New Measurement of the EMC Effect In ^{3}He and ^{4}He

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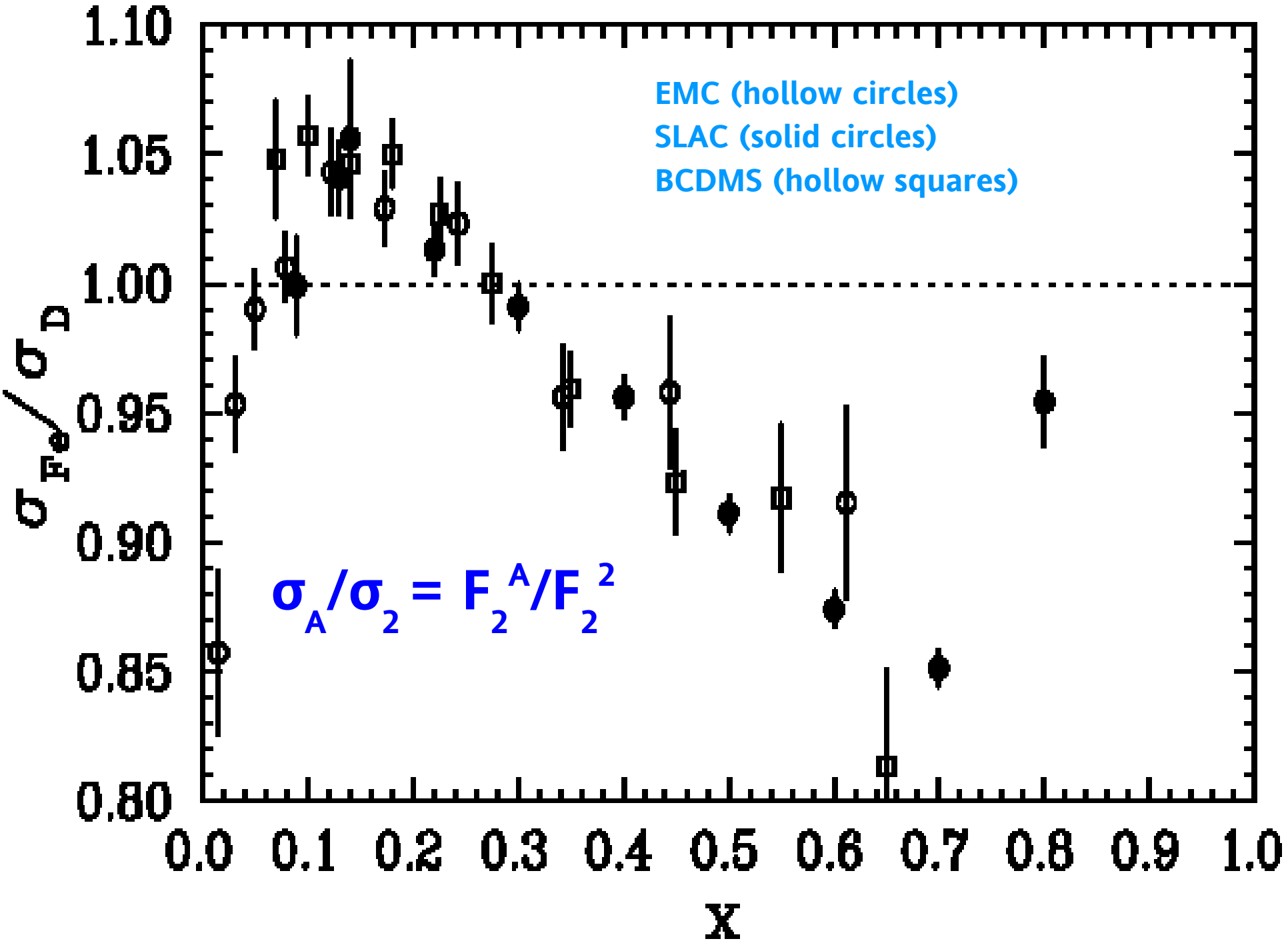
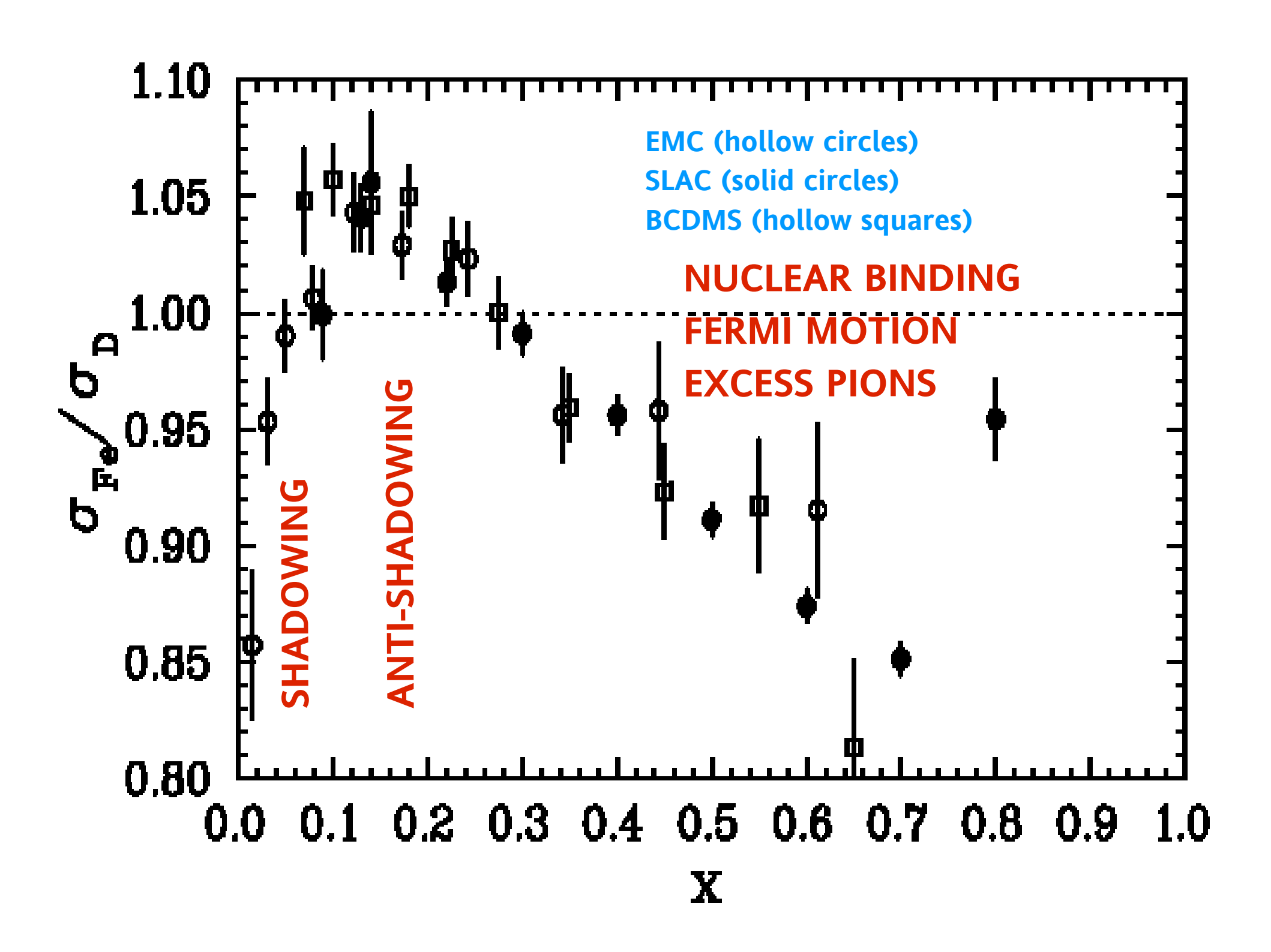
for the
E03-103 Collaboration
Jefferson Lab, Hall C

DIS 06
Tsukuba, Japan
April 22, 2006


EMC (hollow circles)
SLAC (solid circles)
BCDMS (hollow squares)
$\sigma_A/\sigma_2 = F_2^A/F_2^2$
σ_{Fe}/σ_D
x
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

The EMC effect has been with us for over 20 years.

much experimental and theoretical effort has been devoted
to understanding the details.


EMC (hollow circles)
SLAC (solid circles)
BCDMS (hollow squares)
NUCLEAR BINDING
FERMI MOTION
EXCESS PIONS
SHADOWING
ANTI-SHADOWING
σ Fe / σ D
x
1.10
1.05
1.00
0.95
0.90
0.85
0.80
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0

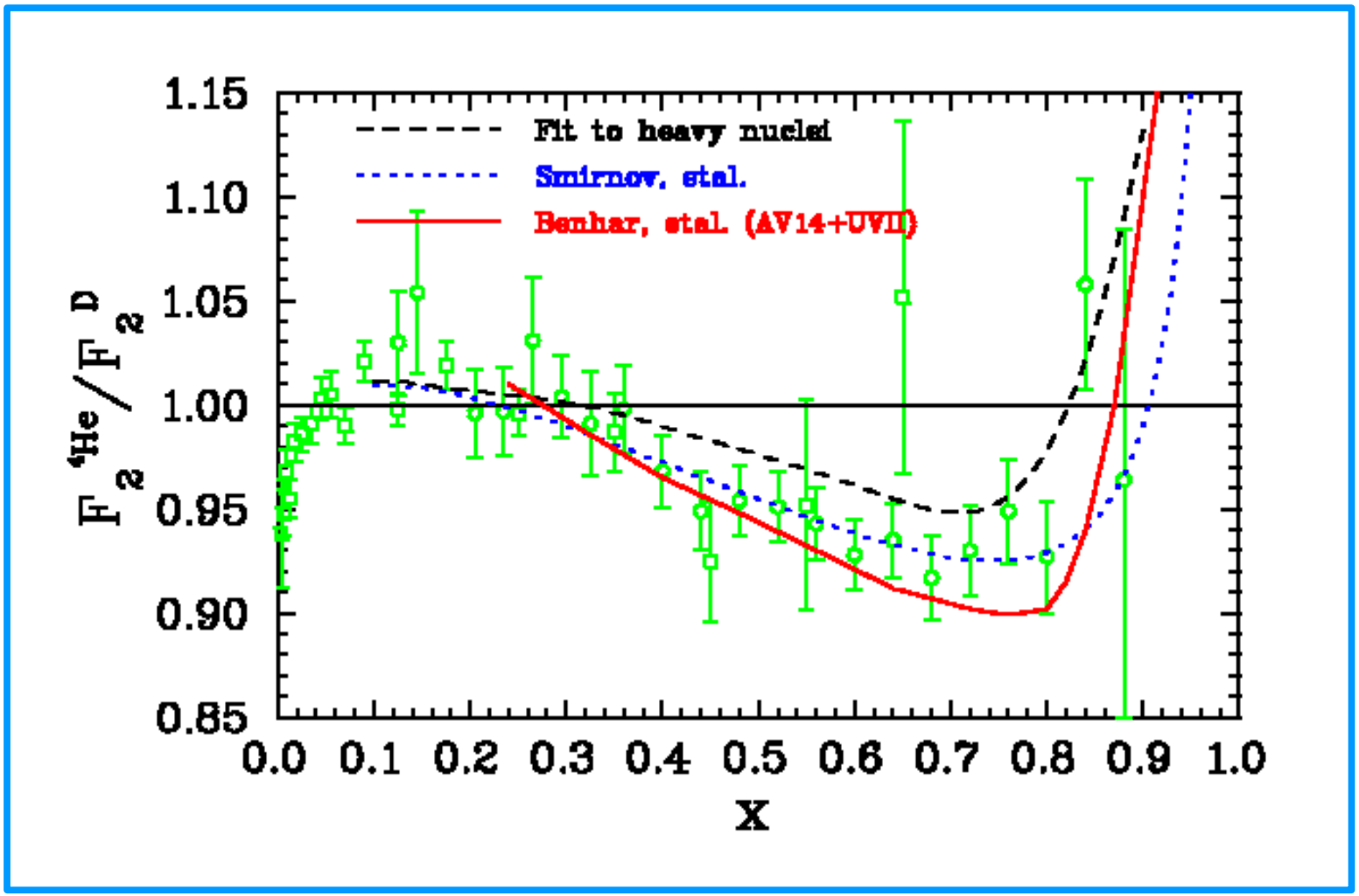
The EMC effect has been with us for over 20 years.

much experimental and theoretical effort has been devoted to understanding the details of the effect.

most of effort has been focused on heavy targets (C, Fe, Au…)

There is a dearth of data for light targets.

- **^{4}He – well studied by SLAC, but need more precision**
- **^{3}He – low x studied at HERMES, no data for x>0.4**
- **^{3}H – no data**



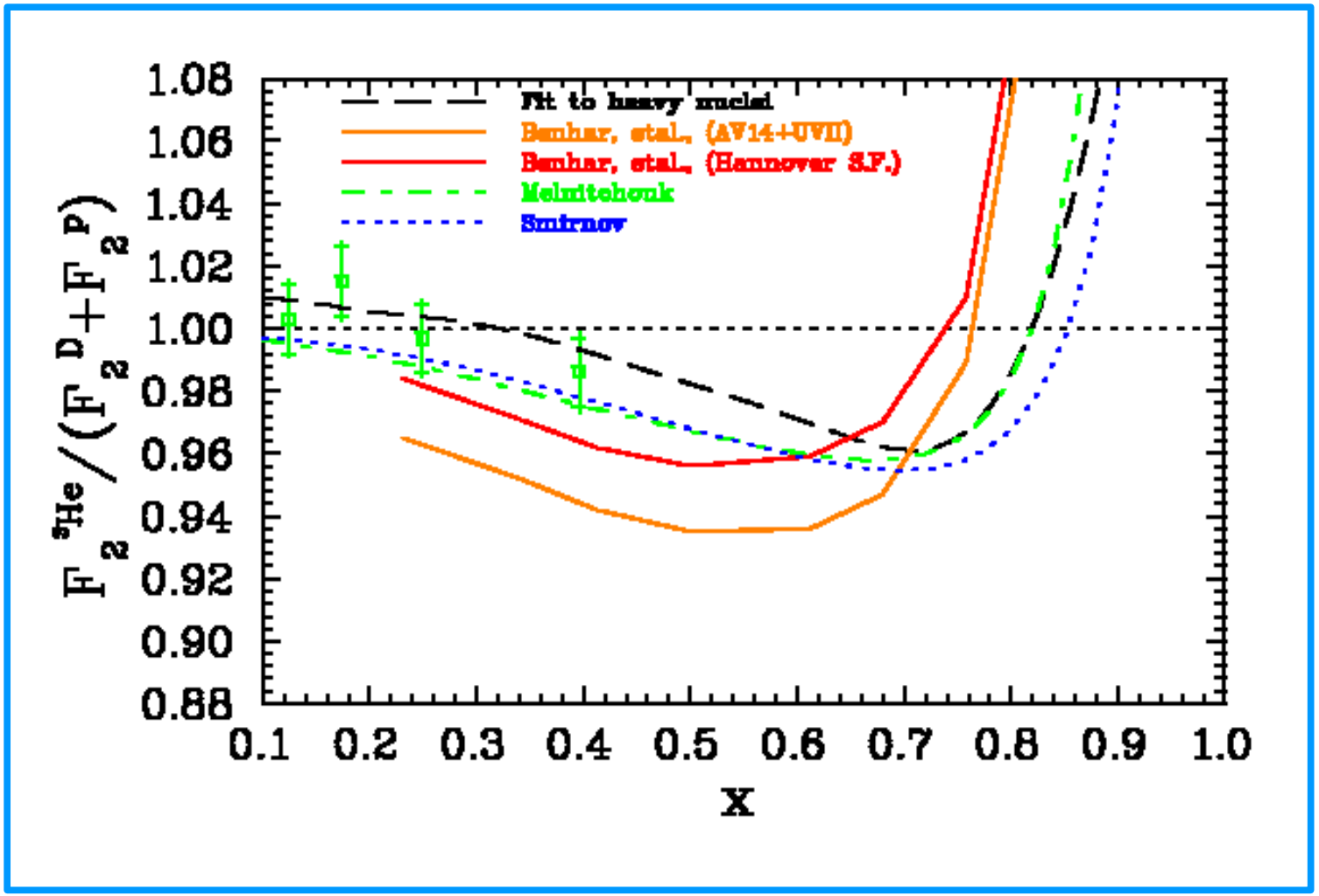
^{4}He

Anomalously tightly bound

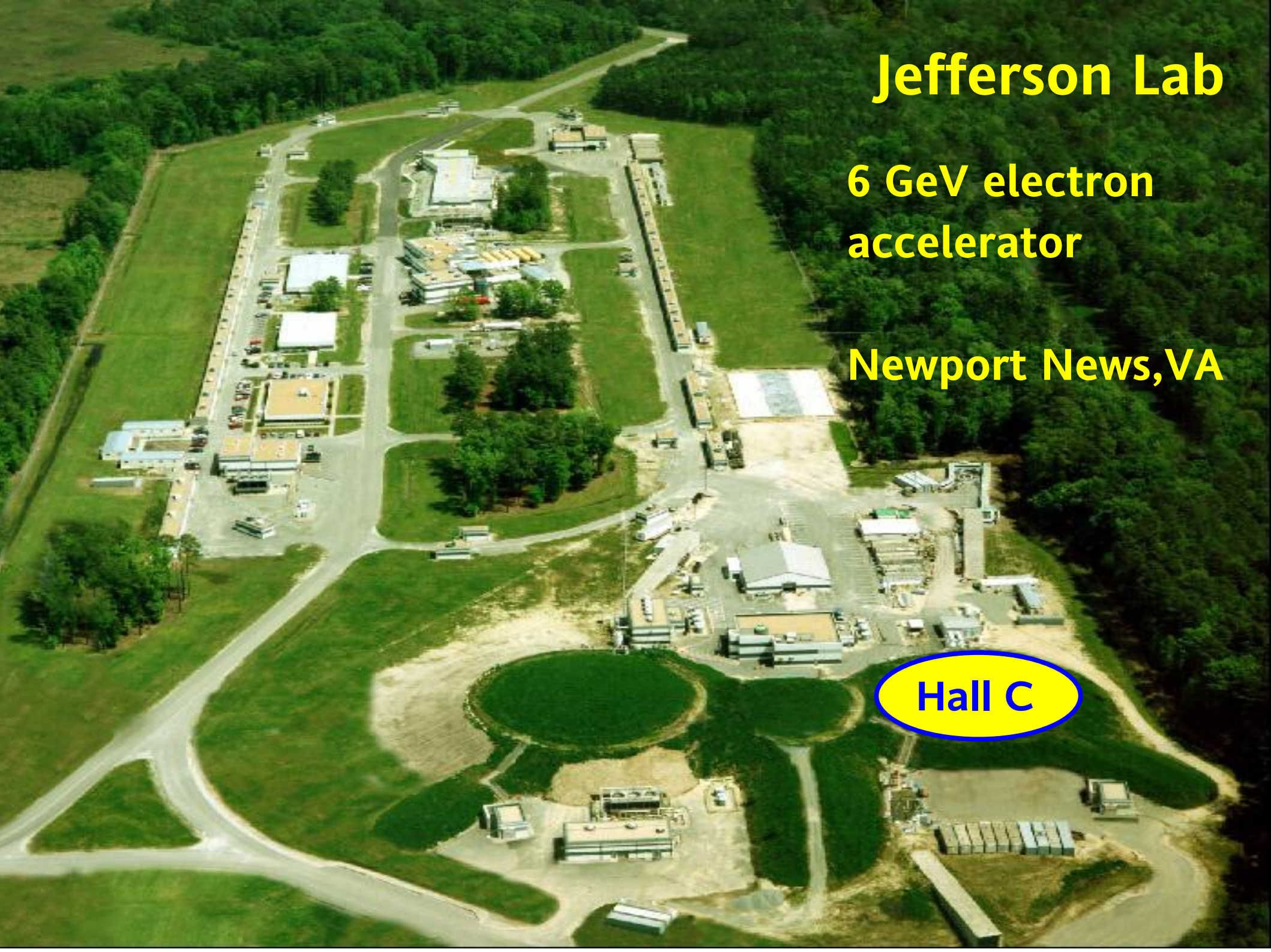
well studied at SLAC: need more precision

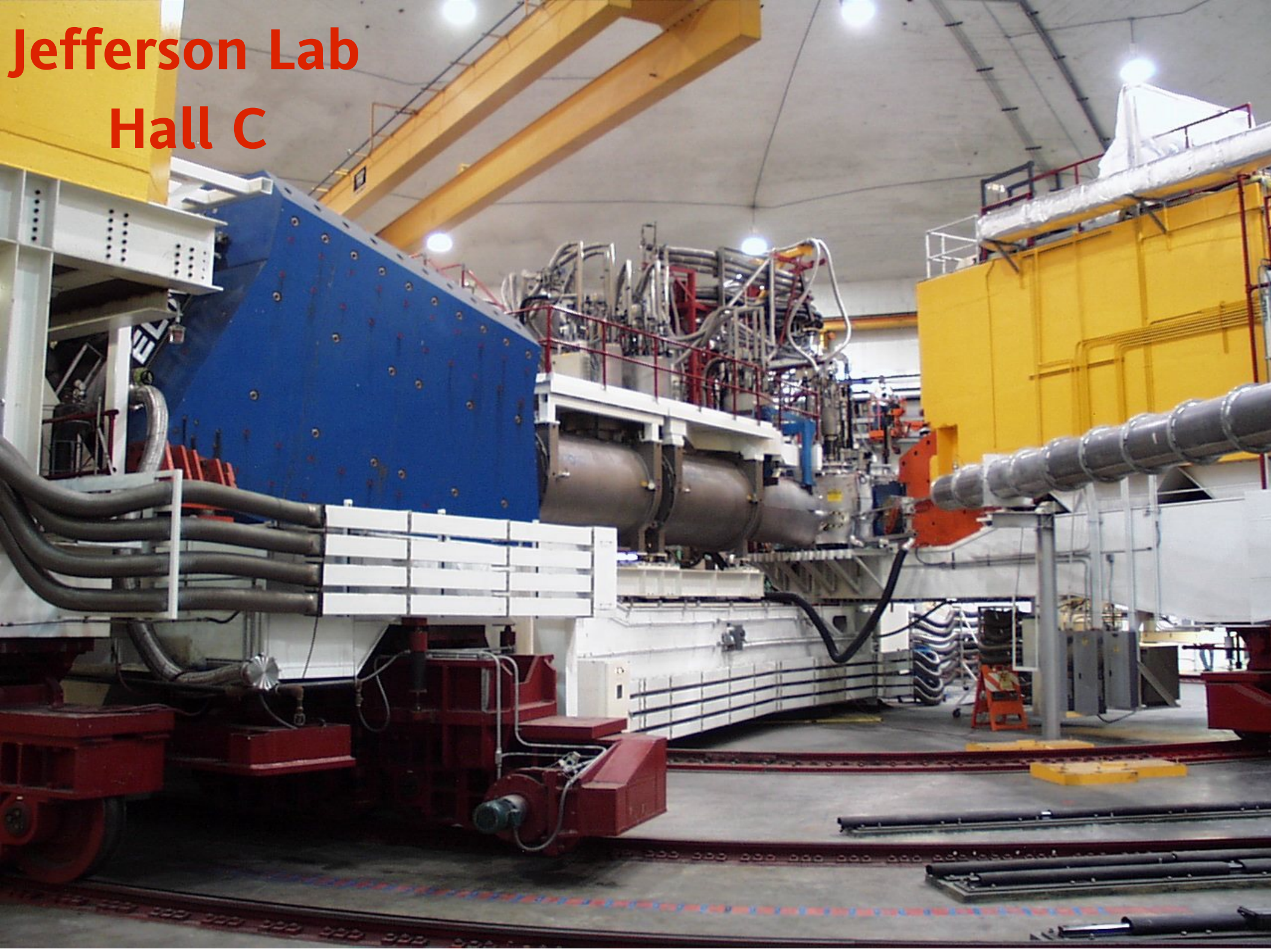
^{3}He

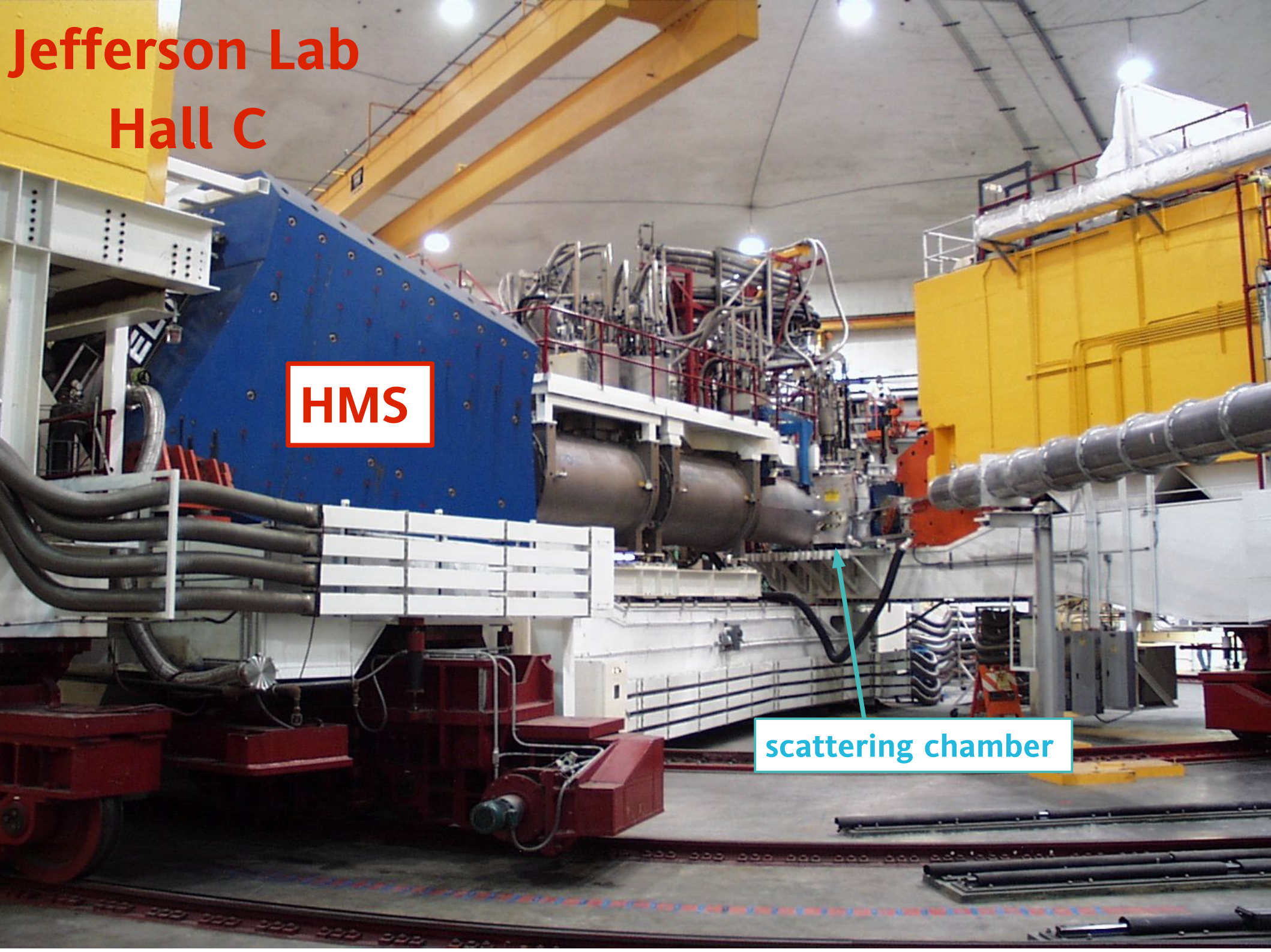
low x data from HERMES, but no data for x>0.4




Jefferson Lab


Jefferson Lab
6 GeV electron accelerator
Newport News,VA
Hall C


Jefferson Lab
Hall C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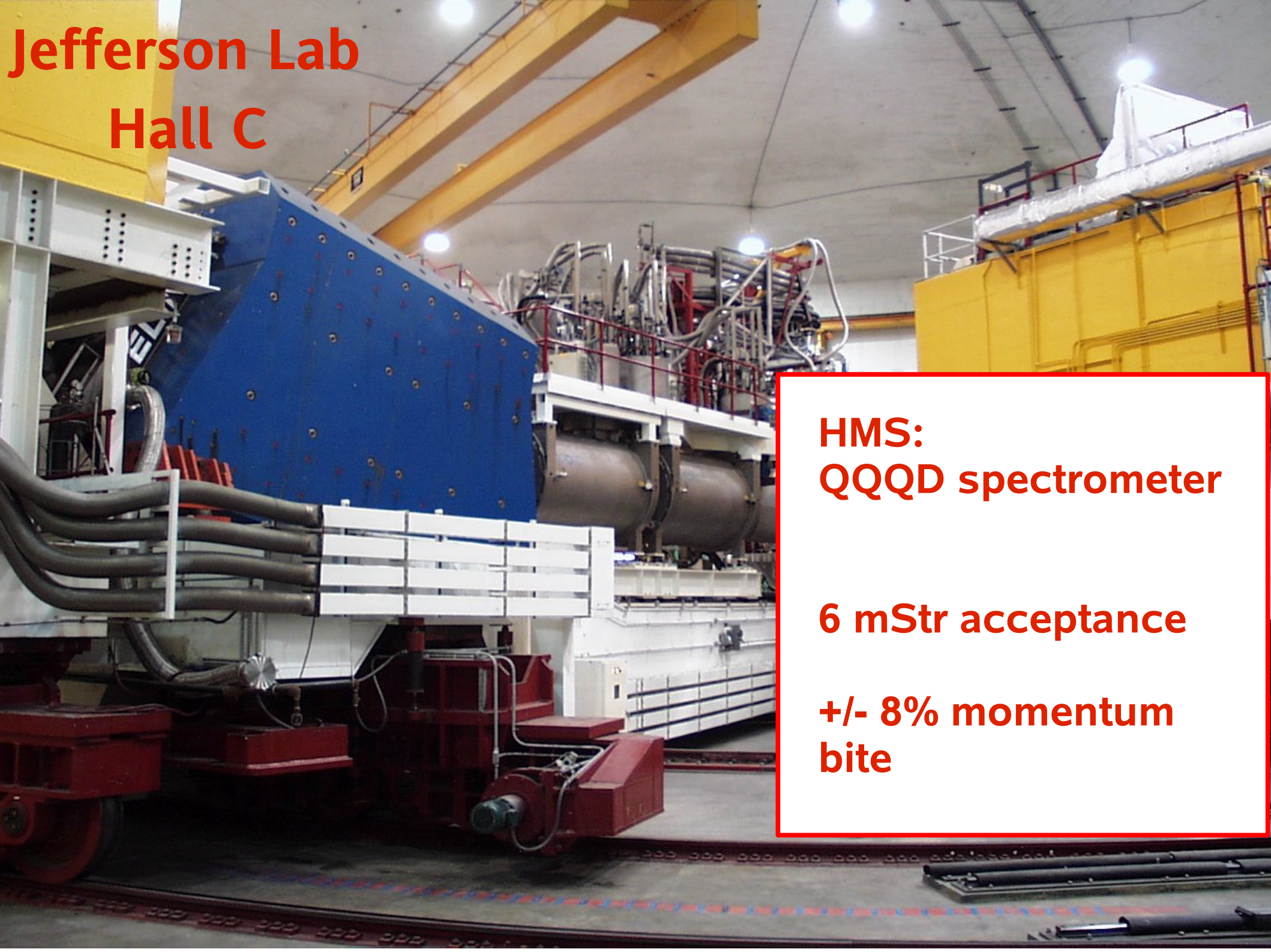
HMS
scattering chamber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HMS:
QQQD spectrometer
6 mStr acceptance
+/- 8% momentum
bite

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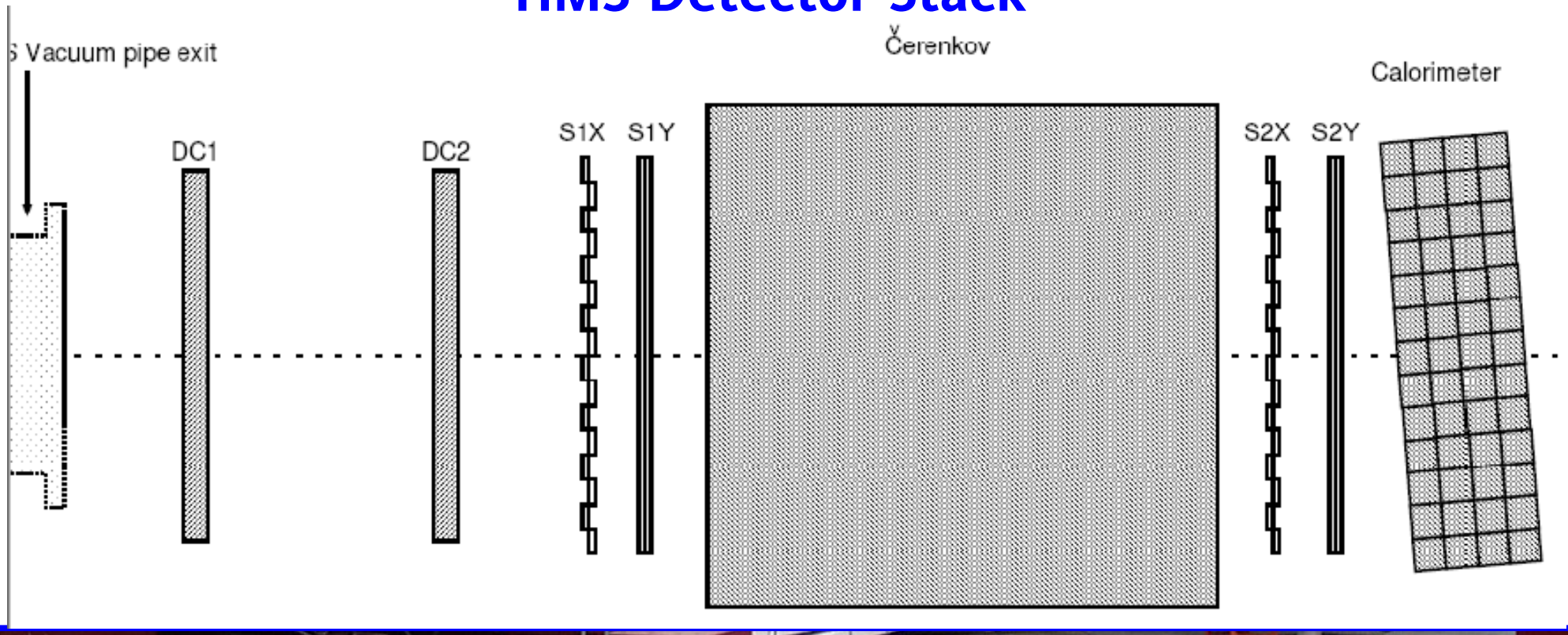
HMS Detector Stack



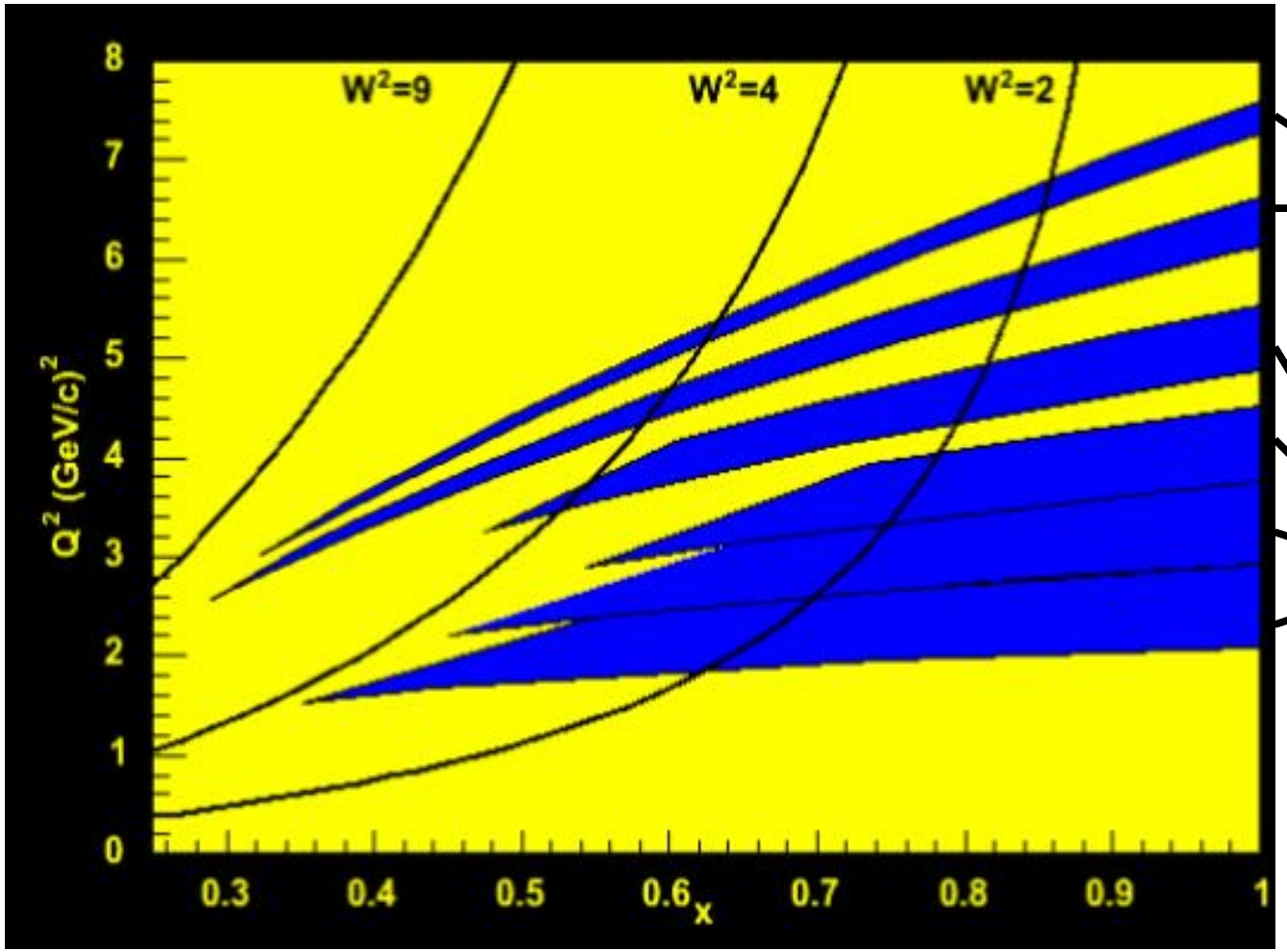
E03-103: EMC effect in light nuclei

Measurment of inclusive electron scattering cross section from H, ^{2}H, ^{3}He, ^{4}He, B, C, Cu, Au

5.67 GeV electron beam

Single-arm measurement in HMS

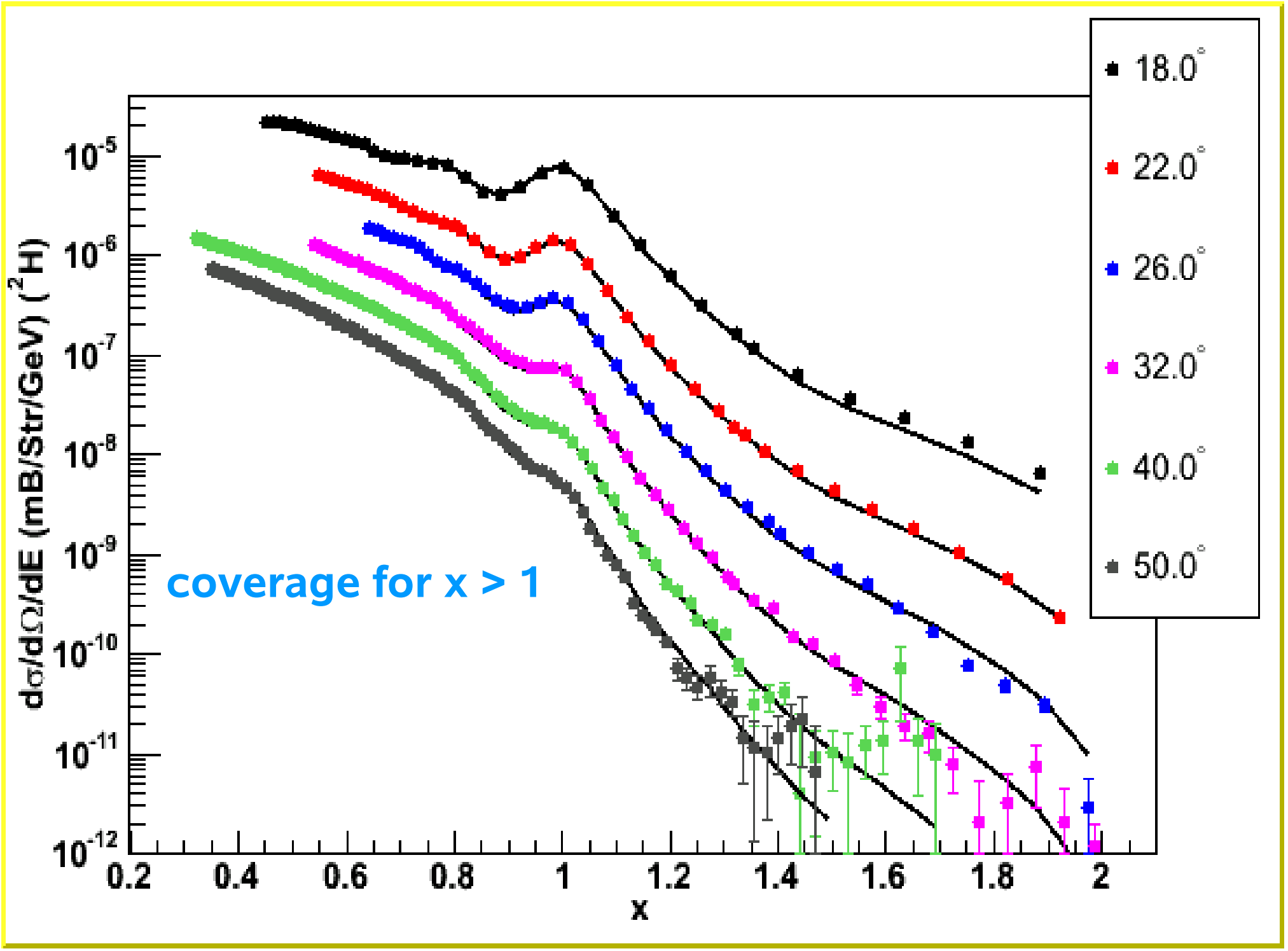
Kinematic Coverage:



Data taken at six angles

main EMC extraction done using large angle (highest Q^2) data.

other angles will provide detailed Q^2 dependence study.


18.0°
22.0°
26.0°
32.0°
40.0°
50.0°
coverage for x > 1
dσ/dΩ/dE (mB/Str/GeV) (^{2}H)
x
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}
10^{-12}
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2

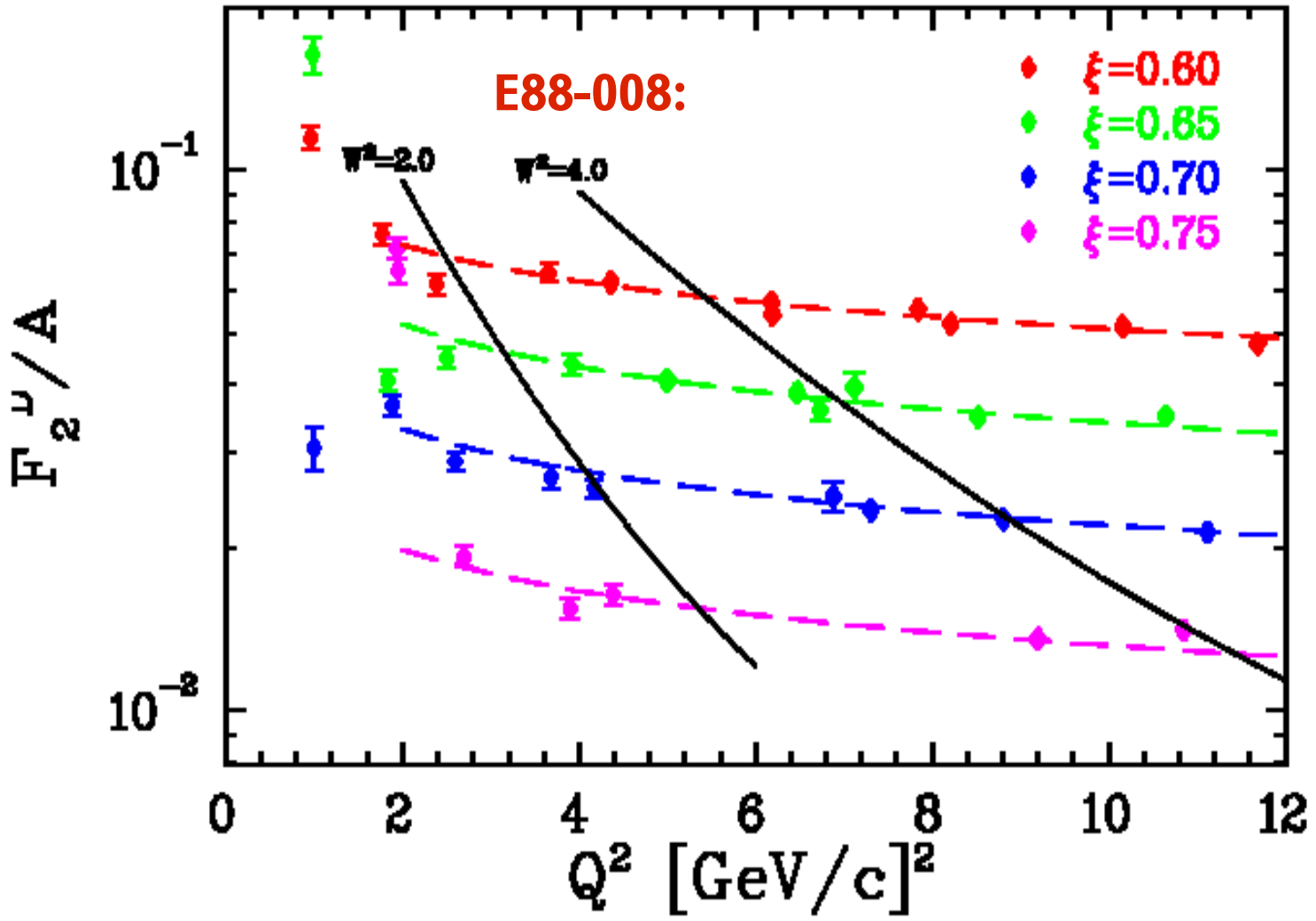
ξ scaling

E03-103 kinematics not very DIS – need to be able to compare to other measurements...need a scaling variable that scales over larger Q^2 range.

$$\xi = 2x/(1 + \sqrt{(1 + 4m^2x^2/Q^2)})$$

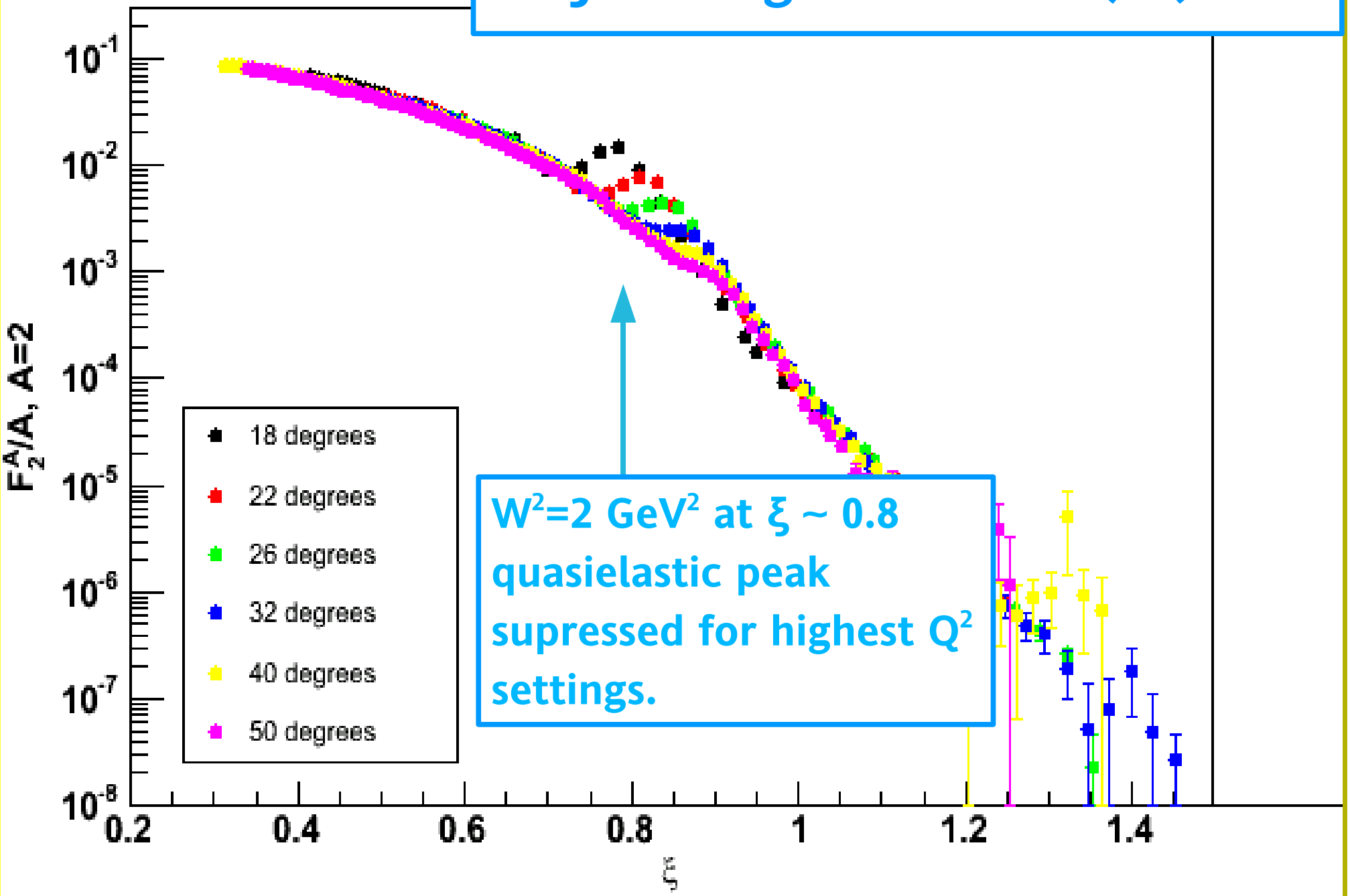
$\xi \rightarrow x$ in the Björken limit

ξ scaling

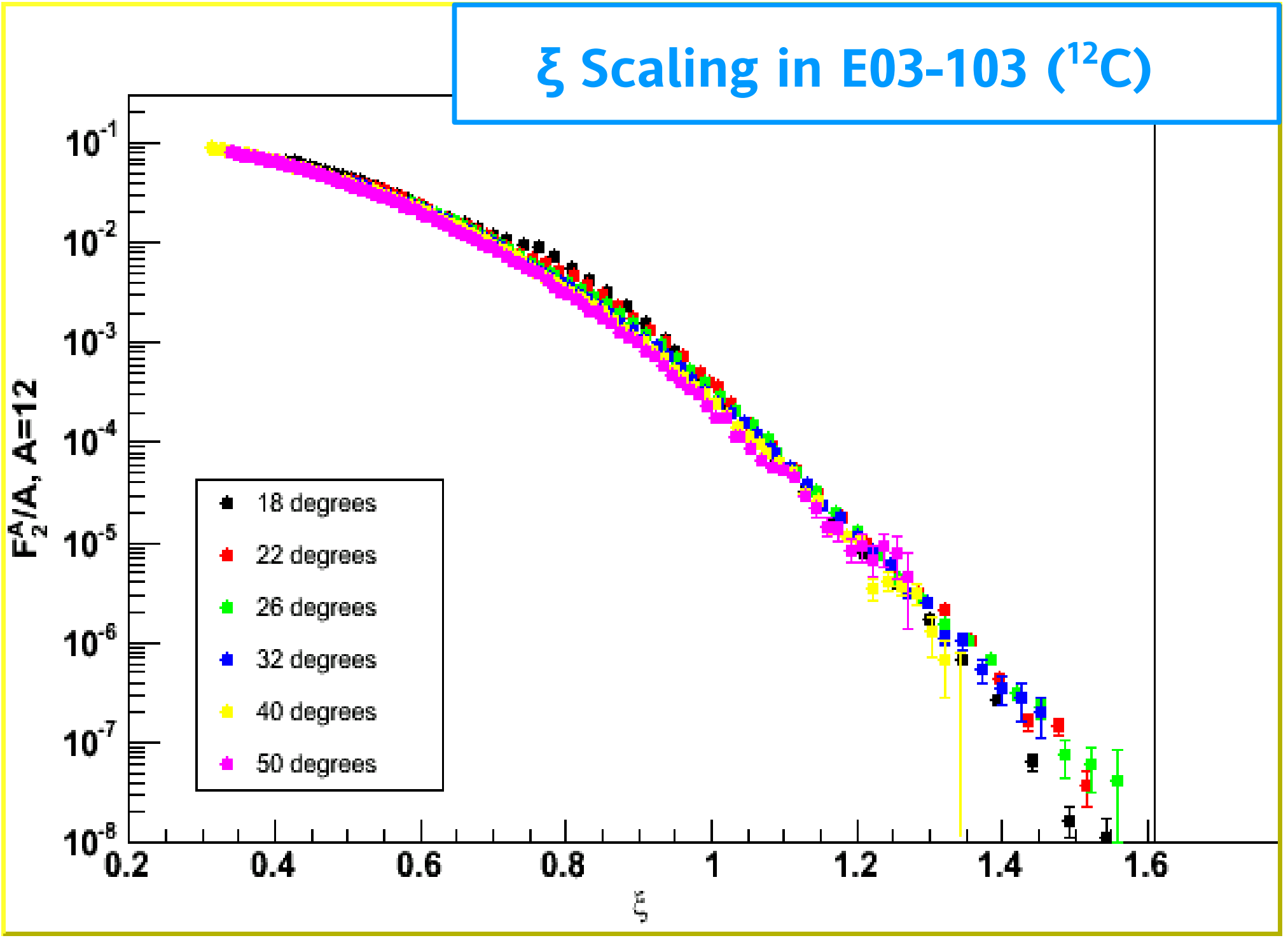


structure functions show scaling in ξ below $W^2 = 4\ GeV^2$, $Q^2 = 4\ GeV^2$

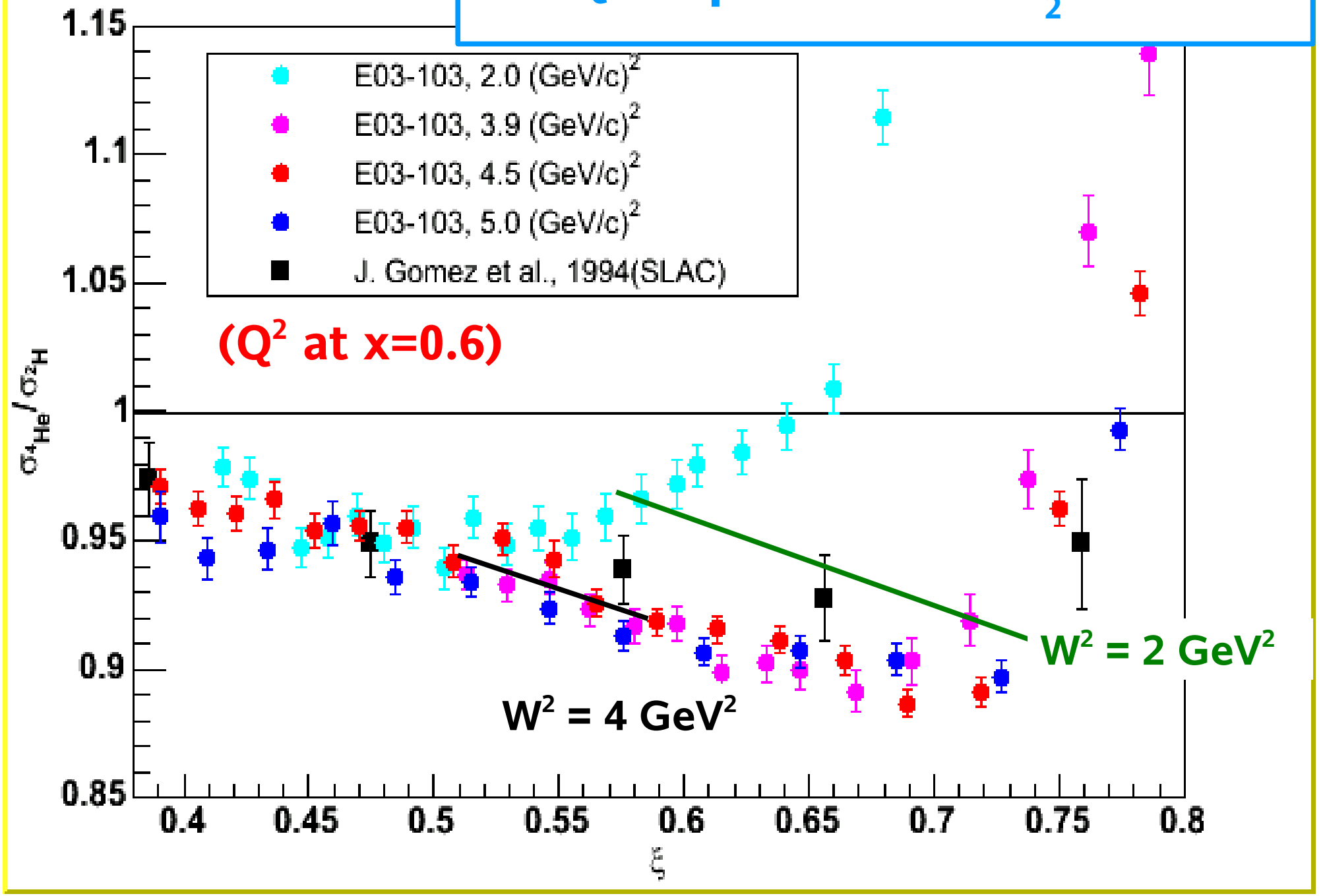
ξ Scaling in E03-103 (^{2}H)



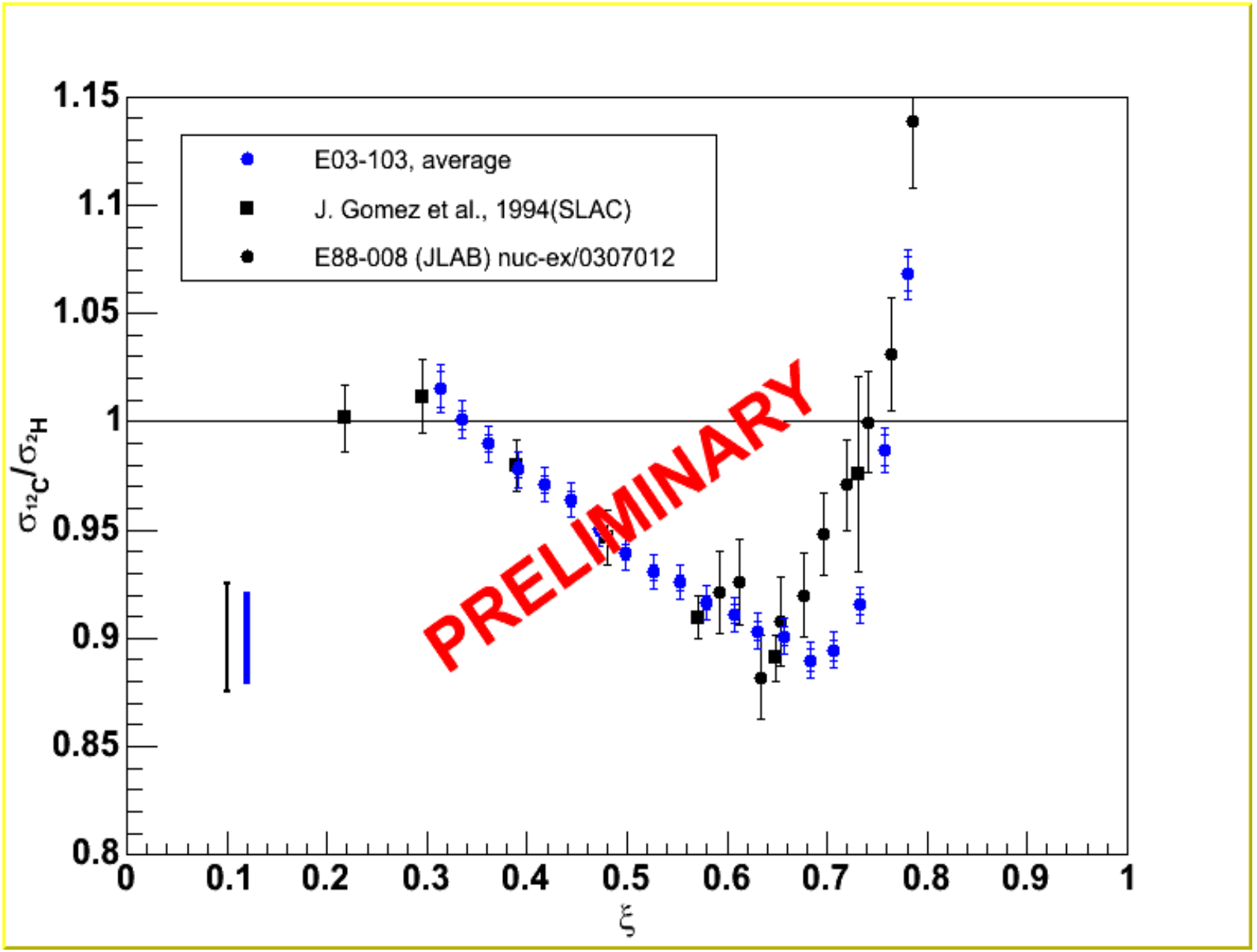
ξ Scaling in E03-103 (^{12}C)



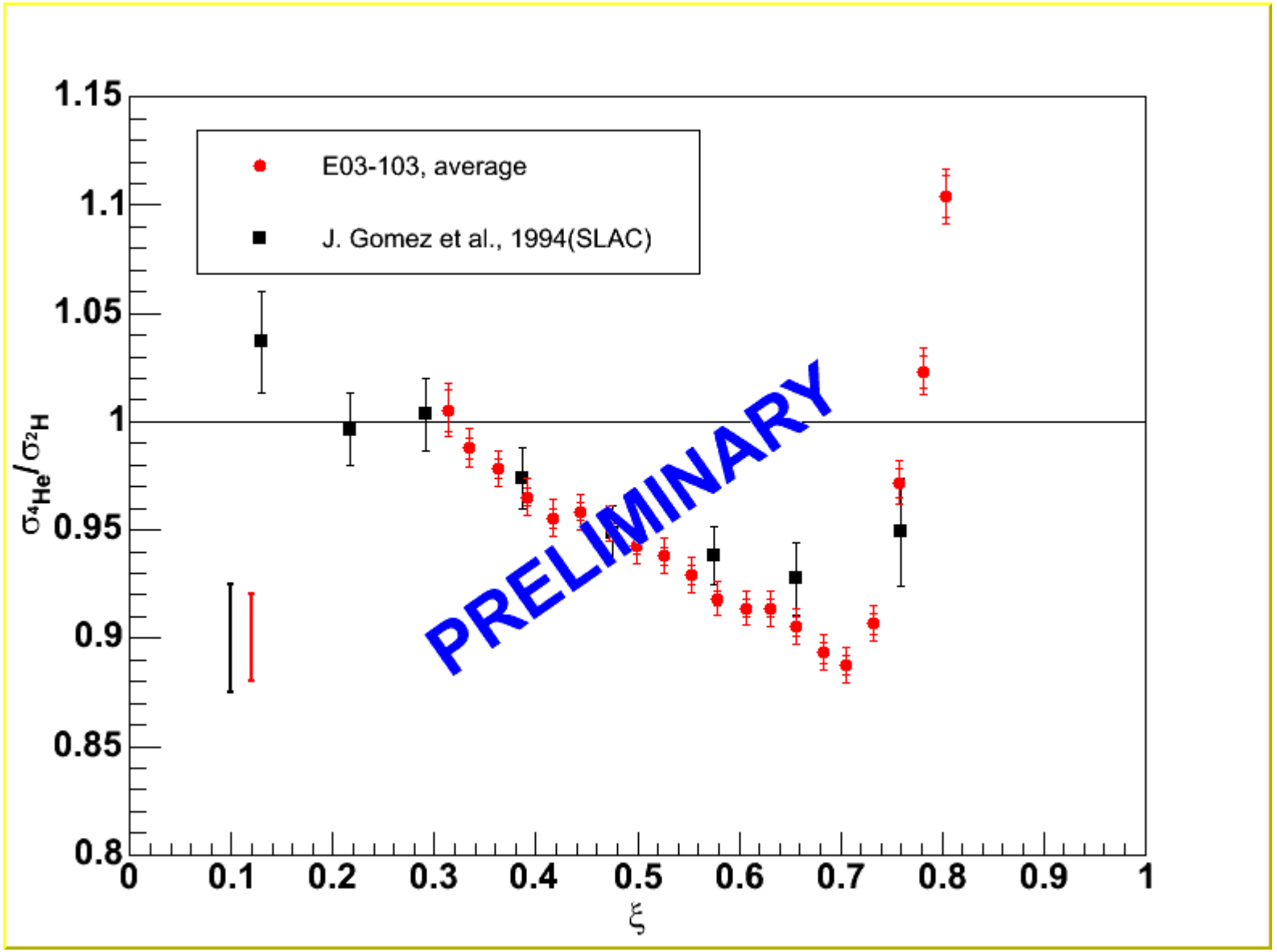
Q^2 depedence of F_2 ratio



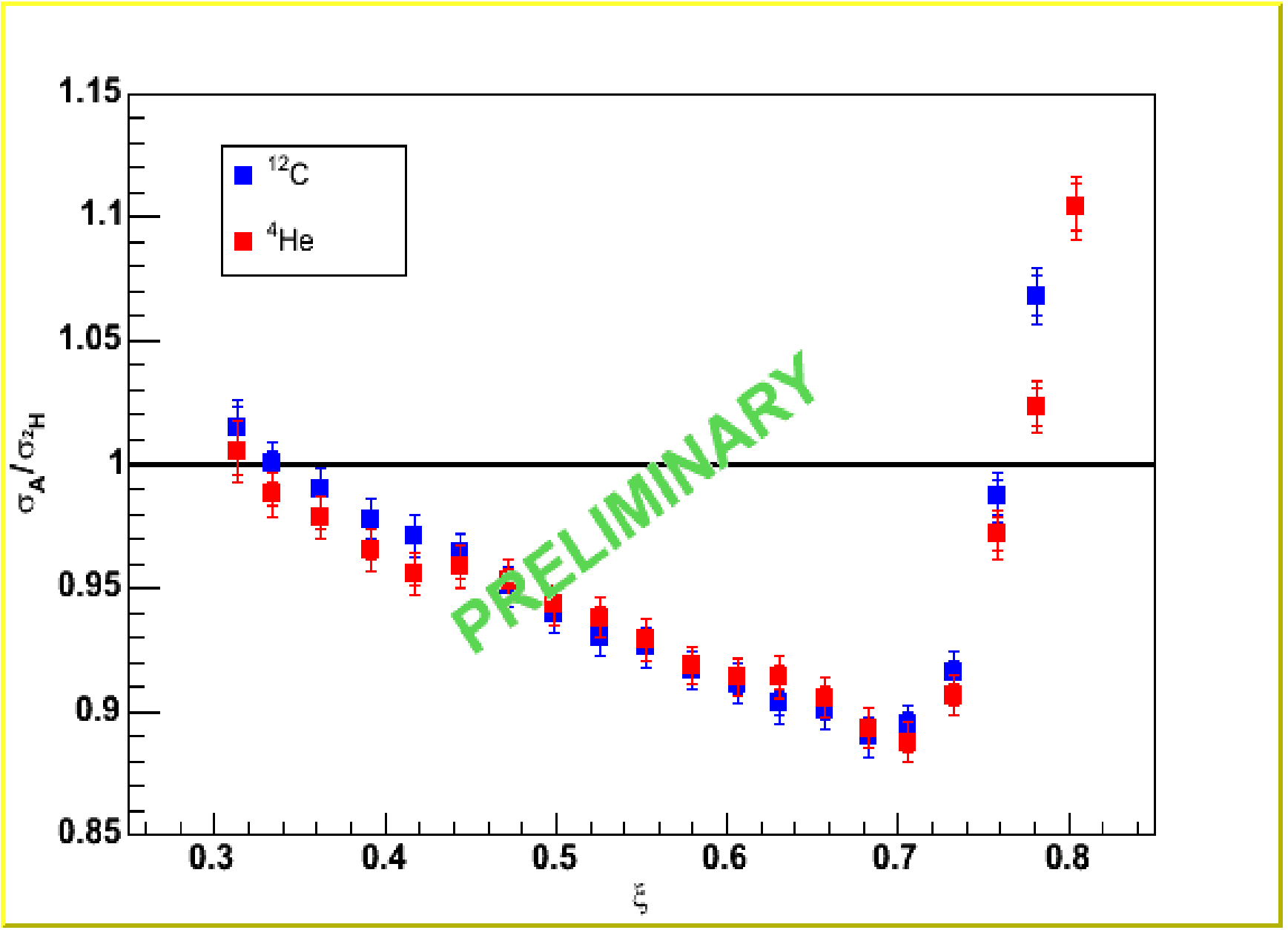
EMC effect in ^{12}C



EMC effect in ^{4}He



EMC effect in ^{4}He as large as in ^{12}C



Neutron Excess:

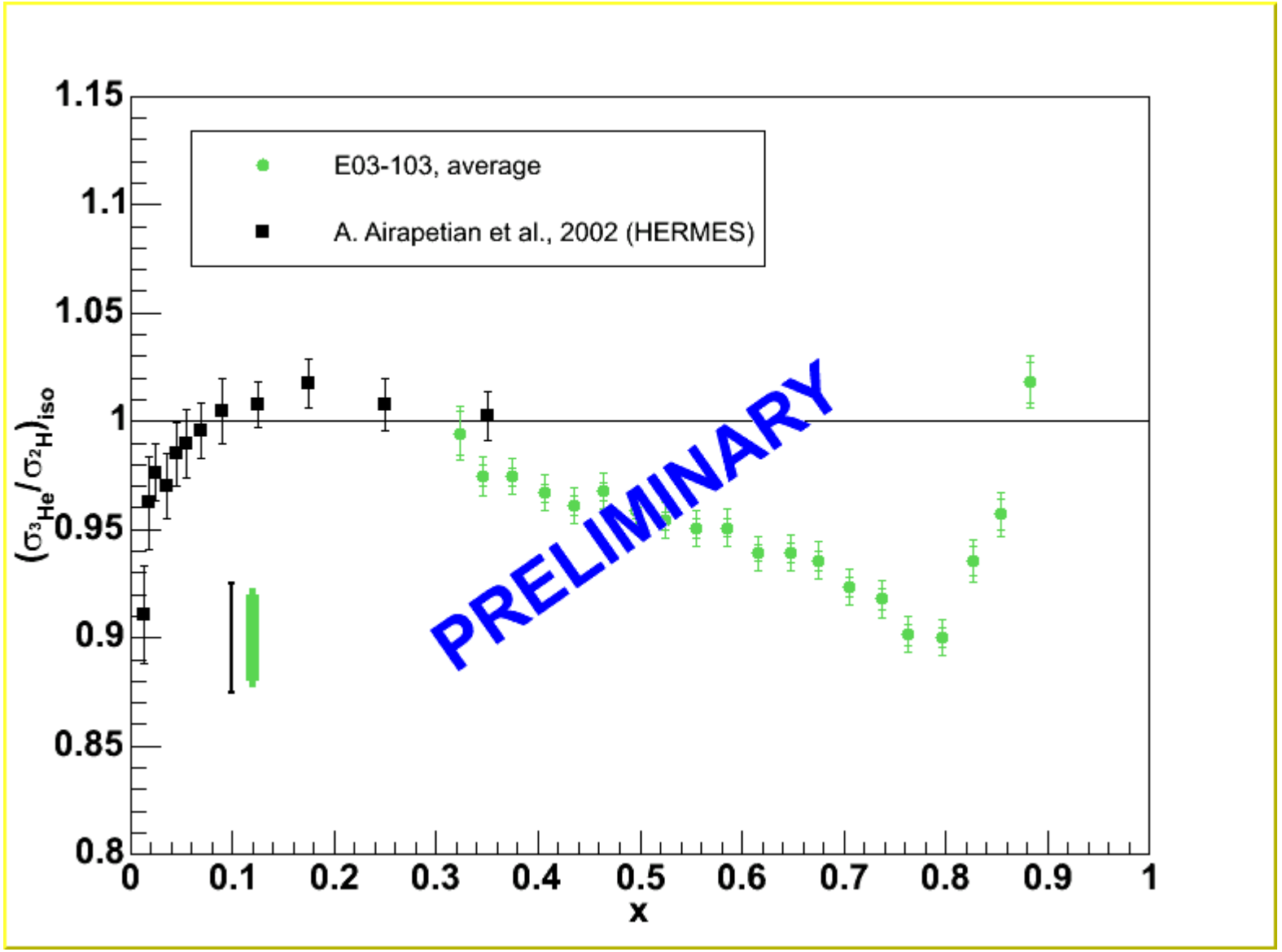
$$\left(\frac{\sigma^A}{\sigma^D}\right) \Big/ \left(\frac{\sigma^A}{\sigma^D}\right)_{is} = \frac{\left(Z + N\frac{F_2^n}{F_2^p}\right)}{0.5A\left(1 + \frac{F_2^n}{F_2^p}\right)}$$

Currently using SLAC Parameterization:

F2n/F2p = 1 – 0.8x

Data were taken on H and ^{2}H at all settings in order to determine F2n/F2p for our kinematics (in progress)

EMC effect in ^{3}He



Systematics:

Source	Absolute Uncertainty	Relative Uncertainty	$\delta\sigma/\sigma$(%)	$\delta R/R$(%) point-to-point	$\delta R/R$(%) scale	$\delta R/R$ (%) Statistical
HMS Momentum	<0.1%	0.01%	0.2	-	-	
Beam Energy	<0.1%	<0.02%	0.2	0.1	-	
θ	0.5mr	0.2mr	0.1	0.1	0.1	
t_D	0.5%		0.5	-	0.5	
t_{He}	1.0%		1.0	-	1.0	
Charge	0.4%	0.3%	0.5	0.42	0.2	
Target Boiling	<1.0%	0.5%	<1.0	0.3	0.3	
Endcap Subtraction	<1.0%	0.2%	<1.0	0.1	0.1	
Acceptance	1.0-2.0%	0.2%	1.0-2.0	0.2	-	
Radiative Corrections	2.0%	0.5%	2.0	0.3	0.4	
Detector Efficiency	0.5%	0.2%	0.5	0.2	-	
Deadtime Correction	<0.5%	0.2%	<0.5	0.1	0.2	
Total			2.7-3.3	0.7%	1.3	0.5-0.7
E139			3.3-3.7	1.6%	2.2	1.0-2.2

Table 4: Systematic uncertainties in the ratio $\sigma_{He}/\sigma_{^3H}$, compared to E139 uncertainties (for ^{4}He).

Measurement limited by systematic error

- target thickness
- charge normalization

Conclusions:

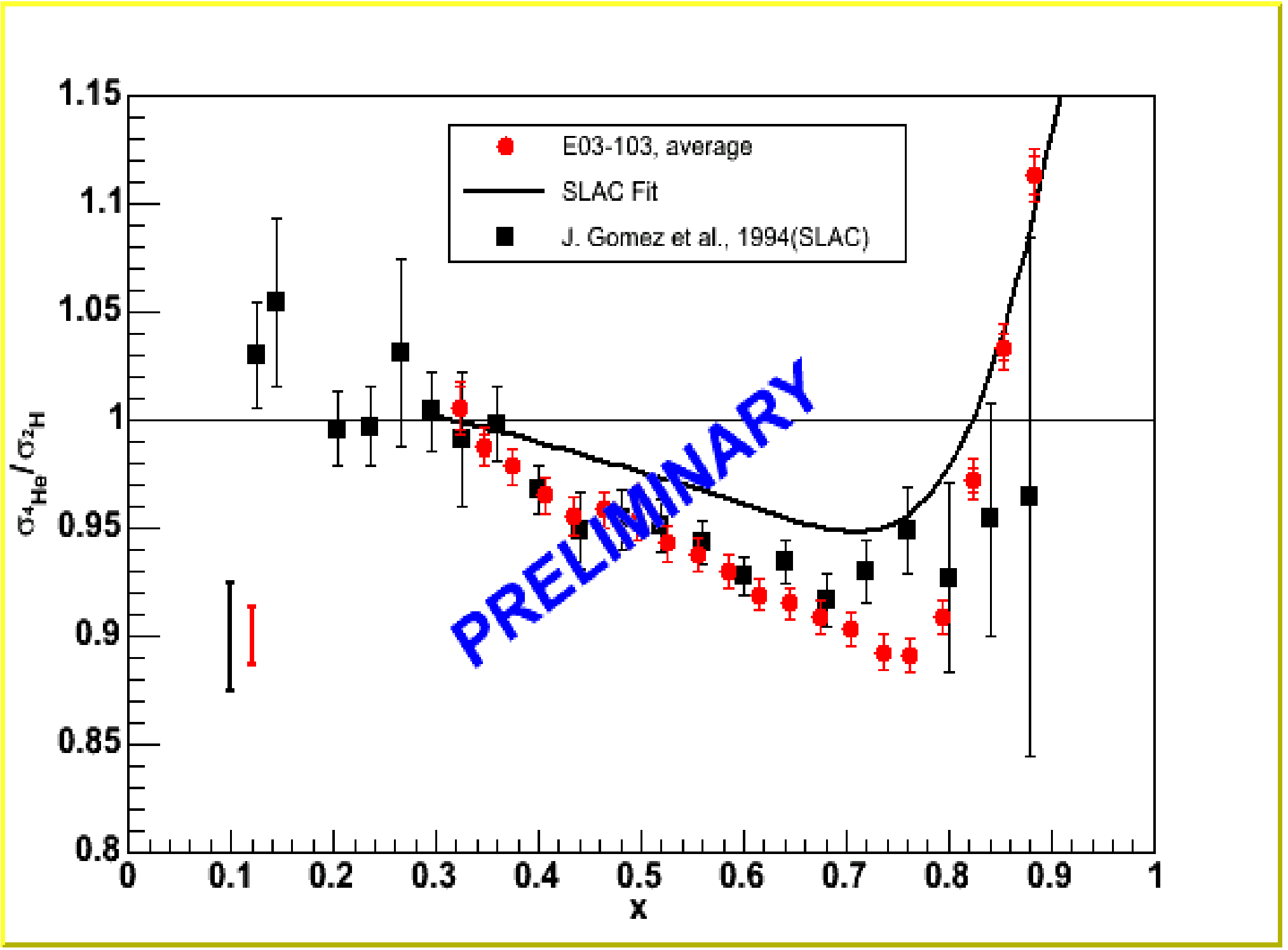
E03-103 has made a precision measurement of the EMC effect in ^{3}He and ^{4}He

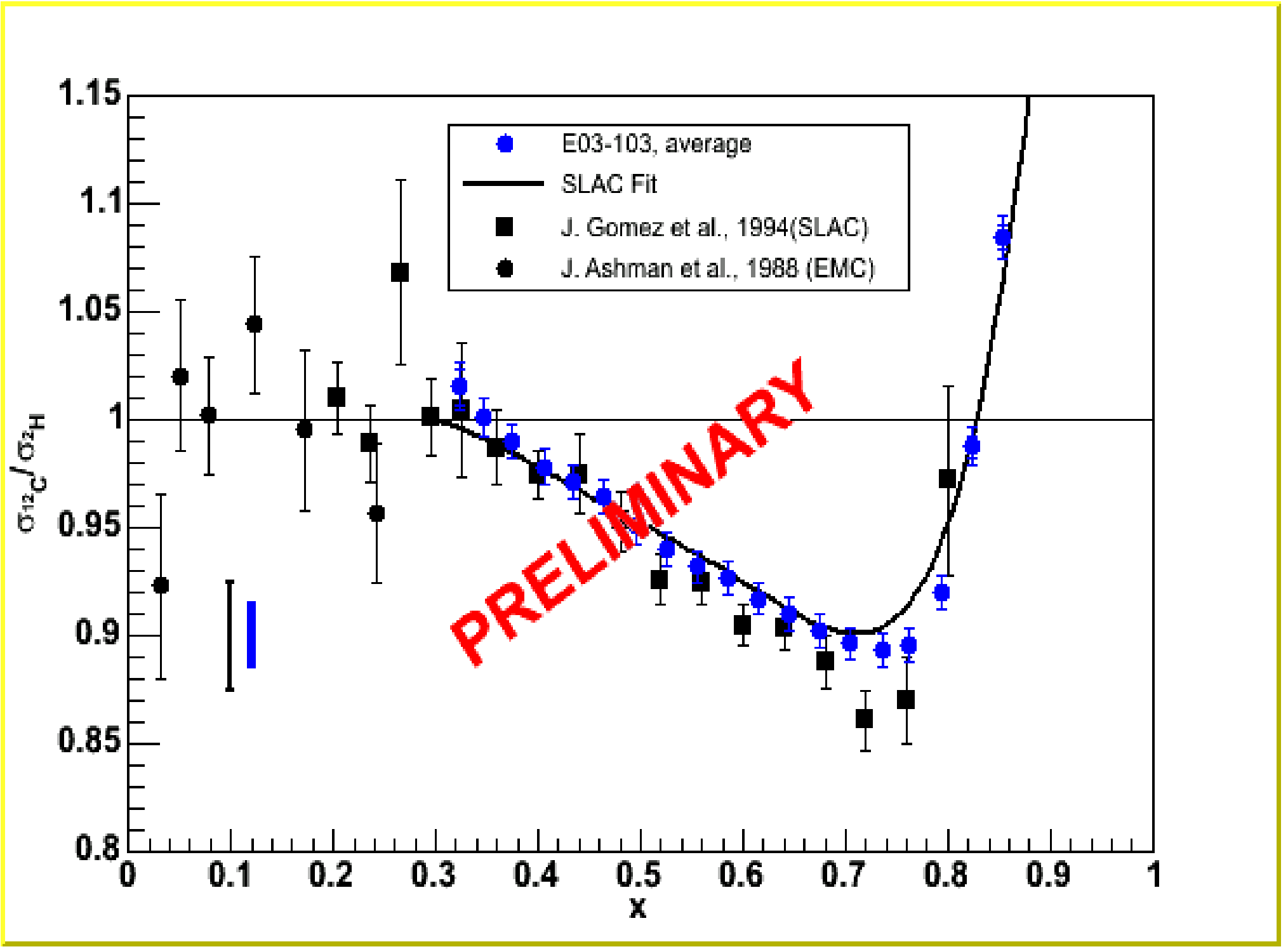
Improved precision
EMC effect in ^{4}He is as large as the effect in ^{12}C

first ever measurement on ^{3}He at x>0.4

Work is currenlty underway on radiative corrections model, and neutron excess correction

Final results coming soon


E03-103, average
SLAC Fit
J. Gomez et al., 1994(SLAC)
PRELIMINARY
$\sigma_{^4He}/\sigma_{^2H}$
x
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


E03-103, average
SLAC Fit
J. Gomez et al., 1994(SLAC)
J. Ashman et al., 1988 (EMC)
PRELIMINARY
$\sigma_{^{12}C}/\sigma_{^2H}$
x
1.15
1.1
1.05
1
0.95
0.9
0.85
0.8
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1