

# Search for Fragments Caused by Breakup of Titan 3C Transtage in the Geostationary Region

**Toshifumi YANAGISAWA**

*Japan Aerospace Exploration Agency (JAXA), Tokyo, Japan*

**Yukihito KITAZAWA**

*IHI Corporation, Tokyo, Japan*

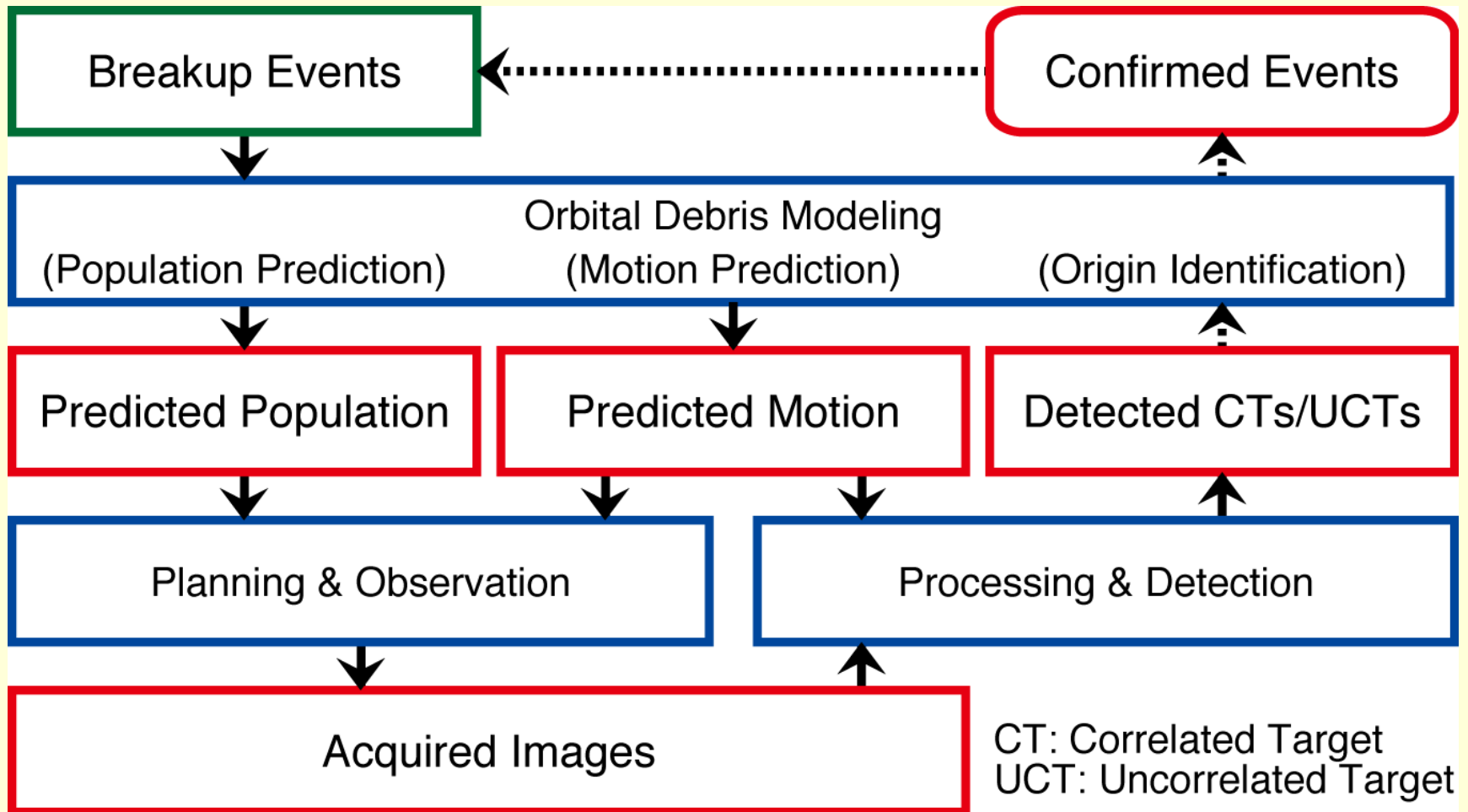
**Toshiya HANADA**

*Kyushu University (KU), Fukuoka, Japan*

## Abstract

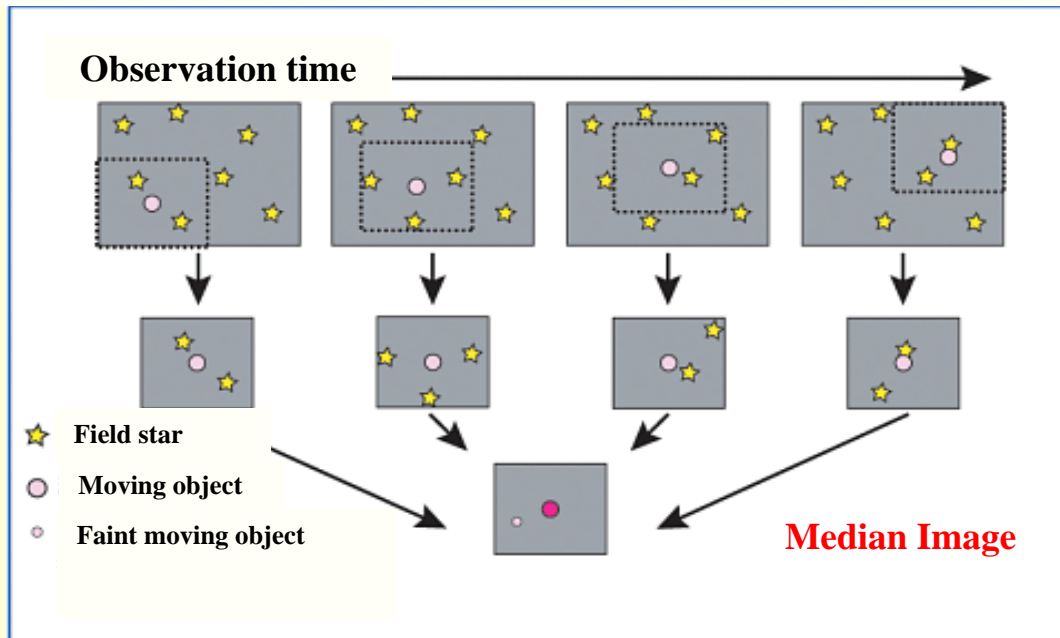
We have performed search observations for fragments caused by breakup of Titan 3C transtage in the geostationary region using the telescopes in Taiwan and JAXA telescope on October 20, 21 and 22 in 2011. We have applied the orbital debris (OD) modeling techniques that can specify when, where and how we should perform observations. 51 cataloged and 96 uncataloged objects were detected. 40 of them were the fragments of Titan3C.

# Observation Strategy

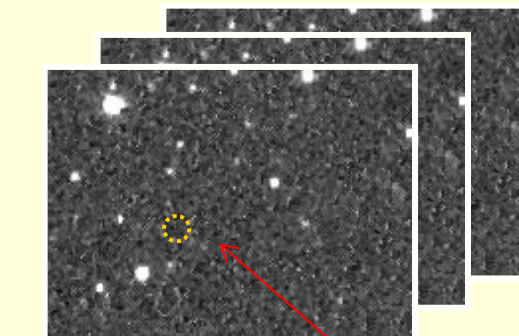


# Image Processing - Stacking method

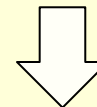
The concept of the stacking method.



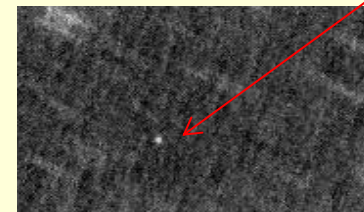
**FPGA board system was developed to reduce analysis time to 1/1000.**



40 frames used for the method.

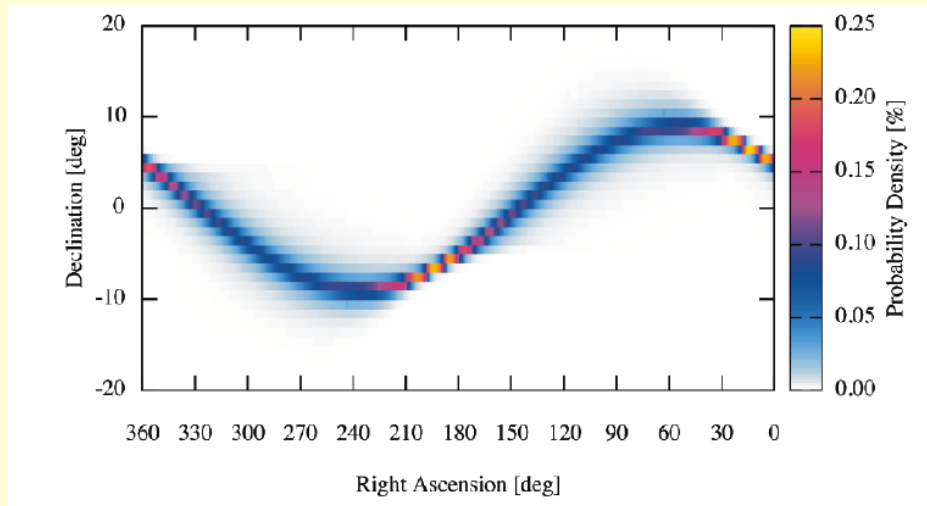


Detected asteroid  
(Invisible before stacking)

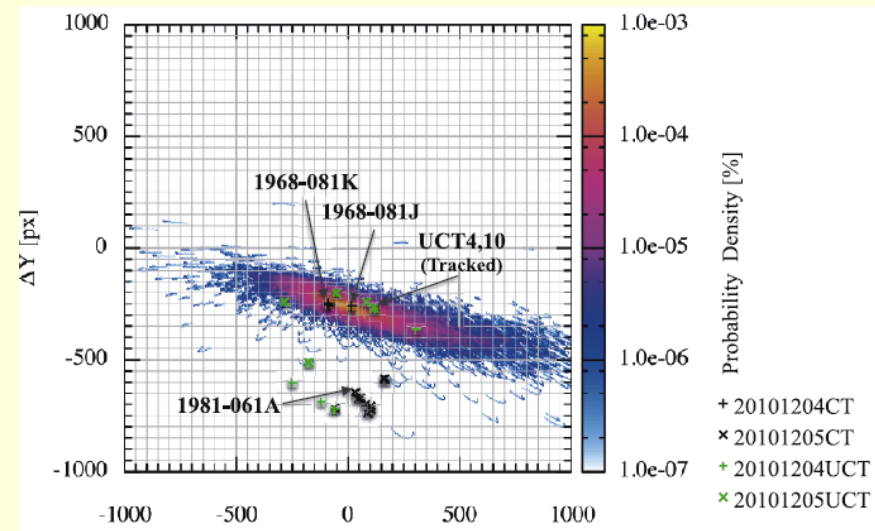


The final image of the stacking method

# Example of Prediction and Observation Results



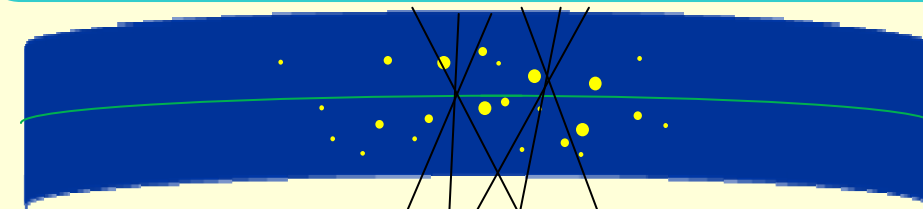
Population prediction  
(Titan 3C fragments)



Motion prediction  
(Titan 3C fragments compared with  
observation data)



# Observation



Pointing direction  
is changed  
every 4 minutes.



Lulin 1m telescope TAOS telescope



JAXA telescope

1<sup>st</sup> field

1-second exposure  $\times 1$   
4-seconds exposure  $\times 32$



2<sup>nd</sup> field

1-second exposure  $\times 1$   
4-seconds exposure  $\times 32$



3<sup>rd</sup> field

1-second exposure  $\times 1$   
4-seconds exposure  $\times 32$



Observation sequence

**LOT**

**D: 1m**

**FOV:  $0.2 \times 0.4^\circ$**

**TAOS**

**D: 0.5m**

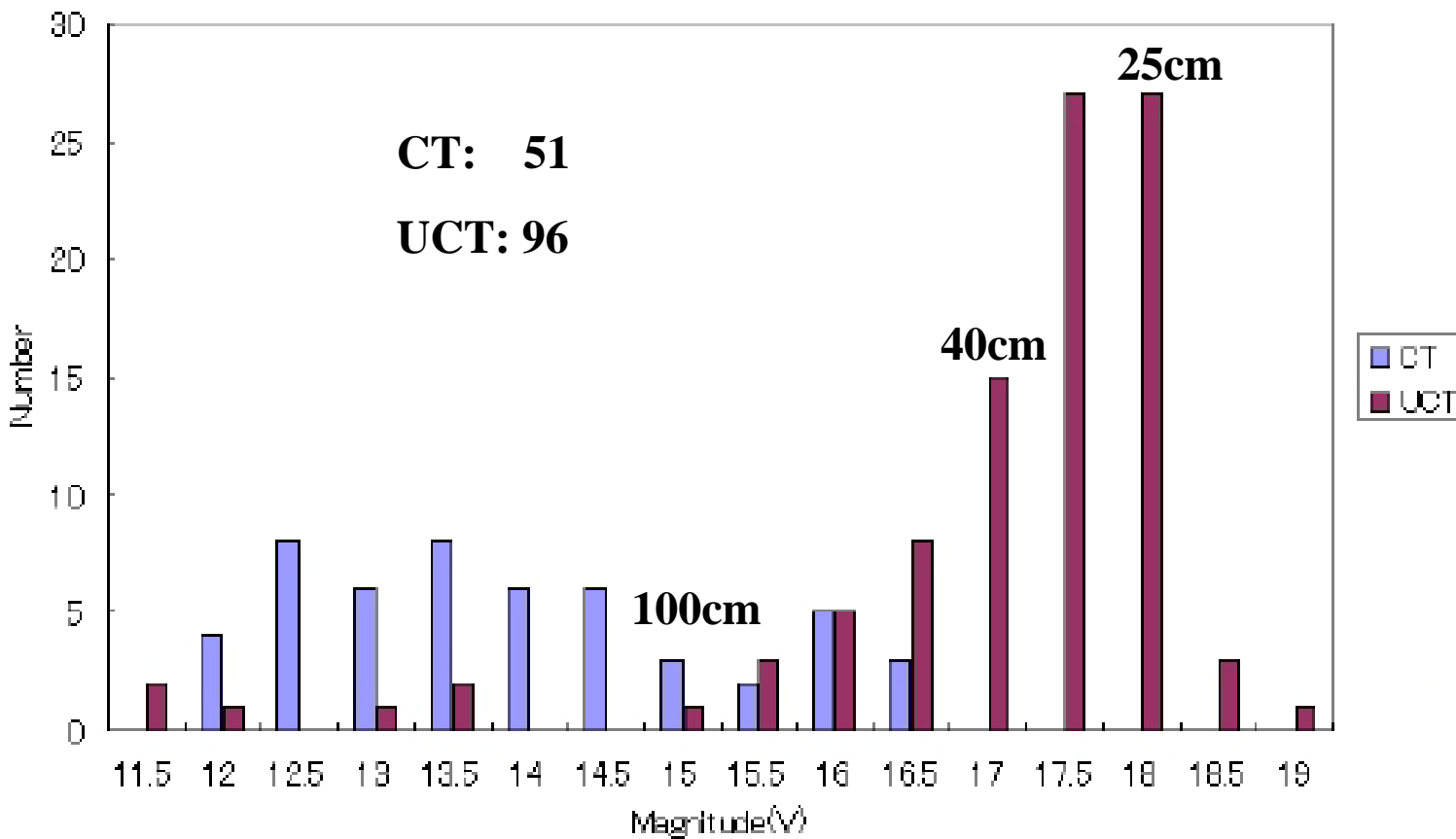
**FOV:  $1.3 \times 1.3^\circ$**

**Nyukasa**

**D: 0.35m**

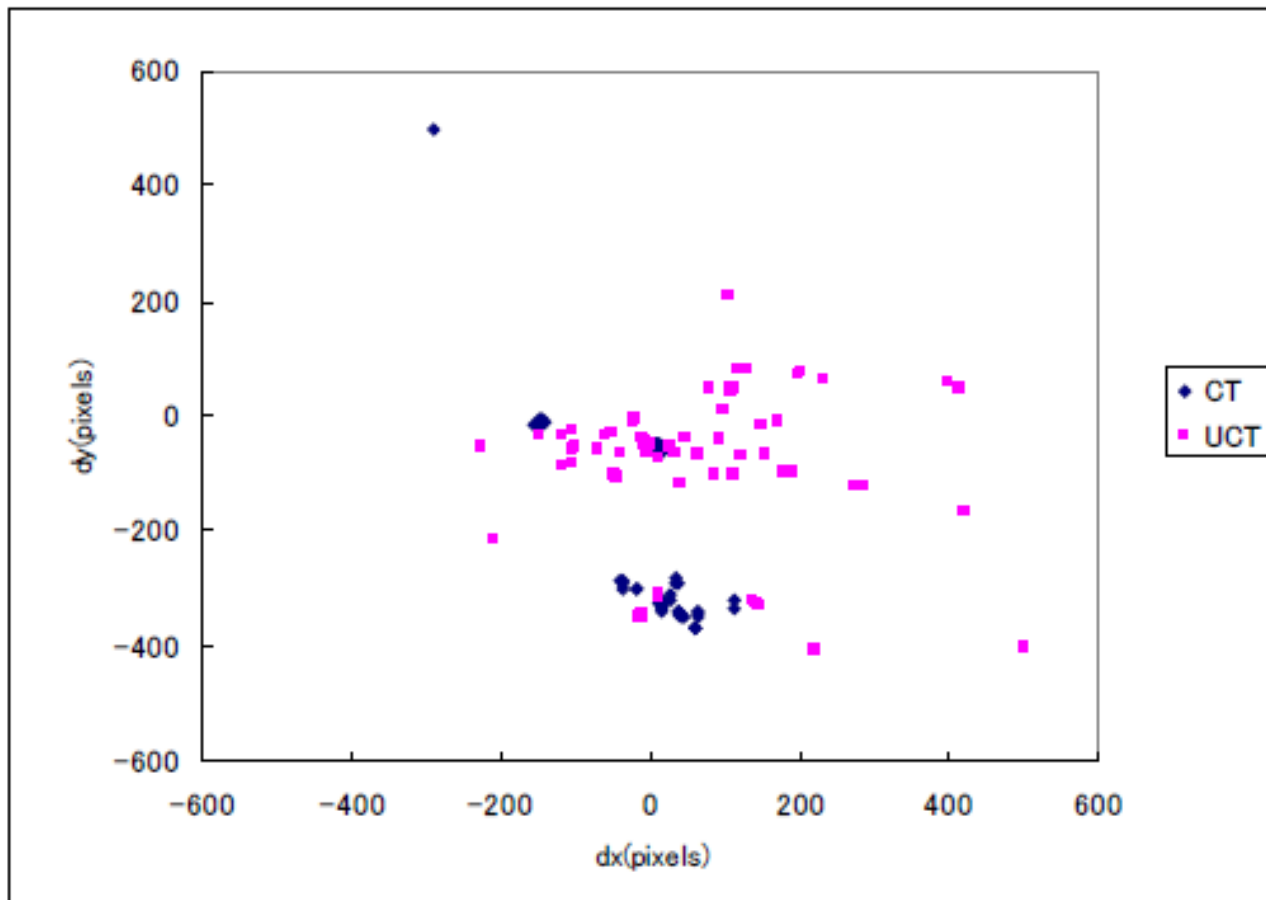
**FOV:  $1.3 \times 1.3^\circ$**

# Results



**Magnitude distribution of detected objects**

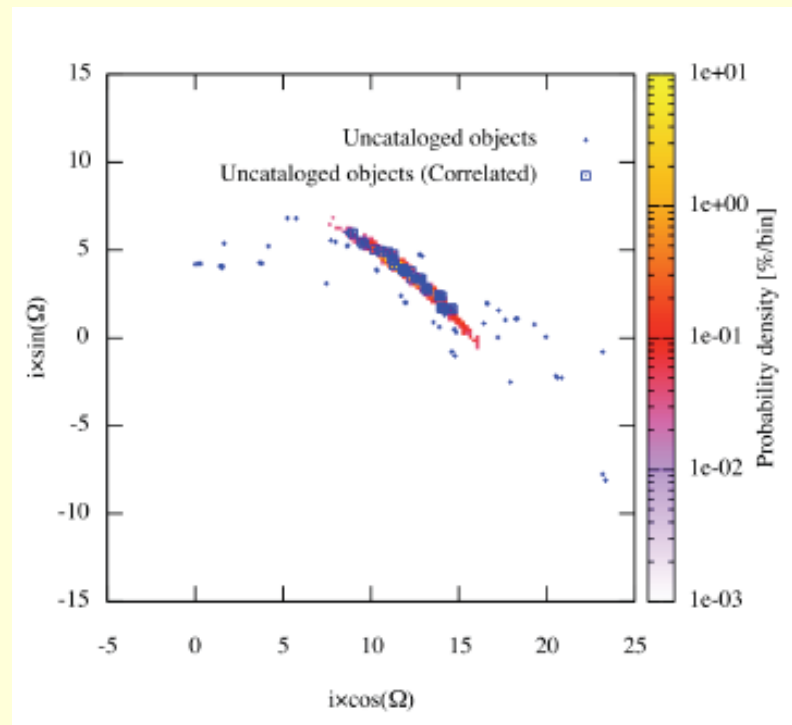
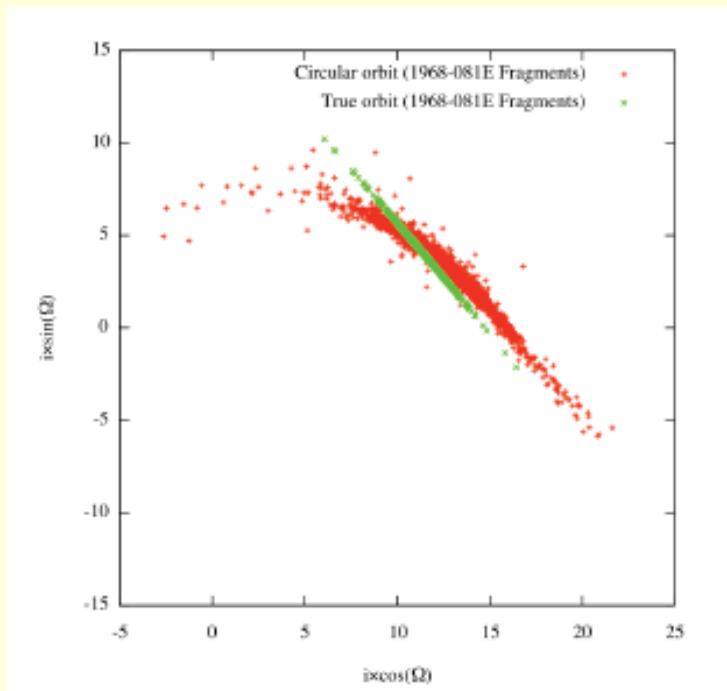
# Results



**Motion distribution of detected objects**



# Origin identification



**True orbit at  
the breakup**

**Propagation**

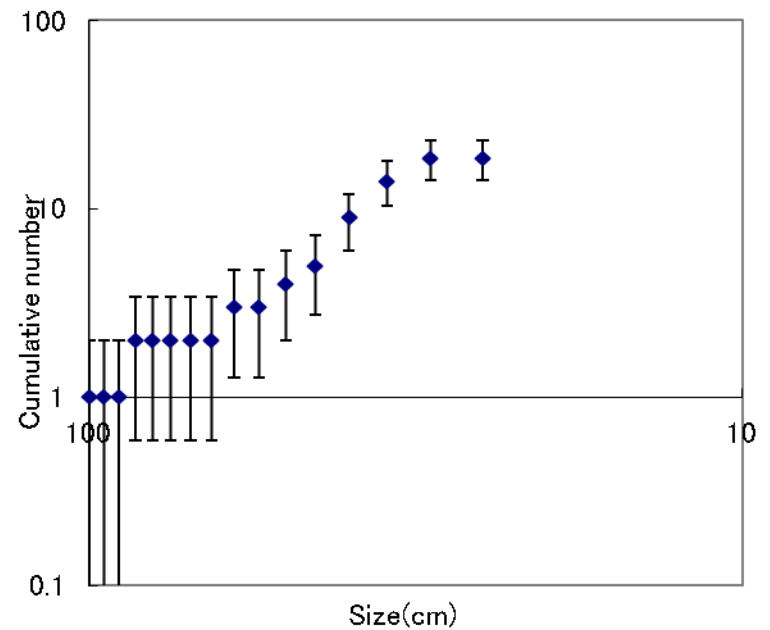
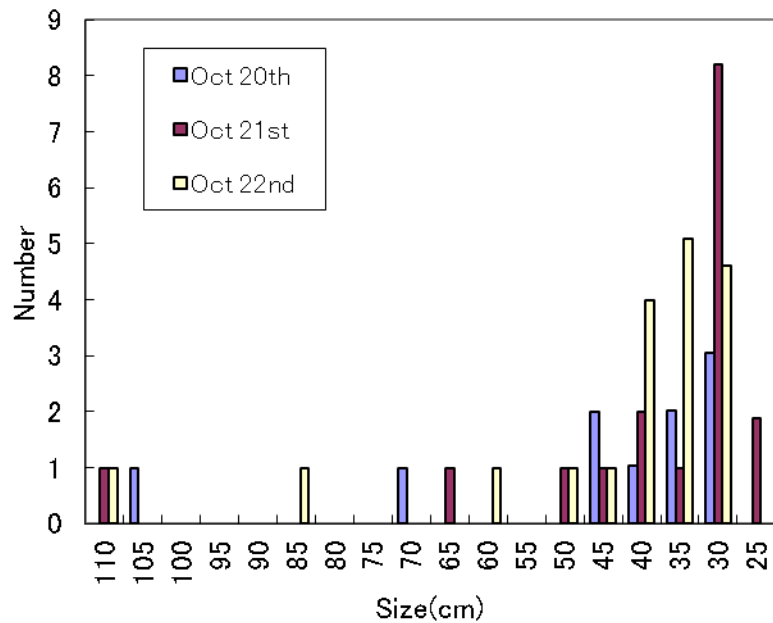
**True orbit at  
present**

**Circular orbit  
at the breakup**

**Inverse-propagation**

**Circular orbit  
at present**

# Size distribution



## Summary

We have performed search observations for fragments caused by breakup of Titan 3C transtage in the geostationary region using the telescopes in Taiwan and JAXA telescope on October 20, 21 and 22 in 2011. We have applied the orbital debris (OD) modeling techniques that can specify when, where and how we should perform observations. 51 cataloged and 96 uncataloged objects were detected. 40 of them were the fragments of Titan3C and the size distribution was derived.