SPACE::LAB

esa

SPACE::TALK #01

Z Košíc na orbitu Zeme a ešte ďalej...

Ing. Ján Baláž, PhD.

IEP SAS SPACE PHYSICS

ÚEF SAV

SLOVENSKÁ AKADÉMIA VIED ACADEMIA SCIENTIARUM SLOVACA

SPACE::LAB

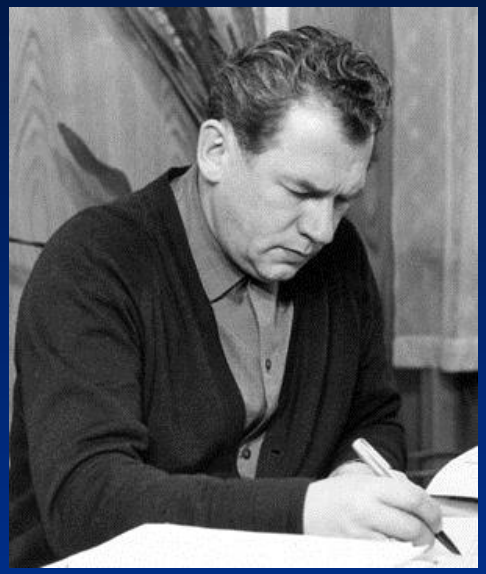
Z Košíc na orbitu Zeme

... a ešte ďalej...

IEP SAS
SPACE PHYSICS

Z histórie košického kozmického výskumu

- Tradícia už od začiatku 50-tych rokov 20. storočia, prof. Dubinský na LŠ
- INTERKOZMOS – kozmické lety, už od r. 1970



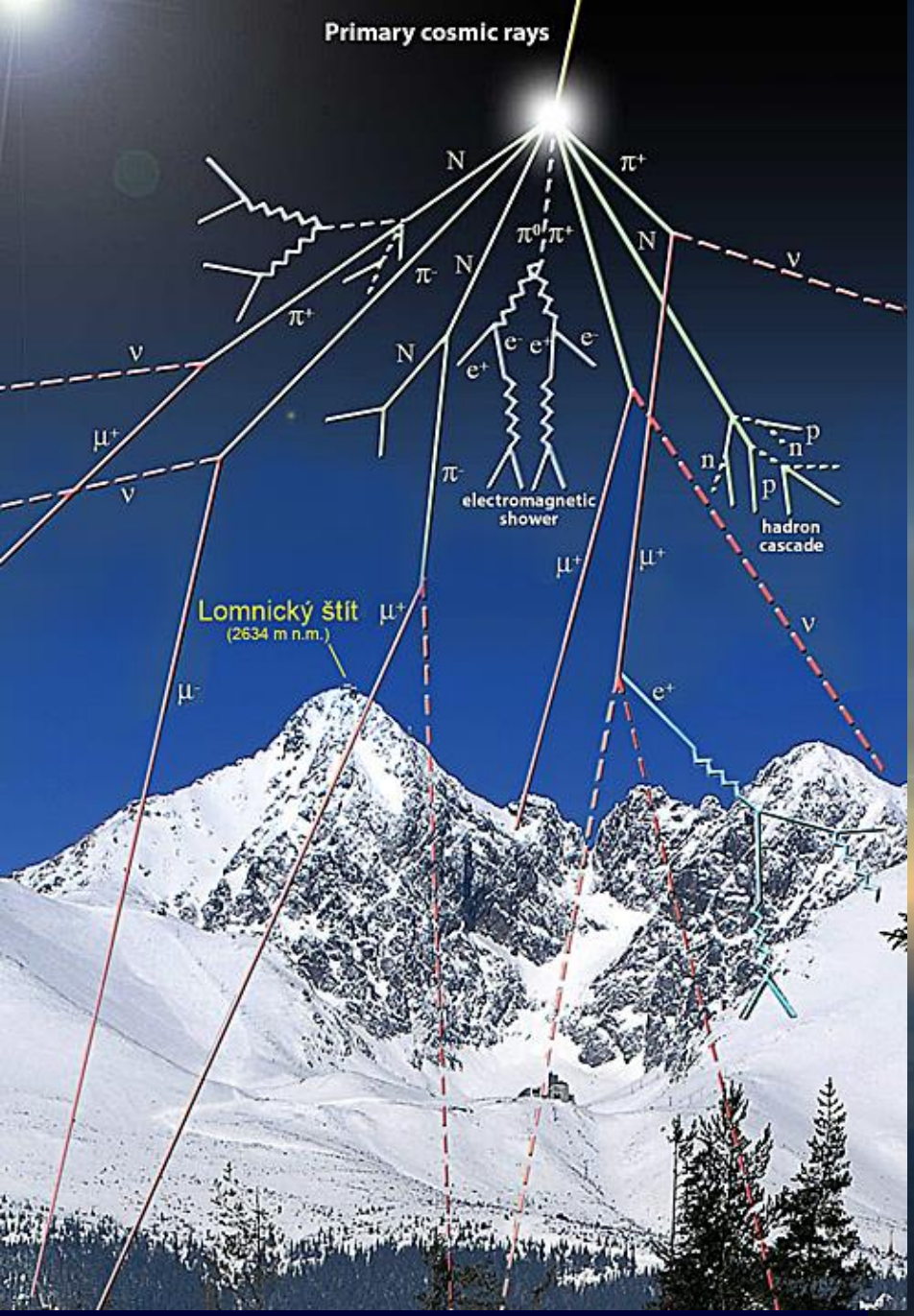
Prof. Juraj Dubinský
(*1914 – †1994)

Prof. Karel Kudela
(*1946 - †2019)

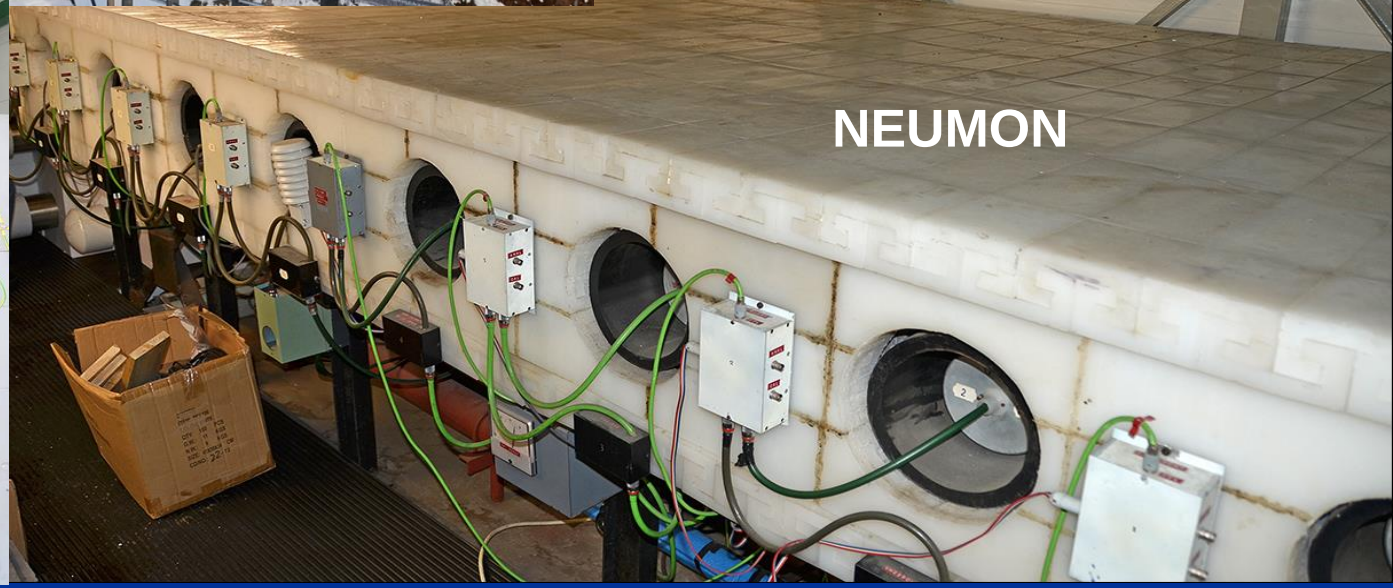
Ing. Jozef Rojko, CSc
(*1934 - †2011)

- **Kozmická fyzika:** výskum fyzikálnych vzťahov v systéme Slnko–Zem a heliosfére prostredníctvom kozmického žiarenia a kozmických energetických častíc.
- **Kozmické inžinierstvo:** vývoj prístrojovej techniky pre vesmírne sondy

Registrácia kozmického žiarenia
na Lomnickom štíte
(2634 m. nm)
IGY 1957 / 58
ÚEF zabezpečuje dodnes
(http://neutronmonitor.ta3.sk)

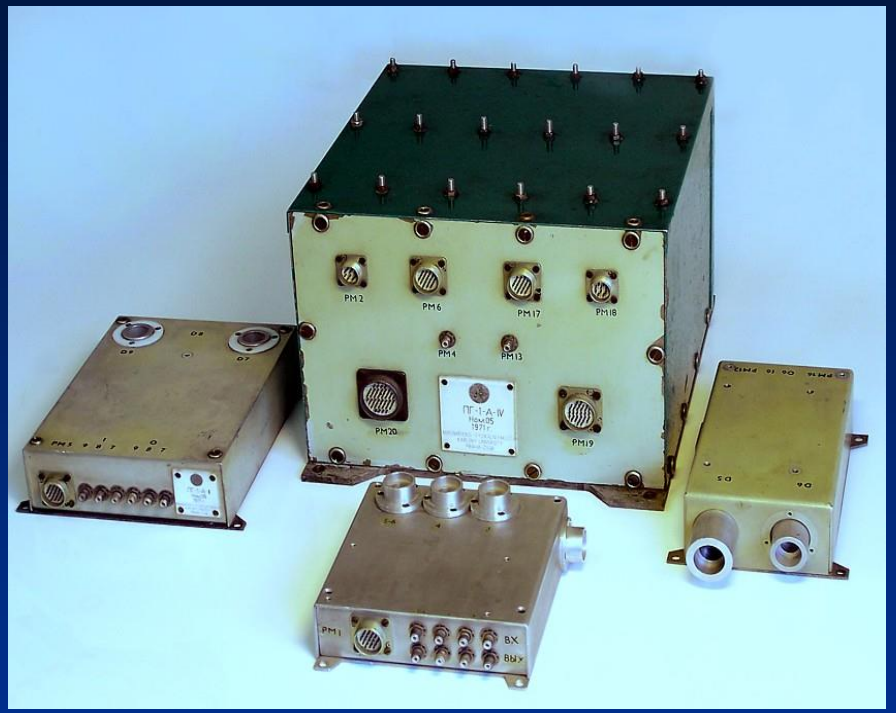


Detektory kozmického žiarenia na Lomnickom štíte



Nukleárne emulzie a PG-1 ... od r. 1970

RNDr. Ladislav Just, CSc
(*1946 - †2004)



PG-1
(UK-Praha, IK-3, IK-5, IK-13)

Orbitálna stanica MIR († 23. 03. 2001)

© NASA – STS 12.06.1998

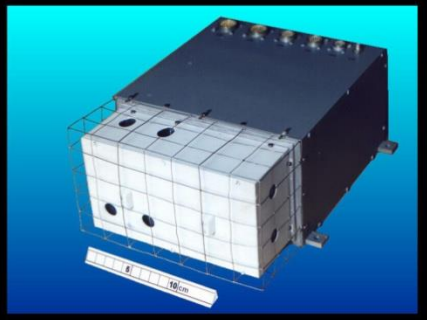
Nukleárne emulzie

DOZIMETRIA
Misia ŠTEFÁNIK
(1999)

Ivan BELLA

SK-1
Interkozmos-17 (1977)

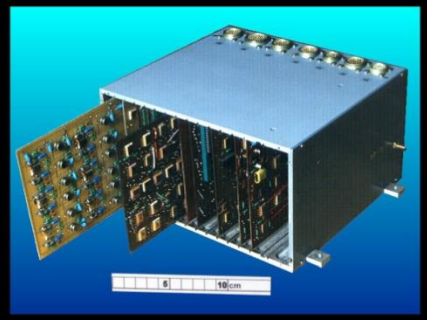
DOK-T
Prognoz-10 (1981)



DOK-1
Intershock (1985)

SPE-1
Active (1989), MIR (1996)

DOK-S
Active (1989)...1996 (4x)



SONG-E
Coronas-I (1994), -F.(2001)

DOK-2
Interball (1995, 1996)

SLED-2
MARS-96 (1996)

NUADU
Double Star (2004)

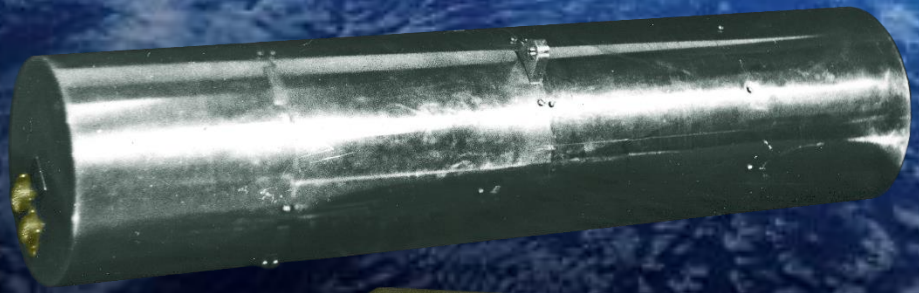
ESS
ESA-Rosetta (2004)

MEP-2
Radioastron (2011)

PICAM
BepiColombo (2018)

Interkozmos-17
* 24.9.1977

AUOS-Z



SK-1

PROGNOZ

DOK-T
PROGNOZ-10
(1981)

DOK-1
INTERSHOCK
(1985)

DOK-2
INTERBALL-T
(1995)
INTERBALL-A
(1996)

ACTIVE 1989

AUOS-Z

SPE-1

Satelity MAGION

DOK-S (s FEI-TUKE)

MAGION-2, ACTIVE (1989)

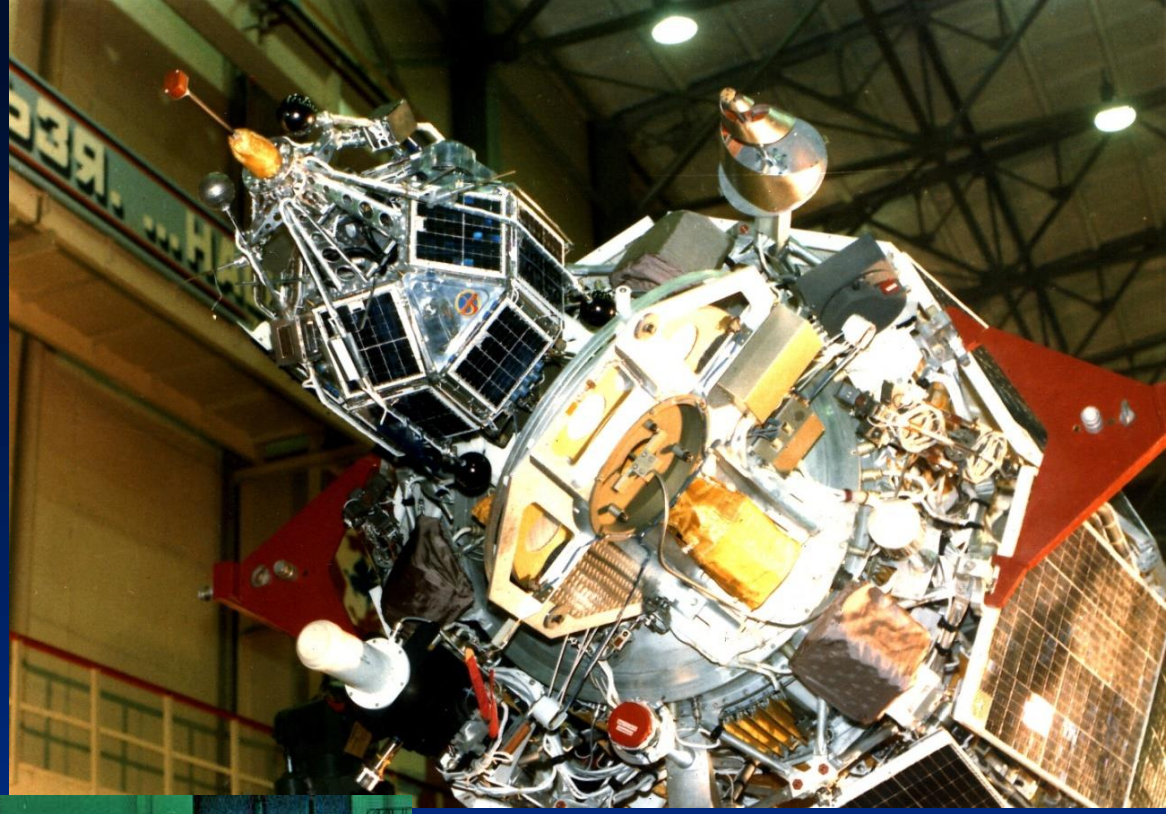
MAGION-3, APEX (1991)

MAGION-4, INTERBALL-T (1995)

MAGION-5, INTERBALL-A (1996)

MAGION a ACTIVE

(AUOS-Z)

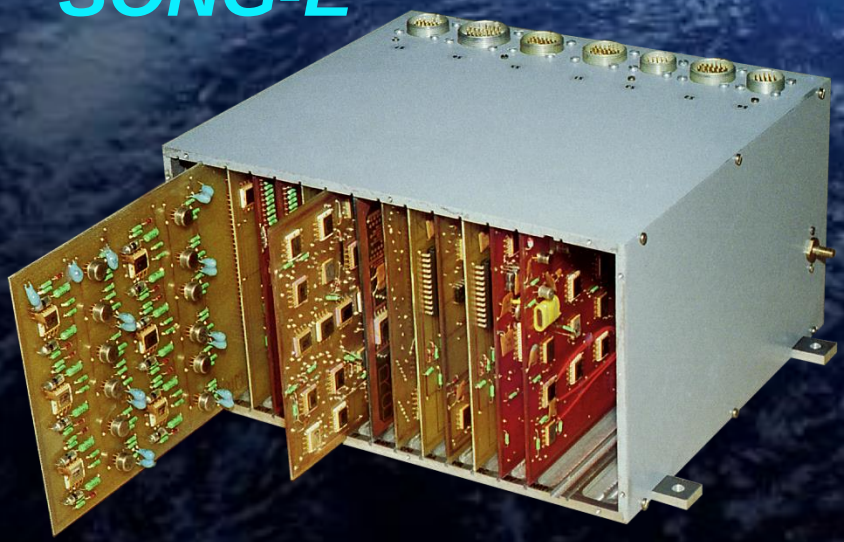


CYKLON

CORONAS - I
2. 3. 1994
CORONAS-F
31. 7. 2001

AUOS-Z

SONG-E



Kozmická fyzika vo vzťahoch Slnko-Zem

- Slnko je zdrojom, ktorý už takmer 5 miliárd rokov zásobuje pozemské životné prostredie energiou nevyhnutnou pre život najmä svojim svetlom a teplom (elektromagnetické žiarenie)

- Až moderná veda odhalila (Explorer-1, 1958, Van Allen), že Slnko na Zem významne pôsobí aj energetickými časticami (korpuskulárne žiarenie)

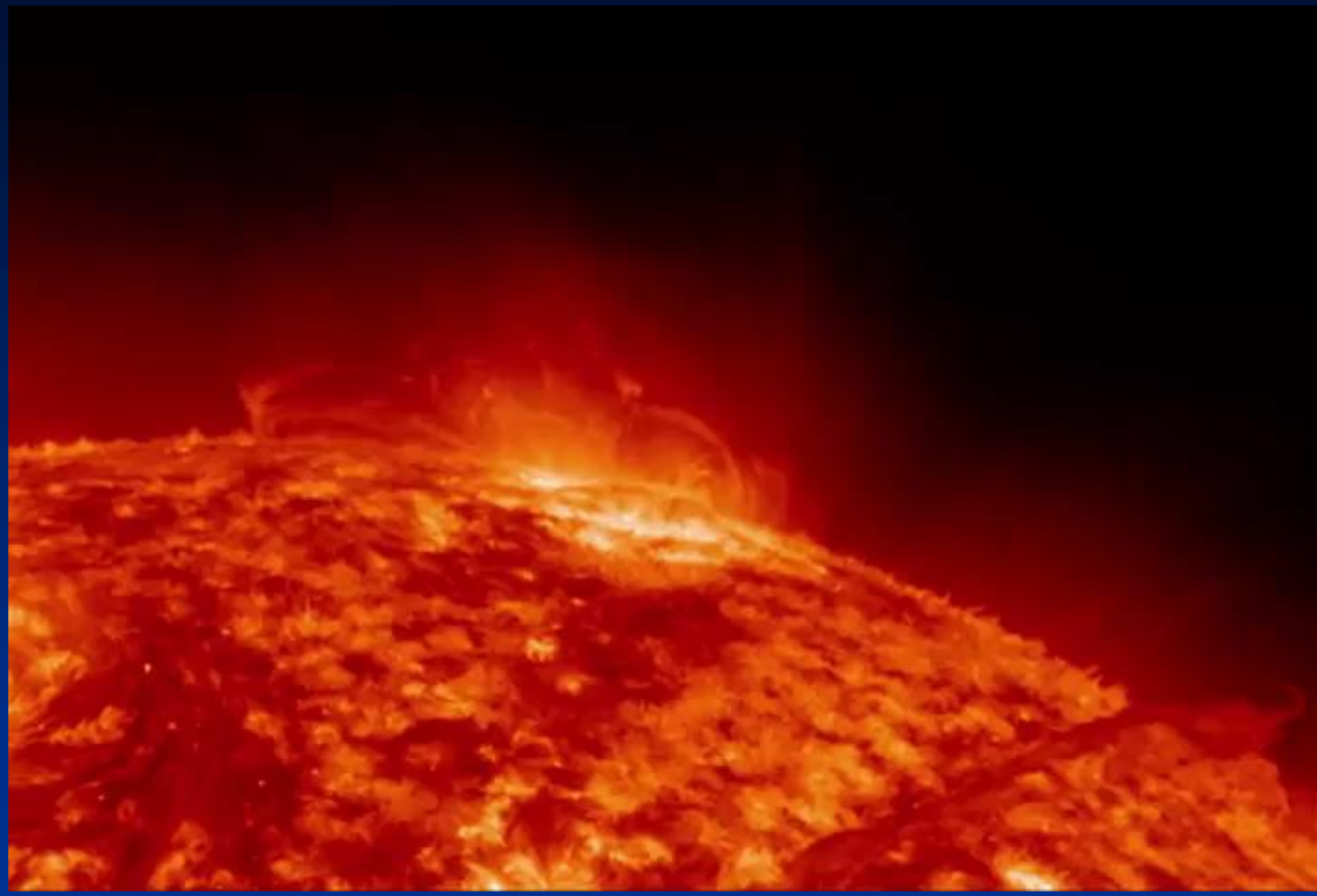
Slnečný vietor

- Je nepretržitý **prúd nabitých energetických častíc** (plazma), ktoré Slnko vyvrhuje do kozmického priestoru
- Typické **zloženie** (ióny): 95% H, 4% He, 1% ťažšie prvky C,N,O,...,Fe, plus elektróny

- Typická **rýchlosť** ustáleného slnečného vetra je okolo 400km/s, no niekedy dosahuje až 800km/s
- Typická **hustota** ustáleného slnečného vetra v blízkosti Zeme je 6 iónov / cm^3

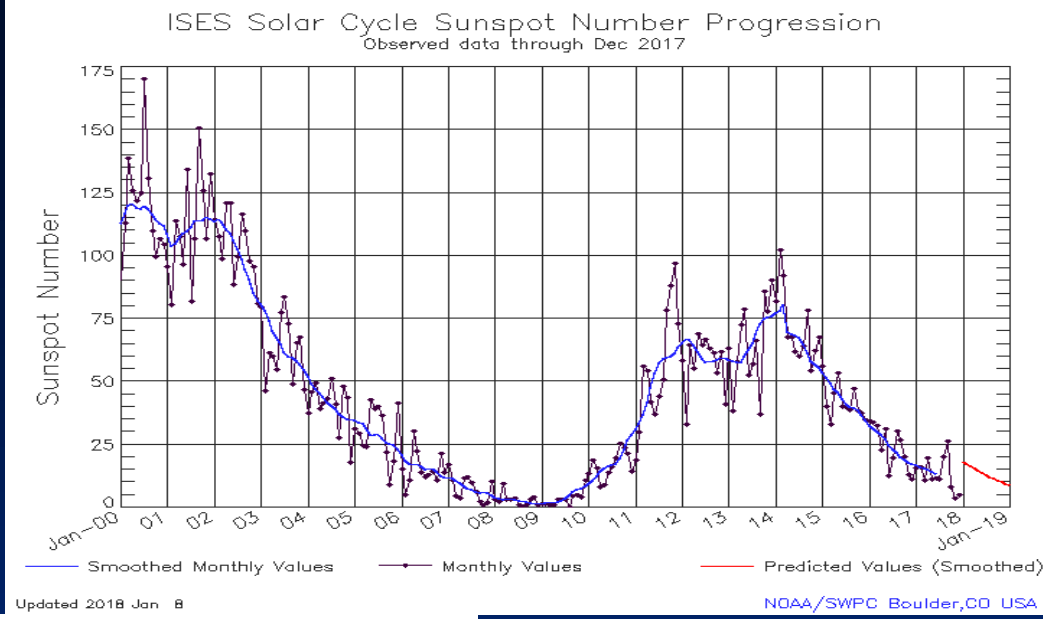
Výrony koronálnej hmoty CME

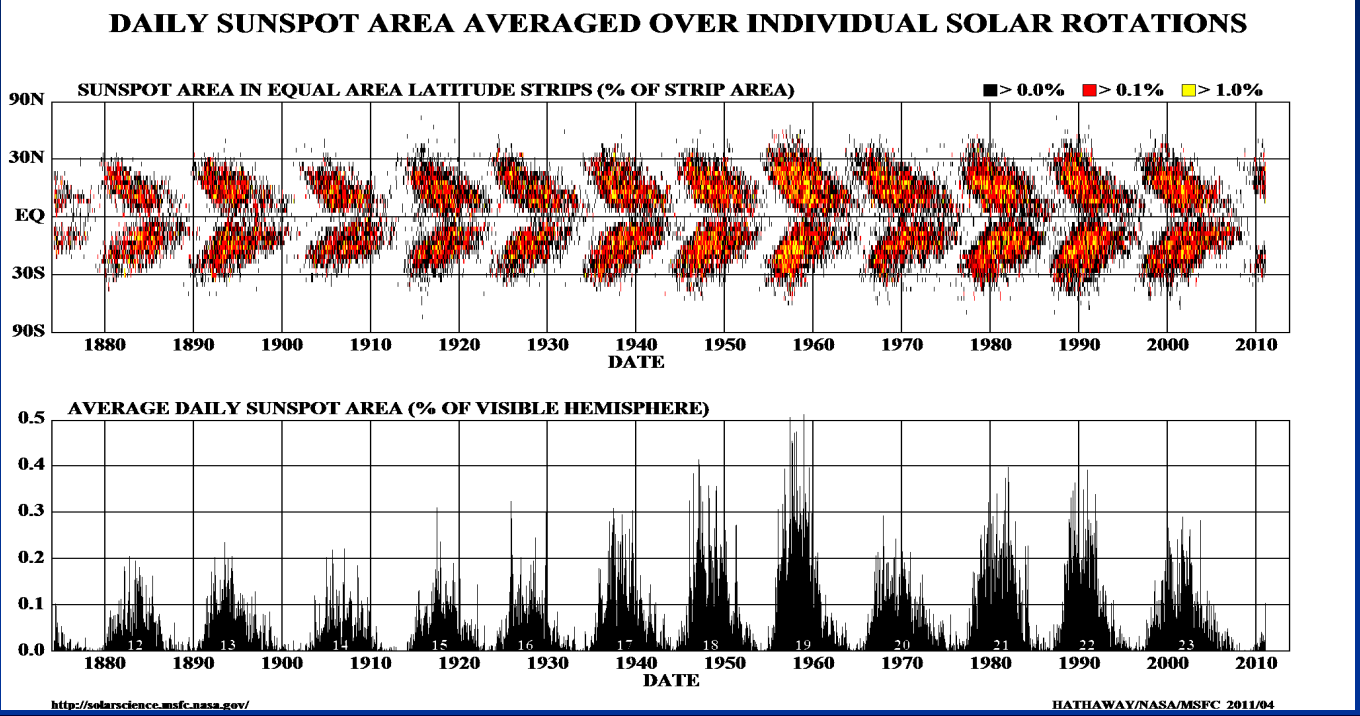
- Homogenitu ustáleného slnečného vetra najviac narušujú tzv. výrony koronálnej hmoty
- ~2-3 CME / deň v sol. maxime, ~1 CME/týž v sol. min.



- CME sú obrovské mraky nabitých slnečných častíc previazaných vlastným magnetickým poľom (tzv. plazmoid)

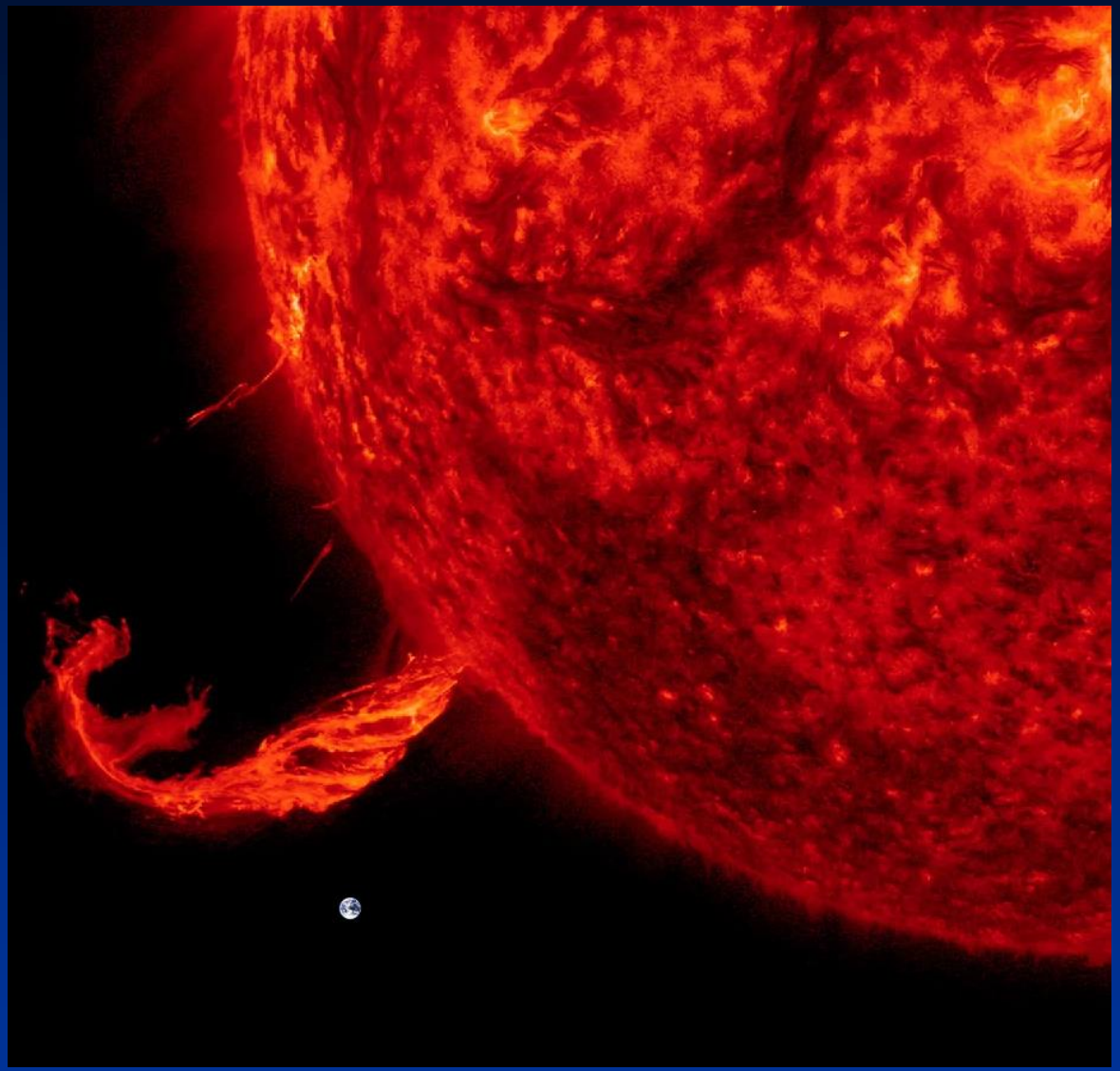
Solárne Cykly
(teraz 24. cyklus od 1755)





Výrony koronálnej hmoty CME

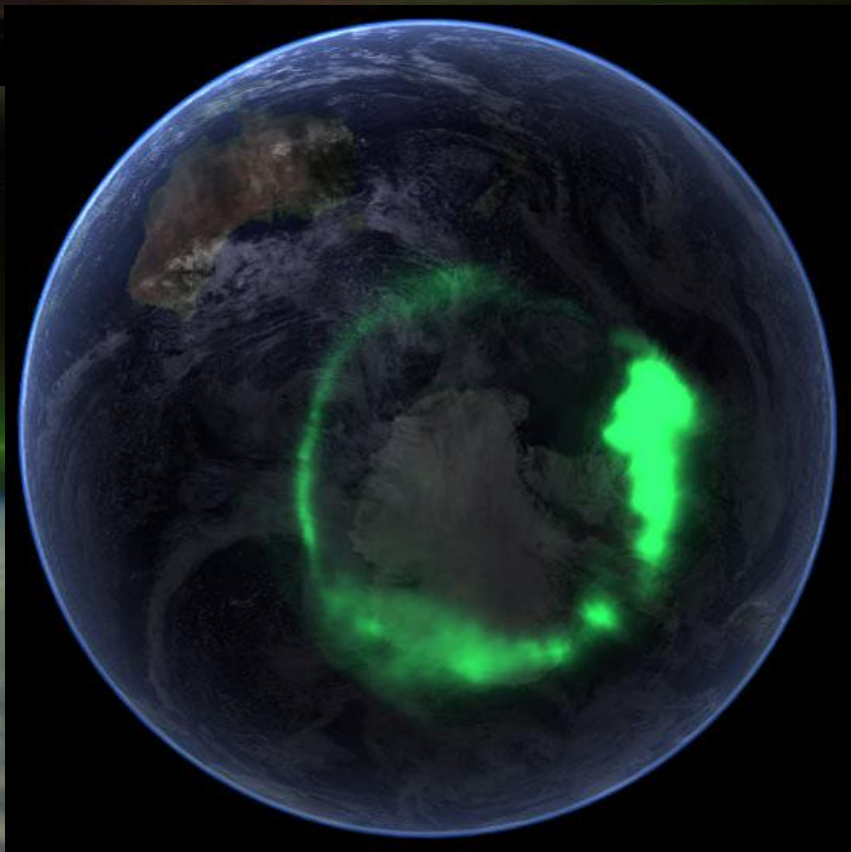
- CME smerujúce k Zemi môžu významne zasiahnuť a ovplyvniť magnetosféru, niekedy aj s fatálnymi následkami
- Rýchlosť, hustota a lokálny smer slnečného vetra a medziplanetárne magnetické pole IMF sú veličiny veľmi premenlivé a určujú tzv. **kozmické počasie**



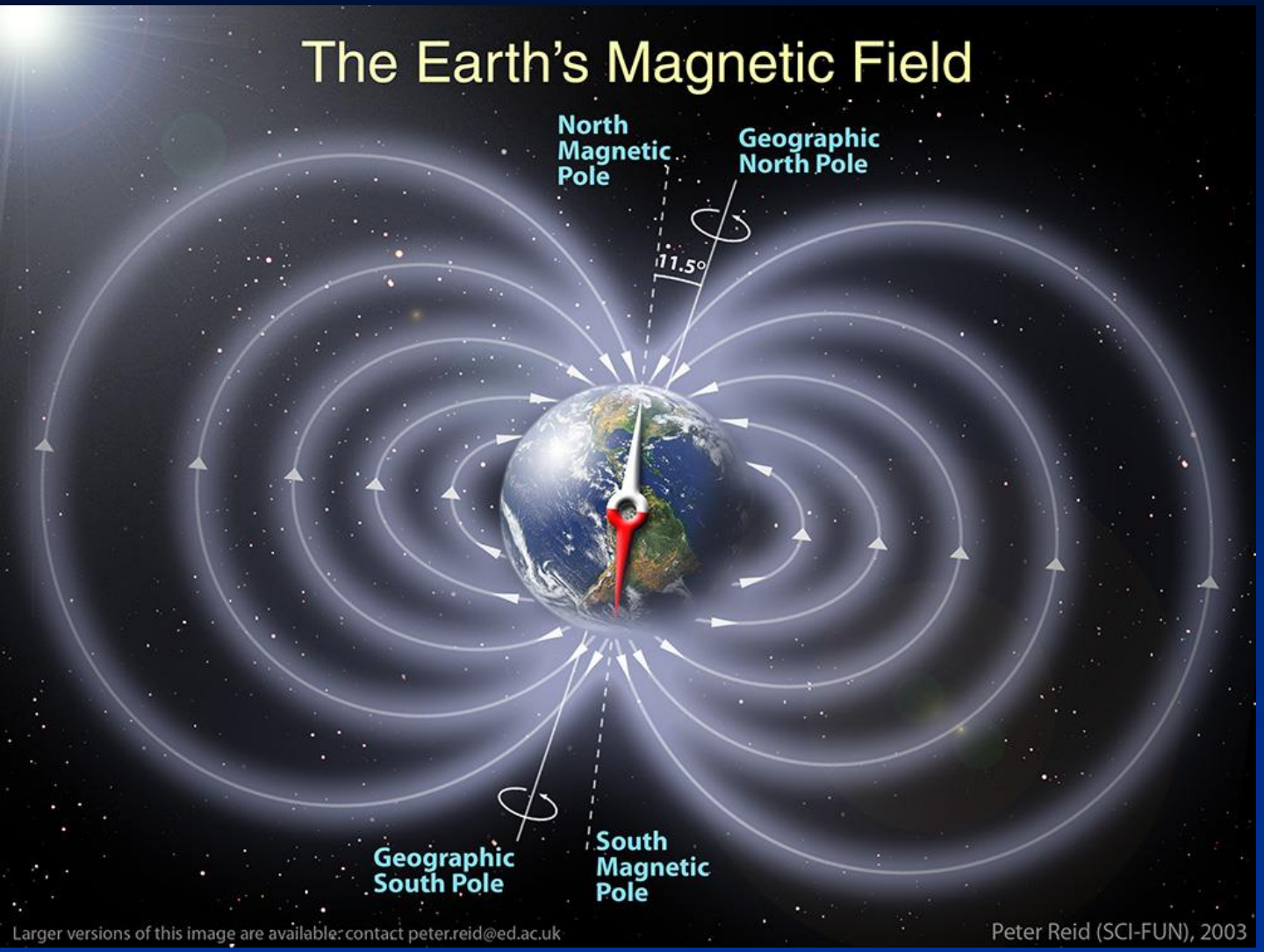
Efekty kozmického počasia

- Ohrozené elektronické systémy satelitov
- Nepredvídateľné zmeny orbít satelitov (predčasný zánik)
- Ohrozené posádky kozmických lodí (ISS)
- Ohrozená posádka a pasažieri diaľkových leteckých liniek, najmä v polárnych oblastiach (ožiarenie)
- Poruchy rádiových komunikačných systémov
- Poruchy energetických sústav
- Elektro-korózia diaľkových potrubí
- Zdravotné problémy citlivých jedincov
- Vplyv na pozemskú klímu, počasie, životné prostredie (ohrev, oblačnosť, atmosférické chemické a jadrové reakcie)
- Polárna žiara

Efekty kozmického počasia



Magnetické pole Zeme

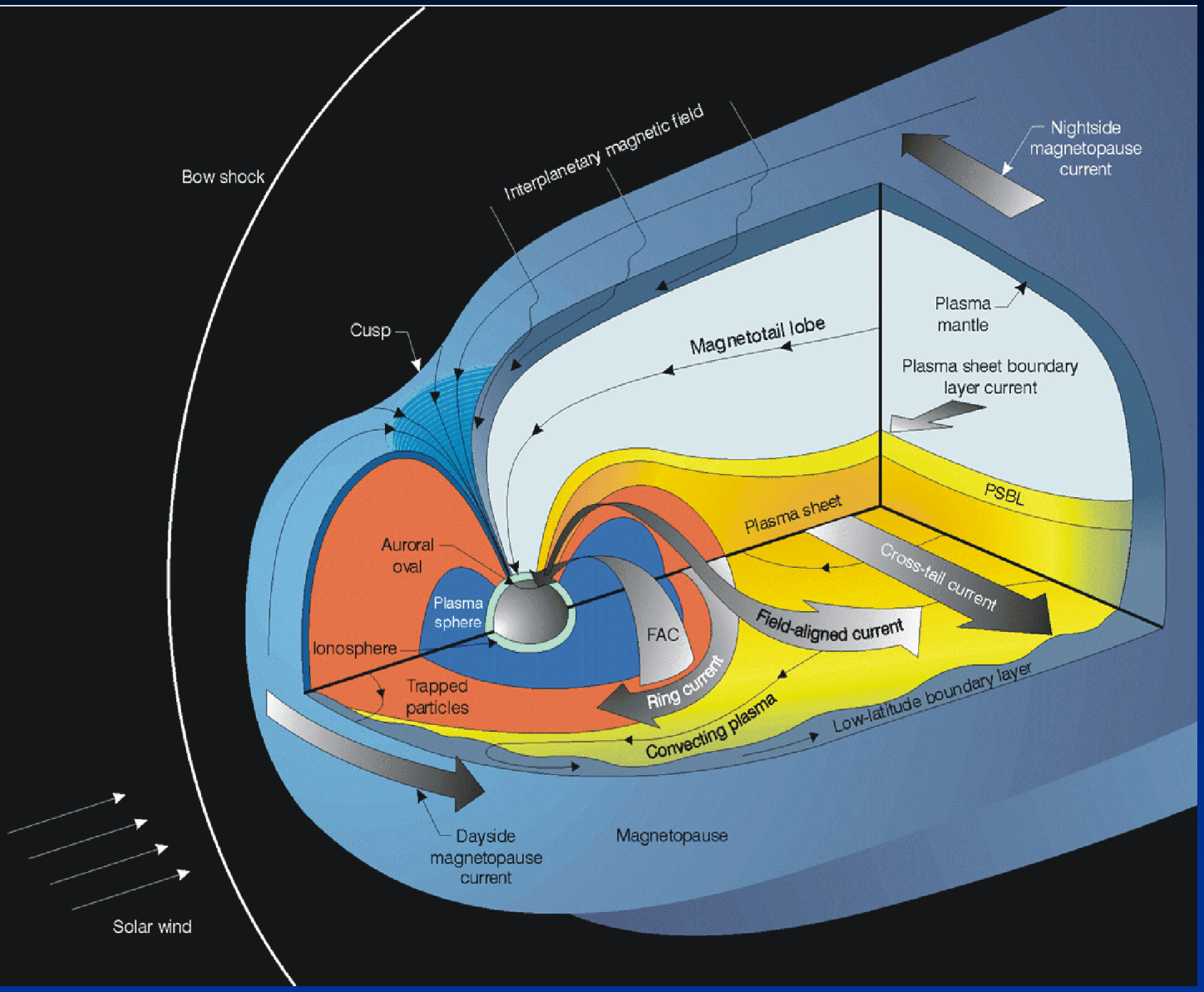


- dipólový charakter
- Pôvod: elektrické prúdy (geodynamo)

.

- nie je stále, zmeny intenzity aj polarity ~ 1 mil rokov

Magnetosféra Zeme

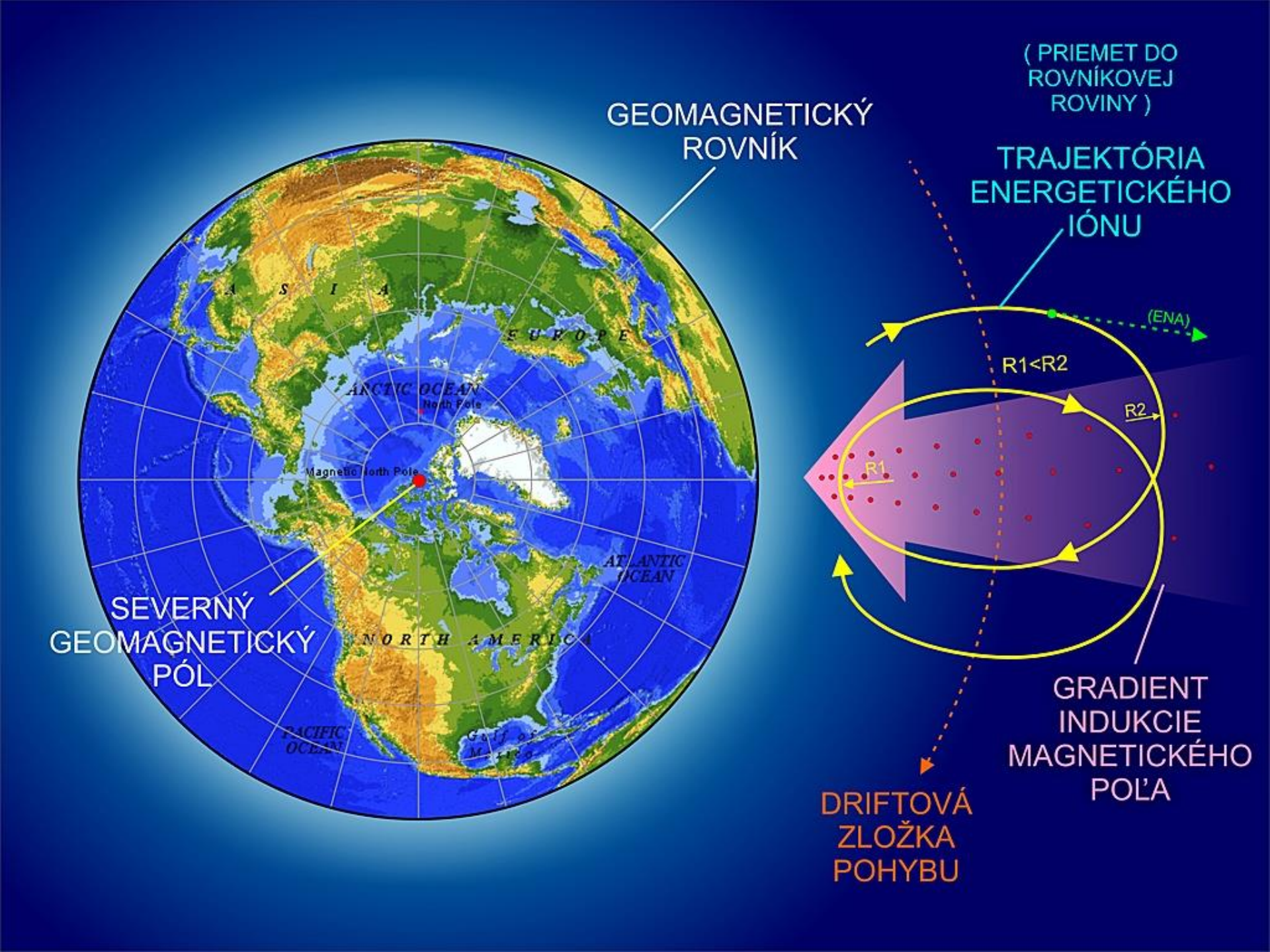


- oblasť, kde dominuje magnetické pole Zeme
- Je produktom interakcie geomagnetického poľa, slnečného vetra a medziplanetárneho magnetického poľa
- Dominuje zóna zachytenej radiácie – Van Allenove radiačné pásy
- Na dennej strane stlačená slnečným vetrom (~70000km)
- Na nočnej strane je silne pretiahnutá do chvosta (~milióny km)

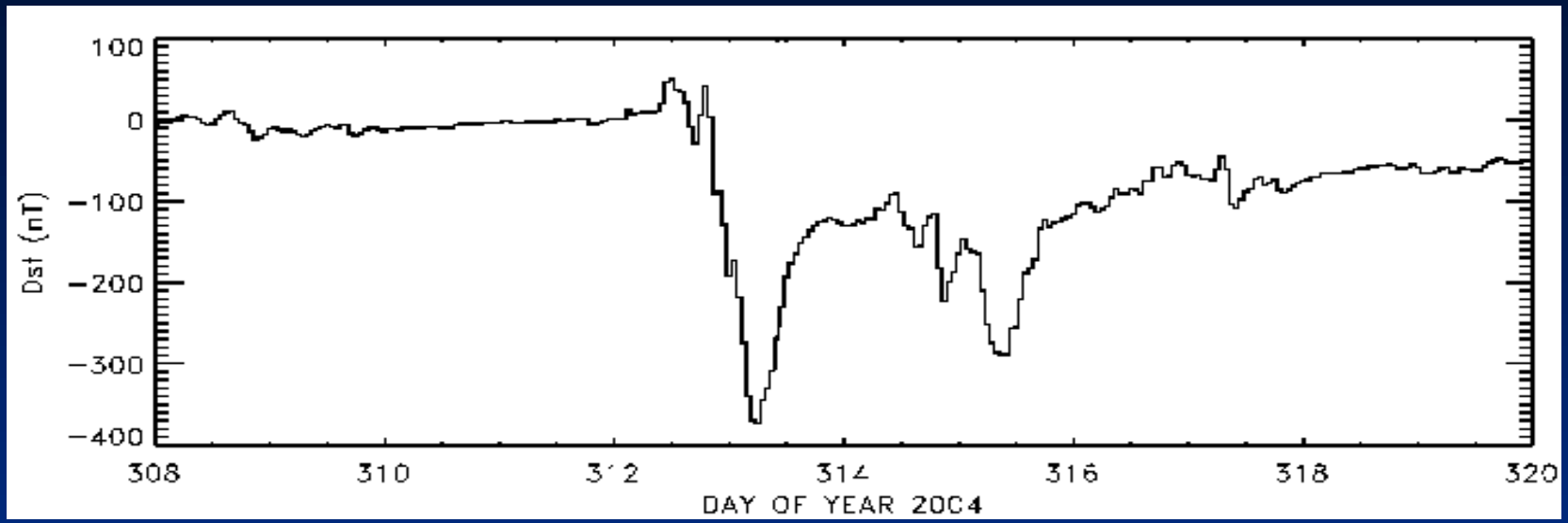
Pohyb nabitých častíc v geomagnetickom poli a zachytená radiácia (Van Allenove radiačné pásy)

- Nabitá častica podlieha v magnetickom poli silovému pôsobeniu. Lorentzova sila: $\mathbf{F} = q(\boldsymbol{v} \times \mathbf{B})$
- Silové pôsobenie geomagnetického poľa odkláňa nabité častice slnečného vetra od priamočiareho pohybu
- Dipólové geomagnetického pole spôsobuje špirálový pohyb a záchyt veľkého množstva energetických častíc do radiačných pásov
- Driftovými pohybmi častíc vznikajú elektrické prúdy


Severný zrkadlový bod
Siločiara zemského magnetického poľa
ENA
Drift iónov
Drift elektrónov
Južný zrkadlový bod
Špirálová trajektória zachytenej nabitej častice


(PRIEMET DO ROVNÍKOVEJ ROVINY)
GEOMAGNETICKÝ ROVNÍK
TRAJEKTÓRIA ENERGETICKÉHO IÓNU
(ENA)
R1<R2
R2
R1
GRADIENT INDUKCIE MAGNETICKÉHO POĽA
DRIFTOVÁ ZLOŽKA POHYBU
SEVERNÝ GEOMAGNETICKÝ PÓL
A S I A
EUROPE
ARCTIC OCEAN
North Pole
Magnetic North Pole
ATLANTIC OCEAN
NORTH AMERICA
PACIFIC OCEAN

Geomagnetické búrky a Prstencový prúd (Ring Current RC)



DST-index *(Disturbance Storm Time)*

Magnetická búrka: Masívny prienik nabitých energetických častíc do magnetosféry pri príchode CME a vhodnej konfigurácii medziplanetárneho magnetického poľa IMF.

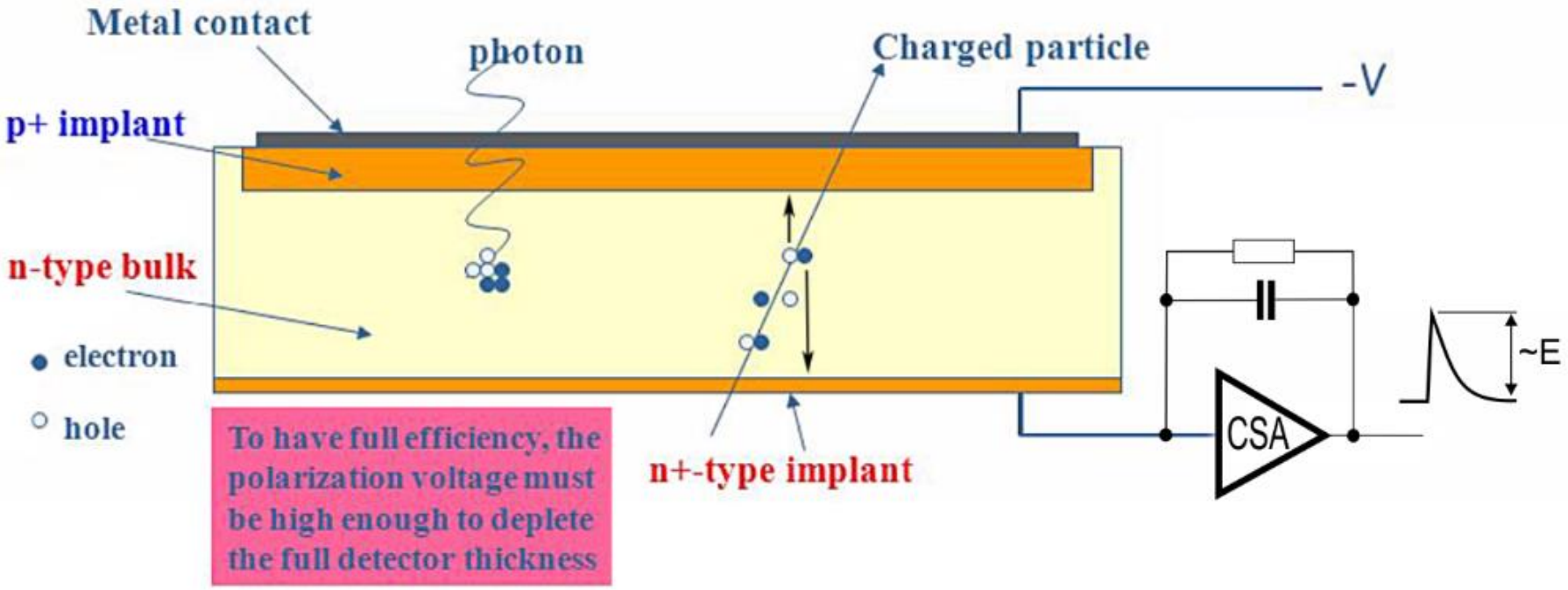
Spektr-R (Radioastron)

2011 – 2019

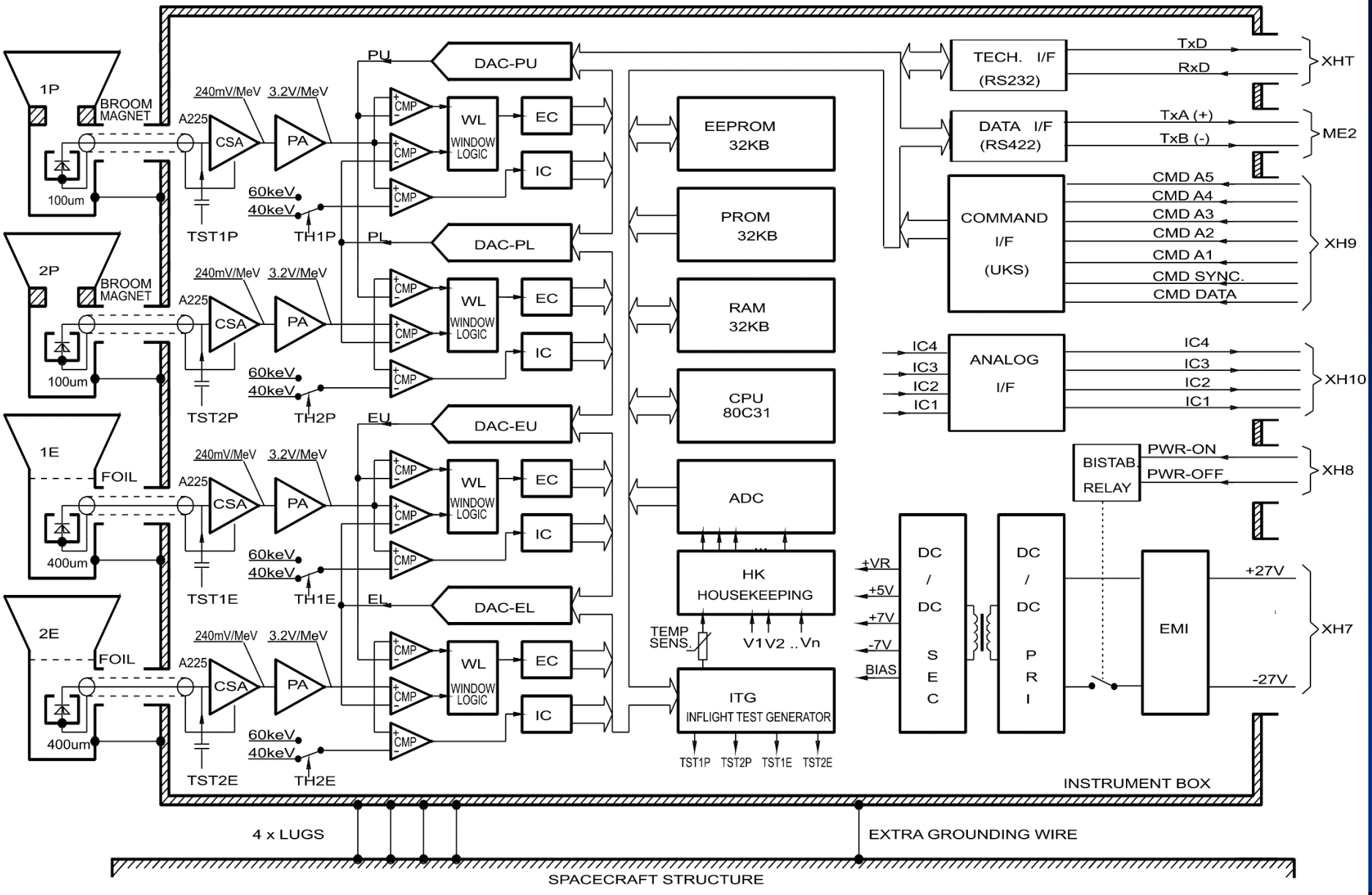
MEP-2

- Rádio-astronomický satelit s 10 metrovou parabolickou anténou na orbite Zeme
- Orbita je vhodná pre kozmo-fyzikálne experimenty

Polovodičový detektor ionizujúceho žiarenia



MEP 2– bloková schéma (Monitor of Energetic Particles)



MEP-2 je košický rekordér, 7,5 roka funkčný na orbite ! ! !

MEP-2 (zatiaľ) najprestížnejší výsledok

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Space Physics

RESEARCH ARTICLE

10.1002/2015JA021077

Oscillations of energetic ions flux near the Earth's bow shock

A. A. Petrukovich[1], T. Inamori[1], J. Balaz[2], K. Kudela[2], M. Slivka[2], I. Strharsky[2], V. A. Gladyshev[1], T. Sarris[3], and E. Sarris[3]

[1]Space Research Institute, Russian Academy of Sciences, Moscow, Russia, [2]Institute of Experimental Physics, Slovakian Academy of Sciences, Kosice, Slovakia, [3]Electrical & Computer Engineering Department, Democritus University of Thrace, Xanthi, Greece

Key Points:
- Oscillations of energetic ions are found in the foreshock
- Energy range is 4–400 keV, periods 10–60 s
- Events are related to fast solar wind

Supporting Information:
- Readme
- Data Set S1
- Table S1

Correspondence to:
A. A. Petrukovich,
apetruko@iki.rssi.ru

Abstract A new type of variability in the foreshock and magnetosheath is revealed with the recent energetic particle experiments monitor of electrons and protons (MEP) onboard Spectr-R spacecraft and solid-state telescope onboard Time History of Events and Macroscale Interactions during Substorms spacecraft, which have high time resolution. Oscillations of energetic ion fluxes are observed in the broad energy range ~4–400 keV, with periods 10–30 s, often rather monochromatic waveform and accompanied with magnetic oscillations. Such events are not so rare (~100 cases are found for 2007–2012) but are associated mostly with high-speed solar wind.

Double Star

(Dvojhviezda, Shuang Xing)

- Spolupráca Čínskej kozmickej agentúry CNSA a Európskej kozmickej agentúry ESA
- Dva satelity pre magnetosférický prieskum TC-1 a TC-2 (*Tan Ce* – Explorer, Prieskumník)
- ENA imager **NUADU** vyvinutý na ÚEF na palube TC-2

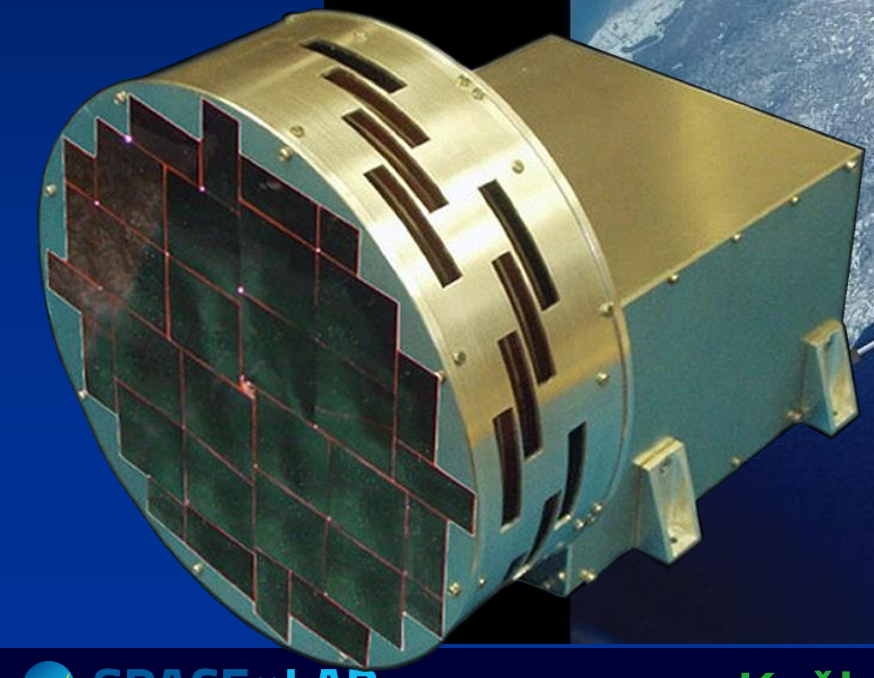
Snímkovací detektor

(imager)

Energetických

Neutrálnych Atómov

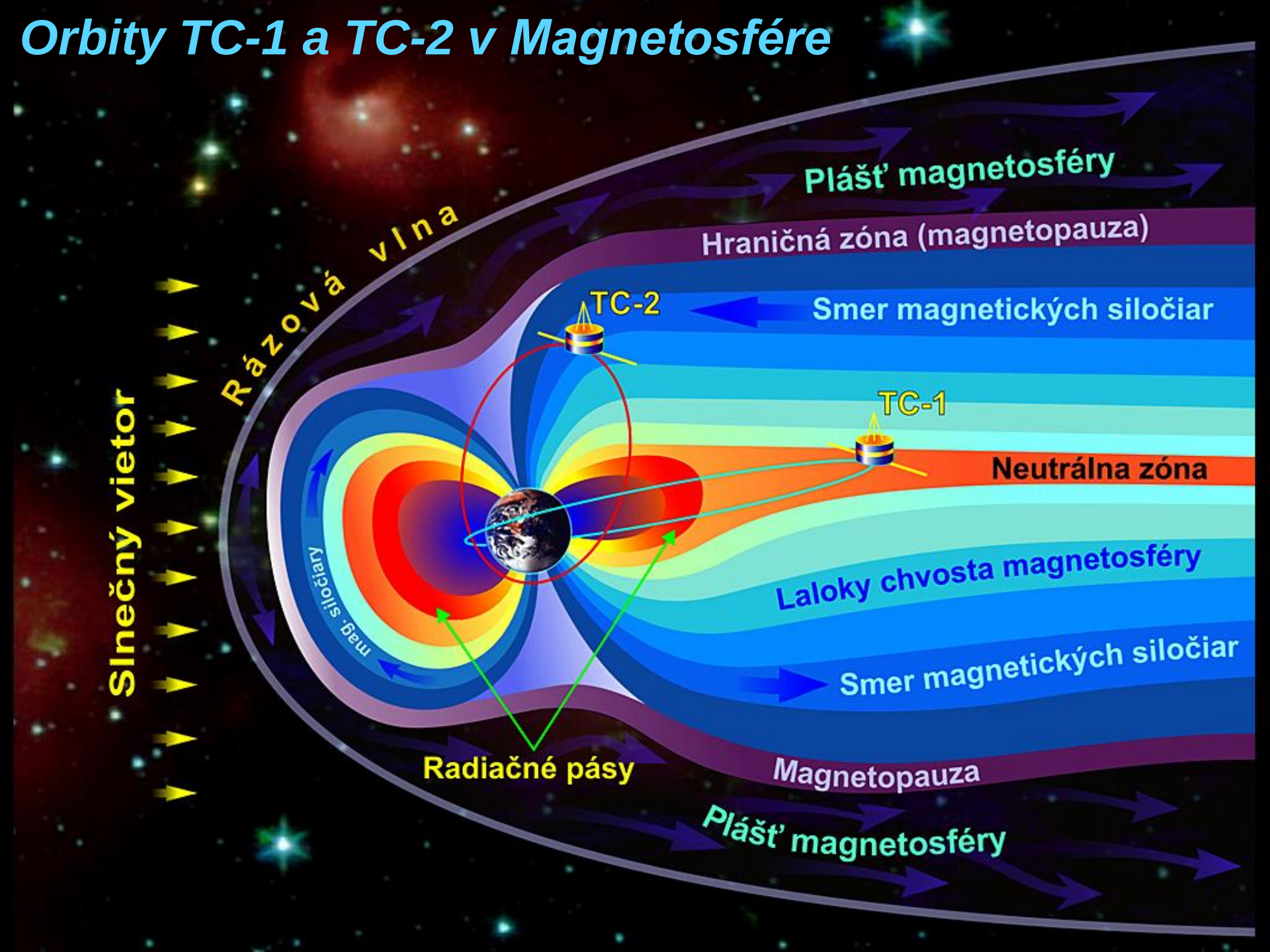
N U A D U



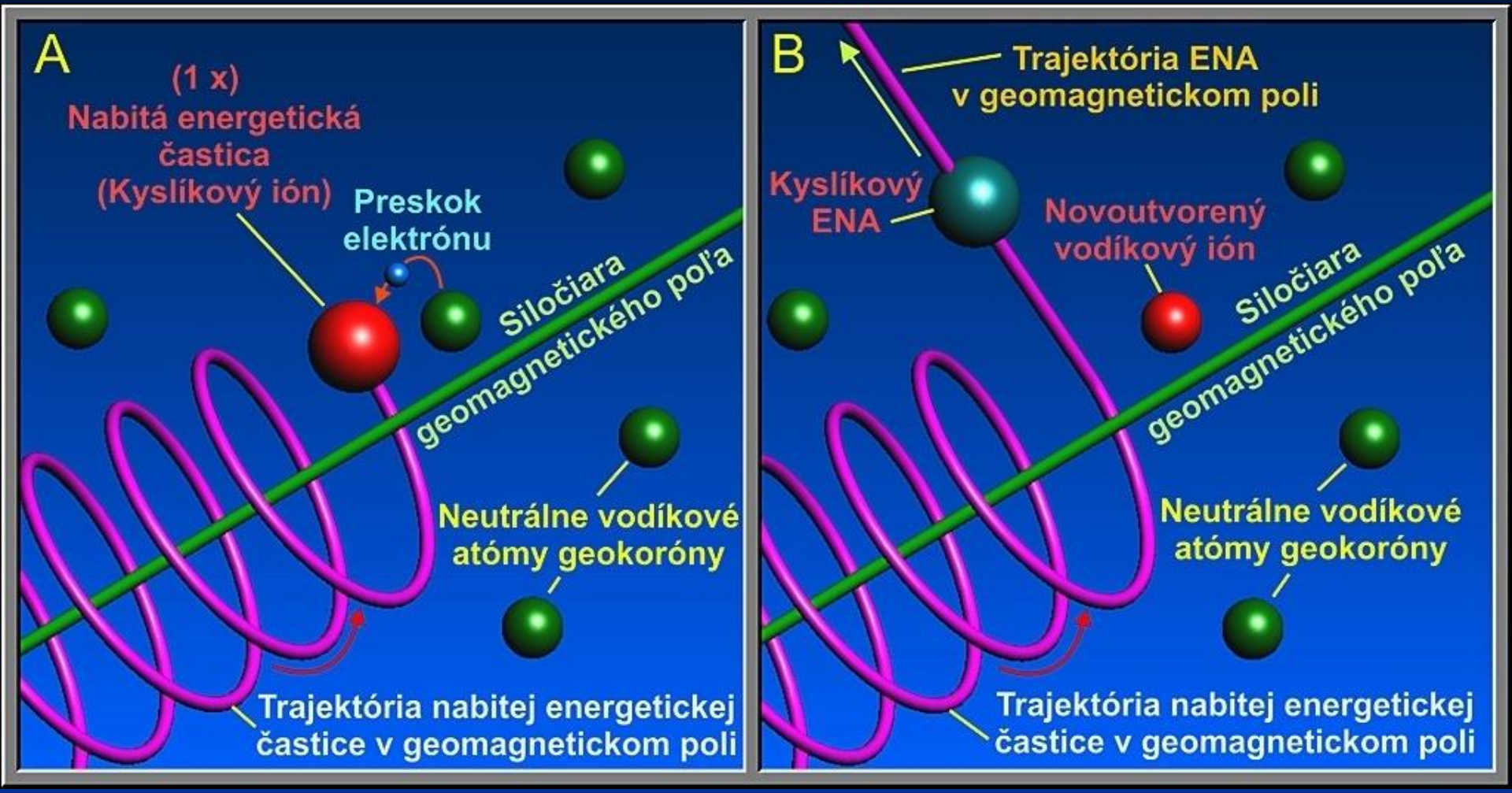
双星 计划

Double Star

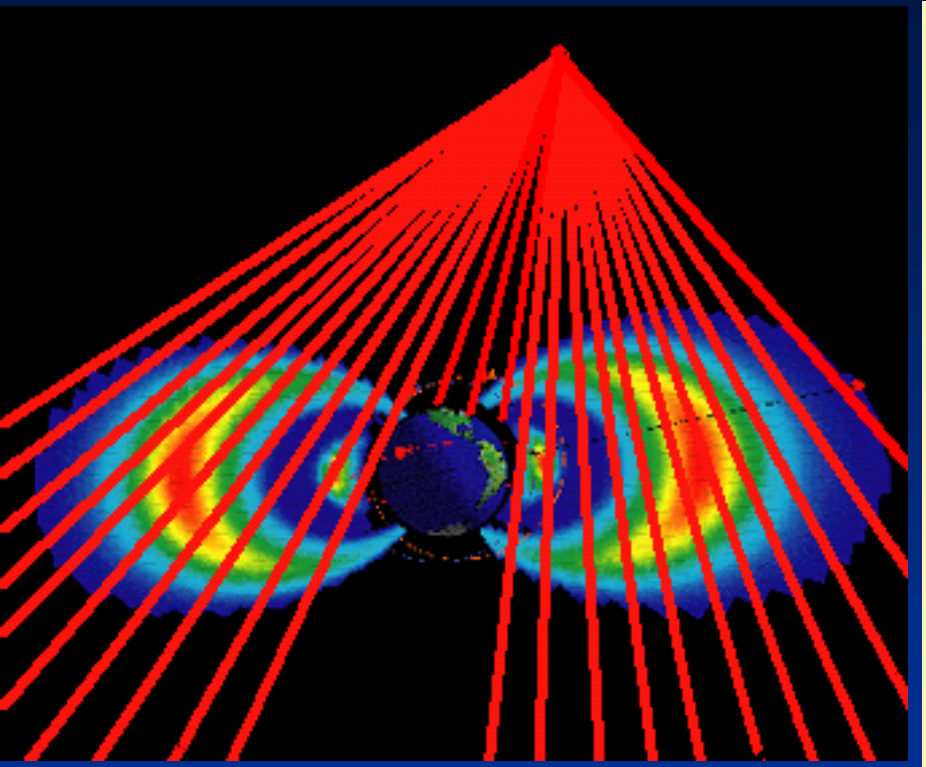
Orbity TC-1 a TC-2 v Magnetosfére

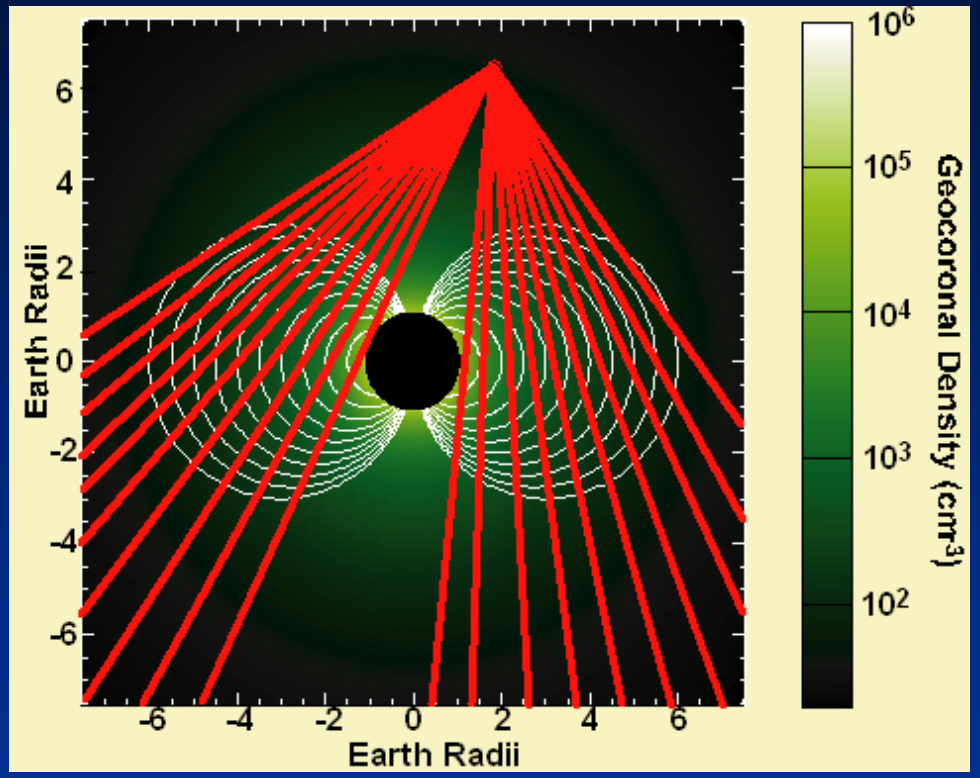


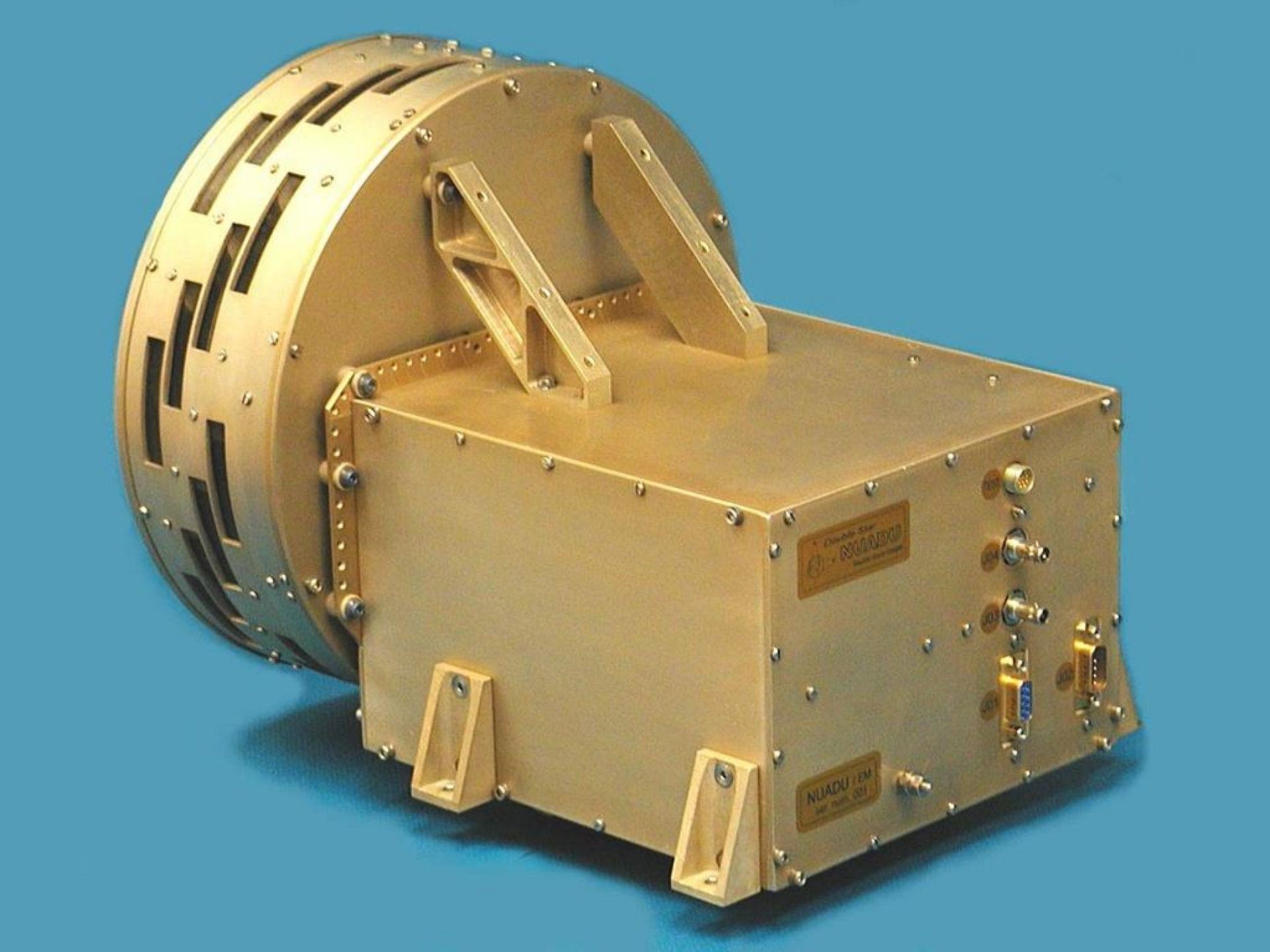
Generovanie ENA v magnetosfére Zeme



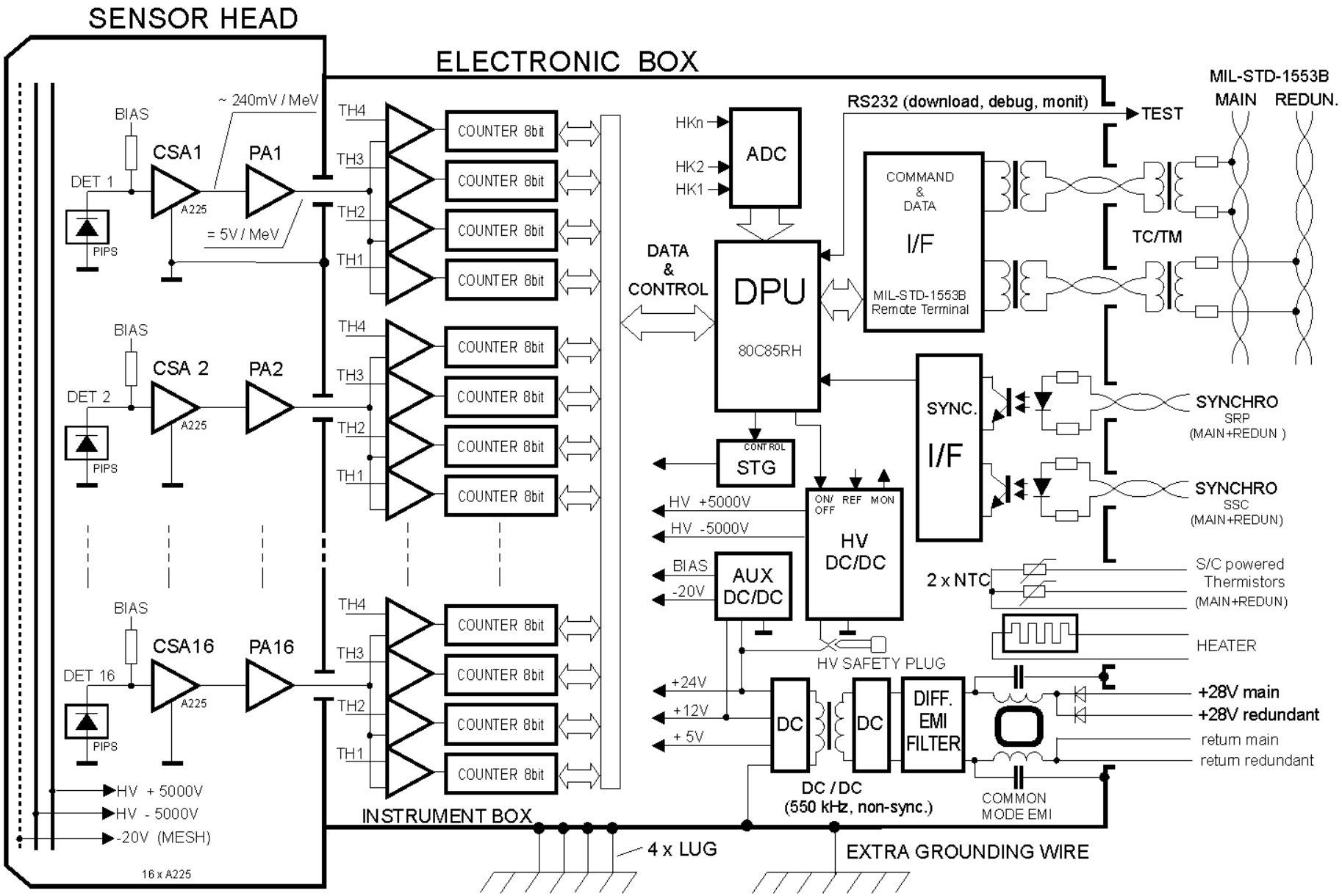
ENA-imaging

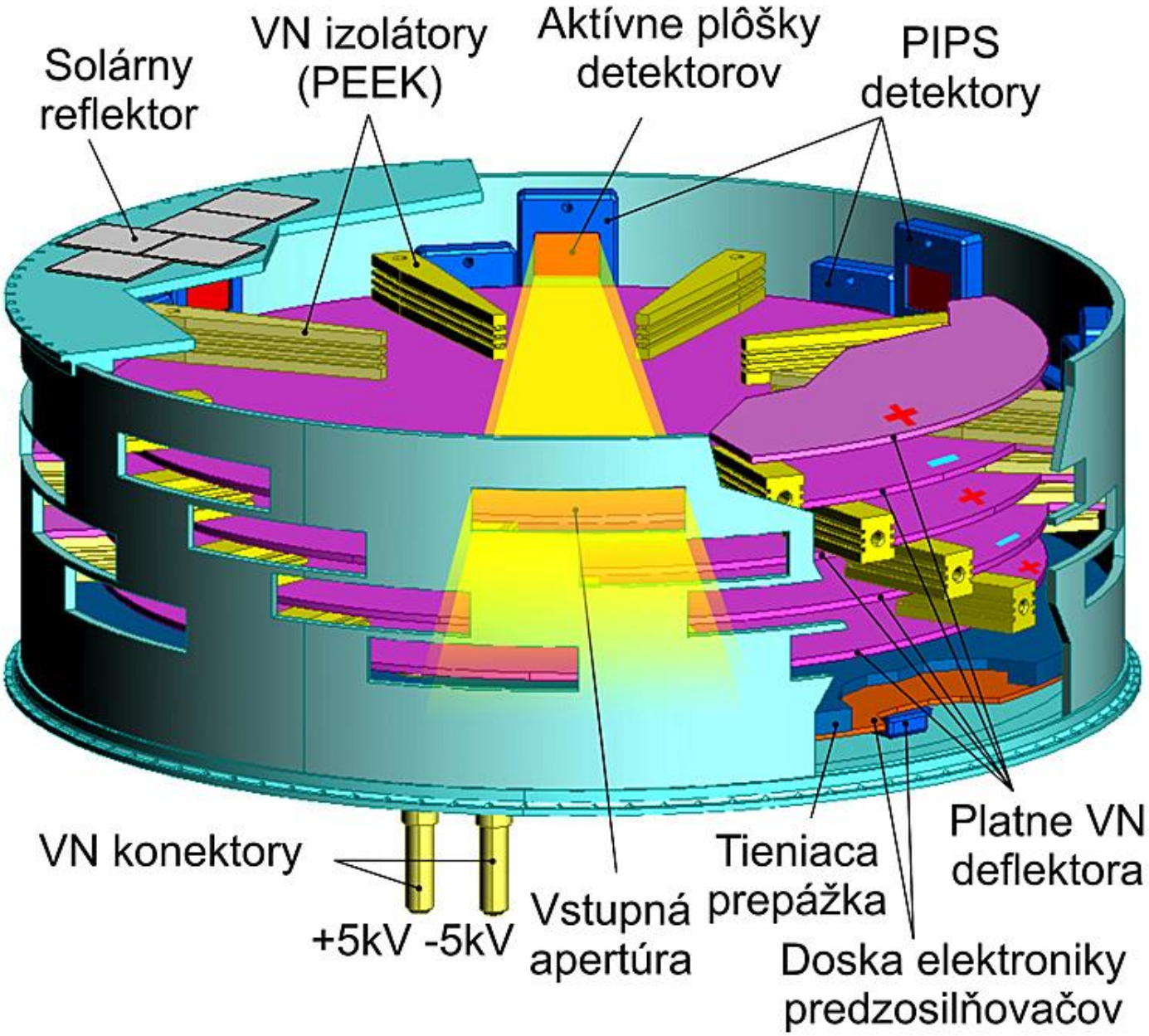


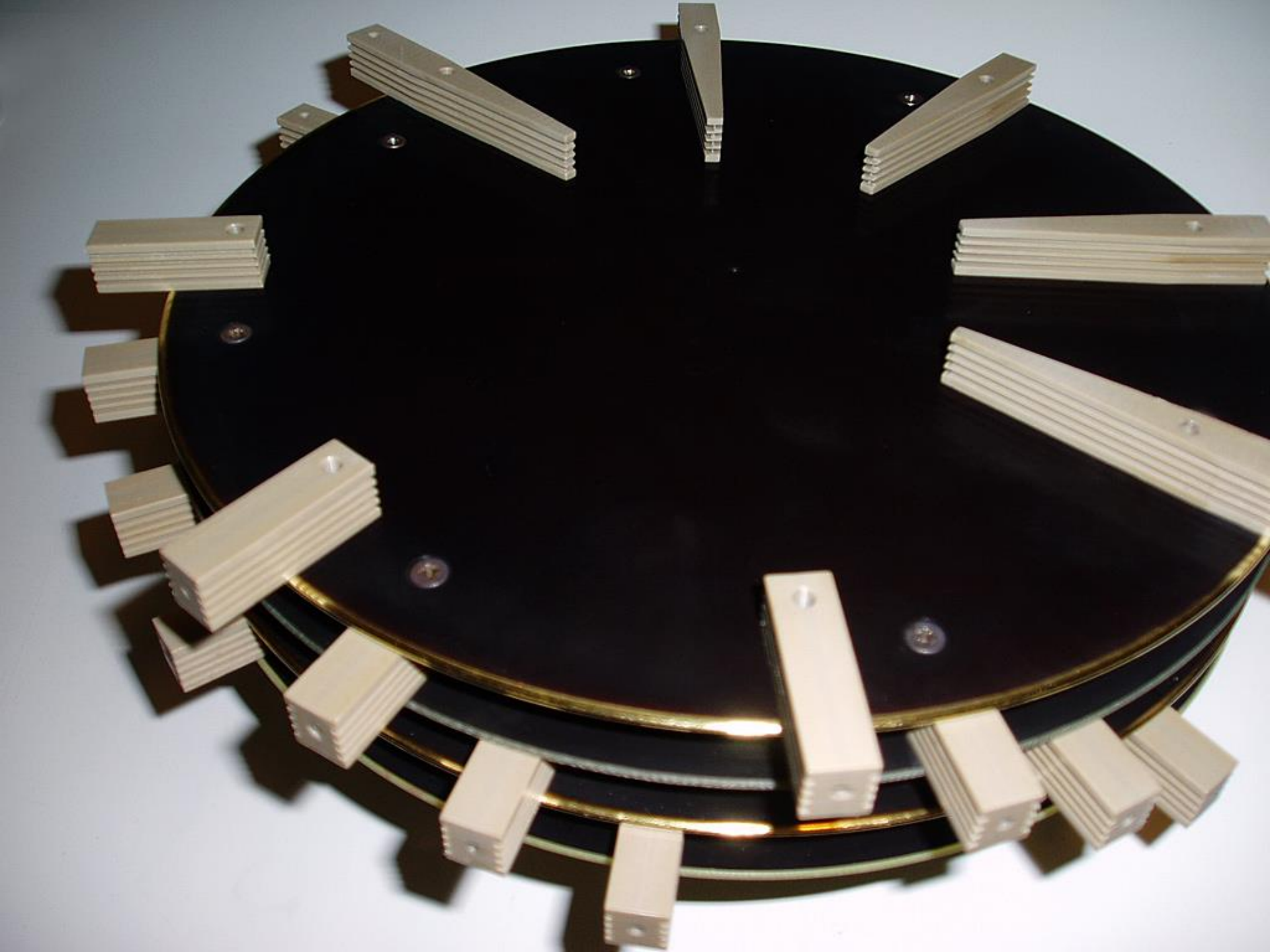

Earth Radii
6
4
2
0
-2
-4
-6
-6
-4
-2
0
2
4
6
Earth Radii
10^6
10^5
10^4
10^3
10^2
Geocoronal Density (cm^{-3})

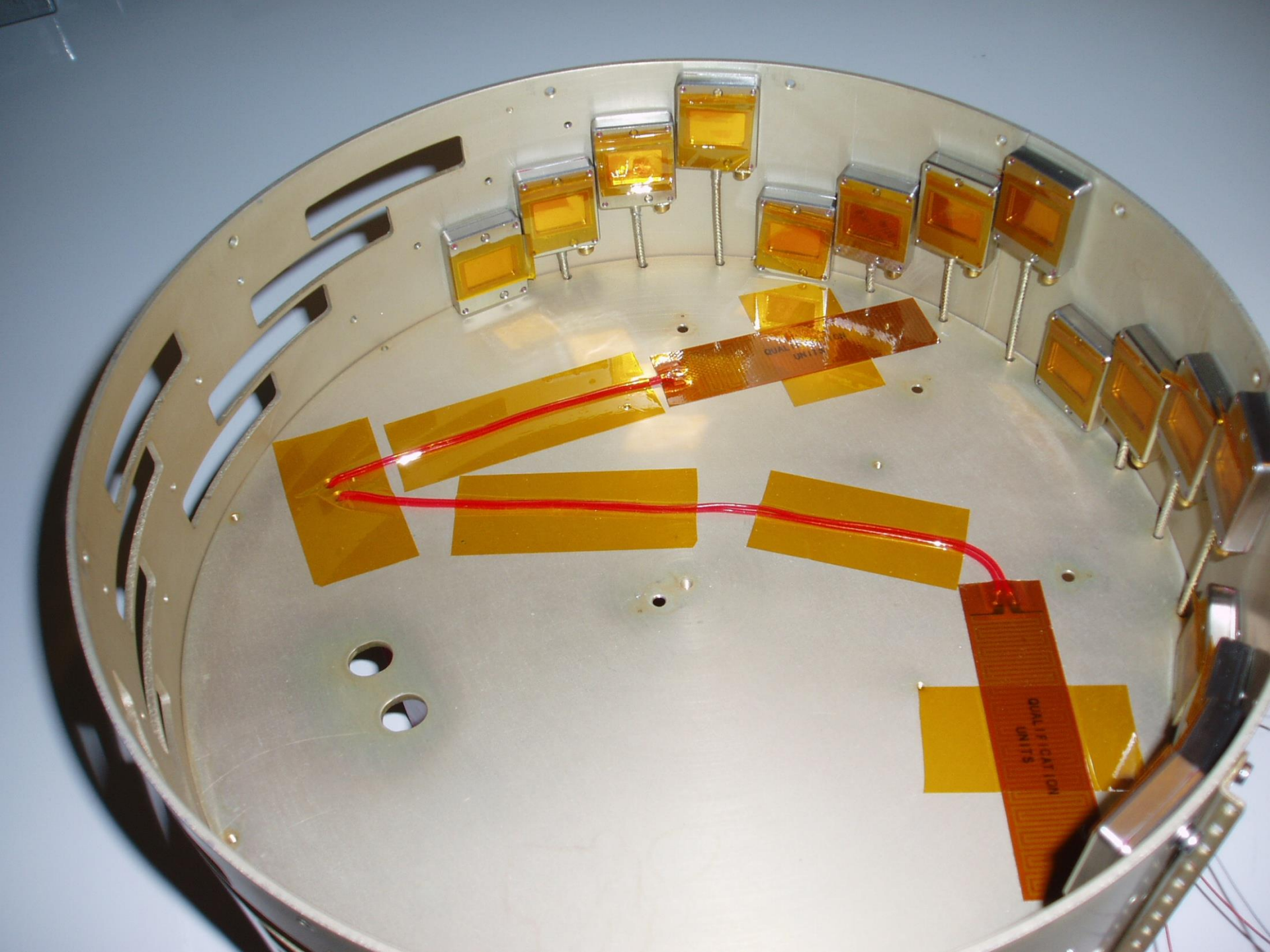

NUADU EM

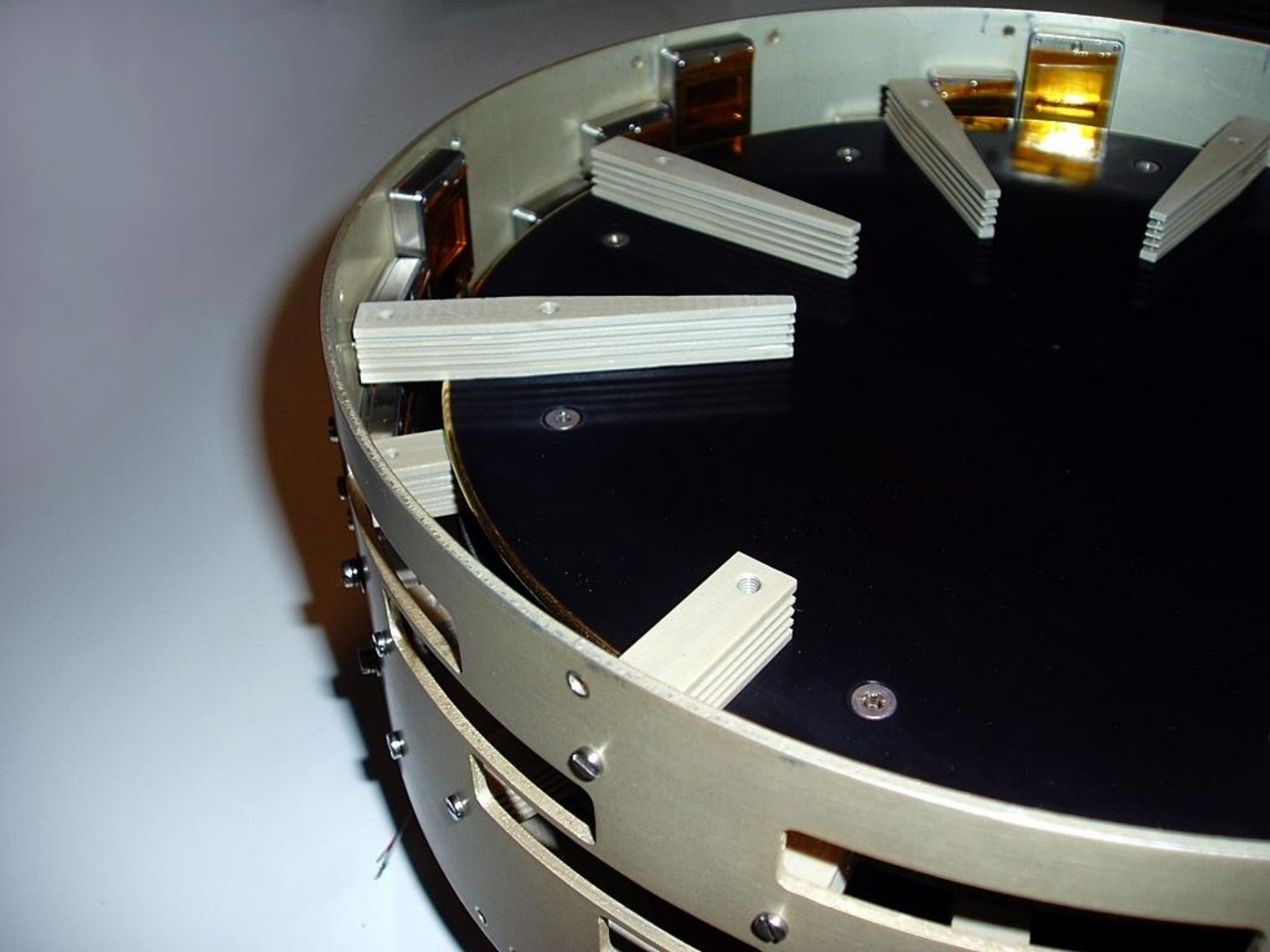
NUADU – funkčná bloková schéma (NeUtral Atom Detection Unit)

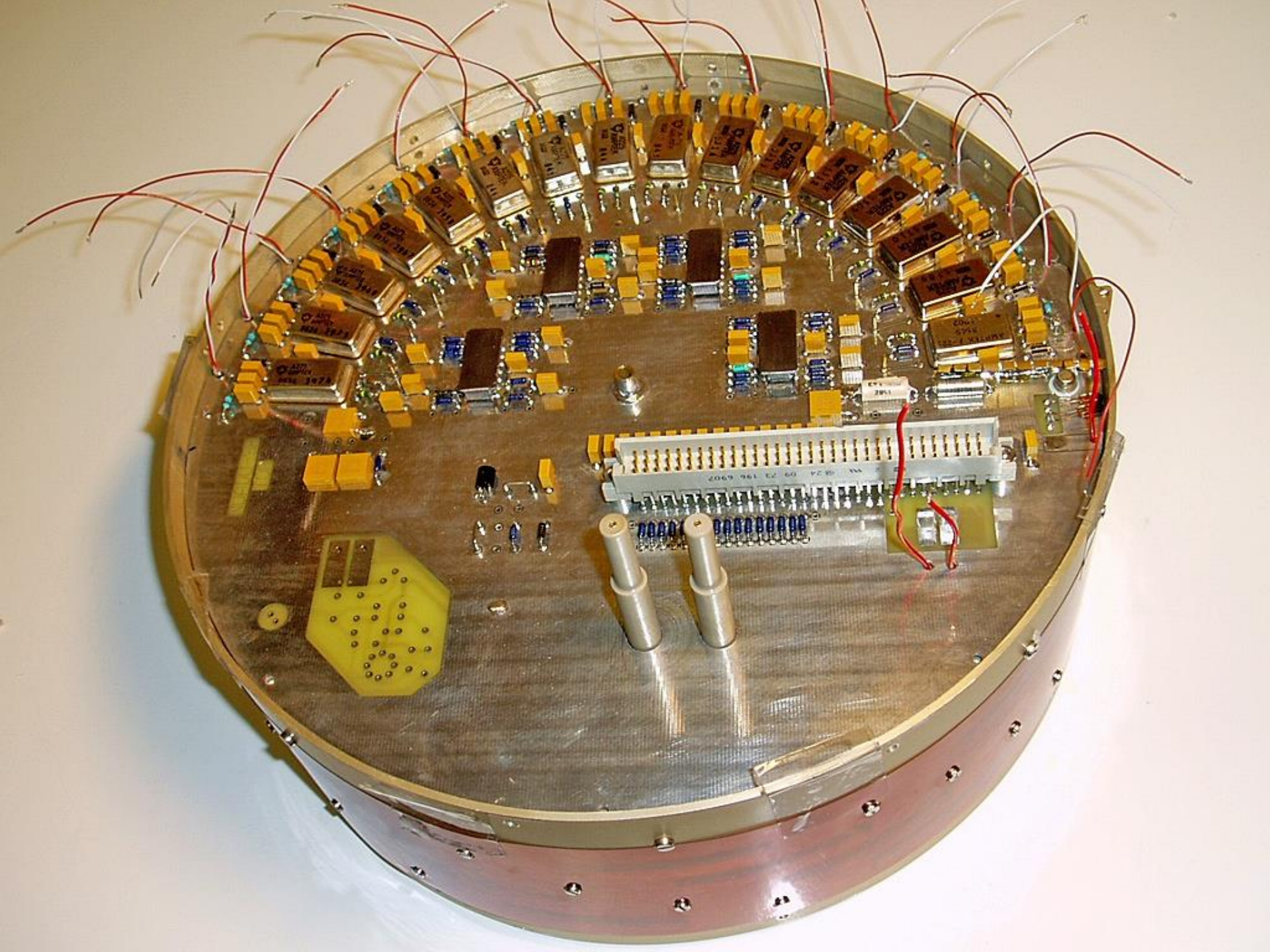


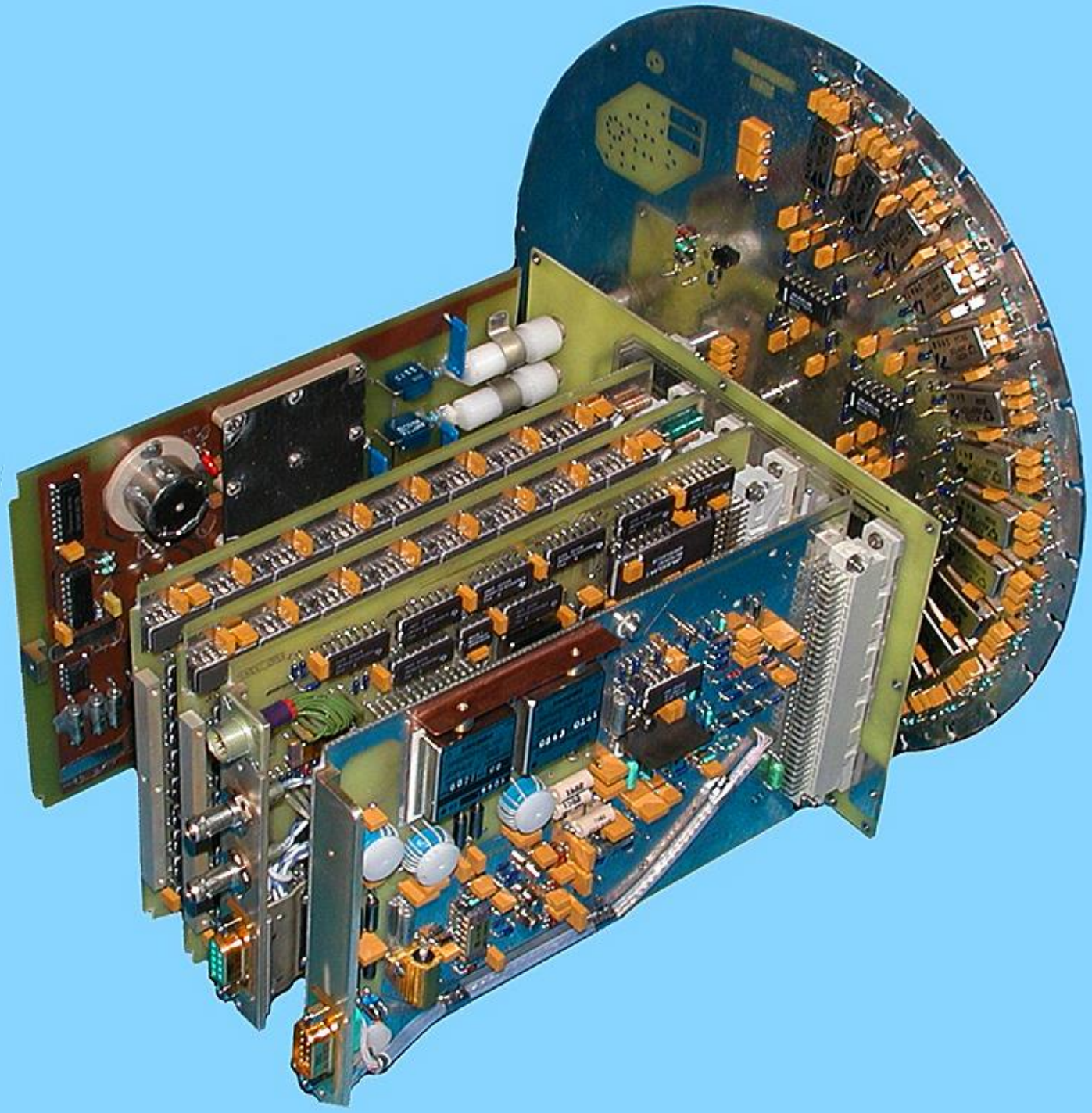

Solárny reflektor
VN izolátory (PEEK)
Aktívne plôšky detektorov
PIPS detektory
VN konektory
+5kV -5kV
Vstupná apertúra
Tieniaca prepážka
Platne VN deflektora
Doska elektroniky predzosilňovačov



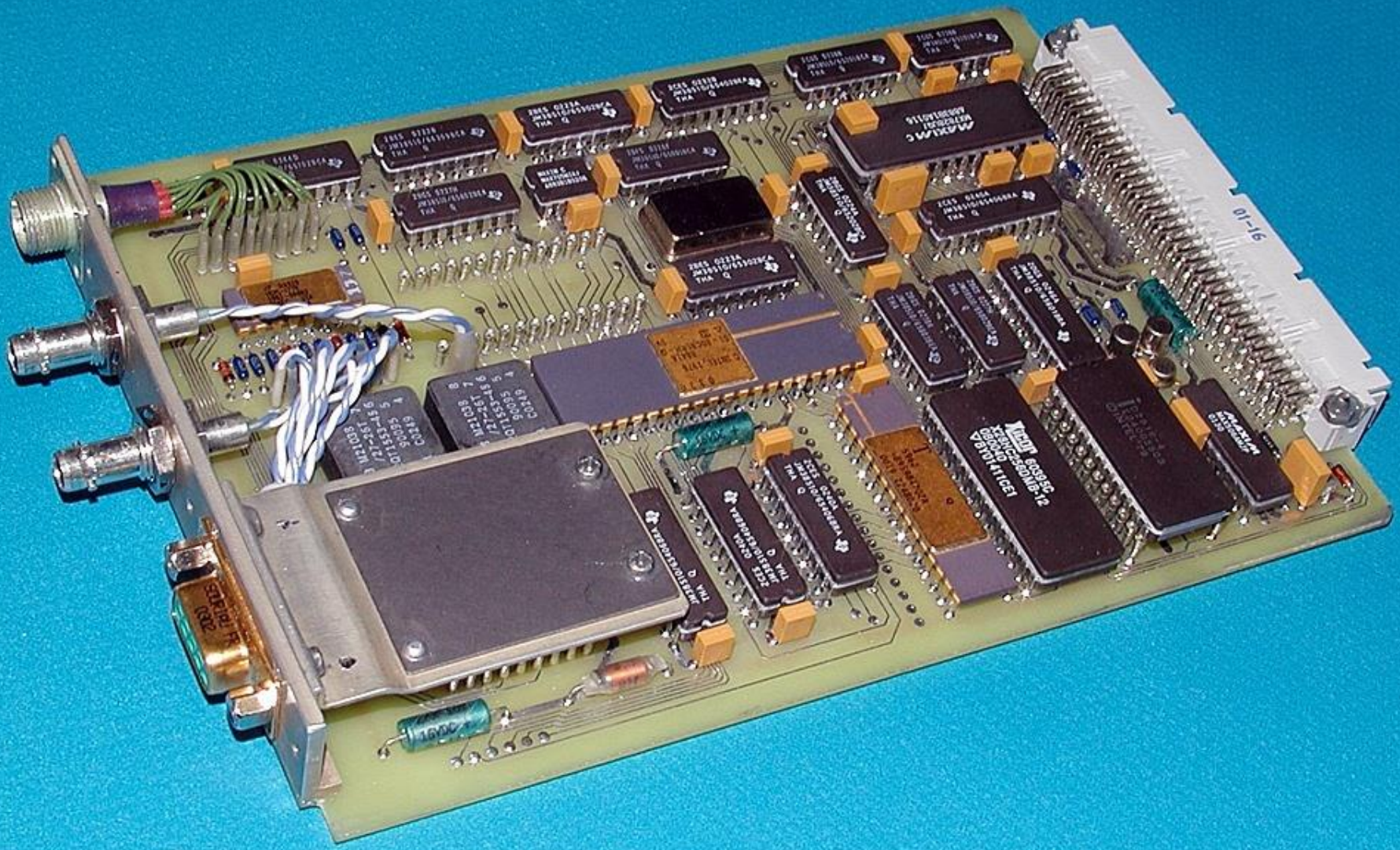

QUALIFICATION
UNITS

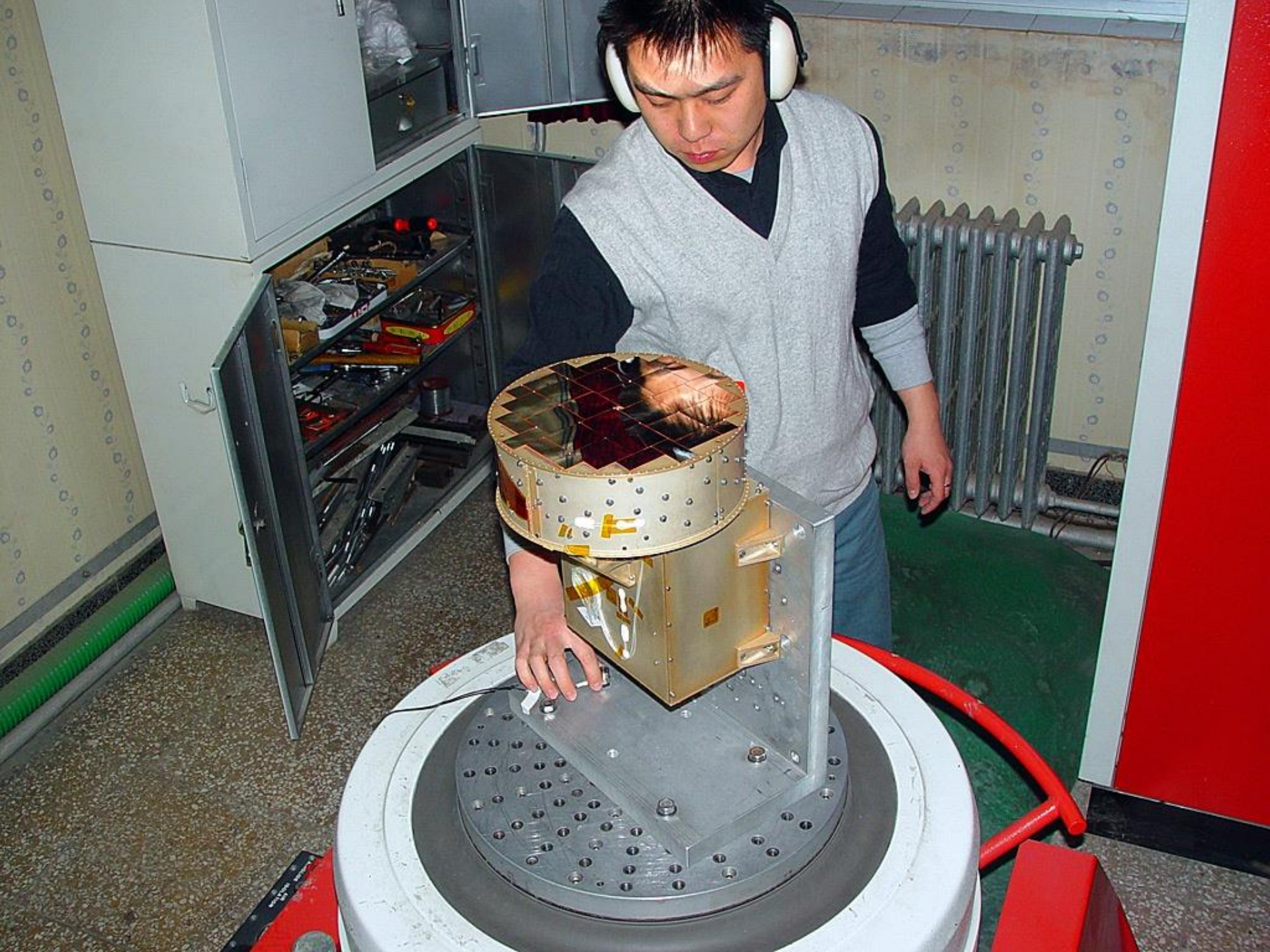




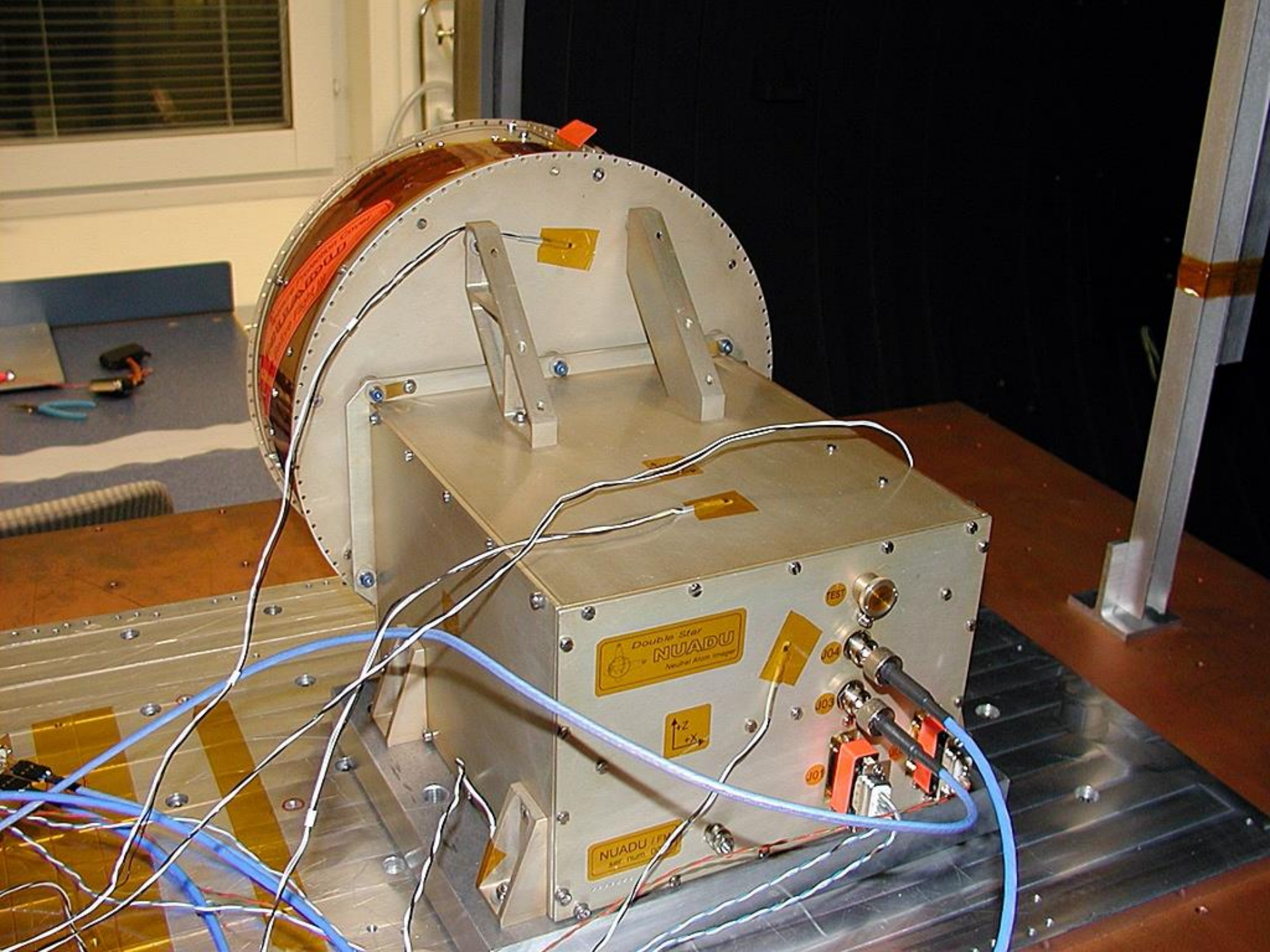


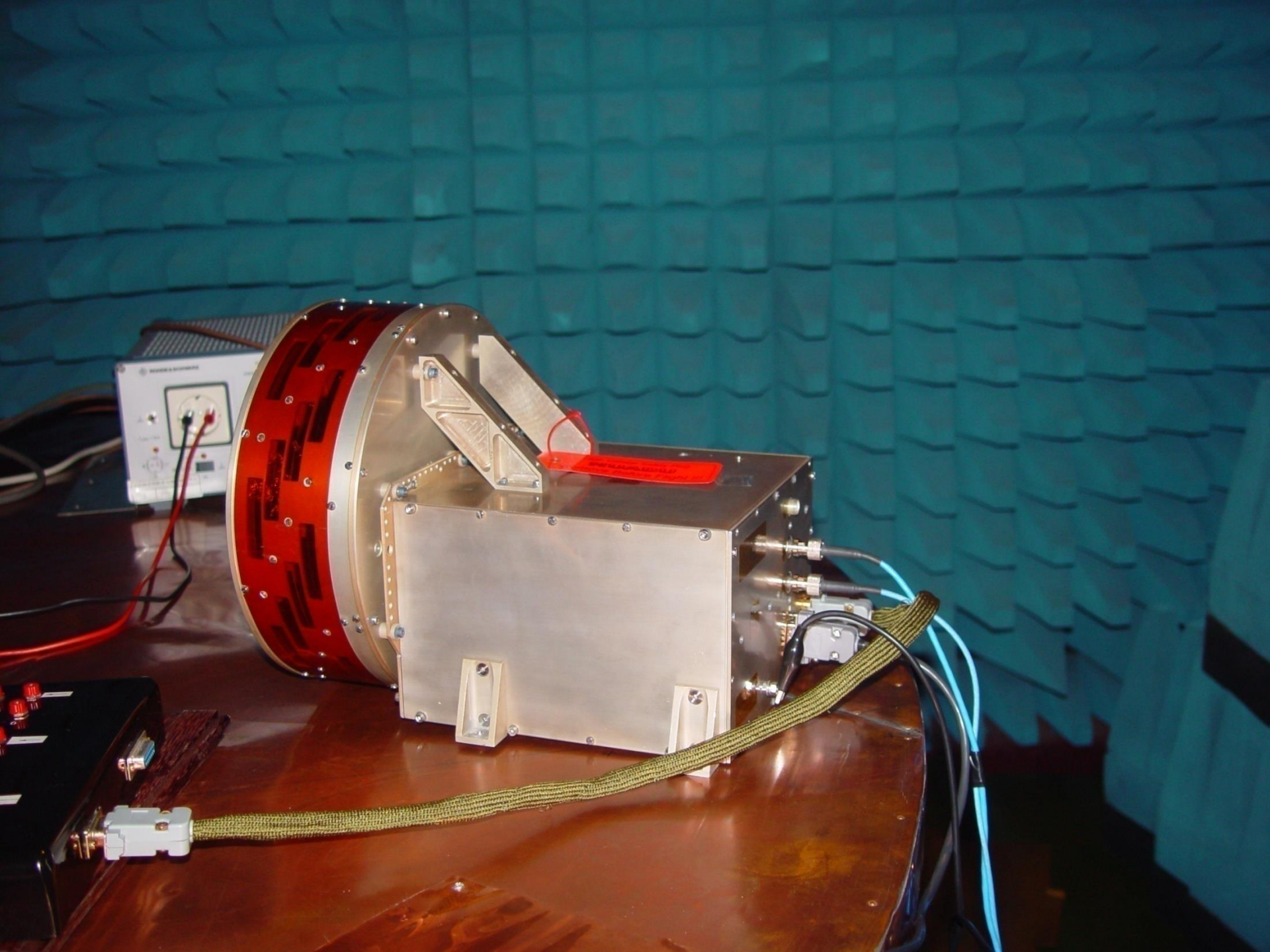
NUADU – DPU (Data Processing Unit)






BALZERS


Double Star
NUADU
Neutral Atom Imager
TEST
J04
J03
J01
+Z
+X



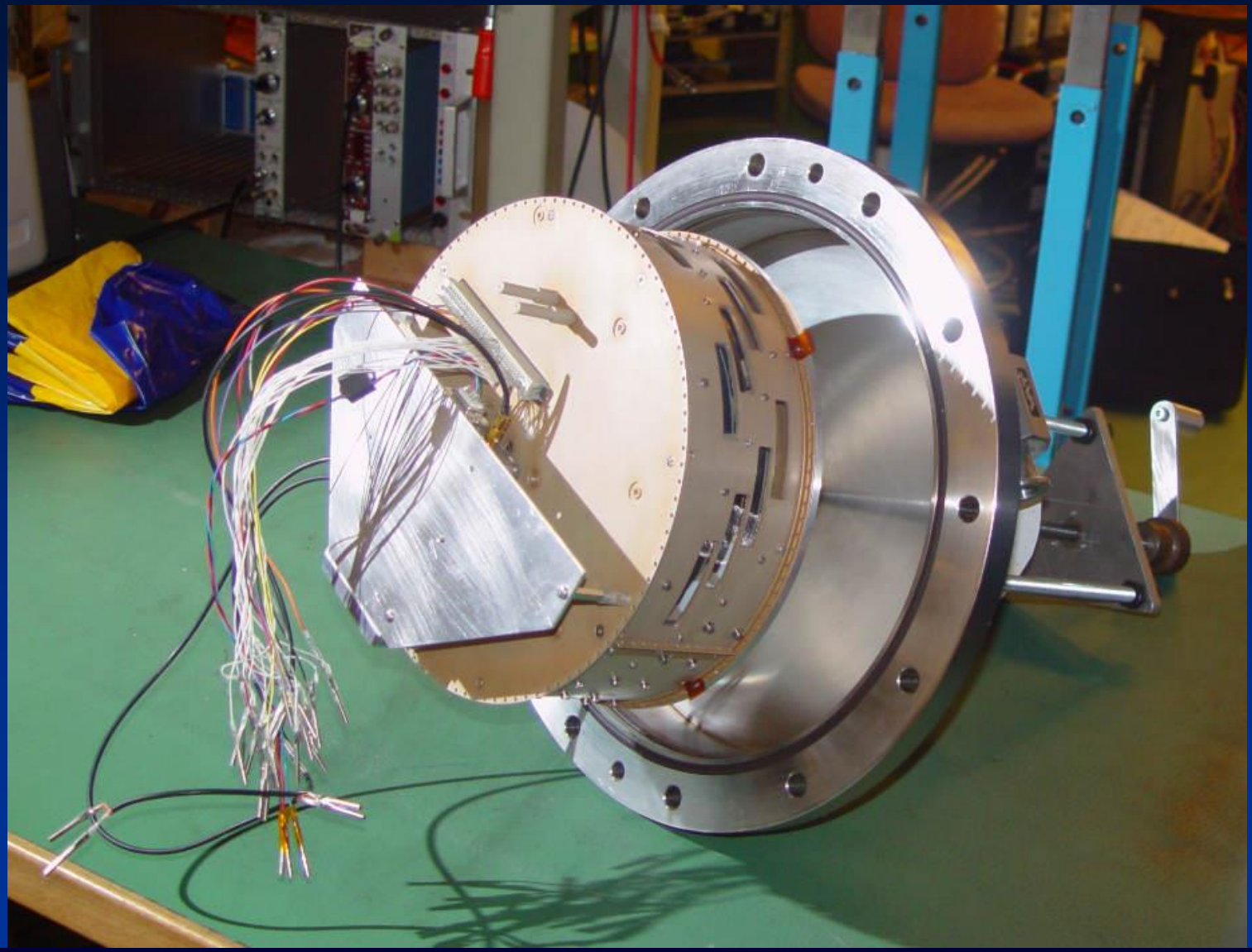

esa

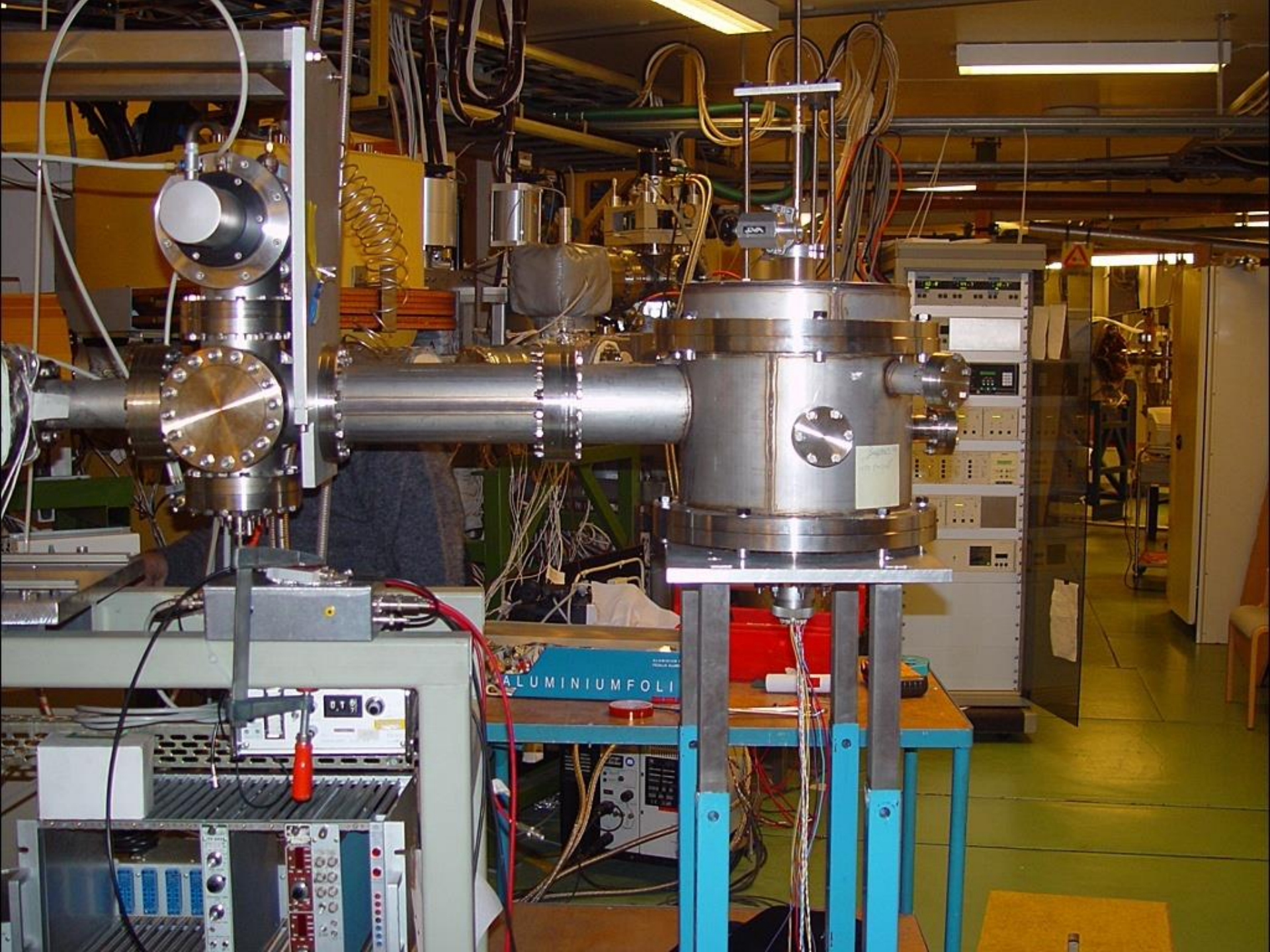
Kalibrácia na časticovom urýchľovači Cryring

Manne Siegbahn Laboratory, Stockholm

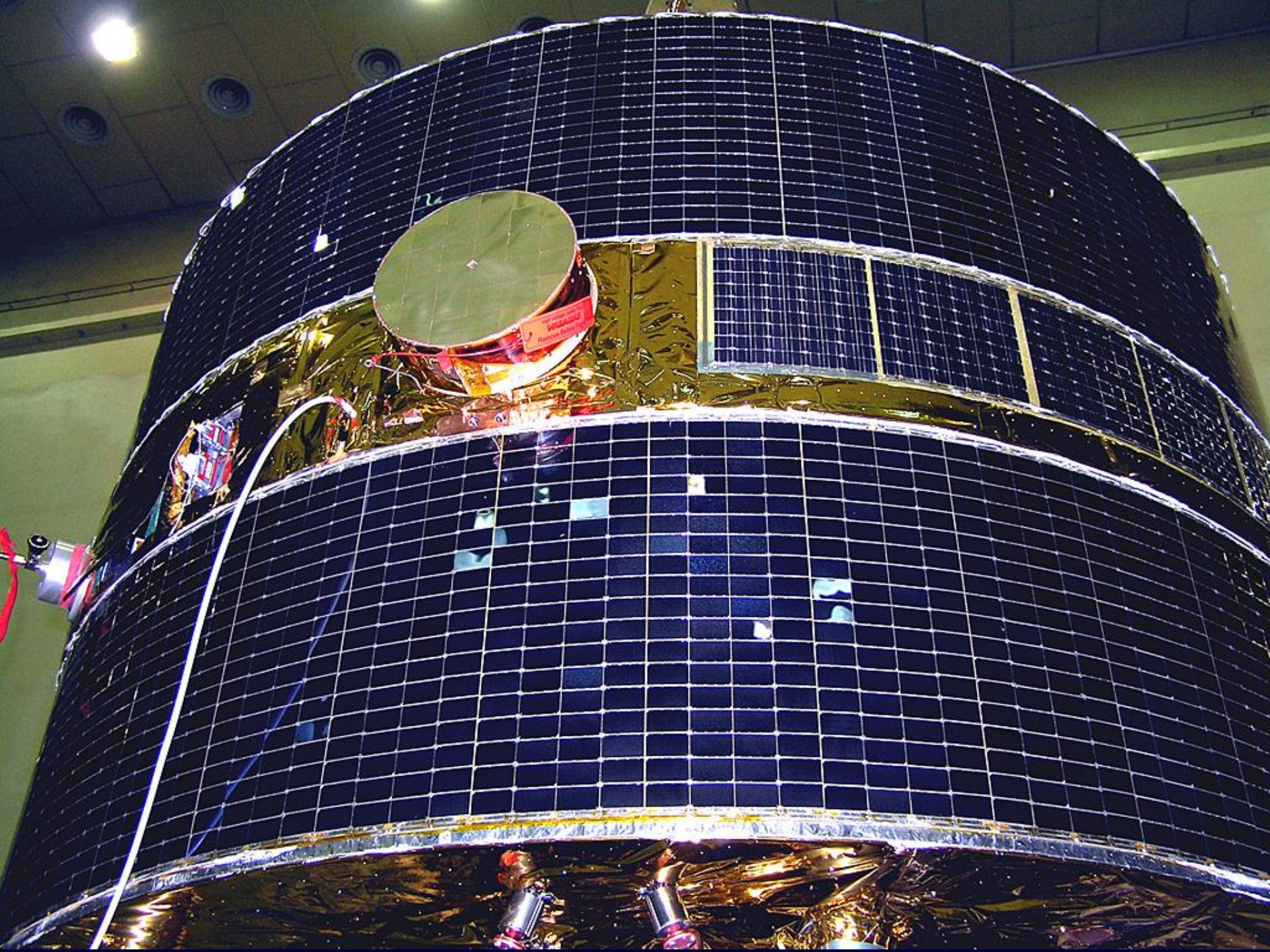
Hydrogen ENA
512.4 keV
293.0 keV
150.6 keV
60.4 keV

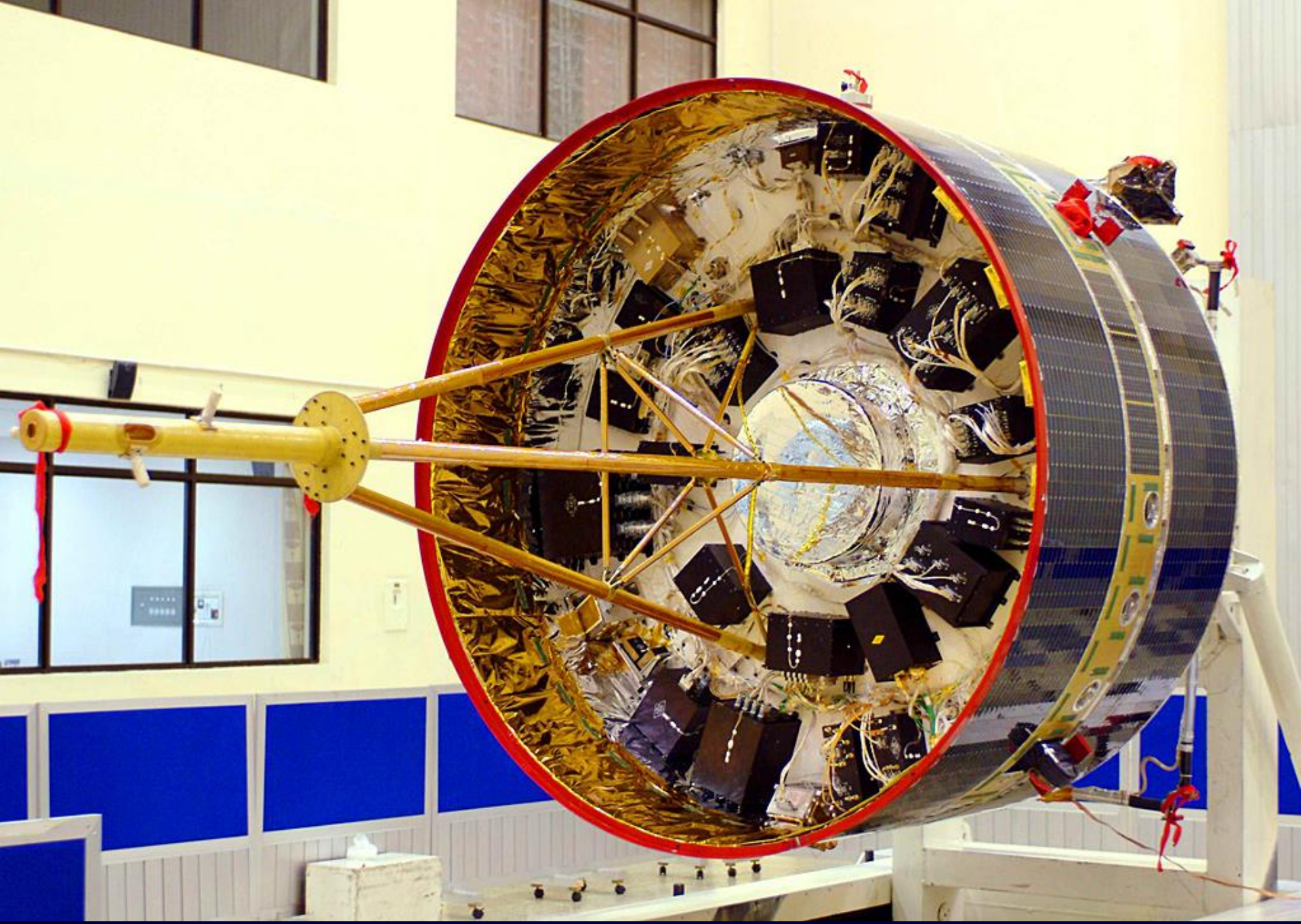
Oxygen ENA
501.8 keV
393.5 keV
301.1 keV
229.9 keV
149.8 keV

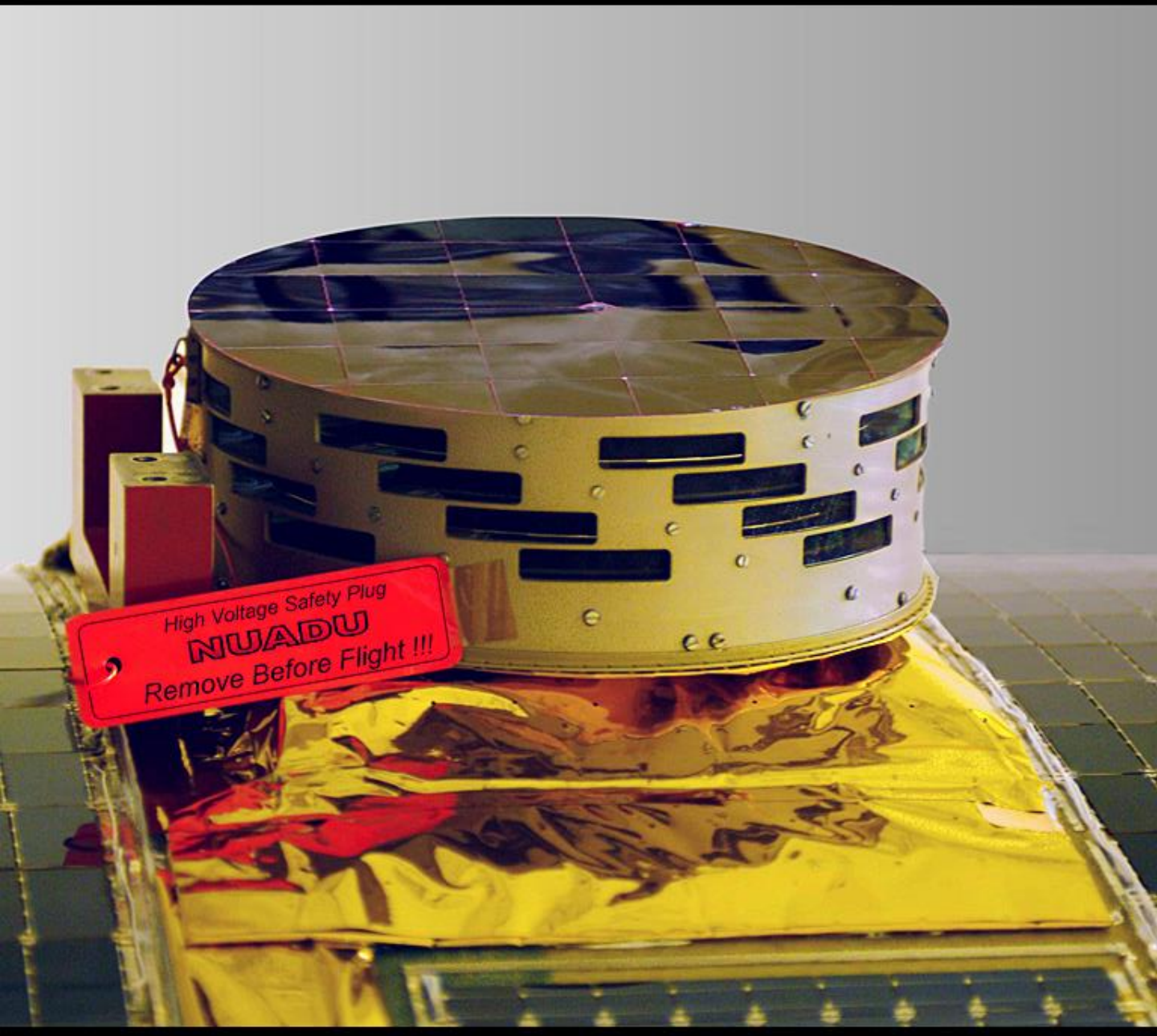



ALUMINIUMFOLI


201-02
TCK11-2
2002



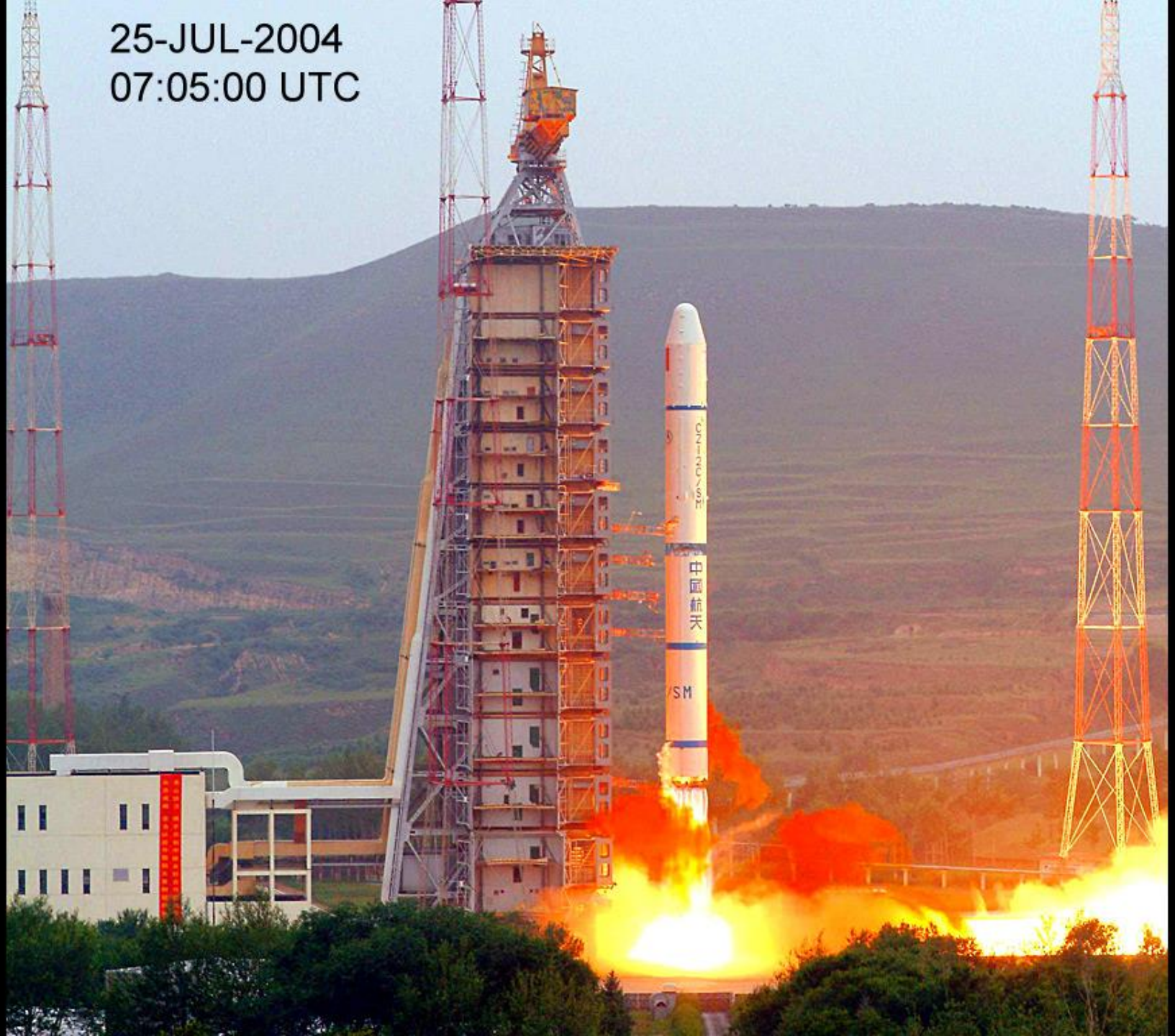



High Voltage Safety Plug
NUADU
Remove Before Flight !!!

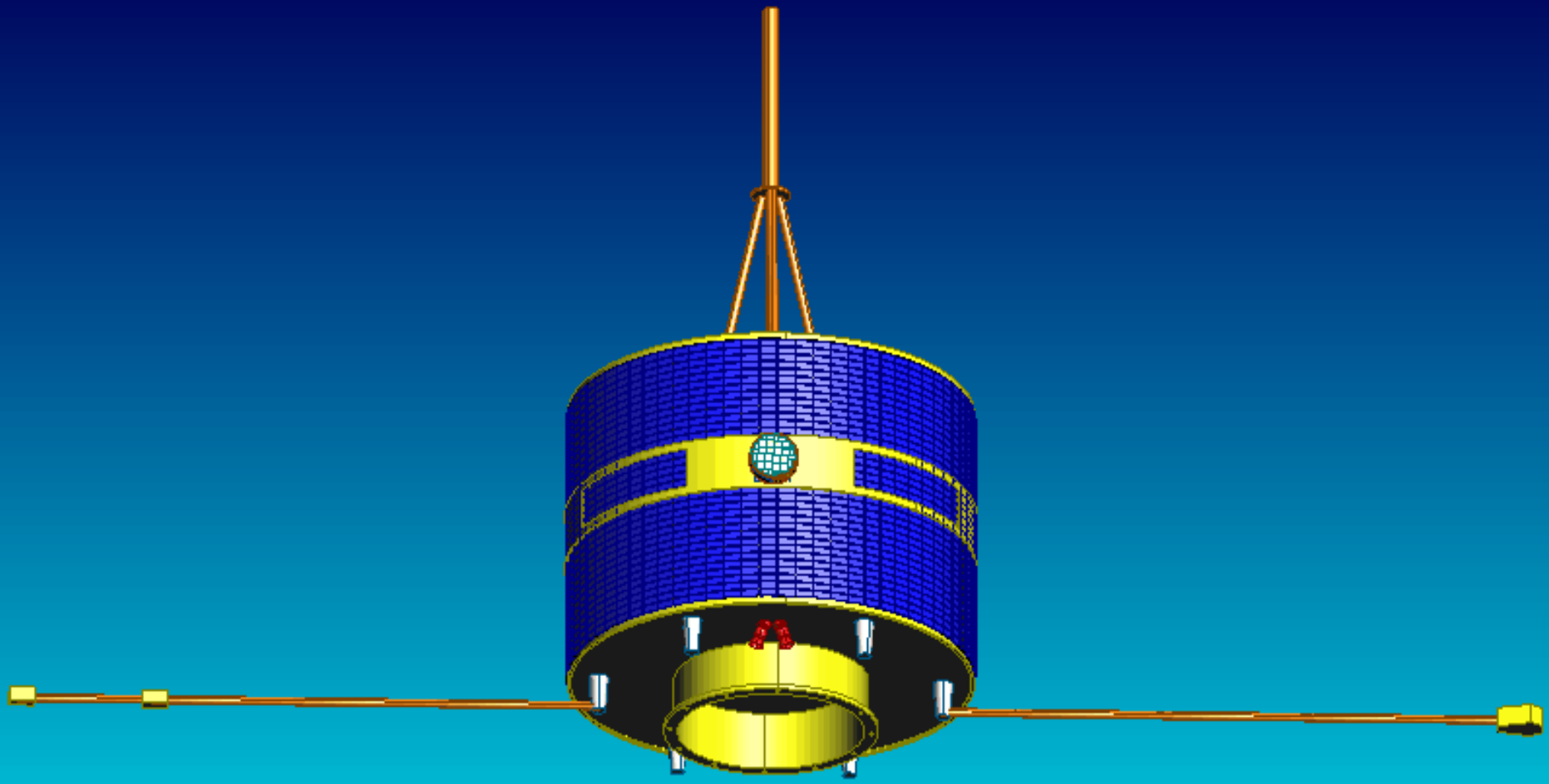
Oficiálne odovzdanie vedeckého nákladu


中国航天
双星计划
DOUBLE STAR
esa


中國航天


25-JUL-2004
07:05:00 UTC


中國航天
/SM



Data graph

FM A7h OBT 13:00:39 04-09-2004 CHKSM 8Ah (OK)

Color spectrum 1

0 248 496 744 992

Status 3 Sum 4 STG ☐ Toggle ☐ HV ☐

5V 5.00 V TmpE +15.6 C HVSet 0 V

Vref 2.50 V TmpD +12.5 C THRSet 71.3 mV

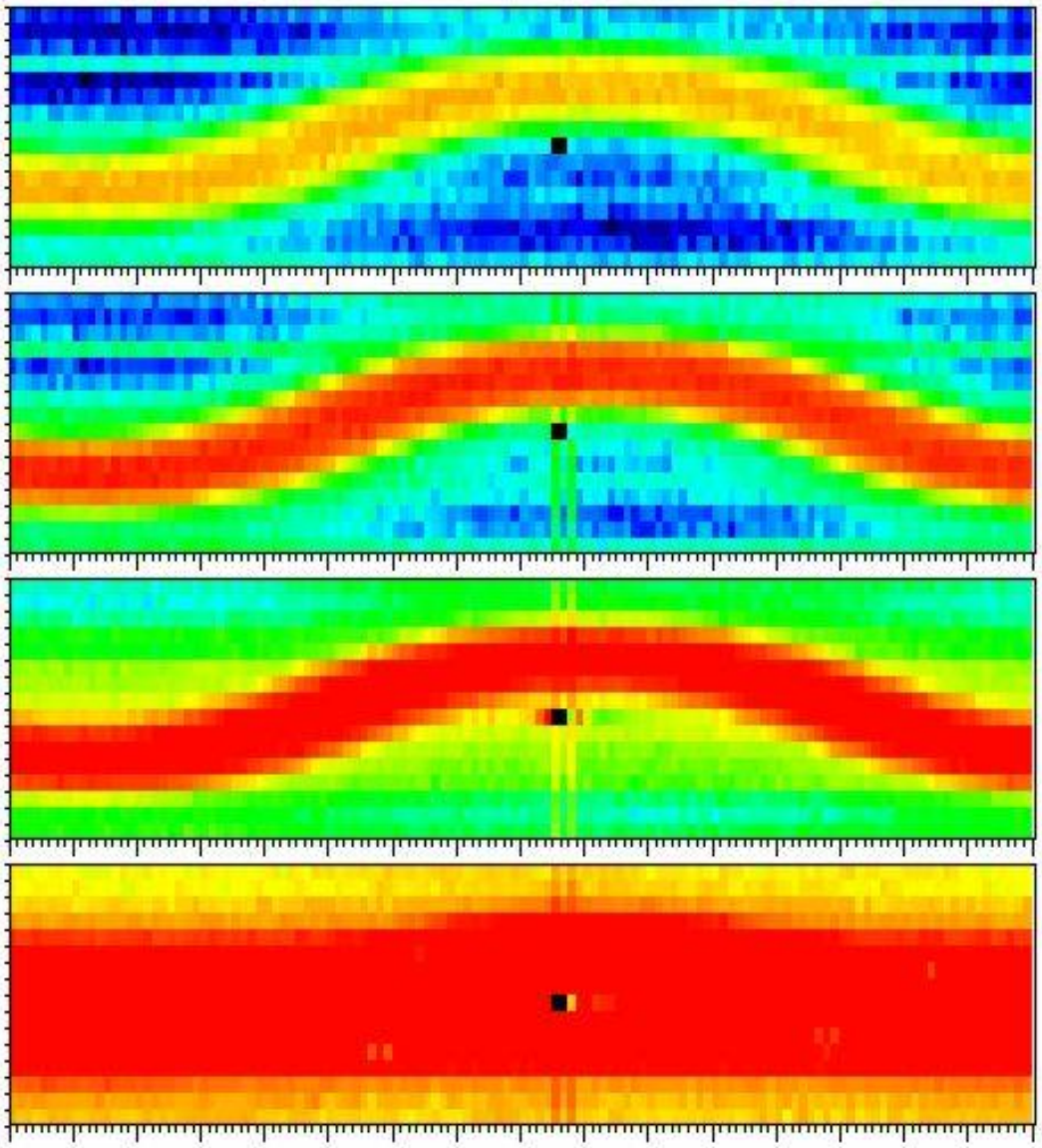
HVCur 4 mA Bias 69.8 V

HV 0 V 24V 23.9 V

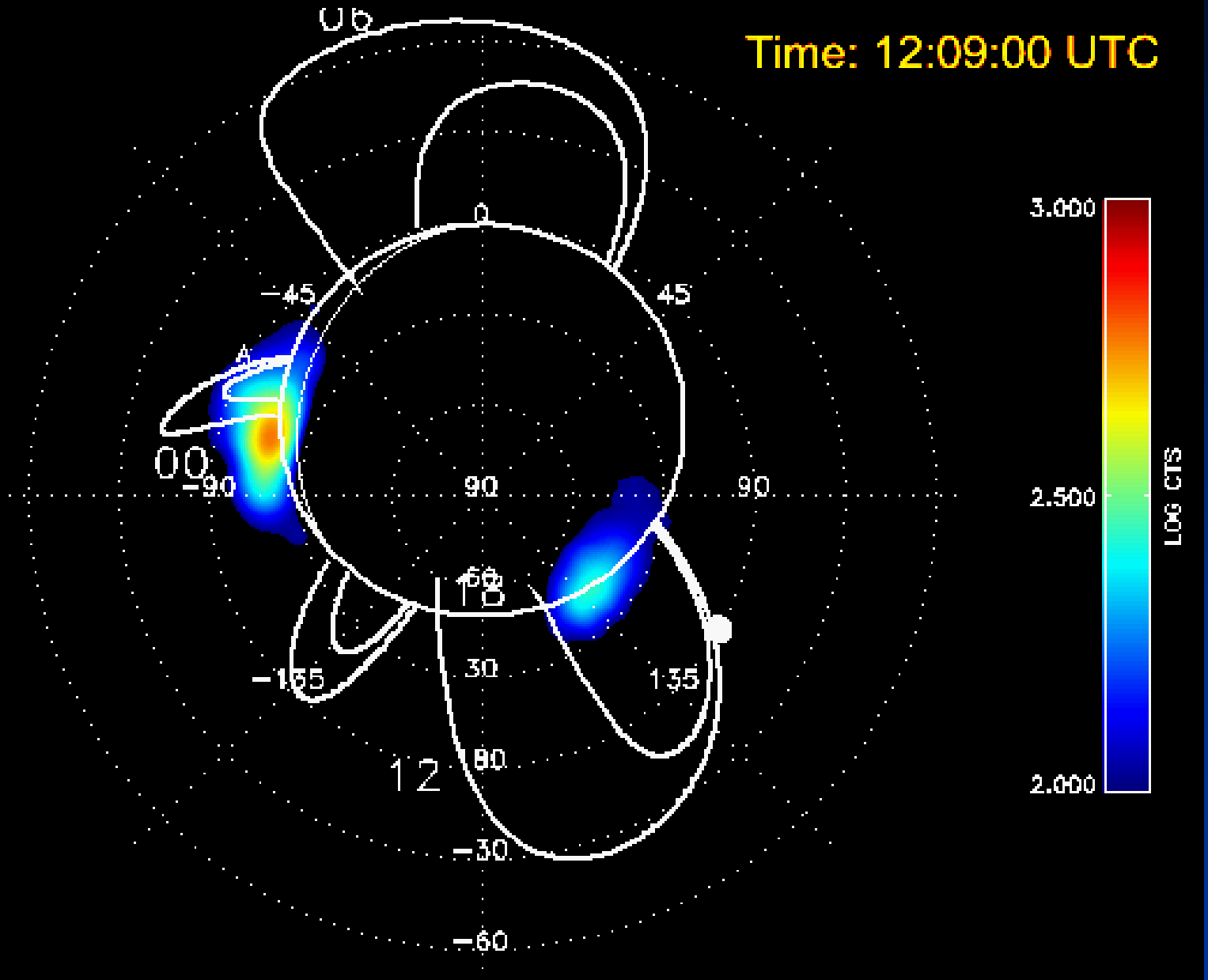
ZENTECH

○ Hex ○ Dec ◉ Cal ☐ Stat

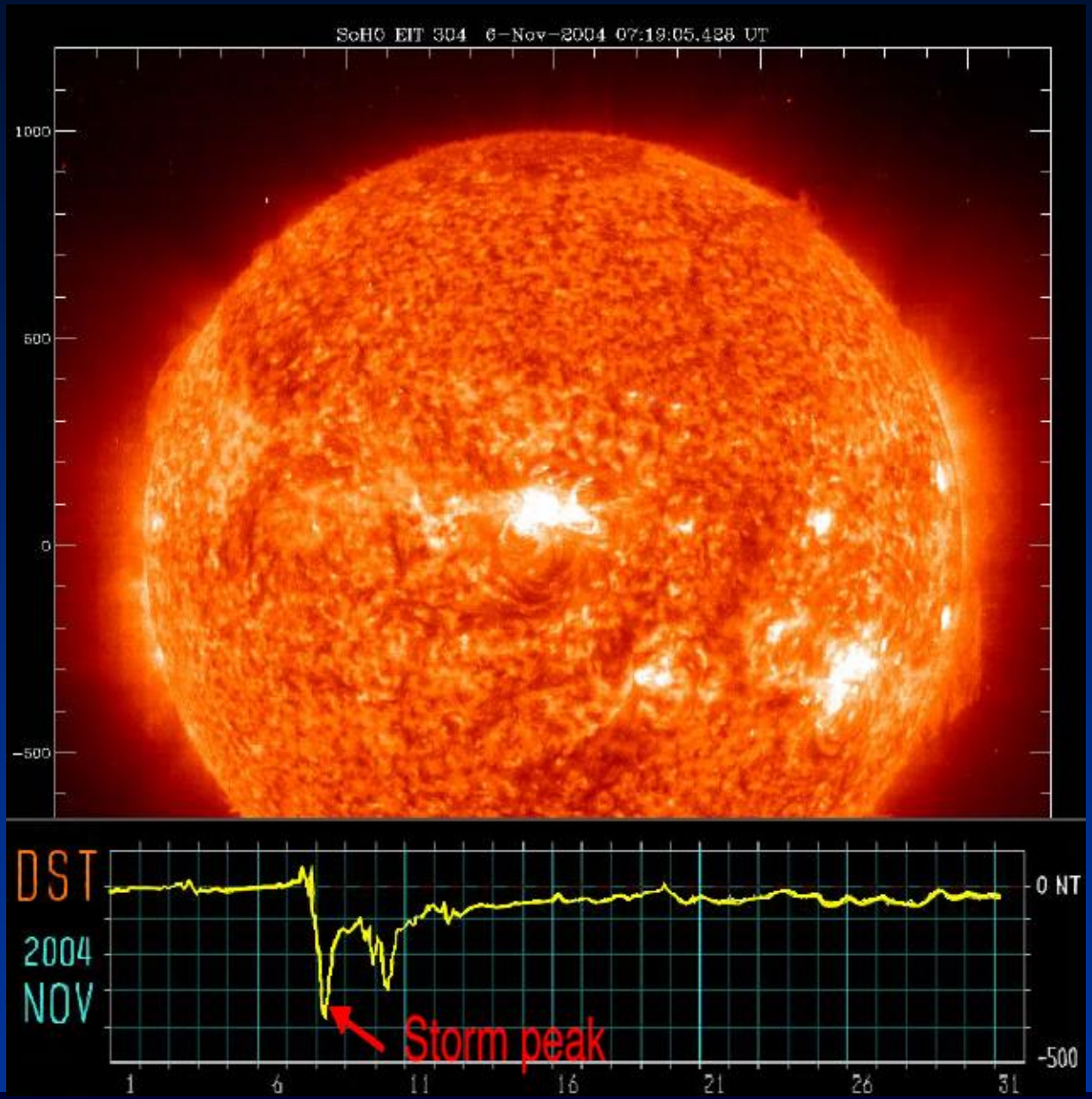
SS	Det.	Treshold			
All	All	Top	Upper	Medium	Lower
001	01	25	36	84	416
001	02	21	28	62	416
001	03	26	42	88	432
001	04	68	96	168	576
001	05	17	26	136	896
001	06	20	44	256	992
001	07	50	72	272	992
001	08	72	116	352	992
001	09	168	272	544	992
001	10	384	640	928	992
001	11	512	896	992	992
001	12	512	896	992	992
001	13	352	576	768	992
001	14	128	224	304	704
001	15	72	116	168	544
001	16	80	120	160	512
002	01	32	44	80	416
002	02	22	29	58	400
002	03	26	38	84	448
002	04	68	88	152	544
002	05	23	38	152	832



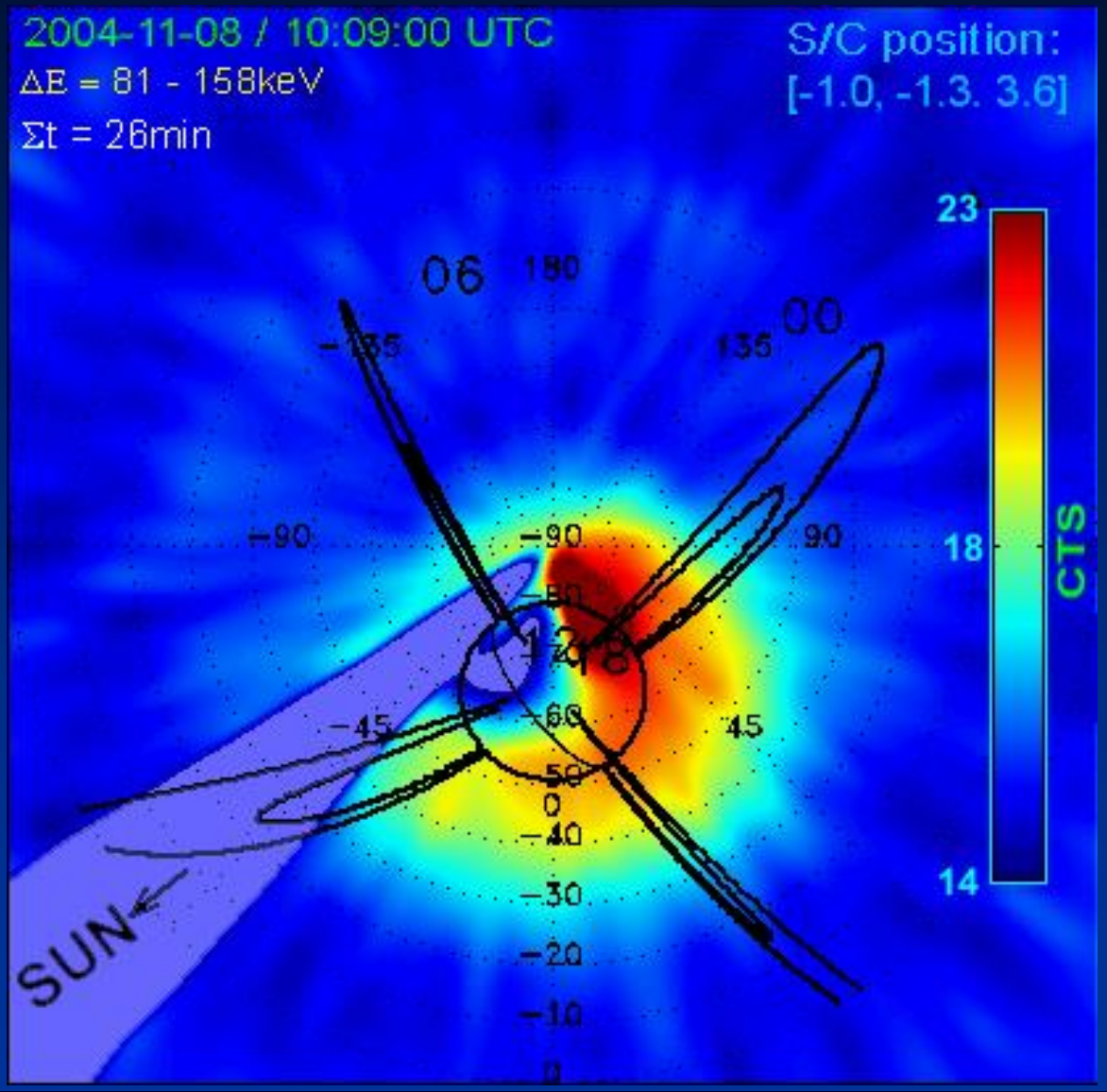
NUADU ENA IMAGE AT SOUTH POLE (50keV) 14-SEP-2004



Magnetická búrka 8.11.2004 (Dst –373nT)



Magnetická búrka 8.11.2004 a ENA image prstencového prúdu zaznamenaný NUADU



NUADU – séria hodnotných vedeckých výsledkov

JGR Space Physics

Magnetospheric Physics | Free Access

Moderate geomagnetic storm (21–22 January 2005) triggered by an outstanding coronal mass ejection viewed via energetic neutral atoms

Susan McKenna-Lawlor, Lu Li, Iannis Dandouras, Pontus C. Brandt, Yihua Zheng, Stas Barabash, Radoslav Bucik, Karel Kudela, Jan Balaz, Igor Strharsky

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ELSEVIER
Nuclear Instruments and Methods in Physics Research A 530 (2004) 311–322
NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH Section A
www.elsevier.com/locate/nima

The energetic NeUtral Atom Detector Unit (NUADU) for China's Double Star Mission and its calibration

Susan McKenna-Lawlor[a,*], Jan Balaz[a], Igor Strharsky[a], Stas Barabash[b], Klas Brinkfeldt[b], Lu Li[c], Chao Shen[c], Jiankui Shi[c], Qingang Zong[c], Karel Kudela[d], Suiyan Fu[e], Edmond C. Roelof[f], Pontus C: son Brandt[f], Iannis Dandouras[g]

Annales Geophysicae, 23, 2953–2959, 2005
SRef-ID: 1432-0576/ag/2005-23-2953
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Annales Geophysicae

Electron pitch angle variations recorded at the high magnetic latitude boundary layer by the NUADU instrument on the TC-2 spacecraft

L. Lu[1], S. McKenna-Lawlor[2], S. Barabash[3], Z. X. Liu[1], J. Balaz[2], K. Brinkfeldt[3], I. Strharsky[2], C. Shen[1], J. K. Shi[1], J. B. Cao[1], S. Y. Fu[4], H. Gunell[2,3], K. Kudela[5], E. C. Roelof[6], P. C. Brandt[6], I. Dandouras[7], T. L. Zhang[8], C. Carr[9], and A. Fazakerley[10]

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Iterative inversion of global magnetospheric information from energy neutral atom (ENA) images recorded by the TC-2/NUADU instrument

LU Li[1†], S. MCKENNA-LAWLOR[2], S. BARABASH[3], J. BALAZ[2, 4], LIU ZhenXing[1], SHEN Chao[1], CAO JinBin[1] & TANG ChaoLing[5]

SCIENCE CHINA
Earth Sciences

·RESEARCH PAPER·

doi: 10.1007/s11430-015-5121-7

The causal sequence investigation of the ring current ion-flux increasing and the magnetotail ion injection during a major storm

LU Li[1*], S MCKENNA-LAWLOR[2], CAO JinBin[3], K KUDELA[4] & J BALAZ[2,4]

SCIENCE CHINA
Earth Sciences
CrossMark

·RESEARCH PAPER·

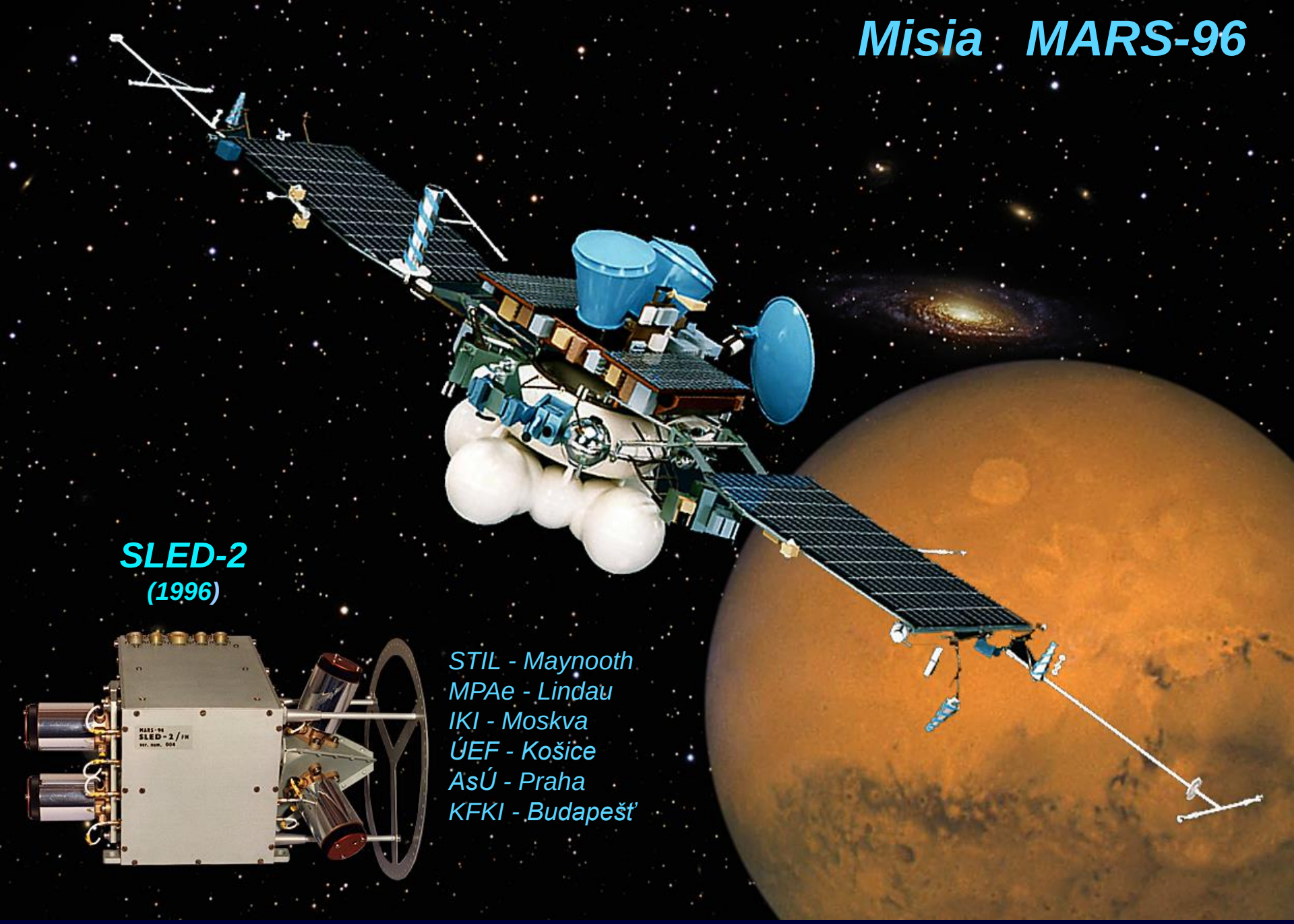
https://doi.org/10.1007/s11430-018-9307-x

Close up observation and inversion of low-altitude ENA emissions during a substorm event

Li LU[1*], Susan MCKENNA-LAWLOR[2] & Jan BALAZ[2,3]

... a ešte d'alej ...

Misia MARS-96



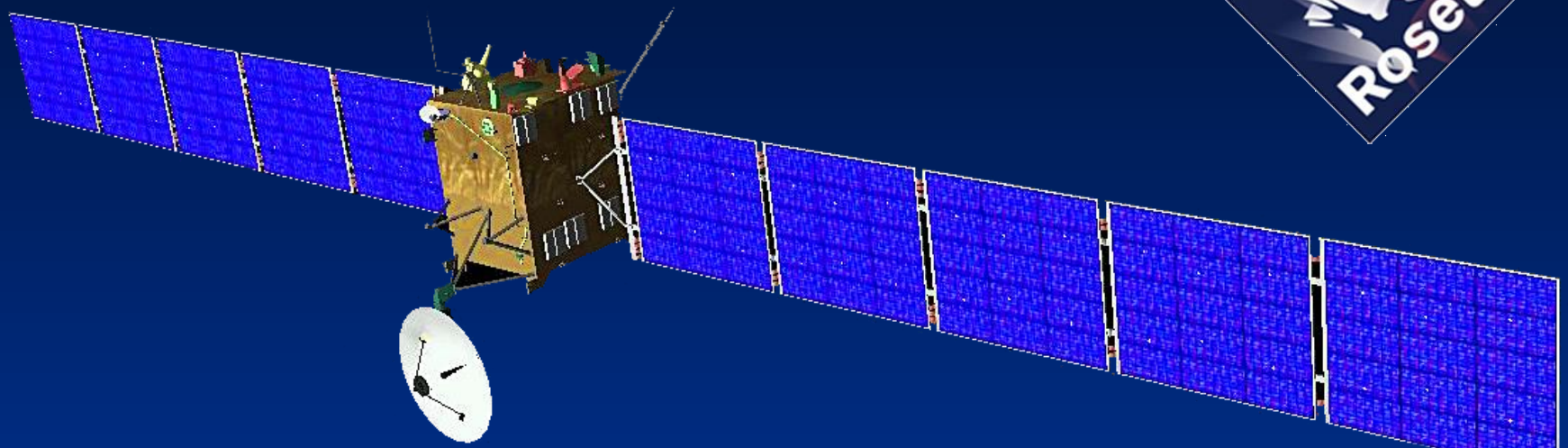
SLED-2
(1996)

STIL - Maynooth
MPAe - Lindau
IKI - Moskva
ÚEF - Košice
AsÚ - Praha
KFKI - Budapešť


SLED

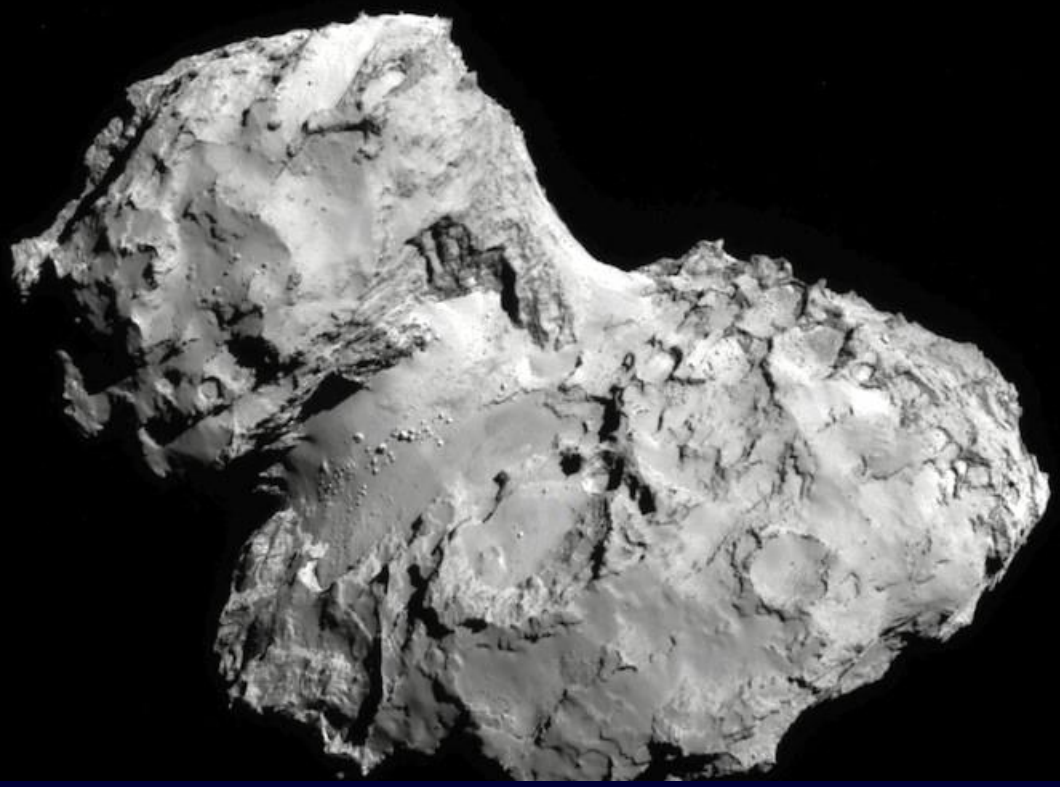
MARS-96 štart 16. 11. 1996

Misia ESA-ROSETTA na kométu



- Misia ESA na kométu 67P/Čurjumov-Gerasimenko
- Prvá misia v histórii ľudstva, ktorá pristála na kométe

Na realizácii elektronického systému ESS sondy sa podieľal aj ÚEF-SAV

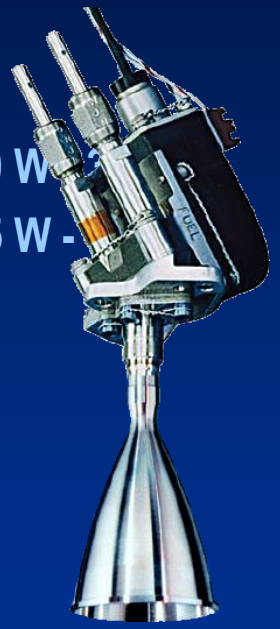


ESS procesor zabezpečoval komunikáciu medzi pristávacím modulom Philae a hlavnou (orbitálnou) sondou.

Základné technické údaje sondy Rosetta

Rozmery:

hlavná štruktúra	2.8 x 2.1 x 2.0 m
rozpätie sol. panelov	32 m
plocha sol.panelov	64 m^2
výkon sol. panelov	8700 W - 1AU
	850 W
	395 W -

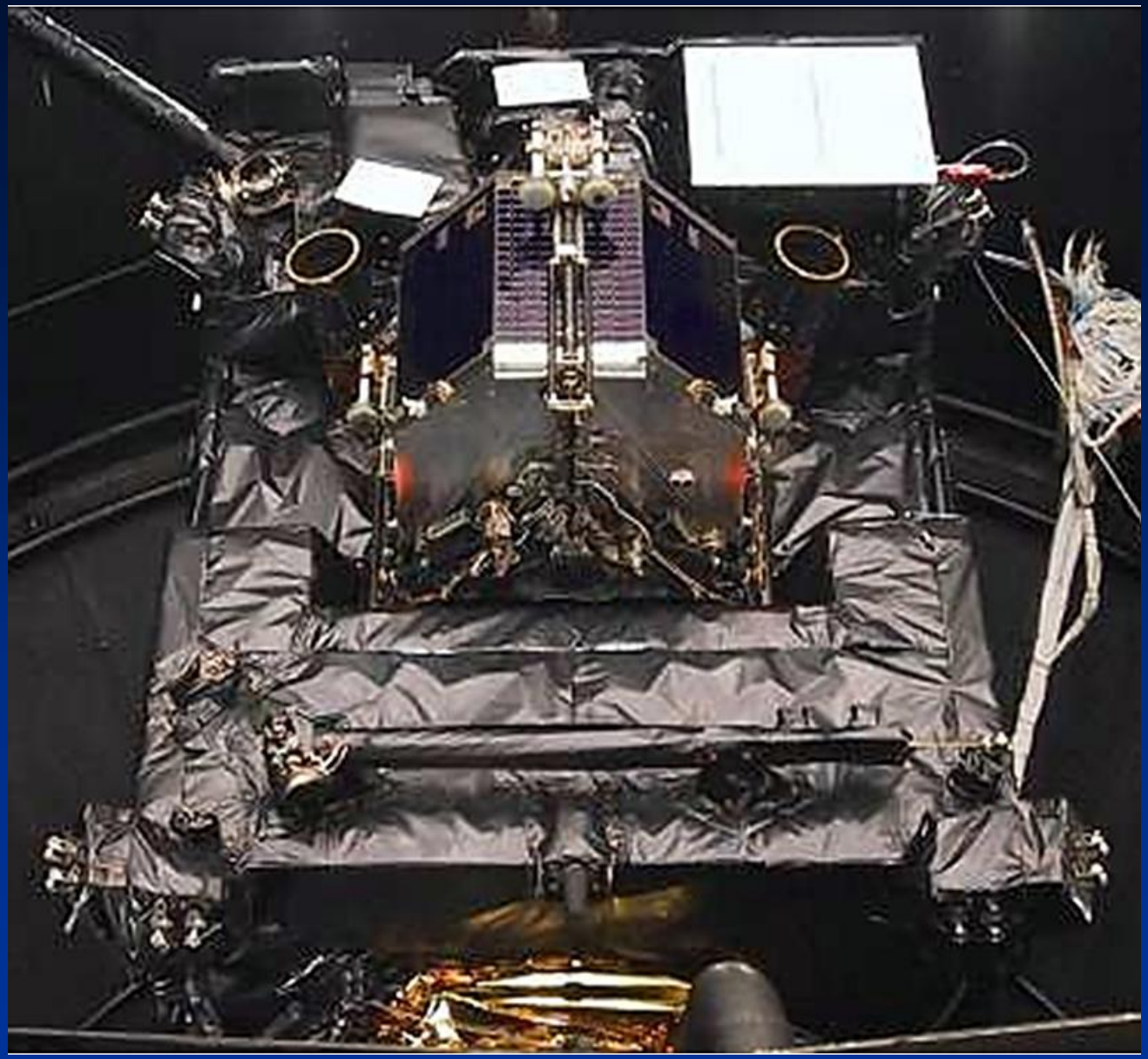


Hmotnosť pri štarte:

celková:	2900 kg
palivo	1720 kg
vedecký náklad	165 kg
Lander Philae	100 kg

Propulzný systém: 24 thrusterov 10N
palivo MMH + N_2O_4
Operačná doba: 12 rokov (2004-2016)

ROSETTA a Philae v laboratóriách ESA-ESTEC

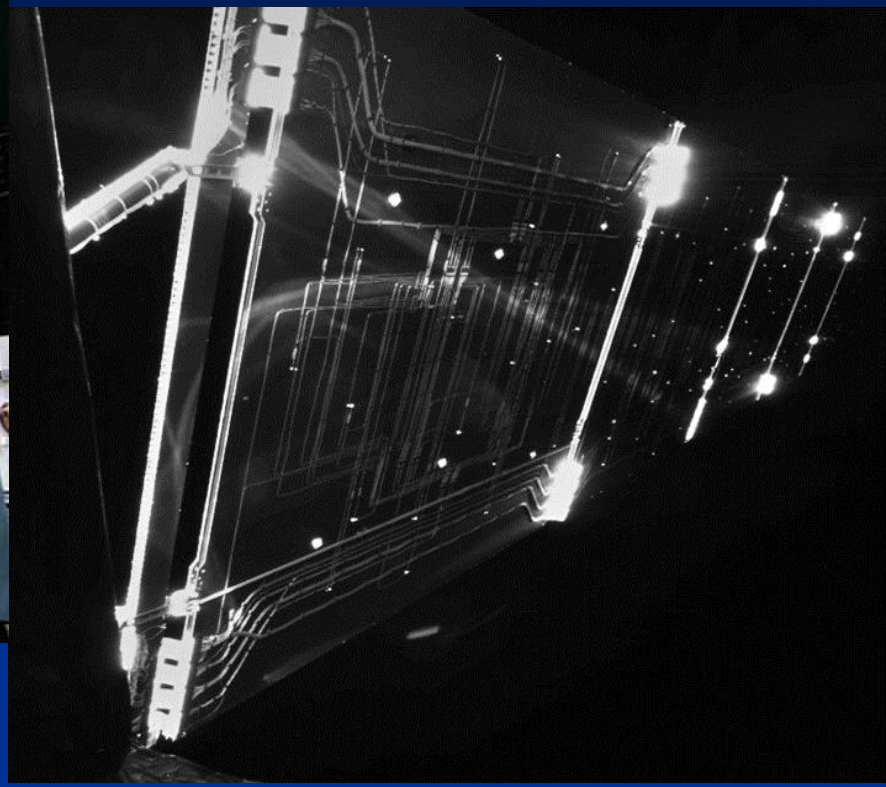


Sonda ROSETTA pozostáva z dvoch častí:

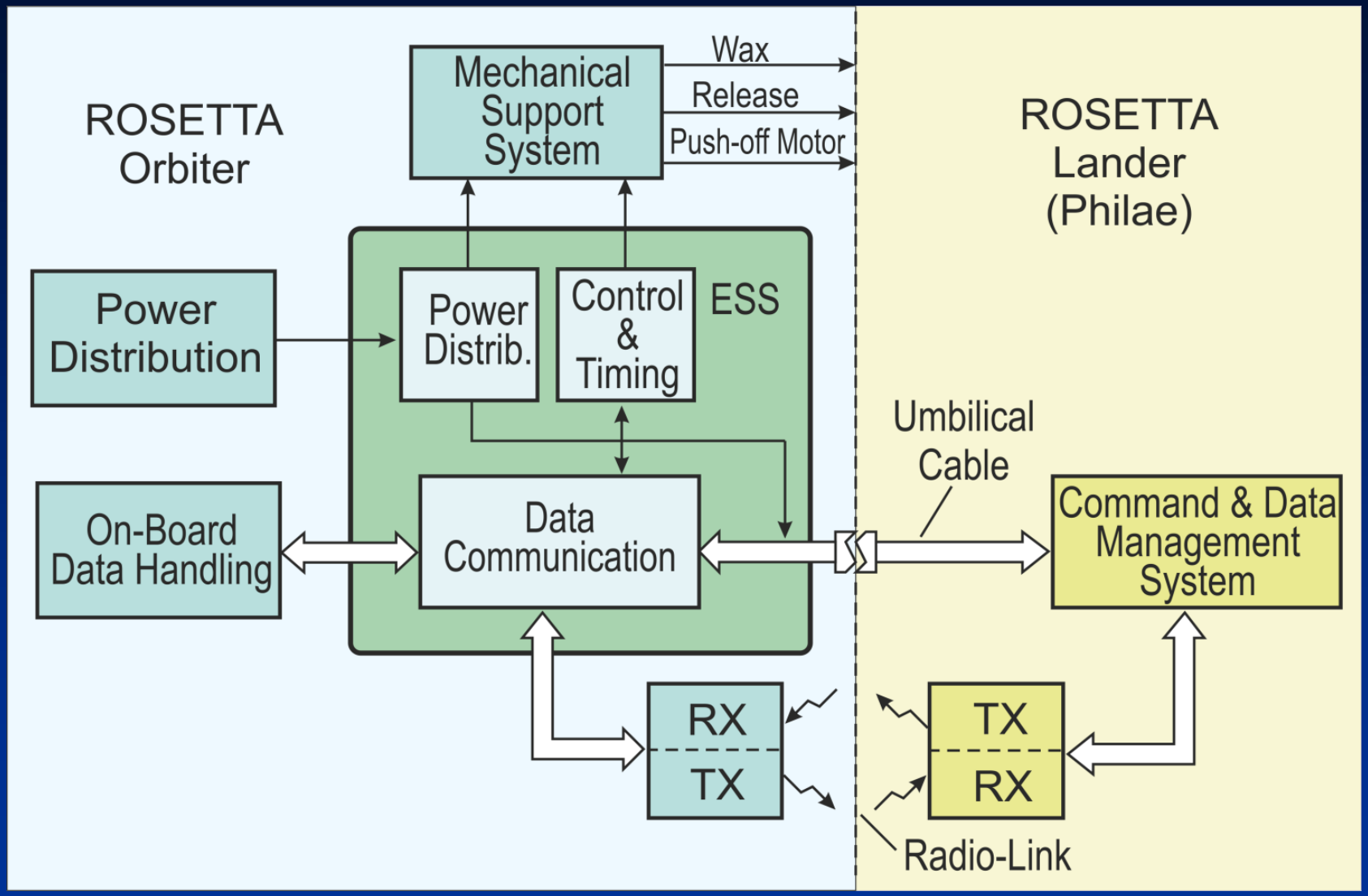
Orbiter – zdržiaval sa 2 roky na rôznych orbitách okolo kometárneho jadra,

Lander – pristál priamo na povrchu jadra.

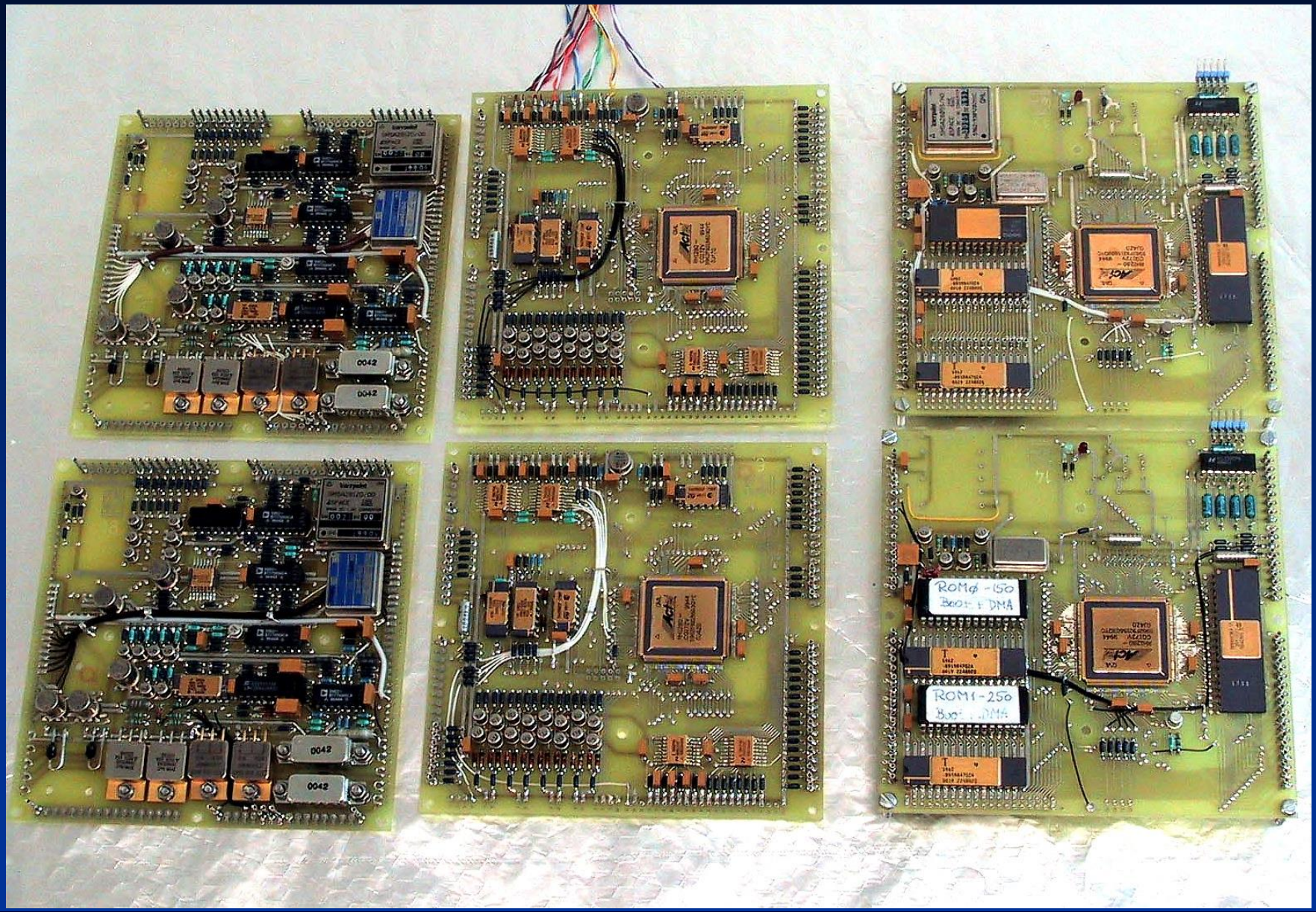
Solárne panely Rosetty (rozpätie 32m, plocha 64m^2)



ESS-procesor (Interface Orbiter – Lander)

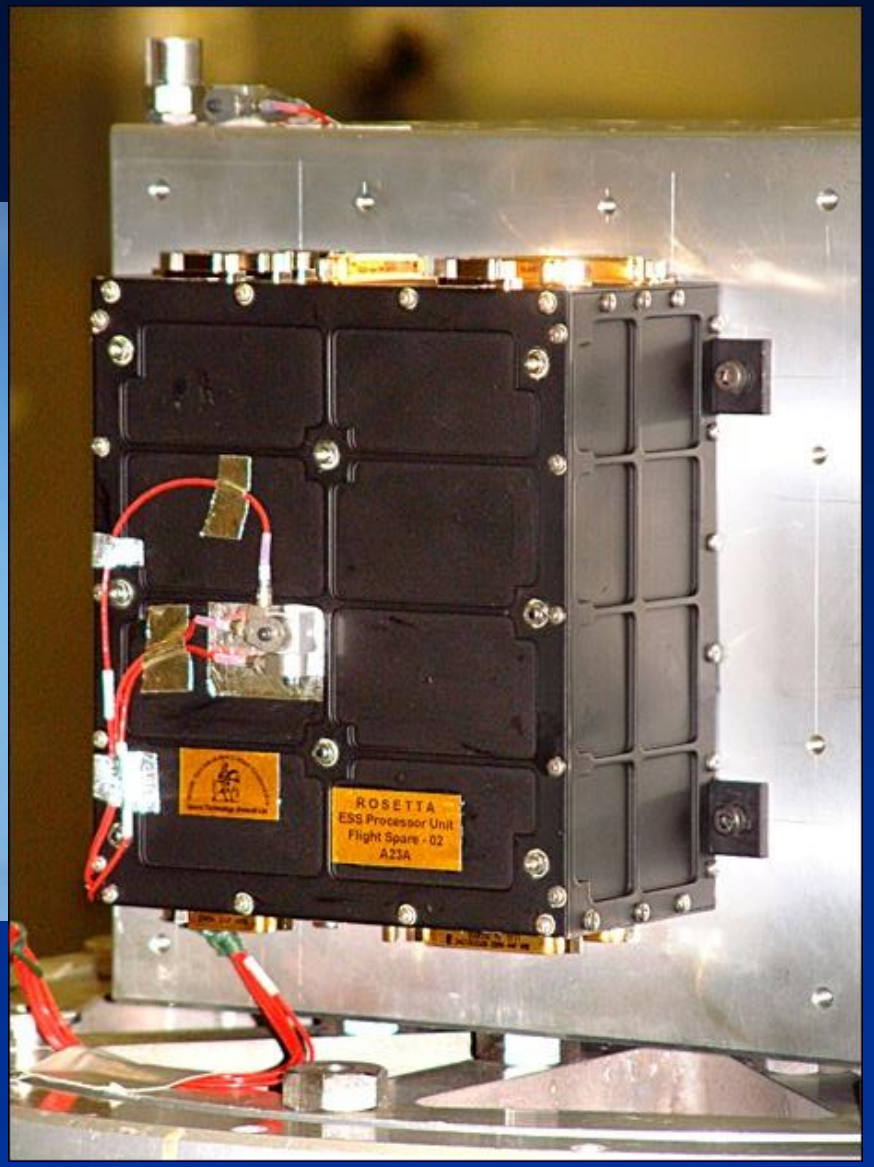


Z realizácie servisného systému ESS

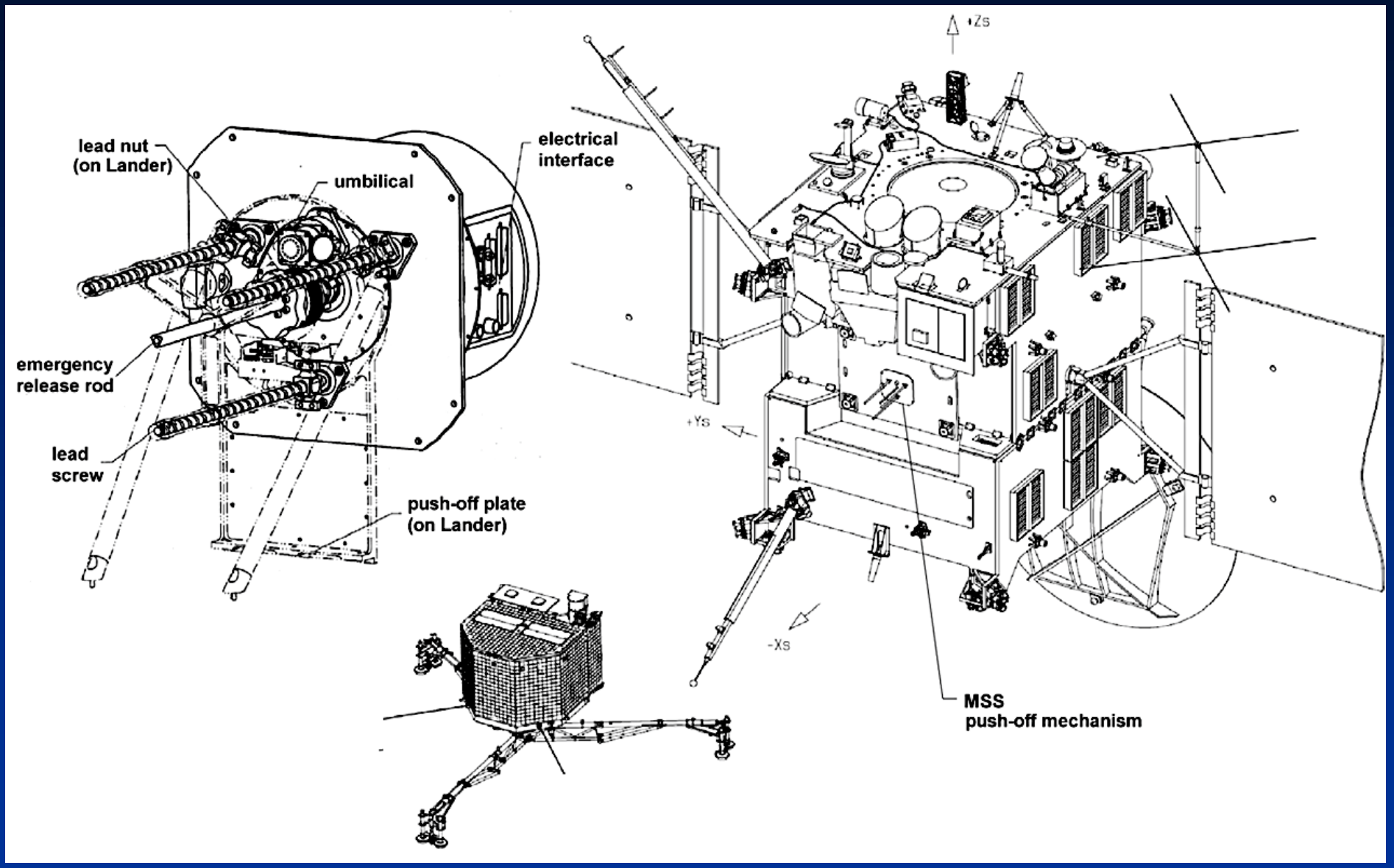


Z realizácie servisného systému ESS

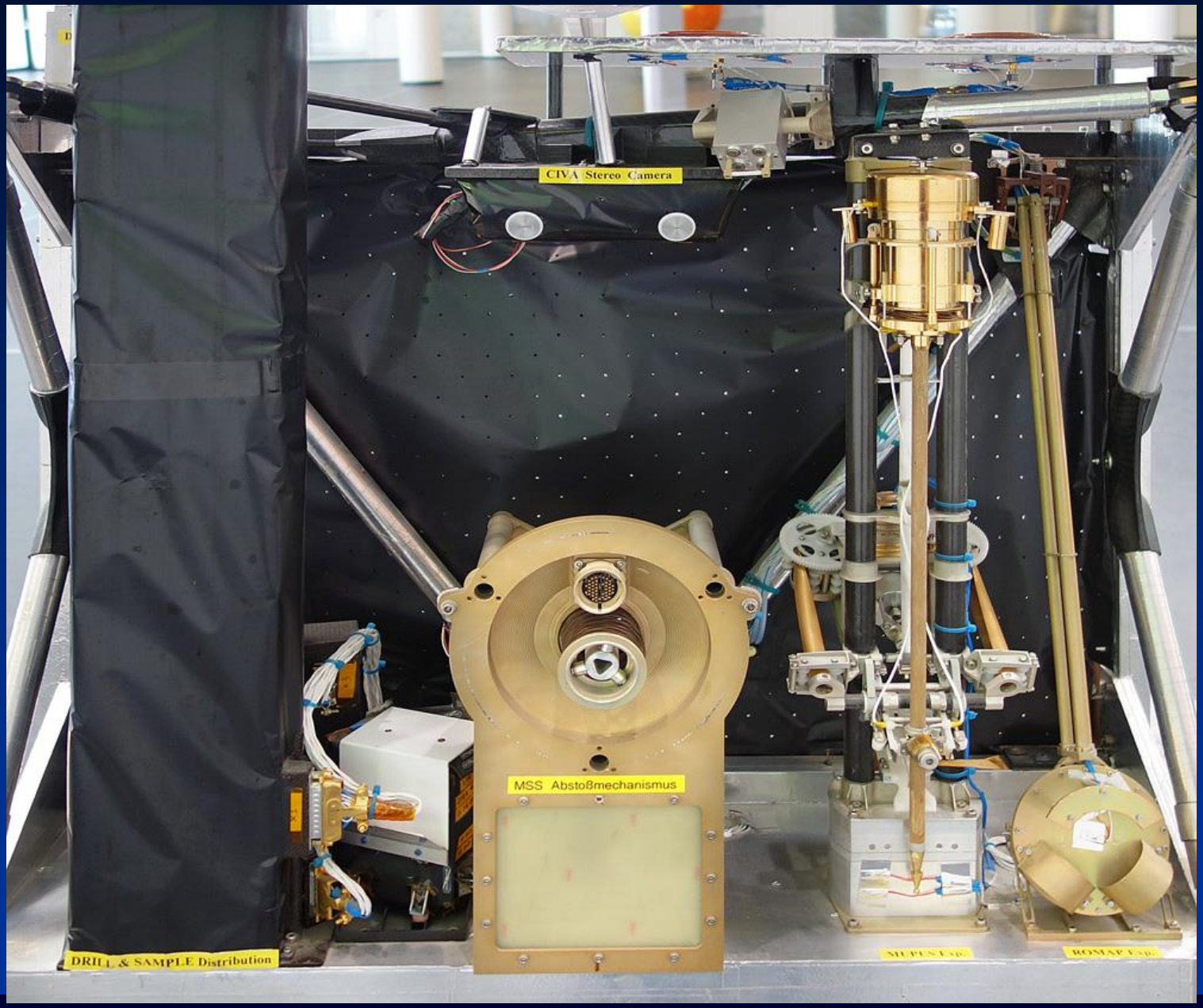
Úplný ESS procesor



Lander - oddeľovací mechanizmus (MSS)



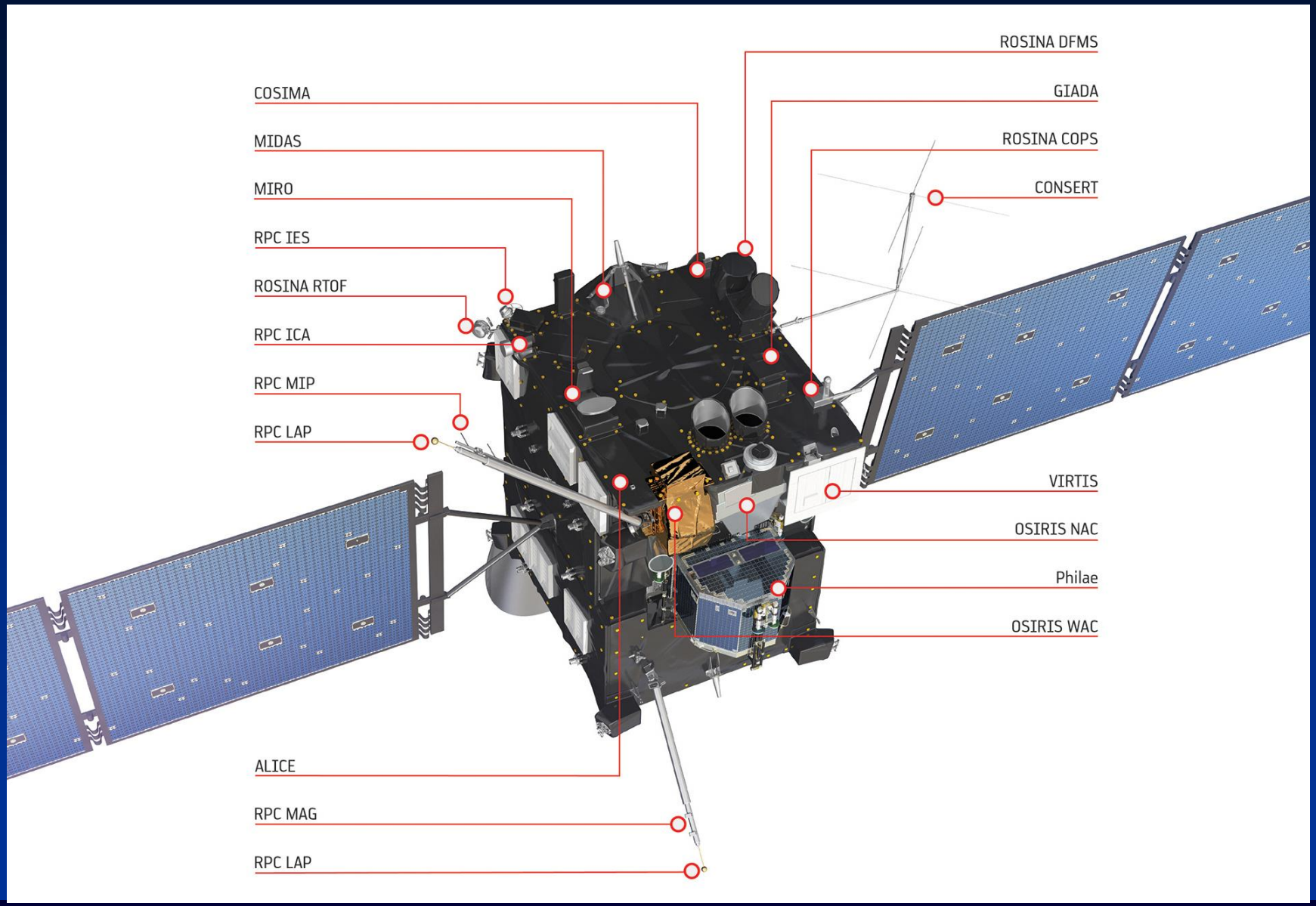
Lander - oddeľovací mechanizmus



Rosetta-Orbiter – Vedecký náklad (payload)

1. **ALICE** Ultraviolet Imaging Spectrometer
2. **CONSERT** Comet Nucleus Sounding Experim. by Radio Transmission
3. **COSIMA** Cometary Secondary Ion Mass Analyser
4. **GIADA** Grain Impact Analyser and Dust Accumulator
5. **MIDAS** Micro-Imaging Dust Analysis System
6. **MIRO** Microwave Instrument for the Rosetta Orbiter
7. **OSIRIS** Rosetta Orbiter Imaging System
8. **ROSINA** Rosetta Orbiter Spectrometer for Ion and Neutral Analysis
9. **RPC** Rosetta Plasma Consortium
10. **RSI** Radio Science Investigation
11. **VIRTIS** Visible and Infrared Mapping Spectrometer

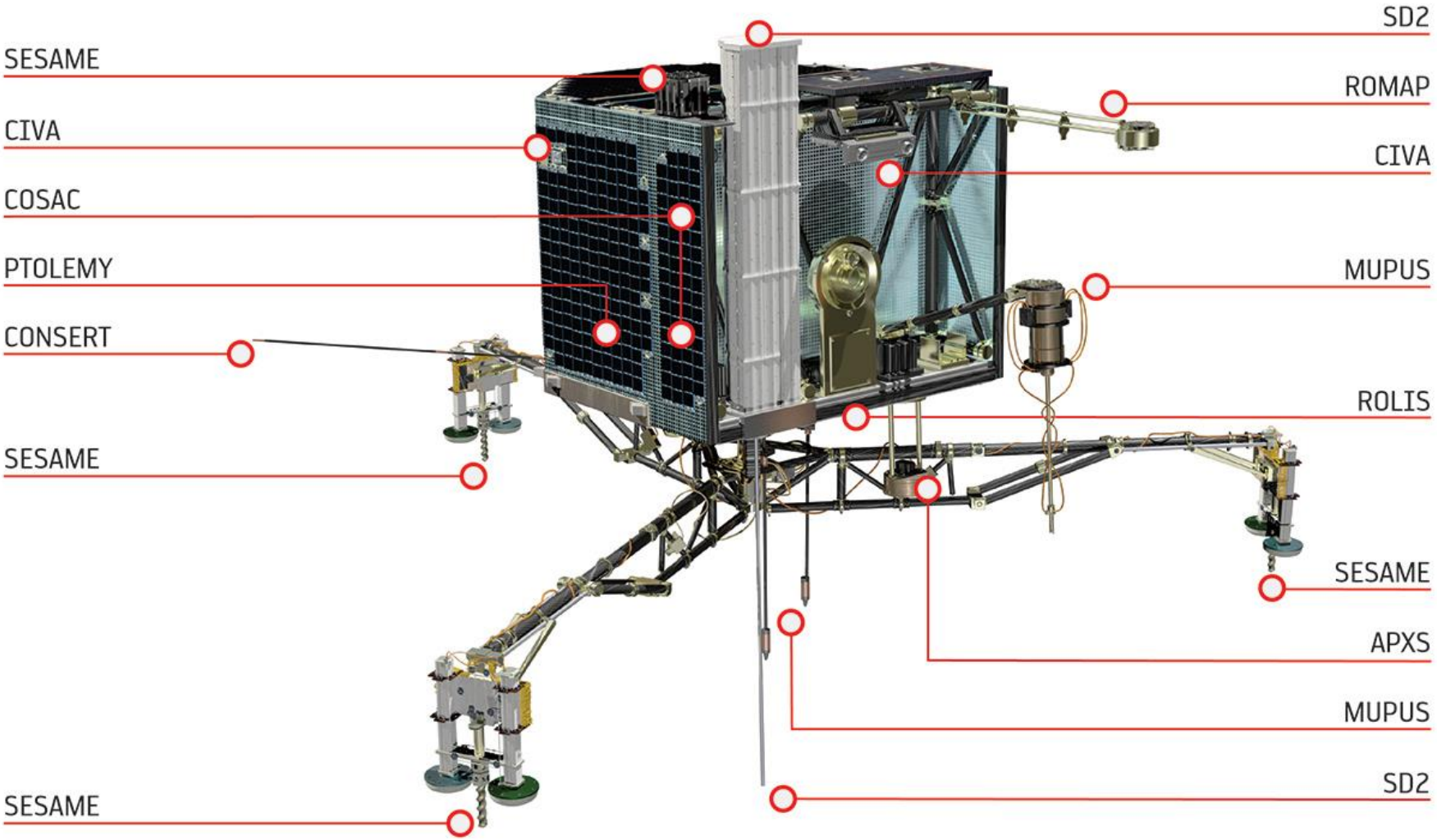
Orbiter – rozmiestnenie vedeckého nákladu



Lander Philae - Vedecký náklad

1. **APXS** Alpha-X-ray spektrometer
2. **ÇIVA** Panoramatická a mikroskopické stereo-kamery
3. **CONSERT** Rádiová tomografia jadra (s CONSERT – orbiter)
4. **COSAC** Analyzátor plynov - prvková a molekulárna analýza (chiral.)
5. **PTOLEMY** Analyzátor plynov - izotopová analýza
6. **MUPUS** Meranie podpovrchových vlastností (penetrátor)
7. **ROLIS** „Down looking camera“ – detailné snímkovanie povrchu
8. **ROMAP** Magnetometer a plazmový monitor
9. **SD2** Vŕtací systém a transport vzoriek na analýzu
10. **SESAME** Seizmický, elektrický, akustický a prachový monitoring

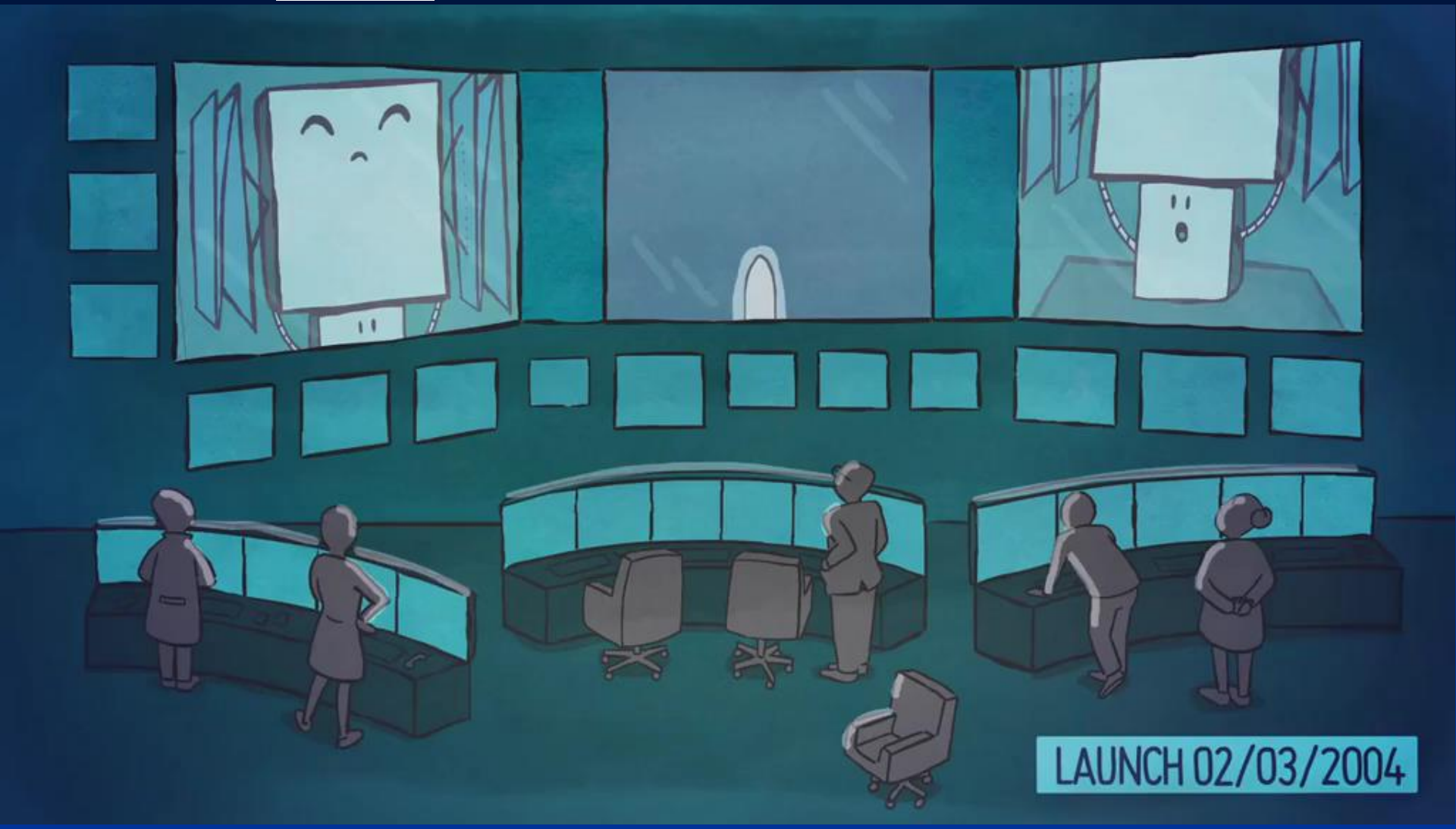
Lander - rozmiestnenie vedeckého nákladu

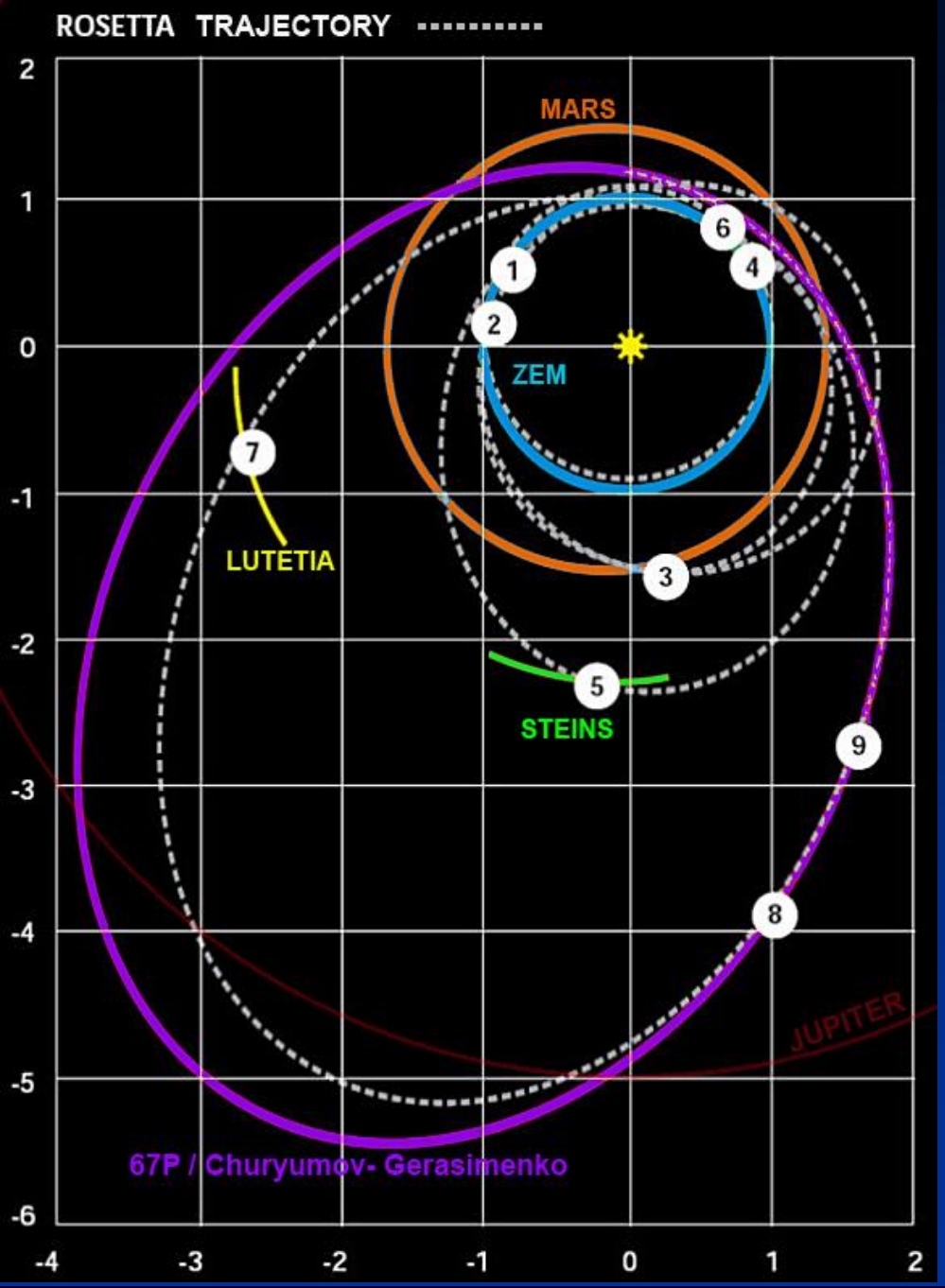


Štart sondy ROSETTA
02-MAR-2004
(kozmodróm ESA Kourou, Francúzska Guyana)

The amazing adventures of Rosetta and Philae

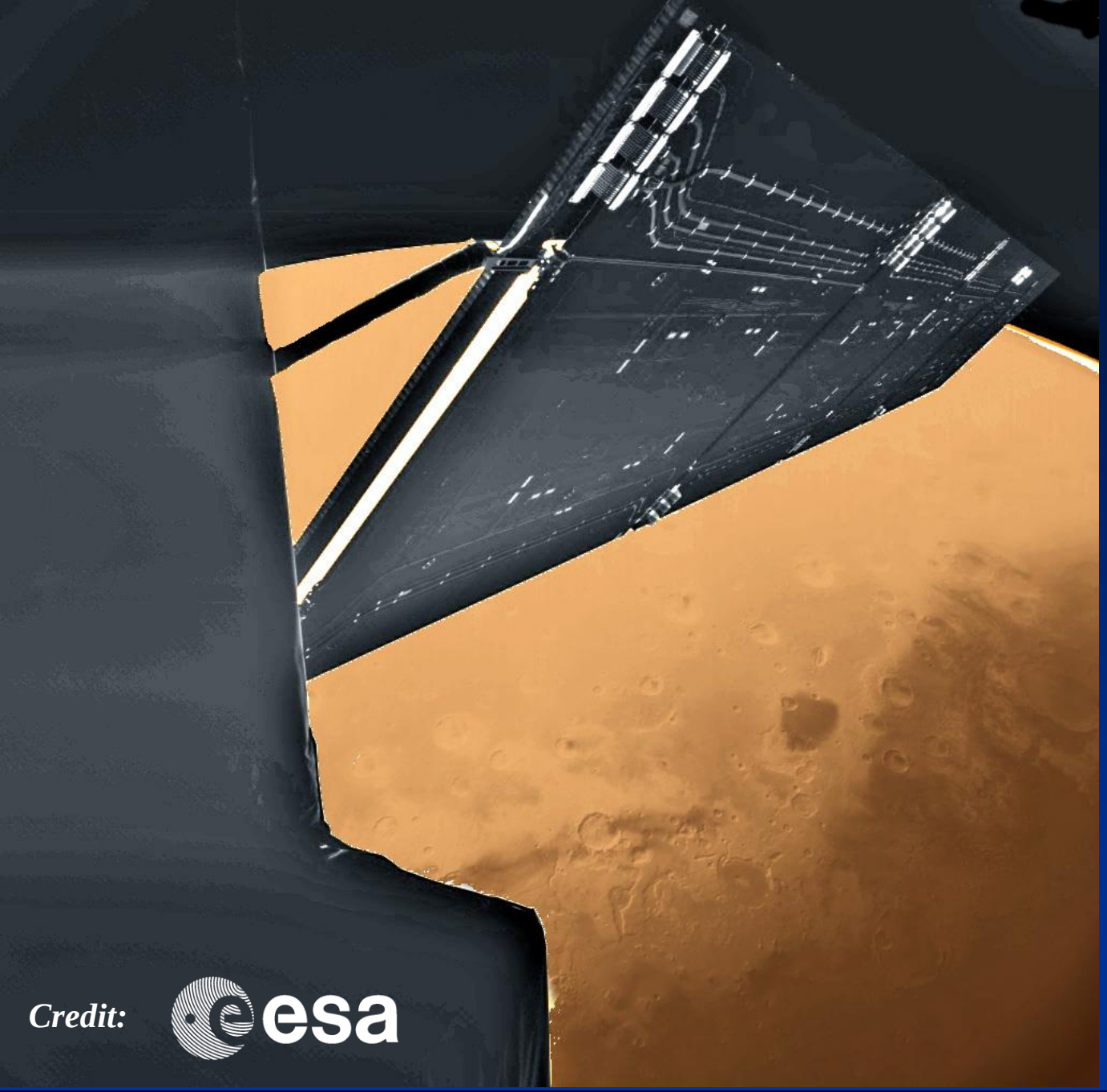
esa YouTube *(Úžasné dobrodružstvá Rosetty a Philae)*





Letový plán sondy ROSETTA

1. **2004-03-02 Štart (Kourou)**
2. **2005-03-04 Zem (prelet 1950km)**
3. **2007-02-25 Mars (prelet 250km)**
4. **2007-11-13 Zem (prelet 5300km)**
5. **2008-09-05 Steins (prelet 802km)**
6. **2009-11-13 Zem (prelet 2481km)**
7. **2010-07-10 Lutetia (prelet 3162km)**
8. (2011-06-08 - 2014-01-20) – hibernácia
9. **2014-08-06 67P (rendezvous~100km)**
10. **2014-11-12 67P (pristátie Philae)**
11. **2015-08-13 Perihélium** (1.2432AU)
12. **2016-09-30 Koniec misie** (Grand Finale)



Rosetta nad planétou Mars

25. 02. 2007

h = 250.6 km

316 mil km od Zeme

“Stávka o miliardu” (One-Billion Gamble)”

foto: CIVA-P

Druhý prelet nad planétou Zem

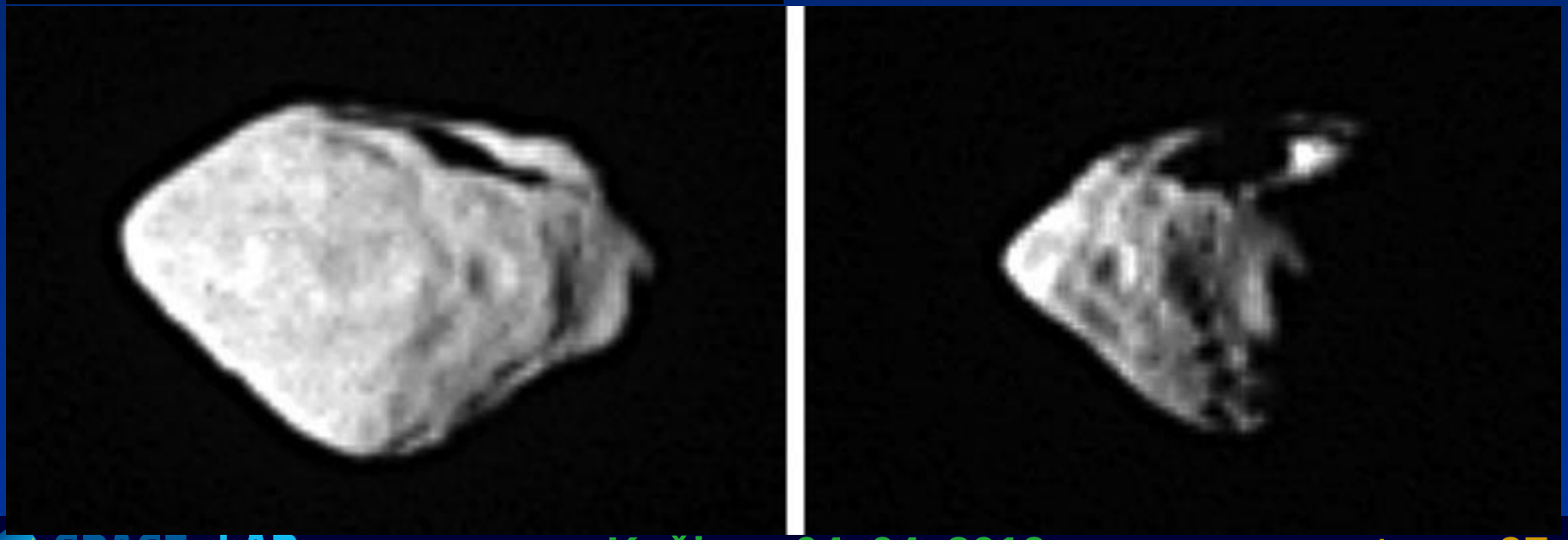
(13. 11. 2007, 5300km , Catalina Sky Survey: 2007 VN_{84} !!!)

Asteroid 2867 Steins *(05. 09. 2008, 802km, 8,6 km-s)*

„Diamantový tvar“,

Rozmery 6.67 × 5.81 × 4.47 km^3

Pokrytý plytkými krátermi



Posledný prelet nad planétou Zem *(13.11.2009, 2481 km)*

Asteroid 21 Lutetia

(10. 07. 2010, 3162 km, 15km-s)

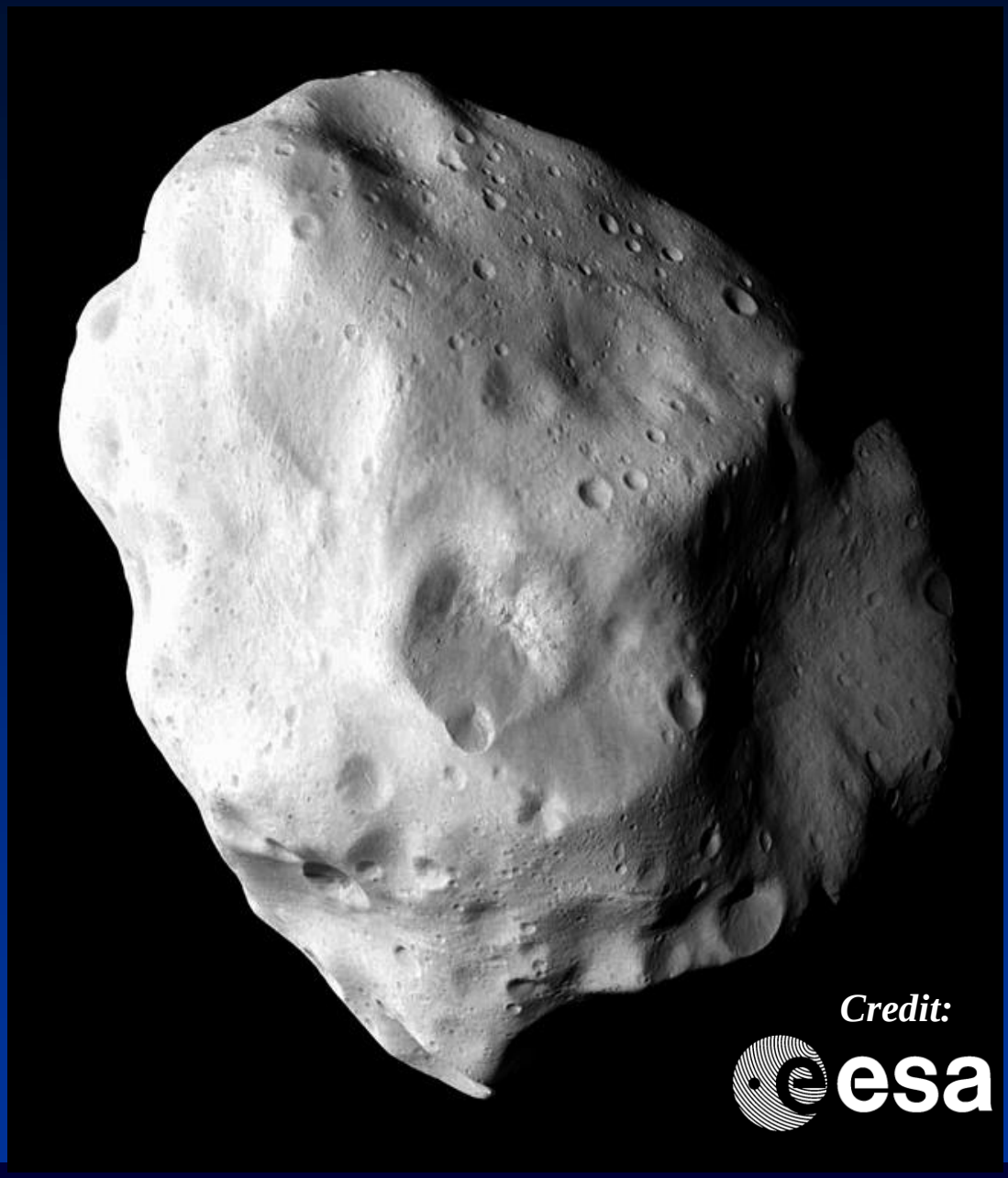
OSIRIS *imaging*

(1px = 60m)

Hmotnosť 1.7 x 10^{18} kg,

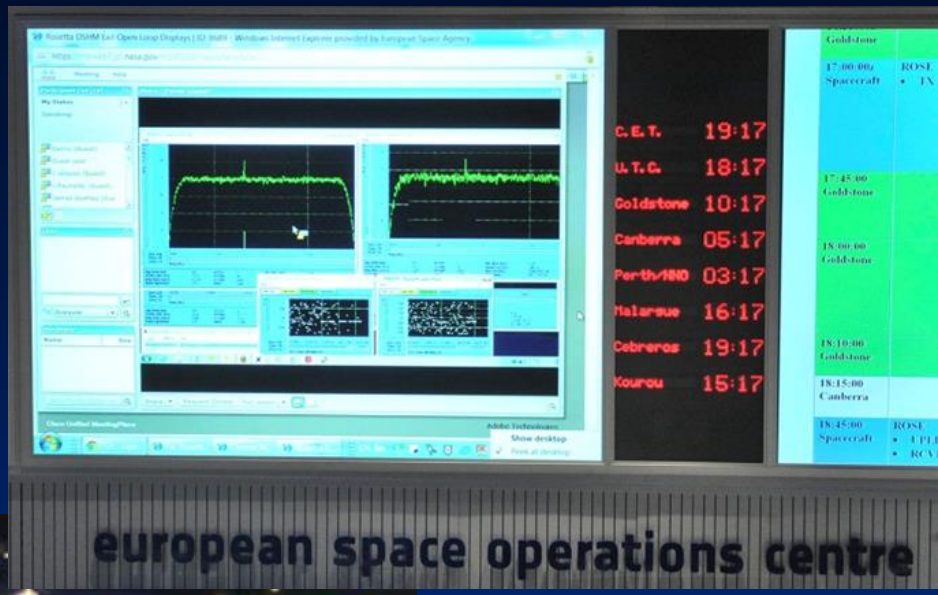
Hustota ~ 3.4 g-cm^3

Vnútro asi bolo kedysi pretavené.

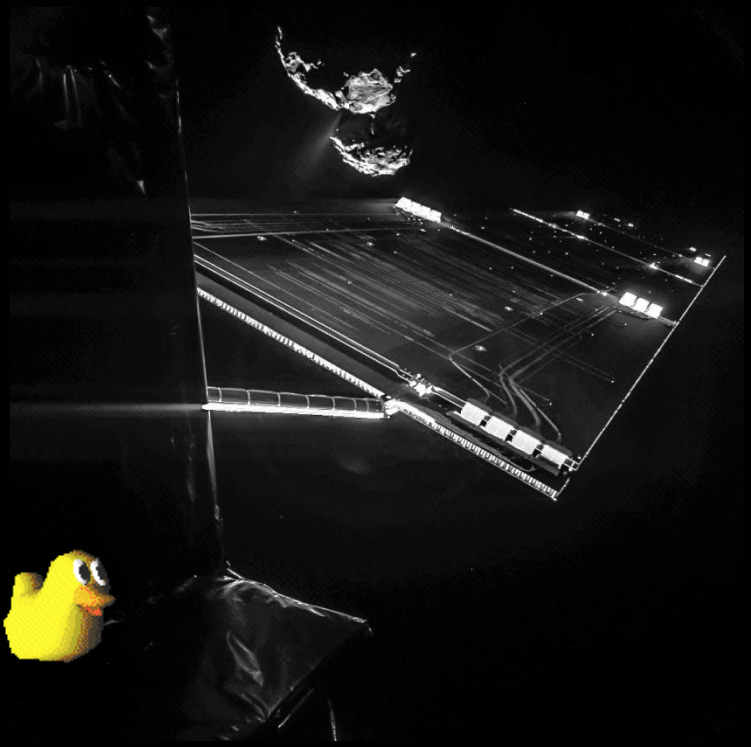


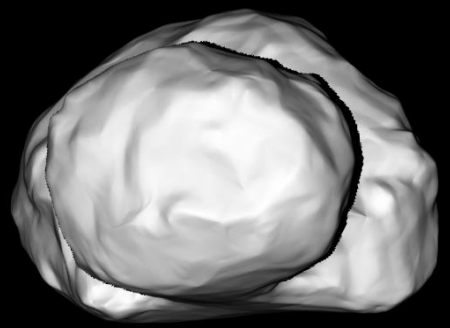
Prebudenie z hibernácie

20. 01. 2014



Rendezvous s 67P (august 2014)





Comet 67P/Churyumov-Gerasimenko from Rosetta - 31 August 2014
ESA/Rosetta/NAVCAM/Ken Kremer/Marco Di Lorenzo

Rendezvous s 67P (august 2014)

Rendezvous s 67P (6 august 2014)

Nové dáta o 67P/C-G z „Blízkeho stretnutia“

Rozmery (malý lalok)	2,5 × 2,5 × 2,0 km	OSIRIS
Rozmery (veľký lalok)	4,1 × 3,2 × 1,3 km	OSIRIS
Perióda rotácie	12,4043 hod	OSIRIS
Orientácia osi rotácie	RA: 69°; DE: 64°	OSIRIS
Hmotnosť	10^{13} kg (10 miliárd ton)	RSI
Objem	25 km^3	OSIRIS
Hustota	0,4 $g\text{-}cm^3$	RSI- OSIRIS
Rýchlosť odparovania	0,3 l-s (6-2014); 1–5 l-s (7-8-2014)	MIRO
Povrchová teplota	205–230 K (−68-−93°C, 7-8-2014)	VIRTIS
Podpovrchová teplota	30–160 K (−113-−243 °C, 8-2014)	MIRO
Detekované plyny	CO, CO_2, CH_3OH (methylalk.), CH_4(metán) NH_3 (amoniak), H_2S (sírovodík)	ROSINA
Veľkosť prach. častíc	~ 0.1 µm - ~0.01µm	COSIMA-GIADA

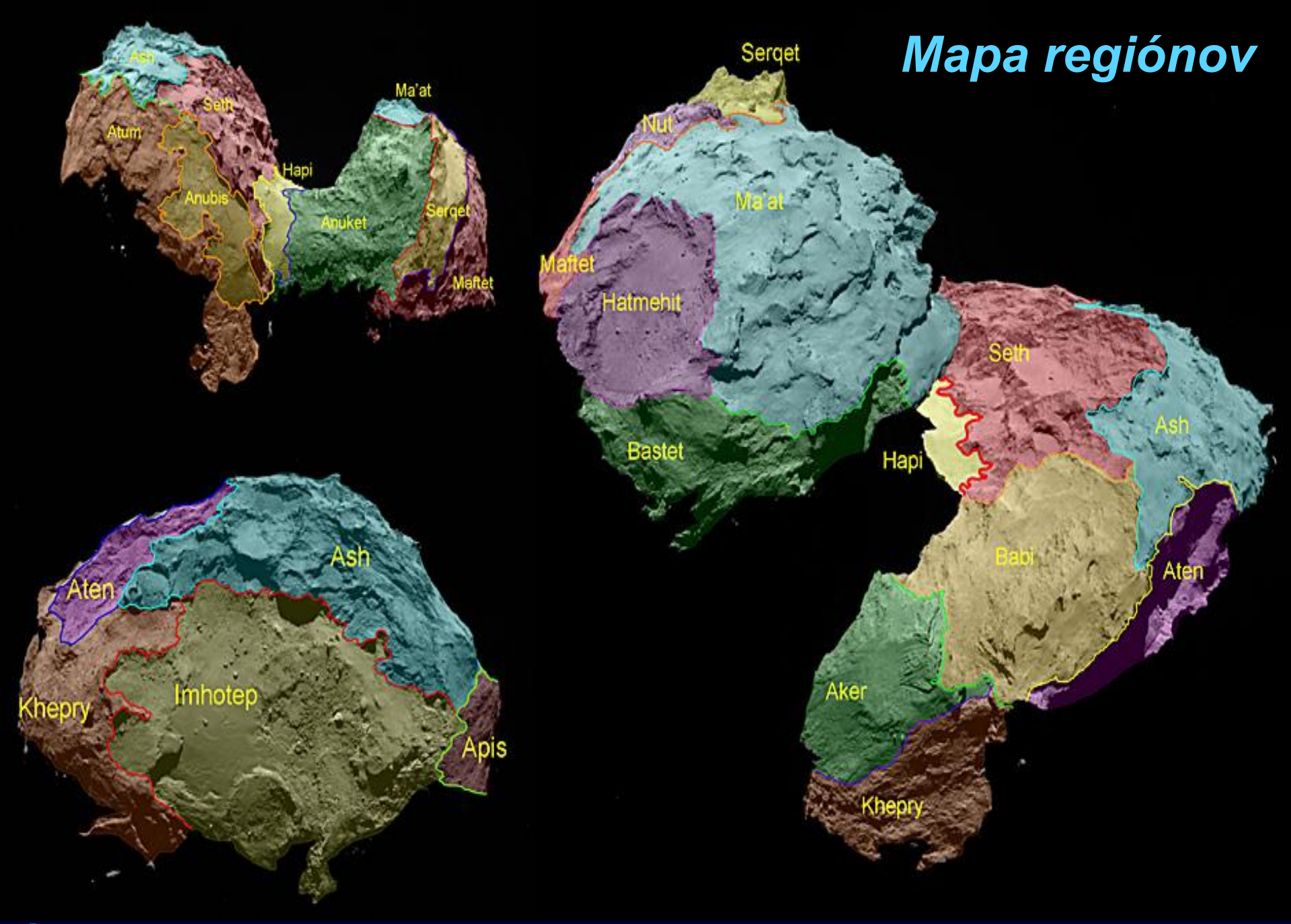
Nové dáta o 67P/C-G z „Blízkeho stretnutia“

ROSINA (Rosetta Orbiter Sensor for Ion and Neutral Analysis)

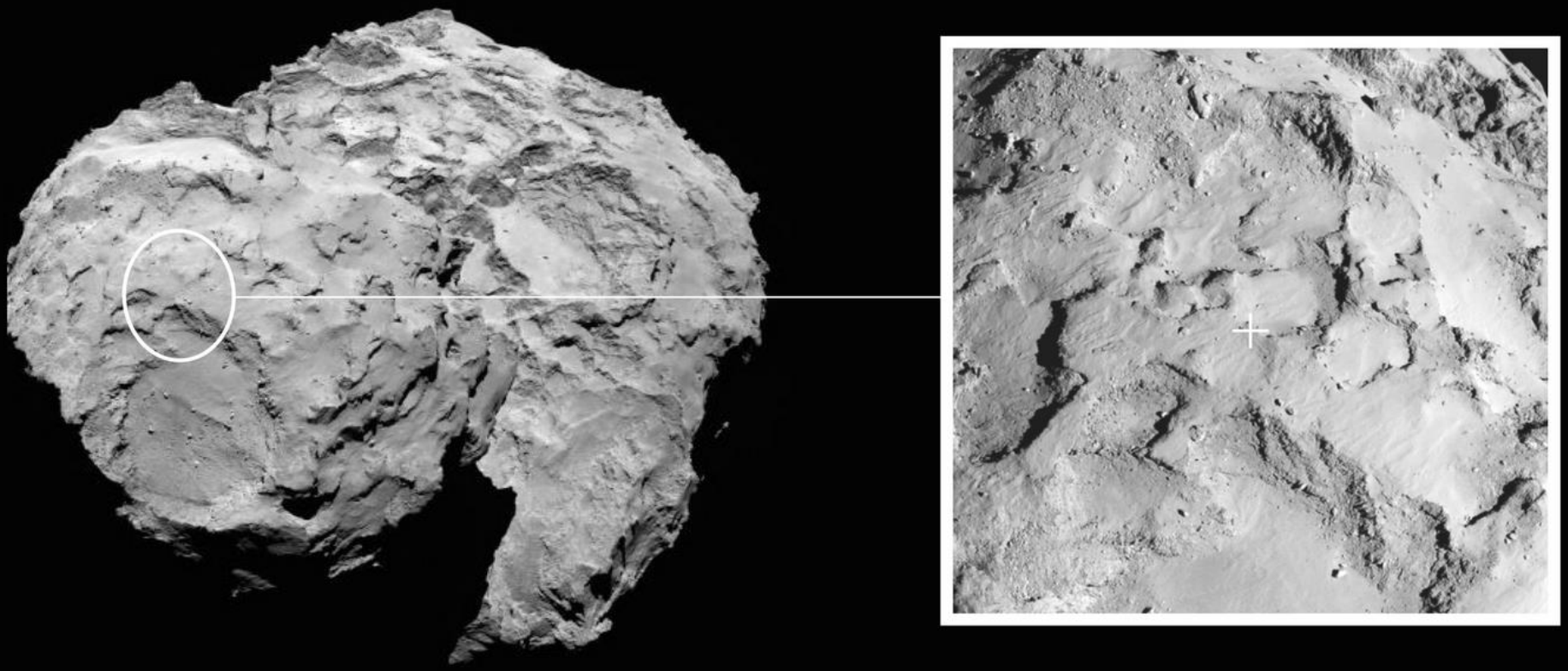
Detected gases, organic compounds and radicals in the coma

$H_2{}^{16}O$	HDO	HCl	C_2H_6O	and
$H_2{}^{17}O$	N_2	$H^{37}Cl$	C_6H_4	many
$H_2{}^{18}O$	CO	CH_3OH	N_2H_4	more
CO_2	C_2H_2	OCS	$N^{18}O$	
H_2S	C_2H_4	CH_2O_4	H_2NO	
$H_2{}^{34}S$	C_2H_6	C_6H_6	$H^{15}NO$	
SO_2	CH_2N	C_3H_2	O_2	
CS_2	C_2HN	OH	H_2O_2	
HCN	C_2	$C^{34}S$	PH_3	
Ar^{36}	C_3	NO_2	CH_3CN	
Ar^{38}	C_2N	$C^{18}O^{16}O$	SO	

Mapa regiónov



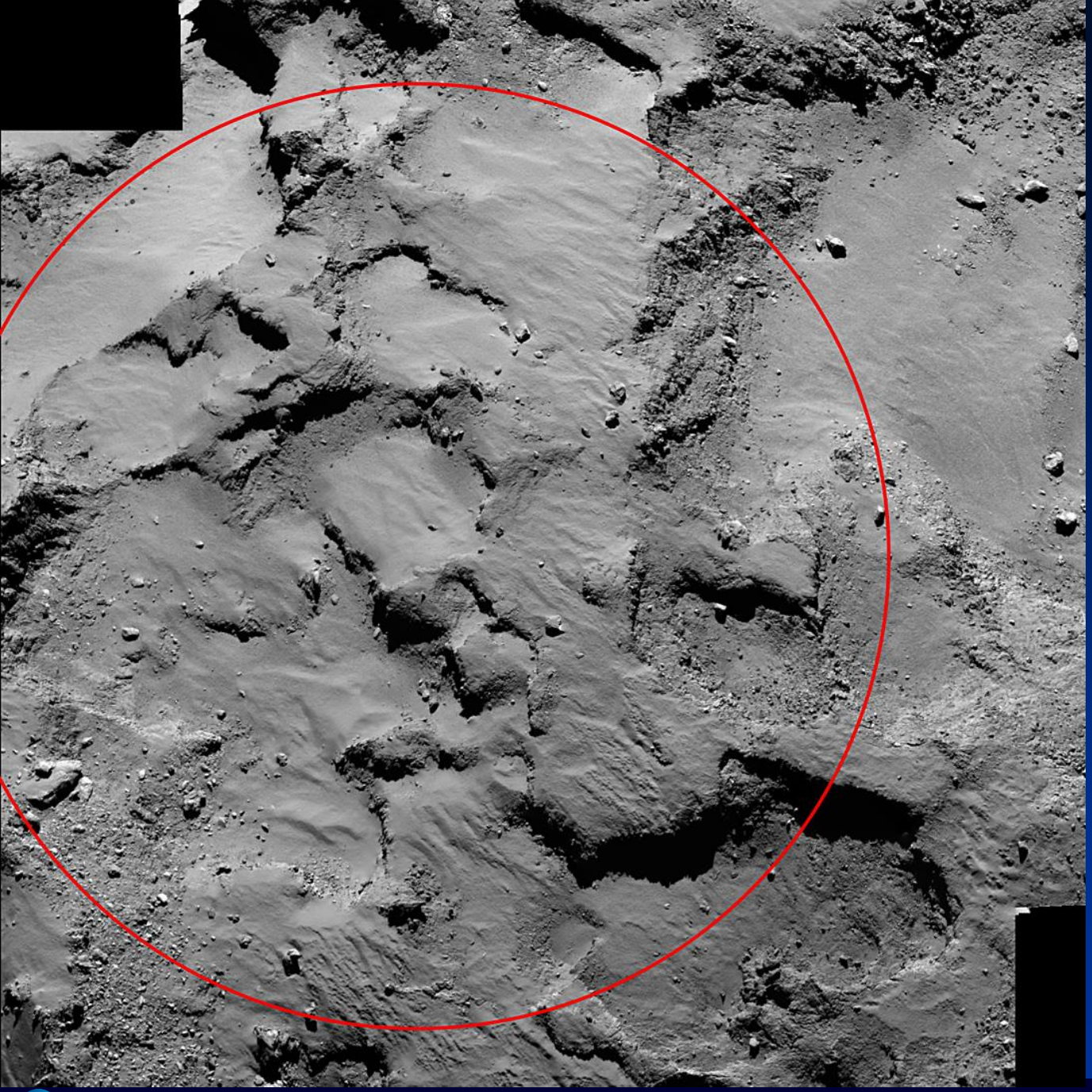
Výber miesta na pristátie (sep. 2014) vybraný bod „J“ Agilkia



Bezpečnostné kritériá: Plochý terén s malým sklonom a bez väčších balvanov.

Technické kritériá: Profil osvetlenia, teplota povrchu, kompaktnosť povrchu, spoľahlivá komunikácia s orbiterom.

Vedecké kritériá: Reprezentatívne materiálové zloženie, primeraná povrchová aktivita po priblížení k Slnku.



AGILKIA

OSIRIS telefoto

14 September 2014

Záber z výšky 30 km.

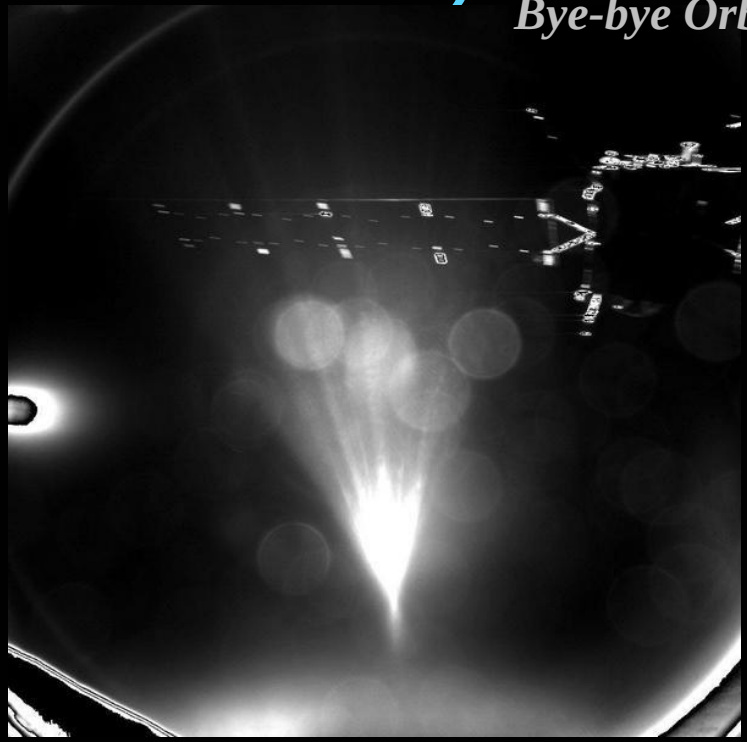
Polomer kruhu 500 m.

Pristátie na kométe 67P (12 november 2014)

Pristátie na kométe 67P (12 november 2014)

Bye-bye Philae

Bye-bye Orbiter

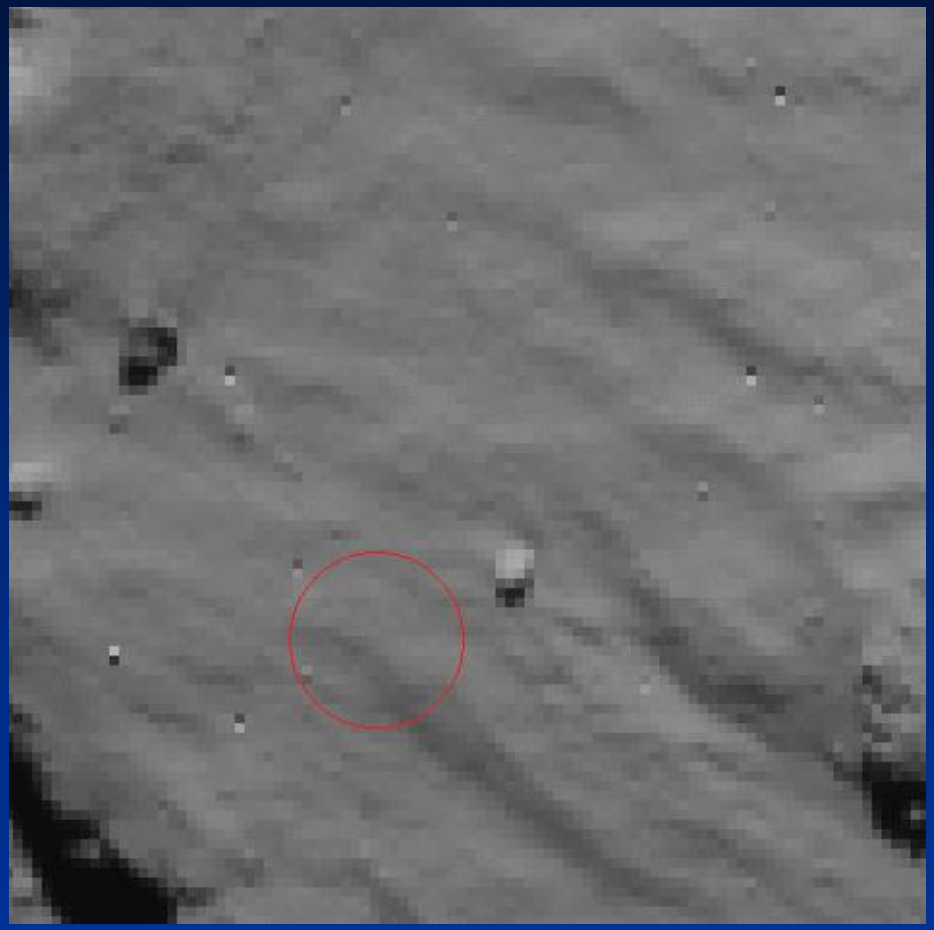


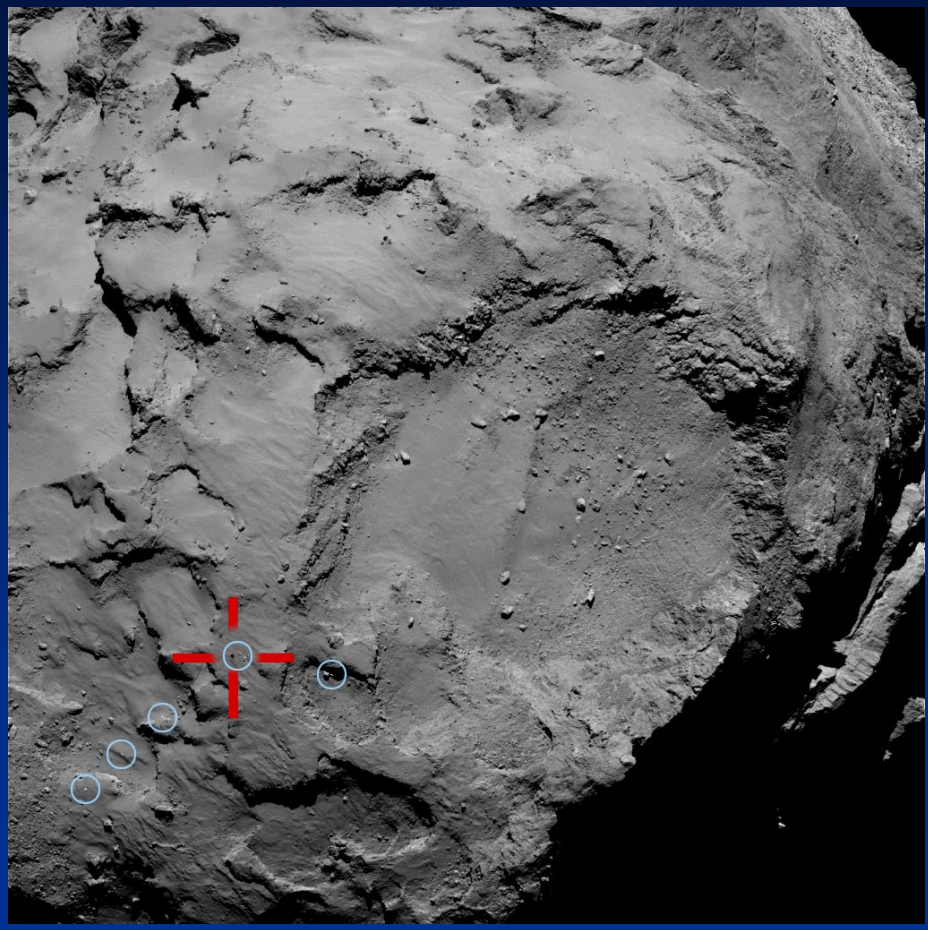
ROLIS 3 km

ROLIS 40m

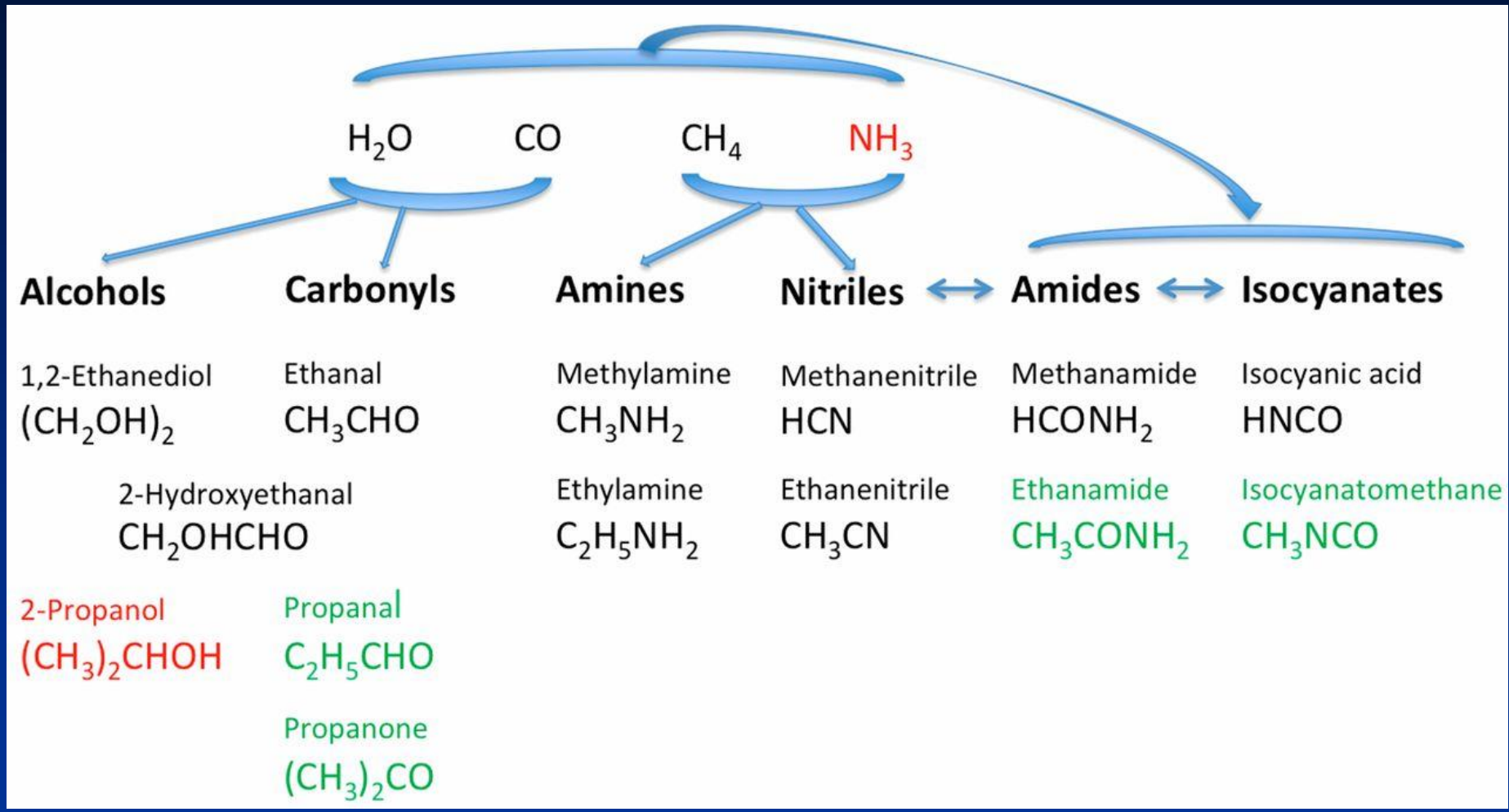
Welcome to a Comet ! *(Abydos)*

Kde je Philae ? (NavCam)





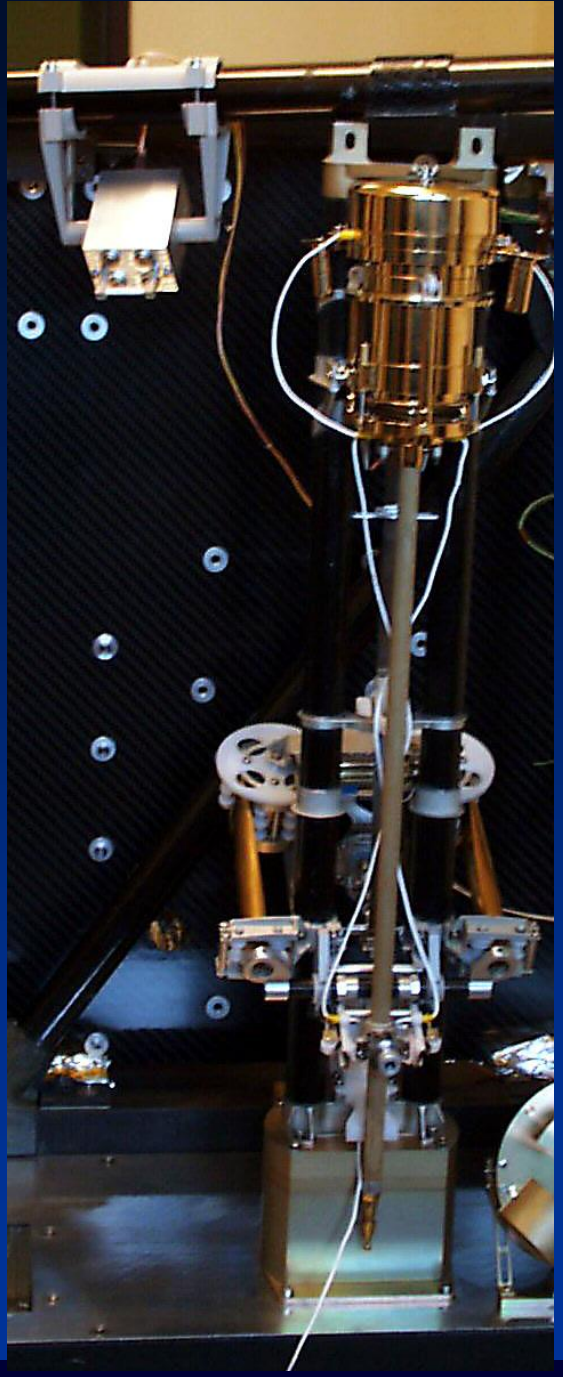
Chemické rodiny detegované Philae



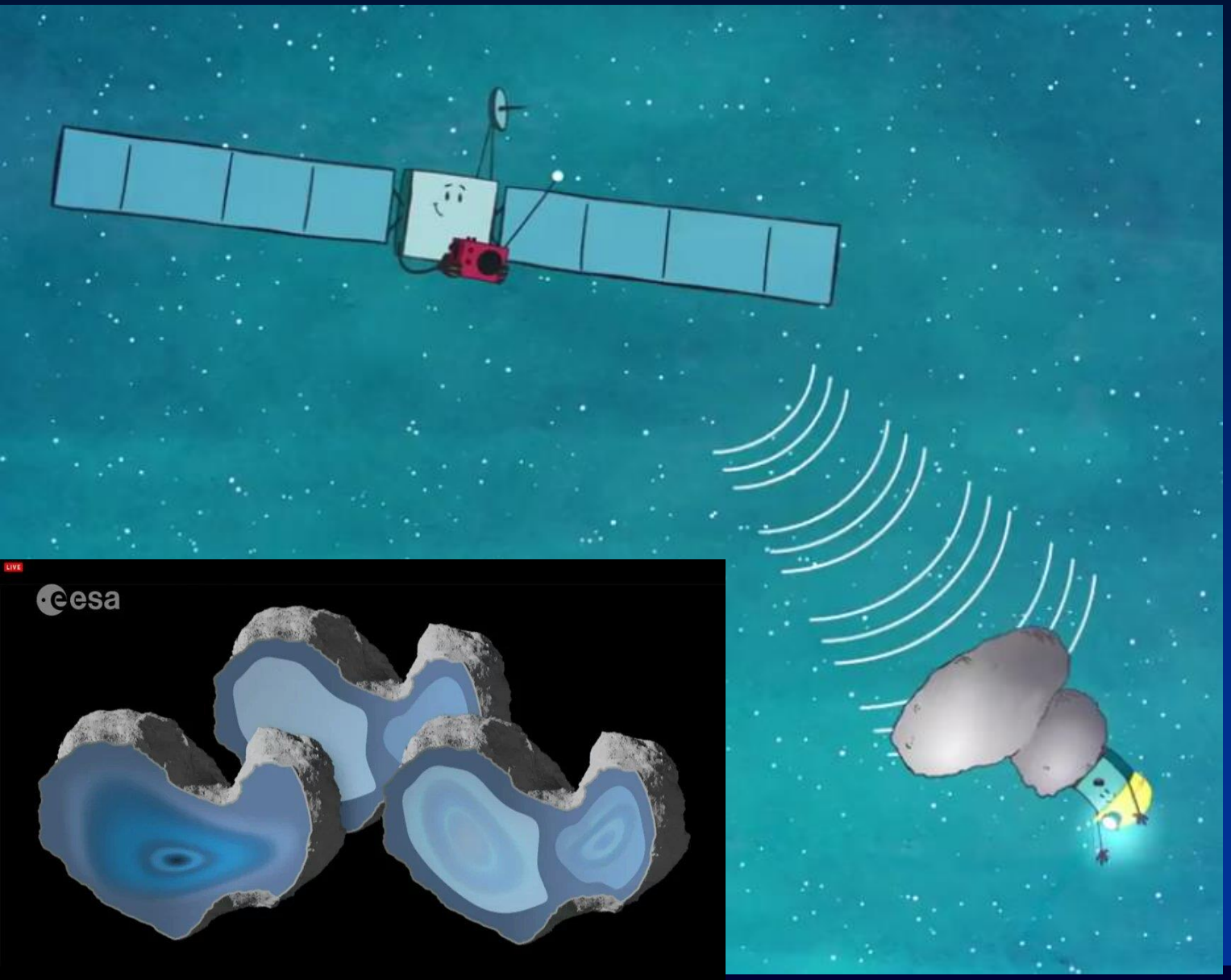
MUPUS, SESAME

„Vŕtacie kladivo“ MUPUS nedokázalo pri obmedzenom napájaní preraziť tvrdú ľadovú krustu. Tá je pokrytá vrstvou prachu.

Podobné vlastnosti potvrdil SESAME.



CONSERT – rádiová tomografia



CONSERT

zistil pomerne homogénne vnútro jadra kométy, žiadne dutiny väčšie ako 100m.

Prachová zložka zodpovedá uhlíkatým chondritom.

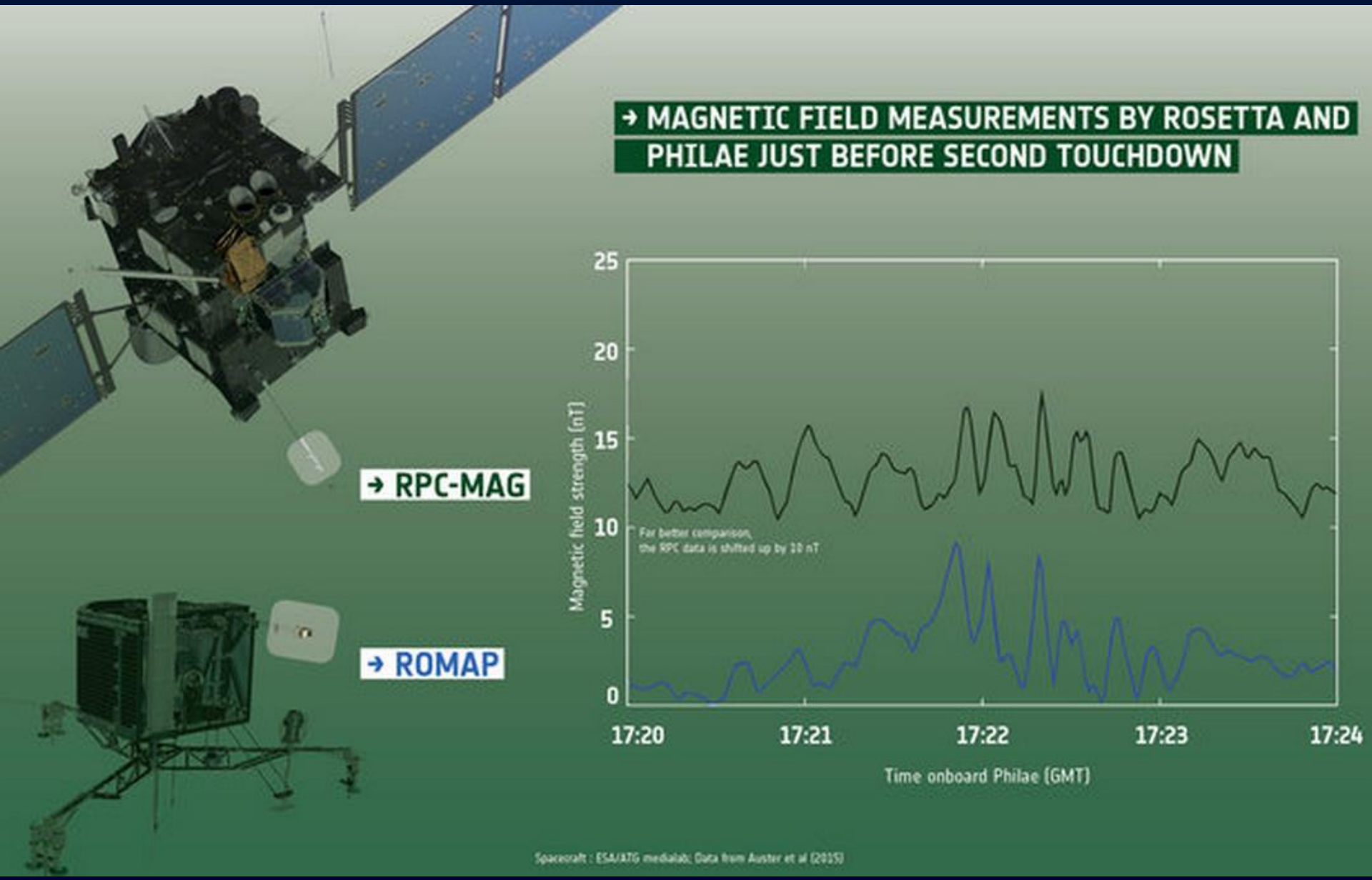
Philae pracoval 57 hodín, vykonal asi 80% plánovaných úloh a potom sa kvôli nedostatku energie hibernoval

Spojenia s Philae

Connection	Date	Duration
nominal	12-Nov-2014	2,5 days
1	13-Jun-2015	78 sec
2	14-Jun-2015	4:04 min
3	19-Jun-2015	18:53 min
4	20-Jun-2015	31:01 min
5	21-Jun-2015	11:25 min
6	24-Jun-2015	17:11min
7	09-July-2015	22 min

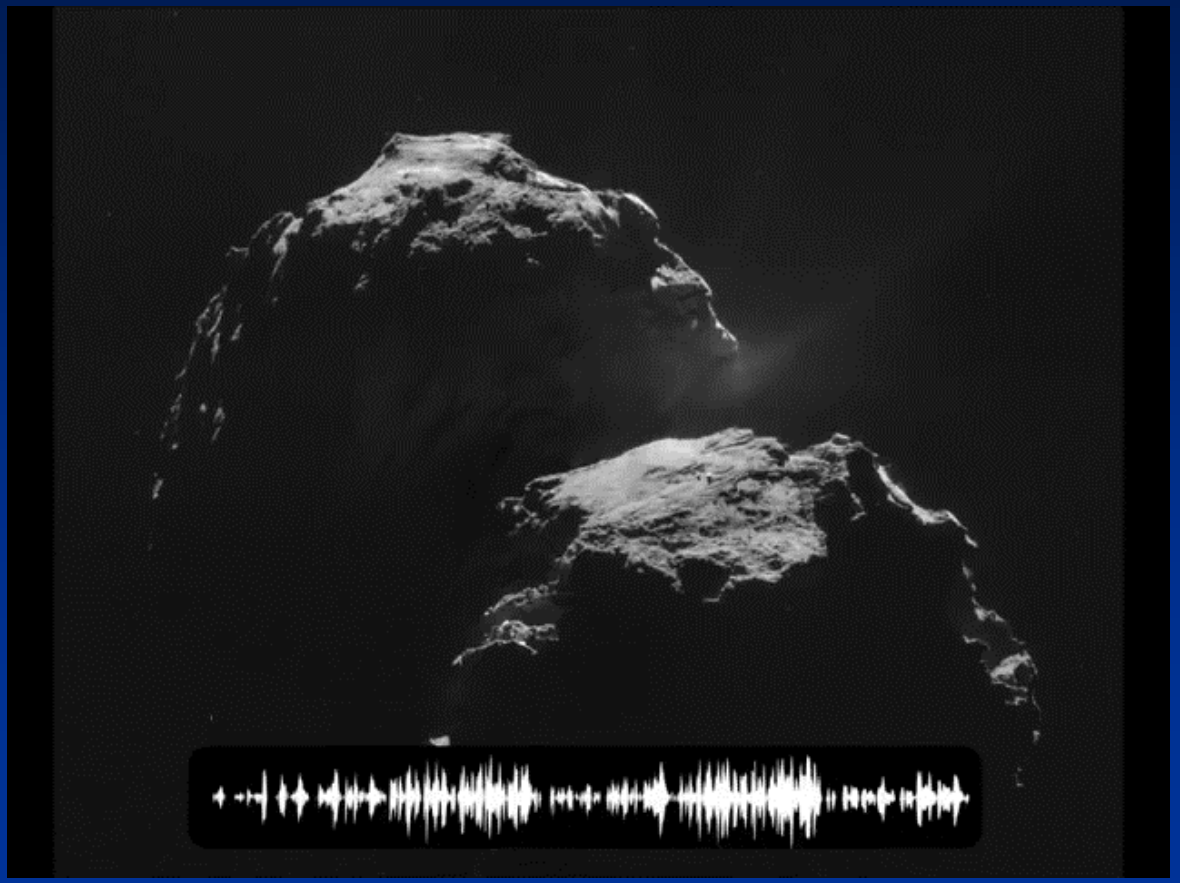
ESS procesor „načúval“, či sa Philae neozve až do augusta 2016 !

Skoro žiadne magnetické pole

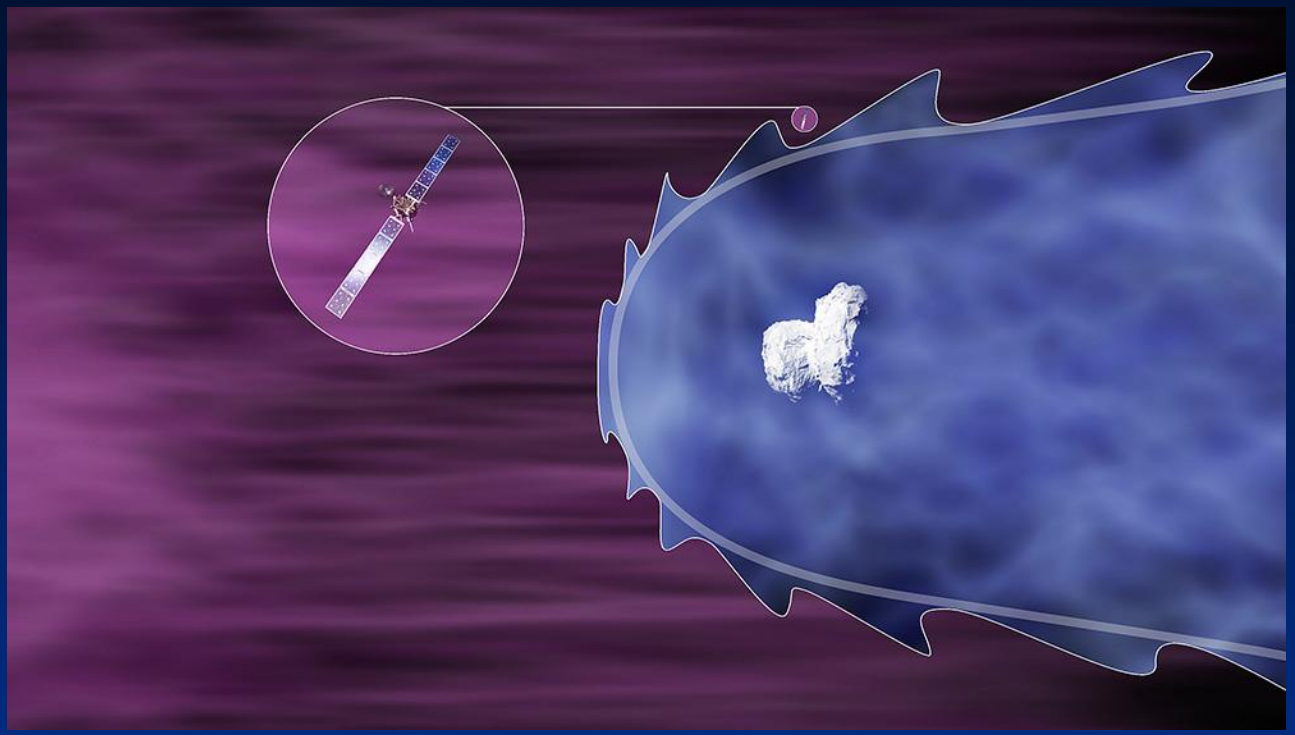


„Spievajúca kométa“

Slnečný vietor reaguje s ionizovaným plynom a prachom a vyvoláva jemné variácie magnetického poľa. Prevedené do počuteľného rozsahu (20Hz-20kHz) jej vyniesli prezývku „spievajúca kométa“.

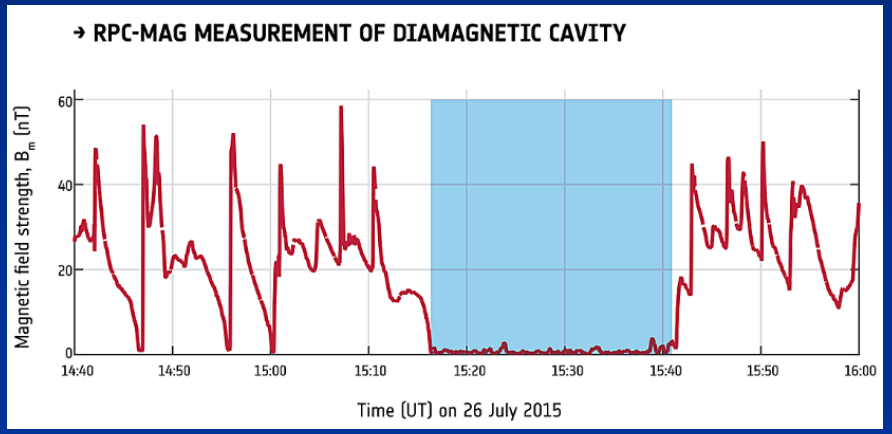


Veľká diamagnetická kavita (bublina) okolo jadra

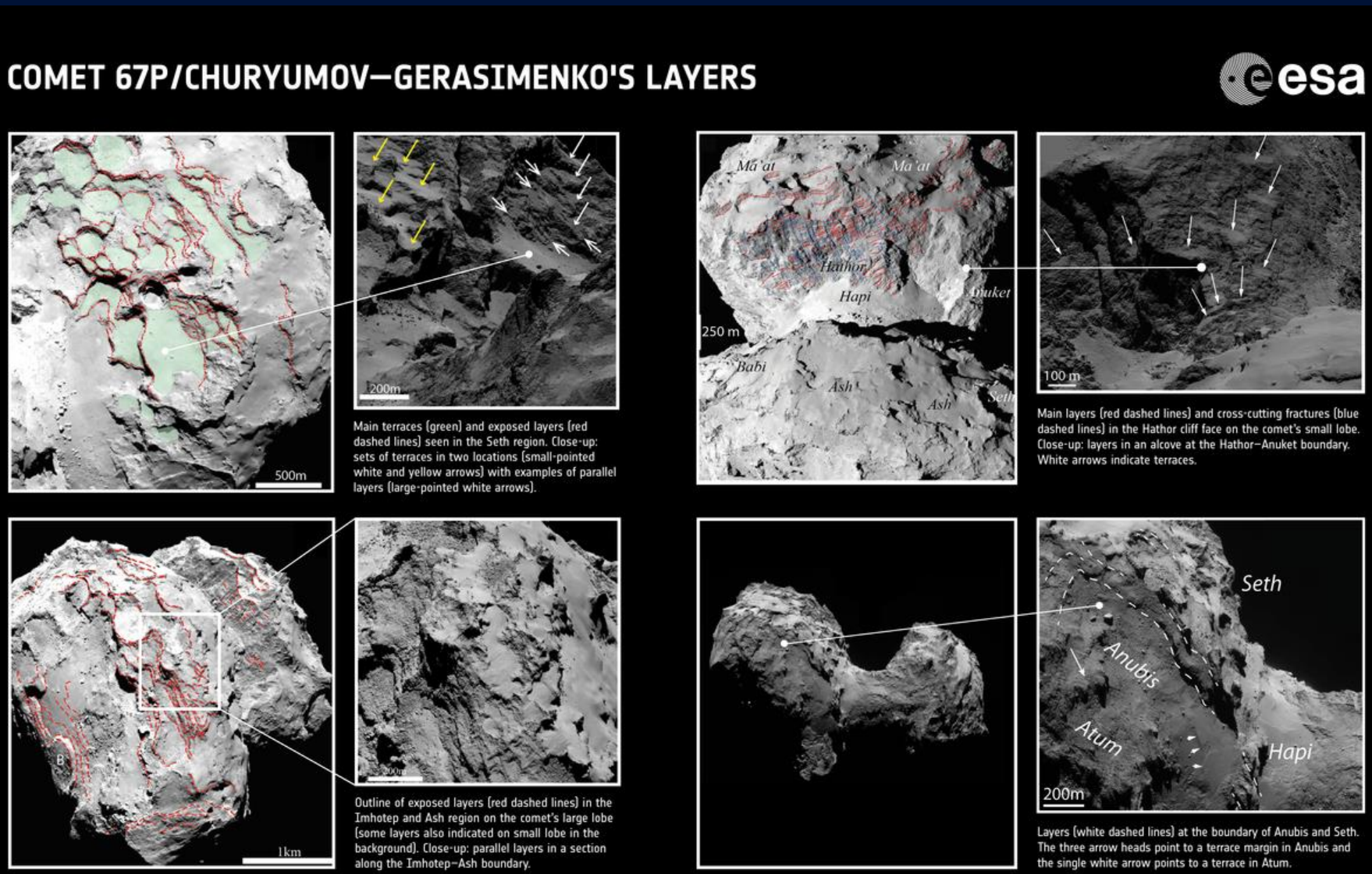


Rosetta detegovala podstatne väčšiu kavitu než bola predpovedaná modelmi.

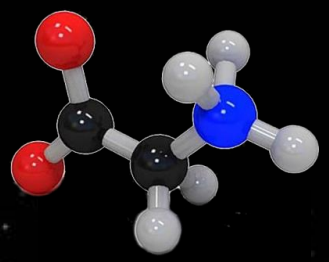
Diamagnetická kavita vzniká reakciou slnečného vetra a plynovo-plazmového prostredia okolo kométy v perihéliu.



67P vznikla „pomalou zrážkou“ dvoch telies

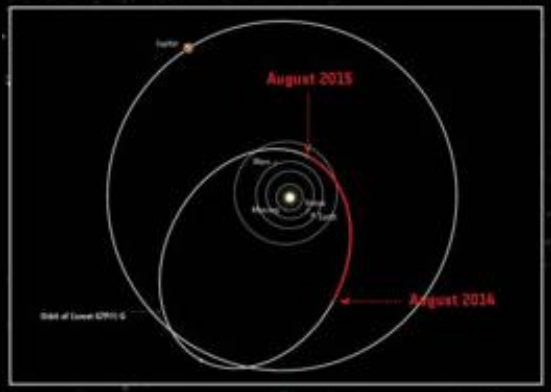


Bio-prekurzory fosfor a aminokyselina glycín

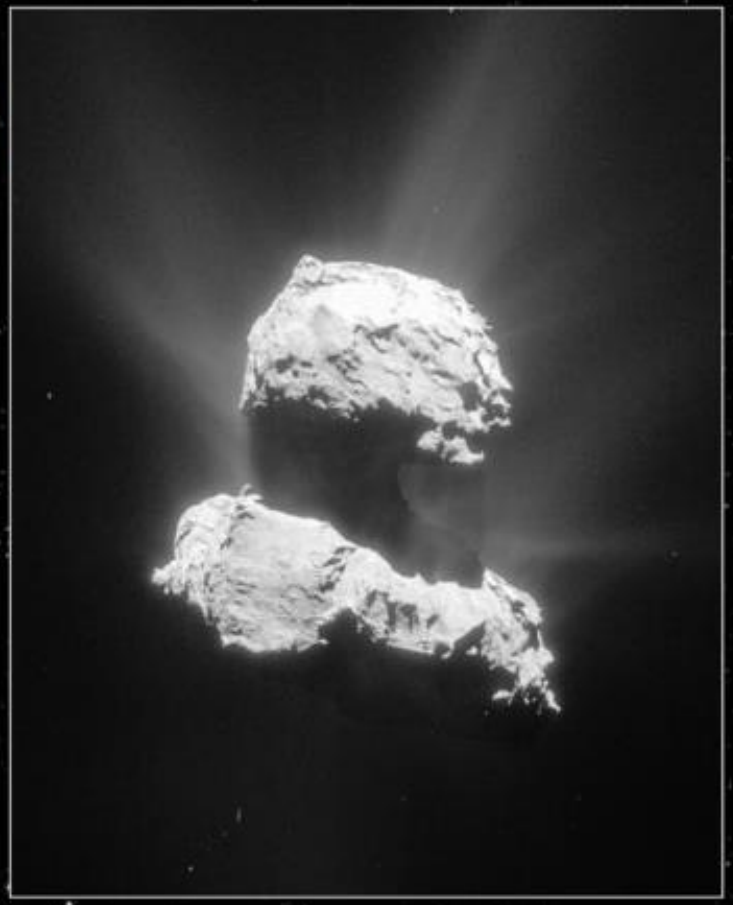


ROSETTA'S COMET CONTAINS INGREDIENTS FOR LIFE

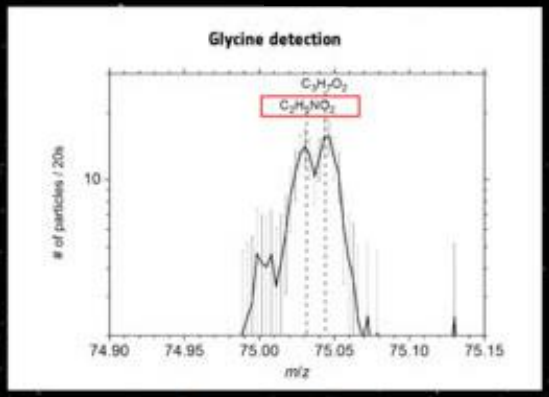
The measurements were made with the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis Double-Focusing Mass Spectrometer (ROSINA-DFMS).



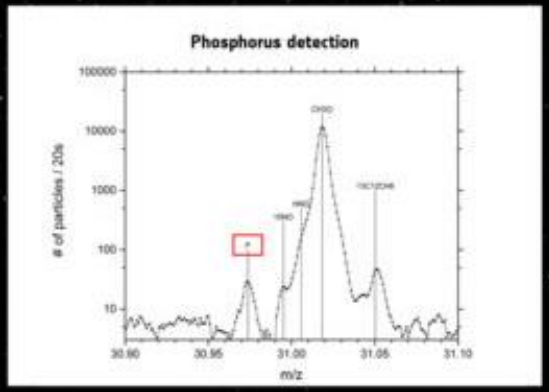
The data were collected between August 2014 and August 2015.



The measurements were made when Rosetta was between 10 and 200 km from the comet.



Spectrum indicating glycine ($C_2H_5NO_2$) detection on 9 July 2015. The simple amino acid glycine is a biologically important organic compound commonly found in proteins.



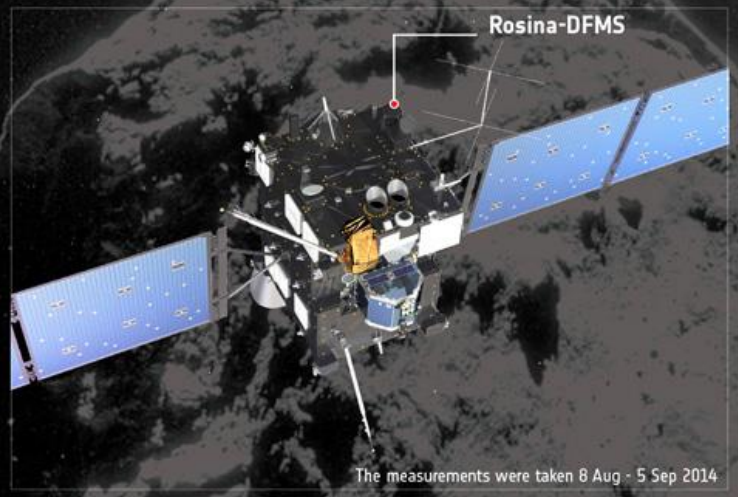
Spectrum indicating phosphorus (P) detection, along with other gases, on 26 October 2014. Phosphorus is a key element in all living organisms. It is found in DNA, RNA and in cell membranes, and it is used in transporting chemical energy within cells for metabolism.

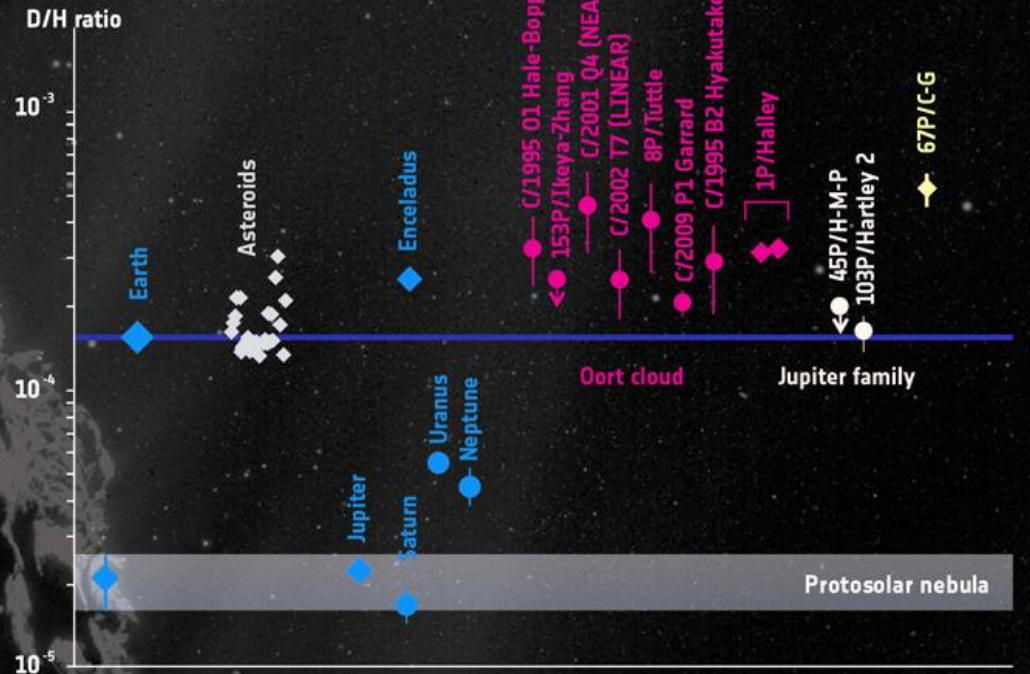
Voda z kométy 67P je iná... (viac ťažkého vodíka)

Rosetta's ROSINA instrument finds Comet 67P/Churyumov-Gerasimenko's water vapour to have a significantly different composition to Earth's oceans.

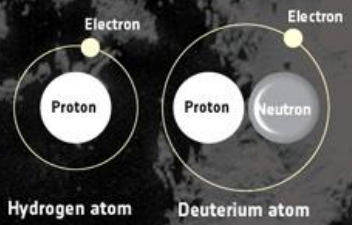
Zem: 1.56×10^{-4} (0.0156 %)

67P: 5.3×10^{-4} (0.053 %)





The ratio of deuterium to hydrogen in water is a key diagnostic to determining where in the Solar System an object originated and in what proportion asteroids and comets may have contributed to Earth's oceans



D/H ratio for different Solar System objects, grouped by colour as planets and moons (blue), chrondritic meteorites from the Asteroid Belt (grey), comets originating from the Oort cloud (purple) and Jupiter family comets (pink). Comet 67P/C-G, a Jupiter family comet, is highlighted in yellow. ◆ = data obtained in situ ● = data obtained by astronomical methods

www.esa.int

Spacecraft: ESA/ATG medialab; Comet: ESA/Rosetta/NAVCAM; Data: Altwegg et al. 2014 and references therein.

European Space Agency

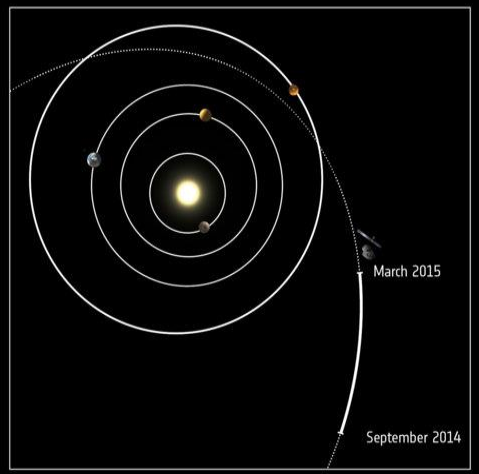
Detekcia množstva molekulárneho kyslíka (ROSINA)

Veľmi starý kyslík, uväznený v zmrazenom materiáli a uvoľňovaný pri slnečnej erózii.

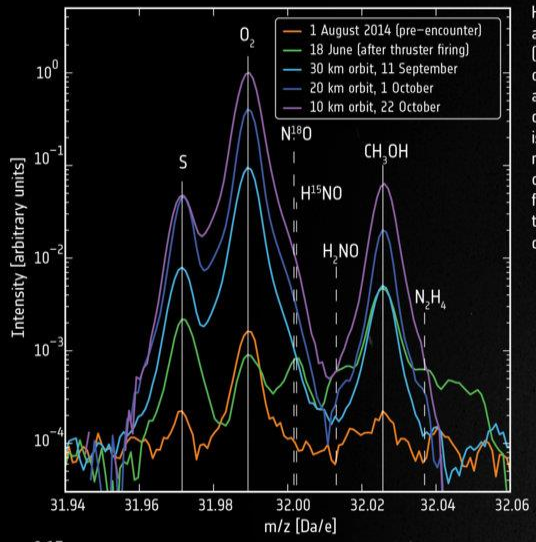
esa

→ ROSETTA HAS MADE THE FIRST DETECTION OF MOLECULAR OXYGEN AT A COMET

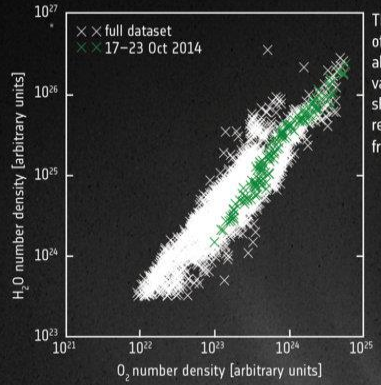
The measurements were made with the Rosetta Orbiter Spectrometer for Ion and Neutral Analysis Double-Focusing Mass Spectrometer (ROSINA-DFMS).



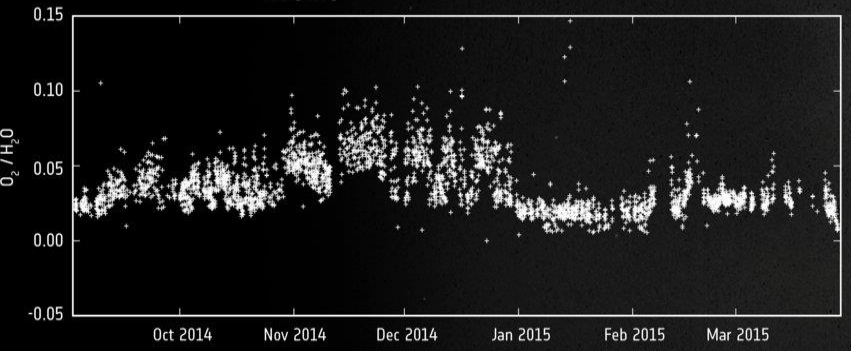
The results were collected between September 2014 and March 2015.



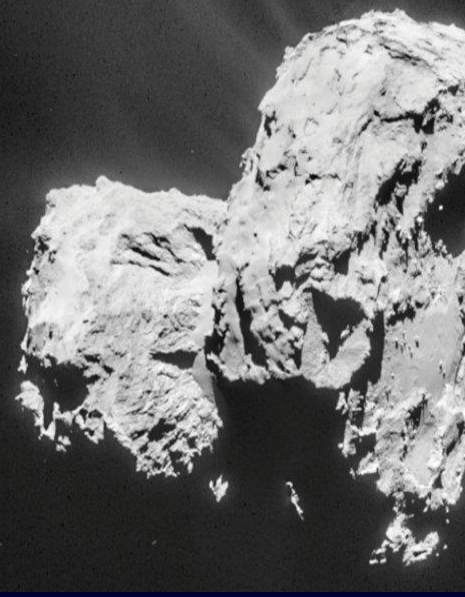
High-resolution measurements allowed molecular oxygen (O_2) to be distinguished from other species like sulphur (S) and methanol (CH_3OH). The detection of the coma gases is stronger closer to the comet nucleus, as expected. The contribution to the detection from contamination from the spacecraft thruster firings during manoeuvres is very low.



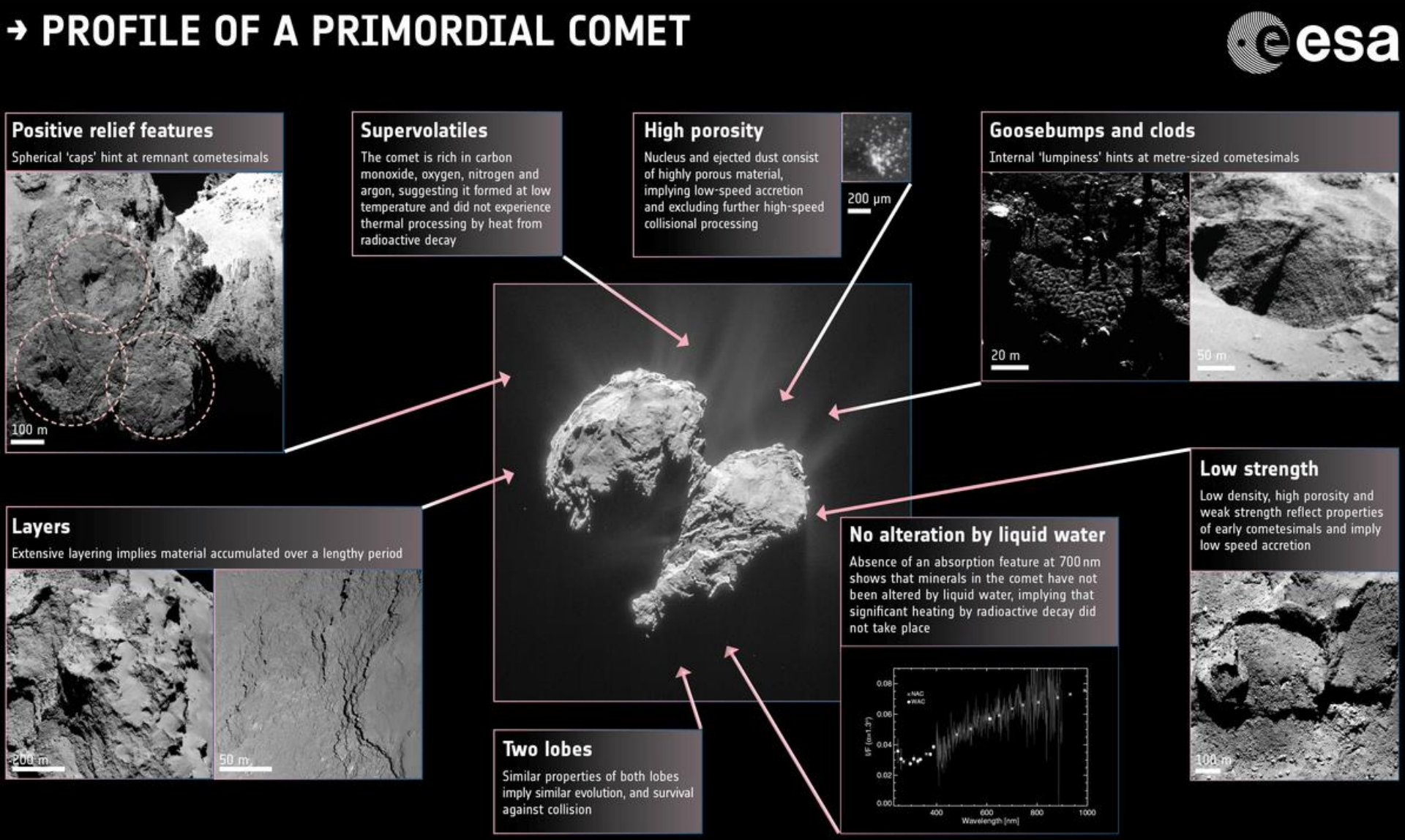
The strong correlation of molecular oxygen abundance with water vapour indicates a shared origin and release mechanism from the nucleus.

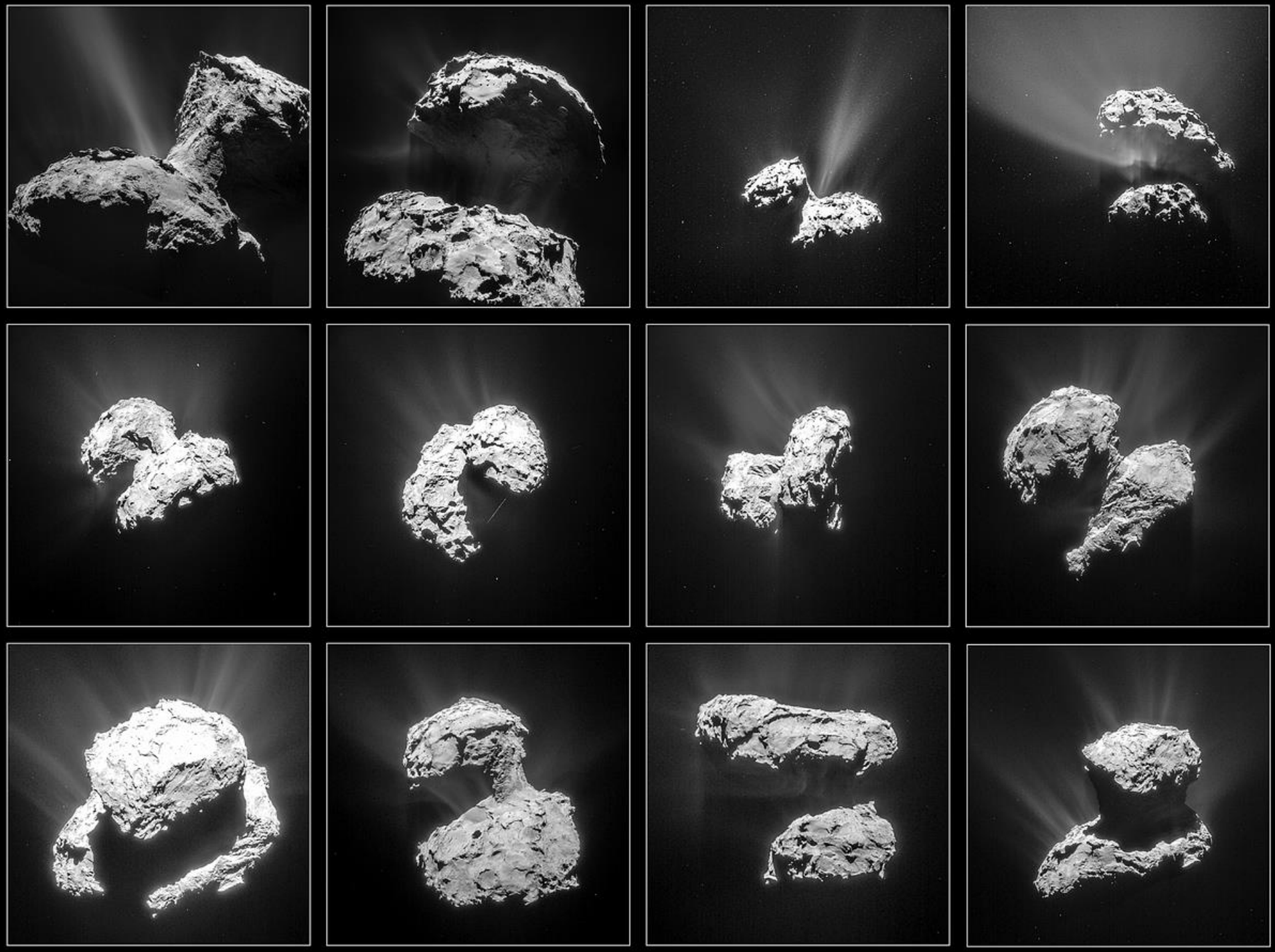


The O_2/H_2O ratio does not vary significantly over the study period. Short-lived strong variations are attributed to the decrease of the O_2 ratio for occasionally higher H_2O abundances linked to the daily water-ice cycle. The overall consistent level implies that O_2 is not produced today by solar wind or UV interaction with surface ices, otherwise it would rapidly decrease due to the comet´s increased activity. Instead, the O_2 must have been incorporated into the comet´s ices during its formation in the early Solar System, and is being released with the water vapour today.



67P je ozaj prvotný materiál , ktorý neprešiel formáciou



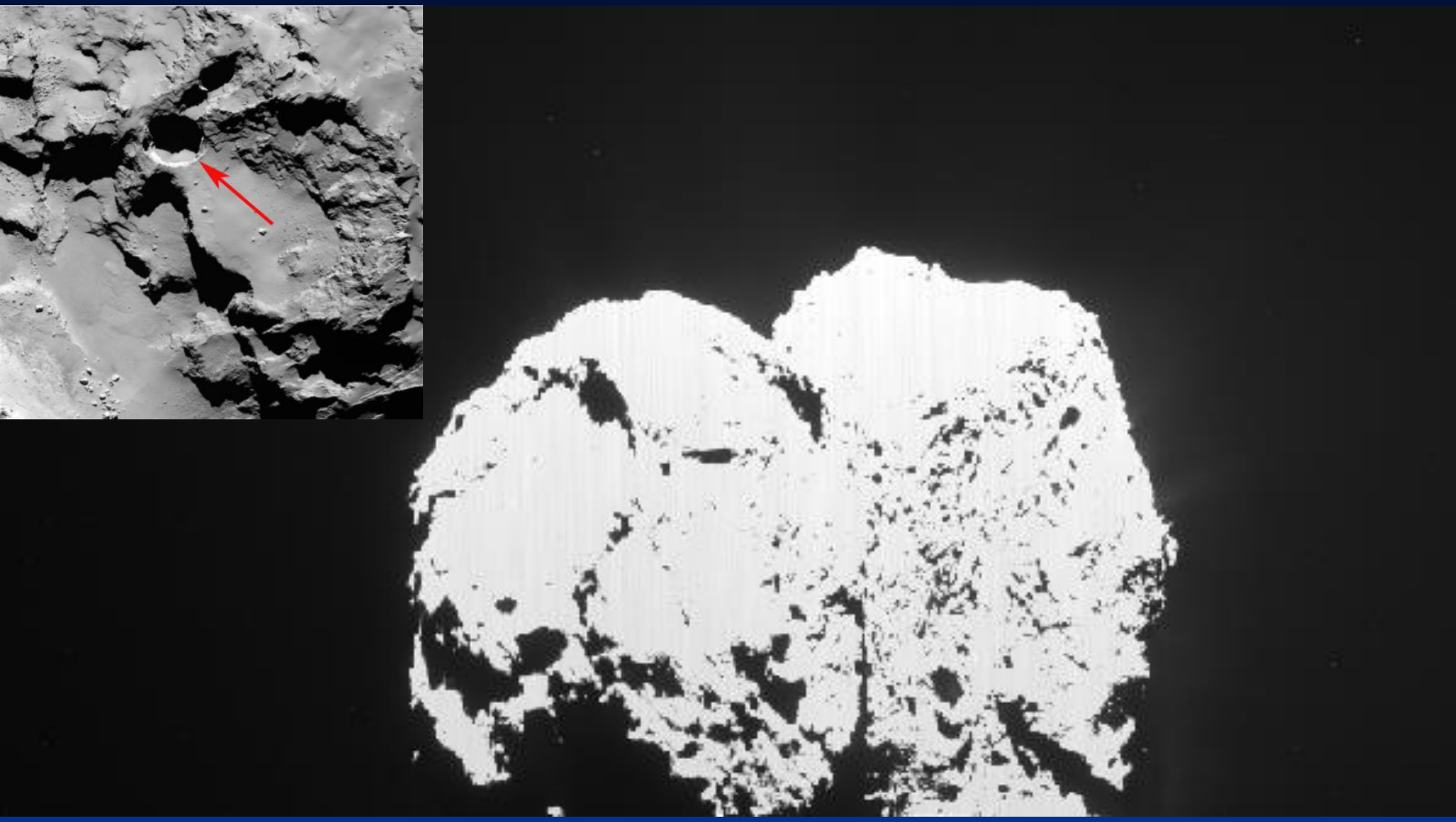


Prebúdzanie kométy...

67P v perihéliu (13. 8.2015)

Prachové prostredie v perihéliu (Osiris)

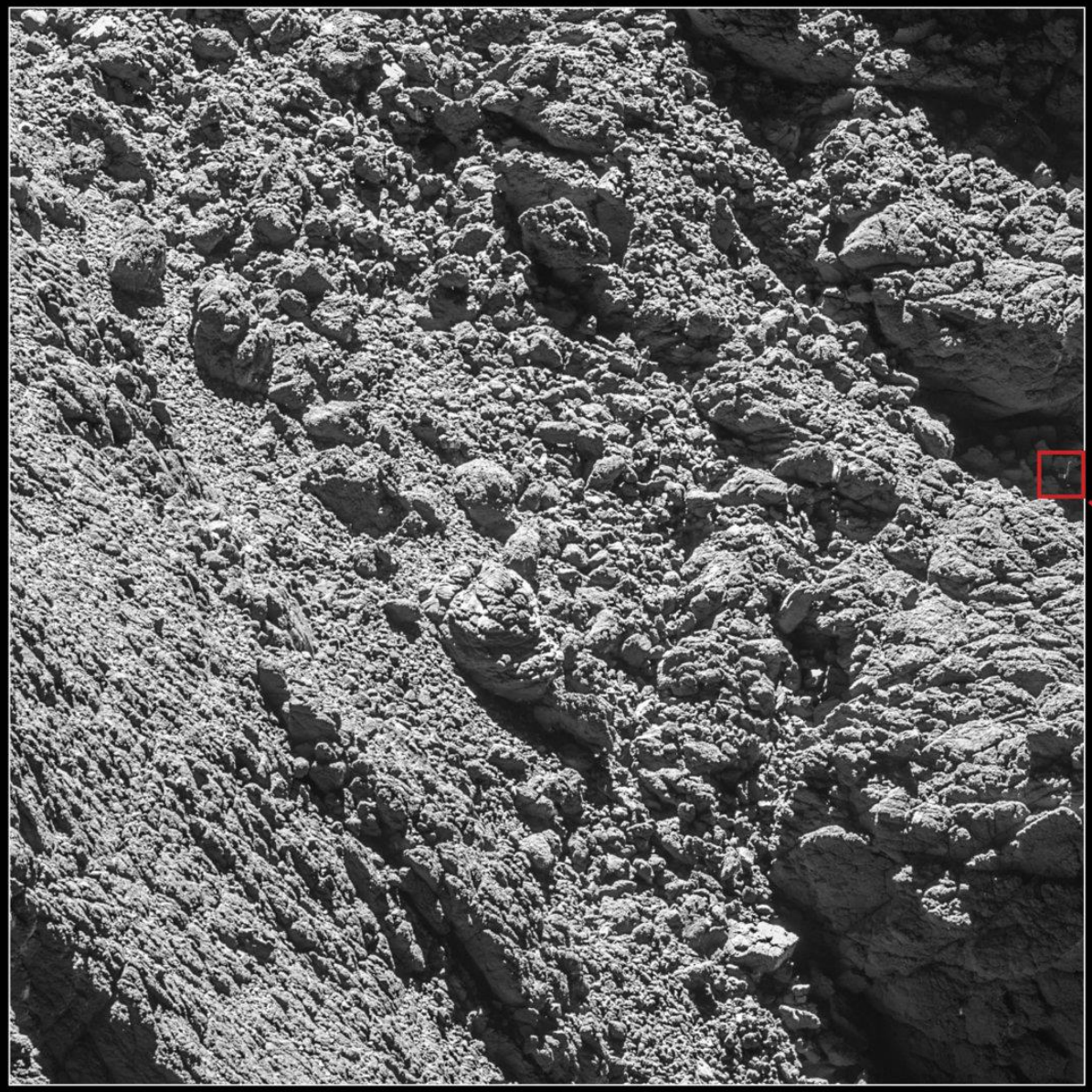
Náhle vzplanutie „outburst“ (19.2.2016)

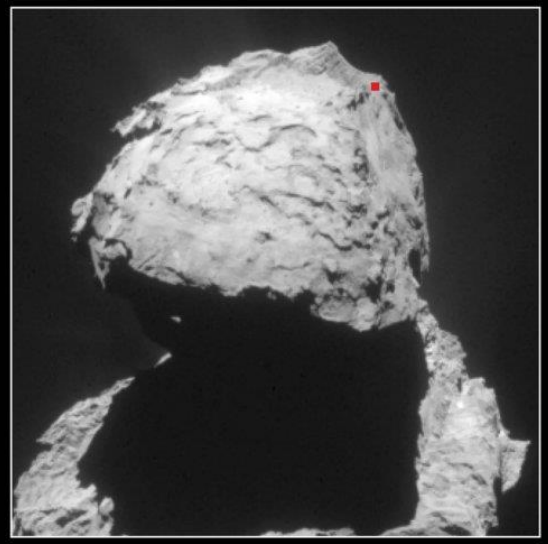


Pohľad na kométu z jej chvosta...(27. 3. 2016)

Philae nájdený !!! (5. 9. 2016)

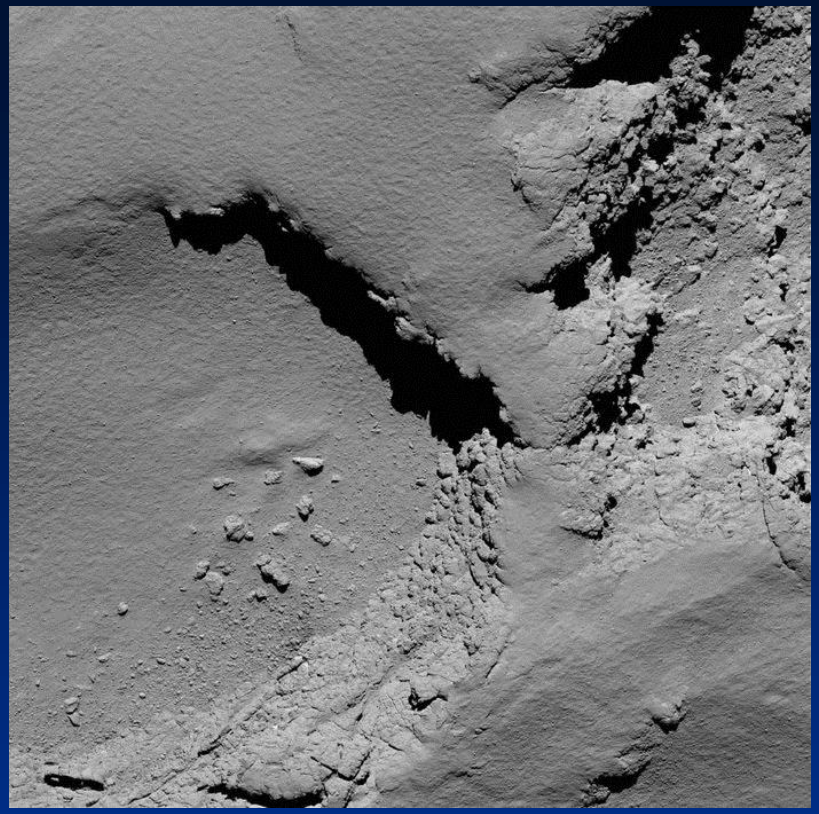
Abydos z výšky 2700 m

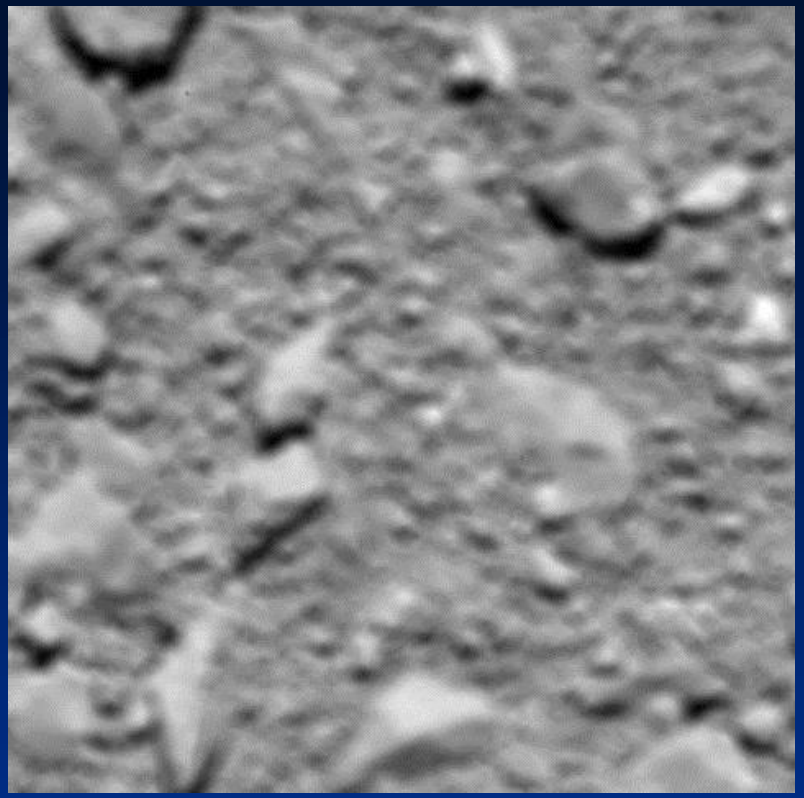




Rosetta “Grand finale” 30 septembra 2016

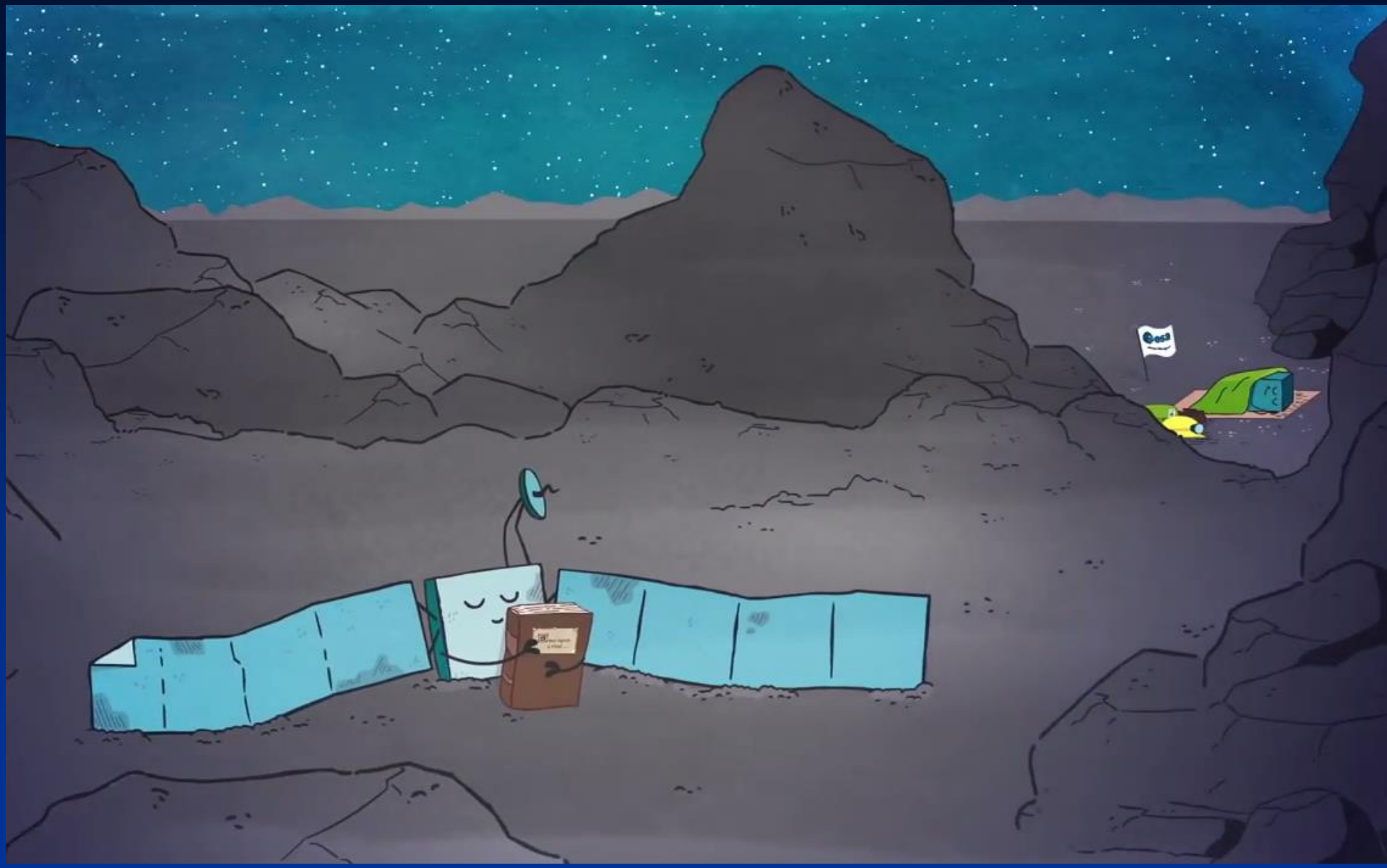
Posledné zábery 5700m 20m





Posledné rádiové signály

Rosetta a Philae – odpočívajte v pokoji



Nespočet vedeckých publikácií v prestížnych časopisoch... (doposiaľ, aj v budúcnosti)

This is only the beginning...

Report

67P/Churyumov-Gerasimenko, a Jupiter family comet with a high D/H ratio

K. Altwegg *et al.*

In situ mass spectrometry reveals a deuterium-to-hydrogen ratio three times that of Earth, which is suggestive of diverse origins for comets in this class.

Report

The organic-rich surface of comet 67P/Churyumov-Gerasimenko as seen by VIRTIS/Rosetta

F. Capaccioni *et al.*

The reflectance behavior of an illuminated comet is consistent with the presence of nonvolatile organics and sparse water ice.

Report

Time variability and heterogeneity in the coma of 67P/Churyumov-Gerasimenko

M. Hässig *et al.*

Mass spectrometry performed in situ shows a highly heterogeneous coma with large diurnal and possibly seasonal variations.

RELATED PODCAST

Report

Birth of a comet magnetosphere: A spring of water ions

H. Nilsson *et al.*

The interaction of the solar wind and a comet atmosphere is characterized through detection of the energetic ion environment.

Report

Subsurface properties and early activity of comet 67P/Churyumov-Gerasimenko

S. Gulkis *et al.*

Measurements at a comet yield water production rates and an assessment of low thermal inertia.

Research Article

On the nucleus structure and activity of comet 67P/Churyumov-Gerasimenko

H. Sierks *et al.*

A comet with an unusual shape has an array of surface features and high porosity, with early outgassing between its two lobes.

Research Article

The morphological diversity of comet 67P/Churyumov-Gerasimenko

N. Thomas *et al.*

Images with better than 1-meter-per-pixel resolution shows a comet's morphology with evidence for complex active processes.

Research Article

Dust measurements in the coma of comet 67P/Churyumov-Gerasimenko inbound to the Sun

A. Rotundi *et al.*

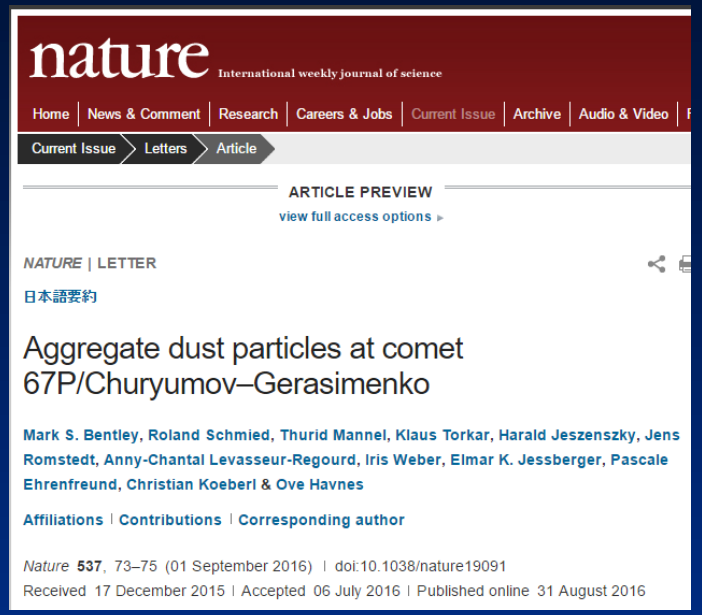
Observations of the dust outflow show bound and unbound grains and imply a comparatively high dust-to-gas ratio of 4.

Latest News

Close-ups of comet Churyumov-Gerasimenko/67P reveal an actively sculpted surface

E. Hand

Diversity of features points to a more complicated cometary birth.



The presence of clathrates in comet 67P/Churyumov-Gerasimenko

Article in Science Advances · April 2016

DOI: 10.1126/sciadv.1501781

Properties of the 67P/Churyumov-Gerasimenko interior revealed by CONSERT radar

Article in Science · July 2015

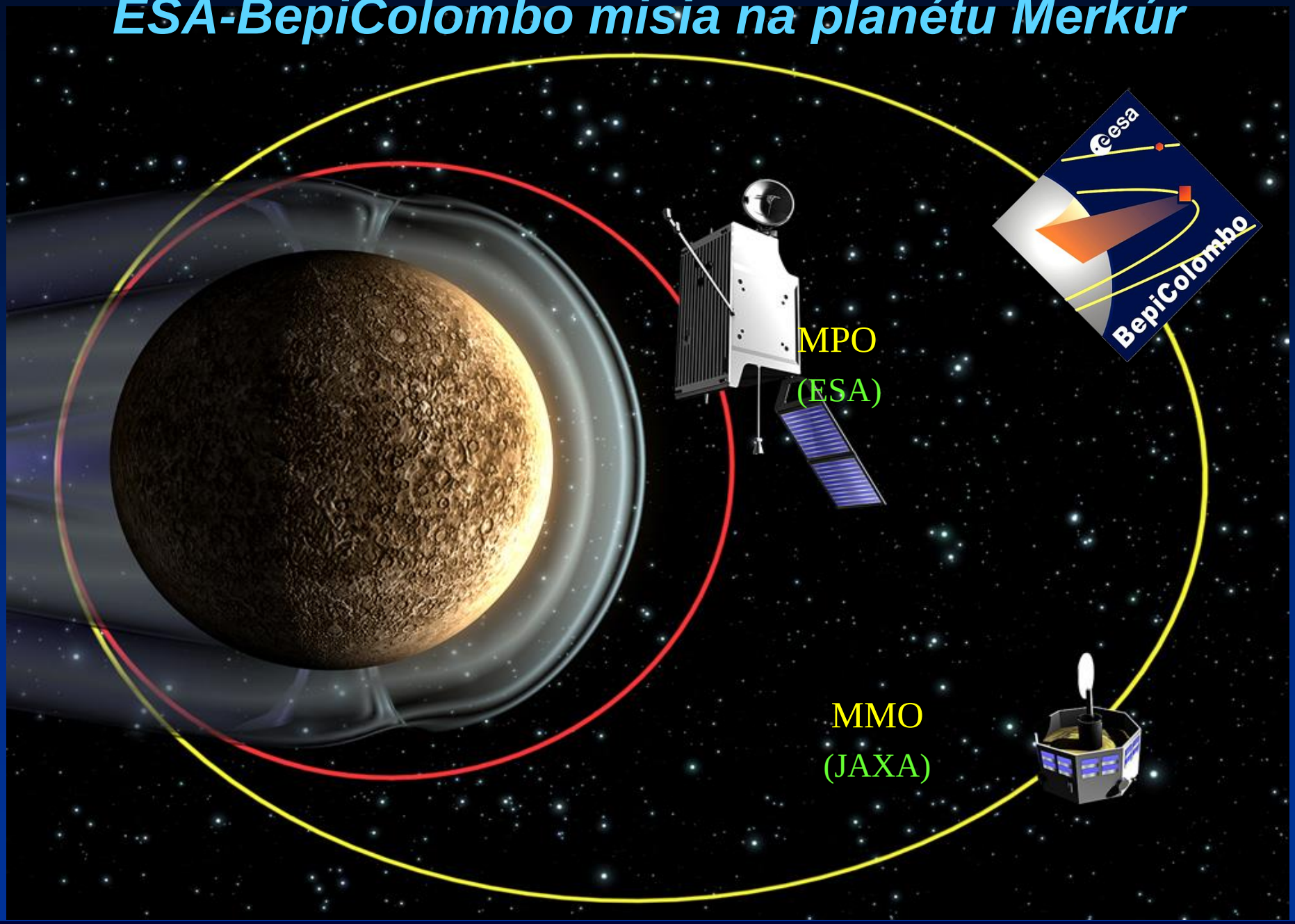
DOI: 10.1126/science.aab0639

Rosetta - záverom

- *ROSETTA sa ako prvá sonda v histórii stala spolu-pútnikom kométy a sledovala ju zblízka pri jej ceste okolo Slnka*

- *Prvýkrát v histórii dielo vytvorené človekom kontrolovane pristálo na kométe a analyzovalo vzorky jej materiálu.*

ESA-BepiColombo misia na planétu Merkúr

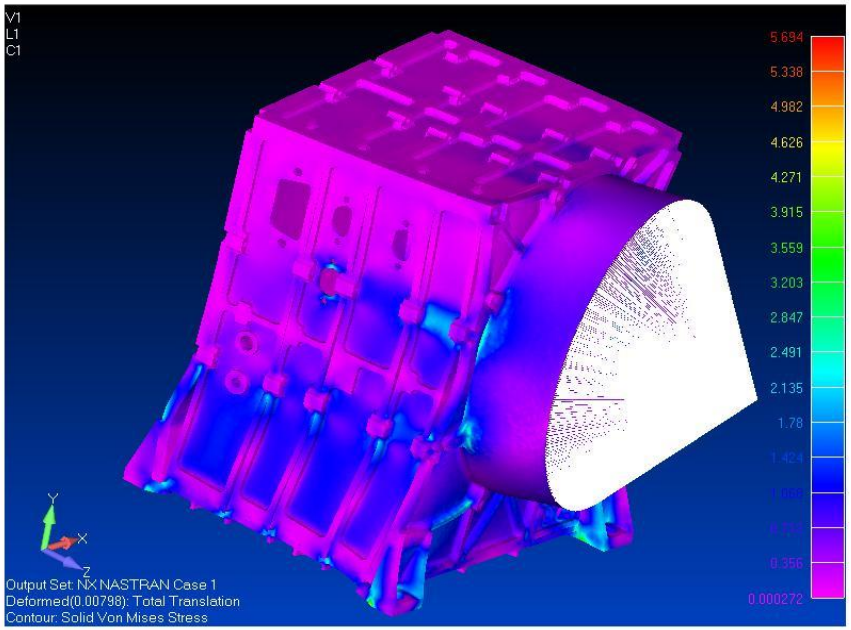


ESA-BepiColombo, Mission to Mercury

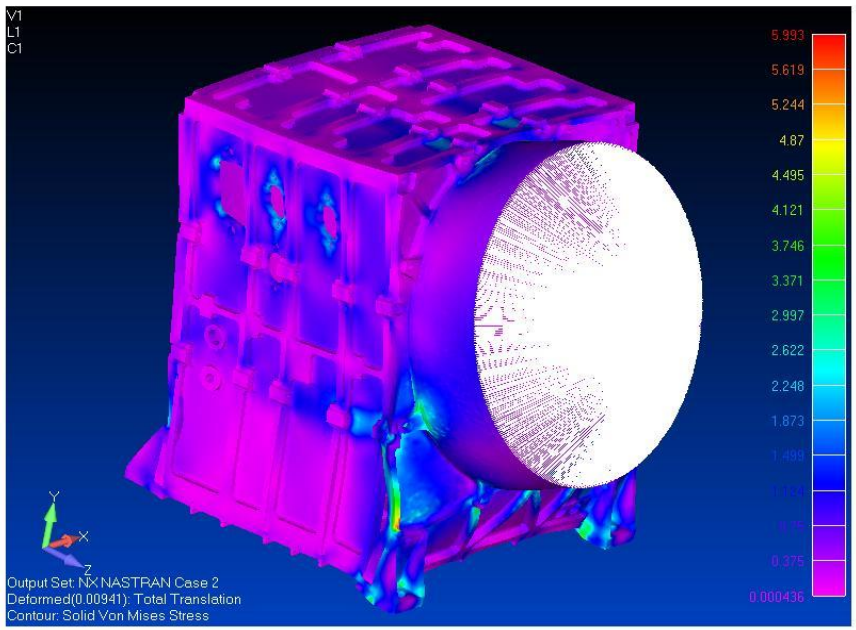
SERENA

PICAM (Planetary Ion CAMera)

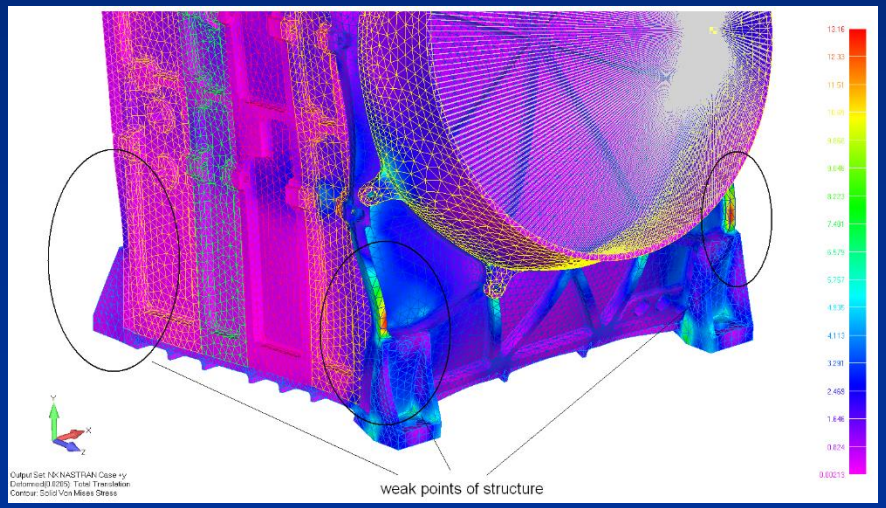
PICAM- Ebox pevnostné analýzy (FEA)

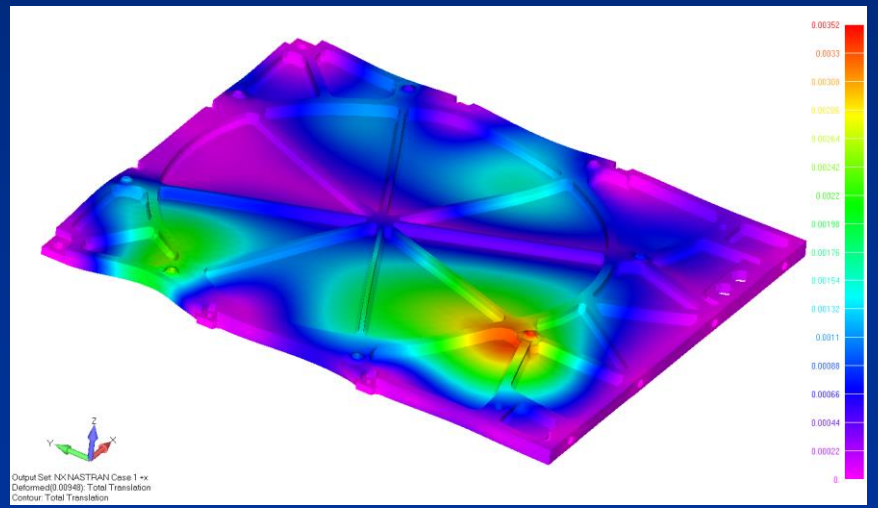


zatazenie do strany +X

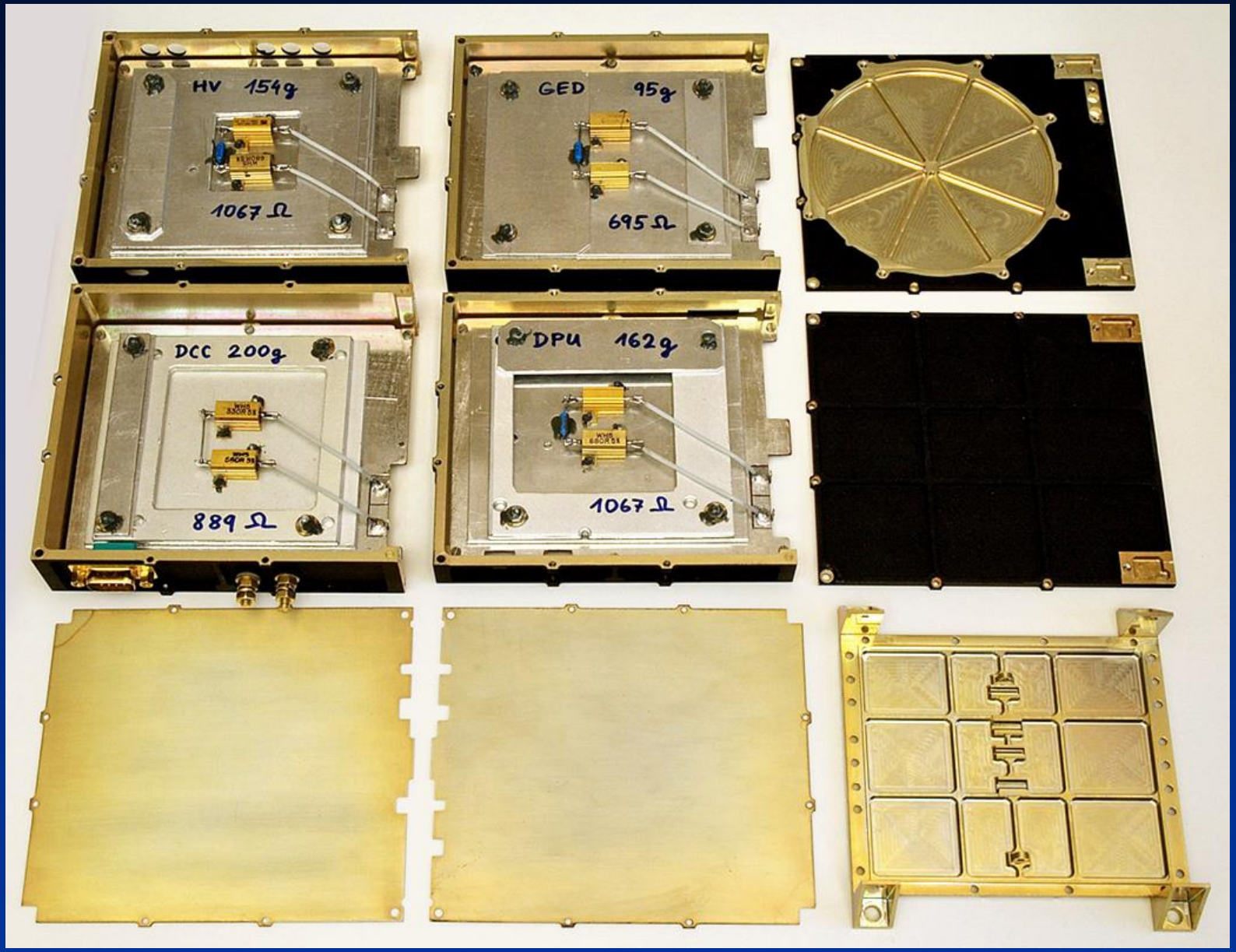


zatazenie hore +Y

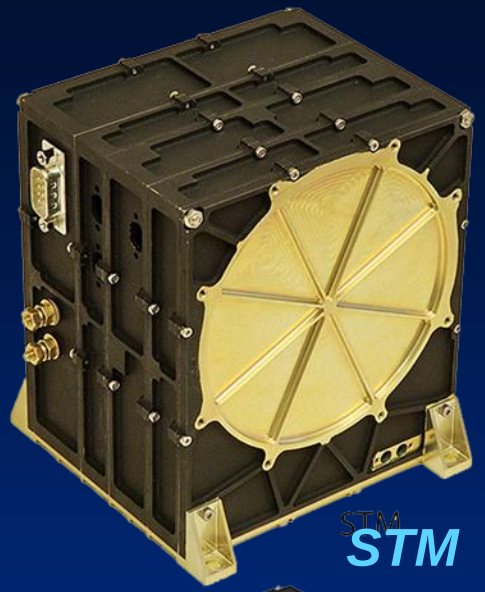




PICAM - STM (Structural Thermal Model)



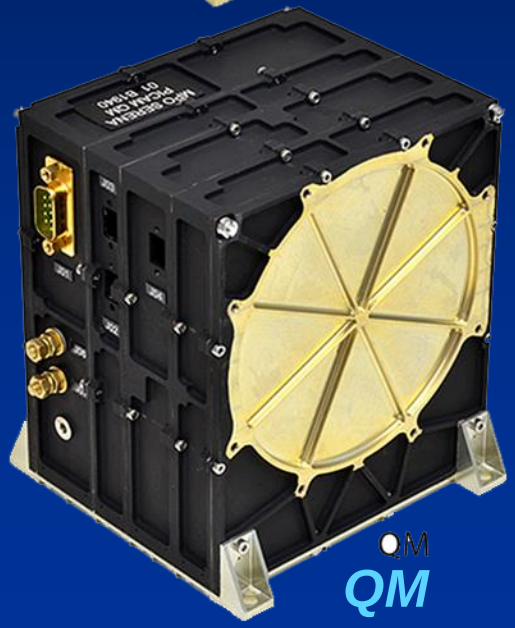
PICAM- Ebox (Made in Slovakia)



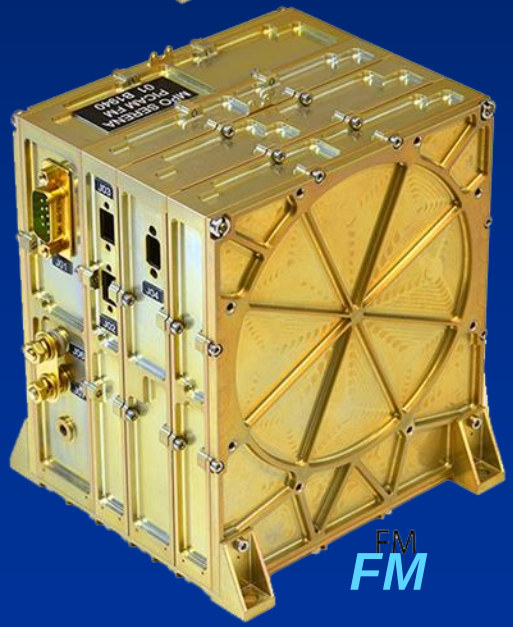
STM

PM

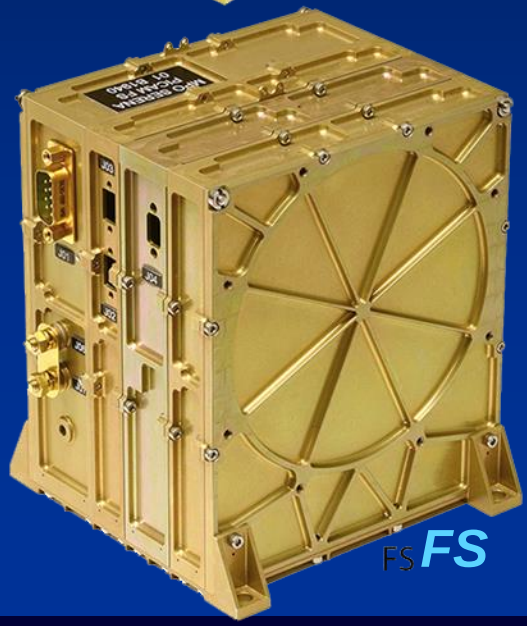
EM



QM



FM



FS

BepiColombo štart 20.10.2018

ESA - JUICE (JUpiter ICy moons Explorer)

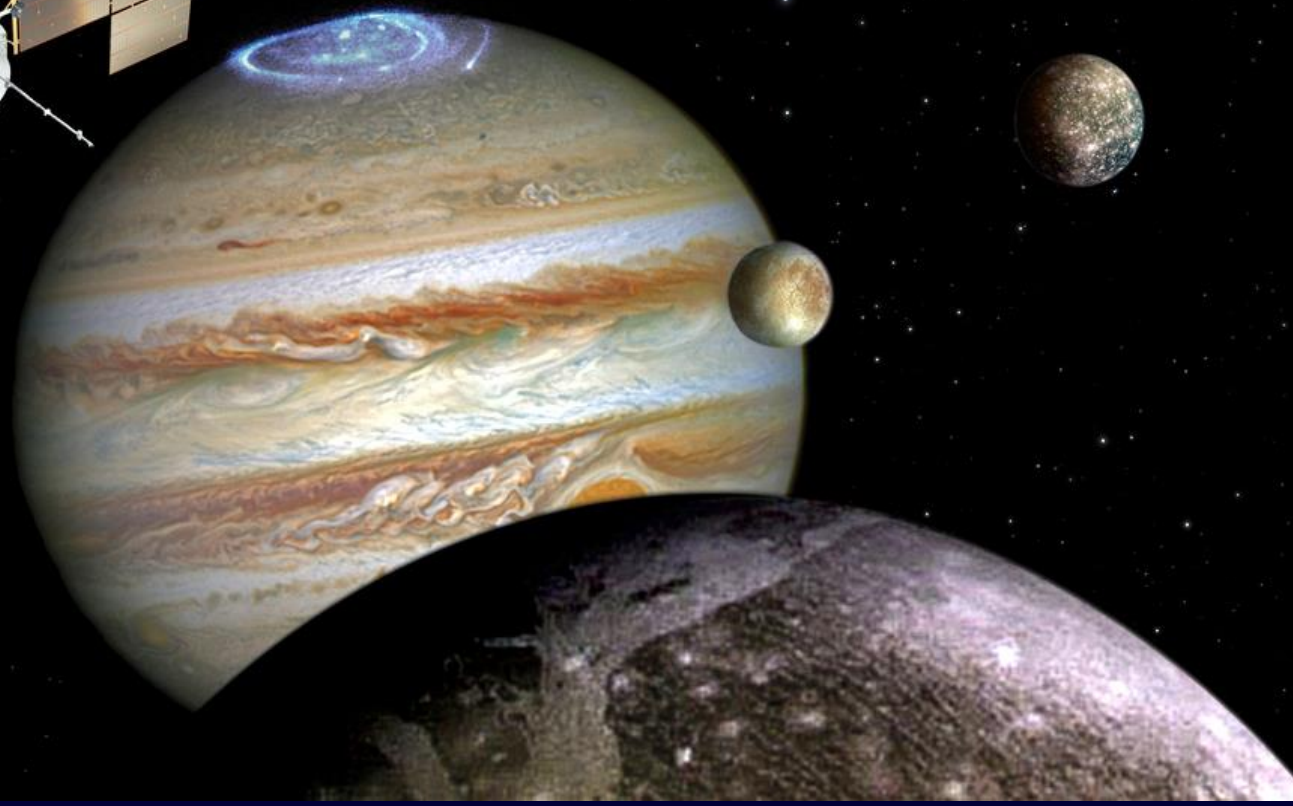
2022 – 2030 - 2032

esa

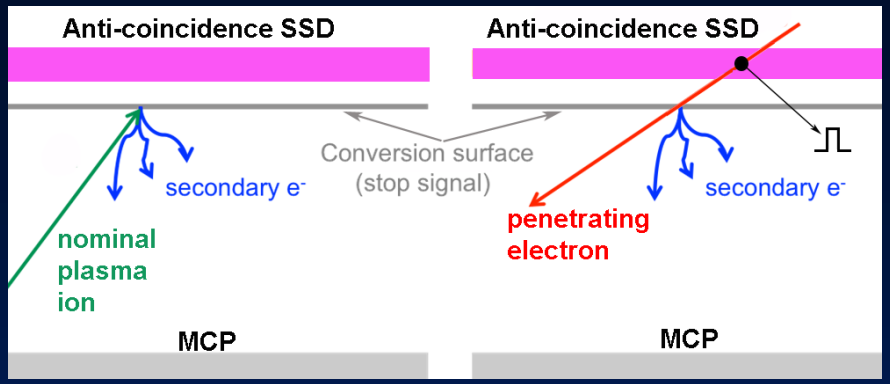
IRF

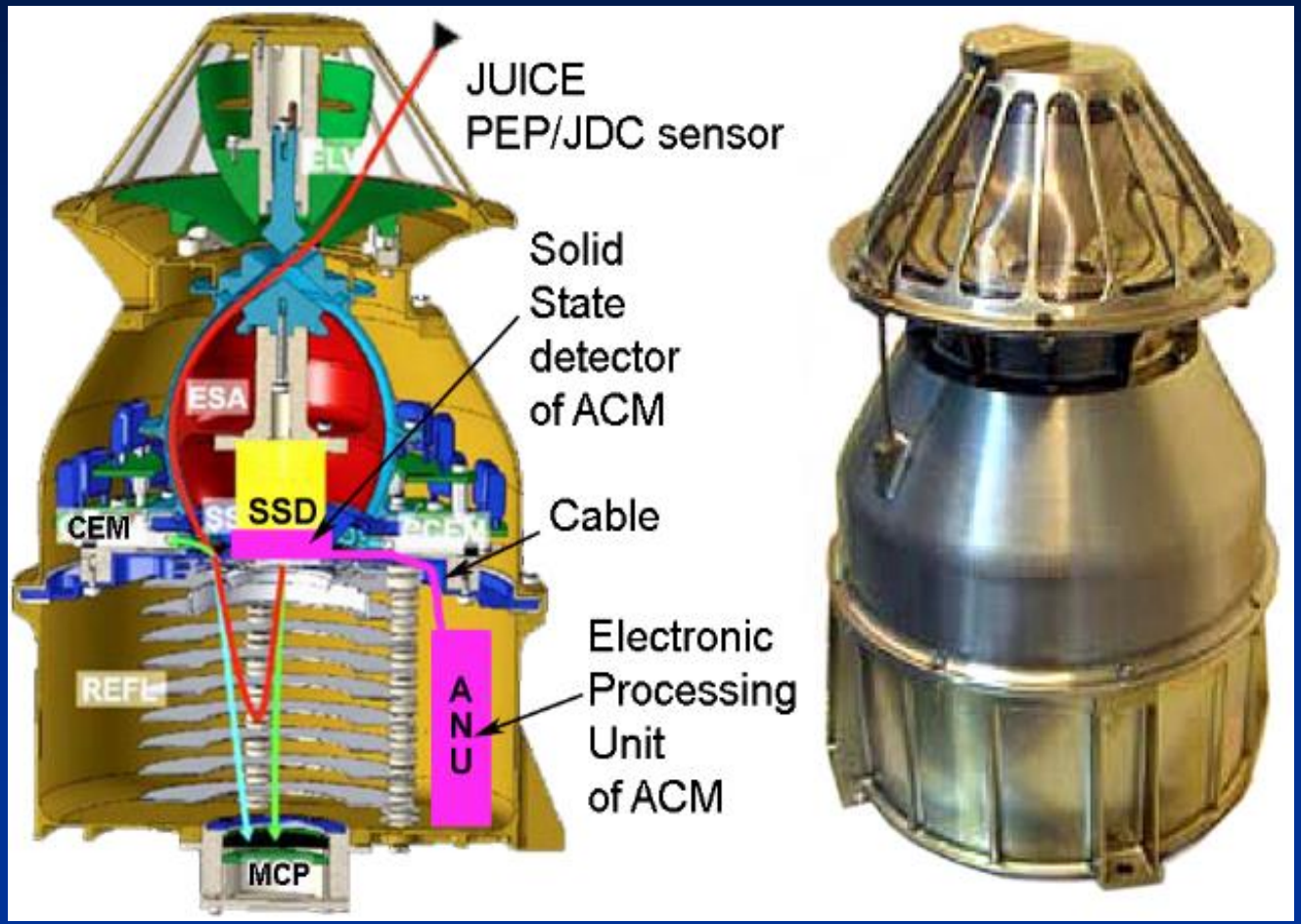
***PEP** (Plasma Environment Package)*

***JDC** (Jovian plasma Dynamics and Composition)*

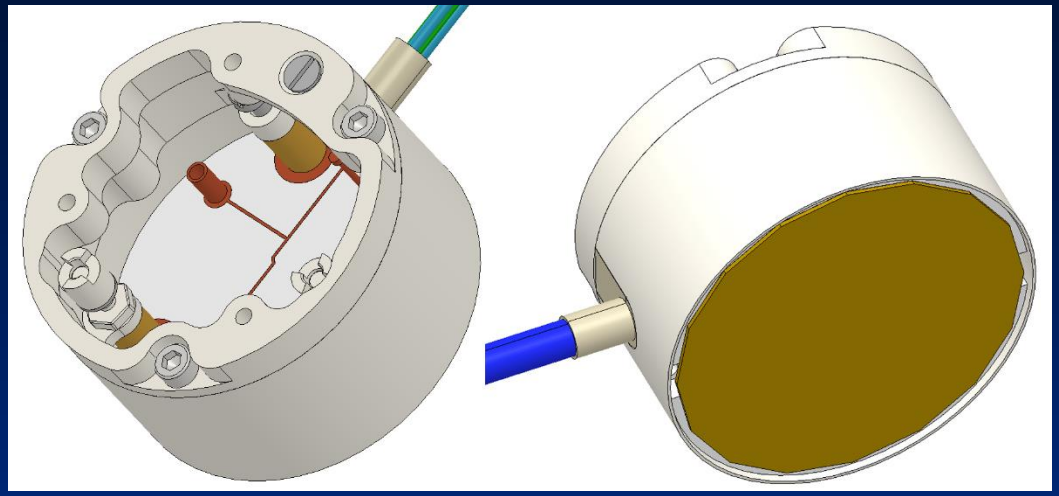


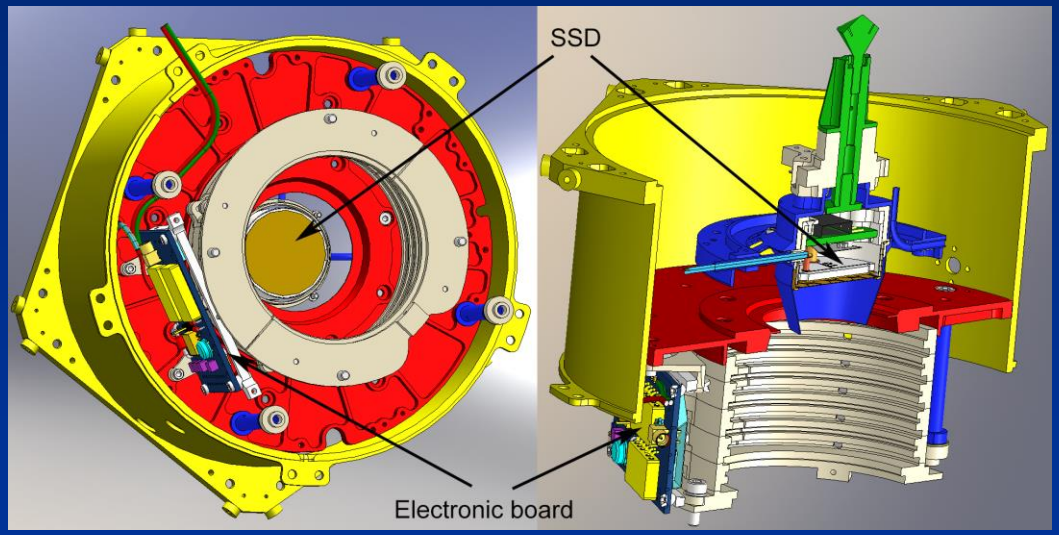
Anti-koincidenčný modul ACM pre PEP-JDC

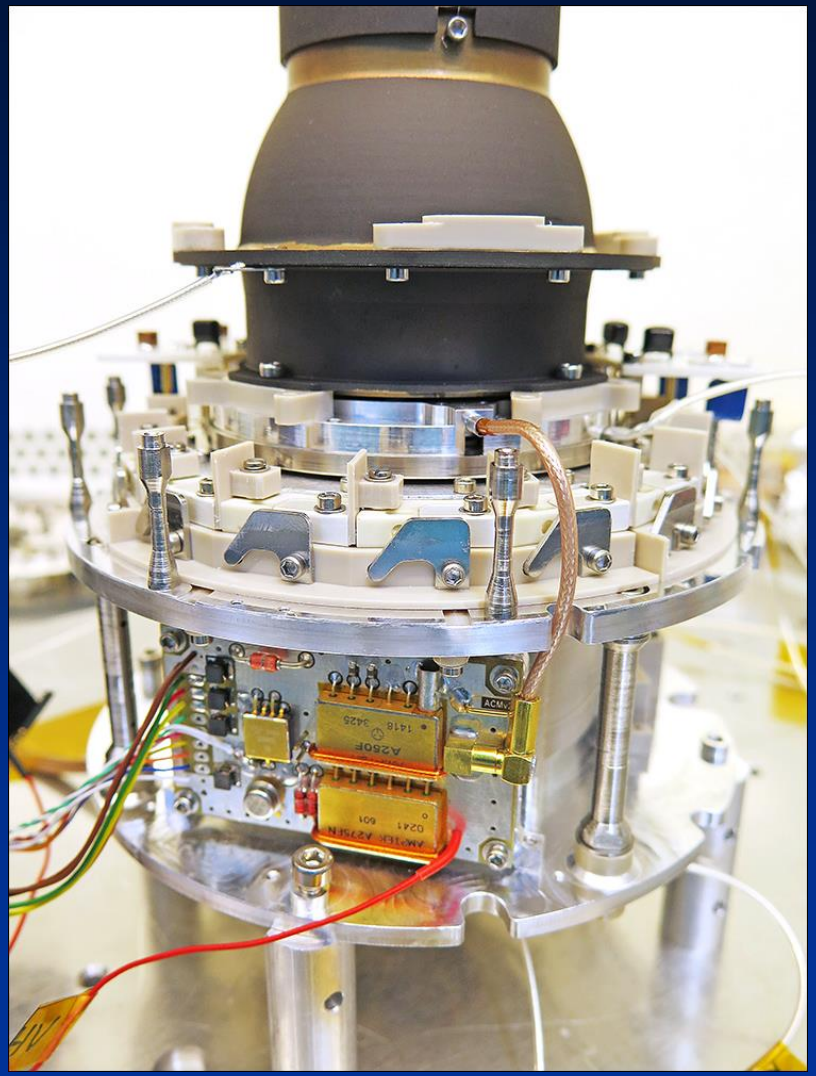




Anti-koincidenčný modul ACM pre PEP-JDC








Ďakujem za pozornosť!