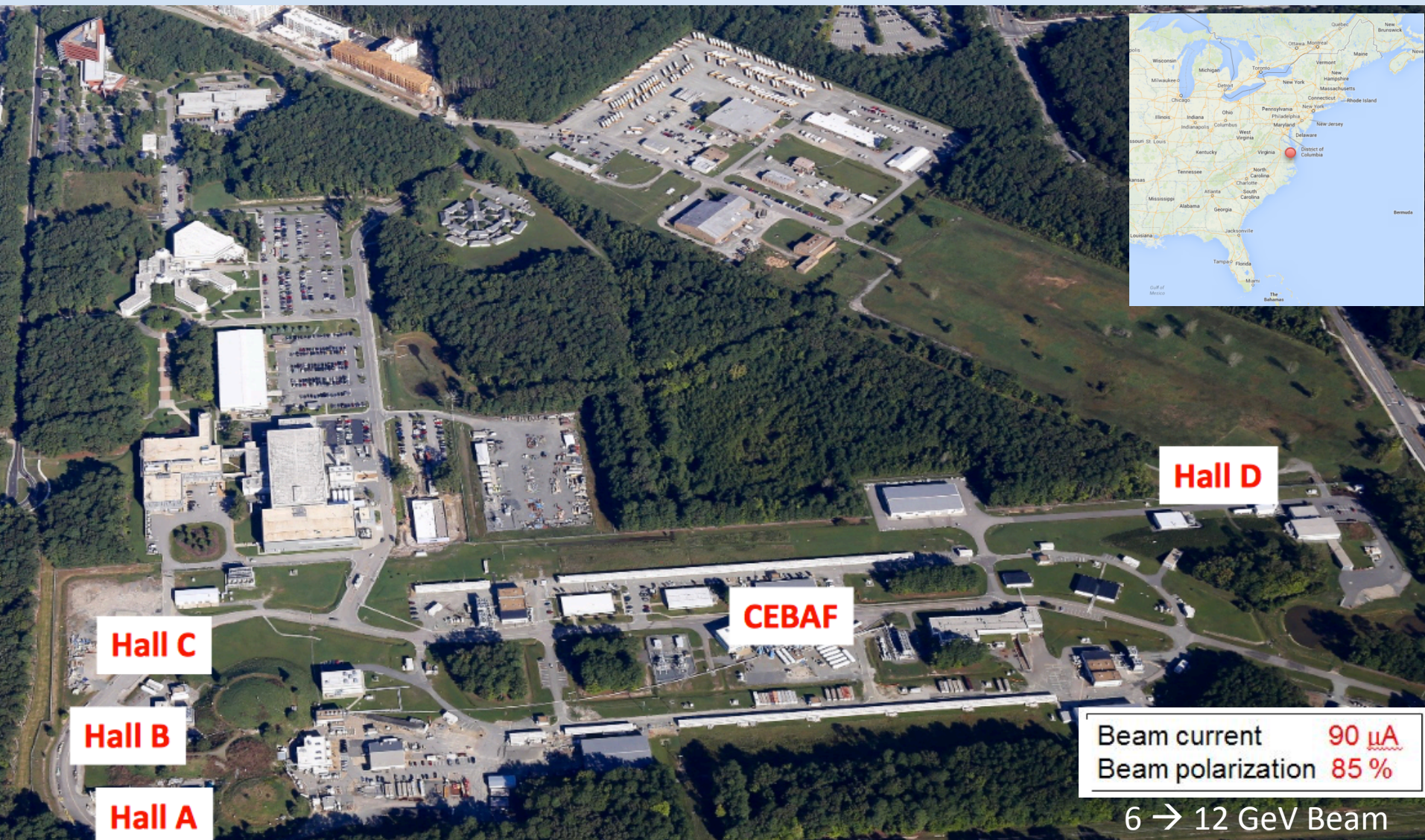




Attività' della Collaborazione Italiana al Thomas Jefferson National Accelerator Facility

Contalbrigo Marco - INFN Ferrara

Thomas Jefferson National Accelerator Facility, Newport News, VA, USA



RM1, CT, BA

Nucleon 3D

FE, LNF, GE

E07-109 Proton form factor '22
 E17-004 Neutron form factor '22
 E09-018 SIDIS off neutron (^3He) '23

E06-112 Quark dynamics '18
 E12-008 TMDs '18
 C11-111 TMDs '21
 C12-009 Dihadron probes '21

Nuclear Potentials

RM1

E17-003 '18
 Lambda- nn off tritium (^3H)

E11-101 '19
 PREX-II: neutron skin

E15-008 '24
 Lambda hypernuclei

Tracker
 HCAL-J

RICH
 HD-ice

Hall-A

Hall-B

Forward
 Tagger

Cristal Calorimetry

Spectroscopy

GE, RM2, TO, PV

E11-005 '18
 MESONX

E12-001A '18
 J/ ψ and penta-quark

E16-010 '18
 Hybrid Baryons

Dark Sector

GE, CT, PV, LNS, RM2, TO, PD

E11-006 HPS '17

E16-001 BDX '24

Patrizia Rossi: Deputy Physics Division

Marco Battaglieri: Hall-B Leader



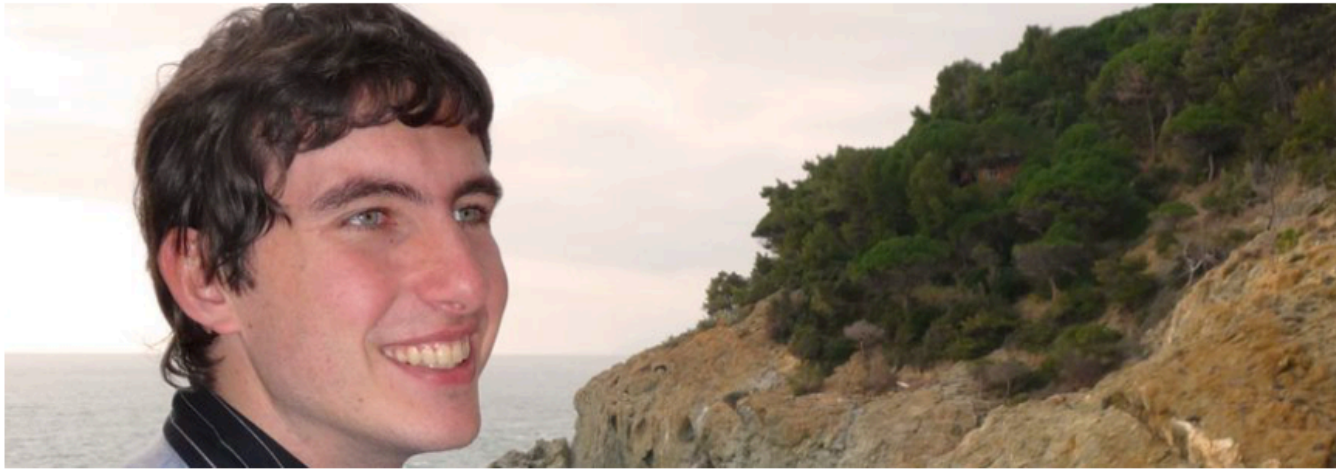
PORTALE INFN

PHONEBOOK

INFO

SERVIZI

[HOME](#)
[ISTITUTO](#)
[STRUTTURE](#)
[ESPERIMENTI](#)
[PROGETTI](#)
[COMUNICAZIONE](#)
[OPPORTUNITÀ DI LAVORO](#)



COMUNICATI STAMPA 2020

1 2 3 4

**ERC: AL RICERCATORE
 INFN ANDREA
 CELENTANO UNO
 STARTING GRANT DI
 QUASI 1,5 MILIONI DI
 EURO PER LA RICERCA
 DELLA MATERIA
 OSCURA CON IL
 PROGETTO POKER**

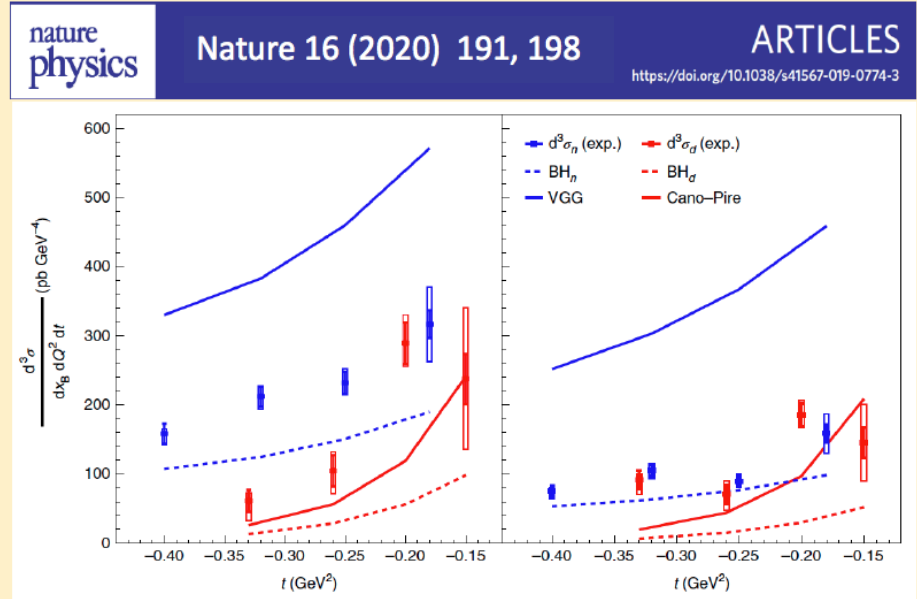
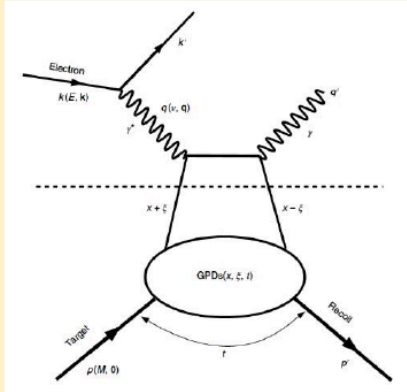
Looking for missing energy in 100 GeV positron annihilation events inside an active dump

Raffaella De Vita: new Hall-B Software Coordinator and CCC member

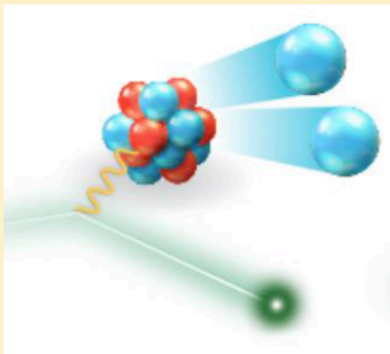
Contalbrigo Marco: confirmed as CLAS DPWG Chair and CCC member

Marzio de Napoli: confirmed as HPS Executive Committee member

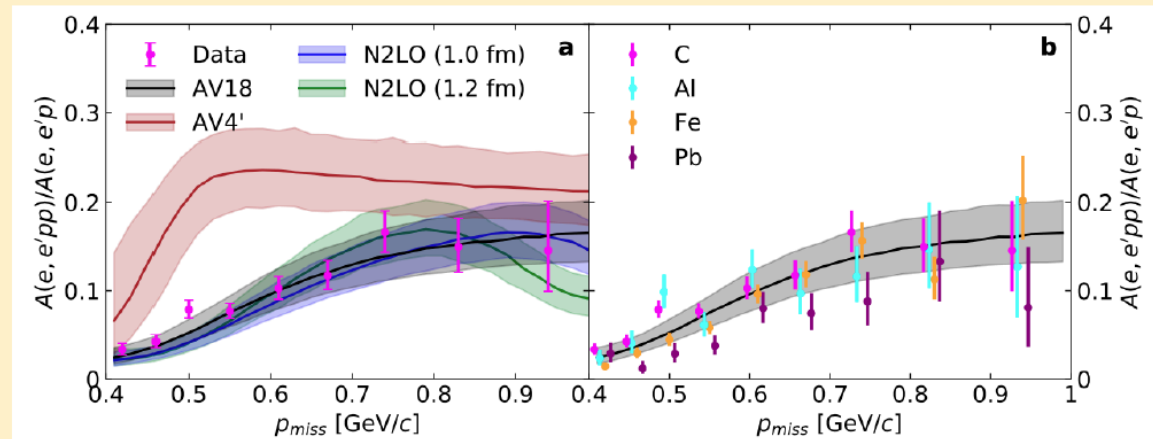
Hall-A deep-virtual Compton scattering measurement on deuteron ($ed \rightarrow ed\gamma$) determines elusive quark flavor contributions to the hadron spin structure



CLAS scattering measurements on short-range correlated nucleon pairs probe nuclear interaction at unprecedented short distances



nature International journal of science
578 (2020) n.7796, 540-544

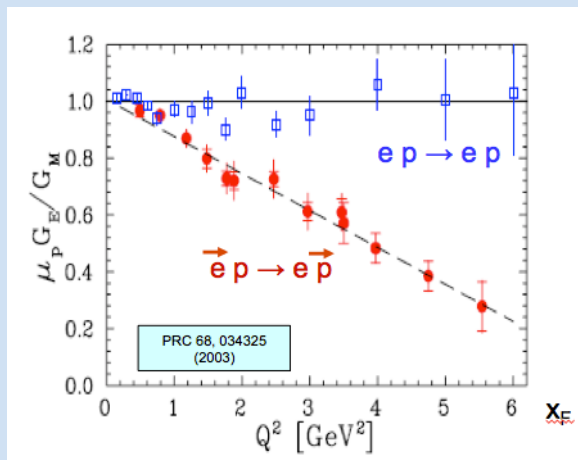


COVID-19: FY20 run being completed with local shifts
Few (~4) overall months delay
INFN installations on hold due to the ESTA suspension till end of 2020
We assumed to be able to move to JLab in 2021

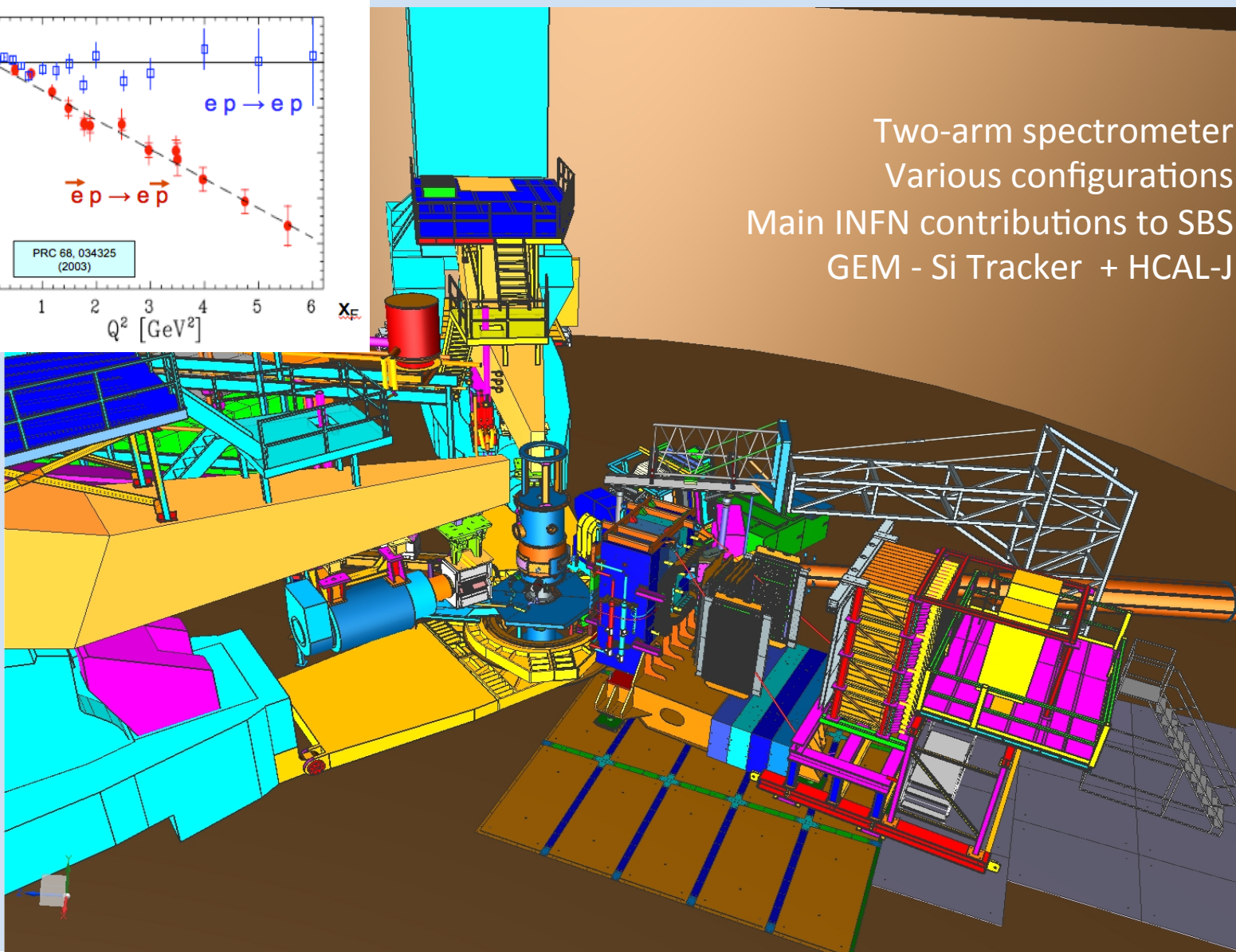
PROBES: EU project in collaboration with Fermilab and LIGO users for secondments in USA
Reached the Grant agreement status
Should facilitate long visit to JLab from summer 2021

PHD: Italian fellowship (Ferrara University) in agreement with JLab
“Study of hadron structure with polarized deep-inelastic scattering”
Candidate selection ongoing

Computing: Allocated CNAF/TIER1 resources under commissioning
5000 HSO6 50 keu
50 TB disk space 7 keu



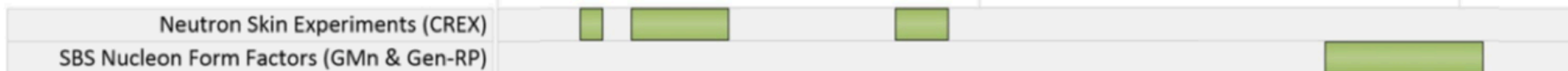
Two-arm spectrometer
 Various configurations
 Main INFN contributions to SBS
 GEM - Si Tracker + HCAL-J



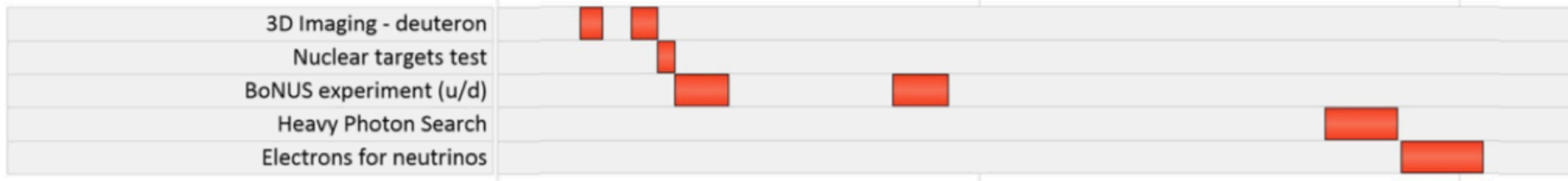
Hall-A:

- 2018 Fall : Esperimenti con bersaglio di **trizio**
- 2019 Summer : **PREX-II** (raggio neutroni piombo)
- 2019 Fall : CREX (raggio neutroni calcio 48)
- 2020** : **CREX**
- 2021...** : **SBS era**

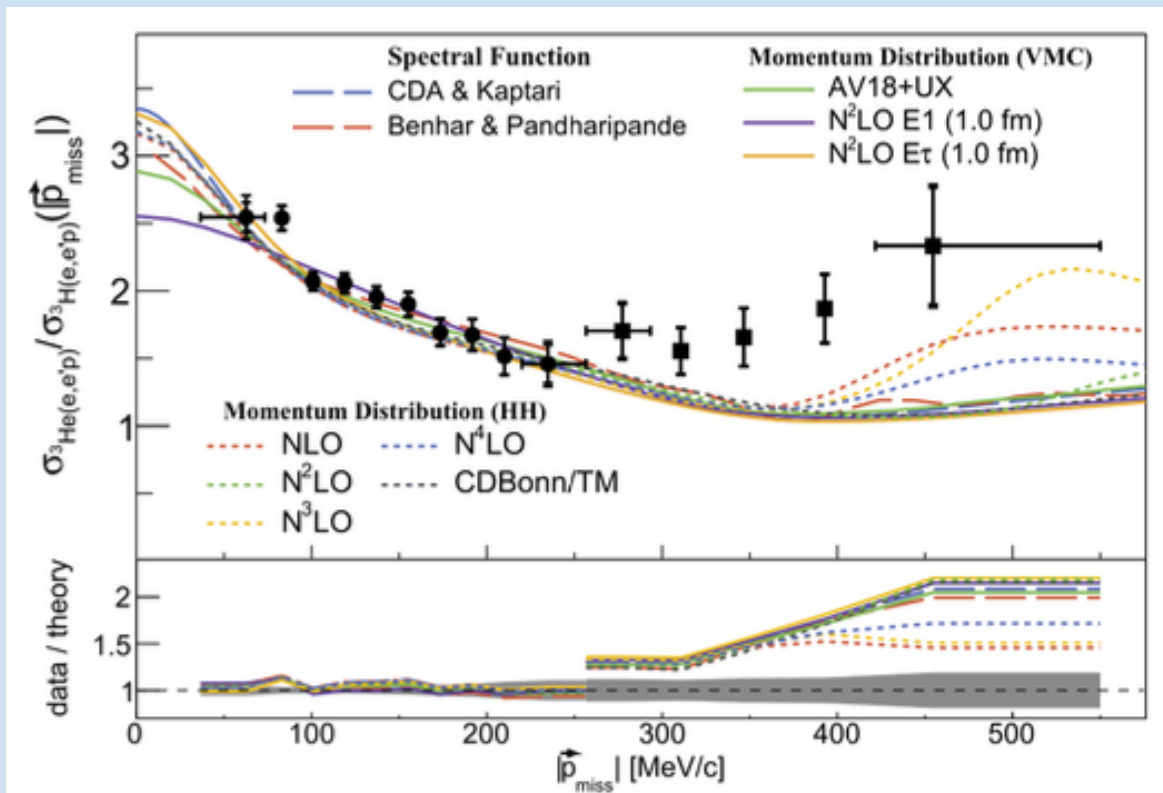
Experimental Hall A



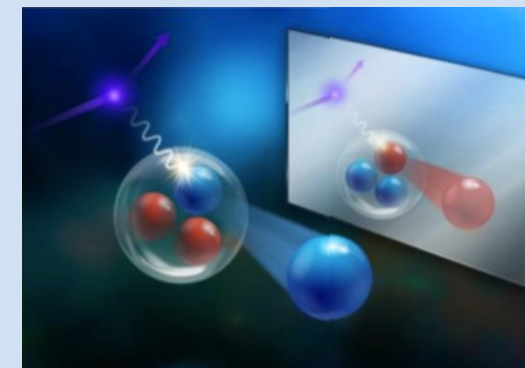
Experimental Hall B



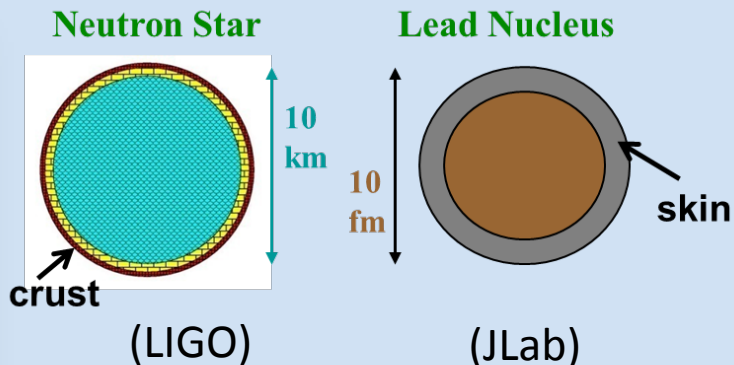
First measurement of the $(e, e'p)$ ${}^3\text{He}/{}^3\text{H}$ cross-section ratio in quasi-elastic dominant reaction mechanism kinematics.



R. Cruz-Torres et al., Phys. Lett. B 797(2019)134890

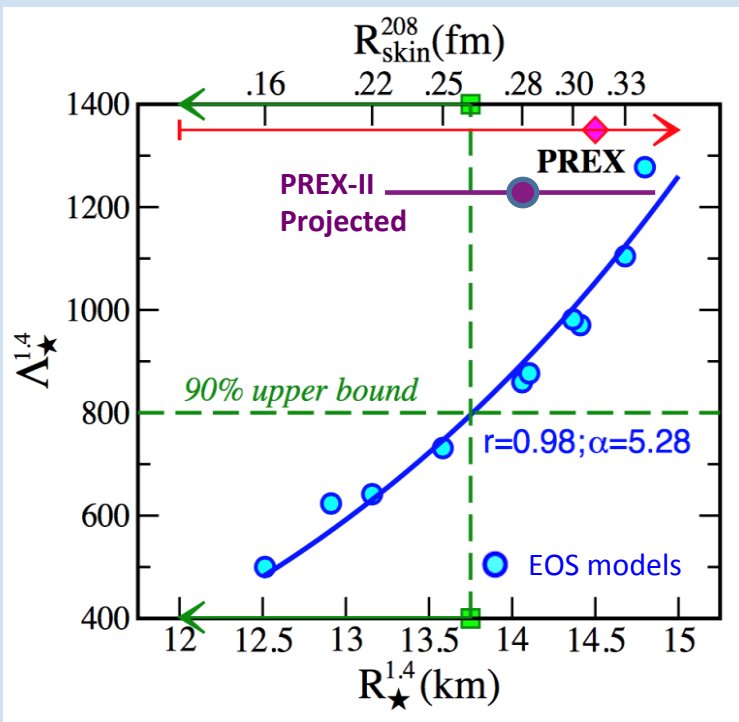


Deviations at large transverse momenta support transition to np short range correlations (at a variance with single nucleon dominance)

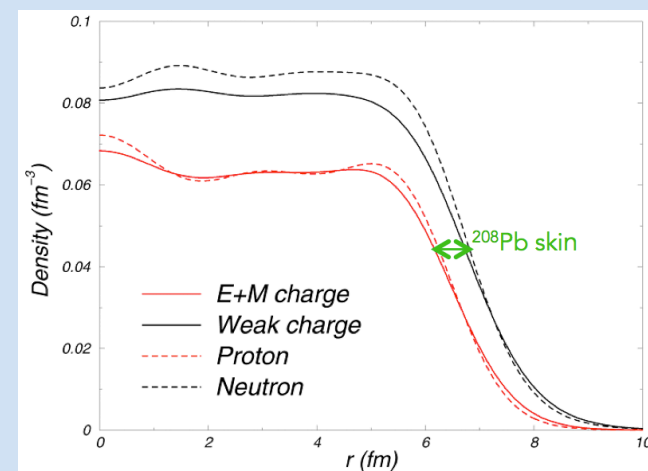


Despite 10^{19} scale difference, common origin from pressure of neutron rich matter vs surface tension or gravity

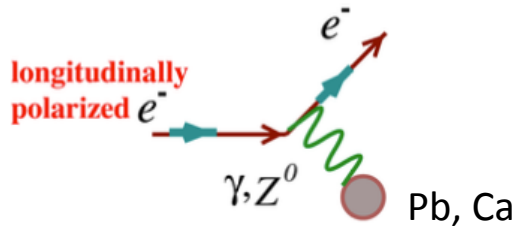
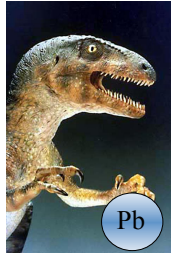
EOS constrained by JLab neutron skin as from GW measurements



PREX experiment



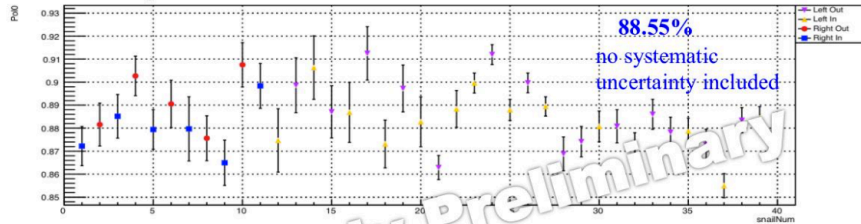
Heavy Nuclei Neutron Skin



$$A_{PV} \sim \frac{G_F Q^2}{4\pi\alpha} \left[\underbrace{1 - 4 \sin^2 \theta_W}_{\sim 0} + \frac{F_n(Q^2)}{F_p(Q^2)} \right]$$

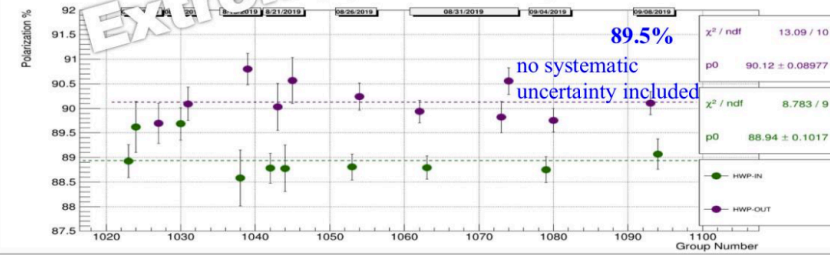
Compton

Pol0 (Sign Corrected) vs Snail

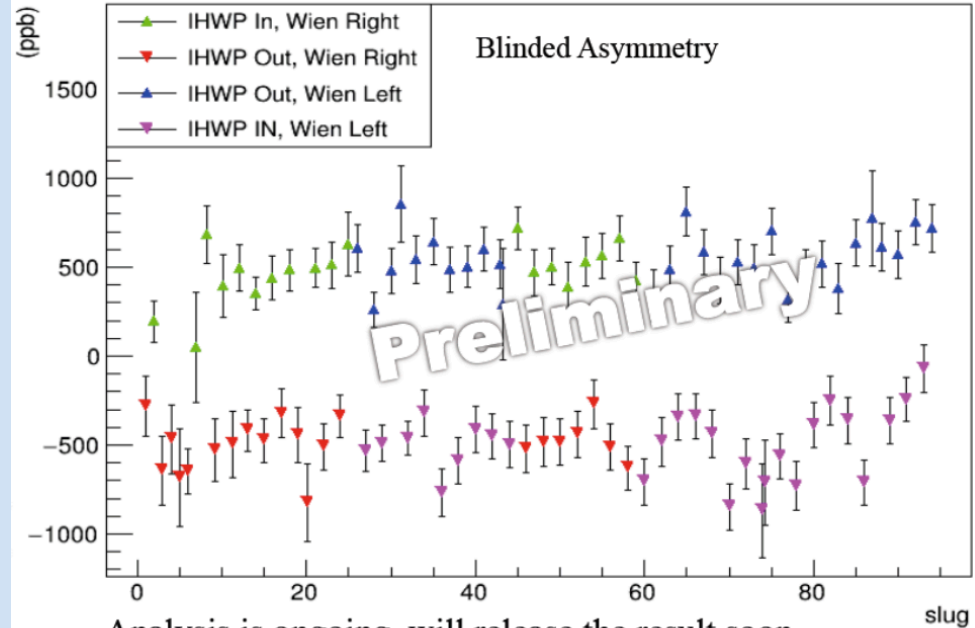


Moller

(Pr) Moller Aug/Sept Polarization :: 4um Scaling Factor 1.01±0.0015



Regression Corrected Asymmetries



80% of the target statistics

~ 89% electron beam polarization

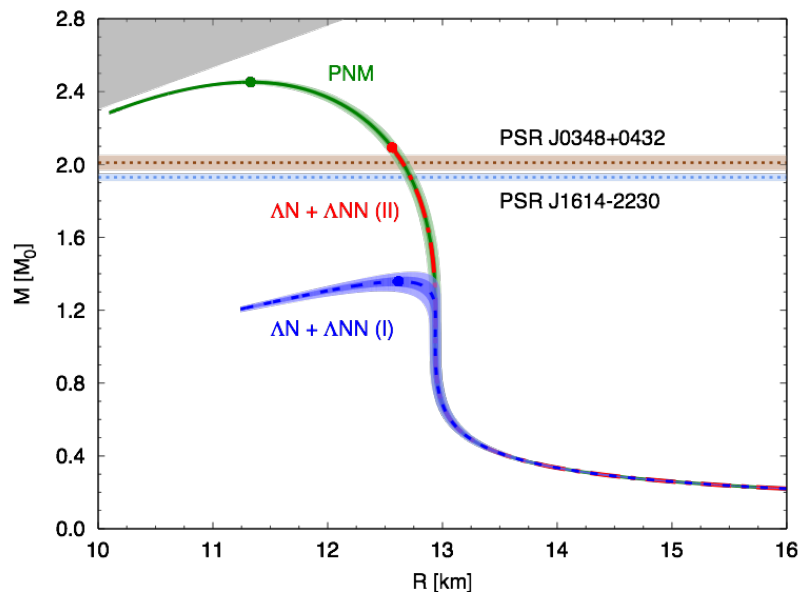
First results
Expected very soon

Three experimental proposals submitted to JLab PAC48 (F. Garibaldi, G.M. Urciuoli):

- ✓ 1. Studying Λ interactions in nuclear matter with the $^{208}\text{Pb}(e,e'K^+)^{208}_{\Lambda}\text{Tl}$ reaction
- ✓ 2. Extension request for E12-17-003: Determining the unknown L-n interaction by investigating the Λ_{nn} resonance
- ✓ 3. High accuracy measurement of nuclear masses of Λ hyperhydrogens ($^3_{\Lambda}\text{H}$ and $^4_{\Lambda}\text{H}$)

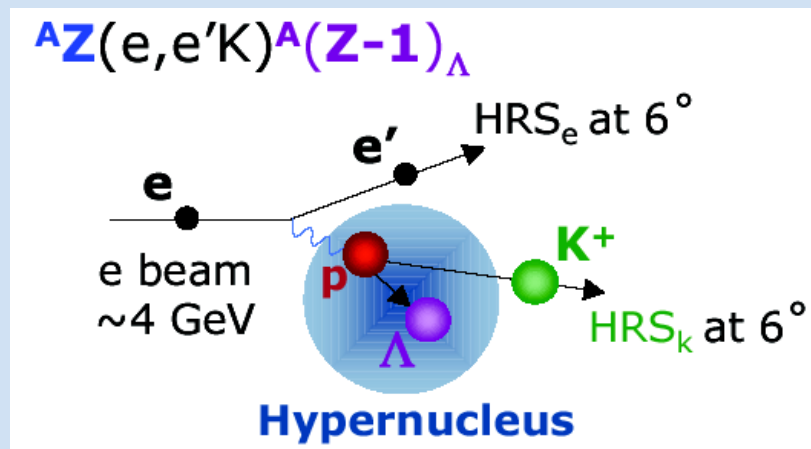
Two main topics: **Neutron star feature explanation**

Search for Charge Symmetry Breaking in Hyperon-nucleon interaction

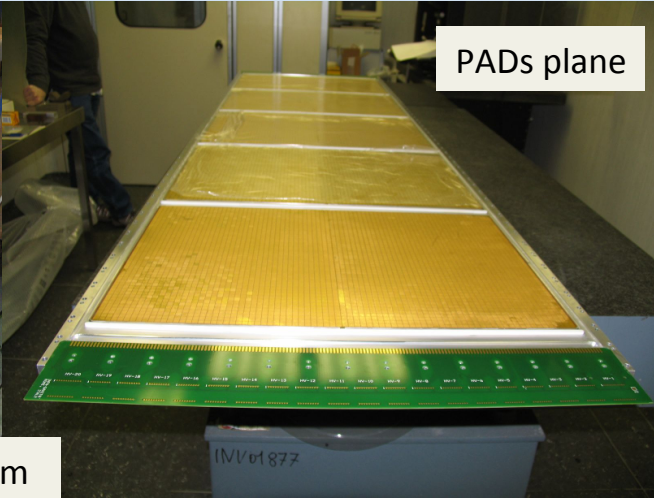
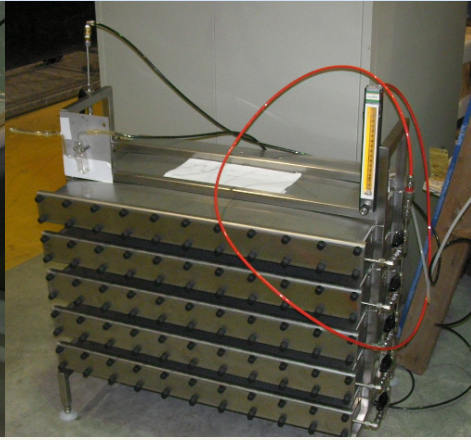
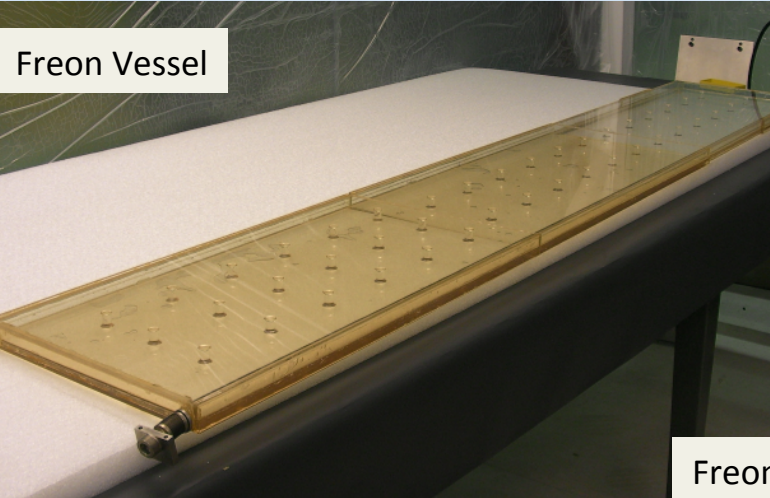


D.Lonardonì *et al.*, Phys. Rev. Lett. 114, 092301 (2015)

All proposals will use a specific technique and apparatus for an already approved exp.



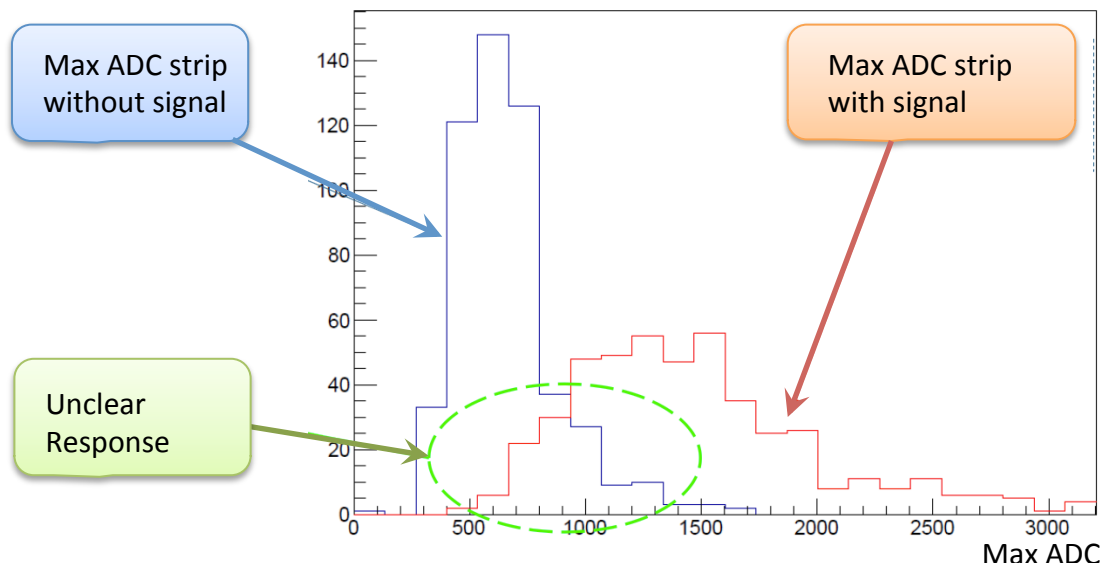
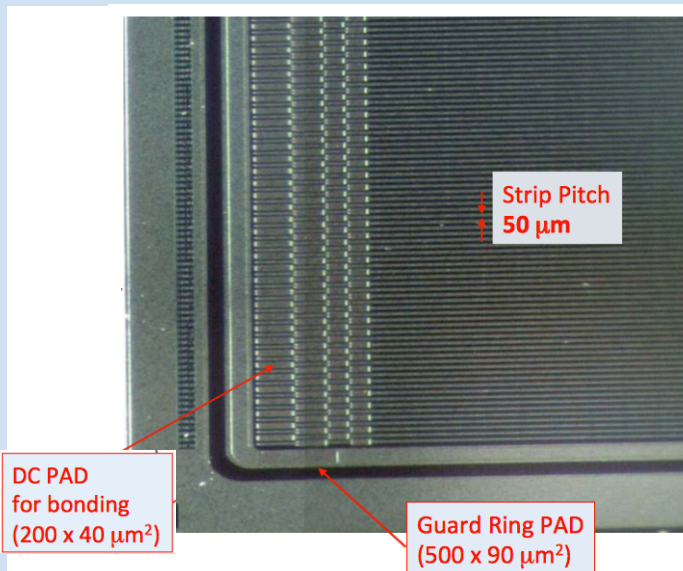
Refurbishment of an already existing detector for kaon identification



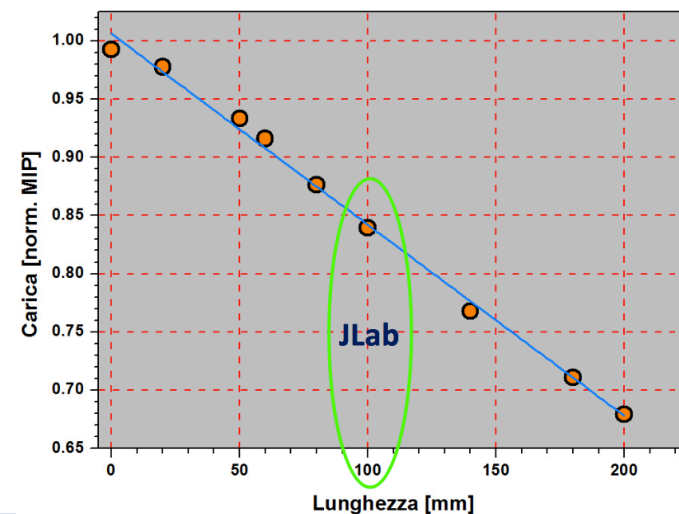
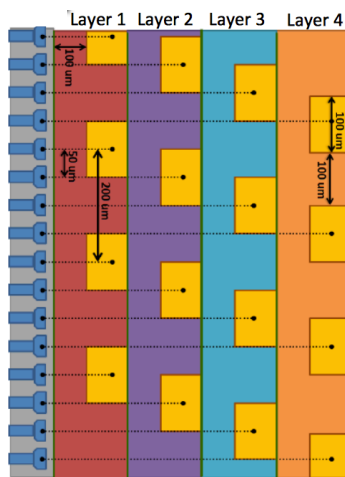
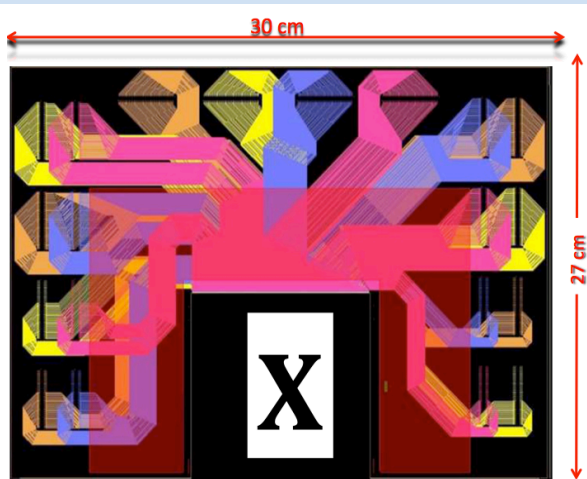
Freon Filtering and Circulation System

10 x 10 cm² single side silicon
2070 strips, 50 μm pitch

Low ~ 50% efficiency dependent on position most likely due to the long strip vs small pitch (detailed simulation and independent experts)



No need to change the involved PCB design but improve charge-sharing analysis, production can move ahead

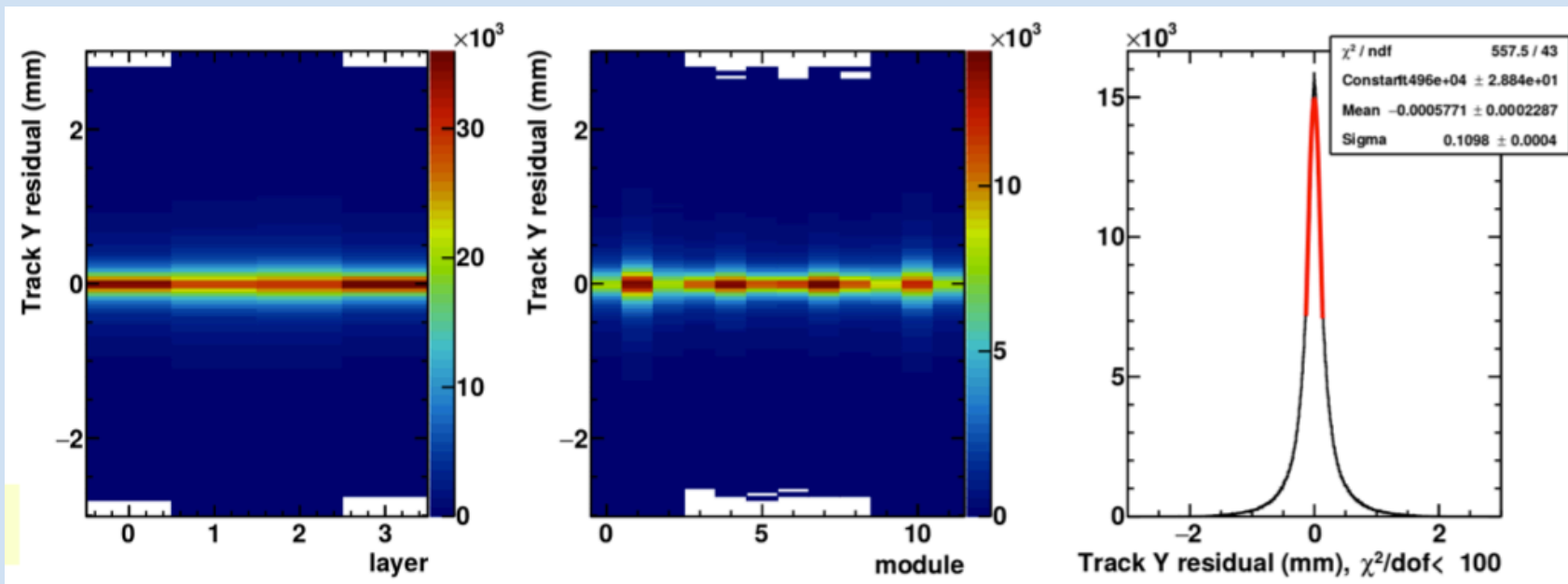
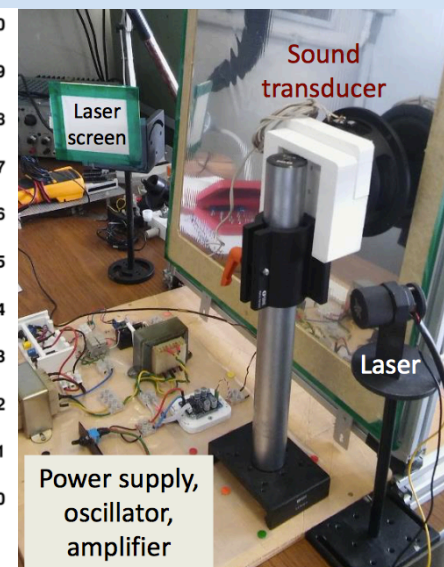
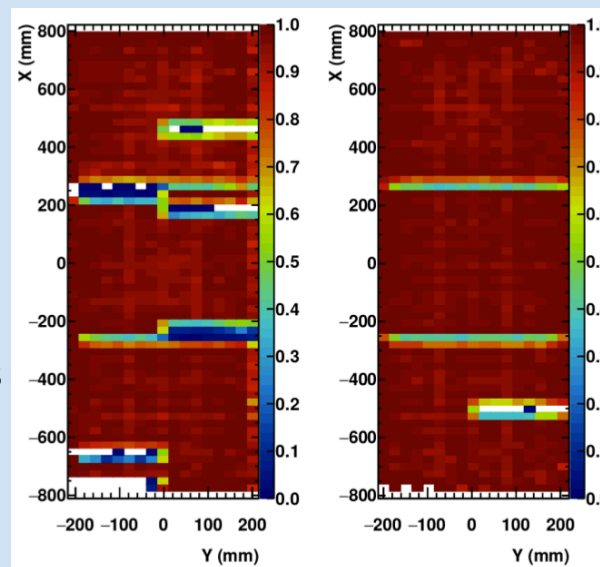


4/6 modules ready for installation
(working with W&M on remote due to COVID)

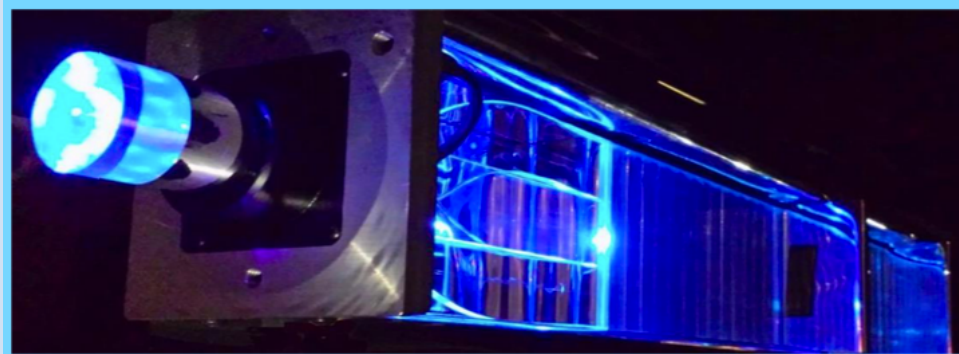
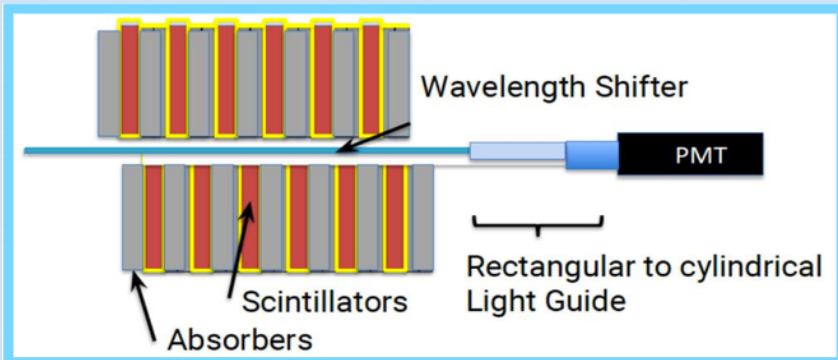
Modules re-arranged for maximum active area
Fifth chamber assembled (j4)
First test of installation in BB frame
Improved drying (N₂ flow) to prevent discharges
GEM cleaning with high frequency acoustic waves
U-V GEM chamber design finalized

Spatial resolution with cosmics: 100-130 μm

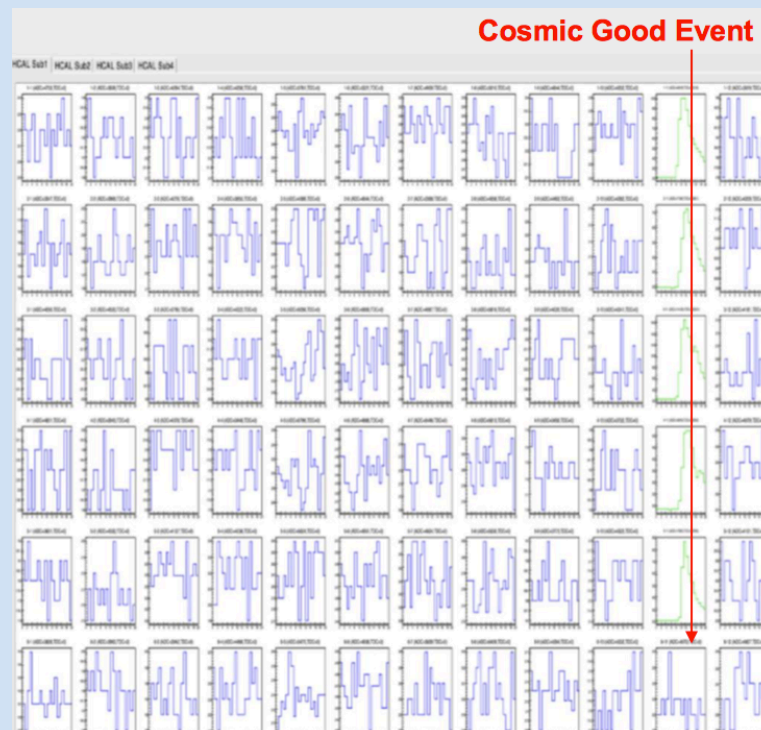
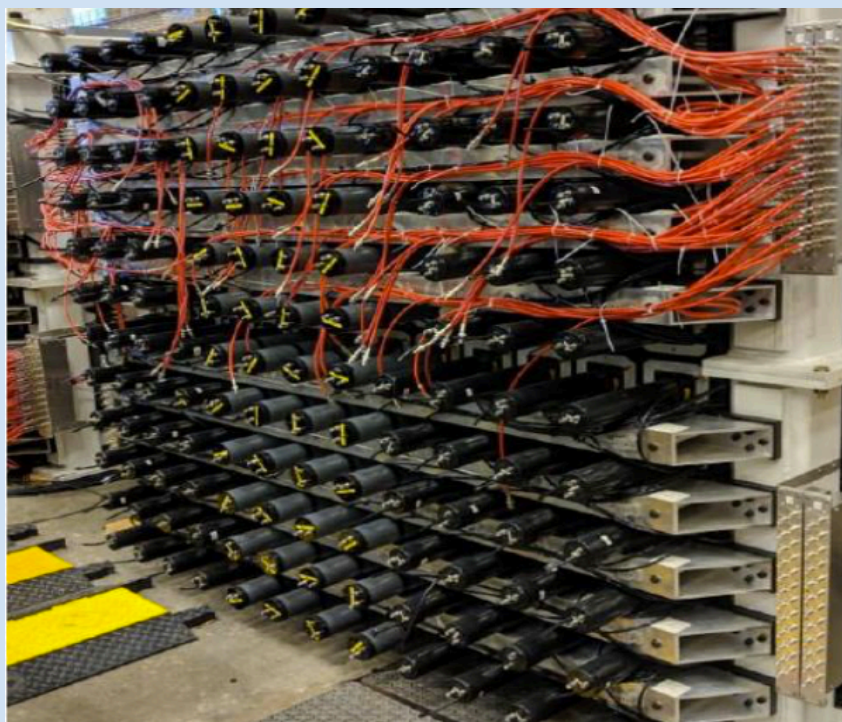
Good efficiency, try to recover shorted sector modules



288/288 modules ready for installation in Hall-A

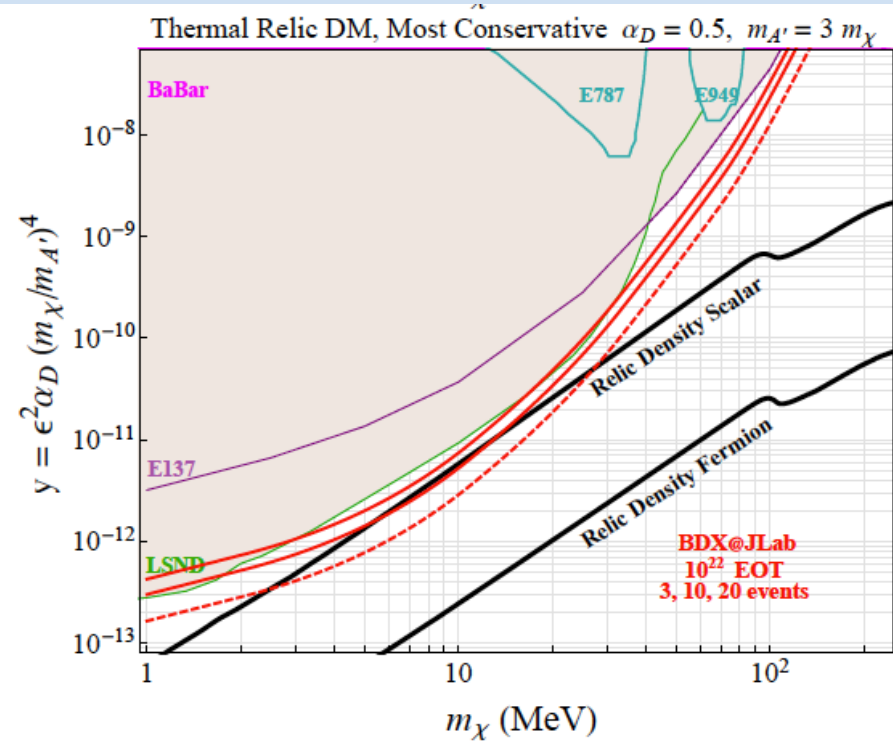
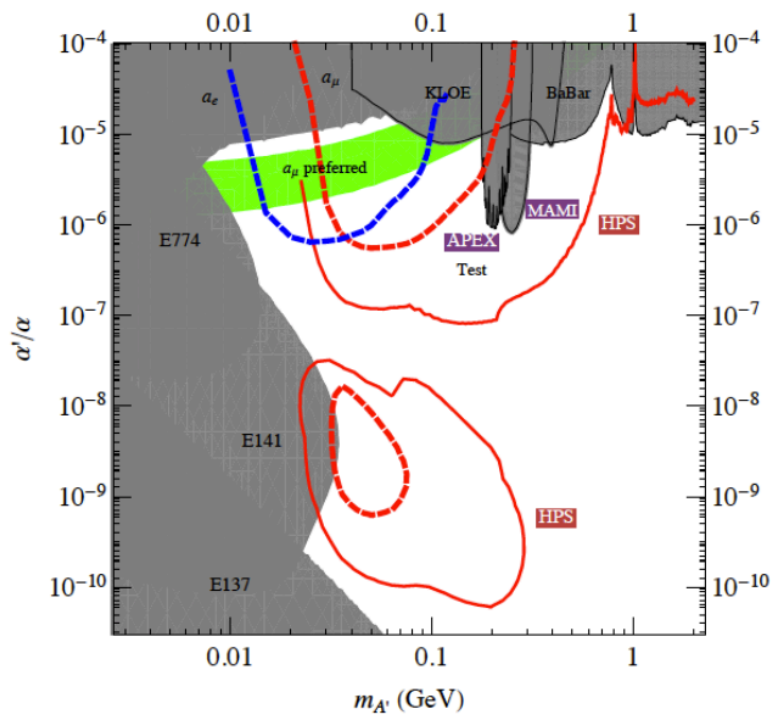
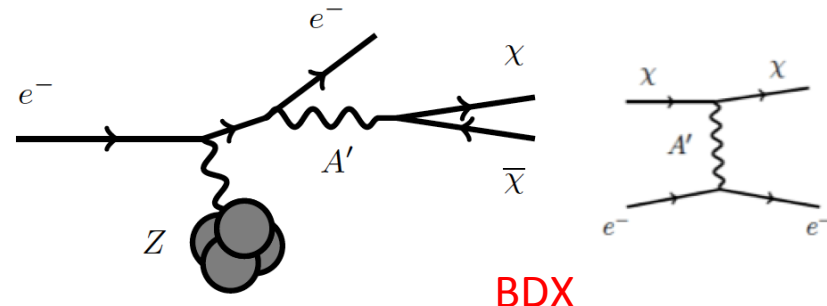
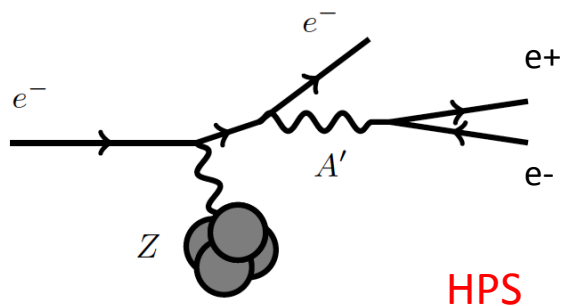


Cosmic test with final electronics provides preliminary time resolution of 0.6 ns





CEBAF intense high-energy electron beam allows to cover unexplored regions

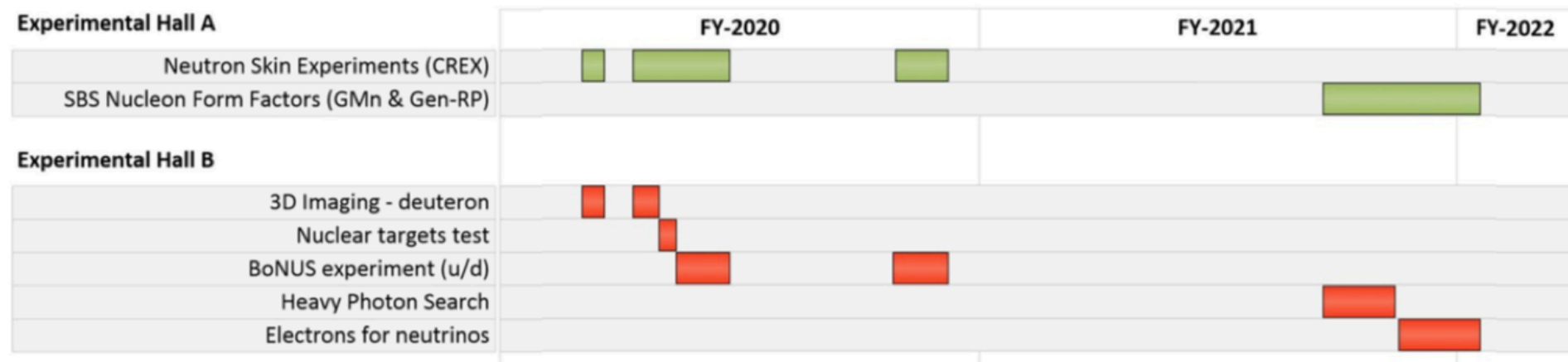


Hall-A:

- 2019 Spring : Esperimento APEX (fotone pesante)
- 2019 Spring : BDX-demo
- 2020:** : **BDX-mini**

Hall-B:

- 2015/6 Summer : HPS Engineering Run
- 2019 Summer : HPS @ 4.6 GeV
- 2021 Summer** : **HPS @ 3.8 GeV**



In 2020:

Pilot run of mini-BDX:

Parasitical

Beyond Hall-A dump

2.2 GeV beam energy

2×10^{21} EOT in spring

Streaming readout tests

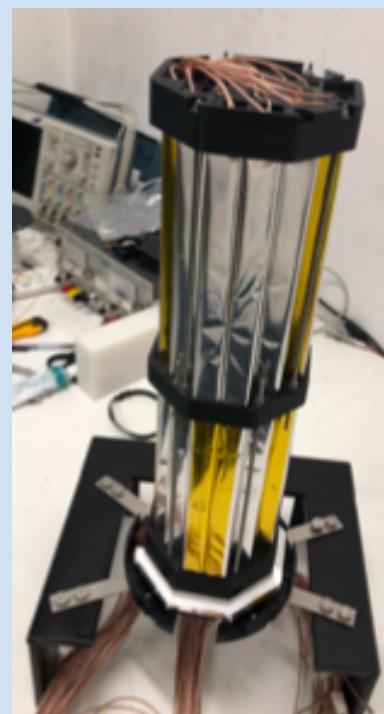
BDX experiment:

Awaiting JLab plan for exp. hall

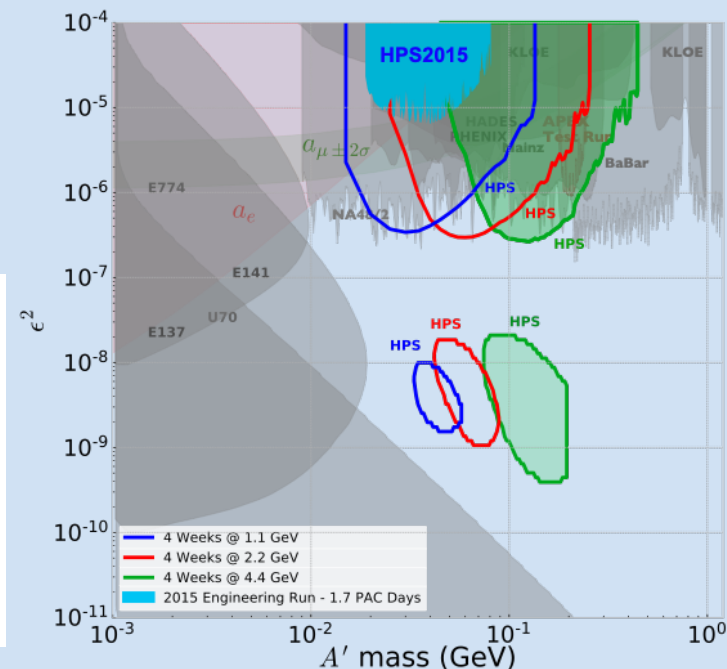
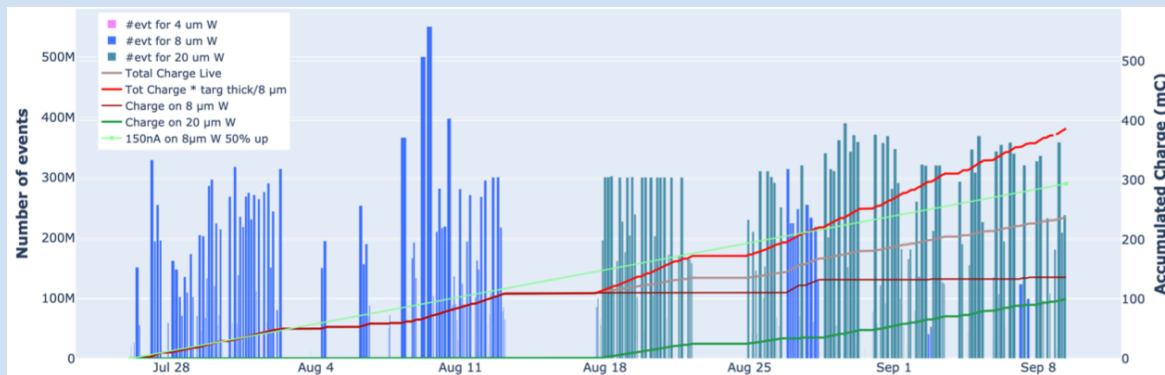
Positron @ JLab

White paper

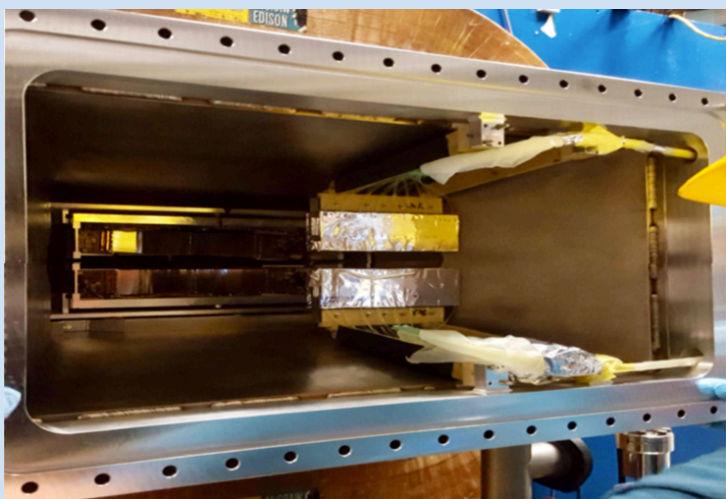
Loi in preparation for PAC49 ('21)



First physics run in summer 2019:
45% of the approved statistics collected
at the maximum foreseen 4.6 GeV energy
with HPS upgraded apparatus



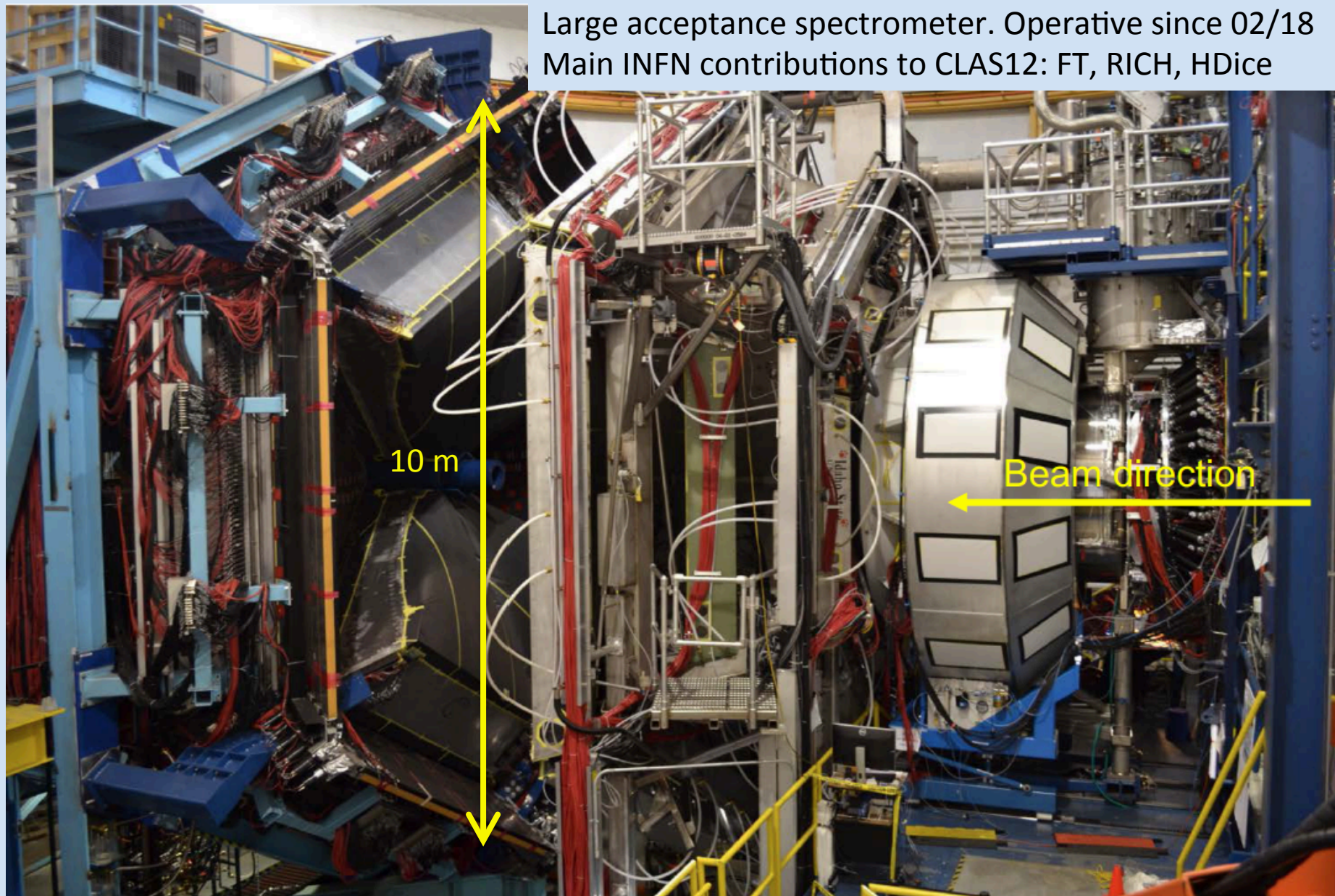
Hodoscope to improve trigger efficiency



Additional silicon layer for better vertexing



Large acceptance spectrometer. Operative since 02/18
 Main INFN contributions to CLAS12: FT, RICH, HDice



CLAS12:

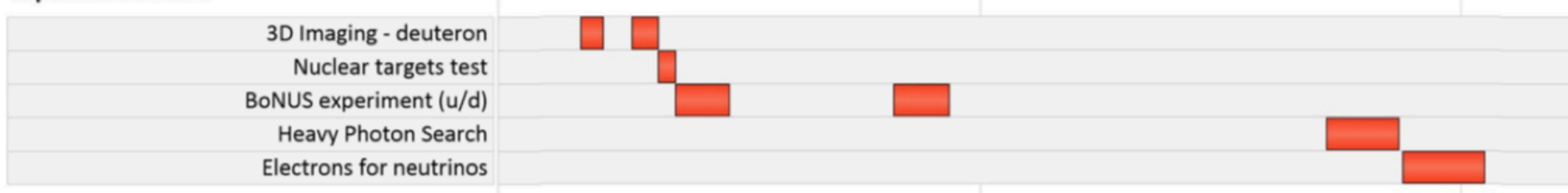
- 2018 Oct – Nov : **RGA-II** (fascio a 10.6 GeV/c, bersaglio di idrogeno)
- 2018 Nov – Dec : RGK-I (fascio a 6.5 e 7.5 GeV/c, bersaglio di idrogeno)
- 2019 Jan – Mar : RGB-I (fascio a 10.6 GeV/c, bersaglio di deuterio)
- 2019 Apr : RGA-III (fascio a 10.6 GeV/c, bersaglio di idrogeno)
- 2019 Oct – Dec : RGB-II (fascio a 10.6 GeV/c, bersaglio di deuterio)
- 2020** : **BoNUS** (tagged scattering off neutron)
- 2021 Fall** : **RGM** (fascio a diverse energie, bersagli nucleari)
- 2022 Spring** : **RGC*** (fascio a 10 GeV/c, bersagli longitudinali)

*Not confirmed yet

Experimental Hall A



Experimental Hall B





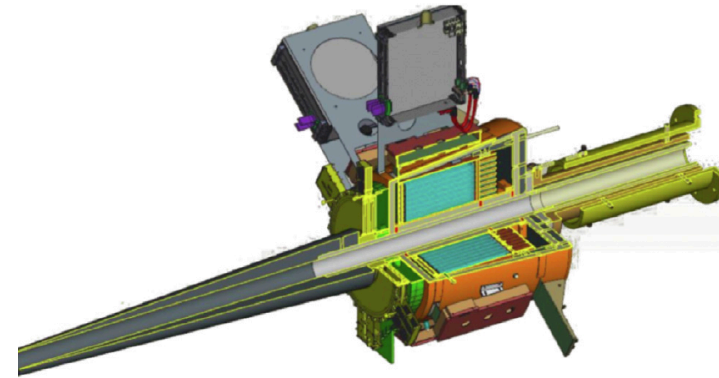
Nuclear Instruments and Methods in Physics
Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment

Volume 959, 11 April 2020, 163475



The CLAS12 Forward Tagger

A. Acker^a, D. Attié^a, S. Aune^a, J. Ball^a, P. Baron^a, M. Bashkanov^b, M. Battaglieri^{c, d} ✉, R. Behary^e, F. Benmokhtar^e, A. Bersani^e, Q. Bertrand^a, D. Besin^a, T. Bey^a, P. Black^f, P. Bonneau^d, F. Bossù^a, R. Boudouin^a, M. Boyer^a ... L. Zana^d



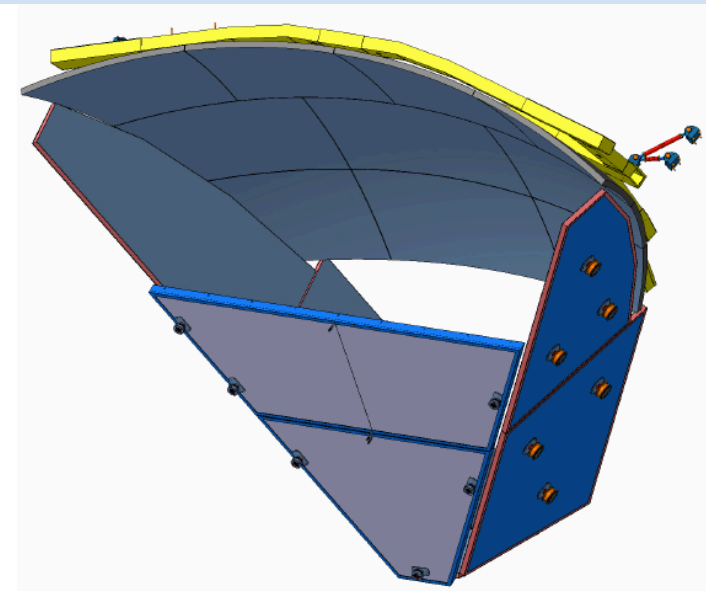
Nuclear Instruments and Methods in Physics
Research Section A: Accelerators, Spectrometers,
Detectors and Associated Equipment

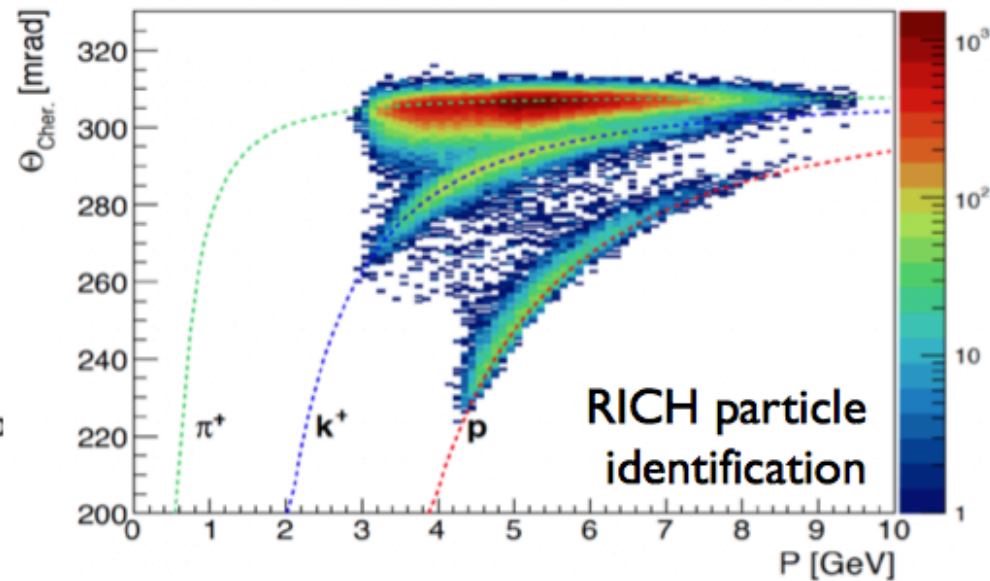
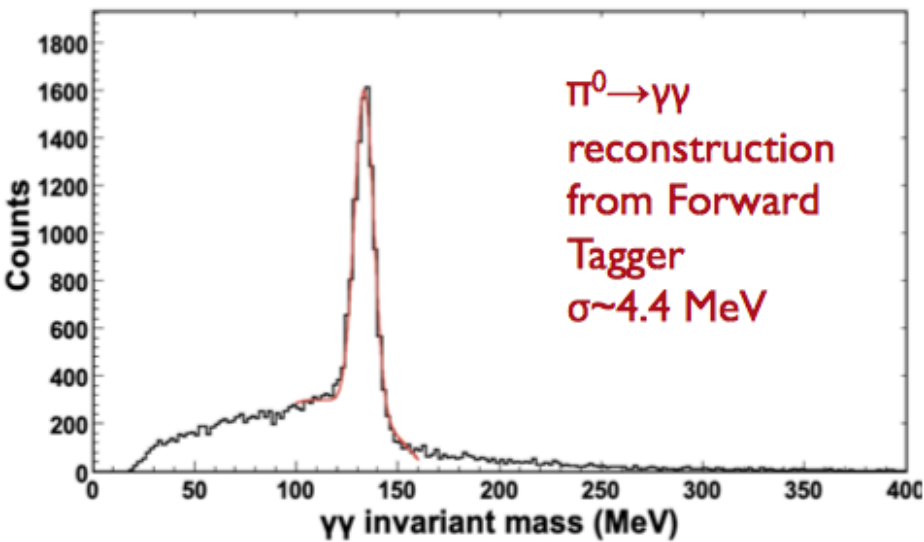
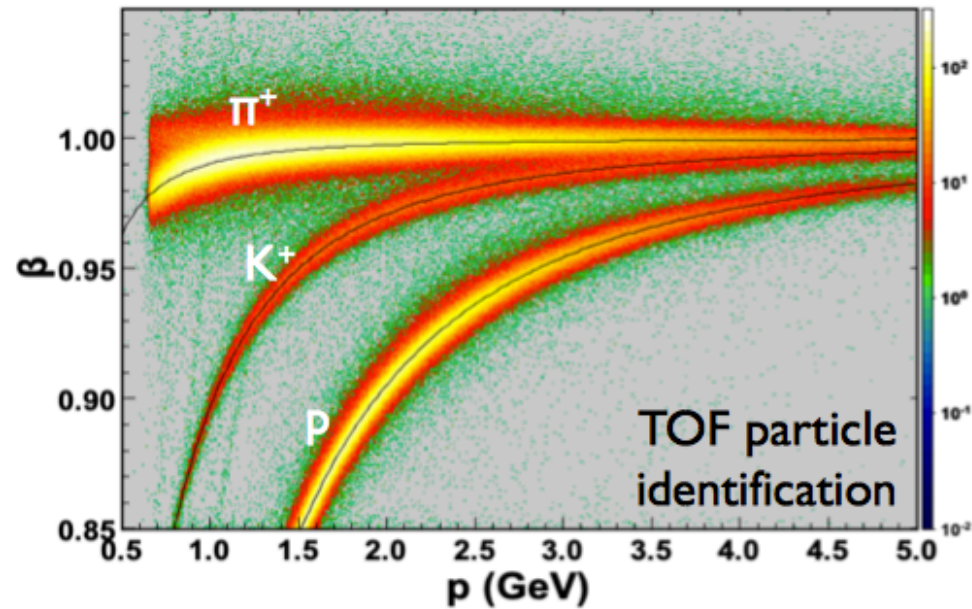
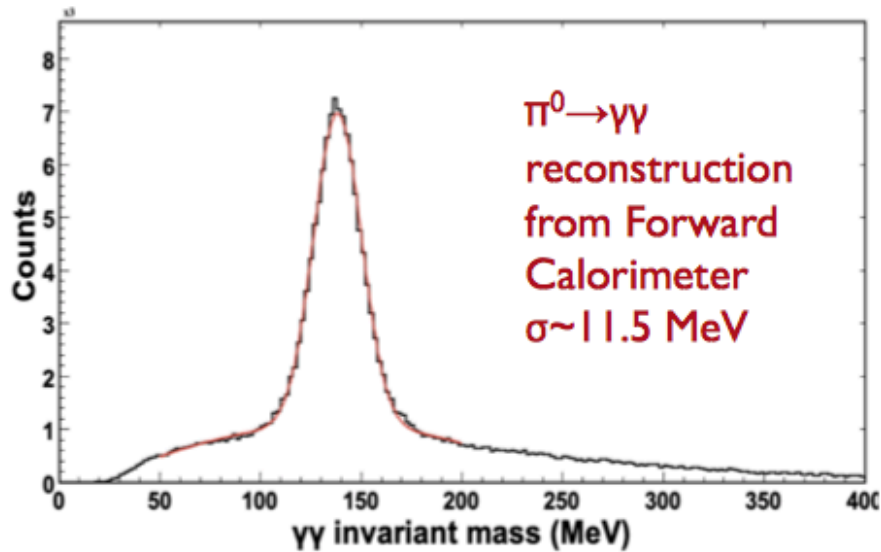
Volume 964, 1 June 2020, 163791



The CLAS12 Ring Imaging Cherenkov detector

M. Contalbrigo^a ✉, V. Kubarovsky^f, M. Mirazita^b, P. Rossi^{f, b}, G. Angelini^{b, j}, H. Avakian^f, K. Bailey^g, I. Balossino^a, L. Barion^a, F. Benmokhtar^h, P. Bonneau^f, W. Briscoe^j, W. Brooks^k, E. Cisbani^c, C. Cuevas^f, P. Degtiarenko^f, C. Dickover^f, K. Hafidi^g ... A. Yegneswaran^f





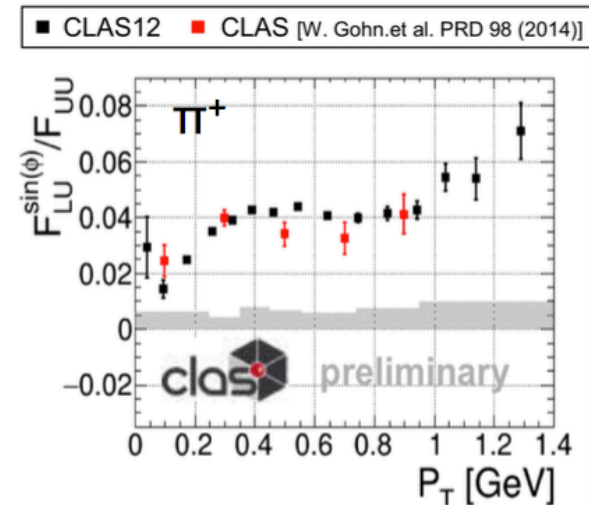
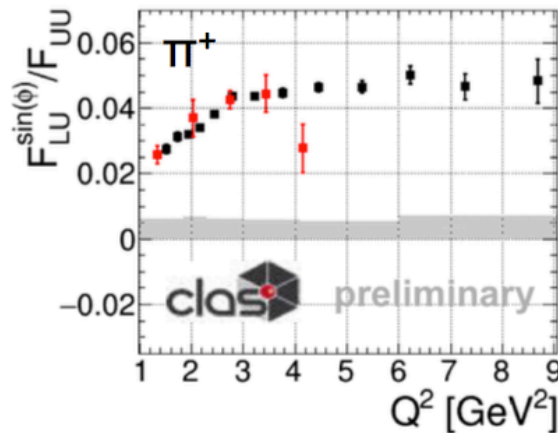
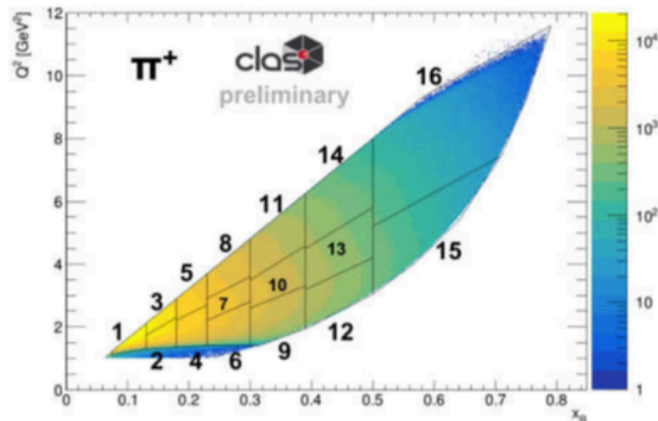
Two SIDIS analyses candidates for 1st publication under review
 Beam spin asymmetries in single π^+ and $\pi^+\pi^-$ pair electro-production
 Sensitive to the strong-force correlations within the nucleon

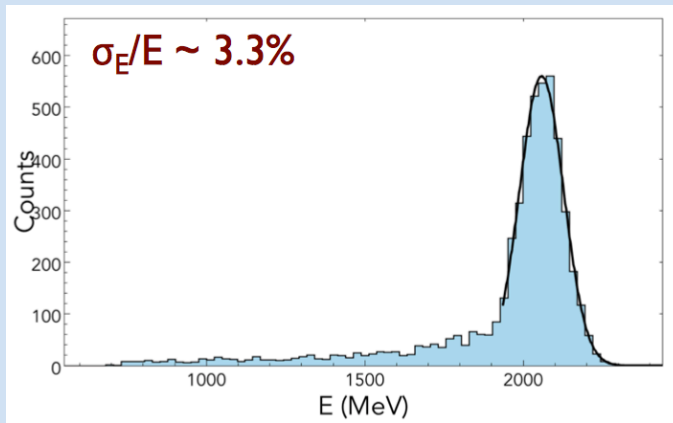
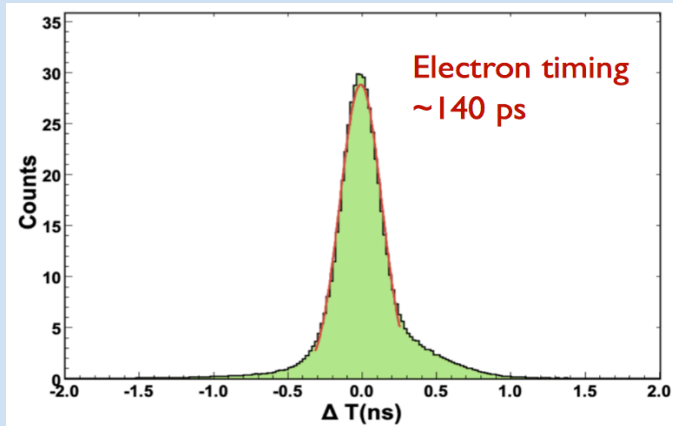
A first multidimensional study of SIDIS π^+ beam spin asymmetry over a wide range of kinematics

Observation of Beam-Spin Asymmetries in the Process $ep \rightarrow e'\pi^+\pi^-X$ with CLAS12
 (Dated: August 31, 2020)

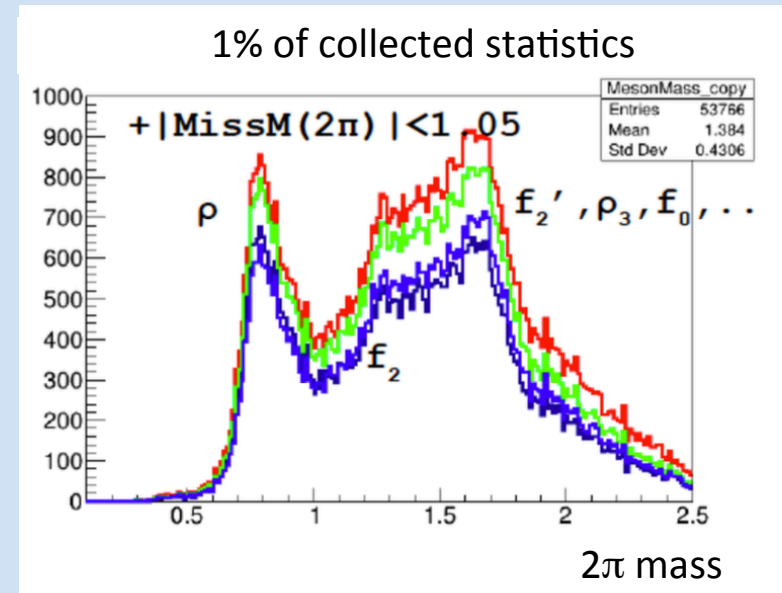
The observation of beam-spin asymmetries in dihadron production in semi-inclusive deep inelastic

- With respect CLAS:
- superior statistics instrumental for multidimensional study (to disentangle
 - extended range well inside the DIS regime



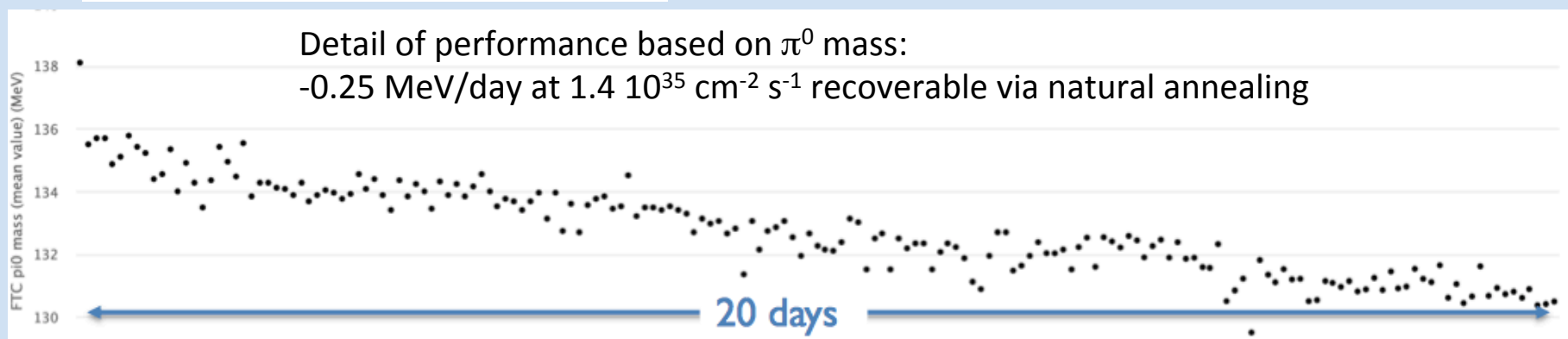


Quasi-real (exotic) meson photo-production
Initial state radiation events

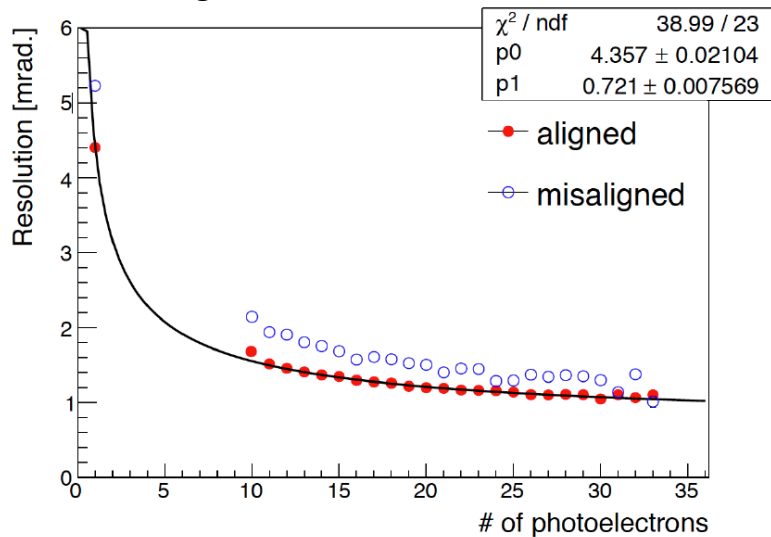


Detail of performance based on π^0 mass:

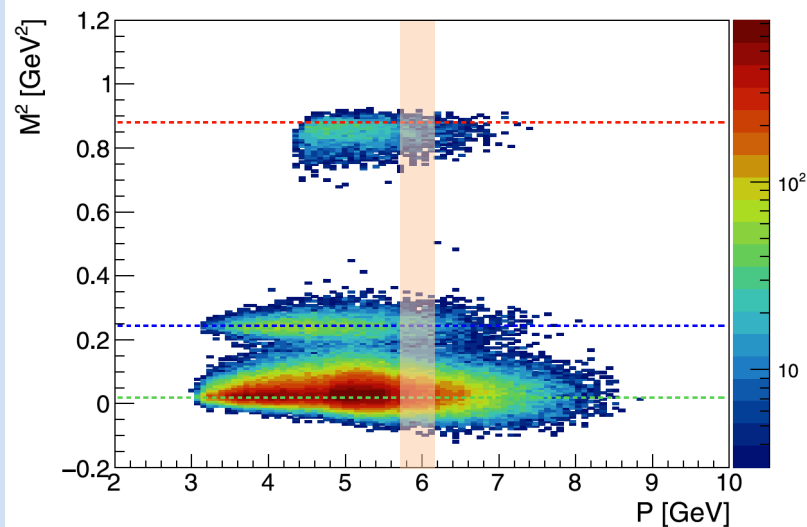
-0.25 MeV/day at $1.4 \cdot 10^{35} \text{ cm}^{-2} \text{ s}^{-1}$ recoverable via natural annealing



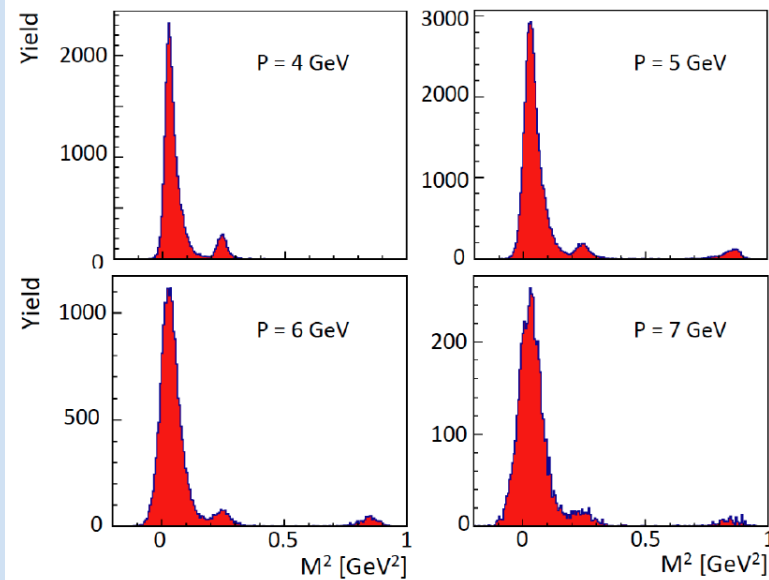
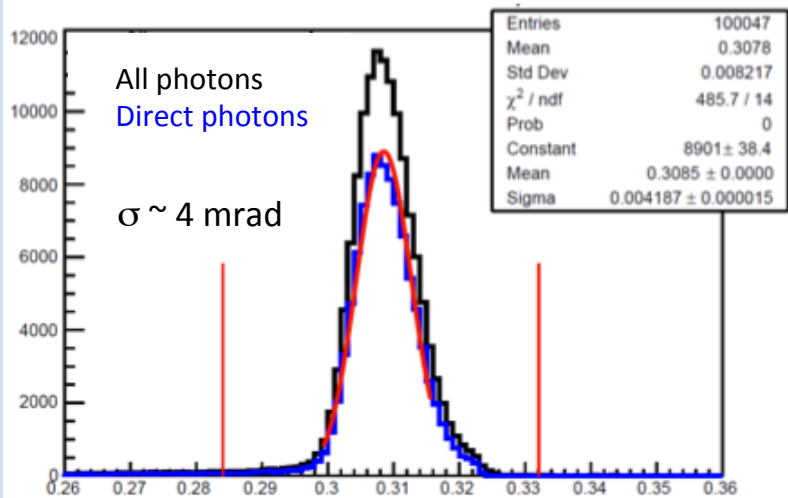
RICH alignment vs CLAS12



PID analysis for one representative aerogel tile



Mirror alignment



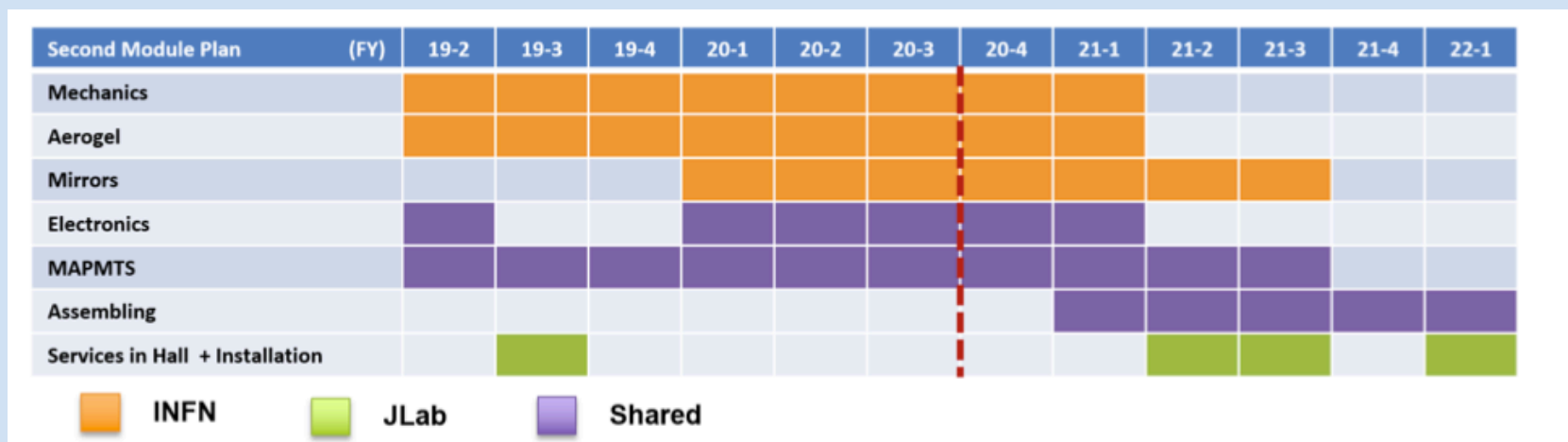


Installation at the end of 2021

In time for the start of demanding polarized target experiments

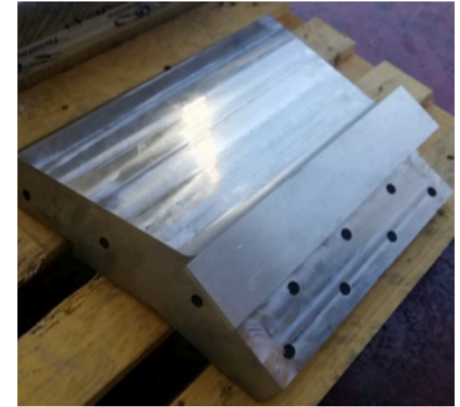
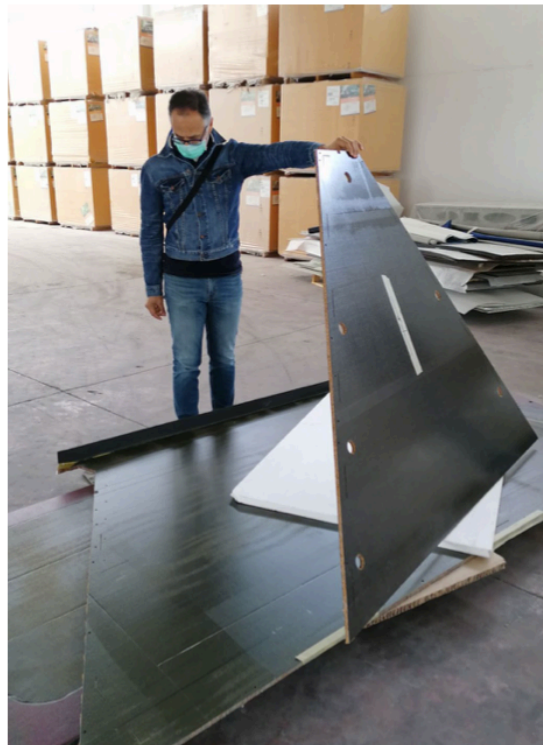
Component production in line with JLab schedule (only ~ 3 months delay due to COVID)

Focus on spherical mirror



Composite materials:

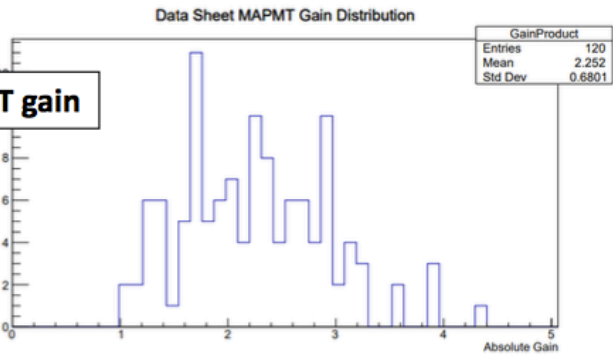
- aluminum + honeycomb / steel outside acceptance
- carbon fiber + honeycomb inside acceptance



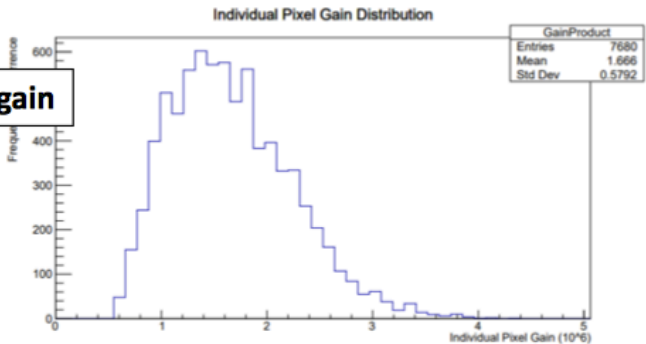
Production well advanced and large fraction already at JLab

First 180 MAPMTs of the JLab orders already delivered, tests ongoing

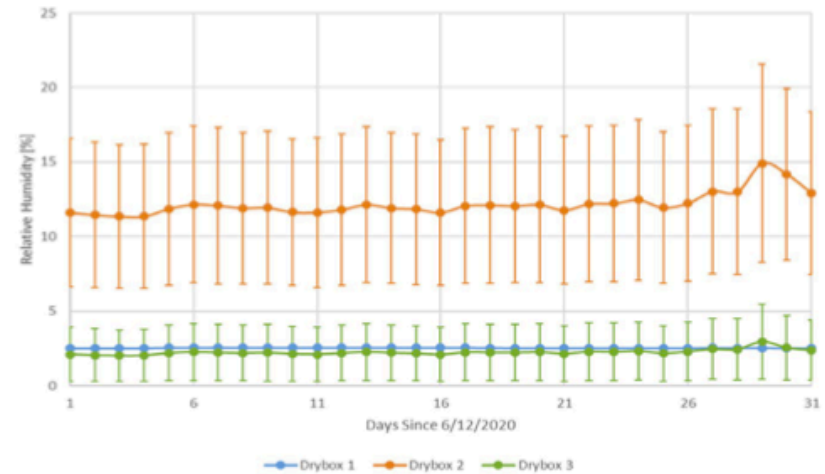
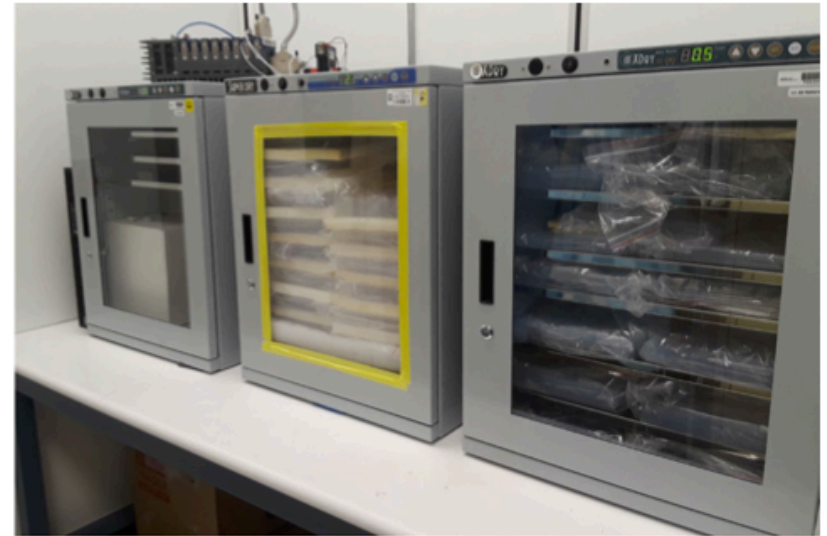
Average MAPMT gain



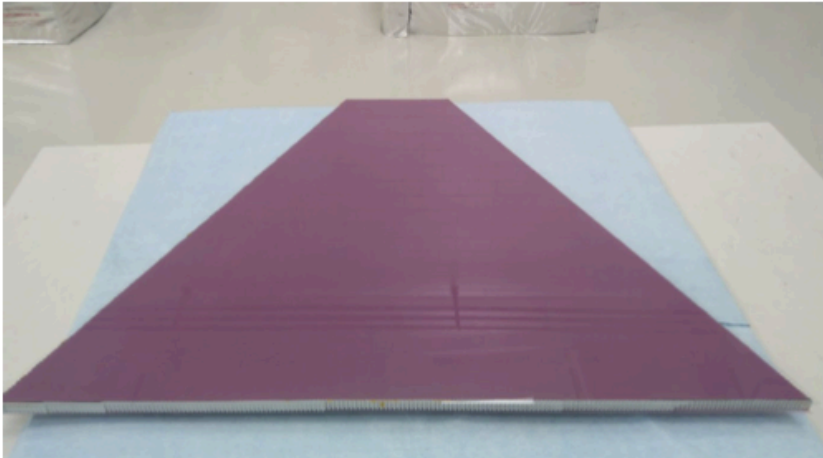
Individual pixel gain



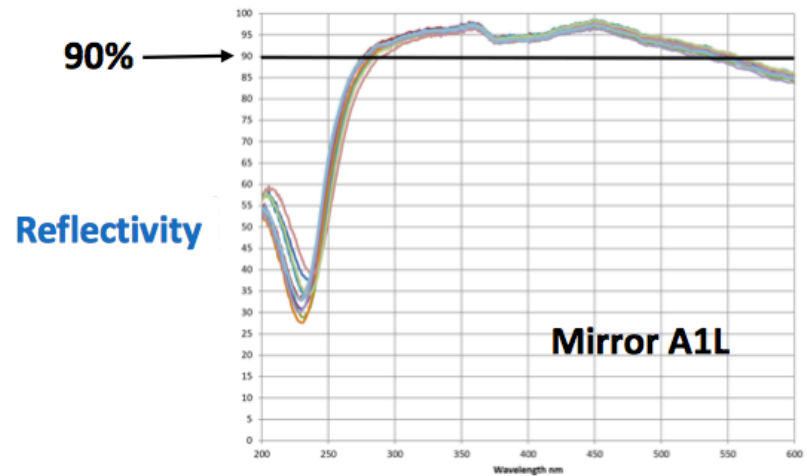
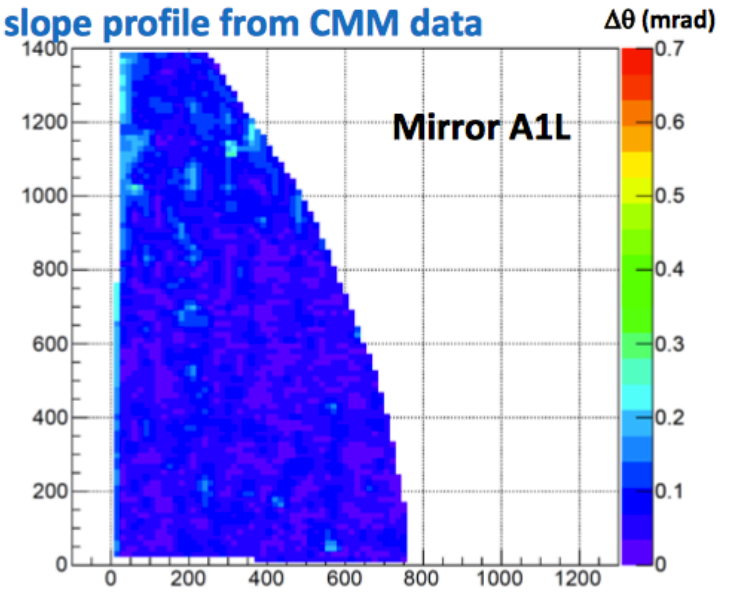
The aerogel is stored in dry boxes and remotely monitored



Glass skin mirros: surface planarity better than RICH 1



Local slope profile from CMM data

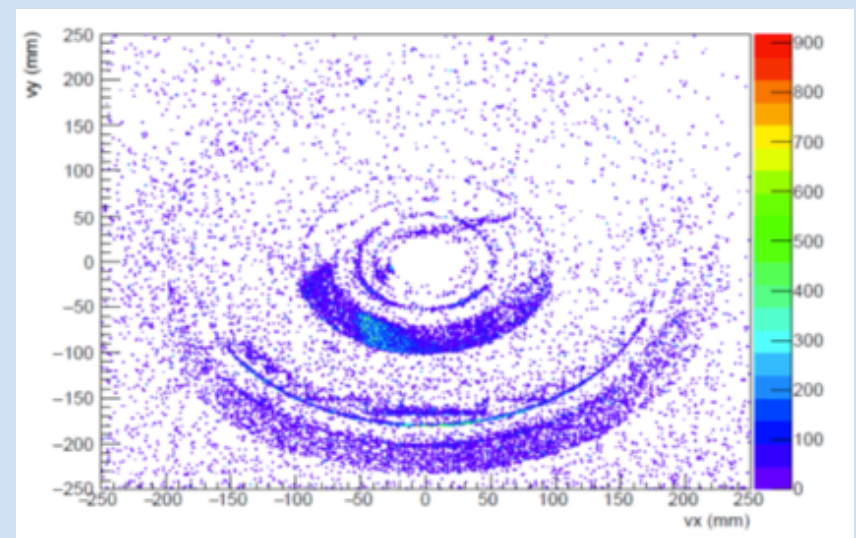
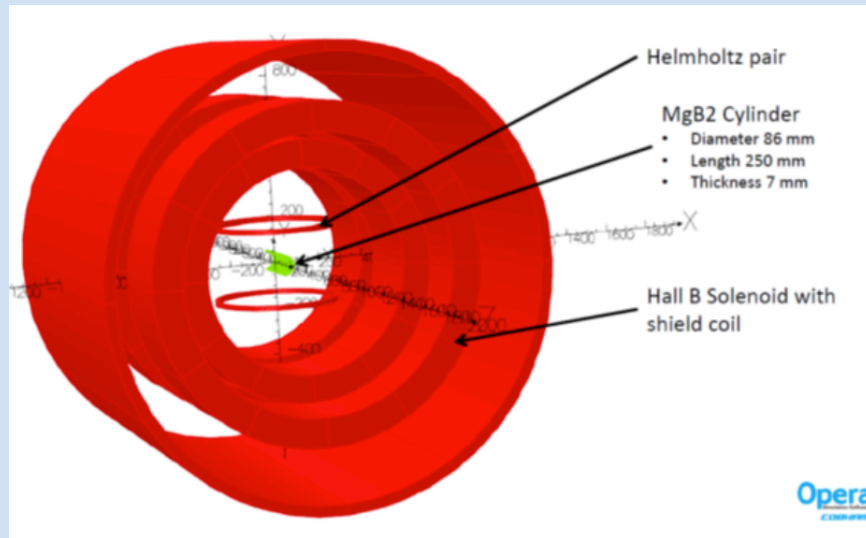


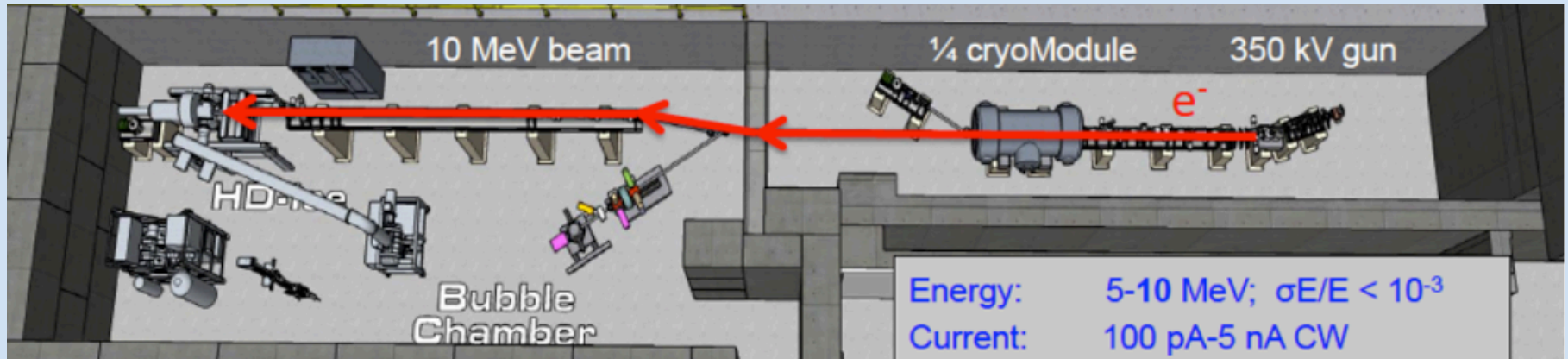
Task force appointed by JLab (Hall-B):

Type	Temperature	Field strength	Uniformity	Magnet
HD-ice*	40 mK	~ 1 T		MgB ₂
Frozen spin NH ₃ /ND ₃ target*	0.1 K	~ 1 T		MgB ₂
Dynamically polarized NH ₃ /ND ₃ target	0.3 K	~ 2.5 T	100 ppm	MgB ₂
High-field stand-alone NH ₃ /ND ₃ target	1 K	~ 5 T	100 ppm	

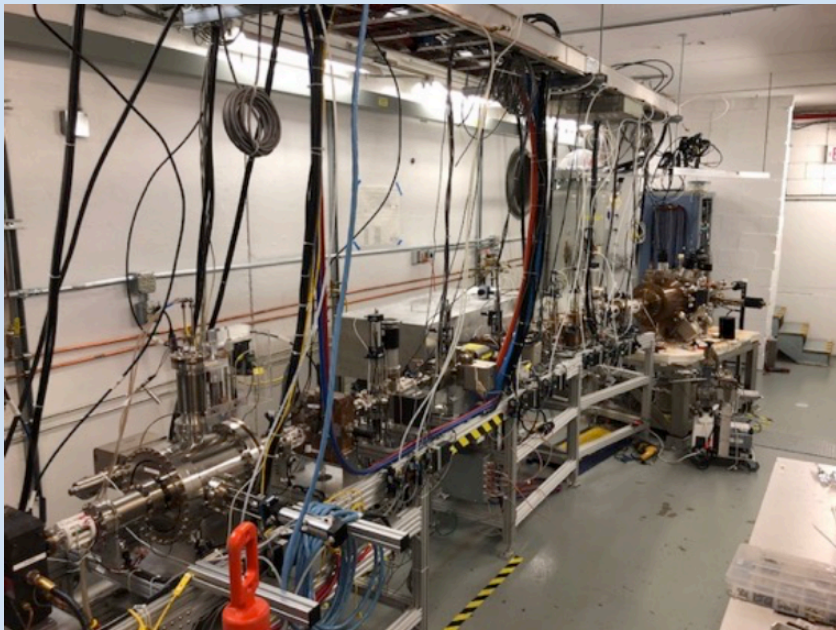
* Polarization sustainability under charged beam has to be demonstrated

Study of Moeller background containment with a target transverse holding field inside the 5T solenoid

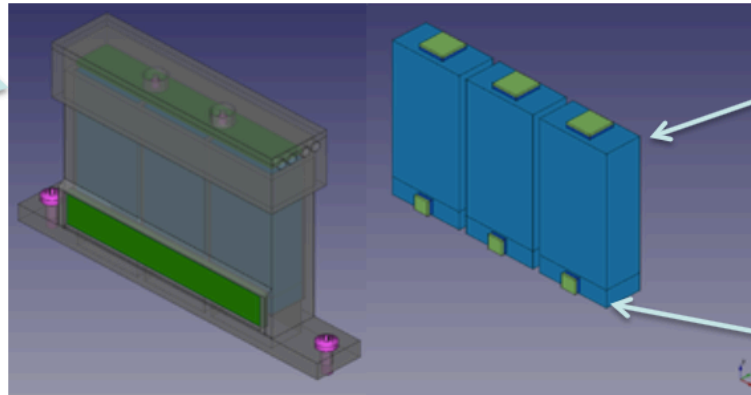
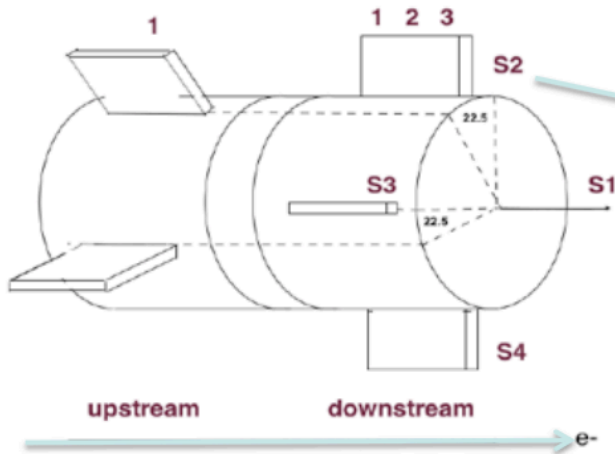




UITF beam line under commissioning: reached the target energy of 9.5 MeV



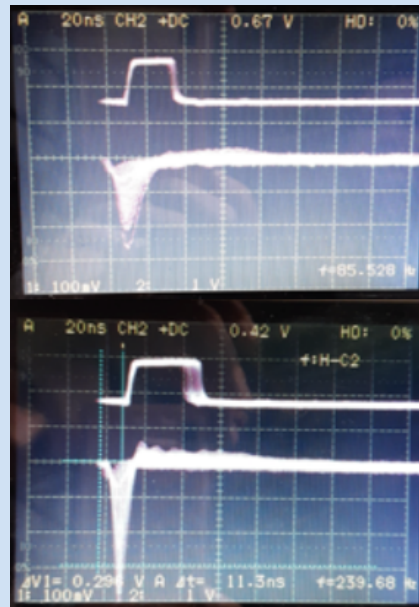
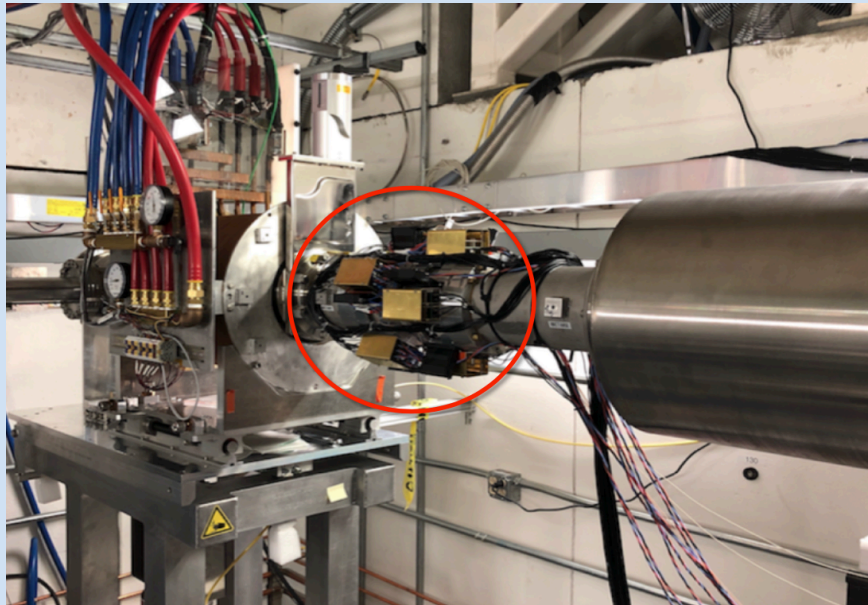
- Electron Beam Monitor: downstream - Moeller scattering
 upstream - elastic backscattering



BC408
 E: 20x10x38 mm
 coupled to 6x6 mm
 SensL SiPm

dE: 20x10x5 mm
 coupled to 3x3 mm
 SensL SiPm

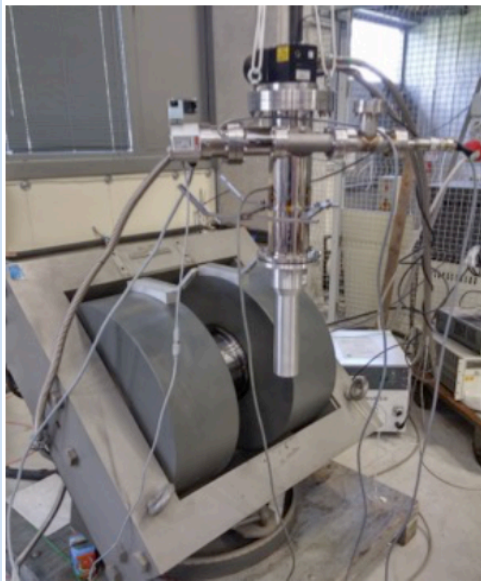
In beam cryostat and beam monitor ready and awaiting first beam



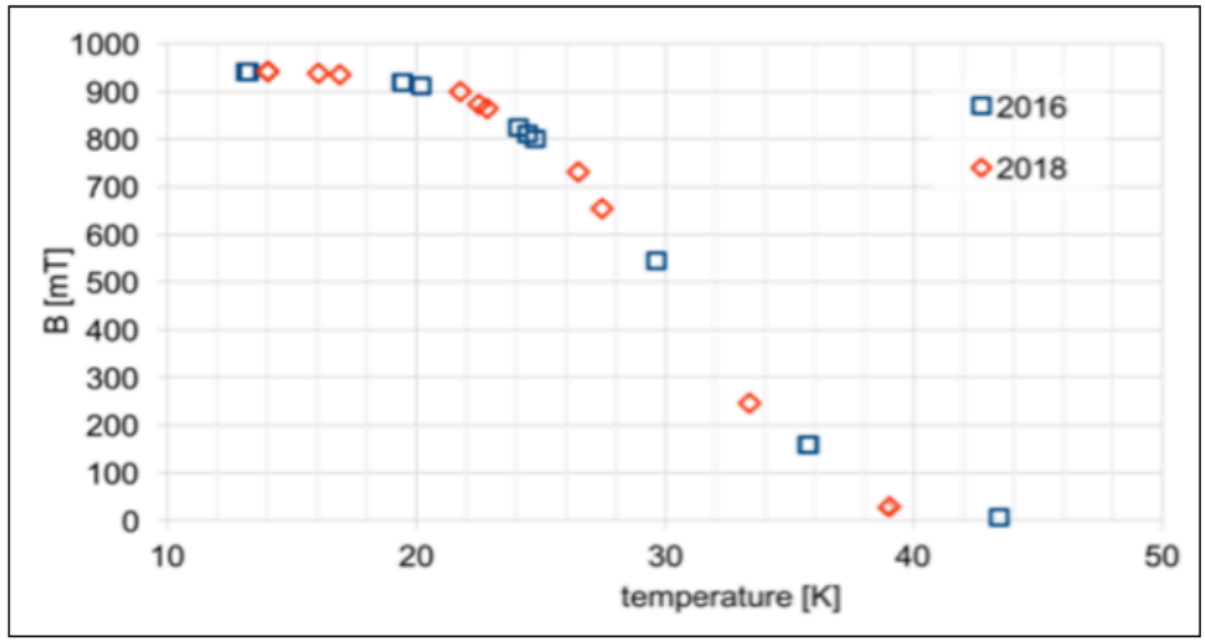
Response to Sr^{90}

Ready for:

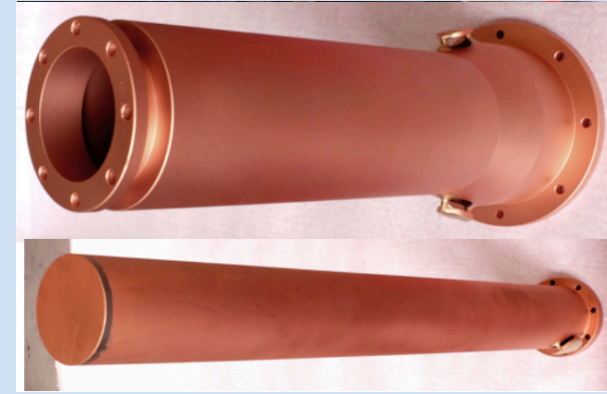
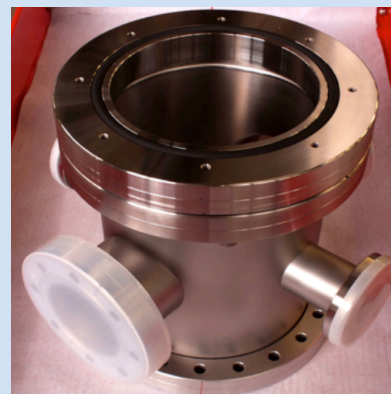
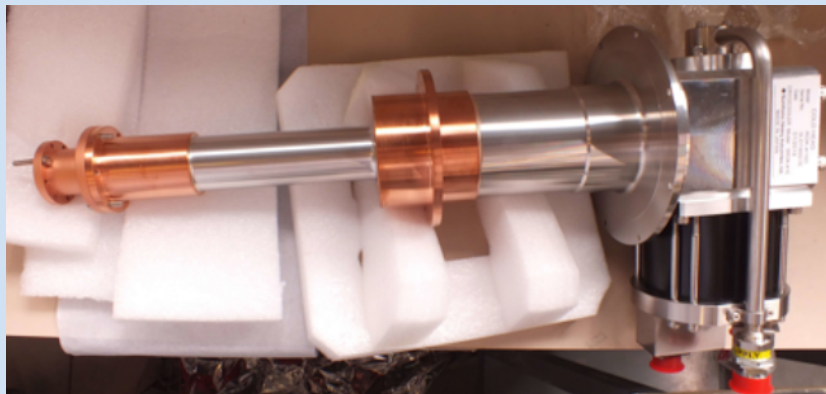
- rate asymmetry
- analog pulses
- trigger
- interlock



MgB₂ trapped magnetization as a function of the working temperature



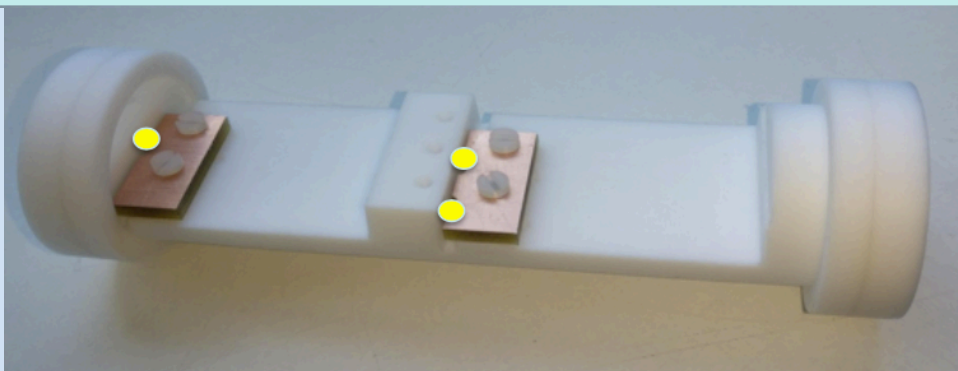
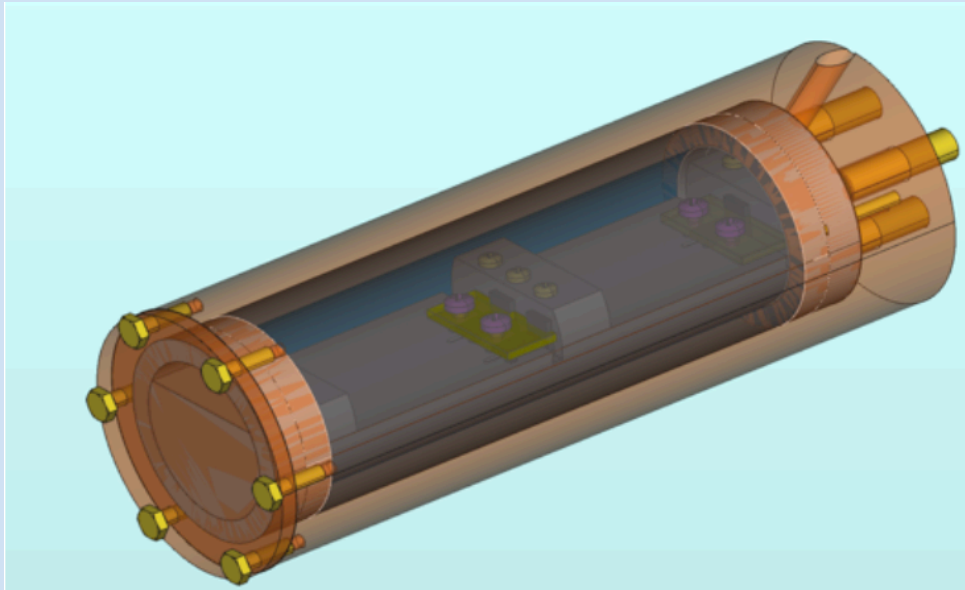
New cool head and cryostat screens to improve the temperature control



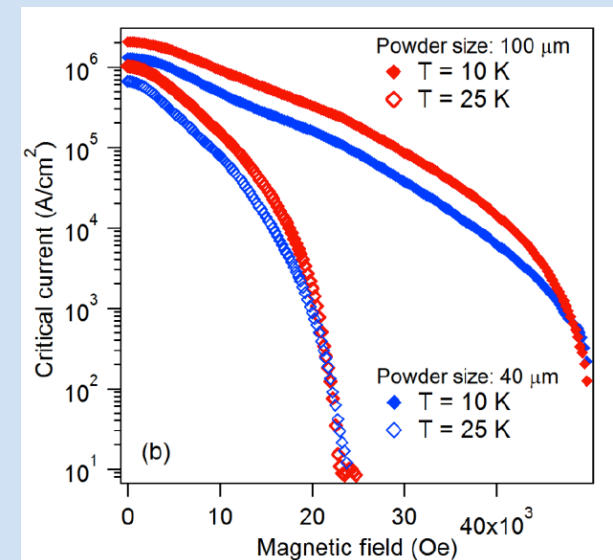
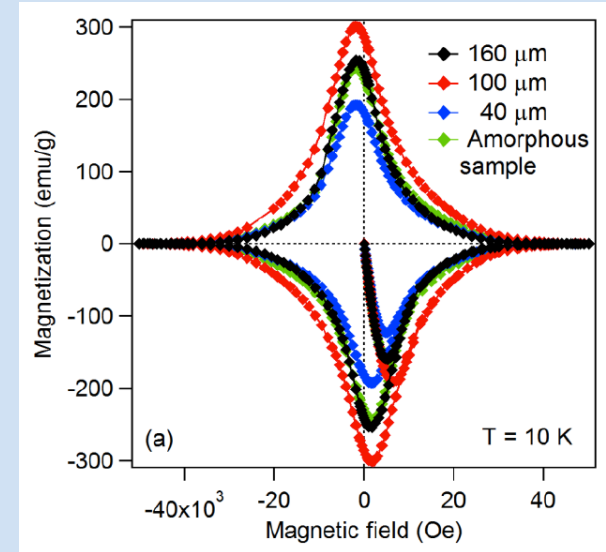
In preparation of double field test and CLAS12 application

New MgB₂ holder to allow

- filed map (6 Hall probes)
- fast sample exchange



MgB₂ characterization with SQUID magnetometer



Milestones Concordate		
Data	Descrizione	Completamento
30-06-2020	BDX: BDX-MINI presa dati cosmici e fascio	100 %
30-06-2020	RICH: Inizio produzione fotosensori secondo modulo	100 %
30-06-2020	CLAS12: Presentazione risultati preliminari sulle asimmetrie di spin del fascio in reazioni esclusive e semiinclusive alle Conferenze di settore.	100 %
30-06-2020	FT e RICH primo modulo: Processamento dati primo run di fisica 	100 %
30-06-2020	FT e RICH primo modulo: Sottomissione articolo tecnico (costruzione e prestazioni).	100 %
30-06-2020	Tracker: Tracciatore GEM integrato in BigBite e pronto per l'installazione in sala A Under reorganization with locals due to COVID	50 %
30-06-2020	Tracker: Completamento caratterizzazione tracker al silicio 30/12/2020	100 %
31-12-2020	BDX Test e commissioning BDX elettronica Streaming RO (WaveBoard 2.0) ?????	60 %
31-12-2020	POLTARG: Completamento apparato di misura della resistenza dei bersagli polarizzati al fascio di elettorni. Commissioning ongoing	90 %
31-12-2020	RICH: Completamento produzione aerogel	80 %
31-12-2020	HCAL-J: Apparato pronto per l'installazione in sala A	100 %

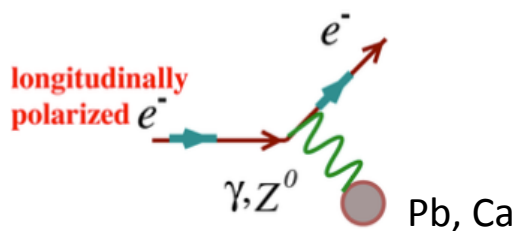
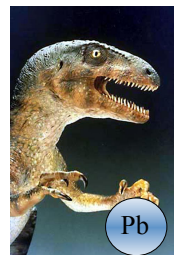
(All but ME)	2019 Assigned	2020 Assigned	2021 Expected	2022 Expected	2023 Expected
Tracker (Hall-A)	15	20	15	10	10
FT (HallB)	20	10	10	10	10
RICH (HallB)	194	300	300	40	10
HCAL-J (HallA)	30	10	10	10	10
PolTarg (HallB)	60	35	70	170	170
HPS+BDX (HallA+B)	37	60	75	170	170
Calcolo (HallA+B)	15	57**	-	-	15
Hyper + WACS (Hall-A)	-	-	20	40	40
Total (HallA+B)	450*	435*	520	450	435

* Accounting for a ~15% fraction that could not be clearly assigned to a specific project

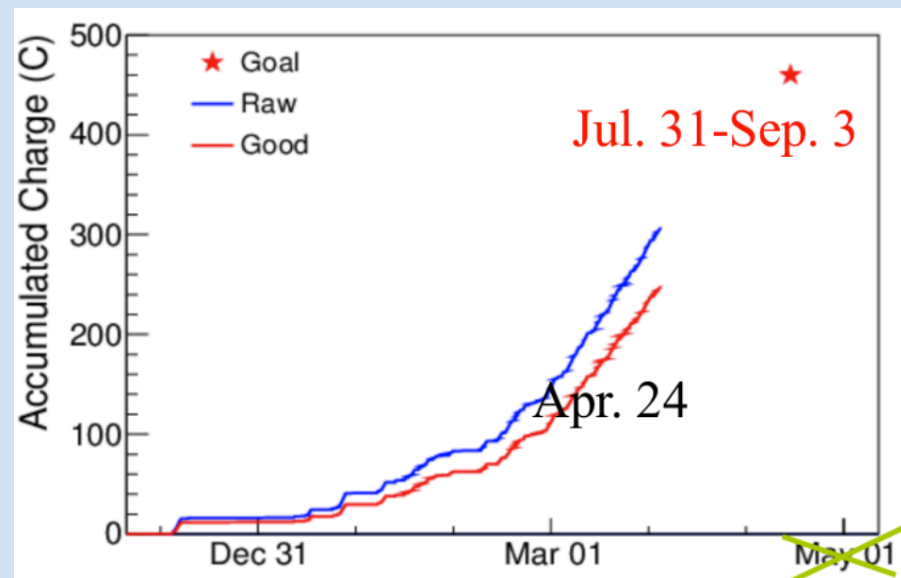
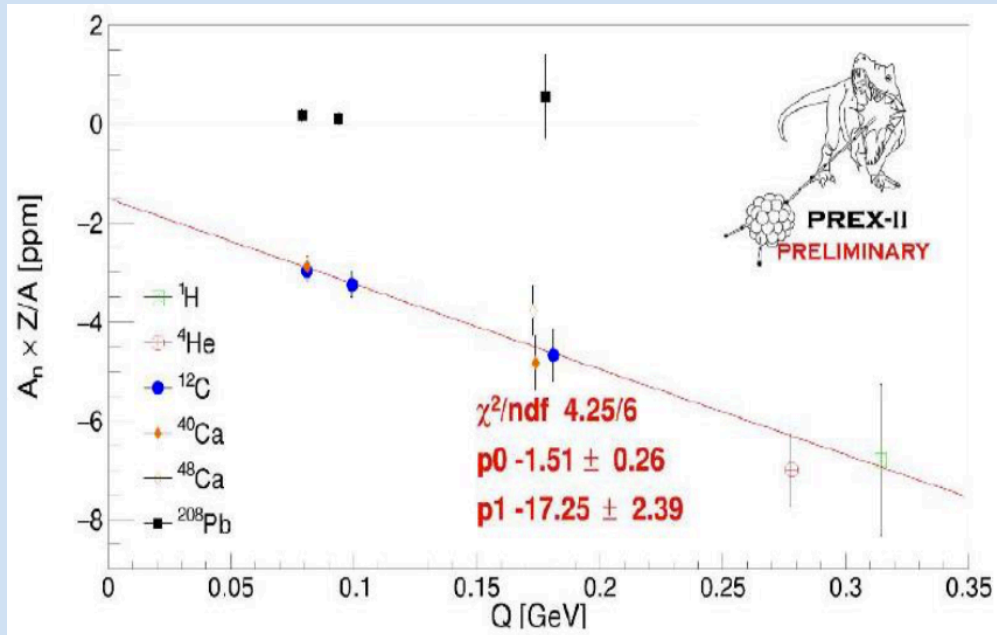
** Giunta INFN

Milestones Concordate		
Data	Descrizione	Completamento
30/02/2021	Calcolo: Integrazione delle risorse CNAF nel sistema di calcolo distribuito del JLab	0
30/04/2021	RICH: Completamento produzione specchi a pelle di vetro	0
30/06/2021	Tracker: Inizio commissioning tracciatore integrato in BigBite	0
30/06/2021	Tracker: Caratterizzazione secondo batch di sensori SiD	0
30/06/2021	BDX: Completamento articolo tecnico BDX-mini	0
30/06/2021	CLAS12: Prima pubblicazione di fisica	0
30/09/2021	RICH: Completamento produzione sensori	0
30/12/2021	PREX-II: Primi risultati di fisica dell'esperimento	0
30/12/2021	POLTARG: Definizione del progetto di integrazione bersaglio trasverso in CLAS12	0
30/12/2021	HCAL-J: Inizio commissioning apparato	0

Heavy Nuclei Neutron Skin



$$A_{PV} \sim \frac{G_F Q^2}{4\pi\alpha} \left[\underbrace{1 - 4\sin^2\theta_W}_{\sim 0} + \frac{F_n(Q^2)}{F_p(Q^2)} \right]$$



Transverse beam polarization Asymmetry

Deviations indication of two photon exchange ?

Spring 2020:

- 54% of target statistics
- ~ 87% electron beam polarization

Data taking resumed at the end of July