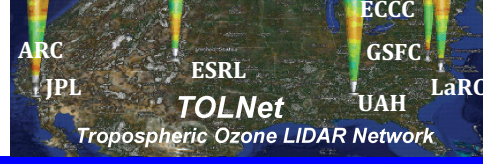


Tropospheric Ozone Lidar Upgrade and Automation at JPL Table Mountain Facility

Fernando Chouza[1], Thierry Leblanc[1], Mark Brewer[1], Patrick Wang[1]

[1] *Jet Propulsion Laboratory, California Institute of Technology, Wrightwood, CA*

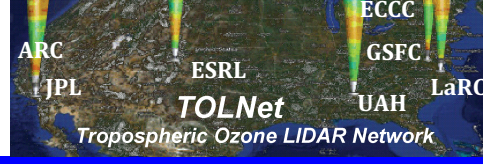
Contents

- **TMTOL Overview**
-
- **Tropospheric ozone lidar automation**
  - *Hardware*
  - *Acquisition software*
- **Very-near-range receiver**
  - *Setup*
  - *Tests/Validation*
- **Summary**

TMTOL Overview

- **Transmitter**
  - *Dual Nd:YAG + FHG*
  - *266 nm @ 30 Hz / 65 mJ*
  - *Dual Raman cell arrangement*
  - *About 15 mJ output power per cell*
- **High altitude receiver (> 6 km AGL)**
  - *0.91-m Newtonian telescope*
  - *Dual-fiber arrangement*
  - *289/299 nm wavelengths*
- **Low altitude receiver (1-7 km AGL)**
  - *Dual refractive telescope*
  - *Fiber-coupled arrangement*
  - *289/299 nm wavelengths*
- **Very-near-range receiver (0.1-2 km ALG) – New!**
  - *Single refractive telescope*
  - *All free-space (no fibers)*
  - *266/289 nm wavelengths*

Lidar automation: Hardware

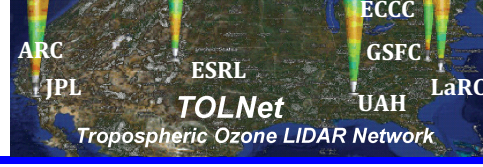


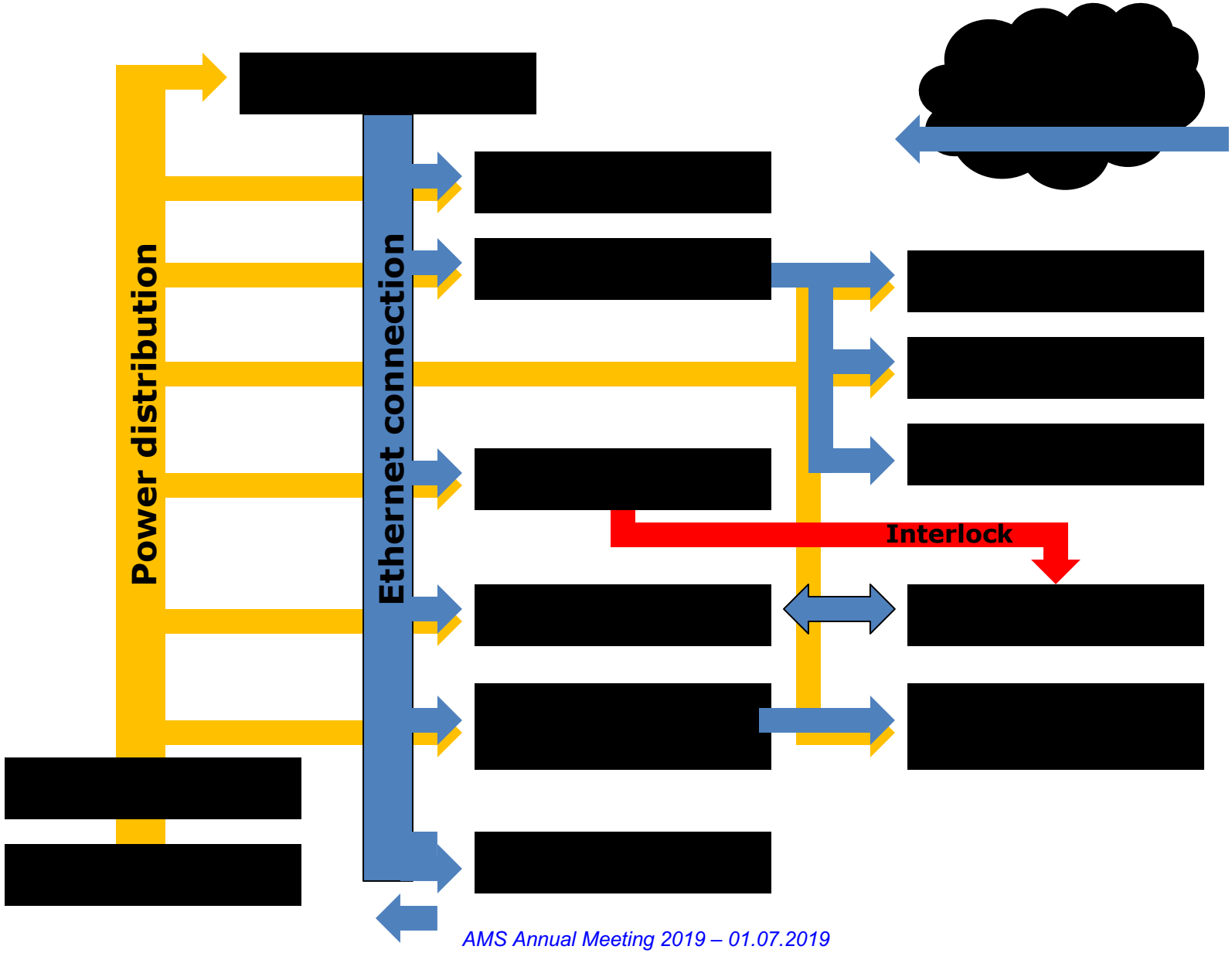
- **Design criteria / Required features**
  - *Modular approach for easy tests and modifications.*
  - *Hardware interlocking for the lidar hatch in case of rain.*
  - *Easy replaceable control PC (i.e. no special interface or acquisition cards installed on the PC).*
  - *Ability to reset every component remotely.*

Key implementation features

- *Ethernet as the preferred technology for communication with the different peripherals*
- *Power distribution based on Ethernet controlled power distributions units (PDUs).*

Lidar automation: Hardware



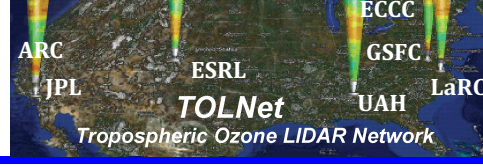


Lidar automation: Acquisition software

- **Design criteria / Required features**
  - *Modular approach for easy tests and modifications.*
  - *Portable to other lidar systems at TMF.*
  - *HDF5 data storage (1 minute time resolution).*
  - *Easy remote access.*
  - *Email report on acquisition start and end.*
  - *Detailed system status logging*

- **Implementation**
  - ***Python + Bokeh** (interactive visualization library).*
  - *Free and open source software.*
  - *Code divided in five modules (**scheduler, housekeeping, alignment, acquisition, and web interface**). Connection between modules is implemented with sockets.*
  - *Interface running on a **web browser**.*

Lidar automation: Software



[redacted]

[redacted]

python

[redacted]

python

HK

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

python

[redacted]

python

Alignment

[redacted]

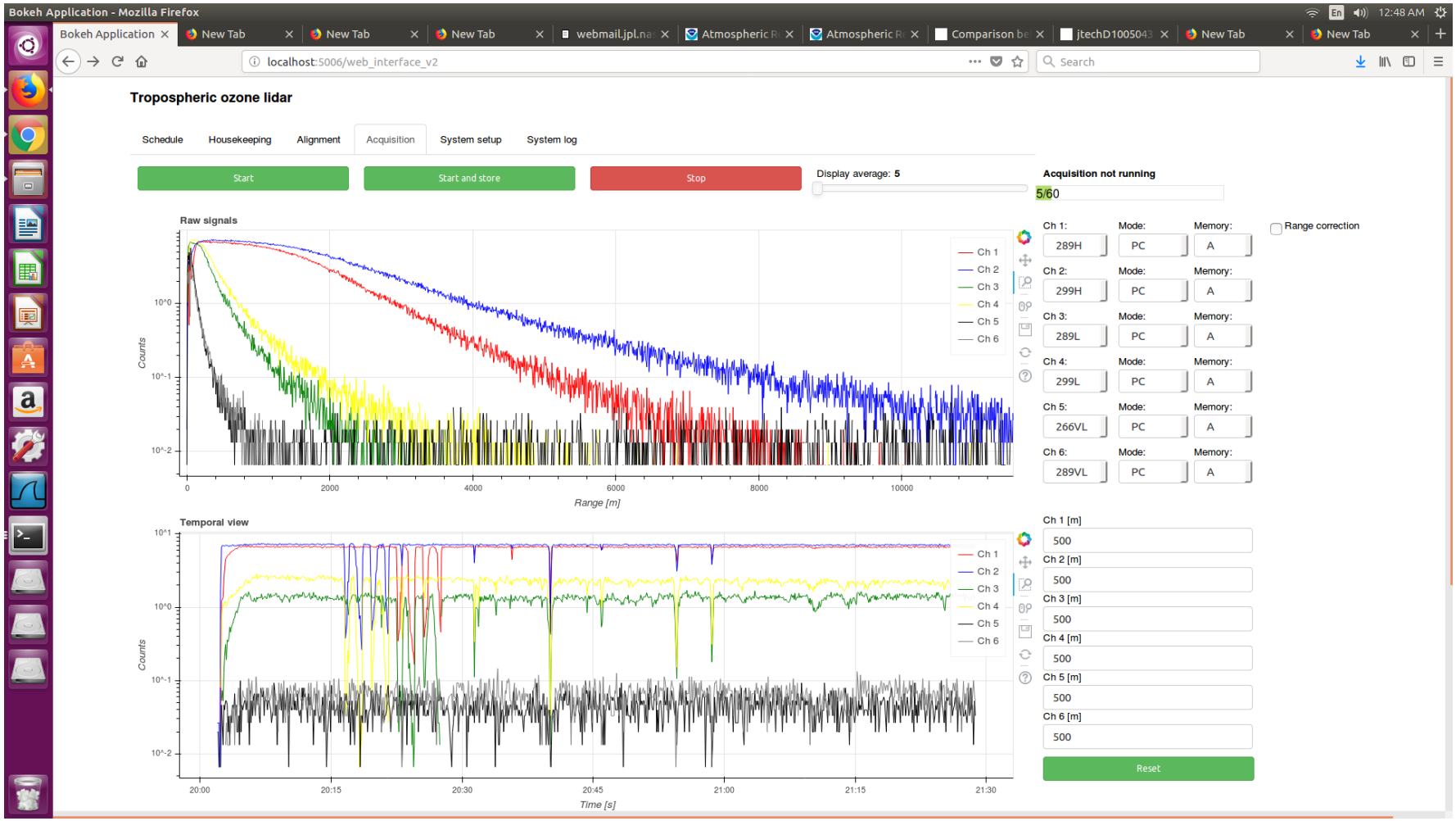
[redacted]

python

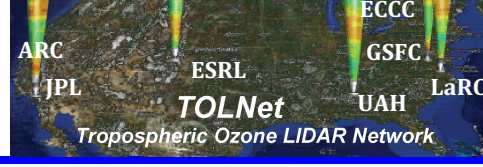
HDF5: HK + Alignment + Acquisition

[redacted]

Lidar automation: Software

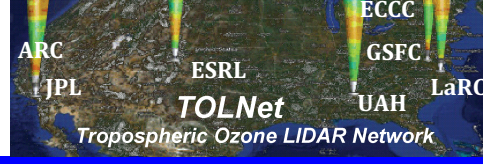


Very-near-range receiver: Setup



- **Design criteria / Required features**
  - *Range: 100 - 1000 m*
  - *Signal dynamic range: 3 orders of magnitude (assuming no extinction, only r**2 dependency)*
  - *Originally Raman channels were planned, but the available power is not enough. Around 10 times more power @ 266 nm is needed.*
  - *Alternative: 266 nm / 289 nm wavelength pair*
- *Available power @ 266 nm: 10 - 20 mW*

Very-near-range receiver: Tests

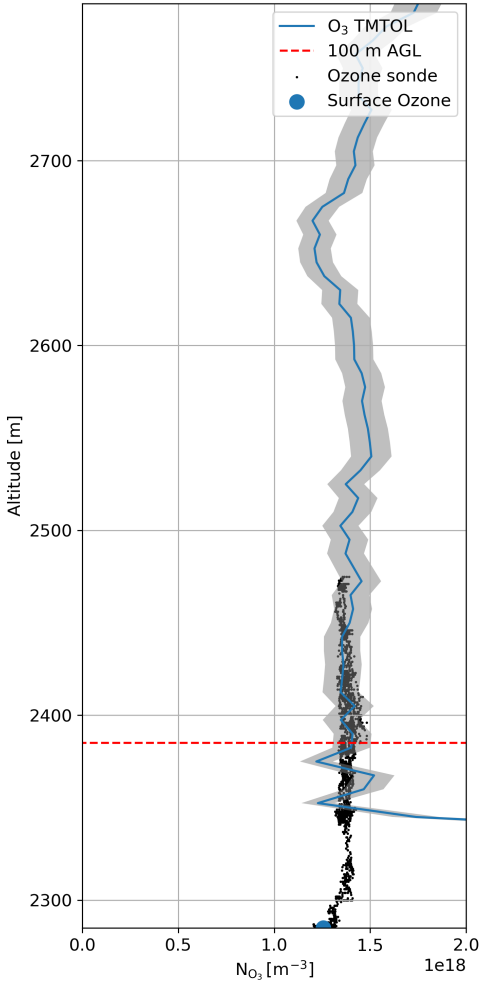


- **Validation**

- *A tethered balloon with an ozone sonde was used to perform some tests on the new very-near-range receiver (right).*

- *Only measurements on very calm conditions can be carried out with the tethered balloon.*

- *Systematic differences observed between the surface ozone measurements (below) are mainly due to surface ozone destruction.*



Summary

- **Lidar automation**
  - *TMTOL is currently operating twice a day in autonomous mode.*
  - *This automation scheme is now implemented in all TMF lidars (stratospheric ozone lidar and Raman water vapor lidar).*
  - *Some functions, like laser power monitoring and cloud coverage monitoring still have to be implemented.*

- **Very-near-range receiver**
  - *Inter-comparison with ECC sonde mounted on a tethered-balloon show agreement within 5% down to 100 m AGL.*
  - *Long-term inter-comparisons between the first valid retrieval bin (100 m AGL) and a co-located surface ozone meter (i49) show good agreement (within 10 %) and no drift (good stability).*

- **Near future work**
  - *We are in the process of getting a UAV-borne ozone sonde. This would allow us to perform more inter-comparisons with the new receiver.*
  - *Add aerosol capabilities (289+532+1064+Raman).*