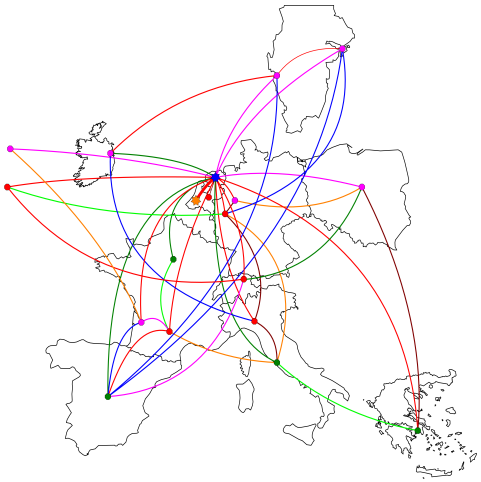
The WBS CCDs as cosmic ray detectors

V. Ossenkopf, KOSMA



HIFI ICC co-location, Groningen,
26-30th March, 2012

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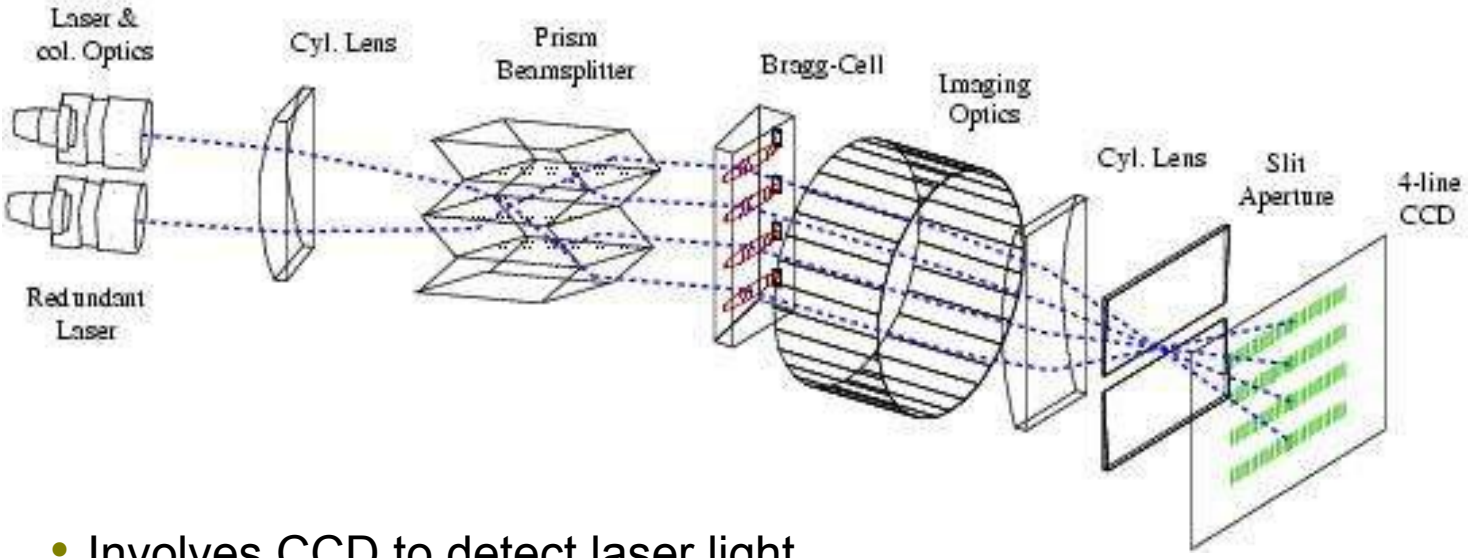
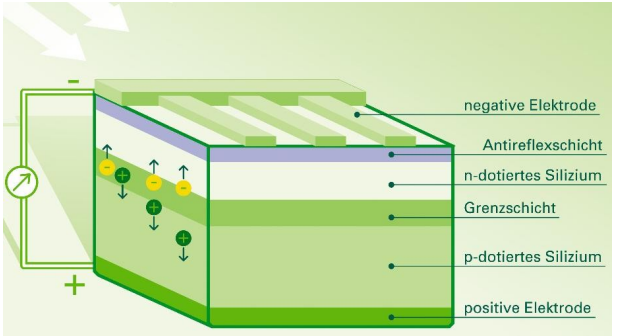
WBS design

WBS is an acusto-**OPTICAL** spectrometer



- Involves CCD to detect laser light
- Always also susceptible to any other radiation producing electron-hole pairs
  - False detections
  - Permanent damage



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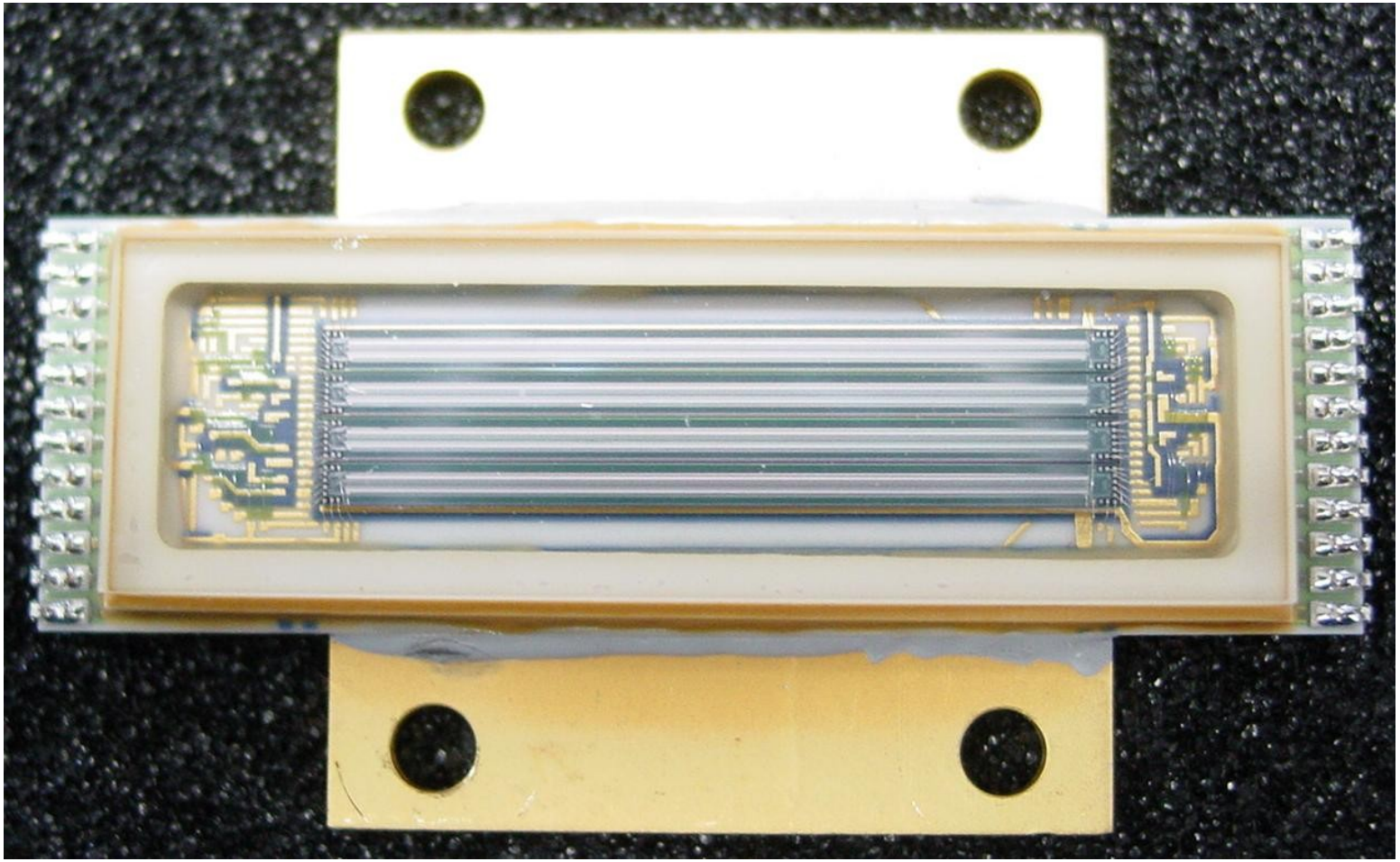
CCD structure



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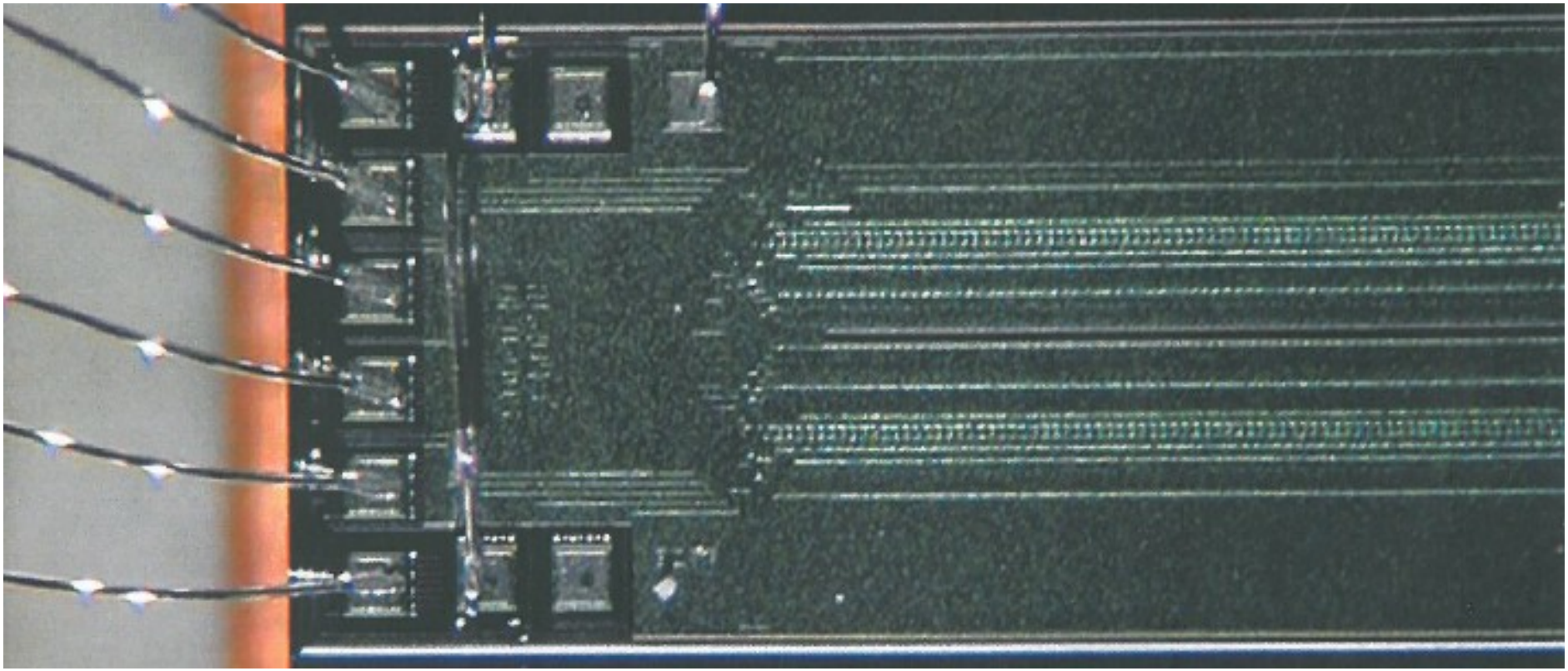
CCD structure



Indiviual CCD subband

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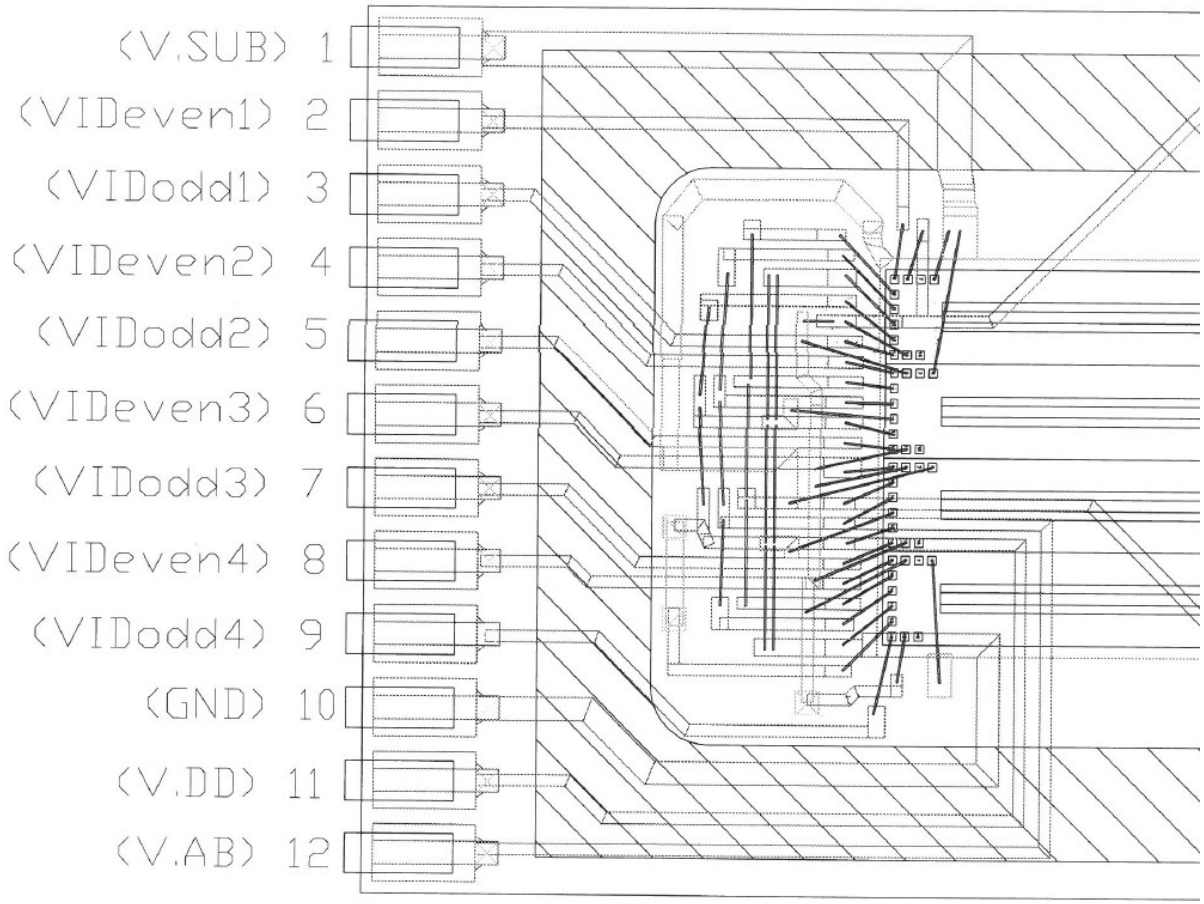
CCD structure



» Seperate readout lines for even and odd channels implemented as shift register

» Made from same GaAs as detector channels

» Covered by paint like dark pixels

→ Susceptive to CR hits like detector pixels

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Previous investigations

- Analysis of dark spectra
  - Measured after laser switch off in every HIFI cycle
  - Measured in QSFT
- Permanent damage should produce different response
  - Nothing seen in analysis from launch to spring 2011
  - No further analysis since then

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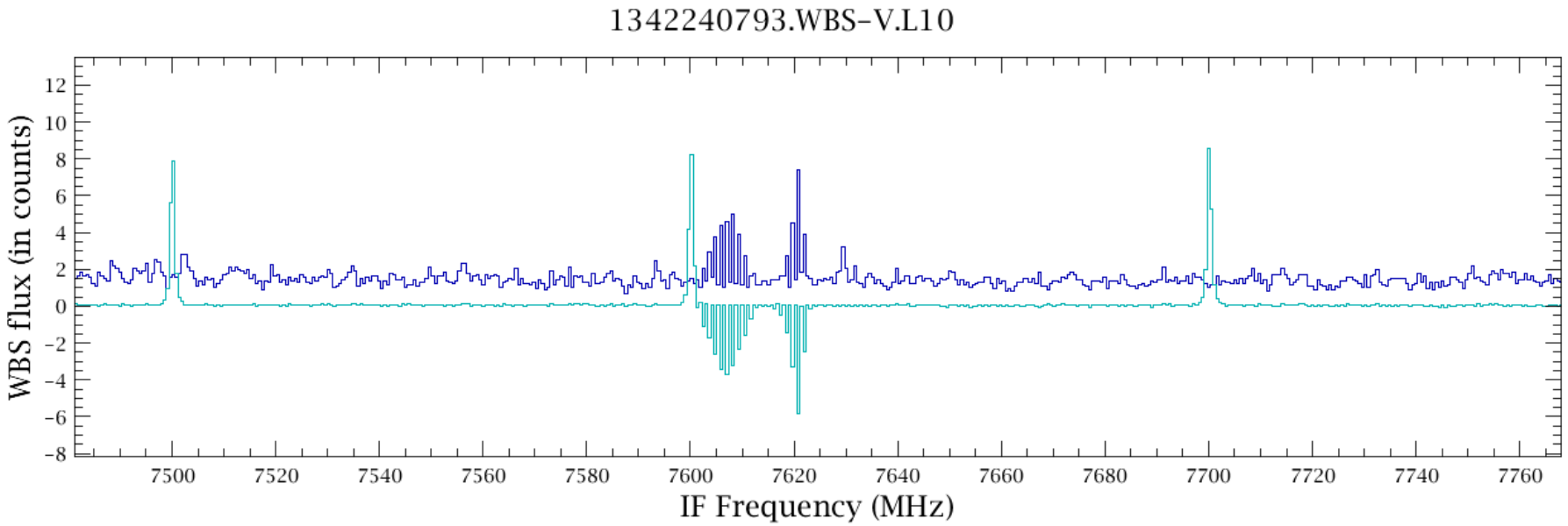
New starting point: HIFI-4700

» Failure of comb calibration due to spurious signal in zero scan

- Spikes in zero scan are seen as negative spikes in comb-zero used for frequency calibration



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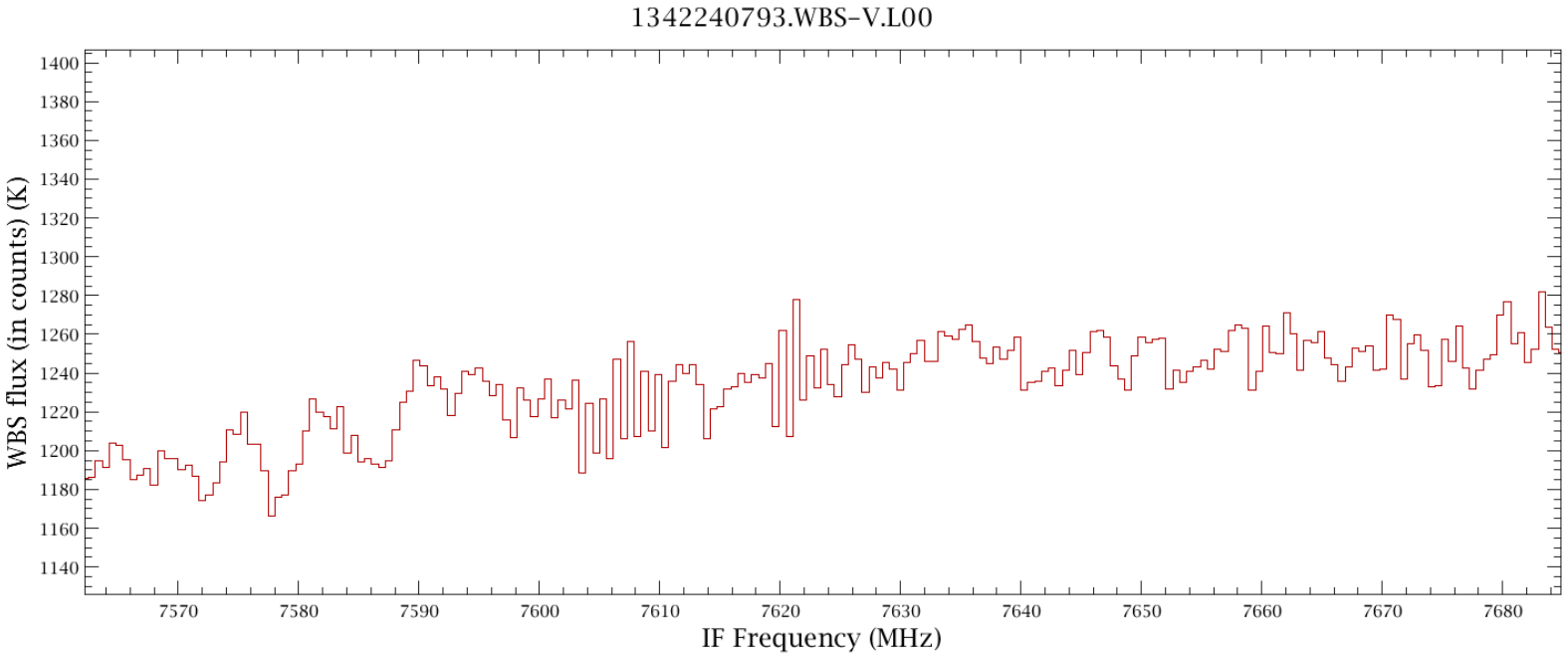
New starting point: HIFI-4700

» Side effect:

- Zero is also used in T_{sys} determination
- Would lead to wrong science calibration with alternative cal. scheme



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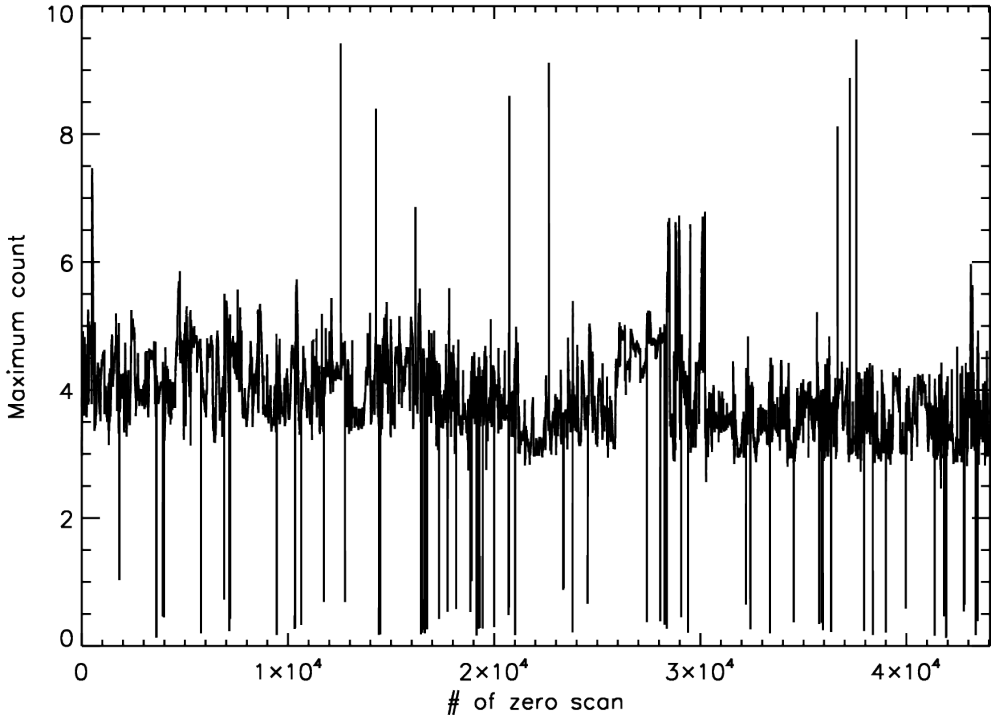
Zero scans

- Readout with well defined “zero” input level
  - Spectra should fully reproducible
  - Measure for WBS optics



44046 zeros measured so far (88092 spectra)

- Finite number of outliers
  - Negative and positive

Maximum count in zero spectra: WBS-H odd channels

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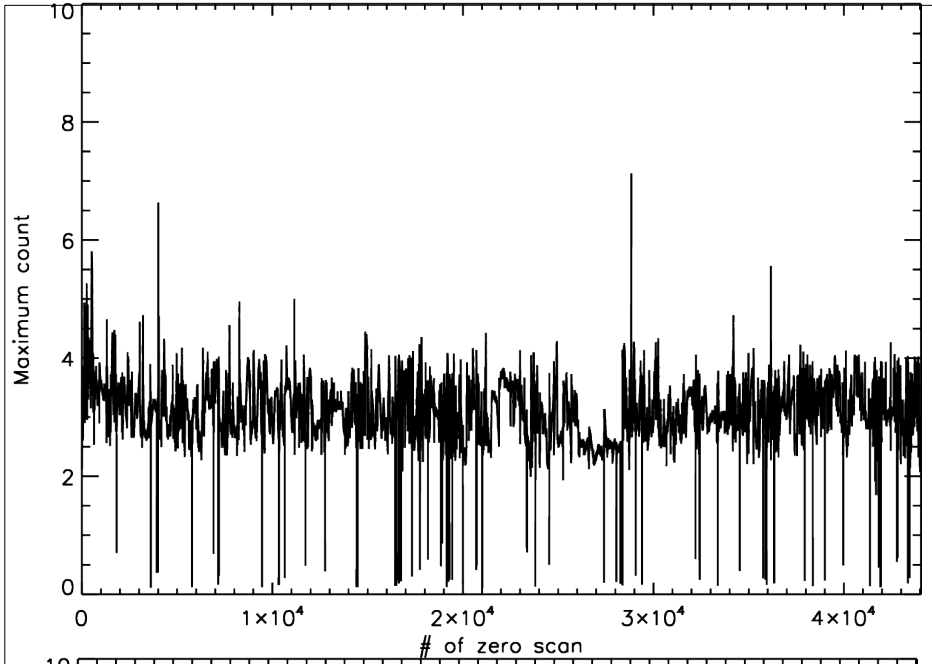

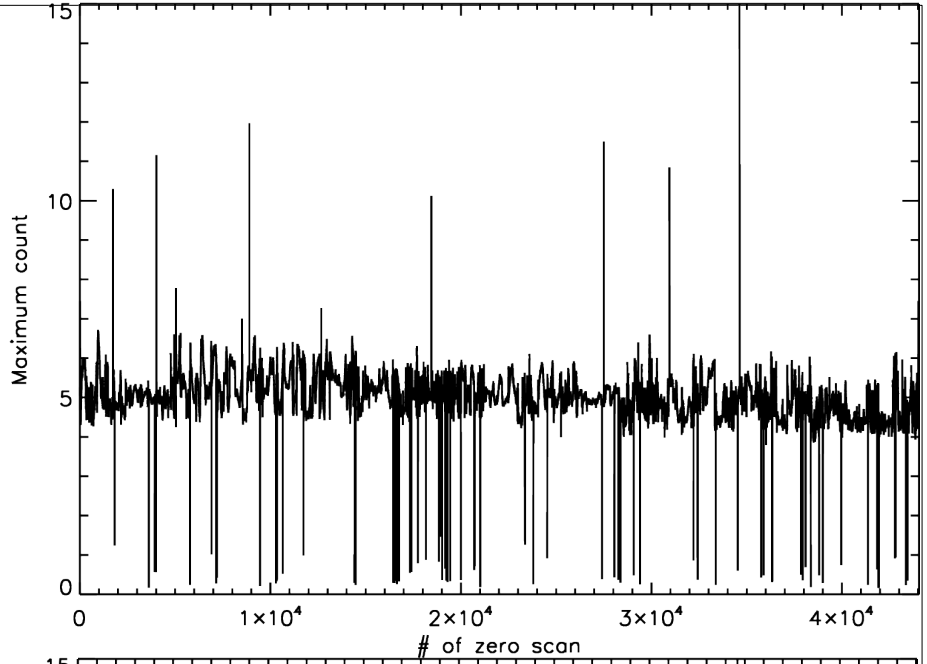

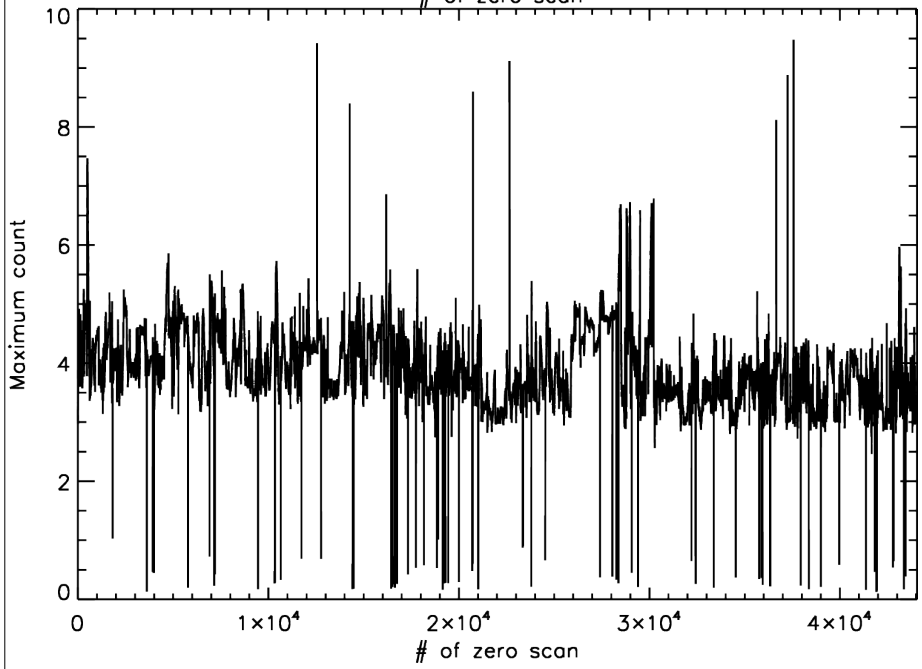

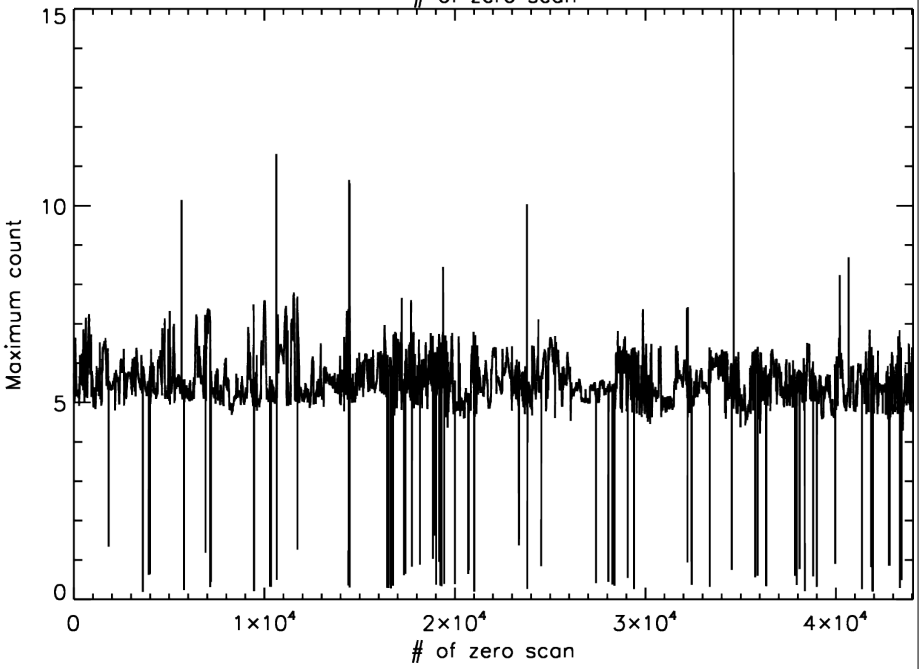

WBS-H: even (top), odd (bottom)

WBS-V: even (top), odd (bottom)

Negative outliers

- 179 zero spectra too low
- Scancount in data frames is wrong
  - Standard scancount = 100 or 101 (depending on exact timing)
  - Division of spectra by too large number: 360-2916
  - Due to unknown bug in OBS
  - Majority (162) of spectra have the same wrong scancount in WBS-H and WBS-V
  - 17 spectra with wrong scancount in one polarization only
- Can be easily excluded
  - Implemented in 9.0 pipeline

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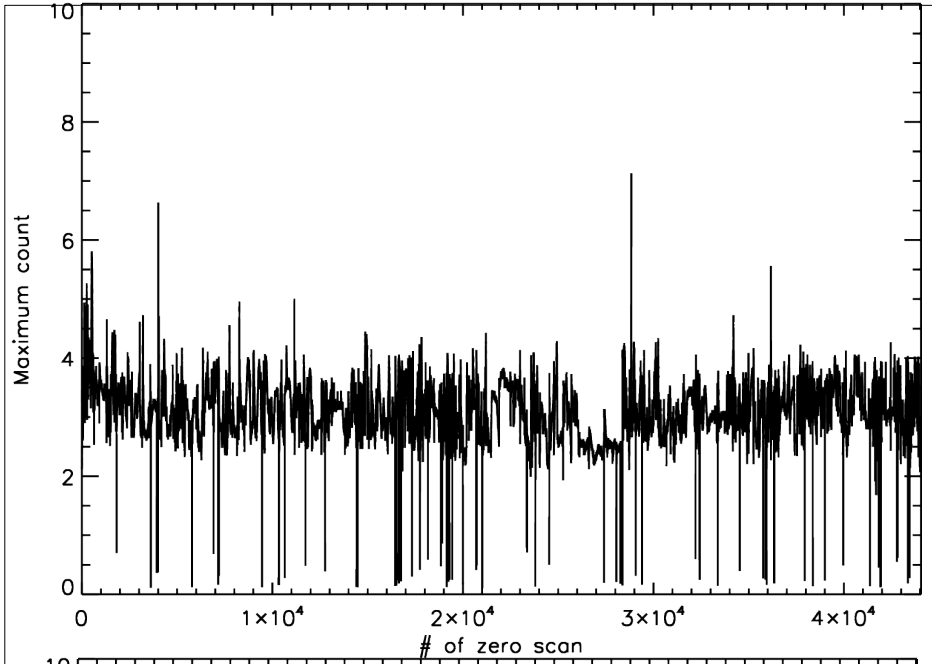

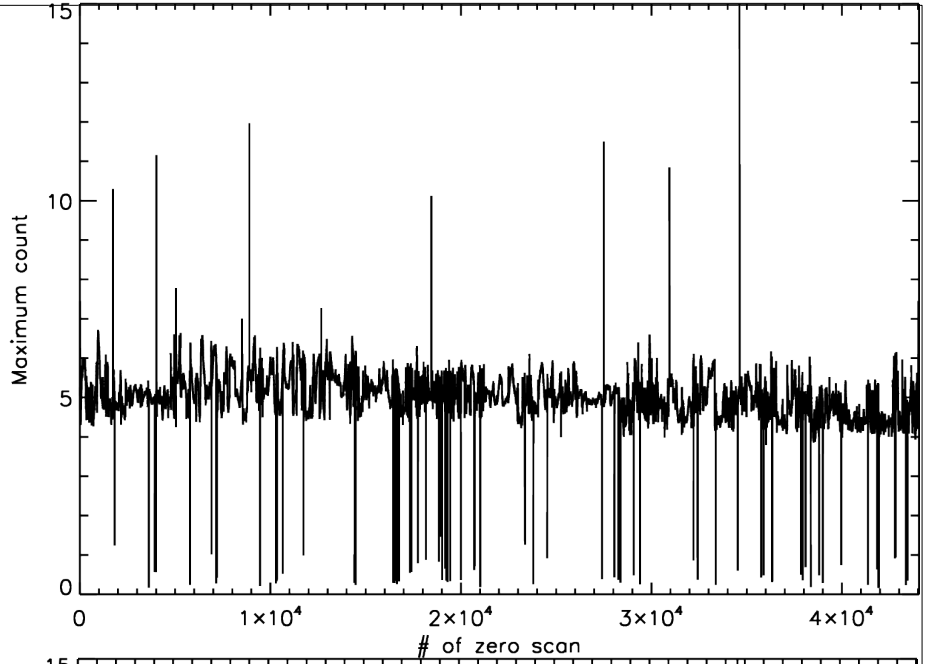

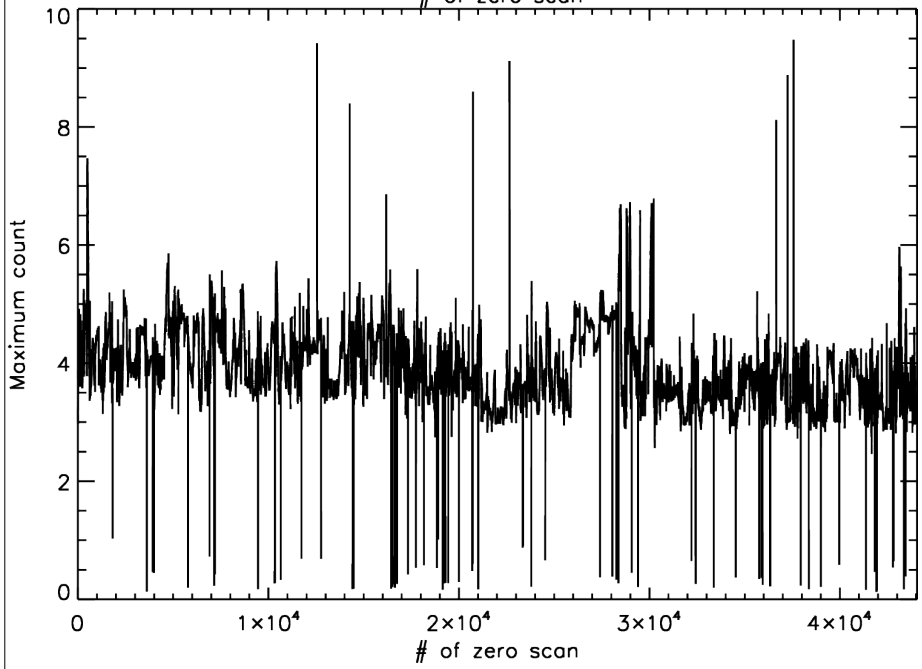

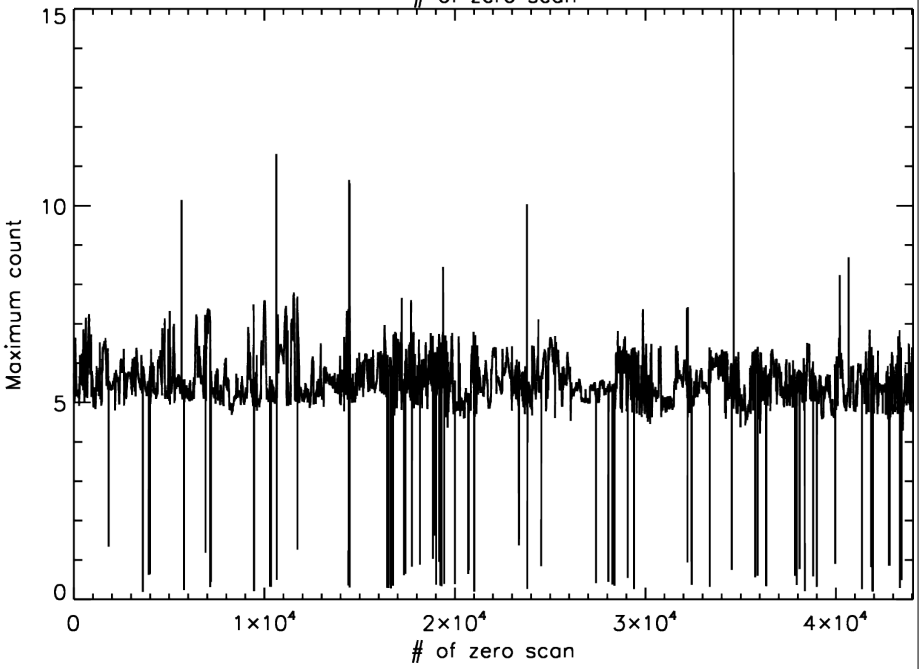

WBS-H: even (top), odd (bottom)

WBS-V: even (top), odd (bottom)

Positive outliers

- Definition of “outlier” not sharp → arbitrary
  - Values used here: 5.5 for WBS-H-even, 7.0 for WBS-H-odd
    7.5 for WBS-V-even, 8.0 for WBS-V-odd
  - Event from HIFI-4700 would not have been caught by this limit
- 36 semi-permanent outliers
  - Mainly detected in WBS-H
- 26 one-scan outliers

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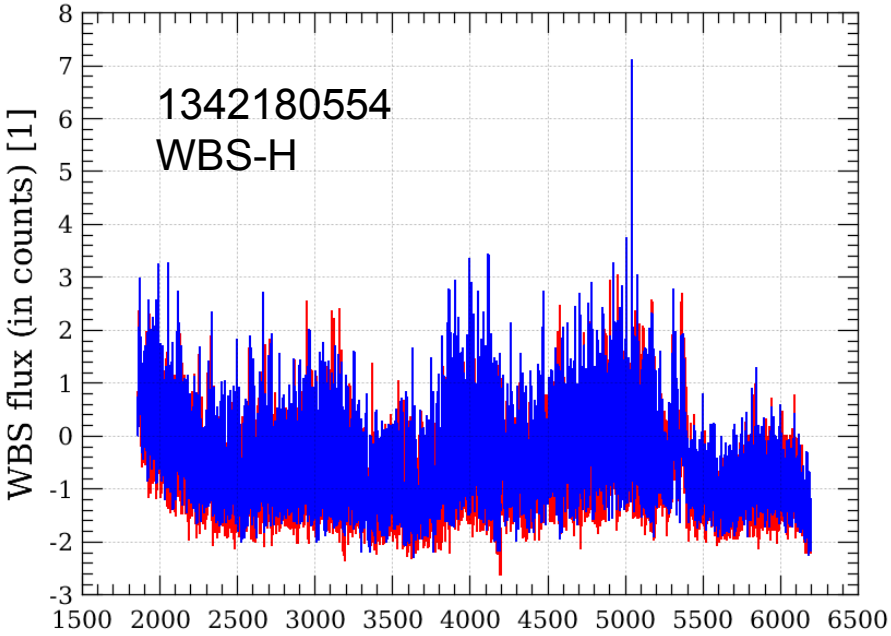
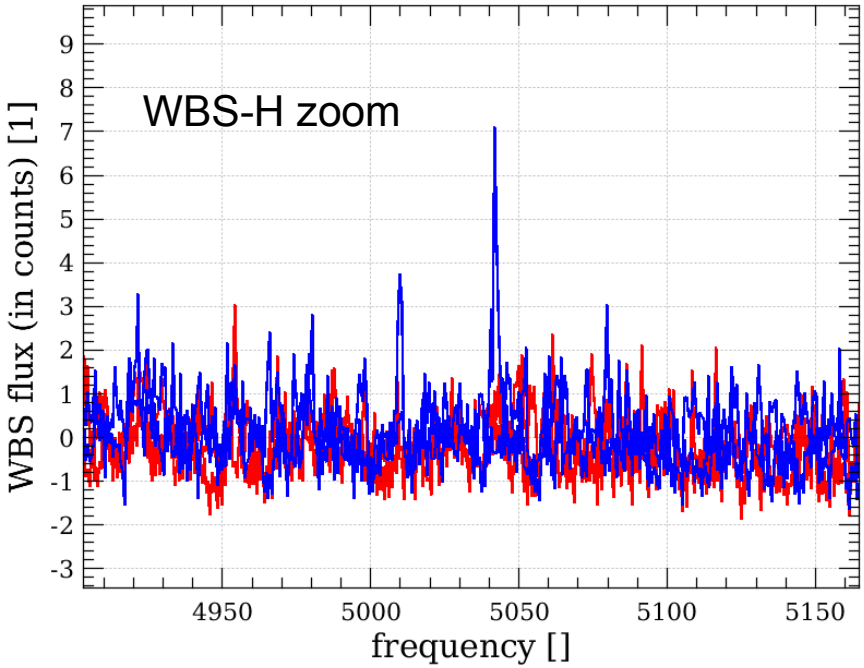
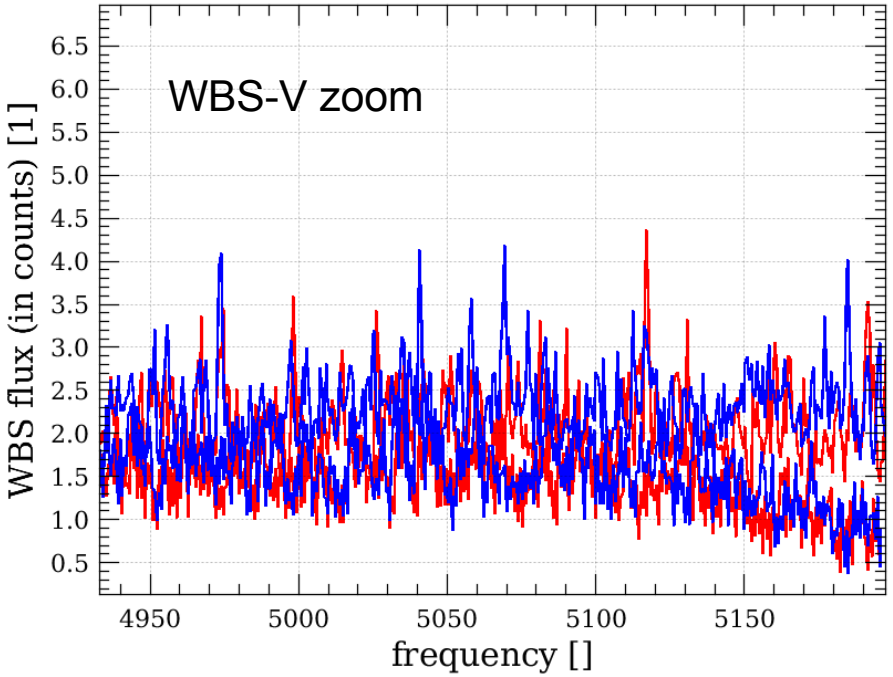
Semi-permanent positive outliers

» probably due to some RF interference

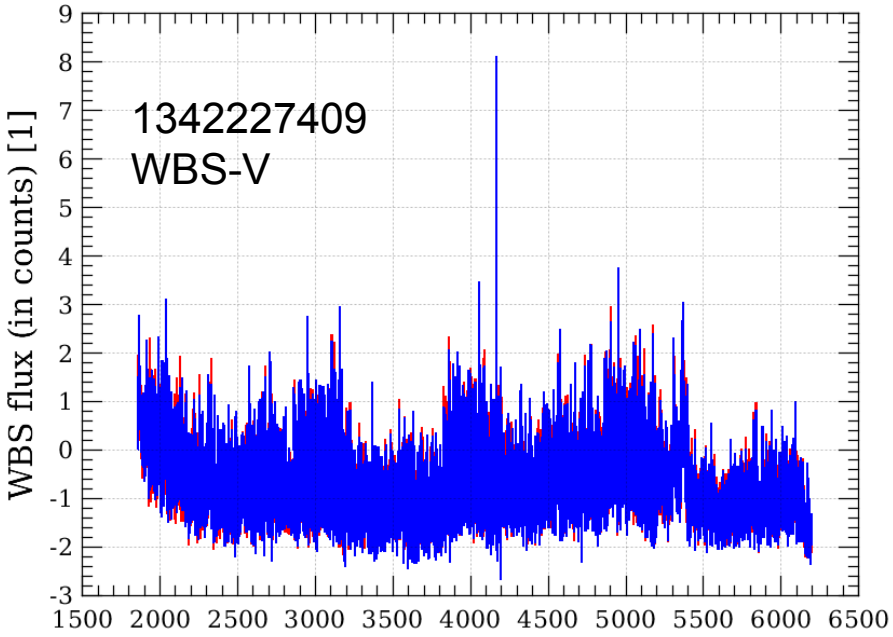


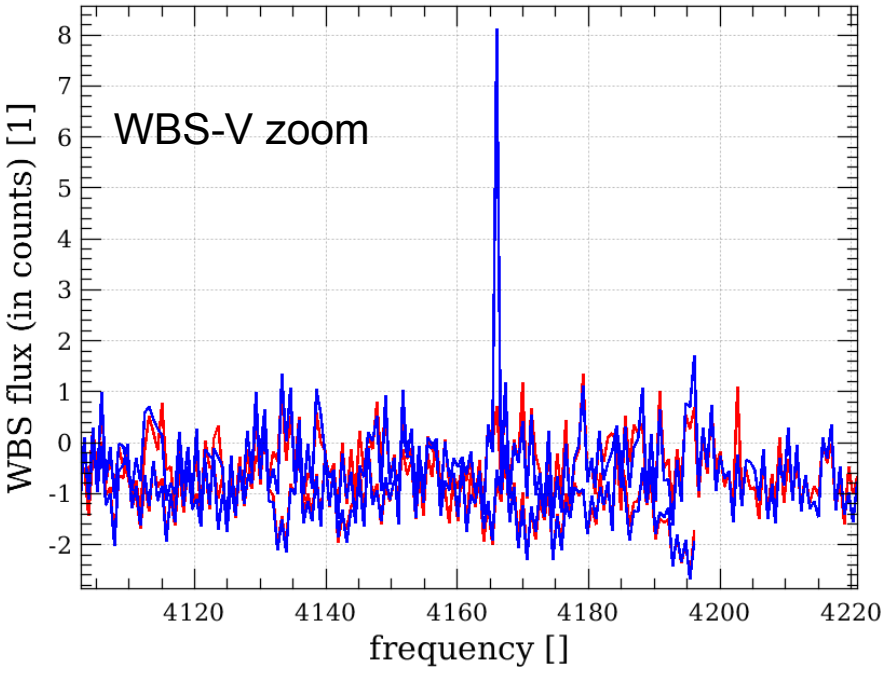




WBS Spectrum Dataset of type: comb WBS-H, ObsID: 235831, WBS_Zero_Comb at t=1324
WBS Spectrum Dataset of type: comb WBS-H, ObsID: 180554, WBS_Zero_Comb at t=9812

HIFI sum spectrum WBS-V, ObsID: 235831, WBS_Zero_Comb at t=13244.9
HIFI sum spectrum WBS-V, ObsID: 180554, WBS_Zero_Comb at t=98129.0





WBS Spectrum Dataset of type: comb WBS-H, ObsID: 235831, WBS_Zero_Comb at t=13244
WBS Spectrum Dataset of type: comb WBS-H, ObsID: 227409, WBS_Zero_Comb at t=23531

Single outliers

- Single spike
  - Width of a few pixels
- Candidate for CR hit
  - Several pixels affected
  - Individual 10ms readout not saturated
    - No overflow
- Mechanism not understood in detail yet

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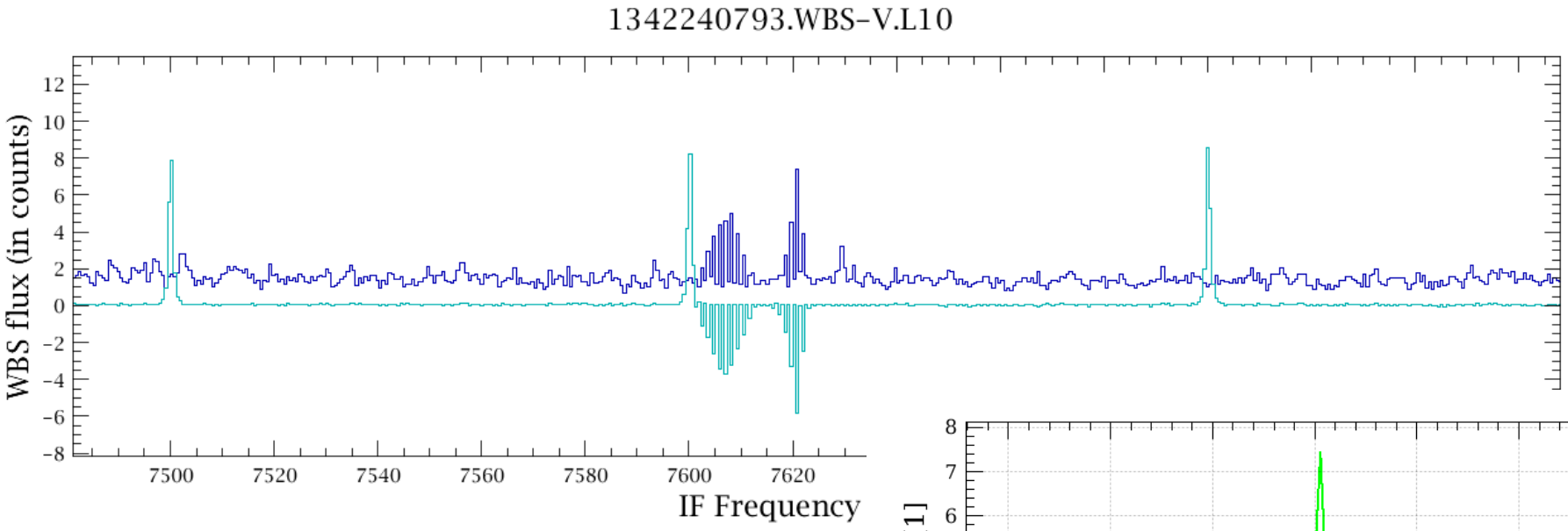
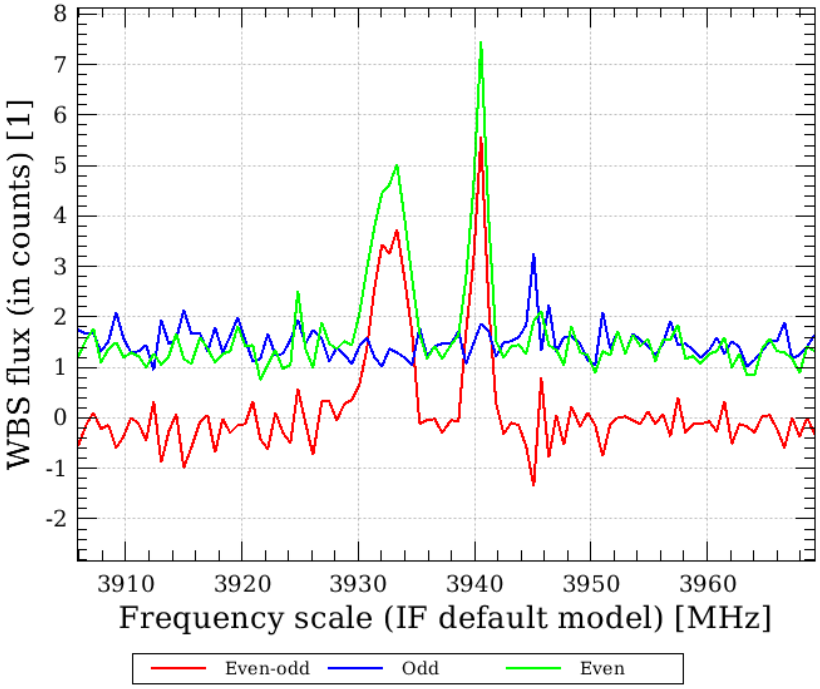
HIFI-4700



» If CR hits readout line, false counts are only generated on even or odd pixels

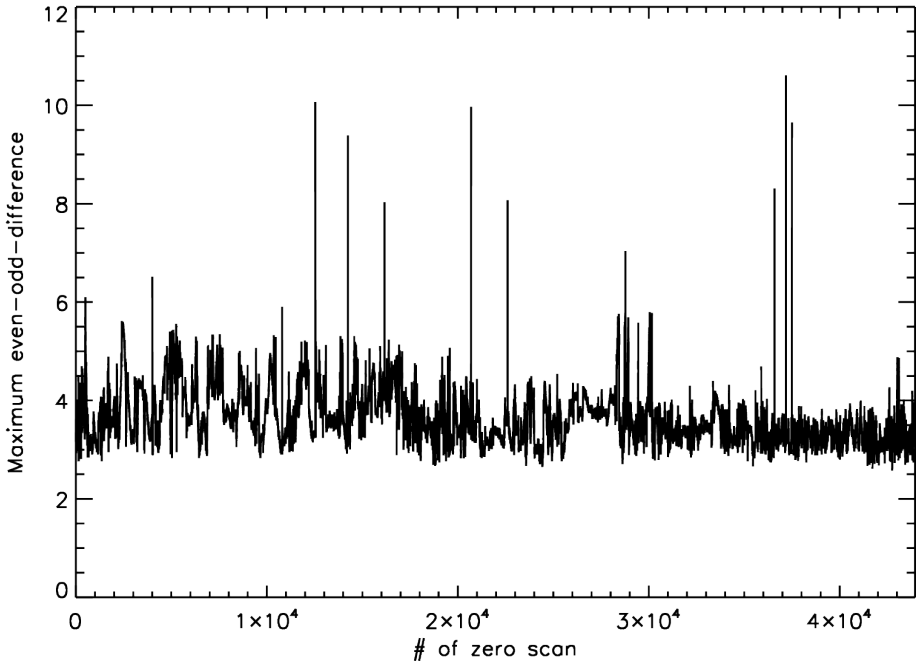
- Open question: Two peaks as events from secondary shower?



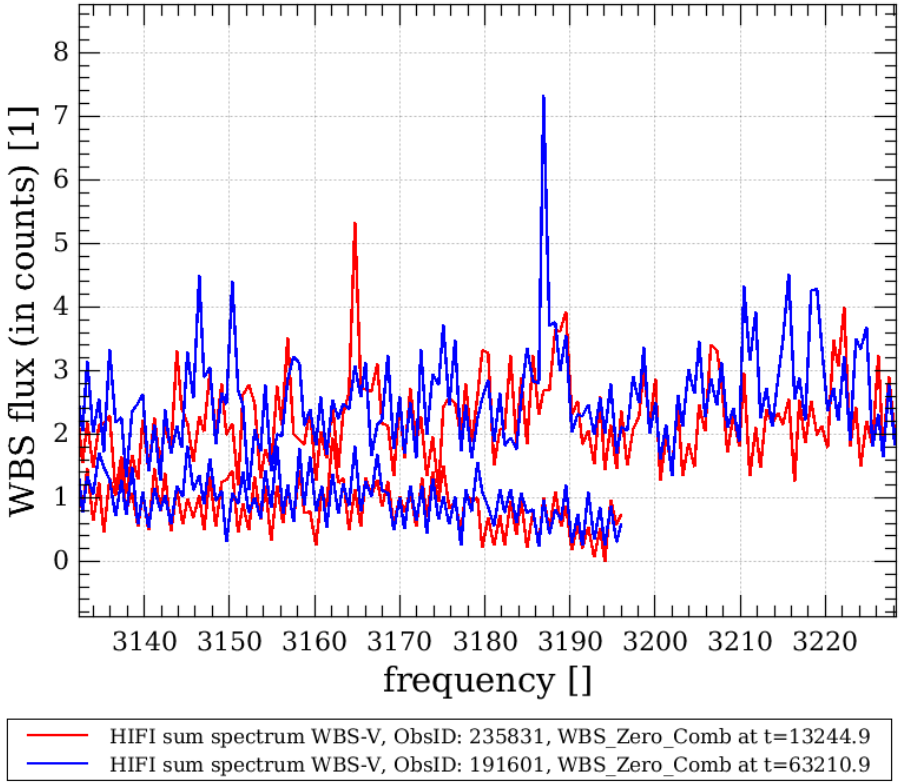
Hits on readout lines

» Even-odd differences as criterion for outliers (soft again)

- 34 spectra identified
- Significance of detection sometimes questionable



Even-odd-difference: WBS-H



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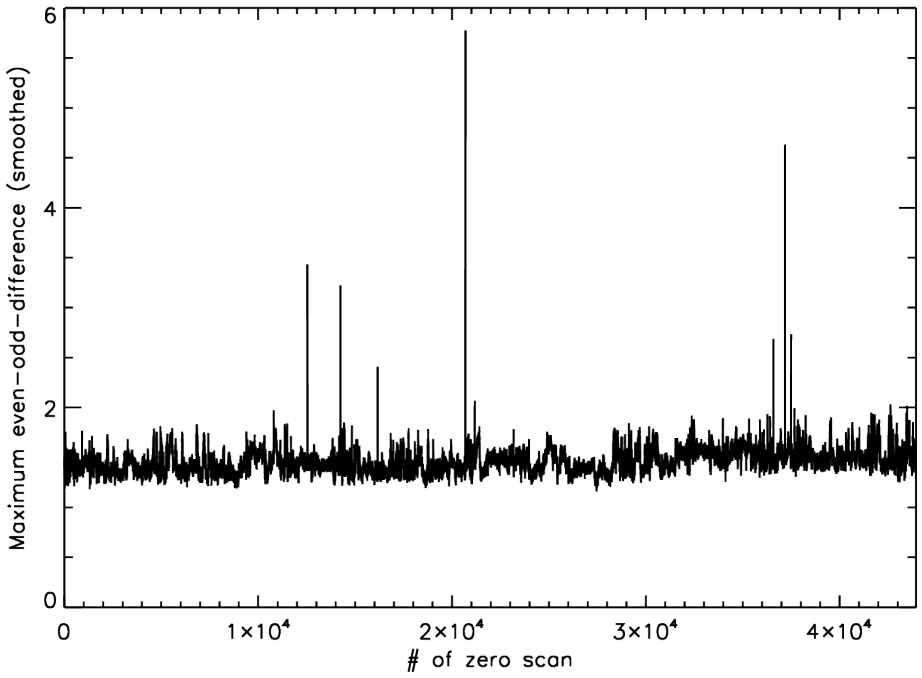
Hits on readout lines

» Criterion clearer when only looking for broad spikes



- 18 spectra
- Removes some spectra from difference list already in positive outlier list
- HIFI-4700 well detected

Even-odd-difference: WBS-H smoothed by factor 5

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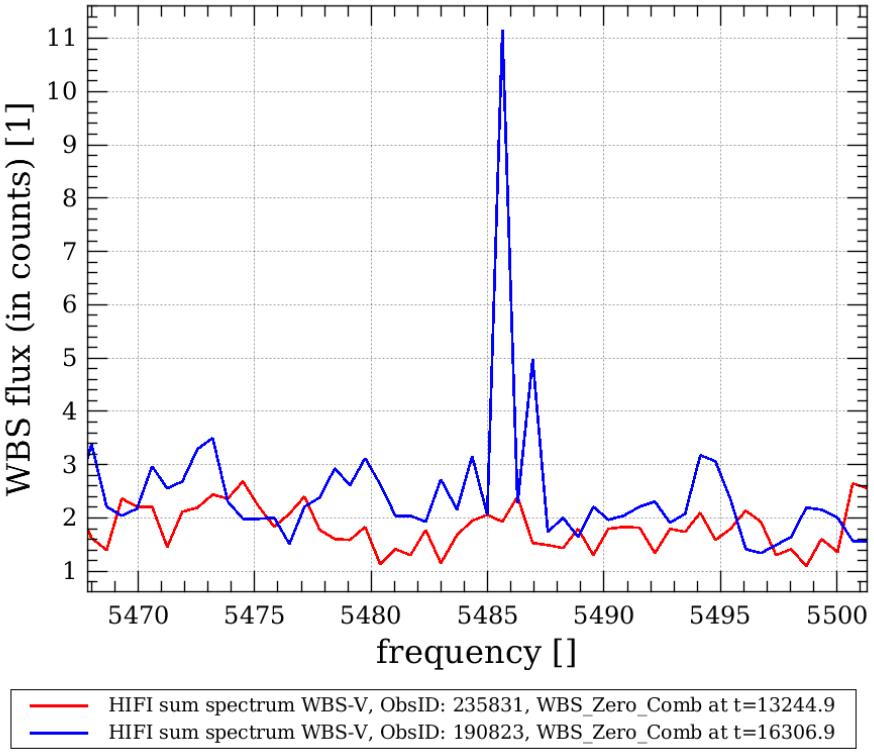
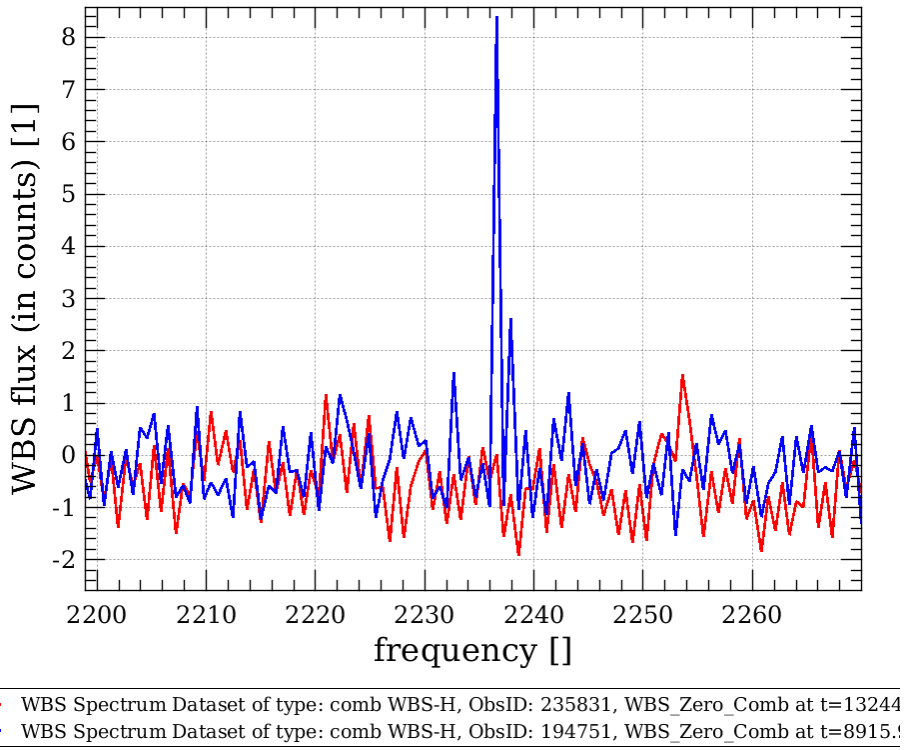
Hits on readout lines





» Example identifications:

Saturating event (WBS-V)

non-saturating (WBS-H)

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Summary

- Ongoing effort
  - All outliers (~ 100 out of 80000 spectra) need to be inspected by hand
  - Definition of best “reference zero” needed
- Questions:
  - Showers versus single events
  - Why are multiple pixels affected?
- By appropriate filtering it may be possible to find events also in the science data
  - Highly non-trivial as the noise exceeds spikes
  - Inspection of comb spectra probably more straight forward
- Two events ahead of solar storms
  - Is there any superfast CME?
  - Potentially important fundamental physics hidden

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