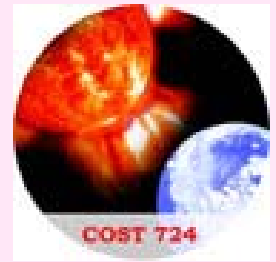


# Parameterization of galactic proton and helium fluxes for future space missions (@ 1AU)

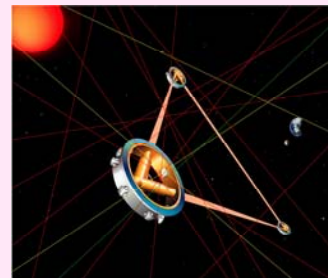
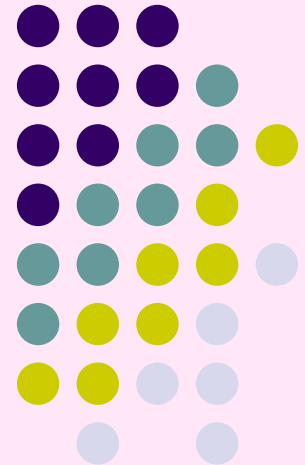


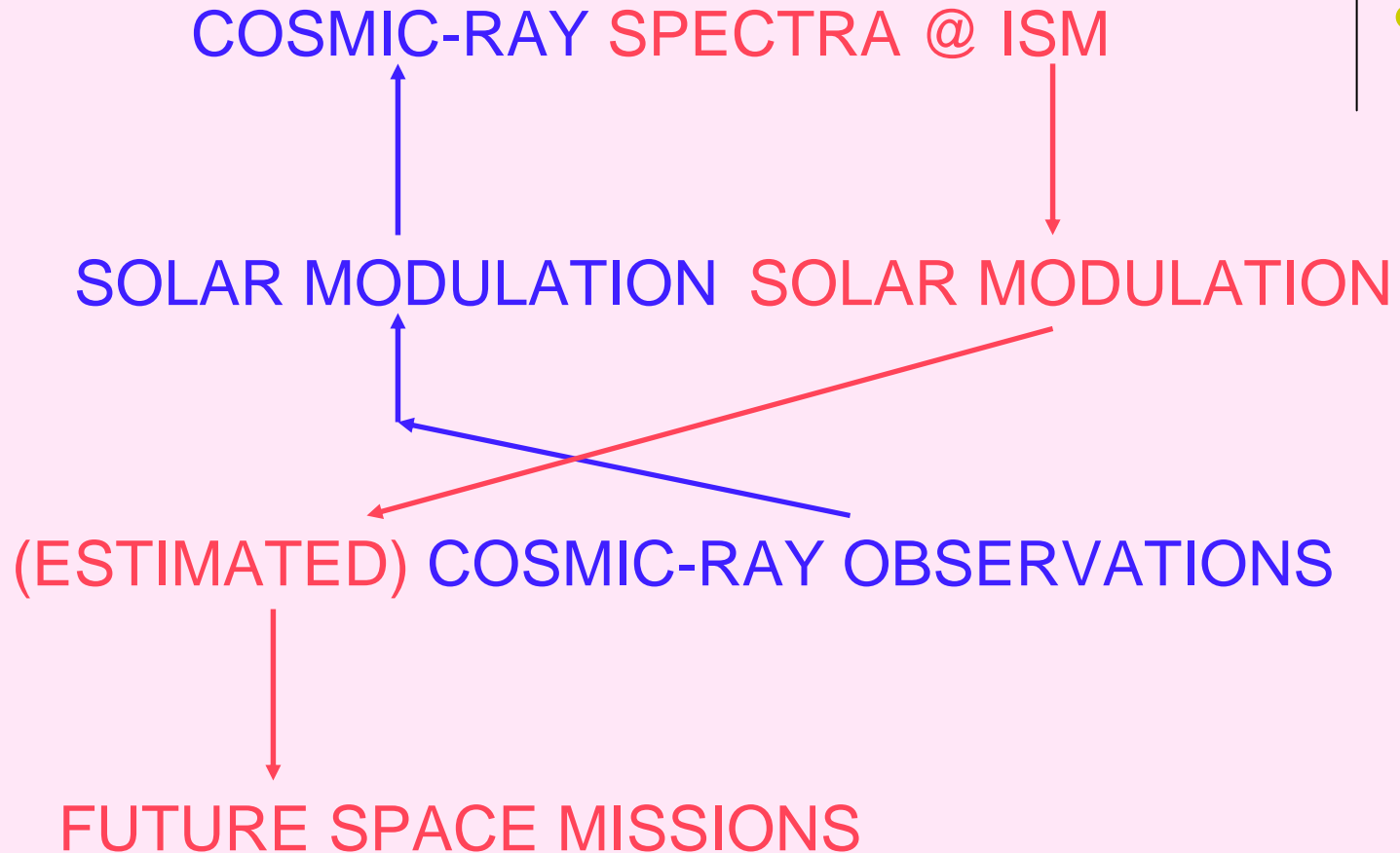
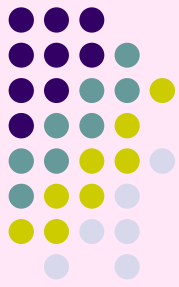
QuickTime™ e un decompressore TIFF (non compresso) sono necessari per visualizzare quest'immagine.

Catia Grimani<sup>1,2</sup> and Michele Fabi<sup>1</sup>

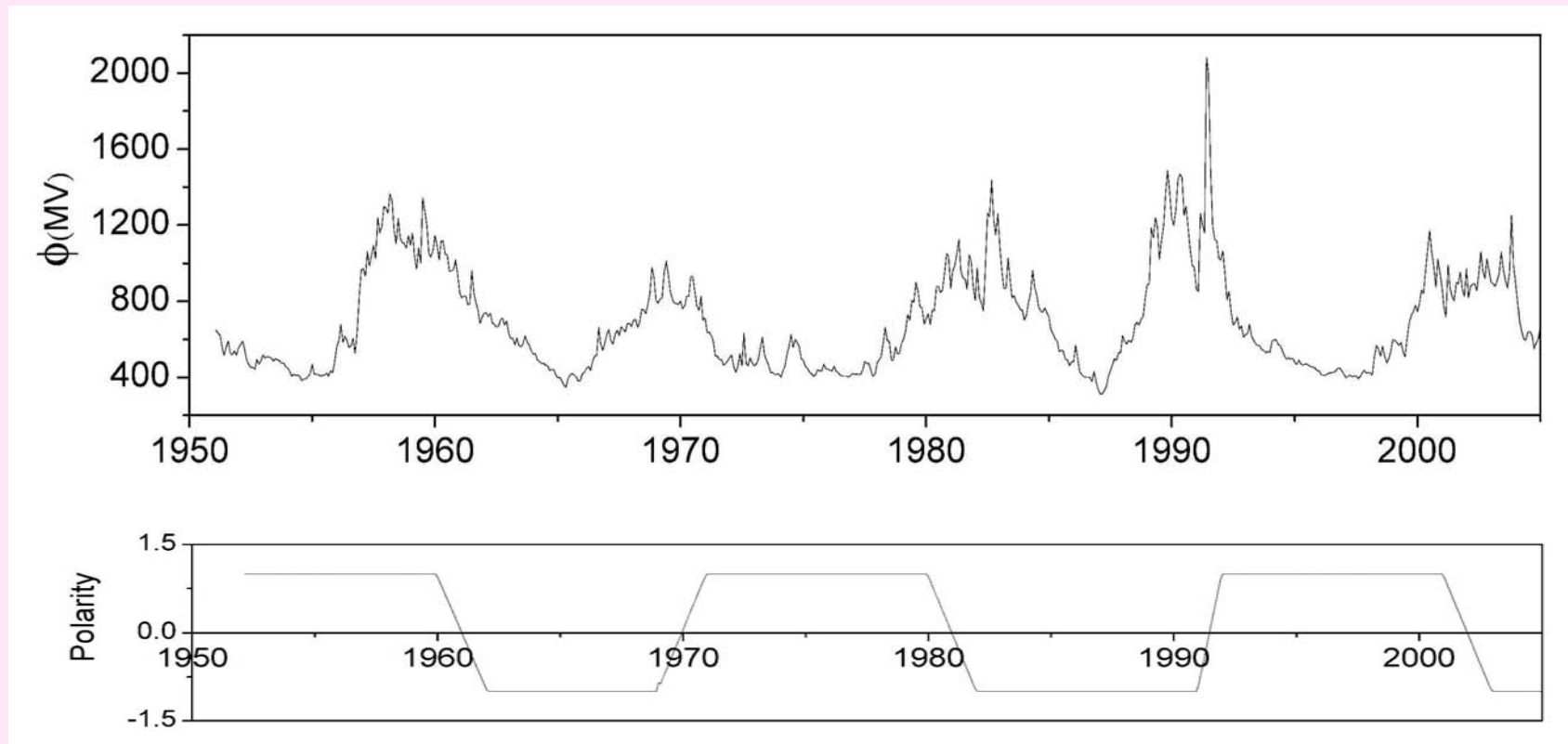
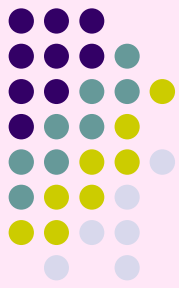
<sup>1</sup>University of Urbino

<sup>2</sup>INFN Florence



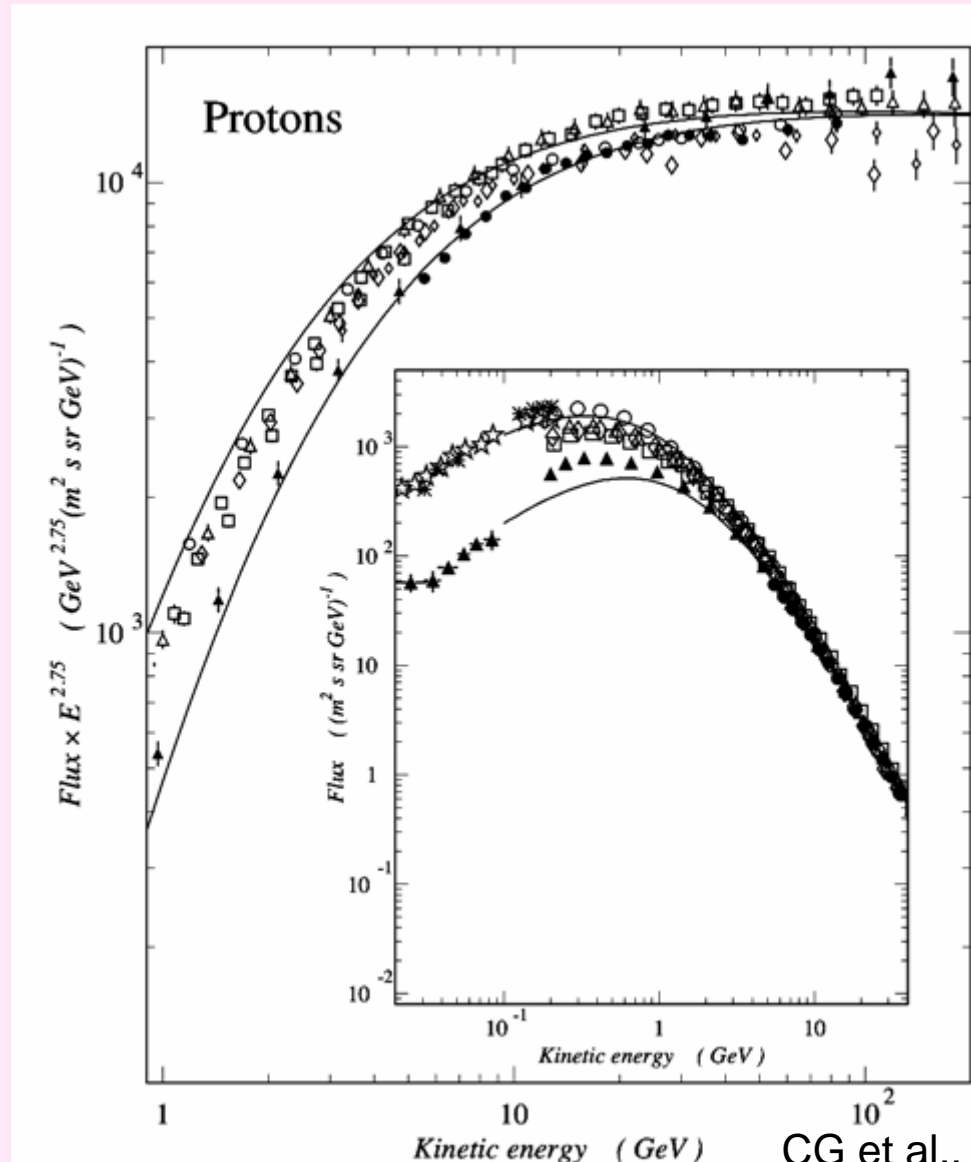
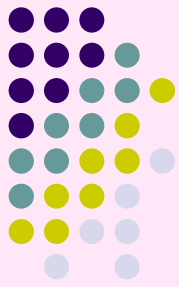


# Solar Modulation, Global Solar Magnetic Field Polarity and GCR long-term variations

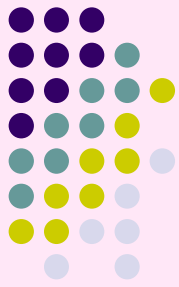


Alanko-Huotari, Mursala, Usoskin and Kovaltsov, Solar Physics, 238, 391, 2006

# Solar modulation effect on GCR



# Solar Modulation of Galactic Cosmic Rays



$$\frac{J(r,E,t)}{E^2-E_0^2} = \frac{J(\infty,E+\Phi)}{(E+\Phi)^2-E_0^2}$$

J: particle flux

r: distance from Sun

E: particle total energy

t: time

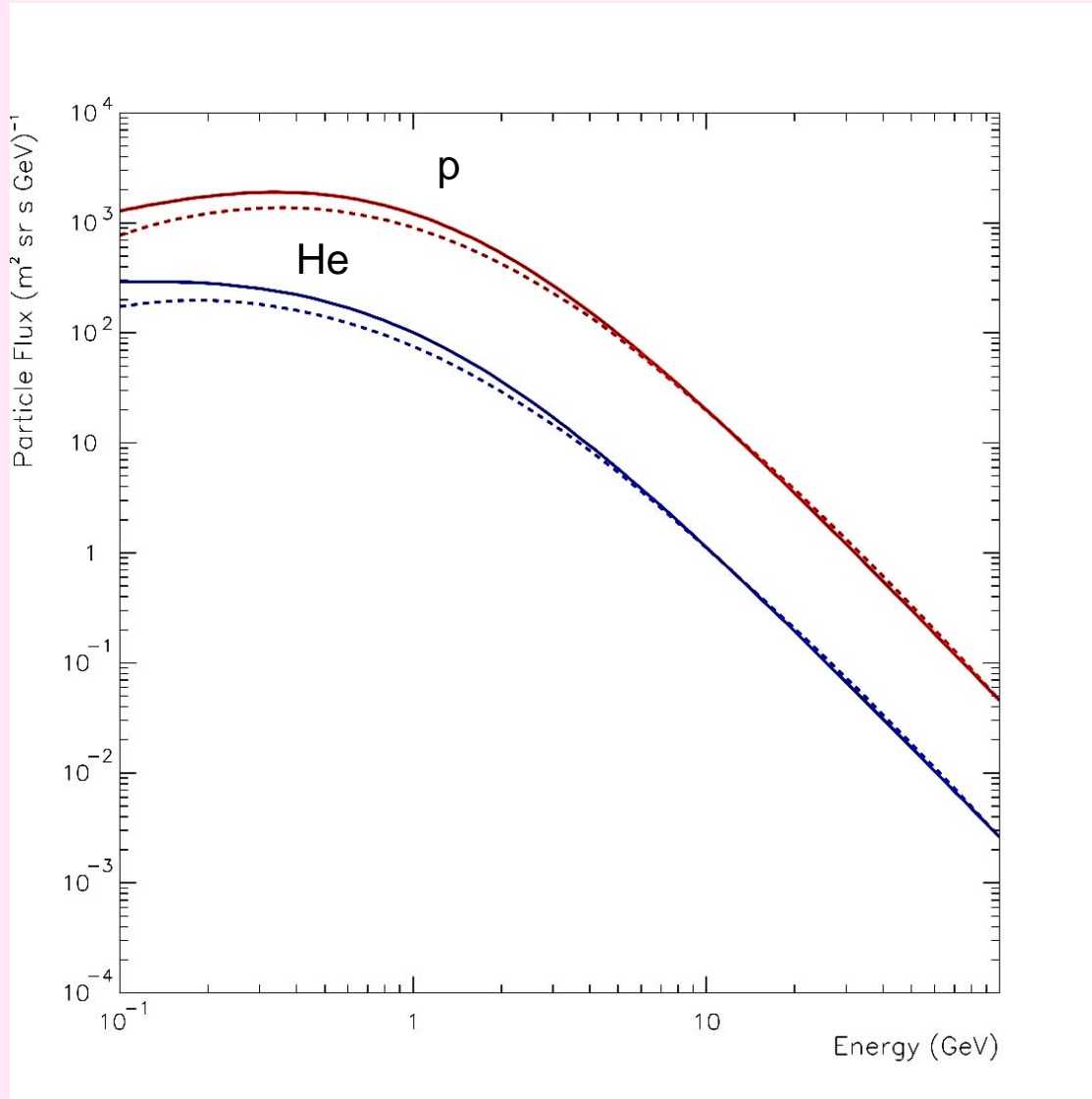
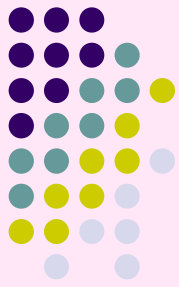
$E_0$  = particle mass

$\Phi$  = particle energy loss from infinity (different for each species)

Gleeson and Axford, Ap. J., 154, 1011, 1968

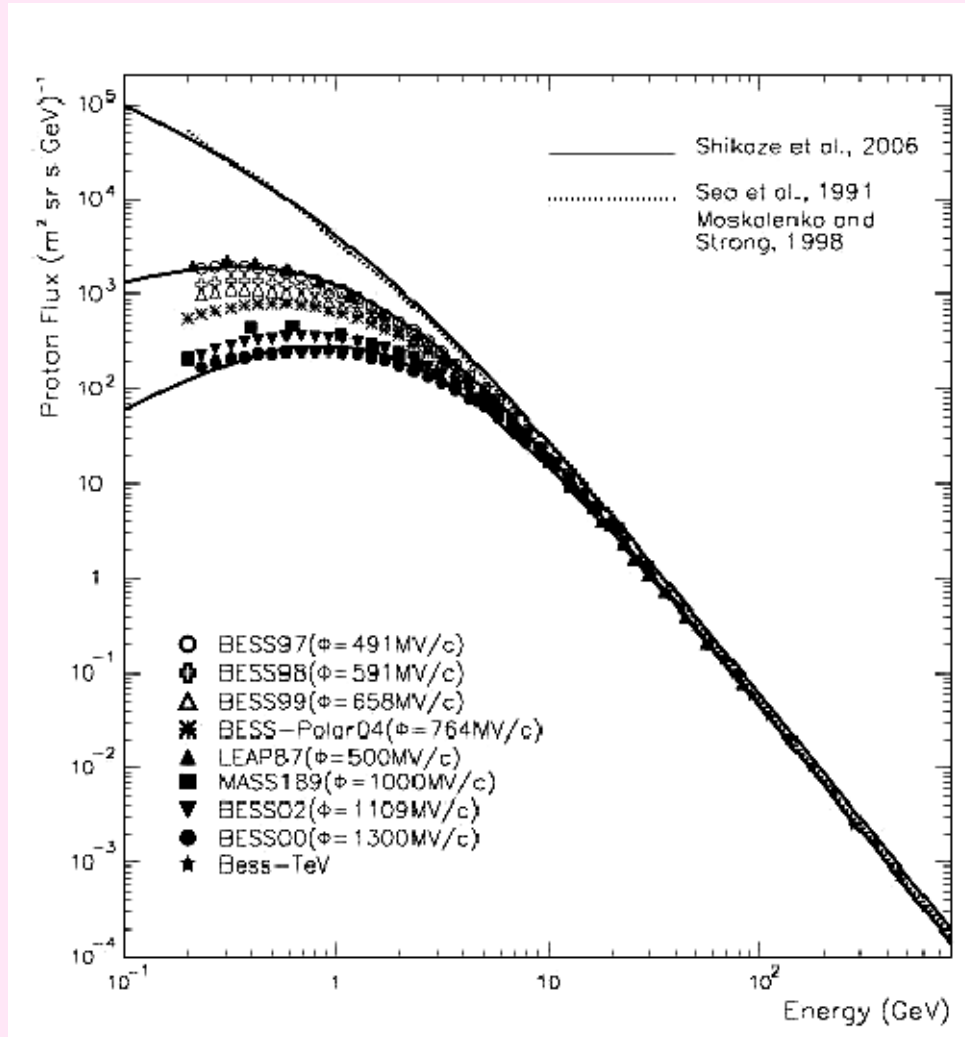
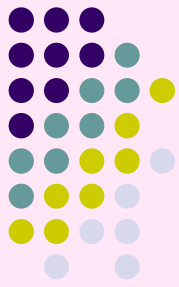
**Ok for positive polarity epoch data only!**

# Solar polarity effect on GCR p and He

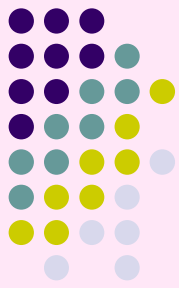


Boella G. et al., J. Geophys. Res. 106:355 2001

# Cosmic-ray proton observations during the last two solar cycles



# Positive polarity cosmic-ray flux parameterization

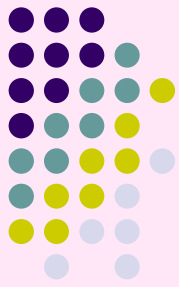


$$F[E(\text{GeV})]=A(E+B)^{-\alpha} E^{\beta} \text{Particles}/(\text{m}^2 \text{ sr s GeV})$$

(Papini, Grimani & Stephens, *Il nuovo Cimento*, 19, 367, 1996; CG et al., *CQG*,21,S629, 2004)

|            | A     | B     | $\alpha$ | $\beta$ |
|------------|-------|-------|----------|---------|
| P (BESS97) | 18000 | 1.09  | 3.66     | 0.87    |
| He(BESS97) | 850   | 0.915 | 3.17     | 0.42    |
| P (BESS00) | 18000 | 1.71  | 4.20     | 1.41    |
| He(BESS00) | 850   | 1.25  | 3.60     | 0.85    |
| P(MASS89)  | 18000 | 1.57  | 3.95     | 1.16    |
| P(BESS02)  | 18000 | 1.60  | 3.99     | 1.20    |

# Reduction factors

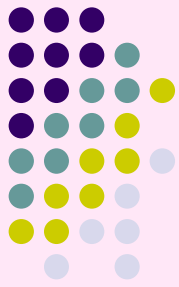


Solar minimum - negative polarity

$$R1=1+(0.4/1.602)*\log E+(0.4/1.602)-0.4 \quad 0.1 < E < 4.0 \text{ GeV(/n)}$$

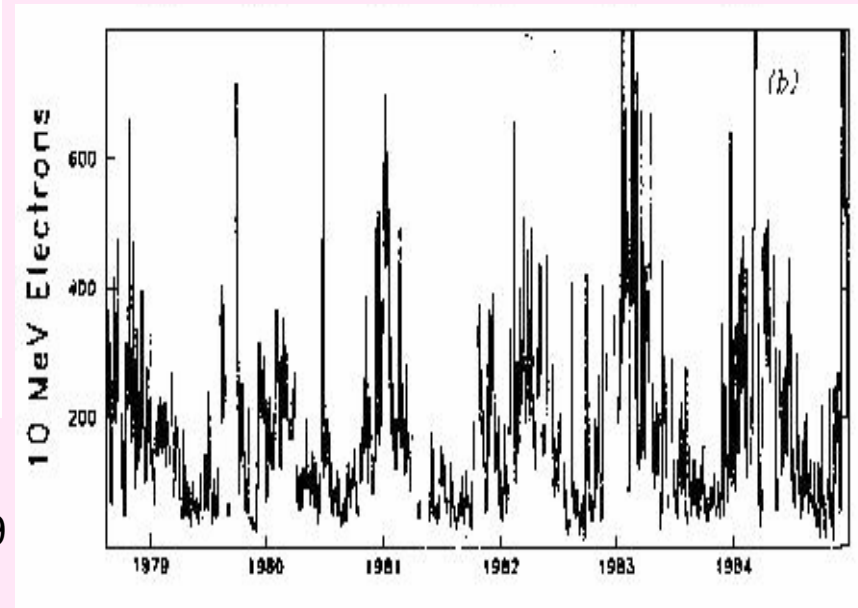
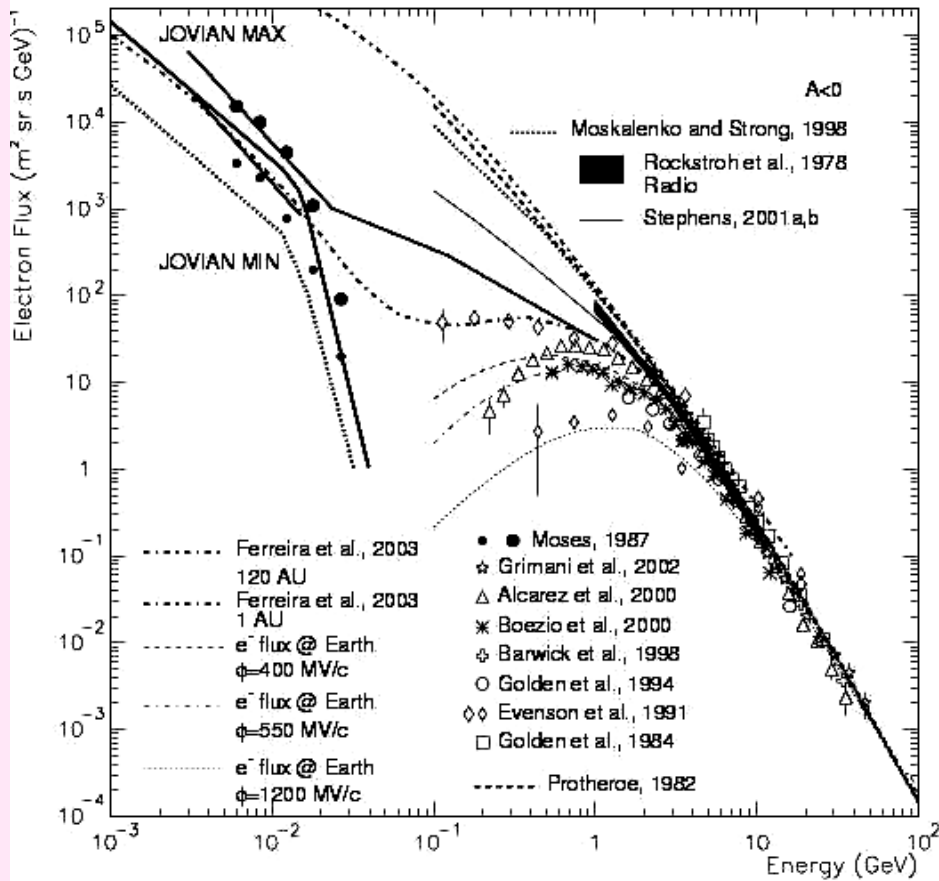
High solar activity - negative polarity

$$R2=0.61+1.41 * E^{-1.2} + 0.146 * E^{1.32} + 0.146 * E^{1.95} \quad 0.1 < E < 1.6 \text{ GeV(/n)}$$



# Electrons

CG et al., AIP Conf. Proc.,  
873, 184, 2006



References on Jovian  $e^-$

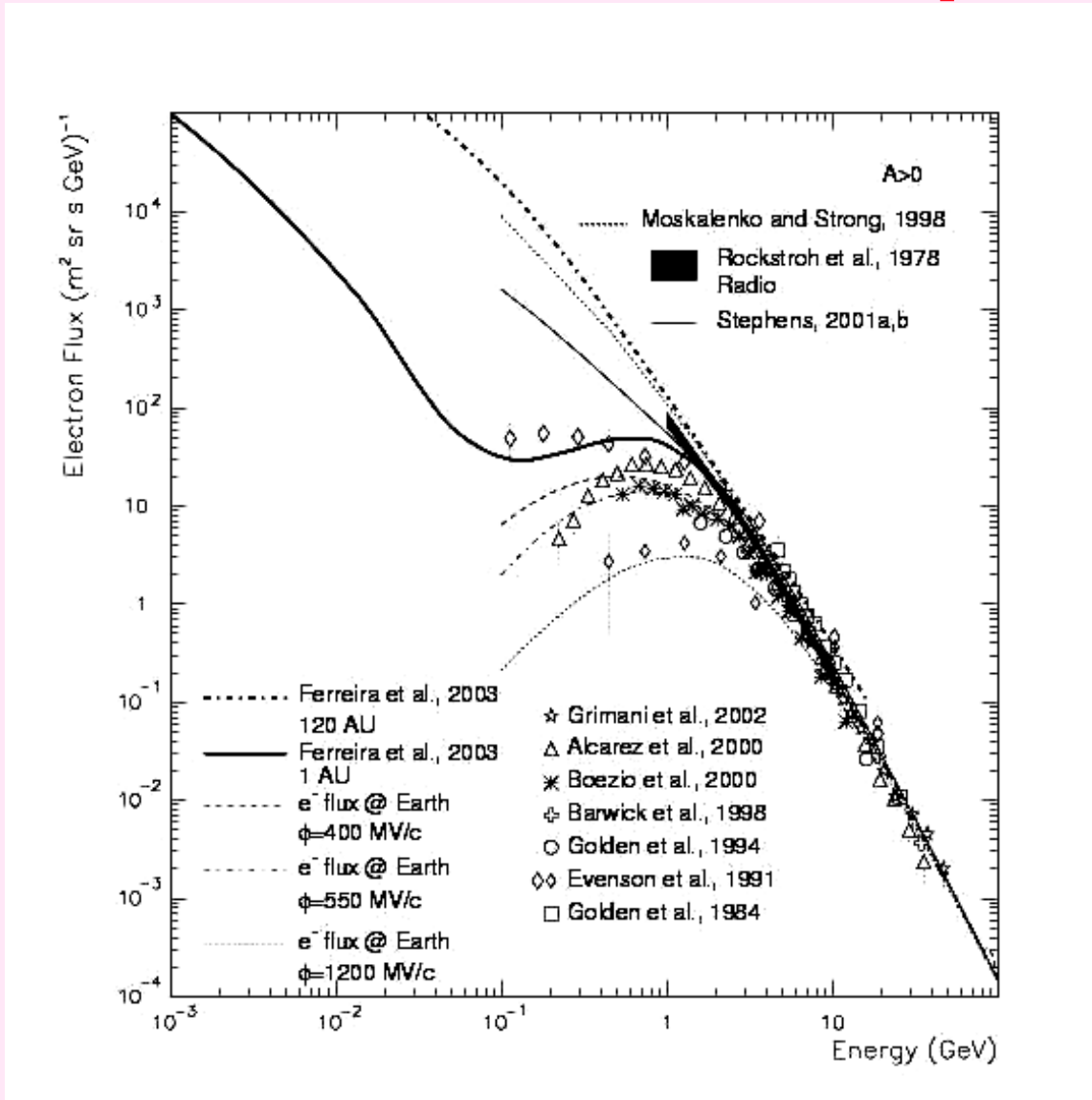
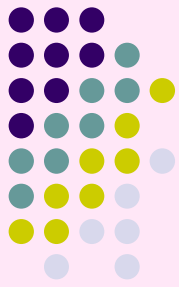
Nieminen, P., ESA/ESTEC E.W.P., 2009 February 1999

Daniel, R. R. & Stephens, S. A., Sp. Science Rev.,  
10, 599, 1970

Moses, Ap. J., 313, 471, 1987

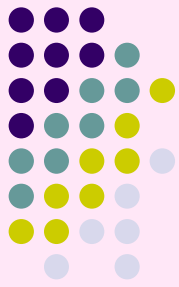
Evenson, Meyer & Moses, 19th ICRC, La Jolla, 1985

# Electrons -Positive polarity



CG et al., AIP Conf. Proc.,  
873, 184, 2006

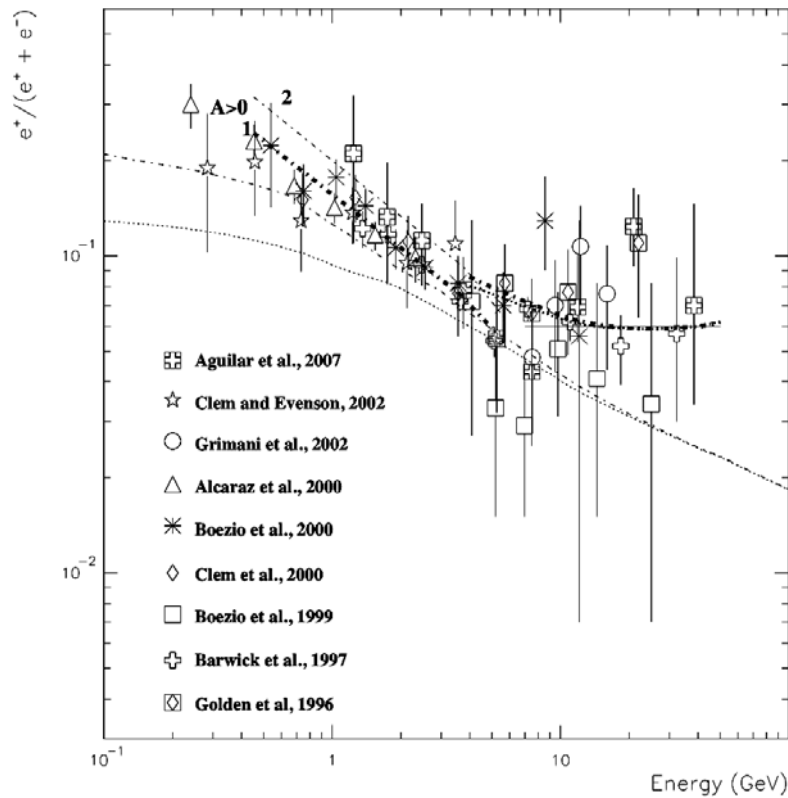
# Positron measurements during the last two solar cycles



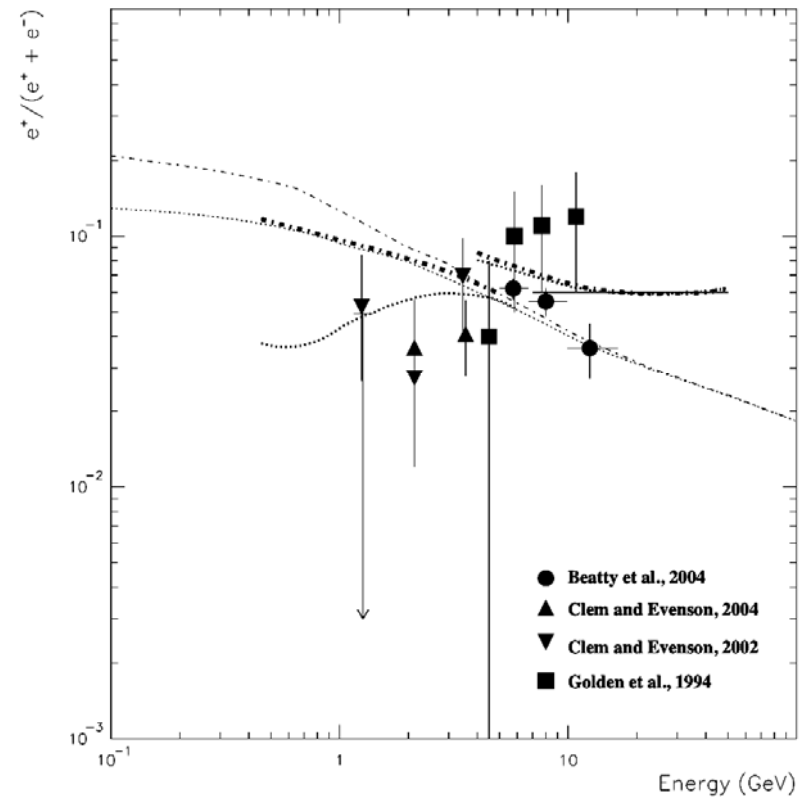
CG, to appear on A&A

Secondary calculations by M&S, 1998

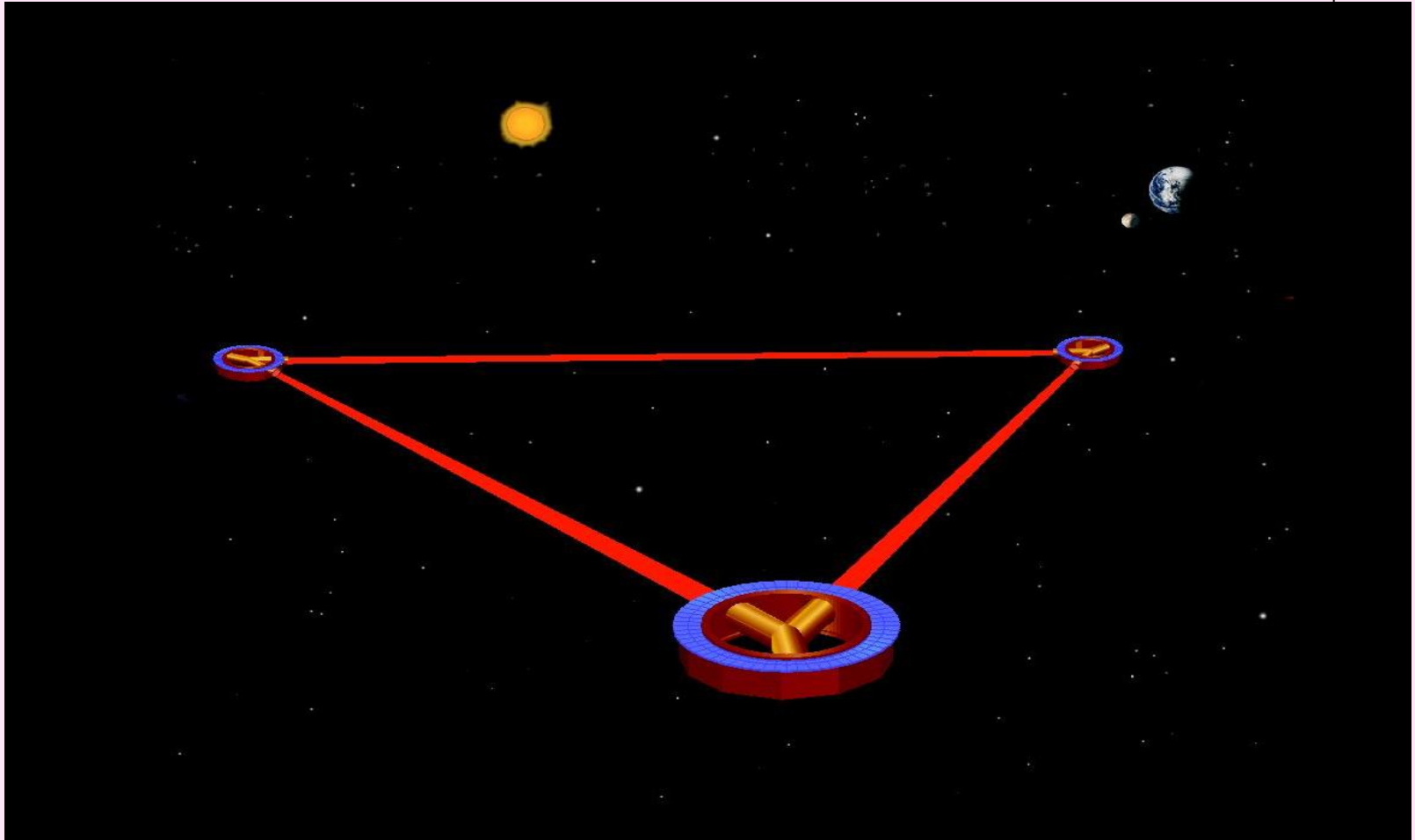
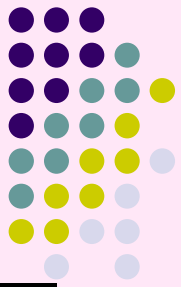
$A > 0$



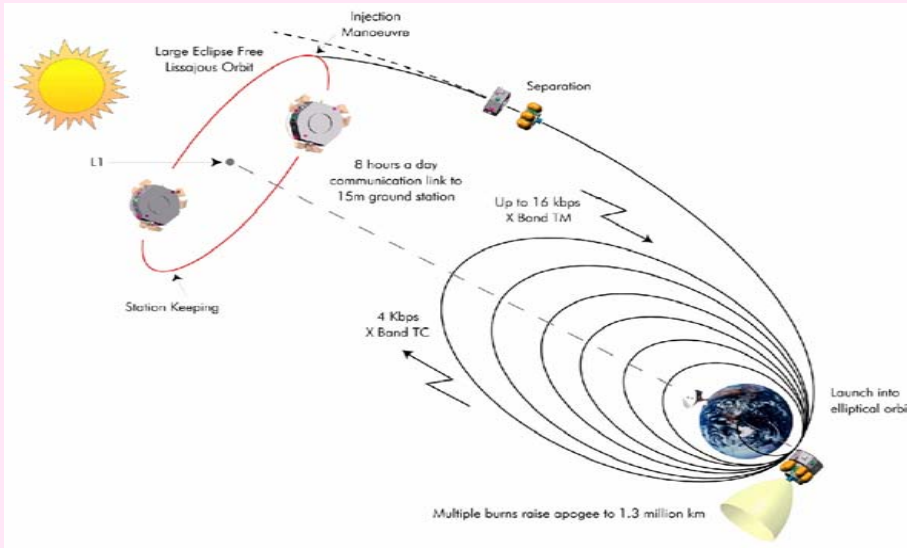
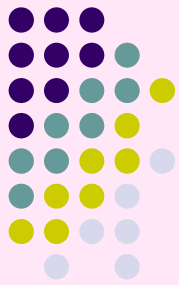
$A < 0$



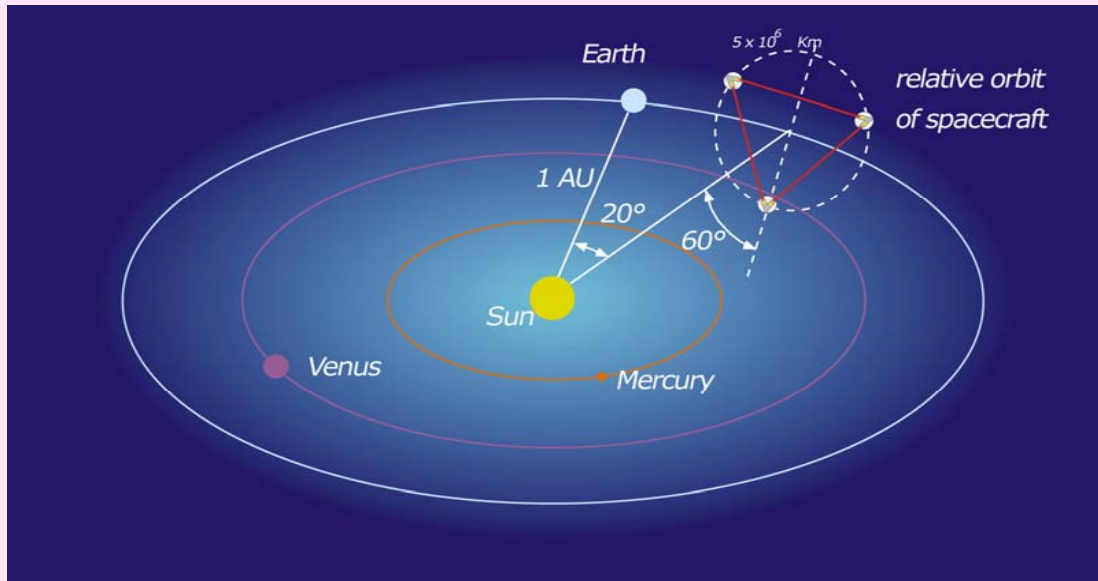
# LISA IN SPACE



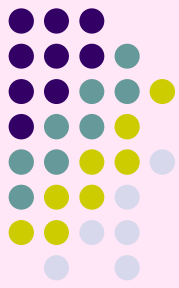
# LISA MISSION CHARACTERISTICS



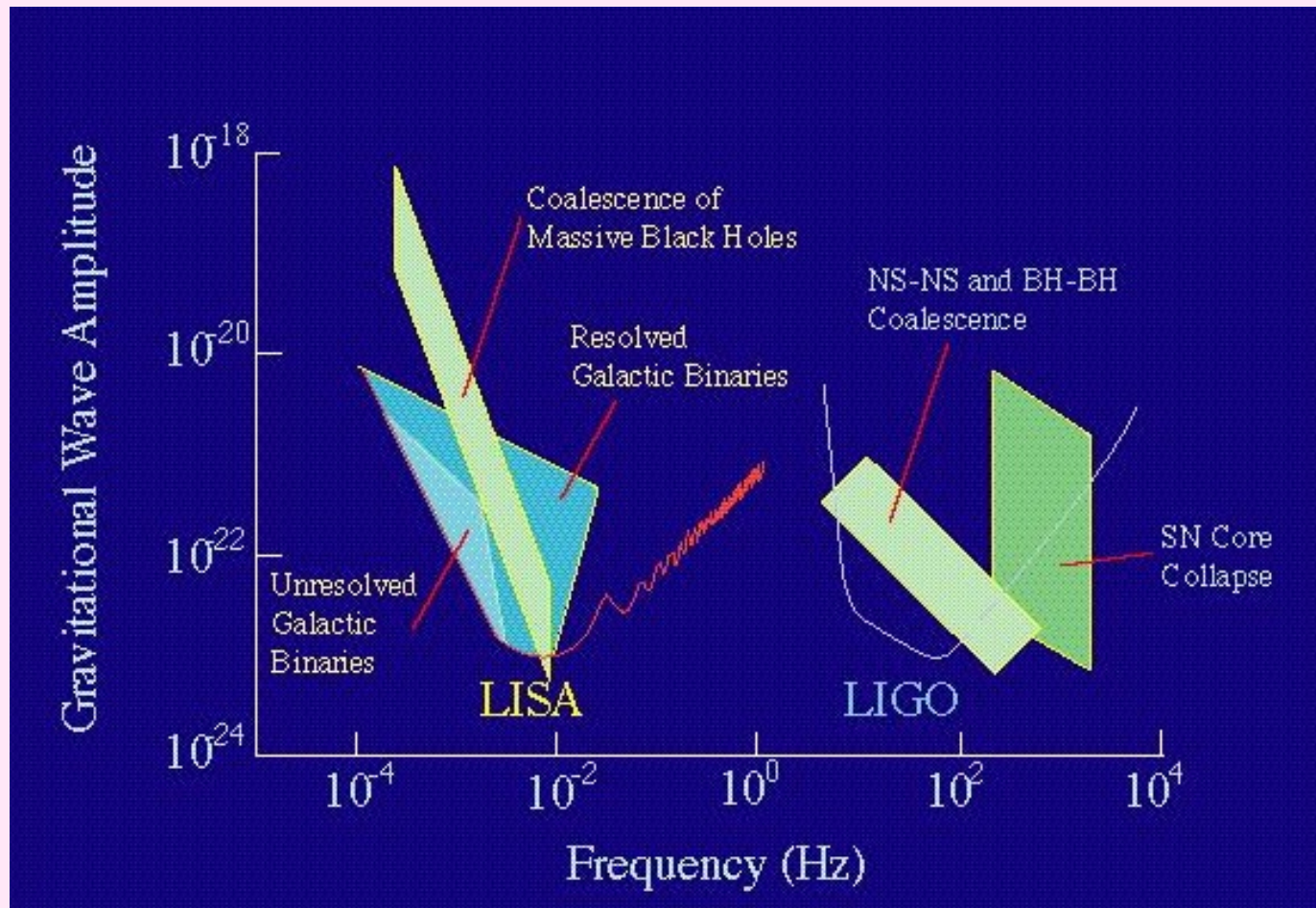
- Distance from the Sun  
 $1.5 \cdot 10^6$  km

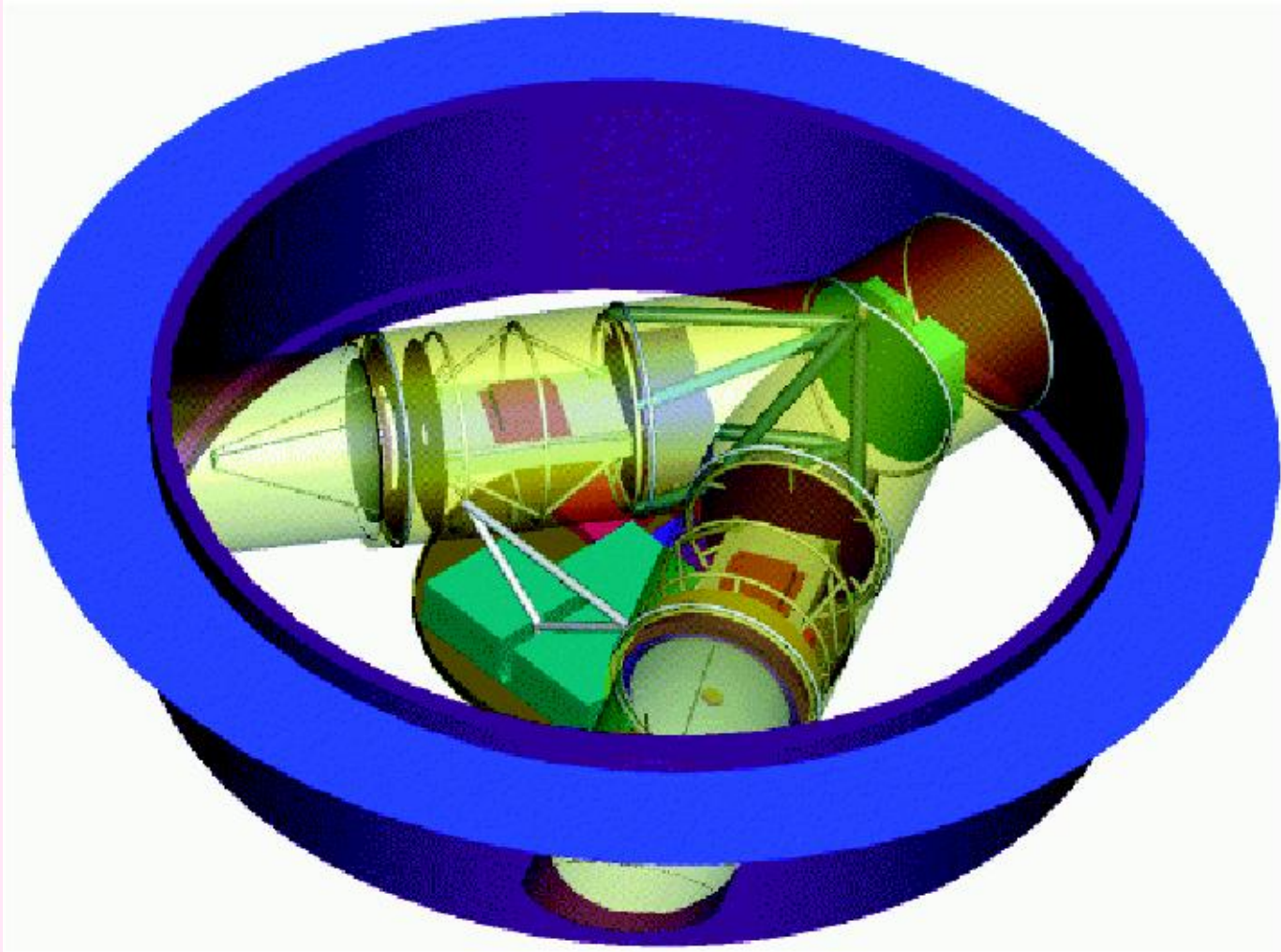
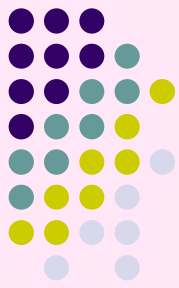


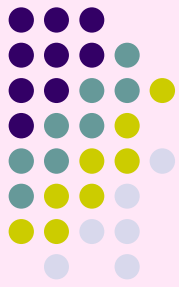
- Distance from the Sun  
0.9933 - 1.0133 AU
- Latitude off the ecliptic  
 $0.7^\circ - 1.0^\circ$
- Longitude difference with respect to Earth  
 $19^\circ - 21^\circ$



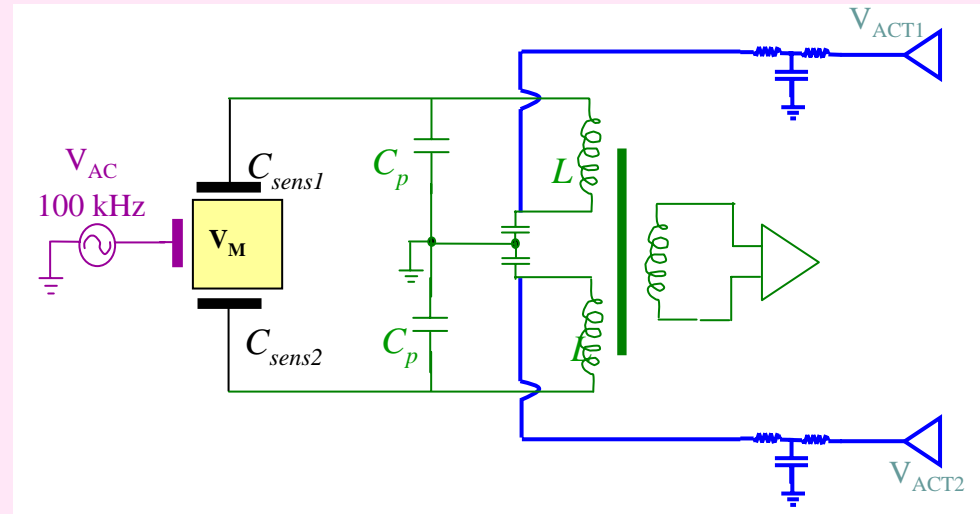
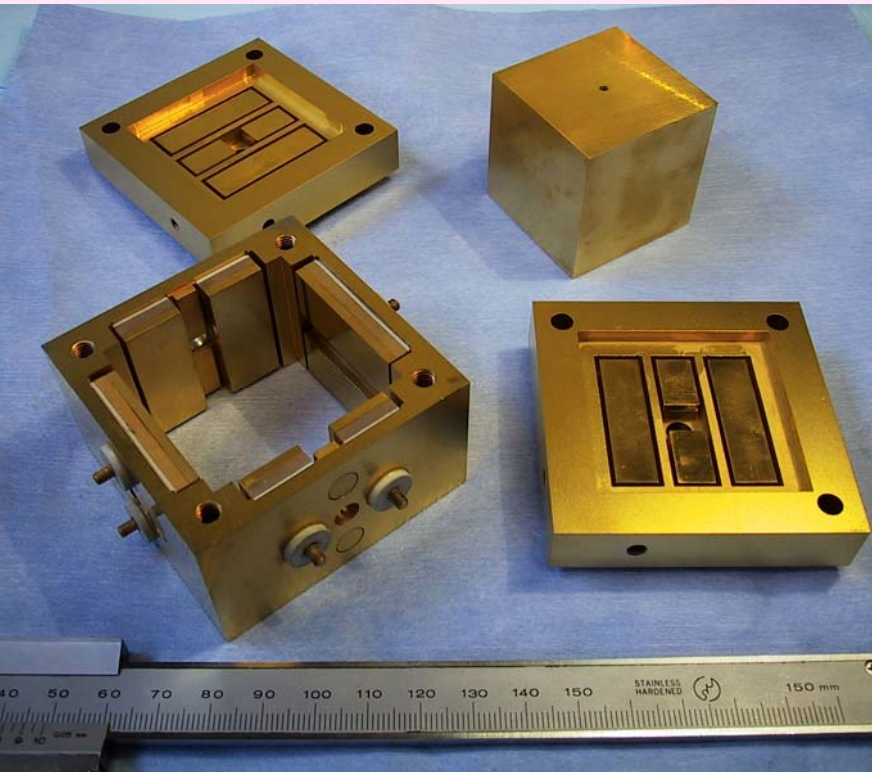
# LISA SCIENTIFIC GOALS



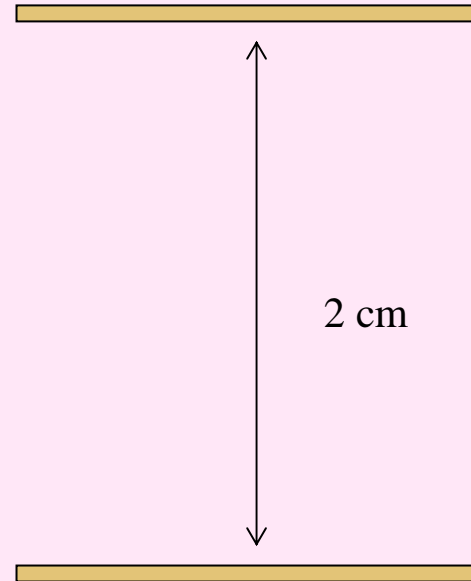
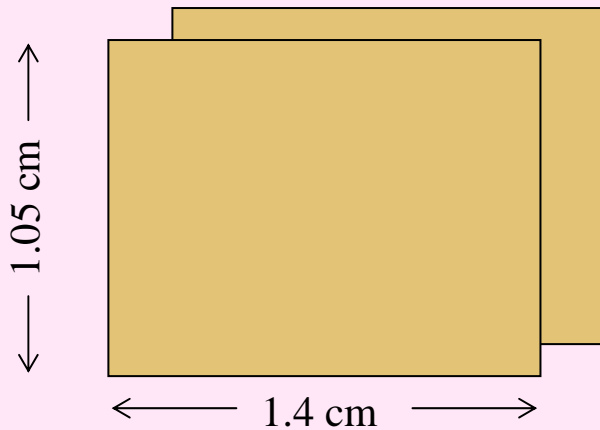
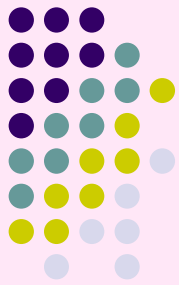




# LISA Inertial sensor and test mass



# SKETCH OF PARTICLE DETECTOR FOR LISA-PF



2 silicon layers

Dimensions:  $1.05 \times 1.4 \text{ cm}^2$

Thickness:  $300 \mu\text{m}$

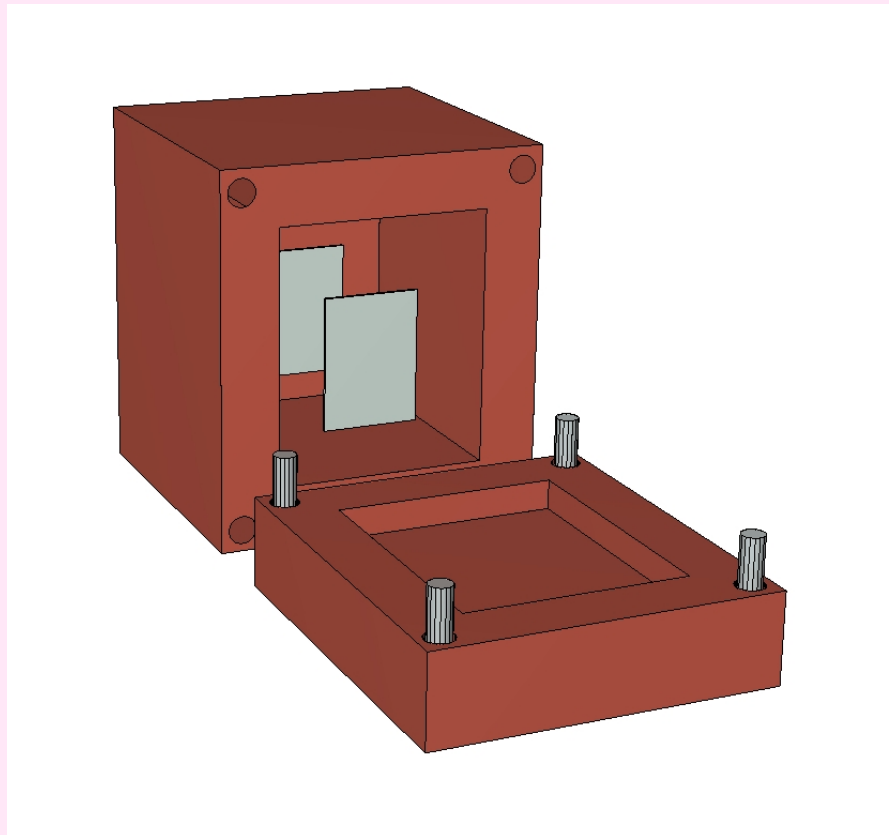
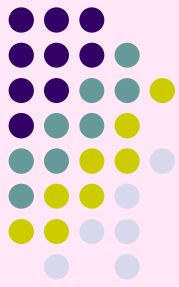
Geometrical factor:

One layer -  $9.24 \text{ cm}^2 \text{ sr}$

Both layers -  $0.87 \text{ cm}^2 \text{ sr}$

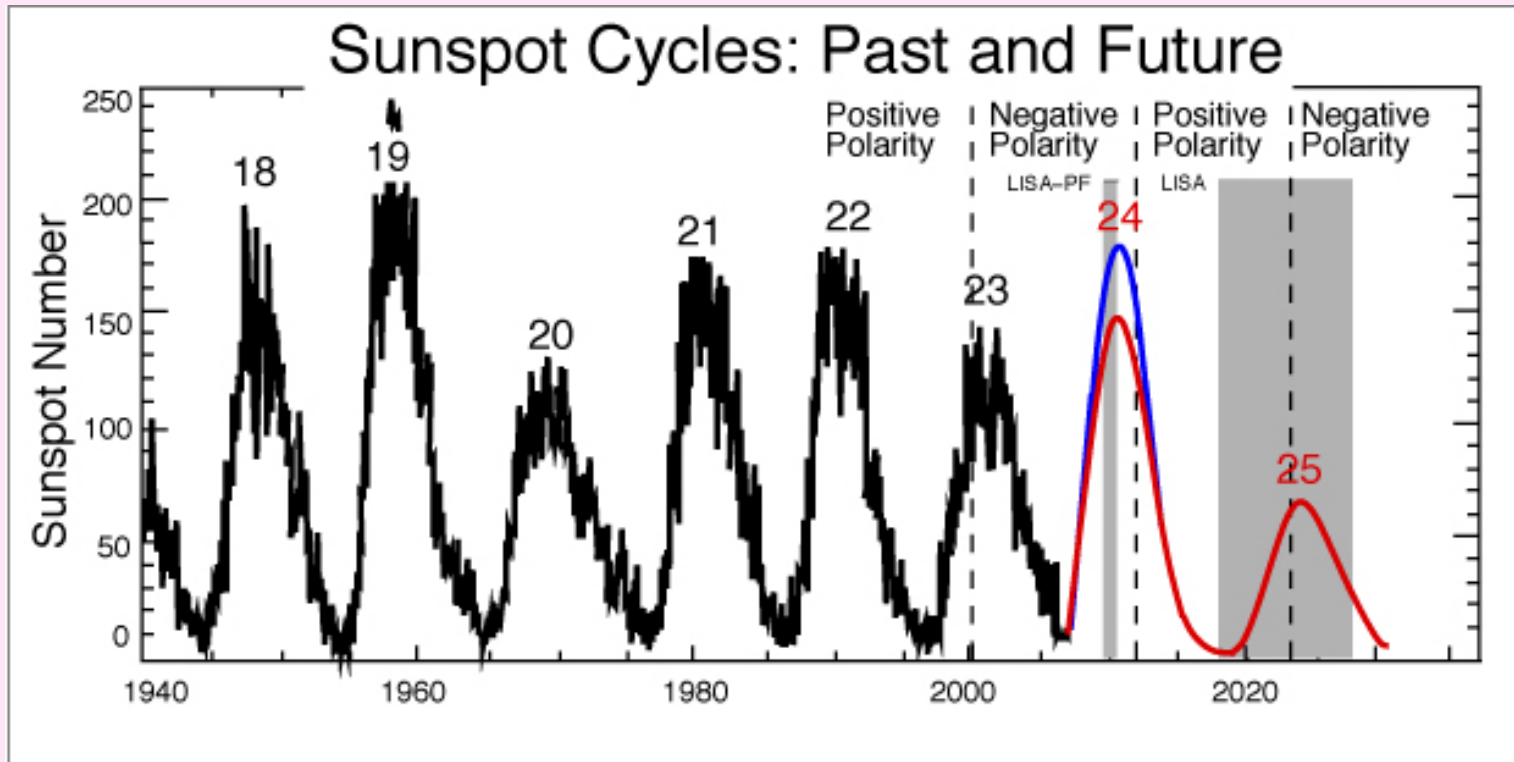
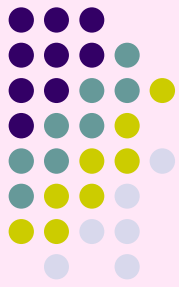
Lobo, 2004

# Radiation monitor countrate and test-mass charging on LISA



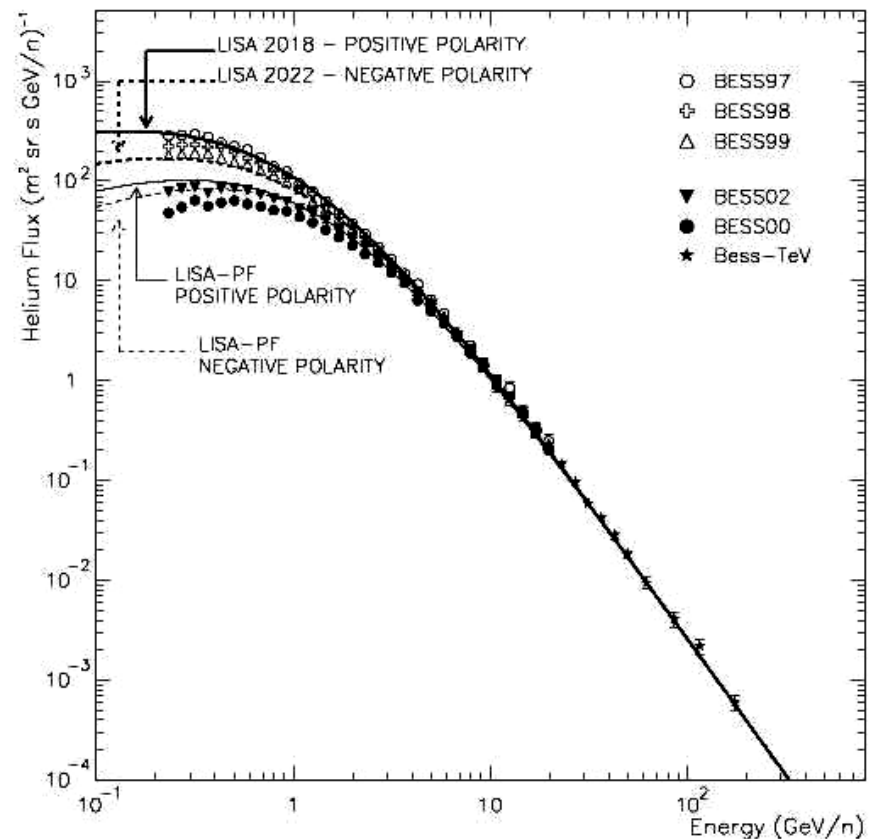
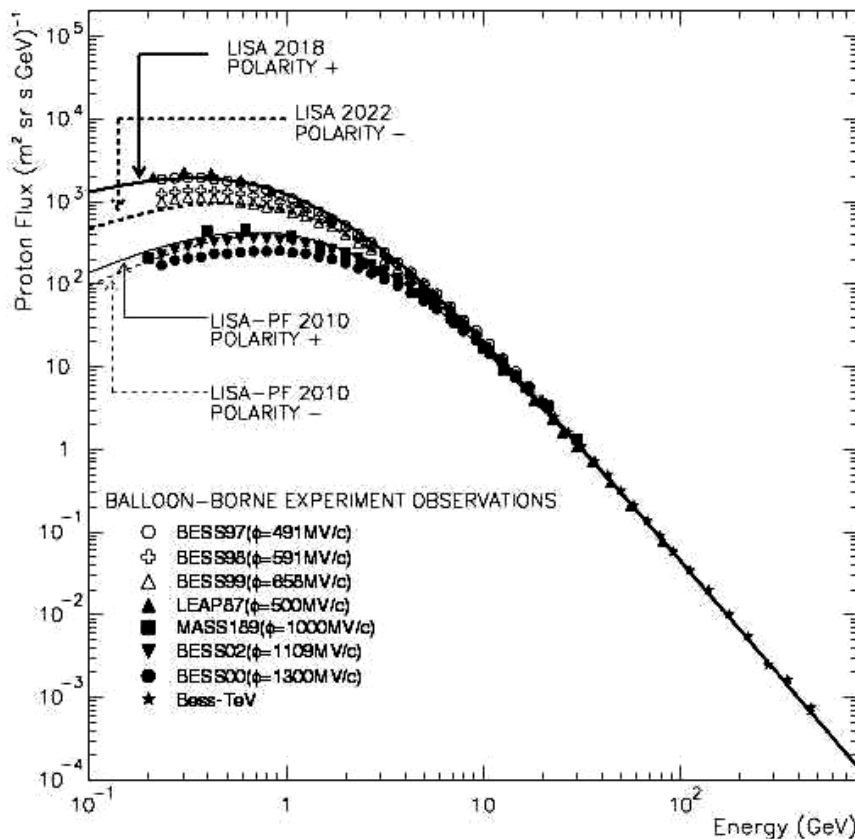
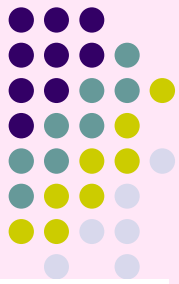
6.4 mm copper box

# Solar modulation during the next two solar cycles



D. Hathaway and Dikpati M. [http://science.nasa.gov/headlines/y2006/10may\\_lagrange.htm](http://science.nasa.gov/headlines/y2006/10may_lagrange.htm)

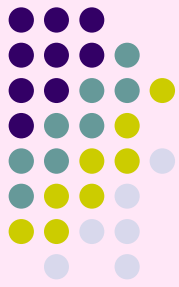
# GCR fluxes at the time of the LISA missions



CG et al., XXX International Cosmic-Ray Conference, Merida, Mexico July 2007

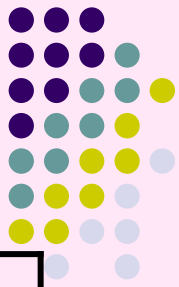
CG et al., 7th Amaldi Conference Sidney Australia July 2007 presented by D. Tombolato

# Proton and Helium flux parameterization at the time of the LISA missions



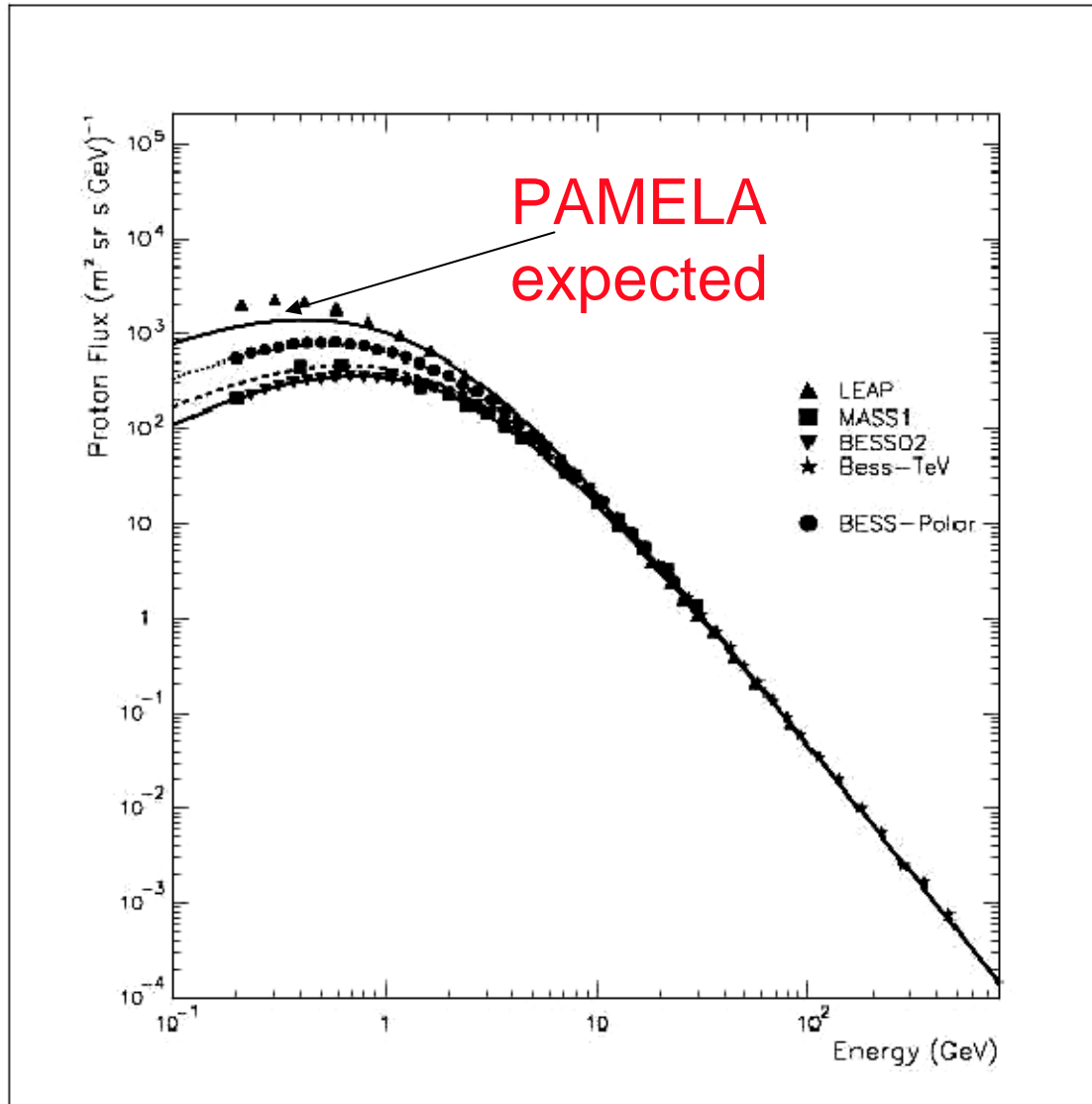
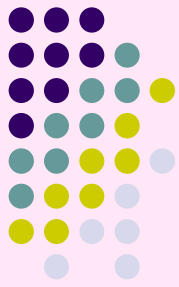
|                                 | Part. | A     | B     | $\alpha$ | $\beta$ | Reduction Factor          |
|---------------------------------|-------|-------|-------|----------|---------|---------------------------|
| LISA-PF<br>Positive<br>Polarity | p     | 18000 | 1.6   | 3.99     | 1.20    |                           |
|                                 | He    | 850   | 1.15  | 3.45     | 0.70    |                           |
| LISA-PF<br>Negative<br>Polarity | p     | 18000 | 1.6   | 3.99     | 1.20    | R1(E)<br>0.1<E<1.6<br>GeV |
|                                 | He    | 850   | 1.15  | 3.45     | 0.70    |                           |
| LISA 2018                       | p     | 18000 | 1.09  | 3.66     | 0.87    |                           |
|                                 | He    | 850   | 0.915 | 3.17     | 0.42    |                           |
| LISA 2022                       | p     | 18000 | 1.27  | 3.66     | 0.87    | R2(E)<br>0.1<E<4.0<br>GeV |
|                                 | He    | 850   | 0.99  | 3.17     | 0.42    |                           |

# Count rate and test-mass charging for the LISA missions (FLUKA Monte Carlo simulation)

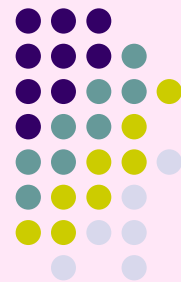


| Mission                                        | Part.           | Test-Mass Charging (%) | Part.     | Radiation Monitor Countrate (%) |
|------------------------------------------------|-----------------|------------------------|-----------|---------------------------------|
| LISA-PF<br>Positive<br>Polarity                | p<br>4He<br>3He | 0.17<br>0.17<br>0.21   | p+4He+3He | 0.40                            |
| LISA-PF<br>Negative<br>Polarity                | p<br>4He<br>3He | 0.13<br>0.11<br>0.18   | p+4He+3He | 0.38                            |
| LISA Sol. Min.<br>2018<br>Positive Polarity    | p<br>4He<br>3He | 1.0<br>1.0<br>1.0      | p+4He+3He | 1.0                             |
| LISA Sol. Max.<br>2022<br>Negative<br>Polarity | p<br>4He<br>3He | 0.53<br>0.50<br>0.51   | p+4He+3He | 0.65                            |

For absolute rates see Araujo et al. Astr. Phys., 22, 451, 2005



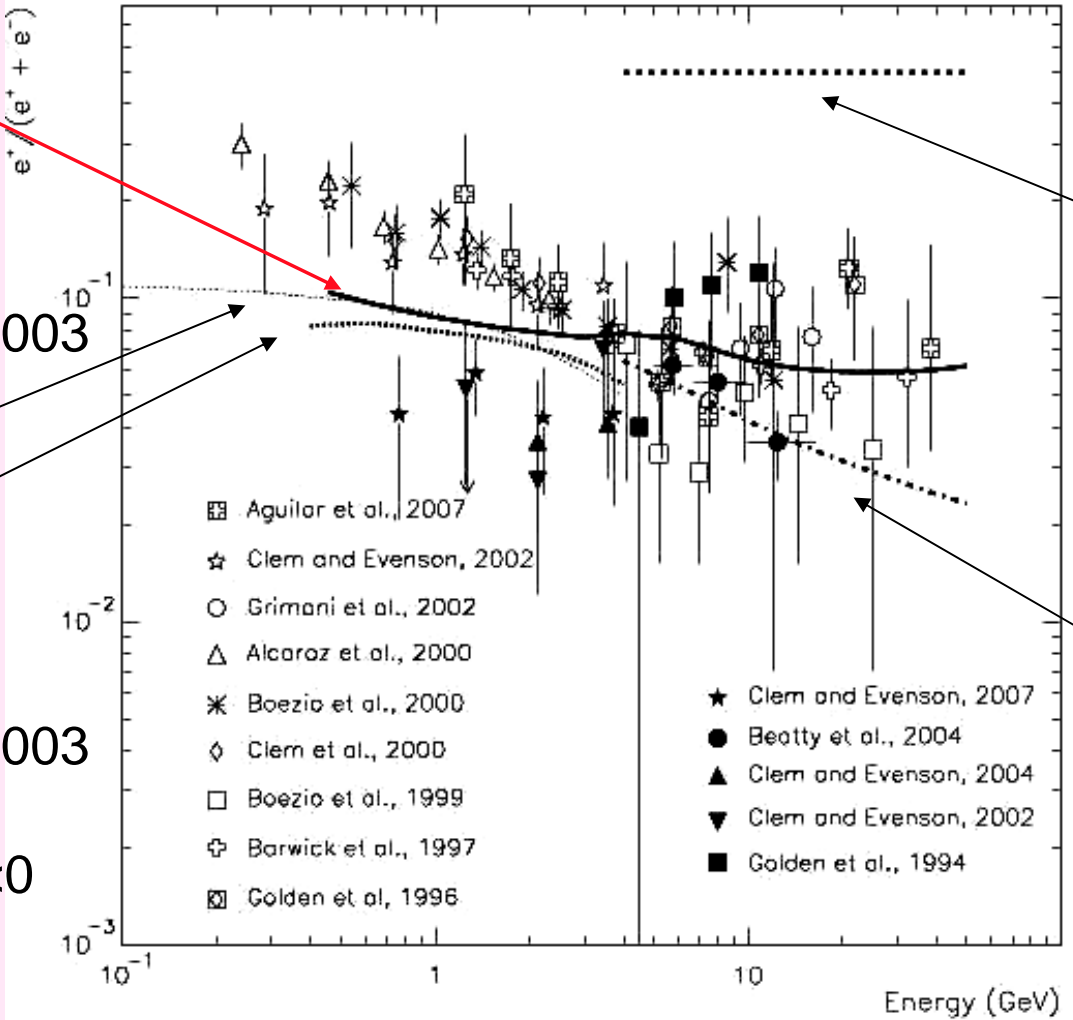
# Positron measurements



PAMELA  
Expected

$e^-$   
Ferreira et al., 2003  
&  $e^+$  M&S98  
 $\phi=1200$  MV/c

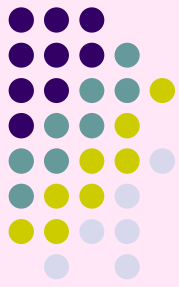
$e^-$   
Ferreira et al., 2003  
&  $e^+$  M&S98  
 $\phi=550$  MV/c  $A<0$



Pulsar  
component

M&S98

CG to appear  
on A&A



**Thank you for your attention!**