Coulomb Sum Rule Experiment

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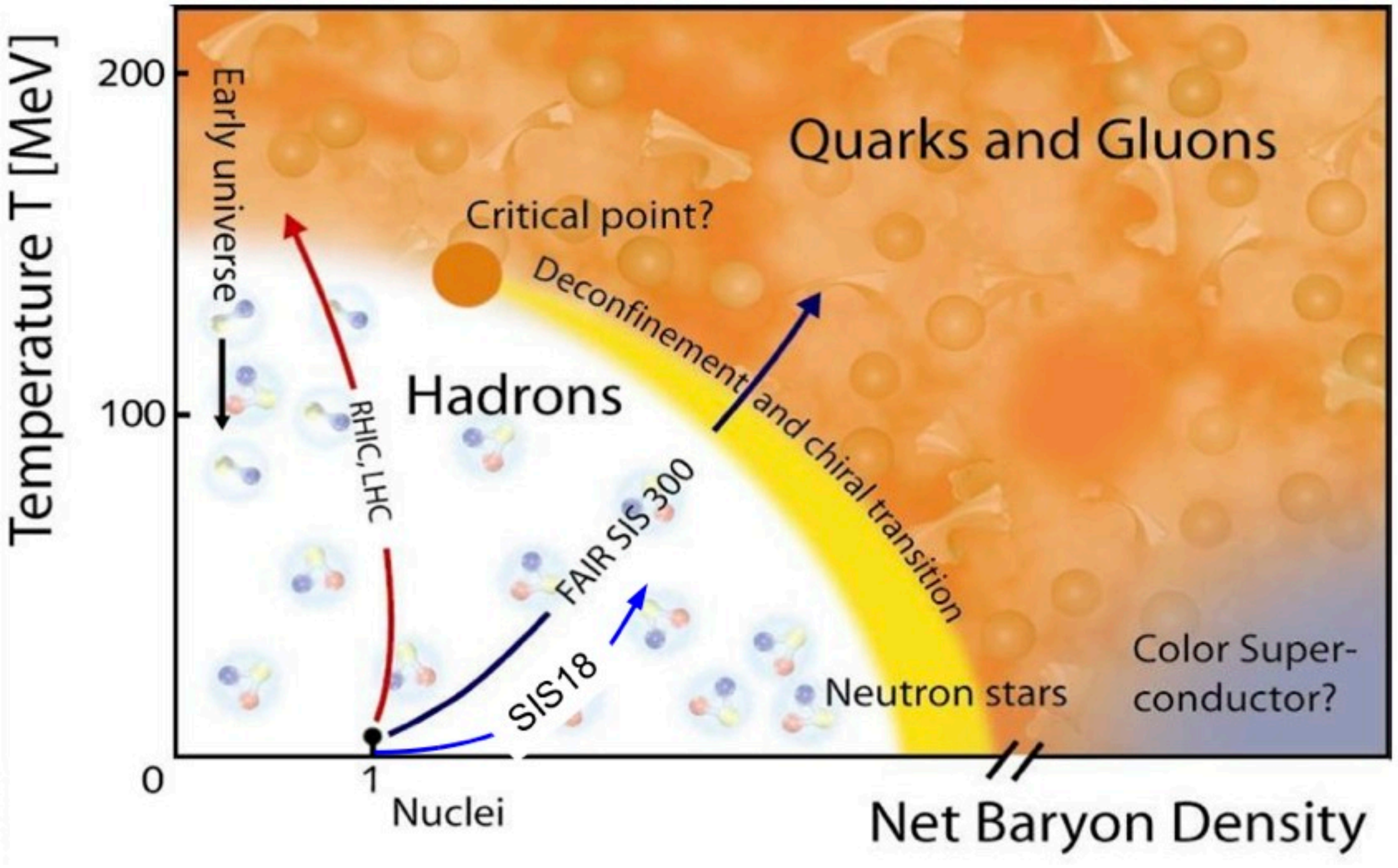
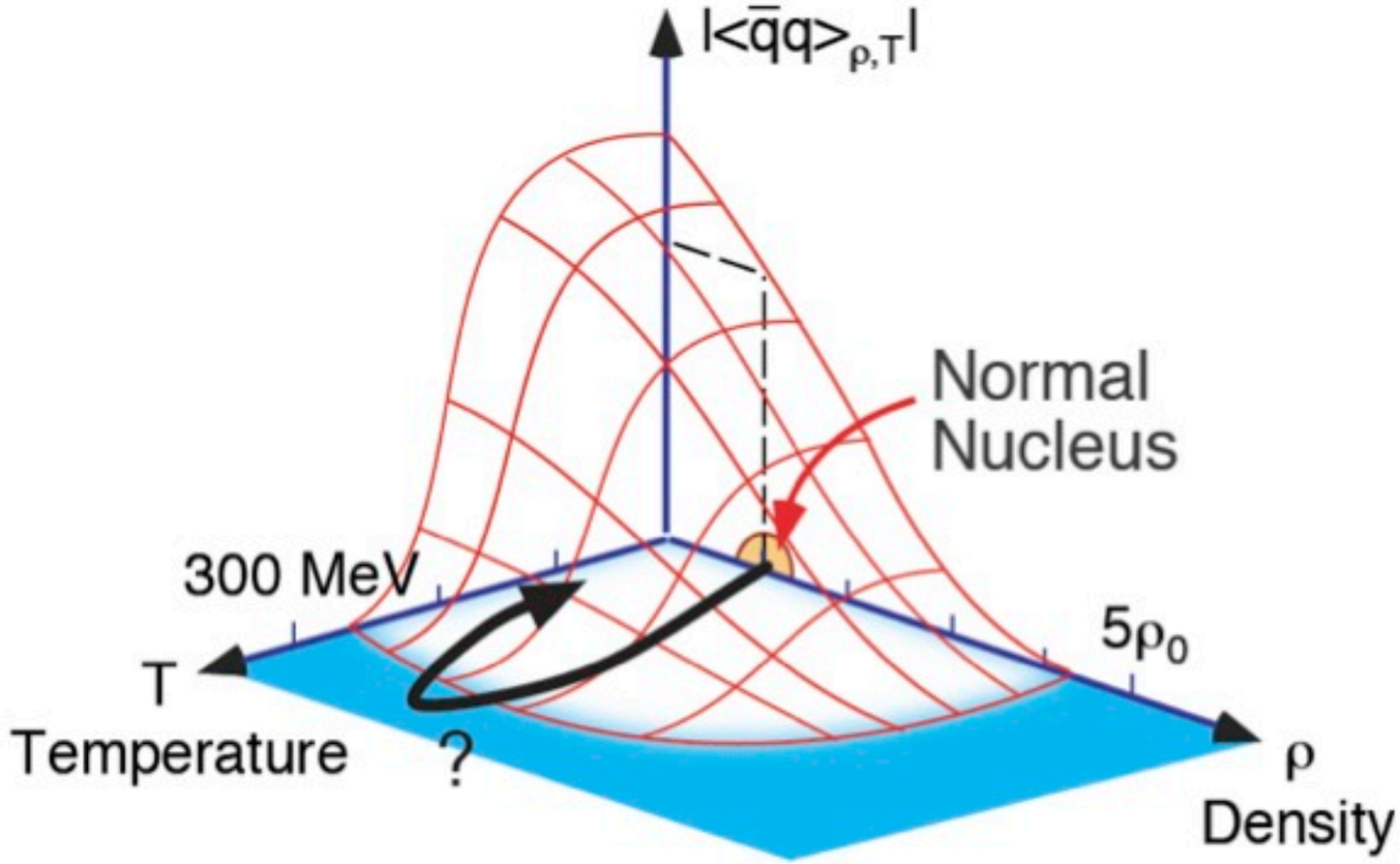
Why is the proton so heavy?

- $m_u \sim m_d \sim 5$ MeV
- $M_p \sim 1$ GeV
- Chiral condensate $\langle 0|\bar{q}q|0\rangle \neq 0$
  - Chiral symmetry breaking

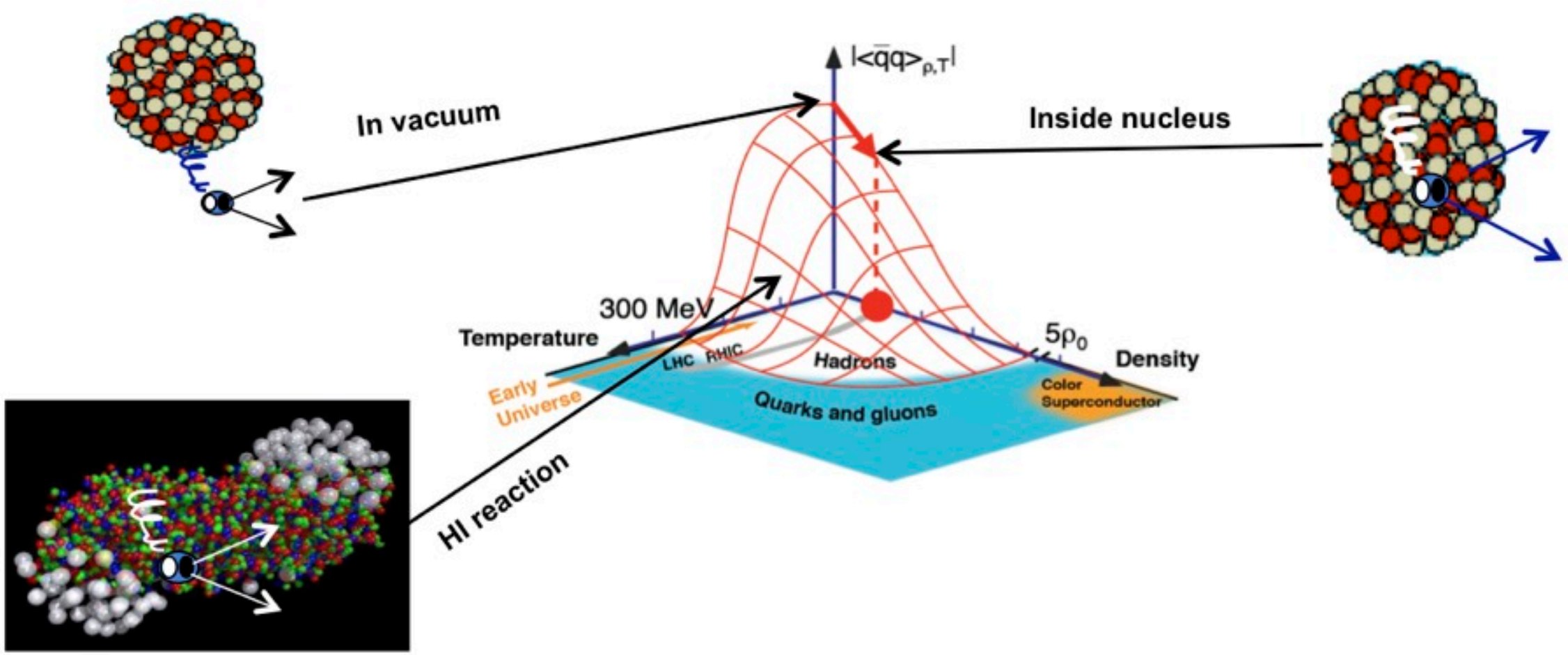
QCD Phase Diagram



Quark Condensate



Probing QCD Diagram



Indications of Chiral Symmetry Restoration

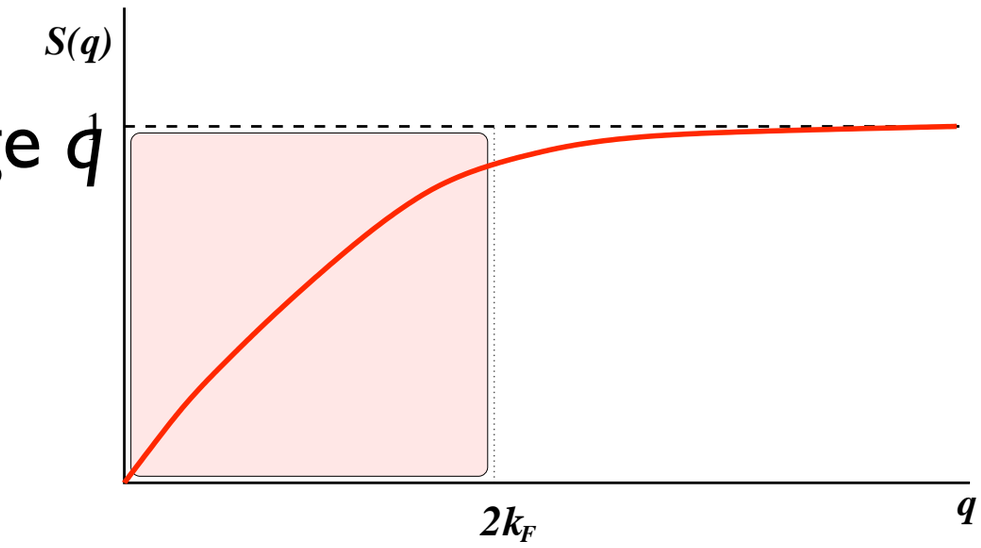
- Modifications of hadron properties inside the nucleus
- Coulomb Sum is one of these properties.

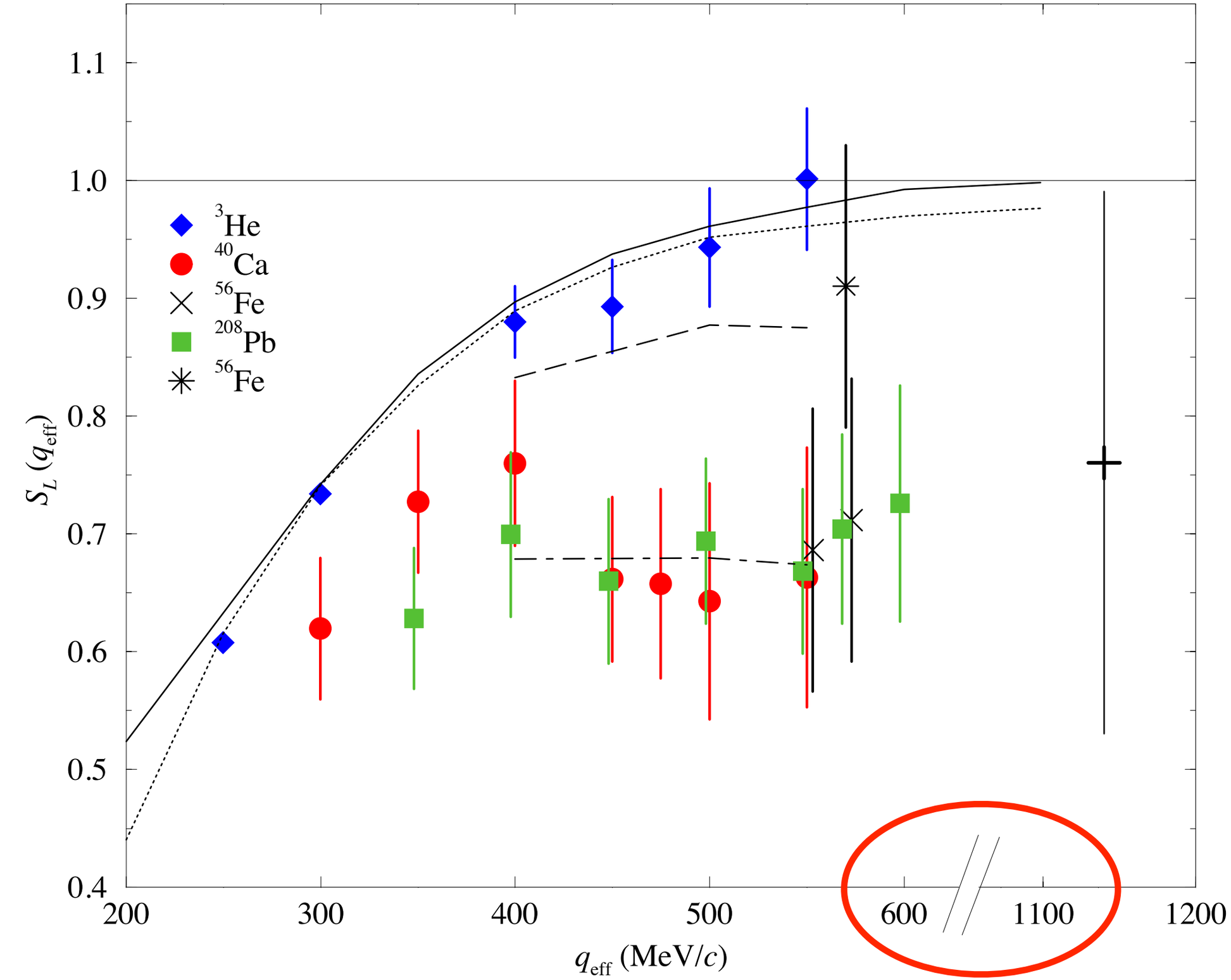
In Short

- Measurement of response functions R_L and R_T from quasi-elastic electron scattering
- Integral of R_L = Coulomb Sum (S_L)
- Study Saturation/Quenching of Coulomb Sum on various nuclei: ^{4}He, ^{12}C, ^{56}Fe, ^{208}Pb
- Probing nucleons inside the nucleus

Coulomb Sum Rule in a Nutshell

- Coulomb Sum Rule
  - $S_L(q) \rightarrow 1$ at sufficiently large q
- Deviation from unity
  - at small q
    - Pauli blocking
    - NN long range correlations
  - at large $q(>>2k_F)$
    - Short range correlations
    - Nucleon properties in the nuclear medium




1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
$S_L\,(q_{\rm eff})$
^{3}He
^{40}Ca
^{56}Fe
^{208}Pb
^{56}Fe
200
300
400
500
600
1100
1200
$q_{\rm eff}$ (MeV/c)

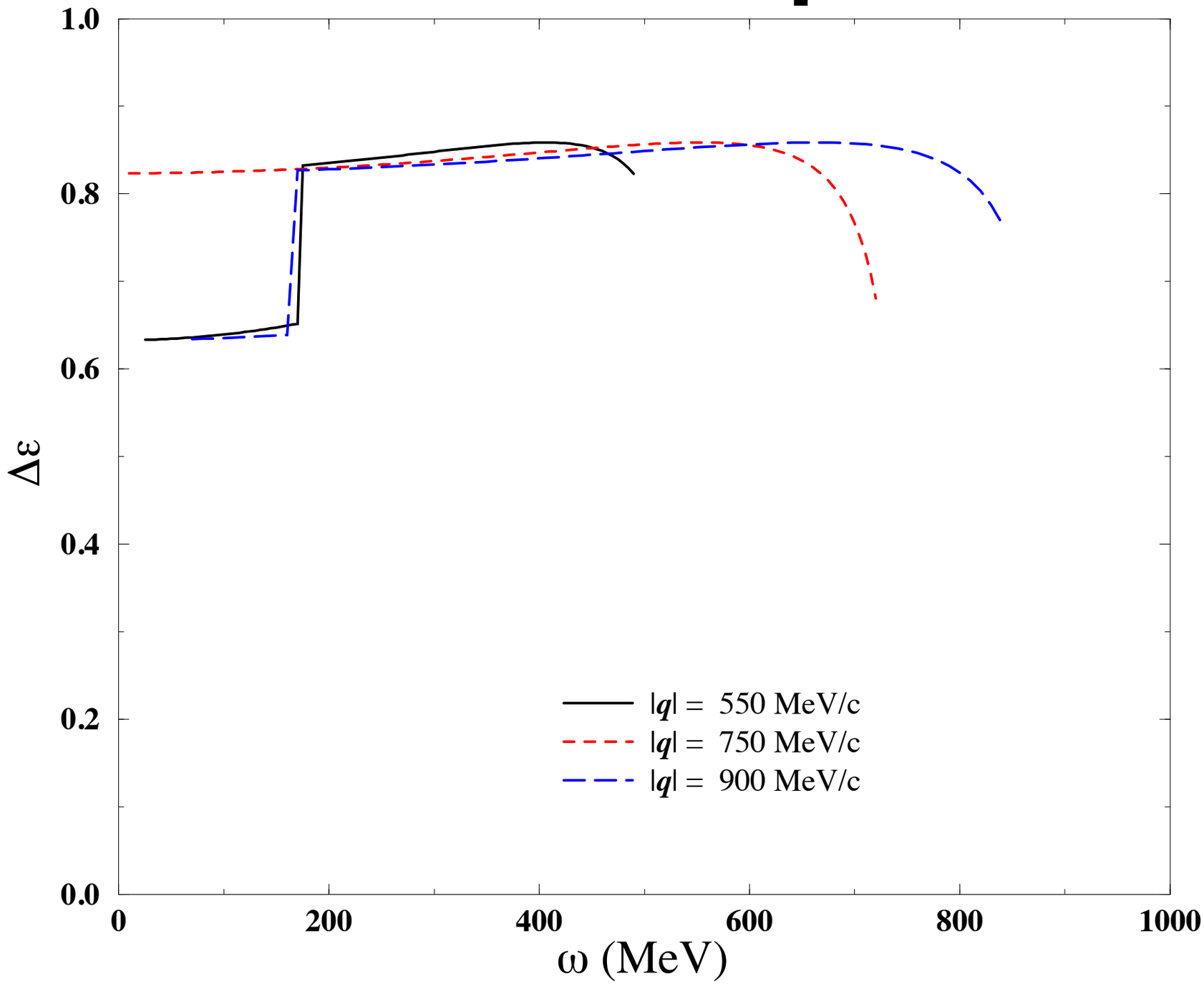
Experiment

- Beam: 16 energies from 0.4 to 4.0 GeV
- Scattering angles: 15°, 60°, 90°, 120°
- Targets: ^{4}He, ^{12}C, ^{27}Al, ^{56}Fe, ^{208}Pb
- Spectrometer momenta range from 4 GeV down to 100 MeV
- Covers q from 550 to 1000 MeV/c

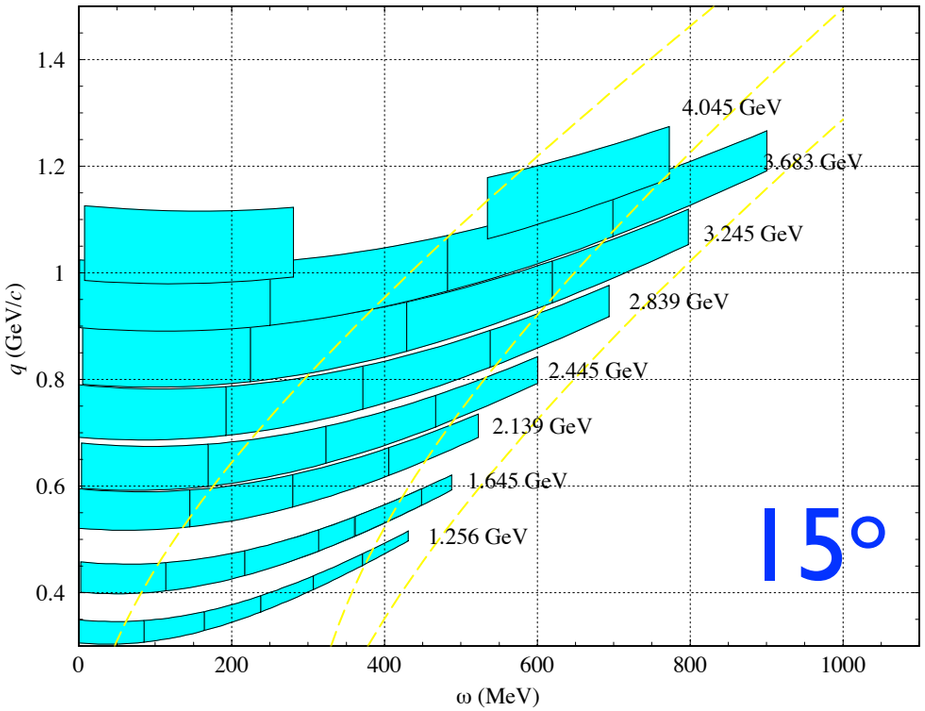
What's New?

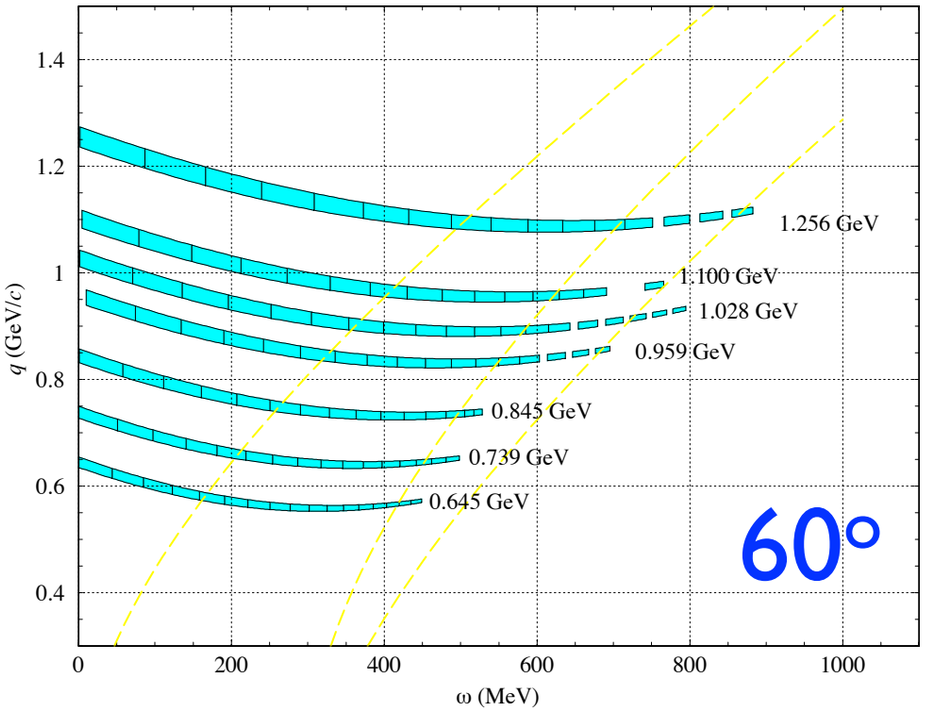
- Comfortable high values of q
  - From 550 MeV/c to 1000 MeV/c
  - High enough for clean observation of CSR
  - Previously unexplored region
- Comprehensive single experiment
  - Largest lever arm
  - Measurement at 4 angles
- Better control of background with NaI detector

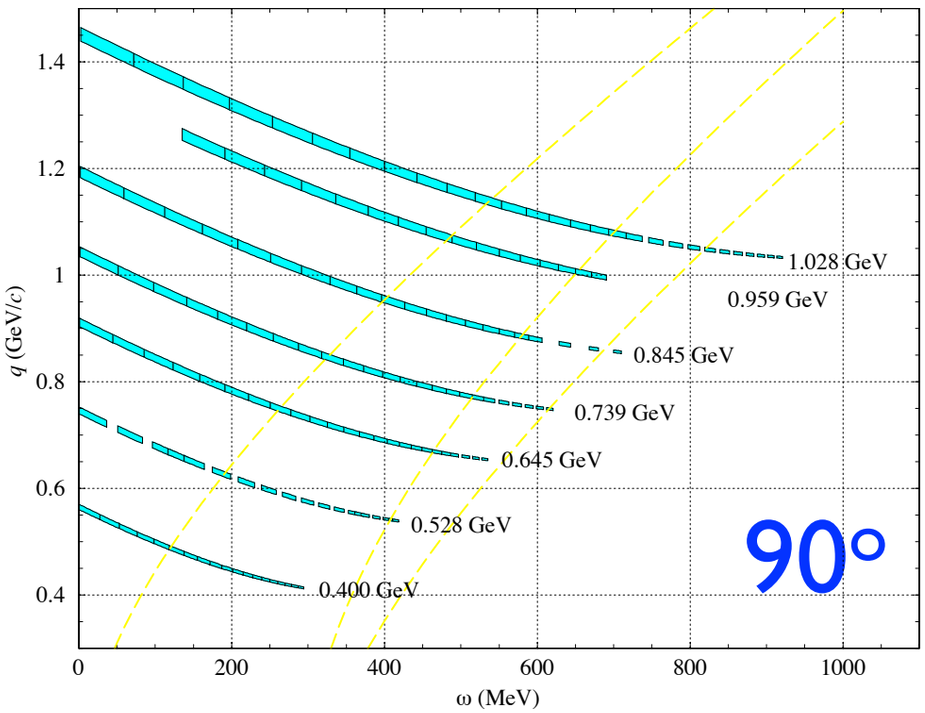
Lever arm for Rosenbluth Separation

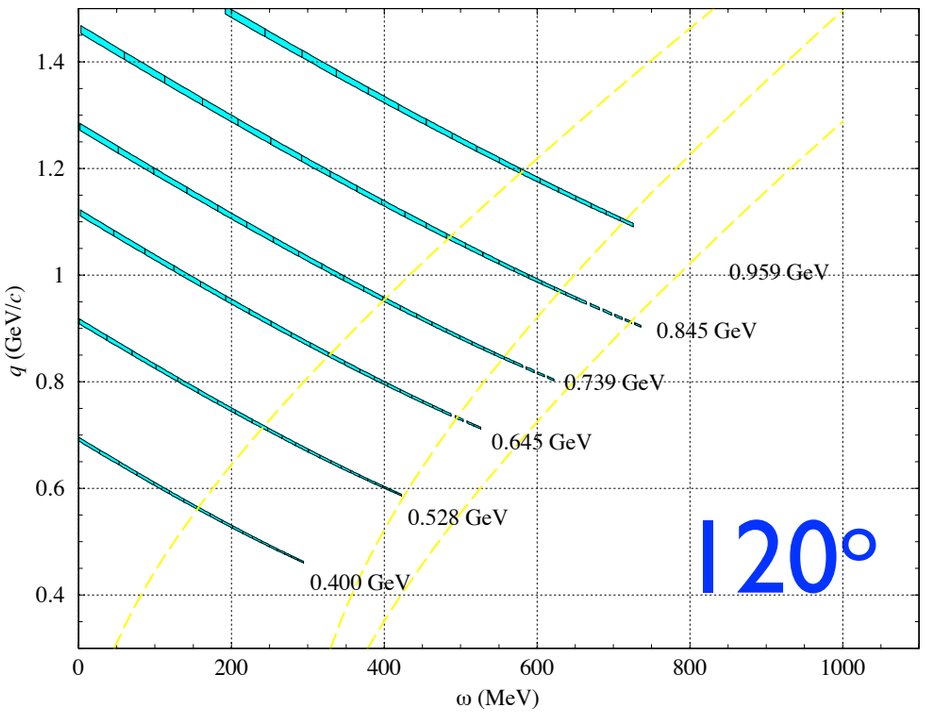


Kinematic Coverage

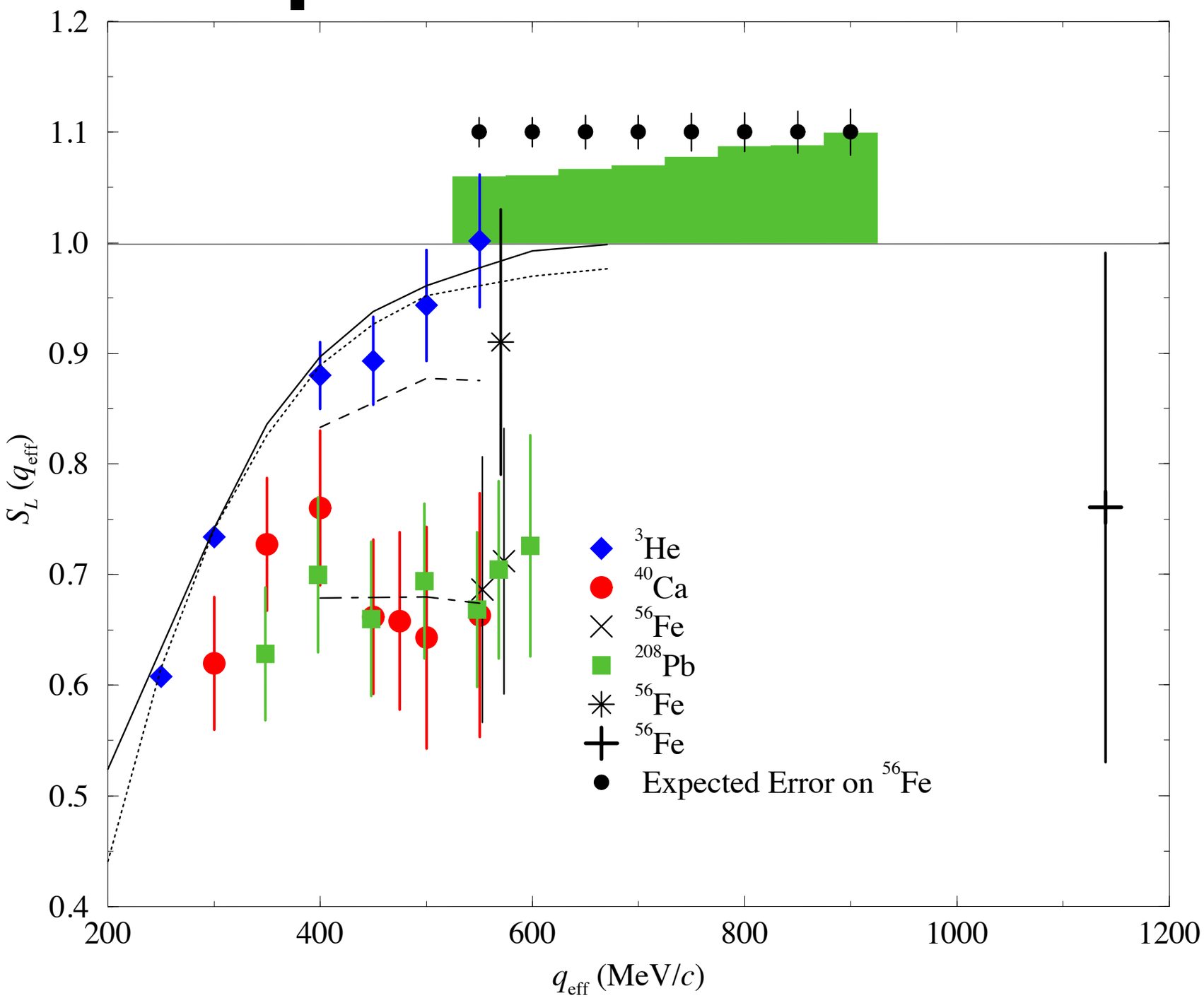








Expected Error



Summary

- One of the fundamental questions in nuclear physics
- A few new features
  - High enough momentum transfer, previously unexplored.
  - Comprehensive single experiment
  - Independent energy measurement for background reduction
- Hope to answer the question on the CSR