The Q^p_{Weak} Experiment:

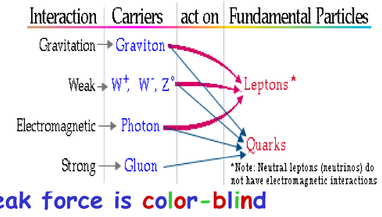
"A Search for new physics beyond the Standard Model at the TeV Scale"

The Institutions

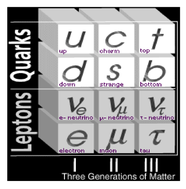
JLab, LANL, MIT, TRIUMF, William & Mary, Univ. of Manitoba, Virginia Tech, Louisiana Tech, Univ. of Connecticut, Univ. Nacional Autonoma de Mexico, Univ. of Northern British Columbia, Univ. of New Hampshire, Ohio Univ., Mississippi State, Hampton Univ., Yerevan Physics Institute

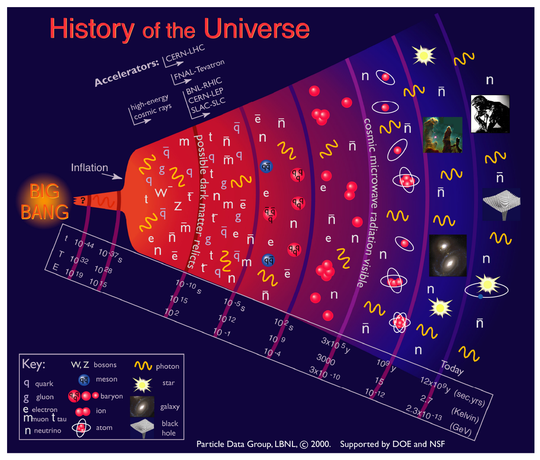
The Standard Model

- **Three generations of Fermions**
  - quark favors differ in masses and in electro-weak charges
- **Four fundamental interactions**



- **Electro-weak force is color-blind**
  - (e,e') measures quark flavor charges





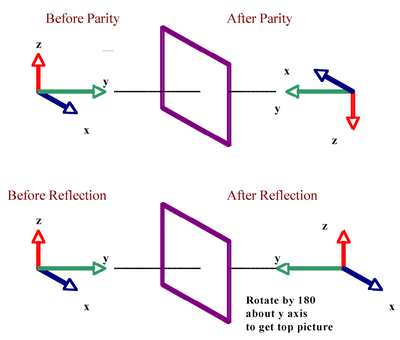
The Standard Model

The Standard Model is the name given to the current theory of fundamental particles and how they interact. This theory includes:

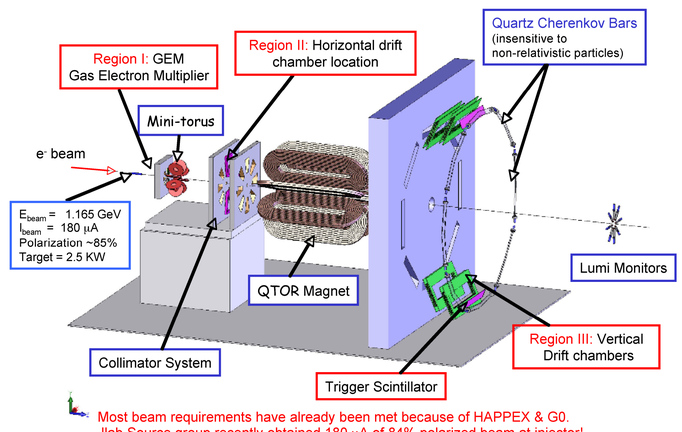
- Strong interactions due to the color charges of quarks and gluons.
- A combined theory of weak and electromagnetic interaction, known as electroweak theory, that introduces W and Z bosons as the carrier particles of weak processes, and photons as mediators to electromagnetic interactions.
- The theory does not include the effects of gravitational interactions. These effects are tiny under high-energy Physics situations, and can be neglected in describing the experiments. Eventually, we need a theory that also includes a correct quantum version of gravitational interactions, but this is not yet achieved.
- The Standard Model was the triumph of particle physics of the 1970's . It incorporated all that was known at that time and has since then successfully predicted the outcome of a large variety of experiments.

Parity

- Mathematics --Let x→ -x, y→ -y, and z→ -z or mirror reflection and rotation



The Q^p_{Weak} Apparatus



Most beam requirements have already been met because of HAPPEX & G0.
Jlab Source group recently obtained 180 μA of 84% polarized beam at injector!

Asymmetry Measurements with 1 - 4 GeV/c Electrons

"What you measure/observe at different levels of precision - range shown is also related to Q^2 of measurement"

- ~10^{-3} to 10^{-4} Basic form factors (G_{En}, G_{Ep}, …).
- ~10^{-5} to 10^{-6} Asymmetry scale - Standard Model.
- ~10^{-6} to 10^{-7} Observe/Measure the strange Quark currents of the proton.
- ~10^{-8} to 10^{-9} Precision tests of Standard Model new physics at the 1-10 TeV scale?

The Basic Idea

- 1st measurement of $Q^p_{Weak} = 1 - 4\sin^2\theta_W$
  - 1st SM test at JLab
- SM makes firm prediction for Q^p_{Weak}
  - based on running of $\sin^2\theta_W$ from Z^0 pole
    - a 10 σ effect in the Qweak experiment.
  - deviation from SM prediction → new physics
    - even sensitive to *which* SM extension
    - agreement would constrain SM extensions
  - precise measurement possible
    - hadronic corrections small, & *measured*

Anticipated Q^p_{Weak} Uncertainties

	$\Delta A_{phys} / A_{phys}$	$\Delta Q^p_{weak} / Q^p_{weak}$
Statistical (2200 hours production)	1.8%	2.9%
Systematic:		
Hadronic structure uncertainties	--	1.9%
Beam polarimetry	1.0%	1.6%
Absolute Q^2 determination	0.5%	1.1%
Backgrounds	0.5%	0.8%
Helicity-correlated Beam Properties	0.5%	0.8%
Total	**2.2%**	**4.1%**

An additional uncertainty associated with QCD corrections applied to the extraction of $\sin^2\theta_W$: it raises $\Delta\sin^2\theta_W / \sin^2\theta_W$ from 0.2% to 0.3%.

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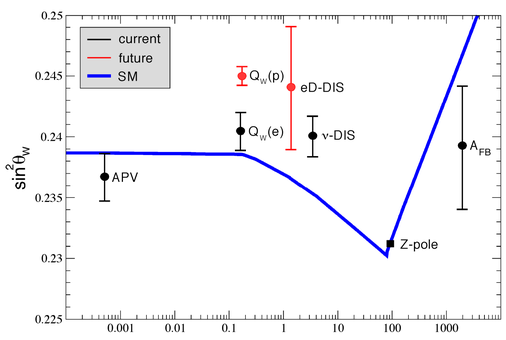

Qweak will provide a stand alone constraint on SM extensions an stronger when combined with other low Q^2 experiments.