The effects of burst DM on drift

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The paper is in good enough shape to start writing in earnest, but there are a few more things to do before we can have a complete draft. Last week I emailed Ziggy Pleunis from the CHIME/FRB team for help with the data for FRB180814 after searching for the burst in 100ms chunks still failed to reveal any signal. He said he would be able to help me out this coming week. I also sent along our FRB121102 paper to him and asked if he had any feedback on it.

The following is his response:

`Hi Mohammed, Thank you for your email. I did read your paper when it appeared on the arXiv and I think it is a nice idea that you are pursuing.`

`I am a bit worried about the covariance of the drift rates you are measuring with DM, as the DMs of repeaters are known to change with time and potentially also from burst to burst. What we did in the CHIME/FRB 'eight new' and 'nine new repeaters' papers for fitting linear sub-burst drifting rates is re-sampling the autocorrelations dedispersed to different DM values and see how the drift rate varied with DM to test how robust the drift rate measurements were. Something like that might be worth trying for your analysis too, or you could try and show that definitely the drifts you are seeing are not proportional to frequency^-2 as expected for dispersion through a cold and tenuous plasma.`

I thanked him for his feedback and mentioned our test of the robustness of the trend by varying the DM for all the bursts and seeing that while the fit parameter changed, there was still a reciprocal relationship between the drift and burst duration. I also quickly checked that the drifts are not proportional to ν_{obs}^{-2} but since we used data that was already dedispersed, this is something the original authors of the data would have checked as well when dedispersing.

However there remain some points that we should consider addressing if we want our paper to be convincing to the FRB community:

1. The DM of bursts from FRB121102 can vary significantly with time and/or with burst.
2. Our error analysis on the drift measurements does not incorporate the error on the DM for each burst.

Point 1:

We use data that has all been dedispersed to the same DM. I compiled a list of the DMs we used as well as the range of DMs that the individual bursts can have:

Source	DM pc/cm^3
FRB121102 Gajjar (11A and 11D)	565
FRB121102 Michilli	559.7
FRB180916.J0158+65 (CHIME)	348.82
FRB180814.J0455+73 (CHIME)	189.4

Table 1: DMs used in our paper

Source	DM Range pc/cm^3
FRB121102 Spitler 2014	553-569
FRB121102 Gajjar 2018	562-636
FRB121102 Michilli 2018	˜559.7±6
FRB180916 CHIME 2020	348-350
FRB180814.J0455+74 Amiri 2019	188.9-190

Table 2: Range of DMs from individual bursts

Looking at sources 180916 and 180814 for example, the DM range is quite small, and we are likely safe given the test we did earlier with varying the DMs of those sources. However the DM for FRB121102 can vary by quite a bit, and in particular the DM for the Gajjar bursts we used in our paper span a range of 583-601 pc/cm^3, which may move those points in a significant way. It's worth noting that in Gajjar et al., the DMs they report in their table are for maximizing S/N, but they choose a different DM (565 pc/cm^3) because it optimizes the structure of 11A.

I believe we can address this point by performing a similar test to what we did for 180916 where we varied the DM for all the bursts together, but instead we randomly adjust the DMs of individual bursts and confirm that the trend remains.

Point 2:

Propagating the DM error through to the error on the drift measurement and having an accurate error bar will settle the quickest criticism that our paper prompts. We can perhaps do this analytically, given that the dispersive equation is given by

$$\Delta t = k_{\mathrm{DM}}(\nu_{\mathrm{lo}}^{-2} - \nu_{\mathrm{hi}}^{-2}) \times \mathrm{DM}, \tag{1}$$

which shifts the intensity data and adds an error on the time data.

Another way to achieve this is as Ziggy suggested: sample DMs from a gaussian distribution with the published 1σ errors, dedisperse the burst to that DM and find the corresponding distribution of drift measurements. The width of the distribution of the drift measurements can then be used in the error bar.