

RESCEU Summer School 2020

On the use of CHIME to Detect Long-Duration Radio Transients from Neutron Star Mergers

Minori Shikauchi

(<https://insidetheperimeter.ca/canadian-telescope-chimes-breakthrough/>)

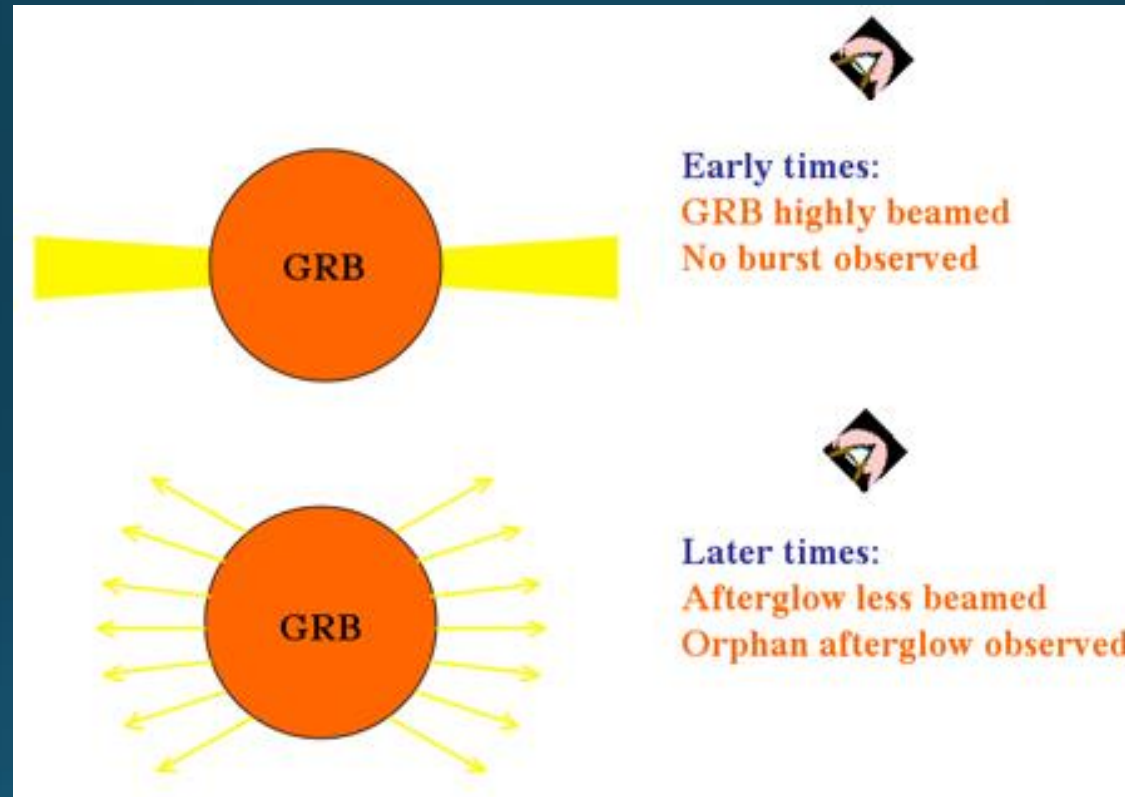
Afterglows Can Reveal SGRBs' Features

- relativistic jet -> beaming-corrected energy scale
- estimation of surrounding medium

* weakness*

- Fainter ($\sim \mu\text{Jy}$ -mJy)
- Directivity of prompt emissions
 - > ~ 100 detected in X-ray to radio, only 4 in radio
- Difficult to confirm afterglows without prompt emissions

Orphan Afterglows : Less Biased to Jet Directions



(<https://astronomy.swin.edu.au/cosmos/O/Orphan+Afterglow>)

- Observation of orphan afterglows may increase the number of detected SGRBs drastically

CHIME: Powerful Observatory for Orphan Afterglows



(<https://chime-experiment.ca/en#a8>)

- Originally designed for making 3D map of neutral Hydrogen
- Greatly contributes to fast radio bursts

CHIME: Powerful Observatory for Orphan Afterglows

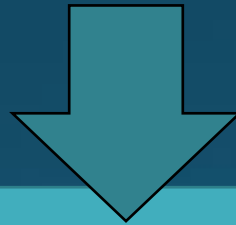


- Originally designed for making 3D map of neutral Hydrogen
- Greatly contributes to fast radio bursts

If the progenitor of SGRBs is binary neutron star mergers, 100 thousand at most orphan afterglows can be detected!!

Aim of My Work

- Analyze CHIME's data to detect orphan afterglows from SGRBs with CHIME
- discuss a mystery of SGRBs, e.g. their drive mechanism and origins



Develop an analysis pipeline to detect orphan afterglows from SGRBs with CHIME

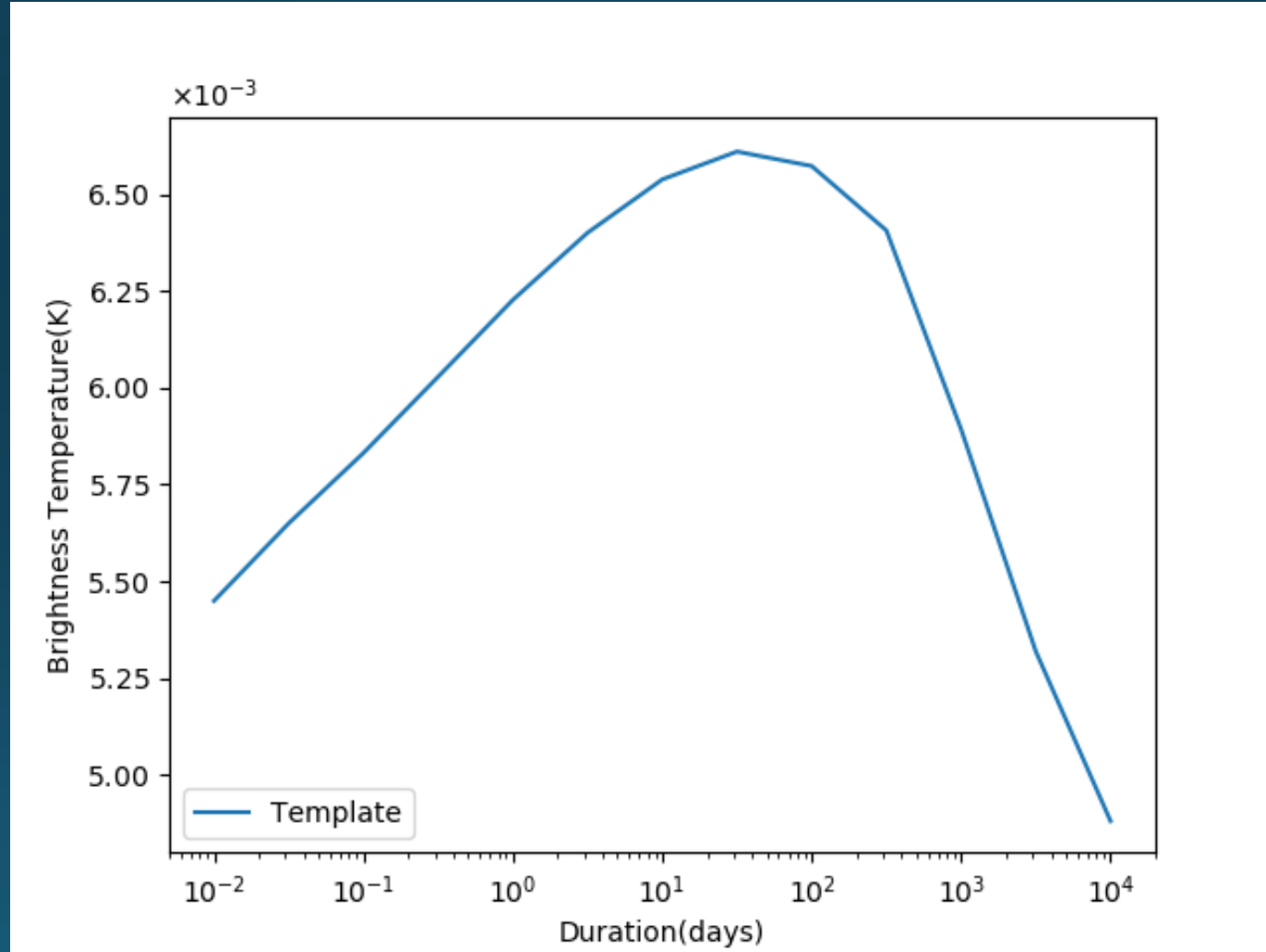
Scheme of Analysis Pipeline

- Prepare templates of light curves of afterglows
- Simulate point sources whose brightness changes with time
- Recover light curves from the simulation
- Assess “false detection rate” as a function of apparent luminosity

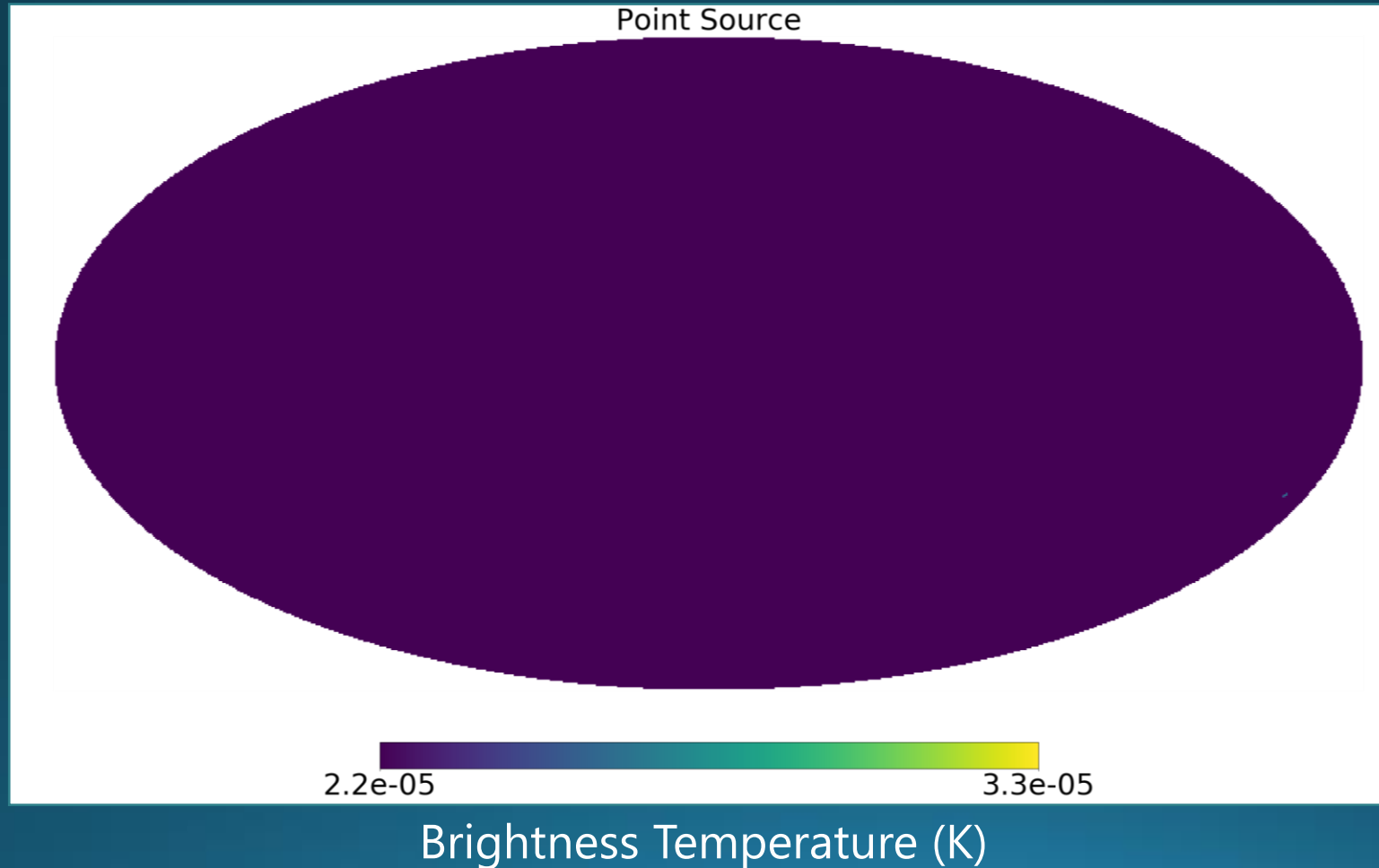
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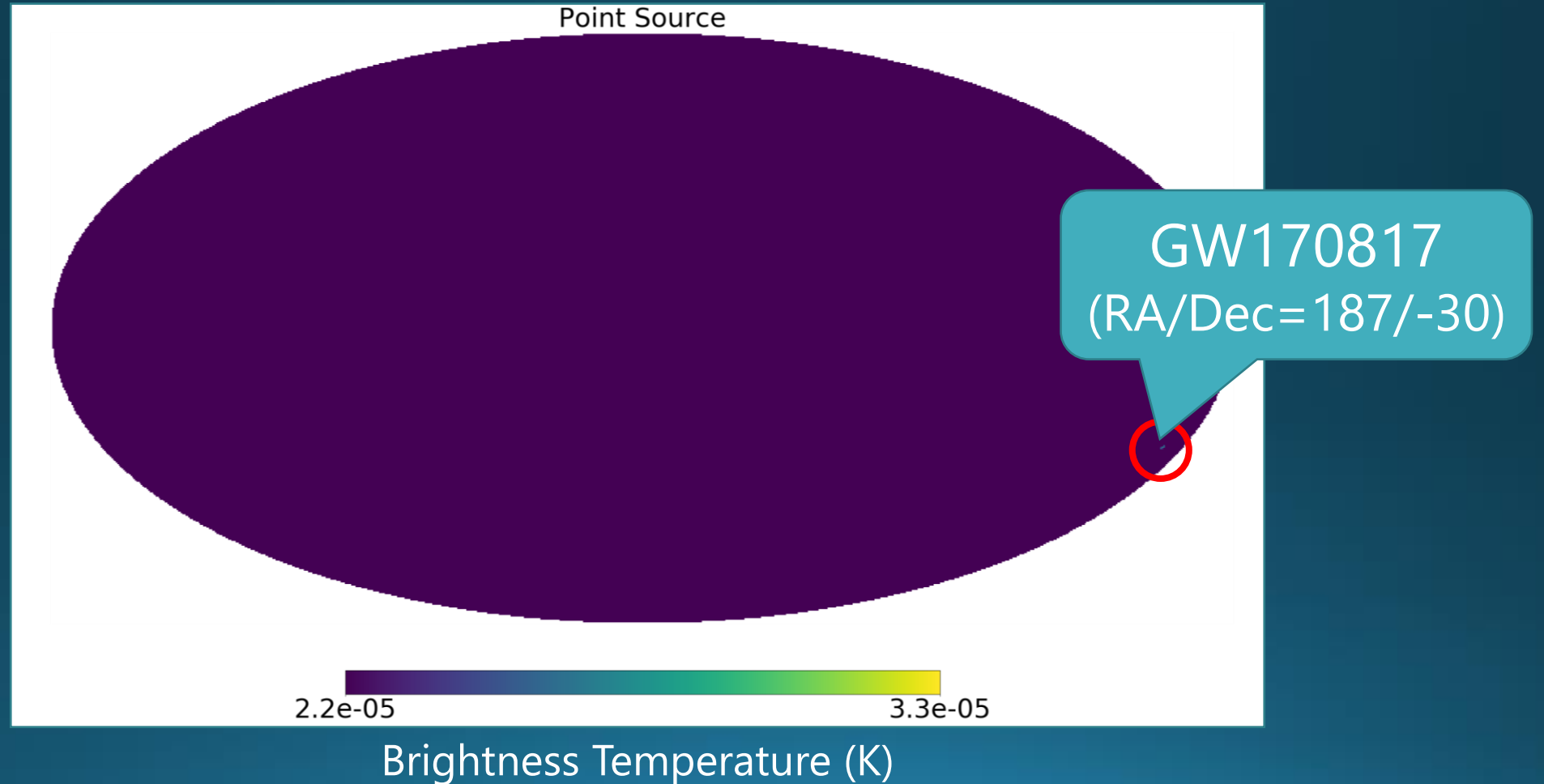
Template Light Curve



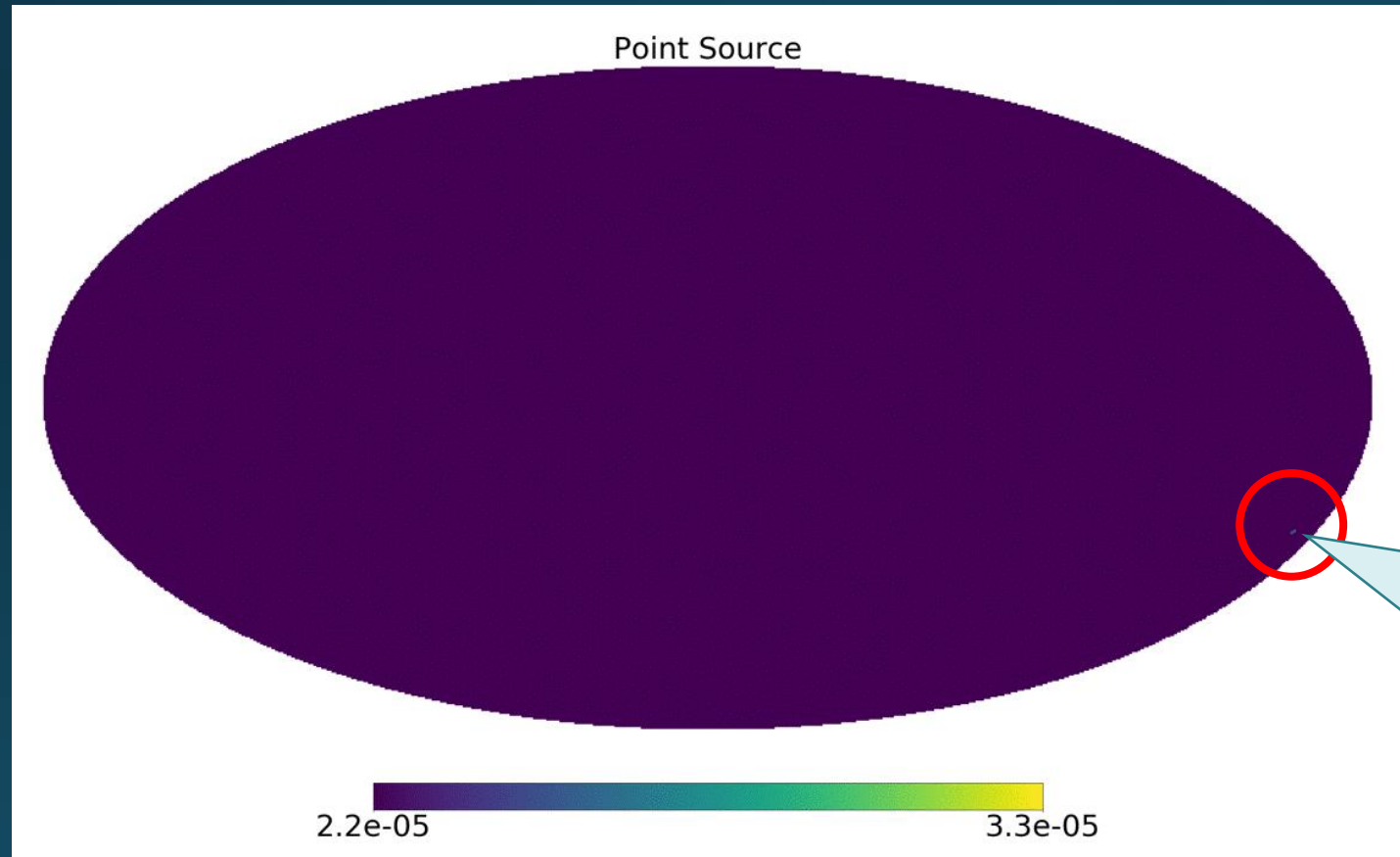
Point Source in the simulated sky with "cora"



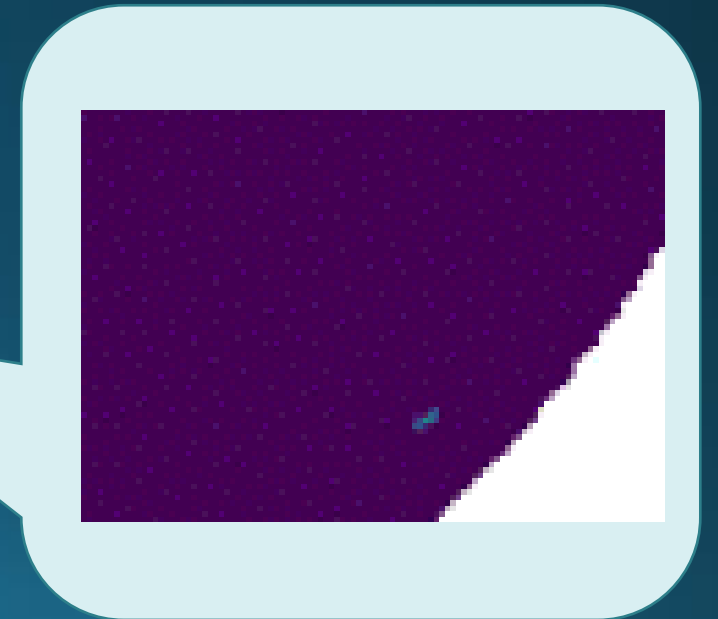
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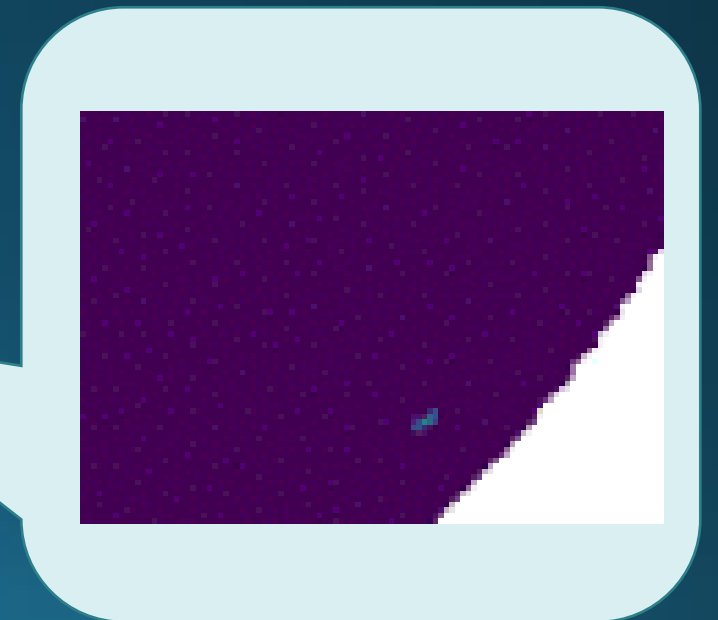
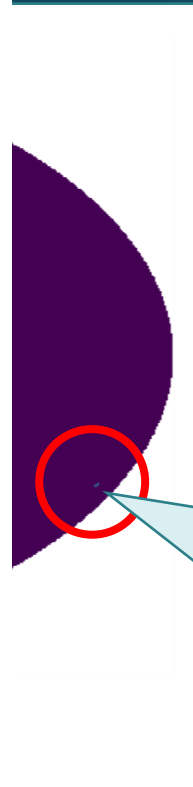
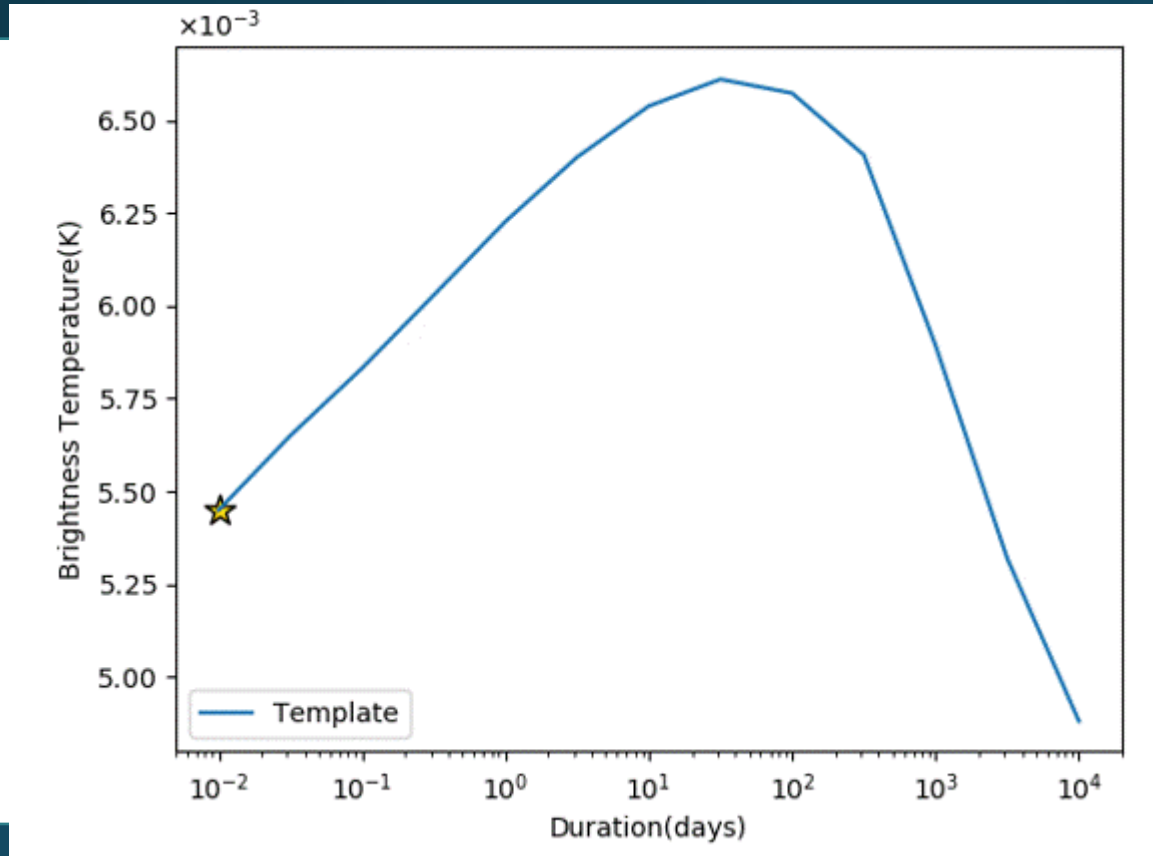
Point Source with Time-dependent Brightness



Brightness Temperature (K)

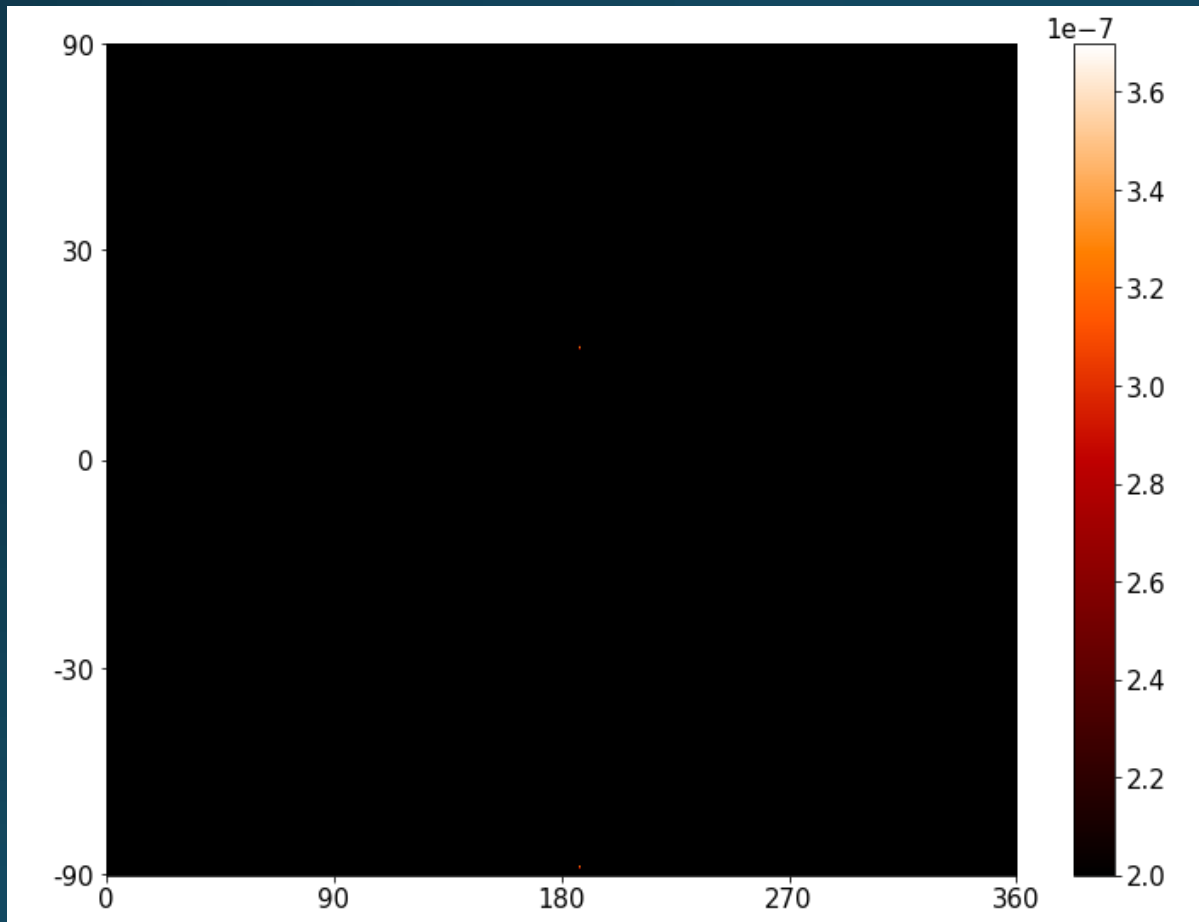


Point Source with Time-dependent Brightness



"Ringmap" with "caput" : FFT of visibility

"Elevation"
(Dec - CHIME's latitude)



RA(Degree)

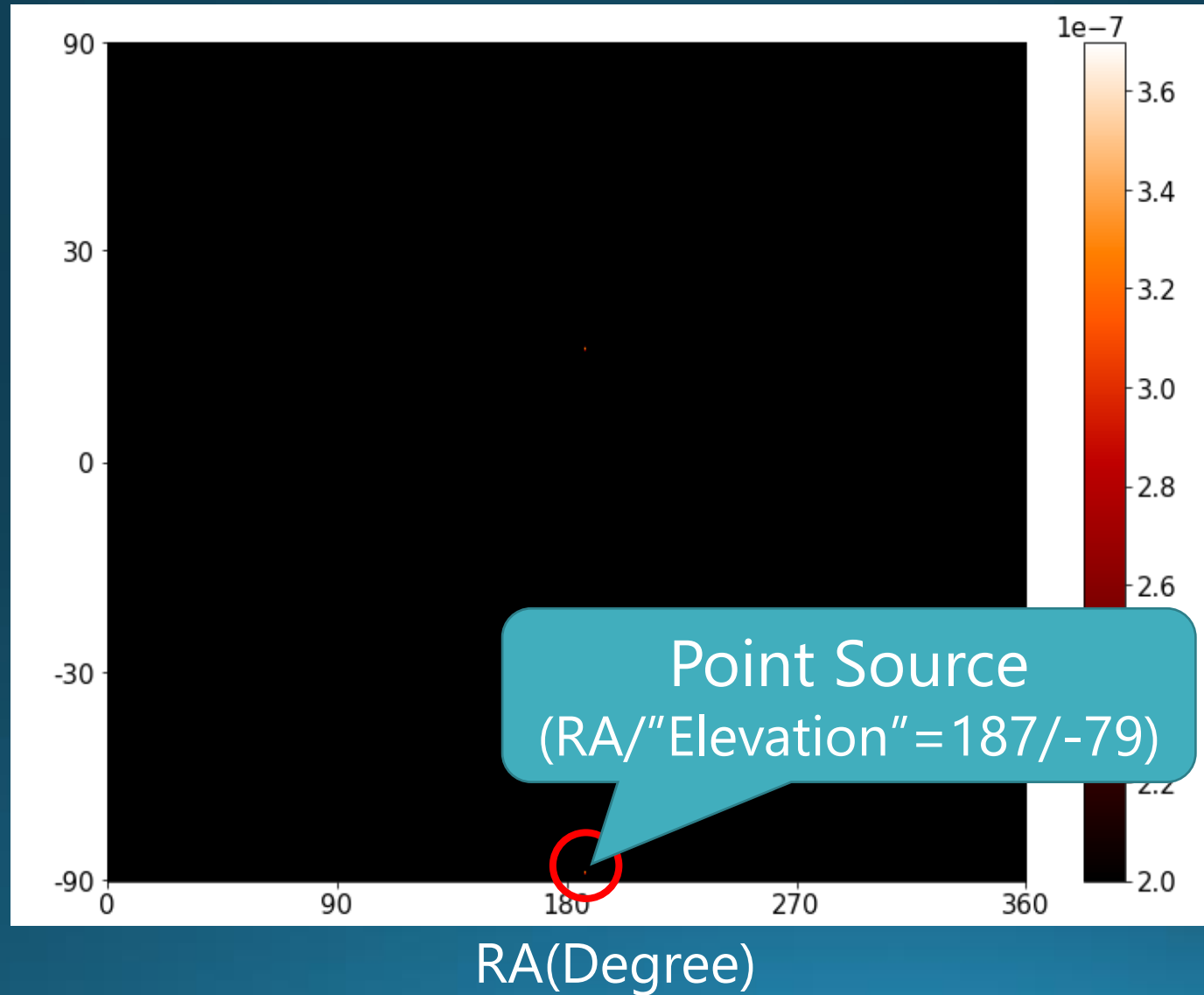
- Visibility : cross-correlation between two antenna signals

$$V_{ij} = \frac{1}{\Omega_{ij}} \int d^2 \hat{n} A_i(\hat{n}) A_j^*(\hat{n}) e^{2\pi i \hat{n} \cdot \mathbf{u}_{ij}} T(\hat{n})$$

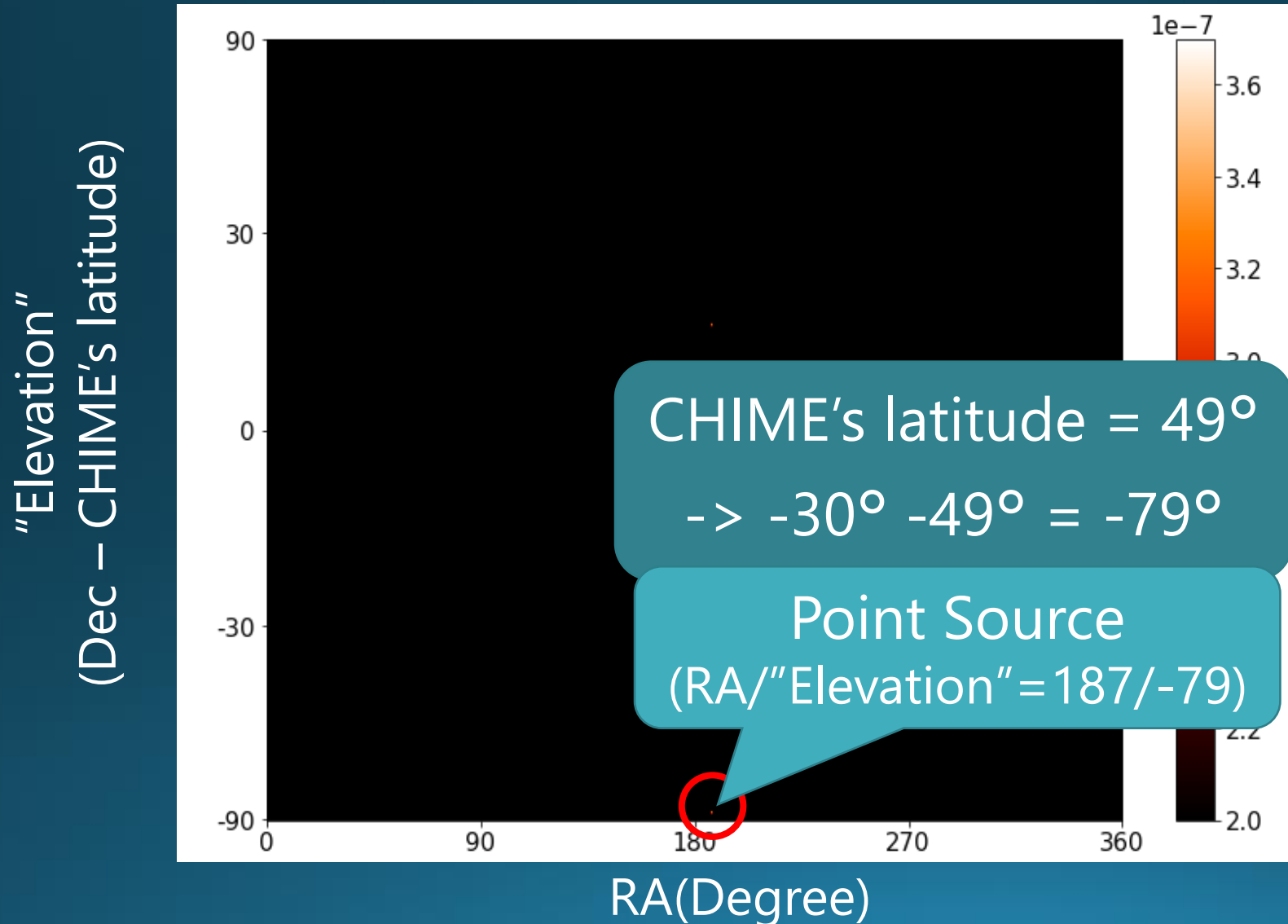
- FFT of visibility
 \propto brightness temperature distribution in the sky

"Ringmap" with "caput" : FFT of visibility

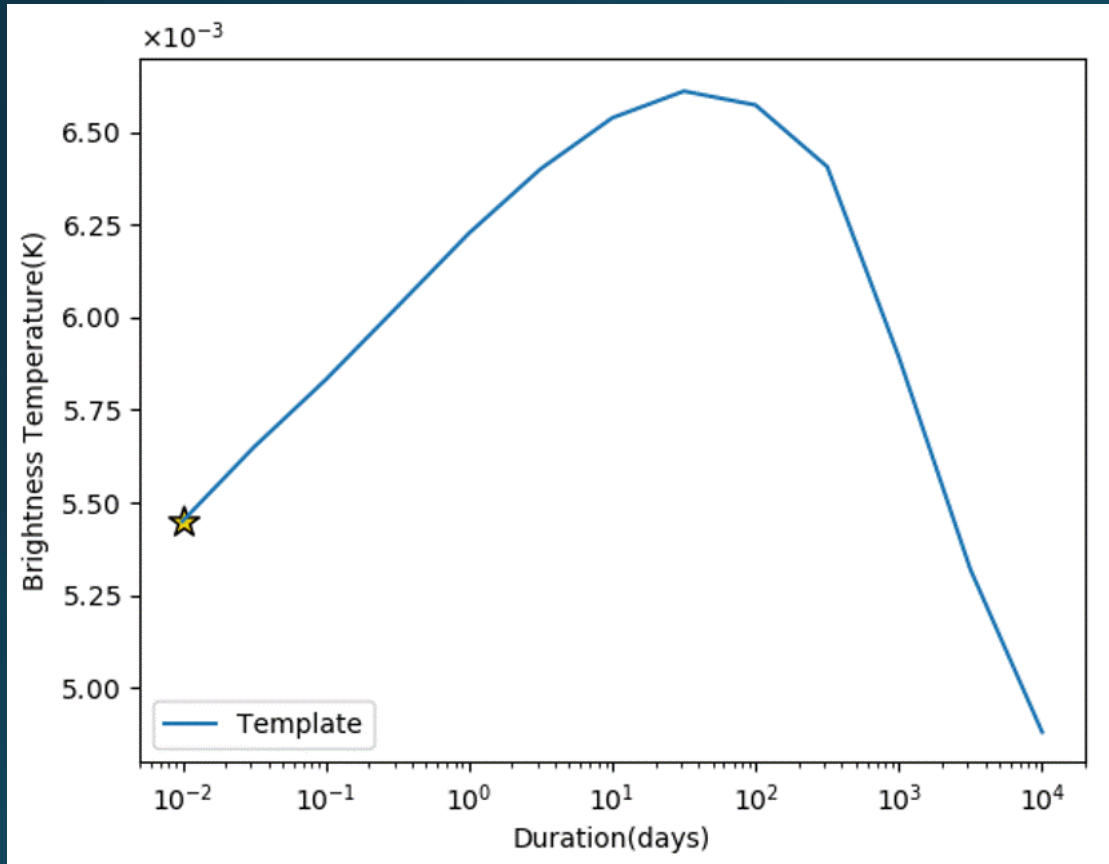
"Elevation"
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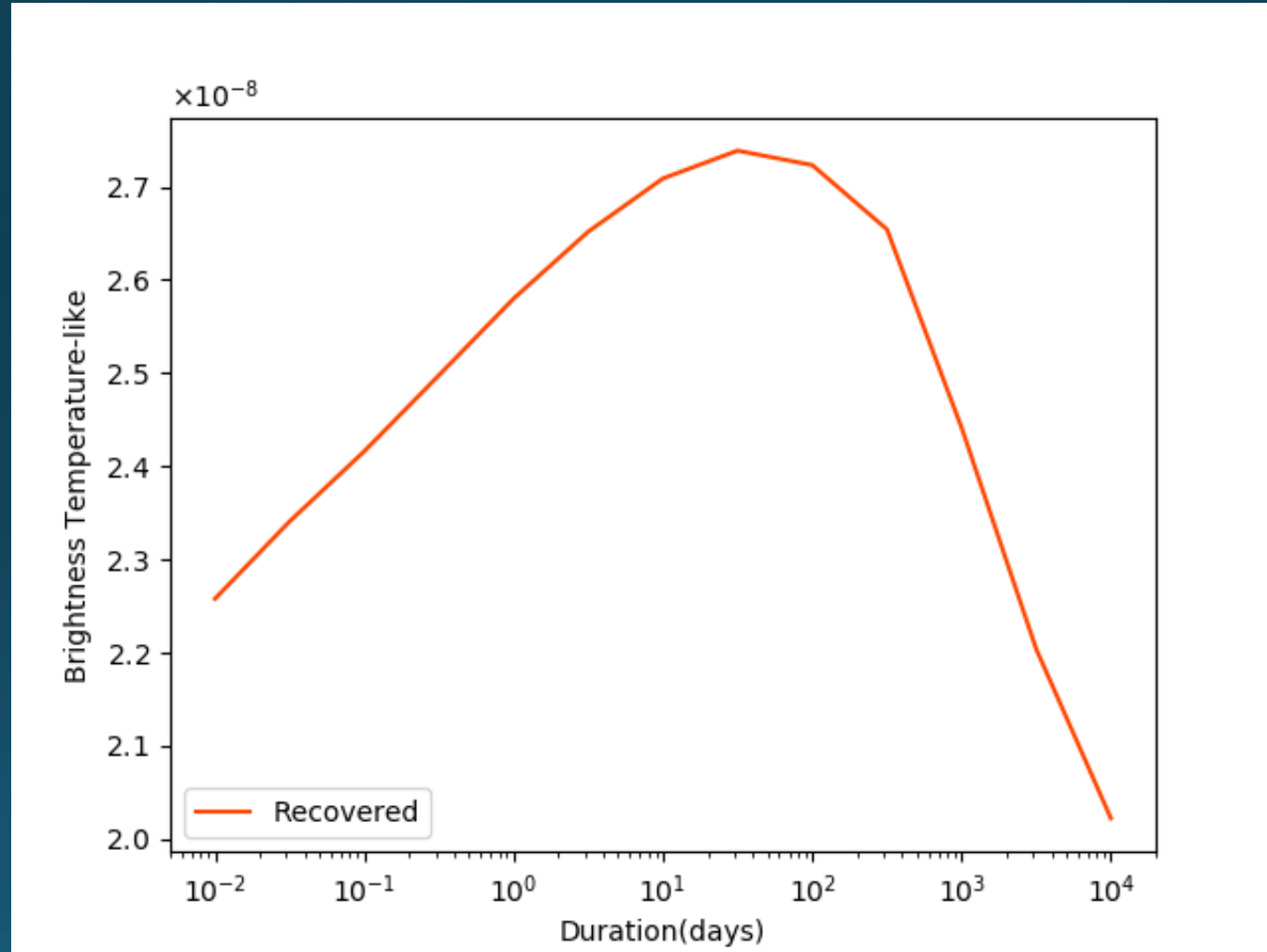
"Ringmap" with "caput" : FFT of visibility



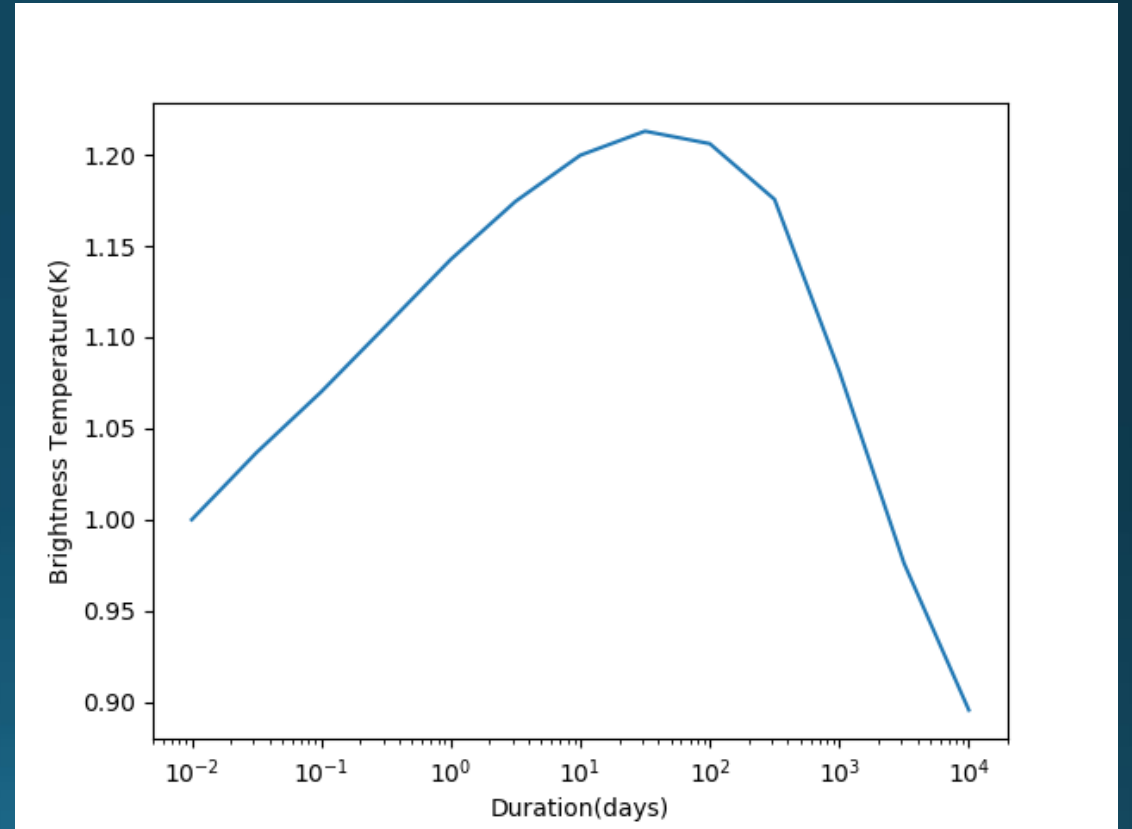
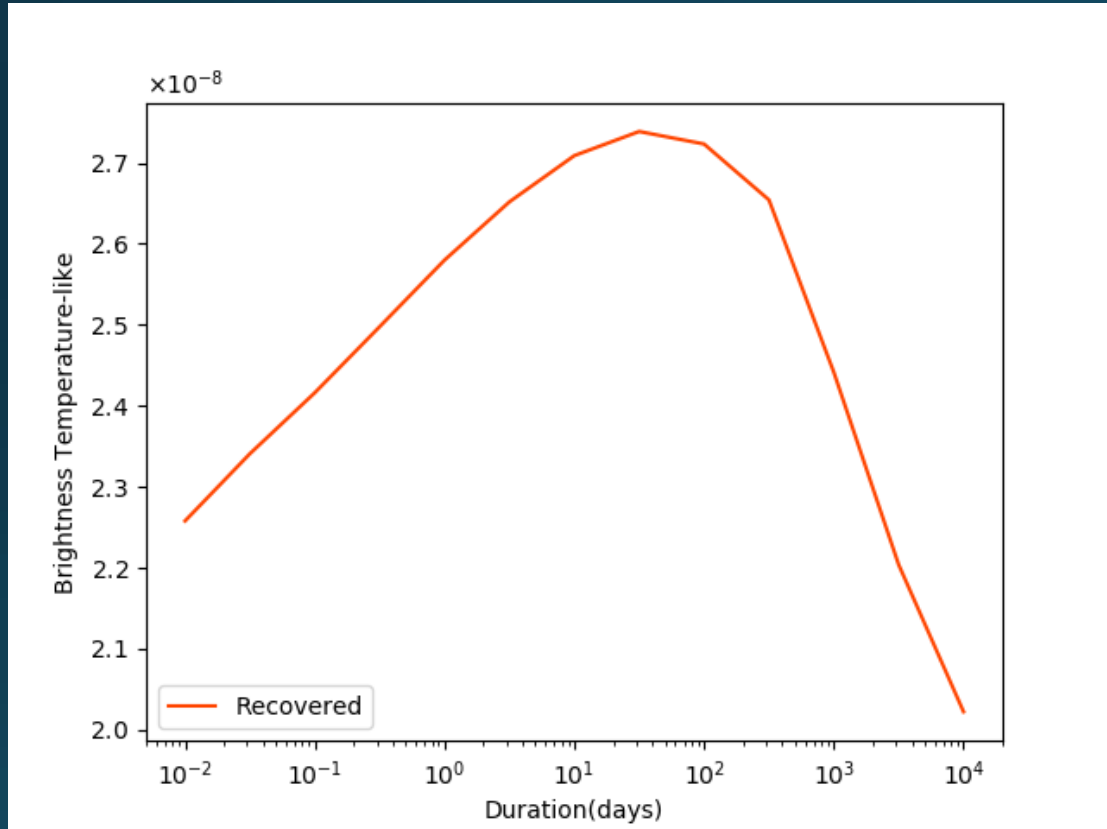
Timeseries of "Ringmap" Follows the Template



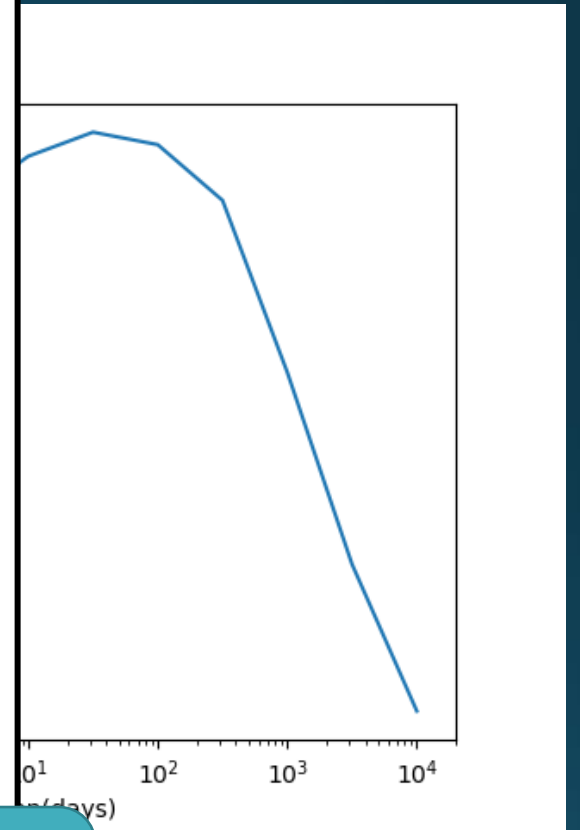
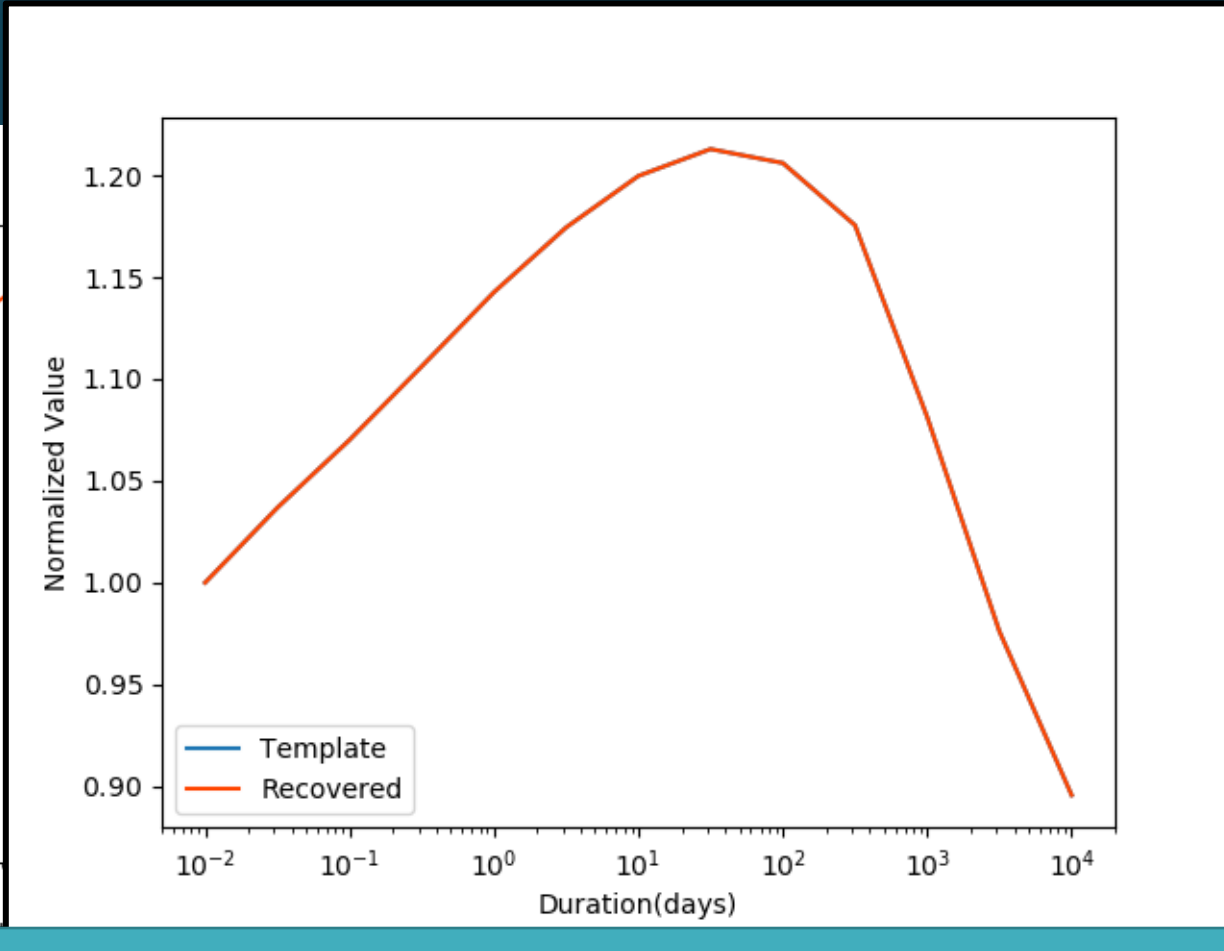
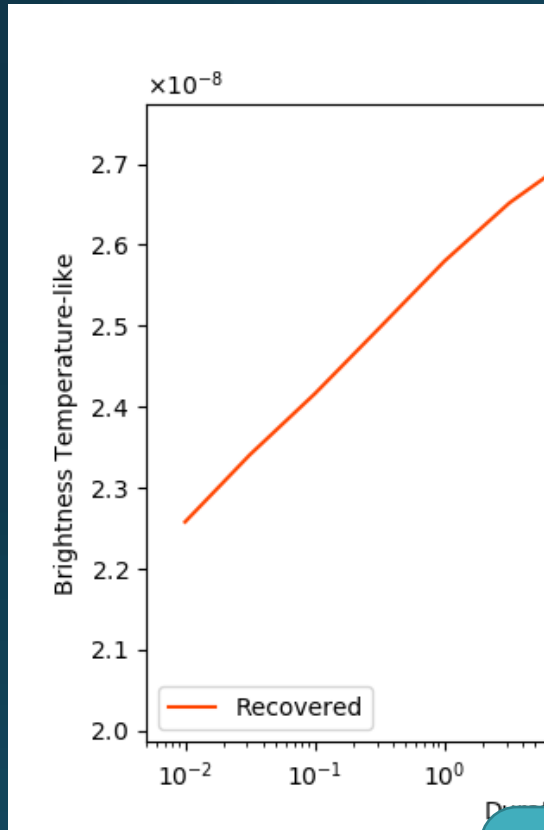
Recovered Light Curve



Comparison with Template



Comparison with Template



Successfully recovered the same shape of light curve as the template

Summary & Future Work

- Automated some processes using CHIME's open software
 - Making a time-series of simulated skymaps with time-dependent brightness temperature
 - Recovering light curves from the simulation data
- Prepare a "template bank" of afterglow light curves
 - Using analytic models with smart calculations of complicated structure of relativistic jets (Lin+2018)
- Assess "false detection rate" as a function of apparent luminosity