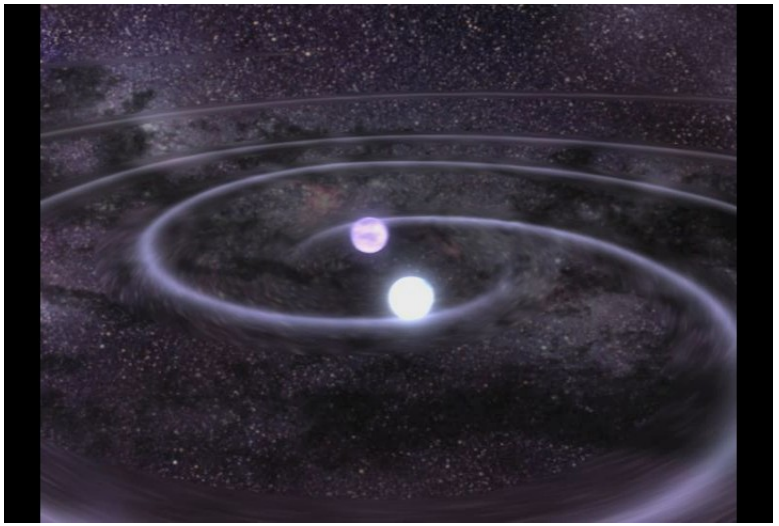
Fast Radio Bursts
(no longer just a sample of one)

Duncan Lorimer
Dept. of Physics and Astronomy
West Virginia University

Credit: Swinburne

What....

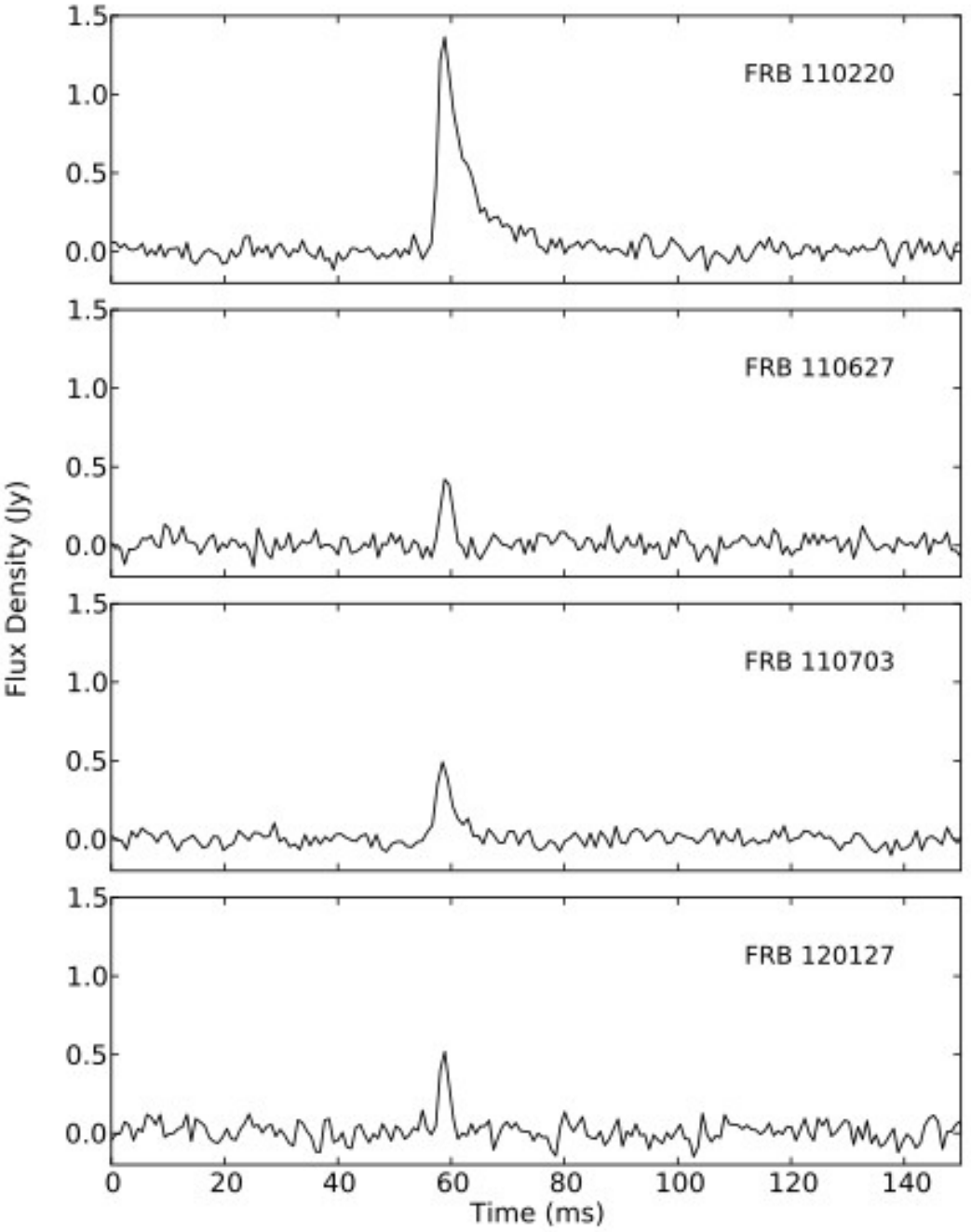
- are they?
- happened in '07?
- happened after that?
- happened in '13?
- could they be?
- can we use them for?
- next?



Credit: NASA/Goddard

What are they?

- Peak flux > 0.5 Jy
- Observed @ 1.4 GHz
- Pulse widths > few ms
- Singular events
- Different sky locations
- Highly dispersed
  - beyond Milky Way
- One event every 10 s!!!



From Thornton et al. (2013)

Photograph by Miloslav Druckmüller

MAGELLANIC CLOUDS. DECEMBER 201

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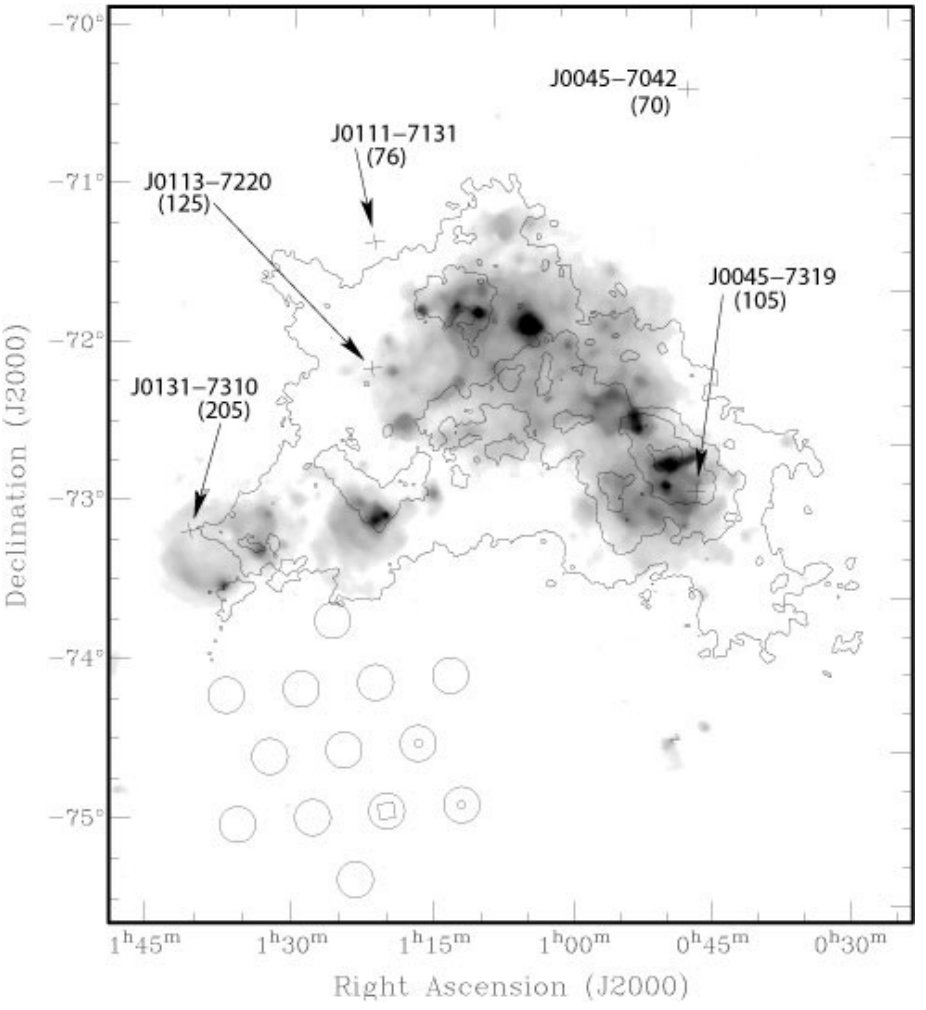
What happened back in 2007?

Credit: ATNF



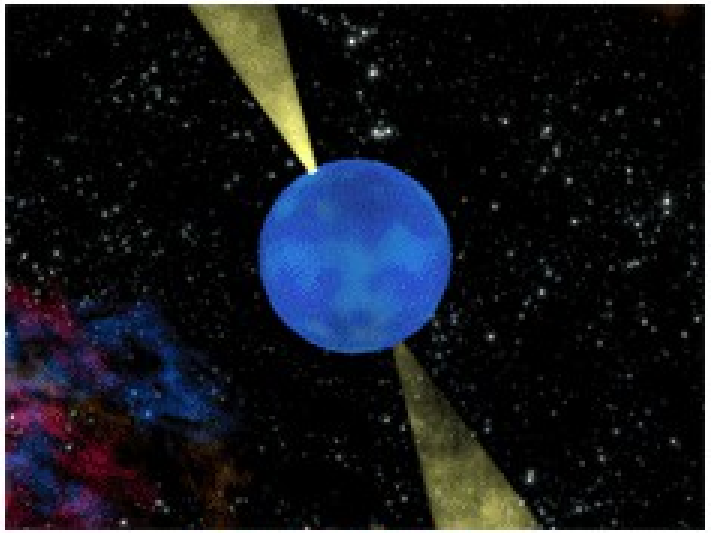
Credit: Froney Crawford

Parkes had been used to find ~20 pulsars in the LMC and SMC

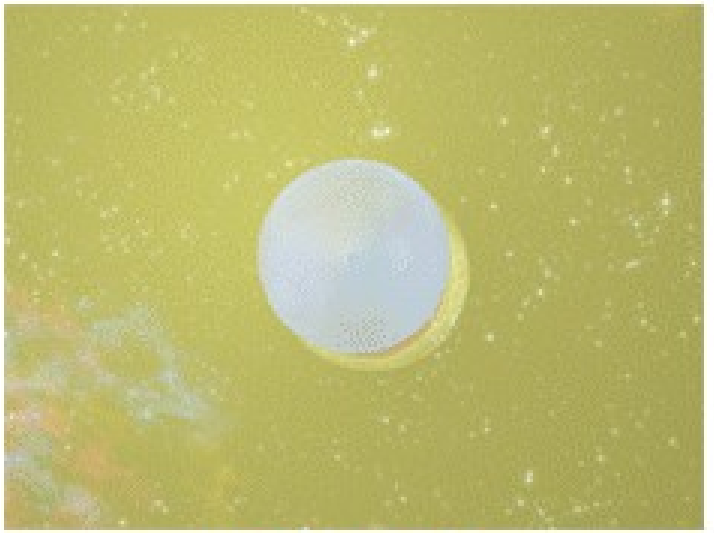
Pulsars emit periodic signals

Lighthouse "off"

Lighthouse "on"



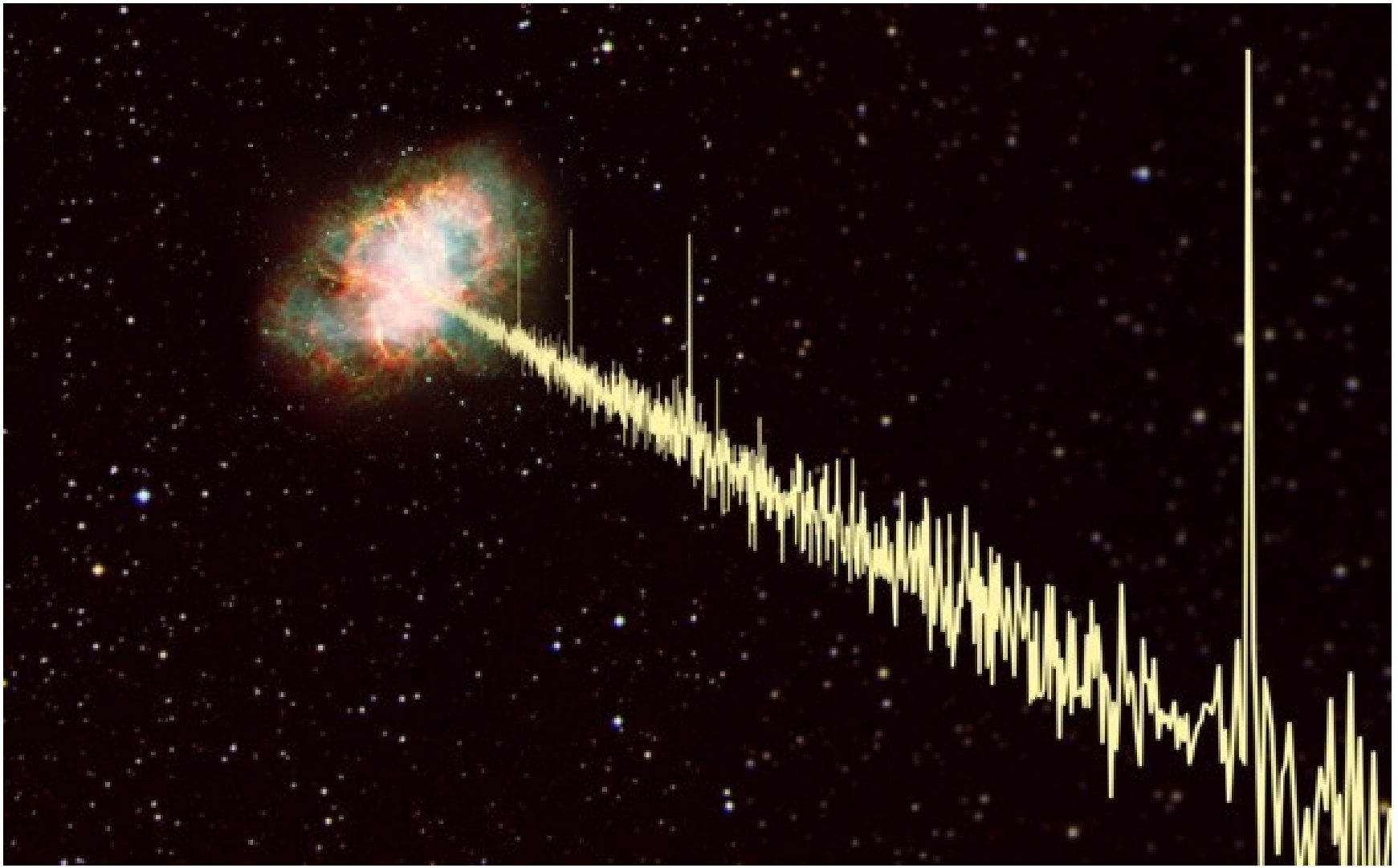
Pulsar "off"



Pulsar "on"

Credit: airynothing.com

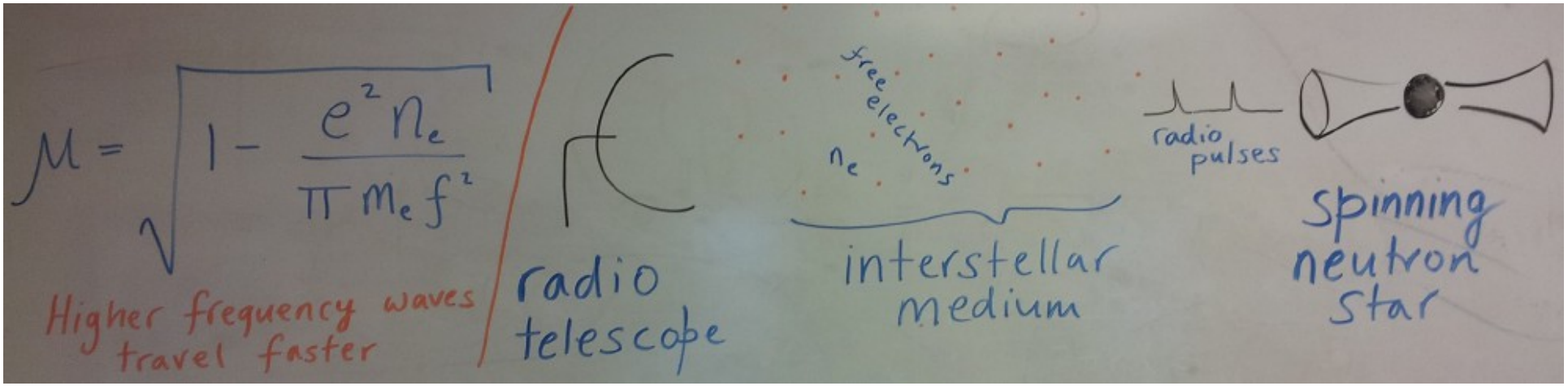
New idea: search for "giant pulses"

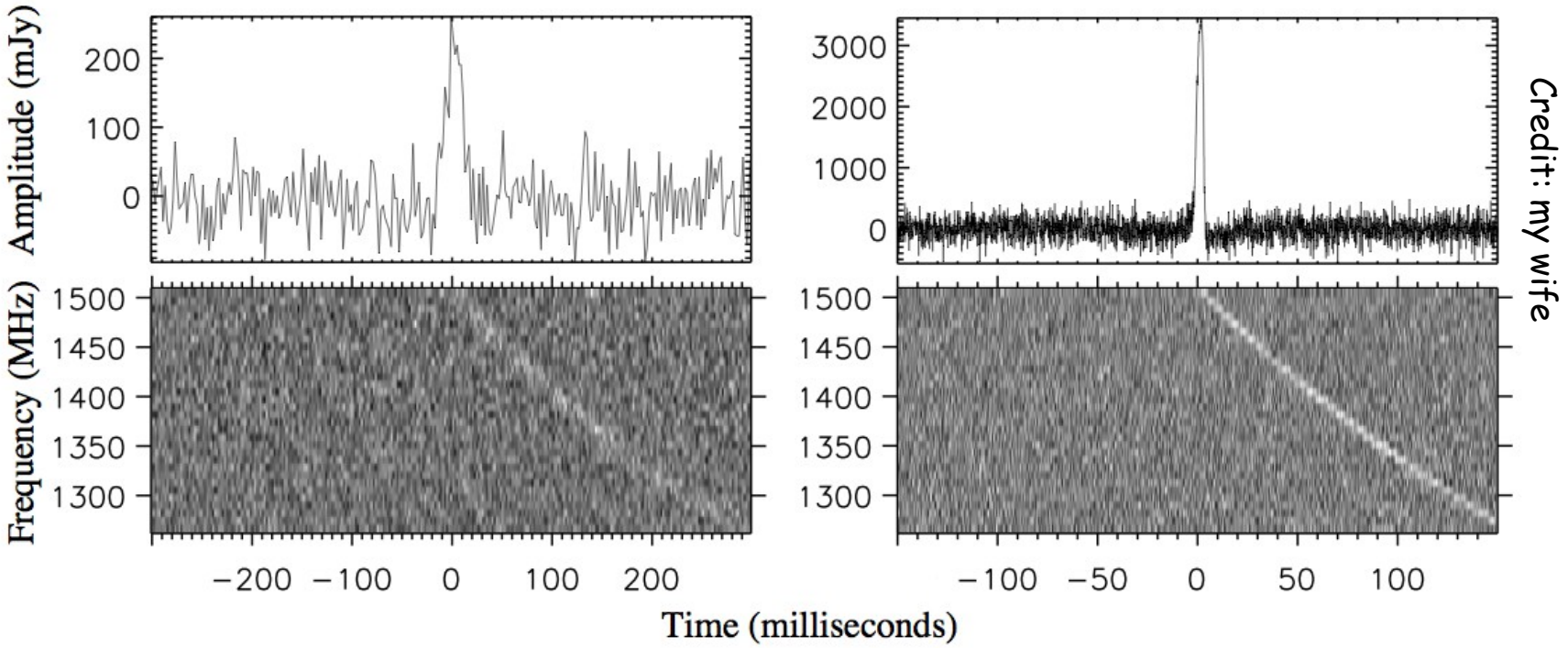


Credit: Joeri van Leeuwen

Enlisted help of then WVU undergraduate student David Narkevic

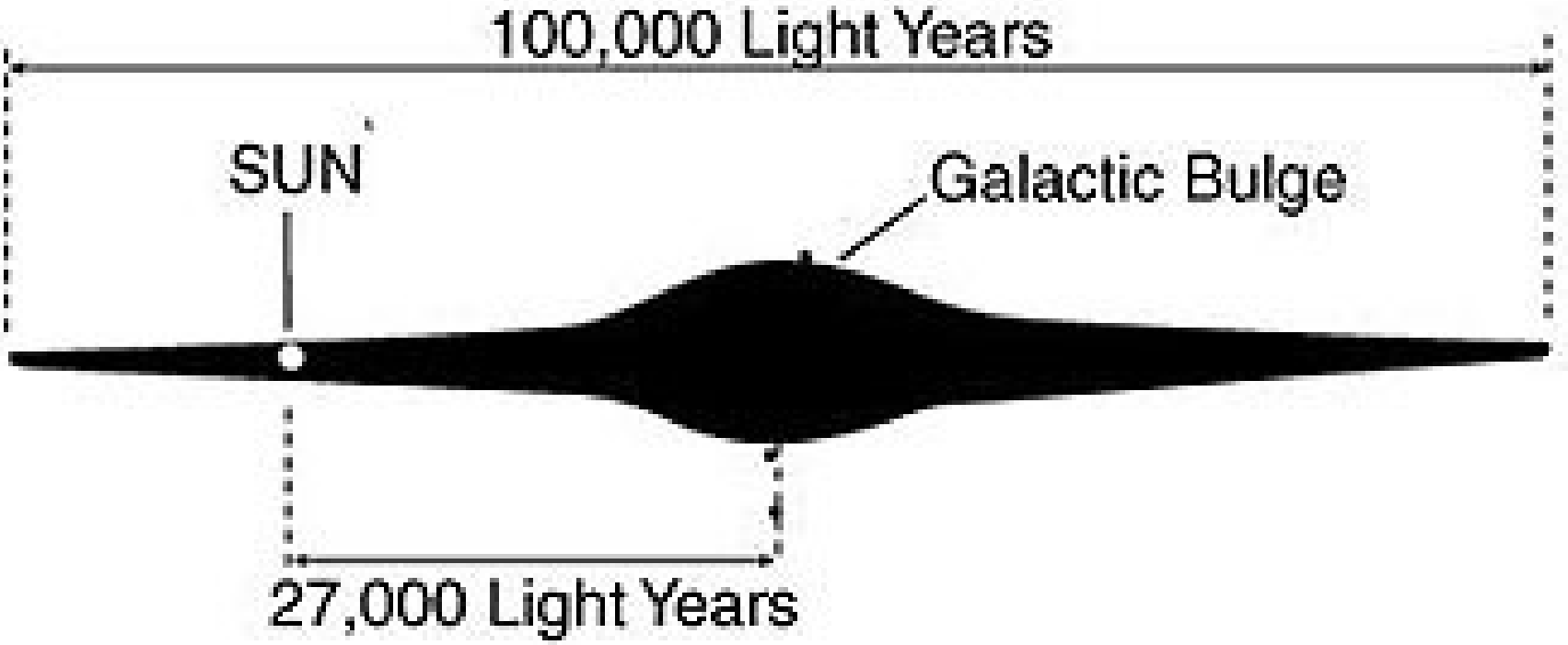
Must correct for dispersion





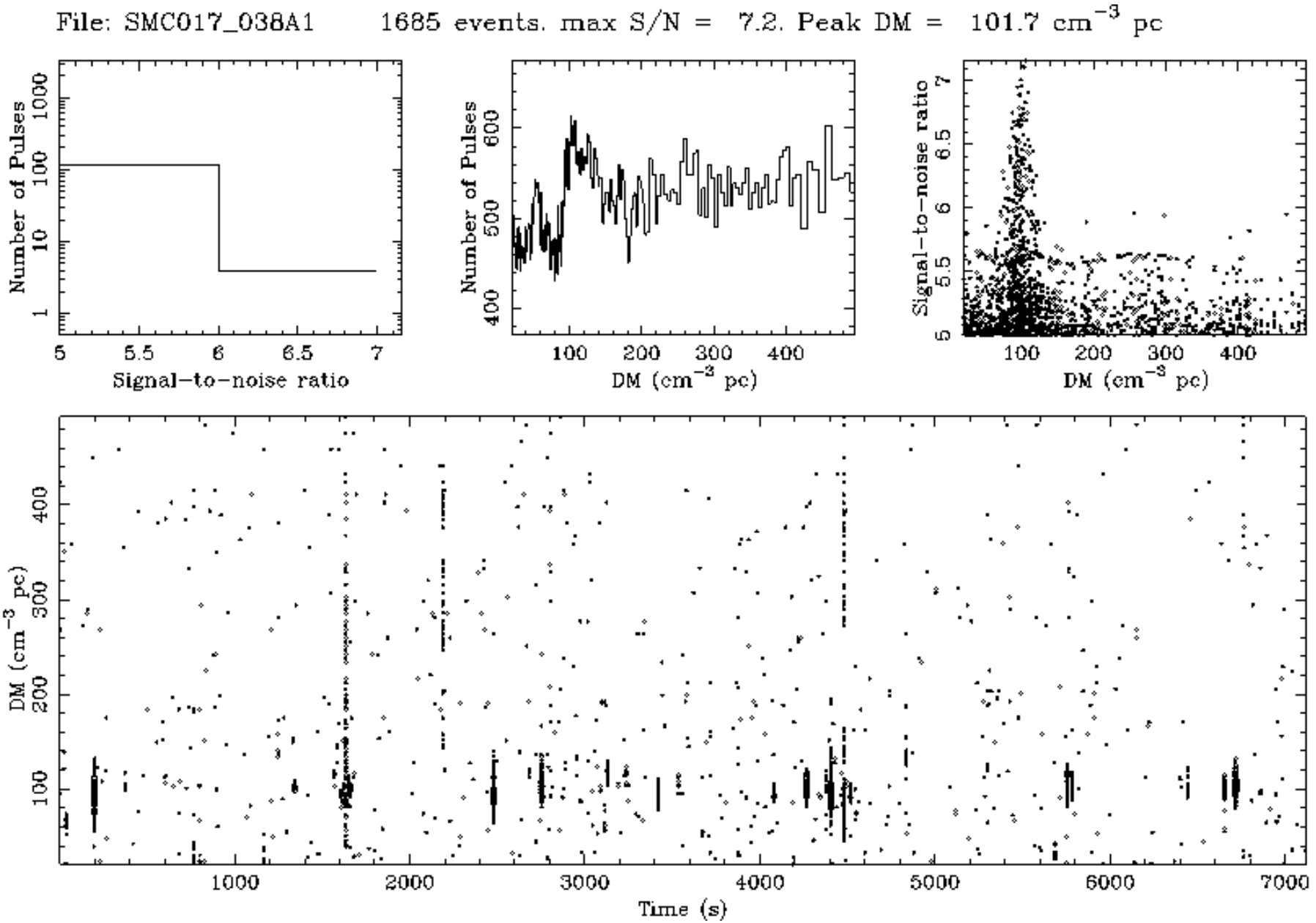
End up with a search over "DM"

$$\mathrm{DM} = \int_0^D n_e dl \simeq \overline{n_e} D$$

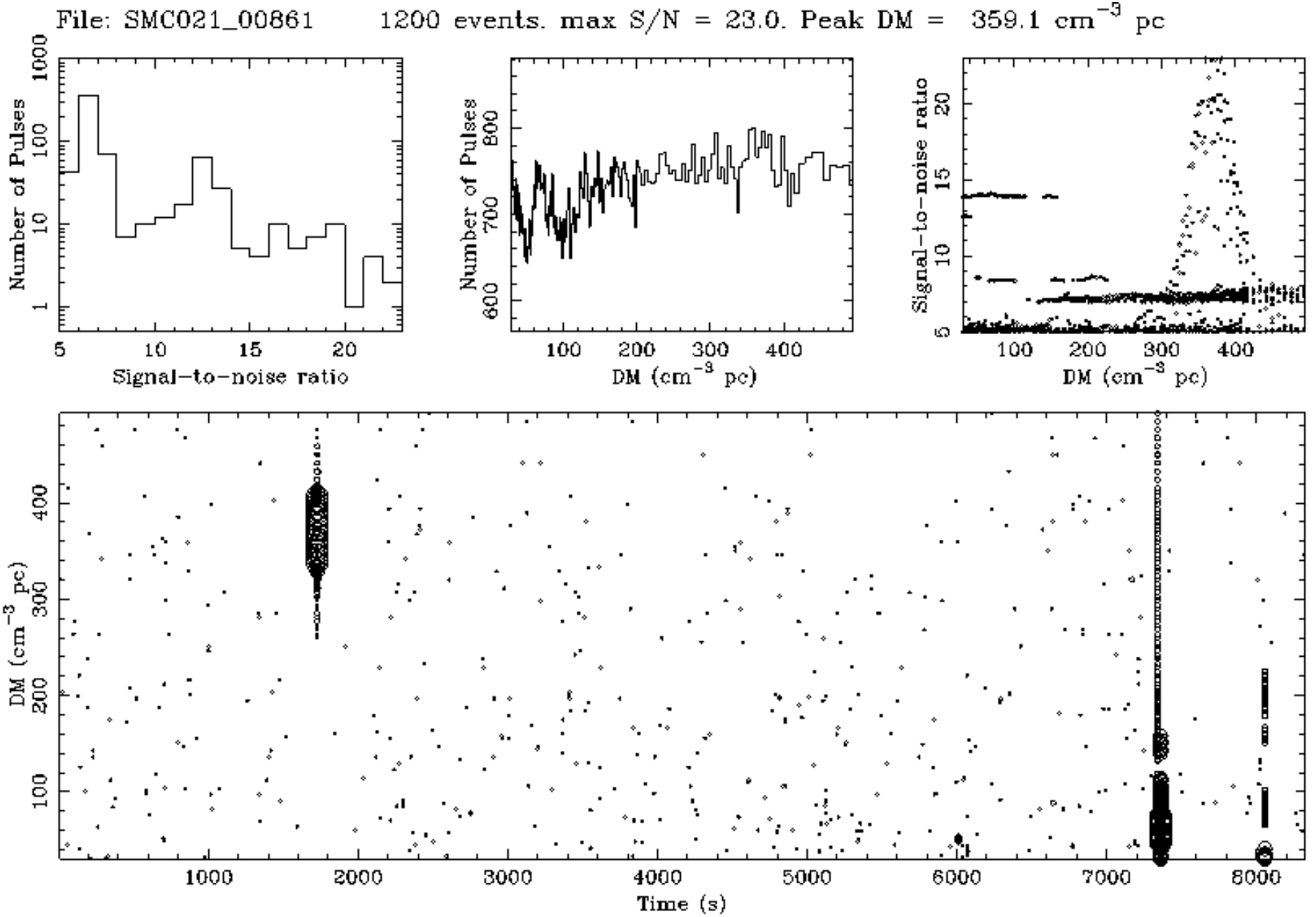


Credit: fas.org

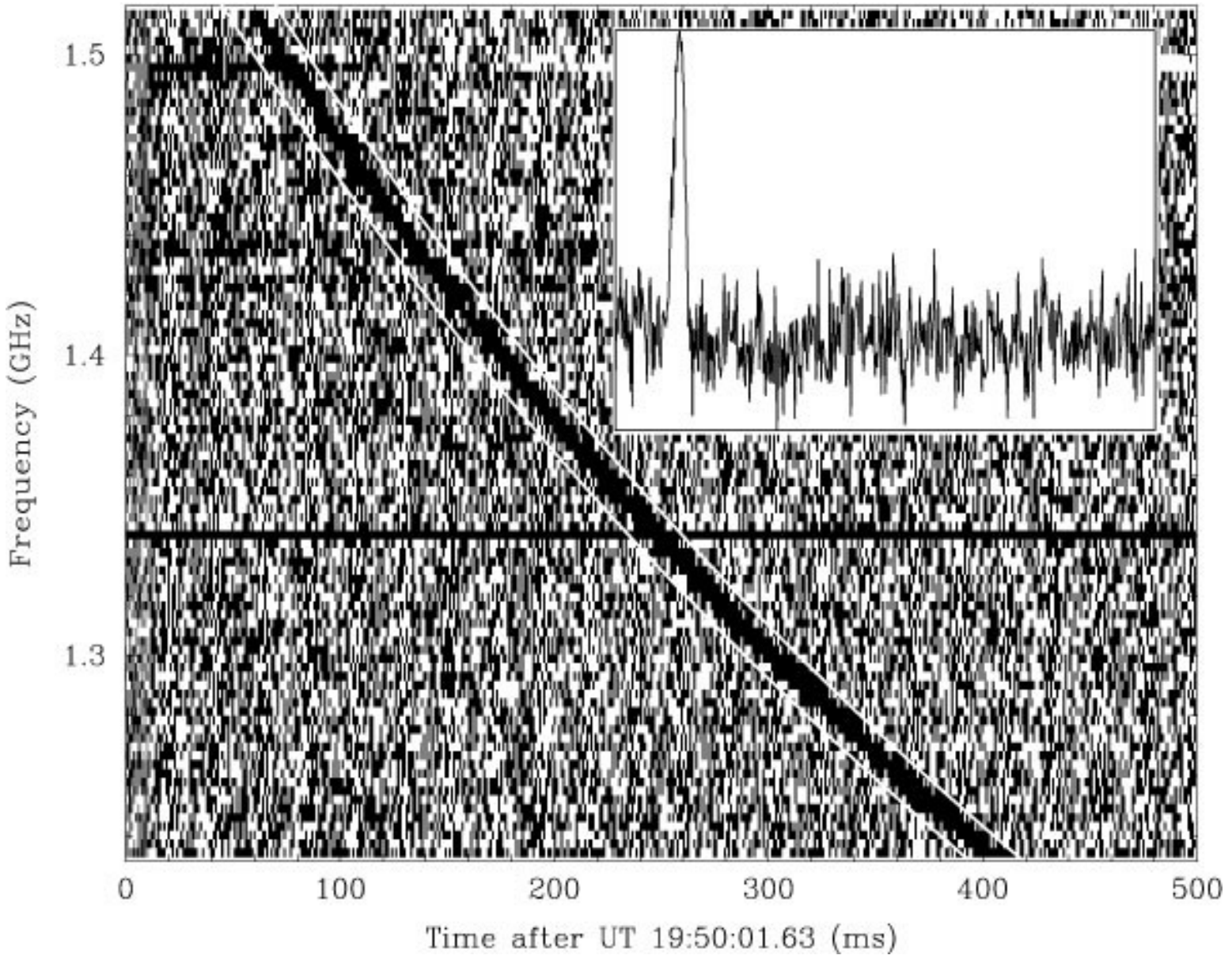
David was looking for this…



...but he found this!



Here's what the data look like



Here's how we left it...

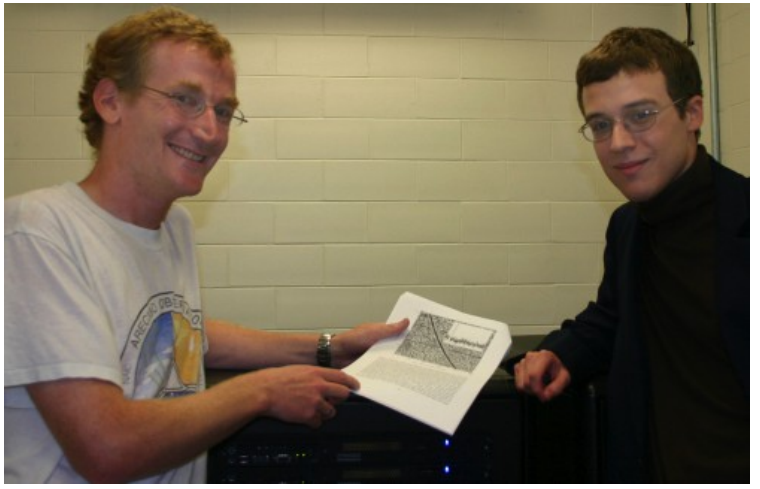
A Bright Millisecond Radio Burst of Extragalactic Origin

D. R. Lorimer,[1,2]* M. Bailes,[3] M. A. McLaughlin,[1,2] D. J. Narkevic,[1] F. Crawford[4]

Pulsar surveys offer a rare opportunity to monitor the radio sky for impulsive burst-like events with millisecond durations. We analyzed archival survey data and found a 30-jansky dispersed burst, less than 5 milliseconds in duration, located 3° from the Small Magellanic Cloud. The burst properties argue against a physical association with our Galaxy or the Small Magellanic Cloud. Current models for the free electron content in the universe imply that the burst is less than 1 gigaparsec distant. No further bursts were seen in 90 hours of additional observations, which implies that it was a singular event such as a supernova or coalescence of relativistic objects. Hundreds of similar events could occur every day and, if detected, could serve as cosmological probes.

Questions/Comments:

* Why so bright?
* Why no weaker events?
* Should be detectable in other surveys



What happened next?

THE ASTROPHYSICAL JOURNAL, 727:18 (5pp), 2011 January 20 doi:10.1088/0004-637X/727/1/18
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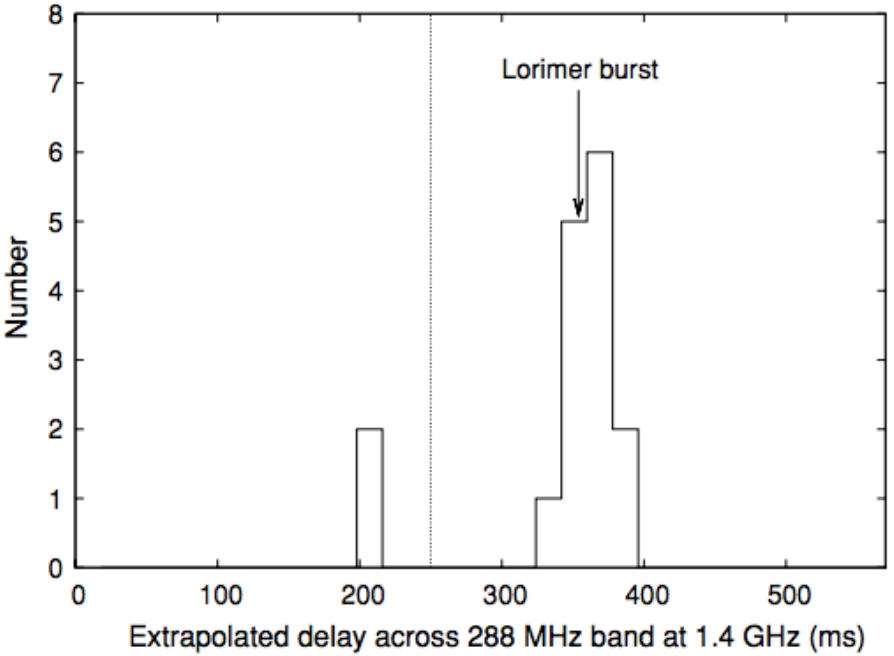
RADIO BURSTS WITH EXTRAGALACTIC SPECTRAL CHARACTERISTICS SHOW TERRESTRIAL ORIGINS

S. BURKE-SPOLAOR[1,5], MATTHEW BAILES[1], RONALD EKERS[2], JEAN-PIERRE MACQUART[3], AND FRONEFIELD CRAWFORD III[4]
[1] Centre for Astrophysics and Supercomputing, Swinburne University of Technology, Mail H39, P.O. Box 218, Hawthorn VIC 3122, Australia; sburke@astro.swin.edu.au
[2] CSIRO Australia Telescope National Facility, P.O. Box 76, Epping NSW 1710, Australia
[3] ICRAR/Curtin Institute of Radio Astronomy, GPO Box U1987, Perth WA 6845, Australia
[4] Department of Physics and Astronomy, Franklin and Marshall College, Lancaster, PA 17604, USA
Received 2010 July 19; accepted 2010 October 29; published 2010 December 28

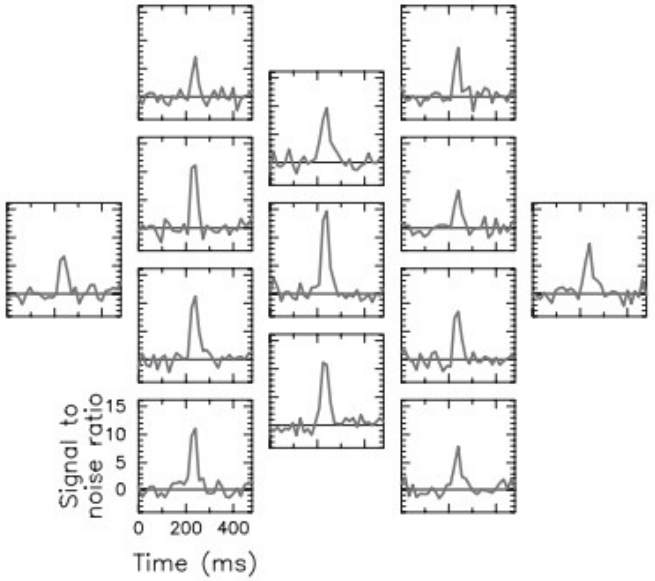
Greek Mythology

Perytons are winged Elk that cast human shadows.

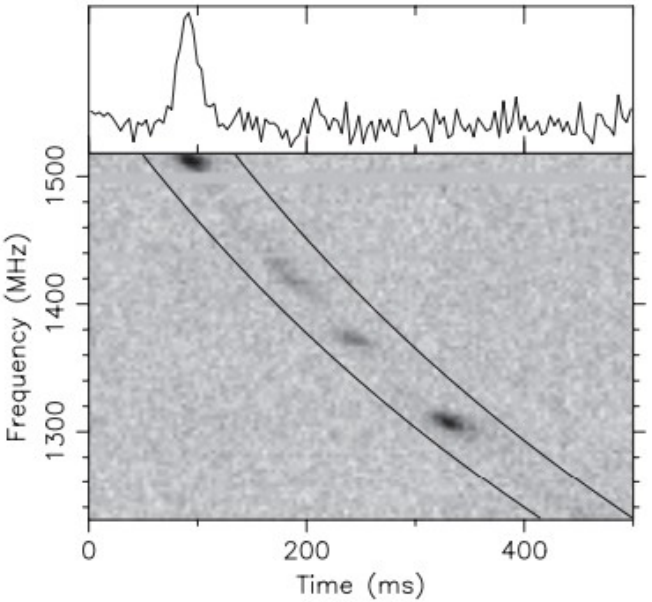
Credit: Wikipedia



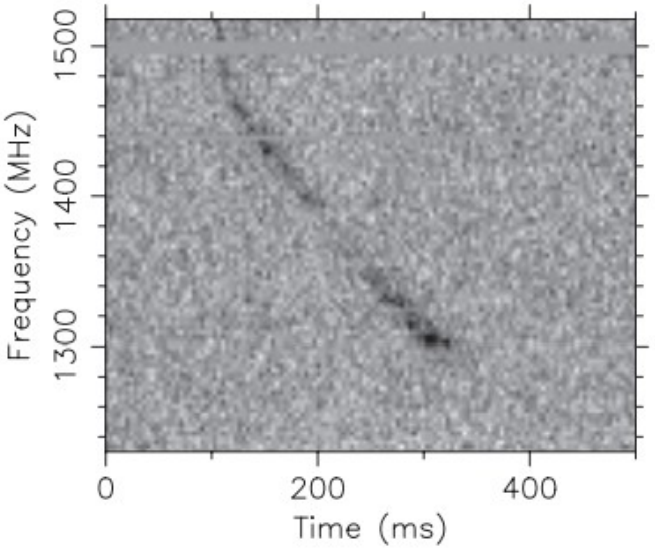
Peryton frequency structure

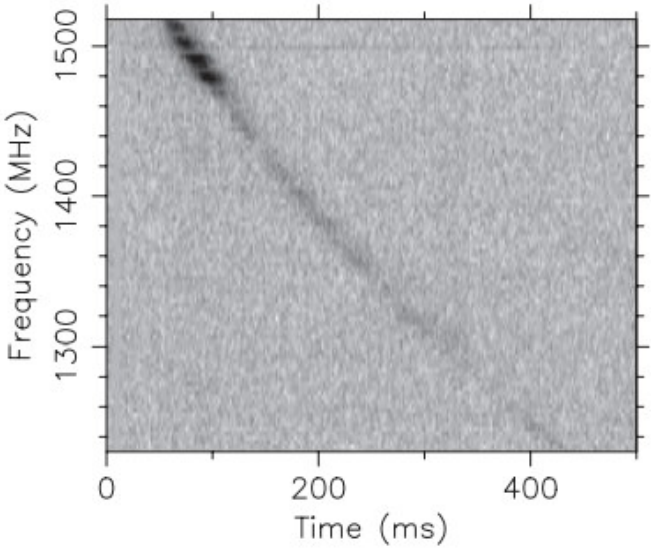


(a) Peryton 08 in 13 beams



(b) Peryton 08





Credit: Burke-Spolaor et al.

Even my own wife begins to doubt...

A search for dispersed radio bursts in archival Parkes Multibeam Pulsar Survey data

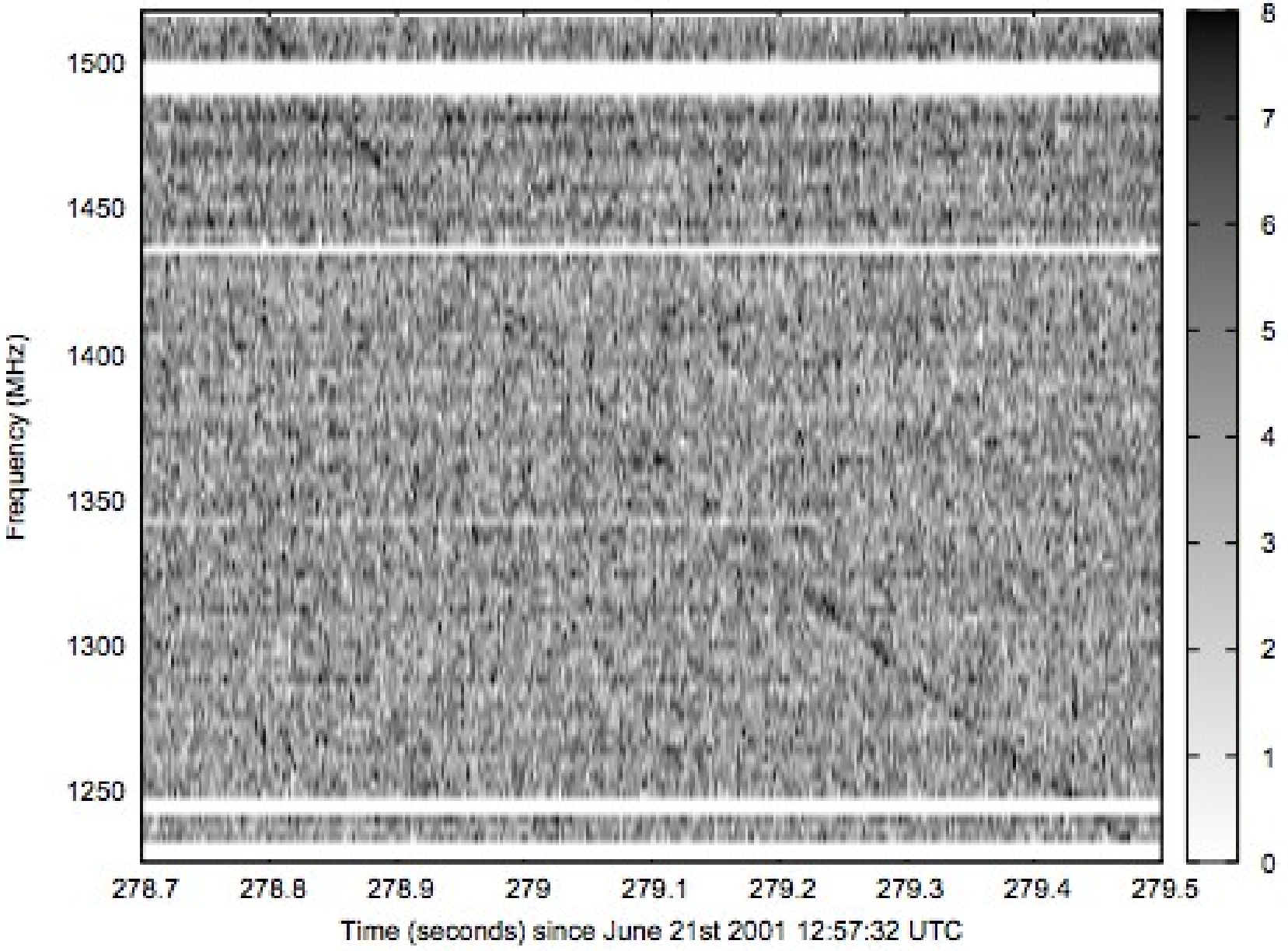
Manjari Bagchi[1⋆], Angela Cortes Nieves[1] and Maura McLaughlin[1,2]

ABSTRACT

A number of different classes of potentially extra-terrestrial bursts of radio emission have been observed in surveys with the Parkes 64m radio telescope, including "Rotating Radio Transients", the "Lorimer burst" and "perytons". Rotating Radio Transients are radio pulsars which are best detectable in single-pulse searches. The Lorimer burst is a highly dispersed isolated radio burst with properties suggestive of extragalactic origin. Perytons share the frequency-swept nature of the Rotating Radio Transients and Lorimer burst, but unlike these events appear in all thirteen beams of the Parkes Multibeam receiver and are probably a form of peculiar radio frequency interference. In order to constrain these and other radio source populations further, we searched the archival Parkes Multibeam Pulsar Survey data for events similar to any of these. We did not find any new Rotating Radio Transients or bursts like the Lorimer burst. We did, however, discover four peryton-like events. Similar to the perytons, these four bursts are highly dispersed, detected in all thirteen beams of the Parkes multibeam receiver, and have pulse widths between 20–30 ms. Unlike perytons, these bursts are not associated with atmospheric events like rain or lightning. These facts may indicate that lightning was not responsible for the peryton phenomenon. Moreover, the lack of highly dispersed celestial signals is the evidence that the Lorimer burst is unlikely to belong to a cosmological source population.

But, out of the blue, came this...

Keane et al. (2011, 2012)

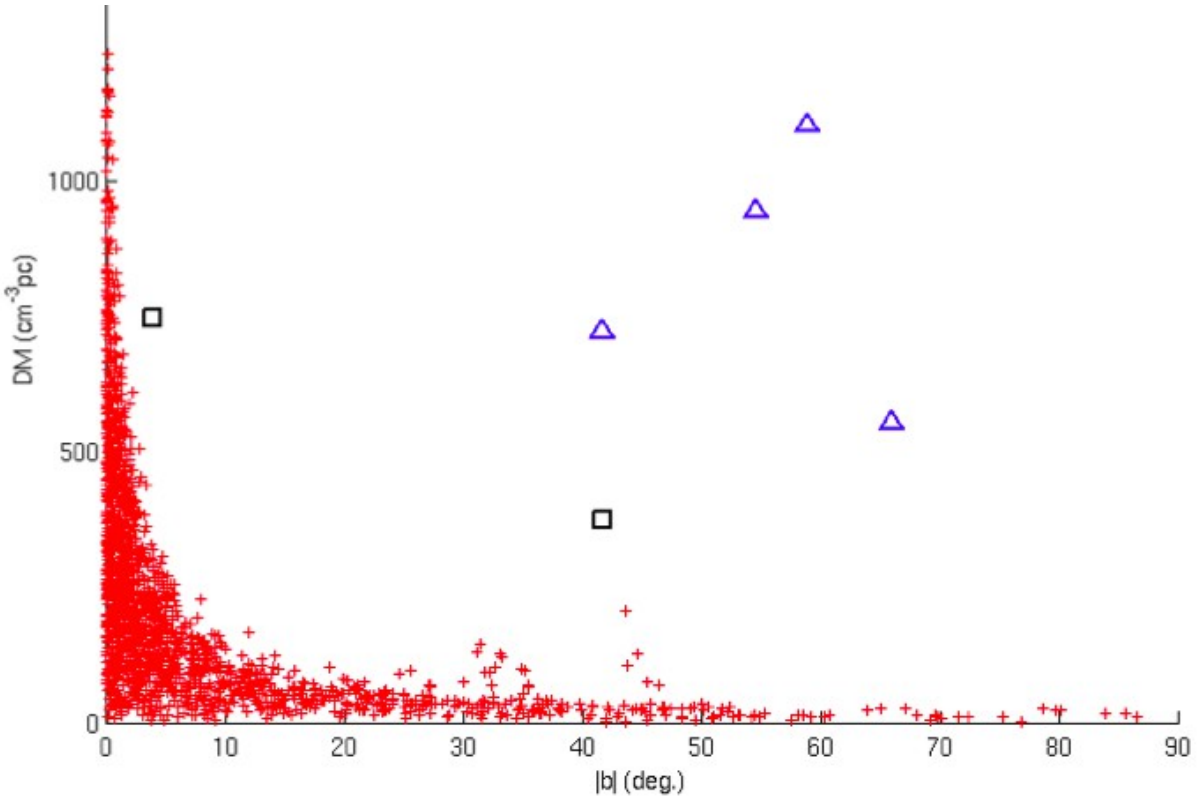


Credit: Keane et al. 2011/2012

What just happened?

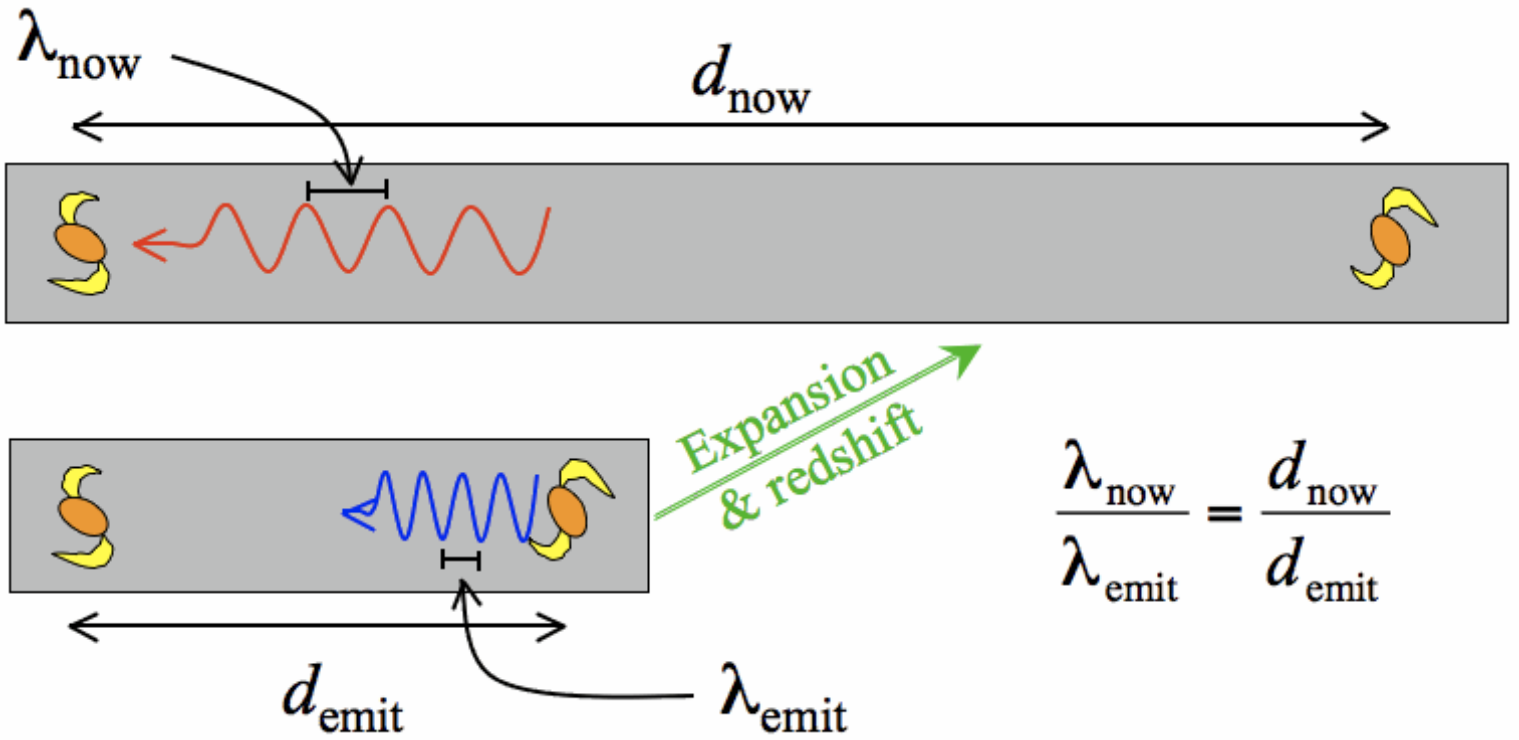
A Population of Fast Radio Bursts at Cosmological Distances

D. Thornton,[1,2*] B. Stappers,[1] M. Bailes,[3,4] B. Barsdell,[3,4] S. Bates,[5] N. D. R. Bhat,[3,4,6] M. Burgay,[7] S. Burke-Spolaor,[8] D. J. Champion,[9] P. Coster,[2,3] N. D'Amico,[10,7] A. Jameson,[3,4] S. Johnston,[2] M. Keith,[2] M. Kramer,[9,1] L. Levin,[5] S. Milia,[7] C. Ng,[9] A. Possenti,[7] W. van Straten[3,4]



- Lorimer bursts?
- Sparkers?
- FARTS?
- FRBs

Cosmological redshift

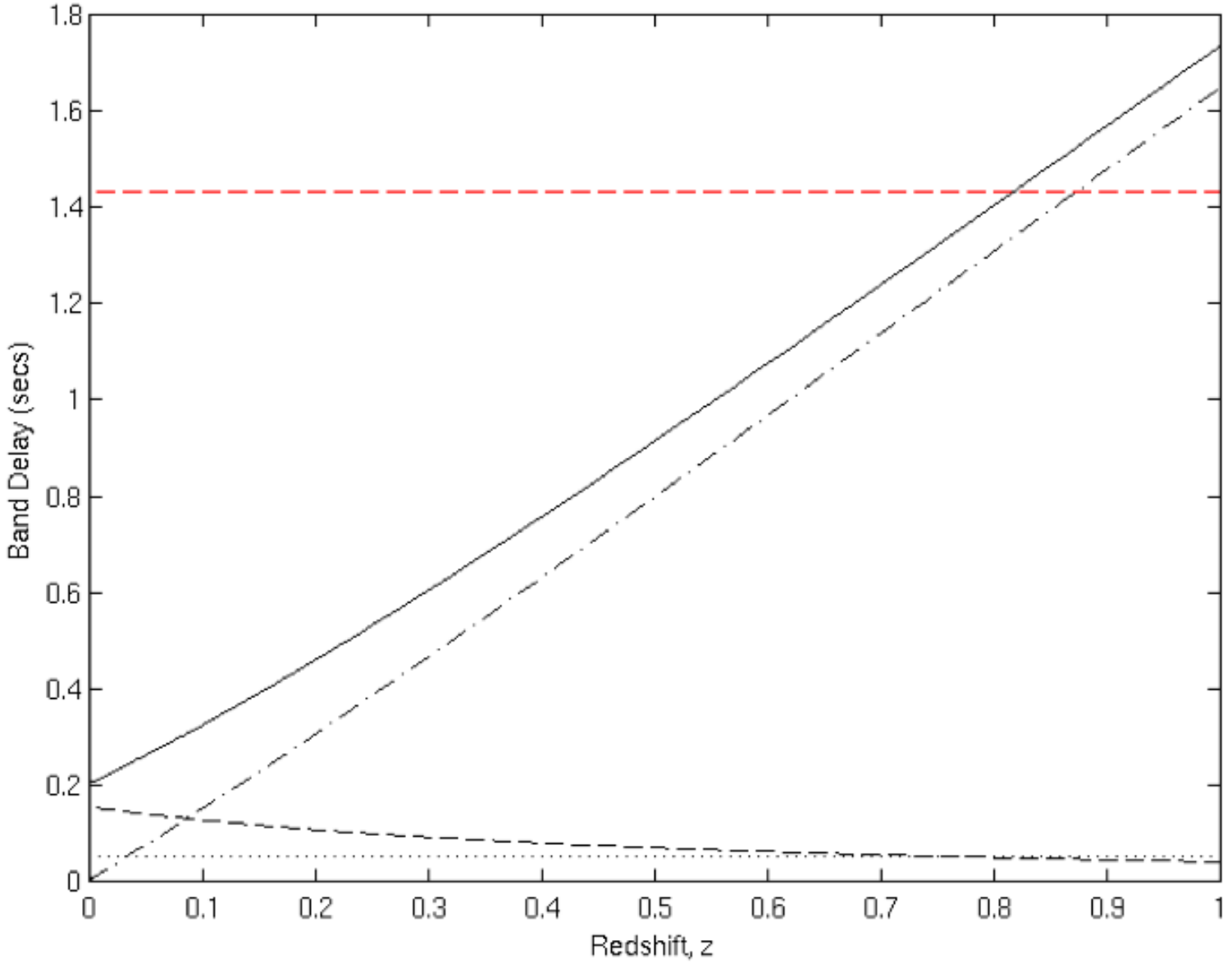


$$\frac{\lambda_{now}}{\lambda_{emit}} = \frac{d_{now}}{d_{emit}}$$

$$z = \frac{\lambda_{obs} - \lambda_{emit}}{\lambda_{emit}} \rightarrow (1+z) = \lambda_{obs}/\lambda_{emit}$$

Credit: Whittle "Extragalactic Astronomy" (UVA)

DM delay in FRB 110220

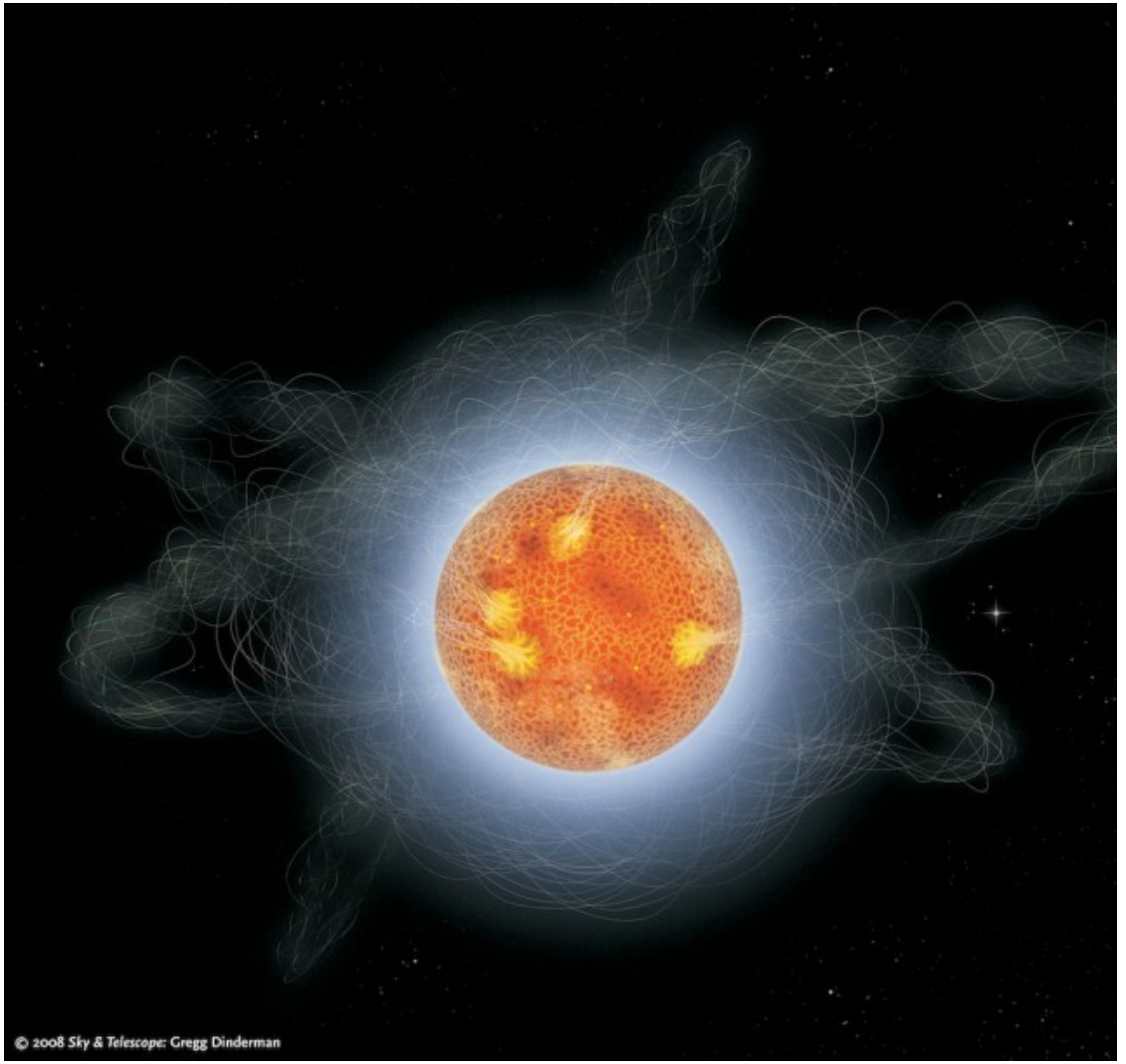


Credit: Thornton et al. (2013)

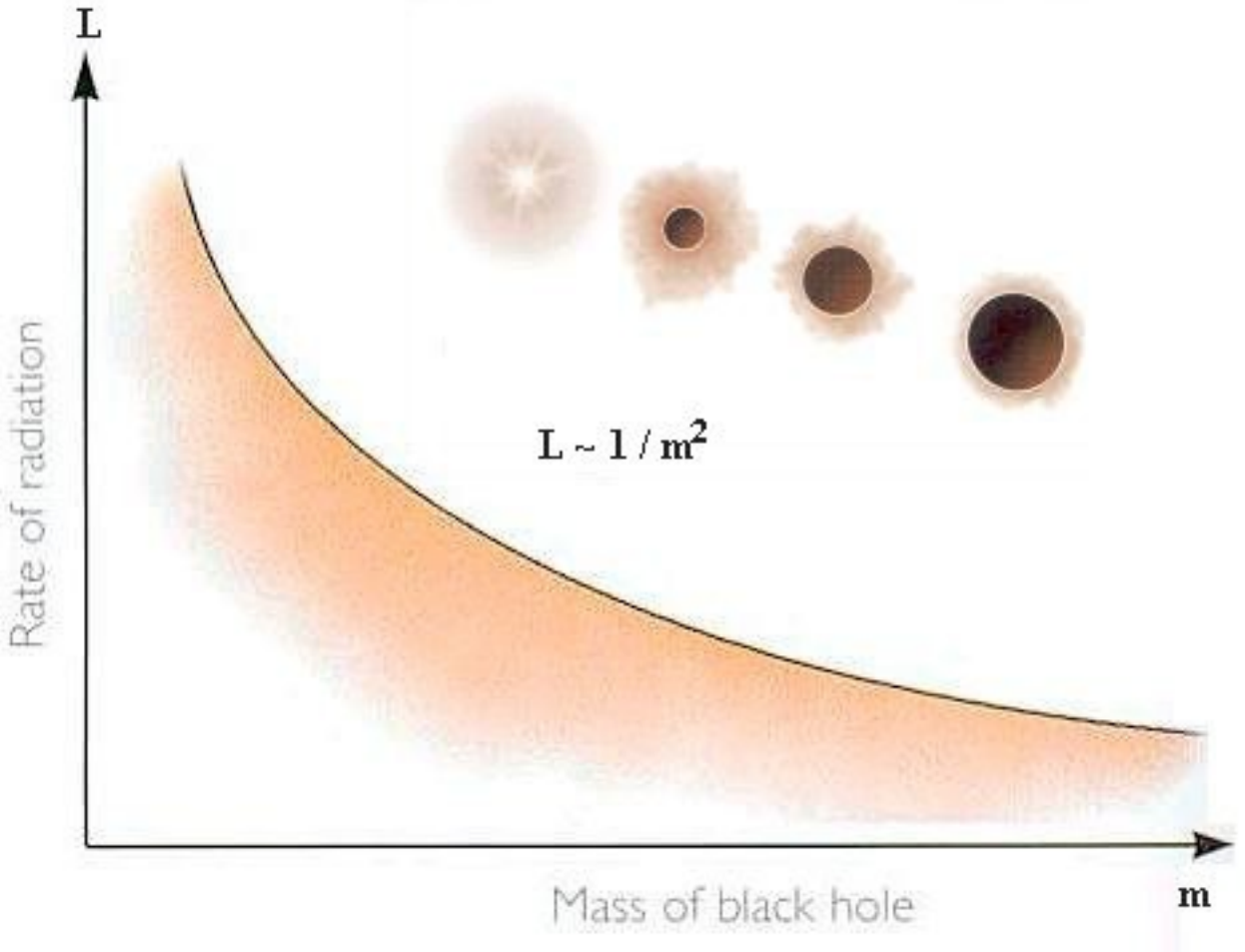
What could they be?

- Collapsing neutron stars
- Evaporating black holes
- Coalescing neutron stars
- Magnetar flares
- Supernovae
- Giant pulses
- Galactic flare stars
- Something else?

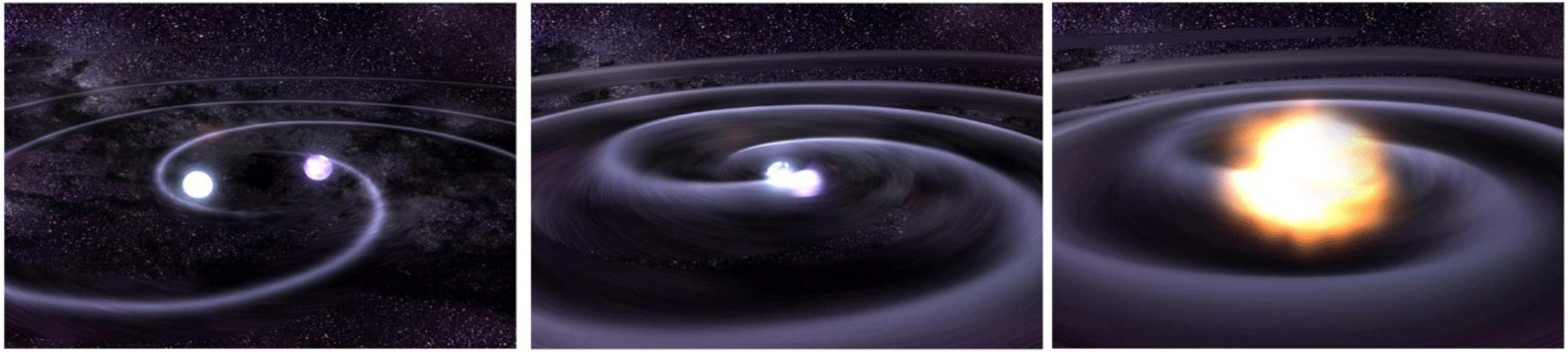
Blitzars?



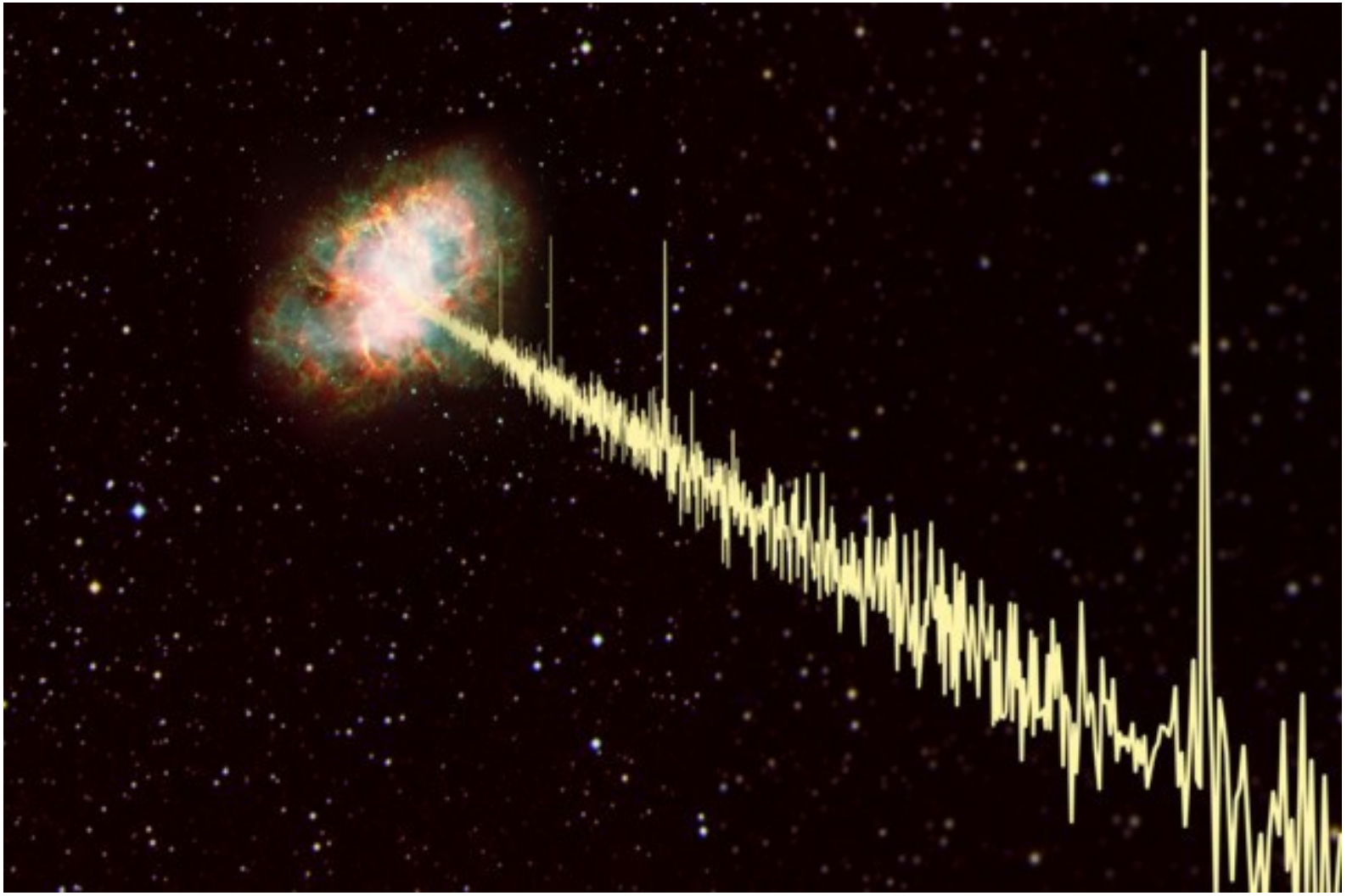
Primordial black holes?



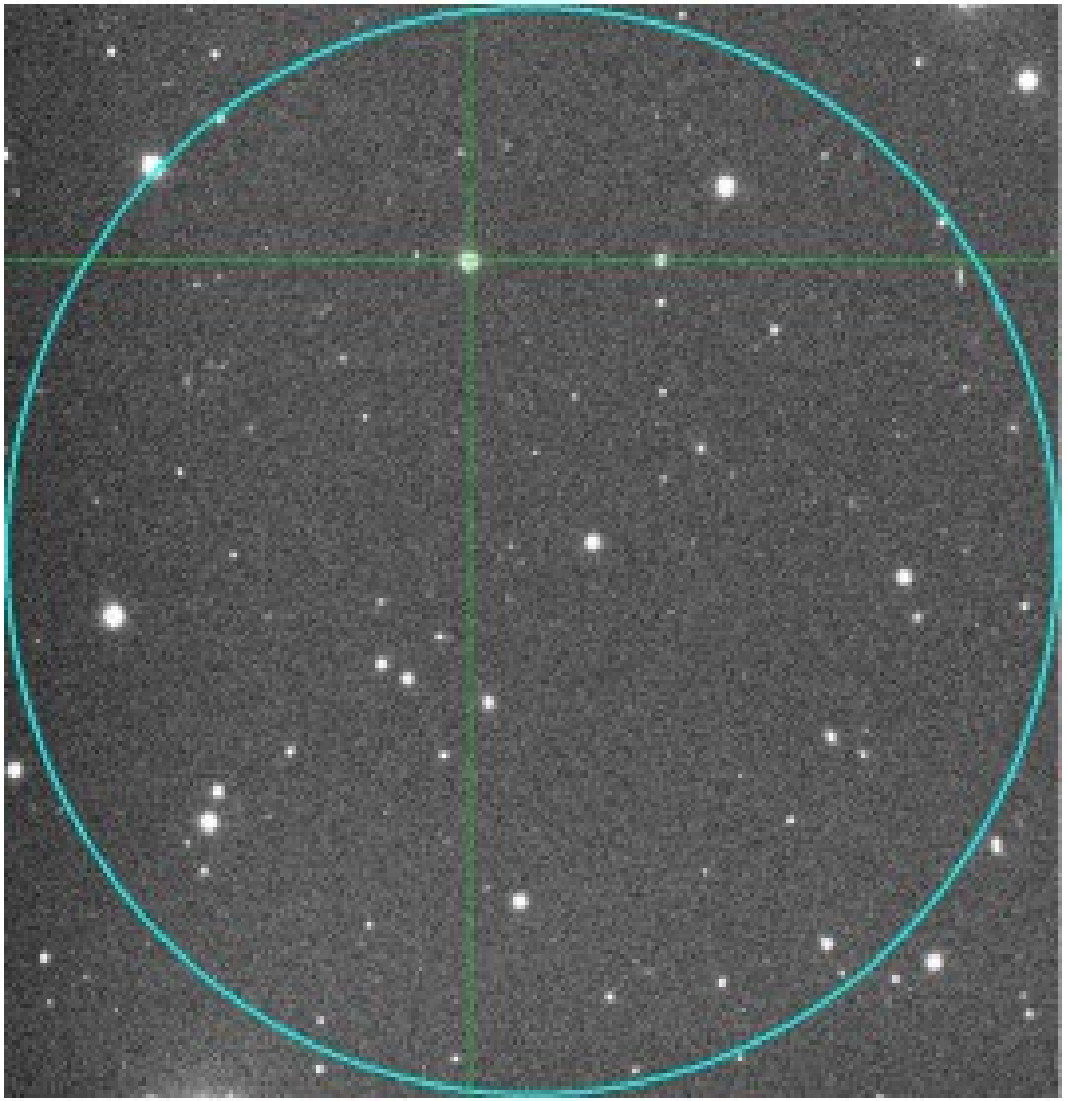
Neutron star inspirals?



Very rare giant pulses?



Galactic flaring stars?



What can we do with 'em?

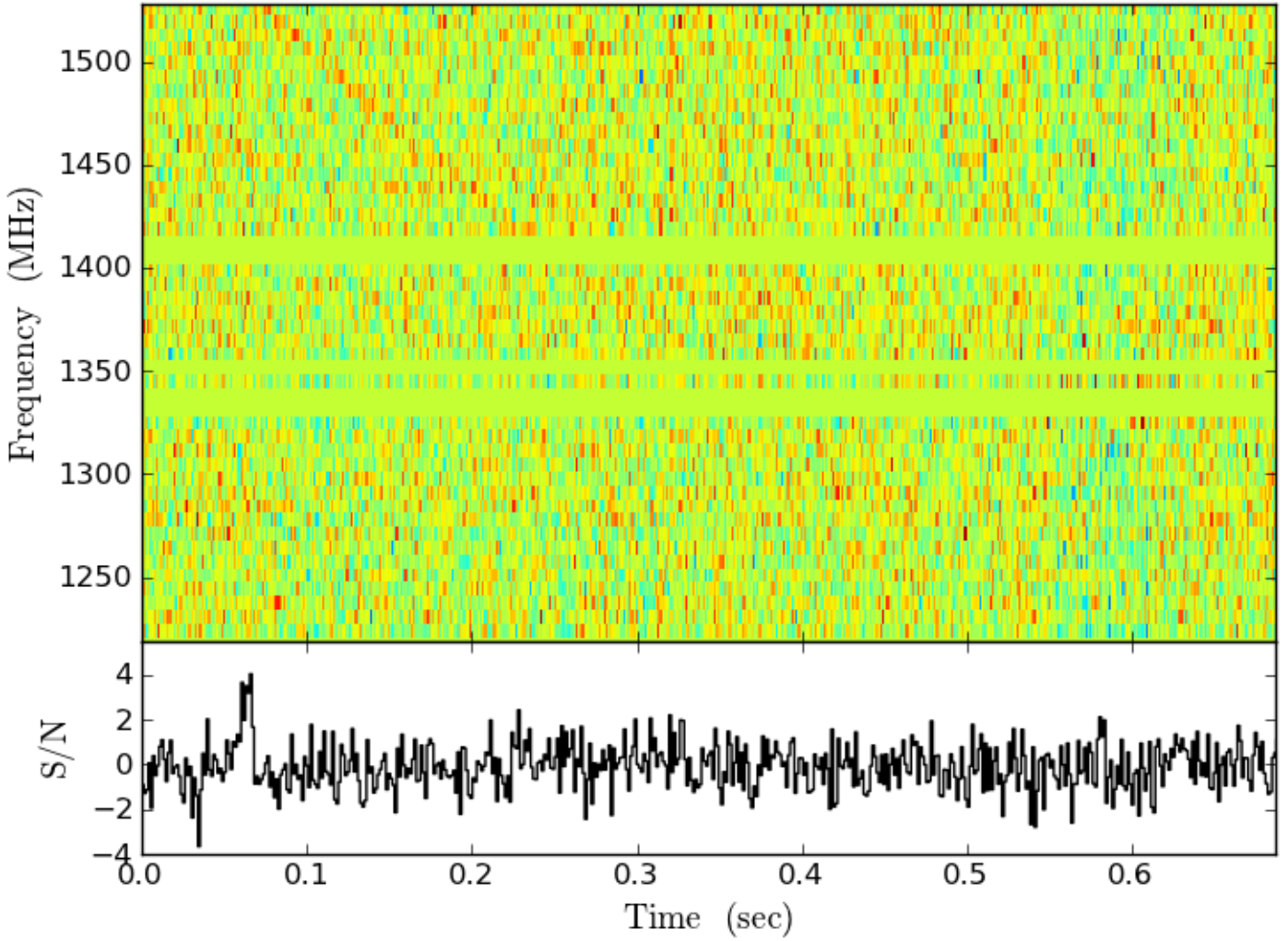
(assuming that they are extragalactic)

- Measure the distance → origins
- Measure the intergalactic DM
- Measure the intergalactic B-field
- Probe population at different redshifts

→ We desperately need to locate bursts in or close to real time (now being done)

What next?

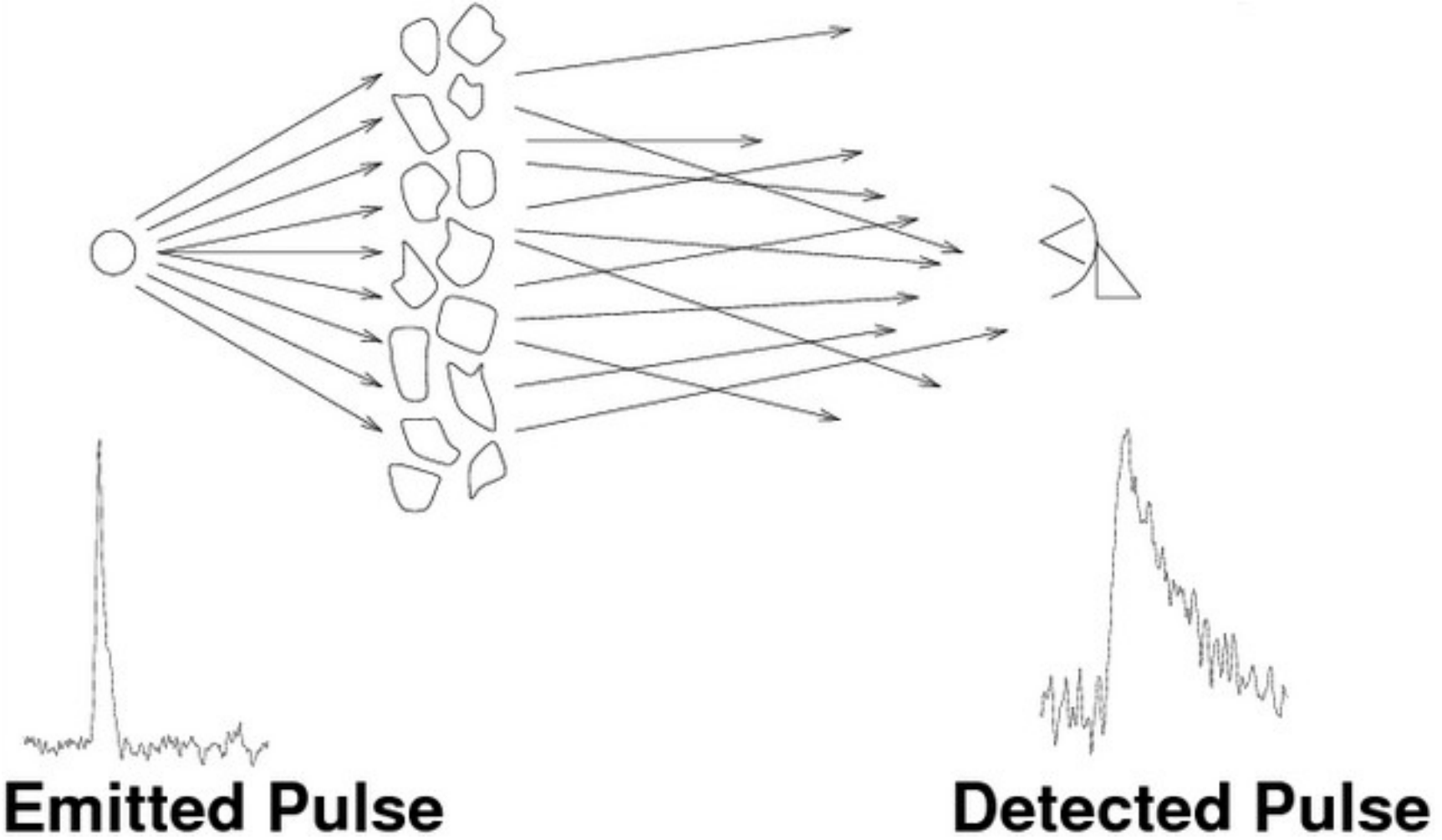
- Find bursts with other telescopes



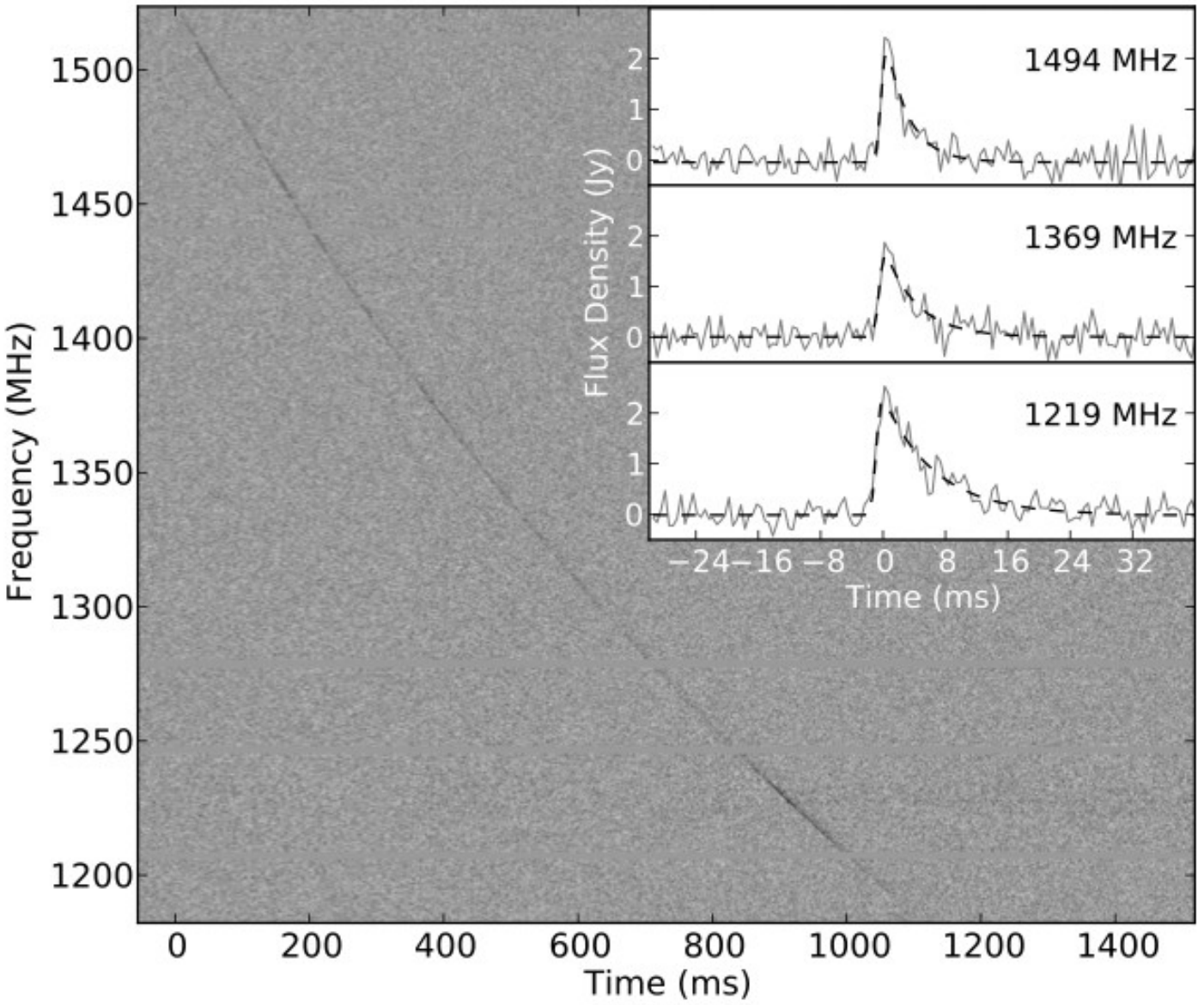
Credit: Spitler et al. (2013, in preparation)

What next?

- Find bursts with other telescopes
- Find them at different frequencies



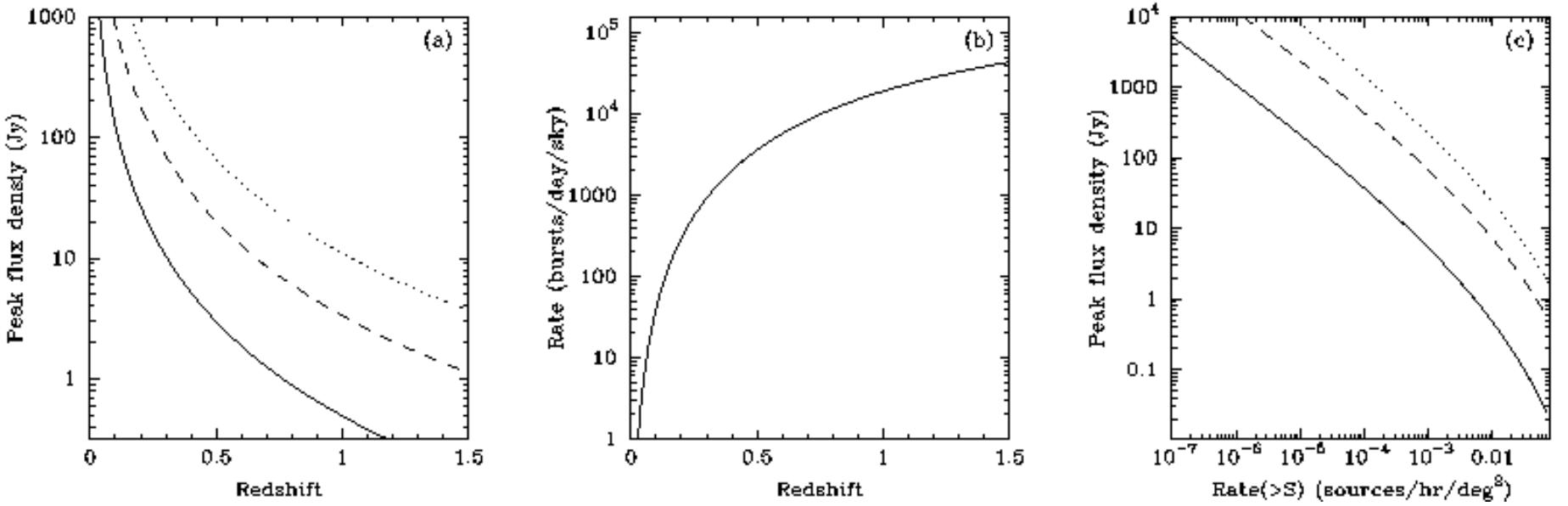
Scattering in FRB 110220



Credit: Thornton et al. 2013

What next?

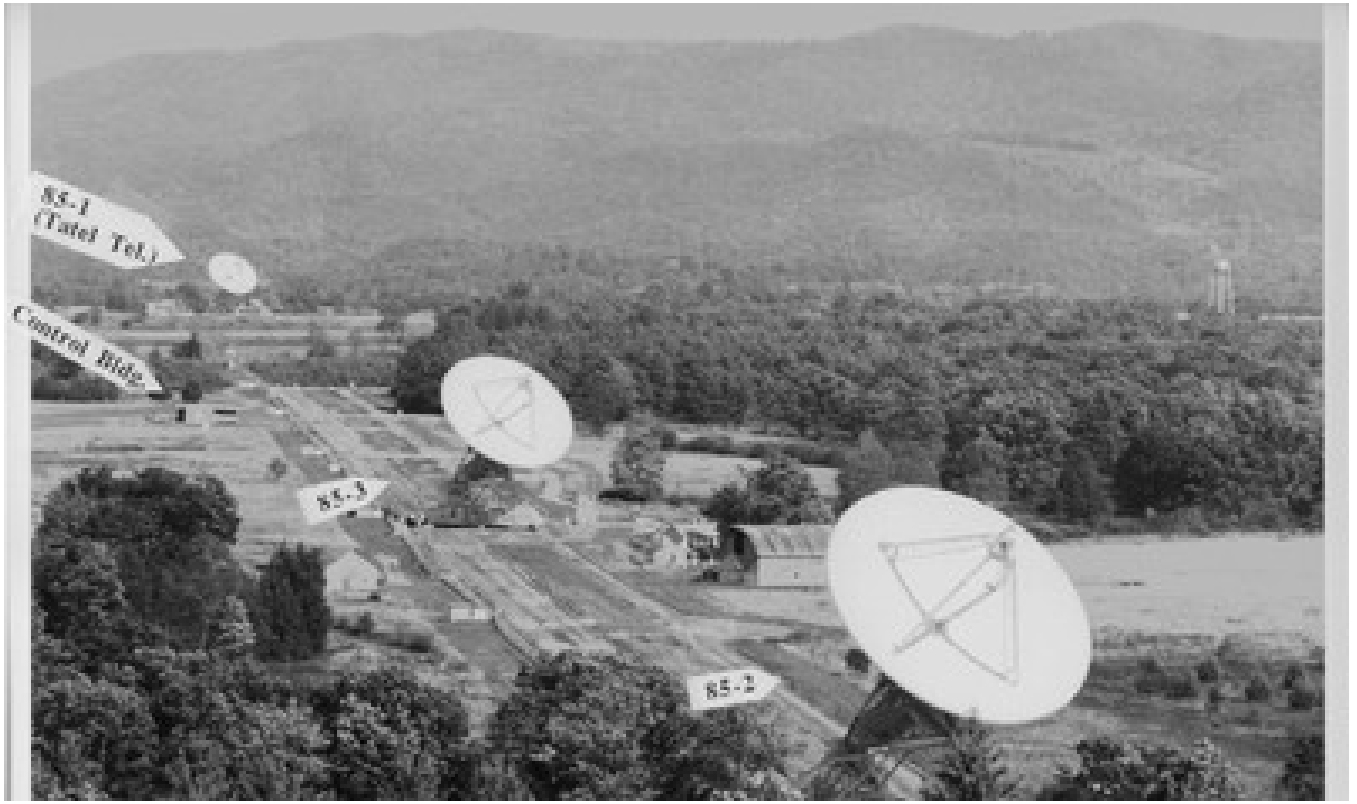
- Find bursts with other telescopes
- Find them at different frequencies
- Characterize population (10 so far!)



Lorimer et al. (2013), MNRAS, 436, L5

What's going on at WVU?

- Searching archival data (Rane, McMann)
- Realtime detectors @ GBT, Arecibo
- Proposal for a new array at Green Bank



Credit: NRAO