Distinguishability in EIT

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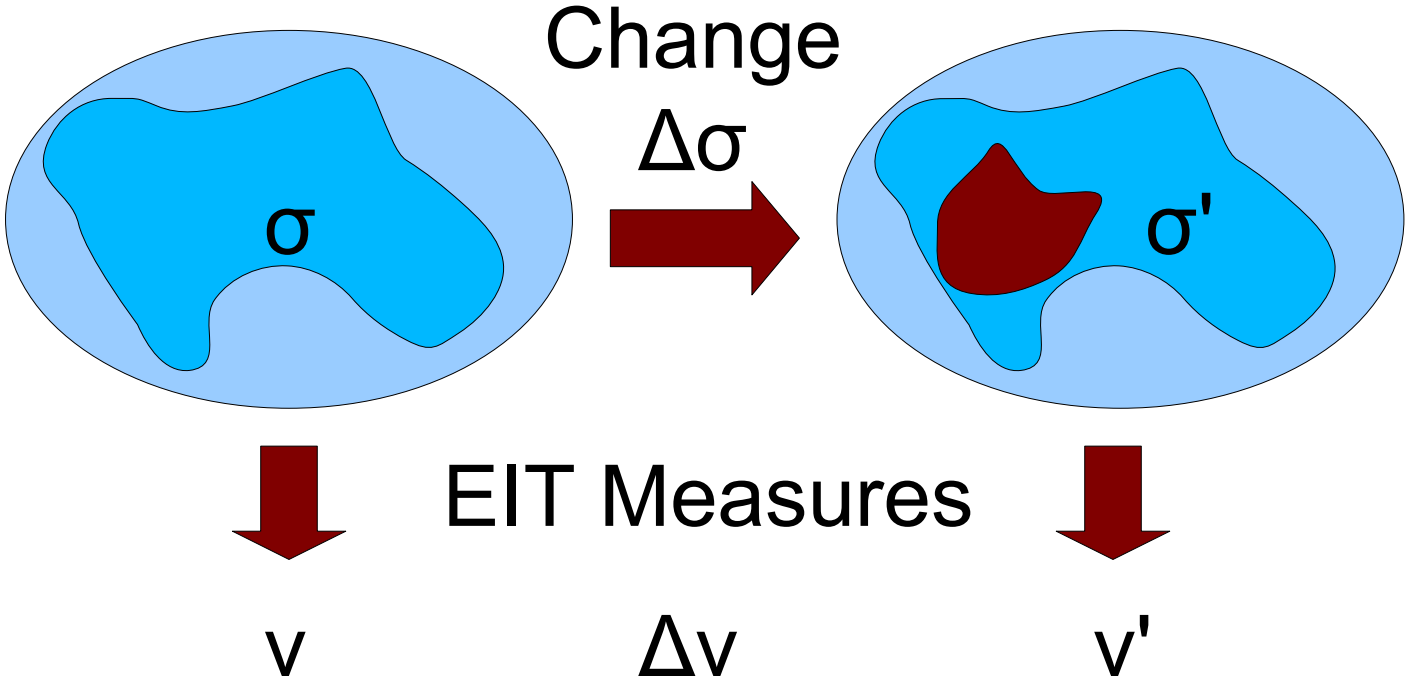
Distinguishability problem #1

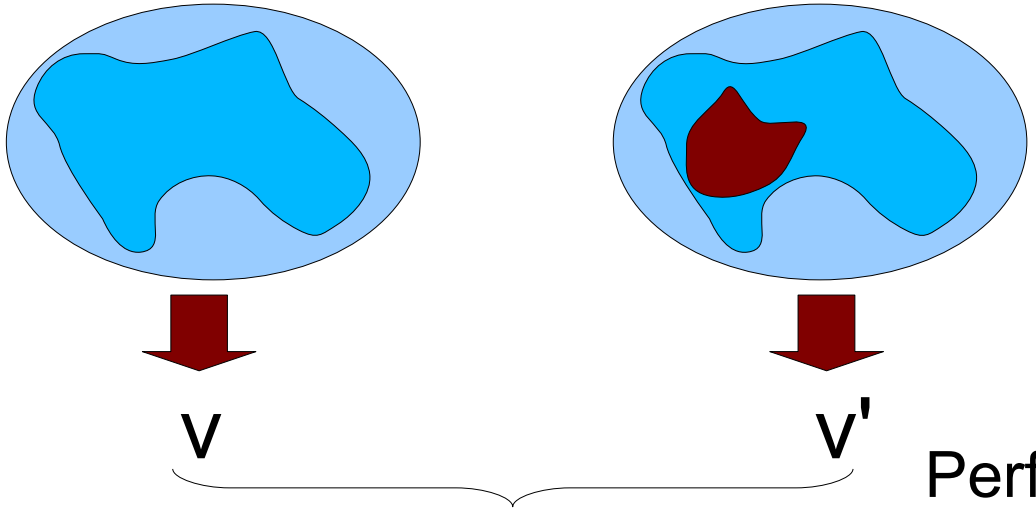


Distinguishability Question:

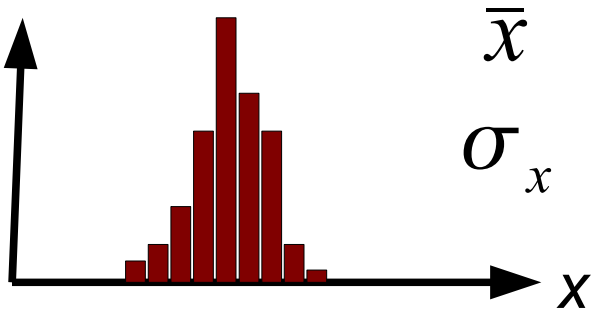
Based on Δv, can we tell if Δσ occured?

What is the significance of the test?

Detection Strategy

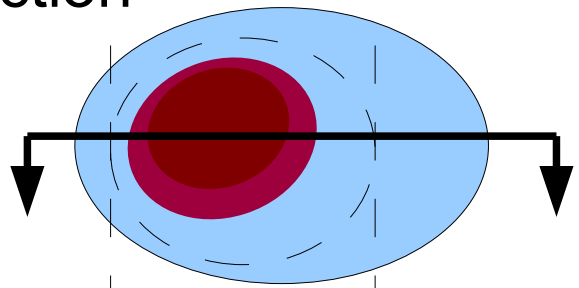


Perform multiple measures



Δv

Use linear Reconstruction



Including noise

Sum image in ROI => *x*

How to interpret

- Signal to noise ratio
  - This is an image SNR
  - We can calculate a Noise Figure (NF) as

$$SNR_{image} = \frac{\bar{x}}{\sigma_x}$$

$$NF = \frac{SNR_{image}}{SNR_{data}}$$

- Hypothesis test *z*-score
  - Determine *p*(*distinguishability)*

$$z = \frac{\bar{x}}{\sigma_x}$$

- *SNR / z* depends on
  - Size of signal (Δσ / stimulation current)
  - Data noise (for each channel)
  - Reconstruction algorithm

Want to avoid this dependence

Distinguishability from EIT data

- Equivalent to classic distinguishability formulations (Isaacson 86, Lionheart 01)
- Given a large ROI

$$z = \frac{\bar{x}}{\sigma_x} = \frac{\bar{x}}{\sqrt{R_{ROI}^t \Sigma_n R_{ROI}}} = \bar{x}\sqrt{J_{ROI}^t \Sigma_n^{-1} J_{ROI}}$$

Doesn't depend on reconstruction

R=reconstruction matrix,

J=jacobian,

Σ_n=channel noise

Distinguish current patterns

- Using the change in transfer impedance matrix (T_{Δ})

$$\Delta V = M T_{\Delta} C$$

Measurements (differential)

Current Patterns

$$z = \bar{x} \sqrt{\|\cdot\|^2 + \|\cdot\|^2 + \cdots}$$

Noise norm for each current pattern

$= C^t T_{\Delta} M^t \Sigma^{-1} M T_{\Delta} C$

Choose current patterns

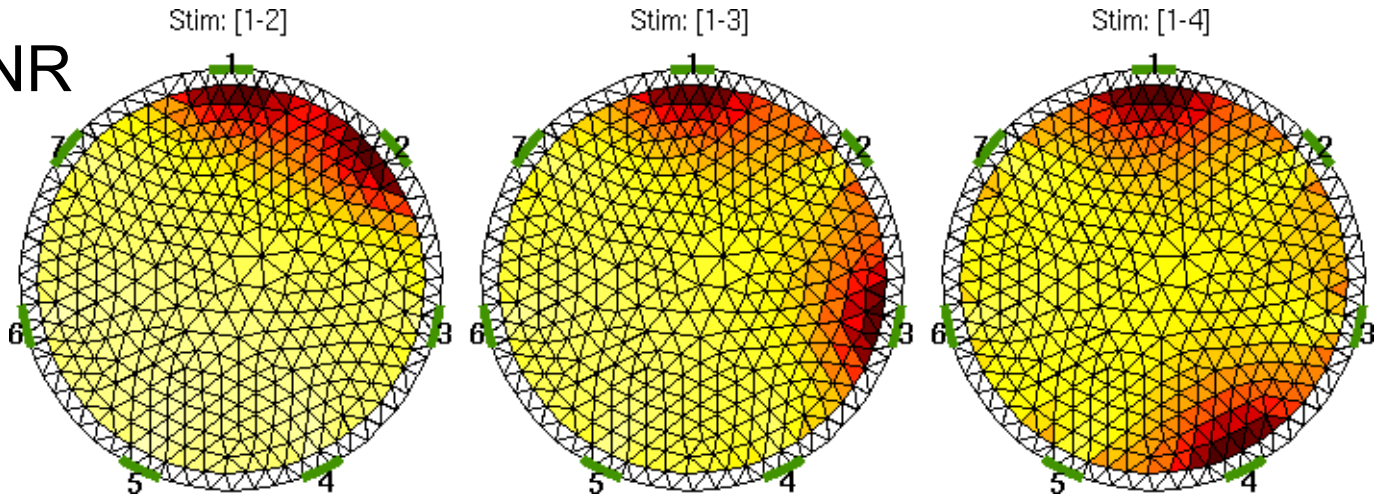
Why not just use the best pattern?

- Electrical safety constraint
  - Total current => bipolar drive
  - Current/electrode => Walsh patterns
- Need good distinguishability throughout the region of interest
  - For each pattern, for each region
    - Calculate *z*
  - Choose set of patterns which are globally optimal

Distinguishability for one pattern

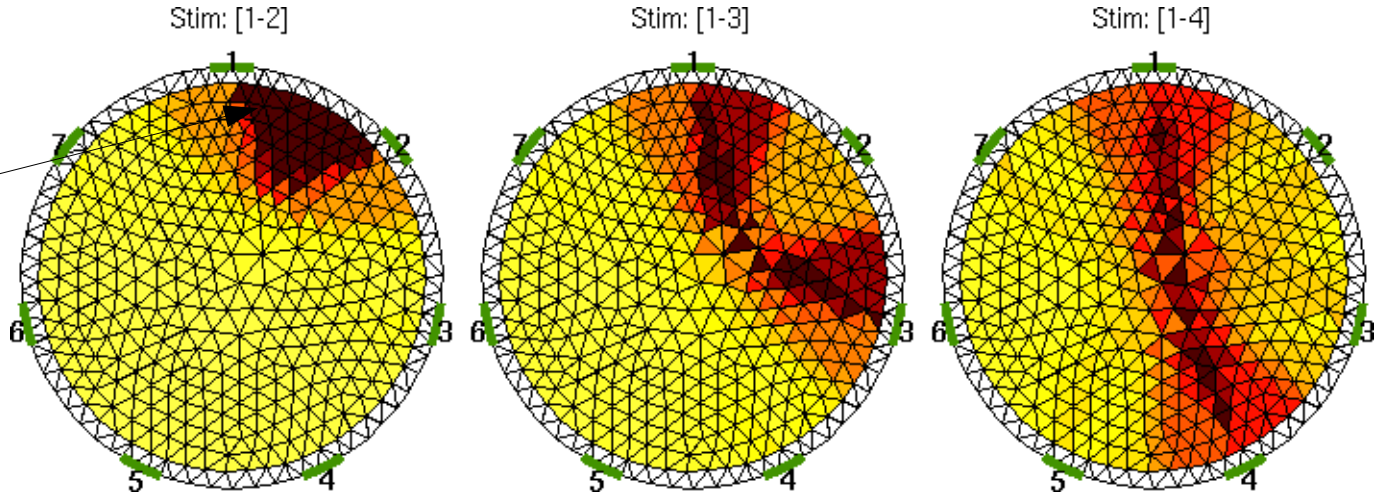
Bipolar stimulation patterns

SNR



SNR order

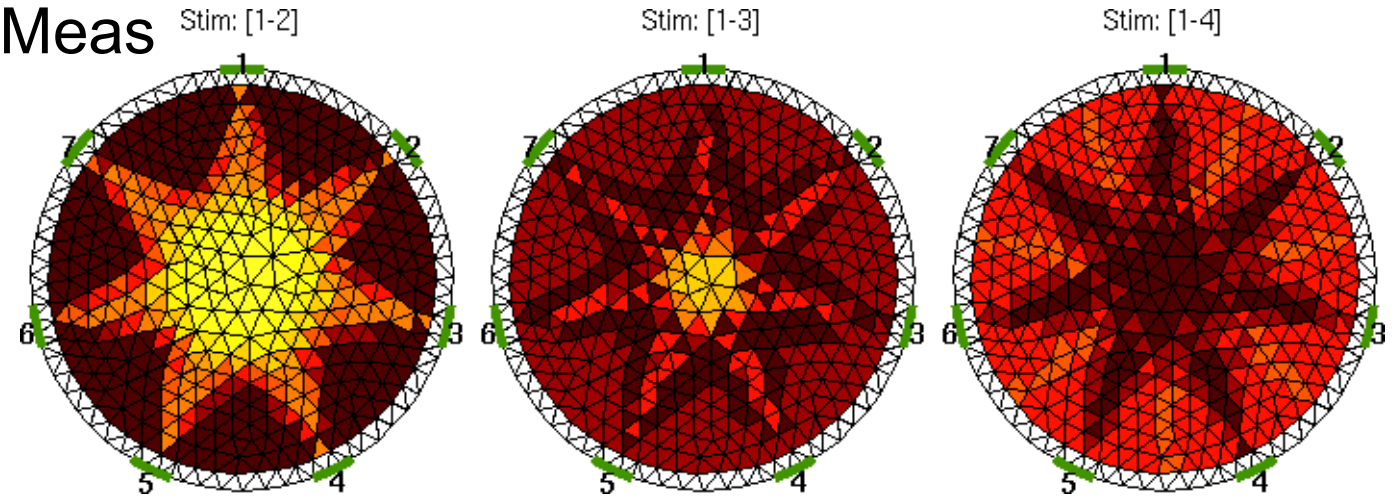
Element has highest SNR for this pattern than any other



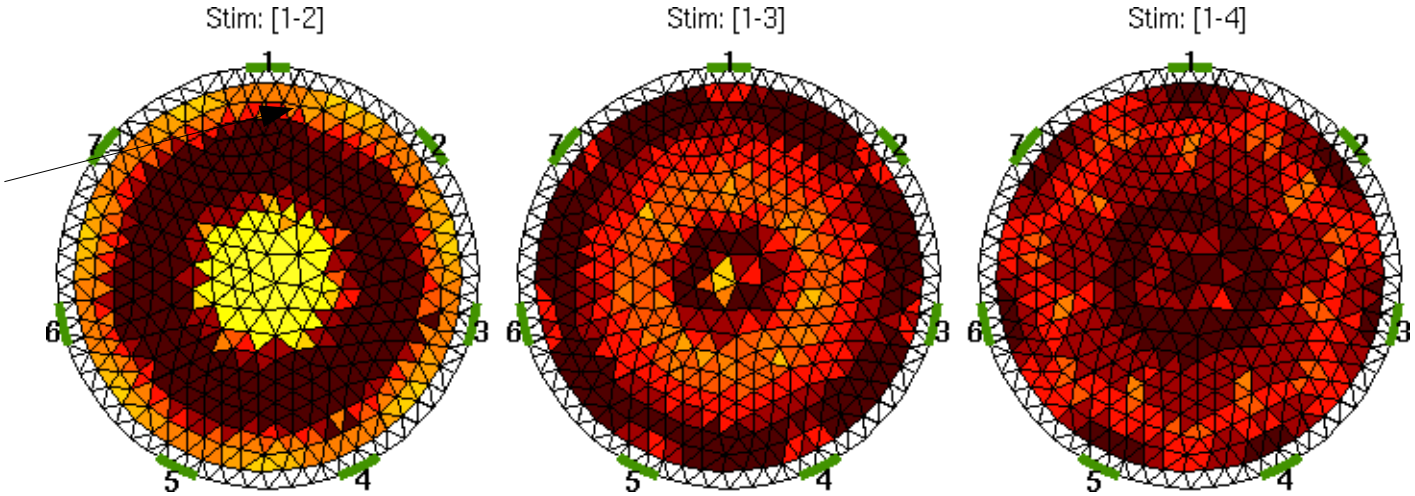
Distinguishability for pattern set

SNR order for complete Sequence of bipolar stimulation patterns

All Meas



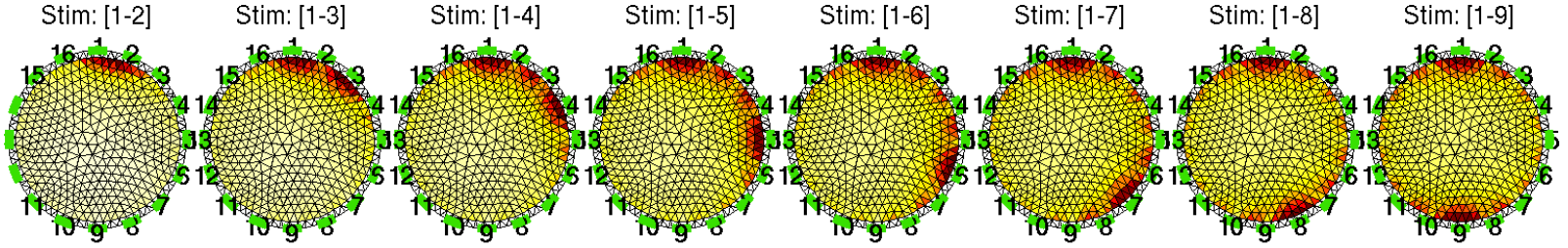
No Meas on driven electrodes



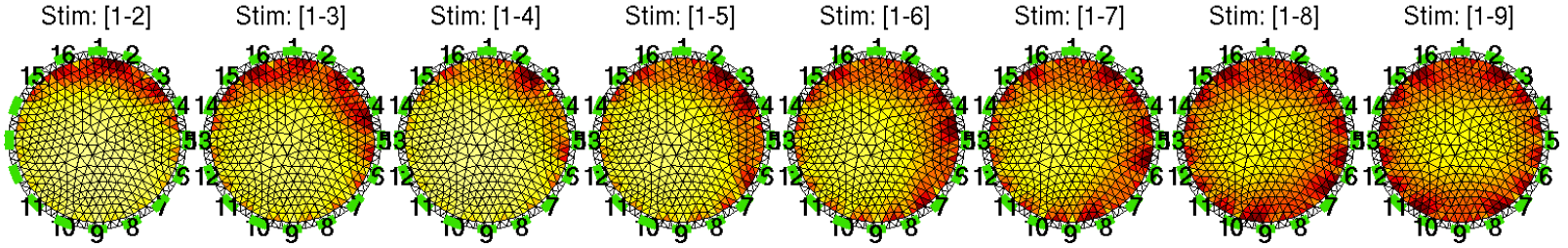
For 16 electrodes

SNR:

All Meas

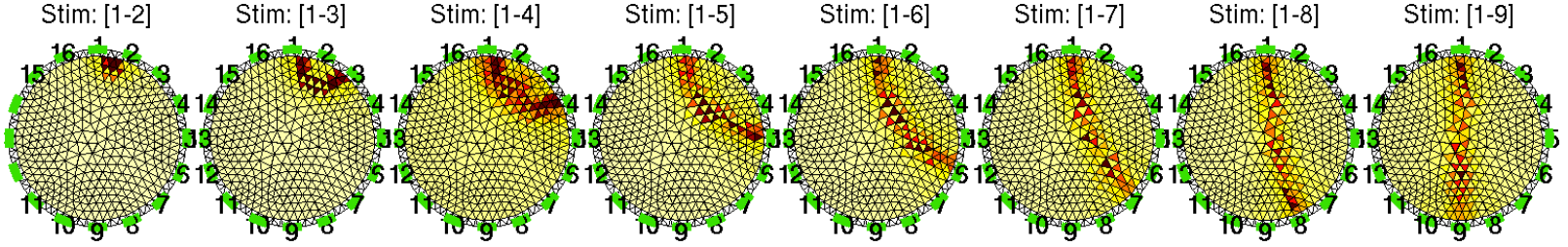


No stim meas

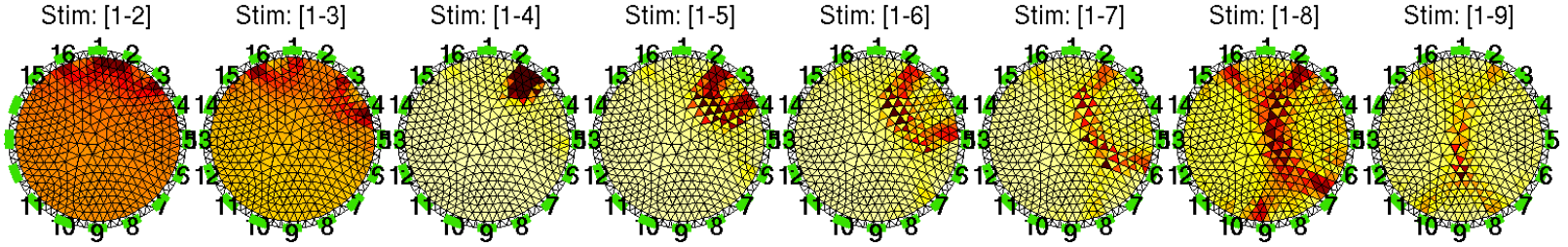


SNR order:

All Meas

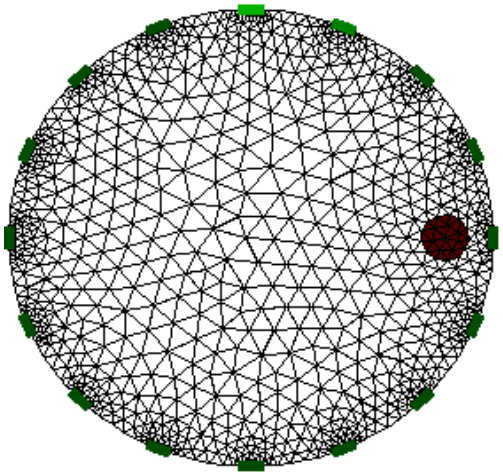


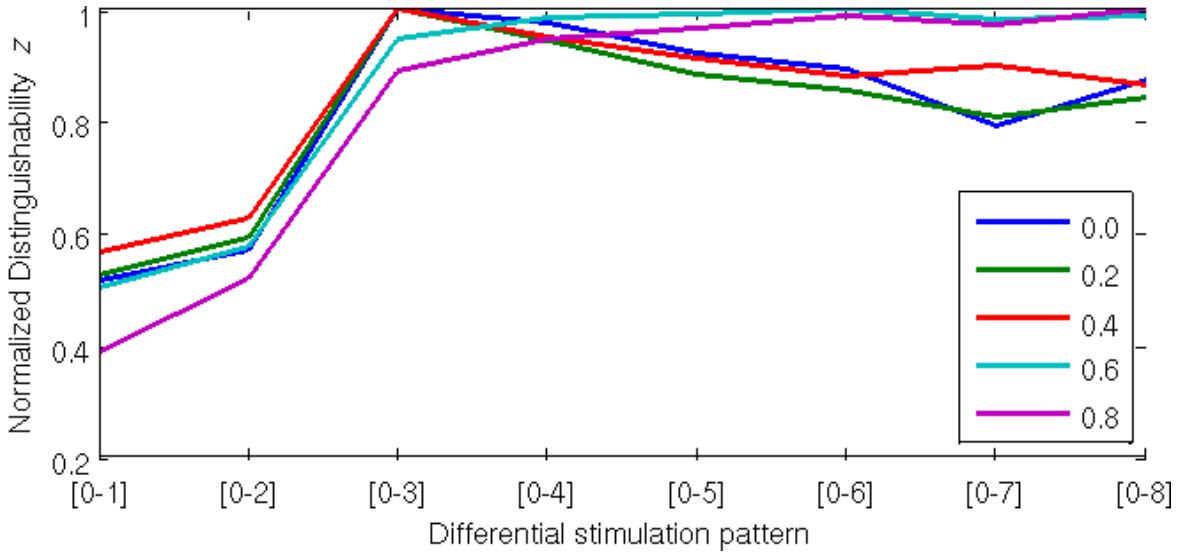
No stim meas



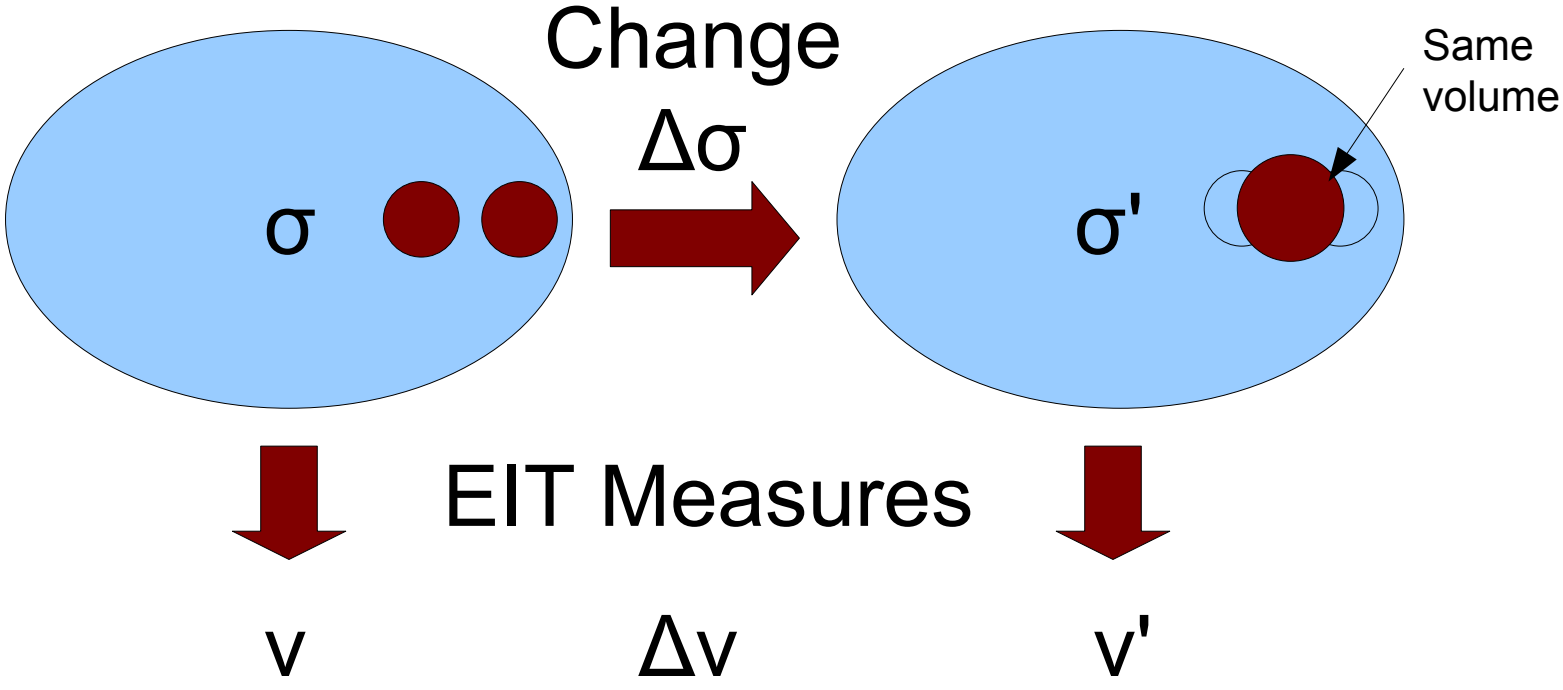
Choosing optimal patterns

- For a given choice of region of interest, compare regions in terms of SNR





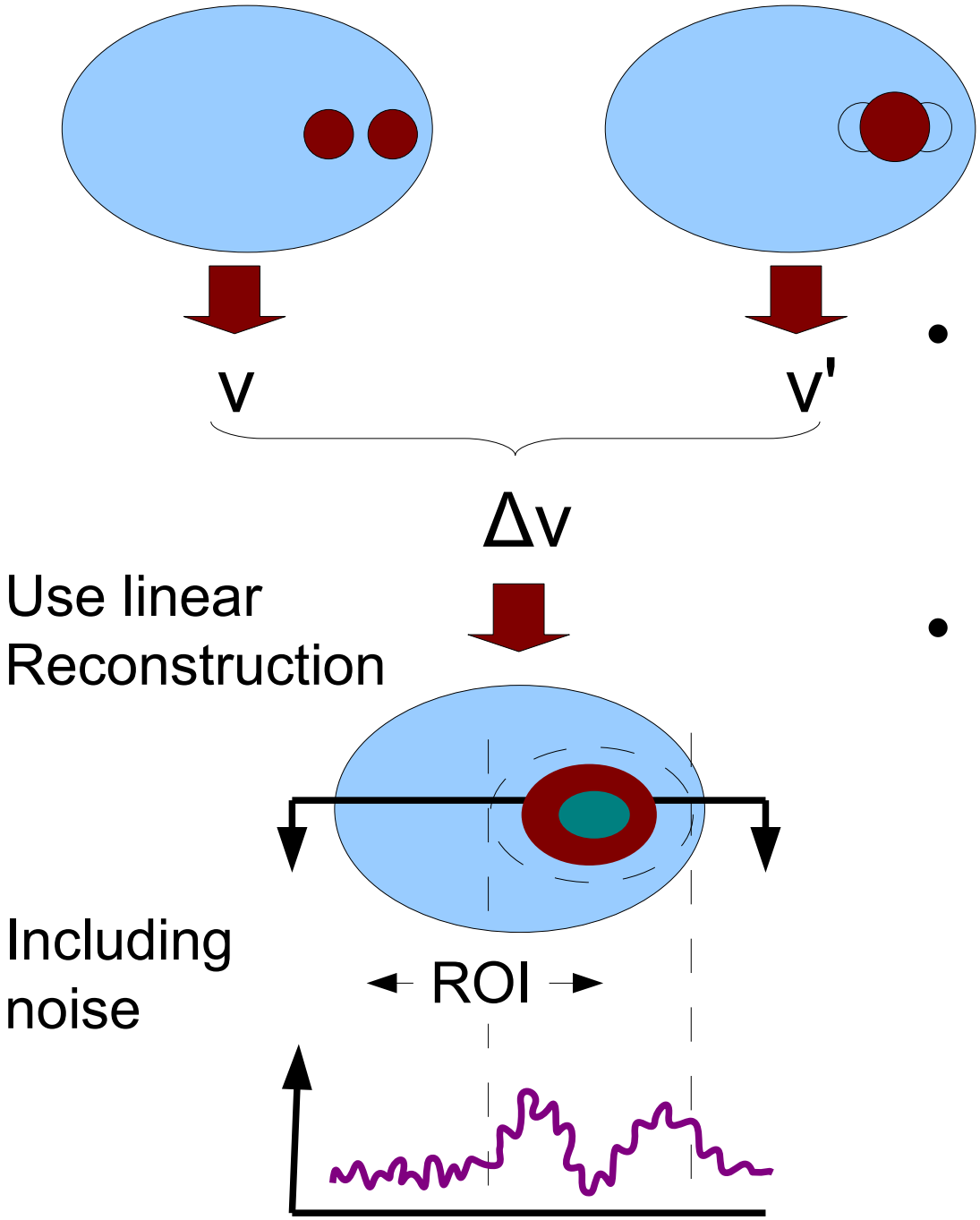
Distinguishability problem #2



Distinguishability Question:

Based on Δv, can we tell if there are two or one objects? How close?

Detection Strategy #2



- SNR depends on noise and on resolution
- Idea: use same calc as for #1, but replace

  J_{ROI} by

  $J_1 - J_2$.