Green Bank's role in Pulsars and Transients
Duncan Lorimer, Dept. of Physics and Astronomy, West Virginia University
Some landmark GB pulsar surveys

- Staelin & Reifenstein
  - Giant pulses from the Crab nebula
- 300 ft surveys
  - B1931+24 (emphasis on patience!)
- Some memorable GBT targets
  - Terzan 5 (Ransom et al.; Prager et al. 2017)
  - 3C58 PSR/SNR (Camilo et al. 2002)
- GBT Drift
  - Missing link pulsar!
  - Triple system
  - Pulsar Search Collaboratory
- GBNCC
  - 156 and counting (20 MSPs)
Future GB pulsar surveys

- **Galactic Center**
  - Keep on pushing (VEGAS...)

- **Other targeted searches**
  - Globular clusters
  - High-energy point sources

- **300-400 MHz (P-band) surveys**
  - Done by 2020?

- **Focal Plane Array**
  - Deep Galactic plane L-band surveys
    - e.g. GBT sky 1 hr dwells $|\ell|<5$
    - >3000 new normal PSRs; >300 new MSPs
    - See [http://psrpop.phys.wvu.edu](http://psrpop.phys.wvu.edu)
Ongoing non-timing projects

• Interstellar medium
  – DM / RM
  – Flux modulations → scintillation
  – Scattering
  – Parallaxes

• Single-pulse studies with higher fidelity
  – Fine structure in normal pulsars
  – Millisecond pulsars

• Pulsar intermittency/state switching
  – Resurgence in last decade
Rotating Radio Transients (RRATs)

McLaughlin et al. (2006)

http://astro.phys.wvu.edu/rratalog – currently over 100 known
Pulsar intermittency

Credit: Kramer et al. 2006
Spin-state changing

Seymour+DL (2013)
- Low-D attractors?
FRB lowdown

- Two dozen known so far
- Flux > 0.5 Jy @ 1.4 GHz
- Pulse widths > few ms
- Highly dispersed
- Weakly scattered
- One FRB so far repeats!
- Few arcmin localization
- One counterpart so far
- ~few x 1000/day/sky

Credit: Thornton et al. (2013)
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. Crawford⁴

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.

Lorimer bursts are real!  

Matthew Bailes  Dec 12 (3 days ago)
to me ⊳

Hey Dunc - spectacular news about the repeating Arecibo FRB/Lorimer burst!

Looks like Lorimer bursts are real after all!

Cheers - Matthew
2016: FRB 121102 repeats!

No!

No!

Maybe?

... or maybe something else?
2017: FRB 121102 localized!

Credit: NRAO

z = 0.19
(2.3 billion yr)
We're not sure what FRBs are!

- **What is the source of FRB 121102?**
  - Are the radio sources related?
  - Magnetar/AGN interaction?
- **Is FRB 121102 representative?**
  - Do all FRBs repeat?
  - Are there multiple classes?
- **What are best strategies going forward?**
  - Positional localization crucial
  - Large area coverage also needed
What might FRBs probe?

- **New/exciting physics**
  - Cosmological NS census?
  - Non-stellar origin?
  - Fundamental tests?
- **The intergalactic medium**
  - Electron content → missing baryons?
  - Magnetic field || to line of sight
- **Cosmology**
  - Rulers
  - DM halos, DM/DE parameterization
GBTrans [Ellingson et al.]

- 1.4 GHz / 50 MHz
- Realtime processing
- FRB rate \( \sim 1/\) month?
- Target nearby clusters
- Beginning “shadowing”
  - Swift
  - LIGO
  - Fermi
  - CHIMERA
FRBs at Arecibo - ALFABURST

- 7 beams - commensal observing
- 56 MHz current bandwidth
- DM range out to 10,000 pc/cc
- Realtime pipeline (similar to Parkes)
2015: FRB 110523 at GBT

Credit: Masui et al. (2015)
1 beam - commensal observing
Even when other feeds in use!
800 MHz current bandwidth
DM range out to 10,000 pc/cc
Realtime pipeline
Strategies going forward

- **Single dish surveys**
  - FAST
  - FLAG → FLAG++??
  - ALFABURST → ALPACA → ++?

- **Broadband single-dish follow-up**
  - High sensitivity
  - FRB spectra?

- **Shadowing by other arrays?**
  - Build something at GB?
  - Make use of RQZ
  - Potential for a PSR telescope?
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We would like to be here...
L-band Array of Small Arrays (LASA)

- Dipole [512 of these]
- Stand (2 dipoles) [256 of these]
- Quad (4 stands, 8 dipoles) [64 of these]
- Radome
- Ground Plane
- Coaxial cables connecting quads to the DBF [128 of these]
- Fibers
- Power

Credit: Steve Ellingson
L-band Array of Small Arrays (LASA)

Each supertile is a daisy chain of up to 10 tiles:

- Supertile 1
  - Beams 1-4
  - Beams 5-8
  - Beams 9-12
  - Beams 13-16
- Supertile 2
  - Beams 1-4
  - Beams 5-8
  - Beams 9-12
  - Beams 13-16
- Supertile 3
  - Beams 1-4
  - Beams 5-8
  - Beams 9-12
  - Beams 13-16

Up to 10 km 10 Gb/s ethernet on optical fiber

10 Gb/s ethernet switch
Serves as corner turner

Inter-tile beamformers & spectrometers

Full-Stokes dynamic spectra from inter-tile beams

Dynamic spectrum folding & dispersed pulse detection

Post-processing cluster

Remote M&C
NRAO site network

Credit: Steve Ellingson
L-band Array of Small Arrays (LASA)
L-band Array of Small Arrays (LASA)

![Graph showing FRB rate vs. Peak signal-to-noise ratio for LASA-512, LASA-30, and LASA-3, comparing them to CHIME, UTMOST, and Parkes.]
(My) bold predictions

- **2020:** 100s FRBs found
  - CHIME
  - REALFAST
  - ASKAP
- **2025:** 1000s of FRBs known
  - SKA and its pathfinders
- **2030:** FRBs essential cosmological tools
  - Many papers on this already!