Polarimeter energy dependence

What design works for each energy range?
- Efficiency?
- Average analyzing power?

Are there optimum energies for polarimetry?

What systematic errors appear for each design?

Are there gaps in our information?
- What new data is needed?

All targets are thick carbon slabs.
Except at highest energy, elastic scattering is separated by an absorber.

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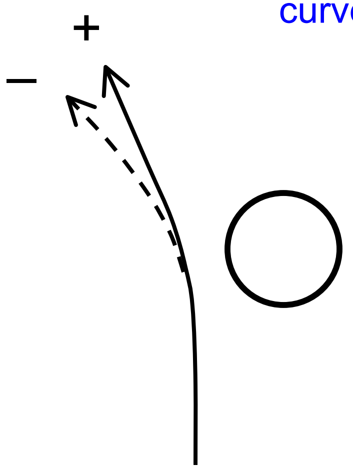
Energies < 70 MeV
Coulomb rainbow scattering

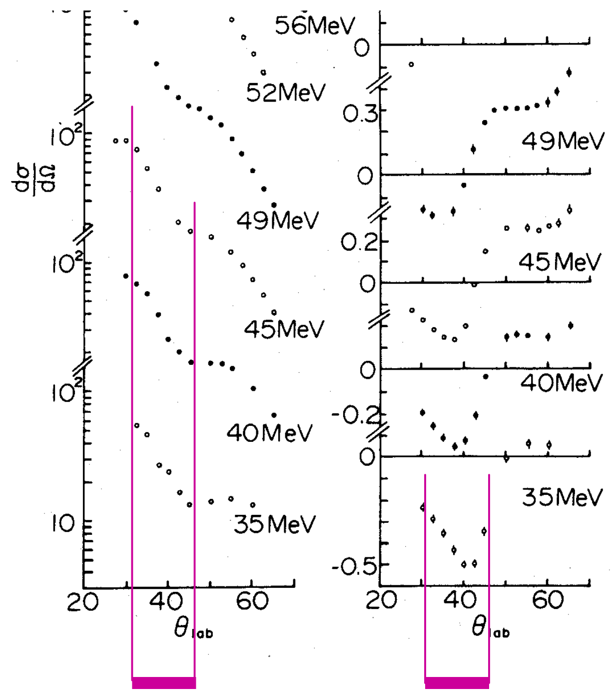
Forward-angle trajectories curved in Coulomb field



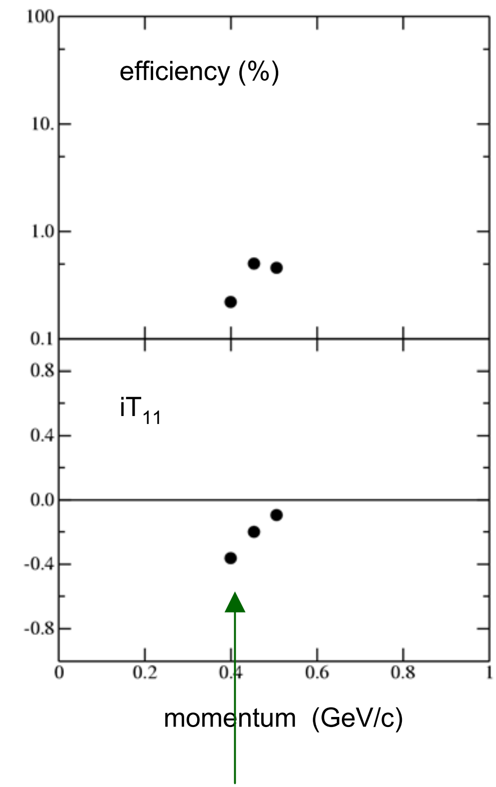
Spin-orbit force causes (+) to bend toward smaller angles.

If the cross section is FALLING with angle, then at any angle, spin (–) will dominate. This makes $iT_{11} < 0$.

Work in this region.

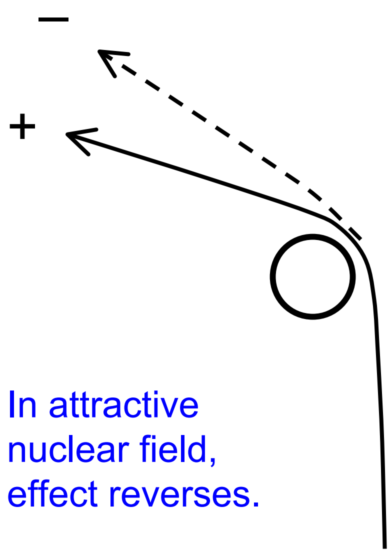


estimated operating characteristics



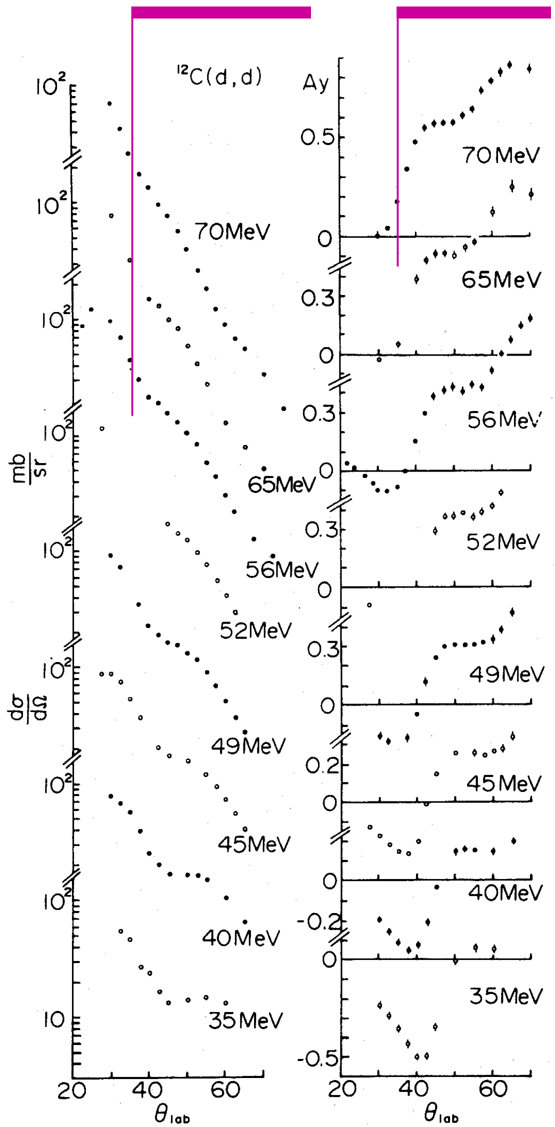
40 MeV design was here.

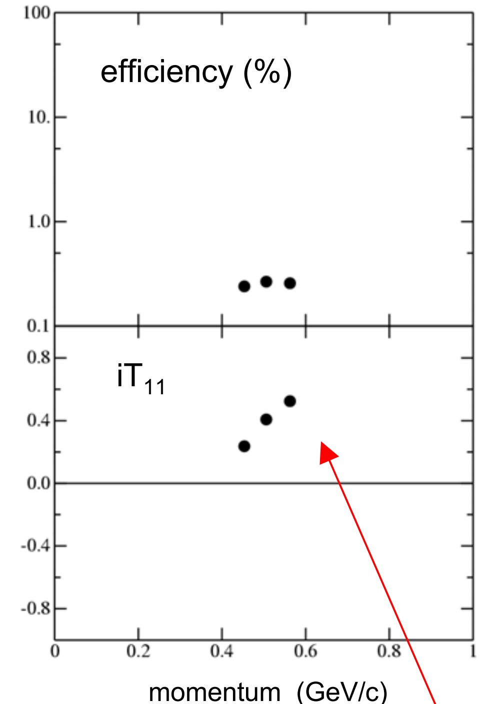
Energy > 40 MeV
Nuclear rainbow scattering



In attractive
nuclear field,
effect reverses.

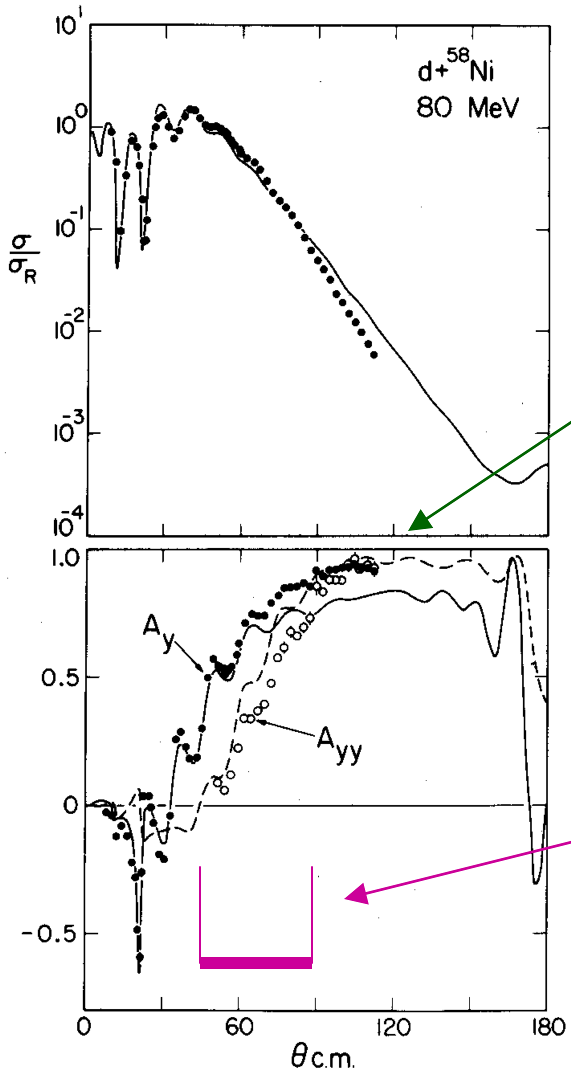
These analyzing
powers get very
large while the
cross section
falls exponentially.





Data run out while spin
sensitivity improves.
Higher energy data
are needed.

More about nuclear rainbow scattering…

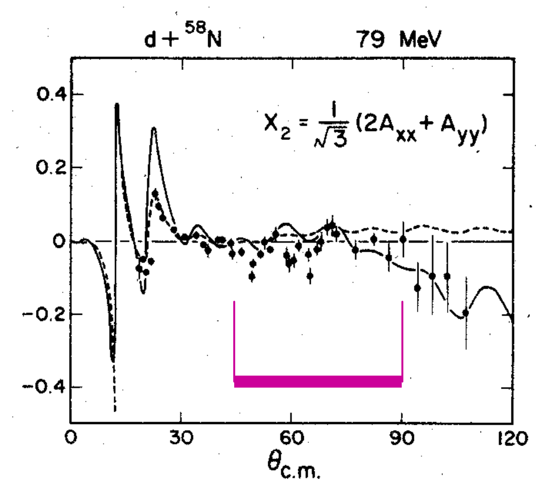


NOTE: Once analyzing power start to rise for elastic scattering, it rises for ALL inelastic and particle transfer channels. Thus an inclusive polarimeter will gain efficiency. (Estimates here consider only the elastic.)

Very large angle analyzing powers approach their limit, could be used for *in situ* calibration.

Most useful where analyzing power starts to rise and cross section is still large.

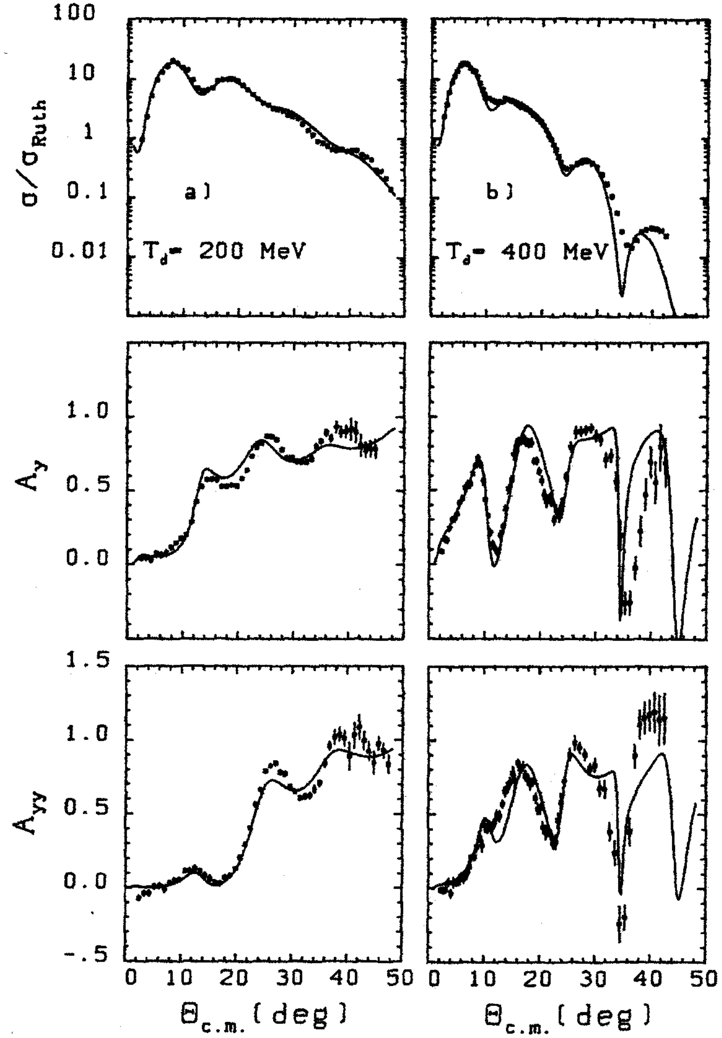
Sensitive to inner angle cut.



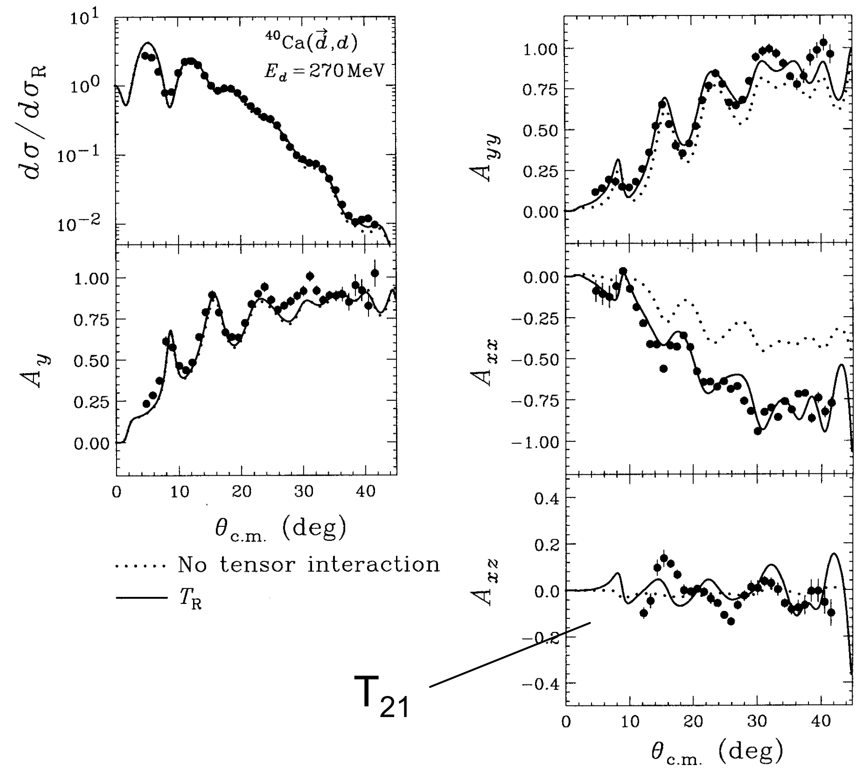
Non-spin-orbit observables such as T_{21} or X_2 are small.

… rainbow at higher energy

Oxygen target



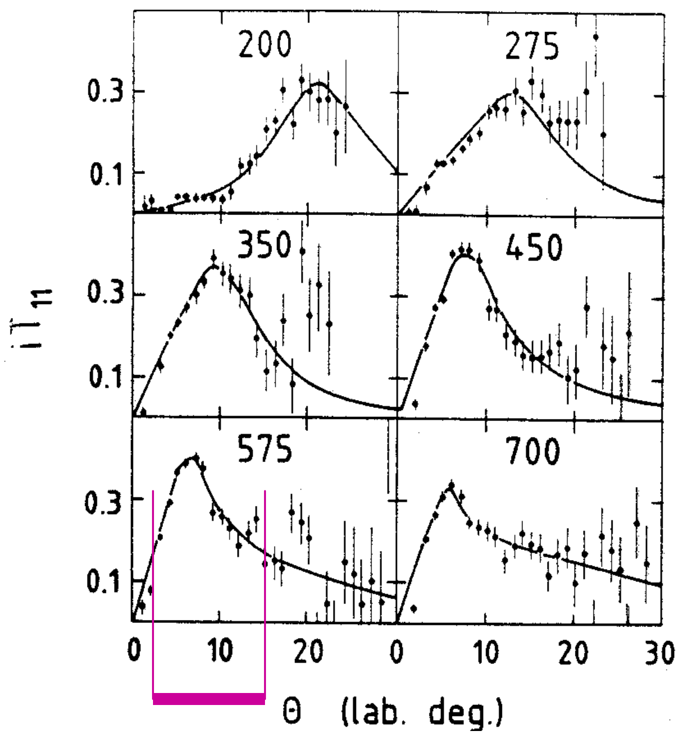
Calcium target



T_{21}

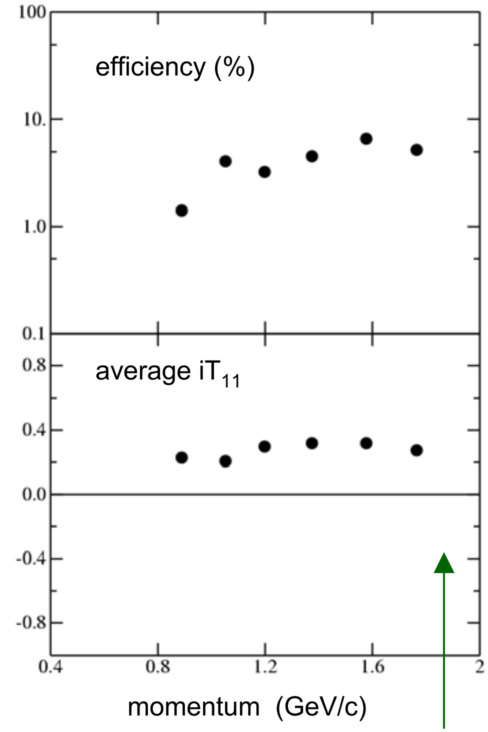
Energy > 200 MeV
Absorptive spin-orbit

Absorption eventually reduces nuclear rainbow. But forward-angle spin-orbit effect grows in.



Work here.

Forward-angle cross sections are large!

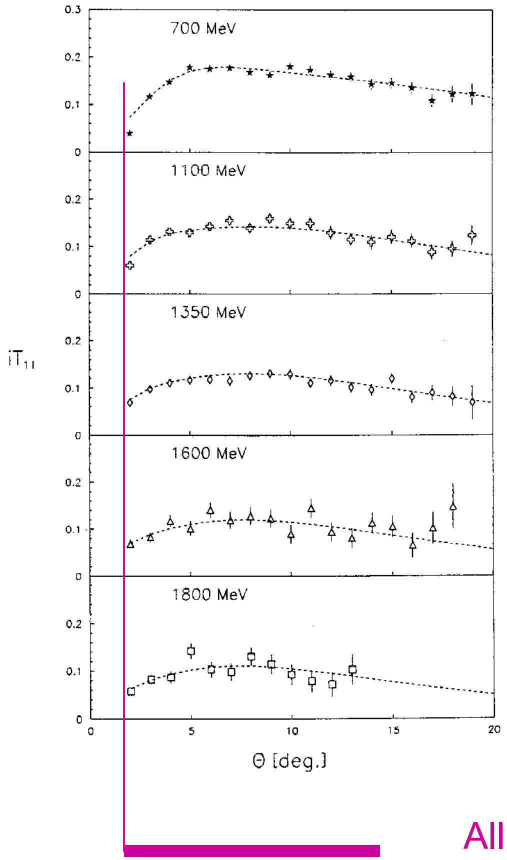


Efficiency rises while average iT_{11} falls.

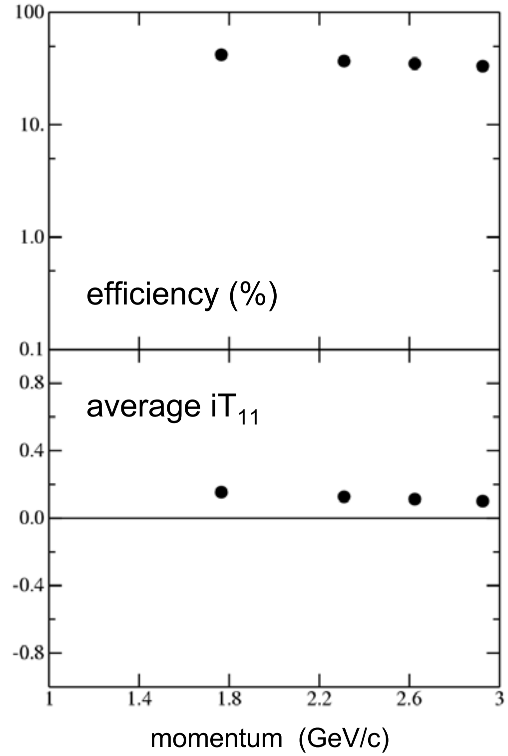
AGS ring

At about 700 MeV, the use of an iron absorber to separate the elastic scattering loses its effectiveness. Then iT_{11} starts to decline.

Energy > 700 MeV
Absorptive spin-orbit
no particle identification



All angles past 1.5° are kept.

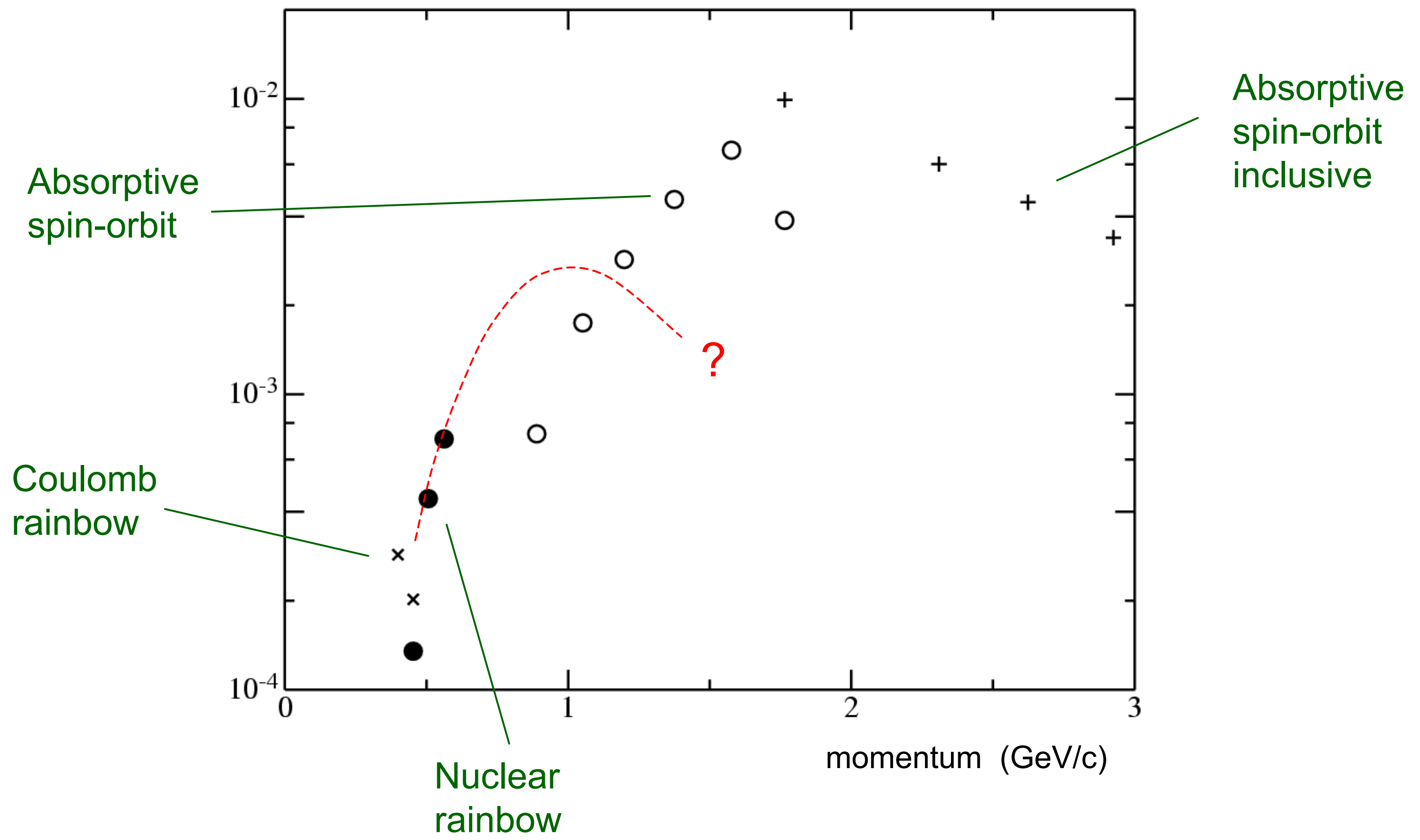


Higher efficiency but smaller analyzing power.

For these cases the carbon target thickness was held fixed at 30 cm.

Summary

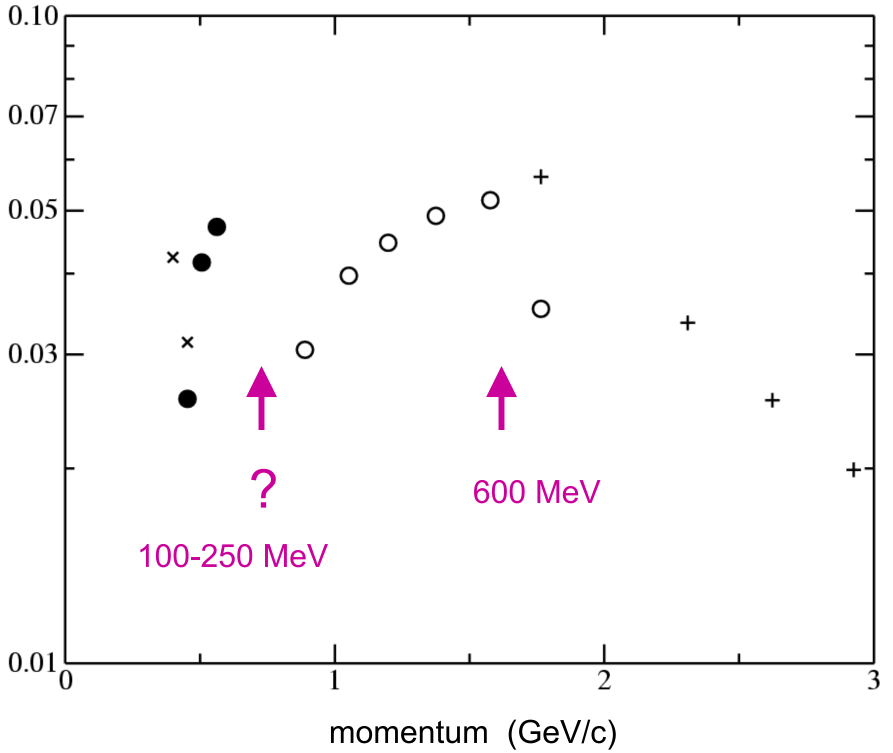
Figure of merit = effiency $\times \langle iT_{11} \rangle^2$



Extrapolation of nuclear rainbow effect is not known.

Can this information be useful for planning?

Consider: $\frac{\text{precision}}{\text{cost}} = \frac{\sqrt{FOM}}{p}$



possible optimum polarimeter points