

IceCube Upgrade Project Status

*Farshid Feyzi - Project Manager
September 17, 2019*

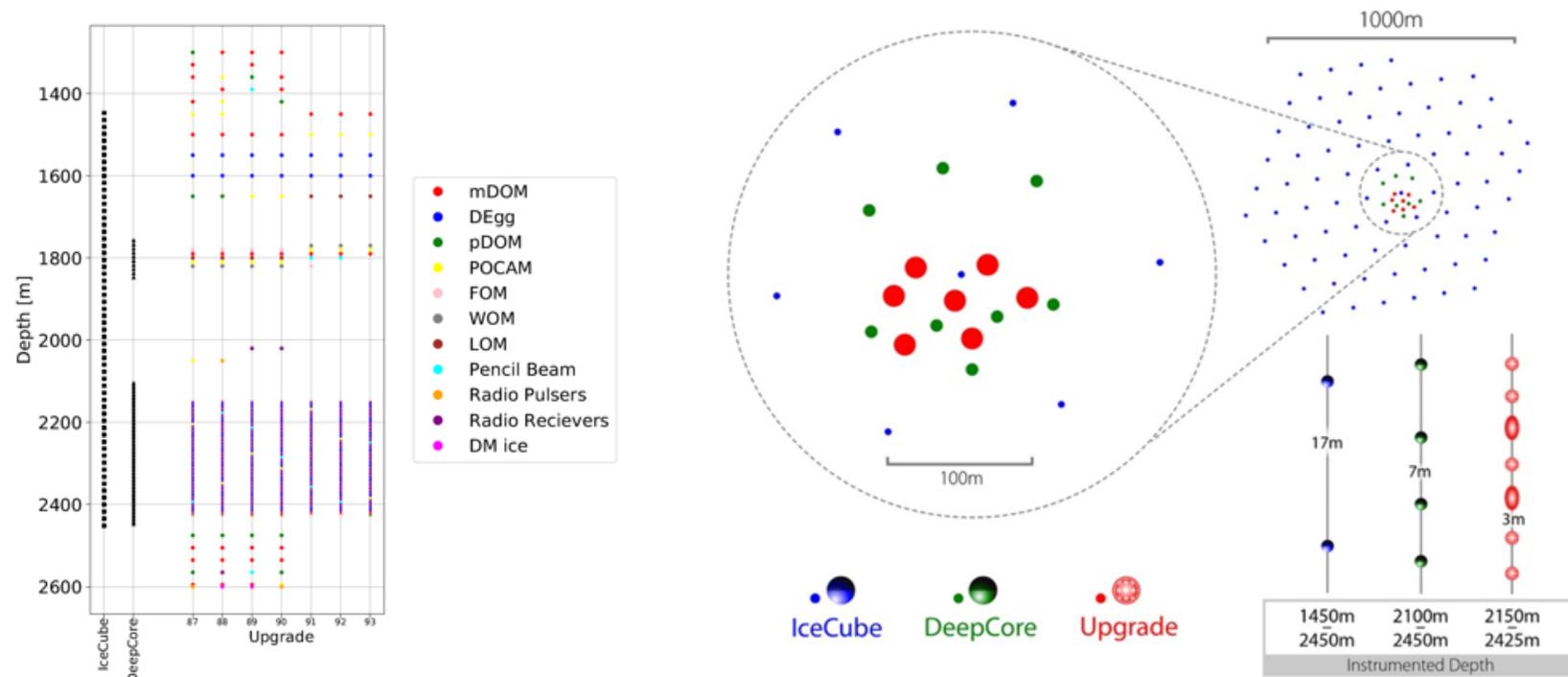


Outline

- Objectives of the IceCube Upgrade
- Cooperative agreement and contributions in kind
- PY1 performance
- Technical progress
- Summary

The IceCube Upgrade Technical Baseline

Objectives: (1) Provide a densely populated ice region within IceCube to improve energy and angular reconstruction and track / cascade classification for atmospheric neutrino events in the energy range 5 – 50 GeV for world's best measurement of $U_{\tau 3}$ allowing a probe of beyond standard model physics. (2) Exploit opportunity to deploy additional calibration instrumentation to better characterize the ice to improve IceCube's sensitivity to astrophysical neutrinos.



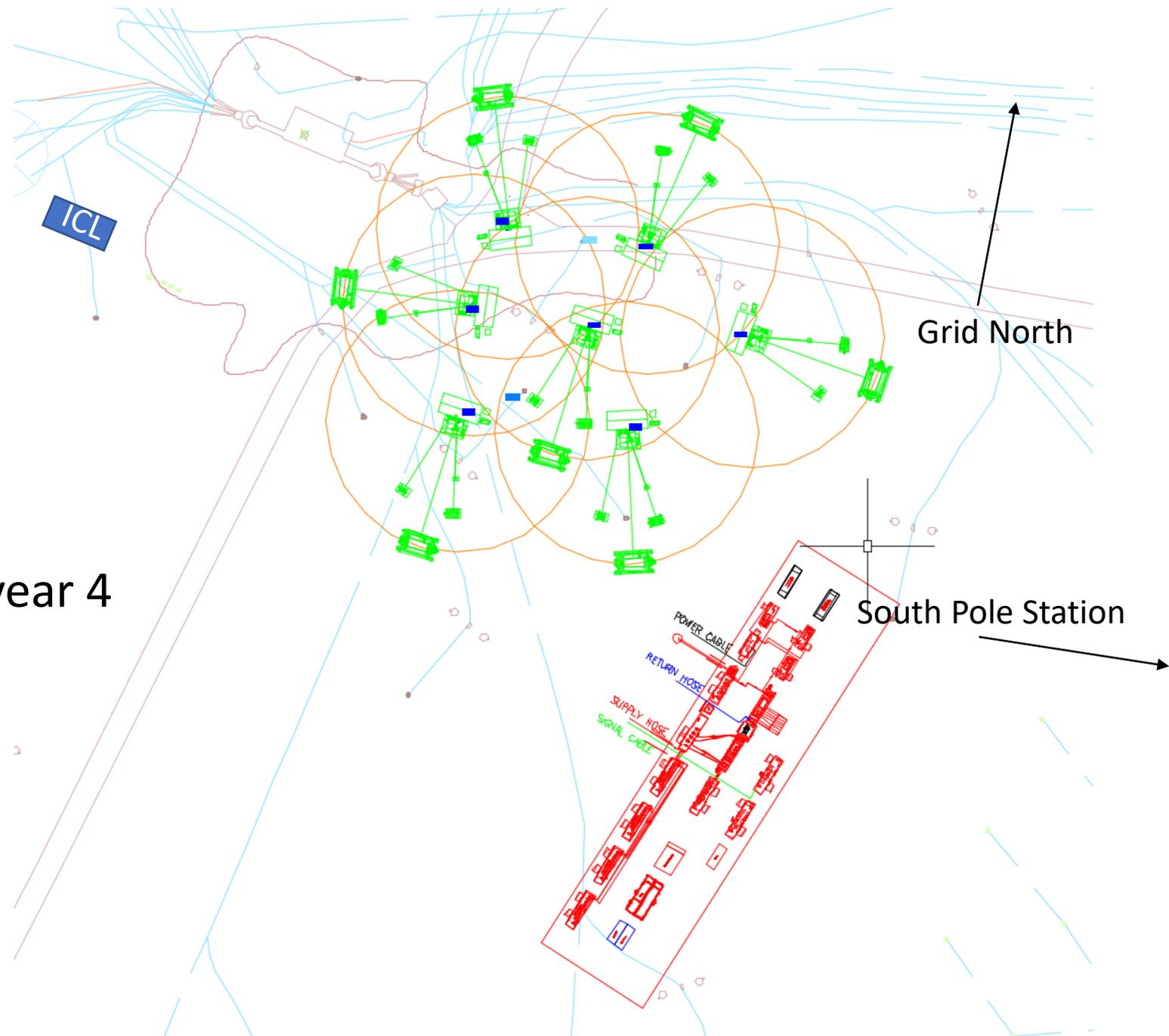
Upgrade Scope

- Unchanged since start
- Interesting technical opportunities

String	87	88	89	90	91	92	93	TOTAL
mDOM	55	56	58	53	61	59	60	402
DEgg	39	39	40	39	40	40	40	277
pDOM	1	1	2	1	2	4	3	14
WOM	2	2	1	2	1	1	1	10
FOM	2	2	0	0	1	1	1	7
POCAM	2	2	5	3	2	3	4	21
PB	1	2	1	2	3	1	1	11
PS	1	1	1	1	1	1	1	7
DM ice	0	0	1	0	0	1	0	2
RP	0	1	0	0	1	0	1	3
RR	1	0	0	0	0	2	0	3
AH	0	0	1	1	0	0	0	2
LOM	2	1	1	3	0	1	1	9
AP	2	1	2	1	1	1	2	10
ALL	108	108	113	106	113	115	115	778

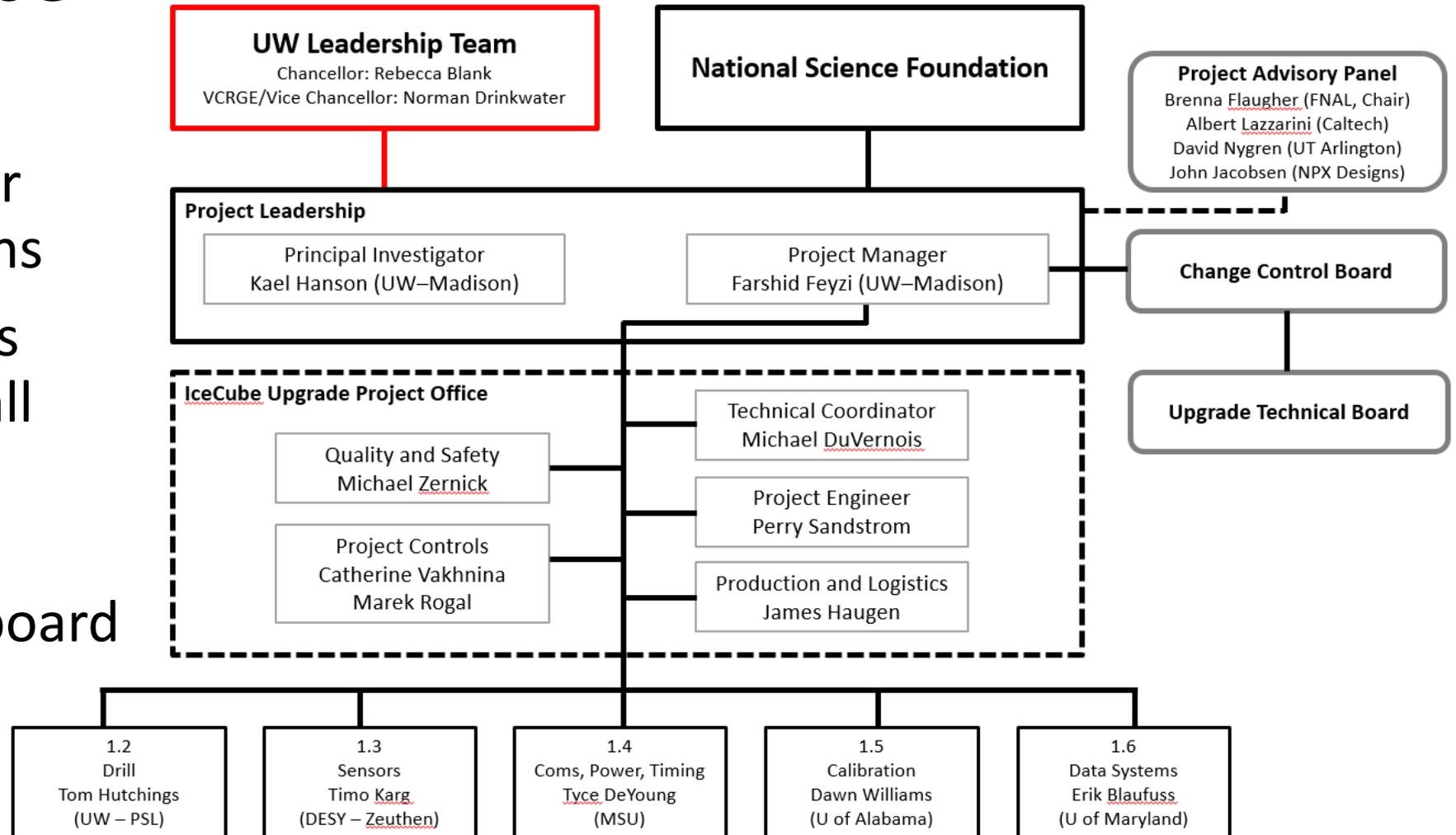
Surface Plan

- Very close holes
- Logistics and cable management focus
- Integration with ICL
- Wet drill test project year 4



Project Office

- Organization strengthened per recommendations
- Level 2 managers responsible for all scope
- Tech board and change control board fully functional



Funding profile in Cooperative Agreement

FYI (NSF Appropriation year)	Baseline	Contingency	Total	PY
FY18	\$4,069,959	\$664,979	\$4,734,938	1
FY19	\$5,130,419	\$575,002	\$5,705,421	2
FY20	\$3,638,072	\$362,229	\$4,000,301	3
FY21	\$3,604,047	\$464,748	\$4,068,795	4
FY22	\$3,985,016	\$788,853	\$4,473,869	5
Total	\$20,127,513	\$2,855,811	\$22,983,324	



Performance
Measurement Baseline

Secured

Pending

IceCube Upgrade In-Kind Contributions

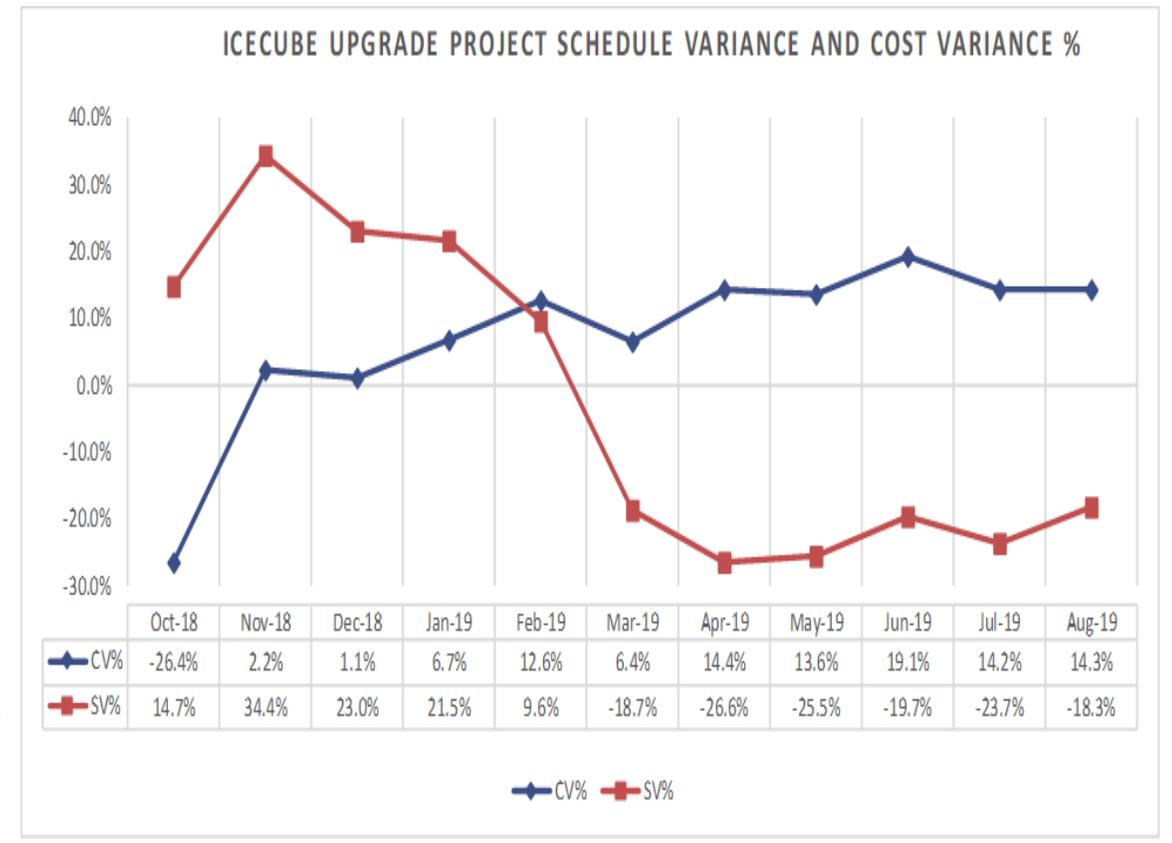
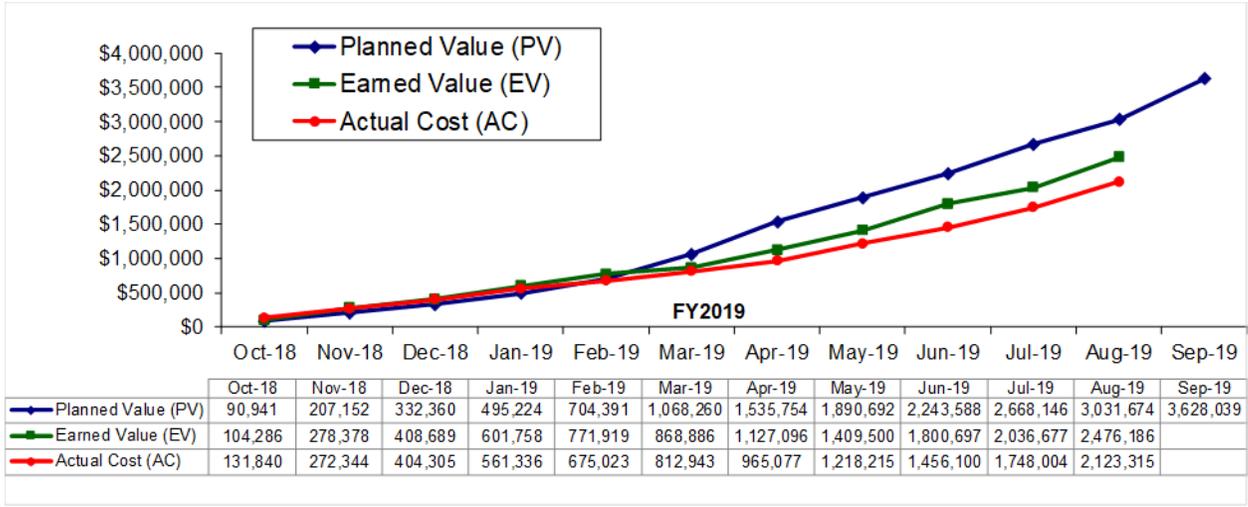
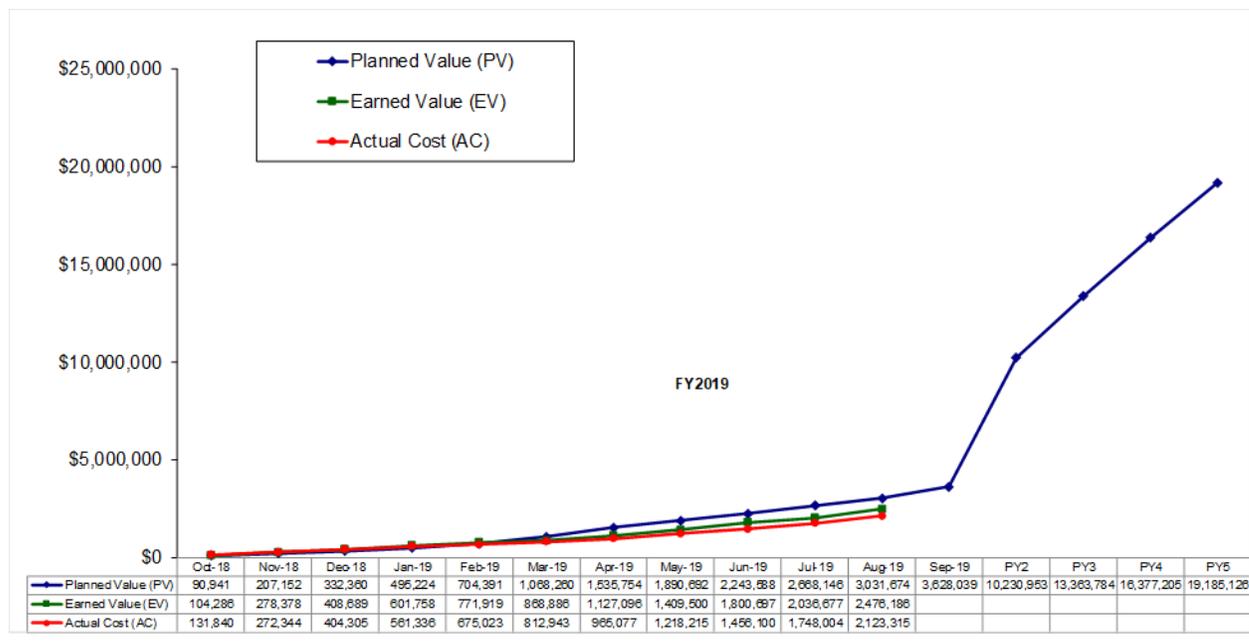


	1.2 IceCube Upgrade drill	1.3 Deep ice sensor modules	1.4 Comms Power and timing	1.5 Calibration and Characterization	1.6 M&O data systems integration
German Universities (BMBF)		mDOM modules (\$0.6M); 1.5 FTE Tech		Acoustic sensors and pinger (0.09M) 1.2 FTE Tech; 0.3 FTE EE	
Chiba (JPS/MEXT)		DEgg modules (\$3M)			
DESY		Procurement, production and testing of mDOM modules (\$3.25M); 2 FTE EE, 1 FTE ME; 3 FTE	1 FTE EE	0.5 FTE	0.5 FTE
Geneva		module hardware (\$0.5M)			
IceCube					M&O- DAQ/ExpControl/ Icetray, etc. Collaboration- simulation/ reco software
Karlsruhe Institute of Technology		mDOM modules (\$2.5M)			
Muenster		mDOM hardware (\$0.07M) 3 FTE			
T.U. Munich				POCAM sensor modules (\$0.6M)	
Michigan State University		Production and test facilities (\$0.8M); Labour for module production and testing (3 FTE)	7 main cables and breakout assemblies (\$2.56M)		
SKKU				Camera systems (\$0.04M), 3 FTE; (0.2M), 2.5 FTE	
Uppsala/Stockholm (Swedish research Council)	drill crew (\$0.8M)	mDOM modules (\$1.6M)	(\$0.5M)	pencil beam source (\$0.05M)	
Total	\$0.8M	\$9.62M, 10.5 FTE; \$2.7M	\$2.56M, 1 FTE; \$0.5M	\$0.73M, 4.5 FTE; \$0.25M, 2.5 FTE	

Funding Management

- Total NSF Performance Measurement Baseline (PMB) \$22.983M unchanged since Sept 2018, this includes contingency
- Contingency increased to 19% while keeping PMB constant
- PMB does not include contributions in kind
- PMB and contributions in kind tracked in project schedule
- PMB scope tracked in Earned Value Management System (EVMS)
- Yearly detail planning in August and September
- PY2 detail planning is in progress and will be added to PY3-PY5 yearly plans to arrive at estimate to complete-must stay within PMB
- Maintain contingency level in accordance with risk and cost uncertainty
- PY2 detail planning will be added to PY1 actuals to arrive at scope of PY2 work to stay within PY1+PY2 commitment

Earned Value Management System Tracking NSF funded scope only Contributions in kind managed by L2s



Technical Progress

- Following slides from L2s summarizing technical progress

WBS 1.2: Drill

- Generator-1: Overhaul is complete
- Control System: Motor drive selection complete/testing is underway
- Drill Hose: Procurement is in process (governor's waiver approved)
- Independent Firm Drill: Completing testing, repairs, and upgrades
- Equipment: 287B Skidsteer and 2 snowmobiles procured
- Site Plan/GPR Map: Developed and delivered to ASC
- Property Control: Custodianship of EHWD is in process
- Drill Heads: Initial assessment, sensors/telemetry system being tested
- Support: All ASC season support activities coordinated and scheduled

T. Hutchings

Drill - Schematic

ENHANCED HOT WATER DRILL – IceCube Upgrade

PSL v20190301

SYSTEM SCHEMATIC

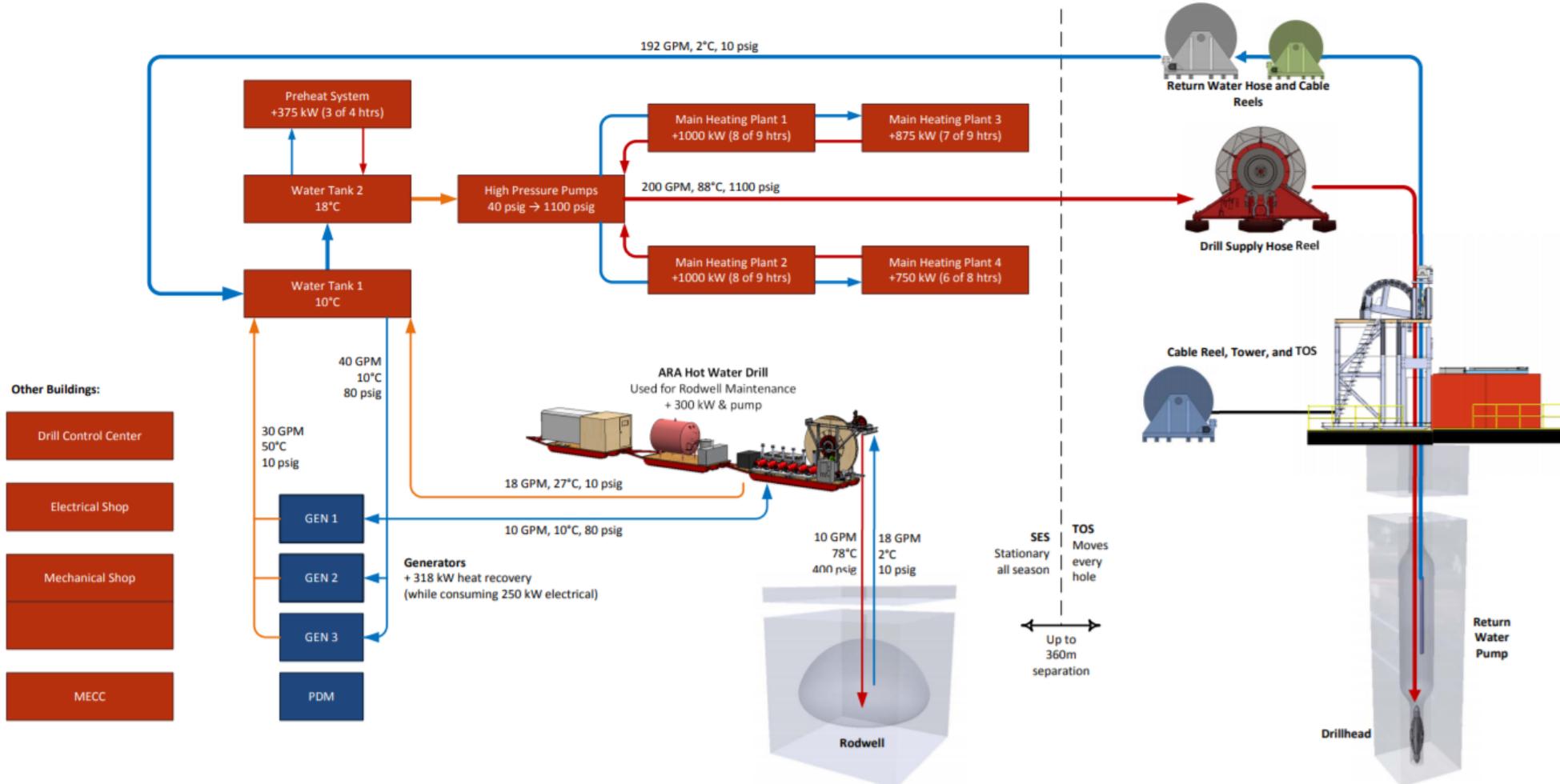
Intent: Drill 7 IceCube-magnitude holes in one season to support installation of the IceCube Upgrade

Capacities: 4.6 MW thermal delivered to drill nozzle; 250 kW system electrical load

Run two gensets at a time, each at 125 kW, third genset is online backup

Makeup water obtained from stationary Rodwell, supported by ARA Hot Water Drill (pump, heat, hose reel – RWS no longer available)

T. Hutchings



Current Drill Equipment Status



WBS 1.3: Deep Ice Sensors

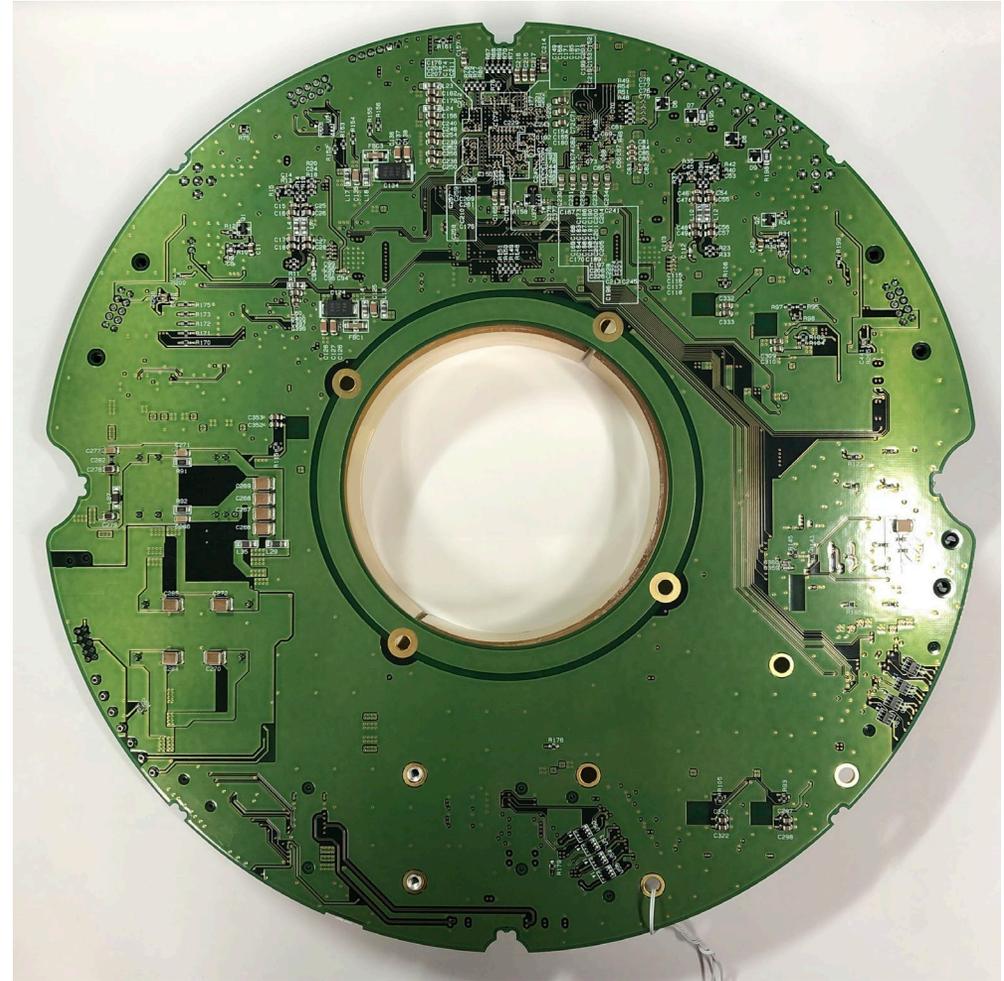
- mDOM
 - Readout and High Voltage PDR passed in Aug. 2019
 - Procurement of 10,500 PMTs commenced at KIT
- D-Egg
 - Delivered Rev. 2 mainboards allow developing DOM firmware and software
 - High Voltage system finalized
 - Preparing for production start in Jan. 2020
- PDOM
 - Unification of D-Egg and PDOM mainboard schematics
- Ice Comms Module
 - Prototypes delivered to D-Egg group and integrated
 - Close to final design (review passed in Aug. 2019)
- Special Devices
 - First review of special devices planned for Spring 2020 Collaboration Meeting

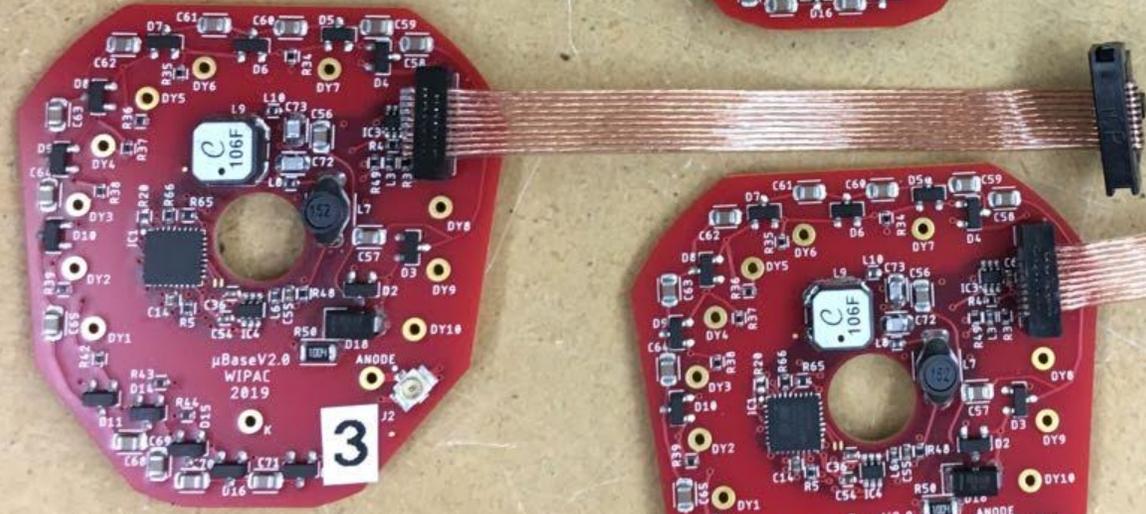
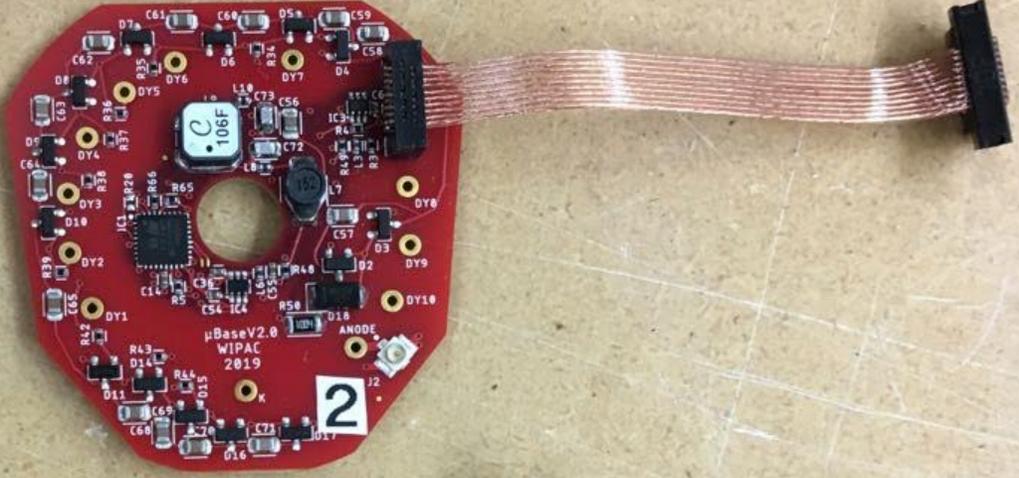
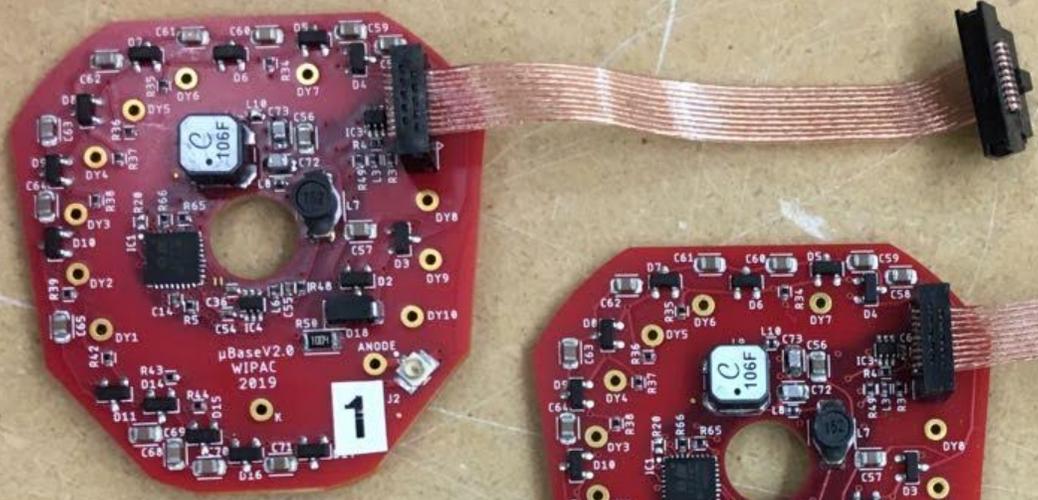


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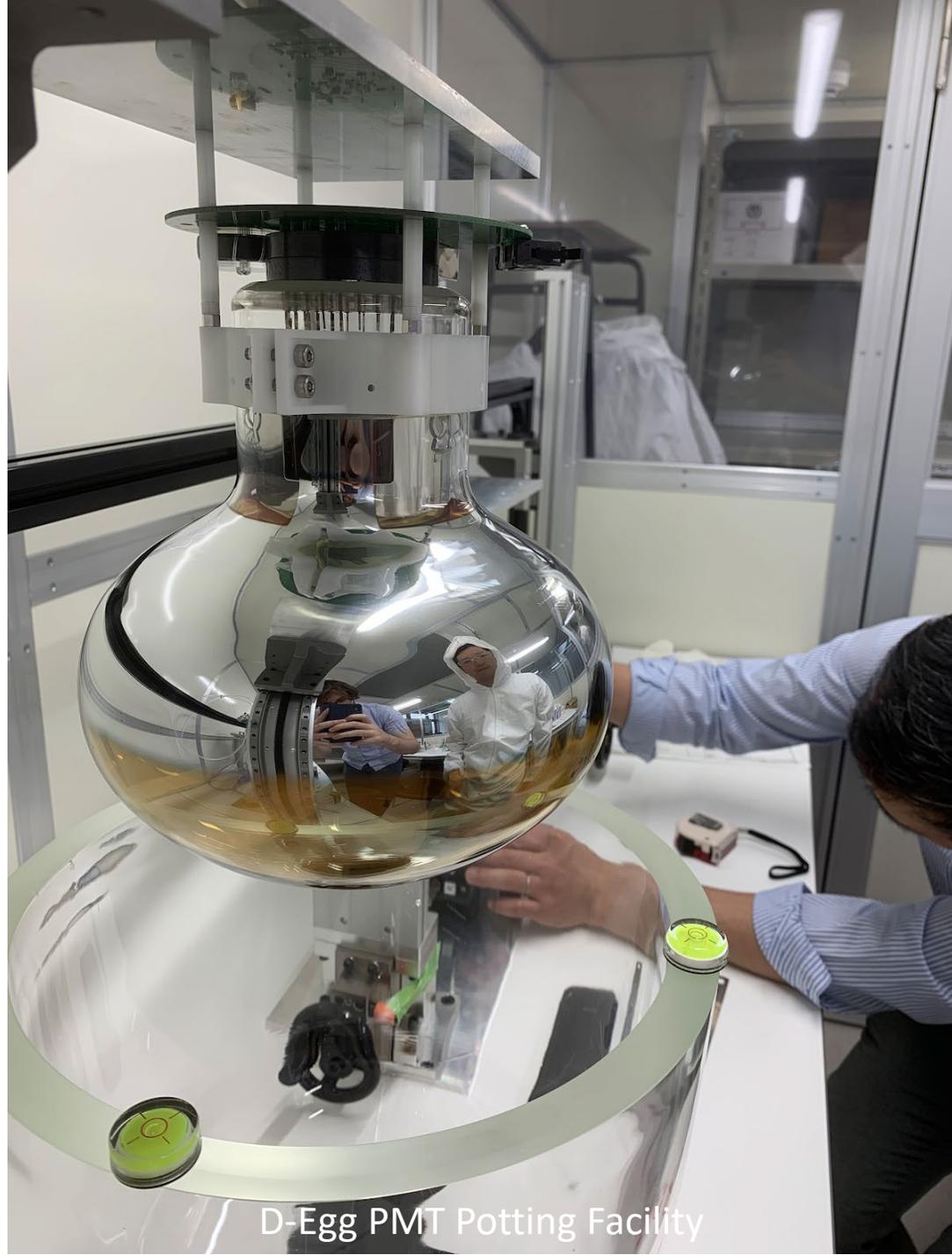
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Half-mDOM Freezing Test

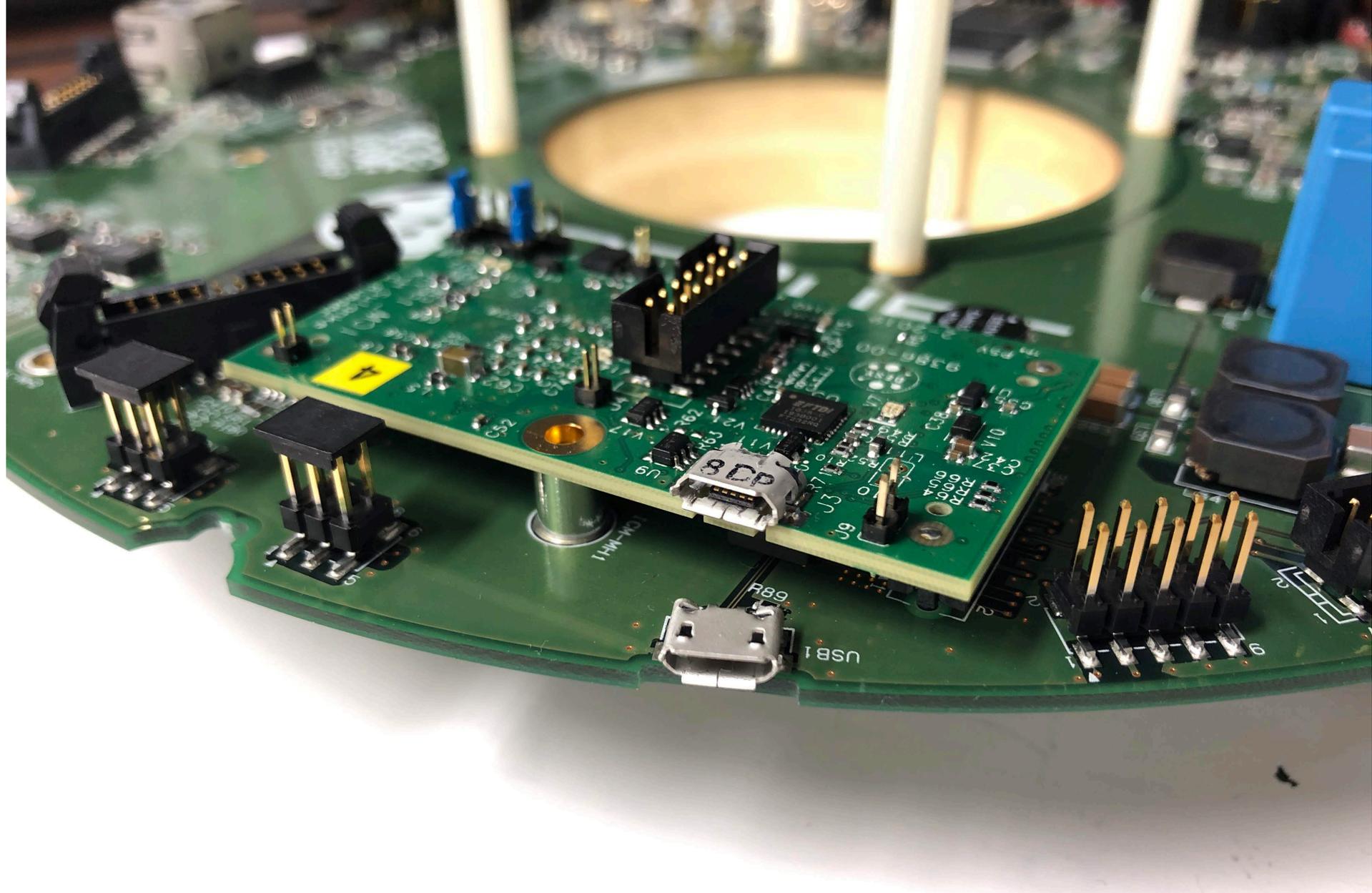




mDOM High Voltage Bases (μ Base)



T. Karg

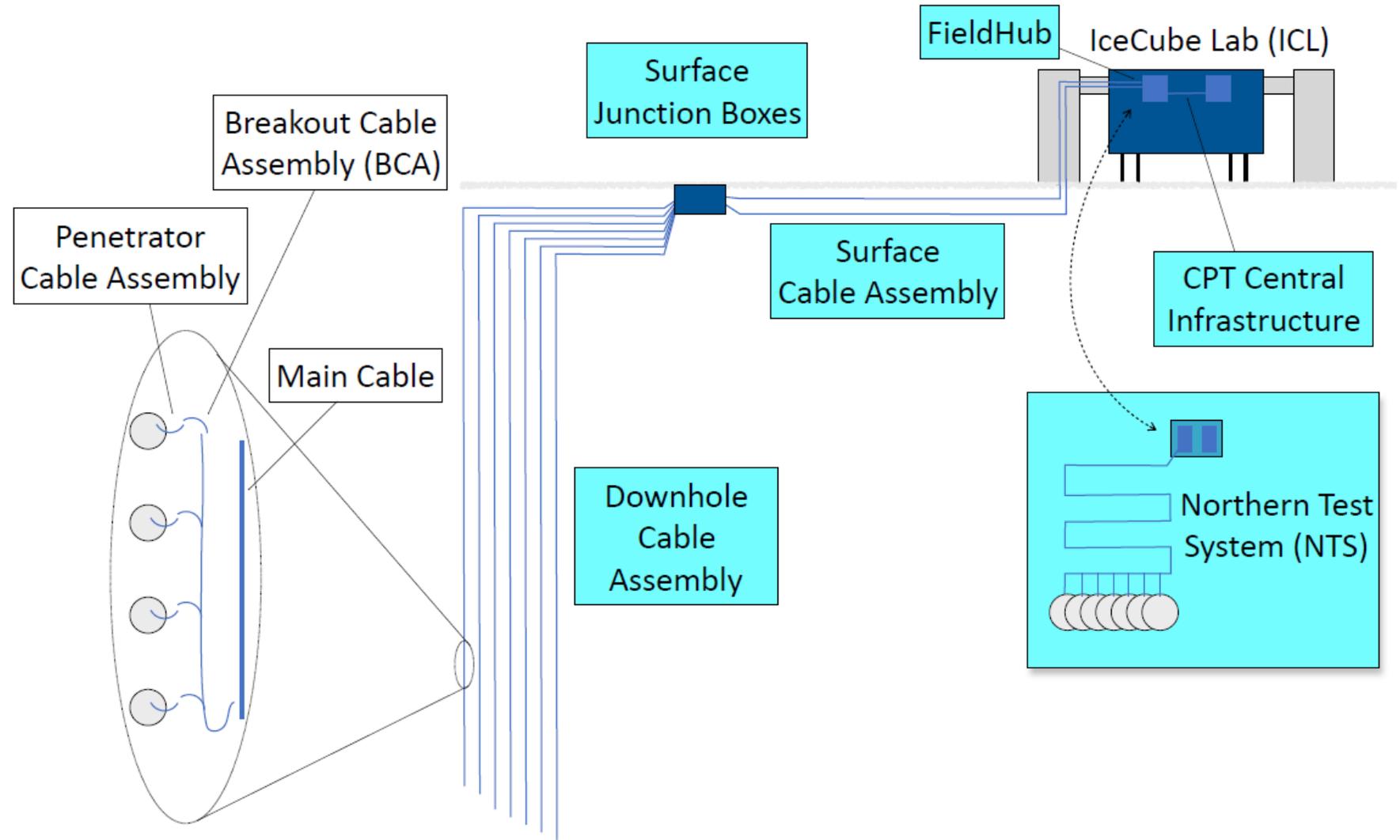


WBS 1.4: Comms/Power/Timing Systems

- Main cables
 - Test quads produced by Hexatronic this week, under evaluation at factory
 - Discussions ongoing with three other potential suppliers
- Penetrator cable assemblies
 - Prototypes in production from three suppliers, RFP to be issued in coming weeks
- Surface cables
 - Layout determined with ASC, to be confirmed by GPR survey this season
- FieldHubs
 - Mini-FieldHub production underway, to be shipped to labs in November
- CPT infrastructure and Northern Test System
 - Timing and comms units (GPS clock, White Rabbit) delivered, to be installed at NTS in Oct.
 - Smart power distribution prototype being assembled, power supply selection beginning

Updated Configuration

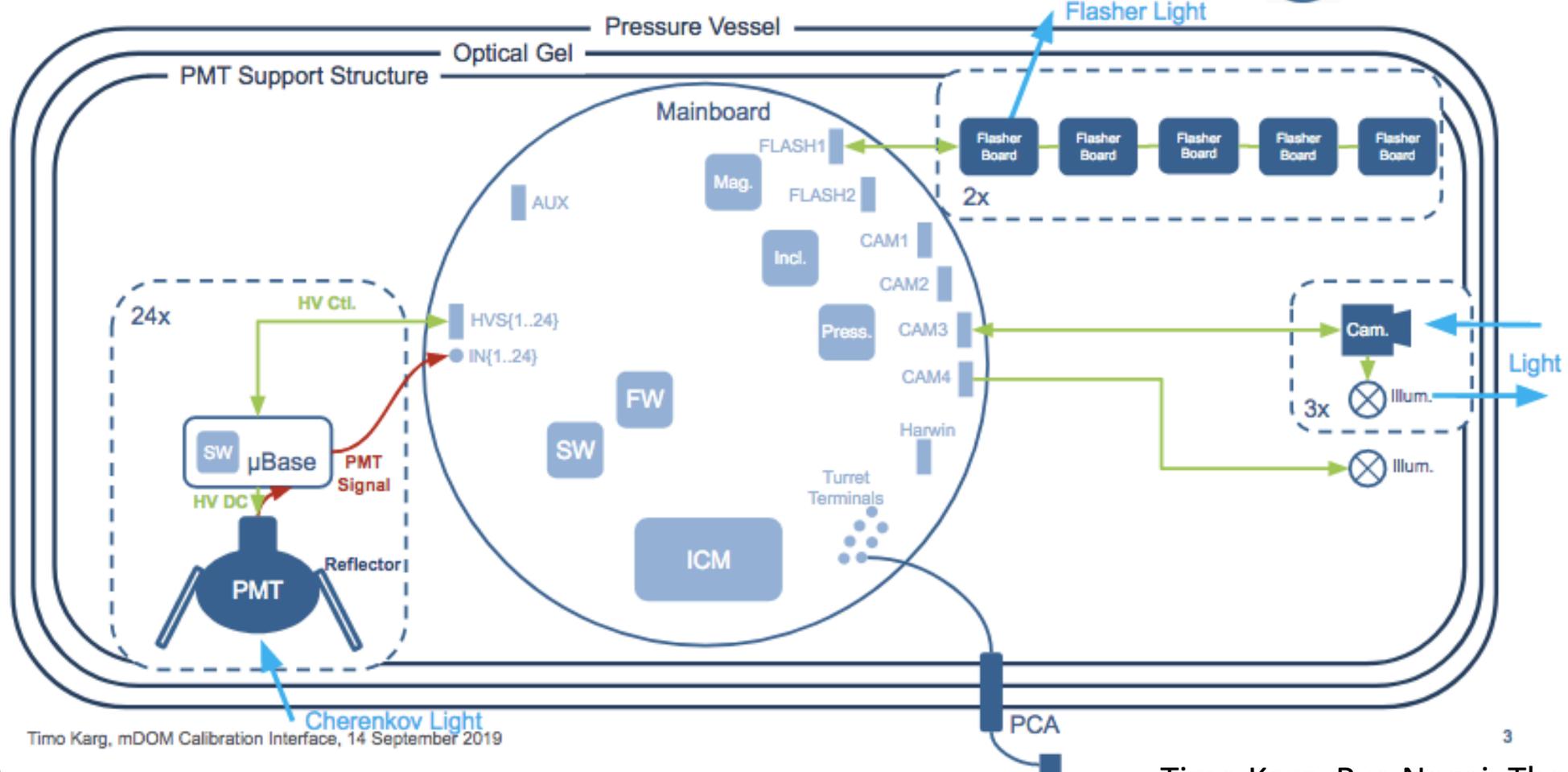
- IDF eliminated,
- Will use 2 surface junction boxes
- FieldHub moved to ICL



WBS 1.5: Calibration and Characterization

- Scope for devices onboard photosensors has been set at:
 - Flashers and cameras controlled by a calibration interface integrated into the mainboard (mDOM and D-egg)
 - Common flasher circuit (modified Kapustinsky) and 405 nm LEDs for all flashers
 - 12 LEDs (8 horizontal, 4 downward facing) and 3 cameras, 3 camera illumination boards per D-egg
 - 10 LEDs (8 outward facing, 1 upward, 1 downward facing) and 3 cameras, 4 camera illumination boards per mDOM)
 - Accelerometer, magnetometer and pressure sensors on the mainboard
 - Control software is being written for all of these devices
- Standalone devices: POCAM (isotropic light source), PencilBeam (collimated/steerable light source) and Acoustic (sensor + pinger assembly)
 - Discussions underway for common mini-mainboard for these devices
 - Reviews start in October 21-22 for POCAM, January TBD for PencilBeam and acoustic

Calibration Interface Sector of the Mainboard



Timo Karg, mDOM Calibration Interface, 14 September 2019

WBS 1.6: Data Systems

- Data Systems and Integration efforts here will ensure that new sensors and calibration devices deployed in the Upgrade become first-class members of the overall uniform IceCube data systems
 - Triggering and DAQ readout
 - Treatment in online and offline data processing and filtering
 - Inclusion in analysis level simulation and data samples
- Leverage our rich software ecosystem from IceCube to speed progress to analysis results that take advantage of new OM sensors and calibration devices
- Strong team from IceCube maintenance and operations in place to lead this effort

Summary

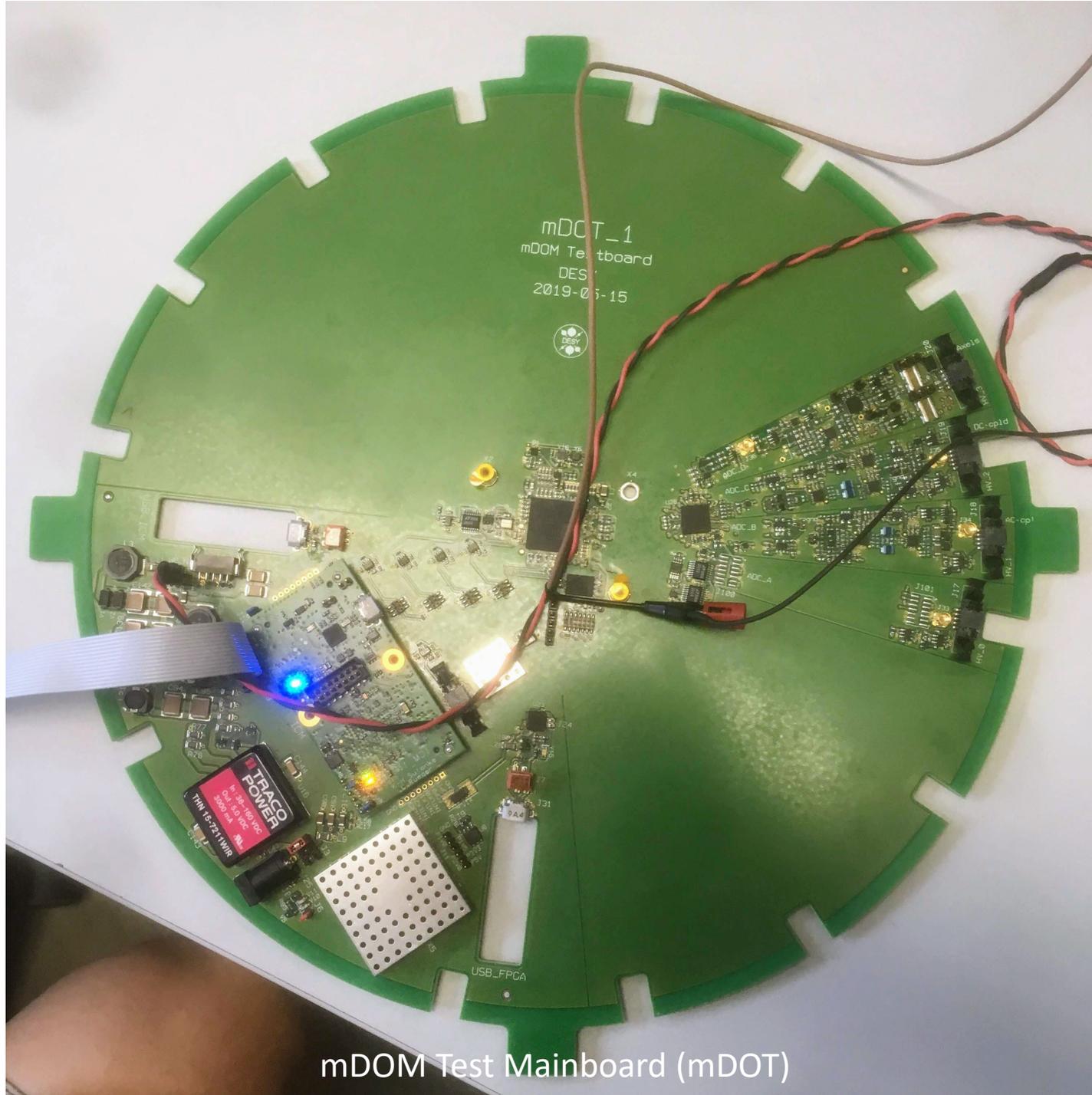
- PY1 was project formation year, momentum building
- PY2 plan is a significant increase, need to push the schedule
- Time critical project, have only one season to drill and deploy
- Many design reviews in the near future, must pass all
- DOM failure statistics in Gen1 is a good lesson, all things could happen in one season – QA for all hardware and deployment a must
- Safety is critical, no incidents can happen at all anywhere
- BUT, we are experienced, committed and have time to get it right

Thank You!

Backup

Cost and Schedule Development and Tracking

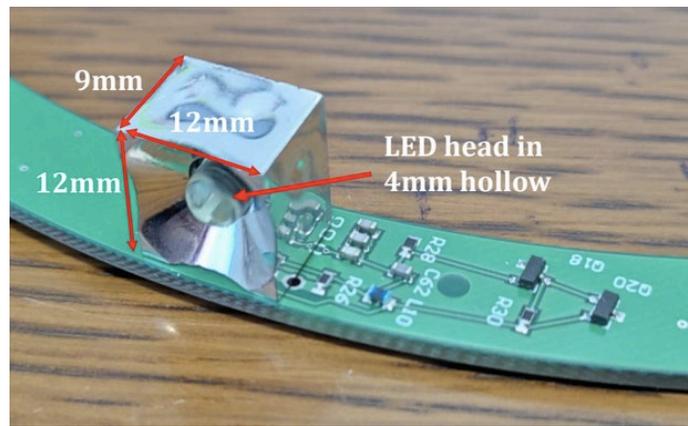
- Project schedule was assembled in Project - includes all Upgrade scope
- Cost estimates were assembled in Excel – includes only NSF funded scope
- Have switched to Smartsheet for cost and schedule development plus tracking
- Cost and schedule data were imported to Smartsheet
- Detail planning tools well developed for cost estimating
- Schedule development tools in progress



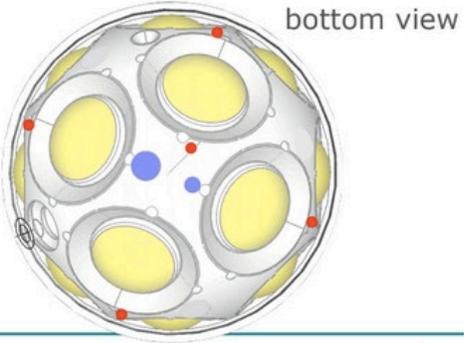
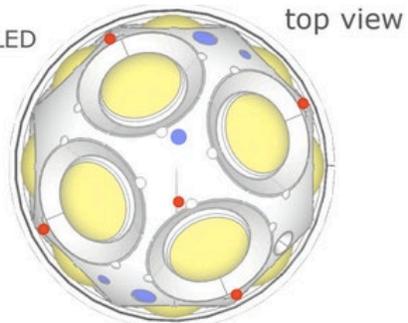
mDOM Test Mainboard (mDOT)

T. Karg

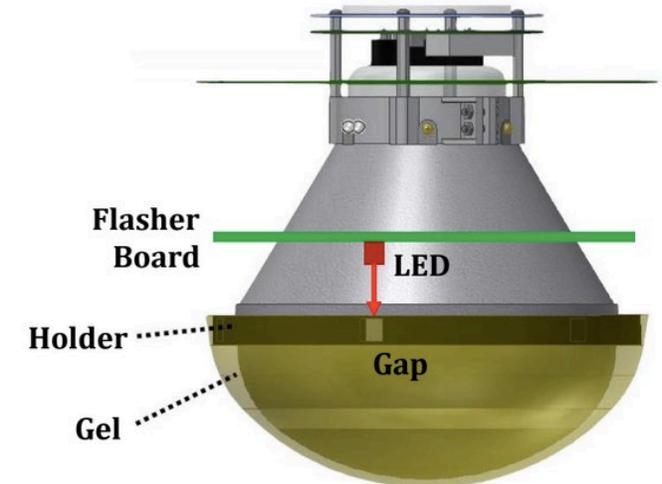
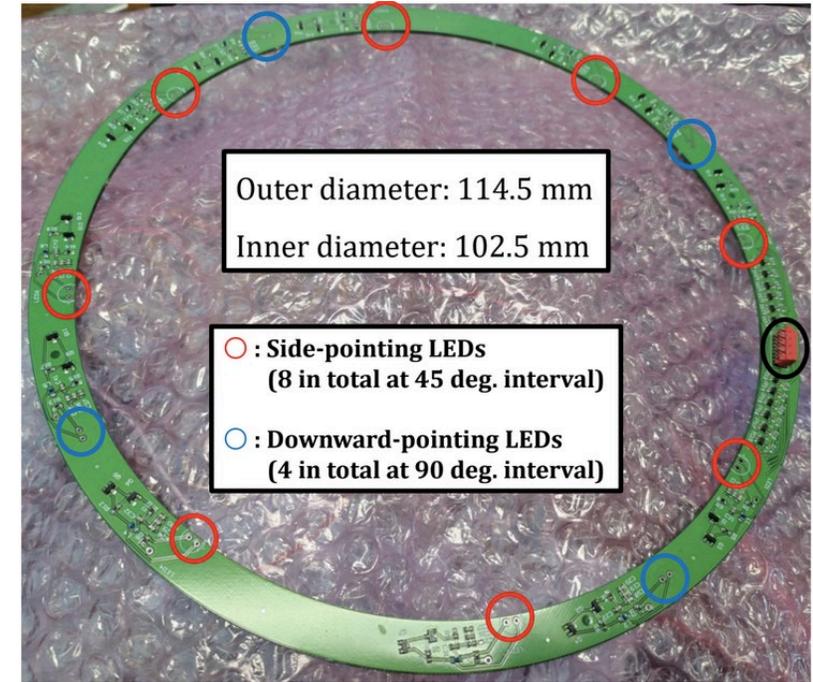
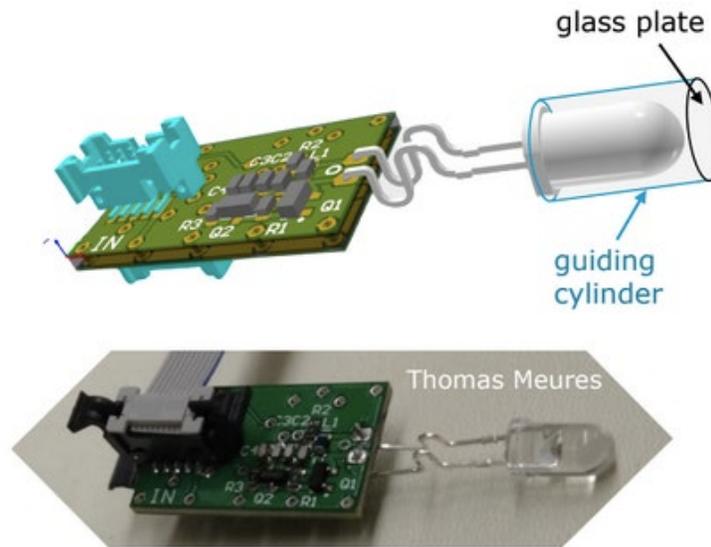
Flashers



- flasher LED
- camera
- ill. LED

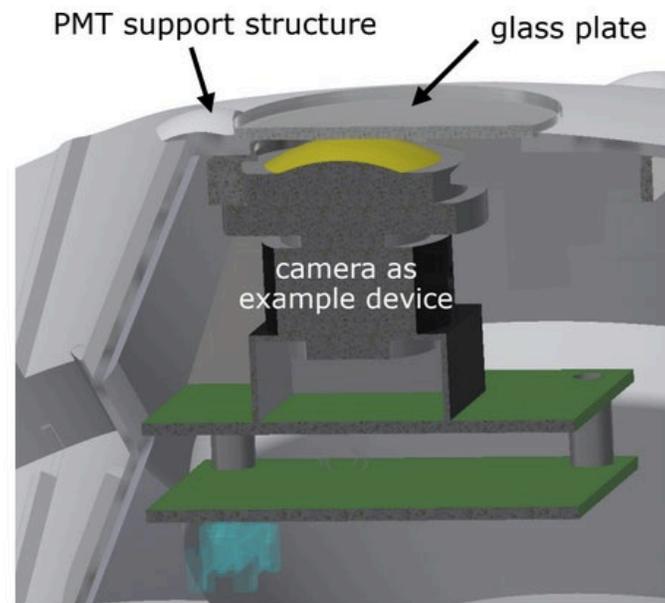
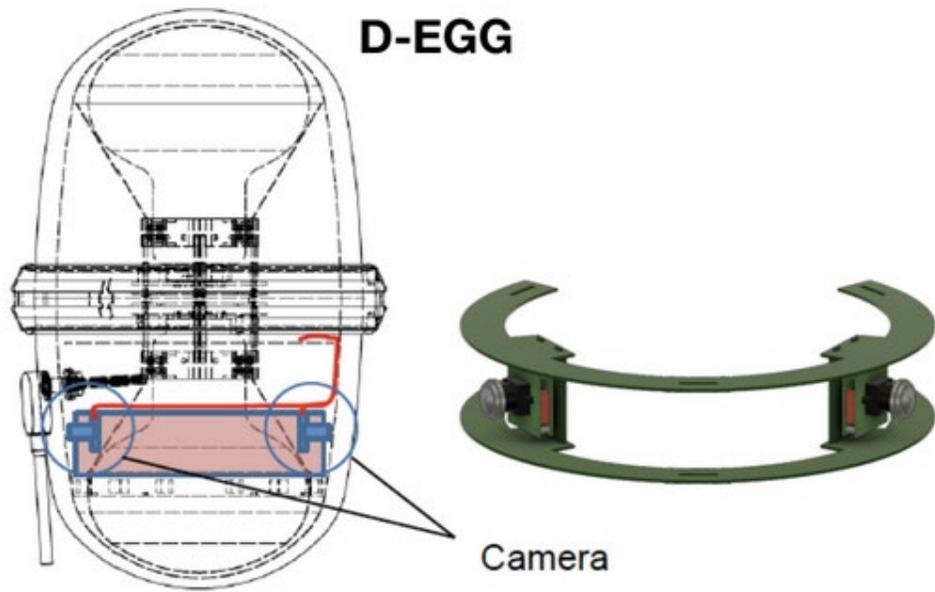


D-EGG



MDOM

Cameras



MDOM



Carsten Rott, Christoph Toennis, Alexander Kappes

