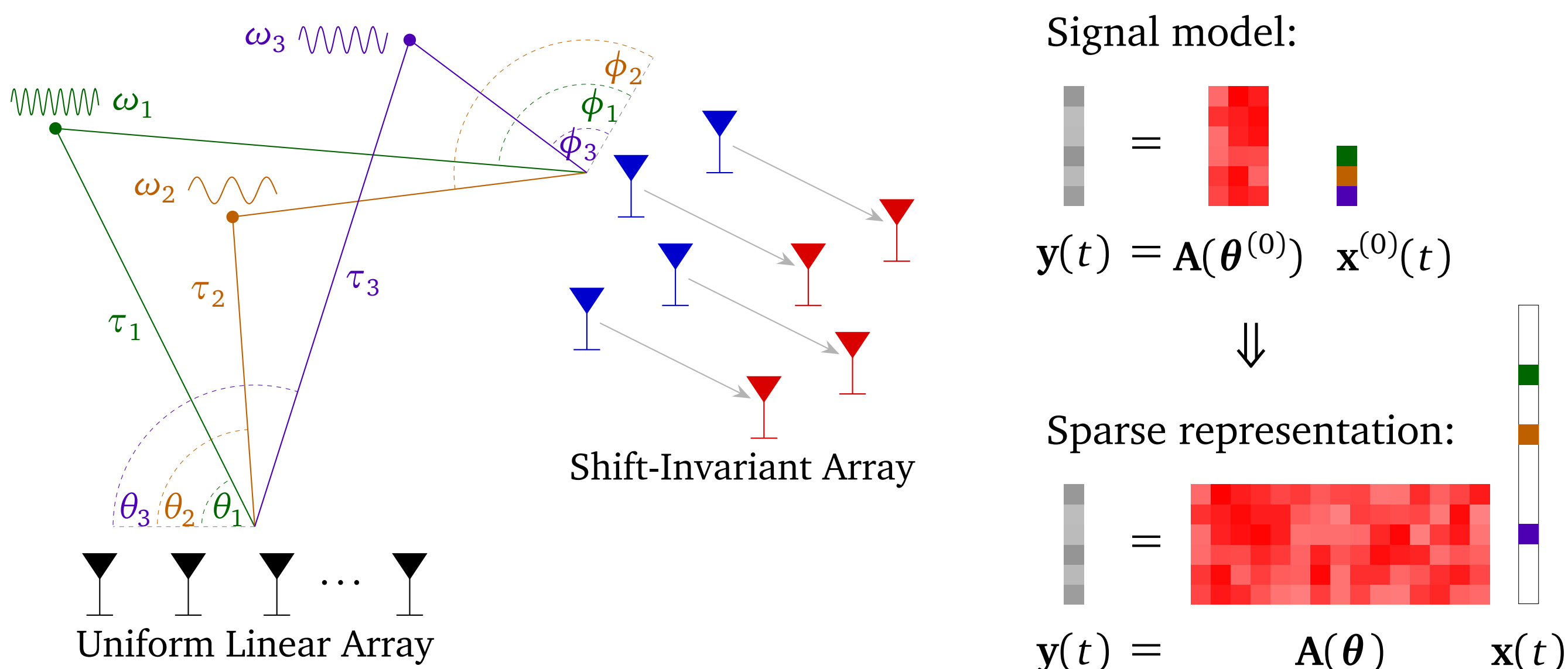


# Exploiting Structure in Compressed Sensing Using Side Constraints – EXPRESS

Martin Haardt, Marius Pesavento, and Marc Pfetsch

## Low Rank Model and Sparse Representation



## Research Objectives in EXPRESS

A) Compressed Sensing (CS) for **parameter estimation** with **structural side constraints**

$$\begin{aligned} \ell_0\text{-minimization problem: } & \min_x \{\|x\|_0 : Ax = y\} \\ \ell_1\text{-minimization problem: } & \min_x \{\|x\|_1 : Ax = y\} \\ \ell_0\text{-denoising problem: } & \min_x \{\|x\|_0 : \|Ax - y\|_2 \leq \epsilon\} \\ \ell_1\text{-denoising problem: } & \min_x \{\|x\|_1 : \|Ax - y\|_2 \leq \epsilon\} \end{aligned}$$

B) Novel approach: **model identifiability** using CS

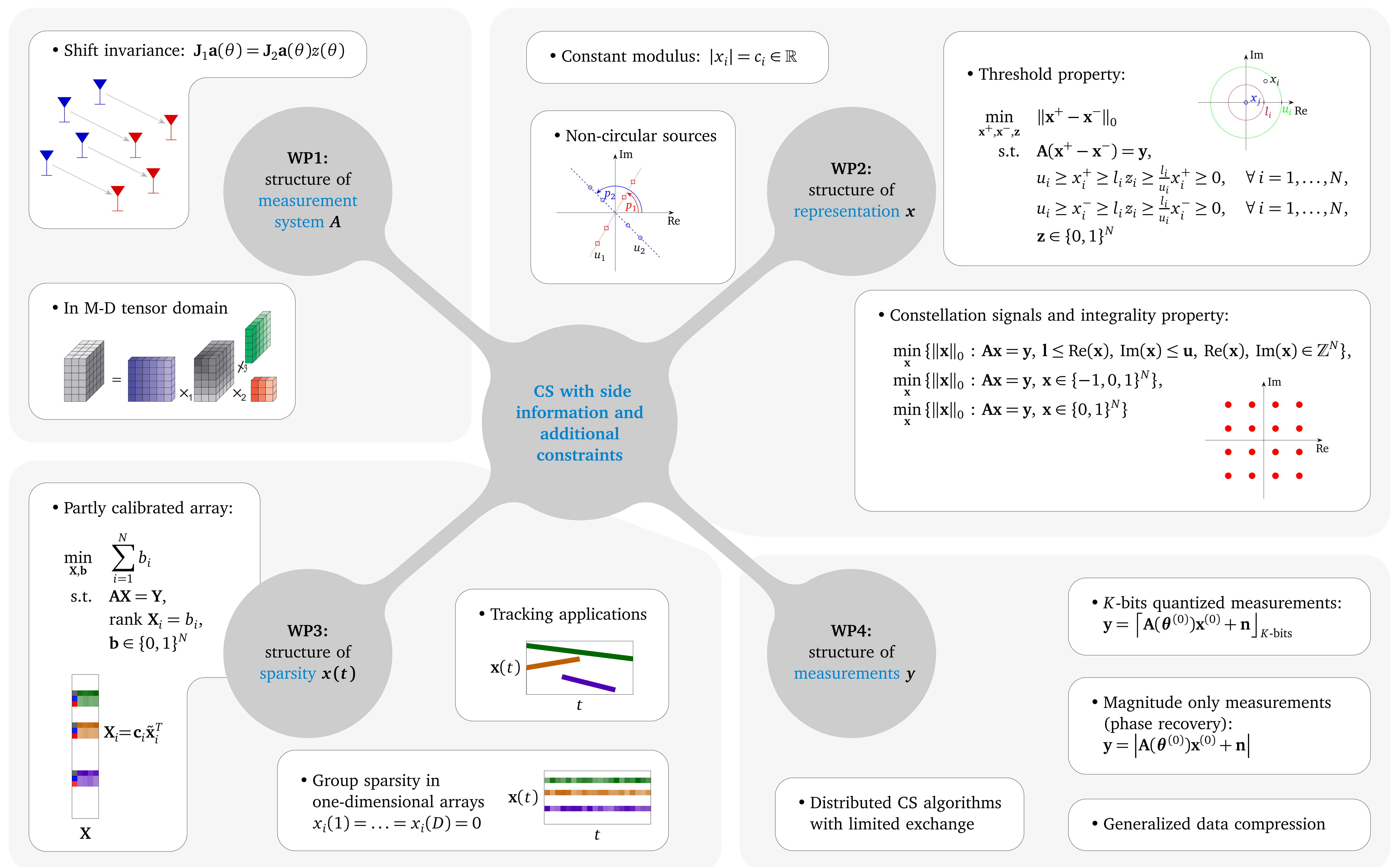
What is the maximum number  $L^*$  of signal components that can uniquely be identified?

$$\begin{aligned} \text{Kruskal rank} \quad L^* = \min_x \quad & \|x\|_0 - 1 \\ \text{subject to} \quad & A(\theta)x = 0, \quad \|x\| = 1 \end{aligned}$$

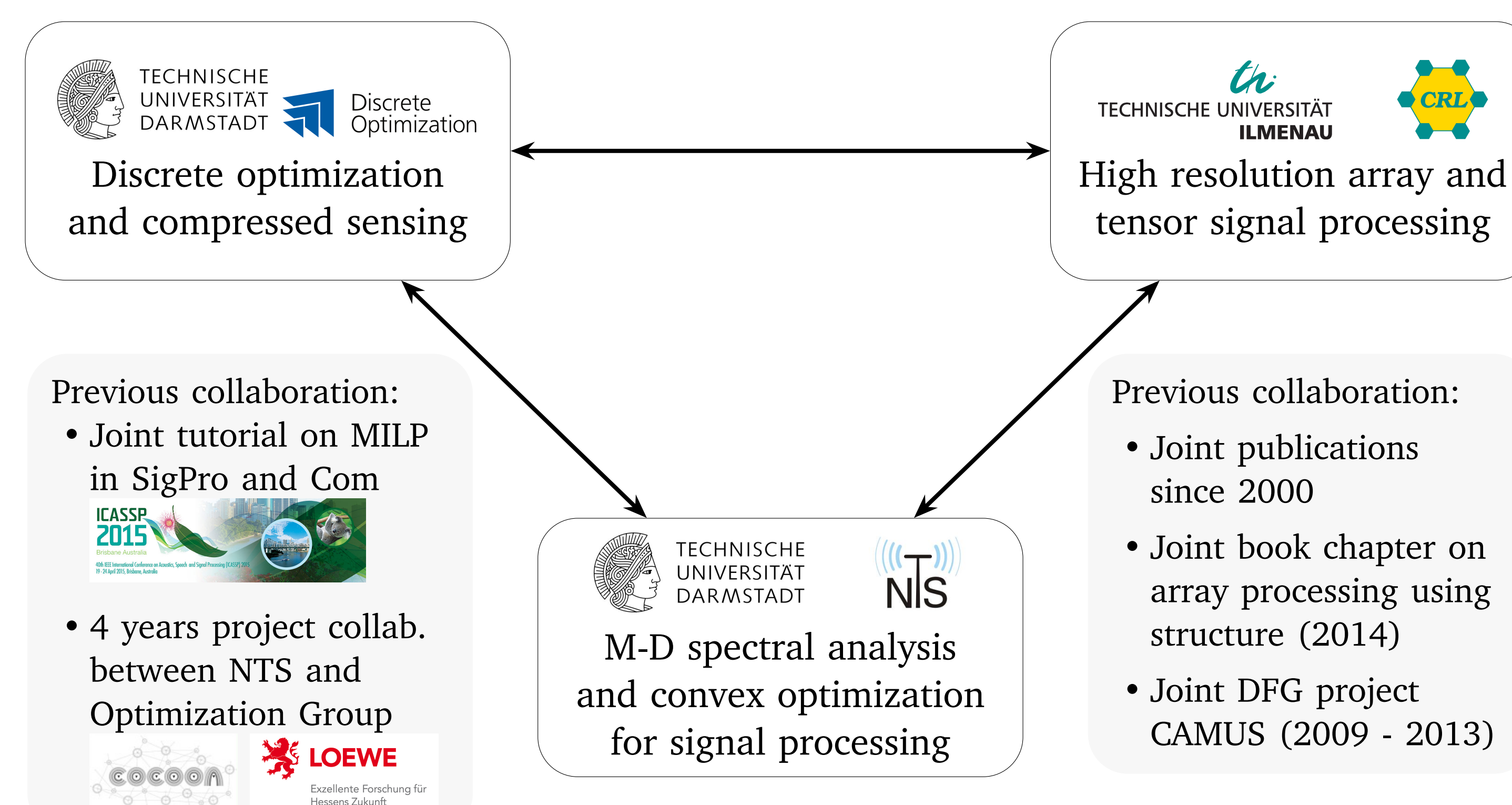
C) Handling large problems with **multidimensional (M-D) structures**

D) Exploring **relationship** between  $\ell_0$  and  $\ell_1$  under side constraints

## Exploiting Different Types of Structure



## EXPRESS Consortium and Existing Cooperations



## List of Project-Related Publications

- S. Jocar and M. E. Pfetsch, "Exact and approximate sparse solutions of underdetermined linear equations," *SIAM J. Sci. Comput.*, vol. 31, no. 1, pp. 23–44, 2008.
- A. M. Tillmann and M. E. Pfetsch, "The computational complexity of the restricted isometry property, the nullspace property, and related concepts in compressed sensing," *IEEE Transactions on Information Theory*, vol. 60, no. 2, pp. 1248–1259, 2014.
- C. Steffens, P. Parvazi, and M. Pesavento, "Direction finding and array calibration based on sparse reconstruction in partly calibrated arrays," in *Proc. of the Sensor Array Multichannel (SAM) Workshop*, A Coruna, Spain, 2014.
- M. Pesavento, A. Gershman, and K. M. Wong, "Direction finding in partly calibrated sensor arrays composed of multiple subarrays," *IEEE Transactions on Signal Processing*, vol. 50, no. 9, pp. 2103–2115, Sep 2002.
- Y. Cheng, M. Pesavento, and A. Philipp, "Joint network optimization and downlink beamforming for comp transmissions using mixed integer conic programming," *IEEE Transactions on Signal Processing*, vol. 61, no. 16, pp. 3972–3987, Aug 2013.
- M. Haardt and J. A. Nossek, "Unitary ESPRIT: How to obtain increased estimation accuracy with a reduced computational burden," *IEEE Transactions on Signal Processing*, vol. 43, no. 5, pp. 1232–1242, May 1995.
- M. Haardt, F. Roemer, and G. Del Galdo, "Higher-order SVD-based subspace estimation to improve the parameter estimation accuracy in multidimensional harmonic retrieval problems," *IEEE Transactions on Signal Processing*, vol. 56, no. 7, pp. 3198–3213, July 2008.
- M. Haardt, M. Pesavento, F. Roemer, and M. N. El Korso, "Subspace methods and exploitation of special array structures," in *Academic Press Library in Signal Processing: Volume 3 – Array and Statistical Signal Processing*, A. M. Zoubir, M. Viberg, R. Chellappa, and S. Theodoridis, Eds., vol. 3. Elsevier, 2014, pp. 651–717, chapter 15.
- M. Pesavento, A. B. Gershman, and M. Haardt, "Unitary root-MUSIC with a real-valued eigendecomposition: a theoretical and experimental performance study," *IEEE Transactions on Signal Processing*, vol. 48, no. 5, pp. 1306–1314, May 2000.
- F. Roemer, G. Del Galdo, and M. Haardt, "Tensor-based algorithms for learning multidimensional separable dictionaries," in *Proc. IEEE Int. Conf. Acoust., Speech, Signal Process. (ICASSP)*, Florence, Italy, May 2014, pp. 3991–3995.