Part I:
Scientific Motivation for Replicate Coring at Hercules Dome:

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1. Ability to replicate / confirm measurements and findings

- Why do measurements need to be replicated in general?
    - Verify measurement integrity
    - Mitigate analytical issues during main core measurements
    - Confirm novel findings / measurements made with new techniques

- Example of specific scientific application:
    - Is the decadal/centennial variability in water isotopes spatially coherent even on very short distance scales? (Markle)

- With a 98 mm diameter core, we will be very limited on available Herc Dome ice
    - Unlikely that ice for replication of any type of measurement would be immediately available from the main core

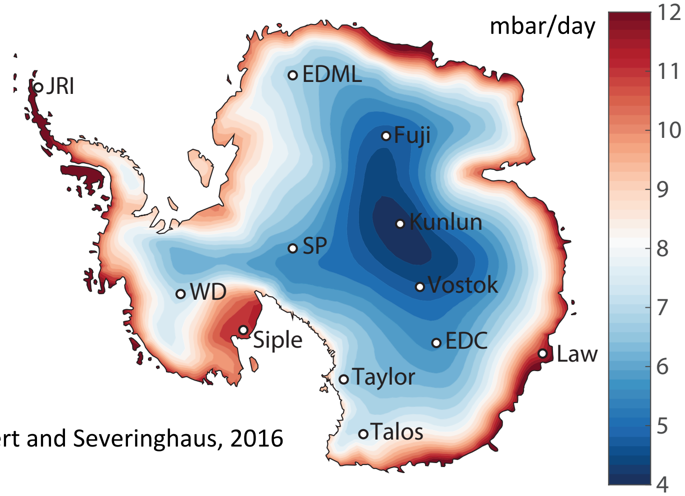
2. Provide larger ice amounts needed for some studies

- Last Interglacial (Eemian) ice annual layer thickness could be as low as ≈1 mm. The entire Eemian could be contained in as little as ≈10 m

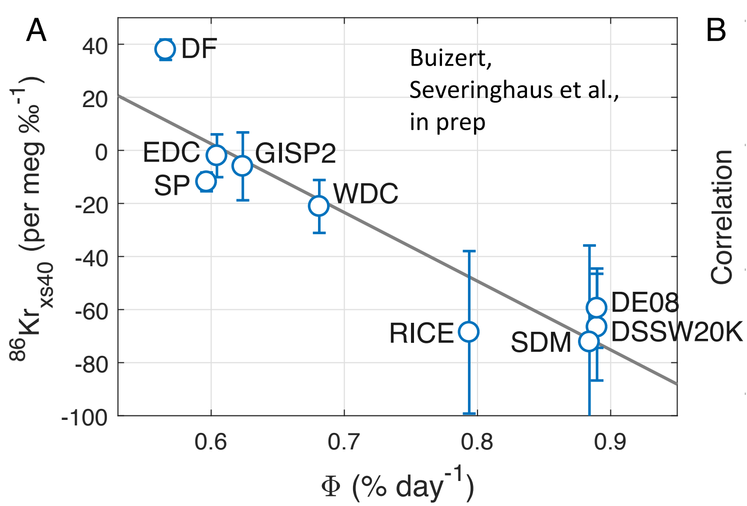
- Examples of studies / questions for Eemian that can probably only be answered if replicate cores were available (require ≈300 – 2000 g ice):
  - Impact of regional and global volcanism on Eemian climate (tephra studies, Kurbatov, Dunbar and Iverson)
  - Investigating Eemian dust sources and atmospheric transport – geochemical composition and physical properties, including new techniques (Aarons; Kreutz and colleagues)
  - Investigating wildfire activity and emissions in a warmer world using C_2H_6, C_2H_2, CO isotopes, $\delta^{13}CH_4$ (Aydin, Saltzmann, Petrenko, Brook)
  - Climate sensitivity of terrestrial Gross Primary Productivity (GPP) using COS and possibly $\delta^{13}CO_2$ (Aydin, Saltzmann, maybe also Brook)
  - Investigating greenhouse gas cycling (CO_2, CH_4, N_2O) during Termination II and last glacial onset using isotopes (Brook)

- Studies in other time intervals that also require larger sample amounts -- see above; also $^{14}CO_2$ for improving radiocarbon calibration curve (Petrenko)

3. Improve chances of success with answering the key driving questions for Hercules Dome project



Buizert and Severinghaus, 2016



- "How much, how fast?" with respect to the possible WAIS collapse during Eemian
- What if the water isotope approach yields inconclusive results?
- ^{86}Kr excess can record the intensity of firn barometric pumping (or storminess)
- If WAIS collapsed during the Eemian, Hercules Dome would be closer to coast, lower altitude and stormier → more pronounced ^{86}Kr excess
- Can also get timing of collapse
- Large ≈800 g samples needed

Part II:
Shallow Coring at Dome C to Understand Galactic Cosmic Ray Flux Variability

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How constant is the galactic cosmic ray flux?

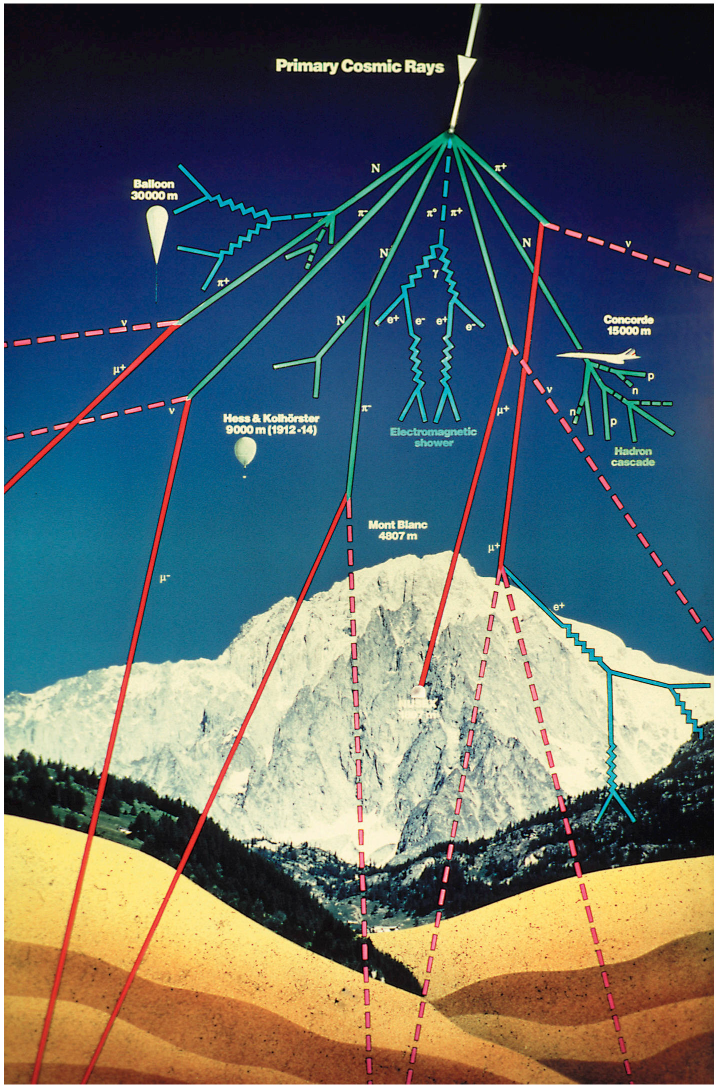

Image: CERN

<u>Useful for:</u>

- Improving estimates of past solar activity and irradiance (based on atmospheric ^{10}Be and ^{14}C)
- Understanding glacial exposure histories, erosion rates, ice dynamics (based on in situ ^{14}C, ^{10}Be, ^{36}Cl, ^{26}Al)
- Discerning past changes in supernovae activity

Measurements of cosmogenic nuclides in meteorites suggest that cosmic ray flux is stable on long time scales, but uncertainties are 30% or larger

How can ^{14}CO in ice cores record the past cosmic ray flux?

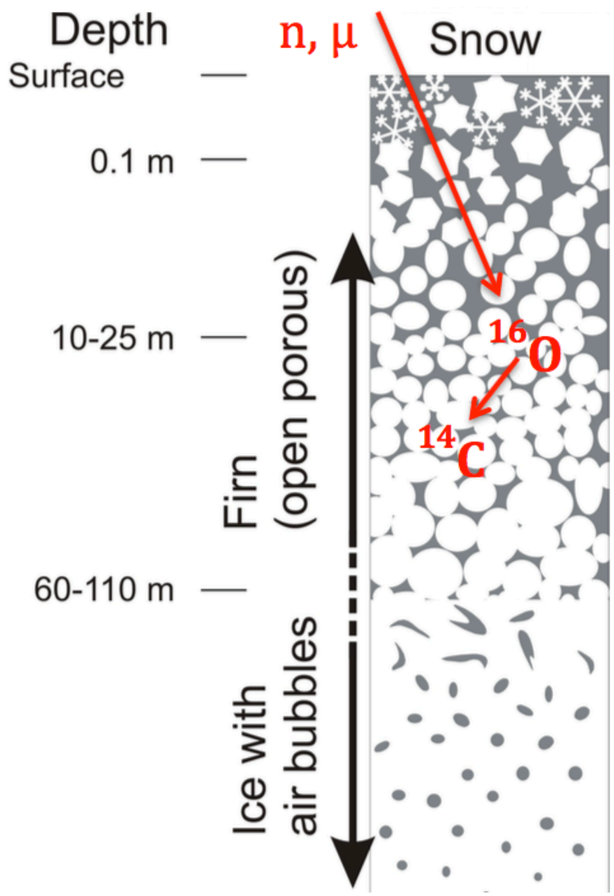

Figure: Modified from Schwander, 2007, EQS

- In situ cosmogenic ^{14}C: neutrons, muons
- Leaks out of firn grains, but fully retained below firn layer
- In situ cosmogenic ^{14}C dominates the CO phase at most ice core sites
    - Muon-produced ^{14}C signal below firn layer
    - Higher-energy cosmic rays
    - Insensitive to solar or geomagnetic modulation – pure signal of galactic cosmic ray intensity
- Dome C: low accumulation rate helps to maximize ^{14}C signal
- Should be able to constrain long-term (kyr-scale) cosmic ray flux variability over past ≈7 kyr to ≈15%

Logistics

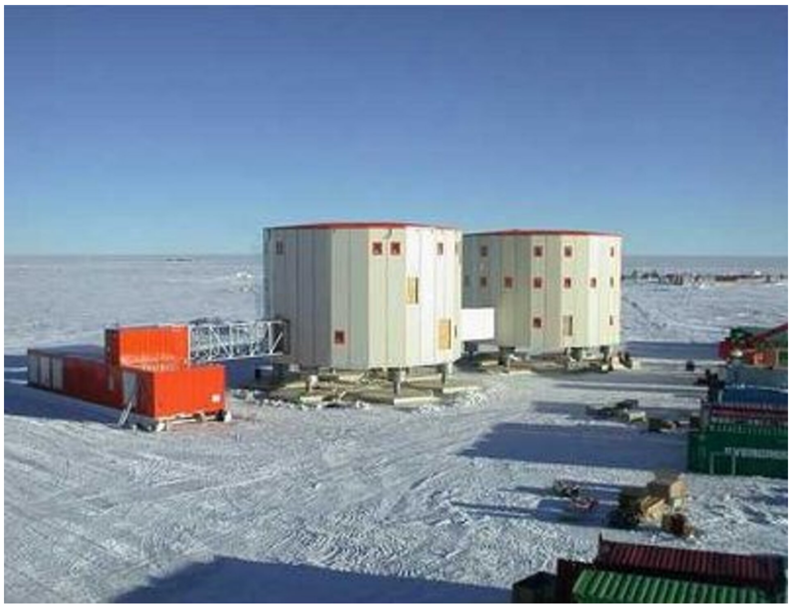

Image: European Space Agency

- Partnership with French program
  - Joel Savarino
  - Melanie Baroni
- Target drilling season: 2022-23
- 2 dry-drilled cores to 300m with IDP 4” or Foro 400 drill