CS & Physics Meet-Up by Lamarr & B3D

Deep Learning for real-time classification of astronomical radio signals

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für Radioastronomie

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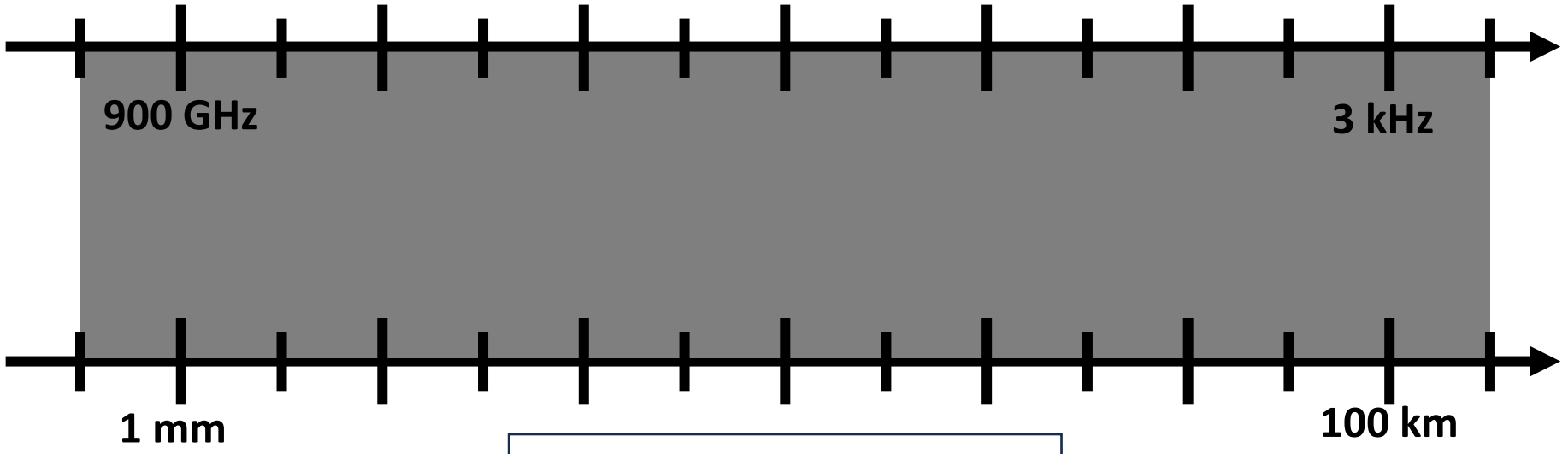
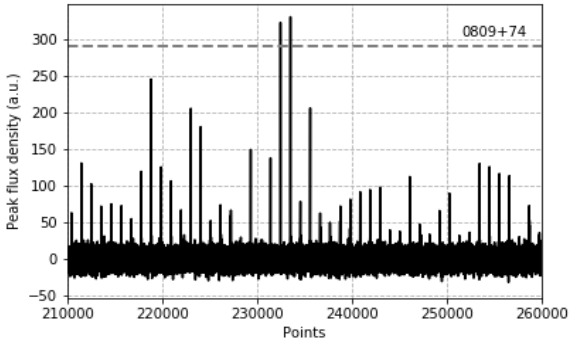
Radio astronomy

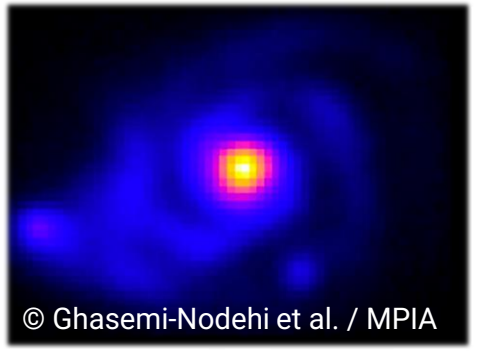


Radio emission

Pulses

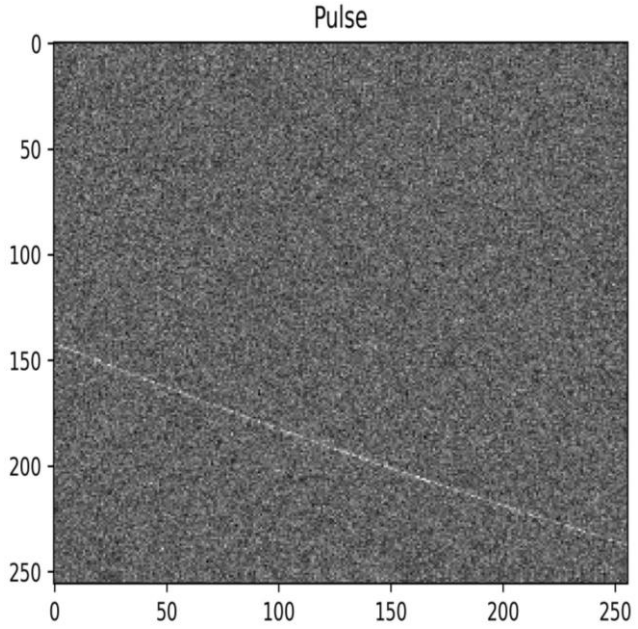


Continuous



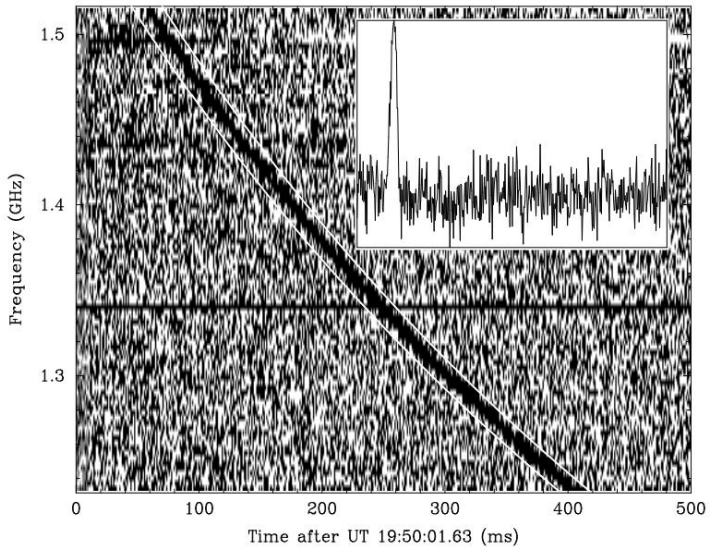
Pulsed radio emission

Pulsar signals show dispersion because they travel through the interstellar medium, which is filled with charged particles that affect the speed of the radio waves, causing signals of lower frequency to arrive later than those of higher frequency.



Pulsars

Fast rotating neutron stars whose pulsed emission is interesting both in itself and in its application to the study of the interstellar medium and the search for gravitational waves.



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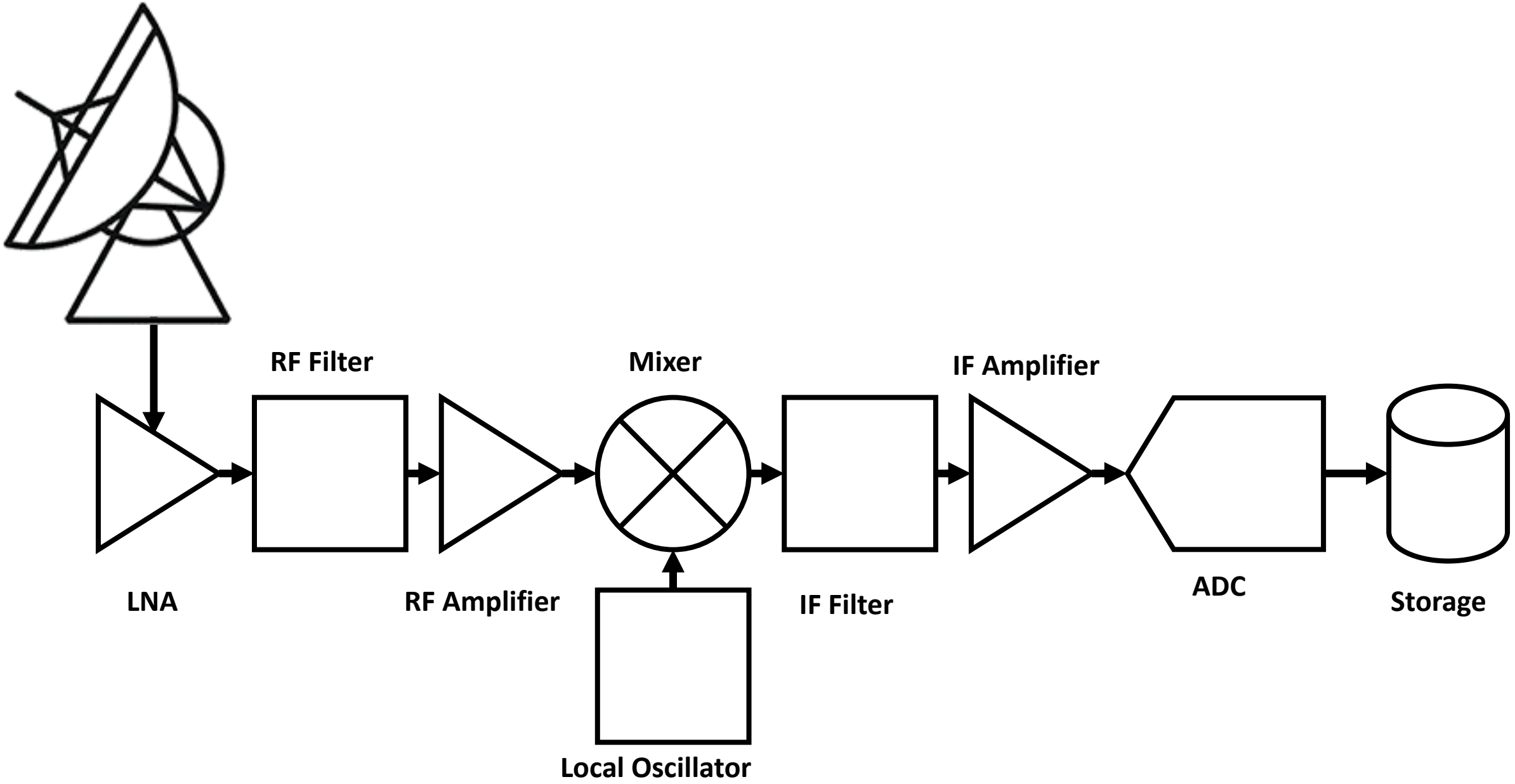
Fast Radio Burst

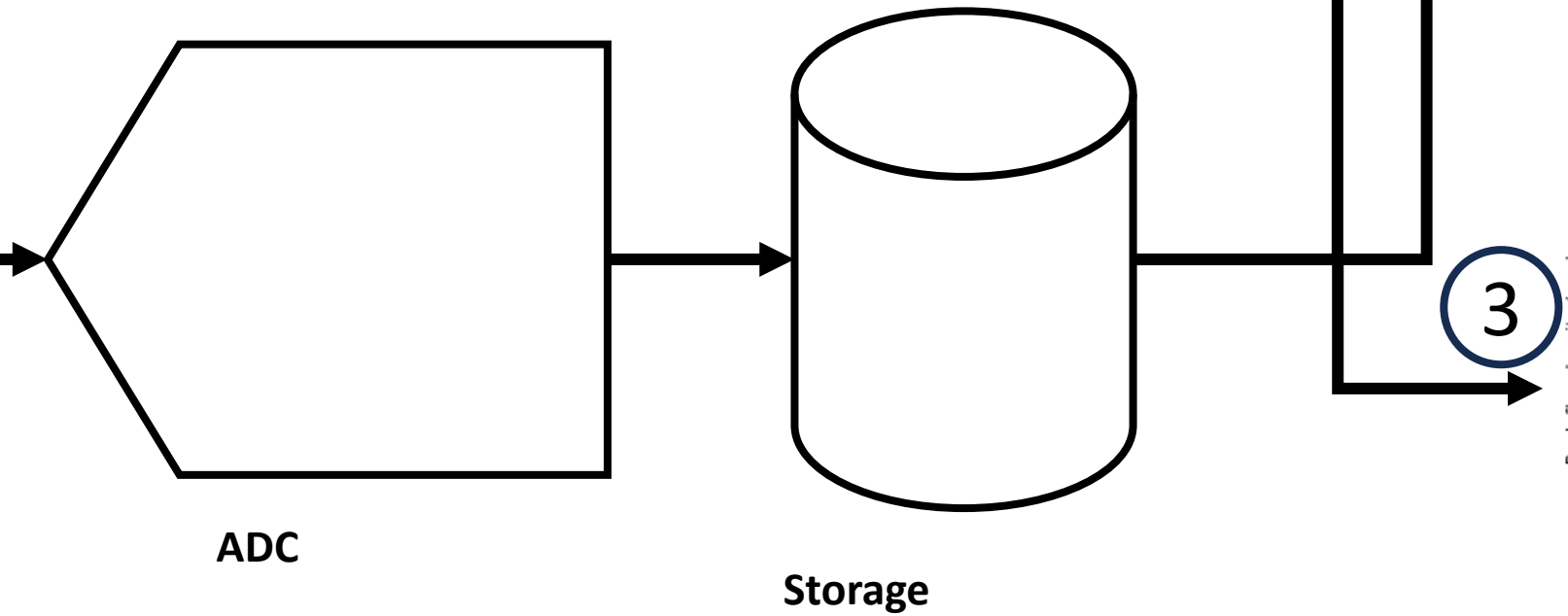
Pulsed radiation, the nature of which is still not fully understood.

Radio astronomy - signal



Data types in radioastronomy

1. Baseband data
2. Filterbank data
3. Time series



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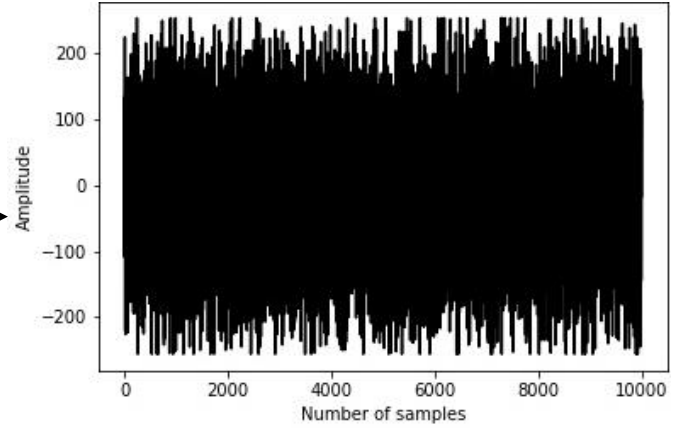

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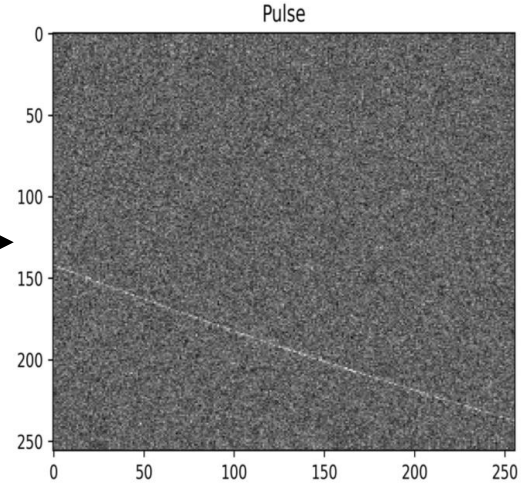

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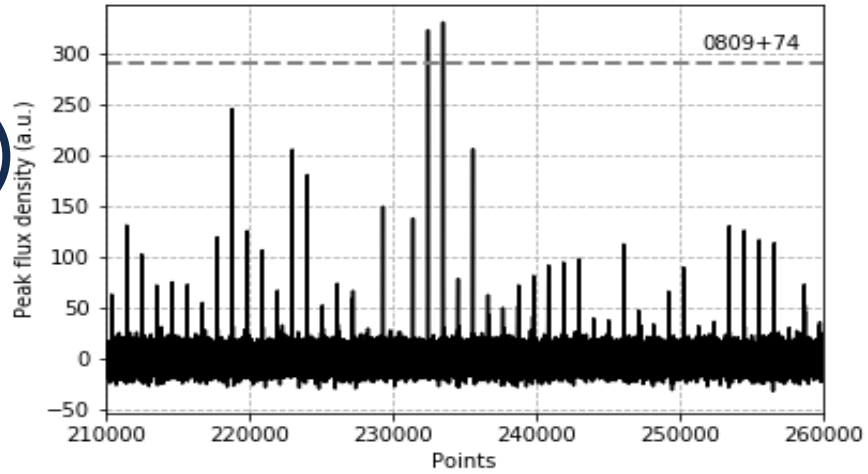


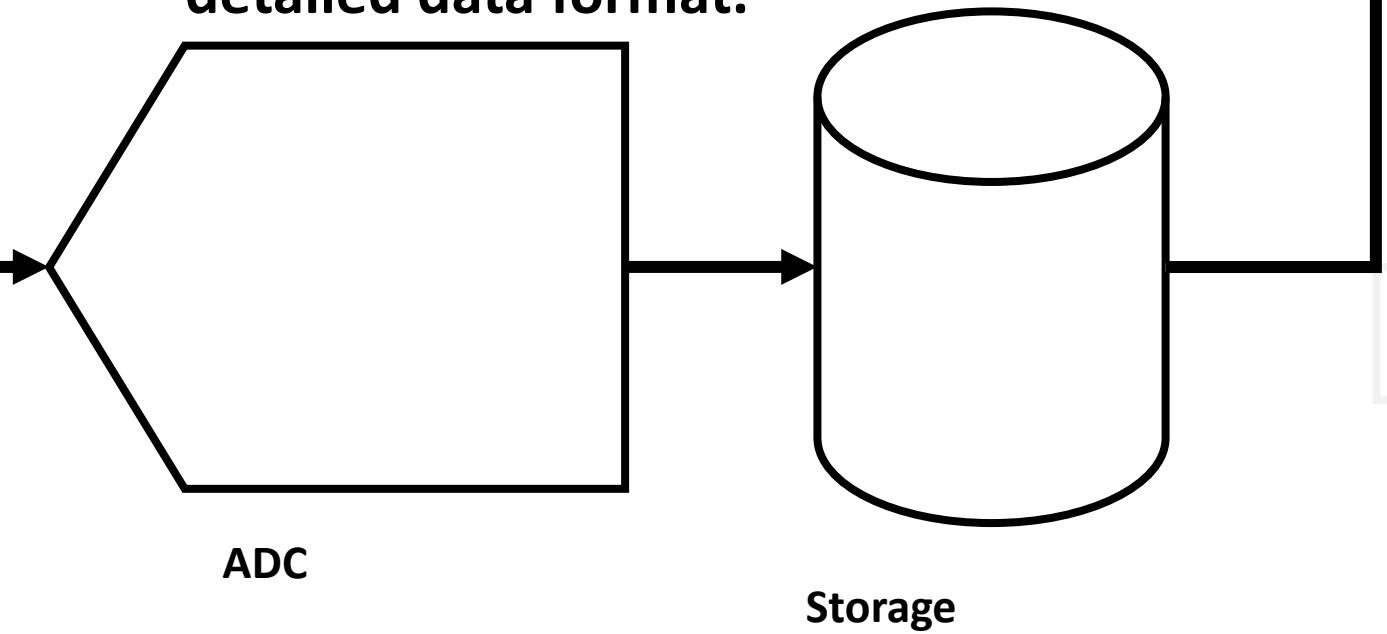
Data types in radioastronomy

1.Baseband data

2.Filterbank data

3.Time series

The stream of voltage data from a radio telescope. The most detailed data format.



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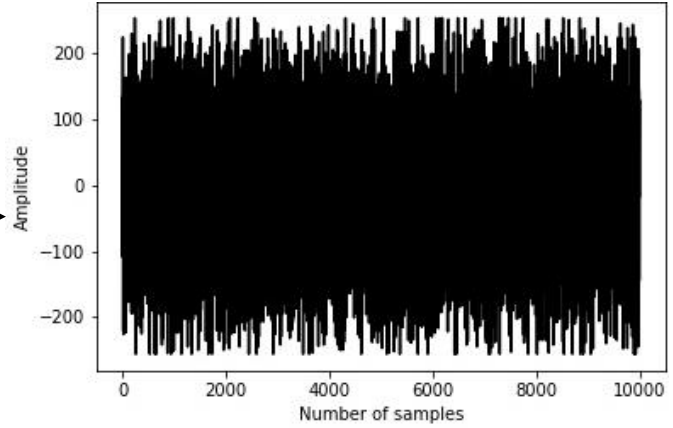

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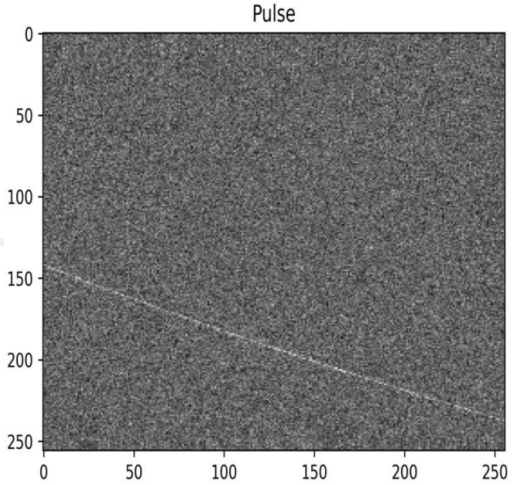

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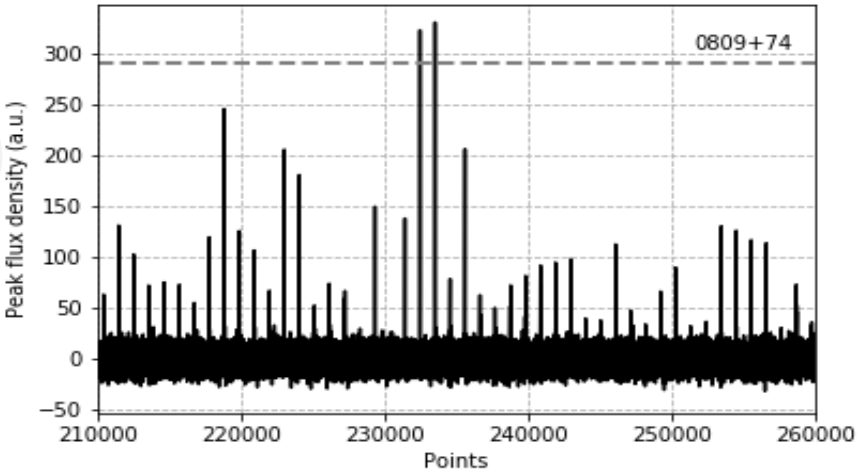

Data types in radioastronomy

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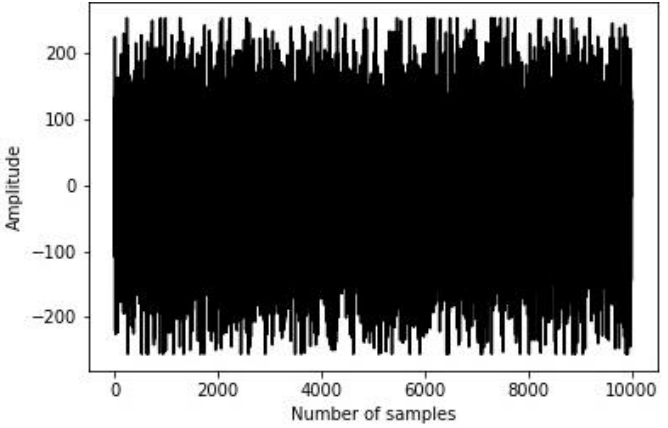
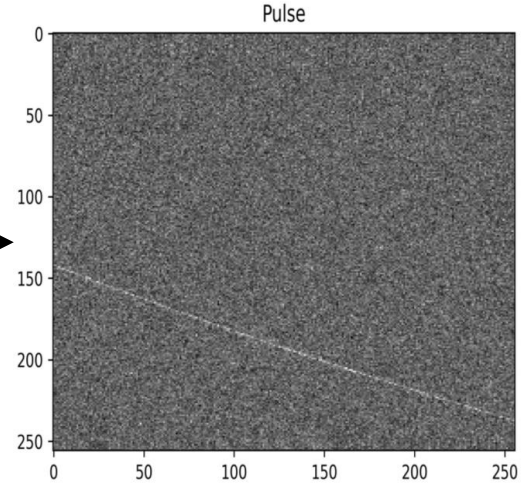
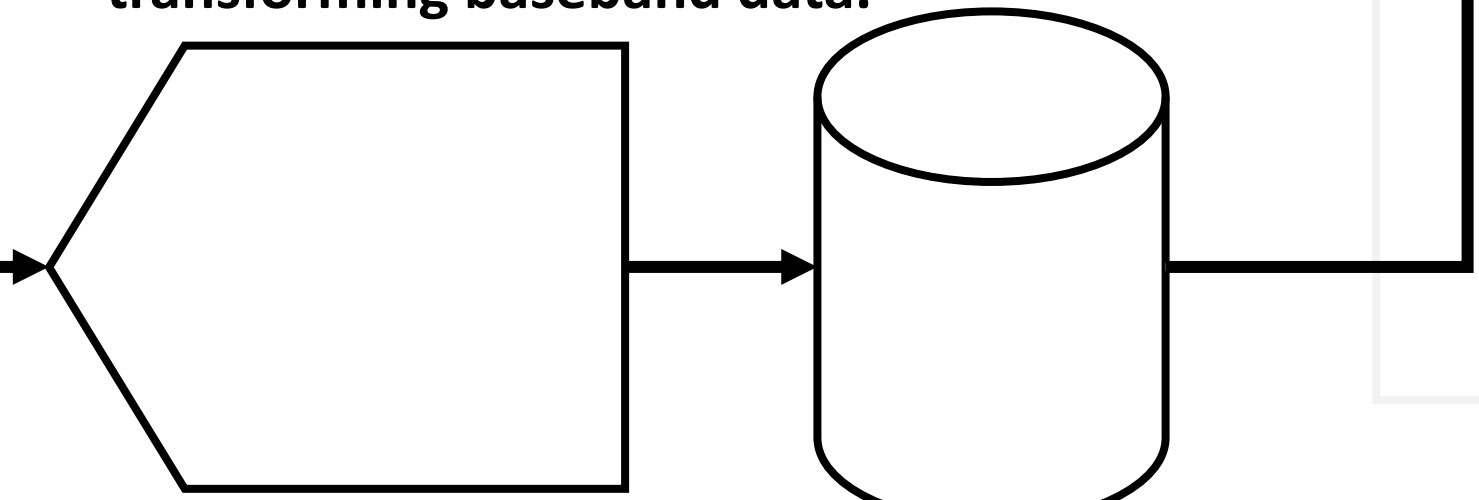


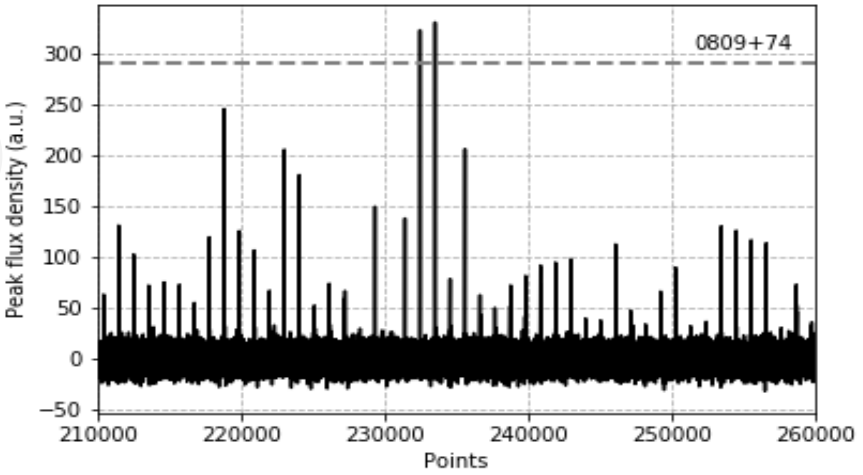


A spectrogram obtained by Fourier transforming baseband data.



ADC

Storage



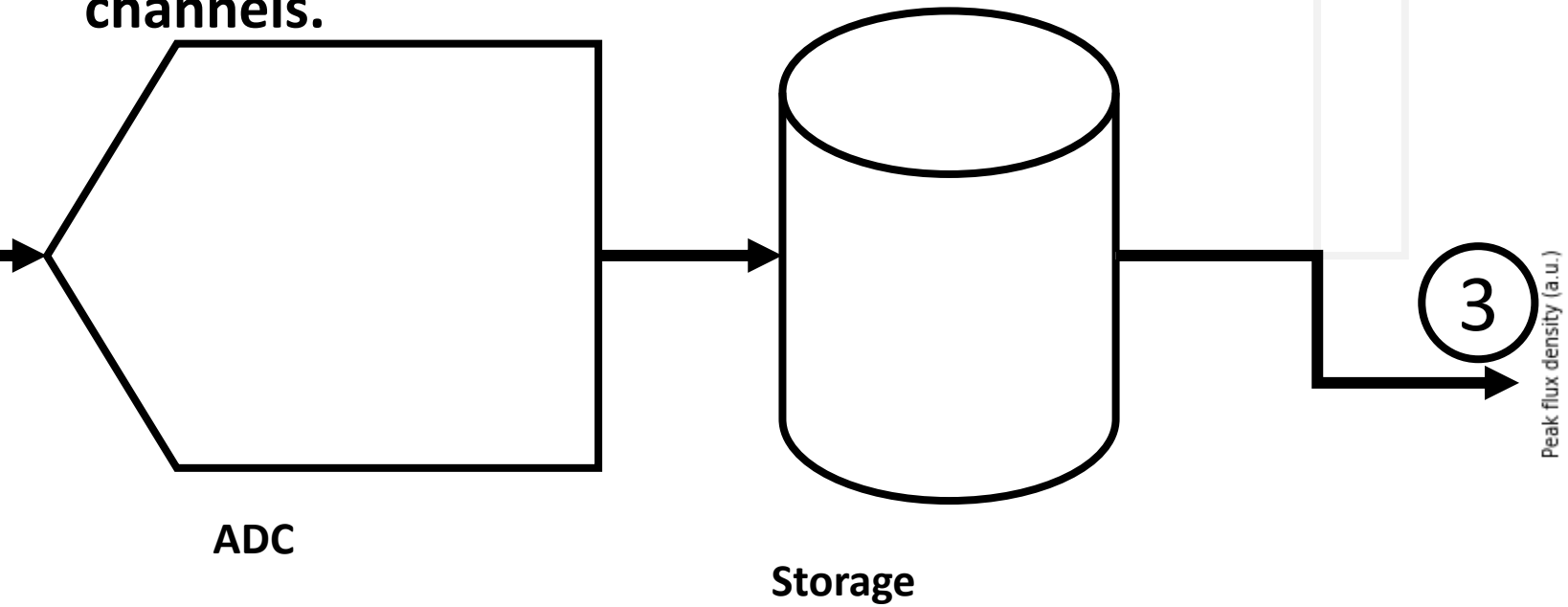
Data types in radioastronomy

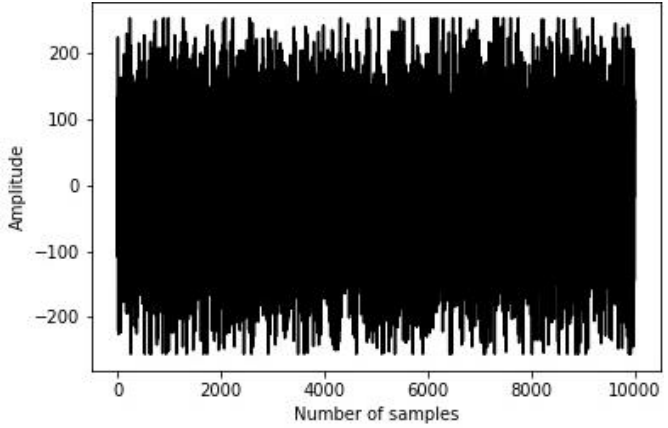
1.Baseband data

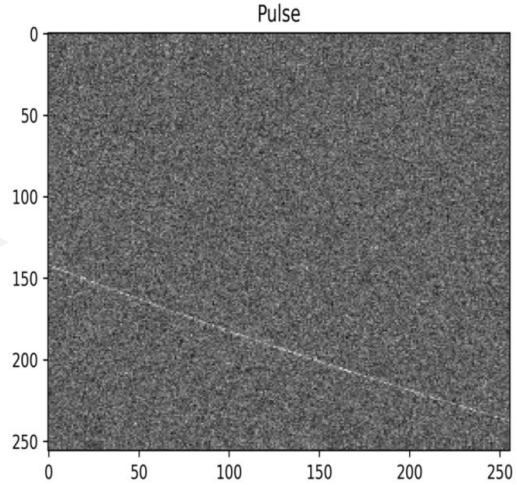
2.Filterbank data

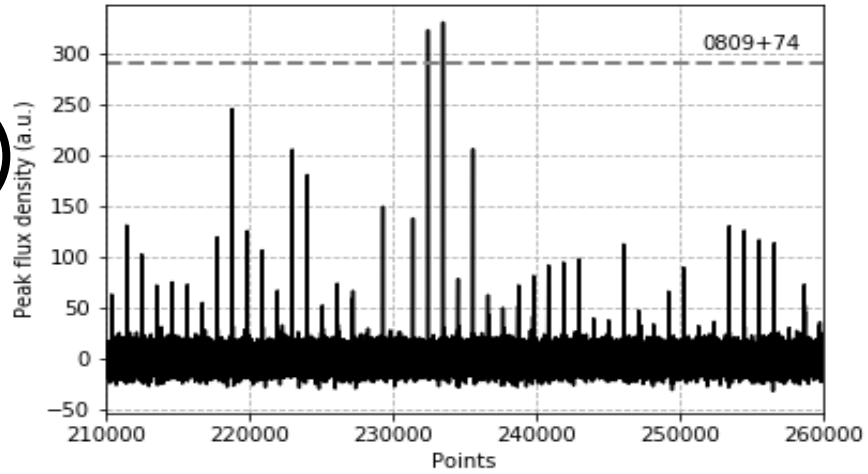
3.Time series

The sequence of pulsar pulses that has been dedispersed and summed across frequency channels.

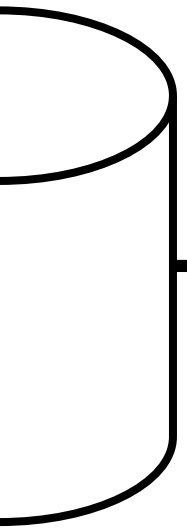








Data types in my



Storage

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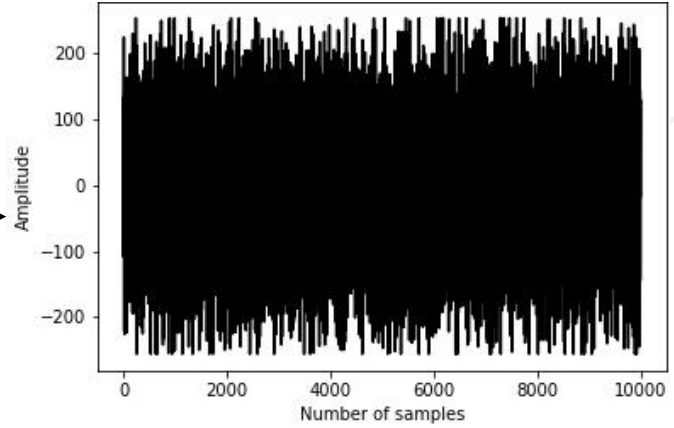
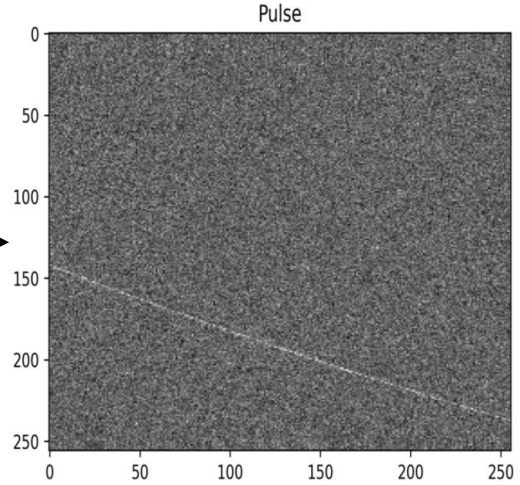


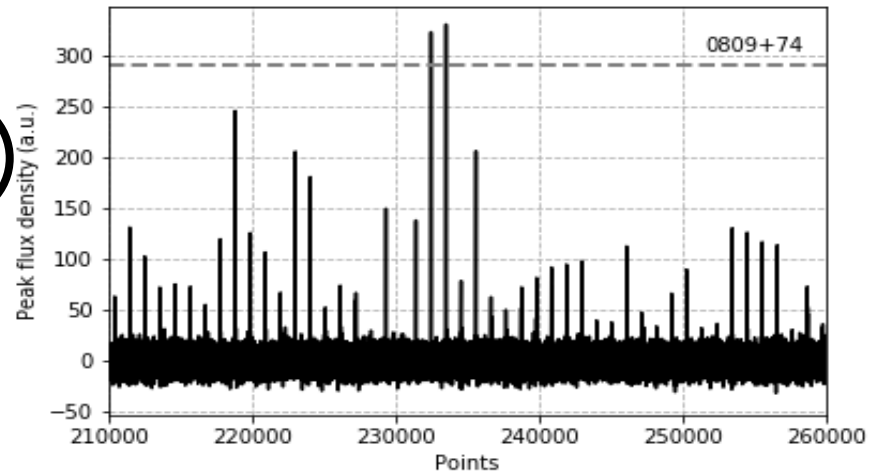
$$X(t)$$

2



$$S(f,t) = \left| \int_{-\infty}^{\infty} X(t) e^{-2\pi i f t} dt \right|$$

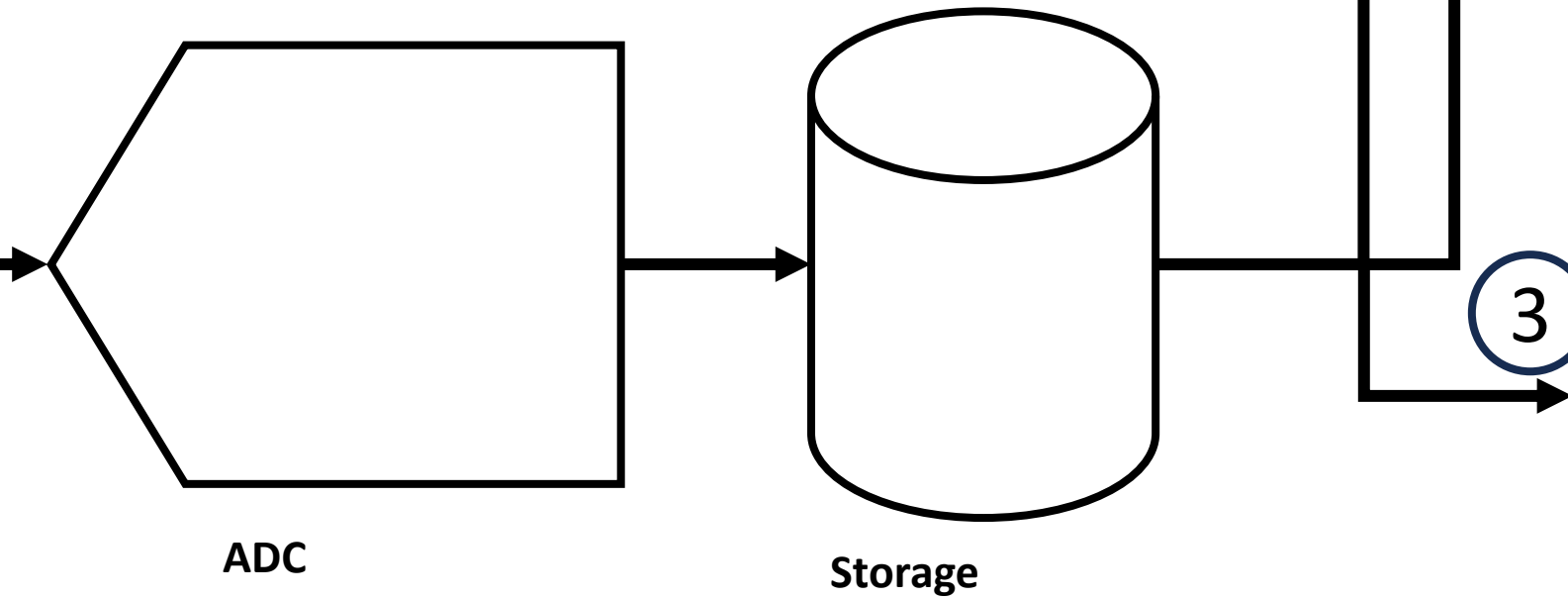
3



$$T(t) = \sum_{f} S(f,t)$$

The aim…

Real-time classification of radio telescope signals and storage of dispersed signals in baseband format.



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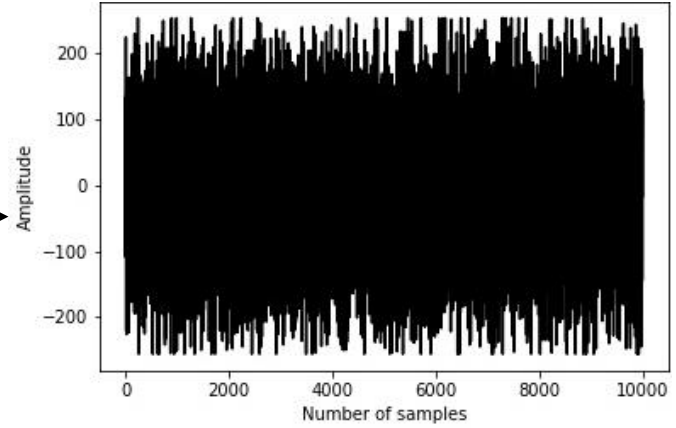

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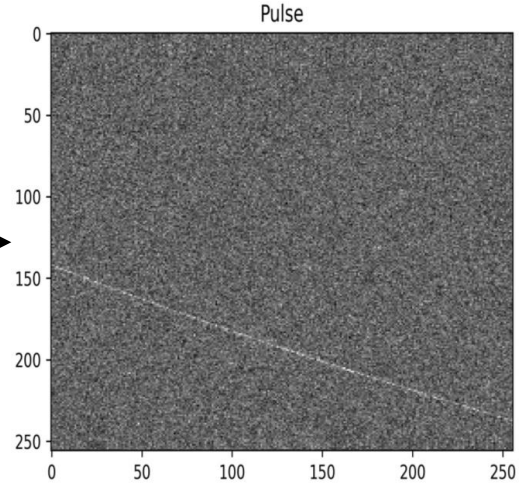

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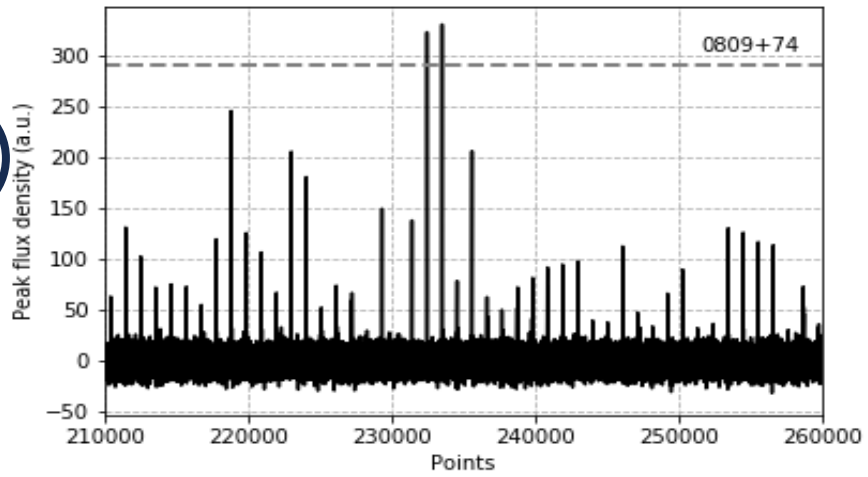
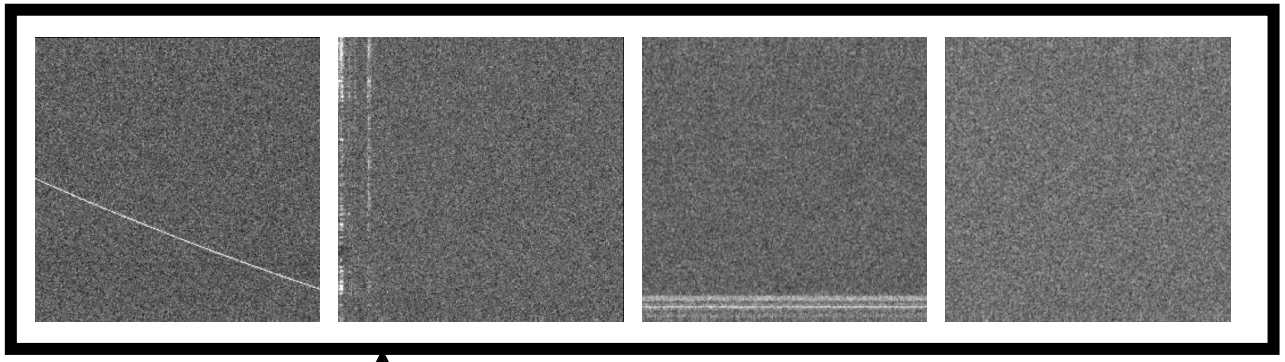
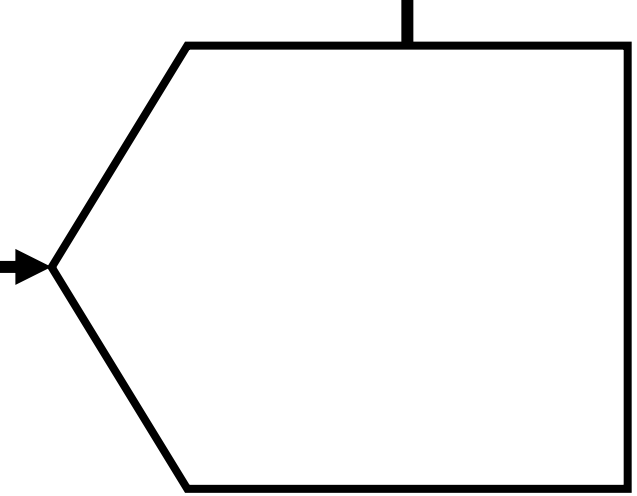


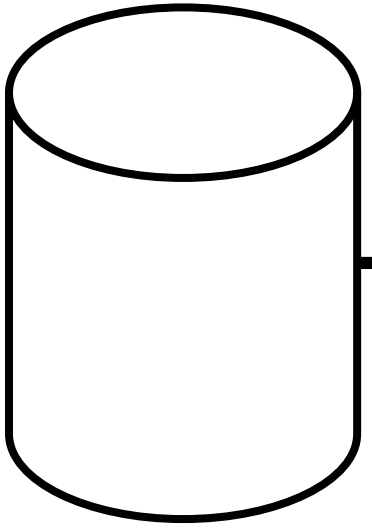
The idea

The model receives data from the telescope in real time





ADC



Storage

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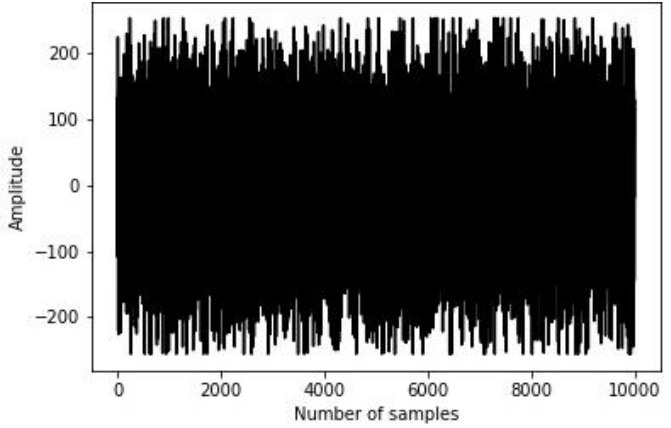

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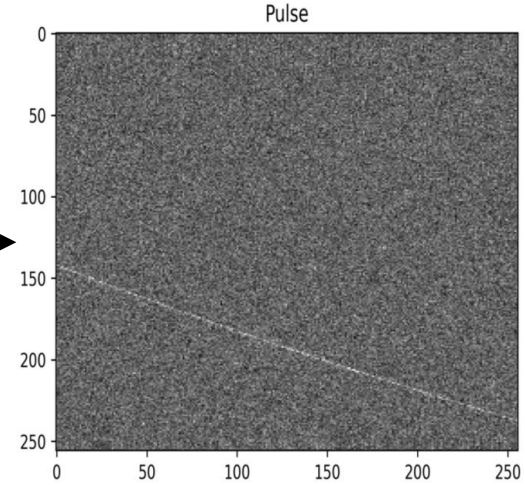

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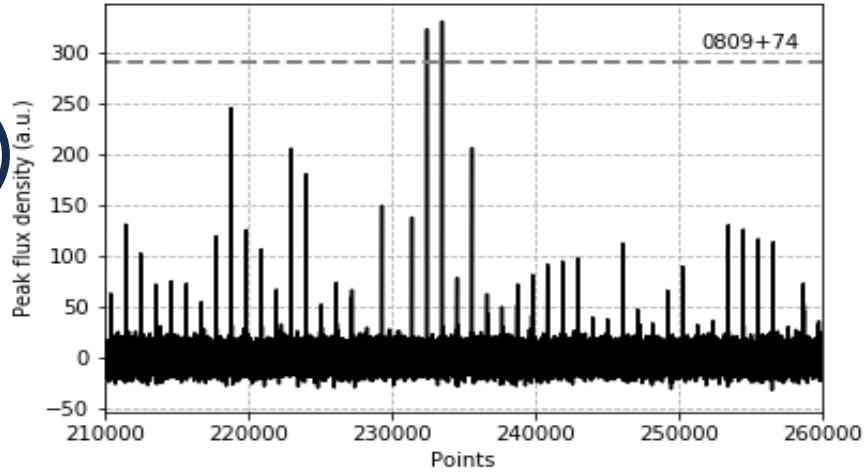
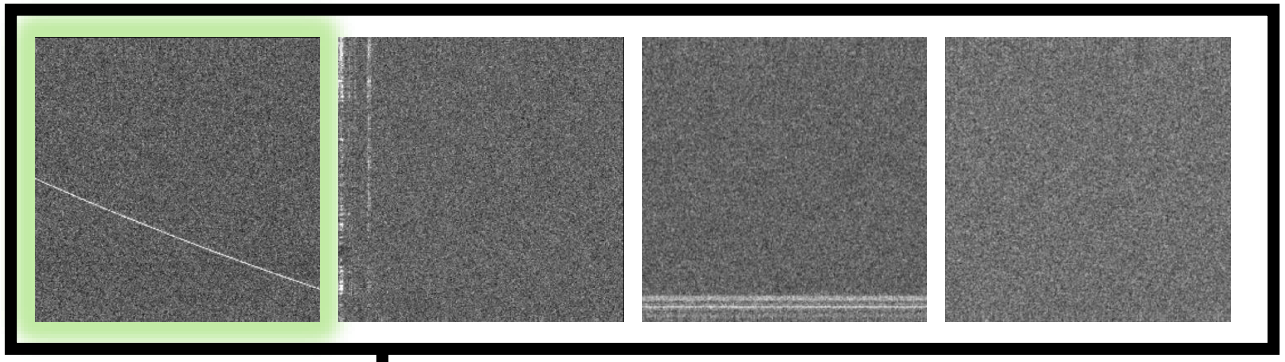
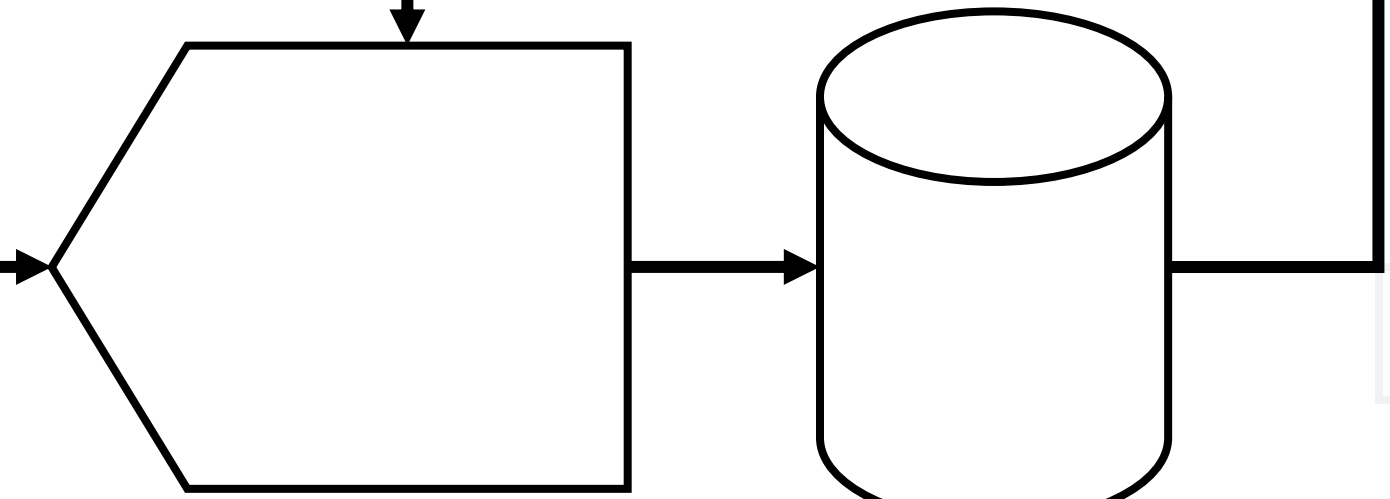


The idea

If there is a signal with dispersion in the analyzed data section, it is saved in baseband format.





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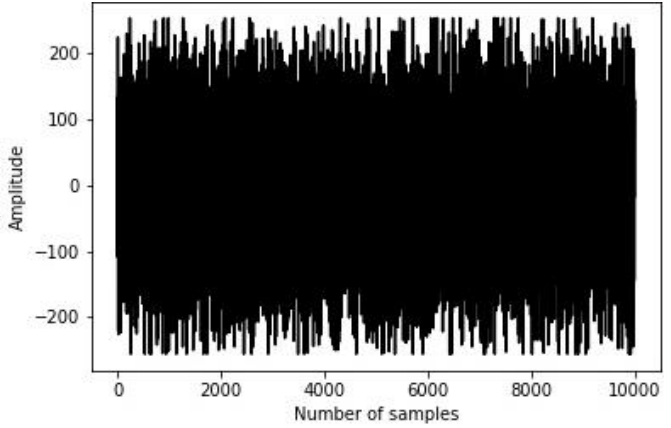

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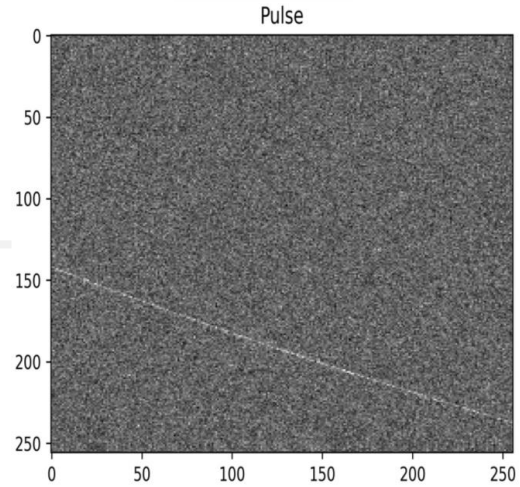

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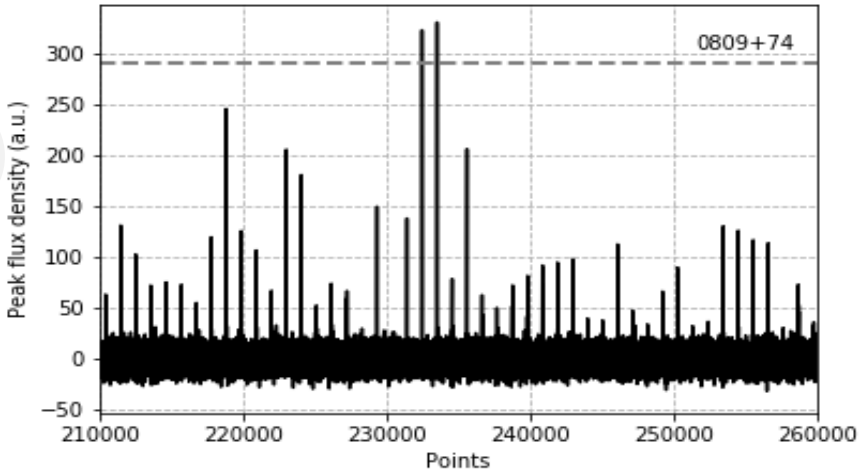
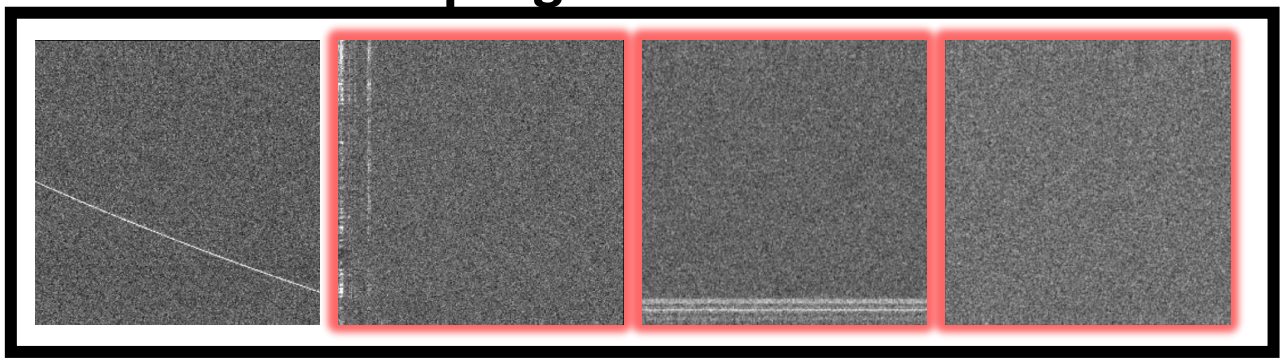
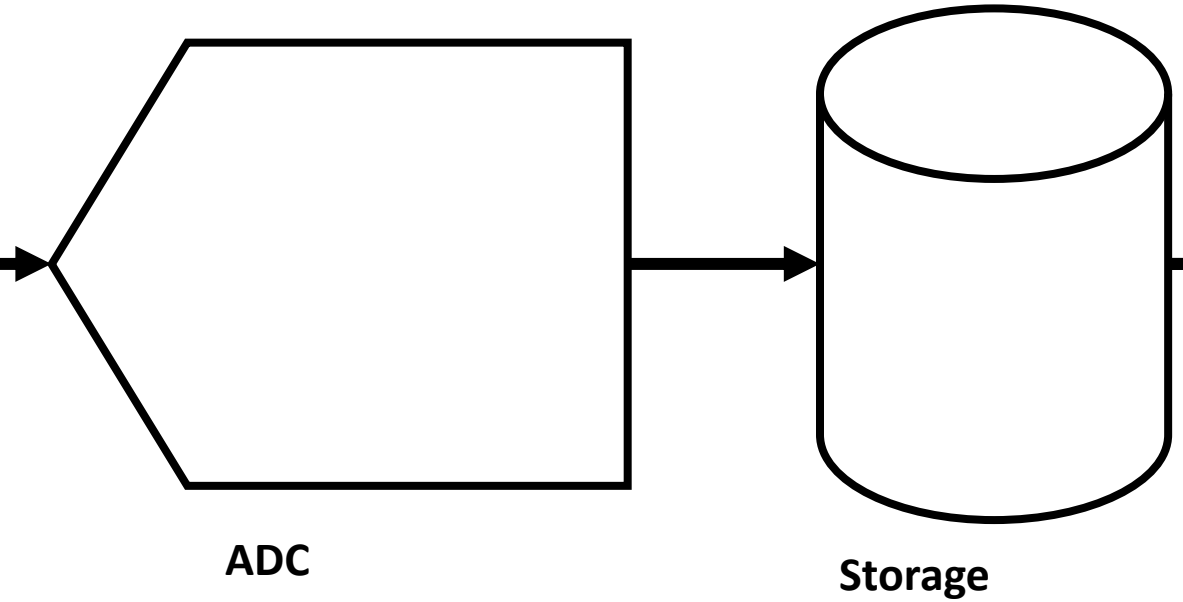


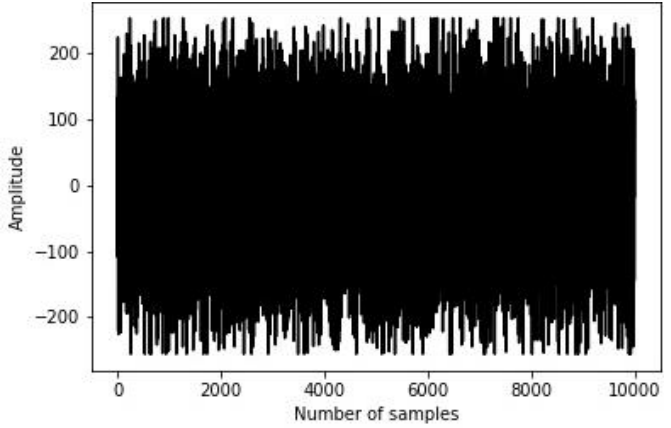
The idea

For other signals, they are stored according to the observation program





1



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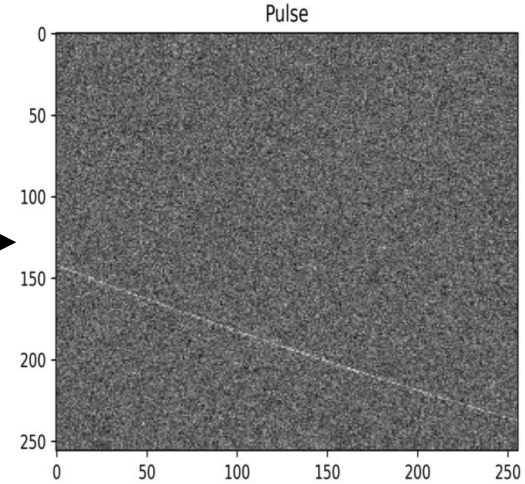

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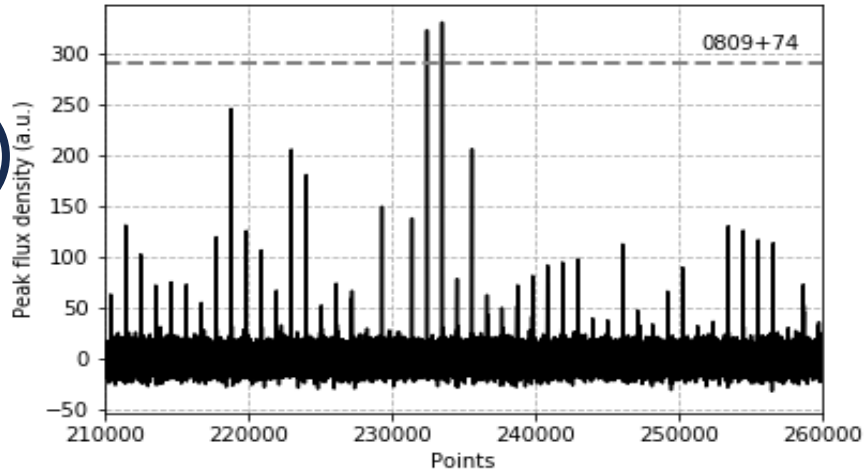
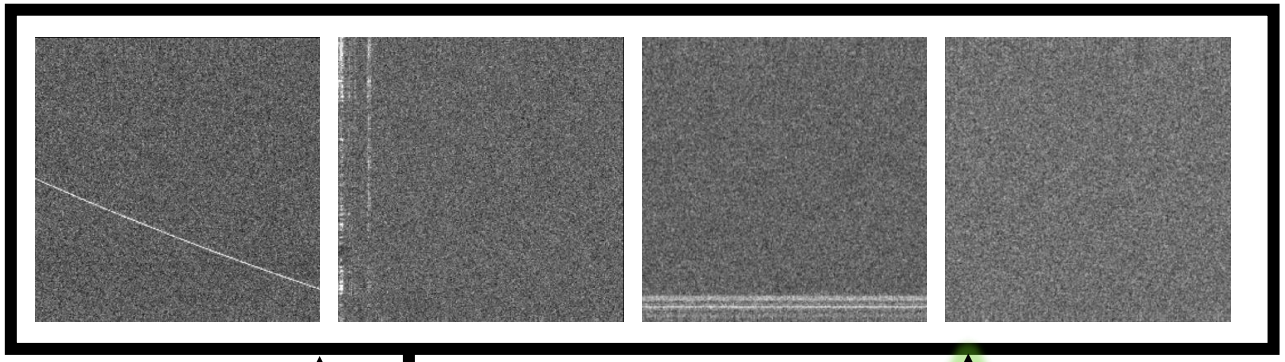
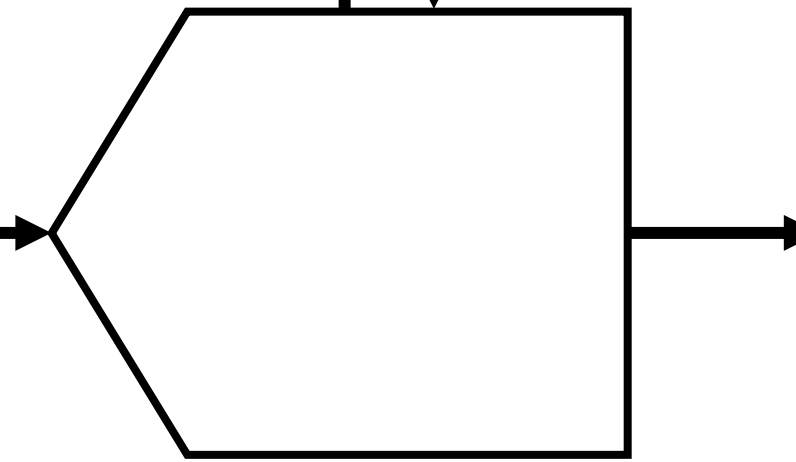


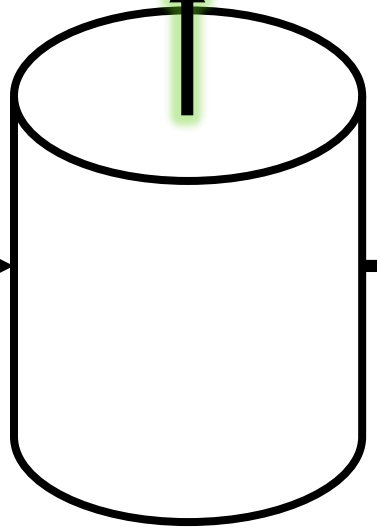
The idea

It is assumed that previously stored signals are used to retrain the model



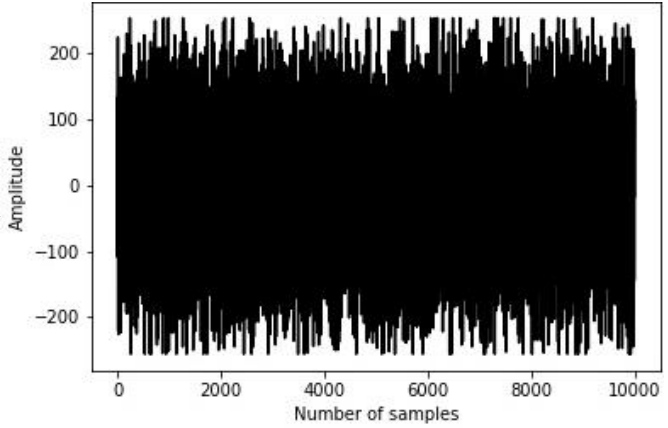


ADC



Storage

1



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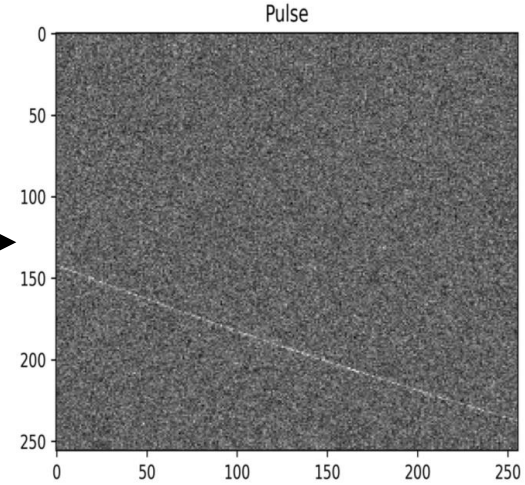

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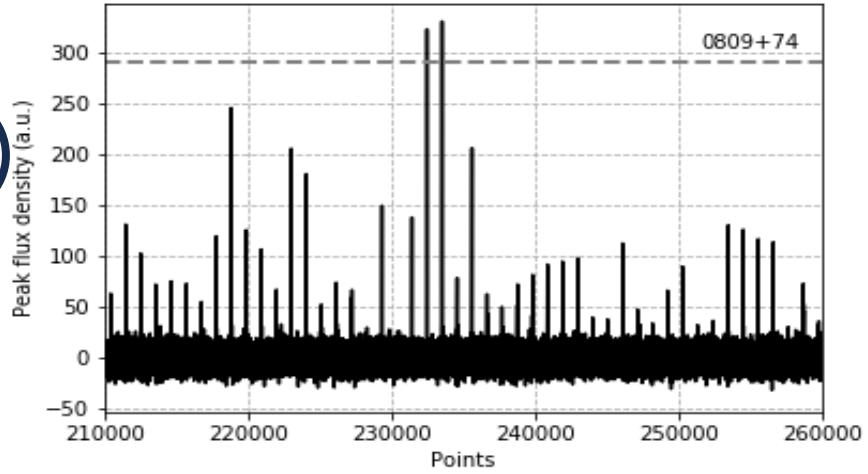
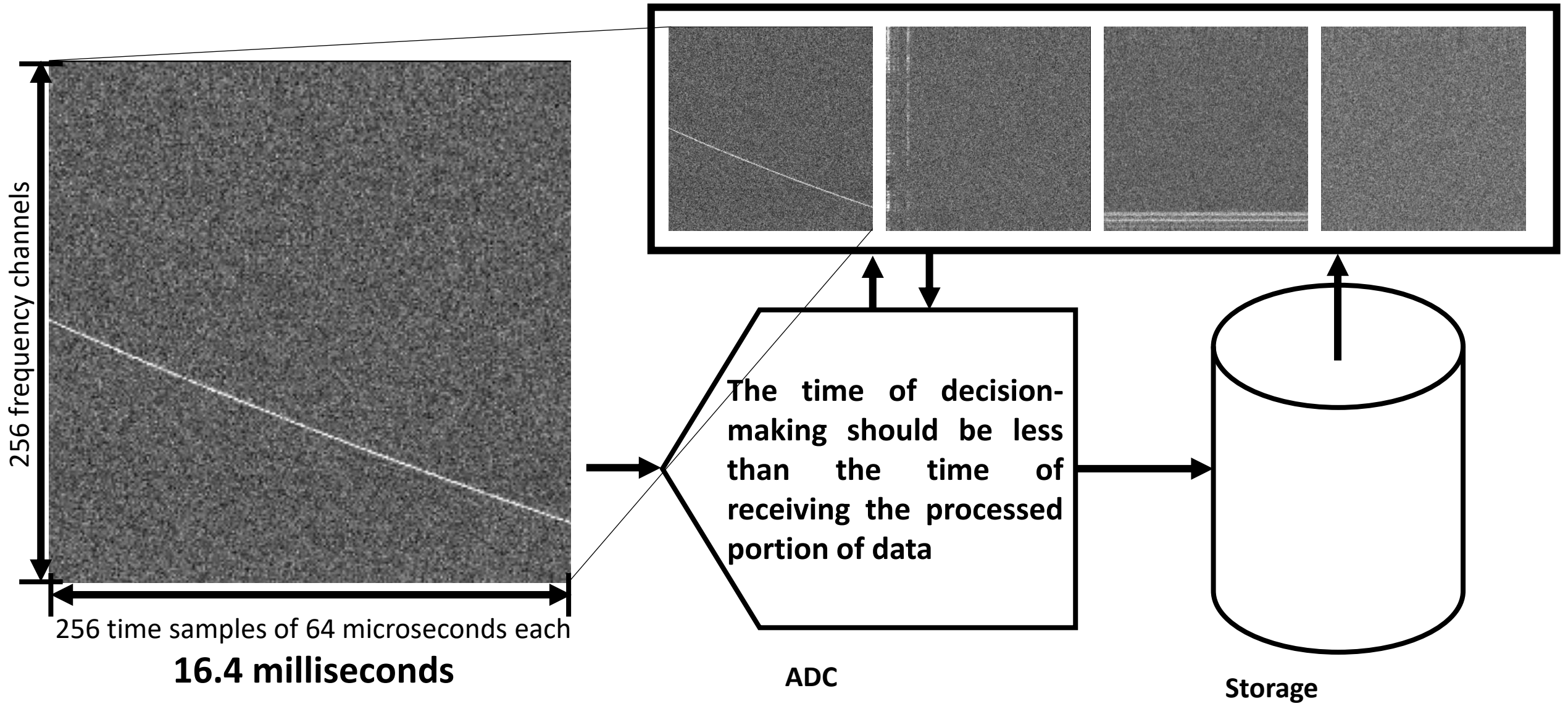
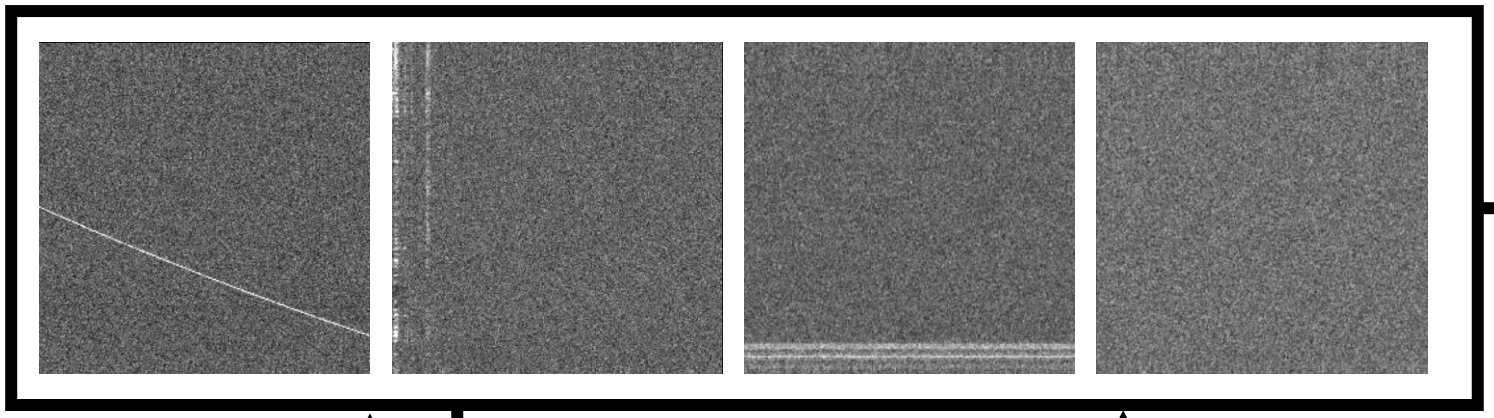


Model requirements - 1



Model requirements - 2



If accuracy == 90%:

The model should be very accurate, so as not to create false triggers and not to load the server with useless data.

Than useless data rate == 10%

For SKA telescope it is 204 GB /s

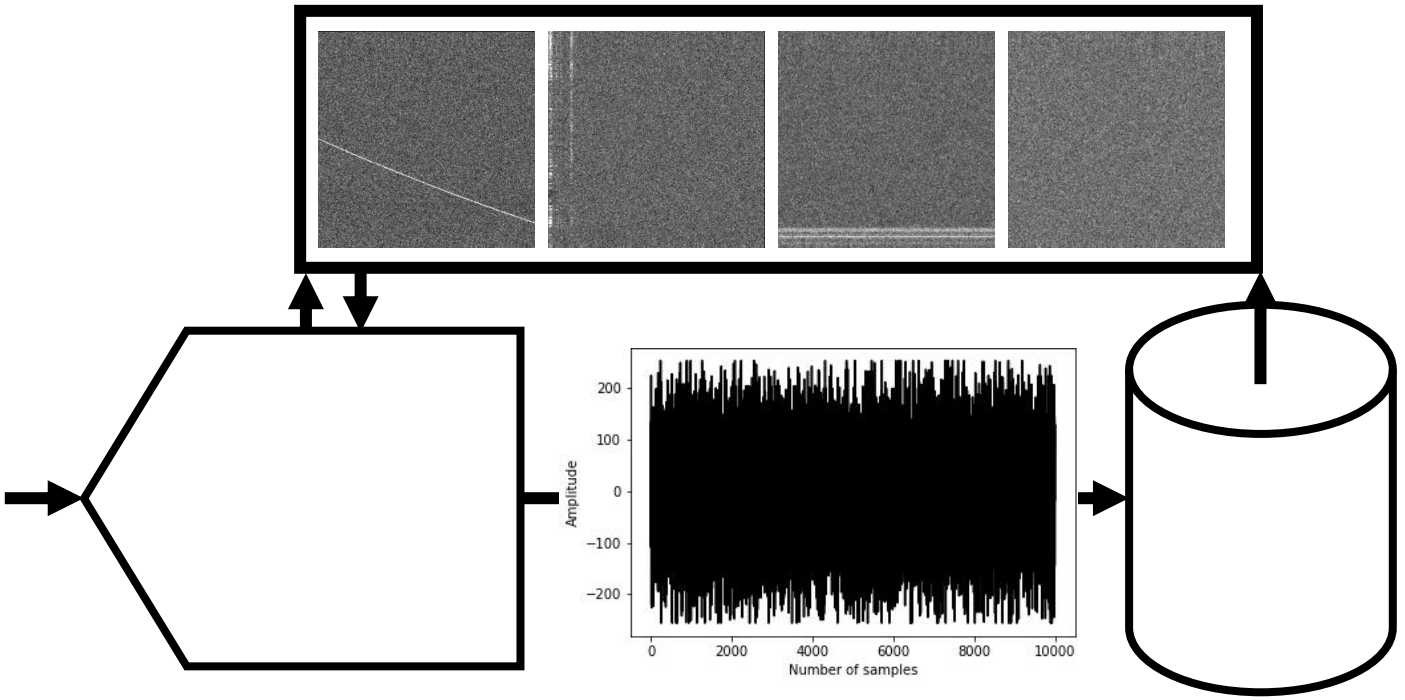
ADC

Storage

The model – our idea

The project's goal is to classify signals received by a radio telescope in real-time.

- If the classified signal exhibits dispersion delay, this segment of data should be saved in the most detailed format possible.
- Classification must occur faster than the time it takes to receive the data segment being classified.
- The classification should be highly accurate to avoid storing large amounts of unnecessary information.



Radio telescopes and data rates

Radio telescope name	Radio telescope exterior	Bitrate per beam	Total bitrate
Effelsberg		P210-7: 11.04 Gb /s	**77 Gb / s (7)**
		UWB: 290 Gb / s	**290 Gb / s (1)**
MeerKAT		107 Mb / s	**0.1 Tb / s (~1024 beams)**
Square Kilometer Array		~ 1 Gb / s	**20 Tb / s (>2200 beams)**