Consiglio di Sezione Allargato
Preventivi 2015
6/7/15

JLAB12-GE 2015/16

M.Battaglieri
INFN-GE Italy

The JLAB12 experiment

The Italian Contribution to the Thomas Jefferson National Accelerator Facility

The JLAB12 Collaboration

e-JLab12

Italian Institutions at JLAB

INFN Bari, , Uni & INFN Cagliari Uni & INFN Catania, Uni & INFN Ferrara, Uni & INFN Genova, INFN LNF, Uni Milano-Bicocca, Uni & INFN Padova, Uni Pavia, Uni Perugia, Uni Roma La Sapienza & INFN Roma, ISS & INFN Gruppo Collegato Sanità, Uni & INFN Roma Tor Vergata, Uni Sassari, Uni & INFN Torino, Uni Trento


Jefferson Lab's accelerator site

- ✳Primary Beam: Electrons
- ✳Beam Energy: 12 GeV
  - $10 > \lambda > 0.1$ fm
  - nucleon → quark transition
  - baryon and meson excited states
- ✳100% Duty Factor (cw) Beam
  - coincidence experiments
  - four simultaneous beams independent E and I
- ✳ Polarization (beam and react.products)
  - spin degrees of freedom
  - weak neutral currents

The physics program

✳Nucleon Structure

- EM, EW, and Flavor-Separated Form Factors
- Structure functions
- Transverse Momentum Distributions (TMD)

✳The Physics of Confinement

- Baryon spectroscopy
- Meson spectroscopy

✳Nuclear Structure and the Quark Structure of Nuclei

- Hypernuclear Physics

✳Search for physics Beyond the Standard Model

- Dark Forces search
- Weak couplings measurement

✳JLAB12, 65 scientists (~45 FTE, 14 INFN Units) is supporting the JLab broad experimental program in HAll-A and Hall-B

✳INFN theoretical community, 30 scientists involved in JLAB12 physics is supporting the experimental effort

✳INFN financial contribution (2009-14): €3.0M

INFN-Genova in JLAB12 experiment

Physics

- Nucleon Structure
- Hadron Spectroscopy
- Light Dark Matter search at Accelerators

Data taking expected for Dec 15

Physics Analysis

- The HAdron SPEctroscopy CenTer (HASPECT)

Equipment

- The CLAS12-RICH FE electronics
- The CLAS12 - Forward Tagger
- The Heavy Photon Search (HPS) - ECal
- The Beam Dump eXperiment (BDX) detector

Projects

- CLASMED - Premiale 2013
- HS-HPH: Hadron Spectroscopy in HPH (WP 6)
- LiQuHaS: Italy-Polland Miur collaborative project
- Big-Dash: S.Paolo Fundation

Outreach

- HASPECT weeks
- LDMA2015
- INFN-DOE summer student program
- Mentoring

People

M. Battaglieri (Resp. Naz)
A. Brunengo (Serv. Calc.)
A. Celentano
R. De Vita (Resp. Loc.)
E. Fanchini
P. Musico (Serv. Eletr.)
M. Osipenko
V. Mathieu
M. Taiuti
M. Ripani
+
G. Ottonello
F. Parodi
R. Cereseto
R. Puppo
V. Vigo
A. Trovato
A. Manco
G. Mini
F. Pratolongo

Hadron Spectroscopy

JLab *MesonEx* program

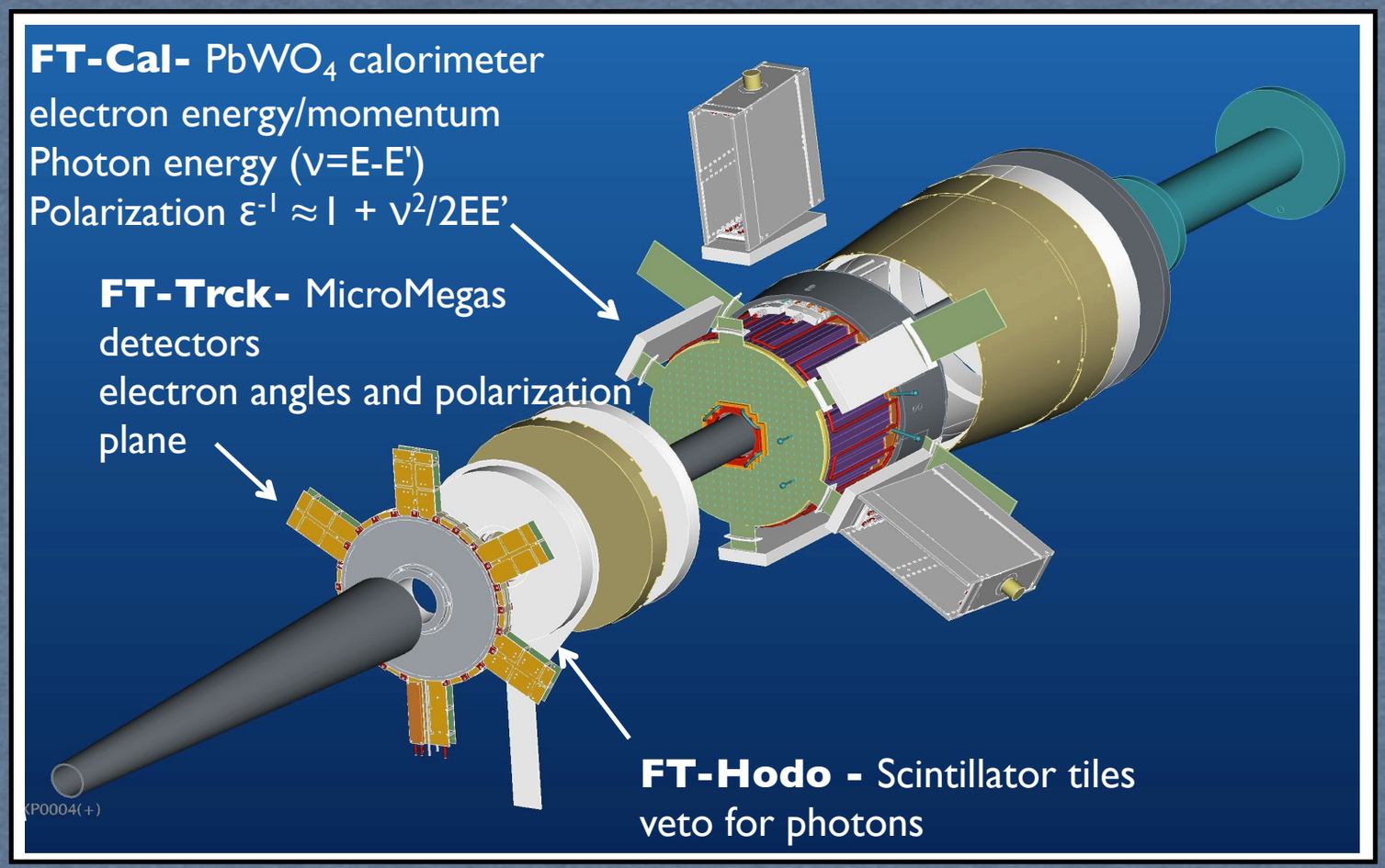
hunting for new configurations beyond qq and qqq

(M.Battaglieri and R. De Vita co-spokesperson)

- Exotic meson search
- Hadron spectroscopy
- J/ψ threshold production

- New equipment to detect e^- scattered at low angle
- Distributed data analysis center: HASPECT

The Forward Tagger for CLAS12



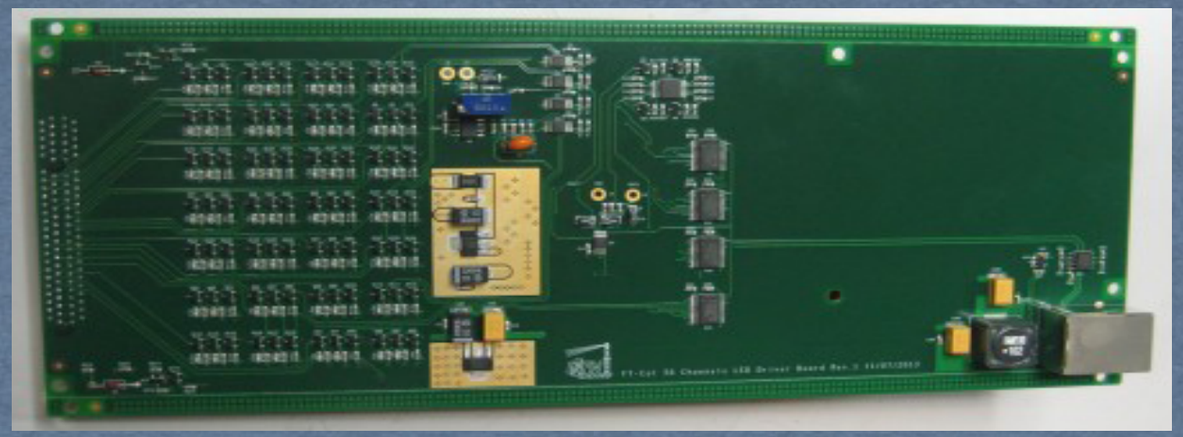
INFN-GE Responsabilities

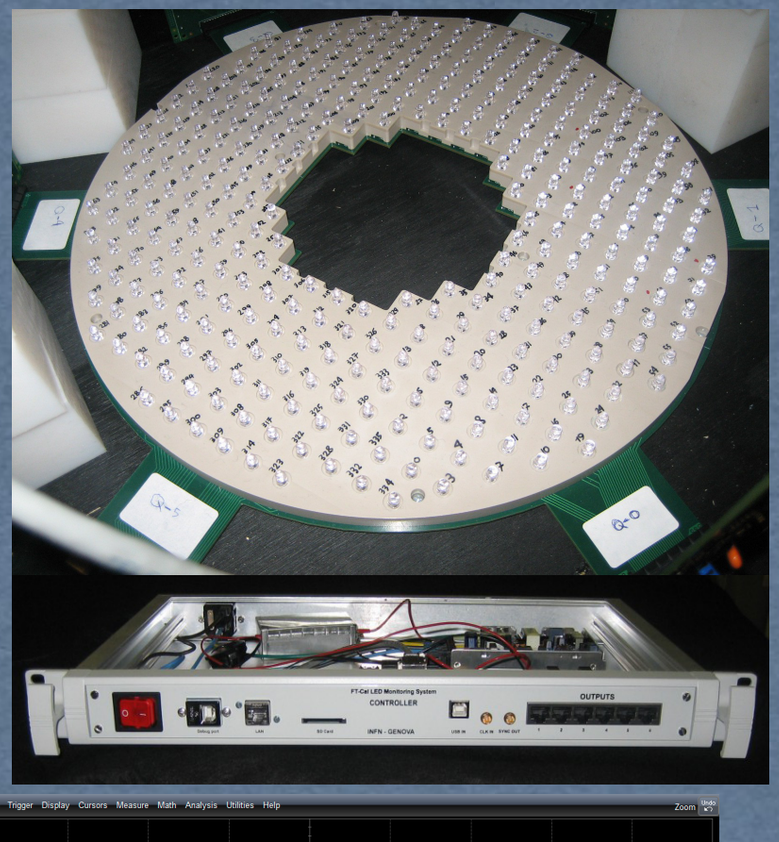
- ✳FT project coordination
- ✳FT mechanical structure
- ✳FT integration in CLAS12
- ✳FT-Cal
- ✳FT-Hodo FE electronics
- ✳CLAS12 Coordinating Committee
- ✳CLAS12 reconstruction sw
- ✳CLAS12 Calibration & Commissioning
- ✳CLAS12 Hadron Spect Working Group

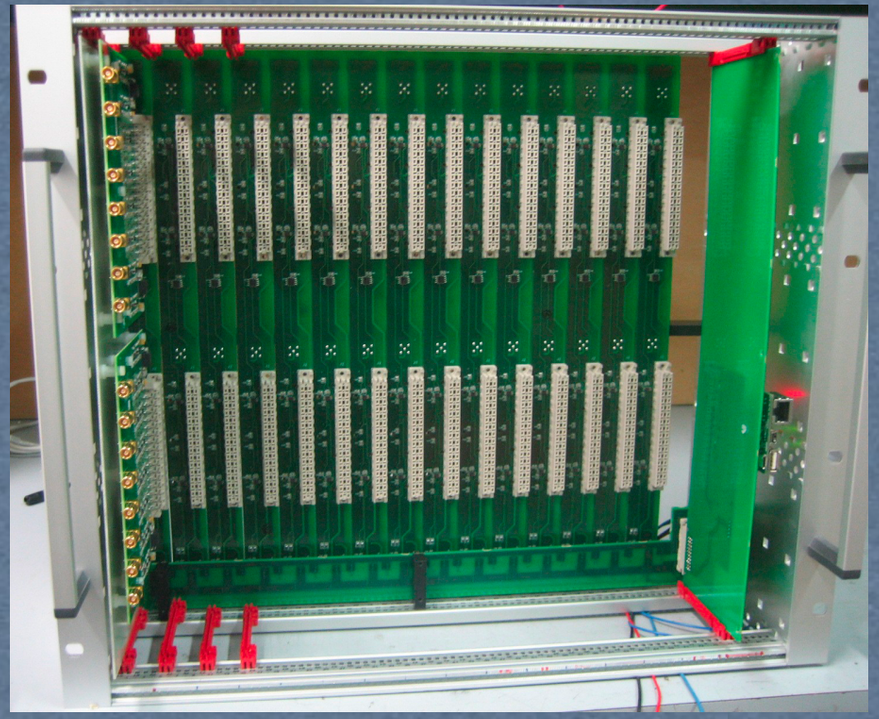
FT ancillary systems

LED Monitoring System (LMS):

- 332 independent LEDs (1 LED/crystal)
- Fully design in Genova

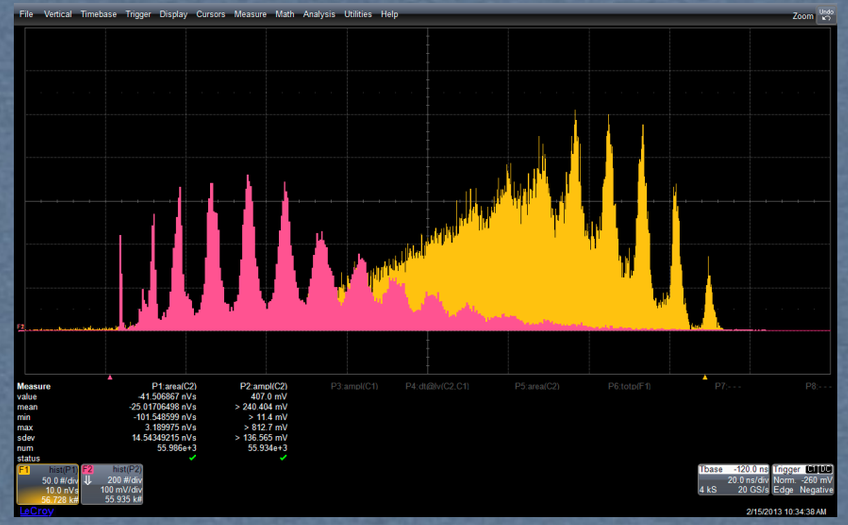


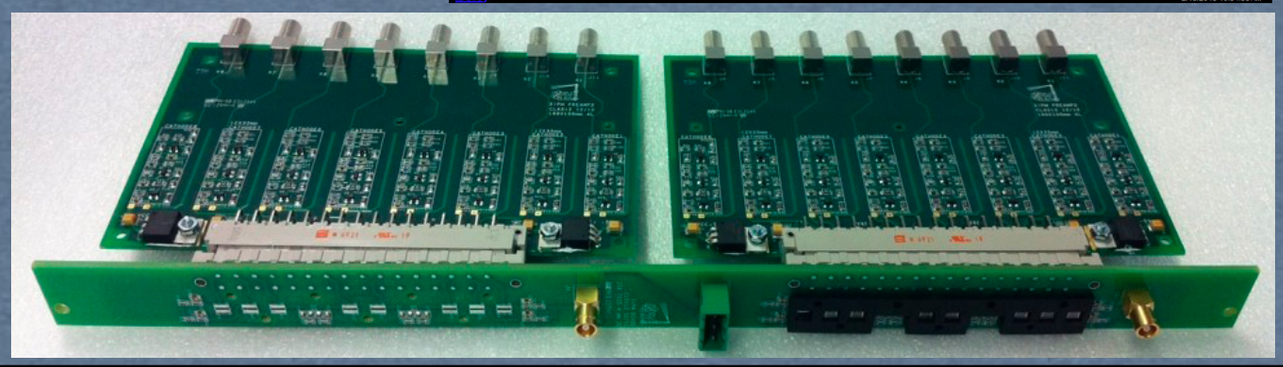




FT-Hodo FE electronics

- 232 SiPM + FE preamps
- Full FE board design in Genova
- Custom crate

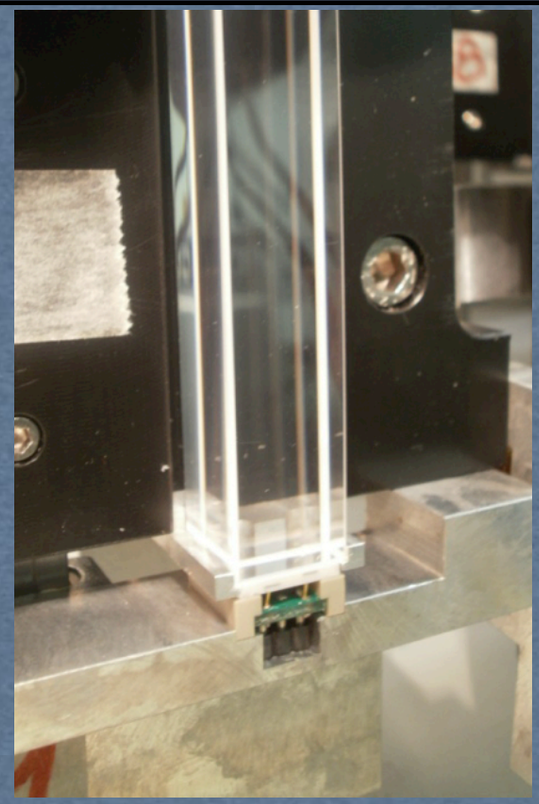


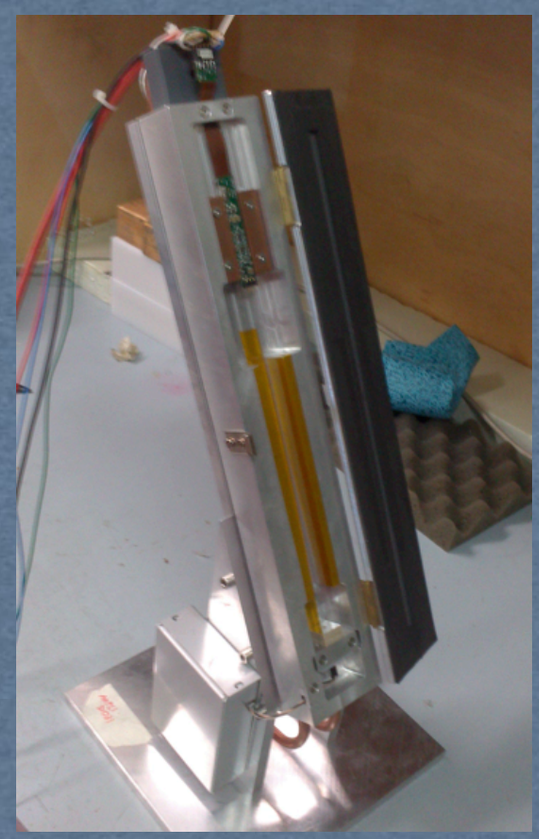


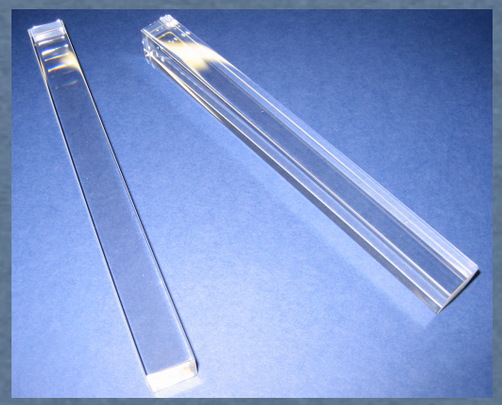
A. Celentano, G. Mini', P. Musico, F. Pratolongo, F. Parodi

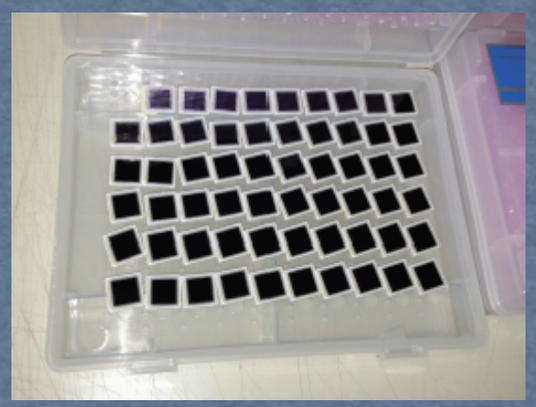
Crystal assembly

- ✳332 good crystals + 10% spares selected for FT-Cal Assembly
- ✳380 LAAPDs fully tested and characterised
- ✳ APDs are powered in groups (36): crystal position (rad hard) matched to APD HV channel
- ✳ APD and VM200 thermally shaped need to be assembled together









F.Parodi, G.Ottonello

FT Assembly

A.Trovato, A.Manco, R.Cereseto, R.Puppo, G.Ottonello
E.Fanchini, M.Campbell, A.Celentano, G.Ottonello

Procedura montaggio
ForwardTagger
Versione 003
Aggiornata il 13-05-2015

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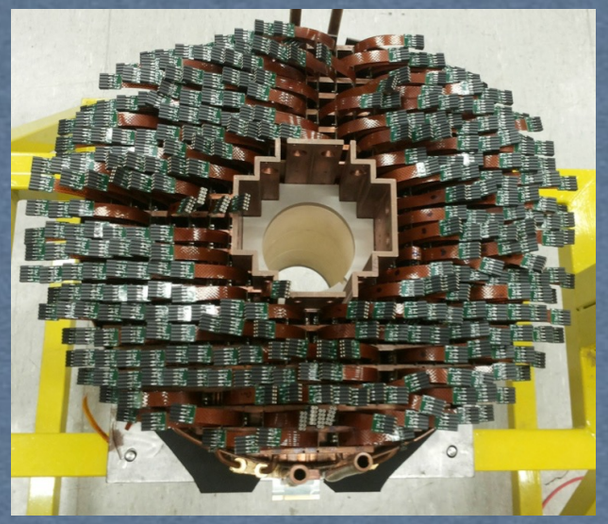
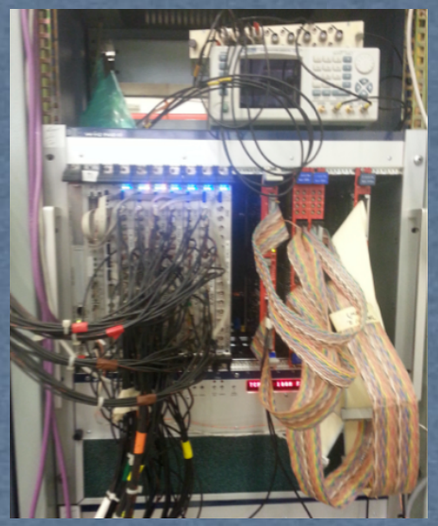
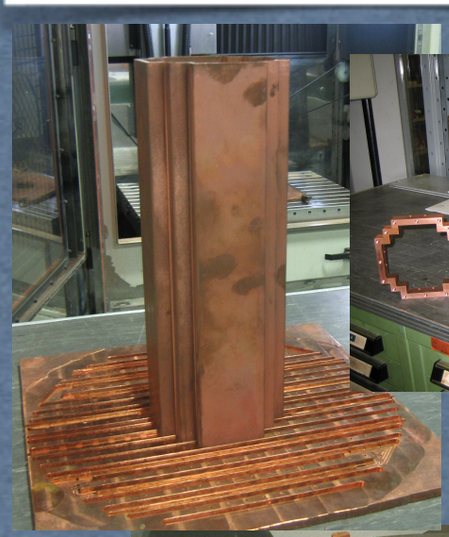
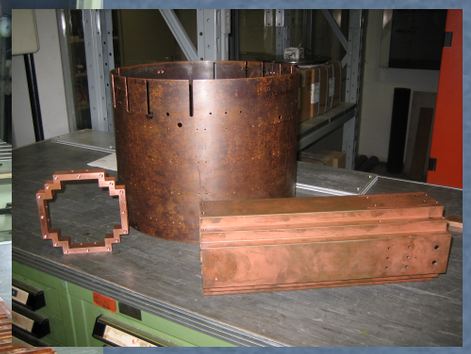
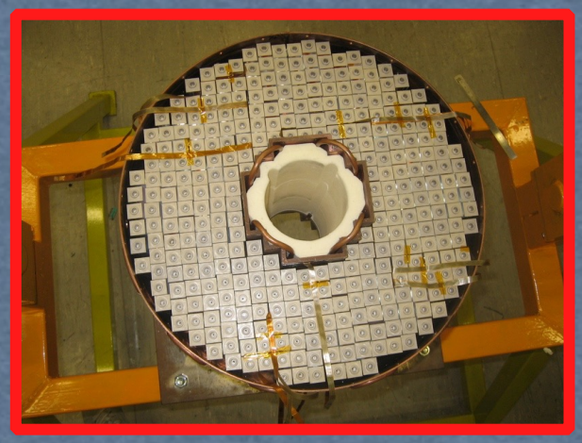
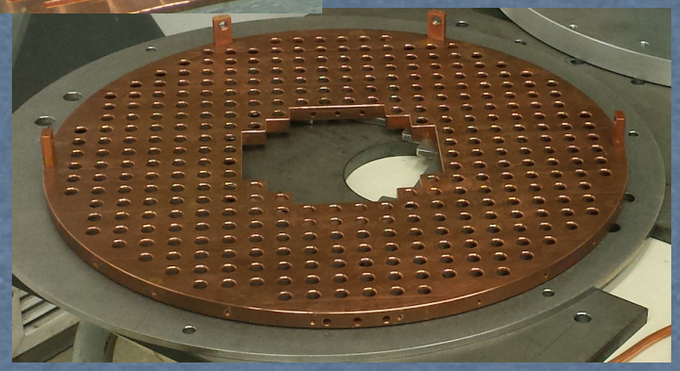


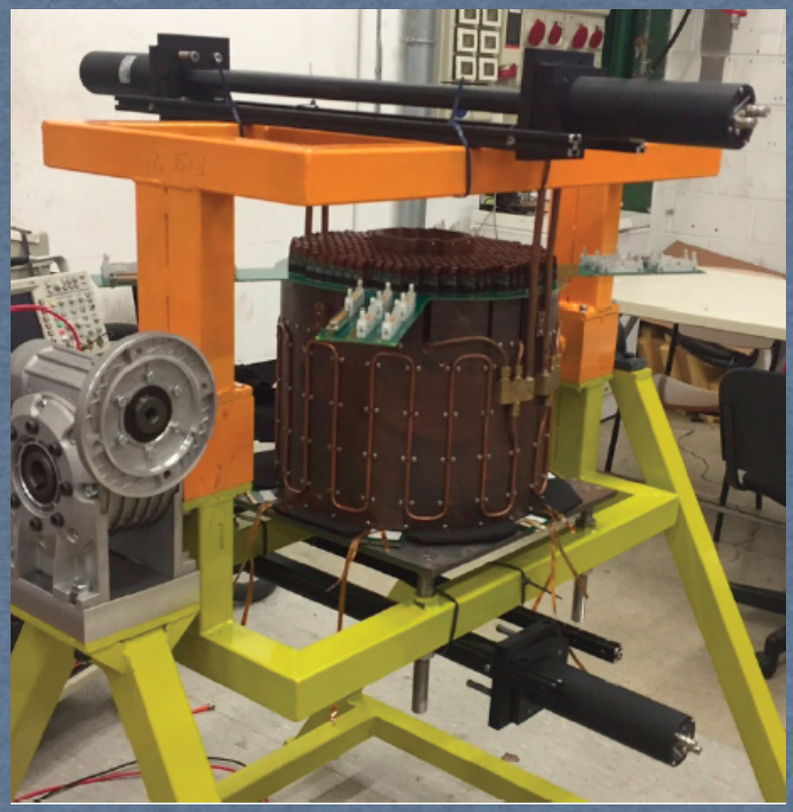










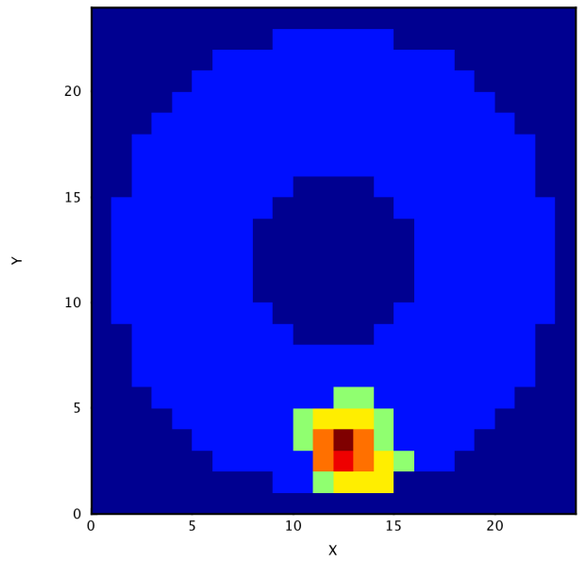


Technical support (mechanical) needed in fall 2015 and spring/fall 2016!

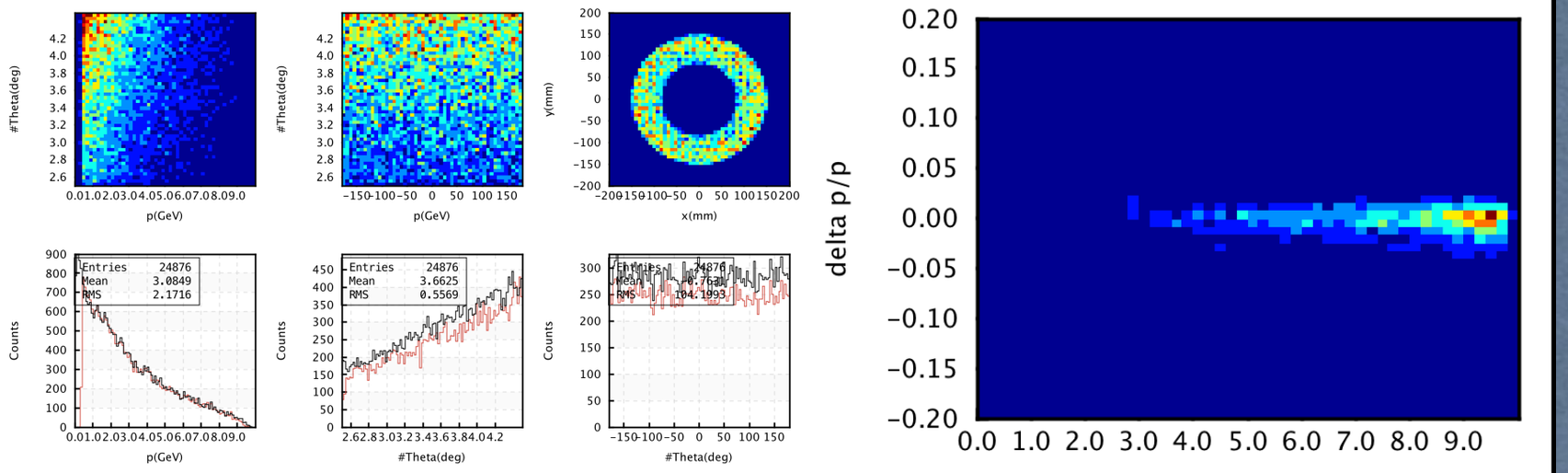
- Summer 15: commissioning with cosmic in Genova
- Fall 15: ship to JLab
- Winter 15: reassembly and commissioning at JLab
- Spring 16: installation in the hall

Data Analysis and Partial Wave Analysis (PWA)

✳ Preparing the 2016 data taking



Gamma and π^0 reconstruction within CLAS12 Rec framework



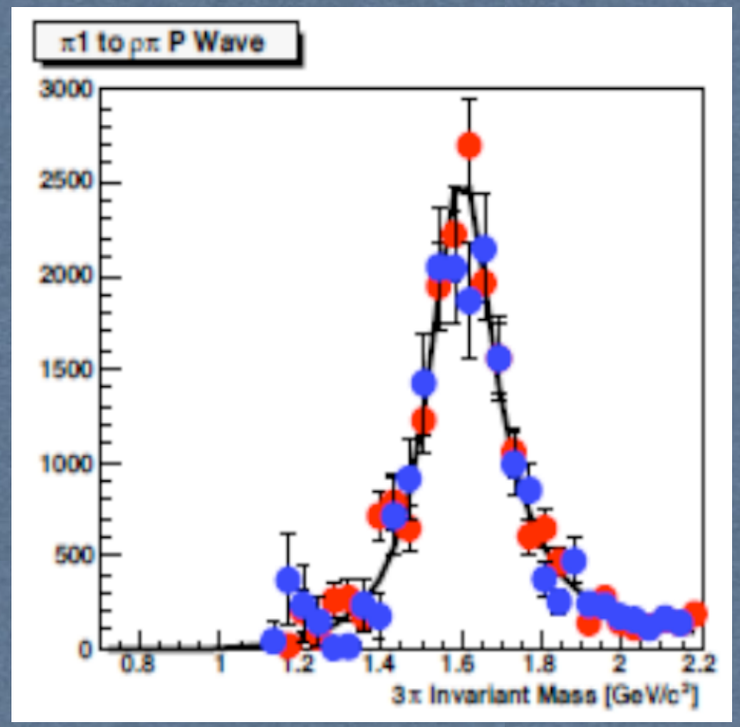
✳ High level physics analysis

HASPECT (HAdron SPEctroscopy CenTer in Genova)

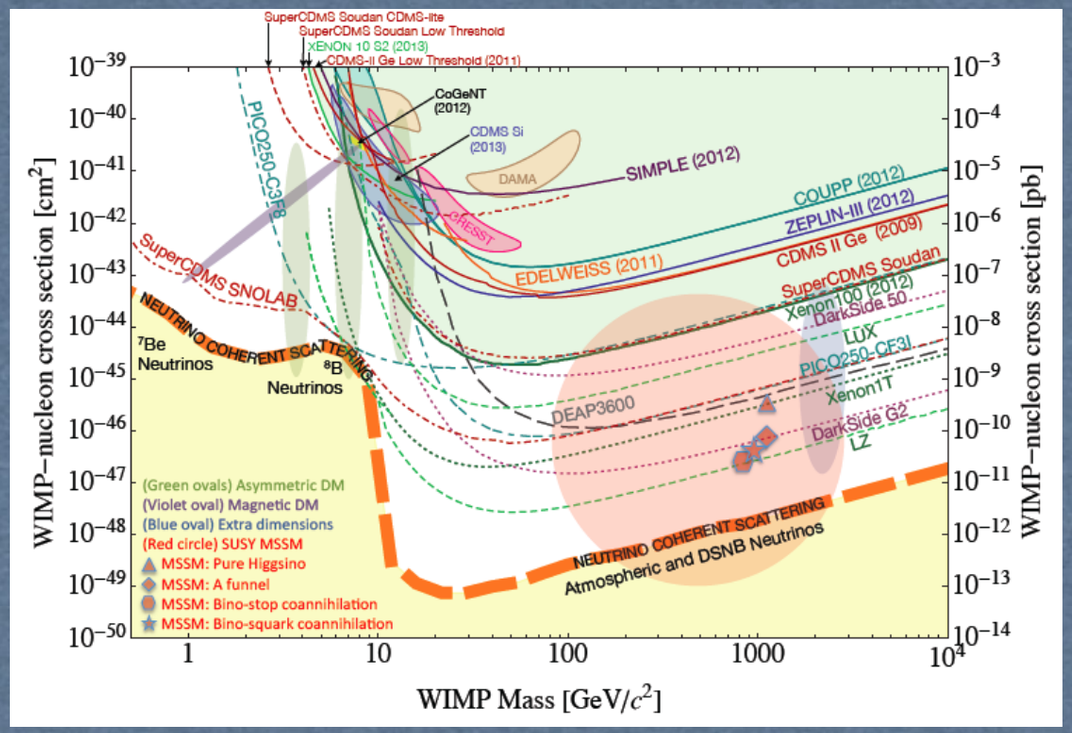
- Dedicated analysis center in Genova (HaSPeCt)
- Dedicated workshop on PWA (PWA-day, ATHOS '12, '13, '15…)
- GPU implementation done and first results available

Reference reaction
$\gamma\, p \rightarrow (n)\, \pi^+ \pi^+ \pi^-$

- Exotic wave X $\rightarrow \rho\, \pi^+ \rightarrow \pi^+ \pi^+ \pi^-$ ($J^{PC} = 1^{-+}$) 2.5 % of the total
- Events projected onto CLAS12 (GEMC) and fitted (PWA)
- Statistics correspond to few days of running
- Full reconstruction tested on pseudo-data
- New analysis framework based on JAVA



Light Dark Matter Search at Accelerators



Dark matter direct search focused in the mass region 10 GeV - 10 TeV

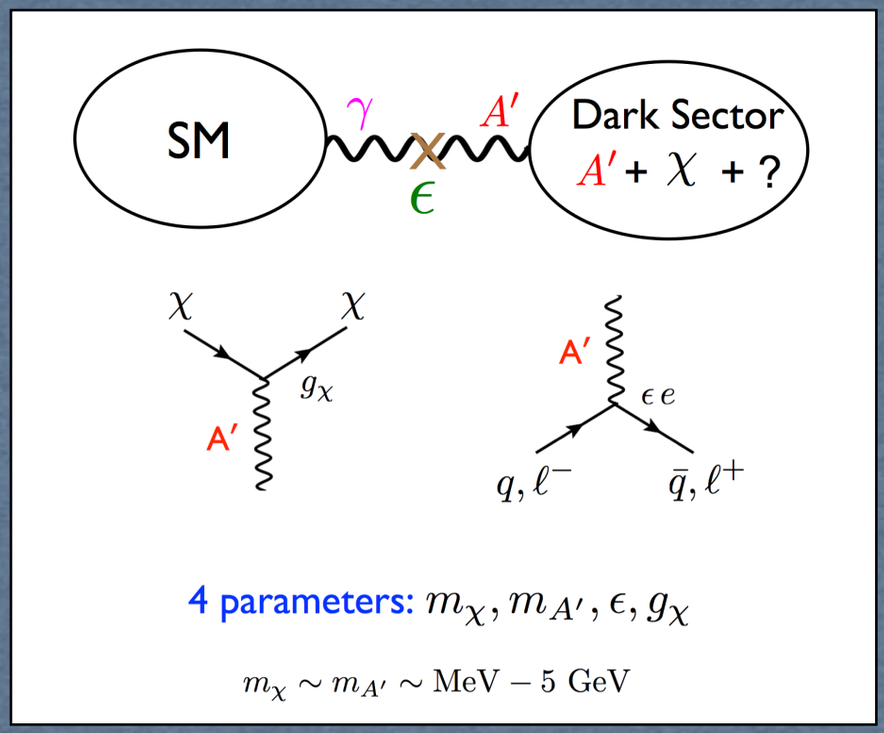
- WIMP: weakly interacting massive particles with weak scale mass provides the correct DM relic abundance
- DM detection by measuring the (heavy) nucleus recoil of slow moving cosmological DM
- No signal in direct detection → no sensitivity to light DM (<1 GeV)

Forces / Matter	EM	Weak	Strong	New force?
Electron	✓	✓	—	—
Neutrino	—	✓	—	—
Quarks	✓	✓	✓	—
Dark Matter?	—	—	—	✓

What if DM interaction is mediated by a new force?

High intensity/moderate energy (electron beam) can cover an unexplored mass range searching for:

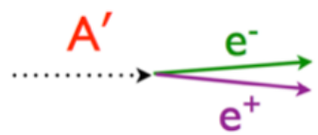
- a new boson (A') - Light DM particles



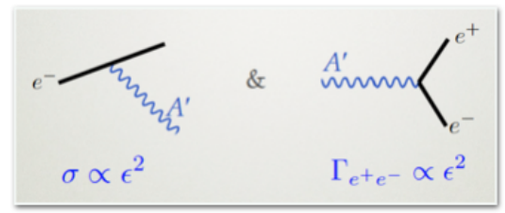
4 parameters: $m_\chi, m_{A'}, \epsilon, g_\chi$

$m_\chi \sim m_{A'} \sim \text{MeV} - 5\ \text{GeV}$

Visible

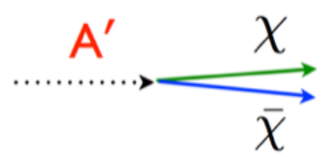


- *Minimal* decay
- Decay regulated by ε^2
- Independent on m_χ
- Requires $m_{A'} < 2m_\chi$

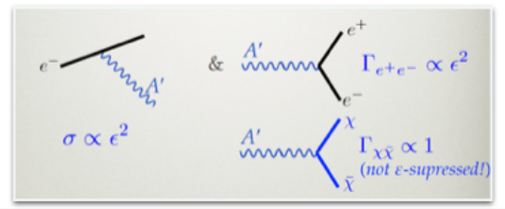


The HPS experiment at Jefferson Lab

Invisible

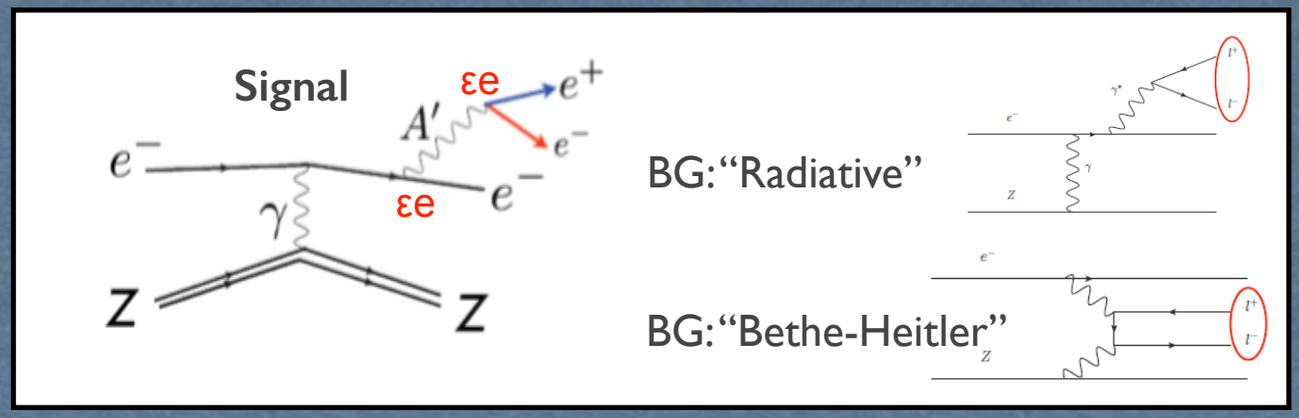


- $m_\chi < 2m_{A'}$
- i) stable and invisible
- ii) decays to SM particles
- Independent on ε



The BDX experiment at Jefferson Lab

The HPS experiment - Heavy Photon Search



Heavy photon signatures in HPS

1) Bump Hunting (BH)

Narrow e+e-resonance over a QED background

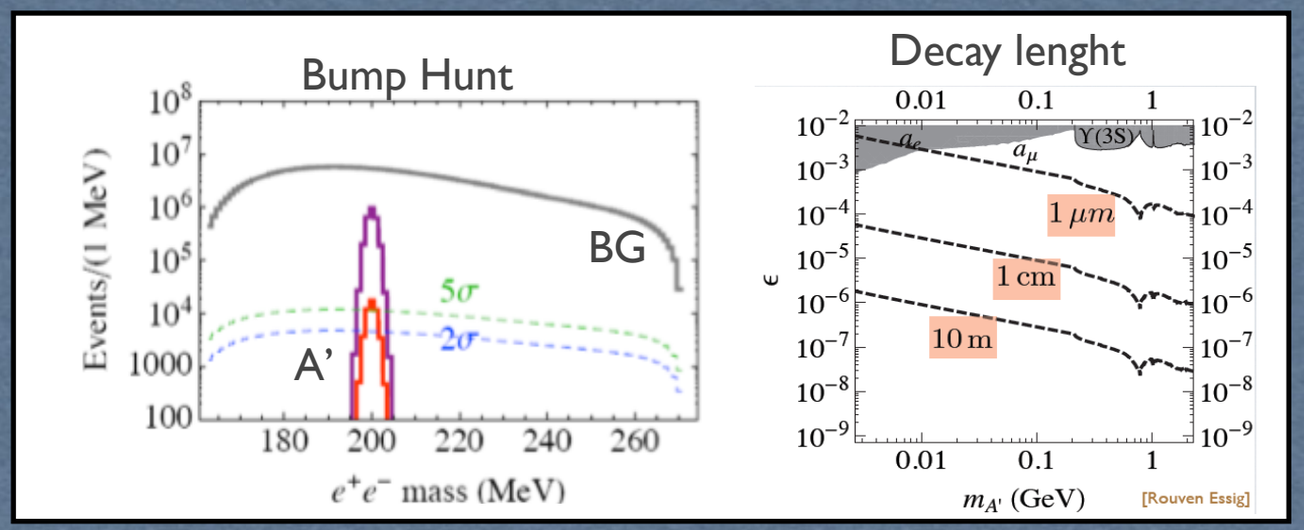
➥ good mass resolution: $\sigma_{A'mass}$~1 MeV

2) Secondary decay vertex (vertexing)

Detached vertex from few mm to tens cm

➥ good spacial resolution: σ_{vertex}~1mm

BH + Vertexing = enhanced experimental reach



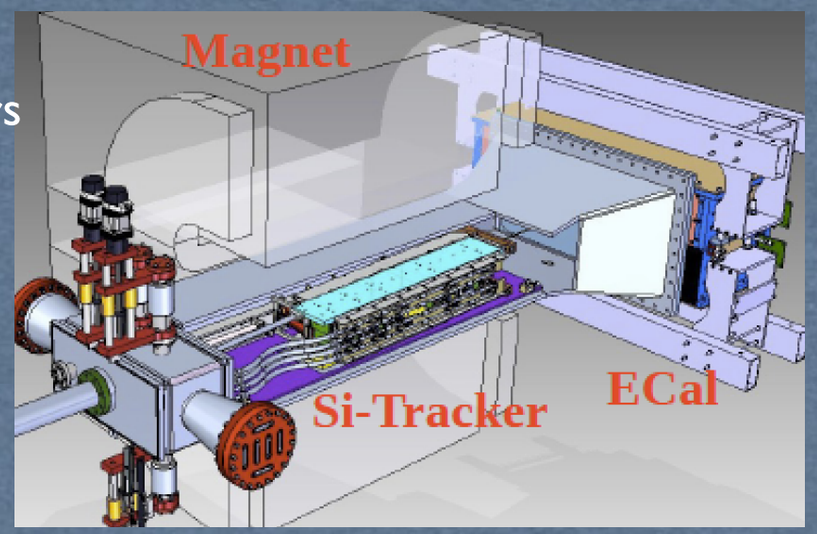
The HPS set-up

Requirements:

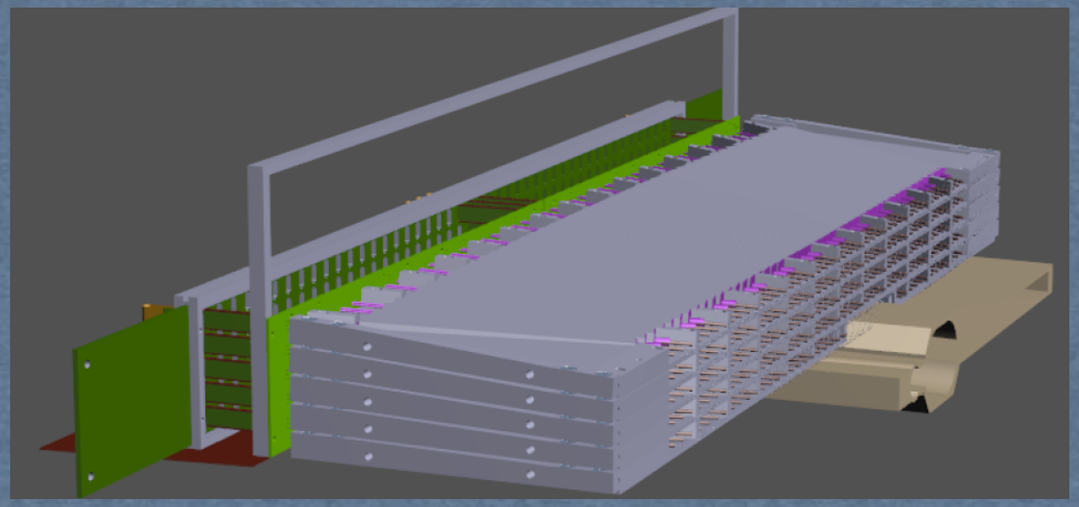
- forward angles coverage
- detector close to the target
- good spacial resolution: σ_{vertex}~1mm (vertexing)
- good mass resolution: $\sigma_{A'mass}$~1 MeV (bump hunting)

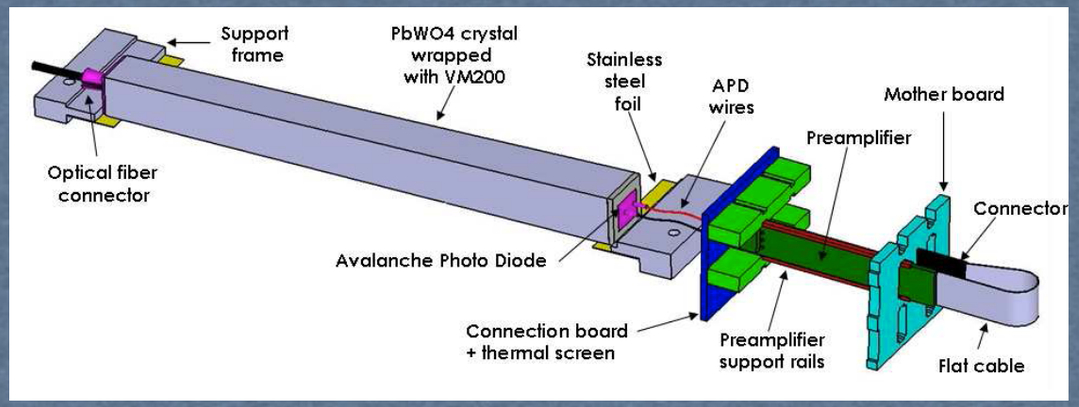
Experimental set-up

- B field to bend e+/e- pairs
- Si TRCK for vertexing
- EM cal for triggering

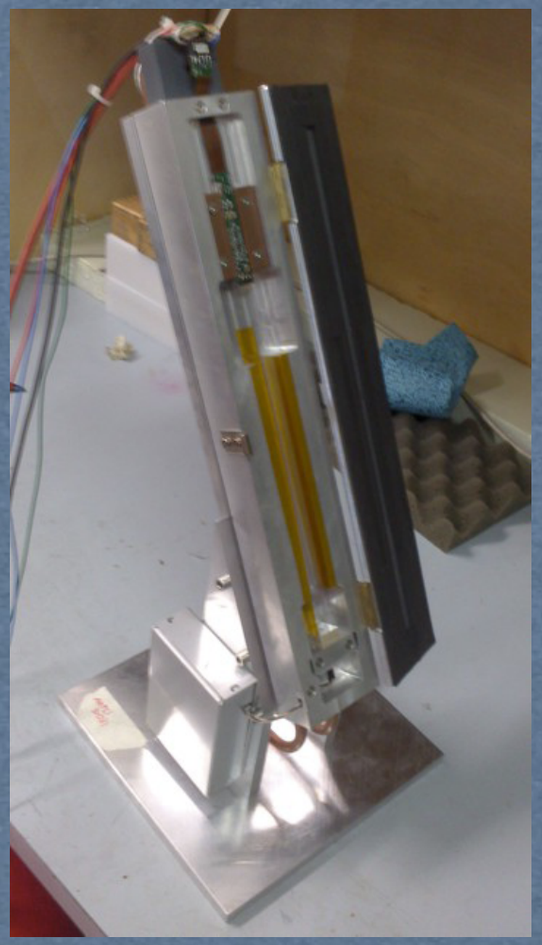


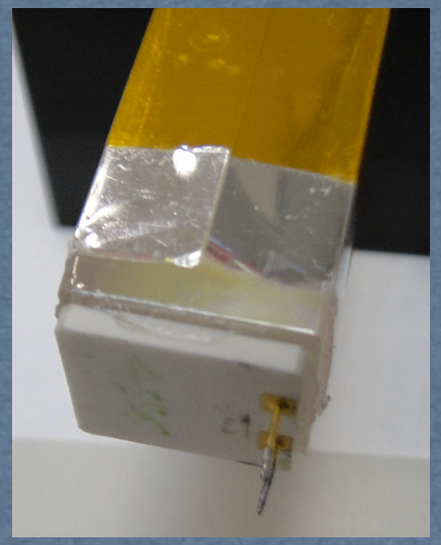
HPS-ECal



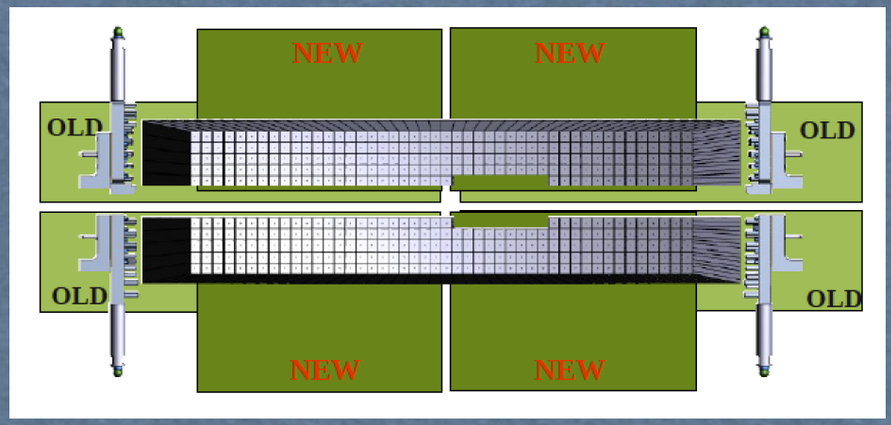


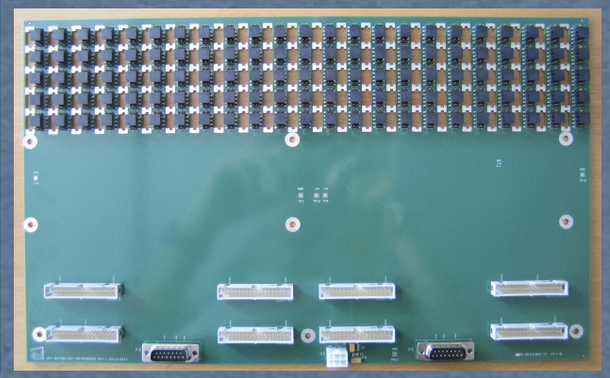
1) APDs replacement: all CMS-like APDs have been replaced by LA-APDs





2) Motherboards design and replacement



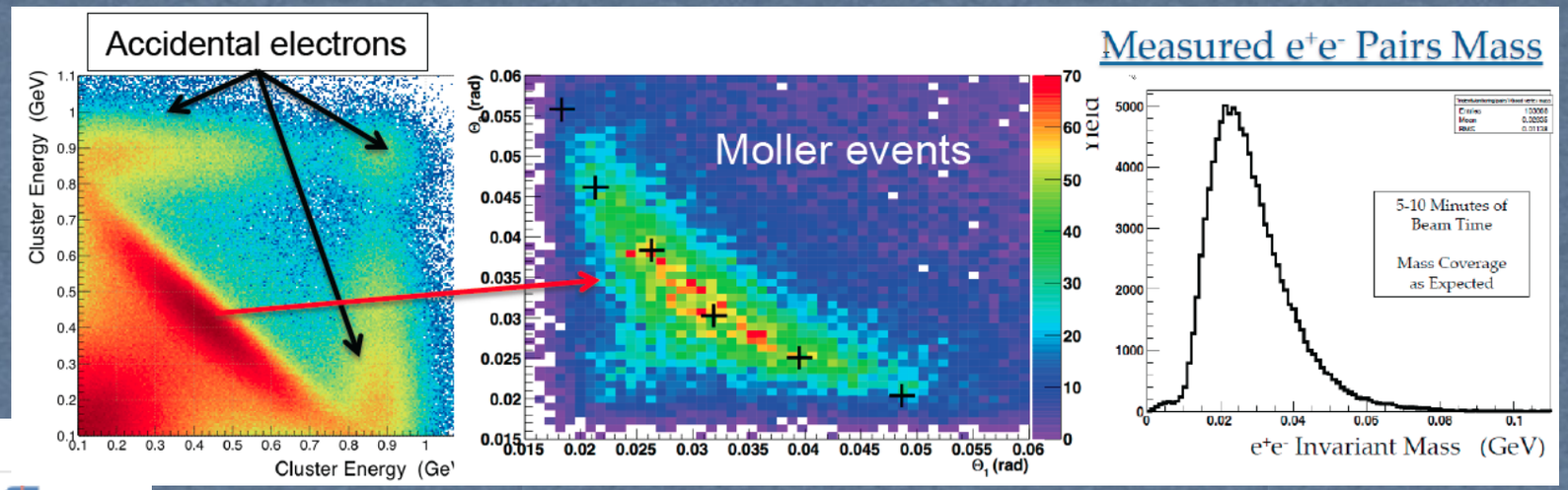


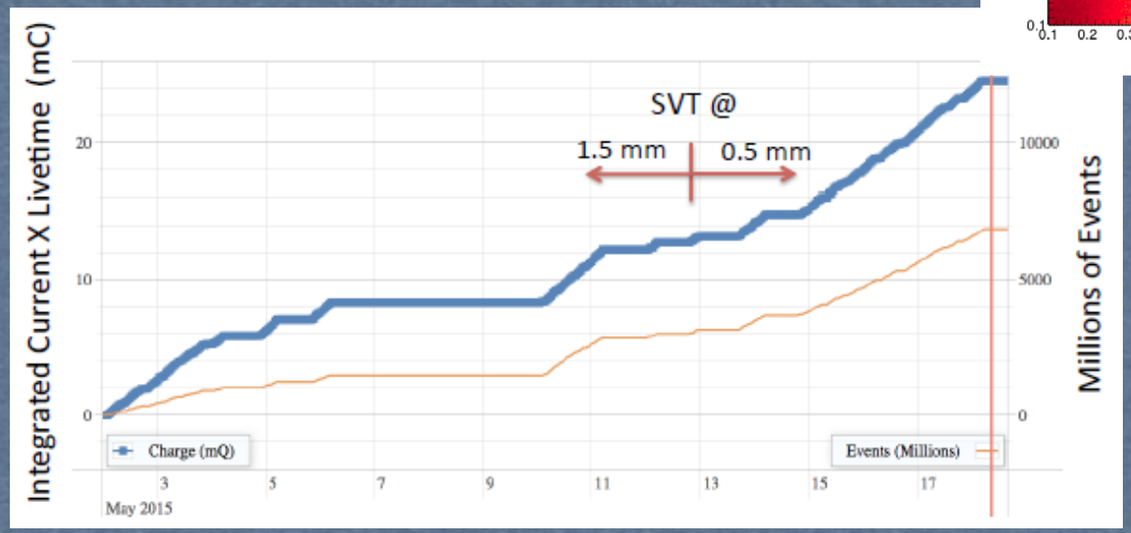
3) LED monitoring system: design, construction and test

A. Celentano, G. Mini', P. Musico, F. Pratolongo, G. Ottonello

HPS - Status and Plans

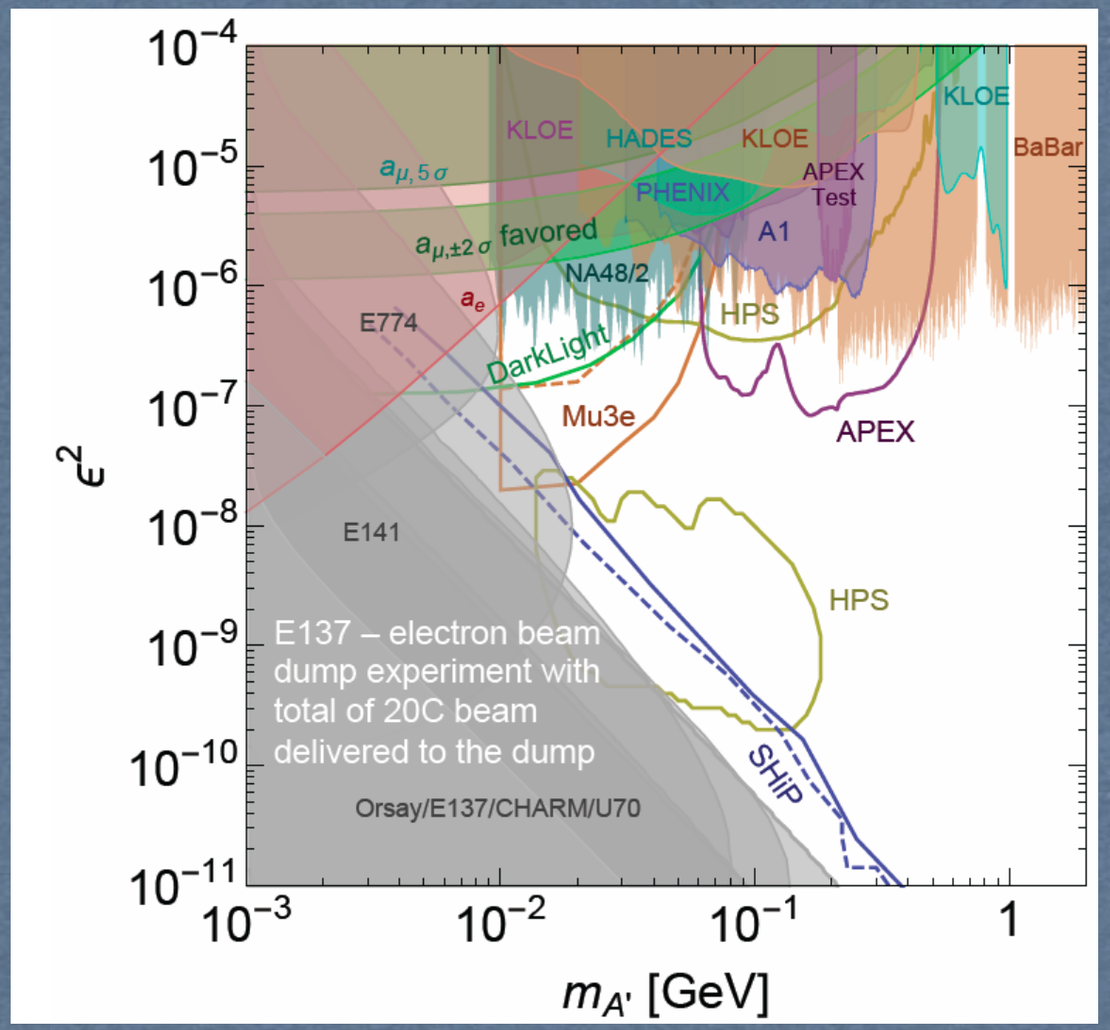
- ✳ Installation in the Hall in fall 14
- ✳Test run In Dec 14
- ✳Engineering run @1GeV in Apr/May 15
- ✳2-PAC days (over 180 approved!) at the nominal setting





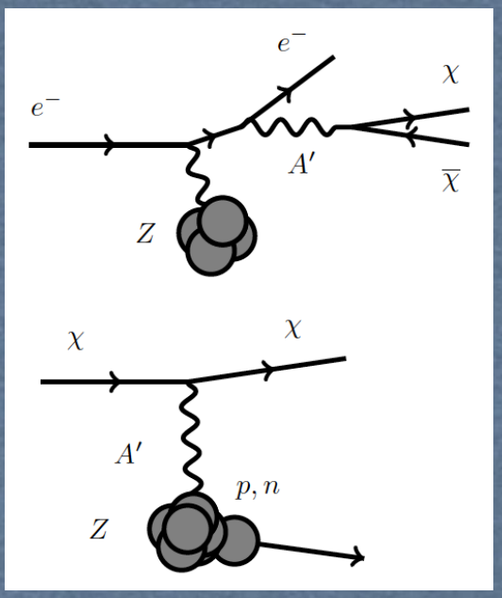
Plans

- ✳Possible run in fall 2015 and/or spring 2016
- ✳No major technical support needed



Beam Dump eXperiment - BDX

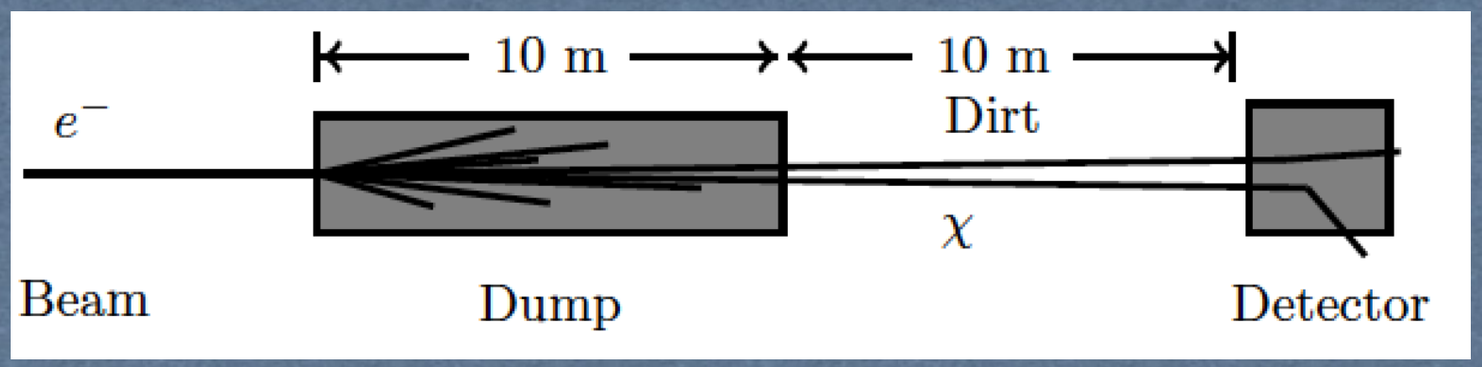
(M.Battaglieri, A. Celentano and R. De Vita co-spokesperson)



Two steps process:

I) An electron irradiates an A' and the A' promptly decays to a χ (DM) pair

II) The χ elastically scatters on a e^-/nucleon in the detector producing a visible recoil (GeV/MeV)



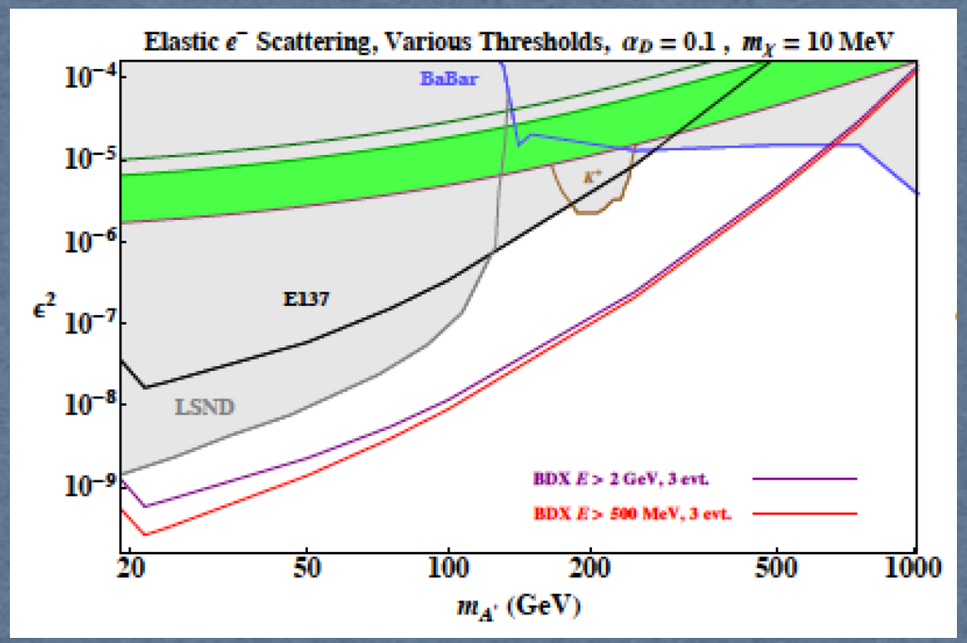
~1 m^3 segmented scintillator
detect e^- E>0.5 GeV
detect p T>10 MeV

Key issue: bg rejection

BDX@JLab reach

- 1m3 detector
- 10^{22} EOT (100 uA for 6 months, full parasitic)
- realistic estimates of cosmogenic and beam-related background

At least, two orders of magnitudes better than any previous experiments



- BDX LOI submitted to JLAB PAC42 - August 2014 (http://arxiv.org/abs/1406.3028)
- Positive feedback: physics case highly appreciated, encouraged to present a full proposal

✓full detector design

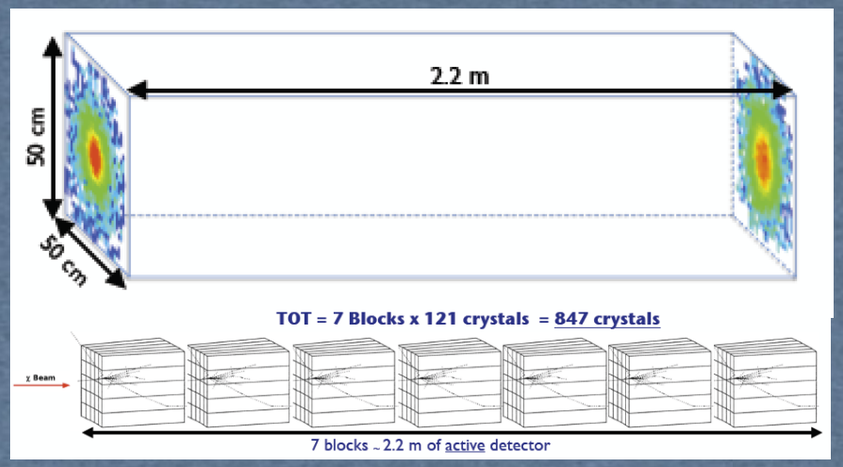
✓full simulations

✓full background measurement with a prototype

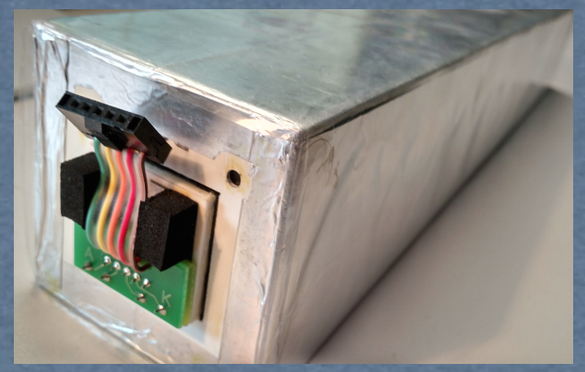
✓full theory motivations and competition with other exps

BDX activity at INFN-GE

✳ The BDX detector: reuse of BaBar Ecal endcup CsI crystals



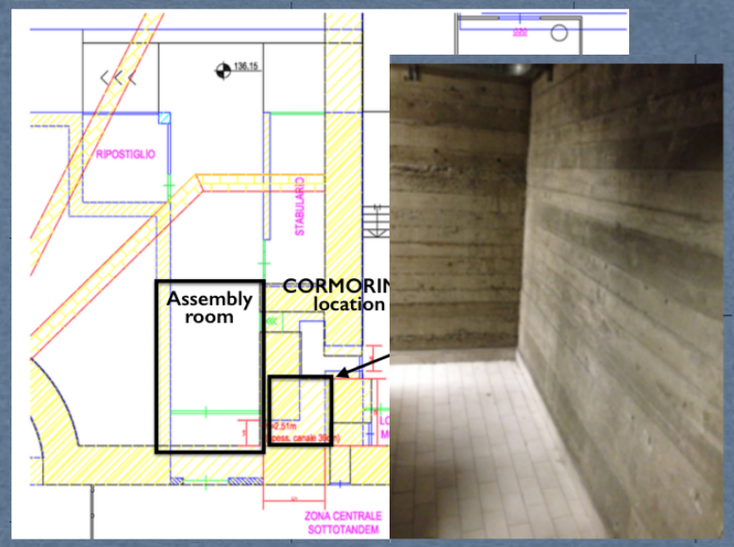
★ ~800 BaBar EndCup crystals
★ Modular detector: change front face dimensions and length by easily rearranging
★ Each module is made by an array of 11x11 (front face ~50x50 cm2) or 9x9 (front face ~40x40 cm2) crystals matrix



★ Under study: old pin-diode readout or sipm readout (re-use of FT-Hodo FE electronics)
★ Plans: assemble a prototype to be tested at LNF-BTF and LNS

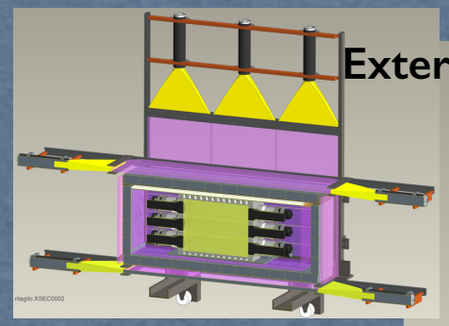
✳ The cosmic background: BDX tests @LNS

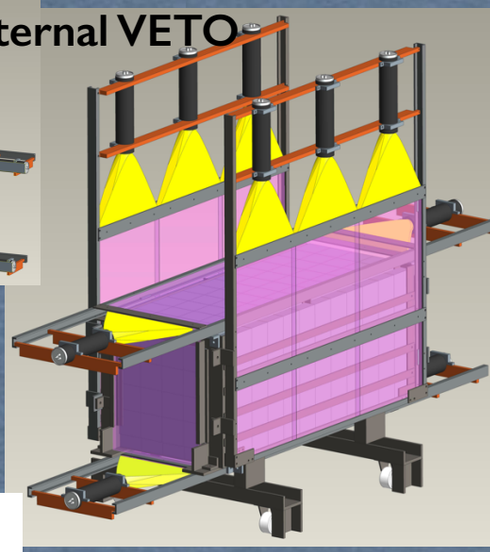
- Validate MC results
- Test of different crystals
- Quantify background rates vs energy thresholds
  - Test of different veto solutions
  - Measure of veto efficiencies
  - Shielding optimization

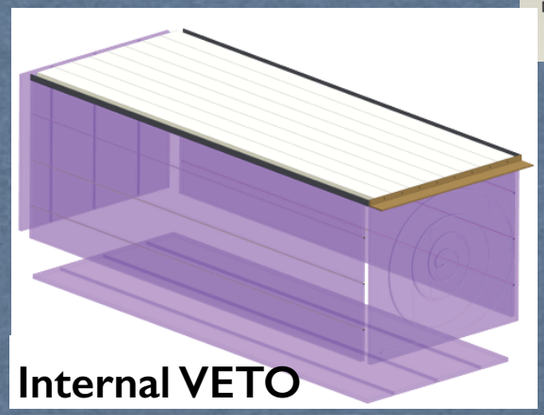


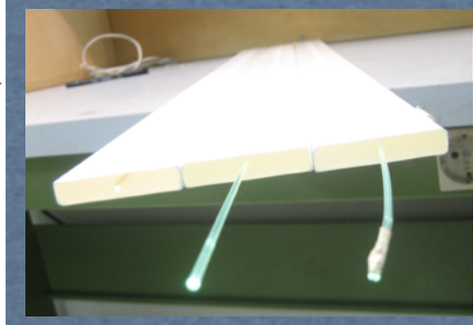
Plans

✳ Assemble a prototype
✳ Cosmic tests at LNS
✳ Mechanical and electronic support needed









A.Celentano, S.Minutoli, F.Pratolongo, R. Cereseto, V.Vigo, F.Parodi, G. Ottonello

Projects & Outreach

Projects

- CLASMED - Premiale 2013
- HS-HPH (Hadron Spectroscopy in EU-Hadron Physics in Horizon2020) (?)
- LiQuHaS (Light Quarks Hadron Spectroscopy): Italy-Polland Miur collaborative project
- Big-Dash (Big-Data Access, Storage and Hosting): S.Paolo Foundation (?)

Outreach

- HASPECT weeks in Genova (and at ECT*)
- CLAS12 European Workshop (co-organized with CT)
- LDMA2015
- INFN-DOE summer student program:
  - A.Beiter in 2014 and A.Licastro in 2015 (Canisius College)'BDX Event Display (BED
- Mentoring (2014/15):
  - I.Balossino (Utorino): The LED system for HPS-ECal
  - N.Clnko (OhioU): The LED system for the FT-Cal
  - I.Stankovich and S.Hughes (UEdinburgh): The FT-Hodo FE electronic test
  - Max Campbell (OhioU): 'FT-Cal assembly and commissioning'
  - H.Mann, I.Davenport, M.Yates (JamesMadisonU): 'FT-Cal cosmic ray tests'

HASPECT week - Genova - Dec 17 - 18, 2014

Workshop location: Istituto Nazionale di Fisica Nucleare
Department of Physics
Via Dodecaneso 33
Genova
Room 604 (located at 6th floor)
[illegible] to have some suggestions to reach the Department from city center, train stations, airport ...

Practical information

- How to get to Genova
- How to reach the Physics Department

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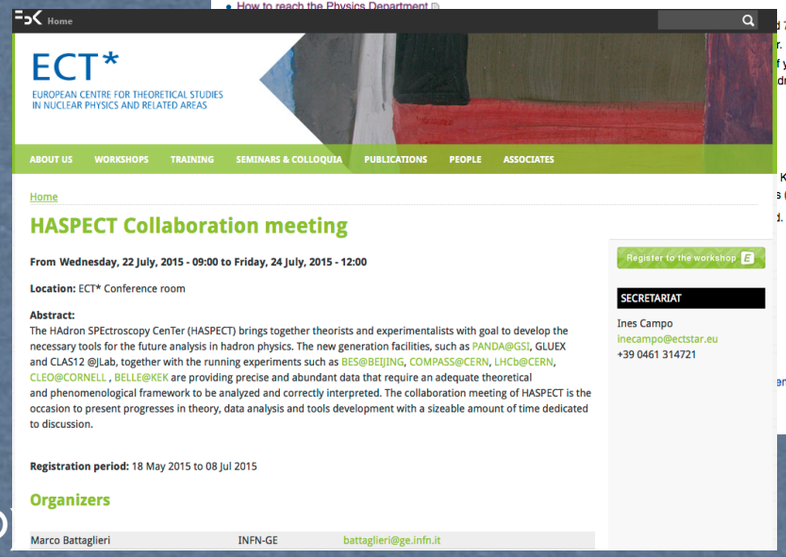
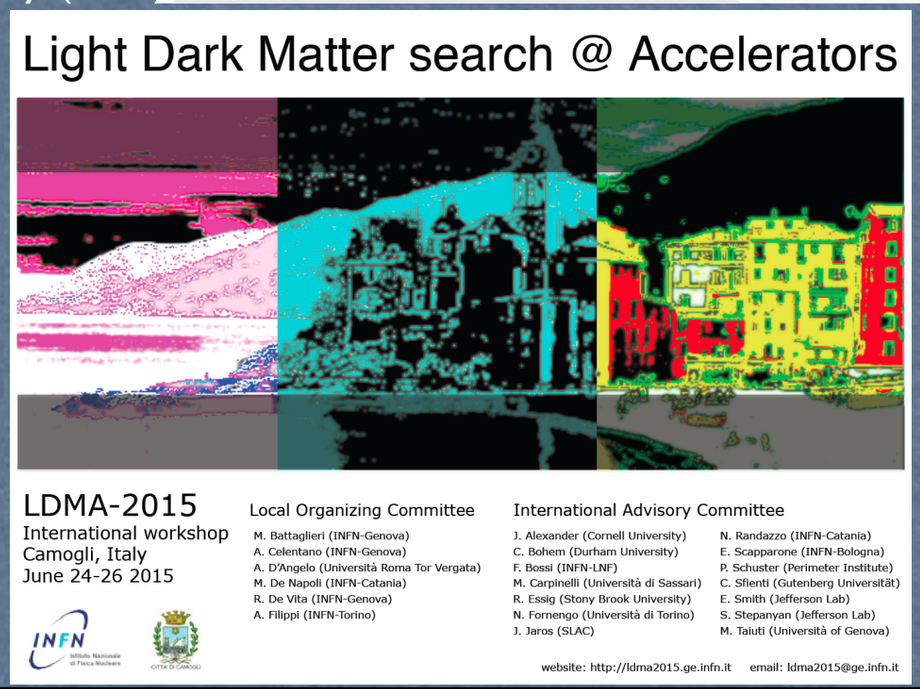
dministration; -

K. Hicks (remote),
s (remote), L.Zana

enovaFinal.pdf





2016: resources and budget

People

Esperimento	Nome	Qualifica	%	Note	Totale
JLAB12	M. Battaglieri	Primo Ricercatore	100%		6.0 FTE
	A. Brunengo	Primo Tecnologo	30%		
	A. Celentano	Borsista	10%		
	R. De Vita	Ricercatore	100%		
	E. Fanchini	Assegnista	100%		
	V. Mathieu	Ricercatore straniero	50%		
	P. Musico	Primo Tecnologo	30%	TBC	
	M. Osipenko	Ricercatore	60%		
	M. Ripani	Primo Ricercatore	50%		
	M. Taiuti	Prof. Ordinario	70%		

Resources

Esperimento	Servizio	Attività	M. U.	Impatto
JLAB12	Calcolo e Retii	Supporto manutenzione workstations e nodi di calcolo della farm	3	
	Officina Elettronica	Realizzazione pre-amplificatori BDX e assistenza montaggio e test rivelatori + Supporto tecnico G. Ottonello	6 + 8	
	Officina Meccanica	Completamento piccole parti per rivelatore Forward Tagger e supporto installazione	8	
	Progettazione Meccanica	Supporto integrazione, montaggio e installazione Forward Tagger e BDX, supporto tecnico F. Parodi	4 + 8	

Budget

Esperimento	Capitolo	Richiesta (k€)
JLAB12	Missioni	57
	Inventariabile	10
	Costruzione apparati	120
	Consumo	5