Data Quality in EIT

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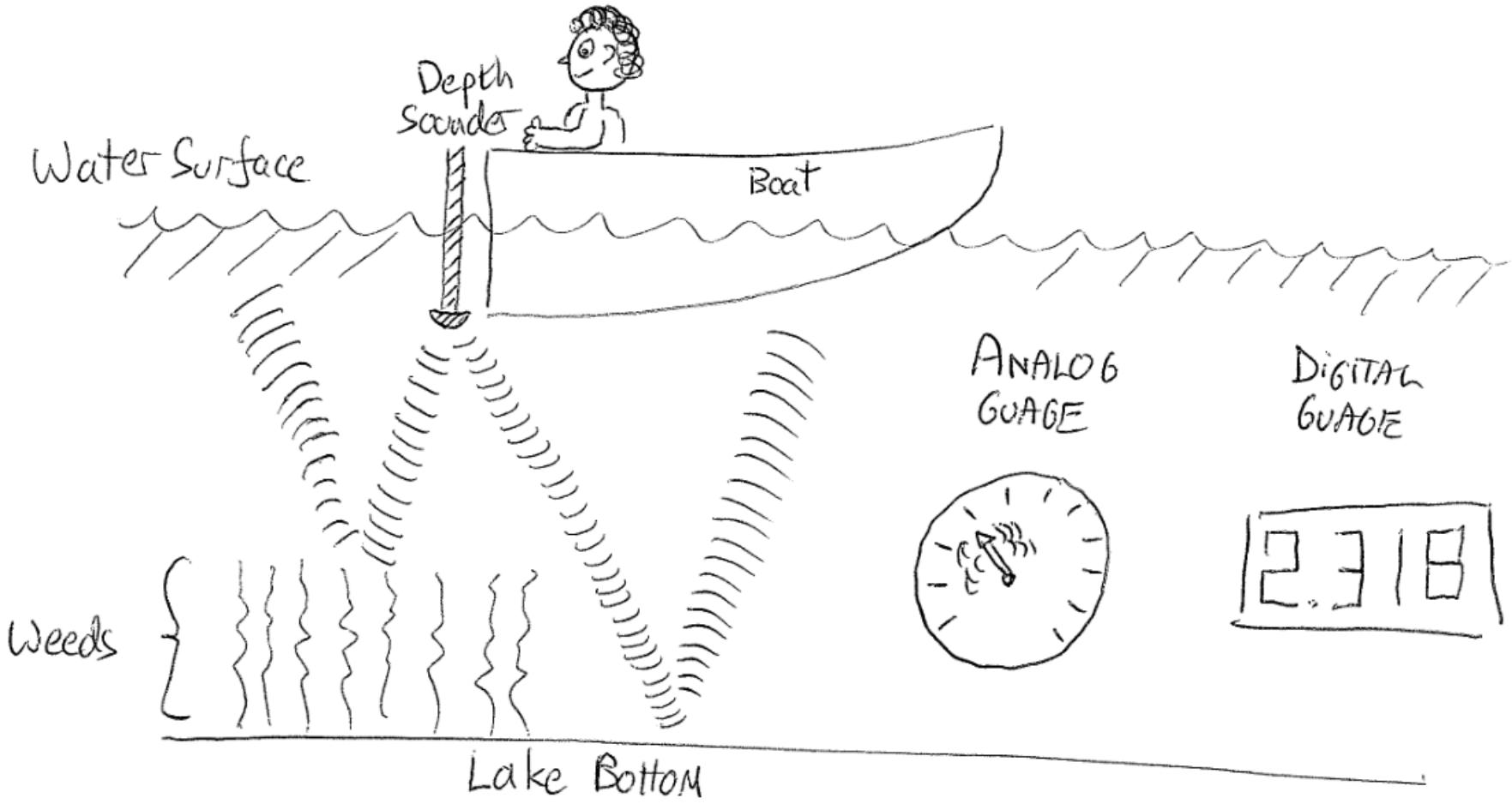
Data Quality



Motivation

- For clinical monitoring, need to assess the quality of the delivered information
- For Example:
  - signal quality indicator on mobile phones or medical devices such as pulseoximeters
- Our task: provide a single quantitative data quality indicator in real-time

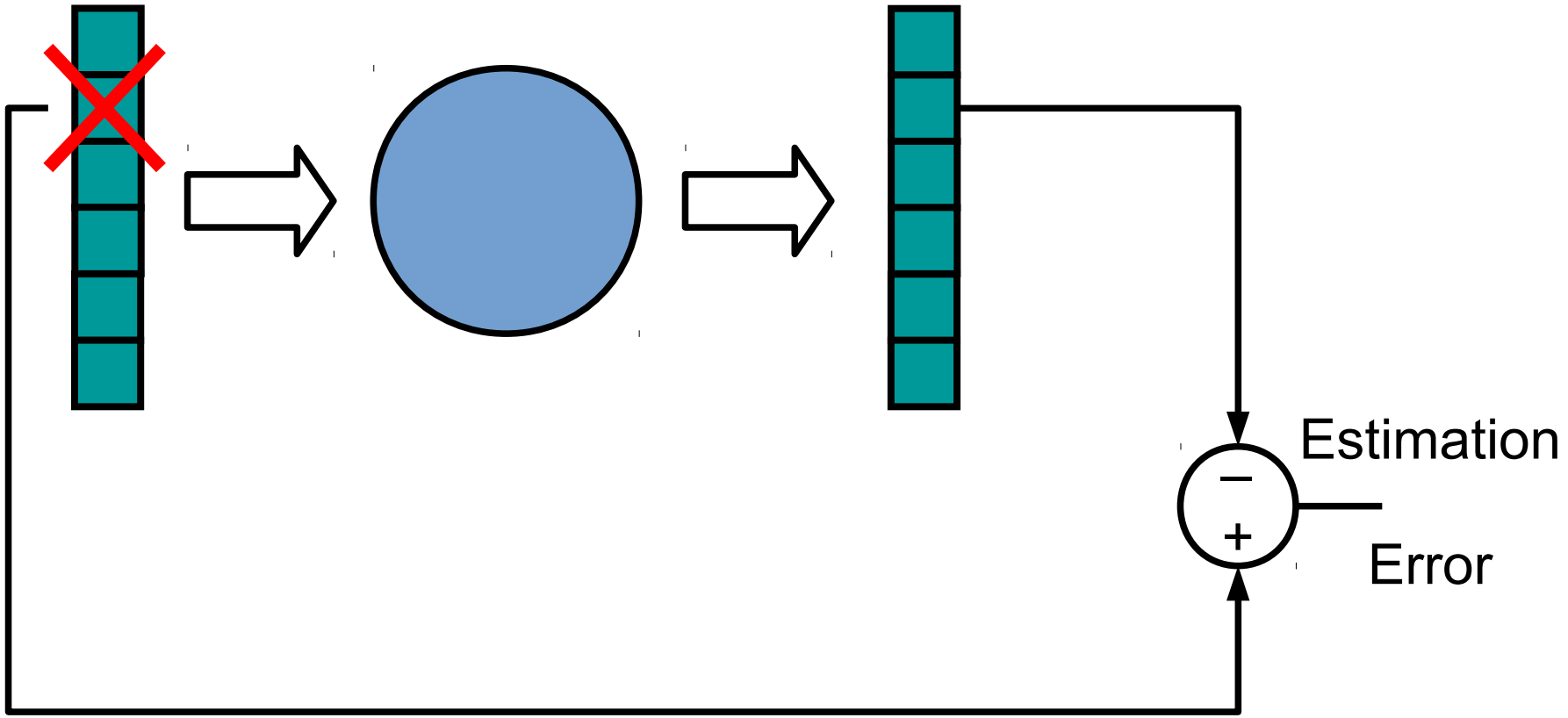
- Use data quality measure to
  - evaluate output quality
  - independent of reconstruction algorithm

Requirements for Data Quality Metric q

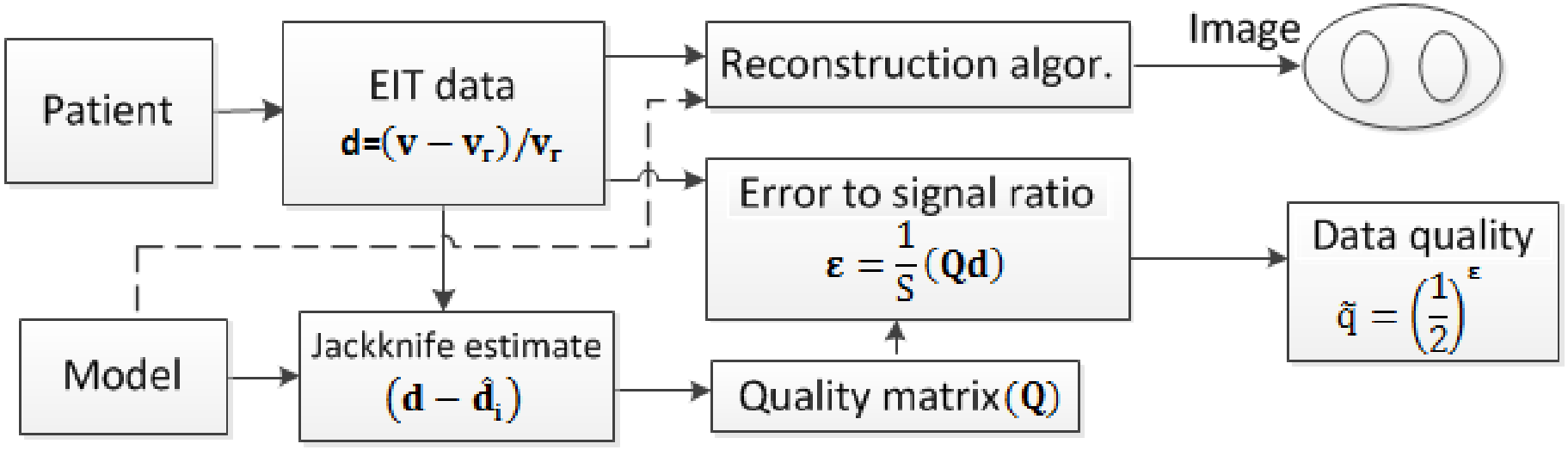
q should have the following requirements

- Bounded: $0 \leq q \leq 1$: 0=bad, 1=good
- adding "good" data should **increase** q.
- adding "bad" data should **decrease** q.
- q should be low if data are wrong
  - (e.g. electrodes were placed incorrectly).

Data Quality Formulation



Data Quality Formulation



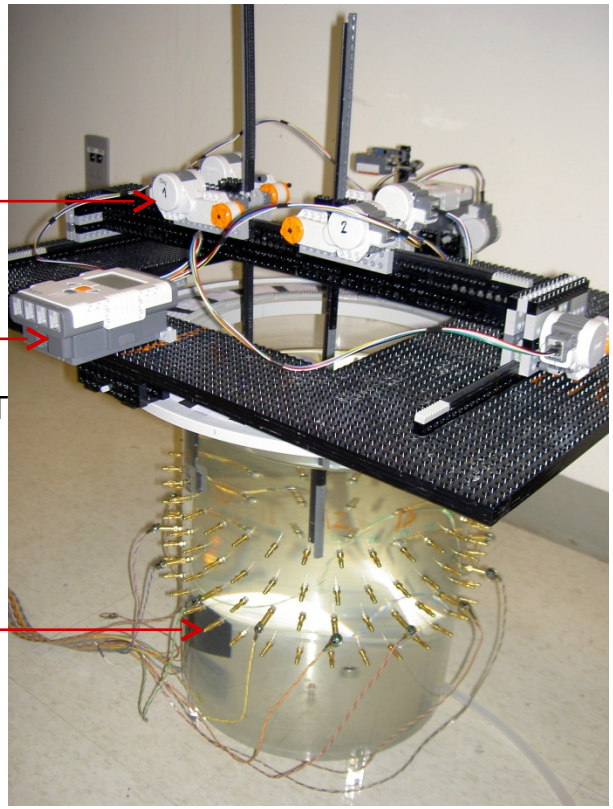
$$\mathbf{R}_i = \boldsymbol{\Sigma}_m \mathbf{J}^T \left(\mathbf{J}\boldsymbol{\Sigma}_m \mathbf{J}^T + \lambda^2 \boldsymbol{\Sigma}_n\right)^{-1}$$

$$\mathbf{R}_i = \boldsymbol{\Sigma}_m \mathbf{J}^T \left(\mathbf{J}\boldsymbol{\Sigma}_m \mathbf{J}^T + \lambda^2 \left(\mathbf{I} + \mu \boldsymbol{\Theta}_i\right)\right)^{-1}$$

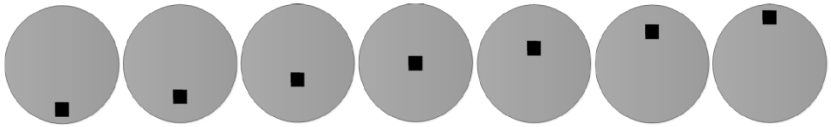
Assume data noise on channel i is much larger $\mu \geq 0$

$$\begin{aligned} \varepsilon_i &= \frac{1}{S}\left(\boldsymbol{\theta}_i^T \left(\mathbf{d} - \hat{\mathbf{d}}\right)\right) = \frac{1}{S}\left(\boldsymbol{\theta}_i^T \left(\mathbf{d} - \mathbf{J}\mathbf{R}_i\mathbf{d}\right)\right) \\ &= \frac{1}{S}\left(\boldsymbol{\theta}_i^T \left(\mathbf{I} - \mathbf{J}\mathbf{R}_i\right)\mathbf{d}\right). \end{aligned}$$

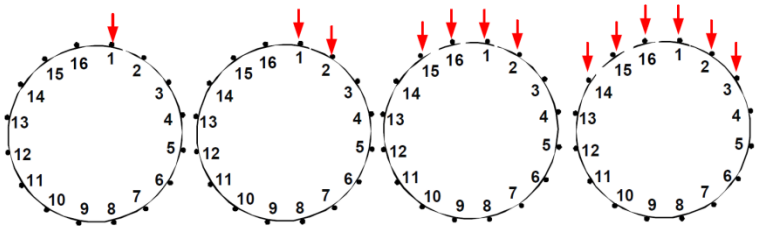
Experimental Set-up: Phantom Data



Object/locations: a non-conductive cube



Failing electrode protocol:



Connectivity (resistors):

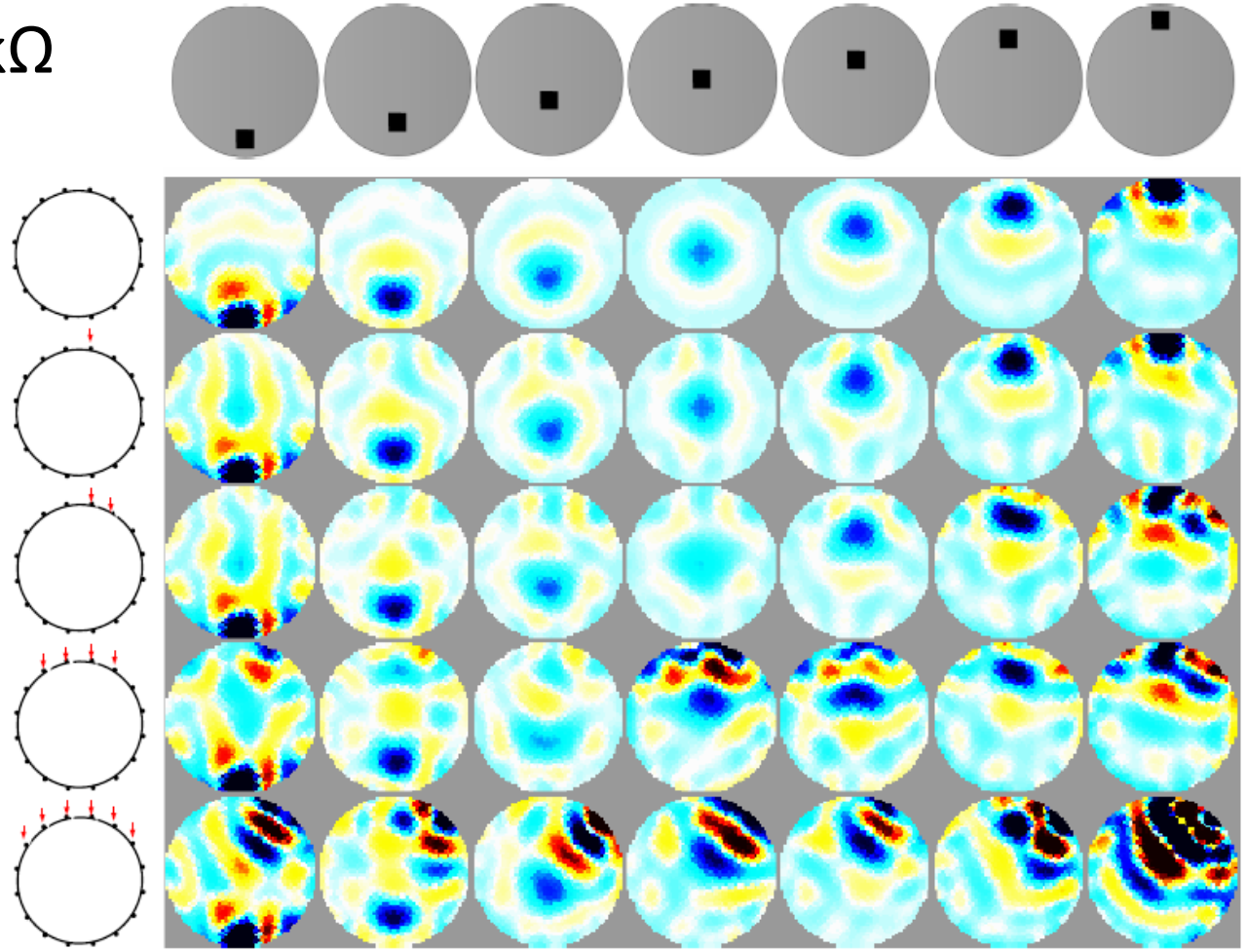
- 1 kΩ
- 4.7 kΩ
- 100 kΩ
- Open

Measurement system:

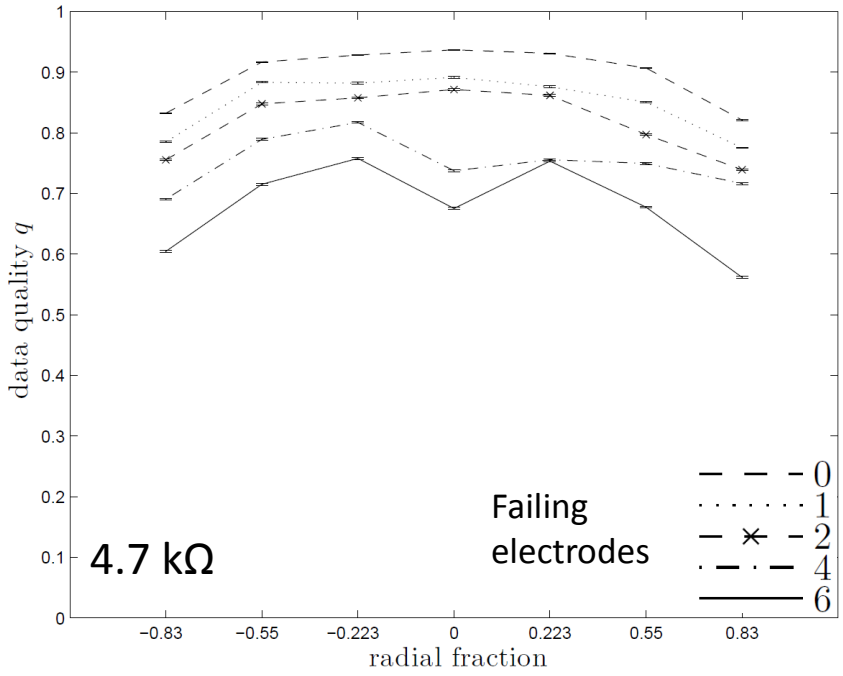
- Phantom tank and a test object
- Robotic system
- Sigma Tome II EIT System
  (Ecole Polytechnique Montreal, Canada)

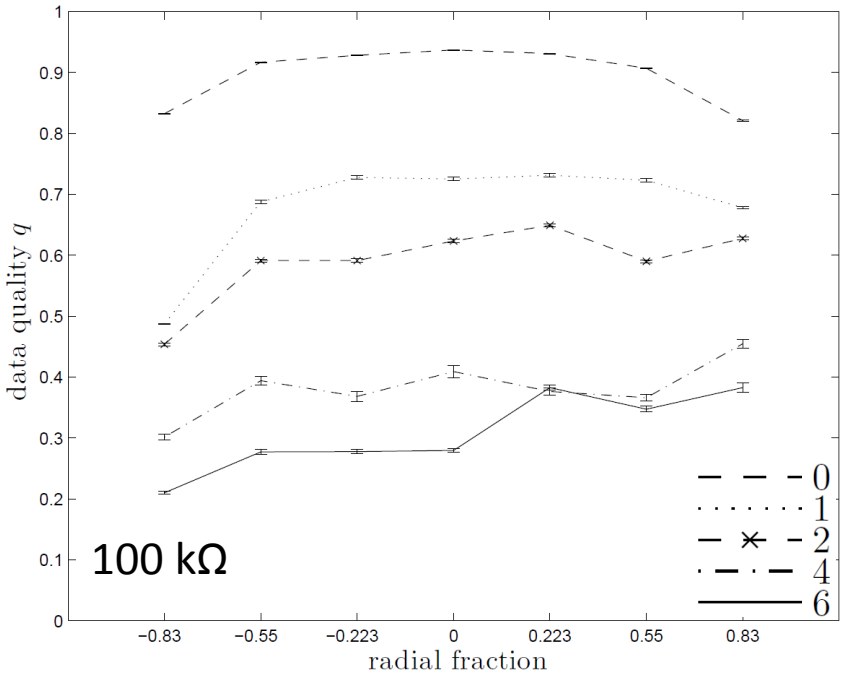
Results 1: q for Phantom Measurement

4.7 kΩ

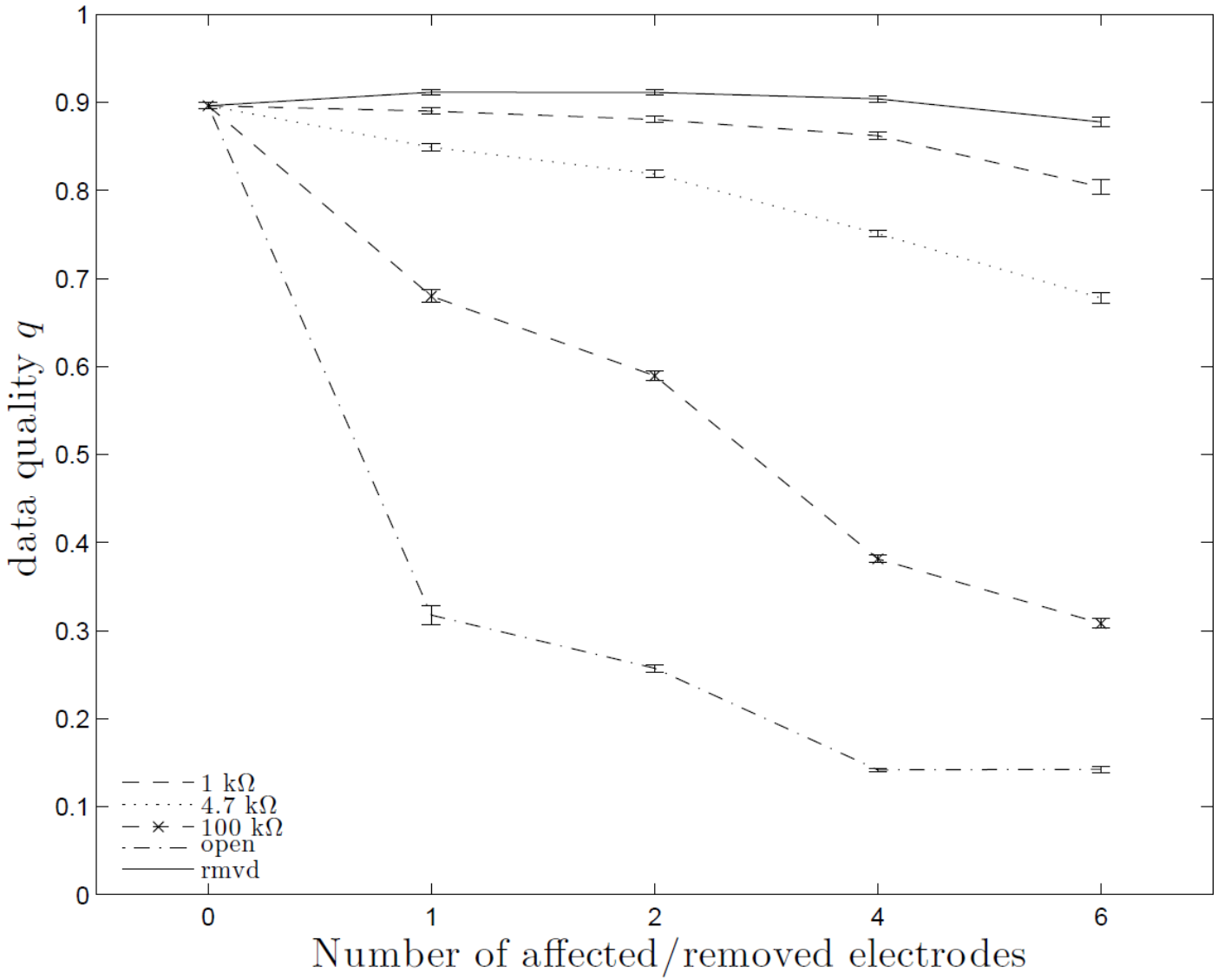


Results 1: q for Phantom Measurement





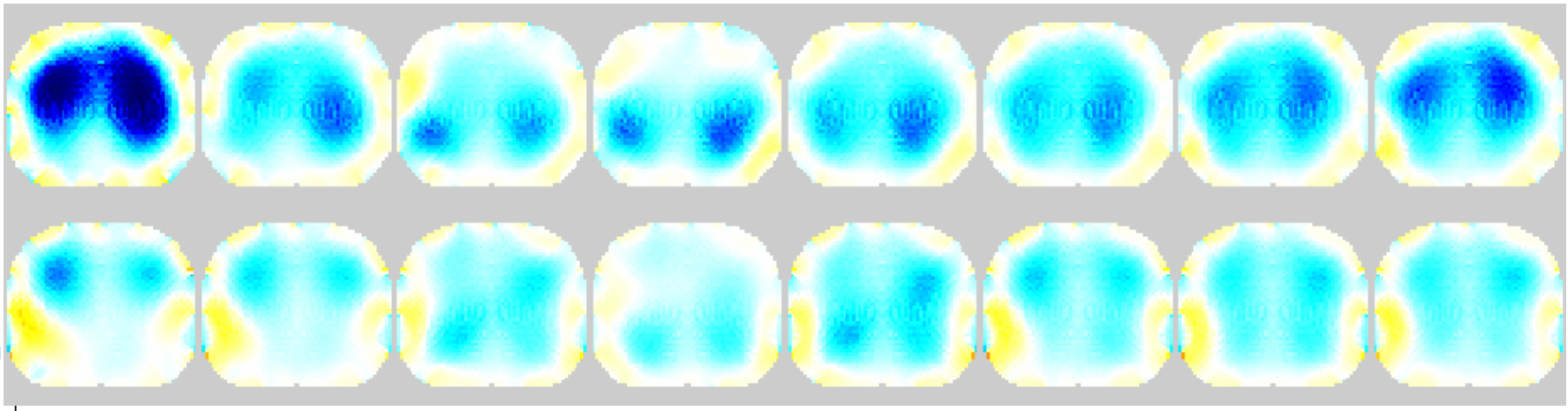
Results 1: q for Phantom Measurement

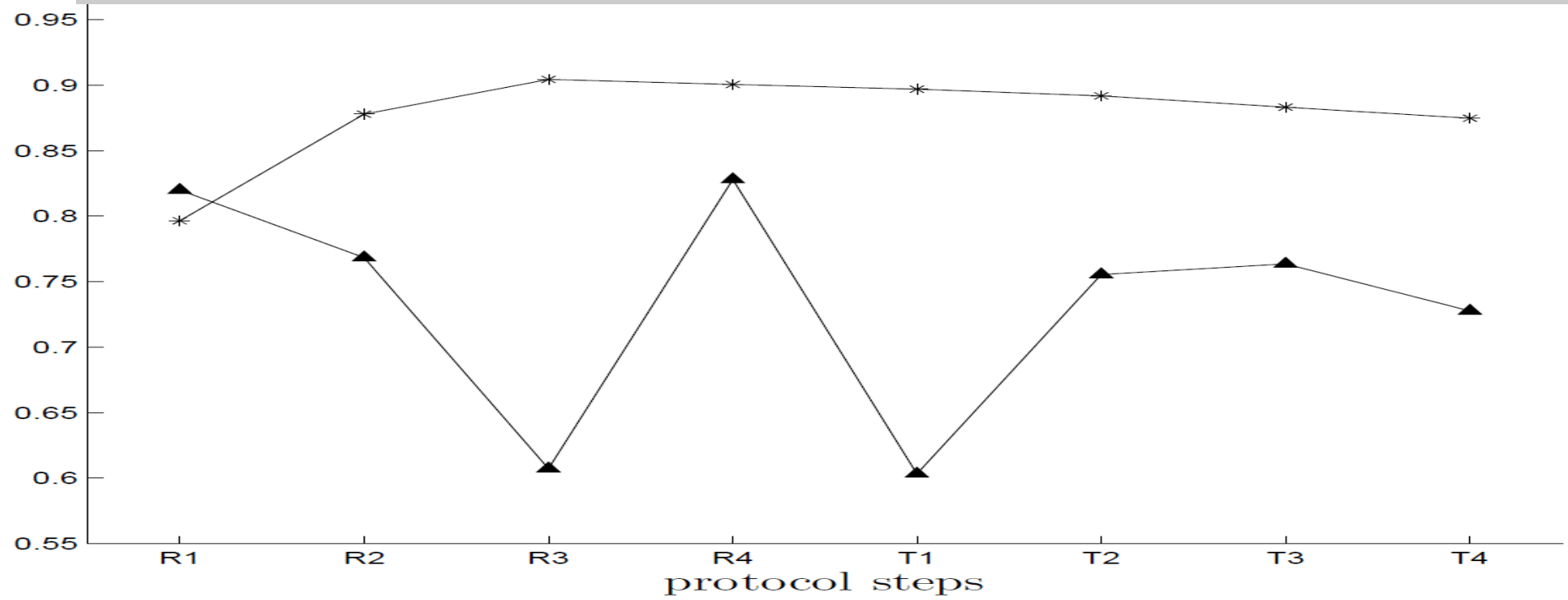


Experimental Protocol– Human Ventilation

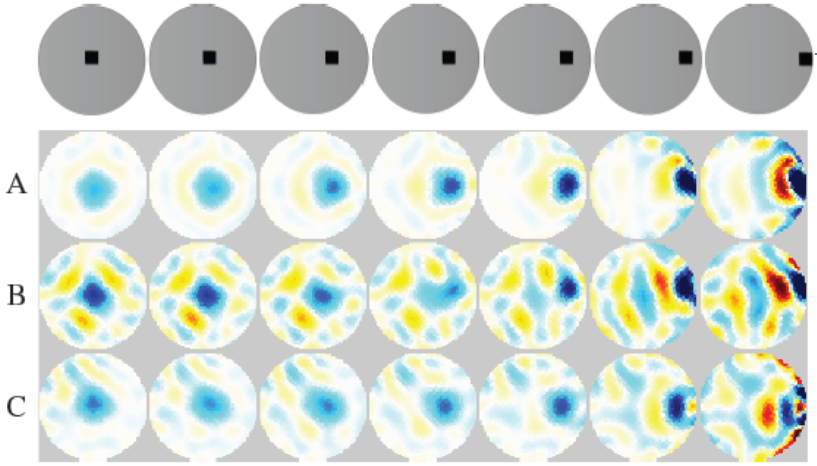
- PEEP – Positive end-expiratory pressure
- Experimental Protocol consisted of:
  - Baseline ventilation stage
  - Lung recruitment stage (increased airway pressure): R1 – R4
  - PEEP titration stage (decreased airway pressure): T1– T4
- Selected patient 1 and patient 7
- Goe-MT II EIT device (CareFusion, Hoechberg, Germany)

Results 2: q for Human Lung Ventilation

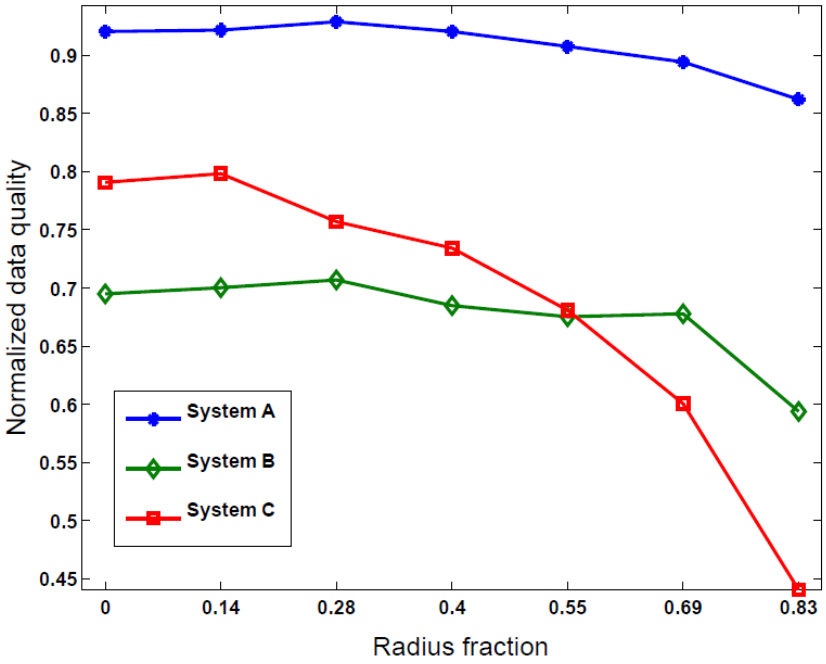




Results 3: q for EIT System Comparison

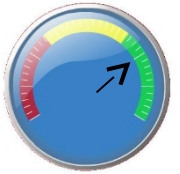


Touching the electrode



- **SNR** is common method to evaluate system performance
- 3 different EIT systems: A, B, C
- Average SNR: 44.2, 44.5 and 45.9 dB under similar scenario
- q offered useful quantitative information
- The threshold for q below which measurements is no longer usable is system dependent, but it can be easily estimated through experiments

Discussion



Goal: help avoid false interpretation

- Data quality formulation
- This is just a start. We need
  - Experimental/clinical experience
  - What other factors are relevant to quality?