightarrow {}^{59}Mn^* \longrightarrow$ Measure evaporated particle yields

Better ideas are welcome!