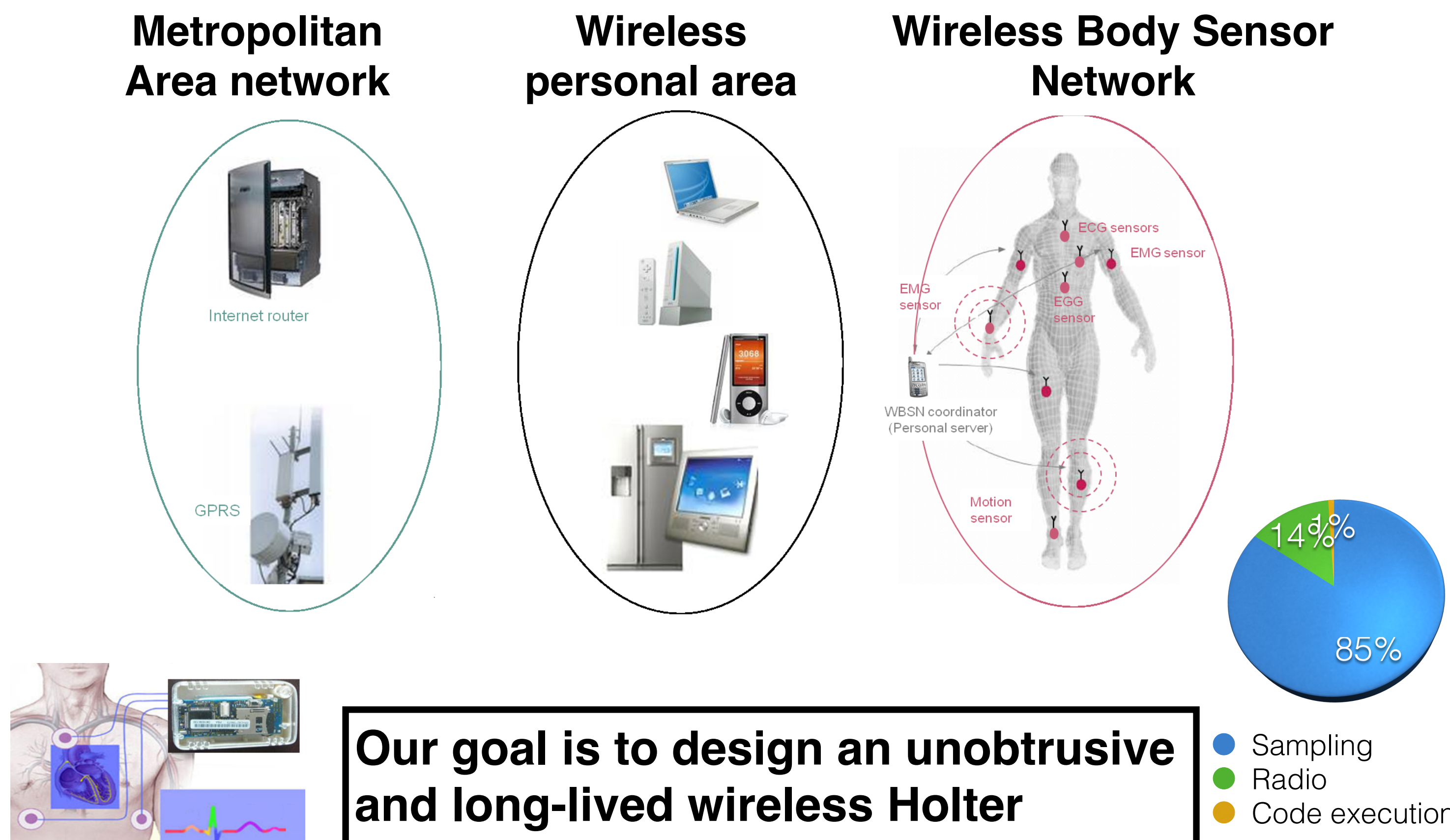


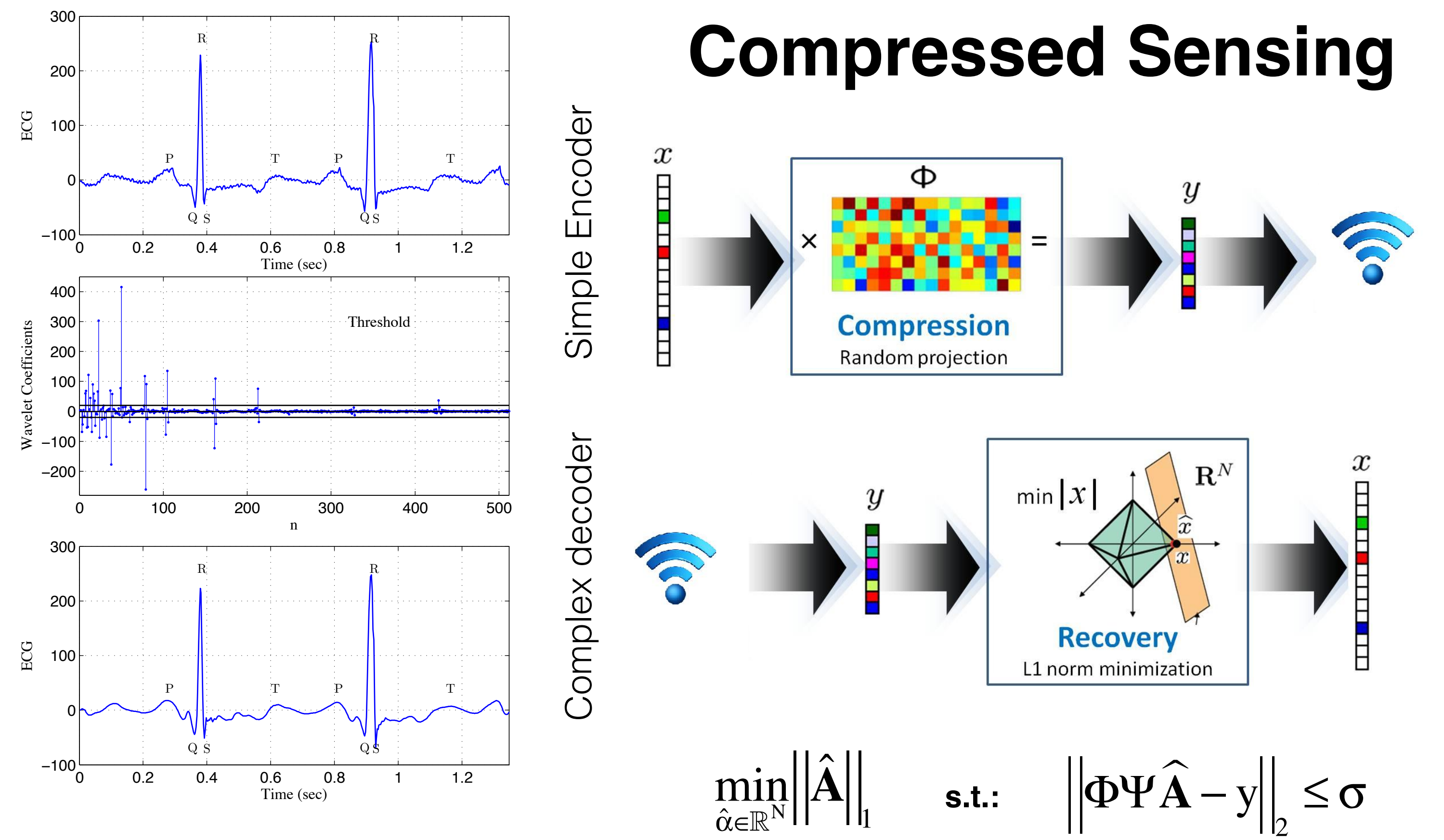
POWER-EFFICIENT ECG SENSING FRONT-END

Hossein Mamaghanian, David Atienza and Pierre Vanderghenst

Wireless Body Sensor Network (WBSN)

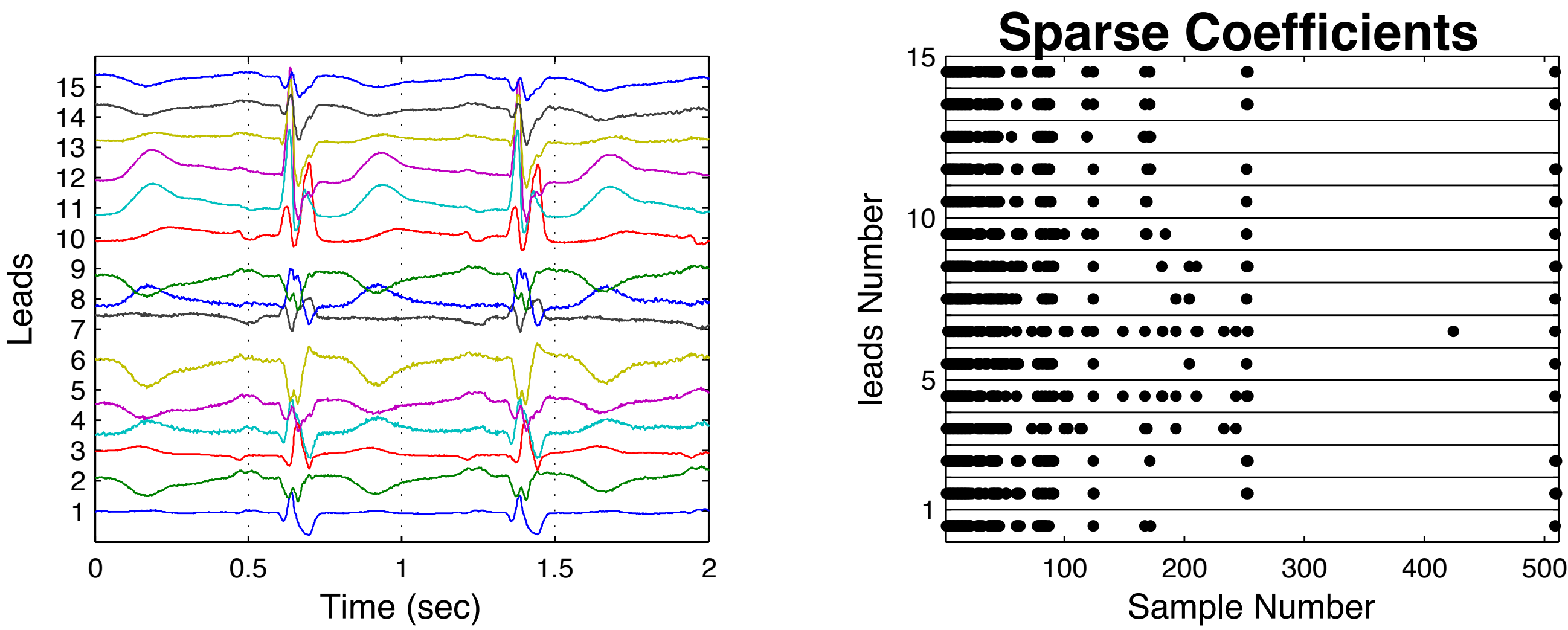


ECG is Highly Sparse



Joint Compressed Sensing (CS)

Strong Correlation among Multi-Leads ECG



Joint Compressed Sensing

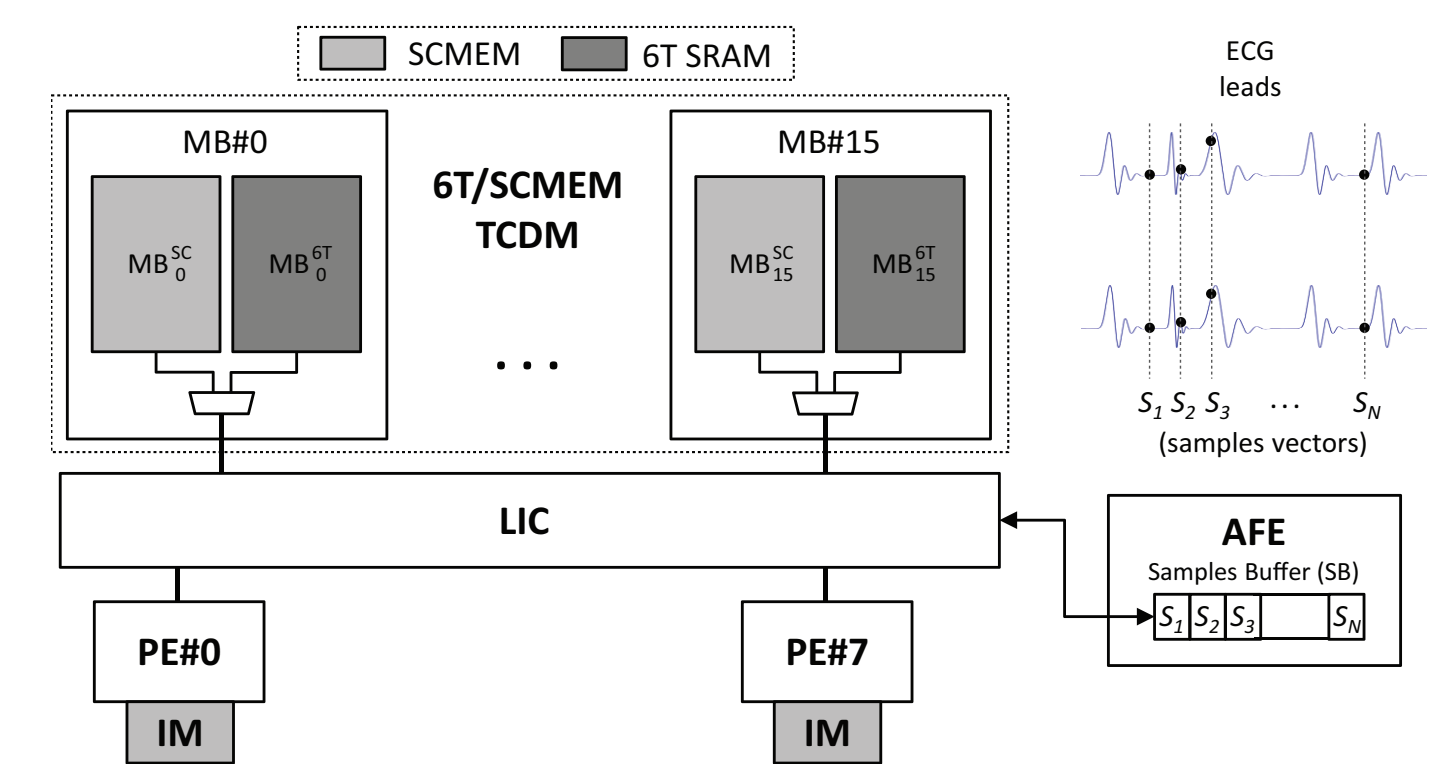
$$Y = \Phi X = \Phi \Psi A$$

Joint Recovery:

$$\min_{\hat{A} \in \mathbb{R}^N} \|\hat{A}\|_{1,2} \quad \text{s.t.} \quad \|\Phi \Psi \hat{A} - y\|_2 \leq \sigma$$

Robust Compressed Sensing

- Use of 6 Transistor SRAM (6T) cell memories are not reliable in supply voltage scaling.
- Hybrid memory architecture with 6T SRAM and SCMEM working on a aggressive voltage scaling. [1]

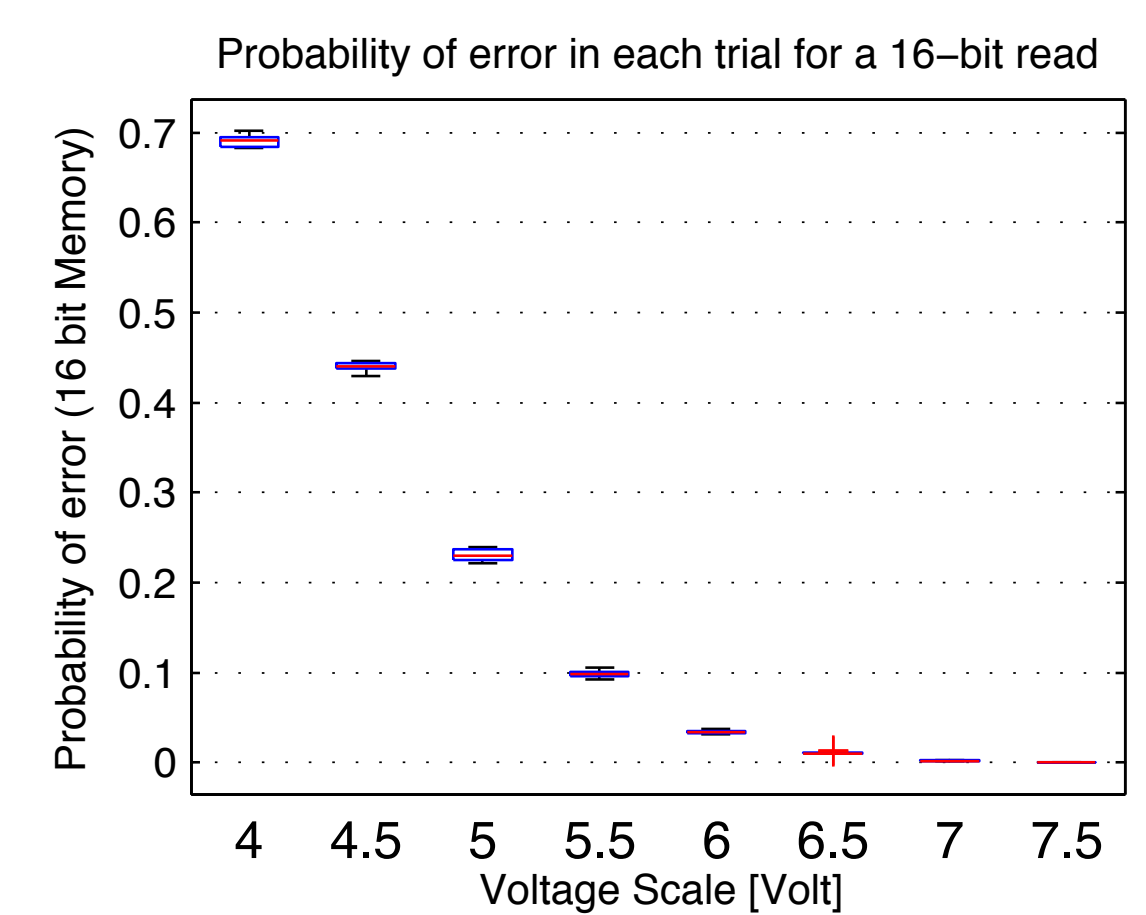


Errors in sensing matrix

- Joint comp with Error (E): $Y = (\Phi + E)X = (\Phi + E)\Psi A$
- Unbounded bit-flip errors due to voltage scaling.
- Normal CS fails with a high probability.

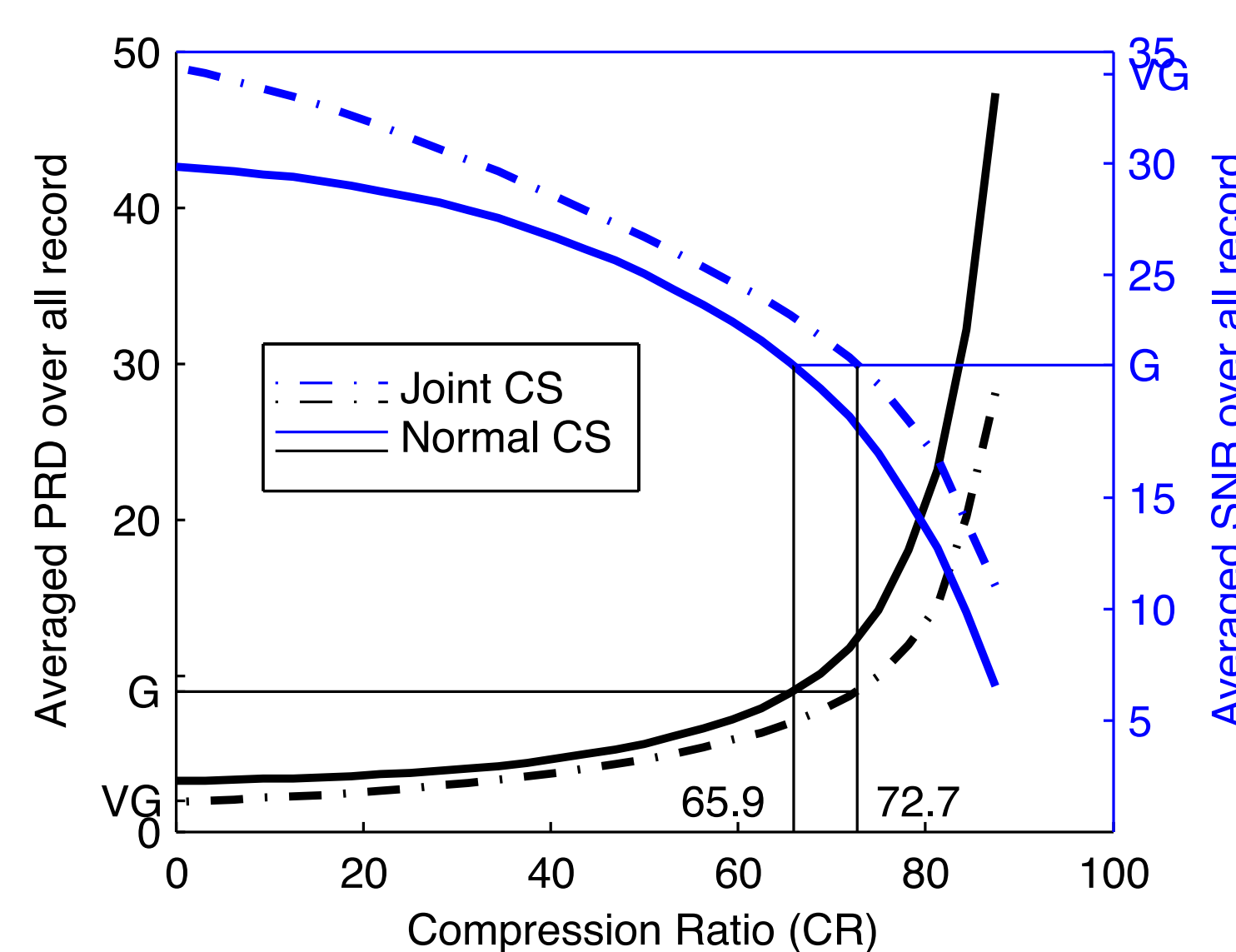
Robust Compressed Sensing

$$\min_{\hat{A}, \hat{E}} \|\hat{A}\|_{1,2} + \lambda \|\hat{E}\|_1 \quad \text{s.t.} \quad \|(\Phi + \hat{E})\Psi \hat{A} - Y\|_2 \leq \sigma$$

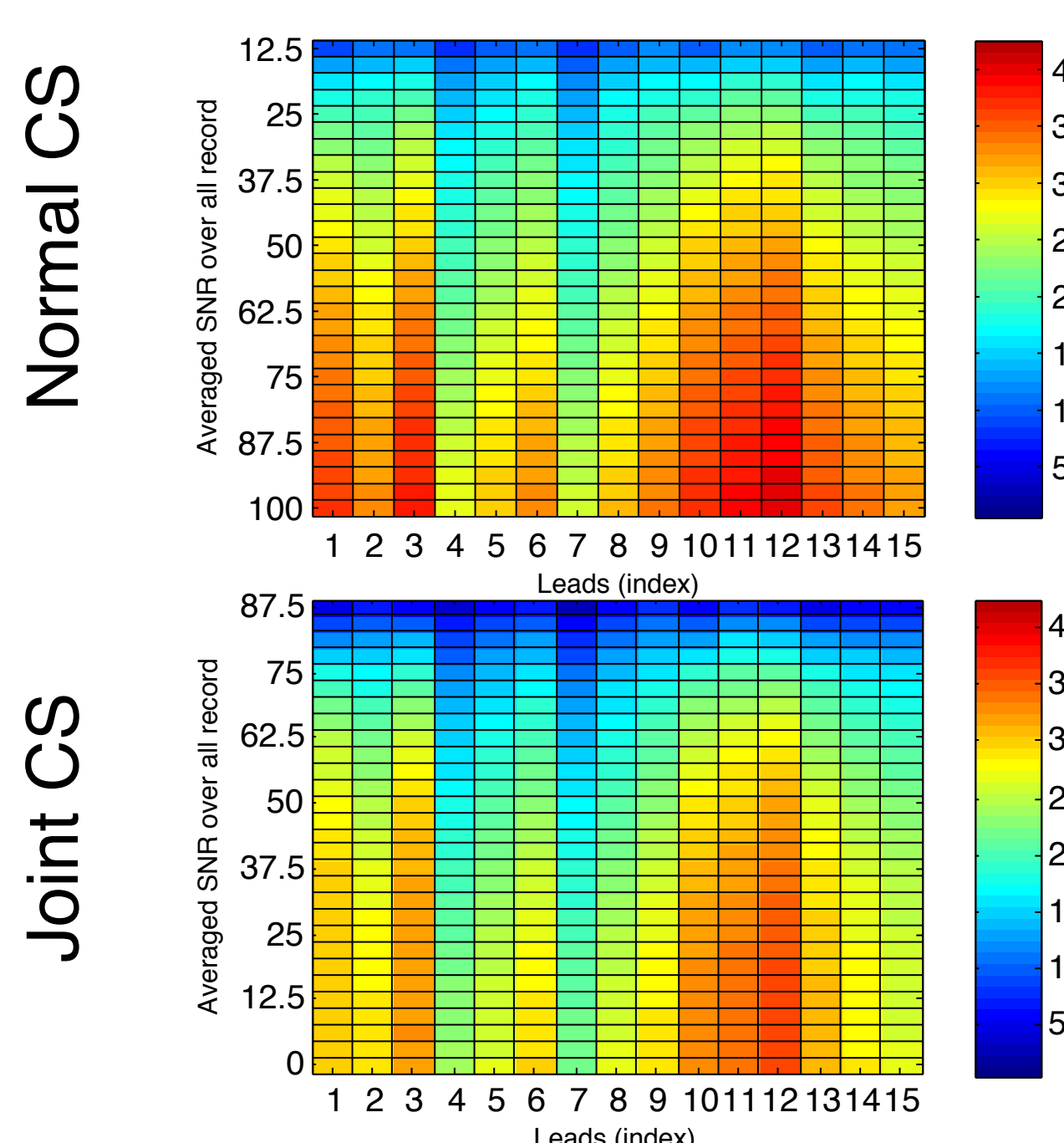


Results and Power Consumption

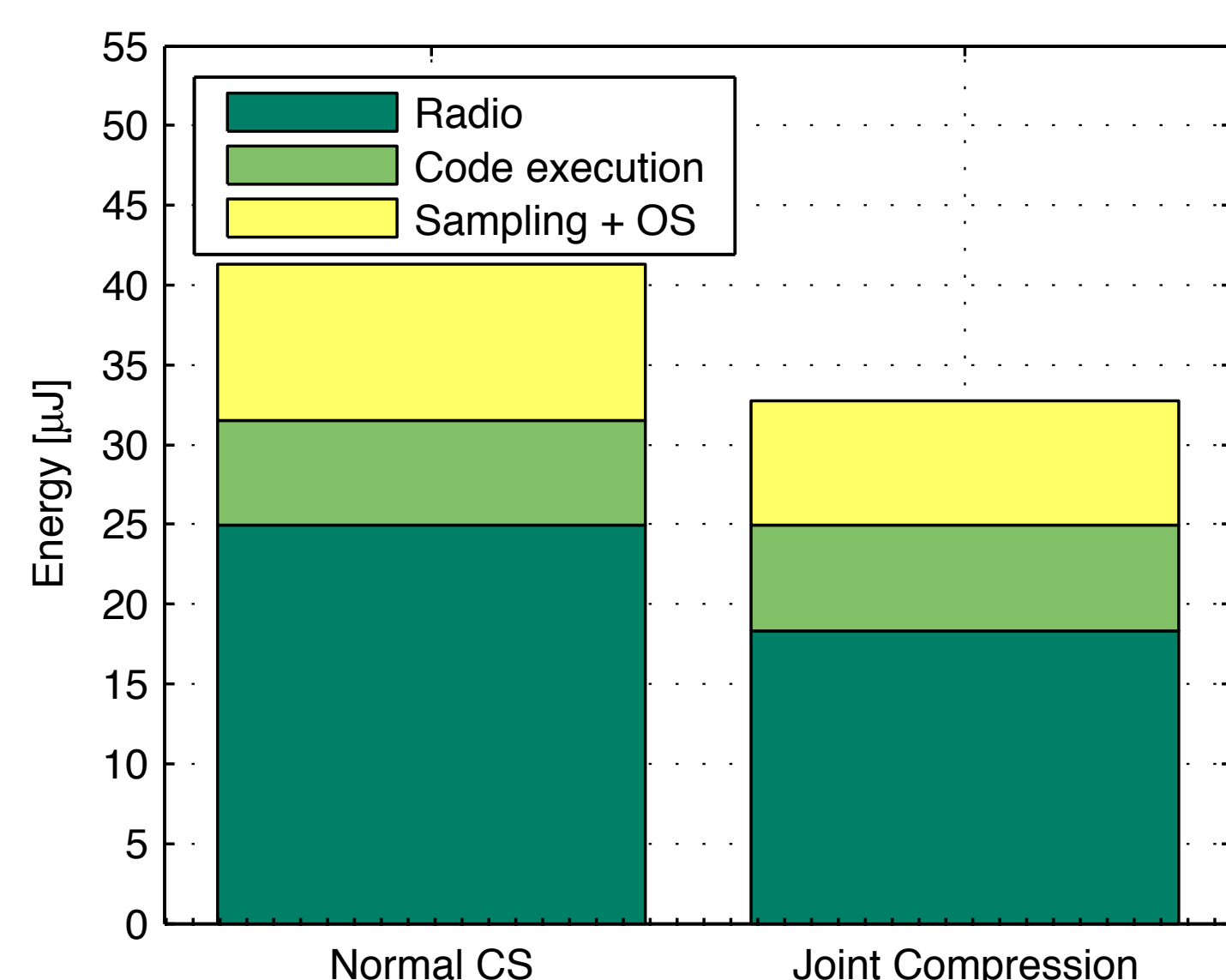
- Better Quality of reconstruction.
- Stable recovery using fewer measurements
- Faster reconstruction



Reconstruction quality for each lead

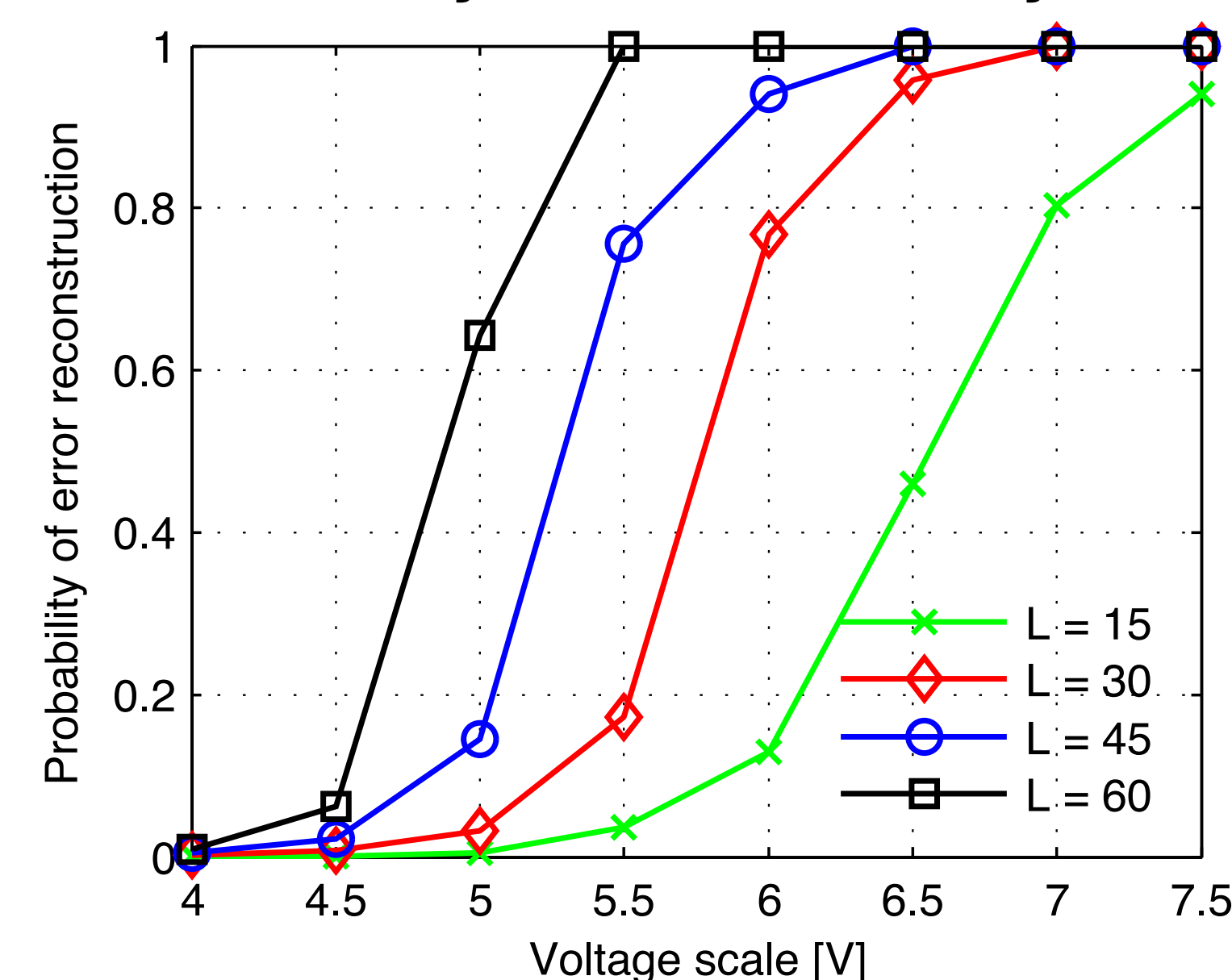


26% node lifetime extension

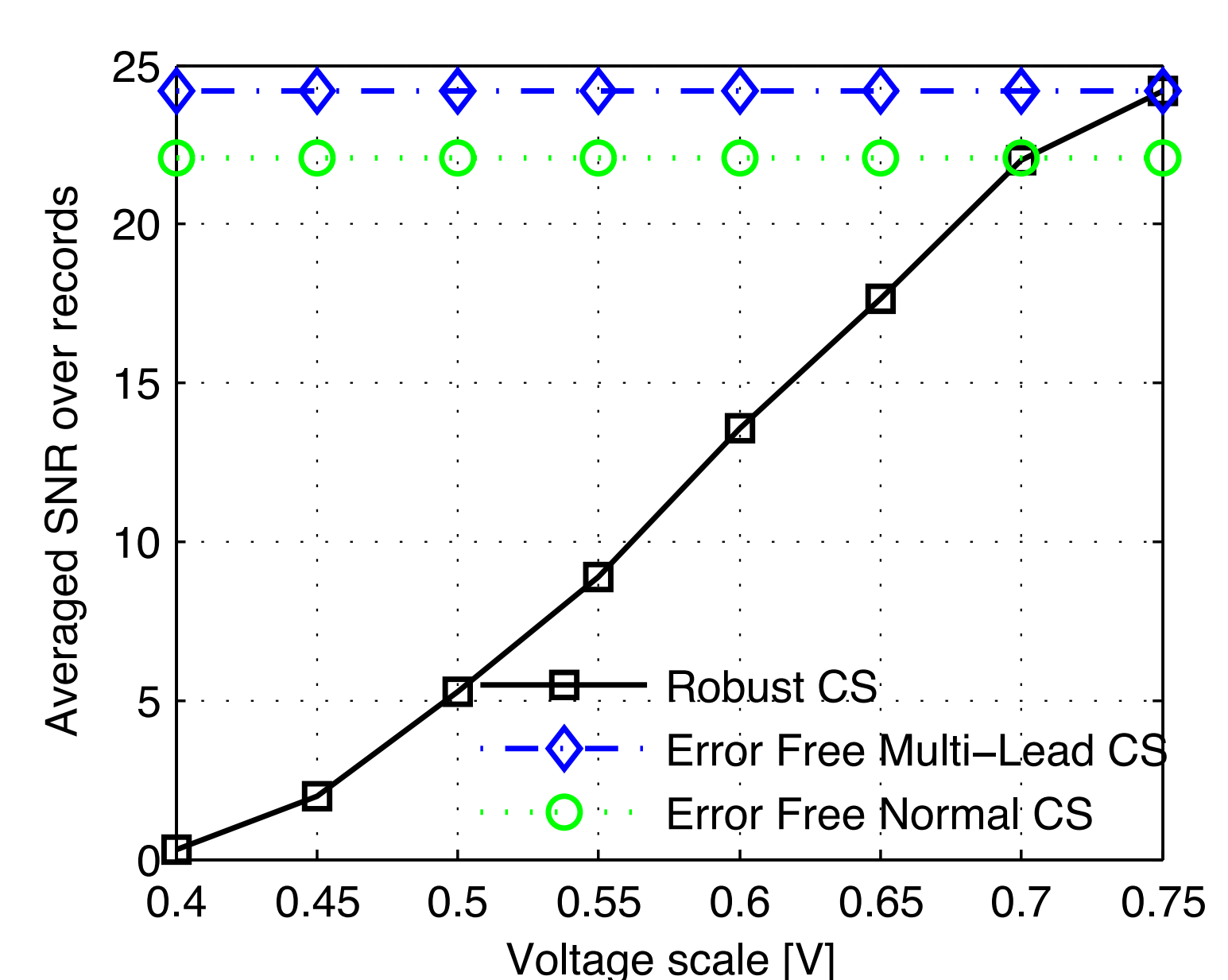


Error Recovery and Performance Results

Probability of error recovery



Reconstruction Quality



Design reach to 60% reduction in Power consumption

- Group sparsity is successful in exploiting the structural correlation in sparsity support among the multi-leads.
- Adding model for sparsity structure leads to fast and robust reconstruction.

- H. Mamaghanian, et al., "Power-Efficient Joint Compressed Sensing of Multi-Lead ECG Signals", Proc. of IEEE ICASSP, May 2014.
- D. Bortolotti, H. Mamaghanian, et al., "Approximate Compressed Sensing: Ultra-Low Power Biosignal Processing via Aggressive Voltage Scaling on a Hybrid Memory Multi-core Processor", Proc. IEEE ISLPED, August 2014.