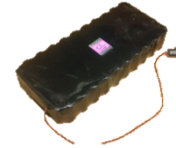
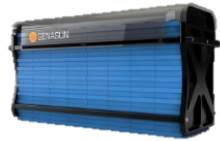


PASSCAL Battery Update

Paul Carpenter

4/12/2016

Power Storage



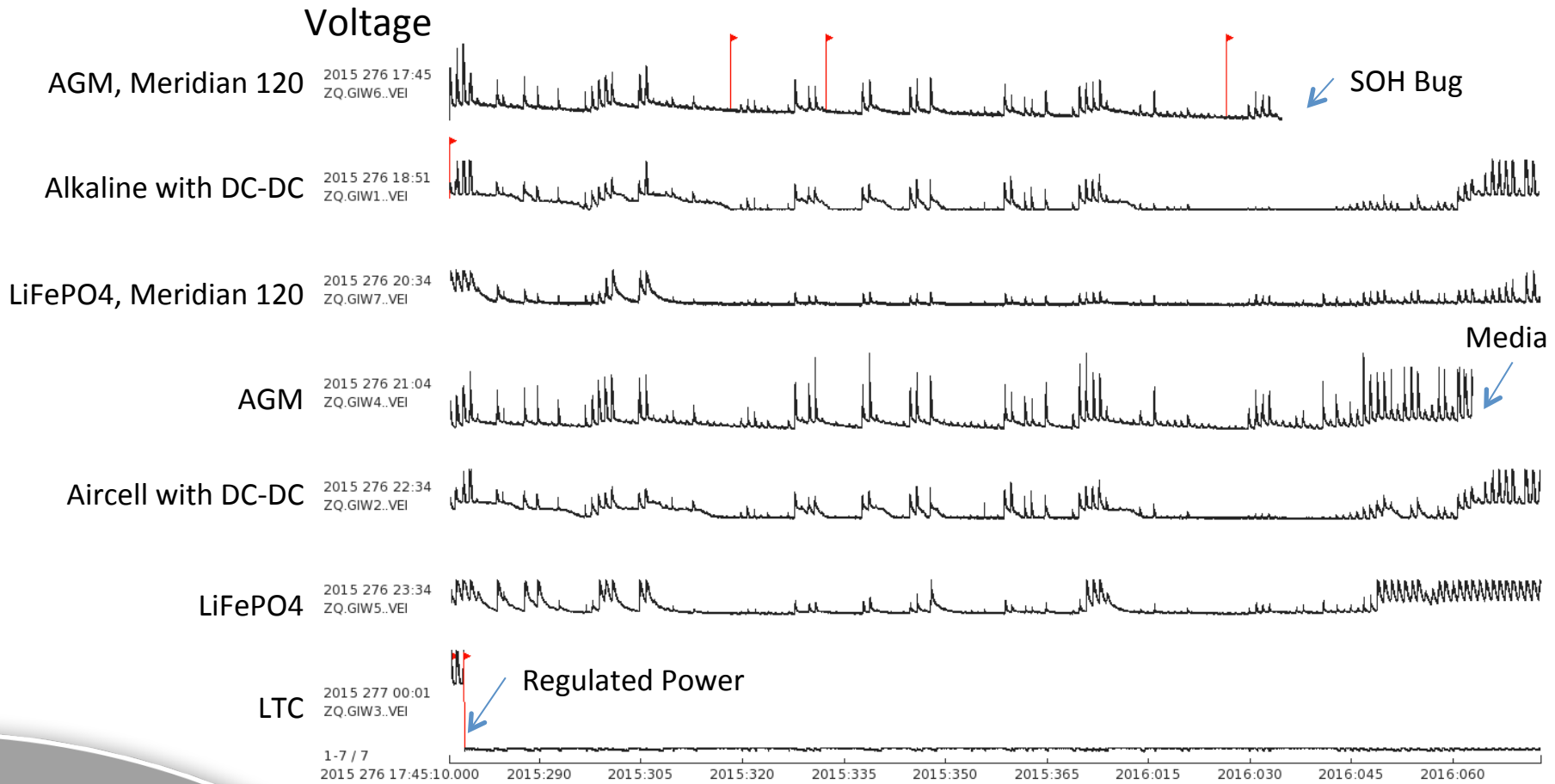
	LiFePO ₄ Secondary	AGM Secondary	Li-SOCl ₂ Primary	Air Alkaline Primary
Gravimetric Energy Density	37 Wh/lbs 36 Wh/lbs @ -20C	21.5 Wh/lbs 15 Wh/lbs @ -20C	311 Wh/lbs 304 Wh/lbs @ -20C	200 Wh/lbs TBD Wh/lbs @ -20C
Volumetric Energy Density	1.94 Wh/in ³ 1.90 Wh/in ³ @ -20C	2.07 Wh/in ³ 1.45 Wh/in ³ @ -20C	16.4 Wh/in ³ 16.1 Wh/in ³ @ -20C	11.5 Wh/in ³ TBD Wh/in ³ @ -20C
Cost	1.13 \$/Wh 1.16 \$/Wh @ -20C	0.187 \$/Wh 0.27 \$/Wh @ -20C	0.27 \$/Wh 0.28 \$/Wh @ -20C	0.11 \$/Wh TBD \$/Wh @ -20C
Type	Rechargeable	Rechargeable	Not rechargeable	Not rechargeable
Cold de-rate	Very Low	Medium	Very Low	High to Medium
Notes	<ul style="list-style-type: none"> • Very large number of charge cycles • Haz Cargo • New Technology 	<ul style="list-style-type: none"> • Years of experience using 	<ul style="list-style-type: none"> • Haz cargo • Long lead time • Replaced on regular schedule 	<ul style="list-style-type: none"> • DC-DC Converter • Very temperature sensitive

Battery Chemistries at Taku Glacier

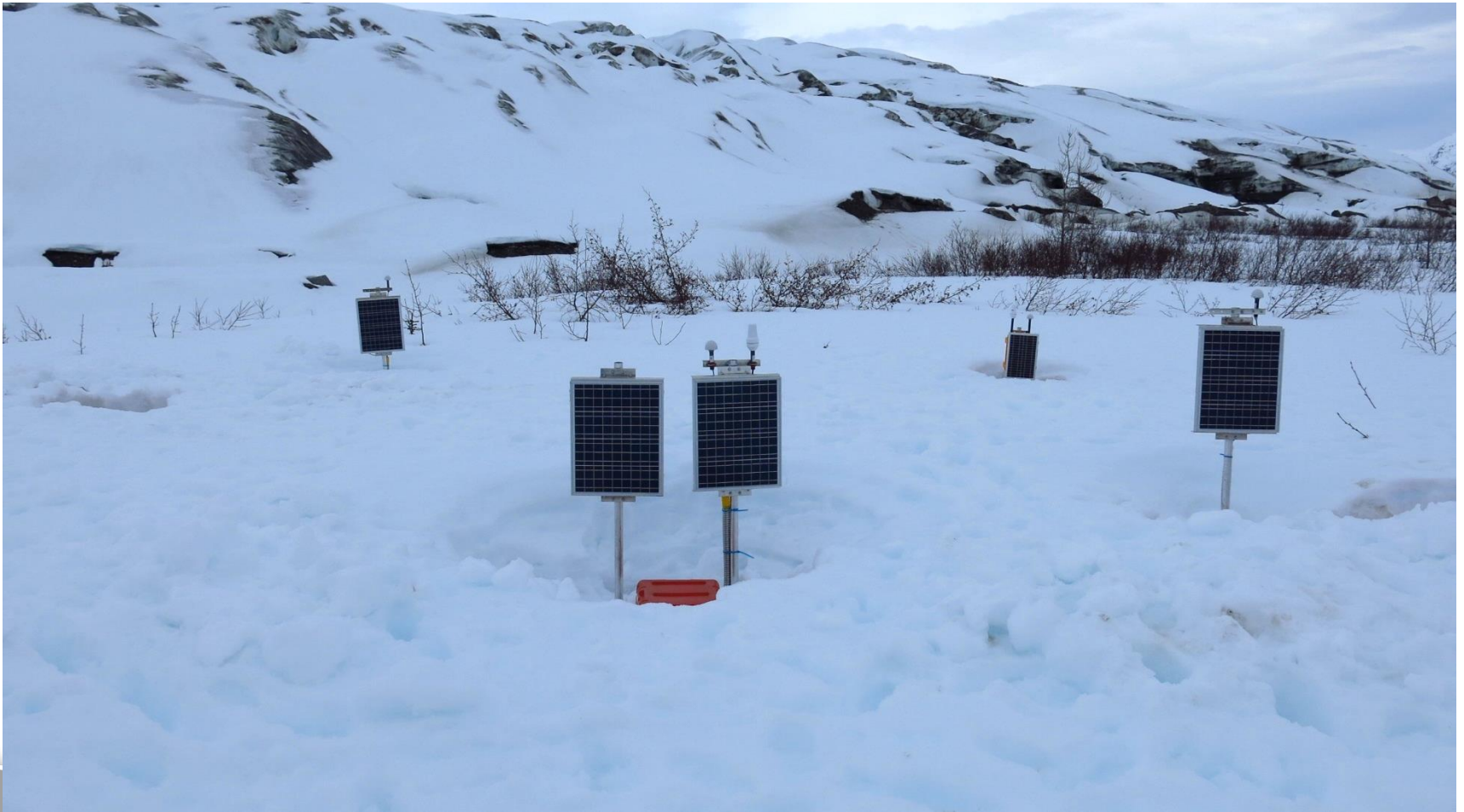
Station	Chemistry	# Batteries	SIU	Sensor	Panel
Winter 1	Alkaline	30x MN918	External	Compact	20W
Winter 2	Aircell	3x 6V 4AS10	External	Compact	20W
Winter 3	LTC	2x Custom Pack	External	Compact	20W
Winter 4	AGM	4x 108Ah	Internal	Compact	45W
Winter 5	LiFePO4	3x 100Ah	Internal	Compact	45W
Winter 6	AGM	8x 108Ah	Internal	120	45W
Winter 7	LiFePO4	6x 100Ah	Internal	120	2x 45W



Battery Results at Taku Glacier



Taku Glacier



Air Alkaline Batteries

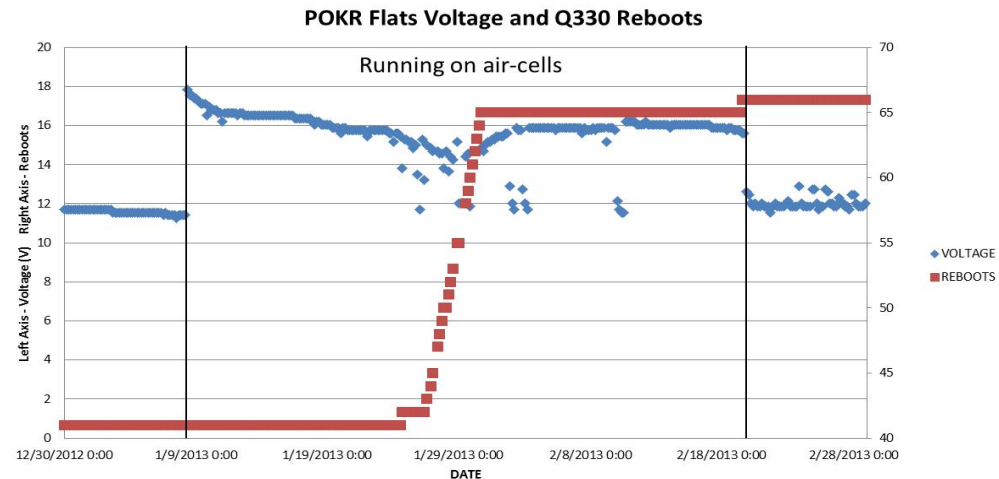
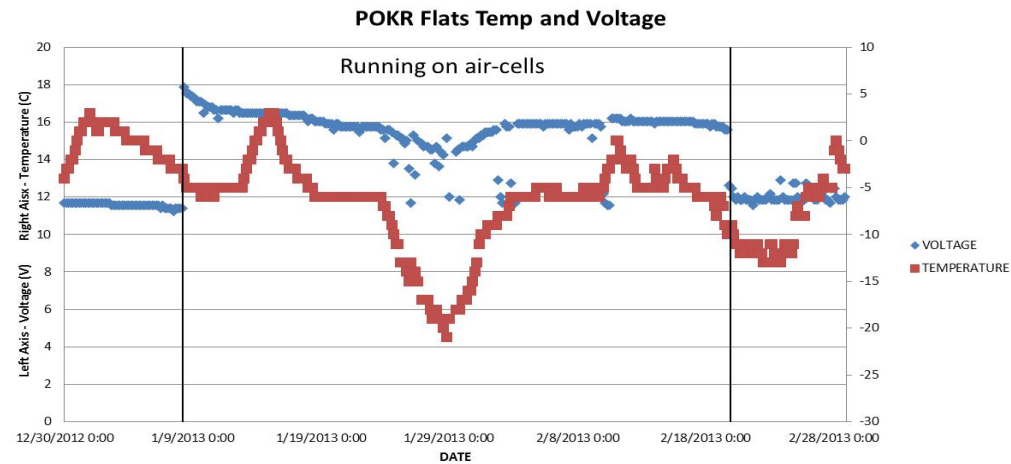
Due to increasing demand/interest in Air Alkaline Batteries, PASSCAL has been testing cells in a variety of conditions to verify characteristics.

Pros

- High energy density
- Inexpensive
- Non-hazardous (easy to ship)

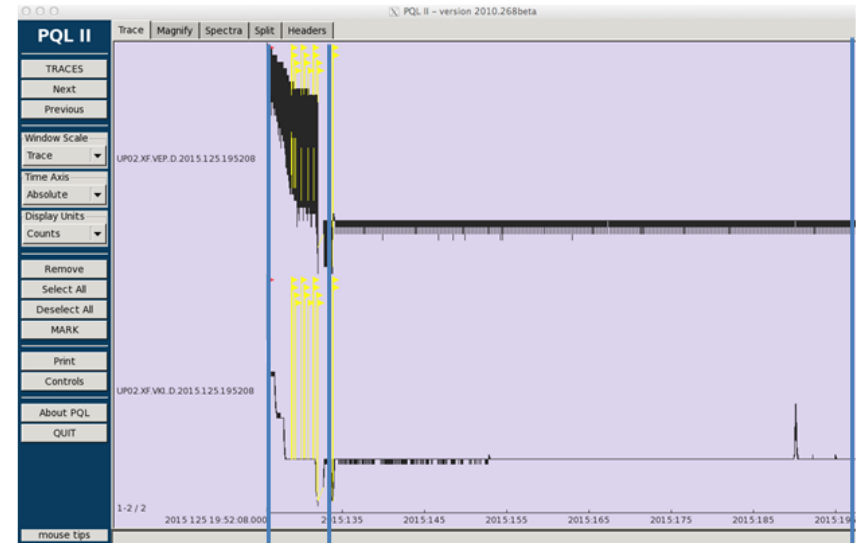
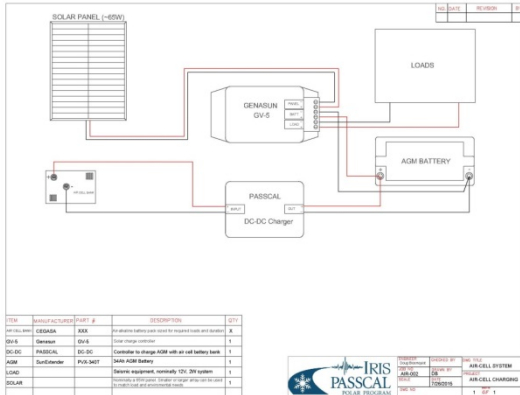
Cons

- High Impedance (can't source large amounts of current)
- Poor cold weather performance
- Require air supply



Air Alkaline Batteries

DC-DC convertor: In an attempt to bypass the cold weather limitations of Aircells, PASSCAL developed a DC-DC convertor to “trickle charge” a secondary battery capable of sourcing more current in the cold.



System running on 34Ah AGM battery -20C with DC-DC converter used to maintain the battery's voltage with air cell bank

System running on air cells only. Note the reboots and data loss starting at -20C

DC-DC Field Results

GIW1 (winter, with a LiFePO4 battery, and an alkaline external power box)

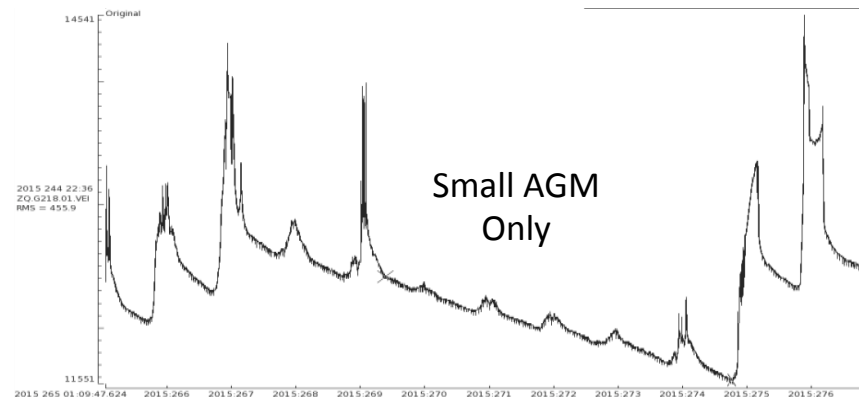
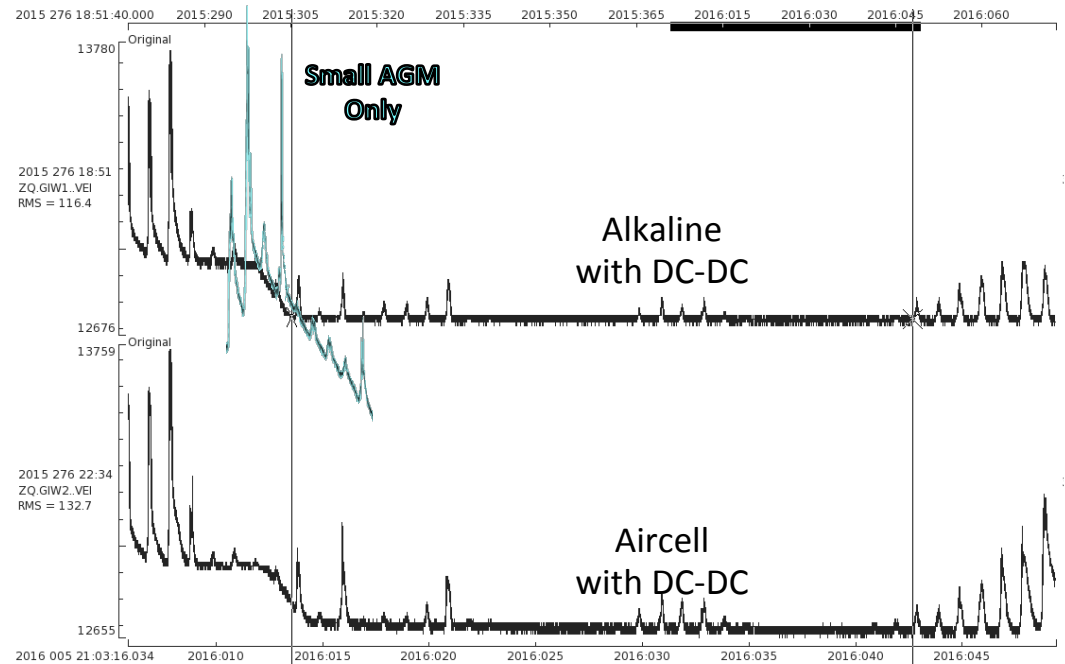
- Over ~29 days of low sunlight
- Maintained ~12.7V

GIW2 (winter, with a LiFePO4 battery, and an aircell external power box)

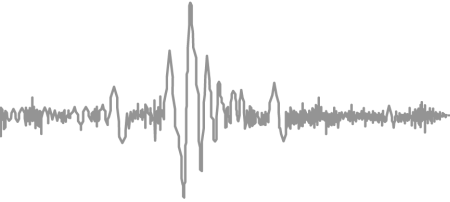
- Over ~29 days of low sunlight
- Maintained ~12.7V

GI01 (summer, with an AGM battery)

- Over ~5 days of low sunlight
- Dropped from ~12.4V to ~11.6 V.
- About half of the other comparable summer stations LVD'd.



Acknowledgements



NSF: National Science Foundation

IRIS: Incorporated Research Institutions for Seismology

NMT: New Mexico Tech

