

CONTEXT

During the past years, high resolution algorithms (HRA), such as Multiple Signal Classification (MUSIC) have been applied for active simultaneous range and bearing estimation for buried objects, showing promising results. However, these techniques perform poorly when faced to correlated signals and rely on heavy assumption on the used antennas.

SIGNAL MODEL

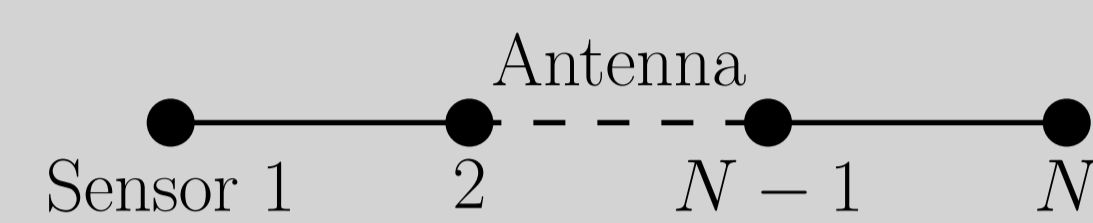
Sensor j output at frequency f :

$$r(f, j) = \sum_{p=1}^P c_p(j) s(f) \exp(-2i\pi f \tau_{j,p}^{(j, \theta_p, \rho_p)}) + n(f, j)$$

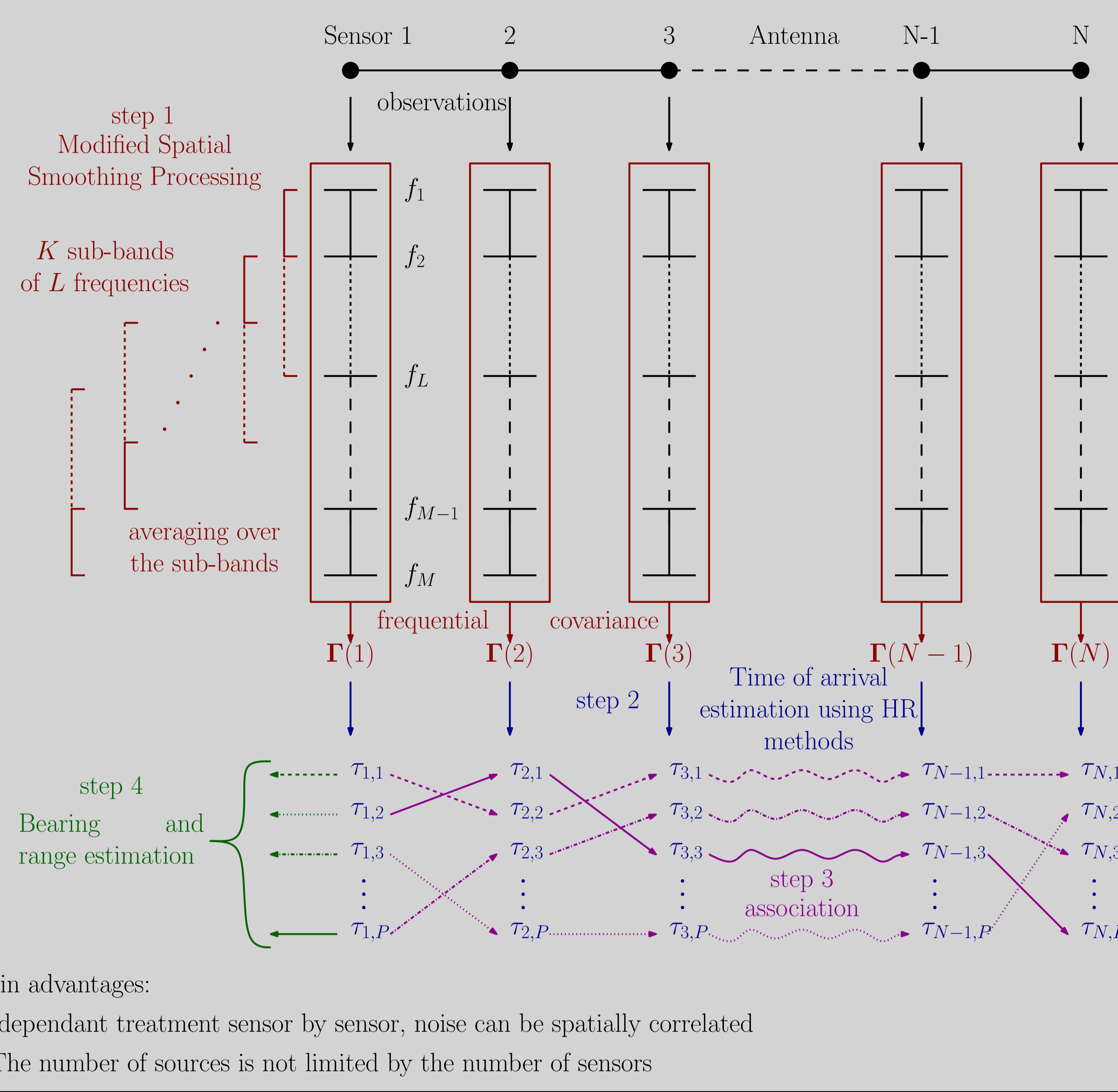
mixture of P echoes of a known signal can be modelled as:

or as: $\mathbf{r}(j) = \mathbf{\Lambda} \mathbf{A}(j) \mathbf{c}(j) + \tilde{\mathbf{n}}(j), j = 1, \dots, N$

- $\mathbf{r}(j) = [r(f_1)(j), \dots, r(f_M)(j)]^T$
- $\mathbf{\Lambda} = \text{diag}(\tilde{s}(f_1)(j), \dots, \tilde{s}(f_M)(j))$
- $\mathbf{A}(j) = [\mathbf{a}(\tau_{j,1}), \dots, \mathbf{a}(\tau_{j,P})]$
- $\mathbf{c}(j) = [c_1(j), \dots, c_P(j)]^T$
- $\tilde{\mathbf{n}}(j) = [n(f_1)(j), n(f_2)(j), \dots, n(f_M)(j)]^T$
- $\mathbf{\Gamma}(j) = E[\mathbf{r}(j)\mathbf{r}^H(j)]$



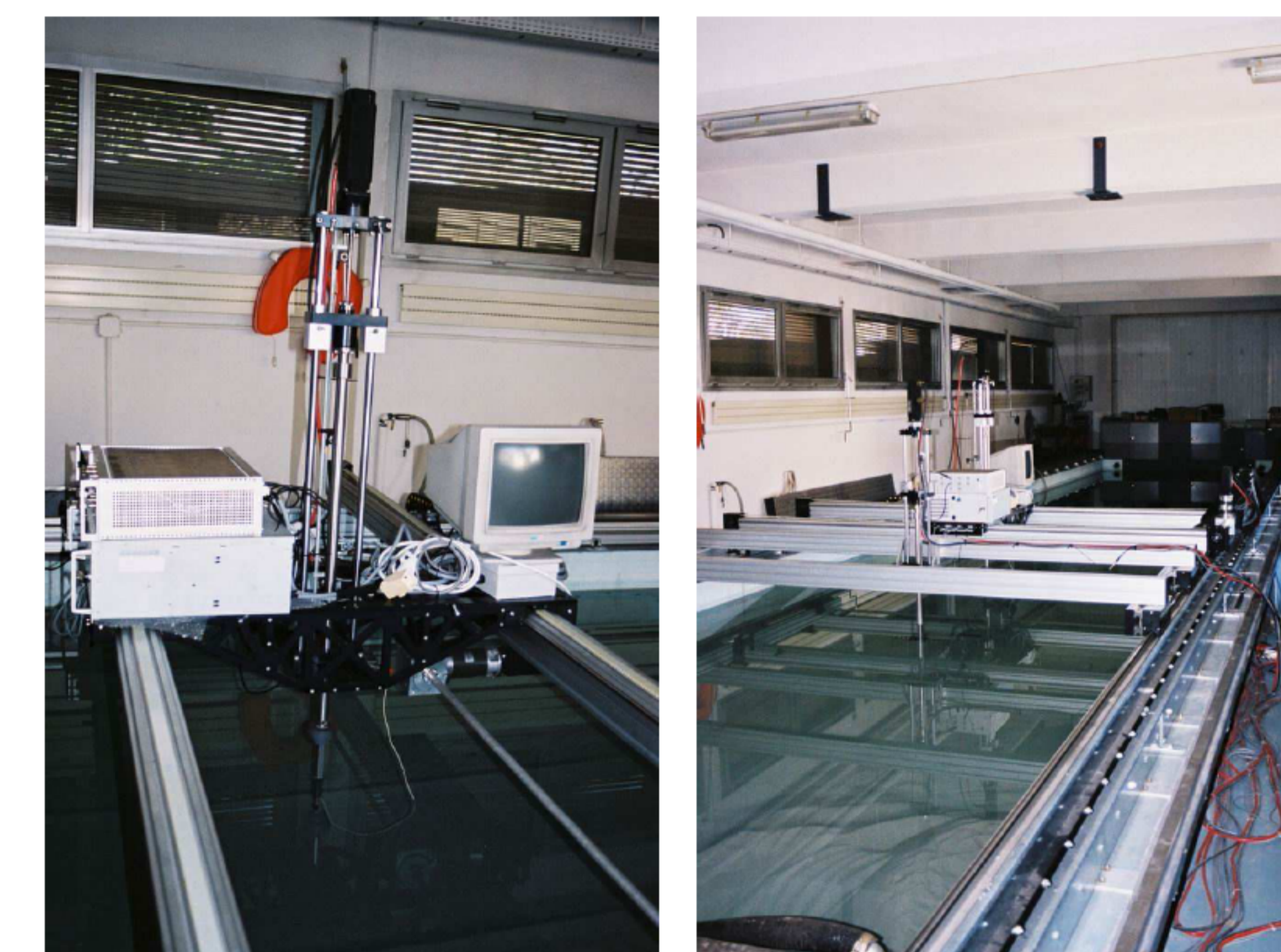
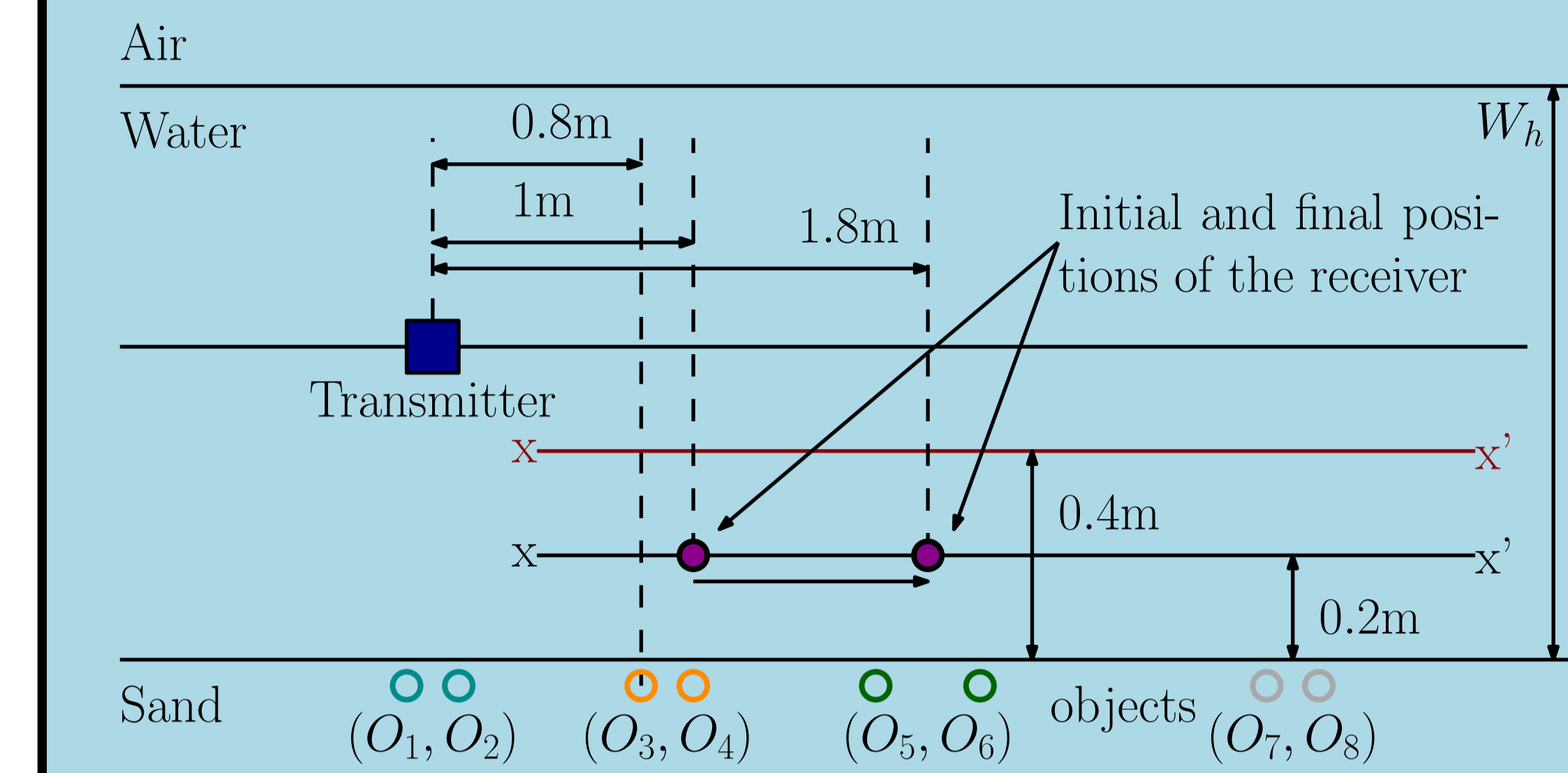
INCOHERENT SENSOR BY SENSOR METHOD



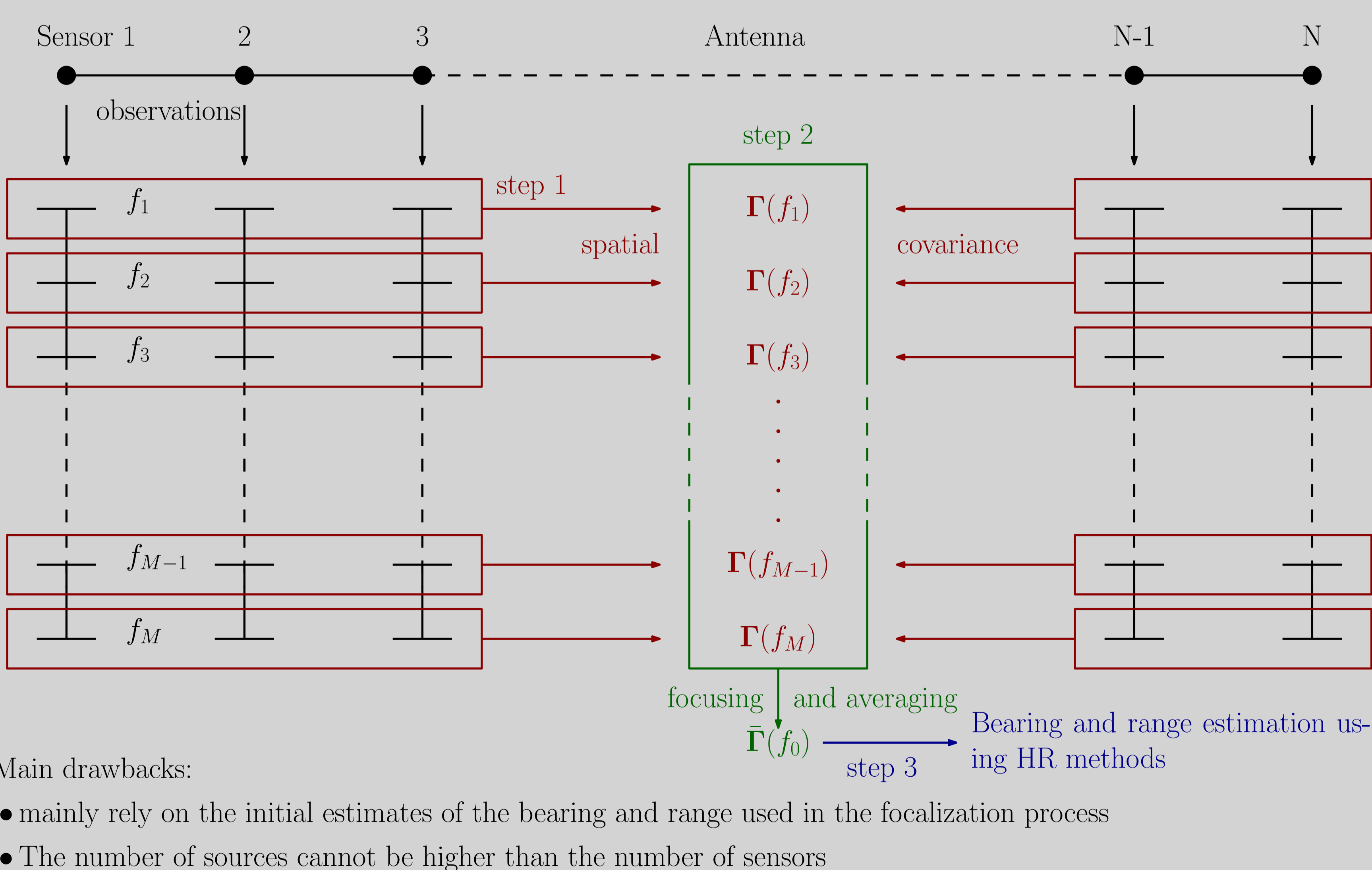
Main advantages:

- Independent treatment sensor by sensor, noise can be spatially correlated
- The number of sources is not limited by the number of sensors

EXPERIMENTAL SETUP



COHERENT SIGNAL SUBSPACE METHOD



Main drawbacks:

- mainly rely on the initial estimates of the bearing and range used in the focalization process
- The number of sources cannot be higher than the number of sensors

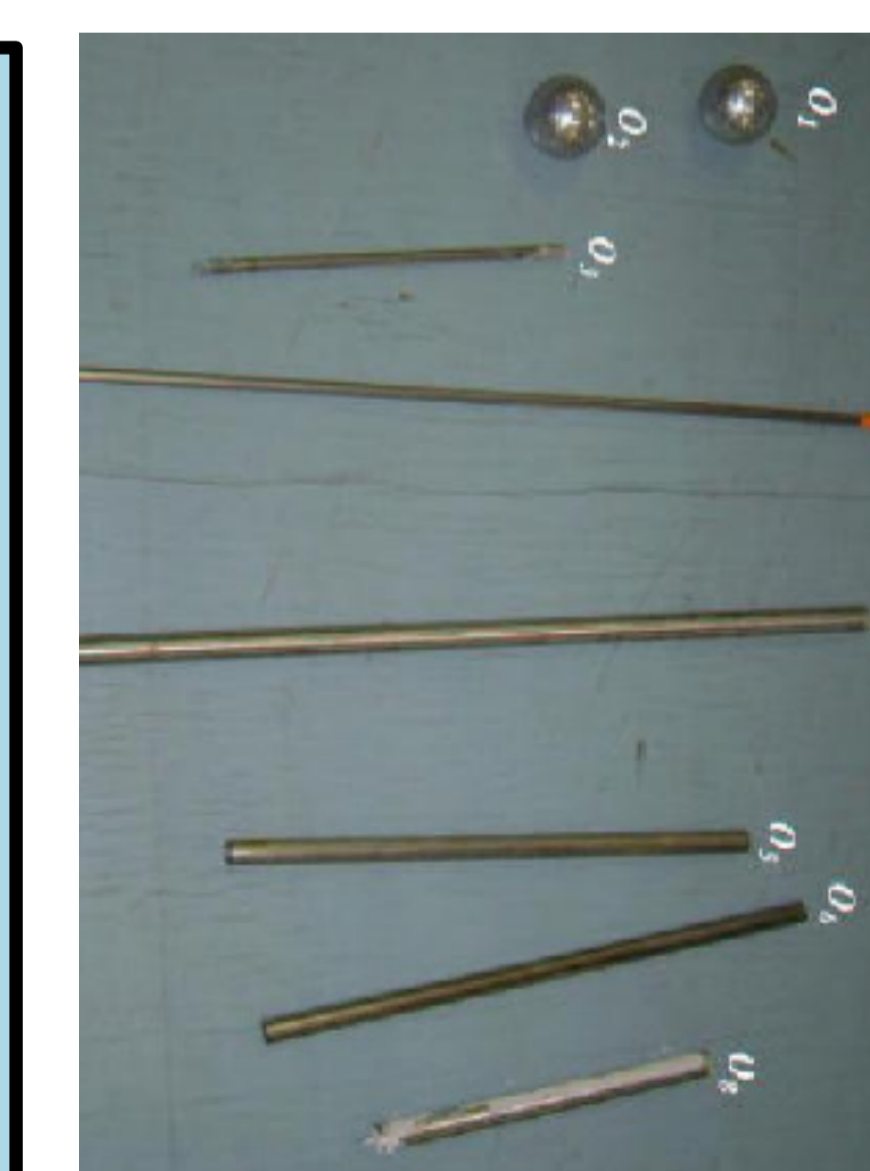
BURIED OBJECTS' FEATURES

E_1, \dots, E_4 with $(O_1, O_2), \dots, (O_7, O_8)$ and XX' fixed at 0.2 m

E_5, \dots, E_8 with $(O_1, O_2), \dots, (O_7, O_8)$ and XX' fixed at 0.4 m

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8
$\theta_{1exp}(\circ)$	20	23	33.2	32.4	-52.1	-70	-51.6	
$\rho_{1exp}(\text{m})$	0.3	0.24	0.26	0.65	0.65	1.24	0.65	
$\theta_{2exp}(\circ)$	22	9.2	20	5.8	-22	-41	-65.3	-49
$\rho_{2exp}(\text{m})$	0.32	0.22	0.24	0.22	0.45	0.56	1.17	0.64

Objects positions



RESULTS

	E_1	E_2	E_3	E_4	E_5	E_6	E_7	E_8
Coherent Signal Subspace Method								
$\theta_{1est}(\circ)$	20	23	33	32	-49	-52	-70	-52
$\rho_{1est}(\text{m})$	0.31	0.25	0.29	0.28	0.65	0.63	1.21	0.63
$\theta_{2est}(\circ)$	22.5	9	20	6	-22	-40	-65	-50
$\rho_{2est}(\text{m})$	0.33	0.25	0.25	0.23	0.44	0.53	1.2	0.63
Incoherent Sensor by Sensor Method								
$\theta_{1est}(\circ)$	20	23	33	32	-50	-52	-70	-51
$\rho_{1est}(\text{m})$	0.31	0.24	0.25	0.26	0.65	0.64	1.25	0.64
$\theta_{2est}(\circ)$	22.1	8.95	20	5.9	-22	-41	-65	-49
$\rho_{2est}(\text{m})$	0.32	0.23	0.23	0.22	0.45	0.55	1.2	0.64

The estimated values of object range and bearing

CONCLUSION

One of the main targets of array processing is the estimation of the parameters: bearings of the buried objects and the objects-sensors ranges. The proposed localization algorithm treats the impinging signals sensor by sensor, the different time of arrival of the received signals are estimated. Then, by considering the spatial evolution of these times of arrival the object ranges and bearings are obtained. This method also works in a situation where there is less sensors than sources. The obtained results on scaled tank tests are promising, showing a better accuracy than for usual methods.

REFERENCES

- [1] R. O. Schmidt, **Multiple emitter location and signal parameters estimation**, *IEEE Transactions on Antennas and Propagation*, 34(3):276-280, March 1986.
- [2] Z. Saida and S. Bourennane, **Cumulant-based coherent signal subspace method for bearing and range estimation**, *EURASIP Journal on Advances in Signal Processing*, 2007(1):84576, 2007.
- [3] G. Villemin, C. Fossati and S. Bourennane, **Spatio-temporal-based joint range and angle estimation for wideband signals**, *EURASIP Journal on Advances in Signal Processing*, 2013(1):131, 2013.
- [4] G. Villemin, C. Fossati and S. Bourennane, **Efficient time of arrival estimation in the presence of multipath propagation**, *J. Acoust. Soc. Am.*, 134, EL301, October 2013.

