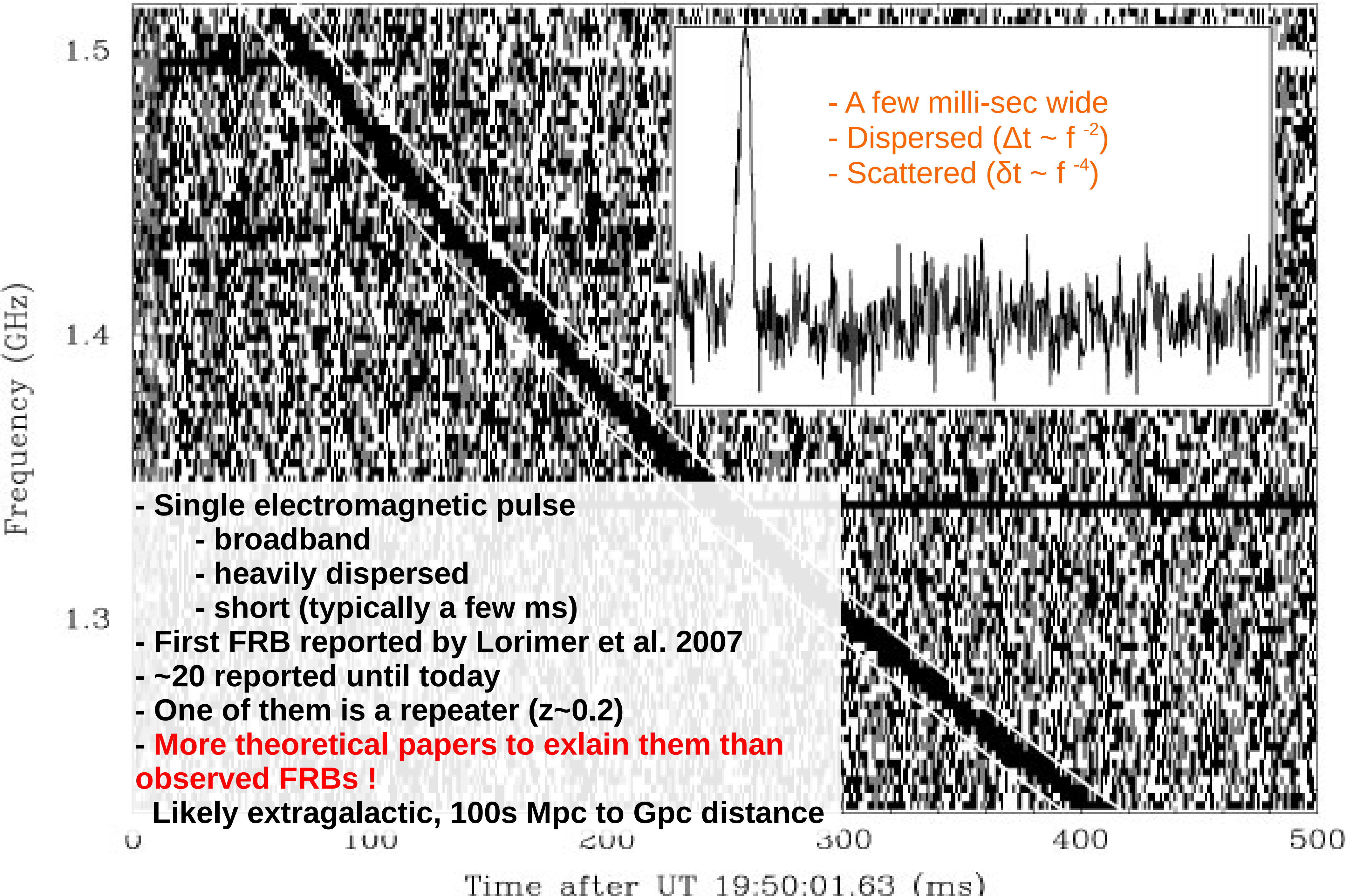
FRB with GRAND

Fabrice Mottez, Philippe Zarka, Cyril Tasse

FRB with GRAND



- A few milli-sec wide
- Dispersed ($\Delta t \sim f^{-2}$)
- Scattered ($\delta t \sim f^{-4}$)

- Single electromagnetic pulse
  - **broadband**
  - **heavily dispersed**
  - **short (typically a few ms)**

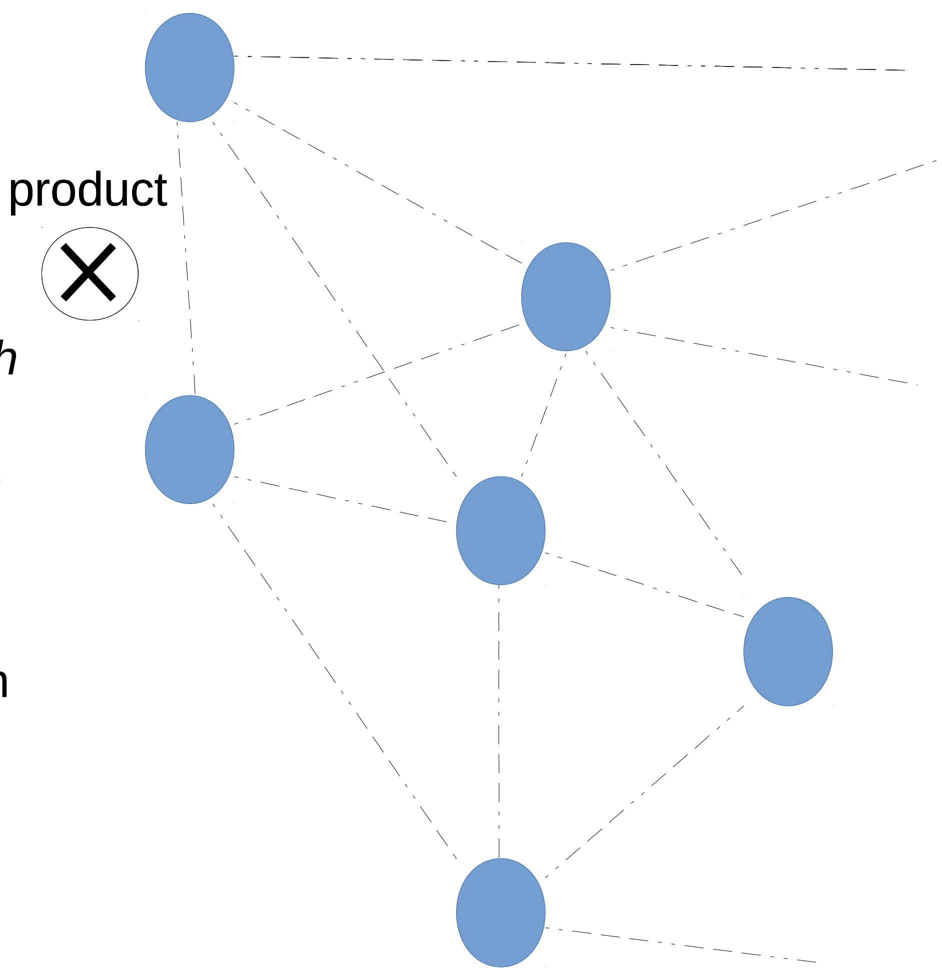
- First FRB reported by Lorimer et al. 2007
- ~20 reported until today
- One of them is a repeater (z~0.2)
- More theoretical papers to exlain them than observed FRBs !
Likely extragalactic, 100s Mpc to Gpc distance

GRAND setup ?

Use it in interferometric mode to do imaging ?

PROs
- Do imaging on the sphere at the resolution of the ~longest baseline
- A voltage correlation is computed for *each* pair of antenna
- Sensitive since we have ~n^2 independent data points per dt/df

CONs
- Because of decorrelation effect: very high trafic dt/df
- **That's a project >SKA – no way ...**

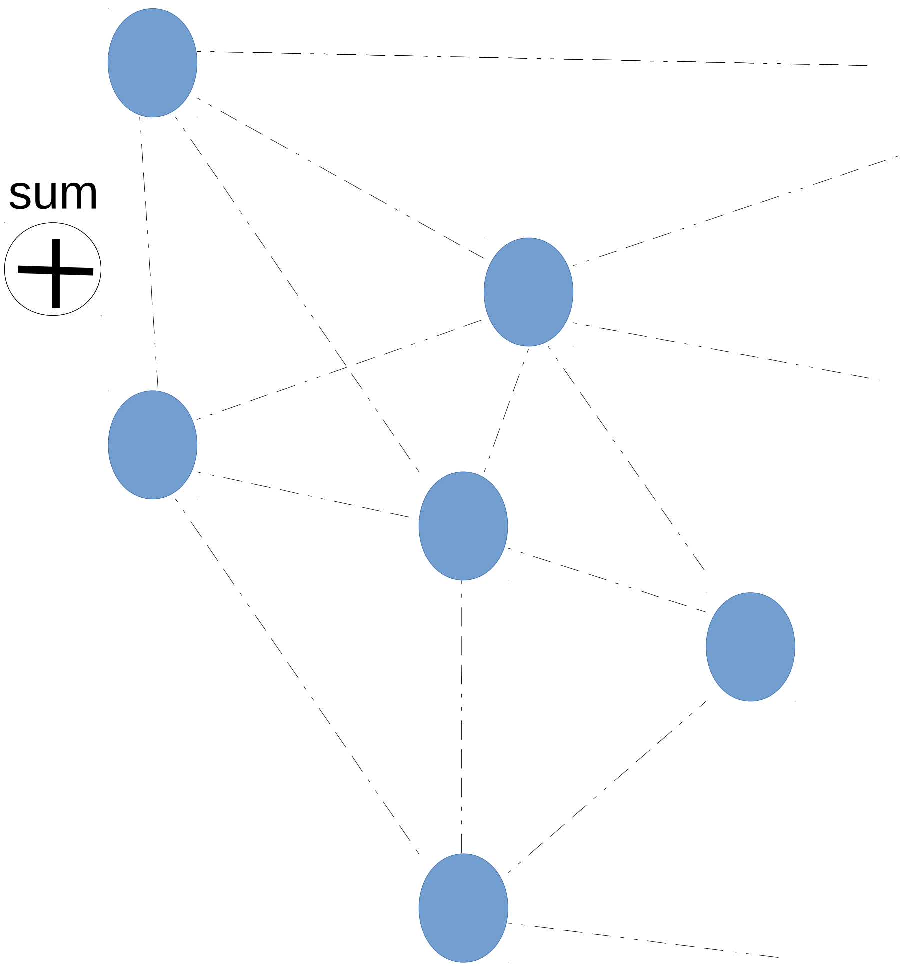


GRAND setup ?

Compute the (phased) sum of voltages (beamformed mode)

PROs
- Same sensitivity as previous setup

CONs
- Still crazy trafic
- Single pixel observation
- Multitude of very large grating lobes
- Careful flagging required (per antenna)

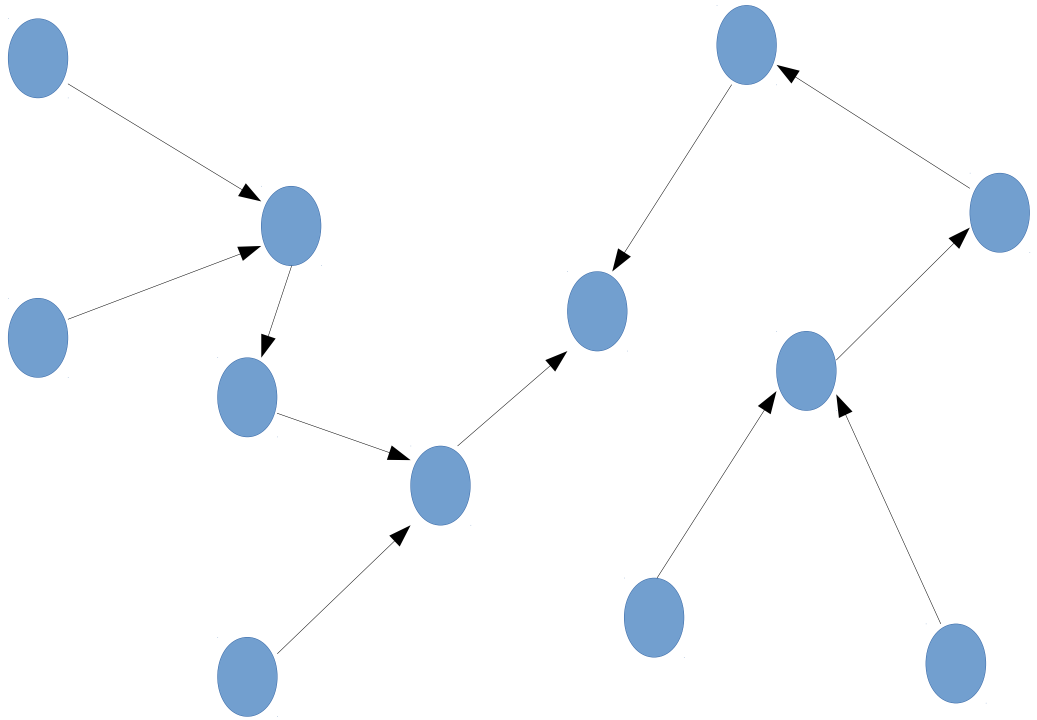


GRAND setup ?

Compute the autocorrelation on each antenna and then compute their sum

PROs
- FoV is that of an individual antenna (~2π sr)
- Little trafic

CONs
- Sensitivity is $n^{1/2}$ less than interferometer
- No information on the direction of arrival
- Careful flagging required (per antenna)



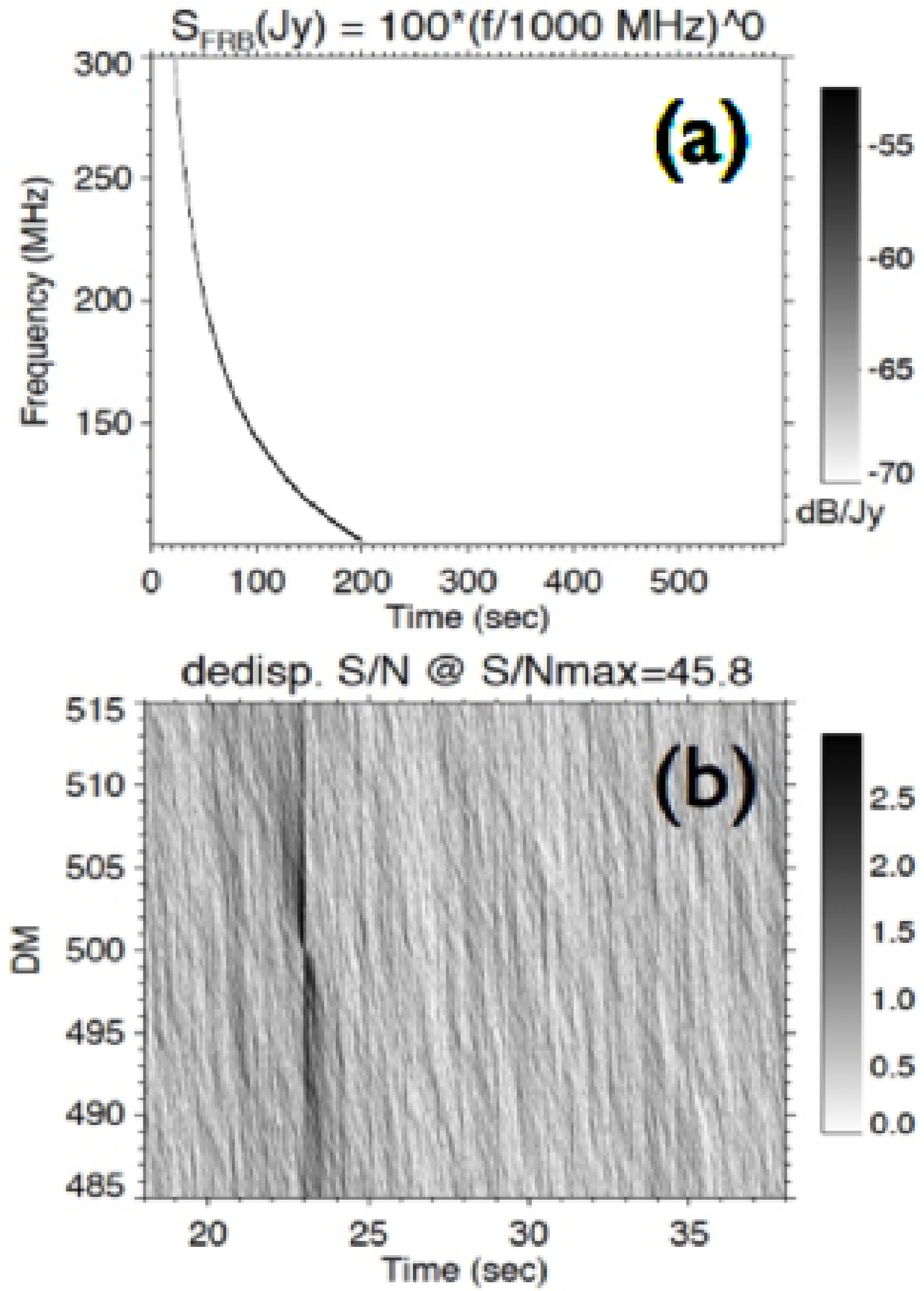
Simulations : What can we detect with that setup?

- Simulations by PZ

Finding the dt-df signal with 1.6 MB/s data rate (10 msec x 25 kHz, 2 bytes encoding)

- A wide variety of FRB have been simulated taking into account
  - galactic noise ($T_{sys} \propto 60\ \lambda^{2.55}$)
  - dispersion ($\Delta t \sim f^{-2}$)
  - scattering due to the free electrons on the line-of-sight ($\delta t \sim f^{-4}$)

Simulations : What can we detect with that setup?



(i) dispersed (DM = 500 pc.cm^{-3}) and (ii) diffused 100 Jy and 5 ms long FRB pulse (the simulated galactic noise is not shown since its power largely dominates the signal).

The bottom panel (b) shows the result of a blind search. GRAND would detect that event with an SNR $\sim$ 50. The FRB dispersive drift lasts for $\sim$ 185 s ($\sim$ 370 s for DM = 1000 pc.cm -3)

Simulations : What can we detect with that setup?

- FRB detectability seems thus possible with GRAND at intensity levels comparable to the Lorimer et al. (2007) burst (30 Jy).

- With alpha=0 (flat spectrum), we should have ~100 FRB/sky/day

- The major uncertainty is the FRB spectrum - and even existence - at low-frequency, i.e. the turnover frequency.

- FRB may be detected at a rate between null to a few thousand per day

- If we indeed detect many FRBs, many things we could think of doing (IGM studies ? Cosmology ?)

Questions that could be answered

Knowing their DM and dates, not their location

- How many FRB sources ?
- What is the proportion of FRB repeaters ? (Same DM)
- Better staticstics on repeaters : do the burst follow a Poisson distribution. Or something more structured ? Are there periodic repeaters ?
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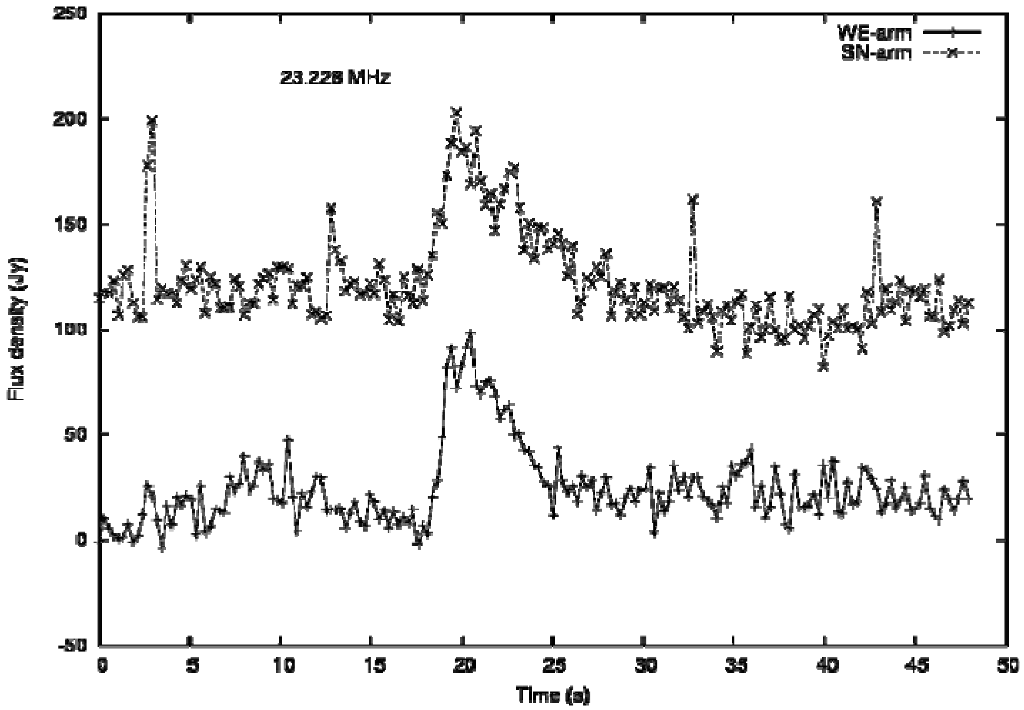
Giant Radio Pulses with GRAND

Giant Radio Pulses (GRP)

- They come from a handful of known pulsars : Crab, B1937+21, PSR in LMC…
- Radio pulses > 1000 more energetic than regular pulses
- Random distribution in time
- Can be frequent (~ min for the Crab)
- A lot of observations, from 20 MHz to 18 GHz.
- Unknown cause

Shape of GRP

- Shorter than FRB : microsecond (ms for FRB)
- Same dispersion measure as their pulsar DM~100 pc cm-3
- More frequent than FRB.
- Most intense FRB at 2.2 GHz : 5 MJy.
- Most intense FRB at 23 MHz : 100 Jy, above 50 Jy for .



Integrated flux (in time) vs freq. GRP of PSR B1937+21

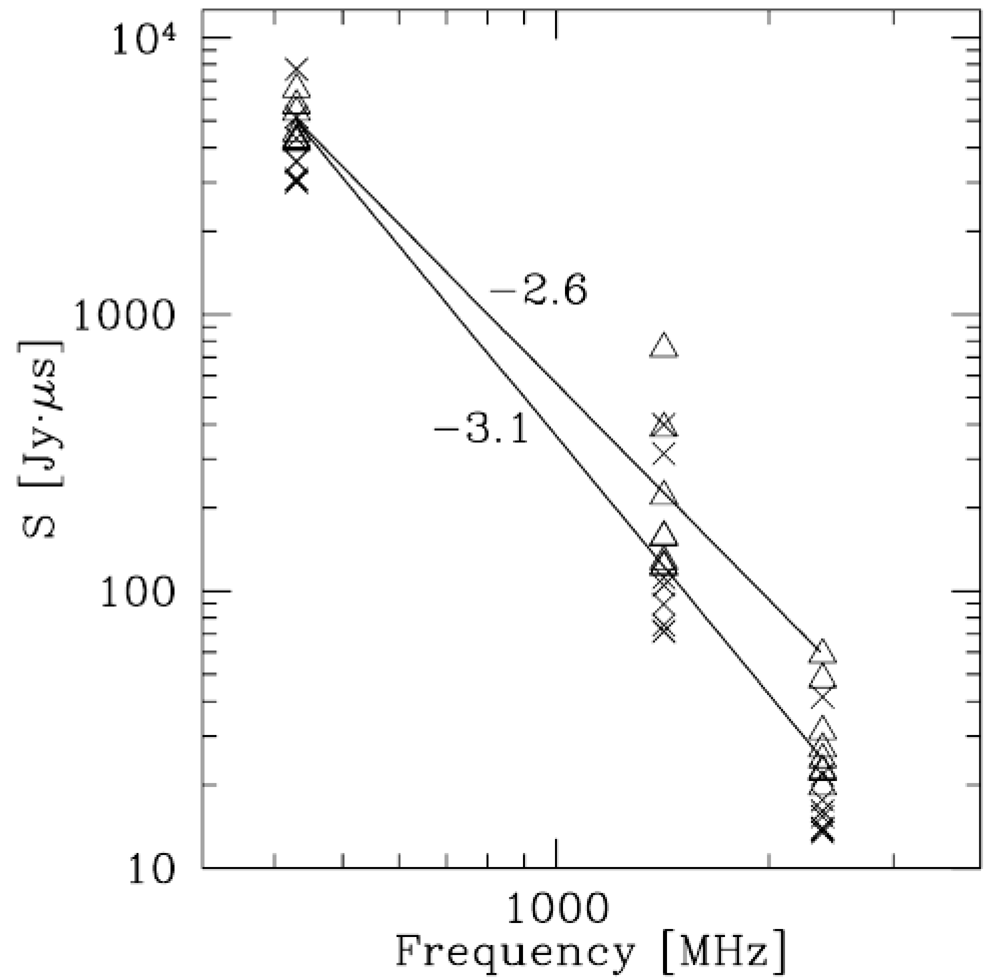


FIG. 10.—Giant pulse integrated flux density vs. frequency for the 8 strongest giant pulses in the MP and in the IP taken from equal-length scans of 15 minutes on MJD 51,364 (430 MHz), 50,893 (1420 MHz), and 51,391 (2380 MHz). At each frequency, the absolute flux density calibration was calculated independent of scintillation using the spectral model of Foster et al. (1991). This power-law model has a spectral index for normal emission of −2.6; that slope is indicated above. There is some evidence that the spectrum of the strongest giant pulses is steeper; the best-fit power-law model, with index −3.1, is also shown.

What could be done with GRAND

- If GRAND sees FRB, it will see GRP, anyway.
- Is there an upper-cutoff in the amplitude distribution ? If no, imagine a 1 Gjy GRP : same energy and same shape at FRBs.
- Indeed some models consider FRB as super-Giant radio pulses.
- Discover more GRP pulsars.
- Are there pulsars with seldom GRP ? (Contrarily to Crab and its frequent GRP.) GRAND can improve these statistics.