A Sort-of Tissue Equivalent Proportional Counter (STEPC) for Space Radiation Dosimetry Applications

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Research Objectives

• Evolutionary approach to TE ionization chamber and proportional counter design, fabrication, and testing;
• Common 2” φ spherical chamber design;
• Alternative TE plastics;
• Alternative anode wire, field tube, and grid wire configurations;
• Alternatives in fill gas composition and pressure;
• Alternative detector/spectrometer electronics;
• Testing of instruments on near-space Balloon flights.
Design of Prototype STEPC

- Pressurized Steel Canister
- Anode Wire
- Ionization Cavity made of Tissue Equivalent plastic or alternative material
- Preamplifier Circuit
- High Voltage
- Signal
- Gas Fill Tube and Valve
- Preamplifier Power

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STEPC Prototype Features

Similar in design to FarWest LET-SW2 2” single wire counter, but includes:

• built in preamplifier (Cremat CR-110).
• double O-ring resealable container,
• removable $^{241}\text{Am}$ check source.

Currently five versions of STEPC:

• A-150 Tissue Equivalent Plastic,
• Nylon,
• Acrylic,
• Polyethylene,
• Polystyrene.
STEPC Prototype Circuitry

Electrical feedthroughs

Signal out
12 V
+12 V
HV

CR-110 preamp

Detector
STEPC Prototype

Detector in a can

STEPC’s guts
Stabilization of gas gain as a function of time since STEPC gas fill
Uncalibrated Lineal Energy spectrum from 5.49/5.44 MeV $^{241}$Am $\alpha$-particles measured in A-150 STEPC operating at 1400 V and 173 Torr.
Initial testing at HIMAC with 150 MeV/amu $^4$He and 500 MeV/amu $^{56}$Fe beams

- BIO Room using 10 cm diameter beam
- scintillator to monitor beam flux
Uncalibrated lineal energy (y) spectra measured by the Nylon STEPC during exposures to bare and range modulated $^4$He beams at HIMAC.
Uncalibrated lineal energy (y) spectra measured by the Nylon STEPC during exposures to the $^4$He beams at orientations perpendicular to and parallel to the axis of container
Uncalibrated lineal energy (y) spectra measured by the five STEPC detectors during exposures to the \(^4\text{He}\) beam behind 12 cm of absorber.
Uncalibrated lineal energy ($y$) spectra measured by the polystyrene STEPC in the HIMAC $^{56}$Fe beam behind 0.0, 3.0, and 5.0 cm water equivalent absorber.
STEPC Characterization at the ProCure Proton Treatment Center in Oklahoma City, USA
Dose Distributions as a function of Lineal Energy for 87 MeV Protons at ProCure using multiple STEPCs
Dose Distributions as a function of Lineal Energy for Protons at ProCure with the A-150 STEPC

![Graph showing dose distributions as a function of lineal energy for protons at ProCure with the A-150 STEPC. The x-axis represents lineal energy (keV/µm) ranging from 0.1 to 10, and the y-axis represents D(y) (counts keV/µm) ranging from 0 to 1000. The graph includes data for different proton energies: 195 MeV (black), 69 MeV (red), 40 MeV (blue), and 15.5 MeV (green).]
Portable, Autonomous STEPC for high altitude balloon testing

- Integrated into STEPC Container
  - Ionization Cavity ✓
  - Preamplifier: Cremat CR-110 ✓
  - Amplifier: Cremat CR-200 or Amptek
  - Spectrometer/ADC: Bridgeport Instruments Emorpho, XIA µDXP, Amptek DP4
  - High voltage power supply: EMCO or similar DC/DC converter

- External to STEPC Container
  - Microcontroller/Datalogger
  - Battery-based power supply
Conclusions

- Prototype STEPCs have been designed, fabricated and are now being characterized and calibrated.

- Currently comparing STEPCs with ionization cavities made of different materials to assess effect of composition on detector response.

- Currently designing amplifier, spectrometer, and HVPS that will fit in container with existing ionization cavity and preamp.

- Portable, autonomous STEPC, including power supply and data logging computer will be tested on a high altitude balloon mission in early 2011 (we hope).