



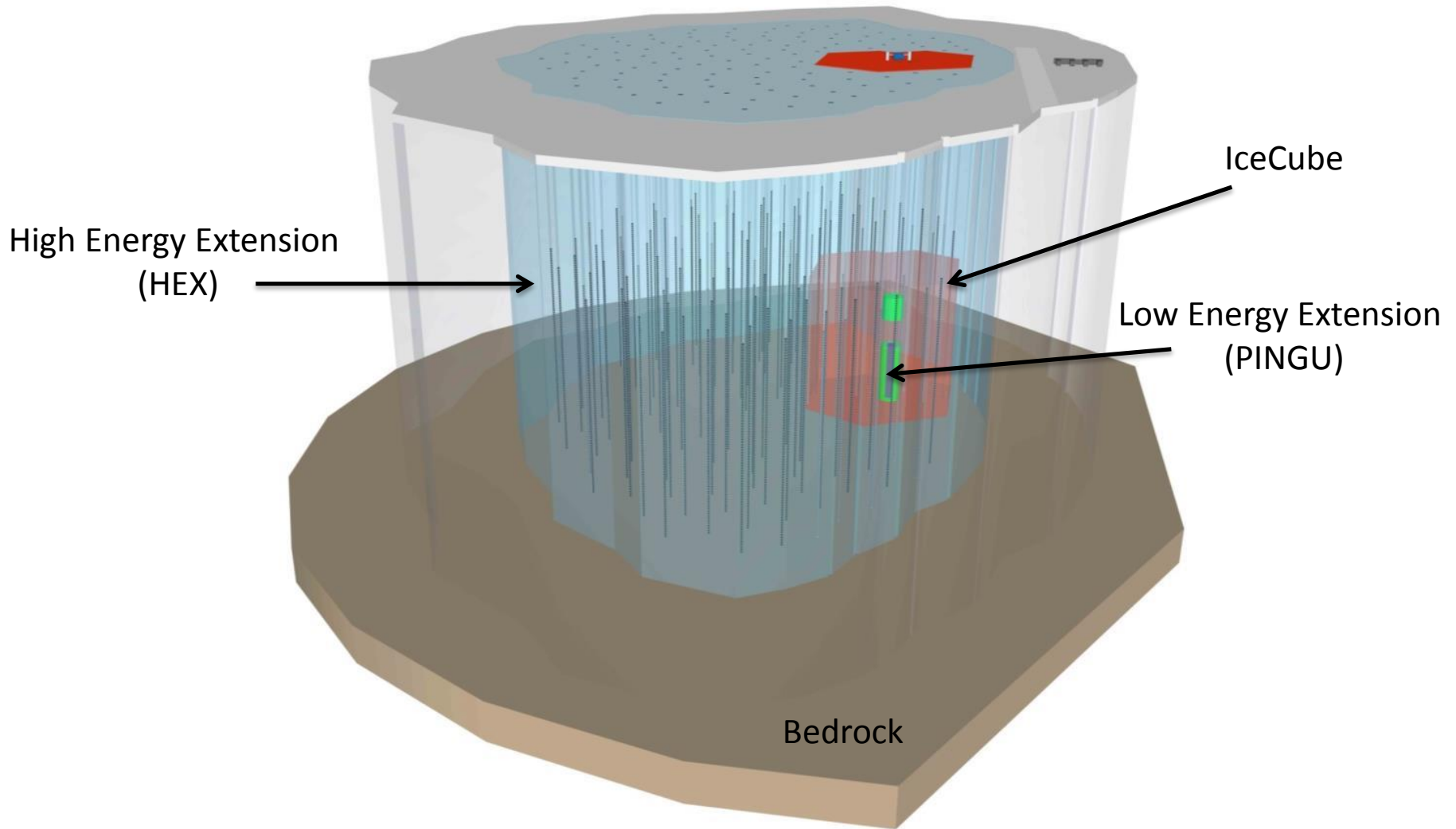
Generation-2 DOM Development for IceCube Extensions

John Kelley for the IceCube /
PINGU Collaboration

September 20, 2014

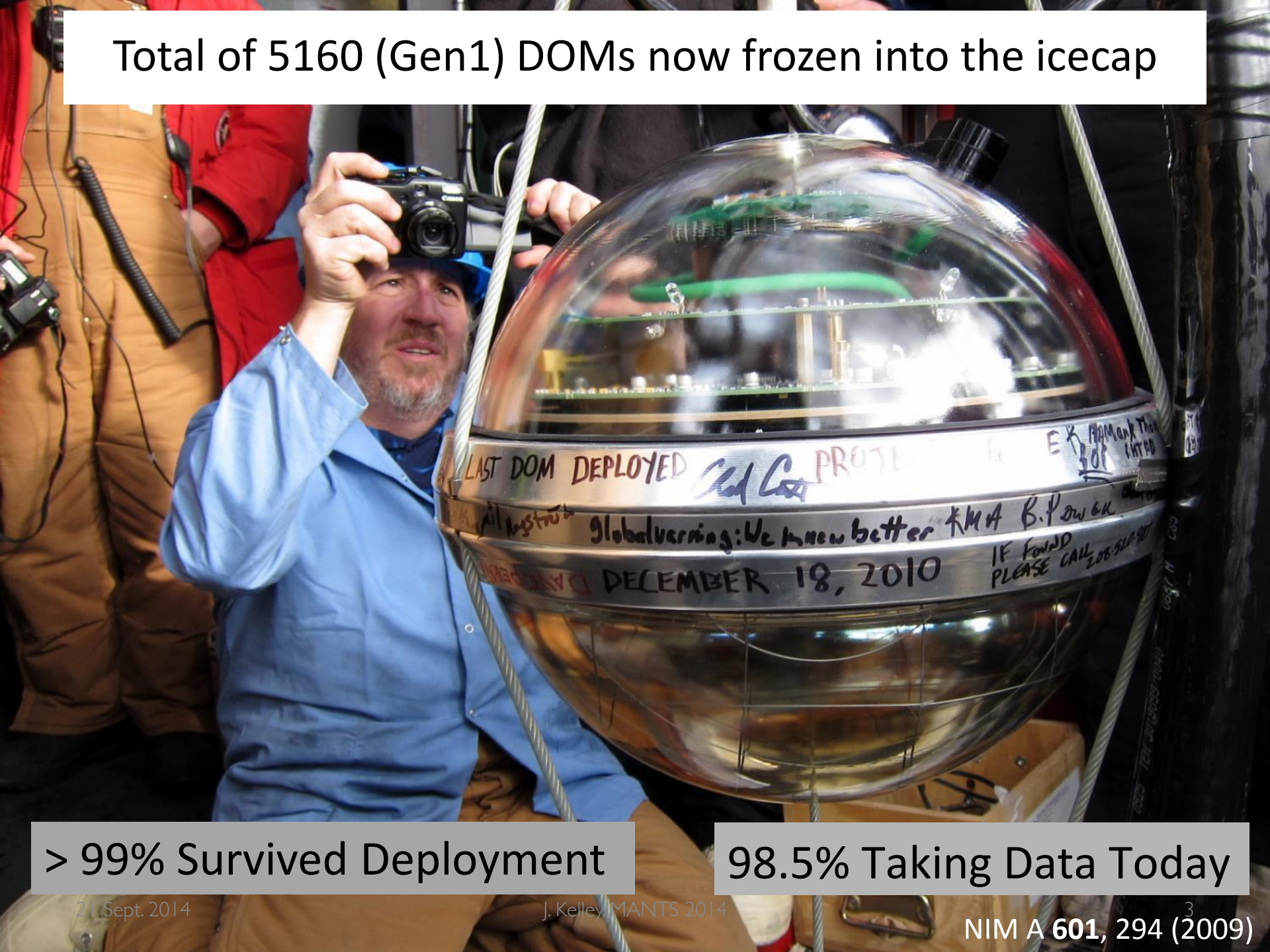
MANTS, Geneva, Switzerland

IceCube Extension Plans



“PINGU” = Precision IceCube Next Generation Upgrade

Total of 5160 (Gen1) DOMs now frozen into the icecap

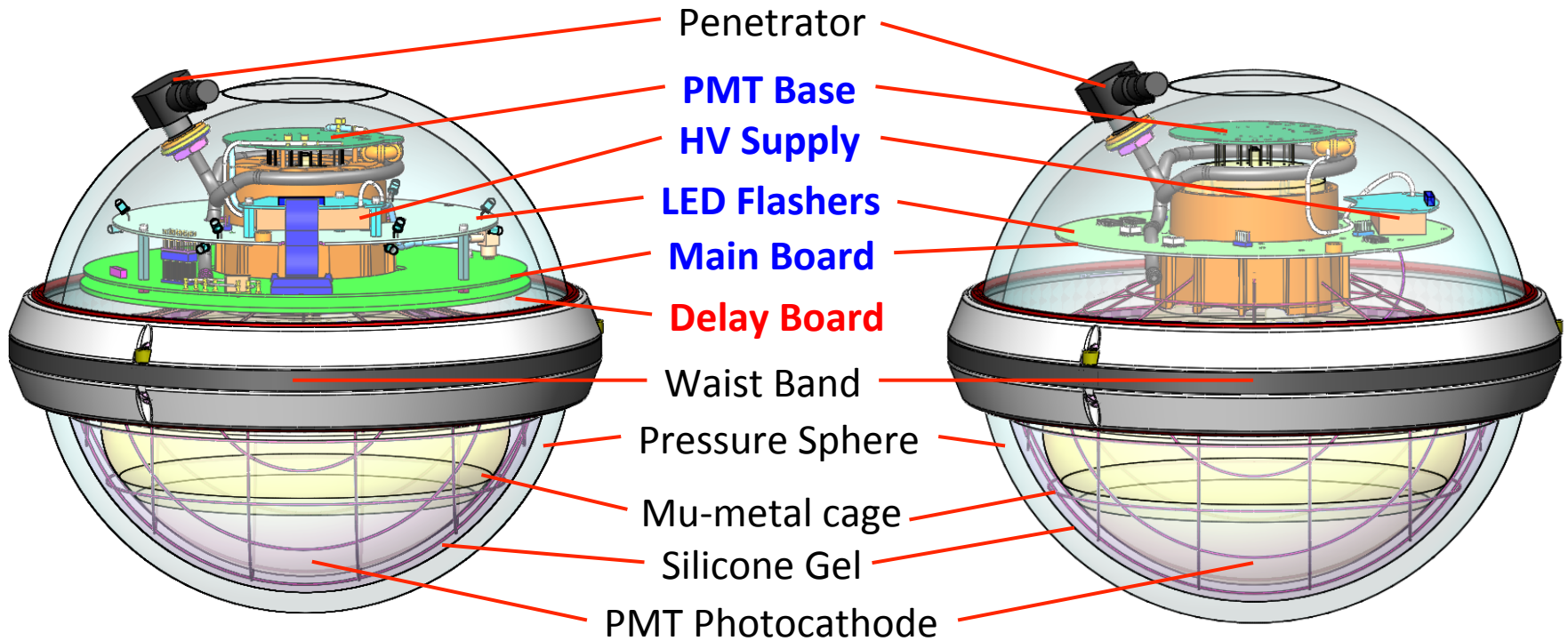


> 99% Survived Deployment

98.5% Taking Data Today

Generation2 (Gen2) DOM*

Assumption for baseline



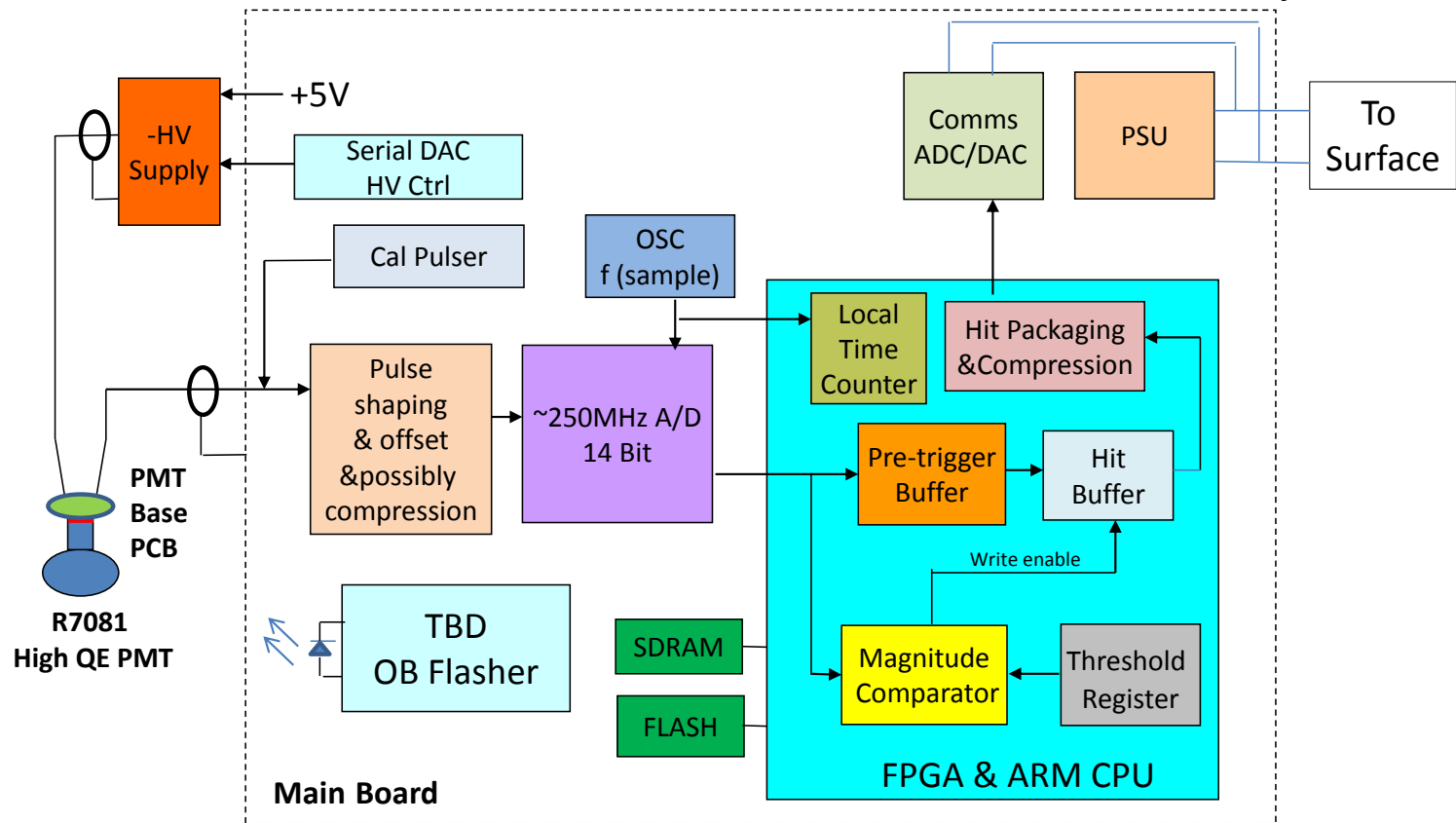
IceCube
DOM

KEY:
Component identical
Component eliminated
Component redesigned

Gen2
DOM

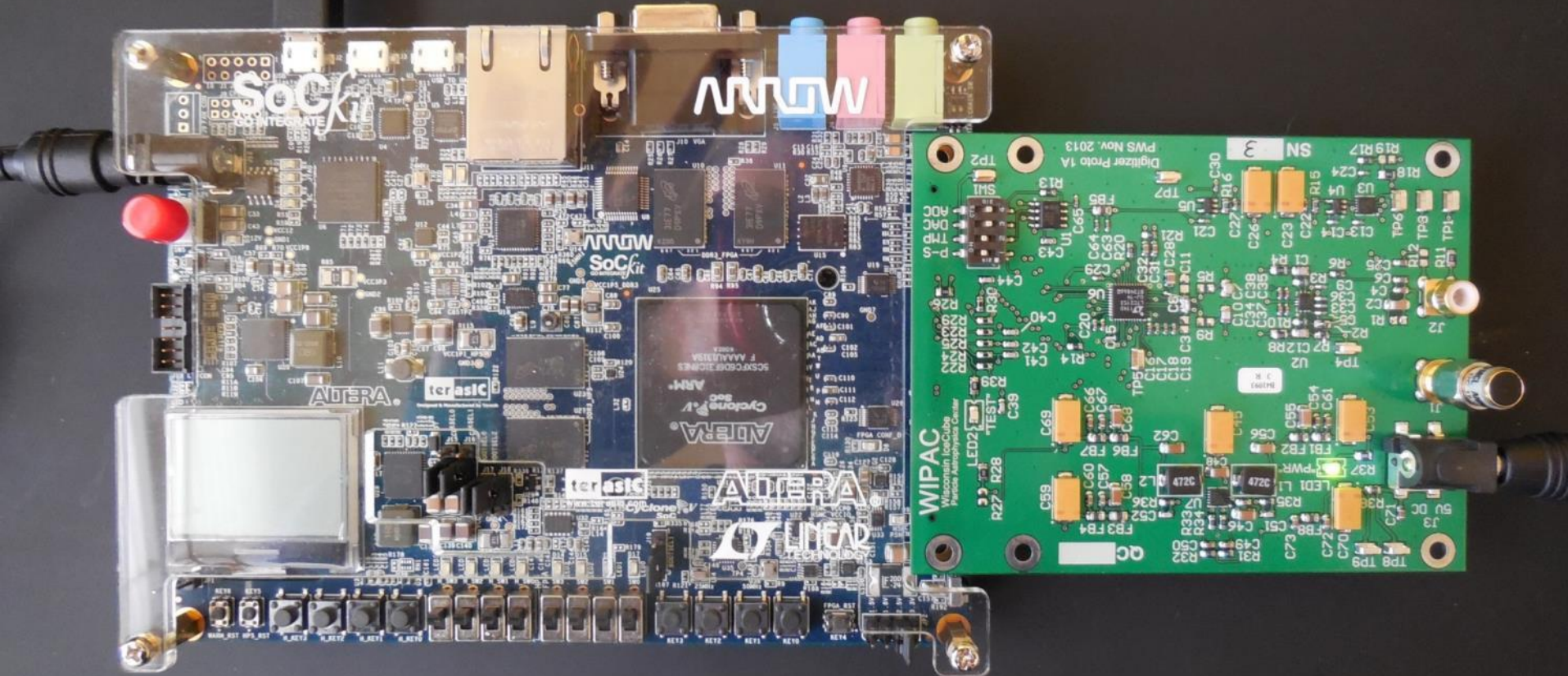
Gen2 DOM Block Diagram

P. Sandstrom, Univ. of Wisconsin–Madison



- Modernize obsolete / unavailable components (ATWDs, FPGA)
- Simplify by using high-resolution ADC (single gain channel), digital triggering

DDC 1 Bench Testing

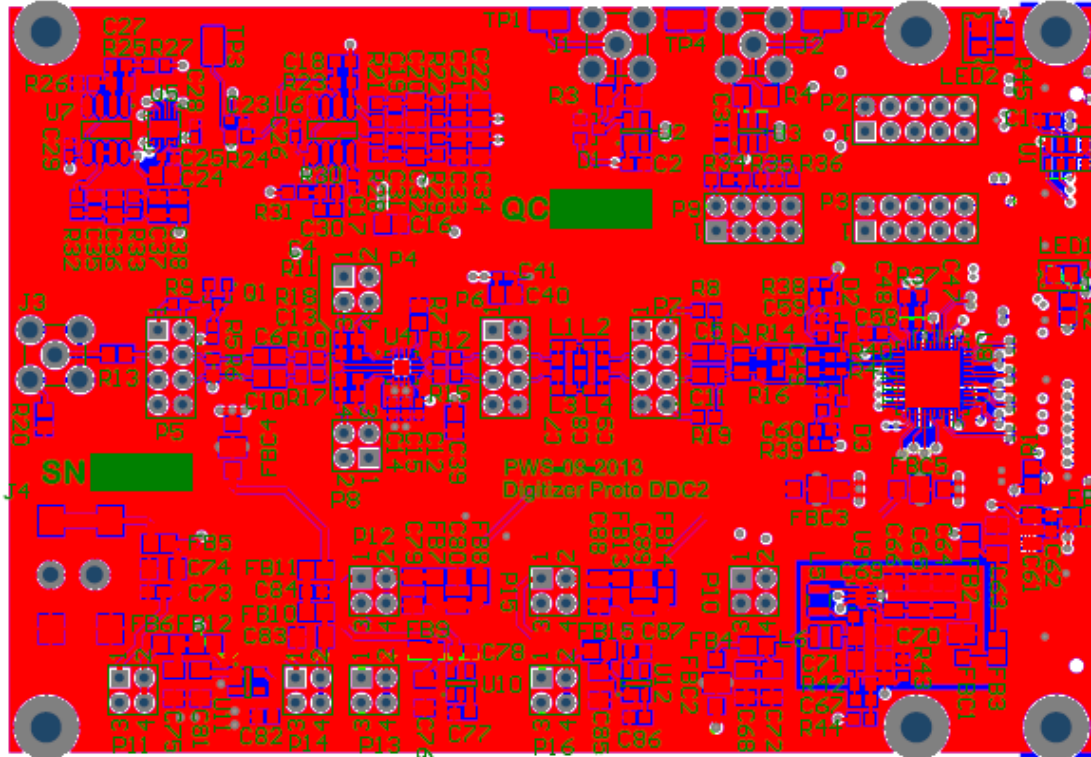


FPGA Evaluation "SOCKit"

Digitizer Daughter Card "DDC-1"

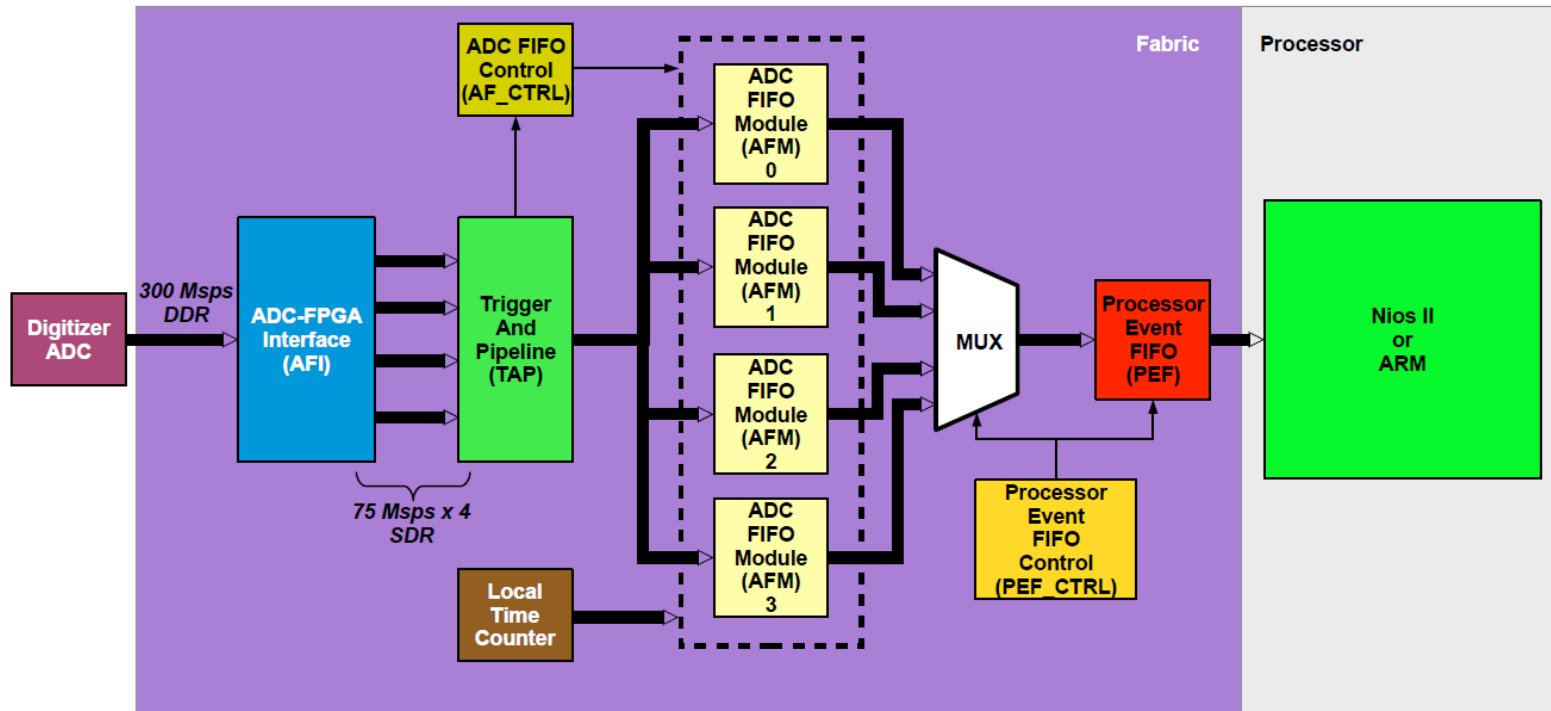
Second Revision

DDC-2 Printed Circuit Board *Fabricated early October*



New ADC (AD4149), revised analog FE, optional amplitude compressor

Digitizer Readout Firmware



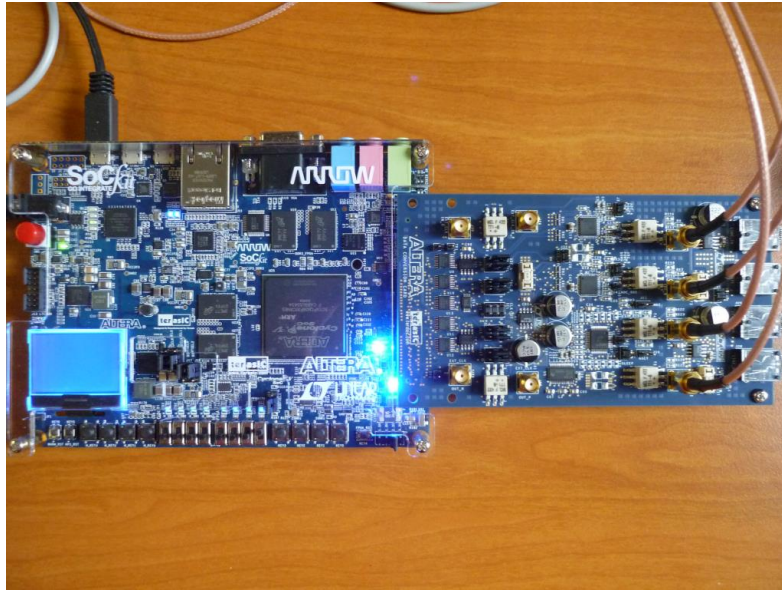
Prototype triggering and readout firmware complete

Study: ADC noise, feature extraction, power dissipation, processing requirements

T. Anderson, J. Groh (Penn State)

In-Ice Cable Communications

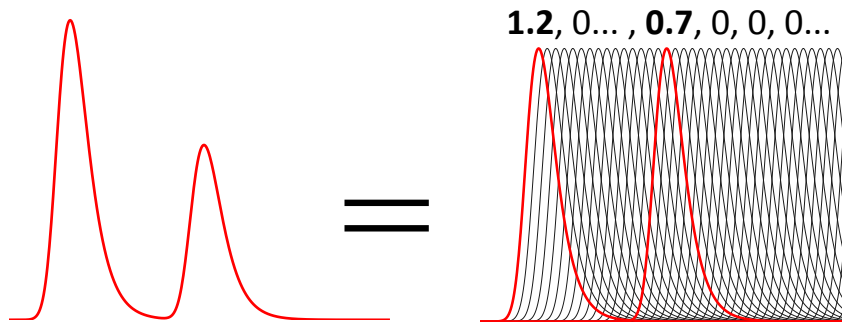
comms prototyping setup



K. Hanson, E. Pinat *Université Libre de Bruxelles*

- IceCube: custom amplitude shift key protocol
 - half duplex
 - 0.5 Mbps / DOM
 - 2 DOMs / twisted pair
 - time synchronization separate, requires comms silence
- Gen2 DOM: 16-QAM
 - full duplex
 - 0.25 Mbps down + 1.0 Mbps up / DOM
 - 4 DOMs / twisted pair
 - time synchronization integrated with phase recovery

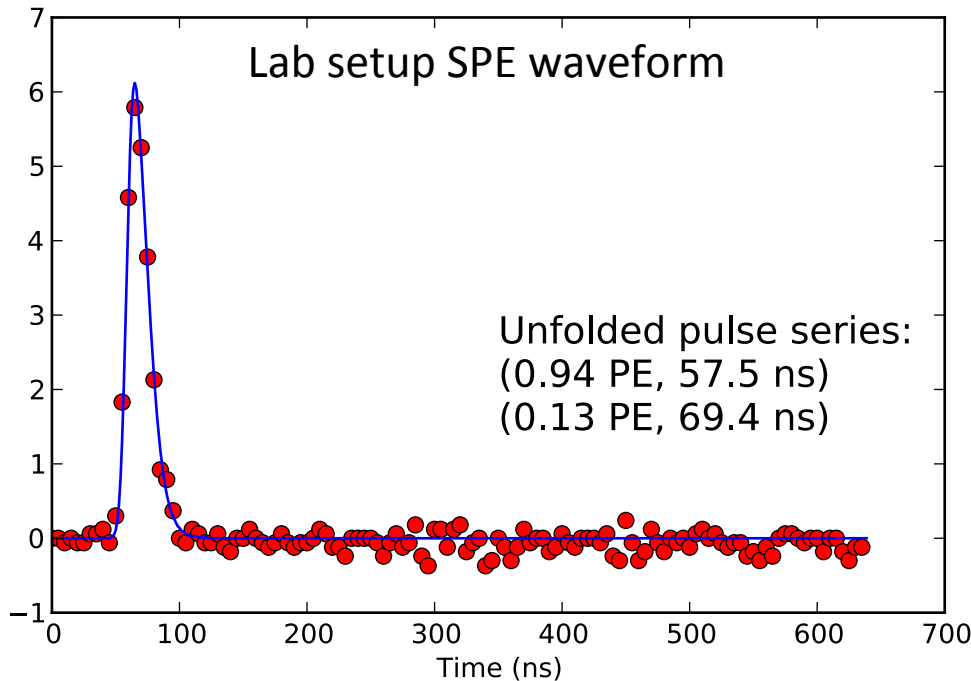
In-DOM Feature Extraction



- IceCube: pulse template unfolding to extract (charge, time) pairs from waveforms

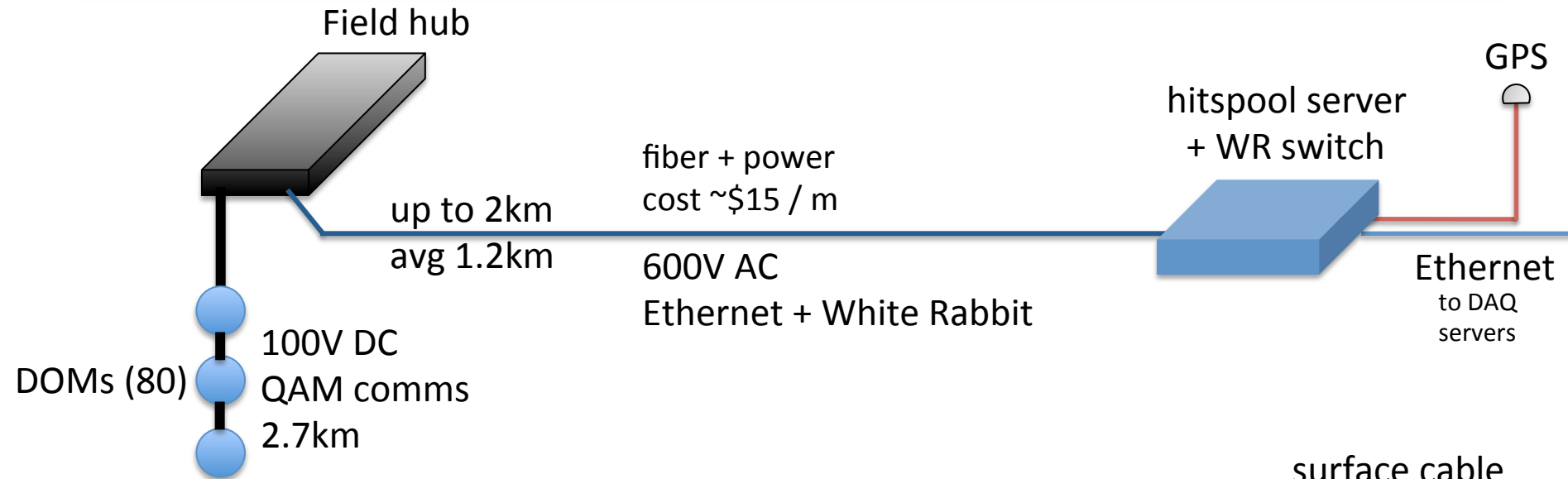
- now running on filtering cluster at South Pole

JINST 9 P03009 (2014)



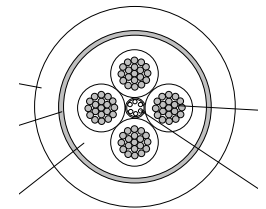
- Increase in CPU power: run directly on Gen2DOM
 - excellent compression for SPEs
 - now testing on ARM-based development board

DOM Readout (High-energy Extension)



- Hubs at top of hole
 - simplified DOM-to-Ethernet functionality (+timing)
 - AC high voltage + fiber to counting house
 - White Rabbit to synchronize hubs

surface cable cross-section



1.5 cm OD

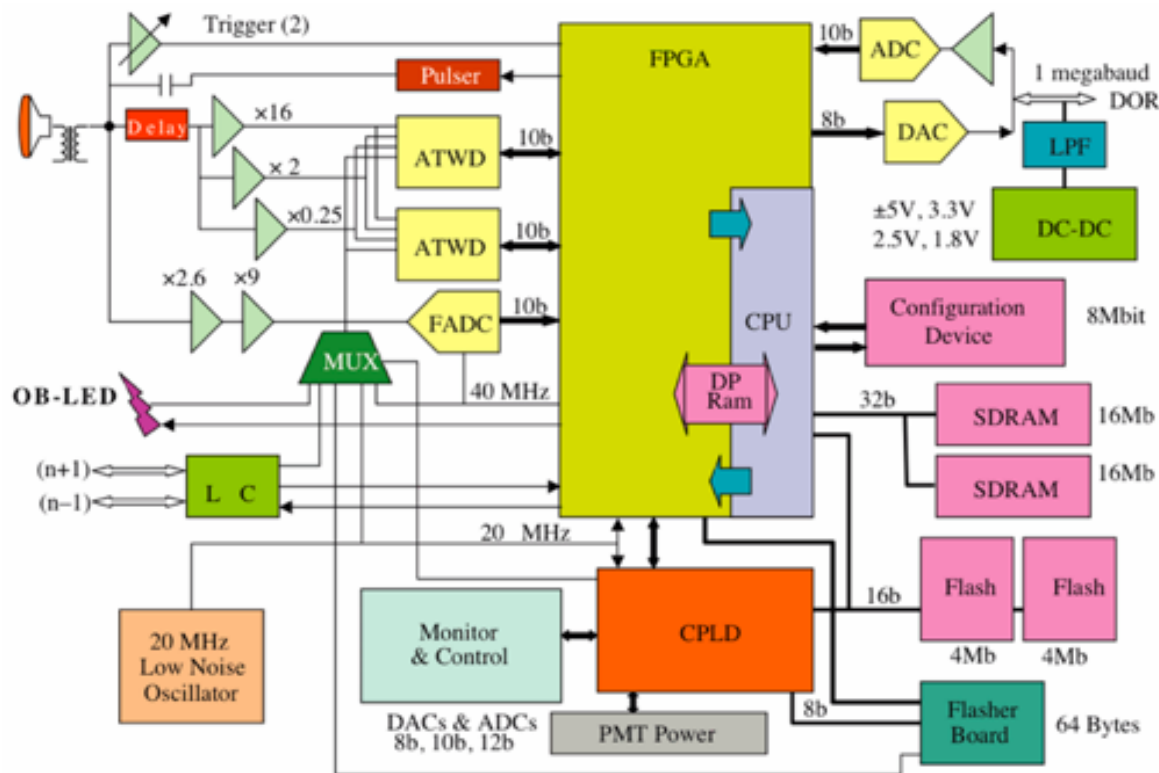
- Pros: reduced cable costs, power; higher-speed comms
- Challenges: cold; hubs not easily serviceable during winter

Summary

- Gen2 DOM keeps many successful components of IceCube DOM
 - high-QE Hamamatsu PMT, sphere, penetrator, gel
 - modernized digitizer, FPGA, comms
- Design of new components well underway
 - second revision of front-end / digitizer board
 - QAM communication prototyping underway
 - new HV supply, PMT coupling toroid design in progress
- New opportunities and challenges
 - likely more CPU horsepower in DOM
 - high-energy extension means moving some readout hardware out of the counting house

Backup

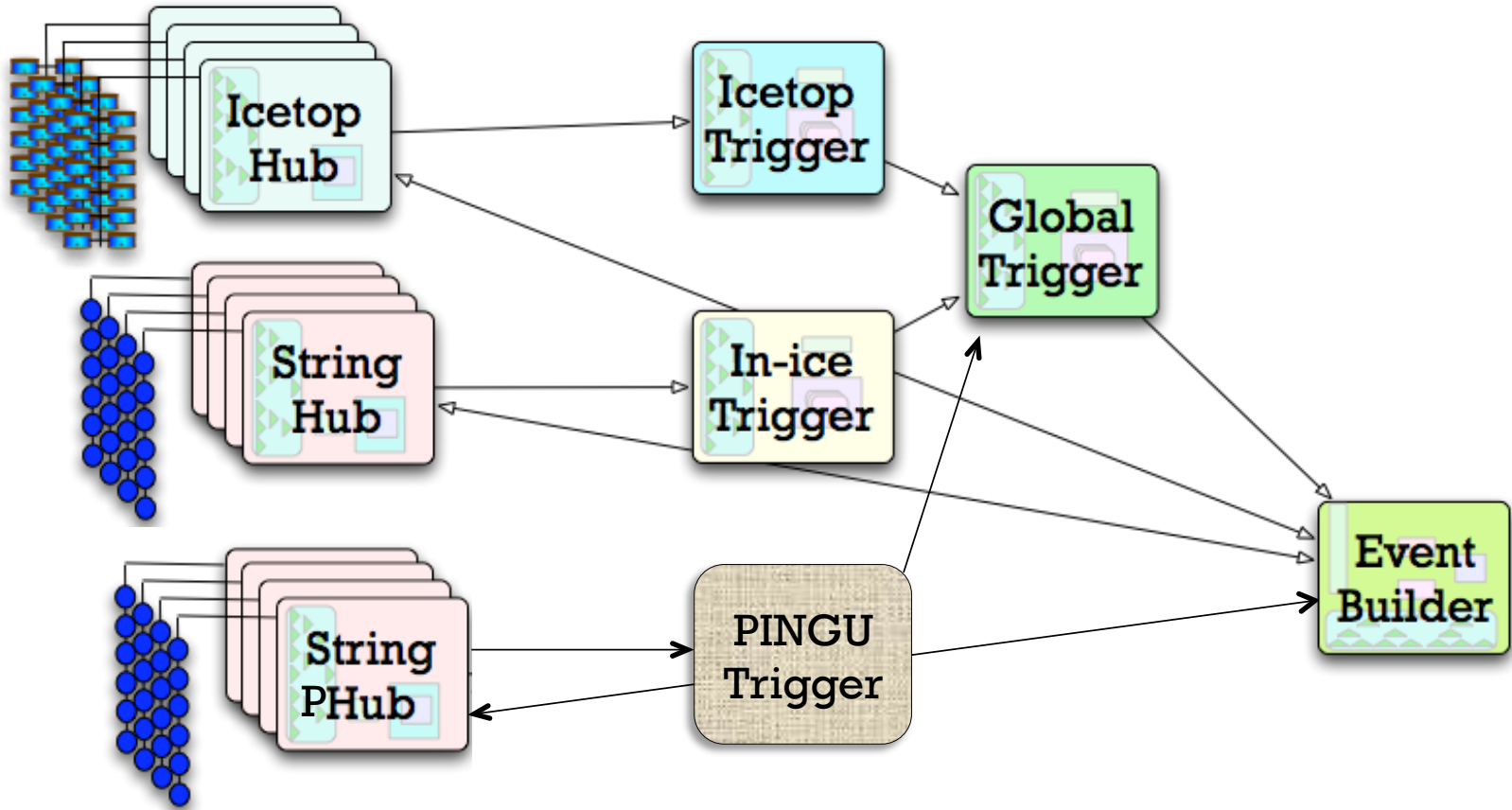
IceCube DOM Mainboard



"The IceCube Data Acquisition Subsystem: Signal Capture, Digitization, and Time-Stamping"

Nuclear Instruments and Methods in Physics Research A 601 (2009) 294–316

IceCube+PINGU DAQ Integration



Tight DAQ integration with separate PINGU trigger component

- readout all of PINGU+IceCube, but trigger is PINGU-only