E12-06-101: Measurement of the Charged Pion Form Factor (F_π) to High Q^2

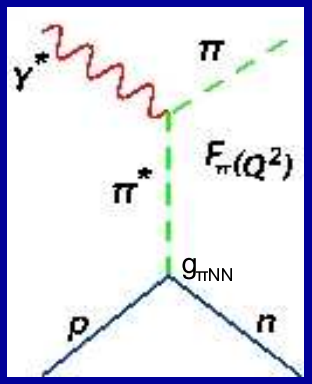
- The pion form factor is a topic of fundamental importance to our understanding of hadronic structure.
- The pion is the lightest QCD system and one of the simplest.
  - Calculated as a first test-case by all models of hadronic structure. → "The positronium atom of QCD".
- Clearest test case for study of transition between non-perturbative and perturbative regions of QCD.

F_π is experimentally challenging to determine.

- Above Q^2>0.3 GeV^2, one must employ the $p(e,e'\pi^+)n$ reaction.
- At small $-t$<0.2 GeV^2, the t-channel diagram dominates σ_L.
- In the t-pole approximation

$$\frac{d\sigma_L}{dt} \propto F_\pi^{\,2}$$

- In the actual extraction, a model incorporating the π^+ production mechanism is used to extract F_π from σ_L.



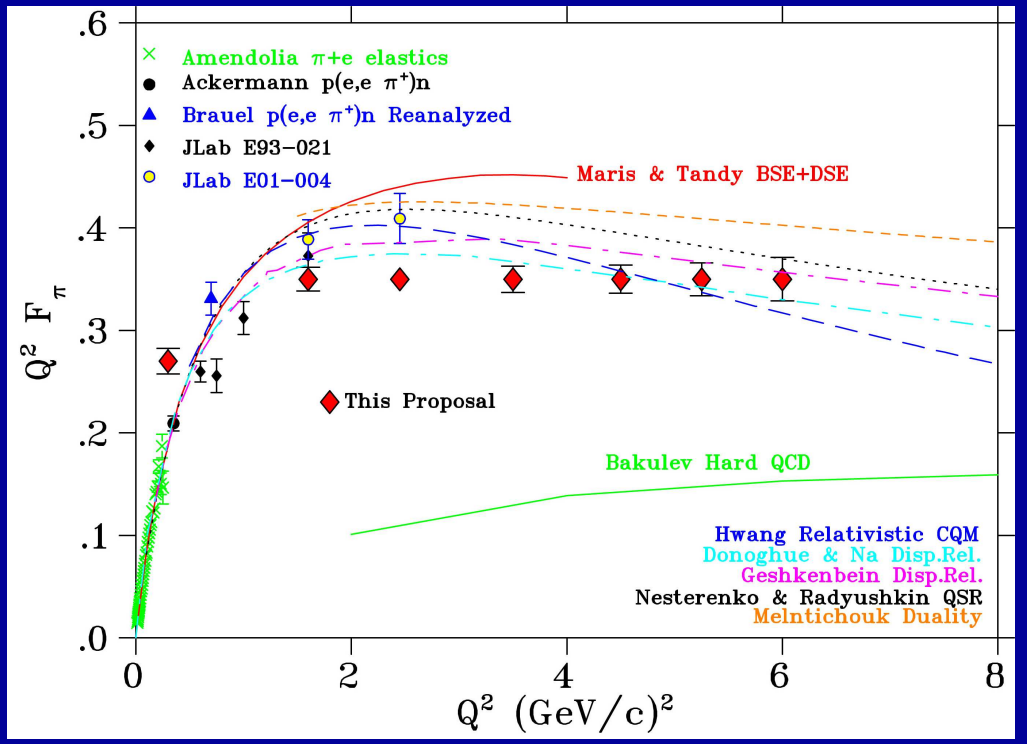
Jefferson Lab is only lab with capability for reliable F_π measurements.

Completed Hall C experiments have established validity of experimental technique and are among the top-cited works from JLab to date.

SHMS with 5.5° forward angle capability and controlled systematics essential for extending precision F_π measurements to higher Q^2.

- Statistical and uncorrelated systematic uncertainties amplified by $\Delta\varepsilon$.
- Rate estimates based on conservative extrapolation of p(e,e'π^+)n data.
- Q^2=6 GeV^2 set by 11 GeV beam & $-t_{min}$<0.2 GeV^2 requirement.

New higher Q^2 data would challenge QCD-based models in the most rigorous manner and provide a real advance in our understanding of light quark systems.



Many model-dependence tests are also proposed to better establish the reliability of the extracted F_π values

- Verify that electroproduction technique yields results consistent with π-e elastic scattering at same Q^2.
  - Q^2=0.30 GeV^2 comparison with exact values from π-*e* elastics.
  - $-t_{min}$=0.005 GeV^2 is 50% smaller than any previous electroproduction data.
- Extract form factor at several values of $-t_{min}$ for fixed Q^2.

	Q^2 (GeV^2)	W (GeV)	$-t_{min}$ (GeV^2)	F_π
Fπ-1	1.60	1.95	0.150	0.233 ±0.014 ±0.012
Fπ-2	1.60	2.22	0.095	0.243 ±0.012 ±0.013
This Proposal	**1.60**	**3.00**	**0.029**	

  - Fπ-1,2 consistent within uncertainties despite ~50% different distances to pole.
  - New test much closer to pole, 2nd test planned also at Q^2=2.45 GeV^2.
- Verify that π-pole diagram is really the dominant contribution to the reaction mechanism.
  - (e,e'π^-)/(e,e'π^+) ratios with ^{2}H target at Q^2=1.60, 3.50 GeV^2 to verify *t*-channel dominance of σ_L data.

A unique opportunity for JLab to dramatically improve the $F_\pi(Q^2)$ database.