

# LAMBDA in a nutshell

LAMBDA is gempa's advanced seismic and infrasound array processing package for detecting and locating earthquakes, explosions and other events outside of network coverage.

It includes an interactive and an automatic module to detect and pick phases with time, slowness and backazimuth as well as the locations. Time or frequency-domain slowness-backazimuth stacking or back projection as well as plane-wave fitting of manual picks and 3C polarization analysis are available. Arrays can be optimized interactively.

The array picks and the locations can be further processed by public SeisComP or gempa modules. For example the different array picks and picks from just a few more stations can be combined for more reliable locations and interactively analyzed.

#### **FEATURES**

- Seismic and infrasound arrays
- Automatic or interactive analysis
- Single and multiple arrays
- Array configuration: maps or tables
- Array response function
- Slowness-backazimuth analysis
- PMCC analysis
- Location by back projection
- Interactive beam forming
- Inversion of manual phase picks
- 3C single-station polarization analysis
- FK analysis and Beam packing
- Custom travel-time tables







### Array design and response function

Use LAMBDA to design arrays. The array response describes the sensitivity of an array for detecting and resolving seismic signals with different frequency contents arriving from particular directions. It is formed interactively for slowness and frequency ranges. Inter-station distances and differential travel-times assist in optimizing the array setup.

## Beam forming and 3C polarization

Beam parameters are found by beam-forming and semblance analysis. All detections can be selected individually in time (top). The semblance maximum (right) points towards the source. With array response contours on top artefacts are identified. Raw and beam waveforms show the picks with their SNR. From the 3C polarization the parameters are derived interactively.

## Locating by back projection

Location grids can be defined to search for events by back projection. Phase type and custom traveltimes can be chosen. The semblance is the considered measure of waveform coherency and the likelihood of an event on the grid. Where the semblance is highest the event location is defined. The resulting detection contains the source origin and the pick time measured on the beam.

#### **TECHNOLOGY**

LAMBDA is the new innovative automatic and interactive array processing software developed by gempa for local, regional and teleseismic array processing. It allows to detect weak signals and to identify the source location.

The interactive GUI provides array configuration by selecting stations on a map or from tables and full control over the all array processing parameters. The final settings are stored for further use in profiles. They include array configuration, slowness range, filter bands etc. The generated profiles can be applied to automatic array processing.

Spectral waveform analysis as Fourier spectrum plots and spectrogram views simplify the determination of optimal frequency bands.

The direction and the slowness of waves arriving at the array are estimated by F-K analysis or beampacking or PMCC, by plane-wave inversion of phase picks at the array elements or by polarization analysis of 3C stations. By waveform stacking the signal-to-noise ratio is optimized and even weak signals are detected.

By back projection waveforms are stacked along travel-time curves from potential sources which are simultaneously located.

Connected to SeisComP the LAMBDA sends the picks to the messaging system along with their time, backazimuth and slowness information as well as the derived origins for further automatic or manual processing.