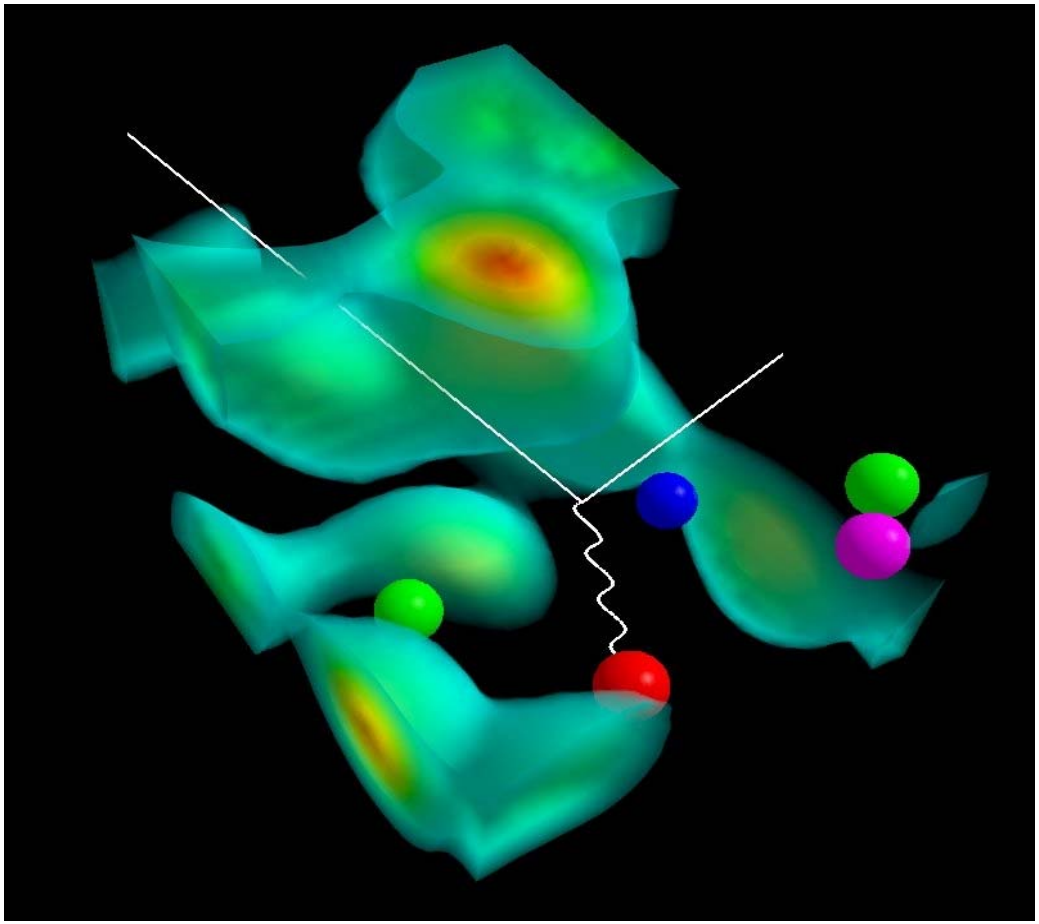
All Managers Meeting : Feb 15th 2007



A. W. Thomas

Experimental Program Highlights

- **Hall A:**
  - **Installation and maintenance work continues.**
  - **Elastic electron scattering tests on Li and B began Feb 8.**
  - **Next regularly scheduled experiment is a study of correlations and relativistic effects in the nuclear medium using a Pb target.**

- **Hall B:**
  - **Being readied for the installation of the FROST target.**
  - **International workshop to discuss CLAS12 hosted Feb. 2-3:**
    - **Proposed upgrade of CEBAF CLAS detector hardware and software developments and to devise future activities in preparation for upcoming reviews in March/April and the CD-2 review in summer of 2007.**
    - **Over 70 participants from 32 institutions**

Experimental Program Highlights (Cont'd.)

Hall C:

- Prep work with HMS installation for 2007 experiments
- The G0 backward angle run in Hall C continued accumulating statistics with a 35 microamp, 362 MeV beam on the liquid deuterium target.
- Hall C Collaboration meeting held Jan. 25-26
- QWeak Collaboration held Feb. 1-2

PAC 31:

- Held week of January 29 -- 6GeV PAC with 15 proposals and 2 letters of intent reviewed.

Accelerator:

- Successful delivery of half-pass 362 MeV beam to Hall C for the G0 experiment
- Maintenance and beam studies took place this month

Theory Center

- **Excited Baryon Analysis Center alive and well.**

  Led by Harry Lee from ANL Theory

  Collaboration with Bonn, Juelich, many other institutions (including traditional partners at MSU etc.

  AIM to provide comprehensive analysis of JLab (and world data)
  - to extract masses and properties of excited states of the nucleon

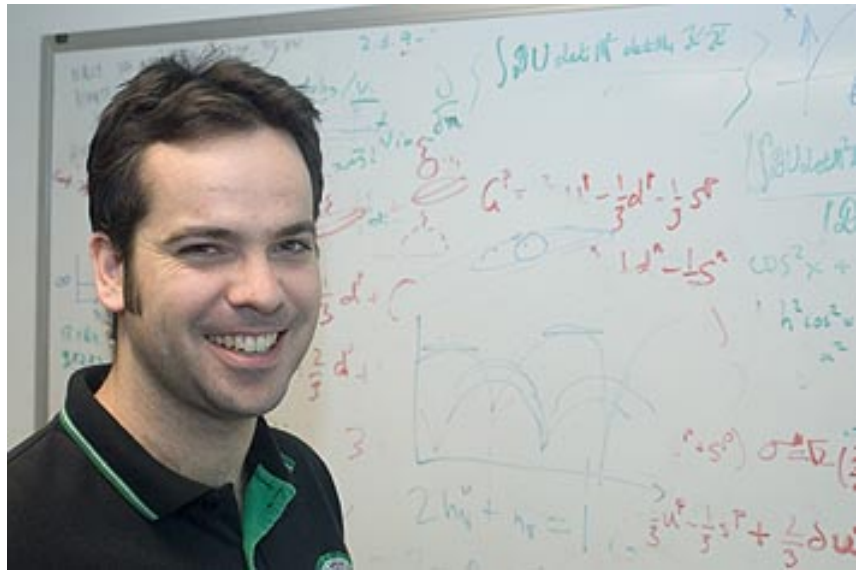
  CRUCIAL TO UNDERSTAND QCD

- **Complemented by Lattice QCD calculations of same quantities**

  - also exciting simulations underway for Gluex
  - major recent success with INCITE proposal:
  ~1 Teraflops-years on major new DOE machine at ORNL

Eugene P. Wigner Fellow at ANL

Ross Young (from the Theory Center) recently won one of 3 lab wide Fellowships – analogous to the Isgur Fellowship at JLab



more about his work later…

New Lattice QCD Cluster

- **Jefferson Lab will host in 2007 the second terascale machine that is part of a 4 year Office of Science LQCD Computing project funded by NP and HEP.**
- **This $9.8M project, running FY2006 – FY2009, provides almost half of the computing capacity for LQCD in the US.**
- **A larger, follow on project to be proposed to start in FY2010 will deploy computers of scale $5M each year, as compared to the $1.5M machines now being deployed.**
- **The 7n cluster will consist of 396 nodes interconnected by double data rate infiniband (20 Gbits/sec).**
- **Each node has two dual-core AMD 2218 processors and 4 GBytes of memory. An upgrade to quad-core this summer will be evaluated when chips become available.**
- **With the anticipated upgrade, this machine will sustain 3 TeraFlop/s, quadrupling the capacity for LQCD at Jefferson Lab.**
- **The dual-core machine should arrive in April and be put into production in May.**

12 GeV Upgrade

DOE SC OPA 12 GeV Mini Project Review held Jan. 30

- **R&D testing underway for the "1/4 Cryomodule that incorporates all the design features intended for the 12 GeV cryomodules".**
  - **One cavity operated at 17.7 Megavolts per meter (MV/m) with an intrinsic Q of ~1x1010, exceeding the minimum specification and, demonstrating successful correction of thermal management problems from 2005 testing of Renascence**
- **Vendors being sought to provide pre-construction services to independently validate cost estimates of conventional facilities**

2007 NSAC Long Range Planning

- **JLab very active role; strong presence of staff and users at APS-DNP Town Hall Meetings: January 12-14 at Rutgers and January 19-21 in Chicago**

- **Outcome: 12 GeV Upgrade of Jefferson Lab was once again affirmed as the top priority of scientists active in hadronic physics by representatives of the community gathered at Rutgers**

- **White papers being developed to be used as input to the LRP – draft expected in April**

- **Resolution committee meeting in Galveston, 1st week May**

Free Electron Laser

- **FEL annual review took place at JLab on Jan. 17-18**

- **Jan. 22-23 JLab hosted workshop: Designs and Applications of FELs for research on High Magnetic Fields:**
  - **3rd in a series of meetings to help guide the evolution of an FEL facility at the National High Magnetic Field Laboratory. NHMFL-FEL is an ongoing collaboration between Florida State, Jefferson Lab, UCSB, and others.**
  - **Focused on scientific opportunities afforded by the combination of FEL light sources and high magnetic fields.**

- **MTAC meeting held here on Feb. 6**

- **Today, Fred will take us through the FEL's past, its accomplishments, and future plans.**

Budget

- **President's FY08 budget rolled out on 2/5/07 -- potential good news for FY08:**
  - **Office of Science '08 is proposed at $4.39B: up 7.2% over FY07 PB.**
  - **Nuclear Physics '08 funding at $471M: increase of 3.5% for NP over FY07 PB**
  - **JLab's '08 funding is requested at $102.4M: up 6.3% over FY07 PB.**
  - **12 GeV proposed funding at $13.5M of PED and $1M of construction funding**
  - **Lab leadership is planning visits to the Hill with staffers, next week on '08 behalf**

- **At present: Continuing Resolution for FY07 -- still in effect:**
  - **House and Senate approved '07 + $300M for Office of Science**
  - **NP has made no commitment as yet as to distribution**

Budget (Cont'd.)

Efforts to mitigate:

- **Lab leadership has clearly communicated severe impacts of worst case scenario to DOE and is working with DOE to secure FY07 PB funding and commitment with ACI**

- **User community: UGBOD chair led letter writing campaign effort to Congressmen and Senators from their institutions outlining impacts of CR and urging the passage of the 07 president's budget (which already received bipartisan support)**

- **Letter from Congressional members to Chairs of Appropriations Committees and E&W Appropriations subcommittees urging passage of $4.1B for funding level for SC as Congress works on Joint Funding resolution for remainder of FY07 in support of ACI**

- **Lab submitted amendment to the Commonwealth of Va. budget to include $10M over three years for Hall D construction funding for the 12 GeV Upgrade. (At present, $500K is most likely VA funding)**

Other

- Virginia Regional Science Bowl held at JLab, Saturday, Feb. 10.
  - 19 schools competed, with first place going to Thomas Jefferson School for Science and Technology – this is their 6th consecutive win
  - Many thanks to Jan and the Sci. Ed. Department as well as the numerous JLab staff who volunteered in the many positions during the day-long event.

- Patent awards ceremony held 2/13. 14 awards total (27 recipients at event)

Safety

- 102 days since last TRC or DART event

- Craig will brief us on the 10CFR81 Worker Safety and Health Program Regulations - new rules for DOE contractors regarding Health and Safety and what it means for us.

Fundamental Forces

	Gravity	Weak (Electroweak)	Electromagnetic (Electroweak)	Strong
Carried By	Graviton (not yet observed)	W^+ W^- Z^0	Photon	Gluon
Acts on	All	Quarks and Leptons	Quarks and Charged Leptons and W^+ W^-	Quarks and Gluons

There are four fundamental forces:

- **Gravity:** holds us to the earth, binds solar systems, galaxies..
- **Electromagnetic:** e.m. radiation, chemistry, biology..
- **Weak:** radioactivity, neutrino physics of supernovae, etc.
- **Strong:** all familiar matter, nuclear energy, powers sun & stars

Building Blocks of the Universe

FERMIONS

matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2

Flavor	Mass GeV/c^2	Electric charge
ν_e electron neutrino	$<1\times10^{-8}$	0
e electron	0.000511	−1
ν_μ muon neutrino	<0.0002	0
μ muon	0.106	−1
ν_τ tau neutrino	<0.02	0
τ tau	1.7771	−1

Quarks spin = 1/2

Flavor	Approx. Mass GeV/c^2	Electric charge
u up	0.003	2/3
d down	0.006	−1/3
c charm	1.3	2/3
s strange	0.1	−1/3
t top	175	2/3
b bottom	4.3	−1/3

- **Each quark comes in 3 "colours": red, green and blue.**
- **Leptons do not carry color charge.**

These are the building blocks of matter!

Force Carriers of the Universe

BOSONS

force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1

Name	Mass GeV/c^2	Electric charge
γ photon	0	0
W^-	80.4	–1
W^+	80.4	+1
Z^0	91.187	0

Strong (color) spin = 1

Name	Mass GeV/c^2	Electric charge
g gluon	0	0

- The massless photon mediates the long-range e.m. interactions.
- Gluons carry color and mediate the strong interaction.
- The very massive W^-, W^+, and Z^0 bosons mediate the weak interaction

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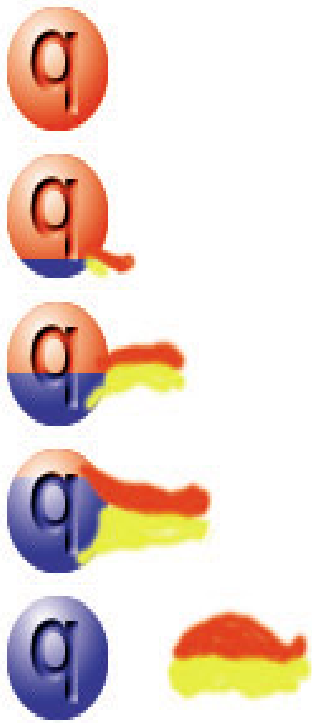
Quantum Chromodynamics (QCD)

- **Photons do not carry electric charge.**
- **Gluons *do* carry colour charge!**
- **Gluons can directly interact with other gluons!**
- **This is new!**



A red quark emitting a red-anti-blue gluon to leave a blue quark.

Quark-quark force grows WEAKER as quarks come close
≡ "Asymptotic Freedom"

QCD: Mesons

Mesons $q\bar{q}$

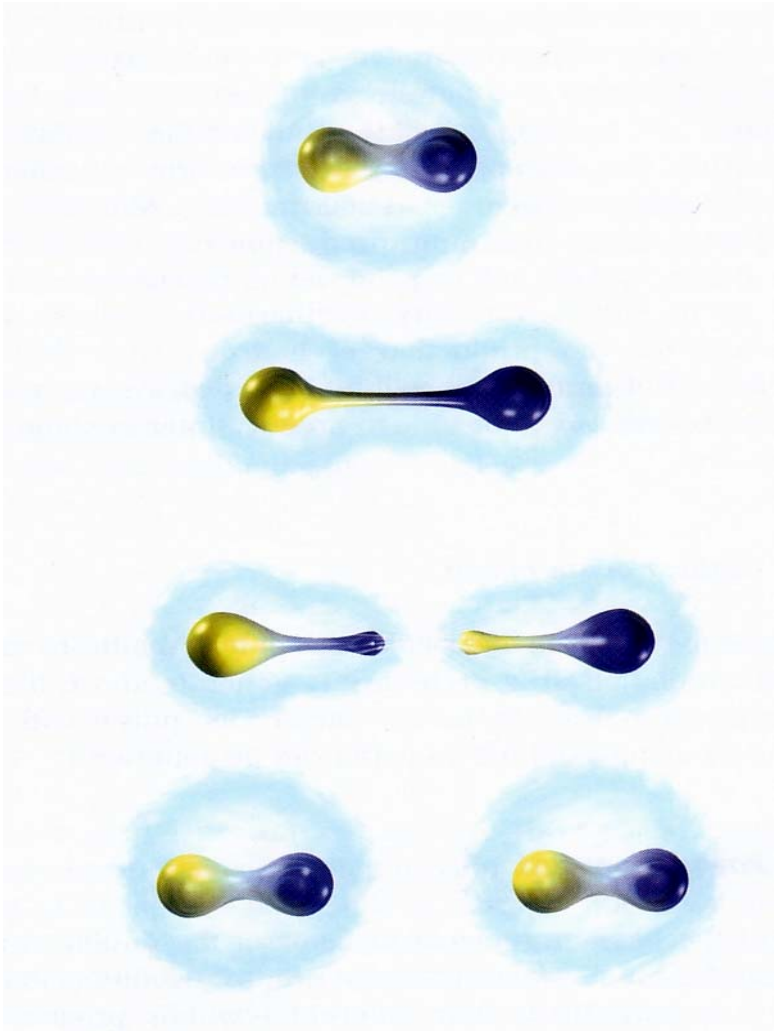
Mesons are bosonic hadrons.
There are about 140 types of mesons.

Symbol	Name	Quark content	Electric charge	Mass GeV/c^2	Spin
π^+	pion	$u\bar{d}$	+1	0.140	0
K^-	kaon	$s\bar{u}$	–1	0.494	0
ρ^+	rho	$u\bar{d}$	+1	0.770	1
B^0	B-zero	$d\bar{b}$	0	5.279	0
η_c	eta-c	$c\bar{c}$	0	2 .980	0

- **Mesons are made up of a quark - anti-quark pair with equal and opposite color charges.**
- **PION is special has zero mass as $m_{u,d} \rightarrow 0$**

$$m_\pi^2 \sim m_{u,d}$$

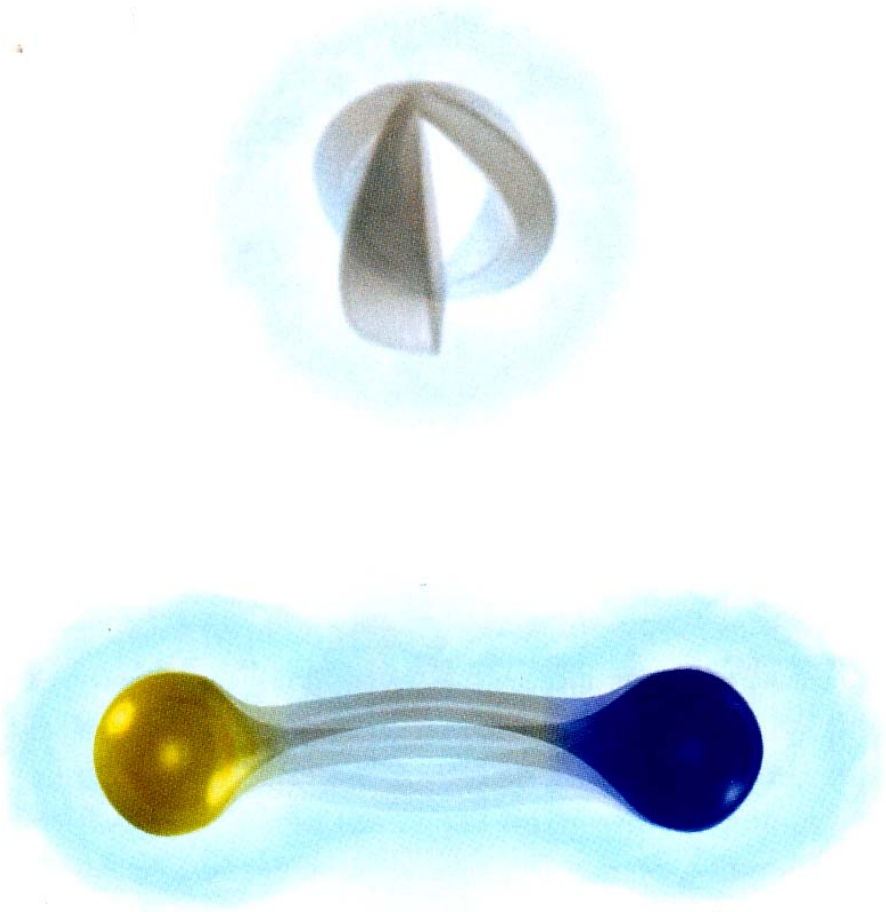
String Breaking



It is impossible to isolate a quark.

- **Quarks are *"Confined "***
- **Restoring force is 10 tons regardless of separation!**
- **String can break BUT makes two colorless objects!**

QCD: Exotics

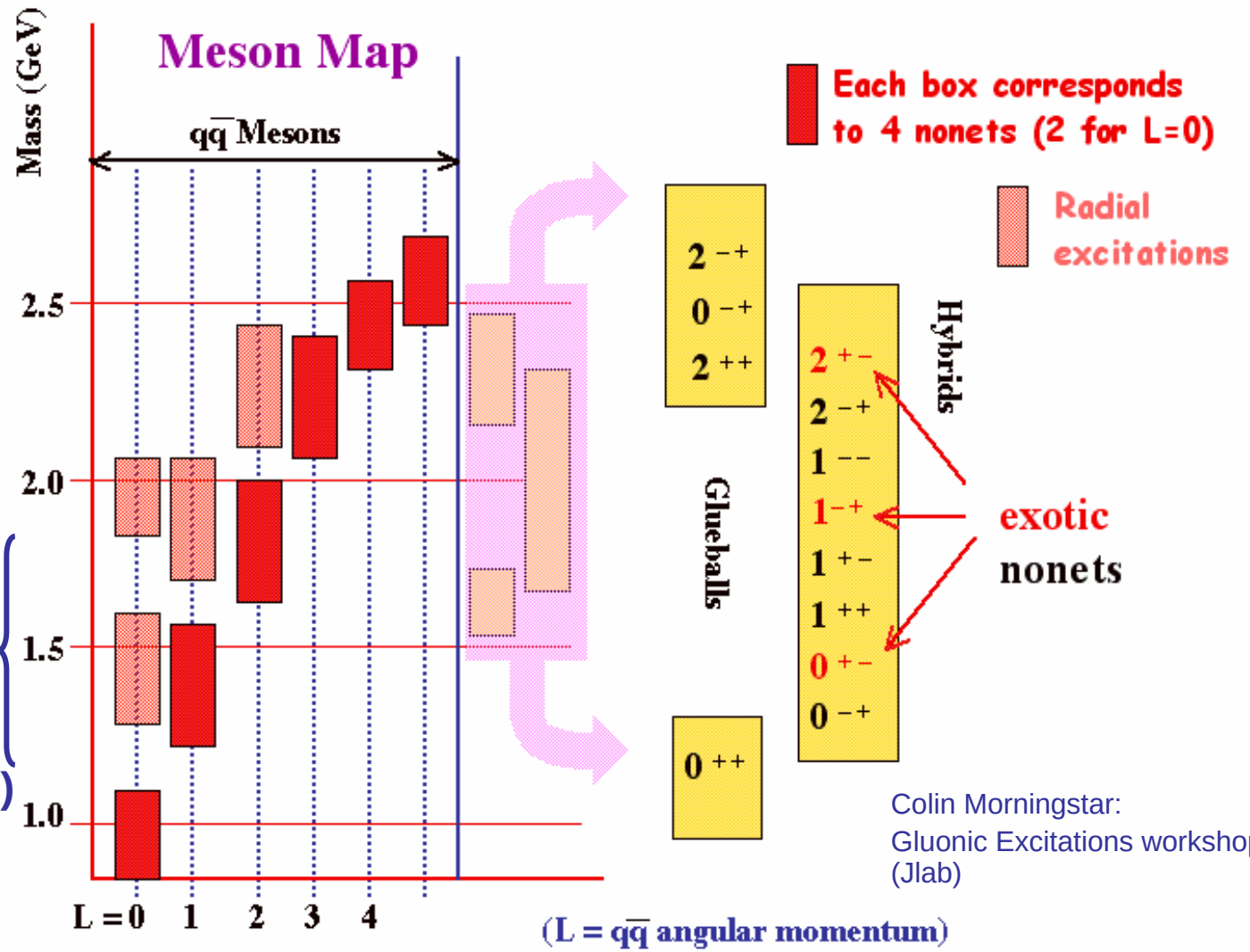


QCD predicts the existence of exotic mesons

Glueballs are mesons without valence quarks

Other exotics involve excitation or vibration of gluons

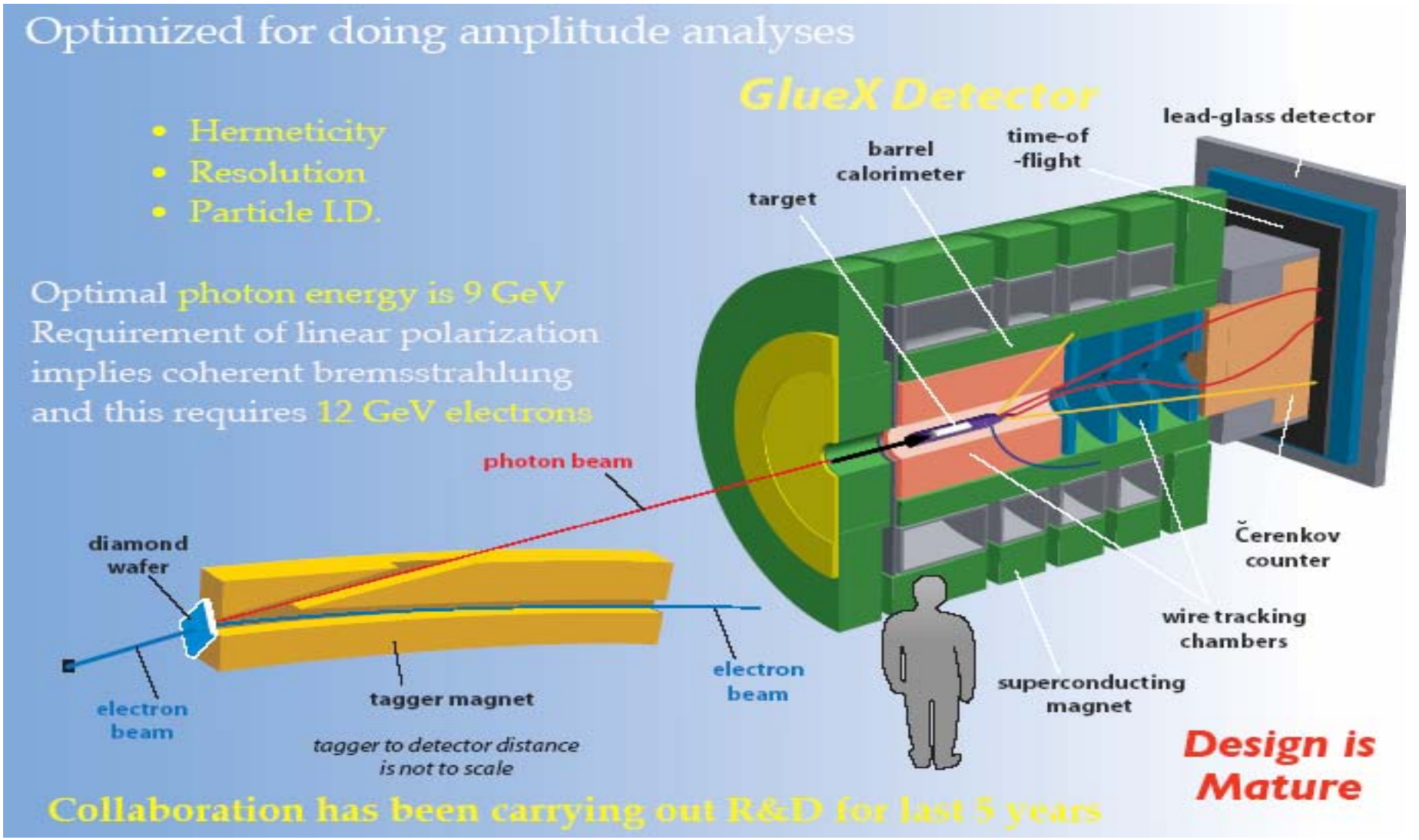
Glueballs and hybrid mesons



Initial search FY07 – G12 (CLAS)

Colin Morningstar:
Gluonic Excitations workshop, 2003 (Jlab)

Gluex: Hall D


Optimized for doing amplitude analyses
• Hermeticity
• Resolution
• Particle I.D.
Optimal photon energy is 9 GeV
Requirement of linear polarization
implies coherent bremsstrahlung
and this requires 12 GeV electrons
GlueX Detector
lead-glass detector
time-of
-flight
barrel
calorimeter
target
photon beam
diamond
wafer
Čerenkov
counter
wire tracking
chambers
electron
beam
tagger magnet
electron
beam
superconducting
magnet
tagger to detector distance
is not to scale
Design is
Mature
Collaboration has been carrying out R&D for last 5 years

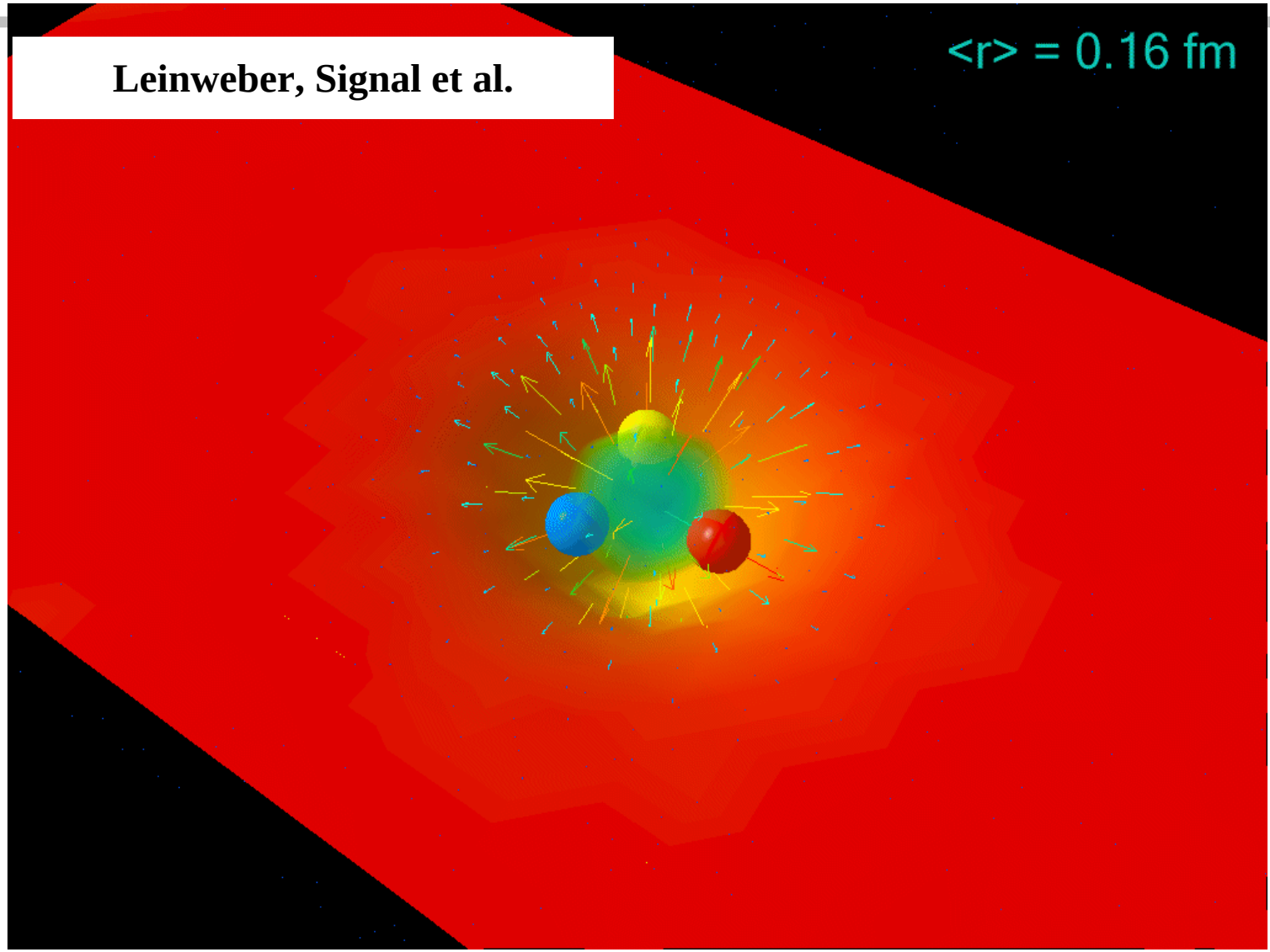
QCD and the Origin of Mass

$$u + u + d = \text{proton}$$

$$\text{mass: } 0.003 + 0.003 + 0.006 \neq 0.938$$

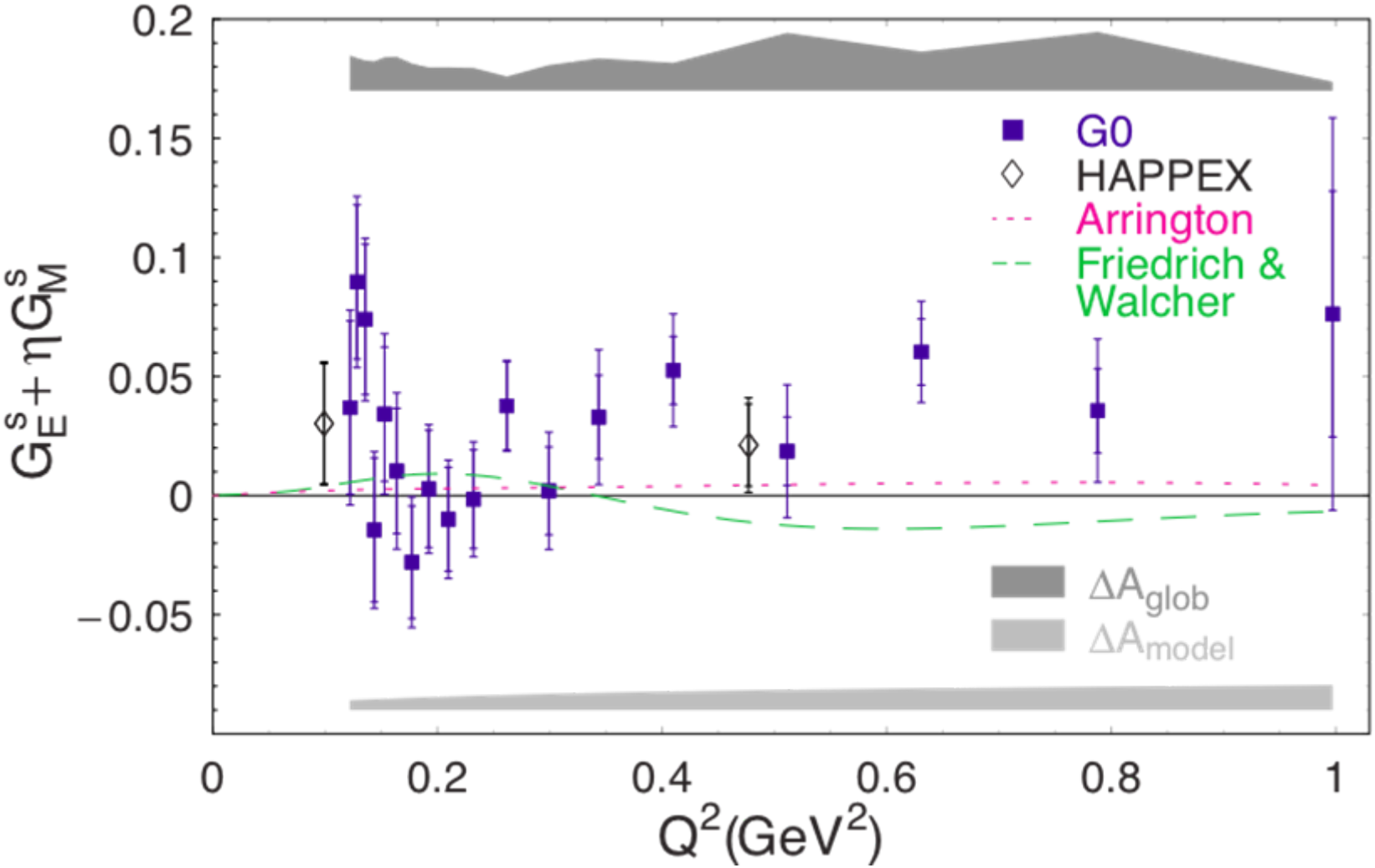
HOW does the rest of the proton mass arise?

Lattice QCD Simulation of Vacuum Structure



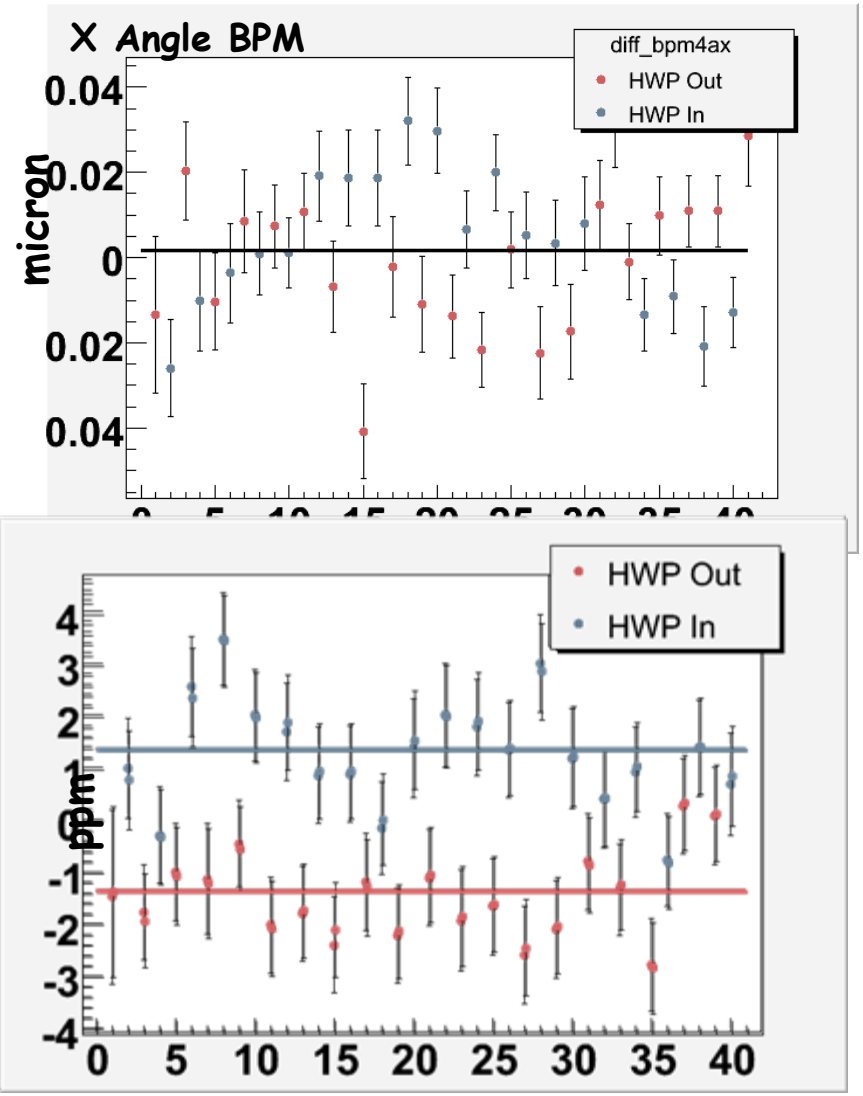
Leinweber, Signal et al.

World Data on "PVES" Dominated by G0



Q^2 – dependence : G0 Phys Rev Lett 95 (2005)

Latest HAPPEx Run : Outstanding Achievement !



Surpassed Beam Asymmetry Goals for Hydrogen Run

Energy: -0.25 ppb

X Target: 1 nm

X Angle: 2 nm

Y Target : 1 nm

Y Angle: <1 nm

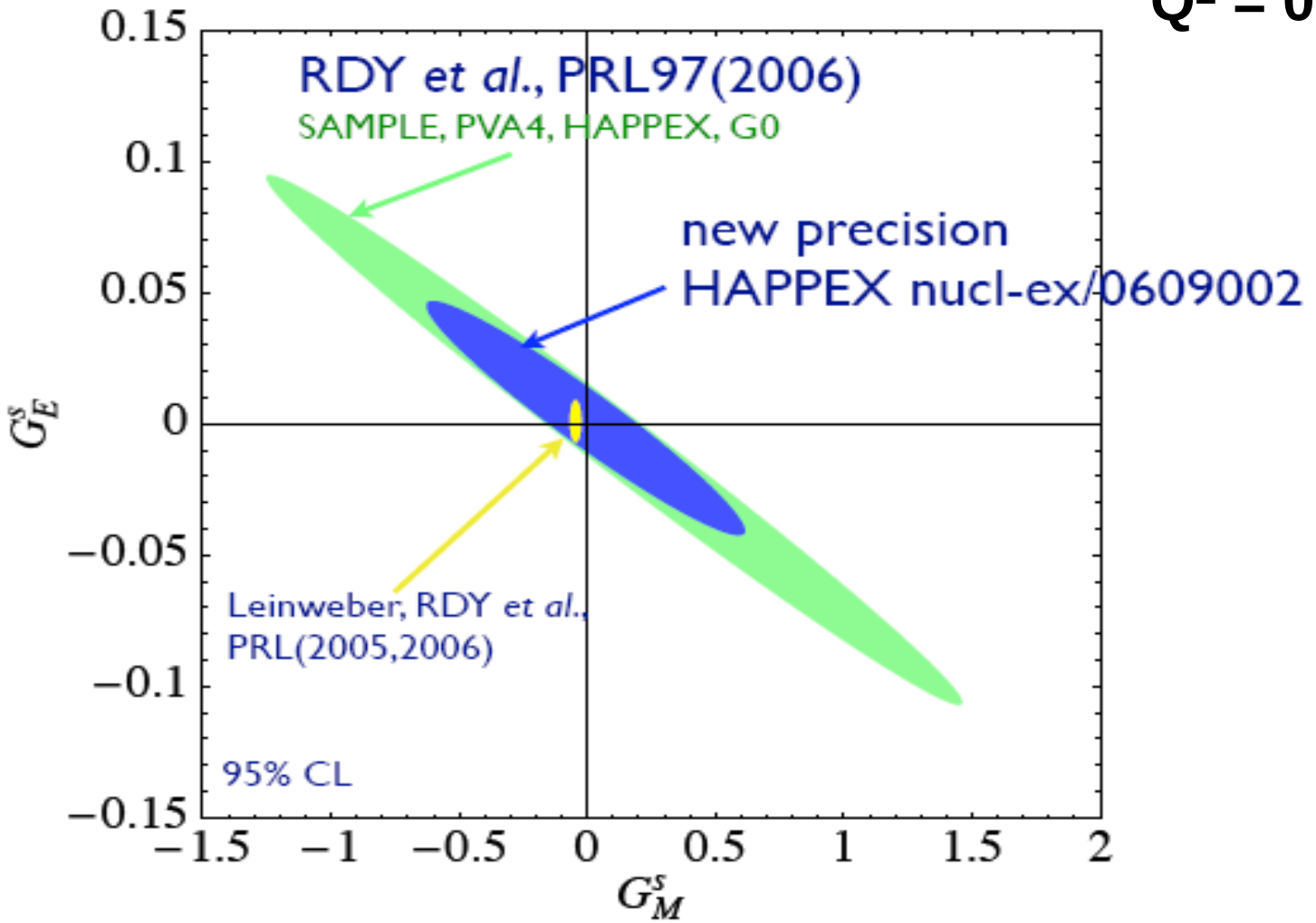
← **Corrected and Raw**

Total correction for beam position asymmetry on Left, Right, or ALL detector: 10 ppb

from Kent Paschke

Factor of two from latest HAPPEx Measurement

$Q^2 = 0.1\ GeV^2$



$G_E^s = 0.002 \pm 0.018 \quad G_M^s = -0.01 \pm 0.25$

Strange Form Factor Measurements – Future Plans

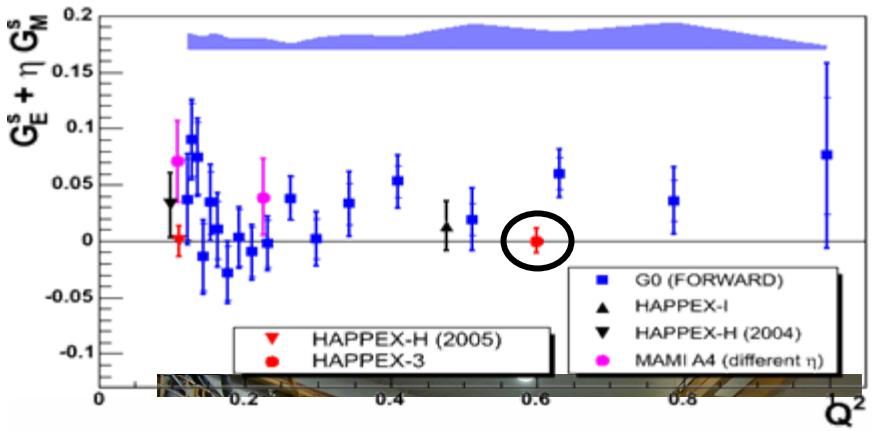
HAPPEx: "HAPPEx3"
measure $G^s_E + 0.48G^s_M$ with high precision at Q^2~0.6 GeV^2

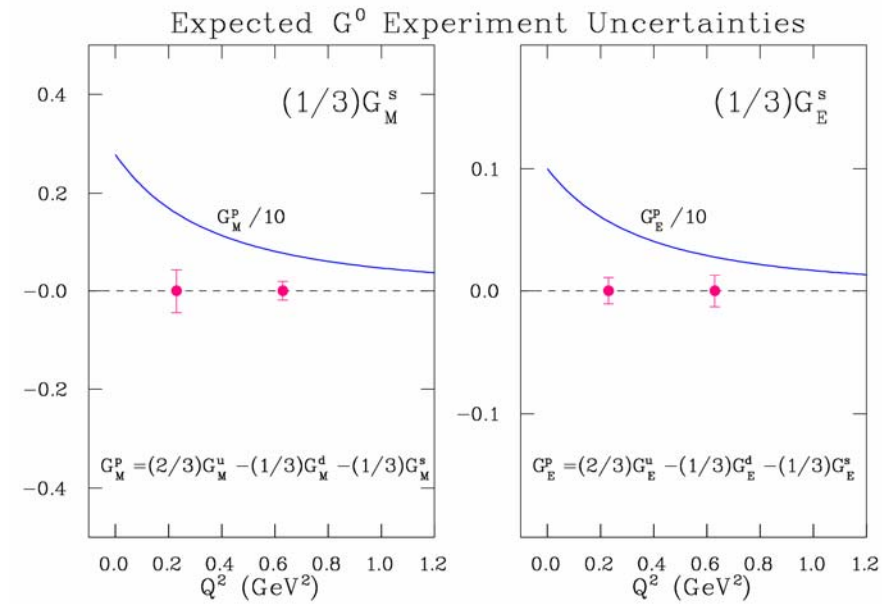
G^0: Turn experiment around

- detect electrons at $\theta = 108^o$
- add Cerenkov for pion rejection
- measure at Q^2 = .23 and .63 GeV^2
- LH_2 and LD_2 targets

Mainz A4: Turn experiment around

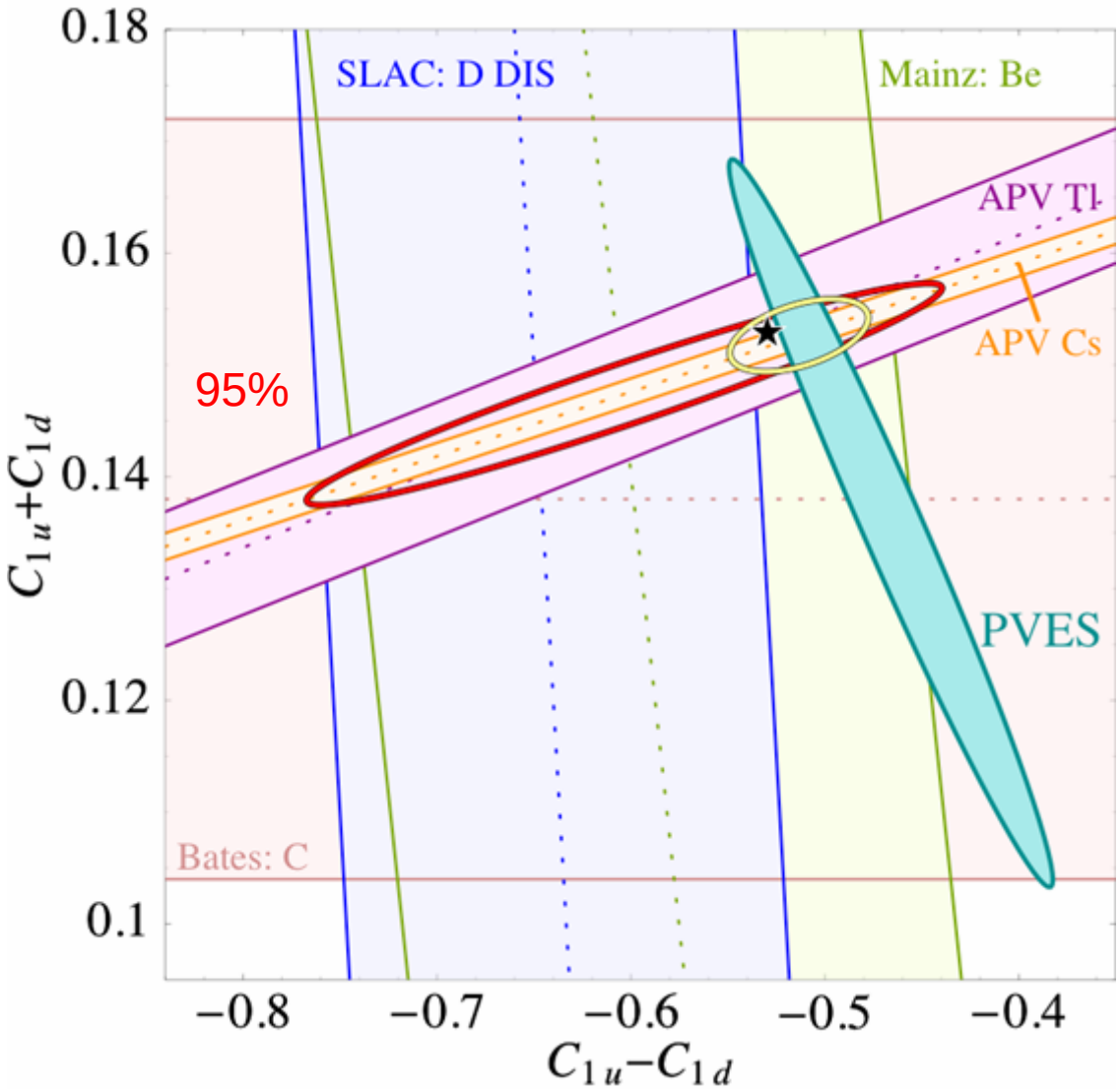
- detect electrons at $\theta = 145^o$
- Measure at Q^2 = .23 and .47 GeV^2
- LH_2 and LD_2 targets





from Mark Pitt

Can we use PVES to Test the Standard Model?



(Young et al.)

Dramatic improvement in knowledge of weak couplings!

Factor of 5 increase in precision of Standard Model test

Model-independent limits on New Physics

$$\mathcal{L}_{\mathrm{SM}}^{\mathrm{PV}} = -\frac{G_F}{\sqrt{2}}\bar{e}\gamma_\mu\gamma_5 e \sum_q C_{1q}^{\mathrm{SM}}\bar{q}\gamma^\mu q$$

Erler et al., PR D68 (2003)

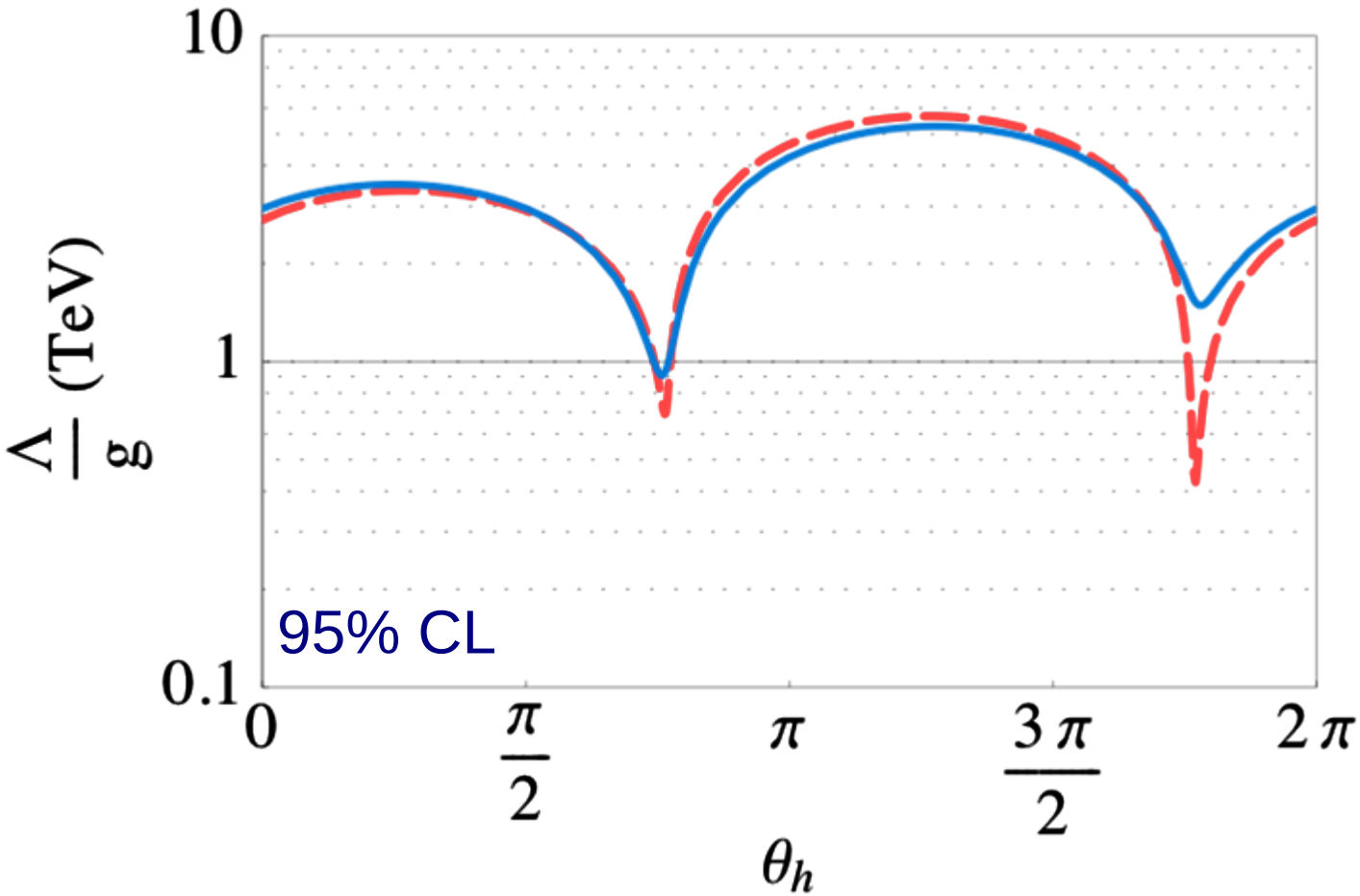
$$\mathcal{L}_{\mathrm{NP}}^{\mathrm{PV}} = \frac{g^2}{4\Lambda^2}\bar{e}\gamma_\mu\gamma_5 e \sum_q h_V^q \bar{q}\gamma^\mu q$$

Full isospin coverage for limits on new physics!

$$h_V^u = \cos\theta_h \qquad h_V^d = \sin\theta_h$$

Data sets limits on $\dfrac{g^2}{\Lambda^2}$

Lower bound on NP scale



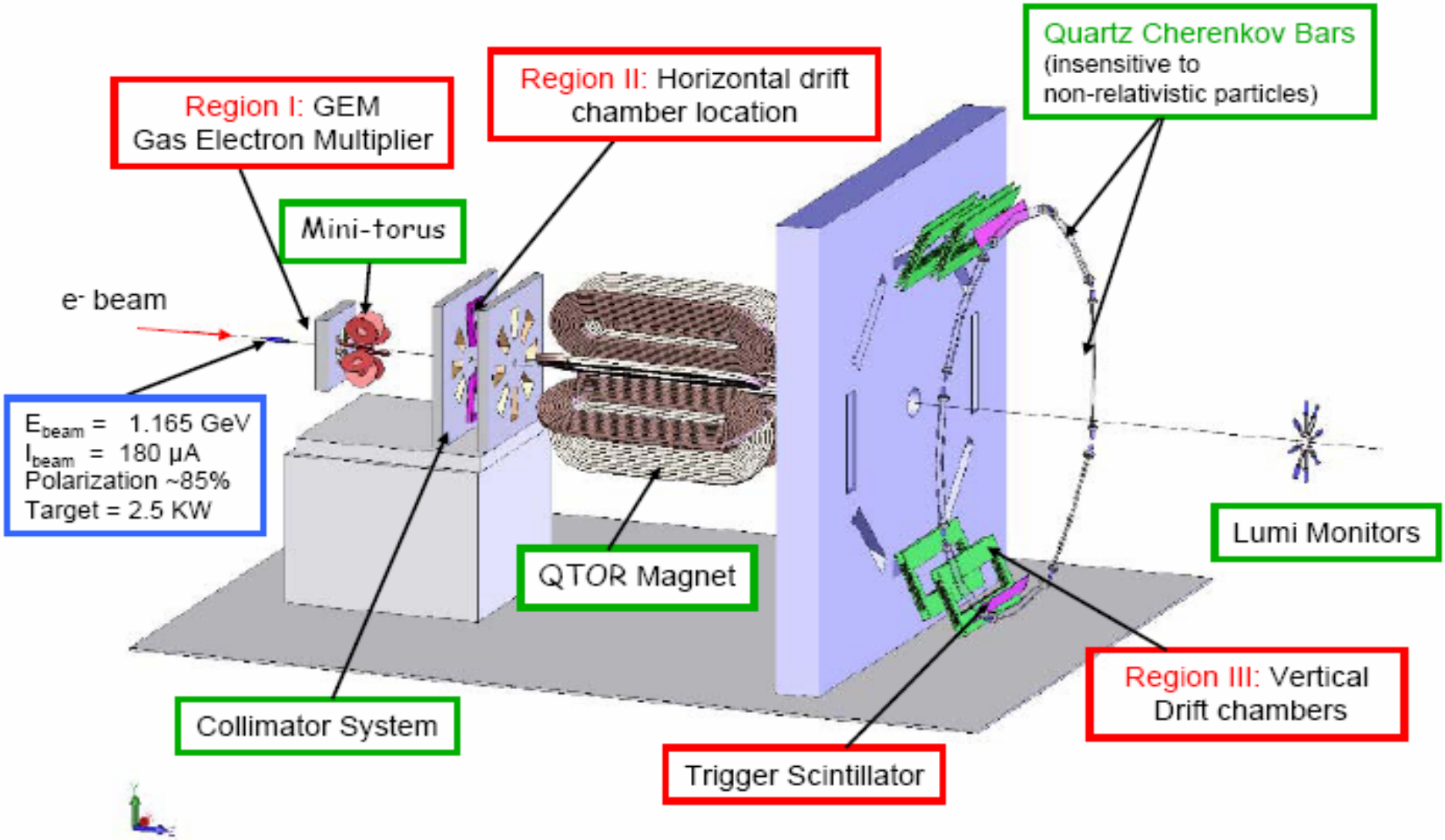
with PVES

Atomic only

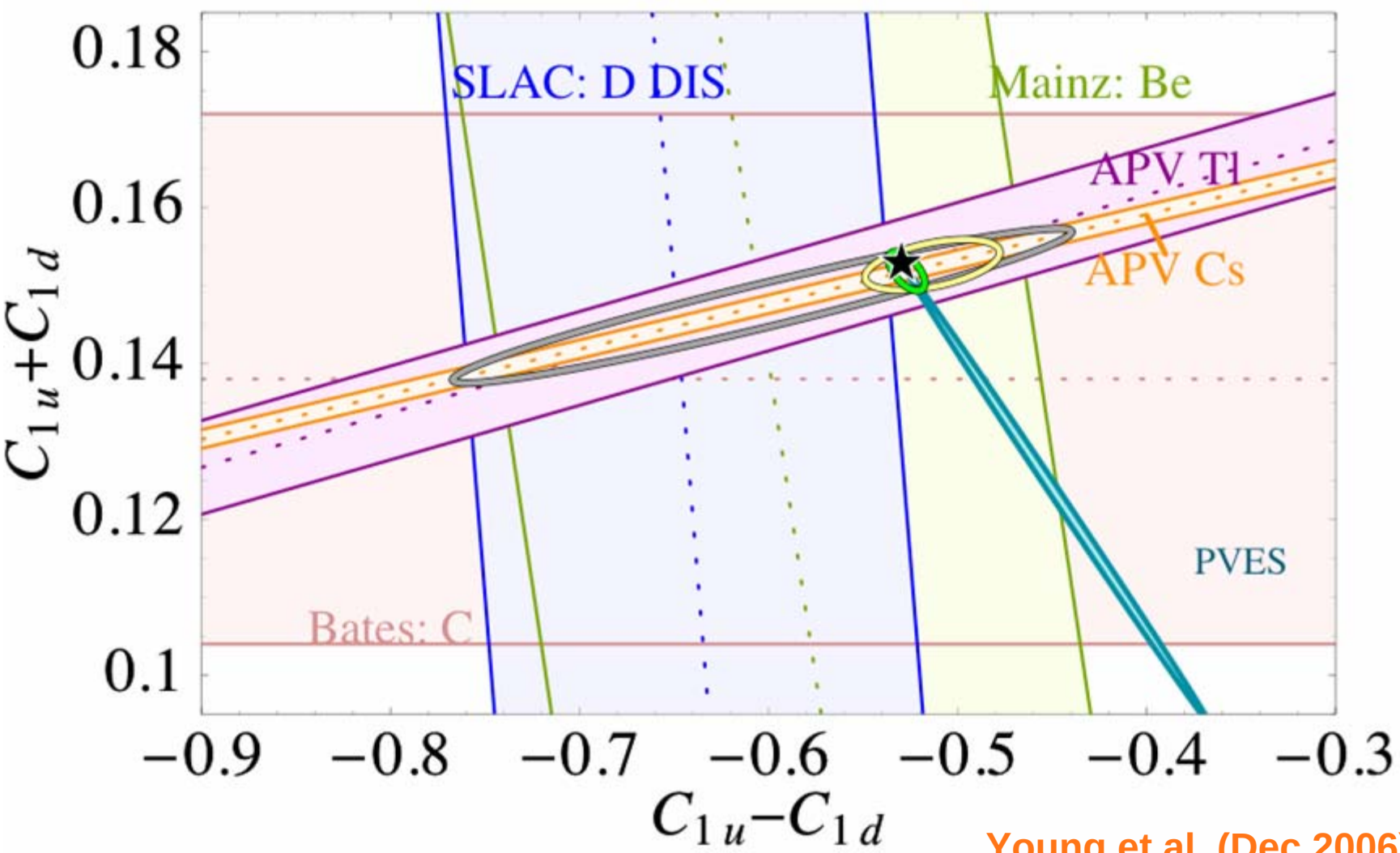
Young et al.
(Dec 2006)

New physics scale >0.9 TeV! (up from 0.4 TeV)

Q_{weak} Apparatus

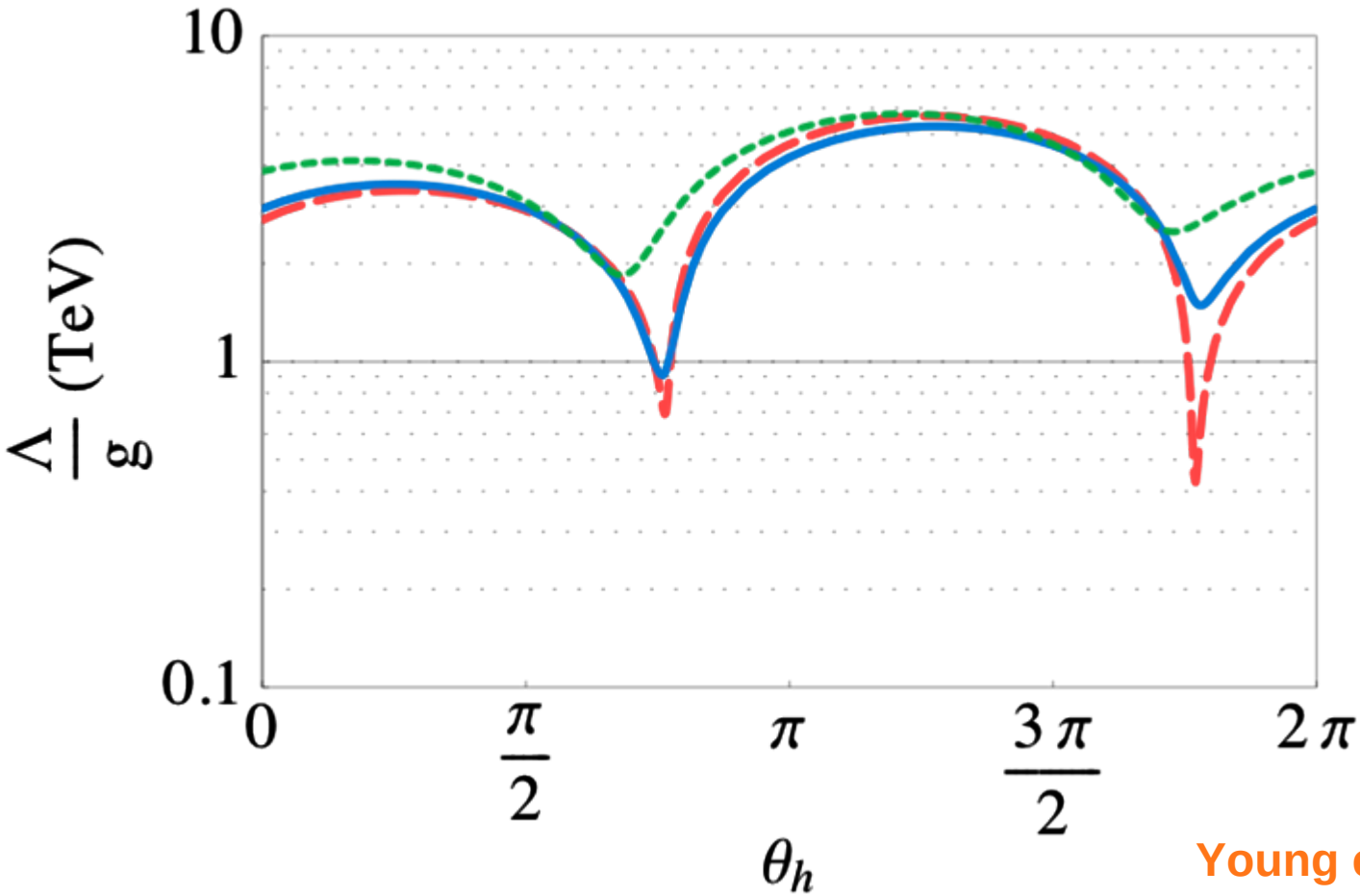


Possible Impact of Qweak



Young et al. (Dec 2006)

New Physics Limits
(if result consistent with Standard Model)



future Qweak

with PVES

Atomic only

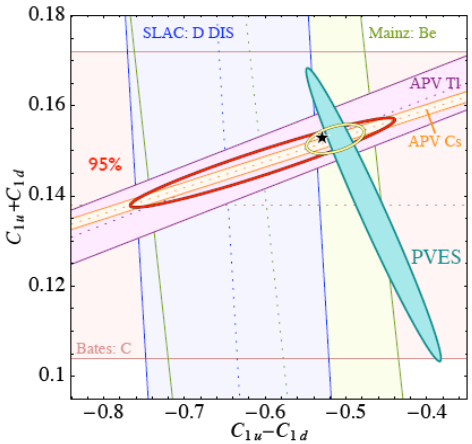
95% CL

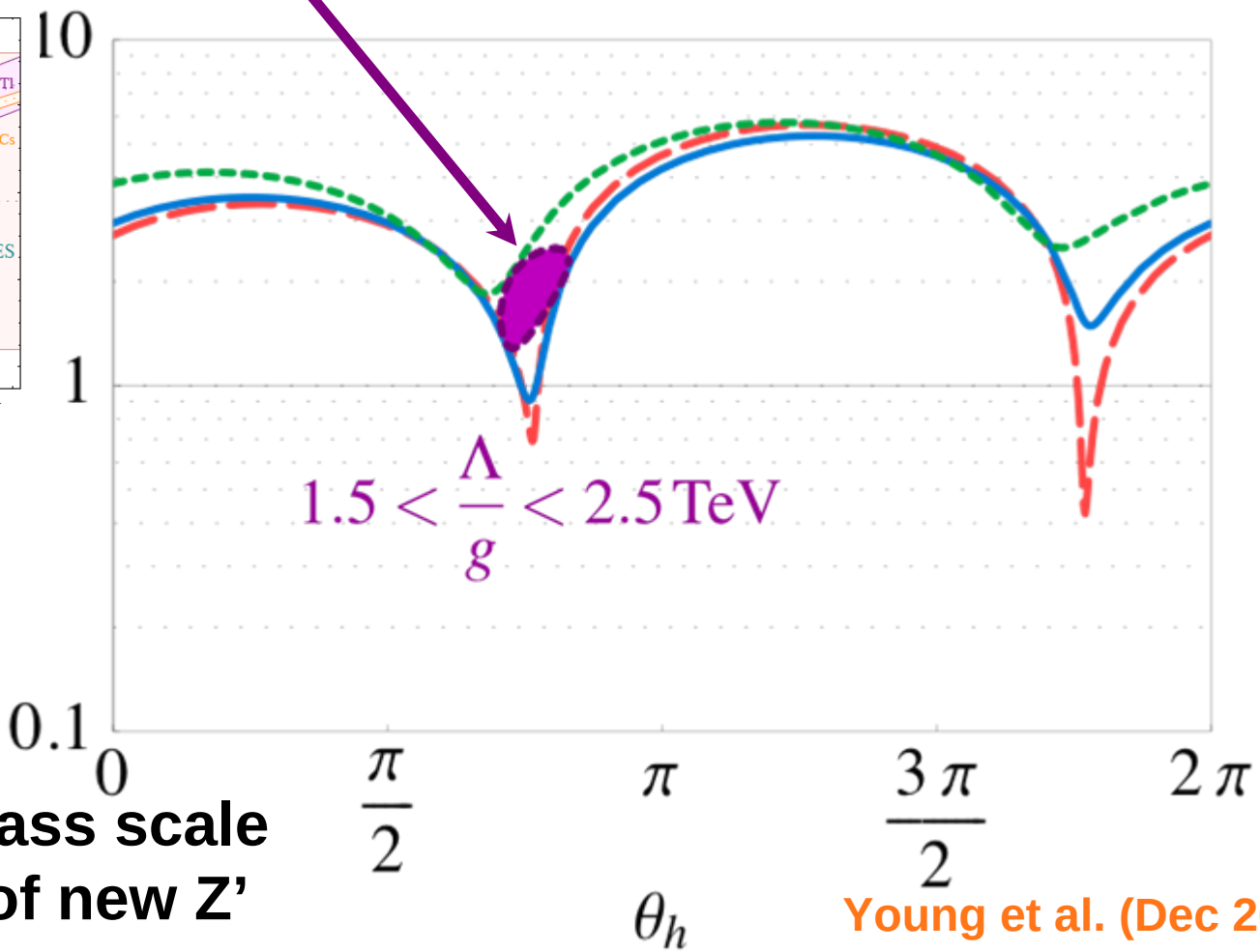
Young et al. (Dec 2006)

Qweak constrains new physics to beyond 2 TeV

But: Q_{weak} has real discovery potential!

IF: Q_{weak} takes central value of current PVES measurement





Q_{weak} yields mass scale and coupling of new Z'

Young et al. (Dec 2006)

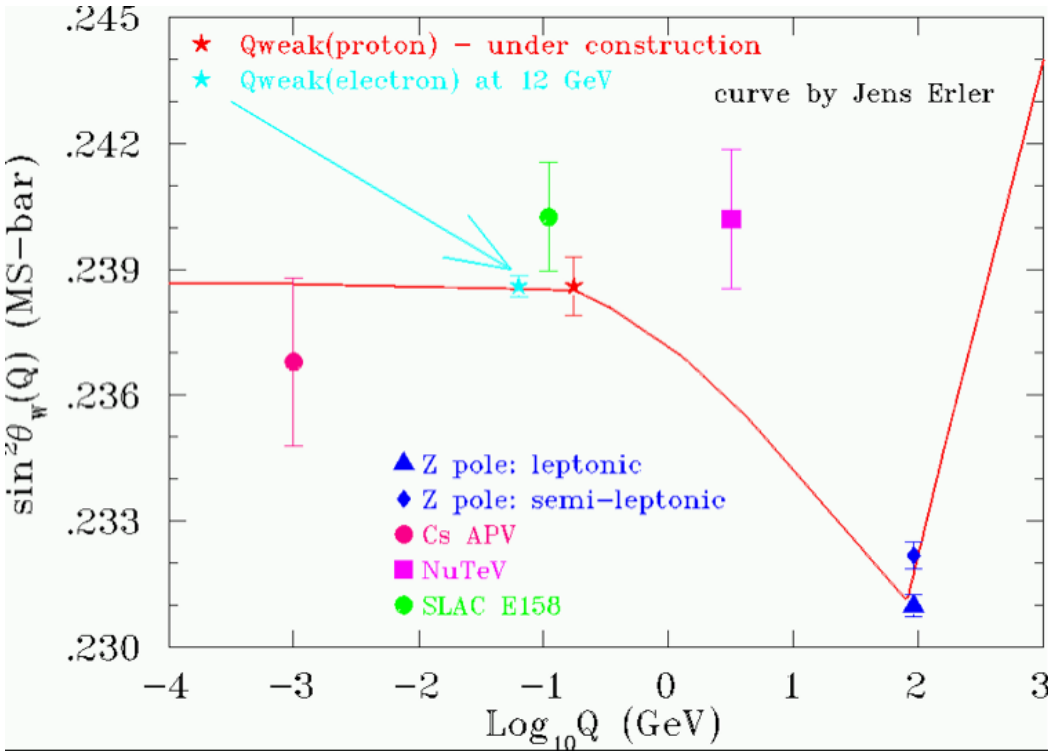
Future Möller Experiment at 12 GeV

Appears feasible to measure $\sin^2\theta_W$ to $\pm$ 0.0002

Consensus Statement from December 2006 Workshop:

"There was overwhelming enthusiasm to aggressively proceed with the design of such an experiment"

"unique sensitivity to properties of new physics phenomena such as R-parity violating SUSY"



Axion Search : Recent Observation by PVLAS

Polarization experiments

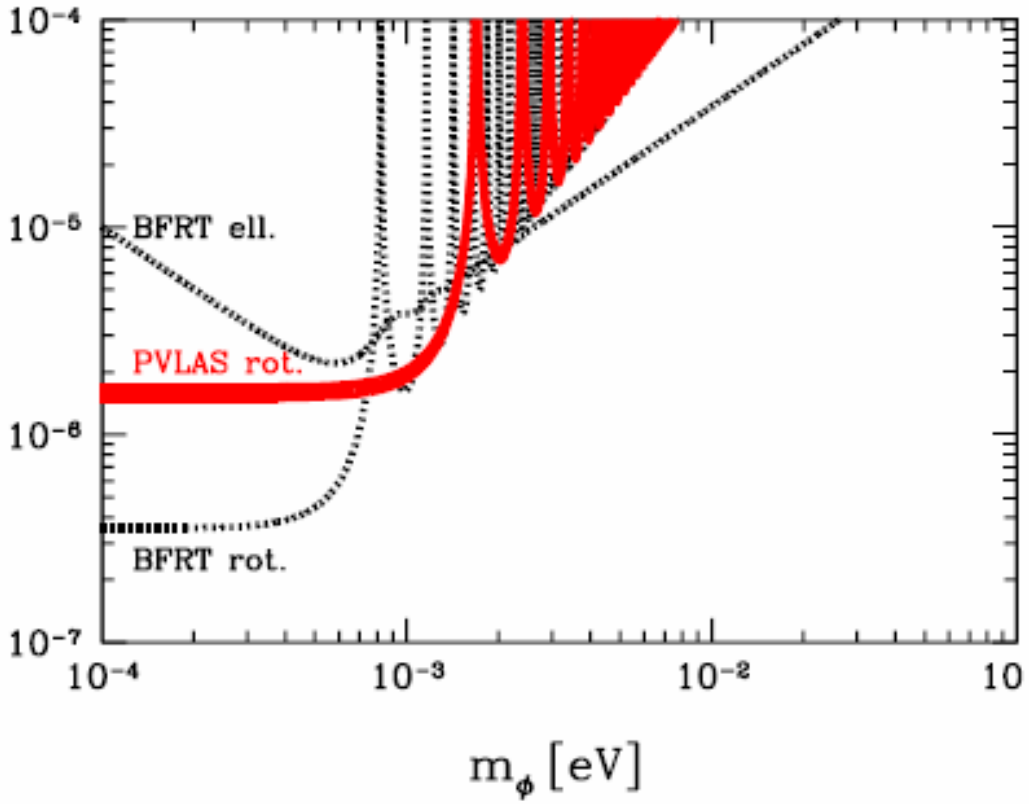
- Send linearly polarized laser beam through transverse magnetic field ⇒ measure changes in polarization state
- Real and virtual production induce
  - **rotation:** photons polarized || $\boldsymbol{B}$ will disappear leading to apparent rotation of polarization plane by

$$\varepsilon_\phi = -N_r \left(\frac{gB\ell}{4}\right)^2 F(q\ell)\,\sin 2\theta$$

  - **ellipticity:** virtual production causes retardation between $\boldsymbol{E}_{||}$ and $\boldsymbol{E}_\perp$ ⇒ elliptic polarization

$$\psi_\phi \approx \frac{N_r}{6}\left(\frac{g\,B\,\ell}{4}\right)^2 \frac{m_\phi^2\,\ell}{\omega}\,\sin 2\,\theta$$

for small masses, $m_\phi^2\ell/4\omega \ll 1$.

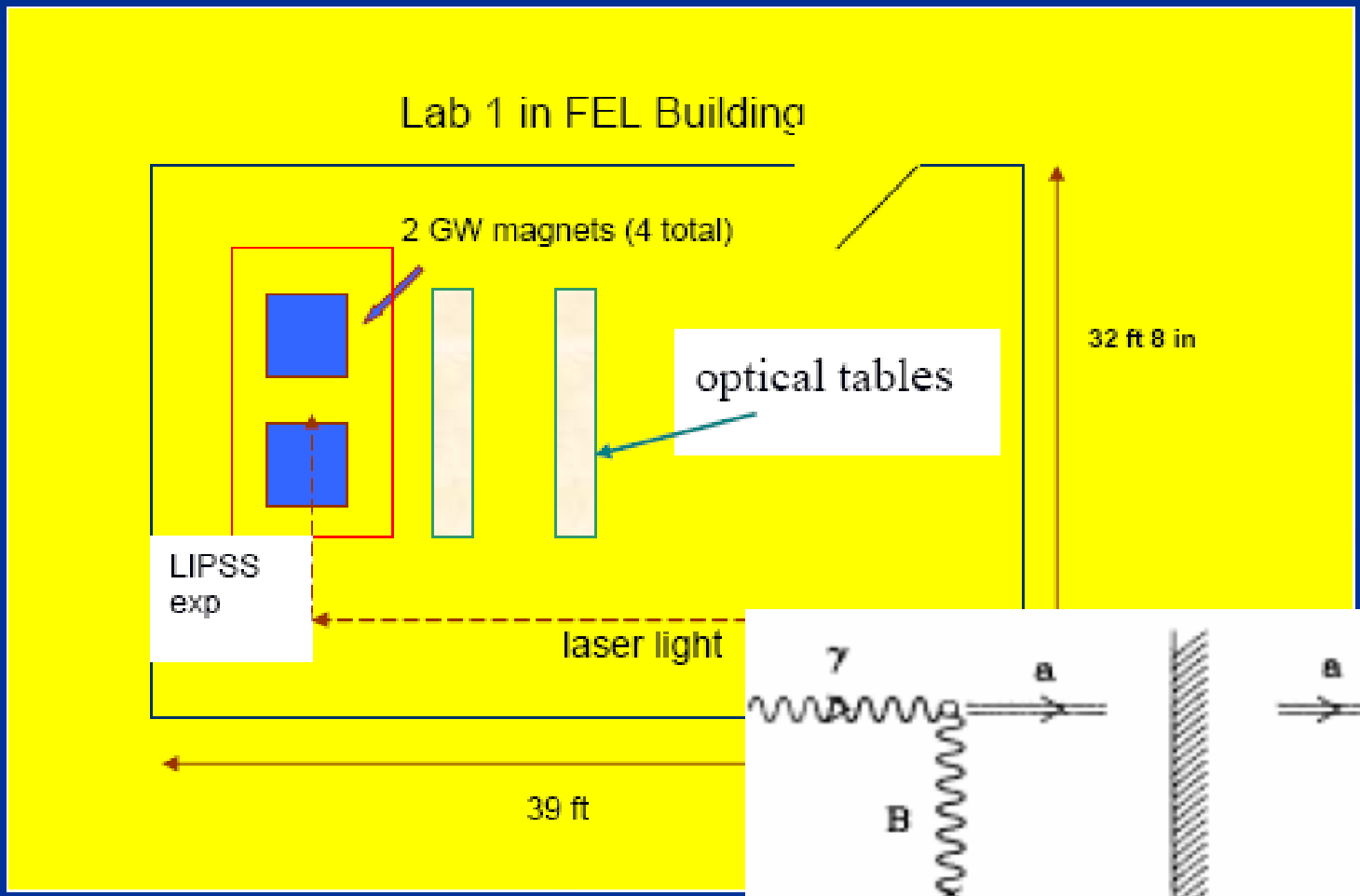


Publication: [Zavattini *et al.* '05]

$$1.7 \times 10^{-6}\ \text{GeV}^{-1} \lesssim g \lesssim 1.0 \times 10^{-5}\ \text{GeV}^{-1}$$
$$0.7\ \text{meV} \lesssim m_\phi \lesssim 2.0\ \text{meV}$$

From K. Baker

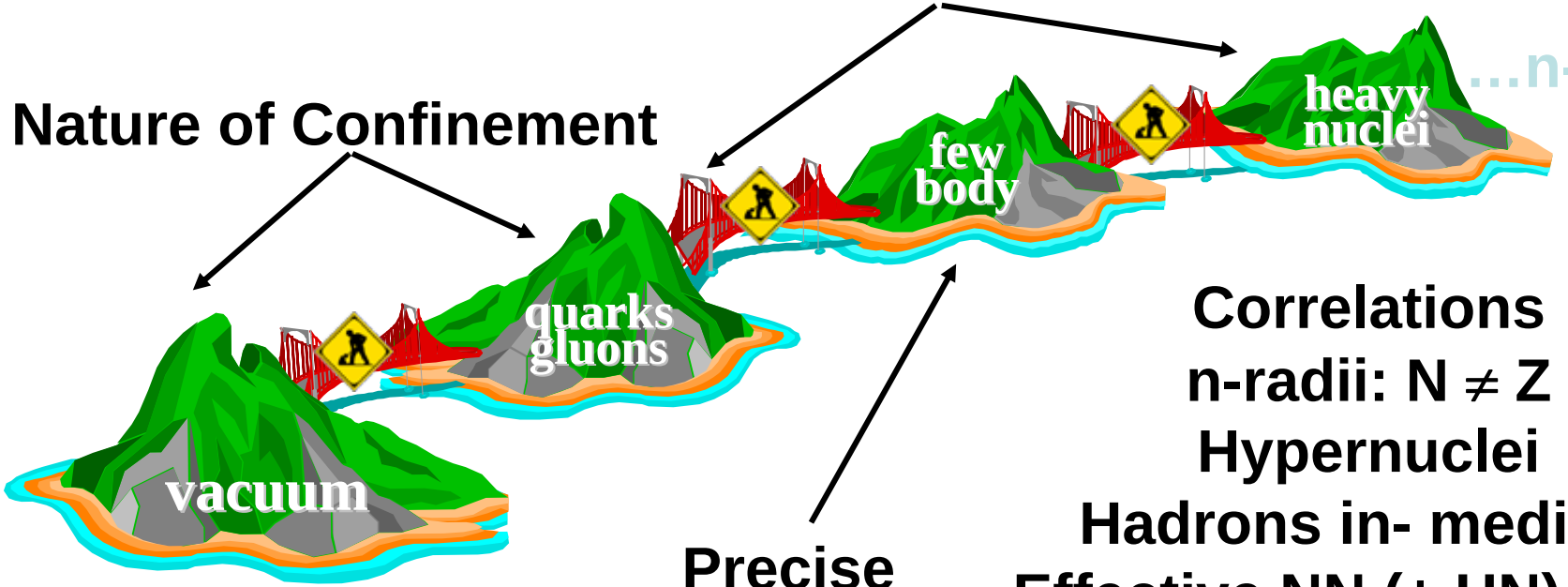
The experiment will be mounted in Laboratory 1 in the FEL Building. There will be two GW magnets used for PS generation, and two for photon regeneration.



Program Central to Nuclear Science

Quark-Gluon Structure Of Nucleons and Nuclei

Nature of Confinement



Correlations
n-radii: N ≠ Z
Hypernuclei
Hadrons in- medium
Effective NN (+ HN) force

Precise few-nucleon calculations

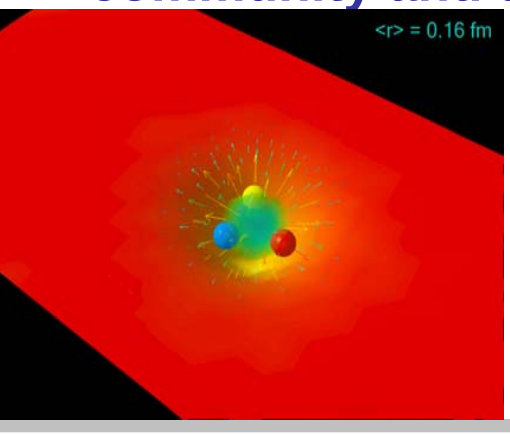
Exotic mesons and baryons

World Community in 2013 and Beyond

- With 12 GeV Upgrade will have three major new facilities investigating nuclear physics at quark level (QCD) : FAIR (GSI, Germany), J-PARC (Japan) and JLab*

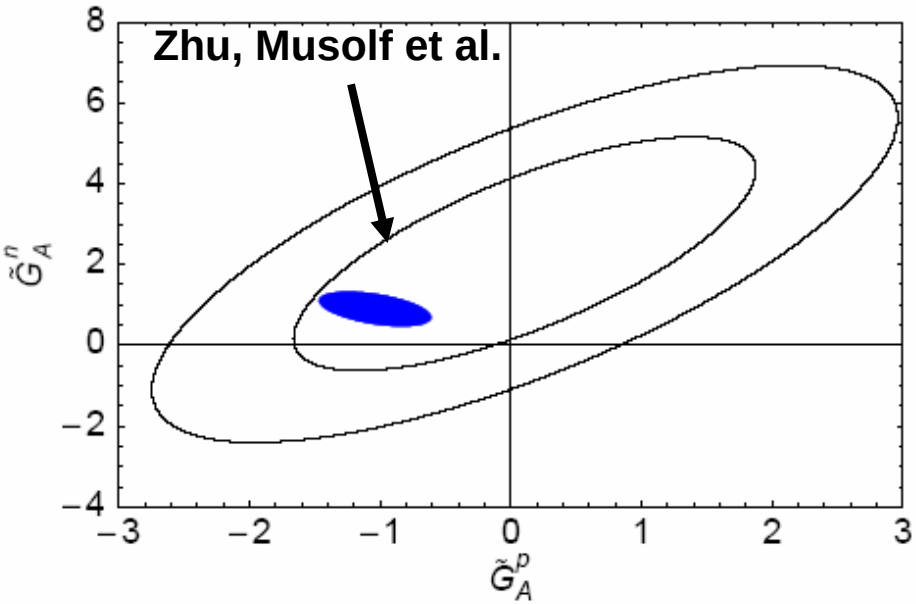
- Complementary programs (e.g. charmed vs light-quark exotics, hadrons in - medium….etc.)

- Wonderful opportunities to build international community and take our field to a new level



* Unique: only electromagnetic machine

Axial Form Factors

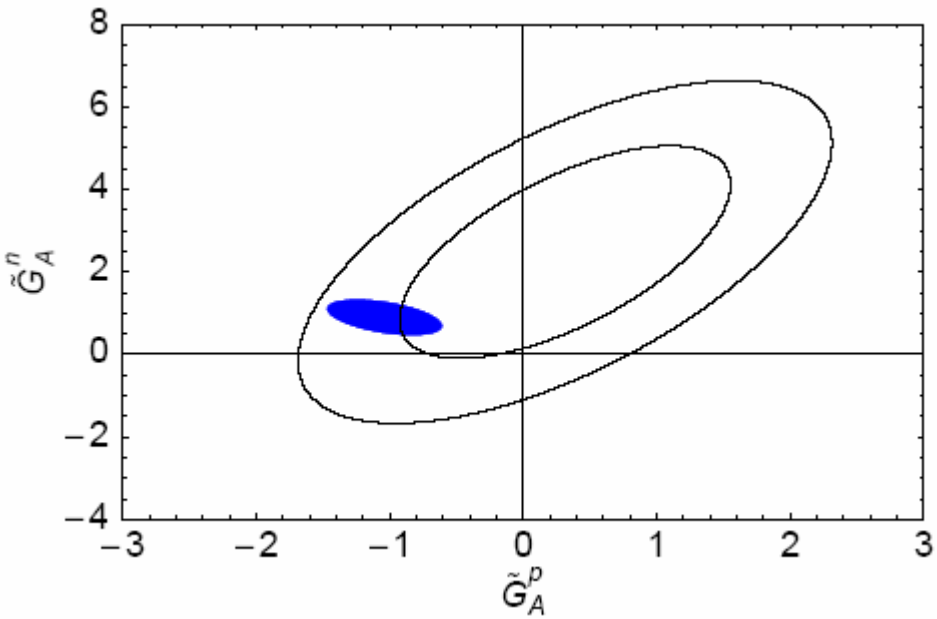


World Data pre-latest HAPPEx

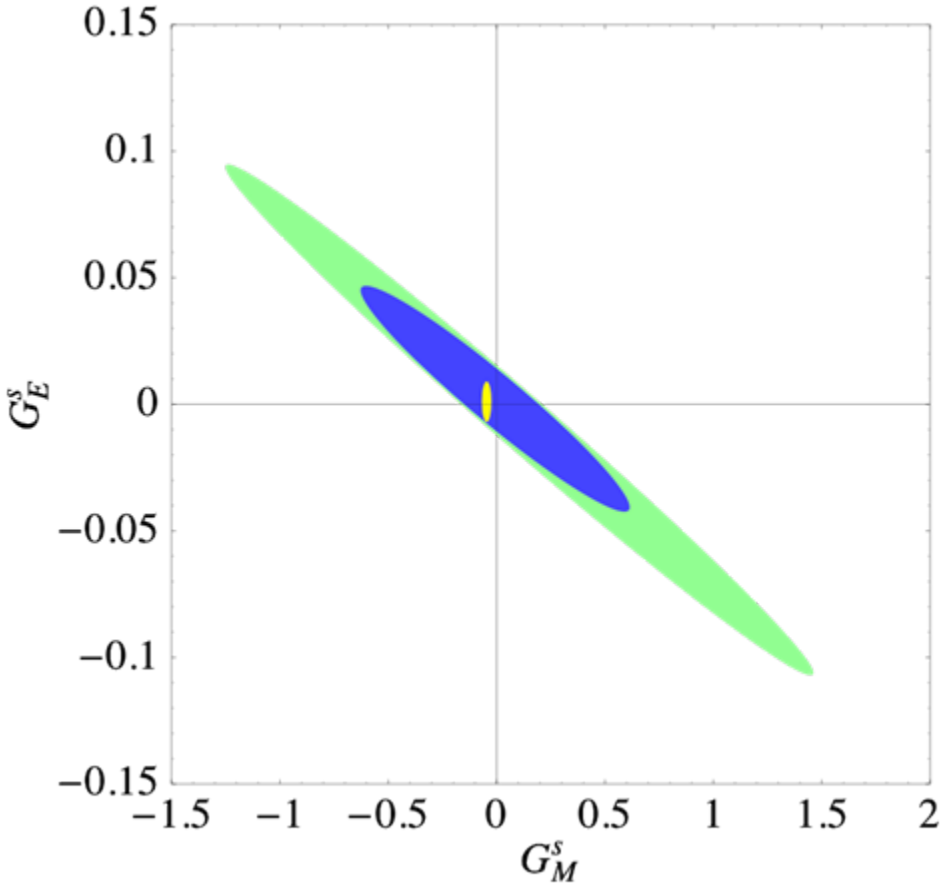
(Young et al., nucl-ex/0604010)

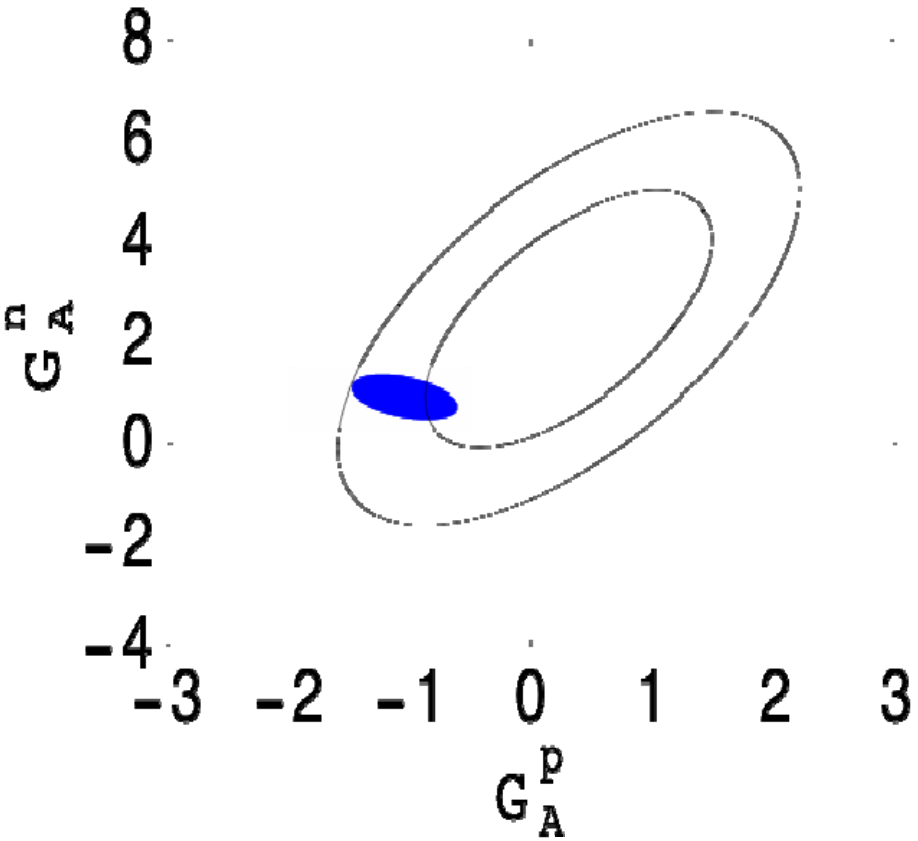
World Data with new HAPPEx

(Young, Roche, Carlini and Thomas, extended analysis)



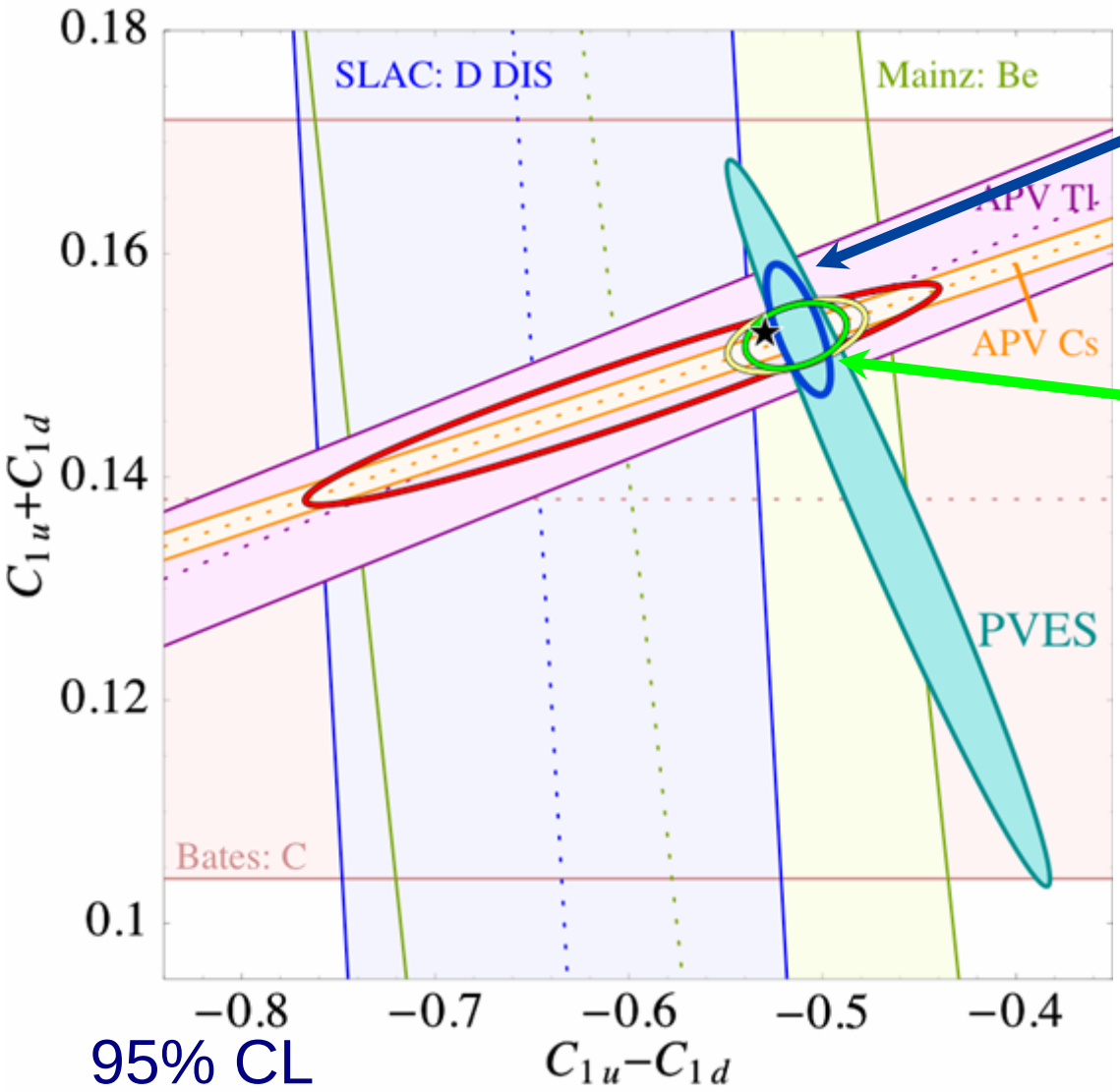
Theory Constraint?





Repeat analysis with theory as an input

Impact of theory?

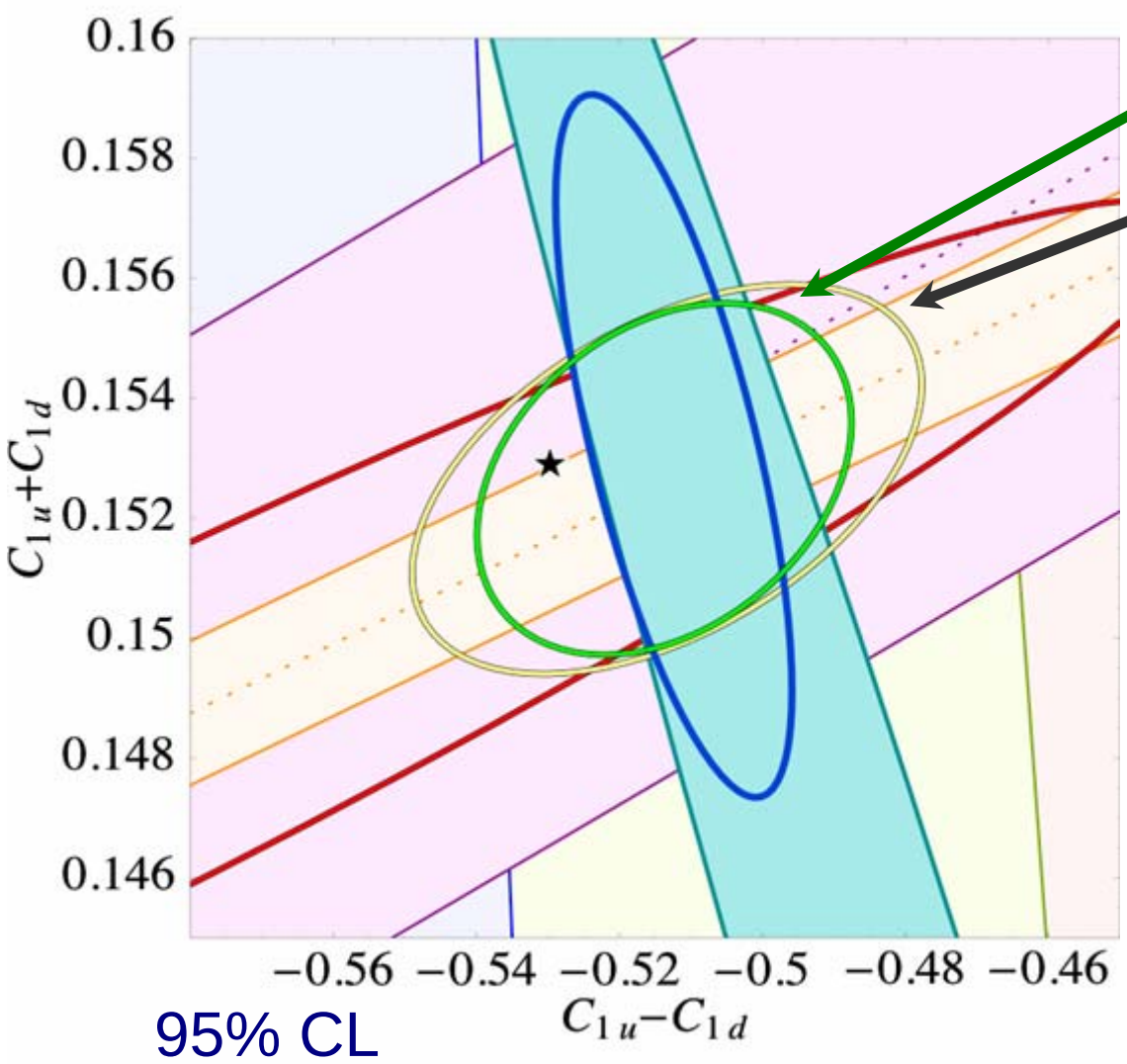


PVES with theory

Net constraint

95% CL

Conclusions unchanged



with theory

without theory

Results largely insensitive to best theory constraints.

Can simply use experimental constraints!

Budget (Cont'd.)

Other **Impacts of worst case**:

- **Nuclear physics running weeks reduced from a planned 36 to19.**
- **Research equipment needed in FY08 will not be built, resulting in about one lost year of research effort in FY07 and FY08.**
- **Efforts to restore full 6 GeV operation delayed.**
- **Infrastructure maintenance and improvements delayed:**
  puts DOE SC maintenance metrics at risk.

What will we do under worst case?:

- **Protect the Lab's future by protecting the 12 GeV Upgrade Project.**
- **Maintain the current workforce.**
- **Implement planned safety and cyber security improvements.**
- **Cut costs through reduced procurements.**
- **Selectively hire critical expertise needed to deliver 12 GeV Upgrade and research program.**
- **Reprogram some PED funds from base operations**
- **Terminate the experimental program for remainder of the year.**