Pulsed Doppler lidar instruments

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Outline of Presentation

- Description of instruments, recent improvements and options
- Examples of data products
- Post processing of raw data
- Summary

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Description of instruments (1)

Stream Line^{Pro}

- Internal scanner which gives access to a conical field-of-regard optimised for profiling in the boundary layer and lower troposphere.
- Real-time data processing to 12km is available with a 100% duty cycle.
- Pro-XR: Increased performance
- Flexible software allows profiling to be achieved with a variety of scan geometries, scan sequences and temporal resolutions.
- Power consumption: 130W 24V DC (+340W at 50^{0}C)
- Pro-Lite: Lower power version available if power limited (80W)
- Environmental: -20 to 50^{0}C
- Weight: 65Kg
- Dimensions: 60x53x40cm
- New improved heated blower
- Autonomous, Rugged and Eye-safe: Class 1M

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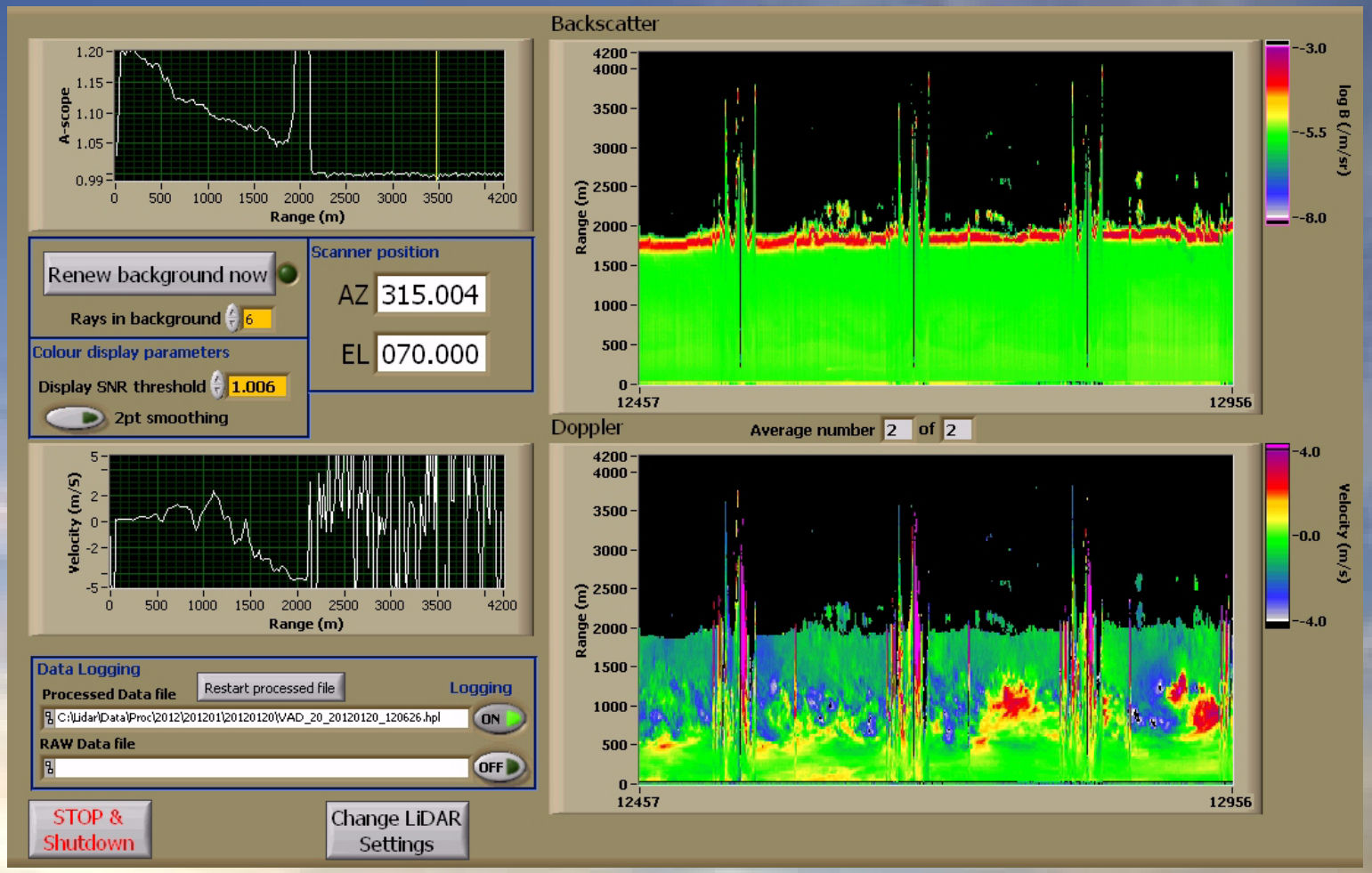
Real time display (visualisation mode)



Vertical stares with periodic wind profiles

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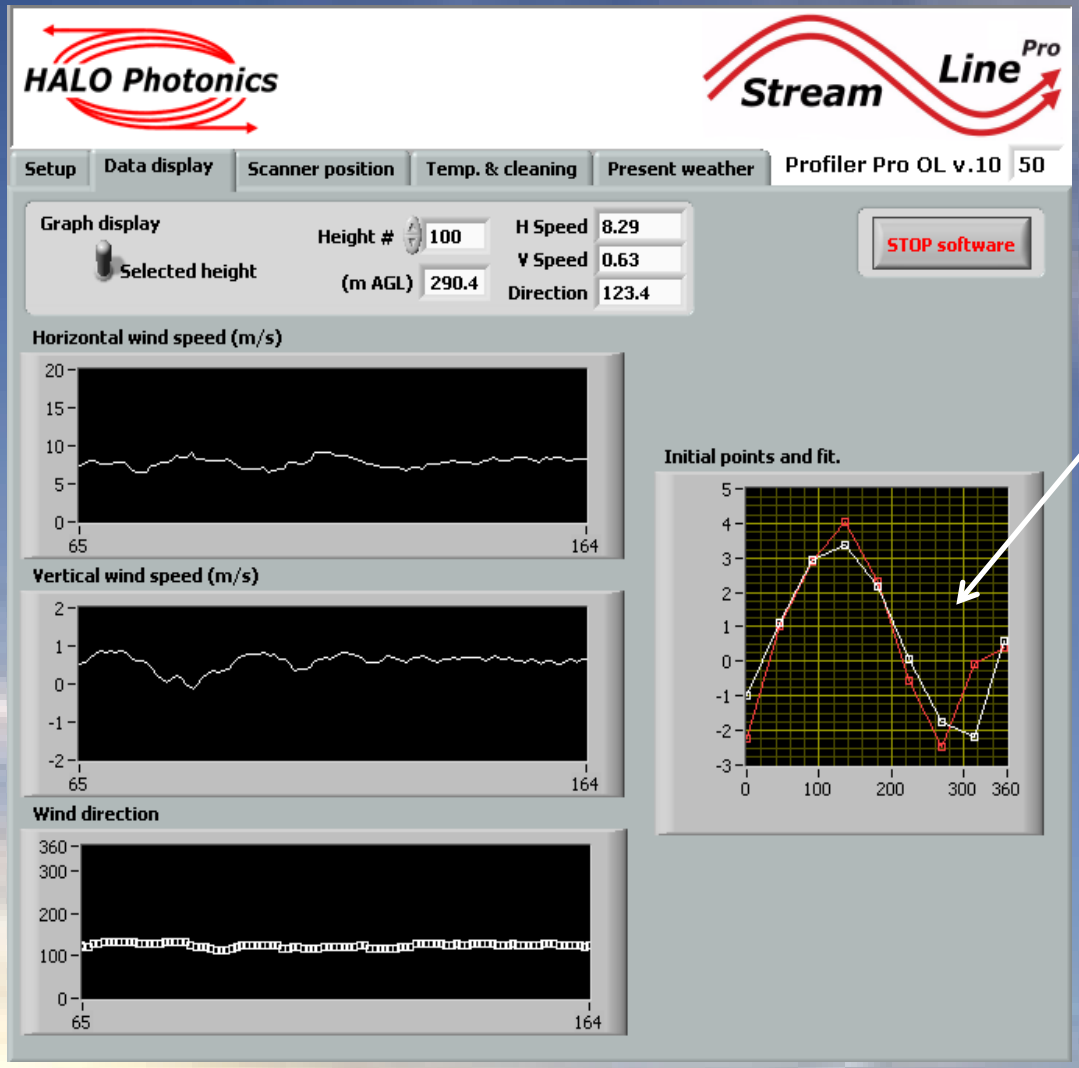
Real time display (virtual mast mode)



The number of rays and the scan geometry are variable.

Matrix inversion for u,v & w

A screen shot from the continuous profiling mode showing time histories of horizontal & vertical wind speed and bearing for a selected height

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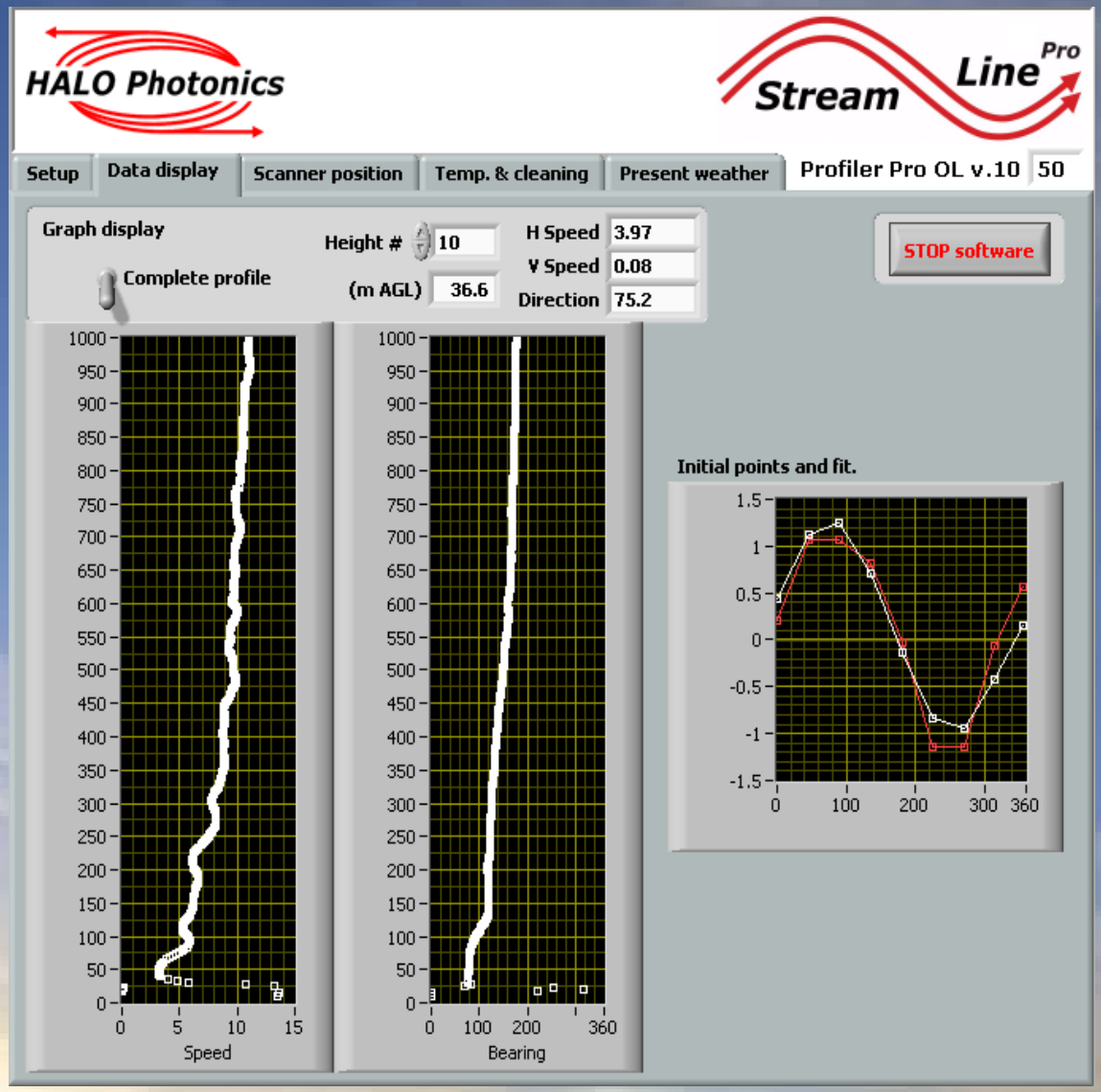
Real time display (virtual mast mode)



Boundary layer wind profiles at 2.6m height resolution every few seconds

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Description of instruments (2)
Stream Line^{XR}

- New compact version of the Stream Line pulsed Doppler lidar with an all-sky scanner
- Enclosure 25% smaller
- Extended range using more powerful transmitter
- New high performance signal processor
- Scan queue synchronised to GPS time
- Step-stare and continuous scanning
- Unlimited daily schedule
- Feedback scanning
- Full control of scanner parameters
- Overlapped range gates
- Raw data storage

- Mass approximately 85Kg
- Enclosure dimensions: 630 x 530 x 400mm
- Power requirement: 24V DC, 150W
- Extra 340 W for enhanced active cooling option for 50^{0}C ambient temperatures

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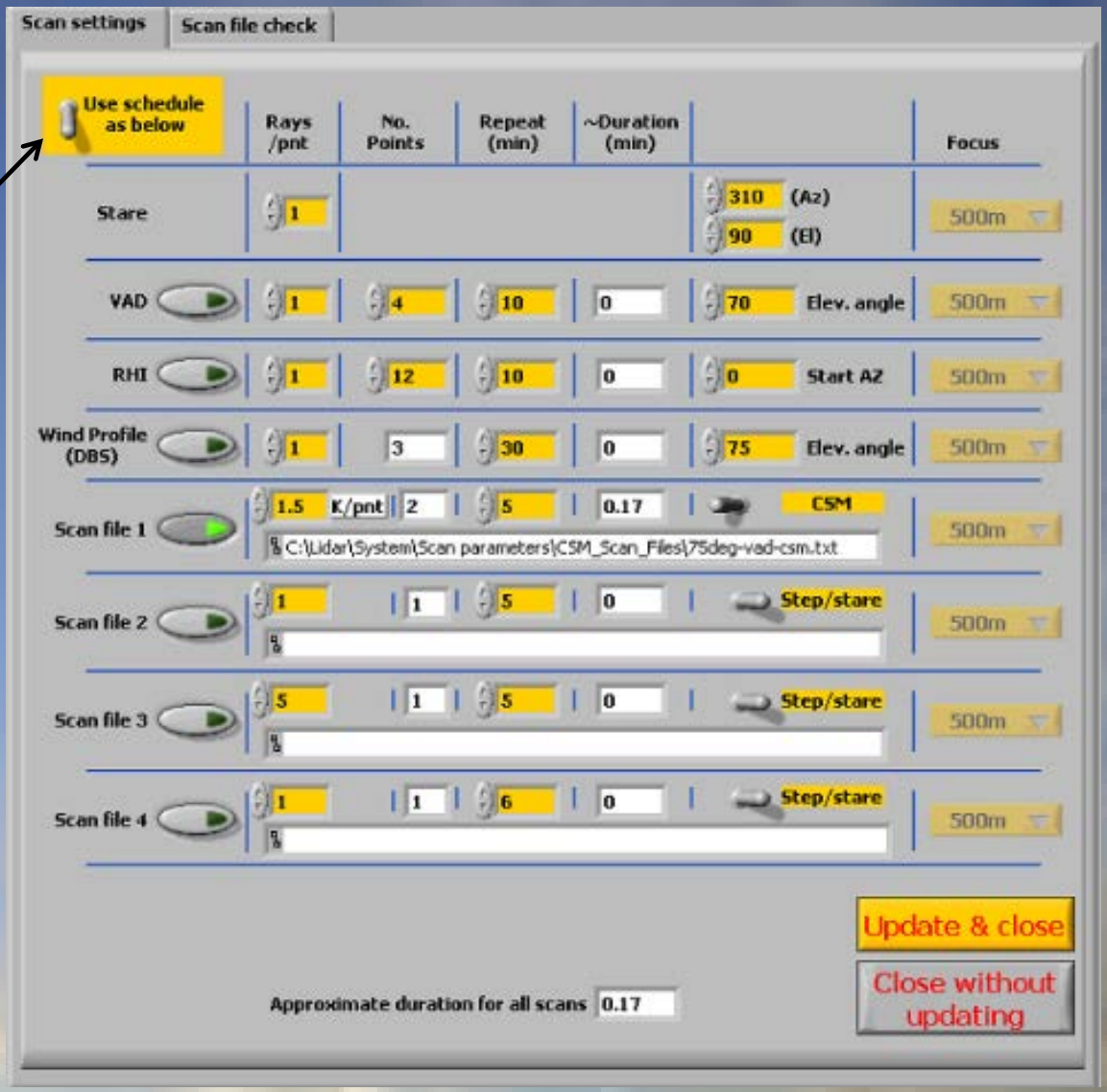
Stream Line^{XR} scan scheduler

As table or unlimited daily sequence, synchronised to GPS time

Step-stare or continuous scan



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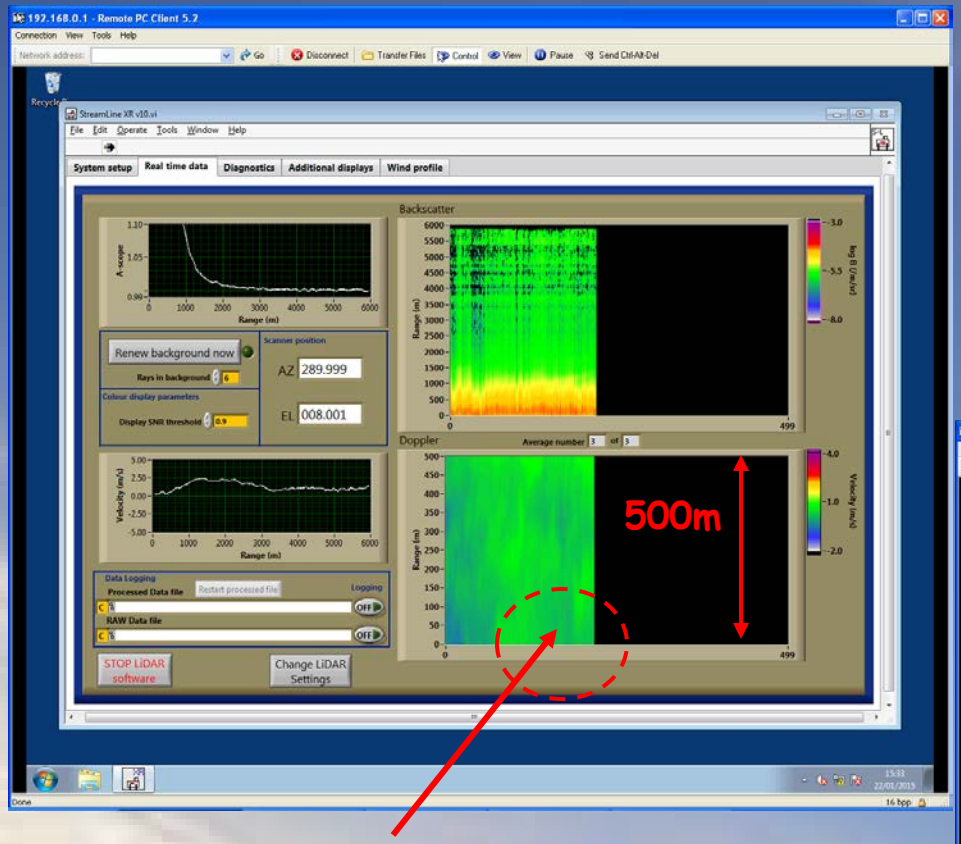
Stream Line^{XR}



No blind zone, first usable range gate is the first gate

New signal processor extracts good Doppler estimates to lower SNR (-31dB wideband)

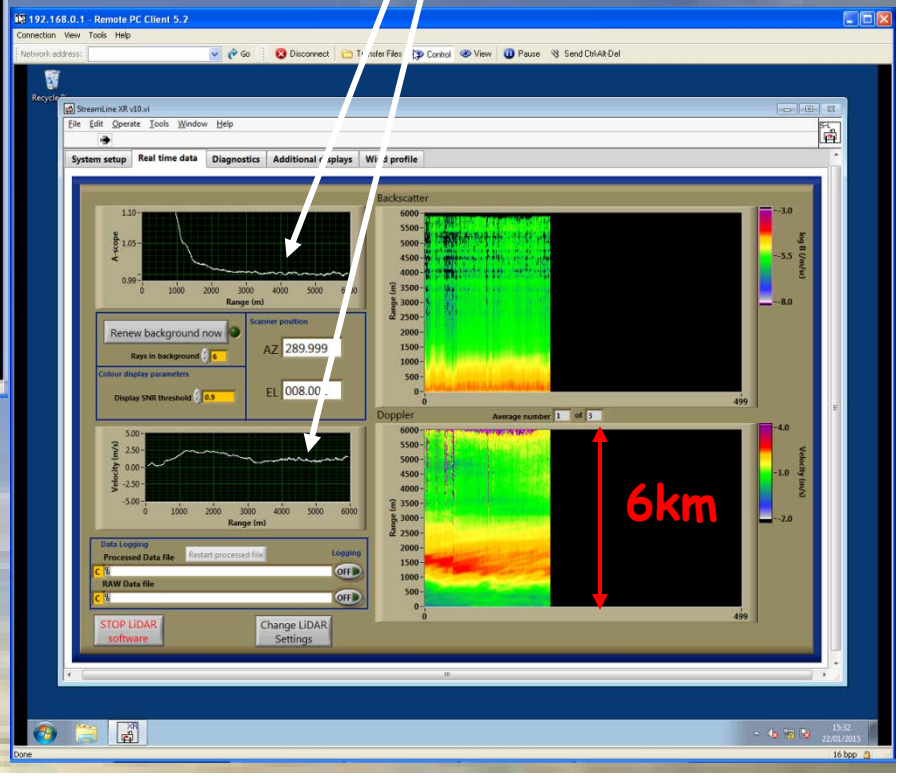


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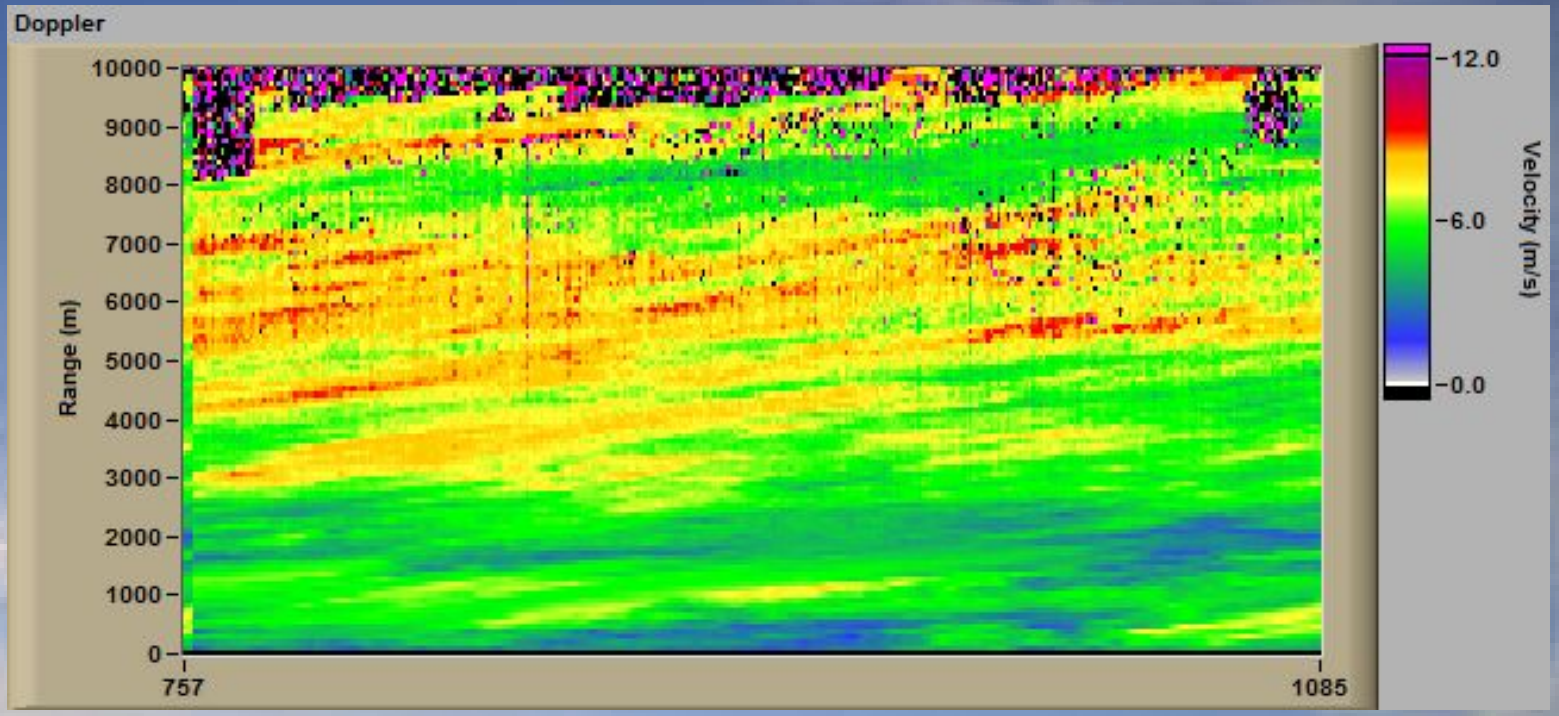
Illustration of post-processing raw data



Range/time/Doppler plot for a fixed LOS
40m gates, 1 second average per ray, 6 minute record

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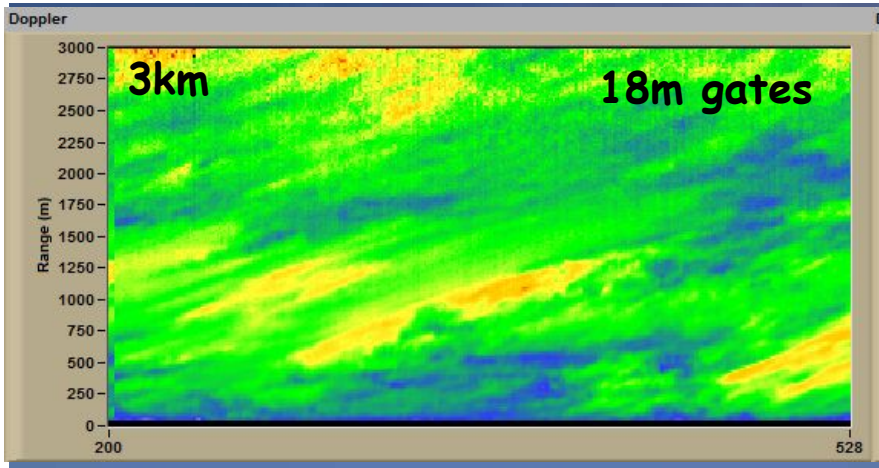
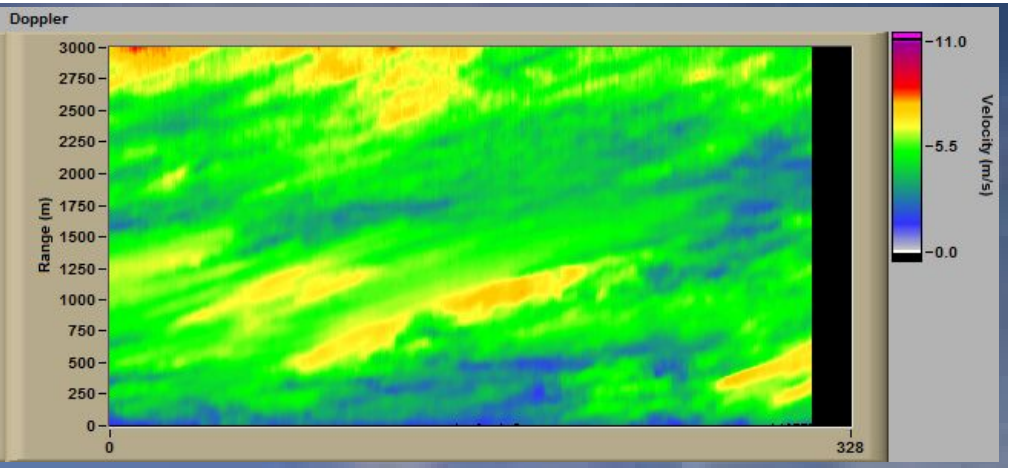
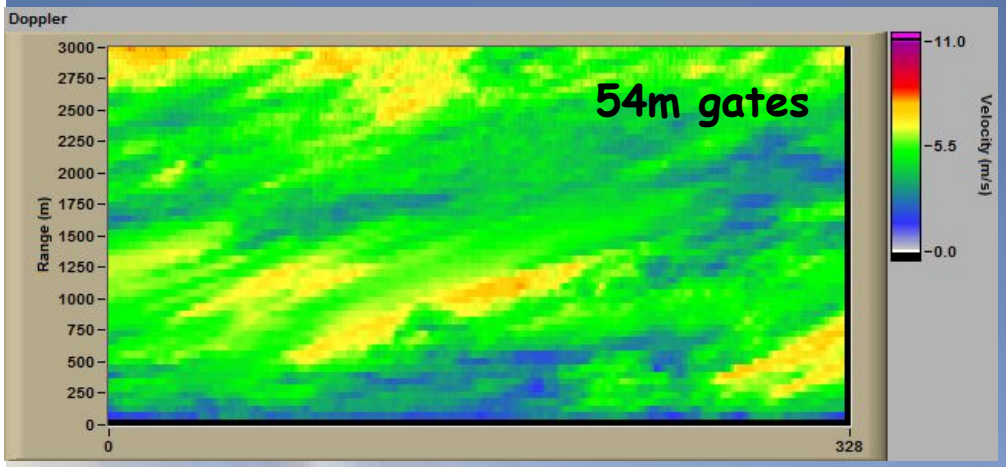
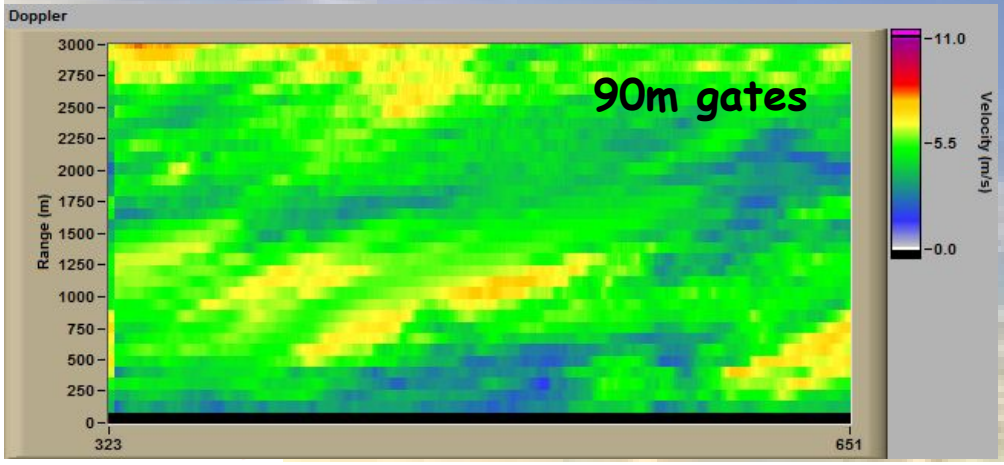
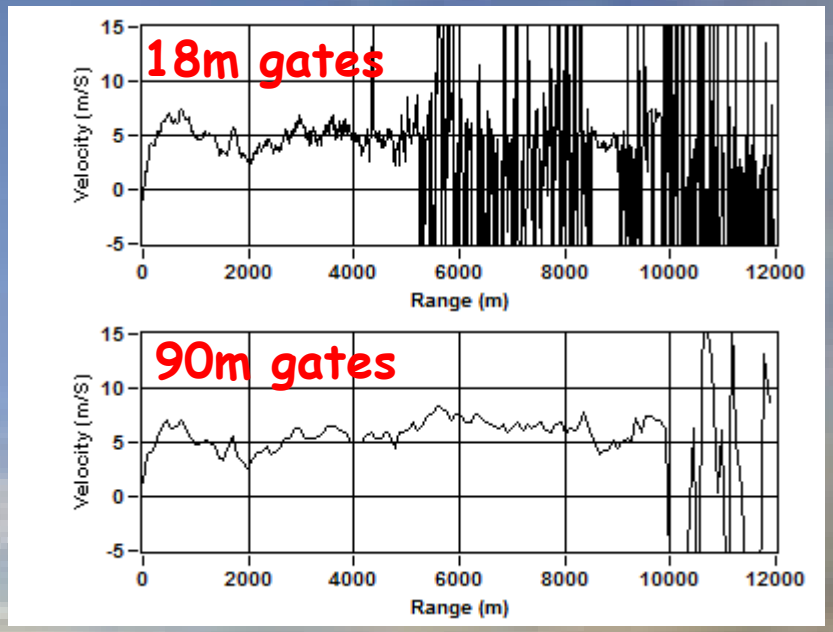




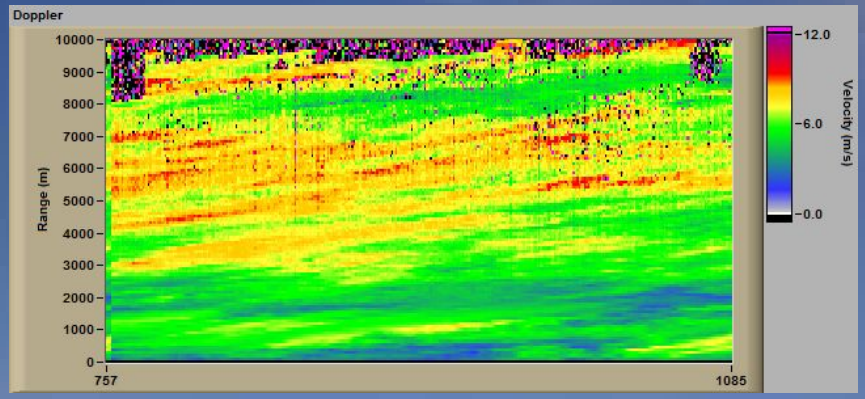


90m gates, 3m offset

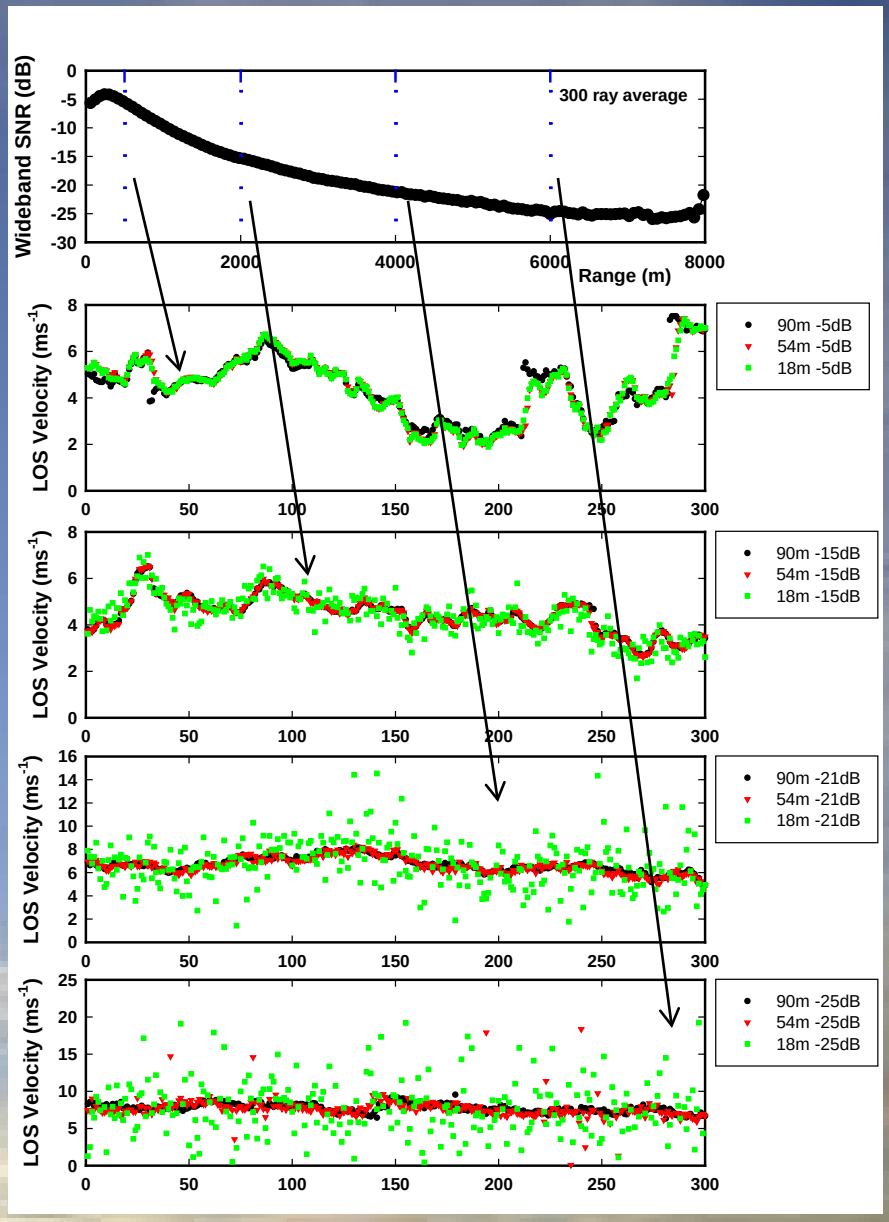




Velocity estimates versus SNR and gate length



Atmospheric variability/lidar error



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Jan Schween's talk

Error due to turbulence ?

- variability to turbulence is in a convective BL much larger than the Doppler error :

$$\overline{D_1 D_1}_{\mathrm{obs}} = \overline{D_1 D_1}_{\mathrm{turb}} + \Delta D^2 \approx \overline{D_1 D_1}_{\mathrm{turb}}$$

  => accuracy of Doppler retrieval is not liming factor
- Consider making *many* vast VAD scans with *fewer* points
- Determine covariance matrix of Dopplers

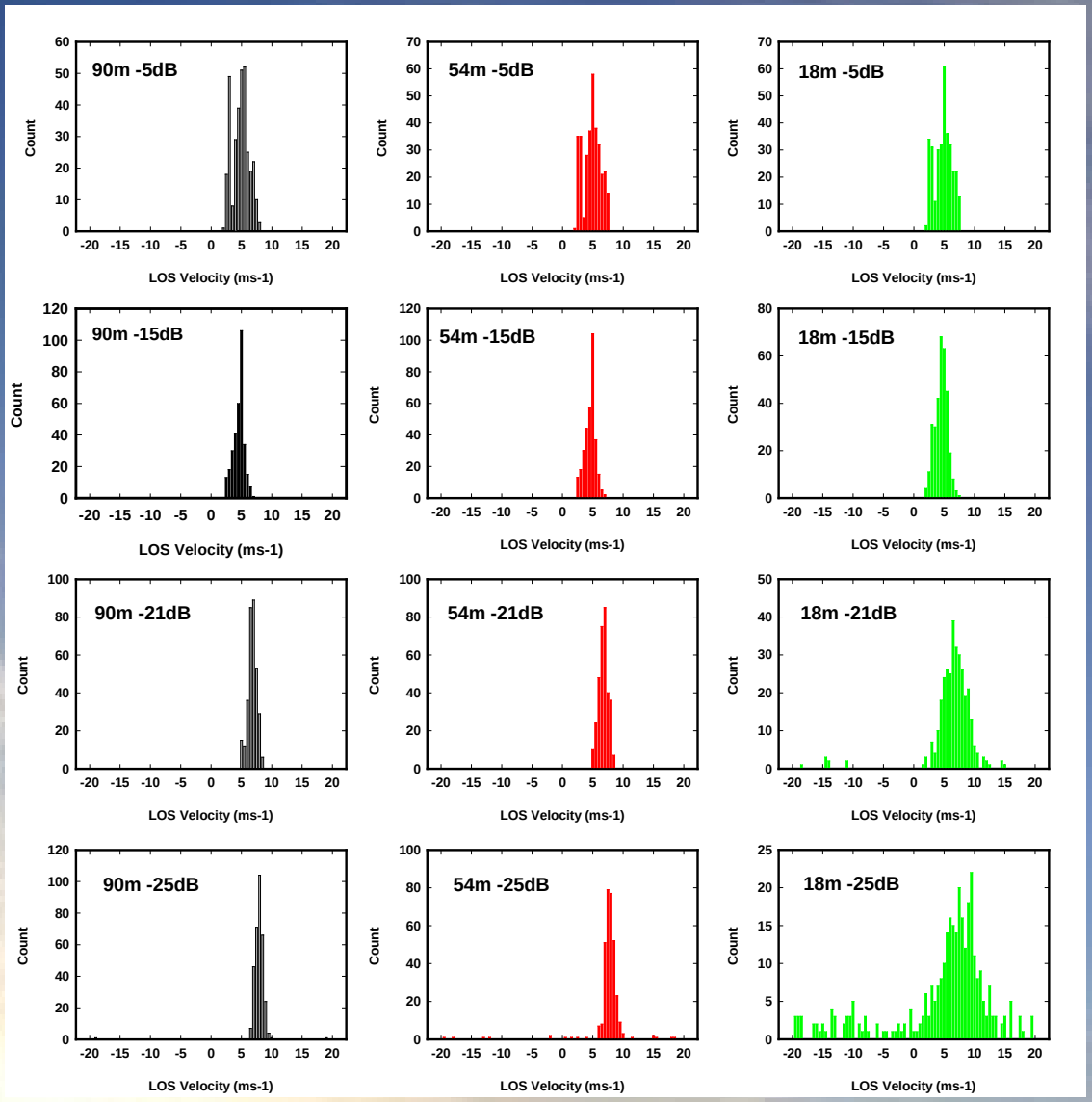
$$\overline{\overline{\sigma_D^2}} = \begin{pmatrix} \overline{D_1' D_1'} & \overline{D_1' D_2'} & \cdots \\ \overline{D_2' D_1'} & \overline{D_2' D_2'} & \cdots \\ \vdots & \vdots & \ddots \end{pmatrix}$$

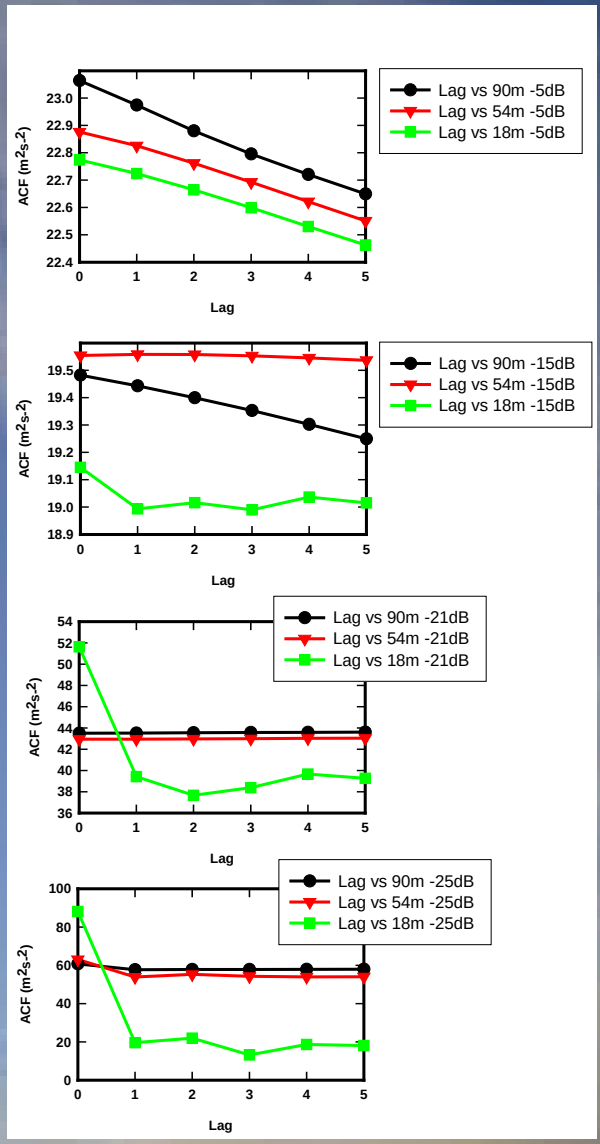
- And calculate covariance matrix for Cartesian wind components

$$\overline{\overline{\sigma_v^2}} = \bar{\bar{M}} \cdot \overline{\overline{\sigma_D^2}} \cdot \bar{\bar{M}}^t = \begin{pmatrix} \sigma_{uu} & \sigma_{uv} & \sigma_{uw} \\ \sigma_{uv} & \sigma_{vv} & \sigma_{vw} \\ \sigma_{uw} & \sigma_{vw} & \sigma_{ww} \end{pmatrix}$$

- => Can we get enough VAD scans to ensure statisitical

Velocity estimates versus SNR and gate length





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Summary

- Two basic instrument concepts:
  - Profiling
  - All-sky scanning
- Recent upgrades:
  - High power transmitter
  - More powerful signal processor
  - Reduced size, weight & power consumption
  - More flexible scanning
  - Improved thermal characteristics
- New features offer greater scope for optimisation of performance

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