



Preliminary Results of Differential-Loran Studies with All-in-View Receiver

by

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Experimental Setup

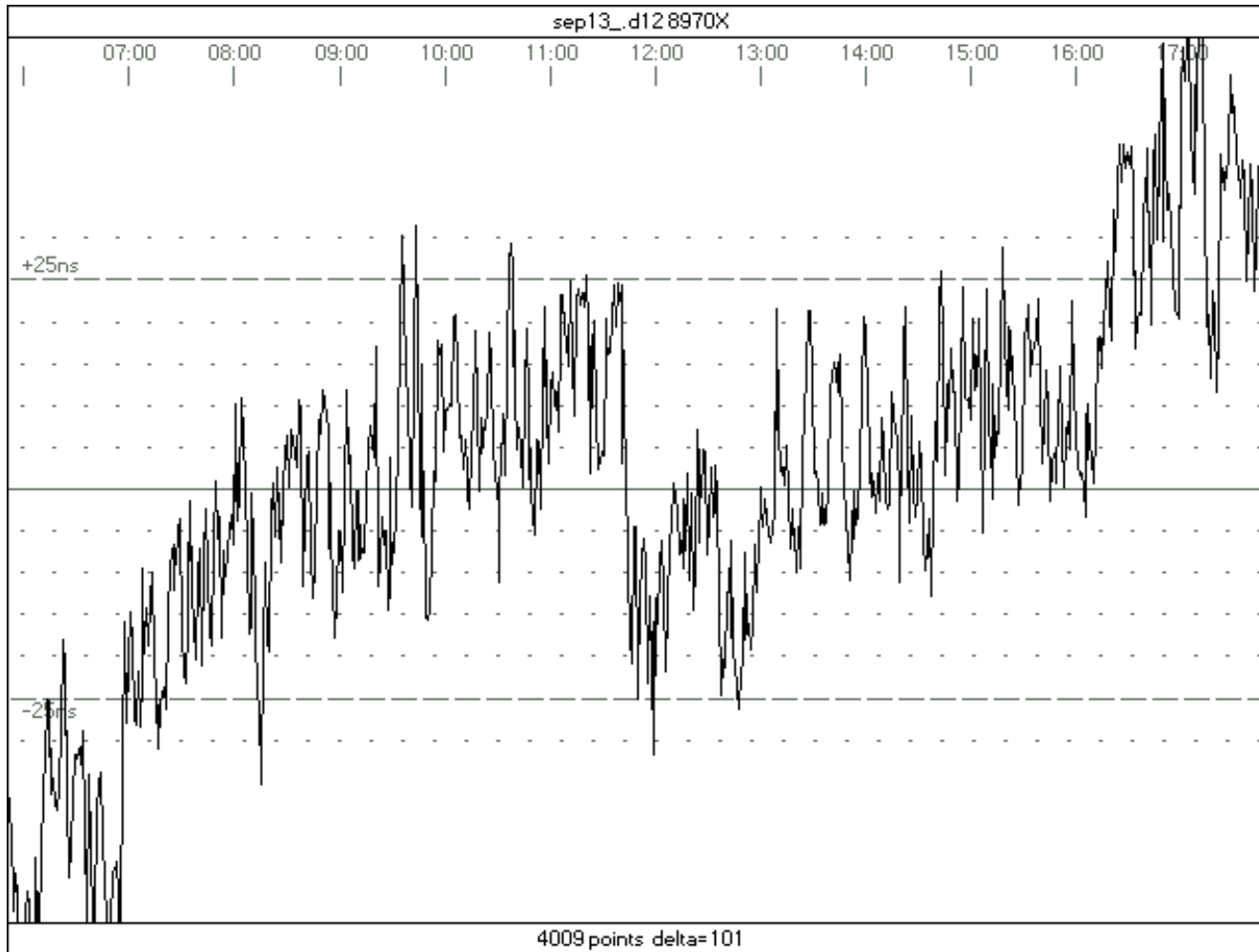
- SatMate 1020 all-in-view receiver with e-field antenna placed on roof of building in Sun Prairie, WI, approximately 20 km northeast of Locus' Madison location
- GPS position recorded next to SatMate antenna
- Identical setup on Locus' roof
- SatMate 1020 using 60 second averaging and 60 second intervals
- Remote SatMate data transmitted in real time via Locus' 2.4.GHz FHSS modem, OS2400
- Corrections applied at Locus





- GPS and SatMate receivers
- OS2400 with high gain antenna
- Computer to log GPS position
- Terrain largely rolling hills with several lakes

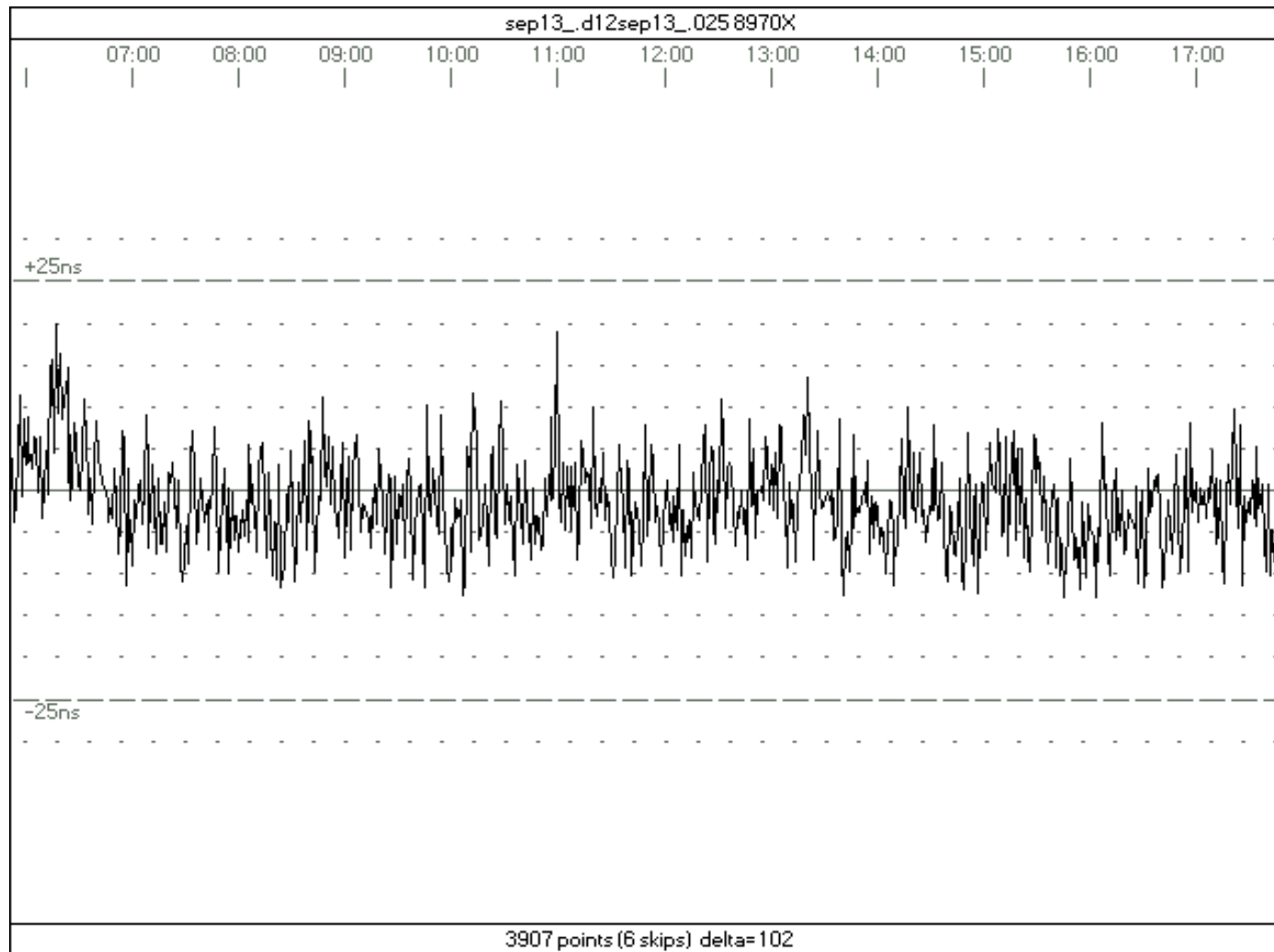
September 13, 2002 - 8970Y TD in Madison



- Approximately 12 hour recording
- Large sustained jumps likely local phase adjustments
- Note TD drifts of ~ 75 ns, or ~ 25 meters

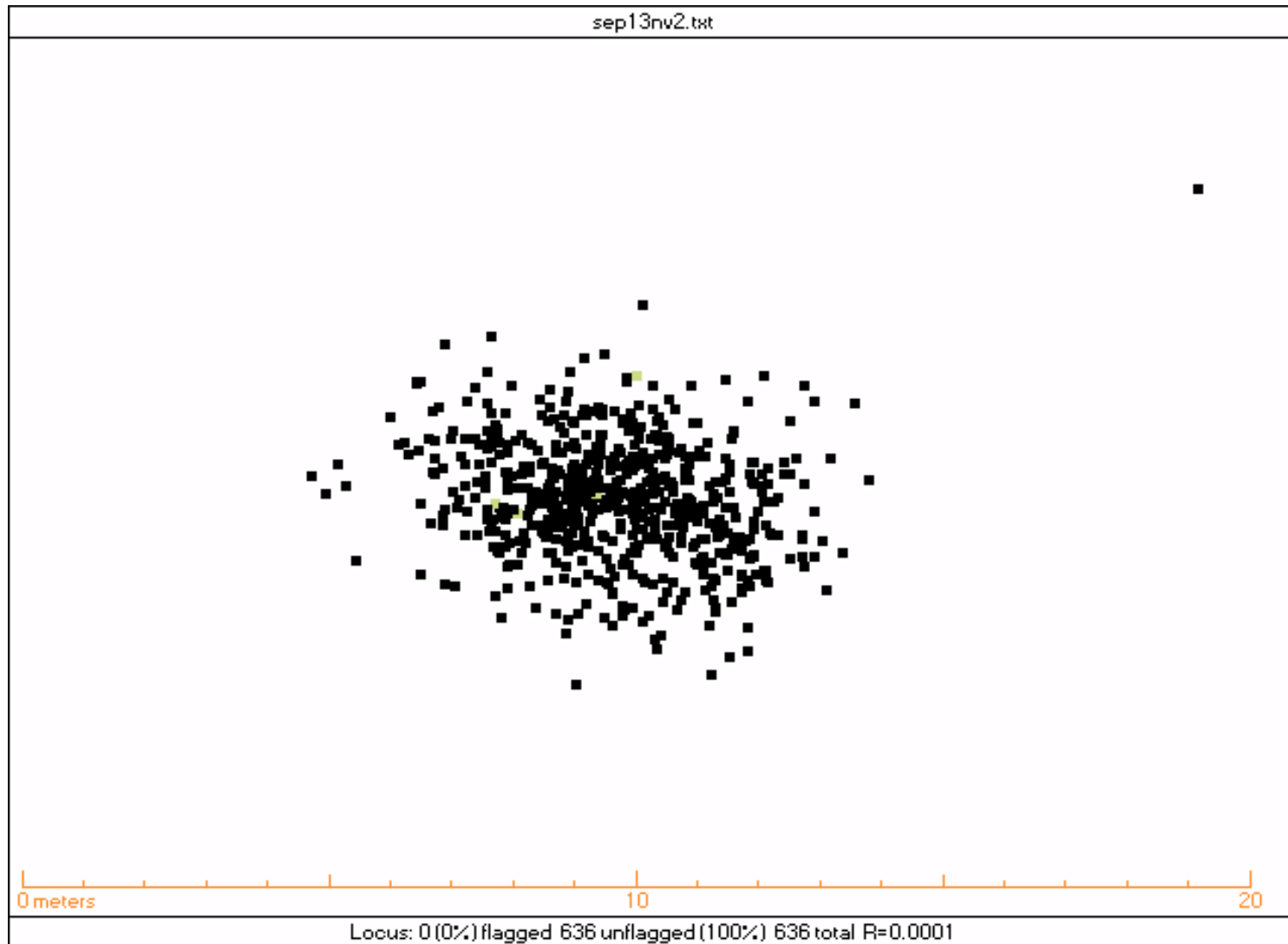
September 13, 2002

8970Y Sun Prairie TD Corrected with Madison TD



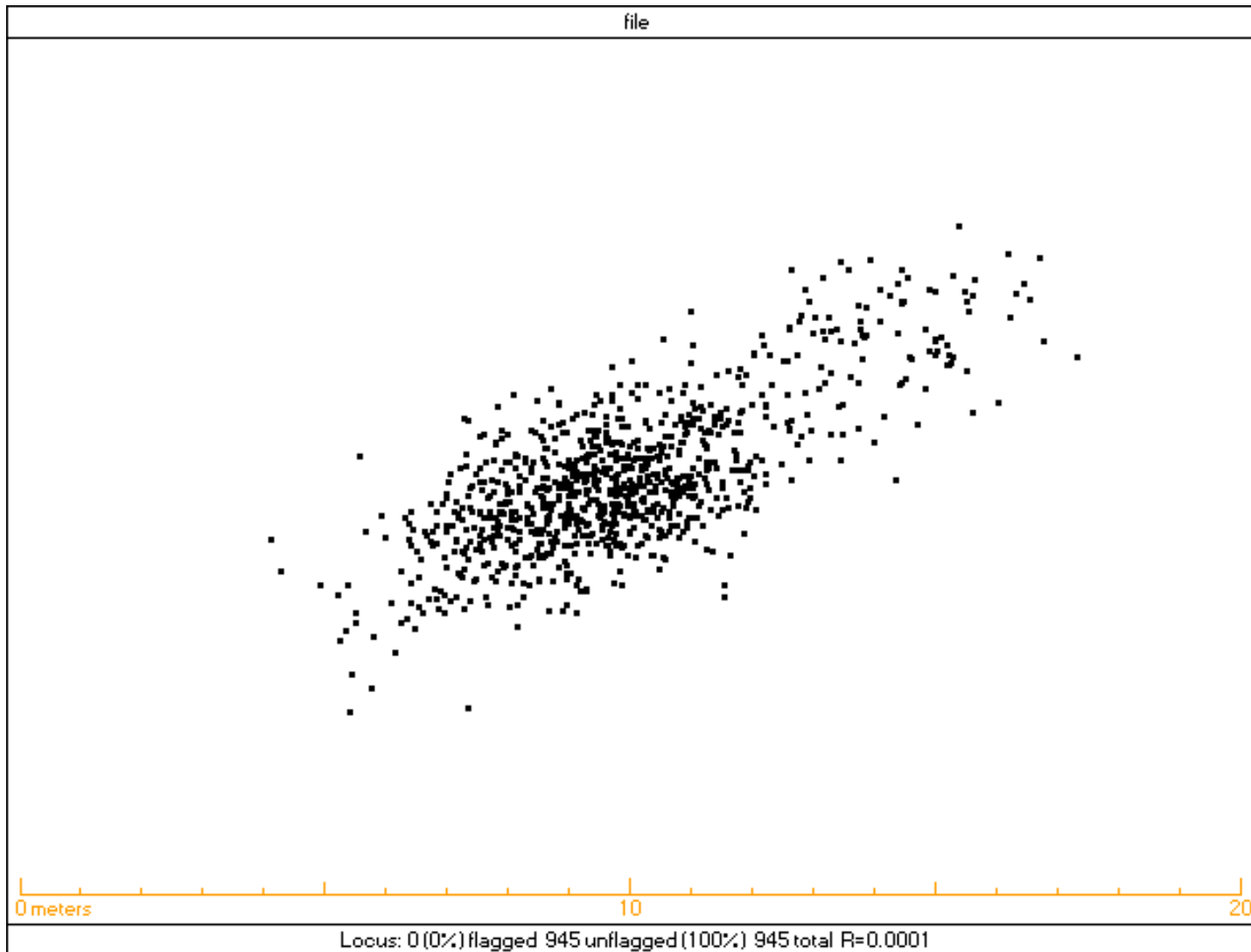
- RMS noise is now 5-6 ns, or ~ 1.7 meters

September 13, 2002 - Scatter Plot for Sun Prairie



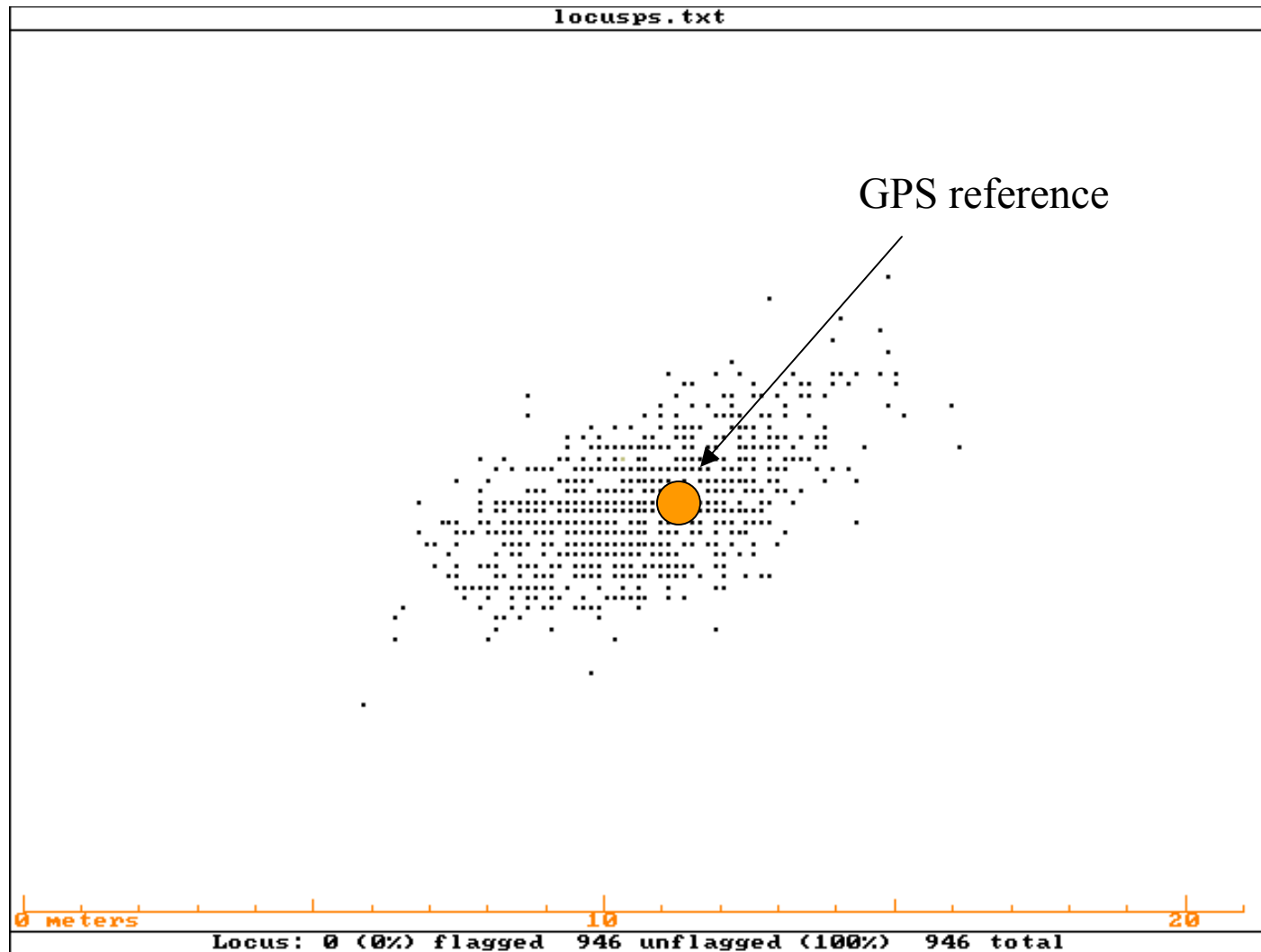
- Corrected by subtracting TOAs and converting to lat/lon
- Approximates dynamic differential results using ASFs

September 16, 2002 - Raw Scatter Plot for Madison



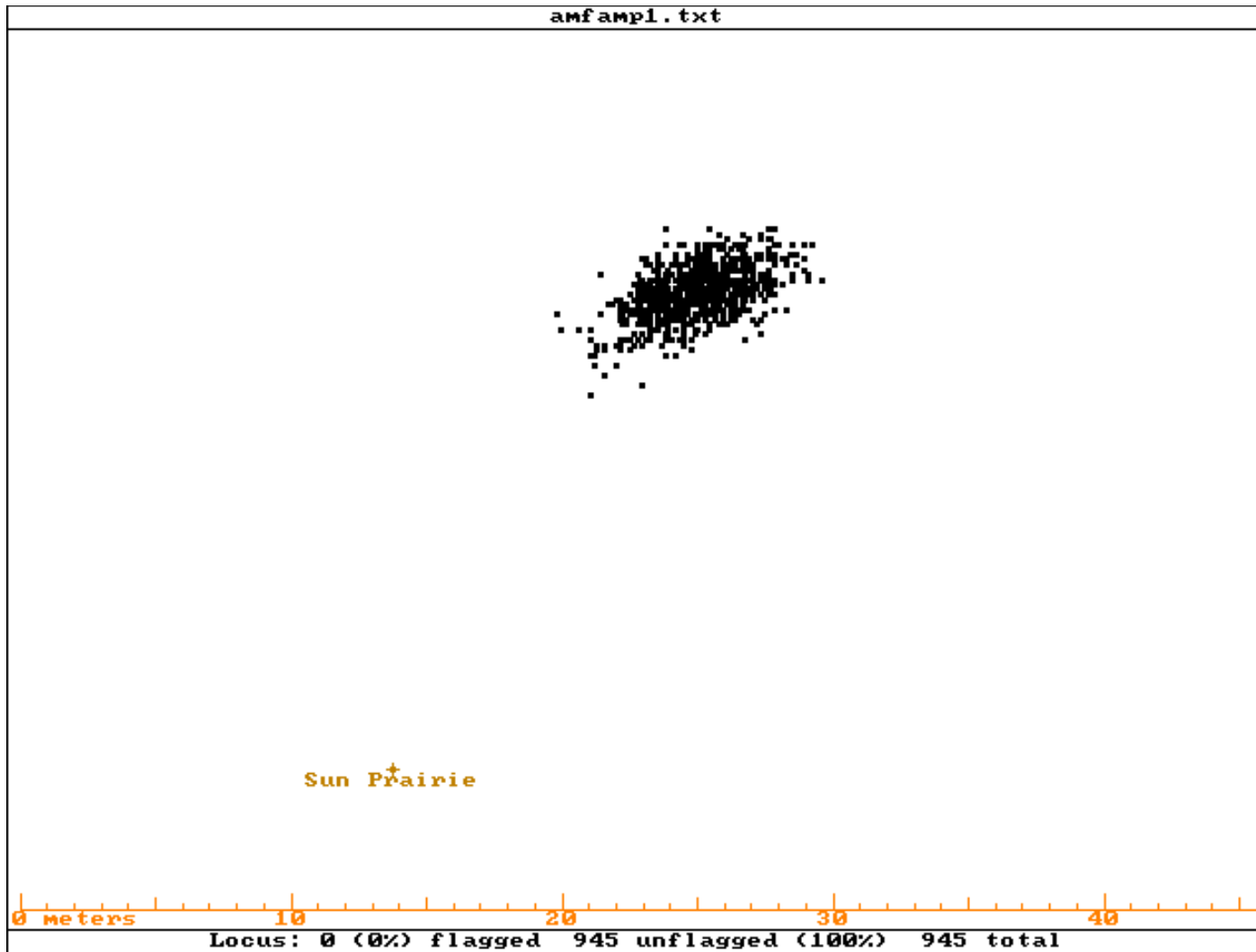
- Overnight data run, therefore noisier
- Set of average, quasi-ASFs then generated for Madison

September 16, 2002 - Scatter Plot for Madison



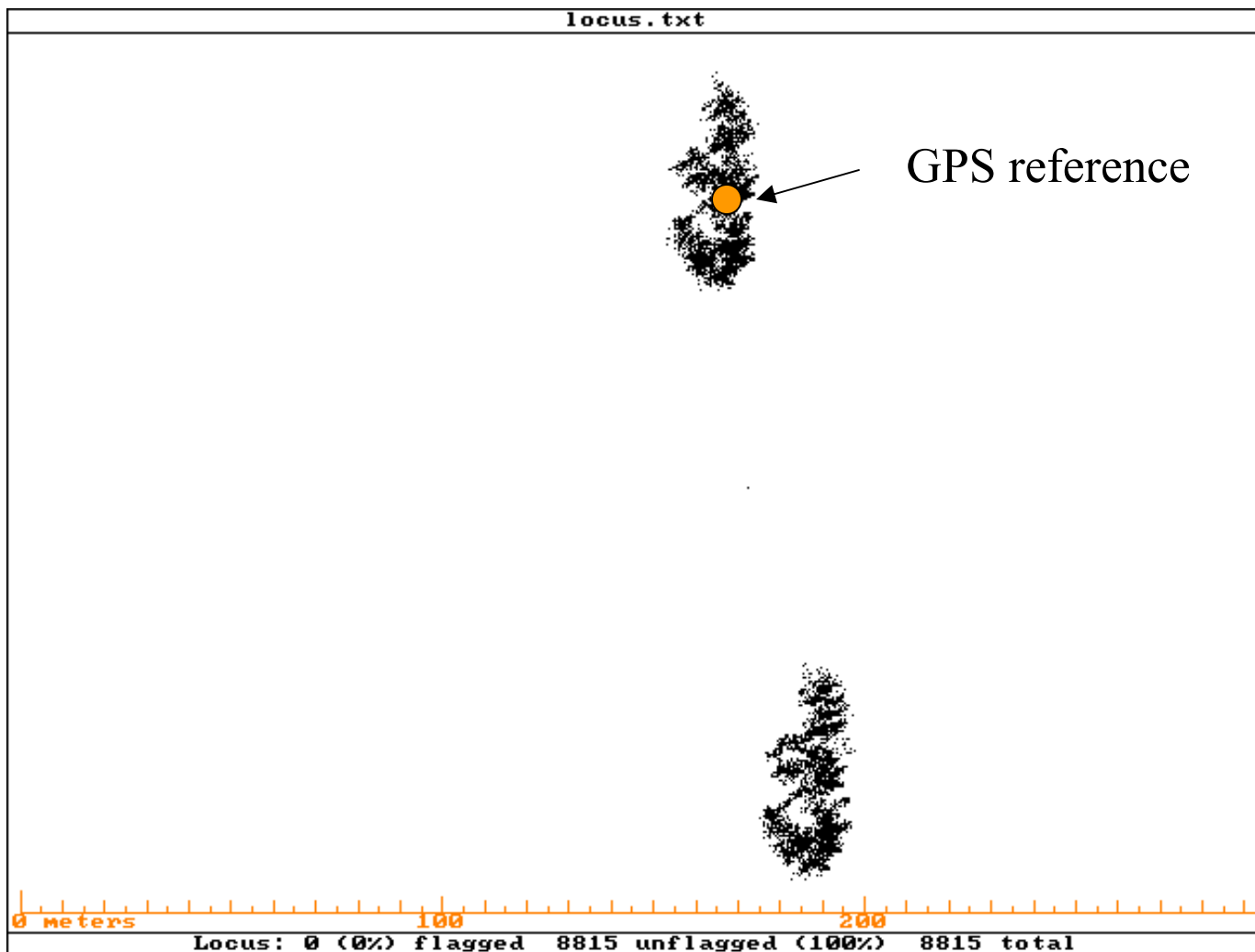
- Overnight data run using average, quasi-ASFs generated for Madison
- Sanity check to ensure GPS and Loran overlap
- GPS data point shown from September 13, 2002

September 16, 2002 - Scatter Plot for Sun Prairie



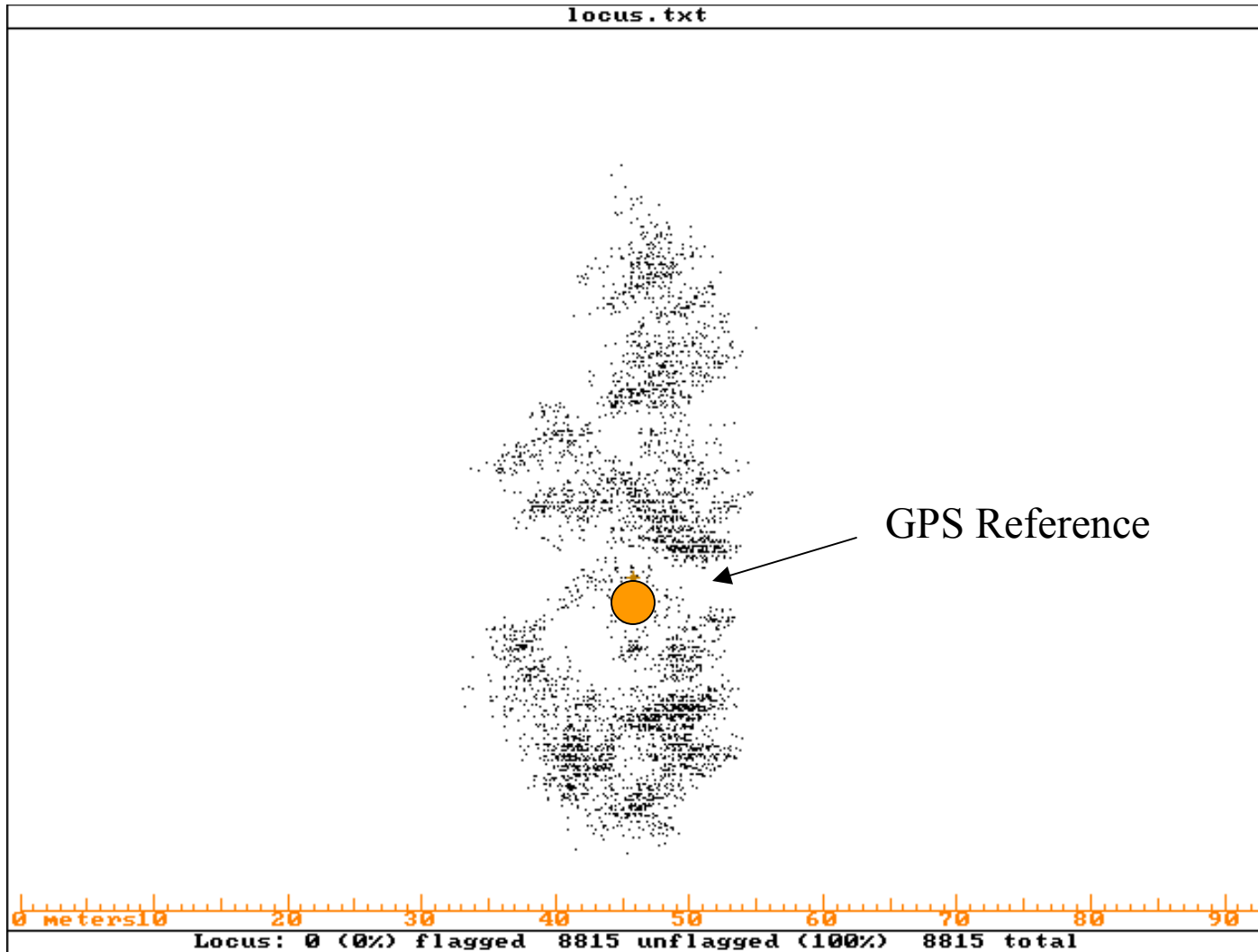
- Overnight data run using average, quasi-ASFs generated for Madison
- GPS data point shown for reference

October 11, 2002 - System Check for Madison



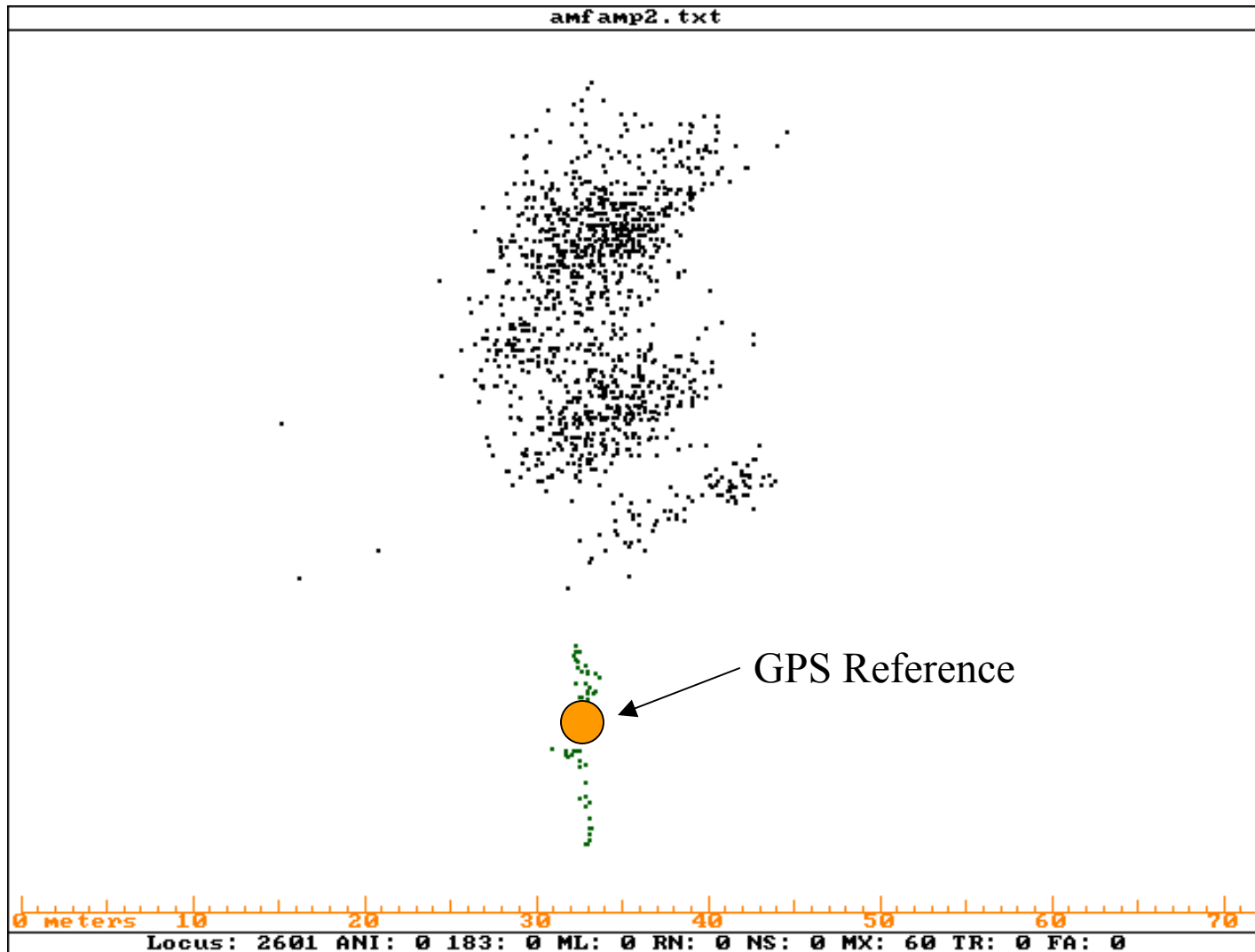
- Bottom scatter plot uncorrected
- Top scatter plot corrected with ASFs generated with GPS reference
- Note distinct clumping of Loran positions indicating timing jumps

October 11, 2002 - Close up of ASF Corrected Scatter Plot for Madison



- Distinct clumping of Loran data due to timing jumps more apparent

October 14, 2002 - Scatter Plot for Sun Prairie



- Differential Loran using October 11, 2002 Madison ASF corrections
- Distinct clumping of Loran data due to timing jumps apparent

Observations and Recommendations

- **Stabilize time of transmission control as much as possible.**
- **20 ns jumps, and even 10 ns jumps, represent a significant portion of the 20 m error budget for harbor entrance and approach.**
- **Elimination of all timing jumps would be best possible solution, e.g. by frequency steering control equipment.**
- **Stable timing control has the added benefit of reducing bandwidth of differential Loran correction link.**
- **Investigate broadcast of limited number of ASF corrections for differential Loran, i.e. for stations used in nav solution.**

Summary

- **Preliminary differential Loran studies using corrections derived over ~ 20 km appear to produce absolute accuracies compatible with USCG harbor entrance and approach target specification of 8 - 20 meters (95%).**
- **Performance demonstrated is limited by current Loran control system, and will improve when ongoing upgrades to Loran control infrastructure are complete.**
- **A differential Loran test bed has been established, and studies can now continue throughout seasons.**