

Coupled Channel Calculations

06/26/2008



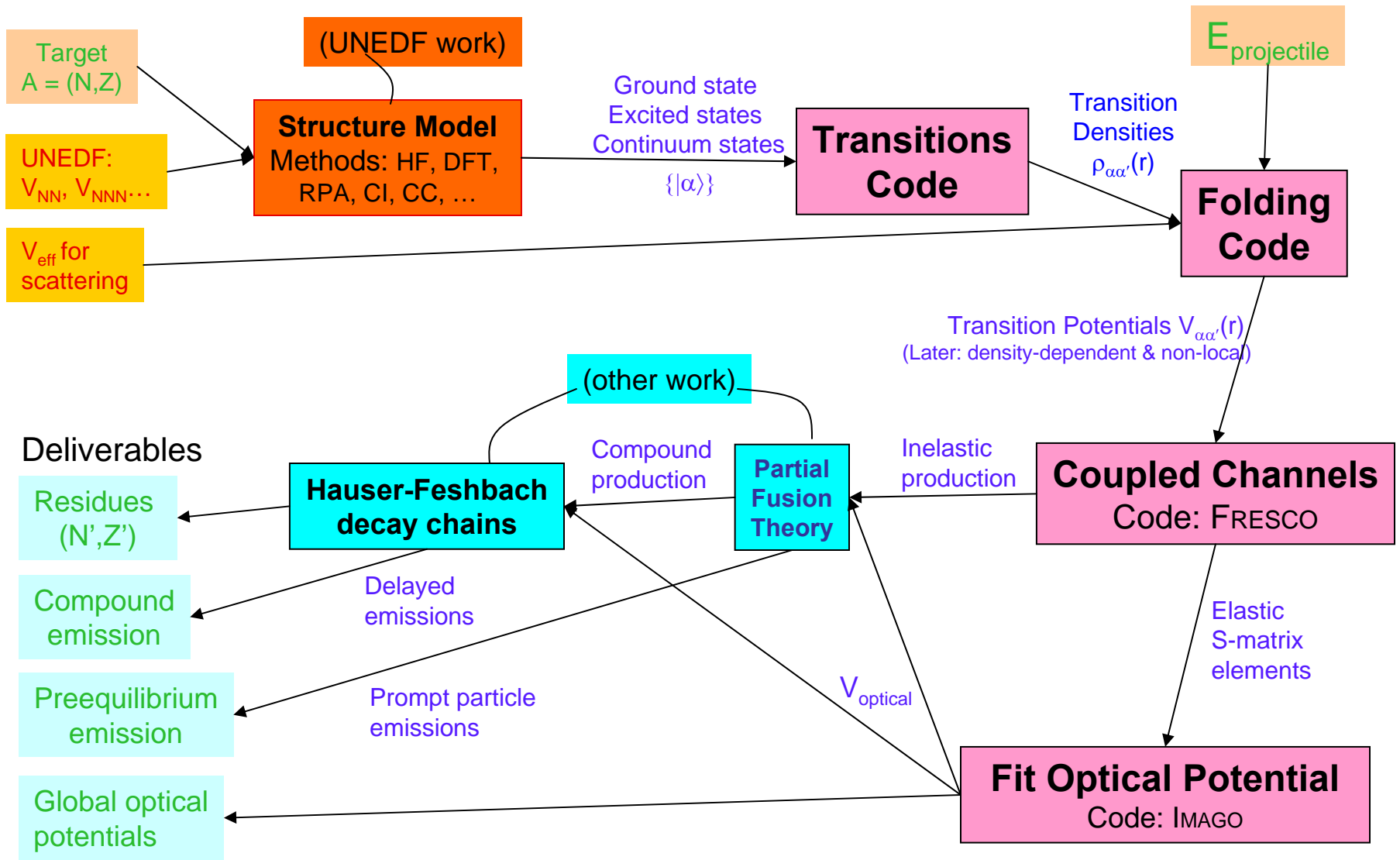
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Lawrence Livermore National Laboratory



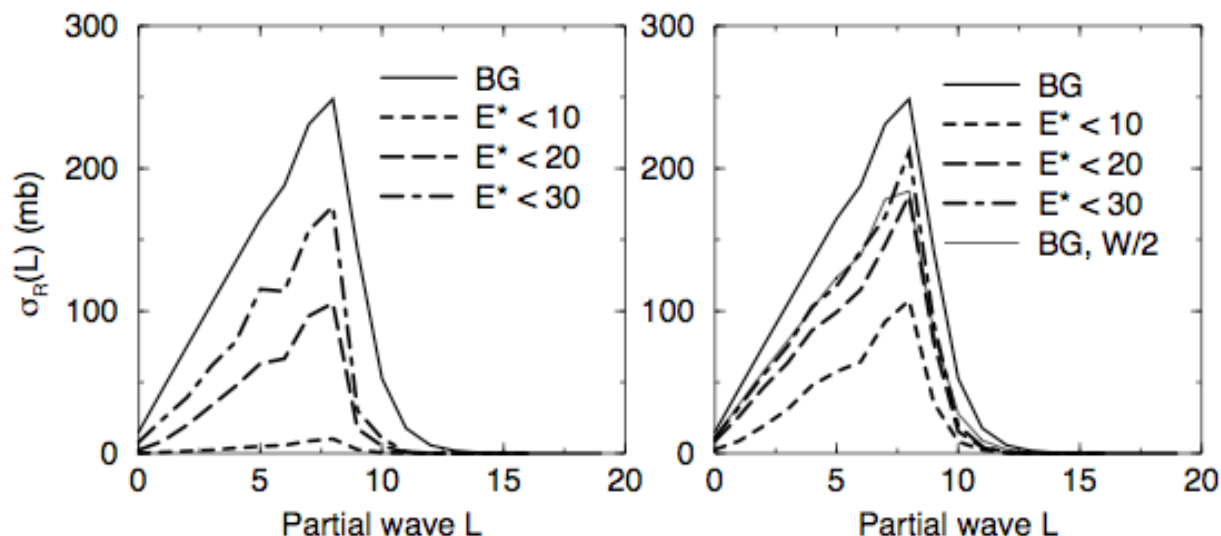
KEY:
Code Modules
 UNEDF Ab-initio Input
 User Inputs/Outputs
 Exchanged Data
 Future research

$\sigma(n+A \rightarrow X_i)$ at energy $E_{\text{projectile}}$
Computational Workflow

**UNEDF
 Reaction
 work**

Starting Point

- PH and RPA Structure Calculations for ^{90}Zr
- $n + ^{90}\text{Zr}$ scattering with $E_{\text{lab}} = 40\text{MeV}$
- CC to PH or RPA states, $E^* < 10, 20, 30 \text{ MeV}$
- Real part of Becchetti-Greenlees as Bare Potential



CC accounts only for 50% of BG cross-section

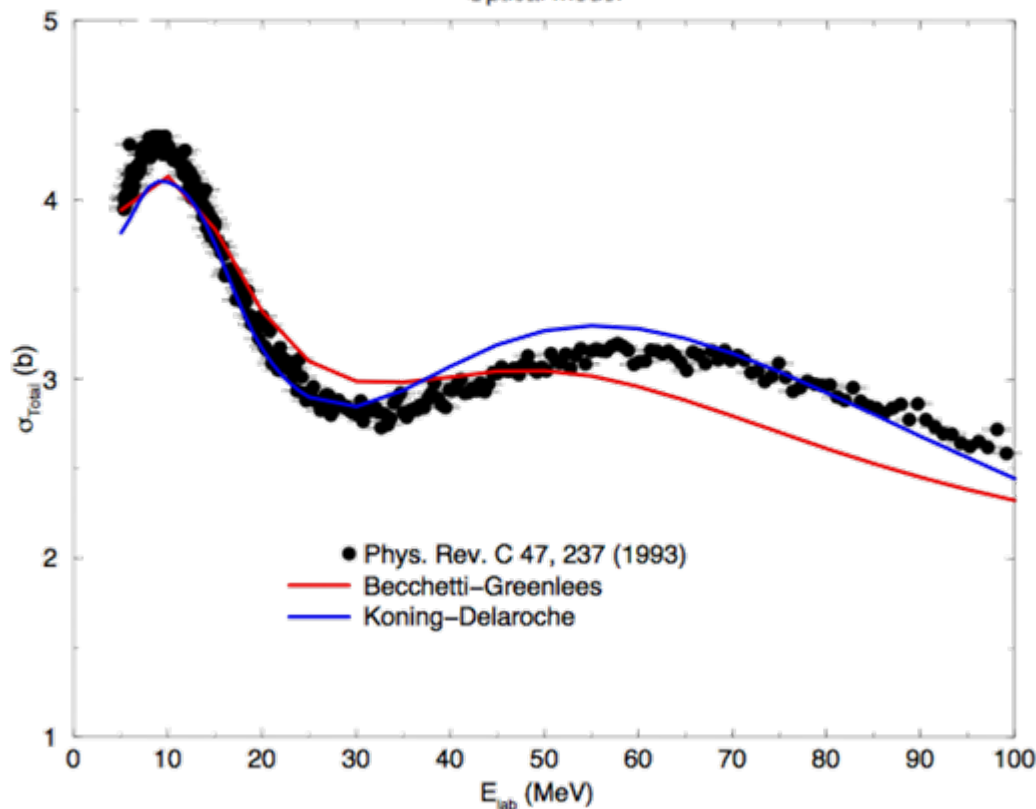
Why only 50%?

- RPA structure model may still be improved
(i.e. first 2^+ state $\langle \otimes \rangle$ $E^*=2.2$ MeV not 4.6 MeV as predicted by RPA)
 - Only couplings to/from g.s.: Couplings *between* excited states needed to be considered
 - “Second RPA” framework: states built from $2p2h$, not only $1p1h$
 - No Transfer Reactions were taken into account
-
- **Why compare to optical model?**
 - Optical Potential contains effects of the couplings
 - Bare Pot. for CC: Need for diagonal monopole potential

Comparison with Experimental Data

$^{90}\text{Zr}(n,n)$ Total Cross-sections

$n + ^{90}\text{Zr}$
Optical Model



Koning-Delaroche Optical Potential gives better description of data than **Becchetti-Greelees!**

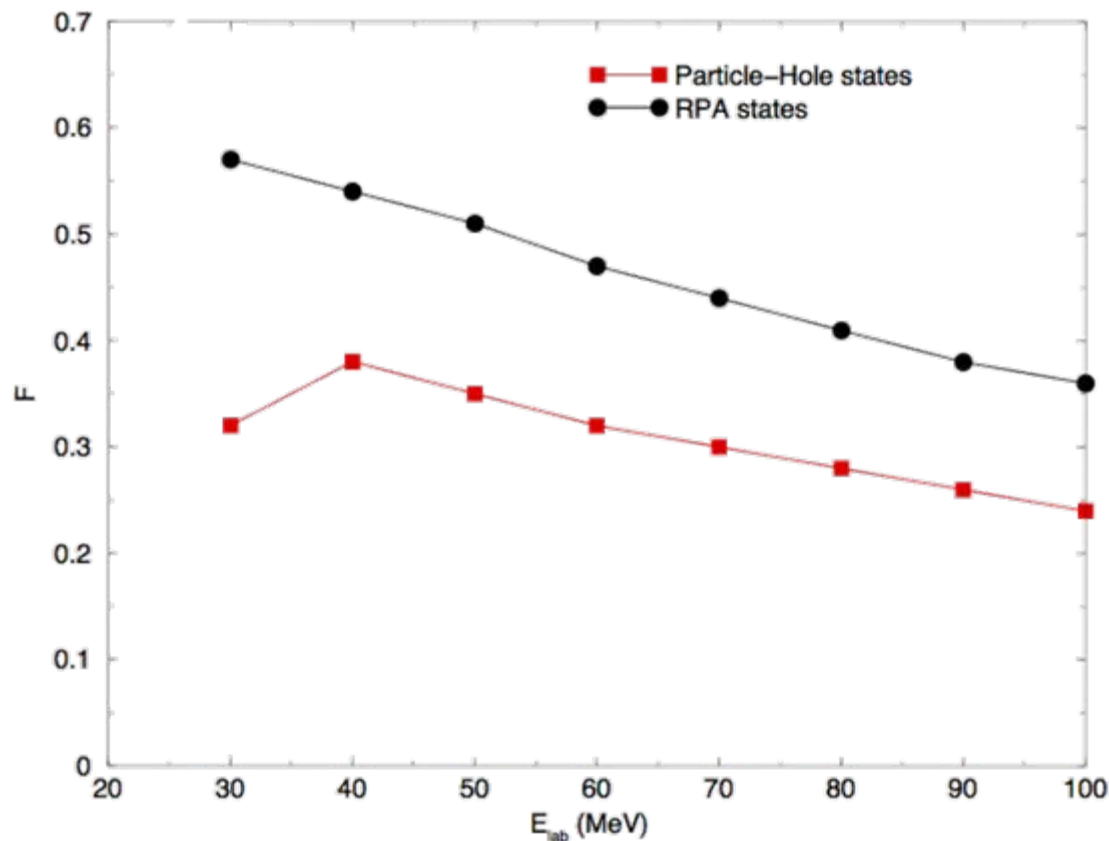
Use real part of **KD** optical potential as the bare pot. in further CC calculations!

Energy Dependence of σ_R

F \bowtie Fraction of the imaginary potential of Optical Model reproduced by CC Calculations of Reaction Cross-Sections

Coupling to RPA states gives better description of σ_R than to PH states!

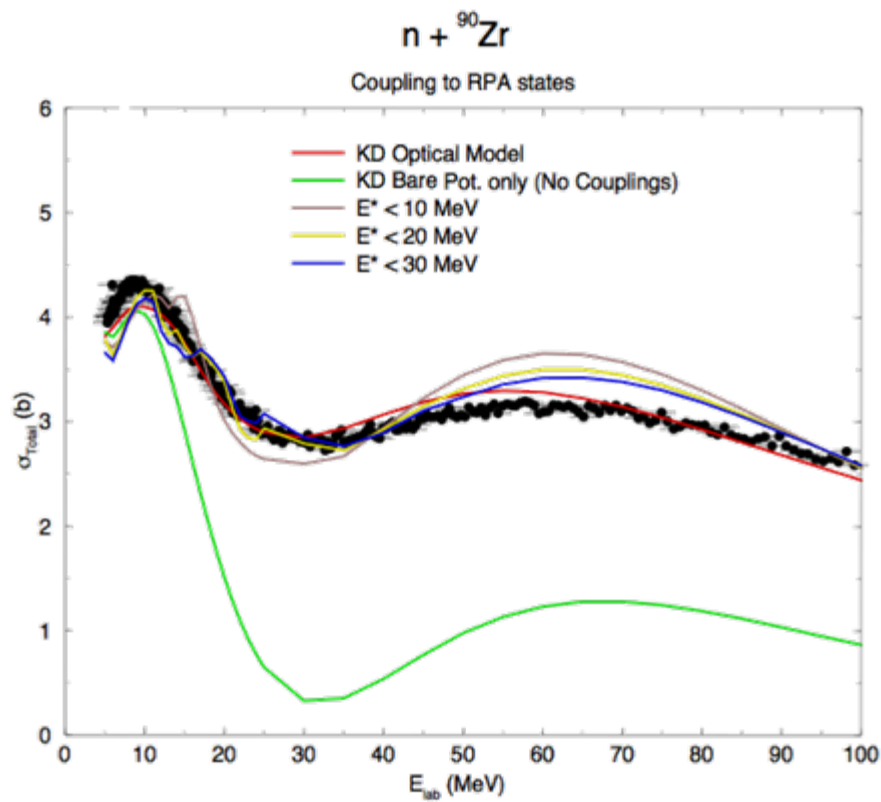
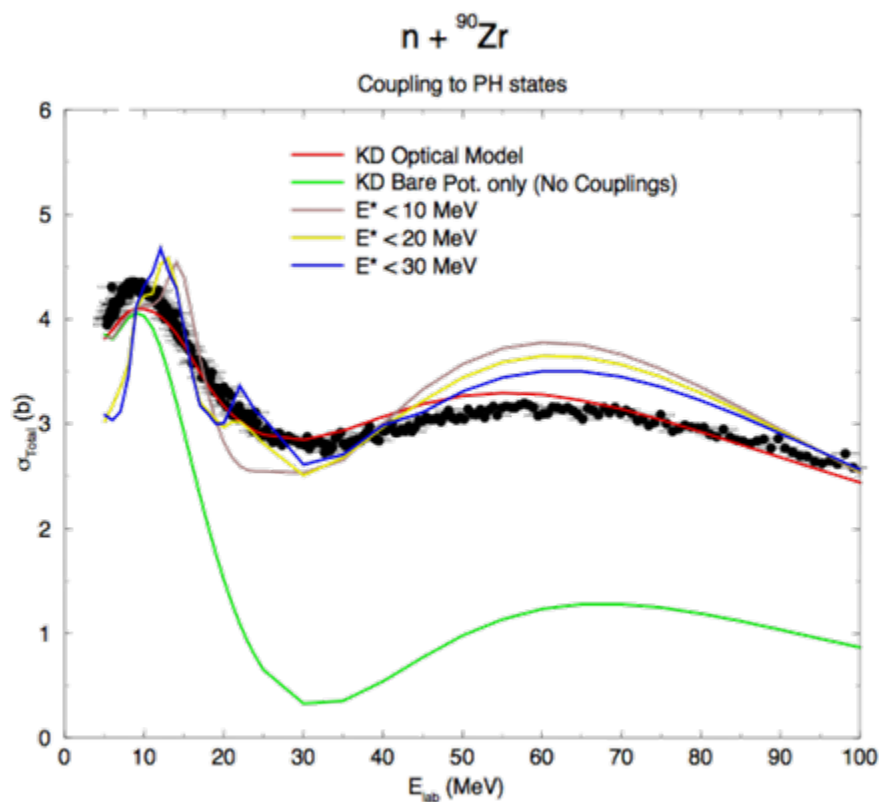
(Still needs improvement)



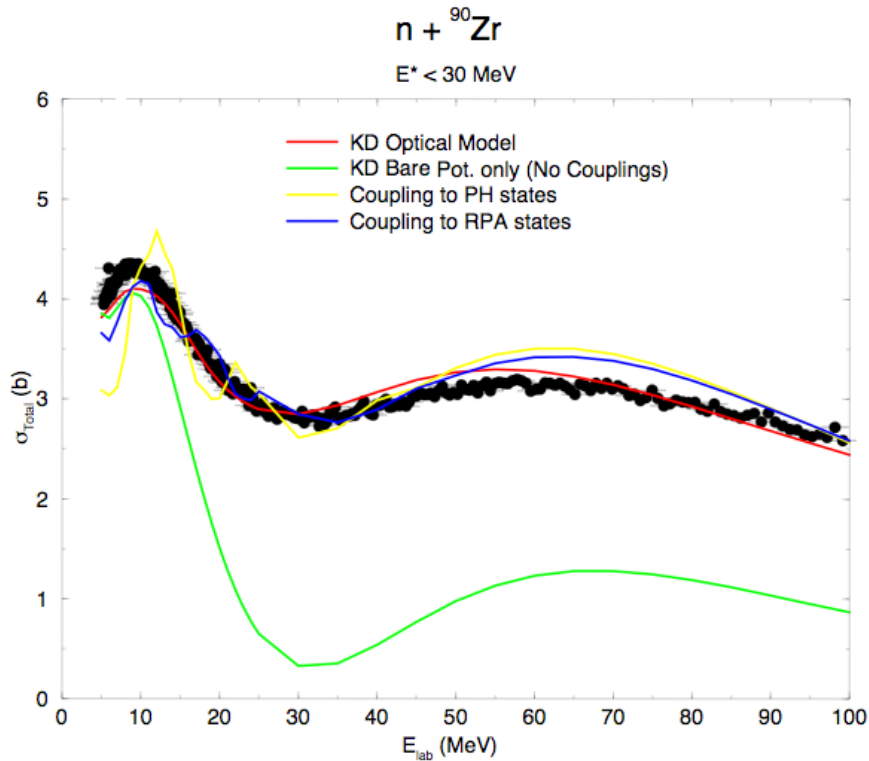
Energy Dependence of σ_T

Real part of Koning-Delaroche Optical Potential as CC Bare Potential

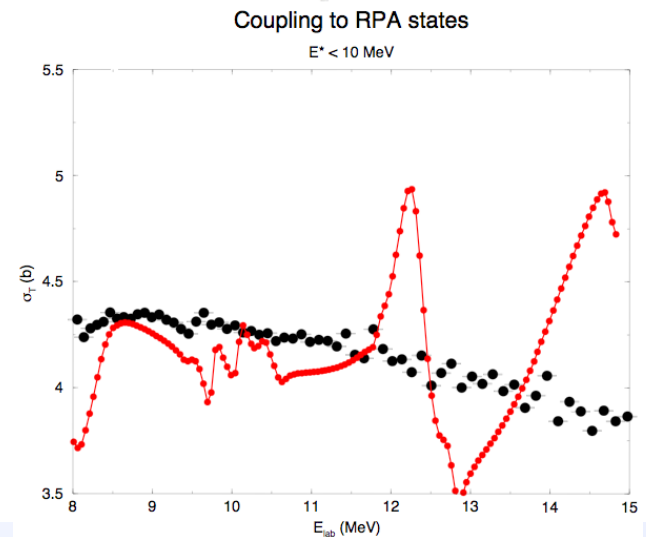
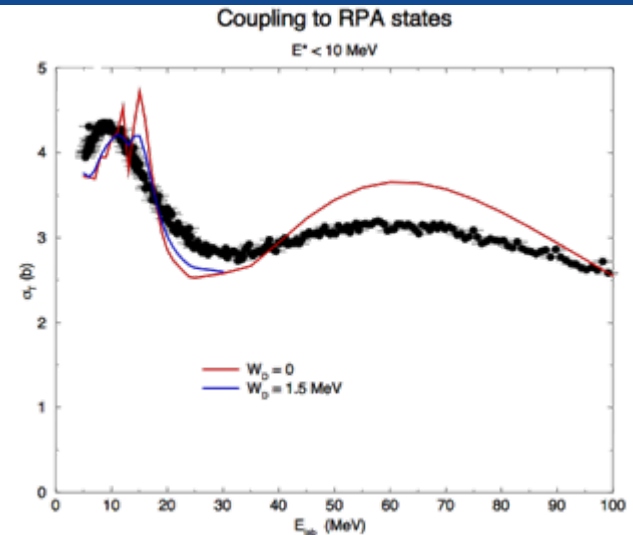
Small Imaginary part for $E_{lab} \leq 30$ MeV



$E^* < 30 \text{ MeV}$



- Important effect of couplings
- Problems at low energies
- Still needs improvements

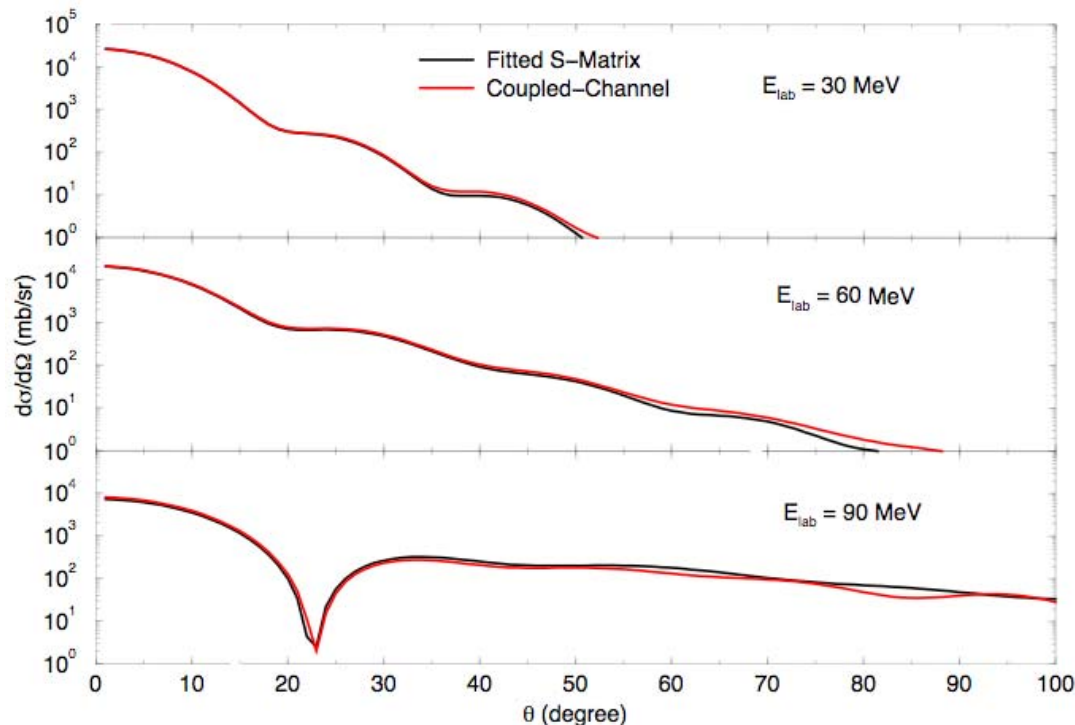
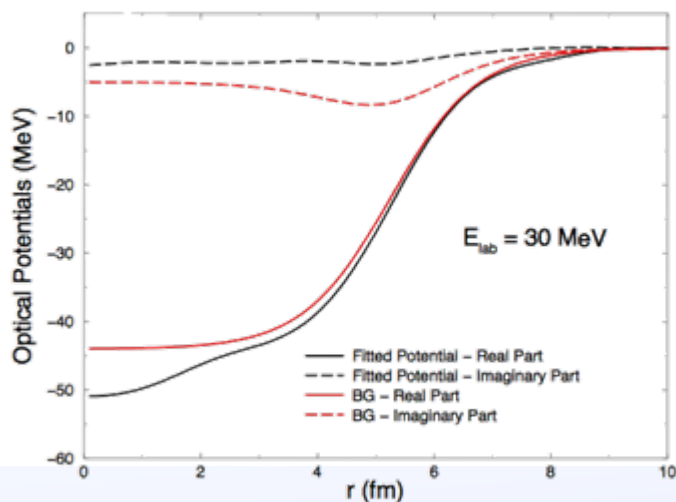


S-Matrix fits with *IMAGO* (G. Arbanas)

- CC with real part of Becchetti-Greebles as Bare Potential
- Extracted corresponding S-Matrix coefficients
- Obtained OP that fits S-Matrix incorporating energy dependence:

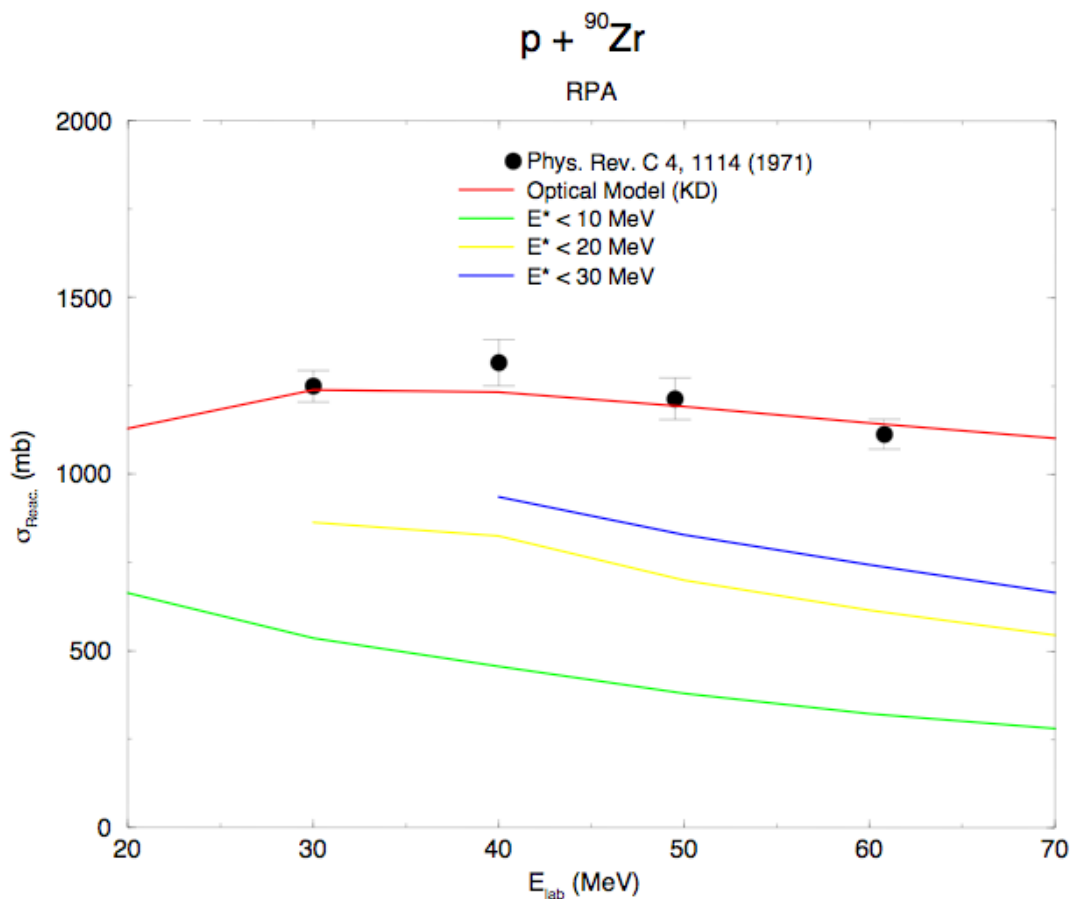
$$V_c(E,r) = F_c(E) U_c(r)$$

- Calculated Elastic cross-sections with Optical Potential



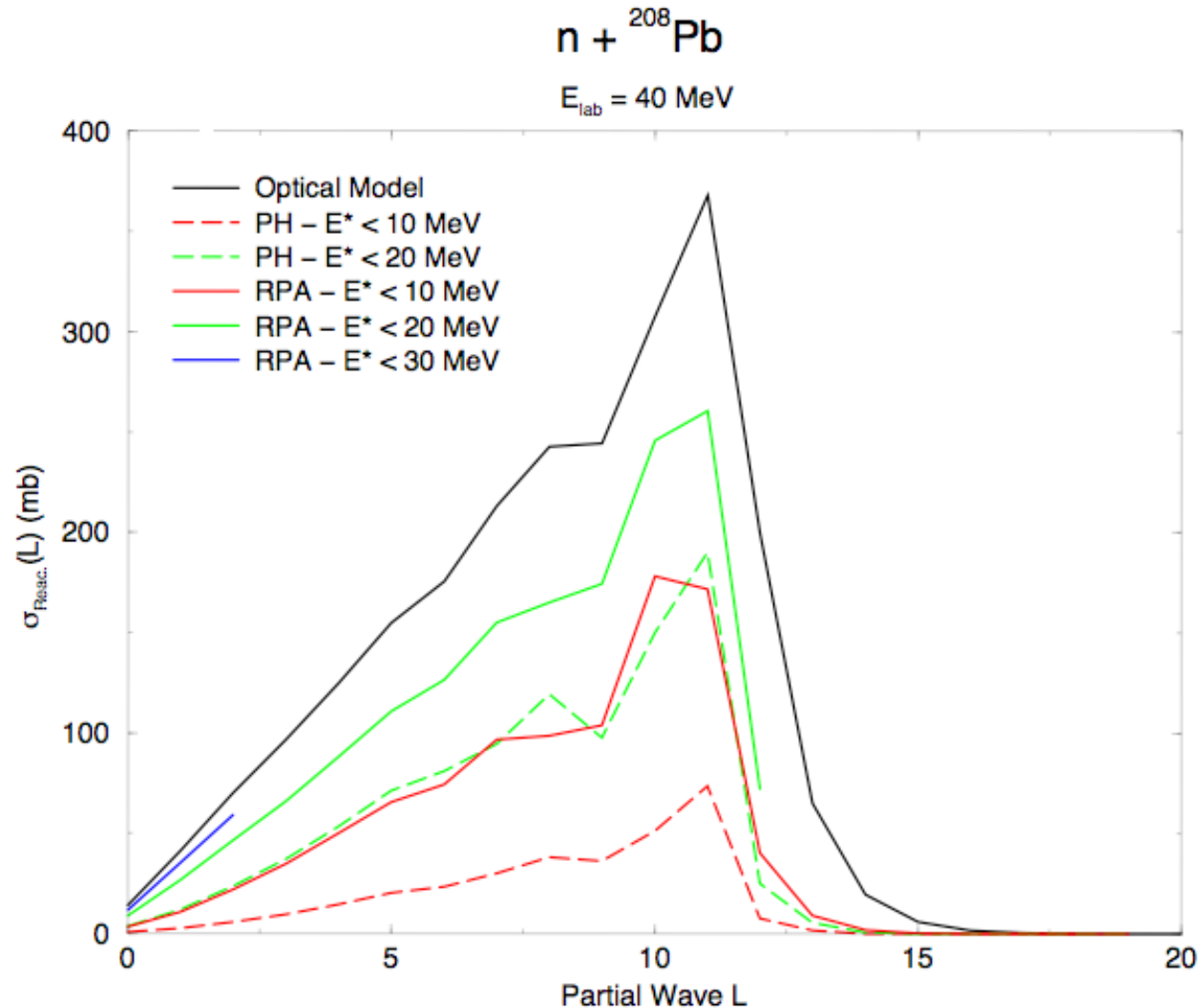
CC Calculations for $p + {}^{90}\text{Zr}$

Comparison to Reaction Cross-Sections Exp. Data



- Needs more couplings
- Numerical problems at low energies

n + ²⁰⁸Pb - Preliminary Results



Future Work - Next Steps

- Improve low-energy approach
- Analyze reactions involving other nuclei: ^{208}Pb → More States!
- Add couplings *between* excited states
- Investigate energy-dependence of off-diagonal potentials
- Investigate density dependence of interaction (J. Escher)
- Use improved RPA model
- “Second RPA”: states built from 2p2h (later years)
- Include couplings to transfer channels (later years)