# Status report on Run-Group B

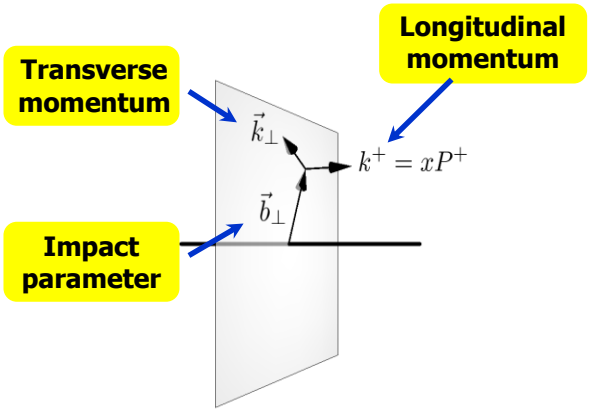
- Physics goals
- Presentation of the RG-B experiments
- Running conditions
- Things to do and issues

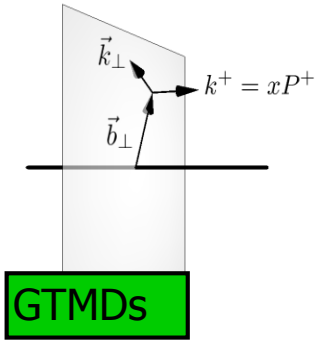
Silvia Niccolai, IPN Orsay

DPWG, JLab, March 30 2017

# Multi-dimensional mapping of the nucleon

A complete picture of nucleon structure requires the **measurement of all these distributions**.



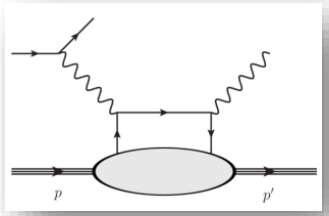



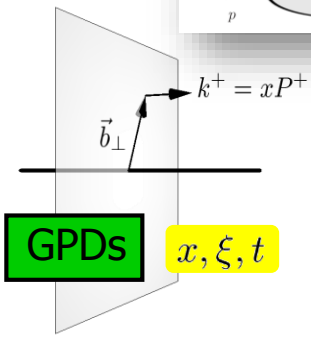

$x, \xi, k_\perp^2, \vec{k}_\perp \cdot \vec{\Delta}_\perp, t$

$\int \mathrm{d}^2\vec{k}_\perp$

$\int \mathrm{d}^2\vec{b}_\perp$

**DVCS**

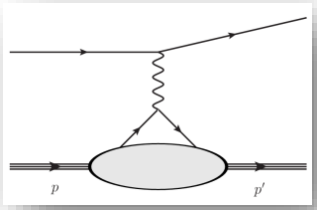


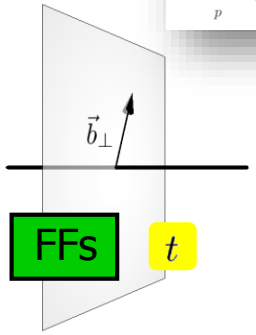



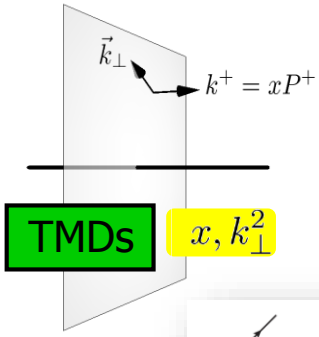

$\int \mathrm{d}x$

$\int \mathrm{d}^2\vec{b}_\perp$

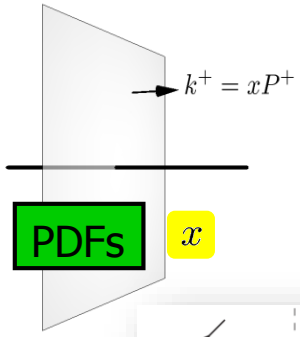
**Elastic Scattering**



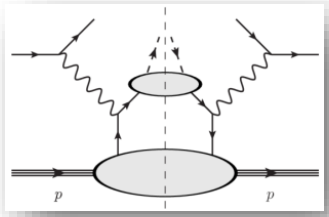



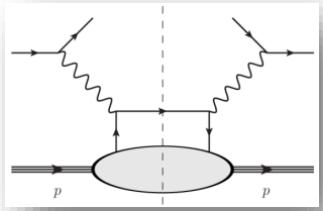

$\int \mathrm{d}^2\vec{k}_\perp$




**SIDIS**




**DIS**




Run-Group B aims to measure all these distributions, using **deuteron** as a **neutron target** → **Quark-flavor separation, combining with proton results**

# CLAS12 Run-Group B

- Common features to all experiments of RG-B: **liquid deuterium** target, **11-GeV** beam
- Approved PAC days: **146**; days in Volker's run-groups table: **90**
- 4 PAC-approved experiments, 1 high-impact experiment, 2 run-group experiments

| | | | | |
|---|---|---|---|---|
| E12-07-104 | Neutron magnetic form factor | G. Gilfoyle | A- | 30 |
| E12-09-007(a) | Study of partonic distributions in SIDIS kaon production | K. Hafidi | A- | 56 |
| E12-09-008 | Boer-Mulders asymmetry in K SIDIS | M. Contalbrigo | A- | 56 |
| E12-11-003 | Deeply virtual Compton scattering on the neutron | S. Niccolai | A (HI) | 90 |
| E12-09-008b | Collinear nucleon structure at twist-3 | S. Pisano | -- | |
| E12-11-003a | In medium structure functions, SRC, and the EMC effect | O. Hen | -- | |

**A scheduling request for 2018 was submitted in July 2016**

**RG-preparation meetings started last week**

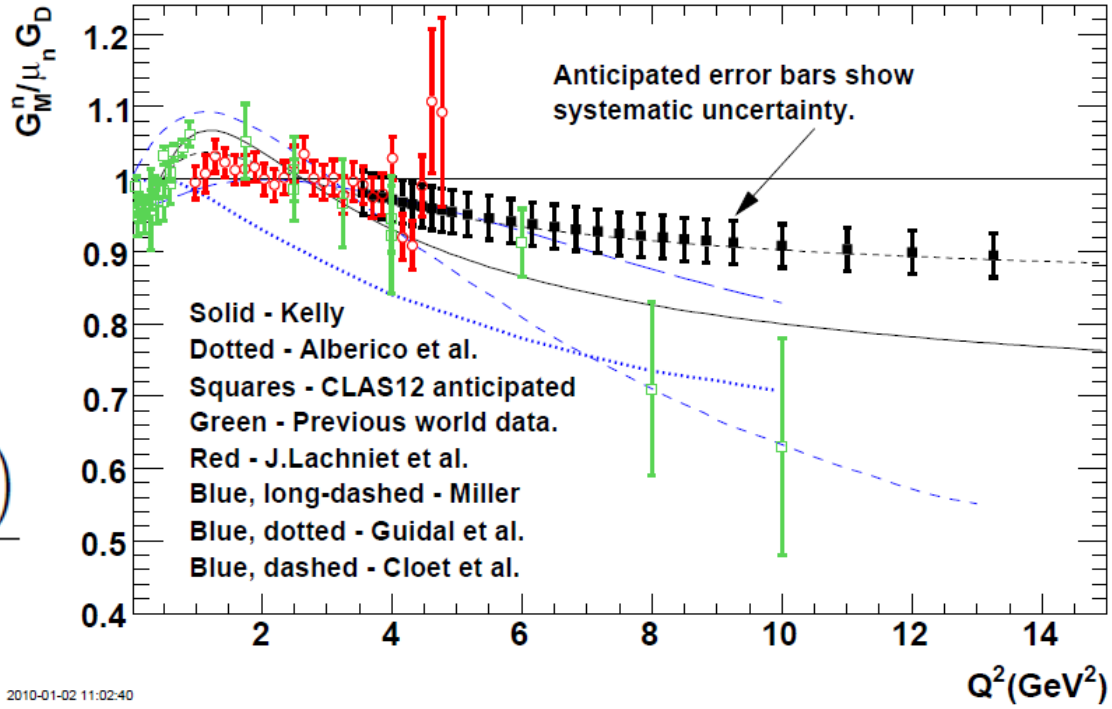
# E12-07-104: Measurement of the Neutron Magnetic Form Factor at High $Q^2$ Using the Ratio Method on Deuterium

Spokespersons: W. Brooks, G. Gilfoyle, K. Hafidi

**Goal**: extract $G_M^n$ for $3<Q^2<14$ GeV$^2$ via the ratio of **quasi-elastic e-n** and **quasi-elastic e-p** on deuteron

$$R = \frac{\frac{d\sigma}{d\Omega}(^2\mathrm{H}(e,e'n)_{QE})}{\frac{d\sigma}{d\Omega}(^2\mathrm{H}(e,e'p)_{QE})} =$$

$$= a(Q^2)\frac{\sigma^n_{mott}(G_E^{n\,2} + \frac{\tau_n}{\varepsilon_n}G_M^{n\,2})\left(\frac{1}{1+\tau_n}\right)}{\frac{d\sigma}{d\Omega}(^1\mathrm{H}(e,e')p)}$$



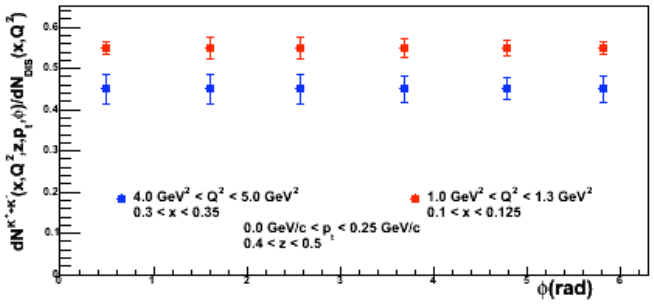

- **Both particles** of the two quasi-elastic final states will be detected in CLAS12
- Neutrons will be detected in the FEC, PCAL and FTOF
- A ***dual target*** (H/D) is required to **monitor neutron efficiency**, minimizing systematics
- Approved for 30 days of running

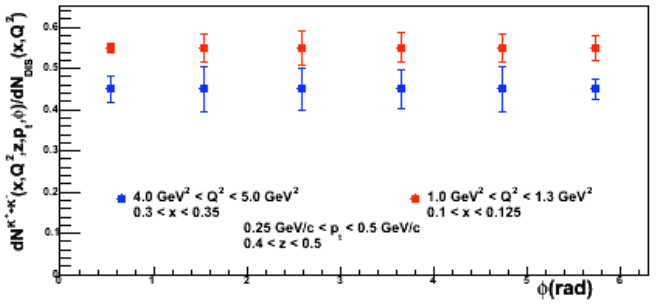
# E12-09-007a: Study of partonic distributions in SIDIS K production

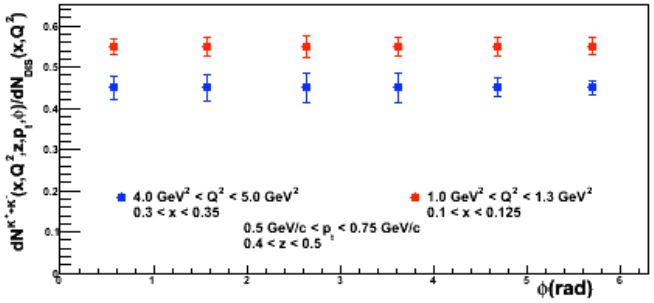
Spokespersons: H. Avakian, F. Benmoktar, A. El Alaoui, K. Hafidi, M. Mirazita

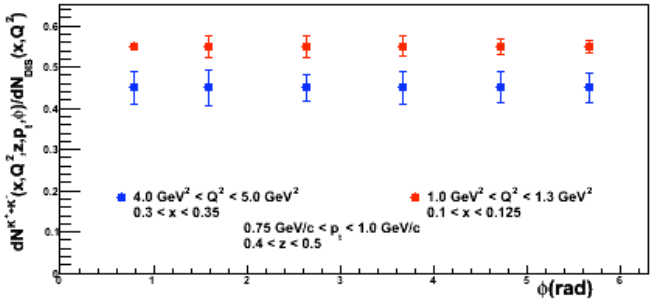
**Goal**: measure **multiplicities** for various hadrons ($\pi^+$, $\pi^-$, $\pi^0$, $K^+$, $K^-$, $K^0_s$) on deuterium, for $0.05 < x < 0.7$
→ improve parametrizations of **fragmentation functions**
→ **strange parton distribution functions**

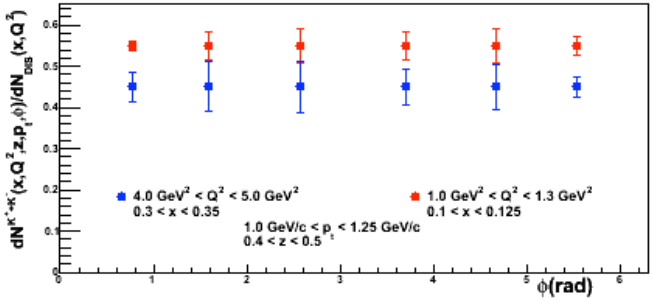
- Part of an extensive program on unpolarized and polarized **proton and deuterium** targets (**RG-C**)
- 56 days approved (***dual H/D target***)
- **RICH** necessary for kaon ID

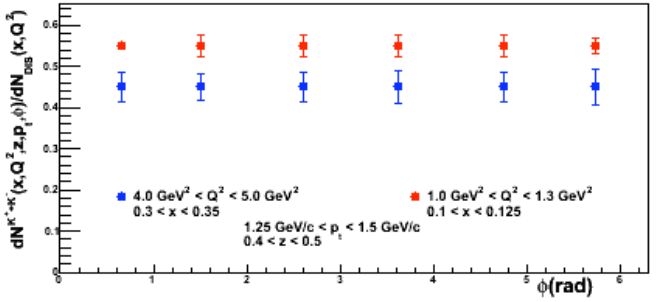


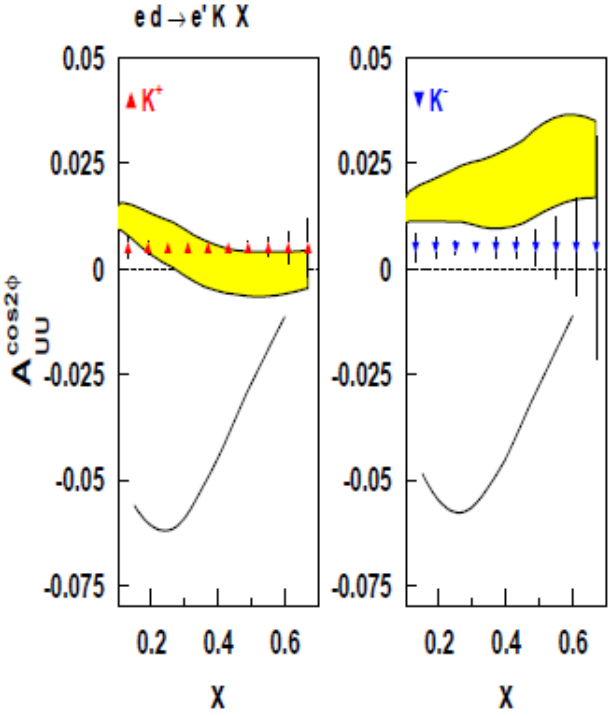



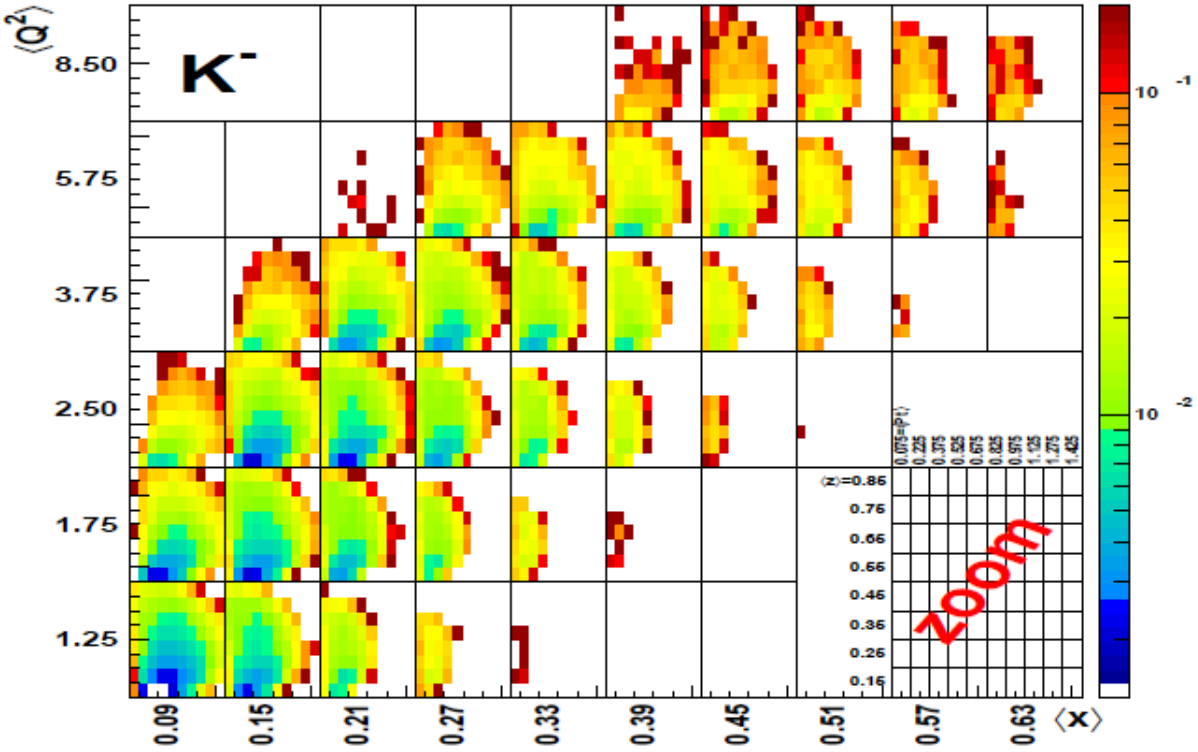



# E12-09-008: Boers-Mulders asymmetry in K SIDIS

Spokespersons: H. Avakian, M. Contalbrigo, K. Joo, Z. Meziani

**Goal**: measurement of **spin azimuthal asymmetries** in **semi-inclusive** electroproduction of **kaons** on unpolarized (proton) and deuteron targets
→ transverse momentum dependence of **valence quark transverse spin distributions**
→ **spin-orbit correlations**




- **RICH** is required for kaon ID
- 56 approved days, on ***dual target*** (H/D), half time with **reverse torus polarity**

# E12-11-003: DVCS on the neutron with CLAS12

Spokespersons: A. El Alaoui,V. Kubarovsky, S. Niccolai, S. Pisano, D. Sokhan

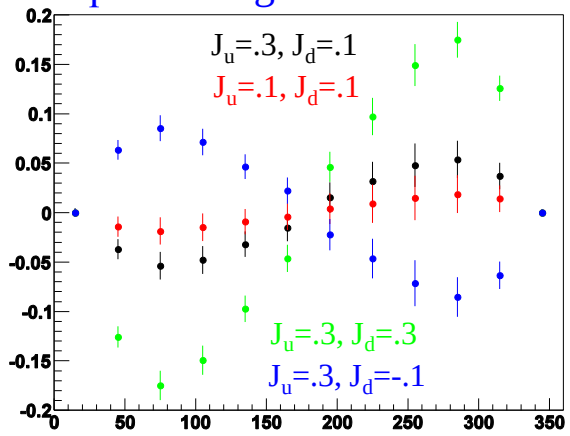
**Goal: beam-spin asymmetry for nDVCS**, the most sensitive observable to the **GPD E**
**Flavor separation of GPDs**

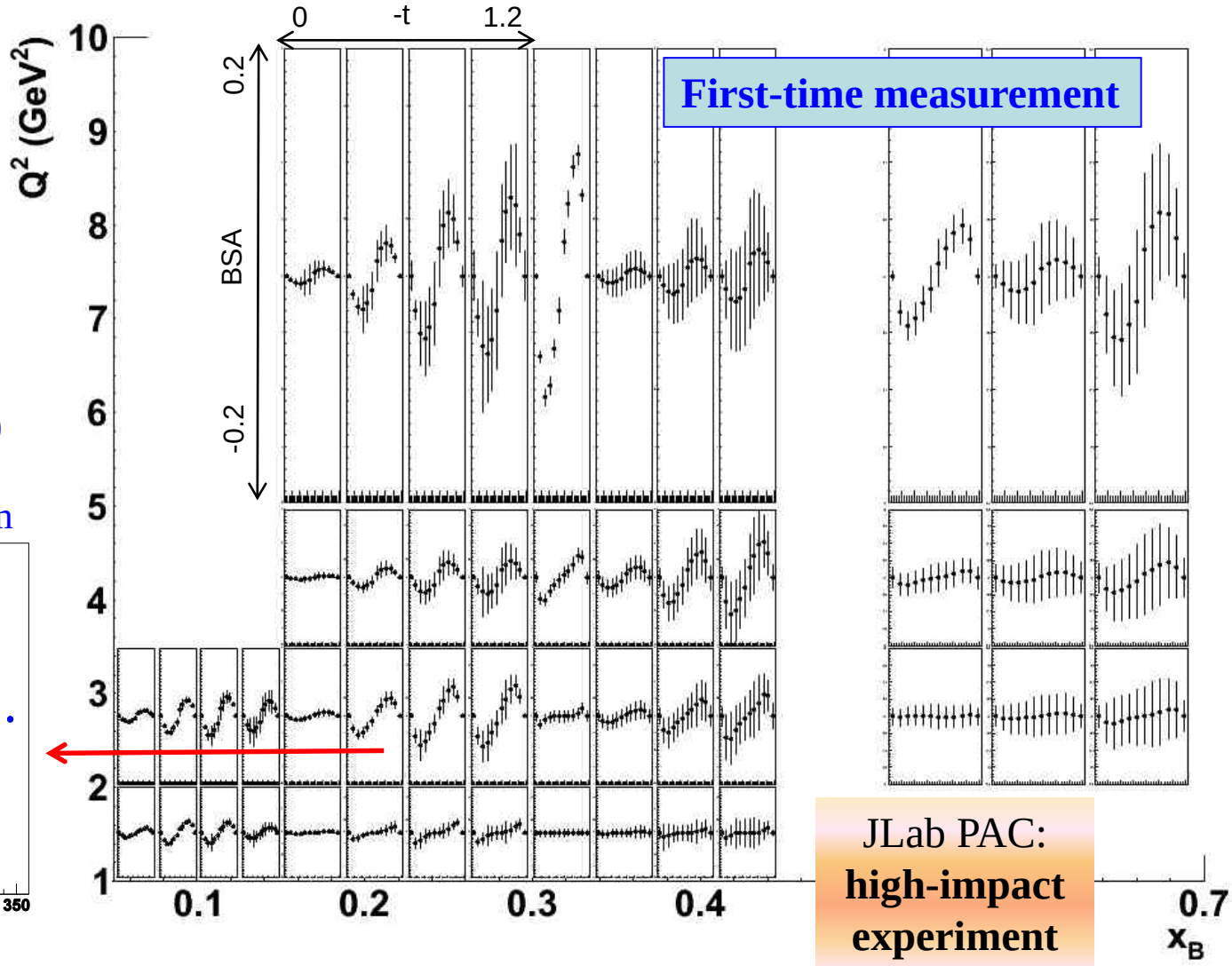
$$(H,E)_u(\xi,\xi,t) = \tfrac{9}{15}\left[4(H,E)_p(\xi,\xi,t) - (H,E)_n(\xi,\xi,t)\right]$$
$$(H,E)_d(\xi,\xi,t) = \tfrac{9}{15}\left[4(H,E)_n(\xi,\xi,t) - (H,E)_p(\xi,\xi,t)\right]$$

***ed→ e(p)nγ***
Exclusive final state
CLAS12+**FT**+CND

- Liquid deuterium target
- L = $10^{35}$ /nucleon
- 90 days (80+10)

Model predictions (VGG) for different values of quarks' angular momentum




**First-time measurement**

JLab PAC:
**high-impact experiment**

# Two run-group proposals

**E12-09-008b: Higher-twist collinear structure of the nucleon through di-hadron SIDIS on unpolarized hydrogen and deuterium**

Spokepersons: A. Courtoy, S. Pisano

- **Goal:** BSA and multiplicities for di-hadron SIDIS production
- ***Same running conditions as E12-09-008 (dual target)***

**E12-11-003a: In Medium Proton Structure Functions, SRC, and the EMC effect**

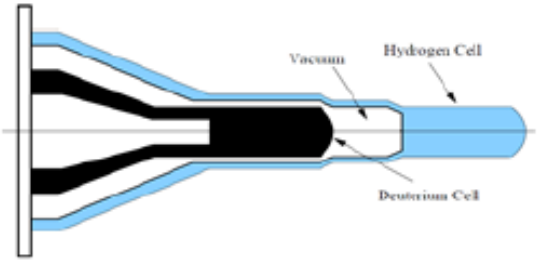
Spokespersons: H. Hakobyan, O. Hen, E. Piasetzky, L. Weinstein

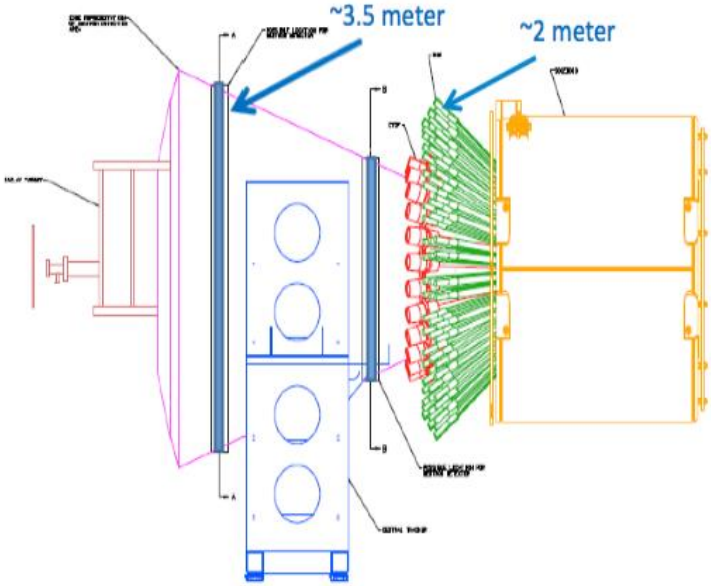
- **Goal**: structure functions of bound protons in deuterium as a function of their initial momentum by "tagging" the DIS on the deuteron detecting high momentum recoiling neutrons emitted at large angle
- ***Same running conditions as E12-11-003a (deuterium target) + BAND detector***

# Running conditions and 2018 run

**Running conditions**:

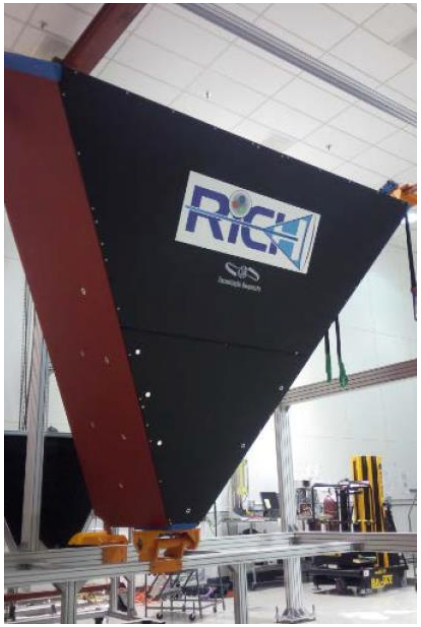
- Target (deuterium only? Dual?)
- Luminosity
- Beam current
- Magnetic field settings
- Ancillary runs

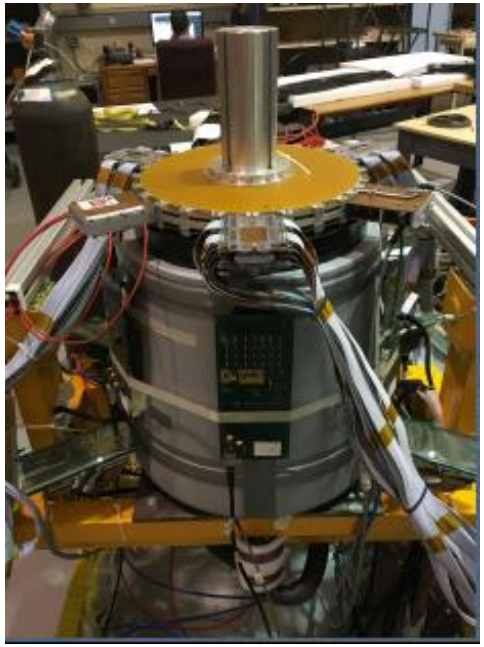



**Readyness for 2018 run**:

- BAND and dual target status?
- CND, RICH and FT should be already in RG A



# Possible RG Schedule (straw man)

| Run Group | Days | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | Remain |
|---|---|---|---|---|---|---|---|---|---|
| All Run Groups | **1036**[#)] | 30 | 15 | 95 | 105 | 105 | 105 | 105 | 456 |
| **HPS** | 180* | 15 | | 35 | 10 | 10 | 10 | 10 | 90 |
| **PRad** | 15* | 15 | | | | | | | 0 |
| **CLAS12 Comm** | | | 3 15 | | | | | | 0 |
| RG-A + RG-K (proton) | 239* | | 10 | 20/15 25 | | 35 | 20 | | 114* |
| RG-B (deuteron) | 90* | | | | 40 | | | | 50* |
| RG-F (BoNuS) | 42* | | | | 21 | | | | 21 |
| RG-C ($NH_3$) | 120 | | | | 35 | 25 | | | 60 |
| RG-C-b ($ND_3$) | 65 | | | | | 35 | | | 30 |
| RG-E (Hadr.) | 60 | | | | | | 35 | | 25 |
| RG-H (Transv. Target) | 110* | | | | | | 40 | 20 | 50 |
| RG-D (CT) | 60 | | | | | | | 40 | 20 |
| RG-G (LiD) | 55 | | | | | | | 35 | 20 |

[#)] incl. RG-H

CEBAF Large Acceptance Spectrometer

# Things to do, discussion items

- We would like to **run in 2018**, as we had requested
- Work is needed to agree on **running conditions**:
  - ✓ Does it make sense to use a dual target when there are already 139 days on proton?
  - ✓ Or should we merge RG-A and RG-B using always a dual target?
  - ✓ Proposals submitted ~10 years ago: have things changed? Conditions could be revised?
- **Full simulations** (GEMC+reconstruction) should be run, to determine optimal settings
- Monthly (and more frequent, when needed) meetings have started
- Joint meetings with RG-A should be considered as well

***Open issue*: how are the RG days of *Volker's table computed?***

***RG-B has 90 days, as nDVCS***

***RG-A has 139 days, which is 19 days more than the longest approved experiment***

***→ the number of days of RG-A has been adjusted to account for different running conditions***

***This should be done also for RG-B, and for all other run groups as well!***

***Minimum number of days for RG-B: 118*** *(90+28 inbending)*

# Hall B – Run Groups

Hall B

| Proposal | Physics | Contact | Rating | Days | Group | New equipment | Energy | Run Group | Target |
|---|---|---|---|---|---|---|---|---|---|
| **E12-06-108** | Hard exclusive electro-production of $\pi^0$, $\eta$ | Stoler | B | 80 | 139 | RICH (1 sector) Forward tagger | 11 | A F. Sabatié | liquid $H_2$ |
| E12-06-108A | Exclusive N*->KY Studies with CLAS12 | Carman | | (60) | | | | | |
| E12-06-108B | Transition Form Factor of the $\eta'$ Meson with CLAS12 | Kunkel | | (80) | | | | | |
| **E12-06-112** | Proton's quark dynamics in SIDIS pion production | Avakian | A | 60 | | | | | |
| E12-06-112A | Semi-inclusive $\Lambda$ productiuon in target fragmentation region | Mirazita | | (60) | | | | | |
| E12-06-112B | Colinear nucleon structure at twist-3 | Pisano | | (60) | | | | | |
| E12-06-119(a) | Deeply Virtual Compton Scattering | Sabatie | A | 80 | | | | | |
| E12-09-003 | Excitation of nucleon resonances at high $Q^2$ | Gothe | B+ | 40 | | | | | |
| **E12-11-005** | Hadron spectroscopy with forward tagger | Battaglieri | A- | 119 | | | | | |
| E12-11-005A | Photoproduction of the very strangest baryon | Guo | | (120) | | | | | |
| E12-12-001 | Timelike Compton Scatt. & J/ψ production in e+e- | Nadel-Turonski | A- | 120 | | | | | |
| E12-12-007 | Exclusive φ meson electroproduction with CLAS12 | Stoler, Weiss | B+ | 60 | | | | | |
| E12-07-104 | Neutron magnetic form factor | Gilfoyle | A- | 30 | 90 | Neutron detector RICH (1 sector) Forward tagger | 11 | B K. Hafidi | liquid $D_2$ target |
| E12-09-007(a) | Study of partonic distributions in SIDIS kaon production | Hafidi | A- | 30 | | | | | |
| **E12-09-008** | Boer-Mulders asymmetry in K SIDIS w/ H and D targets | Contalbrigo | A- | 56 | | | | | |
| E12-09-008A | Hadron production in target fragmentation region | Mirazita | | (60) | | | | | |
| E12-09-008B | Colinear nucleon structuer at twist-3 | Pisano | | (60) | | | | | |
| **E12-11-003** | DVCS on neutron target | Niccolai | A | 90 | | | | | |
| E12-11-003A | In medium structure functions, SRC, and the EMC effect | Hen | | (90) | | | | | |
| **Beam time partial sum** | | | | **765 (1355)** | **229** | | | | |

**Experiment ending with A or B are run group experiments approved by the CLAS collaboration. They are running parallel to the experiments with same experiment number. Experiments ending with (a) and (b) take data with both run groups.**