CAN CROSS SECTIONS BE ACCURATELY KNOWN A PRIORI?

M.T. Pigni [1)], F.S. Dietrich [1), 2)], M. Herman [1)], P. Obložinský [1)]

[1)]National Nuclear Data Center, Brookhaven National Laboratory

[2)]Nuclear Theory & Modeling Group, Lawrence Livermore National Laboratory

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Office of Science U.S. DEPARTMENT OF ENERGY

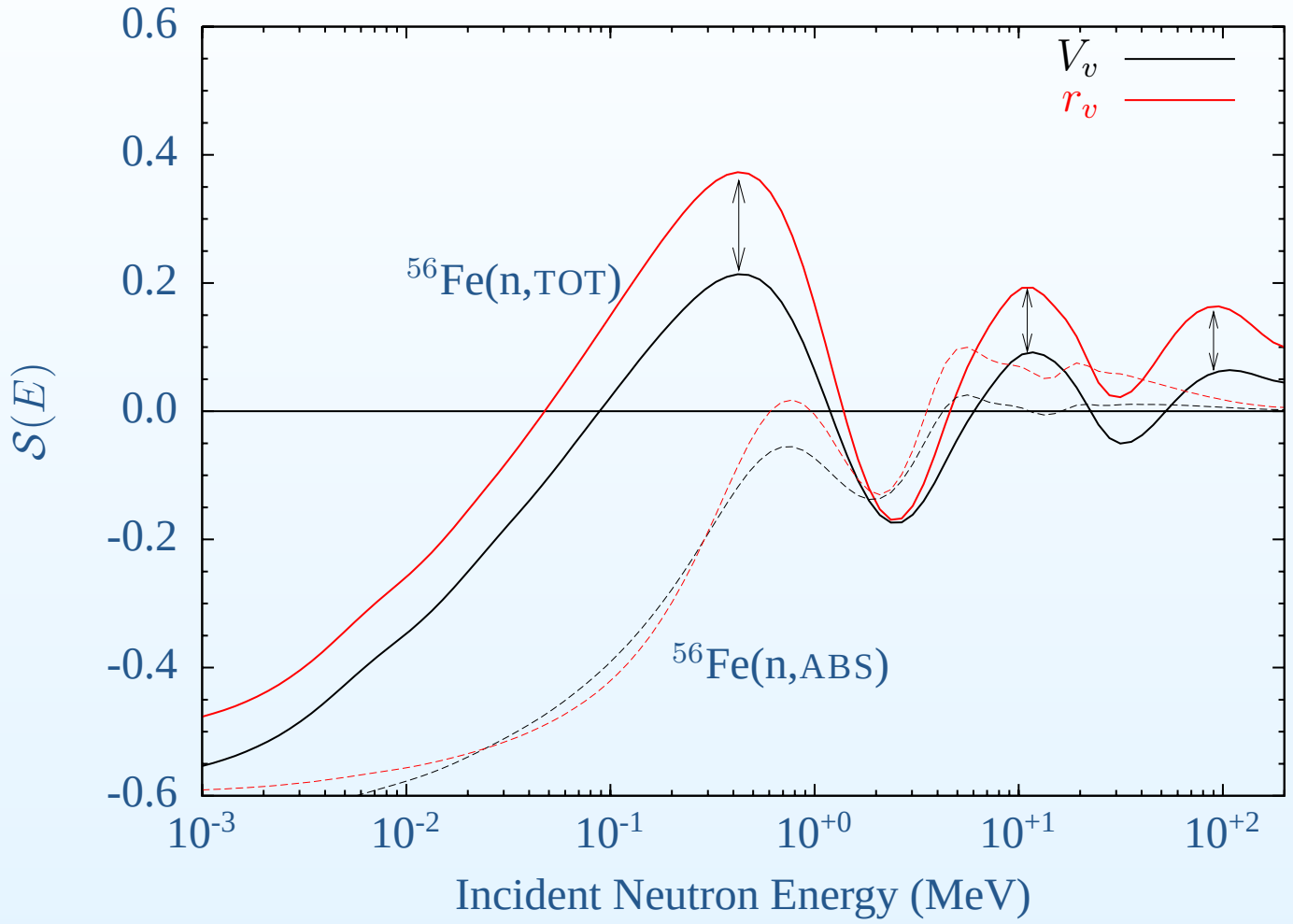
Brookhaven Science Associates

BROOKHAVEN NATIONAL LABORATORY

INTRODUCTION

- ✓ In the "low-fidelity covariance project" families of distinct maxima and minima were observed in the neutron total cross-section uncertainties between 5 keV and 20 MeV.
- ✓ These oscillations were seen to result mostly from the perturbation of V_v, the real volume depth.
- ✓ To investigate their origin, we calculated total cross sections perturbing V_v by its expected uncertainty $\pm\Delta V_v$ and inspecting the effect of this perturbation on the partial wave cross sections.
- ✓ From the total cross-section uncertainty analysis, we tried to get implications on the total reaction cross sections (absorption).

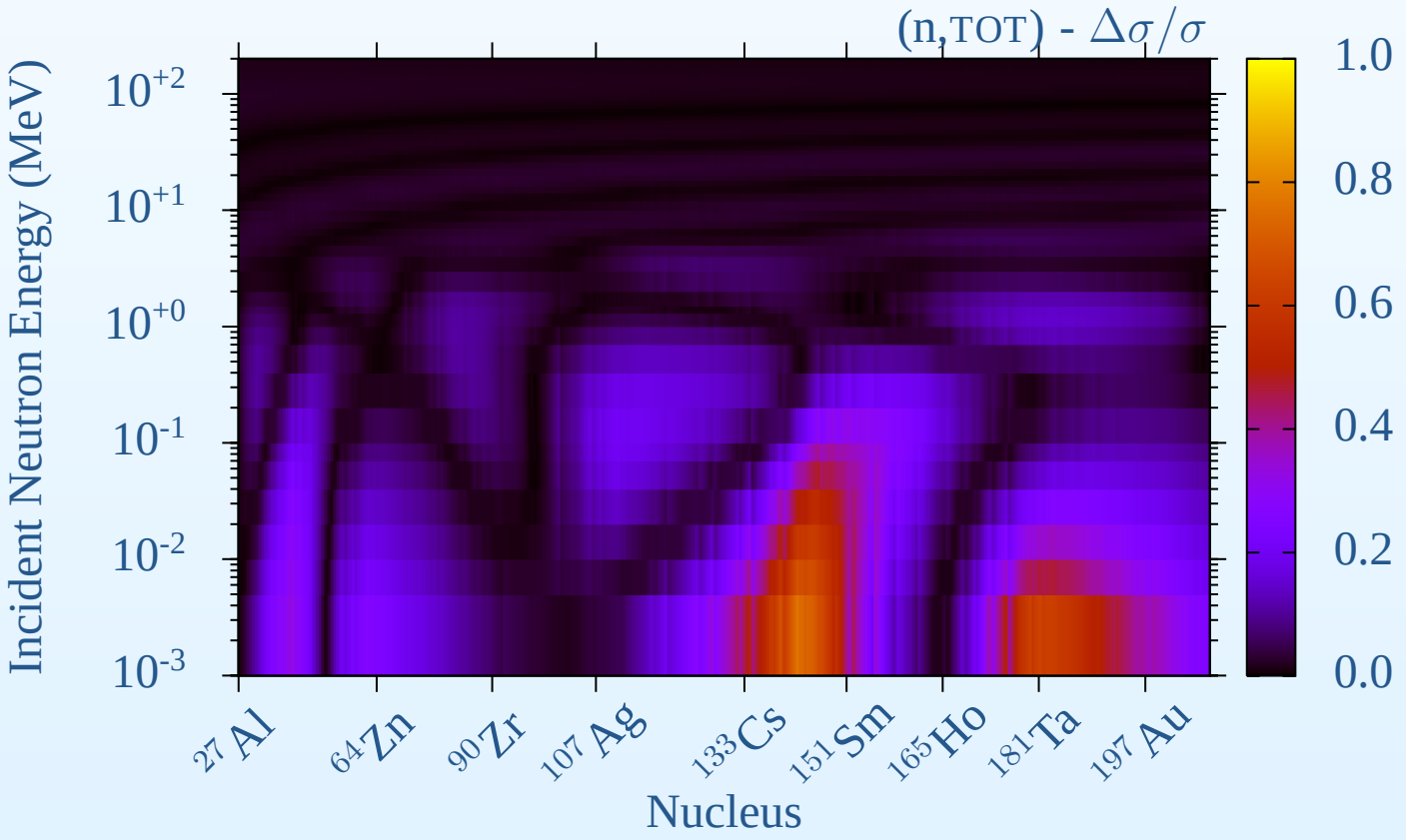
PARAMETER CORRELATION: V_v, r_v



- Almost complete correlation between V_v and r_v
- Total cross section dependence like $V_v r_v^2$

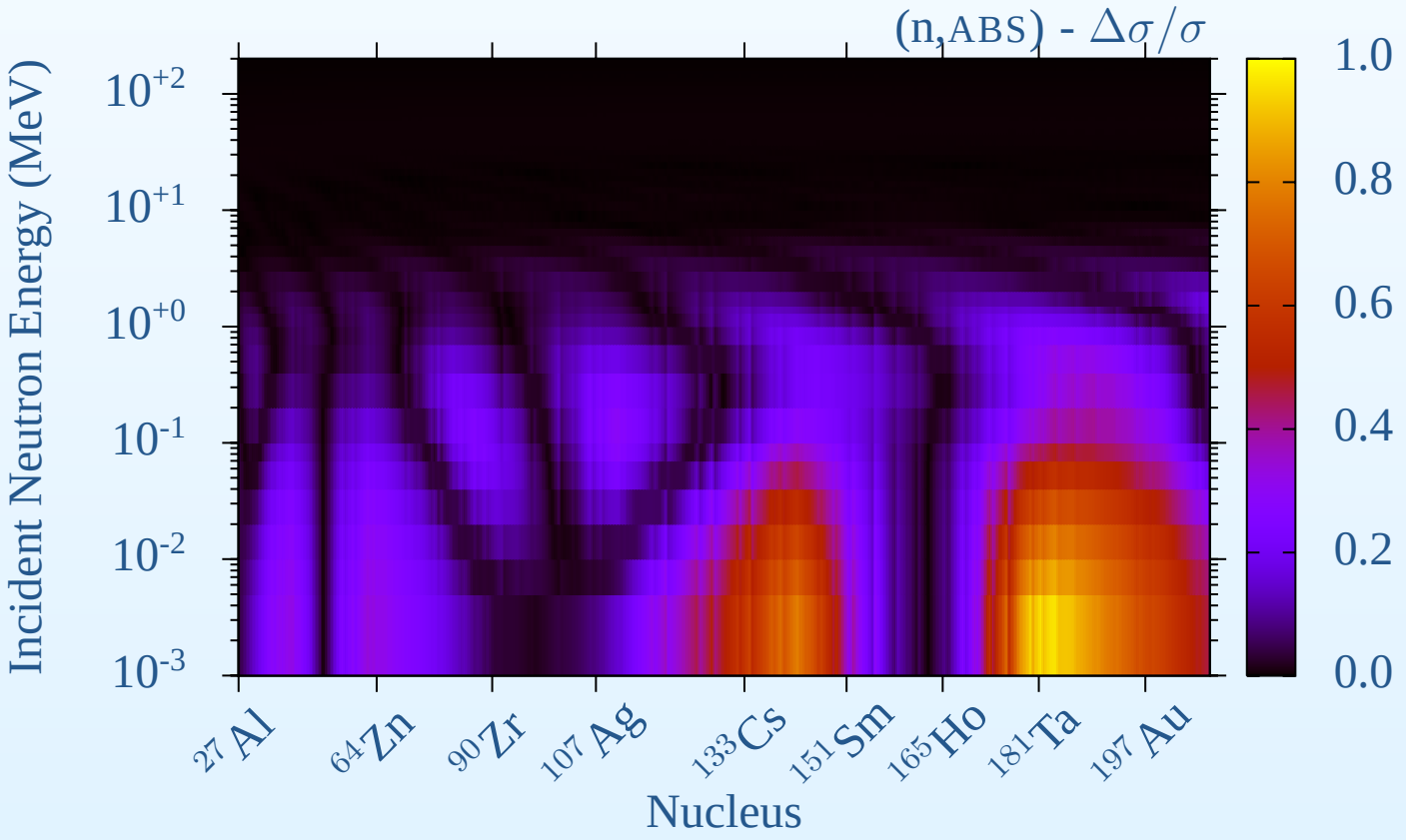
RESULTS: MATERIALS FROM ^{27}Al TO ^{210}Bi

$$(\Delta\sigma_{\text{TOT}})^2 = \frac{\partial\sigma_{\text{TOT}}}{\partial V_v}(\Delta V_v)^2\frac{\partial\sigma_{\text{TOT}}}{\partial V_v}\,, \qquad \Delta V_v = \pm 3\%$$



RESULTS: MATERIALS FROM ^{27}Al TO ^{210}Bi

$$(\Delta\sigma_{\text{ABS}})^2 = \frac{\partial\sigma_{\text{ABS}}}{\partial V_v}(\Delta V_v)^2\frac{\partial\sigma_{\text{ABS}}}{\partial V_v}\,, \qquad \Delta V_v = \pm 3\%$$



S-MATRIX FORMALISM

$$S_\ell^\pm(\lambda) = e^{2i\eta_\ell^\pm(\lambda)} = \alpha_\ell^\pm(\lambda) e^{i\beta_\ell^\pm(\lambda)} \qquad \alpha_\ell, \beta_\ell \in \mathbb{R}$$

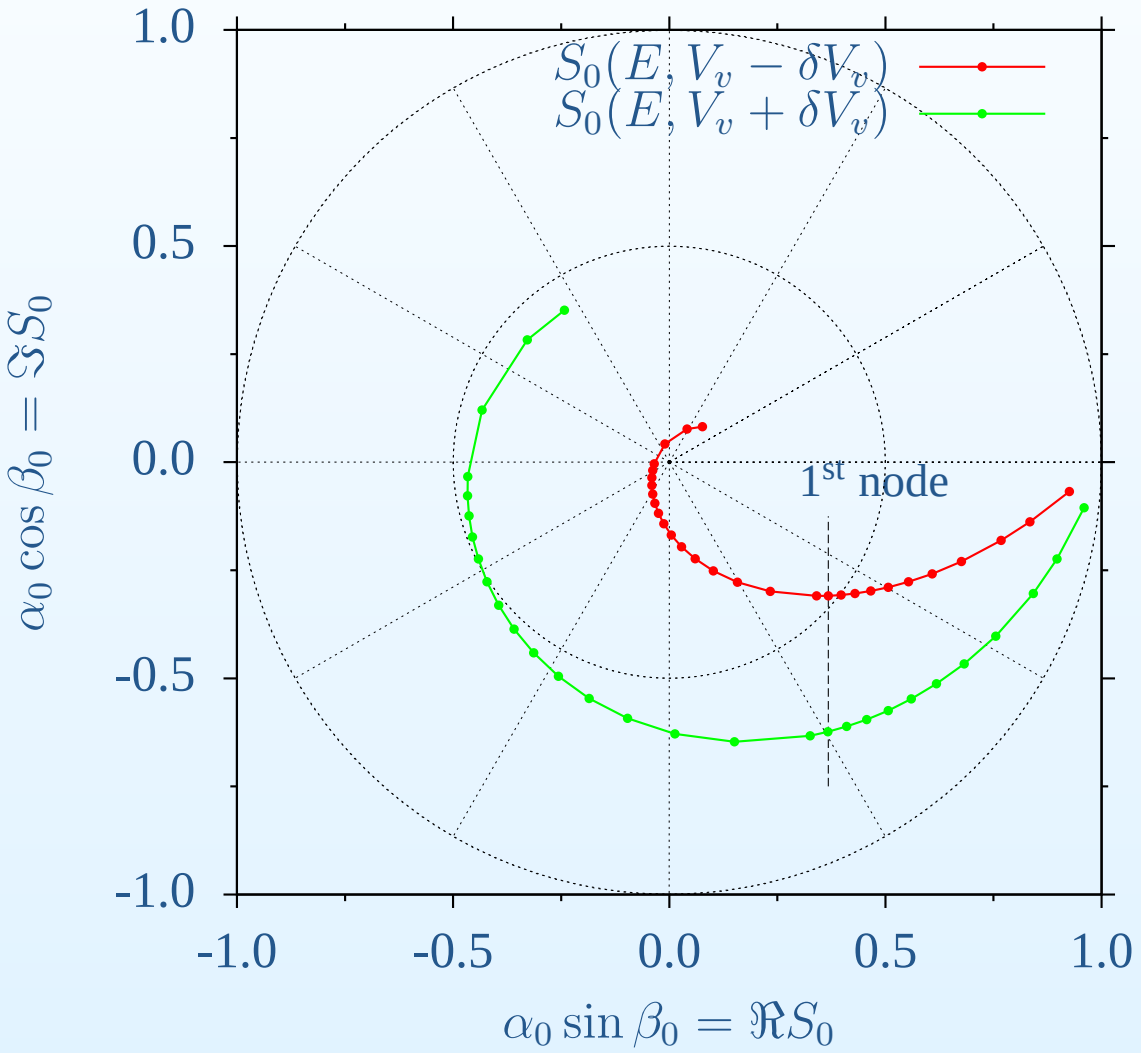
$$\sigma_{\text{TOT}} = \frac{\lambda^2}{2\pi} \sum_{\ell=0}^{+\infty} (\ell+1)(1 - \Re S_\ell^+) + \ell(1 - \Re S_\ell^-)\,,$$

$$\sigma_{\text{ABS}} = \frac{\lambda^2}{\pi} \sum_{\ell=0}^{+\infty} (\ell+1)(1 - |S_\ell^+|^2) + \ell(1 - |S_\ell^-|^2)\,,$$

$$\sigma_{\text{EL}} = \frac{\lambda^2}{\pi} \sum_{\ell=0}^{+\infty} (\ell+1)|1 - S_\ell^+|^2 + \ell|1 - S_\ell^-|^2\,.$$

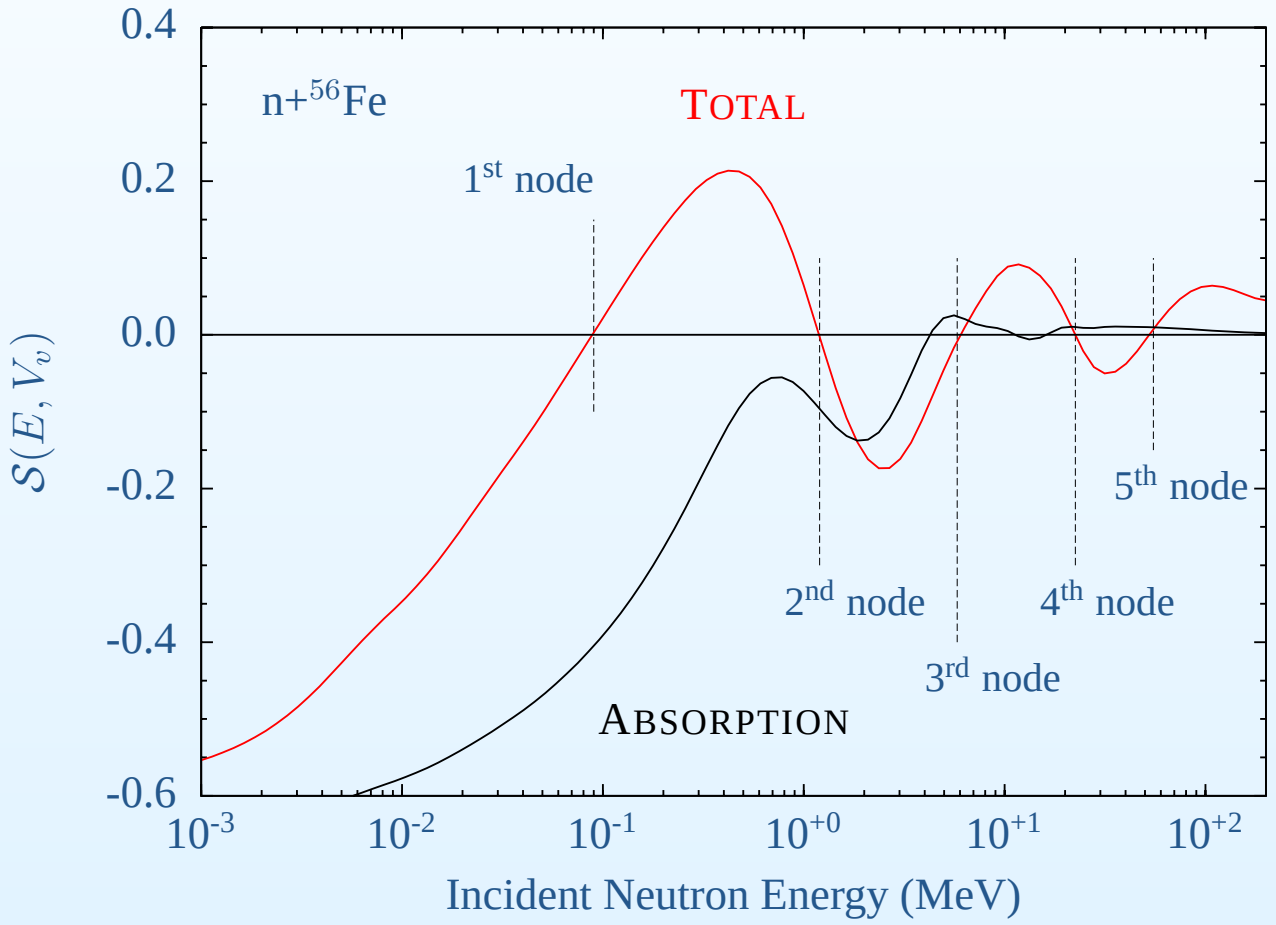
ARGAND DIAGRAM FOR $\ell = 0$

$$S_0 \equiv e^{2i\eta_0} = \alpha_0 e^{i\beta_0} = \alpha_0(\cos\beta_0 + i\sin\beta_0)$$



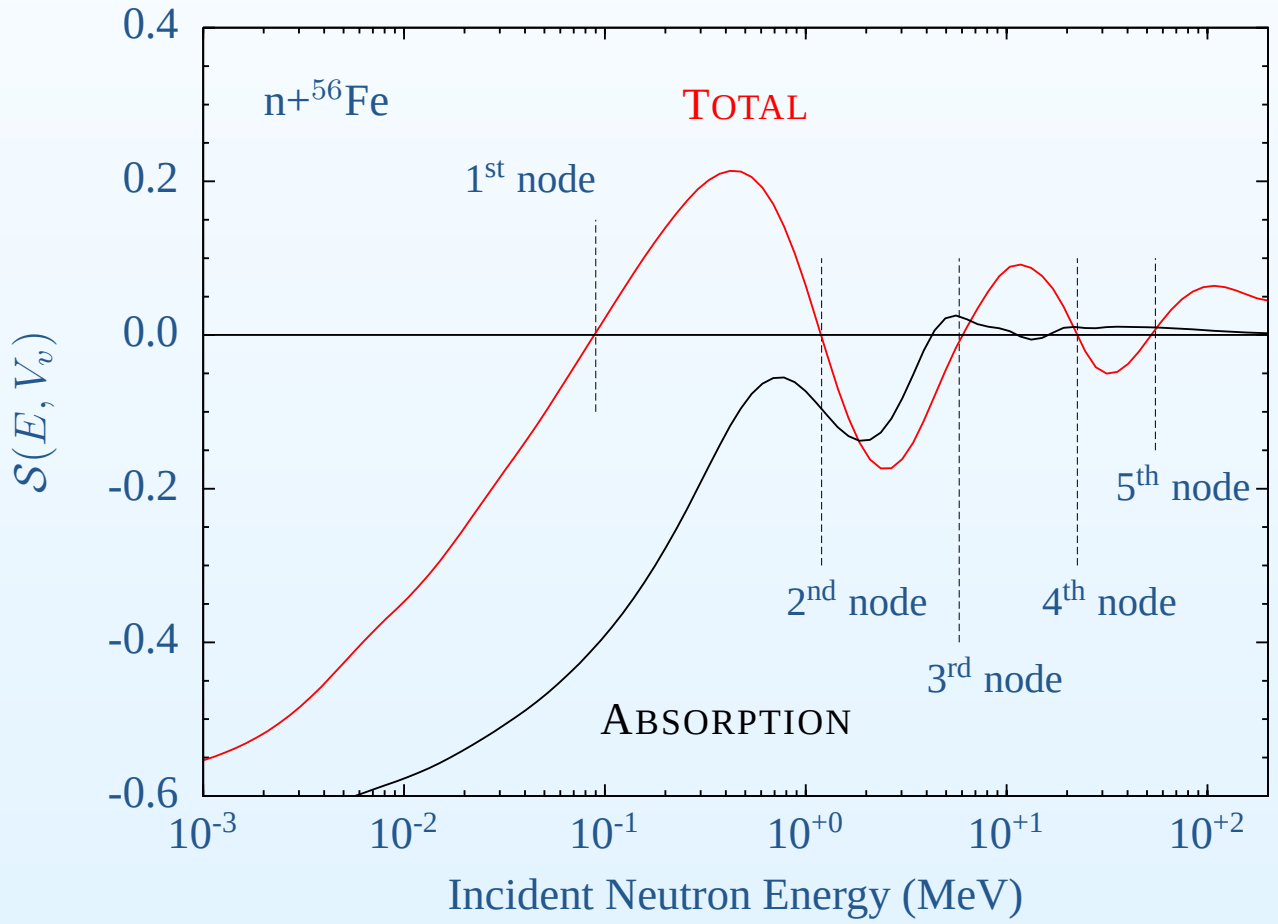
Sensitivity Plots

$$\mathcal{S}(E, V_v) = 2 \cdot \frac{\delta V_v}{\sigma} \cdot \frac{\partial \sigma}{\partial V_v} = 2 \cdot \frac{\delta V_v}{\sigma} \cdot \sum_{\ell=0}^{+\infty} \frac{\partial \sigma_\ell}{\partial V_v}$$

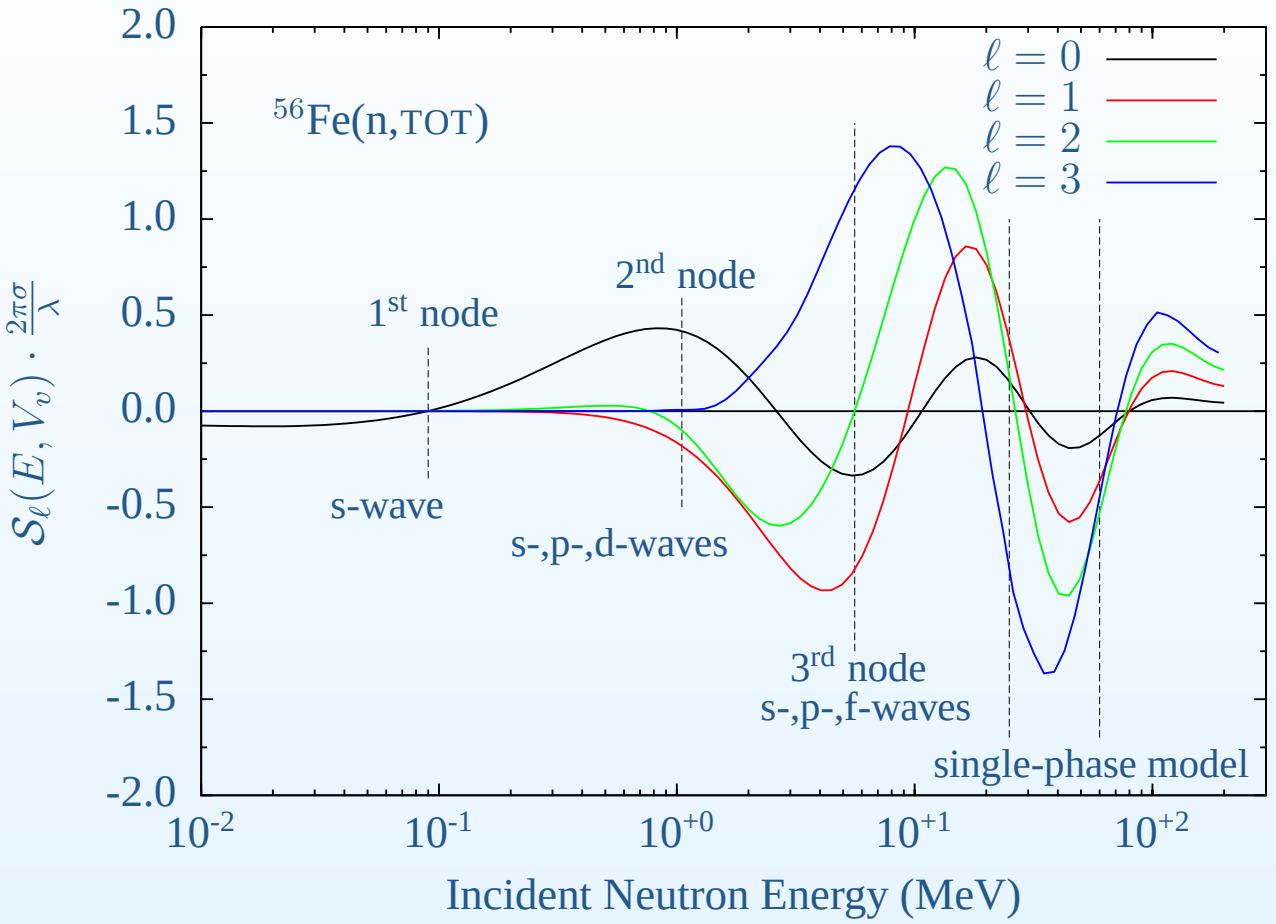


Sensitivity Plots

- Maxima and minima in TOTAL do not correspond in ABSORPTION

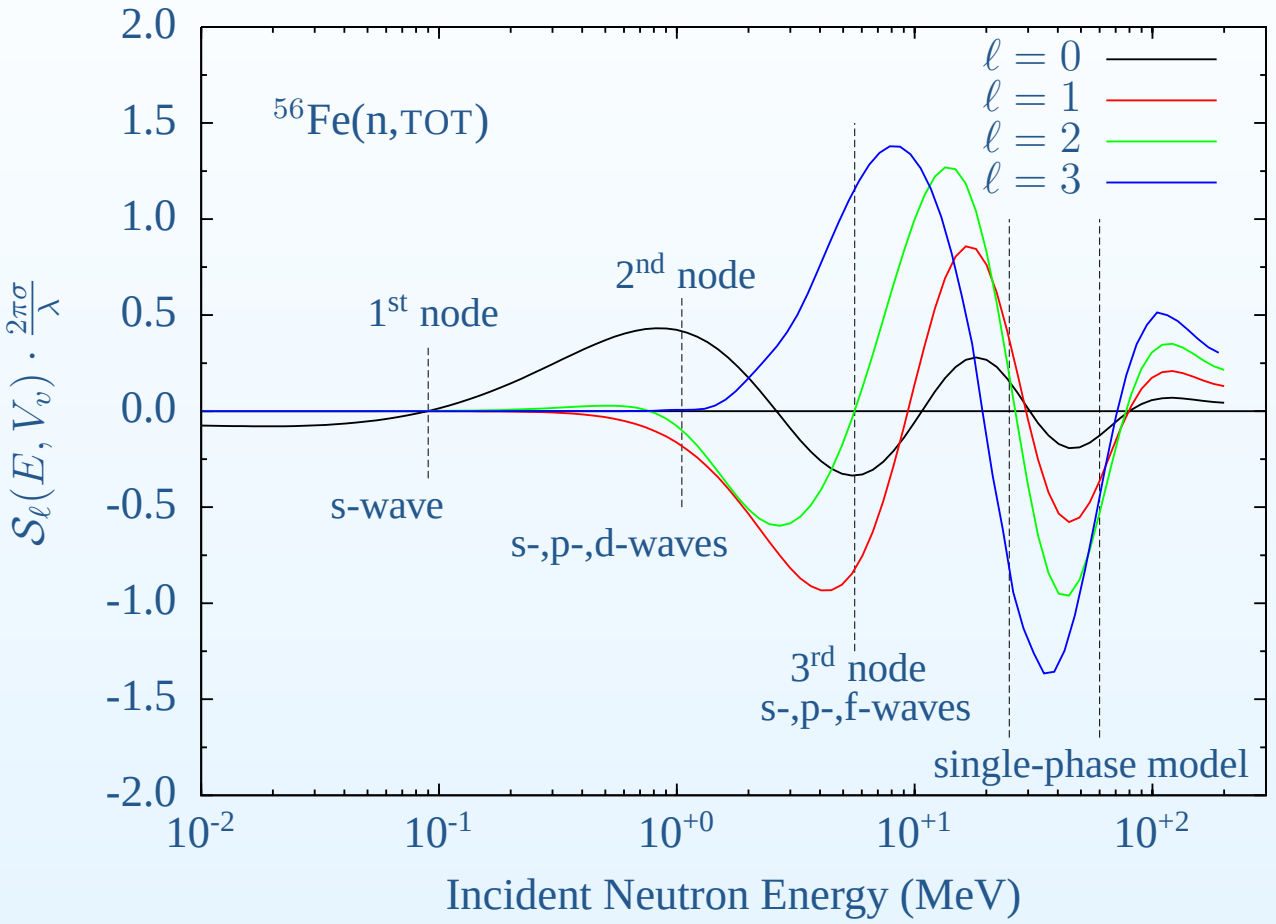


Sensitivity Plots



- $\lesssim$ 7 MeV interplay among s-,p-,d-,. . . partial waves

SENSITIVITY PLOTS



- Single-phase model (i.e. Ramsauer effect) assumes effective S-matrix - $S_{\text{eff}} \equiv e^{2i\eta} = \alpha e^{i\beta}$ - independent from ℓ.

Conclusions and Outlook

- ✓ We generate a very comprehensive set of cross section uncertainties (about 650 materials) in order to explain the oscillating patterns found in the previous "low-fidelity covariance project".
- ✓ The sensitivity analysis on two optical parameters, V_v and r_v, confirmed their almost complete correlation in the (n,TOT) channel (E$\gtrsim$ a few MeV), but not necessary in the reaction cross section.
- ✓ We explained the origin of these minima in terms of the interplay of a few partial waves (low-energy) and the single-channel model (E$\gtrsim$ a few MeV).
- In the future, we intend to ultimate the partial-waves analysis for the complete set of materials and, eventually, to find a systematic on the A-mass number.