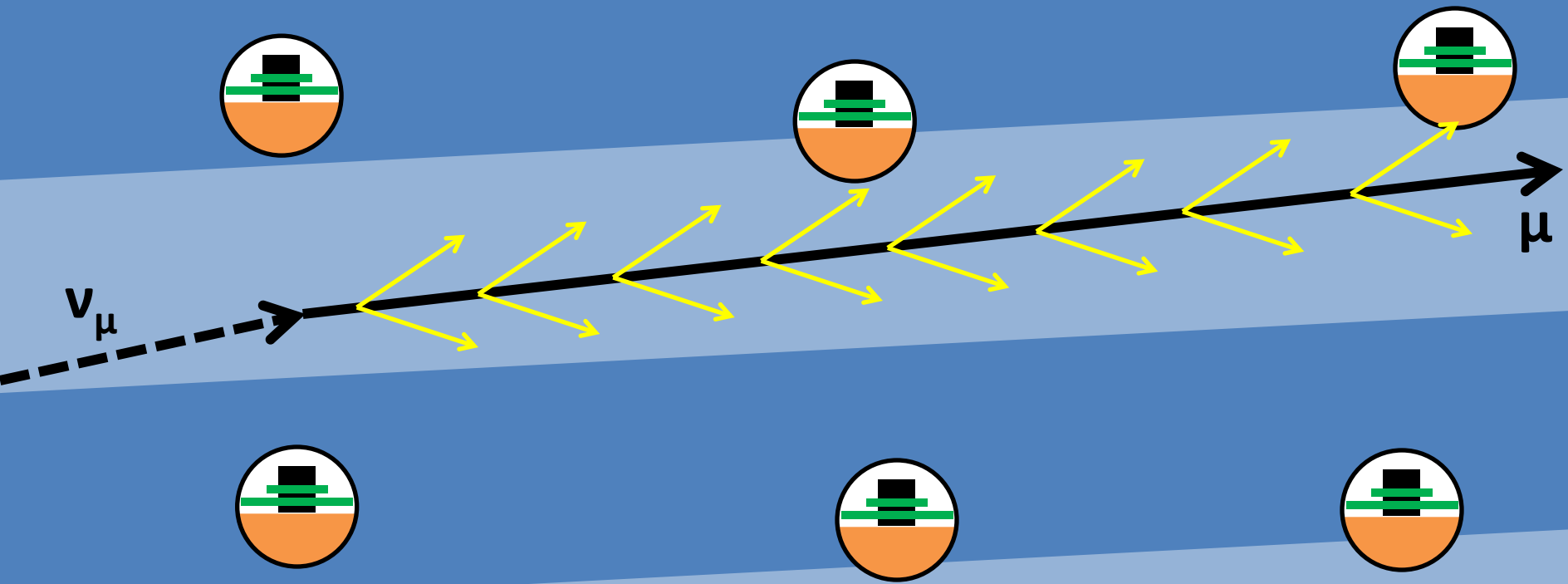
Calibration

Summer Blot (DESY)
IceCube M&O Review
Madison, WI
January 8, 2019

Calibration scope

- DOM response
- Geometry
- Ice properties

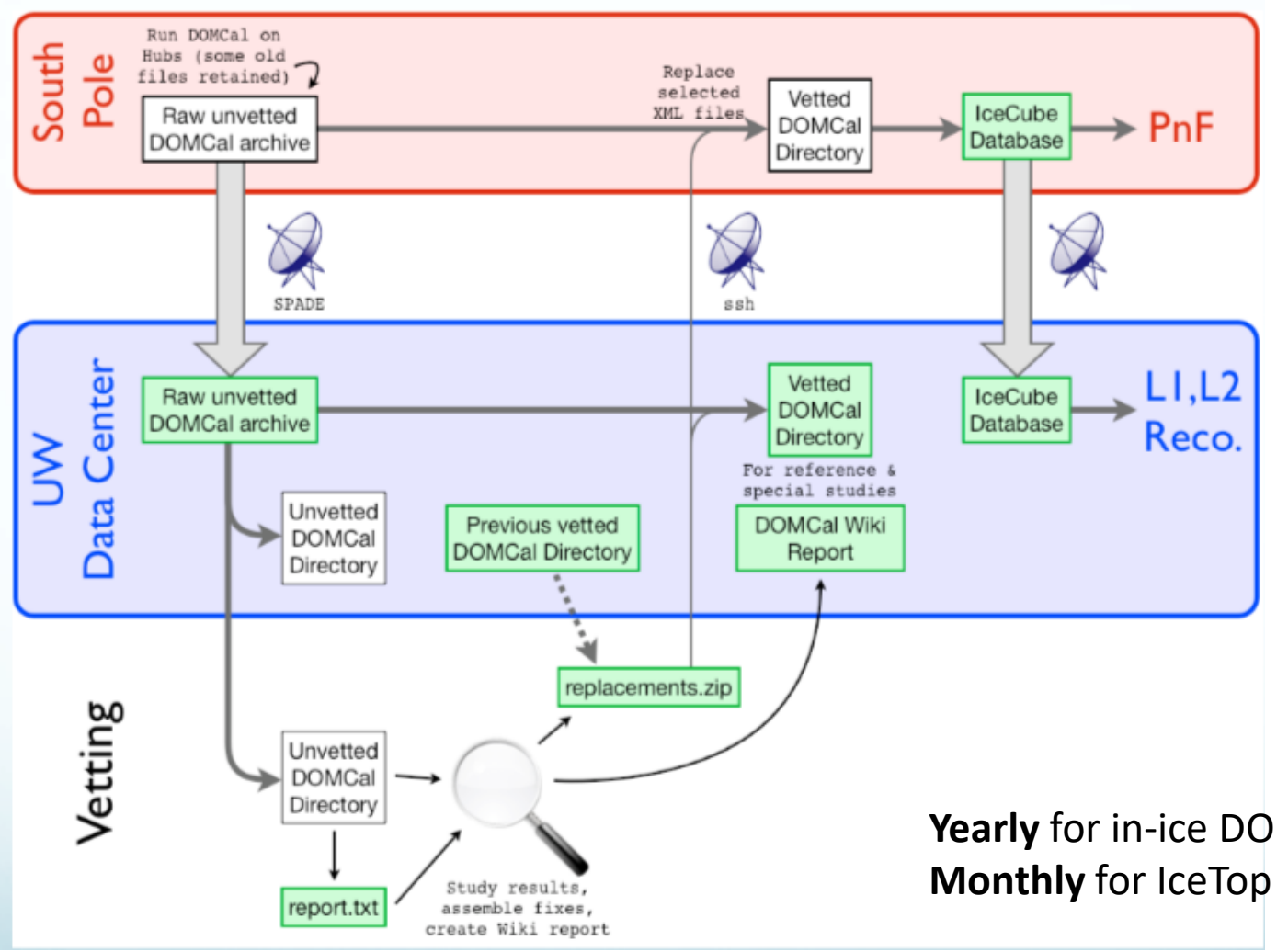
Waveform



Calibration devices

- DOM on-board self-calibration system (DOMCal)
- LED flashers (12 @ 400nm / DOM; 16 cDOMs with)
- 2 lasers “Standard Candles”
- ~~2 rotating video cameras “Sweden cameras”~~ both motors dead
- 8 dust logs from pre-string deployment
- Functioning inclinometers on 47 DOMs
- Pressure sensors
- Atmospheric muons

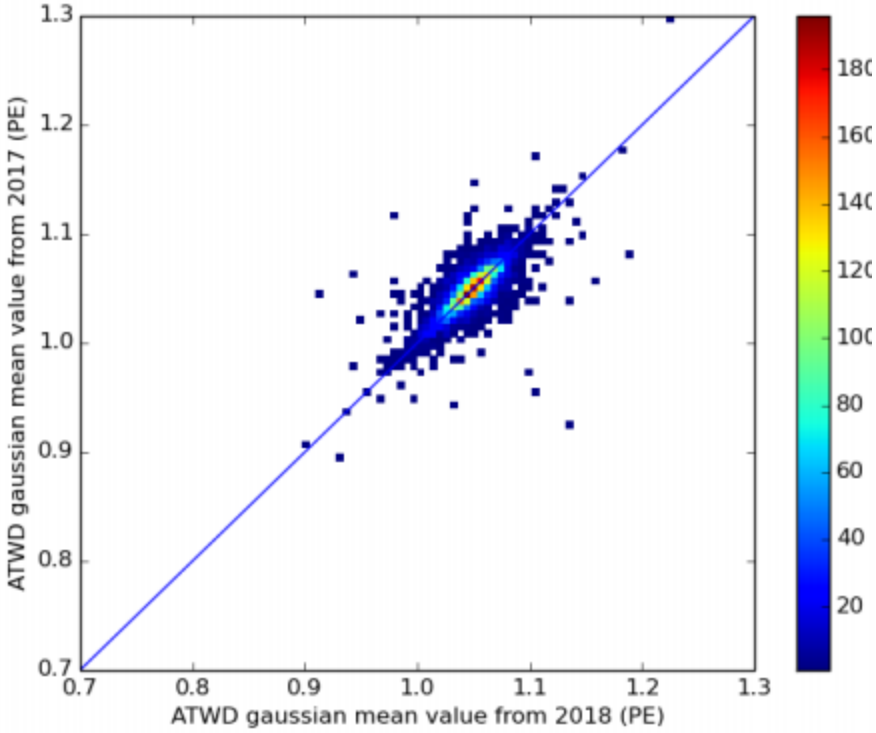
Calibration devices: DOMCal



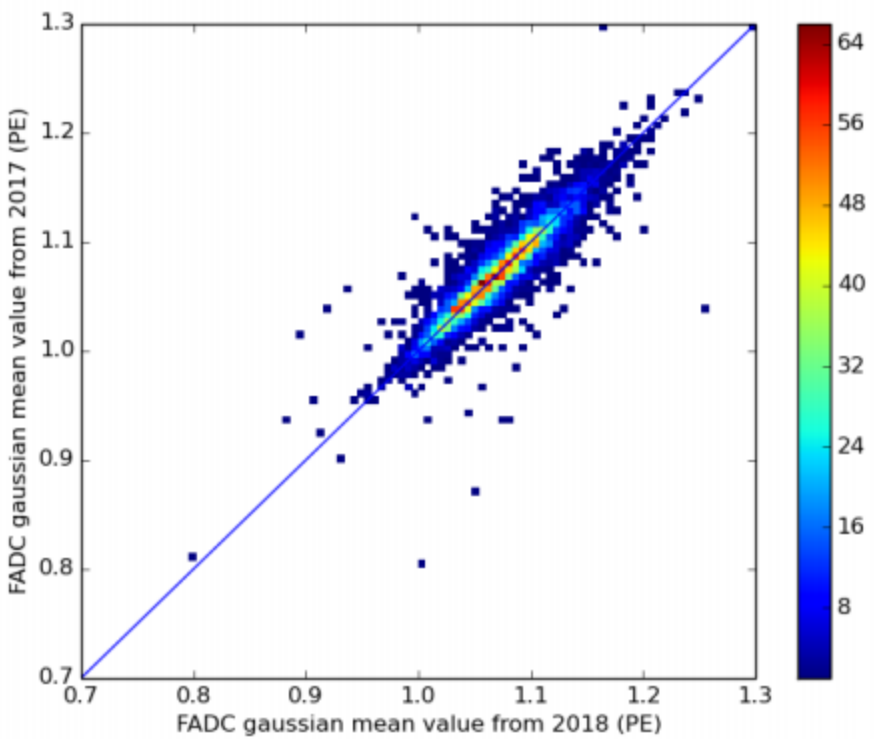
Yearly for in-ice DOMs
Monthly for IceTop DOMs

In-ice OM stability

ATWD



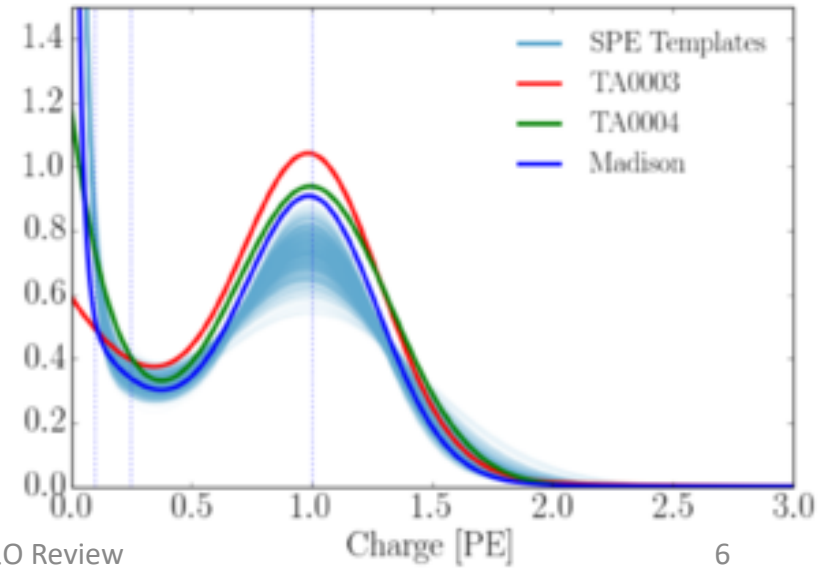
FADC



SPE recalibration

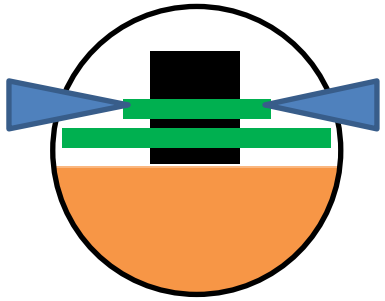
- Recalibration of SPE charge distribution resulted in gain correction of approx. -4% for all DOMs
- Resulted in “pass2” re-processing of all data
- Further improvement to improve low level charge distribution modelling: personalized SPE templates for each DOM in Monte Carlo simulation

Plot of old SPE peak mean versus new



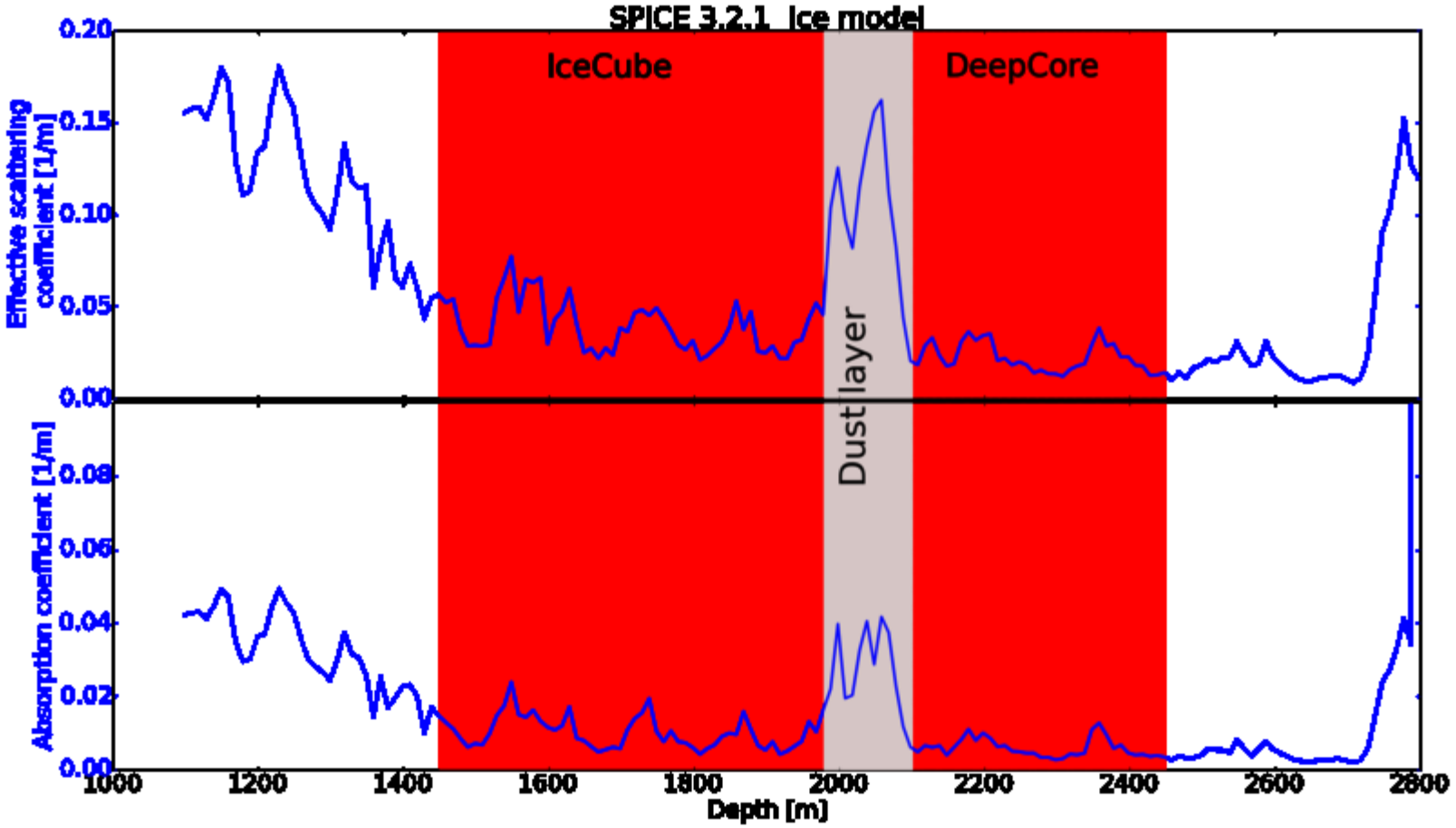
Calibration devices: LED flashers

- 12 / DOM @ 400 nm; 6 horizontal, 6 vertical
- 16 cDOMs with 340, 370, 450 and 505 nm
- Documentation via wiki pages



Include Dima's table showing model error progression from SpiceMie to Spice 3.2.1

Calibration devices: LED flashers



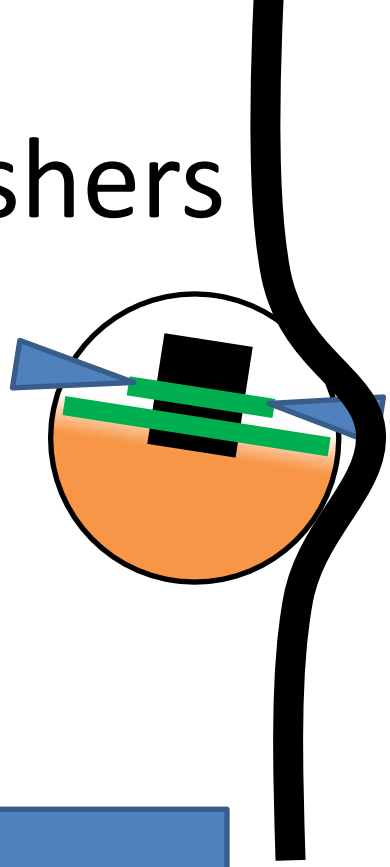
Anisotropy of scattering*: ~7%

*New models of anisotropy with glaciological underpinning currently being tested

Some more specific slide on anisotropy

- ?

Calibration devices: LED flashers

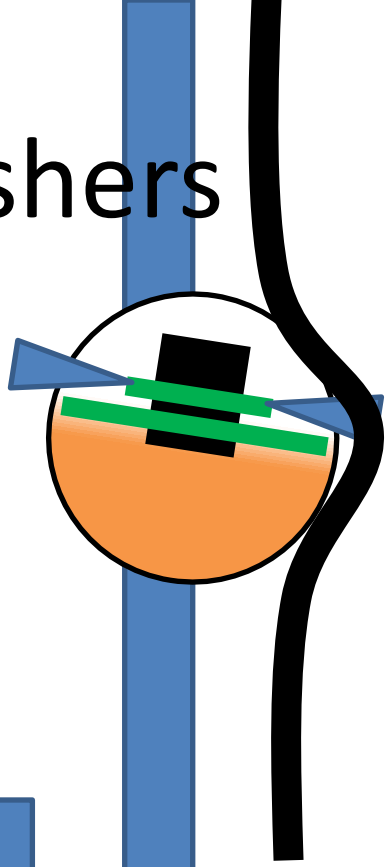


- In 2017-18 collected X TB of single LED data
- Investigating DOM-wise systematics: e.g. tilt, cable shadow
- Azimuthal position of main cable known better than 1% for most OM's

Plot demonstrating impact of cable shadow

Plot showing cable shadow fits

Calibration devices: LED flashers



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- Investigating DOM-wise systematics: e.g. tilt, cable shadow
- Azimuthal position of main cable known better than 1% for most OM's
- **New!** Direct simulation of photon propagation through bubble column

Plot showing new flasher derived hole ice models

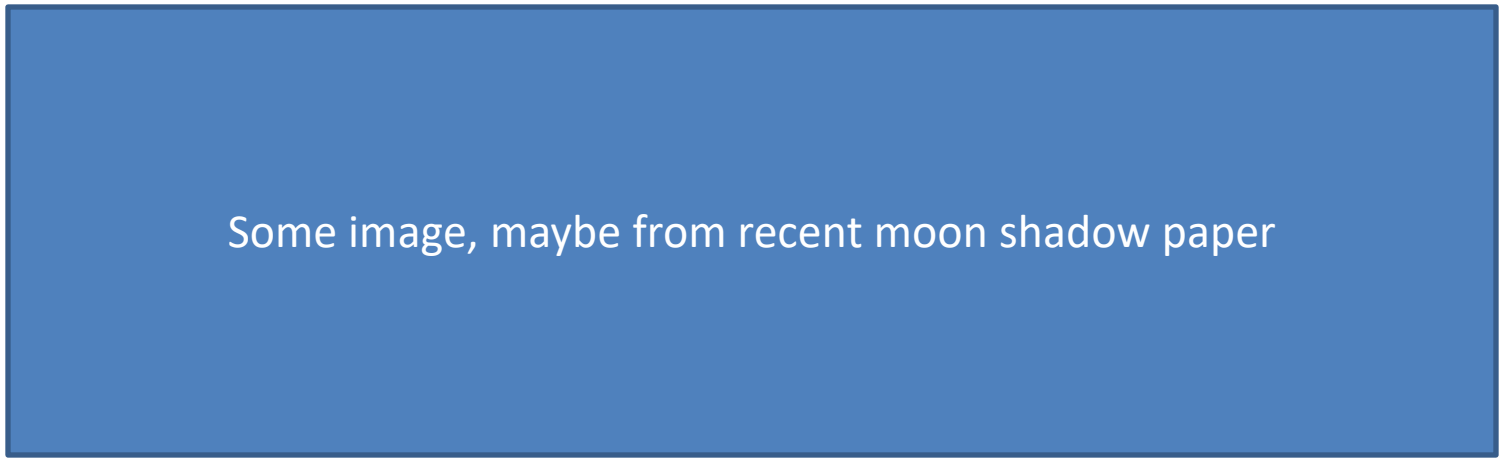
Direct sim picture

Additional in-ice calibration devices

- Standard candle
  - 337 nm pulsed nitrogen laser with Cherenkov cone emission pattern
  - Energy scale, linearity
- Sweden cameras
  - Monitor deployment, freeze-in process
  - Qualitative assessment of local ice properties: bubbly ice
  - **New!** Simulation of camera optics to make quantitative measurements

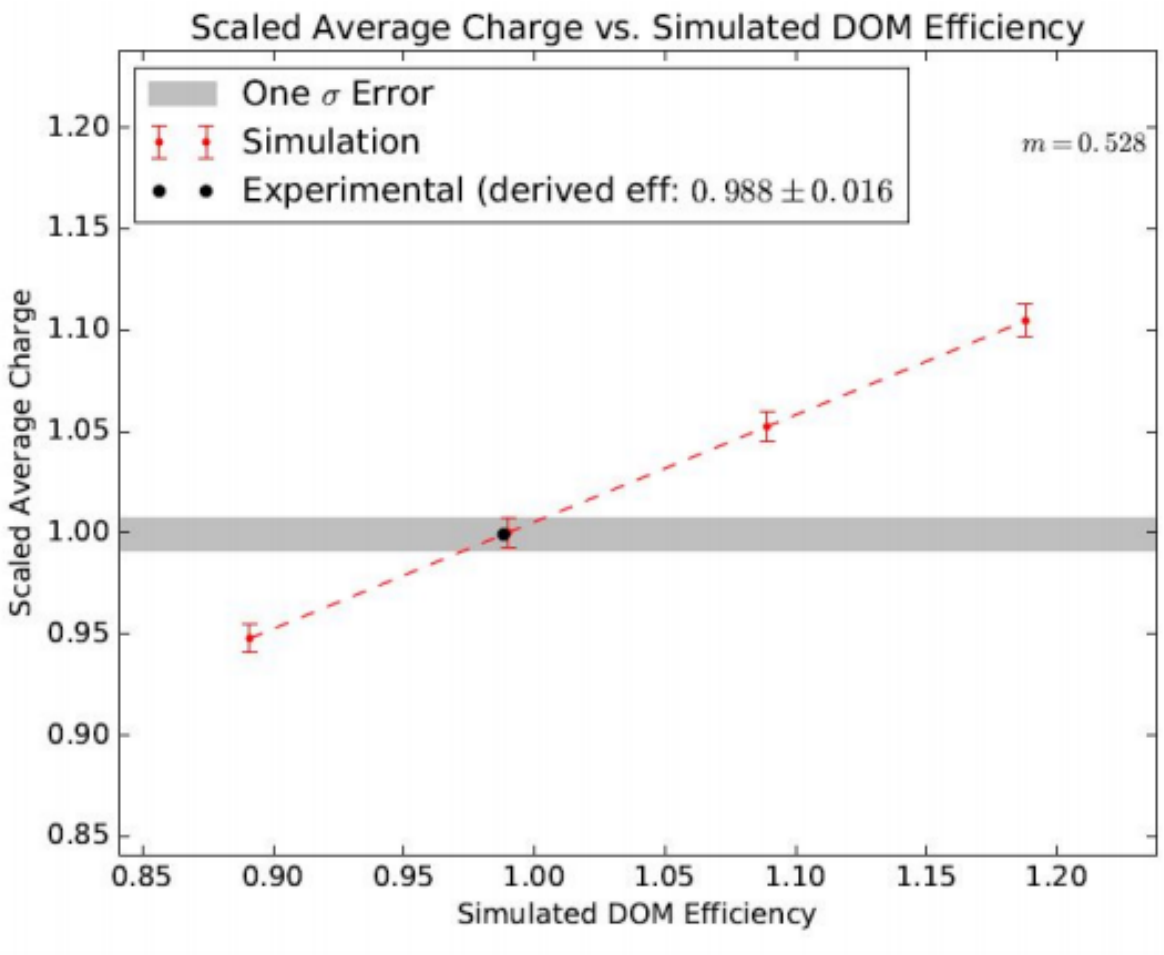
Atmospheric muons

- High statistics, natural calibration source
- Verify many calibration constants
  - DOM efficiency
  - Anisotropy of ice properties
  - Absolute pointing (moon shadow)



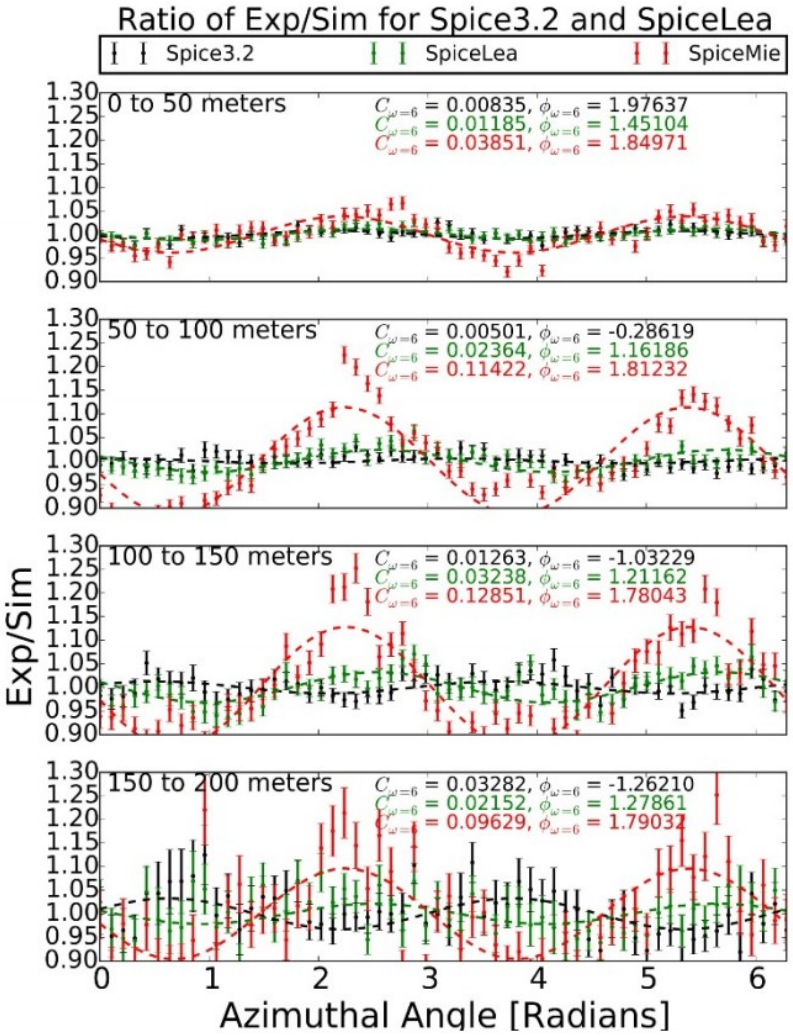
Atmospheric muons

Cartoon



Atmospheric muons

Will reformat plot so that the slide looks nicer



Current status of calibration activities

- DOM response is stable since gain re-calibration
- Constantly improving understanding of the ice and developing new fitting techniques
  - **New:** using machine learning techniques to speed up fitting
- Physics analyses constantly pushing the limits of reconstruction and require more precise modeling of ice and DOM-wise properties
  - Astrophysical tau identification, hadronic cascade identification from early muons and delayed neutron capture, inelasticity
- Starting to reach the limits of current calibration device capabilities
- The need to reduce systematic uncertainties is one of the driving forces behind the IceCube Upgrade

Lab measurements

- DOM efficiency, DOM crossing muons
- Picture of C. Wendt’s setup at madison
- Snolab noise measurements

Calibration: looking towards the future

- Several devices in R&D/prototype phase for IceCube Upgrade and Gen2
- Building on experience with IceCube to determine new device capabilities and requirements
- Using the SPIceCore at South Pole to cross-calibrate ice properties while simultaneously testing many of these new technologies

POCAM

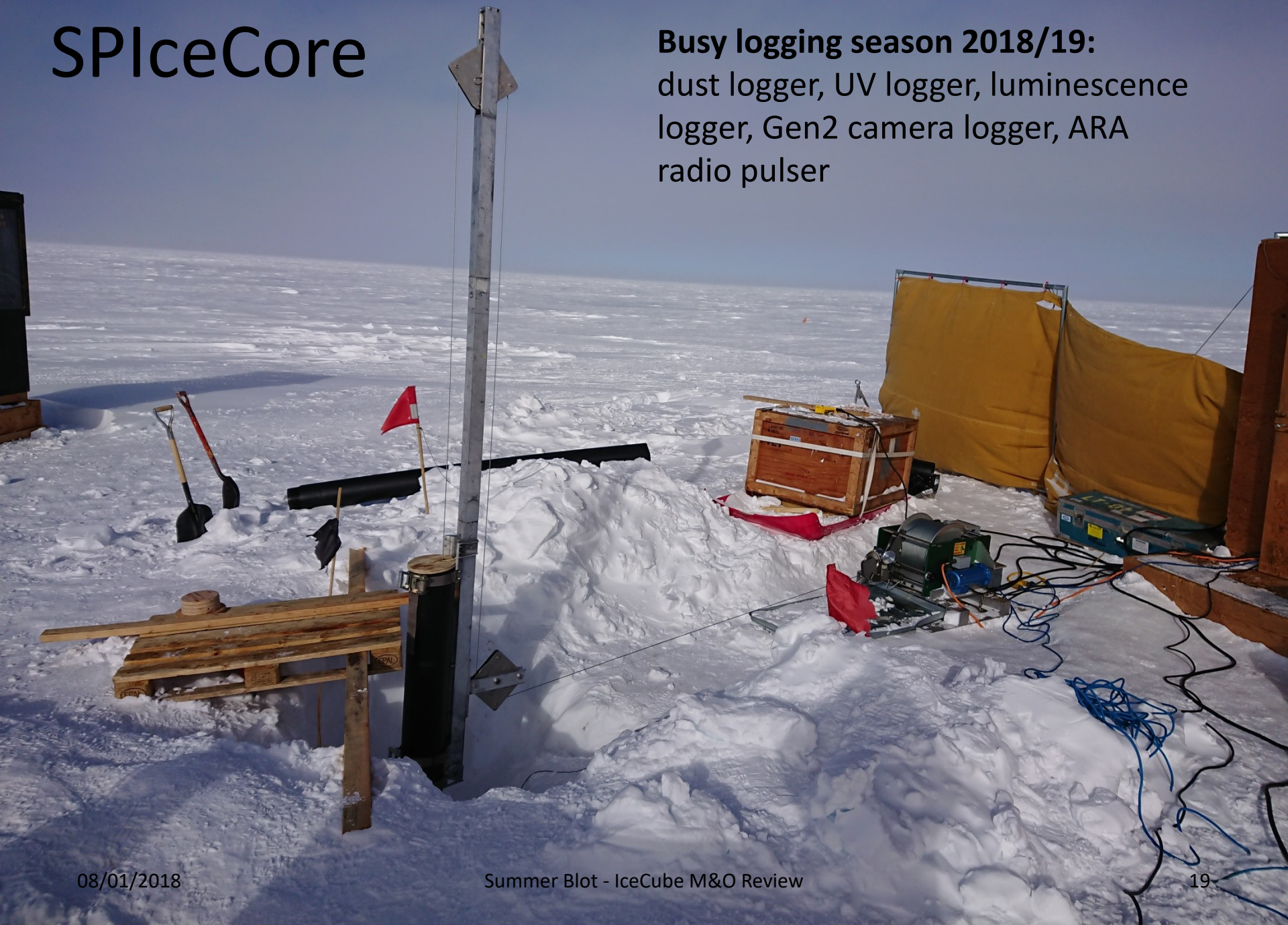
Cameras

Acoustic sensors

Rotating pencil beam

SPIceCore

Busy logging season 2018/19:
dust logger, UV logger, luminescence logger, Gen2 camera logger, ARA radio pulser



Outlook

- Finalize DOM efficiency verification study using muons
- Achieve better understanding and modelling of anisotropy
- Continue to develop new fitting techniques and data samples
- Further improve communication and coordination with other work groups for faster incorporation of new calibration constants