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Calibration slide

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Spike sorting
- A serious problem -

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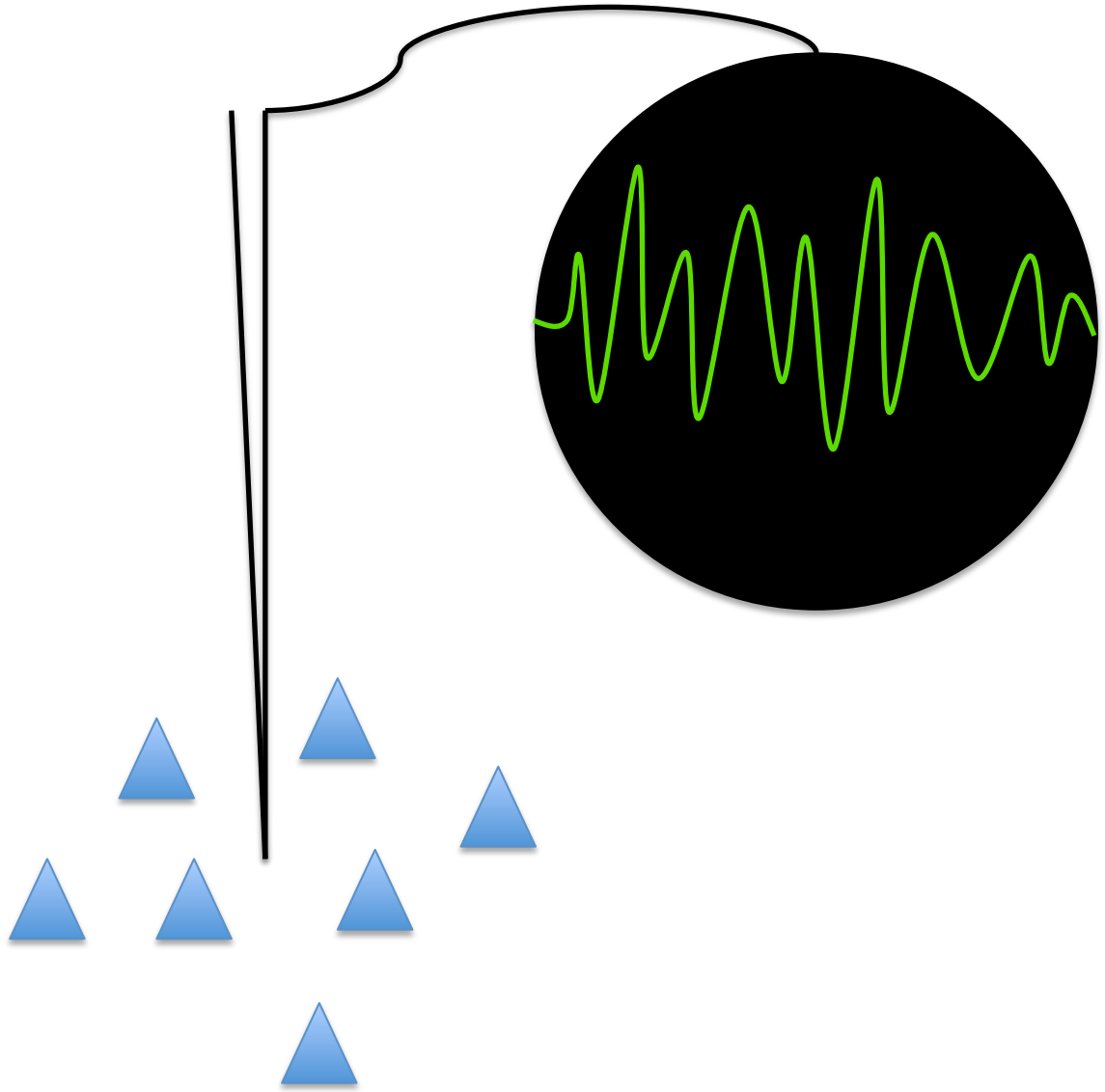
The problem



Why it is tricky

- This is an instantiation of a larger class of problems: An inverse problem.
- Solutions are − in principle − underdetermined.

On inverse problems…

- 3 + 4 = 7
- 4 + 3 = 7
- 1 + 6 = 7
- 6 + 1 = 7
- 7 = ?
- Working backwards from the results is inherently ambiguous.
- The same output could have been produced by an infinite number of inputs/sources
- The only way to deal with that is to nail down one of the inputs as a constraint.
- For instance, if I tell you that the result is 7 and one of the inputs is 2, you know that the other input is…

What people do

0. Don’t do it
1. Online spike sorting (manual)
2. Offline spike sorting (manual)
3. Offline spike sorting (increasingly fully automated)

0. Don’t do it

- Declare that good spike sorting is extremely time consuming, not critical to the question of the study and cannot be done well.
- Solution: Just don’t do it at all.
- How?
- Declare that all signals from a single electrode are a “multi-unit cluster” and move on.

Assessment

Advantages

- The most time-efficient solution.

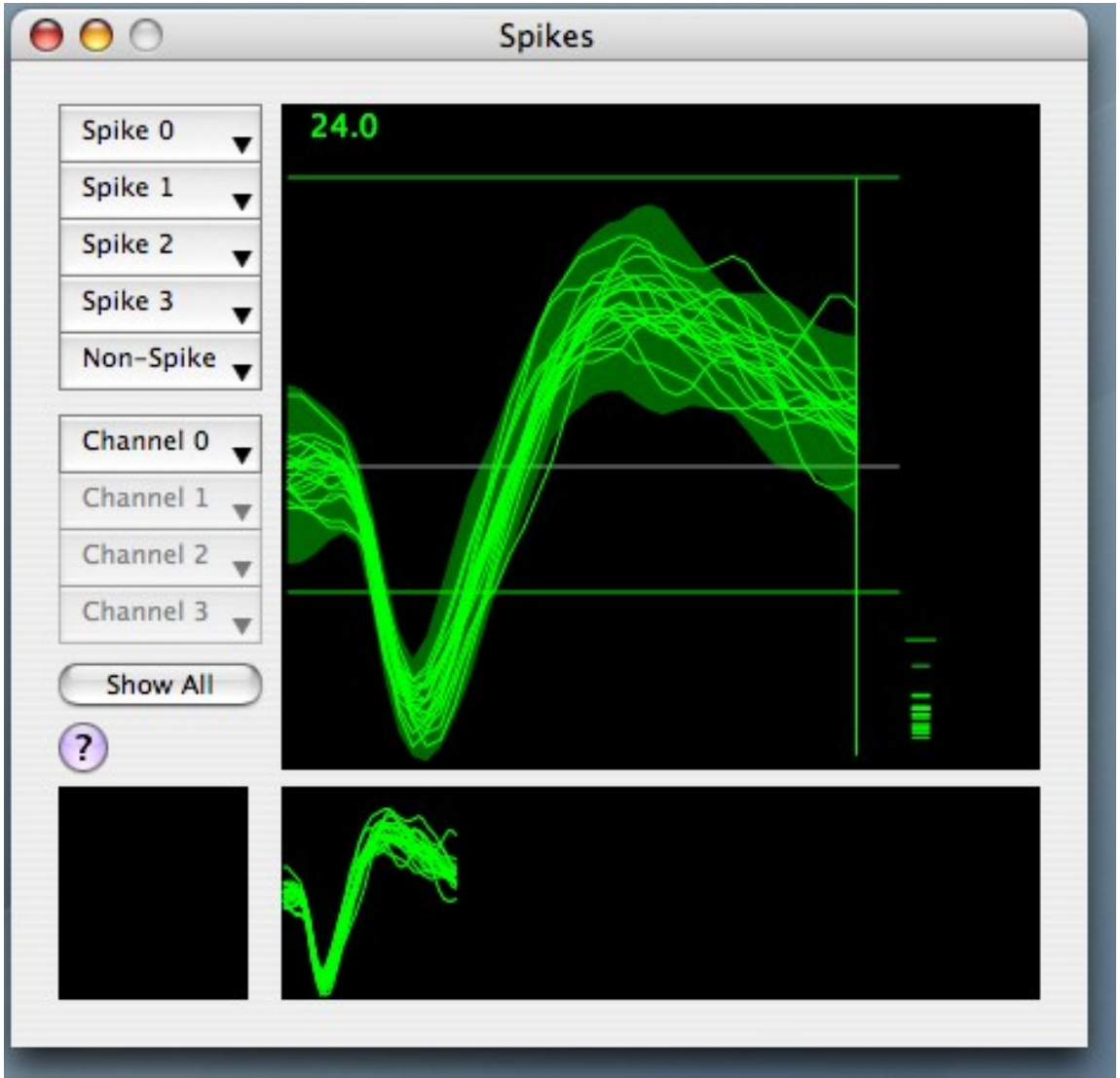
Disadvantages

- Sacrificing the key advantages of doing spike recordings in the first place (in contrast to LFP).
- If the question does rely on resolving signals from single neurons, this gives misleading results (e.g. absolute firing rates, relative tuning width, multi-peak tuning curves, …)

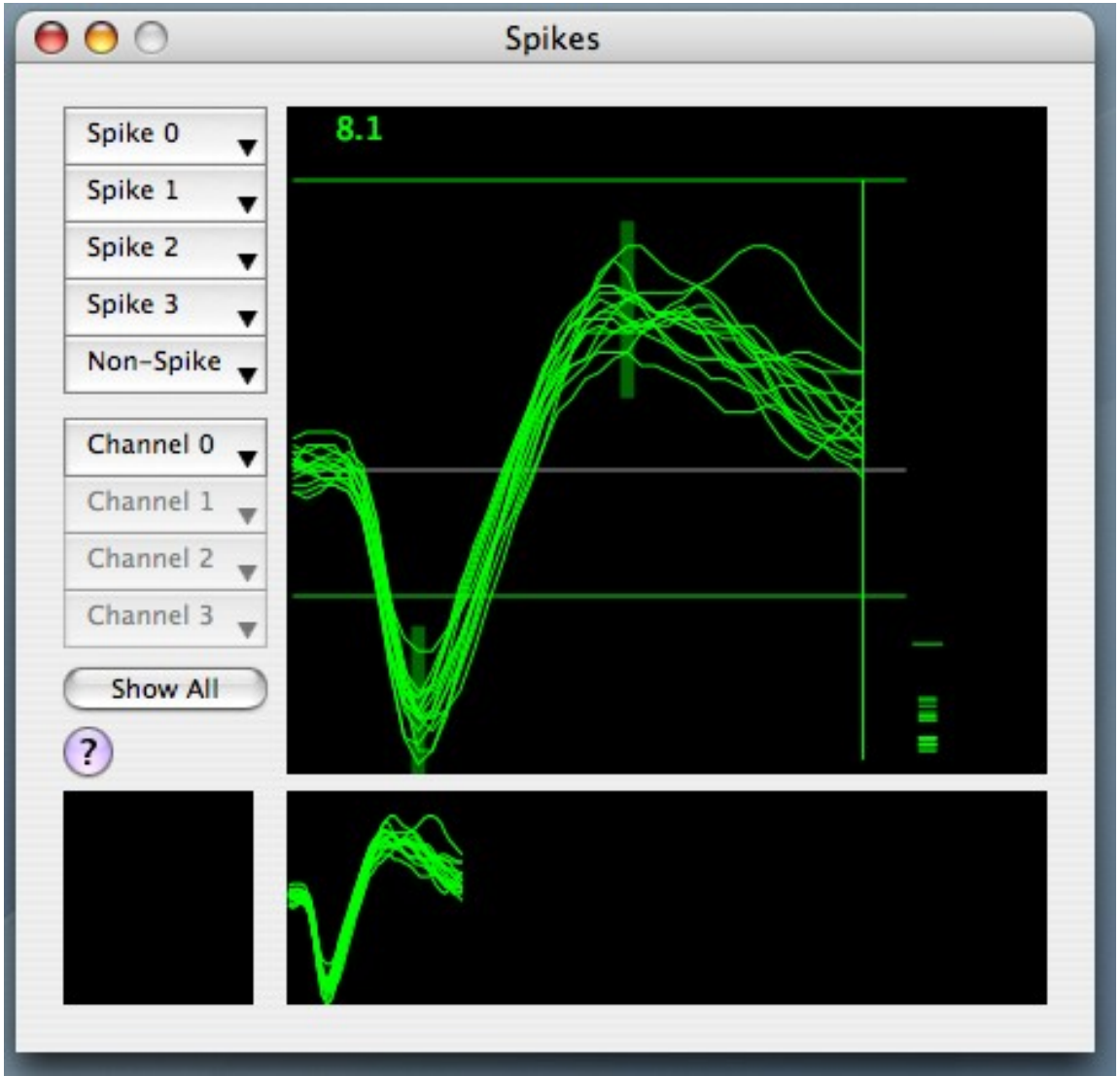
1. Online spike sorting

- Implicit heuristic: Because spike sorting is an unsolved problem, it is best avoided.

Thresholding



Window discrimination



Live demo (EXPO)

Assessment

Advantages

- Straightforward
- Yields extremely clean data if done properly.

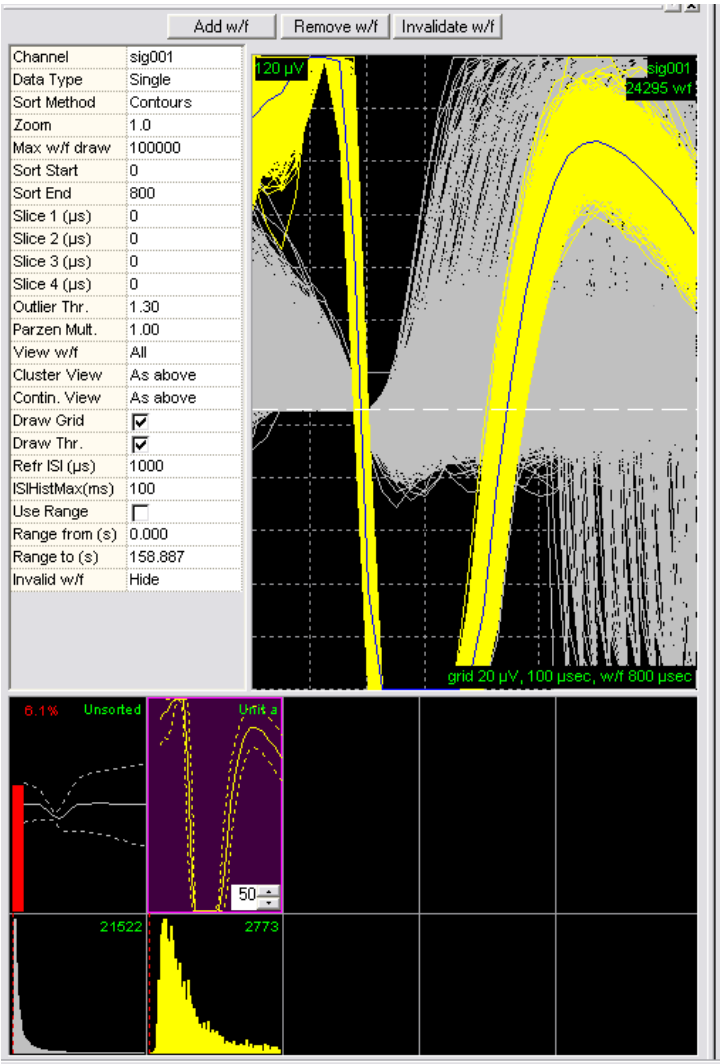
Disadvantages

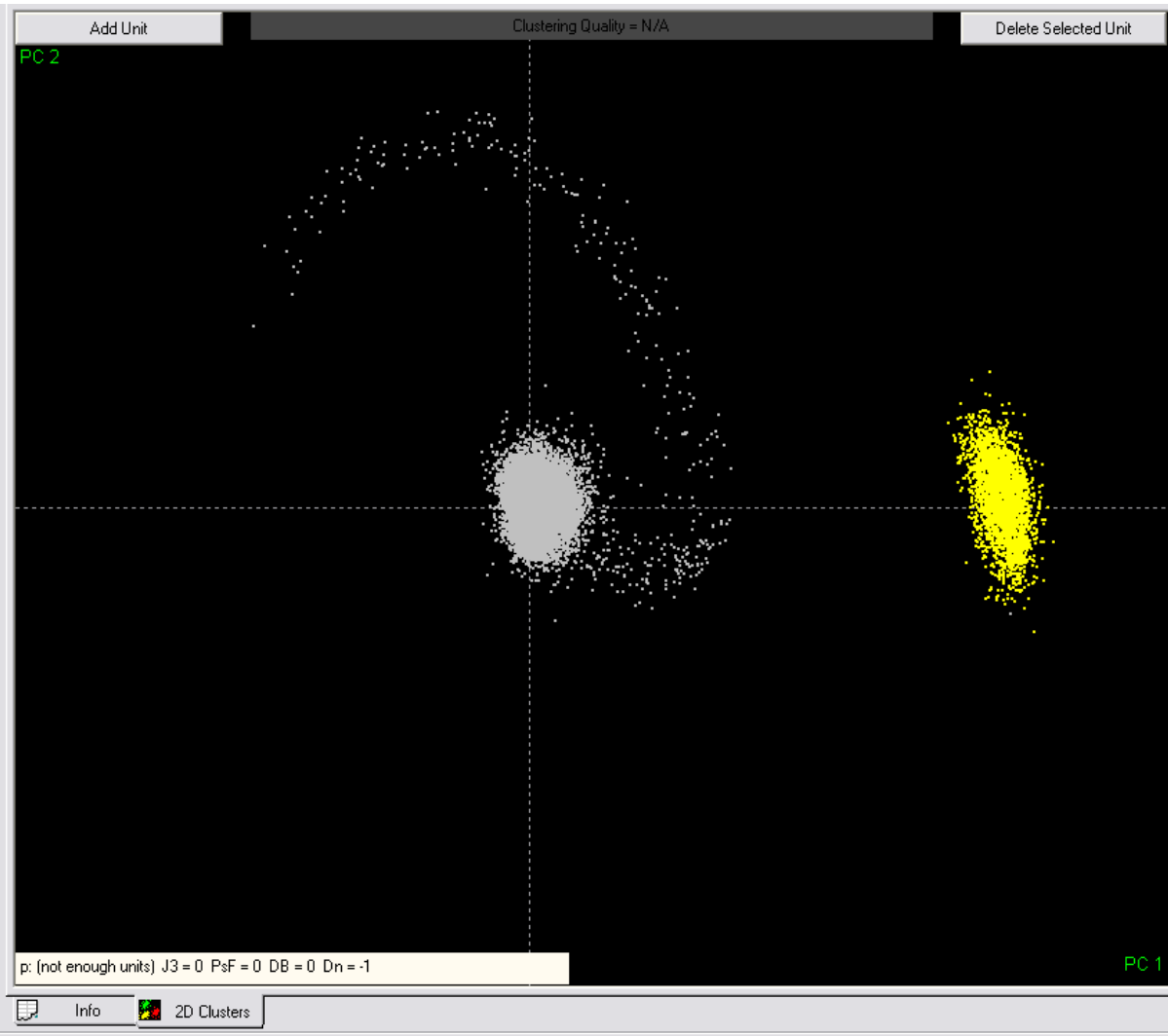
- Requires constant vigilance to "maintain isolation" (new neurons "pop up", others die down, most change shape over time).
- Losing most of the potential signal if criteria are stringent enough.
- No clear metrics for what is "good enough" other than "this looks good enough"
- Not practical for arrays

2. Offline spike sorting

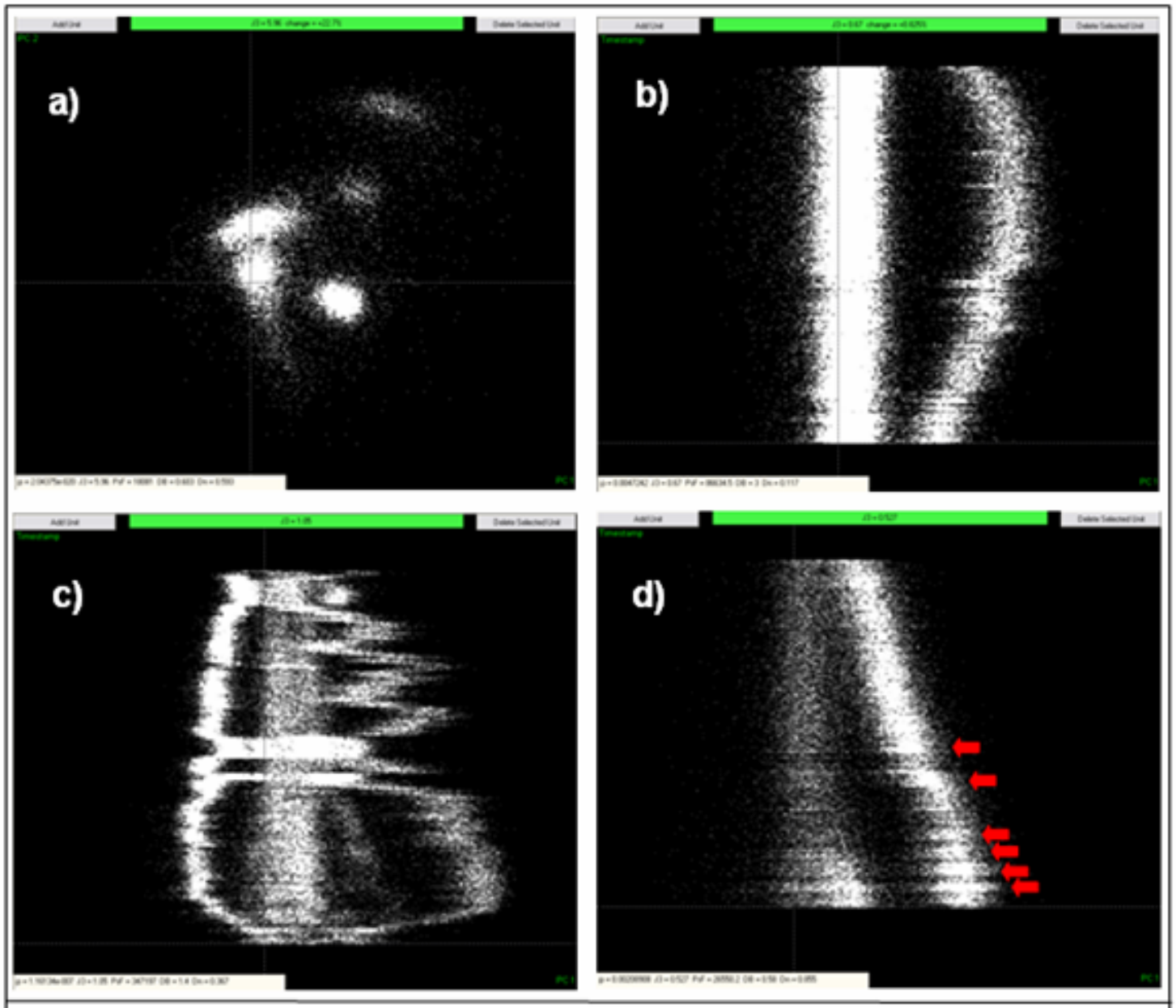
- Implicit assumptions: Spikes from the same neuron have roughly the same shape (allowing for measurement noise).
- So if one does a PCA of the shape, signals from different neurons will resolve into different, distinguishable clusters that can be resolved visually (“cluster-cutting”)

“Cluster-cutting”

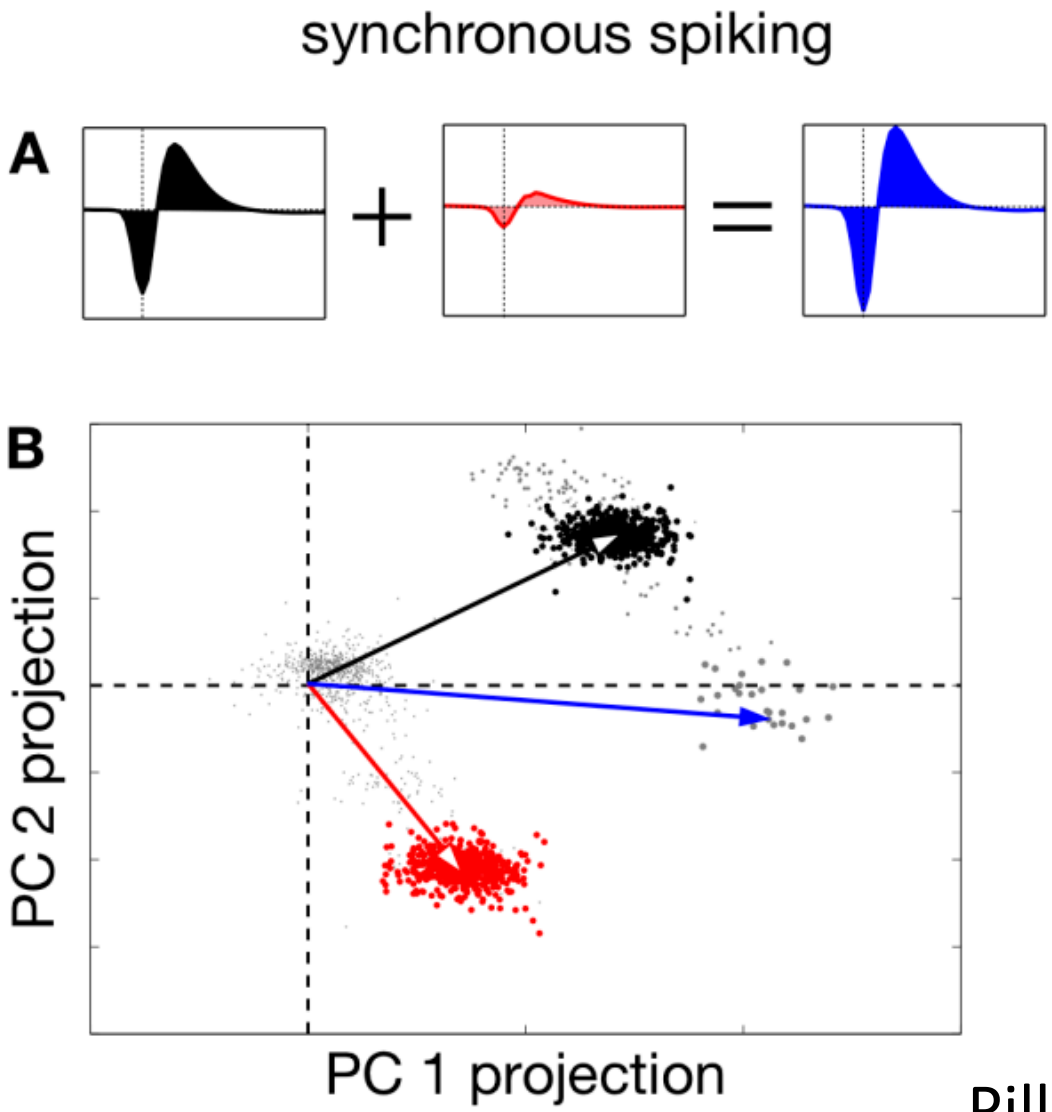




Documented non-stationarities

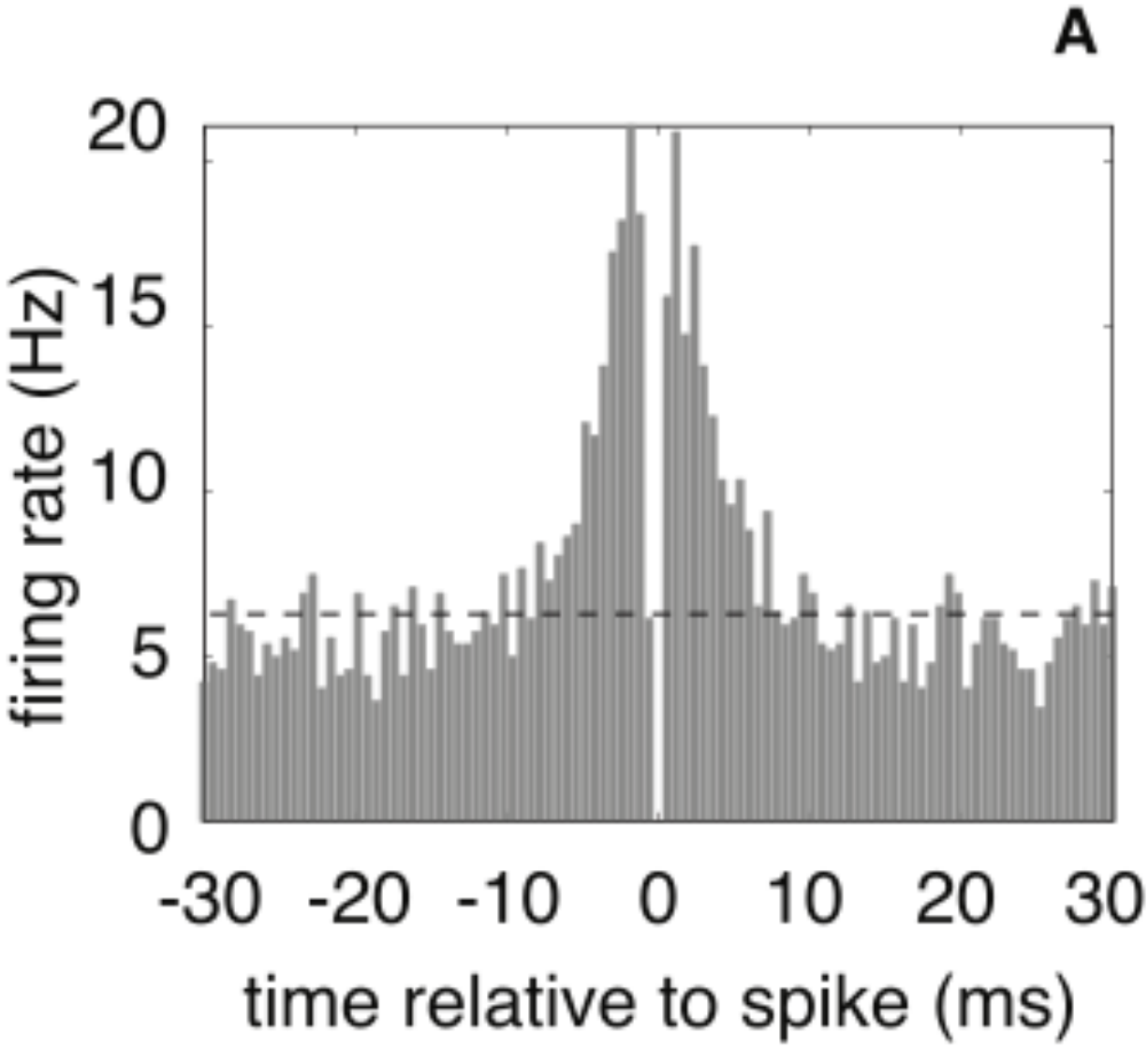


Synchronous spike superimpose linearly



Pillow et al. (2013)

Why is this a concern?



Pillow et al. (2013)

Matlab offline sorter

Assessment

Advantages

- Keeps most of the signal.
- Allows to do due diligence offline.
- Allows to sort huge arrays.

Disadvantages

- Extremely time-consuming and tedious if done manually.
- No clear or binding metrics as to what constitutes a good sort across labs (or even within).
- Can’t recover a good sort from a bad recording.
- We know that the key assumption (stationarity of the waveform) is not met in many recordings, particularly long ones.

3. Algorithmic approaches

- The future? (The end of the beginning)