FREQUENTLY ASKED QUESTIONS

Q: When you have two annuli, why don't you simply quote their intersection points to define the error box?

A: In general, the annuli obtained by triangulations are small circles on the celestial sphere, so their curvature is not always negligible, and a simple, four-sided error box cannot be defined. Here are the formulas for finding the intersections for those cases where it may be useful. Let $\alpha_1, \delta_1, \theta_1$ and $\alpha_2, \delta_2, \theta_2$ be the right ascension, declination, and radii of the two small circles. Let α, δ be the right ascension and declination of the intersection points. Then

$\sin\delta = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

where

a=$-\cos^2\delta_1 \cos^2\delta_2 \sin^2(\alpha_1-\alpha_2) + 2\sin\delta_1 \sin\delta_2 \cos\delta_1 \cos\delta_2 \cos(\alpha_1-\alpha_2) - \sin^2\delta_2 \cos^2\delta_1 - \sin^2\delta_1 \cos^2\delta_2$,

b=$-2(\cos\theta_1 \sin\delta_2 + \cos\theta_2 \sin\delta_1)\cos\delta_1 \cos\delta_2 \cos(\alpha_1-\alpha_2) + 2\cos\theta_2 \sin\delta_2 \cos^2\delta_1 + 2\cos\theta_1 \sin\delta_1 \cos^2\delta_2$,

and

c=$\cos^2\delta_1 \cos^2\delta_2 \sin^2(\alpha_1-\alpha_2) + 2\cos\theta_2 \cos\theta_1 \cos\delta_1 \cos\delta_2 \cos(\alpha_1-\alpha_2) - \cos^2\theta_2 \cos^2\delta_1 - \cos^2\theta_1 \cos^2\delta_2$,

For each of the two values of the declination δ the corresponding right ascension α is given by

$\alpha = \alpha_1 + \cos^{-1}\frac{\cos\theta_1 - \sin\delta \sin\delta_1}{\cos\delta \cos\delta_1}$

Note that these formulas can also be used to calculate the intersection points of an IPN annulus and a BATSE or BeppoSAX error circle, for example. Just let $\alpha_2, \delta_2, \theta_2$ be the right ascension, declination, and radius of the circle.

Q: I have an object located at α_1, δ_1 and I want to know if any GRB position is consistent with it. How do I calculate this?

A: Let $\alpha_2, \delta_2, \theta_2, d\theta_2$ be the right ascension, declination, radius, and half-width of an annulus. Then the distance between the object and the annulus center is given by

$d = \mid \cos^{-1}(\sin(\delta_1)\sin(\delta_2) + \cos(\delta_1)\cos(\delta_2)\cos(\alpha_1-\alpha_2)) \mid$.

If the position of the object is consistent with the IPN annulus,

$\theta_2 - d\theta_2 \leq d \leq \theta_2 + d\theta_2$

If there is a second annulus defining the GRB position, repeat the procedure for it.

Q: There are entries in the table with two annuli. The GRB therefore has two possible arrival directions. How do I know which one is the correct one?

A: There are many possibilities. 1) In some cases, we just don't have any way of choosing. 2) In other cases, the table contains a BATSE, COMPTEL, EGRET, WATCH, PHEBUS, SIGMA, or SAX location which can be used to distinguish between the two possibilities. 3) The Konus ecliptic latitude band encompasses one intersection, but not the other. 4) Planet-blocking eliminates one intersection. 5) The correct intersection can be determined because there is additional information which is not in the table yet. I have started to add known intersection points to this table (in the columns containing Other Localization RA, Dec, and R), but this is not complete. In the meantime, if you are interested in a small number of events, contact me by e-mail.

Q: When you triangulate a burst, do you simply compare the trigger times of each pair of spacecraft to get an annulus?

A: No. All pairs of time histories are cross-correlated, and two statistics are calculated: the correlation coefficient and the chi-squared. The confidence intervals for the lag, which determine the annulus width, are derived from the chi-squared statistic.

Q: Are these the most accurate descriptions of the IPN error boxes?

A: If only two or three spacecraft observed a burst, then the most accurate description of the error box is one or two annuli, which are given here. However, if four or more widely separated spacecraft observed an event, an error ellipse can be derived, which is a more accurate description, and one which covers a smaller area.