The past, present and future of space debris measurements at EISCAT

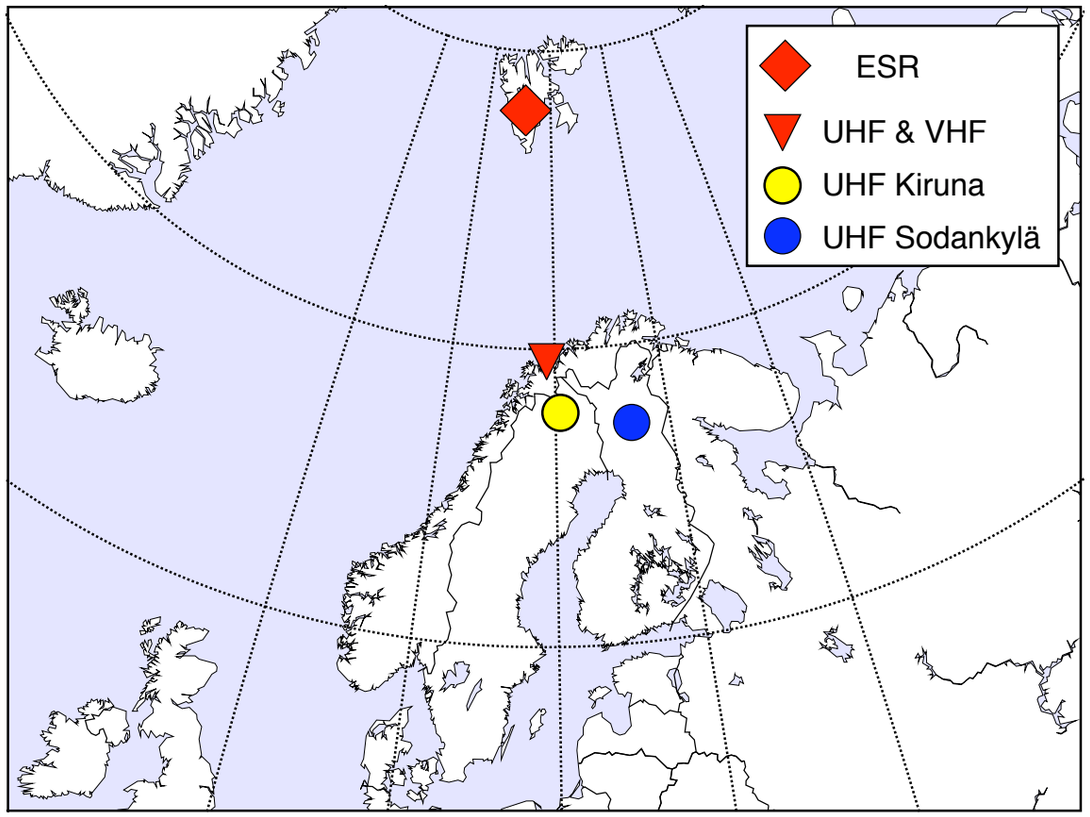
J Markkanen, EISCAT

J Vierinen, SGO

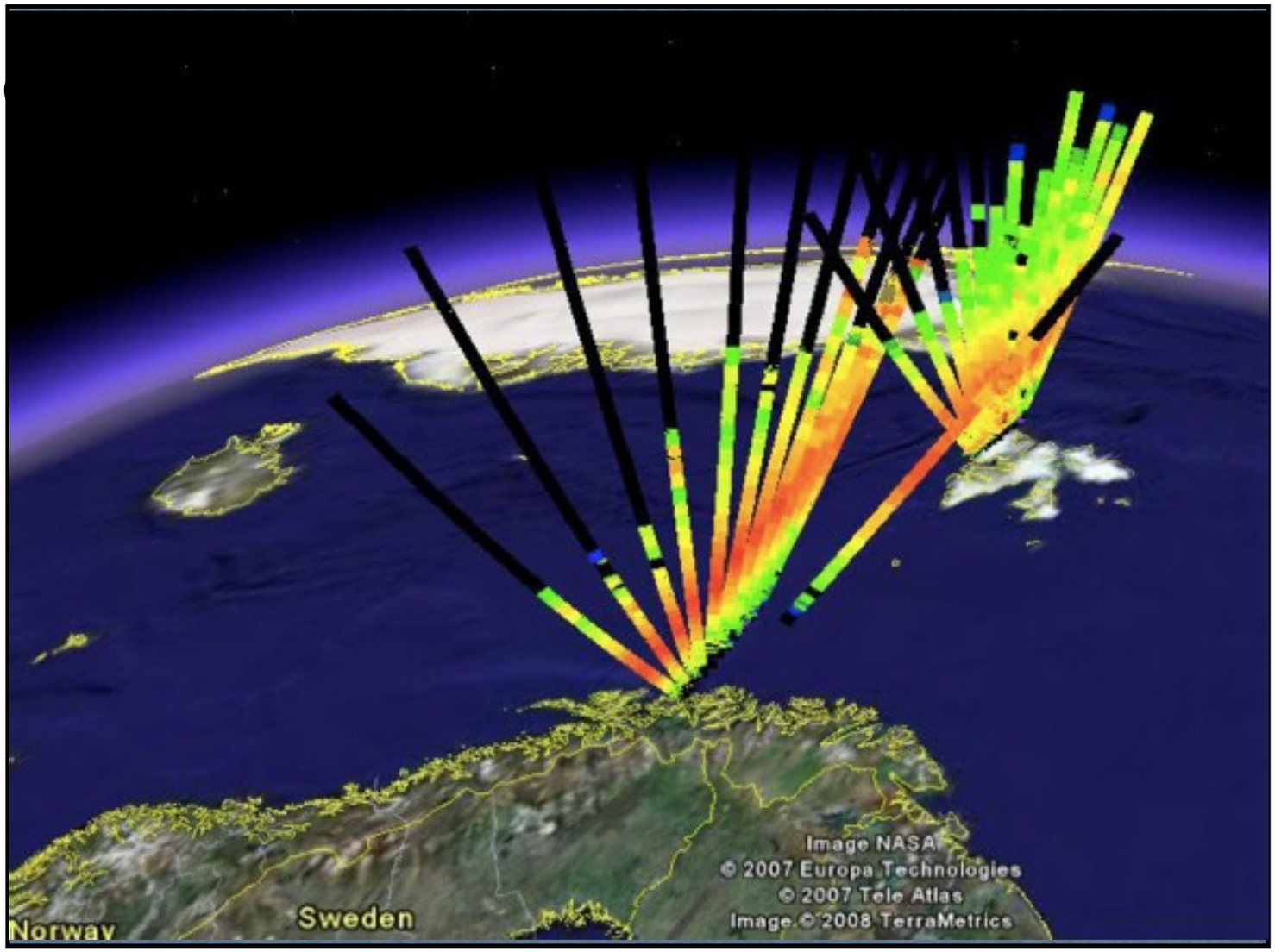
- The EISCAT system
- Past and Present - some examples
- Future - EISCAT 3D - SSA

CEAS-09 26 - 29 Oct 2009, Manchester, UK

Three ionospheric research radars



(Courtesy of Y Ogawa and A Saito, and Google Earth)

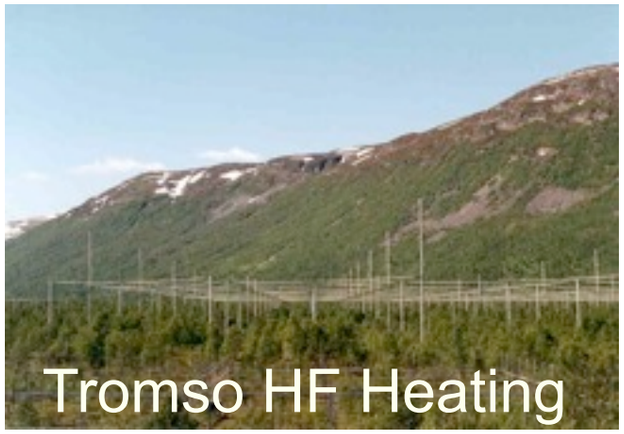


EISCAT scientific association

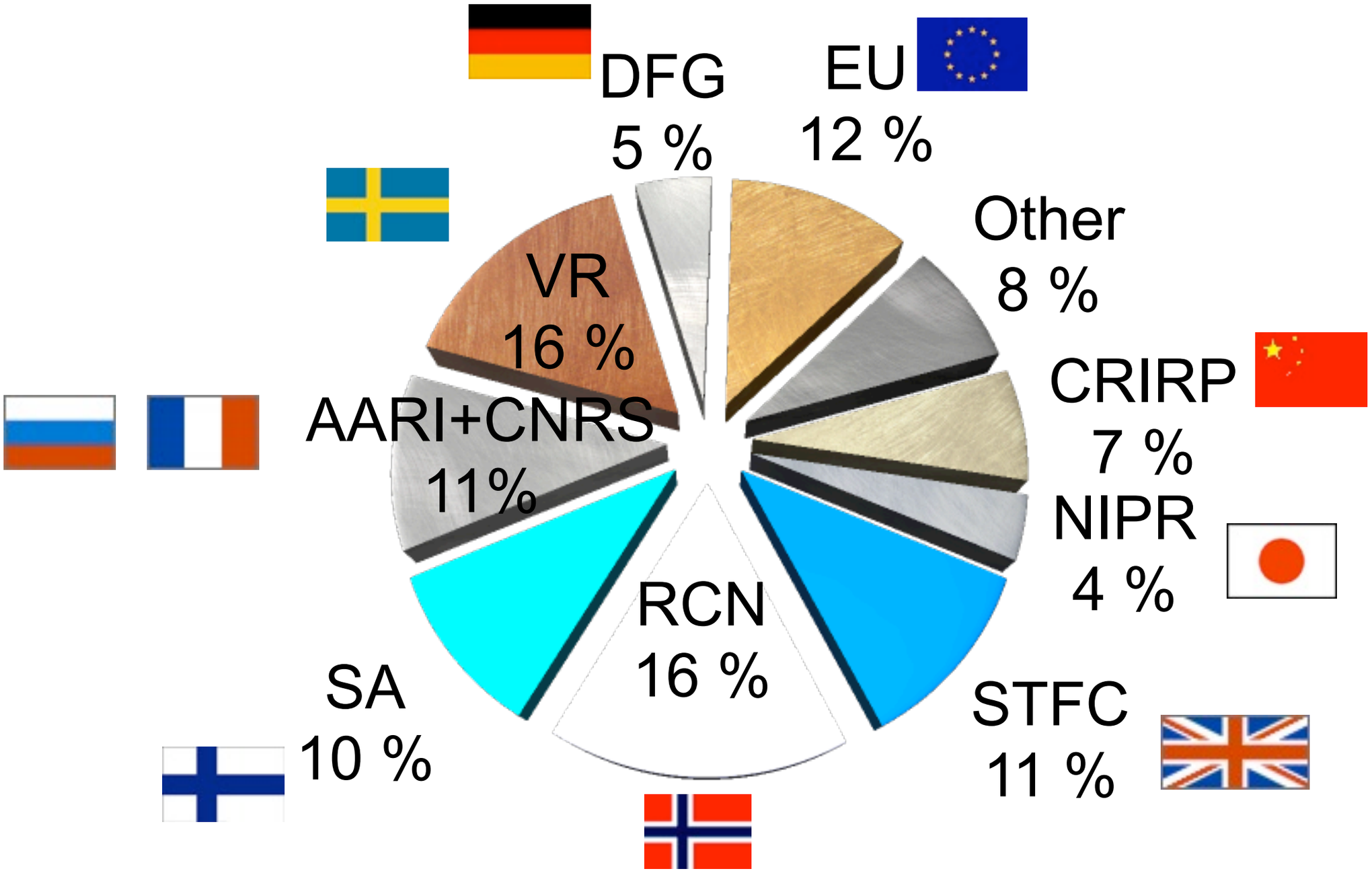
2009

Associate countries

Contributing



Operation costs 2008: 3.2 M EUR

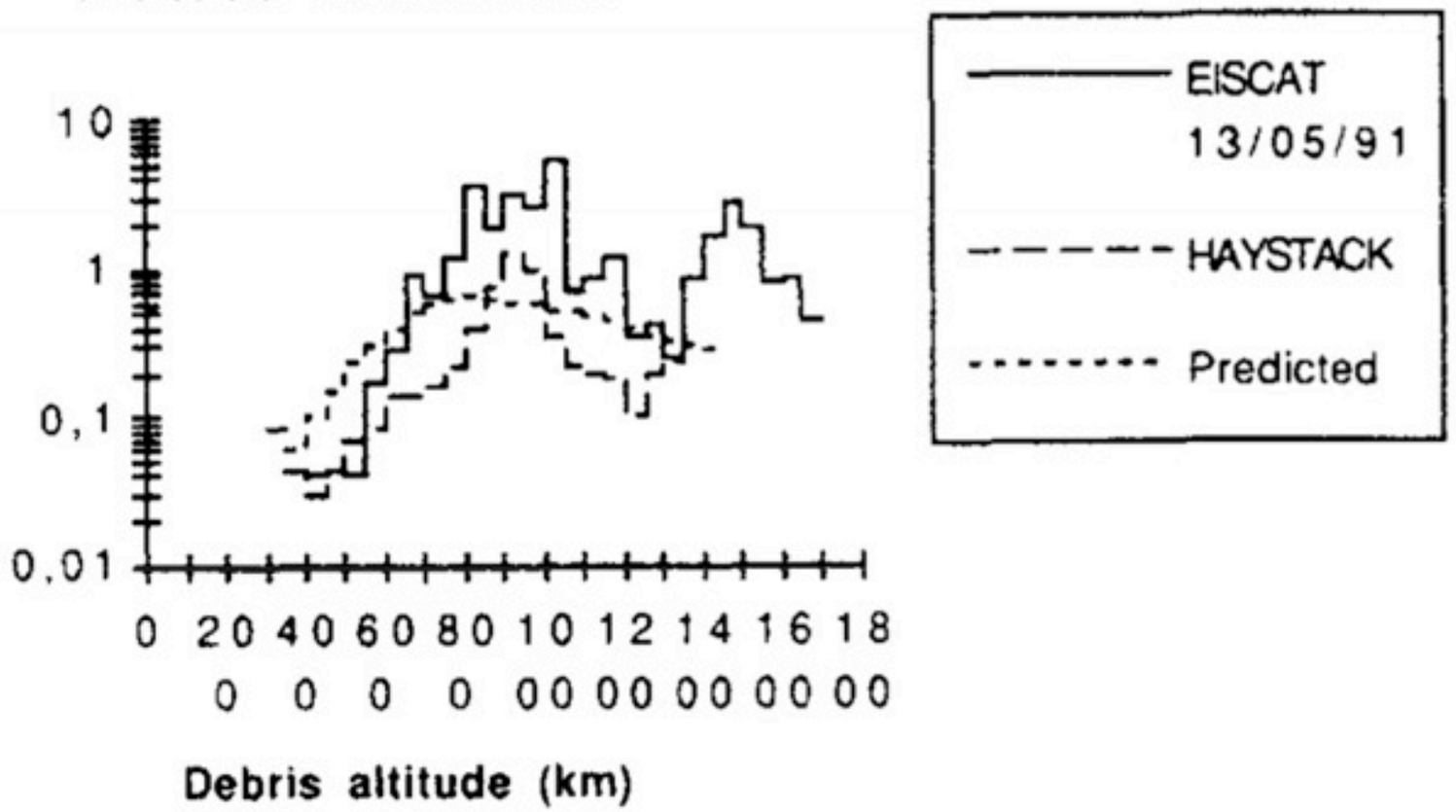


The Past

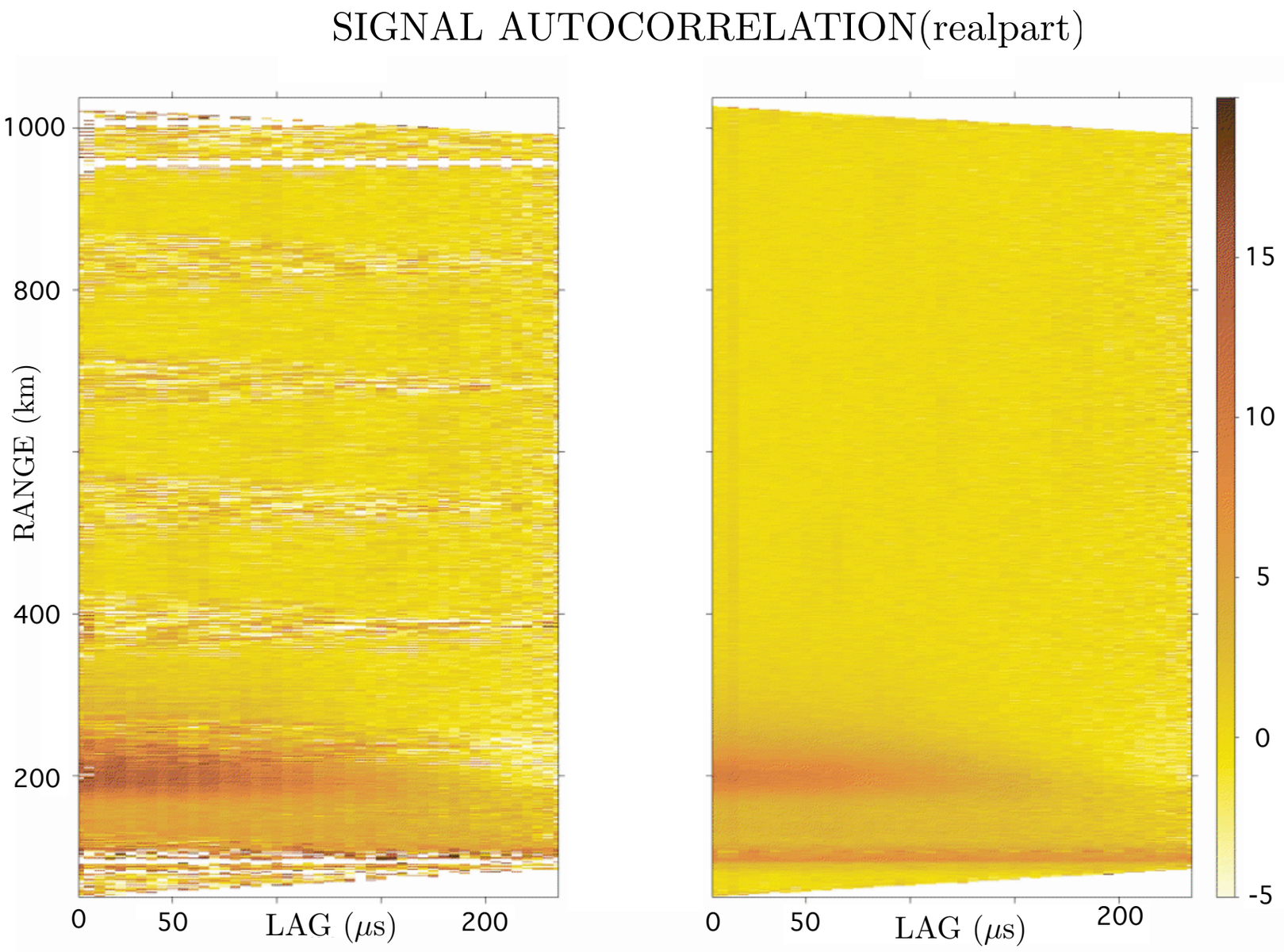
The beginning

Mandeville, Riboni, Blelly
Adv. Space Res. 16, 11, 1995

Interpretation of EISCAT
radar data for orbital debris study



Debris in standard ionospheric data



2nd wave

ESA CONTRACT 1
2000-2001

MEASUREMENTS OF SMALL-SIZE DEBRIS WITH BACKSCATTER OF RADIO WAVES

J Markkanen, M Lehtinen, A Huuskonen, A Väänänen

Is feasible

Sodankylä Geophysical Observatory

CONTRACT 2
2003-2004

REAL-TIME SMALL-SIZE SPACE DEBRIS DETECTION WITH EISCAT RADAR FACILITIES

J Markkanen and M Postila

Is practical

EISCAT Scientific Association

Measurements prior the International Polar Year

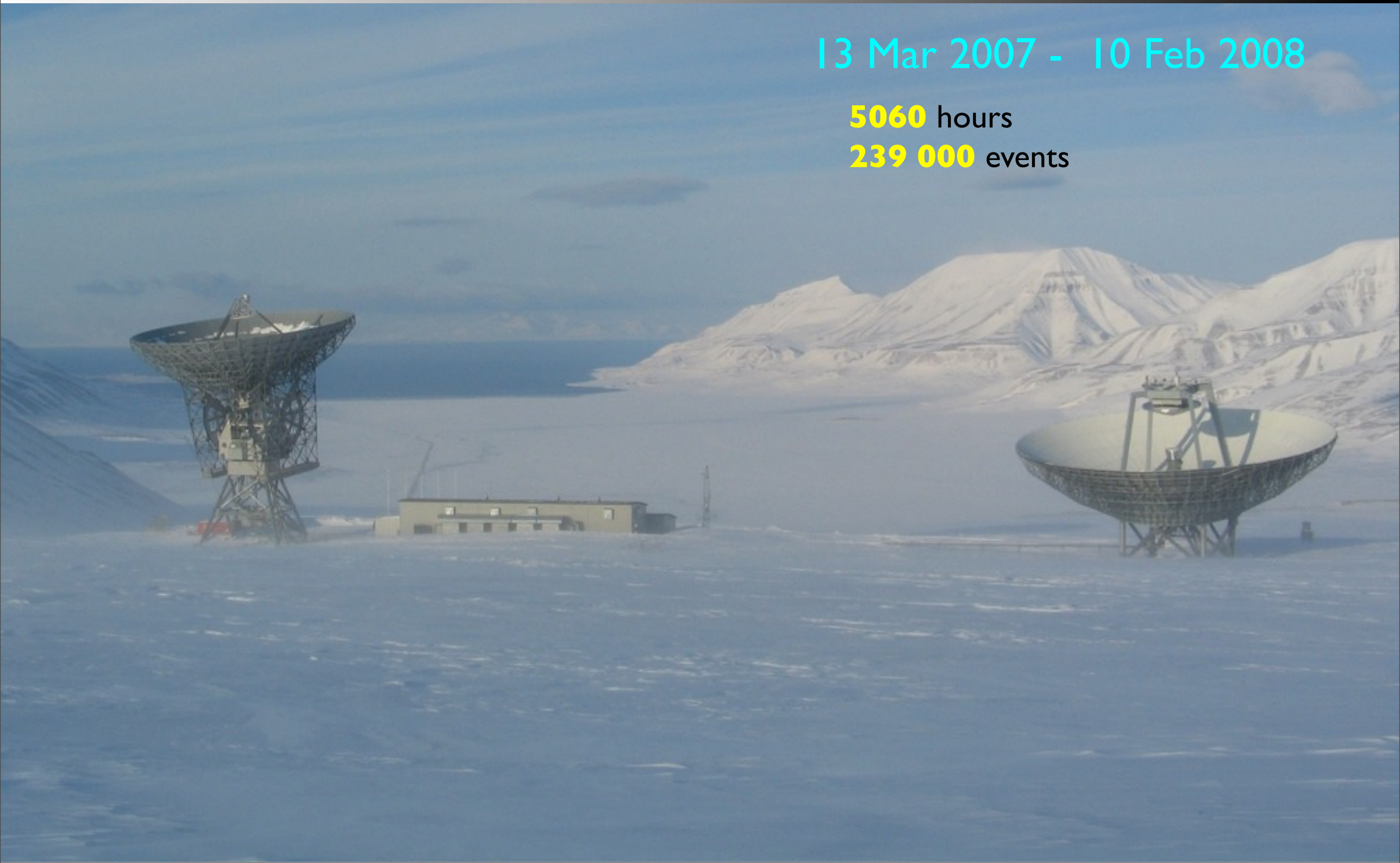
experiment	date	hours	events
Tau2 FA	9-13 Nov 04	100	1520
Manda FA	11-13 Aug 05	51	800
Tau2 4-park	7-29 Sep 05	545	5150
Tau0 42m	10 Nov 05	24	650
Manda FA	17-20 Nov 05	79	1350
Tau2 FA	13 Mar-6 Apr 06	387	6820
Steffe 42m	17-23 Mar 06	138	5240
Steffeleo 32m	8-9 Jul 06	24	1660
	Total	1296	23190

Measurements during the IPY

13 Mar 2007 - 10 Feb 2008

5060 hours

239 000 events



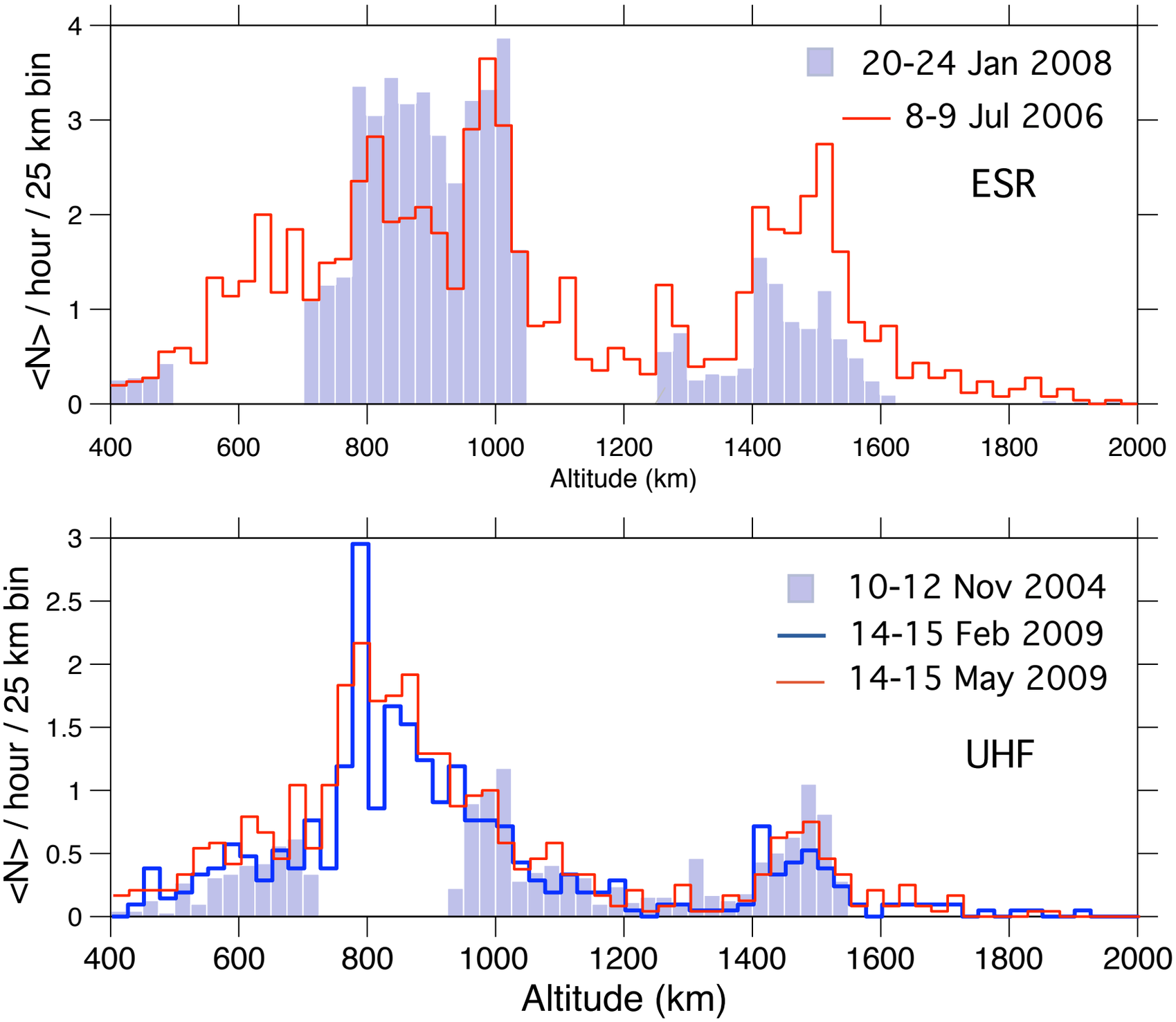
Measurement strategy

- Piggy-packed measurements
- Dedicated receiver back-end
- Coherent integration in data processing

Measurement characteristics

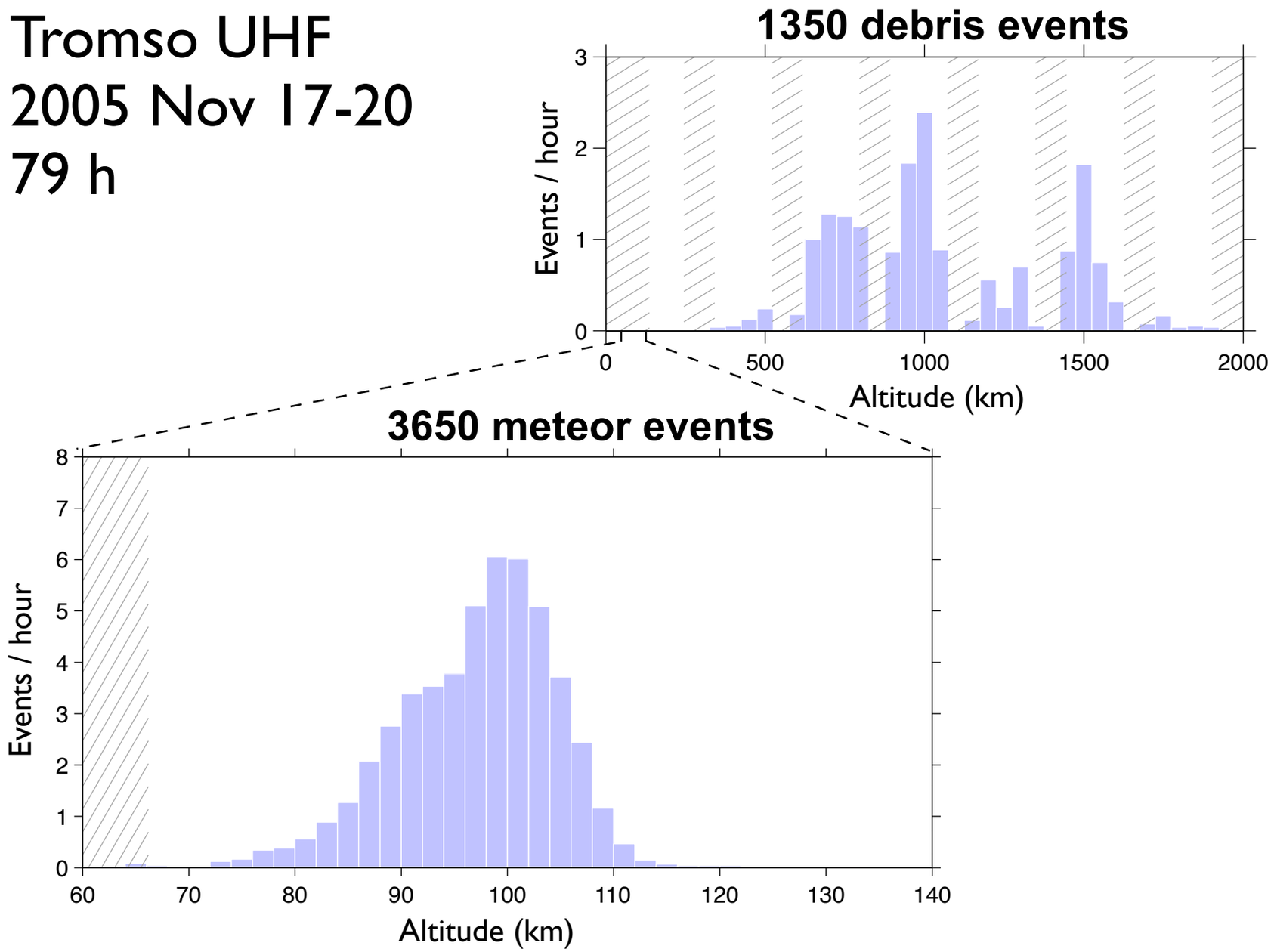
- Two latitudes (70 and 78 N)
- Three wavelengths (1.33 m, 0.60 m, 0.32 m)
- 4+2 antennas
- Long time series (up to a year... so far)
- Decent detection sensitivity (3-4 cm @ 1000 km)
- Magnetic field aligned pointing direction
- Only statistical info on RCS
- Gaps in altitude coverage in standard measurements

Debris event rate v. altitude



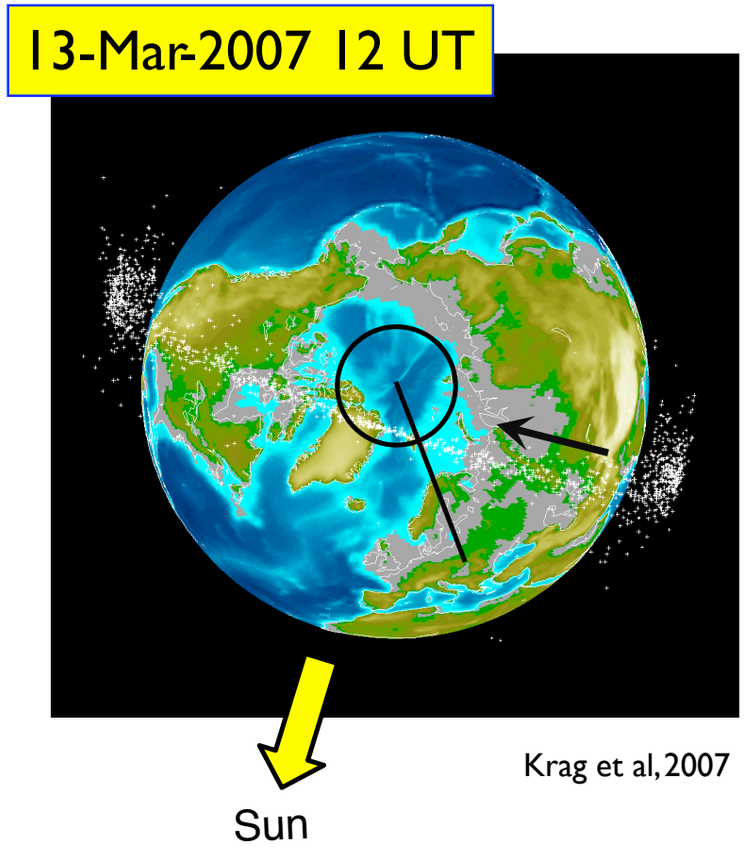
Debris/meteor event rate v. altitude

Tromso UHF
2005 Nov 17-20
79 h

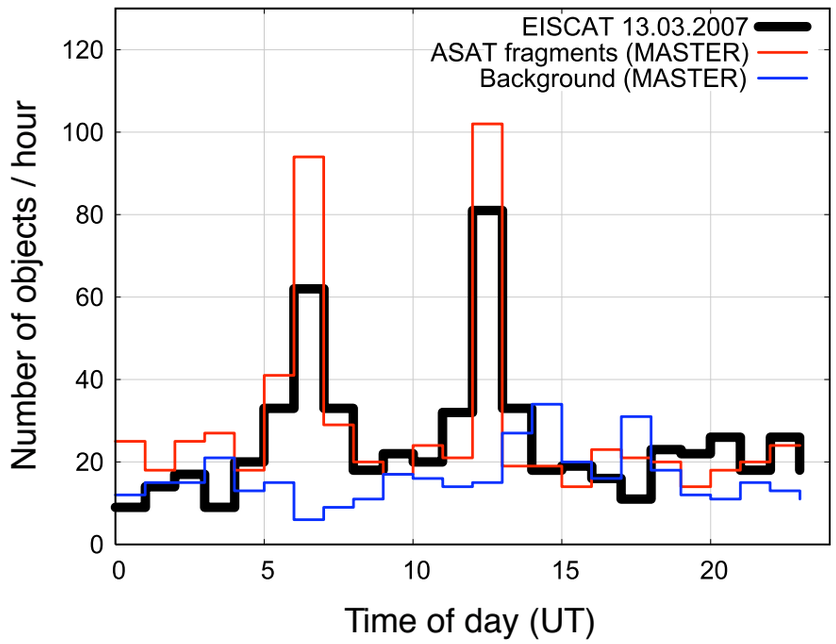


EISCAT space debris during the IPY

FY 1C debris cloud



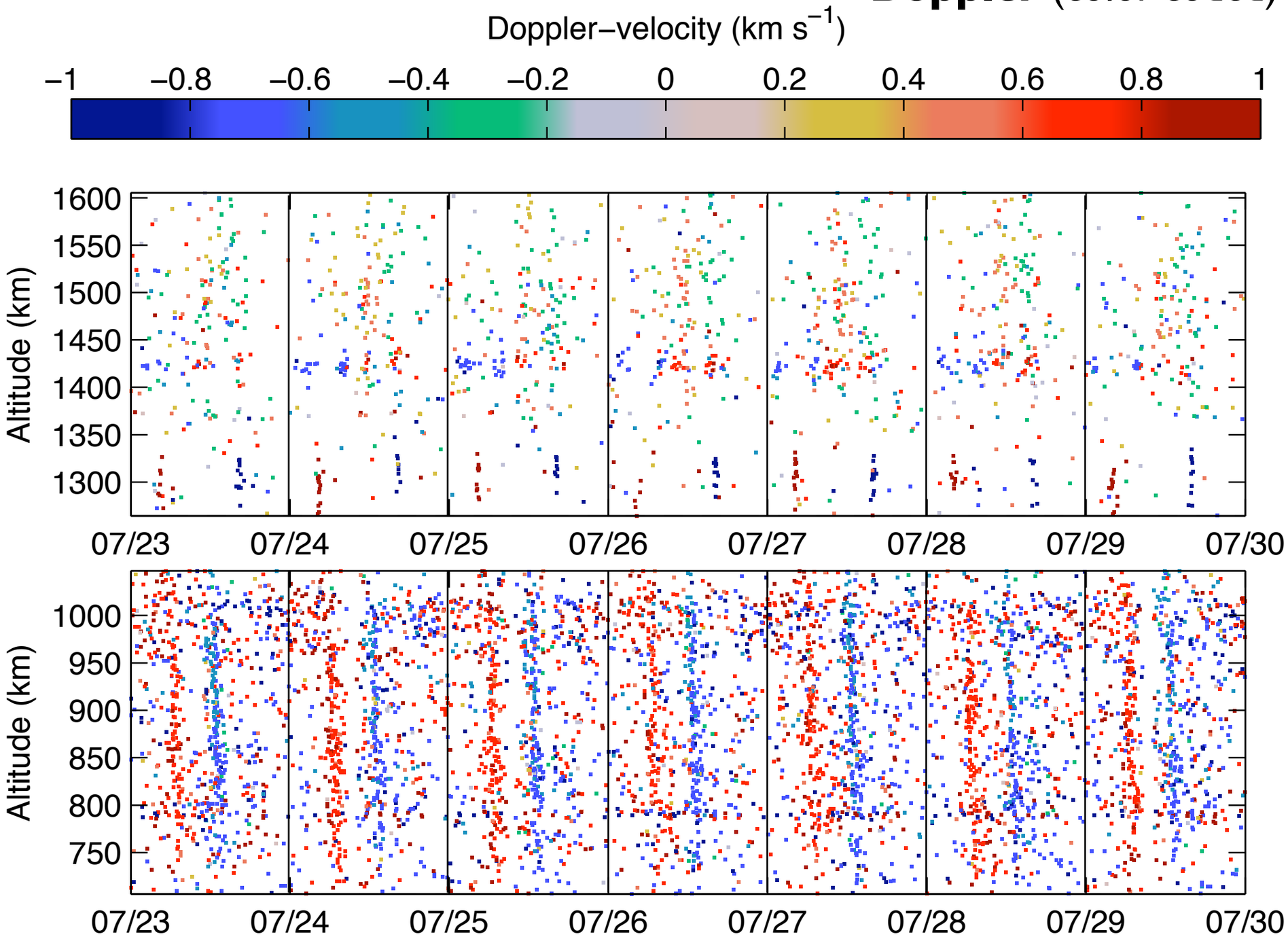
Krag et al, 2007



EISCAT space debris during the IPY

23-29 Jul 2007

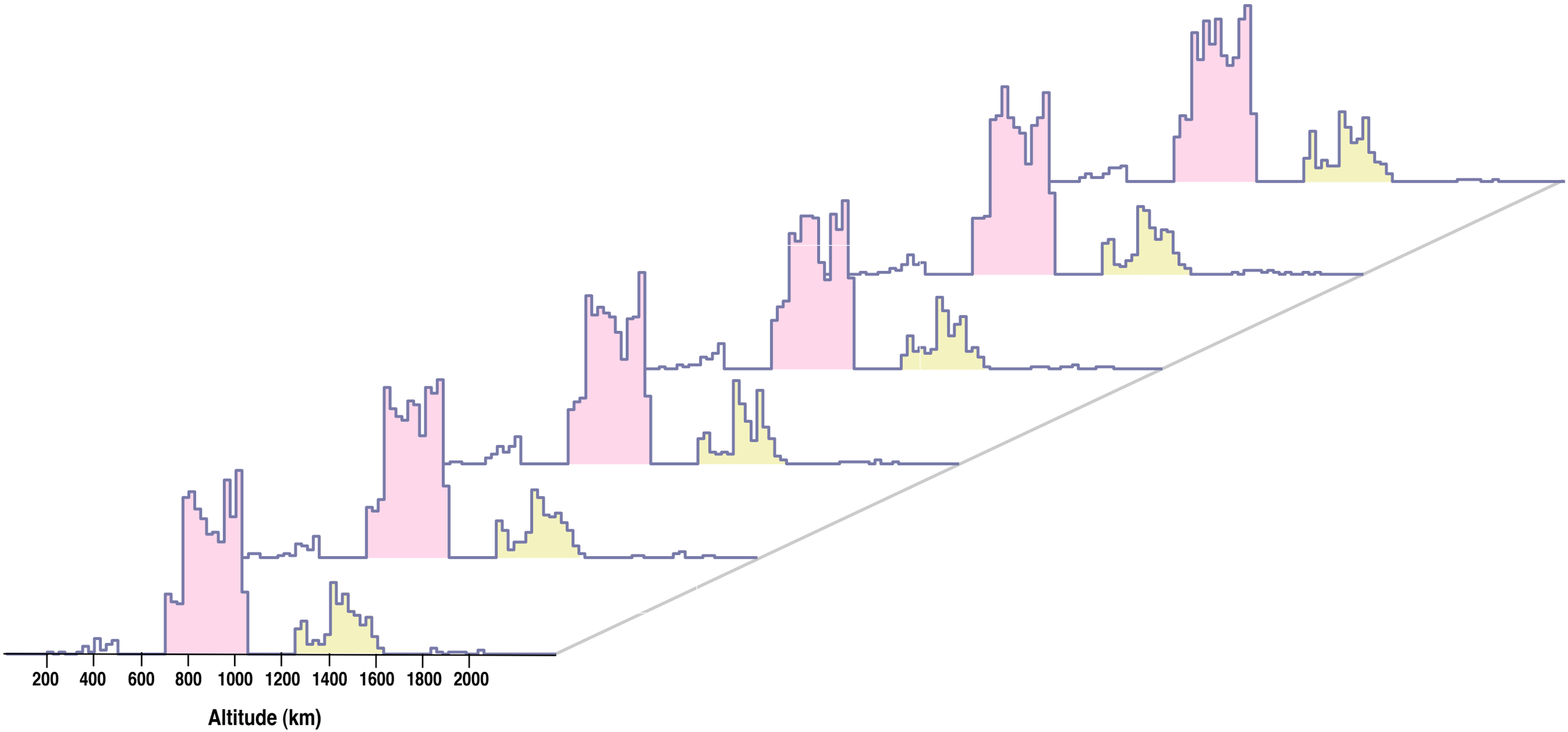
Altitude v **Time** &
Doppler (color-coded)



EISCAT space debris during the IPY

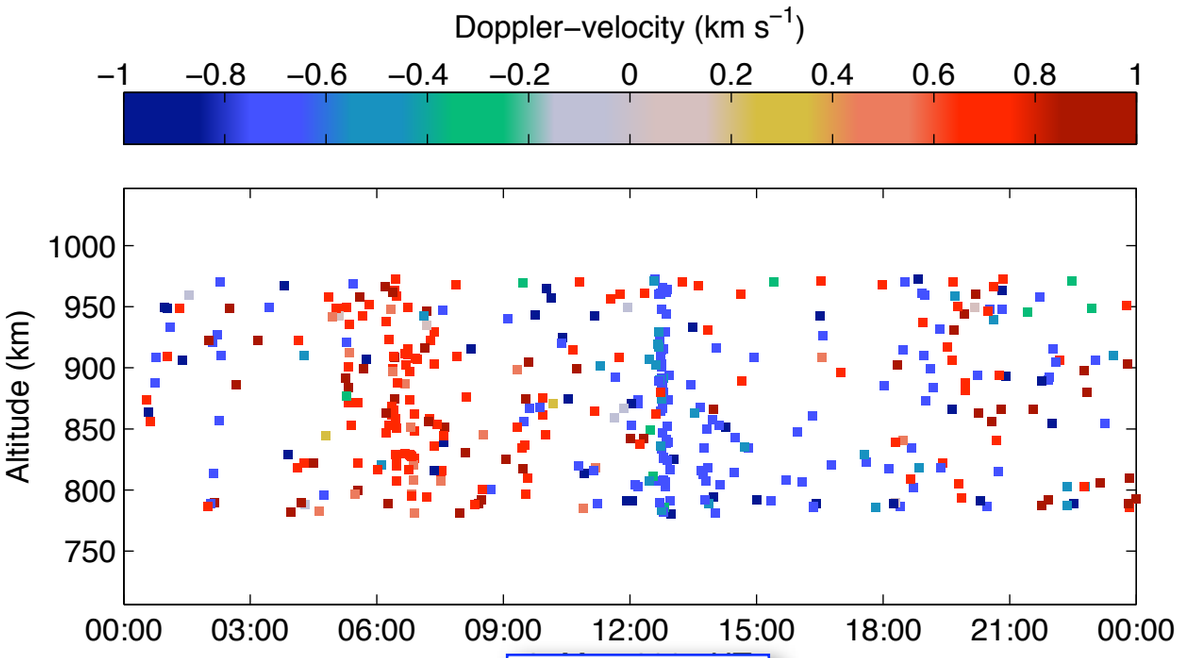
19-24 Jan 2008

Daily event rate v altitude

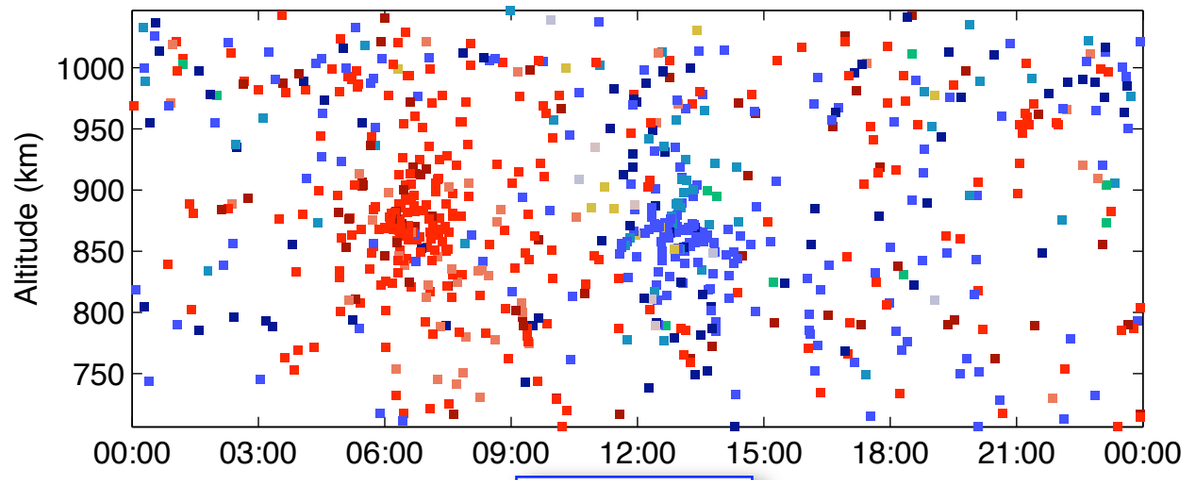


FY 1C debris cloud during the IPY

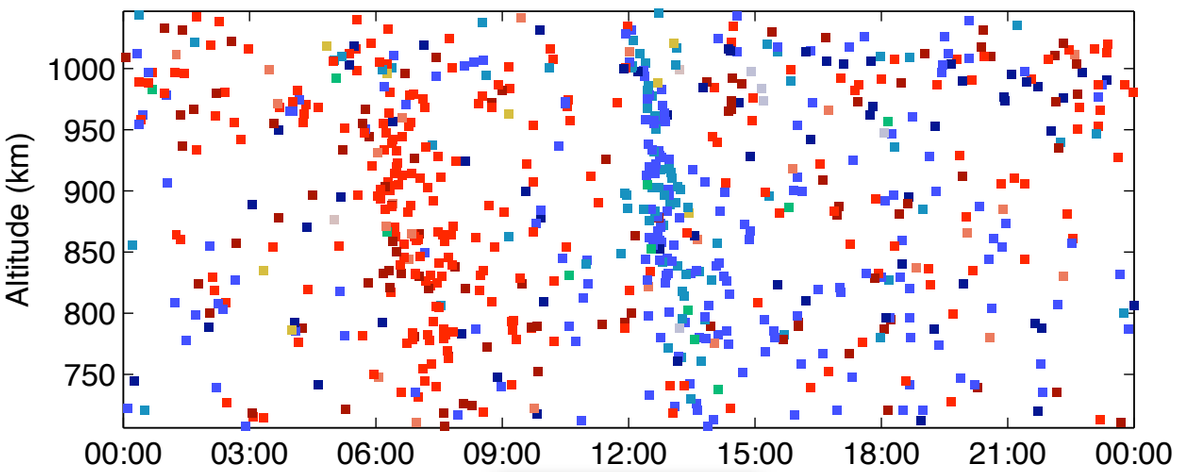
Altitude v Time



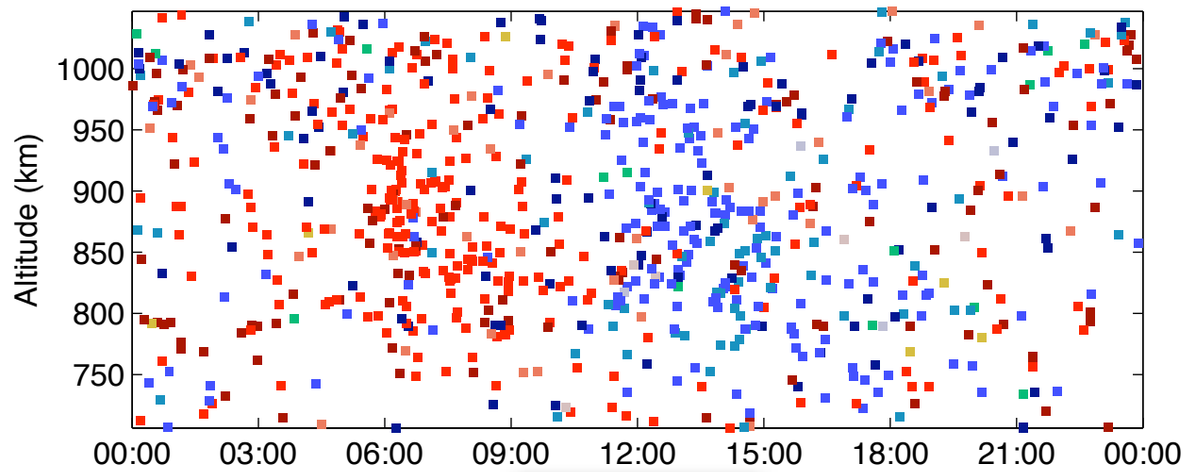
13-Mar-2007



15-Jul-2007



12-Aug-2007

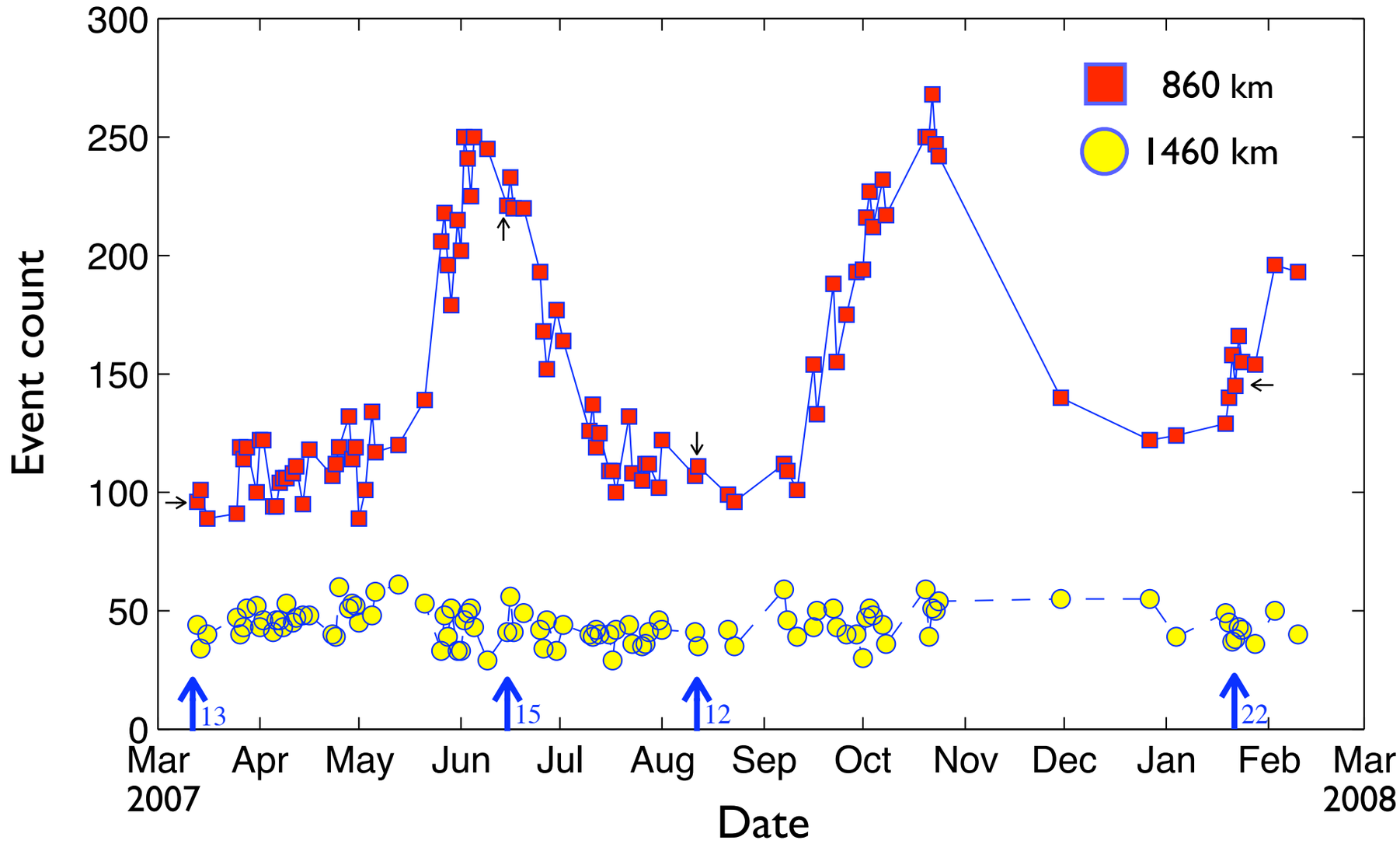


22-Jan-2007

FY 1C debris cloud during the IPY

13 Mar 2007-
10 Feb 2008

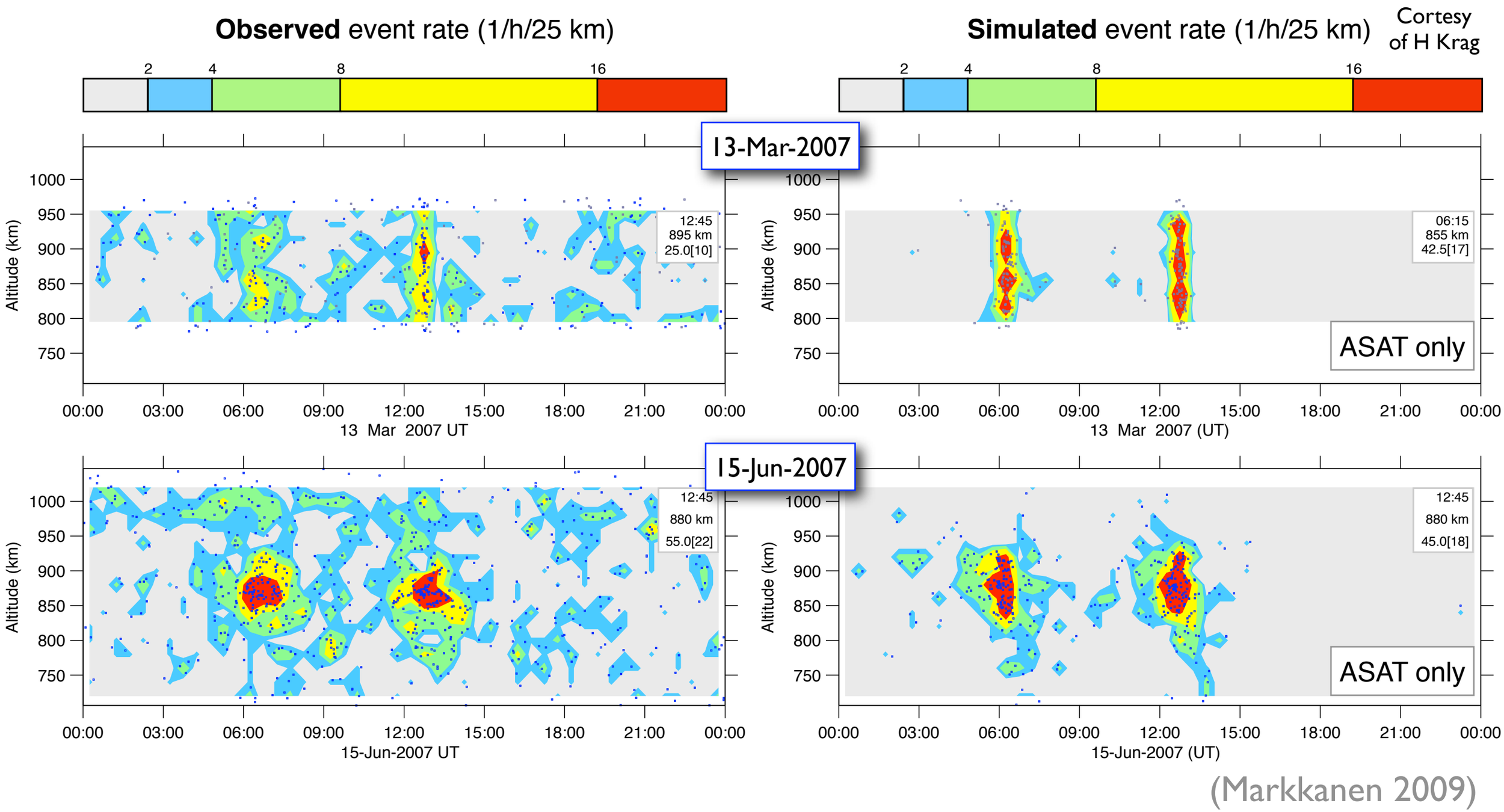
Daily event count
in two 50 km wide altitude zones



(Markkanen 2009)

FY 1C debris cloud during the IPY

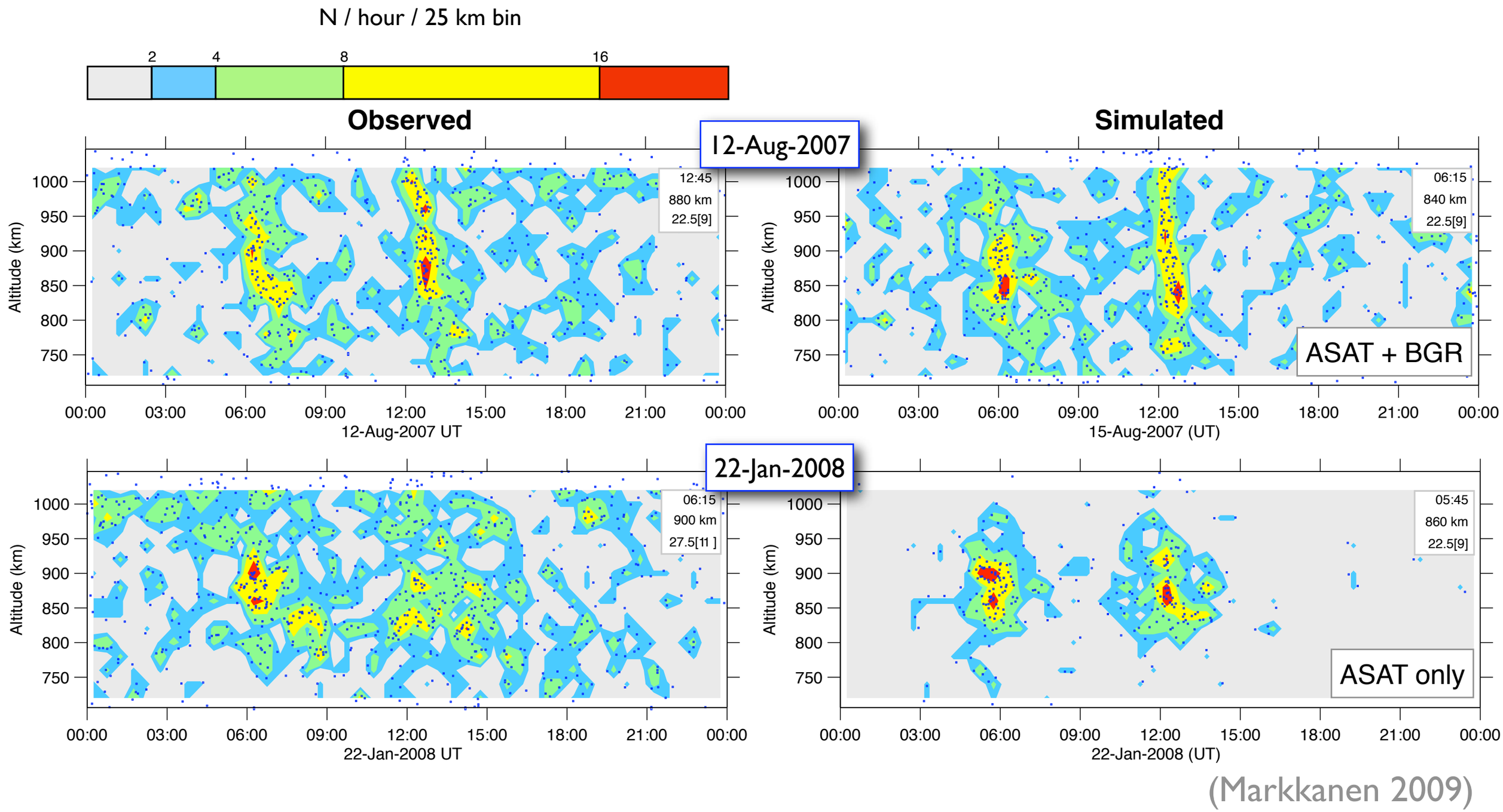
Altitude v Time



(Markkanen 2009)

FY 1C debris cloud during the IPY

Altitude v Time

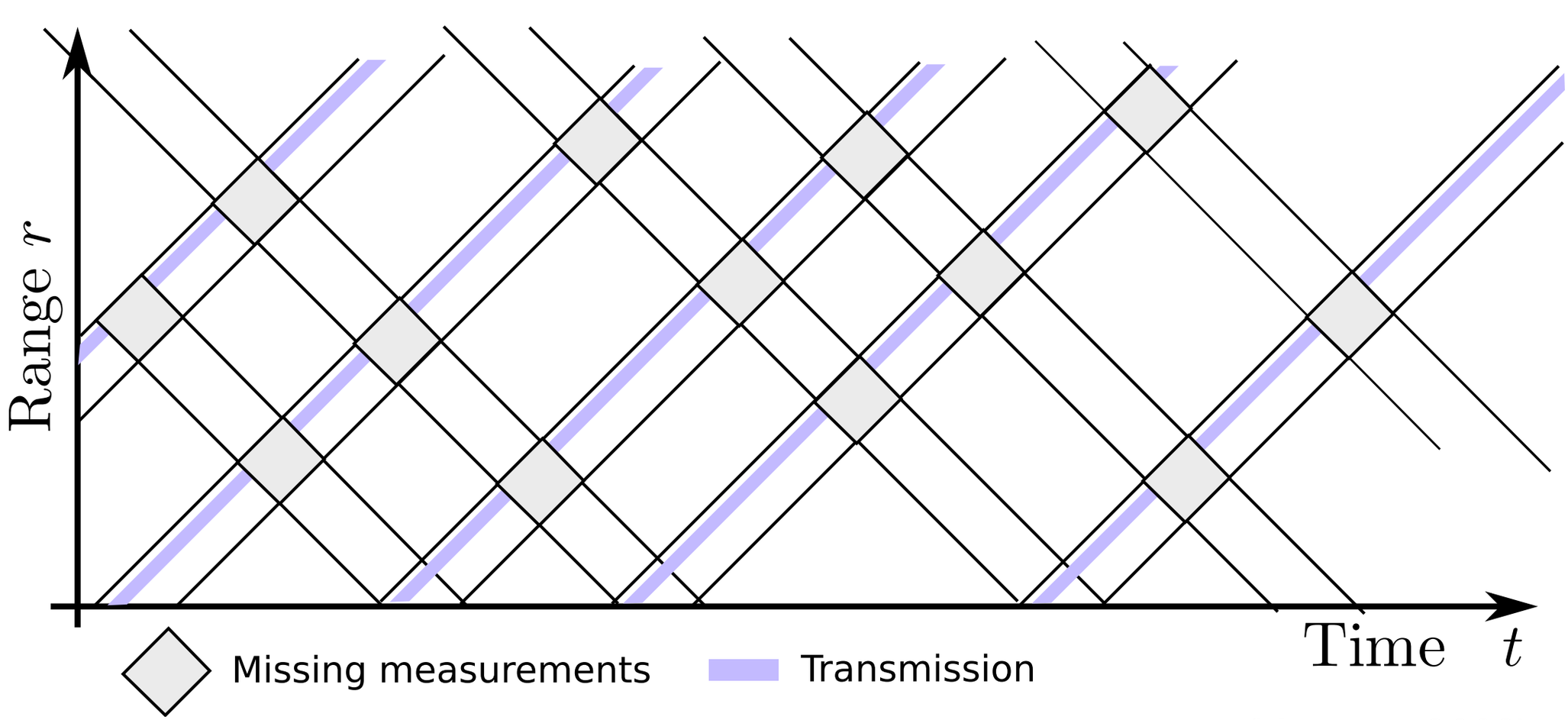


(Markkanen 2009)

The Present

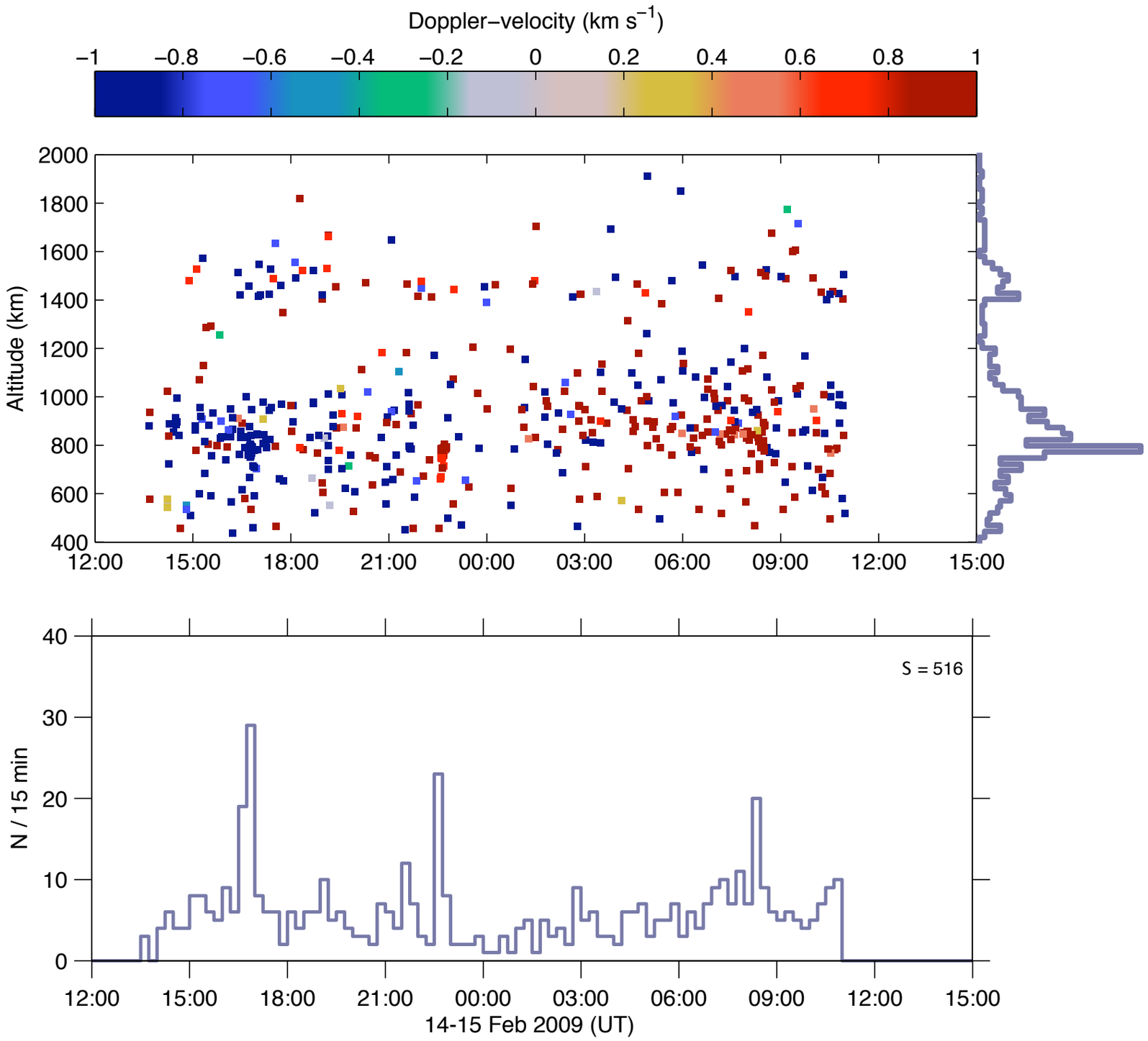
New gapless measurements

- Also D-, E- and F-region ionospheric measurement
- 16000 km gapless Space Debris, meteor head echoes
- Non-uniform interpulse period in transmission



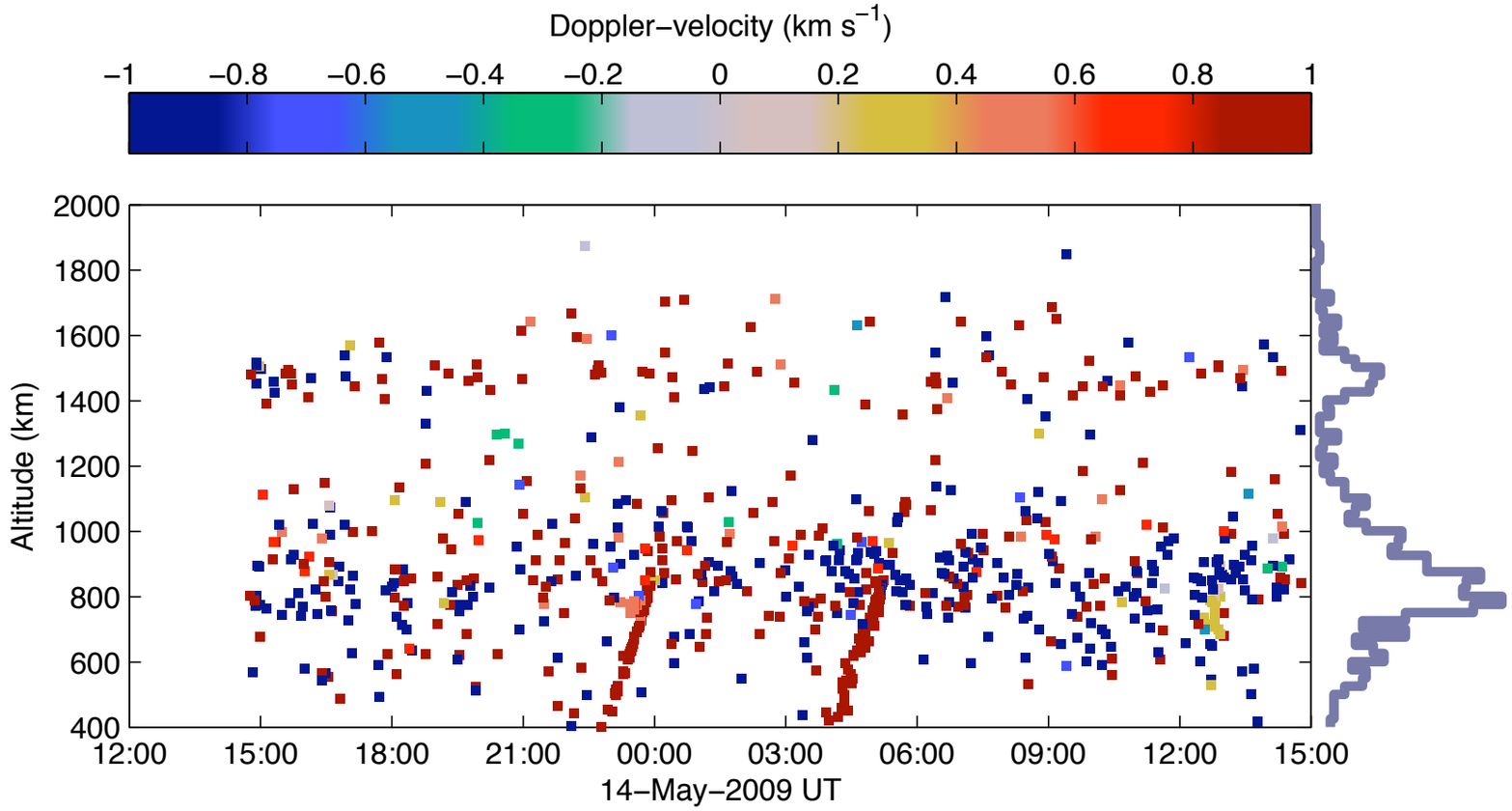
(Vierinen 2009)

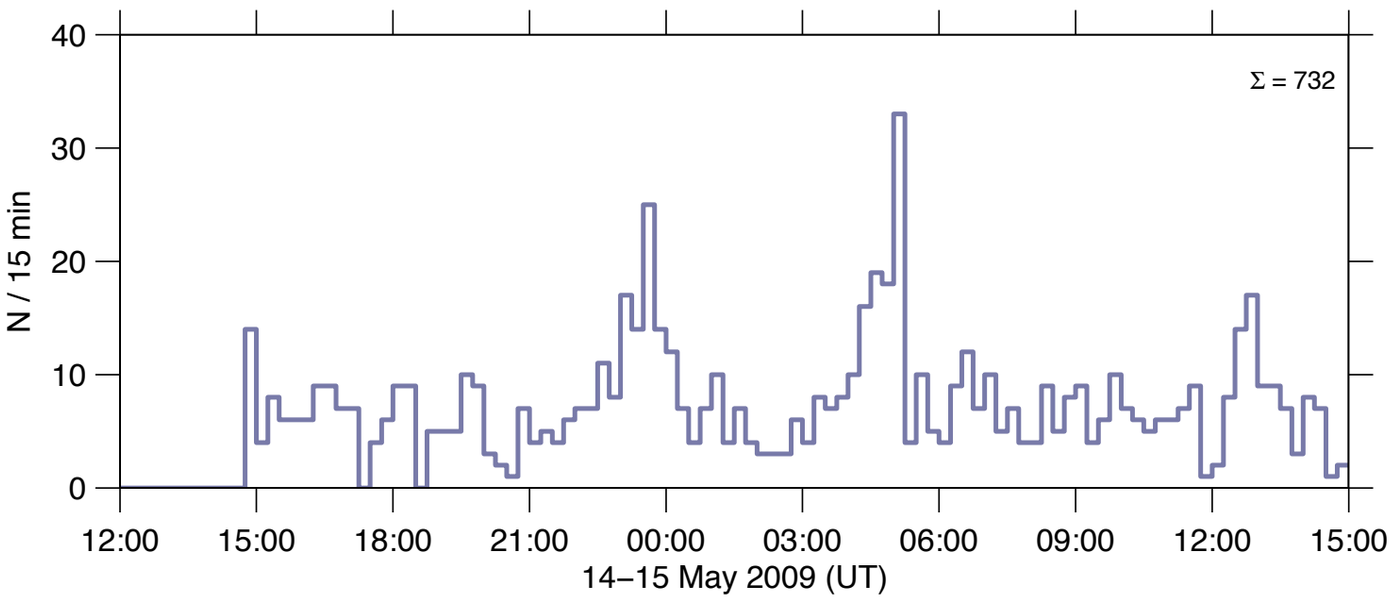
COSMOS - IRIDIUM



14-15 Feb 2009
Tromso UHF

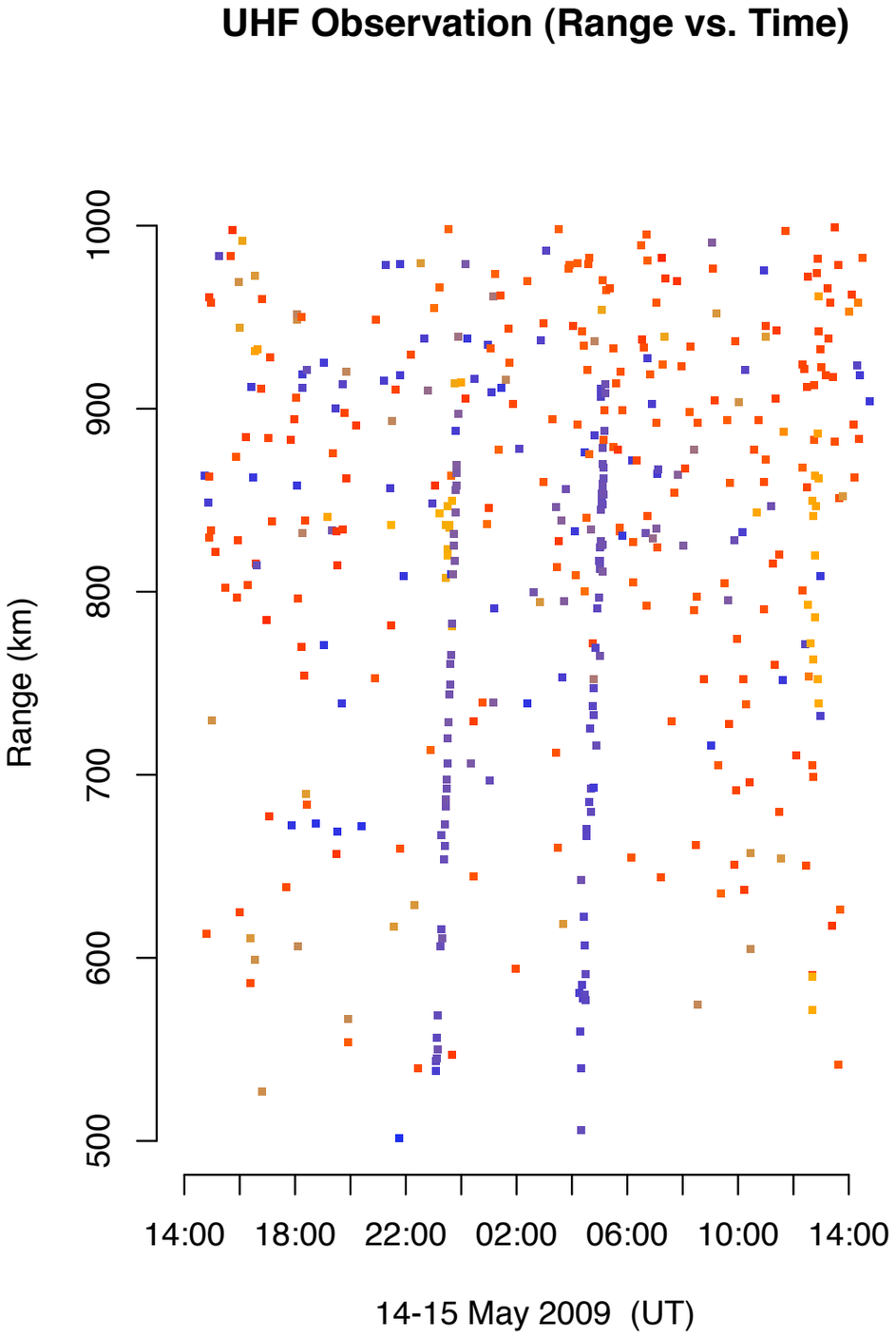
COSMOS - IRIDIUM

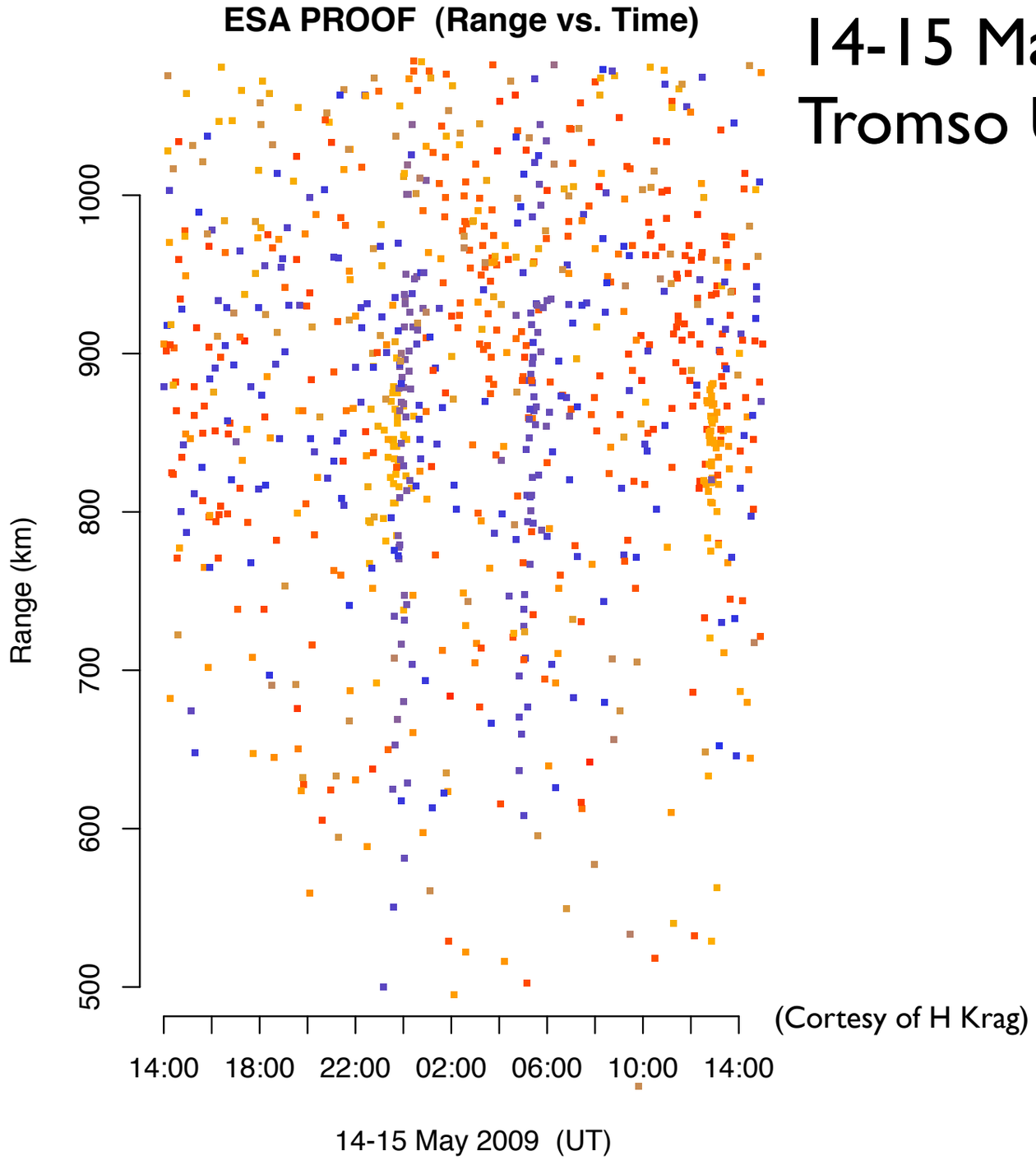




14-15 May 2009
Tromso UHF

COSMOS - IRIDIUM

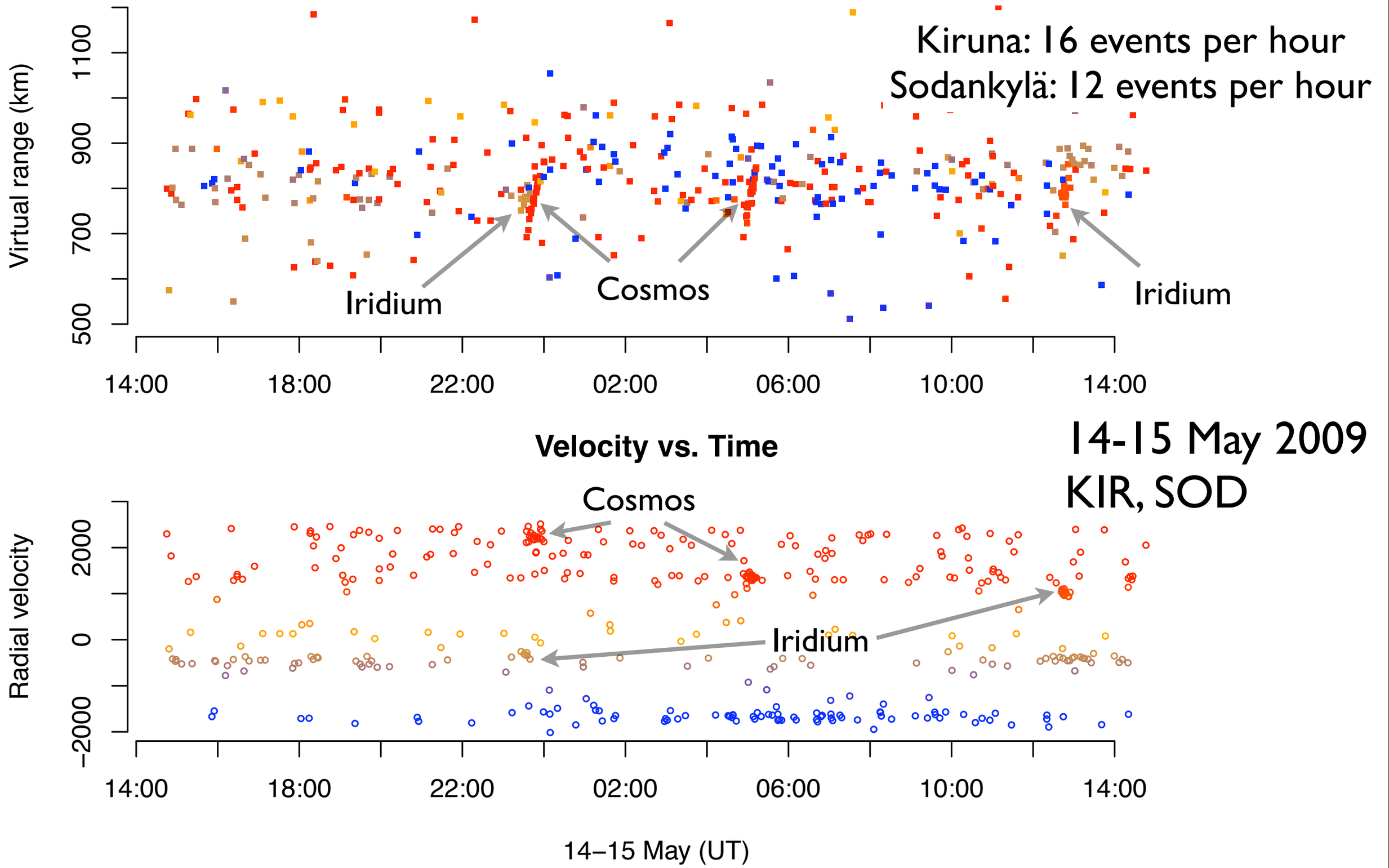




14-15 May 2009
Tromso UHF

(Cortesy of H Krag)

Bi-static detections



The Future

EISCAT 3D

Next generation European
Incoherent Scatter Radar system

- **Design Study 2005-2009**
- **Preparatory phase 2010-2013**
- Construction 2014-2015
- Operation 2015-

EISCAT 3D

European Strategy Forum
on Research Infrastructures

ESFRI

The EUROPEAN Next-Generation Incoherent Scatter Radar proposal EISCAT_3D was accepted on the ESFRI Roadmap of Large-Scale European Research Infrastructures for the next 20-30 years.

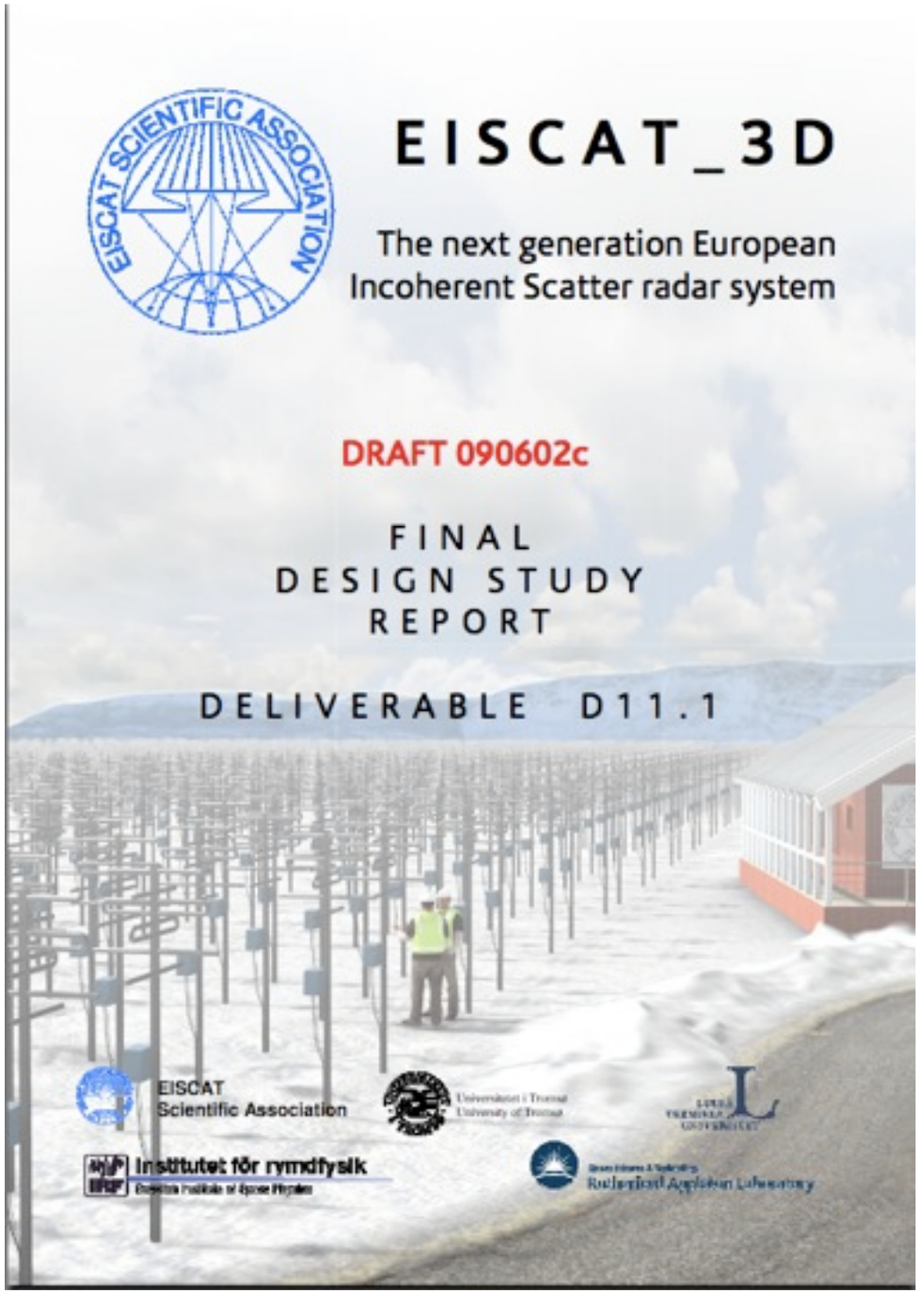
EUROPEAN ROADMAP
FOR RESEARCH
INFRASTRUCTURES

Roadmap 2008

EISCAT 3D: breadboarding

National applications

- **Swedish** universities' joint national infrastructure application 29.4.2009
  - 2 receiver sites
  - one small Tx/Rx
- **Norwegian** users sent application 4.6.2009
- **Finnish** users sent application 23.9.2009
  - 400 000 EUR
  - prototyping a software radio and distributed computing solution in 50 MHz radar



EISCAT 3D: science goals: space environment

-
- Space Weather
- Coupling between lower and upper atmosphere
- **Space debris**

  Orbital elements
- Meteors
  - Orbits
  - Meteoric input
- Planetary Radars
  - Near-Earth Objects
- Solar Wind measurements (and coronal radar)
-
-

EISCAT 3D & space debris

~ Core array parameters

- 16000 element filled circular array (120 m diam.)

- Beam width ~0.6 degr.

- 300+300 W solid state transmitters

- Freq. ~ 235 MHz

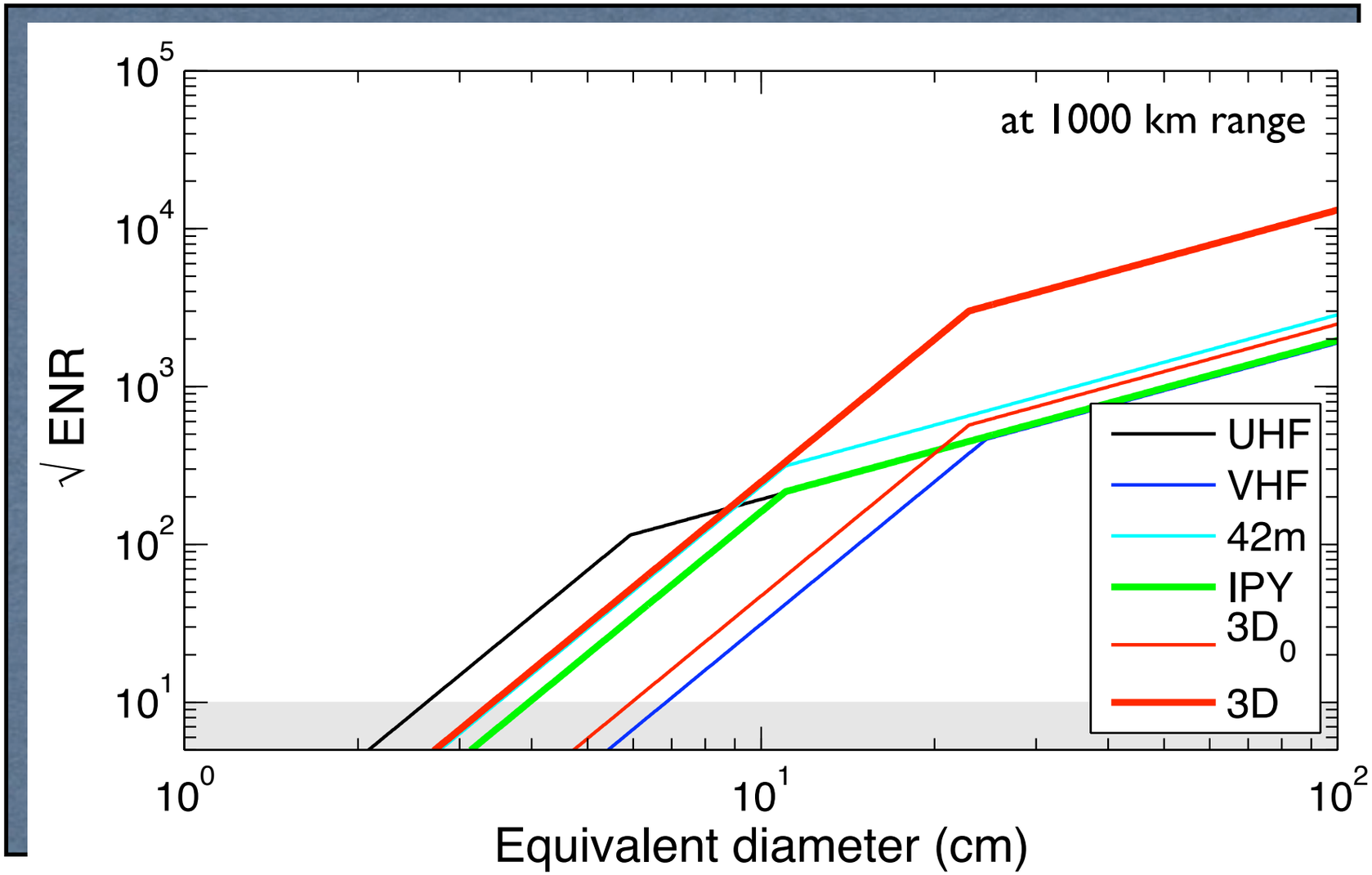
- Inst. 1 dB bandwidth ~5 MHz

- Arbitrary waveform modulation

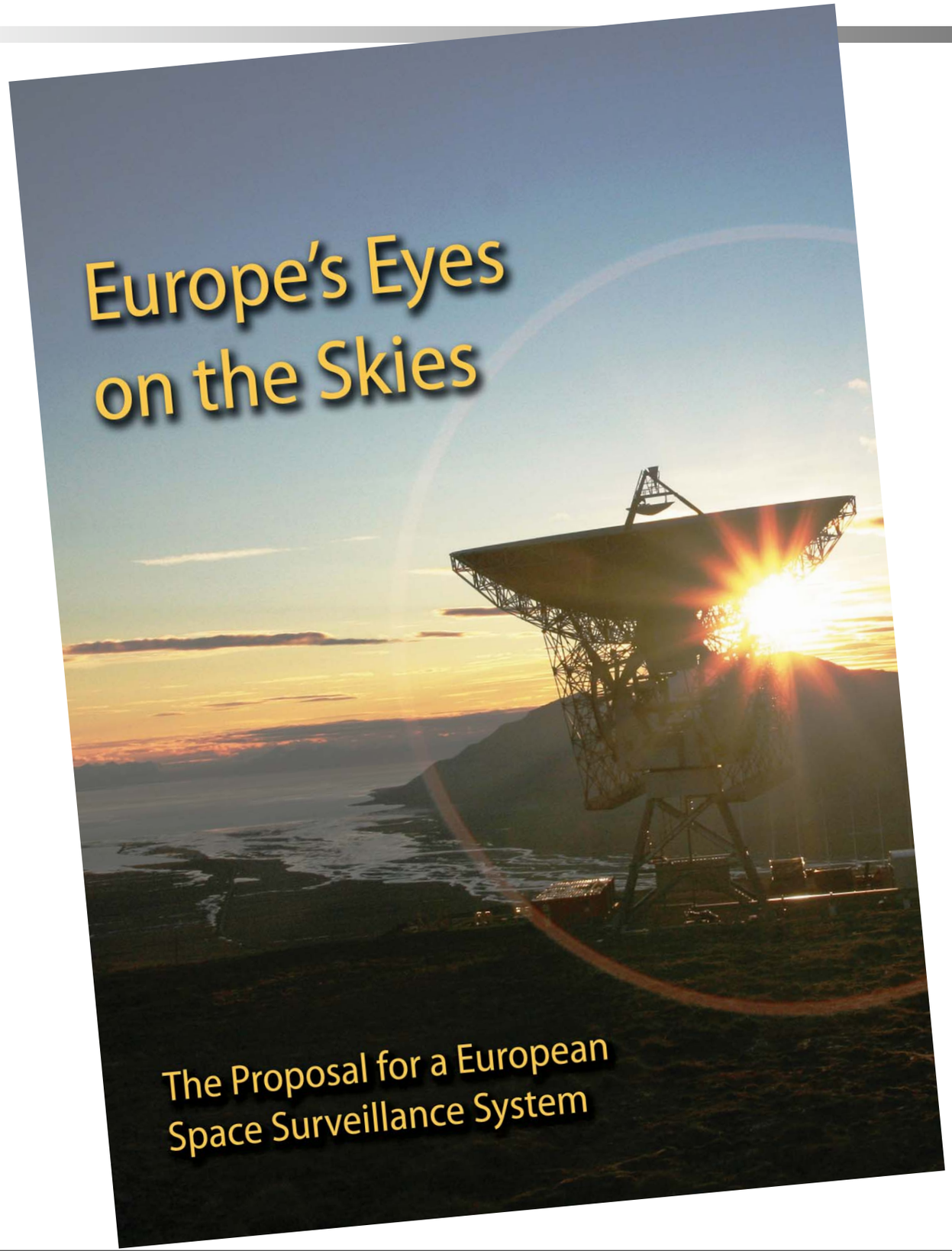
- 20 % duty cycle

- 190 K noise temp. on reception

Detection sensitivity



EISCAT & SSA



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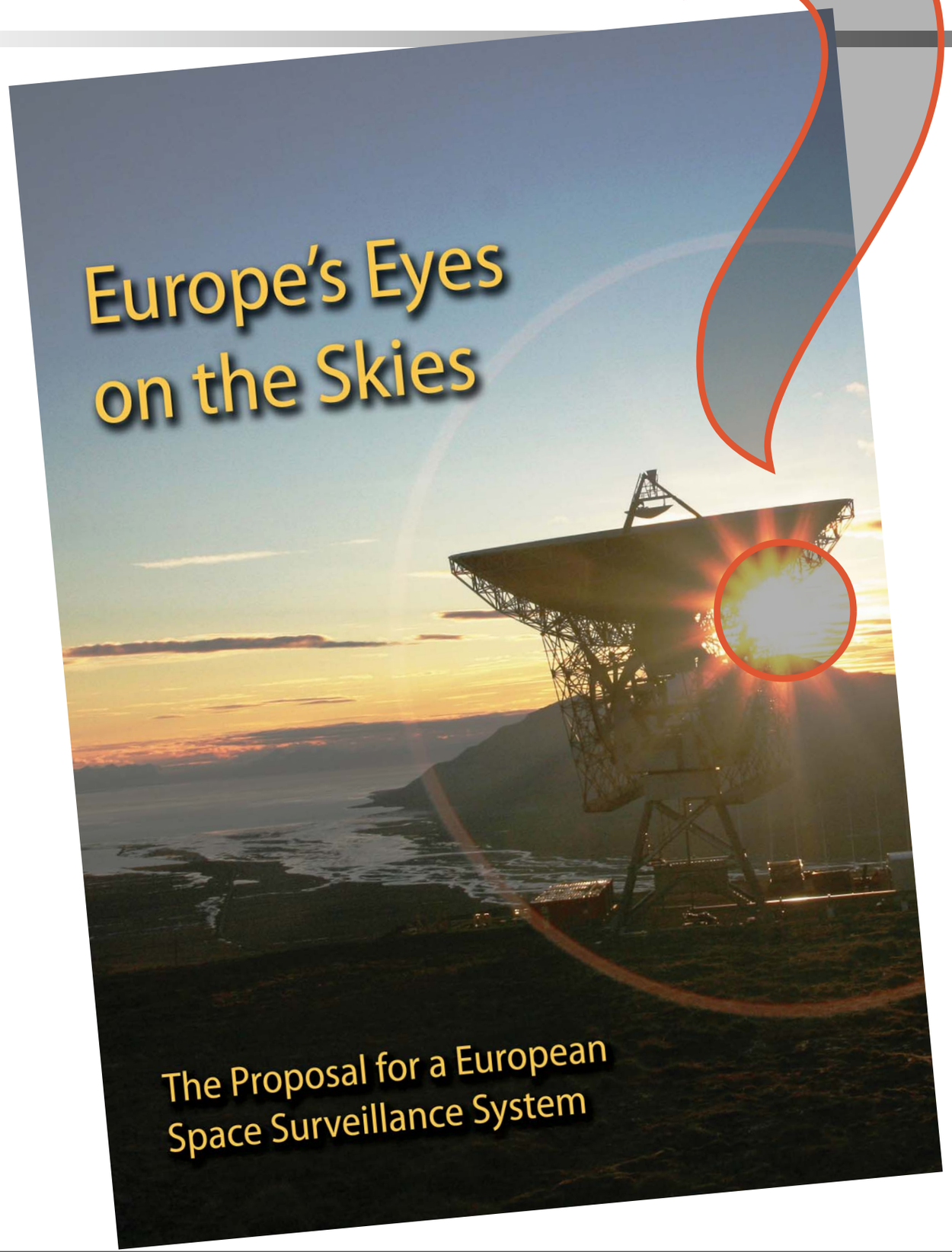
esa bulletin 133 - february 2008

EISCAT & SSA



No Connection

yet

between

EISCAT (3D)

and

SSA
Preparatory
Programme