Coordinate Detector for the SBS Project

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on behalf of M. Khandakar, Idaho State

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Acknowledgements

- Many people & institutions taking part:

  - CNU: Peter Monaghan, Ralph Marinaro, T. Miller
  - Idaho State: M. Khandakar, Vitali Baturin
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  - JLab: B. Wojtsekhowski, M. Jones, Chuck Long, L. Pentchev, A. Gavalya & the Electronics Group

Project Milestones

Level	Milestone	Scheduled Date	Status
3	Finish testing of module prototype	8/30/2014	Completed
3	Scintillator ordered	9/30/2014	Completed
2	CDet module design completed	11/30/2014	Completed
3	WLS fibers ordered	1/15/2015	Completed
3	Scintillator shipped for machining	4/30/2015	Completed
3	Begin preparation of WLS fibers	6/15/2015	Completed
3	Begin construction of CDet module	9/01/2015	Completed
3	Assembled one CDet module	10/15/2015	Completed
3	Assembled one CDet plane	3/15/2016	Completed
2	Coordinate Detector Assembled	8/15/2016	Completed
1	Project completion	1/29/2017	Completed

Key Performance Parameters

|	
CDet coordinate resolution	< 3.0 mm
Time Resolution	$\approx$ 1.0 ns
Efficiency per plane	> 95 %
Electronic dead time, given data rate of 0.5 MHz per bar	$\approx$ 2.5 %

SBS 2015 DOE Review

1) "The CDet has made great progress and is on schedule for August 2016 delivery."

   ▪ Assembly completed on 15th August 2016

2) "A slow controls system should be developed."

   ▪ Slow controls development started in June 2016

Coordinate Detector (CDet)

- A scintillator detector for charged particle detection.

- **GEp**: placed in front of the electromagnetic calorimeter (ECAL) to measure electron track vertical coordinate

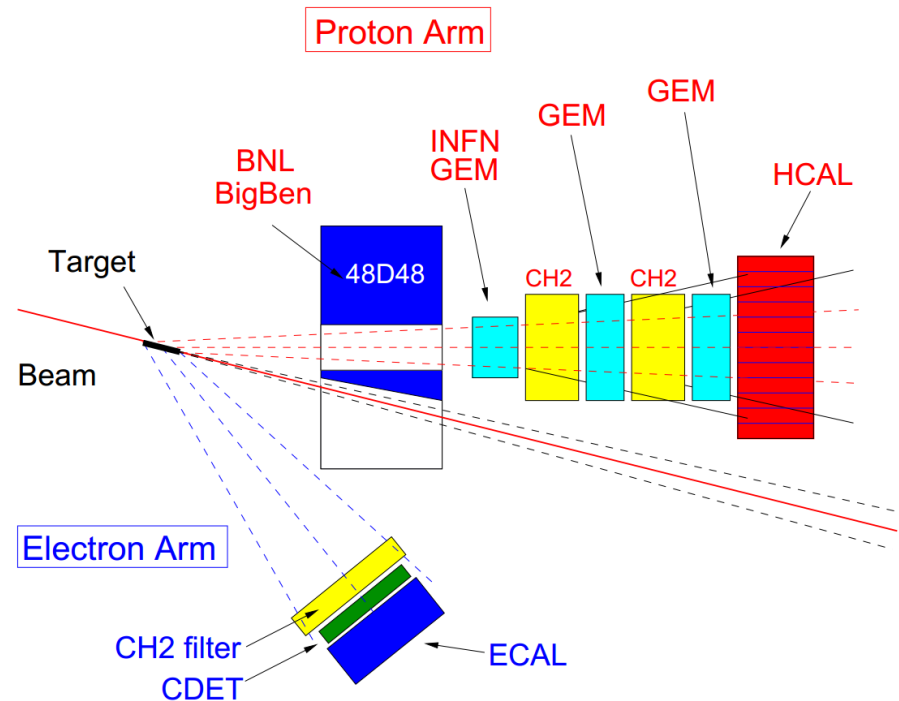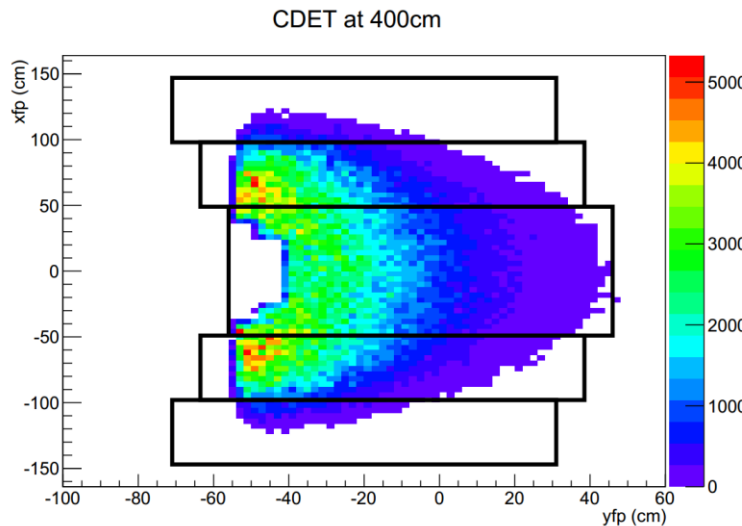- **GEn/GMn**: placed in front of hadron calorimeter (HCAL) to tag protons.
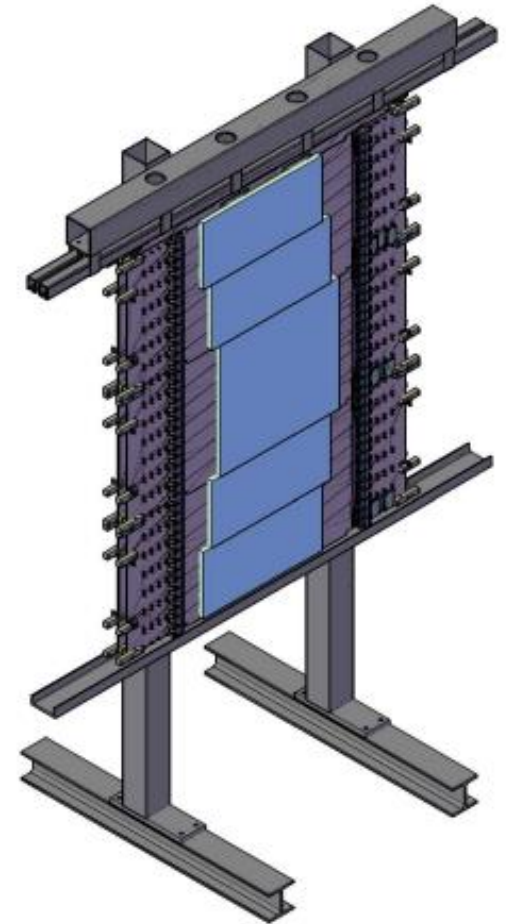
Functions of CDet

- GEp : use angular correlation between the scattered electron and the recoil proton to determine the correct proton track.

- CDet will measure electron vertical coordinate to reconstruct electron scattering angle
  - Aid in reconstruction of proton track with efficiencies > 95%

- Apply angular e-p correlation cut factor of two tighter due to smaller coordinate resolution.

Layout of GEp Experiment

CDET at 400cm

Proton form factors ratio, GEp (E12−07−109)

Proton Arm

GEM

GEM

GEM

INFN
GEM

BNL
BigBen

HCAL

Target

48D48   CH2   CH2
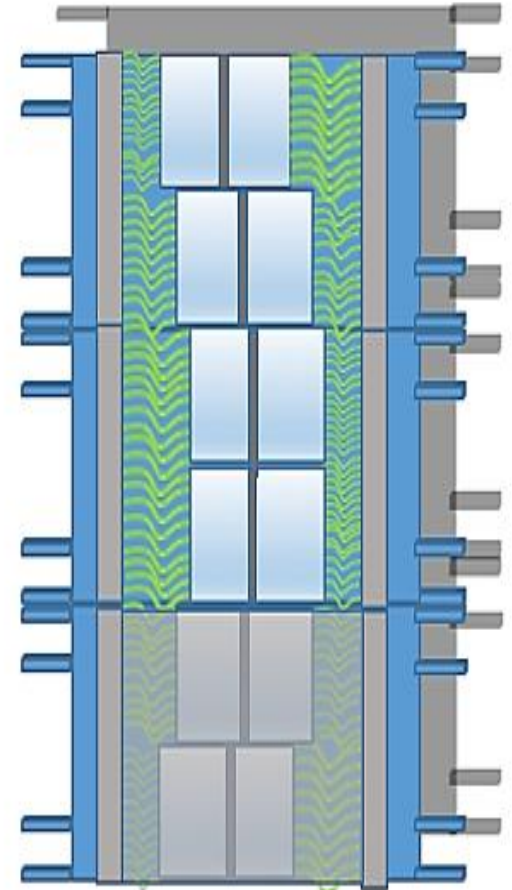
Beam

Electron Arm

CH2 filter

CDET

ECAL

- Placed in front of ECAL in electron arm, CDet is a vertical coordinate detector the GEp experiment

Coordinate Detector Configuration

- Detector has two planes each with an active area of (102 x 294) cm^2

- 6 modules; 3 per plane; 28 scintillator groups in each module.

- Each group consists of 14 scintillator paddles.

- Total of 2352 channels.

- Each paddle has a wavelength shifting fiber (WLS) along its center for light collection.

- Each group of WLS connected to 16-channel maPMT

# CDet Module Layout

View from target to CDet

Side View

Increasing angles $0 - 18°$

Increasing angles $0 - 18°$
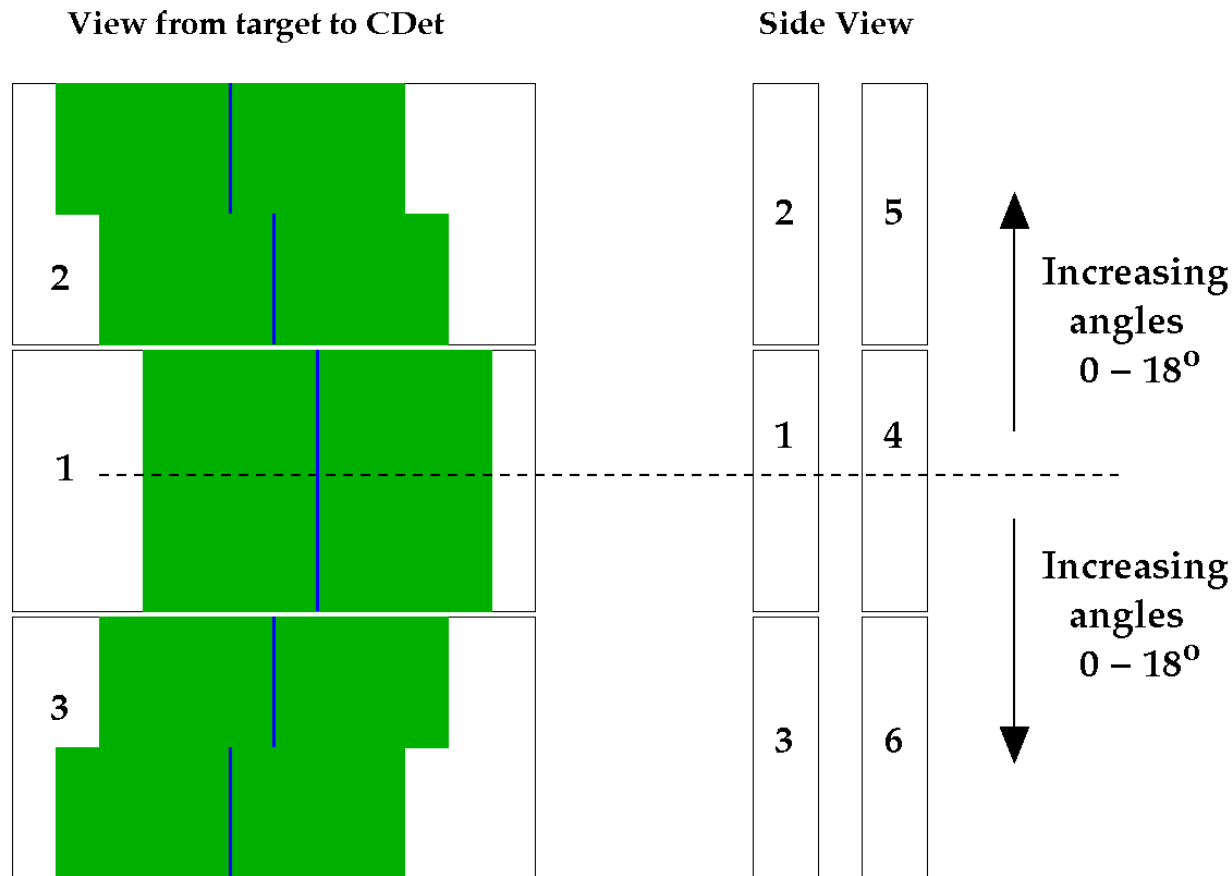
- Center mirror for left/right divide
- Allows cone acceptance matching

- Scintillator paddles angled to point shortest side directly at the target.

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Group Construction

- Each scintillator paddle individually wrapped in aluminized mylar.

- Fourteen paddles combined in each group.

- Used custom jig to assemble each group with the correct angular spread (0.86^o)
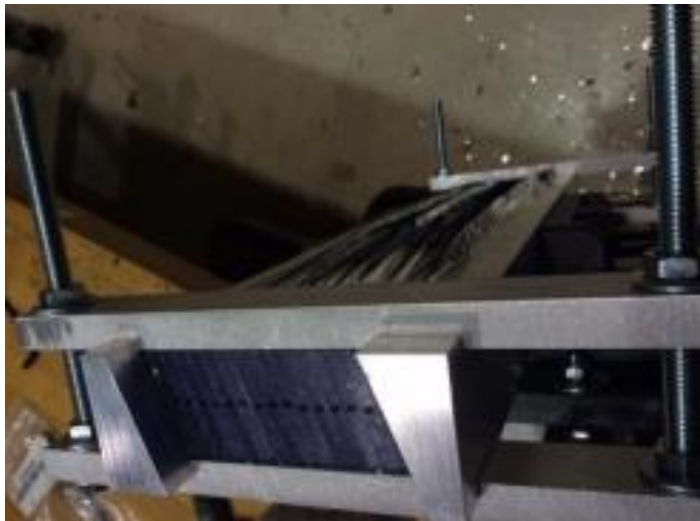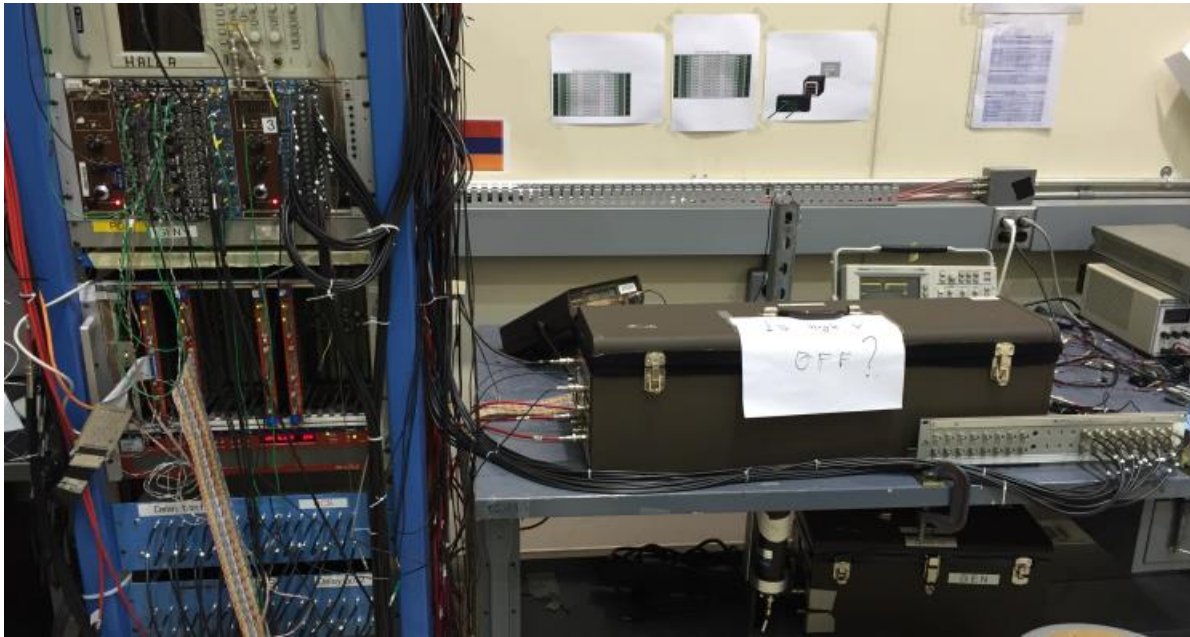
Quality Control Checks

- Kept records for each scintillator group from construction and single-group cosmic testing.

- Keep track of bars ready for assembly

- Plan our work to accumulate the groups required for each module in sequence.

- Visual inspection; cleanout of extrusions; cosmic test – determine number of photoelectrons; wrap for final assembly.
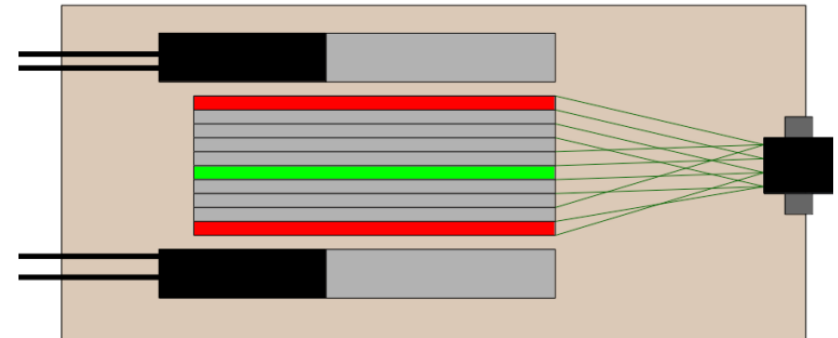
- Any required repairs found early.

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Record Keeping

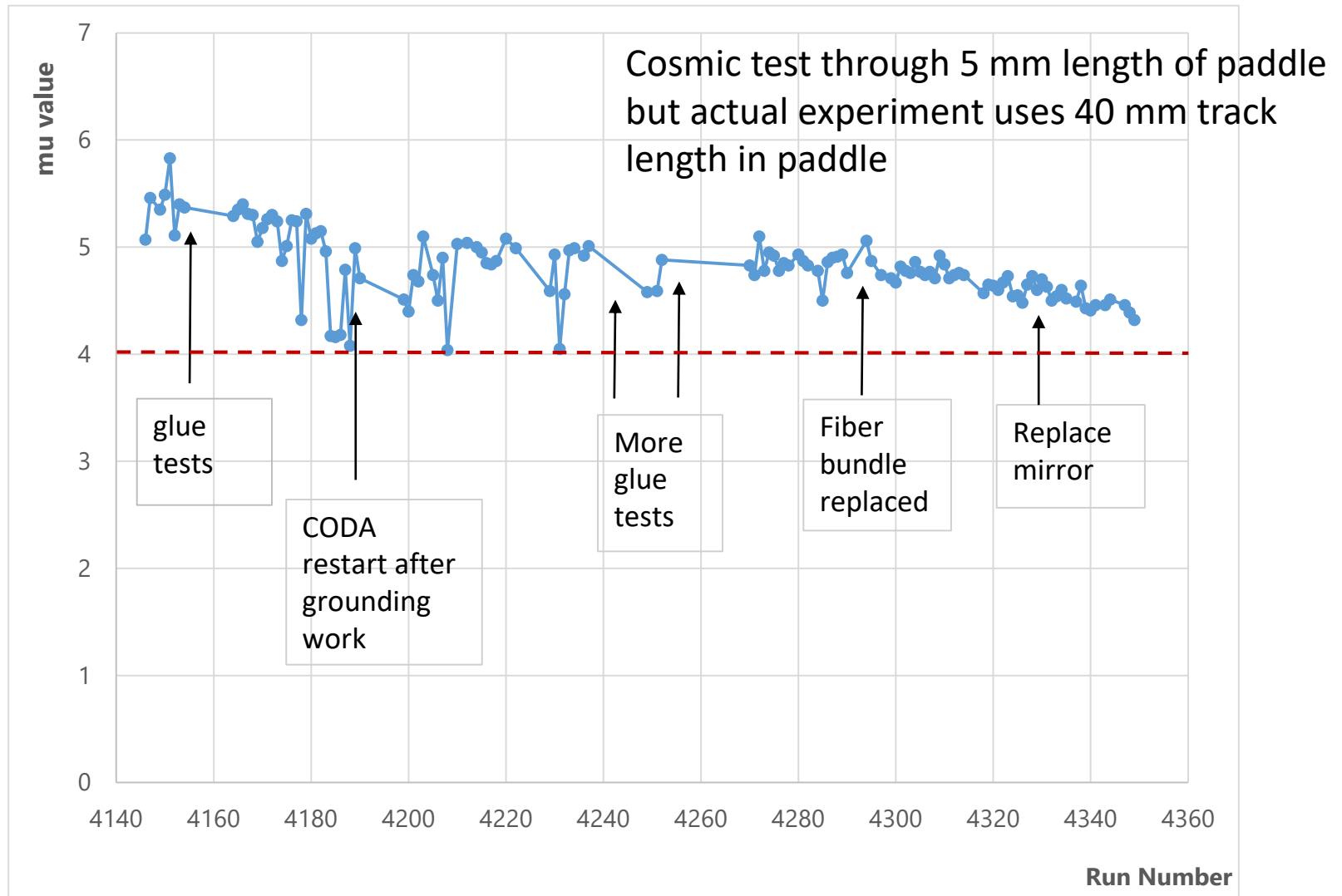| Group Label	Visual Inspection	Cleaned	Cosmic Test Date	Run #	Data analyzed?	Average Mu	Std. Dev.	Ready to assemble
M5-8UL	Yes	Yes	07/10/16	4343	Yes	4.46	1.12	PM
M5-9UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-10UL	Yes	Yes	07/18/16	4344	Yes	4.51	1.13	PM
M5-11UL	Yes	Yes	07/18/16	4349	Yes	4.32	1.02	PM
M5-12UL	Yes	Yes	07/18/16	4346	xx/xx/xx	x.xx		"Name"
M5-13UL	Yes	Yes	07/19/16	4347	Yes	4.46	1.12	PM
M5-14UL	Yes	Yes	07/20/16	4348	Yes	4.39	1.05	PM
M5-15UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-16UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-17UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-18UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-19UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-20UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-21UL	No	No	xx/xx/xx	xxxx	xx/xx/xx	x.xx		"Name"
M5-8UR	Yes	Yes	06/24/16	4327	Yes	4.65	1.17	RM
M5-9UR	Yes	Yes	06/27/16	4328	Yes	4.73	1.2	RM
M5-10UR	Yes	Yes	06/28/16	4329	Yes	4.6	1.15	RM
M5-11UR	Yes	Yes	06/29/16	4330	Yes	4.7	1.16	RM
M5-12UR	Yes	Yes	06/30/16	4331	Yes	4.63	1.17	RM
M5-13UR	Yes	Yes	07/01/16	4332	Yes	4.5	1.12	RM
M5-14UR	Yes	Yes	07/05/16	4333	Yes	4.54	1.15	RM
M5-15UR	Yes	Yes	07/06/16	4334	Yes	4.6	1.16	RM
M5-16UR	Yes	Yes	07/07/16	4335	Yes	4.52	1.14	RM
M5-17UR	Yes	Yes	07/08/16	4337	Yes	4.49	1.12	PM
M5-18UR	Yes	Yes	07/08/16	4338	Yes	4.64	1.19	PM
M5-19UR	Yes	Yes	07/09/16	4339	Yes	4.43	1.09	PM
M5-20UR	Yes	Yes	07/09/16	4340	Yes	4.41	1.11	PM
M5-21UR	Yes	Yes	07/10/16	4341	Yes	4.46	1.11	PM

Single Bar Cosmic Testing

- Test each bar with cosmics
- Determine μ for each bar
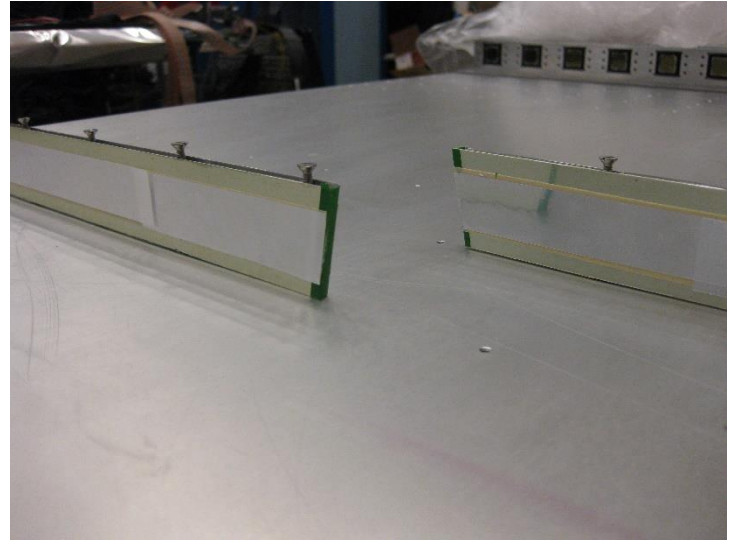- μ is a measure of number photoelectrons produced

Single Bar Mu-graph

Cosmic test through 5 mm length of paddle but actual experiment uses 40 mm track length in paddle

- glue tests
- CODA restart after grounding work
- More glue tests
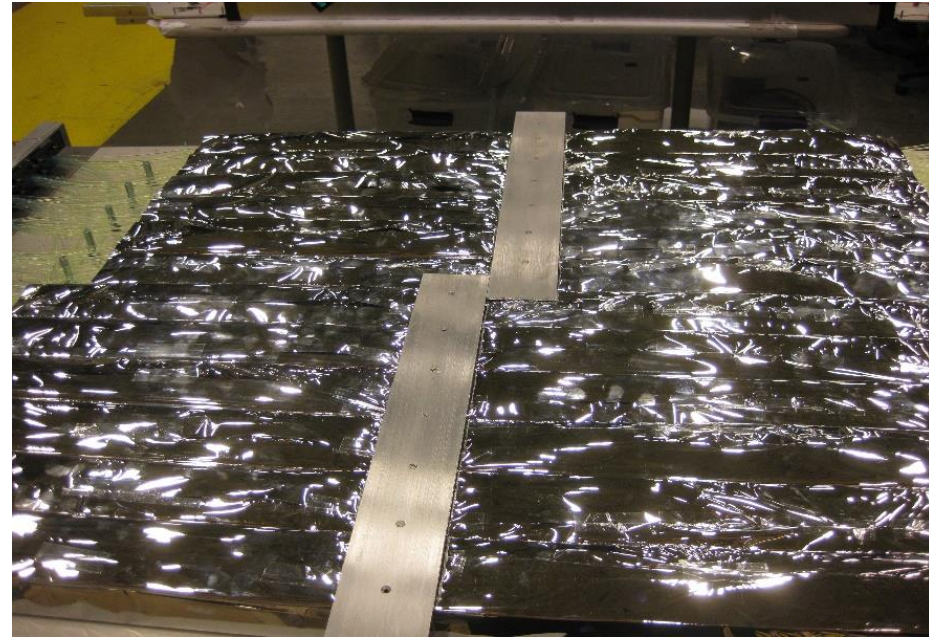- Fiber bundle replaced
- Replace mirror

Module Assembly

Module Assembly

- Note the staggered mirrors
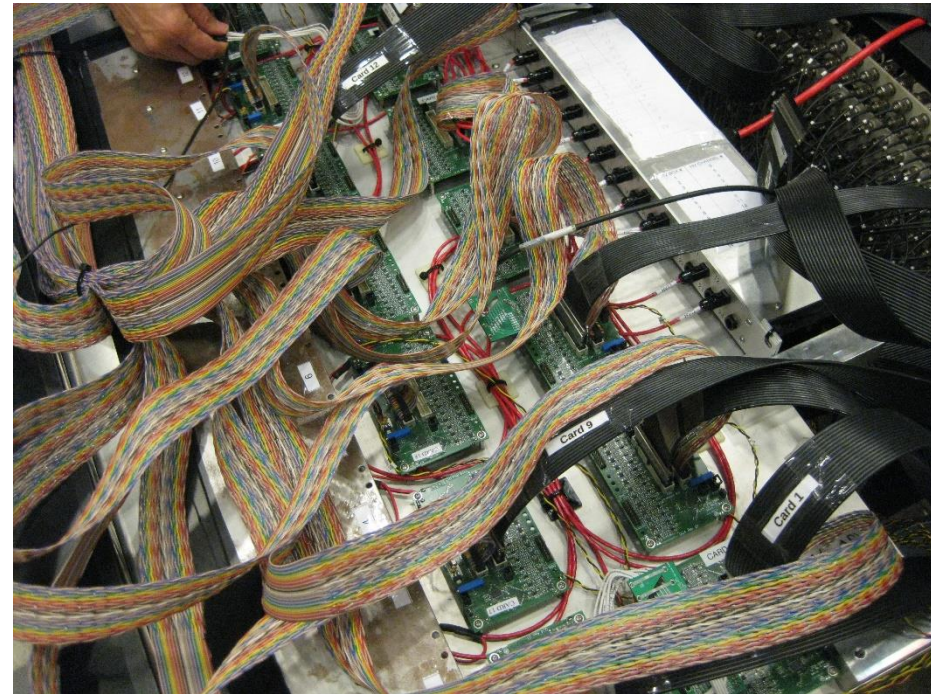 - required new set of clamping plates made

Module Assembly Completed!

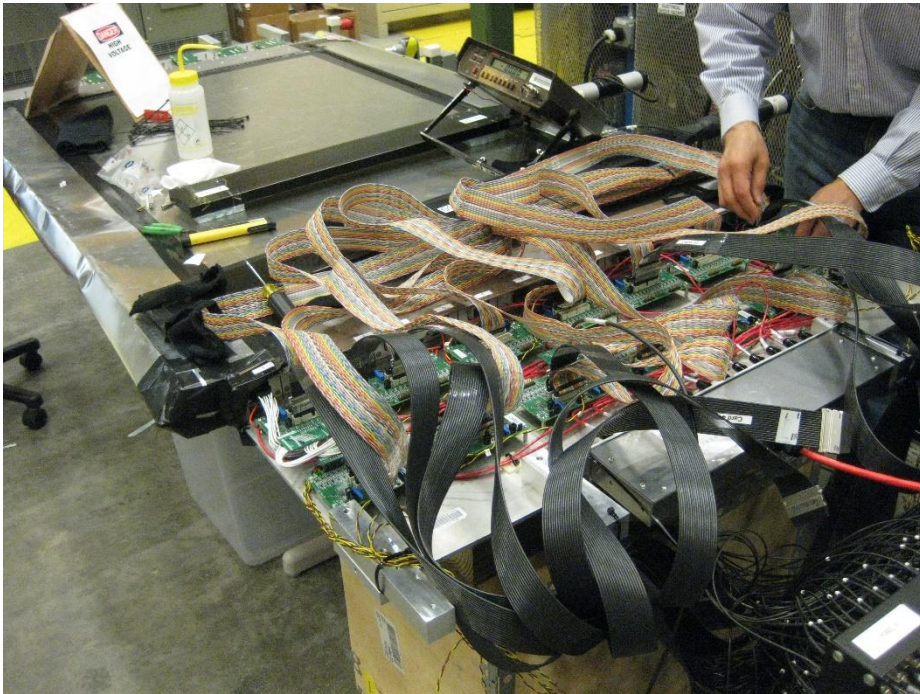- All six modules assembled; awaiting testing.

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Module 1

- One half fully instrumented – ADC & TDC
- All NINO cards installed.
- Commissioning in progress.

Equipment Status

HV control and modules	Using existing
HV cables	WBS 2.1 purchased
9 Fastbus crates	Using existing
9 SFI Fastbus	Using existing
9 VME CPU	WBS 2.1 purchased
9 JLab TI	WBS 2.1 purchased
1877 TDCs	Using existing
Multi-Anode PMTs & bases	Using existing
WLS Fibers	WBS 2.1 purchased
Scintillators	WBS 2.1 purchased
Module Frames	WBS 2.1 purchased
NINO amplifier/discriminator cards	Glasgow Univ. purchased
Cables (ribbon, PMT-NINO)	INFN-Catania purchased
CDet Frame	WBS 2.1 purchased
CDet Absorber	WBS 2.1 purchased

Summary

- CDet part of SBS (WBS 2.1) completed on time.

- Collaboration formed and moving ahead with detector commissioning.

- CDet commissioning in progress.

Extra Slides

Software Development

- Remote high voltage control established for CAEN crates.

- Software decoder for DAQ written and working.
  - DAQ has been tested and run for a single group+NINO output.

- Still have to develop the online analyzer software for the detector.
  - Expect this to evolve as the commissioning testing is worked through.
  - CNU committed effort and students to this.

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Commissioning Plans

- Install all NINO cards throughout all modules as they become available.

- Install and test the charge equalization cards for PMT output into NINO cards.

- Tune the charge equalization for whole detector.

- Checkout of all channels in detector.

- Test the analysis software by taking data during the commissioning phase.