Current and future radiation (monitoring) issues from an ESA astronaut perspective

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some thoughts,
speculations,
simulations
and detectors

Radiation Detection and Dosimetry Workshop, Houston, 6 Apr, 2006;

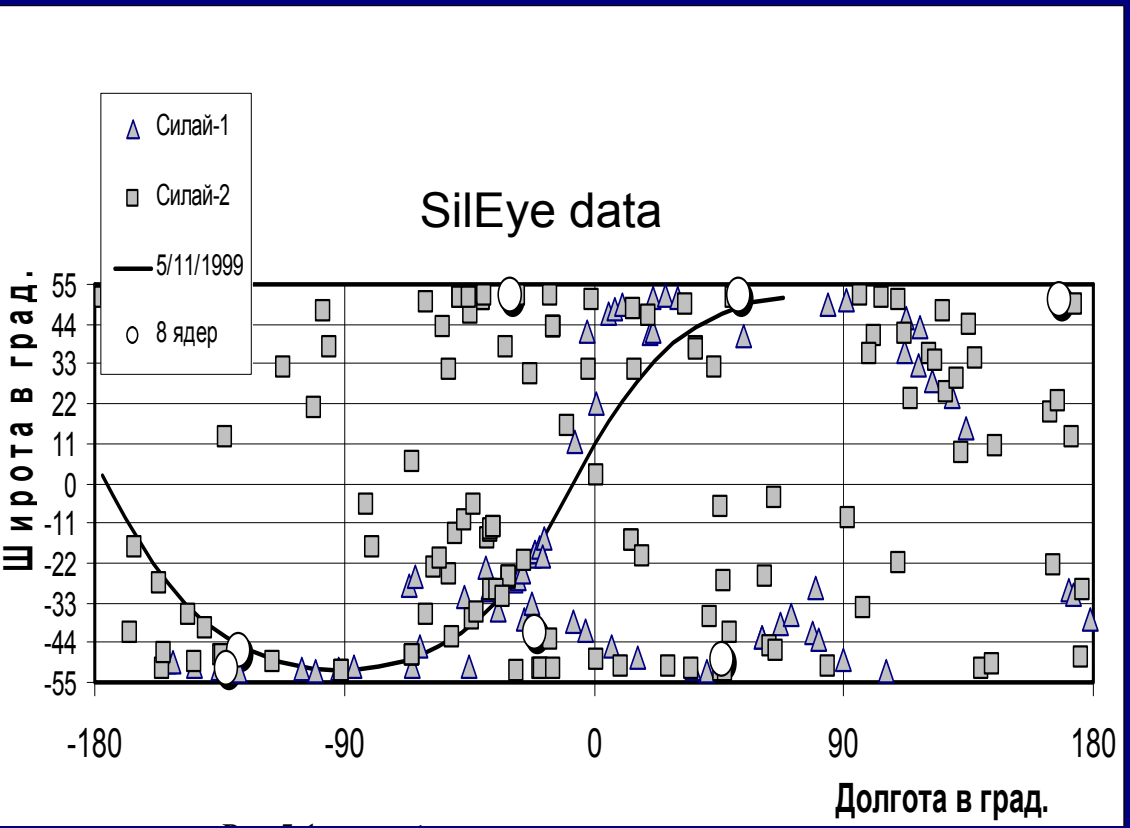
First of all:

On behalf of all astronauts…

Space Travel is risky

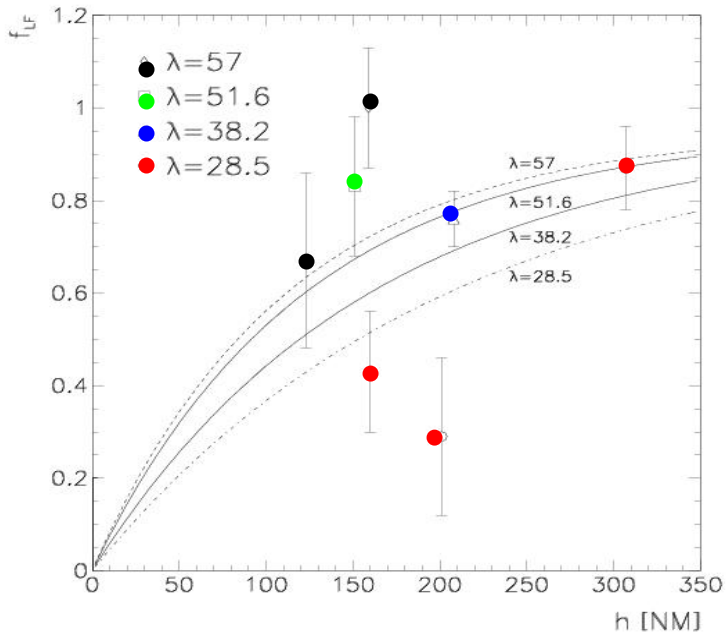
- We do our best to control the risks
- Radiation risks are less known than many other risks
  - Not so big in LEO, except in case of a huge SPE
  - Is a BIG concern for going to Mars and also for extended stays on the Moon (Sci.Am. Mar'06, E. Parker, "Shielding Space Travelers")
  - Maybe a Moon base has to be buried under meters of soil!
  - Not so easy to measure doses
  - Even harder to determine the medical risk for a given dose!
  - To be on the safe side, present rules set reasonably low dose limits (ALARA)
  - The best hope might be that future studies will determine that the risk for a given dose is lower than now feared and/or medication to mediate radiation risk will be found.
- There will always be people ready to take the risk – but is it ethical?
- To control the risk, amongst other things, we have to measure the doses!

Radiation detection by eye



Geographical distribution of Light Flashes observed on Mir

(from S. Avdeev's thesis)

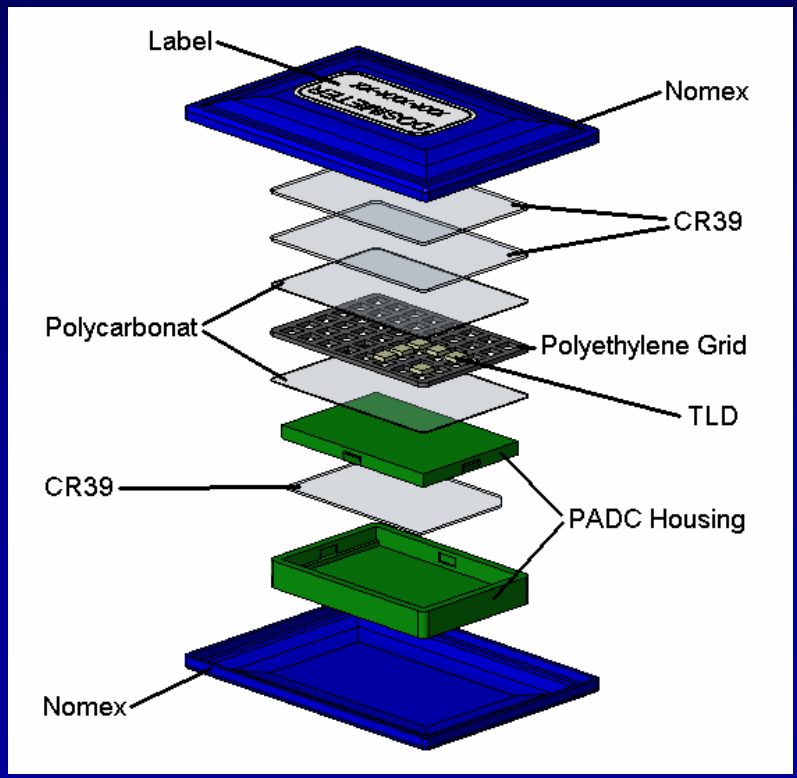


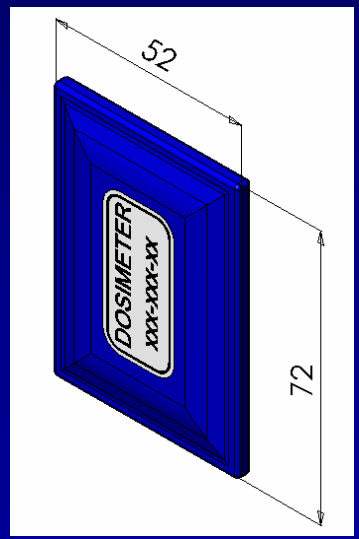
Light Flash probability as a function of altitude and inclination on shuttle flights

(From a survey appearing in April issue of ASEM)

ESA to monitor and operate radiation doses for European astronauts in the future

- Step 1: New “European Crew Personal Dosimeter” (EuCPD) built by DLR, Cologne under contract from ESA/ESTEC
  - “traditional” design with TLDs, PADC, and CR39.



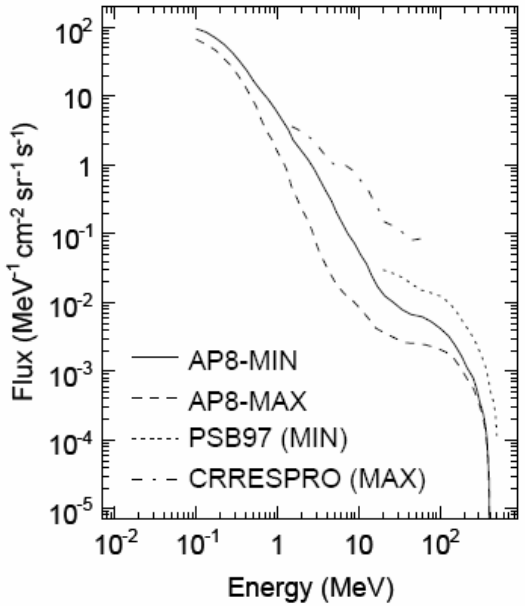


EuCPD, cont.

- Operational implementation by ESA/EAC medical office (U. Straube)
- Verify concept during ASTROLAB (T. Reiter) and STS-116 (C. Fuglesang)
  - will also wear NASA dosimeters to get an intercalibration
  - Each mission brings 5 EuCPDs
- Special EVA-measurements: during STS-116 about 20 hours in 11 days will be EVA.
- Future: Active personal dosimeters.
  - Will be important when going beyond LEO.
  - A challenge to make small enough and still cover all significant contributions: protons, neutrons, heavy ions
  - On the astronaut's wishlist☺

Measurements are good – but we must also be able to predict what doses to expect.

- There is still a lot to learn on calculating doses!
- Uncertainties in radiation environment models ⟶
  - Put as many instruments as possible on all space probes
- Limits in models / programs that calculate the dose given an external radiation field.
  - NASA solves this with numerical solutions of Boltzman transport equations (HZETRN, J.W.Wilson et al.)
  - In Europe we are trying a full scale Monte Carlo method using Geant4. (Having faith in Moore's law☺)
  - Both methods useful and should complement each other. The former is fast, the second can in principle be as detailed as one wish.

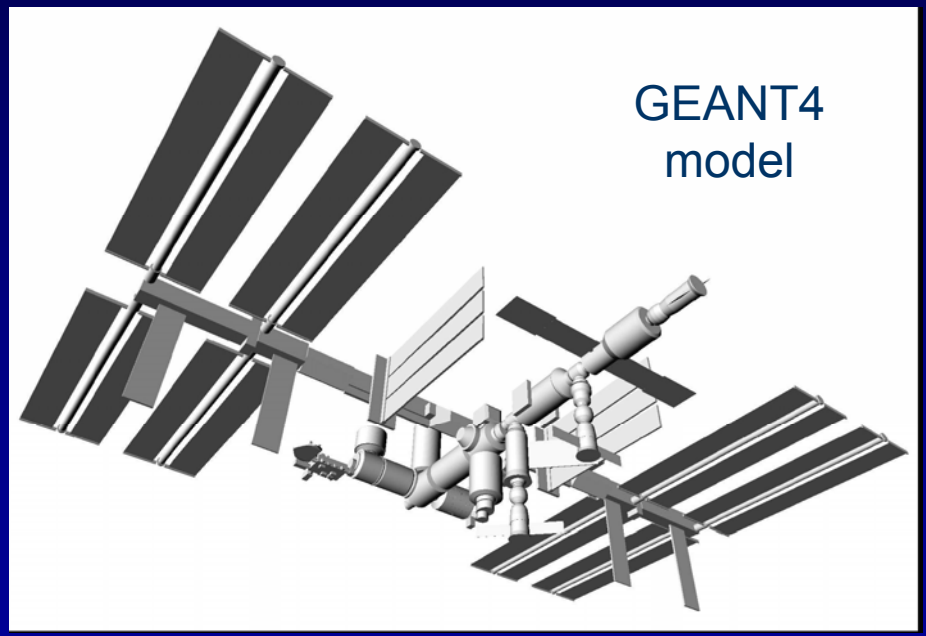


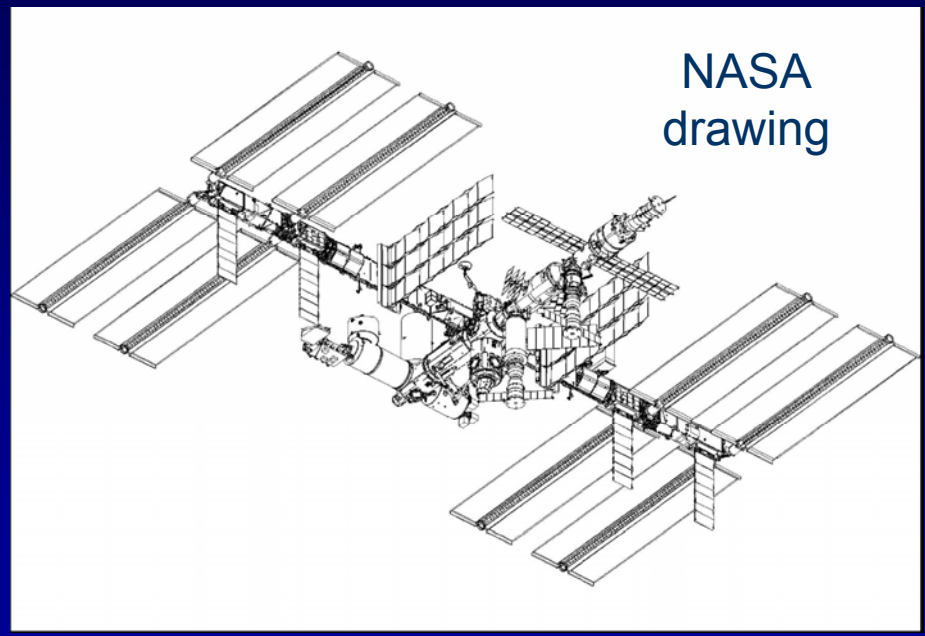
(a) Comparison of models of orbit-averaged trapped proton spectra for 380 km altitude and 51.6° inclination. Solar minimum (maximum) models labeled with MIN (MAX).

D E S I R E

Dose Estimation by Simulation of the ISS Radiation Environment

KTH, Stockholm and ESA
Tore Ersmark et al.

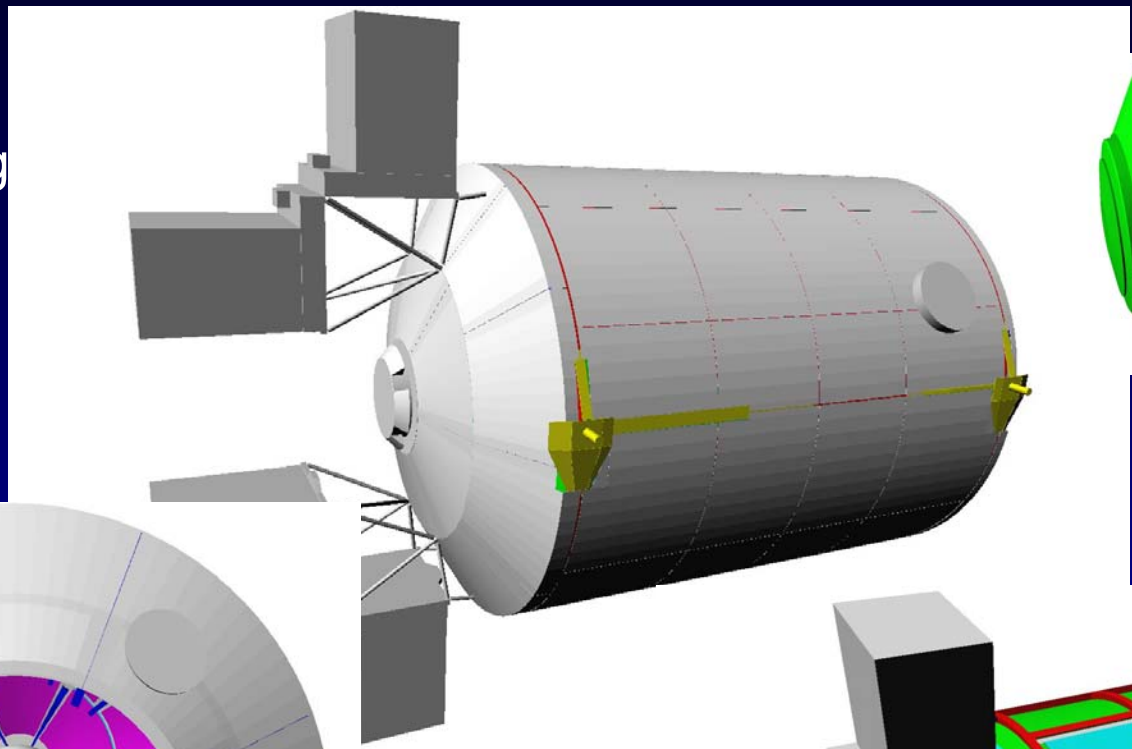


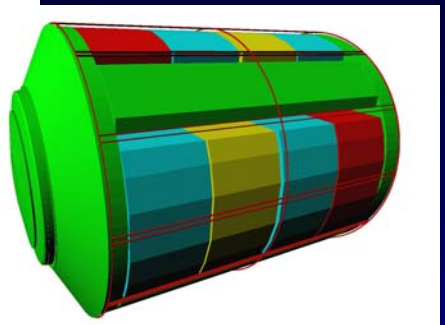


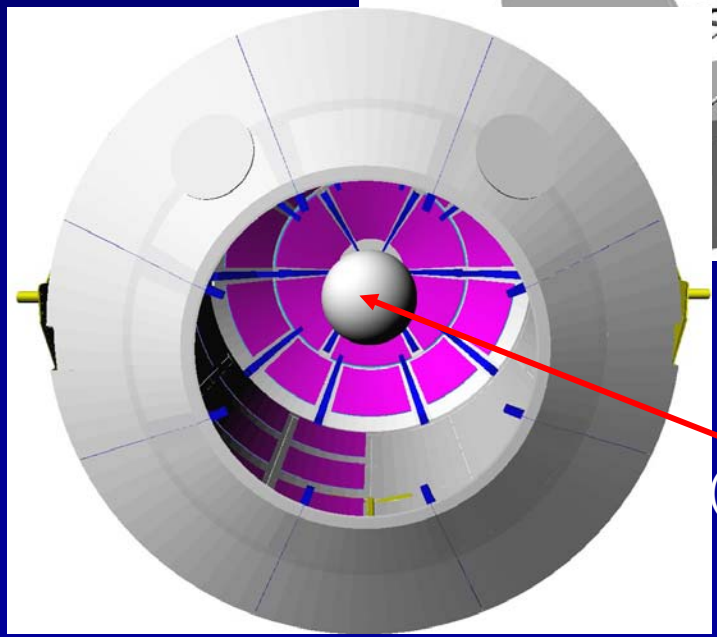
ISS (stage 14A) - 350 volumes
- 352 tons

The “Columbus3” Geant4 geometry

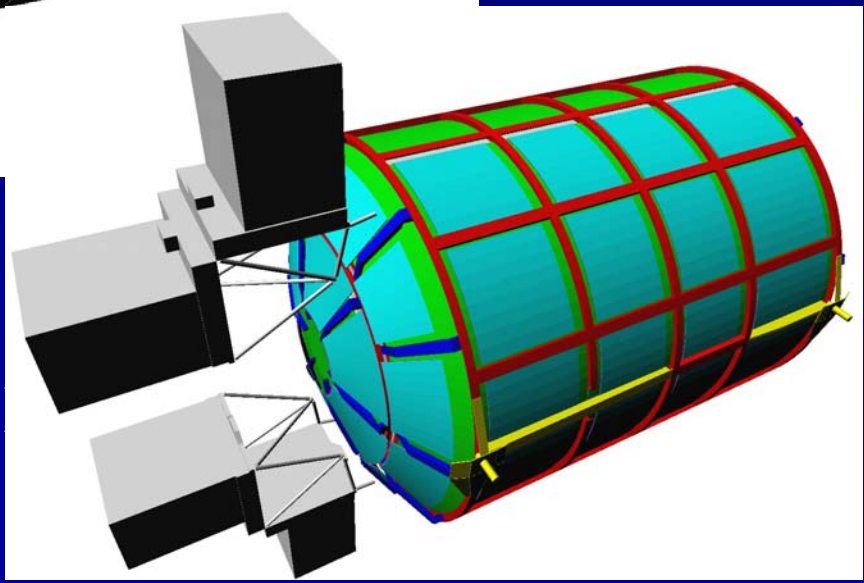
- 750 volumes
- 16750 kg
- Detailed geometry





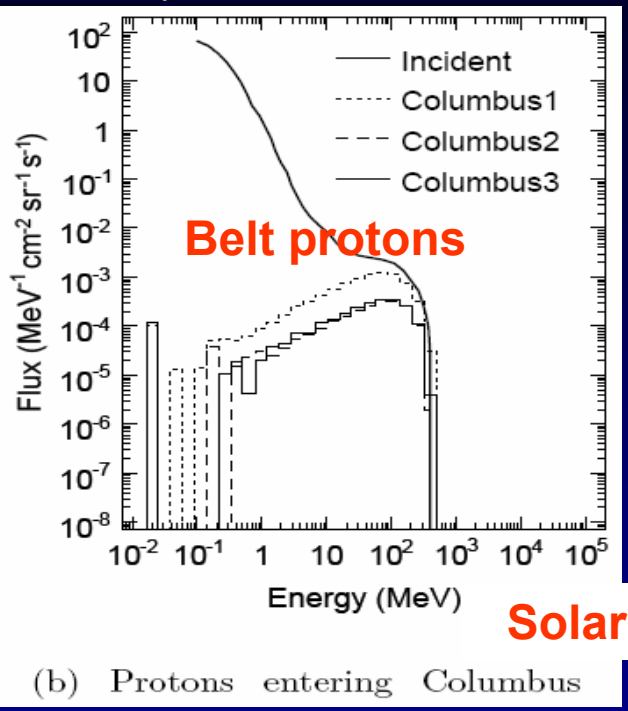


“Dosimeter”
(ICRU-sphere

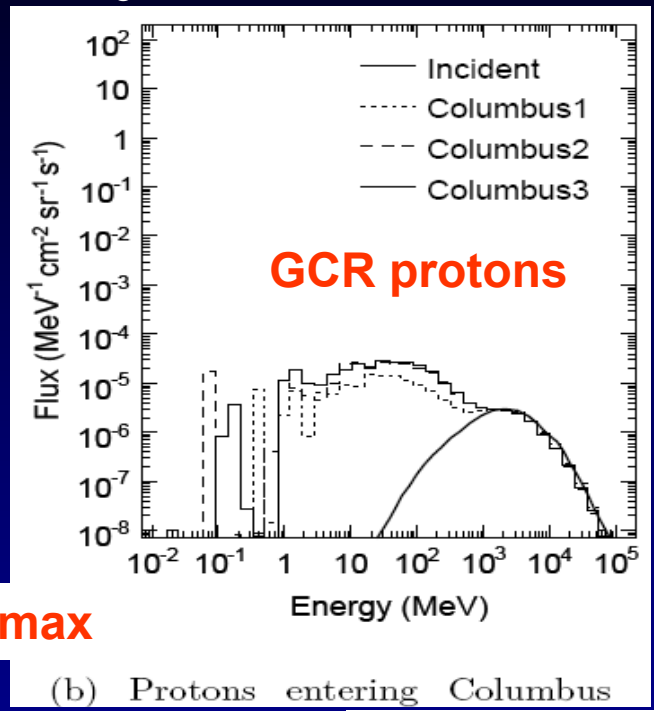


"Implementation of a detailed Geant4 geometry model of the International Space Station and the Columbus modul"

Paper submitted to Rad. Meas. detailing the Geant4 model and illustrated by some radiation examples



(b) Protons entering Columbus



(b) Protons entering Columbus

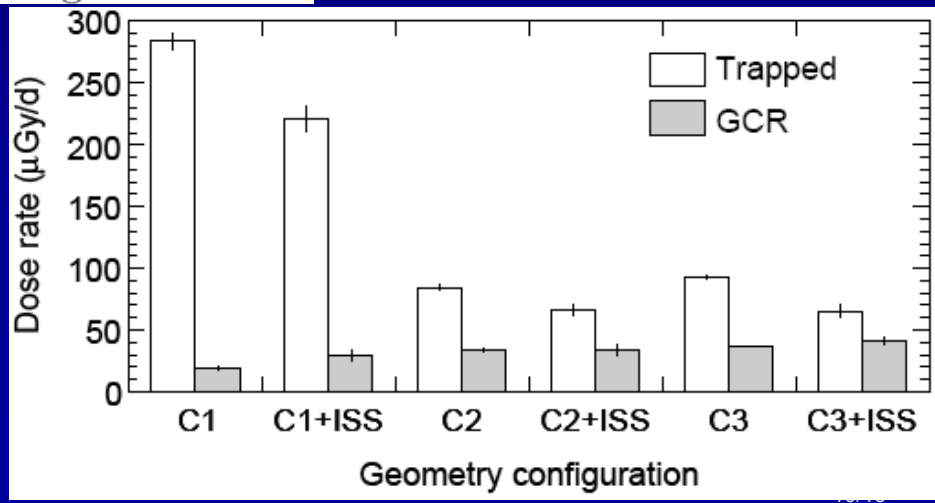
Solar max

- Columbus1: only "shell" - 10 volumes
  - 4400 kg
- Columbus2: Simplified Col3 with only 23 volumes (same mass = 16750 kg)

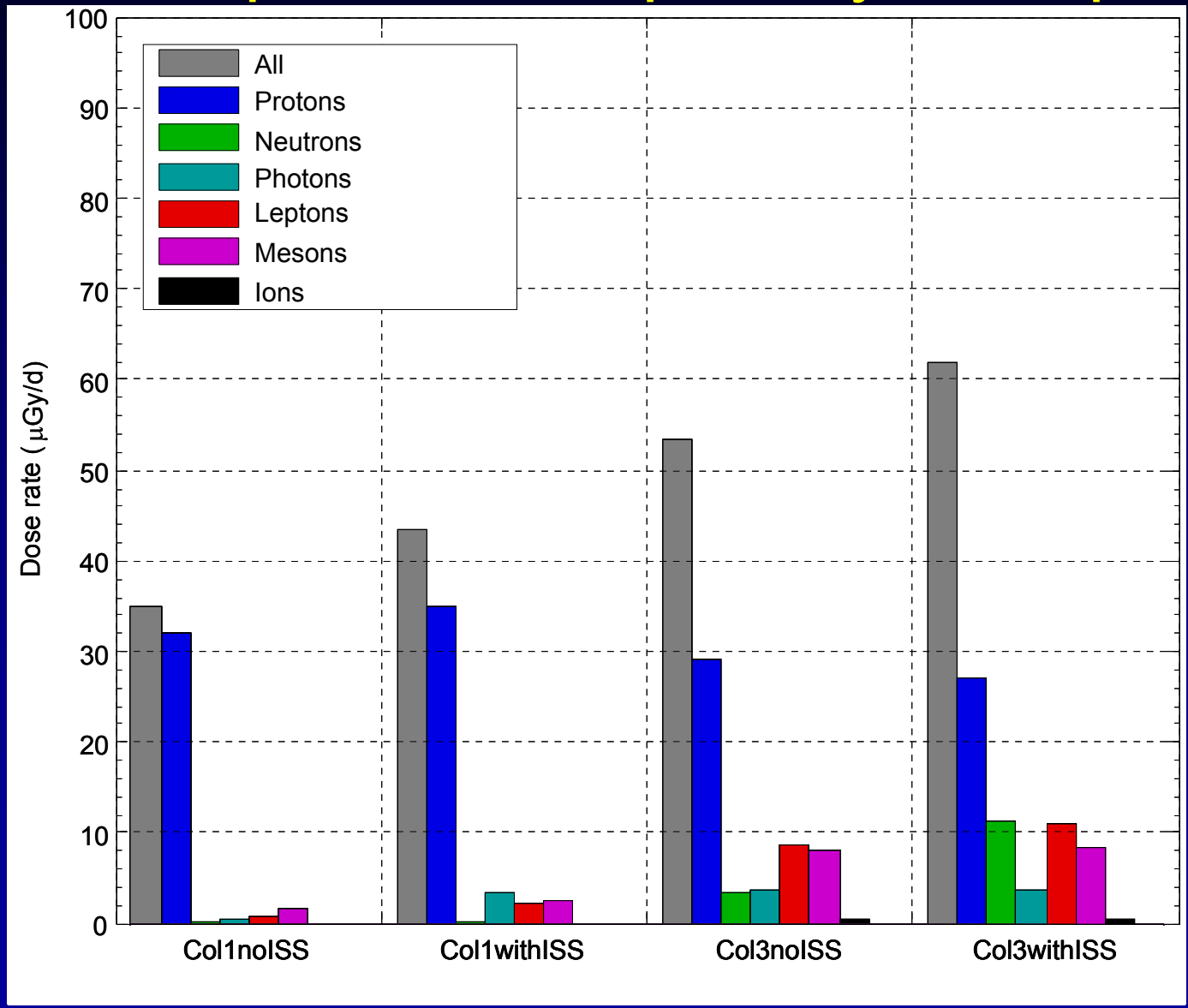
Increased shielding => decreased dose for belt p:s, but increase dose for GCS p:s!

ISS data: ~ 160 μGy/d

Ions still missing in simulations



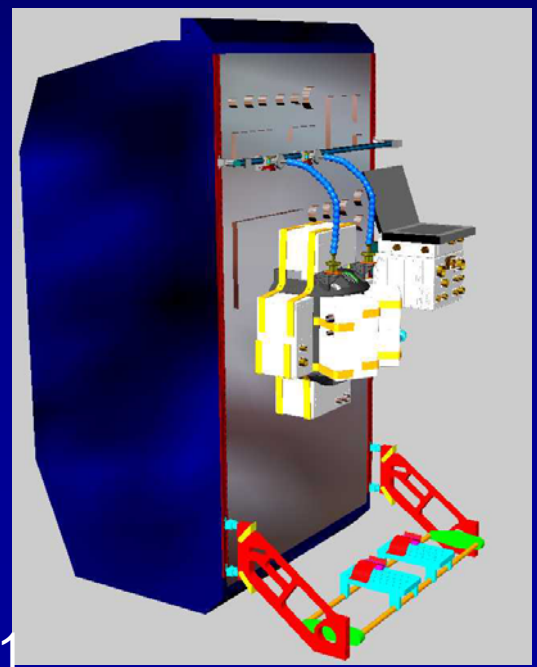
Dose contribution from different secondary particles species from primary GCR protons



Next

- Compare DESIRE predictions with detailed ISS data: Alteino/Altcriss, ALTEA, EuCPD,…
  - This part will include making Geant4 model of detector(s) and data analysis
- Fine-tune DESIRE and/or Geant4 (if necessary)
- Apply on exploration vehicles (Aurora)
  - Search for good radiation protection strategies. (Magnetic shielding?)

Alteino/SilEye3 – taking data on ISS now (Altcriss)

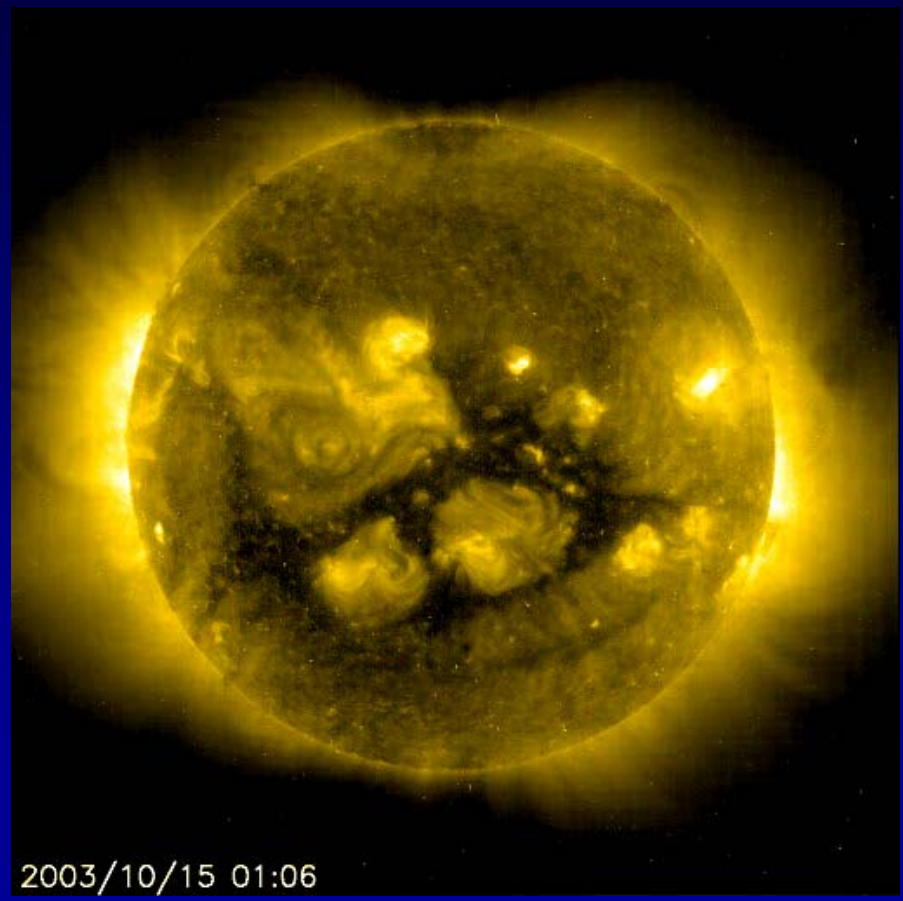


ALTEA – to be launched on STS-121

Space weather

- Particular concern for astronauts: **Solar Particle Events**
  - Bad news (1): Huge amount of particles
  - Good news: Few with E> 1GeV => Can shield with reasoanble amount of material
  - Bad news (2): Impossible to predict in advance (although solar activity will tell something about the likelihood)

- Best we can do is to monitor the sun and the interplanetary space.
  - Some effects may give up to a day or two of forewarning before a solar storm hits.



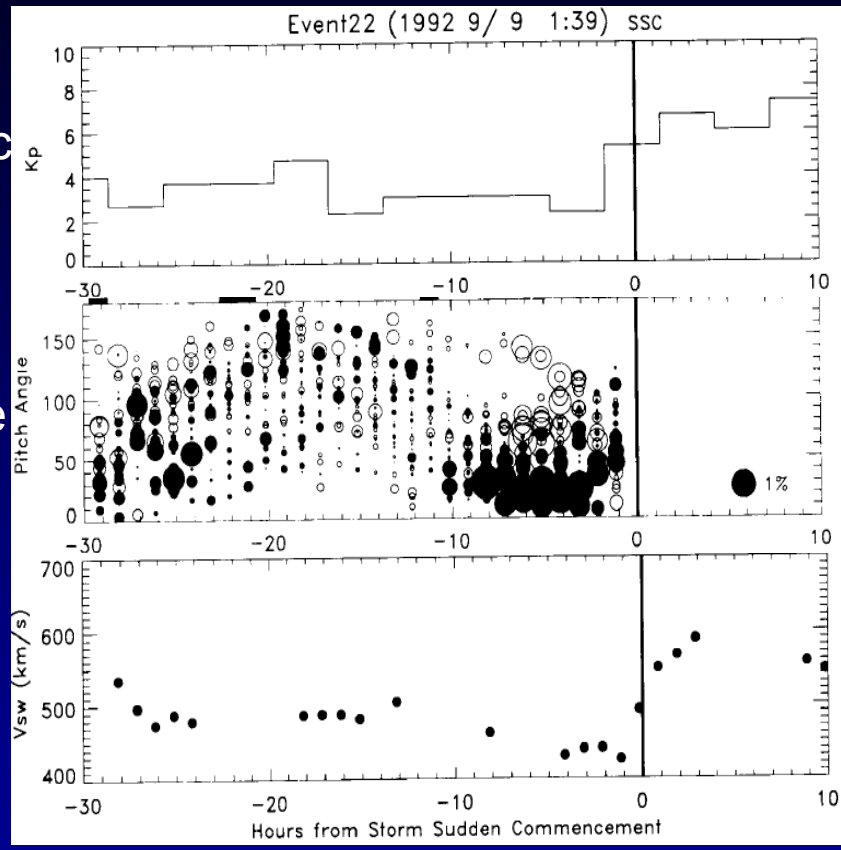
Muon rate anisotropy monitoring on ground

- Global network (Japan, Australia, Antarctica, Brazil)
- ESA supporting a new muon detector in Germany (MuSTaNG)

Geomagnetic field index

Muon rate deviation

Solar wind speed



Munakata K. et al. J. Geophys. Res. 105, A12, 27457(2000)

Don't know how well this could work, but some kind of "storm warning system" is desirable

Conclusion

- Europe & ESA are involved in all aspects of radiation issues
- The more we can measure and monitor, the better – the question rather is how much can we afford, or need?
- Measurements, theories, calculations – it all has to come together.
- Largest uncertainty still is medical risks given the dose.

We ARE going back to the moon, and then further.

We NEED to know and control the radiation risks!