Development of Tissue Equivalent Detectors for Space Crew Dosimetry and Characterization of the Space Radiation Environment

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Three NASA EPSCoR Components

- Research
- Infrastructure
- Education/Outreach

EPSCoR =
Experimental Program to Stimulate Competitive Research

Research Objectives

- Evolutionary Approach to TE ion chamber and proportional counter design, fabrication, and testing
- Investigation of T.E. plastics
  - response to electrons, protons, neutrons, and heavy ions
  - analysis of outgassing products by residual gas analyzer
- Common spherical chamber design
- Alternative anode wire, field tube, and grid wire configurations
- Alternatives in fill gas composition and pressure
- Detector Electronics
- Testing of instruments on Near-Space Balloon flights

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Infrastructure Objectives

- Compression/Injection molding of chambers
- Techniques for fabrication of chambers, threading of anode wires, sealing of pressurized container, etc.
- Electronics design and fabrication: design and simulate circuits on computer, fabricate printed circuit boards, use of SMD components in circuits
- Model radiation response of detector (FLUKA), exposure during balloon flight (LaRC AIR, Corsika), E/V field in chamber (Garfield)
- Detector calibration (x/γ-rays, 250 MeV protons, cosmic ray muons, <20 MeV electrons, etc.)

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Education/Outreach Objectives

- Promote Science, Technology, Engineering, & Mathematics (STEM) education and interest/enthusiasm in NASA's mission by enabling high school and undergraduate college students to conduct meaningful research using Near Space Balloons
- Involve undergraduate students in detector testing, calibration, and near-space balloon flights
- Design and test Near-Space Standard Science Platform (NS^3P) for use by undergraduate college students and high school students on near-space balloon flights
- Develop and test curriculum for use of NS^3P in college and high school science programs

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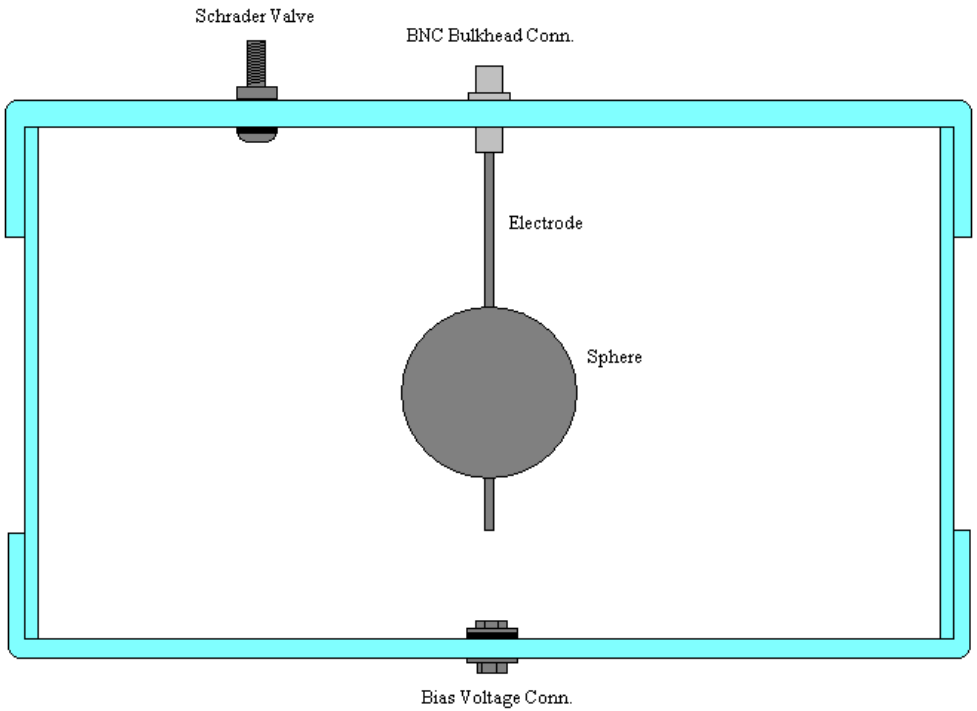
Balloon Borne Ionization Chamber (BBIC)



- 8 liter volume
- 1/8” thick PVC pipe and end caps
- interior coated with colloidal graphite
- fill gas: 1 atm air
- Chamber Potential: +40 V

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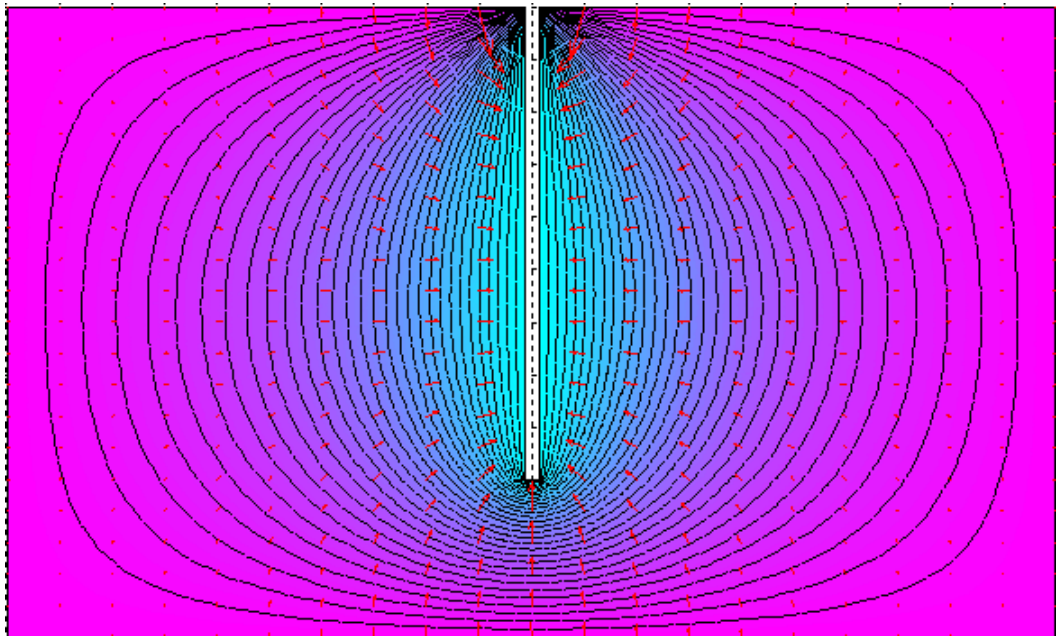
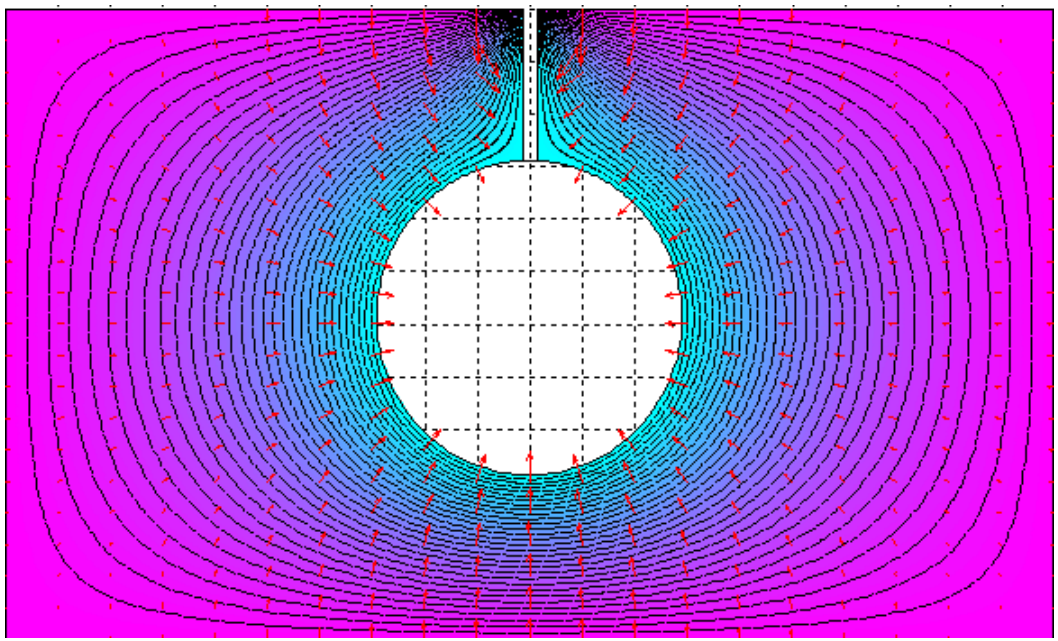
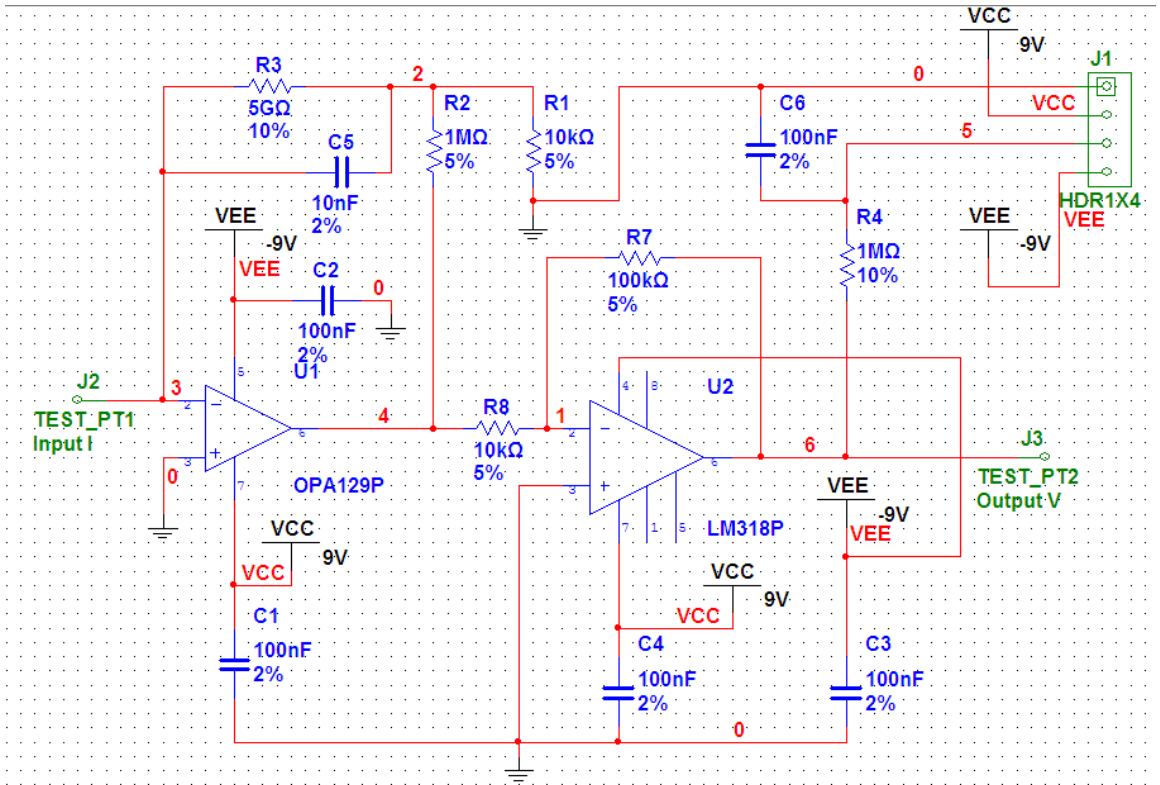


Electric Field inside chamber



Electric Field inside chamber, w/graphic coated sphere attached to center electrode

BBIC Electrometer



FET input op-amp (OPA129) with resistive feedback followed by a second gain stage and low pass filter

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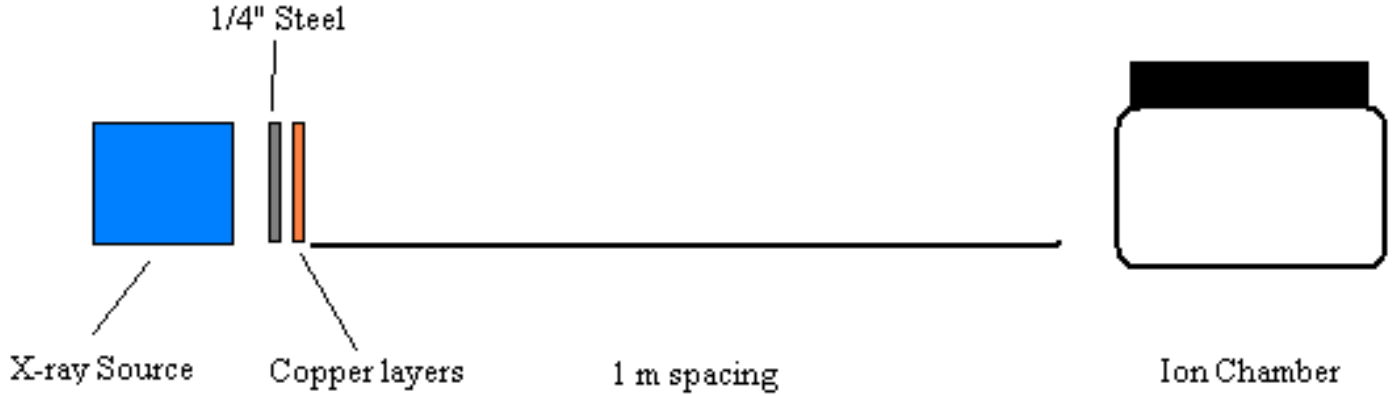
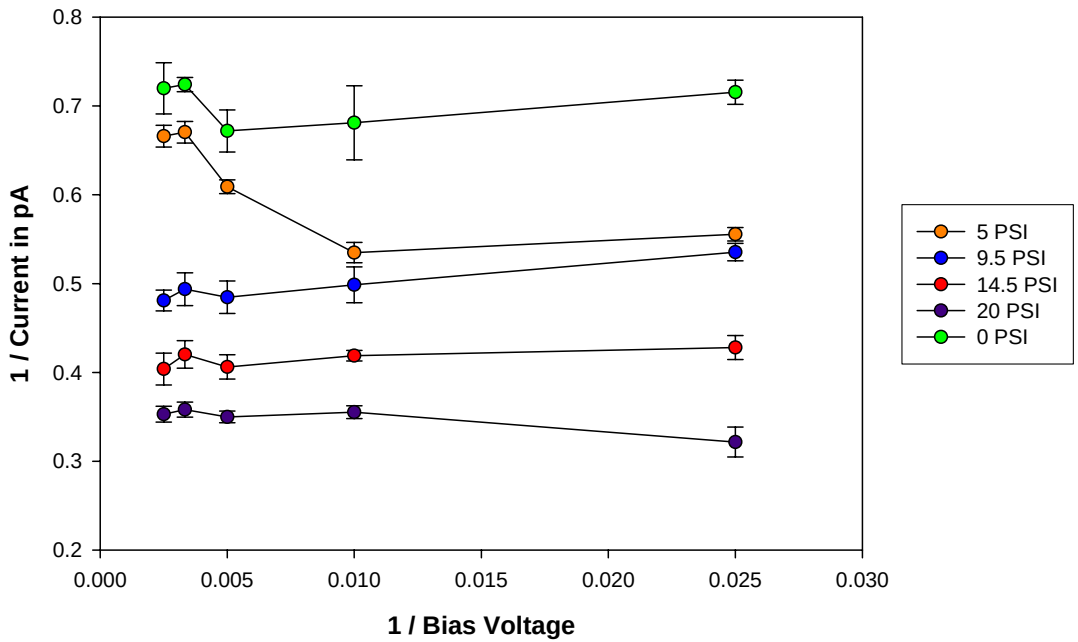
BBIC Calibration



80 kV_p x-rays behind 1/4” steel & variable thicknesses of Cu



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Instrument Testing on Near Space Balloons

- Atmospheric Radiation Environment dominated by cosmic ray secondaries up to and beyond Pfotzer Maximum, and primaries at higher altitudes
- Pressures range from 1 atm (>1000 g/cm^2) to near vacuum (<10 g/cm^2)
- Temperatures down to -40°C when stratosphere passing through stratosphere
- Vibration of ~±3 g following balloon burst
- Initial cost of <$3000 for radio transmitters, receivers, beacons, etc.
- ~$500 per flight ($300 for balloon, $200 for helium)

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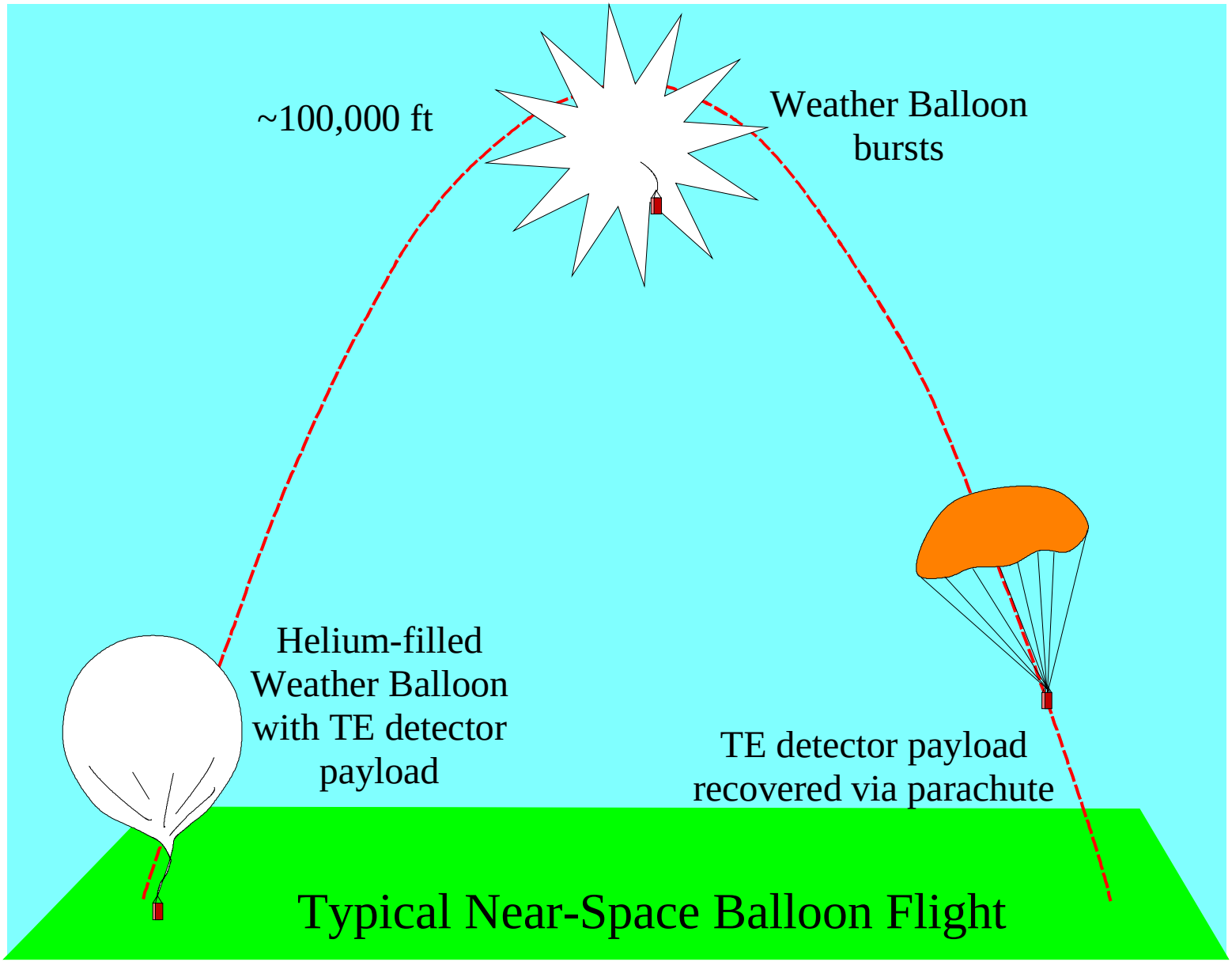

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First Flight of BBIC

10 July 2008, launched at 9:18 AM from OSU

OSU Campus

Stillwater, OK

(famous as site of the
12th WRMISS in 2007)

Penetrating the Cloud Layer

Pfotzer Maximum

~20 km

Max. Altitude:
104,000 ft or
~32 km

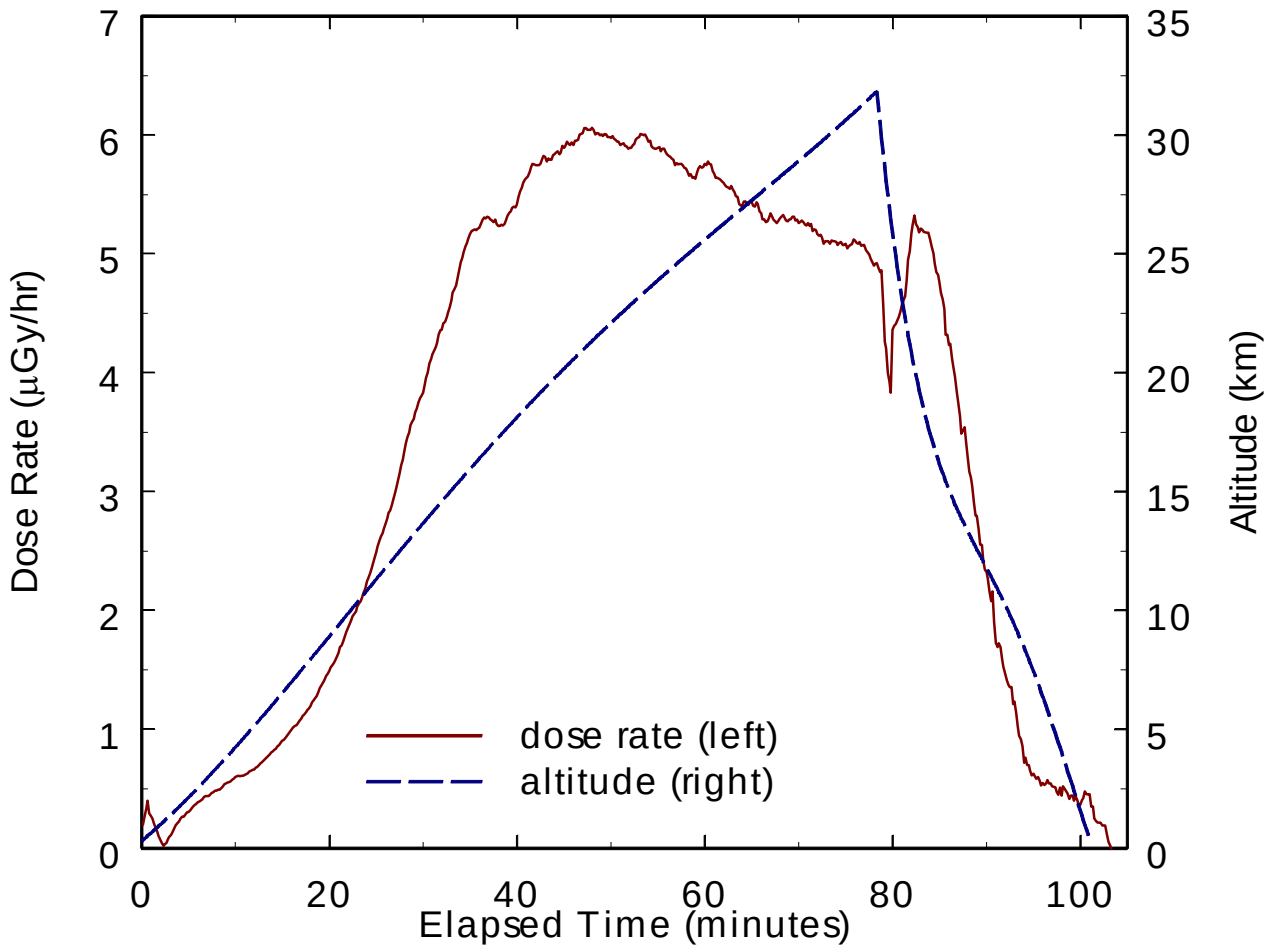
Coming Down
(fast)

Smooth Landing on Oklahoma Steppes (just like Soyuz)

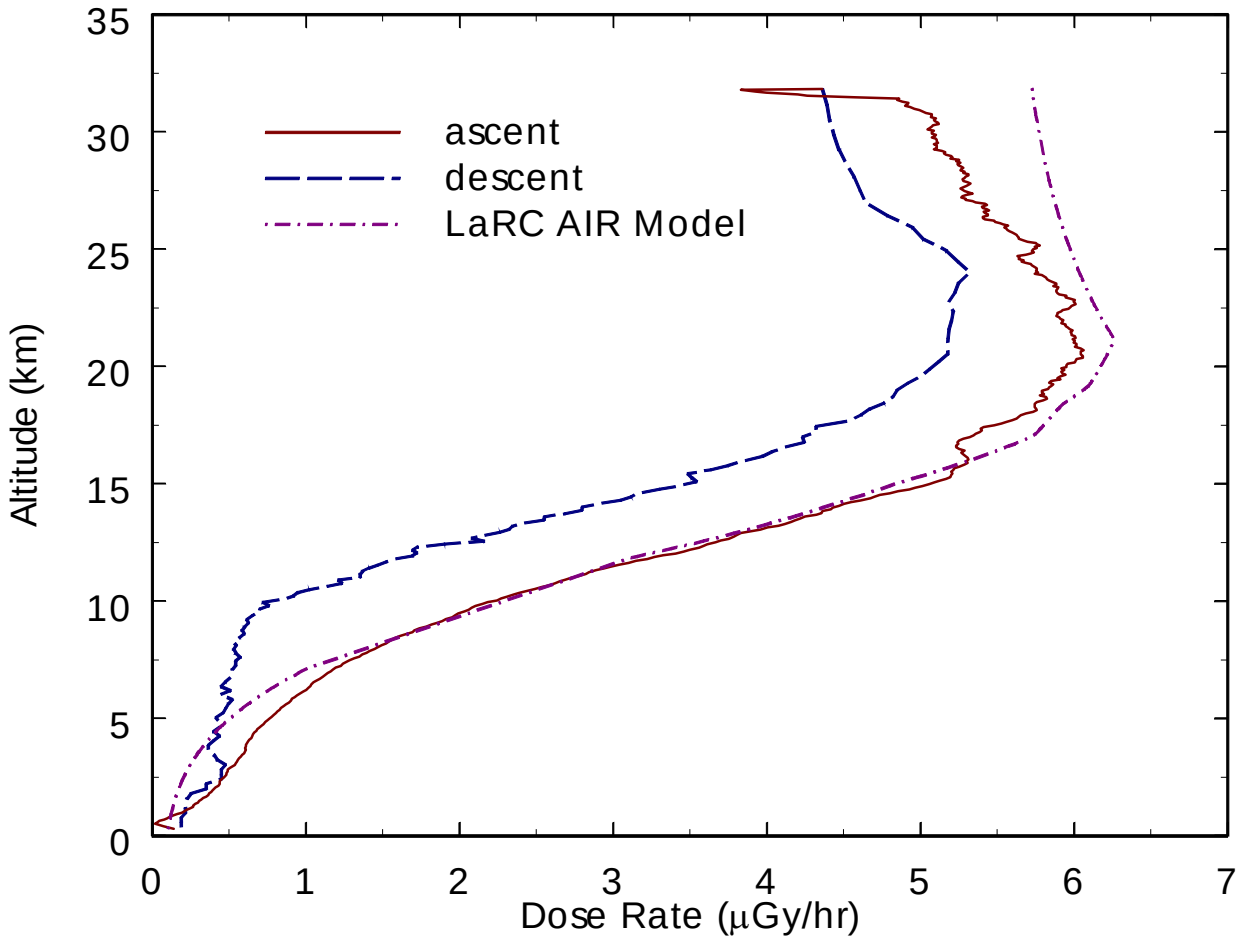
Recovery Team (with muddy feet, but no helicopter)

Carl examines BBIC after recovery...
“Looks OK to me”

BBIC Flight 1 Dose Rate and Altitude as functions of flight time



BBIC Flight 1 Dose Rate/Altitude Profiles for Ascent and Descent



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On-going Work

- 2nd Flight of BBIC scheduled for Nov. 2008
  - Charge-balanced current integrating electrometer (dynamic range of 7 orders of magnitude in dose... useful in SPE monitor/alarm?)
  - 3-axis accelerometer to assess vibrational noise
- Investigation of Tissue Equivalent materials: analysis of outgassing products with Residual Gas Analyzer
- Investigation of COTS and custom pre-amps, shaping amps, ADCs, and DSP circuits
- Learning techniques for fabrication of chambers, threading of anode wires, sealing of pressurized container, etc.

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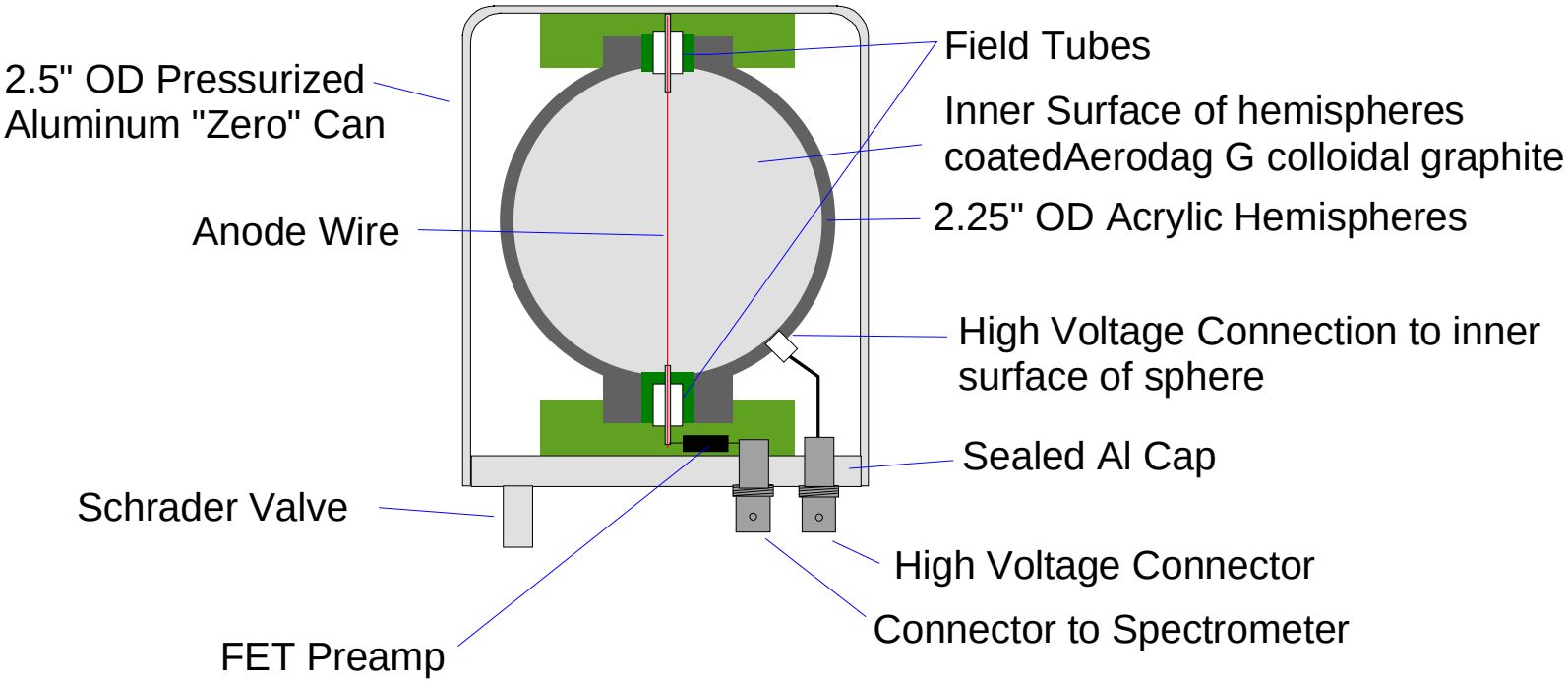
Design of Initial Proportional Counter



- 2”ϕ Acrylic Benjamin Chamber
- Spectrometer based on Flash ADC and Digital Pulse Processing circuit
- 1st Flight scheduled for Apr. 2009
- 2nd Flight: Jul/Aug 2009 on Devon Island, Northern Canada.

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Near-Space Standard Science Platform (NS^3P)

- Sensor Suite
  - Dose Rate from Balloon Borne Ionization Chamber
  - Temperature/Pressure/Humidity
  - 3-axis Accelerometer
  - UV and Visible Light
  - Geographic position from GPS
  - 3-axis Fluxgate Magnetometer
  - ....
- Additional components include Microcontroller or PC/104 computer, multiplexing ADC, Data Logger, RF Transmitter, etc.
- Distributed to high schools, colleges, etc., either in kit form or fully assembled
- Prediction of dose rate profile from computer model (e.g. interpolated look up table based on PHITS calculations)

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Conclusions

- New direction for OSU Radiation Physics Laboratory (after 40+ years of measuring little holes in plastic)
- Research in T.E. Ionization Chamber and Proportional Counter design hopefully applicable to future space radiation dosimetry instrumentation
- Testing active detectors on Near Space Balloons ...cheap alternative to accelerator and space flight testing (~$500 for balloon + helium)
- Opportunity to promote Radiation Physics among science students ...provide new educational opportunities and attract students to Space Science, Radiation Science, Nuclear and Cosmic Ray Physics, etc.

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