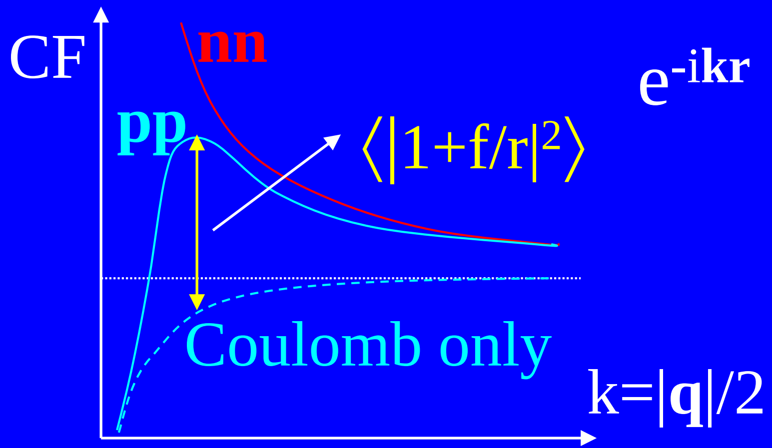
Proton-deuteron femtoscopy in BM@N

- FSI correlations
- Calculation of p-d CF
- Summary

Final State Interaction

Similar to Coulomb distortion of β-decay Fermi'34: $\langle|\psi_{-\mathbf{k}}(\mathbf{r})|^2\rangle$? t

Migdal, Watson, Sakharov, … Koonin, GKW, LL, ...



s-wave strong FSI &

r > d = strong int. range

$e^{-i\mathbf{kr}} \xrightarrow{FSI} \psi_{-\mathbf{k}}(\mathbf{r}) \rightarrow [\ e^{-i\mathbf{kr}} + f(k)e^{ikr}/r\ ]$

no Coulomb

⇒ FSI is sensitive to source size r_0 and scattering amplitude f & strong int. potential form if r_0 <~ d

FSI **complicates CF analysis** but makes possible:

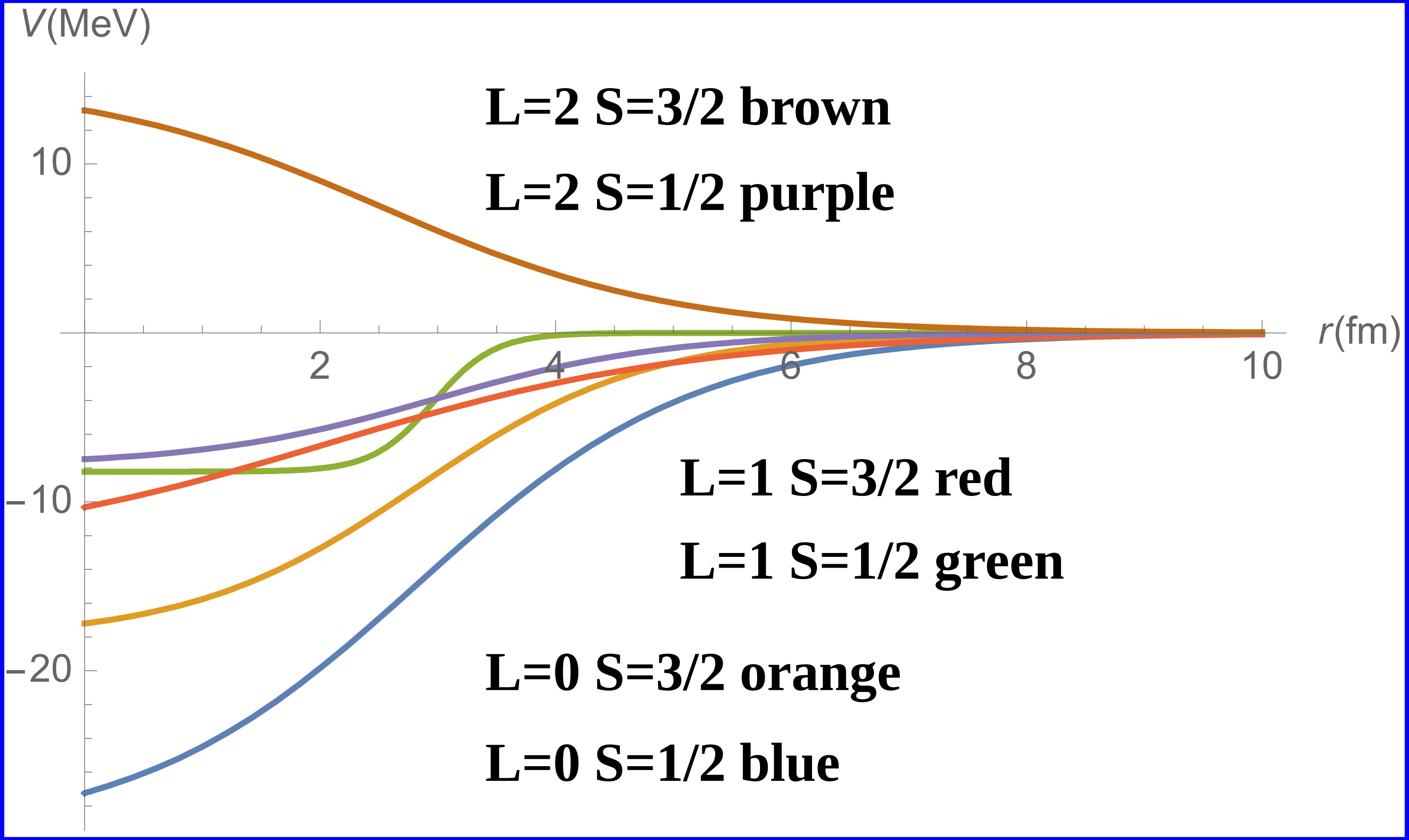
→ **Femtoscopy with nonidentical particles** πK, πp, ..
including relative space-time asymmetries delays, flow

→ **Study "exotic" scattering** ππ, πK, KK, πΛ, pΛ, ΛΛ, $\bar{p}\bar{p}$ ..
the measurement of strange particle interaction is highly required to understand the properties (EoS) of neutron stars

pd - Woods-Saxon potentials

ruther wide potential ranges of 3-4 fm

due to a large deuteron size



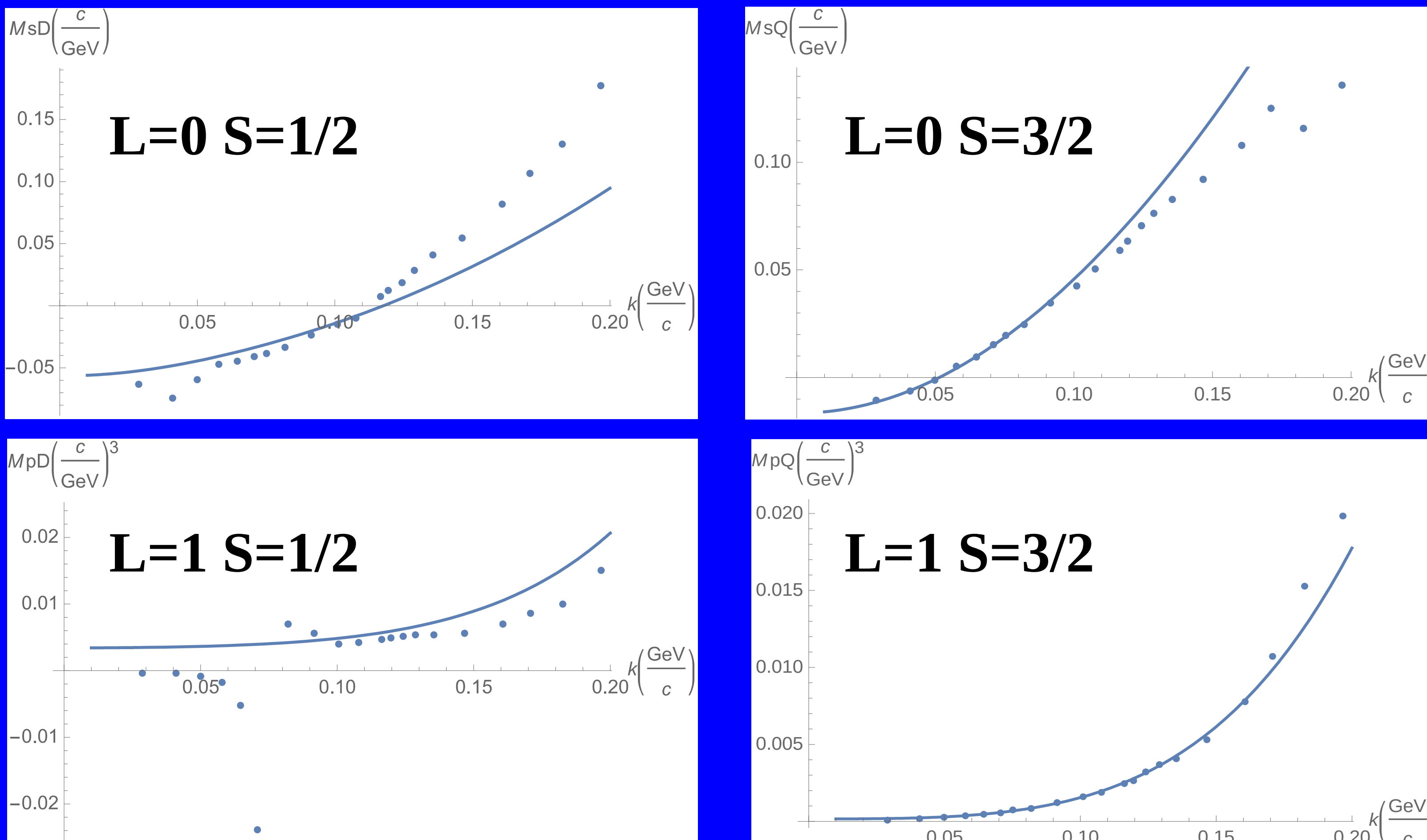
Effective range functions: $1/f_0+d_0k^2/2+\ldots$

($\to k\cot\delta$ if no Coulomb int.):

points – from pd phase shifts Arvieux'74

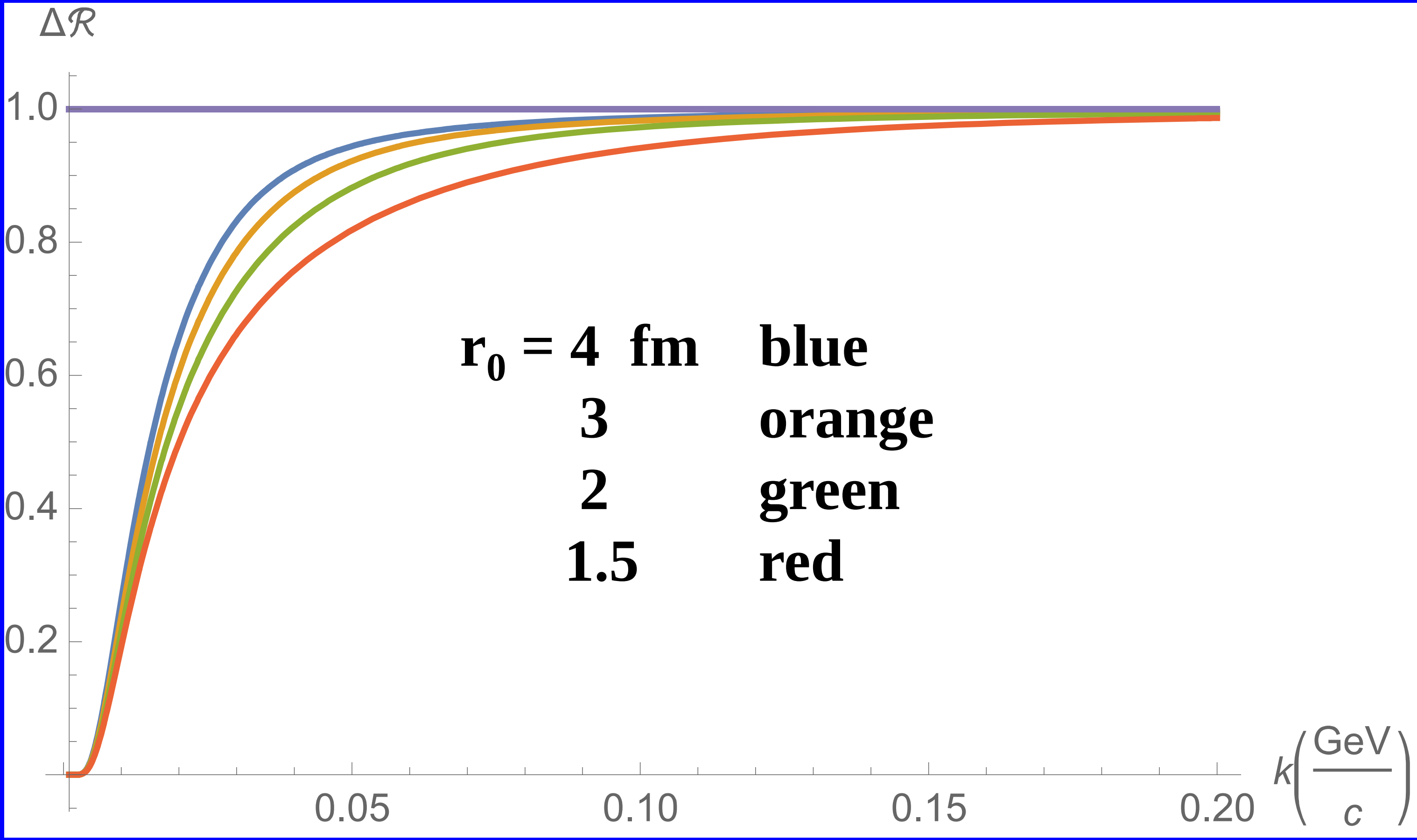
curves – from WS-potentials Jennings'86

→ problem for S=1/2



Coulomb contribution to CF vs r_0

$\rightarrow$ 1 at large r_0



r_0 = 4 fm blue

3 orange

2 green

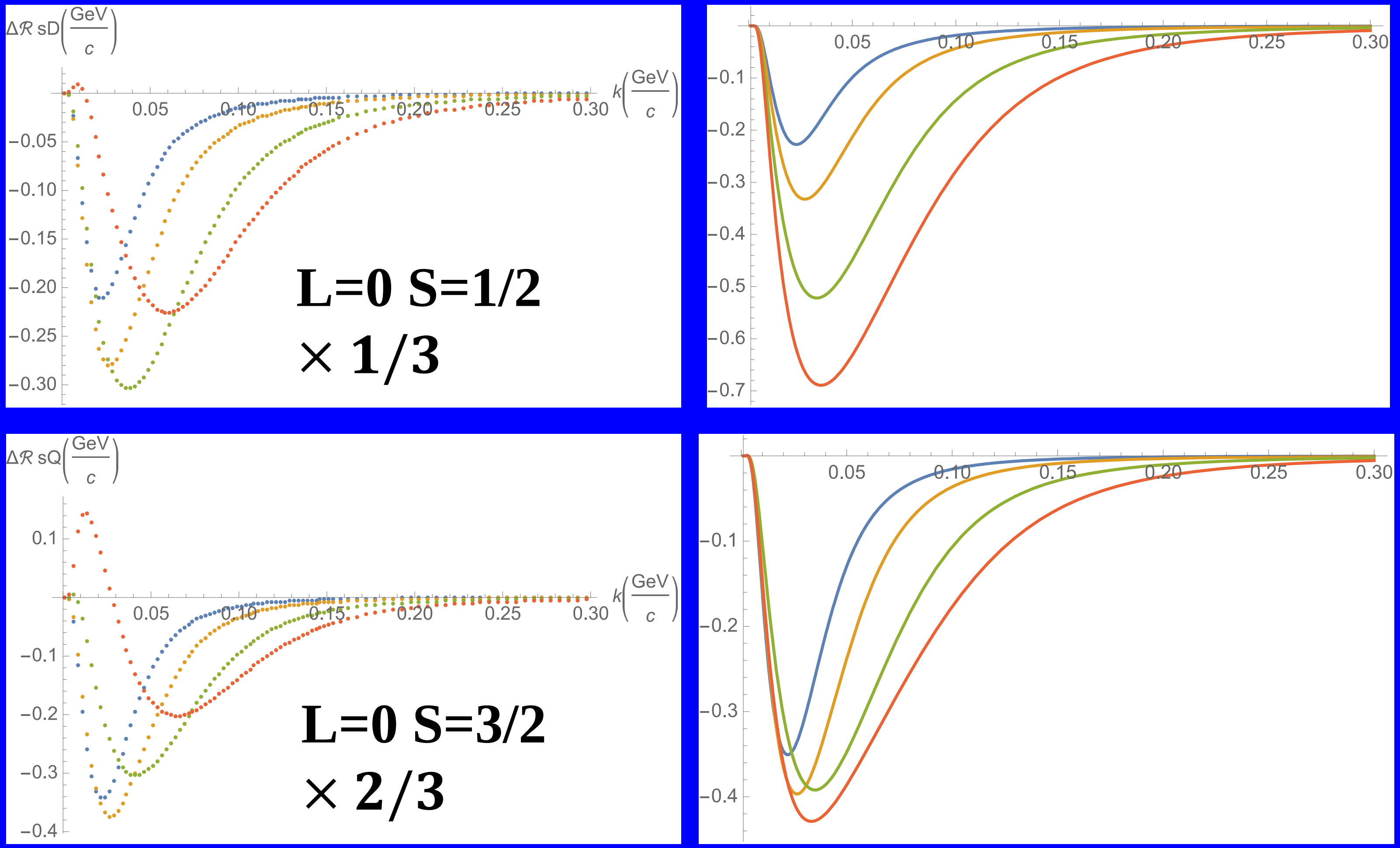
1.5 red

ΔCF from FSI WS-potentials at L=0 S=1/2 & 3/2 vs r_0

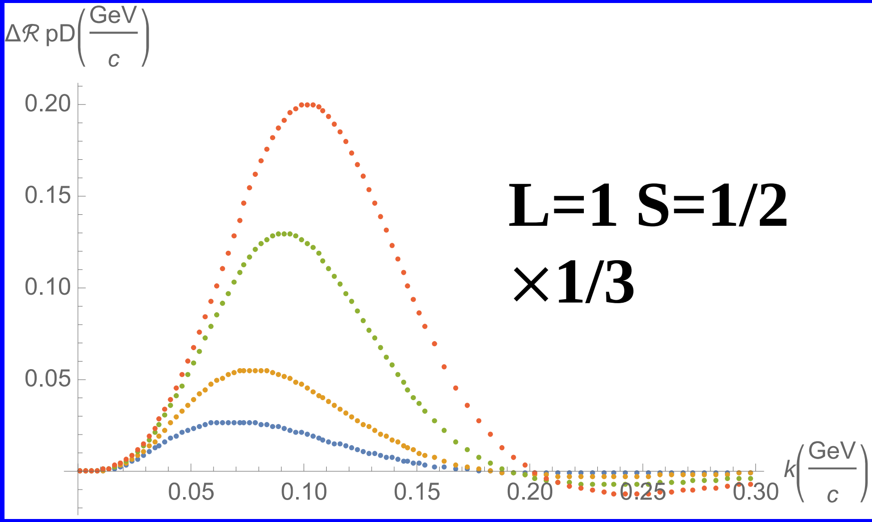
r_0 [fm] = 4-blue 3-orange 2-green 1.5-red

points - exact

curves – approx. inner pot. region: OK for r_0 > 3 fm



ΔCF from FSI WS-potentials at L=1 S=1/2 & 3/2 vs r_0



r_0 = 4 fm blue
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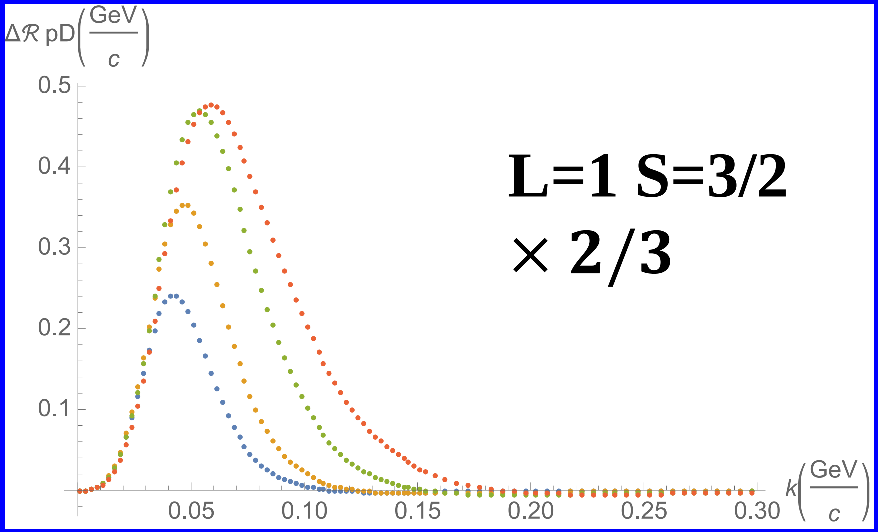

- **ΔCF(L=1) shifted to higher k**
- **ΔCF(L=1) $\ll$ ΔCF(L=0) at S=1/2**
- **ΔCF(L=1) $\sim -\Delta CF$(L=0) at S=3/2**

Conclusions from pd CFs

- calculations for BM@N assume:
  - neglect of the deuteron structure
  - approx. inner integral using pd phase shifts Arvieux'74
  - s-wave dominance in strong FSI (exact Coulomb FSI)
- comparison with pd potentials Jennings'86:
  - discrepancy between phase shifts Arvieux and potentials Jennings (especially for S=1/2)
  - the potentials yield essential p-wave contribution at S=3/2
- careful p (d)-wave analysis is required (including possible dependence on total angular momentum – neglected by both Arvieux and Jennings)
- 3-body effects should be estimated, e.g.

  Mrowczynski'20: $\exp[-r^2/(4r_0^2)] \rightarrow \exp[-r^2/(3r_0^2)]$ since coalescence: $r_0^2(d)= r_0^2/2$

  Viviani'23: full 3-body calculation modifies the above ansatz at small k

Thank you for the attention