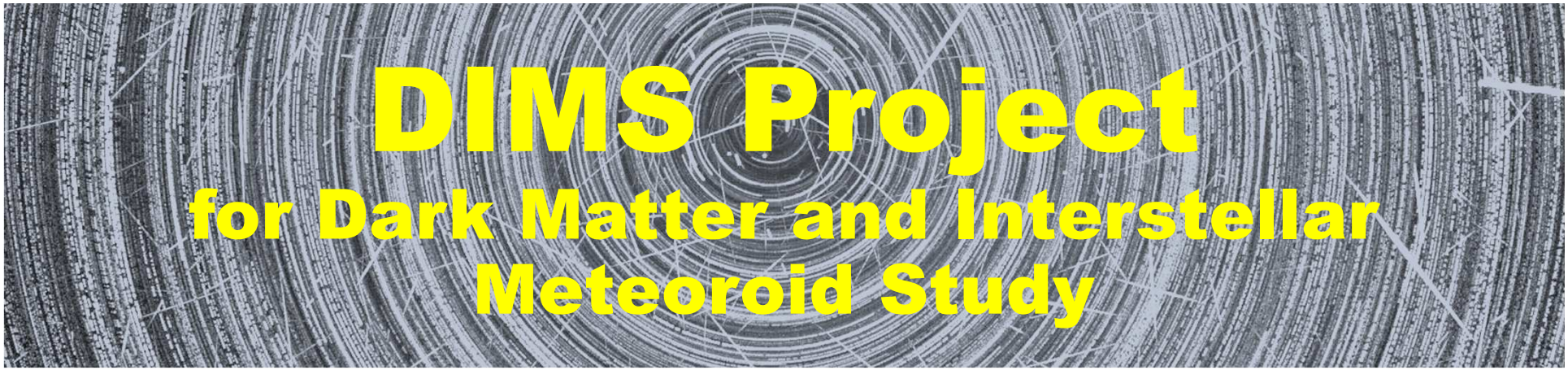

DIMS Project
for Dark Matter and Interstellar Meteoroid Study

F. Kajino[a], R. Ide[a], M. Arahori[a], S. Tada[a], K. Nadamoto[a], Y. Tameda[b], Y. Iwami[b], D. Shinto[b], M. Bertaina[c,d] D. Barghini[d], S. Valenti[d], A. Cellino[c,e], K. Shinozaki[f], M. Casolino[g,h], T. Ebisuzaki[g], Y. Takizawa[g], L. W. Piotrowski[i], H. Sagawa[j], J. Matthews[k], S. Abe[l], I.H. Park[m], S. Kim[n], G. Starkman[o], J. S. Sidhu[o] , Y. Fujiwara

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[o]*Dept. of Phys., Case Western Reserve Univ., USA*

The 2nd DIMS Workshop

December 5th, 2020 by Teleconference

Objects of DIMS Project

- **Search for nuclearites and Strange Quark Matters as the candidates of the macro size dark matters**
- **Study of meteoroids, especially interstellar meteoroids.**
- **Study of other Transient Luminous Effects (TLE's)**
- **Co-observation with JEM-EUSO program such as EUSO-TA, Mini-EUSO, K-EUSO etc.**

Dark Matter Candidates

- **Weakly Interacting Massive Particles (WIMPs)**
- **Axions**
- **Primordial Black Holes**
- **Exotic Candidates**

  WIMPzillas, gravitinos, gluinos

  Q-balls, Q-nuggets, SIMPS

  Fermi Balls, EW Balls and GUT Balls

  New Class of Dark Matter Objects

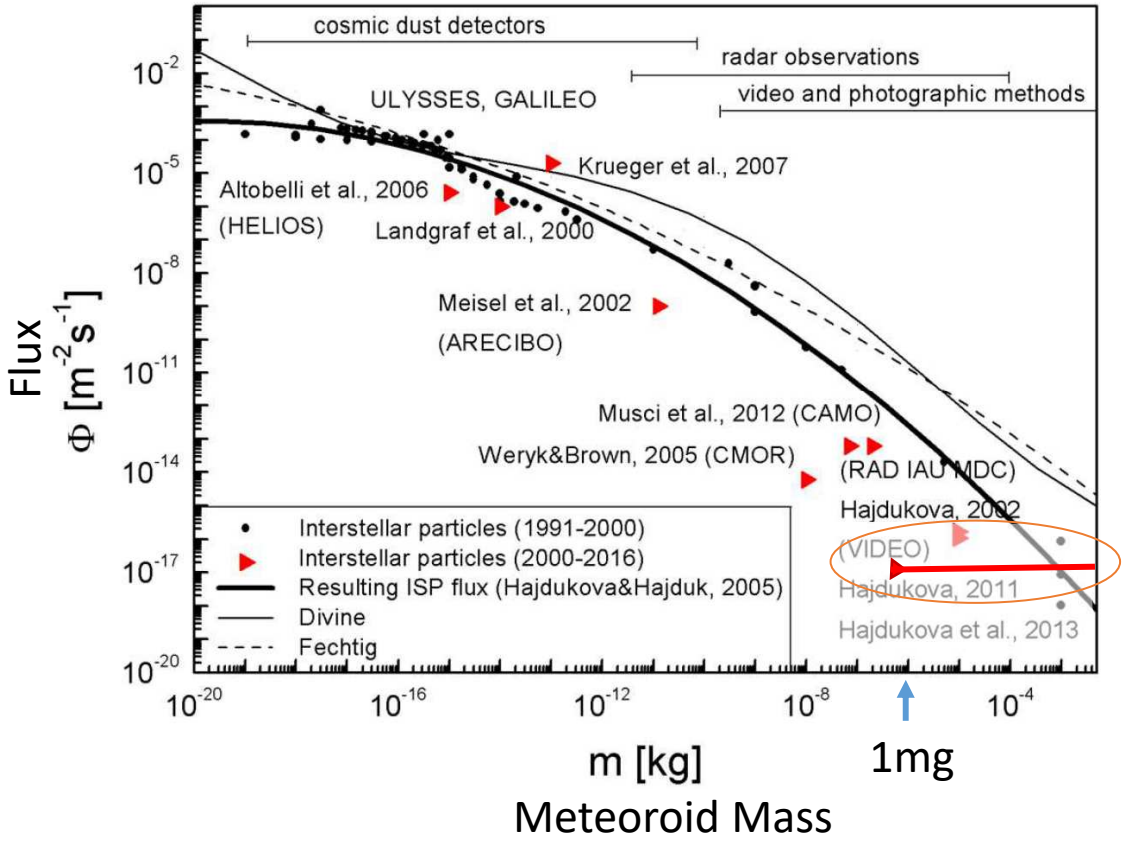
  Mirror Dark Matter …

K. Arun et al. arXiv 1704.06155

Dark matter doesn't have to interact weakly if it's very massive.

Glenn Starkman 2015

Possibility to Observe Interstellar Meteoroids from Outside the Solar System



Expected flux limits with 1 year observation

No.1 System : 1.3×10^{-17} $m^{-2}\,s^{-1}$

(Observation efficiency in time is assumed to be 0.09)

Difference between Nuclearites and Meteoroids

Meteoroids

Meteoroid material is evaporated and ionized. Light is emitted from the ionized gas.

Meteoroids bound in the solar system

Elliptical orbit, v < 72 km/s
most meteoroids

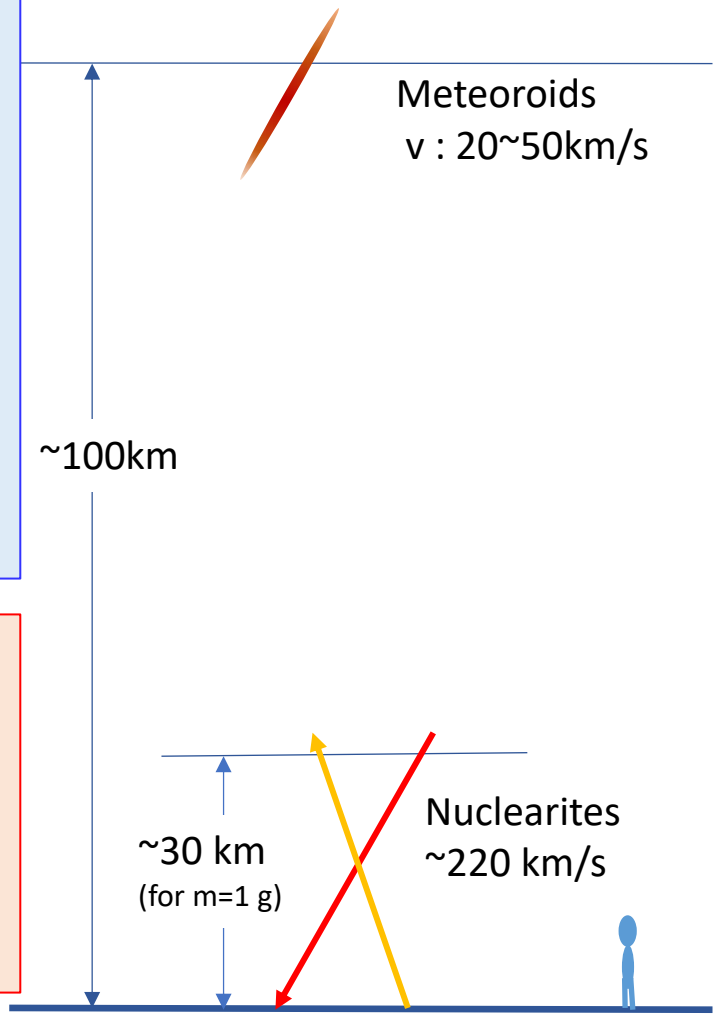
Interstellar meteoroids

Hyperbolic orbit, v > 72 km/s
Orbital velocity of Earth = 30 km/s
Escape velocity at earth orbit = 42 km/s

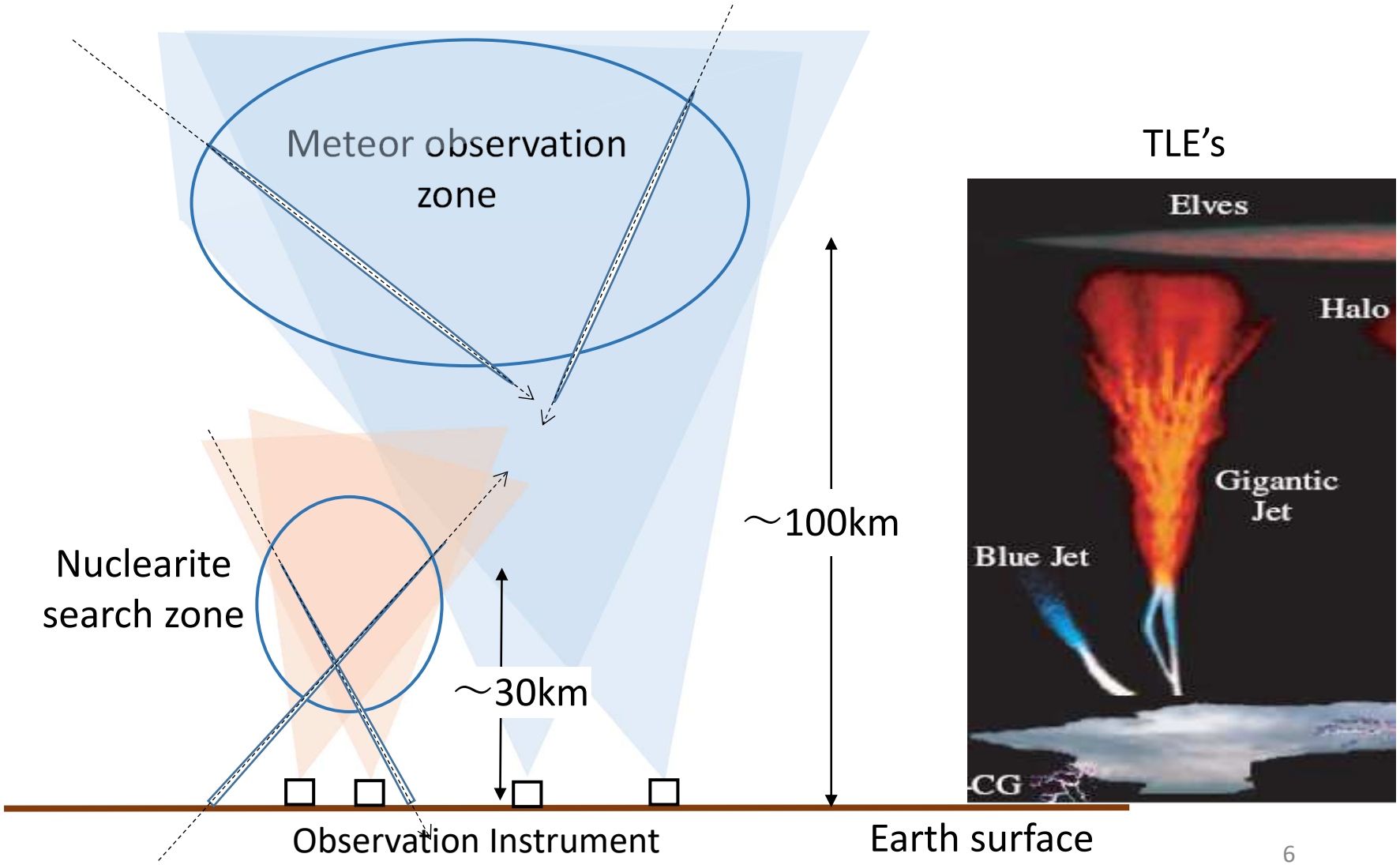
Nuclearites/SQM

Light is emitted as black-body radiation from an expanding cylindrical thermal shock wave by elastic or quasi-elastic collisions with the ambient atoms.

Average velocity v_N : ~220 km/s



DIMS Observation Concept



Test of Observation System

HDMI Cable

Video Capture

USB Cable

PC
Windows 10

UFO Capture

UFO Capture:
motion capture software

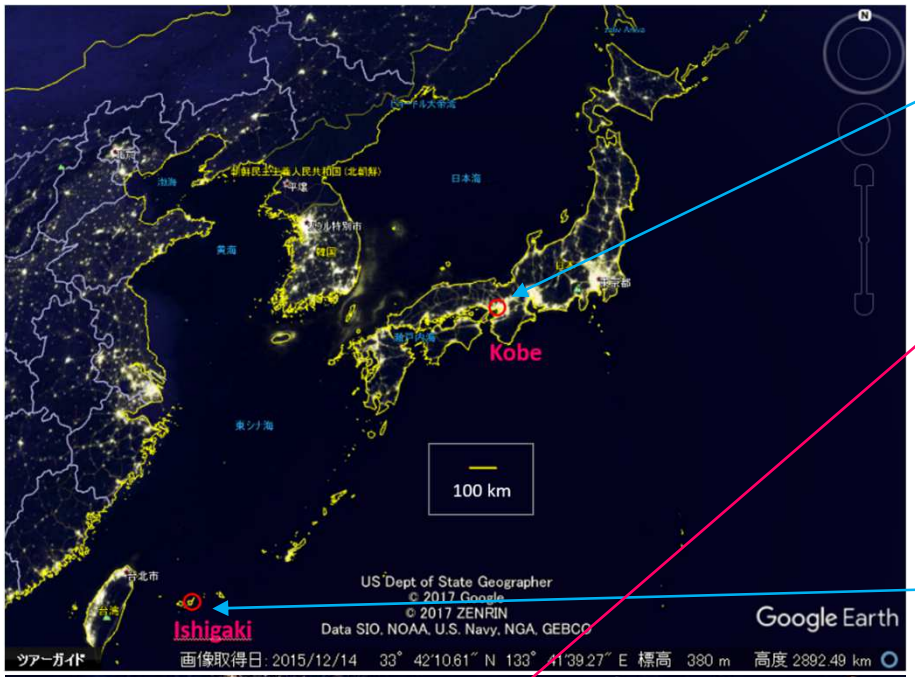
Canon ME20F-SH
Monochrome type

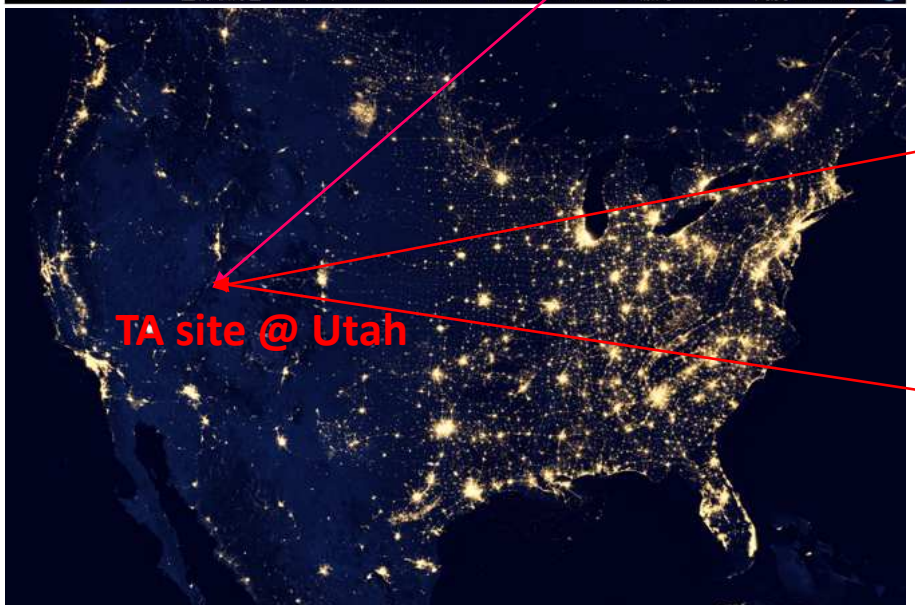
Lens: Canon
EF 35mm f / 1.4L

FoV: 56.2° × 33.4°

Observation at TA-BRM
Aug. 31, 2019

Past Observation Periods and Sites





- Jan. 1st -4th, 2017
- Okamoto and Miki, Hyogo, Japan

- Aug. 20th -Sept. 1st, 2017
- Telescope Array site Utah, USA

- Dec. 25th -28th, 2017
- Ishigaki, Okinawa, Japan

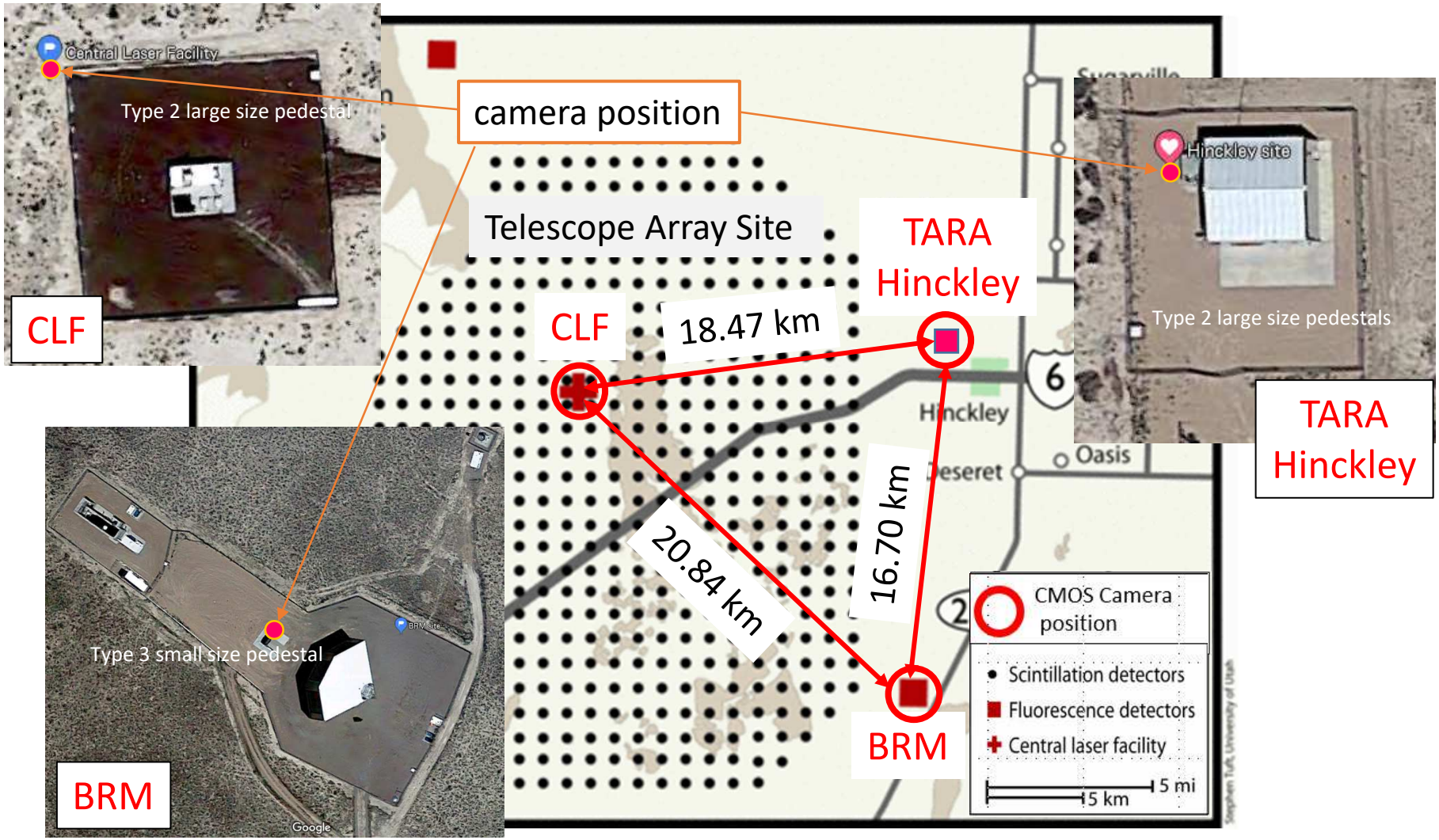
- Sept. 7th -11th, 2018
- Telescope Array site, Utah

- Aug. 28th –Sept. 1st, 2019
- Telescope Array site, Utah

Past Observation Summary
(2017–2019)

Obs. period	Feature	ISO sensitivity	Number of meteors	Meteor Type
Jan 2017	Stereo obs. at Okamoto and Miki	102,400	~34	shower from Quadrantids
			~46	sporadic
			13	*coincident*
Aug – Sept 2017	Single camera at TA site	51,200 ~ 409,600	329	sporadic
Dec 2017	3 types of cameras at Ishigaki, Okinawa	204,800	318	sporadic
Sept 2018	Stereo obs. by 3 cameras at TA site	204,800	~2000	sporadic
Sept 2019	Stereo obs. by 2 cameras at TA site	204,800	3840	sporadic

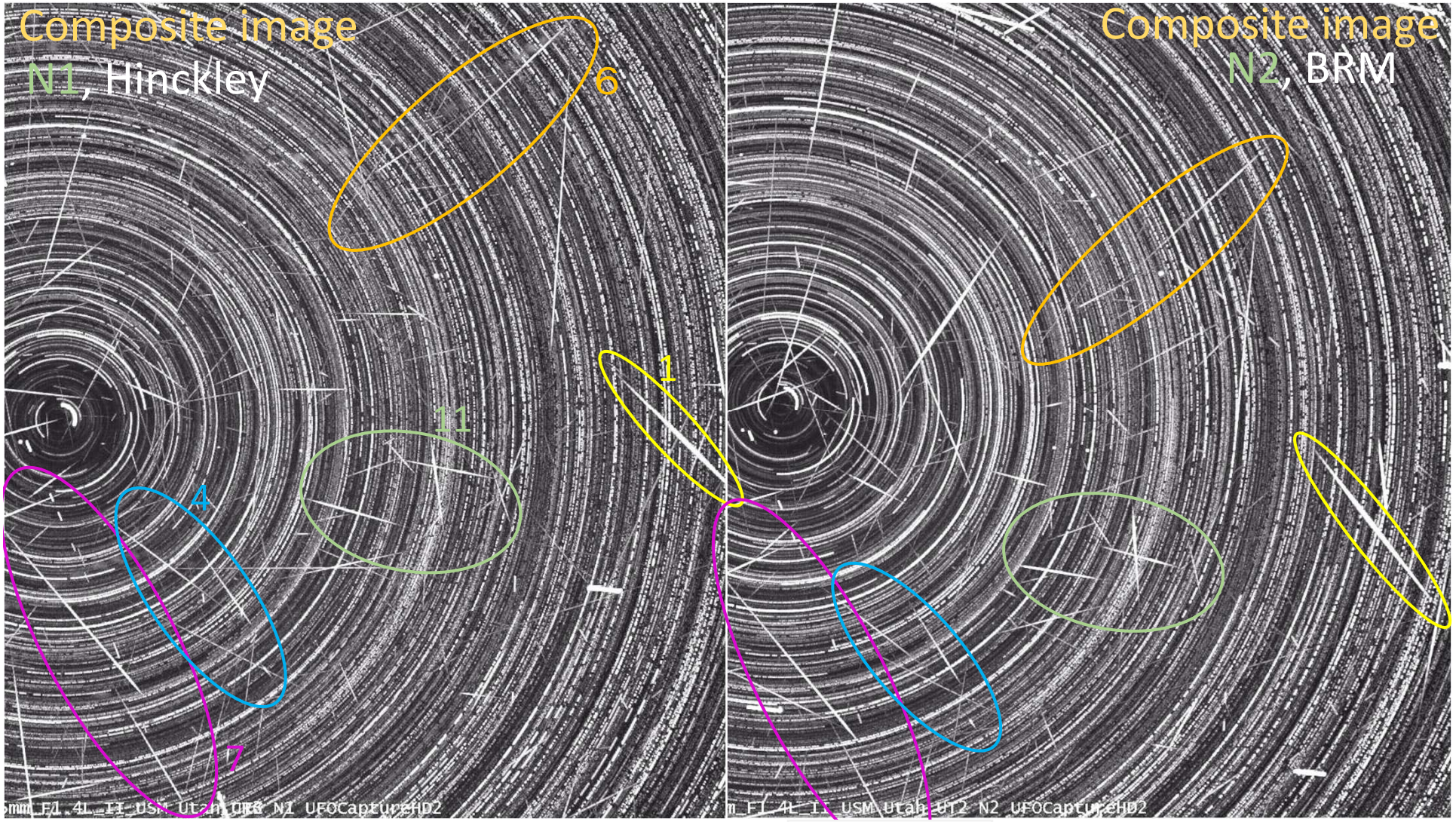
Test Observation Site in 2019



2 cameras were used at a time for the observation.

Simultaneous Events

4th night: 8/31 22:29 – 9/1 5:00 MDT, 2019 (6h 31min)

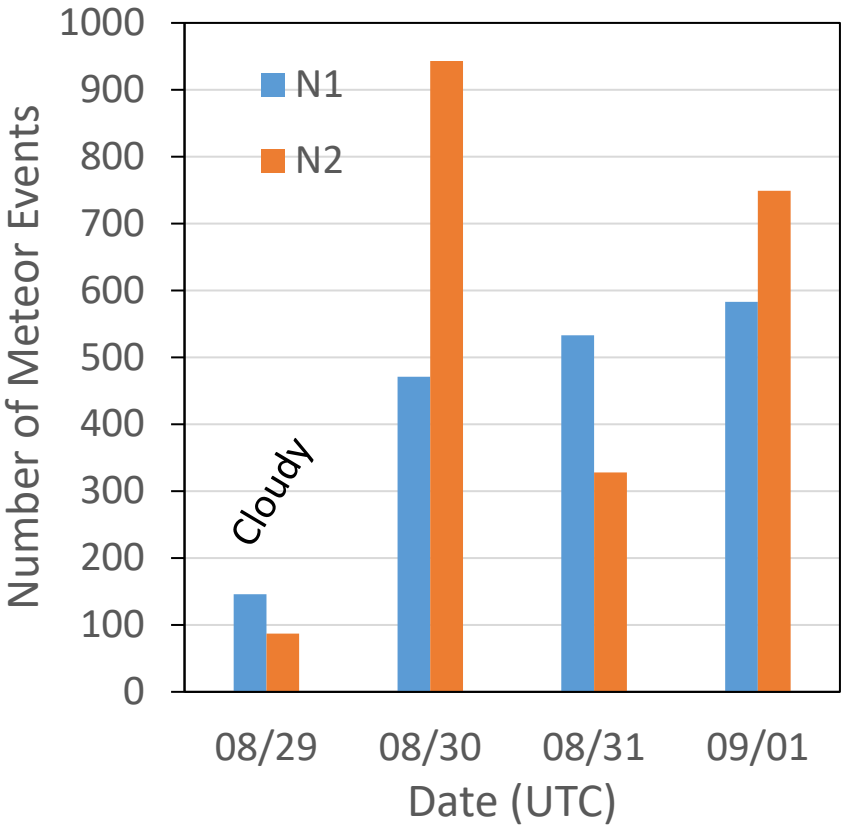


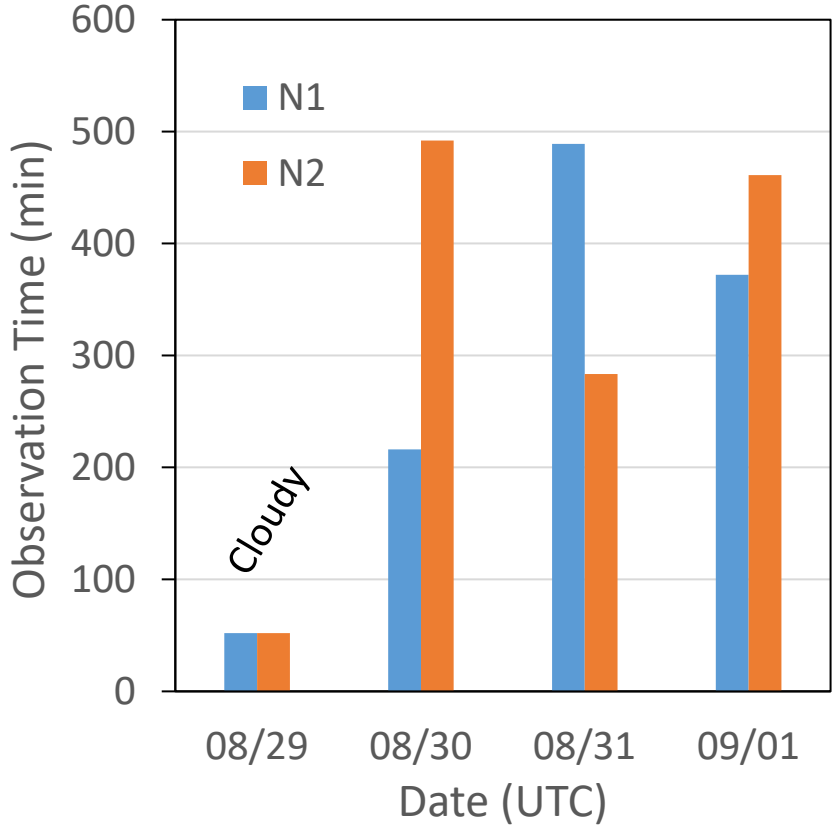
About 75% of events in N1 are observed simultaneously in N2.

Number of the simultaneous events are obtained to be 362 in this night.

Observed Number of Meteors

Aug. 29th – Sep. 1 UTC. 2019 (4 nights)



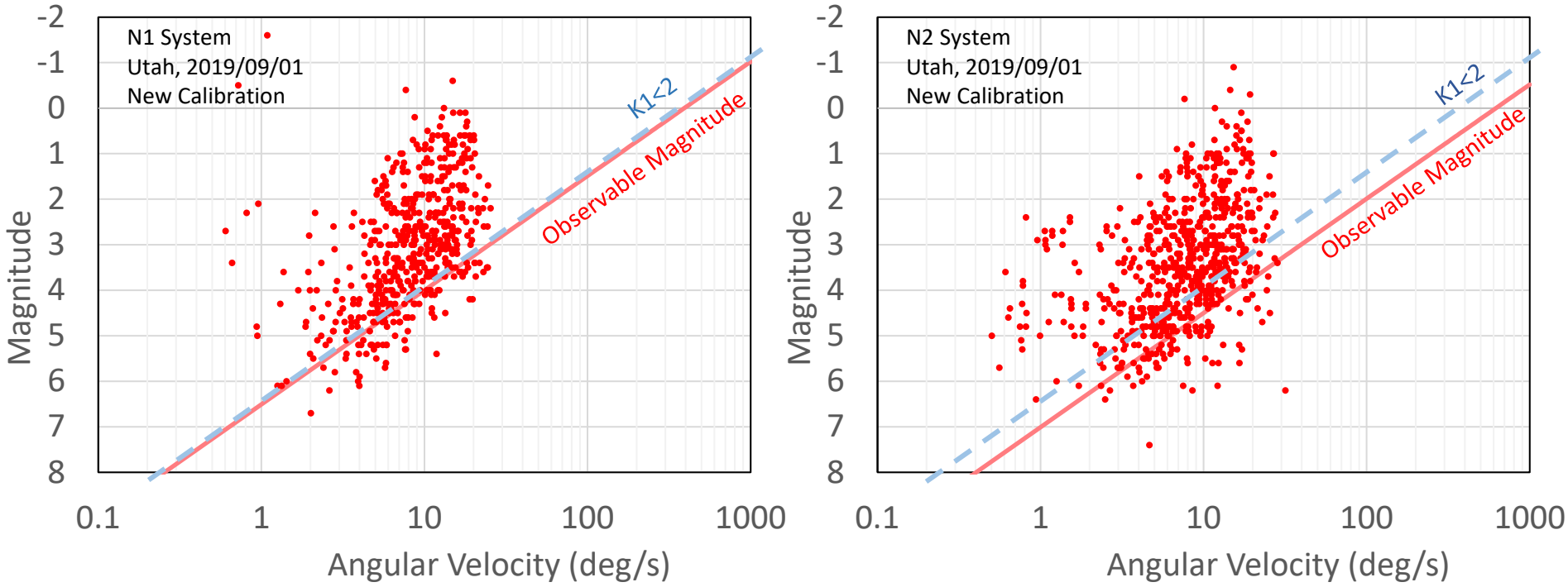


N1: 1733 events
N2: 2107 events
N1+N2: 3840 events

N1: 1129 min = 18.8 h
N2: 1288 min = 21.5 h

DIMS can observe several hundred events per night per camera.

Magnitude vs. Angular Velocity

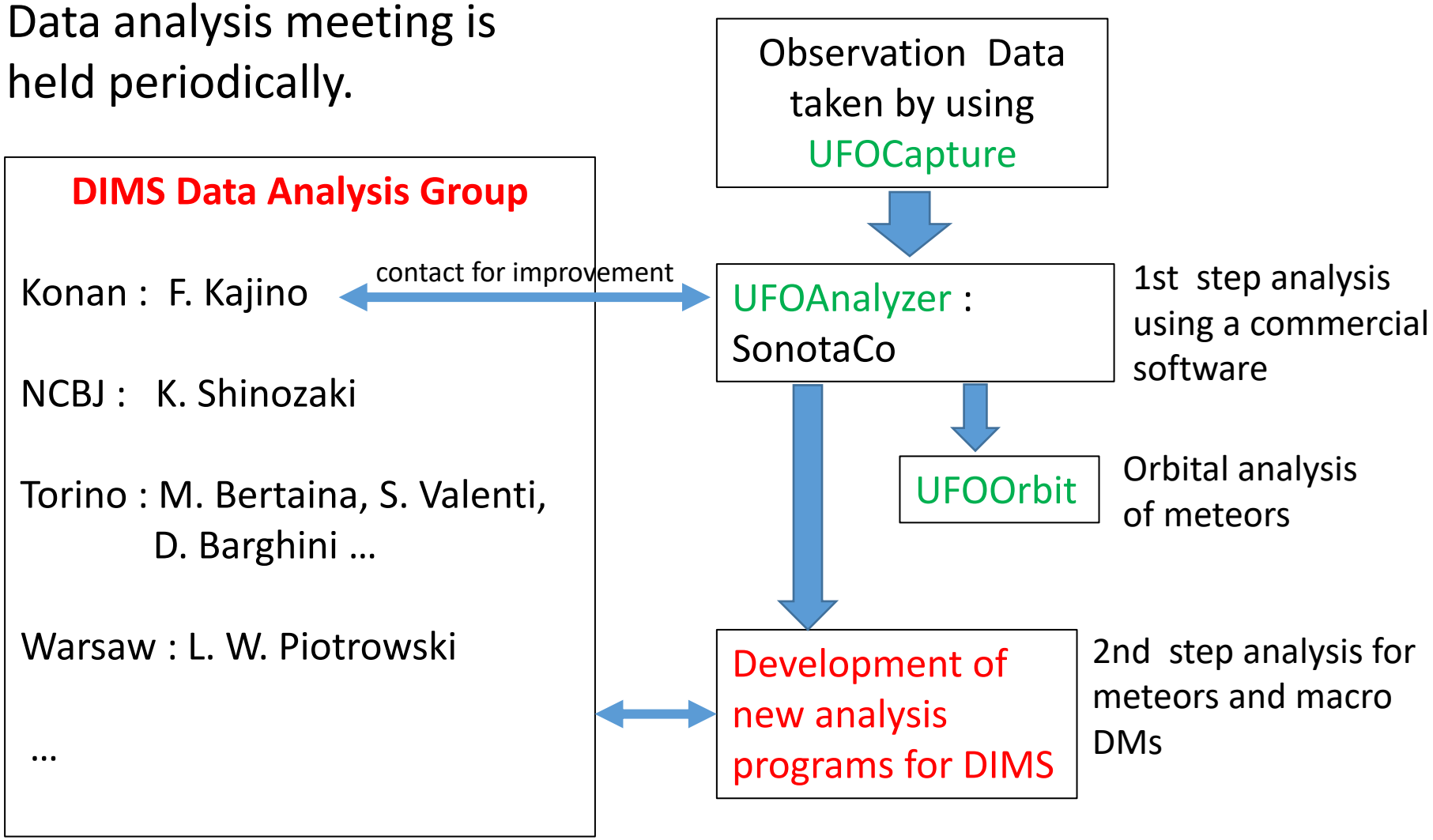


N2 was about 0.5 mag more sensitive than N1.

We estimate Nuclearite flux limit using K1<2 dashed line drawn in the figures.

Concept of Data Analysis

Data analysis meeting is held periodically.



Video Data Analysis using Meteor Trigger Program

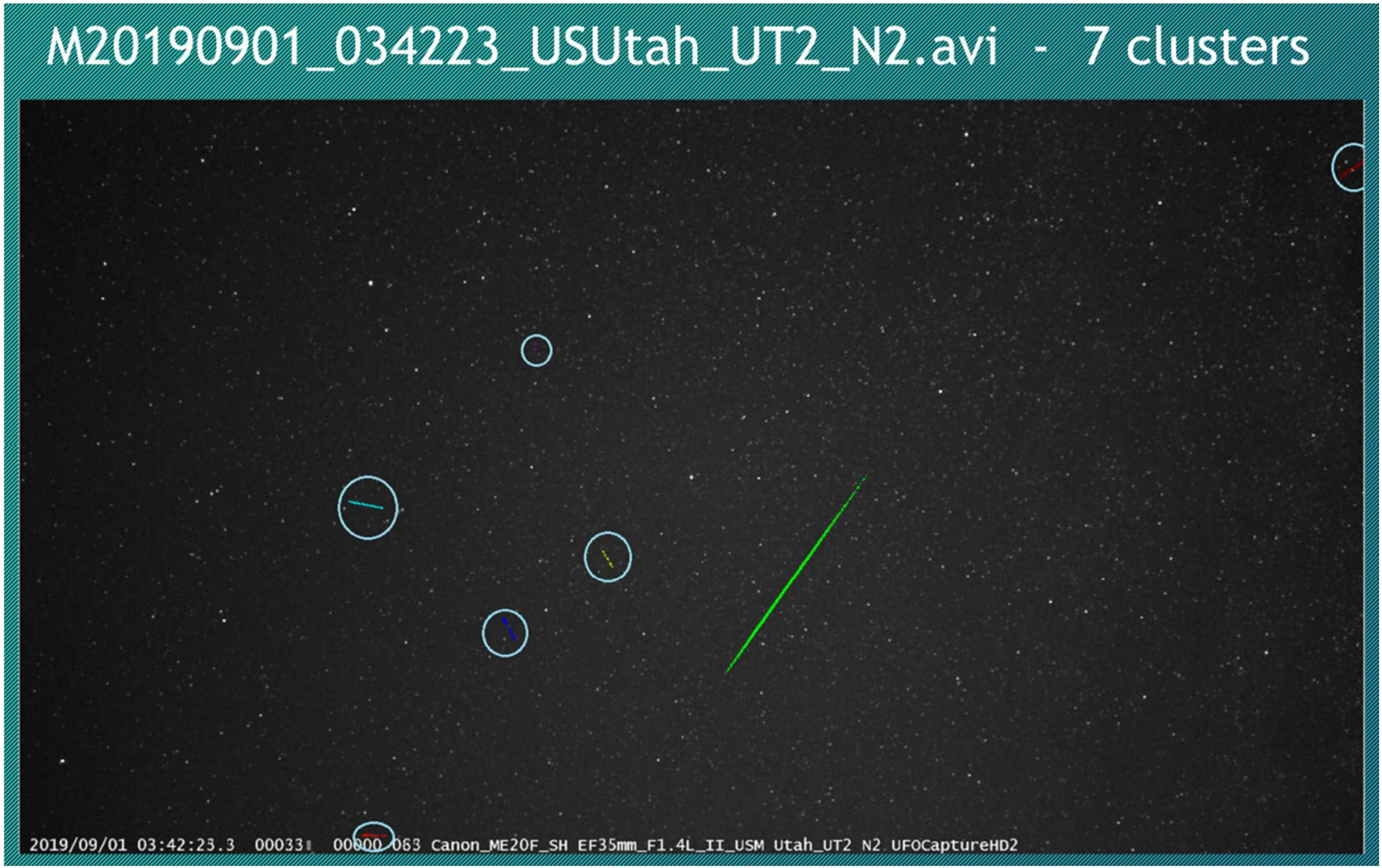
S. Valenti, D. Barghini

Videos from N2 camera of 2019 data have been analyzed

- 659 videos
- 898 clusters revealed
  - 457 videos with 1 cluster
  - 131 videos with 2 clusters
  - 33 videos with 3 clusters
  - 7 videos with 4 clusters
  - 3 videos with 5 clusters
  - 2 videos with 6 clusters
  - 1 video with 7 clusters

Video Data Analysis using Meteor Trigger Program

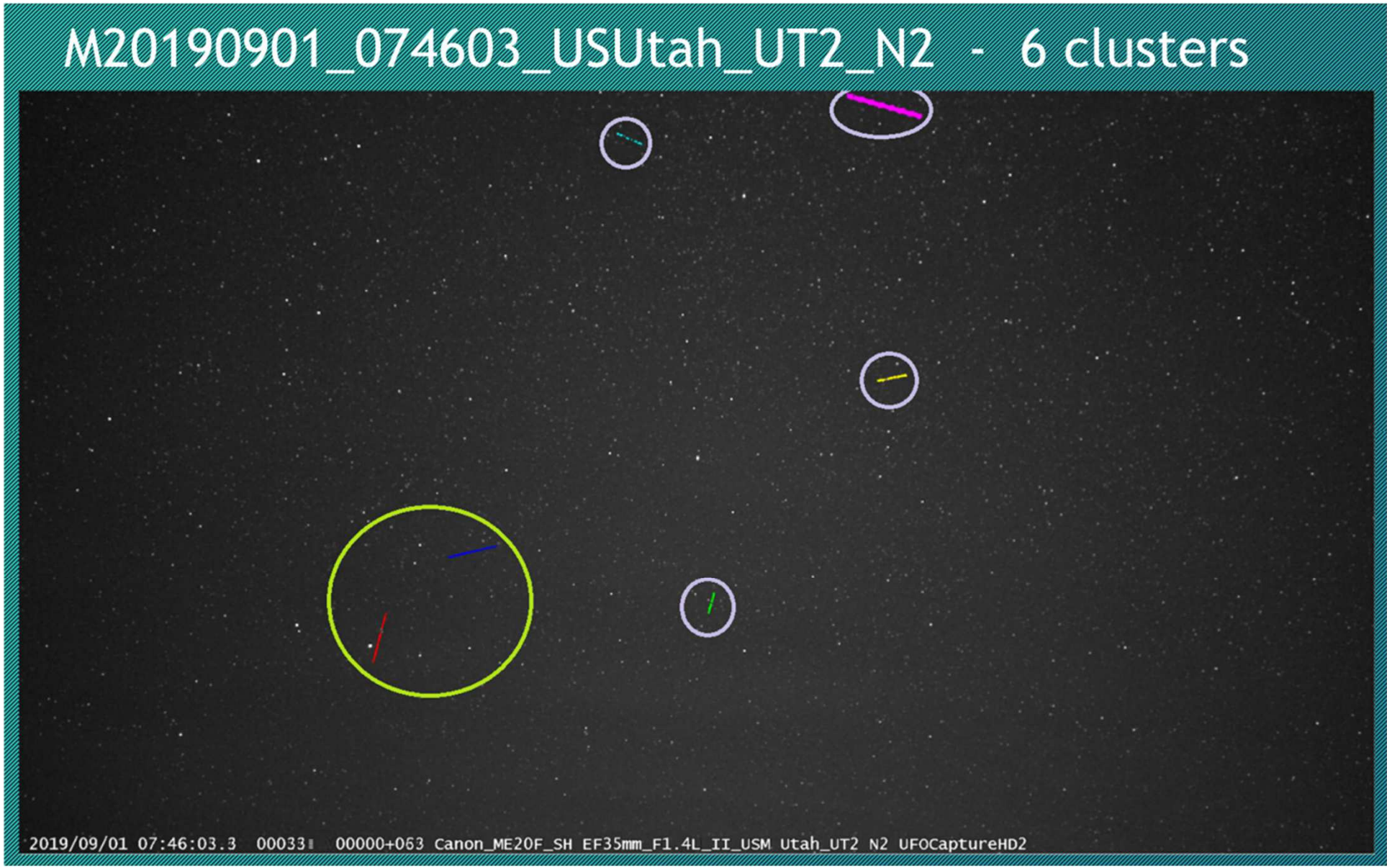
S. Valenti, D. Barghini



1 meteor and many satellite tracks were found

Video Data Analysis using Meteor Trigger Program

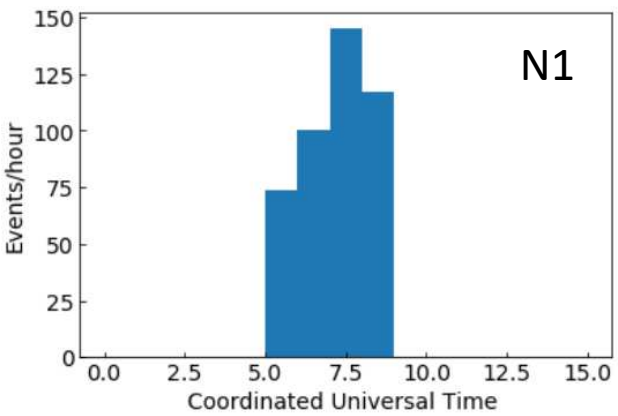
S. Valenti, D. Barghini

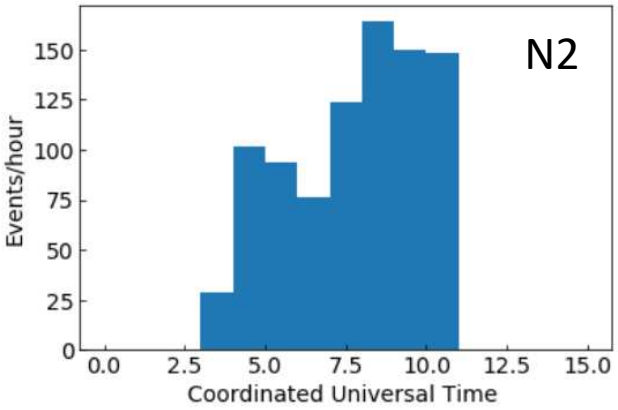


Event Time Distribution

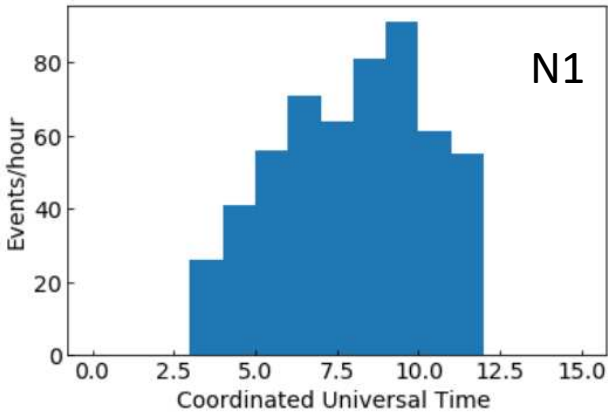
F. Kajino

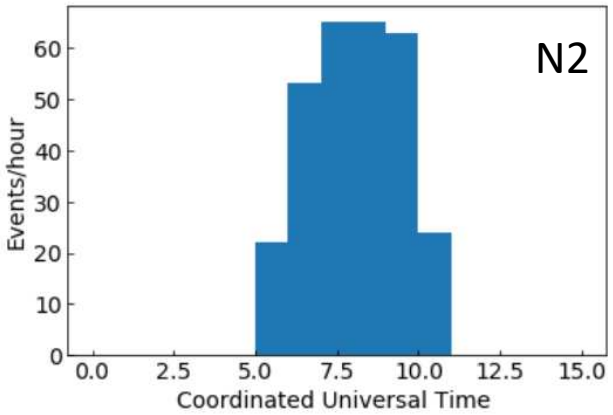
Aug. 30, 2019



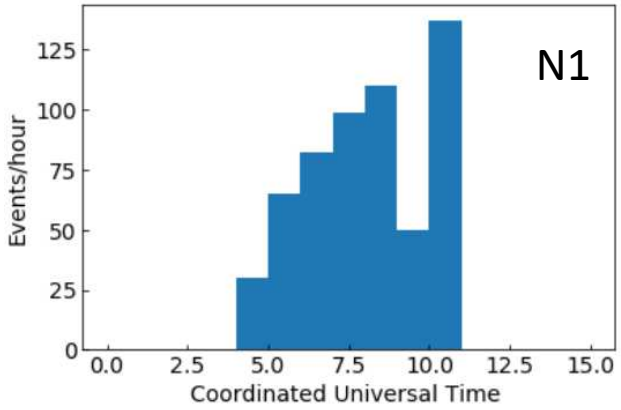


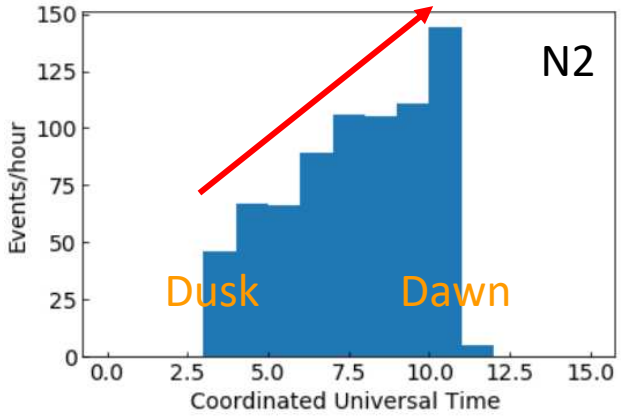
Aug. 31, 2019





Sept. 1, 2019

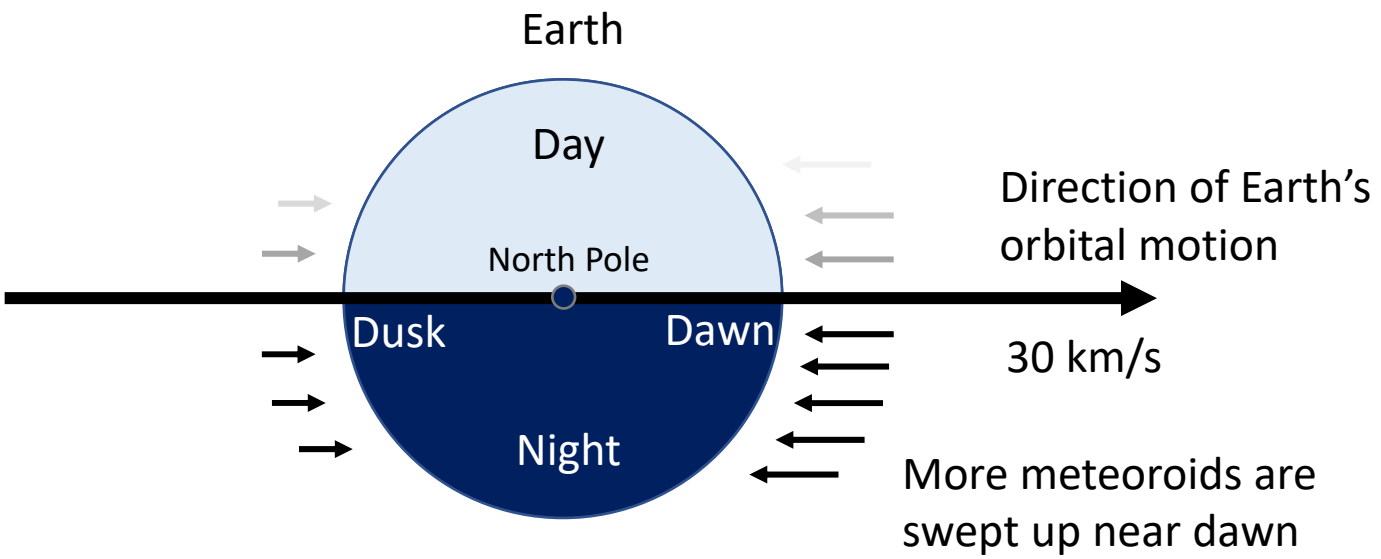




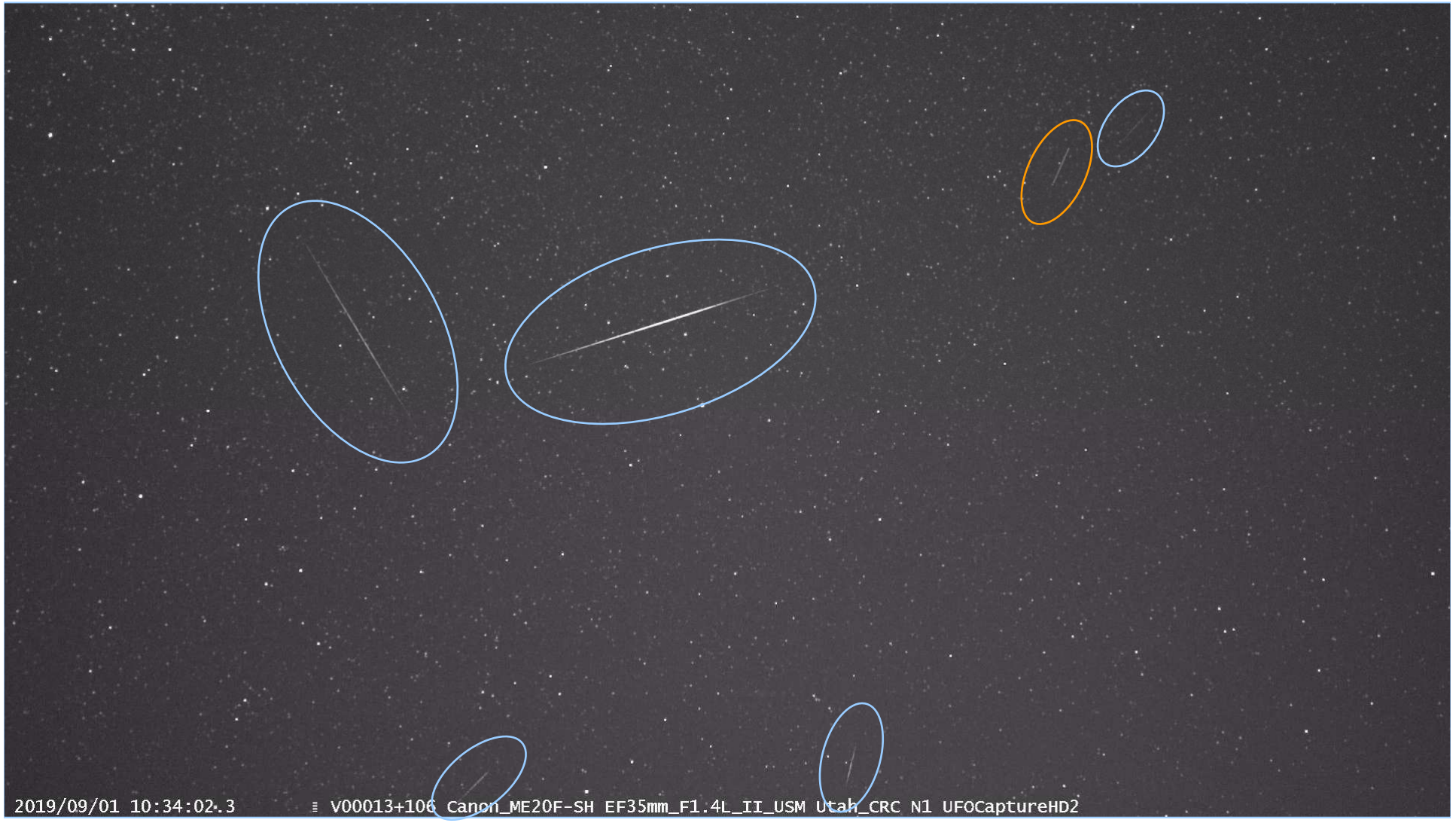
These distribution include not only meteor events but also flush events.

We can see more meteor events near dawn than those near dusk.

Why More Meteors near Dawn?



Example of Multiple Meteor Events

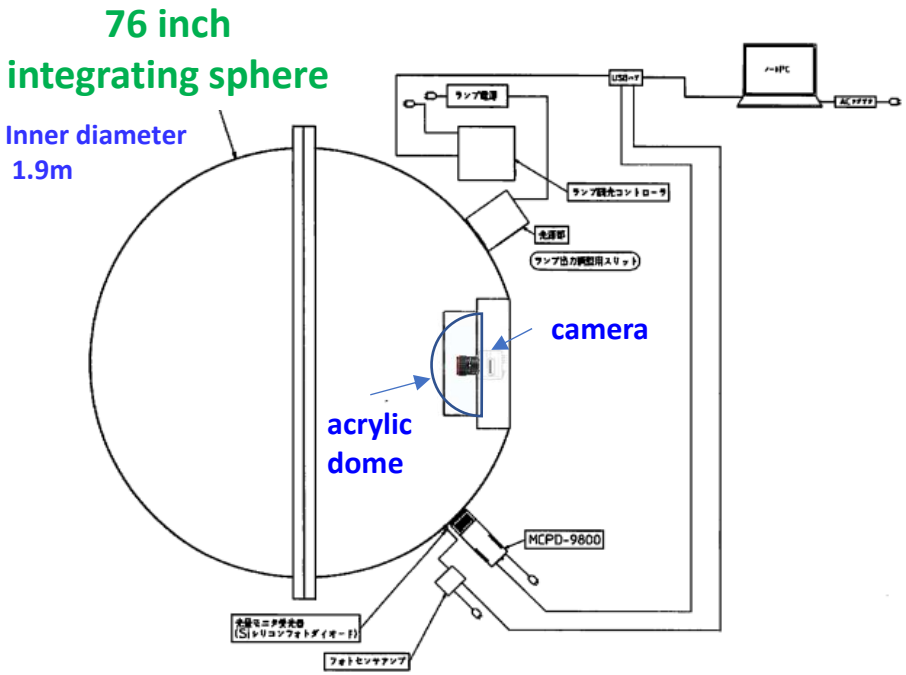


M20190901_103402_USUtah_CRC_N1P.jpg

5 meteors and 1 satellite can be seen in 5.2 sec

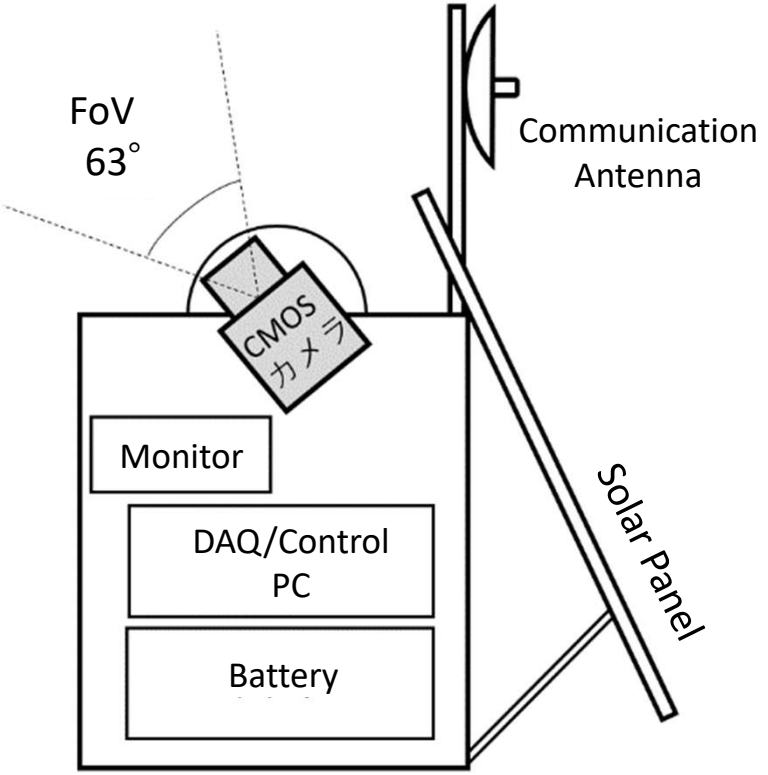
Camera calibration at National Institute of Polar Res.

Calibration using the large integrating sphere



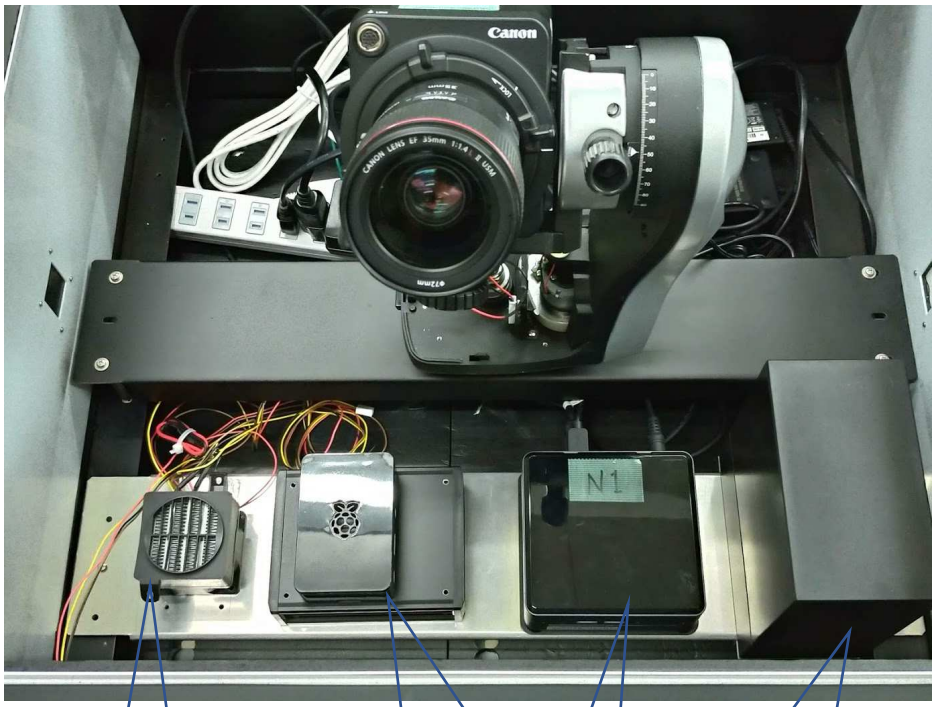
http://polaris.nipr.ac.jp/~uap/IntegrationSphere/

DIMS Camera Box



Conceptual design of the camera station

Camera Box Inside



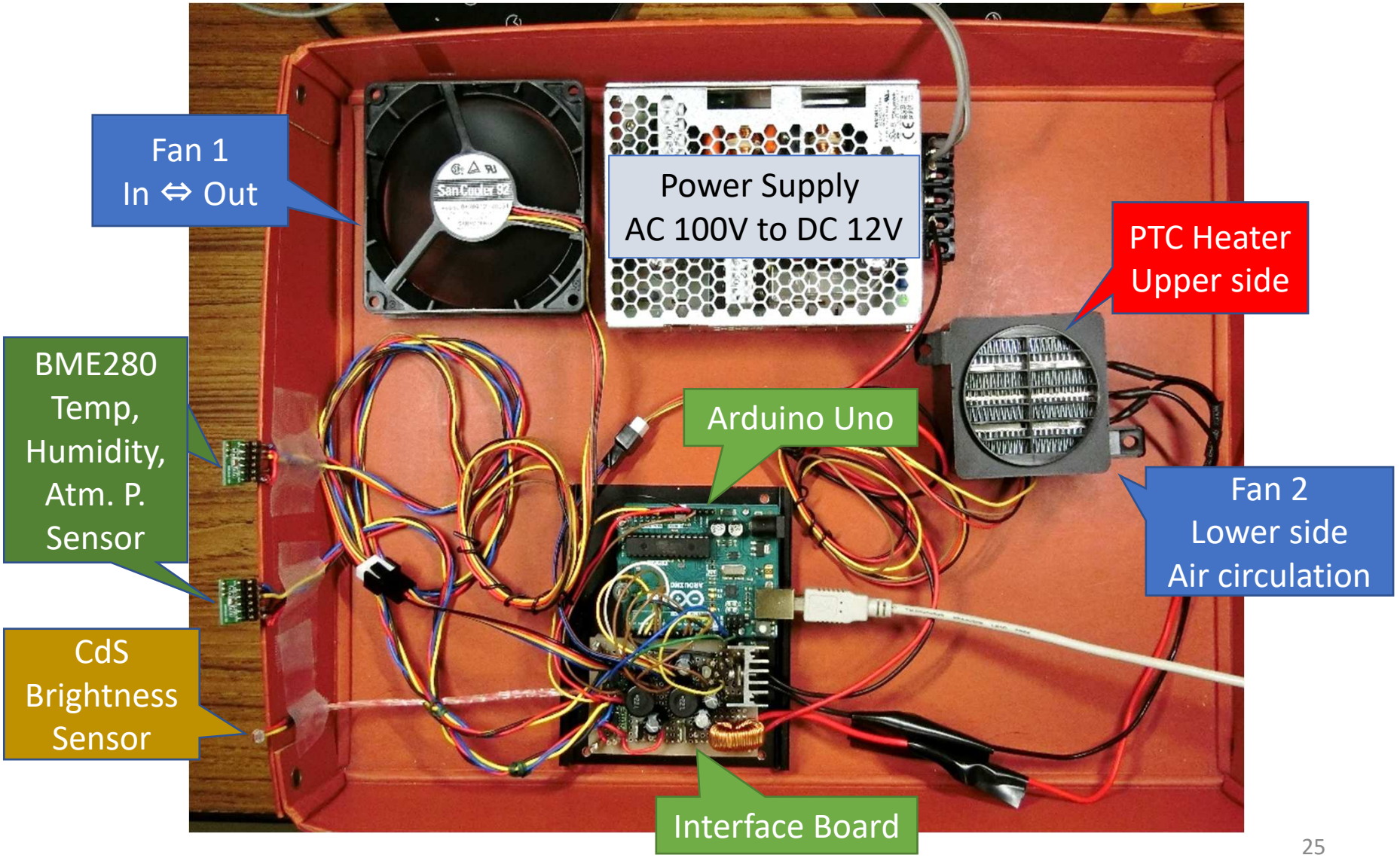
Fan & Heater

Arduino & Raspberry Pi

PC

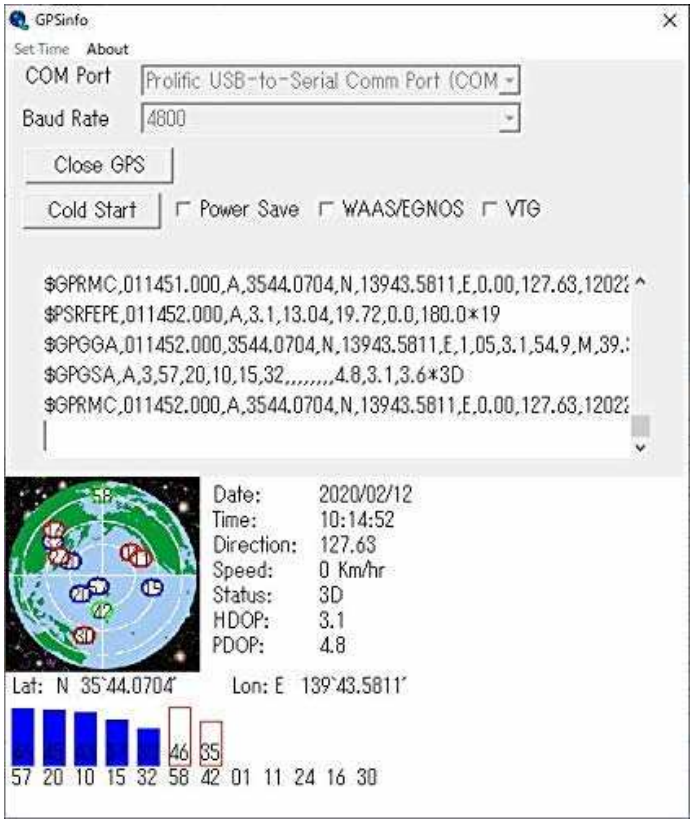
HDD 12TB x 2

Arduino, Interface, Sensors, Fans, Heater



GPS Receiver

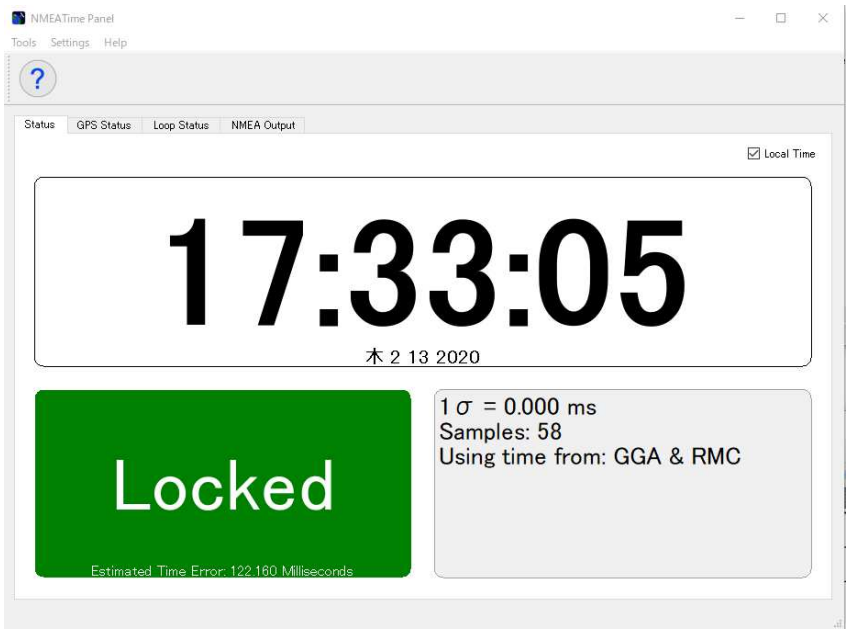
GLOBALSAT BU-353S4 USB
GPS Receiver

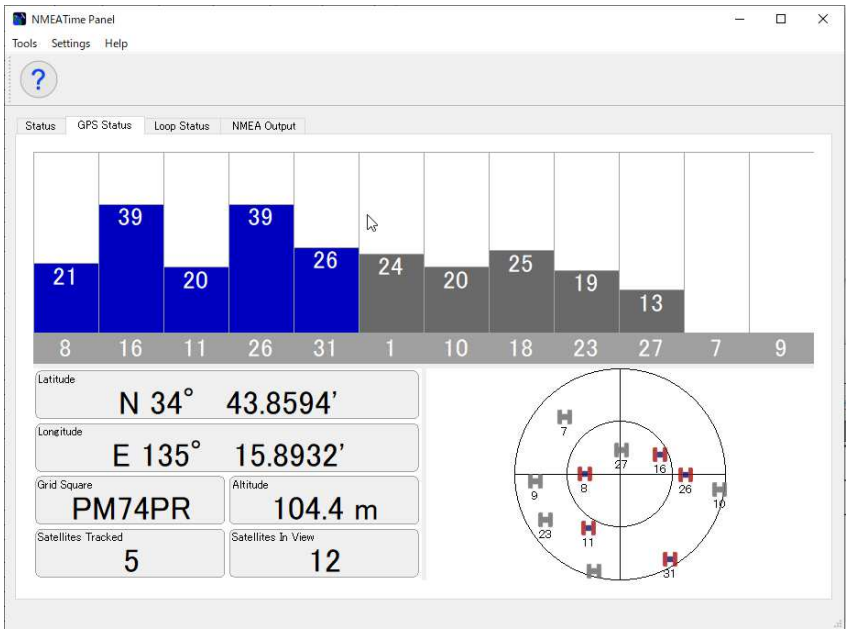


Specification: 1µs synchronized to GPS time

NMEATime2 Software for PC GPS Time Synchronization

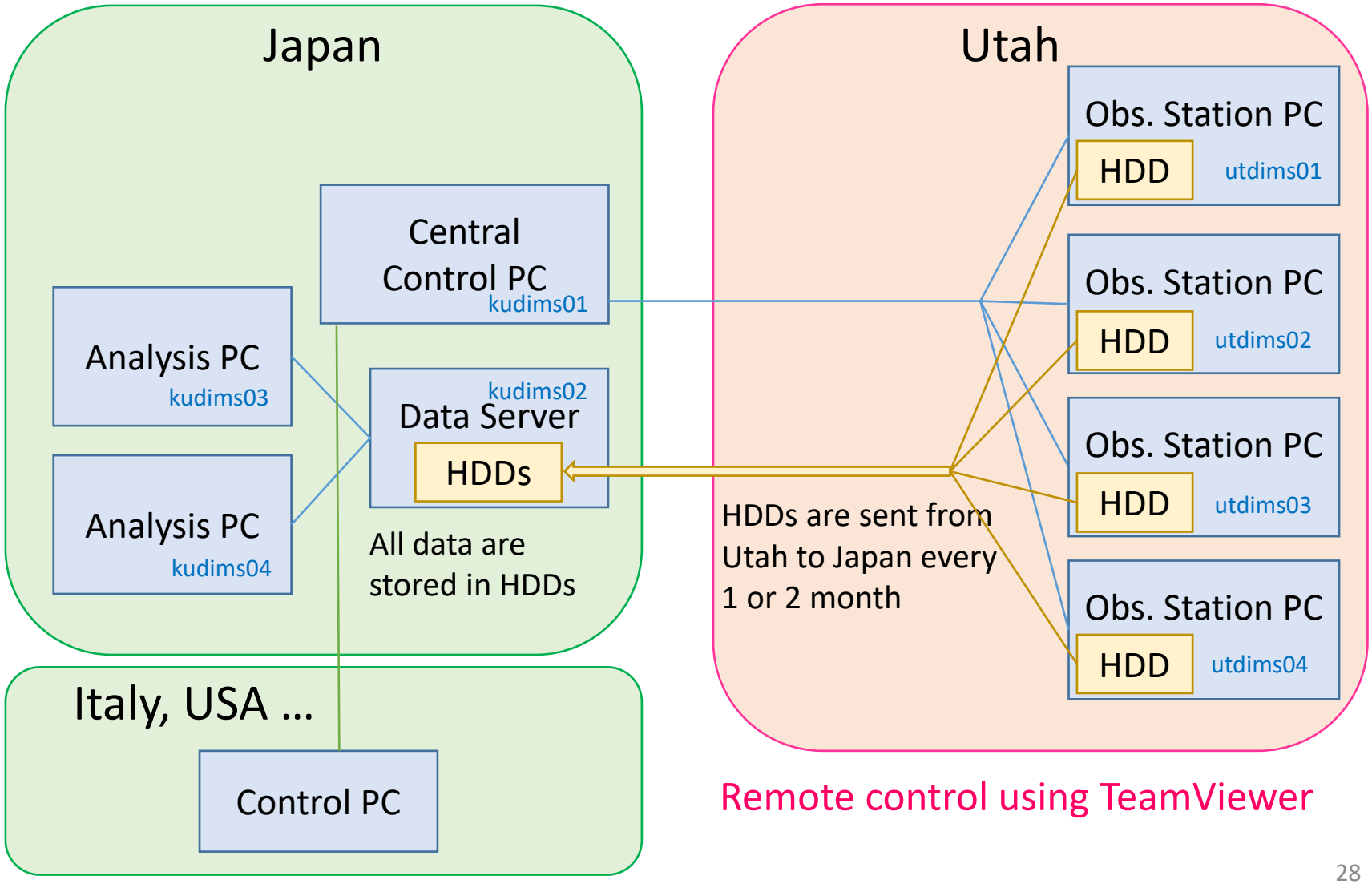
- NMEATime2 is PC time synchronization software that synchronizes the PC clock to the time from a GPS receiver.



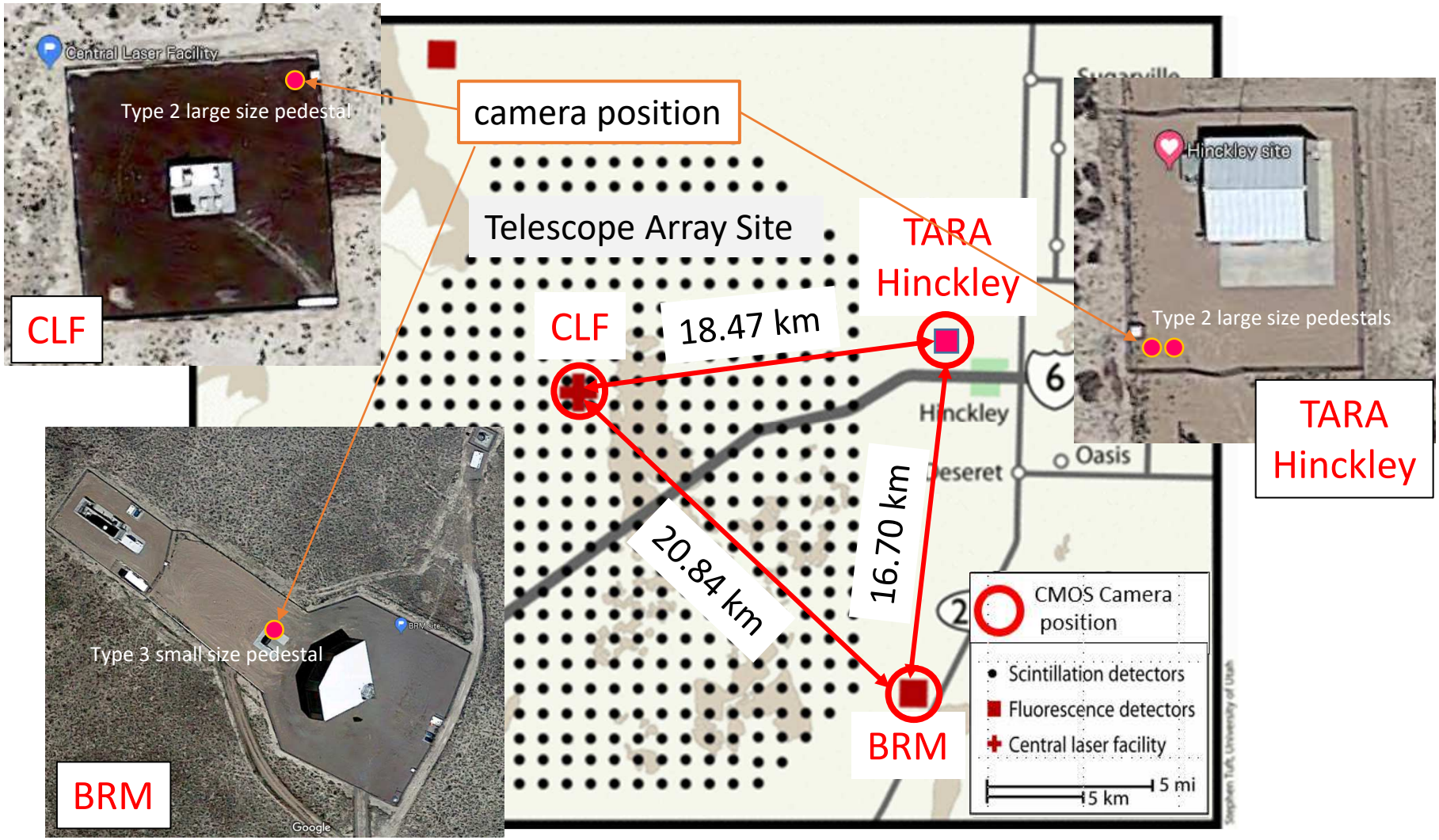


Measurement : PC time are synchronized to the GPS time within about 1ms.

DIMS Observation System



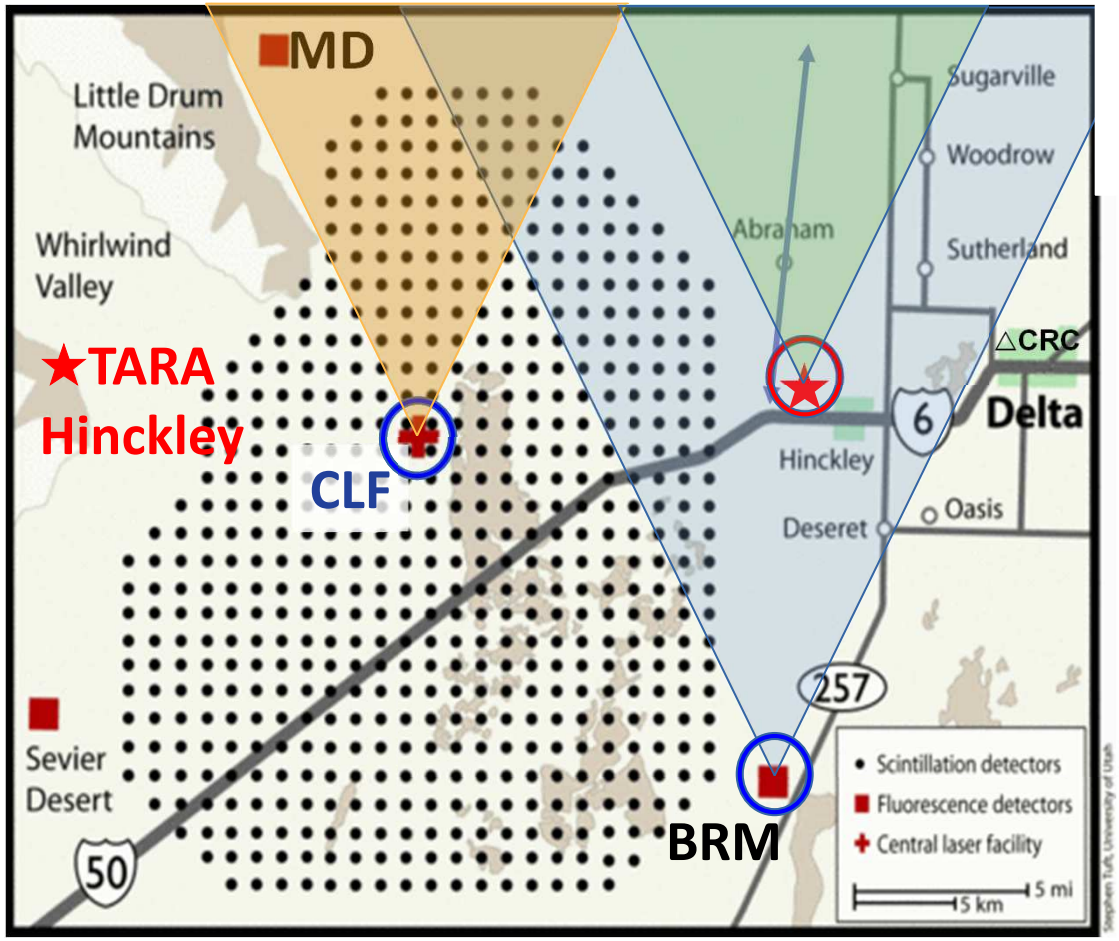
Installation Site of DIMS Cameras



A few more camera stations may be added in near future!

Configuration of Camera Stations (1)

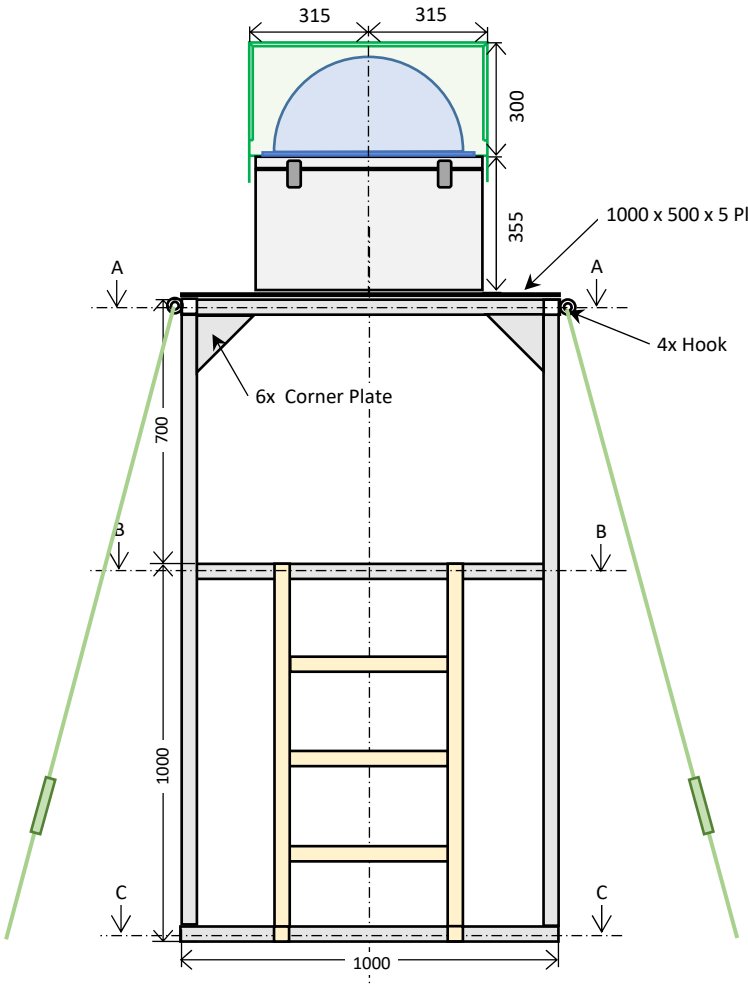
3 Stations



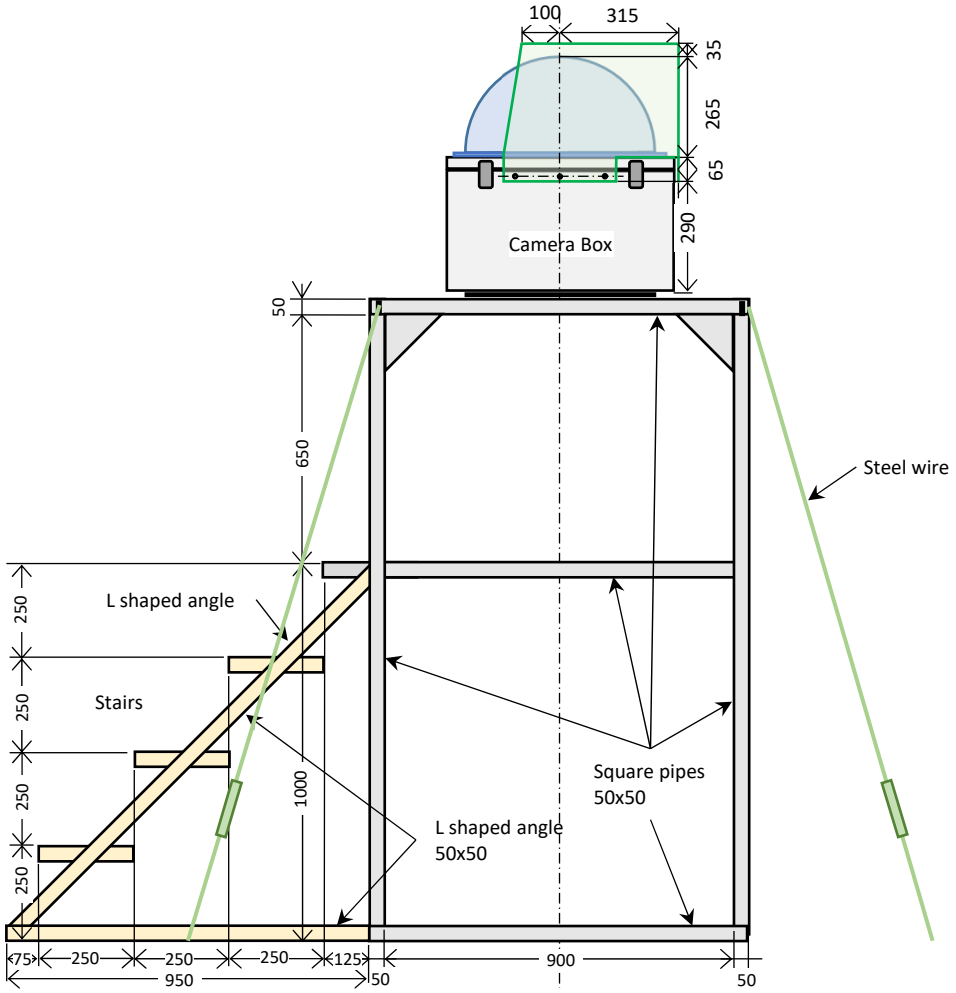
We need to optimize positions and directions of the cameras to observe both of meteors and macro DMs.

4 camera stations are designed to observe north direction
- to avoid Sun shine
- to avoid trigger problem

for seeing too numerous stars



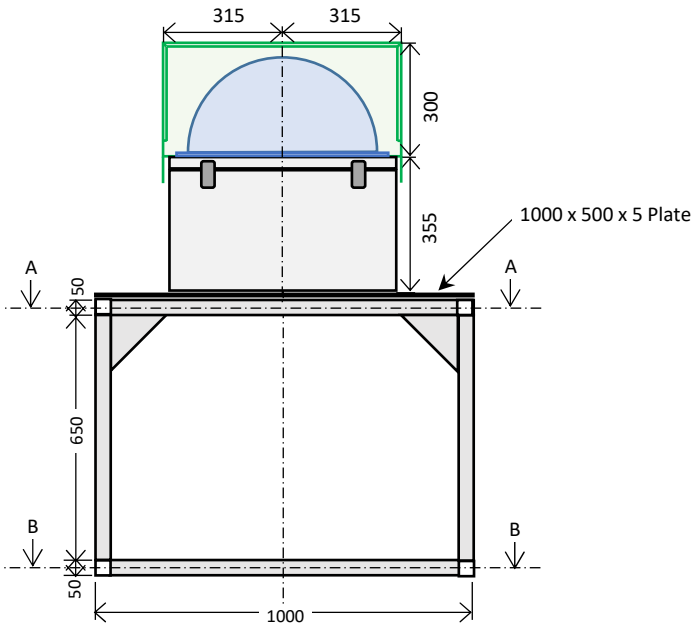
Front view



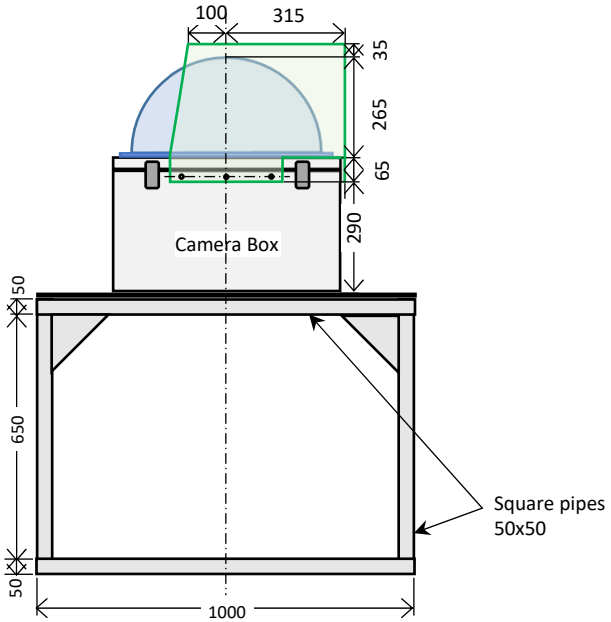
Side view

Tall size pedestals will be set at TARA and CLF.

DIMS Observation Station Type 2 Pedestal and Camera Box Part 1
Date : Sept. 11, 2020
Drawn by : F. Kajino, Konan Univ.
Unit : mm



Front view



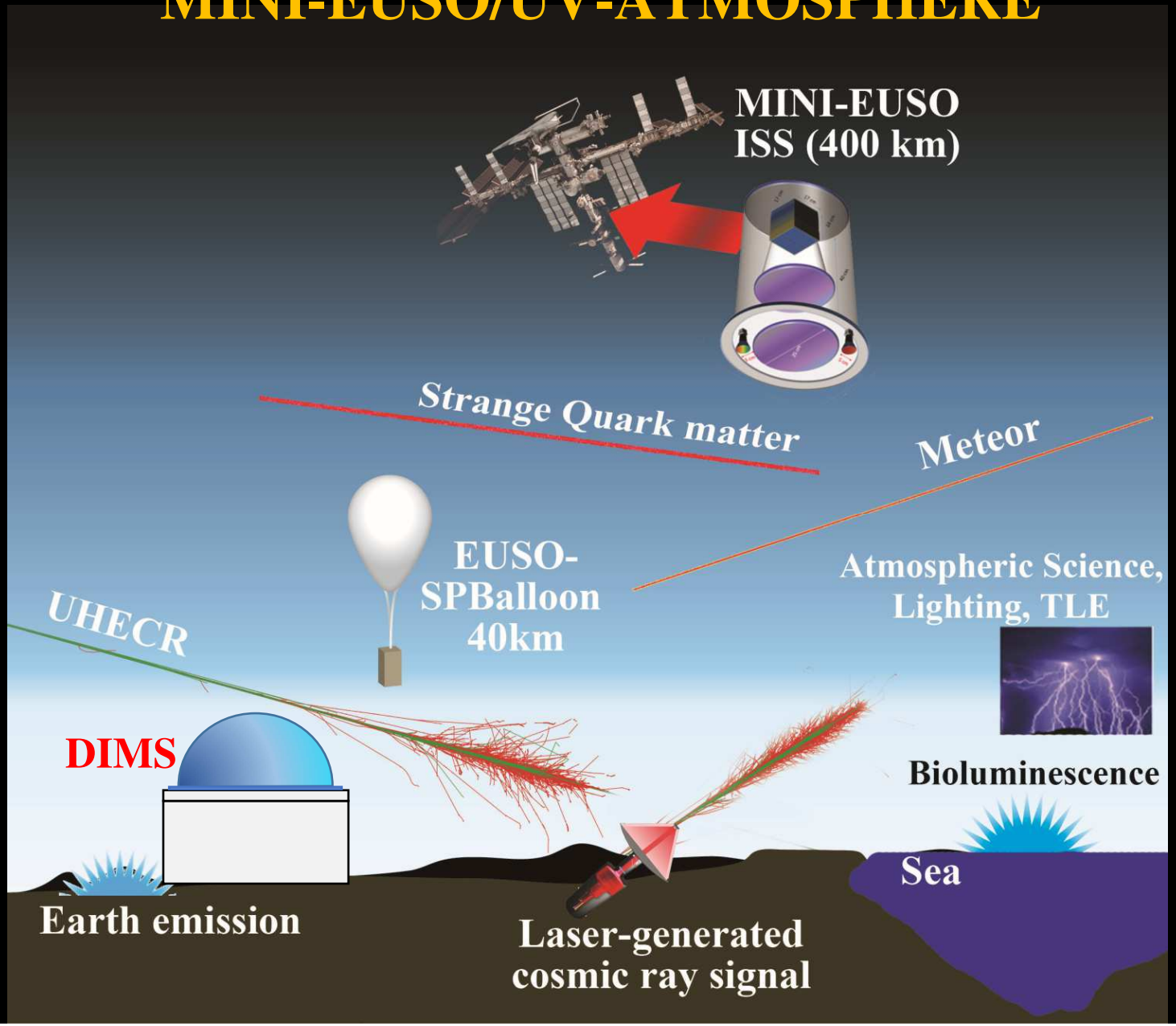
Side view

Small size pedestal will be set at BRM.

DIMS Observation Station Type 3 Pedestal and Camera Box Part 1
Date : Sept. 11, 2020
Drawn by : F. Kajino, Konan Univ.
Unit : mm

Co-Observation with JEM-EUSO program

MINI-EUSO/UV-ATMOSPHERE



Schedule

2020

Jan. Shipped 1 camera box to Utah

Nov. Ordered of 4 camera pedestals

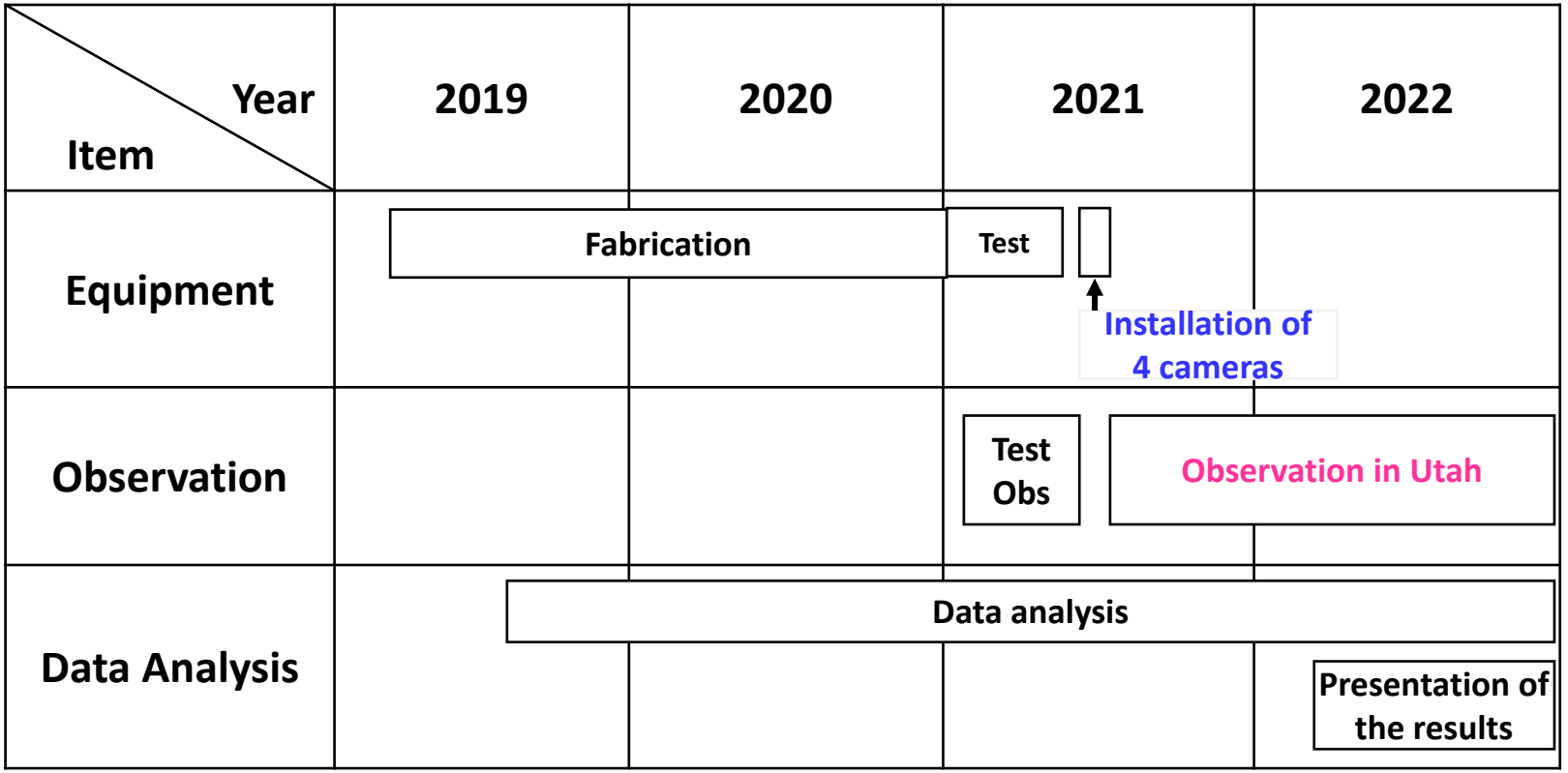
2021

Jan. Installation of 4 camera pedestals

2 tall pedestals at TARA, 1 tall pedestal at CLF, 1 short pedestal at BRM

July? Shipping 3 camera boxes to Utah (delay caused by COVID-19)

Aug. ? Installation of a cameras at TA site, Utah



Summary

- We are developing DIMS project to search for Nuclearites/SQMs and interstellar meteoroids.
- 4 camera stations will be Installed next summer.
- A few more stations may be added in near future.
- DIMS can co-observe with JEM-EUSO program such as EUSO-TA, mini EUSO, K-EUSO …
- We need many collaborators to operate in long term and to analyze huge data.
- DIMS observation at Utah is coming soon!