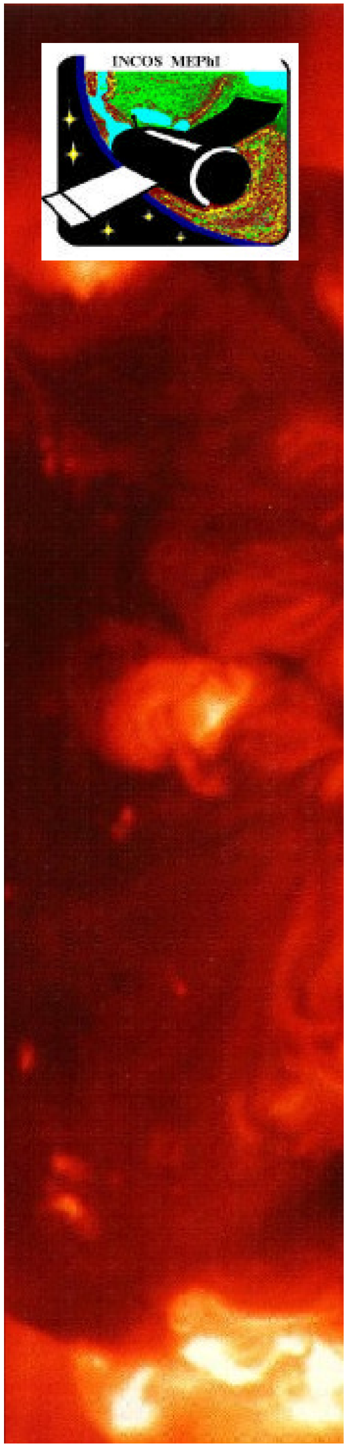

Study of the ion fluxes in the vicinity of Earth

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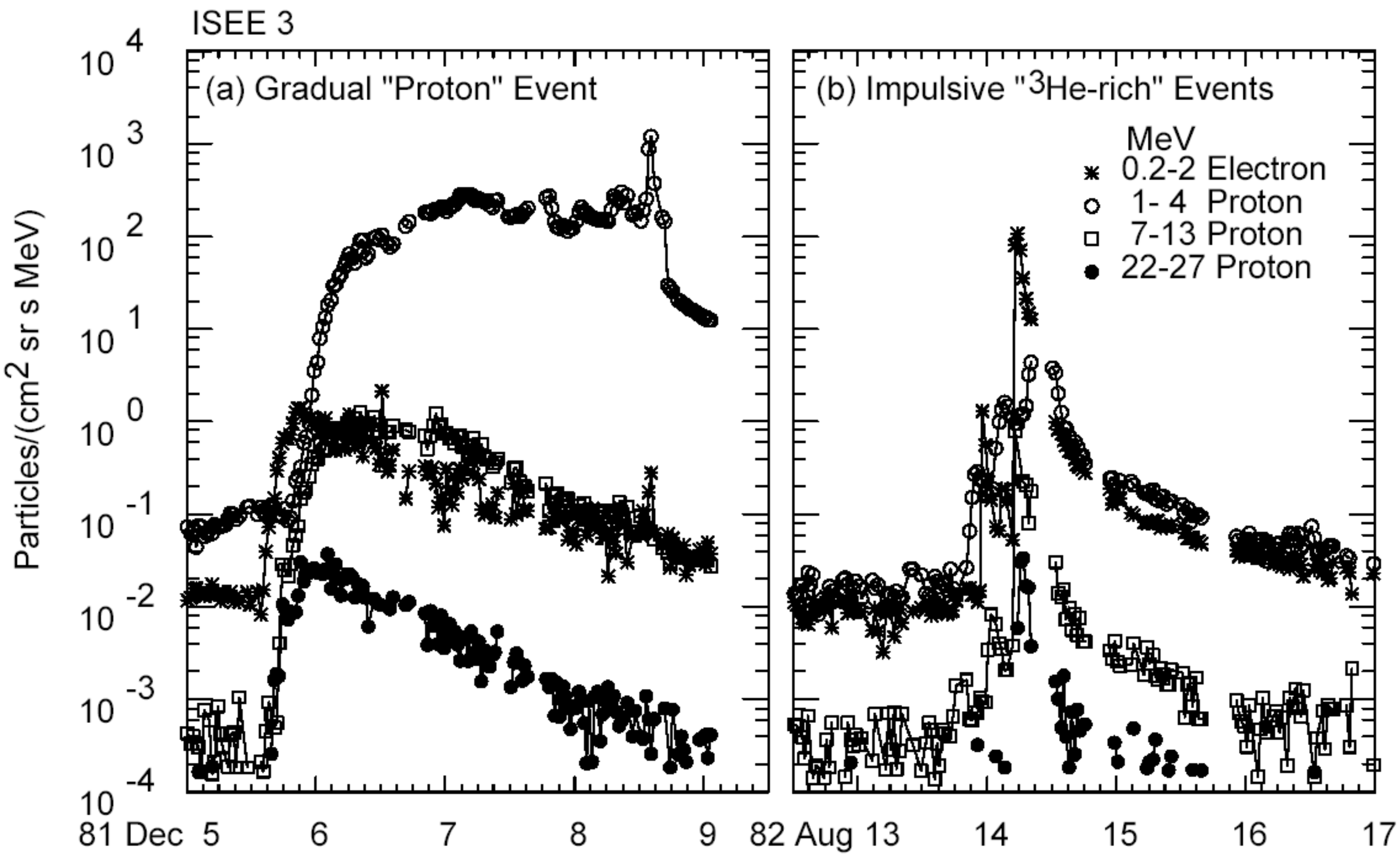
NRNU MEPhI

COPUOS Vienna, February 2010

SOLAR COSMIC RAYS

- SOLAR ENERGETIC PARTICLE GENERATION (SEP)
- CORONAL MASS EJECTION (CME)
- *GRADUAL SEP EVENTS*
- *IMPULSIVE SEP EVENTS*

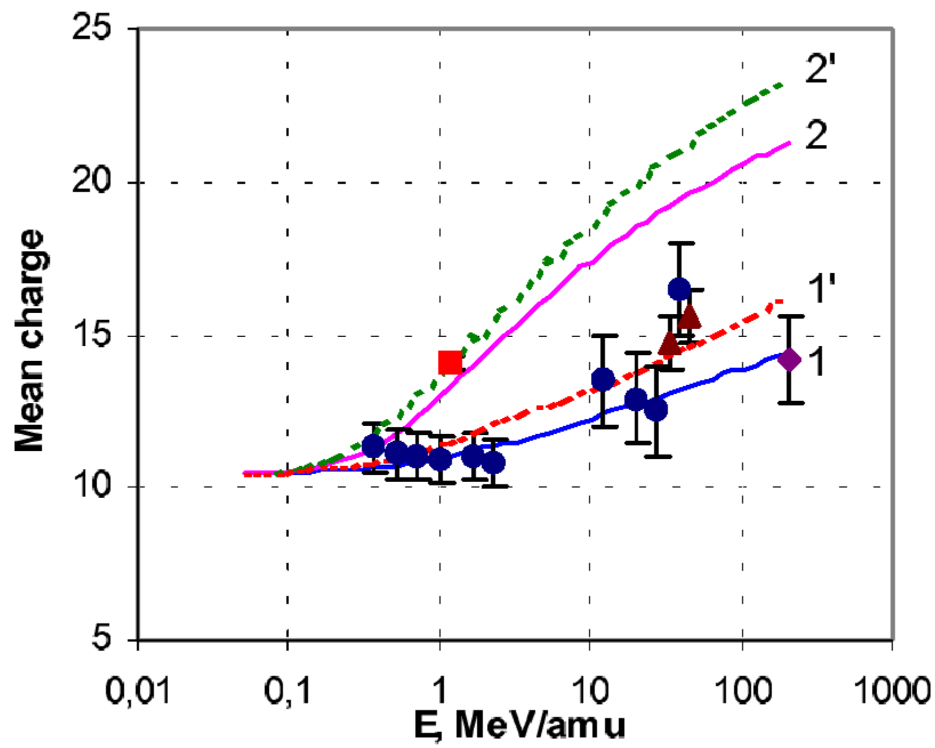
Gradual and impulsive SEP events



SEP events

Characteristics	Impulsive	Gradual
Particles	electrons, ^{3}He and heavy ions: H/He~10, ^{3}He/^{4}He~1, Fe/O~1	protons heavy ions: ^{3}He/^{4}He~0.005, Fe/O~0.1
Duration	Hours	Days
Soft X-ray radiation	Impulsive	Long duration
Coronal Mass Ejection (CME)	Usually absent	Available
Frequency for Solar maximum	~1000 per year	~ 20 per year

“Gradual” SEP events:
Mean Fe ion charge versus energy



Stovpyuk & Ostryakov, 1999

***S* –** spectral index of wave turbulence;

T_a – acceleration time;

N – plasma density.

1: S=5/3;T_a=1.7-1.2s; N=5×10^8cm^{-3}

2: S=5/3;Ta=1.7-1.2s; N=5×10^9cm^{-3}

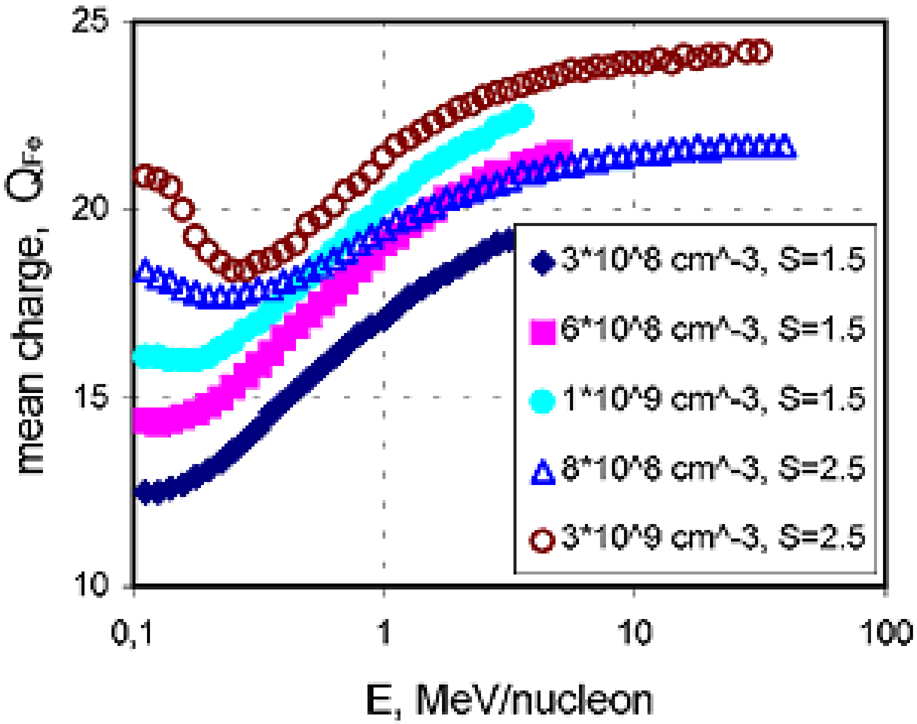
1’: S=3;Ta=1-3.3s; N=5×10^8cm^{-3}

2’: S=3;Ta=1-3.3s; N=5×10^9cm^{-3}

Temperature: T=1.26×10^6 K.

Experimental data: Oetliker et al. (1997); Luhn et al. (1984); Leske et al. (1995); Tylka et al. (1995).

“Impulsive” SEP events:
Mean Fe ion charge versus energy



Kartavykh & Ostryakov, 1999

S **-** spectral index of wave turbulence;

N – plasma density.

1: S=1.5; N=3×10^8 cm^{-3}

2: S=1.5; N=6×10^8 cm^{-3}

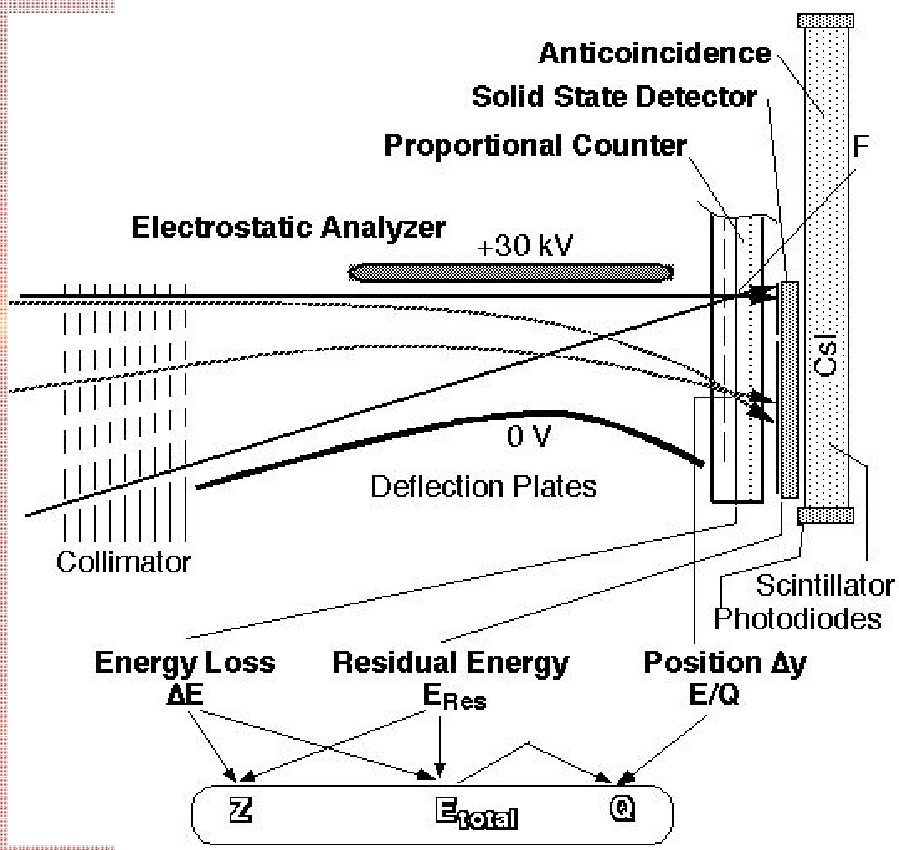
3: S=1.5; N=1×10^9 cm^{-3}

4: S=2.5; N=8×10^8 cm^{-3}

5: S=2.5; N=3×10^9 cm^{-3}

Temperature: T=1×10^6 K.

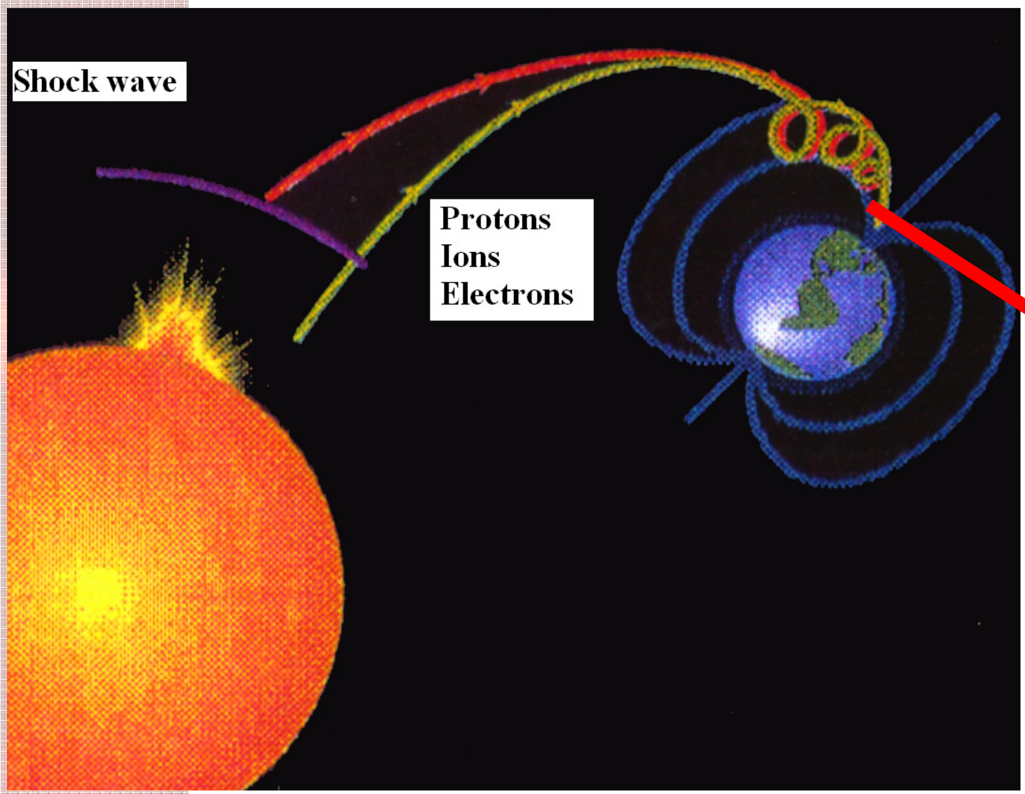
CR ion charge measurement: Ion charge analysers



SEPICA during the hoist onto ACE

The measurement of ion charge at low energies (<5 MeV/n for Fe)

CR ion charge measurement:
Geomagnetic separator of ion charge



$1/L_c^2 = aR + b$

INCOS MEPhI

The main ideas of geomagnetic filter technique

(Proposed by Oetliker M., et al. 1997 for SAMPEX)

- Earth orbiting spacecraft **detects ions** inside the Earth’s magnetic field.
- Cut-off latitude depends ***linearly*** on the ion rigidity.
- **Rigidity** for particles is mapped versus latitude and linear dependence coefficients are derived.
- **The ion charge** can be obtained knowing this dependence and measuring the ion energy and ion rigidity.

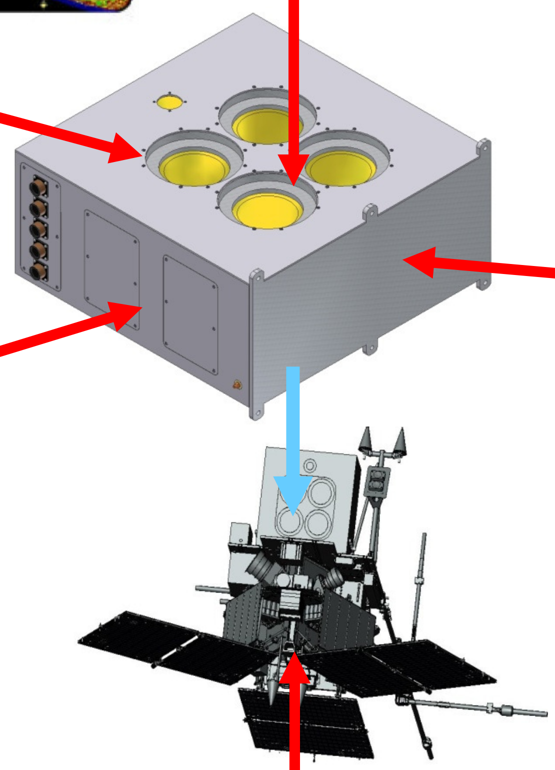
The experiments for the study of ion and isotope composition of Cosmic Rays

Instrument	Energy range, MeV/n	Elements	Geomfactor, cm^2sr	Orbit parameters
MONICA	10 – 300	H – Ni	100	Circular, 670-830 km (inside geomagnetic field)
NINA, NINA-2	10-200	H - O	8	Circular, 835 km (inside geomagnetic field)
MAST(SAMPEX)	15 – 200	He – Ni	8 – 14	Circular, 600 km (inside geomagnetic field)
HILT(SAMPEX)	4 – 150	He – Ni	60	The same
SEPICA(ACE)	0.2 – 3	H – Fe	0.2	In L1 point
SIS(ACE)	10 – 100	He – Ni	40	In L1 point
CRIS(ACE)	20 – 500	Be – Ni	250	In L1 point

The project “MONICA”
Monitor of cosmic ray nuclei and ions

Space Physics Institute of NRNU MEPhI

Lebedev Physical Institute of RAS



Joint Institute for Nuclear Research

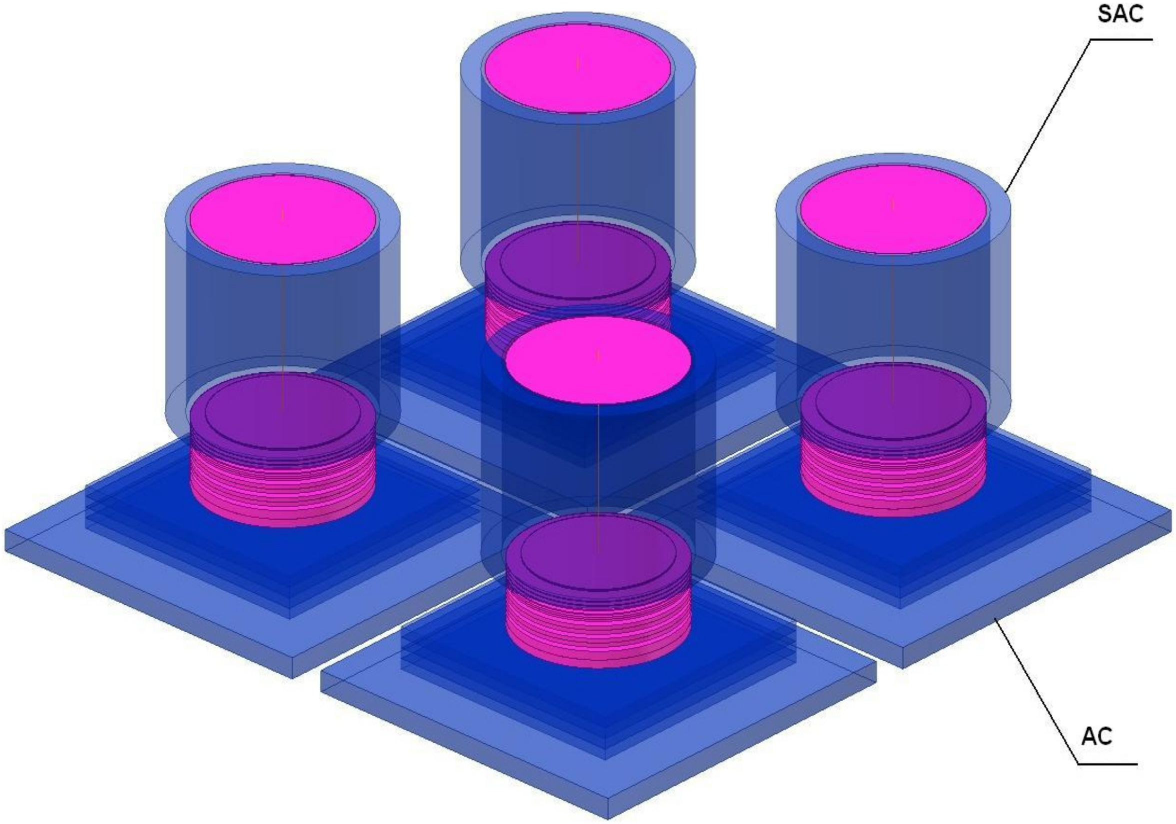
Ioffe Physical-Technical Institute of RAS

Lavochkin Association

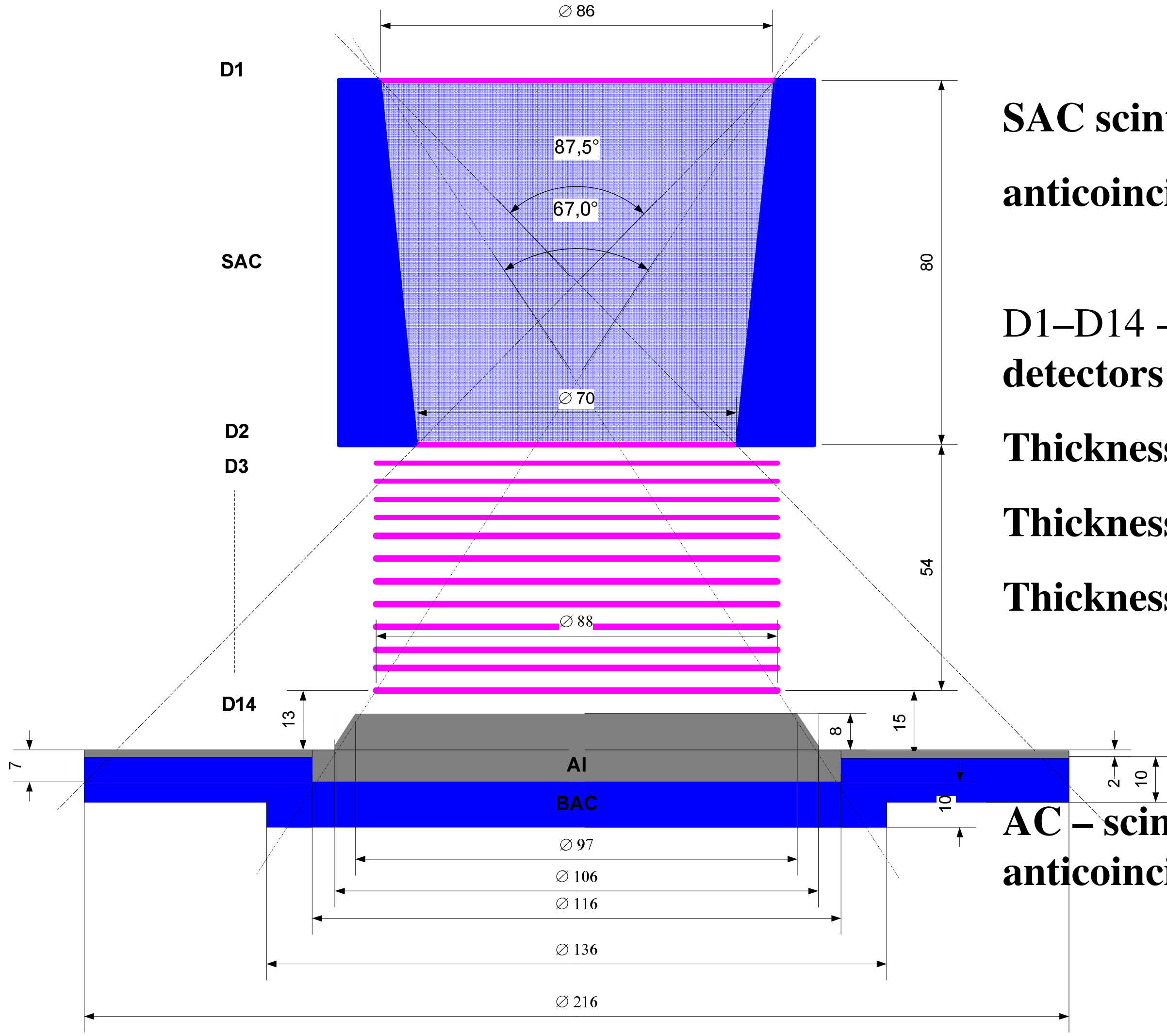
The mail goals of MONICA experiment

- **Measurement of *ion charge states*, as well as elemental, isotope composition and energy spectra of SEP fluxes from He to Ni in 10-300 MeV/n energy range for individual SEP events (including small impulsive SEP events).**
- **Measurement of ACR ion ionic charge and isotope composition, including elements and isotopes(sulfur, isotopes of oxygen and neon and others); measurement of ACR energy spectra.**
- **Measurement of GCR and ACR fluxes modulation with the purpose of study of conditions of particle propagation in heliosphere.**
- **Study of CR penetration into Earth magnetosphere under conditions of its strong disturbances during the solar-magnetosphere events.**

MONICA physical scheme



Layout of spectrometer



SAC scintillator anticoincidence detector

D1–D14 - **silicon strip detectors**

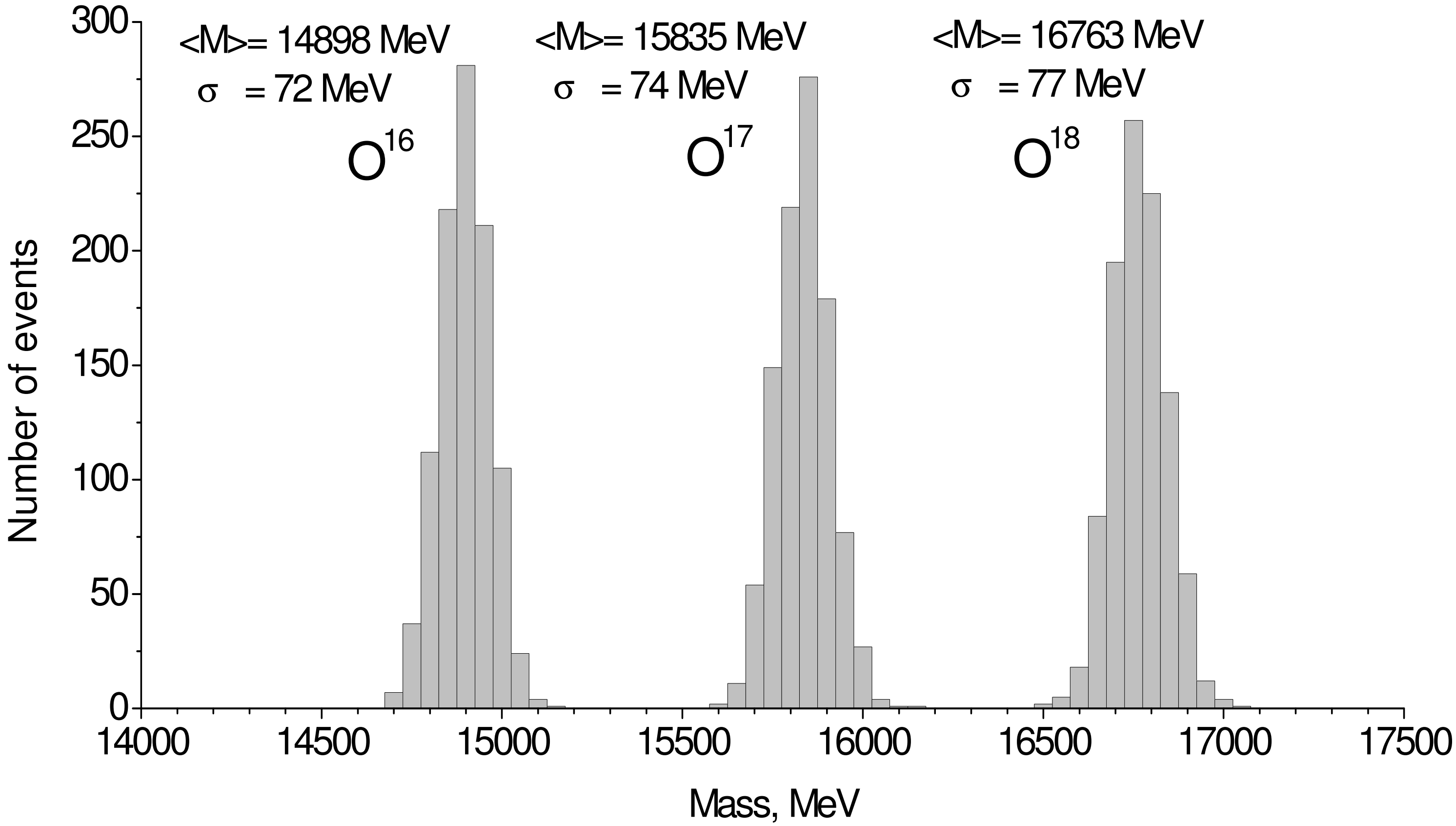
Thickness D1, D2 – 100 μ

Thickness D3-D5 – 300 μ

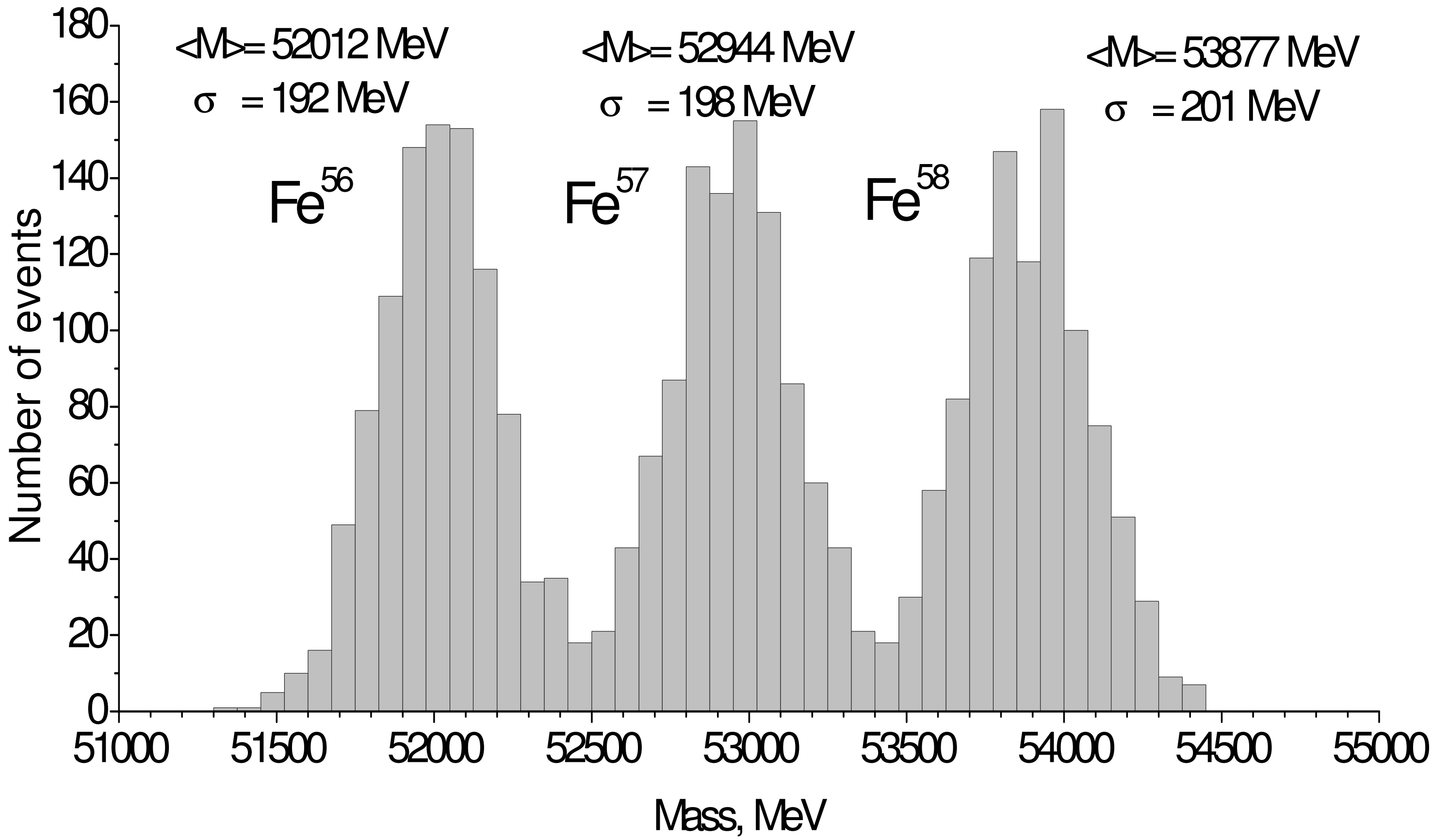
Thickness D6-D14 – 1000 μ

AC – scintillator anticoincidence detector

MONICA main physics characteristics: Mass resolution for oxygen



MONICA main physics characteristics: Mass resolution for iron

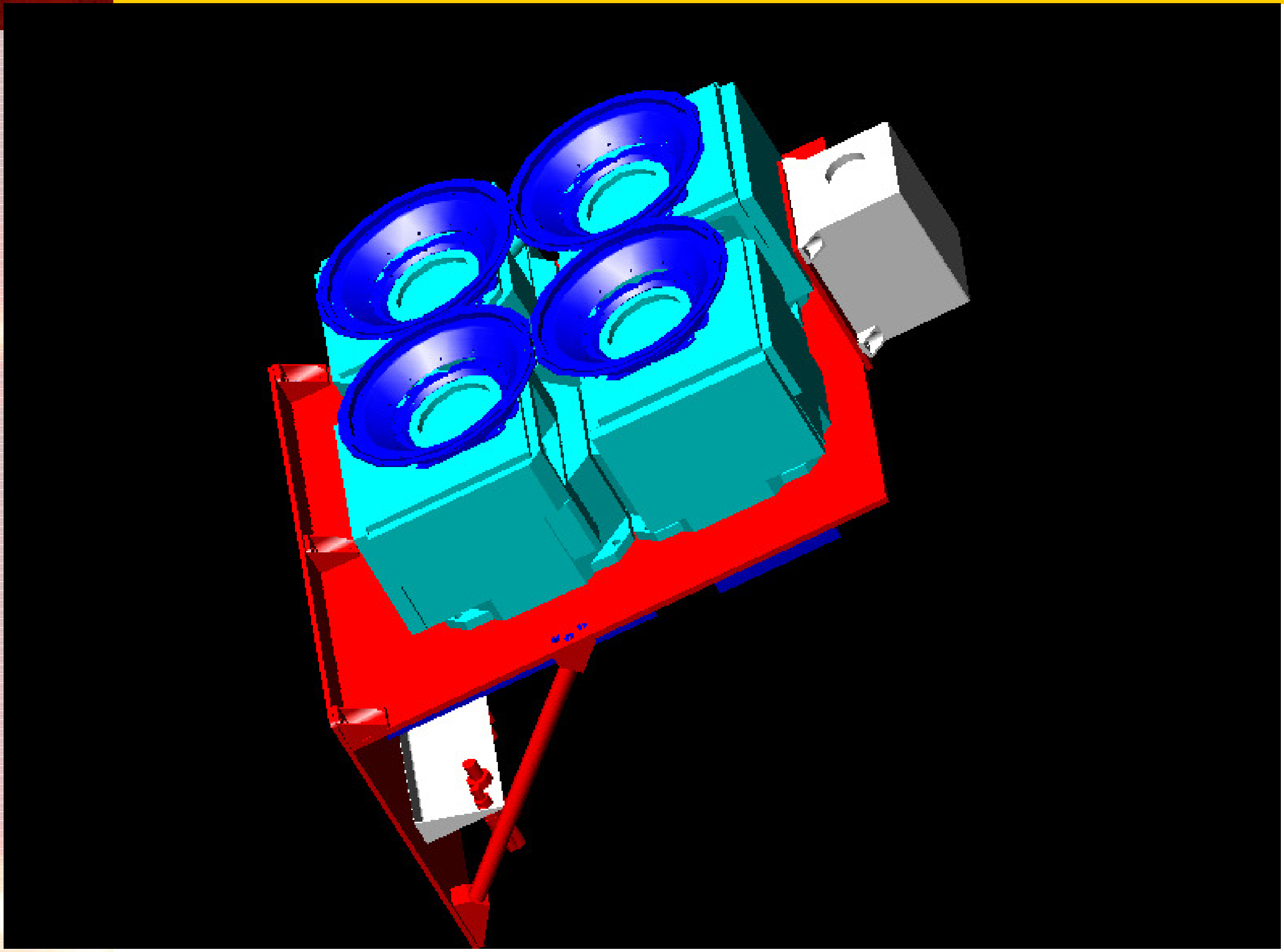


Physics and technical characteristics of MONICA spectrometer

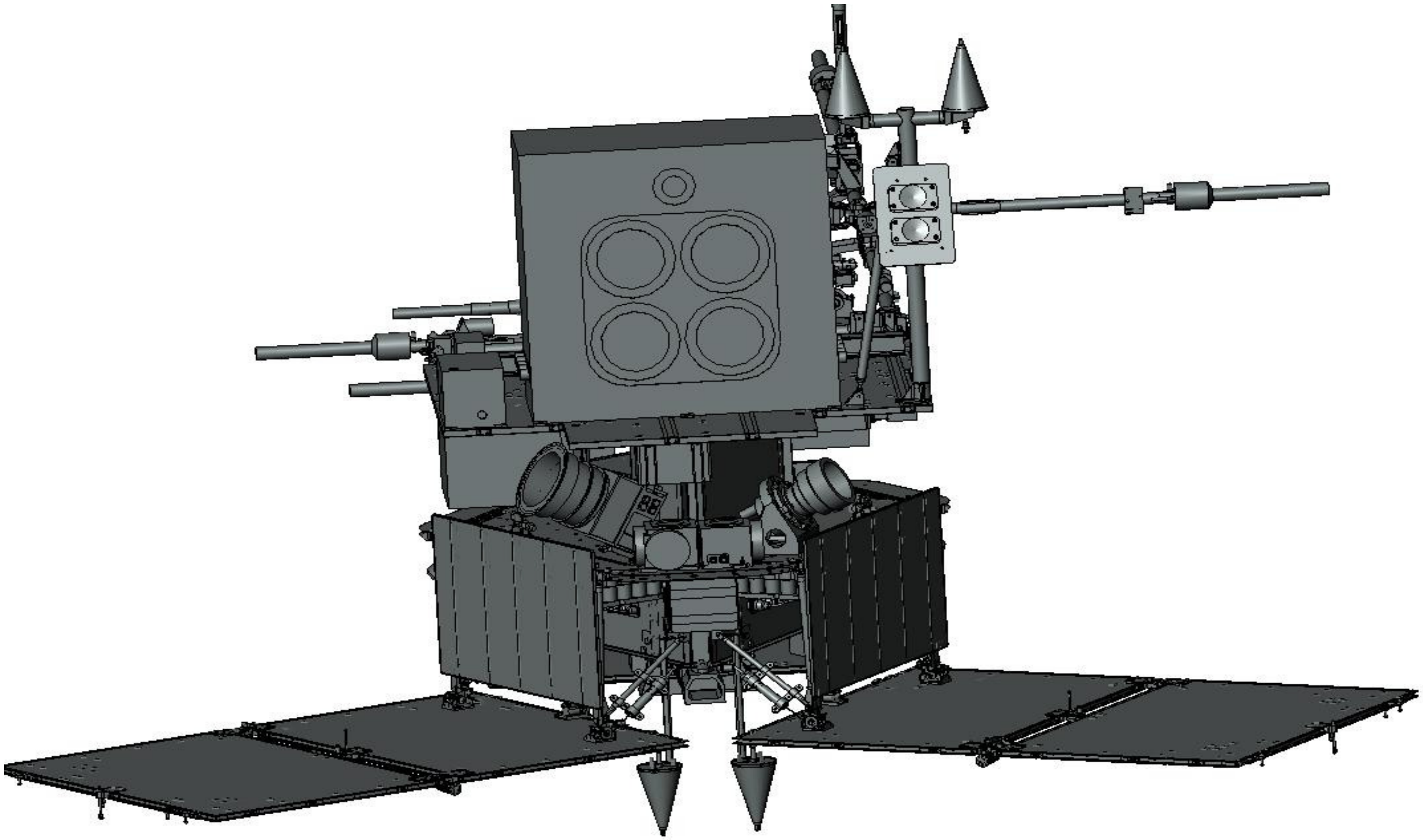
Geometry factor	100 $cm^2 sr$
Field of view	±45°
Angular resolution	1°
Energy range: H CNO Fe	7-70 MeV 12-150 MeV/n 20-290 MeV/n
Energy resolution	1%
Mass resolution: H CNO Fe	0.02 amu 0.08 amu 0.2 amu
Time resolution	50 ns
Dead time	<1 ms

Outline dimensions	650×650×300 mm
Mass	60 kg
Power consumption	70 W
Power supply voltage	27 V
Matter in aperture	Not more then 0.05 g/cm^2
Mass memory	1 Gbyte
Information downloads frequency	one per day and more

View of MONIKA spectrometer



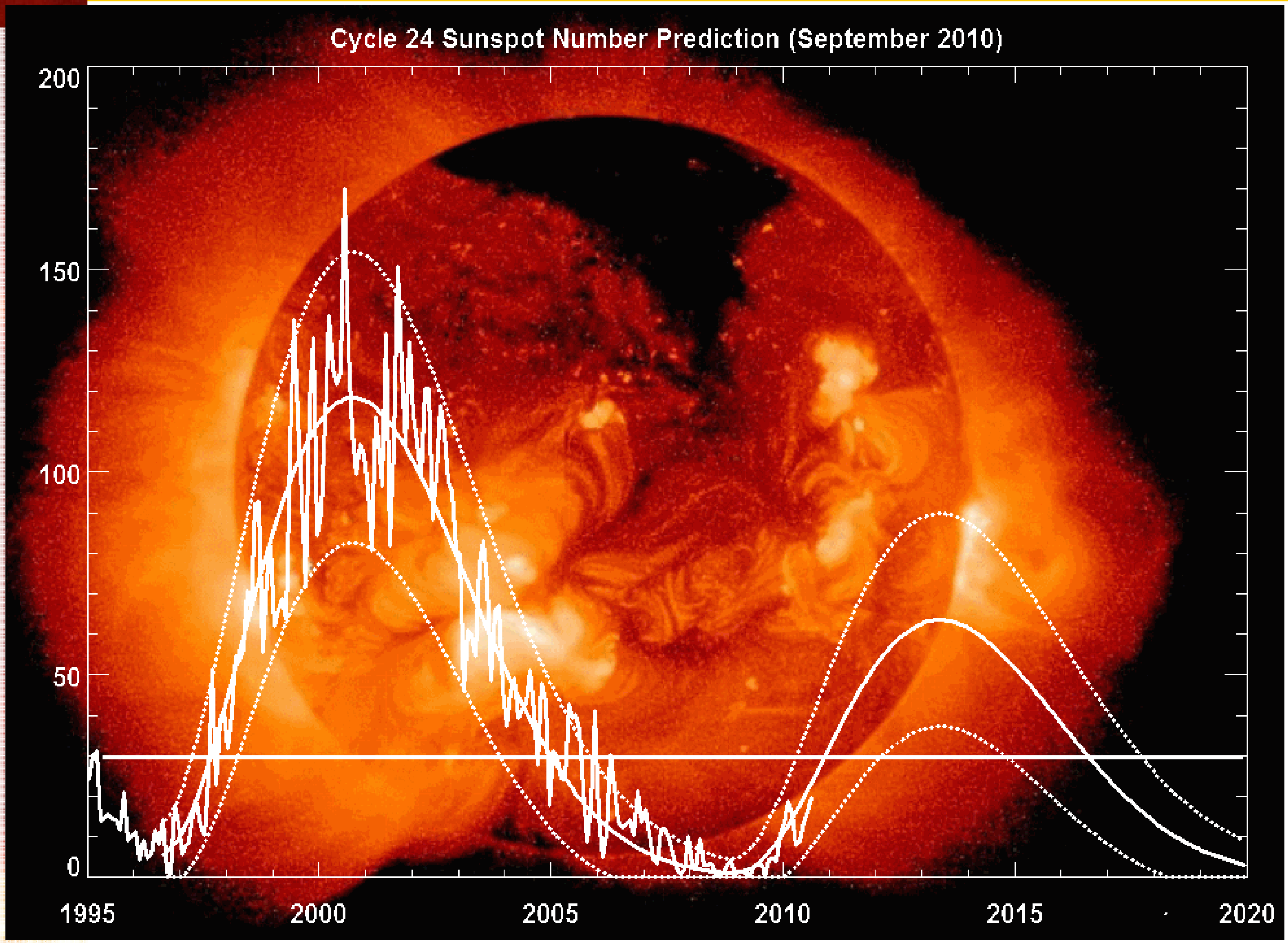
Small Size Satellite



Orbit parameters, launcher, lifetime

- SSA orbit parameters were chosen to achieve MONICA scientific objectives. The required orbit parameters are:
- type – near-Earth circular;
- altitude – 600-800 km;
- type – polar
- MONICA instrument should be pointed to zenith with accuracy better then ±0.5°. The satellite navigation systems should provide the accuracy of SSA position knowing of 1 km. The satellite axes orientation must be known with accuracy better then ±0.5°.
- The most probable launcher for MONICA is Soyuz rocket with Fregat acceleration module.
- The observations will be carried out continuously as monitoring mode. Duration of the mission is more than 3 years.

24 Solar sycle



Ishkov V.N. 2011

THANK YOU

FOR YOUR ATTENTION