

An Observer's View of Requirements for a Global Array

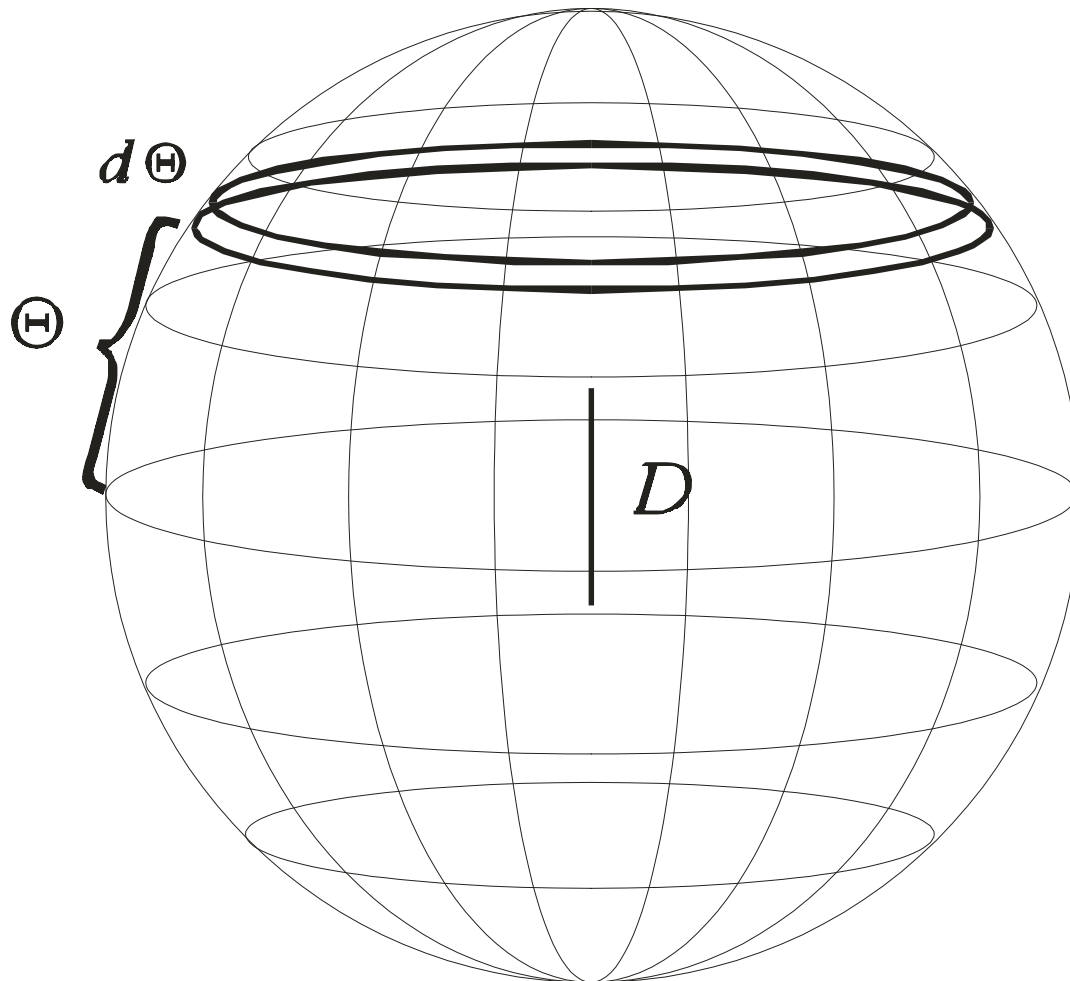
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Outline

- Review of position determination.
- Arguments for extending the global array.
- How to design the array.
- Why measure positions? Lessons from recent astronomical history.

Position Info from Time Delay



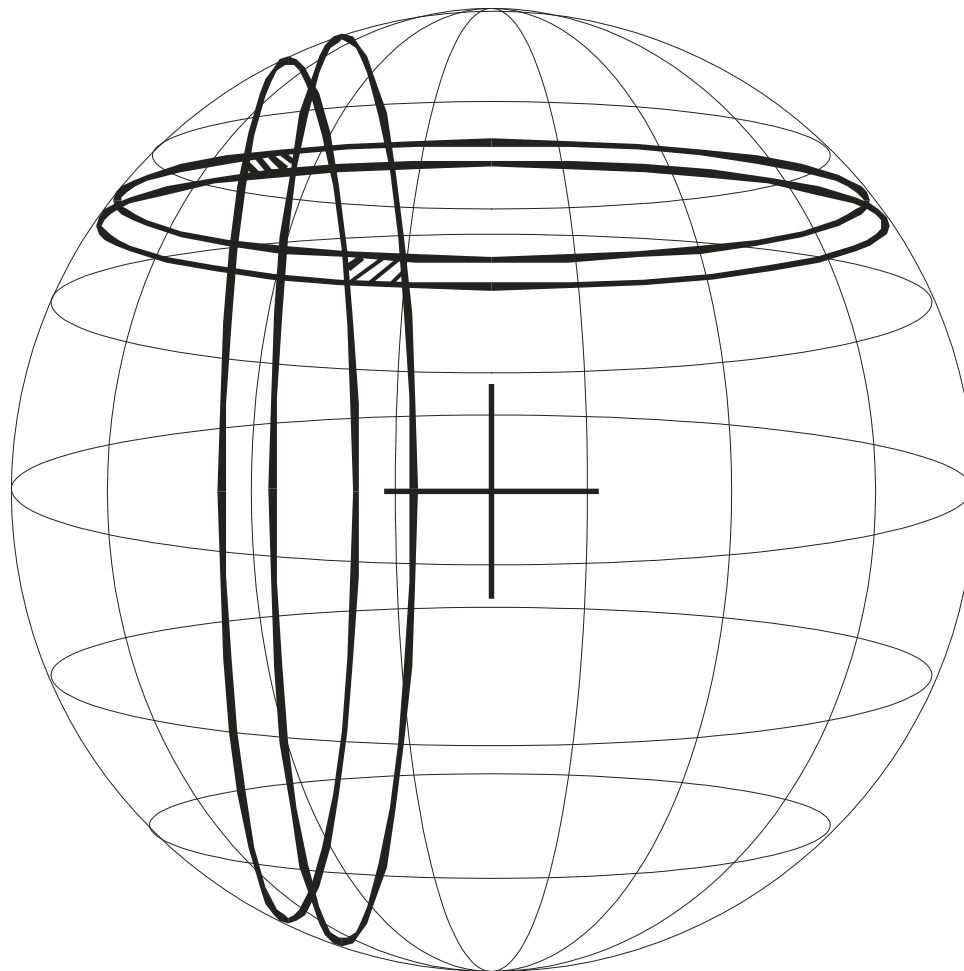
Position, precision

$$\Theta = \arcsin \frac{c\tau}{D}$$

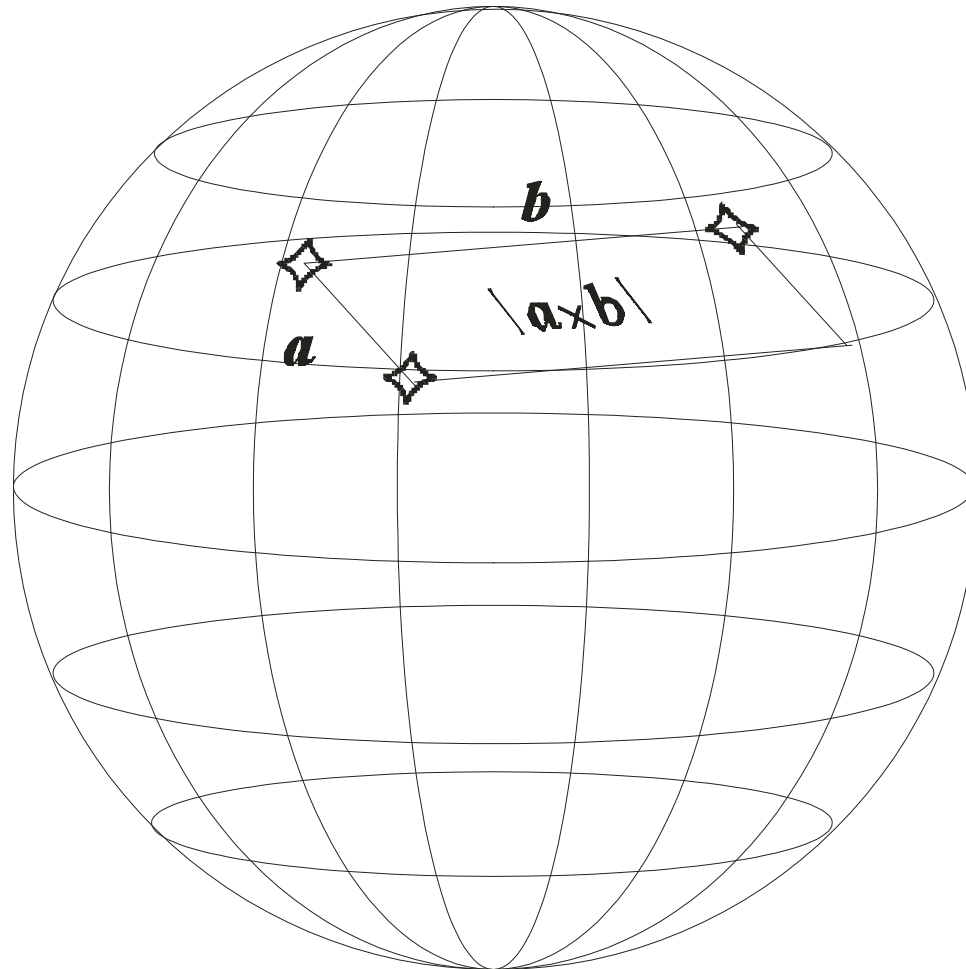
$$d\Theta = d\tau \frac{c}{D} \frac{1}{\sqrt{1 - \frac{c^2\tau^2}{D^2}}}$$

If $D = 6000$ km and $d\tau = 0.1$ msec, then
 $d\Theta \sim 1/4$ degree.

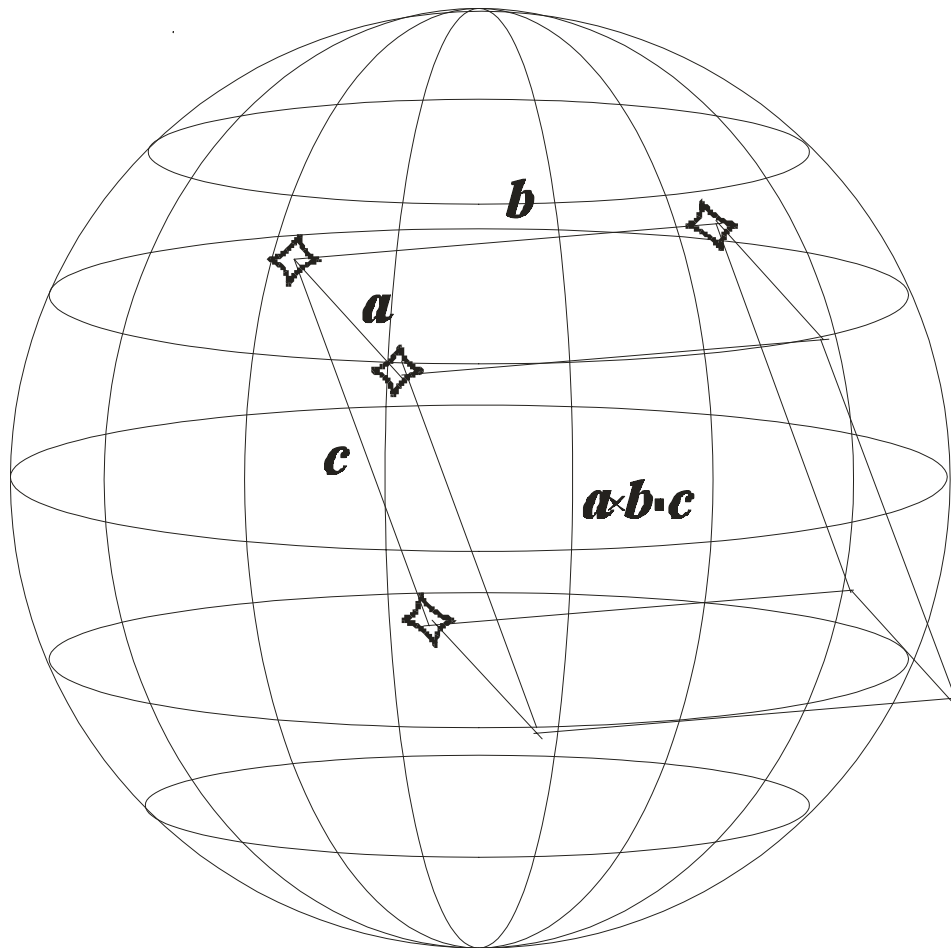
Two Baselines Almost Does It



FOM for a 3-Detector Array



FOM for a 4-Detector Array



An extended global array gives us

- Somewhat better sensitivity,
- Somewhat better sky coverage,
- *Substantially better position information.*

If we want clues to the nature of sources of unknown signals, then we need ways to get the best possible information on source positions. We have to prepare to become *astronomers*.

How to design the array

These seem obvious:

- Long baselines.
- Large Volume FOM.

Questions:

- “Matched” orientation?
- How much benefit from matched performance (i.e. noise spectra)?

Position Precision in Astronomy

- Some kinds of astronomical inferences can be drawn from data with error boxes with diameters of several degrees, e.g.
 - test for isotropy, or
 - match to Milky Way.
- Identification with specific objects typically requires precision of order 1 arcmin or better.

Bright X-ray sources are a few kpc away

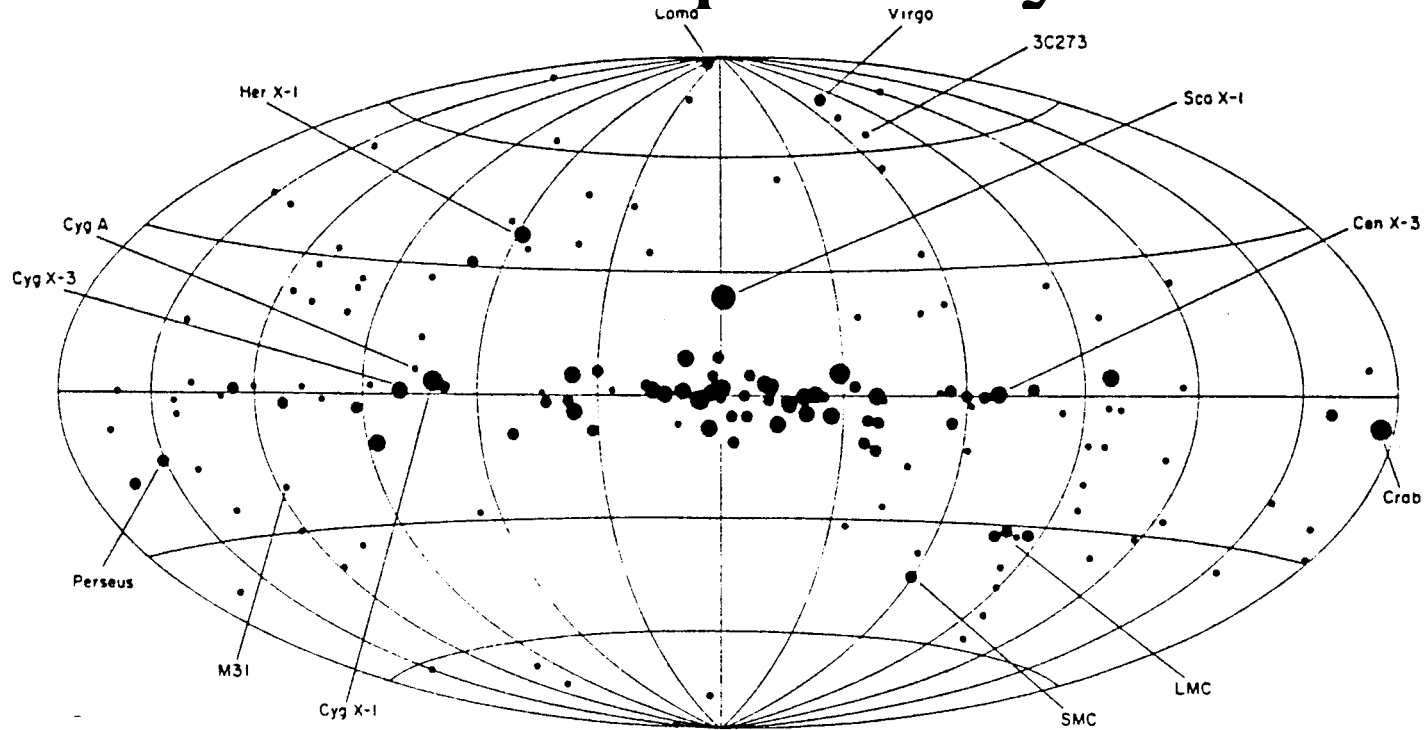


Fig. 4.1. A map of the X-ray sky in galactic coordinates derived from the 3U Catalog. The location of each X-ray source is approximately shown. The size of the dots is proportionate to the logarithm of the intensity. Several of the sources of outstanding astrophysical interest are shown.

Crude positions work when ...

All-sky map tells a story.

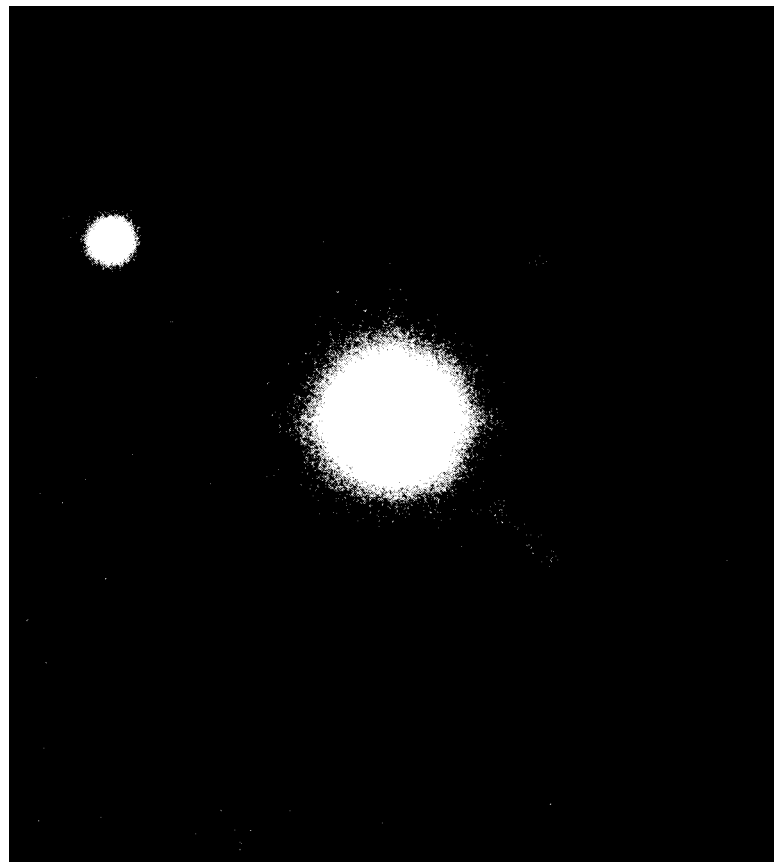
Milky Way is a distinctive pattern, even with crude positions, and indicates a very definite spatial distribution of sources.

Q: What other maps tell a story?

Isotropic map (but can be ambiguous)

Distribution of nearby galaxies (but starts to get isotropic past the Virgo Cluster.)

Discovery of quasars required error boxes of 1 arcsec



Tiny error boxes needed when ...

- You are looking for a needle in a haystack.
There are a lot of 13th mag stars. Many more
19th mag stars.
- Distinguishing features are hard to
recognize
3C273's jet only showed up on top quality photos
Redshifts take work, need specific target.

Early gamma ray burst maps were very crude, gave few clues

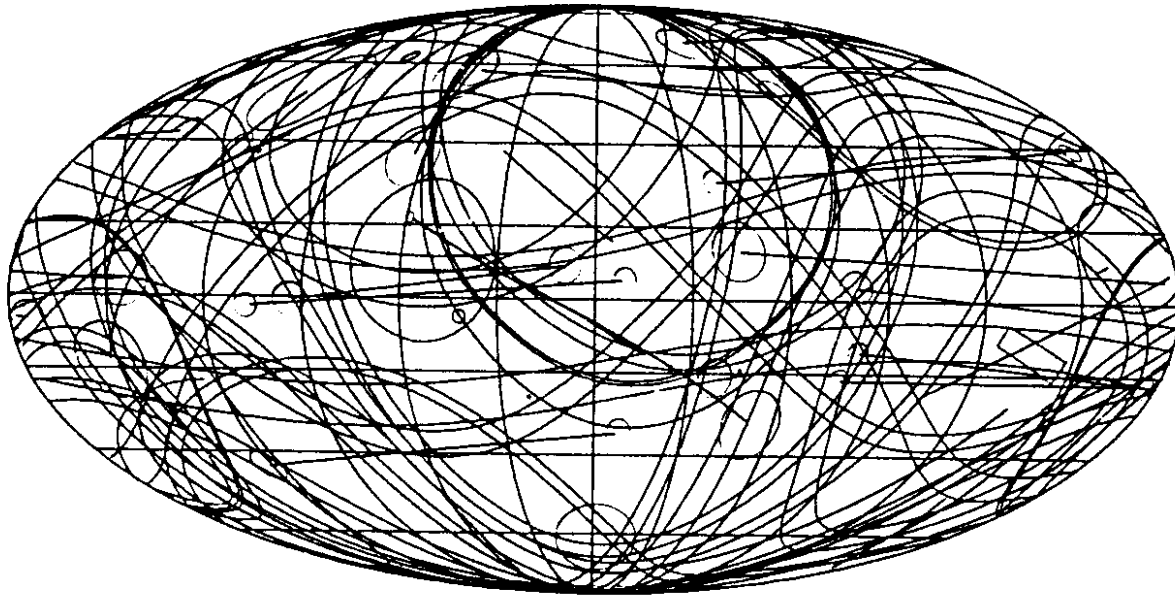
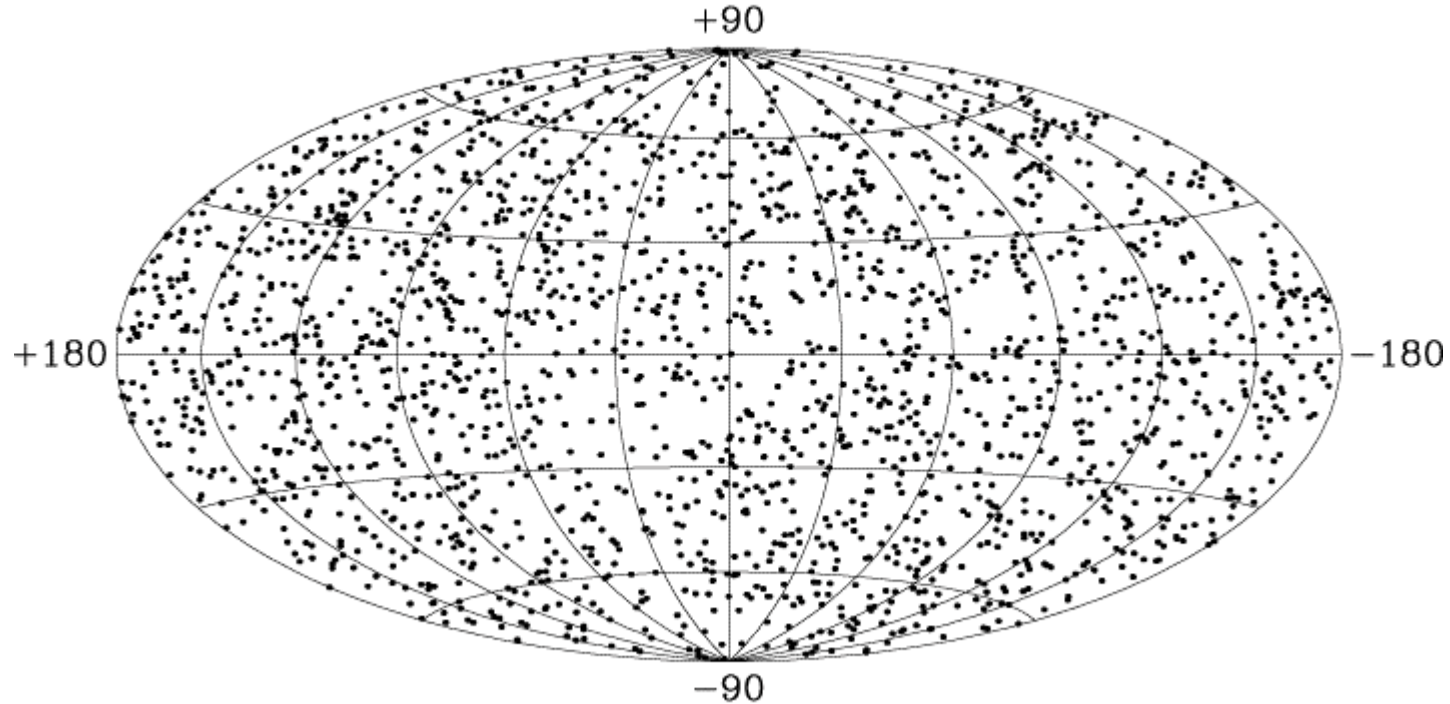


Figure 1.19. The 62 localizations of Klebesadel et al. (1982) (91) in galactic coordinates. 78% of the sky is covered by these 3σ regions. From Atteia et al., 1985 (155).

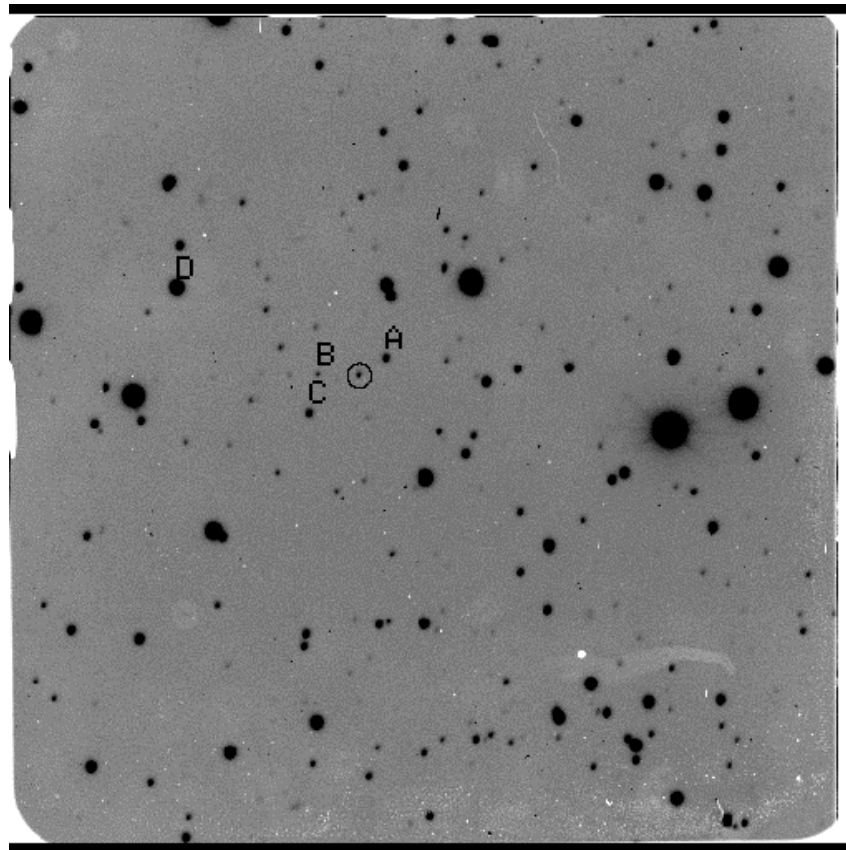
BATSE (5 degree errors) showed sources were cosmological

2000 BATSE Gamma-Ray Bursts

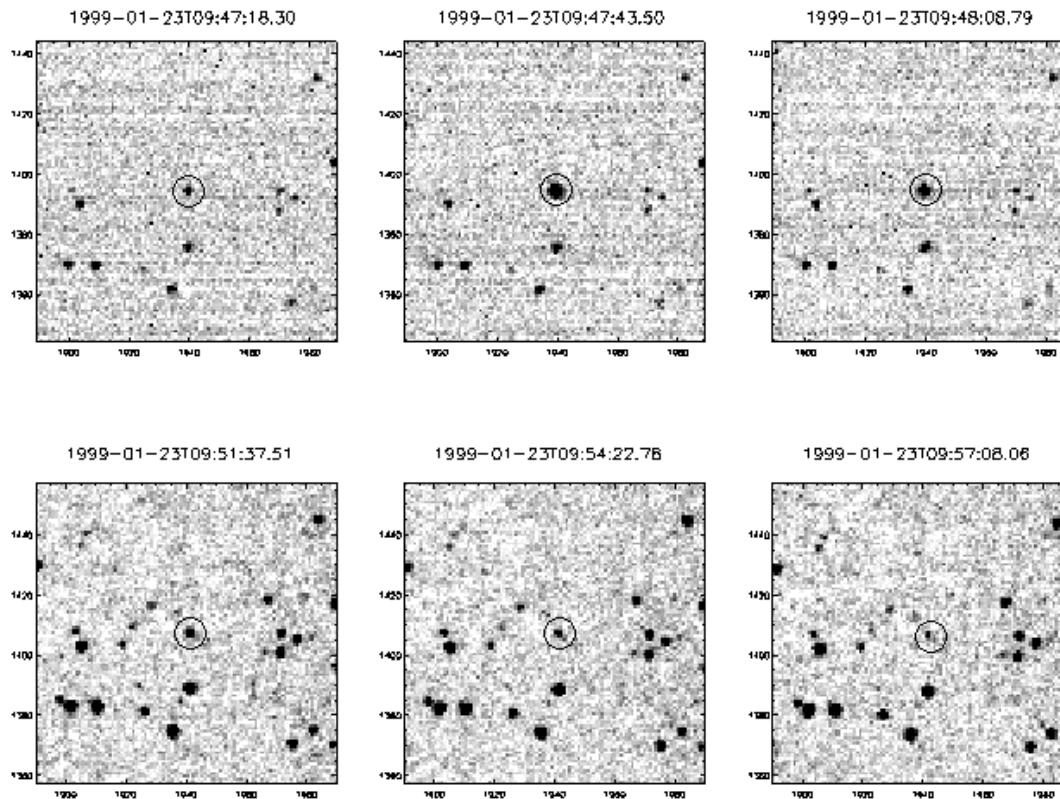


Galactic Coordinates

BeppoSAX (3 arcmin errors) yielded optical IDs of GRBs (GRB980519, 19th mag)



BATSE + ROTSE (22 sec response time) shows 9th mag counterpart of GRB990123



An optical ID from a big error box! How?

- ROTSE camera found counterpart of GRB990123 using only the 5 degree error box of BATSE observations
- Distinguishing feature was transient behavior.
- We may be in this situation for most of our sources.
- Can we organize prompt follow-up?

Lessons from history?

- If we are lucky, we'll find signals we didn't expect. Then, we'll need to figure out what we are seeing.
- We'll need all the help we can get from other branches of astronomy.
- To meet astronomers half way, we need to give them good positions. A global array is the best way to do this.