

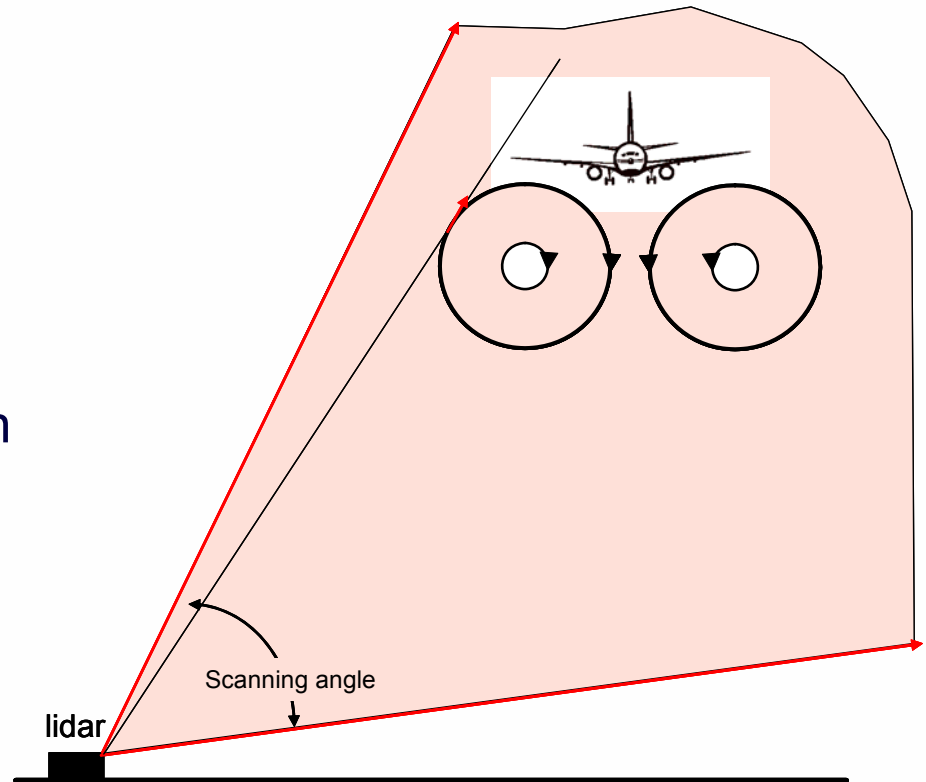
# Pulsed 1.5 micron Lidar for Wake Vortex Measurements and Monitoring : CREDOS Trials on Frankfurt Airport

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# Lidar configuration during CREDOS

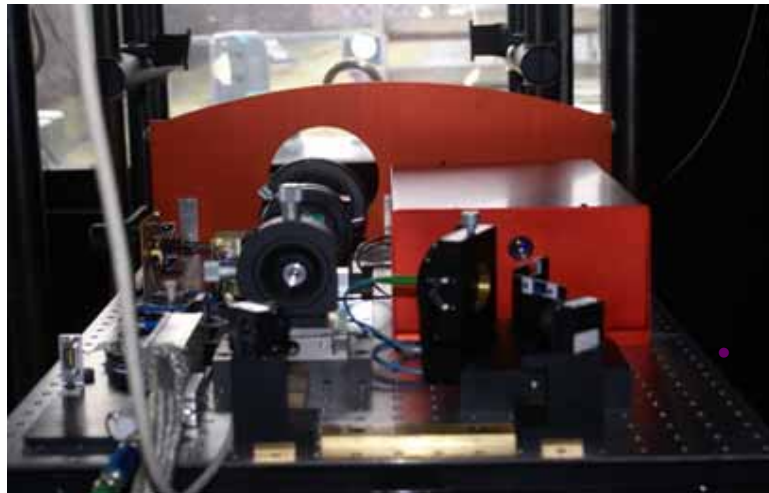
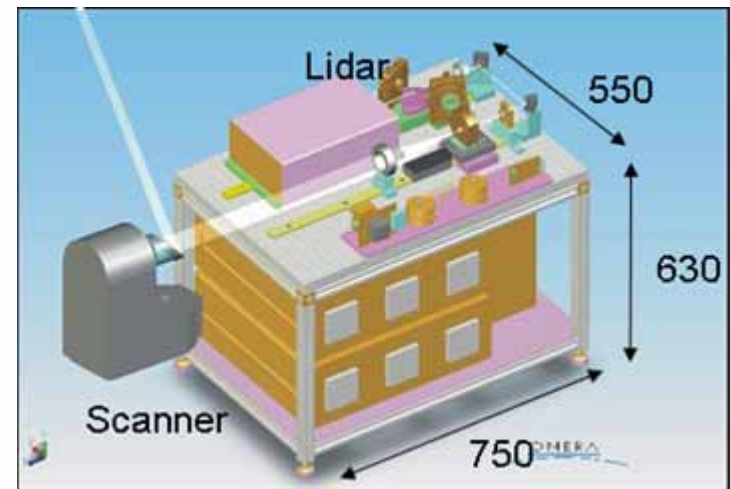
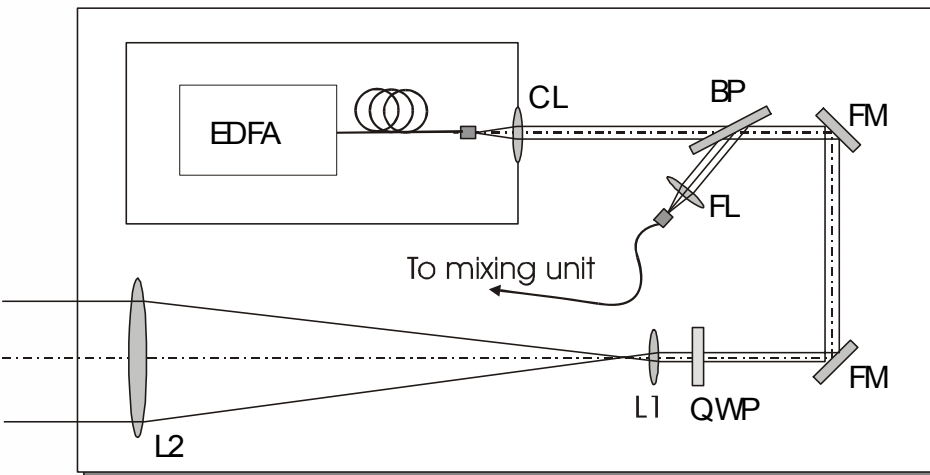
- CREDOS : **Crosswind - Reduced Separations for Departure Operations**
- 6th framework programme
- Campaign : Frankfurt 03/2007
- Scanning plane perpendicular to the trajectory
- Location : 200m from glide path (to allow good angular resolution while enough field of view)
- Fast scan period to 'freeze' the vortices : 4s for  $60^\circ$
- Observing mostly departures



# Field tests at Francfort airport CREDOS CAMPAIGN (february –March 2007)



# SWAN lidar set up for CREDOS campaign at Francfort (february –March 2007)



## SWAN lidar characteristics :

- wavelength: **1.55  $\mu\text{m}$**
- range : **400m**
- min distance: **50m**
- Speed resolution : **< 1 m/s**
- Frame rate : **0.25Hz**

## Laser characteristics (made in Onera):

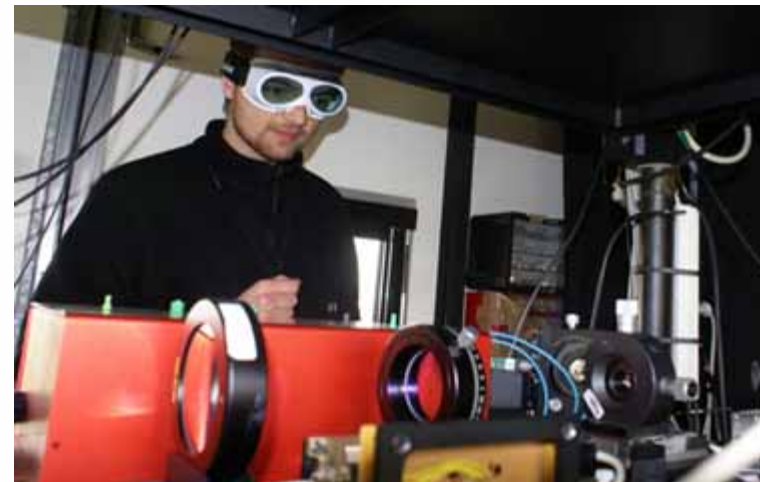
- 60  $\mu\text{J}$  per pulse, PM
- 250 ns pulse duration
- 15 kHz rep. Rate
- < 0,5 MHz linewidth ,  $M^2=1.3$

# SWAN: lidar processing for wake vortex

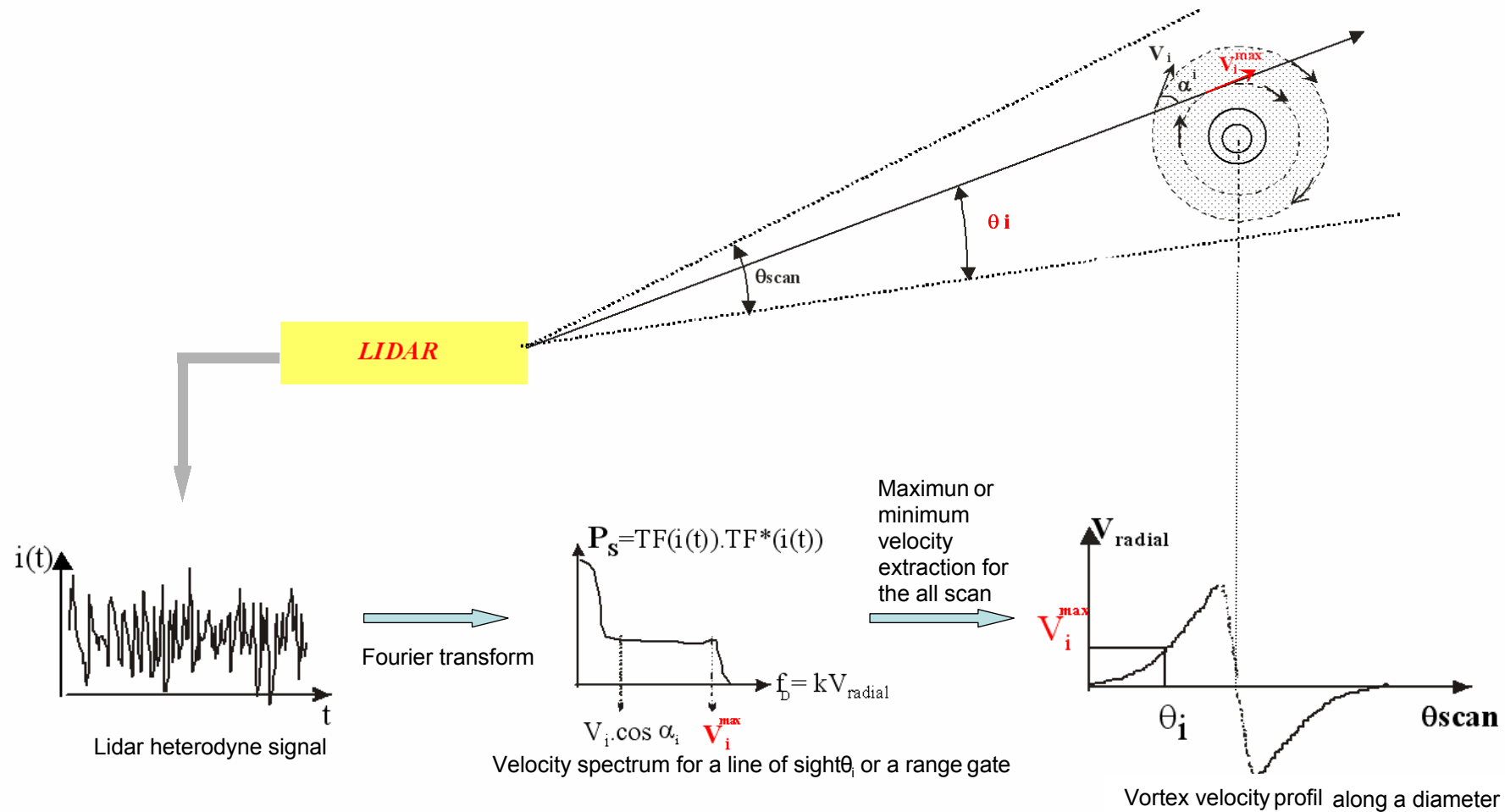
- Real time signal processing and display:
  - longitudinal spatial resolution: 2.4 m (overlap of range gates)
  - lateral spatial resolution: 35 cm@200m(0,1°)
  - Velocity resolution: < 1 m/s

High level processing:

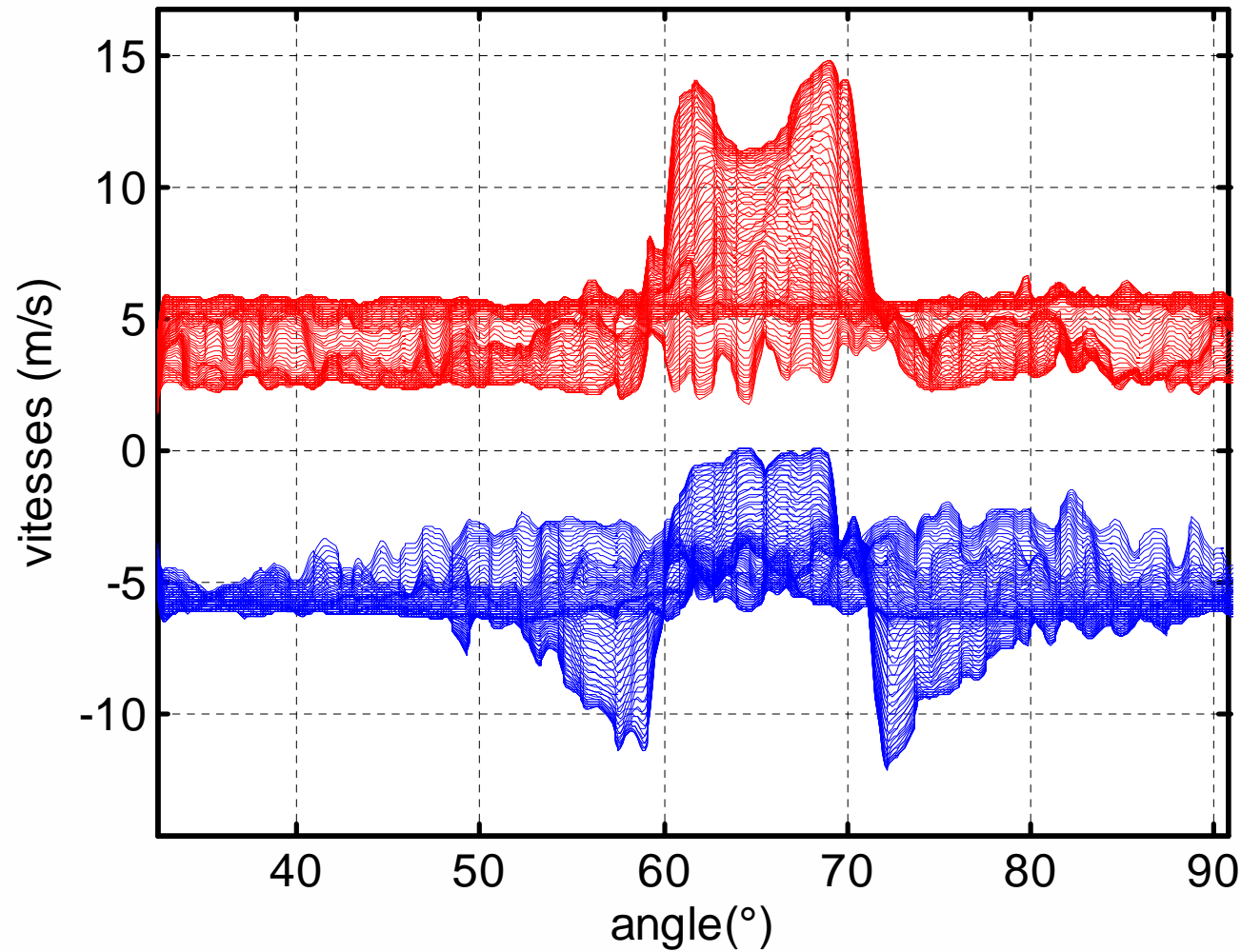
- core position,
- velocity profiles,
- circulation vs time/span



# SWAN : wake vortex signal processing

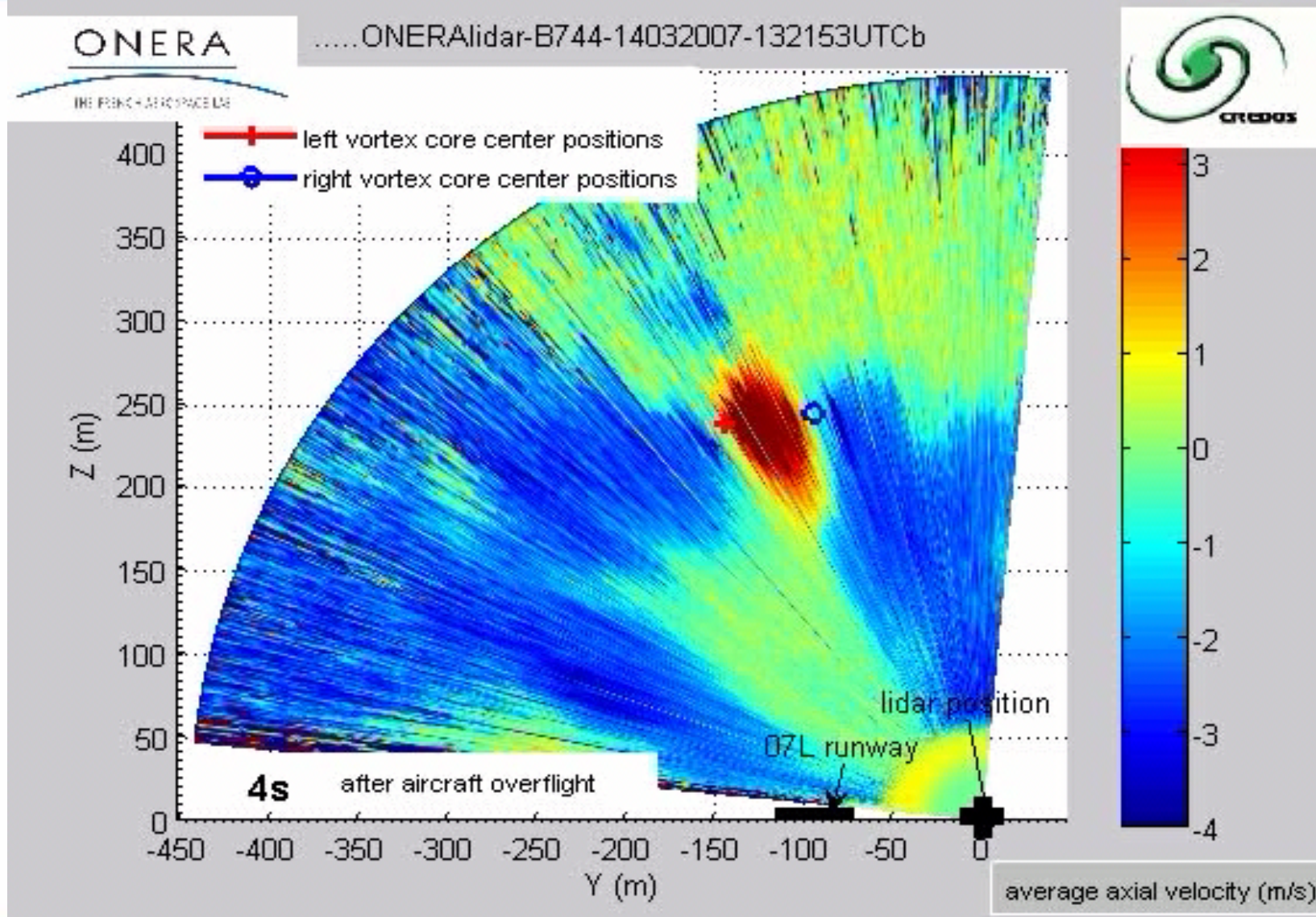


# SWAN : Wake vortex spectra analysis



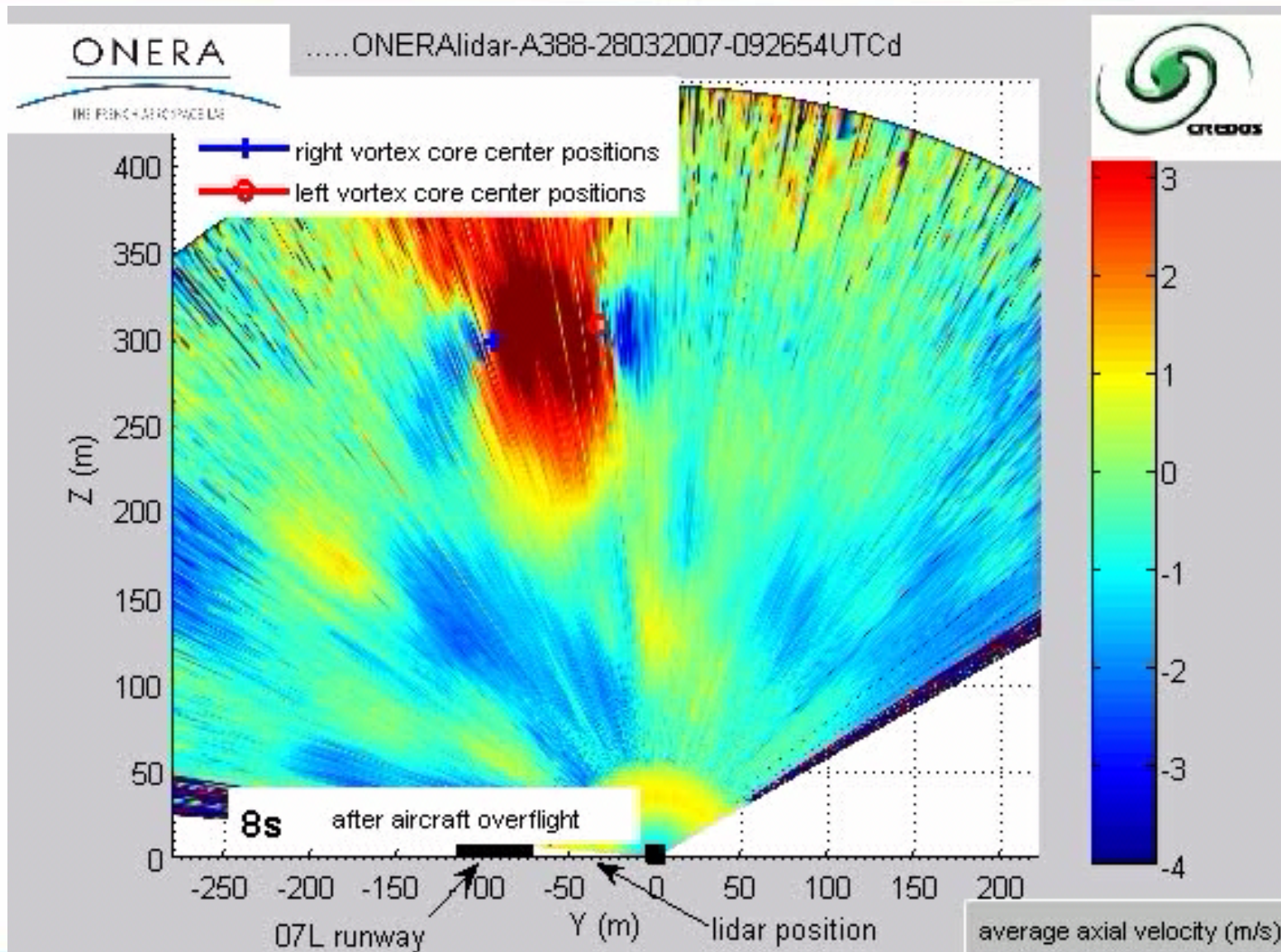
# CREDOS CAMPAIGN Orly/Francfort 2007

## B744

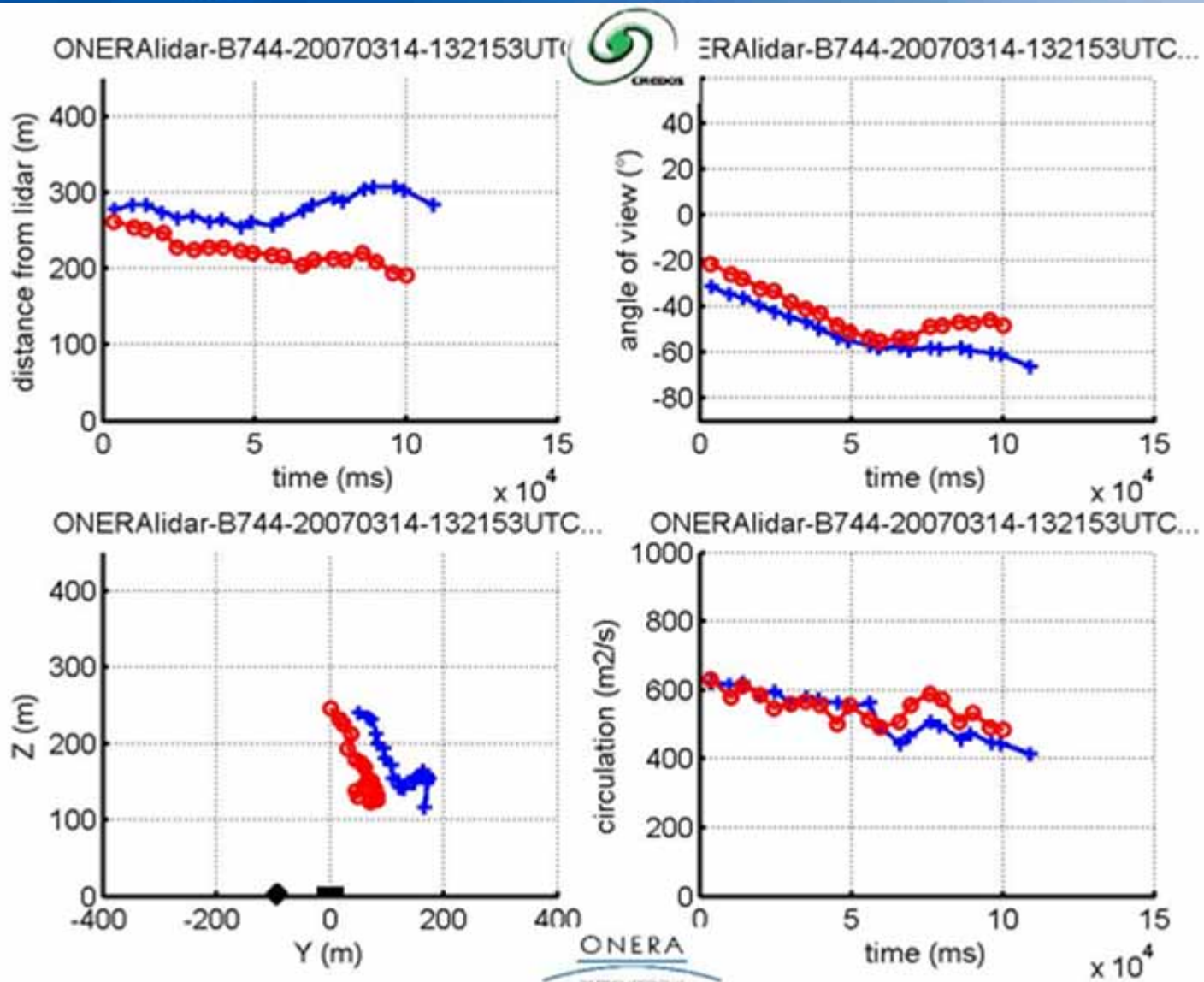


# CREDOS CAMPAIGN Orly/Francfort 2007

## B744



# Signal processing outputs



# Statistical analysis of CREDOS departure measurements

- 180 measurements of heavies
- The core position error is about  $\pm 2$  m
- The circulation error is about 10%.
- Vortex separations ( at first measurement after overflight ) agree with theoretical value for 90% overflights
- Measurement duration  $> 1$  min for 50 % overflights .

# From Laboratory to operational product

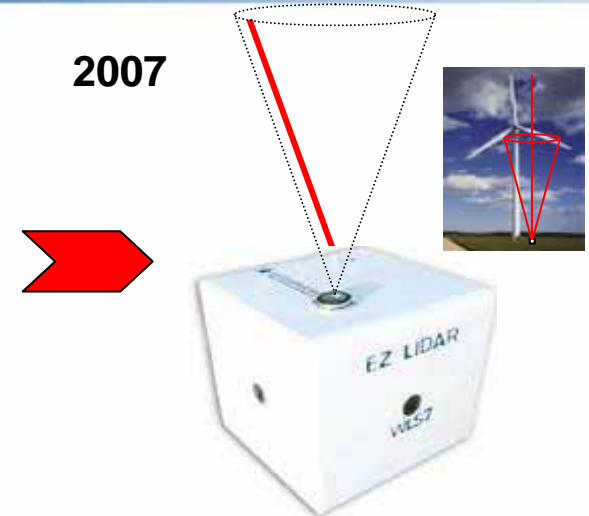
ONERA Lab 2005



Leosphere 2006



2007



2007

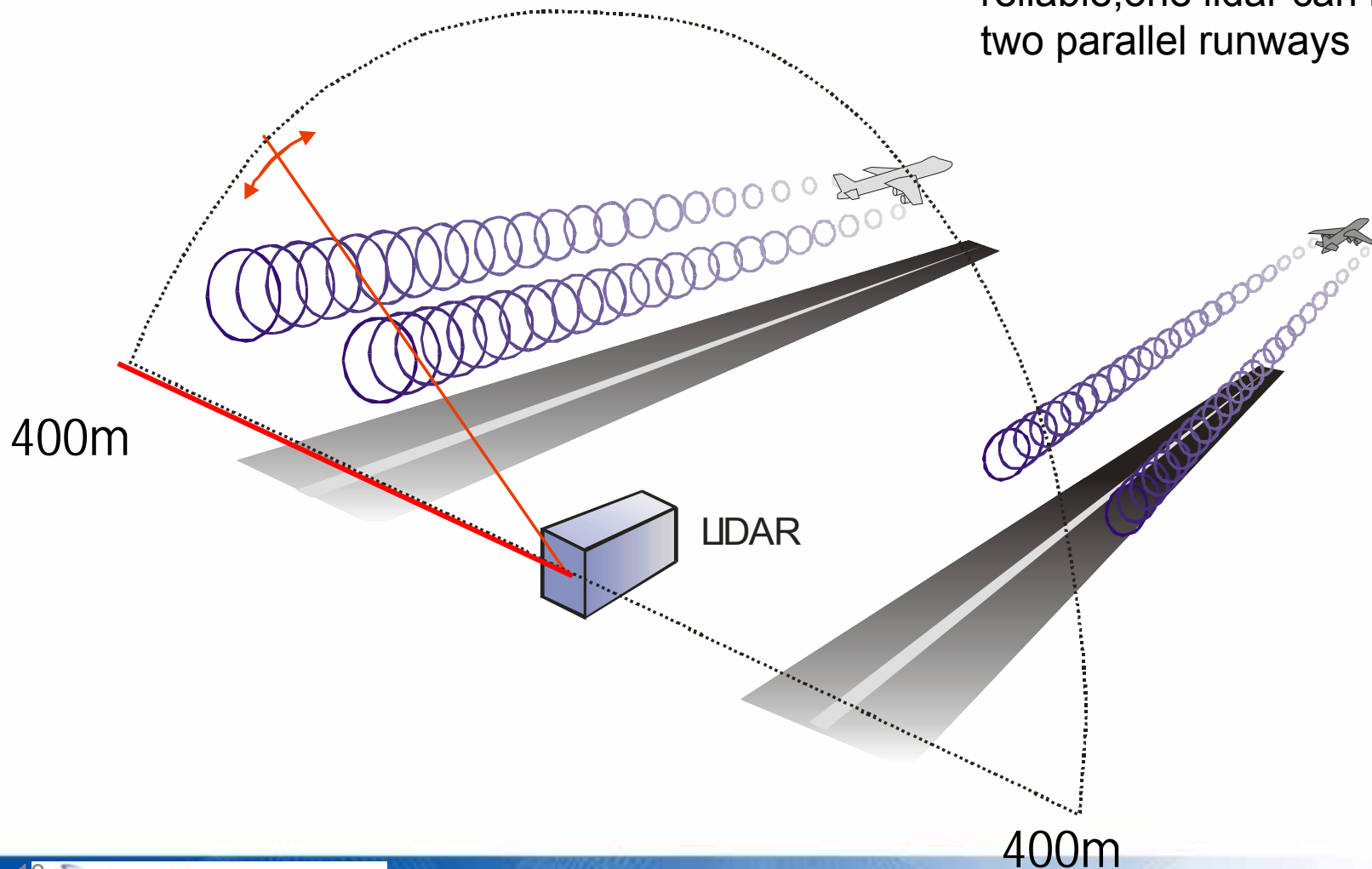


...2011+

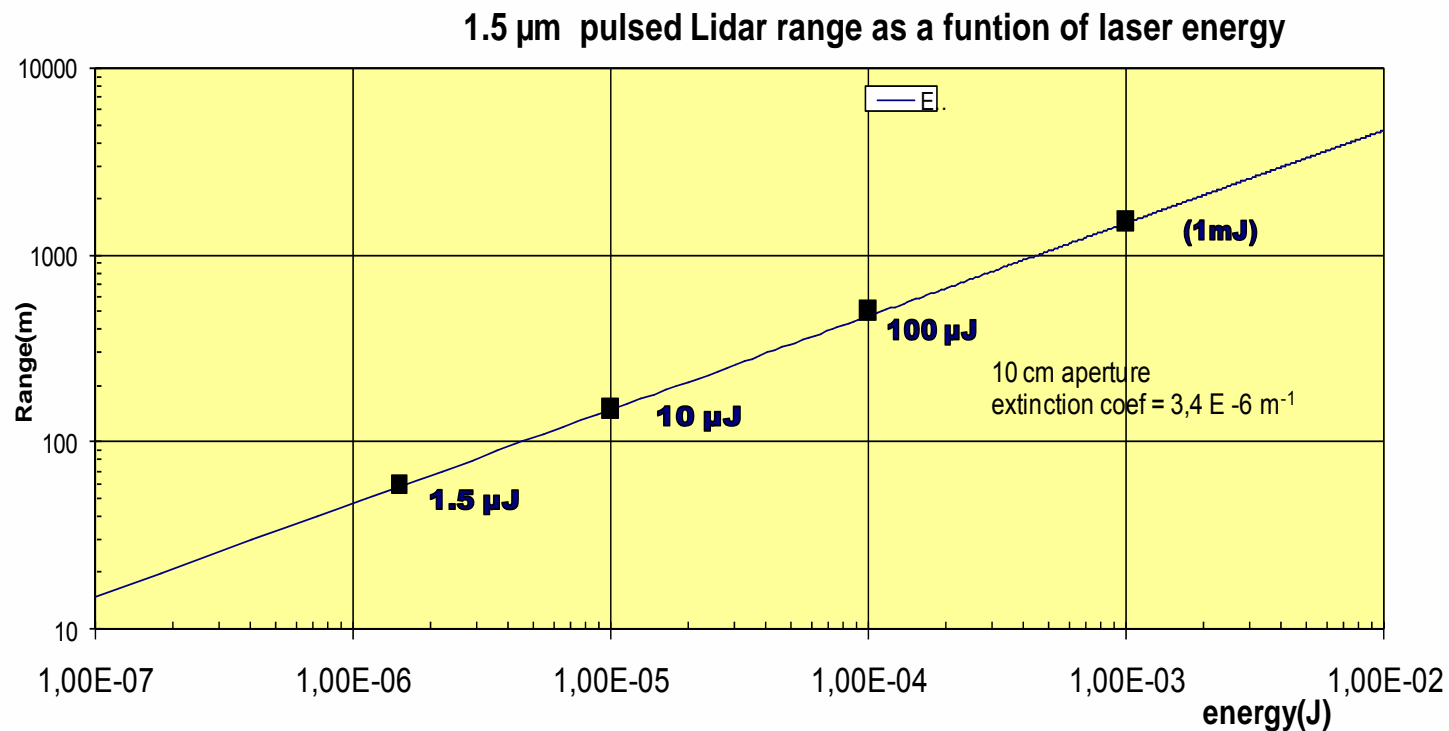


# Parallel runway monitoring

If compact, autonomous and reliable, one lidar can monitor two parallel runways



# Lidar range vs Pulse Energy



—— Range resolution 30m (pulses 200ns) – integration time 0.1s

# Conclusions

- Wake vortex detection with fiber laser lidar has been demonstrated during CREDOS campaign.
- Technology is affordable ( telecom components) and now commercially available at Leosphere for wind monitoring applications.
- Fiber laser technology is scalable for longer range or faster application .
- Signal processing hardware is mature and automatic algorithms for operational wake vortex monitoring are to be developed.
- Such compact scanning lidars could be used widely on airports to gather statistical information on wake vortices trajectories and circulation.





# Wake vortex transversal measurements (SWAN lidar)

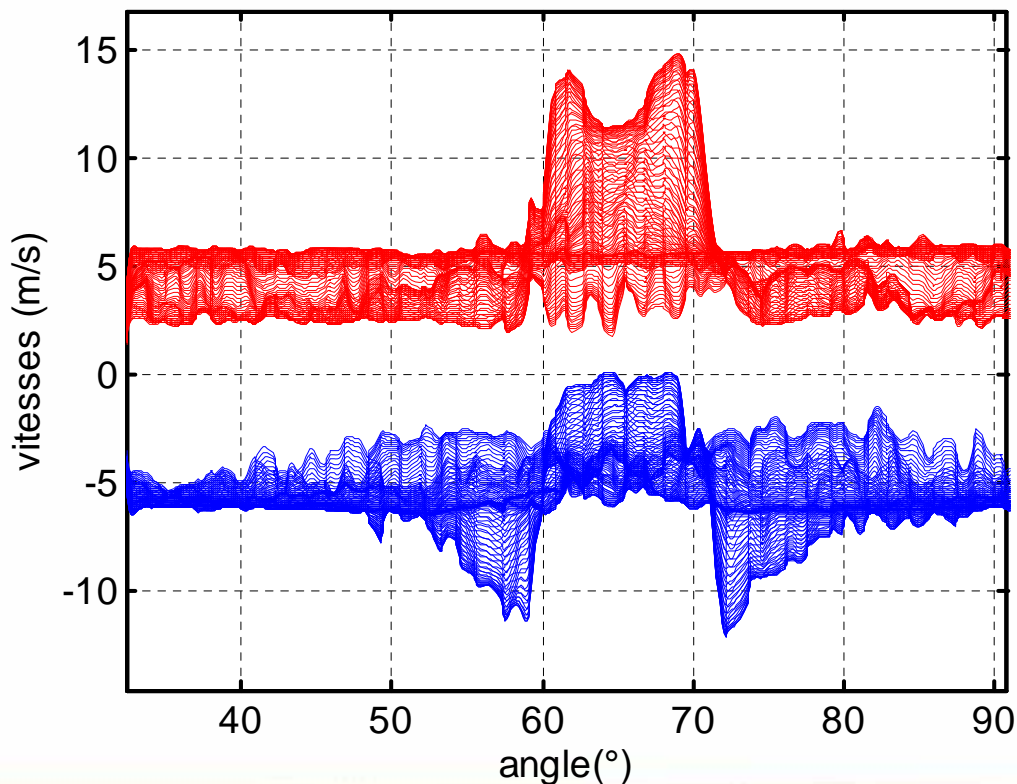
## Conclusions

- Robust & reliable (trip to Frankfurt without adjustment)
- Real time display of velocity map
- Further works :
  - Automatic & real time wake vortex signal processing
  - Down sizing
  - Unattended operation

# CREDOS : Analyse spectrale des tourbillons

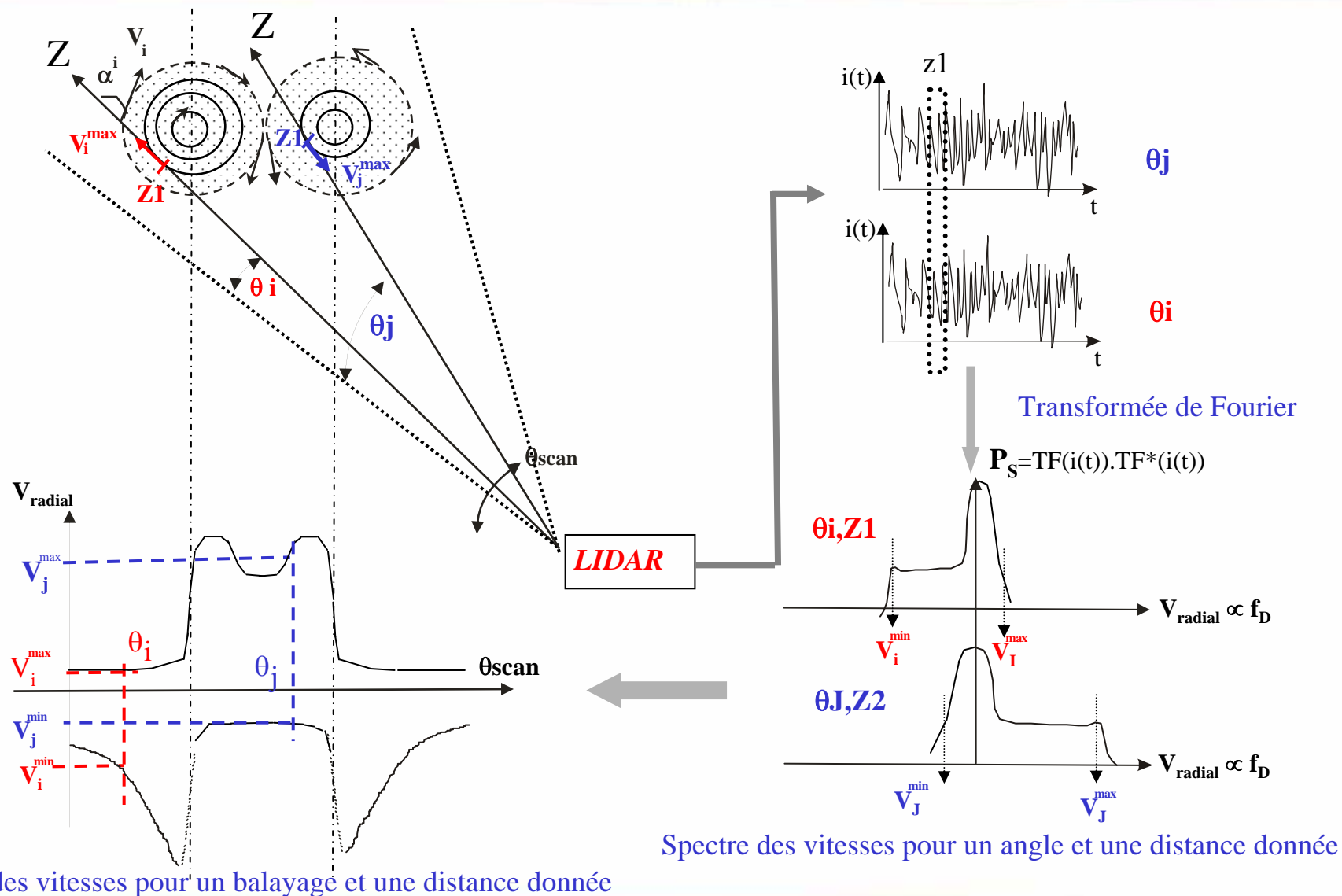
## Développement d'un traitement du signal optimal

Le profil de vitesse est obtenu en traitement en temps différé en cherchant, après seuillage, la valeur maximale ou minimale de vitesse dans la porte de mesure. Pour chaque distance de mesure, on trace ces valeurs maximales et minimales en fonction de l'angle de balayage, on obtient le réseau de courbes rouges et bleues

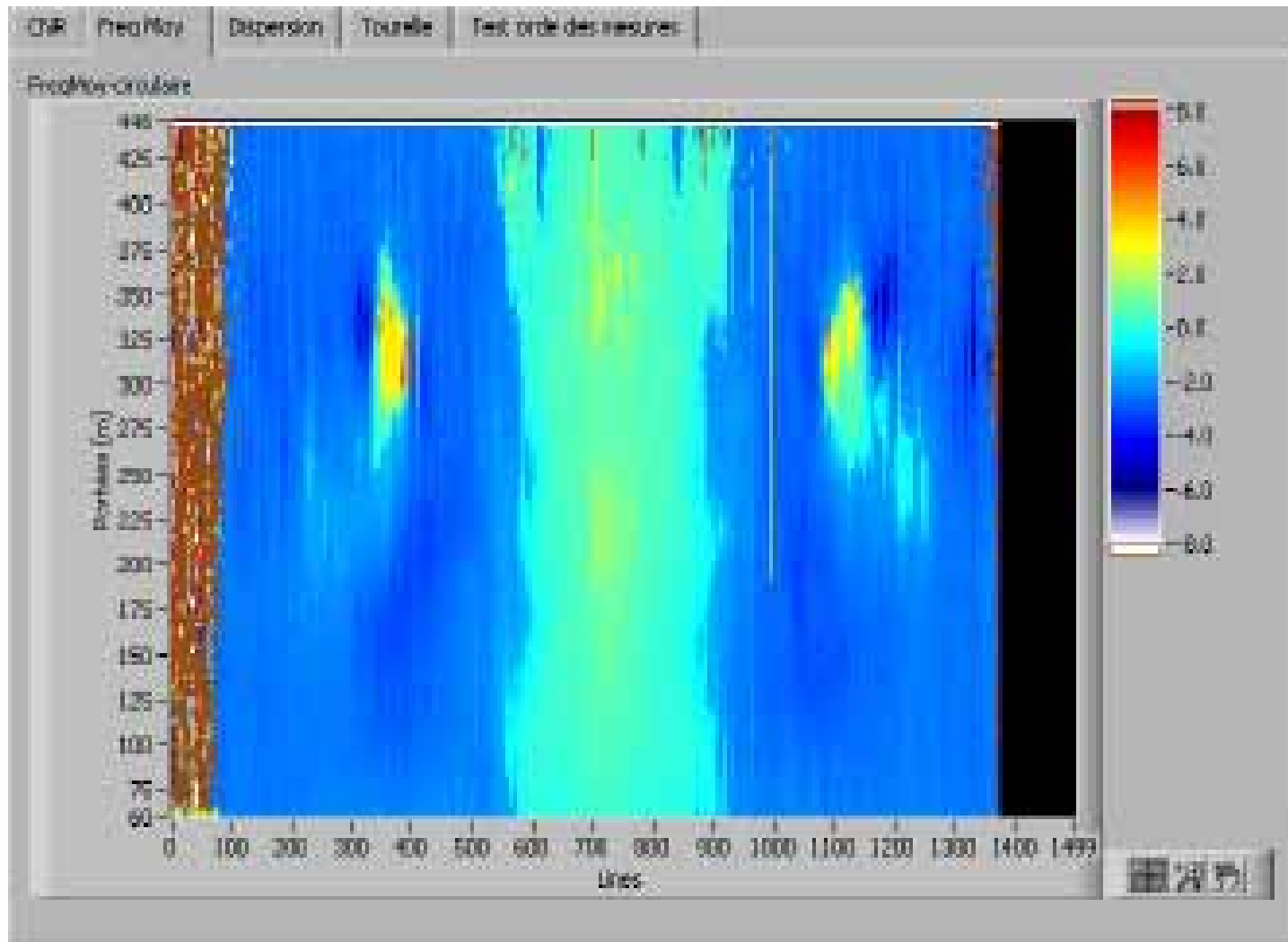


→ Position du coeur,  
circulation vs temps/balayage

# CREDOS : Traitement du signal des vortex



# SWAN : REAL TIME display of velocity map

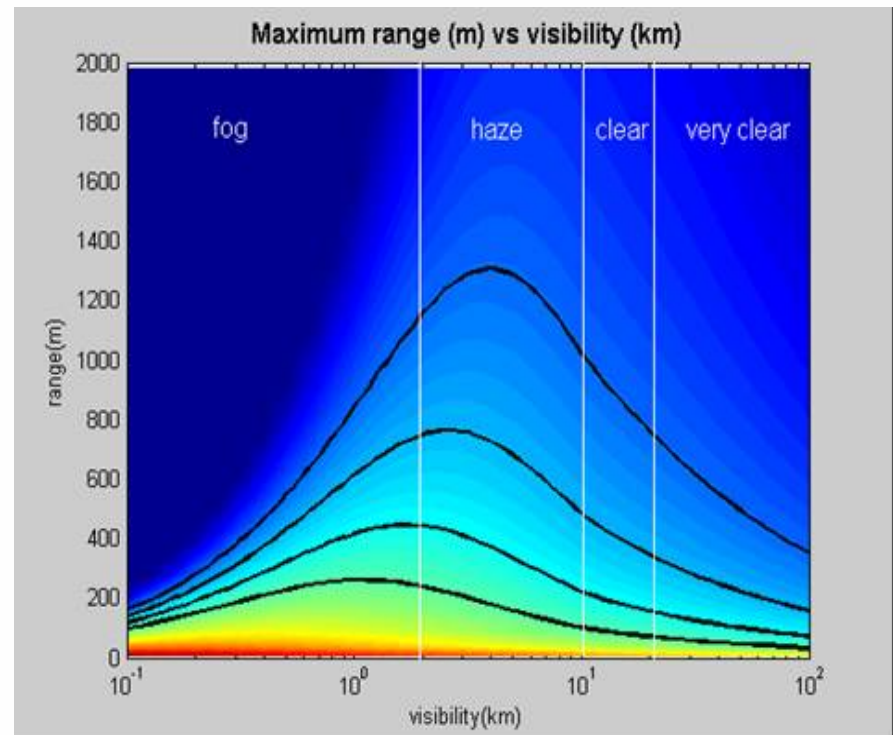


# Mesure des « Wake –Vortex » sur sites aéroportuaire

- Weather limitations

*Clear stratified sky, low visibility, heavy rain, very low clouds*

- Windline+Weather tower and TDWR : only solution under heavy rain
- LIDAR is adapted to most meteo situations



# Wake Vortex monitoring SWAN Lidar- Cremos campaign

