Cosmogenic Activation in the DM-Ice Experiment

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APS April Meeting
Session D11: Dark Matter II
13 April 2013









DM-Ice Logistics

Before running a dark matter experiment at the South Pole . . .

DM-ICE17 Component Sources
- Crystals: Boulby, UK
- Steel: Sandviken, SWE

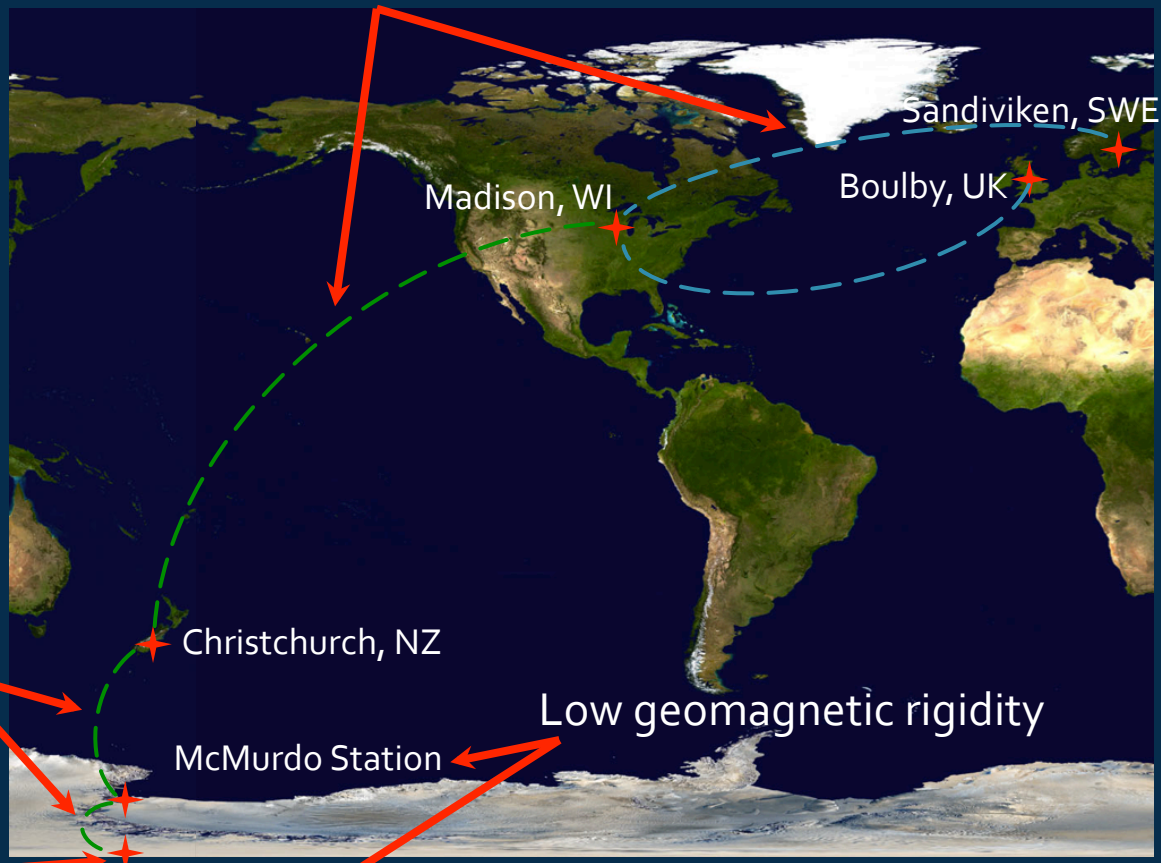
DM-ICE17 Construction
- Madison, WI, USA

Polar Program Waypoints
- Christchurch, NZ
- McMurdo Station
- South Pole Station



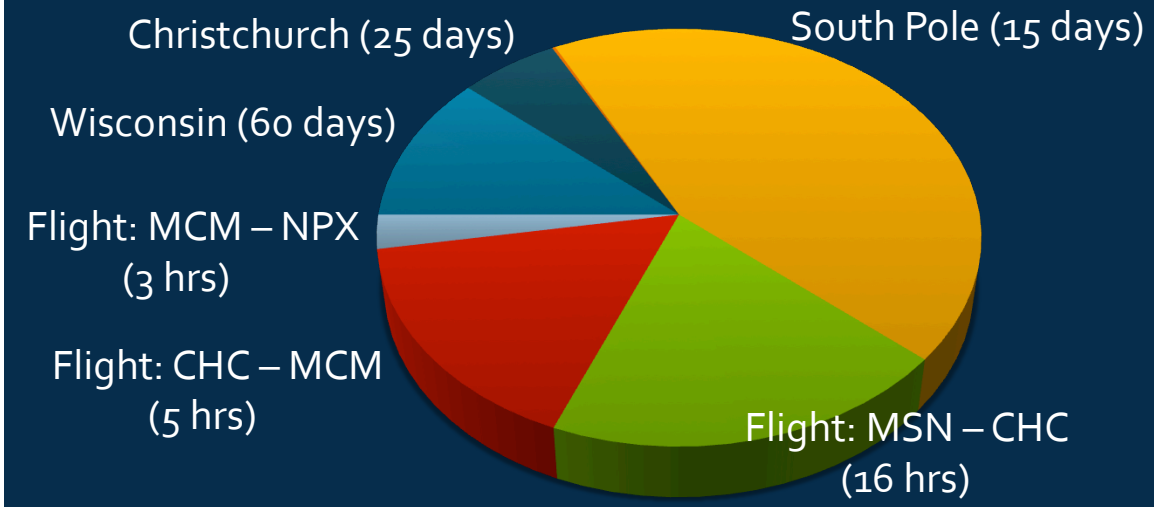
Cosmogenic Activation Hazards

Location	Relative Neutron Rate (to sea level)
Madison, WI	1.26
South Pole	9.7
Commercial Flight	130



Cosmogenic Isotopes

- Activity of cosmogenic isotopes simulated by:
  - COSMO code for NaI
  - Literature values for Steel and Copper
- Breakdown of crystal activation by travel stage:



Crystal	Steel
^{3}H	^{7}Be
^{7}Be	^{46}Sc
^{22}Na	^{48}V
^{113}Sn	^{51}Cr
^{121m}Te	^{52}Mn
^{123m}Te	^{54}Mn
^{125m}Te	^{56}Co
^{127m}Te	^{56}Ni
^{125}I	^{58}Co
^{127}Xe	

Cosmogenic Simulation Effects

Long-lived cosmogenic isotopes from crystal and pressure vessel are expected to persist into data taking

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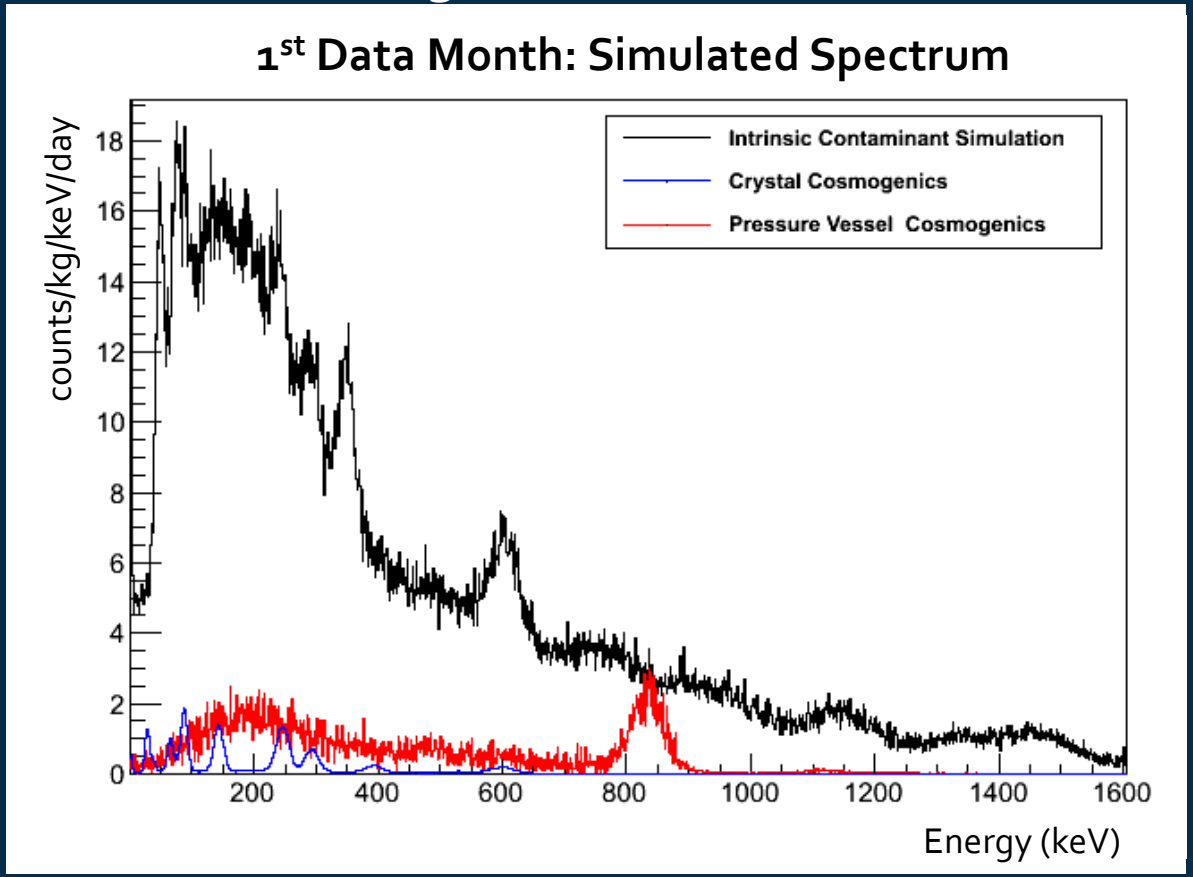
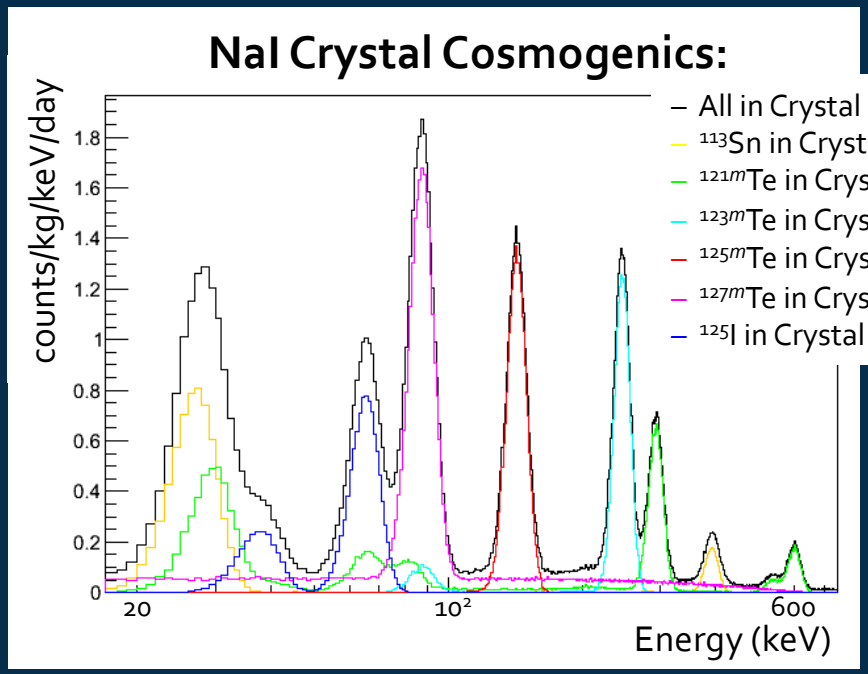
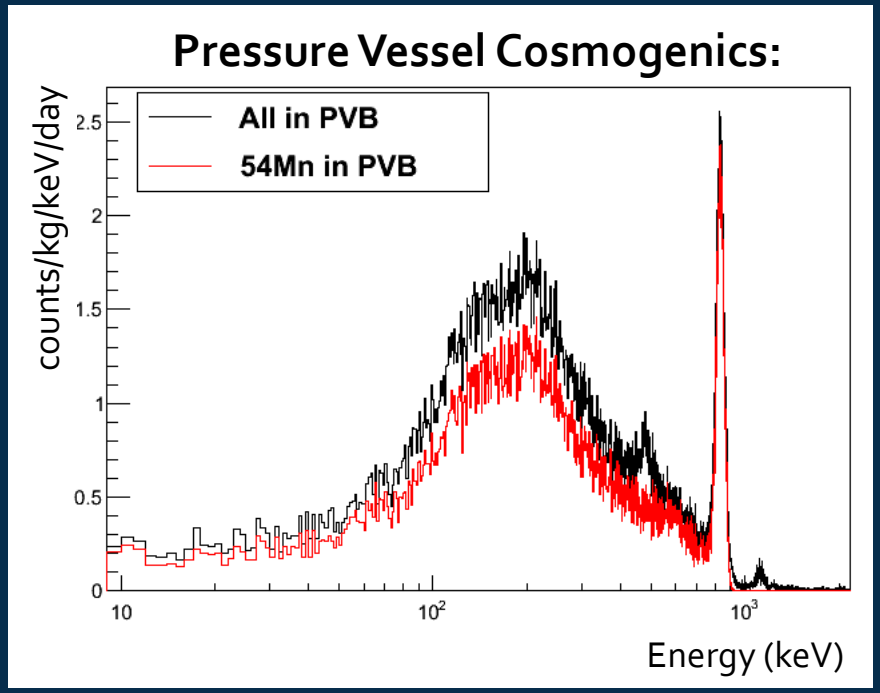


Cosmogenic Signals in July 2011*

* (6.5 months after deployment, first month of data run)

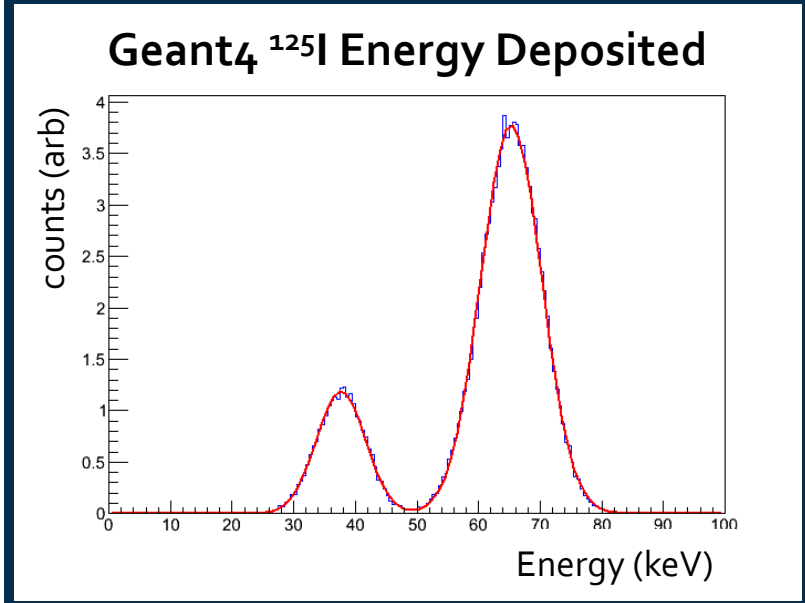
- NaI Crystal
  - Still expect clear peaks from multiple isotopes
- Steel Pressure Vessel
  - ^{54}Mn is only significant isotope

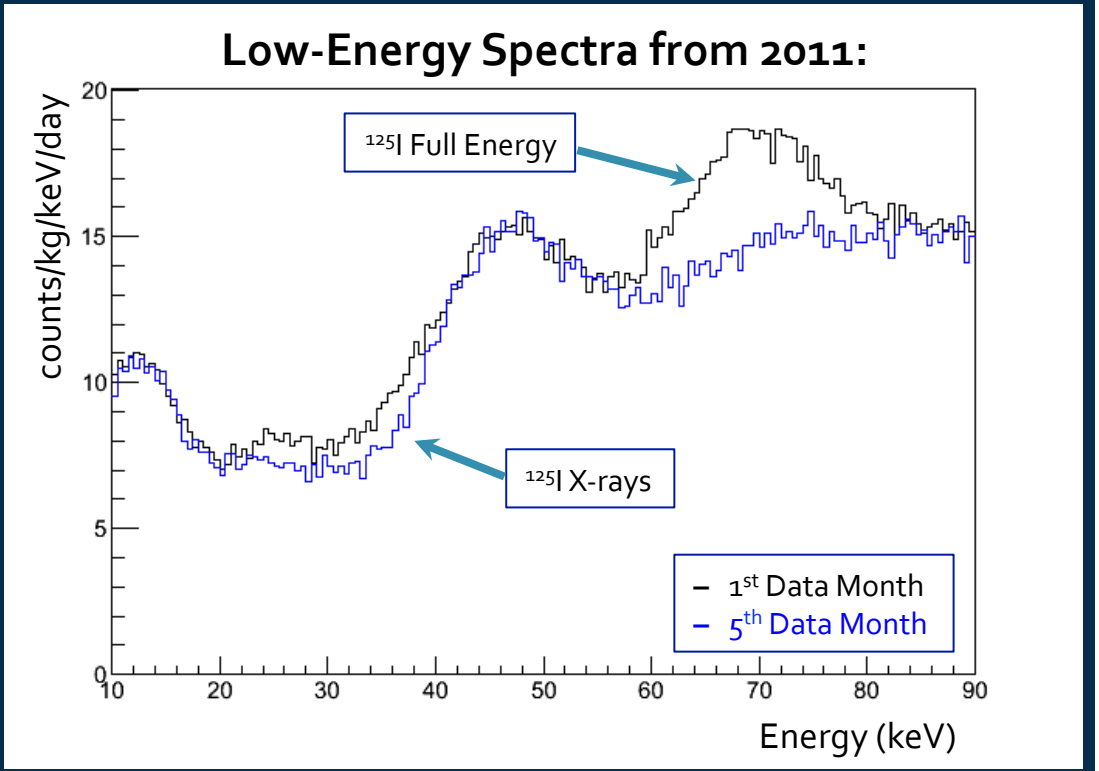




^{125}I in DM–Ice17 Spectrum

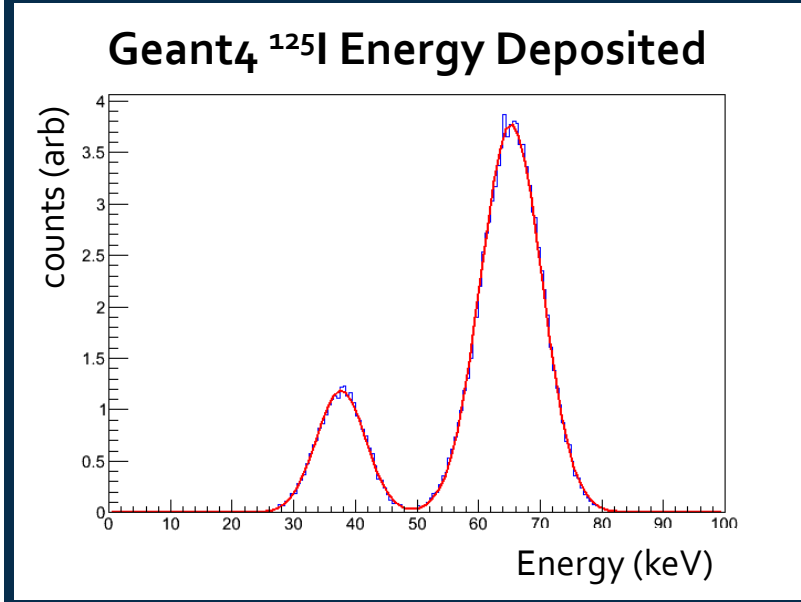
- ^{125}I ($t_{1/2}$ = 59.4 days) is good candidate for search in early data months

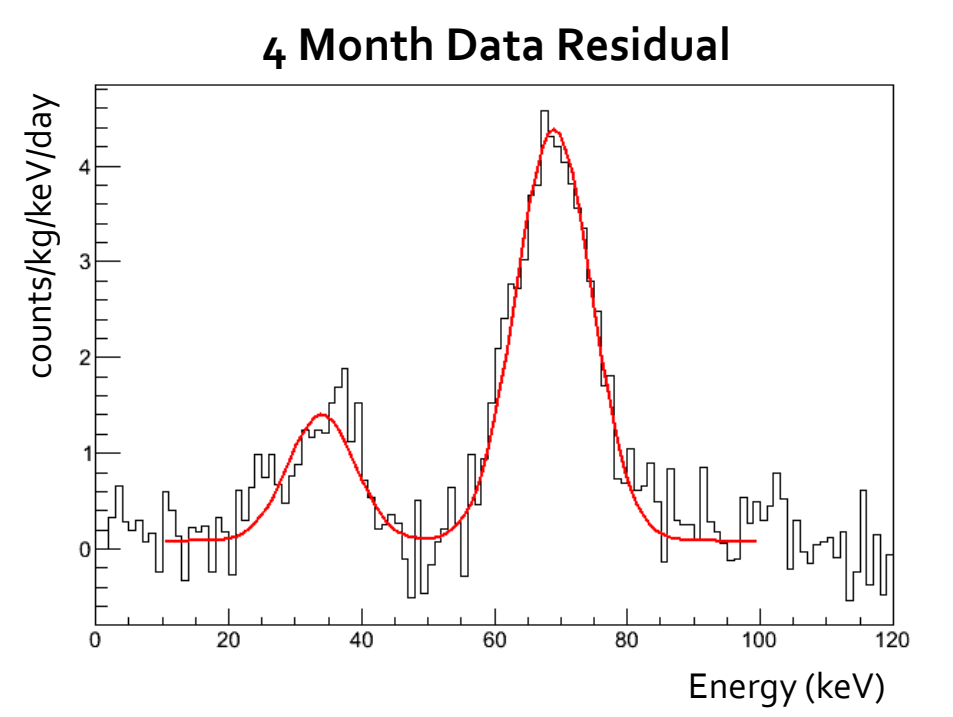




^{125}I Data to Simulation

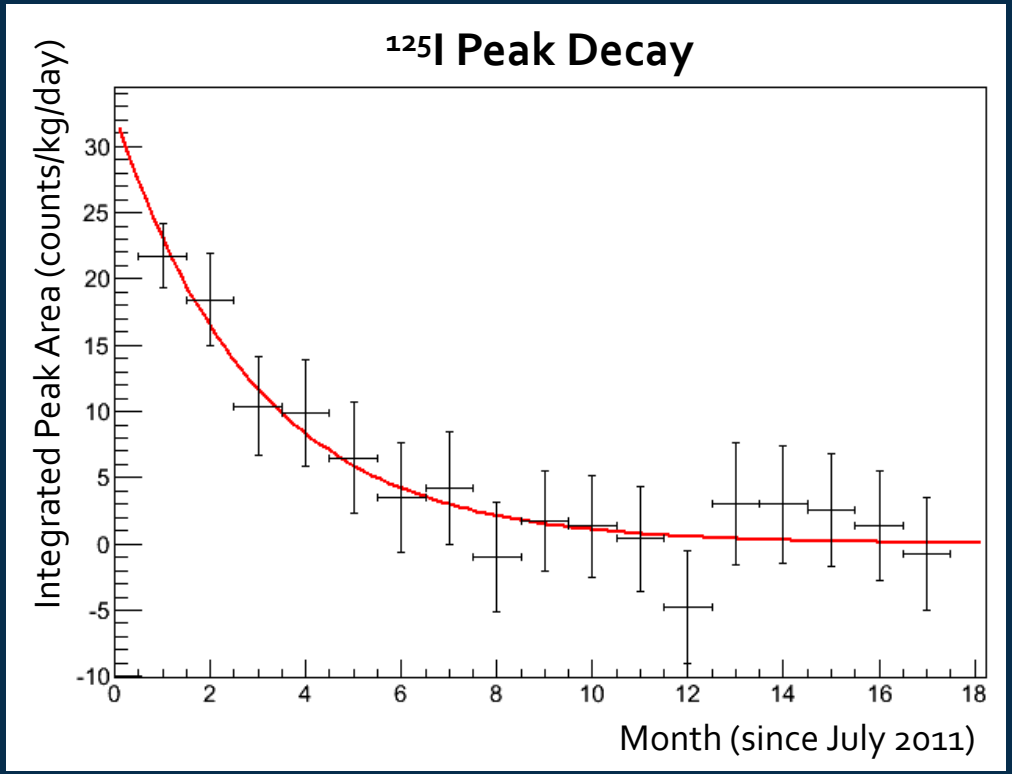
- Residual between two months of data reveals clean ^{125}I peaks:





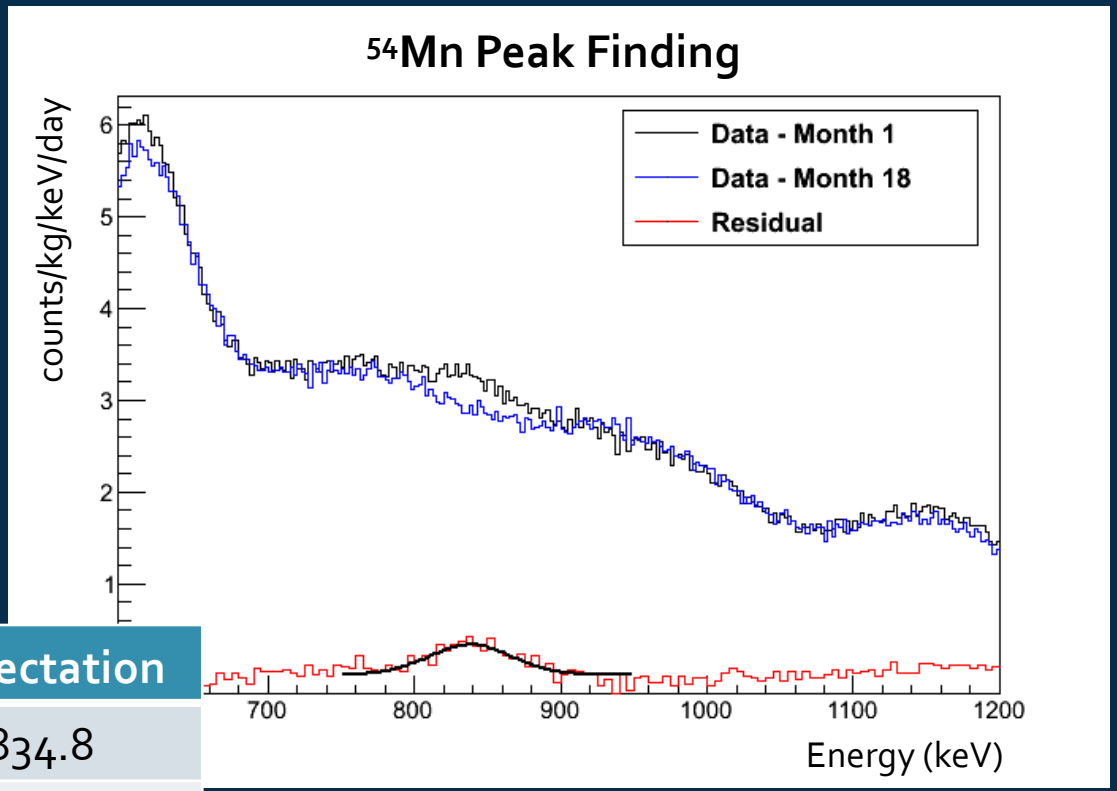
^{125}I Peak Decay

- $\lambda = 0.3500 \pm 0.0157$ month^{-1}
  - $t_{1/2} = 59.41 \pm 2.66$ days
  - (59.4 days)
- Deploy activity:
  - 1151 ± 118 cpd/kg



^{54}Mn in DM-Ice17 data

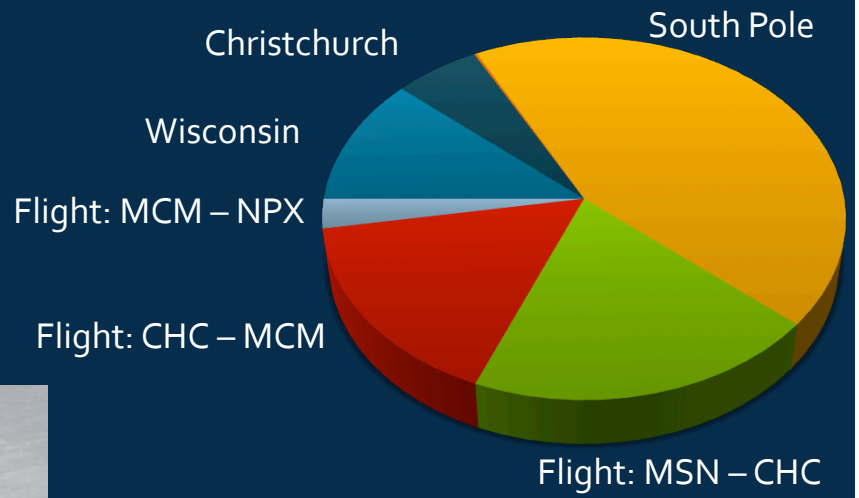
- γ-line expected from ^{54}Mn
  - E_γ = 835 keV
  - $t_{1/2}$ = 312.03 days



	Fit	Expectation
Energy (keV)	836.1 ± 3.0	834.8
Sigma (keV)	36.9 ± 3.7	23.3
Deploy Rate (decays/day)	51,700 ± 6,500	135,800

Cosmogenic Mitigation at Pole

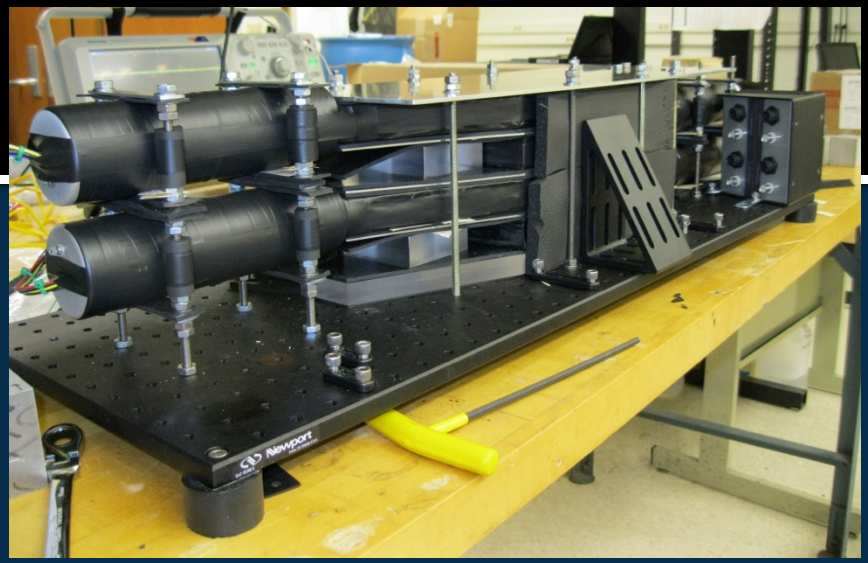
- Time on surface at South Pole can be most damaging stage for cosmogenics:





South Pole is topographically flat and station buildings provide minimal overburden

Tunnel Storage



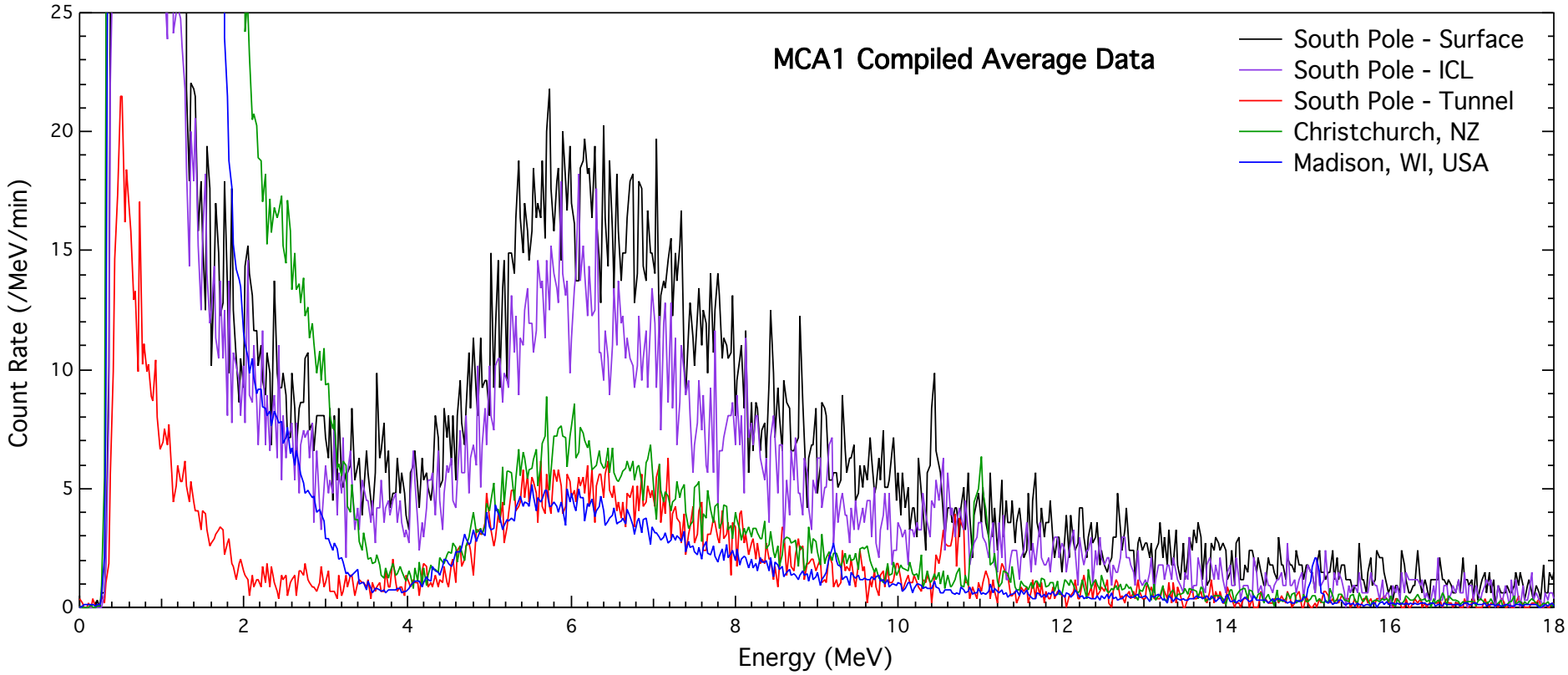
- 40-50 ft firn overburden
  - ~ 10 m.w.e.
  - ~ 30% of surface muon rate





Muon Flux Reduction

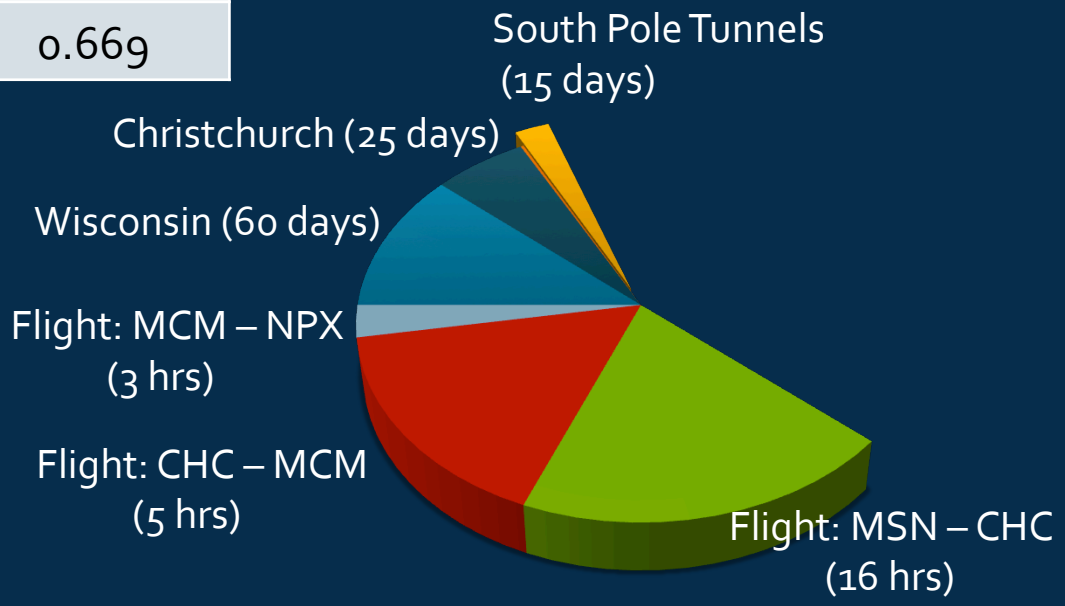
- Muon spectra comparison of South Pole sites with Christchurch and Madison data



Muon Flux

Location	Elevation (ft)	Relative Intensity*
South Pole - Surface	9190	2.60
South Pole – ICL	9190	1.89
South Pole – Tunnel	9190	0.795
Christchurch, NZ	120	1.00
Madison, WI, USA	880	0.669

*Relative to Christchurch – approximately sea level



Conclusions

- Cosmogenic activation is a significant concern for running a low-background detector at the South Pole
  - Mitigation strategies can significantly reduce activation levels
- Cosmogenic lines can also be helpful in calibration of remote detector
  - See Antonia Hubbard's talk, (D11.00008)