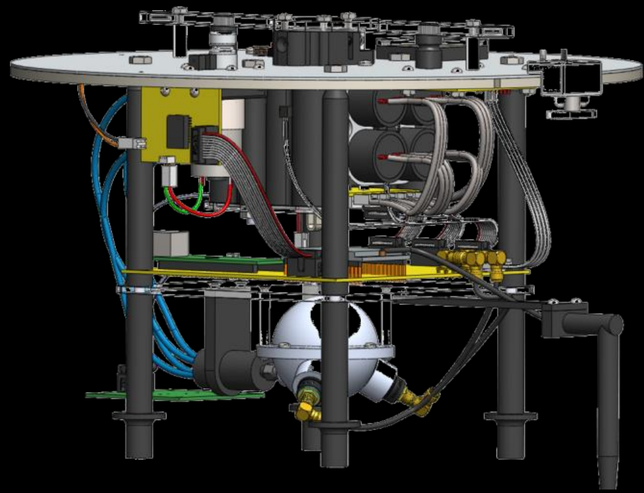
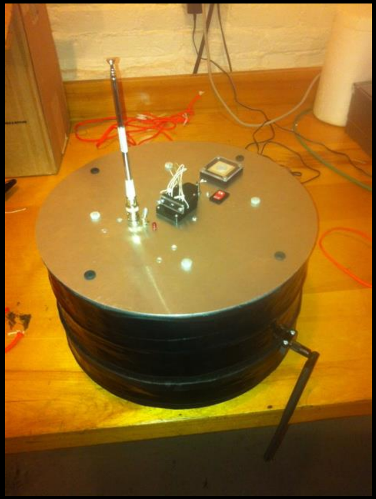
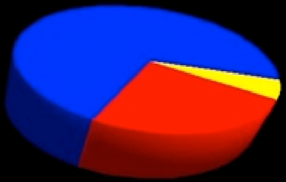
ALTAIR: Precision Photometric Calibration via Low-Cost Artificial Light Sources Above the Atmosphere







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Univ. of Victoria

Airborne Laser for Telescopic Atmospheric Interference Reduction

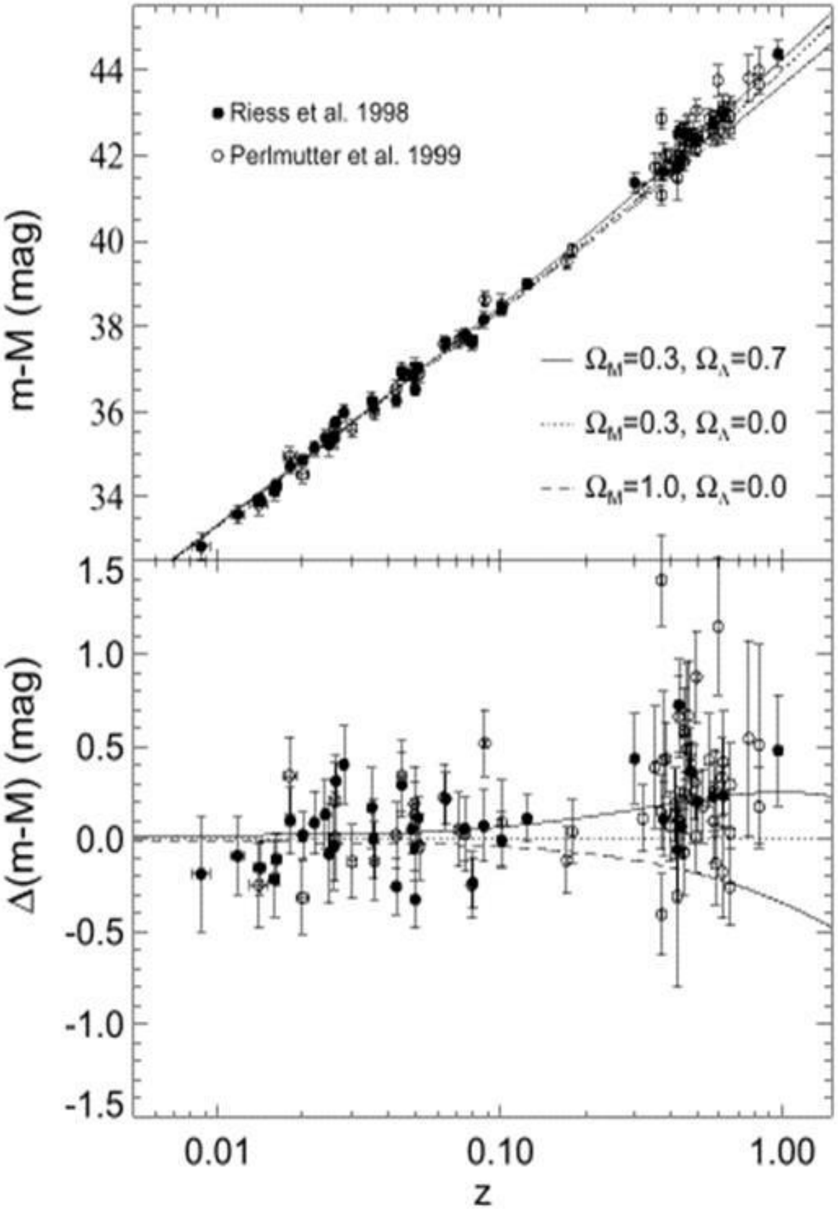
Our Story so far …….

Supernova surveys in the 1990s revealed that the Hubble expansion is accelerating.

The acceleration is caused by mysterious “dark energy.”

The challenge of the 1990s was supernova statistics; the challenge of today is to measure Supernova flux at better than 1% precision.

Calibration is the critical item for further progress in supernova surveys.



Uncertainty on supernova photometry COMPLETELY DOMINATES both present & future SNIa dark energy measurements

SNLS: *Conley et al (2011), ApJS **192**, 1:*

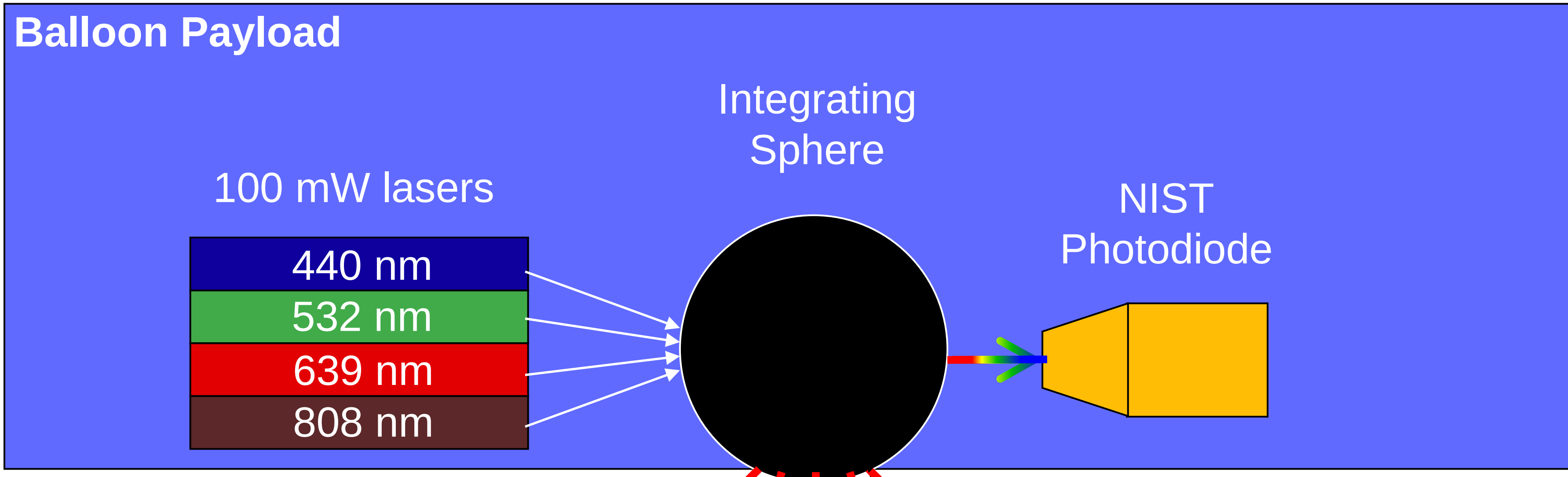
Table 7: Identified systematic uncertainties

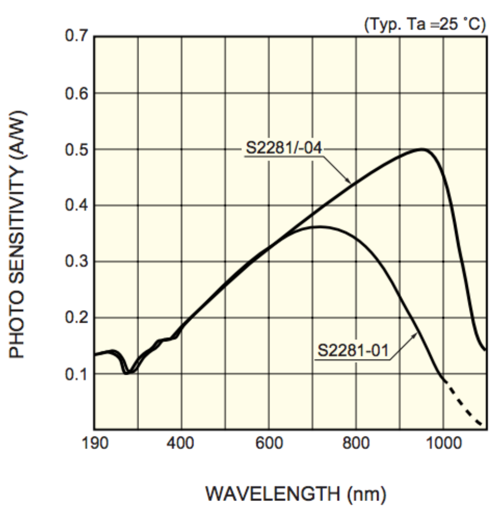
Description	Ω_m	w	Rel. Area [a]	w for Ω_m=0.27
Stat only	$0.19^{+0.08}_{-0.10}$	$-0.90^{+0.16}_{-0.20}$	1	-1.031 ± 0.058
All systematics	0.18 ± 0.10	$-0.91^{+0.17}_{-0.24}$	1.85	$-1.08^{+0.10}_{-0.11}$
Calibration	$0.191^{+0.095}_{-0.104}$	$-0.92^{+0.17}_{-0.23}$	1.79	-1.06 ± 0.10
SN model	$0.195^{+0.086}_{-0.101}$	$-0.90^{+0.16}_{-0.20}$	1.02	-1.027 ± 0.059
Peculiar velocities	$0.197^{+0.084}_{-0.100}$	$-0.91^{+0.16}_{-0.20}$	1.03	-1.034 ± 0.059
Malmquist bias	$0.198^{+0.084}_{-0.100}$	$-0.91^{+0.16}_{-0.20}$	1.07	-1.037 ± 0.060
non-Ia contamination	$0.19^{+0.08}_{-0.10}$	$-0.90^{+0.16}_{-0.20}$	1	-1.031 ± 0.058
MW extinction correction	$0.196^{+0.084}_{-0.100}$	$-0.90^{+0.16}_{-0.20}$	1.05	-1.032 ± 0.060
SN evolution	$0.185^{+0.088}_{-0.099}$	$-0.88^{+0.15}_{-0.20}$	1.02	-1.028 ± 0.059
Host relation	$0.198^{+0.085}_{-0.102}$	$-0.91^{+0.16}_{-0.21}$	1.08	-1.034 ± 0.061

[a] Area relative to statistical only fit of the contour enclosing 68.3% of the total probability.

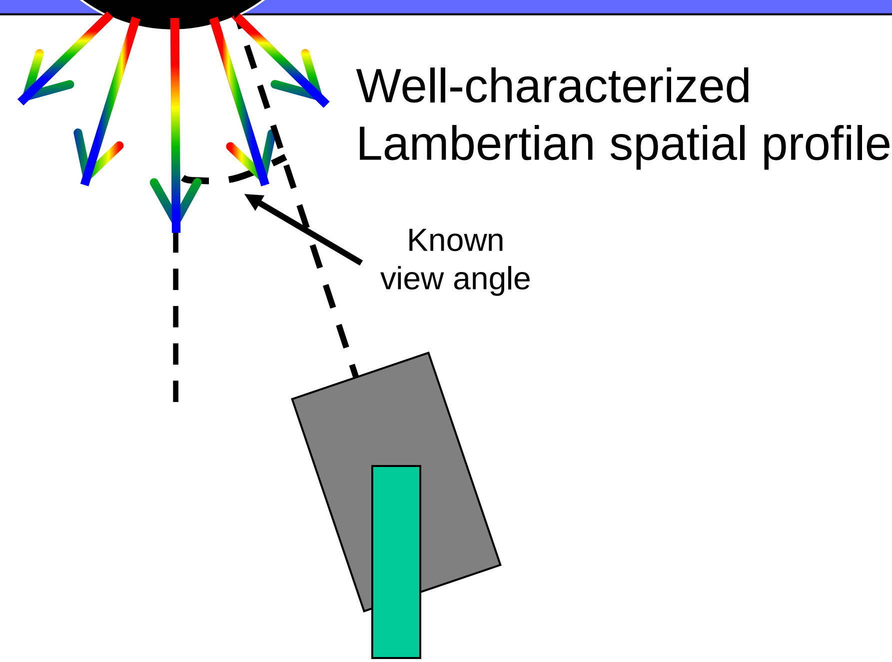
Note. — Results including statistical and identified systematic uncertainties broken down into cat In each case the constraints are given including the statistical uncertainties and only the stated sys contribution. The importance of each class of systematic uncertainties can be judged by the relat compared with the statistical-only fit.

Technique: *A 0.1% Calibrated, Mobile Source Above the Atmosphere*

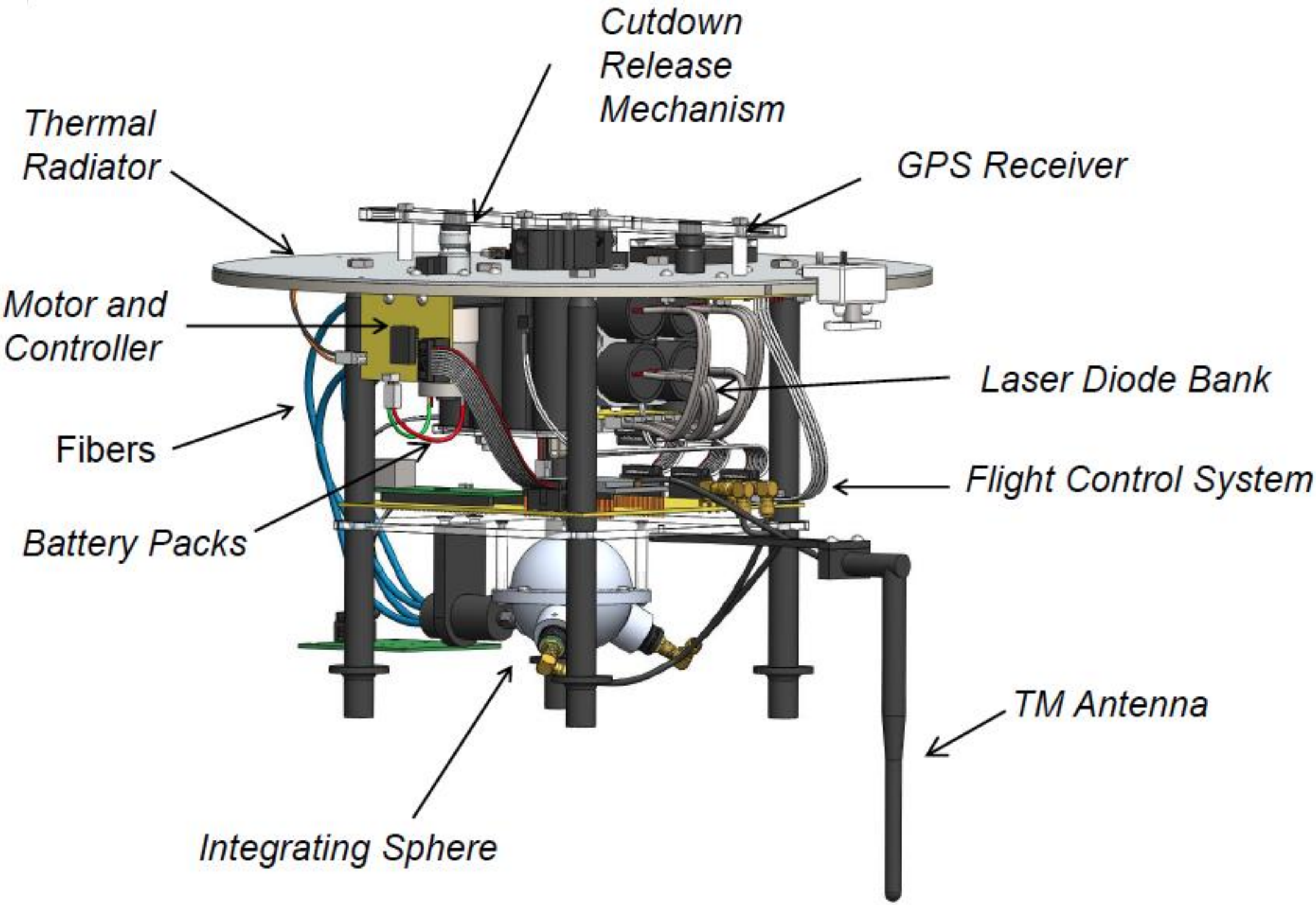




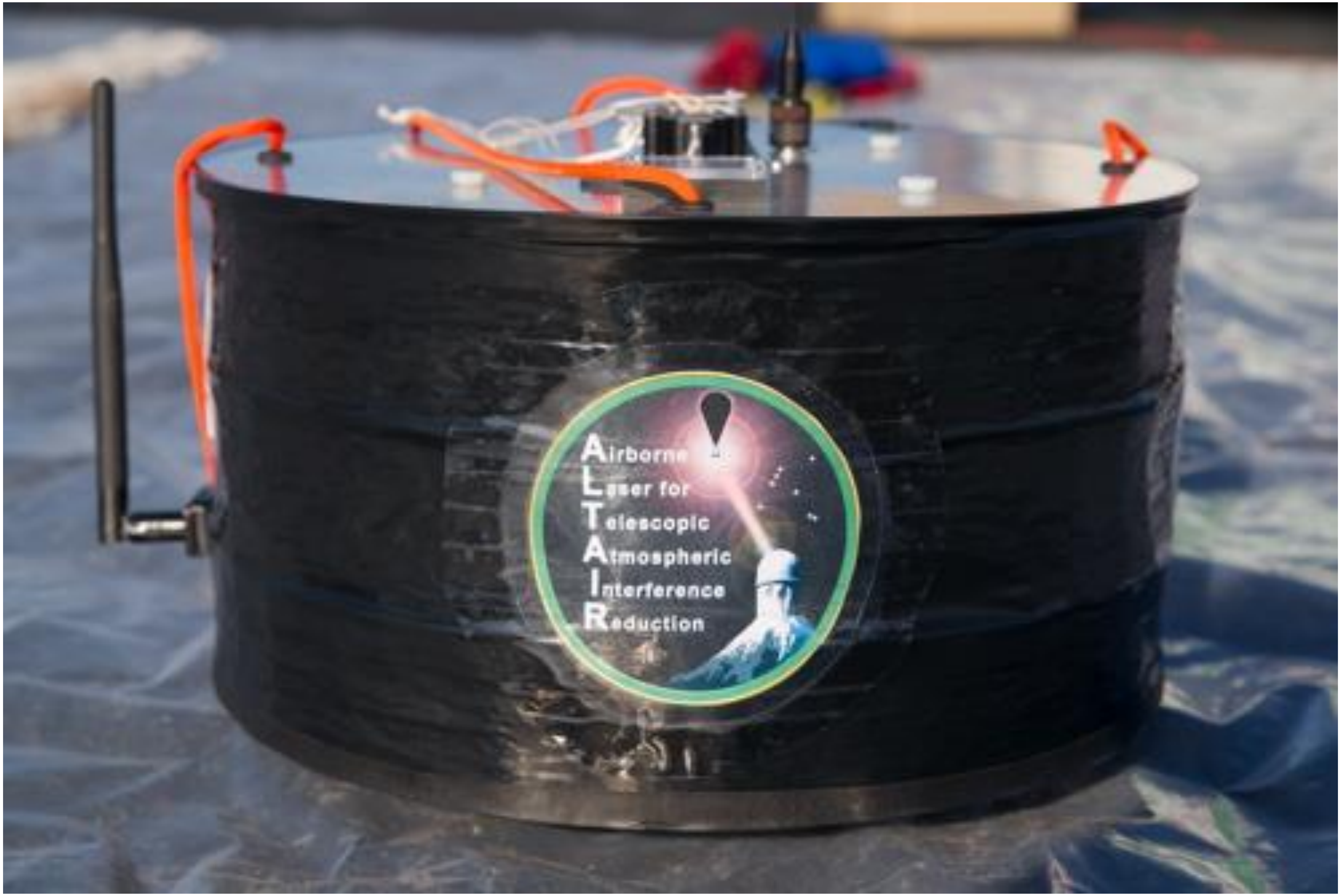
NIST-calibrated (< 0.1% absolute)
photodiode spectral response



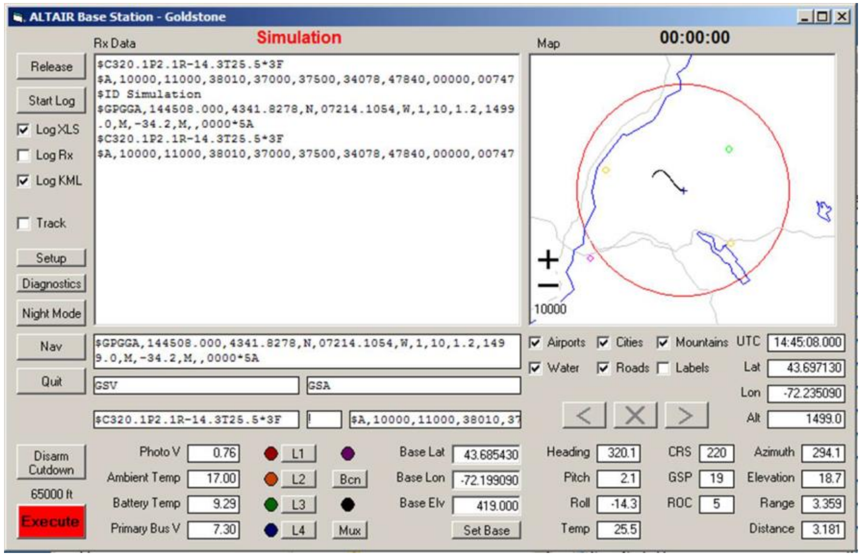
Payload Design



Payload


Airborne
Laser for
Telescopic
Atmospheric
Interference
Reduction

Flight Control

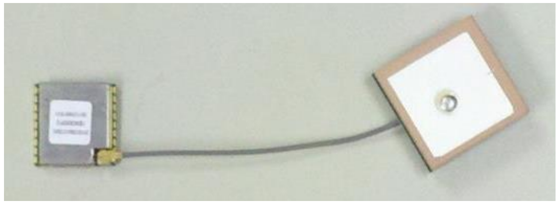


910 MHz directional antennas, range approx. 60 km. Always ≥ 2 ground stations in contact.

Onboard primary radio
(RFM DNT900P, 1W omni, 200 kbps)

Onboard payload attitude accelerometer/magnetometer

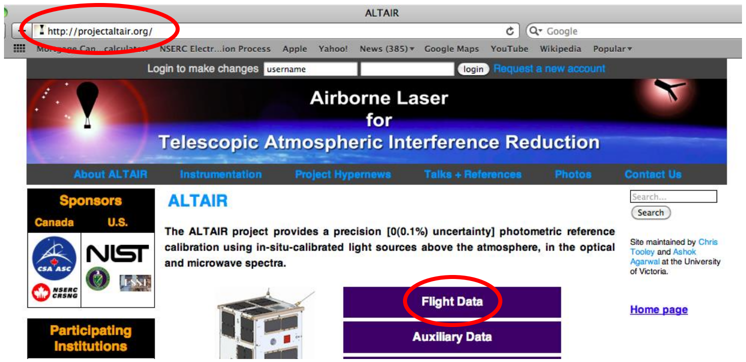
(Ocean Server OS4000T)

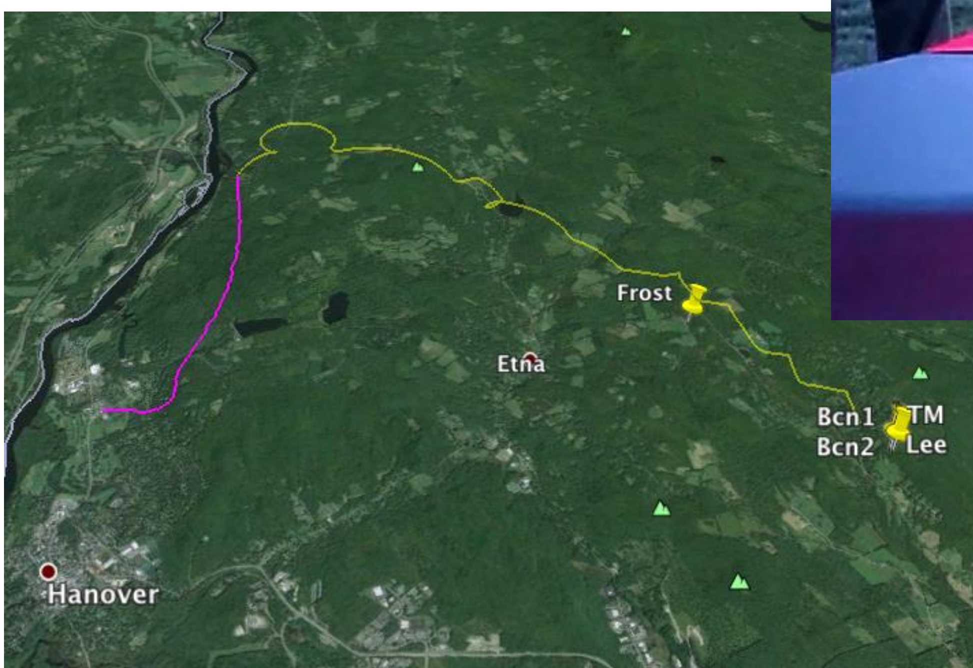


Onboard high-altitude-capable GPS (Inventek ISM300F2)

Flights and Data (so far)

Twelve flights to date (most recent 1 month ago),
all test flights over New Hampshire so far.



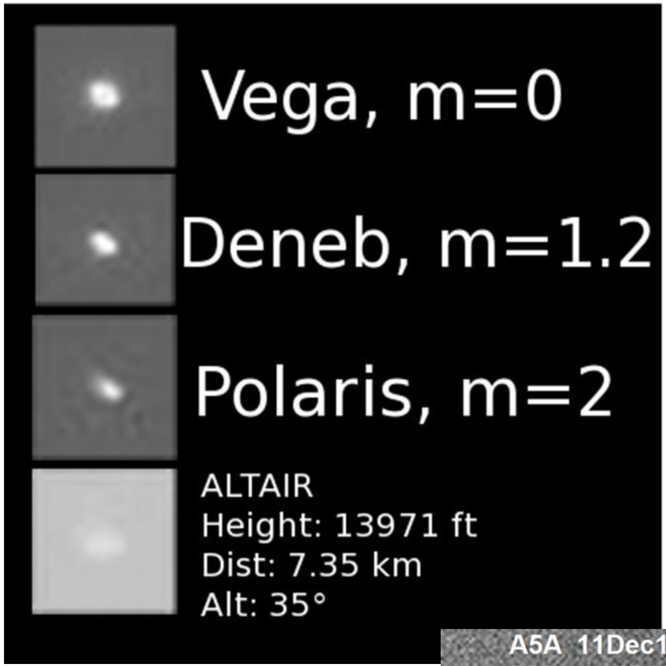


<u>All available online:</u>
Telemetry, .kml files,
photodiode monitoring data,
ground imagery, photometry …

Imagery, and Upcoming Plans

Portable observation station:

Meade LX200GPS 12" telescope



We will be performing **full end-to-end flight tests** of ALTAIR photometric precision **this summer** …

with SBIG ST-8300 camera:

… then on to flight tests over Mt. Hopkins (AZ) and Pan-STARRS (Maui).

Following that, we intend to begin flight testing in Chile in 2016.

Conclusion

- **Artificial sources are, in principle, able to reach up to two orders of magnitude better photometric calibration precision than any natural light sources.**
  1) Can ***study them into the lab before and after use***, unlike stars.
  2) Can ***monitor them in-situ***, in real time.
  3) Can be used to ***calibrate white dwarfs*** (and the Moon) very precisely, and on a detector-based standards scale.
  4) Small balloons are ***inexpensive***.
  5) Your ***choice of spectrum*** & color on demand (including microwave! etc.), …and ***brightness***, … ***location*** in the sky, and time of night (or day), …

- **This is a core program for LSST: will be a primary photometry calibration method for LSST SNIa observations.**
- ***MORE NEWS AND DATA FROM US SOON !!!***

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