# Beam-forming Tutorial

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Before our journey of Beam-forming, some basic principles of it are necessary, see material from article *ARRAY SEISMOLOGY:METHOD AND APPLICATIONS* by *Sebastian Rost* and *Christine Thomas*, 2002.

**1. Prepare your SAC format data, but note that header variations of SAC file: stlo(longitude of station) stla(latitude of station) are valid;**

**2. Just run executable program beamforing with arguments as below,**

```
beamforming sacfile.lst t1 t2  fre_low fre_high slow_low slow_high slow_step baz_step outputfile
```

| | |
|---|---|
| **<t1>** | Beginning time of inputting SAC files |
| **<t2>** | Ending time of inputting SAC files |
| **<sacfile.lst>** | File containing inputting SAC files |
| **<fre_low>** | Low limitation frequency of bandpass filter |
| **<fre_high>** | High limitation frequency of bandpass filter |
| **<slow_low>** | Low limitation slowness of scanning |
| **<slow_high>** | High limitation slowness of scanning |
| **<slow_step>** | Step slowness length of scanning |
| **<baz_step>** | Step back-azimuth length of scanning |
| **<outputfile>** | Outputting results file containing 3 columns<br>col1: back-azimuth col2: slowness col3: cross-coeffient |

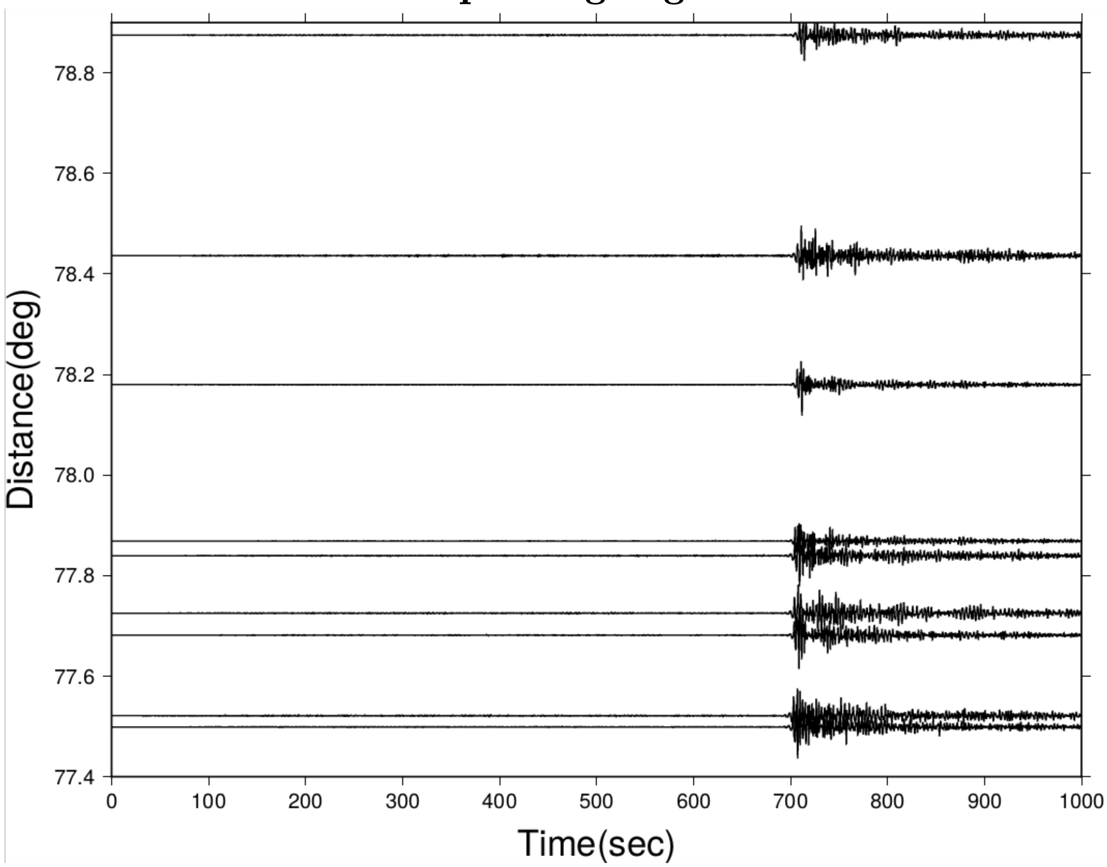
**ATTENTION!!! program runs on Linux platform, actually Fedora 25, SAC (Seismic Analysis Code) with version 101.6a is necessary here!**

**3. plotting script is saved in file "plot.sh", ATTENTION, run "plot.sh" requires GMT(the Generic Mapping Tools), here with version 5.3.1,**

5.2.1 will be OK;

4. Here give an example,

raw SAC format data plotting is given first below




now we get information of this earthquake event:

```
[$]saclst kzdate kztime stlo stla evlo evla evdp gcarc baz f 2011.236.17.46.11.0*.SAC
2011.236.17.46.11.0000.XB.PM05..BHZ.M.SAC   2011/08/24 17:46:11.000     -5.3368    35.2134    -74.538    -7.6203      149.3    77.7252    251.508
2011.236.17.46.11.0000.XB.PM06..BHZ.M.SAC   2011/08/24 17:46:11.000      -5.639    35.3086    -74.538    -7.6203      149.3    77.5211    251.297
2011.236.17.46.11.0000.XB.PM09..BHZ.M.SAC   2011/08/24 17:46:11.000     -5.1145    35.0273    -74.538    -7.6203      149.3    77.8395    251.686
2011.236.17.46.11.0000.XB.PM18..BHZ.M.SAC   2011/08/24 17:46:11.000     -4.8195      34.15    -74.538    -7.6203      149.3    77.7984    252.048
2011.236.17.46.11.0000.XB.PM20..BHZ.M.SAC   2011/08/24 17:46:11.000     -5.0329    33.9064    -74.538    -7.6203      149.3    77.5548    251.968
2011.236.17.46.11.0000.XB.PM21..BHZ.M.SAC   2011/08/24 17:46:11.000     -5.3197    33.7205    -74.538    -7.6203      149.3    77.2702    251.832
2011.236.17.46.11.0001.XB.PM15..BHZ.M.SAC   2011/08/24 17:46:11.000     -4.6997    34.4694    -74.538    -7.6203      149.3    77.9909    252.057
2011.236.17.46.11.0200.XB.PM12..BHZ.M.SAC   2011/08/24 17:46:11.020     -4.6084    34.8505    -74.538    -7.6203      149.3    78.1797    252.037
```

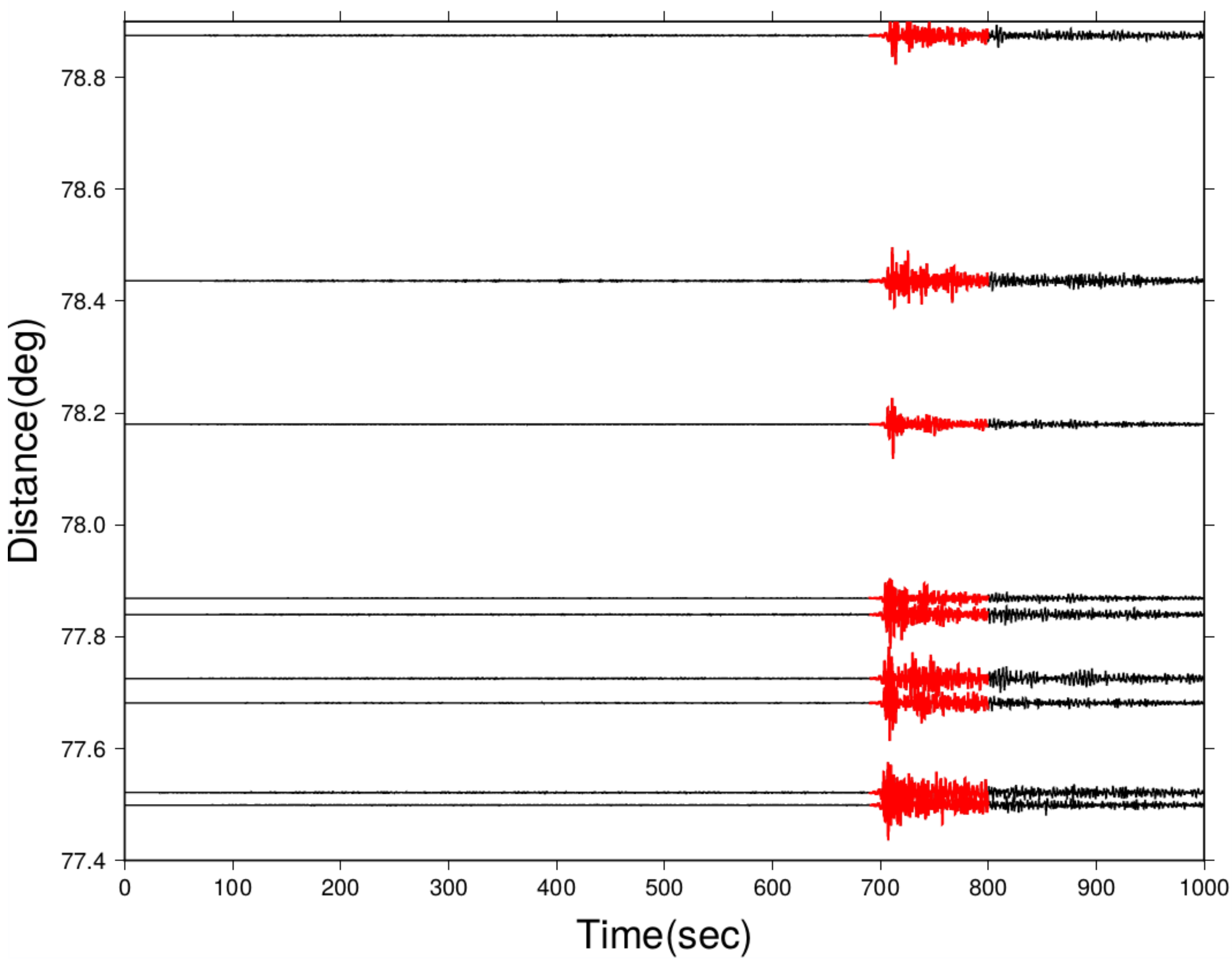
then calculate predicted information of what seismic phase we are interested, here PcP, directed P, maybe there arrival times are not really divergent.

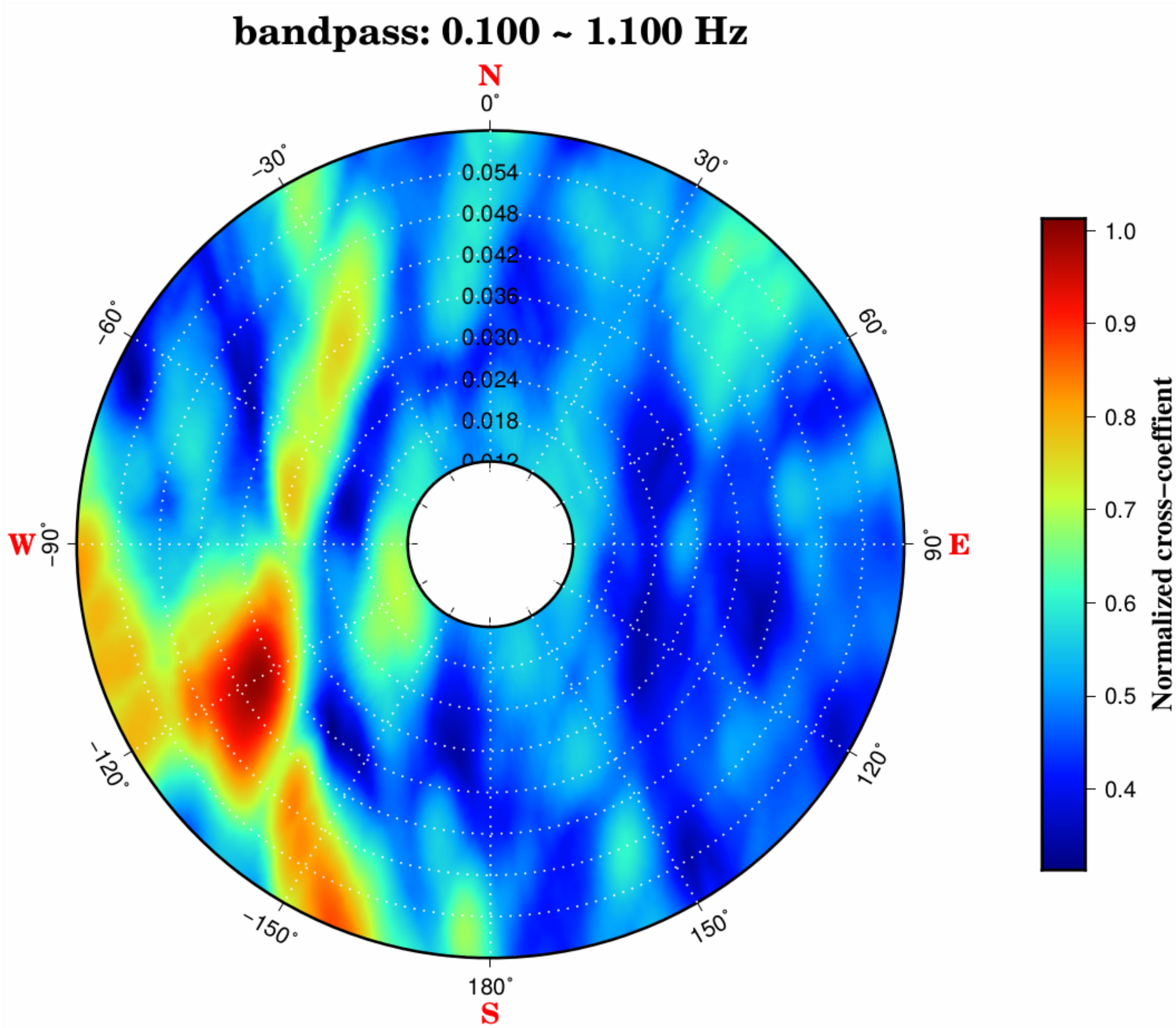
```
[$]taup_time -h 149.3 -deg 77.8 -mod prem

Model: prem
Distance   Depth   Phase   Travel    Ray Param  Takeoff  Incident  Purist    Purist
  (deg)     (km)   Name    Time (s)  p (s/deg)   (deg)    (deg)   Distance   Name
-----------------------------------------------------------------------------------
   77.80   149.3   P        699.72     5.511     24.06    16.71    77.80   = P
   77.80   149.3   PcP      708.84     4.331     18.69    13.06    77.80   = PcP
   77.80   149.3   pP       735.51     5.598    155.53    16.98    77.80   = pP
   77.80   149.3   PKiKP   1036.17     1.525      6.48     4.56    77.80   = PKiKP
   77.80   149.3   S       1280.67    10.685     25.93    17.91    77.80   = S
   77.80   149.3   SKS     1298.08     7.051     16.77    11.71    77.80   = SKS
   77.80   149.3   ScS     1305.61     8.113     19.39    13.50    77.80   = ScS
   77.80   149.3   sS      1344.31    10.838    153.67    18.17    77.80   = sS
   77.80   149.3   SKiKS   1451.99     1.638      3.84     2.70    77.80   = SKiKS
```

**now we execute beam-forming, and result is visualized below,**

**beamforming listfile 690 800 0.1 1.1 0 0.06 0.001 1 out.txt**






**Result reveals the back-azimuth is 248 degree, which is near to realistic 251 or 252 degree. And the horizontal slowness is 0.039 sec/km namely 4.3366 sec/degree, which indicates the seismic phase PcP.**