Interpretation of TEPC Measurements in Space Flights for Radiation Monitoring

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Introduction

- The quality factor used in radiation protection is defined as a function of LET, Q(Q(LET))
- TEPCs measure the average quality factors as a function of linear energy (y, Q(LET))
- A model of the TEPC response for charged particles:
  - energy deposition as a function of impact parameter from the ion's path to the volume
  - the escape of energy out of sensitive volume by ė-rays
  - the entry of ė-rays from the high-density wall into the low-density gas-volume
- TEPC response for broad spectrum of HZE particles:
  - the weighted function of discrete Monte-Carlo simulation data of the energy deposition

Approach to Radiation Evaluation

- Transport properties of spacecraft:
  - NASA BRYNTRN/HZETRN code system
  - Nuclear interaction model: Quantum Multiple Scattering Fragmentation (OMSFRG)
- TEPC detector response function:
  - Analytic model for frequent event spectra for trapped protons
  - Monte-Carlo track simulation for frequent event spectra for HZE particles

Analytic Model for Track Structure

Frequency Distribution for Energy Imparted by Ions

\[
\frac{df}{dt} = 2 \pi \int d \phi \, d \theta \, dE_x \, dE_y \, dE_z \, dE_{\text{kin}} \left( f_x(t) + f_y(t) \right)
\]

where \( n_x(t) \) is the number of events as a function of impact parameter \( t \)
\( f_x(t) \) is ions through the volume
\( f_y(t) \) is ions outside the volume
\( \Phi(t) \) is the radial dose distribution
\( \delta(t) \) is the frequency average of the distribution at \( t \)

Dependence of Frequency Distribution on \( t \)

\[
L \sim 2 \pi \int d \phi \, d \theta \, \left( \frac{df_x}{dt} + \frac{df_y}{dt} \right)
\]

where \( D_r \) is the radial dose from primary or secondary electrons
\( D_{\text{esc}} \) is the radial dose from excitation

\( f_{\text{esc}} \) is Mean and Variance Correction for ė-ray Diffusion

For example, the variance is

\[
\sigma^2(t) = \int dE_x \, dE_y \, dE_z \, dE_{\text{kin}} \, \sigma^2(t)
\]

where \( \delta(t) \) is the quotient of the second by the 1st moment

Event Spectra for an Ion of E MeVamu

TEPC Response Function

\( f_x(t), f_y(t) = f_x(t) + f_y(t) \)

The Linear Energy Distribution behind Shielding

\( f_x(t) = \int dE_x \, dE_y \, dE_z \, dE_{\text{kin}} \left( f_x(t) + f_y(t) \right) \)

where \( d_x \) is the directional weighting coefficients for spacecraft shielding
\( d_x \) is the directional weighting coefficient for instrument
\( \phi \) is flux from BRYNTRN or HZETRN

Monte-Carlo Simulation of Walled TEPC in 1-μm Tissue Site for Oxygen Ions

Shuttle Tissue Equivalent Proportional Counter (STS-89, January 1998)

Event Distributions

\( Q(\text{LET}) \) and \( Q(y) \) for Trapped Radiation as a Function of Aluminum Thickness

Quality Factors of LET and Lineal Energy for Various Ions

Concluding Remarks and Future Works

Trapped protons:
- The model calculation of integral flux is very close to the TEPC measured data except above 100 keV/μm
- Target fragmentation to be included in the model
- \( 1.98 \leq Q_{\text{d(LET)}}(y) \leq 2.58 \) as measured by the TEPC
- \( 1.65 \leq Q_{\text{d(LET)}}(y) \leq 1.65 \) as calculated from LET distribution using BRYNTRN
- \( 2.07 \leq Q_{\text{d(LET)}}(y) \leq 2.07 \) as calculated from \( y \) distribution determined from TEPC response function and BRYNTRN

HZE particles of GCR:
- \( Q(y) < Q(\text{LET}) \) for HZE particles in the major interval of \( y \) or LET
- TEPCs underestimate the average quality factor for GCR
- Monte-Carlo simulation to be made for broad spectrum of ion types and energies extended to 1000's MeV/μm, and low y components with better statistic
- Radiation transport calculation of TEPC response will be compared with the TEPC measured data of GCR for the code validation effort and interpretation of radiation monitoring

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<th>Sphere Thickness g/cm²</th>
<th>( Q_{\text{avg}}(\text{LET}) )</th>
<th>( Q_{\text{avg}}(y) )</th>
<th>Measured ( Q_{\text{avg}}(\text{LET}) )</th>
<th>Measured ( Q_{\text{avg}}(y) )</th>
<th>( Q_{\text{avg}}(\text{LET})/Q_{\text{avg}}(y) )</th>
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