A FAST GRB SOURCE LOCALIZATION PIPELINE FOR THE ADVANCED PARTICLE-ASTROPHYSICS TELESCOPE

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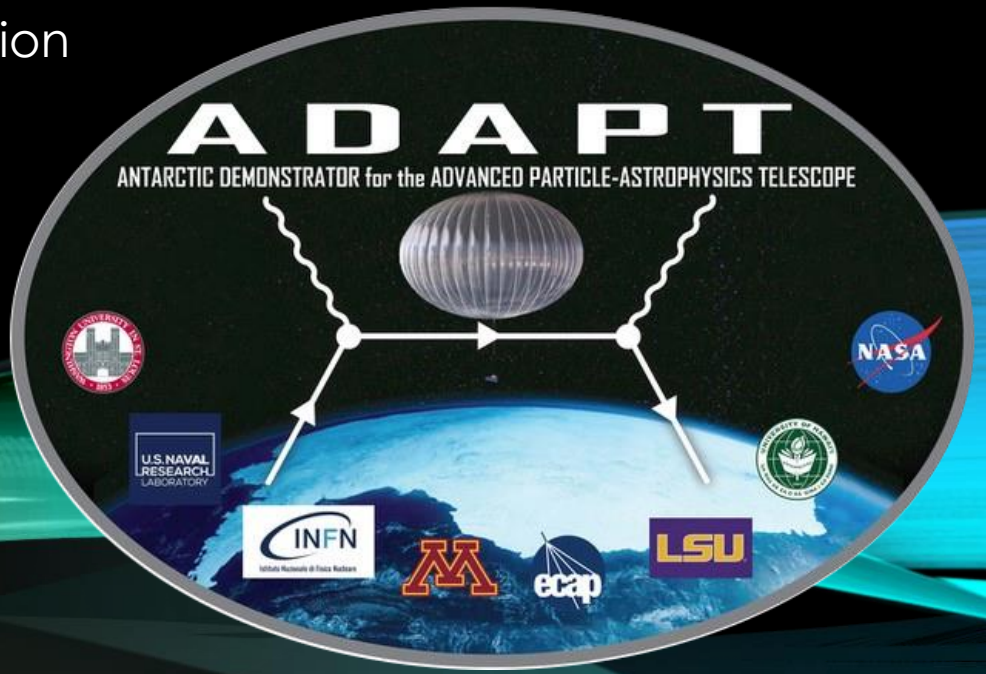
For the ADAPT Collaboration



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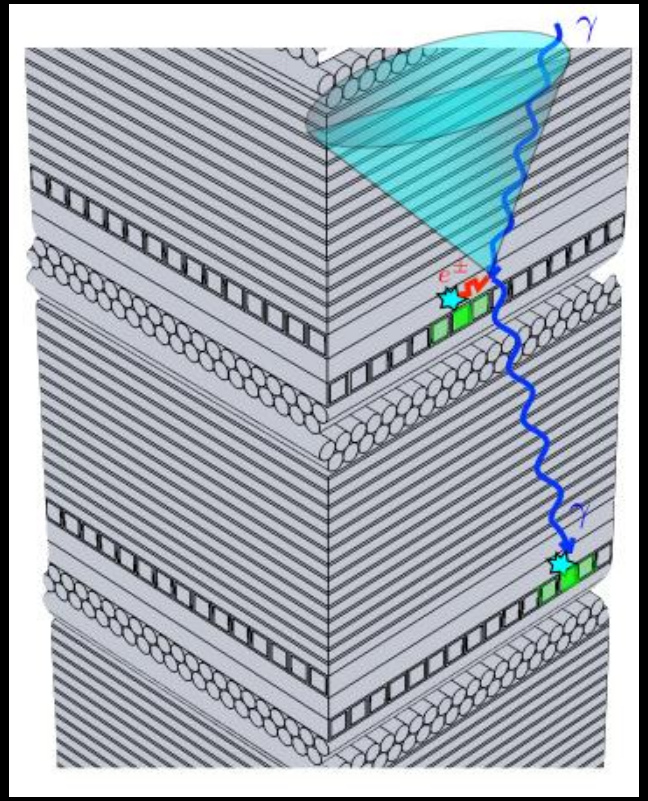
INTRODUCTION

- The Advanced Particle-astrophysics Telescope is a space-based observatory
- Surveys the entire sky for gamma-ray sources
- Needs to rapidly communicate with narrow-band instruments for follow-up observations
- APT will fly with low-powered computing hardware
- We have developed an efficient pipeline to localize GRBs in real-time

RECONSTRUCTION PROBLEM

- We focus on energies in Compton regime
- The GRB's source can be constrained to a circle defined by:
  - The vector described by the first two interactions
  - The scattering angle determined by the Compton law
- The detector reports a sequence of interactions
- Order is unknown
- Need to reconstruct interaction order to determine coordinates and energies of first two interactions

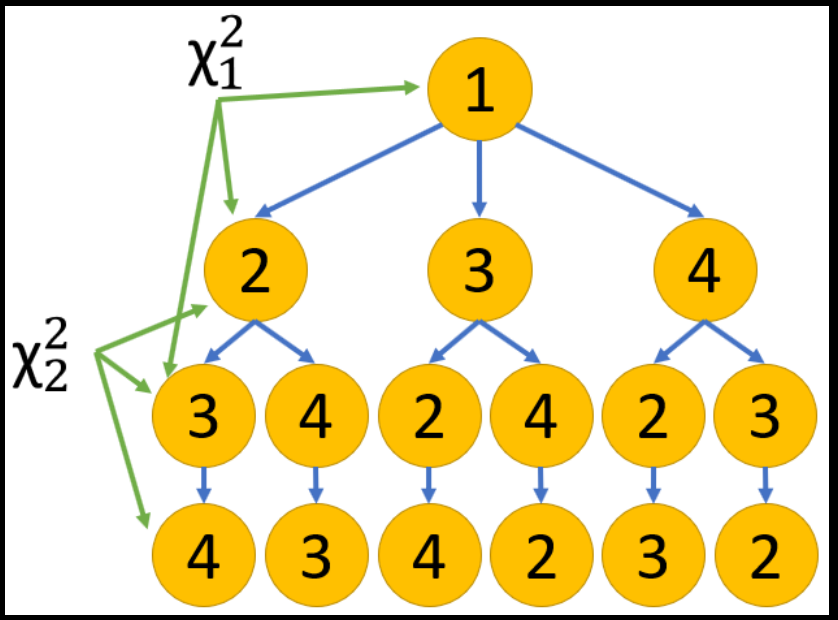


RECONSTRUCTION METHODS

- Based on Boggs and Jean 2000
- Infer the ordering that minimizes:

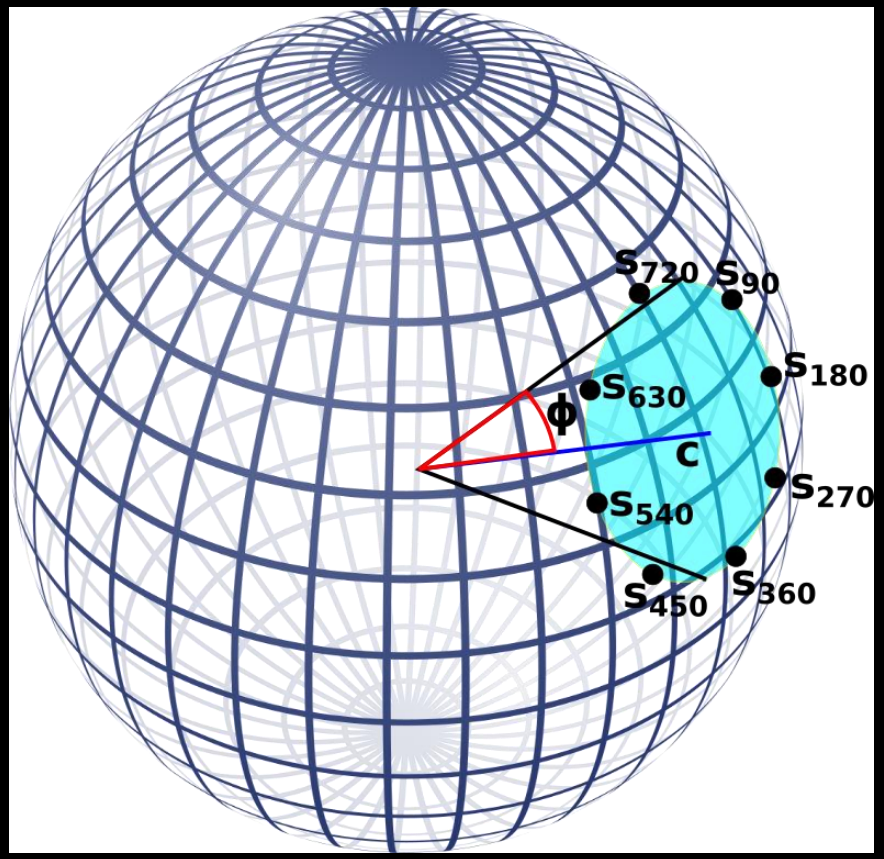
$$\chi^2 = \sum_{i=2}^{N-1} \chi_i^2 = \frac{1}{N-2} \sum_{i=2}^{N-1} \frac{(\eta_i - \eta_i')^2}{\delta\eta_i^2 + \delta\eta_i'^2}$$

- Represents disagreement between measured angles and those implied by the Compton law
- We implement a *tree traversal*
- Computation of the χ^2 contribution for a common initial subsequence need only happen once
- We can prune the tree as it is traversed



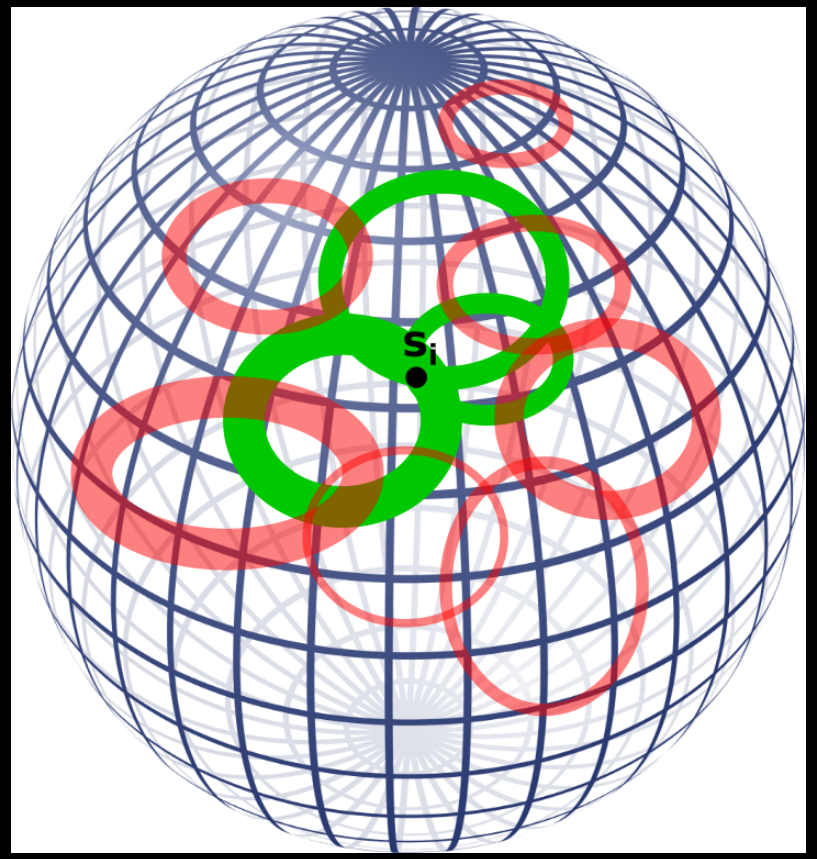
INITIAL SOURCE APPROXIMATION

- Reconstruction propagates an annulus <**c**, φ , σ>
- Multiple annuli allow us to infer a source direction
- We sample multiple annuli
- Estimate a likely source direction contained within each one
- Average these source estimates to compute a rough approximation



ITERATIVE LEAST-SQUARES REFINEMENT

- We take the initial approximation
- Identify annuli close to this approximation
- Use these annuli as inputs to least-squares problem
- Approximation updated with solution
- Iterate 20 times to get final source estimate



RESULTS

- Localization Accuracy
- All listed values in degrees
- 1000 trials for each fluence

Fluence	Mean Error	Std Dev	68% Containment	95% Containment
0.03 MeV/cm^2	2.15	1.22	**2.53**	4.42
0.1 MeV/cm^2	1.21	0.64	1.45	2.32
0.3 MeV/cm^2	0.70	0.36	0.87	1.32
1.0 MeV/cm^2	0.35	0.20	0.42	**0.72**

- Execution Times
- Tested on Raspberry Pi 3 Model B+
- 200 trials for each fluence