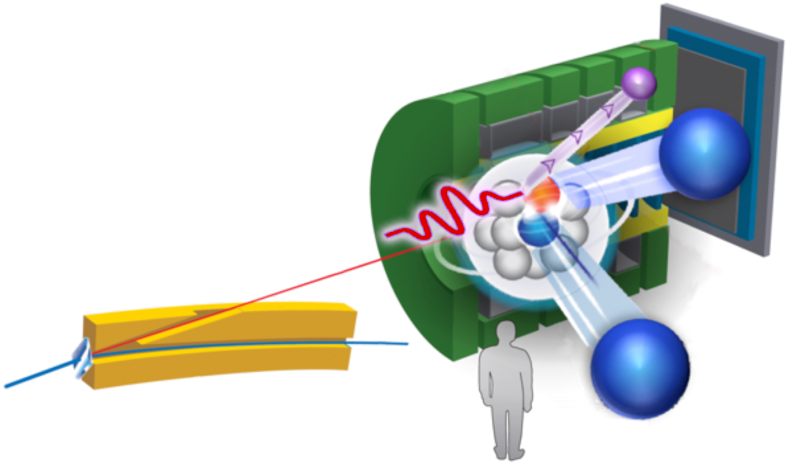


SRC@GlueX

Experiment & Analysis Report

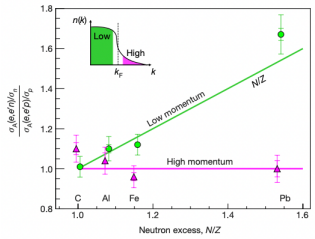
Tim Kolar

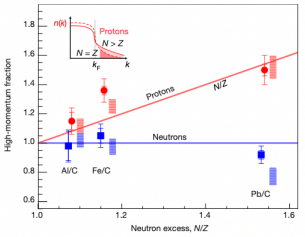
SRC Collaboration Meeting

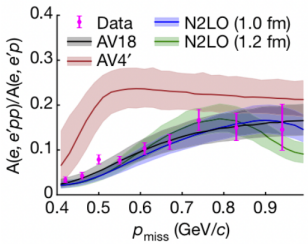
Aug. 8, 2022

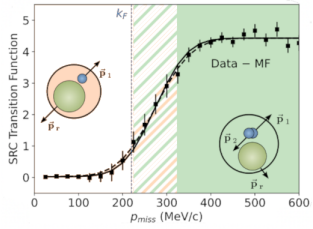
Motivation - Understanding SRCs

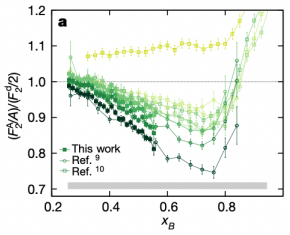
- Using **electron probe** proved to be very successful...

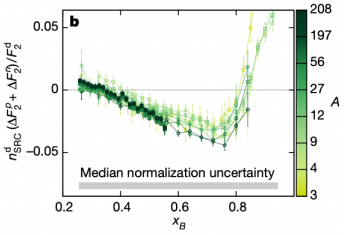












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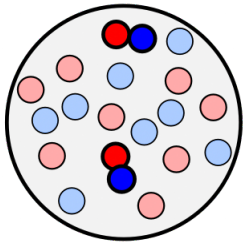
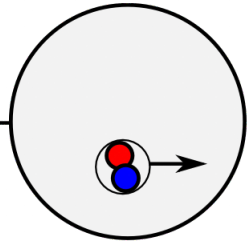
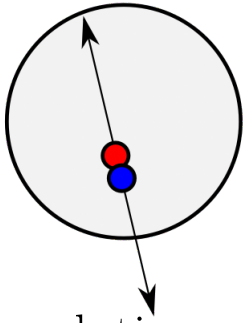


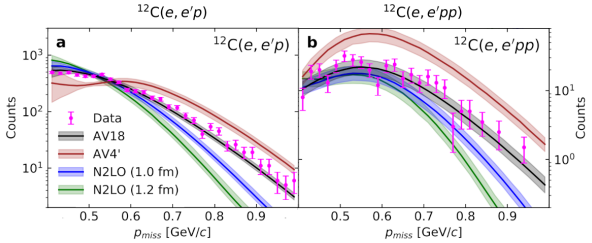
Pair abundances

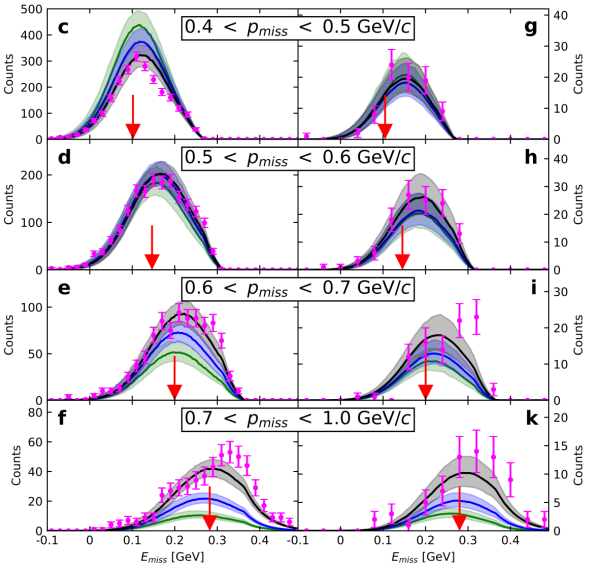


Pair CM motion



Pair relative motion





Motivation - Complexity Leads to Assumptions

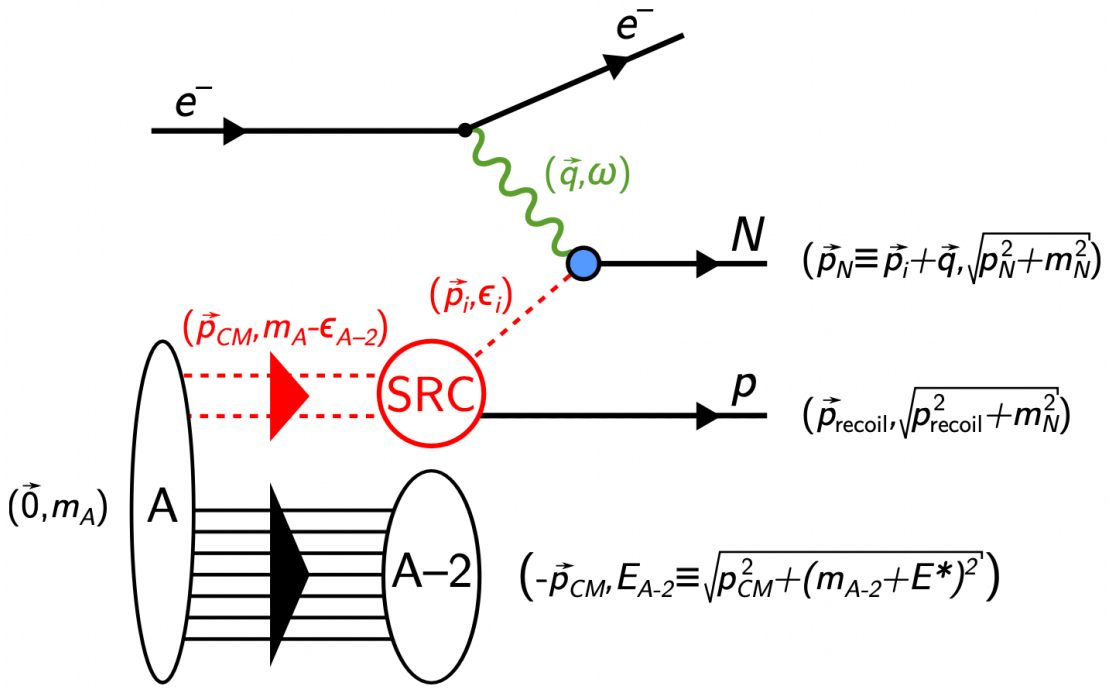
- ..., but using single probe leaves some doubts on validity of certain assumptions

→ Scale separation

→ Relativistic effects

→ Reaction mechanisms

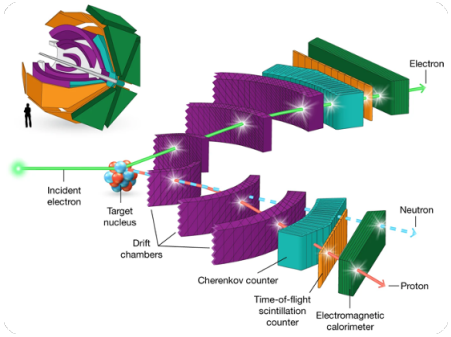
→ FSI, MEC, IC

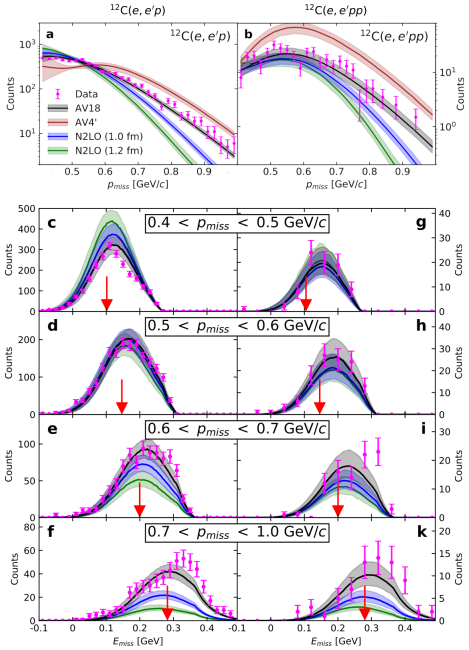


R. Weiss et al., PLB 791 pp. 242–248 (2019)
A. Schmidt et al., Nature 578 pp. 540–544 (2020)
J. R. Pybus et al., PLB 805 135429 (2020)

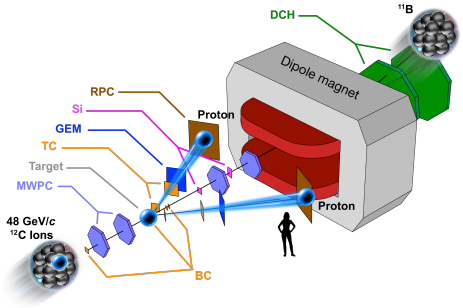
Motivation - A Tale of Three Probes

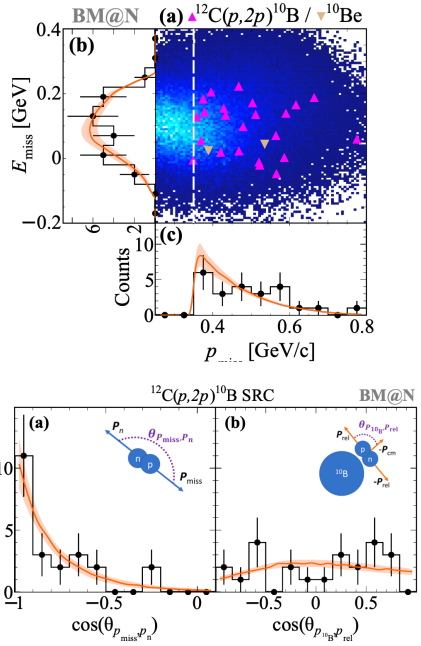
◦ Electron



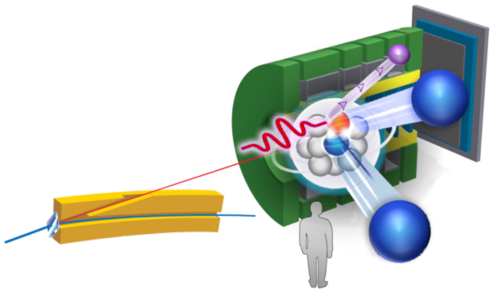


◦ Hadron





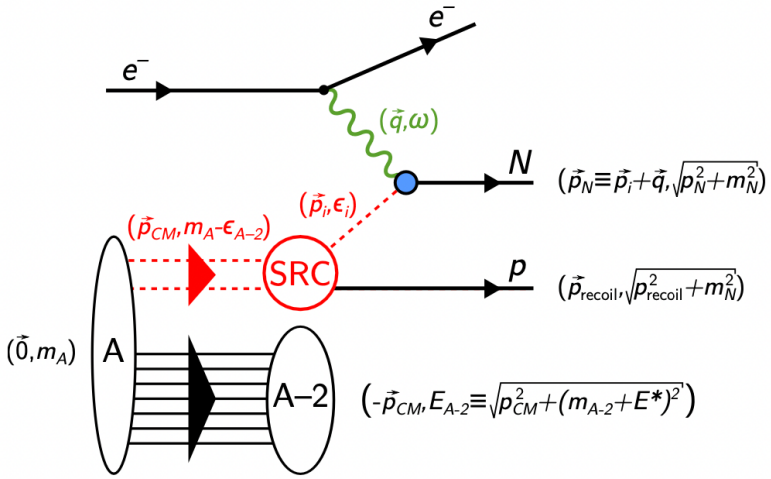
◦ Photon

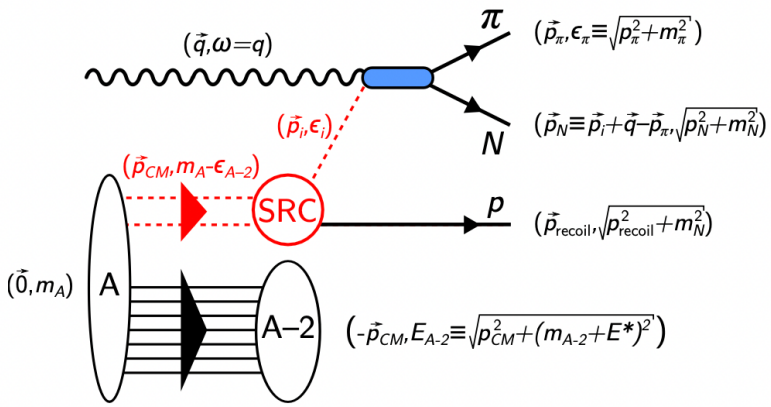


See also talks from
J. Pybus & P. Sharp

Motivation - Test of Foundamentals

- Using **photoproduction** we can **test foundamental assumptions**





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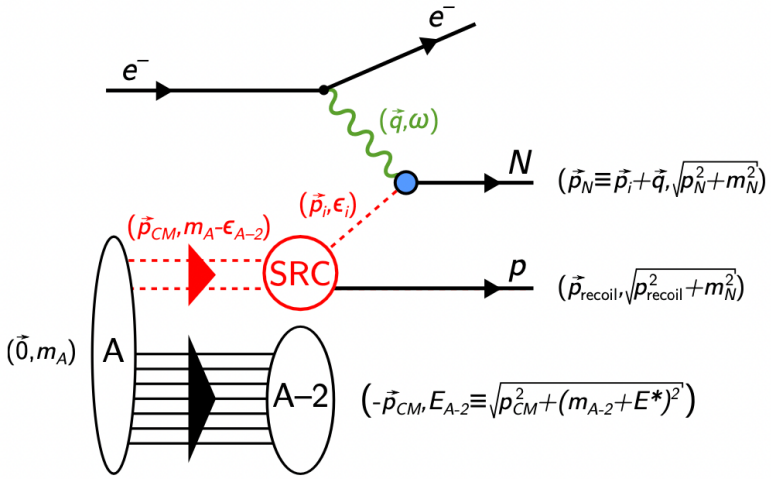

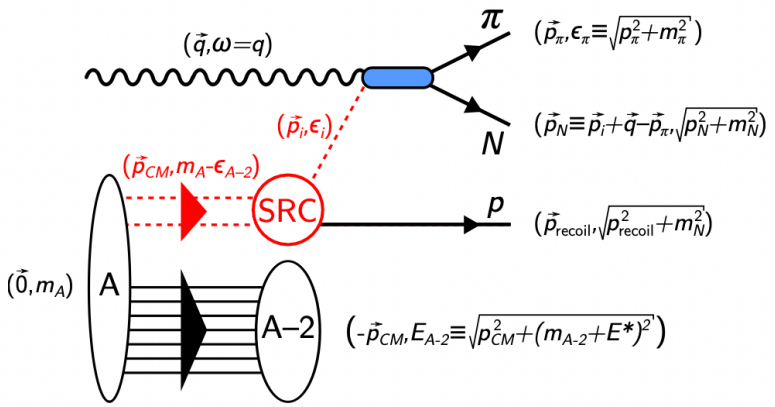

- Different photoproduction reactions available

γp			γn		
$\gamma p \to \pi^0 p$	$\gamma p \to \rho^0 p$	$\gamma p \to \eta p$	$\gamma n \to \pi^0 n$	$\gamma n \to \rho^- p$	$\gamma n \to \eta n$
$\gamma p \to \pi^+ n$	$\gamma p \to \rho^+ n$	$\gamma p \to \omega p$	$\gamma n \to \pi^- p$		$\gamma n \to \omega n$
$\gamma p \to \pi^- \Delta^{++}$	$\gamma p \to K^+ \Lambda^0$	$\gamma p \to \phi p$		$\gamma n \to K^0 \Lambda^0$	$\gamma n \to \phi n$
$\gamma p \to \pi^0 \Delta^+$	$\gamma p \to K^+ \Sigma^0$	$\gamma p \to J/\psi p$	$\gamma n \to \pi^- \Delta^+$	$\gamma n \to K^0 \Sigma^0$	$\gamma n \to J/\psi n$
$\gamma p \to \pi^+ \Delta^0$	$\gamma p \to K^0 \Sigma^+$			$\gamma n \to K^+ \Sigma^-$	

Motivation - Other Nuclear Physics

◦ **Branching ratio (BR) modification**

→ Proton described as a superposition of different Fock states

$$|p\rangle_{\text{free}} = \alpha_{PLC}\,|PLC\rangle + \alpha_{3qq\bar{q}}\,|3qq\bar{q}\rangle + \alpha_{3q\pi}\,|3q\pi\rangle \ldots$$

$$|p\rangle_{\text{bound}} = \alpha^*_{PLC}\,|PLC\rangle + \alpha^*_{3qq\bar{q}}\,|3qq\bar{q}\rangle + \alpha^*_{3q\pi}\,|3q\pi\rangle \ldots$$

Motivation - Other Nuclear Physics

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$$|p\rangle_{\text{bound}} = \alpha^*_{PLC}\,|PLC\rangle + \alpha^*_{3qq\bar{q}}\,|3qq\bar{q}\rangle + \alpha^*_{3q\pi}\,|3q\pi\rangle \ldots$$

→ Difference in coupling of high-energy photon to individal-configuration Fock states might be reflected in the BR modification (e.g. $\gamma p \to \pi^0 p$ vs. $\gamma p \to \eta p$)

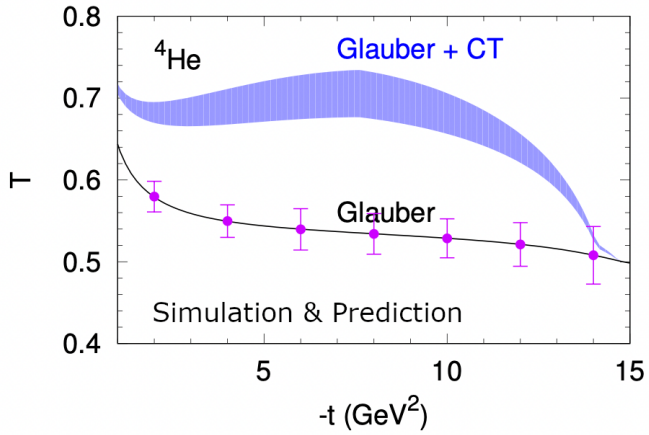
→ Effect could be enhanced in certain kinematic regions (e.g. SRC, hight s, t, u,...)

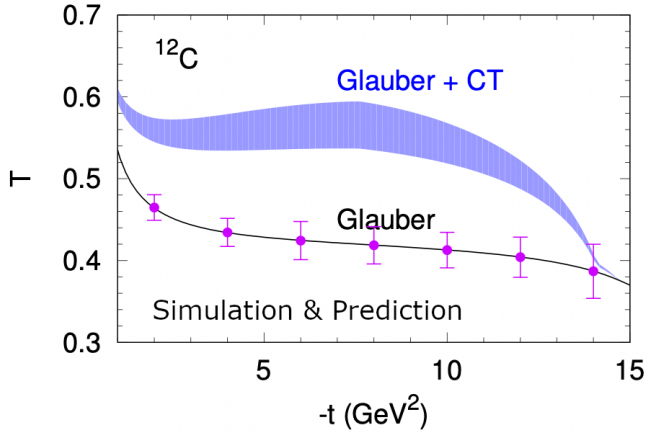
Motivation - Other Nuclear Physics

- Branching ratio (BR) modification
- **Onset of color transparency (CT)**

$$T = \frac{\sigma(\gamma n \to \pi^- p)_A}{\sigma(\gamma n \to \pi^- p)_D}$$

→ Vanishing of the final (and initial) state interactions of hadrons at high momentum transfer due to the hadrons of reduced transverse size





Motivation - Other Nuclear Physics

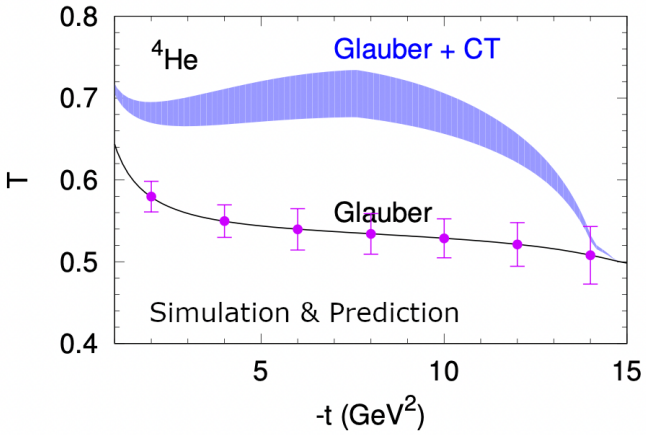
- Branching ratio (BR) modification
- **Onset of color transparency (CT)**

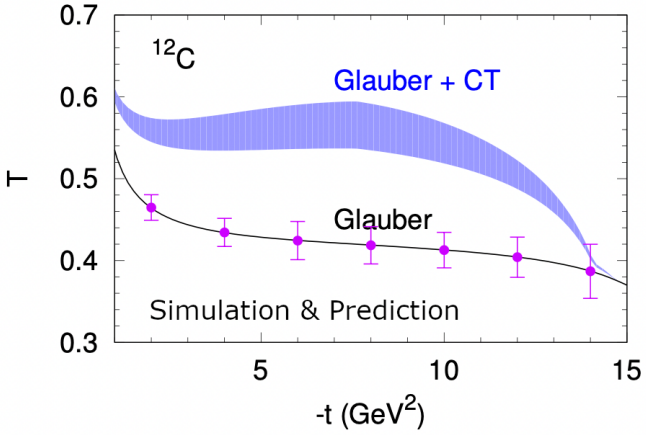
$$T = \frac{\sigma(\gamma n \to \pi^- p)_A}{\sigma(\gamma n \to \pi^- p)_D}$$

→ Vanishing of the final (and initial) state interactions of hadrons at high momentum transfer due to the hadrons of reduced transverse size

→ Currently looking at ρ^0 channel (D. Bhesha - MSU)

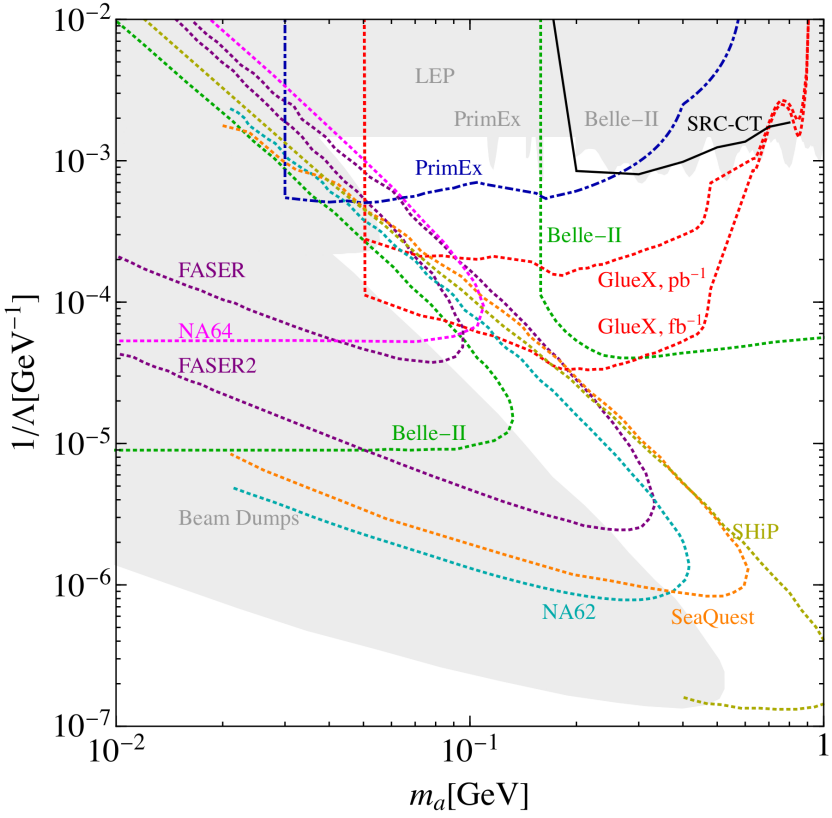
→ HERMES observed CT in ratio of ^{14}N to ^{1}H CSs for ρ^0 electroproduction (Airapetian et al.)





Motivation - Other Nuclear Physics

- Branching ratio (BR) modification
- Onset of color transparency (CT)
- **Axion-like particle search** (J. Pybus - MIT)



Motivation - Other Nuclear Physics

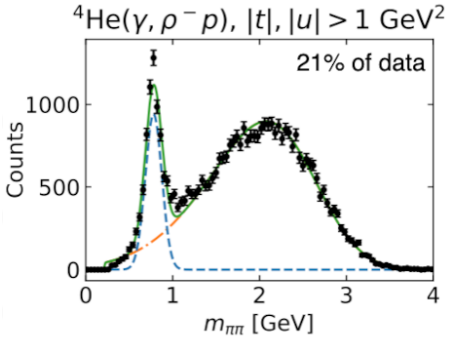
- Branching ratio (BR) modification
- Onset of color transparency (CT)
- Axion-like particle search (J. Pybus - MIT)
- **Neutron structure through $\gamma n \to \phi n$** (B. Yu - DU)
- **Beam asymmetry in π^- photoproduction off a neutron** (E. Logan - GW)

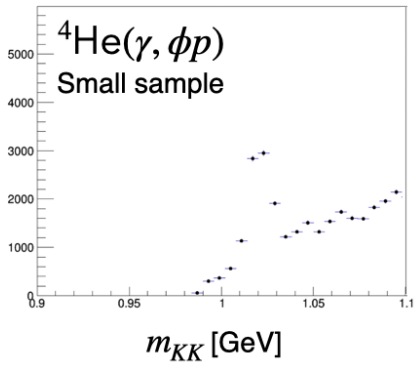
Motivation - Other Nuclear Physics

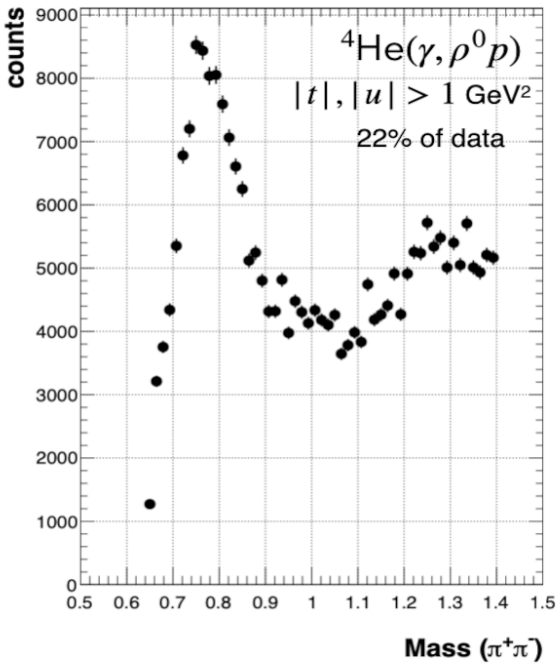
- We have a list of possible analyses, but we are open to any new ideas

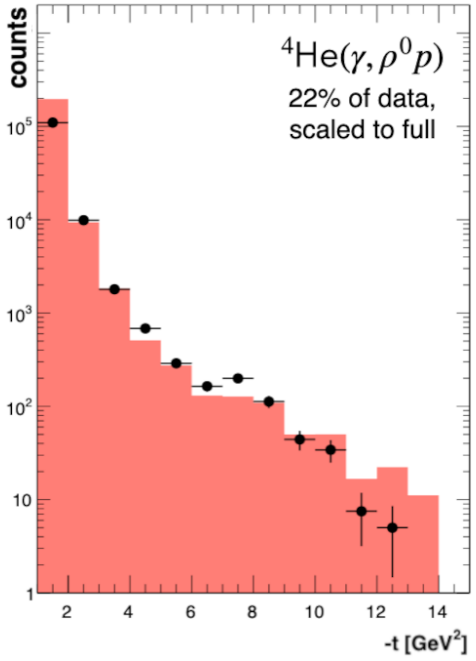
Photoproduction branching Ratio Modification	Measuring the Gluon Radius of Light Nuclei using Coherent Vector Meson Photoproduction with a Real Photon Beam	Observation of the Tensor Dominance of Nuclear SRCs using ρ0 Photoproduction with a Real Photon Beam
Meauring the Gluon Structure of the Bound Proton with Incoherent Vector Meson Photoproduction from Light Nuclei		Measuring the Tensor-to-Scalar Transition in Nuclear SRC using ρ0 and ρ- Photoproduction
Measuring the Pion Cloud of the Bound Proton with Incoherent Pion Photoproduction from Light Nuclei		Measuring the Relative SRC Abundance in Light Nuclei using High-Momentum Scaling in ρ0 Photoproduction
Measuring the Pion Cloud of the Bound neutron	Measurement of Sub-Threshold J/ψ Photoproduction from Light Nuclei	PrimEx-eta measurements using 3 decay different eta decay modes (2γ and 3π) with He and Carbon targets
	Measurement of J/Psi production on neutron from light nuclei	Coherent u-channel photoproduction
Axion-Like particle search in coherent di-photon production	Measurement of ϕ photoproduction on neutron from light nuclei	d*(2380) Dibaryon photoproduction in γ d -> pn or γ d ->
	Beam spin asymmetries in d(γ,π0), d(γ,π0p)n, d(γ,π-p)p	Test of dominance of handbag mech.
A' search/ QED mesons, Anomolous soft photon	K- mass modification in medium	Observation of Constituent Scaling in Deuteron Photodisintegration to Eγ=8 GeV
KTeV anomaly		Hidden color searches in the ratio γ d --> Delta++ Delta- to γ d --> p n
Measurement of Color Transparency in Light Nuclei with π- Photoproduction Using a Real Photon Beam	Measurement of Color Transparency in Light Nuclei with pho0 Photoproduction Using a Real Photon Beam	Hidden color searches in the ratio γ d --> J/Psi p n to γ d --> p n

Experiment Report





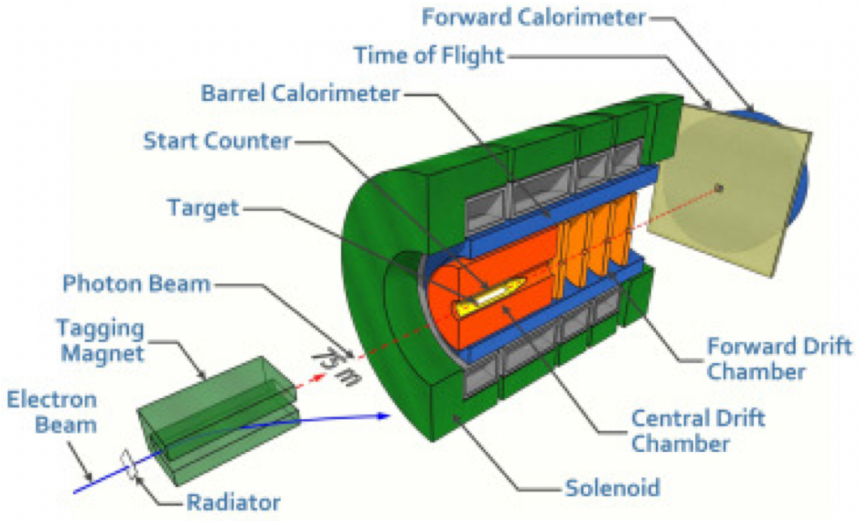


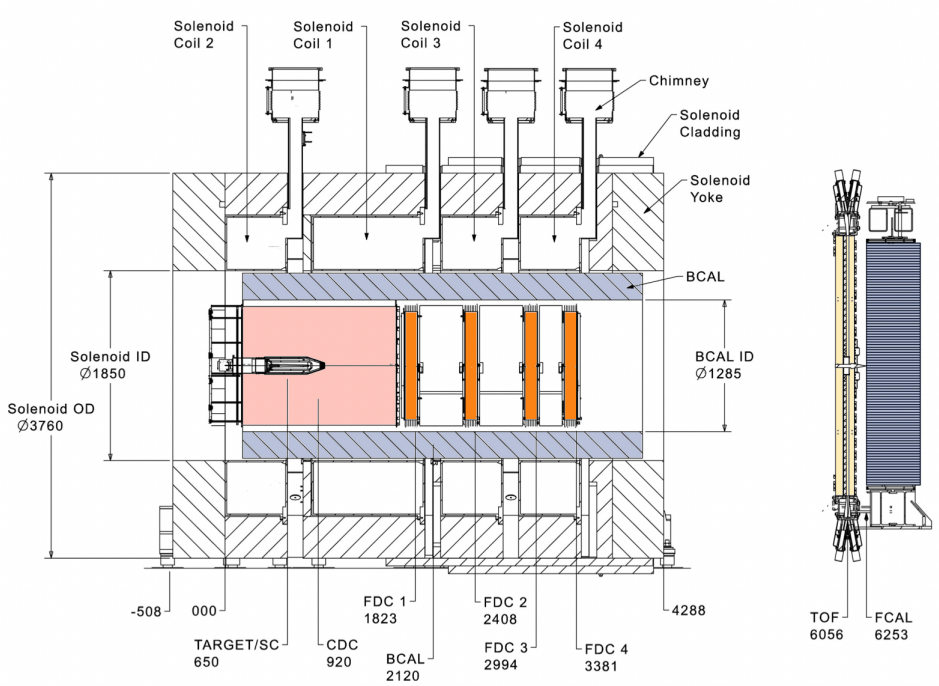


	D	^{4}He	^{12}C
Days	4	10	14
Int. Lumi. (E_γ>7 GeV) [pb^{-1}]	17.1	16.1	6.9

- Expected to start ∼2-month data cook in Aug

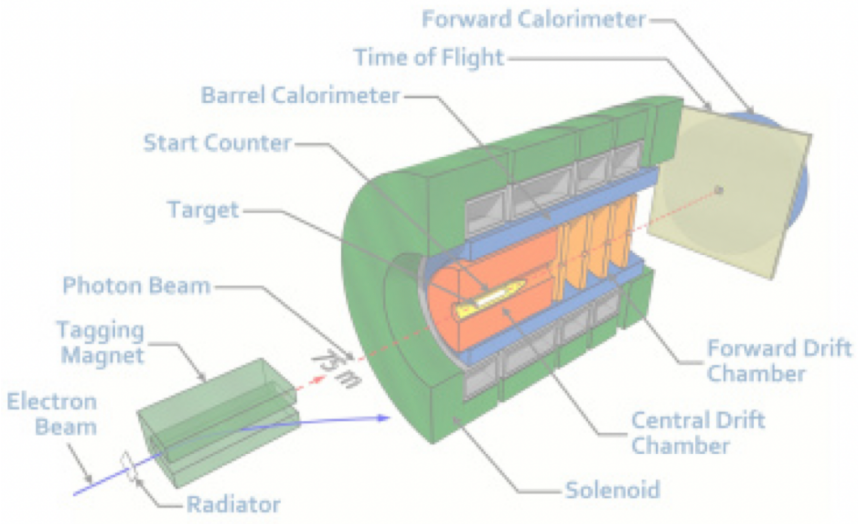
The GlueX Detector

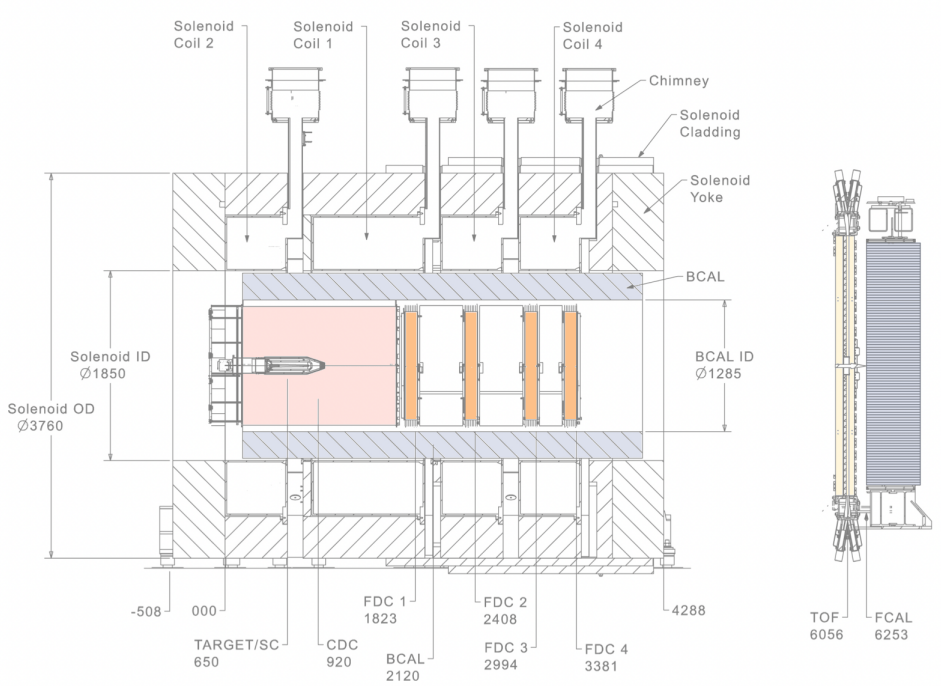




The GlueX Detector

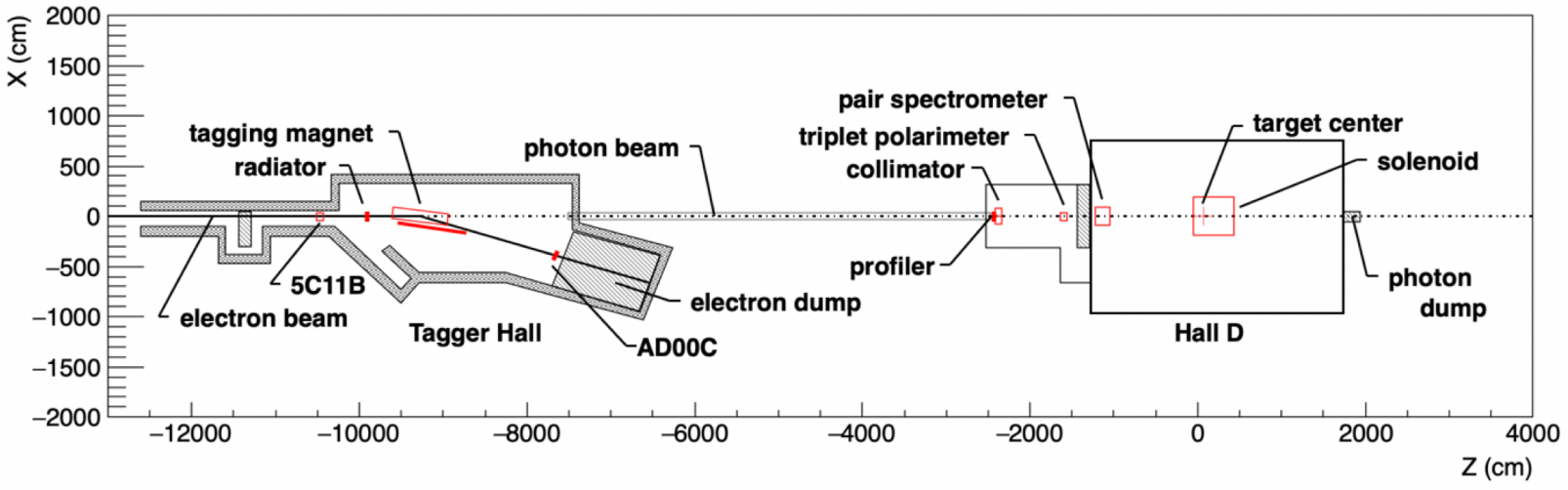
- $\sim 4\pi$ coverage
- high trigger rate - 40 kHz
  (roughly $2.5 \cdot 10^7\ \gamma/s$ in coherent peak)
- Good photon detection efficiency
  and energy reconstruction

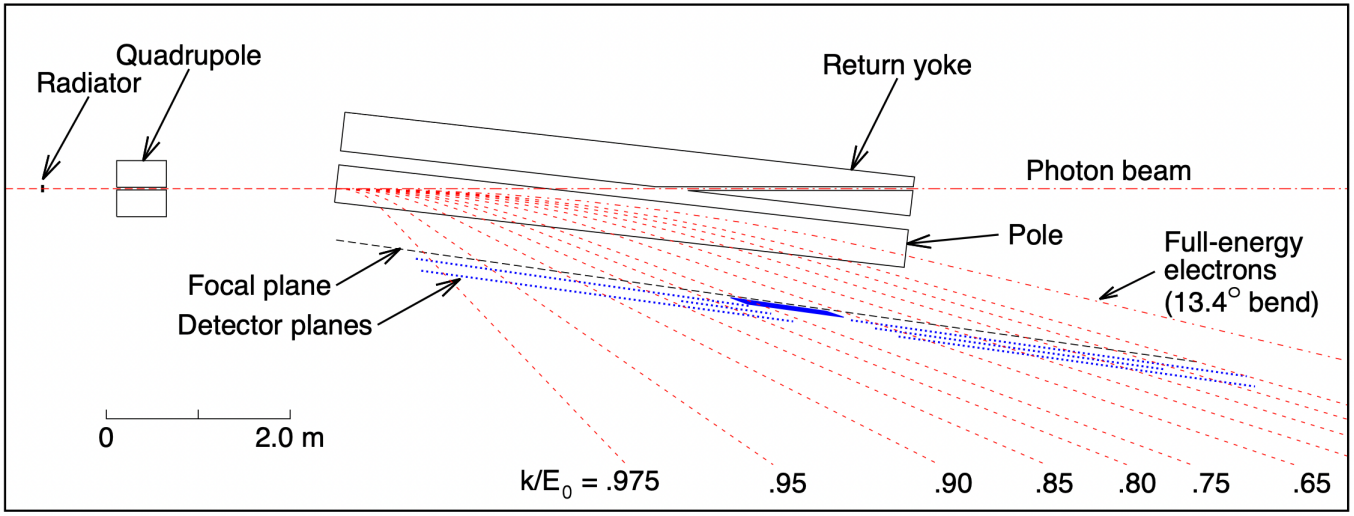




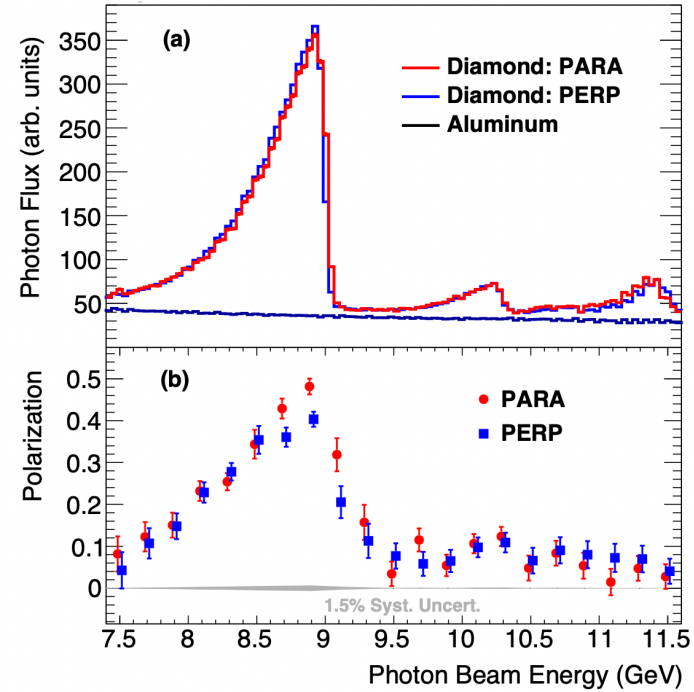
- Poor momentum resolution
  (better transverse than longitudinal)
- Poor charged particle ID compared
  with CLAS

GlueX - Beam


X (cm)
2000
1500
1000
500
0
−500
−1000
−1500
−2000
−12000
−10000
−8000
−6000
−4000
−2000
0
2000
4000
Z (cm)
tagging magnet
radiator
photon beam
pair spectrometer
triplet polarimeter
collimator
target center
solenoid
5C11B
electron beam
Tagger Hall
electron dump
AD00C
profiler
Hall D
photon
dump

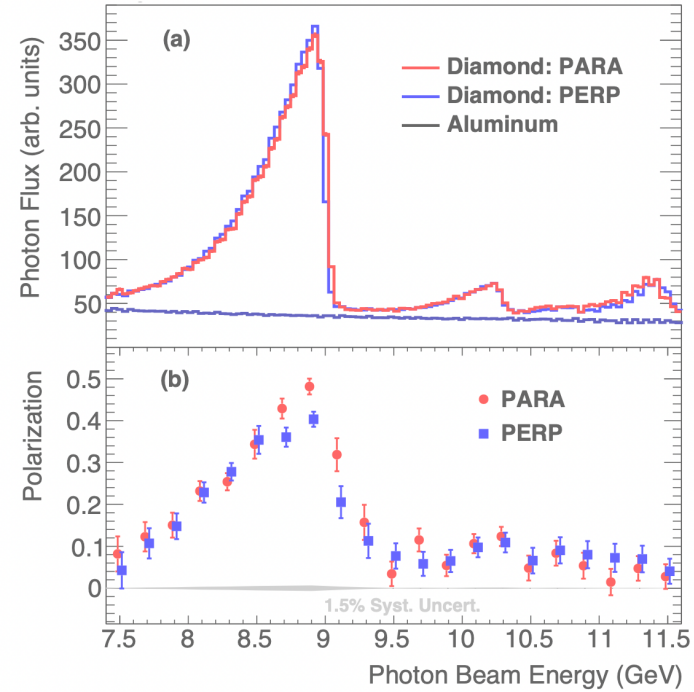

Quadrupole
Radiator
Return yoke
Photon beam
Pole
Full-energy
electrons
(13.4° bend)
Focal plane
Detector planes
0
2.0 m
k/E0 = .975
.95
.90
.85
.80
.75
.65

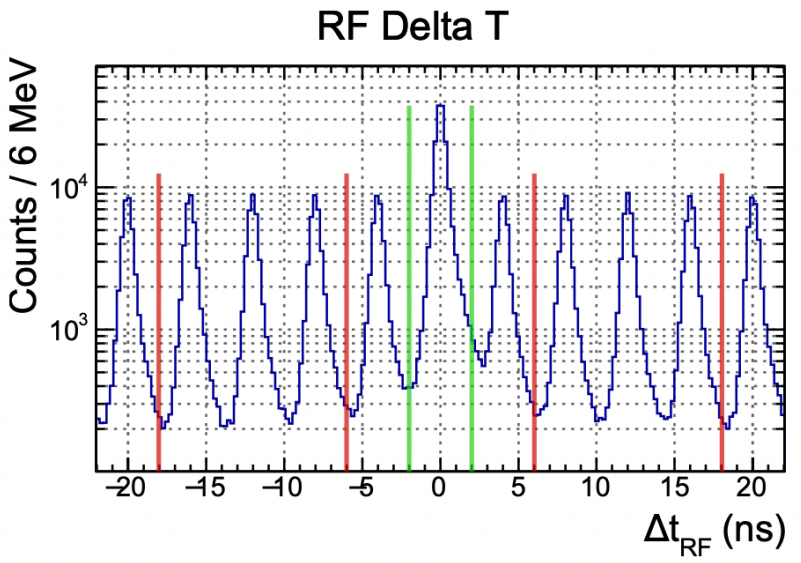
GlueX - Beam



- $6\,\mathrm{GeV} < E_\gamma < 10.8\,\mathrm{GeV}$
- Up to $P = 0.5$ under coherent peak

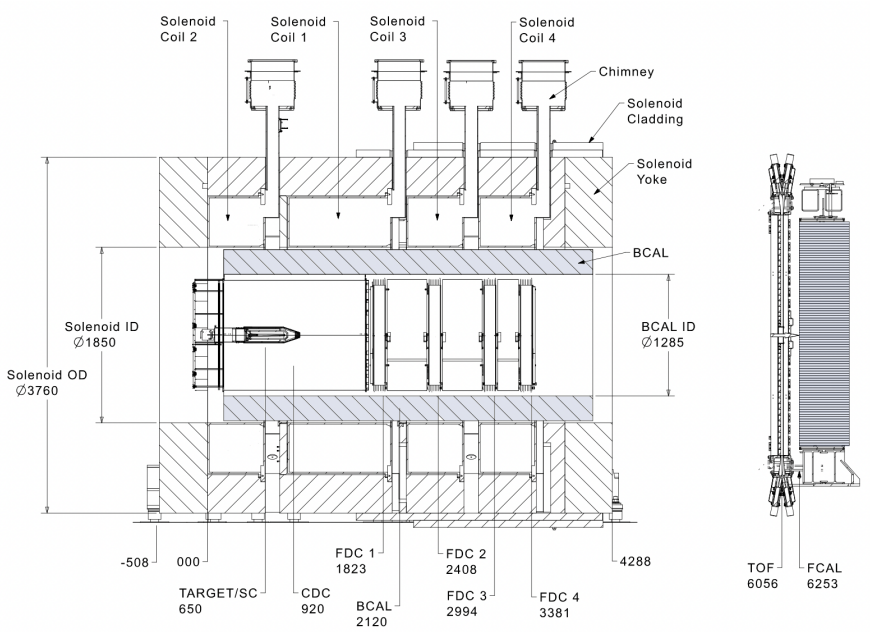
GlueX - Beam





- $6\,\mathrm{GeV} < E_\gamma < 10.8\,\mathrm{GeV}$
- Up to $P = 0.5$ under coherent peak
- Tagger pileup $\rightarrow$ need for accidentals substraction

GlueX - Trigger & Timing

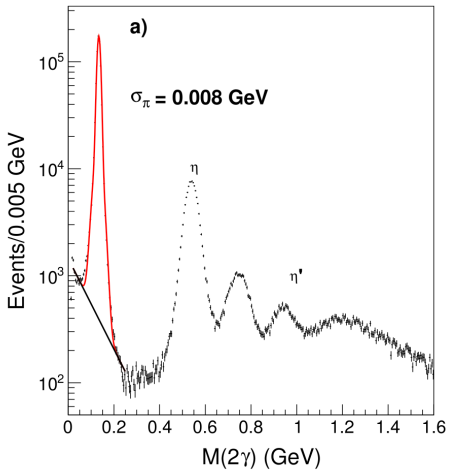


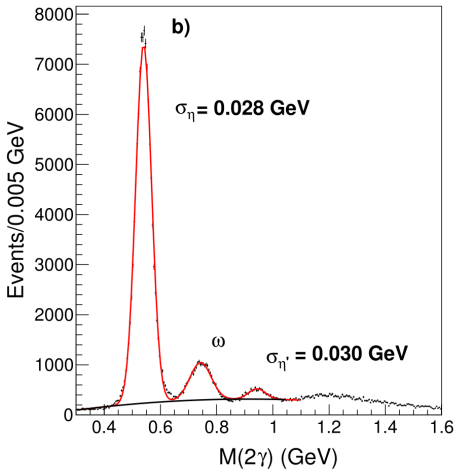
- Trigger based on energy depositions in the BCAL and FCAL

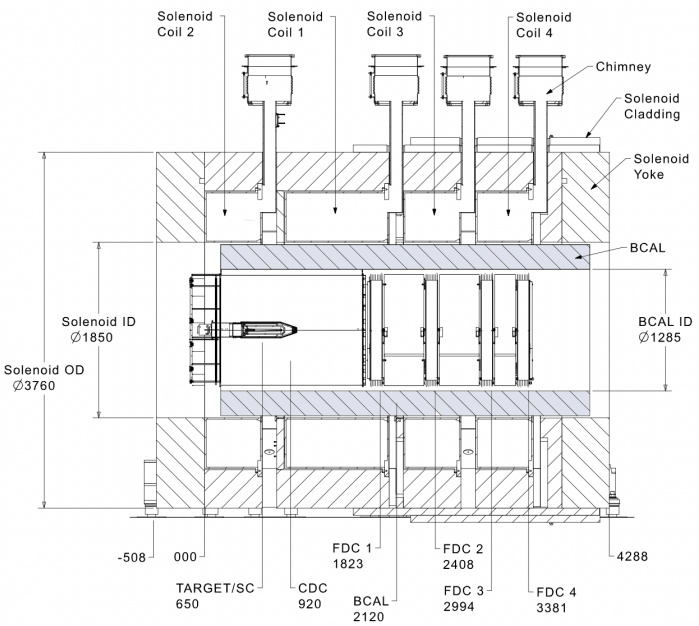
  1. $2 \times E_{\mathrm{FCAL}} + E_{\mathrm{BCAL}} > 1\,\mathrm{GeV}$, $E_{\mathrm{FCAL}} > 0\,\mathrm{GeV}$, or (most events produce forward-going energy)
  2. $E_{\mathrm{BCAL}} > 1.2\mathrm{GeV}$ (events with large transverse energy e.g. J/Ψ decay)

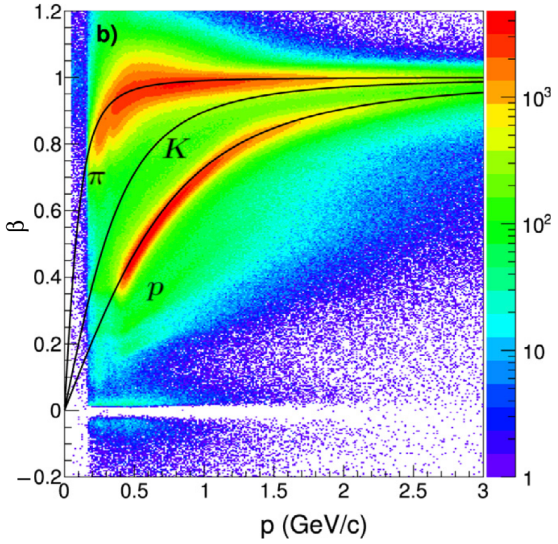
- Can be augmented with use of scintillator detectors (PS, taggers, ST, TOF, or TAC)

GlueX - BCAL & FCAL

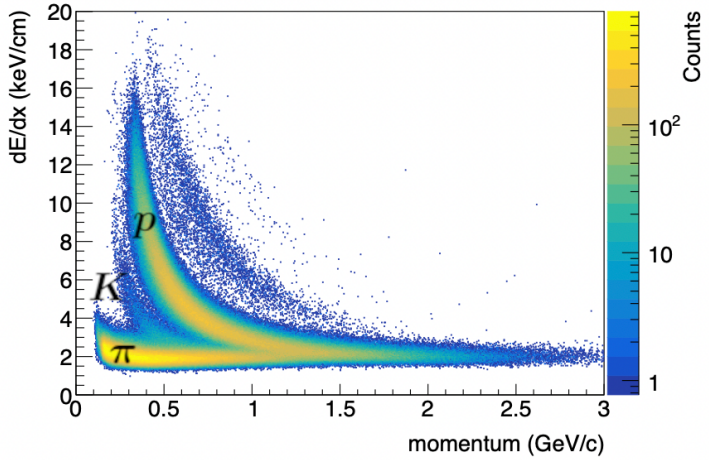


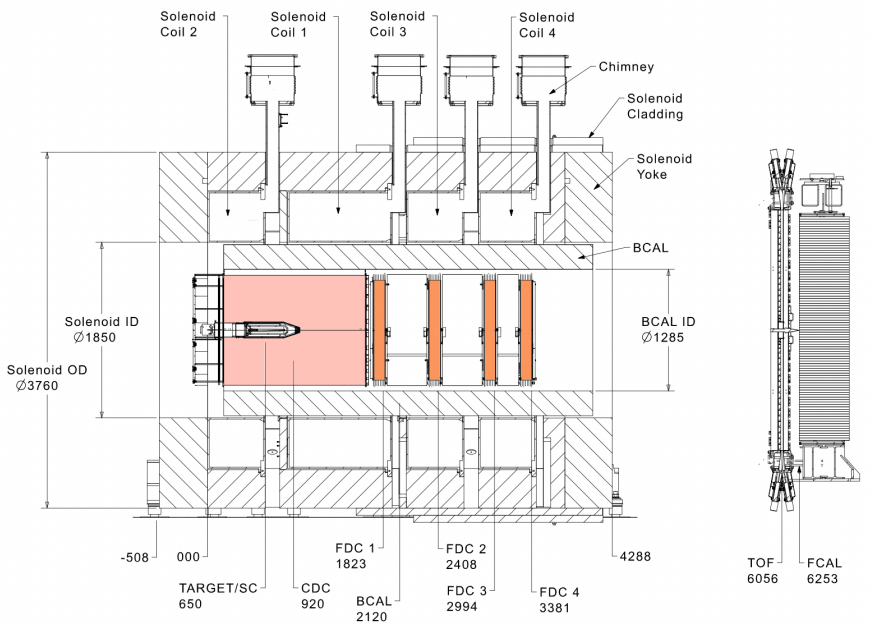


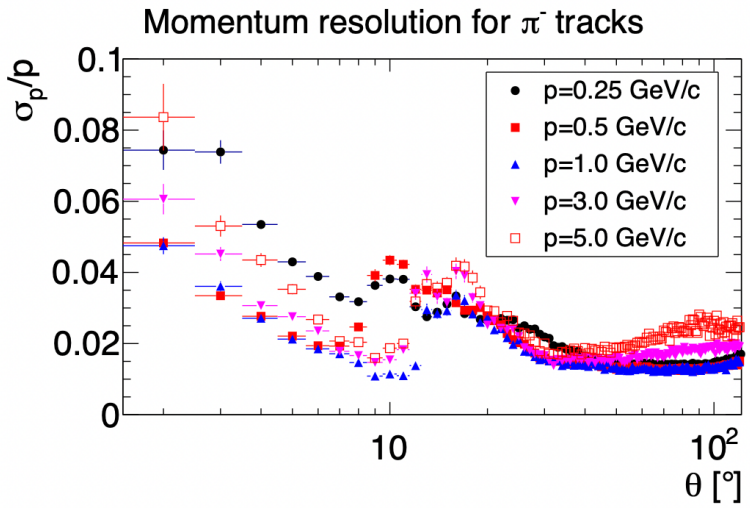


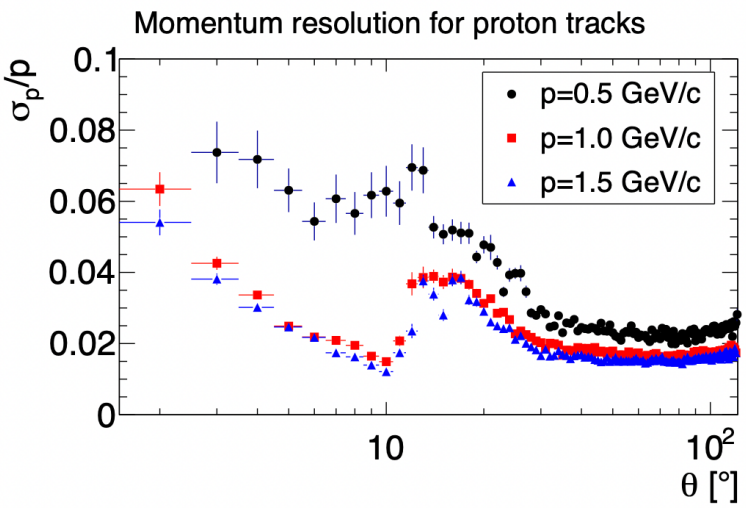


GlueX - CDC & FDC

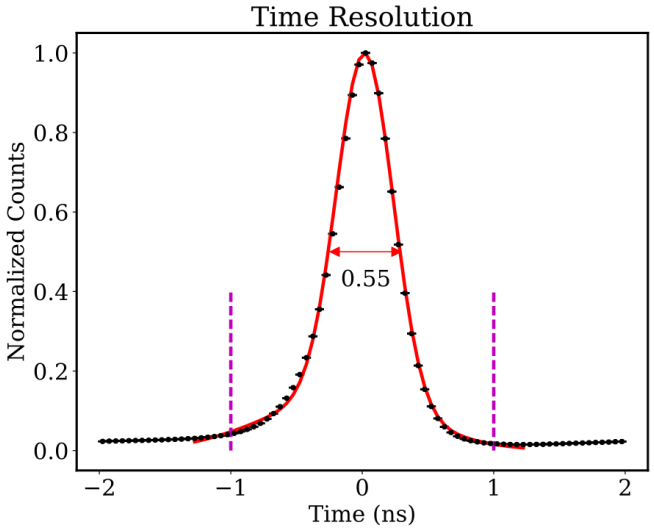


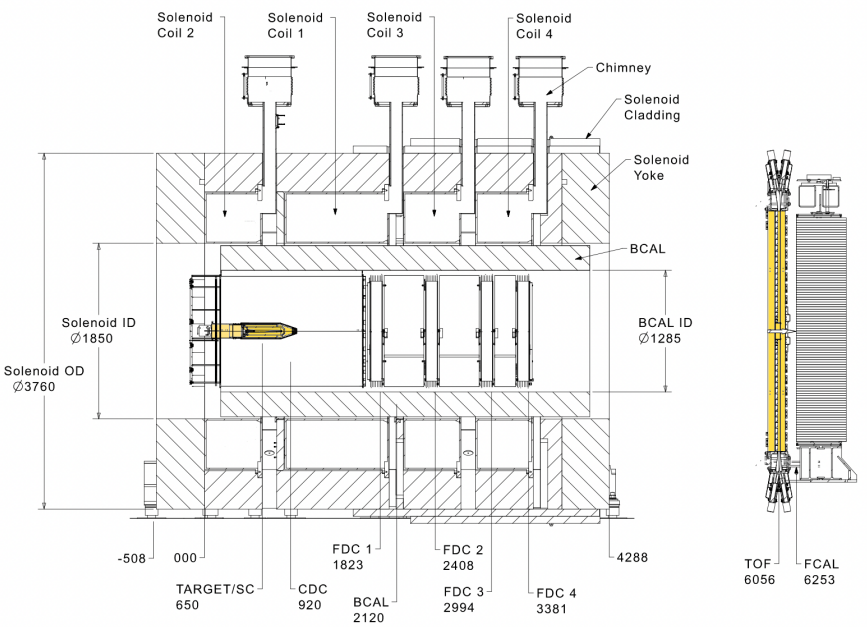


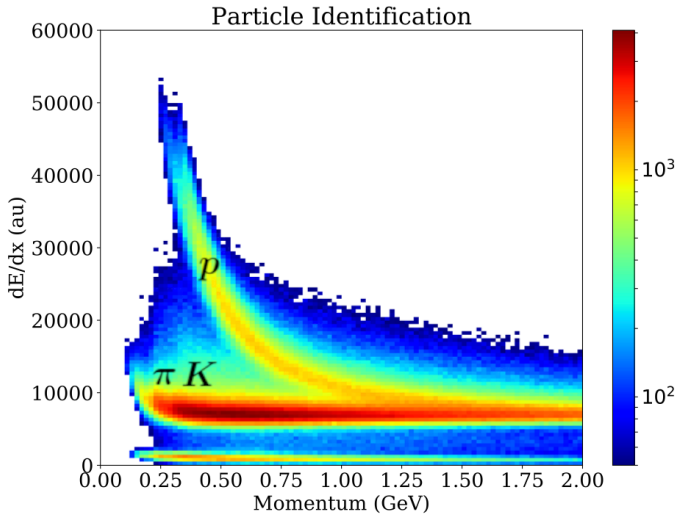


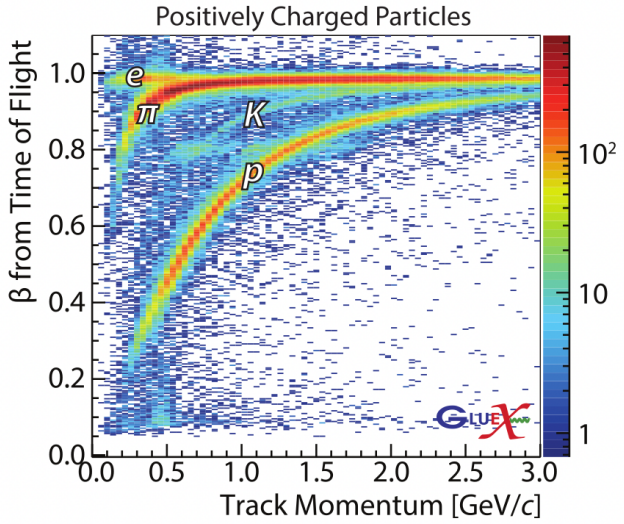


GlueX - ST & TOF


Time Resolution
Normalized Counts
Time (ns)
0.55

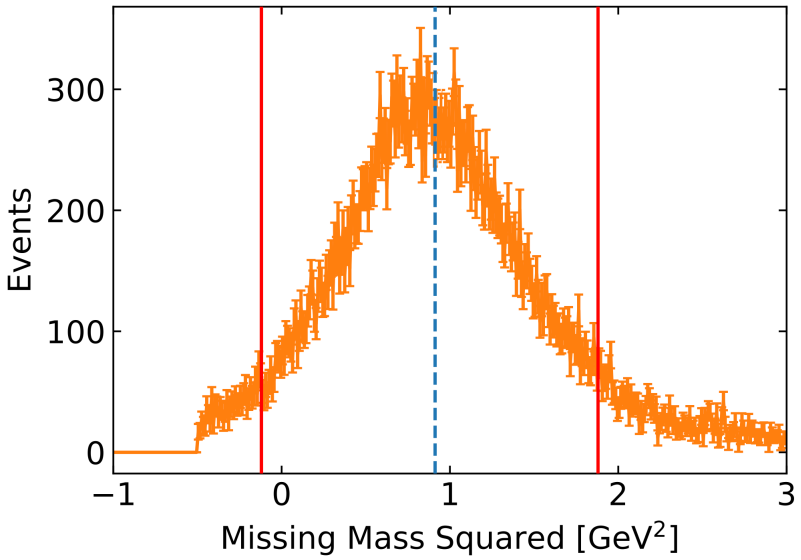

Solenoid Coil 2
Solenoid Coil 1
Solenoid Coil 3
Solenoid Coil 4
Chimney
Solenoid Cladding
Solenoid Yoke
BCAL
Solenoid ID Ø1850
Solenoid OD Ø3760
BCAL ID Ø1285
-508
000
TARGET/SC 650
CDC 920
FDC 1 1823
BCAL 2120
FDC 2 2408
FDC 3 2994
FDC 4 3381
4288
TOF 6056
FCAL 6253

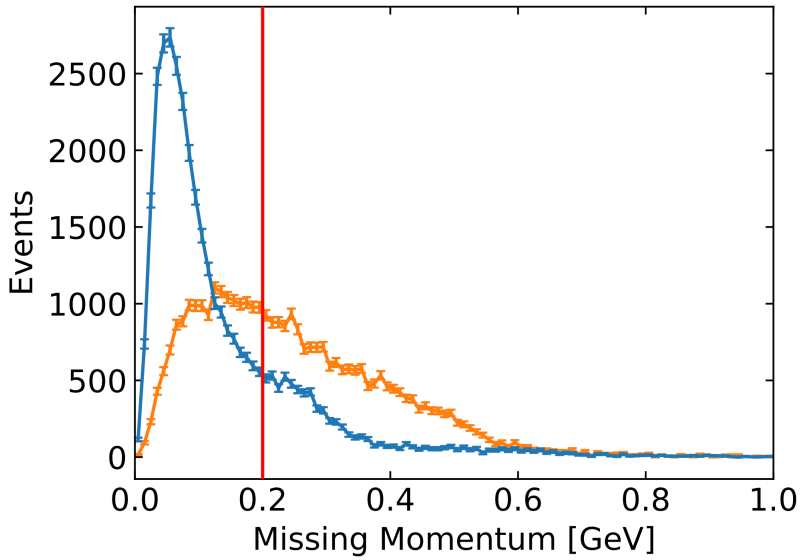

Particle Identification
dE/dx (au)
Momentum (GeV)
p
π K


Positively Charged Particles
β from Time of Flight
Track Momentum [GeV/c]
e
π
K
p

GlueX - Kinematic Fitting

- KinFit uses constraints based on the assumed reaction
- helps tackle bad momentum resolution of GlueX
- works best for ^{1}H, better for D than higher A
- e.g. $\gamma + D \rightarrow \rho^- + p + (p)$





Thank you!