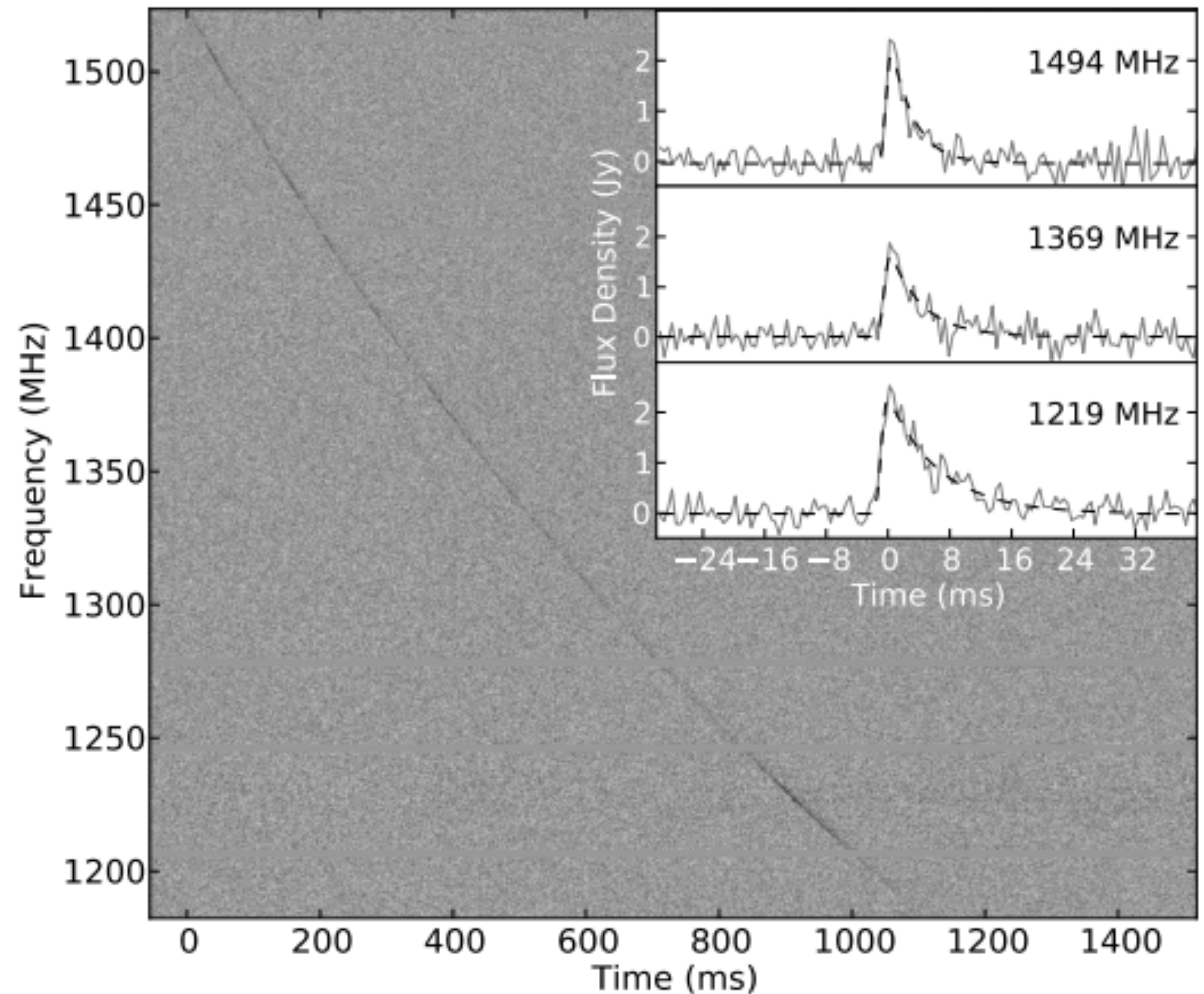# A VOEvent standard for fast radio bursts

Emily Petroff
New Era of Multi-Messenger Astrophysics
Groningen, NL
26 March, 2019

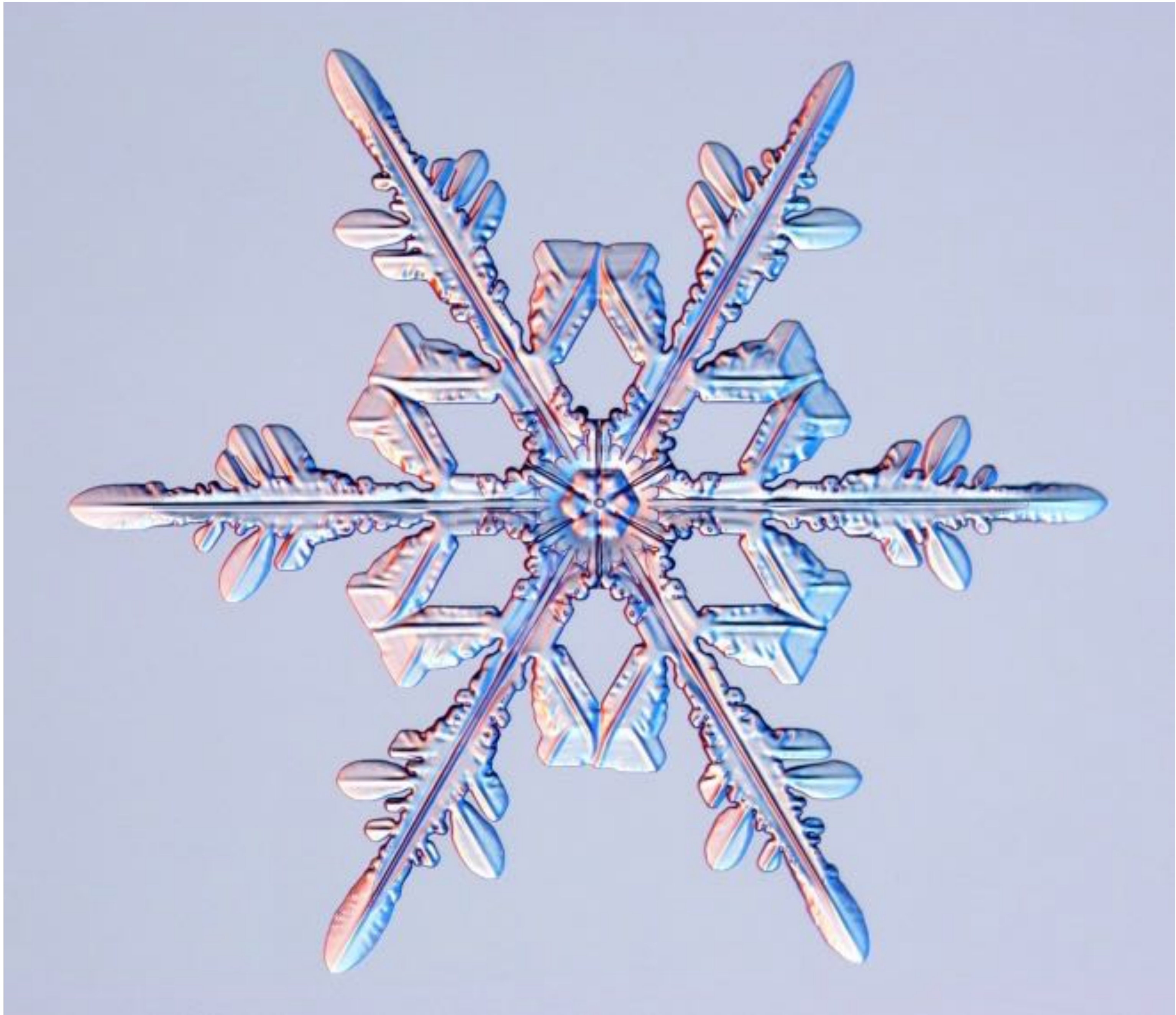# Fast radio bursts

- Bright, impulsive transients

- Millisecond timescales

- High dispersion measure

- Rate ~ O[1000] day^{-1}

- O[100] sources currently known

Thornton et al. (2013)

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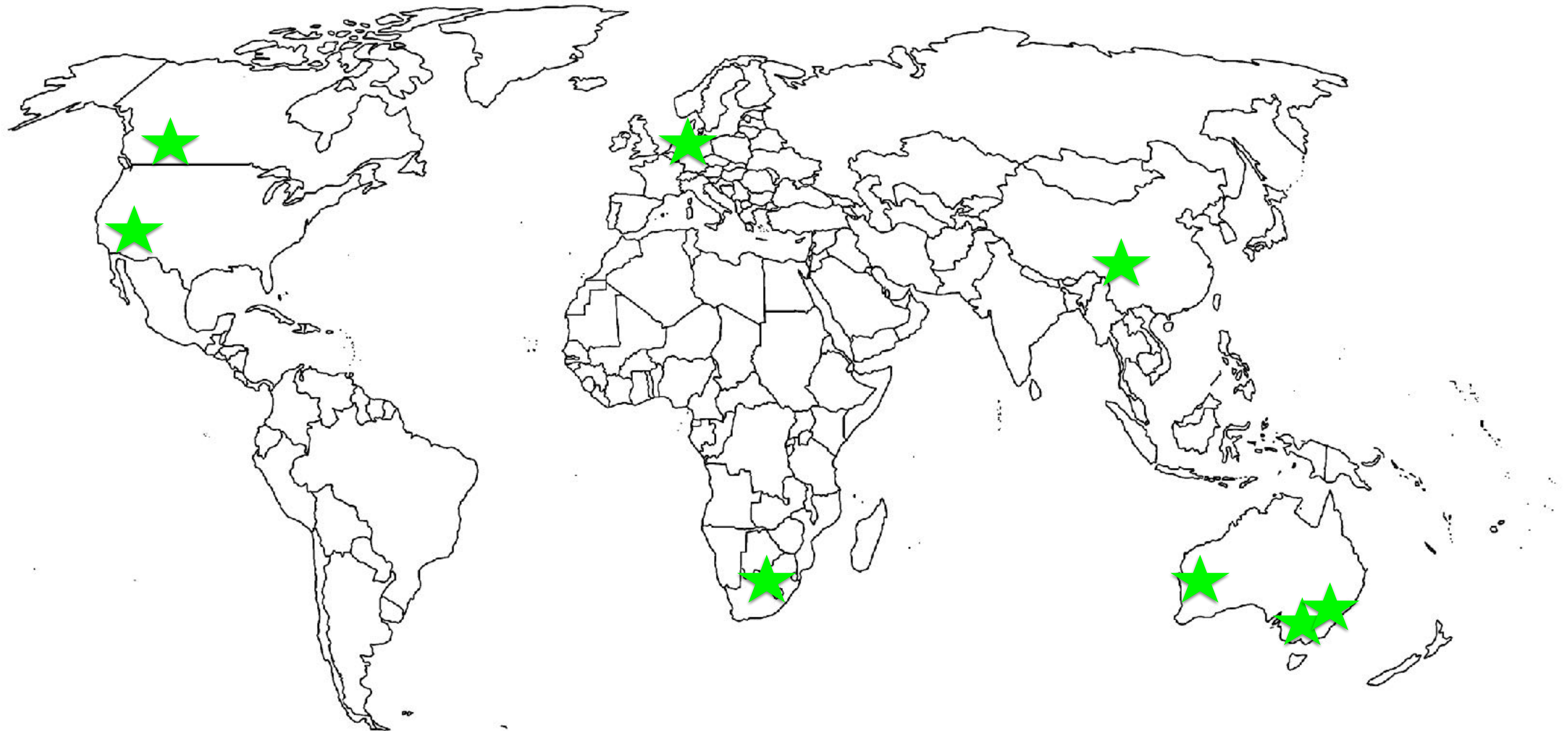
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Real-time detection of FRBs

Hundreds of FRBs per year

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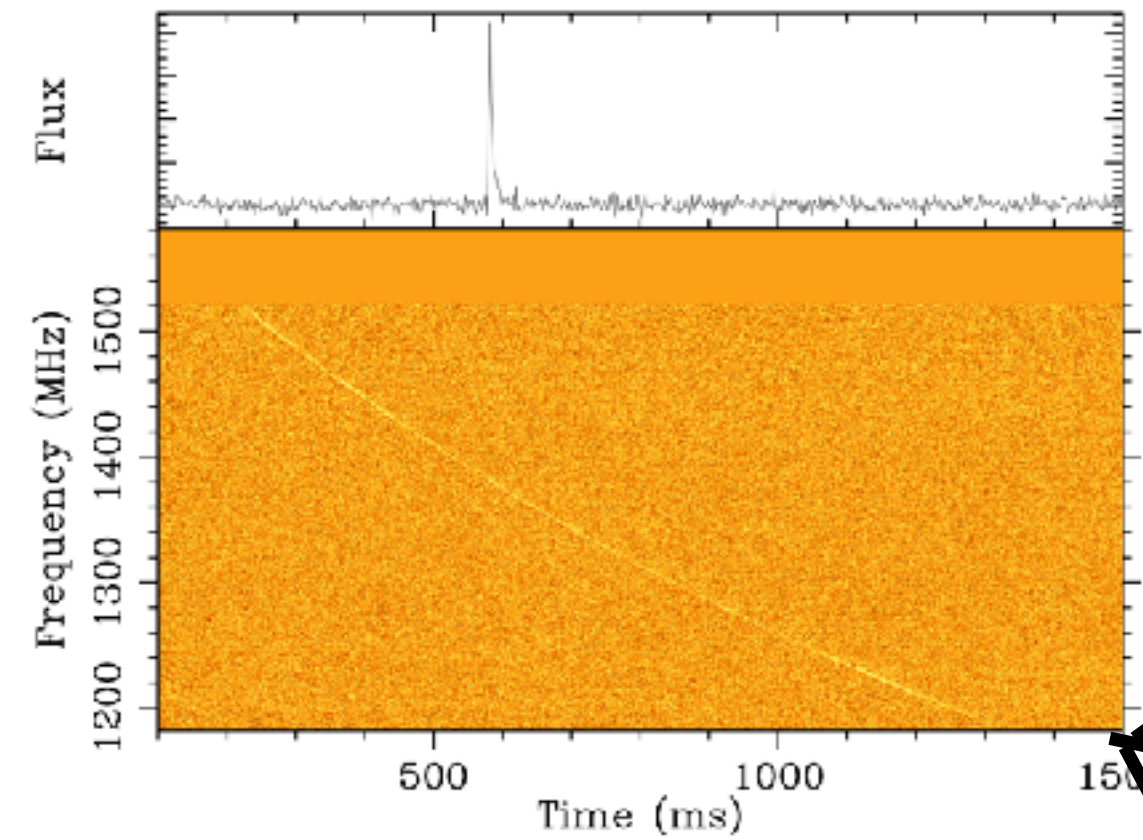
Communicating new FRBs

- Fast

- Informative

- Standardized

- Agreed upon by the majority of the community

- Well-established

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VOEvent Standard for Fast Radio Bursts

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arXiv: 1710.08155

ABSTRACT

Fast radio bursts are a new class of transient radio phenomena currently detected as millisecond radio pulses with very high dispersion measures. As new radio surveys begin searching for FRBs a large population is expected to be detected in real-time, triggering a range of multi-wavelength and multi-messenger telescopes to search for repeating bursts and/or associated emission. Here we propose a method for disseminating FRB triggers using Virtual Observatory Events (VOEvents). This format was developed and is used successfully for transient alerts across the electromagnetic spectrum and for multi-messenger signals such as gravitational waves. In this paper we outline a proposed VOEvent standard for FRBs that includes the essential parameters of the event and where these parameters should be specified within the structure of the event. An additional advantage to the use of VOEvents for FRBs is that the events can automatically be ingested into the FRB Catalogue (FRBCAT) enabling real-time updates for public use. We welcome feedback from the community on the proposed standard outlined below and encourage those interested to join the nascent working group forming around this topic.

Introduction

Fast radio bursts (FRBs) are one of the most exciting topics in modern astrophysics. FRBs are detected as millisecond radio

Elements of a VOEvent

- <Who> : Telescope and author information

- <What> : All parameters that describe the FRB go here

- <WhenWhere> : Time of observation, position in the sky, telescope location

- <How> : Data links, survey webpage, instrument details, etc.

- <Why> : FRB name, importance

```
<Why importance="0 - 1">
    <Concept>[Flag that importance corresponds to]</Concept><Description>[Elaboration on flag criteria]</Description>
    <Name>FRBYYMMDD</Name> <!-- Name of the FRB -->
</Why>
```

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Types of VOEvents

- 1. Detection

- 2. Subsequent

- 3. Update

- 4. Retraction

- A. Search

- B. Targeted

```
38        -->
39        <Group name="event parameters">
40            <Param dataType="float" name="dm" ucd="phys.dispMeasure" unit="pc/cm^3" value=""/>
41            <Param dataType="float" name="dm_error" ucd="stat.error;phys.dispMeasure" unit="pc/cm^3" value=""/>
42            <Param dataType="float" name="width" ucd="time.duration;src.var.pulse" unit="ms" value=""/>
43            <Param dataType="float" name="snr" ucd="stat.snr" value=""/>
44            <Param dataType="float" name="flux" ucd="phot.flux" unit="Jy" value=""/>
45            <Param dataType="float" name="gl" ucd="pos.galactic.lon" unit="Degrees" value=""/>
46            <Param dataType="float" name="gb" ucd="pos.galactic.lat" unit="Degrees" value=""/>
47            <Param dataType="float" name="dispersion_smearing" unit="ms" value=""/>
48        </Group>
49        <Group name="advanced parameters">
50            <Param dataType="float" name="MW_dm_limit" unit="pc/cm^3" value=""/>
51            <Param name="galactic_electron_model" value=""/><Description>[In case "other": give DOI or discription of model use
52            <Param dataType="float" name="redshift_inferred" ucd="src.redshift" unit="None" value=""><Description>The inferred
53            <Param dataType="float" name="redshift_host" ucd="src.redshift" unit="None" value=""><Description>The redshift of t
54            <Param dataType="float" name="dispersion_smearing" unit="ms" value=""/>
55            <Param dataType="float" name="scattering" ucd="time.duration;src.var.pulse;spect.line.broadening" unit="ms" value="
56            <Param name="scattering_model" value=""/><Description>[In case "other": give DOI or discription of model used]</Des
57            <Param dataType="float" name="dm_index" unit="None" value=""><Description>Dispersion measure index</Description></P
58            <Param dataType="float" name="dm_index_error" unit="None" value=""><Description>Dispersion measure index error</Des
59            <Param dataType="float" name="scattering timescale" unit="ms" value=""><Description>Scattering timescale at 1 GHz</
```

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Required parameters

```xml
    <Param name="target_name" value=""/><Description>The name of the planned target for the follow up observation. If
    <Param name="scan_type" value=""/><Description>Fixed or drift scan performed?</Description>
</Group>
-->
<Group name="event parameters">
    <Param dataType="float" name="dm" ucd="phys.dispMeasure" unit="pc/cm^3" value=""/>
    <Param dataType="float" name="width" ucd="time.duration;src.var.pulse" unit="ms" value=""/>
    <Param dataType="float" name="snr" ucd="stat.snr" value=""/>
    <Param dataType="float" name="flux" ucd="phot.flux" unit="Jy" value=""/>
    <Param dataType="float" name="gl" ucd="pos.galactic.lon" unit="Degrees" value=""/>
    <Param dataType="float" name="gb" ucd="pos.galactic.lat" unit="Degrees" value=""/>
</Group>
<!--
<Group name="advanced parameters">
    <Param dataType="float" name="MW_dm_limit" unit="pc/cm^3" value=""/>
    <Param name="galactic_electron_model" value=""/><Description>[In case "other": give DOI or discription of model use
```

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FRB Catalogue

www.frbcat.org

This catalogue contains up to date information for the published population of Fast Radio Bursts (FRBs). This site is maintained by the FRBCAT team and is updated as new sources are published or refined numbers become available. Sources can now be added to the FRBCAT automatically via the VOEvent Network, details of this process are given in Petroff et al., 2017. FRBs confirmed via publication, or received with a high importance score over the VOEvent Network, are given 'Verified' status and are shown on the default homepage; to see all events (including unverified candidates received via the VOEvent Network) toggle the "Verified events/All events" button below.

Information for each burst is divided into two categories: observed parameters from the available data, and derived parameters produced using a model. Cosmological values are obtained using the Cosmology Calculator (Wright, 2006). The observed parameters are sometimes either lower or upper limits, due to the limitations of the data acquisition systems. Where multiple fits or measurements of a burst have been made each one is provided as a separate sub-entry for the FRB.

You may use the data presented in this catalogue for publications; however, we ask that you cite the paper (Petroff et al., 2016) and provide the url (http://www.frbcat.org). Any issues relating to the use of the catalogue should be addressed to FRBCAT team (primary contact: Emily Petroff).

An up-to-date CSV file containing all parameters for all FRBs is available at the following stable link: http://www.frbcat.org/frbcat.csv

Visible columns	Verified events	Export to CSV		Search	Clear

	FRB ▾	UTC ▾▴	Telescope ▾▴	RAJ ▾▴	DECJ ▾▴	gl ▾▴	gb ▾▴	DM ▾▴	Width ▾▴	S/N ▾▴
✚	FRB180817.J...	2018/08/17 01:49:20.202	CHIME/FRB	15:33	+42:12	68	54	1006.84±0.002	0.37	69.9
✚	FRB180814.J...	2018/08/14 14:20:14.440	CHIME/FRB	15:54	+74:01	108	37	238.32±0.01	0.18	29.7
✚	FRB180814.J...	2018/08/14 14:49:48.022	CHIME/FRB	04:22	+73:44	136	16	189.38±0.09	2.6	24
✚	FRB180812.J...	2018/08/12	CHIME/FRB	01:12	+80:47	123	18	802.57±0.04	1.25	19...

Petroff et al. (2016)
Petroff et al. (2017b)

FRBCat and VOEvents

- FRBCat VOEvent Broker
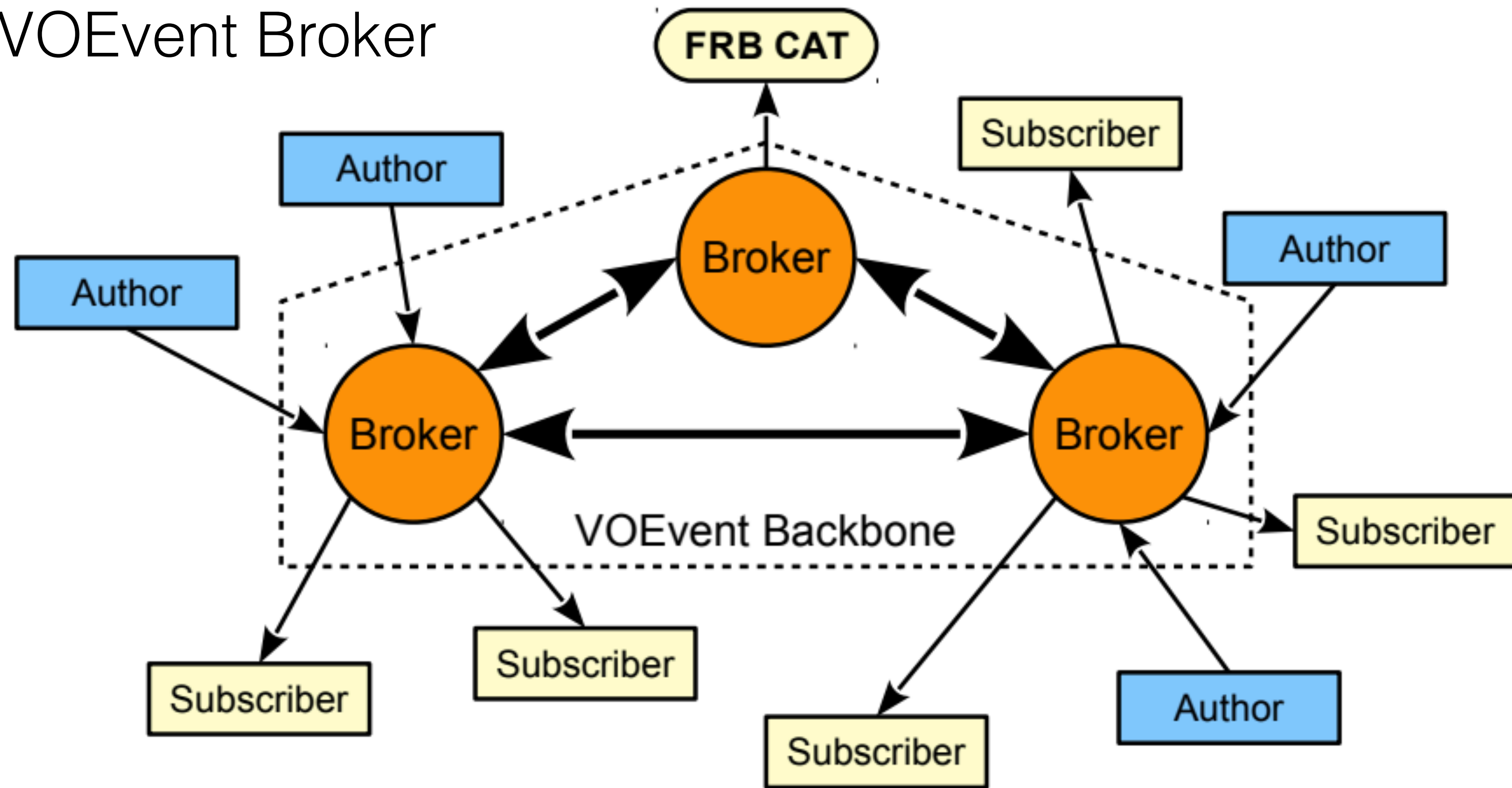
Why should you use FRB VOEvents?

- Standardized

- Open source

- Low latency

- Automatically added to FRBCAT

- We've done most of the work for you!

- Broad agreement to use this standard throughout the FRB community

Convener: E. Petroff
11:00 -- 11:15 **Stardardizing of VOEvent and archives** (E. Petroff)
11:15 -- 11:30 VOEvents and standards (D. Morris)
11:30 -- 12:30 **DISCUSSION**
VOEvents contain information that is useful for later analysis; how do we store that information in a way that can be easily extracted and interpreted later?

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How to get started

- arXiv: 1710.08155

- http://voevent.readthedocs.io/en/latest/

- https://github.com/ebpetroff/FRB_VOEvent

- https://github.com/AA-ALERT/frbcatdb

- FRB parsing/triggering scripts and unit tests coming soon

- Get in touch!

Thank you!