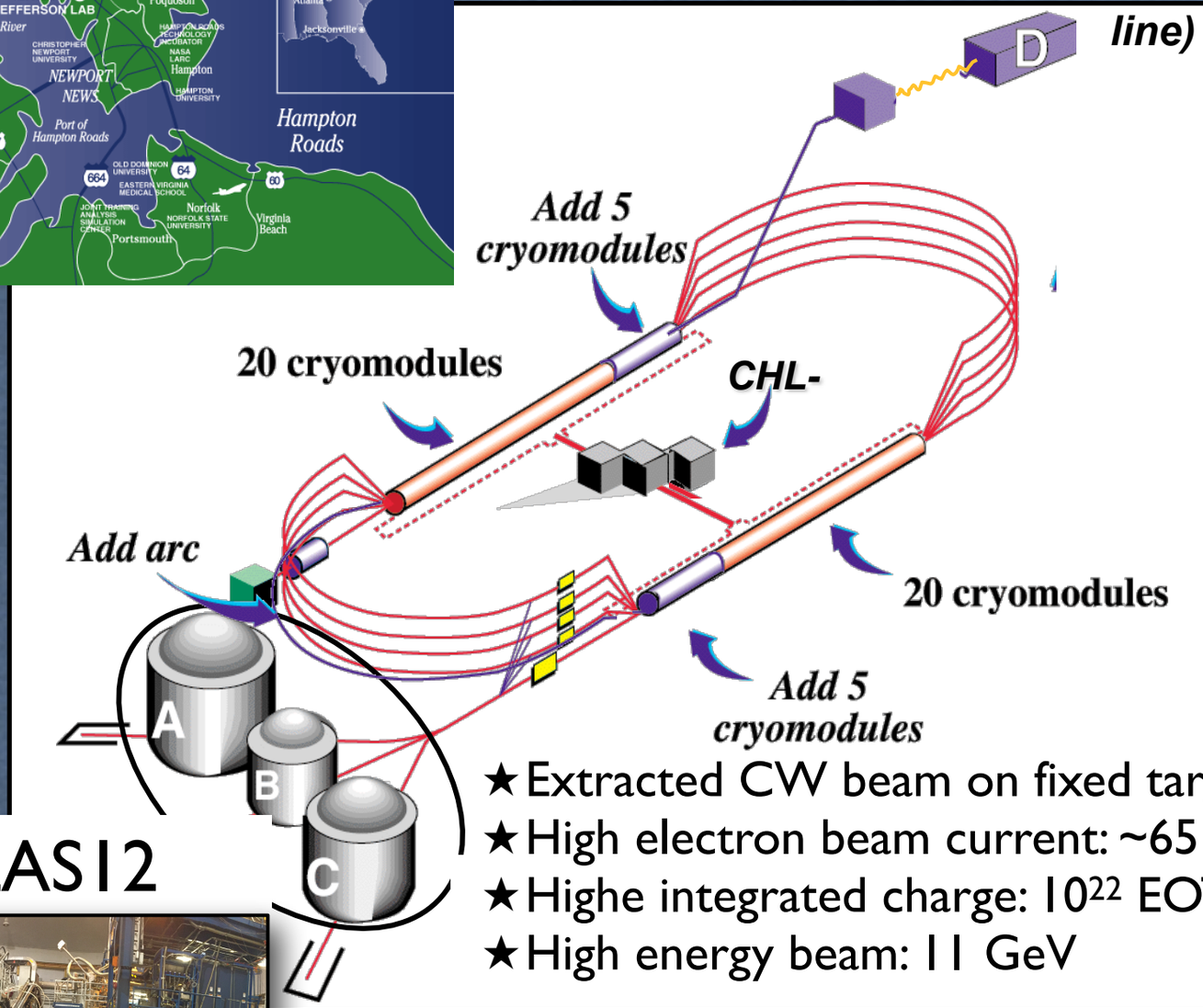
INFN-Ge
CDS
Jul 2 2018

JLAB12-GE: Status and plans

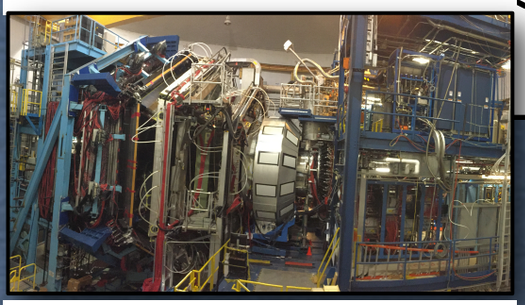
M.Battaglieri
INFN -GE
Italy

JLAB12-GE activities



★ Extracted CW beam on fixed target
★ High electron beam current: ~65 uA
★ Highe integrated charge: 10^{22} EOT
★ High energy beam: 11 GeV

CLAS12



HPS

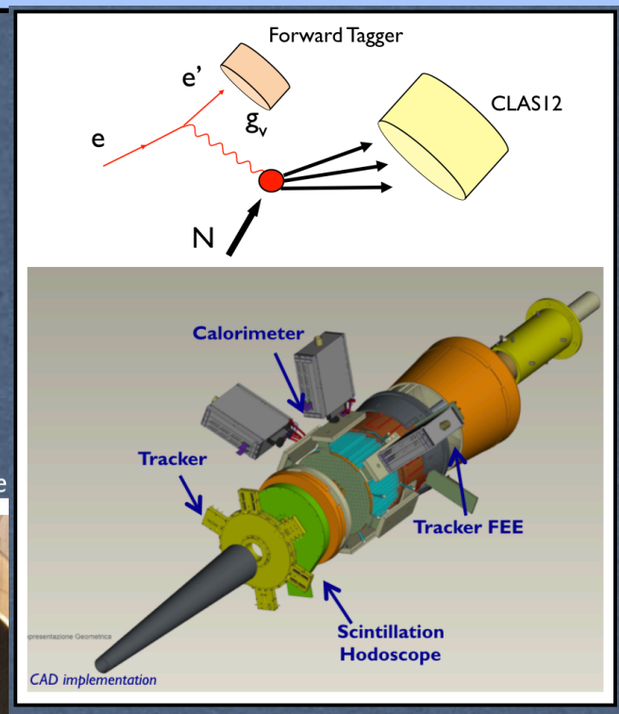
★ The CLAS12 Forward Tagger
★ The HPS experiment
★ SBS, HPS

SBS

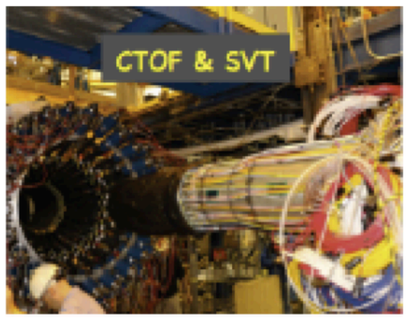
BDX

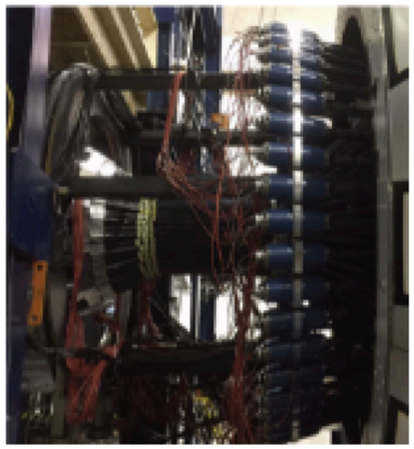
The Forward Tagger and CLAS12

- Meson spectroscopy with photons in CLAS12
  MesonEx - Study the meson spectrum in the 1-3 GeV mass range to identify gluonic excitation of mesons (hybrids) and other quark configuration beyond the CQM
- Quasi-real photo production with CLAS12 (low Q2 electroproduction)

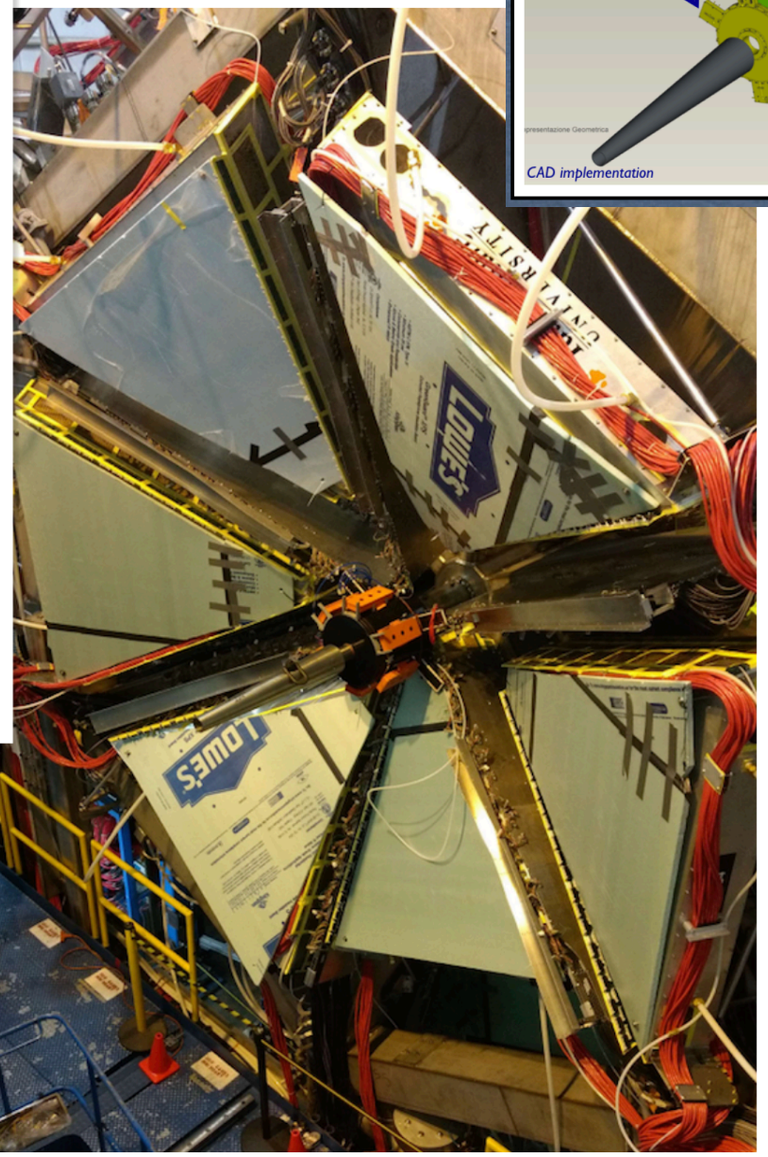


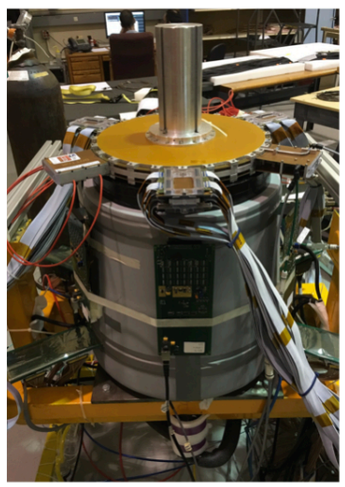
The CLAS12 detector





The





FT-Cal: $PbWO_4$ calorimeter
electron energy/momentum
Photon energy (ν=E-E')
Polarization $\varepsilon^{-1} \approx 1 + \nu^2/2EE'$
INFN-GE, INFN-RM2, INFN-TO, JLab

FT-Hodo: Scintillator tiles
veto for photons
EdinburghU+JMU+NSU+Jlab

FT-Trck: MicroMegas
electron angles and polarization plane
Saclay + OhioU+Jlab

The Forward Tagger and CLAS12

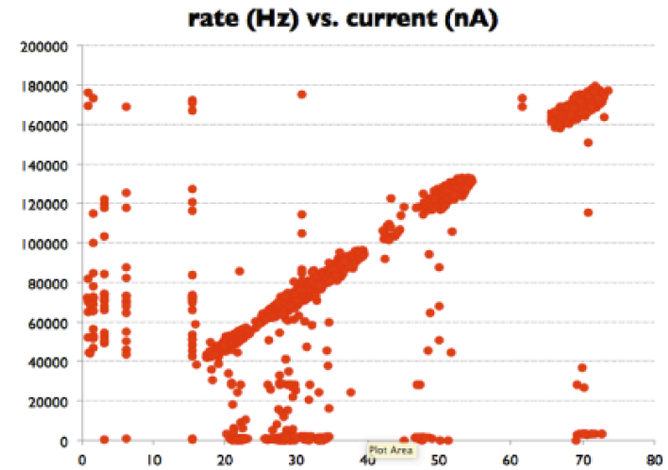
Coordination: INFN-Genova

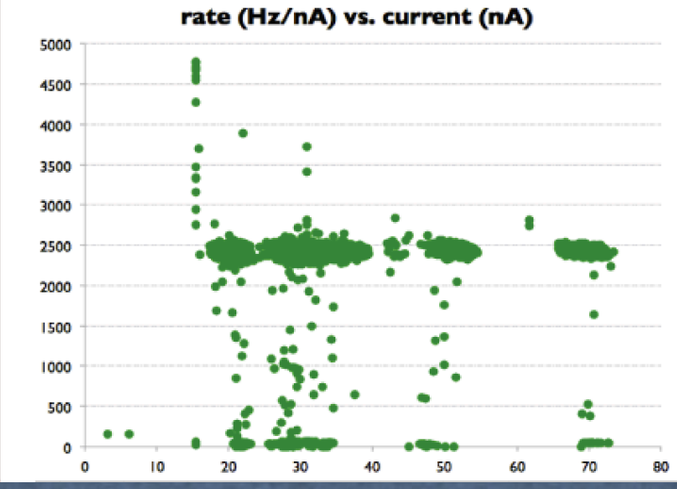
Contributors: CEA, INFN-Ge, INFN-RMTV, U. Edinburg, U. Glasgow, JLab, James Madison U., Norfolk S.U., Ohio U.

- ★ Full Forward Tagger installed in CLAS12 in July 2017
- ★ Commissioned with cosmic ray data in July- November 2017
  - Response of individual detectors
  - Efficiency and energy calibration
  - Relative timing
- ★ Delayed start of on-beam commissioning due to defective fitting in cal; cooling circuit, repaired in Jan18
- ★ On-beam commissioning during CLAS12 engineering run in January 2018
- ★ First physics from February to May 2018 at 10.6 GeV

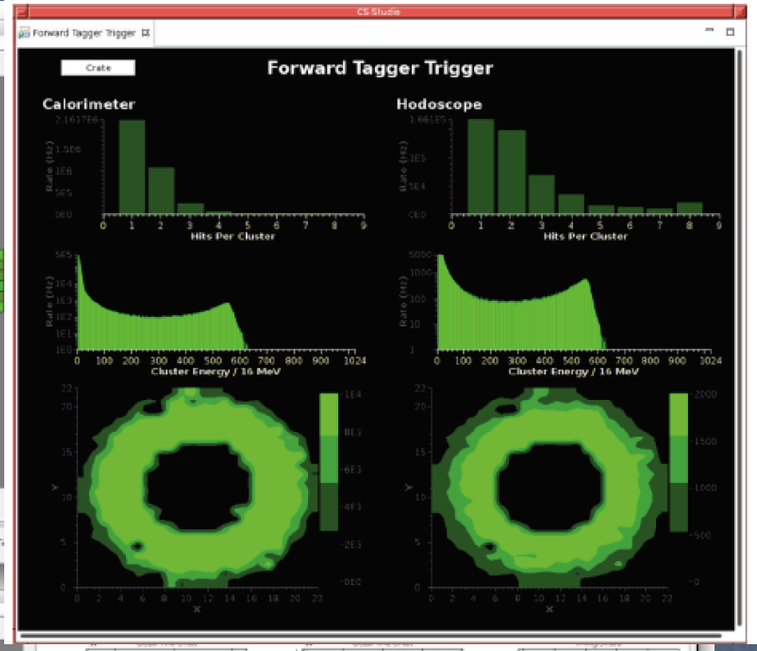
The Forward Tagger and CLAS12

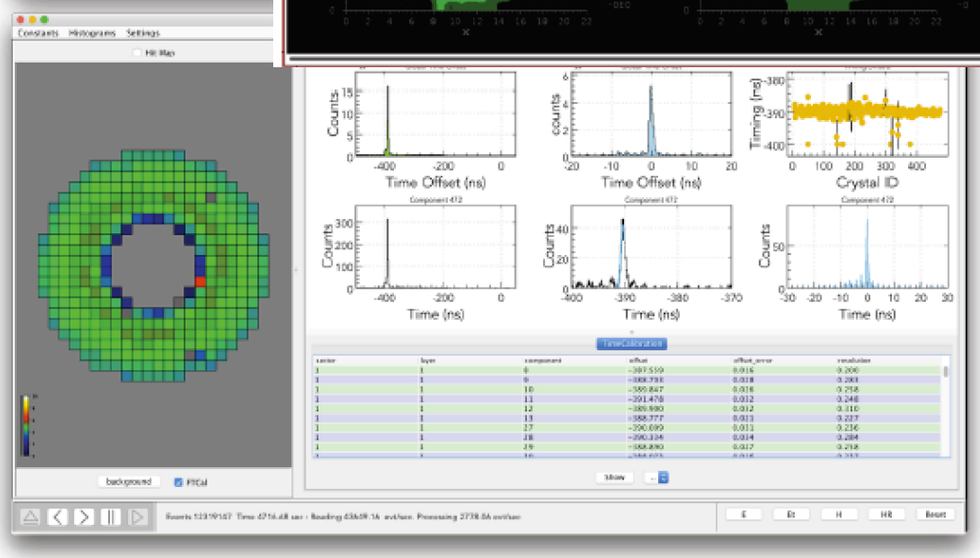
FT trigger designed to detect electrons as the coincidence of a cluster in the calorimeter with matching hits in the hodoscope





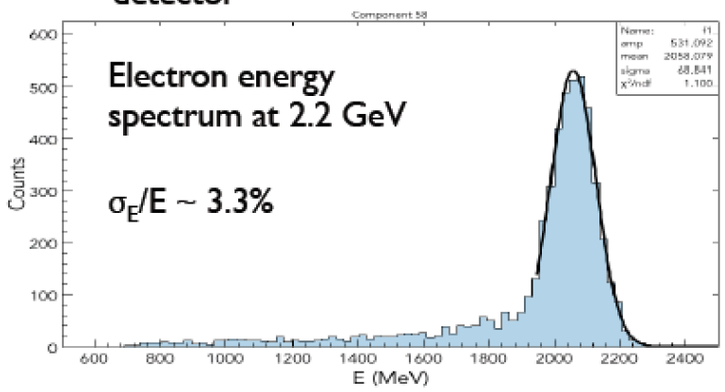
FT trigger monitoring GUI

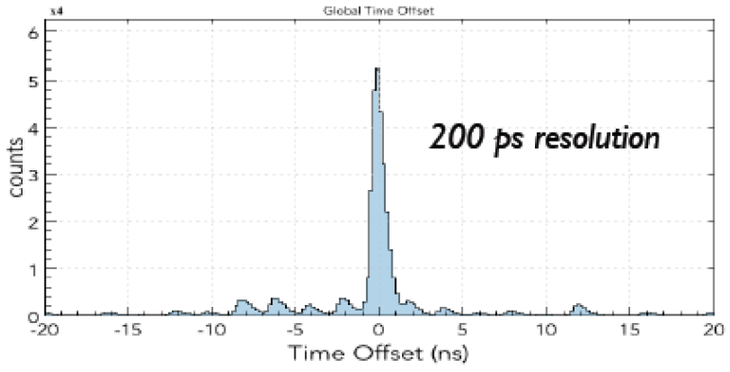




Final calorimeter calibration based on real data:

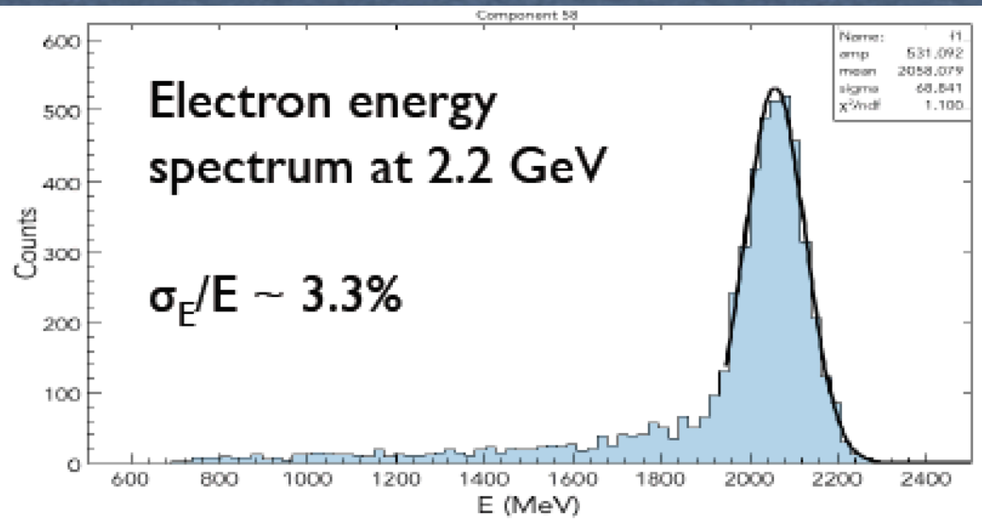
- Energy calibration based on elastic data at 2.2 GeV and 6.4 GeV
- Timing calibration based on coincidence with forward CLAS12 detector



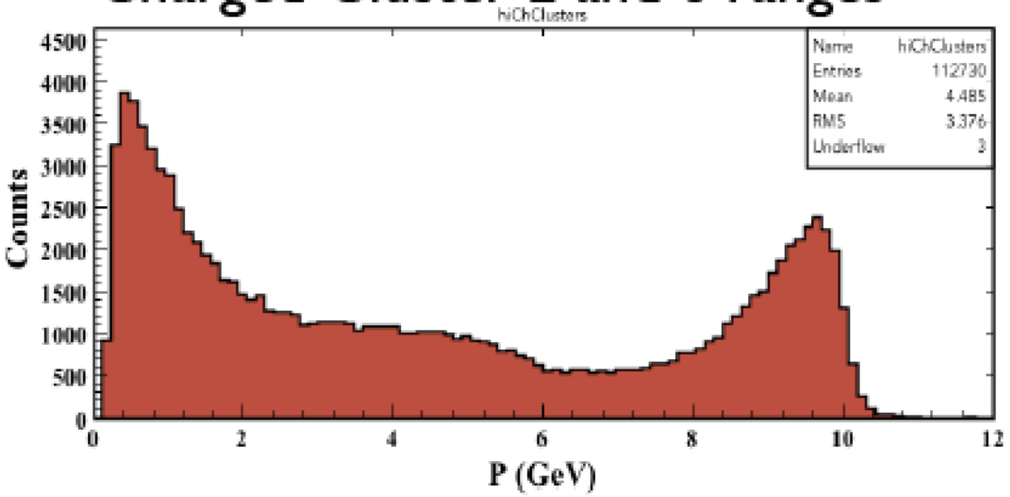


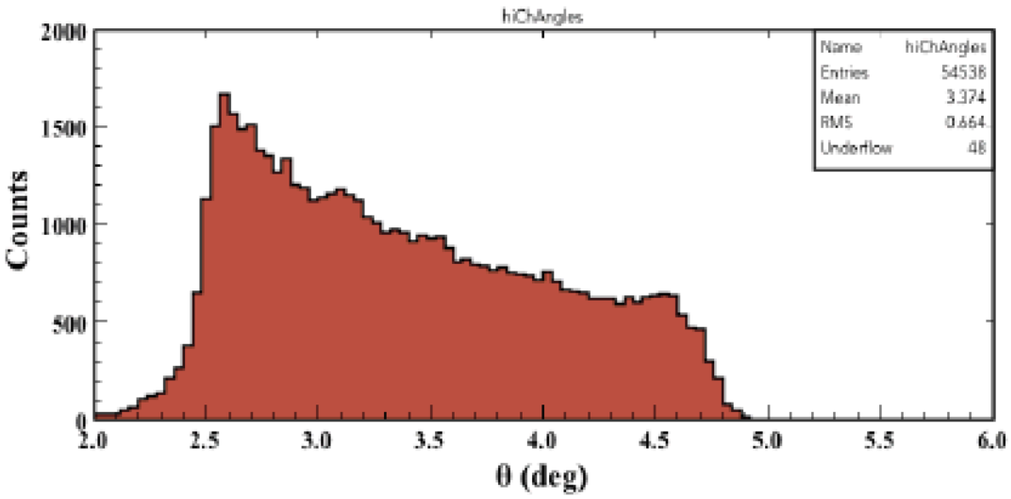
The Forward Tagger and CLAS12

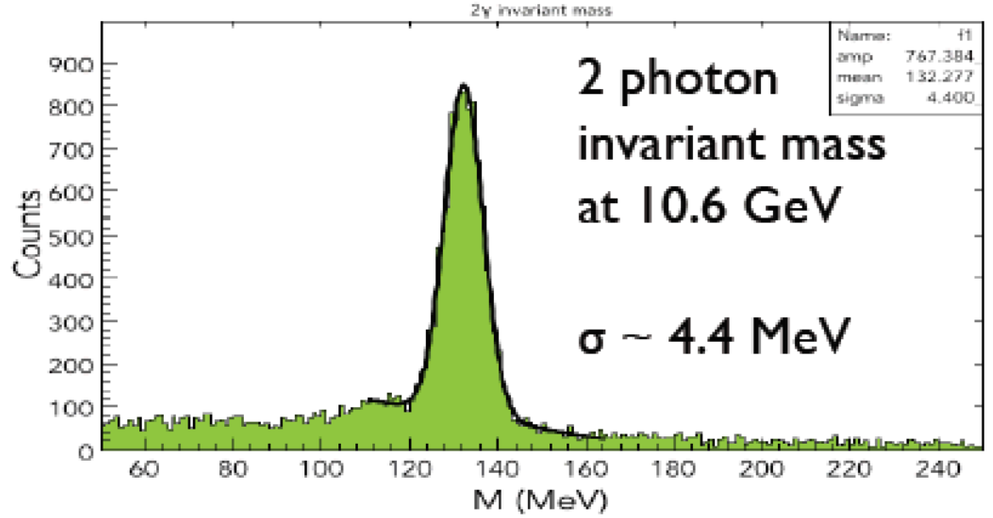
Performance	Expected Value	Measured Value
Azimuthal angular coverage	2.5° to 4.5°	2.6° to 4.6°
EM shower energy range	(0.5-8) GeV	(0.3 – 9.5) GeV
Energy resolution	$\sigma_E/E \leq 2\%/\sqrt{E(GeV)} \oplus 1\%$	3.3% @ 2 GeV
Angular resolution	$\sigma_\theta/\theta \leq 1.5\%$, $\sigma_\phi \leq 2°$	tbd
Time resolution	≤ 300 ps	200 ps



Charged Cluster E and θ ranges







- Energy and angular acceptance match or exceed design ranges
- Initial energy calibration based on elastic electrons at 2.2 GeV: 3.3 % resolution @ 2 GeV still limited by accuracy of calibration (being improved) and energy threshold (20 MeV) used at 2.2 GeV
- Timing resolution on spec

The Forward Tagger and CLAS12

Coordination: INFN-Genova

Contributors: CEA, INFN-Ge, INFN-RMTV, U. Edinburg, U. Glasgow, JLab, James Madison U., Norfolk S.U., Ohio U.

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Plans for 2019

Hardware:
Full restoration of FTCal cooling for T=0°operation in progress
Upgrade of FTHodo front-end electronics under evaluation

Calibrations:
Calibration of spring data in progress

Data analysis:
Trigger efficiency and purity
First physics analysis

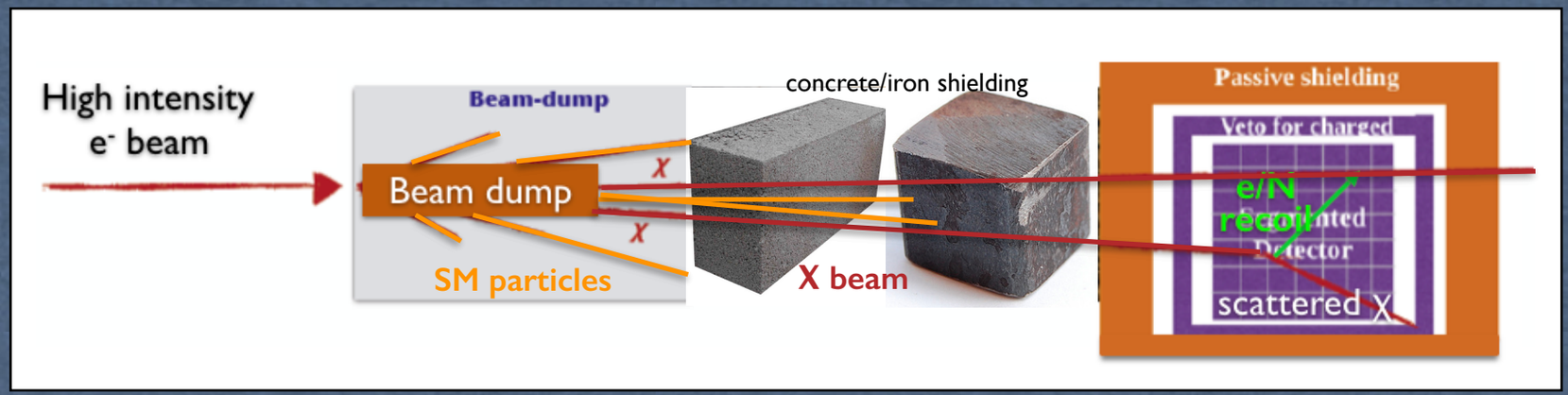
Software:
Maintenance of existing packages
Implementation of FT tracker

Data taking:
Continue data taking after summer break and in 2019

The BDX experiment

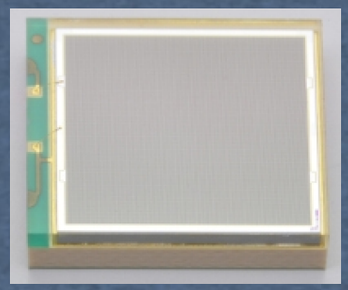
✳ Light Dark Matter search in a Beam Dump experiment (BDX)

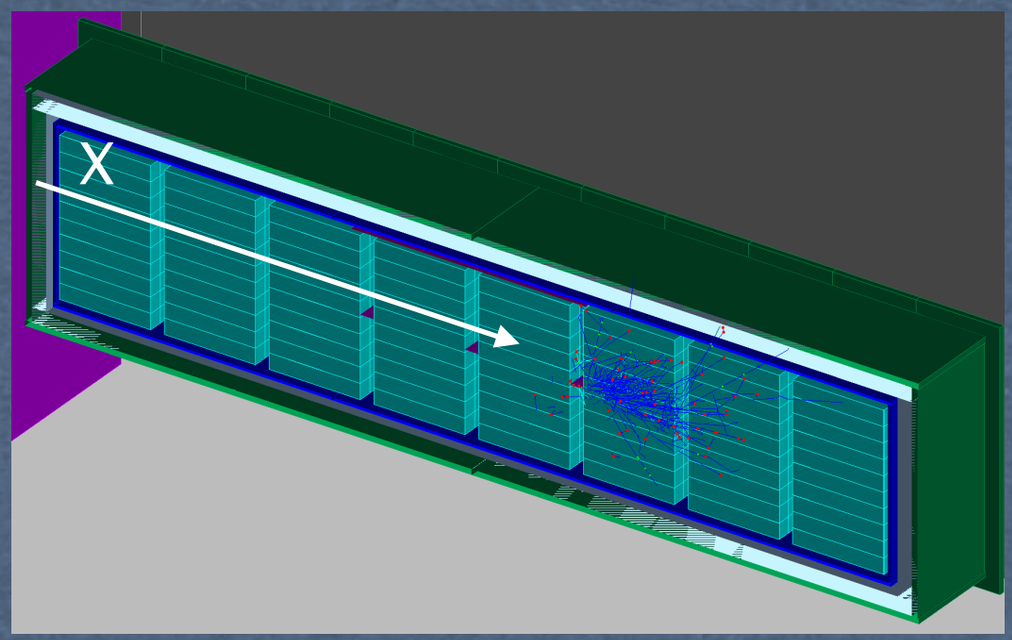
- Two steps process: I) produce a DM beam in the dump; II) detect the DM in a shielded detector



BDX experimental signature:
X-electron/X-N inelastic
→ em shower ~GeV energy

✳ EM Calorimeter (BaBar CSI(Tl) crystals + SiPM) + Active veto (plastic scintillators + WLS + SiPm)





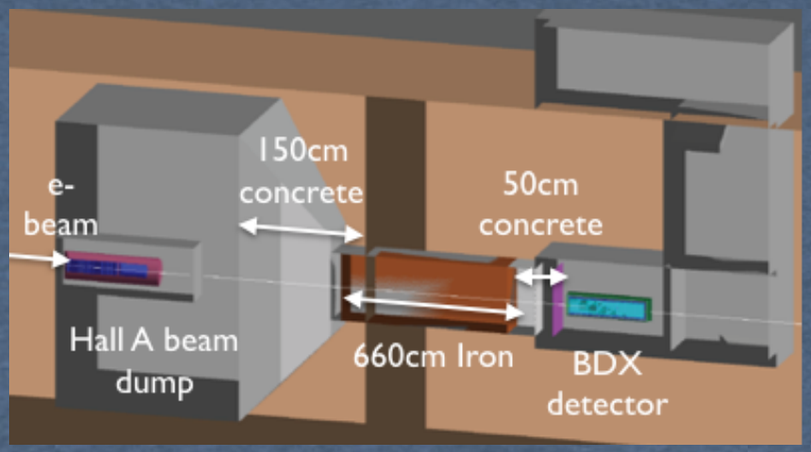
Crystals are available from BABAR em calorimeter

- Size: (5x5)cm² front face, (6x6)cm² back face, 30cm length
- 820 crystals available from end cap

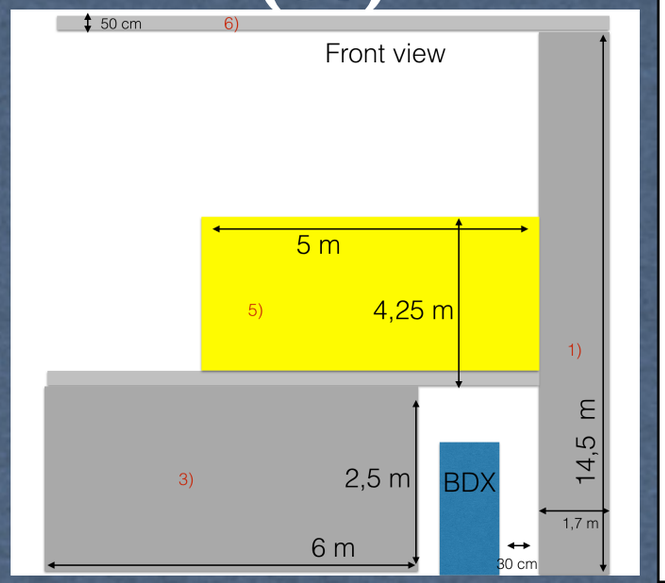
SiPM readout

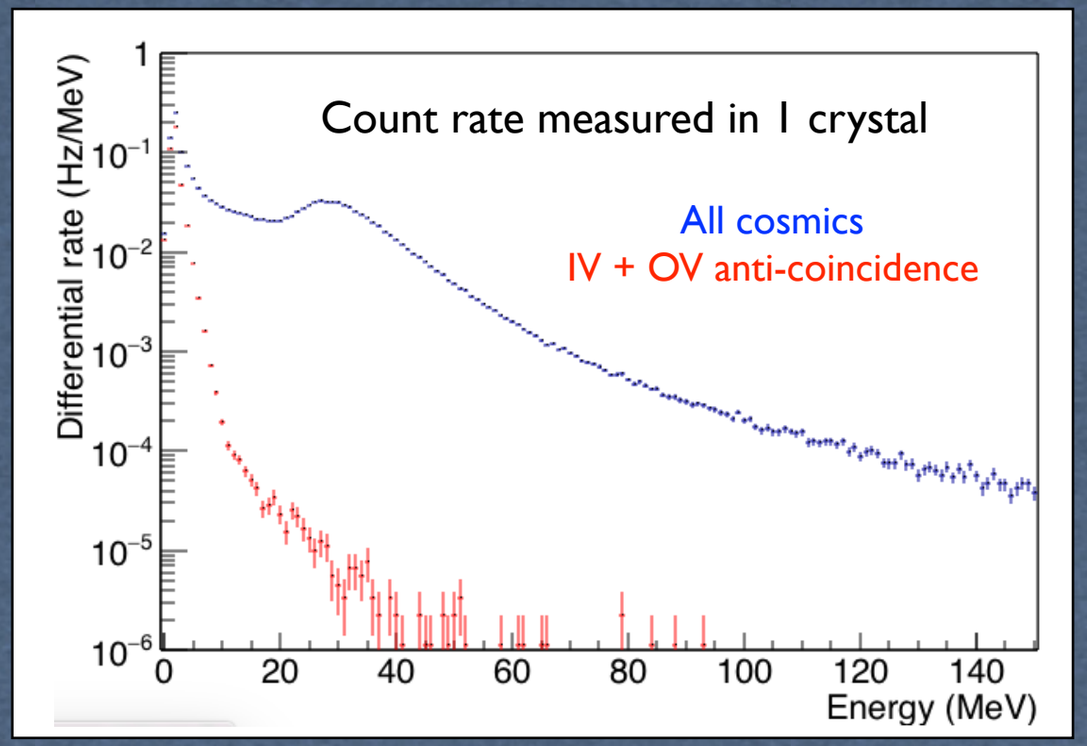
- Size: (6x6) mm², 25μm, 57.6k cells, trenched, pde=25%
- CsI(Tl): 40 pe/MeV
- Time resolution: ~6ns (MIPs)

Cosmic background



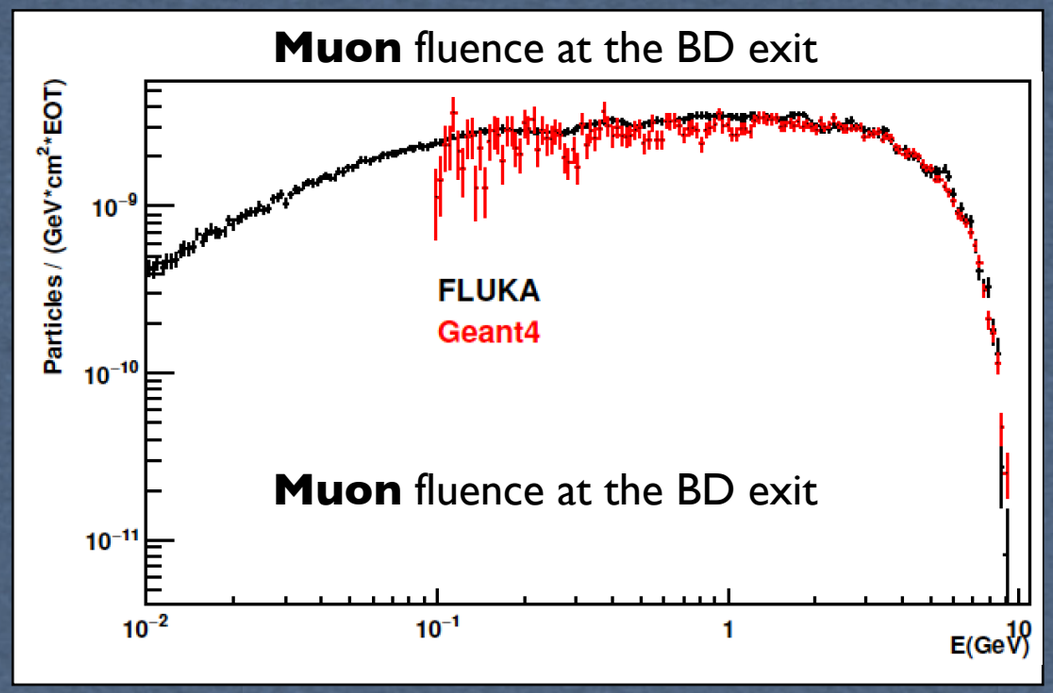
BDX prototipe measurement at LNS (CT)

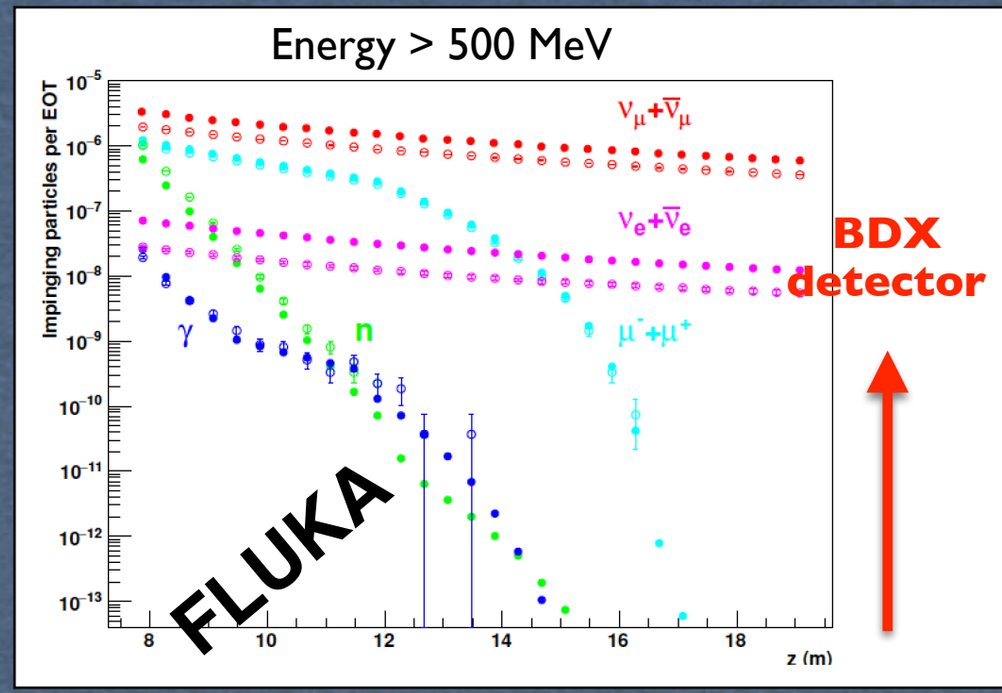




Beam-related background

★ Massive simulations using GEANT4 and FLUKA





BG assessment
High statistics simulation

Simulazioni fondo beam-related in BDX

Problema: simulare 10^{22} elettroni da 11 GeV su bersaglio spesso, con propagazione dei secondari sul detector posto a ~ 20 m di distanza, tracciando particelle fino a 100 MeV (en. Cinetica)

Soluzione: FLUKA, con uso intenso delle funzionalita' di biasing

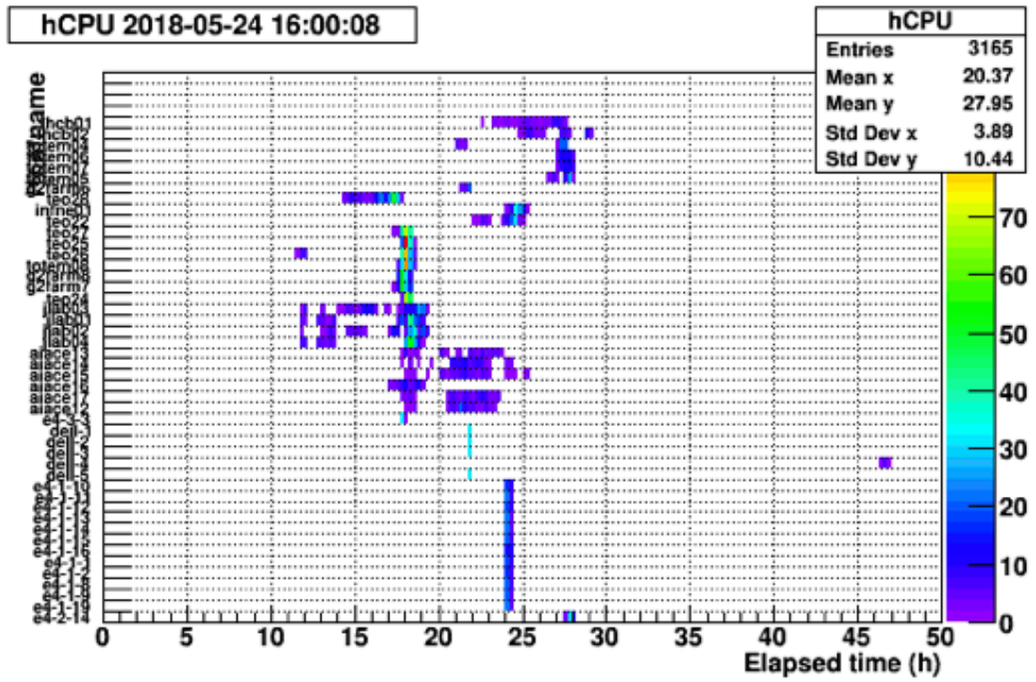
- Leading-particle biasing per sciame EM
- Importance sampling
- Soglia di tracciamento: 99 MeV (cinetici)
- Cross-section biasing: 100x reazioni foto-nucleari, 10^5x γ ->$\mu^+\mu^-$

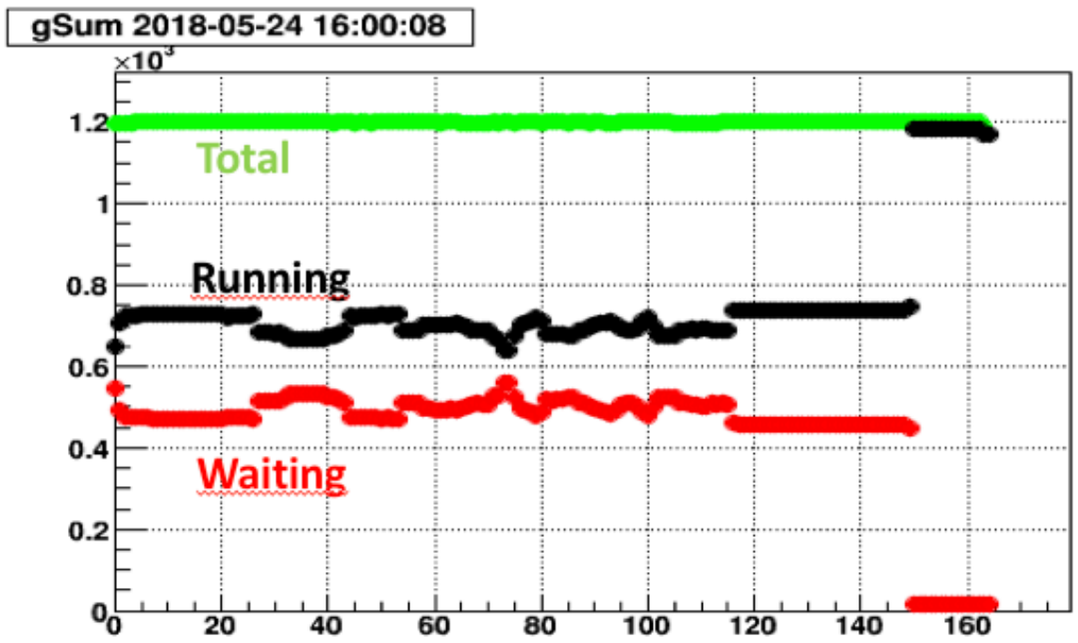
Questo ha permesso di simulare, nella configurazione finale di shielding, ~ 10^{17} EOT.

Tutte le simulazioni sono state eseguite sulla farm locale della Sezione.
Per il run finale:

- 400k run
- 300 cores impiegati per 3 mesi

Piu' una statistica equivalente per run preliminari di ottimizzazione



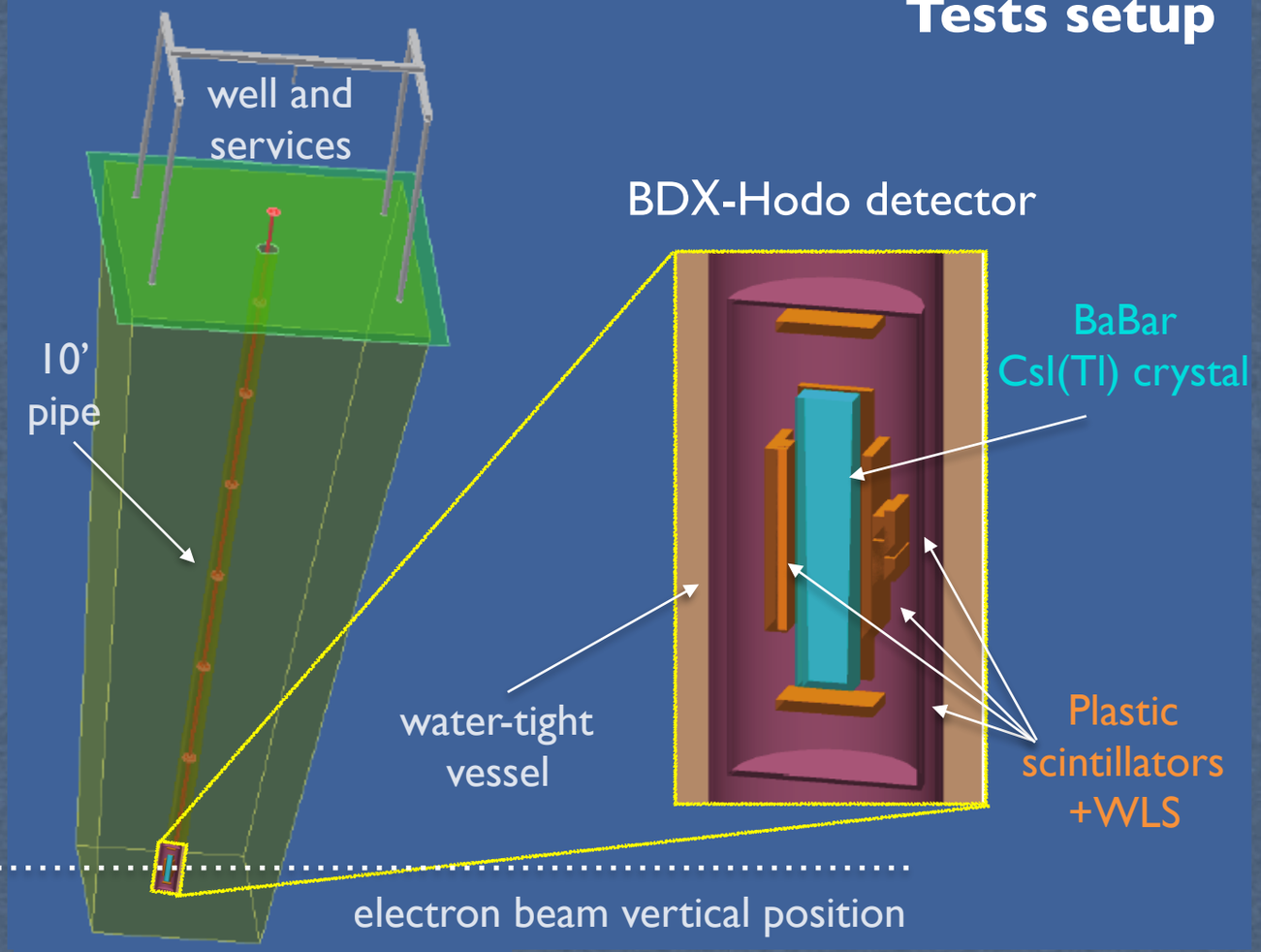


Credit:A.Celentano

Proposed test to measure the beam-on background

- ✳ Measure the muon flux in the proposed BDX location
- ✳ Compare results with simulations
- ✳ Check effects of other beam-related bg not accounted for in the simulations (neutrons, …)

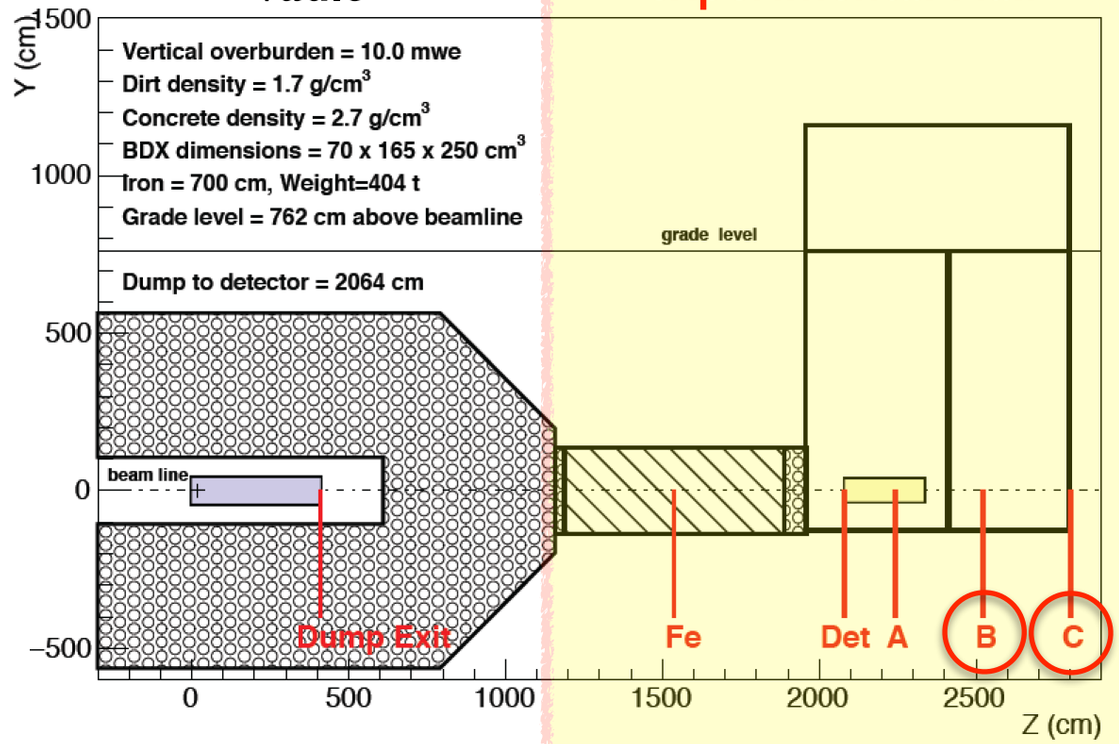
Tests setup



Downstream of the Hall-A beam dump

Hall-A beam-dump vault

Proposed BDX new experimental Hall



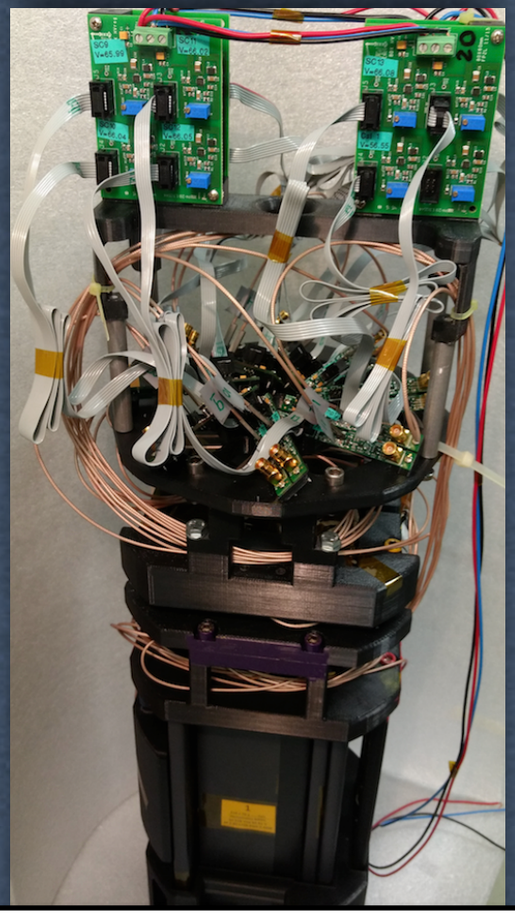
The BDX-Hodo detector

Scintillator paddles

CsI(Tl)

BDX-Hodo in the TEDF

Credit: F.Parodi



The BDX-Hodo fully assembled

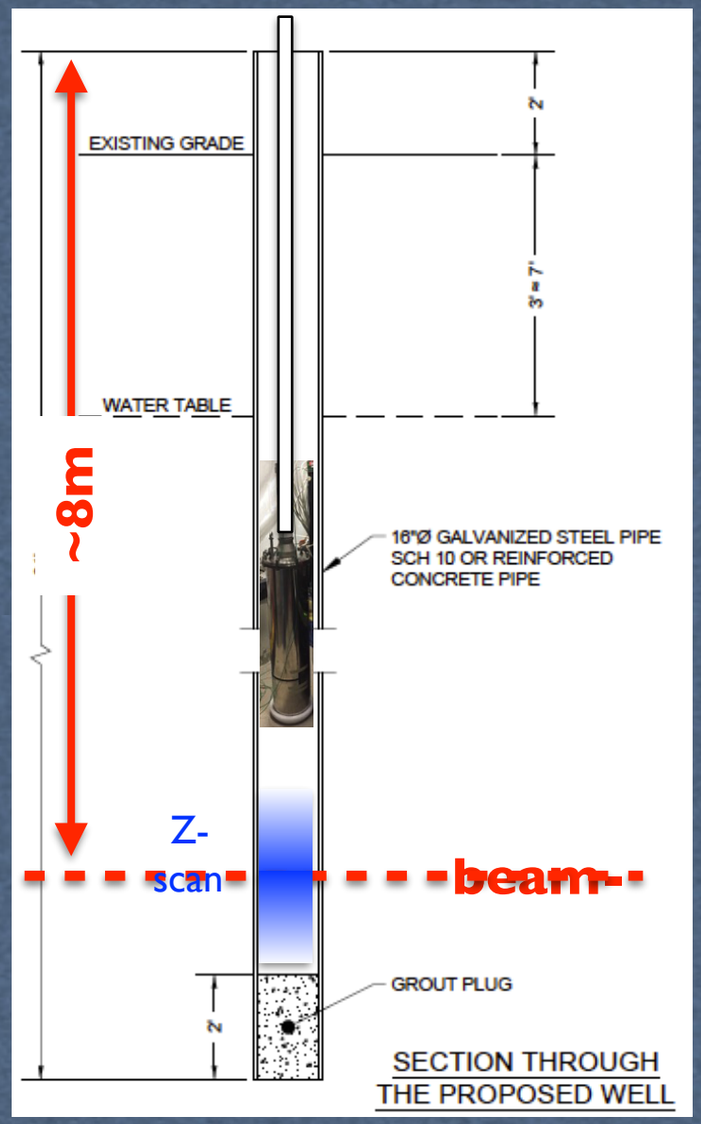
The vessel

Wells digging and pipe installing

The tent

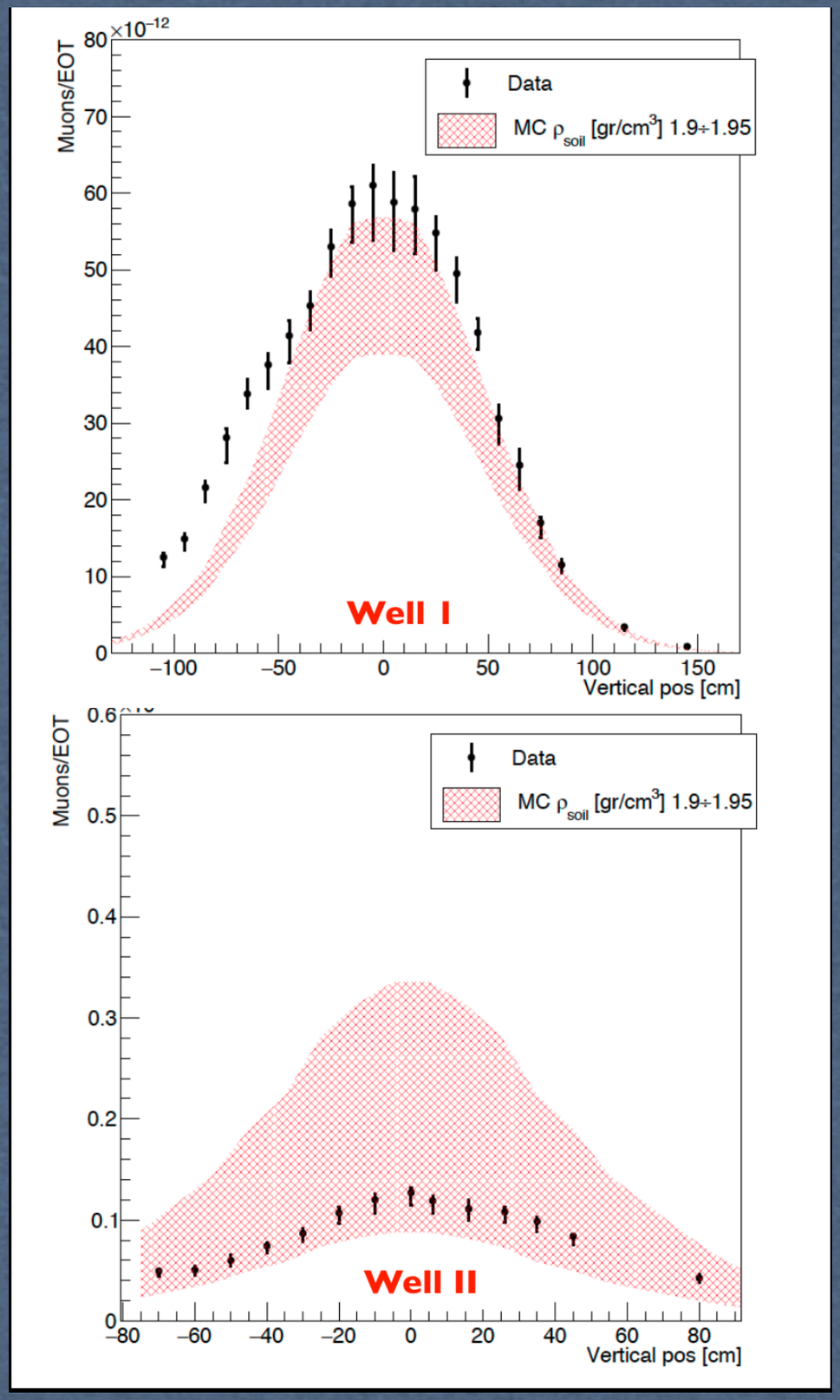
The BDX-Hodo lowered in well 1

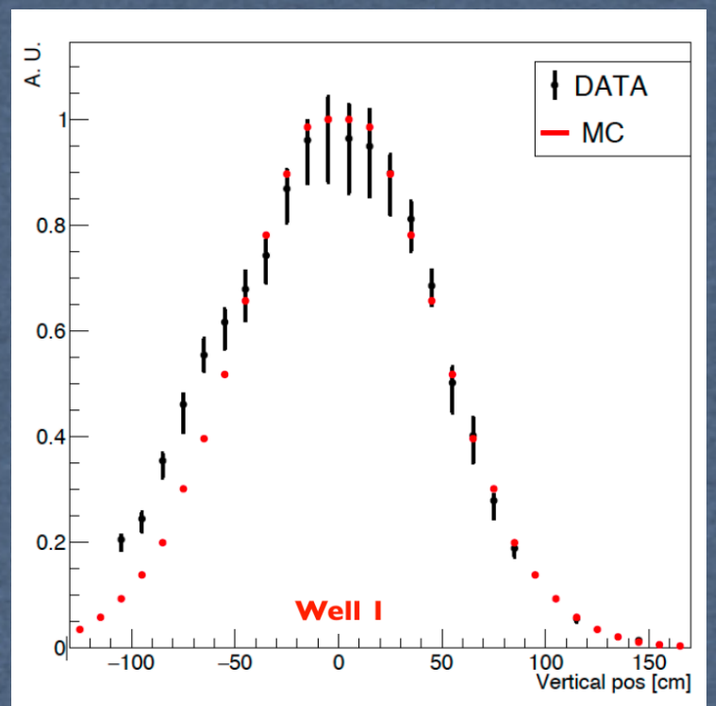
Results



★ Absoluta rates and shape (rate as a function of height) measured/ simulated match pretty well

★ Good control of background and validation of simulation framework (FLUKA/GEANT4)

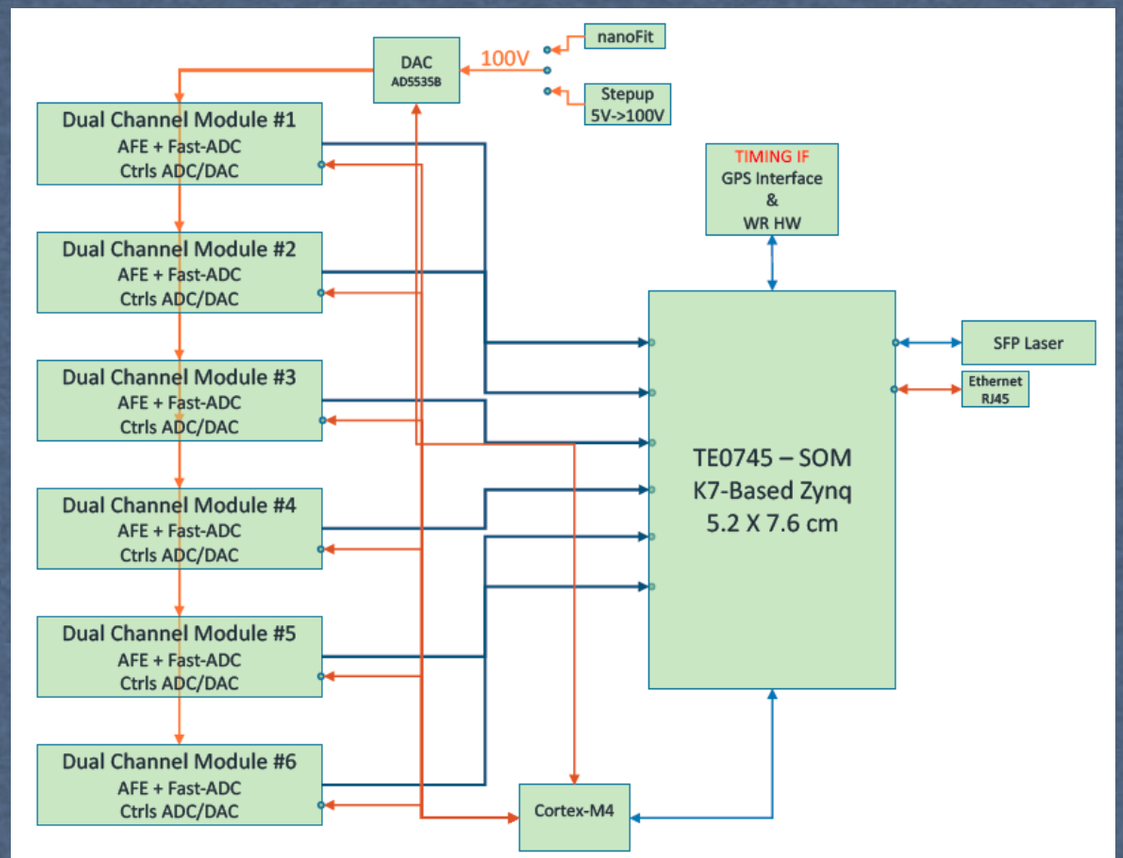


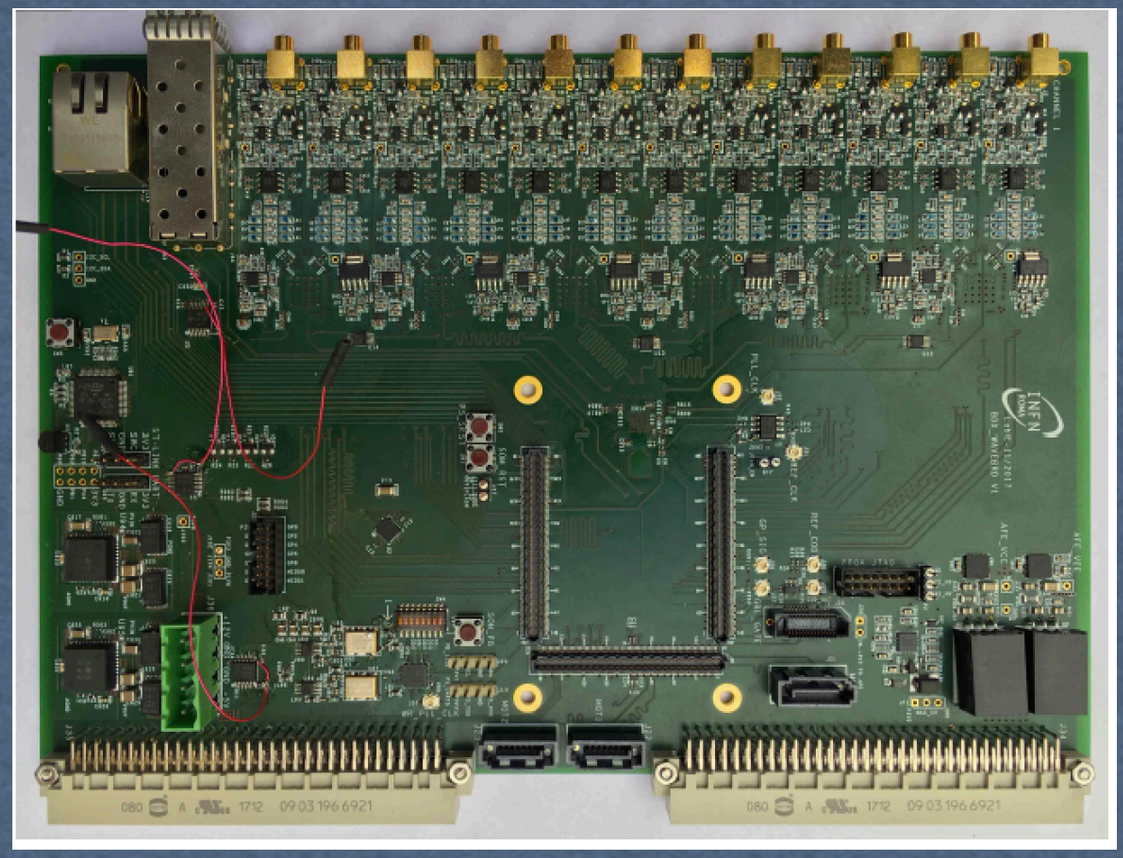


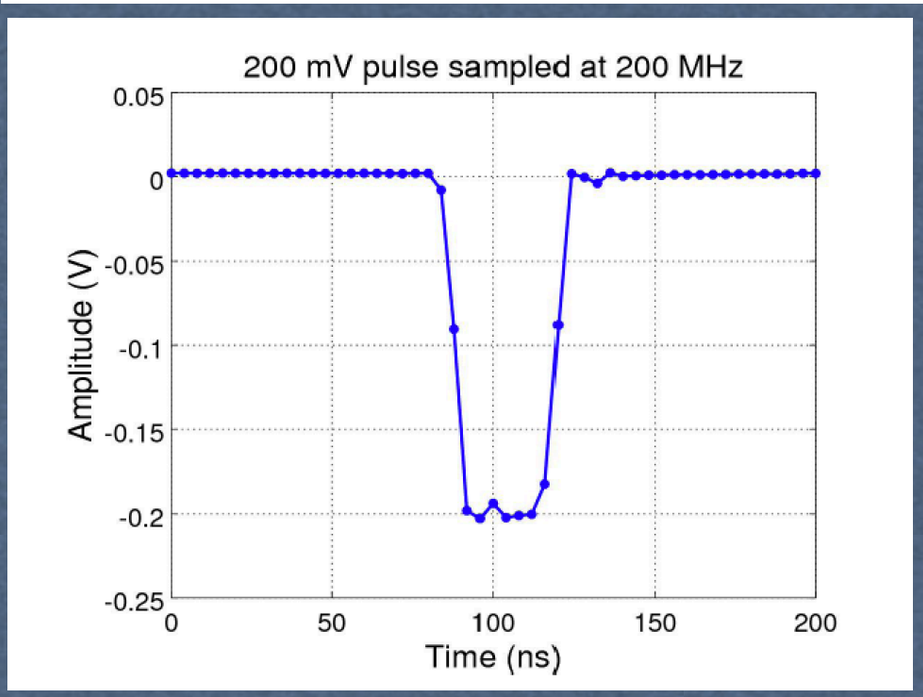
PLANS

- Obtain full approval for BDX proposal (July 2018)
- Move BDX-Prototype from CT to JLAB and continue cosmogenic background studies
- Reconfigure BDX-Hodo detector for (BDX-Pipe) for an exploratory DM measurement
- Start detector/infrastructure design
- Test and validate the new fADC board optimised for SiPM readout (INFN-GE&INFN-RM)

Streaming readout DAQ







- Development of a new triggers fADC board optimised for SiPM readout (INFN-GE&INFN-RM)
- Cost-effective (1/3-1/4 of equivalent CAEN board)
- Multipurpose, versatile, full control of firmware
- First prototype board under test
- Firmware development under progress
- Good results, ready for a II generation by the end of the year
- Synergy between JLAB12 and EIC_NET experiments

SBS, RICH, HPS

- SBS/RICH: contribution to readout electronics
- HPS: ECal maintenance and run shifts
- HPS: new run at 4.55 GeV planned in summer 2019 (4 weeks)

Search for a Dark Photon in Electro-Produced e^+e^- Pairs with the Heavy Photon Search Experiment at JLab

P. Hansson Adrian,[1] N.A. Baltzell,[2] M. Battaglieri,[3] M. Bondi,[3] S. Boyarinov,[2] S. Bueltmann,[4] V.D. Burkert,[2] D. Calvo,[5] M. Carpinelli,[6] A. Celentano,[3] G. Charles,[4] L. Colaneri,[7] W. Cooper,[8] C. Cuevas,[2] A. D'Angelo,[7] N. Dashyan,[9] M. De Napoli,[10] R. De Vita,[3] A. Deur,[2] R. Dupre,[11] H. Egiyan,[2] L. Elouadrhiri,[2] R. Essig,[12] V. Fadeyev,[13] C. Field,[1] A. Filippi,[5] A Freyberger,[2] M. Garçon,[14] N. Gevorgyan,[9] F.X. Girod,[2] N. Graf,[1] M. Graham,[1] K.A. Griffioen,[15] A. Grillo,[13] M. Guidal,[11] R. Herbert,[14] M. Holtrop,[16] J. Jaros,[1] G. Kalicy,[4] M Kahndaker,[17] V. Kubarovsky,[2] E. Leonora,[10] K. Livingston,[18] I. Nakagawa,[1] K. McCarty,[16] J. McCormick,[1] B. McKinnon,[18] K. Moffeit,[18] O. Moreno,[1,13] C. Munoz Camacho,[11] T. Nelson,[1] S. Niccolai,[11] A. Odian,[1] M. Oriunno,[1] M. Osipenko,[3] R. Paremuzyan,[16] S. Pereira,[5] E. Pasyuk,[2] I. Pegg,[15] S. Pisano,[10] E. Preedom,[2] B. Reese,[1] A. Rizzo,[7] P. Schuster,[1,19] Y.G. Sharabian,[2] G. Simi,[20] A. Simonyan,[1] V. Sipala,[6] D. Sokhan,[18] S. Stepanyan,[2] N. Toro,[1,19] S. Uemura,[1] M. Ungaro,[2] H. Vance,[4] H. Voskanyan,[9] L.B. Weinstein,[4] B. Wojtsekhowski,[2] and B. Yale[16]

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[5]*INFN, Sezione di Torino, 10125 Torino, Italy*
[6]*Universit'a di Sassari, 07100 Sassari, Italy*
[7]*Universit'a di Roma Tor Vergata, 00133 Rome Italy*
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[9]*Yerevan Physics Institute, 375036 Yerevan, Armenia*
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[17]*Norfolk State University, Norfolk, Virginia 23504*
[18]*University of Glasgow, Glasgow G12 8QQ, United Kingdom*
[19]*Perimeter Institute, Ontario, Canada N2L 2Y5*
[20]*Universit'a degli di Padova, 35122 Padova, Italy*

(Dated: May 9, 2018)

The Heavy Photon Search experiment took its first data in a 2015 engineering run at the Thomas Jefferson National Accelerator Facility, searching for a prompt, electro-produced dark photon with a mass between 19 and 85 MeV/c^2. A search for a resonance in the e^+e^- invariant mass distribution, using 1.7 days (1170 nb^{-1}) of data, showed no evidence of dark photon decays above the large QED background, confirming earlier searches and demonstrating the full functionality of the experiment. Upper limits on the square of the coupling of the dark photon to the Standard Model photon are set at the level of few x 10^{-6}. Future runs with higher luminosity will explore new territory.

PACS numbers:

First HPS physics results ready for submission

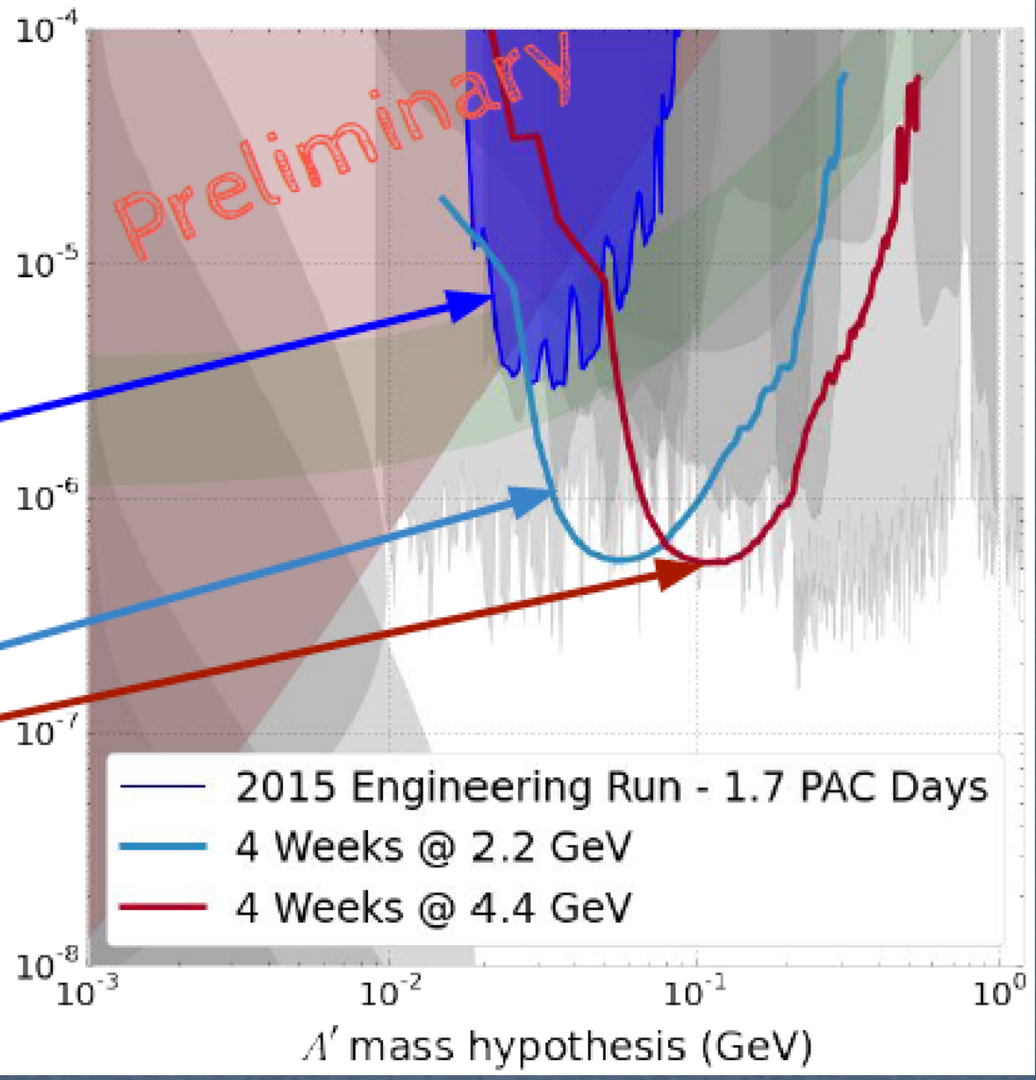
...mp Hunt Experimental Reach

...ll time of running (180
...!

...place in 2018

...Run
...5 GeV

2018-2020 Physics Run
4 Weeks @ 2.2 GeV
4 Weeks @ 4.4 GeV



Publications

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

Volume 8[illegible], 11 May 2017, Pages 89-99

The HPS electromagnetic calorimeter

I. Balossino [a], N. Baltzell [a], M. Battaglieri [c], M. Bondì [d], E. Buchanan [e], D. Calvo [a], A. Celentano [c], G. Charles [f], L. Colaneri [g], A. D'Angelo [g], M. De Napoli [d], R. De Vita [c], R. Dupré [f], H. Egiyan [b], M. Ehrhart [h], A. Filippi [a], M. Garçon [b, i], N. Gevorgyan [j] ... L.B. Weinstein [h]

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Dark photon production through positron annihilation in beam-dump experiments

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(Dated: June 30, 2018)

High energy positron annihilation is a viable mechanism to produce dark photons (A'). This reaction plays a significant role in beam-dump experiments using experiments using multi-GeV electron-beams on thick targets by enhancing the sensitivity to A' production. The positrons produced by the electromagnetic shower can produce an A' via non-resonant ($e^+ + e^- \to \gamma + A'$) and resonant ($e^+$ resonant ann used A'-strah dump experi of two in the

Accepted by PRD

Photoproduction of K^+K^- meson pairs on the proton

S. Lombardo,[1,2] M. Battaglieri,[3] A. Celentano,[3] A. D'Angelo,[4] R. De Vita,[3] A. Filippi,[5] D.I. Glazier,[6] S. M. Hughes,[7] V. Mathieu,[1,8] A. Rizzo,[4] E. Santopinto,[3] I. Stankovic,[7] A. P. Szczepaniak,[1,8,9] D. Watts,[7] L. Zana,[7] and + CLAS members

(The CLAS Collaboration)

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Submitted to PRL

A novel way to search for light dark matter in lepton beam-dump experiments

L. Marsicano,[1,2] M. Battaglieri,[1] M. Bondí,[3] C. D. R. Carvajal,[4] A. Celentano,[1] M. De Napoli,[3] R. De Vita,[1] E. Nardi,[5] M. Raggi,[6] and P. Valente[7]

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(Dated: June 30, 2018)

A novel mechanism to produce and detect Light Dark Matter in experiments making use of GeV electrons (and positrons) impinging on a thick target (beam-dump) is proposed. The positron-rich environment produced by the electromagnetic shower allows to produce an A' via non-resonant ($e^+ + e^- \to \gamma + A'$) and resonant ($e^+ + e^- \to A'$) annihilation on atomic electrons. The latter mechanism, for some selected kinematics, results in a larger sensitivity with respect to limits derived by the commonly used $A' - strahlung$. This idea, applied to Beam Dump Experiments and *active* Beam Dump Experiments pushes down the current limits by an order of magnitude.

PACS numbers: 12.60.-i,13.60.-r,95.35.+d

Accepted by PRL

A multi-channel digitizer board for the BDX experiment

F. Ameli, M. Battaglieri, A. Celentano, M. Capodiferro, M. Chiarusi, G. Chiodi, L. Marsicano, P. Musico, C. A. Nicolau, C. Pellegrino, R. Recchia, D. Ruggieri, L. Stellato

***Abstract*—Due to the lack of results by 'traditional' Dark Matter (DM) searches, the experimental activity extended to search for DM hints at different mass scales, through new experiments performed at accelerators. The Beam Dump eXperiment at Jefferson Laboratory aims to reveal dark matter particles produced in the interaction of an intense electron beam with the beam dump. The electronic board presented in this work is a 12-channel digitizer oriented to High Energy Physics experiments.**

boson called A′ or 'heavy photon'. Depending on the relative masses of the A′ and the DM particles, the A′ can decay to SM particles ('visible' decay) and/or to light DM states ('invisible' decay).

Technological advances allow nowadays running high intensity electron beams of moderate energy well suited for these studies. In this context, the Beam Dump eXperiment (BDX)

Submitted to IEEE

+ ~25 pubblications (Nature, PRL, PRD, PRC, PL, …) by CLAS Collaboration

Consistenza del Gruppo JLAB12

✳Personale Ricercatore e Tecnologo

M. Battaglieri	75%
G. Bracco	50%
A. Celentano	80%
R. De Vita	90%
L. Marsicano	100%
P. Musico	30%
M. Osipenko	30%
M. Ripani	40%
A.Brunengo	30%
S.Grazzi	100%

6.3 FTE

✳Collaboratori Locali

Progettazione Meccanica:
R.Cereseto, R.Puppo, C. Rossi

- *Progettazione Elettronica*
  F. Pratolongo

Officina Meccanica:
A. Trovato

Servizio Calcolo:
A.Brunengo
M.Corosu
E.Salvo

✳Personale Tecnico

G. Ottonello
F. Parodi

✳ Responsibility roles:

- ★ R.De Vita: Chair della CLAS12 Colaboration (2017-19), CLAS12 Software coordinator
- ★ M. Battaglieri: JLab- Travel Fund Committee Chair, CLAS Hadron Spectroscopy Working Group Chair and member of the CLAS Coordinating committee
- ★ A. Celentano: chairman of the HPS PPC
- ★ M. Ripani: Program Advisory Committee, Bonn Electro-syncrotron

✳ Workshop and Conference Organization:

- ★ M. Battaglieri, R. De Vita: Organizing Committee of EUNPC 2018
- ★ M.Battaglieri: IAC ATHOS 2018 (Beijing July 2018)
- ★ M. Battaglieri: ECT* Spectroscopy WS Dec 2018 (Trento)
- ★ M. Battaglieri: HASPECT Week (Krakow, June 2018)

Richieste finanziarie 2018

- Missioni: 69 kEuro (34.5 kEuro CLAS, 20 kEuro HPS, 14.5 kEuro BDX)
  - *Meeting di Collaborazione (HPS+CLAS): 3 x 6 gg x 2persone= 10 kEuro*
  - *Meeting Jlab12 (Italia)2 x 2gg x 3 persone = 2.5 kEuro*
  - *Presa dati CLAS12 (Run Coordinator + FT expert + shifts) = 24.5 kEuro*
  - *Mobilita' spokesperson CLAS = 5k*
  - *Presa dati HPS (6 blocchi da 5 turni + 2 week ECAL expert)= 16 kEuro*
  - *Misure BDX a Jlab (1 x 7 gg x 3 persone) = 6 kEuro*
  - *Test elettronica Bologna e Roma (3 x 4 gg x 2 persone) = 5 kEuro*
- Trasporti: 6 kEuro
  - *Trasporto materiale a Jlab per progetto FT: 1.0 kEuro*
  - *Trasporto materiale a Jlab per progetto BDX: 5 kEuro*
- Consumo: 7.5 kEuro
  - *Forniture azoto e liquido refrigerante per funzionamento FT: 2.5 kEuro*
  - *Magazzino Jlab: 5 kEuro*
  -
- Inventariabile: 20 kEuro
  - *Storage at JLAB 100 TB: 20 kEuro*
- Apparati: 62 kEuro
  - FT: 32 kEuro
    - *Chiller: 20 kEuro*
    - *LED spare drivers: 2 kEuro*
    - *FT-Cal HV spare board: 8 kEuro*
  - BDX: 32 kEuro
    - *1 fADC CAEN per BDX-Pipe*
    - *Veto ext/int BDX-Pipe per misure al JLab : 20 kEu*

Richieste ai servizi

Calcolo e Reti	Supporto manutenzione workstations e nodi di calcolo della farm, manutenzione pagina	3
Officina Elettronica	Supporto progettazione prototipi BDX e manutenzione Forward Tagger + Supporto tecnico G. Ottonello	6 + 6
Officina Meccanica	Supporto per la realizzazione di prototipi per BDX	2
Progettazione Meccanica	Supporto per la progettazione di prototipi per BDX + supporto tecnico F. Parodi	2 + 4
Altro	Spazio in sala Grandi Montaggi per test foto sensori BDX (camera buia) condivisa con DarkSide	