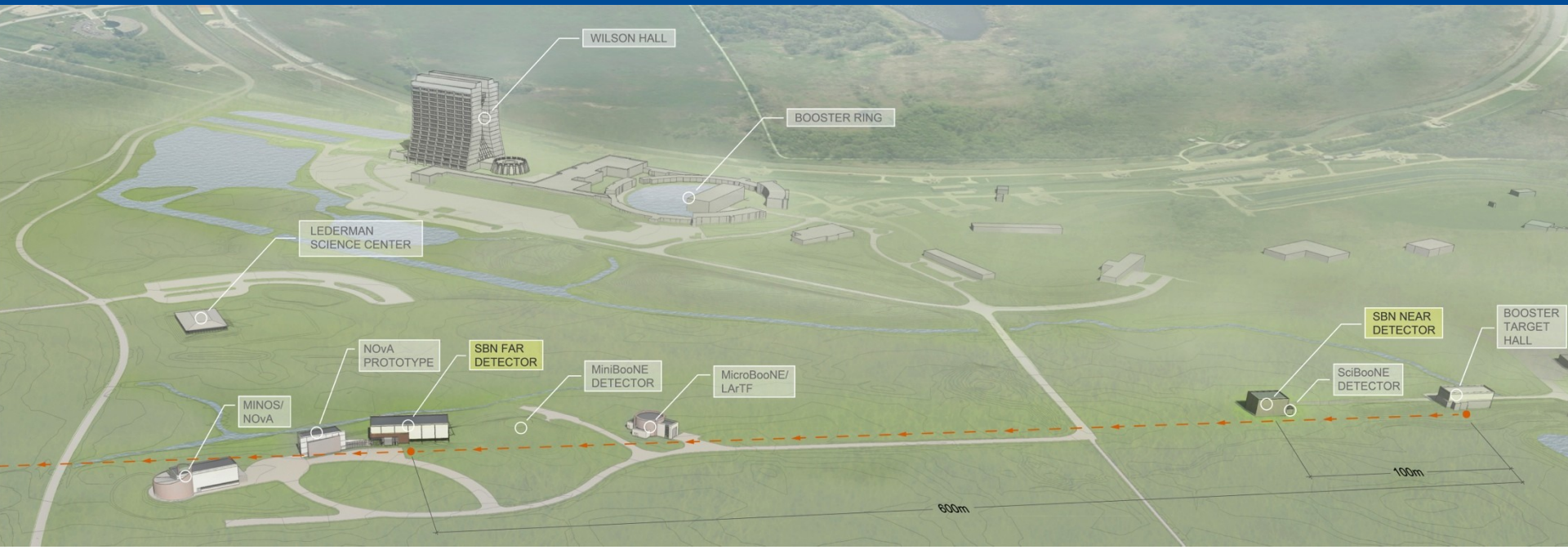


SBND Cosmic Ray Tagger

Igor Kreslo

Director's Progress Review of SBN

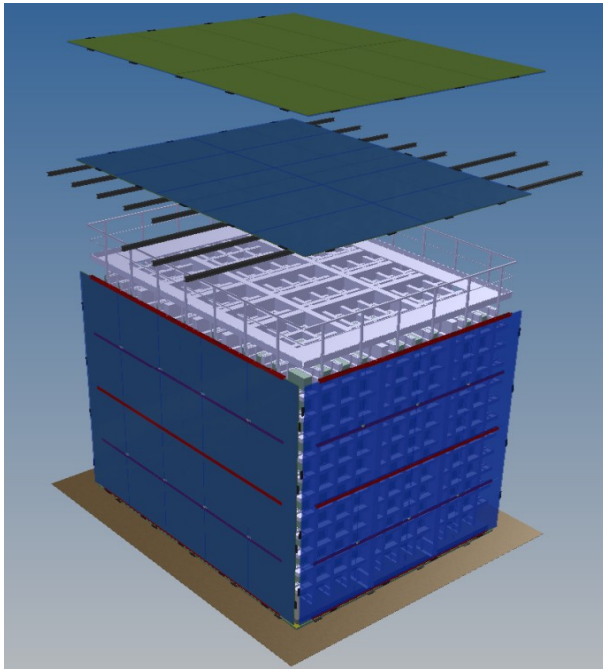
15-17 December 2015

Outline

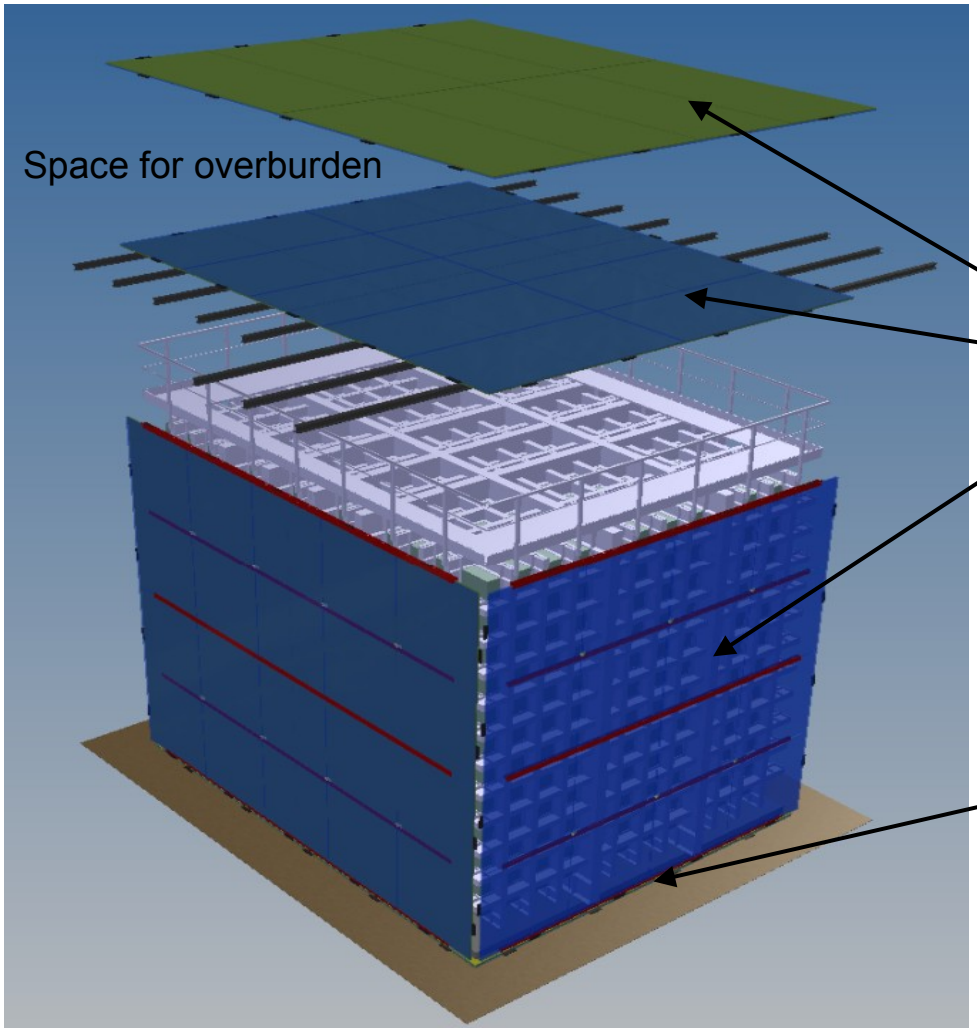
- System Overview (detailed tech. Note is in DocDB 685)
- Interfaces
- Resources
- Basis of Estimate
- Schedule and Cost Summary
- ES&H and QA
- Response to technical review recommendations
- Status of design

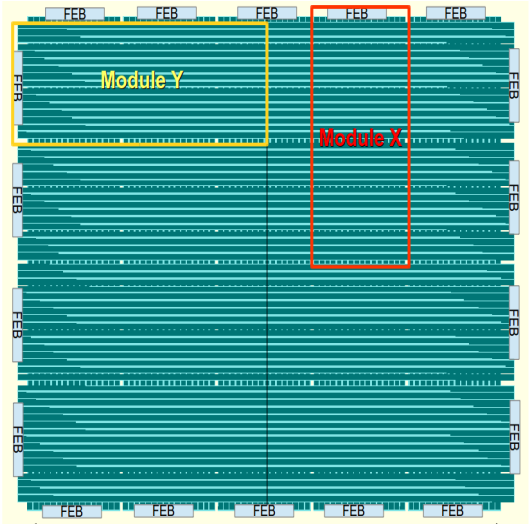
CRT Requirements

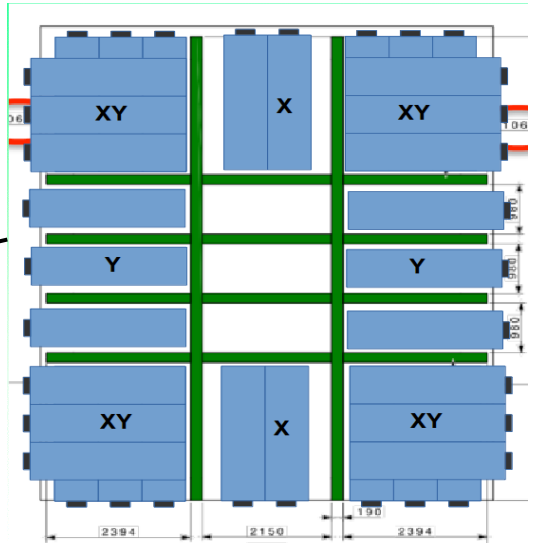
Tagging of charged particles entering TPC cryostat from all directions		
Muon flux coverage	> 90%	
Muon detection efficiency	> 95%	
Coordinate resolution	< 10 cm (2D)	EM-activity around muon
Time tag accuracy	O(ns) RMS	BNB bunch structure
configurable logic trigger to TPC	entering/exiting	



CRT global view







CRT Module structure

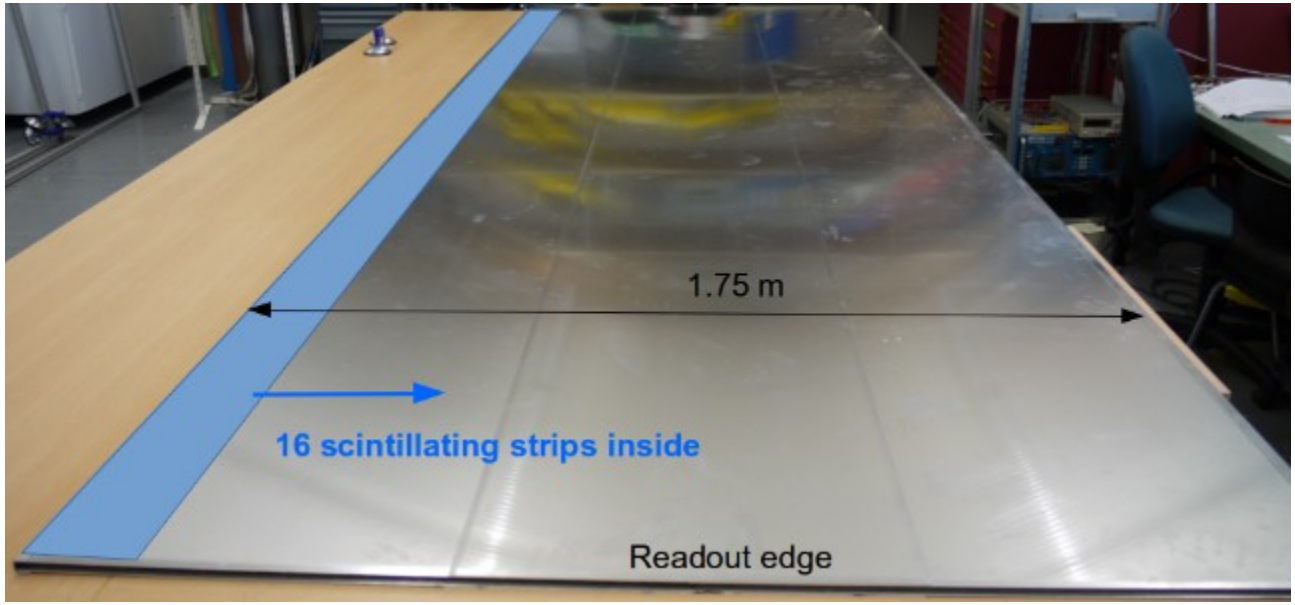
16 strips per module

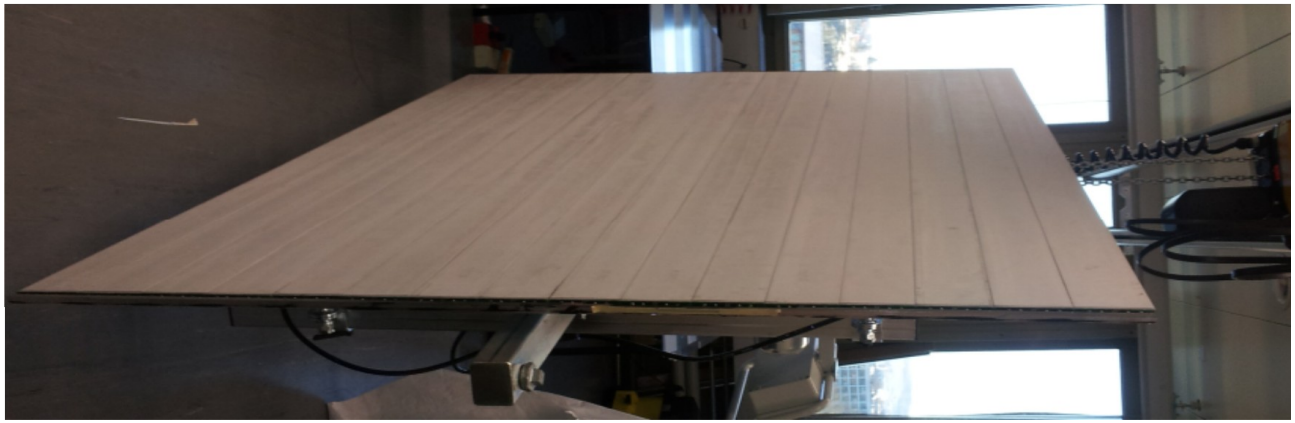
Module length:
3.6m & 4.5m

Module width: ~1.8m

Aluminum case
(2-4 mm thick)

Robust, self-supporting

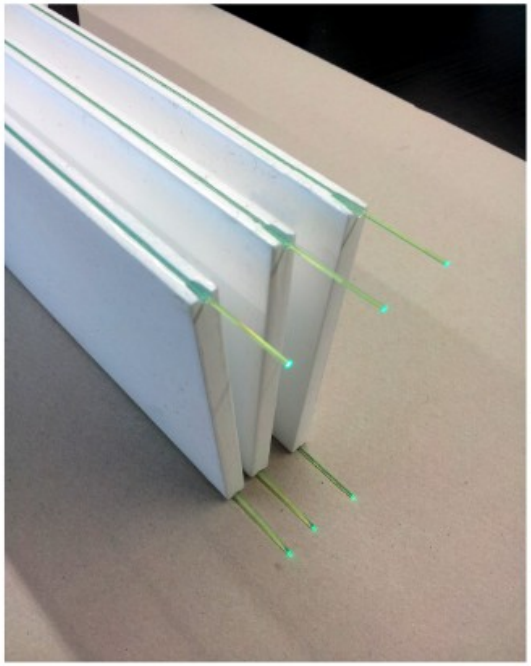


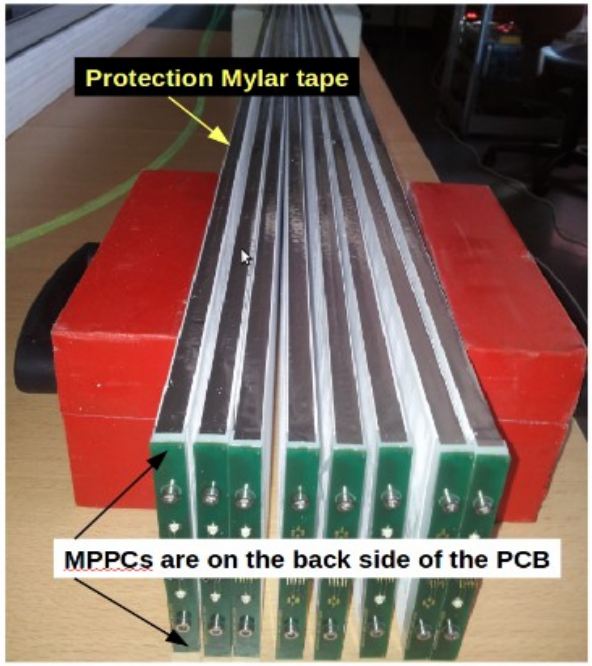


CRT Strip structure

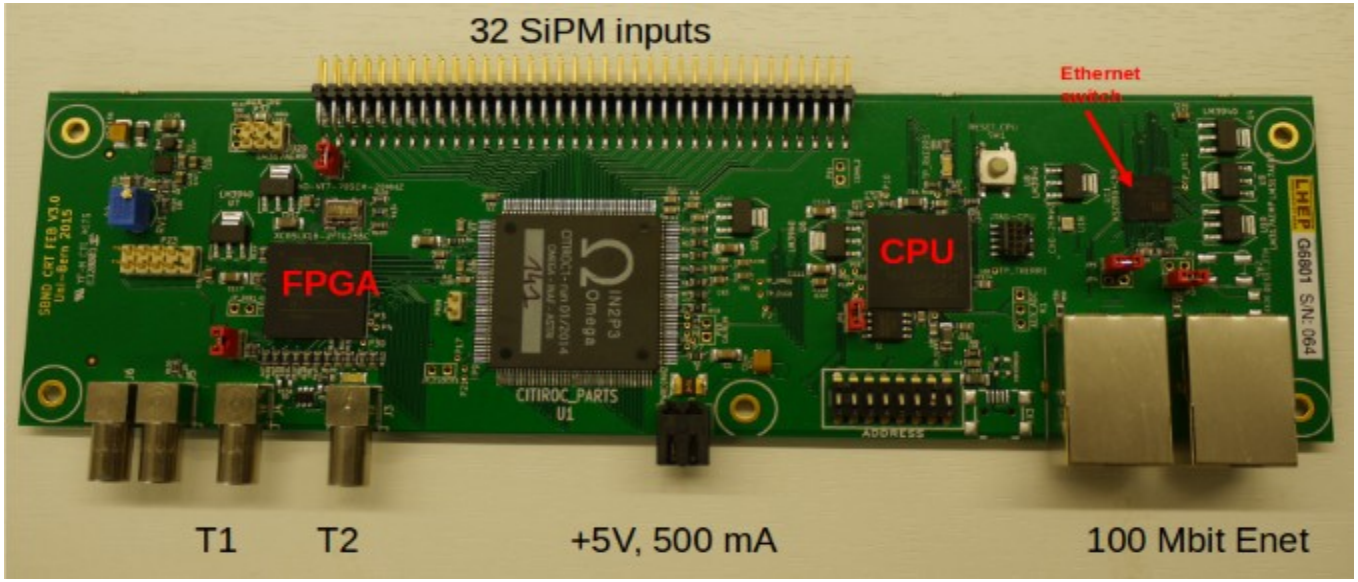
Scintillator: USMS-03 (PS+PTP+POPOP)
Reflective surface (UNIPLAST technology)
WLS fibers: Kuraray Y11(200)MS, 1mm diameter
Optical glue: ESA 7250 polysiloxane compound
SiPM: Hamamatsu S12825-050P

2 SiPMs per strip





CRT Front-End electronic Board (FEB)



CRT Front-End electronic Board (FEB)

Bias voltage 40-90 V, individually adjustable for each of the 32MPPCs

Amplifying and shaping of the MPPC output pulse on each of the 32 channels

Discriminating the shaped signal at a configurable level from 0 to 50 photo-electrons

Signal coincidence from each pair of WLS fibers => trigger

External event validation from other FEB(s) (allows X-Y coincidence)

Time stamp w.r.t. external reference (GPS PPS and BNB RWM), accuracy 1.3 ns RMS

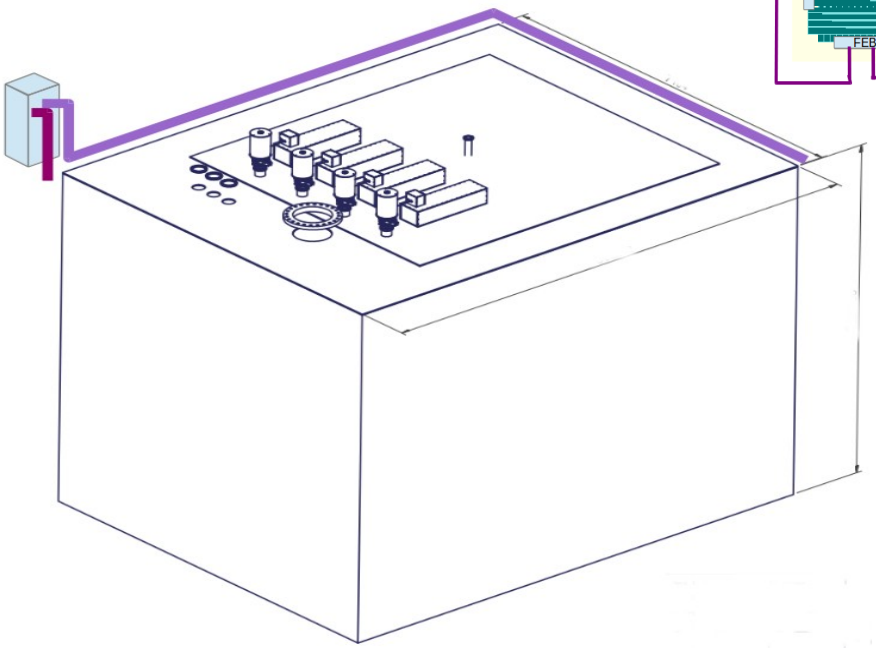
Data buffer for 1024 events

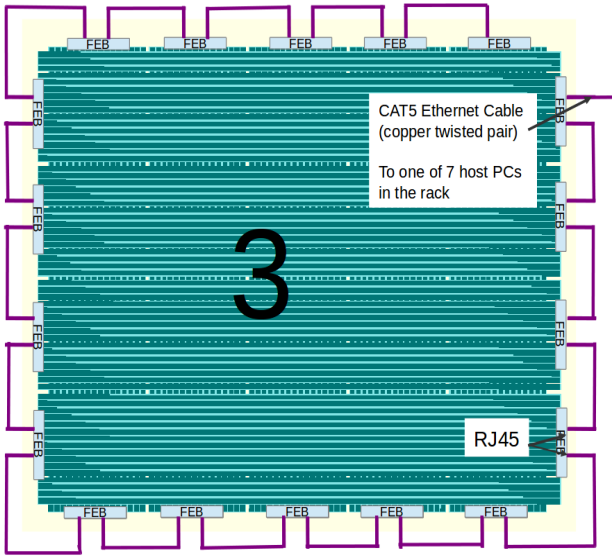
Efficient Ethernet-based back-end communication

Firmware update over Ethernet

CRT DAQ signal distribution

Equipment is distributed over two standard 19" racks





44U Rack

CRT Performance Summary

Muon flux coverage	~ 94%	DocDB 495 R. Guinette et al.
Muon detection efficiency	95% to 99%	DocDB 685 I. Kreslo et al.
Coordinate resolution	< 2 cm (2D)	
Time tag accuracy w.r.t 1 PPS	2-6 ns RMS (electronics: 1.3 ns)	
Amplitude dynamic range	100 p.e. => 3 x MIP Optional: 500 p.e. => 15 x MIP	
S/N ratio for MIP	120	
Detection threshold at S/N=4	70 keV	

Resources

- University of Bern
  - Design and manufacturing of CRT modules and support structure
  - Design and manufacturing of Front-End electronics & DAQ (hardware)
- University of Pennsylvania
  - Design and integration of sub-ns resolution timer mezzanine for CRT FEB
- Illinois Institute of Technology
  - Organization of test stand at FNAL, tests of CRT modules
- CERN
  - Interface with the cryostat external structure
- Fermilab
  - Integration
  - Infrastructure for CRT installation (plane vacuum holder)
  - Design and manufacturing of power and reference signal distribution systems
  - ES&H, Technical Engineering Design Review (TEDR)
  - Safety Engineering Design Review (SEDR)
  - Partial Operation Readiness Clearance (pORC), final ORC
- TUBITAK (Ankara) – provisional, not members yet
  - ES&H

Basis of Estimate (non-DOE expenses)

Task M&S Cost (FY15): **584000**

Task M&S Contingency (% and the contingency rule applied):
25% (M3, M4)

Task Labor (Resource type & work hours or % for duration of task): 12640 hours

Task Labor Contingency (% and the contingency rule applied): 25% and L4

Assumptions:

- See SBN-doc-186 for project key assumptions
- Costs are in FY2015 dollars and do not include indirects.
- Durations are in working days.
- 85% efficiency assumed for labor hours. 1 FTE = 1768 hours for an average year.
- Add your assumptions here for the BOE

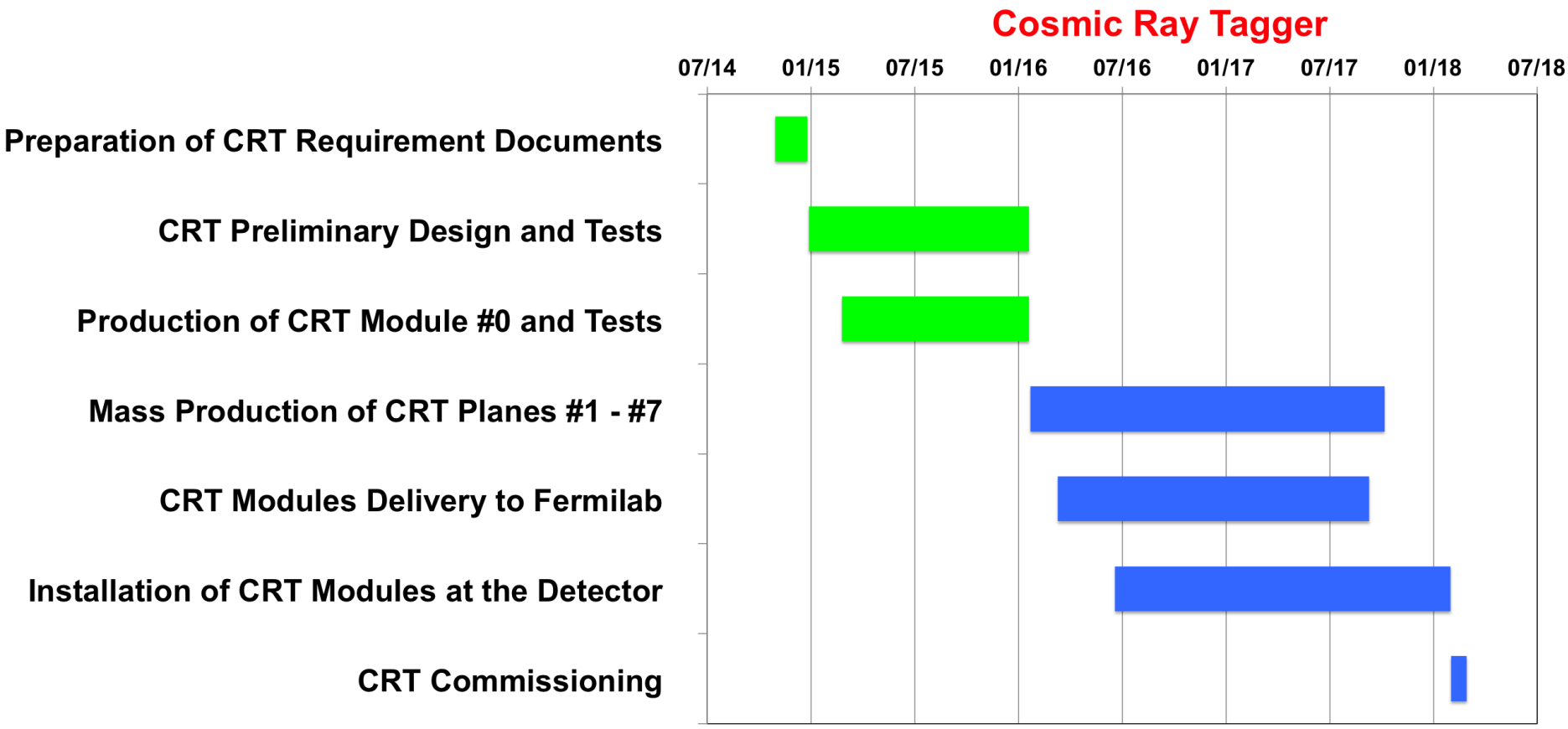
Contingency:

Past experience (OPERA, uBooNE)
Vendor quotes (all components)

Task Table

WBS	WBS Title	Duration (days)	M&S ($)	M&S Contingency (% and rule)	Labor resource and % effort or total hours for each labor resource	Total labors (hours)	Labor Contingency (% and rule)
2.5.1	Cosmic-ray detector engineering design	150	$10 000	30% and M4	Mech. Eng. - 1200 hours; Tech. - 1000 hours	2200	25% and L4
2.5.2	Cosmic-ray detector readout elevtronics design	180	$10 000	30% and M4	Elec. Eng. - 1440 hours; Elec. Tech. - 1000 hours	2440	25% and L4
2.5.3	Fermilab design review - L4 milestone						
2.5.4	Cosmic ray tagger detector and electronics fabrication and assembly	500	$564 000	20% and M3	Mech. Eng. - 4000 hours; Tech. - 4000 hours	8000	25% and L4
2.5.5	Delivery of the cosmic-ray detector for Installation – L4 milestone						
	Total		$584 000			12640	

Schedule


Cosmic Ray Tagger
07/14
01/15
07/15
01/16
07/16
01/17
07/17
01/18
07/18
Preparation of CRT Requirement Documents
CRT Preliminary Design and Tests
Production of CRT Module #0 and Tests
Mass Production of CRT Planes #1 - #7
CRT Modules Delivery to Fermilab
Installation of CRT Modules at the Detector
CRT Commissioning

ES&H, QA

- In accordance with FNAL Environment, Safety and Health Manual (FESHM)
- Electric hazards: SEDR for all custom designed components
- Chemical hazards: MSDS for scintillator, burn test
- Mechanical hazards: TEDR
- Quality Assurance Program:
  - Testing FEBs at LHEP, Bern (done)
  - Testing Modules for light tightness (Bern & FNAL upon delivery)
  - Testing Modules for detection efficiency (Bern & FNAL)

Response to Review Recommendations

SEDR review for the FEB is complete (DocDB 642-v1)

Finding 1.1 -- Alternate conductive path through the chassis metal
Suggestion Acknowledged.
Finding 2.1 -- DC power applied before module is plugged into the SiPM connector
Strong Recommendation Satisfactorily Addressed.
Finding 3.1 -- Module lacks over-current protection
Requirement Satisfactorily Addressed.
Finding 4.1 -- "HV Caution" label required on chassis
Requirement Satisfactorily Addressed.
Finding 4.2 -- Installation procedure for connecting the DC power
Requirement Satisfactorily Addressed.
Finding 4.3 -- HV being inhibited at power-up
Strong Recommendation Satisfactorily Addressed.
Finding 4.4 -- Increase the current-limiting resistor value for the HV output
Strong Recommendation Addressed.

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With the corrections observed with the version 3 module and with the given responses to the findings, no further corrective action is required.

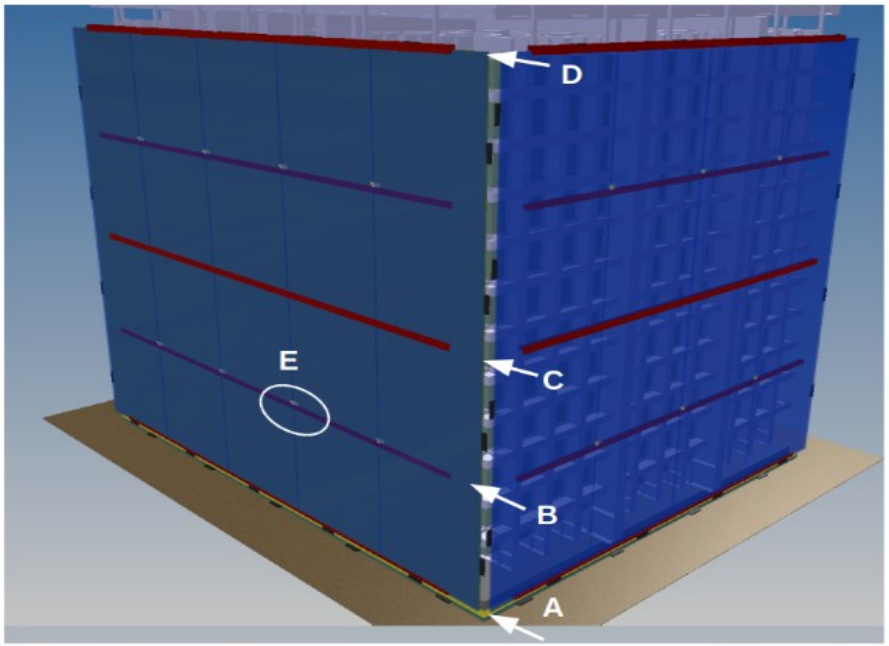
Status of Design

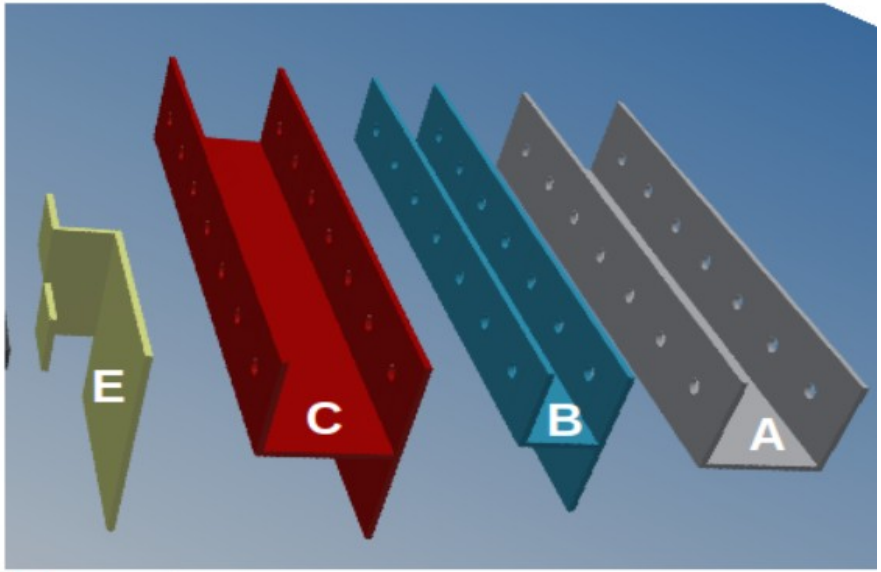
- Design of the system is 100% complete
- 126 required FEBs are manufactured and tested
- Contract with scintillator manufacturer is ready to be signed
- Several full-size Module prototypes are tested in Bern
- Test stand at FNAL is being organized, first tests in beg. 2016

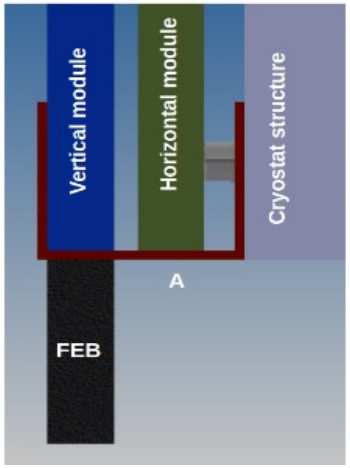
- SEDR for FEB V3.0 is complete
- SEDR for Clock unit – to be done
- TEDR and Production Readiness Review (PRR) are scheduled for 1st week of February 2016

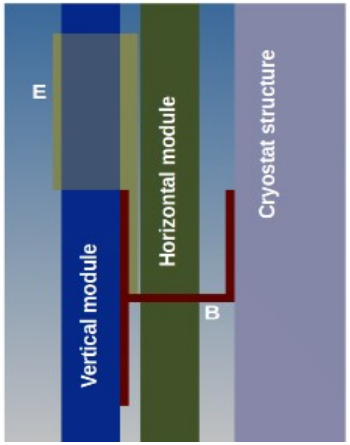
- After reviews - ready for mass production

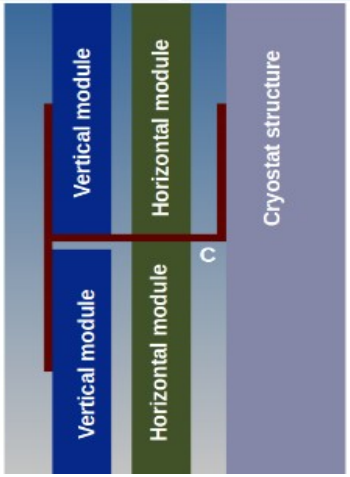
Backup: CRT-Cryostat interfaces

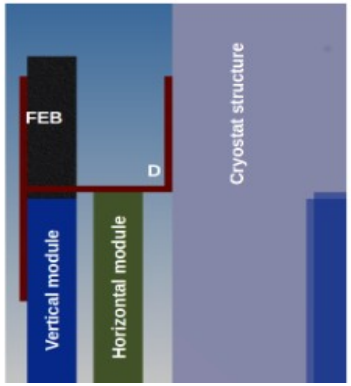


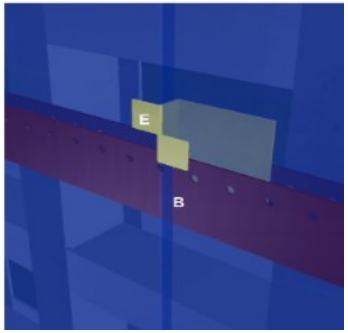




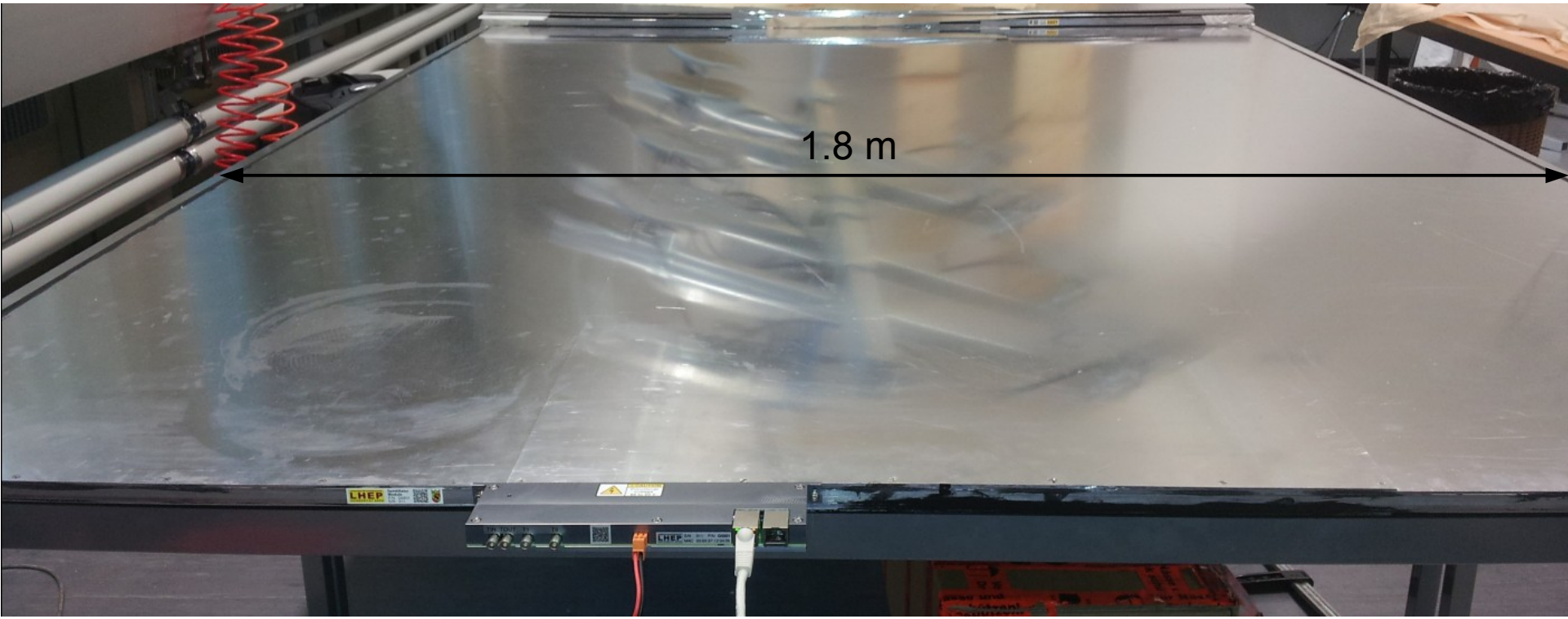


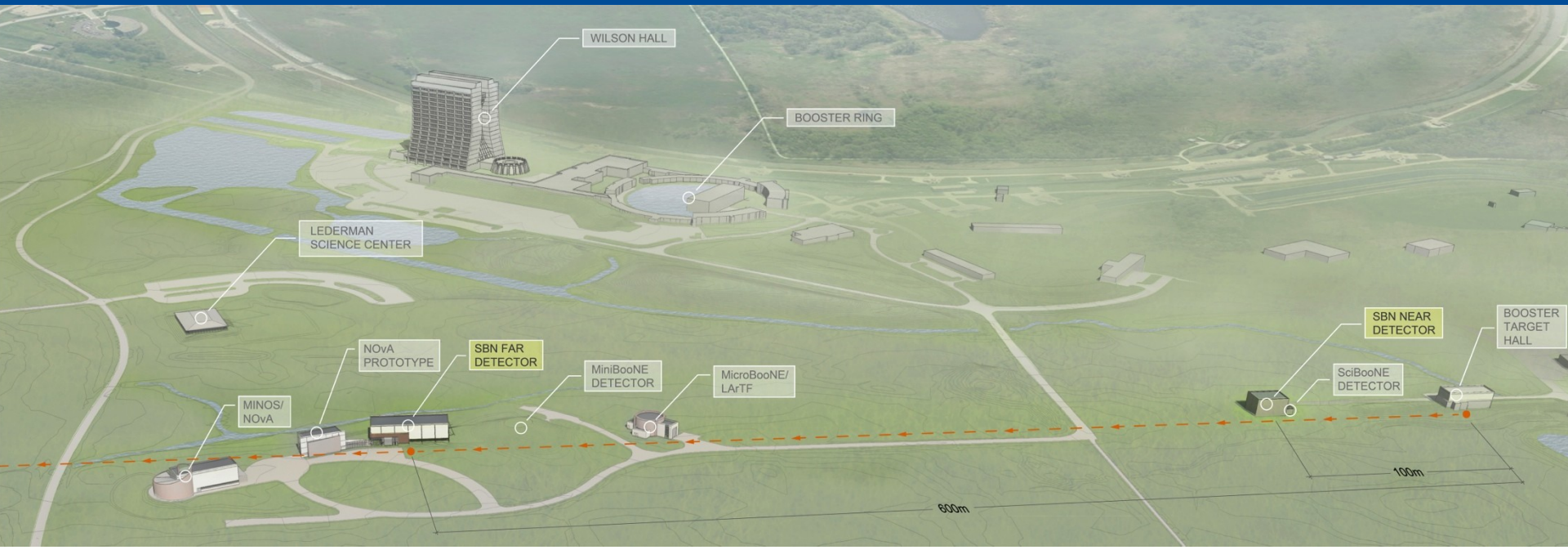






Backup: Module with attached FEB





SBND Laser Calibration System

Igor Kreslo

Director's Progress Review of SBN

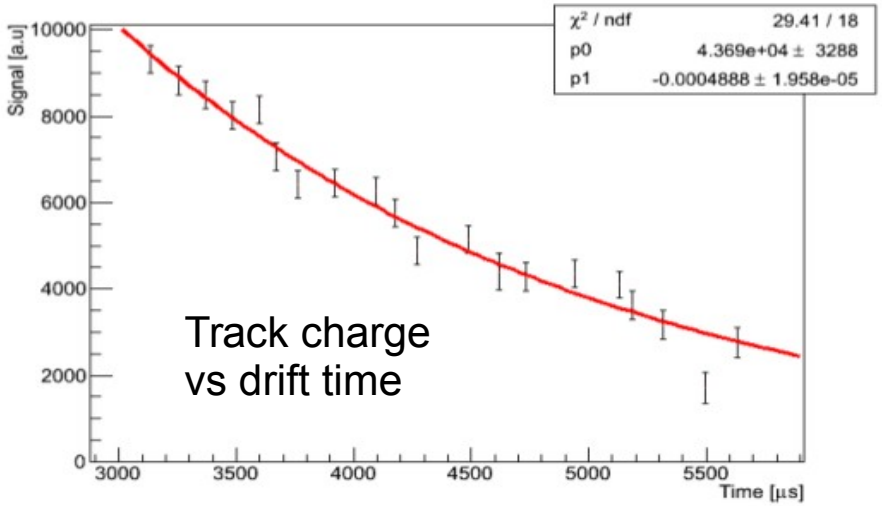
15-17 December 2015

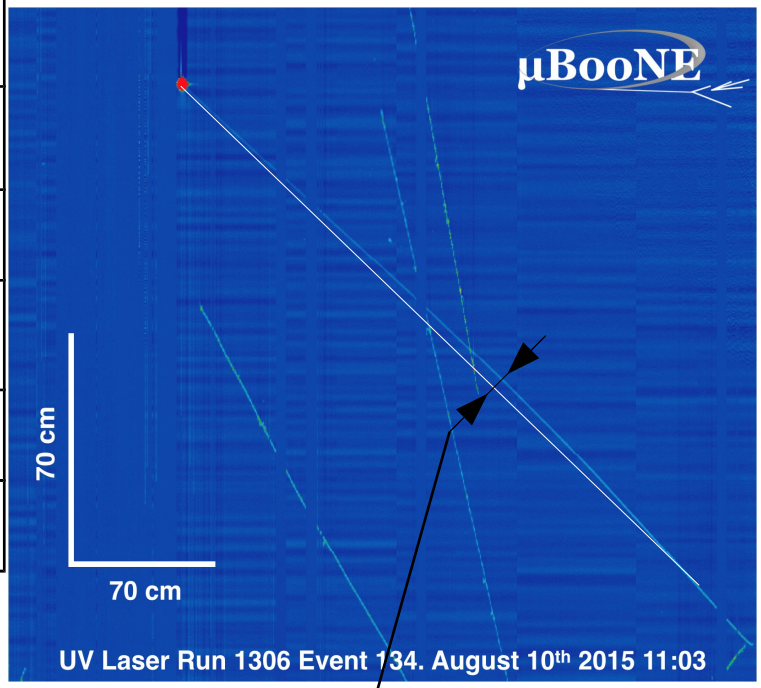
Outline

- System Overview
- Interfaces
- Resources
- Basis of Estimate
- Schedule and Cost Summary
- ES&H and QA
- Status of design

System Requirements

Providing straight ionization tracks across the TPC for field calibration and LAr purity monitoring		
Volume coverage	> 80 %	2 crossing beams
Ionization density	1 to 10 x MIP	
Angular steering accuracy	0.5 mrad	
Repetition rate	< 10 Hz	
Trigger to TPC		

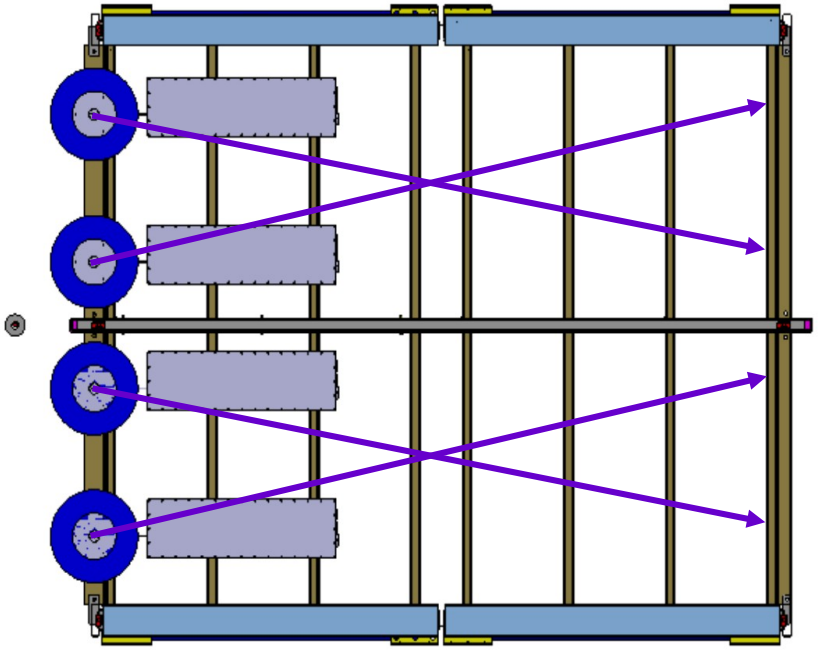


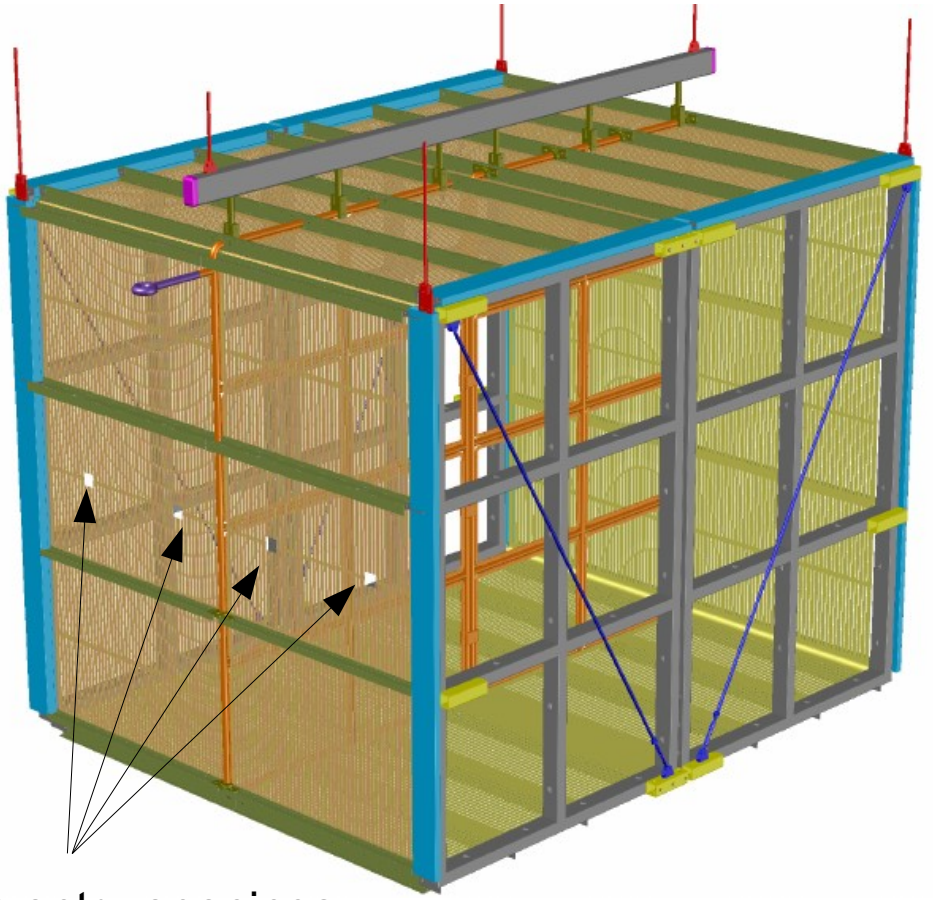


uBooNE: deviation of the track from straight line corresponds to simulation of the drift field

LCS global view

TPC cage top view





Laser beam entry openings

LCS beam steering rotating head optical scheme

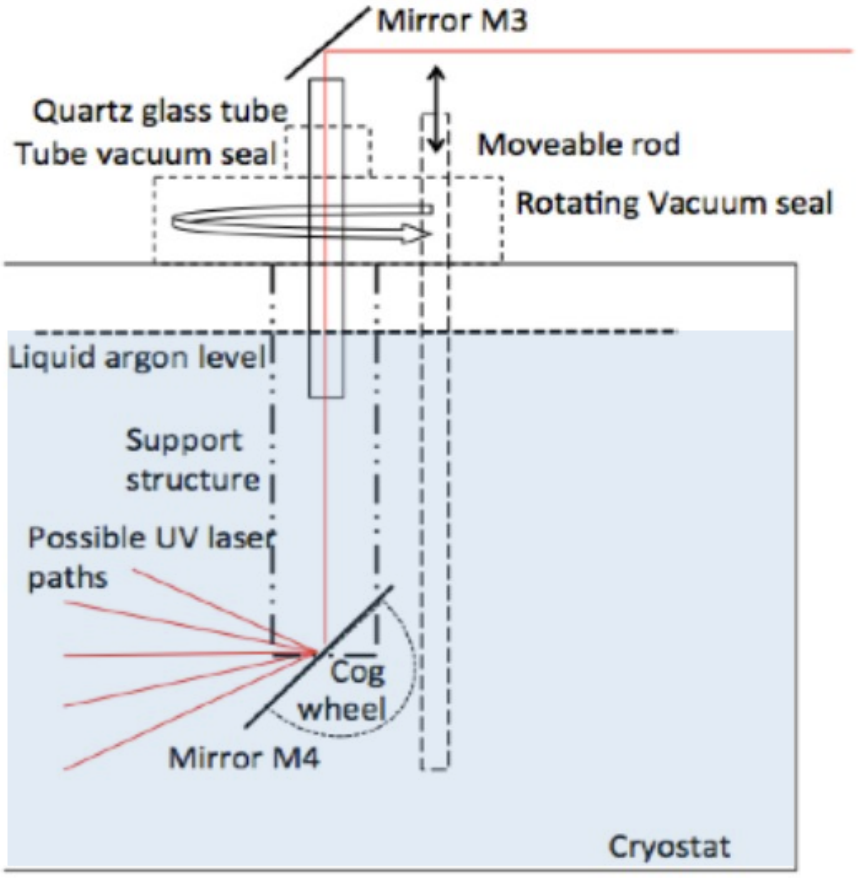
Beam deflection in vertical plane:
+90°, -45°

Beam deflection in horizontal plane:
+90°, -90°

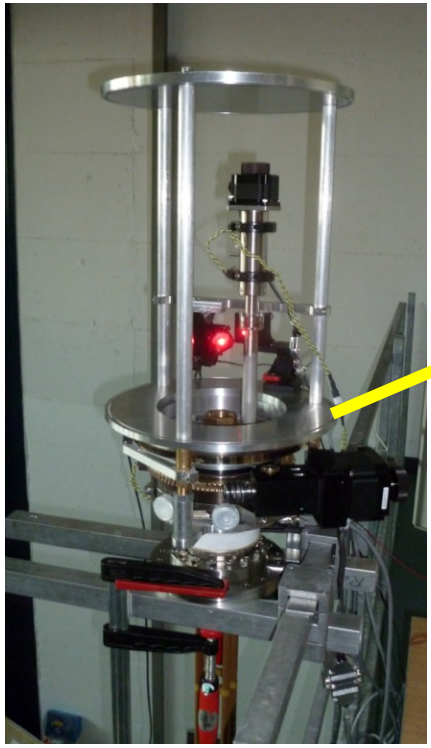
Beam diameter: ~ 5mm

Wavelength: 266 nm

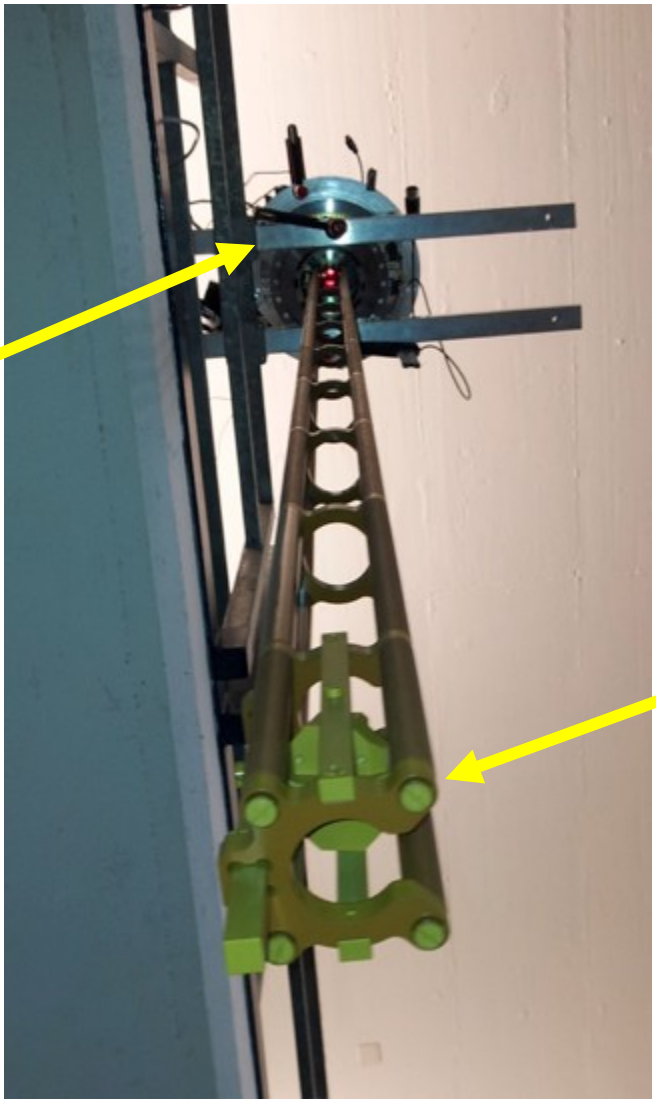
Beam power: 2 MW

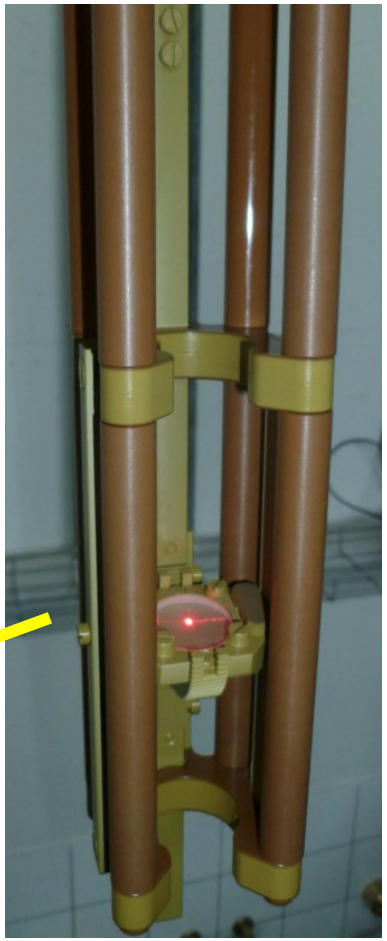


LCS beam steering rotating head



Warm head



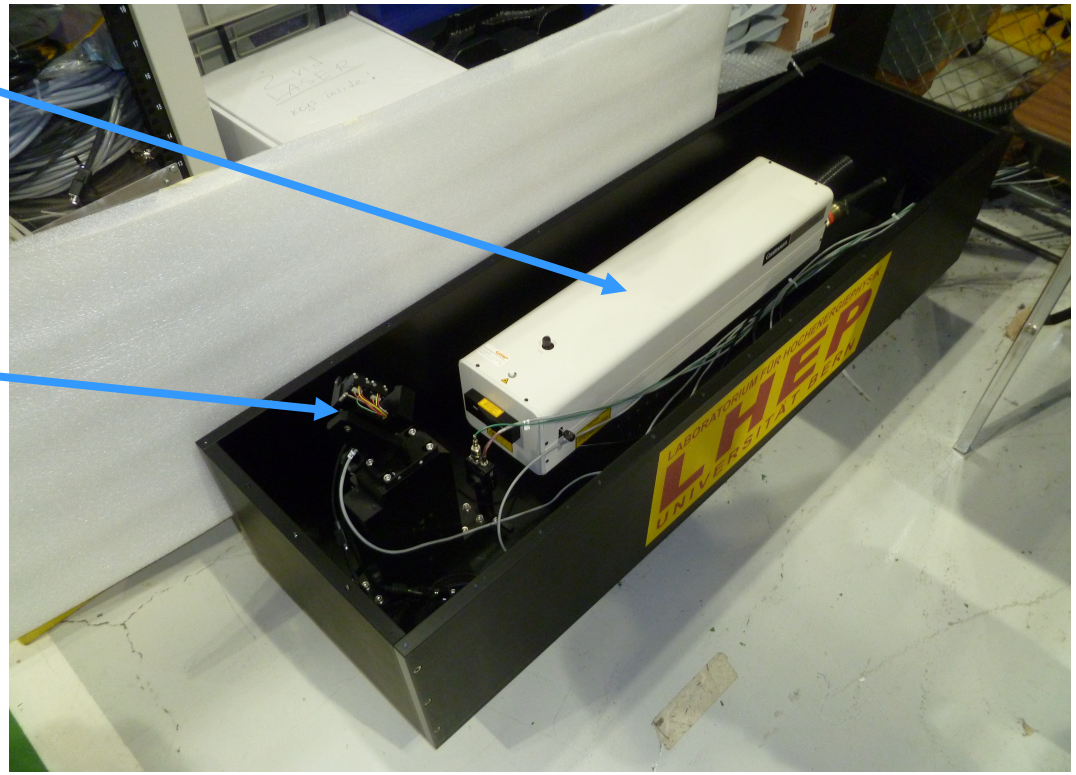


Cold mirror

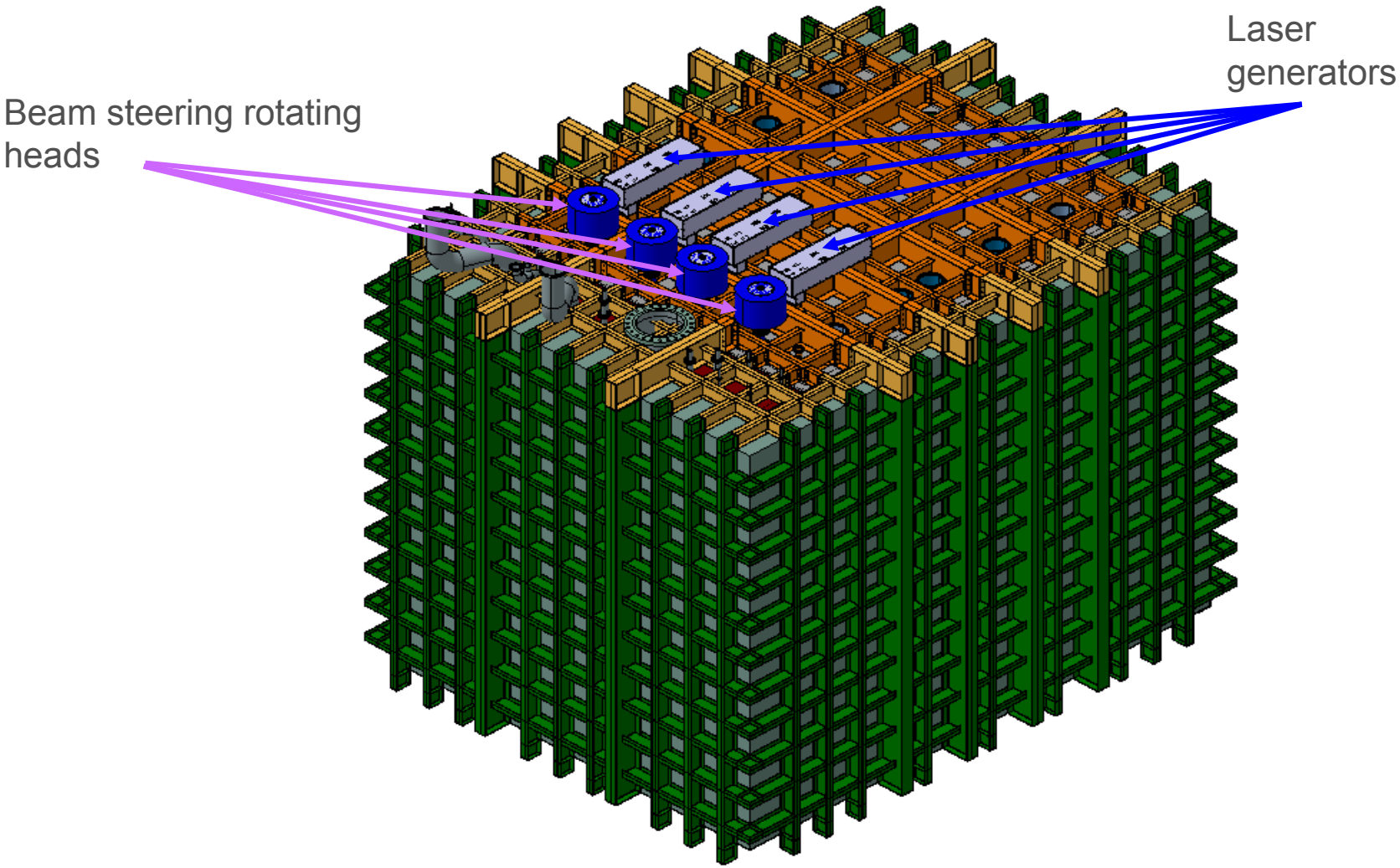
LCS laser generator (Class IV)

Continuum Surelight I-10
Nd:YAG pulsed laser
Rep. rate up to 10 Hz
Two frequency-doubling stages
Output beam: 266 nm , 60 mJ, 5 ns.

Beam conditioning optics
266 nm filter
Attenuator
Diaphragm
Steered exit mirror



LCS - cryostat integration



Resources

University of Bern
Design and manufacturing of LSC components

CERN
Interface with the cryostat cryostat top flange

BNL
Interface with the TPC structure

Fermilab
Infrastructure for LCS installation
Design and manufacturing of power and signal distribution systems
Technical Engineering Design Review (TEDR)
Safety Engineering Design Review (SEDR)
Partial Operation Readiness Clearance (pORC)
Operation Readiness Clearance (ORC)

Basis of Estimate (non-DOE costs)

Task M&S Cost (FY15)**: 420000** **Task M&S Contingency** (% and the contingency rule applied)**:** **20 % (M3, M4)**	**Task Labor** (Resource type & work hours or % for duration of task)**:** **Task Labor Contingency** (% and the contingency rule applied)**:**

Assumptions:

- See SBN-doc-186 for project key assumptions
- Costs are in FY2015 dollars and do not include indirects.
- Durations are in working days.
- 85% efficiency assumed for labor hours. 1 FTE = 1768 hours for an average year.
- Add your assumptions here for the BOE

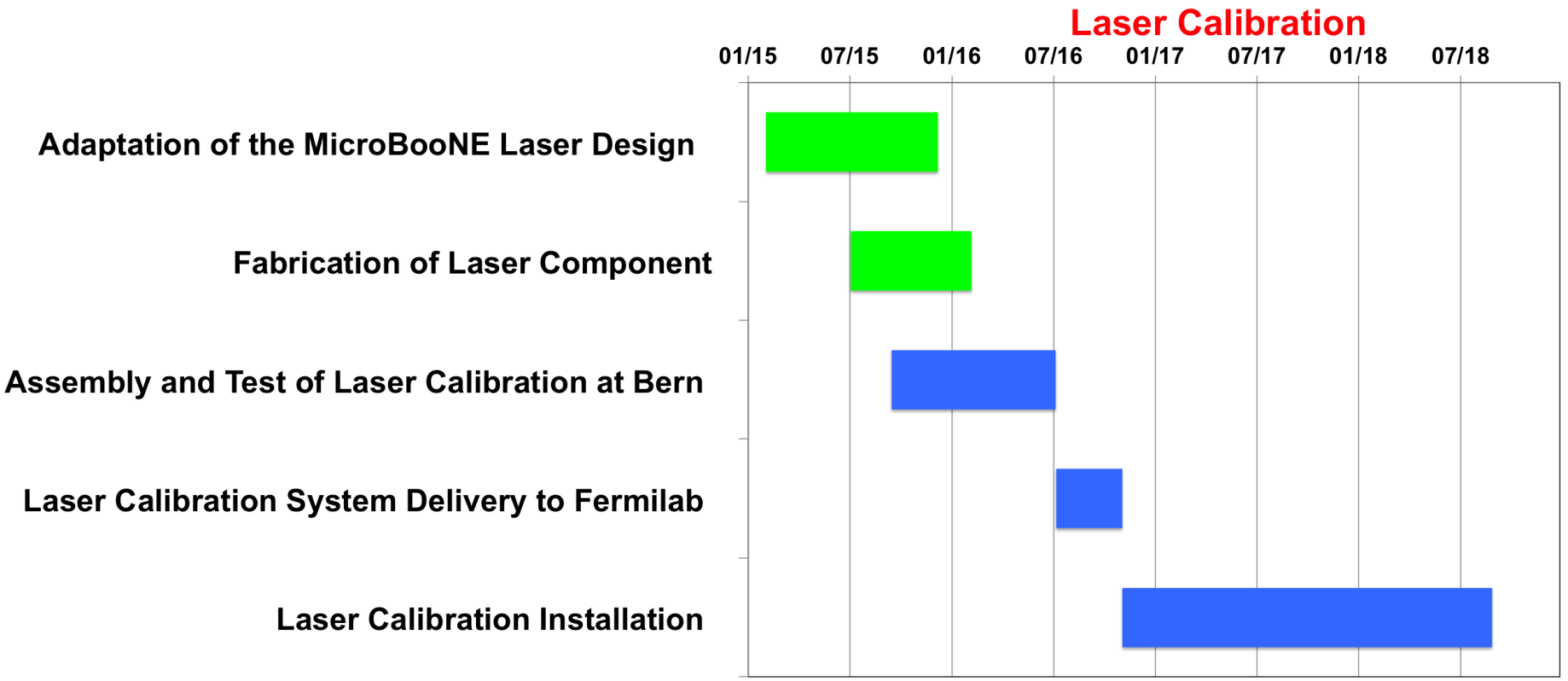
Contingency:

Past experience (uBooNE)
Vendor quotes (all components)

Task Table

WBS	WBS Title	Duration (days)	M&S ($)	M&S Contingency (% and rule)	Labor resource and % effort or total hours for each labor resource	Total labors (hours)	Labor Contingency (% and rule)
2.3.6.1	Adaptation of the MicroBooNE LCS to LAR1ND cryostat	150	$10,000	30% and M4	Mech. Eng. - 400 hours;	400	25% and L4
2.3.6.2	Fabrication of components of LCS	450	$410,000	20% and M3	Mech. Eng. - 2400 hours; Tech. - 1000 hours	3400	15% and L3
	Total		$420,000			3800	

Schedule


Laser Calibration
01/15
07/15
01/16
07/16
01/17
07/17
01/18
07/18
Adaptation of the MicroBooNE Laser Design
Fabrication of Laser Component
Assembly and Test of Laser Calibration at Bern
Laser Calibration System Delivery to Fermilab
Laser Calibration Installation

ES&H, QA

- In accordance with FNAL Environment, Safety and Health Manual (FESHM)

- ES&H considerations:
  - Electrical hazard: SEDR for all custom designed components
  - Laser hazard: SEDR, pORC (Class IV laser)
  - Control rack: pORC
  - Bench pressure test, cryostat pressure test (Fermilab standards)

- Quality Assurance Program:
  - Beam parameters test at the test stand
  - Vacuum leak test

Status of Design

- Almost identical system is in operation in uBooNE
- Design adaptation to SBND is complete

SEDR (similar to uBooNE): to be done
TEDR and Production Readiness Review (PRR) are scheduled for beginning of 2016

After reviews - ready for manufacturing

Backup : optional LCS arrangement