Search for and Identification of Graviton Exchange Effects at High Energy Colliders

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There are many very different NP scenarios that predict new particle exchanges which can lead to CI below direct production threshold.

A partial list of know candidates:

- compositeness
- Z'
- scalar or vector leptoquarks
- R-parity violating sneutrino ($\tilde{\nu}$) exchange
- graviton KK towers in extra dimensional models
- gauge boson KK towers, etc.

Center-edge $A_{\mathrm{CE,FB}}$ and center-edge forward-backward $A_{\mathrm{CE,FB}}$ asymmetries at e^+e^- LC

$$A_{\mathrm{CE}} = \frac{\sigma_{\mathrm{CE}}}{\sigma},$$

where

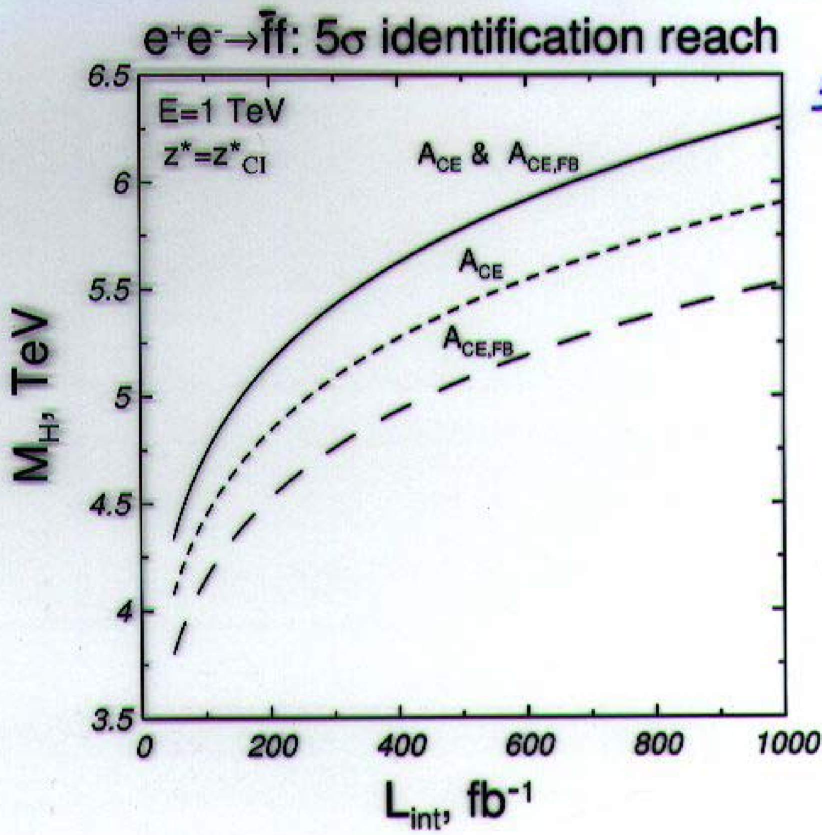
$$\sigma_{\mathrm{CE}} \equiv \sigma_{\mathrm{C}} - \sigma_{\mathrm{E}} = \left[\int_{-z^*}^{z^*} - \left(\int_{-1}^{-z^*} + \int_{z^*}^{1}\right)\right] \frac{d\sigma}{dz} dz.$$

$$A_{\mathrm{CE,FB}} = \frac{\sigma_{\mathrm{CE,FB}}}{\sigma},$$

where

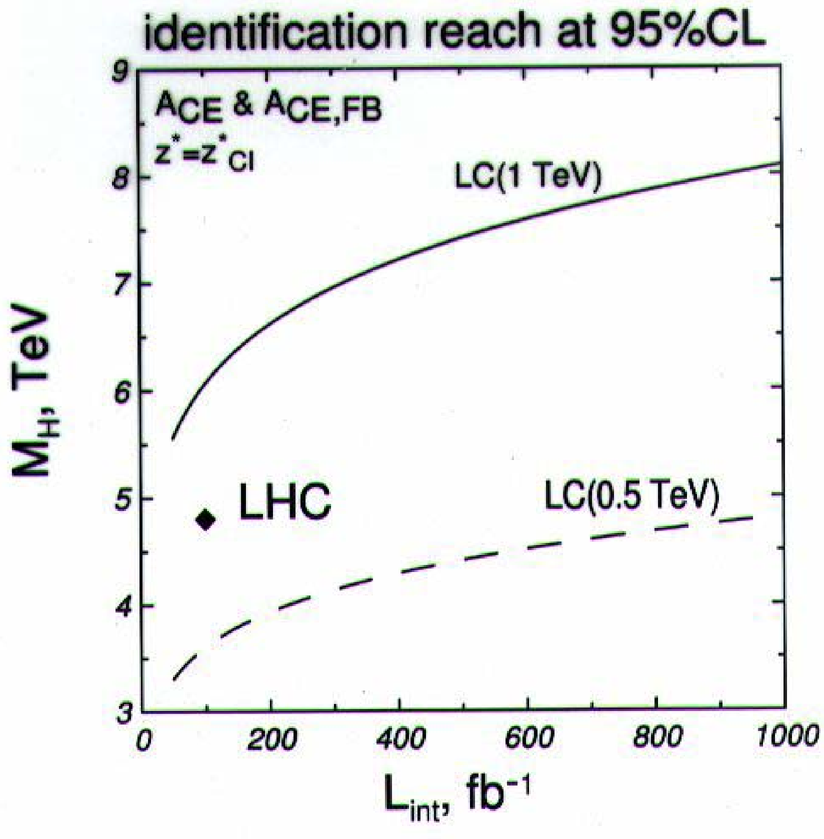
$$\sigma_{\mathrm{C,FB}} = \sigma_{\mathrm{C,F}} - \sigma_{\mathrm{C,B}} = \left[\int_{0}^{z^*} - \int_{-z^*}^{0}\right] \frac{d\sigma}{dz} dz,$$

$$\sigma_{\mathrm{E,FB}} = \sigma_{\mathrm{E,F}} - \sigma_{\mathrm{E,B}} = \left[\int_{z^*}^{1} - \int_{-1}^{-z^*}\right] \frac{d\sigma}{dz} dz.$$



e+e-→f̄f: 5σ identification reach
E=1 TeV
z*=z*CI
ACE & ACE,FB
ACE
ACE,FB
MH, TeV
Lint, fb-1

f=μ, τ, b, c



identification reach at 95%CL
ACE & ACE,FB
z*=z*CI
LC(1 TeV)
LHC
LC(0.5 TeV)
MH, TeV
Lint, fb-1

Contact interaction searches at e^+e^- and e^-e^- linear colliders: role of polarization.

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with A. Pankov

12 October 2004, SPIN 2004, Trieste, ITALY

Introduction: processes

Bhabha $$e^+e^- \to e^+e^- \quad (1)$$

Moller $$e^-e^- \to e^-e^- \quad (2)$$

Muon pair production $$e^+e^- \to \mu^+\mu^- \quad (3)$$

The Lagrangian of Contact Interactions (CI)

$$L_{CI} = \frac{\eta_{ij}}{1+\delta_{ef}} \sum g^2_{eff}\, \varepsilon_{ij} (\bar{e}_i \gamma_\mu e_i)(\bar{f}_j \gamma^\mu f_j)$$

$\delta_{ef} = 1$ for processes (1) and (2); $\delta_{ef} = 0$ for (3).

$$g^2_{eff} = 4\pi; \quad \varepsilon_{ij} = \frac{\eta_{ij}}{\Lambda^2_{ij}}; \quad \eta_{ij} = \pm 1.$$

◆ **A. Pankov, N. Paver,** Eur. Phys. J. C 29, 313-323 (2003)

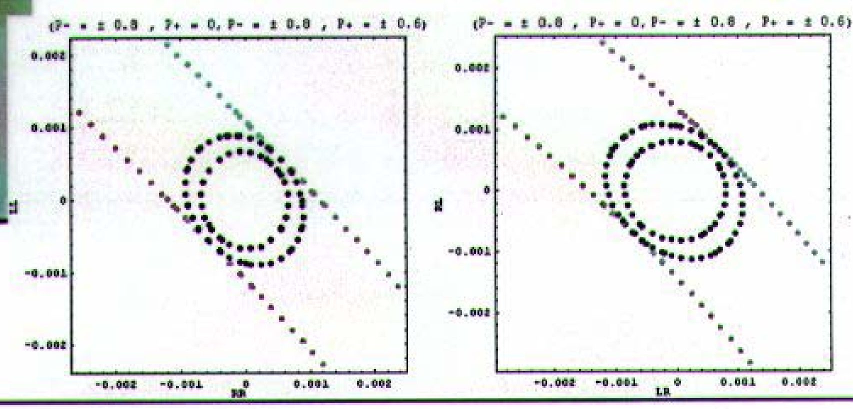
Role of polarization $e^+e^- \to \mu^+\mu^-$

500 GeV, 50 fb^{-1};

$|P^-| = 0.8$, $|P^+| = 0.6$;

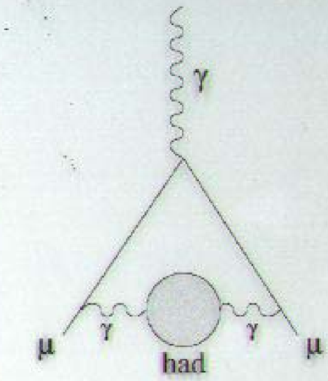
$|P^-| = 0$, $|P^+| = 0$;

$|P^-| = 0.8$, $|P^+| = 0$;



A. Dorokhov

LO Hadronic contribution to $g_\mu - 2$



The calculations are based on the ***spectral representation***

$$a_\mu^{(2)\mathrm{hvp}} = \frac{8}{3}\alpha^2 \int_{4m_\pi^2}^{\infty} dt \frac{K(t)}{t}\frac{1}{\pi}\,\mathrm{Im}\,\Pi(t), \quad K(t) = \int_0^1 dx \frac{x^2 m_\mu^2}{x^2 m_\mu^2/(1-x)+t}$$

which is rewritten via Adler fucntion as

$$a_\mu^{(2)\mathrm{hvp}} = \frac{8}{3}\alpha^2 \int_0^1 dx \frac{(1-x)(1-x/2)}{x} D\left(\frac{x^2}{1-x} m_\mu^2\right)$$

Phenomenological estimates give

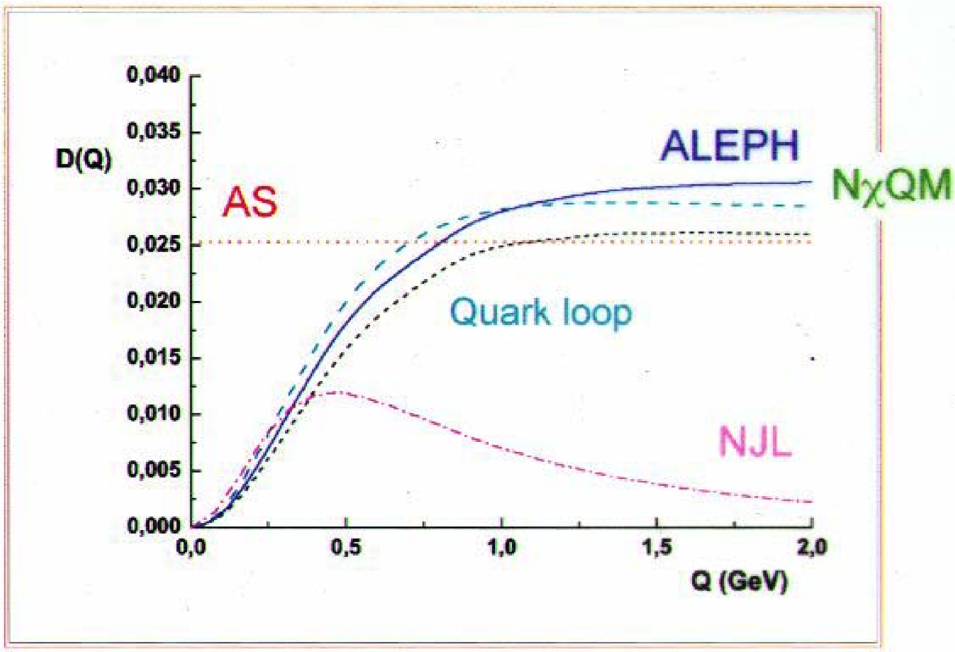
$$a_\mu^{(2)\mathrm{hvp}} = \begin{cases} (6{,}849 \pm 0.077)\cdot 10^{-8}, & e^+e^-, e\pi \\ (6{,}932 \pm 0.076)\cdot 10^{-8}, & e^+e^-, e\pi, \tau \end{cases}$$

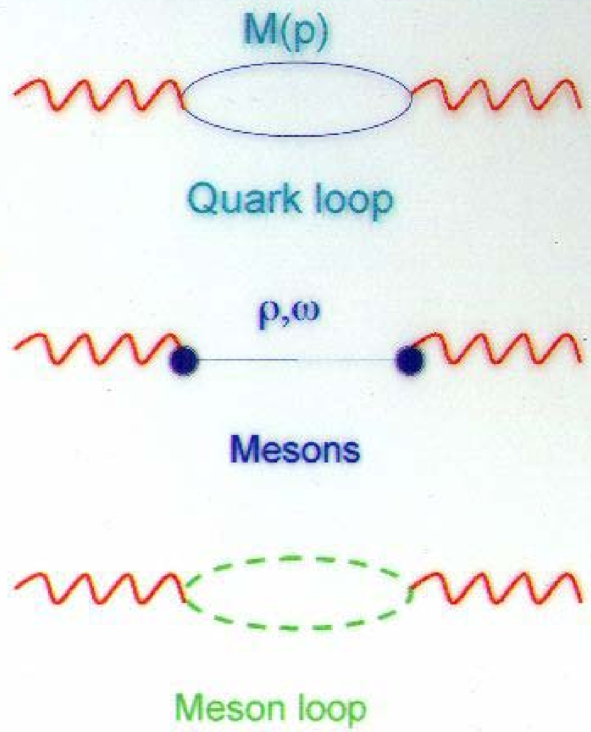
and from NχQM one gets

$$a_{\mu,\mathrm{N}\chi\mathrm{QM}}^{(2)\mathrm{hvp}} = (6{,}23 \pm 0.5)\cdot 10^{-8},$$

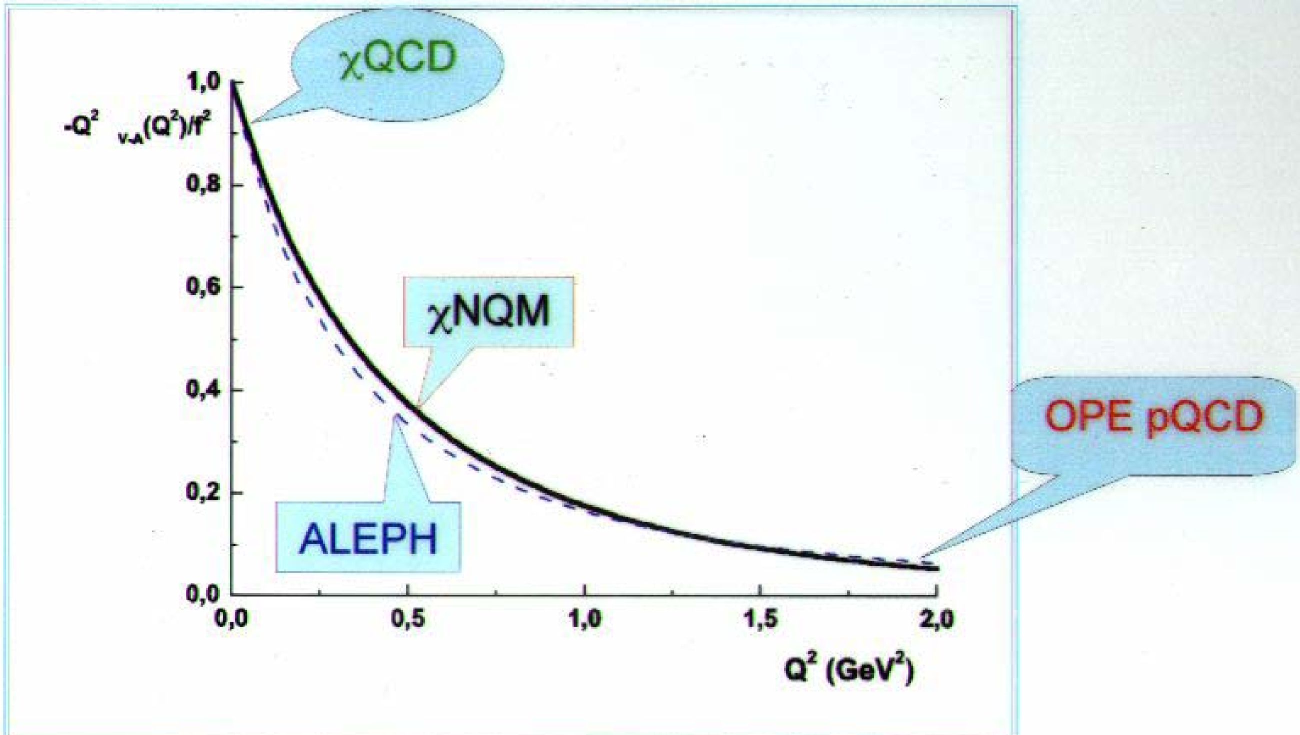
$$a_{\mu,\mathrm{Qloop}}^{(2)\mathrm{hvp}} = 5.33\cdot 10^{-8}, \quad a_{\mu,\rho\omega\text{-mesons}}^{(2)\mathrm{hvp}} = 0.13\cdot 10^{-8}, \quad a_{\mu,\mathrm{Mloop}}^{(2)\mathrm{hvp}} = 0.77\cdot 10^{-8},$$

NχQM Adler function and ALEPH data





V-A: χNQM vs ALEPH



N. Mankoc-Borstnik

of breaking the group $SO(1,13)$, like

$$\mathrm{SO}(1,13)$$

$$\downarrow$$

$$\mathrm{SO}(1,7) \otimes \mathrm{SO}(6)$$

$$\swarrow \qquad\qquad \searrow$$

$$\mathrm{SO}(1,7) \qquad\qquad\qquad \mathrm{SU}(4)$$

$$\swarrow \qquad\qquad\qquad\qquad \downarrow$$

$$\mathrm{SO}(1,3) \otimes \mathrm{SO}(4) \qquad\qquad \mathrm{SU}(3) \otimes \mathrm{U}(1)$$

$$\downarrow \qquad\qquad\qquad\qquad \downarrow$$

$$\mathrm{SO}(1,3) \otimes \mathrm{SU}(2) \otimes \mathrm{U}(1) \qquad\qquad \mathrm{SU}(3) \otimes \mathrm{U}(1)$$

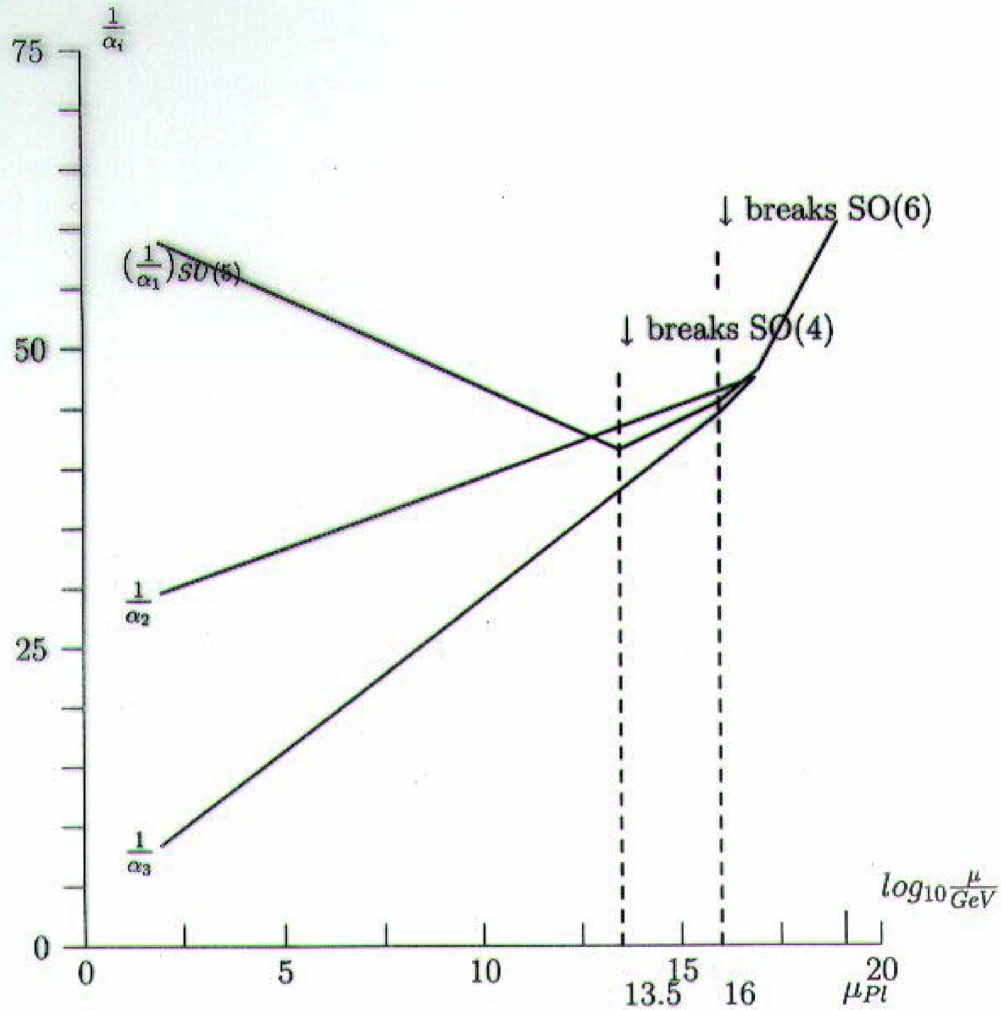
$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}$$

$$\mathrm{SO}(1,3) \otimes \mathrm{SU}(2) \otimes \mathrm{U}(1) \otimes \mathrm{SU}(3) \otimes \mathrm{U}(1)$$

$$\downarrow$$

$$\mathrm{SO}(1,3) \otimes \mathrm{SU}(2) \otimes \mathrm{U}(1) \otimes \mathrm{SU}(3)$$

leading to the known spins, charges and flavors of the leptons and the quarks and the anti-leptons and the anti-quarks, guaranteeing unification of the coupling constants (including the appearance of the p decay at the large enough scale)



We found the running coupling constants, extrapolated from the experimental values by the assumption that the gauge group $SO(4)$ breaks at much lower scale (at around 10^{13} GeV) than the gauge group $SO(6)$ (which breaks at around 10^{17} GeV).

The $SU(2)$ gauge group coupling constant does not change when running together with $(\alpha_{U(1),SO(4)})^{-1}$. The three α's meet and then run together as $SO(1,13)$ (rather SO(10)).

$$\psi^+ \gamma^0 \gamma^h \tilde{S}^{h'h''} \tilde{\omega}_{h'h''\sigma} f^\sigma_h \psi.$$

Both types of terms manifest accordingly as mass terms of quarks and leptons. It is the interactions in higher dimensions which look like a Higgs causing the Yukawa couplings in a four-dimensional part of space.

d) The mass matrices, suggested by the approach, predict **four families of quarks and leptons** and the corresponding "CKM" matrix.

Predictions Preliminary

$m_{u_4} := 199GeV - 222GeV$

The mixing matrix $S_d^+ S_u$ is within the values

M. Rivas

Definition: An **elementary particle** is a mechanical system without excited states. All its kinematical states are kinematical modifications of any one of them.

This implies that if the state of the particle changes it is always possible to find a new inertial observer who describes the elementary particle in the same kinematical state as before.

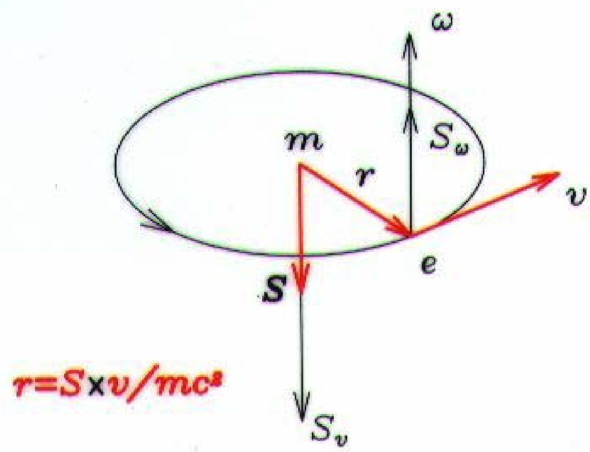
Let us denote by x the set of kinematical variables which are used to describe the kinematical state of the system in a Lagrangian description.

When the particle changes its state x into $x + dx$ at the next instant, this implies that the new values of the kinematical variables $x + dx$ will be obtained from the preceeding ones x by an infinitesimal transformation δg of the kinematical group G of space-time symmetries.

Corollary: The manifold spanned by the kinematical variables is necessarily a **homogeneous space** of the kinematical group G.

The evolution of an elementary particle is thus reduced to the analysis of the updated consecutive inertial observers who describe the particle in the same state.

The total spin $\boldsymbol{S} = \boldsymbol{S}_v + \boldsymbol{S}_\omega = \boldsymbol{v} \times \boldsymbol{V} + \boldsymbol{W}$, has the same direction as the antiorbital part so that the $\boldsymbol{S}_v$ part has to be larger than the other $\boldsymbol{S}_\omega$. When quantizing the system the antiorbital part only quantizes with integer values while the half integer comes from the quantization of the rotational part $\boldsymbol{S}_\omega$, in the opposite direction. This twofold structure of the spin leads to the classical concept of gyromagnetic ratio.



In the center of mass frame it is a system of three degrees of freedom. The coordinates x and y of the point $\boldsymbol{r}$ and the phase α of the rotation of the body frame. This phase is the same as the phase of the orbital motion. The motion is at a constant velocity c, then the system is reduced to a single degree of freedom system. It is a one-dimensional harmonic oscillator of frequency $\omega = mc^2/S$, without excited states.

The ground state energy of this system when quantized,

$$\hbar\omega/2 = mc^2, \quad \omega = mc^2/S, \quad \Rightarrow \quad S = \hbar/2.$$

The negative energy particle corresponds to the time reversed motion with the same spin $\boldsymbol{S}$.

A. Burinskii

MAIN PROPERTIES

- **Gyromagnetic ratio $g = 2$,**
- **Stringy system,**
- **Compton size of the circular Kerr string,**
- **De Broglie modulation of the axial strings, the Dirac equation, stringy carrier of wave function,**
- **A complex twistor-string and relation to the Spinor Helicity Formalism.**

"positive" one. It determines the vector potential of the Kerr-Newman solution

$$A^{\mu} = \frac{er}{r^2 + a^2 \cos^2 \theta} k^{\mu}, \qquad (3)$$

as well as the flow of radiation from the radiative Kerr source

$$T^{\mu\nu}_{rad} \sim \Phi(r, \theta) k^{\mu} k^{\nu}. \qquad (4)$$

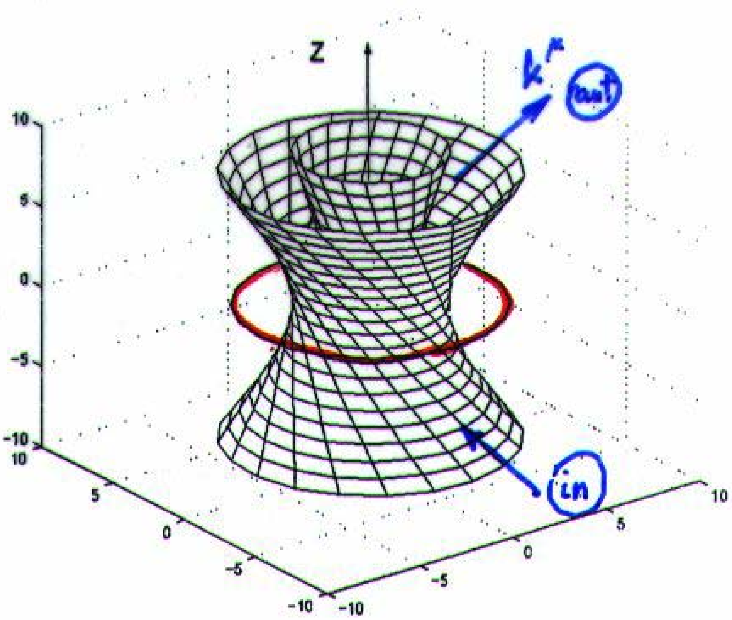
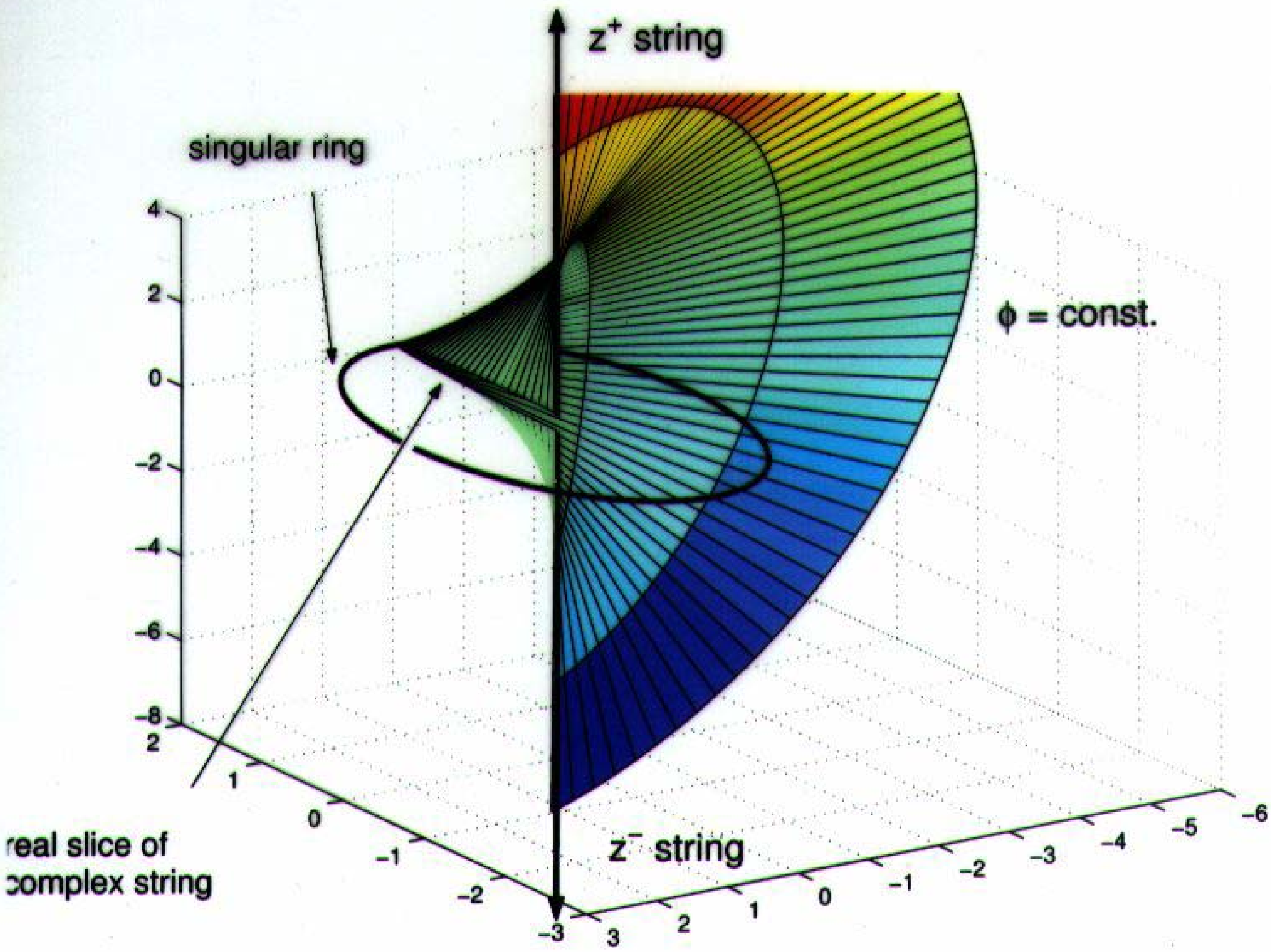


Figure 2: The Kerr singular ring and the Kerr PNC.

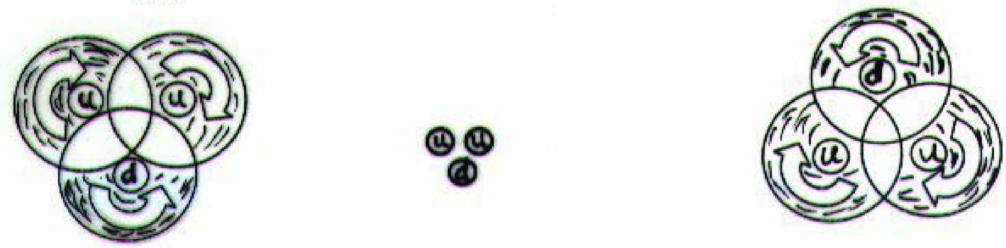


z+ string
singular ring
φ = const.
real slice of
complex string
z− string
4
2
0
−2
−4
−6
−8
2
1
0
−1
−2
−3
3
2
1
0
−1
−2
−3
−4
−5
−6

Quarks – Oscillating Vortices

G.Musulmanbekov

$t = 0$	$t = T/4$	$t = T/2$
$x = x_{max}$	$x = 0$	$x = x_{max}$



Consituent Quarks	Current Quarks **Asymptotic Freedom**	Consituent Quarks

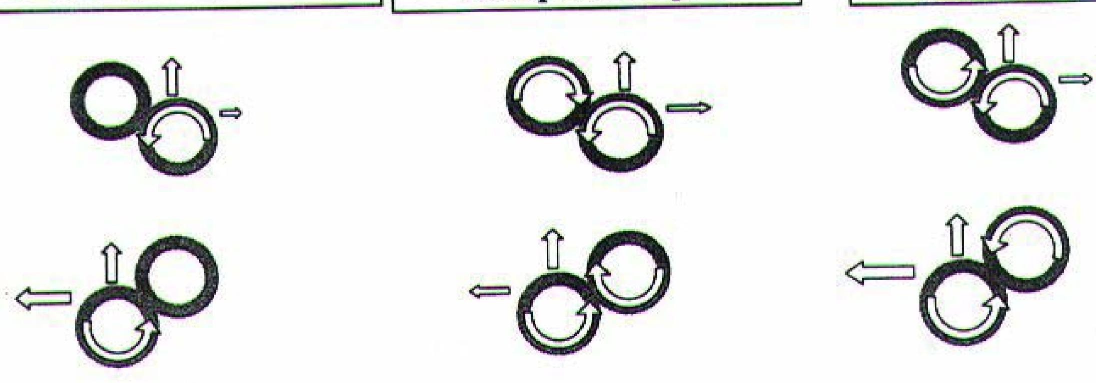
Classical quark spin

$$\mathbf{s_Q} = \mathbf{L_g} = (\ldots)\int_a^\infty d^3r\left[\mathbf{r}\times(\mathbf{E_{ch}}\times\mathbf{B_{ch}})\right]$$

1. Proton spin is defined by the spins of valence quarks.
2. The spin of the valence quark is defined by the orbital momentum of circulating around it gluon field (hadronic current).
3. Sea quarks are not polarized.

Quark – quark scattering in collisions of polarized protons

Single Spin Asymmetry	**Quarks with Anti-parallel Spins**	**Quarks with Parallel Spins**



NEW QCD RELATIONS BETWEEN MAGNETIC MOMENTS OF Σ AND Λ HYPERONS

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(INFN, Sezione di Bari, Bari, Italy)
S.B.Yakovlev
(Physics Department of the Moscow State University, Moscow)
V.S.Zamiralov
(Skobeltsyn Institute of Nuclear Physics, Moscow)

1. Nonlinear relations between magnetic moments Σ^0 and Λ in NRQM.

2. Nonlinear intercrosssed relations between Σ^0 and Λ polarization operators.

3. Intercrosssed relations between $\mu(\Sigma^0)$ и $\mu(\Lambda)$.

D. Carlini

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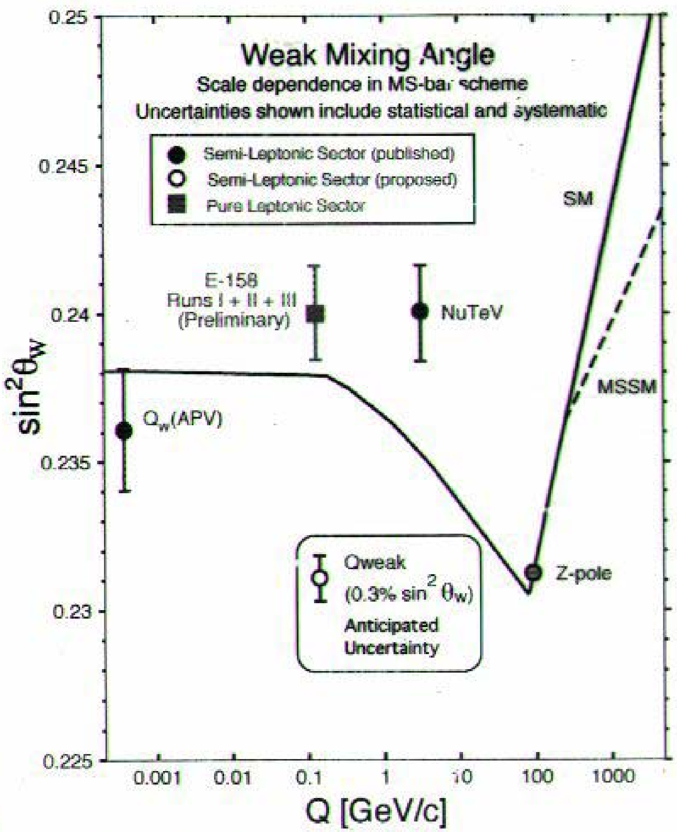
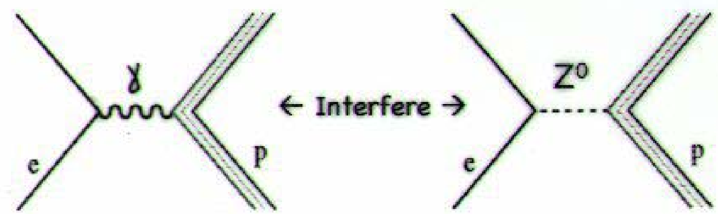
The Q^p_{Weak} Experiment

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



- Extracted values of $\sin^2\theta_W$ must agree with Standard Model or new physics is indicated.

$$Q^p_{weak} = 1 - 4\sin^2\theta_W \sim 0.072$$



- A 4% Q^p_{Weak} measurement probes for new physics at energy scales to:

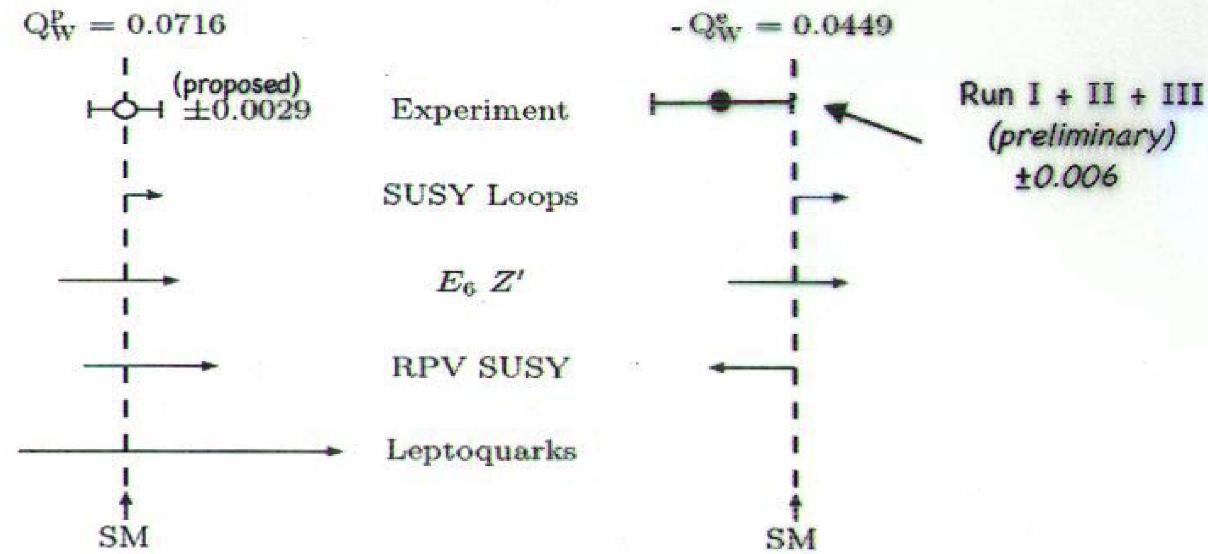
$$\frac{\Lambda}{g} \sim \frac{1}{\sqrt{\sqrt{2}G_F\left|\Delta Q^p_W\right|}} \approx 4.6\ \text{TeV}$$

Qweak will provide a stringent stand alone constraint on Lepto-quark based SM extensions.

With APV and SLAC E158 results Qweak will constrain SM extensions based on extra Z's.

R. D. Carlini 9/16/04

JLab Qweak   SLAC E158



- Q^p_{weak} (semi-leptonic) and E158 (pure leptonic) together make a powerful program to search for and identify new physics.
- Qweak measurement will provide a stringent stand alone constraint on Lepto-quark based extensions to the SM.

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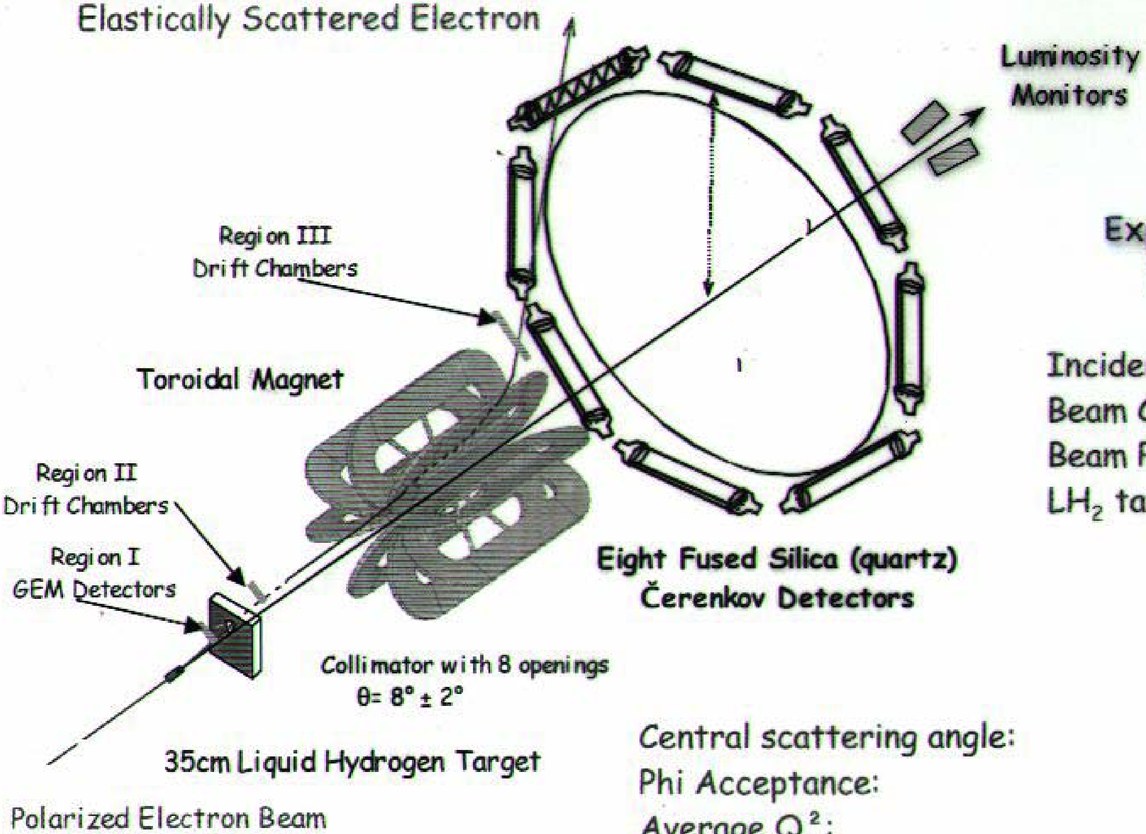
Illustration of the Q^p_{Weak} Experiment



Experiment Parameters (integration mode)

Incident beam energy:	1.165 GeV
Beam Current:	180 μA
Beam Polarization:	~80%
LH_2 target power:	2.5 KW

Central scattering angle:	8° ± 2
Phi Acceptance:	>50% of 2π
Average Q^2:	0.028 GeV^2
Acceptance averaged asymmetry:	-0.28 ppm
Integrated Rate (all sectors):	~6 GHz
Integrated Rate (per detector):	~750 MHz

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