Position reconstruction of acoustic sources with the AMADEUS Detector

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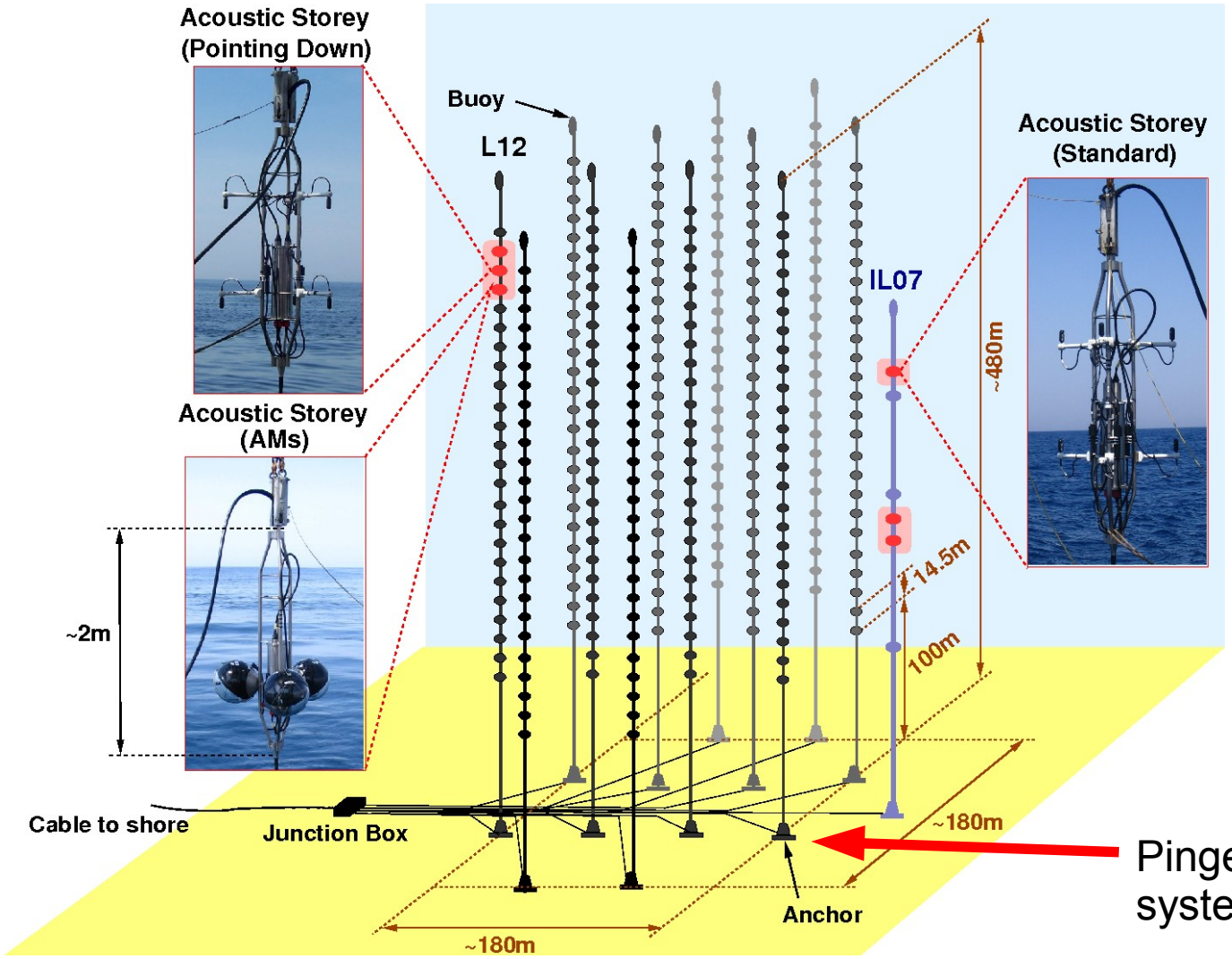
FOR ASTROPARTICLE
PHYSICS

Outline

- AMADEUS
- Direction reconstruction
  - Beam forming
  - Time difference method
- Position reconstruction

AMADEUS in ANTARES



36 acoustic sensors on 6 storys

Pinger for positioning system

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Direction reconstruction

Local clusters allow for quick direction reconstruction.

Methods:

- Beam forming:
  - requires synchronized data only
  - can be applied to random data
- Time difference method:
  - requires signal arrival times
  - minimum of 4 triggered hydrophones

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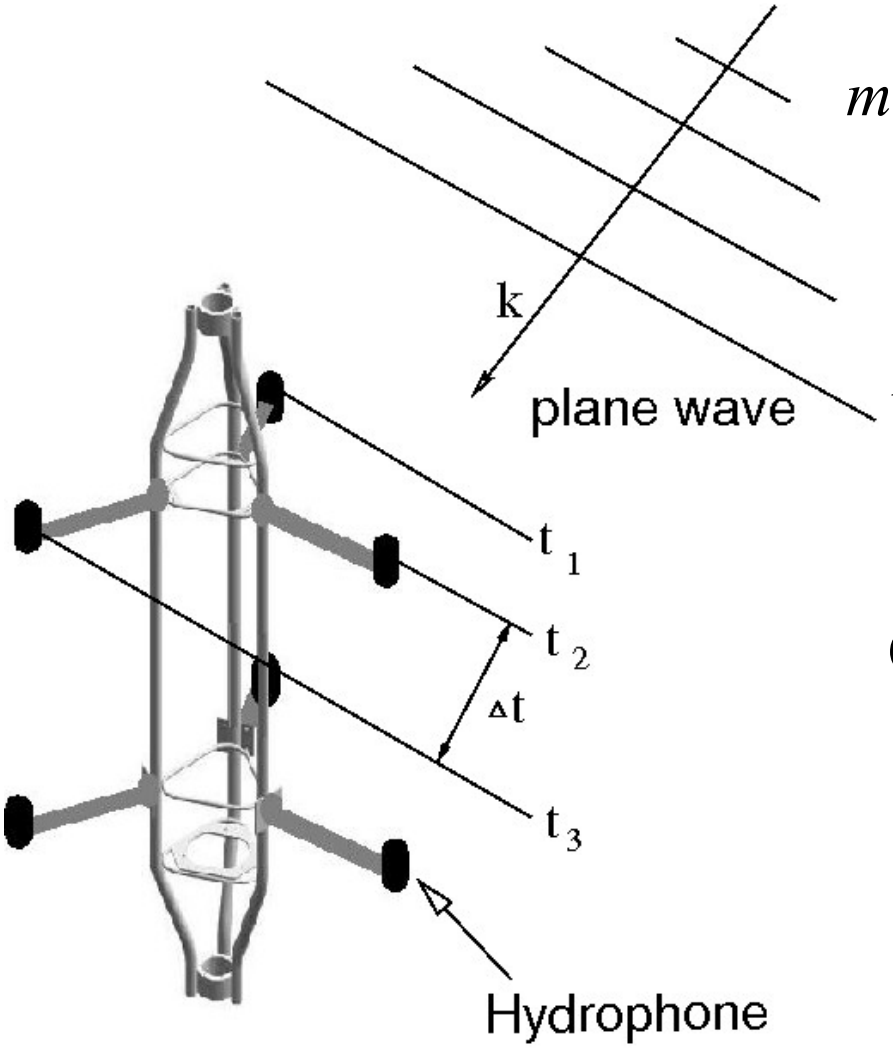
Beam forming



$$max\left(b\left(\vec{k},t\right)=\sum^{N} p_n\left(t-\Delta t_n\left(\vec{k}\right)\right)\right)$$

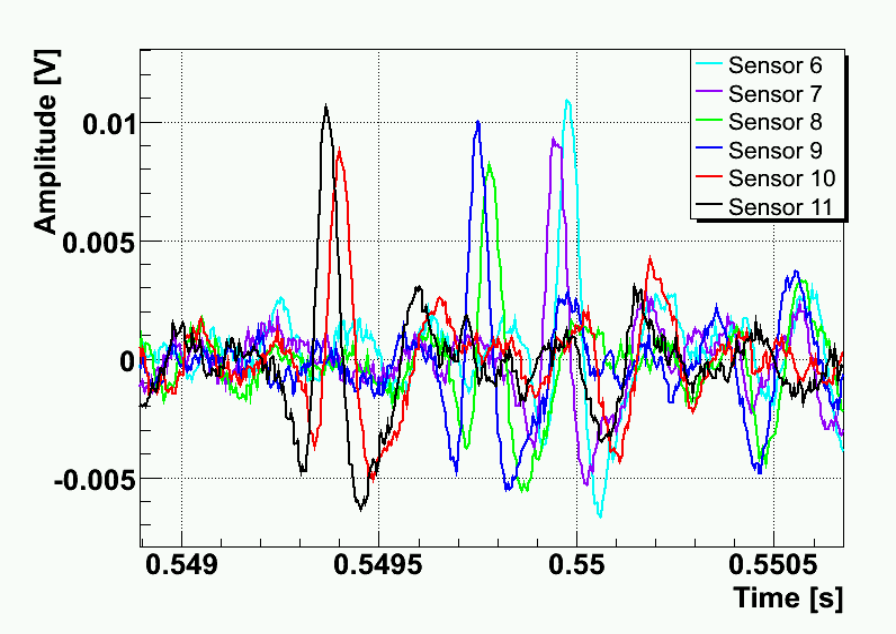
$b\left(\vec{k},t\right)=Beamforming\ output$

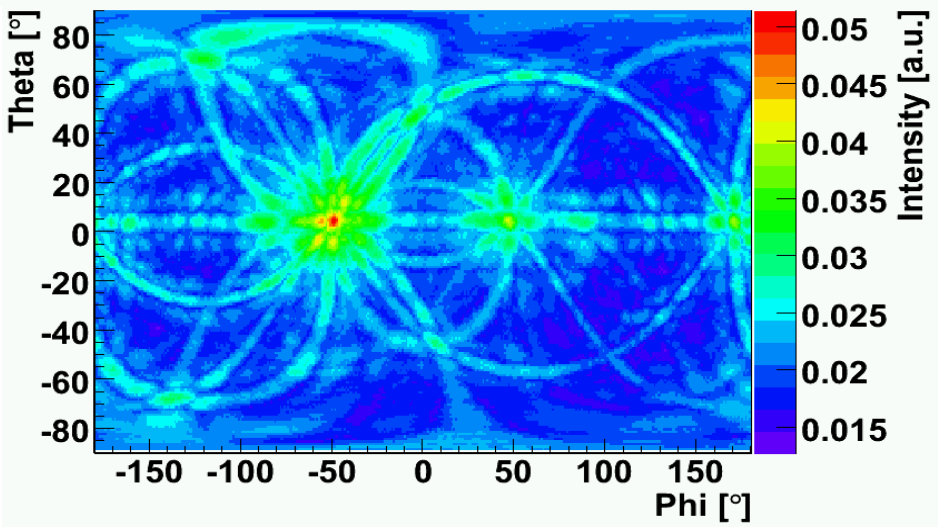
$p\left(t\right)=Signal\ amplitude$

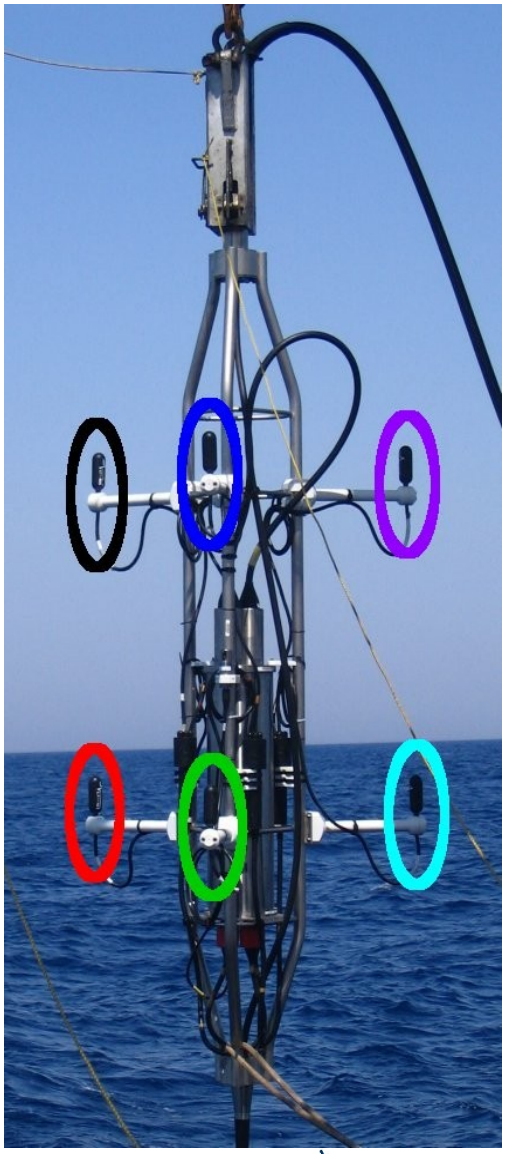
$\Delta t=delay\ time\left(lookup\ table\right)$

Orientation given by compass

Beam forming (Example 1)







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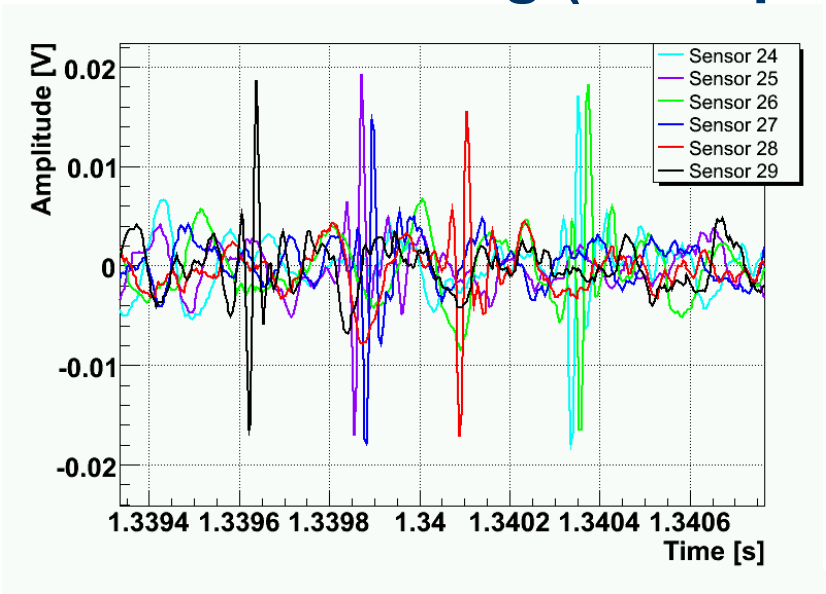
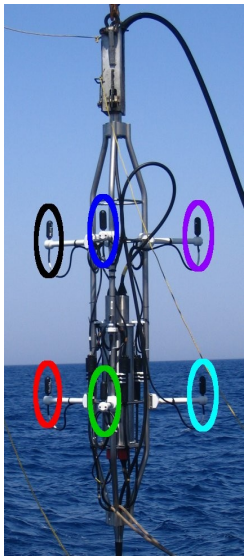
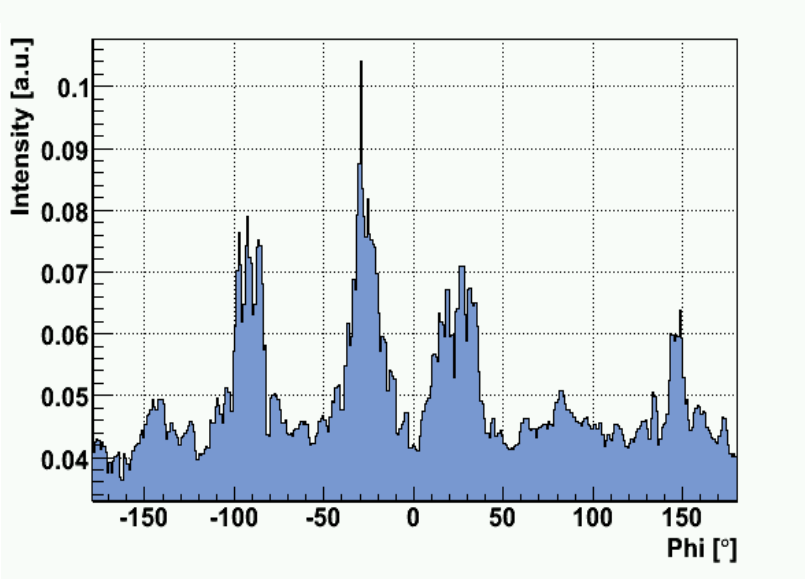
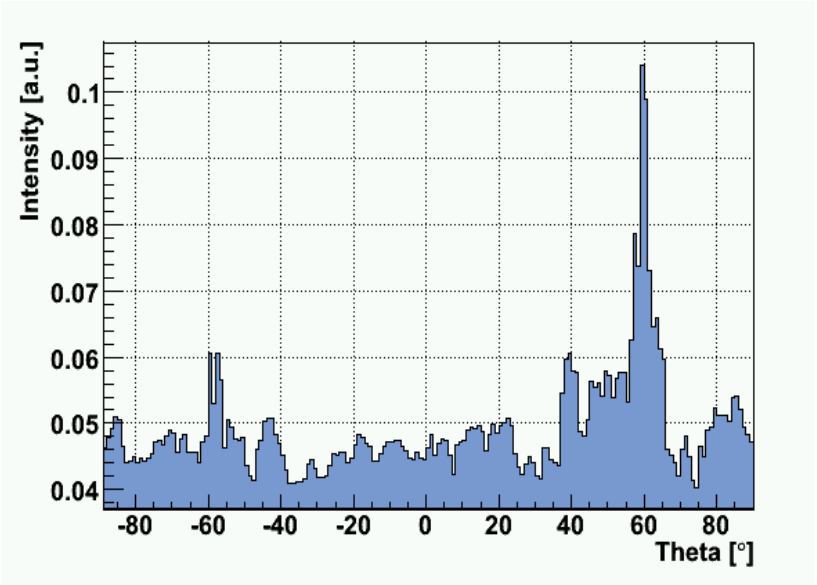
Beam forming (Example 2)

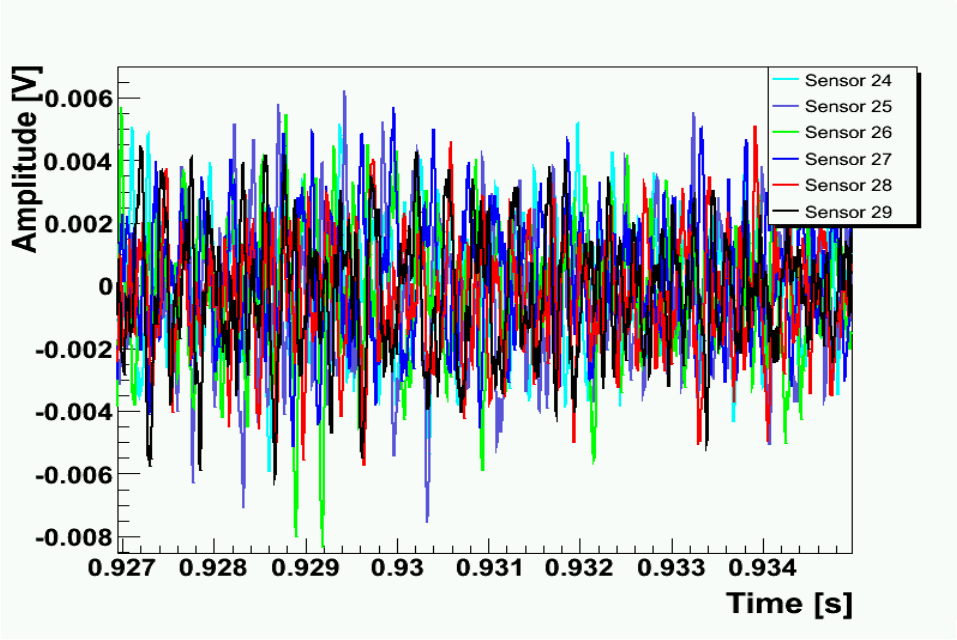


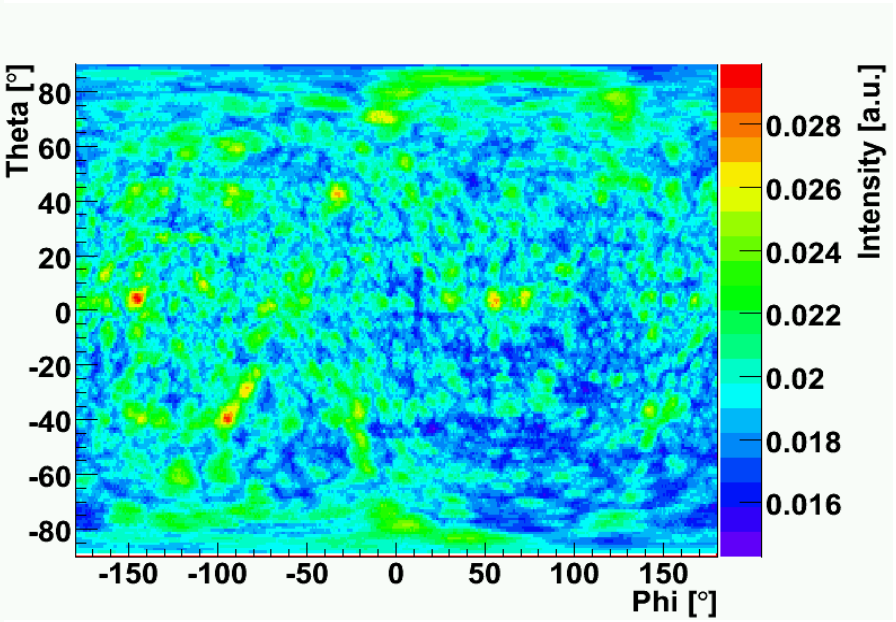






Beam forming (Online Filter Application ??)





- Further studies required !

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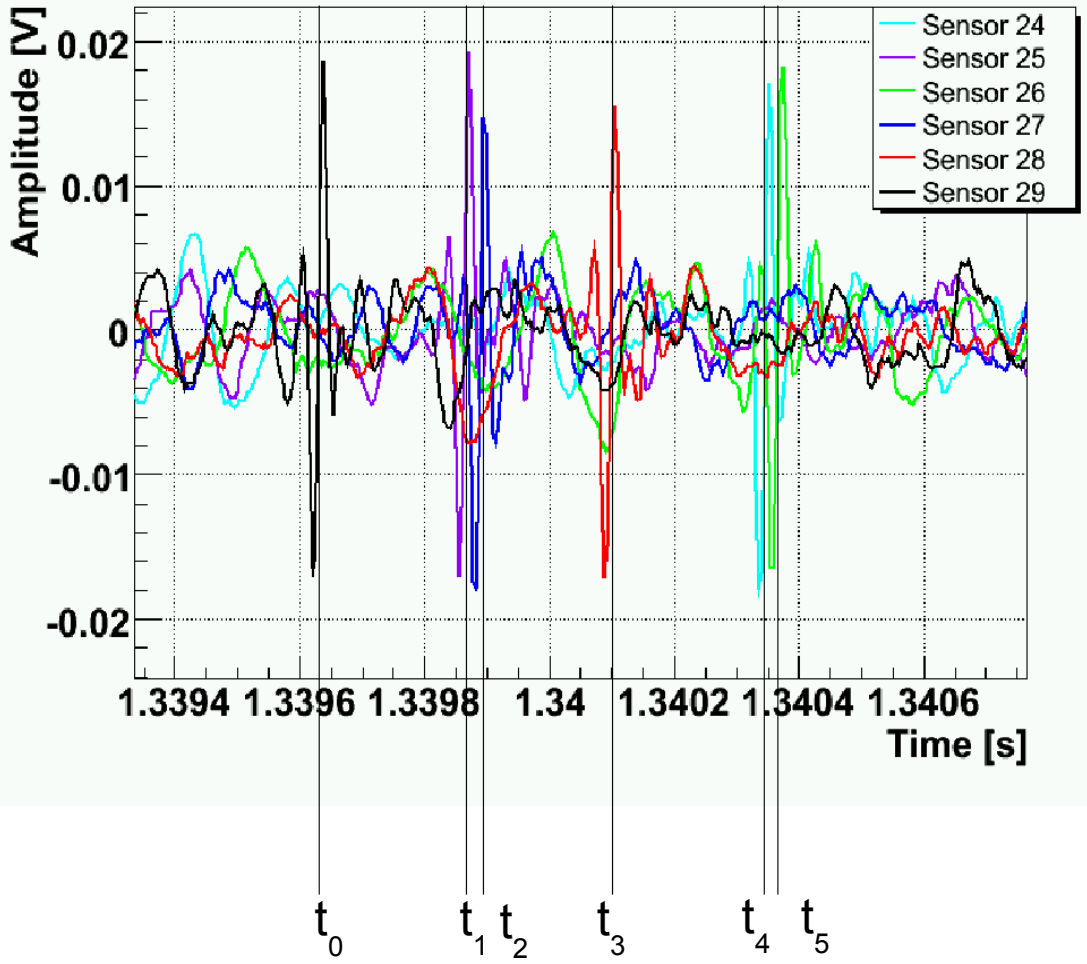
Time difference method

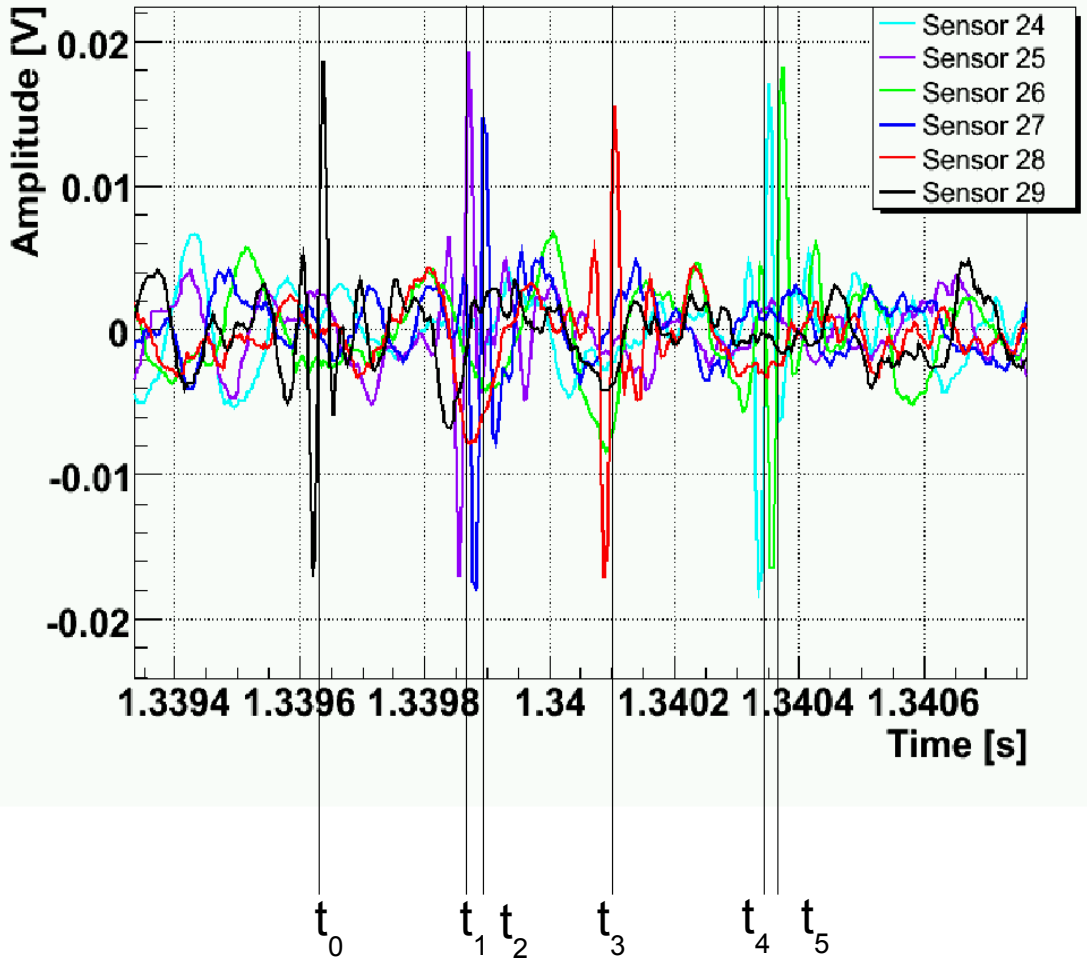


$$min\left(\sum_i \left(t_{i_M} - t_{i_E}(\theta,\phi)\right)^2\right)$$

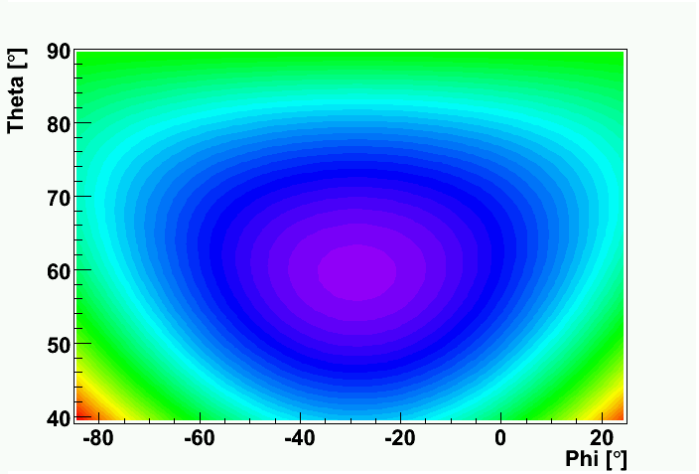
$$t_{i_M} = time\ measured$$

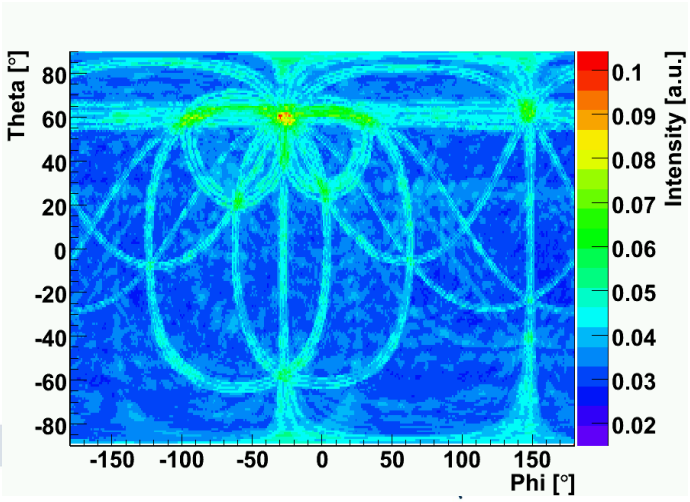
$$t_{i_E} = time\ expected$$

Time difference method

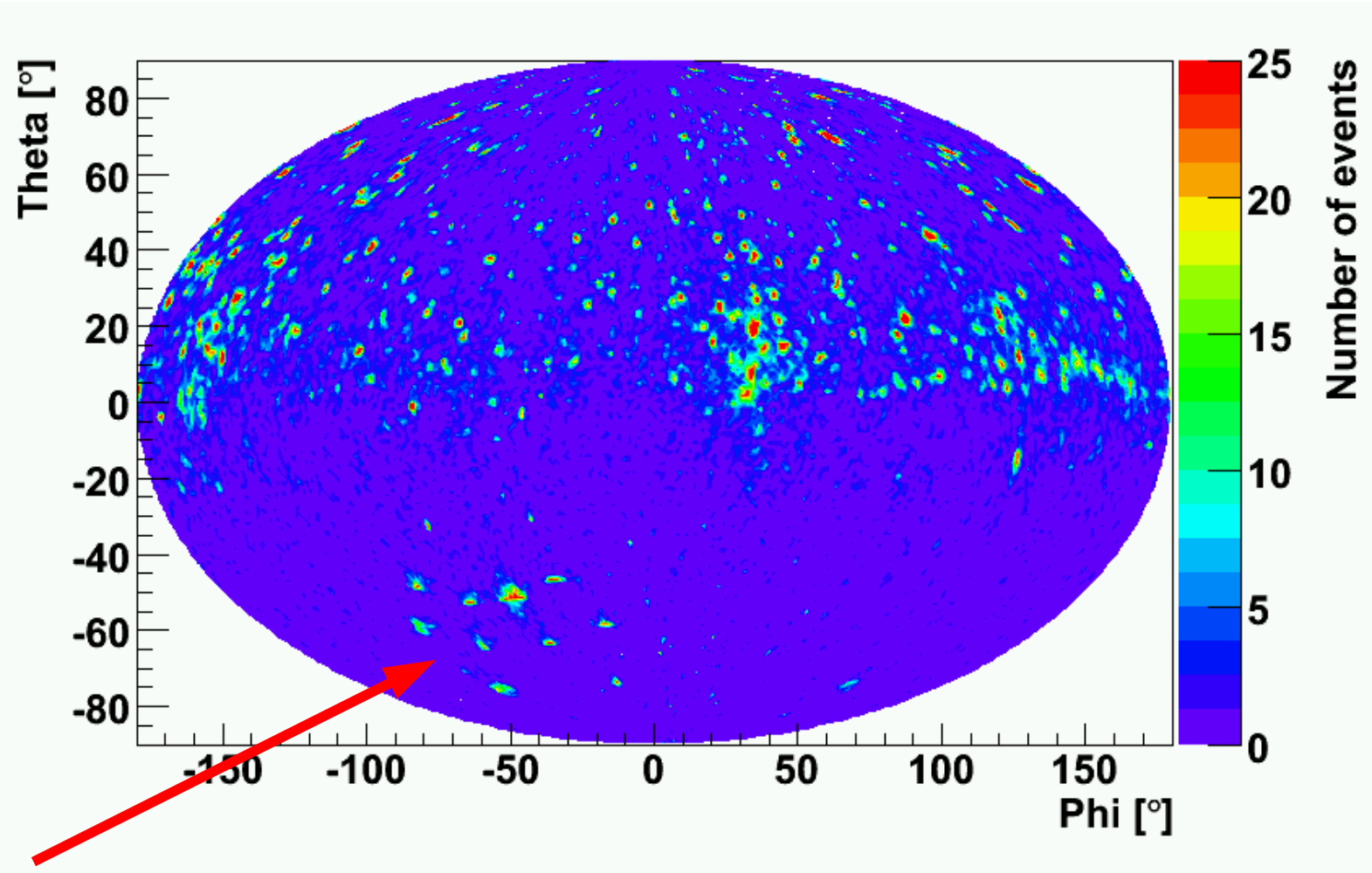


$$min\left(\sum_i \left(t_{i_M} - t_{i_E}(\theta,\phi)\right)^2\right)$$





Source direction distribution



Pingers of ANTARES lines clearly visible

(data from one story on the Instrumentation Line)

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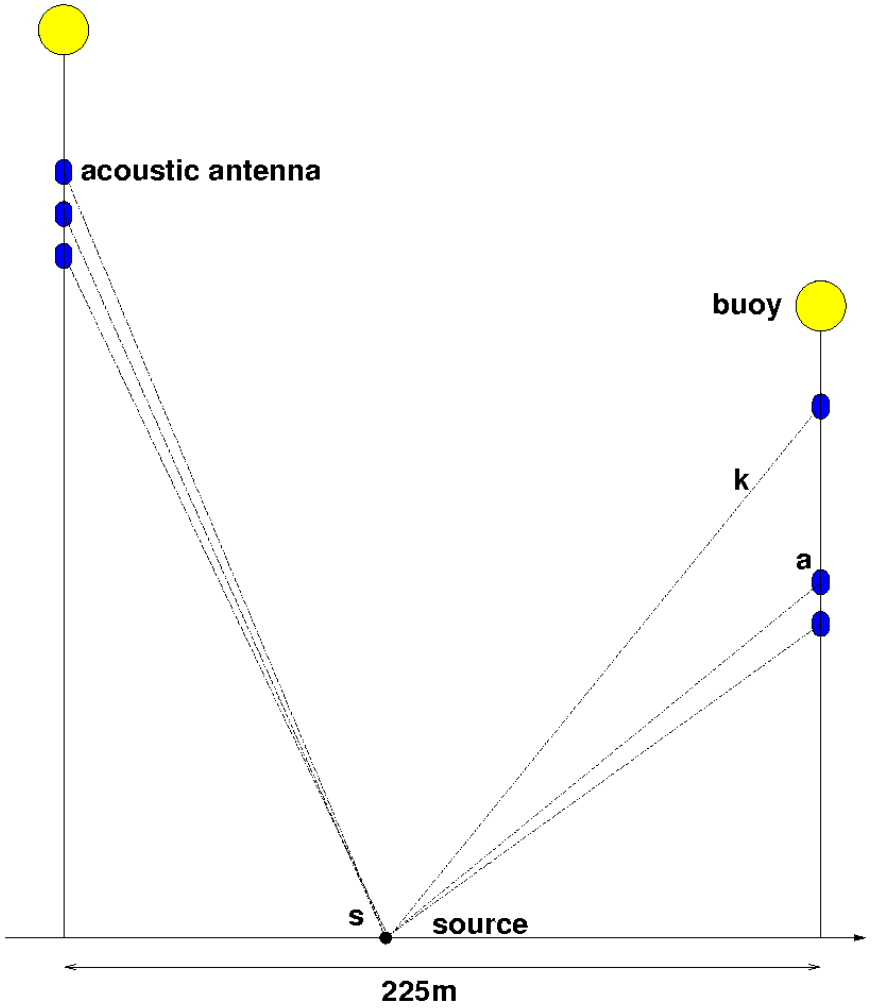
Position Reconstruction



Minimize distance of source to all reconstructed straight lines

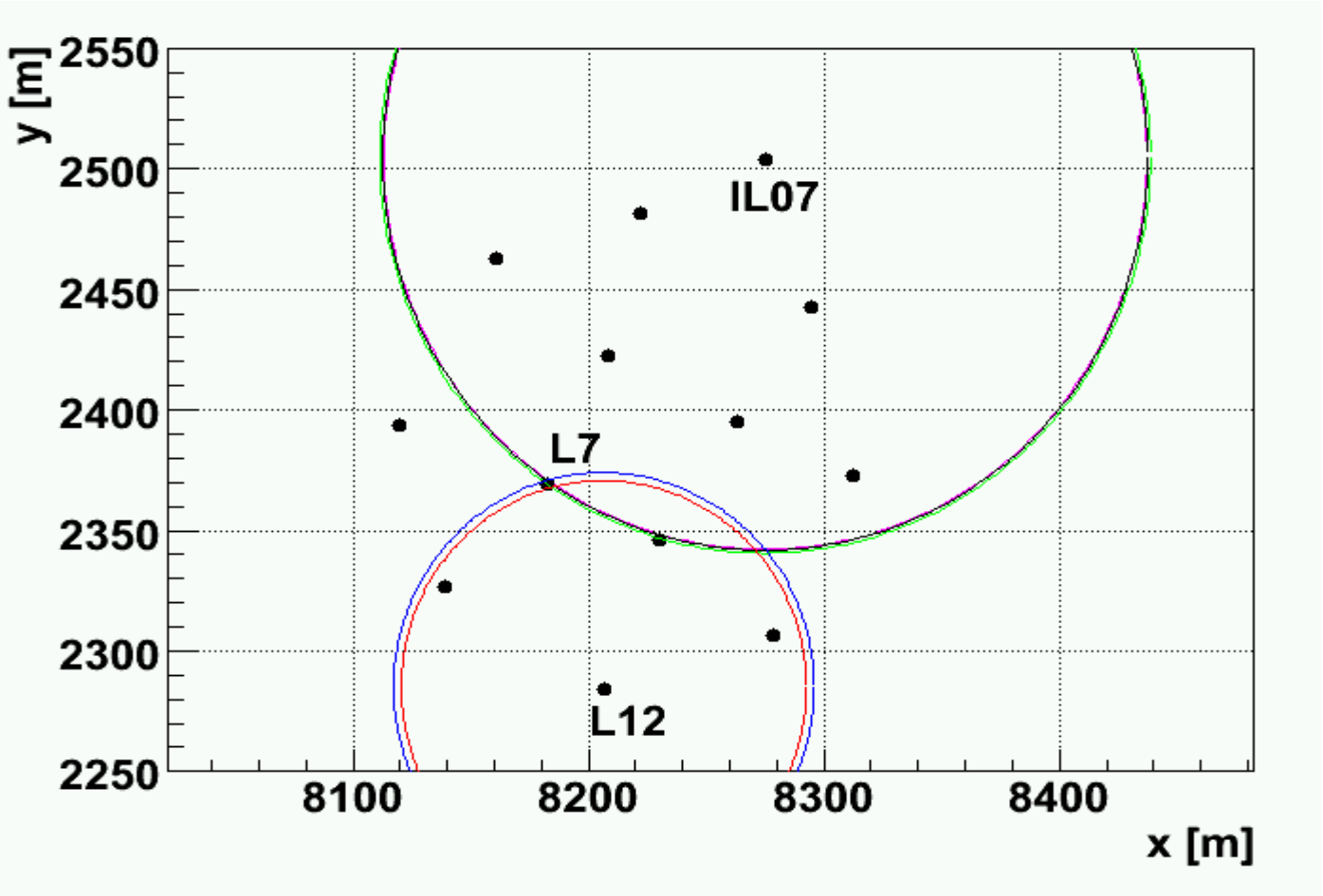
$$\frac{\partial}{\partial \vec{s}}\left(\sum^{N}\left(\vec{s}-\left(\vec{a}_i+n_i\cdot\vec{k}_i\right)\right)^2\right)=\vec{0}$$

$\vec{s}=source$

$\vec{a}=story\ position$

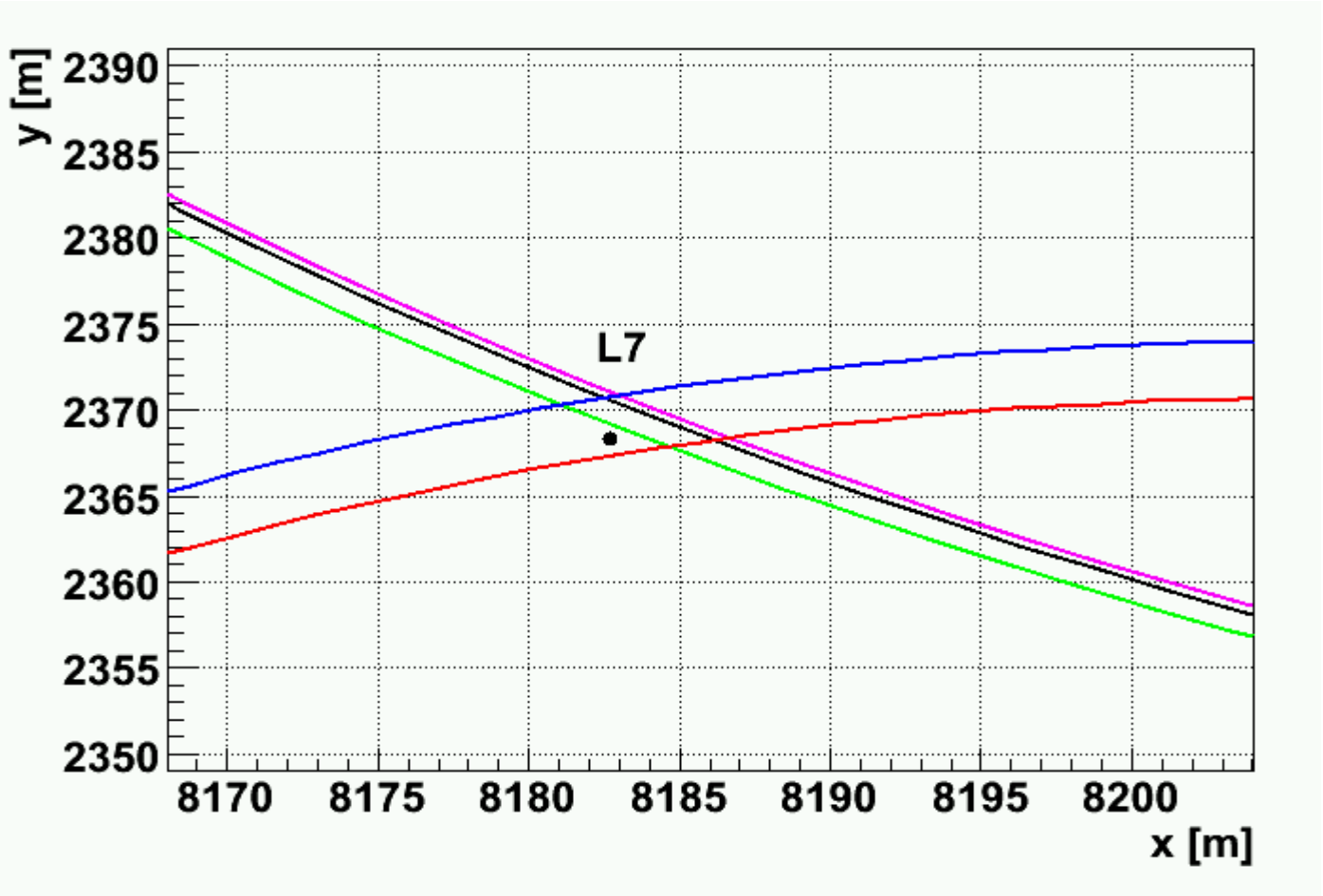
$\vec{k}=reconstructed\ direction$

Position Reconstruction



ANTARES in UTM coordinates

Position Reconstruction (Zoom)



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Summary

- Storys used for direction reconstruction
- Beam forming algorithm works very well (but slow)
- Time difference method more efficient
  - Dependent on threshold
- Full calibration not yet included
- Position reconstruction is on its way

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