The Columbus Radiation Environment & Effects Package (CREEP)

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CREEP Objectives

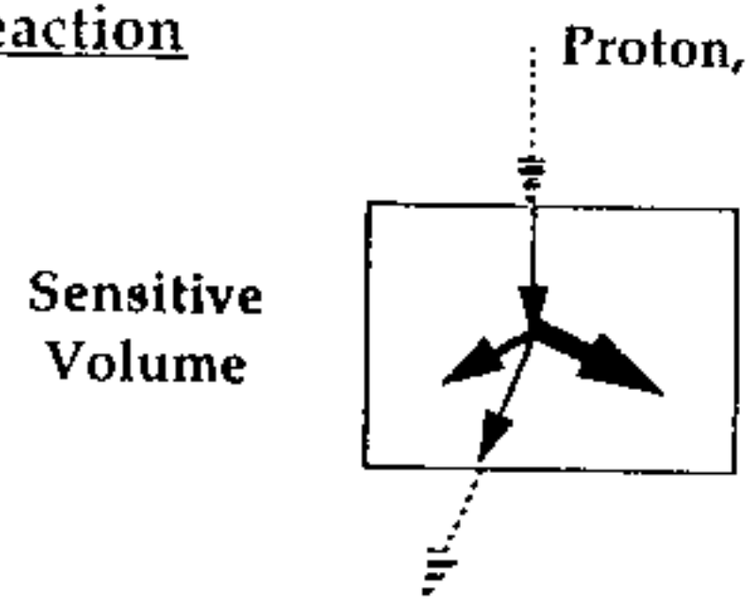
- characterize environments and effects of concern for:
  - other **payloads** (e.g. background, sensor degradation)
  - **systems** (e.g. SEU, latch-up, damage)
  - **long-term utilisation** (well characterized envionment with technology effects)
  - **crew** (long term database of *primary* quantities) space radiation problems will become increasingly important
- ISSA early-utilization will be at **solar maximum** (e.g. solar events)
- provide data for **modelling** (i) environment (ii) shielding
- provide comprehensive **effects data**, with ground **correlations**
- flight test **important space technologies** for wide application

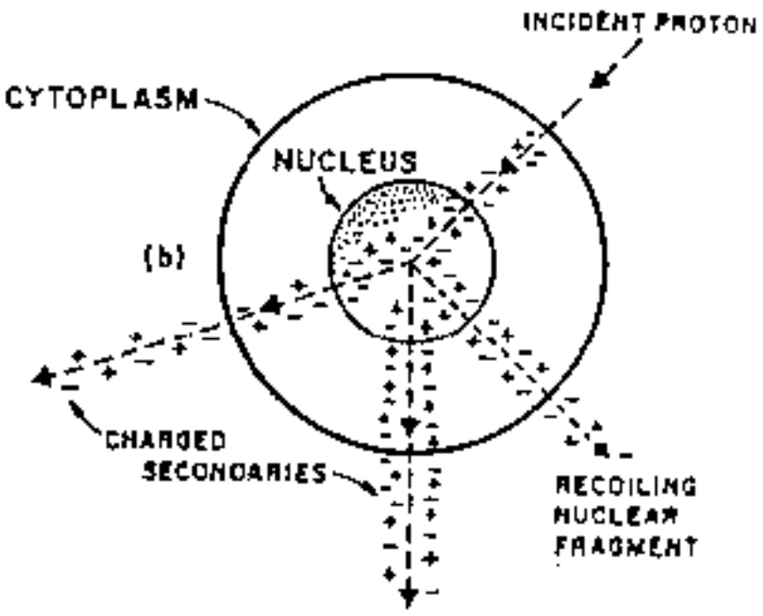
Key problem areas

- ISSA radiation environment interacts with B-field and atmosphere: time-dependent modulation; asymmetries;
- models currently poor;
- 52° orbit exposed to cosmic rays, "solar flares";
- energetic proton effects: SEU; damage; background;
- radiobiological effects to crew;
- radio-activation
- shielding effects and secondary radiations
- "space weather" systems in context of station use and crew protection

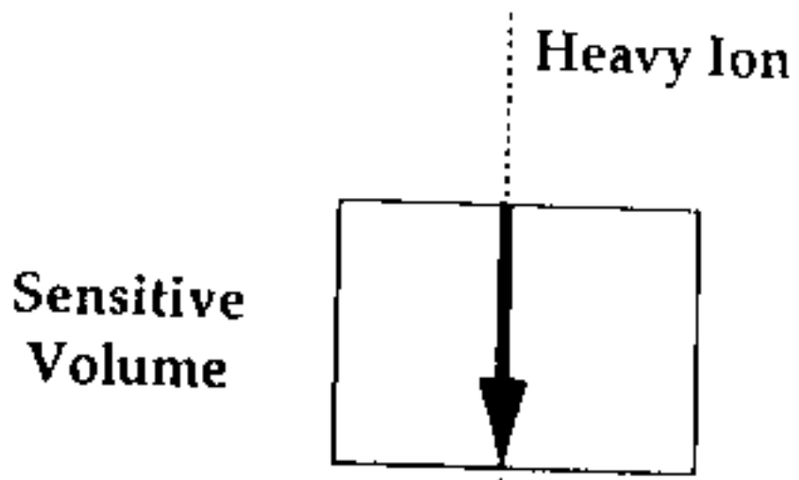
SINGLE EVENT EFFECTS & RADIOBIOLOGICAL EFFECTS

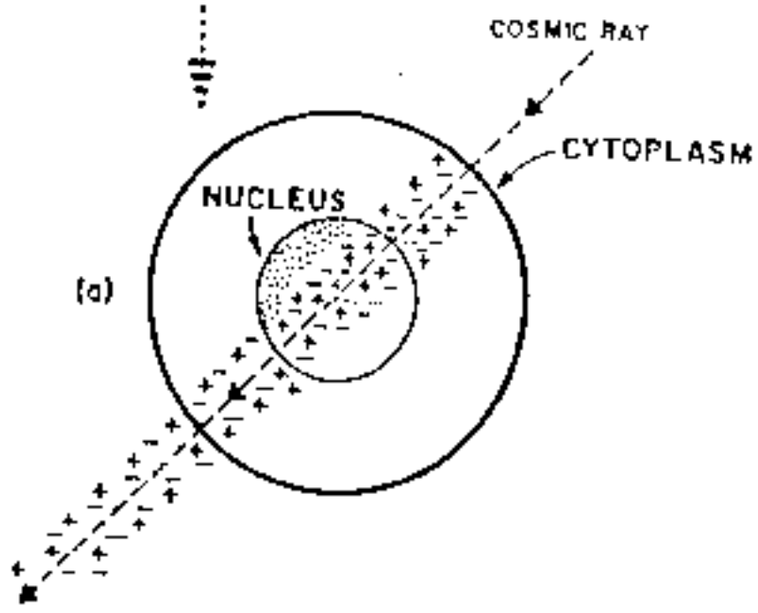
Nuclear Reaction





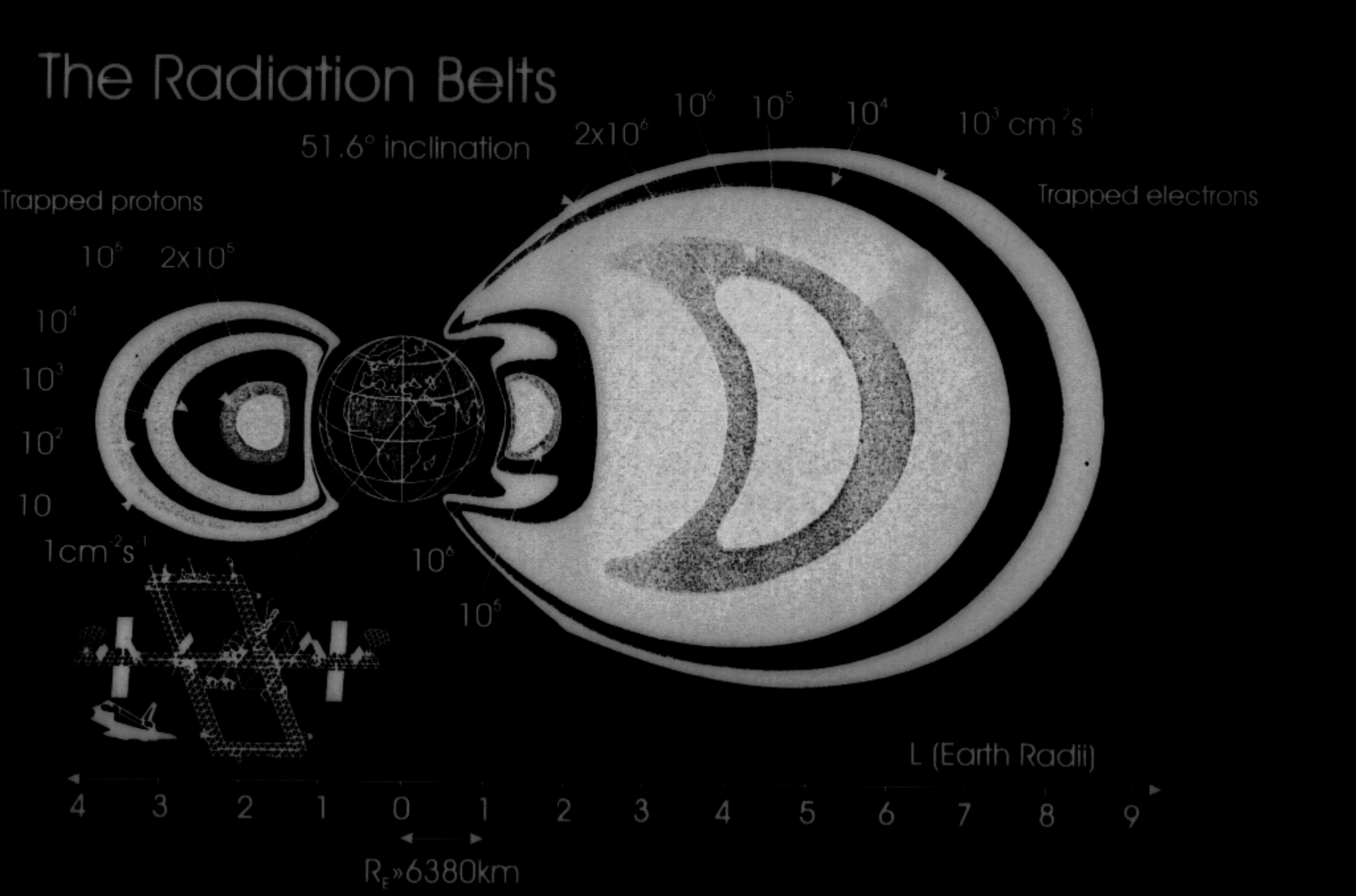
Direct Ionization



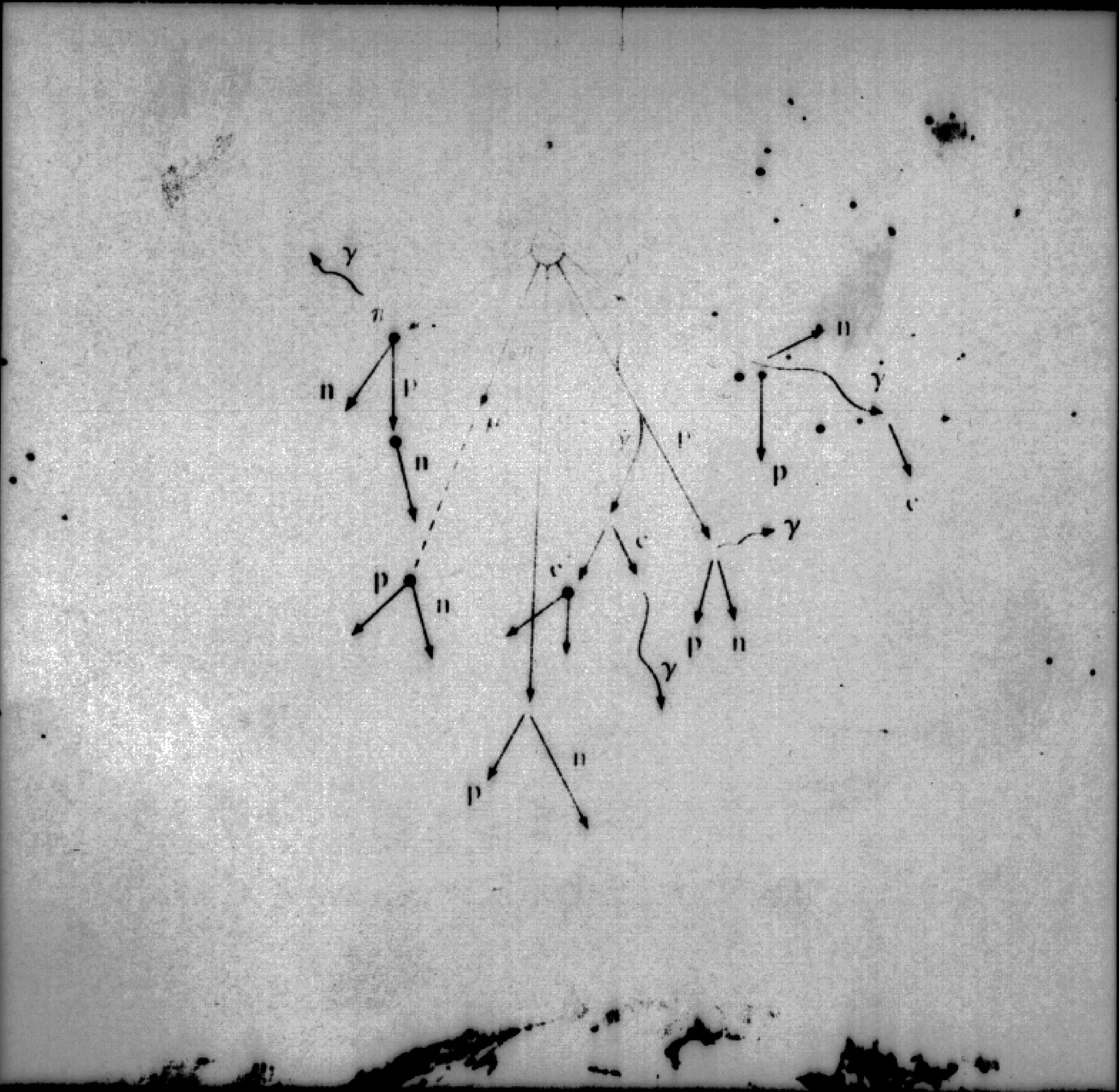


DERA

The Radiation Belts



High inclination LEO missions intersect radiation in the South Atlantic Anomaly and the 'horns' of the outer belt



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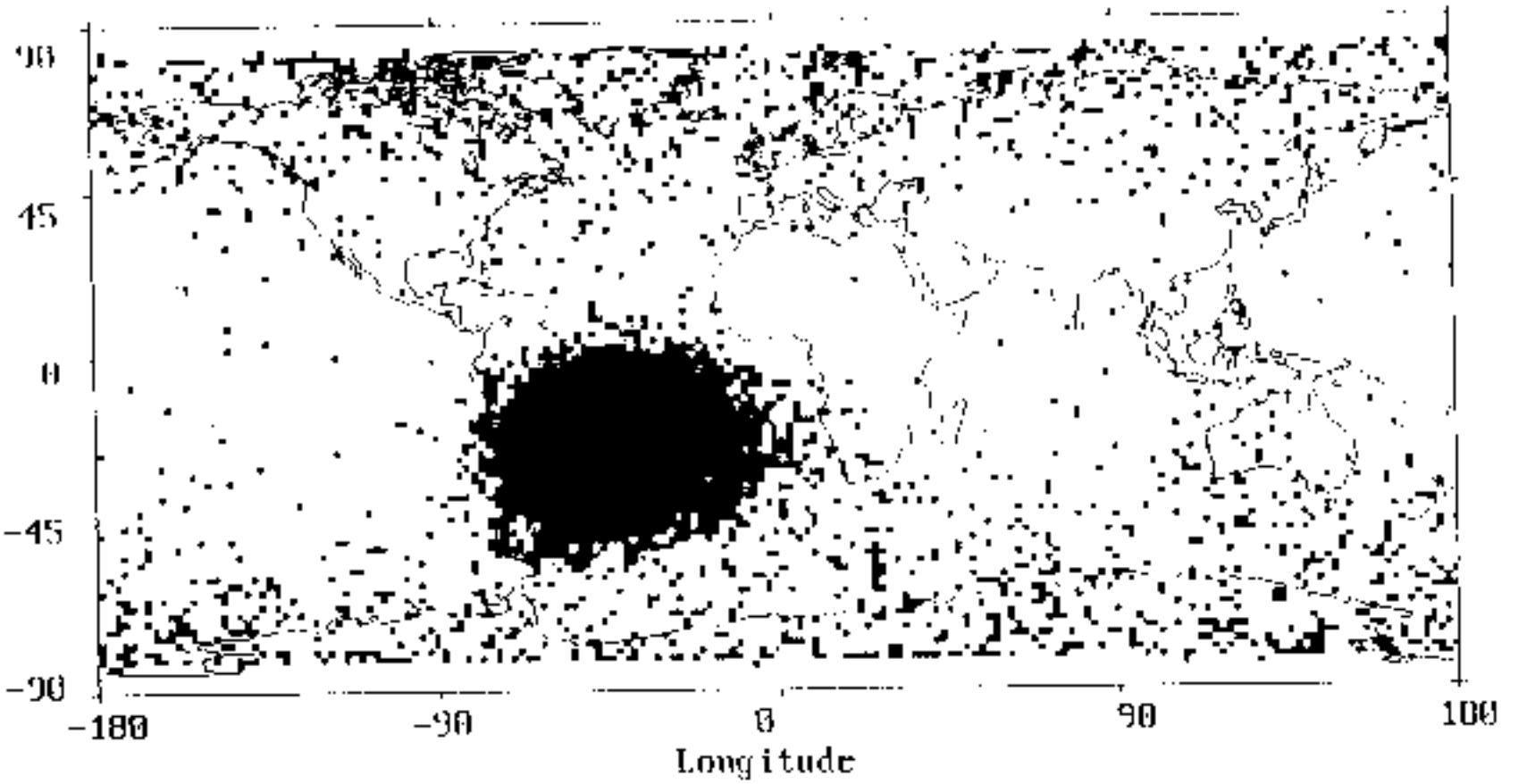
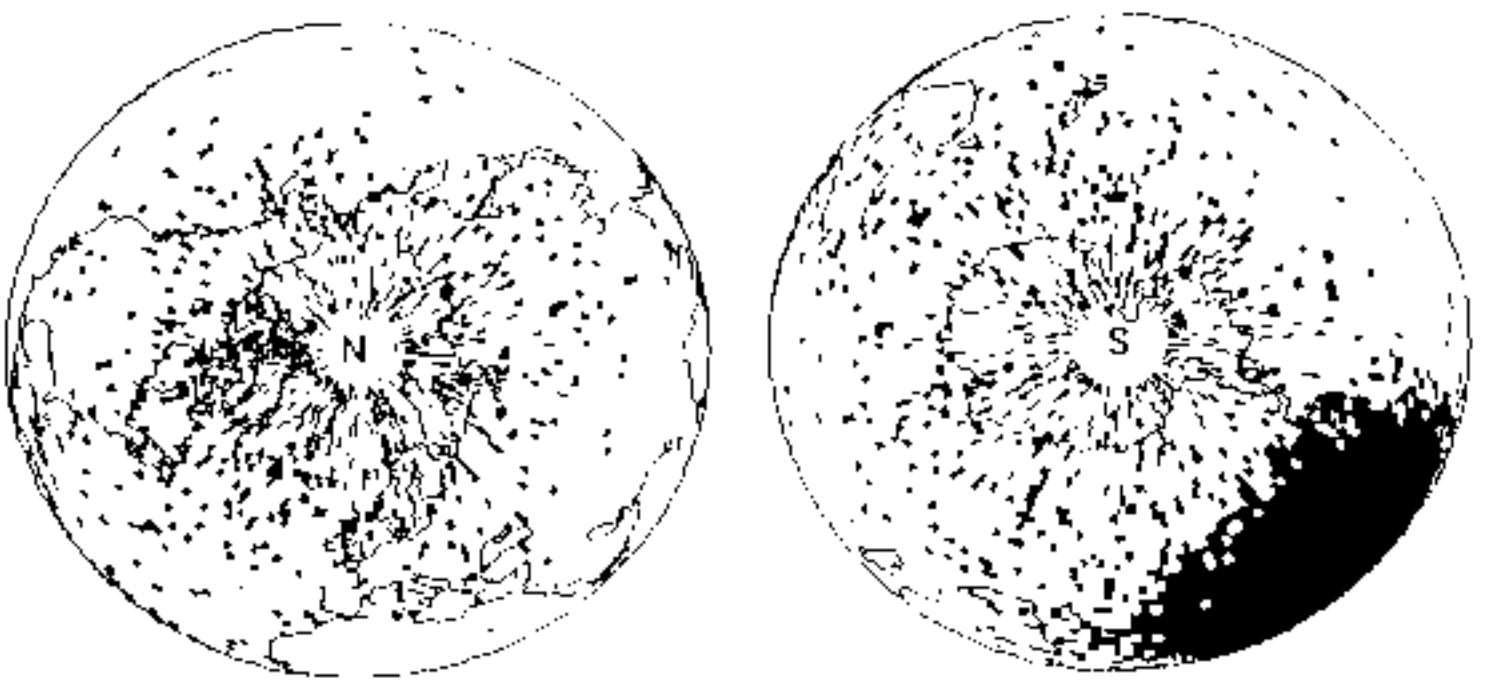
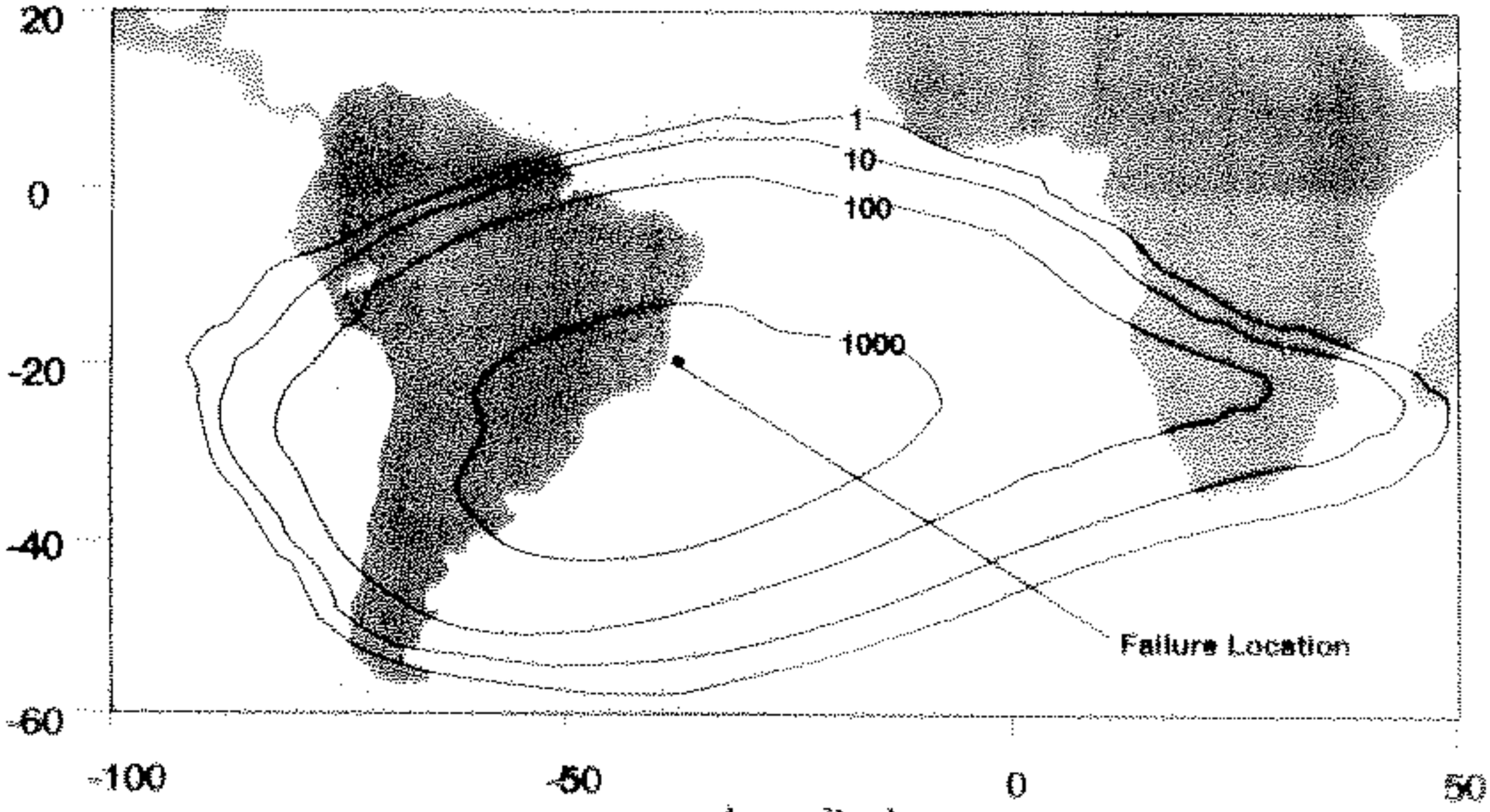
UoSAT 2 OBC MEMORY UPSETS : TEXAS TMS4416 16k x 4 BIT NMOS DRAM





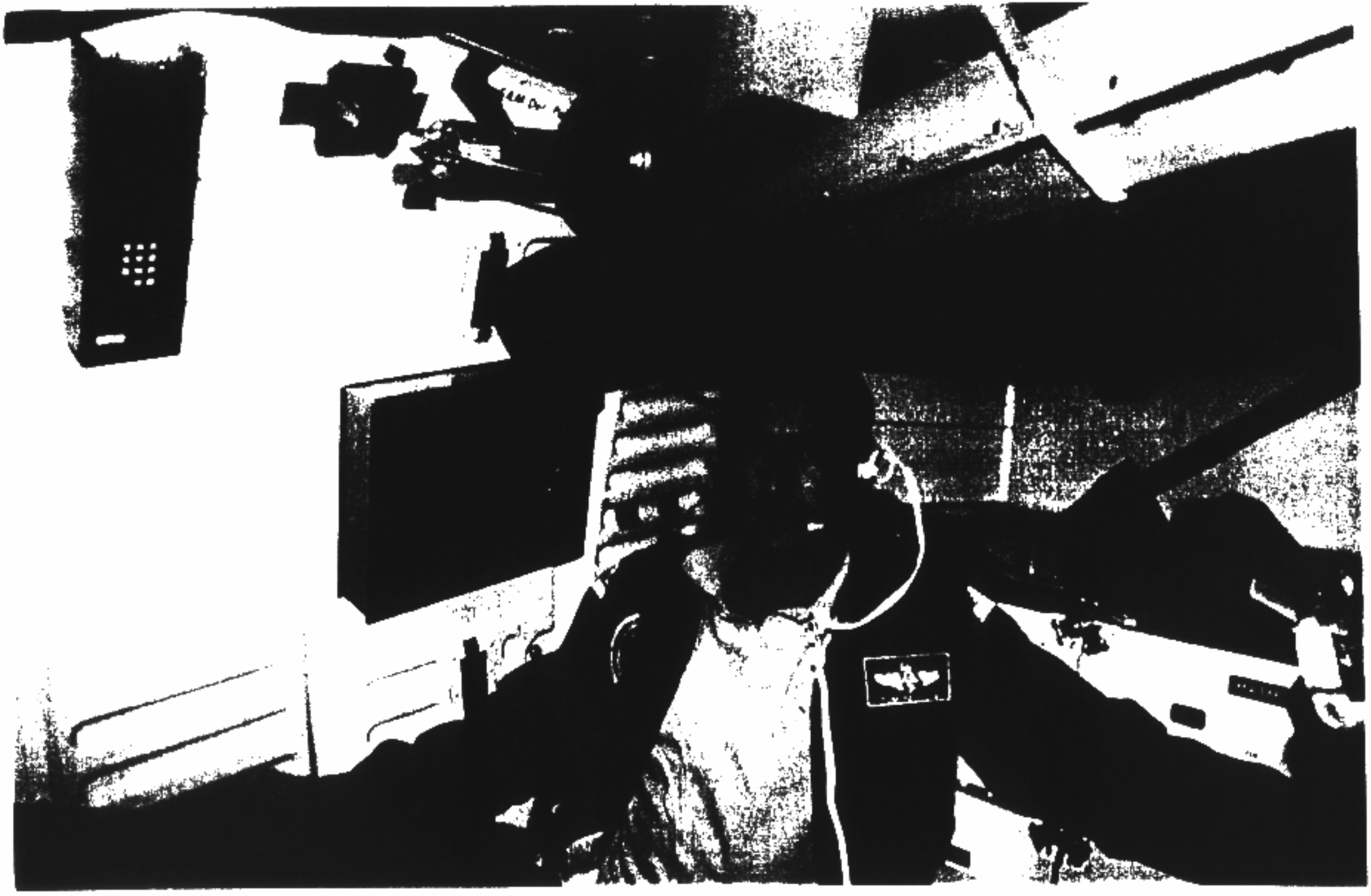
7995 Events in 1364 Days

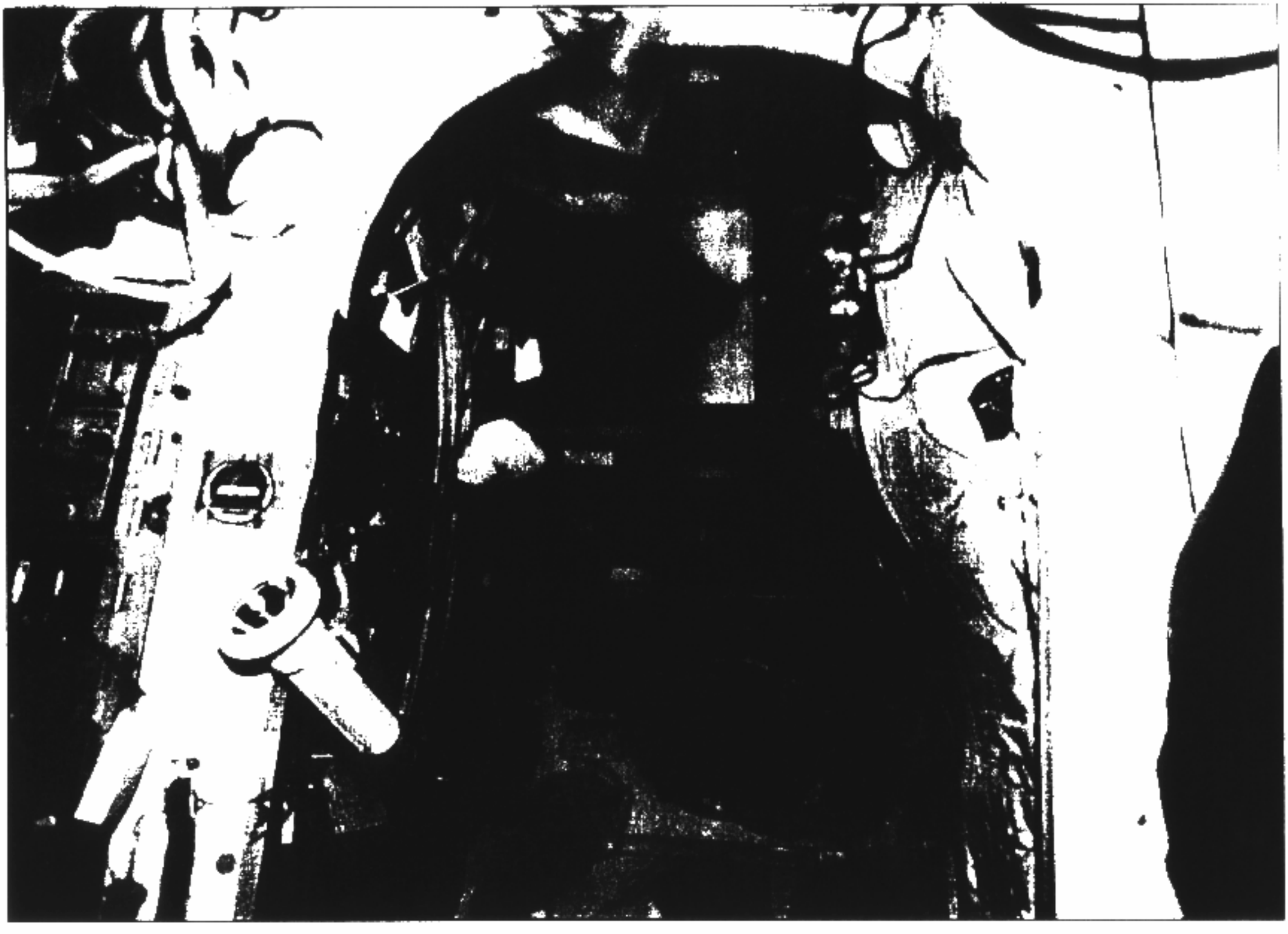
September '88 - May '92



Failure Location in South Atlantic Anomaly showing
Proton contours (p/cm2/sec)

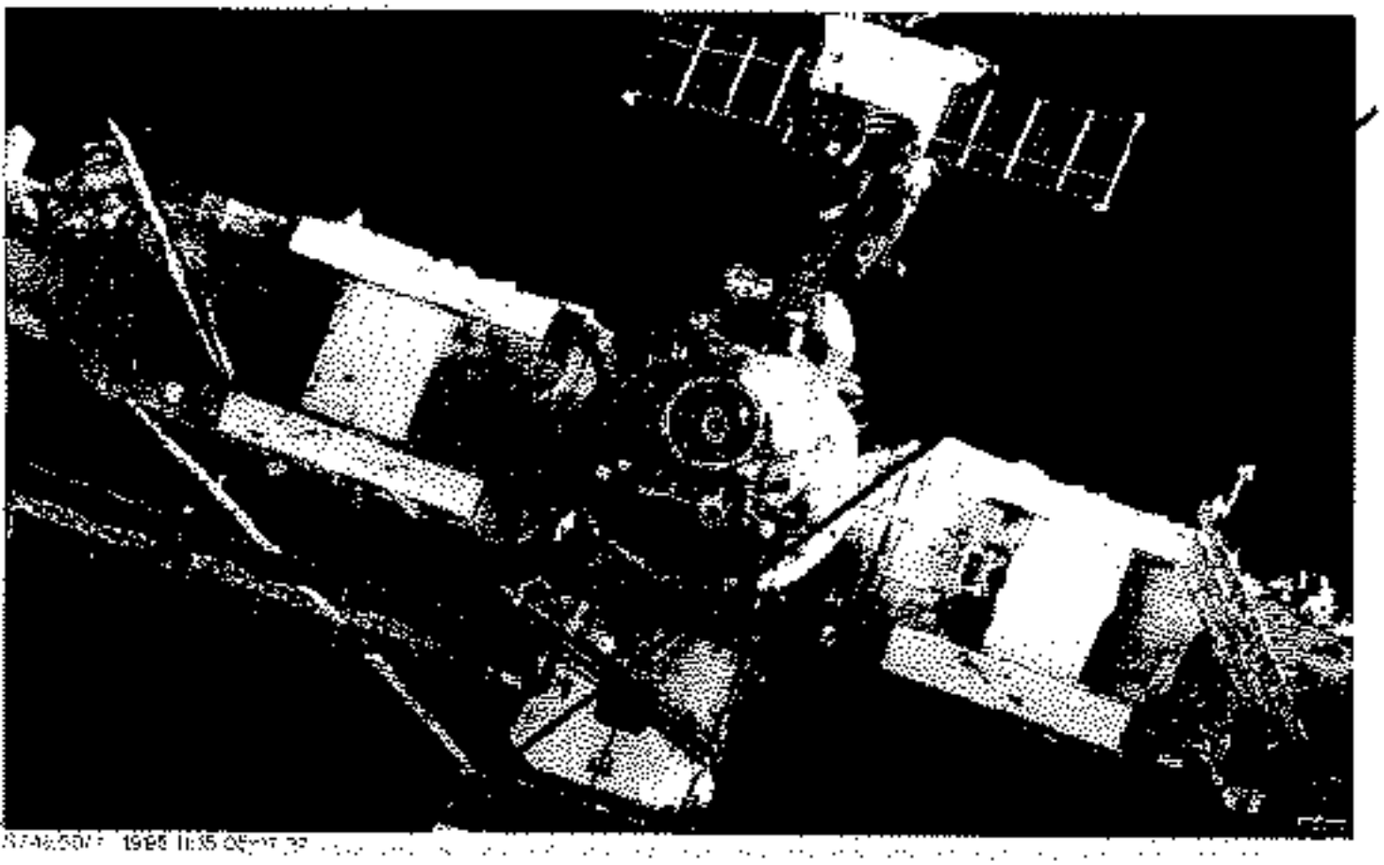
esa





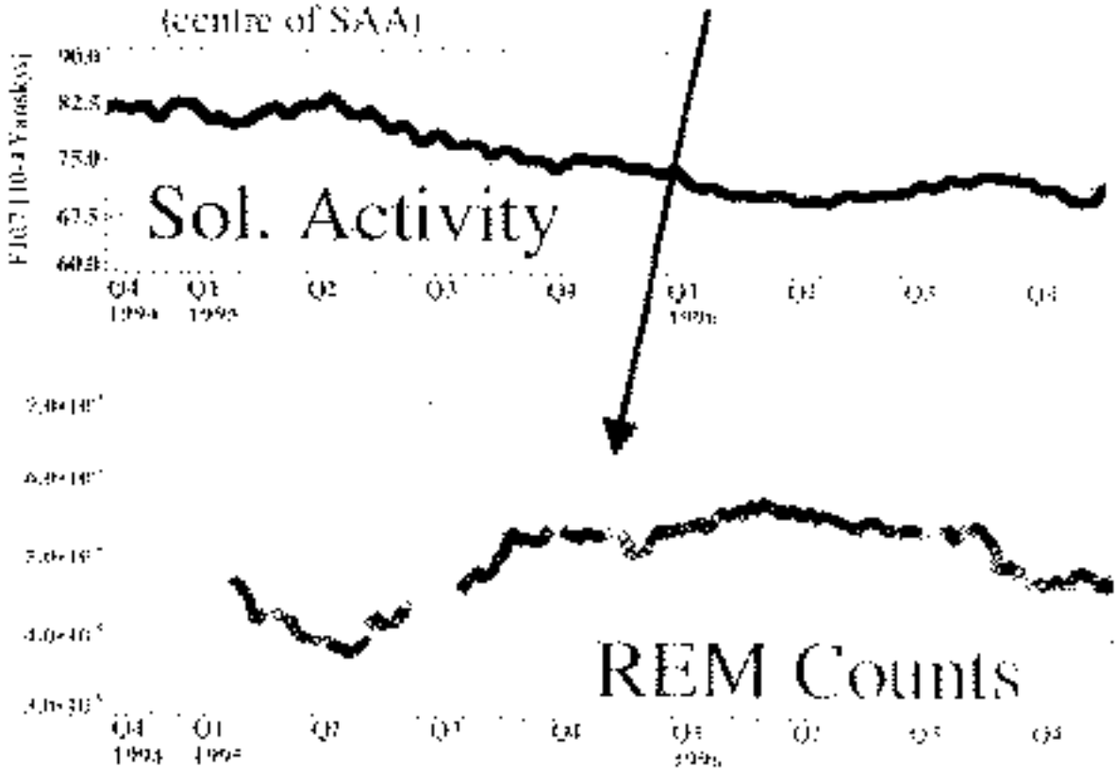
DERA

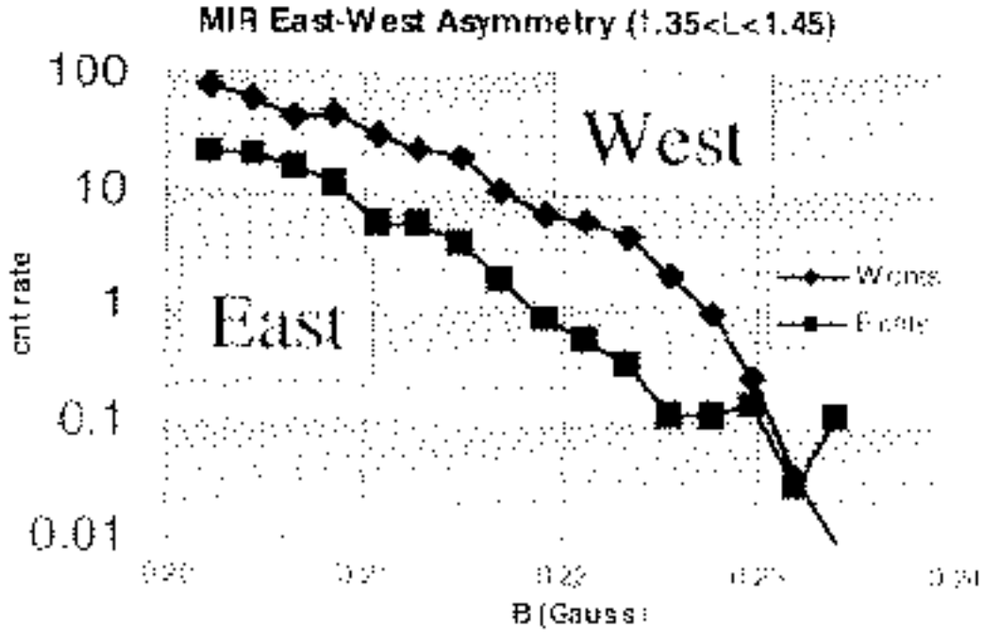
DERA PSI ONERA esa



REM on Outside of MIR: LEO, 400 km, 52° Nov. 1994 - Nov. 1996 (PSI/ESTEC)

Response to atmosphere





Anisotropy in environment

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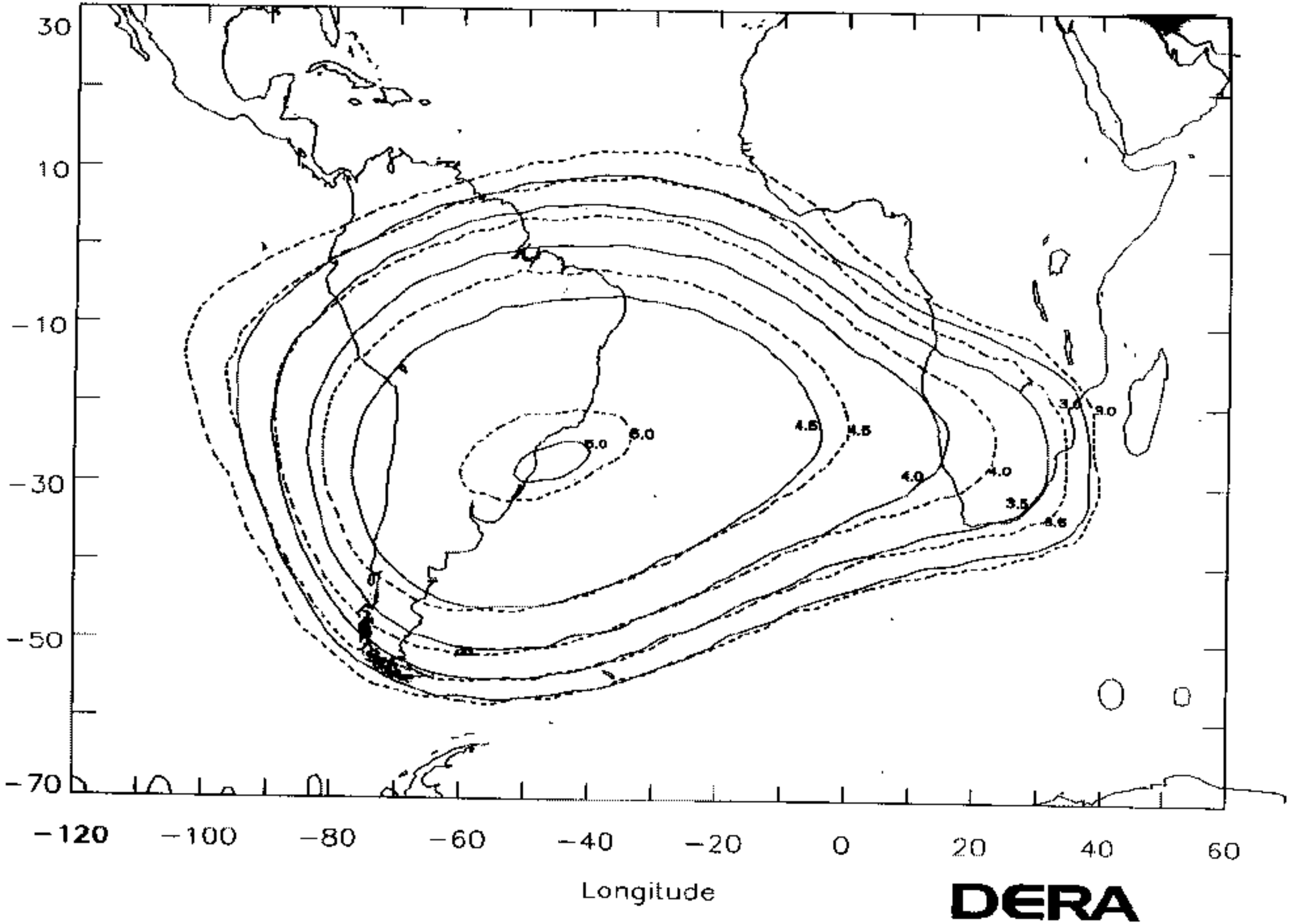
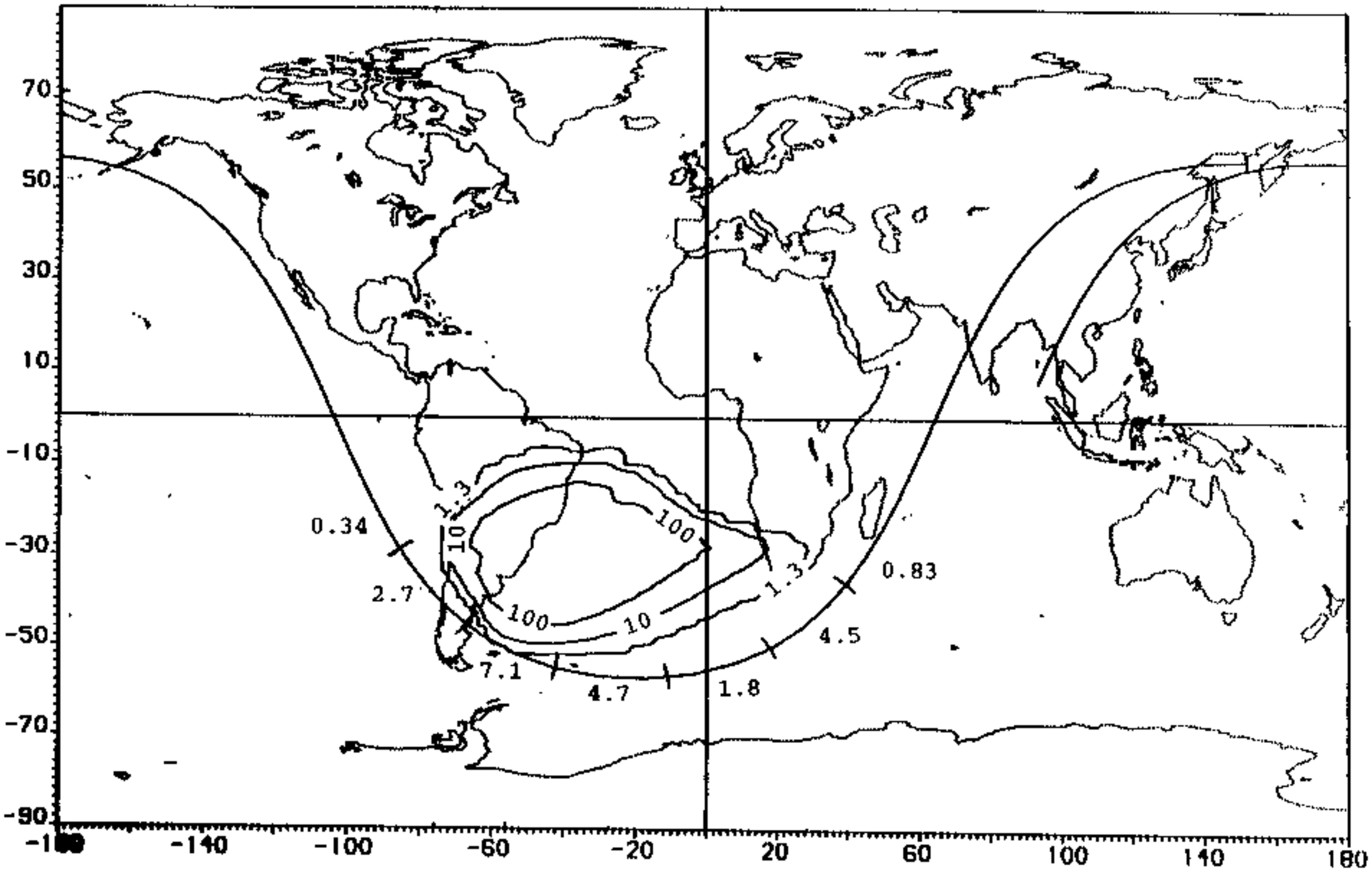
SAA for all 1992 & 1995 UOSAT-3 Ch1 data

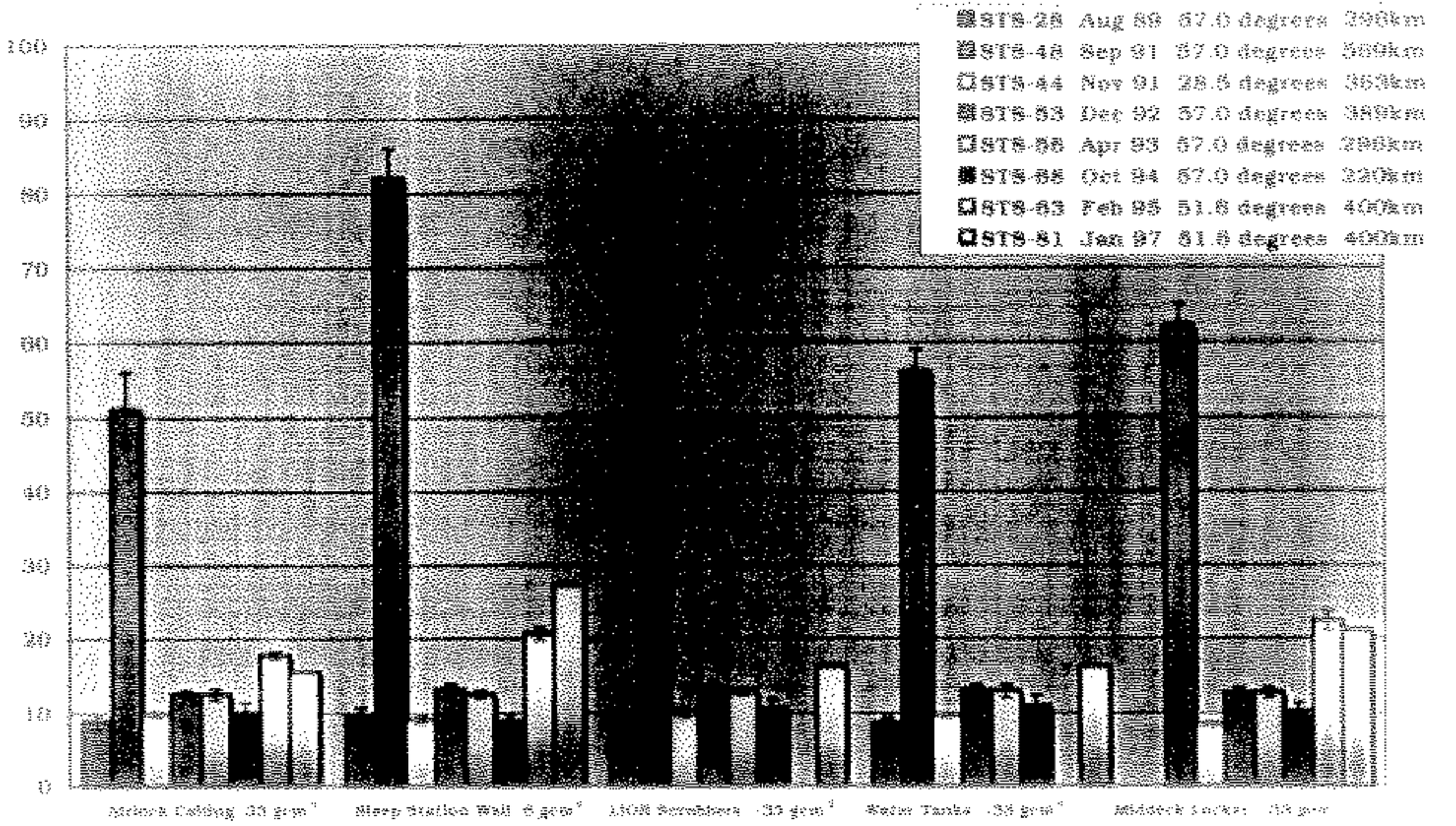


DERA

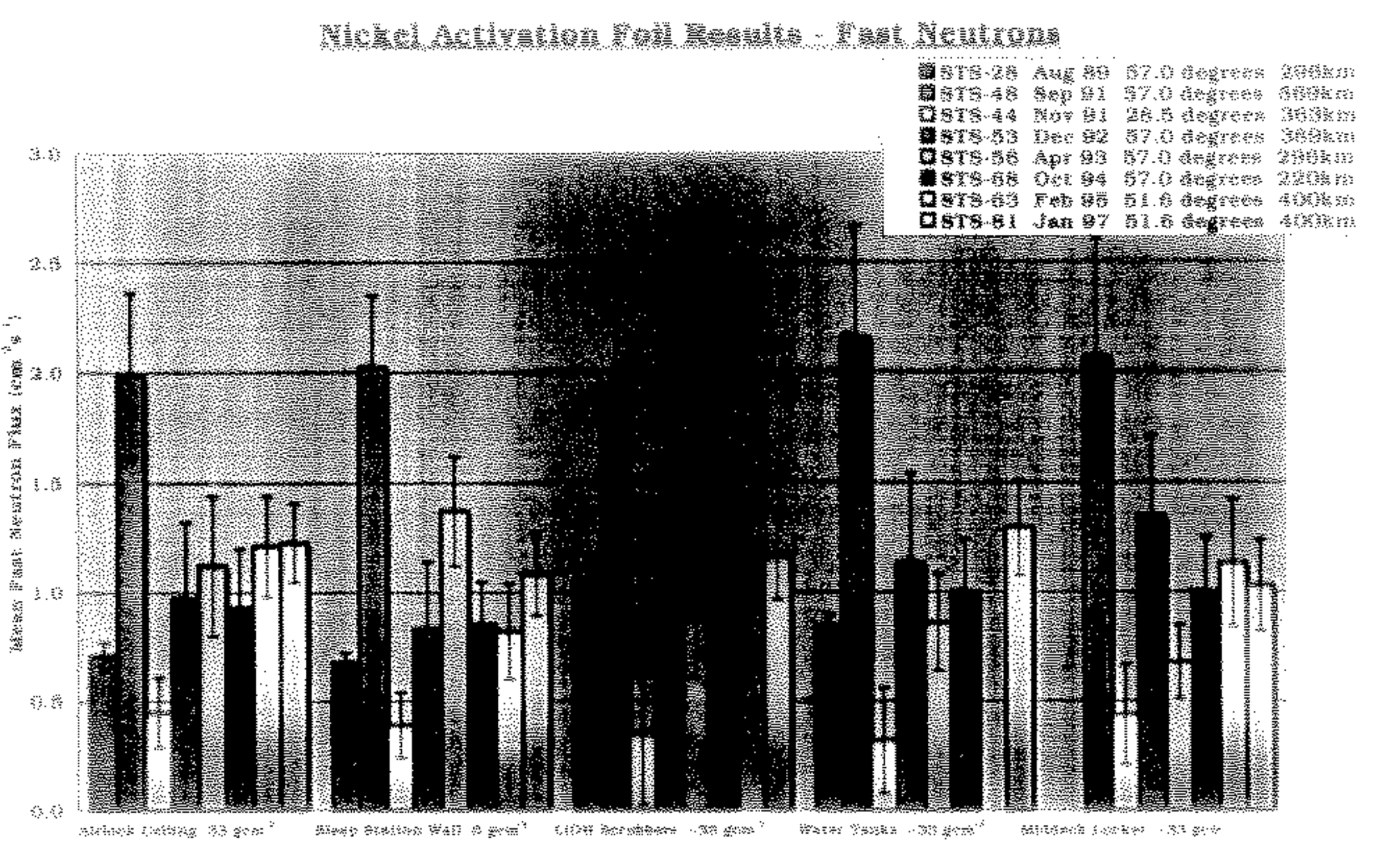
Flux map at 541.0 km for protons > 100.0 MeV at solar maximum
Flux model : AP8 Units : $cm^{-2}s^{-1}$
STS48 MET 1/11:00 to MET 1/13:00 1970 FIELD



Thermoluminescent Dosimeter Results

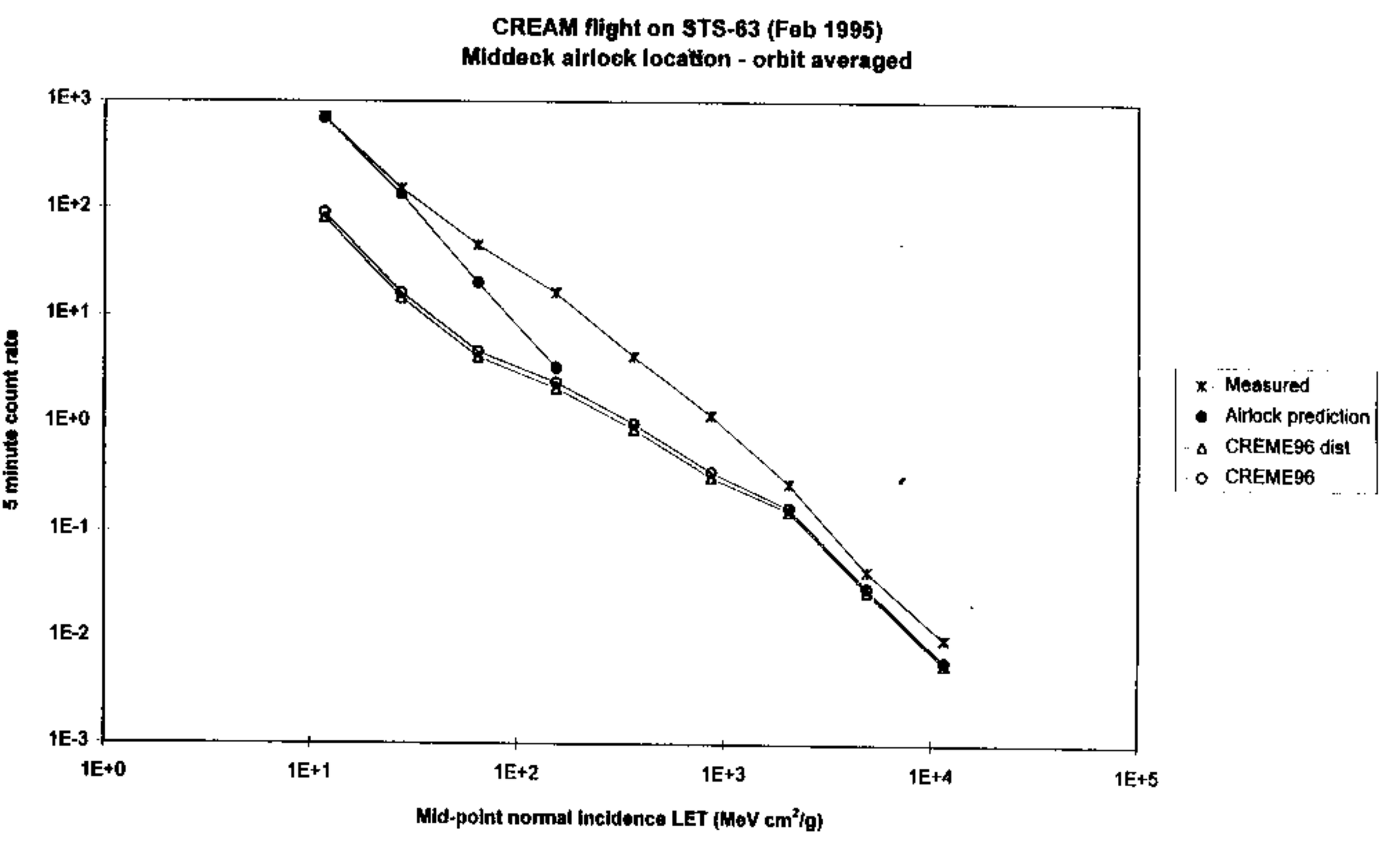


Nickel Activation Foil Results - Fast Neutrons



CREAM passive detector results from on board MIR

Location	STS-89 Long Jan - Jun 98 51.6° 380km Average dose rate from DERA TLD's [mrad(Si)/day]	Thermal neutron flux from gold foil [$cm^{-2}s^{-1}$]	Fast neutron flux from nickel foil [$cm^{-2}s^{-1}$]	STS-89 Short Jan-98 51.6° 380km Mean neutron dose from bubble detectors [mrem/day]
Locn#1 (Sleep Station Core Module)	21.8±1.0	0.148 ± 0.056	1.138 ± 0.061	10.5 ± 2.8
Locn#2 (Panel 410)	18.0±2.8	0.176 ± 0.049	1.363 ± 0.074	10.8 ± 3.3
Locn#3 (KVANT-II Water Tanks)	21.2±0.4	0.163 ± 0.055	1.152 ± 0.075	10.5 ± 3.2
Locn#4 (KVANT-II)	26.4±1.2	0.274 ± 0.053	1.151 ± 0.073	9.8 ± 2.2
Locn#5 (Panel 323)	16.6±0.4	0.203 ± 0.049	1.295 ± 0.074	10.5 ± 2.5


CREAM flight on STS-63 (Feb 1995)
Middeck airlock location - orbit averaged
1E+3
1E+2
1E+1
1E+0
1E-1
1E-2
1E-3
5 minute count rate
1E+0
1E+1
1E+2
1E+3
1E+4
1E+5
Mid-point normal incidence LET (MeV cm²/g)
Measured
Airlock prediction
CREME96 dist
CREME96

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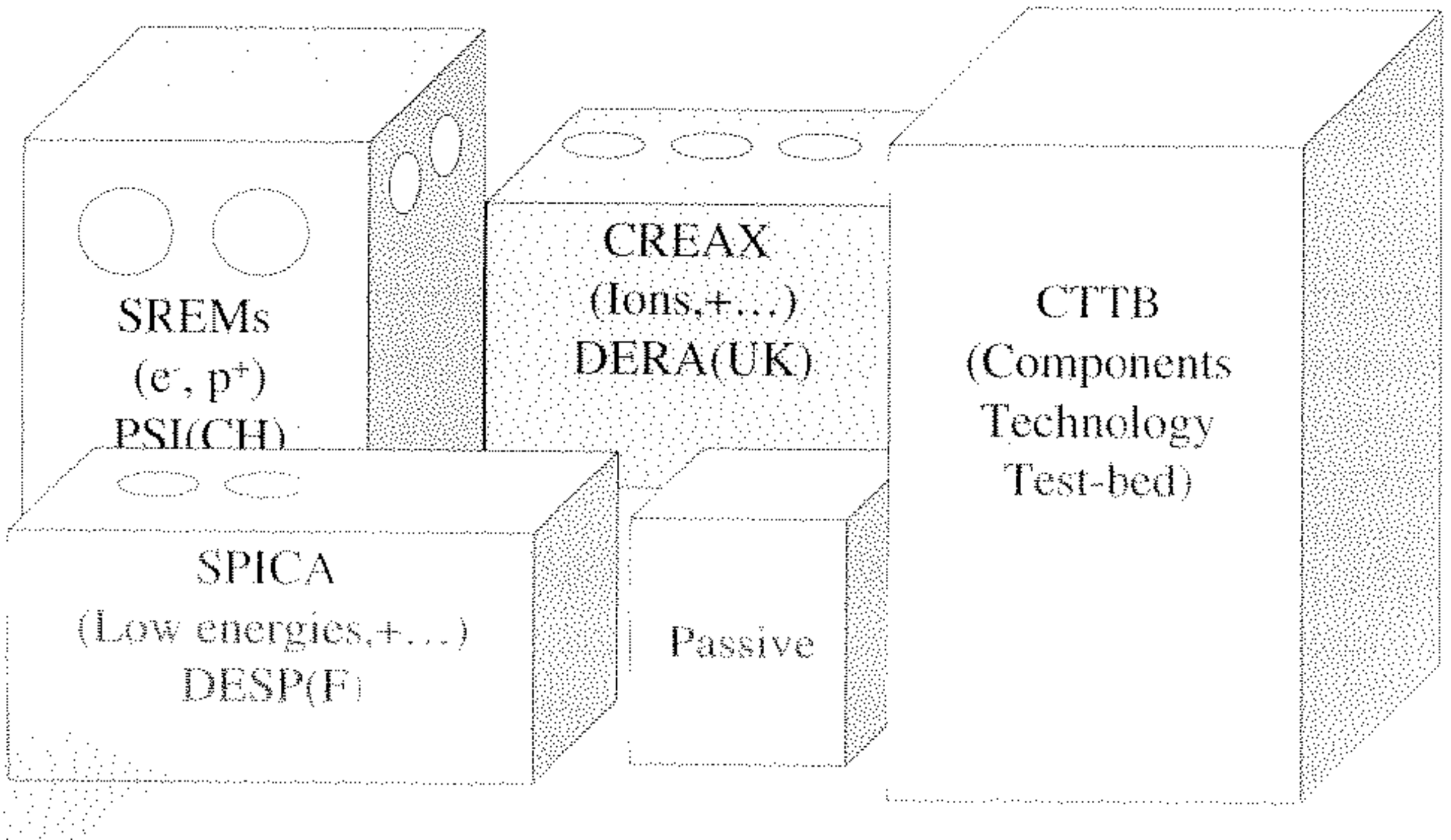
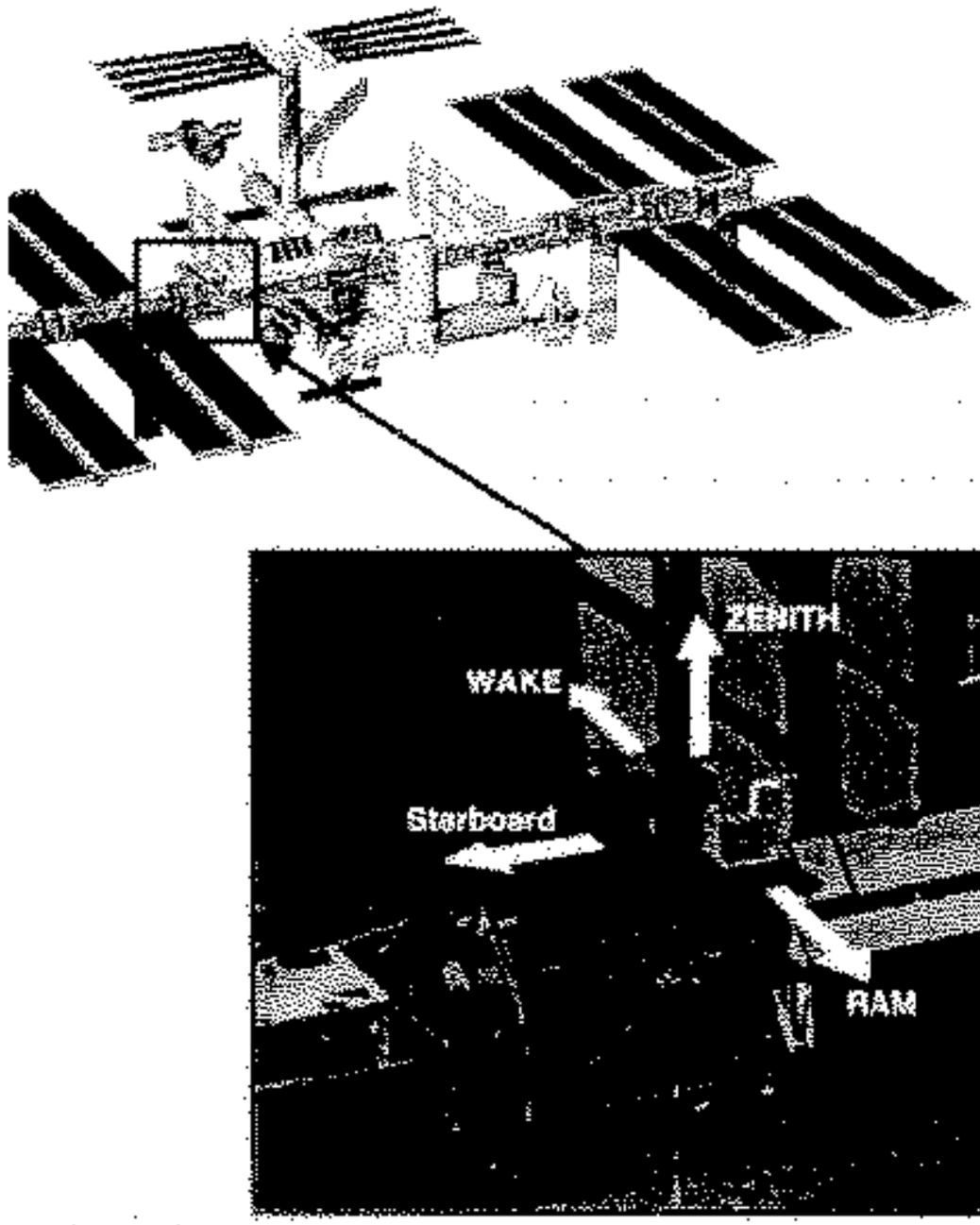
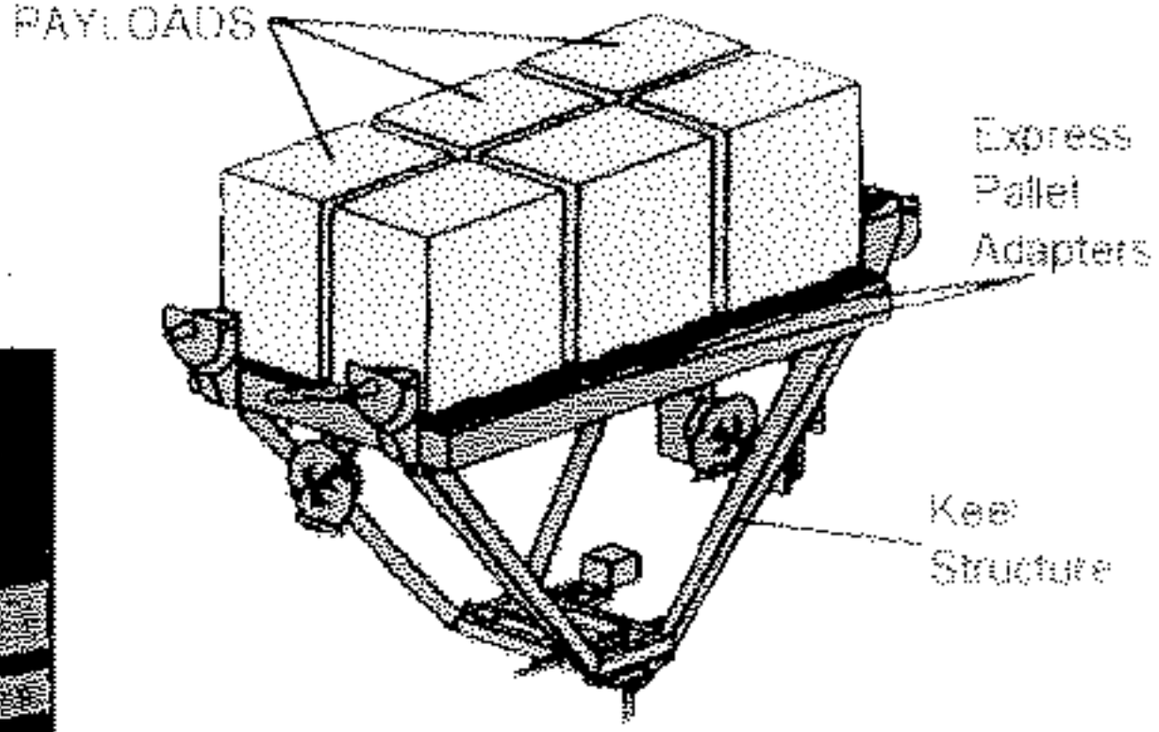


CREEP

SREM (x2)*	Directional electrons & protons (radiation belt, solar energetic particles)	0.5 MeV< E_e <10 MeV 10MeV < E_p< 300 MeV
CREAX*	Ions, protons, nuclear interactions, activation studies	1.5 < LET < 10^5 MeV.cm^2/g
SPICA*	Low energy electrons and protons for materials studies	0.05 MeV < E_e 3 MeV < E_p
CTTB	Sub-experiments for technology research / demonstration / test	Digital, analog, photonic, ...
Ground	- Comprehensive calibration & simulation - CTTB technology pre- & post-flight evaluation;	-European proton (PSI), ion (various) & electron (various) beams;
	Data analysis & dissemination	- open data policy (except commercial) - real-time & near real-time data

* overlapping capabilities exploited for validation





Columbus Radiation Environments and Effects Package

CTTB
(Technology Test-Bed)

- A unit containing technologies for exposure to radiation:
  - Digital Electronics (microprocessors, memories, ASICs,…
  - Analog electronics
  - Photonics (CCD's, fibre-optics opto-electronics,…)
  - others (novel detectors, etc.)
- Coordinated with ground activities
- benefits from comprehensive local sensing
- Opportunities will be co-ordinated by CREEP prime (TBS)
- Supplier pays
- Already interest

Benefits of CREEP

- all key issues addressed
- support to station & payloads, including industry
- further extending & complementing good track record of radiation monitoring in Europe (STRV, MIR, STS, ...)
- unique, comprehensive ground-based part
- possible internal experimental part
- wide international collaboration, including US and Japan
- "space weather" will be important and "high profile" next solar max.
- public visibility: promotion of results, education & awareness