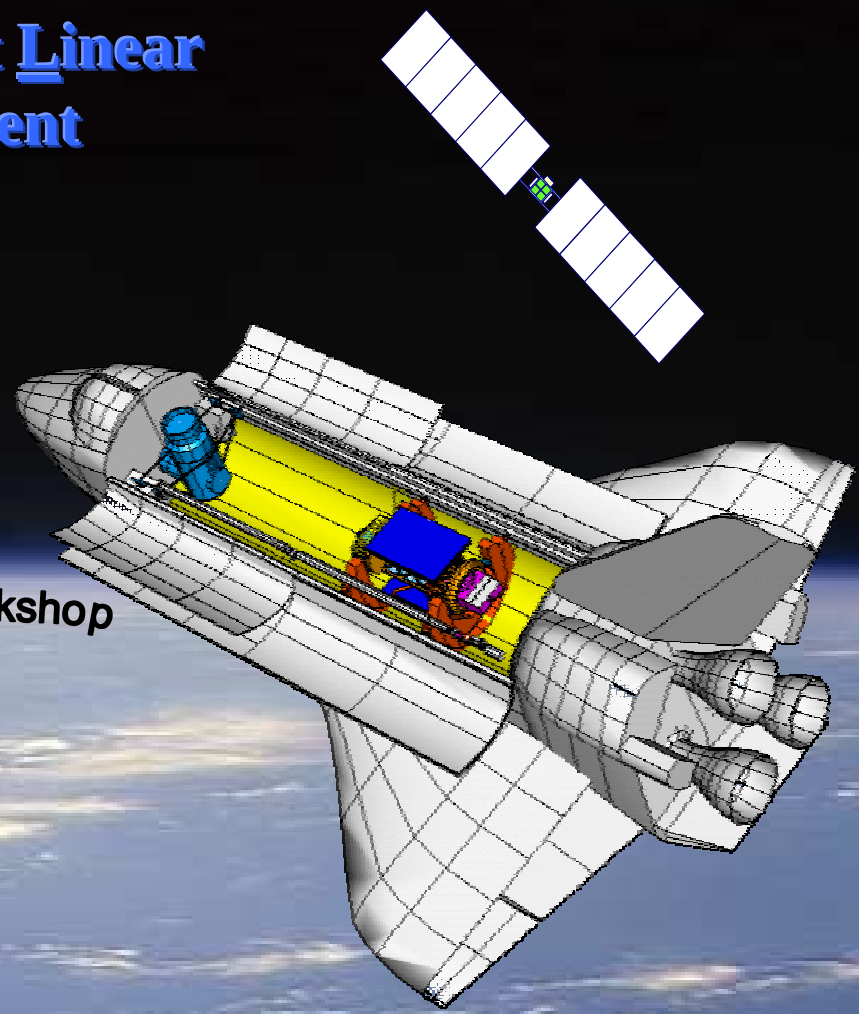
Shielded Heavy-Ion Environment Linear Detector (SHIELD) Experiment

An Experiment for the
Radiation and Technology Demonstration
(RTD) Mission
(Formulation Phase)



NASA Space Radiation Health Investigators' Workshop
29 May 2000

Jack Miller,
Cary Zeitlin, and
Lawrence Heilbronn

Berkeley Lab

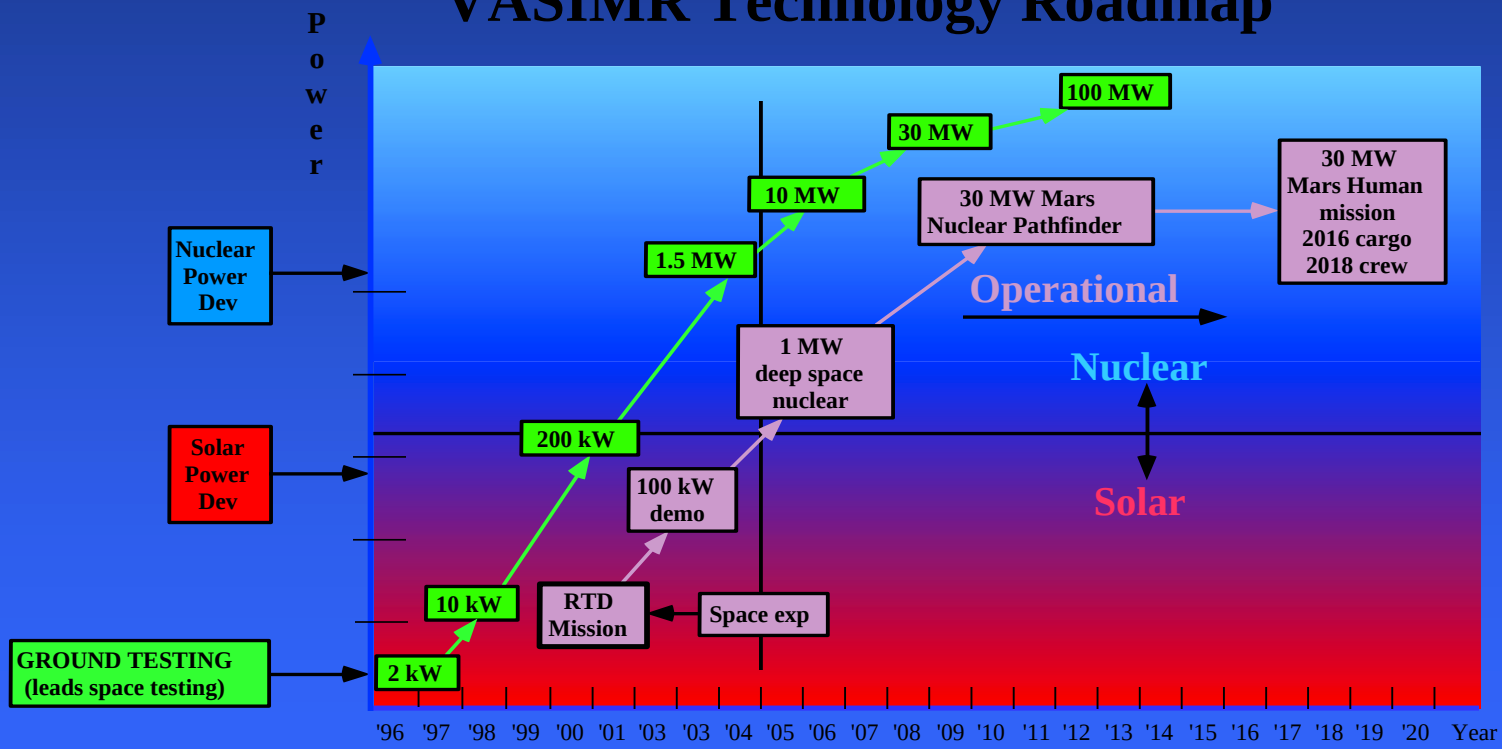
Francis A. Cucinotta and Mark R. Shavers
Johnson Space Center

NASA

John W. Wilson and Robert C. Singleterry, Jr.
Langley Research Center

RTD Mission

VASIMR Technology Roadmap



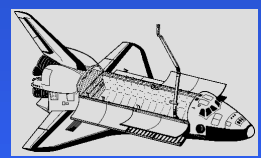
Graph shows VASIMR technology development enabling decision to full implementation in 2004. Linked arrows show ground testing path, always leading space deployment for a given power level (solid arrows in sequence show present lab capability).

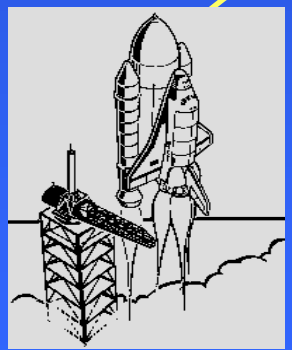
RTD Mission Deployment Scenario

Spiral to 5 ER
(32000 km Alt.)

407 km Alt (1)

Deploy at LEO
(407 km Alt.)





Space Radiation Risk Uncertainties

Space Radiation Environment

GCR: 10%–15%

↘

Shielding & Transport

50%

↘

Biological Response

Q: 200%–500%

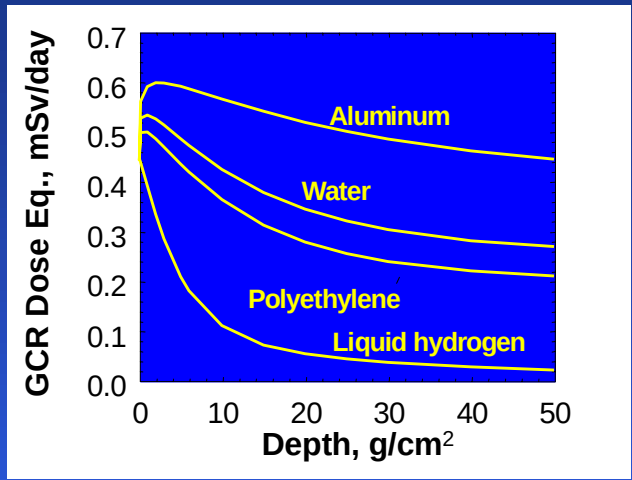
DDREF + other factors: 200%-300%

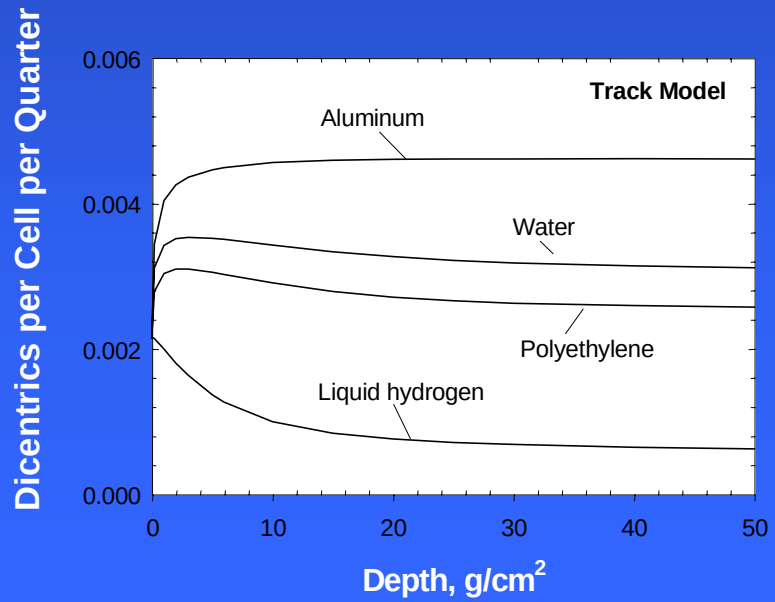
↘

Estimated Response or Risk

Validation of Radiation Protection Methods for HEDS

- The National Academy of Sciences (NAS) review of largest uncertainties for HEDS missions:
  - shielding material properties and role of secondary radiation (neutrons)
  - mechanisms of biological damage and risks of GCR heavy ions
- A major goal of NASA's Strategic Radiation Plan is to validate properties of shielding materials





Validation: Physical and Biological Dosimetry

Comparison of model with measurement for dose and dose equivalent rate on Mir-18

	GCR		Trapped Protons		Total	
	Dose (mGy/day)	Dose Eq. mSv/day	Dose (mGy/day)	Dose Eq. mSv/day	Dose (mGy/day)	Dose Eq. mSv/day
TEPC	0.142	0.461	0.153	0. 298	0.299	0.781
Model	0.141	0.526	0.140	0.219	0.281	0.745

Comparisons of calculations to measurements for fraction of lymphocytes with chromosome aberration (dicentrics) from Mir-18 crew member

Shield/Location	Model	GCR	Trapped p+	Total
Naussica	LET	2.20×10^{-3}	2.19×10^{-3}	4.39×10^{-3}
	Track	2.78×10^{-3}	2.66×10^{-3}	5.44×10^{-3}
Lyulin	LET	2.23×10^{-3}	2.46×10^{-3}	4.69×10^{-3}
	Track	2.76×10^{-3}	3.02×10^{-3}	5.78×10^{-3}
Mir-18 Crew Member	Biodosimetry			$6.4(\pm2)\times10^{-3}$

Current Flight Validation Experiments

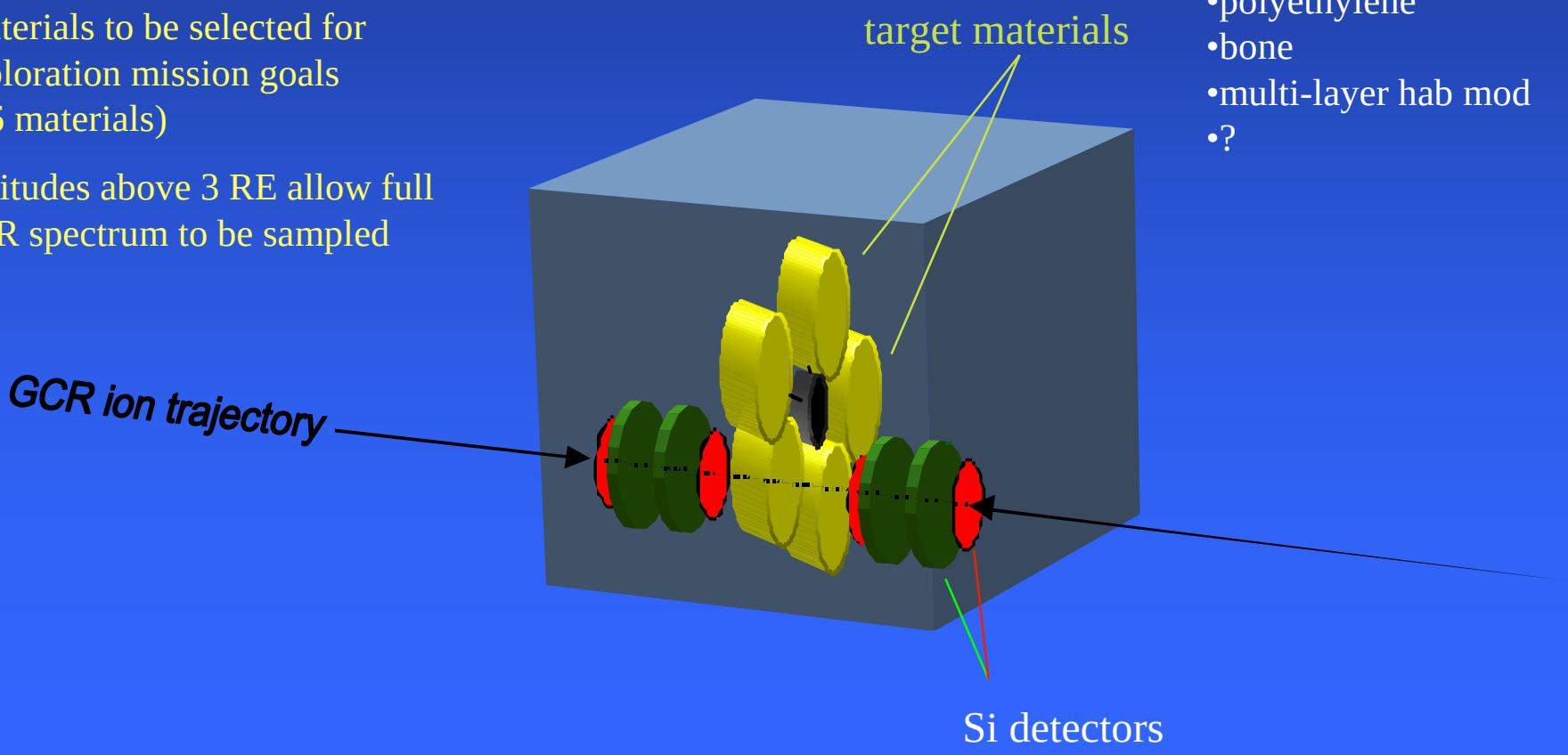
- Space Radiation Environment:
  - ACE including CRIS, ULEIS, and SIS Spectrometers
  - MARS 01, 03, and 05 Experiments
  - ISS CHeCS Operational Dosimetry
  - ISS ACCESS Experiment
- Validation of shielding material effectiveness and transport codes:
  - **None**
- Validation of Biological/Risk Assessment Models including effects of microgravity
  - **None**

RTD and Human Radiation Protection Initiative

- RTD can move beyond radiation environment measurements performed many times in past
- RTD and validation of radiation shielding effectiveness:
  - Allows for full GCR exposures not possible on ISS
  - Provides platform for validation of radiation transport codes
  - Allows advanced shielding materials to be evaluated including liquid hydrogen or helium used in propulsion
- RTD and validation of biological risk assessment models:
  - Potential for returnable payload for future Bio-Explorer in support of risk assessment validation goals of Radiation Strategic Plan

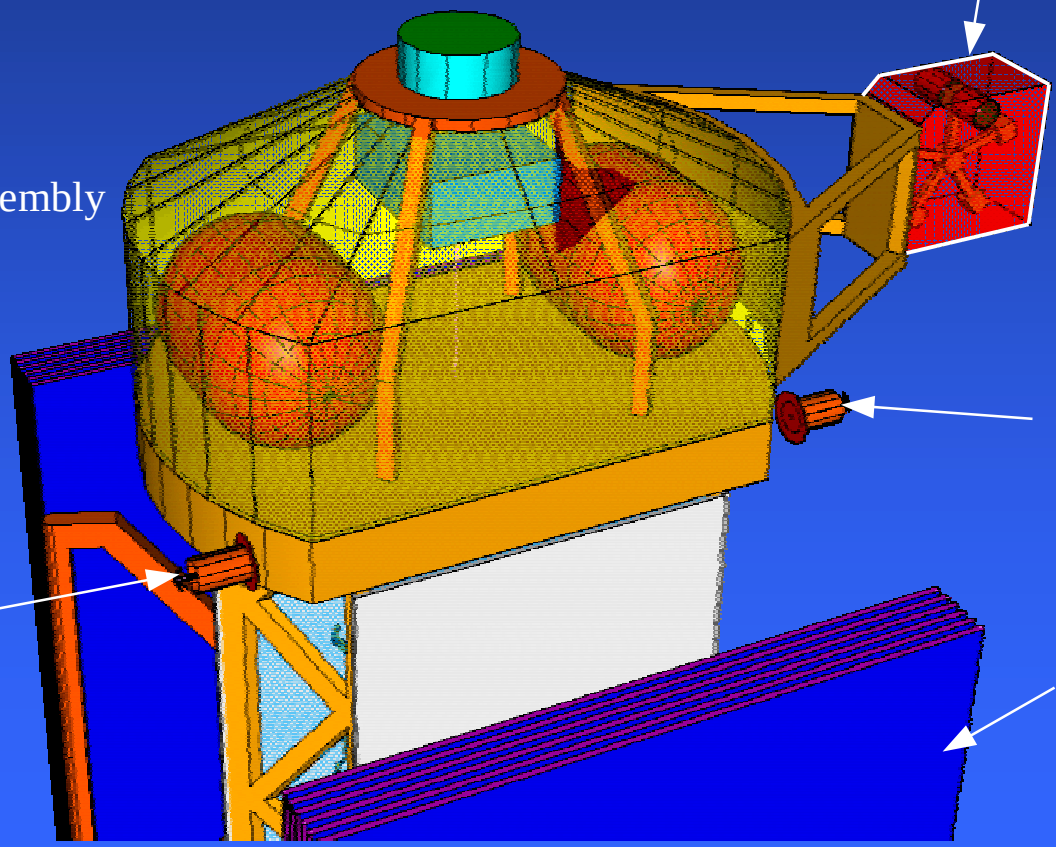
SHIELD

- Silicon stack detectors with rotating material wheel
- Full GCR ion charge resolution (Z = 1 to 28)
- Materials to be selected for Exploration mission goals (4-6 materials)
- Altitudes above 3 RE allow full GCR spectrum to be sampled



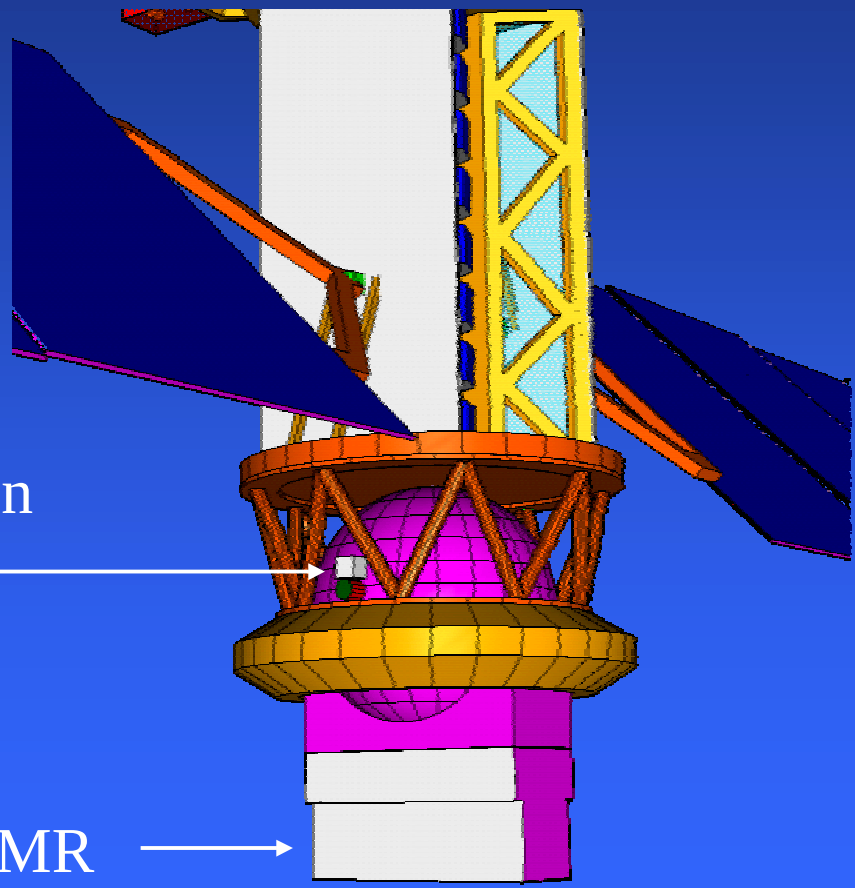
- Al
- polyethylene
- bone
- multi-layer hab mod
- ?

SHIELD Detector Experiment

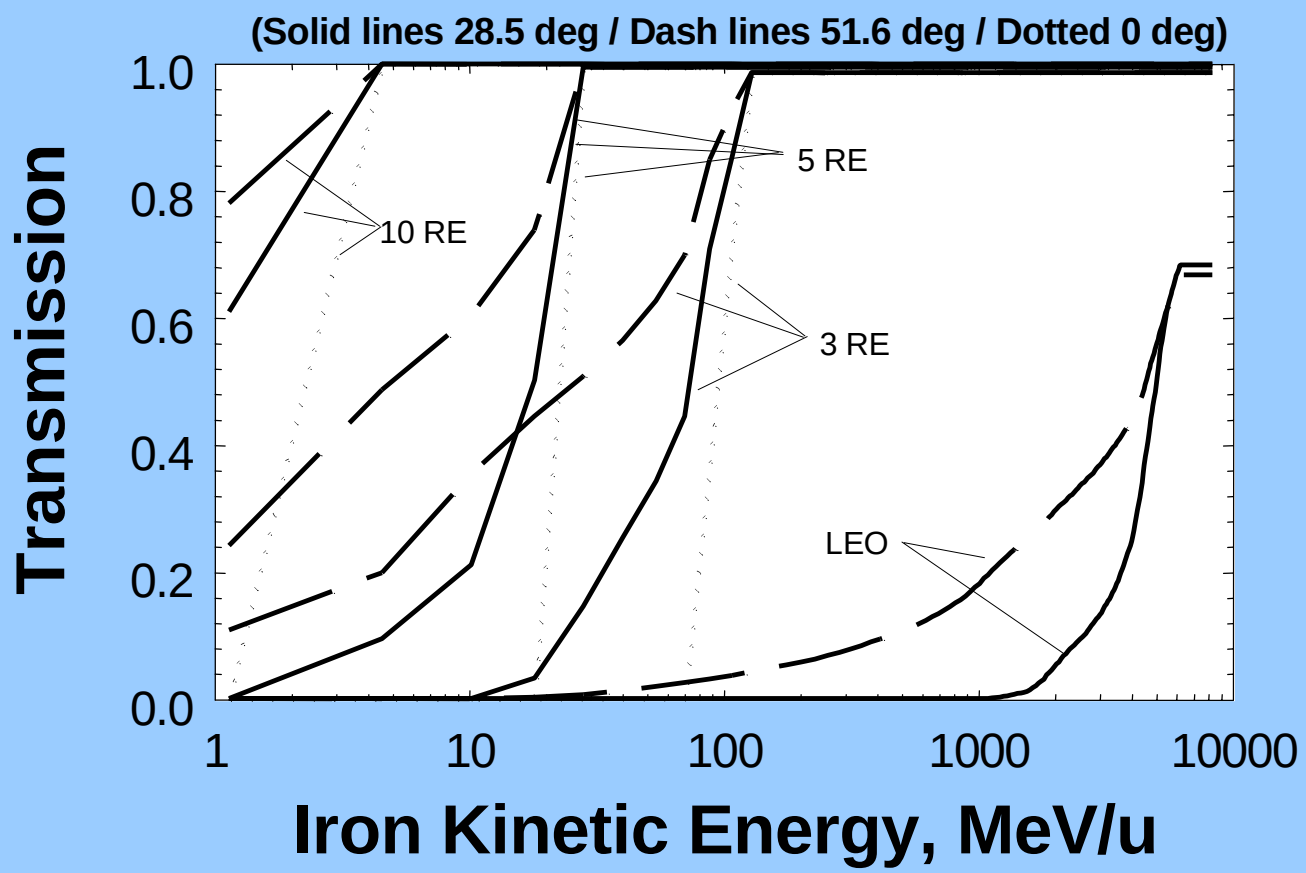


Liquid Hydrogen SHIELD Experiment

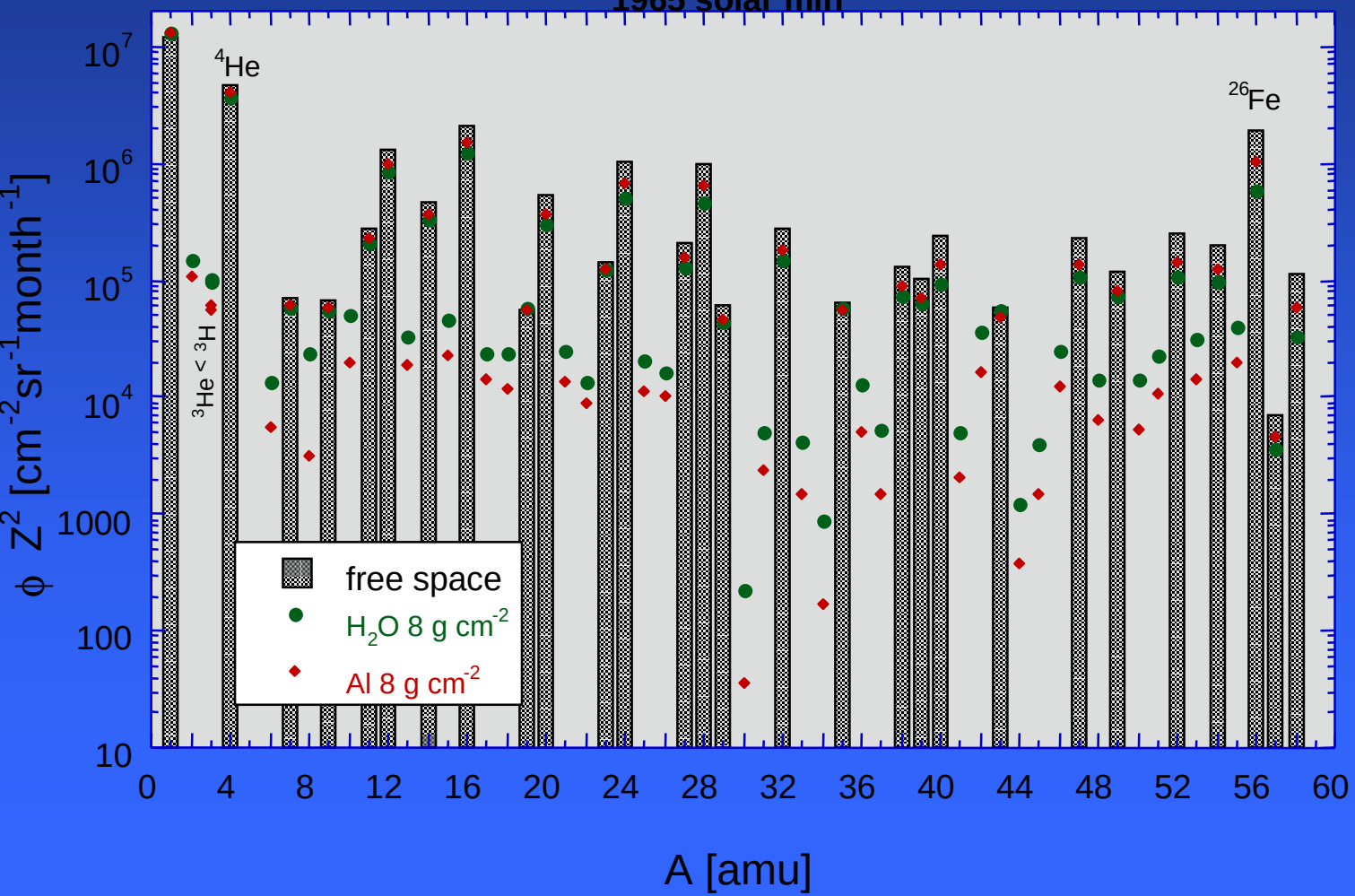
Validation of theoretical prediction of superior properties of hydrogen shielding



Geomagnetic Cutoff of GCR



SHIELD Simulation

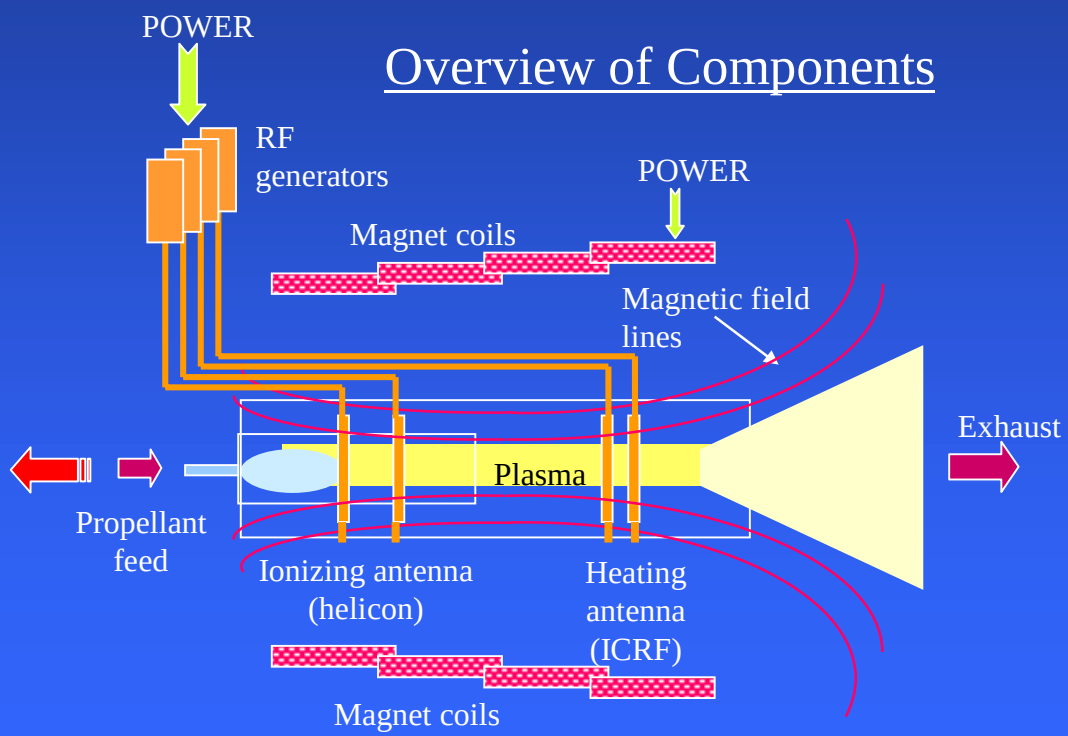


RTD SHIELD

Technical Challenges

- Shadow-less orientation of spectrometers
- Collection and analysis of HI in LI GCR background
- Target material (nuclear equiv to tissue and bone)
- Statistics-balance target thickness/fragmentation with total # particles observed in given collection period
- Telemetry
- Remote controlled vs automated target selection
- Integrity of telemetered data

VASIMR
Variable specific impulse magnetoplasma rocket



Overview of Components

Features of RTD Flight Experiment Rocket

- Fixed specific impulse: 10,000 sec
- Thrust: 0.1 N Flow rate: 1 mg/sec
- 10 kilowatt total power
- Operate during sunlit portion of orbit
- Supercritical hydrogen propellant (50 kg) (32 kg = 12 months continuous operation)
- Superconducting electromagnets (~35 K)
- High-field helicon option