(n,xα) Cross-section Evaluation with Clustering Pre-equilibrium Model

S. Kunieda[*†], R.C. Haight, T. Kawano[*], M.B. Chadwick[*],
T. Fukahori[†] and Y. Watanabe[‡]

[*] *Los Alamos National Laboratory*
[†] *Japan Atomic Energy Agency*
[‡] *Kyushu University*

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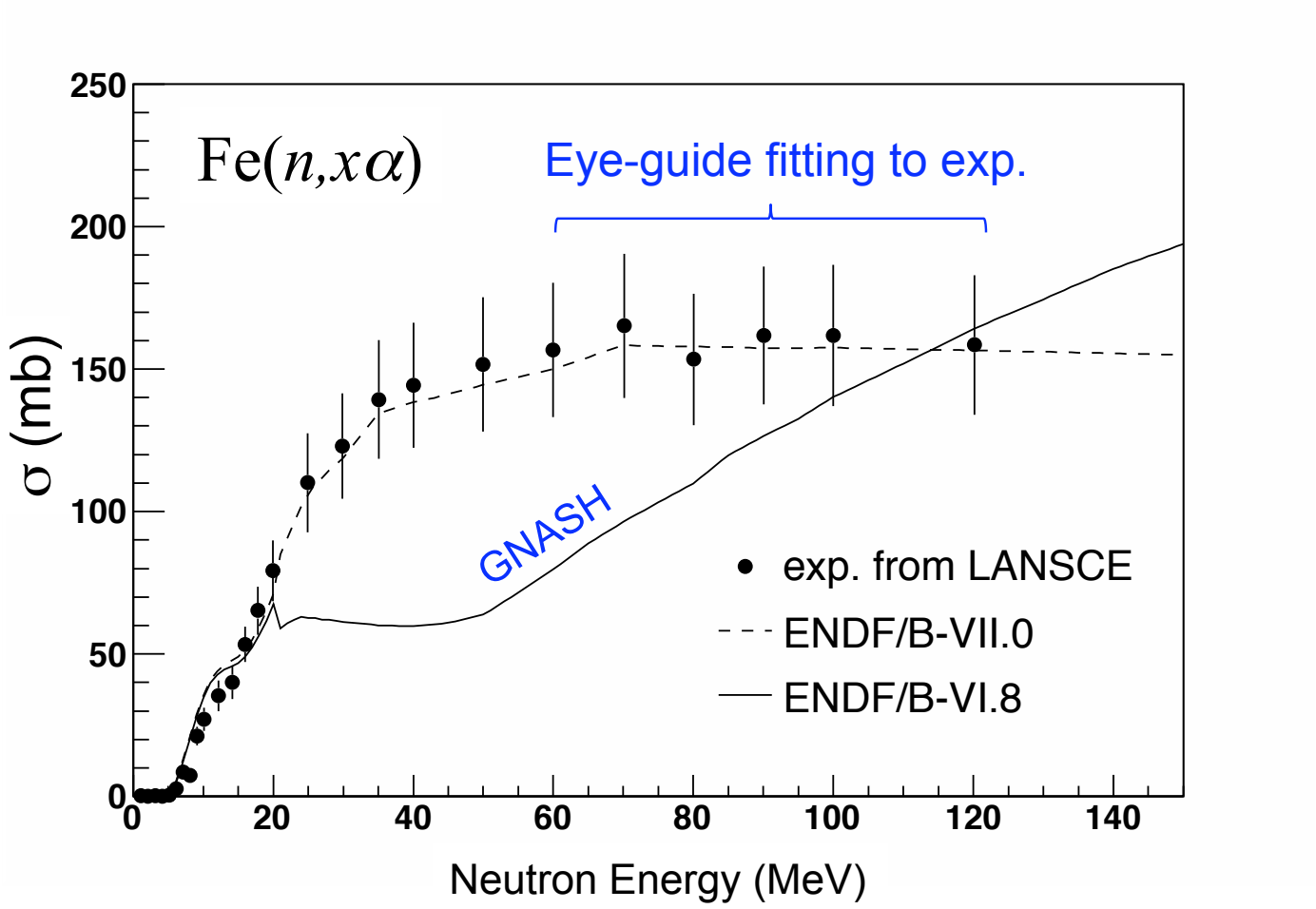
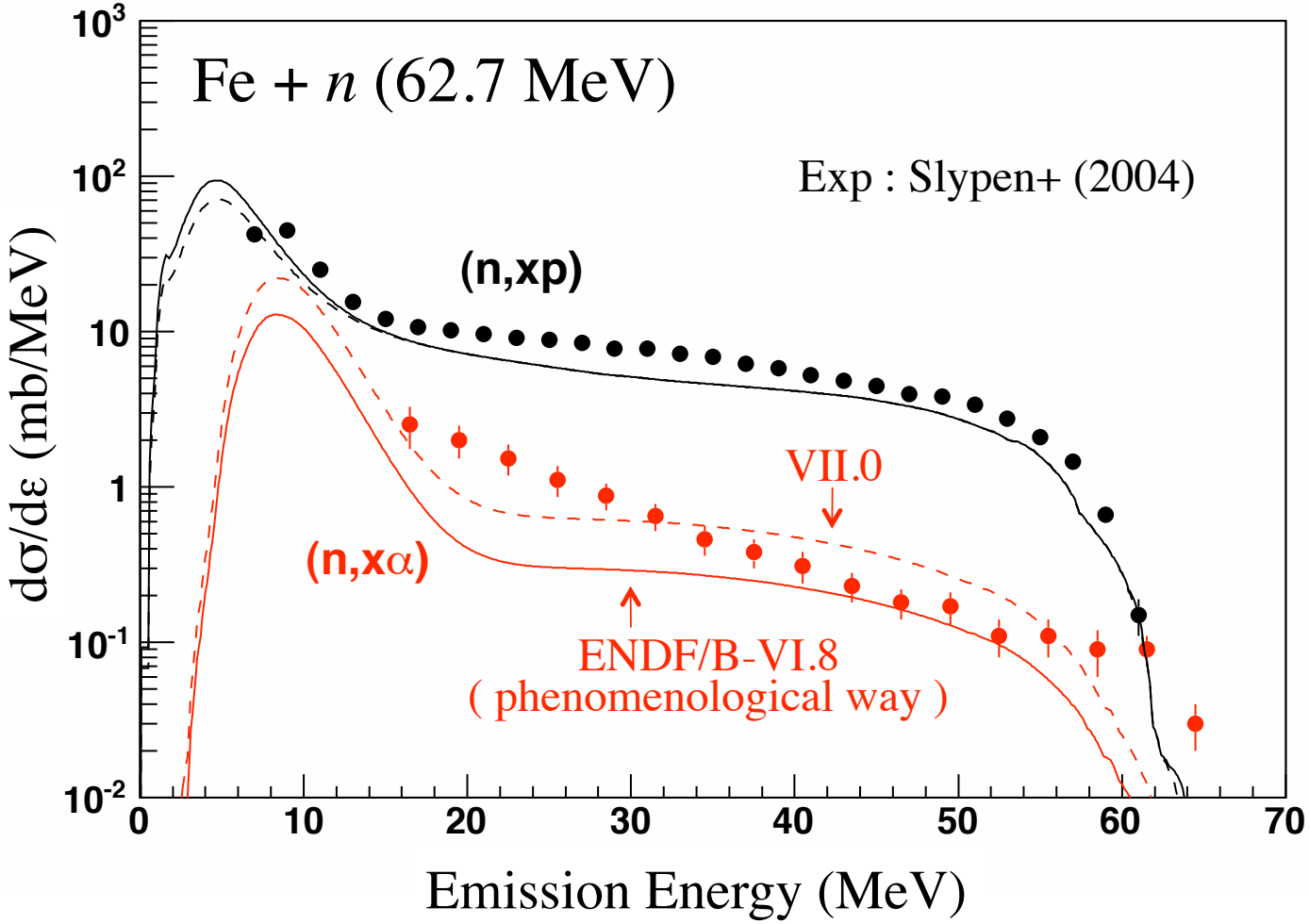
- Status of eval. & model (>20 MeV)
- Modified Iwamoto-Harada model
- New High-energy evaluations for B-VII.1
  (^{50,52,53,54}Cr, ^{54,56,57}Fe and ^{58,60}Ni)

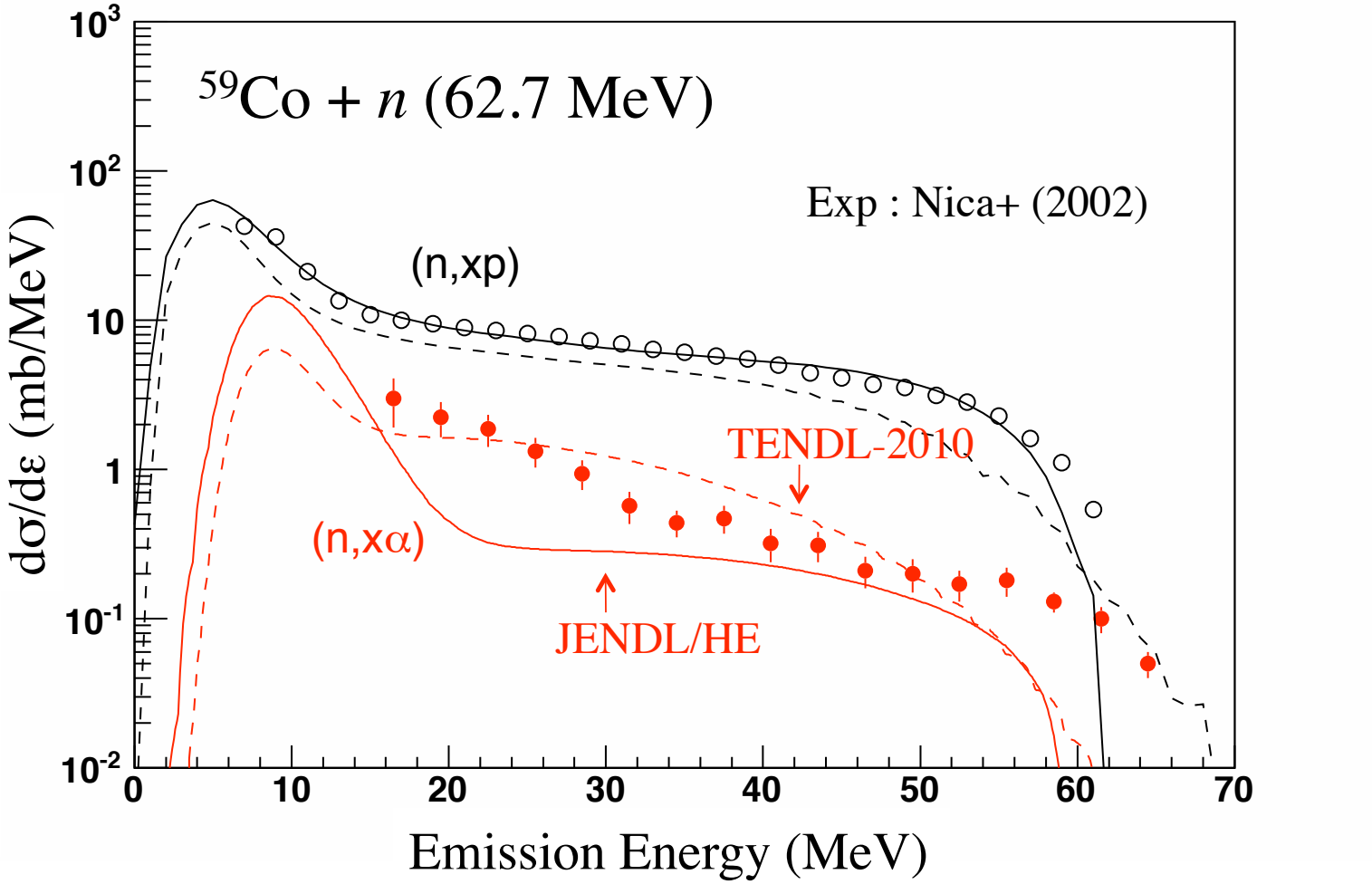
Status of ENDF (>20 MeV)



Status of ENDF (>20 MeV)



Status of Other Libraries



Status of GNASH / TALYS

Pre-equilibrium :

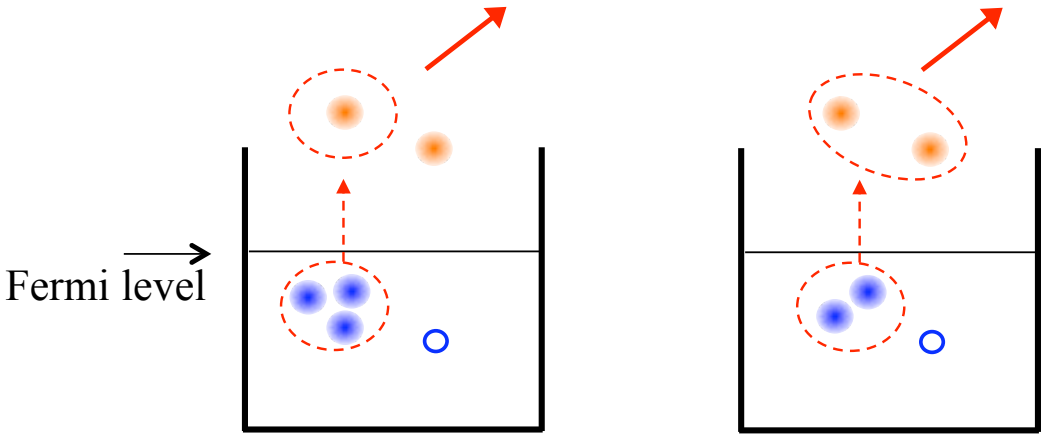
They are based on Kalbach's works

○ **Exciton model** ⟶ nucleons

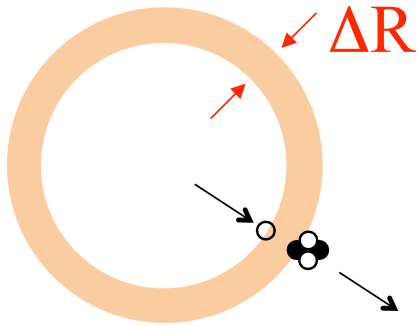
✓ **Phenomenological (exciton) model**

⟶ Composite particles (d, t, ^{3}He, α)

Iwamoto-Harada Model



e.g., from 2p-1h stage



@ nuclear surface

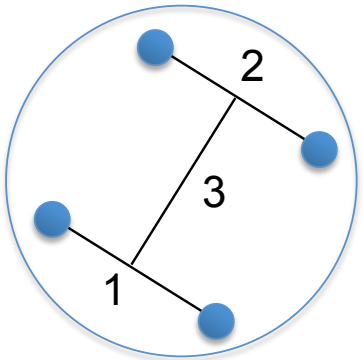
Emission rate

$$W_\alpha(p,h,\epsilon_\alpha) = \frac{\mu_\alpha \epsilon_\alpha \sigma_\alpha}{\pi^2\hbar^3} \frac{\sum_{l+m=4} F_{l,m}(\epsilon_\alpha)\left[\sum_{j=0}^{2}\omega(p-l,h-j,U)+\sum_{j=1}^{2}\omega(p-l-j,h,U)\right]}{\sum_{j=0}^{2}\omega(p,h-j,E)+\sum_{j=1}^{2}\omega(p-j,h,E)}$$

Formation Factors

$$\left|\langle \varphi_\alpha \chi^{(\epsilon_\alpha)}(\mathbf{R}) | \phi_1 \phi_2 \phi_3 \phi_4 \rangle\right|^2$$

$$F_{l,m}(\epsilon_\alpha) \sim \int_S \prod_{i=1}^{3} d\xi_\mathbf{i} d\mathbf{p}_{\xi_\mathbf{i}}$$



$$= \int_S \prod_{i=1}^{3} \underbrace{\xi_i^2 d\xi_i d\Omega_{\xi_i}}_{\text{space}} \underbrace{P_{\xi_i}^2 dP_{\xi_i} d\Omega_{P_{\xi_i}}}_{\text{momentum}}$$

Overlap Integral

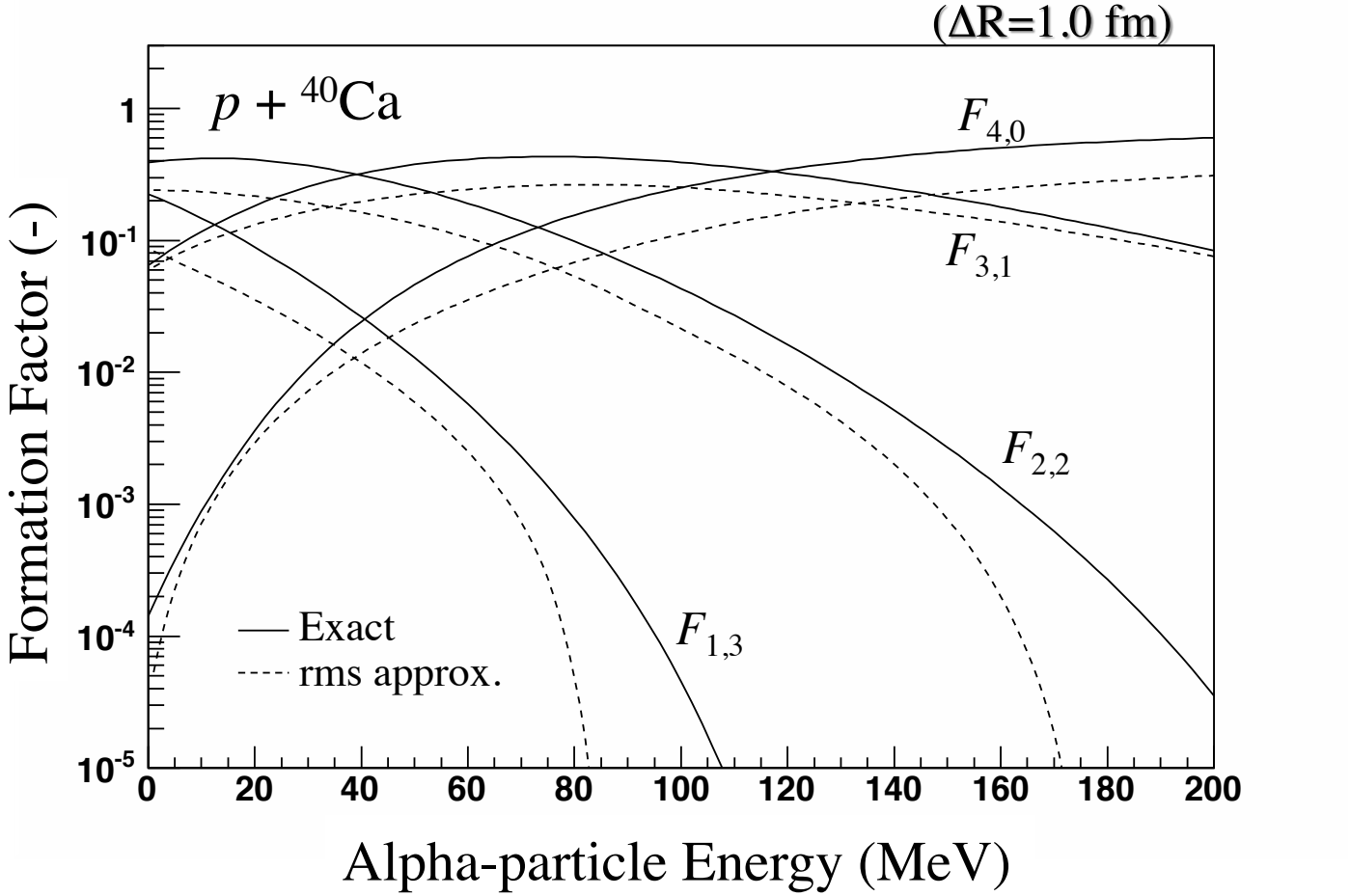
Original : root-mean-square approximation

$$\int_S \xi^2 P_\xi^2 \mathcal{I}(\mathbf{p}_\xi, \xi) d\xi d\Omega_\xi dP_\xi d\Omega_{P_\xi}$$

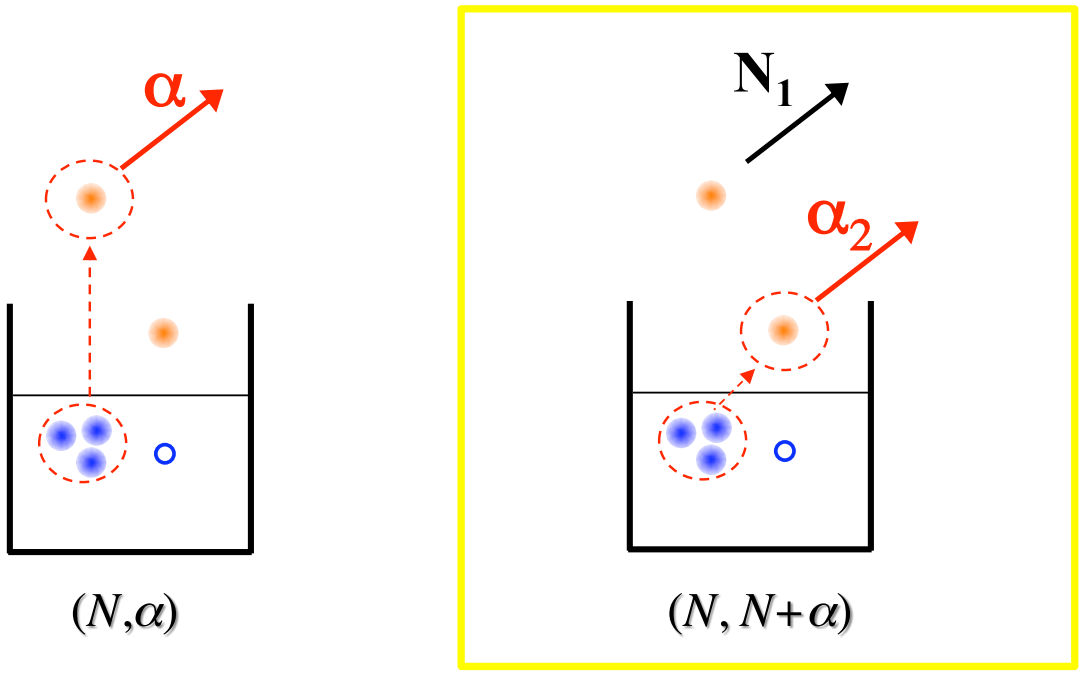
$$\longrightarrow \sim \int_S \delta(\xi - \overline{\xi}) \delta(p_\xi - \overline{p_\xi}) \mathcal{I}(\mathbf{p}_\xi, \xi) d\xi d\Omega_\xi dP_\xi d\Omega_{P_\xi}$$

Present : numerical integration

Exact Calculations for $F_{l,m}(\varepsilon_\alpha)$

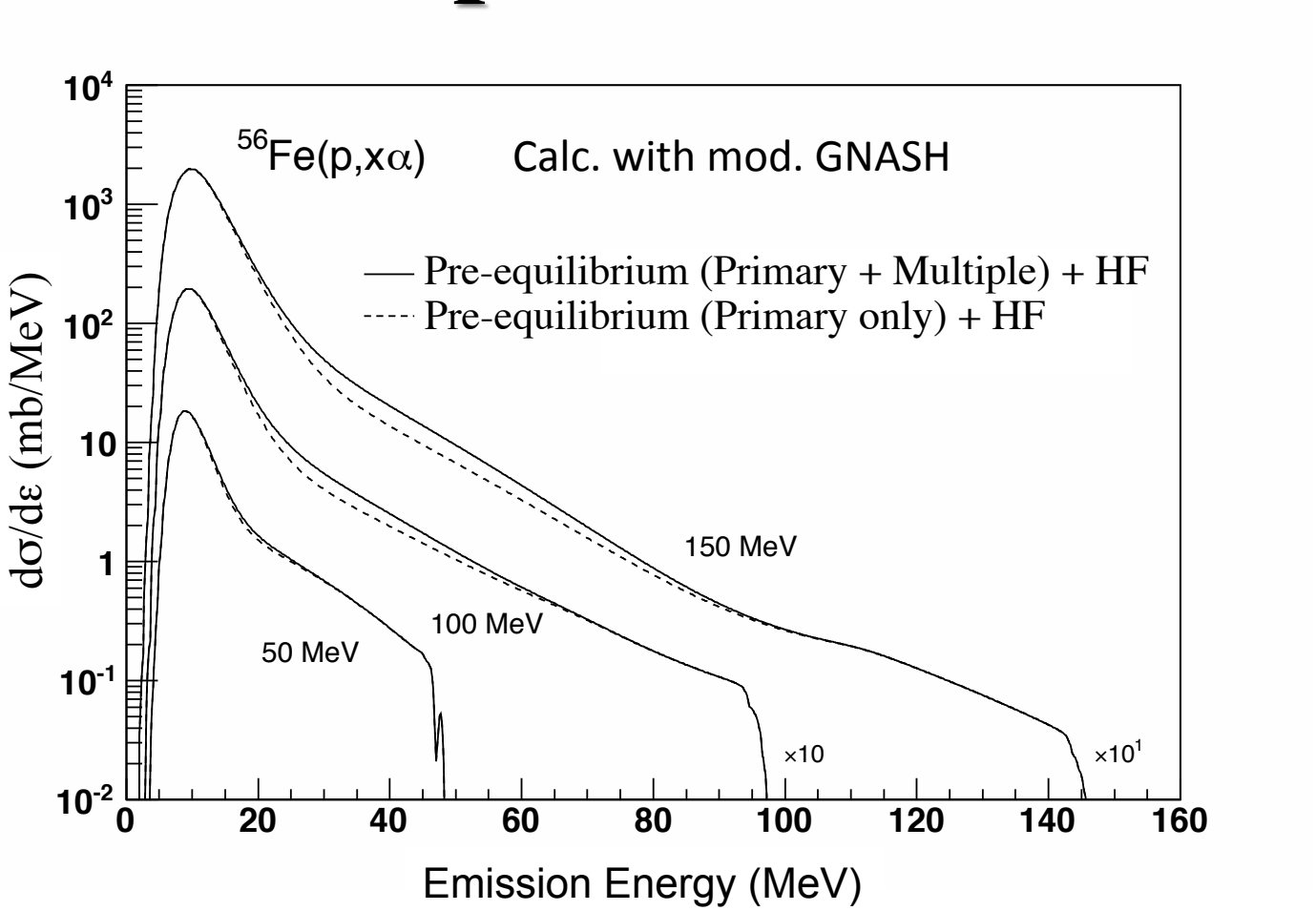


Multiple Emission



$$\left(\frac{d\sigma}{d\epsilon_\alpha}\right)_{p,h} = \sum_{i=\pi,\nu} \int_{\epsilon_\alpha+B}^{U_{max}} \left(\frac{d\sigma}{dU}\right)_i T_\alpha(\epsilon_\alpha) \sum_{l+m=4} F_{l,m}(\epsilon_\alpha) \frac{g}{p} \frac{\omega(p-l,h,U-\epsilon_\alpha-B)}{\omega(p,h,U)} dU$$

Multiple Emissions



Model Parameters

Optical Potential (OMP)

N : Kunieda+ (2007) α : Avrigeanu+ (2009)

Single-particle State Density

$\omega(p, h, E, \infty) f(p, h, E, V)$ Beták & Dobeš (1976)

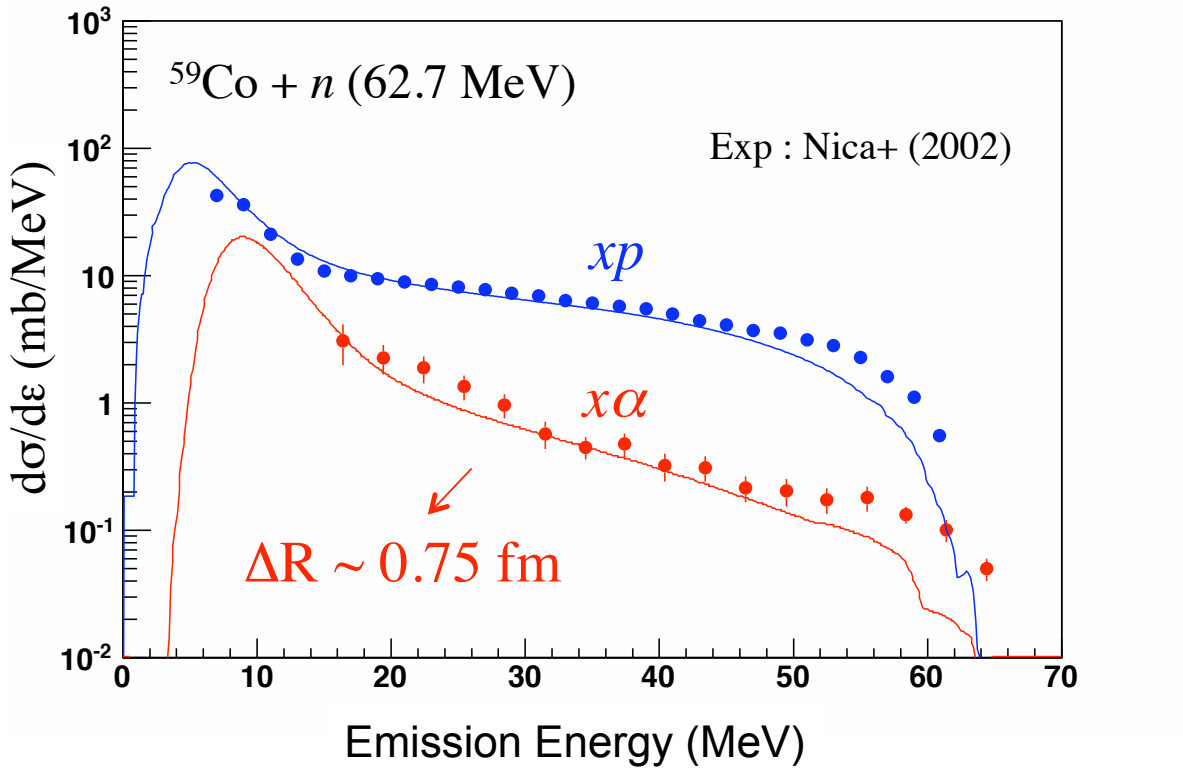
V : Koning & Duijvestijn (2004)

$g = 6a/\pi^2$

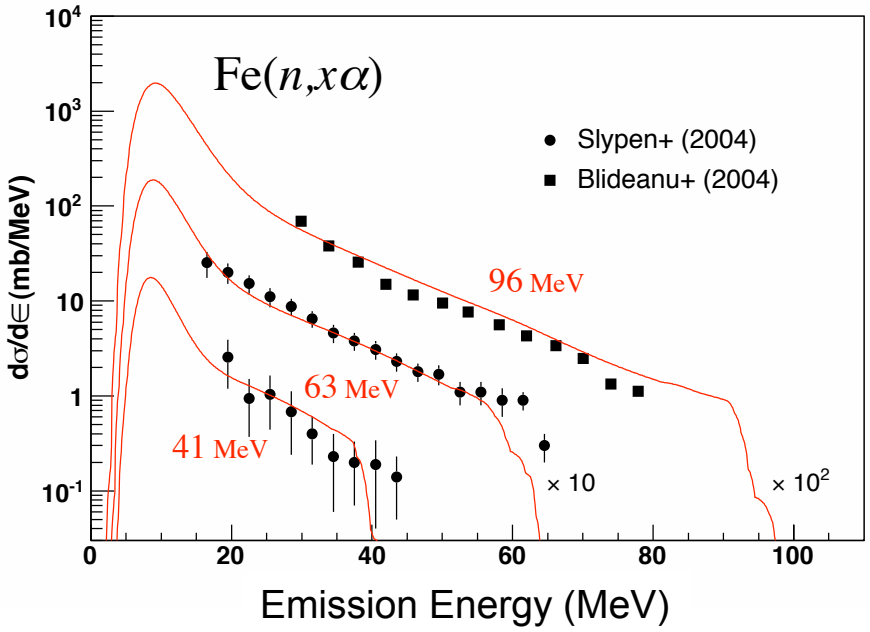
Model Parameters

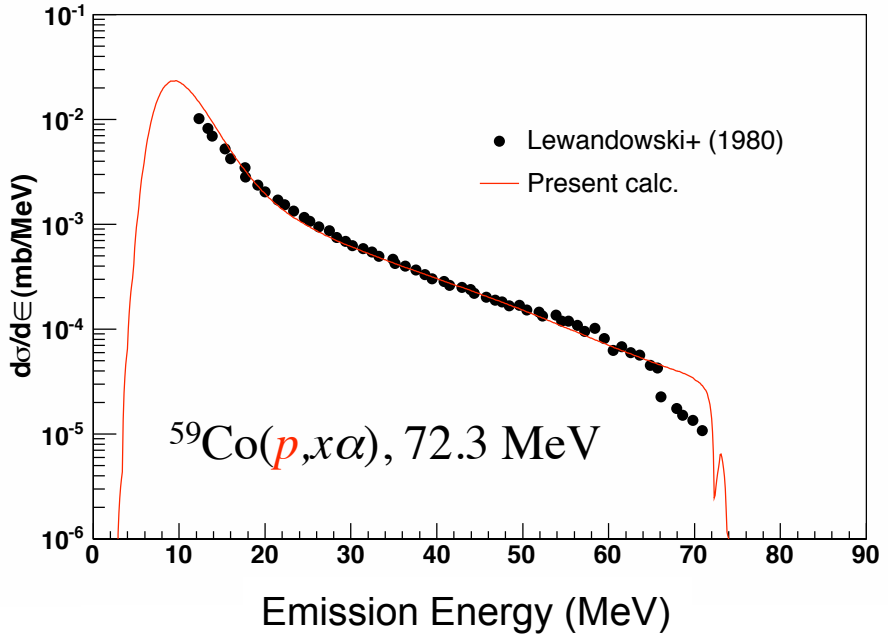
M^2 : Average Matrix Element ⟶ $(n,xp)_{exp.}$

ΔR : Clustering Model Parameter ⟶ $(n,x\alpha)_{exp.}$



Calculation with ΔR=0.75 fm

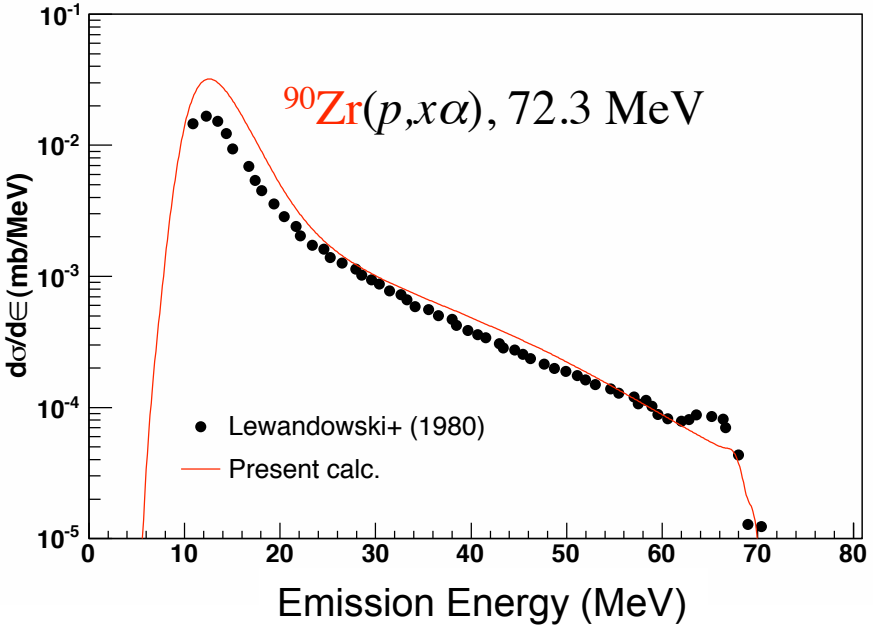


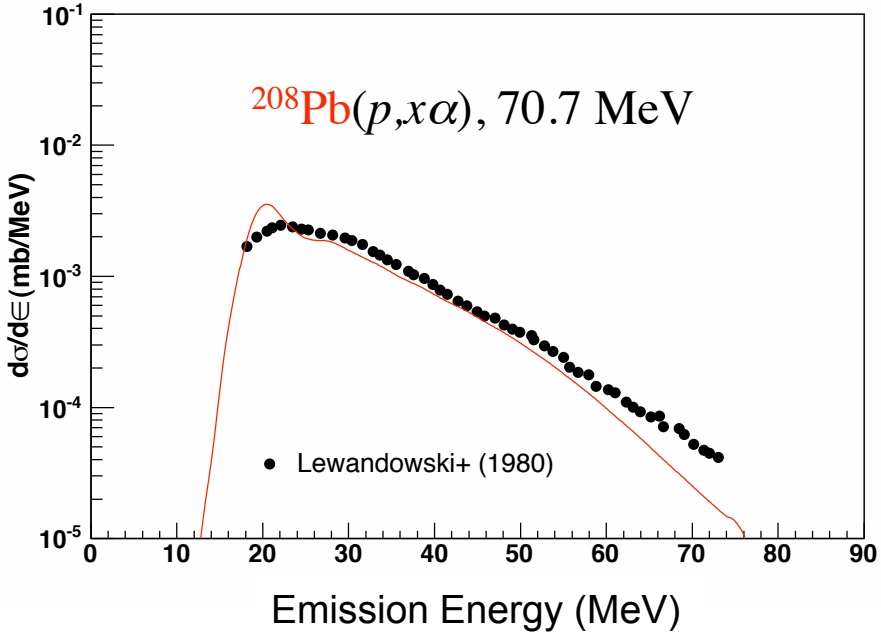


ΔR is less energy-dependent

ΔR is independent of inc. n/p

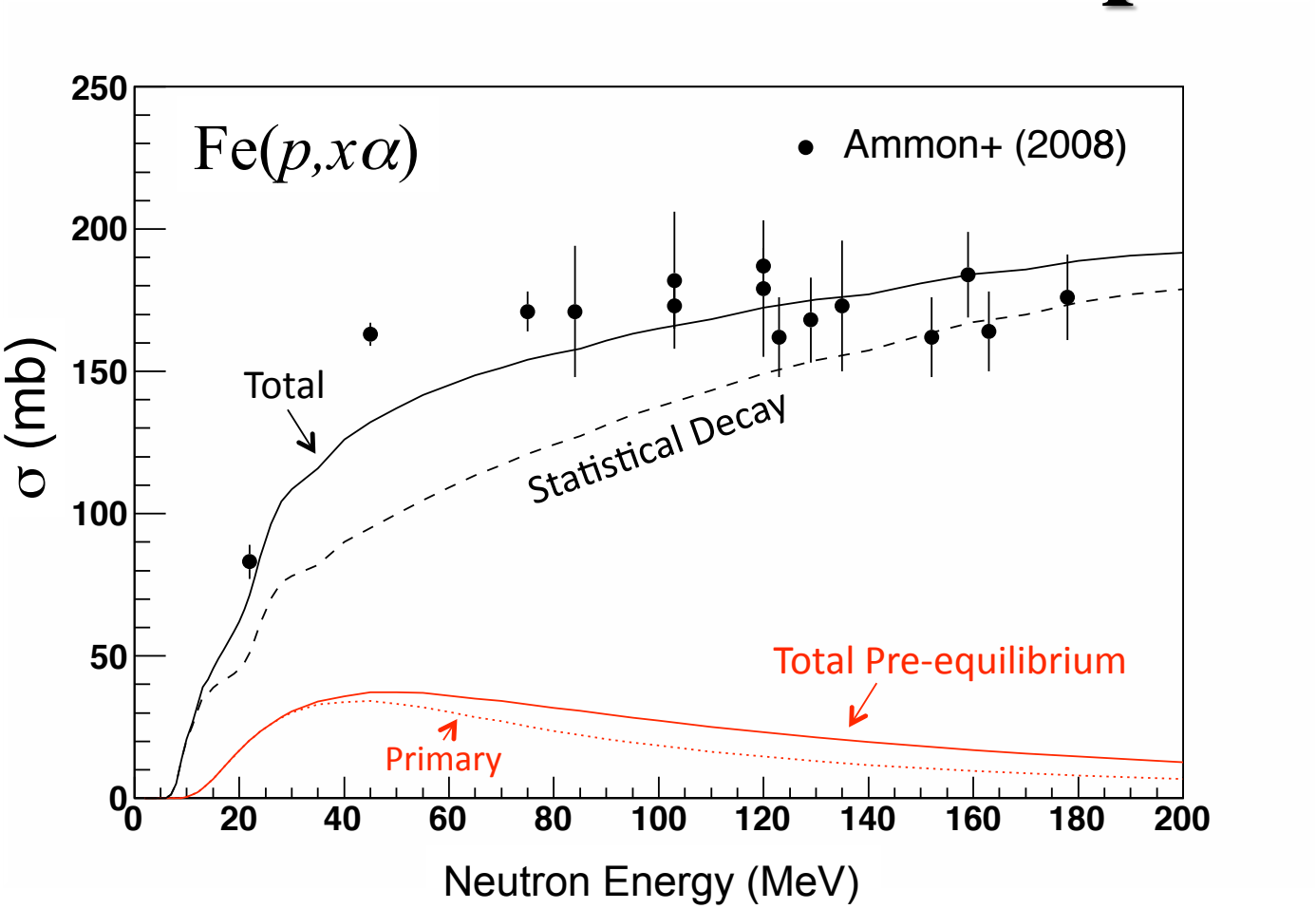
Calculation with ΔR=0.75 fm



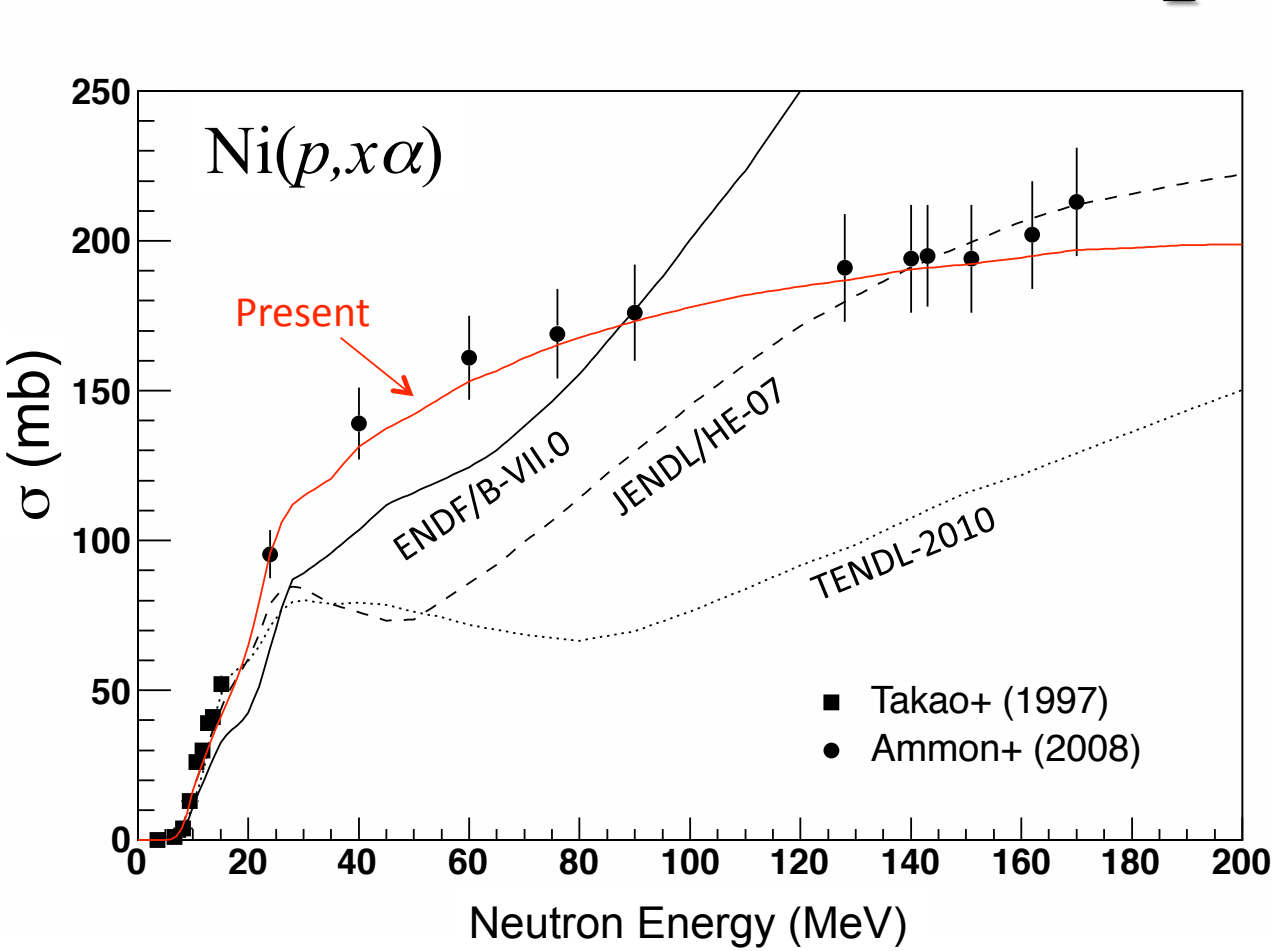


⇨ ΔR is less dependent on nucleus ??

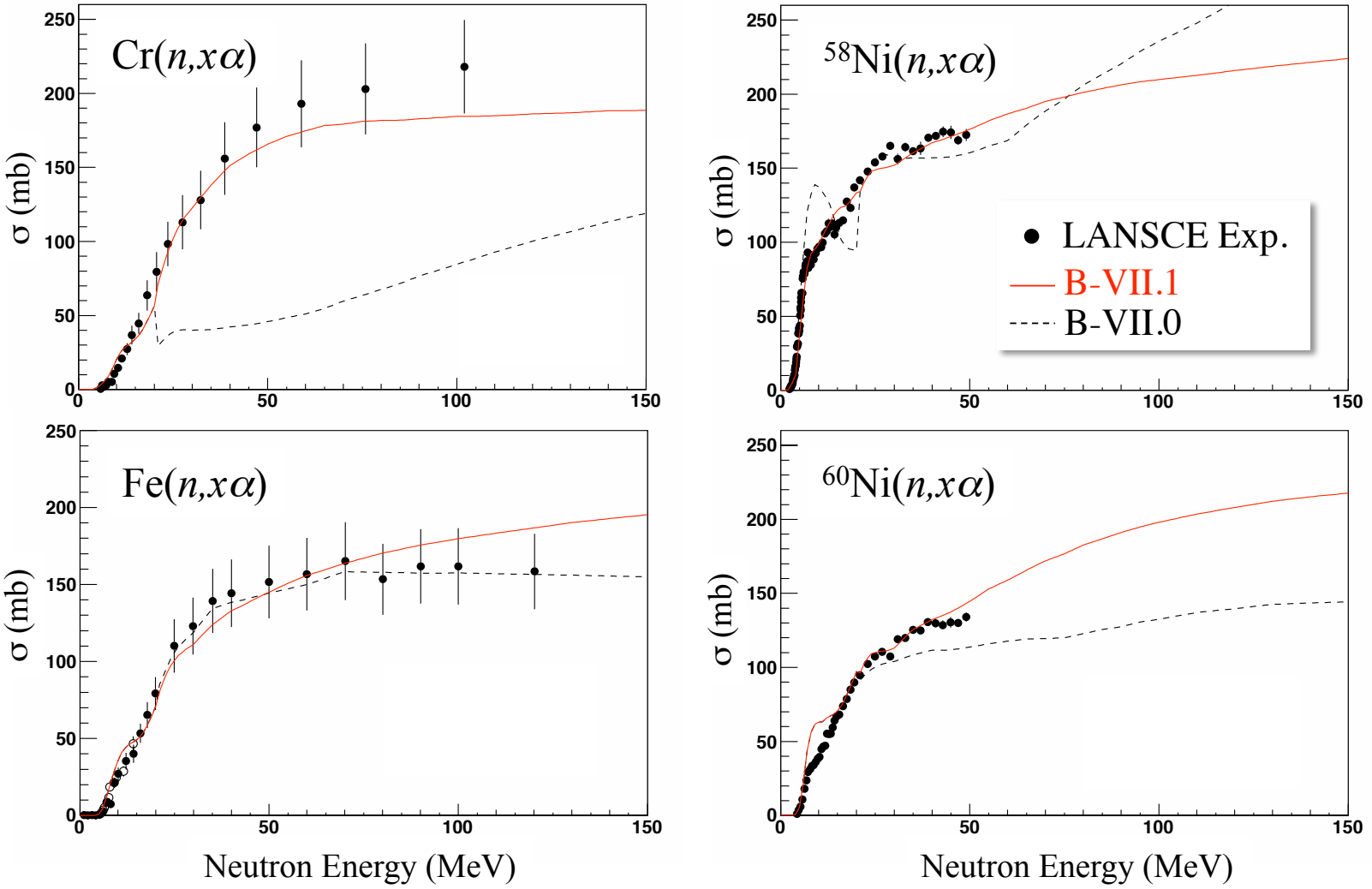
Absolute C. S. - example



Absolute C. S. - example



New Evaluations for B-VII.1



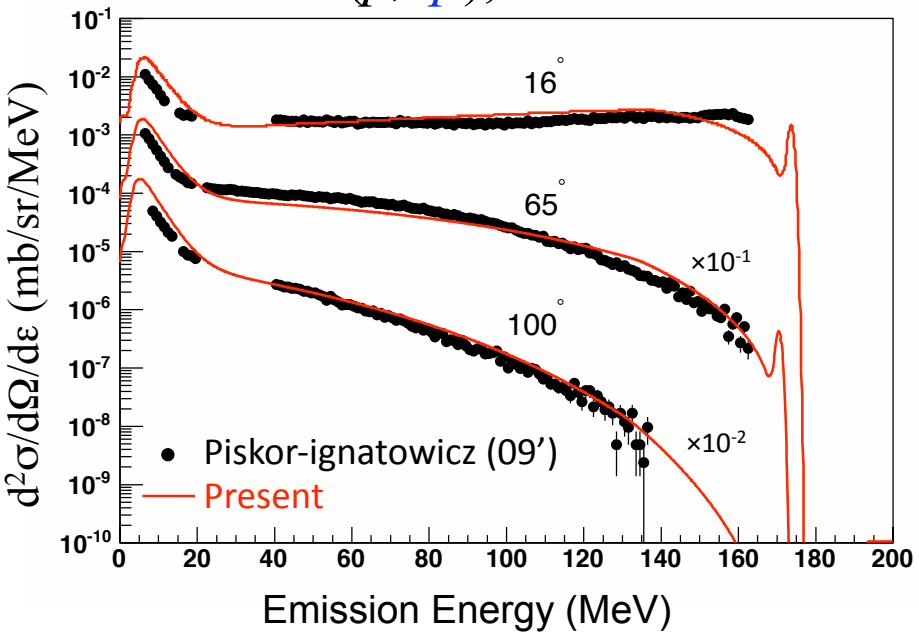
Summary & Conclusion

- Iwamoto-Harada model with exact overlap-integration for alpha-particle
- Multiple emission (alpha-particle) is calculated with I-H model
- ΔR may be less dependent on nucleus (Constraint to the level density parameter)
- New evaluations with those findings for $^{50,52,53,54}Cr$, $^{54,56,57}Fe$ and $^{58,60}Ni$

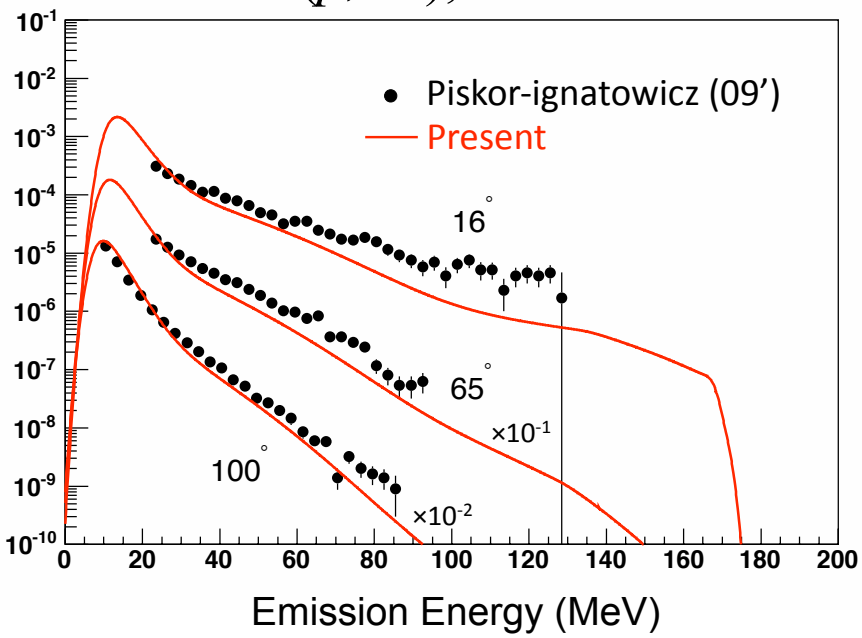
Thank you !

Spectra @ $E_p \geq 150$ MeV

^{58}Ni(p,xp), 175 MeV



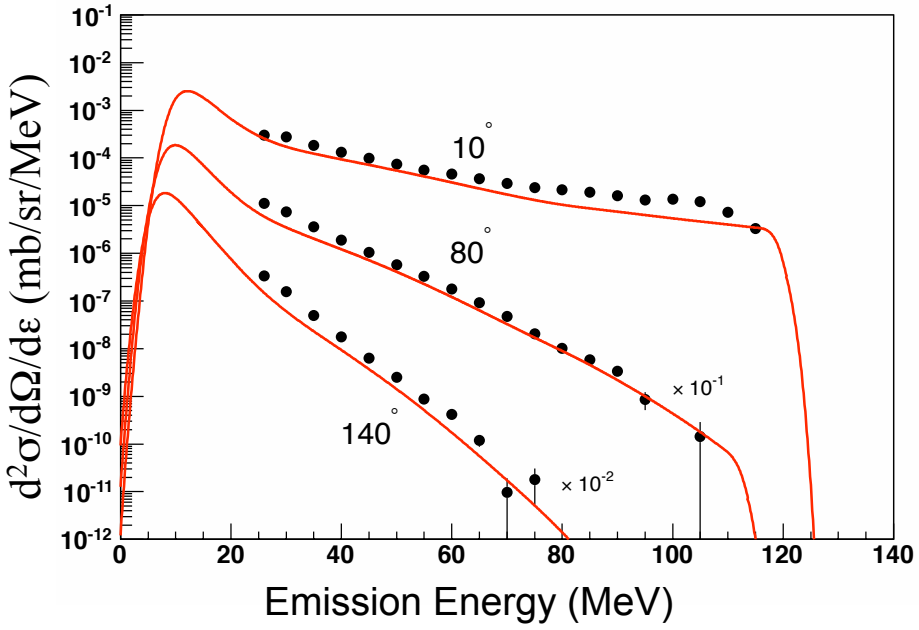
^{58}Ni(p,$x\alpha$), 175 MeV



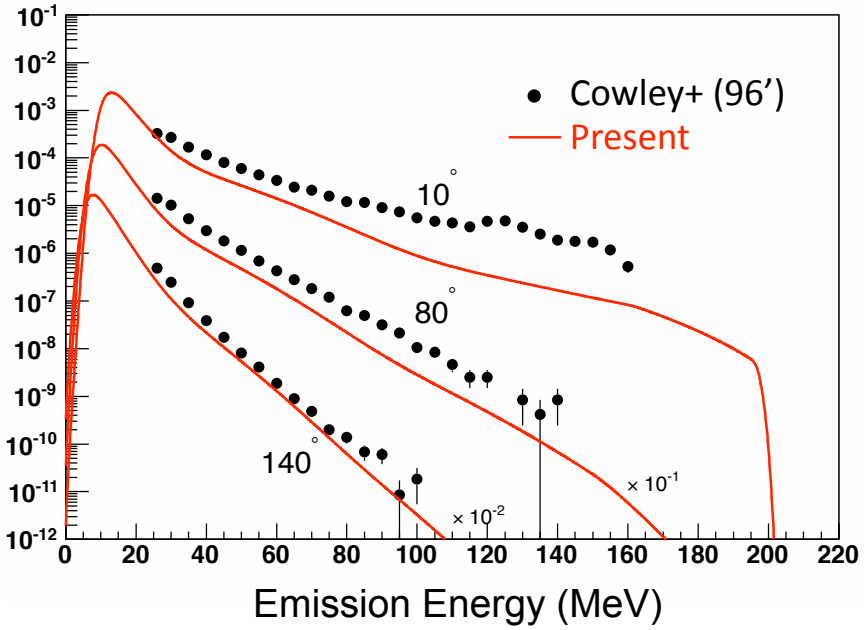
Knock-out ?
Angular distribution ?
ΔR is energy dependent ?

Spectra @ $E_p \geq$ 150 MeV

^{59}Co(p,$x\alpha$), 120 MeV



^{59}Co(p,$x\alpha$), 200 MeV

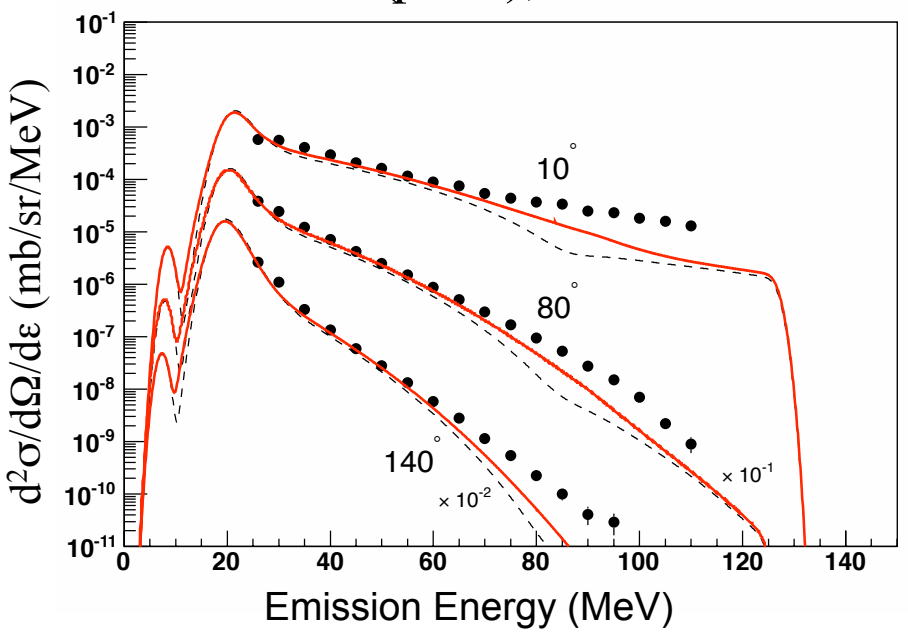


OK

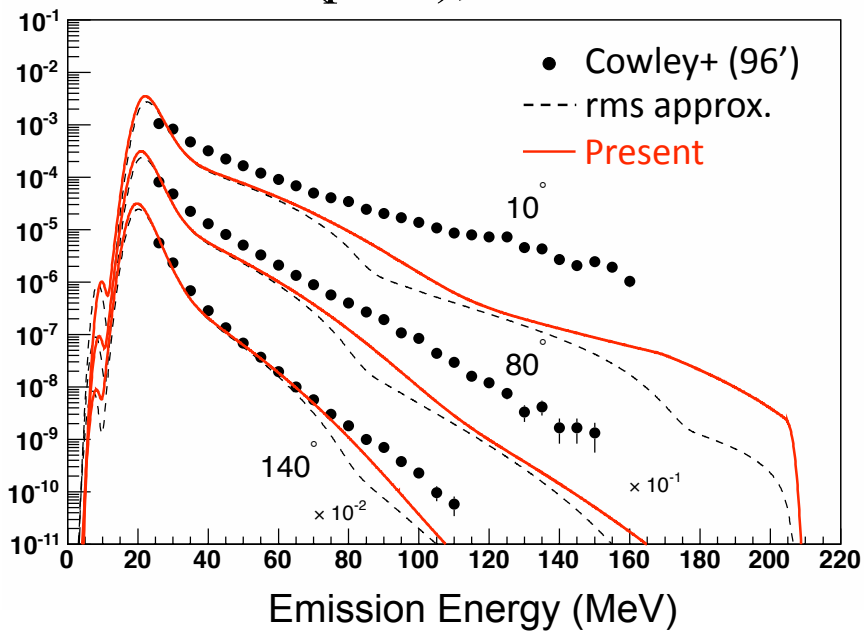
Same as for Ni-58

Spectra @ $E_p \geq$ 150 MeV

^{197}Au(p,$x\alpha$), 120 MeV



^{197}Au(p,$x\alpha$), 200 MeV



Reasonable

Discrepancy is larger

Deuteron Spectra