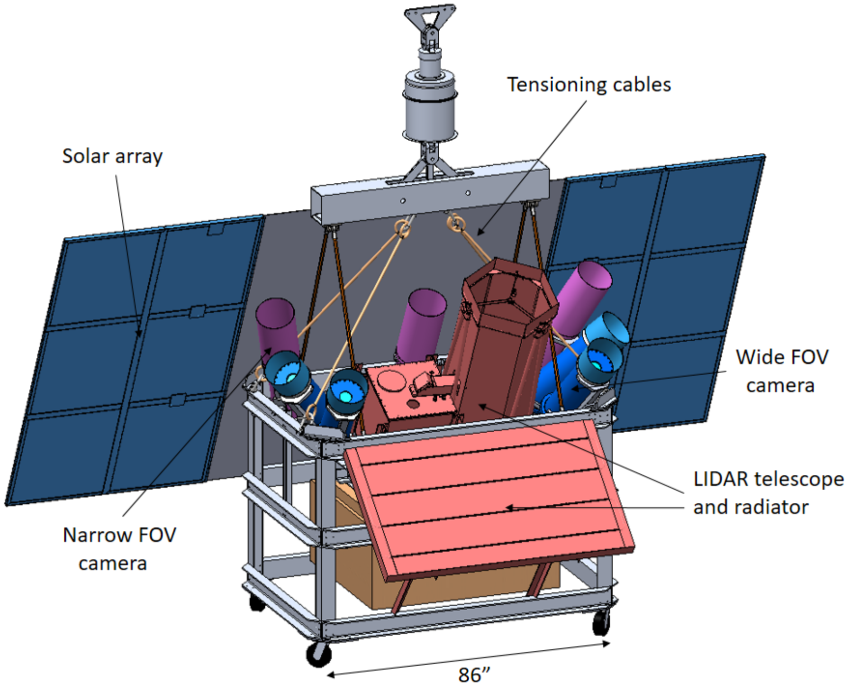
The PMC-Turbo Mission

Dave Fritts[1], Amber Miller[2], Michele Limon[3], Glenn Jones[3], Bjorn Kjellstrand[3], Biff Williams[1], Ling Wang[1], Jason Reimuller[4], Shaul Hanany[5], Christopher Geach[5], Bernd Kaifler[6] and Mike Taylor[7]

[1]GATS, [3]University of Southern California, [3]Columbia University, [4]Integr. Space. S., [5]University of Minnesota, [6]German Aerospace Center, [7]Utah State University

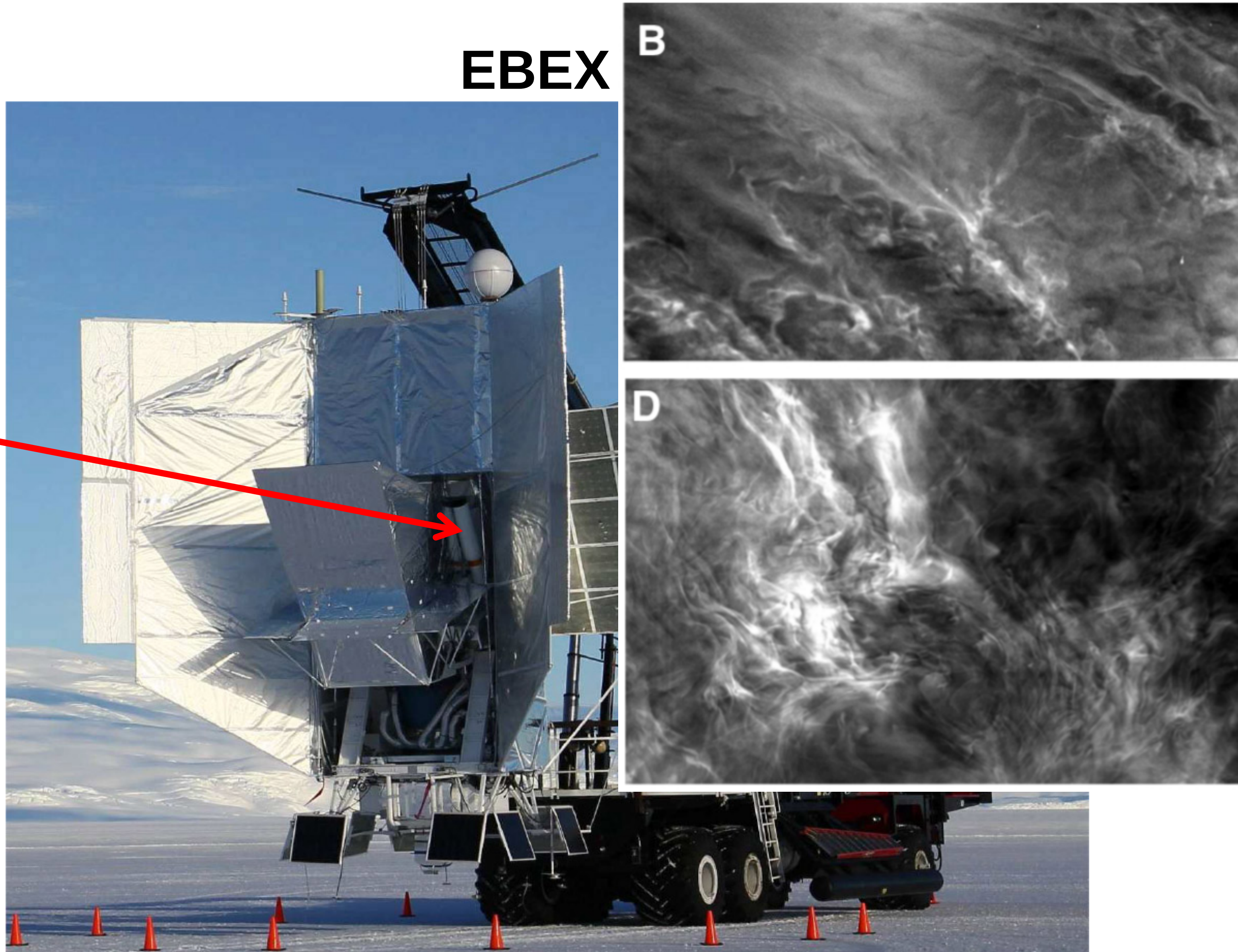


LPMR 2017, Kühlungsborn, Germany

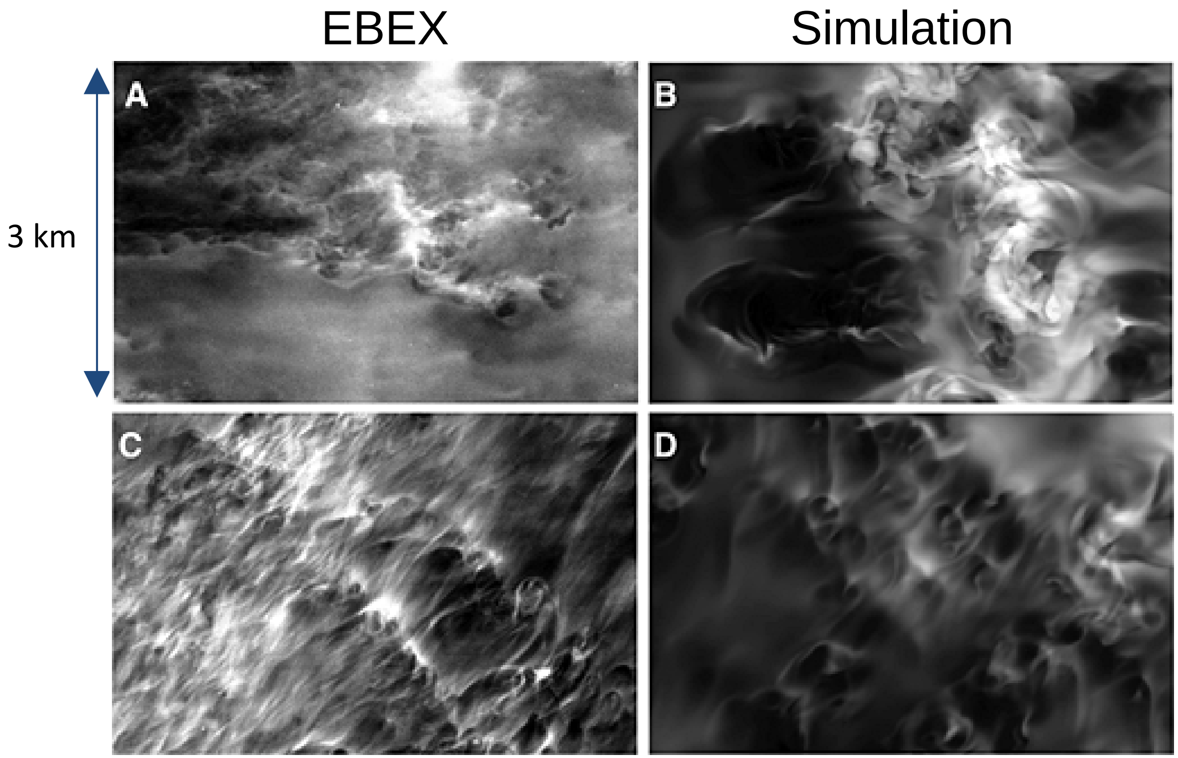
In the beginning was

EBEX

Star
Tracker



Comparison between EBEX and Simulated PMC Images



Panels A and B compare apparent turbulent wakes from localized source regions

Panels C and D show similar cusp-like features

Miller, A. D., D. C. Fritts, D. Chapman, G. Jones, M. Limon, D. Araujo, J. Didier, S. Hillbrand, C. B. Kjellstrand, A. Korotkov, et al. (2015), Stratospheric imaging of polar mesospheric clouds: A new window on small-scale atmospheric dynamics, Geophys. Res. Lett., 42, 6058–606**5**, doi:10.1002/2015GL064758

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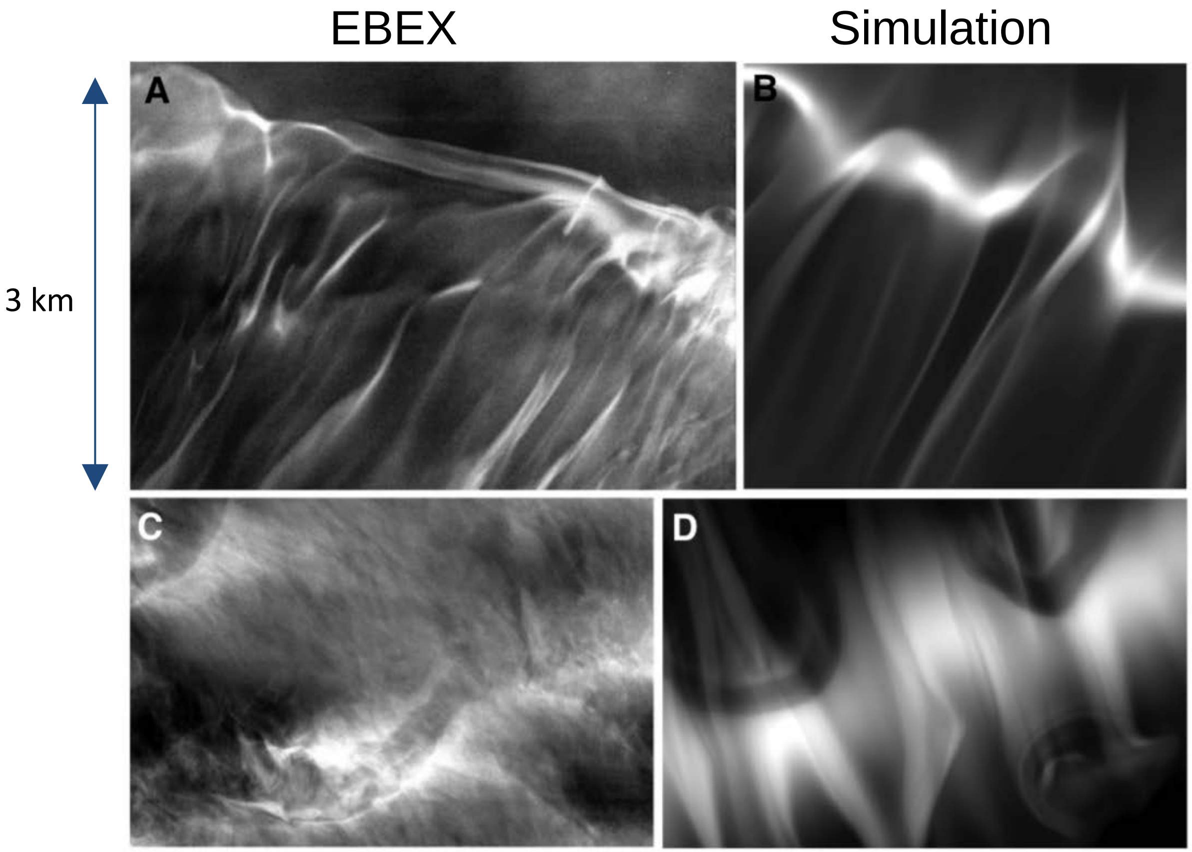


Panel A shows what we believe is a gravity wave breaking front

Panel C exhibits features similar to laminar vortex rings in background turbulence.

Miller, A. D., D. C. Fritts, D. Chapman, G. Jones, M. Limon, D. Araujo, J. Didier, S. Hillbrand, C. B. Kjellstrand, A. Korotkov, et al. (2015), Stratospheric imaging of polar mesospheric clouds: A new window on small-scale atmospheric dynamics, Geophys. Res. Lett., 42, 6058–606**5**, doi:10.1002/2015GL064758

Objectives for a New Mission: PMC-Turbo

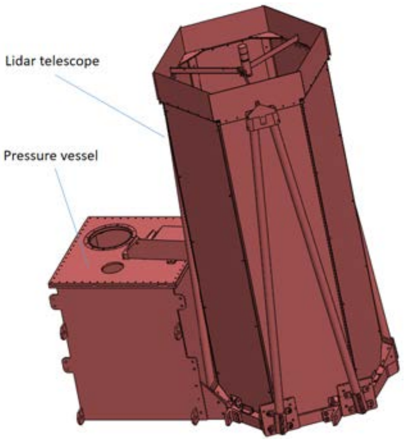
PMC Turbo was designed to identify the dynamics driving turbulence and resolve the details to the smallest scales using PMC as tracers.

The mission seeks to obtain high resolution and high cadence observations of PMC utilizing a high altitude balloon platform.

It is based on heritage from EBEX stratospheric balloon imaging.

PMC-Turbo Experiments

- **4 wide FOV and 3 narrow FOV cameras**
  main payload
  High-resolution PMC imaging (visible)

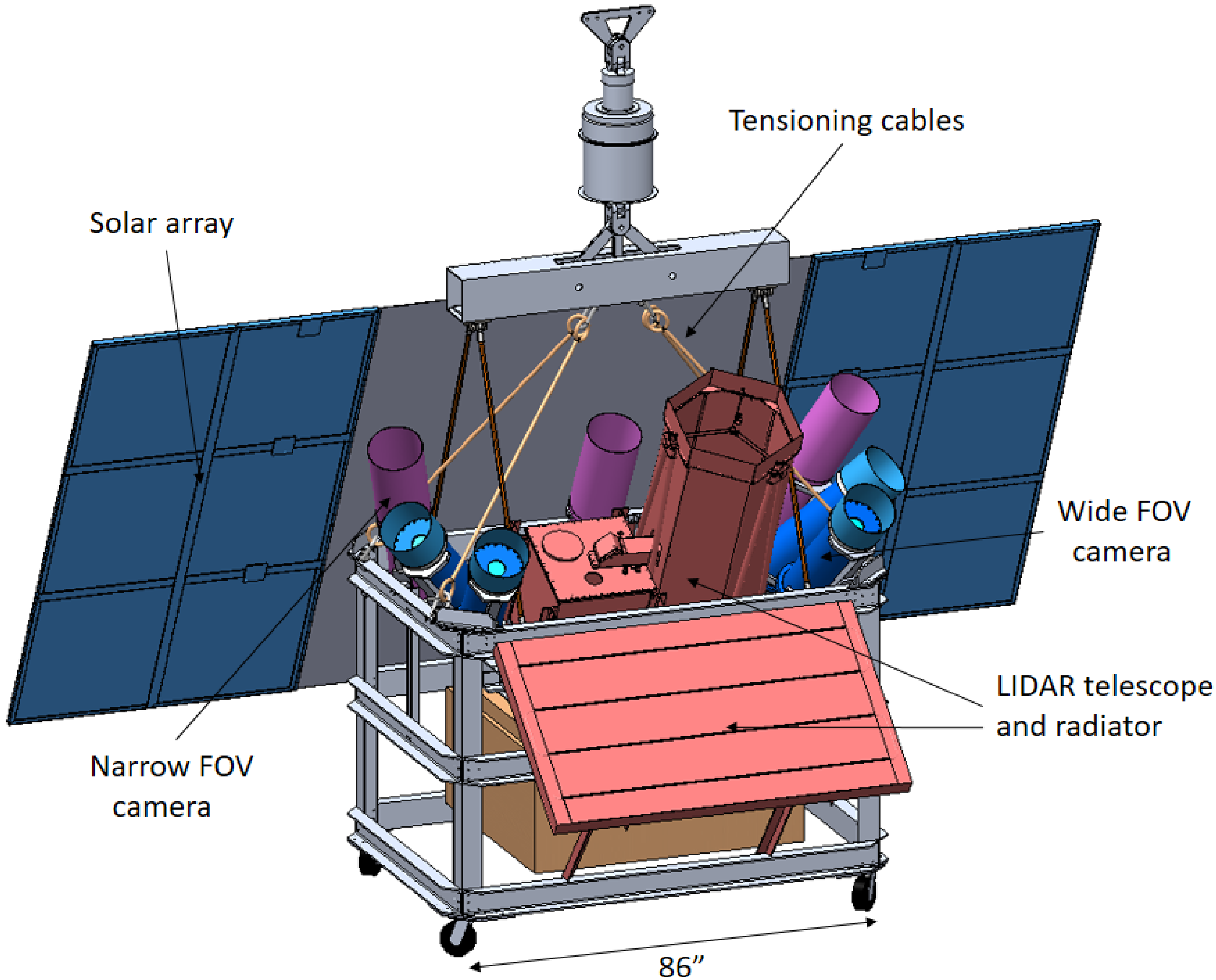


- **The Balloon Lidar Experiment (BOLIDE)**
  contributed by the German Aerospace Center
  PMC vertical backscatter profiles
  Temperature profiles above and below PMC layer

- **OH dayglow imager**
  contributed by Utah State University
  Gravity waves, PMC imaging (IR)

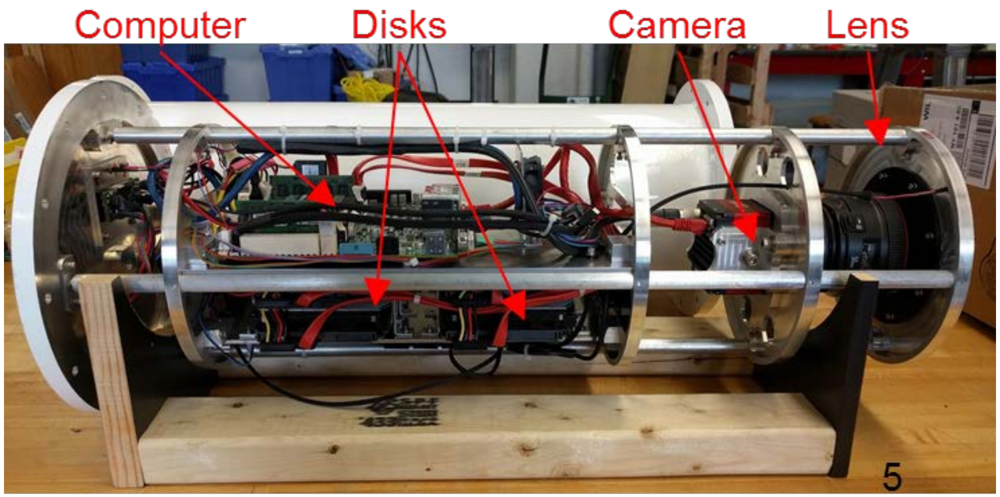
The PMC Turbo Gondola

Mass 800 kg
Power 1.3 kW
Anti-solar pointed
29 MCF balloon
Flight altitude 38 km



Camera Systems

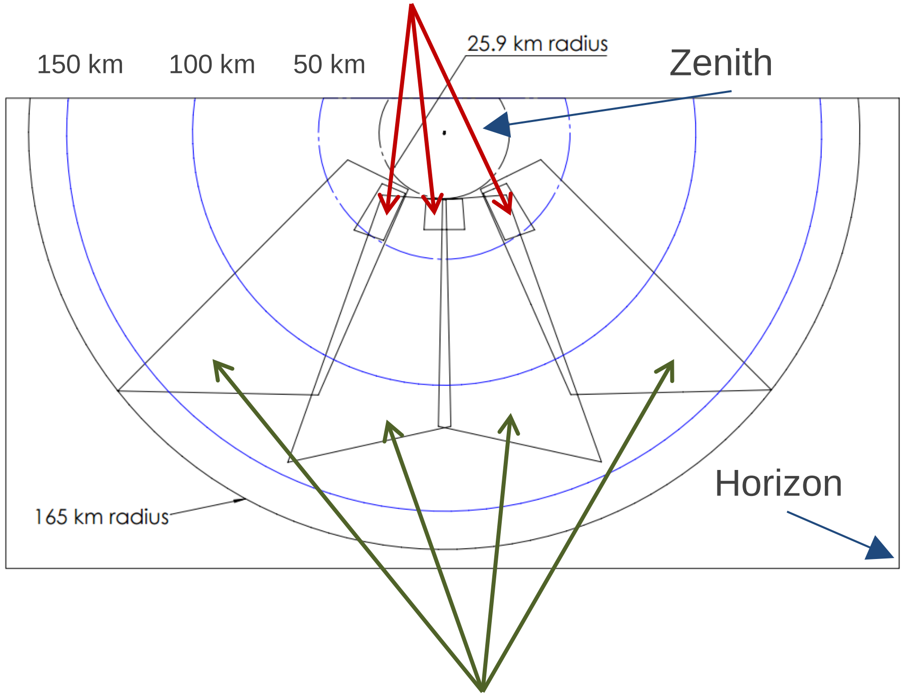
- Based on EBEX star tracker heritage
- Allied Vision camera with 4864 x 3232 pixels
- 3.5 fps sustainable framerate at 100 ms exposure time
- 50 mm and 135 mm lenses
- Each of the 7 camera systems is completely independent
- Commanding capability (exposure and focus settings, frame rate)



PMC-Turbo Vessel

Observation Geometry

3 narrow FOV cameras
10 x 15.2 degree, 3 m resolution



4 wide FOV cameras
39.6 x 26.9 degree, 8 m resolution

Camera systems installed on gondola

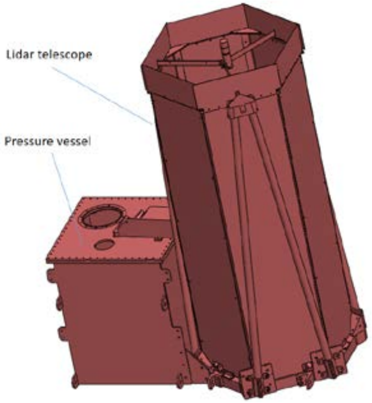
Total 150 x 40 degree FOV, 4 decades of sensitvity!

PMC Imaging Capabilities

Satellite: CIPS	Ground-based (Gerd Baumgarten)	Balloon: EBEX	Balloon: PMC-Turbo
80 x 120 degree FOV	127 × 85 degree and 9.5 × 6.3 degree FOV	4.4 x 3.9 degree FOV	150 x 40 degree FOV, 10 x 15 degree FOV
2 km spatial resolution at nadir	10-20 m spatial resolution	3.7 m spatial resolution	3-8 m spatial resolution

PMC-Turbo will provide a unique and dataset

The Balloon Lidar Experiment (BOLIDE)



Miniaturized Rayleigh backscatter lidar

1 m vertical resolution

Mass 145 kg

includes pressure vessel and radiator

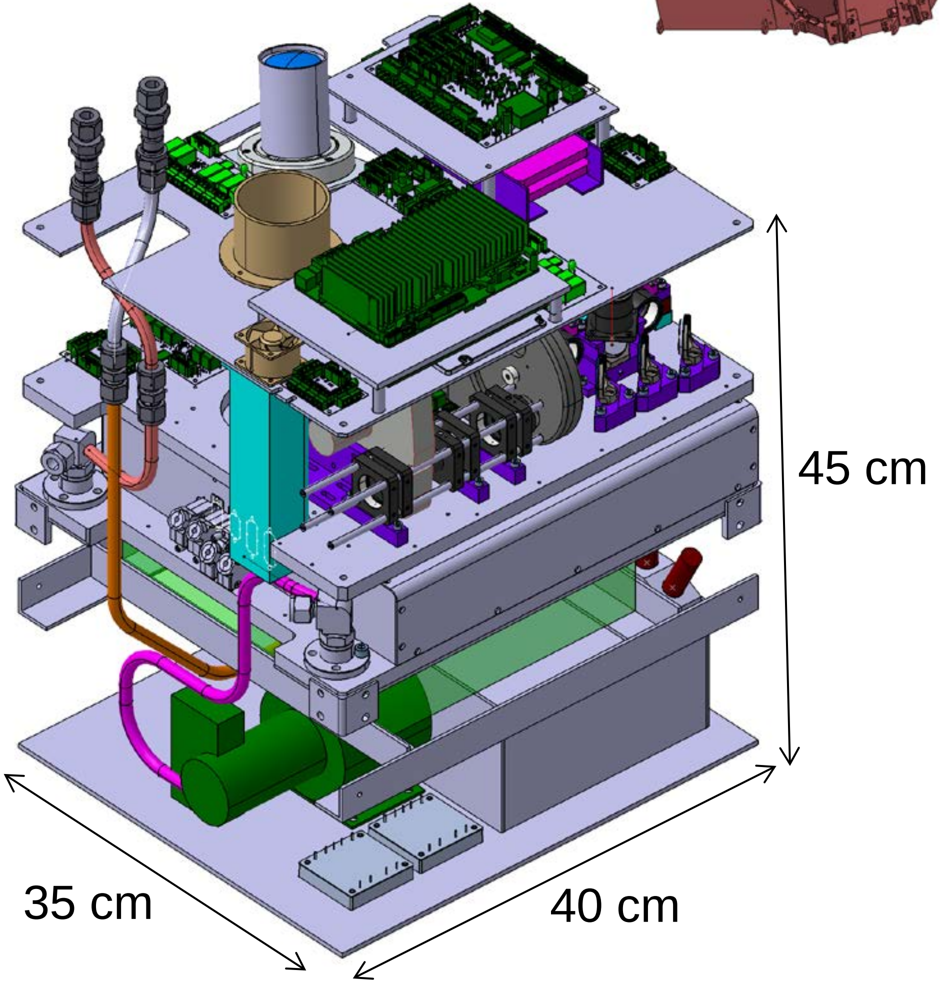
Power 268 W

Laser

- 5 W at 532 nm wavelength
- 100 Hz PRF

Receiver

- 0.5 m diameter telescope
- 90 µrad FOV
- 3 detectors (2 APDs, 1 PMT)
- 0.3 nm wide filters



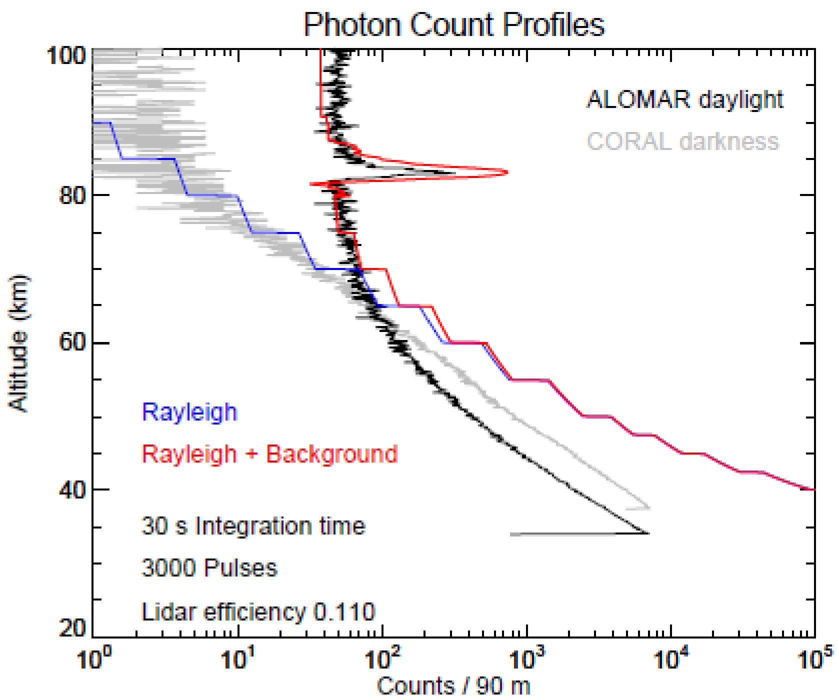
Performance Simulations

Simulation of radiative transfer using the libradtran software package

Emde et al., Geoscientic Model Development, 2016

A factor of ~3 more signal than ALOMAR but same (or slightly less) background

The BOLIDE instrument will provide observations of PMC with unprecedented resolution and SNR

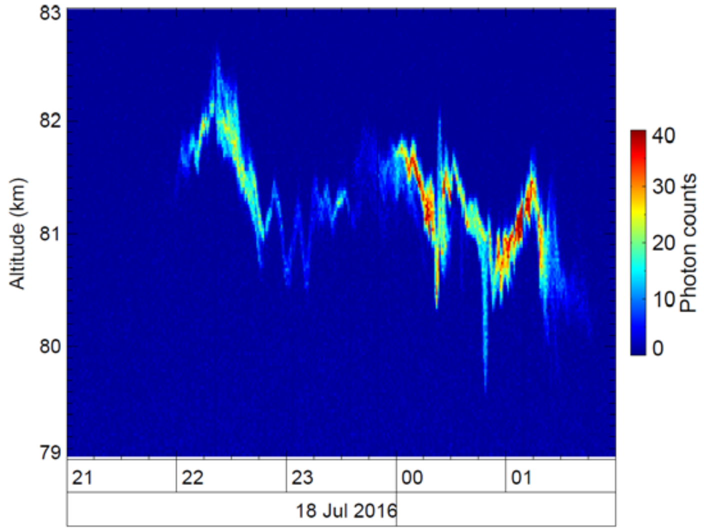


ALOMAR profile curtesy Gerd Baumgarten

Altimetry of PMC

Straight forward for ground-based lidars:

altitude is proportional to range



CORAL lidar, GERES Station

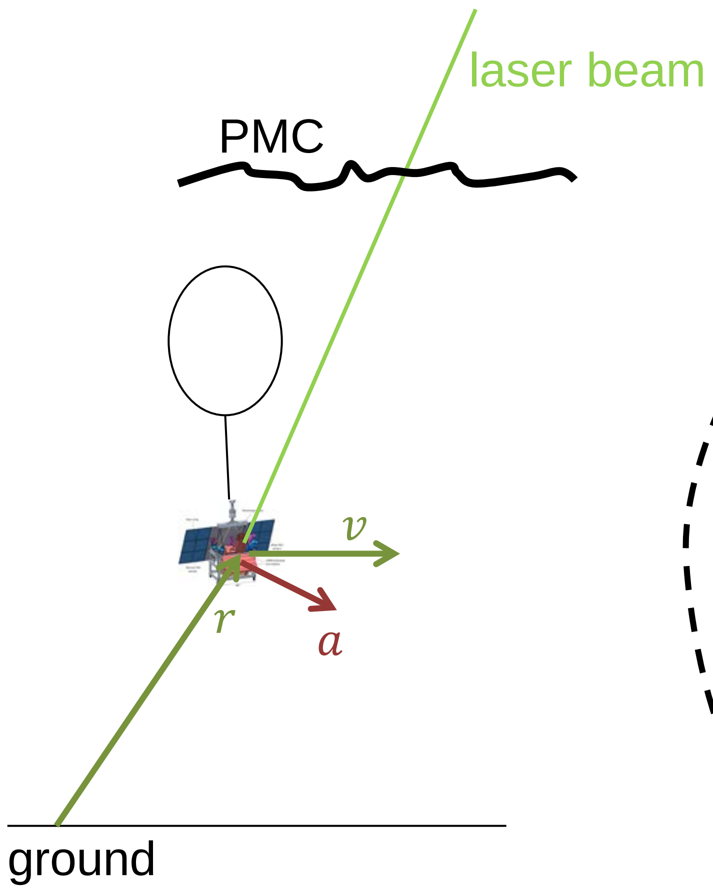
Balloon lidar:

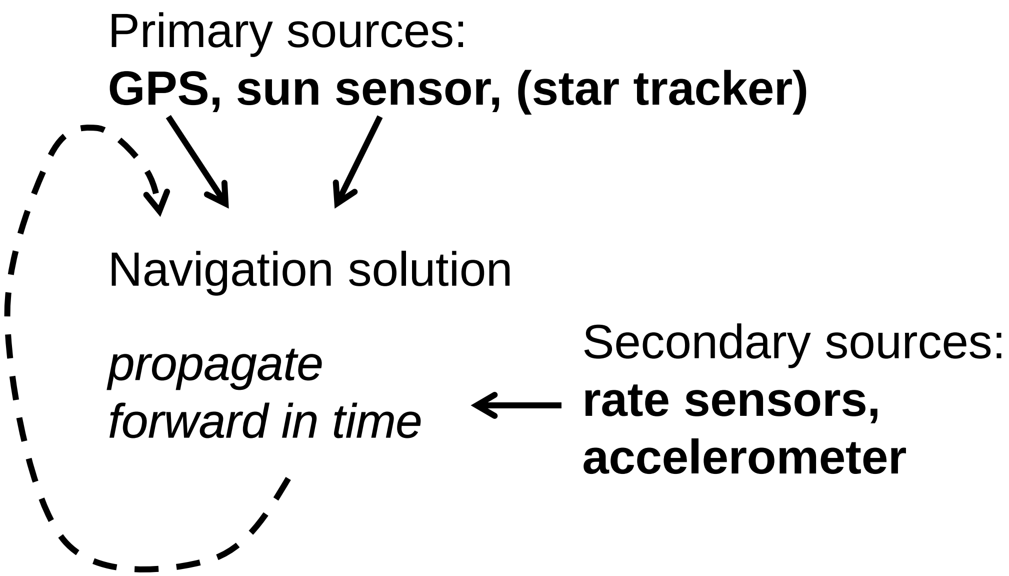
Vertical motion of the gondola due to external and internal forces acting on the balloon

-> lidar profiles are shifted in altitude

Precise **and** **accurate** measurements of the state vector and attitude vector required

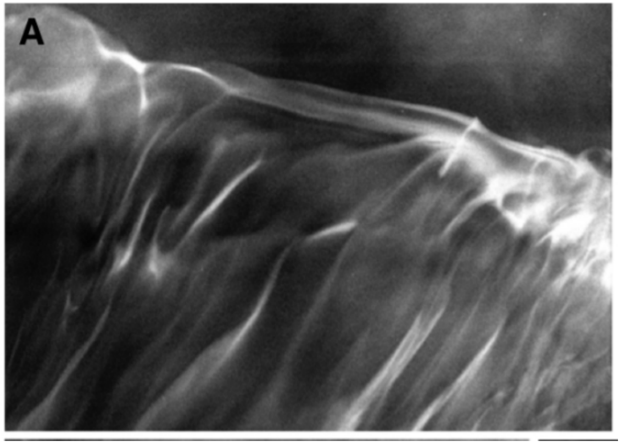
Obtaining a Navigation Solution





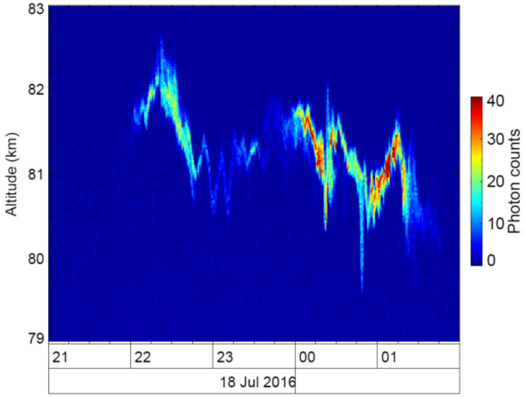
Synergy between PMC Imaging and LIDAR

Imaging

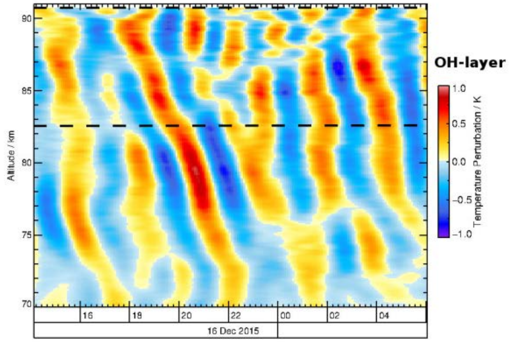


2d view
e.g. identify wave braking,
horizontal wavelength

LIDAR



PMC profiles,
Vertical displacement



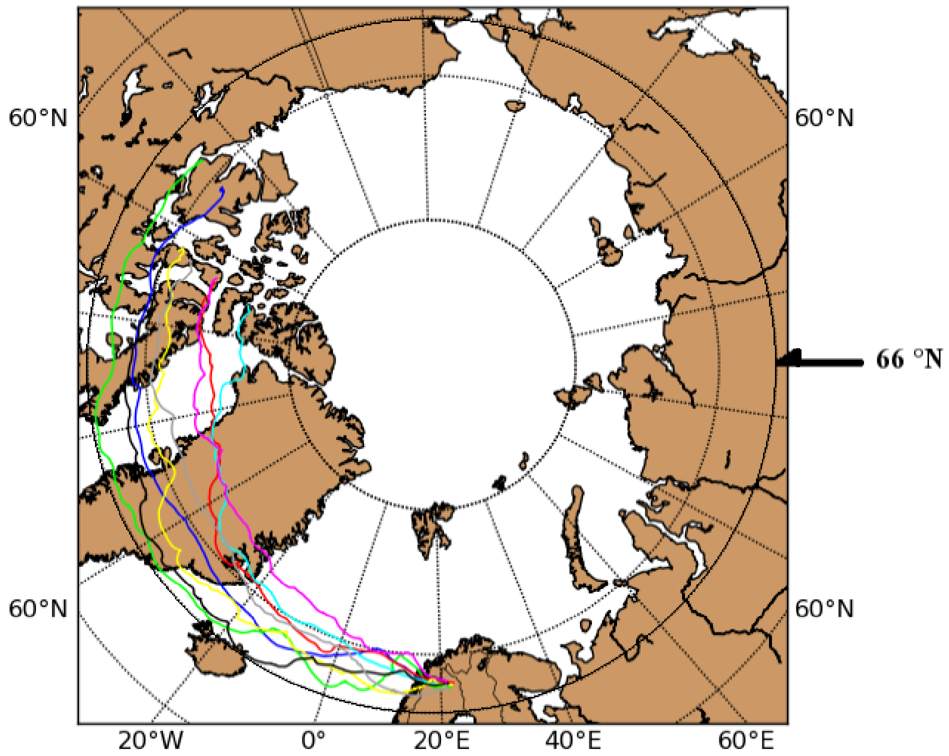
Gravity wave-induced T perturbations:
vertical wavelength, amplitude

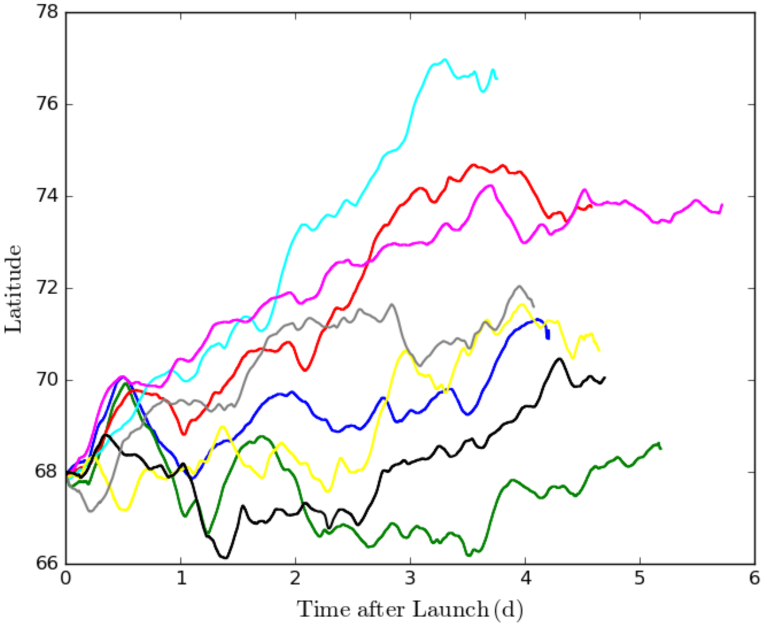
Fantastic prospects **if** everything works as expected, our models are correct, …

Where do we stand now?

- We were not selected for launch from McMurdo, Antarctica, in 2017 for various reasons
- NASA suggested a launch from Kiruna, Sweden, in July 2018 (confirmation pending)
- A launch from Kiruna opens up the possibility for additional ground-based observations. Field campaigns are T.B.D., contributions and suggestions are welcome!

Trajectories of previous launches from Kiruna

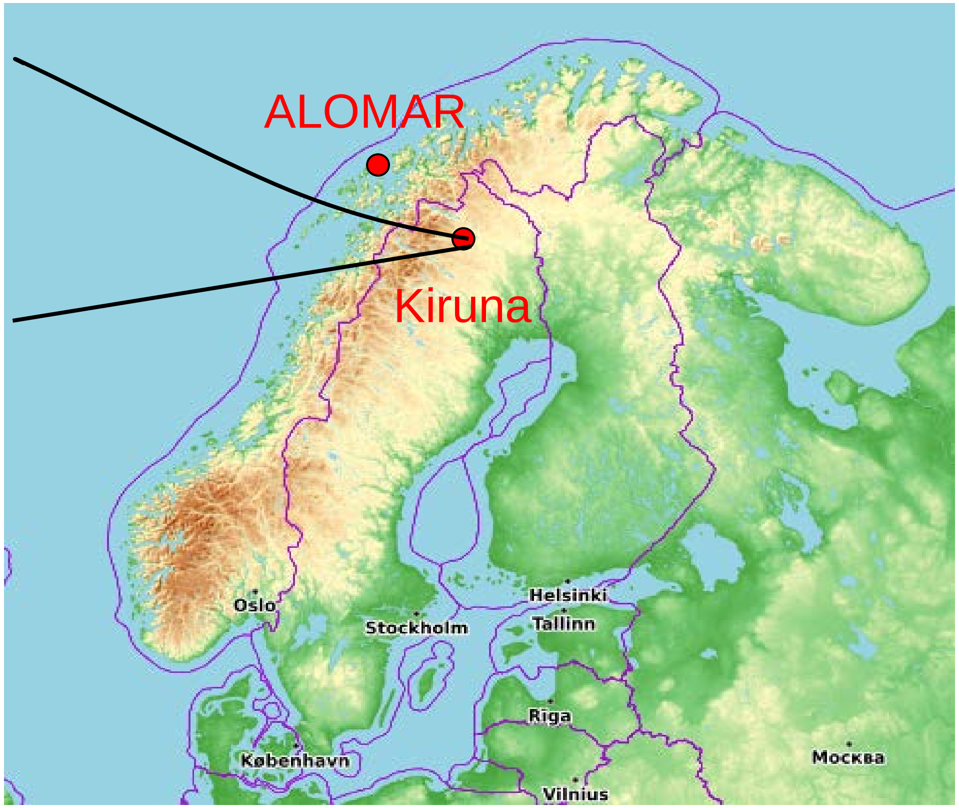




Data courtesy of CSBF
Images courtesy of Wenqian Sun (UMN)

4-5 day flight, termination over northern Canada

Ground-based Observations in Europe?



Trajectories are all south of ALOMAR