Automatic event picking in prestack migrated gathers using a probabilistic neural network

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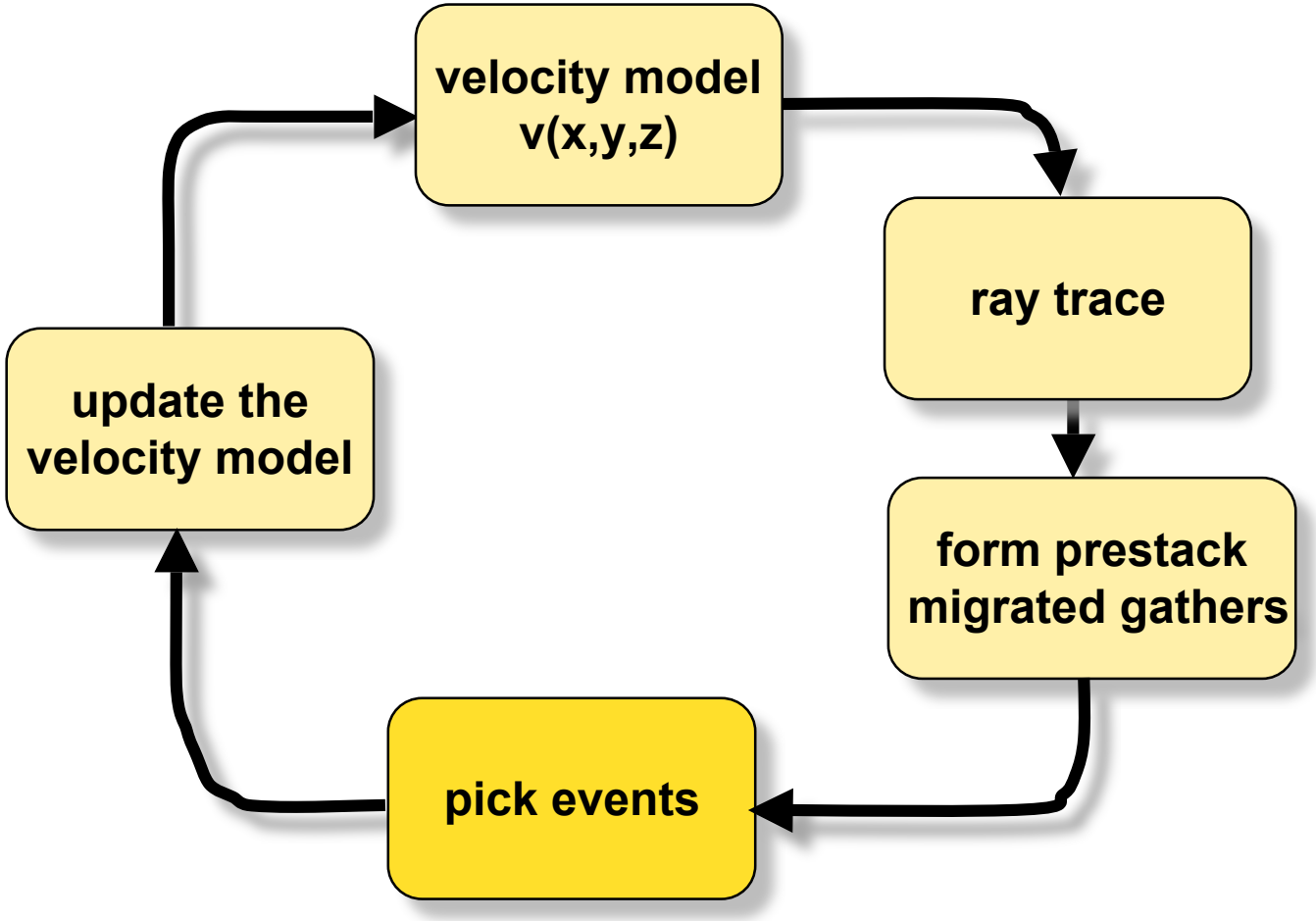
Agenda

- introduction and problem definition
- overview of processing scheme
- detailed example of algorithm application
- summary and future work

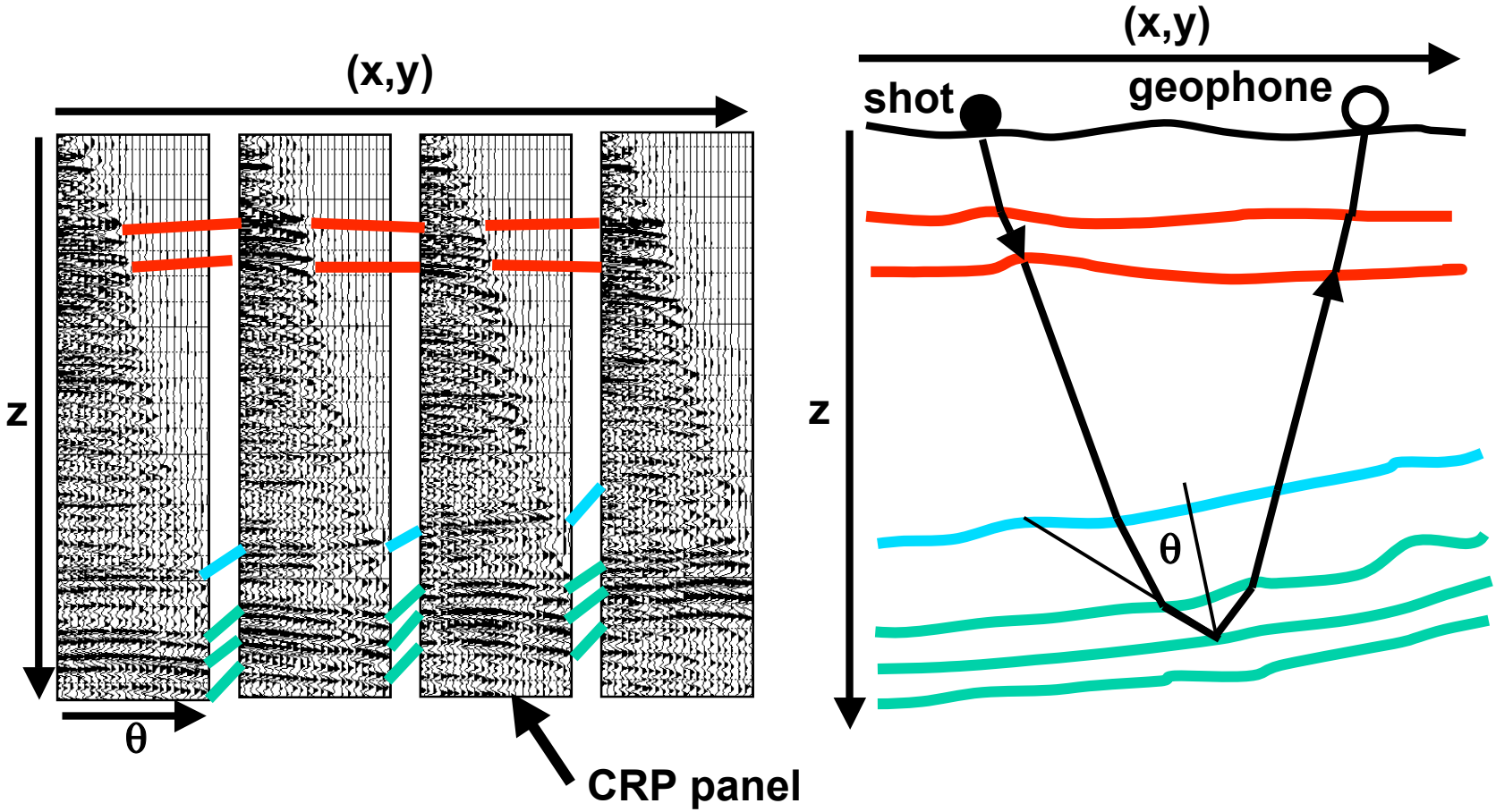
There is a velocity analysis bottleneck in prestack migration



Why does this bottleneck exist?

- **iterative process of converging to velocity model is limited by picking events**
- **picking is currently performed manually**
  - 2D datasets, >10,000 traces
- **not feasible with larger datasets**
  - 3D datasets, >1,000,000 traces
- **done manually for quality control**
  - eliminate “loop skips”
- **goal is to automate the event picking process**
  - manual picks only for training and “context”
  - reduce manual picking to less than 0.1% of data

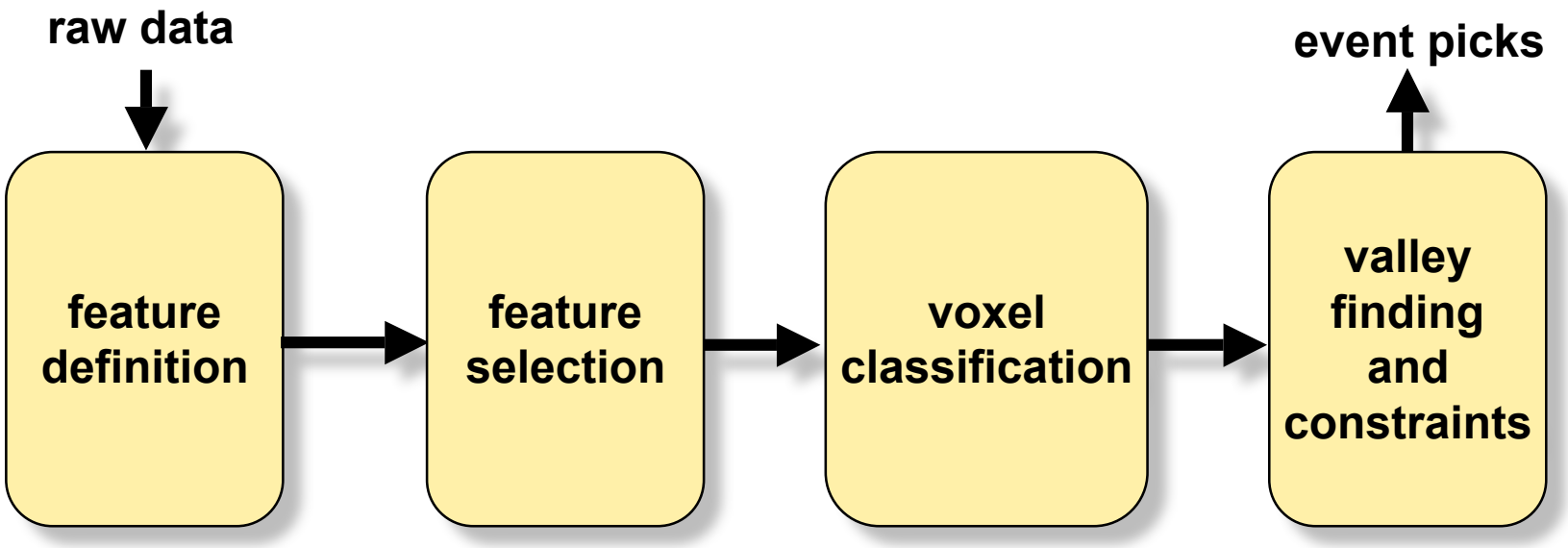
Neural networks automate picking and tracking of events on CRP panels



Several basic ideas and issues guide this work

- **use the simplest techniques that prove to be effective**
- **use approach of:**
  - signal / image processing
  - machine vision
  - supervised learning techniques
- **feature analysis is the key**
  - GIGO
- **exploit information about:**
  - prior knowledge from human experts
  - spatial context

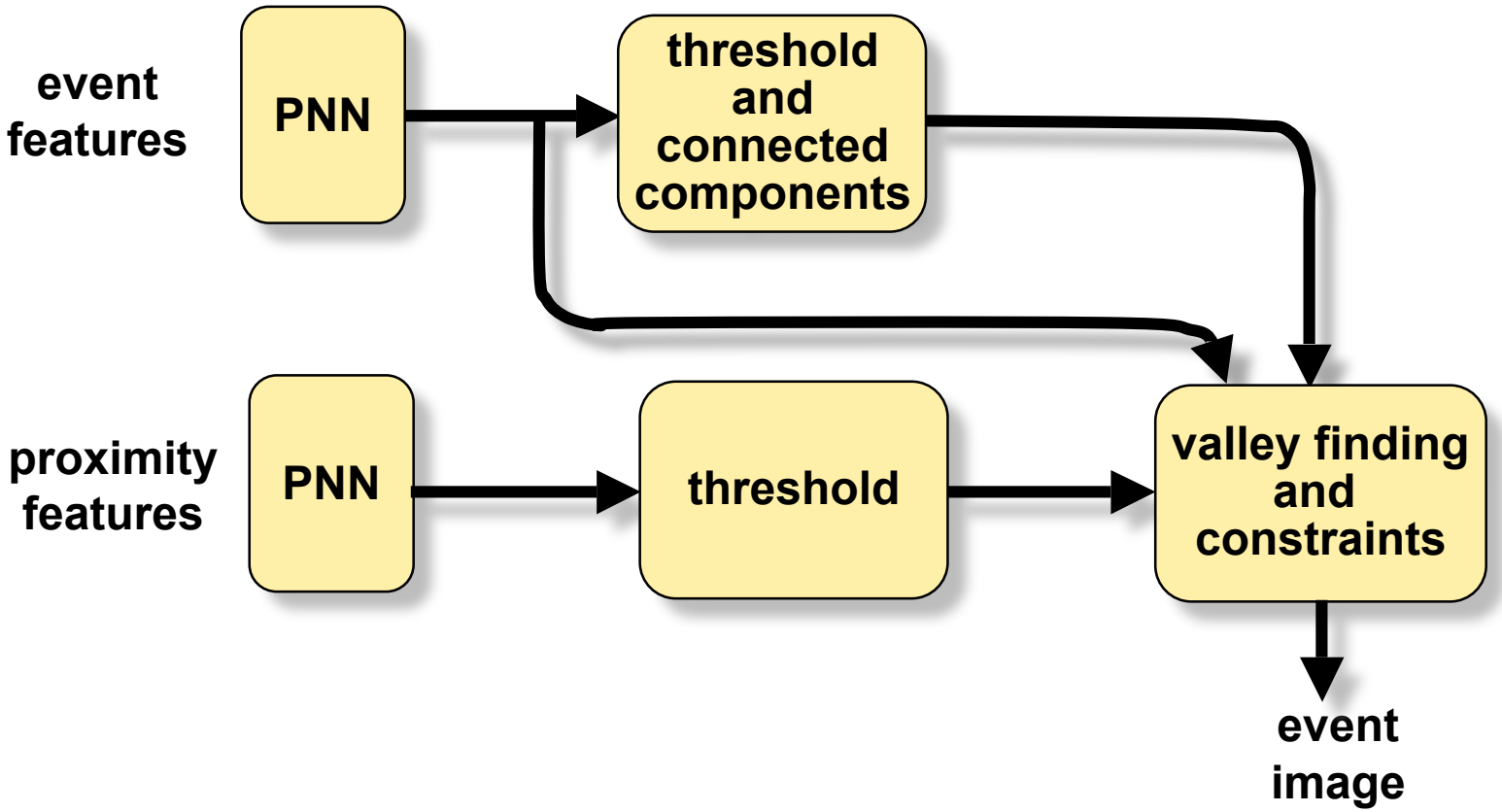
Processing flow



Algorithms used in the processing flow

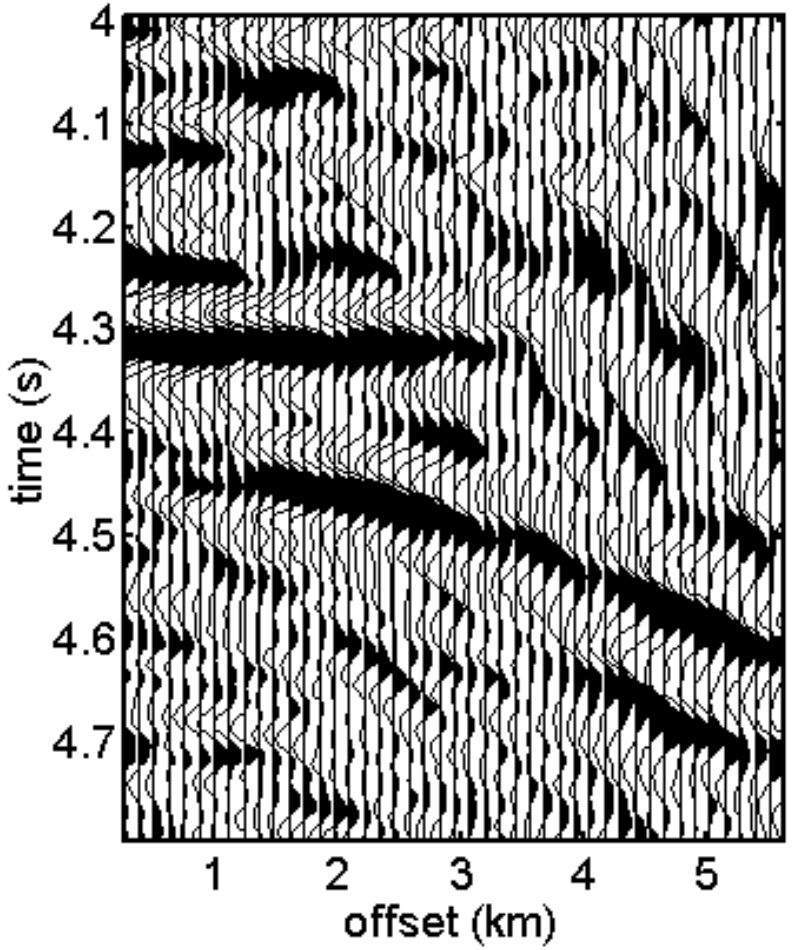
- **feature definition**
  - 2D Gabor transforms
  - semblance
  - amplitude histogram
  - proximity
- **feature selection**
  - sequential forward selection
- **voxel classification**
  - probabilistic neural network (PNN)
  - connected components
- **valley finding and constraints**
  - size
  - continuity

The algorithm used



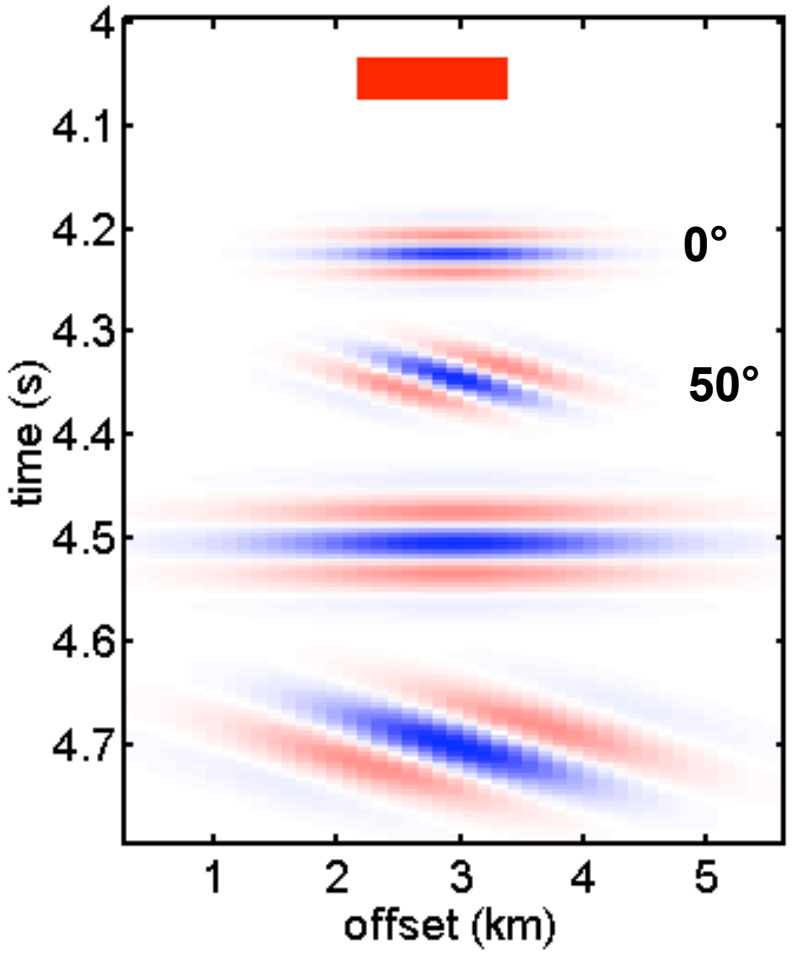
Prestack migrated data (raw data)

- deepwater GOM
- 2D dataset
- JIGSAW prospect

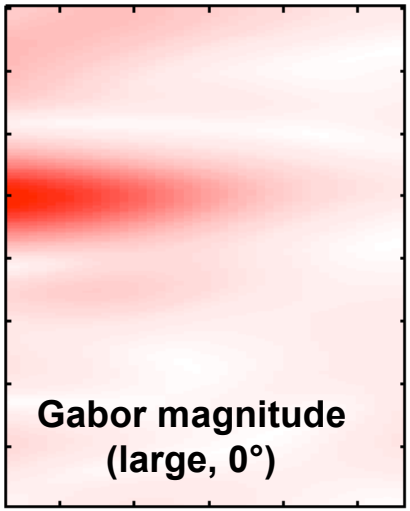


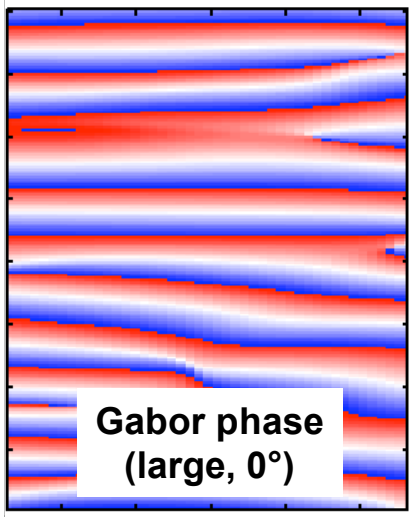
Useful features of the raw data

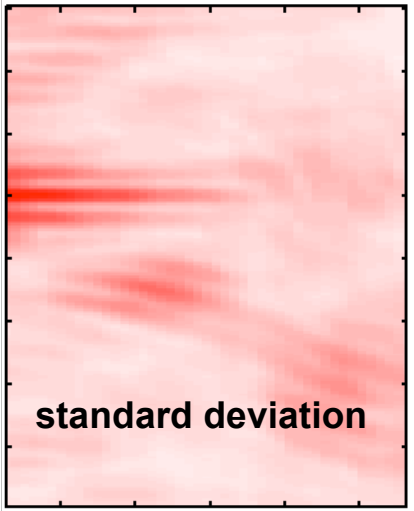
- **statistical moment**
  - mean, etc.
  - moment over red box
- **semblance**
- **Gabor transforms**
  - magnitude & phase
  - 2 scales
  - 4 slopes

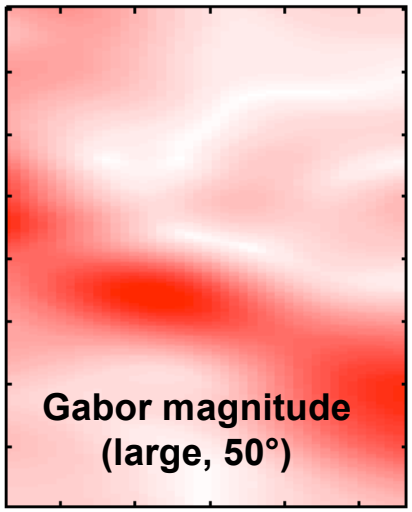


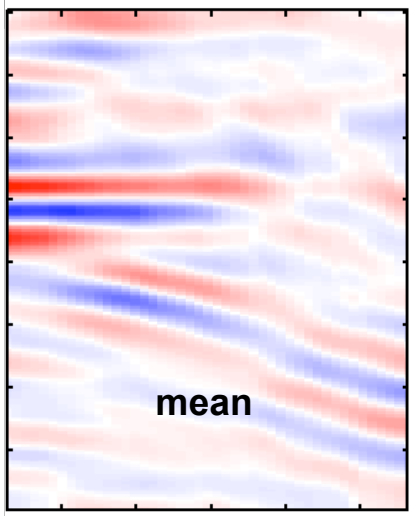
Event feature images are formed

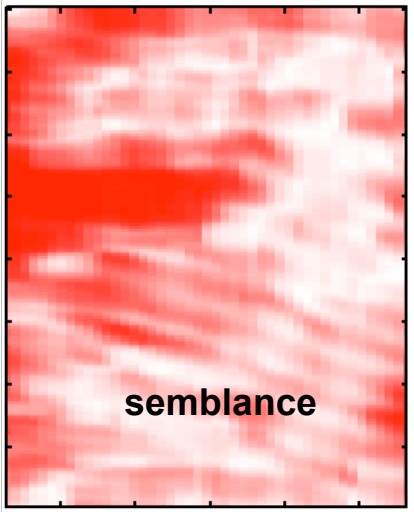




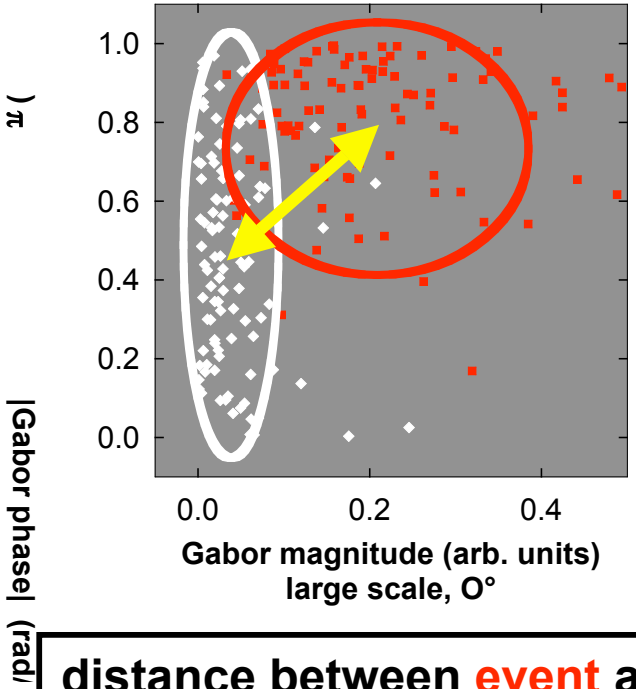




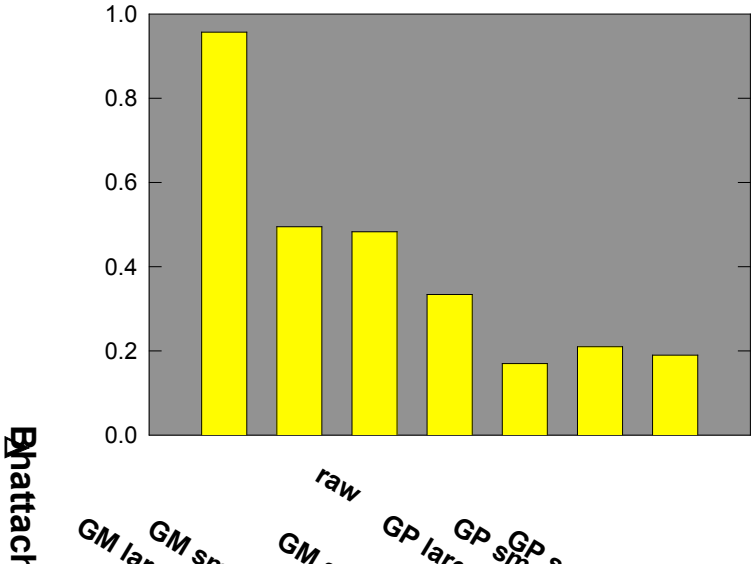




Features are ranked via Sequential Forward Selection algorithm



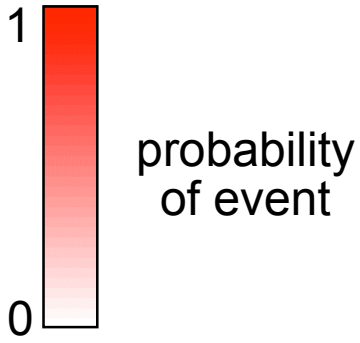
distance between event and background cluster used

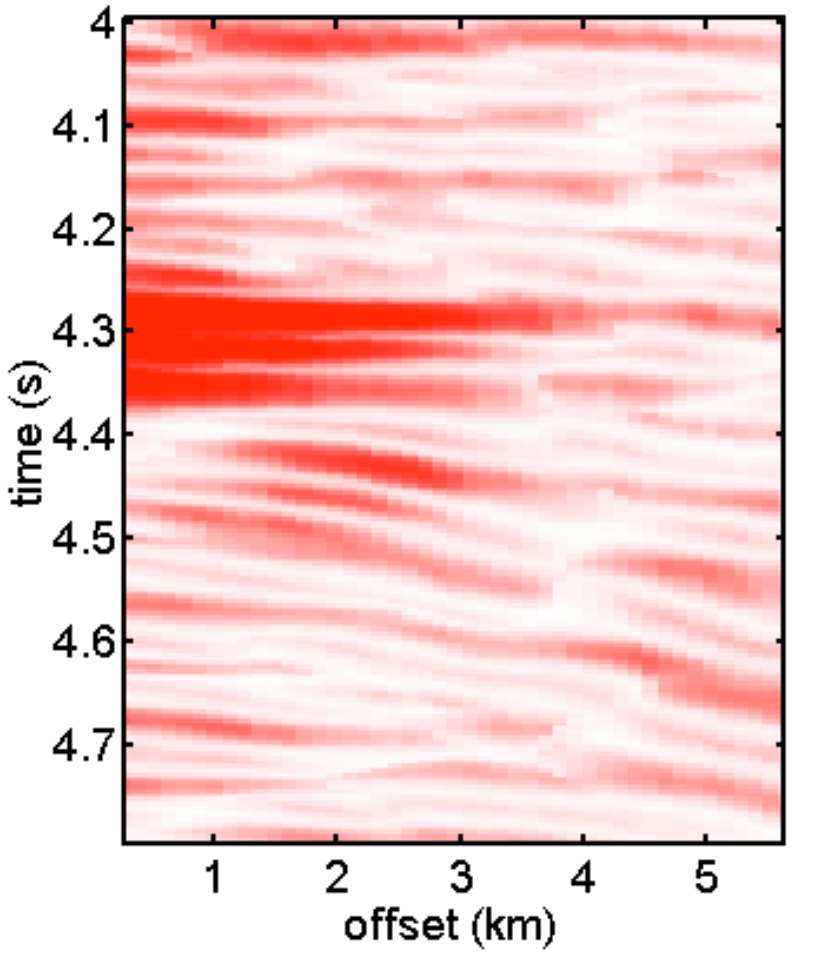


GM = magnitude of Gabor transform
GP = phase of Gabor transform

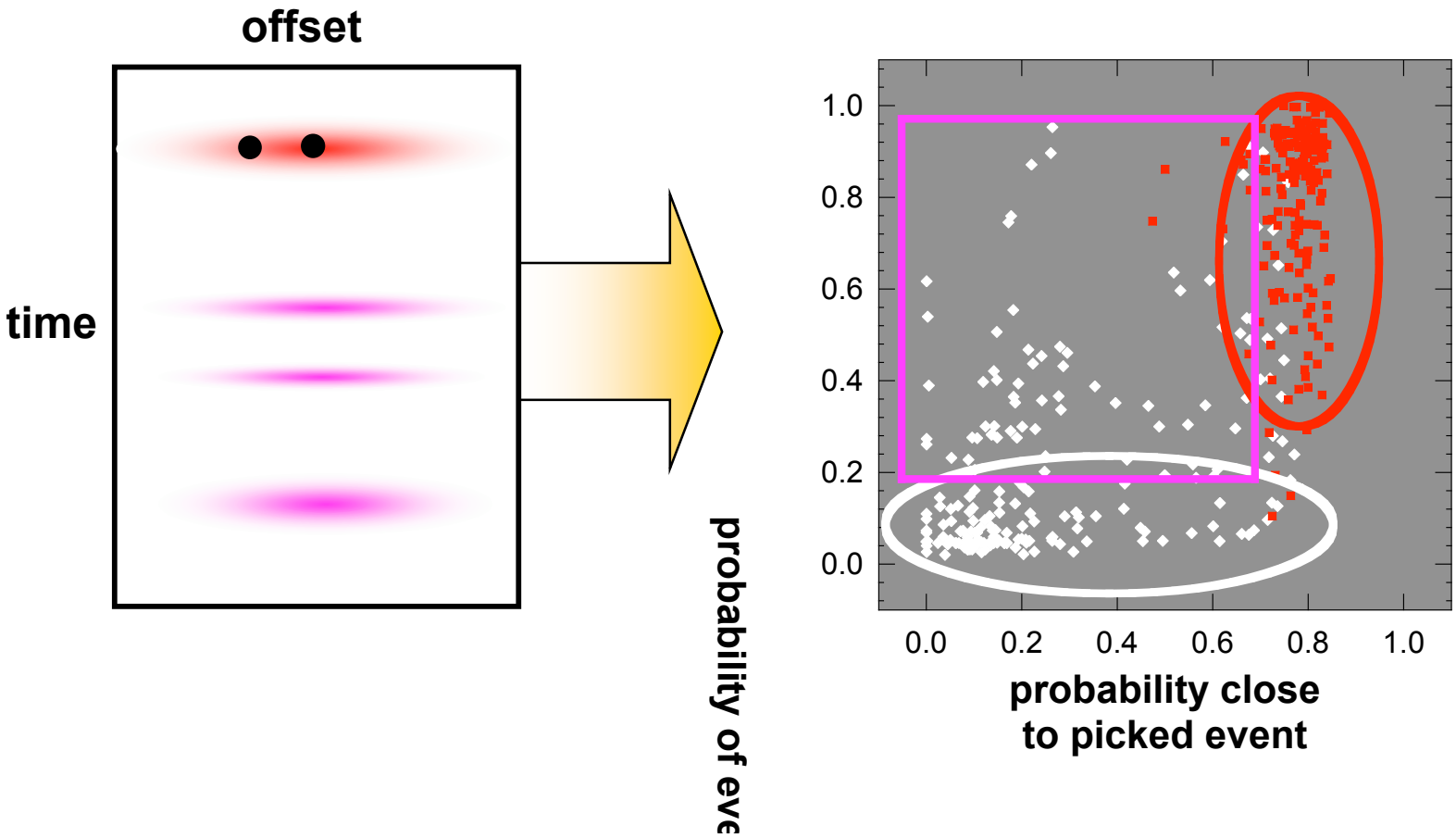
Posterior probability image using event features as input

- **training set**
  - 107 events
  - 100 background
  - 20 out of 468 CRPs
  - 0.5% of picks
- **probability of correct classification**
  - 89% to 96%



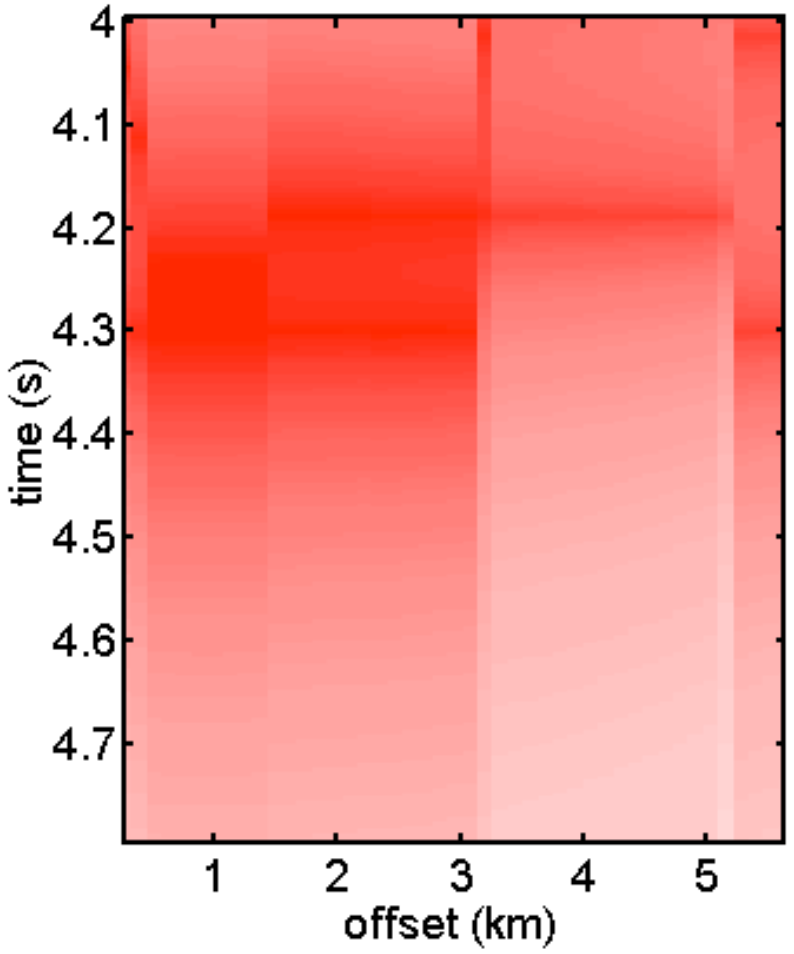


Proximity features allow for human contextual input

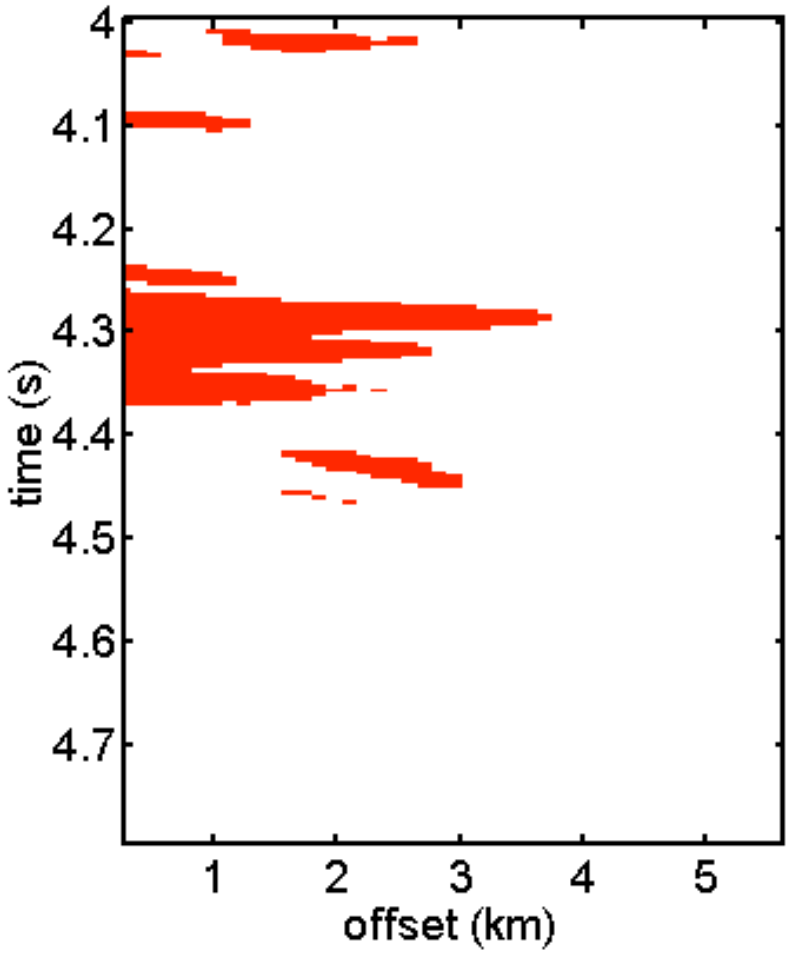


Posterior probability image using proximity features as input

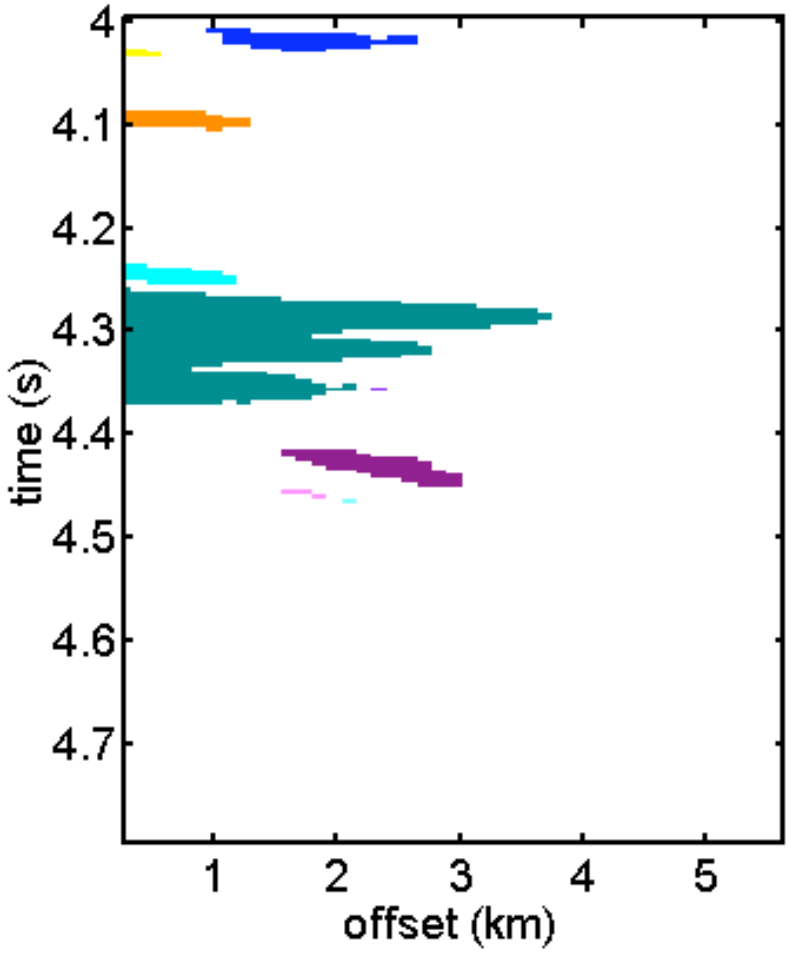
- **193 picks used**
  - 1% of picks
- **mask for constraining search space**



Binary labeled image

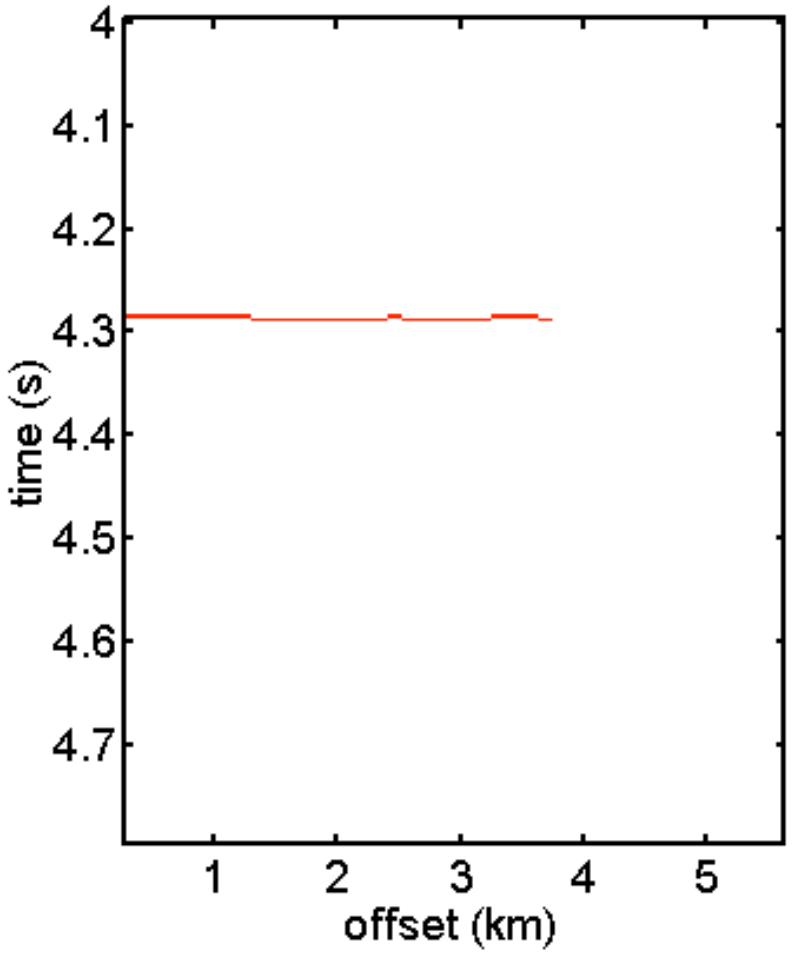


Connected components labeled image

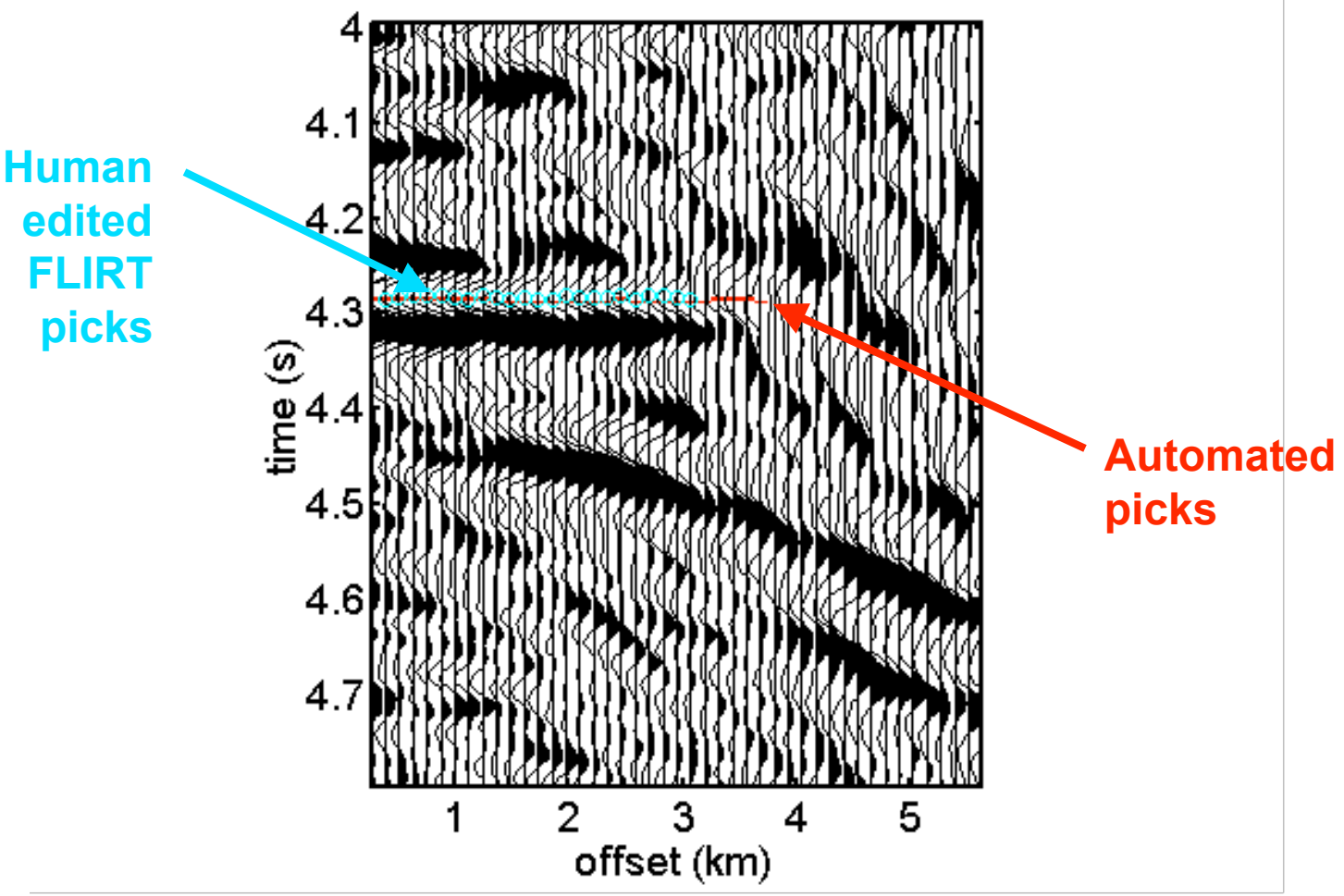


Event image

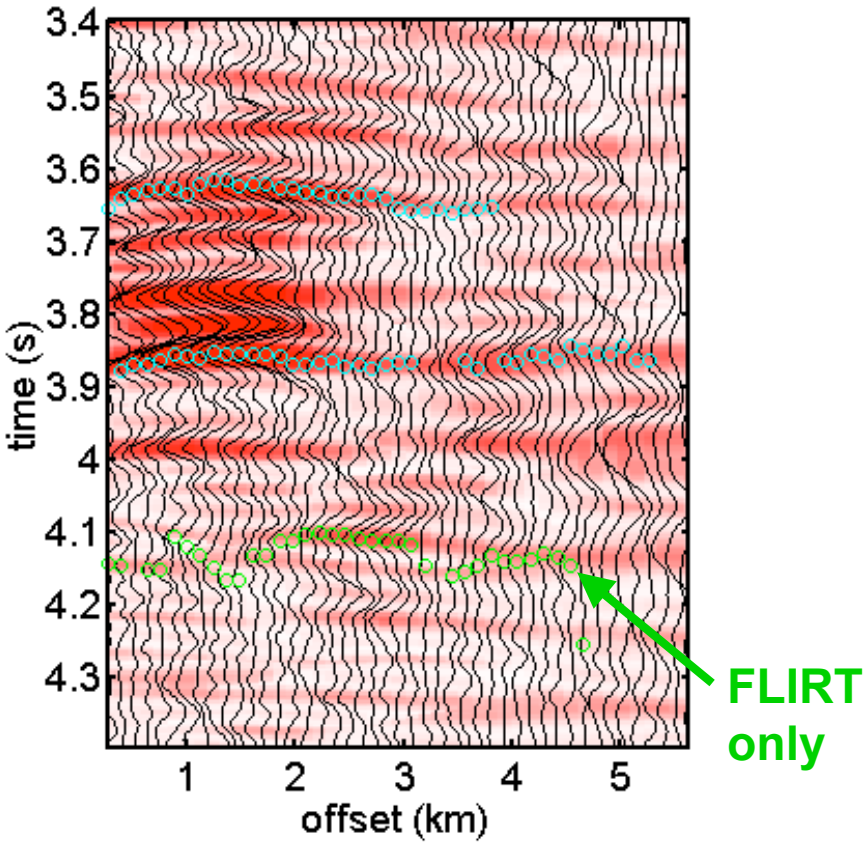
- size
- one time / offset / cloud
- continuous
- max posterior probability

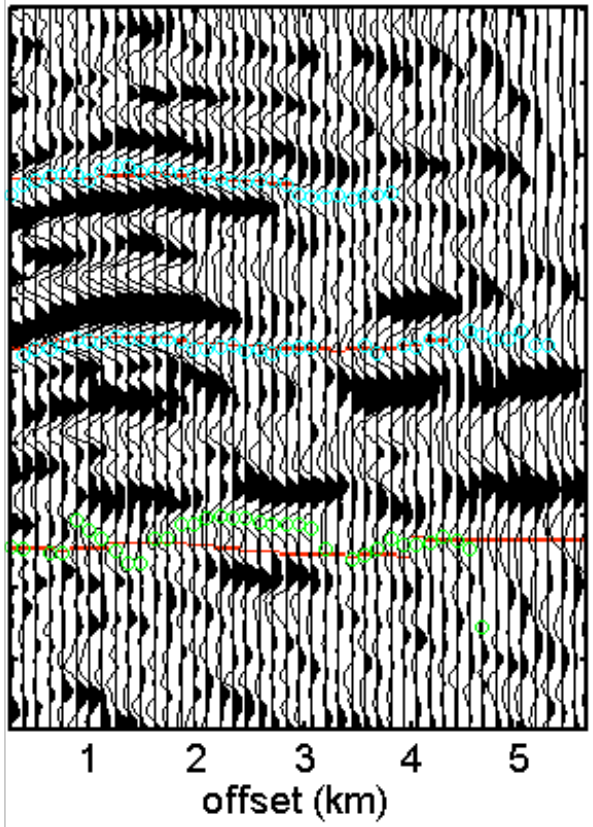


Automated picks compared to human picks

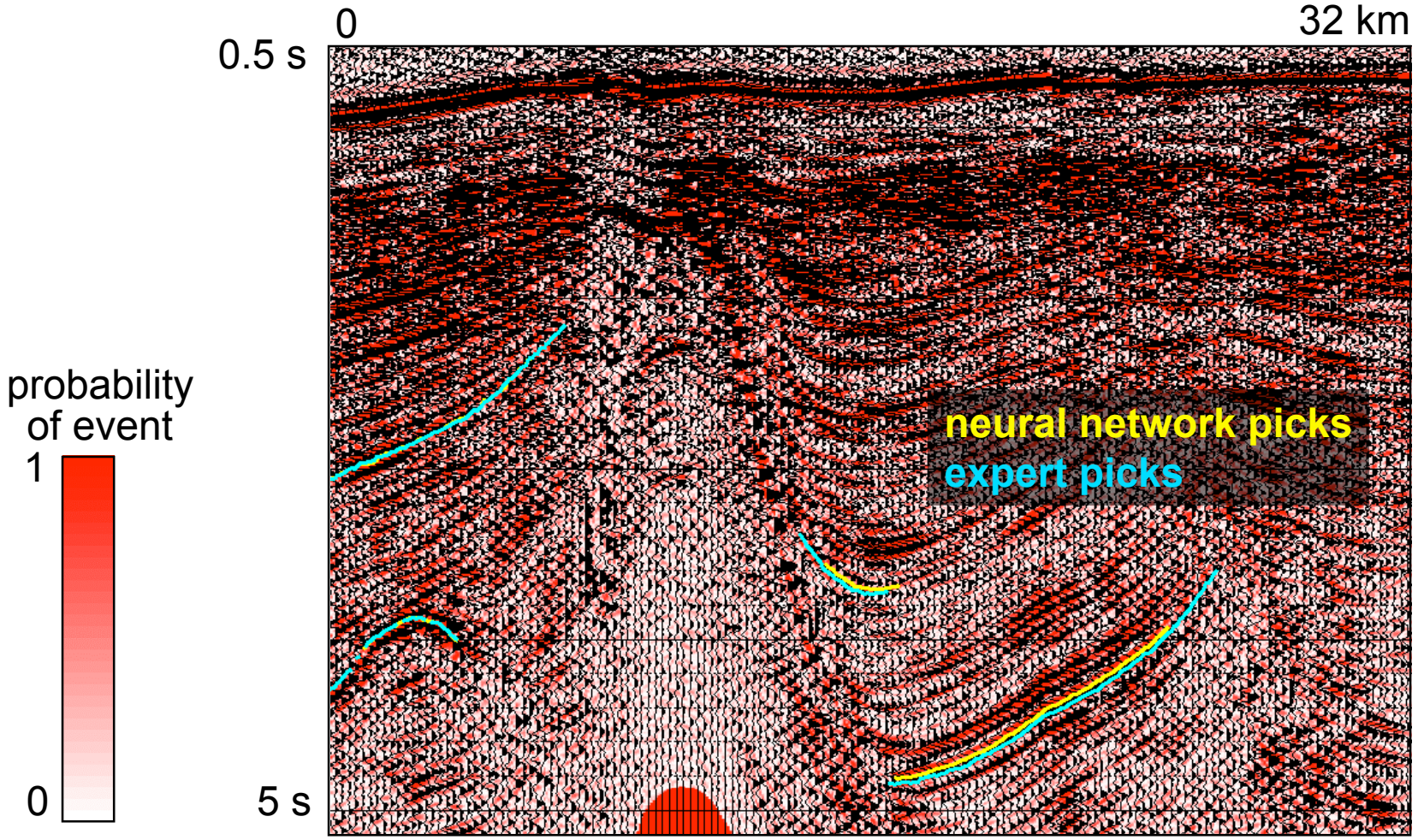


PNN prevents loop skips in low signal to noise data

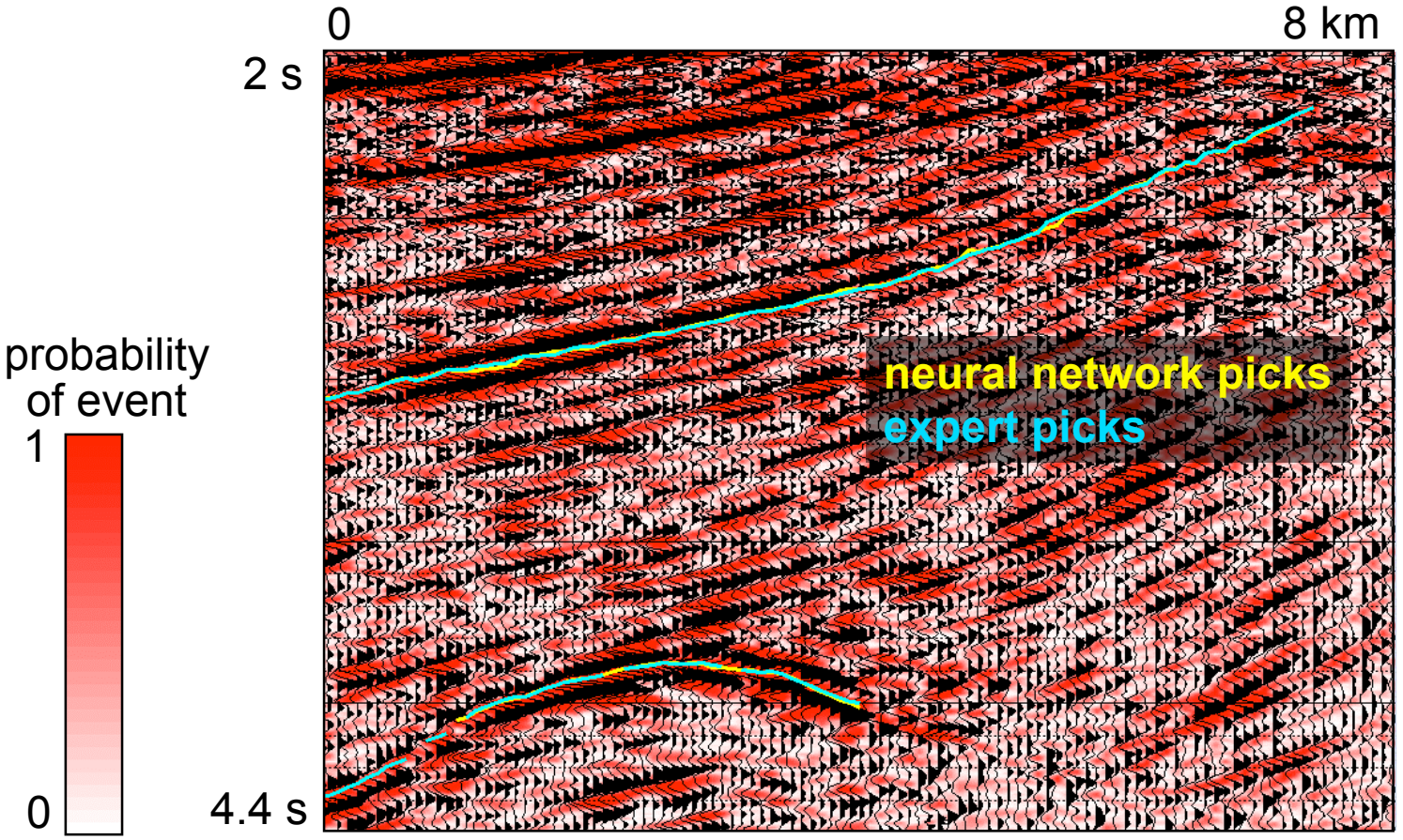




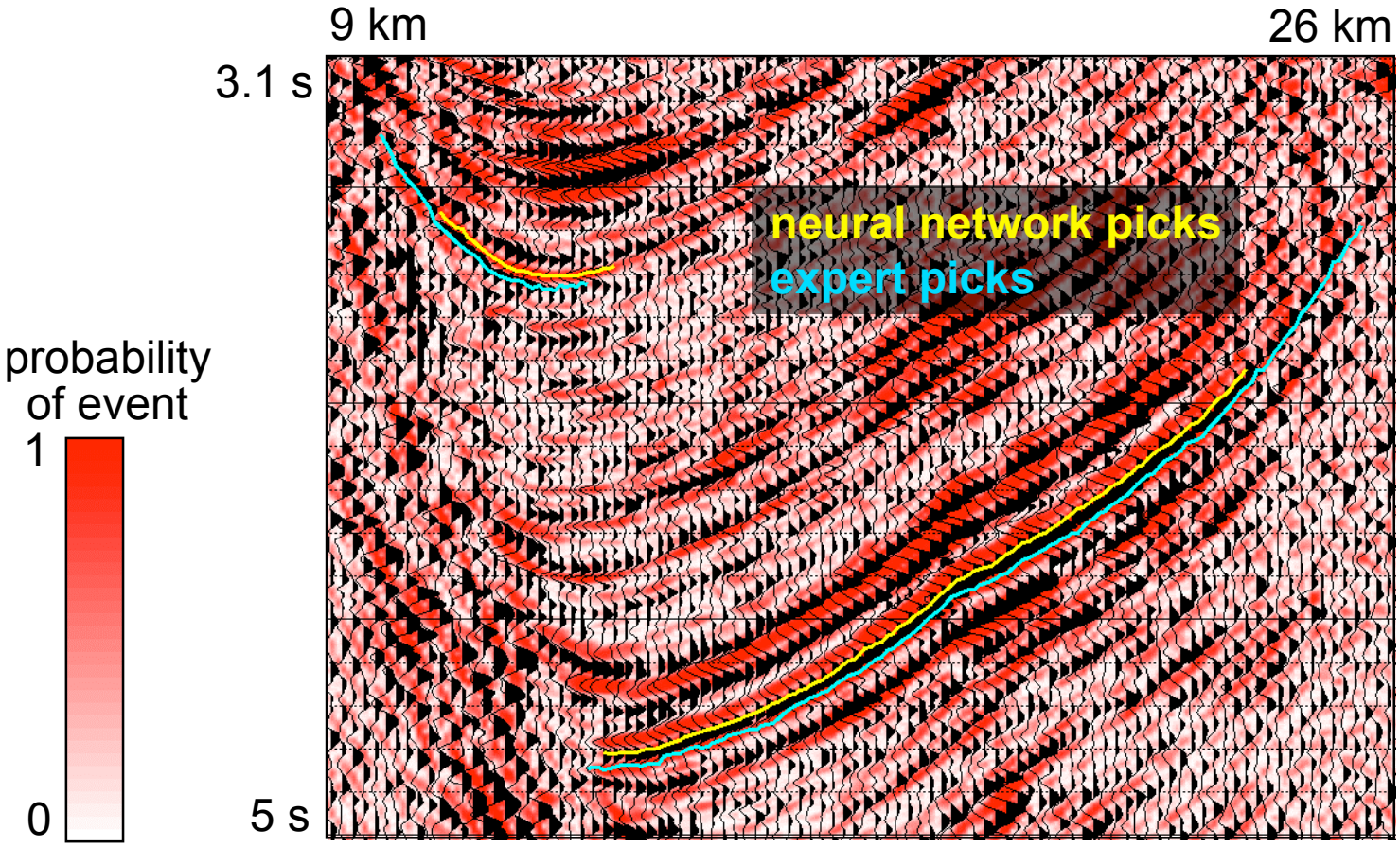
Neural network picker applied to 2D GOM dataset (JIGSAW)



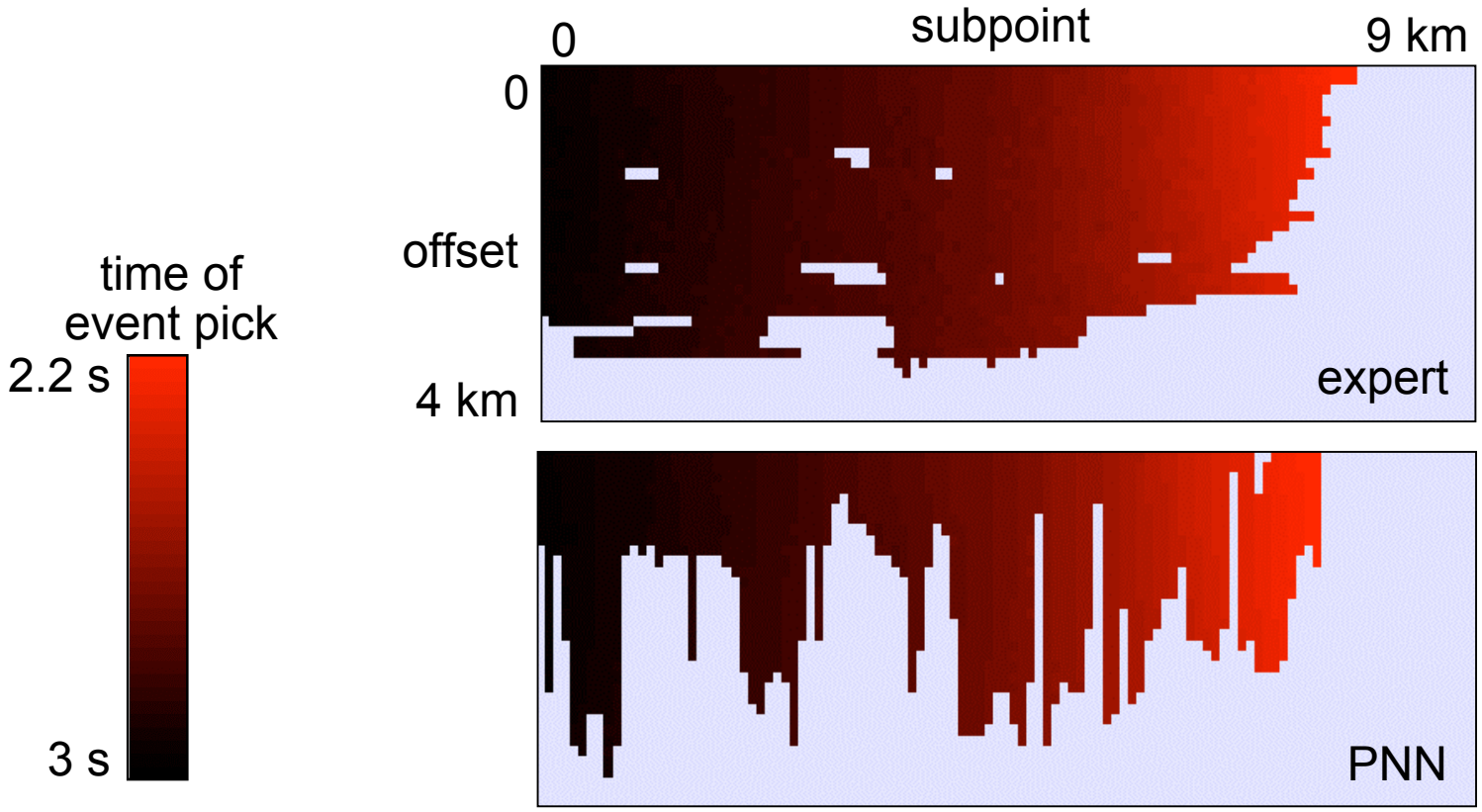
Neural network picks compare well with expert picks



Neural network sometimes consistently picks on different loop



Neural network picker is not as aggressive as expert



Computer time needed

- **15 ms / voxel / feature**
  - interpreted MATLAB
  - PowerBook 5300c
  - 7 features used (6 Gabor, raw data)
- **60 μs / voxel / feature**
  - Sparc Ultra 1
  - compiled C++
  - 7 days for 4 OCS blocks

Summary and future work

- **Gabor transform captures character of event**
  - better than semblance and amplitude histogram
- **PNN combines features into best guess**
  - prevents loop skips
- **proximity is a way to quantify where to look**
- **could enable 3D PSDM**
  - cost reduced from $75,000 to $6,000 (4 OCS blocks)
  - cycle time reduced from 12 weeks to 1 week
  - improve robustness of inversion (more picks)
- **further evaluation needed on other datasets**
- **tracking of PNN result needs to be improved (aggressiveness)**