

(木曾シュミットシンポジウム2018)

MUレーダーとTomo-e Gozen および超高感 度カメラを用いた微光流星の同時観測

Simultaneous faint meteor observation using MU Radar , Tomo-e Gozen
and high-sensitive cameras

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• Background

メテオロイド (Meteoroid): 直径 $30\mu\text{m}$ ~ 1m

ダスト (Interplanetary Dust): 直径 $30\mu\text{m}$ 以下



METEOROID

Meteoroid is a solid natural object of a size roughly between 30 micrometers and 1 meter moving in, or coming from, interplanetary space.

DUST (INTERPLANETARY)

Dust (interplanetary) is finely divided solid matter, with particle sizes in general smaller than meteoroids, moving in, or coming from, interplanetary space.

METEOR

Meteor is the light and associated physical phenomena, which result from the high speed entry of a solid object from space into a gaseous atmosphere.

METEORITE

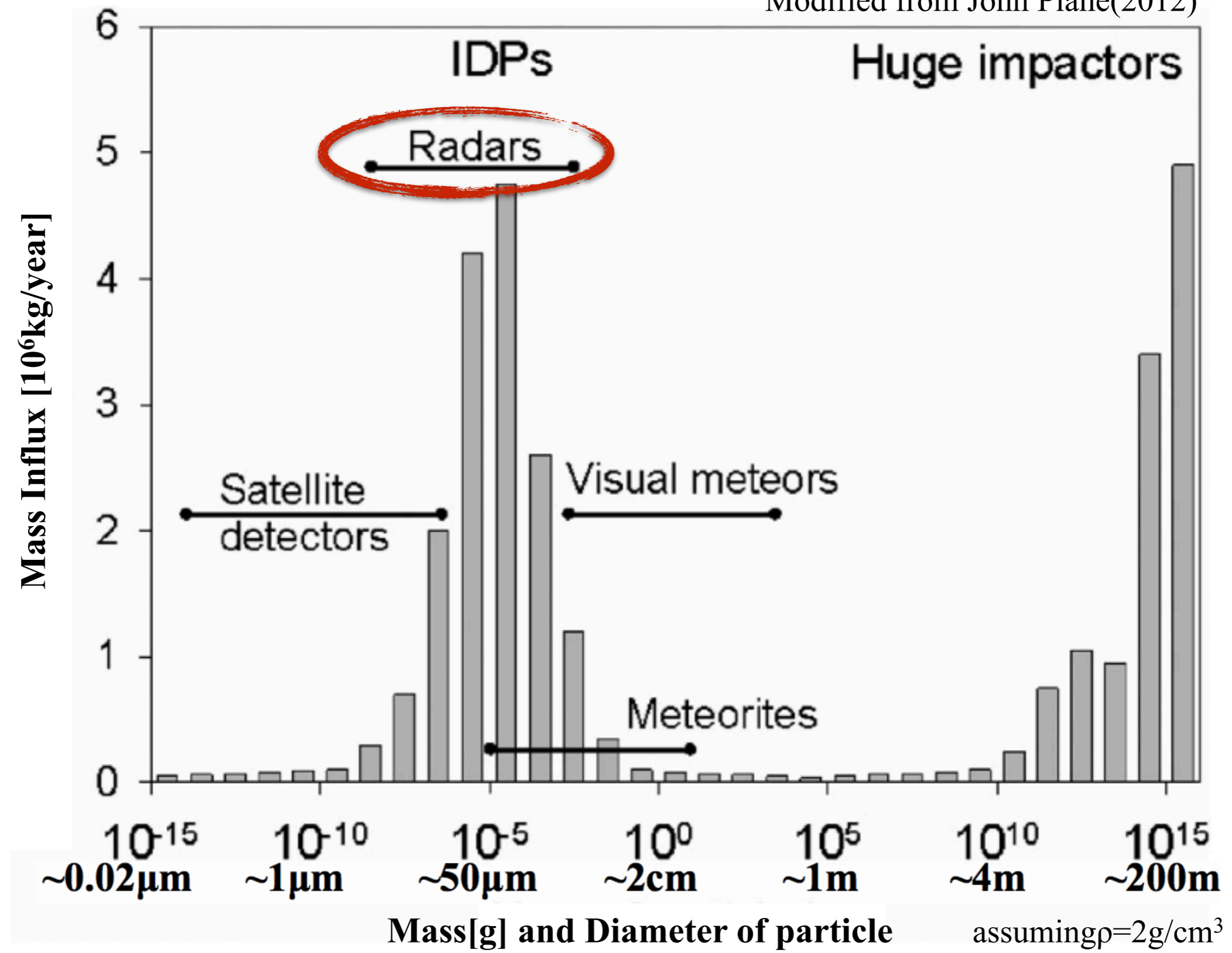
Meteorite is any natural solid object that survived the meteor phase in a gaseous atmosphere without being completely vaporized.



• Background

Meteoroids influx on Earth

Modified from John Plane(2012)



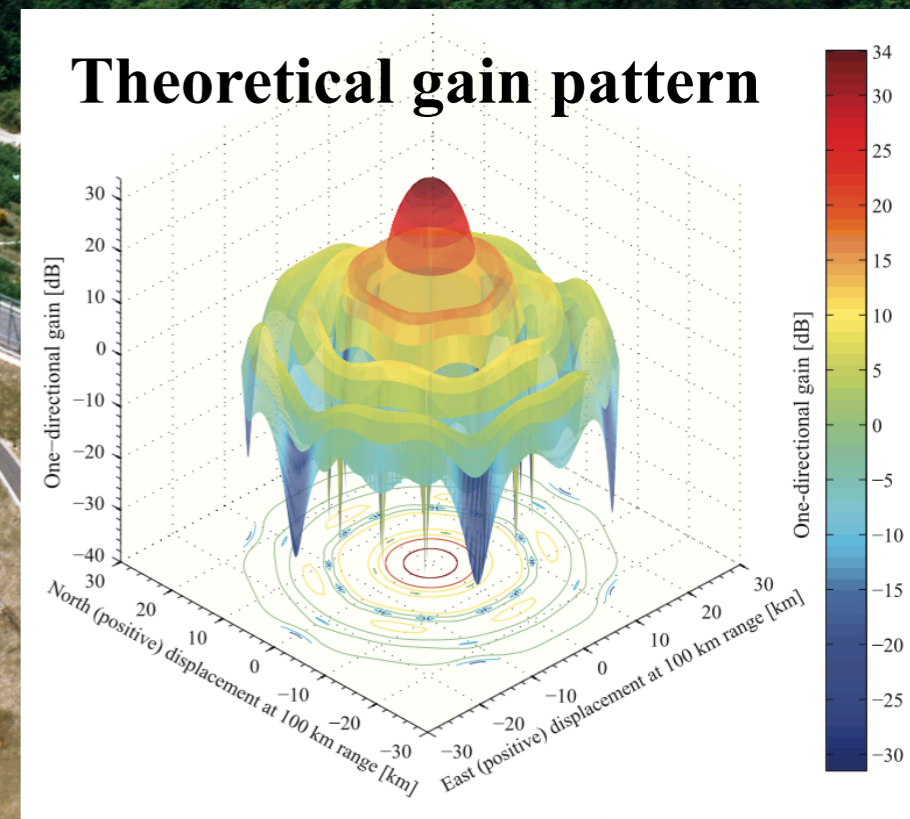
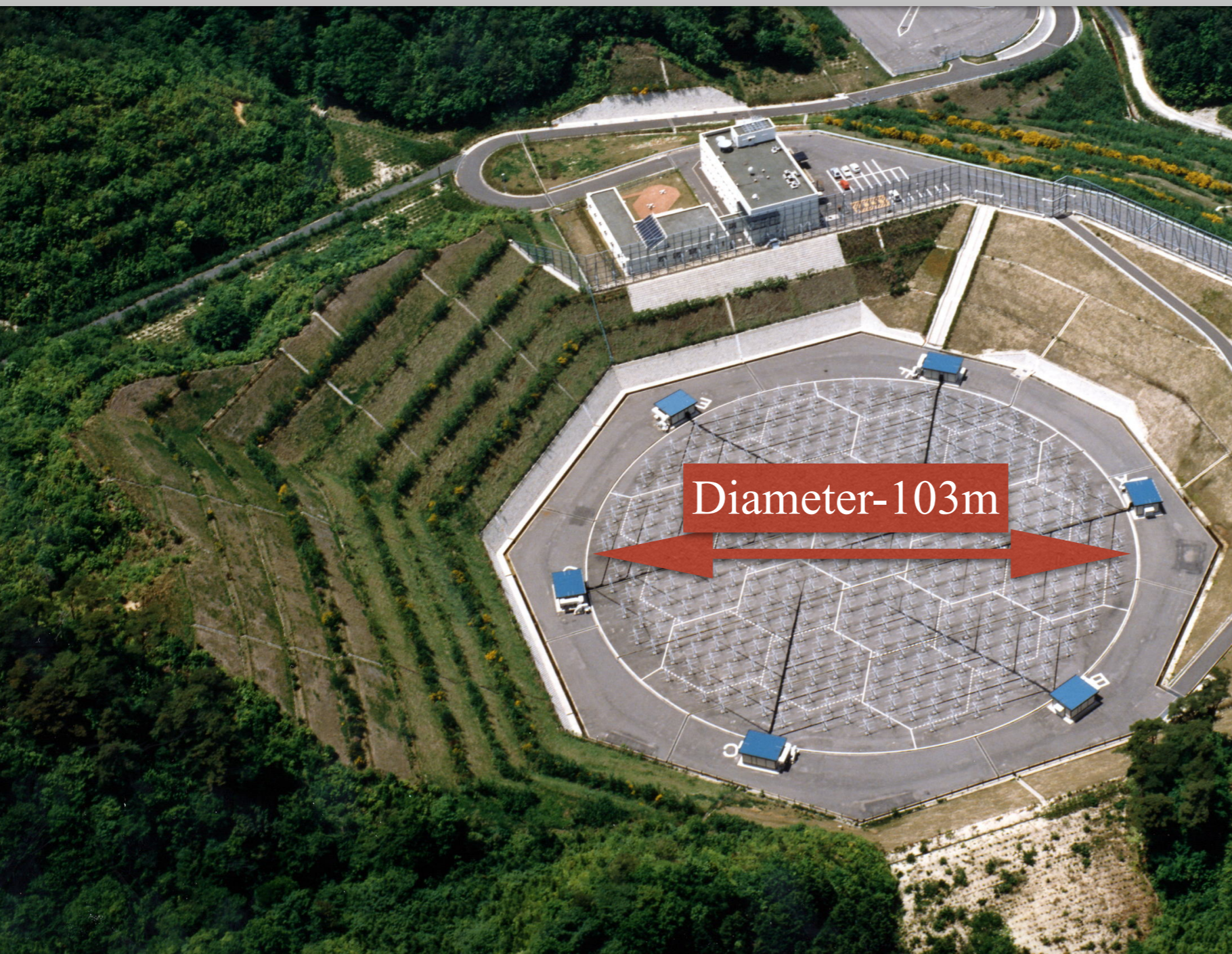
"Cosmic dust in the earth's atmosphere", John M.C.Plane (2012)

• Kyoto University RISH-MU radar ; Middle and Upper Atmosphere Radar

Monostatic coherent pulse Doppler radar

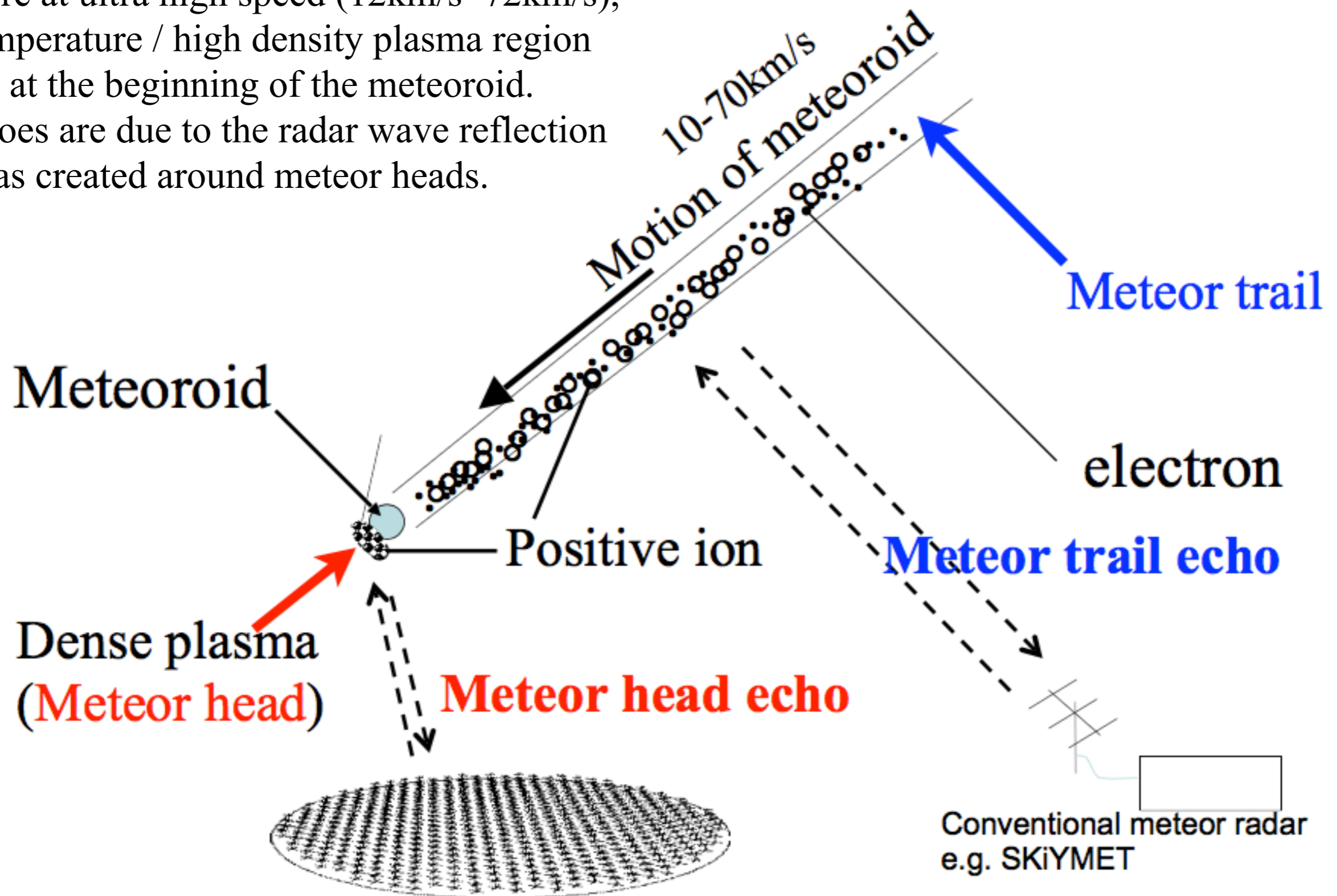
475 crossed Yagi Antennas, VHF(46.5MHz), Peak power 1MW

180,000 meteoroids were detected during 2009~2016

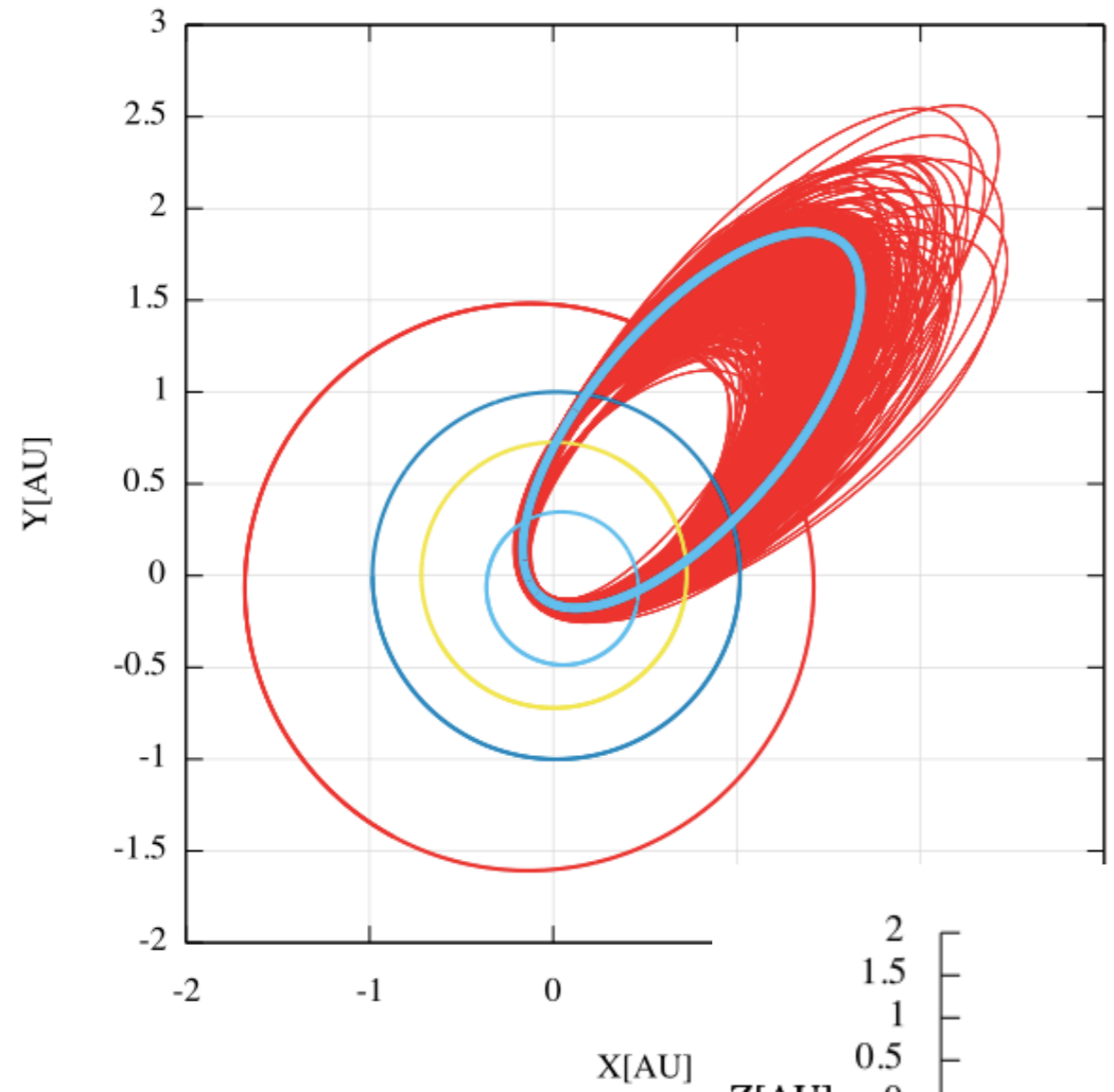


• Head echo observation and Trail echo observation

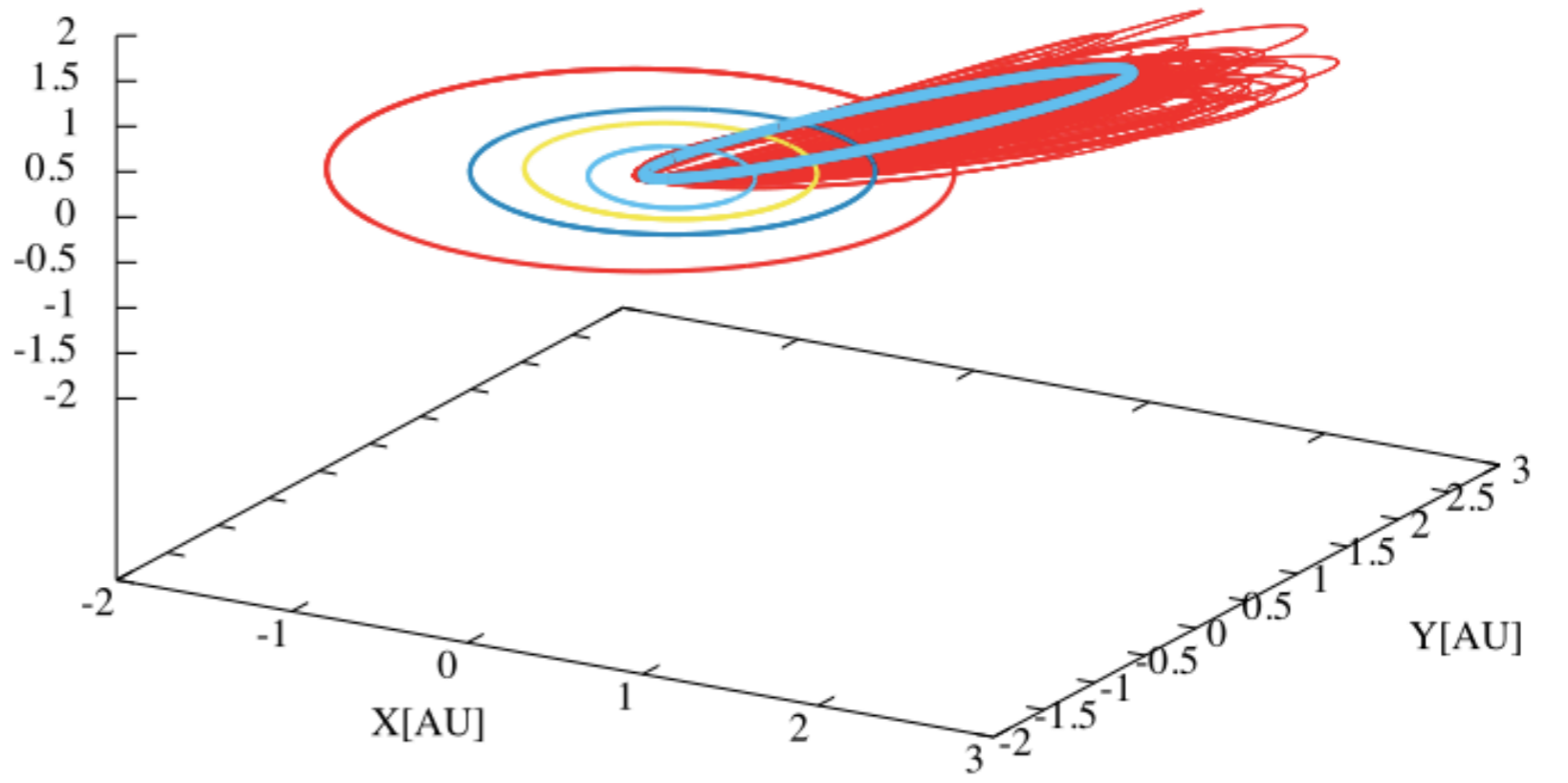
When the meteoroid enters the Earth's atmosphere at ultra high speed (12km/s~72km/s), a high temperature / high density plasma region is formed at the beginning of the meteoroid. Head echoes are due to the radar wave reflection by plasmas created around meteor heads.



• Kyoto University RISH-MU radar ; Middle and Upper Atmosphere Radar

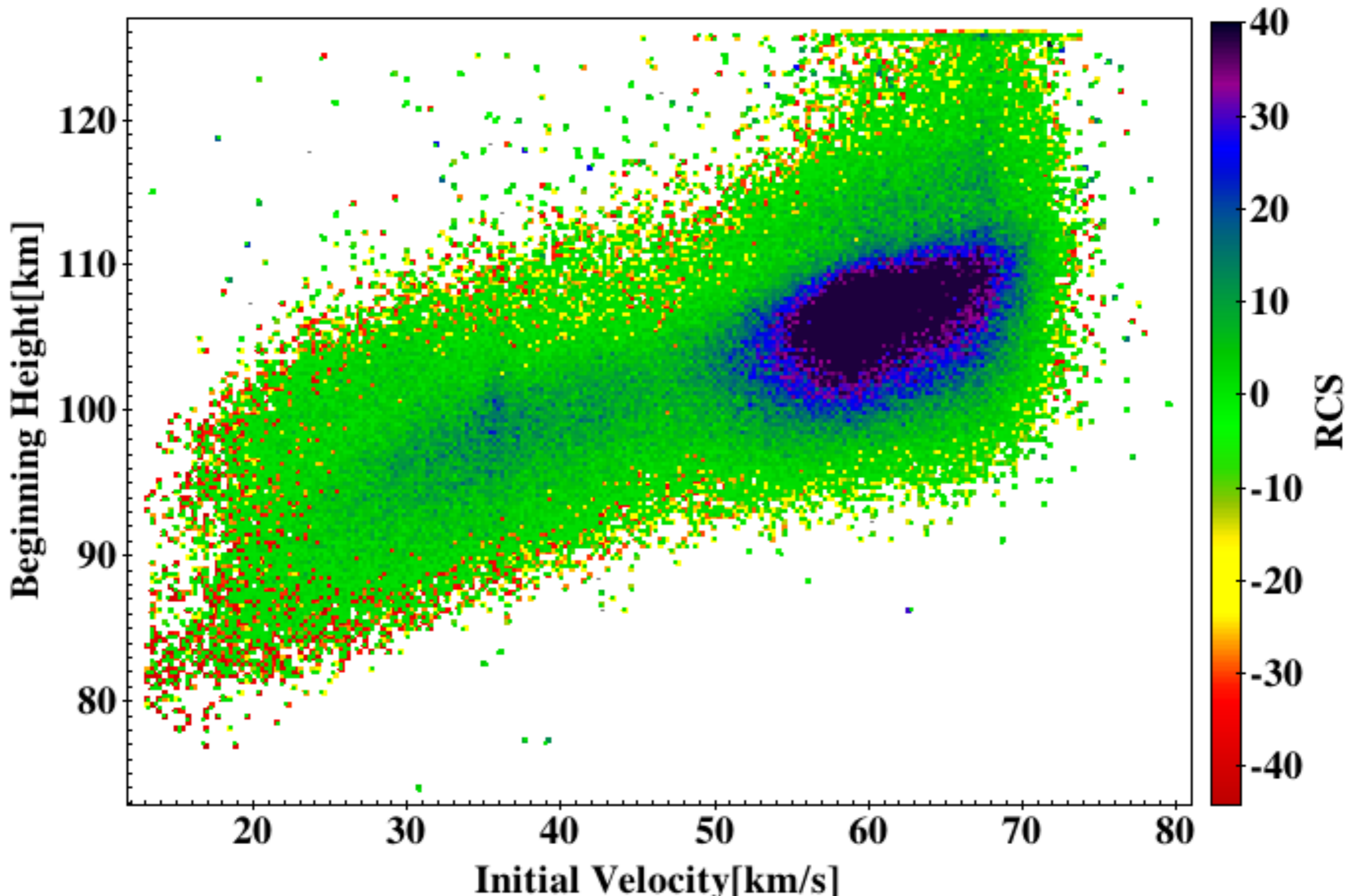


- Mercury — (light blue line)
- Venus — (yellow line)
- Earth — (medium blue line)
- Mars — (red line)
- Geminid — (thick blue line)



- **Radar Cross Section ; RCS**

RCS is involved in the meteoroid's mass, composition, velocity, altitude, etc., it is difficult to convert it to size.



• Simultaneous observation using MU radar and high-sensitive camera

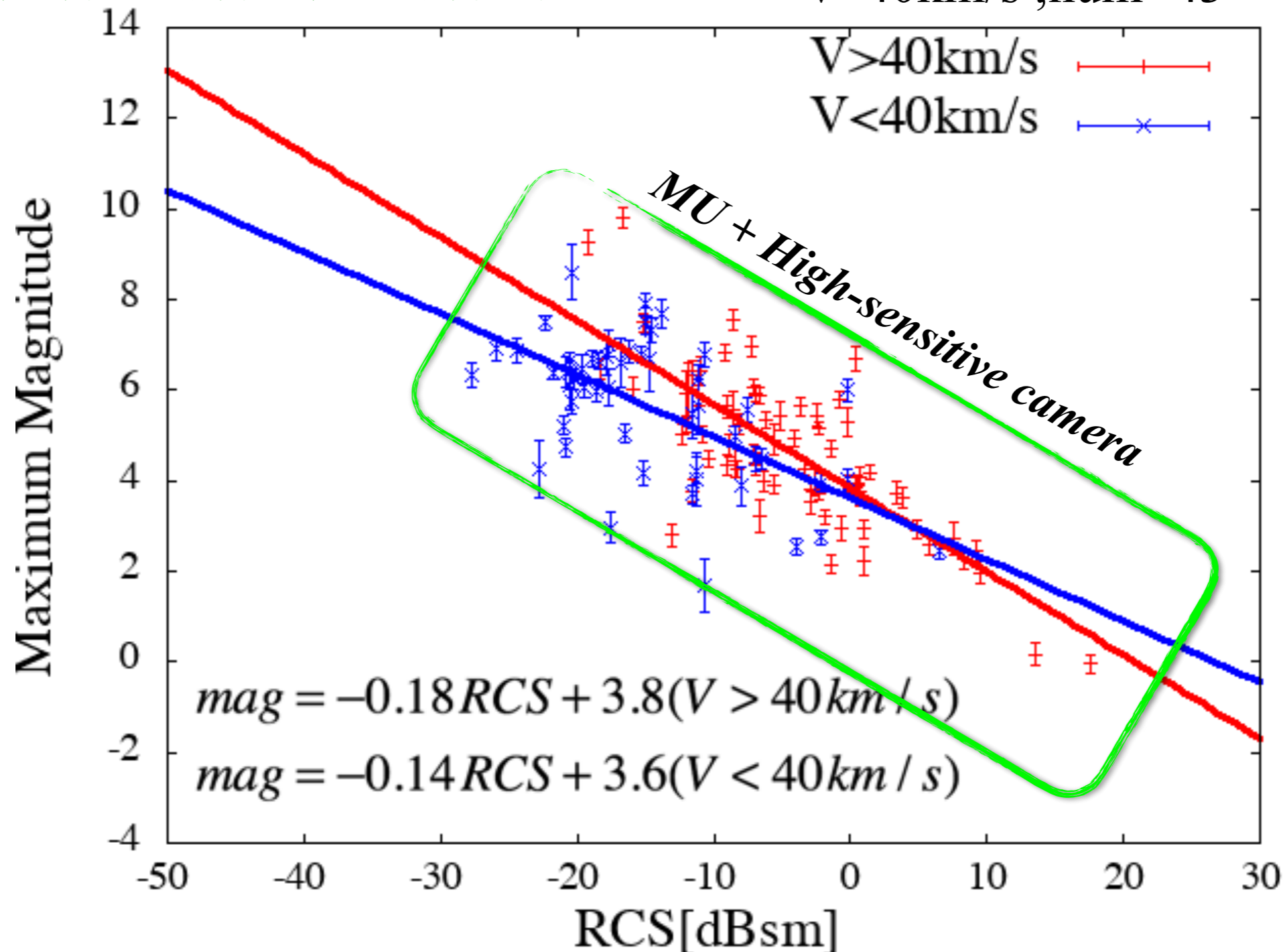
2009 : Sep 24-26, Oct 19-21, Nov 18, Dec 13-14

2010 : Mar 11, Aug 12, Sep 13, Dec 14

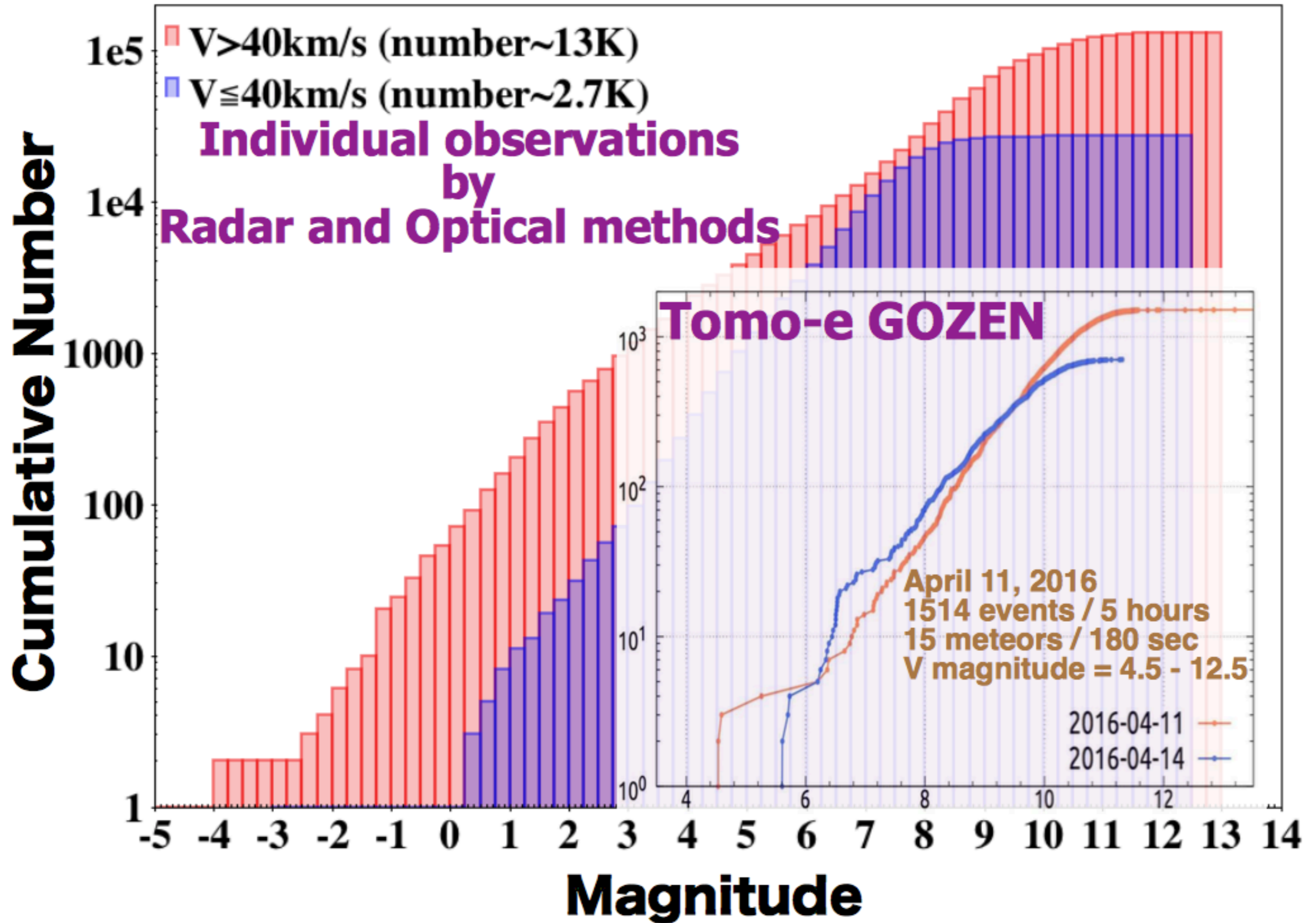
Hmamatu-ICCD+200m/ F1.8

$v > 40 \text{ km/s}$; num=66

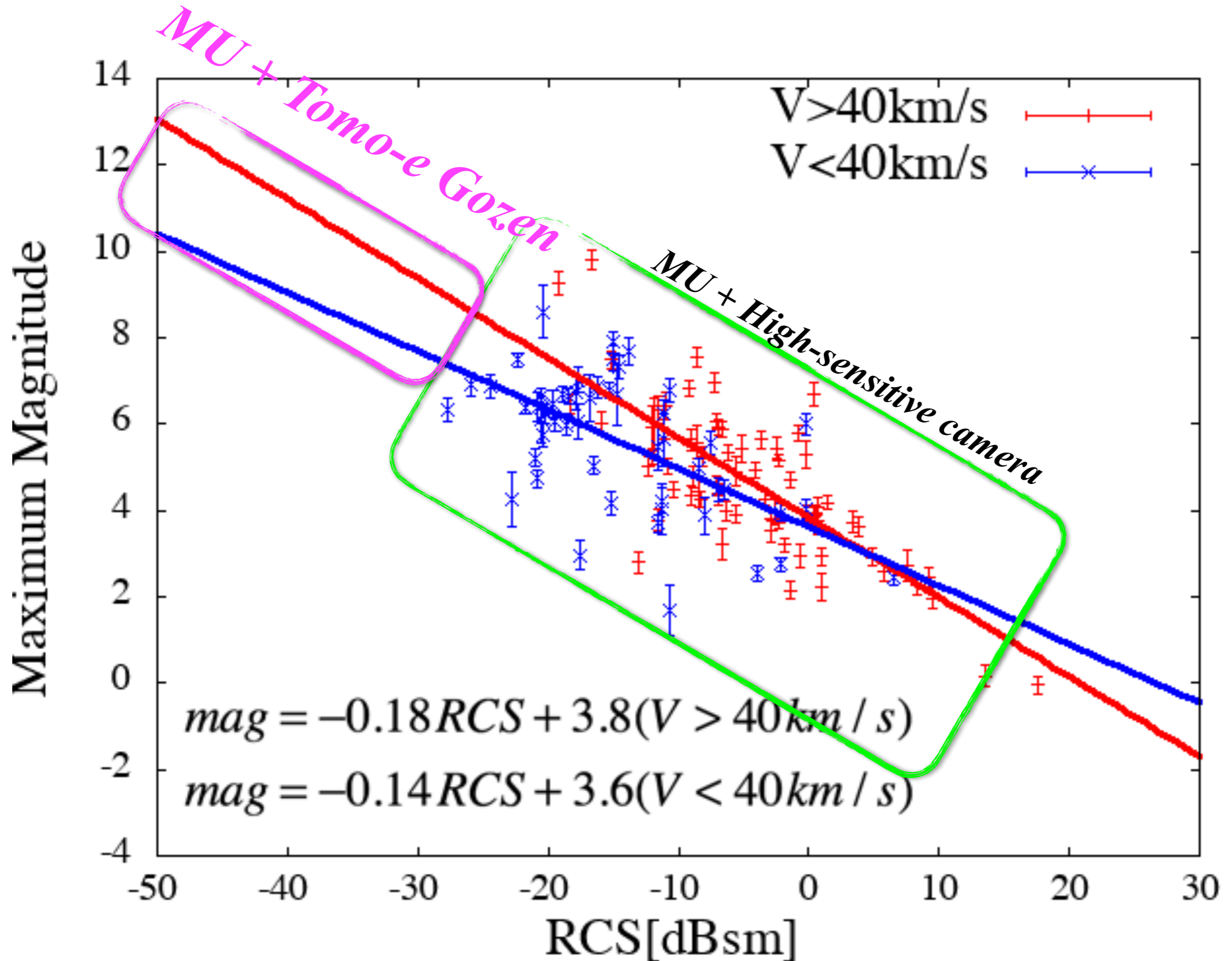
$v < 40 \text{ km/s}$; num=43



- **Magnitude distribution**



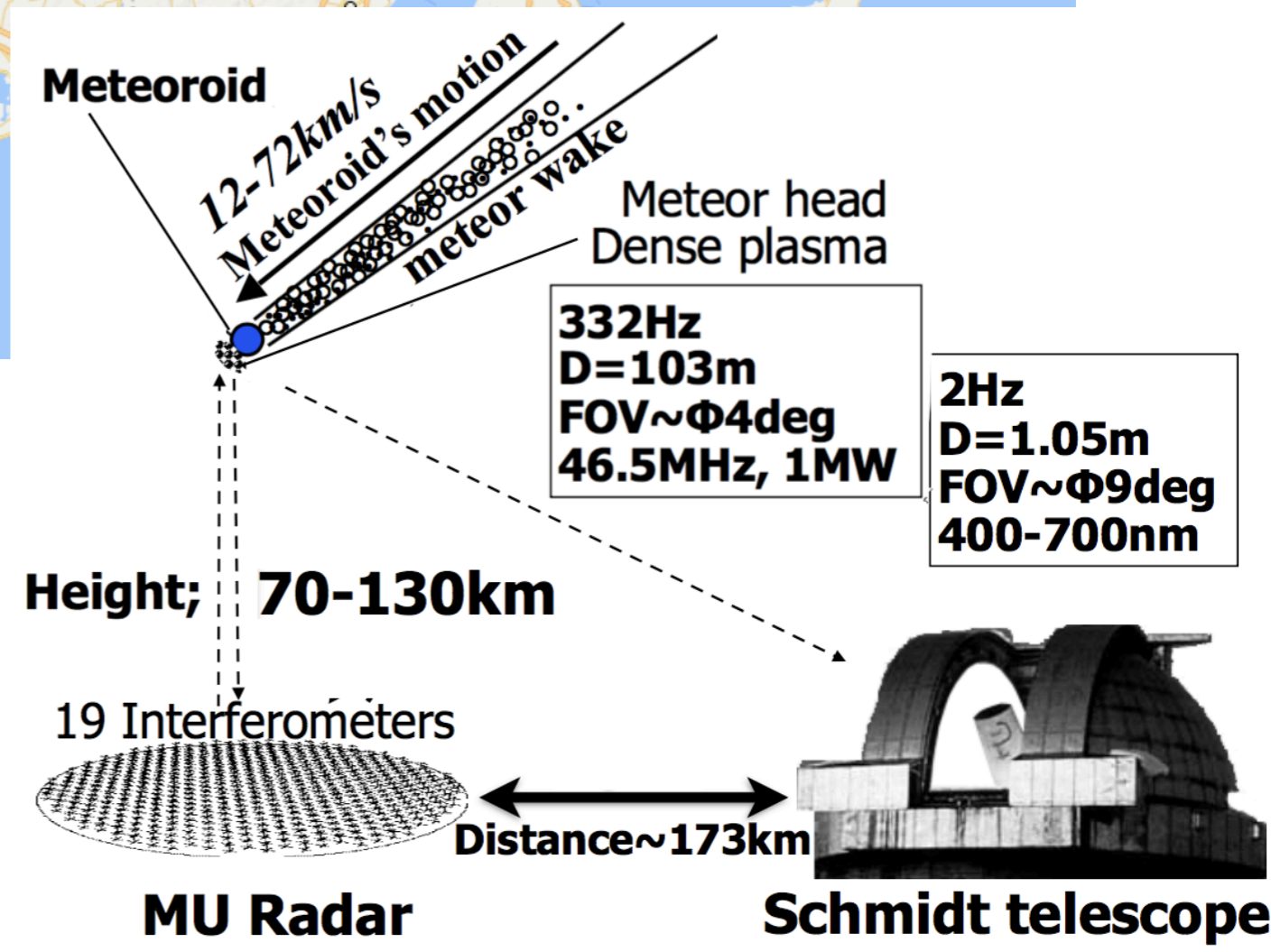
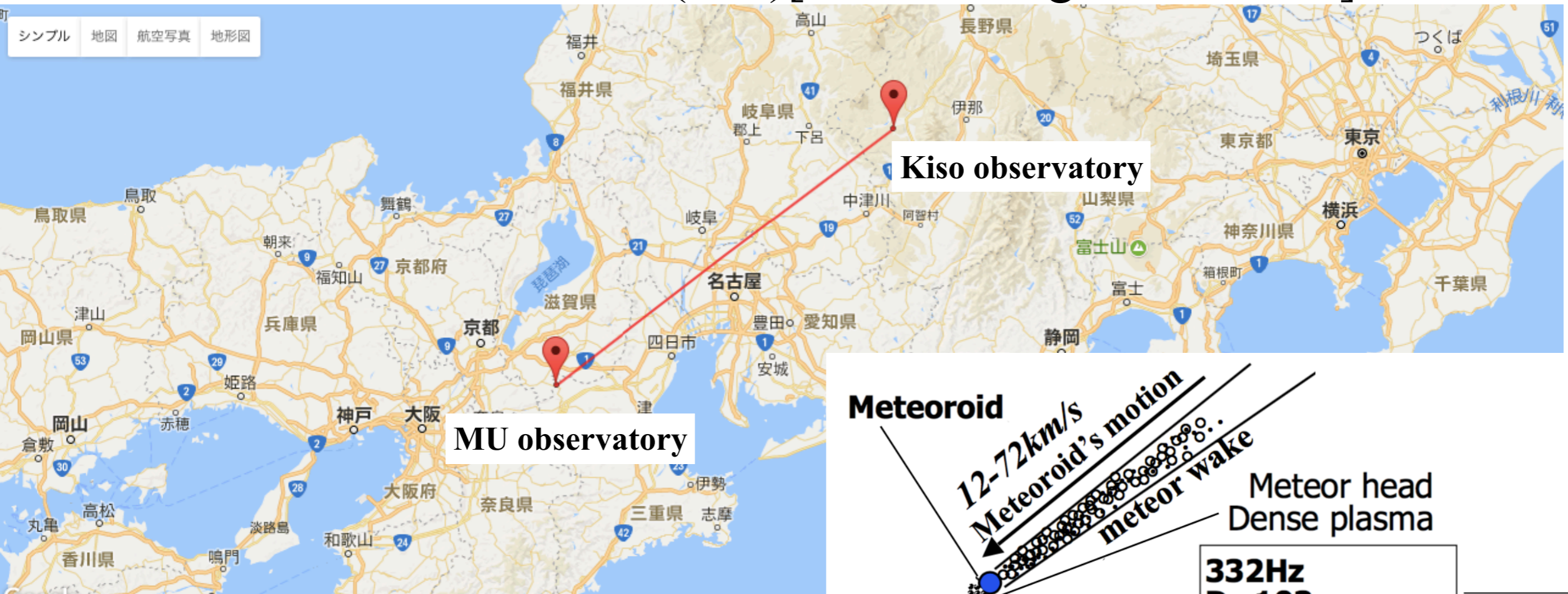
- Simultaneous observation using MU radar and high-sensitive camera



• Observation period

2018/3/19~21 22:00~04:00(JST)[6hours×2nights=12hours]

2018/4/16~22の 22:00~04:00(JST)[6hours×6nights=36hours]



- **Back up observation**

- Kiso observatory

Sony α 7S

SIGMA 35mm/F1.4, 85mm/F1.4

- MU radar

α 7S + 200mm/F1.8

α 7 RIII + 35mm/F1.4

- Osaka(Fujiwara-san)

α 7 RIII + 85mm/F1.4

WATEC-902H2U + 8mm/F1.8



Sony α 7S + 85mm/F1.4



WATEC-902H2U

• Observation(2018.3.19-21)



• **Observation(2018.4.19-22)**

FOV_35mm(Vertical : Horizon): 21.32[deg] : 37.91[deg]

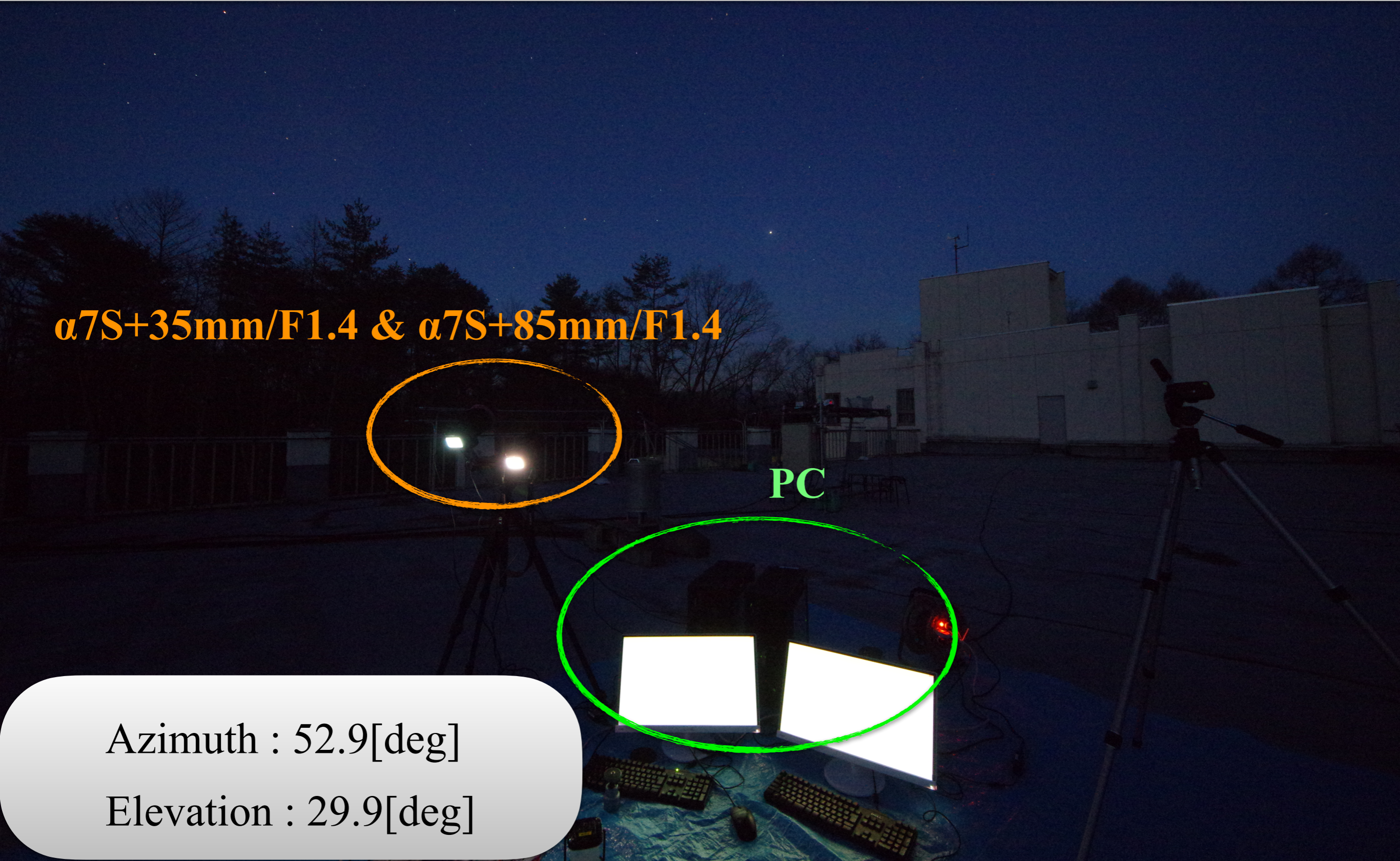
FOV_85mm(Vertical : Horizon): 13.47[deg] : 23.94[deg]

α 7S+35mm/F1.4 & α 7S+85mm/F1.4

PC

Azimuth : 52.9[deg]

Elevation : 29.9[deg]



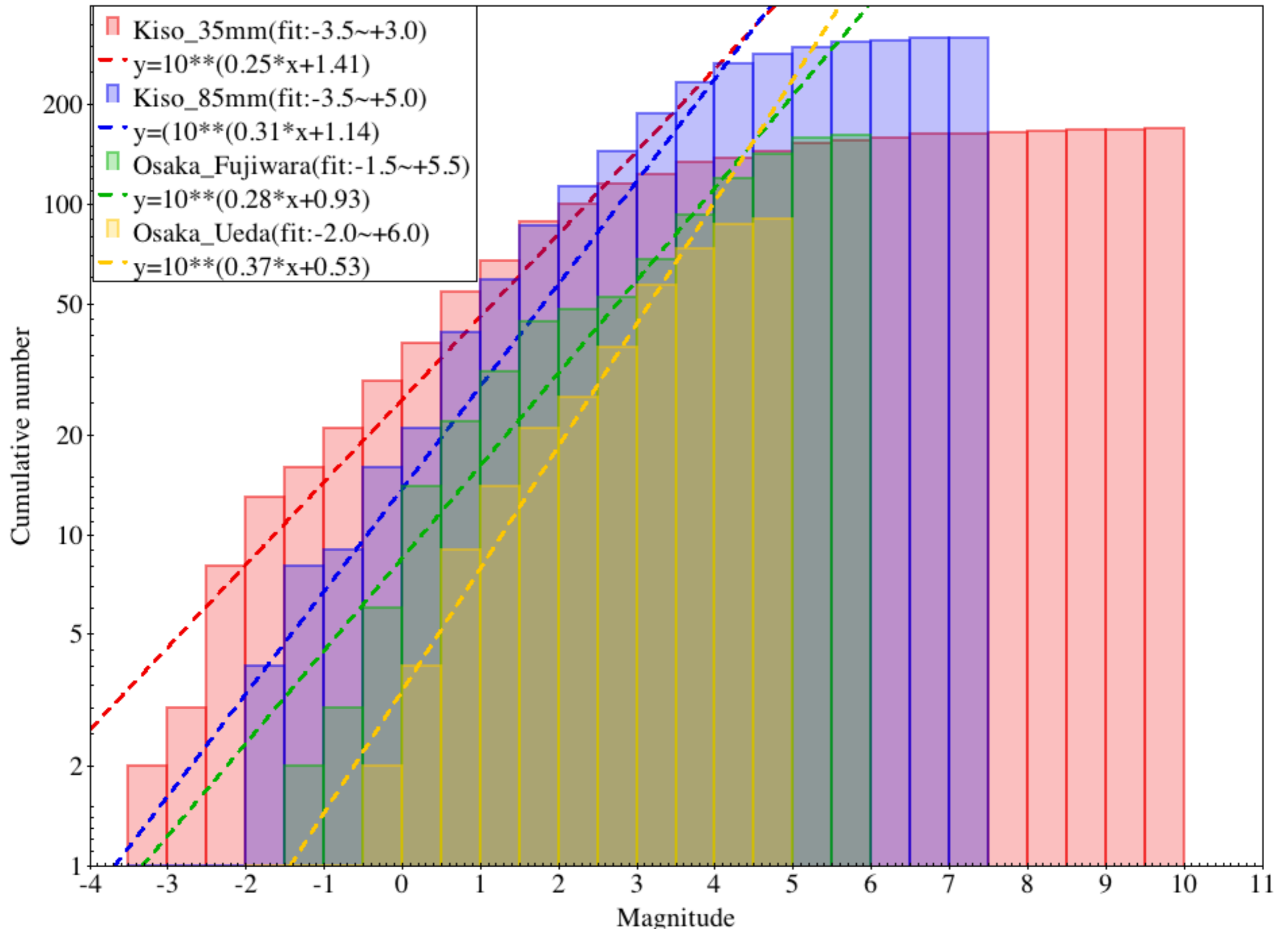
• **Number of meteor**

	Kiso_α7S+35mm	Kiso_α7S+85mm	Osaka	MU_Optical
4/18	-	-	10	60
4/19	73	102	5	37
4/20	44	112	73	-
4/21	52	116	73	-
total	169	318	161	97

• **Simultaneous meteor with MU radar**

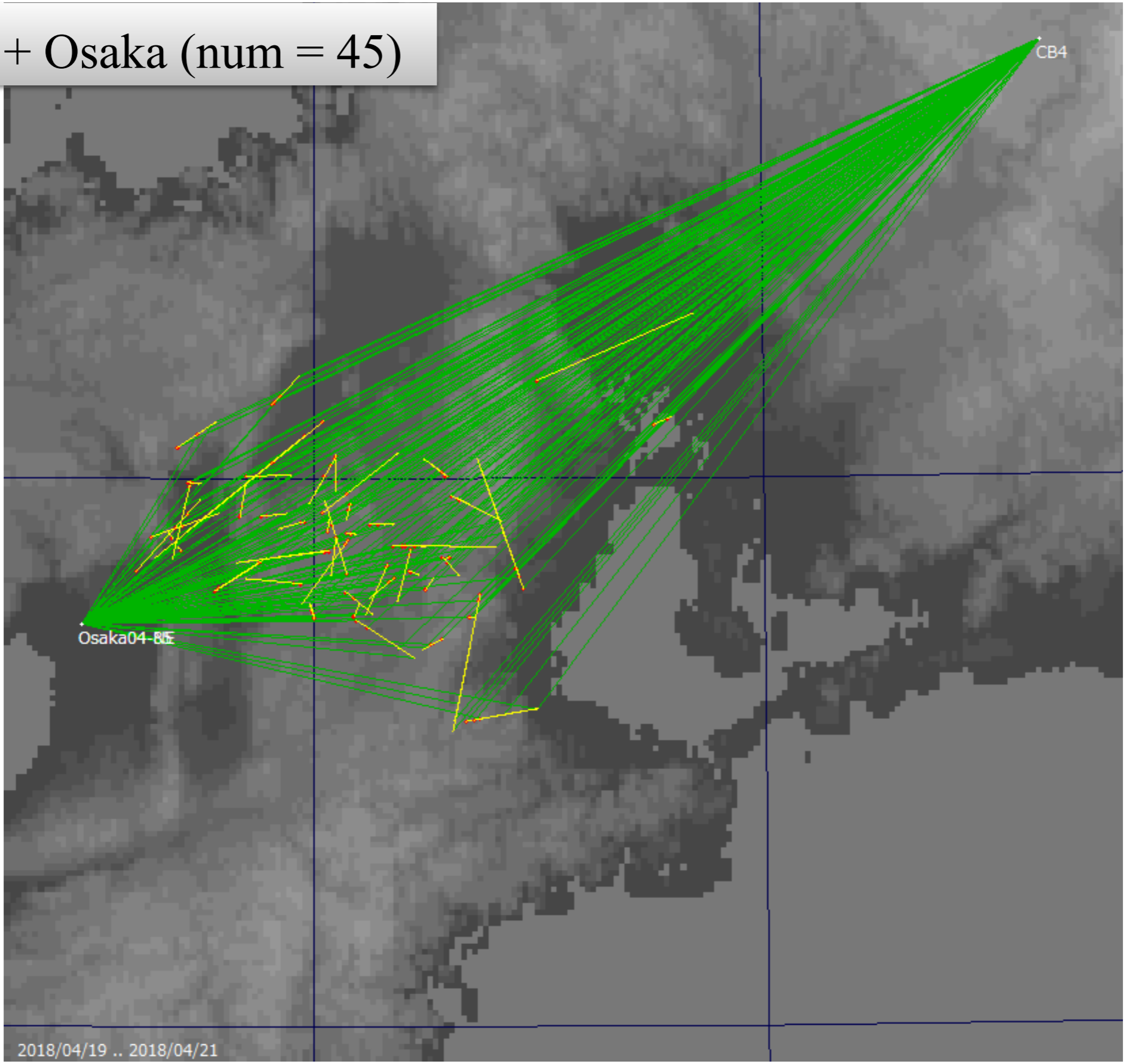
	Kiso_α7S(85mm) + MU radar	Kiso_α7S (35mm)+ MU radar	Osaka + MU radar
time_err =0.5[sec]	22	9	43
time_err =1.0[sec]	30	18	52

• Magnitude distribution



• Simultaneous Meteor(UFOOrbit*)

Kiso_α7S + Osaka (num = 45)



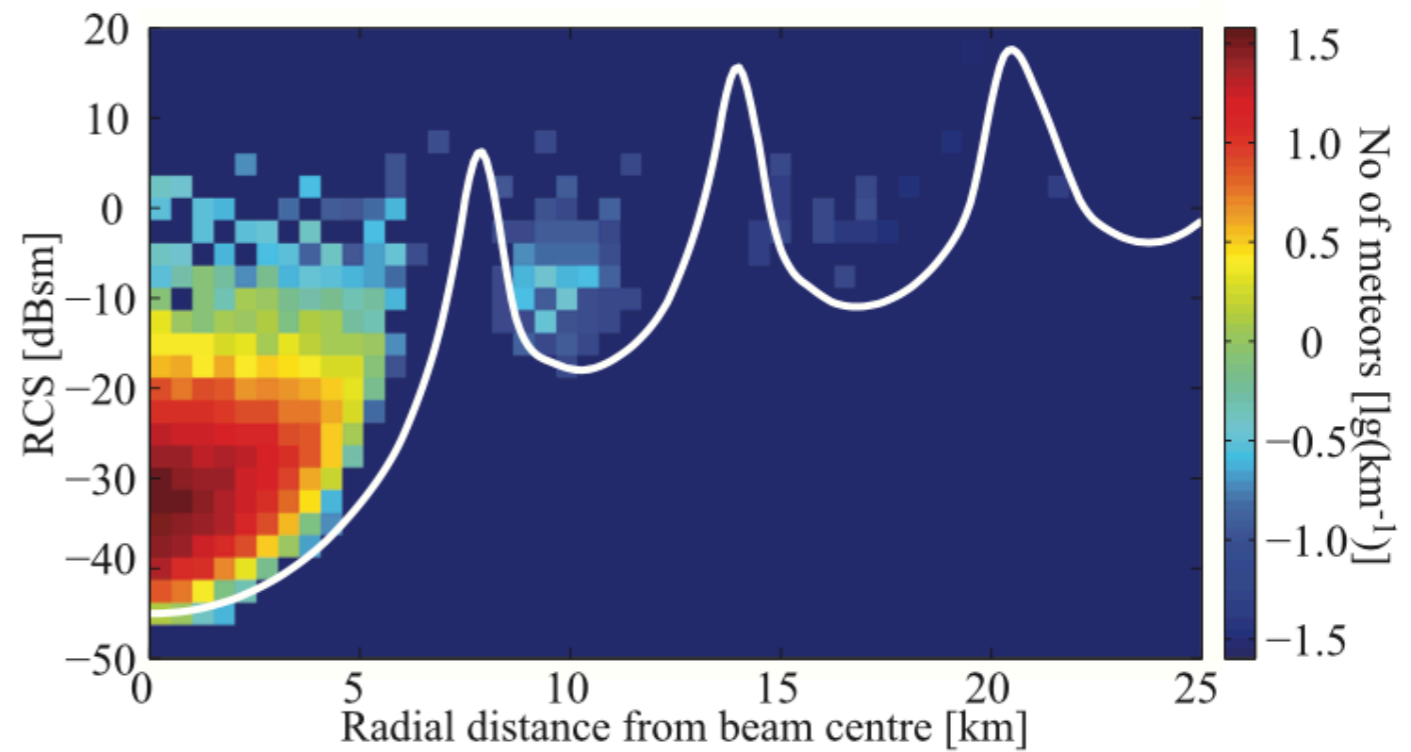
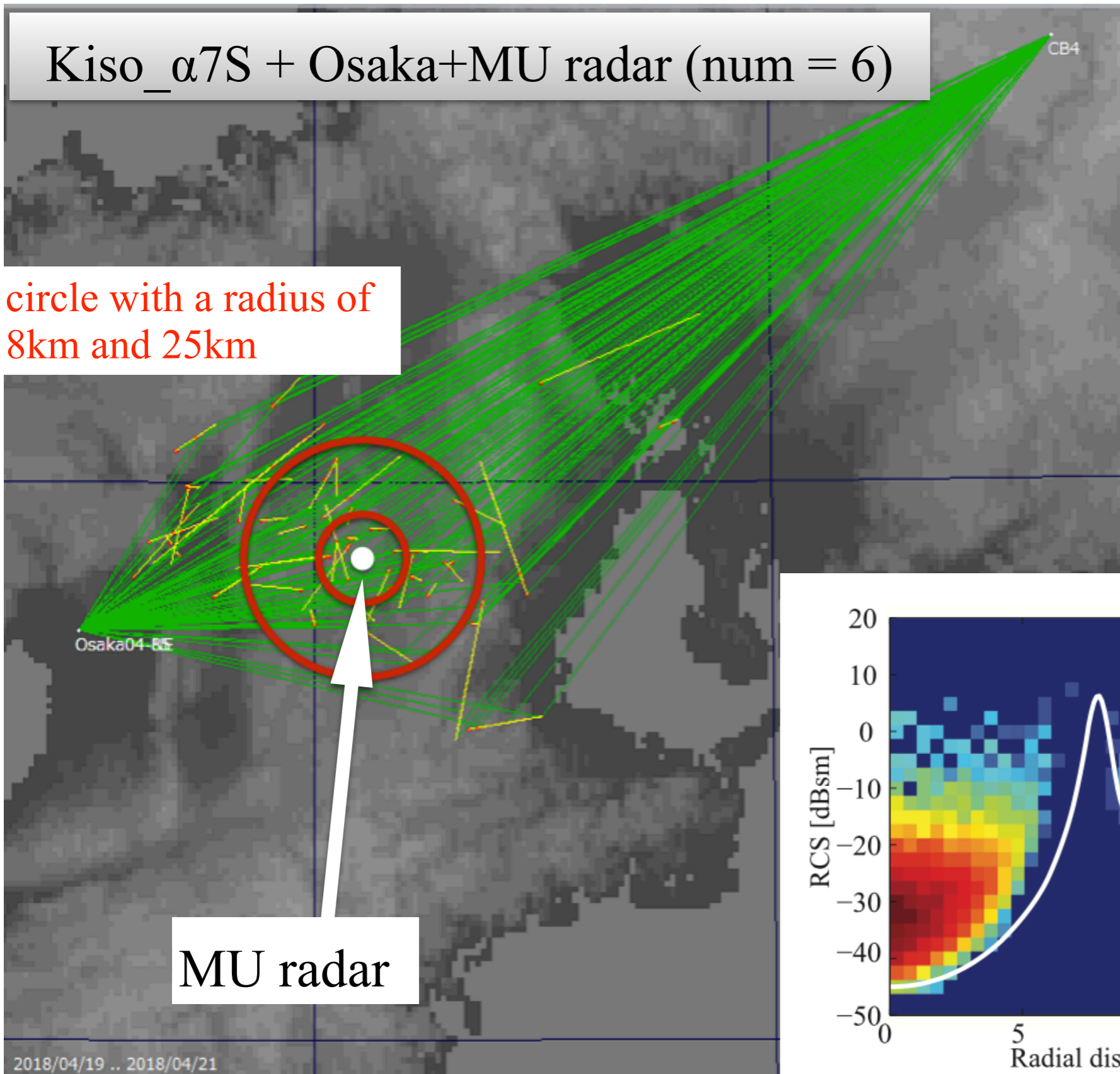
*UFOOrbitV2ver2.52(http://sonotaco.com/e_index.html)

• Simultaneous Meteor(UFOOrbit*)

Kiso_α7S + Osaka+MU radar (num = 6)

circle with a radius of 8km and 25km

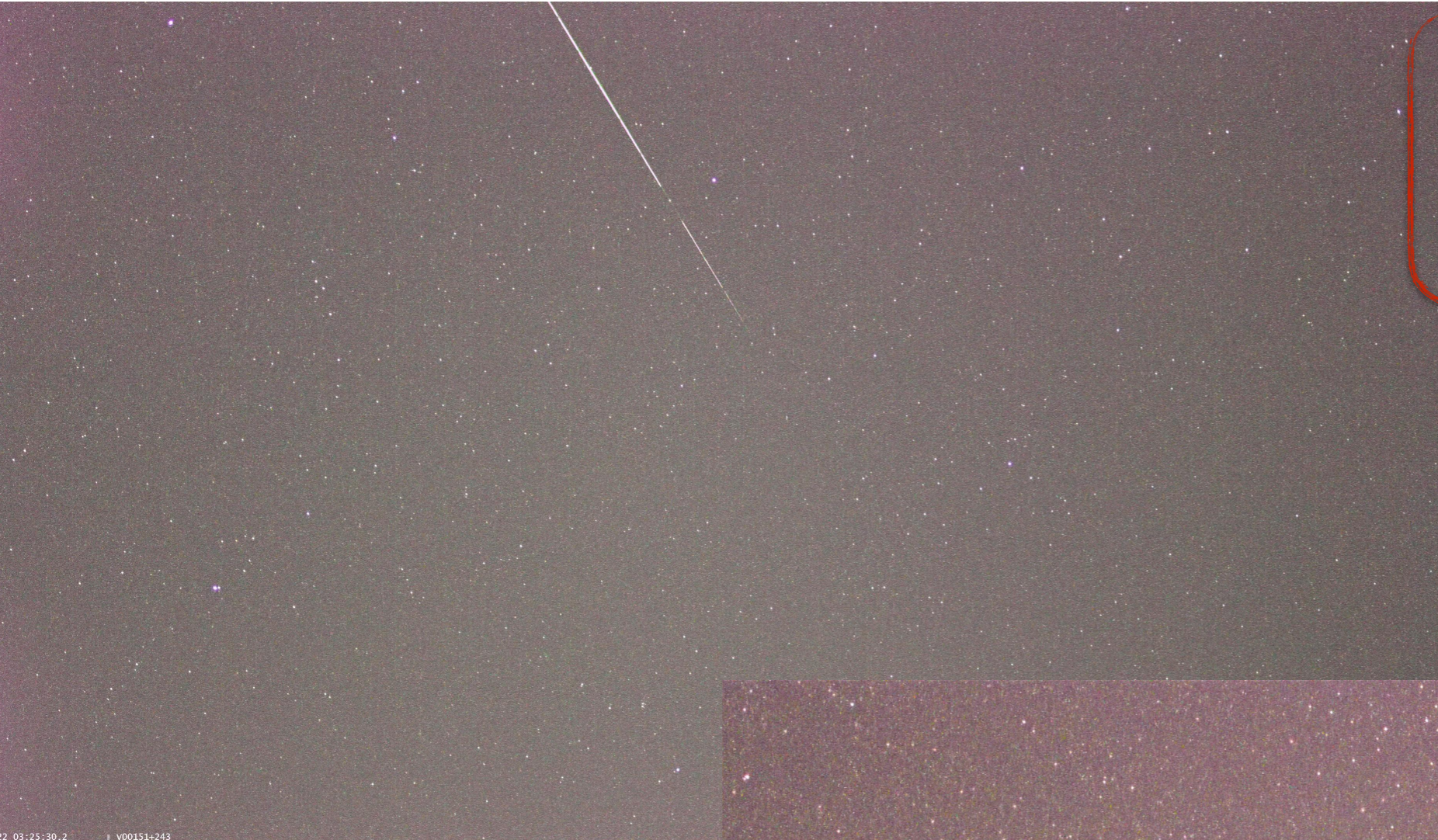
MU radar



*UFOOrbitV2ver2.52(http://sonotaco.com/e_index.html)

”First results from the 2009-2010 MU radar head echo observation program for sporadic and shower meteors: the Orionids 2009 ” ,J.Kero et al.,(2011)

- **Simultaneous Meteor**



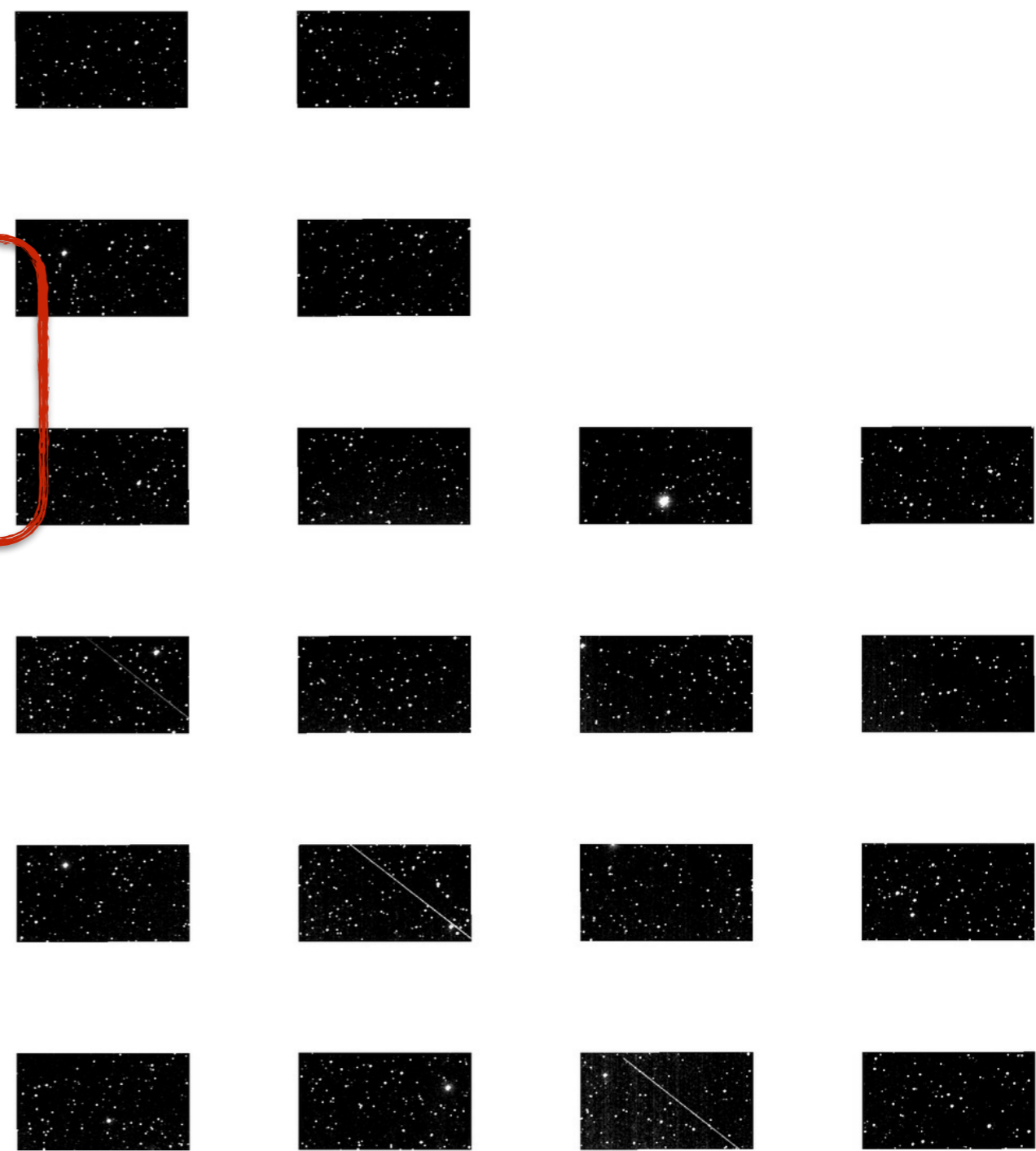
$\alpha 7S+85mm/F1.4$
2018.4.22-03-25-30(JST)



$\alpha 7S +35mm/F1.4$
2018.4.22-03-25-30(JST)

• **Simultaneous Meteor**

Tomo-e Gozen
2018.4.20-23-41-58(JST)

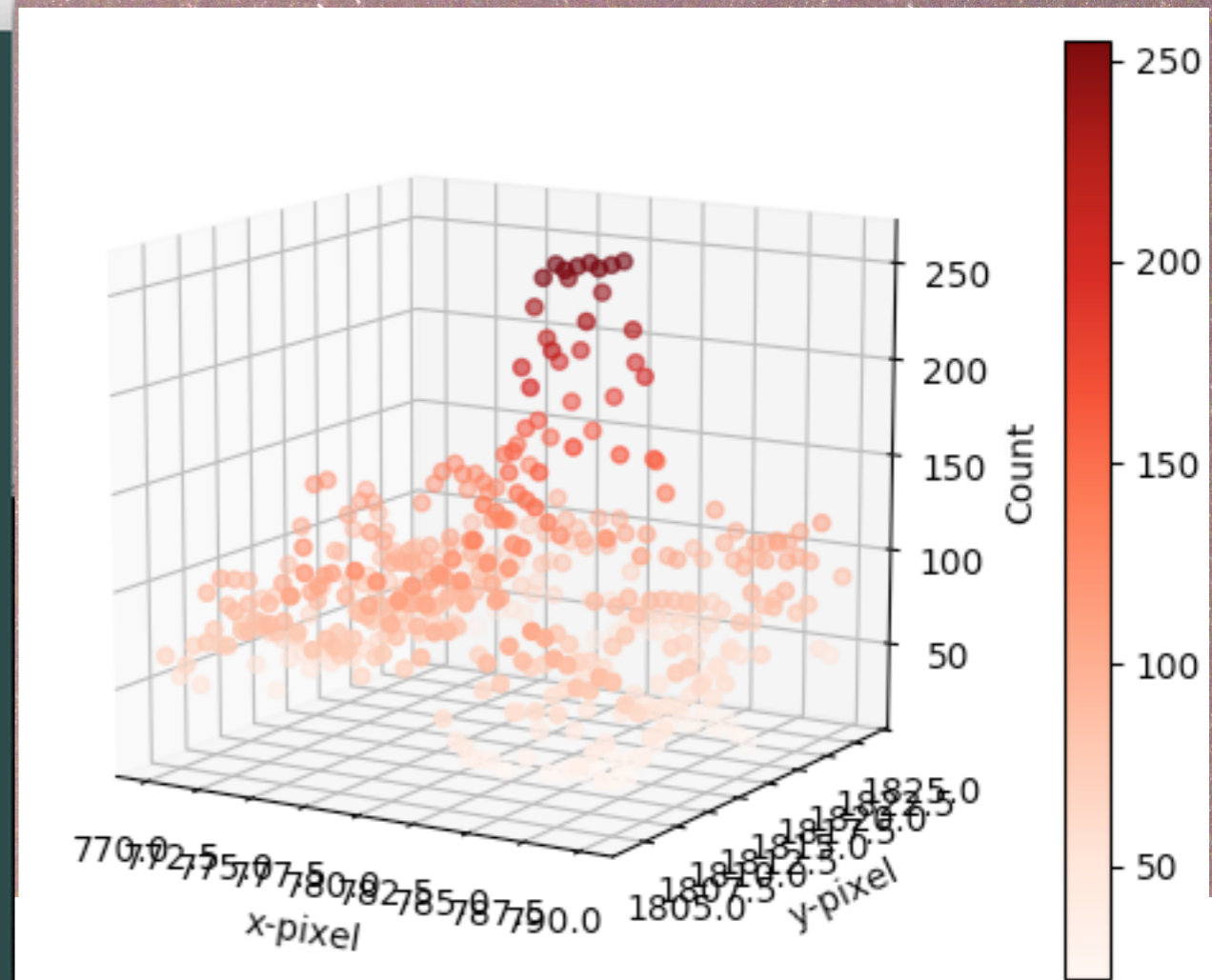
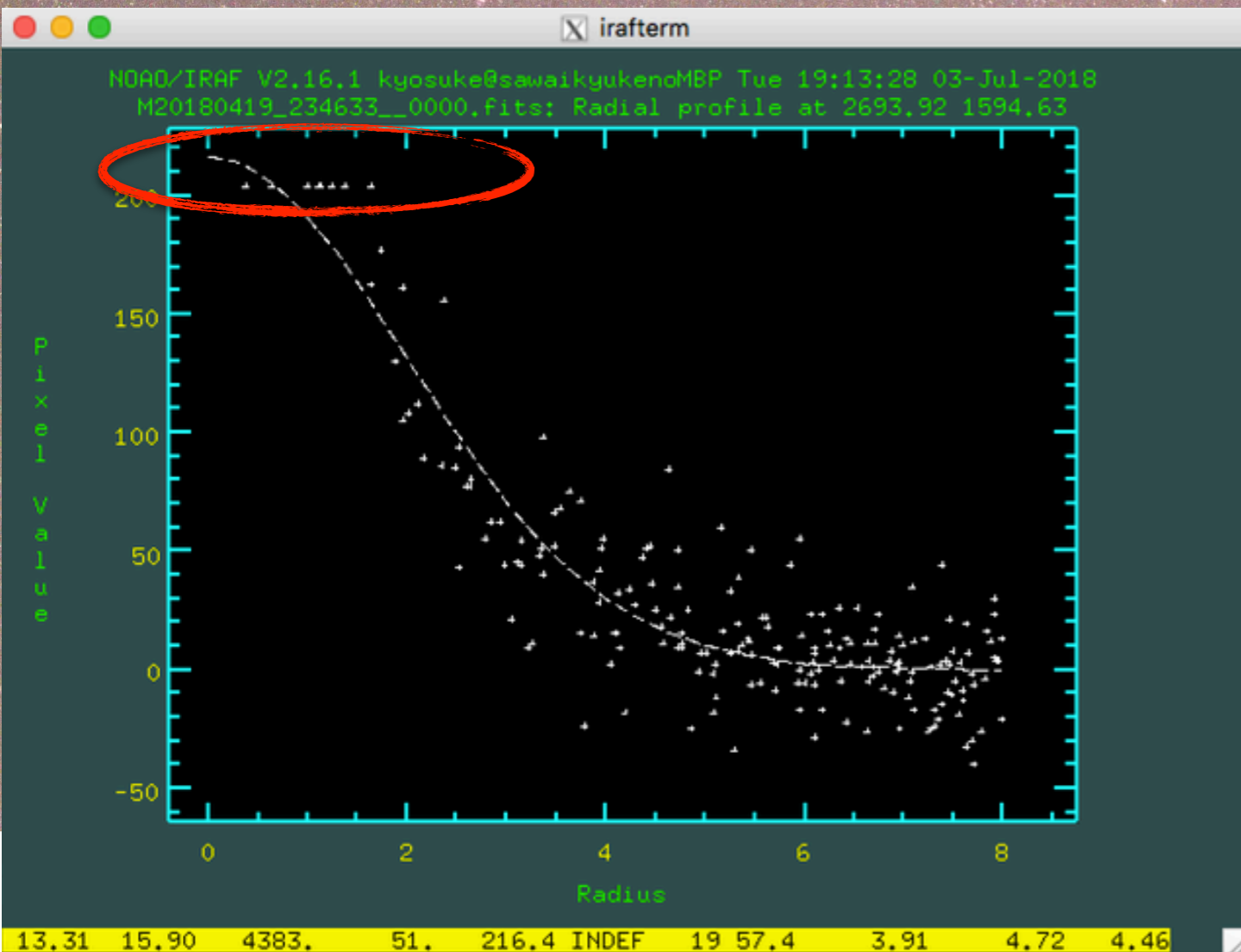
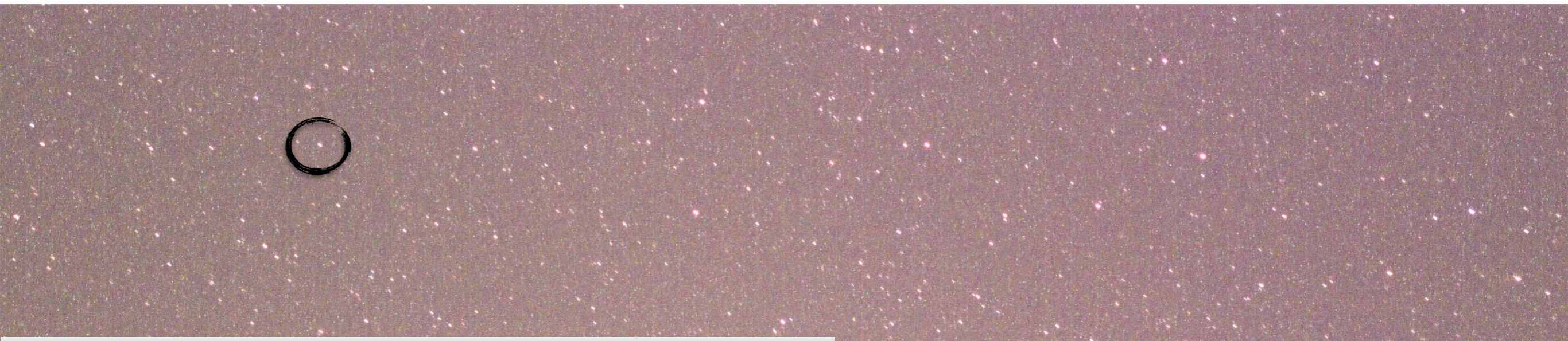


$\alpha 7S+85mm/F1.4$
2018.4.20-23-42-00(JST)



• Current Status

Relative Photometry using Iraf(<http://iraf.noao.edu>)



- **Future work**

Geminids Observation(2018.12.10-17)

Contribute to “Destiny+” science mission

- **Size distribution**
- **Spatial density of dust**
- **Chemical composition**

