Modeling RHESSI TGFs with (more) realistic source locations and geometries

Bryna Hazelton

Physics Department and Santa Cruz Institute for Particle Physics, University of California, Santa Cruz

Collaborators

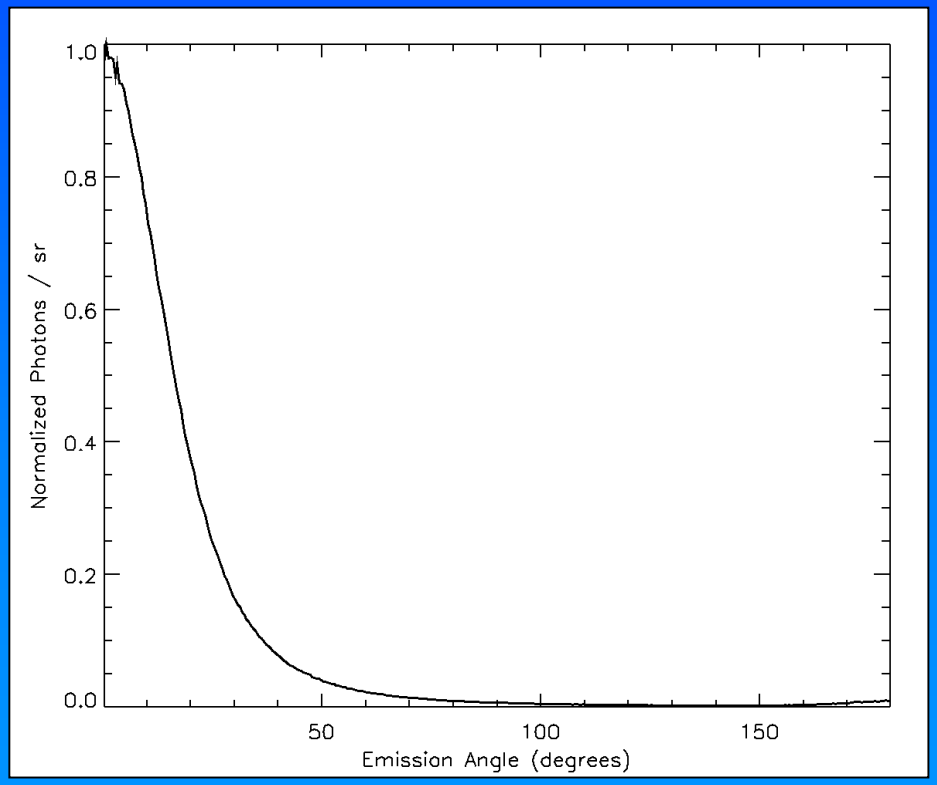
David M. Smith, Brian W. Grefenstette
Physics Department and Santa Cruz Institute for Particle Physics, University of California, Santa Cruz

Joseph R. Dwyer
Department of Physics and Space Sciences, Florida Institute of Technology

Erin H. Lay, Robert H. Holzworth
Department of Earth and Space Science, University of Washington

Runaway Breakdown Simulations

- Monte Carlo simulation by Joe Dwyer
  - Includes all feedback mechanisms
  - Purely vertical electric field
  - Beam is widened by Compton scattering and bremsstrahlung production to ~ 20° HWHM
  - Energetic structure: Harder photons have smaller emission angles.



Photons/sr vs emission angle at end of avalanche region

Relativistic Runaway Models

- GEANT atmospheric propagation
  - Photons from RRB simulation are propagated through the atmosphere using GEANT
- Upward and tilted beams are considered
- Source altitudes: 21 km, 15 km, 13 km, 11 km

TGFs with WWLLN Storms

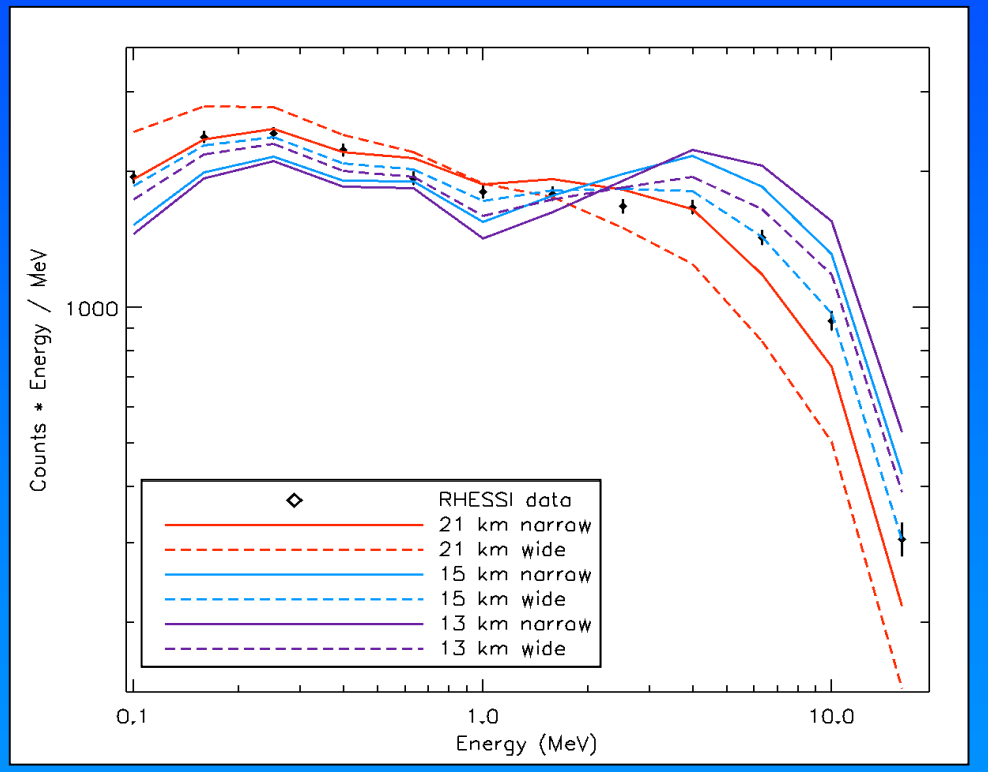
- 362 TGFs with WWLLN data
  - January 2004 - December 2005
- WWLLN strikes within ± 20 minutes of TGF time identify thunderstorm locations
- Distance from strike locations to sub-satellite point is an indication of the sub-satellite to source distance

Distance Separated TGFs

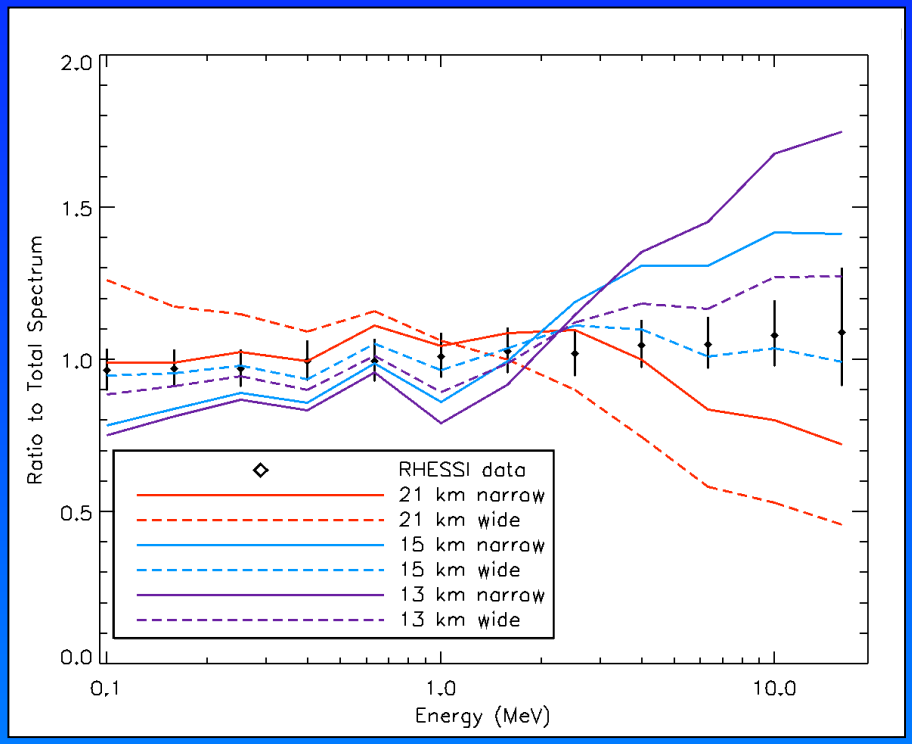
- TGFs with WWLLN data are separated by distance from WWLLN strikes to sub-satellite point
- TGFs with no strikes within 300 km of the sub-satellite point have a softer spectrum

Upward Beam Models

- Narrow Beams
  - Initial angles given by RRB Monte Carlo
- Wide Beams
  - Isotropic in a 45° cone
- 15 km wide beam is best fit



Summed spectrum of all TGFs with WWLLN data and upward beam models.



◀ TGFs with WWLLN strikes within 300 km (316 TGFs)

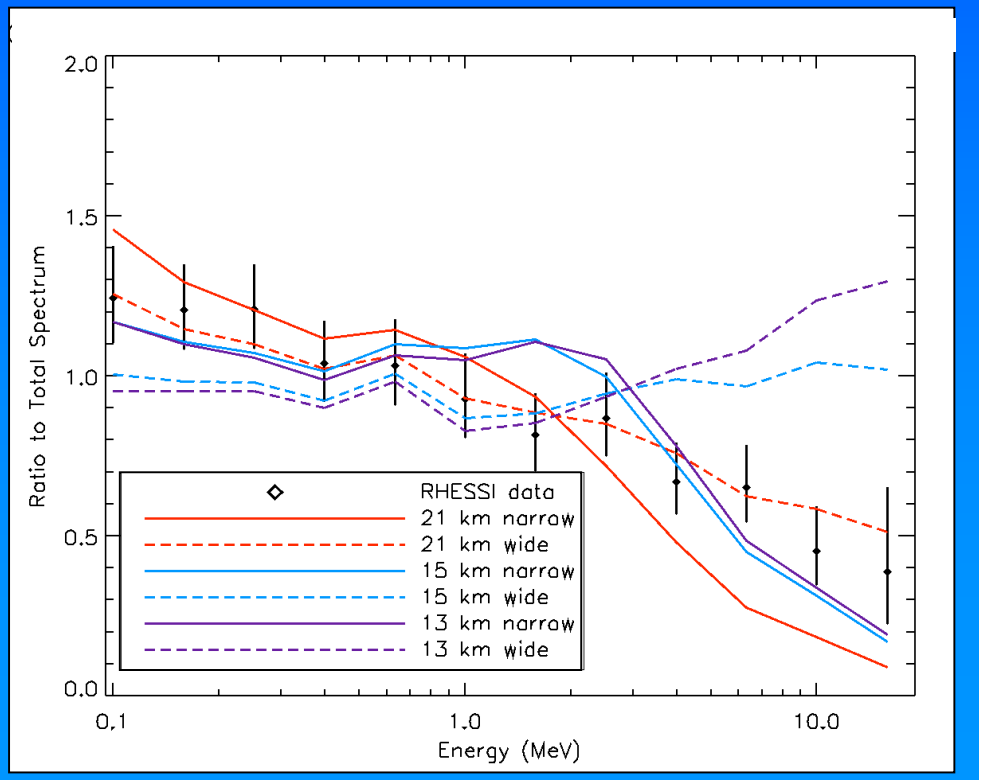
Models are summed inside 300km

15 km wide beam model is best fit

TGFs with no WWLLN strikes within 300 km (46 TGFs) ▶

Models are summed outside 300km

21 km wide model is best fit

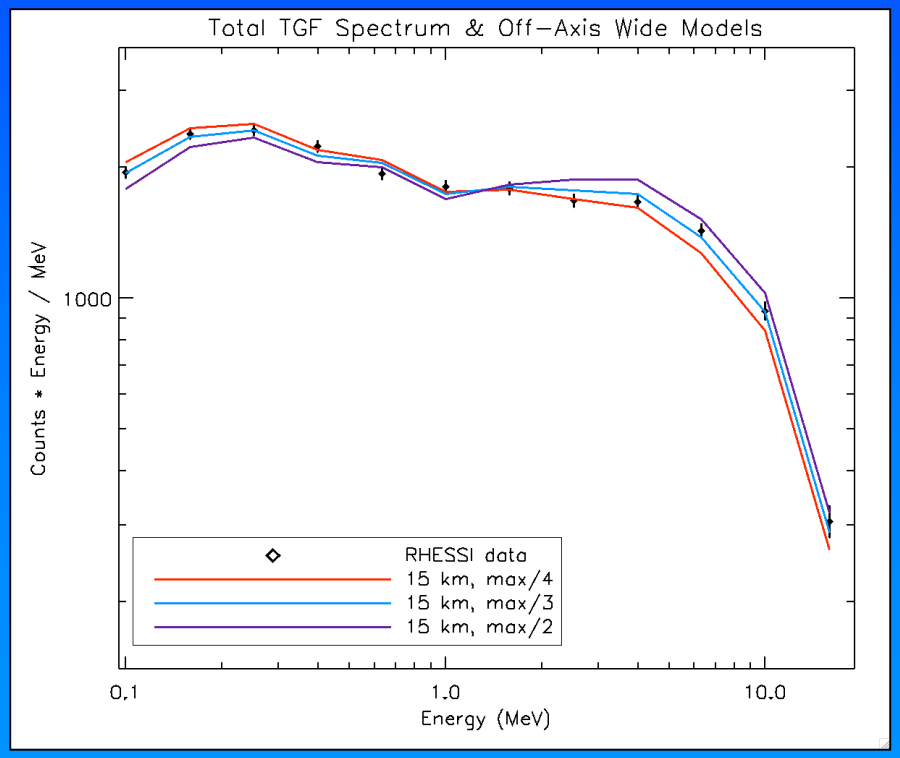


Tilted Beam Models

- Assume isotropic probability distribution for tilt angles from 0° to 90° from vertical
- Accumulate photons in pixels on a sphere at RHESSI altitude for each tilt angle
- Choose a trigger level
  - relative to intensity directly above a vertical beam
- Collect all triggered pixels from all angles in distance bands of interest

Tilted Beam Trigger Effects

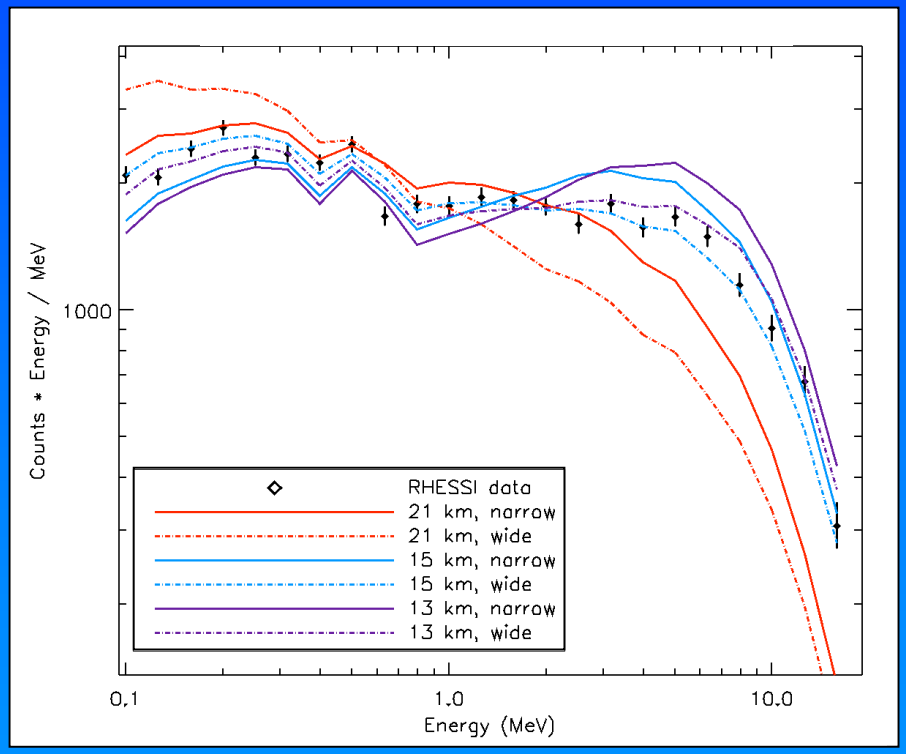
- Trigger level choice has some effect on spectral shape
- A lower trigger threshold results in harder spectra



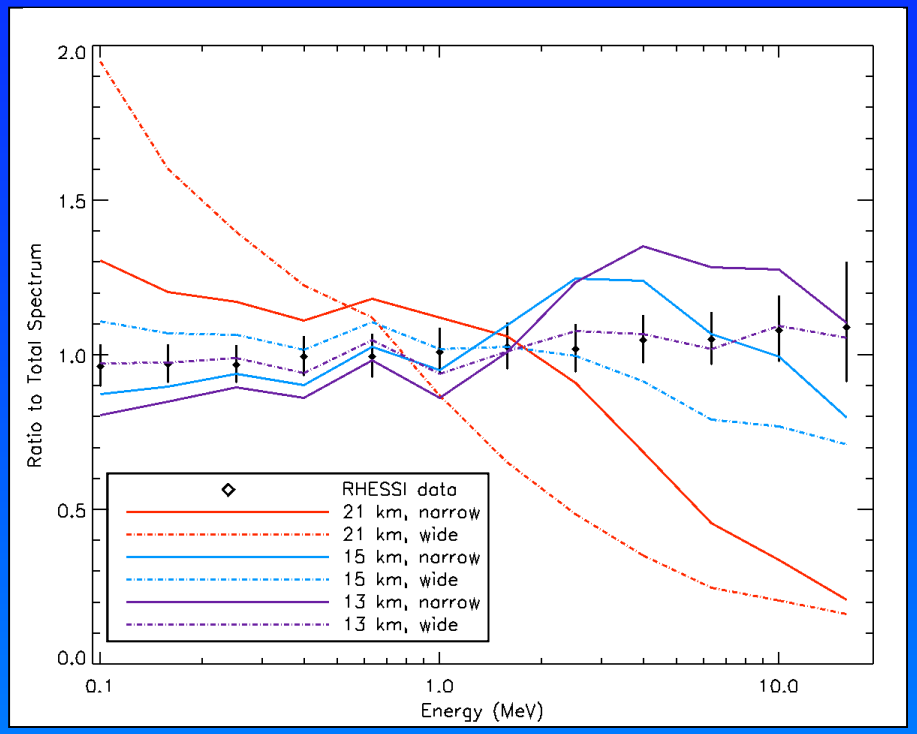
15 km wide beam model with 3 different trigger levels

Tilted Beam Models

- Narrow Beams
  - Photon angles given by RRB simulation
- Wide Beams
  - Narrow beams convolved with a Gaussian, resulting beam ~ 30° HWHM
  - Energy structure is maintained
- 15 km wide beam is best fit



Summed spectrum of all TGFs with WWLLN data and tilted beam models.



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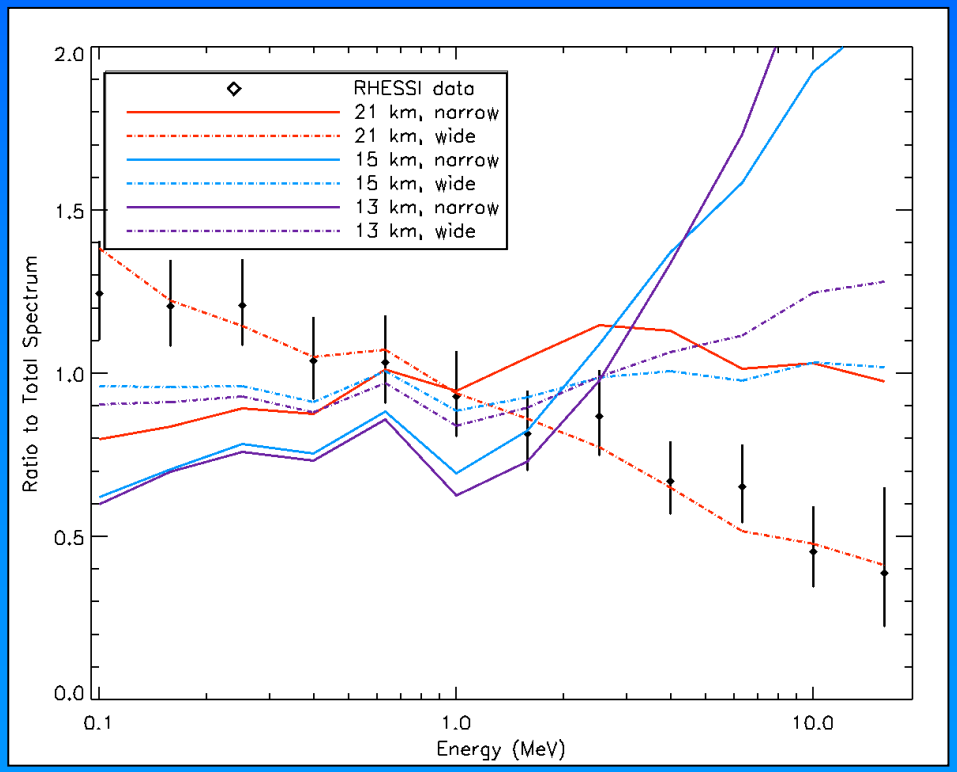

Effects of Deadtime

- Deadtime suppresses the hard peak for close, bright TGFs
  - Total spectrum should be harder
  - Distant spectra will be unchanged, so should be even softer by comparison with total
- Prevents understanding of intrinsic brightness distribution
  - Affects number of very distant events in sample

Conclusions

- Wide beam models fit distance - separated spectra best
- No model fits all the data well
  - 13 - 15 km wide beams fit near TGFs best
  - 21 km wide beams fit far TGFs best
- Future improvements
  - Better beam widening algorithm for upward beams
  - Better trigger choice for tilted beams
  - Different probability distribution for tilt angles
  - Incorporate deadtime effects