# Few-body polarimetry using elastic scattering

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# ANALYZING POWER for POLARIZED LIGHT IONS

$M$ and $Z$: mass and charge of ion with magnetic moment $\mu$

$\mu$: is in units of nuclear magnetons with proton mass $m$

$A_{\mathrm{N}}$: the analyzing power for an incident polarized ion is

2 Im (non-flip) (spin-flip)* / [ (non-flip)$^2$ + (spin-flip)$^2$ ]

non-flip: $i + \rho - \frac{t_{\mathrm{c}}}{t} e^{i\,\delta_c - (b_h - b_{em})\,t}$

$\frac{m}{\sqrt{-t}}$ spin-flip: $i\,I + R - \frac{t_c}{t}\left(\frac{\mu}{Z} - \frac{m}{M}\right) e^{i\,\delta_c \cdots}$

EM and hadronic equal at $-t_c = \frac{4hc\,Z\,Z'}{137\,\sigma_{\mathrm{tot}}} \approx \frac{Z\,Z'}{14\,\sigma_{\mathrm{tot}}}\ \mathrm{GeV}/c^2$

Over $0.001 < -t < 0.01$ Coulomb phase & slope effects: small changes in $\rho$ & $R$

# ANALYZING POWER AT LOW MOMENTUM TRANSFER

The analyzing power for an incident polarized ion is

$$\frac{m}{\sqrt{-t}} A_{\mathrm{N}} = \frac{\frac{t_c}{t}\left(\frac{\mu}{Z} - \frac{m}{M} - I\right) - R + \varrho I}{1 + \varrho^2 + (t_c / t)^2 - (m^2 / t)(\ldots)}$$

and the unknown imaginary spin-flip term, $I$, means that

an experiment is required to evaluate $I$ for polarimetry.

At $0.001 < -t < 0.01$ denominator spin-flip terms are small

& the analyzing power may be approximated in the following:

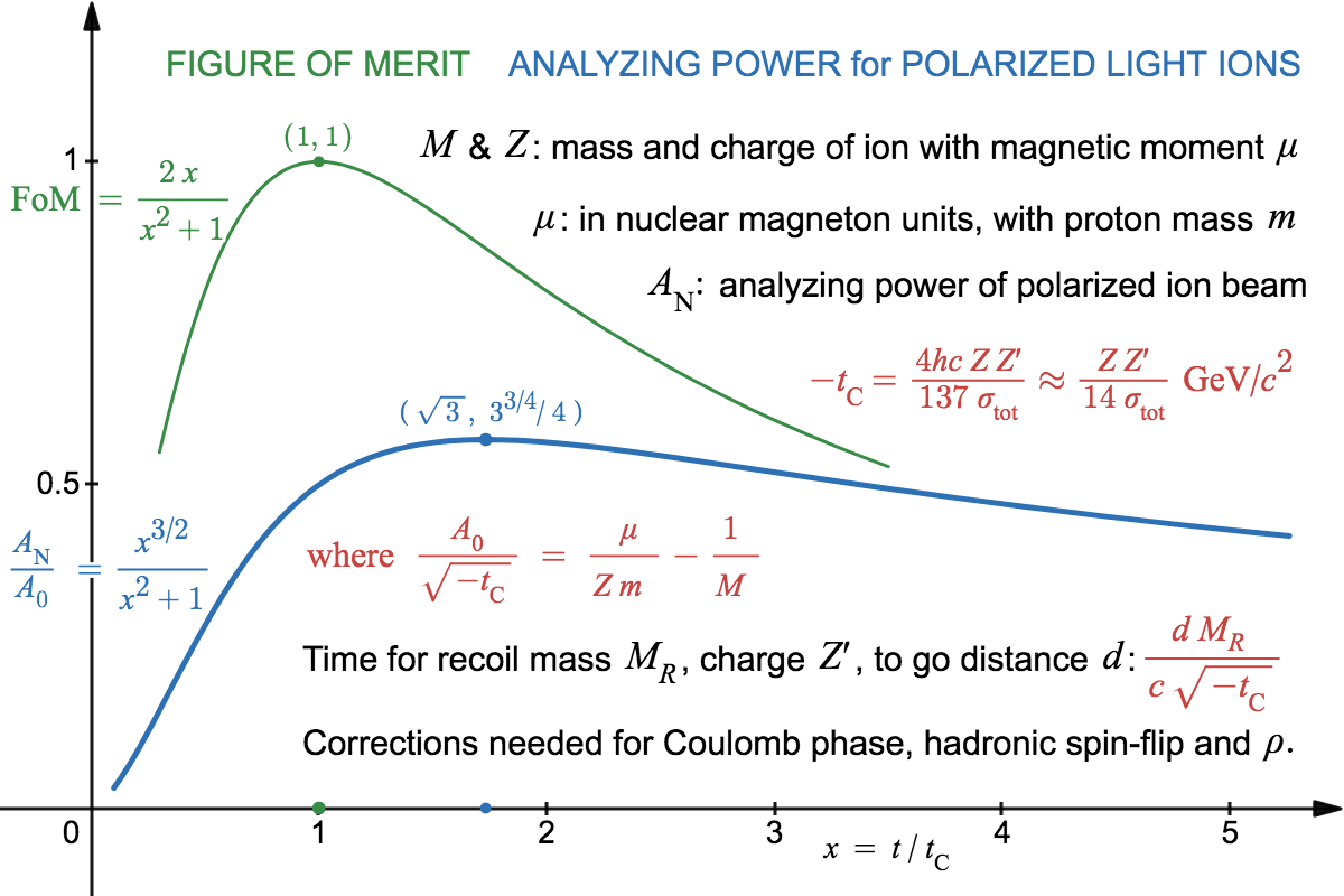

FIGURE OF MERIT
ANALYZING POWER for POLARIZED LIGHT IONS
$M$ & $Z$: mass and charge of ion with magnetic moment $\mu$
$\mu$: in nuclear magneton units, with proton mass $m$
$A_N$: analyzing power of polarized ion beam
$\mathrm{FoM} = \frac{2x}{x^2+1}$
(1, 1)
$-t_C = \frac{4hc\,Z\,Z'}{137\,\sigma_{tot}} \approx \frac{Z\,Z'}{14\,\sigma_{tot}}\ \mathrm{GeV}/c^2$
$(\sqrt{3},\ 3^{3/4}/4)$
$\frac{A_N}{A_0} = \frac{x^{3/2}}{x^2+1}$
where $\frac{A_0}{\sqrt{-t_C}} = \frac{\mu}{Z\,m} - \frac{1}{M}$
Time for recoil mass $M_R$, charge $Z'$, to go distance $d$: $\frac{d\,M_R}{c\sqrt{-t_C}}$
Corrections needed for Coulomb phase, hadronic spin-flip and $\rho$.
1
0.5
0
1
2
3
4
5
$x = t\,/\,t_C$

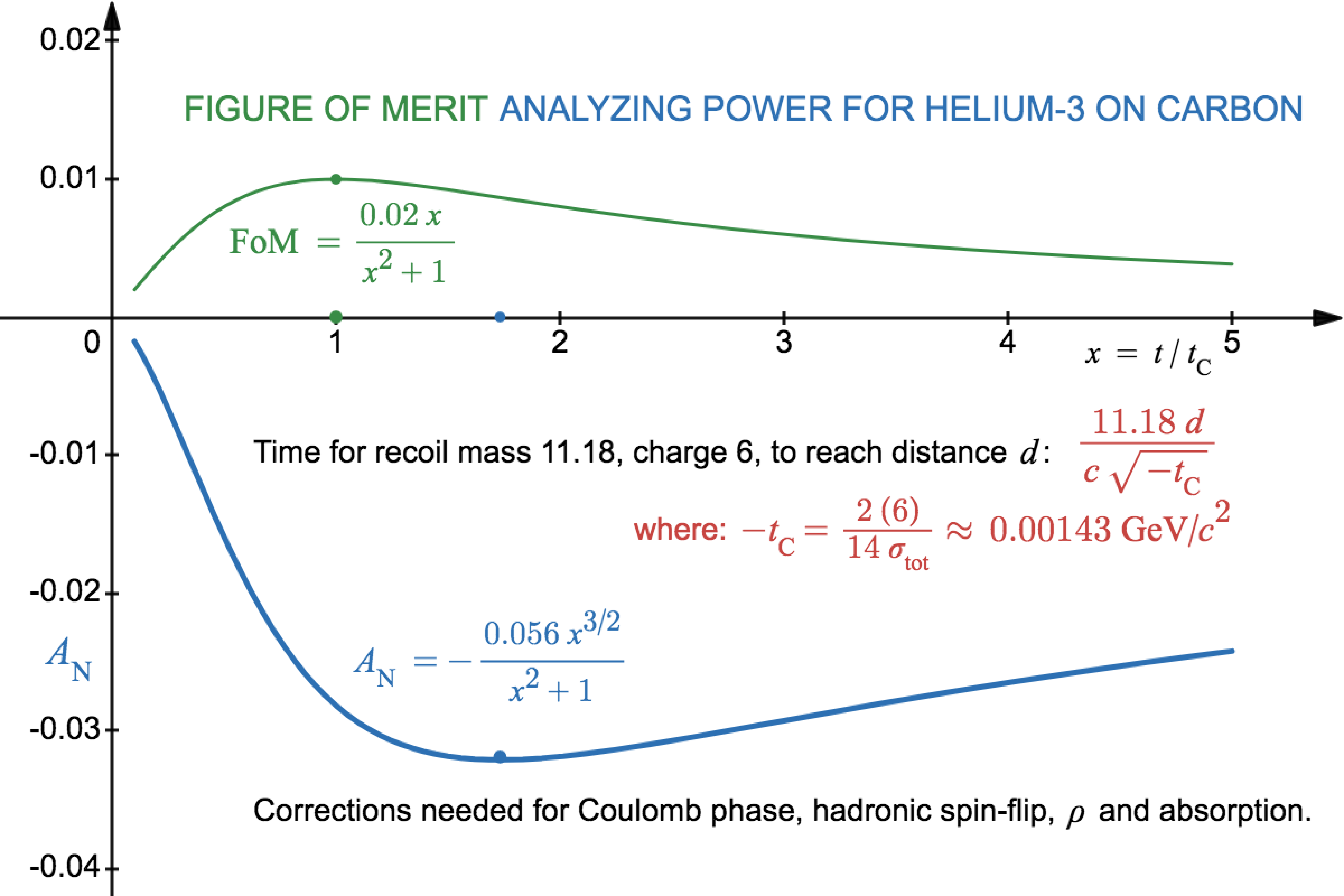
FIGURE OF MERIT ANALYZING POWER FOR HELIUM-3 ON CARBON
$\text{FoM} = \frac{0.02\,x}{x^2+1}$
$x = t\,/\,t_C$
Time for recoil mass 11.18, charge 6, to reach distance $d$: $\frac{11.18\,d}{c\sqrt{-t_C}}$
where: $-t_C = \frac{2\,(6)}{14\,\sigma_{tot}} \approx 0.00143\ \text{GeV}/c^2$
$A_N = -\frac{0.056\,x^{3/2}}{x^2+1}$
$A_N$
Corrections needed for Coulomb phase, hadronic spin-flip, $\rho$ and absorption.
0.02
0.01
0
-0.01
-0.02
-0.03
-0.04
1
2
3
4
5