# AMPS Geospace Radiation Pipeline: From Magnetopause Spectrum to LEO Flux and Cutoffs

AMPS Interface Documentation

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## 1 Pipeline overview

A typical run uses the following stages:

1. Specify particle species and an upstream spectrum $J(E,t)$ at the outer boundary (usually the magnetopause).
2. Choose magnetic and electric field models $\mathbf{B}(\mathbf{r},t)$ and $\mathbf{E}(\mathbf{r},t)$.
3. Define the domain boundary (e.g., Shue magnetopause or a box) and inner loss boundary.
4. Perform trajectory tracing (forward for transport, or backward for cutoffs) through the fields.
5. Derive observables: cutoff rigidity $R_C$, access probability, and flux at the target altitude/location.

## 2 Equations of motion

Particles are advanced with the relativistic Lorentz force:

$$\frac{d\mathbf{r}}{dt} = \mathbf{v}, \tag{1}$$

$$\frac{d\mathbf{p}}{dt} = q\left(\mathbf{E}(\mathbf{r},t) + \mathbf{v}\times\mathbf{B}(\mathbf{r},t)\right), \tag{2}$$

$$\mathbf{p} = \gamma m\mathbf{v}, \qquad \gamma = \left(1-\frac{v^2}{c^2}\right)^{-1/2}. \tag{3}$$

## 3 Cutoff rigidity computation (backtracing)

To compute cutoffs at a target location, AMPS backtraces particles launched with selected rigidities $R$ and direction $\hat{\mathbf{v}}$. For each $R$, the outcome is classified as *allowed* or *forbidden* based on whether the trajectory reaches the outer boundary without intersecting the loss boundary. Scanning across $R$ yields $R_L$, $R_U$, and the effective cutoff $R_C$.

## 4 Flux mapping

Given an upstream spectrum $J(E)$, the flux at a target can be estimated using transmissivity / access probability $T(E,\Omega)$:

$$J_{\text{target}}(E) = \int T(E,\Omega)\, J_{\text{up}}(E,\Omega)\, d\Omega. \tag{4}$$

In a deterministic backtracing approach, $T$ is approximated by the fraction of launched trajectories that are allowed for a given $(E,\Omega)$.

## 5 Reconstructing upstream spectra from GOES

If you want the upstream boundary condition to be event-specific, you can fit a parametric model $J(E;\boldsymbol{\theta}(t))$ to GOES channel data. The forward model integrates $J(E)$ over each channel's energy range (or response function), and the fit is repeated over time.

## 6 Outputs

Typical outputs include:

- $R_L$, $R_U$, and $R_C$ (cutoff rigidity),
- flux maps and time series at selected altitudes/locations,
- access probability vs. energy/rigidity,
- diagnostic trajectories.