

高感度CMOSカメラシステムによる 高速飛翔暗黒物質と流星の探索

DIMS Project for Dark Matter and Interstellar Meteoroid Study

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DIMS Collaboration



令和元年度東京大学宇宙線研究所 共同利用研究成果発表会
東京大学柏キャンパス、2019年12月15日(土)

研究目的

- 暗黒物質の候補の一つであるNucleariteの探索
- 流星、特に太陽系外起源の流星の観測
- その他の大気発光現象
- EUSO-TAやMini-EUSOなどとの共同観測

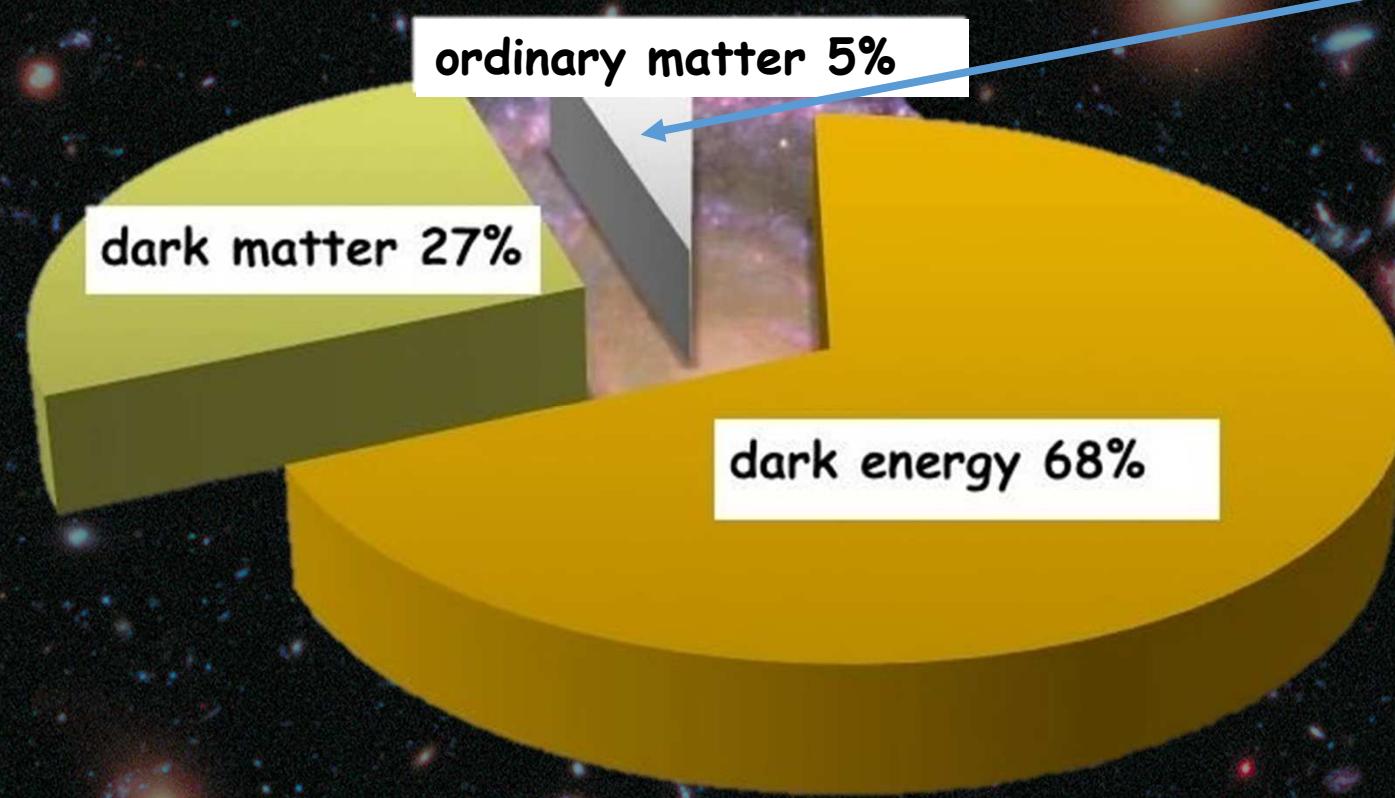


共同利用
Inter-university research

査定額と使途

- 査定額 研究費:2万円、旅費:30万円、合計:32万円
- 使途 ユタへの出張旅費
および現地での実験用物品購入費

What The Universe Is Made Of



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

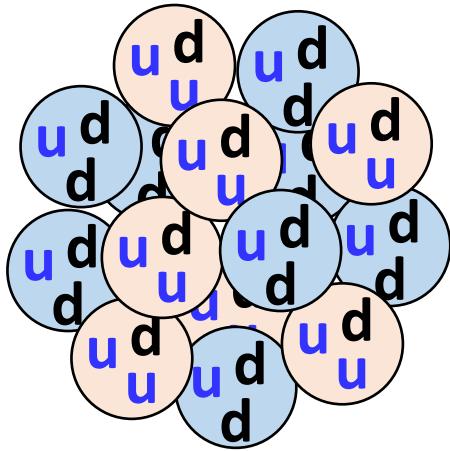
Mirror Dark Matter ...

K. Arun et al. arXiv 1704.06155

**Dark matter doesn't have to interact weakly
if it's very massive. → Macro Dark Matter**

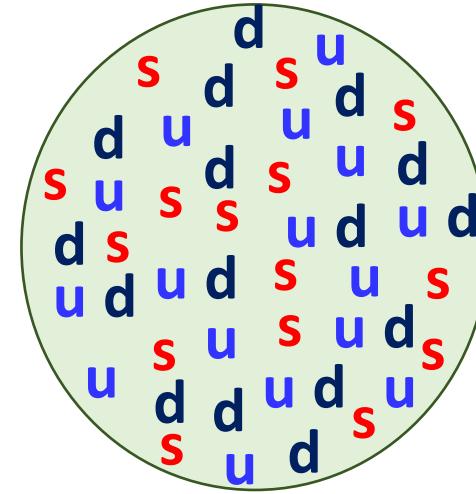
Glenn Starkman, 2015⁴

Strange Quark Matter & Nuclearite



通常の原子核

Quark 3個の組み合わせからなる核子の集合体



Strange Quark Matter (SQM)
および Strangelet

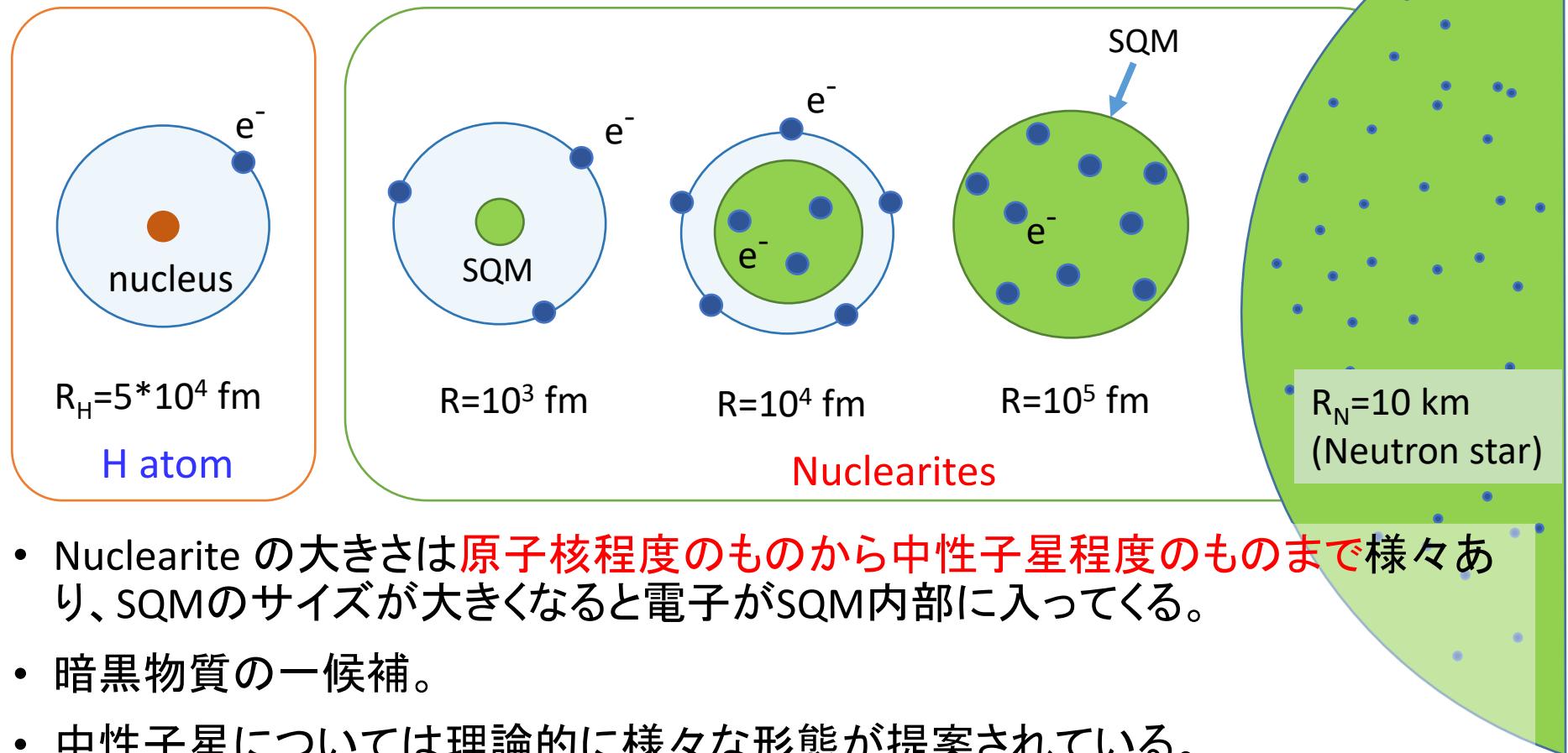
u, d, s quark がほぼ同数からなる
quark の集合体

E. Witten 1984

Nuclearite は SQM の周りが電子で覆われた電気的に中性な塊である。

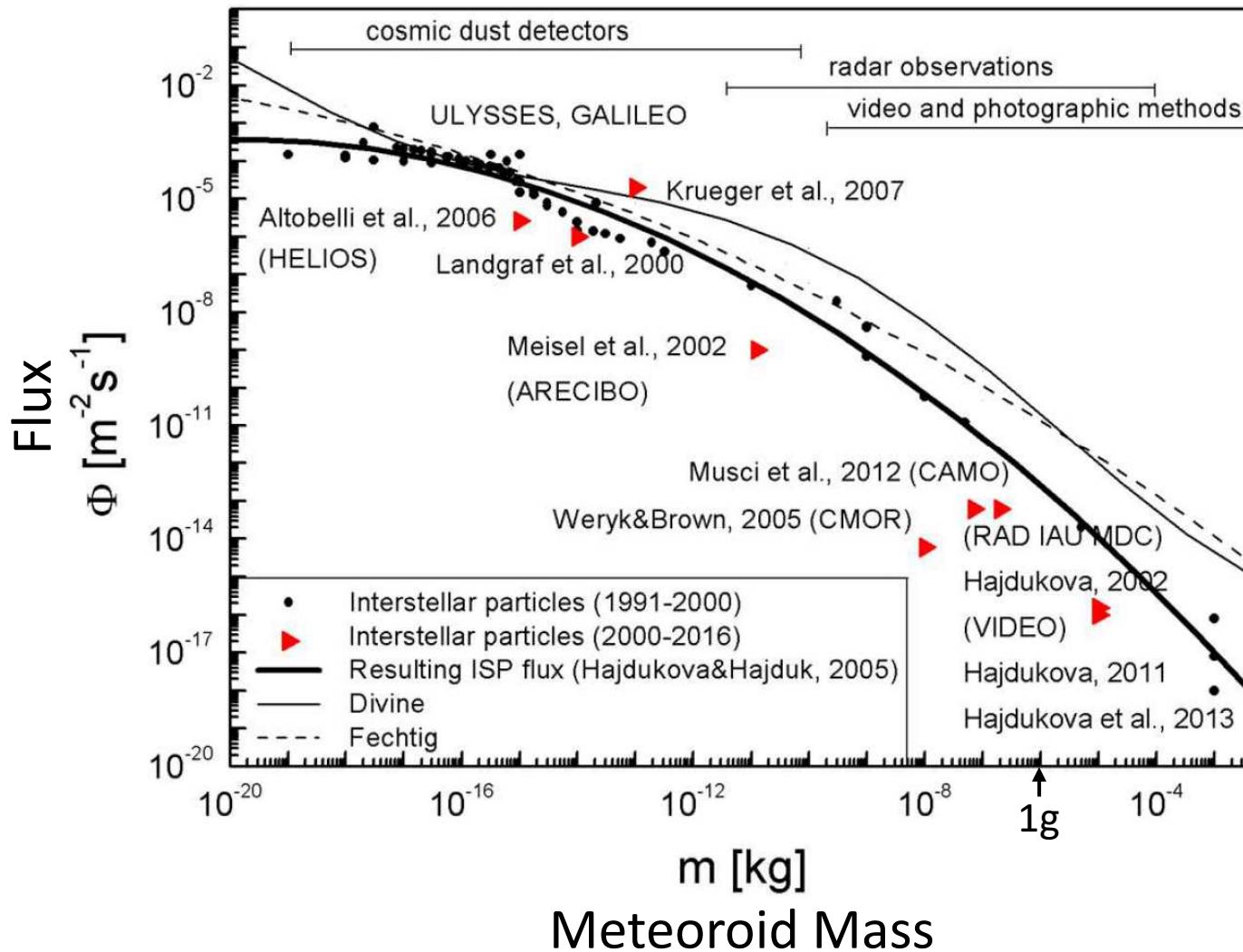
A. De Rujula & S. L. Glashow, 1984

Nuclearite

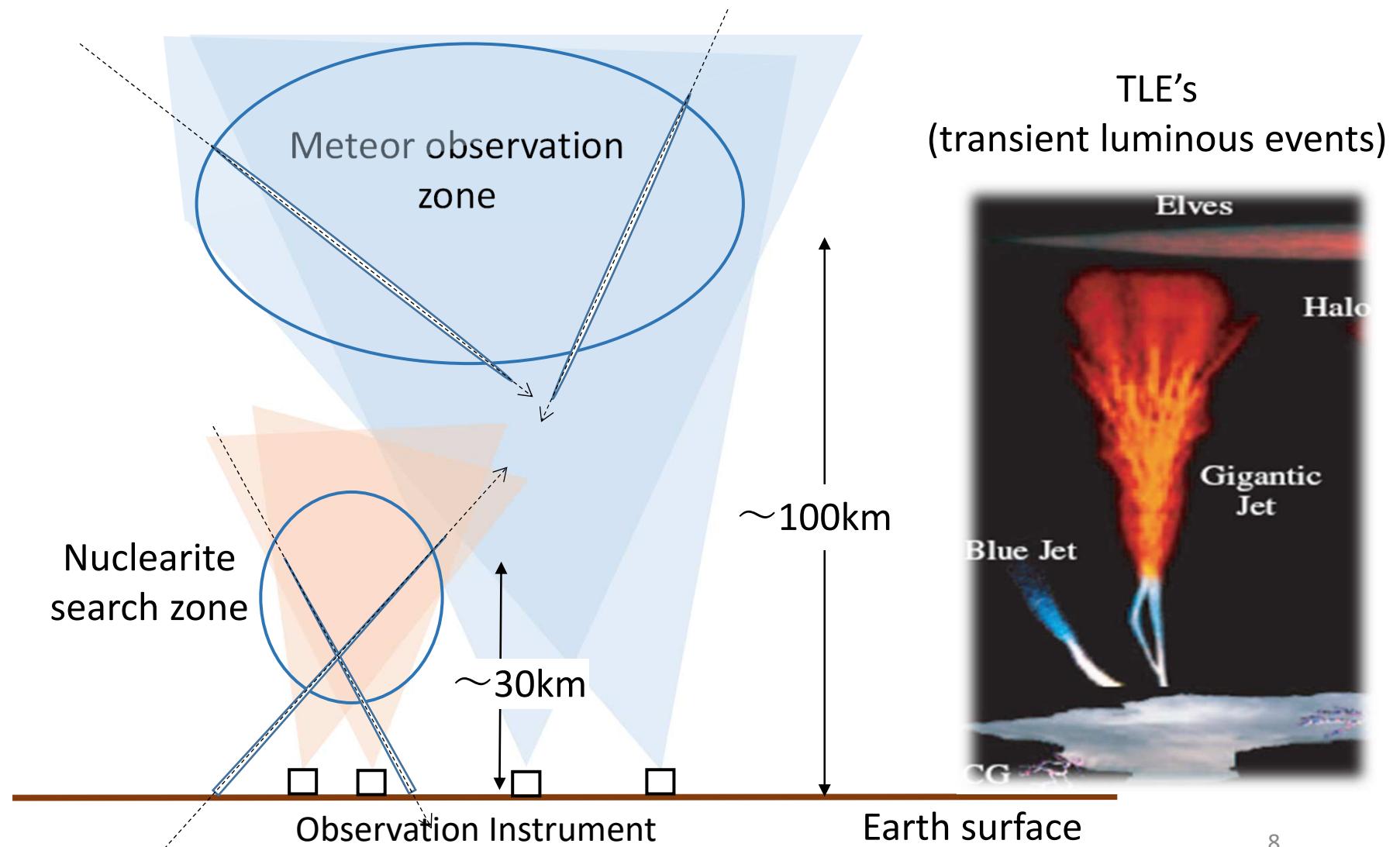


- Nuclearite の大きさは原子核程度のものから中性子星程度のものまで様々あり、SQMのサイズが大きくなると電子がSQM内部に入ってくる。
- 暗黒物質の一候補。
- 中性子星については理論的に様々な形態が提案されている。
- いくつかの中性子星はquark星の可能性があると指摘されている。
- Nuclearite は宇宙初期や中性子星同士の衝突でできる可能性がある。
- これまでに、加速器による生成実験や、自然界にSQMやNuclearite が存在しているかどうかの実験が行われてきた。地震計による探索など。

Interstellar Meteoroids from Outside the Solar System



DIMS Observation Concept



Test of Observation System

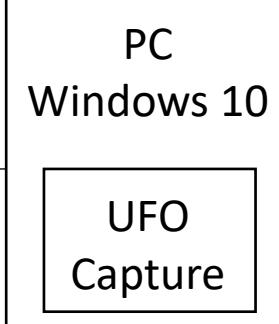


Canon ME20F-SH
Monochrome type

HDMI Cable

Video
Capture

USB Cable

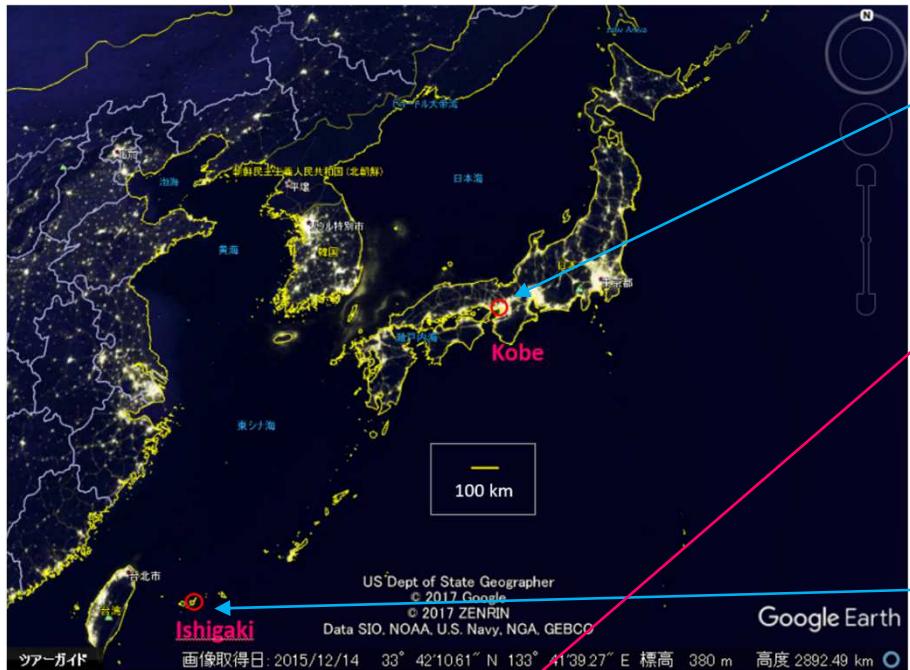


UFO Capture:
motion capture
software



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

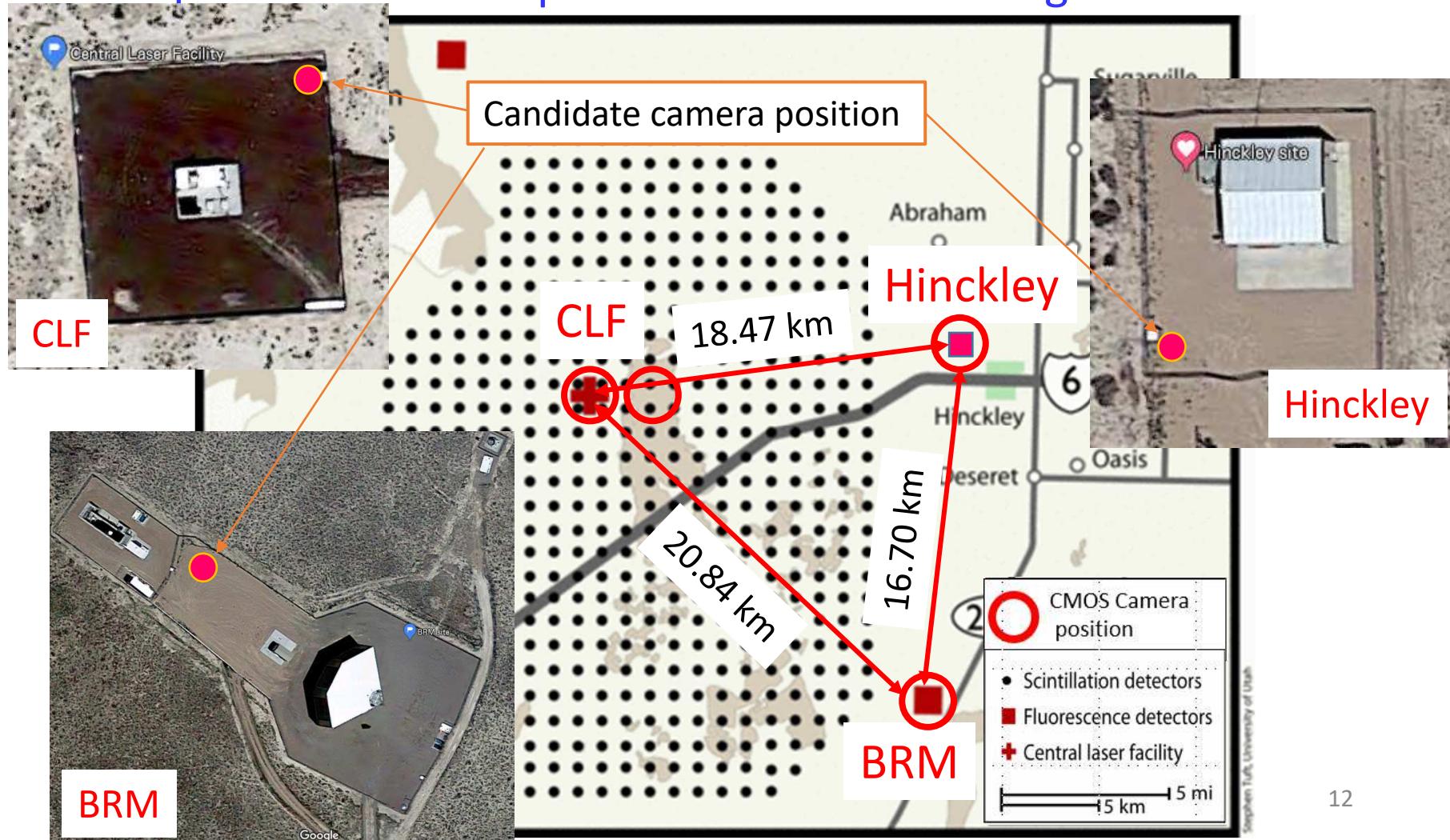
- Aug. 28th –Sept. 1st, 2019
- Telescope Array site, Utah

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

Observation and Site Investigation at TA site

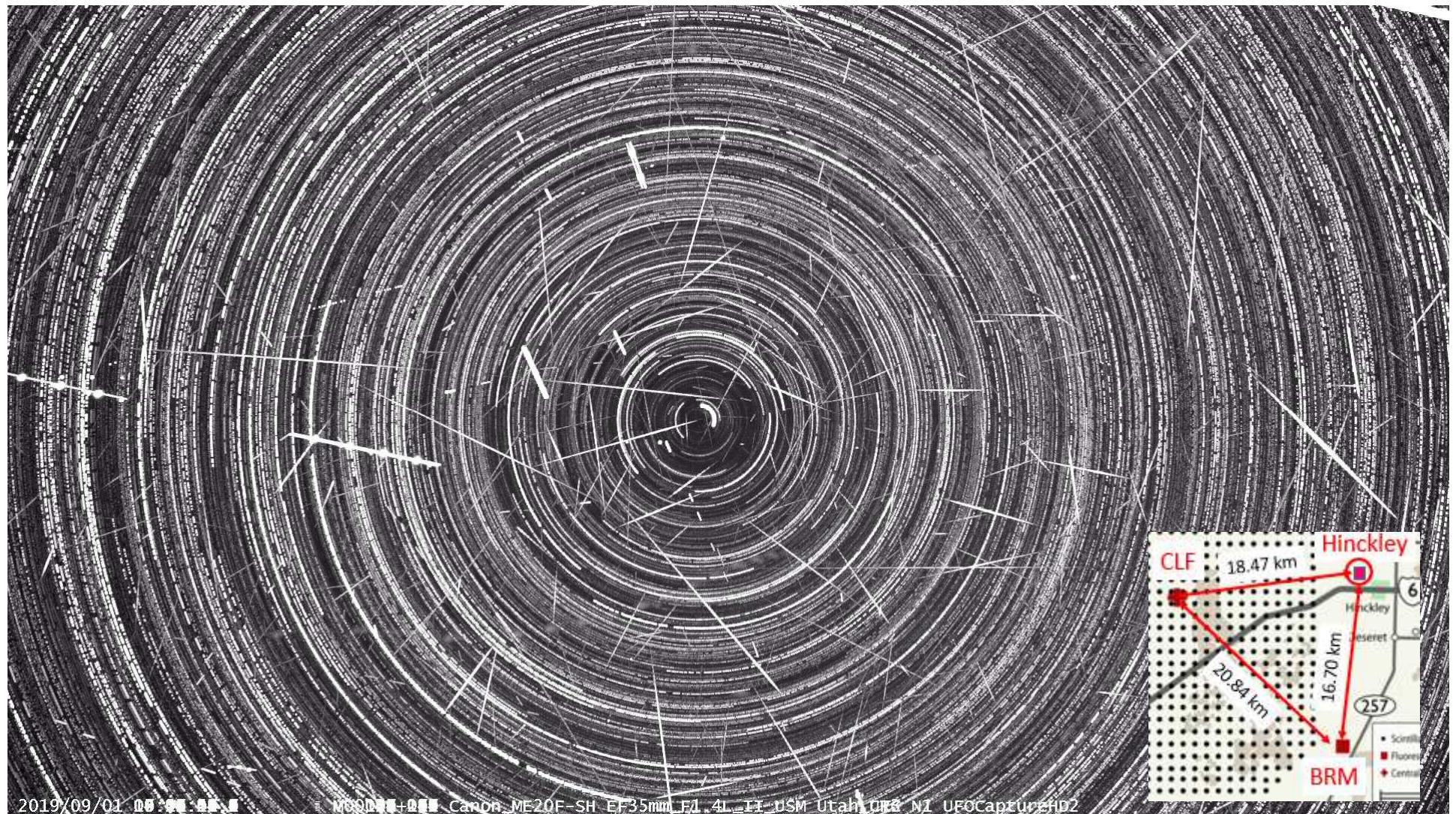
We observed meteors at 3 sites of TA using 2 high sensitivity CMOS cameras from Aug. 28 to Sept. 1 for 4 nights in 2019. Future potential camera positions are also investigated.



Composite photo taken at Hinckley, Utah

N1 camera, detect size = 2&3, incl. cont. rec., IR = on

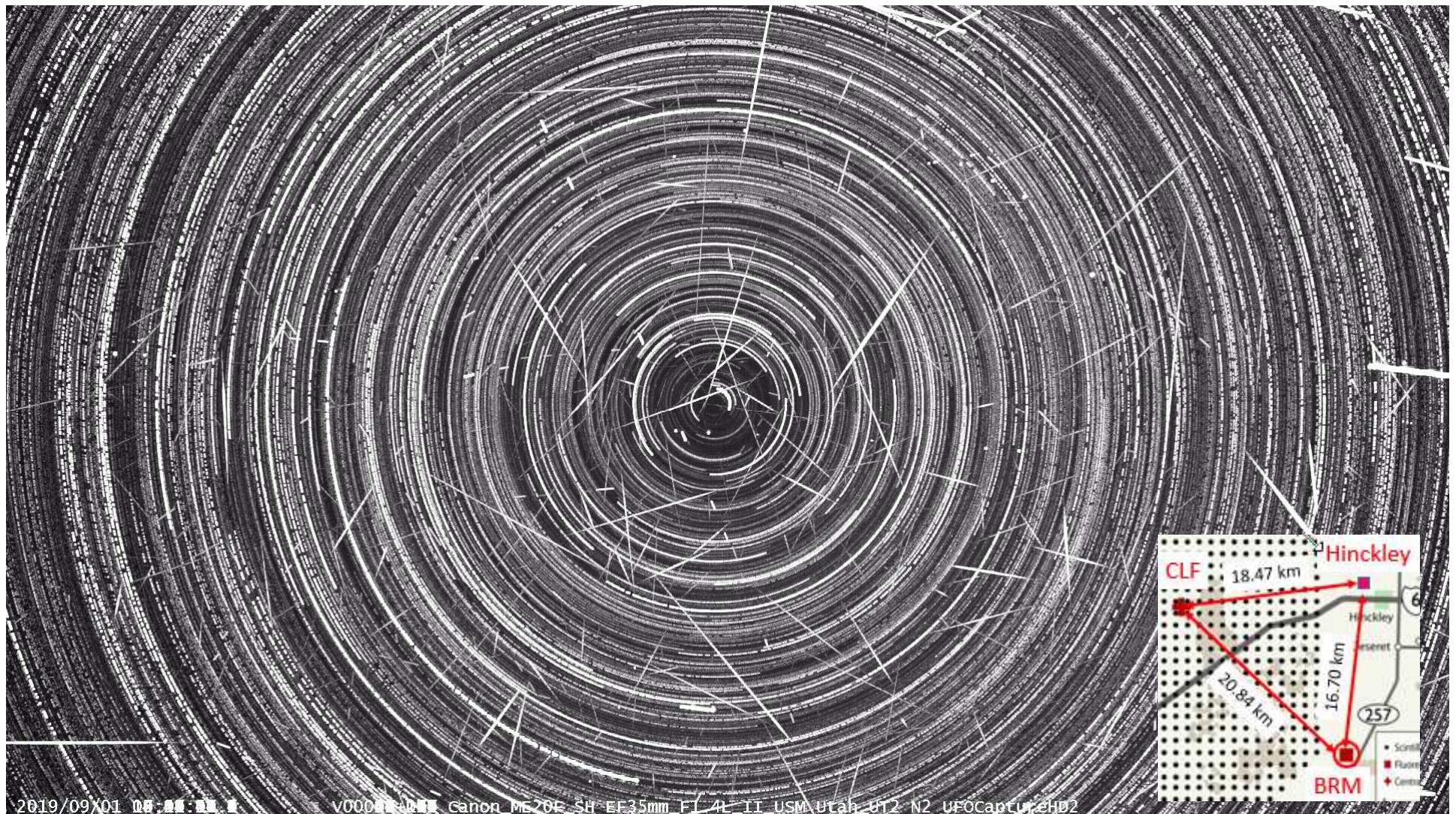
4th night: 8/31 22:29 - 9/1 5:00 MDT, 2019 (6h 31min)



Composite photo taken at BRM, Utah

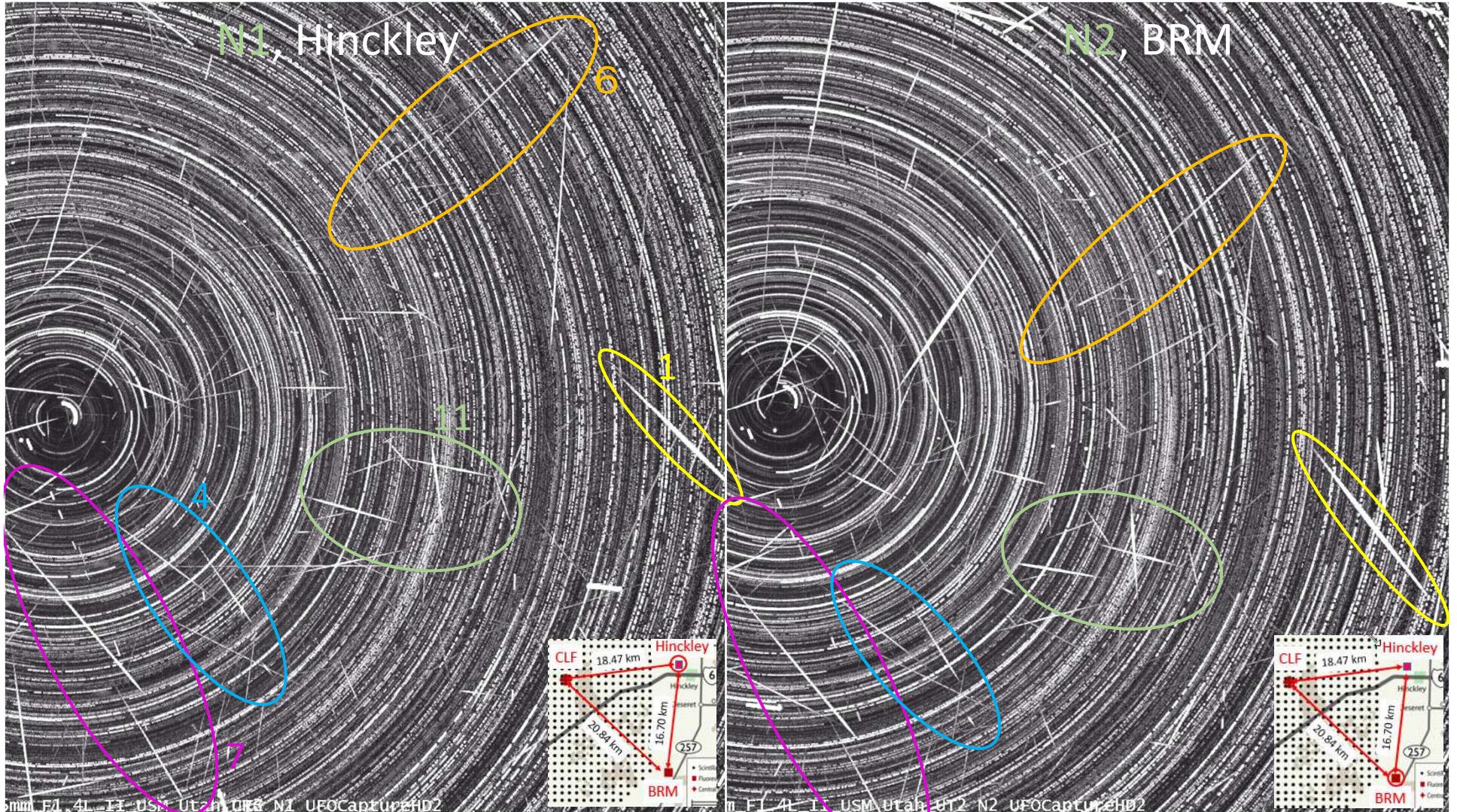
N2 camera, detect size = 2, IR = on

4th night: 8/31 22:30 - 9/1 5:00 MDT, 2019 (6h 30min)



Simultaneous Events

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

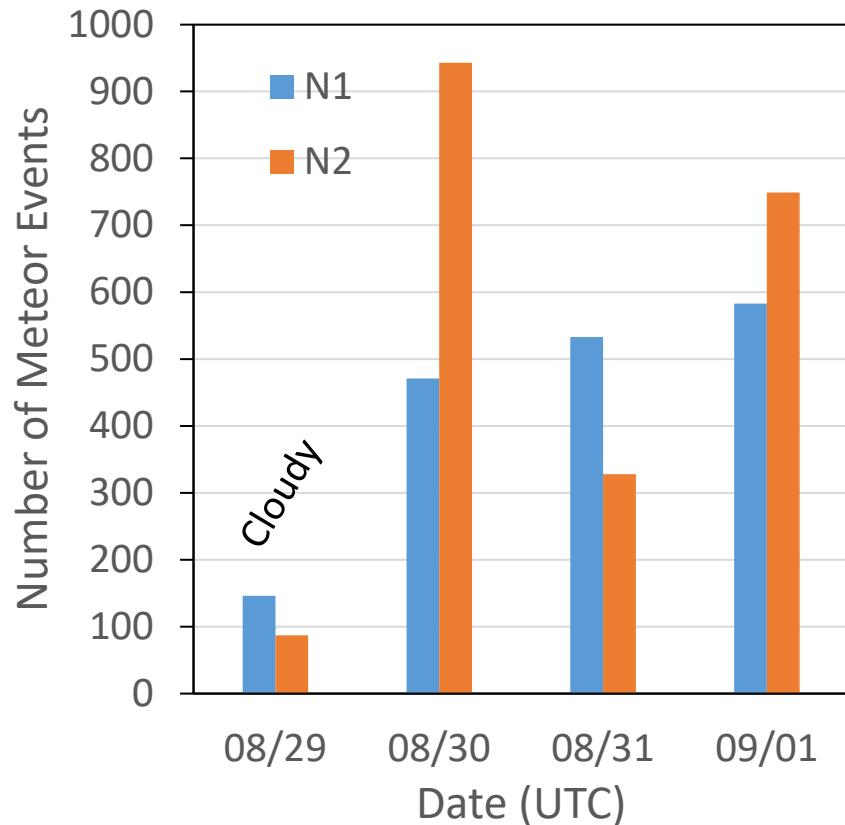


About 75% of events in N1 are observed simultaneously in N2.

Number of the simultaneous events are estimated to be roughly 400 in this night.¹⁵

Observed Number of Meteors

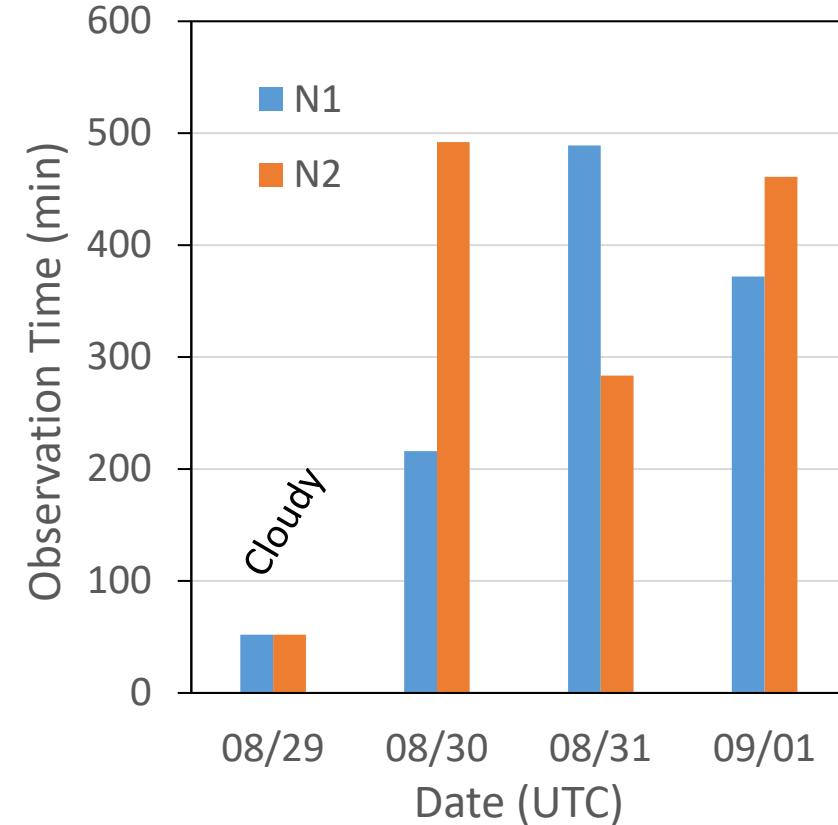
Aug. 29th – Sep. 1 UTC, 2019 (4 nights)



N1: 1733 events

N2: 2107 events

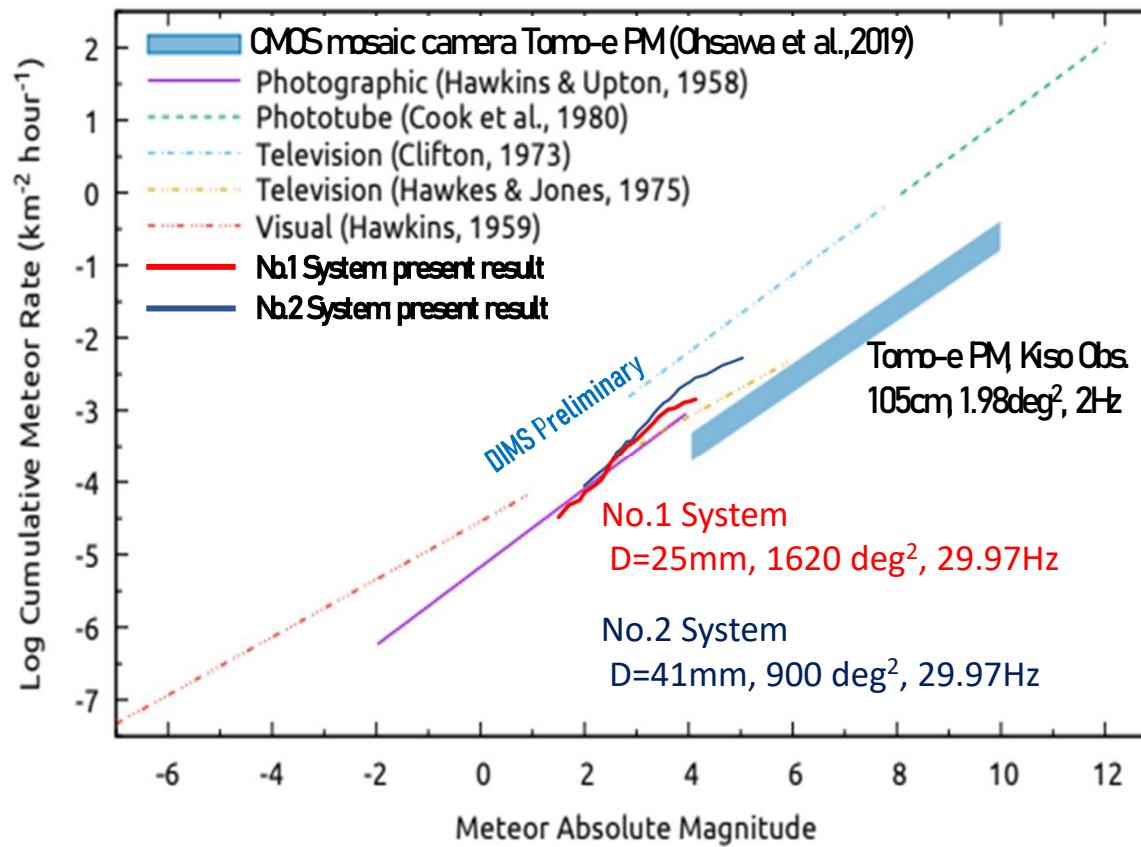
N1+N2: **3840** events



N1: 1129 min = 18.8 h

N2: 1288 min = 21.5 h

Flux vs. Magnitude of Meteors

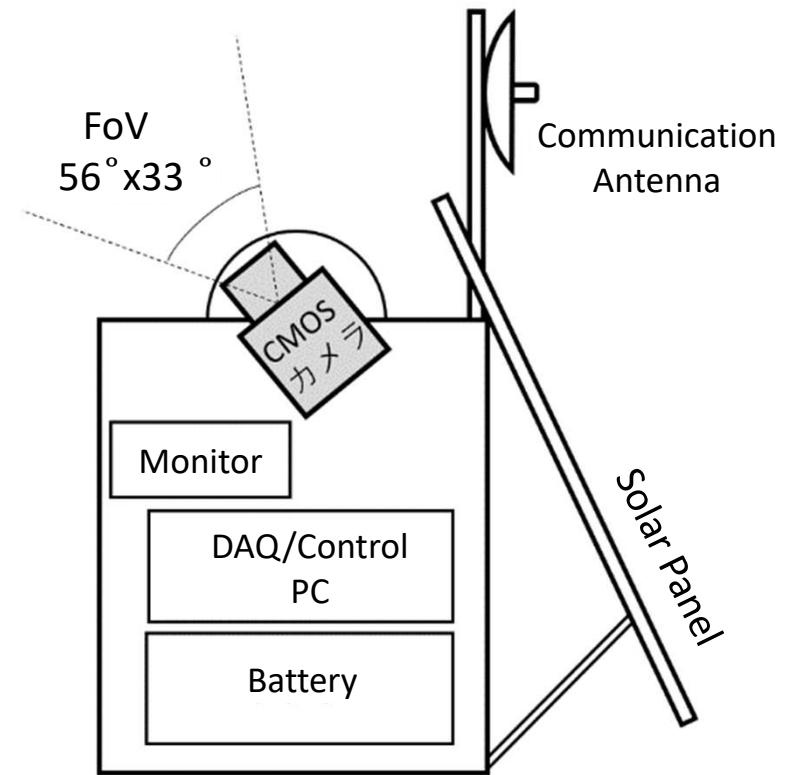


Our preliminary results from No.1 System and No.2 System are consistent with other observational results.

Camera Station

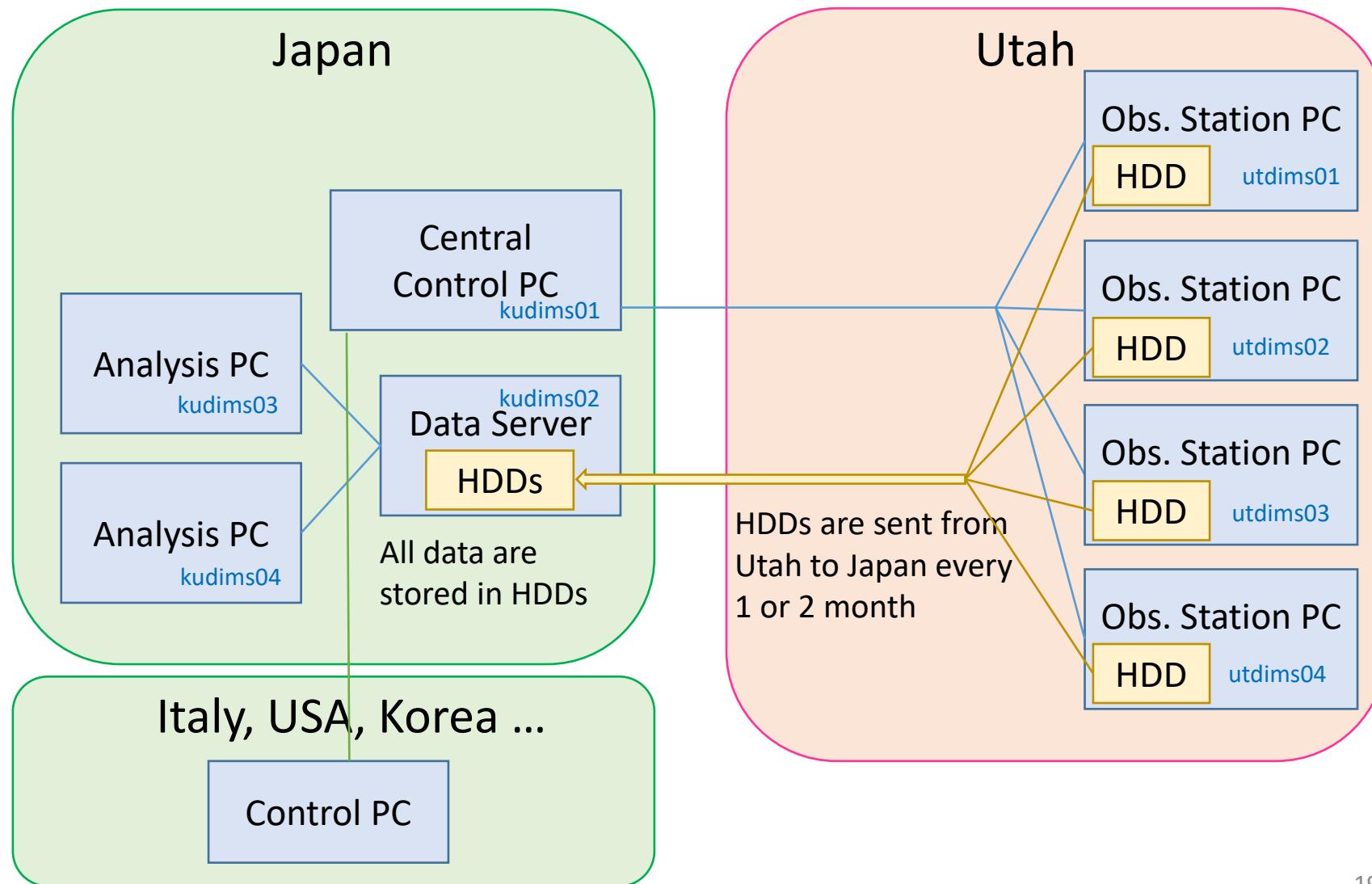


Camera is mounted on a altazimuth mount and is controlled remotely.



Conceptual design of
the camera station

DIMS Observation System



まとめ

高感度CMOSカメラで多くの流星を動画で観測できるシステムを試験してきた。

星は8-9等まで、流星は5-6等程度まで動画で観測できることが分かった。

Macro Dark Matter や太陽系外流星の探索のための
DIMS (Dark Matter and Interstellar Meteoroid Study)
Project を開始した。

12月7日(土)に、**1st DIMS Workshop** を理研で開催した。

国際協力体制(日・米・伊・韓)を整備中。