

“Laboratorio di Astrofisica Spaziale”

Analisi dell'ambiente spaziale: studio del Sole, dell'atmosfera terrestre e della loro interazione; astrodinamica con studio particolareggiato delle orbite e delle caratteristiche di una missione spaziale (propulsione, trasmissione dati, ...)

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348 3804692

Sommario

- Corso:
 - Programma, orario, materiale, esami, disponibilita'
- Motivazioni & Storia
- Astrofisica
- Astronomia
- Fisica della Terra
- Programmi Commerciali
- Programmi Educativi
- Conclusioni

Programma del Corso 1/2

1. INTRODUZIONE ALLA FISICA SPAZIALE

- Scopi dell'esplorazione spaziale
- Storia dell'esplorazione dello spazio

2. IL SOLE E L'AMBIENTE CIRCOSTANTE LA TERRA

- Il Sole
- L'atmosfera
- La ionosfera
- La magnetosfera
- Le fasce di radiazione di Van Allen

3. INTRODUZIONE ALL'ASTRODINAMICA

- Orbite kepleriane
- Generalità sulle orbite
- Cambiamenti d'orbita
- Scelta dell'orbita per un satellite astronomico

Programma del Corso 2/2

4. GEOMETRIA DI UNA MISSIONE SPAZIALE

- Geometria sulla sfera celeste

5. PROPULSIONE E POTENZA NELLO SPAZIO

- Caratteristiche dei motori per razzi
- Sistemi di propulsione
- Sistemi di potenza

6. SISTEMI D'ASSETTO

- Guida e controllo d'assetto
- Sensori d'assetto

7. ULTERIORI SISTEMI DI UN SATELLITE

- Sistema termico di un satellite
- Struttura di un satellite
- Telecomunicazioni di un satellite

8. LABORATORIO CON ARDUINI

Orario & materiale

➤ Mattino:

- Lunedì 14-18 Ed. A Centrale – Aula D
- Martedì 14-18 Ed. F - Aula B

➤ Pomeriggio:

- Venerdì 9-11 Ed. A Centrale – Aula D

➤ Materiale

- Dispense (Italiano)
- Tutto su “Moodle” <https://moodle2.units.it/>
- Libro di riferimento: “Space Mission Analysis and Design” (SMAD), J.R. Wertz and W.J. Larson, 3rd edition, Space Technology Library (in biblioteca)

Esame & disponibilità

➤ Esame:

- Seminario di 20 minuti con un approfondimento di un argomento a piacere (consiglio: venite a parlarne prima)
- Due o tre domande sul programma
- Avvisare almeno una settimana prima

➤ Disponibilità:

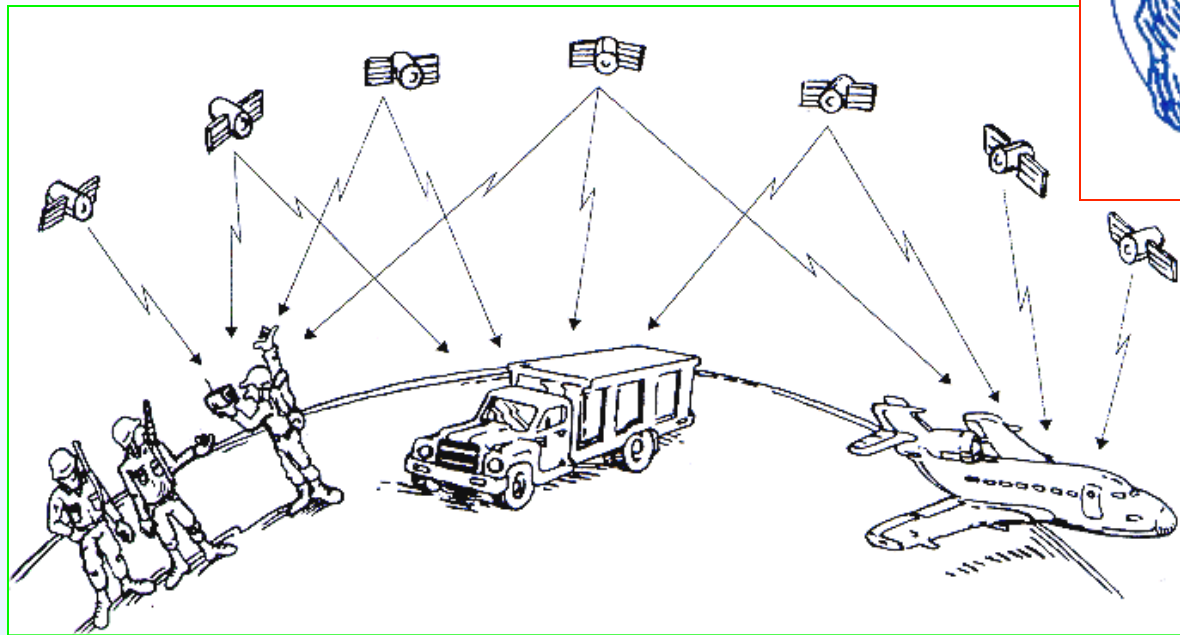
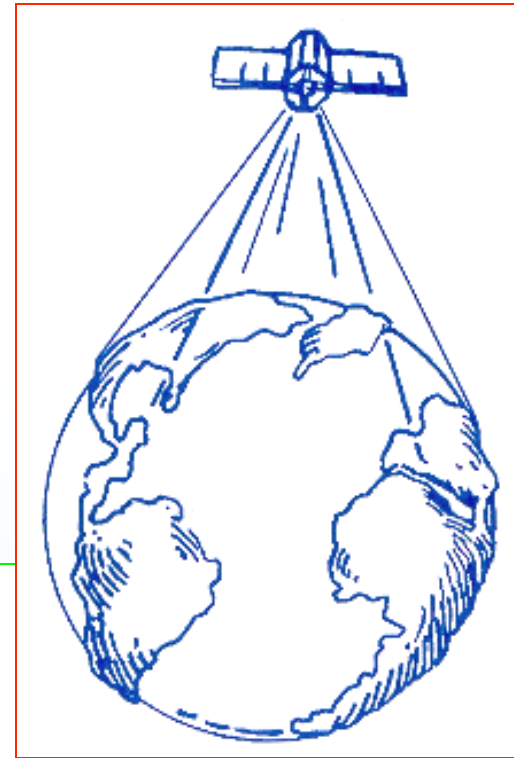
- E.mail o telefono, ~~ricevimento all'Università (mer. 9-10)~~
- Richiesta: lista e-mail e un cellulare di (almeno) una persona di riferimento

➤ Altro:

- PC a disposizione? E.mail & mac-address

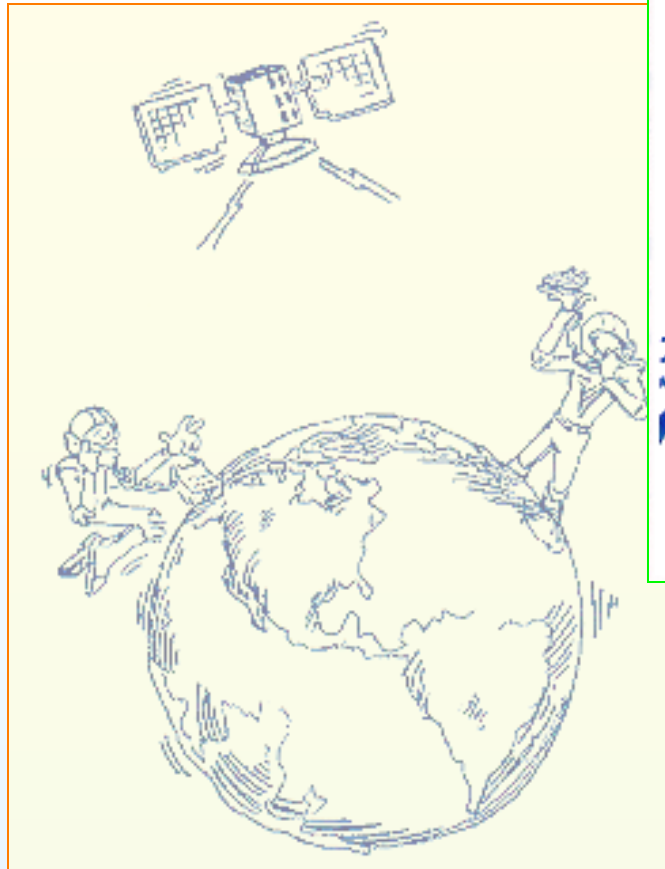
Motivazioni 1/2

- Osservazioni della Terra
- Comunicazioni
- Navigazione



Motivazioni 2/2

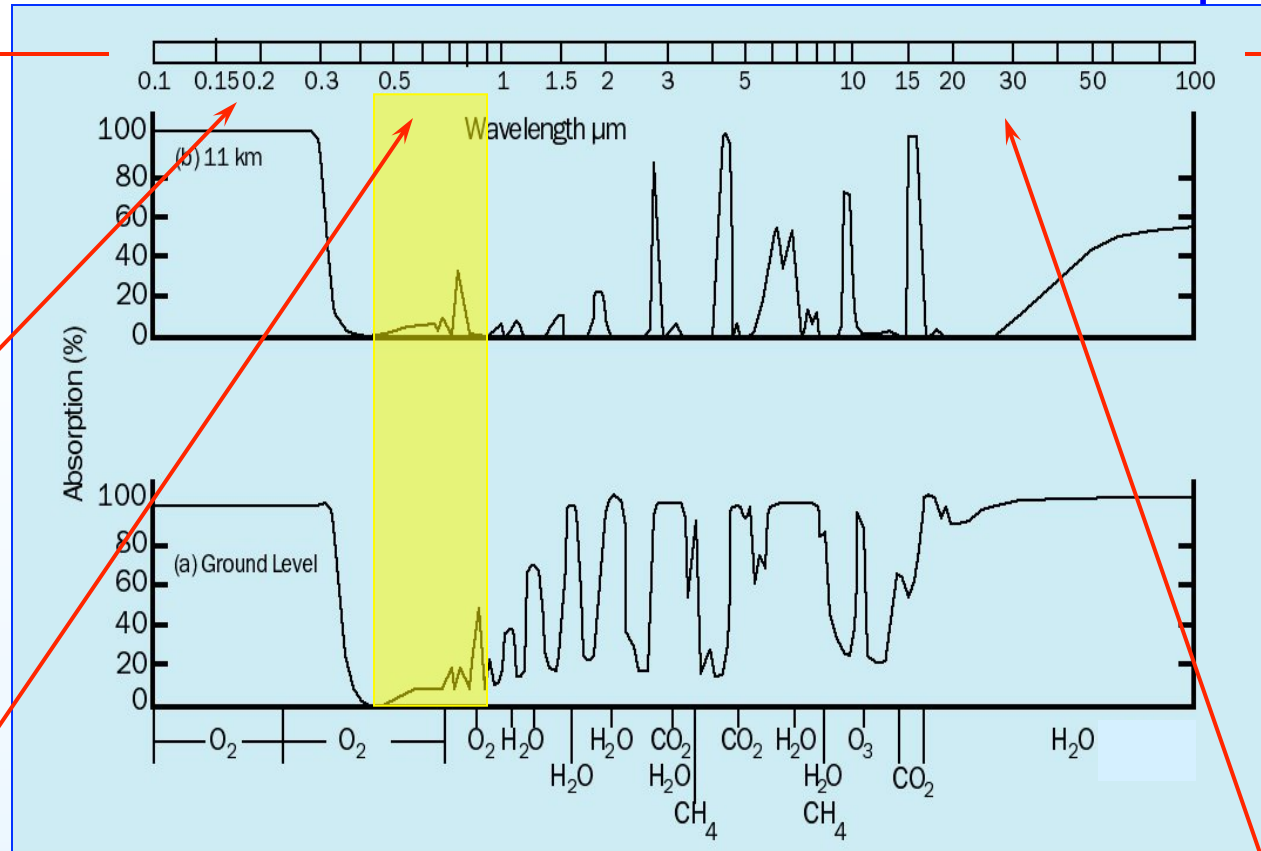
- Scienza
- Esplorazione



Atmosfera

Raggi X / γ : gas intergalattico,
dischi accrescimento

Microonde / Onde Corte:
fondo radiazione cosmica,
elettroni in campi magnetici



UV: stelle
calde

Visibile: stelle fredde

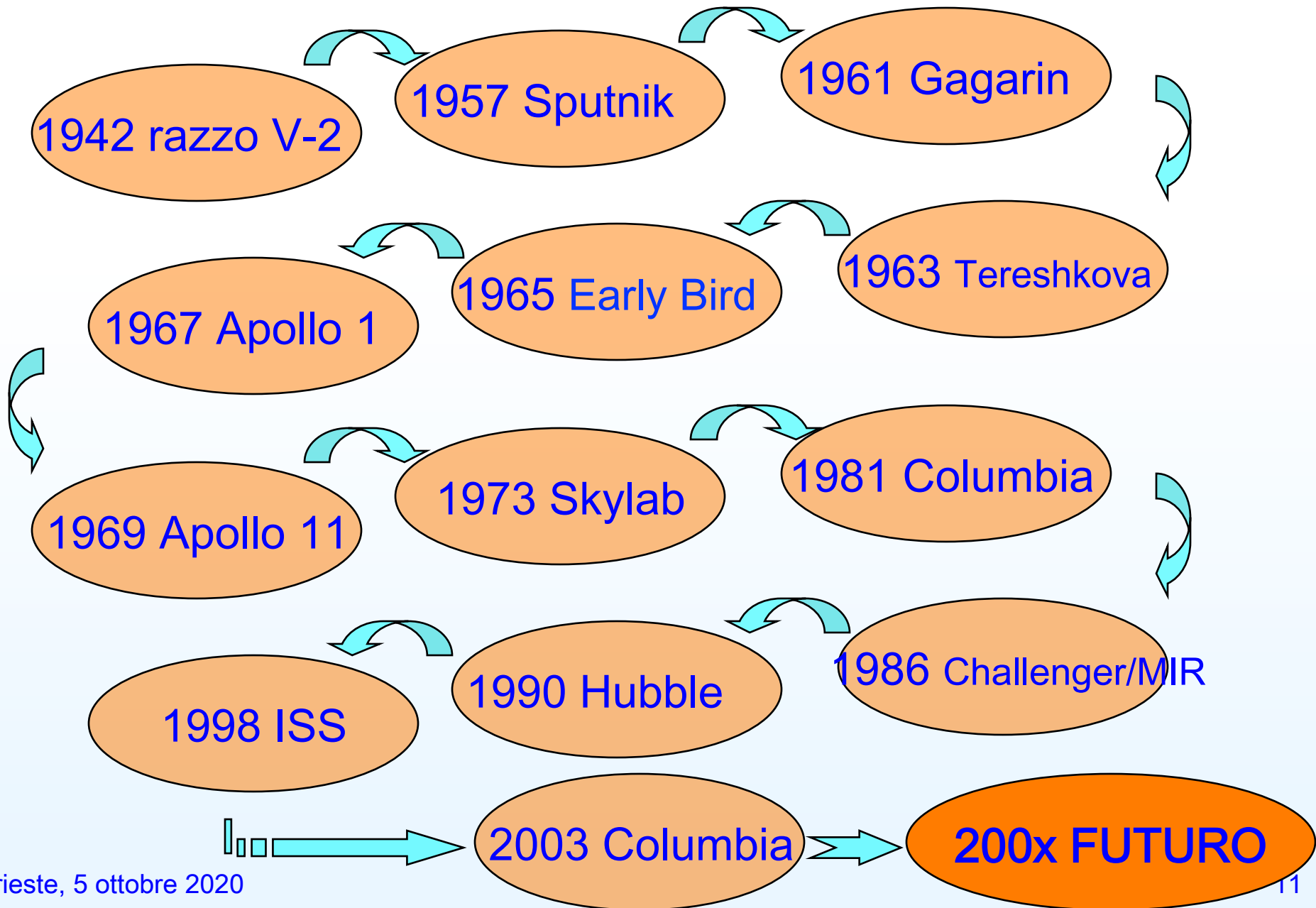
IR: polveri cosmiche, comete

Storia 1

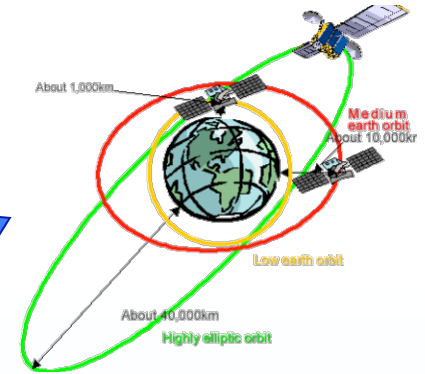


YouTube “Escape Velocity - A Quick History of Space Exploration”

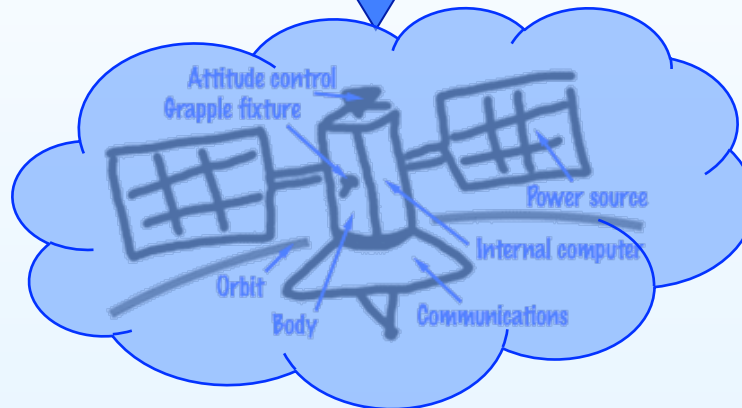
Storia 2



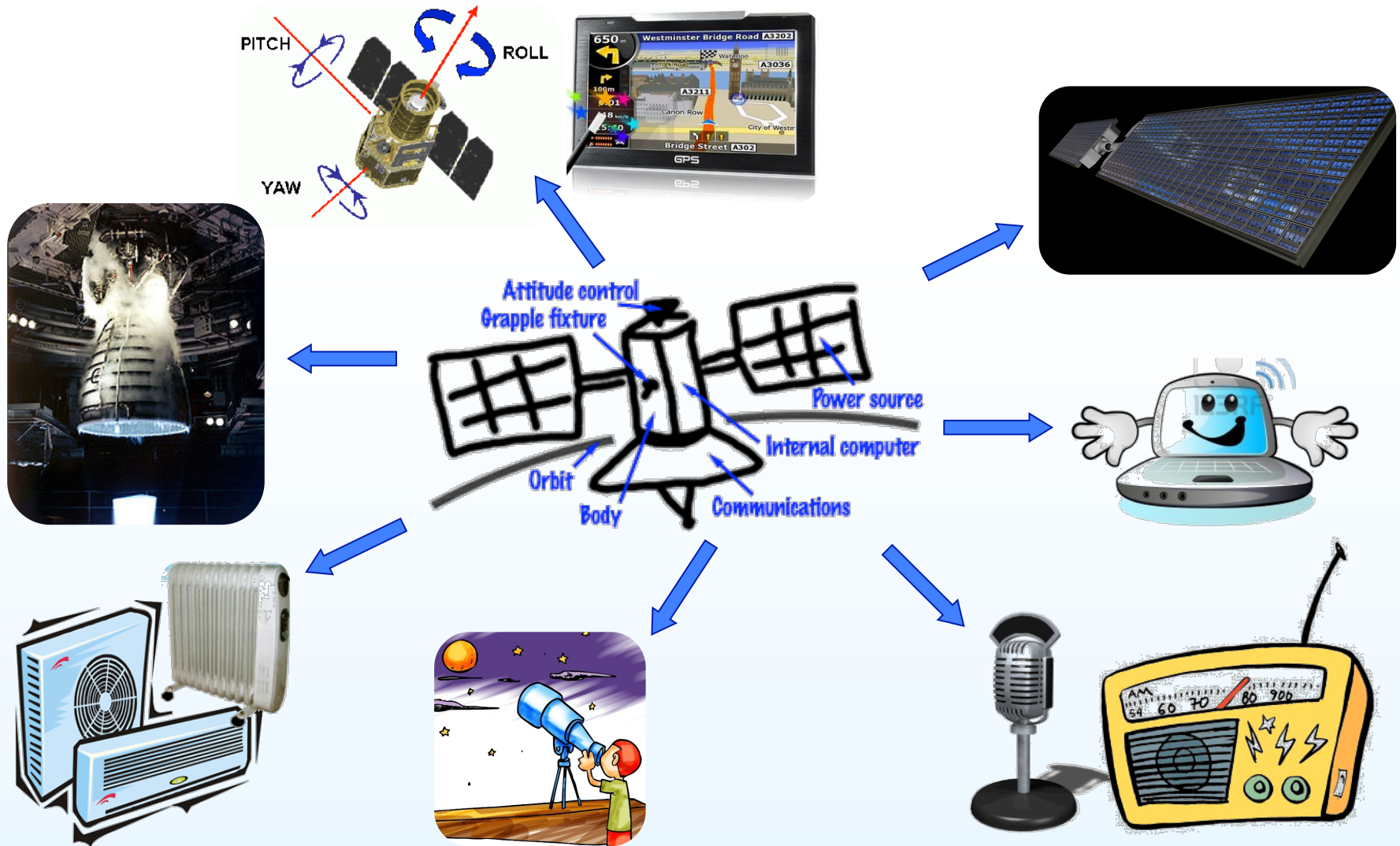
Una Missione Satellitare



© Alex Bannykh * www.ClipartOf.com/73729

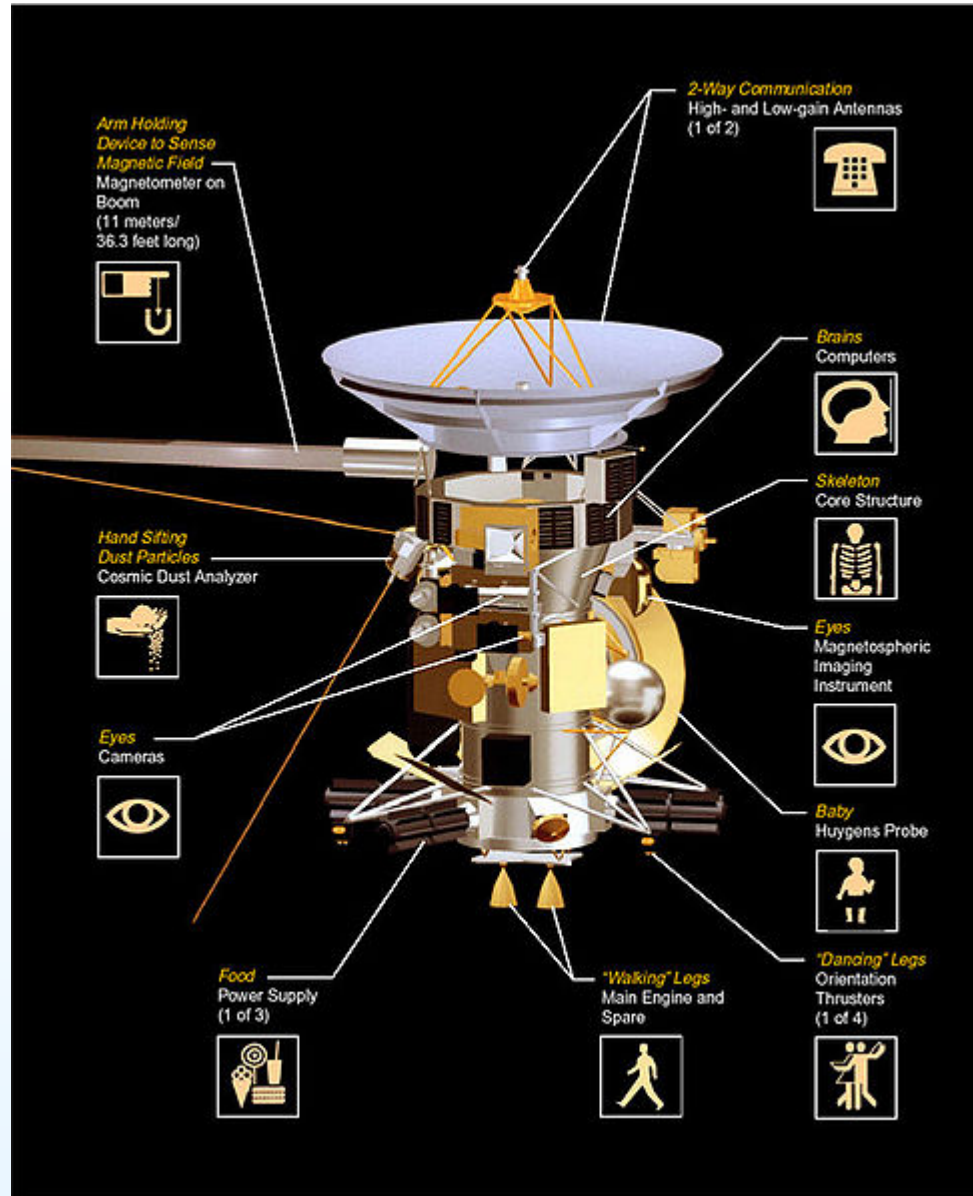


I Sistemi di un Satellite 1/3



I Sistemi di un Satellite 2/2

Cassini – Huygens



Difficoltà Tecniche 1/2

- Condizioni ostili ambiente spaziale:
 - o escursioni termiche
 - o vuoto
 - o dosi di radiazione cosmica
 - o particelle e frammenti
- Problematiche al lancio (vibrazioni)
- Strumentazione di dimensioni, massa e consumi ridotti

Difficoltà Tecniche 2/2

Radiazione nello Spazio (esempio)

Componenti Primarie

- Raggi Cosmici – particelle provenienti dallo spazio profondo
- Particelle Solari – particelle provenienti dal Sole
- Cinture di Radiazione – cinture di particelle energetiche che circondano la Terra

Componenti Secondarie

- Sciame Elettromagnetico – raggi cosmici nell'atmosfera
- Bremsstrahlung – elettroni attraverso un materiale/atmosfera
- Scintillazione (fluorescenza) – particelle attraverso l'azoto atmosferico o componenti ottiche
- Radiazione Cherenkov – flash prodotti da particelle ad alta velocità attraverso materiali

Strategia

Navette Spaziali (Shuttle)

- tempo in orbita breve
- recupero della strumentazione

Satelliti

- tempo in orbita lungo
- impossibilità di recupero della strumentazione

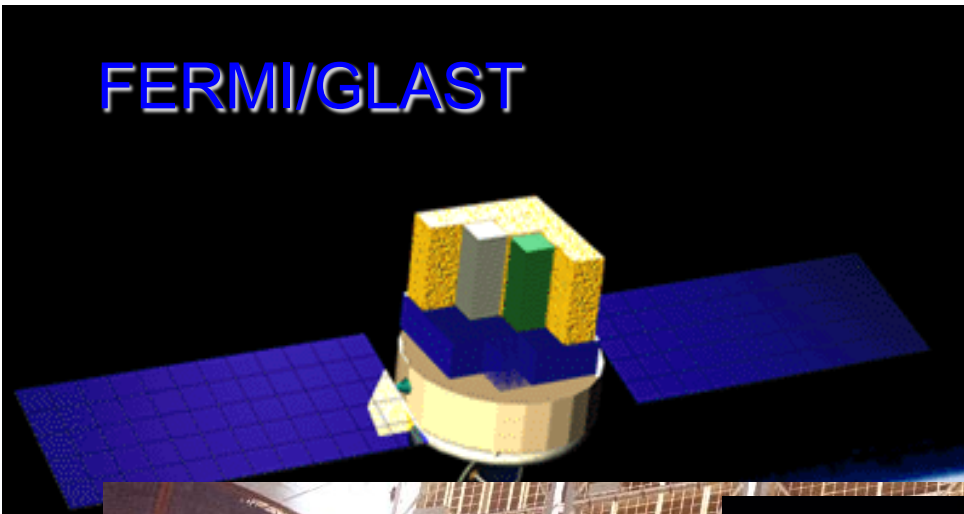
Stazione Spaziale Internazionale (ISS)

- tempo in orbita lungo
- recupero della strumentazione



Astrofisica: XMM - GLAST – AMS

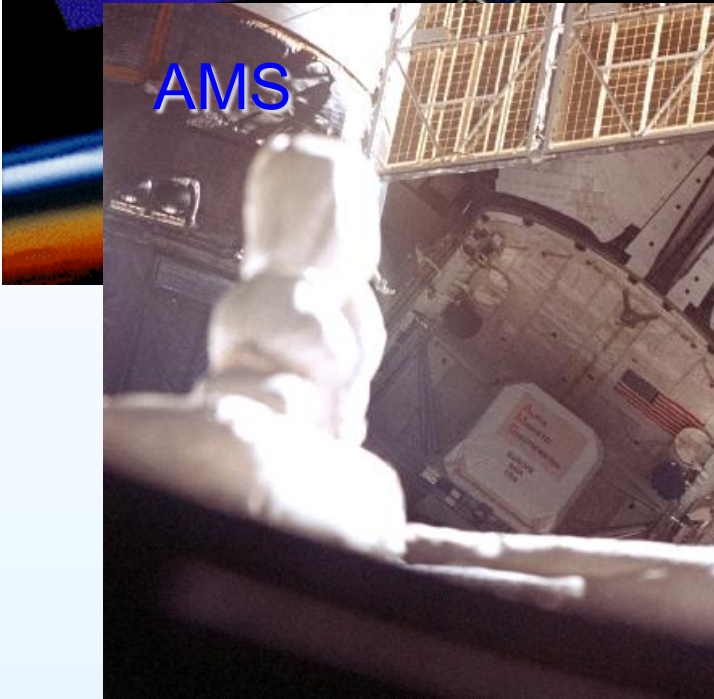
FERMI/GLAST



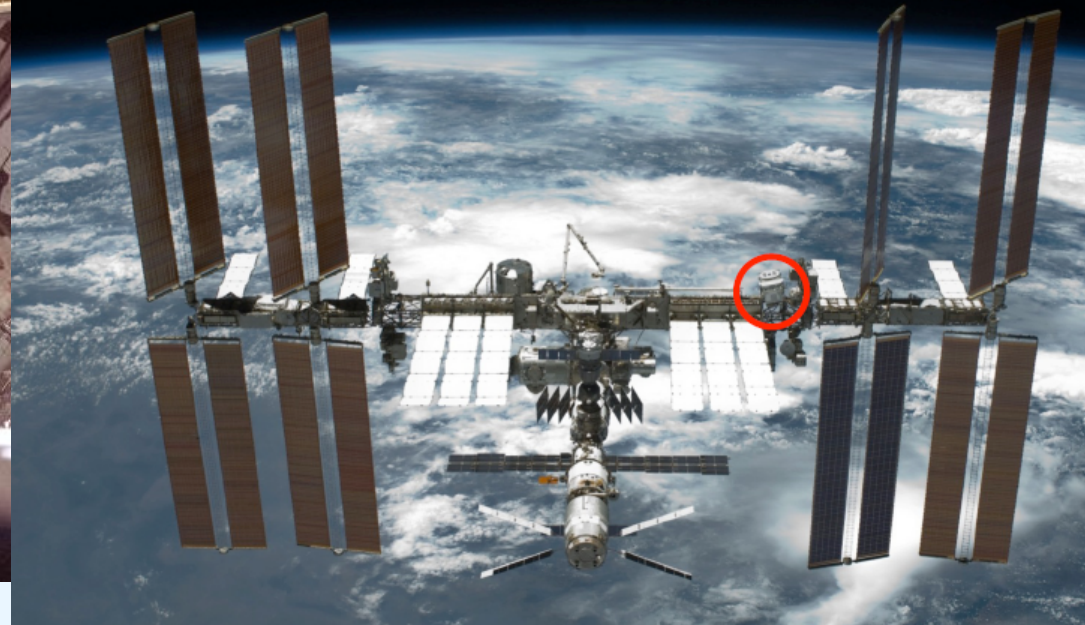
XMM



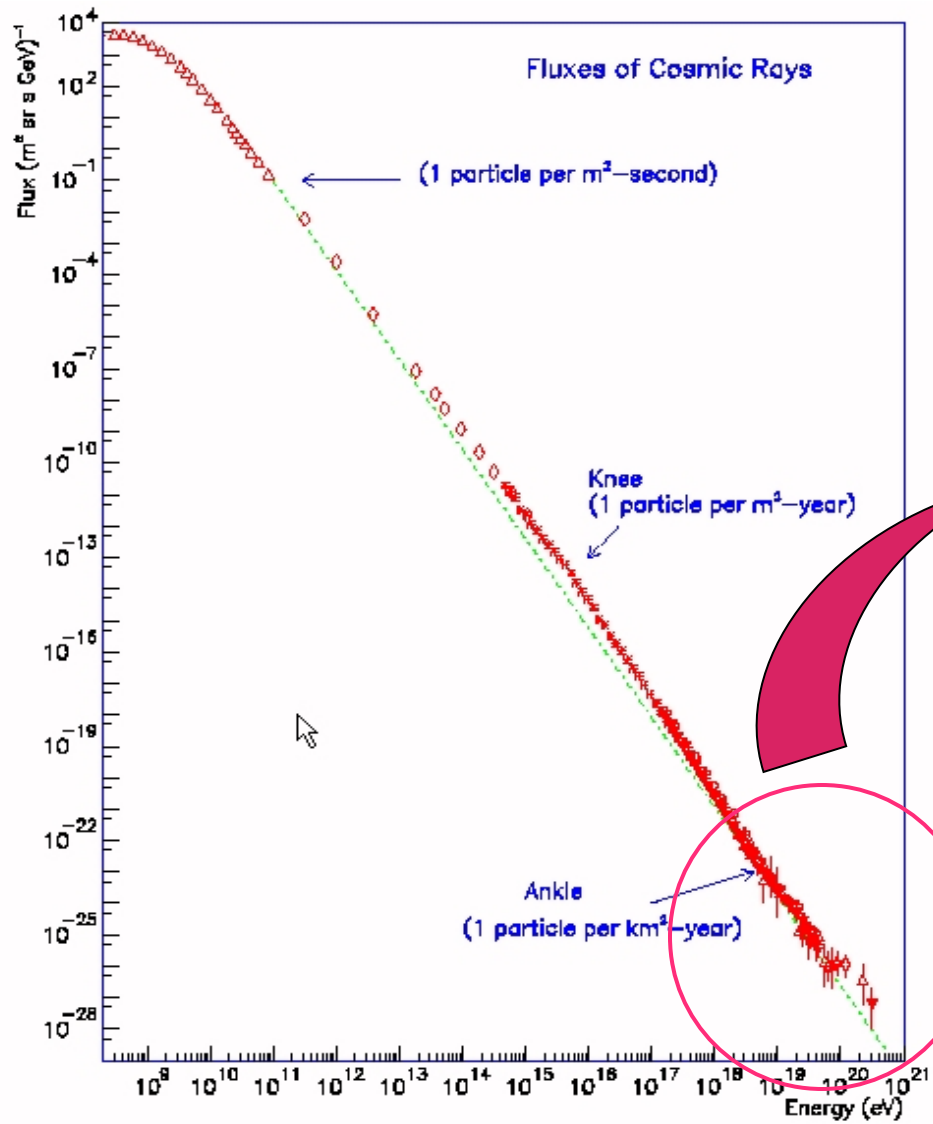
AMS



The Alpha Magnetic Spectrometer (AMS) Experiment



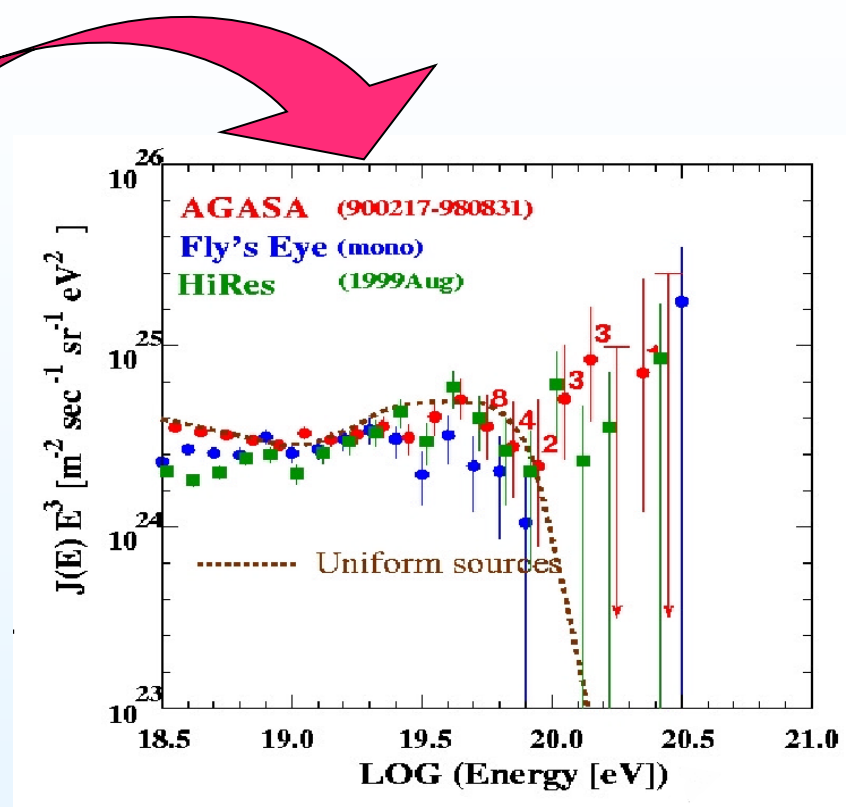
EUSO 1/2



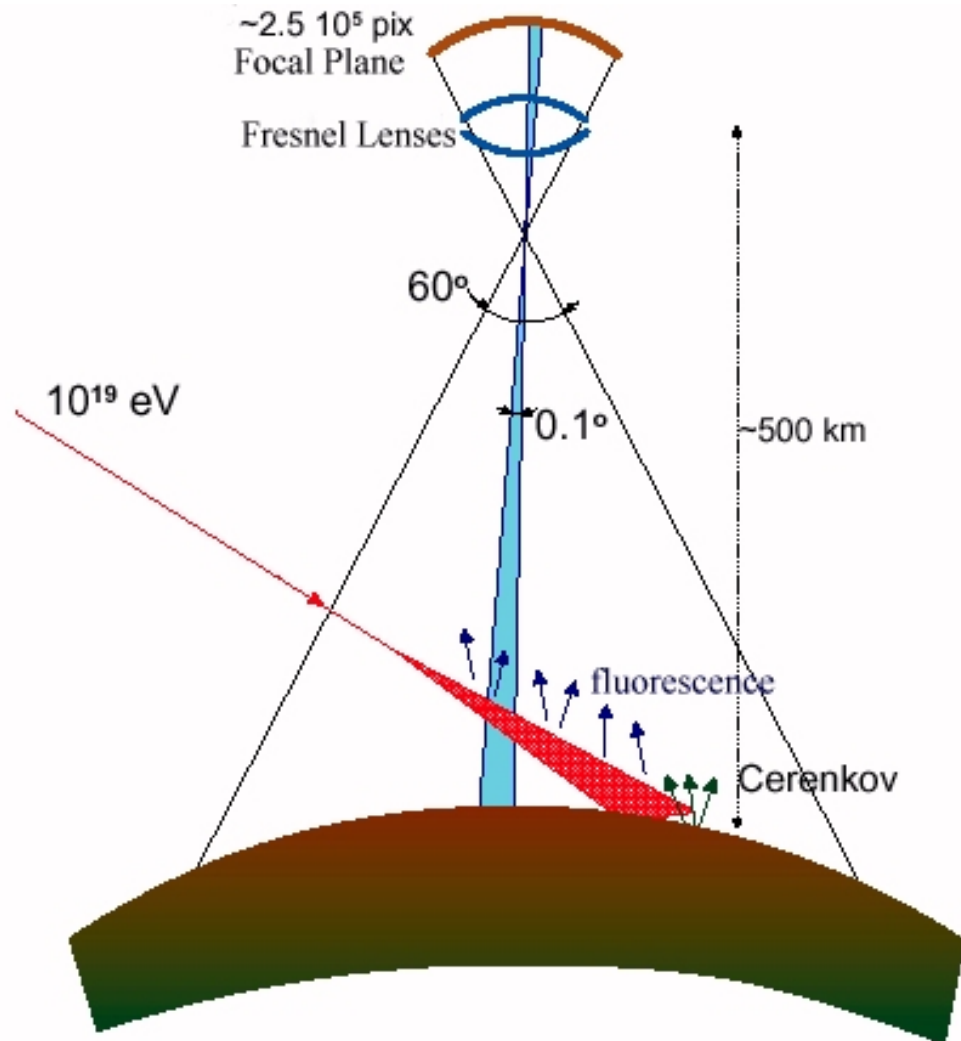
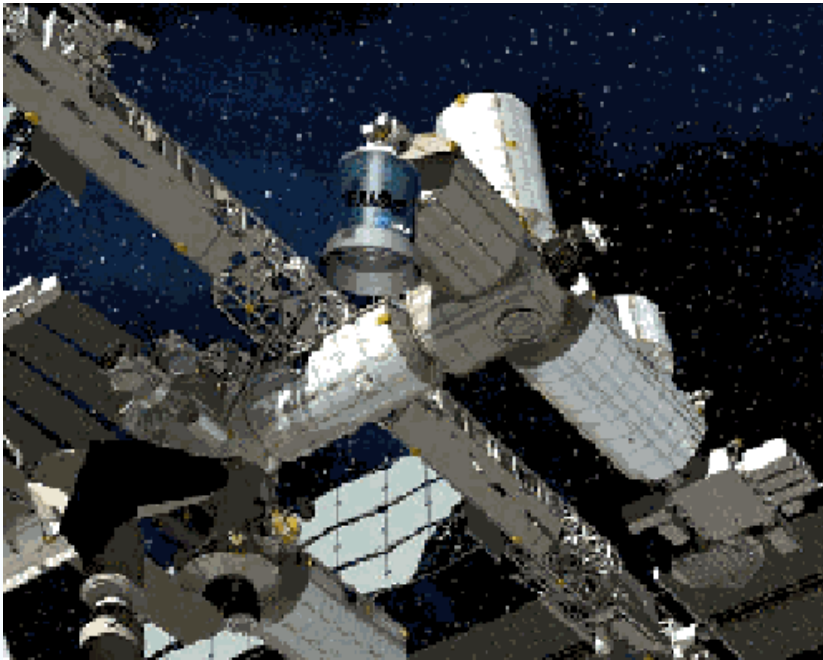
Flusso estremamente basso:
 ≈ 1 evento/sr/ km^2 /secolo



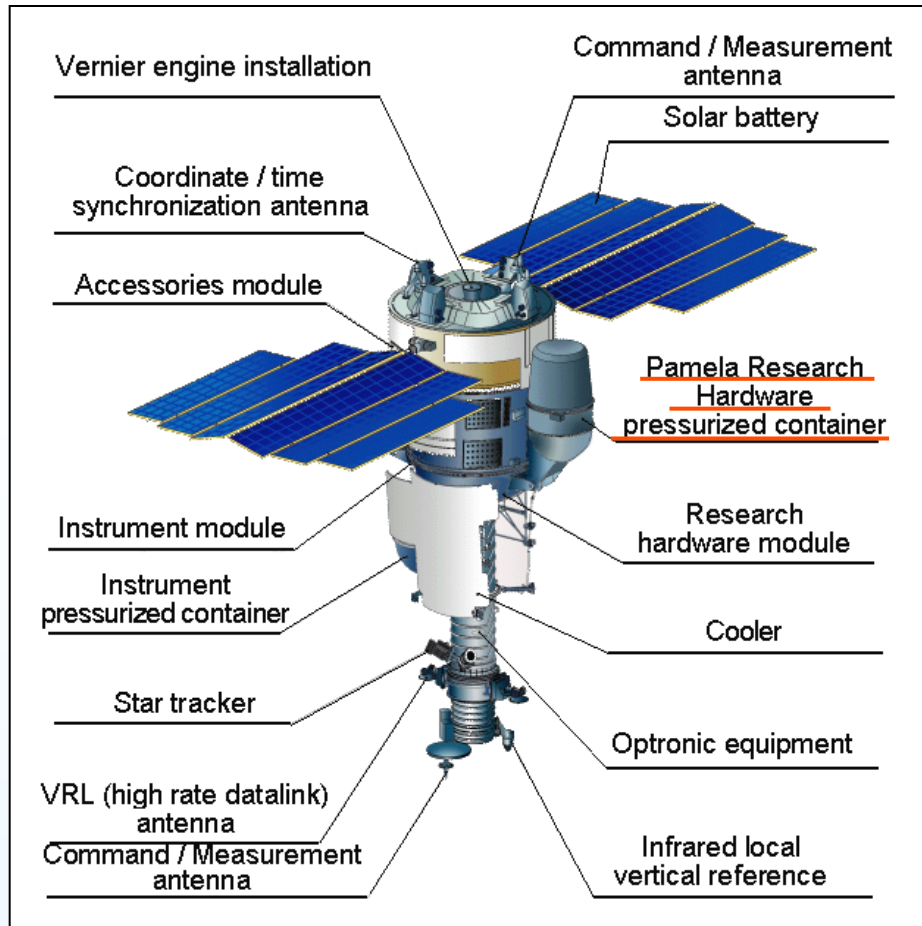
300 eventi



EUSO 2/2



PAMELA 1/4

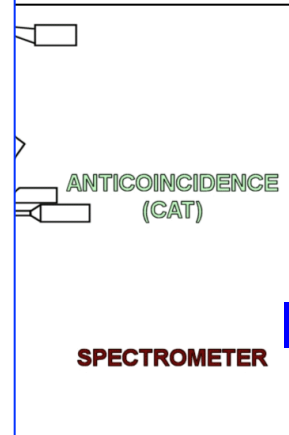


- Multi-spectral remote sensing of earth's surface
 - near-real-time high-quality images
- Built by the Space factory TsSKB Progress in Samara (Russia)
- Operational orbit parameters:
 - inclination $\sim 70^\circ$
 - altitude $\sim 360-600$ km (elliptical)
- Mass: 6.7 tons
- Active life >3 years
- Launch: 15/06/2006
- Data transmitted via Very high-speed Radio Link (VRL)

PAMELA 2/4

GF: 21.5 cm² sr
 Mass: 470 kg
 Size: 130x70x70 cm³
 Power Budget: 360W

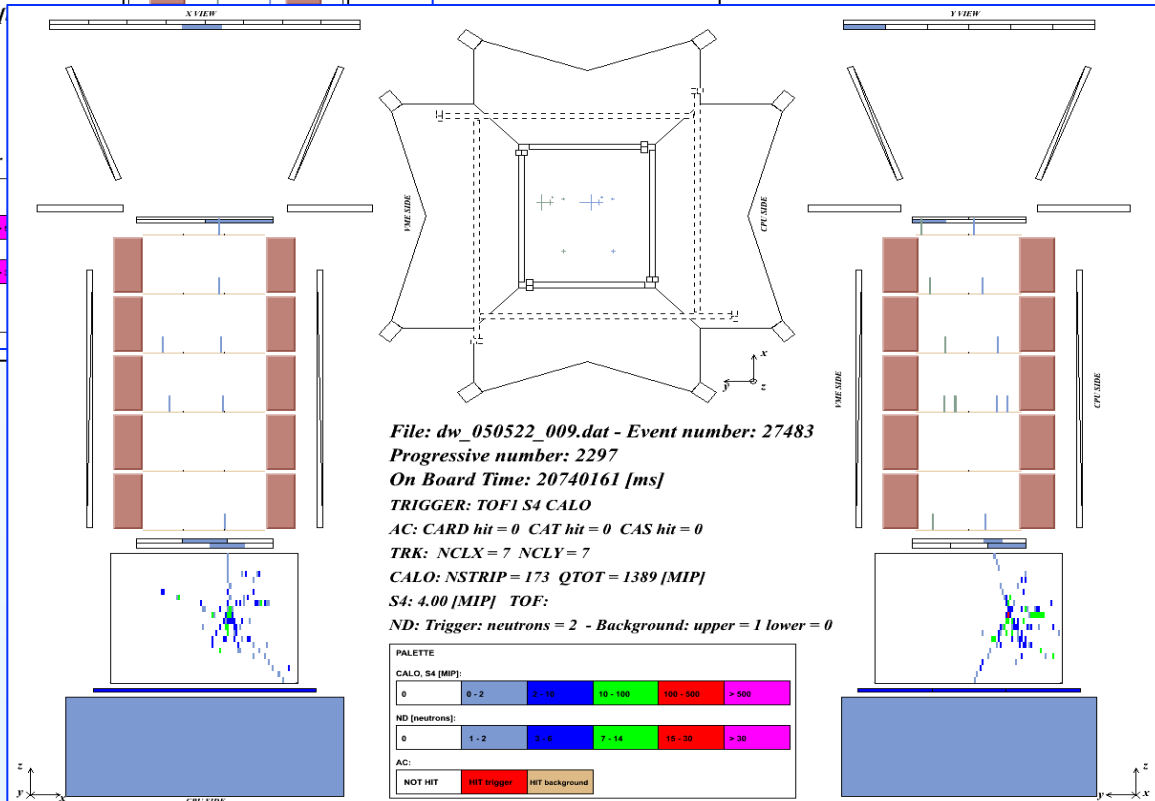
Interacting event



File: dw_050520_002.dat - Event number: 515
 Progressive number: 158
 On Board Time: 2020906 (delta: 1444) [TRIGGER: TOF1 S4
 AC: CARD hit = 0 CAT hit = 0 CAS hit = 0
 TRK: NCLX = 8 NCLY = 8
 CALO: NSTRIP = 50 QTOT = 97 [MIP]
 S4: 2.00 [MIP] TOF:
 ND: Trigger: neutrons = 0 - Background: upper

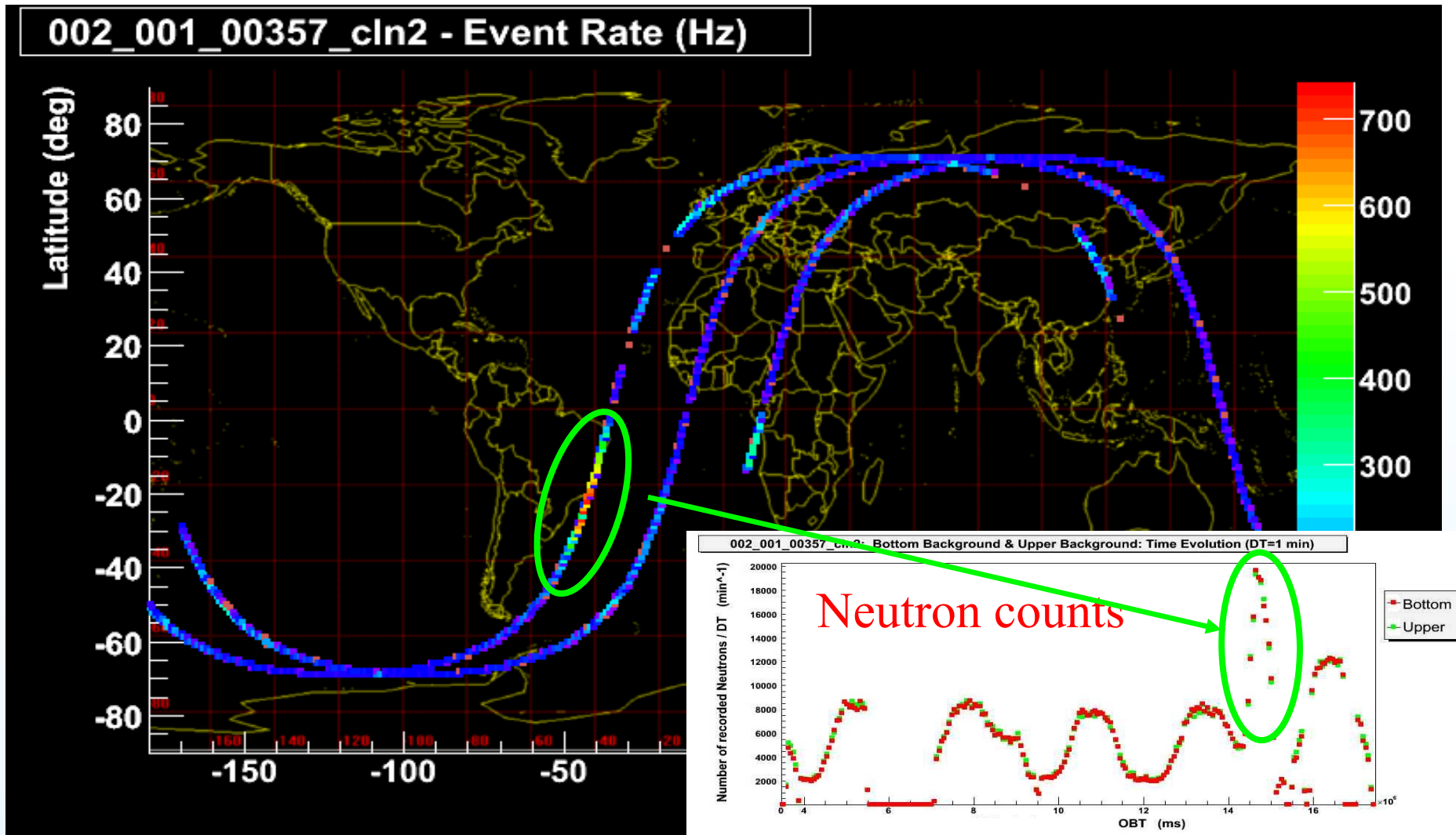
PALETTE					
CALO, S4 [MIP]:					
0	0 - 2	2 - 10	10 - 100	100 - 500	> 500
ND [neutrons]:					
0	1 - 2	3 - 6	7 - 14	15 - 30	> 30
AC:					
NOT HIT	HIT trigger	HIT background			

Non-interacting event

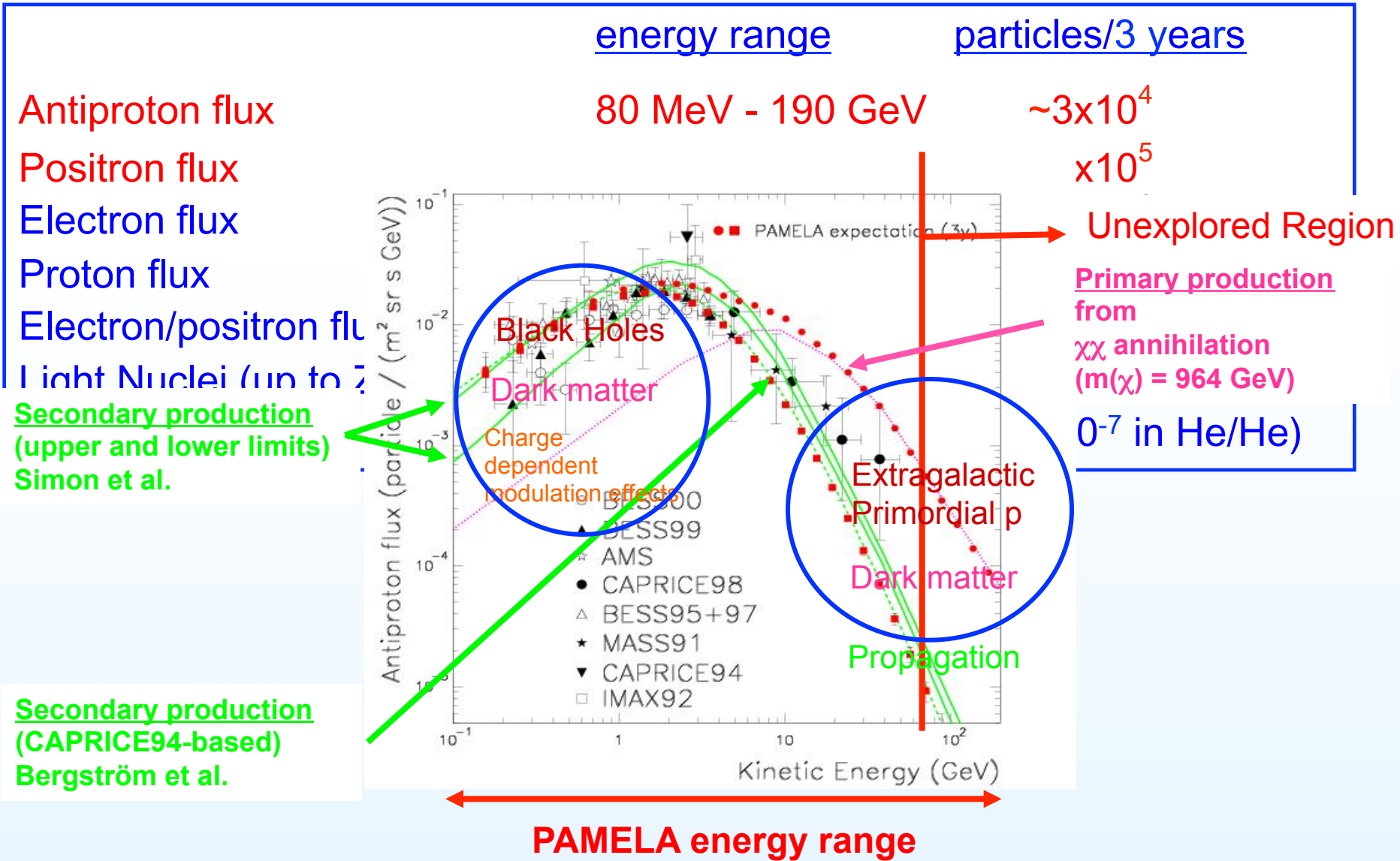


PALETTE					
CALO, S4 [MIP]:					
0	0 - 2	2 - 10	10 - 100	100 - 500	> 500
ND [neutrons]:					
0	1 - 2	3 - 6	7 - 14	15 - 30	> 30
AC:					
NOT HIT	HIT trigger	HIT background			

PAMELA 3/4



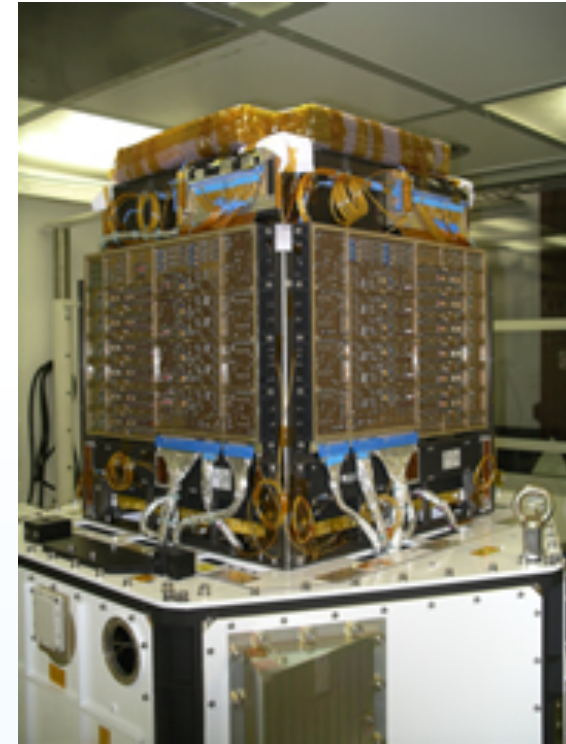
PAMELA 4/4



AGILE 1/2

Astrorivelatore Gamma Immagini LEggero

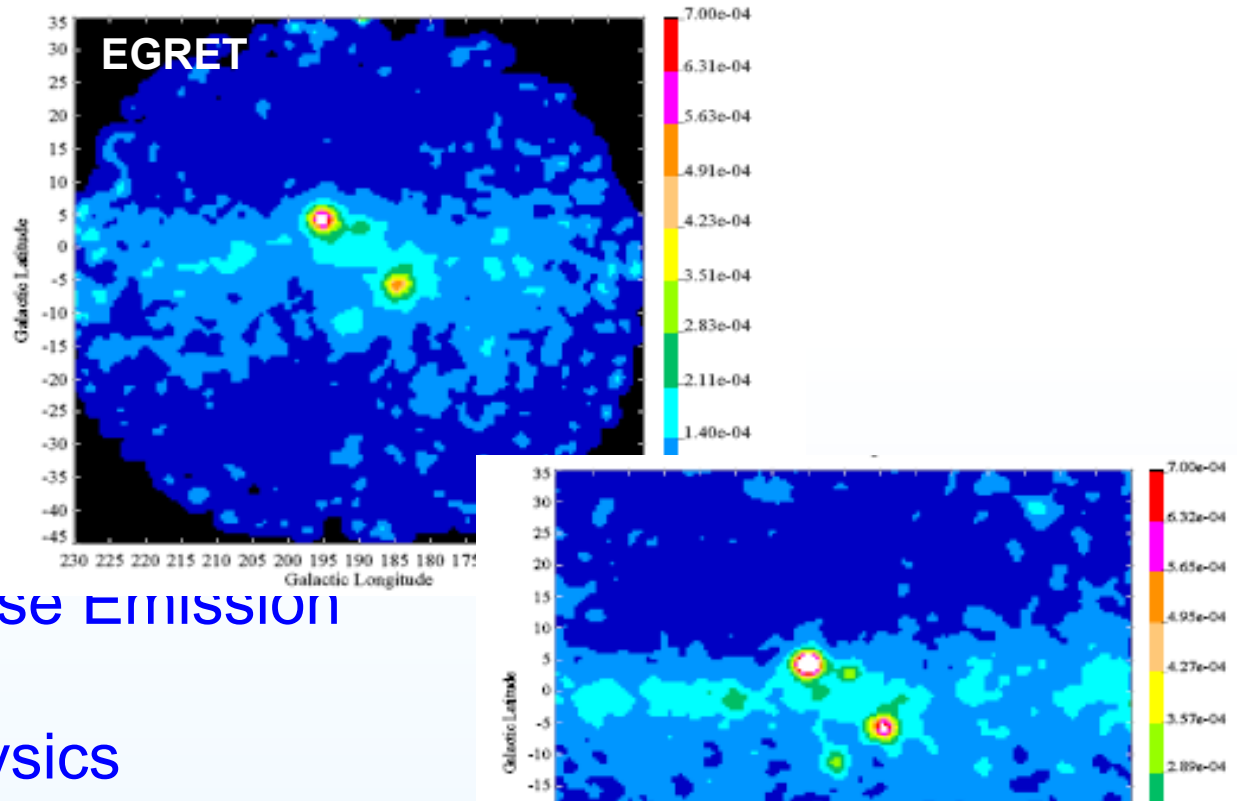
- Missione dedicata all'astrofisica gamma
- Optimal imaging capabilities in both the gamma-ray energy range (30 MeV-30 GeV) and hard X-ray range (15-60 keV)
- Scientific Team: researchers and engineers of INAF-IASF, INFN, and several Italian Universities. The project is headed by M. Tavani (Principal Investigator) and G. Barbiellini (Co-Principal Investigator)
- Participation of several leading companies from the Italian space industry, including CARLO GAVAZZI SPACE, ALCATEL-ALENIA Space LABEN, OERLIKON-CONTRAVES Space, TELESPAZIO, and MIPOT



AGILE 2/2

Major topics are:

- Active Galactic Nuclei
- Gamma Ray Bursts
- Pulsars
- Gamma-Ray Universe
- Supernova Remnants
- Compact Objects
- Gamma-ray Diffuse EMISSION
- TeV Sources
- Fundamental Physics



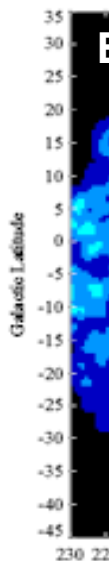
AGILE was successfully launched on April 23, 2007 by the Indian PSLV-C8 rocket from the Sriharikota base (Chennai-Madras).

The AGILE satellite was injected in the nominal equatorial orbit in agreement with the Scientific Requirements of the Mission. The satellite was tracked during its first pass over the ASI Malindi ground station in Kenya on Apr. 23rd. During its first orbit, its radio signal was also independently detected from the Sriharikota and Bangalore ground stations. The satellite is now in the initial Commissioning Phase. All test results are nominal.

AGILE 2/2

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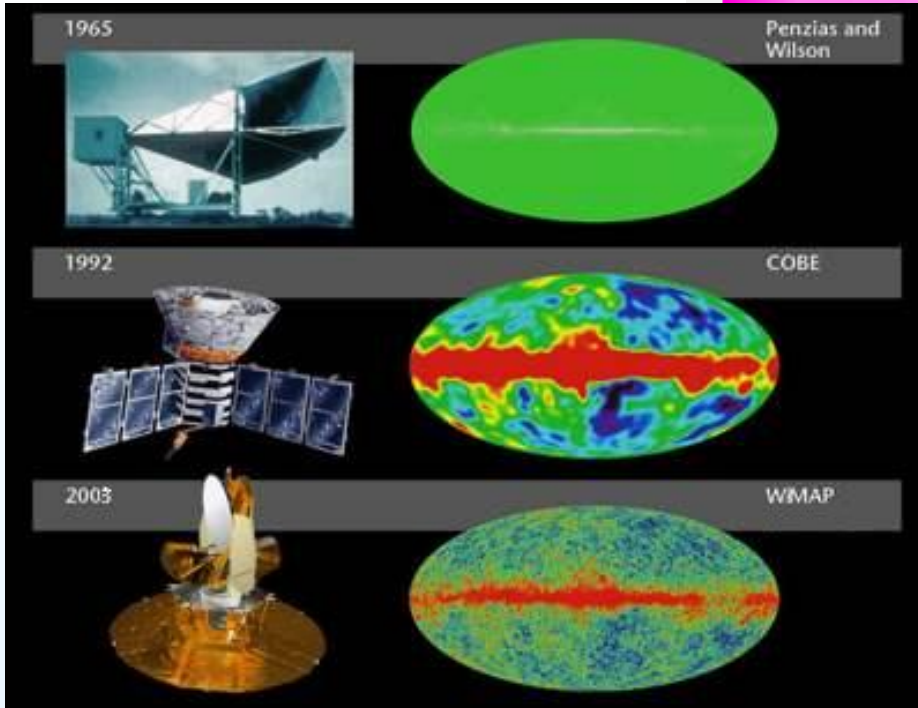
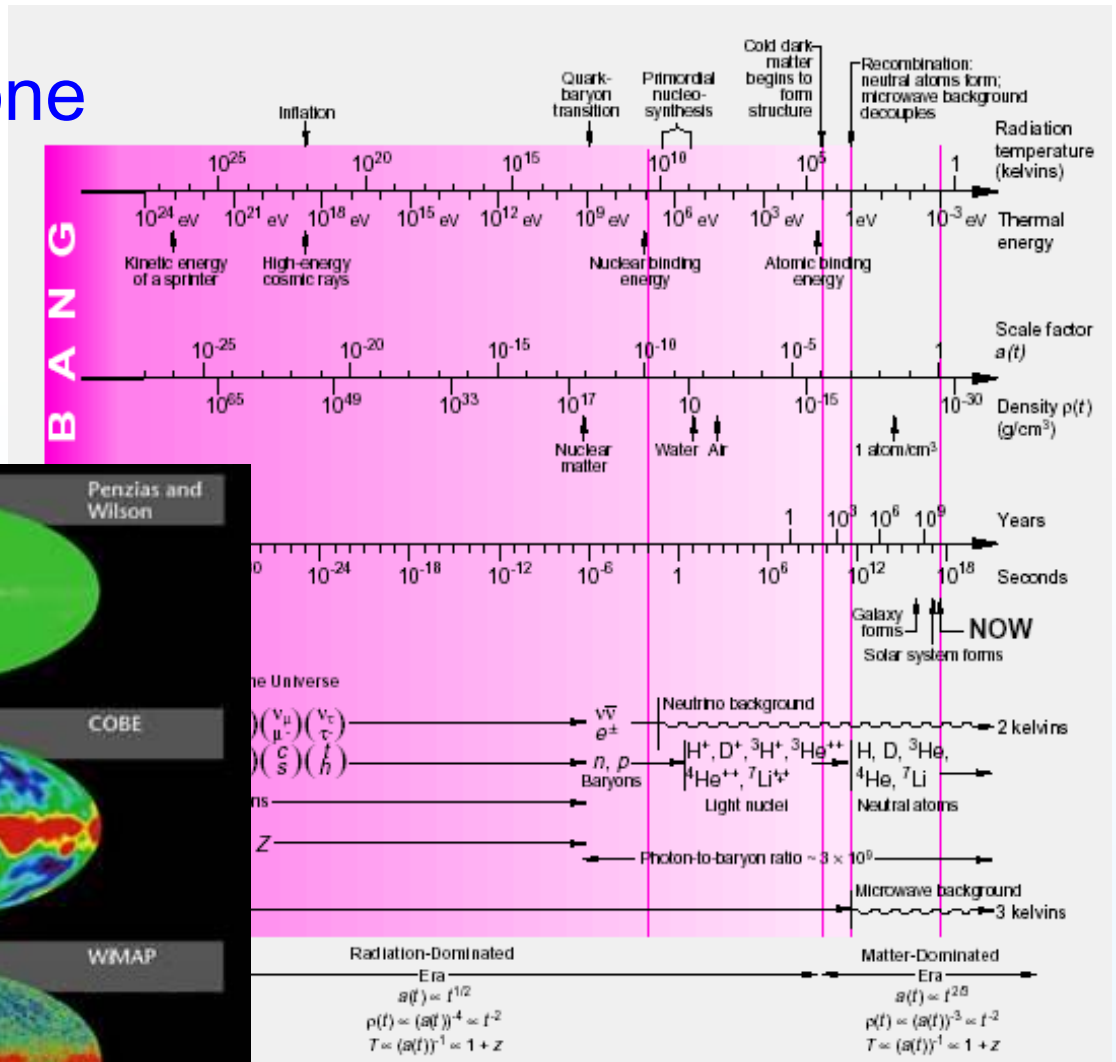
Gamma-ray Imaging Detector (GRID)		
Energy Range	30 MeV – 50 GeV	
Field of view	~ 3 sr	
Sensitivity at 100 MeV (ph cm ⁻² s ⁻¹ MeV ⁻¹)	6 × 10 ⁻⁹	(5σ in 10 ⁶ s)
Sensitivity at 1 GeV (ph cm ⁻² s ⁻¹ MeV ⁻¹)	4 × 10 ⁻¹¹	(5σ in 10 ⁶ s)
Angular Resolution at 1 GeV	36 arcmin	(68% cont. radius)
Source Location Accuracy	~5–20 arcmin	S/N~10
Energy Resolution	ΔE/E~1	at 300 MeV
Absolute Time Resolution	~ 1 μs	
Deadtime	~ 200 μs	
Hard X-ray Imaging Detector (Super-AGILE)		
Energy Range	10 – 40 keV	
Field of view	107° × 68°	FW at Zero Sens.
Sensitivity (at 15 keV)	~5 mCrab	(5σ in 1 day)
Angular Resolution (pixel size)	~ 6 arcmin	
Source Location Accuracy	~2-3 arcmin	S/N~10
Energy Resolution	ΔE<4 keV	
Absolute Time Resolution	~ 4 μs	
Deadtime (for each of the 16 readout units)	~ 4 μs	
Mini-Calorimeter		
Energy Range	0.3 – 200 MeV	
Energy Resolution	~ 1 MeV	above 1 MeV
Absolute Time Resolution	~ 3 μs	
Deadtime (for each of the 30 CsI bars)	~ 20 μs	

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PLANCK 1/3

Fondo di Radiazione



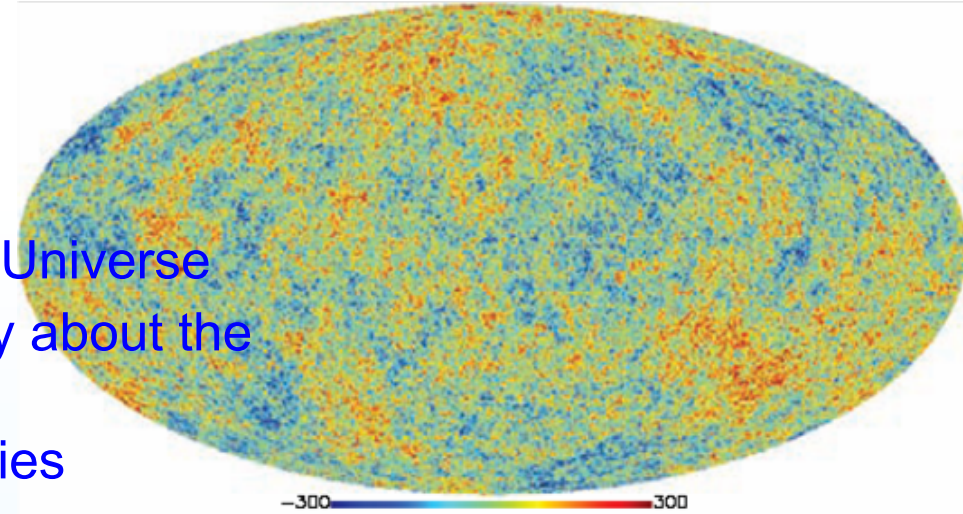
PLANCK 2/3

Planck is the third mission on CMB (first european)

- Better sensitivity ($\Delta T/T \sim 2 \times 10^{-6}$) and angular resolution (up to $5'$)
- Wider frequency range

Main scientific Objectives:

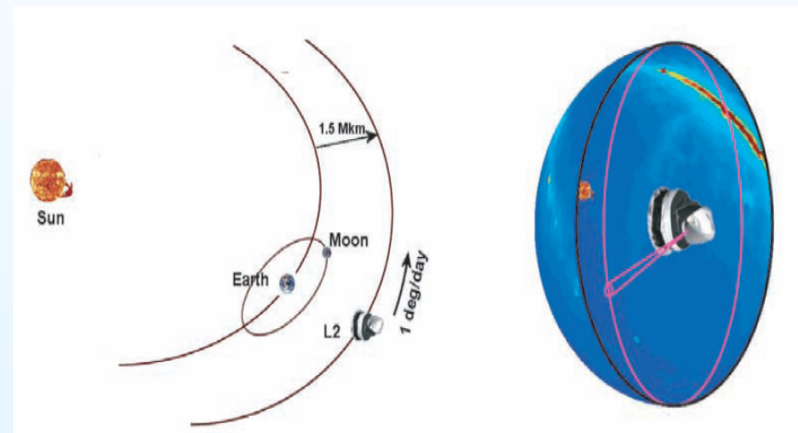
- Determination of geometry of the Universe
- Determination of the correct theory about the Universe origin and evolution
- Complete map of CMB anisotropies



Orbit: Lissajous around Lagrangian point L2 of Earth-Sun-Moon system

Distance from the Earth: 1.5×10^6 km

Spin axis: opposite direction respect to the Sun



PLANCK 2/3

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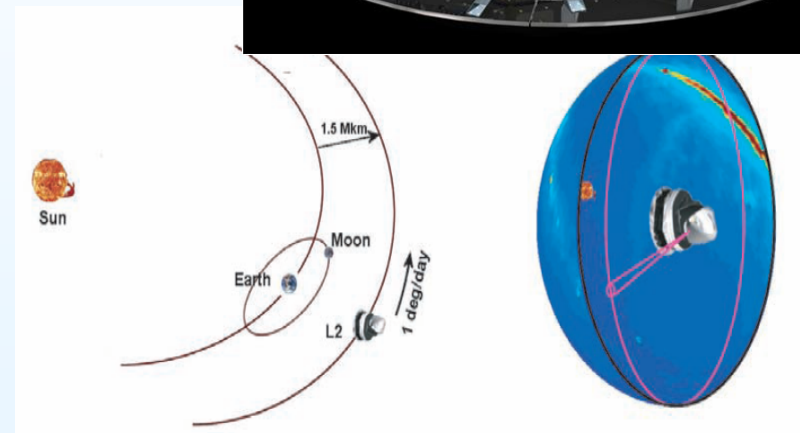
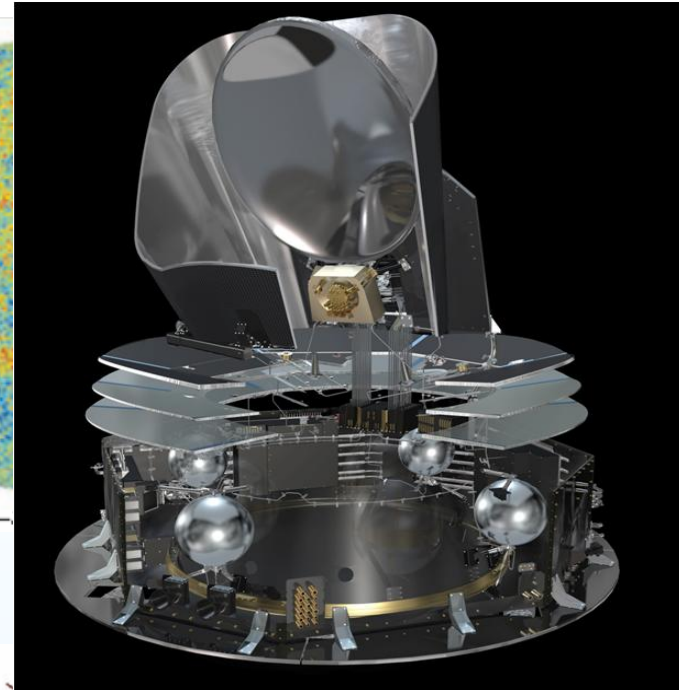
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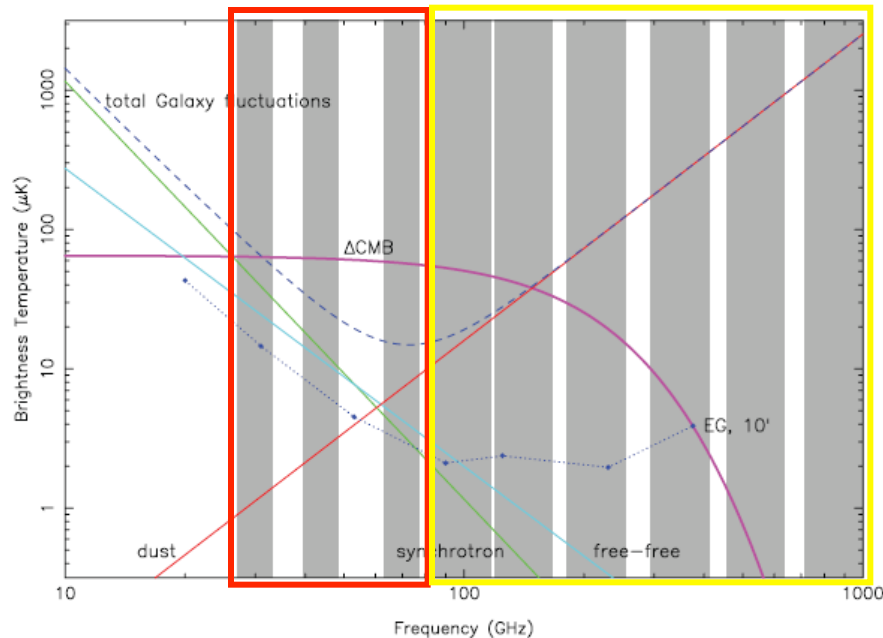
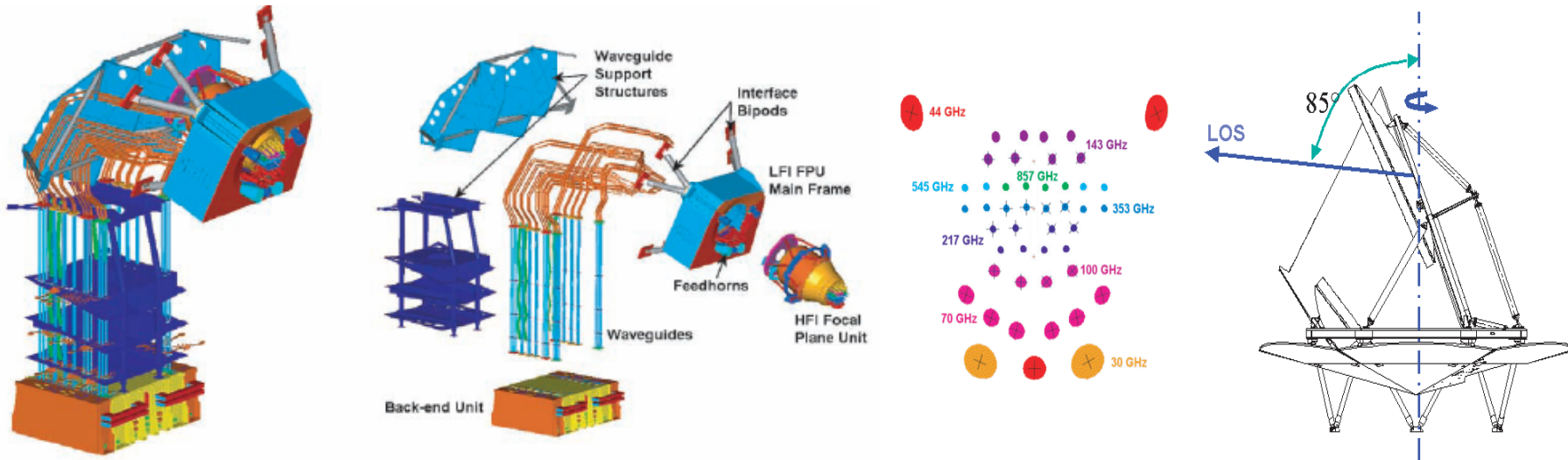
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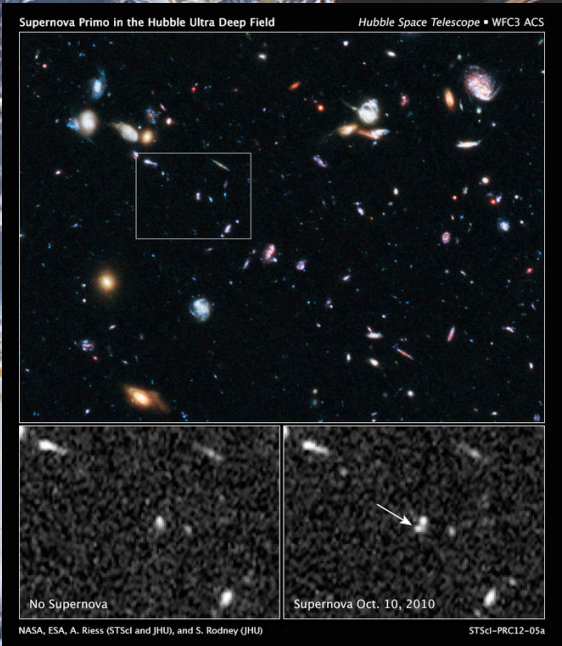


PLANCK 3/3

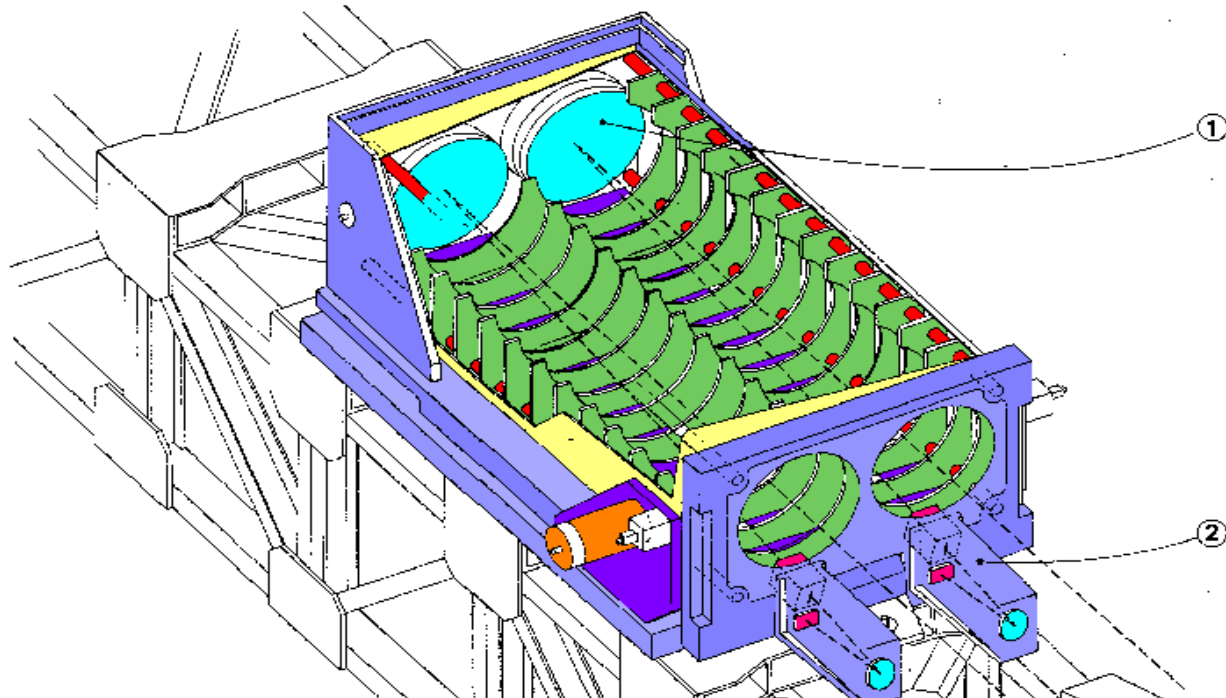


Centre frequency (GHz)	30	44	70
Bandwidth (GHz)	6	8.8	14
Angular resolution (arcminutes, FWHM)	33	24	14
Detector temperature (K)	20 K		
$\Delta T/T$ Intensity [$10^{-6} \mu\text{K/K}$]	2.0	2.7	4.7
$\Delta T/T$ polarization [$\mu\text{K/K}$]	2.8	3.9	6.7

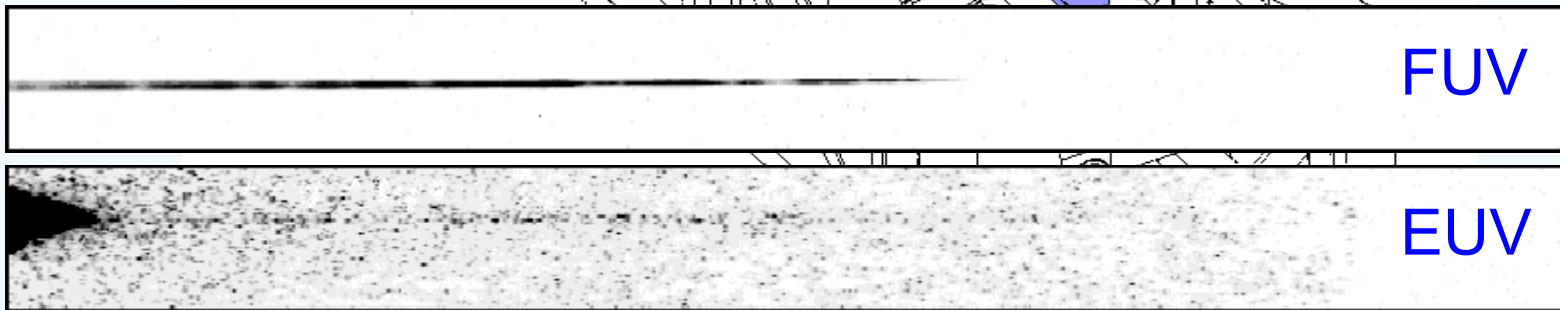
Astronomia: Hubble



Astronomia: UVSTAR 1/4



s
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a
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o



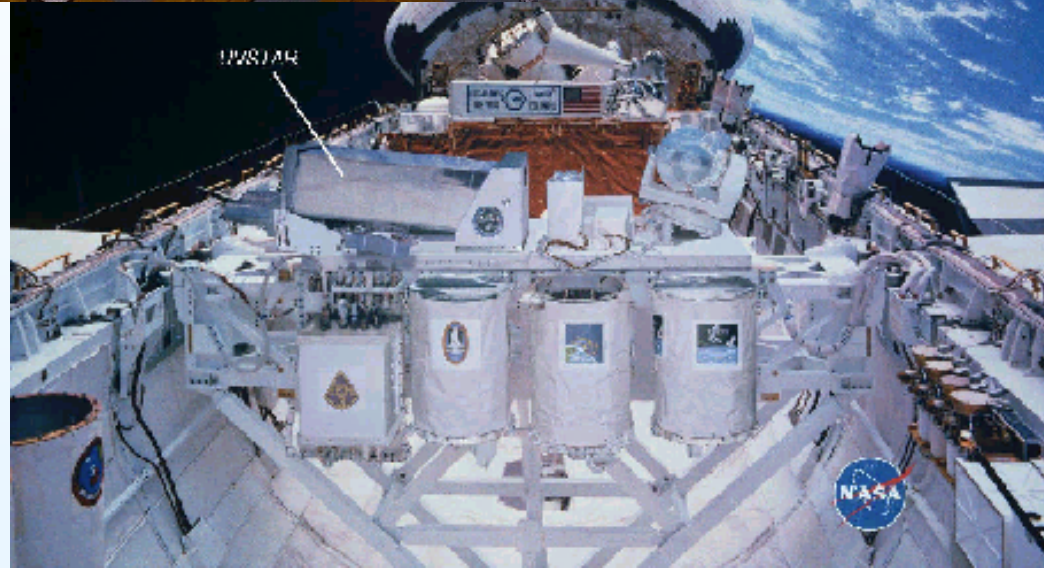
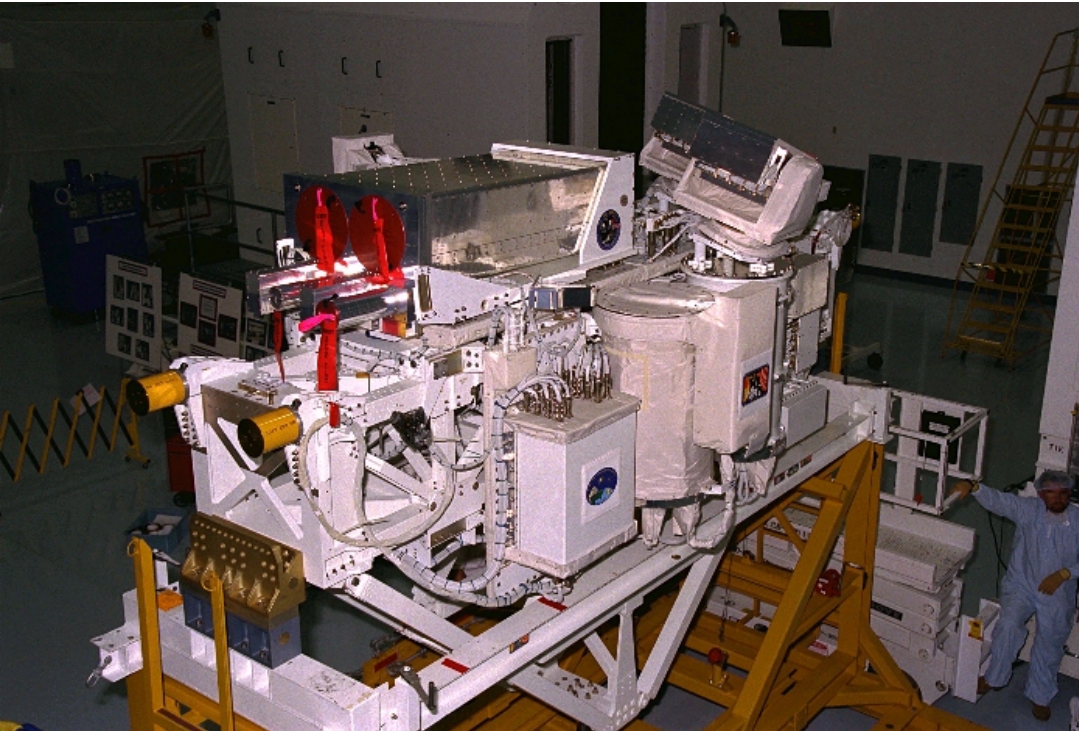
FUV

EUV

1. Mirrors
2. Spectrographs / Detectors
3. Hitchhiker - M Bridge

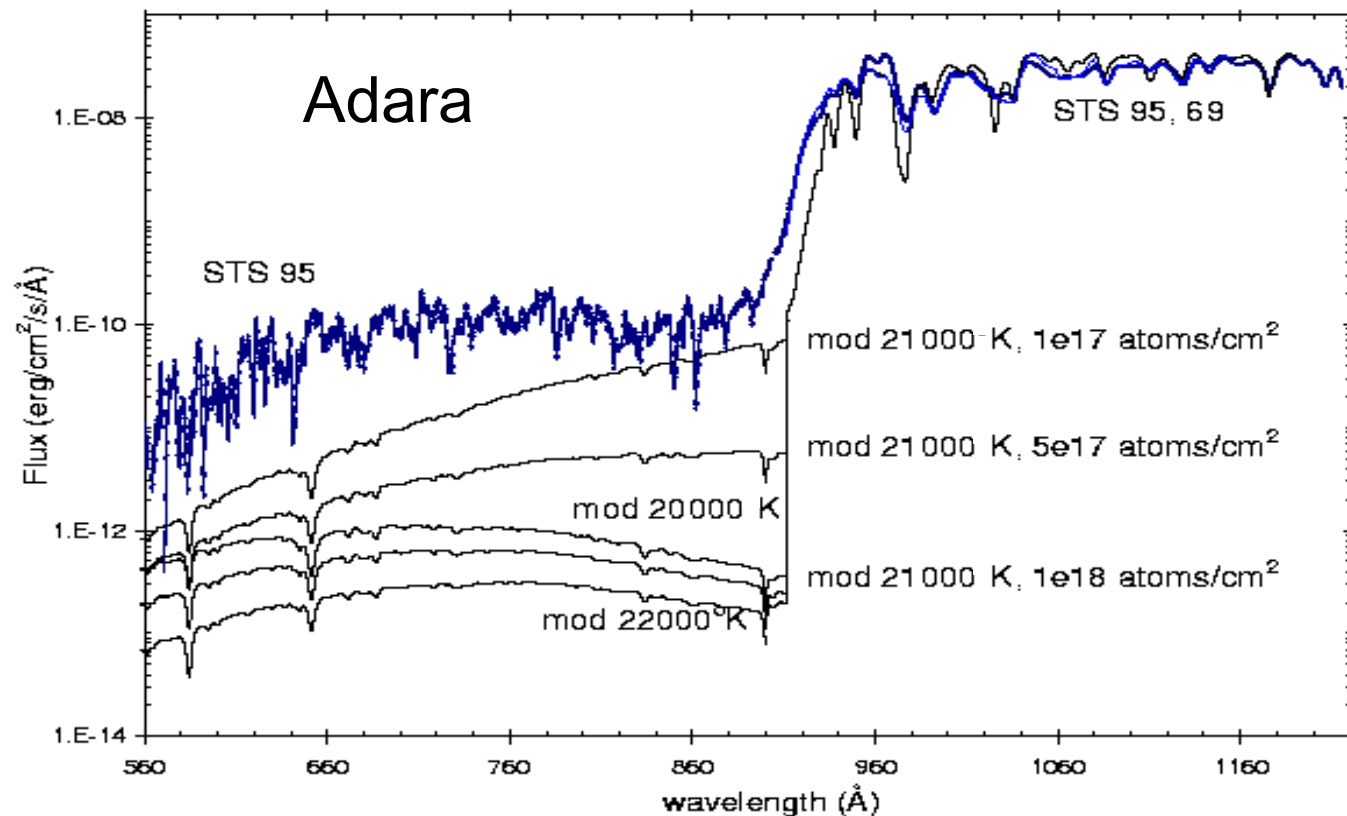
Lunghezza
d'onda

Astronomia: UVSTAR 2/4



Astronomia: UVSTAR 3/4

- sistema di movimentazione autonomo munito di 2 telescopi ausiliari per la direzione di puntamento
- osserva atmosfere stellari, regioni HII, anelli di IO, comete
- analisi spettrale del flusso nelle varie componenti UV (FUV/EUV)



Risultati tecnologici: sistema di puntamento

