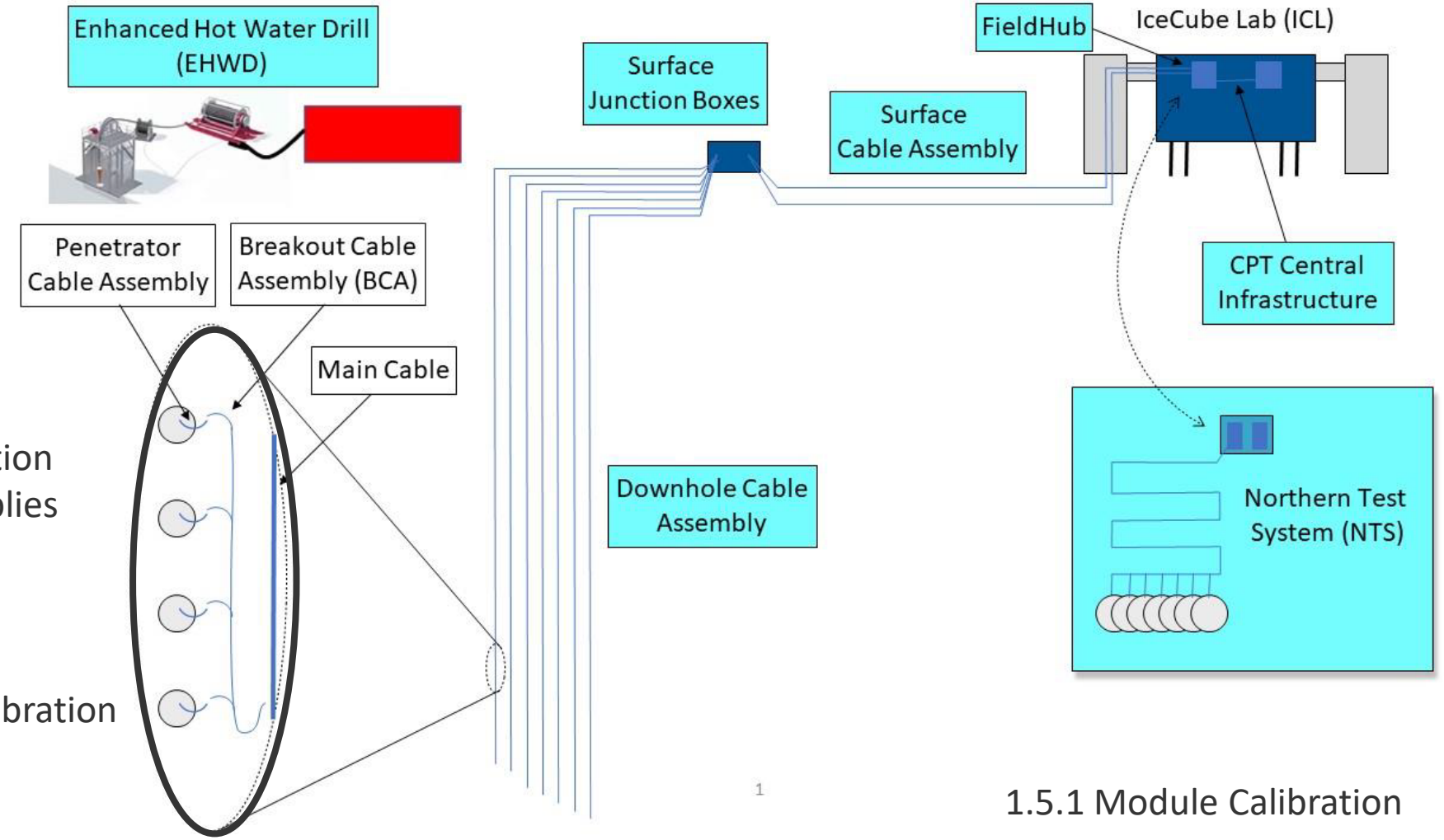
IceCube Upgrade NSF Rebaseline Review
April 26-28, 2022

Dawn Williams, University of Alabama
WBS 1.5: Calibration and Characterization

Brief Bio

- Professor in the Department of Physics and Astronomy at the University of Alabama, IceCube member since beginning of Gen1 construction in 2004
- Extensive experience with IceCube flasher LED calibration system
- Lead of the IceCube Calibration Working Group from 2012 to 2017, starting again May 2022
- IceCube Analysis Coordinator from 2017-2019
- Level 2 Lead for Calibration and Characterization for the IceCube Upgrade, 2018-present
- Level 2 Lead for Calibration and Commissioning for IceCube-Gen2

1.5 Calibration and Characterization area



1.5 Characterization & Calibration

- 1.5.1. Module Calibration
- 1.5.2.Calibration Assemblies
- 1.5.3. Array Calibration
- 1.5.4. Calibration Management

WBS 1.5 Deliverables

- WBS 1.5.1: Module Calibration, L3: Matt Kauer, UW Madison
  - Deliverable is a usable database of calibration constants which can be incorporated into simulation and analysis
- WBS 1.5.2: Calibration Assemblies, L3: Elisa Resconi, TU Munich
  - See next slide
- WBS 1.5.3: Array Calibration, L3: Summer Blot, DESY
  - Deliverable is calibration constants for the deployed array
- WBS 1.5.4: Calibration Management, Dawn Williams, U. Alabama
  - Coordinate all calibration elements, organize reviews, monthly reports, oversee schedule and budget for on-project costs

WBS 1.5.2 Deliverables

WBS 1.5.2 Calibration Assemblies L3: Elisa Resconi, TU Munich	1.5.2.1: Onboard LED Flashers L4: Jack Nuckles, UW Madison	1.5.2.1.1: D-egg flashers (Chiba)
		1.5.2.1.2: mDOM flashers (Mainz)
	1.5.2.2: Standalone Light Sources L4: Elisa Resconi, TU Munich	1.5.2.2.1: POCAM (TU Munich)
		1.5.2.2.2: PencilBeam (UW Madison)
	1.5.2.3: Camera and Light Detection L4: Carsten Rott, SKKU → Utah	1.5.2.3.1: Cameras in Photosensors (Utah)
		1.5.2.3.2: Sweden Camera 2.0 (Stockholm U.)
	1.5.2.4: Acoustic Sensors L4: Christopher Wiebusch, RWTH Aachen	
	1.5.2.5: Inclinometers and Compasses L4: Mike Duvernois, UW Madison	
	1.5.2.6: Mini-Mainboard L4: Christoph Guenther, RWTH Aachen	

WBS 1.5.2 Deliverables

1. Upgrade timing and geometry measurements
2. DOM optical efficiency determination *in situ* to better than 3%
3. 2x reduction in uncertainty due to refrozen hole ice
4. Determine the source and depth dependence of anisotropy in optical scattering in bulk ice
5. Measure acoustic properties of bulk ice for Gen2
6. Measure properties of ice below IceCube instrumented volume
7. Calibration devices which are fully integrated into DAQ and experiment control

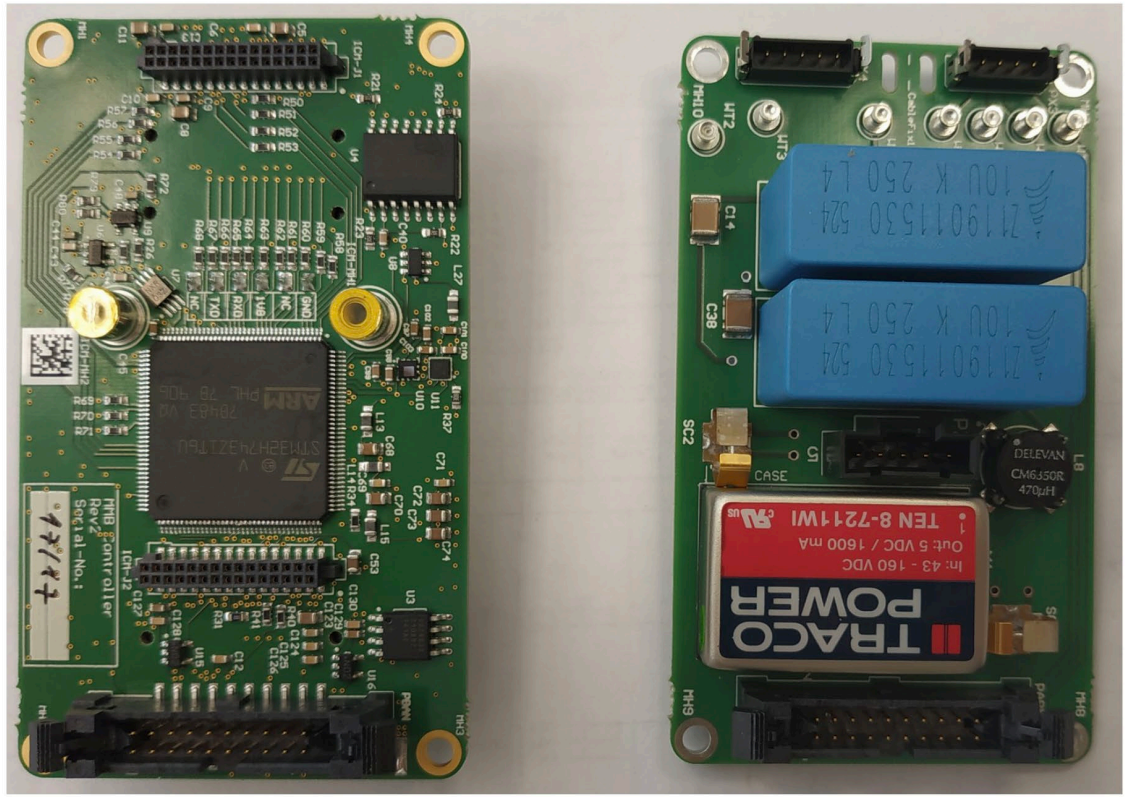
Device	Goal	Number + spares
Cameras (SKKU/Utah)	3	All mDOMs/Deggs/pDOMs
Flashers (Mainz/Chiba)	1, 6	All mDOMs/Deggs/pDOMs
POCAM (TUM)	2, 3, 6	21 + 4
PencilBeam (UW)	4, 6	11 + 2
Acoustic Modules (Aachen)	1, 5, 6	10 + 2
Sweden Camera 2.0 (Stockholm U.)	3	5 + 2
Mini-mainboard (RWTH Aachen)	7	116 + 14

Nearly all hardware and design effort is contributed/in-kind

Current Technical Status and Work to Go

- Flasher and camera production for D-eggs complete, underway for mDOMs, testing is underway with good results so far
- Standalone calibration modules (POCAM, PencilBeam, Acoustic Module, Sweden Camera) have all passed preliminary design review
- Mini-mainboard Rev2 first articles are in the hands of all standalone module design teams, Rev3 design is underway, with Rev3 first articles expected by July 2022
- We still need to procure the winch for the dustlogger (to be borrowed from IceDrill Project)

Current Technical Status and Work to Go



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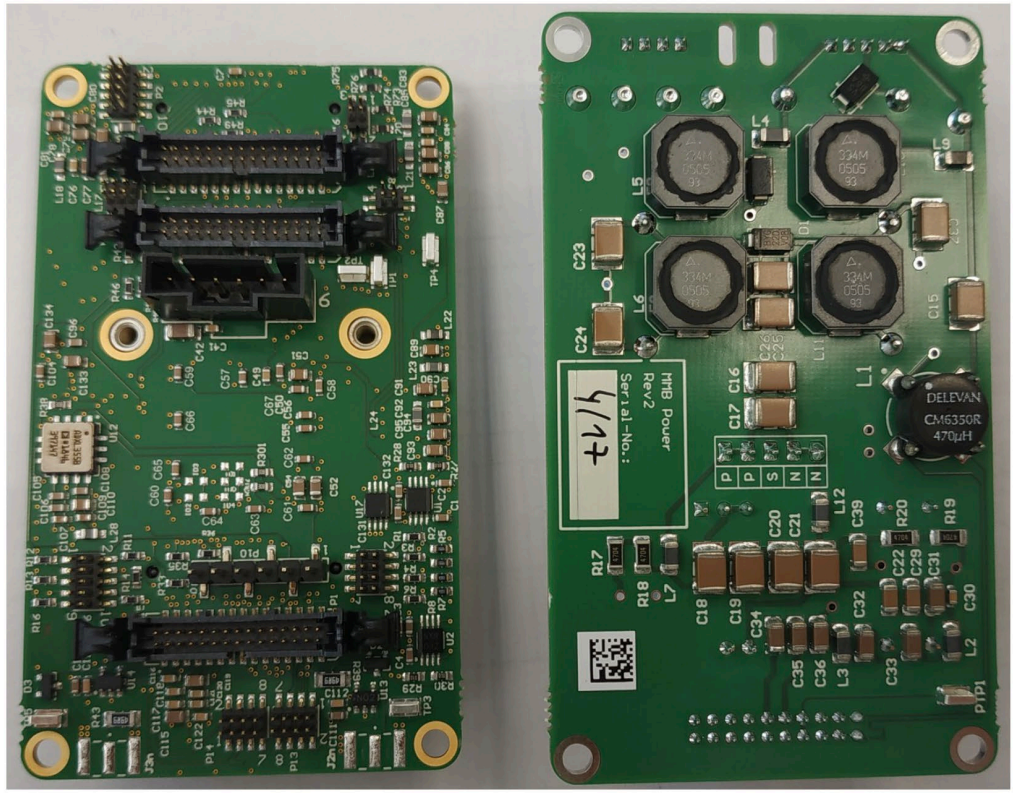


Bottom

Mini-mainboard Rev2 (Christoph Guenther, RWTH Aachen)

Mini-mainboard Rev2 first articles are being tested and a change list for the Rev3 is being developed, components are being purchased ahead of order

Interfaces

- WBS 1.5.2.1 (LED Flashers) and WBS 1.5.2.3.1 (Cameras in Photosensors) interface to WBS 1.3 (Sensors)
  - installed in D-egg, in process of being installed in mDOM
- WBS 1.5.2.2.1 Precision Optical Calibration Module (POCAM), 1.5.2.2.2 (PencilBeam), WBS 1.5.2.3.2 (Sweden Camera), 1.5.2.4 (Acoustic Modules) interface to 1.2.9 (Installation – Off Ice) and 1.2.10 (Installation Field Seasons – Antarctica)
  - These are standalone modules which are attached to strings alongside sensors
- All of the above standalone module WBS areas and WBS 1.5.2.6 (Mini-mainboard) interface with WBS 1.6.1.1.2 (DAQ Interface to Standalone Calibration Devices), 1.6.1.2.2 (Exp. Control Interface to Standalone Calibration Devices), 1.6.1.4.6 (MMB Support Software),
- WBS 1.5.3 Array Calibration interfaces with 1.6.3.2 Calibration Device Simulation

L2 Milestones

Primary	WBS	Milestone
Delivery of Camera mDOM to DESY Completed	1.5.2.3.1.2.19	Delivery of Camera mDOM to DESY Completed
MMB Rev3 delivered	1.5.2.6.10	MMB Rev3 delivered
POCAM Design complete, Final Design Review	1.5.2.2.1.4	POCAM Design complete, Final Design Review
Sweden Camera Final Design Review	1.5.2.3.2.3	Sweden Camera Final Design Review
Acoustic Design complete, Final Design Review	1.5.2.4.6	Acoustic Design complete, Final Design Review
Delivery of Camera mDOM to MSU Completed	1.5.2.3.1.2.34	Delivery of Camera mDOM to MSU Completed
Pencil Beam Final Design Review	1.5.2.2.2.4	Pencil Beam Final Design Review
POCAM ready to ship	1.5.2.2.1.8	POCAM ready to ship
PencilBeam Batch 1 Ready to Ship	1.5.2.2.2.11	PencilBeam Batch 1 Ready to Ship
Sweden Camera Ready to Ship	1.5.2.3.2.5	Sweden Camera Ready to Ship
Acoustic Modules Ready to Ship	1.5.2.4.10	Acoustic Modules Ready to Ship
PencilBeam Batch 2 Ready to Ship	1.5.2.2.2.12	PencilBeam Batch 2 Ready to Ship
Dust Logger and IDP Winch - Ready to Ship	1.5.3.5.2	Dust Logger and IDP Winch - Ready to Ship
Delivery of Preliminary Timimg and Geometry Calibration	1.5.3.3.4	Delivery of Preliminary Timimg and Geometry Calibration
Preliminary Delivery of Dust Logger Data	1.5.3.5.5	Preliminary Delivery of Dust Logger Data

L2 Milestones

- July 2022 – Mini-mainboard Rev3 first articles delivered
- September 2022 – POCAM Final Design Review
- October 2022 – Sweden Camera 2.0 Final Design Review
- November 2022 – Acoustic Module Final Design Review
- March 2023 – PencilBeam Final Design Review
- Fall 2024: Delivery of string 87-88 modules
- Fall 2025: Delivery of string 89-93 modules

Cost and Main Cost Drivers

- Most costs are in-kind
- Management of PencilBeam engineering effort at UW Madison: $119,503.03
- Dust logger and winch testing and shipping: $42,336.19
- Postdoctoral researchers to support calibration: $551,492.07
- Calibration management (salary and travel for L2 lead): $87,813.40
- Total: $801,144.69

Risks

Associated WBS	Risk Description	Risk Title	Risk Origin Date	Last modified Date	Risk Retirement Date	Risk Probability	Impact on schedule	Impact on cost	Impact on technical performance	Schedule Risk Score	Cost Risk Score	Technical Performance Risk Score
	1.5 Characterization and Calibration System											
1.5.2.6	Mini Mainboard may be delayed due to components availailability/supply chain issues	MMB delay	1/27/2022	2/28/2022		Moderate	High	Low	High	High	Moderate	High
1.5.3.5	Dust Logger winch cannot be borrowed from IDP, or IDP is unable to fix it, and a new winch needs to be procured	Dust Logger Winch Procurement	1/27/2022	2/28/2022		Moderate	Low	Moderate	Moderate	Moderate	Moderate	Moderate

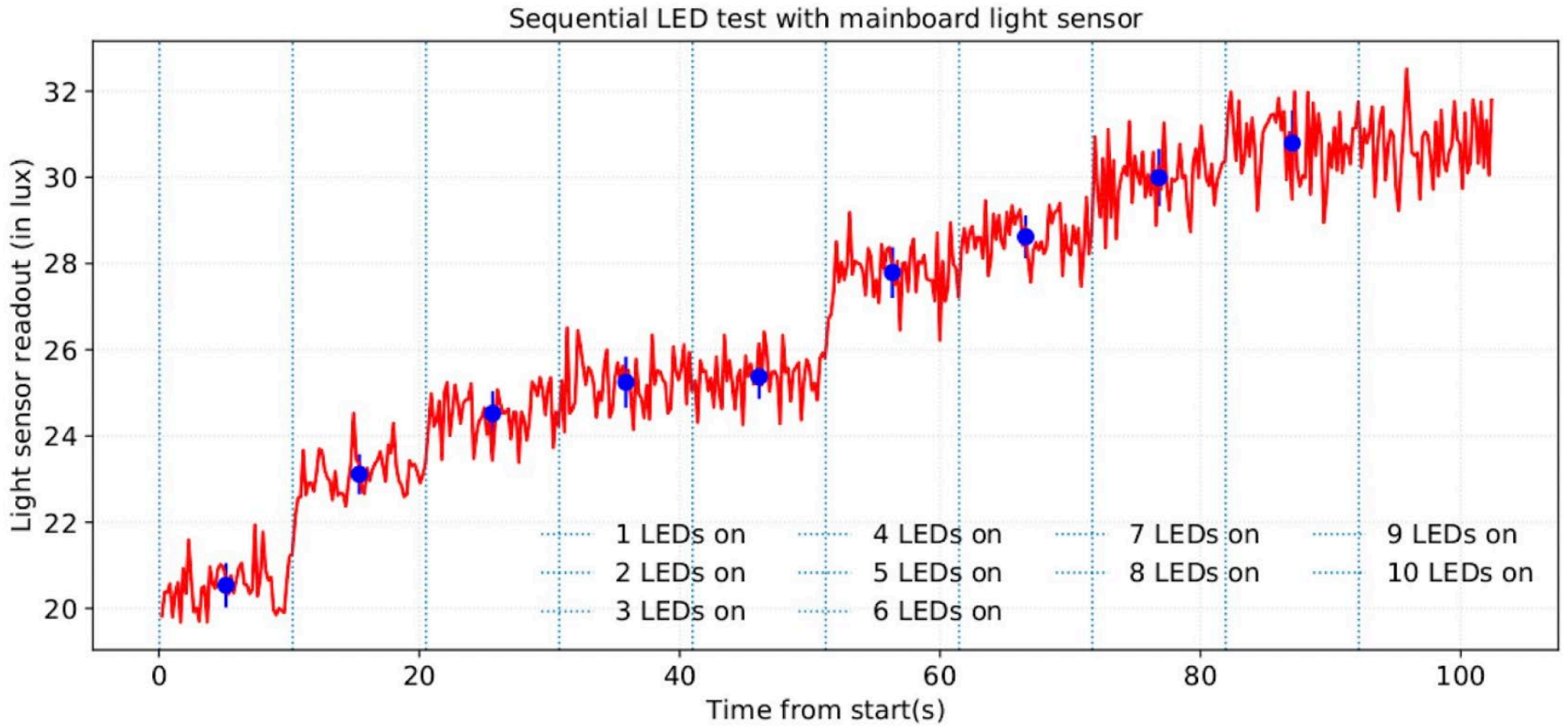
- Major risks
  - Mini Mainboard may be delayed due to components availability and supply chain issues
  - Dust logger winch may not be able to be procured from the IceDrill Project

Conclusion

- Calibration devices onboard mDOMs and D-eggs are in an advanced state, no impediments to integration or module production
- All standalone calibration devices have passed preliminary design review and we expect the Rev3 (final) first articles of the mini-mainboard to be delivered in time for final design reviews
- Electronics components availability remains a concern
- All calibration device teams are highly experienced and are strongly committed to delivering the calibration physics goals promised by the Upgrade

Backup

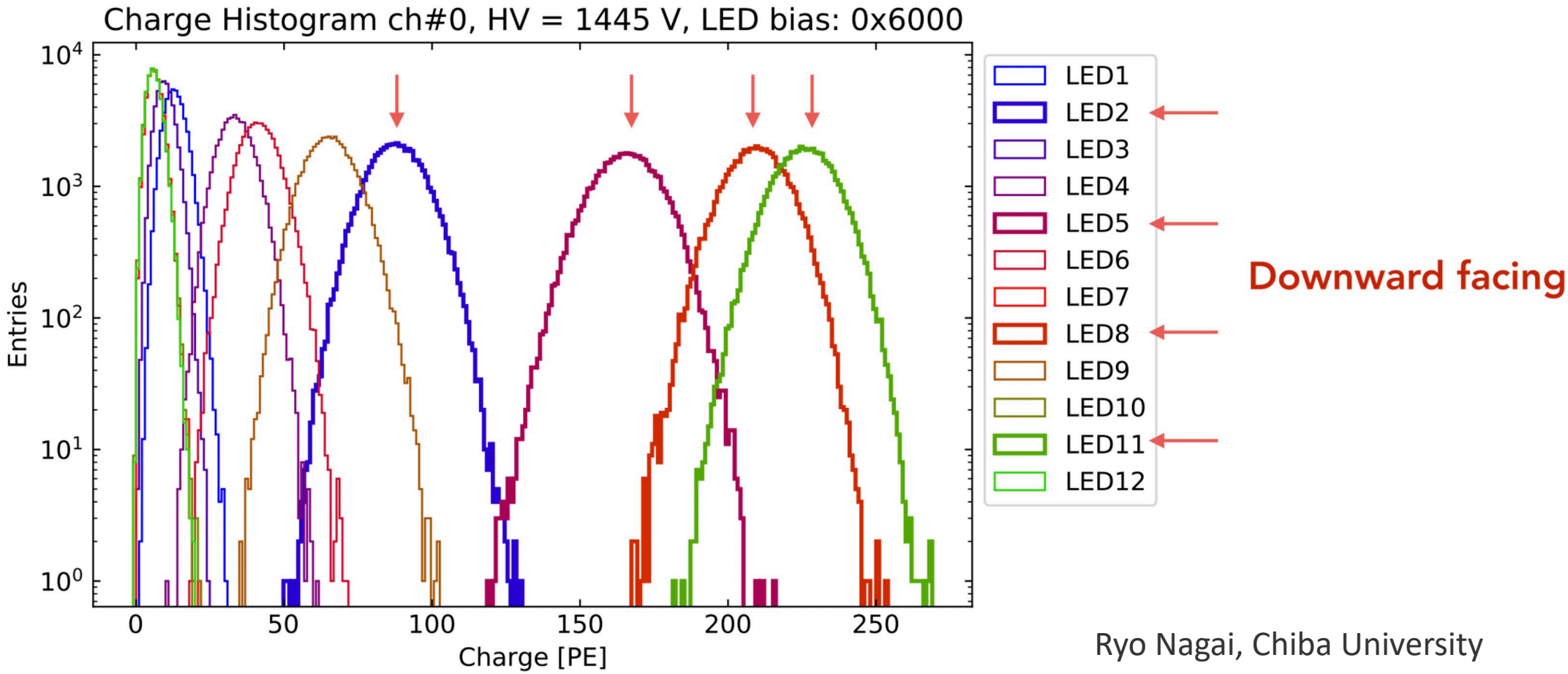
Current Technical Status and Work to Go



Sarah Mechbal, DESY Zeuthen

Flashers have been successfully tested on the mDOM

Current Technical Status and Work to Go



Ryo Nagai, Chiba University

Flashers have been successfully tested on the D-egg

Current Technical Status and Work to Go

Camera firmware and software has been updated to correct issues with mDOM camera readout.

Kalle Sulanke, DESY-Zeuthen