IceCube Upgrade
Calibration and Characterization

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WBS 1.5
ICNO/Upgrade Project - NSF Site Visit Review
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IceCube Upgrade

Outline: WBS 1.5 Calibration and Characterization

- Scope **and** Organization
- Deliverables and Key Requirements
- Schedules, Milestones and Key Activities
- Cost Estimate and In-Kind Contributions
- Technical Progress
- Risks and Mitigation
- Remaining Issues and Challenges
- Summary

WBS 1.5 Scope

- This category is responsible for calibrating and characterizing the detector, which consists of both modules and ice. The deliverables are well characterized modules which meet the high level design requirements of the IceCube upgrade for stability and performance, and improved measurements of the modules and the ice relative to our current knowledge of the detector.

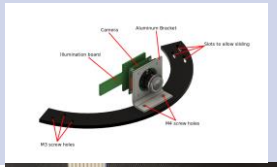
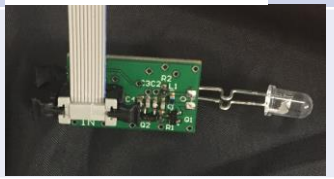
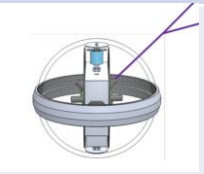
- L2 Lead: Dawn Williams, University of Alabama

WBS 1.5 Organization

- 1.5.1: Module Calibration/ L3 Lead Matt Kauer, UW Madison
  - Individual module response in the lab and after deployment.
- 1.5.2: Calibration Assemblies/ L3 Lead Elisa Resconi, TU Munich
  - Design, testing, production and integration of devices whose purpose is calibration of modules, the ice or both.
- 1.5.3: Array Calibration/ L3 Lead Summer Blot, DESY Zeuthen
  - Characterization and calibration of the deployed array.
- 1.5.4: Calibration Management

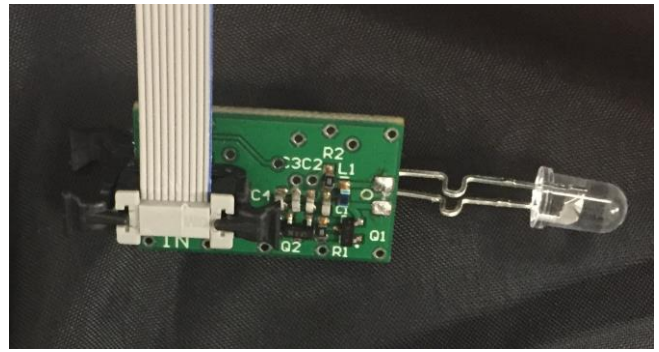
WBS 1.5 Goals and Deliverables

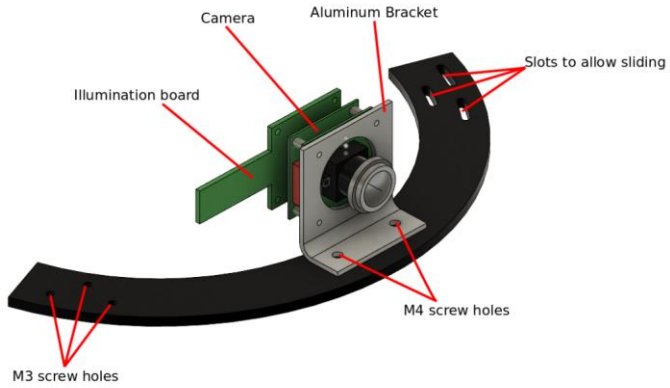
- Upgrade timing and geometry measurements
- DOM optical efficiency determination in situ to better than 3%
- 2x reduction in uncertainty due to refrozen hole ice
- Determine the source and depth dependence of anisotropy in optical scattering in bulk ice
- Measure acoustic properties of bulk ice for Gen2
- Measure properties of ice below Gen2 instrumented volume for Gen2

Device	Goal
Cameras 	3
Flashers 	1, 6
POCAM 	2, 3, 6
PencilBeam 	4, 6
Acoustic Modules 	5, 6

WBS 1.5 Deliverables: Calibration Devices in DOMs

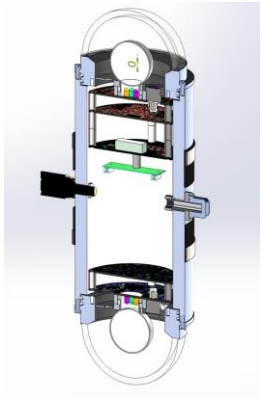
- 1.5.2.1: LED Flashers: common LED and driver circuit
  - 8 horizontal and 4 vertical LEDs per D-egg
  - 8 outward and 2 vertical (1 up, 1 down) per mDOM
- 1.5.2.3: Cameras
  - 3 cameras and 3 camera illumination boards per D-egg and mDOM
- 1.5.2.5: Mainboard-mounted slow control (I2C) devices: accelerometer, magnetometer, pressure sensor

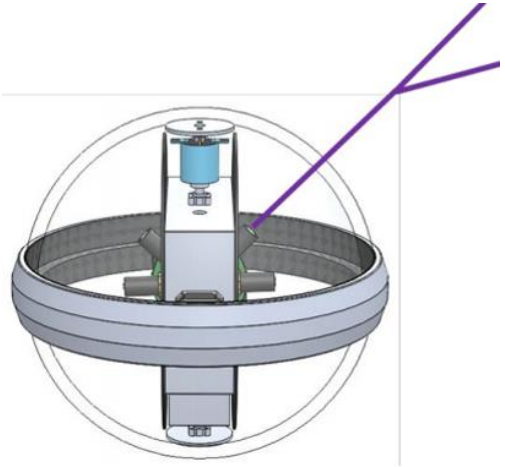




WBS 1.5 Deliverables: Standalone Devices

- 1.5.2.2.1: 21 Precision Optical Calibration Modules (isotropic)
- 1.5.2.2.2: 11 PencilBeam Calibration Modules (collimated, steerable)
- 1.5.2.4: 10 Acoustic Sensor+Receiver Modules
- 1.5.2.7: Common mainboard (“mini-mainboard”) for POCAM, PencilBeam and Acoustic Modules
- Investigating new effort: standalone movable ”Sweden Camera 2.0” modules, scope TBD





WBS Key Requirements

- 1.5.1
  - Sustainable common format and central location for calibration constants
  - Database/data structure for production and in ice calibration
- 1.5.2
  - LED flashers in all DOMs
  - Isotropic light sources
  - Light sources with sufficiently narrow time pulse to probe scattering function
  - Multi-location hole ice measurements
  - All devices, including standalone, controlled by central DAQ/exp control
- 1.5.3
  - Data from calibration devices which can be applied to IceCube data, in usable format, common location

WBS Key Interfaces

- 1.5.1 – Database ready to be used by all FAT sites (1.3)
- 1.5.2
  - Cameras delivered in time for DVT and production for mDOMs and D-eggs (1.3)
  - Standalone devices controlled by central DAQ/experiment control (1.6)
  - All calibration data/metadata from sensors collected through central DAQ/experiment control (1.6)
  - All calibration constants delivered to a central database to be used by IceCube simulation and data processing (1.6)

WBS 1.5- Milestones and Key Activities - Reviews

WBS	Milestone or Activity	Scheduled Finish Date	Forecast Date (Actual if Finished)	Margin (Days)
1.5.2	Onboard calibration device preliminary design review	4/26/19	4/26/19	
1.5.2	Onboard calibration device final design review	9/14/19	9/14/19	
1.5.2.2.1	POCAM preliminary design review	10/22/19	10/22/19	
1.5.2.4	Acoustic preliminary design review	4/25/20	4/25/20	
1.5.2.2.2	PencilBeam preliminary design review	5/4/20	5/4/20	
1.5.2	Standalone device final design reviews	Fall 20/spring 21	Fall 20/spring 21	

WBS 1.5- Milestones and Key Activities - Cameras

WBS	Milestone or Activity	Scheduled Finish Date	Forecast Date (Actual if Finished)	Margin (Days)
1.5.2.3	cameras for D-egg production batch 1	2/15/20	2/15/20	
1.5.2.3	cameras for D-egg production batch 2	7/1/20	6/25/20	6
1.5.2.3	cameras for D-egg production batch 3	5/3/21	4/28/21	5
1.5.2.3	cameras for mDOM DVT	4/23/20	4/20/20	3
1.5.2.3	cameras for mDOM DESY test production	10/7/20	10/1/20	6
1.5.2.3	cameras for mDOM DESY production	1/27/21	1/15/21	12
1.5.2.3	cameras for mDOM MSU test production	4/01/21	3/25/21	7
1.5.2.3	cameras for mDOM MSU production	6/10/21	6/3/21	7

*Late finish directly delays project schedule

WBS 1.5- Milestones and Key Activities

WBS	Milestone or Activity	Scheduled Finish Date	Forecast Date (Actual if Finished)	Margin (Days)
1.5.2.7	Mini-mainboard prototype delivery	3/23/20	3/23/20	
1.5.2.2	*Standalone device shipment September 2022	09/2022	09/2022	
1.5.3.2 1.5.3.3	Delivery of timing, geometry calibration	03/2023	03/2023	
1.5.3.4	Data analysis to deliver array calibration	09/2023	09/2023	

*Late finish directly delays project schedule

WBS NSF Supported Cost Estimate to L3

1.5 Characterization and Calibration	Project Year					
WBS L3	**Year 1* Actual**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**WBS Total**
1.5.2 Camera and Light Detection	**$0**	**$10,200**	**$0**	**$0**	**$0**	**$10,200**
CapEx		$10,200	$0	$0	$0	$10,200
1.5.3 Array Calibration	**$0**	**$0**	**$0**	**$90,716**	**$92,044**	**$182,759**
Labor		$0	$0	$90,716	$92,044	$182,759
1.5.4 Calibration Management and Organization	**$26,168**	**$26,523**	**$26,995**	**$28,450**	**$31,195**	**$113,163**
Labor		$10,833	$9,890	$10,707	$10,985	$42,415
M & S		$4,470	$4,001	$4,247	$4,224	$16,941
Travel		$11,220	$13,105	$13,496	$15,987	$53,807
Annual Total	**$26,168**	**$36,723**	**$26,995**	**$119,165**	**$123,239**	**$306,122**

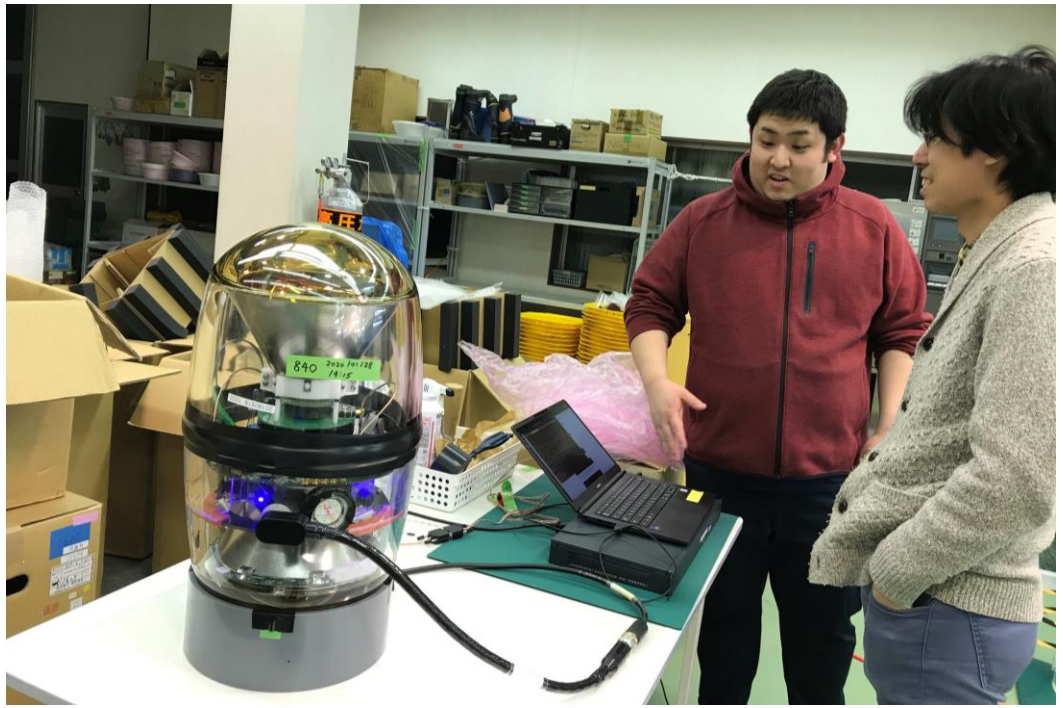
* - Year 1 is not included in totals

WBS 1.5 Contributions in Kind

WBS	Item	Quantity	Institution
1.5.2.3	Cameras for mDOMs	1290	SKKU
1.5.2.3	Cameras for Deggs	900	SKKU
1.5.2.2.1	POCAM	21	TU Munich
1.5.2.2.2	PencilBeam	11	UW Madison
1.5.2.4	Acoustic	10	RWTH Aachen
1.5.2.7	Mini Mainboard layout and first production batch	41	RWTH Aachen

WBS 1.5 Technical Progress

- Scope of onboard devices determined
- Flasher LED and circuit design selected, controlled through mainboard
- Cameras controlled through mainboard, demonstrated in sealed D-egg
- Camera mount improved after initial failure during mechanical testing
- Software issues: cameras must all be on to communicate with any, I2C timeouts on slow control devices: software fixes in progress for these issues



Camera illumination boards in a sealed D-egg

WBS Risks and Mitigation

- Camera holding structure delay means not all D-eggs in the first production batch have cameras installed at the beginning
  - Mitigation: Cameras can be backfilled in D-egg batch 1 in April when new mainboards are installed, will require personnel from SKKU
- Currently there is a mandatory 2 week quarantine on travelers from South Korea to Japan, limiting ability of SKKU personnel to assist with back-filling
  - Secondary mitigation: Sealing of D-eggs may be delayed until mid-June
- Flasher circuit in D-egg requires threshold correction to produce consistent results between boards
  - Mitigation: more detailed lab and *in situ* measurements, requires help from institutions outside of Chiba
- Mini-mainboard project retires risk associated with multiple design efforts for same key requirement in standalone devices

WBS Remaining Issues and Challenges

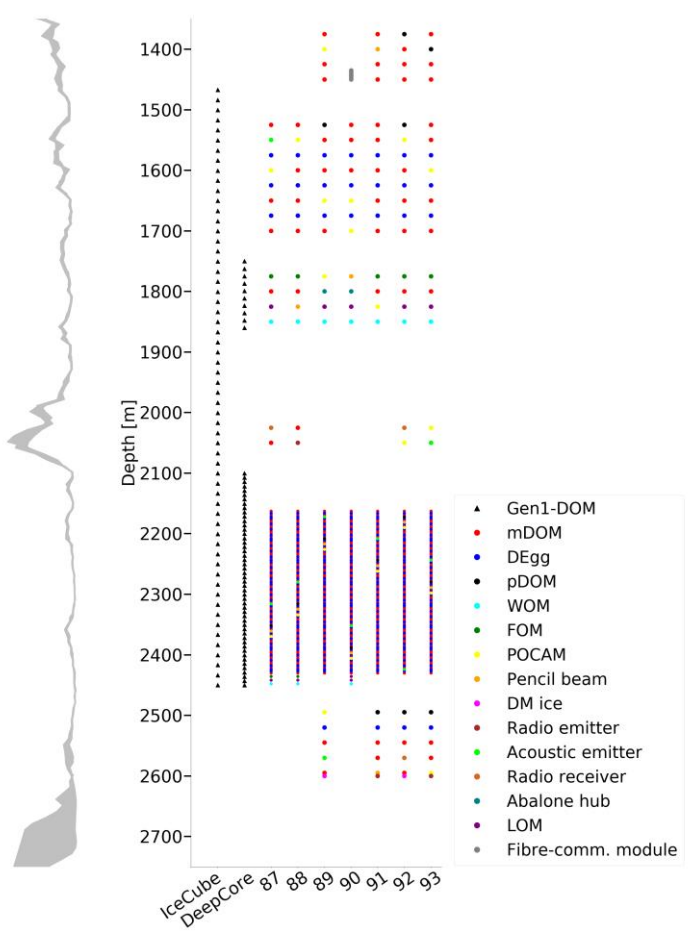
- D-egg integration schedule leaves little time for iterating on test results and re-design of components such as camera mount and flasher electronics
- This puts more burden on lab calibration/characterization, might require individual characterization of all LEDs

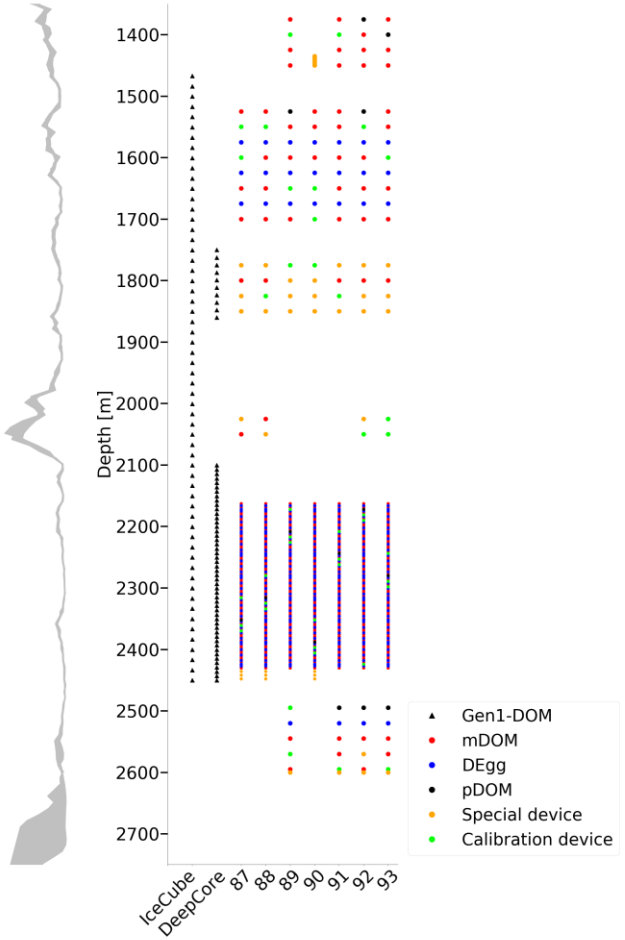
WBS Summary

- WBS 1.5 Calibration and Characterization will deliver well characterized calibration devices which deliver improved calibration constants in the ice
- Calibration is a very busy area with many in-kind contributions, coordination of timelines is a challenge especially in D-egg integration
- A lot of progress has been made in defining device scope and designs
- Much work remains as we enter production and characterize devices

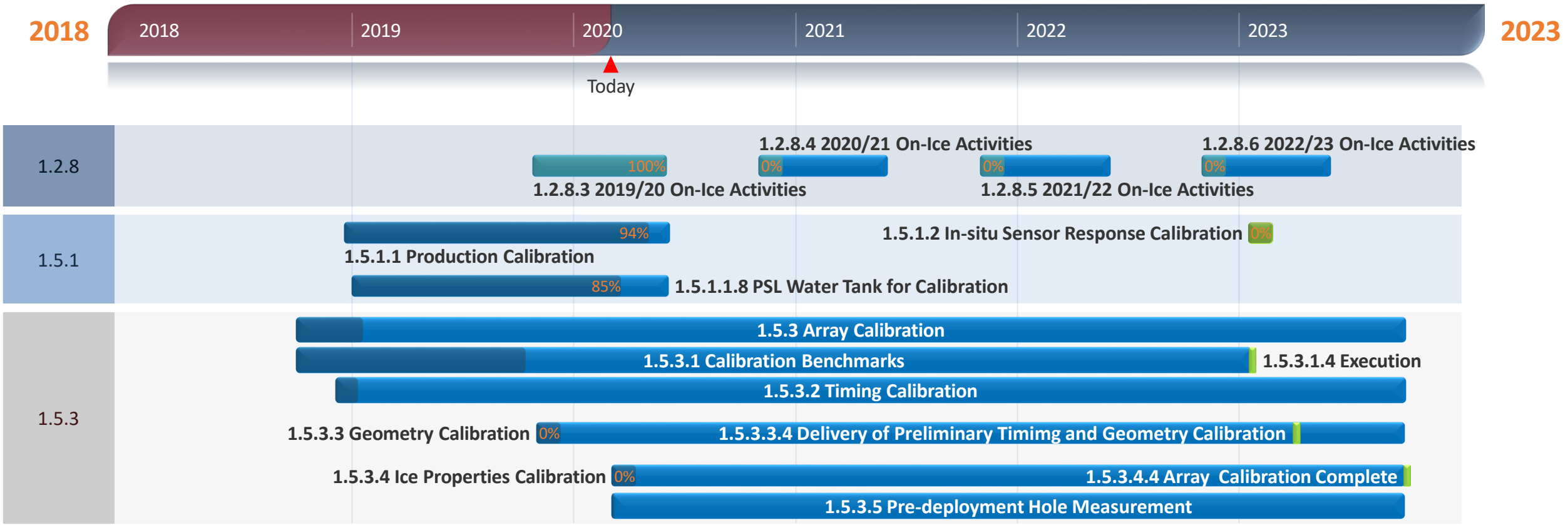
Backup

Upgrade calibration device overview (V55 geometry)





WBS 1.5 Schedule



WBS 1.5 Schedule