

Evolution of the Debris Cloud Generated by the Fengyun-1C Fragmentation Event



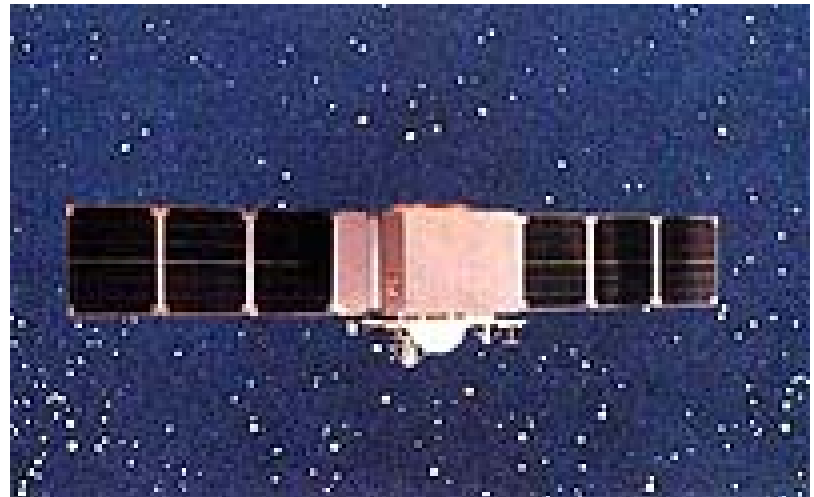
L. Anselmo & C. Pardini

ASI Delegation
ISTI/CNR – Pisa – Italy

Version of 26 June 2007 – 25th IADC Plenary Meeting

The Fengyun-1C Satellite

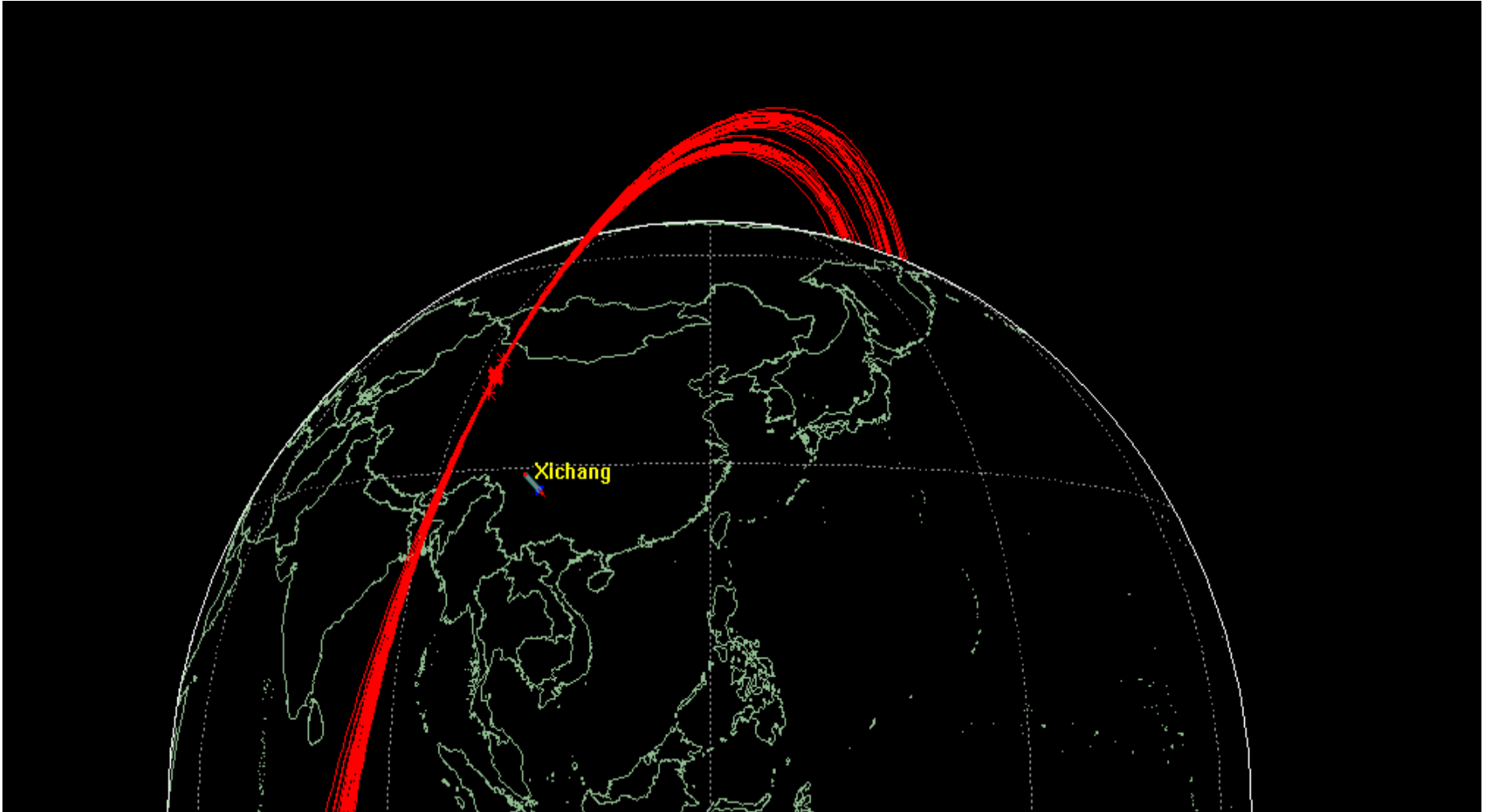
- Launch date: 10 May 1999
- Launch from Taiyuan Satellite Center (CZ-4B)
- Catalog number: 25730 (1999-025A)
- Mass at launch: 958 kg
- Bus size: 2.02 m x 2.00 m x 2.22 m
- Fully functional until 2005
- Orbit before breakup:
 - Perigee: 855 km
 - Apogee: 876 km
 - Inclination: 98.65 deg
 - Period: 102 min



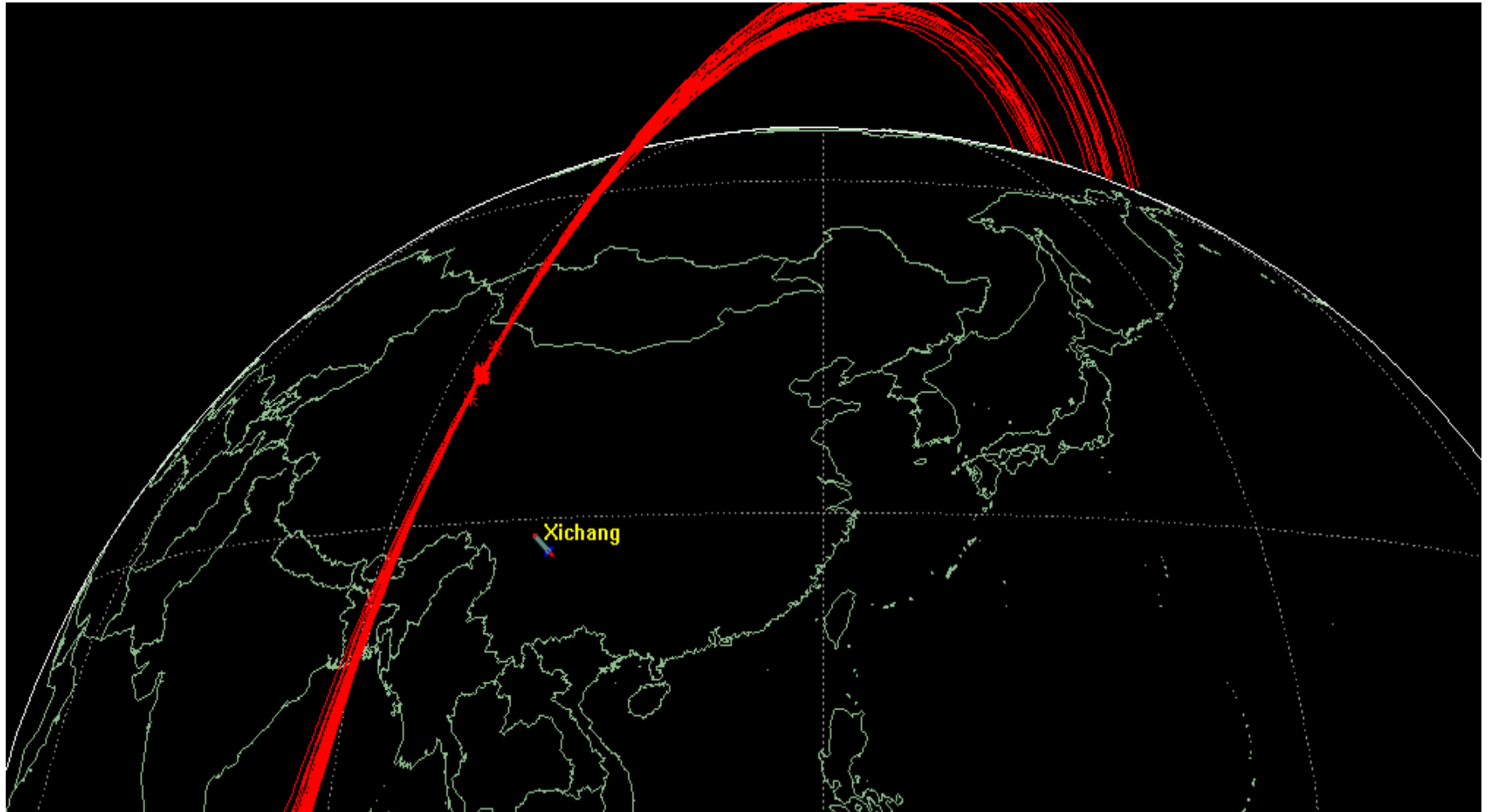
The Fragmentation Event

- Direct ascent ASAT interceptor launched with SC-19 from a mobile ground platform near Xichang Launch Center (Songlin, $\sim 28^{\circ}\text{N}$, 102°E)
- 3rd ASAT test, 1st successful target destruction
- Satellite breakup (ISTI/CNR estimation):
11 January 2007, $\sim 22:26$ UTC
- Satellite altitude at breakup: ~ 863 km
- Sub-satellite point at breakup:
 - Latitude: $\sim 35^{\circ}\text{N}$
 - Longitude: $\sim 100^{\circ}\text{E}$

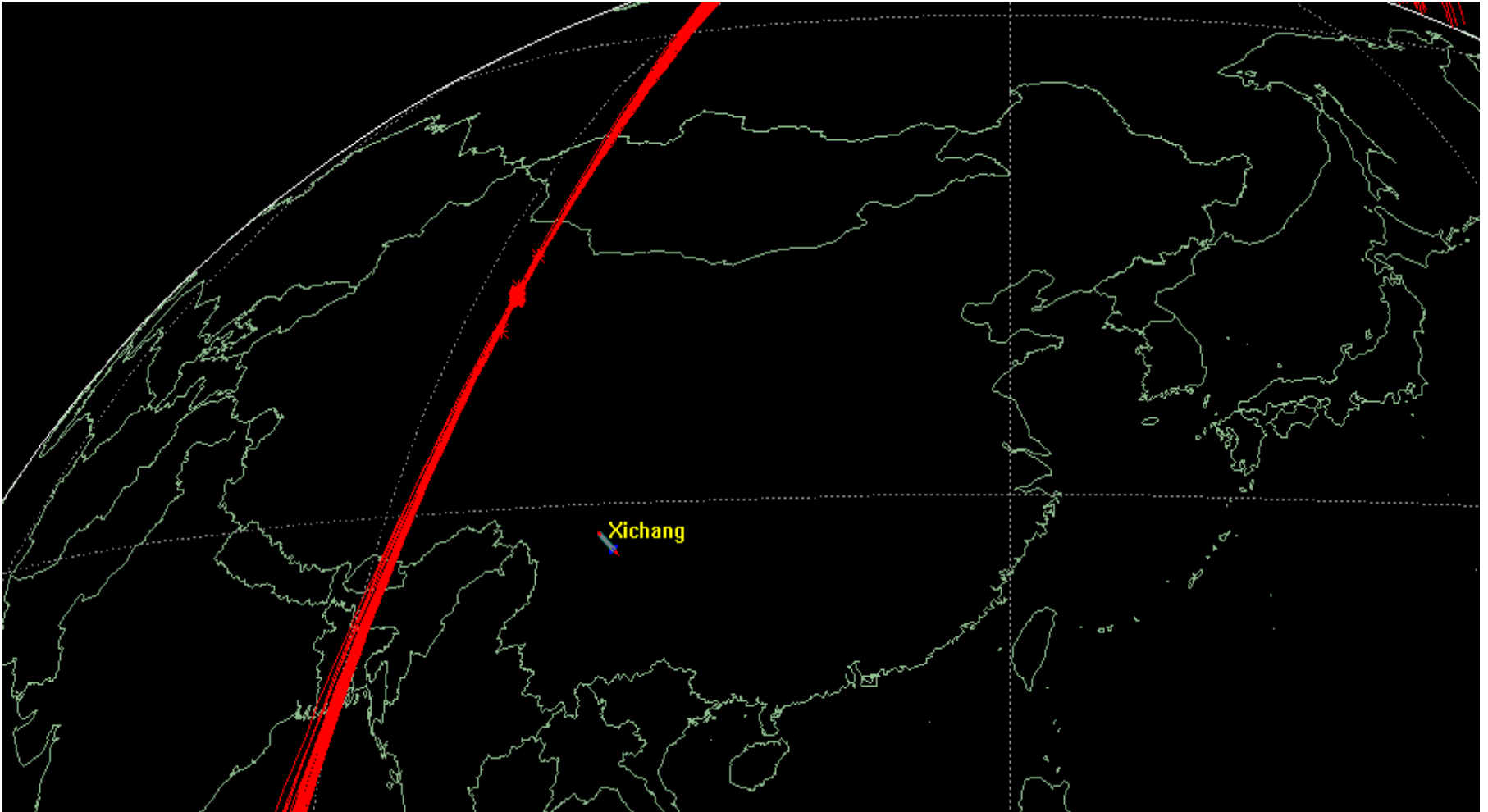
The Fragmentation Event

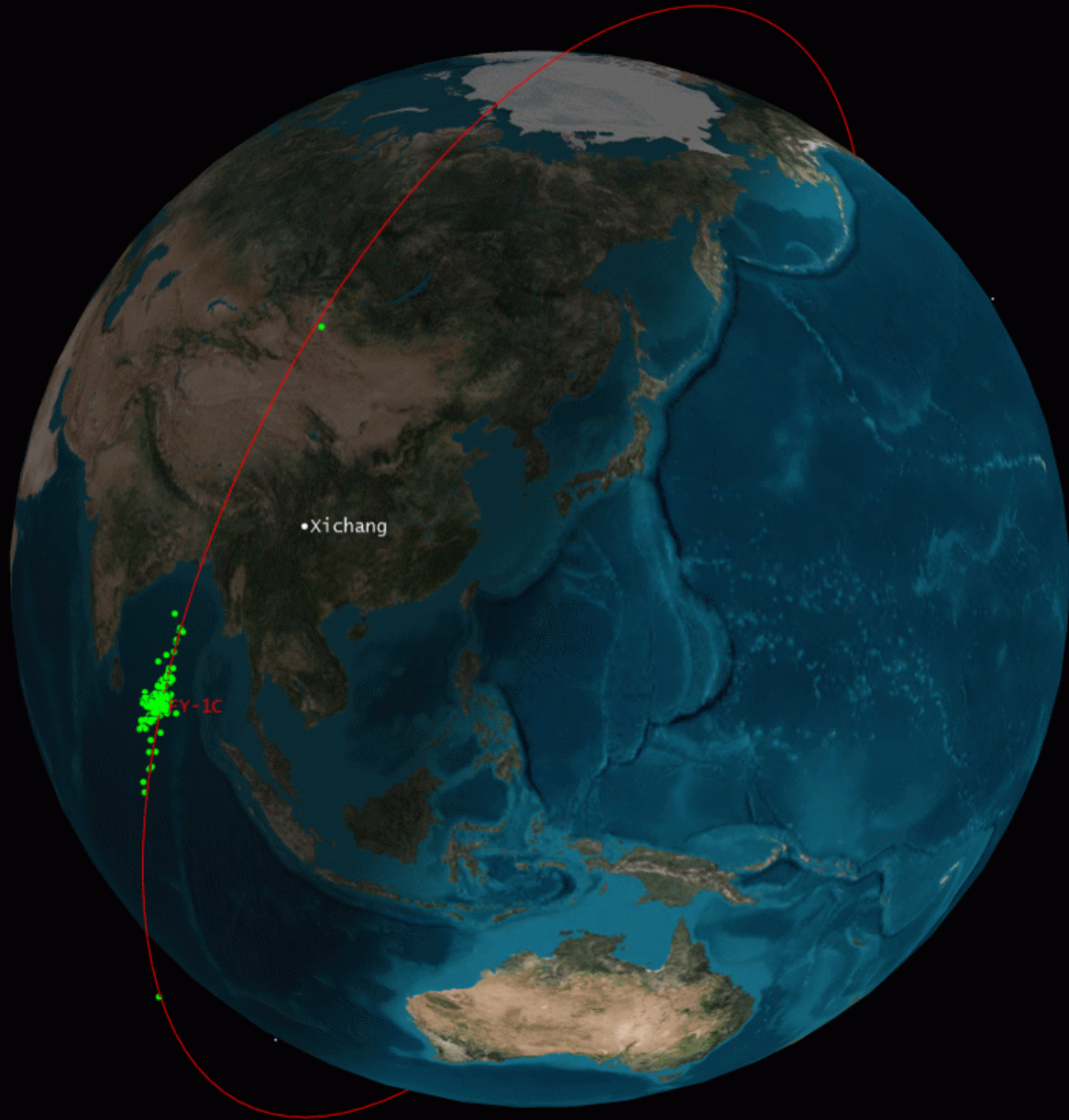


The Fragmentation Event



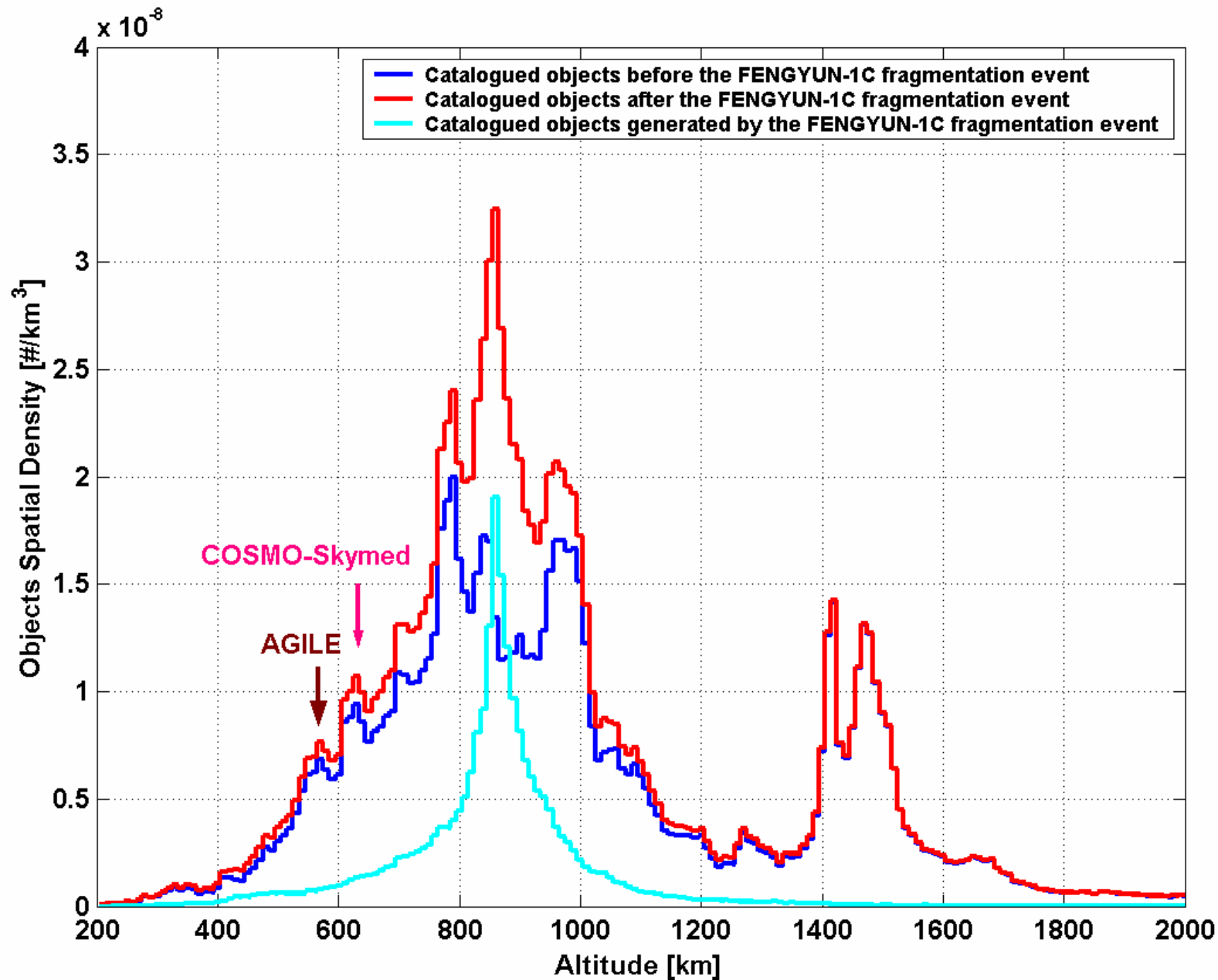
The Fragmentation Event



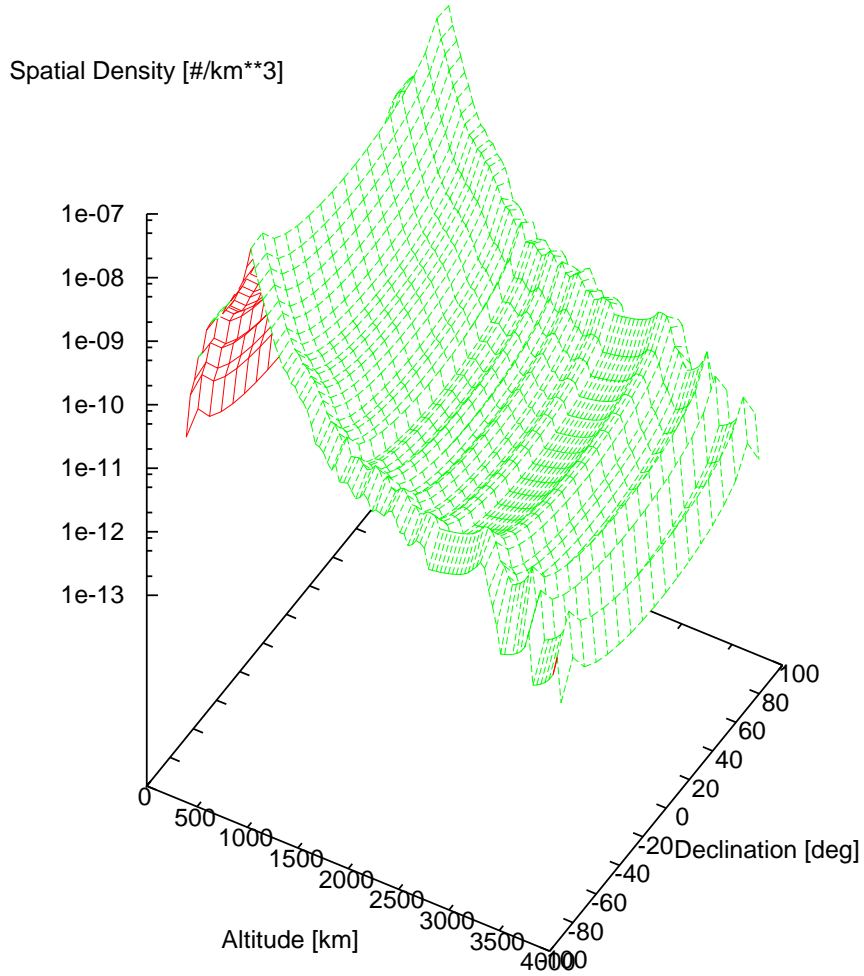


•Xi chang

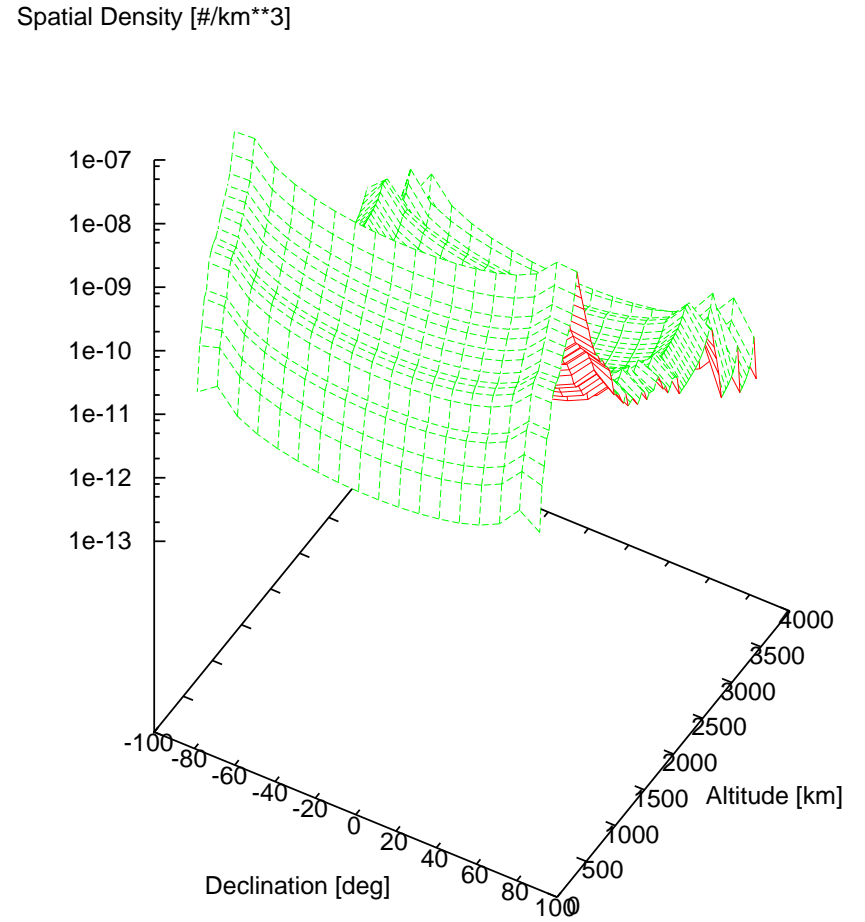
FY-1C



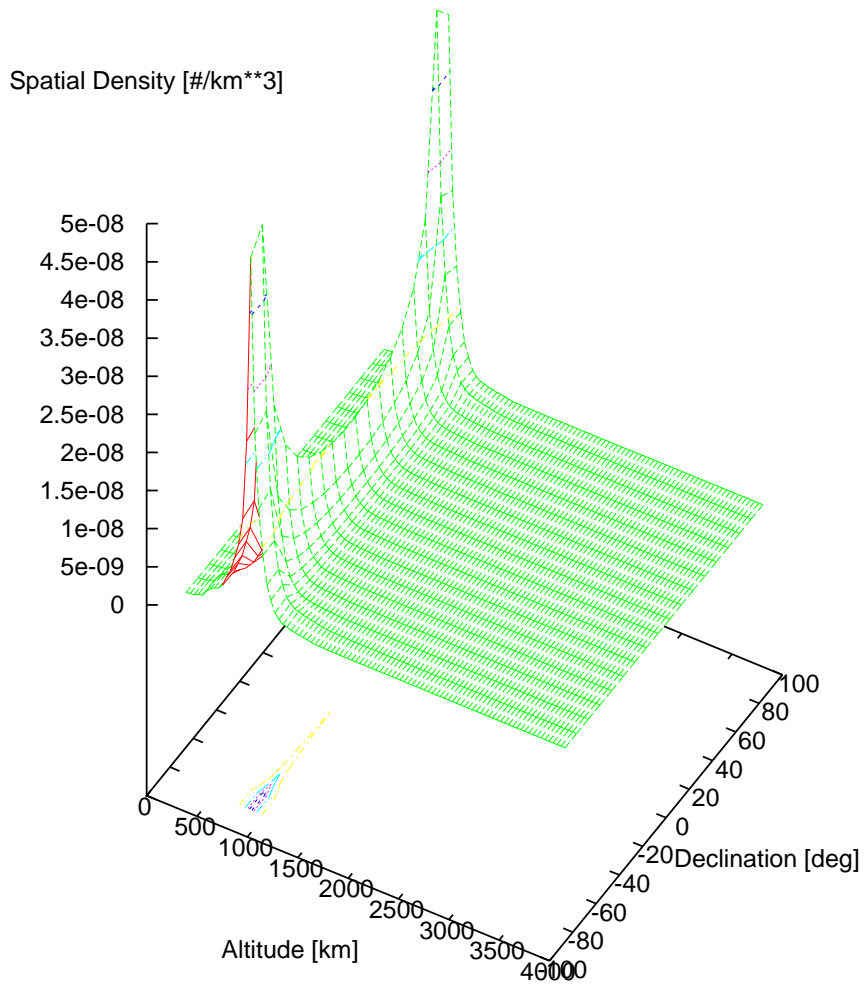
DEBRIS DISTRIBUTION OF THE FENGYUN-1C FRAGMENTATION EVENT



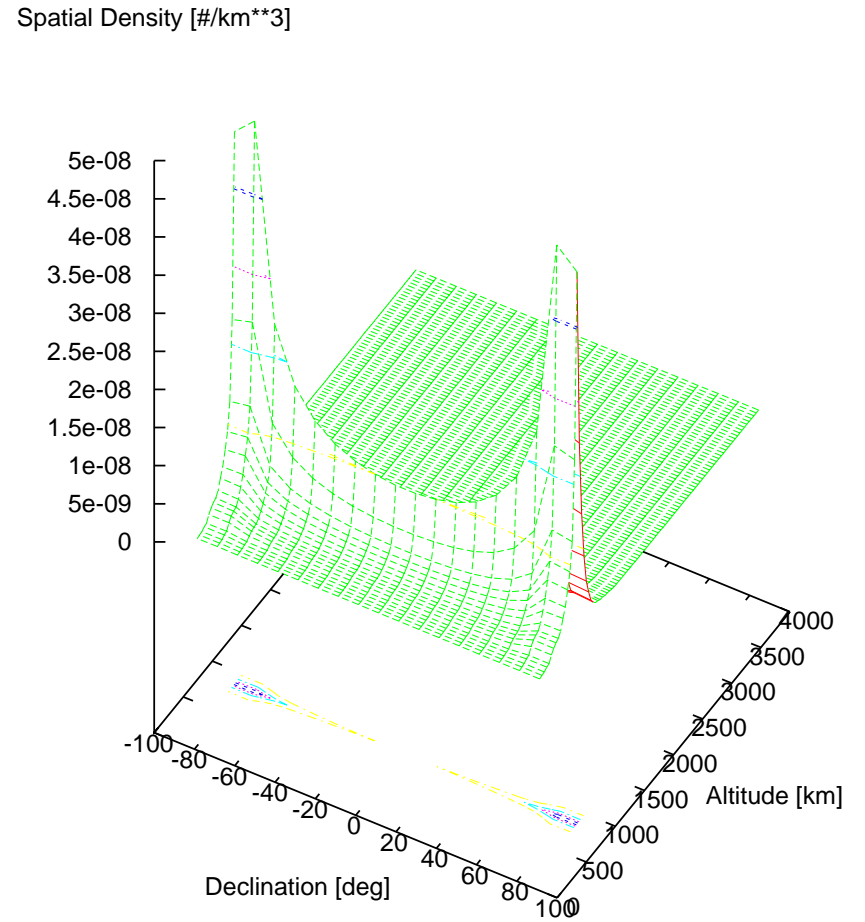
DEBRIS DISTRIBUTION OF THE FENGYUN-1C FRAGMENTATION EVENT



DEBRIS DISTRIBUTION OF THE FENGYUN-1C FRAGMENTATION EVENT



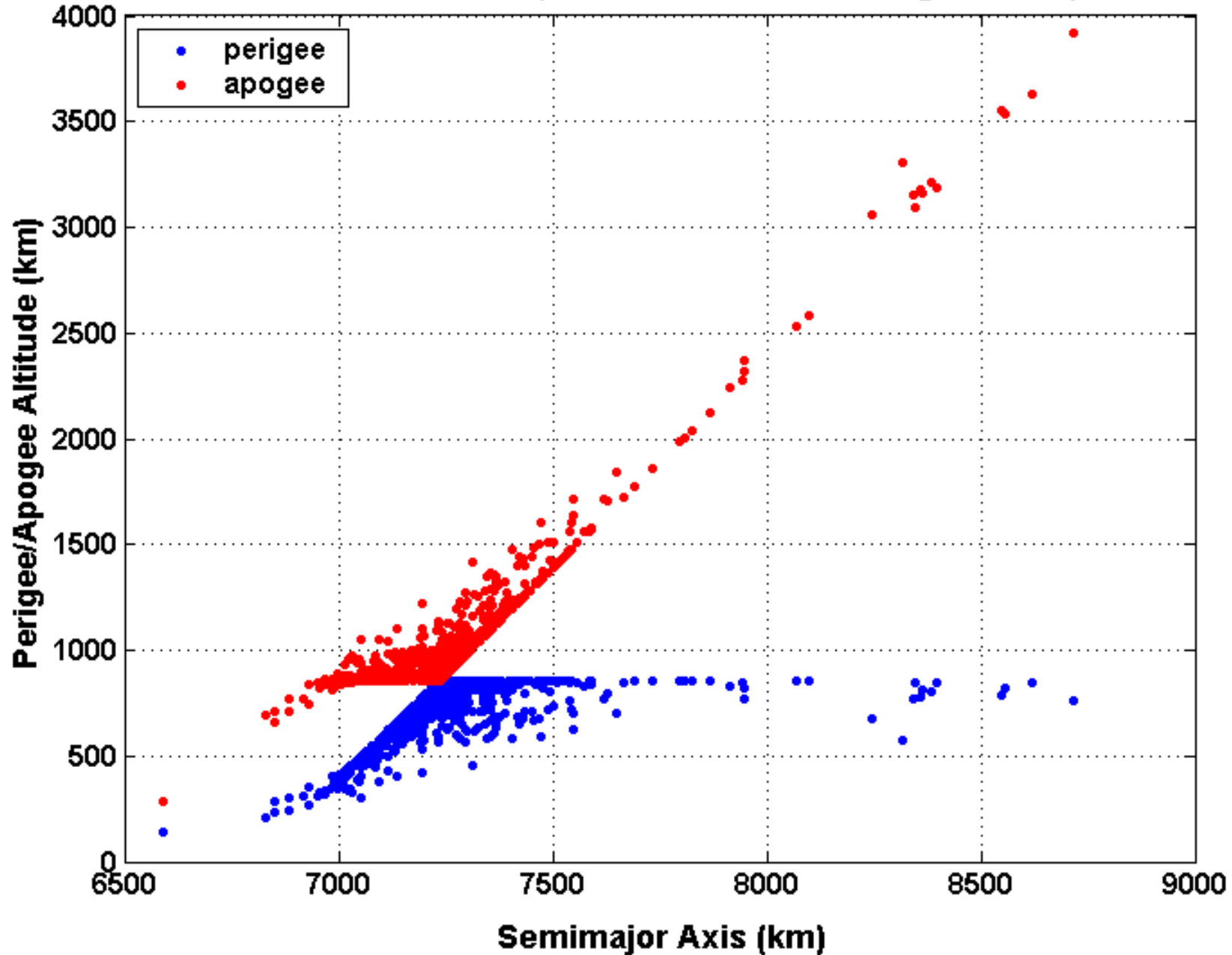
DEBRIS DISTRIBUTION OF THE FENGYUN-1C FRAGMENTATION EVENT



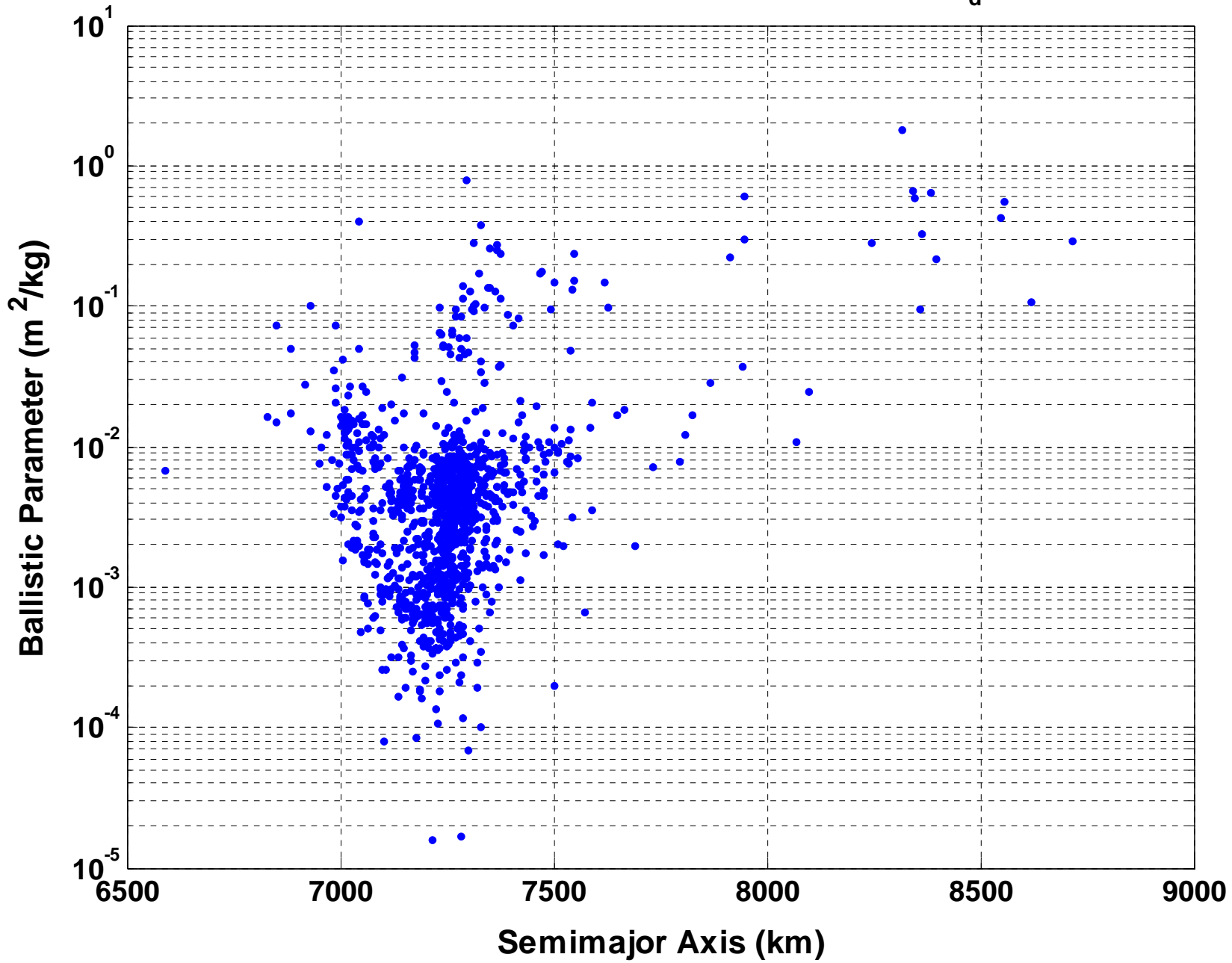
Simulation of Cloud Evolution

- Propagation over 15 years of **1799** fragments, taking into account the following perturbations:
 - Earth gravity field harmonics (16 x 16)
 - Luni-solar third body attraction
 - Solar radiation pressure with eclipses
 - Air drag
- Atmospheric Model: Jacchia-Roberts 1971
- Solar activity prediction: NASA Marshall Space Center 50% percentile prediction for the 10.7 cm solar flux proxy and the planetary geomagnetic index (available until February 2022)
- Ballistic parameter: obtained from B^* (TLEs)

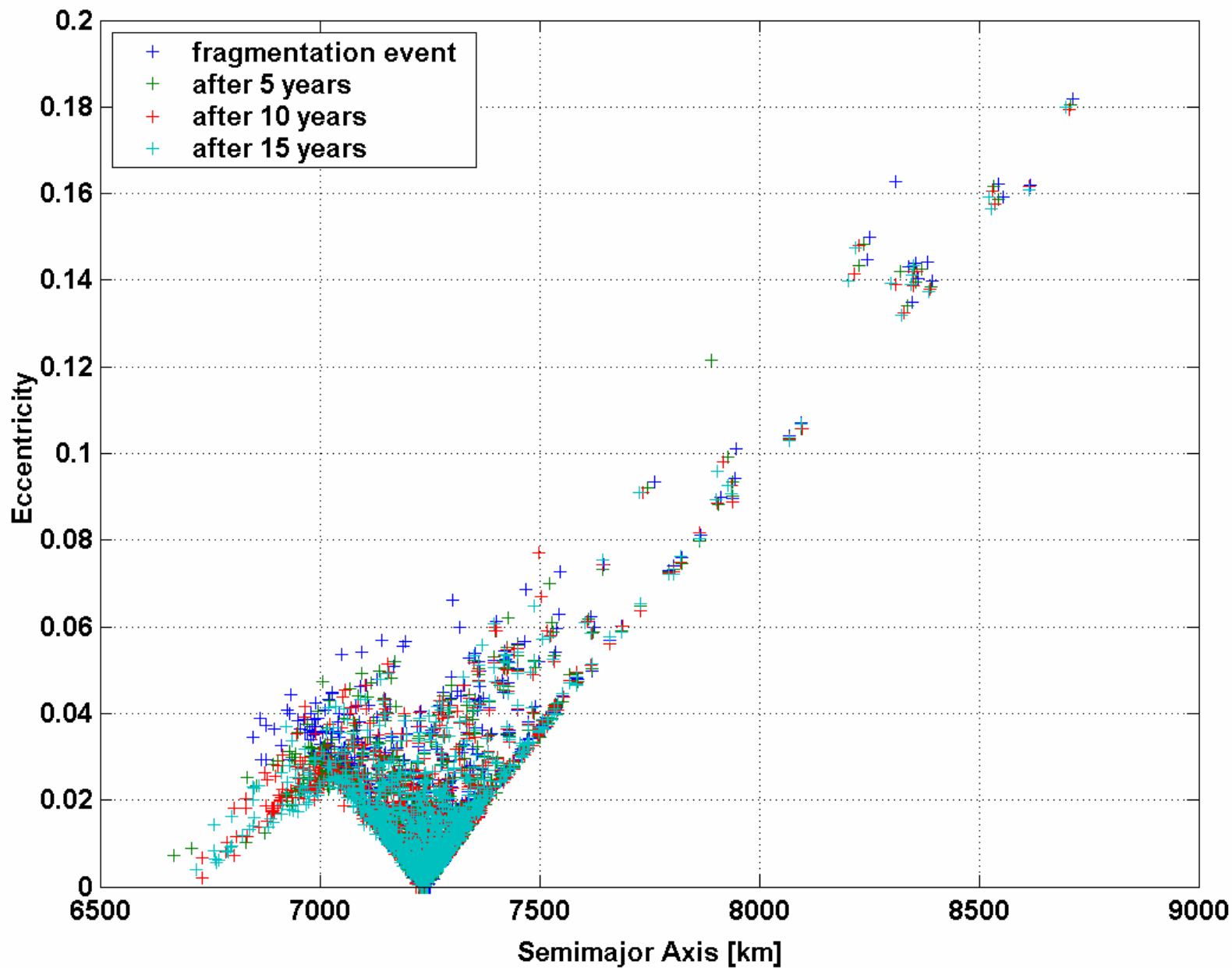
GABBARD DIAGRAM (around 1 month after the fragmentation)



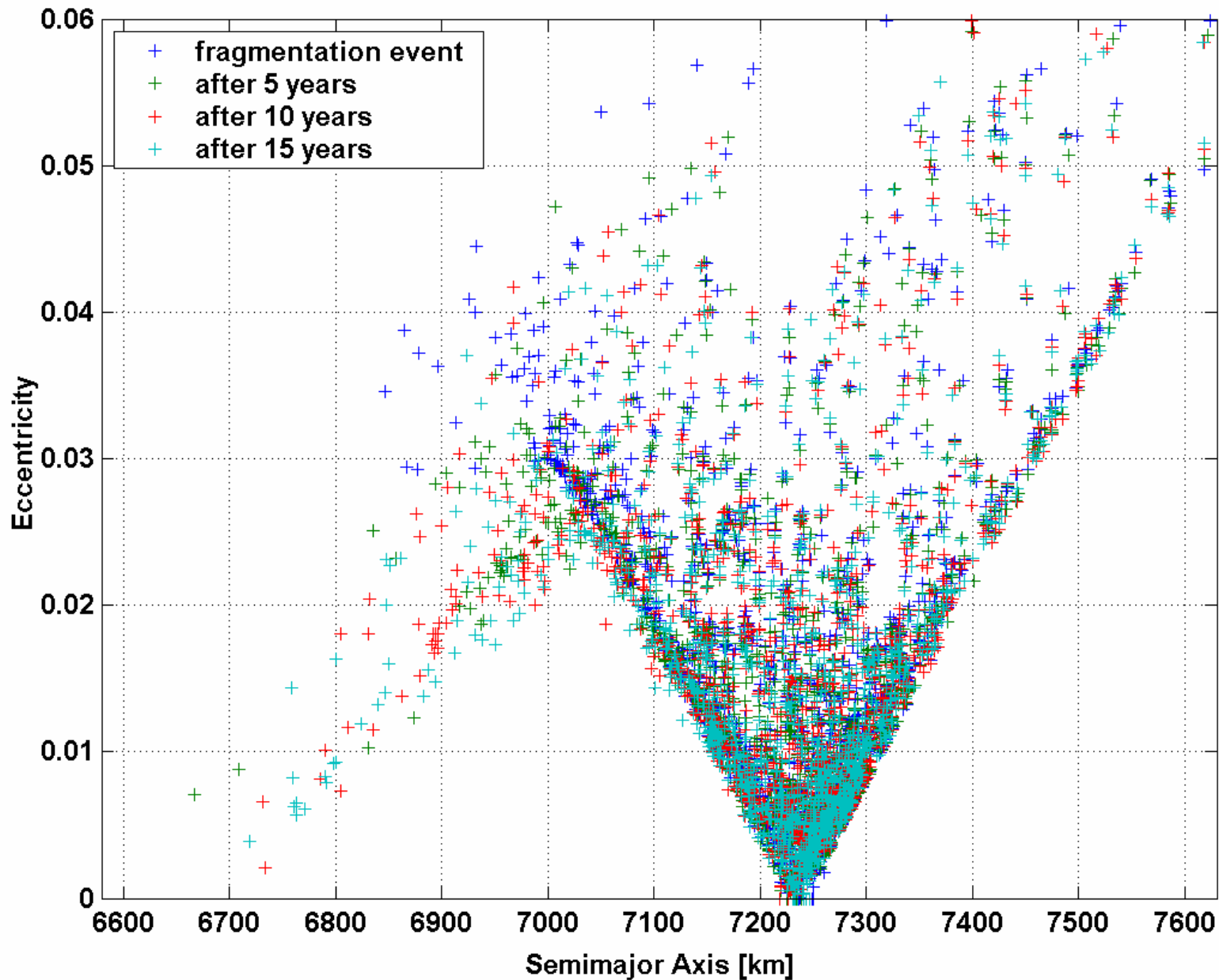
DISTRIBUTION OF BALLISTIC PARAMETERS ($B = C_d A / M$)



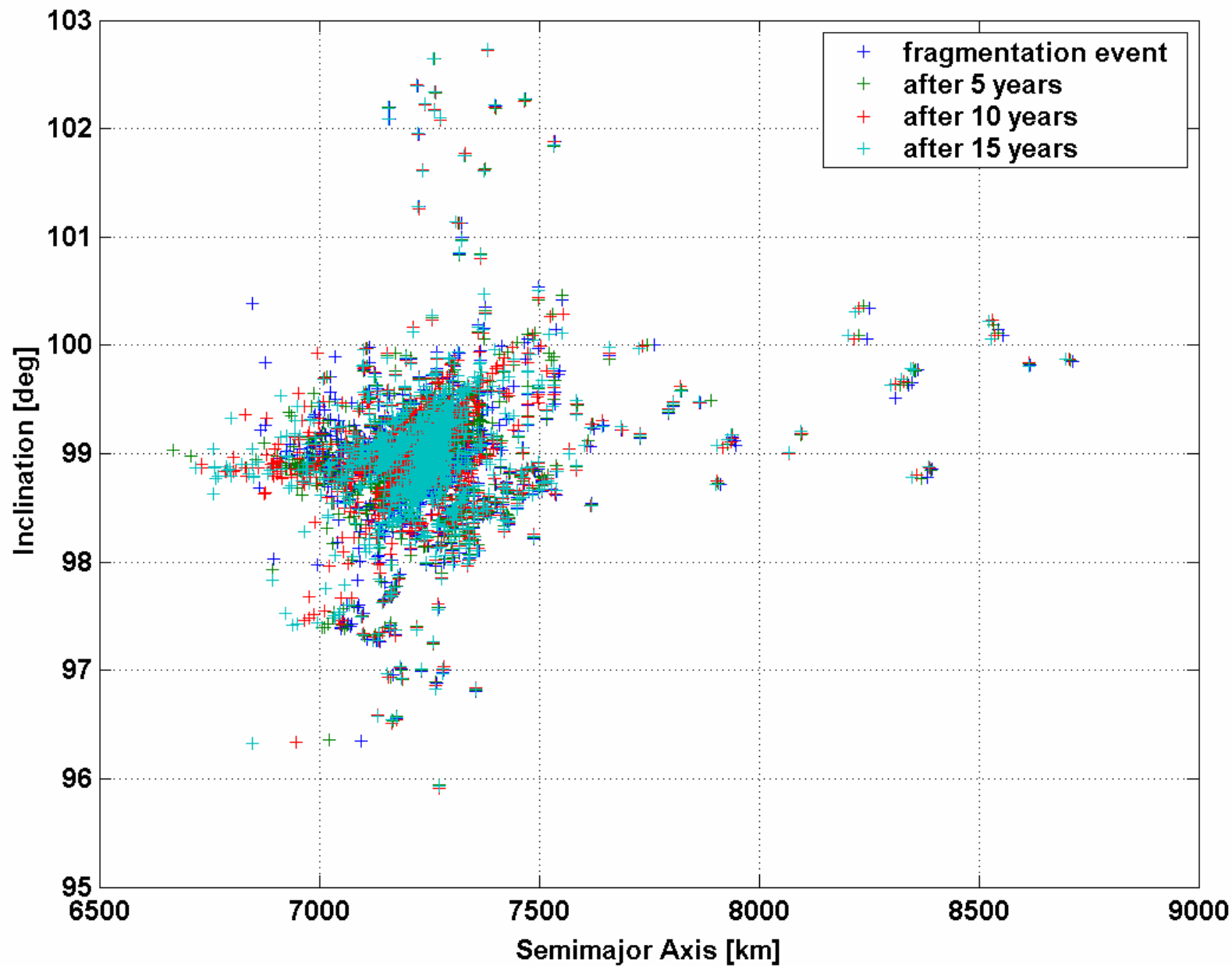
Evolution of eccentricity vs. semimajor axis



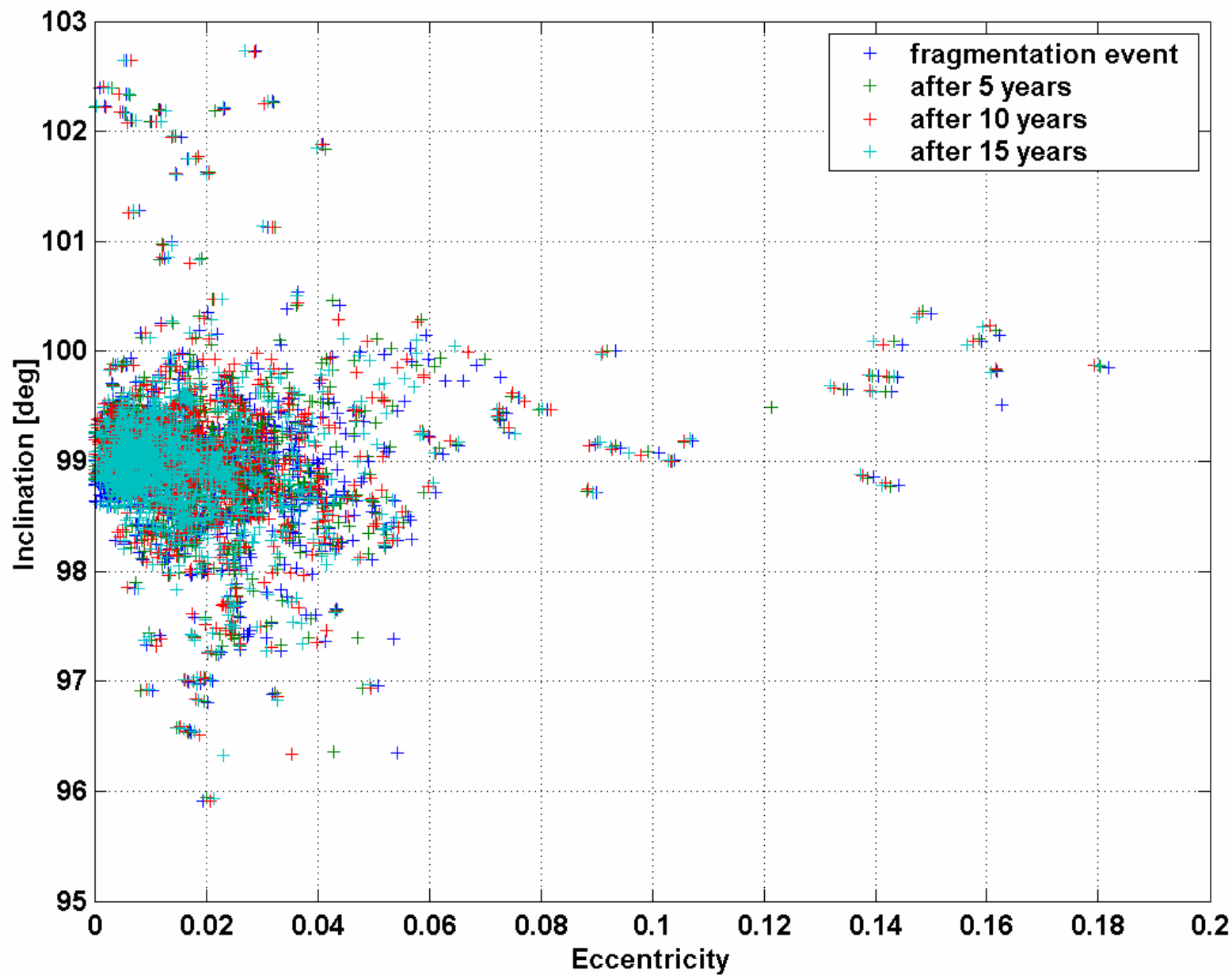
Evolution of eccentricity vs. semimajor axis



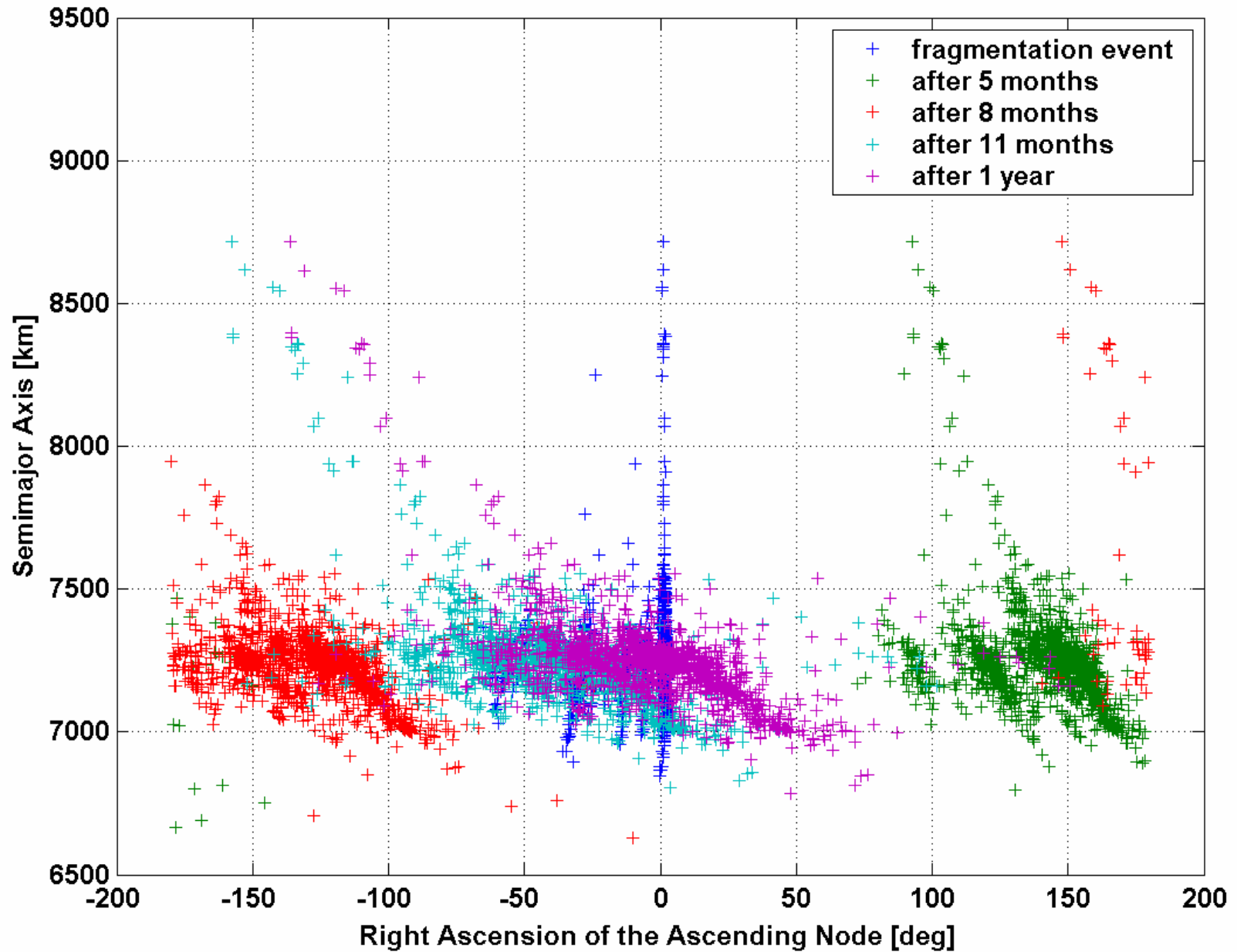
Evolution of inclination vs. semimajor axis



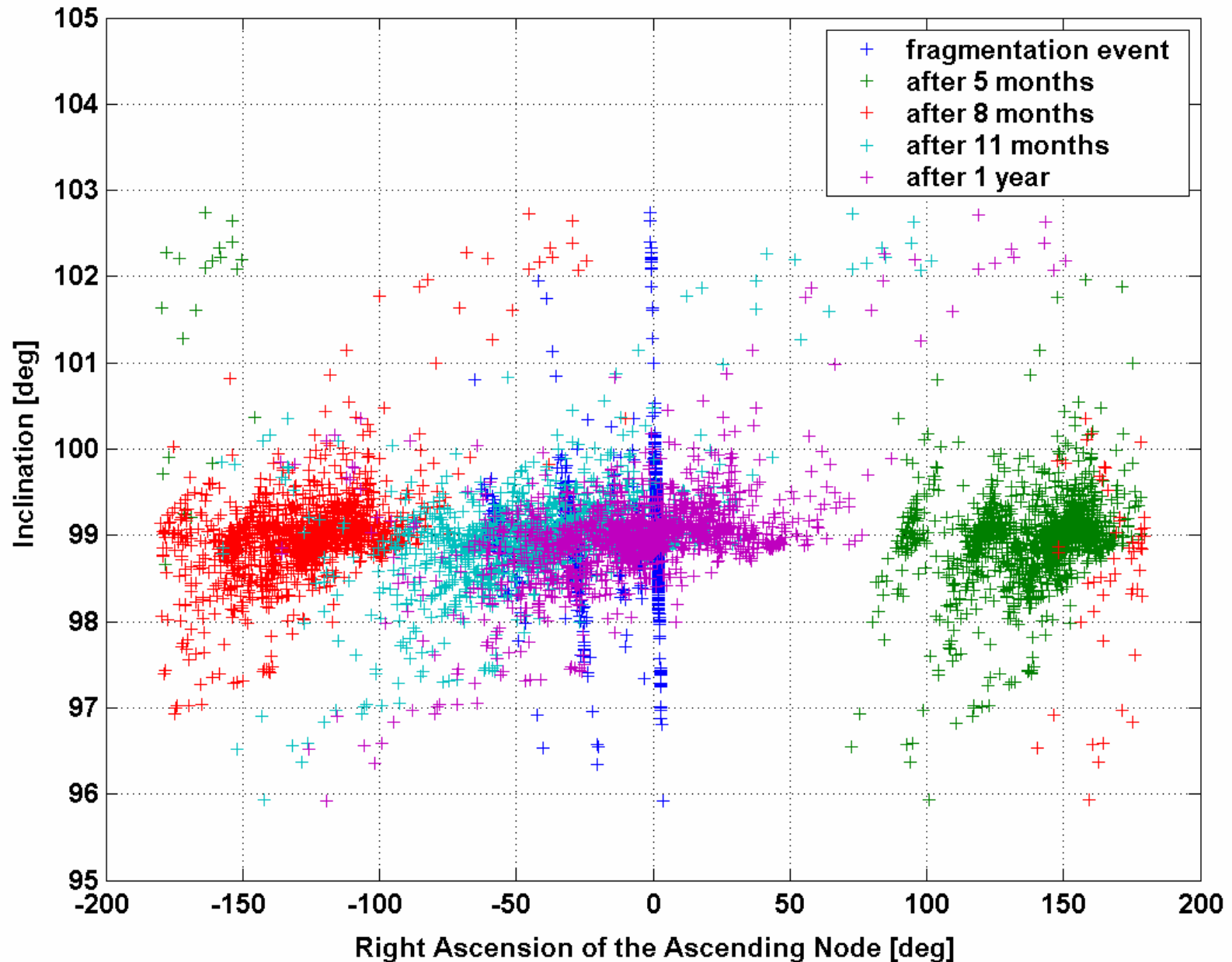
Evolution of inclination vs. eccentricity



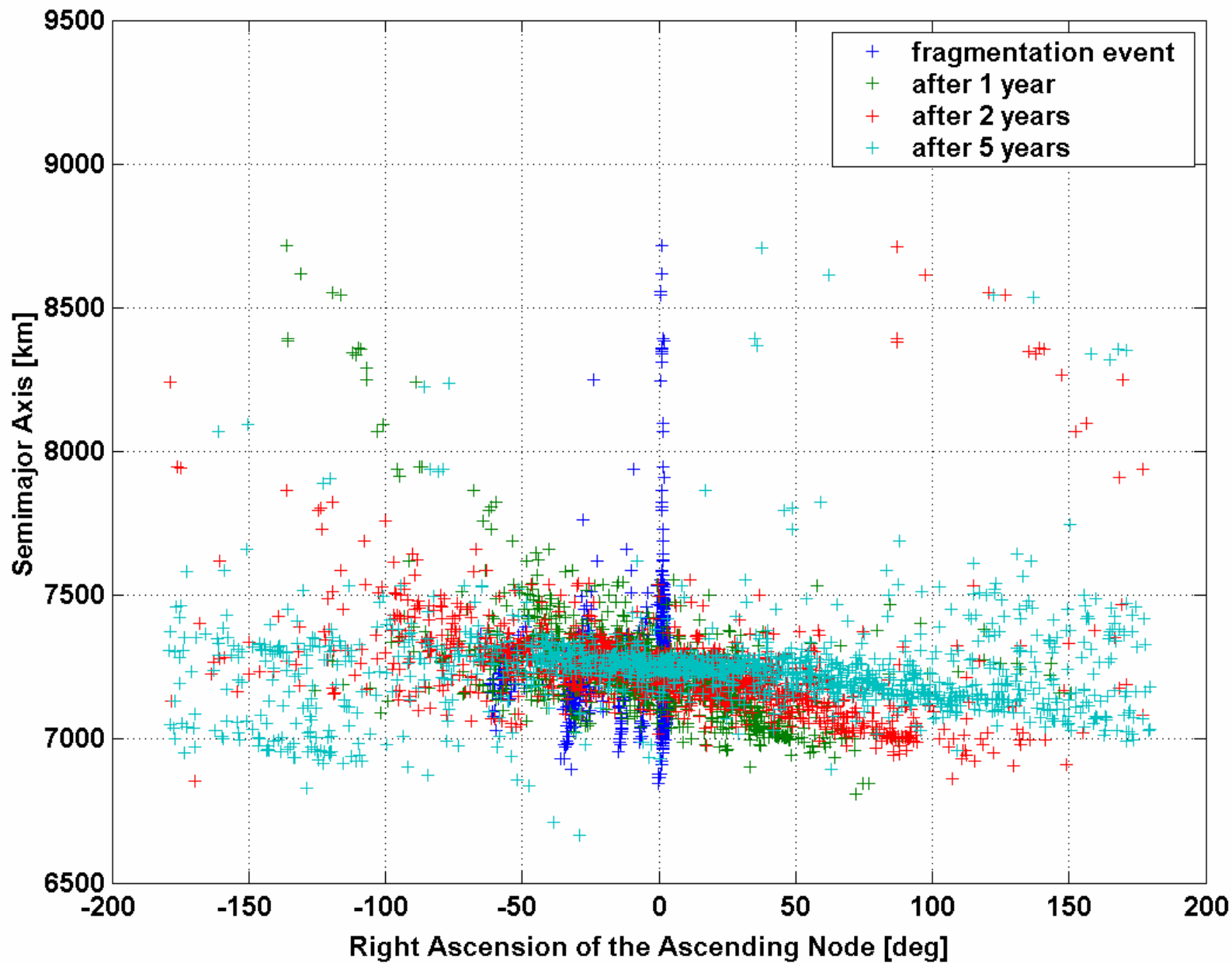
Dispersion of the debris orbit planes during the first year



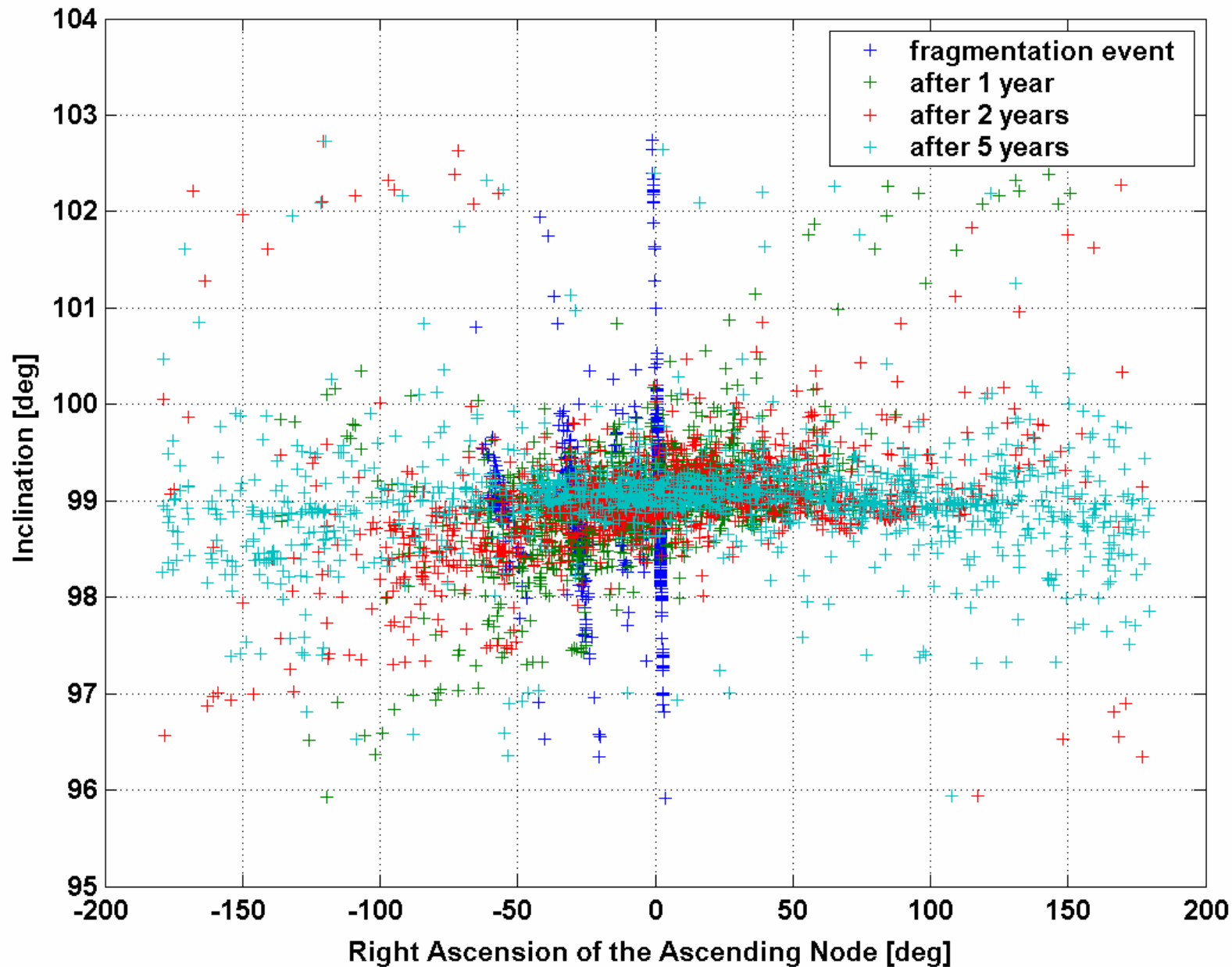
Dispersion of the debris orbit planes during the first year

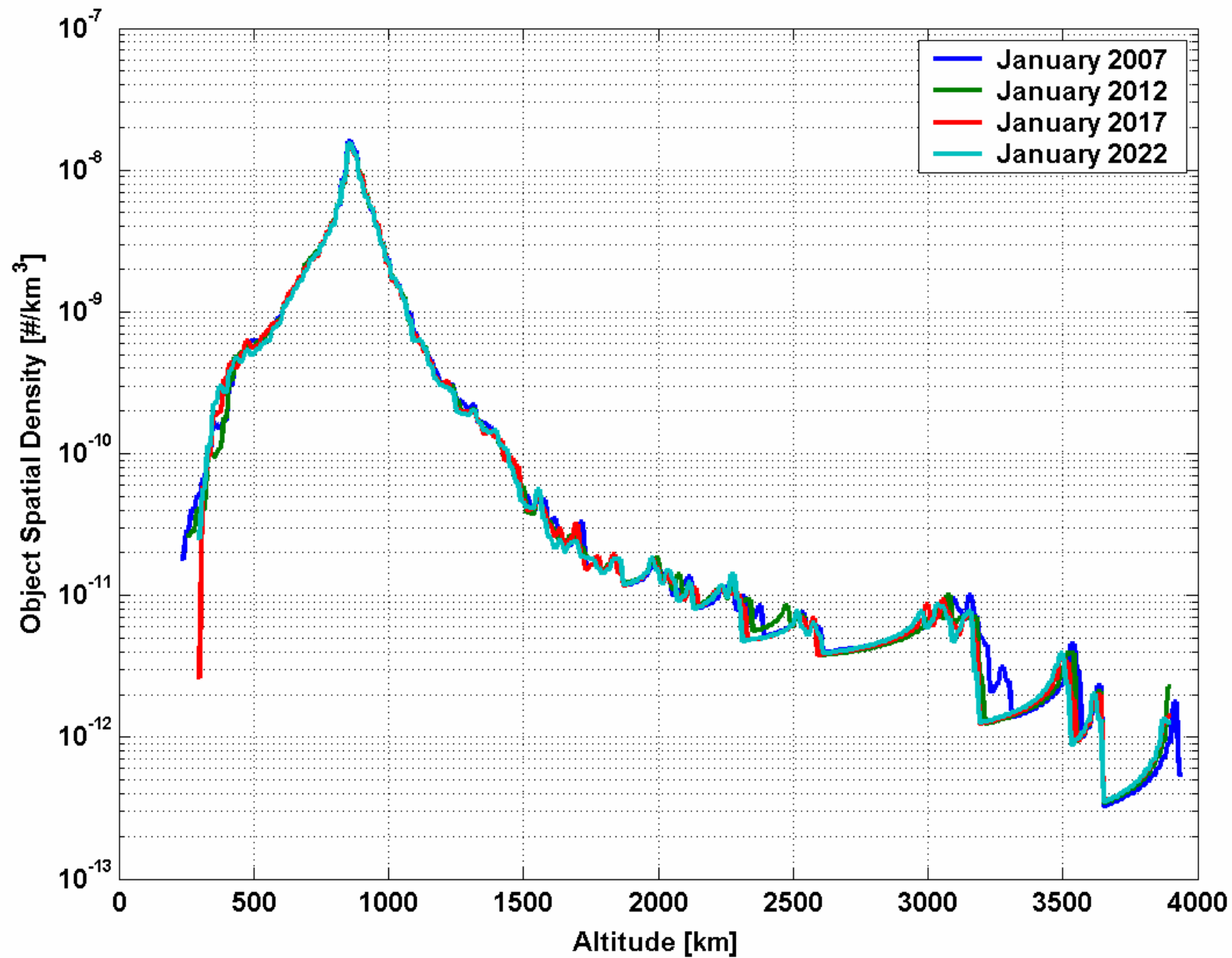


Dispersion of the debris orbit planes during the first 5 years



Dispersion of the debris orbit planes during the first 5 years





Debris Orbital Decay

- Only a few objects (of the 1799 propagated) decay during the first 15 years:
 - 9 after 1 year (0.50%) → 1790 objects in orbit
 - 13 after 2 years (0.72%) → 1786 objects in orbit
 - 29 after 5 years (1.61%) → 1770 objects in orbit
 - 36 after 10 years (2.00%) → 1763 objects in orbit
 - 52 after 15 years (2.89%) → 1747 objects in orbit
- The decay rate may be underestimated because the ballistic parameters B were obtained from B* (TLEs) during a solar cycle minimum
- For this reason, at low altitude (~ 200 km) the values of B were probably underestimated by a factor ~ 2

Conclusions

- The Fengyun-1C cloud is very stable and will not suffer a substantial debris decay in the next 15 years
- The perturbations spread the debris polar orbit planes around the Earth in about 8 months
- The maximum effective ΔV applied by the ASAT test to the observed fragments was ~ 600 m/s
- The a priori impact hazard due to cataloged objects for the Italian operational or planned spacecraft in LEO has been increased by $\sim 17\%$
- Cataloged debris (June 26): 1807 (12 decayed)

Acknowledgments

- Two-Line Elements for debris of the ASAT test courtesy of Space Track Organization (www.space-track.org)
- Two STK-generated images courtesy of Center for Space Standards & Innovation (www.centerforspace.com)
- The Satellite Tool Kit (STK) is a software of Analytical Graphics Incorporated (AGI) (www.agi.com/products/stk80/)
- Three images were generated by the authors with STK, version 4.3.0