

THE GOOD THE BAD AND THE UGLY



By Tommy Marshman
(On behalf of the BWS team)



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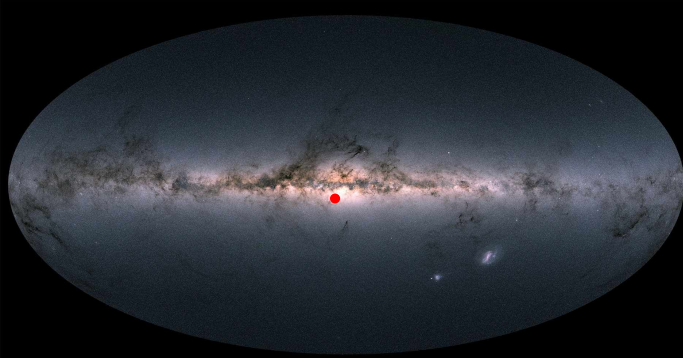


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- Scientific Justification
- Baade's Window Survey (BWS) Details
- BWS Challenges
- Stage 1: "BWS -I: FRBs"
- Stage 2: Pulsars
- Stage 3 and beyond
- Conclusion

Scientific Justification: I

- Demonstrate versatility of UWL - first commensal survey
 - Pulsar and FRB search mode
 - Radio spectral & recombination lines: OH, HI, CH
 - Continuum observations
- Optimise FRB/pulsar search techniques with UWL survey data
- Explore UWL data for new discoveries



Baade's Window

$l = 1.02^\circ$, $b = -3.92^\circ$

Globular Cluster:
NGC 6528

Globular Cluster:
NGC 6522

Contains pulsars:

PSR J1803-3002A

PSR J1803-3002B

PSR J1803-3002C

PSR J1803-3002D

Scientific Justification: II

Baade's Window presents:

- A low dust line of sight to the area between the Galactic bulge, disk and central regions.
- Small well studied area - ~ 1 square degree
- Guaranteed pulsar and spectral line detections
- Includes known exoplanets
- An area yet to be studied in the UWL bandwidth fully

The Baade's Window Survey: Details

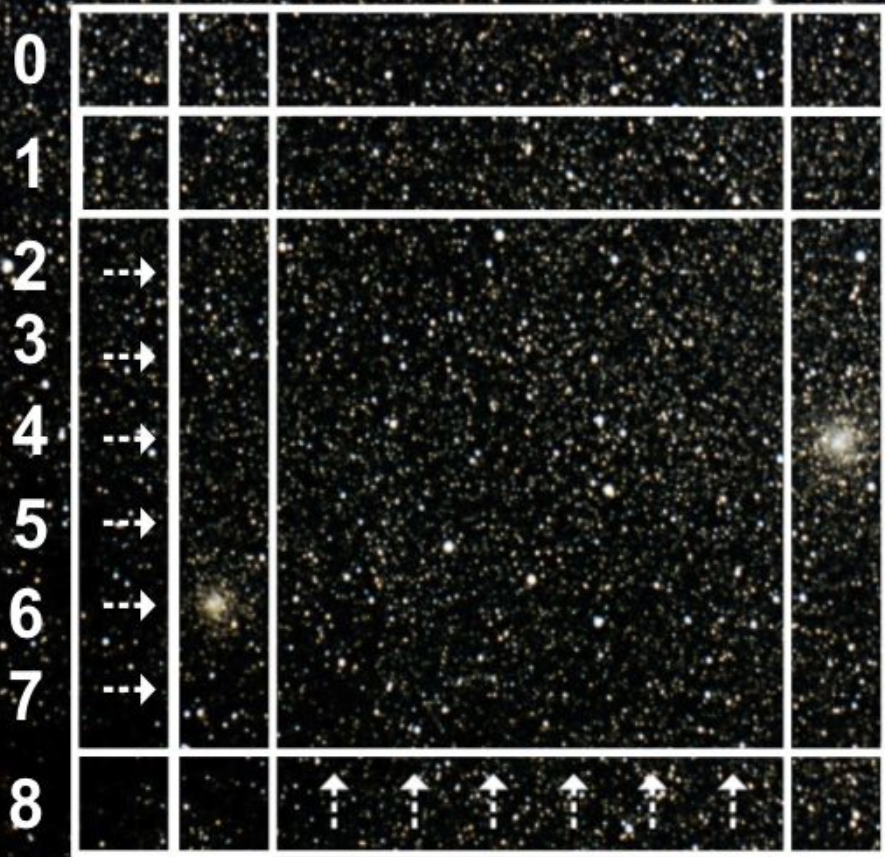
Pulsar Search Mode:

- ~180 hrs observations (9x9 1 hr RA scanning and 9x9 1 hr Dec Scanning)
- UWL Bandwidth = 704 - 4032 MHz
- Sampling time = 64 μ s
- Channel width = 0.125 MHz
- Number of bits = 2

Spectral Line Mode:

- 2¹⁸ frequency channels
- 488Hz resolution
- spectra dumped to disk every 1 second
- 4 polarisation products recorded

RA Scanning



Not to Scale

0 1 2 3 4 5 6 7 8

Dec Scanning



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The Baade's Window Survey: Challenges

Massive Bandwidth:

- 704 - 4032 MHz (~3.3 GHz Bandwidth)

Continuous Scan Observation:

- The observations were conducted with a continuous scanning/moving telescope

Total files:

- 3550 PSR search mode files(inc. calibration files)

Files to be searched:

- ~3389 files = ~34TB
- 13 bands/file = ~44057 bands (to manage bandwidth)



Stage 1: “BWS -I: FRBs”

Search the BWS for FRBs.

Files to be searched:

- ~3389 PSR search mode files (~44057 bands @ 13 bands/file)

Files currently searched:

- 50% of the total ~44057 bands

The Pipeline

PRESTO based pipeline:

- Extract 13 x 256 MHz bands from UWL bandwidth
 - Run `DDplan.py` on each bandwidth to create de-dispersion plan
 - Run `prepsubband` from above de-dispersion plans. (DM <3000
-nsubs = 32, DM = 3000 - 5000 cm⁻³ pc -nsubs = 64)
 - Search de-dispersed data using `single_pulse_search.py` (detection threshold at 7σ)
 - Plot results with plotting threshold at 10σ
- Examine candidates with `pfits_frb`

The Pipeline

Next steps with the pipeline:

- Refining the pipeline/optimising processing - speeding it up for the second half of the data.
- Testing the pipeline sensitivity - SimulateBurst (Rui et al 2022).

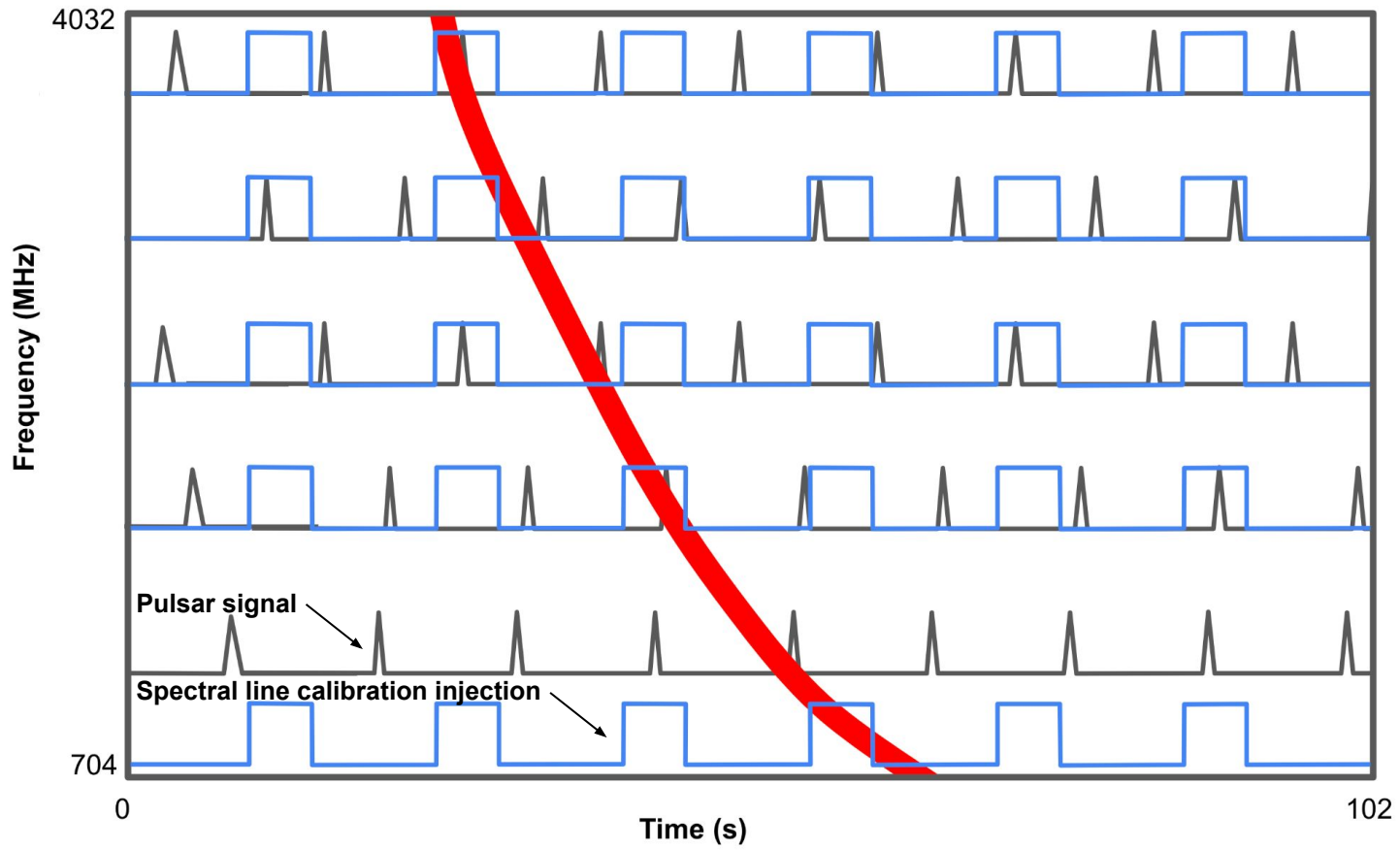
Stage 2: “BWS -II: PSRs”

Steps:

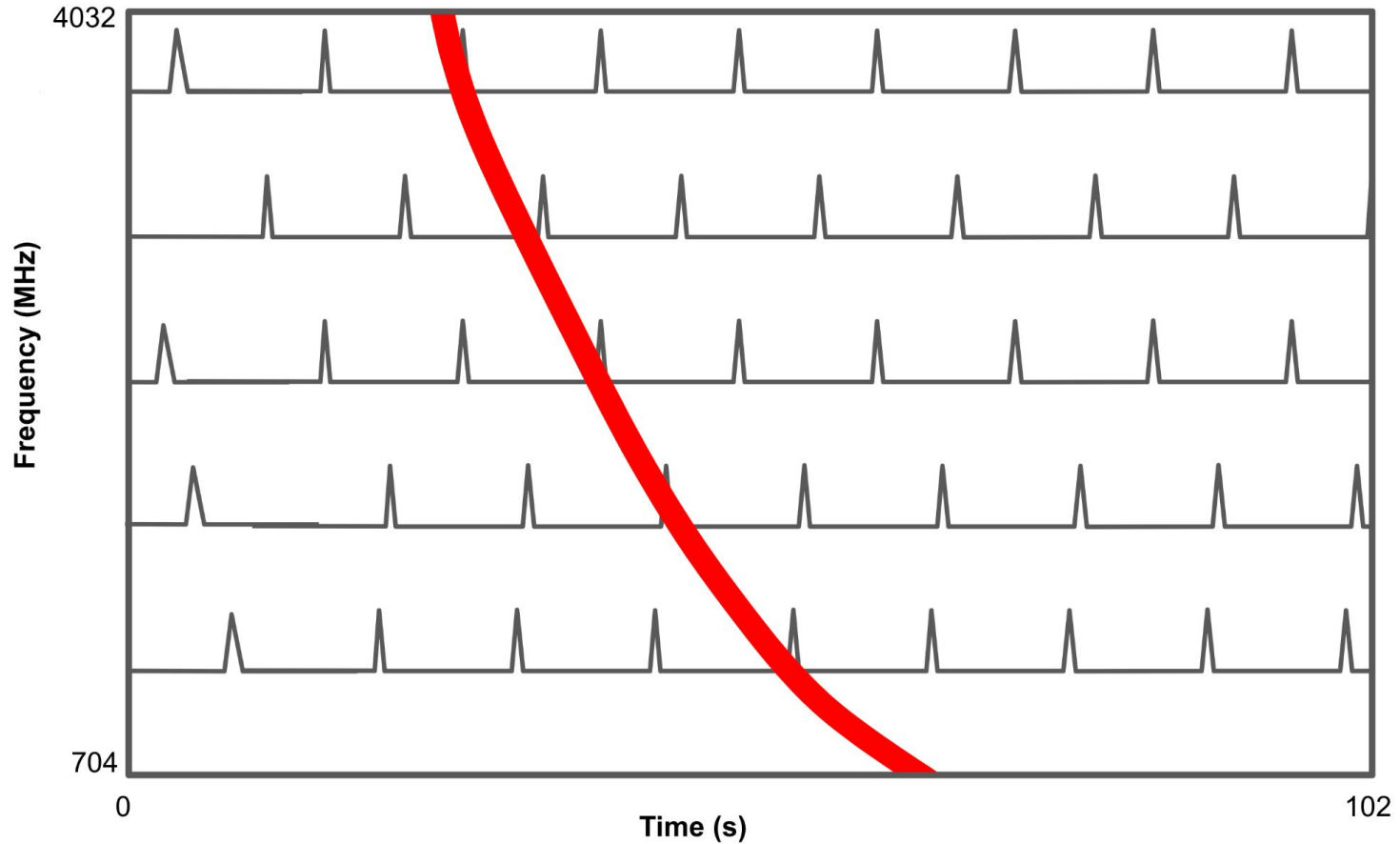
- **Segmentation** - Because the UWL is a single pixel receiver the beam width on the sky is proportional to observing wavelength.
- **Spectral Line Calibration Injection** - Dealing with the calibration noise switching on and off (This will be the same problem faced by the FAST team and the Commensal Radio Astronomy FAST Survey (CRAFTS)).
- **Processing** - observations were optimised for pulsar searching at higher bandwidths so that lower bandwidths are over sampled so this will need to be taken into account to optimise processing speed.

Follow up - Any new pulsars to be followed up with further observations.

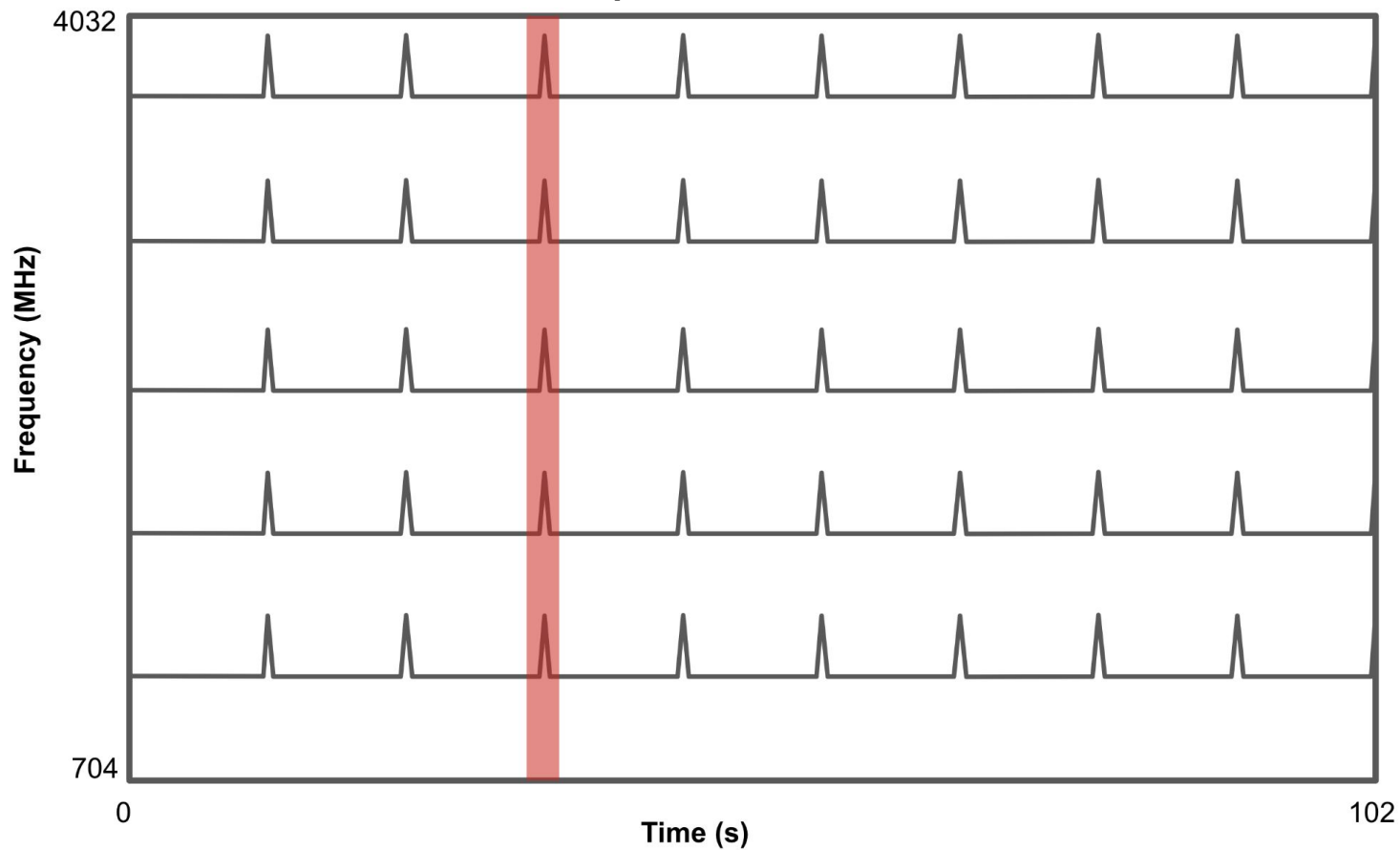
The raw data



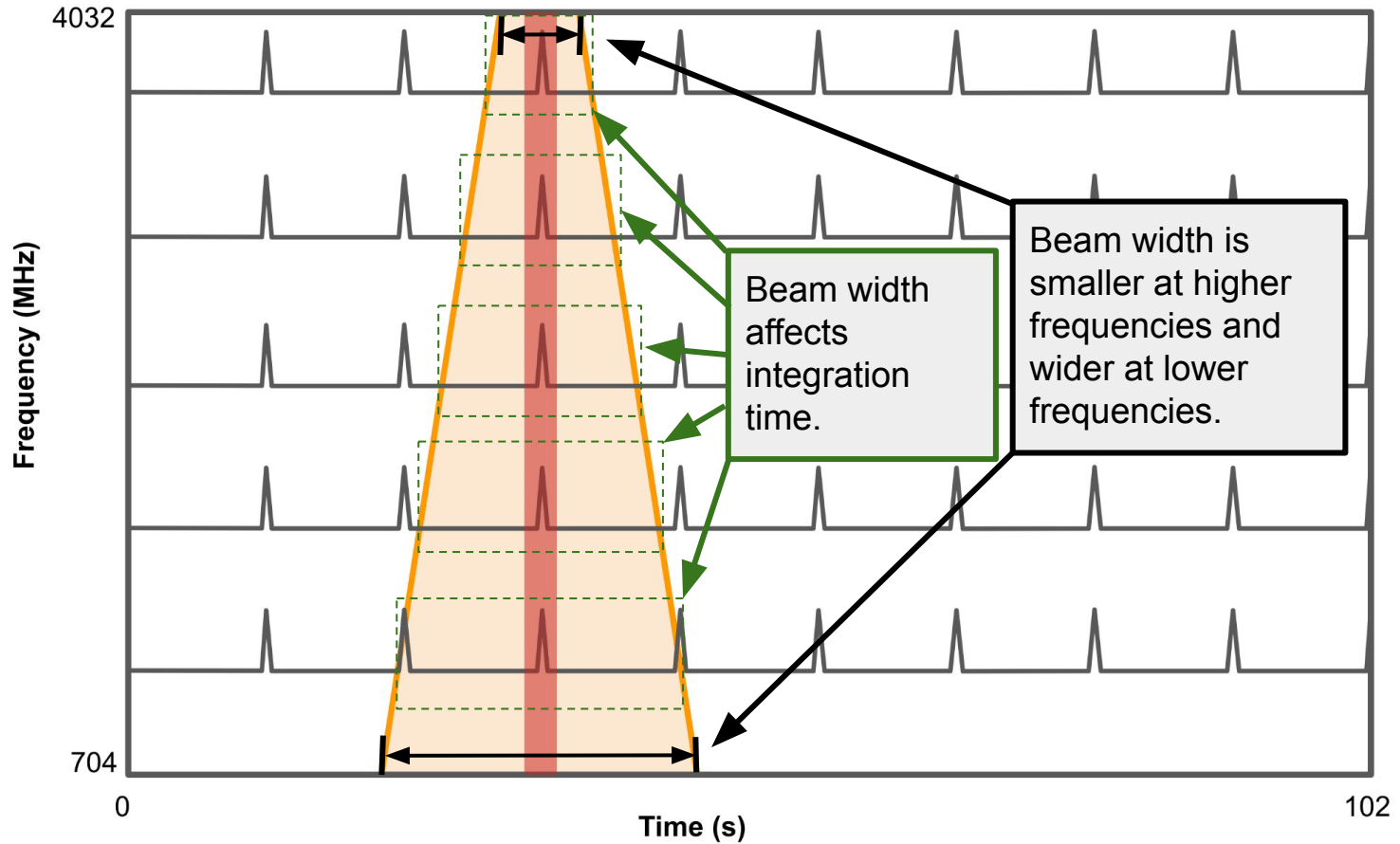
Remove the spectral line calibration injection



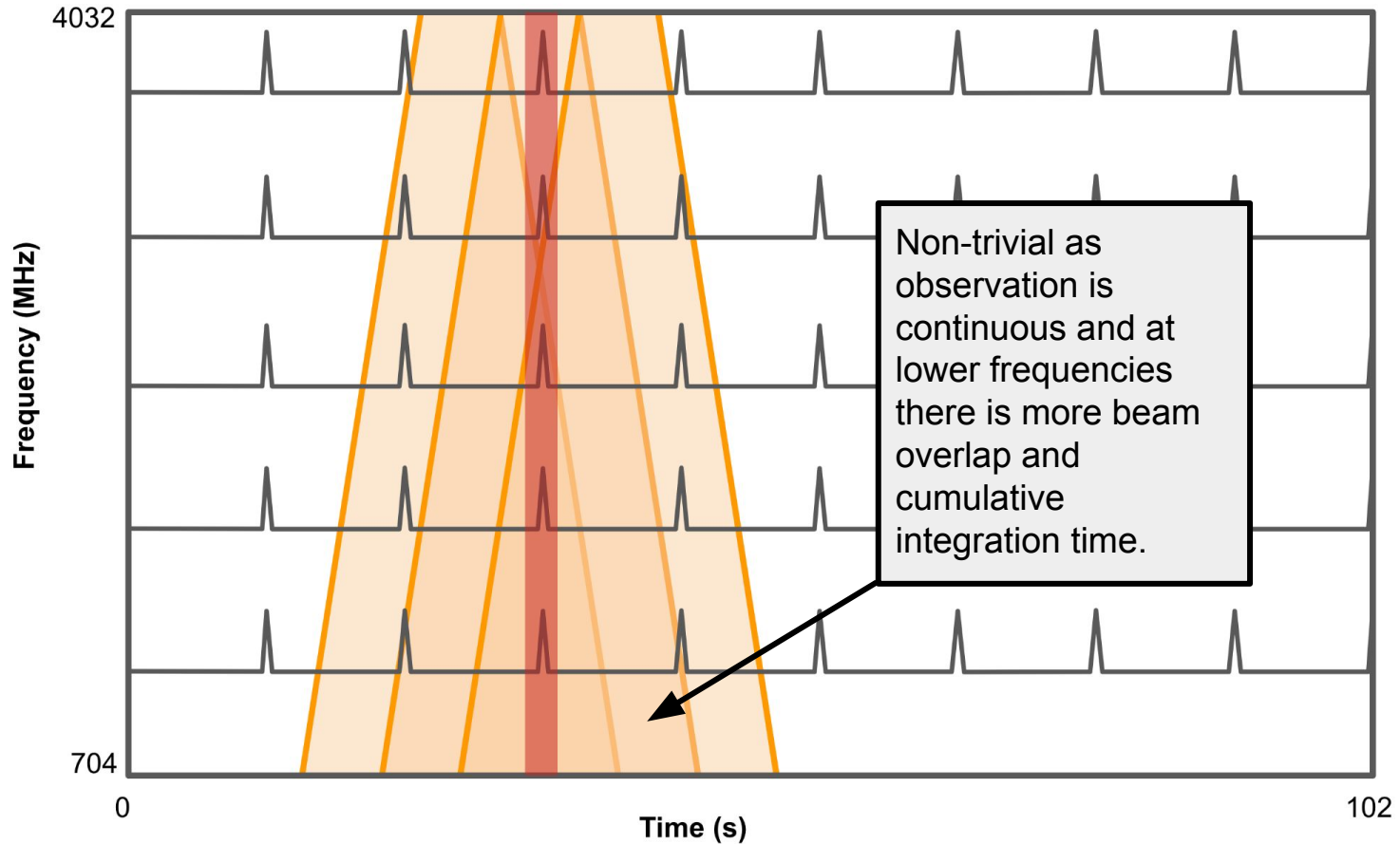
De-disperse the data



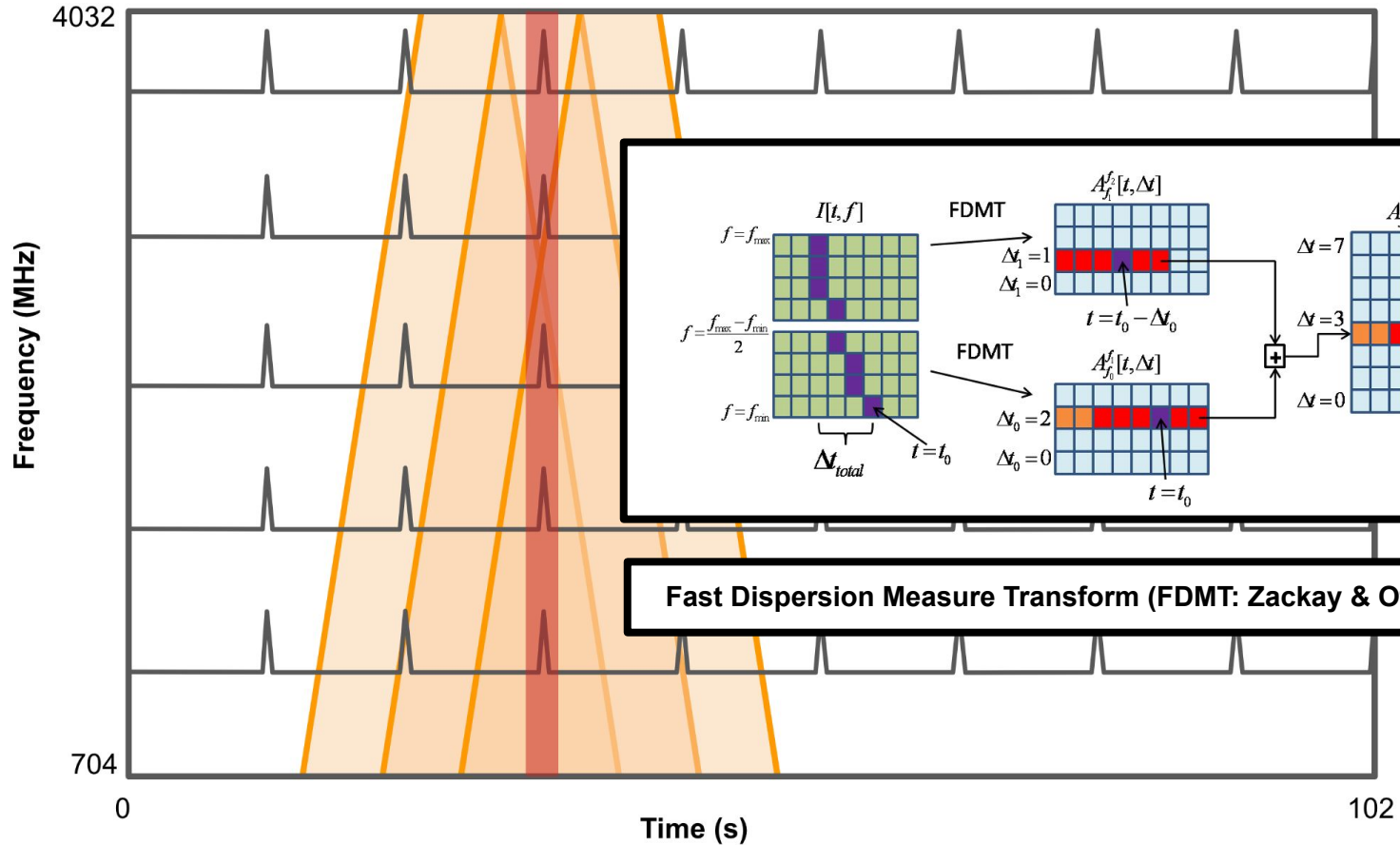
Segment continuous scan data and search for pulsars



Segment the data by time dependent on frequency



Segment the data by time dependent on frequency



Stage 3: New Discoveries



Dr SukYee Yong

CSIRO

Machine Learning/Artificial Intelligence
Future Science Platform postdoc



Dr Rui Luo

CSIRO

Research Plus Postdoctoral Fellow -
Finding the unknown



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Conclusion

The Baade's Window Survey presents the following opportunities:

- Potential new FRB/pulsar discoveries:
 - IGM/cosmological probes, PSR timing etc.
- Spectral line work:
 - ISM and dust probes
- Completely new discoveries:
 - ET phone home, or something unknown
- Explore and test the capabilities of the UWL
- Develop parameters and constraints on utilising the UWL moving forward:
 - Specifically, optimising commensal surveys
- Carry over lessons/considerations for the future Parkes cryogenically-cooled phased-array-feed

The End



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