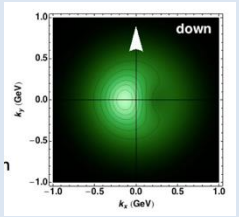
CLAS12 Experiments with a Transversely Polarized Target
Run-Group H

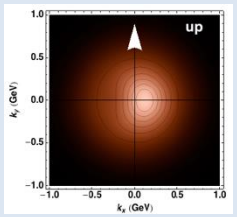
Contalbrigo Marco - INFN Ferrara

RGH Workshop, JLab, 13th- 14th November 2026

TMD (x, k_T) quark polarisation

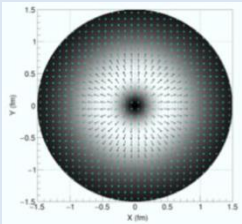
nucleon polarisation: N/q	U	L	T
U	f_1		$h_1^\perp$
L		g_1	$h_{1L}^\perp$
T	$f_{1T}^\perp$	$g_{1T}^\perp$	$h_1, h_{1T}^\perp$

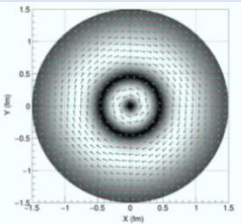




GPD (x, b_T) quark polarisation

nucleon polarisation: N/q	U	L	T
U	H		$\mathcal{E}_T$
L		$\tilde{H}$	$\tilde{E}_T$
T	E	$\tilde{E}$	$H_T, \tilde{H}_T$





Confinement Scale

High Energy Probe
Hard Scale

RGH approved with NH_3 target by PAC 53 - 2025

Experiment	Contact	Title	Rating	PAC days
C12-11-111	M. Contalbrigo	Transverse spin effect in SIDIS at 11 GeV with a transversely polarized target using CLAS12	A	100 + 25
C12-12-009	H. Avakian	Measurement of transversity with di-hadron production in SIDIS with a transversely polarized target	A	100 + 25
C12-12-010	L. Elauadrhiri	Deeply Virtual Compton scattering at 11 GeV with transversely polarized target using the CLAS12 detector	A	100 + 25
C12-11-111A	H. Avakian	Measurements of Single Spin Asymmetries in exclusive production of hadrons with RGH transversely polarized target		100 + 25

Access to unique observables in

- SIDIS hadron ep->ehX
- SIDIS di-hadron ep->ehhX
- DVCS ep->eγp
- DVMP ep->eV^0p

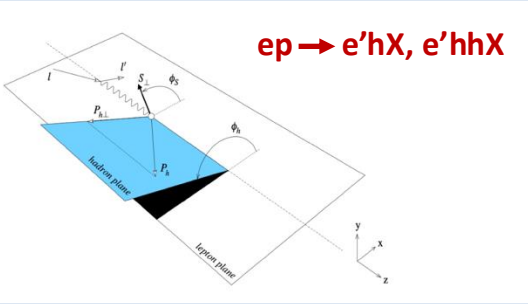
Gather unprecedented information on

Transversity	**Sivers**, $h_{1T}^{\perp}$, $g_{1T}^{\perp}$, $H_1^{\perp}$	**GPD E**
Tensor charge	Spin-orbit effects	Quark OAM

L. Polizzi

H. Avakian

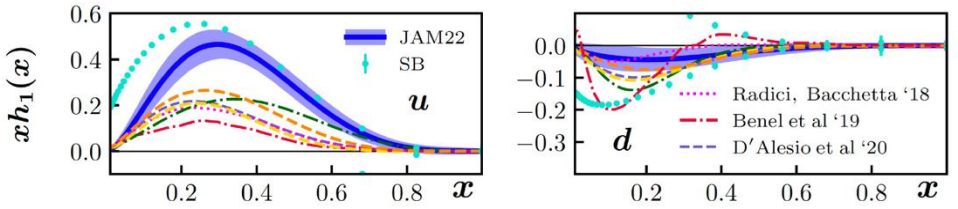
A. Vosen



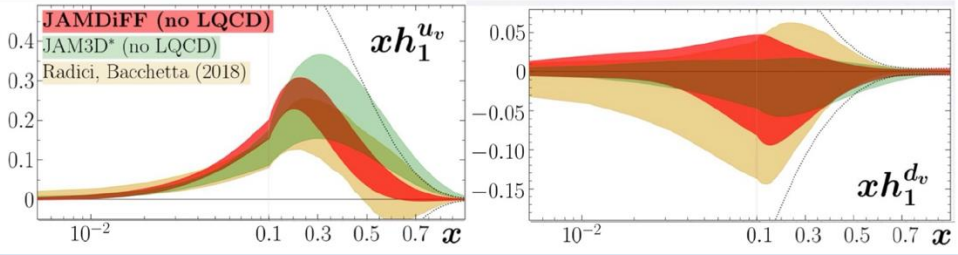
Large sensitivity expected in the valence region
Lack of data above x = 0.3 and no fully differential (4D) analysis available so far

CLAS12 can be the first experiment to achieve a 4D analysis in the valence region

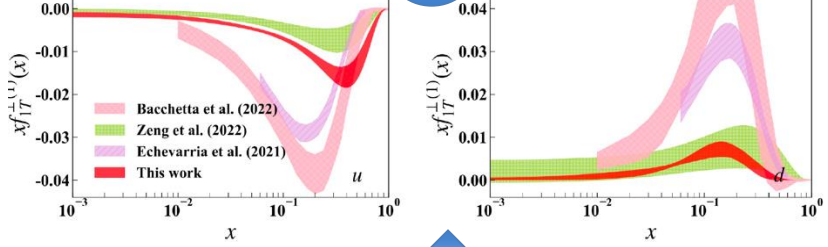
Transversity from single hadron SIDIS



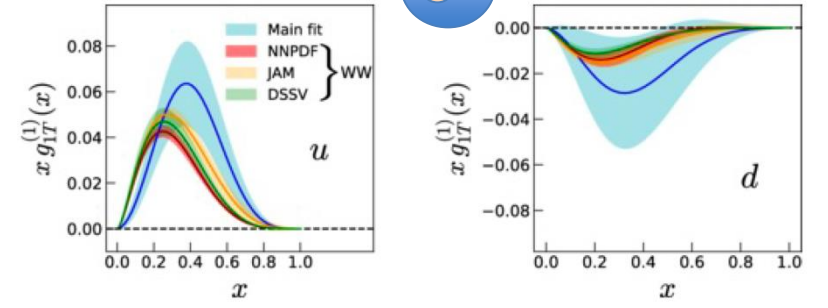
Transversity from di-hadron SIDIS



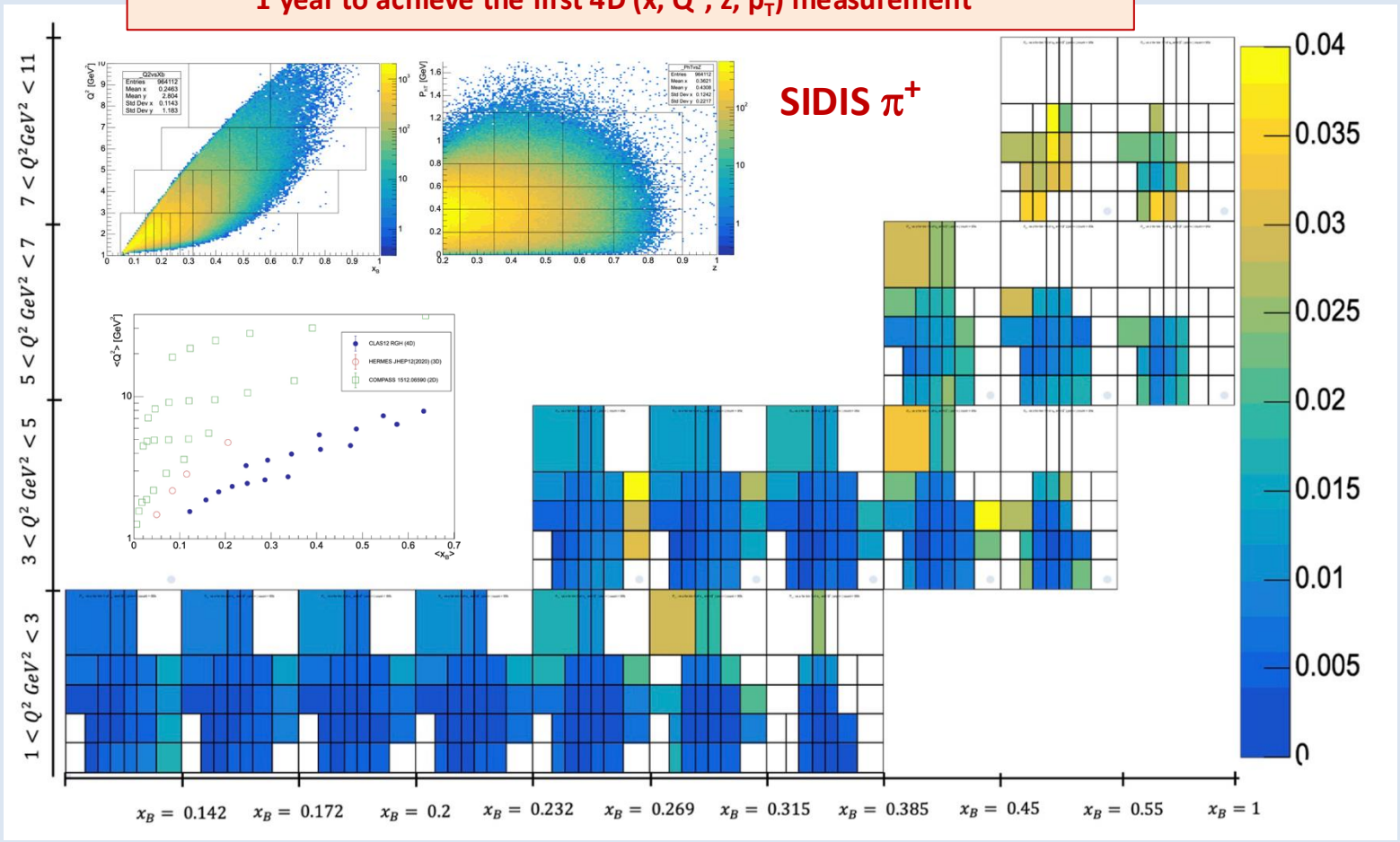
Sivers



Kotzinian-Mulders



~ 1 year to achieve the first 4D (x, Q^2, z, p_T) measurement



GPD E

$$\sum_q \int_{-1}^{+1} dx\, x[H^q(x,\xi,t=0) + E^q(x,\xi,t=0)] = 2\,J_q$$

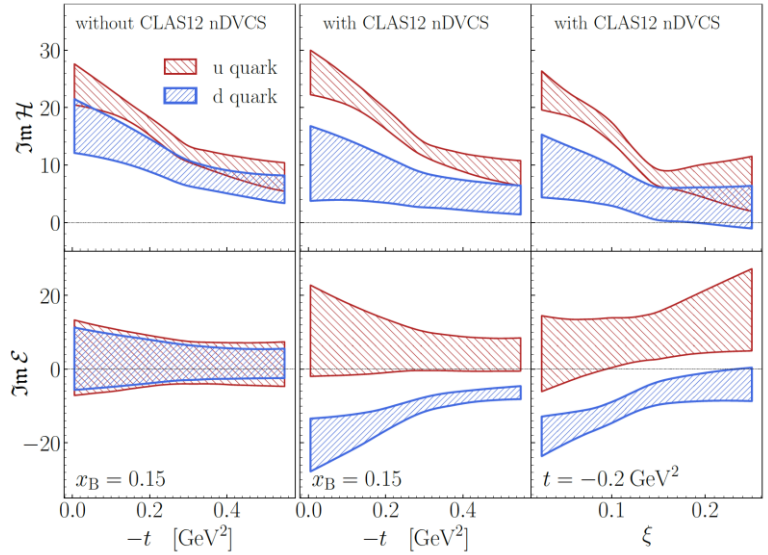
GPD E is essential to pin down the quark dynamics (OAM)
It is poorly known expecially for the u-quark flavor

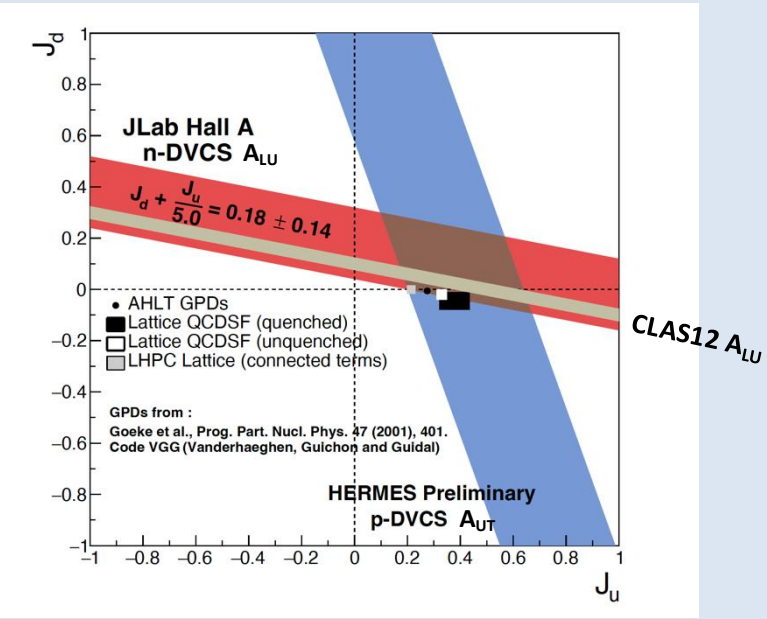
CLAS12 can be the first experiment in exploiting both
A_{LU} measurement on neutron with
A_{UT} measurement on proton

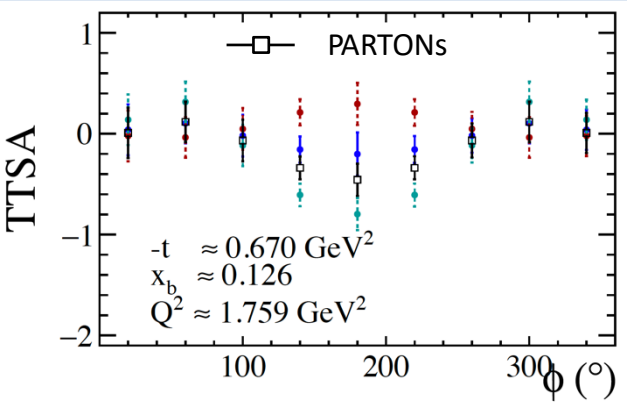
$$\Delta\sigma_{LU} \sim \sin\phi\ \mathrm{Im}\{F_1\mathcal{H} + \xi(F_1+F_2)\widetilde{\mathcal{H}} - kF_2\mathcal{E} + \dots\}$$

$$\Delta\sigma_{UT} \sim \cos\phi\sin(\phi_s-\phi)\mathrm{Im}\{k(F_2\mathcal{H} - F_1\mathcal{E}) + \dots\}$$

CLAS12 RGB measurement of A_{LU} on neutron, Phys.Rev.Lett. 133 (2024) 21, 211903





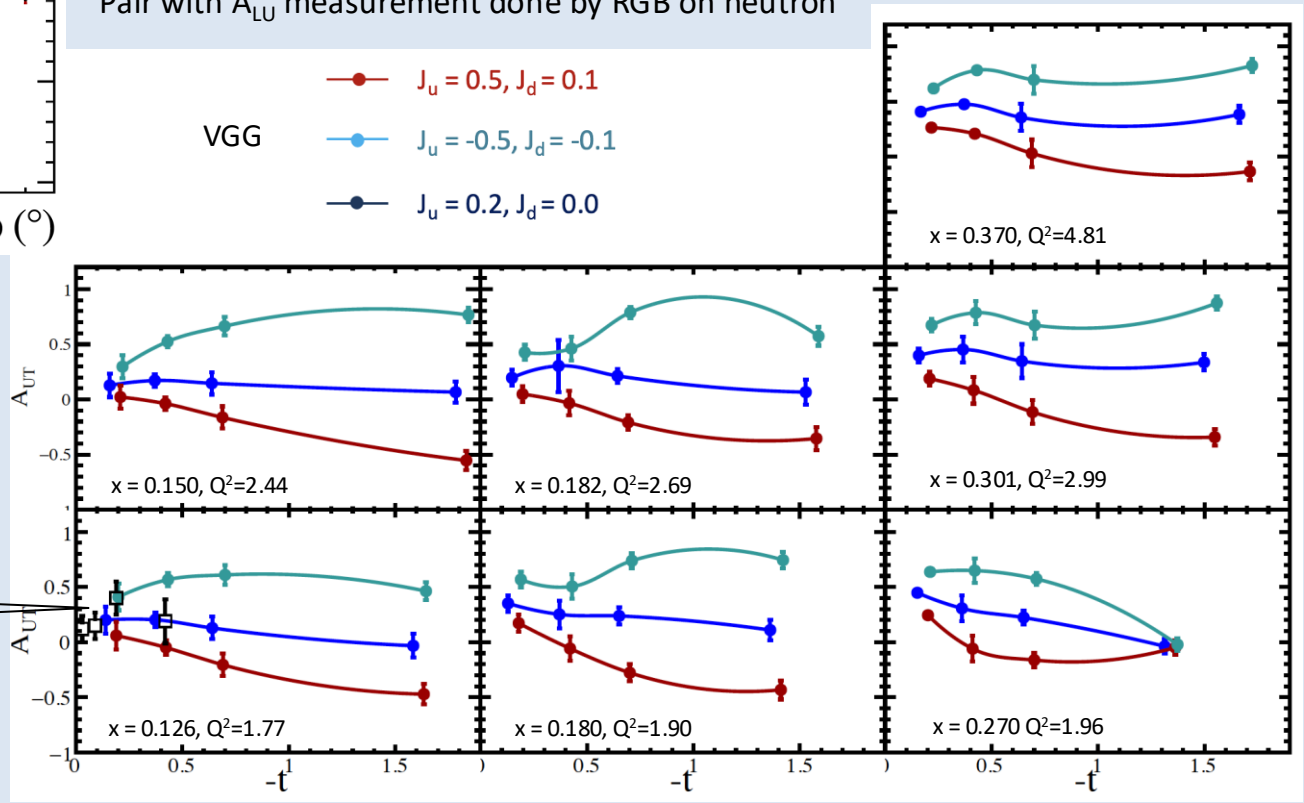


~ 1 year to get unprecedented access to elusive quark angular momenta

Supersede the only other A_{UT} measurement
Pair with A_{LU} measurement done by RGB on neutron

Superior discrimination power between various OAM model hypotheses

HERMES



RGH Timeline

RGH has targeted 2030-31 as potential data-taking slot

This means we need ERR for scheduling in 2029 (about three years from now)

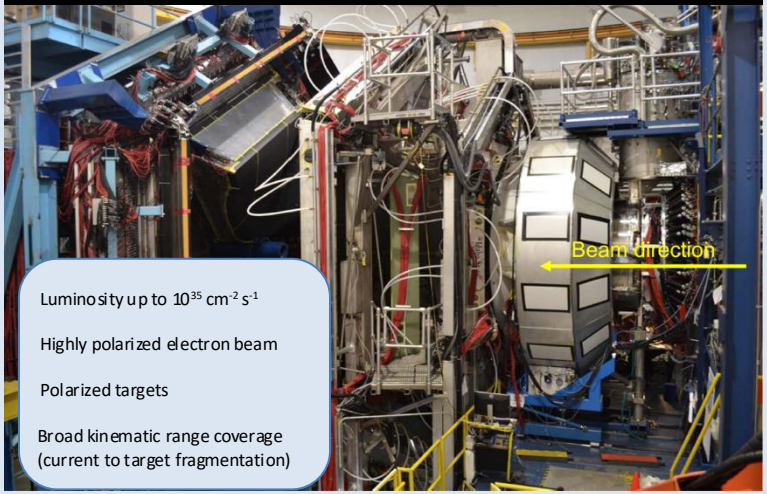
This schedule is technical driven but important external factors may matter

- funding profile
- procurement procedures
- long-lead items

RGH task is to define a baseline ready for procurement within about 1 year.

This workshop will be the first of a series to promote and facilitate the work.

Large acceptance spectrometer. Operational since 02/18



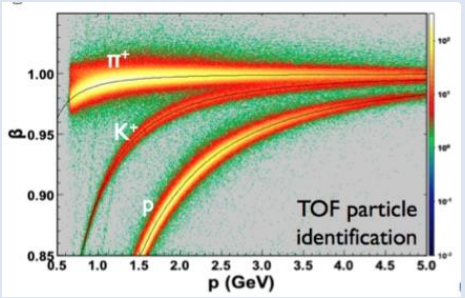
Luminosity up to 10^{35} cm^{-2} s^{-1}

Highly polarized electron beam

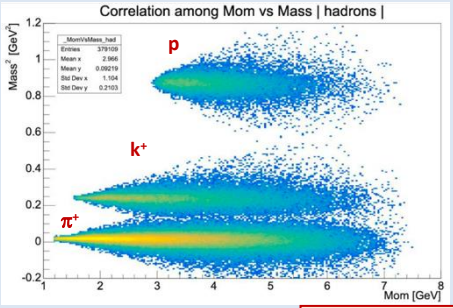
Polarized targets

Broad kinematic range coverage (current to target fragmentation)

Time of flight



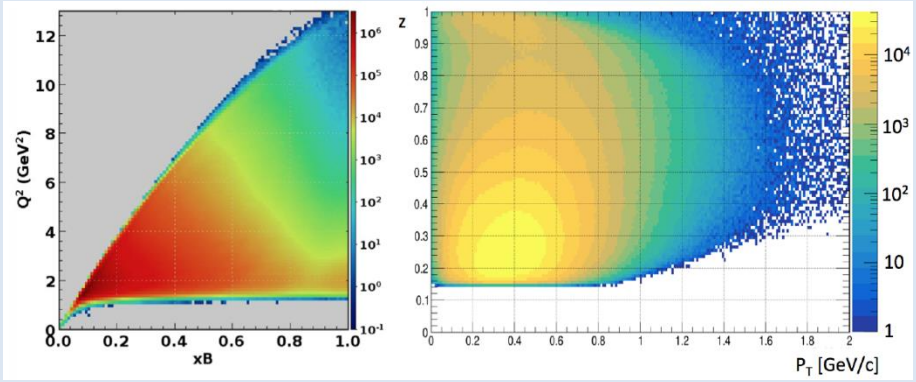
Ring-imaging Cherenkov

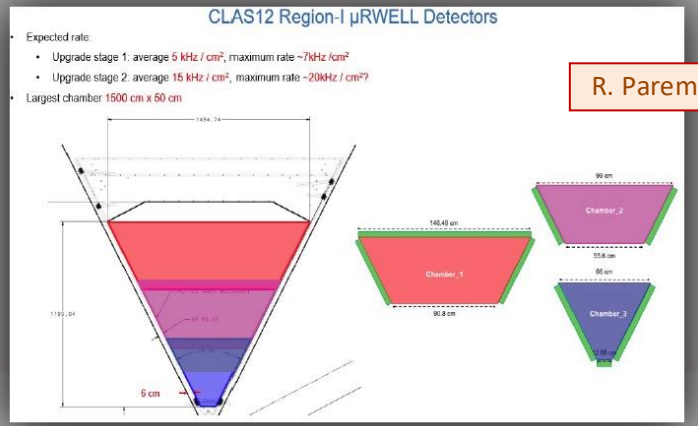


M. Mirazita

Luminosity upgrade Stage-1: 2×10^{35} cm^{-2}s^{-1} 2 years

Stage-2: $> 10^{37}$ cm^{-2}s^{-1} 5-8 years





R. Paremuzyan

HD-ice: ruled out after beam tests at UITF

NH_3: Viable solution to prioritize physics over R&D

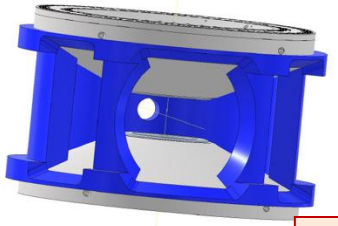
Consolidated dynamically polarized technology

Designed based on already successful realizations

Hall-A G2p-Gep target (replica optimized for HTCC)
Hall-C E12-15-005 magnet (replica optimized for recoil detection)

Magnet design being finalized for procurement


Magnet

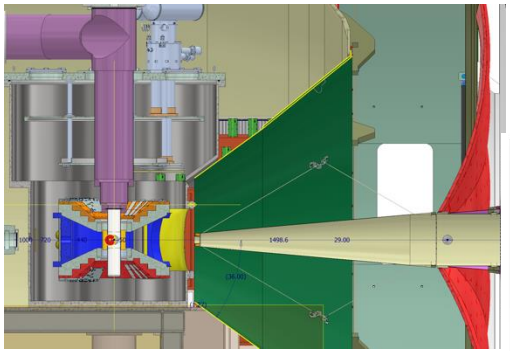


5T dipole acceptance:

± 25° vertical

± 70° horizontal

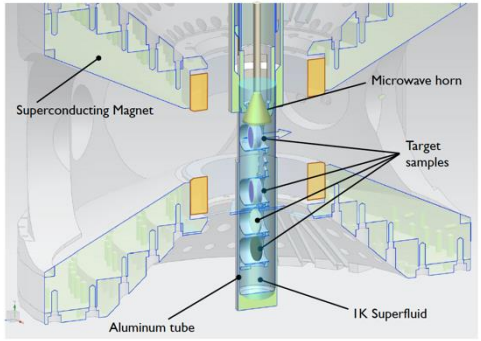
J. Brock



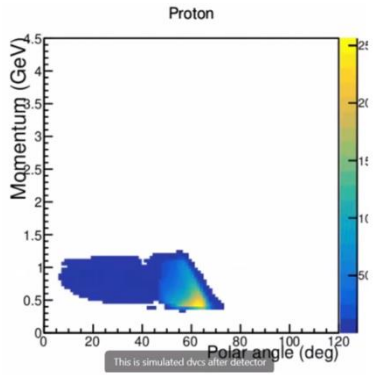
Target cryostat in front of CLAS12

C. Keith

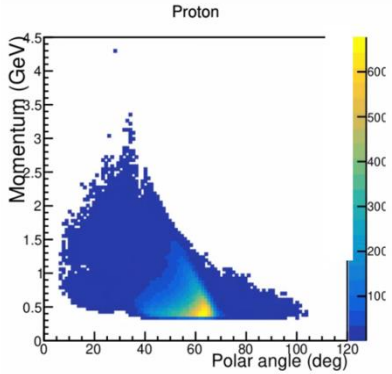
Target ladder details



RGH (MC)



RGA (data)

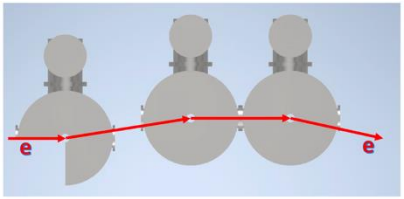


Based on

existing 0.7 cm raster

commercial 7.5T magnets



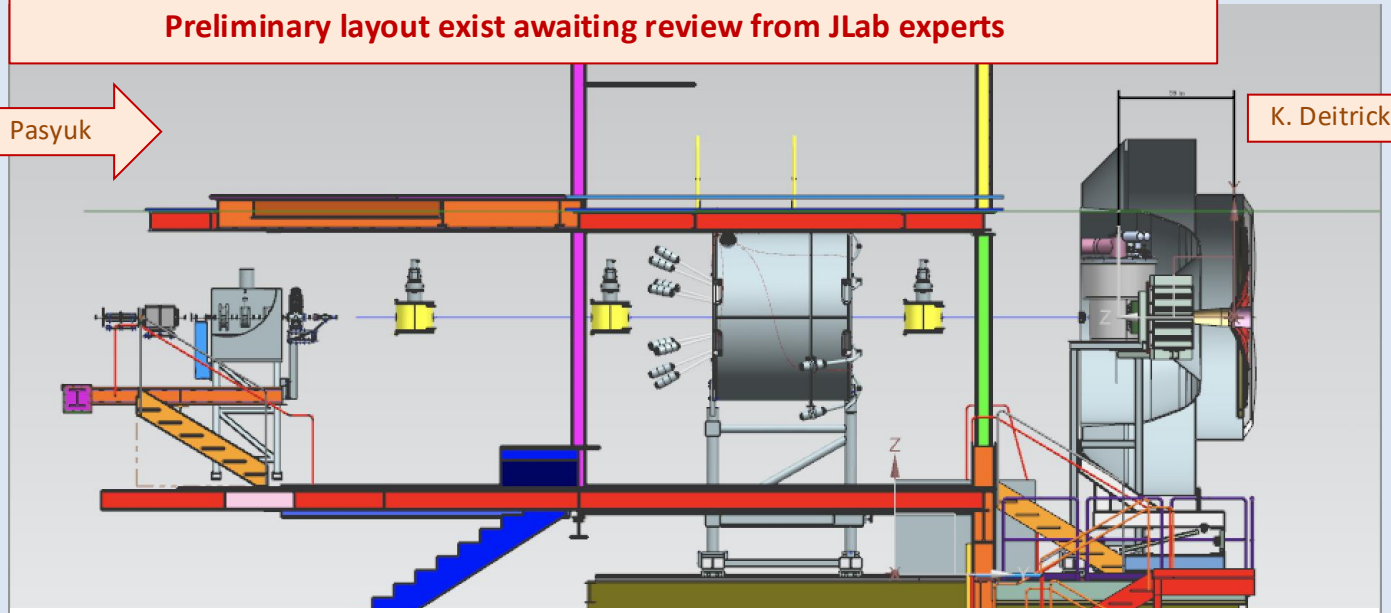


- ✓ space
- ✓ synchrotron radiation
- ✓ beam rastering

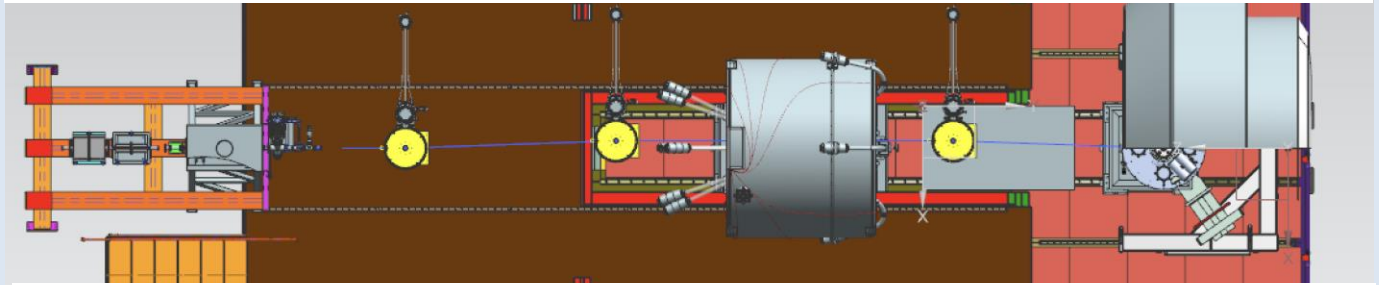
Preliminary layout exist awaiting review from JLab experts

E. Pasyuk

K. Deitrick



2nd Raster BPM Chicane1 Chicane2 Chicane3 Target



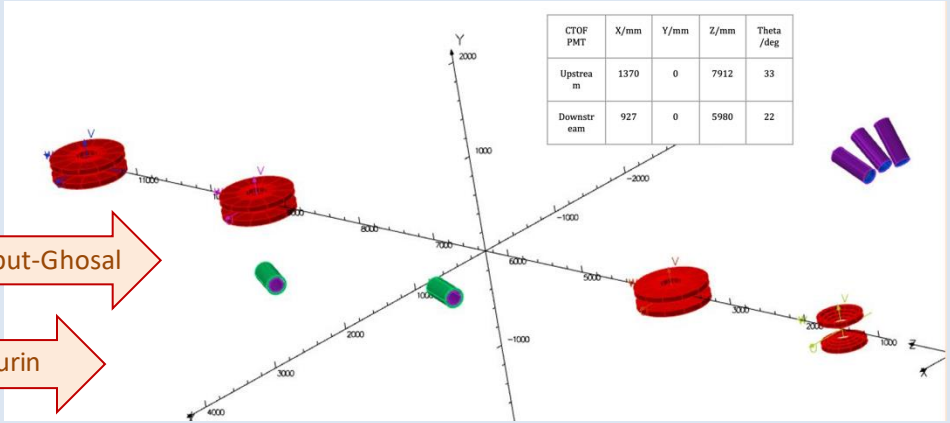
Beam pipe + 1 cm lead in the proper locations suppress synchrotron radiation to a negligible level

Magnetic Model

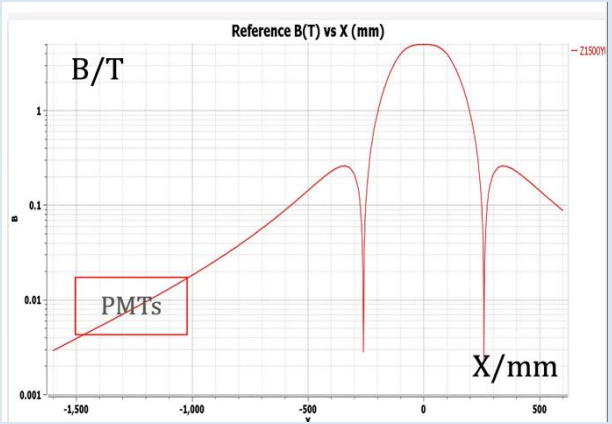
Preliminary analysis exist awaiting review from JLab experts

R. Rajput-Ghosal

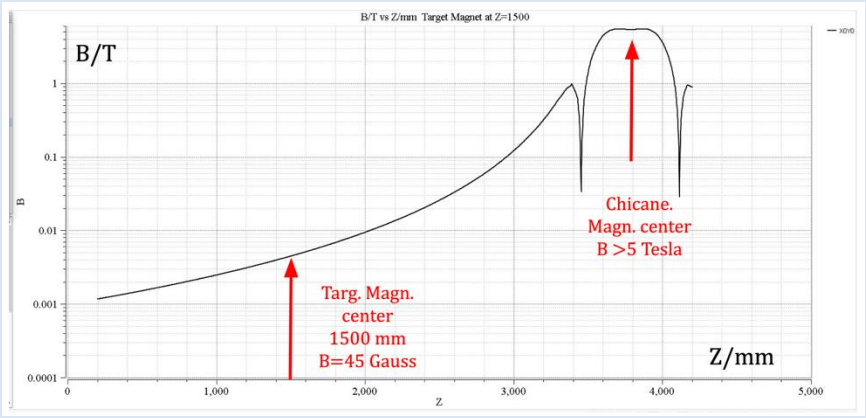
V. Baturin



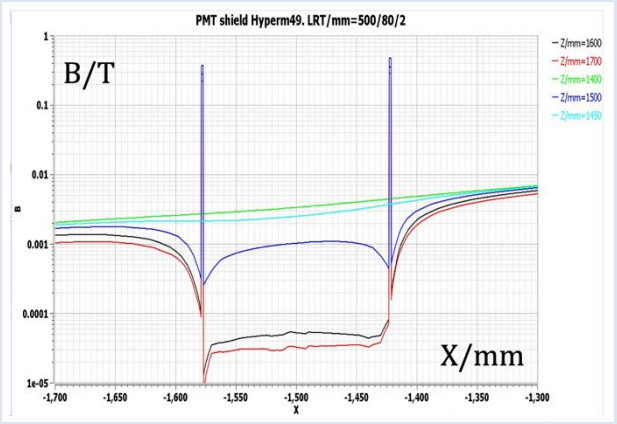
Target fringe field on HTCC PMT position



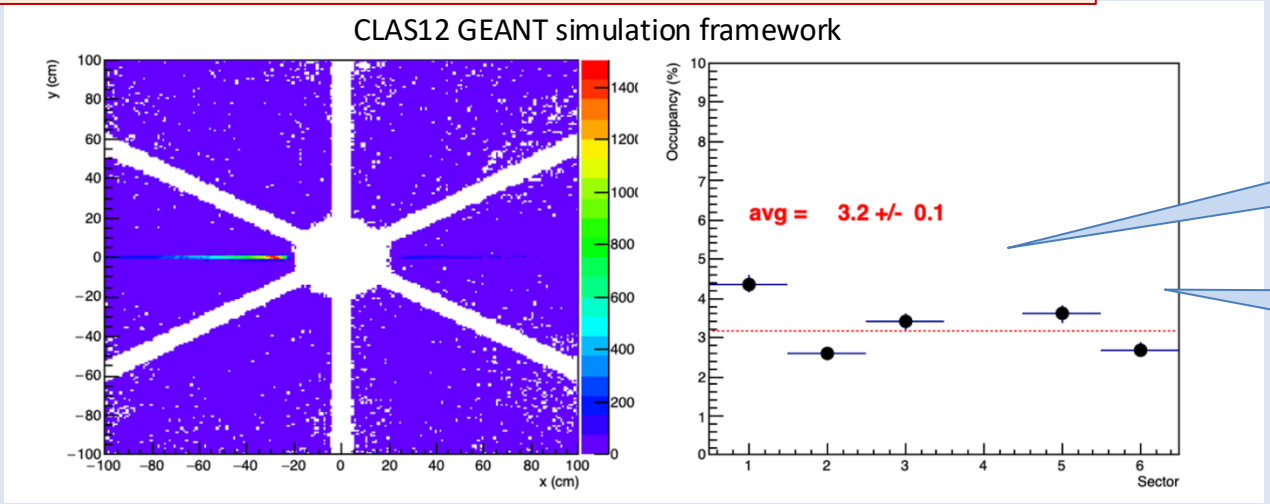
Chicane fringe field on target position

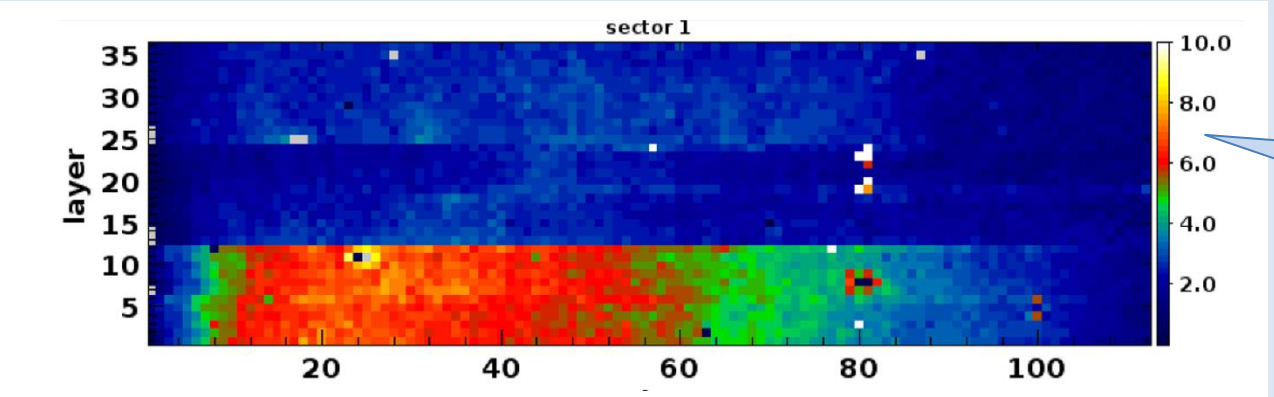


Field on HTCC PMT position



Start looking into the details





RGH MC (NH_3)

Assume to switch OFF DC in sector 4 and move RICH in sector 3

x2 with CLAS12 gate

K. Neupane

J. Kubarovsky

S. Boyarinov

D. Carman

RGC DATA (NH_3)

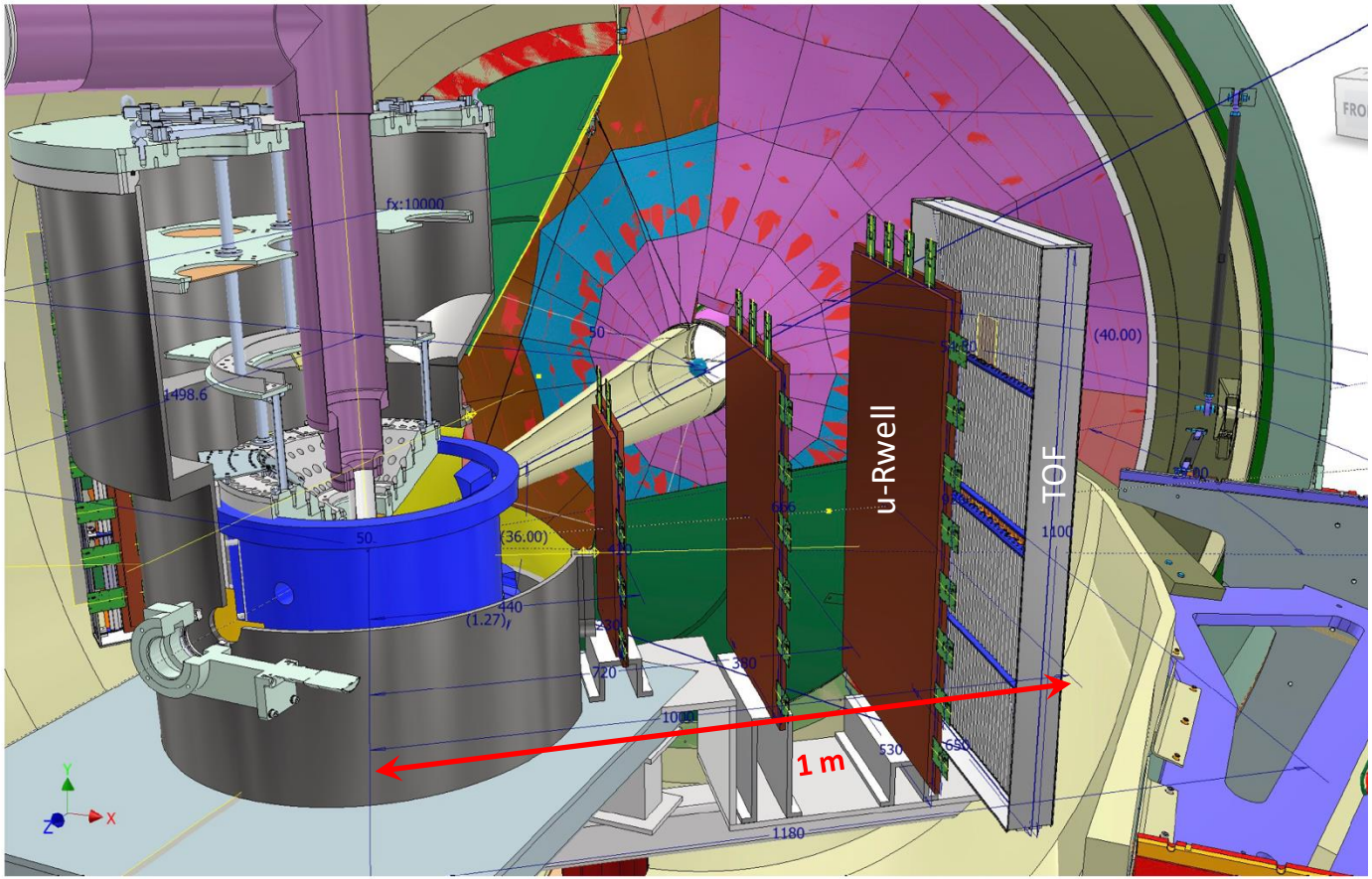
Present performance*

Typical DC occupancy measured at CLAS12

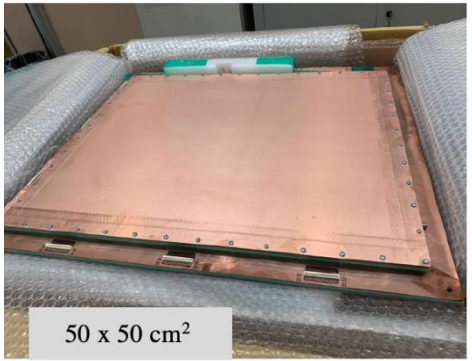
*No high-lumi

New recoil detector to cover the optimized target magnet acceptance.

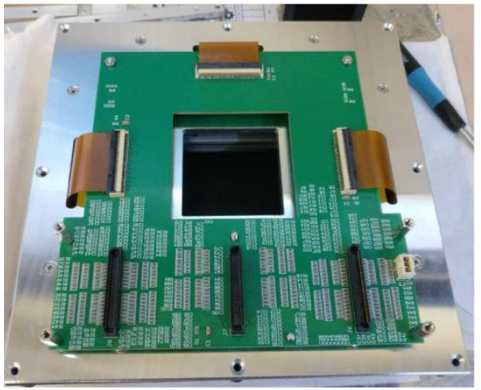
Completion of R&D activity expected in 2027



μ-Rwell tracking

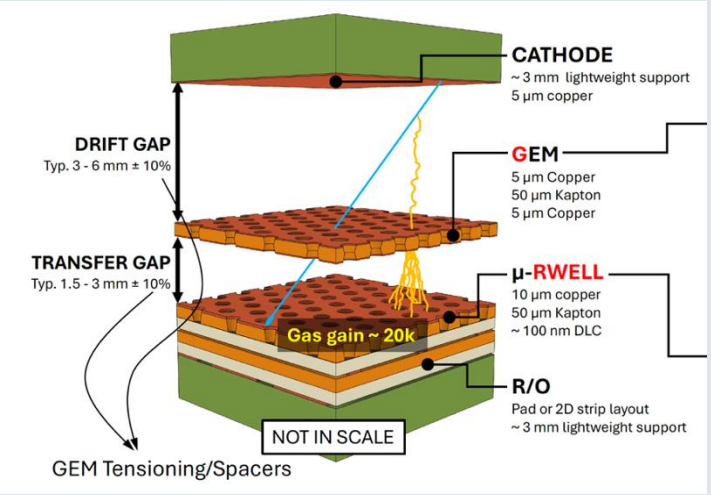


Scintillator + SiPM TOF



μRwell as spin off of the high-lumi project (various prototypes from 10 x 10 cm² up to 40 x 46 cm² exist)

S. Gramigna



GEM-μRwell to provide 2D information with 100 μm resolution

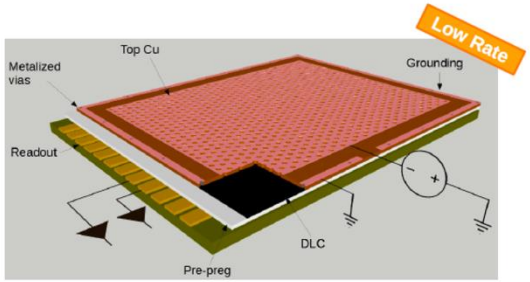
- ✓ Wanted gain/efficiency is preserved below 600 V safe bias
- ✓ < 10 ns time resolution can be achieved from signal shape fit
- ✓ TPC-like readout to correct the impinging angle has been proven

Test-beam at CERN in Oct '24 and new test-beam in July '26

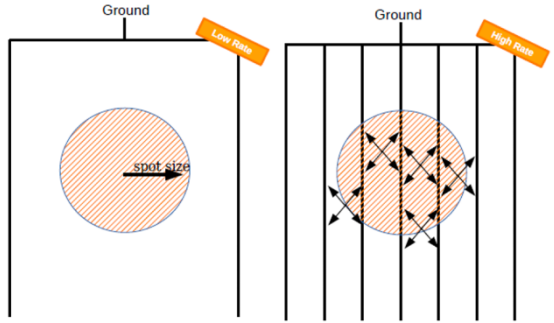
High rate configuration

To overcome the **intrinsic rate limitations** of the Single Resistive Layout, it is necessary to introduce a **high-density grounding network** for the resistive stage (DLC).

Segmentation of the DLC with conductive micro-strips/dots with a typical pitch of 1cm: a sort of **tiling** of the active area using a set of smaller SRL.



Single Resistive Layout (SRL)



Enough (> 10 k) spare channels exist from INFN GEM project for SBS in Hall-A

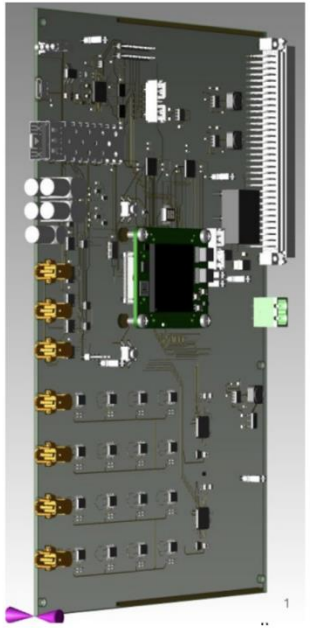
Based on the well-known APV25 chip + SSP DAQ (upgraded version of MPD/backplane under discussion)

E. Cisbani

- ✓ Able to cope with 250 kHz/cm^2 and 60% occupancy
- ✓ Same system used with the μRwell prototypes (adapter boards are required)





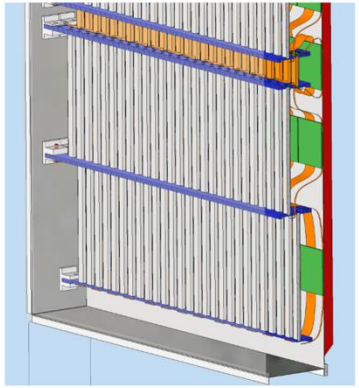


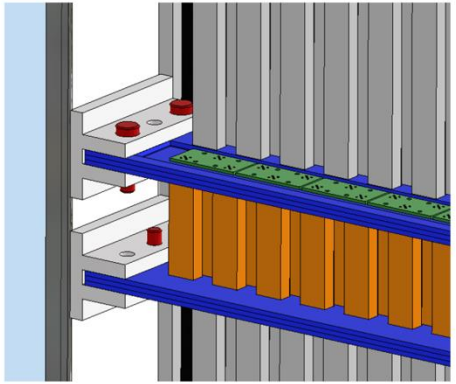




Thin scintillating bars + SiPM with time resolution O(100 ps)*

Technology choice already proven at PAND and MUSE



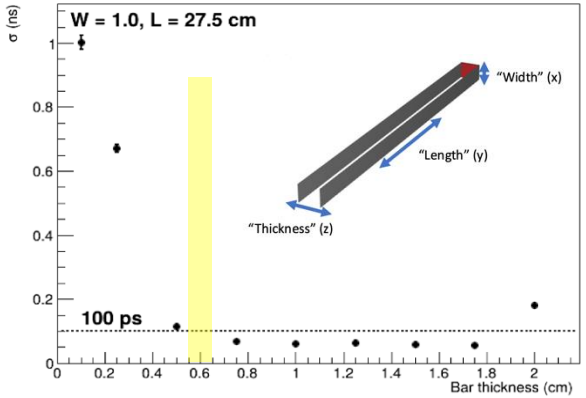




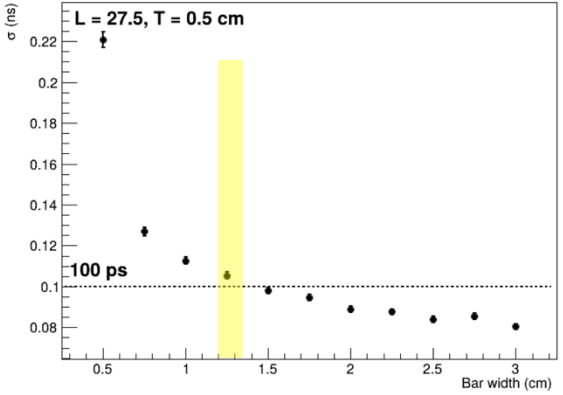
TOF Demonstrator assebled & under test

L. Pappalardo

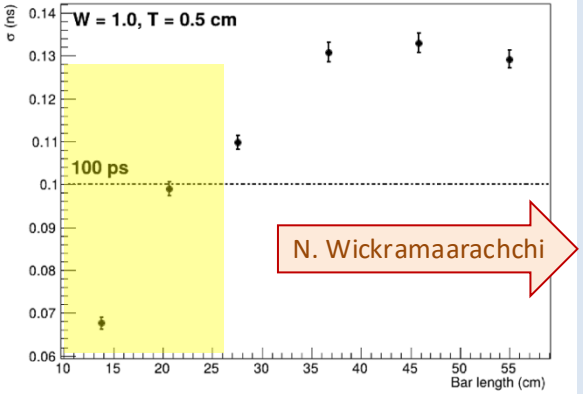
Reconstructed Time Resolution vs Bar thickness



Reconstructed Time Resolution vs Bar width



Reconstructed Time Resolution vs Bar length

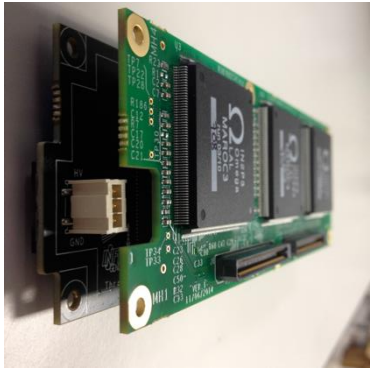


N. Wickramaarachchi

Enough (> 1 k) spare channels from RICH readout now updated to ALERT firmware to meet 100 ps readout jitter

RICH readout

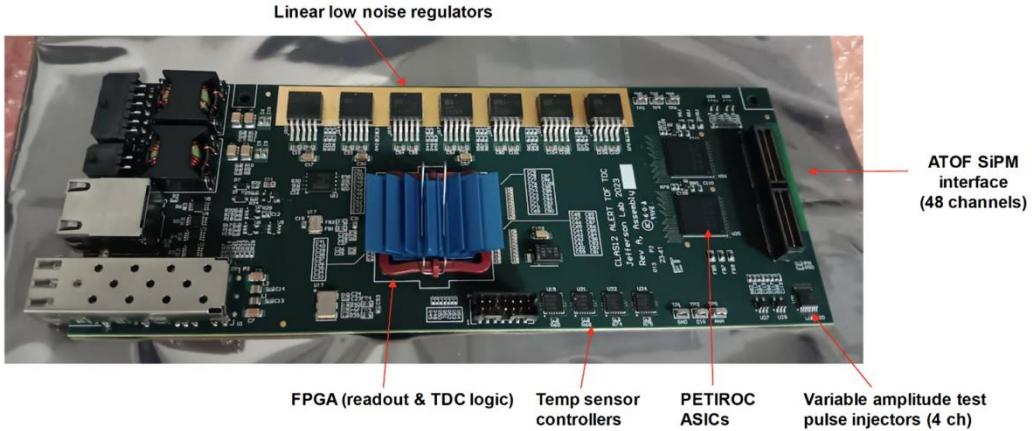
- ✓ MAROC dynamic range can cope with multi-photon signals
- ✓ Clock distribution supports 100 ps readout precision





Option to adopt CLAS12-ALERT readout

- ✓ PETIROC has a better dynamic range (multi-photons)
- ✓ Clock distribution supports 50 ps readout precision



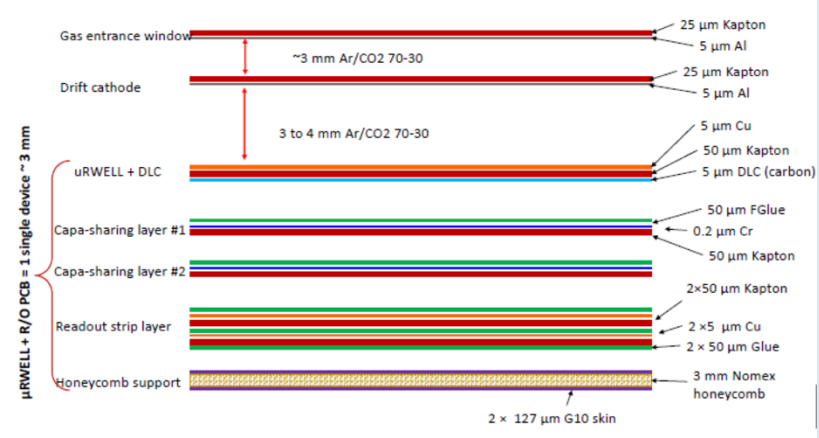
A complete simulation and reconstruction package is under development

uRwell implemented following the High-lumi model (Orsay)

TOF implemented following FTOF model (DUKE)

Specs defined by two “toy” reconstructions implemented for the proposal (INFN, Orsay)

Now: working with software group
to implement an AI assisted tracking

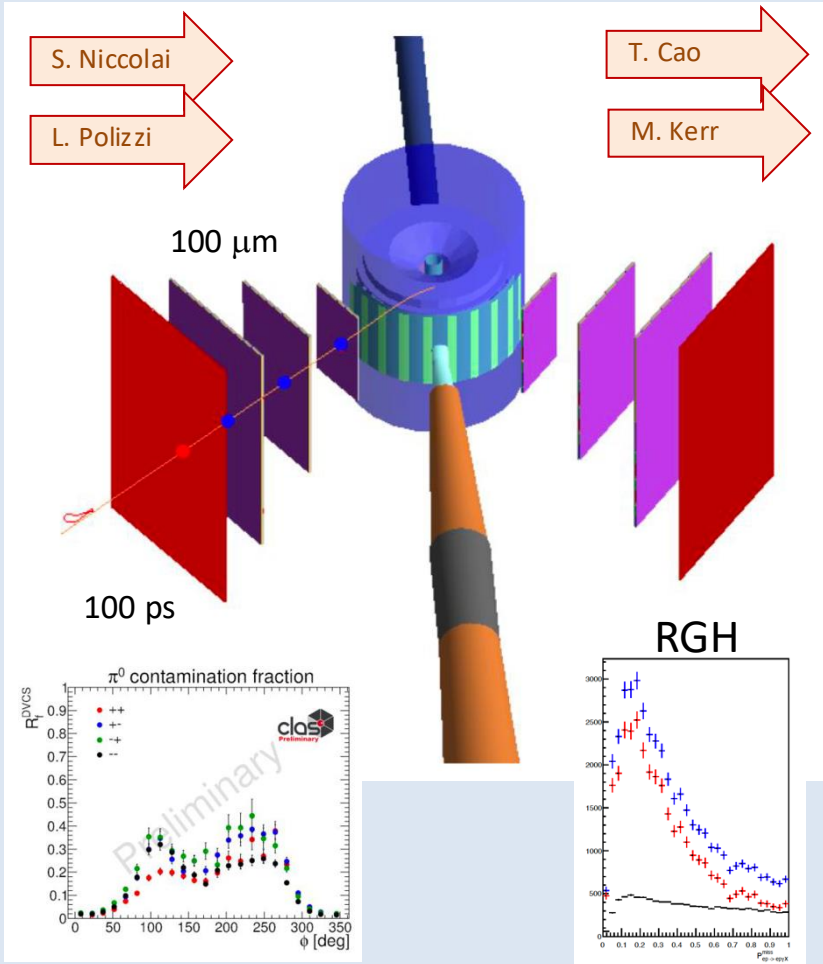


S. Niccolai

L. Polizzi

T. Cao

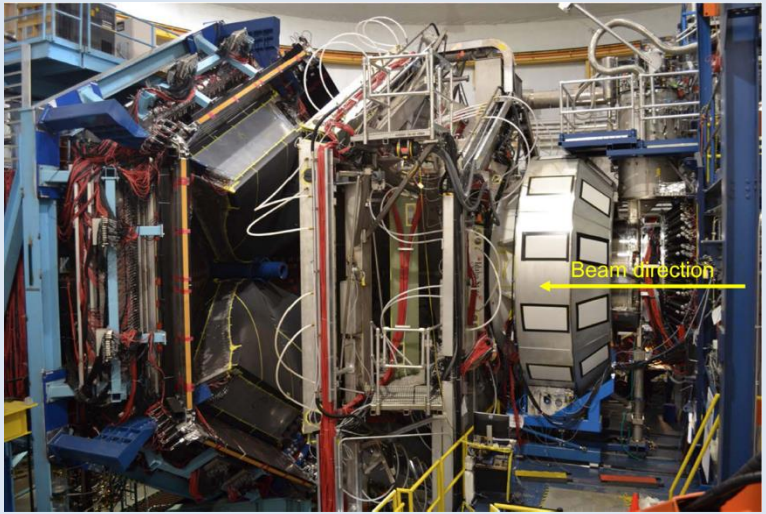
M. Kerr

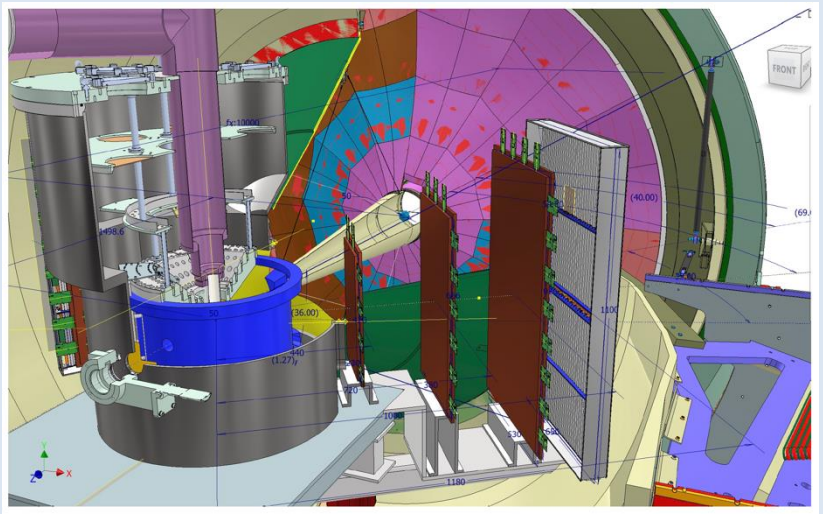


Conclusions

RGH implements the target configuration which is most sensitive to the 3D nucleon structure study and capitalizes on CLAS12 with a complete set of target polarizations

RGH: achieve unprecedent precision in the valence region to significantly improve our understanding of tensor charge, spin-orbit correlations, and quark angular momentum, complementing past and ongoing CLAS12 studies.





Goal of the meeting: Bring everybody on the same page, Review where we are,
Identify aspects that need scrutiny, Define an effective timeline
Promote a cooperative effort to facilitate timely progresses