Development of a TBB trigger from Crabs Giant Pulses

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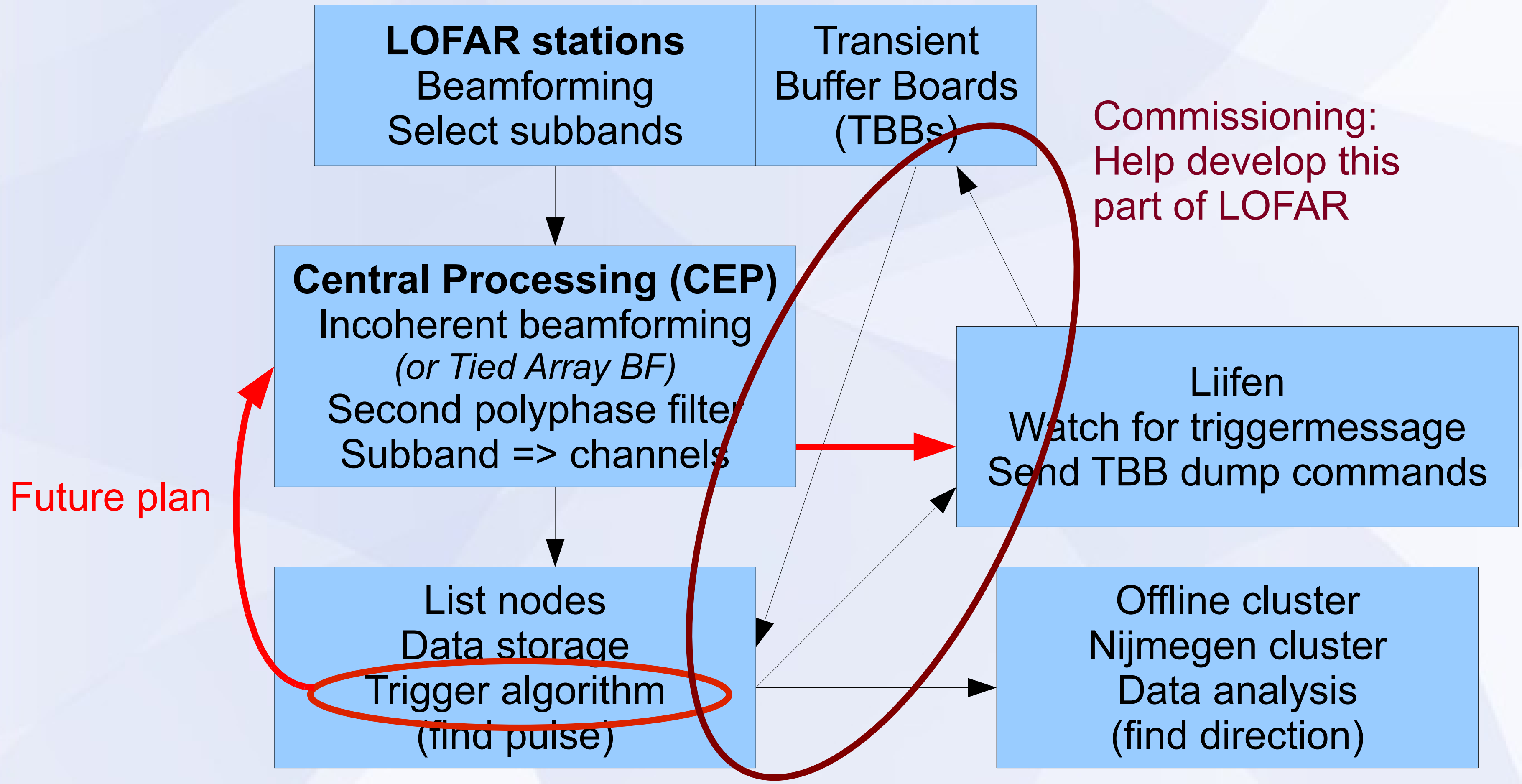
Science goal

- Search for astrophysical fast transients
    - Sub-second
    - Bright
    - (Quasi-) Non-periodic (One time events)
    - Rare (large FOV, long observation time)
- What are they (pulse shape)
- Where are they (position)

Development of a TBB trigger from Crabs Giant Pulses

- Method:
  - Find flash in incoherent beam
    - large FOV
    - Piggyback mode
  - Dump TBB information
    - determine position
- Test source for trigger development
  - Giant Pulses from the Crab pulsar

Observation diagram



Properties Crab pulsar

- In Crab Nebula (high background)
- Period 33.085 ms
- Dispersion measure 56.8 pc cm^{-3}
- 9 pulses per hour >10 kJy (Bhat et al. 2008, 200MHz)
- LOFAR 1 station S.E.F.D. 3.5 kJy @ Crab

LOFAR limitations

- Detect a pulse in one subband (CEP mode)
- Coincidence trigger on multiple SB
- Simple (piggyback mode)
- RFI proof (don't waste time on something wrong)
- At most few triggers/hour (TBB dump time)

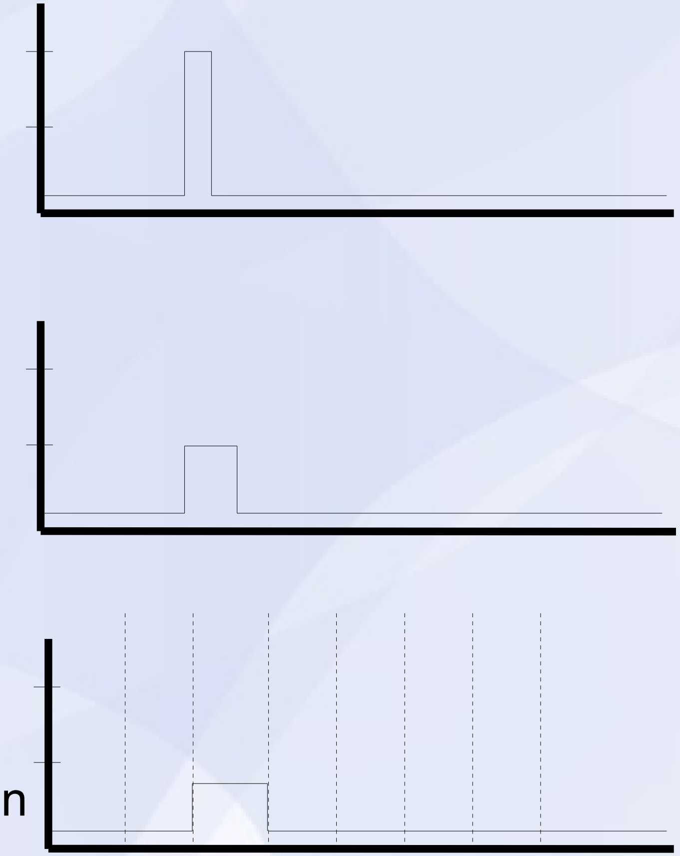
  (only find the most interesting pulses out there)

Dispersion: Smearing vs resolution

Signal

Dispersion smearing

Limited timeresolution



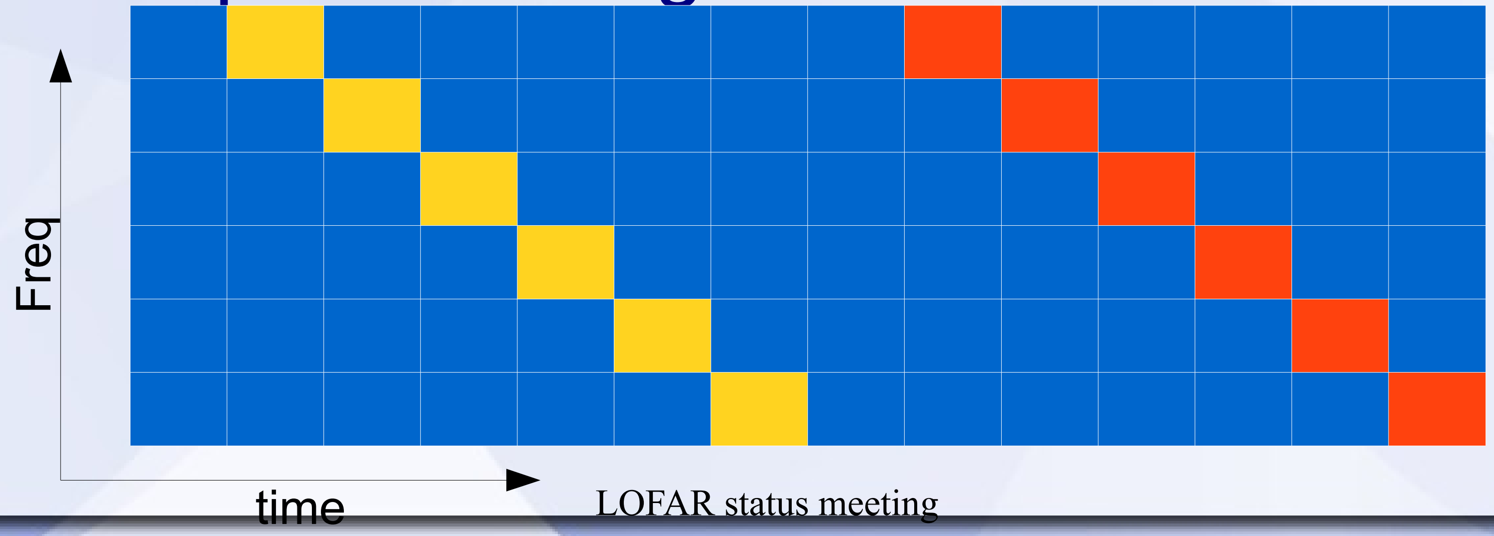
$$\Delta t_{DM} = 8.3\mu s DM \Delta\nu_{MHz}\nu_{GHz}^{-3}$$

Smearing vs time resolution 200 Mhz, DM=56.8		
Bandwidth	Dispersive smearing	Time resolution
2 kHz	118 us	500 us
4 kHz	235 us	250 us
8 kHz	470 us	125 us
16 kHz	940 us	68 us
32 kHz	1880 us	34 us

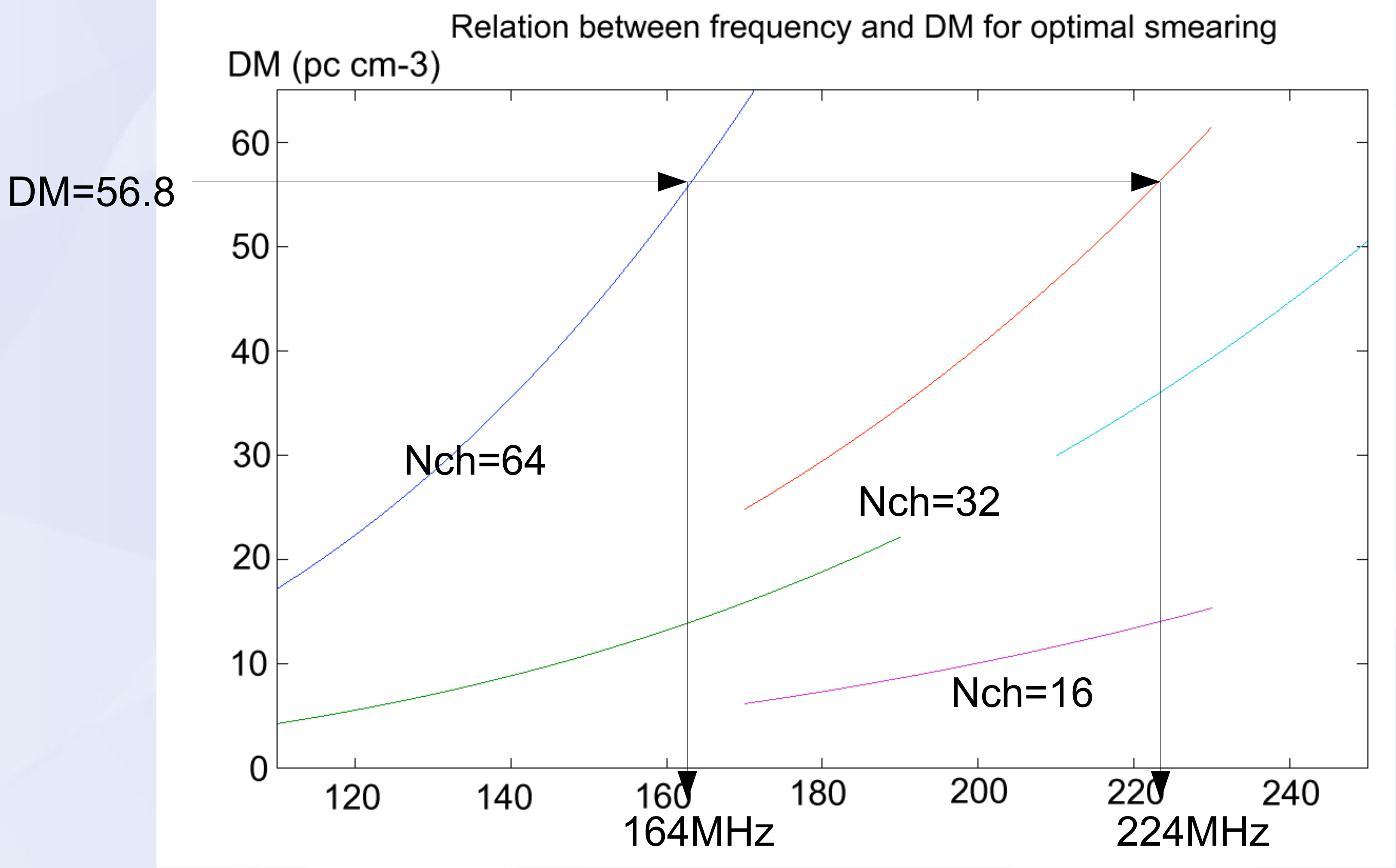
Limited timeresolution gives the same signal, whether it's smeared or not.

De-dispersion

- If frequency and bandwidth at optimal smearing, the signal goes as
  - 1 timestep forward
  - 1 frequency channel lower
- De-dispersion: diagonal sum



Dispersion: Optimal smearing

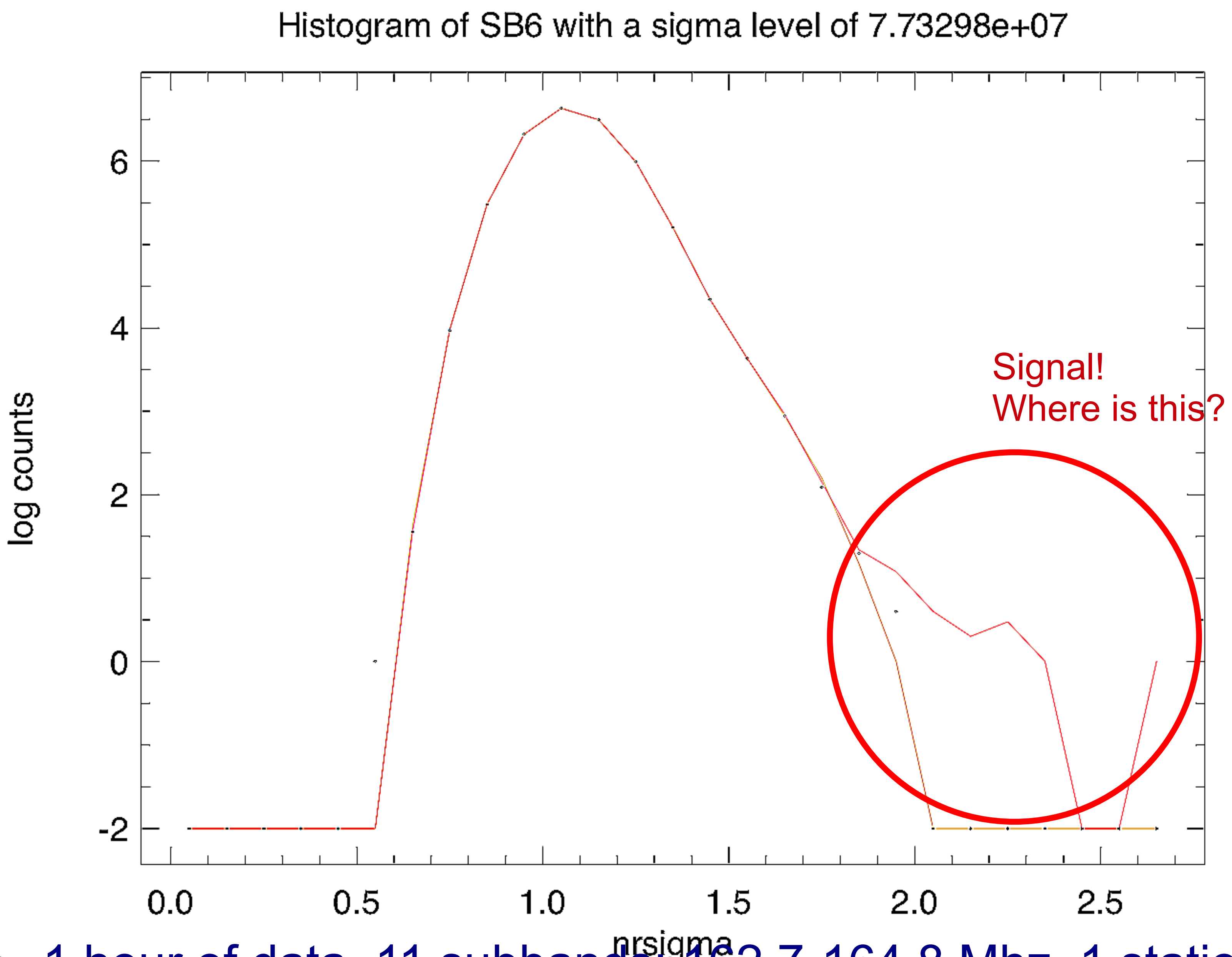


Trigger algorithm (simple)

- Take a SB around 164 Mhz and divide it into 64 channels
- Summing over the channels for 1 timestep gives the background
- Summing diagonally gives the signal
- If the diagonal sum is way out of the expected range, it counts as a signal
- One station should be sensitive enough

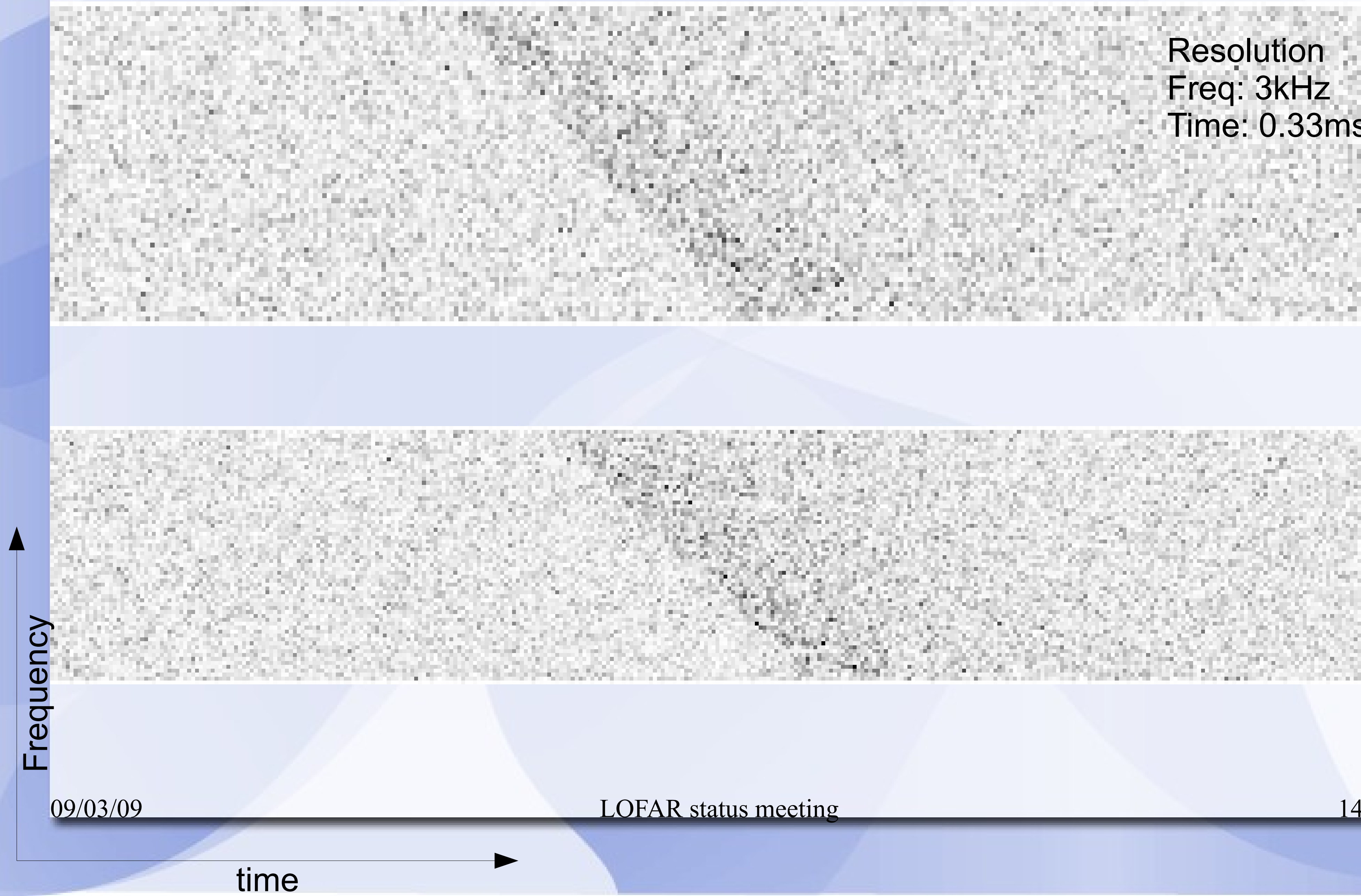
- Theory looks fine, but does it work?

- Observation to test/develop trigger:
  - 1 station
  - 1 hour
  - 11 subbands 162.7-164.8 Mhz
  - Split SBs into 64 channels

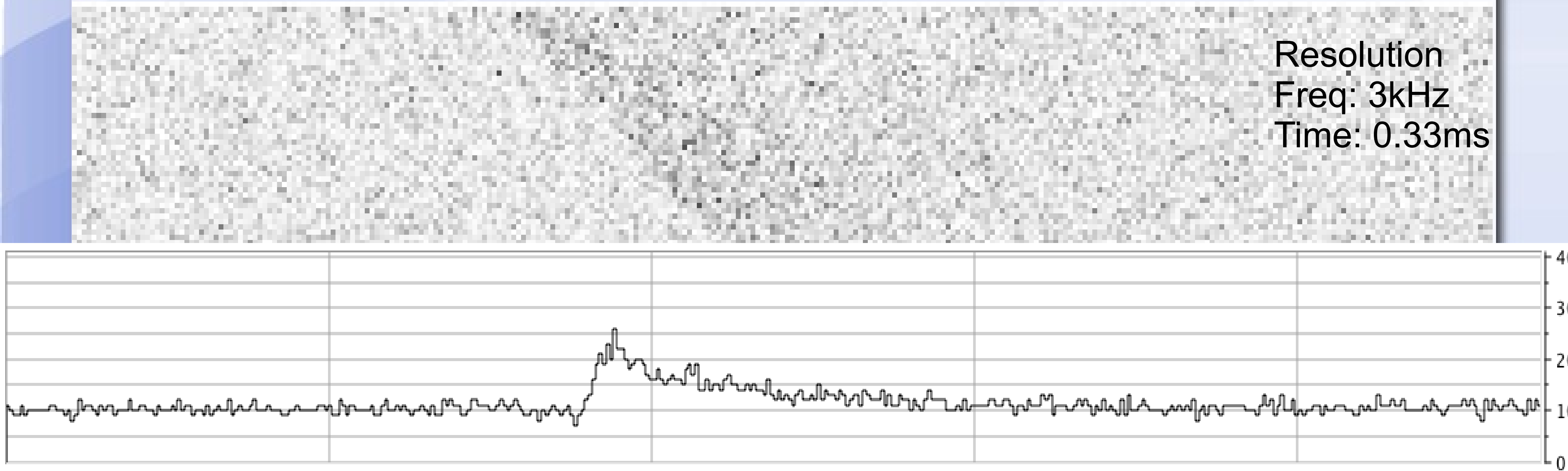


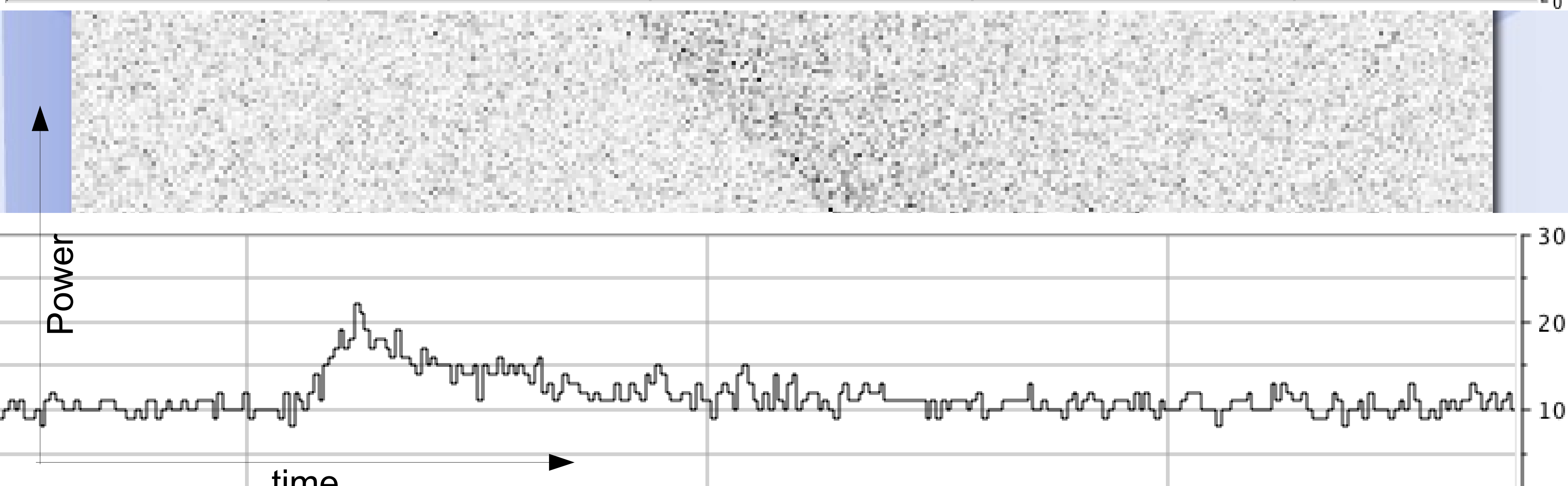
- 1 hour of data, 11 subbands: 162.7-164.8 Mhz, 1 station

2 Giant Pulses found!



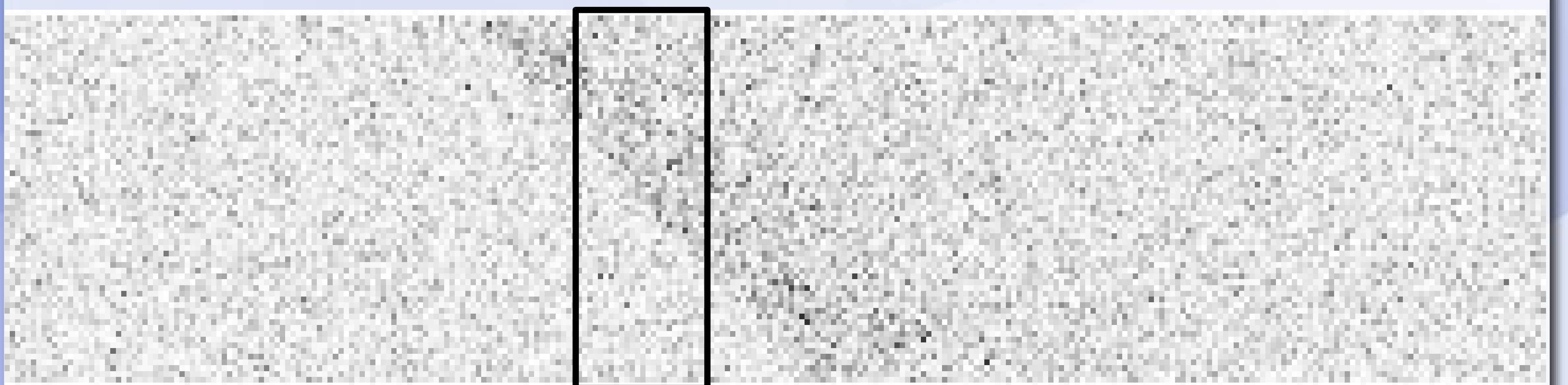
2 Giant Pulses found!





Trigger algorithm (advanced)

- Average over 20 timesteps
- Relatively lower threshold



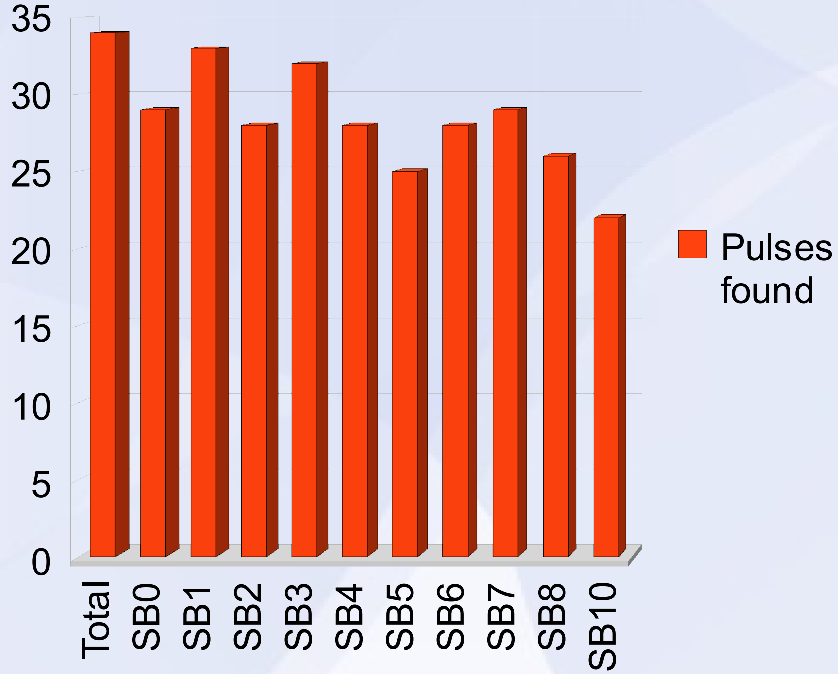
  - # consecutive above threshold
  - Coincidence among minimum #SB

Trigger algorithm (advanced)

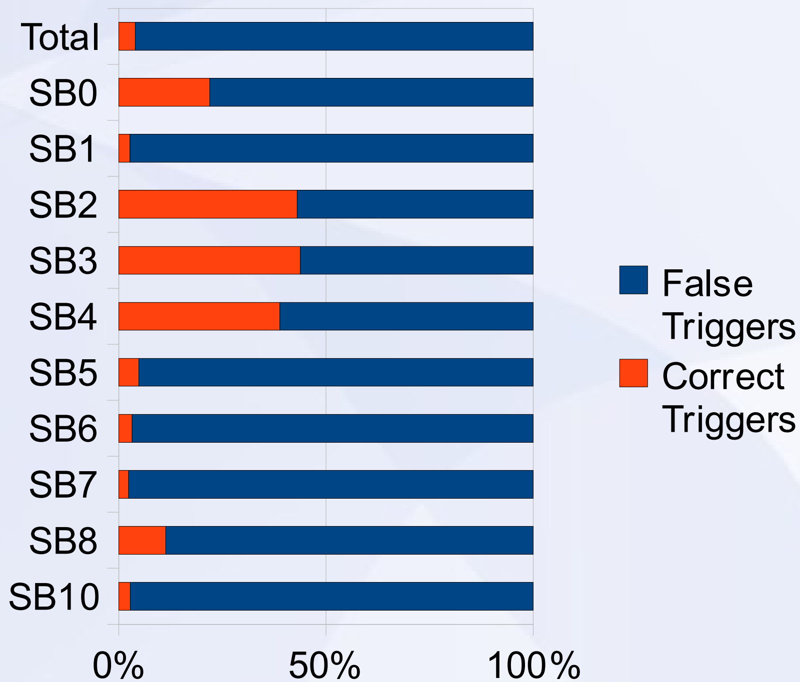
- Average over 20 timesteps
- Relatively lower threshold
- Count how many steps above threshold
- Coincidence check over subbands
- Three trigger variables:
  - Threshold
  - # consecutive above threshold
  - Coincidence among minimum #SB

Trigger algorithm (advanced)

- Parameters: Length≥10, Subbands ≥ 4
- Pulses found: 34 (15 showed in all SBs)

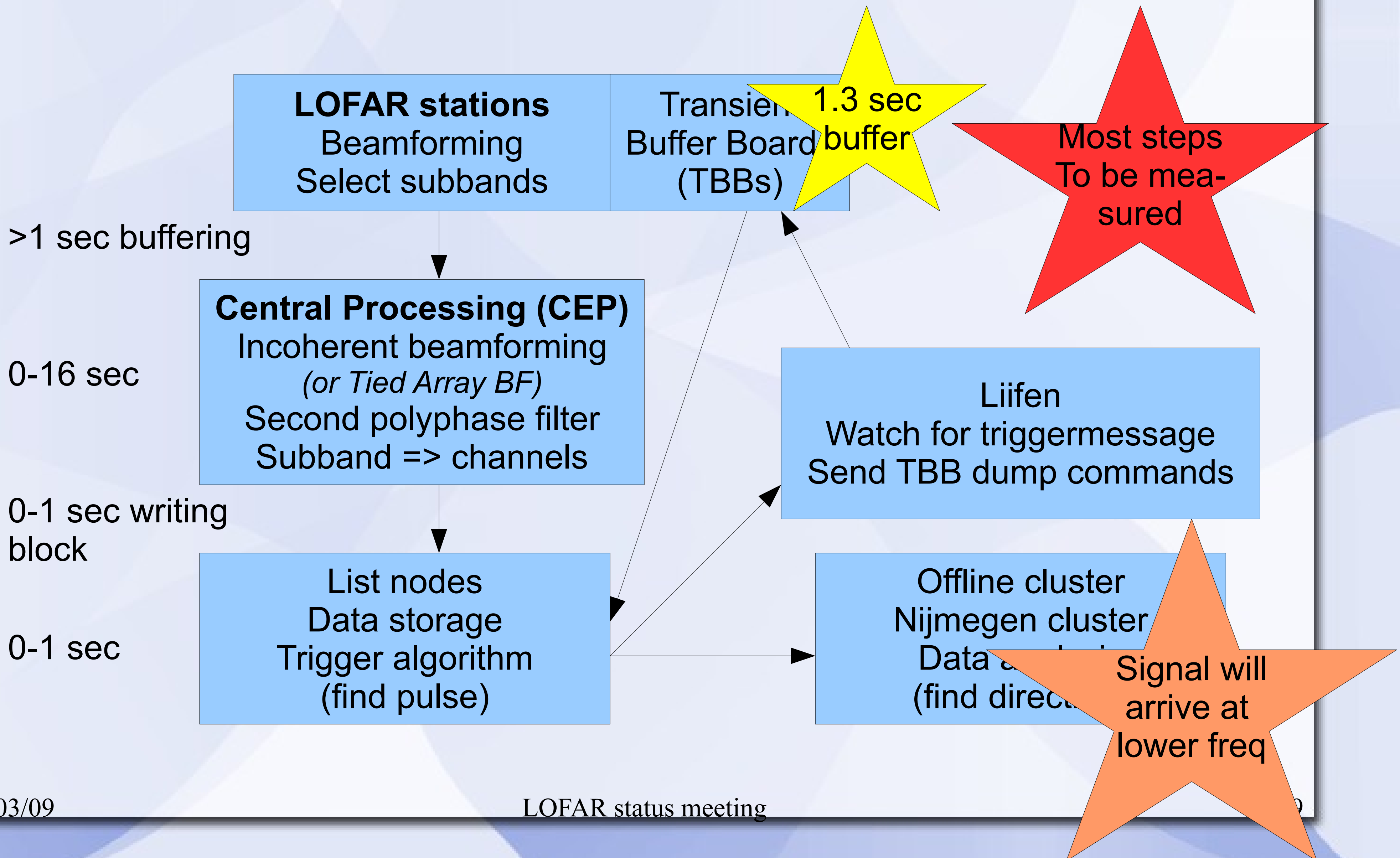


Pulses found in each subband



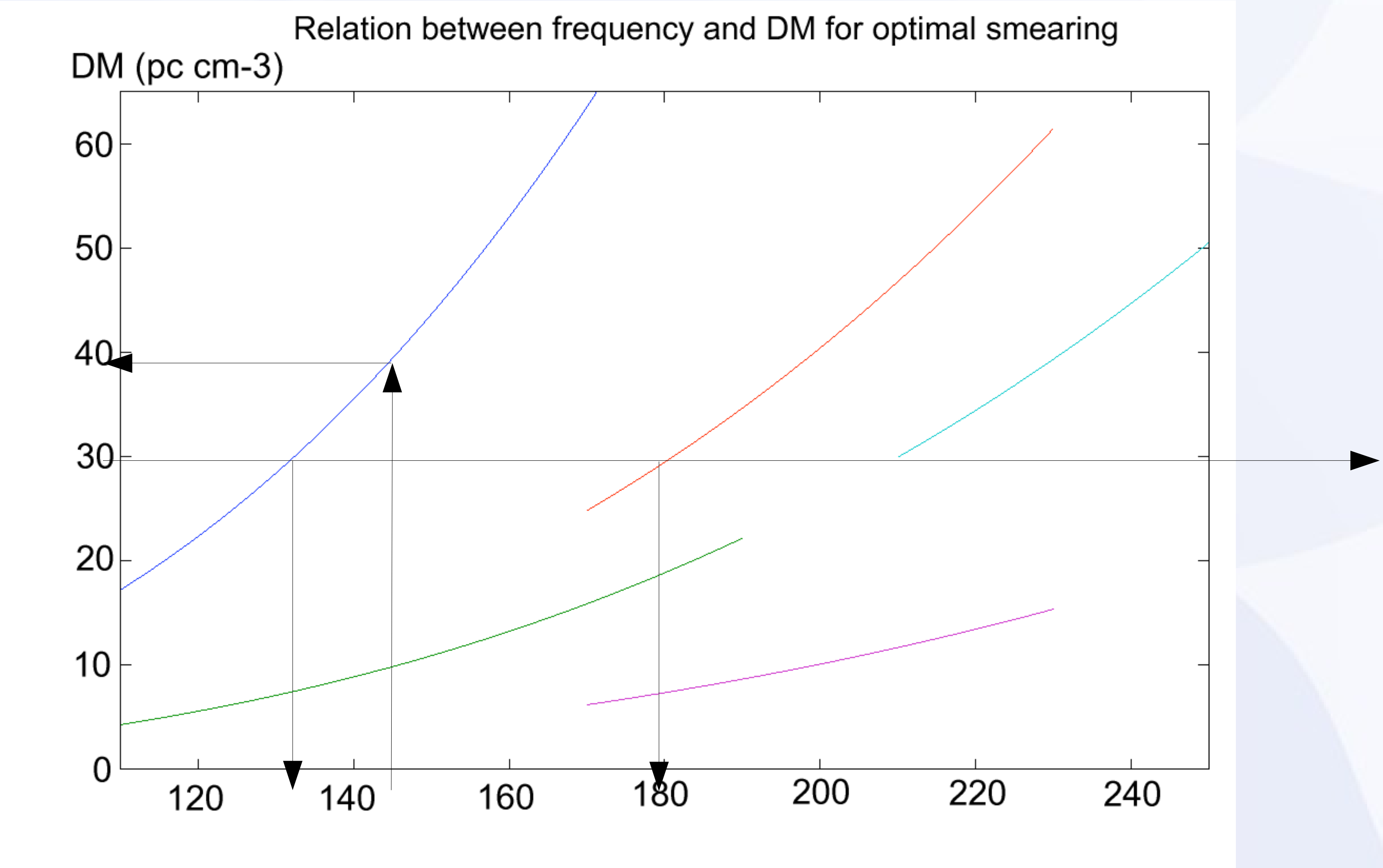
Percentage of real vs false trigger

Time delay



LOFAR stations
Beamforming
Select subbands
Transien
Buffer Board
(TBBs)
1.3 sec
buffer
Most steps
To be mea-
sured
>1 sec buffering
Central Processing (CEP)
Incoherent beamforming
(or Tied Array BF)
Second polyphase filter
Subband => channels
0-16 sec
Liifen
Watch for triggermessage
Send TBB dump commands
0-1 sec writing
block
List nodes
Data storage
Trigger algorithm
(find pulse)
0-1 sec
Offline cluster
Nijmegen cluster
Data a
(find direc
Signal will
arrive at
lower freq

Find other pulses



Conclusion

- The most giant pulses from Crab can be detected using a single LOFAR station and just a few subbands
- The TBB boards can be dumped for this event to determine the origin more exact with multiple stations
- Development still needed on real time trigger
  - Best method
  - Coincidence detection
  - Unbiased (Running average etc)