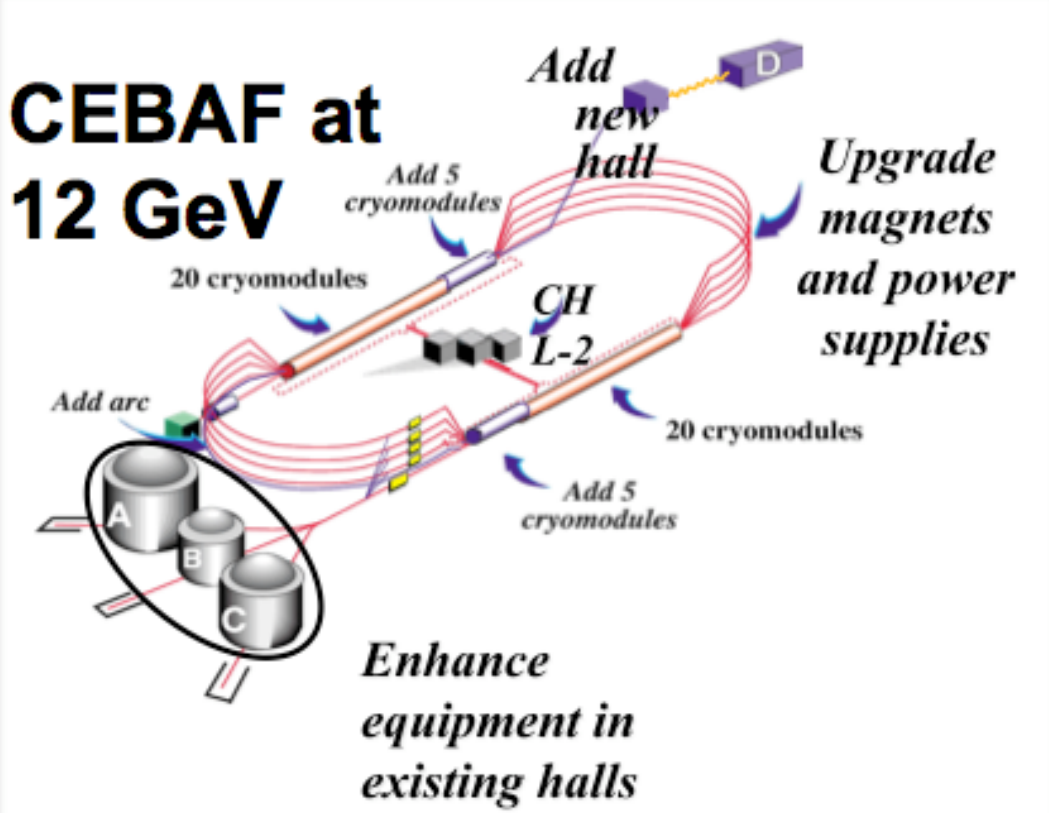
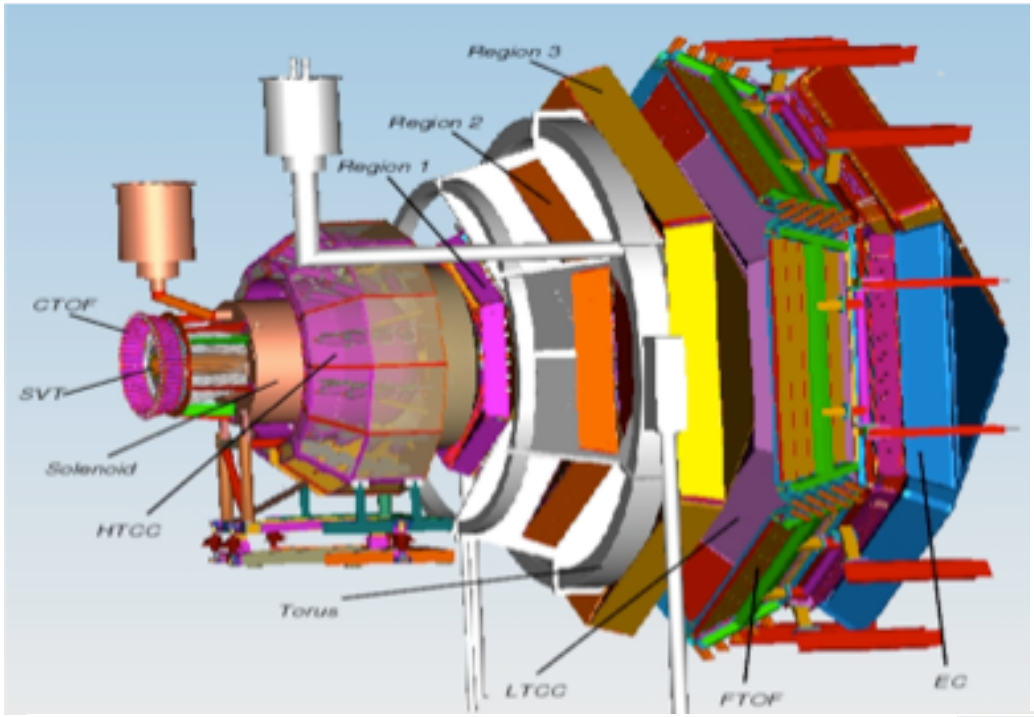
# JLab 12GeV Upgrade

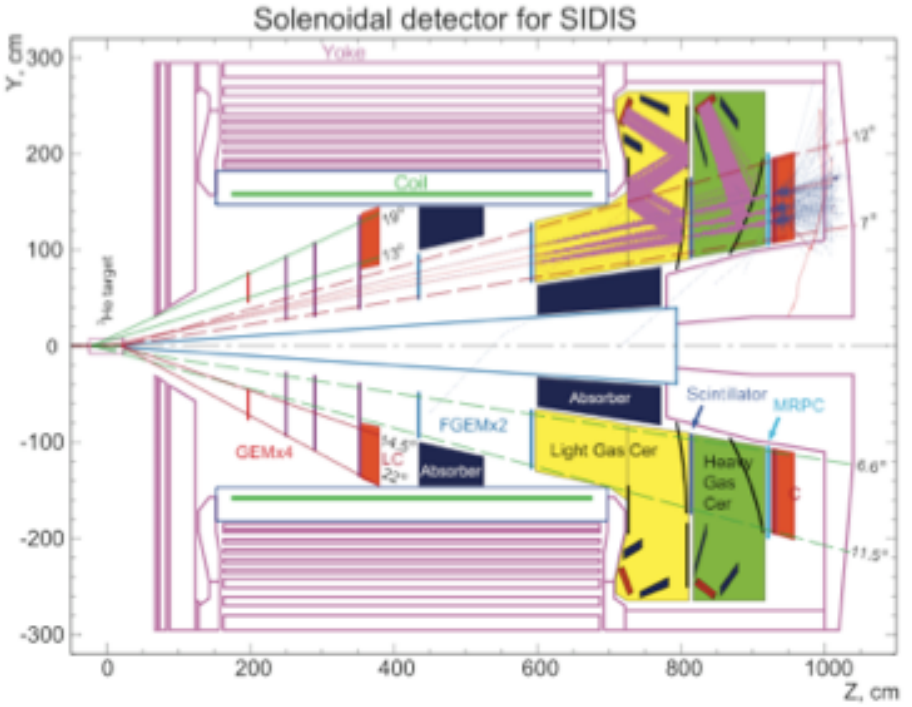
理研/RBRC
中川格

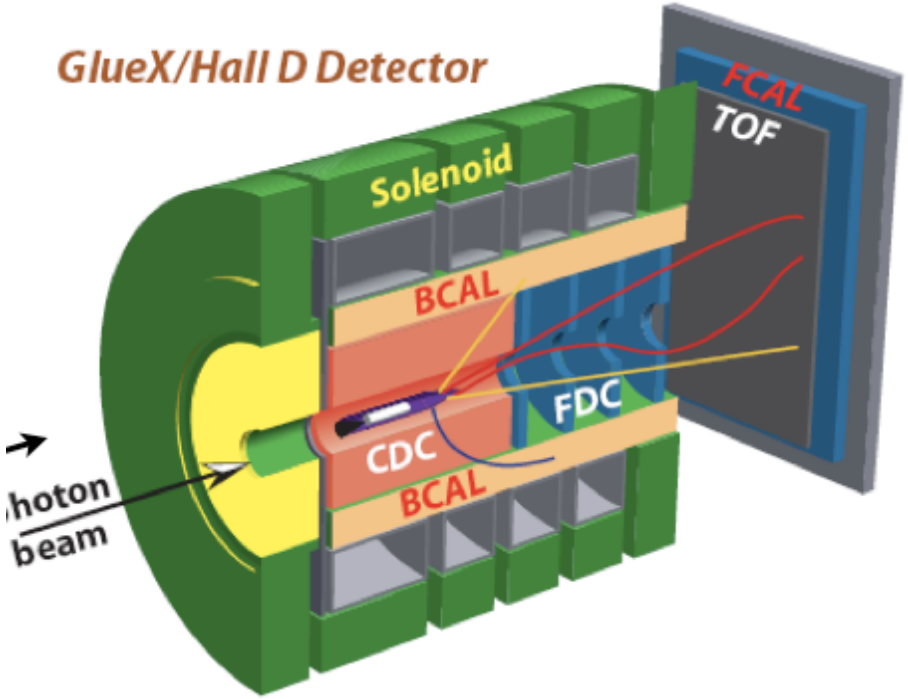
# JLab 12 GeV アップグレード

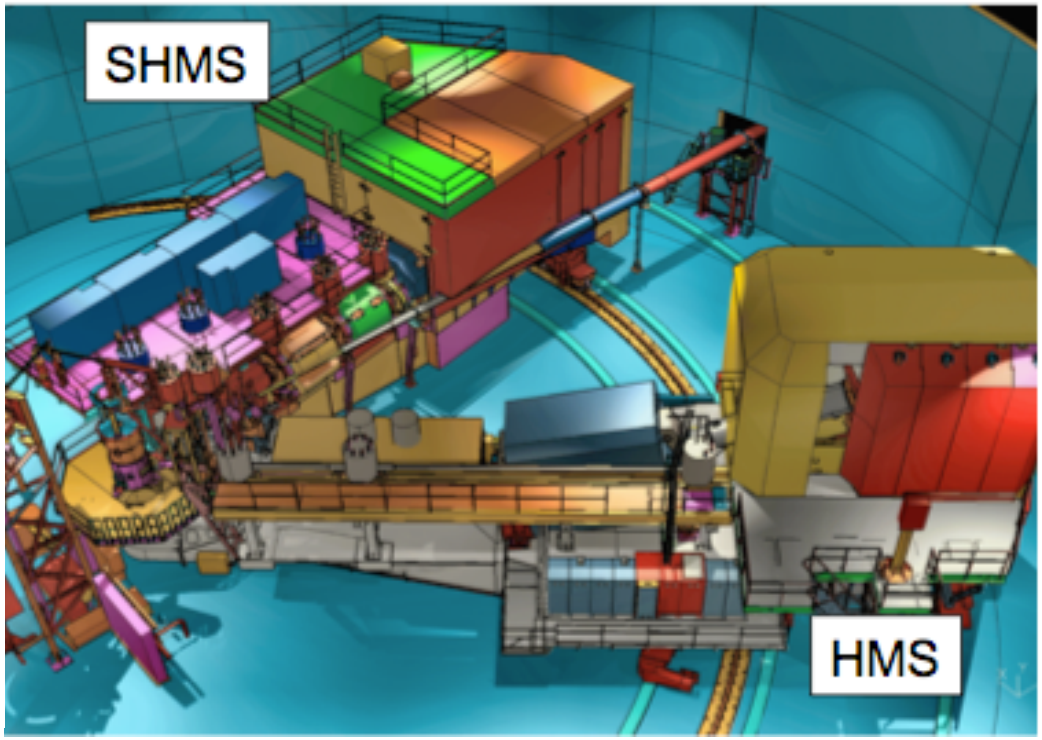



90年代半ばにスタートした実験はすでに140を越え、核子や原子核の構造、反応の理解に貢献してきた。JLabでは更なる詳細研究のため、現行のビームエネルギー6GeVから12GeVへのアップグレード計画が進行中である。すでに新しい実験Hall-Dの建設が始まっており、6GeVビームによる実験も12年には完了予定である。その後3年のシャットダウン期間を授け、2つのリニアックセクションにそれぞれ5基の加速管を追加、アークセクションに5番目のパスを接地する。また3つの実験Hall-A,B,Cの検出器群にも、それぞれ12GeVに適したデザインへのアップグレードが行われる。2013年からコミッショニングを始め、15年に実験が再開される予定である。

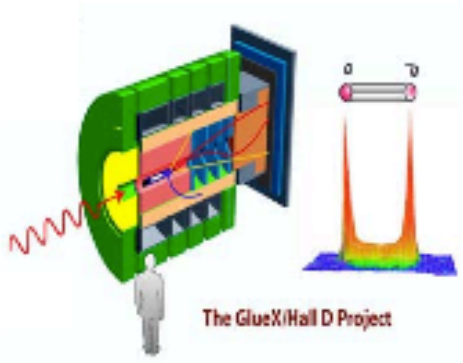

Region 3
Region 2
Region 1
CTOF
SVT
Solenoid
HTCC
Torus
LTCC
FTOF
EC

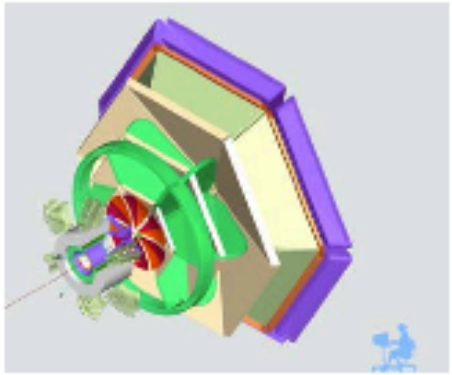

Solenoidal detector for SIDIS
Y, cm
Z, cm
Yoke
Coil
Absorber
Scintillator
MRPC
FGEMx2
GEMx4
Light Gas Cer
Heavy Gas Cer
Absorber

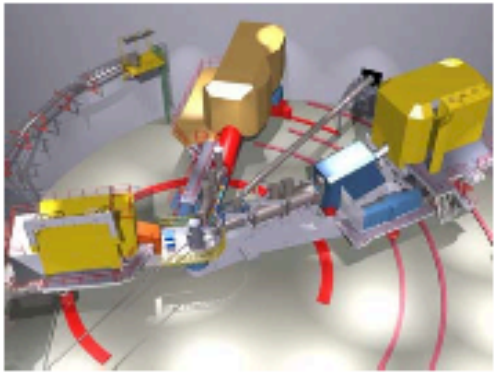

GlueX/Hall D Detector
FCAL
TOF
Solenoid
BCAL
FDC
CDC
BCAL
hoton
beam

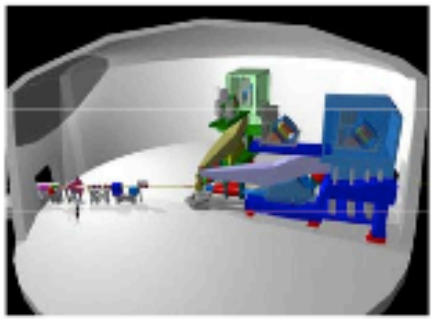

SHMS
HMS

# Overview of Upgrade Technical Performance Requirements



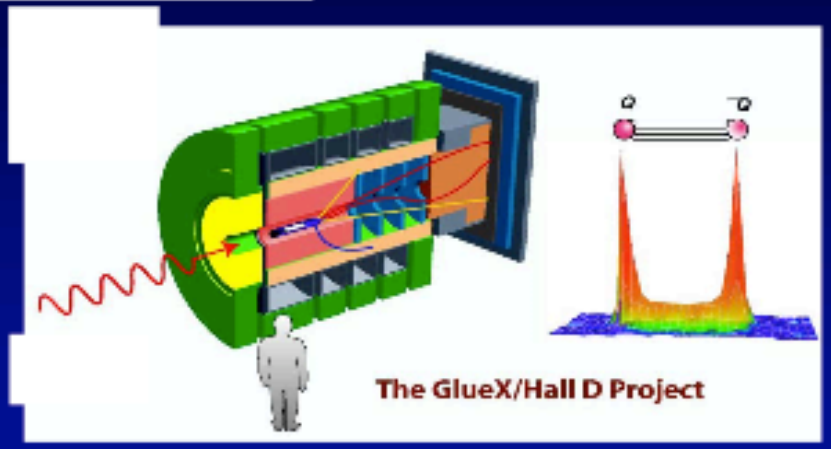


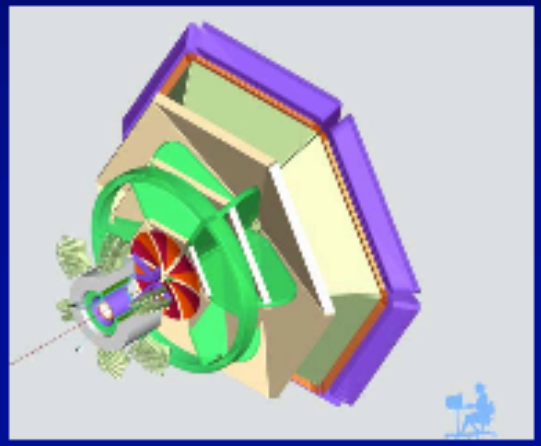


| Hall D | Hall B | Hall C | Hall A |
|---|---|---|---|
| excellent hermeticity | luminosity $10 \times 10^{34}$ | energy reach | installation space |
| polarized photons | hermeticity | precision | |
| $E_\gamma$~8.5–9 GeV | 11 GeV beamline | | |
| $10^8$ photons/s | target flexibility | | |
| good momentum/angle resolution | | excellent momentum resolution | |
| high multiplicity reconstruction | | luminosity up to $10^{38}$ | |
| particle ID | | | |

# 12 GeV Capabilities

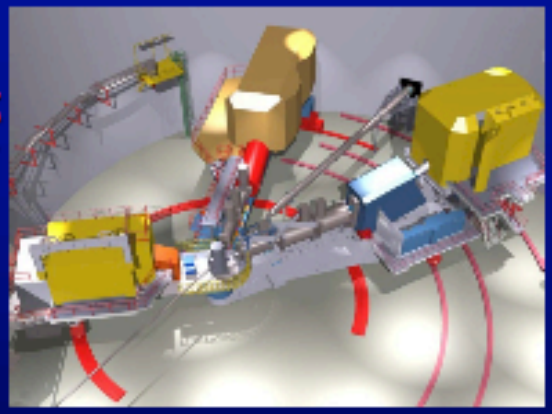
*Hall D* – exploring origin of **confinement** by studying **exotic mesons**

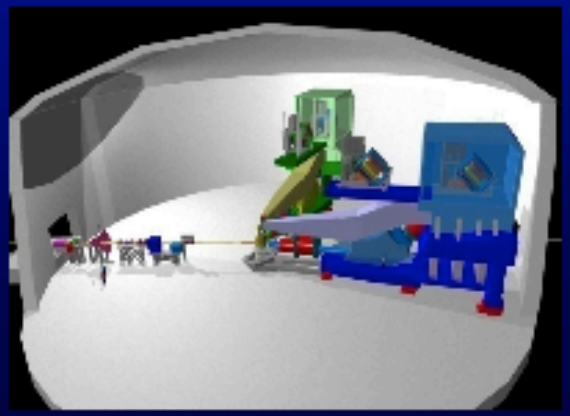


*Hall B* – understanding **nucleon structure** via **generalized parton distributions**

*Hall C* – precision determination of **valence quark properties in nucleons and nuclei**



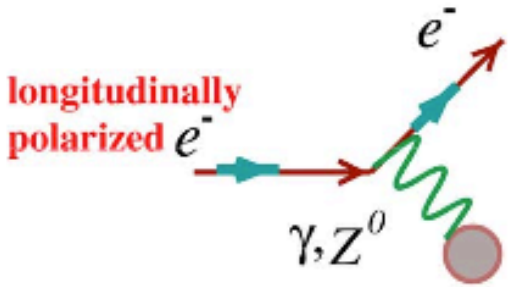


*Hall A* – short range correlations, form factors, hyper-nuclear physics, future **new experiments**

# Highlights of the 12 GeV Science Program

- Unlocking secrets of QCD: quark confinement
- New and revolutionary access to the structure of the proton and neutron
- Discovering the quark structure of nuclei
- High precision tests of the Standard Model

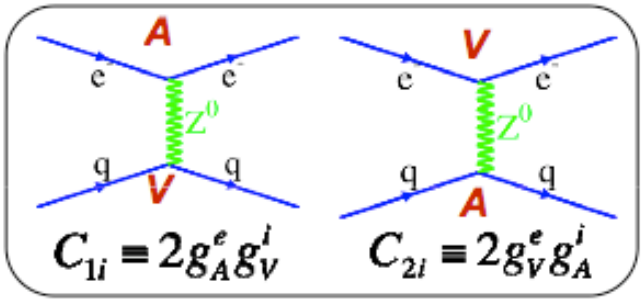
# PV Asymmetries: Any Target




$$\sigma \;\alpha\; |A_\gamma + A_{weak}|^2$$

$$-A_{LR} = A_{PV} = \frac{\sigma_{\uparrow} - \sigma_{\downarrow}}{\sigma_{\uparrow} + \sigma_{\downarrow}} \sim \frac{A_{weak}}{A_\gamma} \sim \frac{G_F Q^2}{4\pi\alpha}\left(g_A^e g_V^T + \beta\, g_V^e g_A^T\right)$$

# Electron-Quark Phenomenology




$$C_{1u} = -\tfrac{1}{2} + \tfrac{4}{3}\sin^2(\theta_W) + \delta C_{1u} \approx -0.19$$
$$C_{1d} = \tfrac{1}{2} - \tfrac{2}{3}\sin^2(\theta_W) + \delta C_{1d} \approx 0.35$$
$$C_{2u} = -\tfrac{1}{2} + 2\sin^2(\theta_W) + \delta C_{2u} \approx -0.030$$
$$C_{2d} = \tfrac{1}{2} - 2\sin^2(\theta_W) + \delta C_{2d} \approx 0.025$$

Moller PV is insensitive to the $C_{ij}$

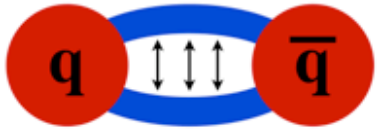
***$C_{1u}$ and $C_{1d}$ will be determined to high precision by $Q_{weak}$, APV Cs***

# Overview of the GlueX Experiment

*a "Quark Model" meson:*


MESON

*but hybrids are also predicted:*




HYBRID MESON

and would shed light on

**Gluonic eXcitations**

*must have "conventional" quantum numbers:*

| | | | |
|---|---|---|---|
| $J^{PC}$ | = | $0^{-+}$ $(\eta,\pi)$ | [S = 0; L = 0; J = 0] |
| | | $0^{++}$ $(f_0,a_0)$ | [S = 1; L = 1; J = 0] |
| | | $1^{++}$ $(f_1,a_1)$ | [S = 1; L = 1; J = 1] |
| | | $1^{+-}$ $(h_1,b_1)$ | [S = 0; L = 1; J = 1] |
| | | $1^{--}$ $(\omega,\rho)$ | [S = 1; L = 0; J = 1] |
| | | etc. | |

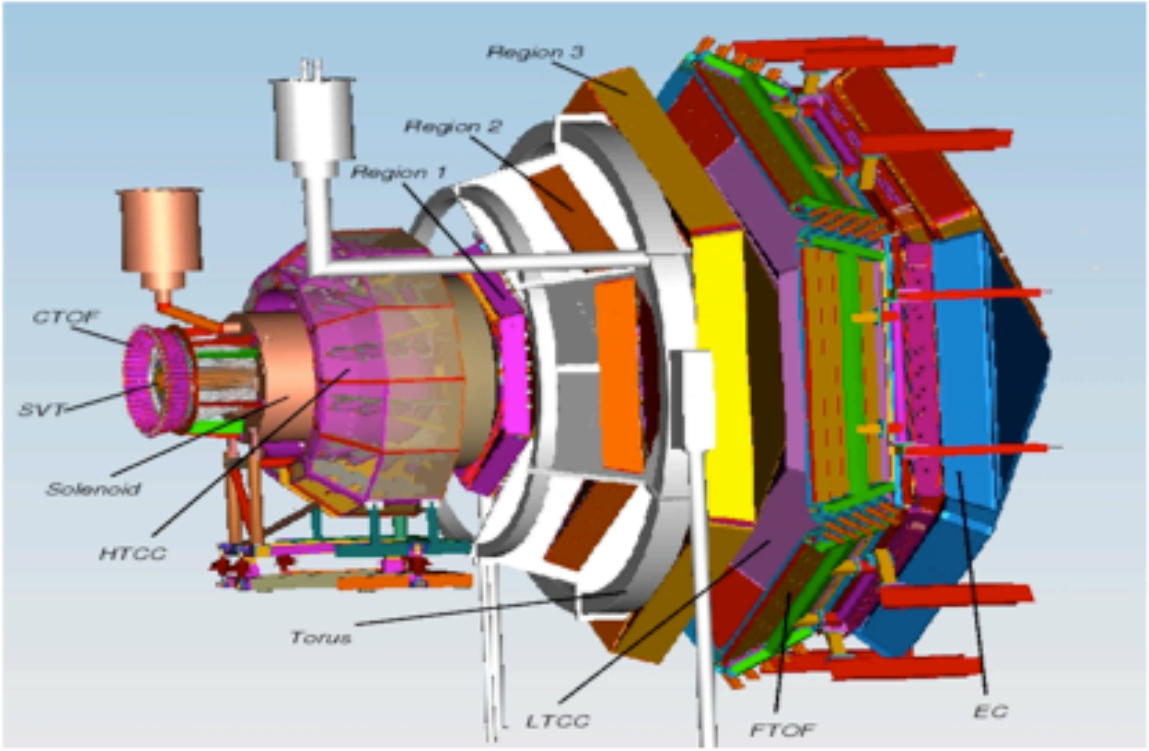
- produce **hybrid mesons** with exotic $J^{PC}$:

*can have "exotic" quantum numbers:*

$J^{PC}$ = $1^{-+}$ $(\eta_1,\pi_1)$ *(for example)*

⇒ ***unambiguous signature for a state beyond the quark model!***

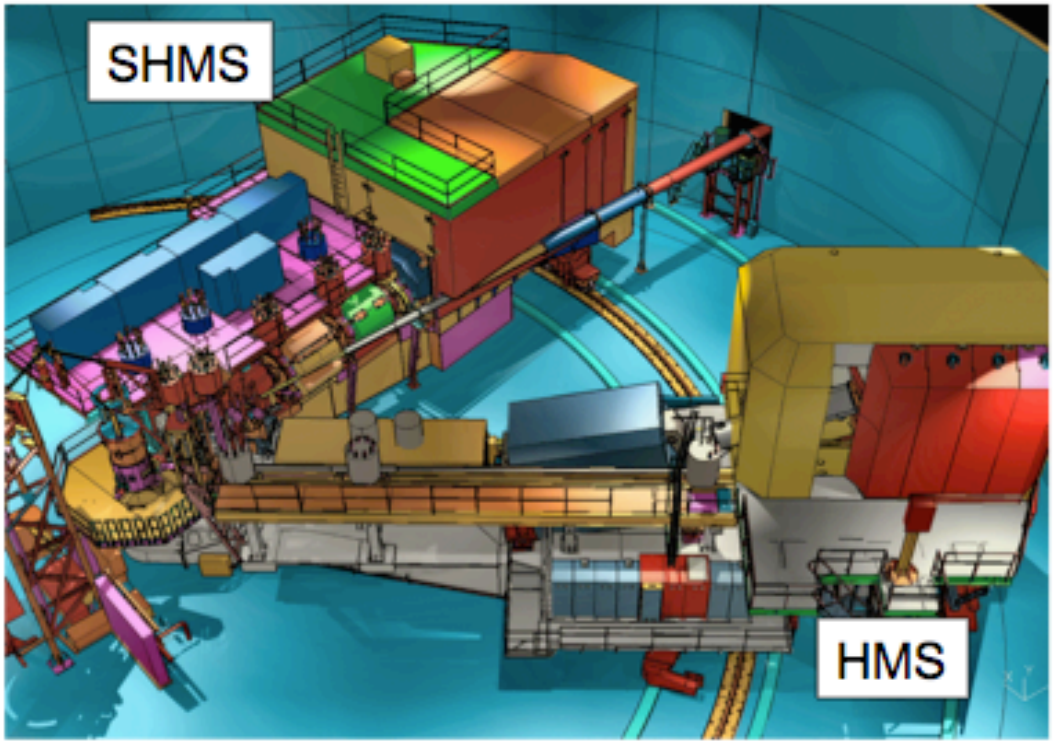
# JLab SIDIS Program: Hall B




CLAS 12 Spectrometer
→large acceptance
$L=10^{35}\ cm^{-2}s^{-1}$
→2 sectors of low-threshold Cerenkov can be replaced with RICH for improved kaon ID

CLAS12 in Hall B will be the "workhorse" of SIDIS at JLab
→ Access to large phase space
→ Measurements of cross sections, single-spin, double-spin asymmetries with full azimuthal acceptance
→Polarized proton and deuteron targets

# JLab SIDIS Program: Hall C




Hall C will provide 2 moderate acceptance, magnetic focusing spectrometers:

**HMS:**
High Momentum Spectrometer
$d\Omega$ ~ *6* msr, $P_0$= *0.5 – 7 GeV/c*
$\theta_0$=*10.5 to 80 degrees*

**SHMS:**
Super-HMS
$d\Omega$ ~ *5* msr, $P_0$= *1 – 11 GeV/c*
$\theta_0$=*5.5 to 40 degrees*

→Spectrometers provide excellent control of systematic uncertainties
→Identical acceptance for positively, negatively charged particles

***Ideal for precision cross section or charge-ratio ($\pi/\pi^+$) measurements***

# Hall C – 12 GeV SIDIS Program

*Approved Hall C SIDIS experiments (so far …)*

Measurement of the Ratio $R=\sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering (E12-06-104)
*Spokespersons: P. Bosted, R. Ent, H. Mkrtchyan*

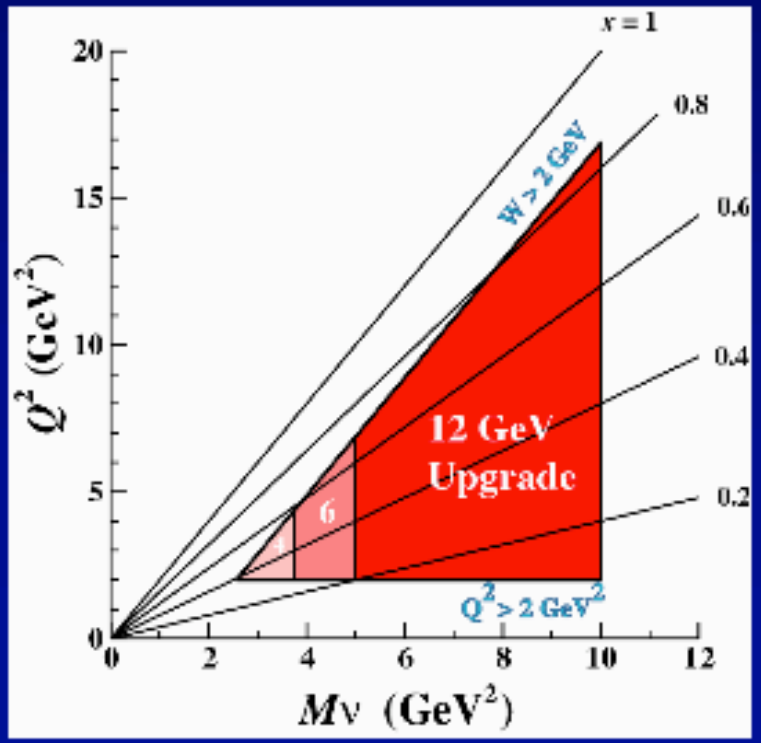
Transverse Momentum Dependence of Semi-Inclusive Pion Production (E12-09-017)
*Spokespersons: P. Bosted, R. Ent, H. Mkrtchyan*

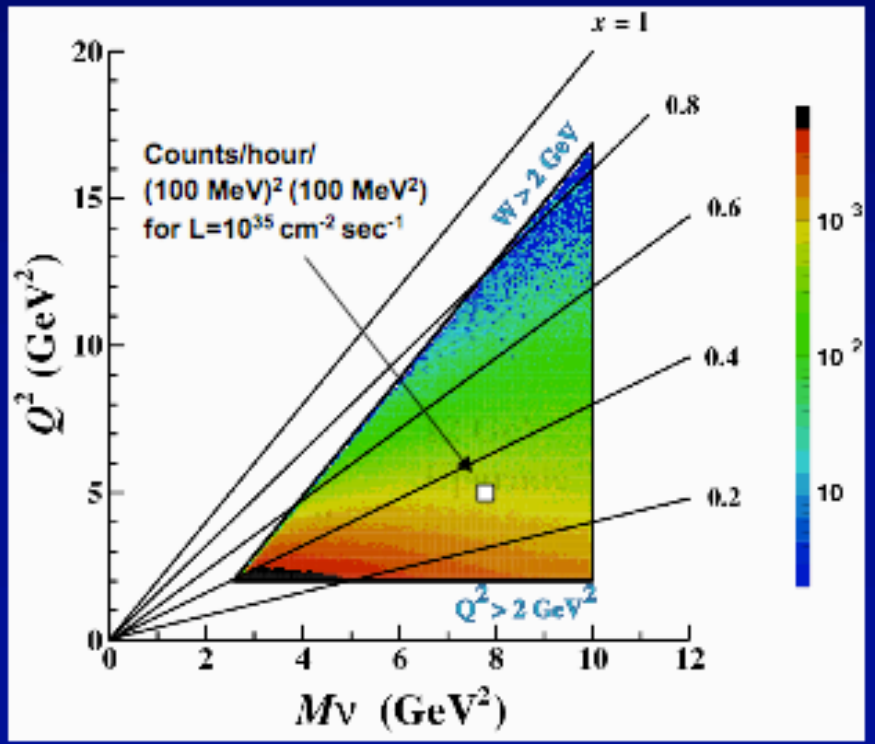
Precise Measurement of $\pi+/\pi-$ Ratios in Semi-inclusive Deep Inelastic Scattering: Charge Symmetry violating Quark Distributions (E12-09-002)
*Spokespersons: K. Hafidi, D. Dutta, D. Gaskell*

# Quark Structure of Nuclei

- (Nucleons and Pions) or (Quarks and Gluons)?
- Not a simple convolution of free nucleon structure with Fermi motion
- In nuclear deep-inelastic scattering, we look directly at the quark structure of nuclei

## 12 GeV Upgrade Provides Substantially Enhanced Access to the DIS Regime

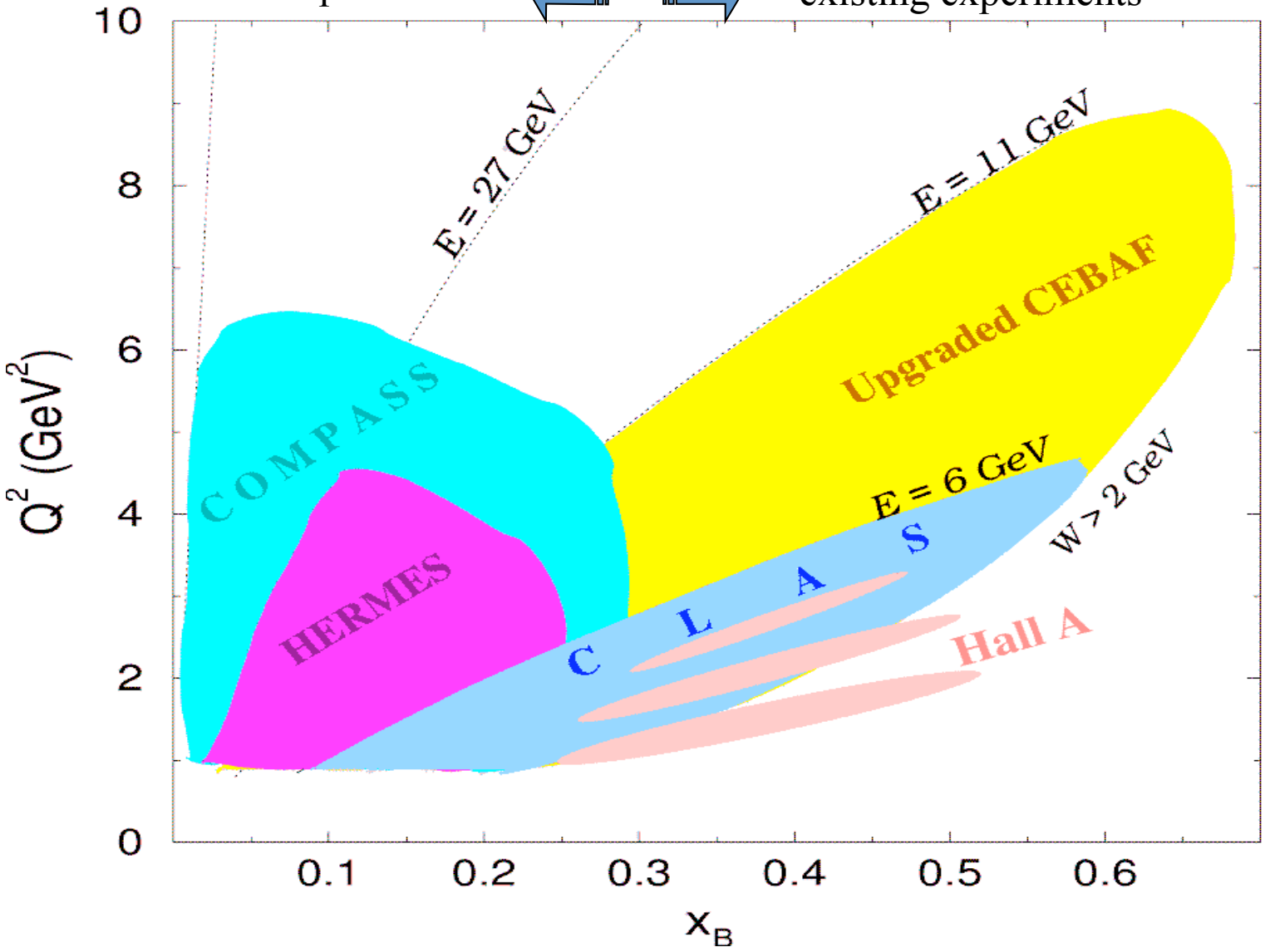


# Kinematics for deeply excl. experiments

compete with other experiments

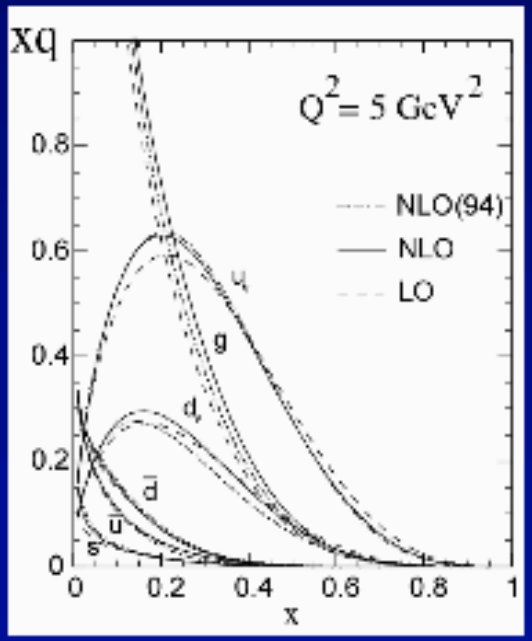
no overlap with other existing experiments

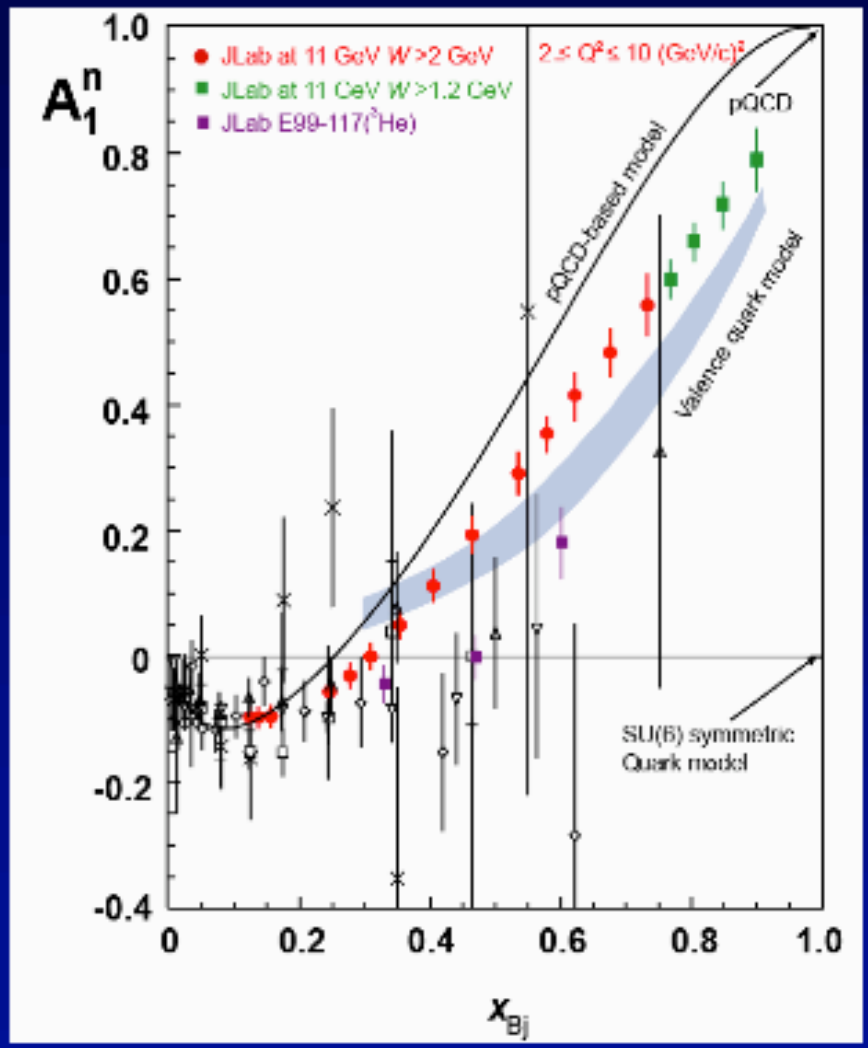


# Measuring High-x Structure Functions

**REQUIRES:**

- High beam polarization
- High electron current
- High target polarization
- Large solid angle spectrometers




**12 GeV will access the regime (x > 0.3), where valence quarks dominate**

# Flavor decomposition using SIDIS

Valence quarks

$E_e$ =11 GeV $NH_3$+He3