Testing external transient buffer boards triggers from the 100m Effelsberg telescope

Sander Ter Veen

Leon Houben, Jörg Rachen, Laura Spitler, David Champion
Heino Falcke, Michael Kramer, Emilio Enriquez

Responsive telescope

- LOFAR is a digital telescope
- Flexible
- Use LOFAR to follow-up transients

My favourite transient:
Fast Radio Bursts

- Mysterious highly **dispersed** pulses
- Extragalactic origin?
- Only seen at 1.4 GHz and 800 MHz
  - What is their low frequency emission?
  - Where do they come from?
- No LOFAR detections so far
- Trigger LOFAR on a bursts seen at higher frequencies
- At least one repeating FRB
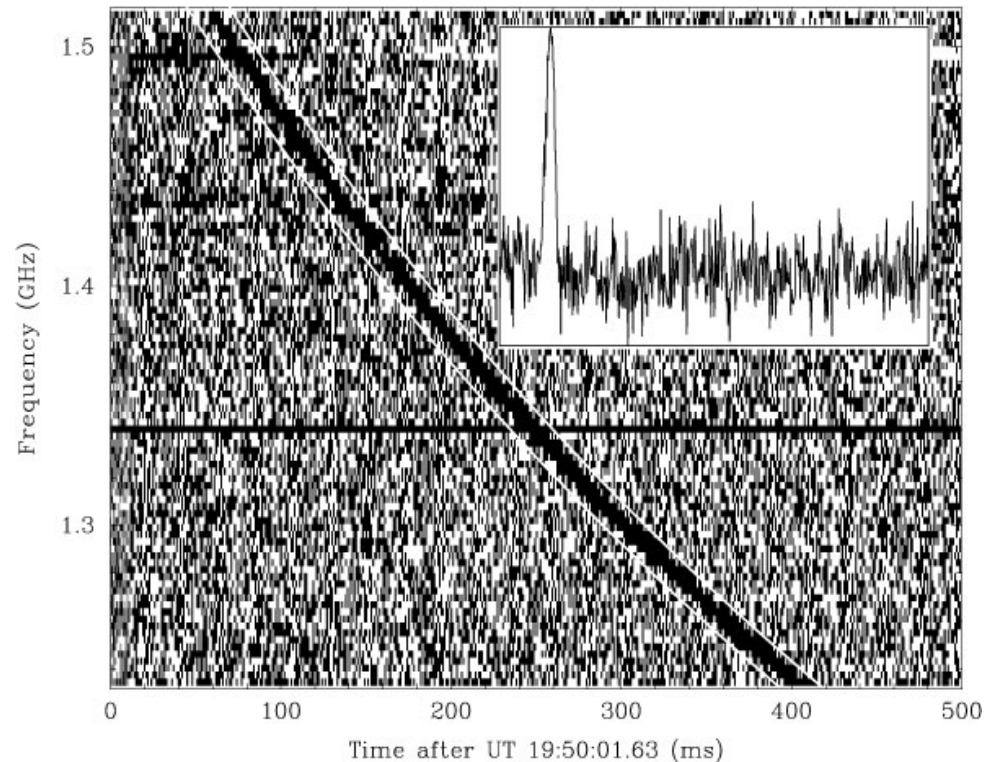
Transient Buffer Board

- Memory for each LOFAR dipole / tile

- Frozen and read-out on an interesting signal

- All-sky capability

- Full timeresolution

- Dual polarisation

HBA All-Sky image from 1 HBA Sub-Array
Image @ 110 MHz, Contours @ 135 MHz
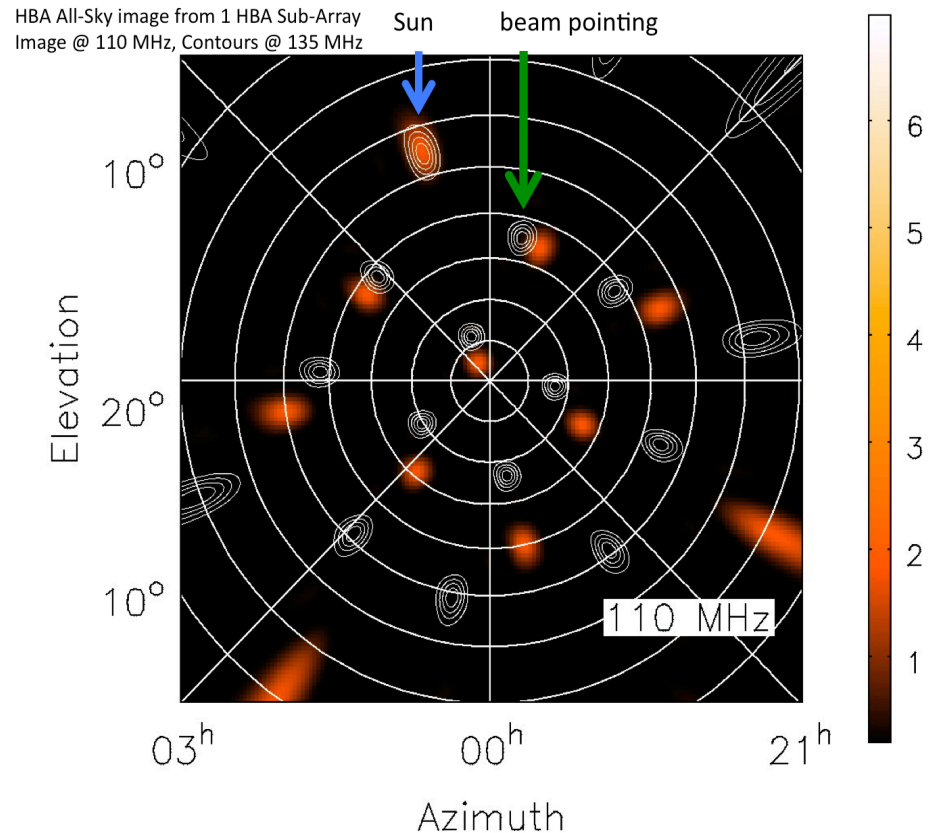
Commissioning test:
Transient Buffer Boards triggered from Effelsberg detection

Effelsberg 100m telescope
High freq detection

LOFAR
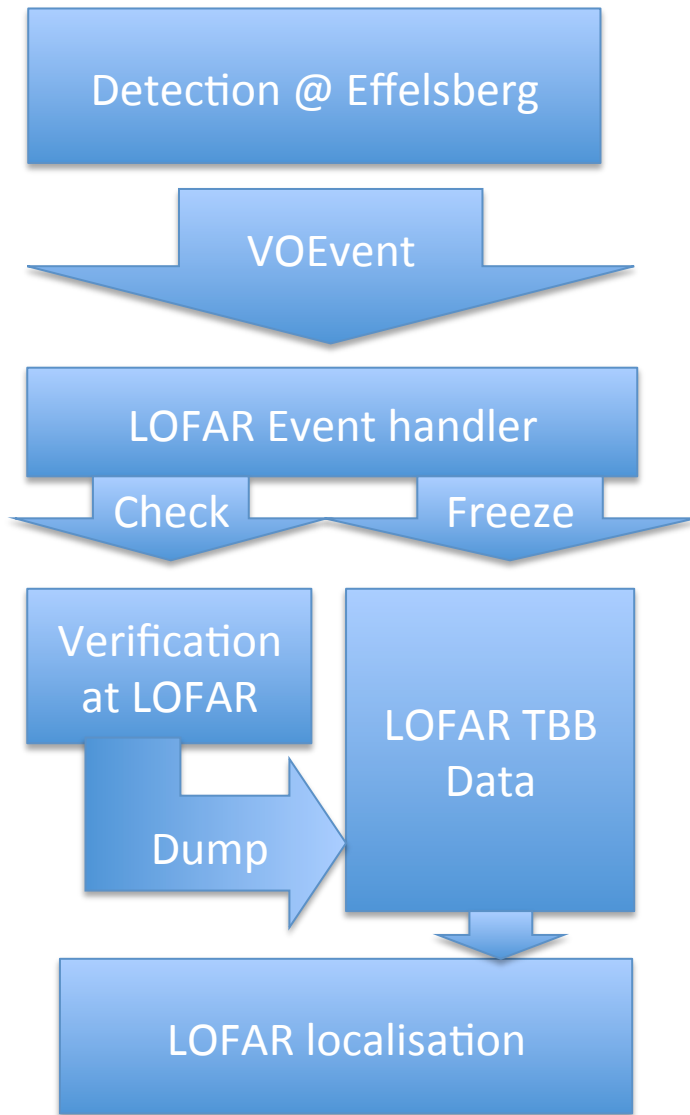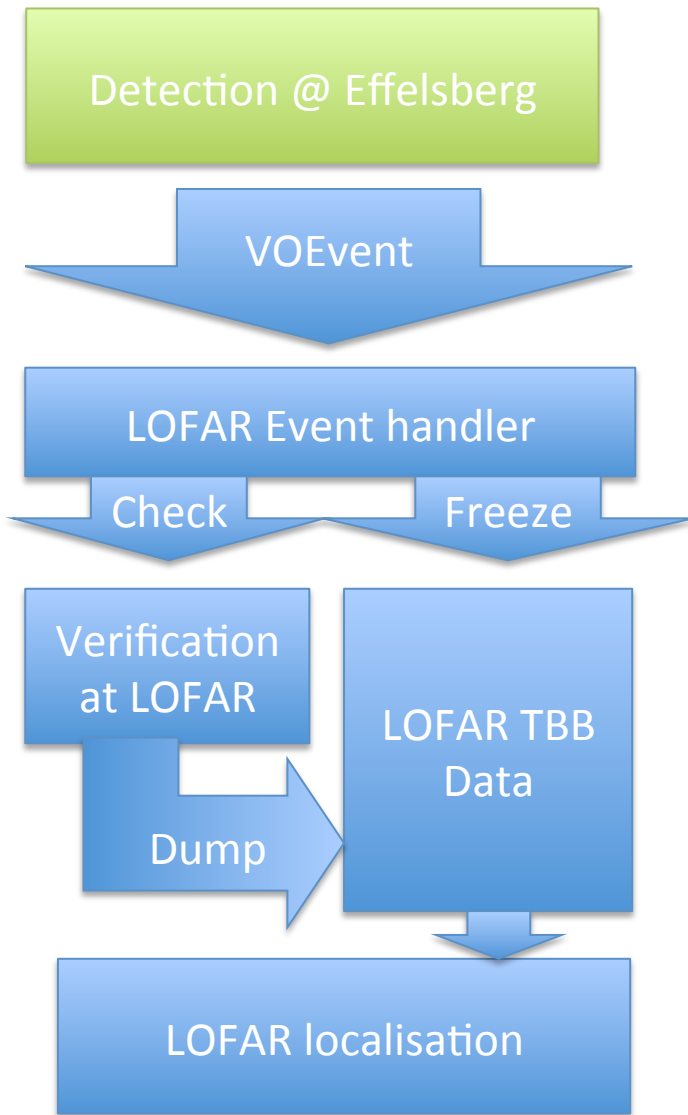Low frequency observation
Localisation

Delay times [s] from 1.3 GHz

DM	250 MHz	190 MHz	150 MHz	110 MHz
141	9	15.9	25.7	48.2
500	32	56	91	170
1000	64	112	182	340

Bandwidth [MHz] in 5 seconds buffer

DM	250 MHz	190 MHz	150 MHz	110 MHz
141	40+	25	15	6
500	17	8	4	2
1000	9	4	2	1

Detection @ Effelsberg

VOEvent

LOFAR Event handler

Check   Freeze

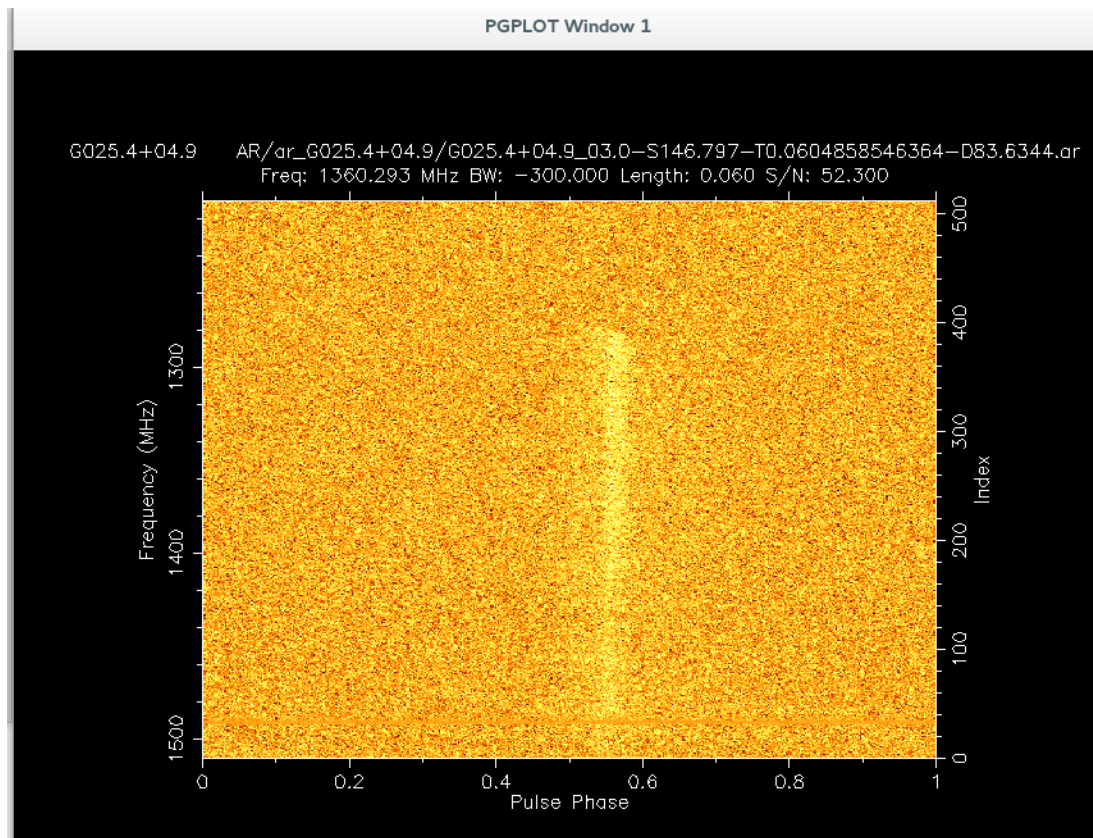Verification
at LOFAR

LOFAR TBB
Data

Dump

LOFAR localisation
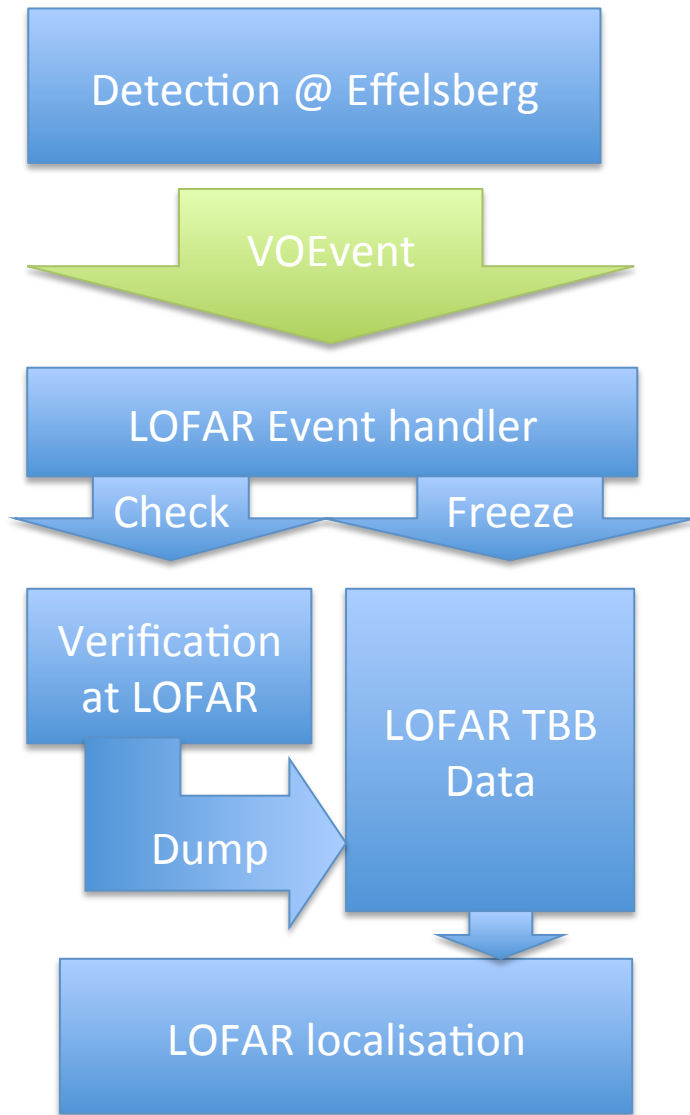
- Running Heimdall, same software that detected Parkes FRBs
- Early test stages
- Manual verification of triggers
- Testing on B2111+46
- DM=141 pc cm^{-3}
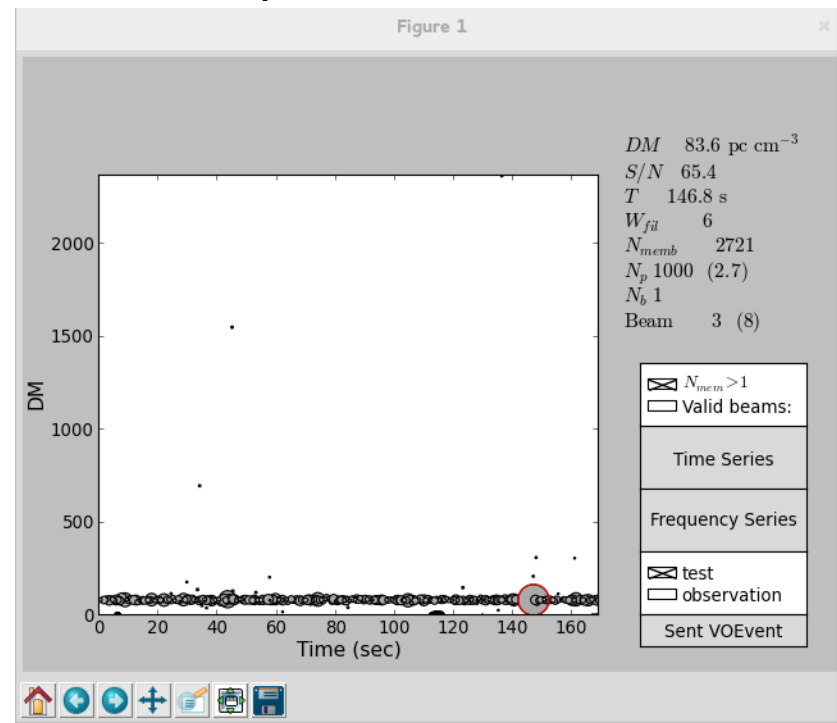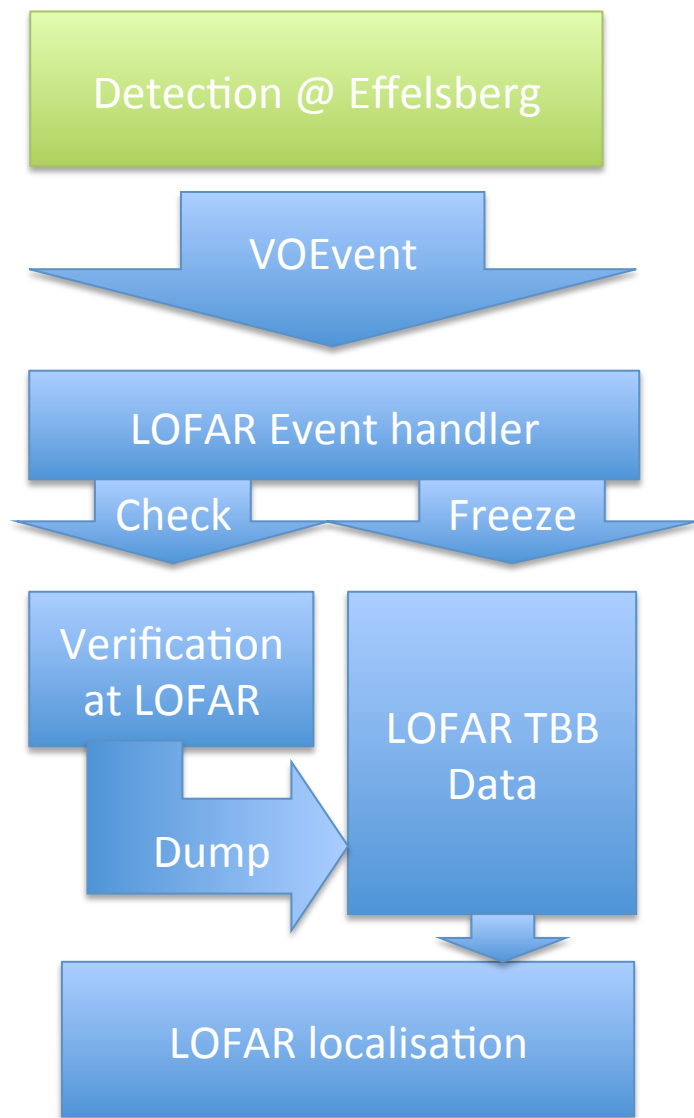
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Detection @ Effelsberg

VOEvent

LOFAR Event handler

Check   Freeze

Verification at LOFAR

LOFAR TBB Data

Dump

LOFAR localisation

- Running Heimdall, same software that detected Parkes FRBs
- Early test stages
- Manual verification of triggers

PGPLOT Window 1

G025.4+04.9   AR/ar_G025.4+04.9/G025.4+04.9_03.0−S146.797−T0.0604858546364−D83.6344.ar
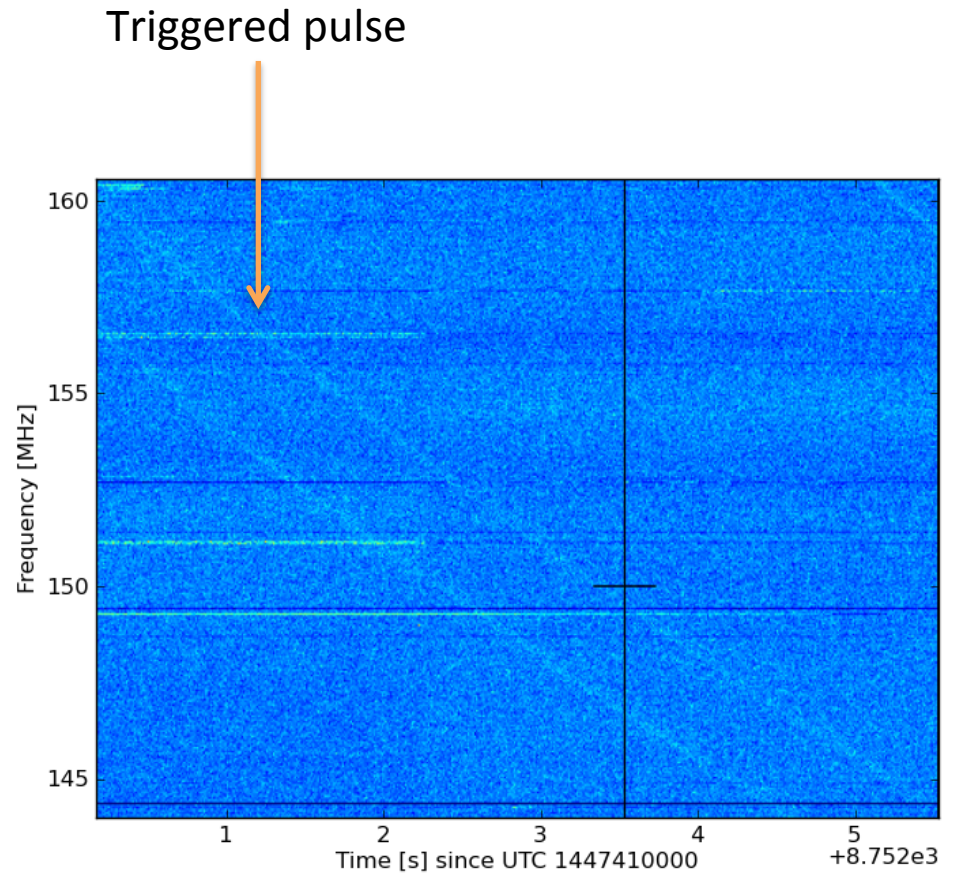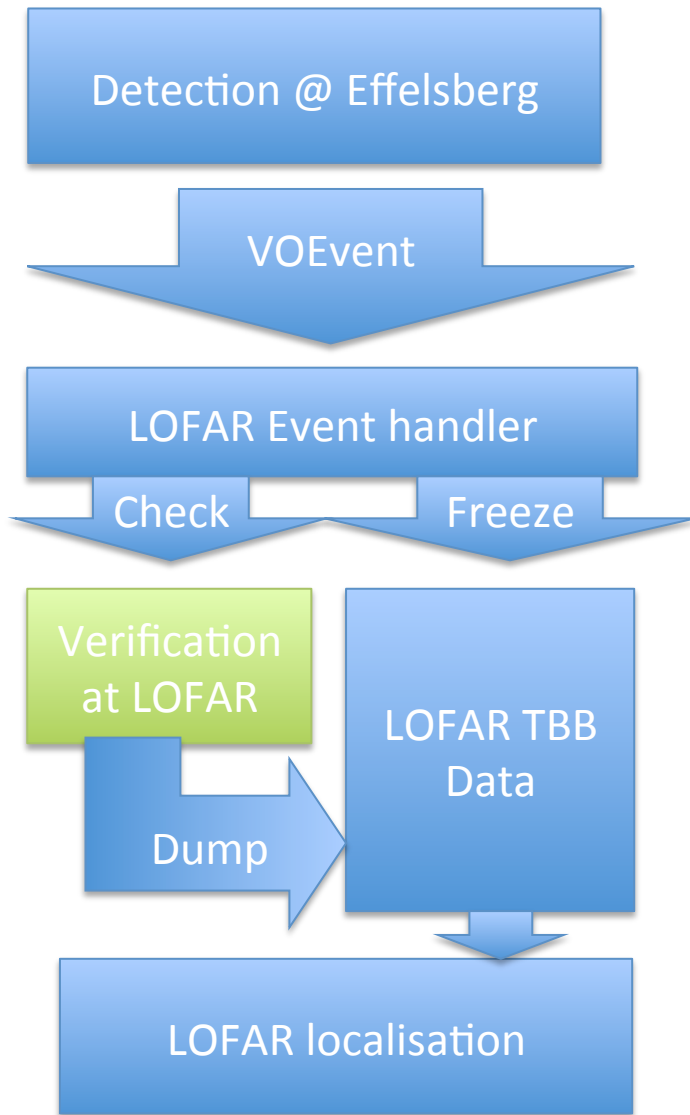Freq: 1360.293 MHz BW: −300.000 Length: 0.060 S/N: 52.300

- VOEvent
  - Communication between observatories for transient follow-up
  - XML message with default and custom parameters
  - Send event time, DM, SNR, observing frequencies **and errors**
  - Position and beamsize
  - Determine stop time based on these parameters
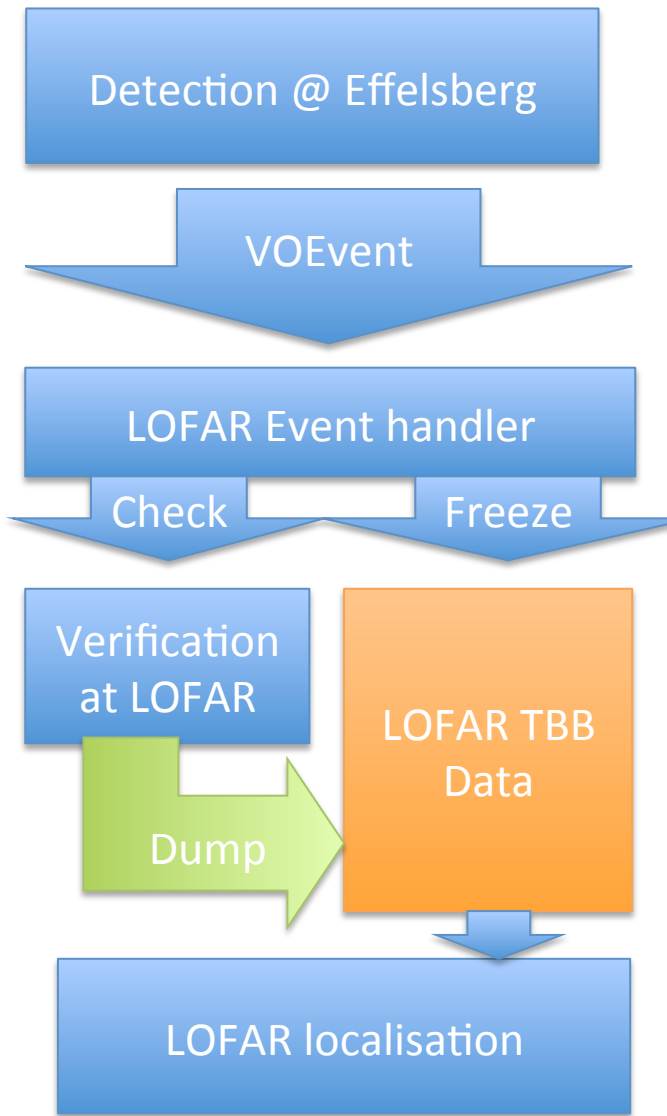 - LOFAR broker subscribed to Effelsberg broker
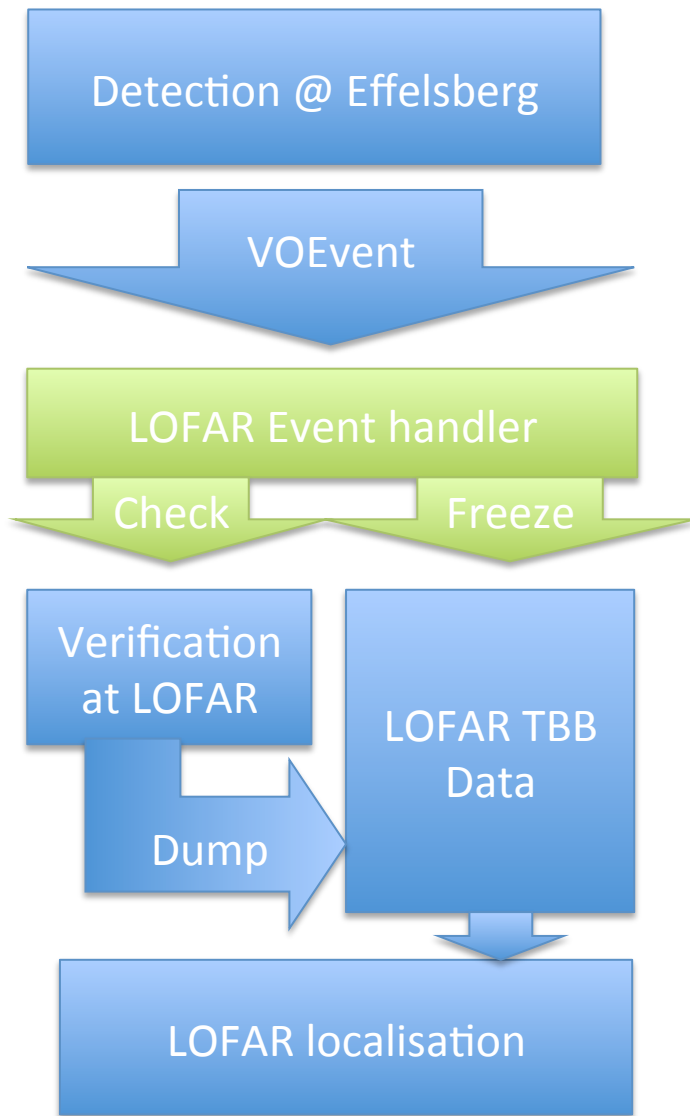
- Calculate time the burst would arrive at LOFAR
- Determine if position is within tile-beam
- Send stop (freeze) command to bufferboards
- Delay time total: 27-36 seconds
  - Calculation Effelsberg (10-12 seconds)
  - Manual verification (20-25 seconds)
  - Communication to LOFAR (10 milliseconds)
  - LOFAR trigger (10 milliseconds)
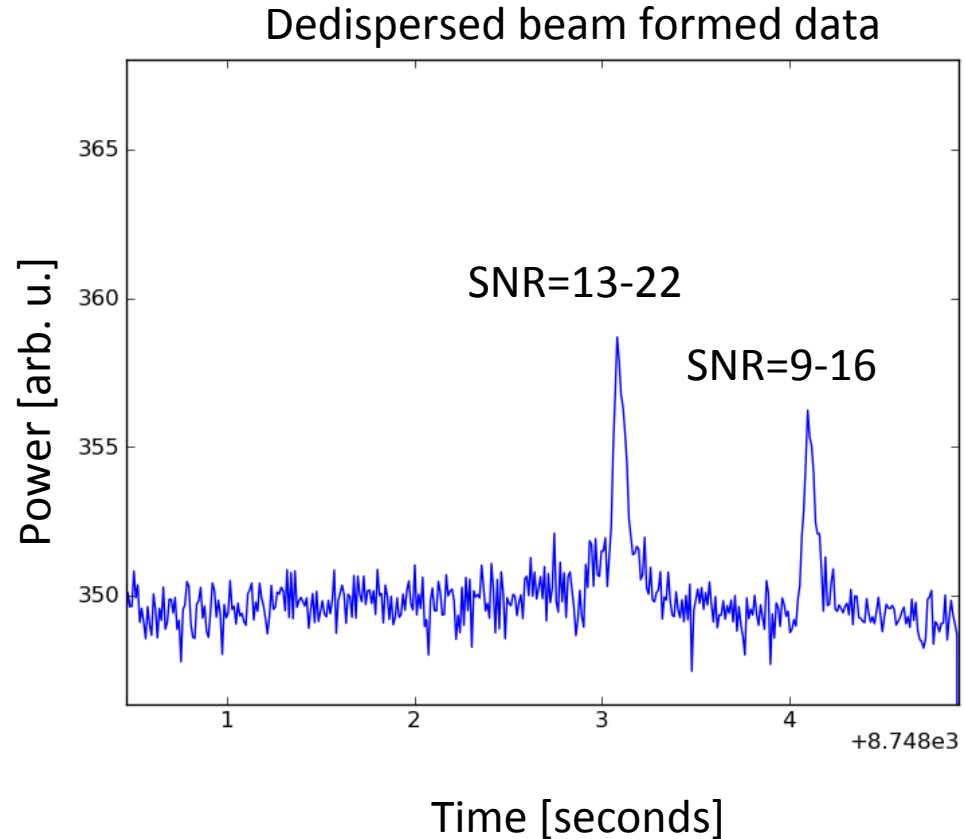 - Record time: 16 seconds

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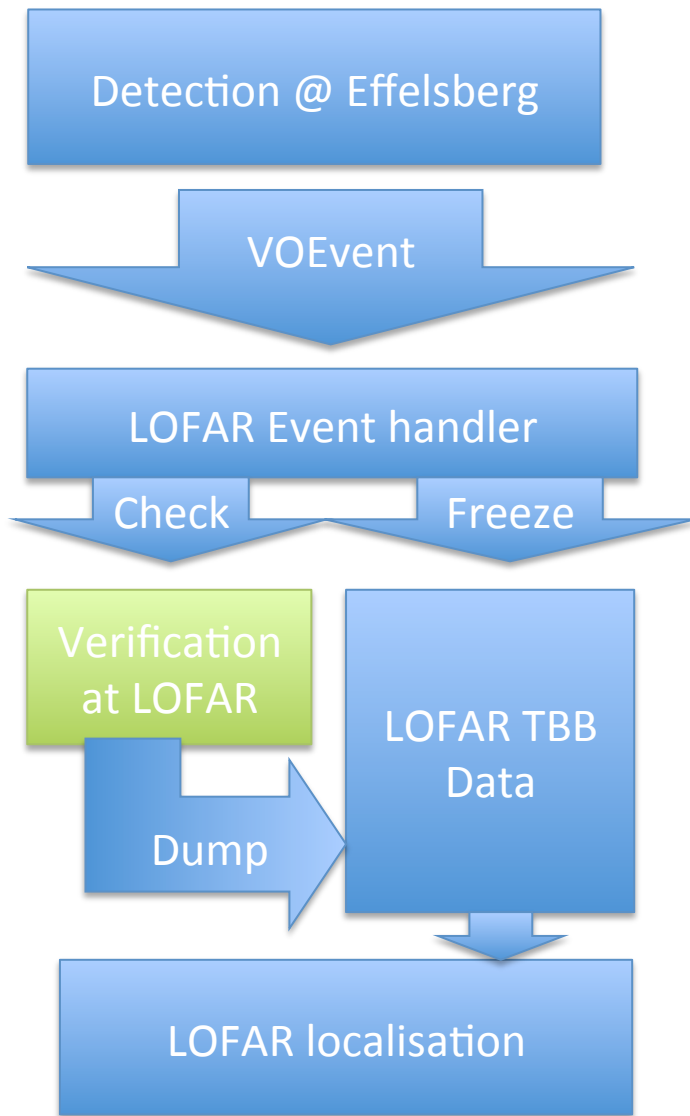
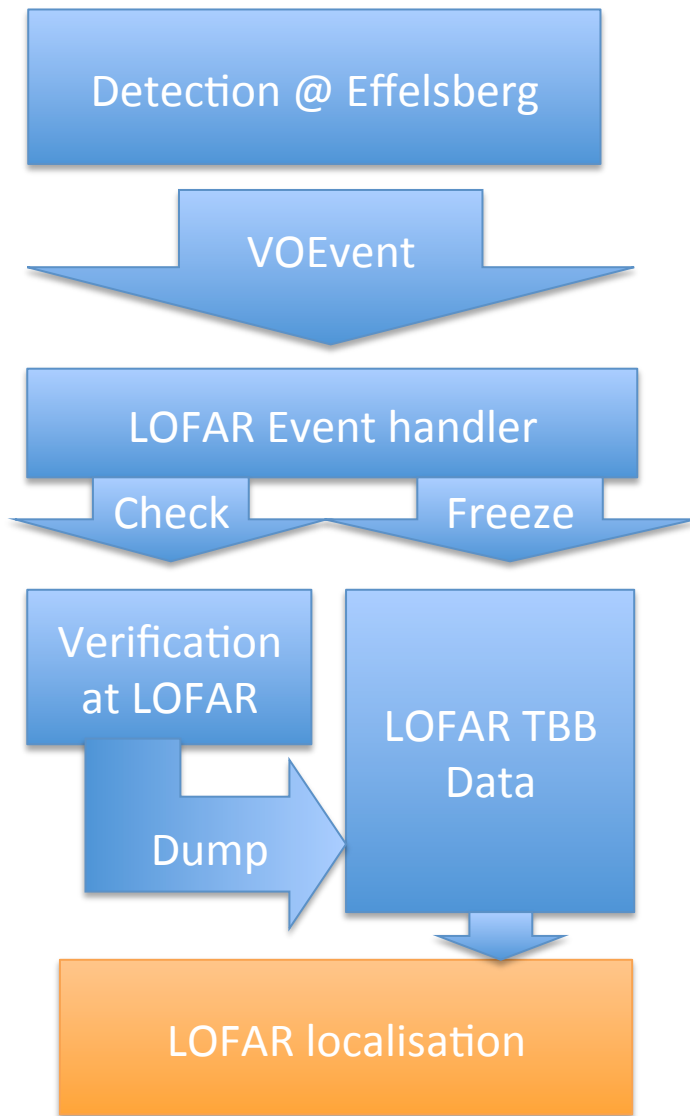- Simultaneous beam formed observations with LOFAR
- Use LOFAR observation to check If pulse is visible
- Check offset between expected / actual time of arrival
  - Offset of 0.1 seconds
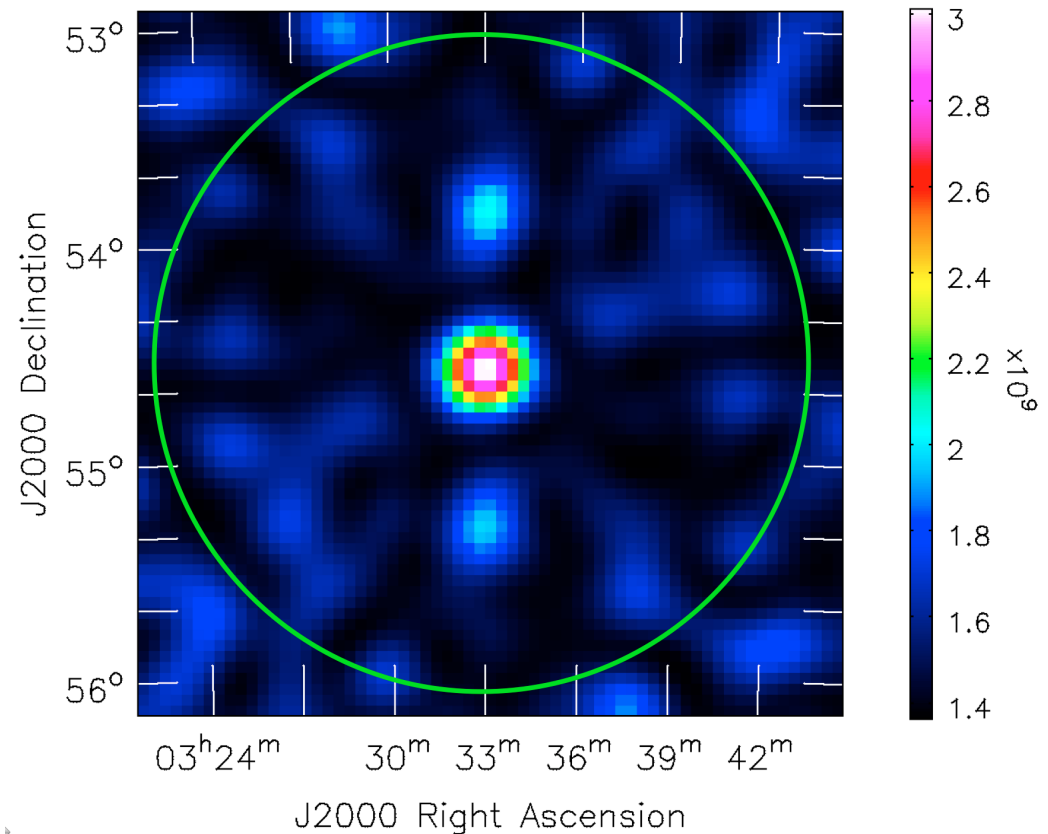 - Time stamp at Effelsberg needs to be verified

Detection @ Effelsberg

VOEvent

LOFAR Event handler

Check   Freeze

Verification
at LOFAR

LOFAR TBB
Data

Dump

LOFAR localisation

Triggered pulse

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Detection @ Effelsberg

VOEvent

LOFAR Event handler

Check   Freeze

Verification at LOFAR

Dump

LOFAR TBB Data

LOFAR localisation

Data taken for two events
TBB data analysis ongoing
From beamformed observation SNR
too low for single station detection

Dedispersed beam formed data

SNR=13-22

SNR=9-16

Power [arb. u.]

365

360

355

350

1   2   3   4

+8.748e3

Time [seconds]

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Detection @ Effelsberg

VOEvent

LOFAR Event handler

Check

Freeze

Verification at LOFAR

LOFAR TBB Data

Dump

LOFAR localisation

- Data analysis ongoing
- Example from B0329+54
  – Superterp only image

Conclusions

- Taken TBB data triggered by the Effelsberg telescope from a pulsar pulse

- First time LOFAR acts as a responsive telescope

- Same pulse detected by LOFAR and Effelsberg

- TBB analysis ongoing