Blackrock Binary-Noise (BN) Stimulation Instruction (BR_stim paradigm)

Lega Lab, UT southwestern Medical Center

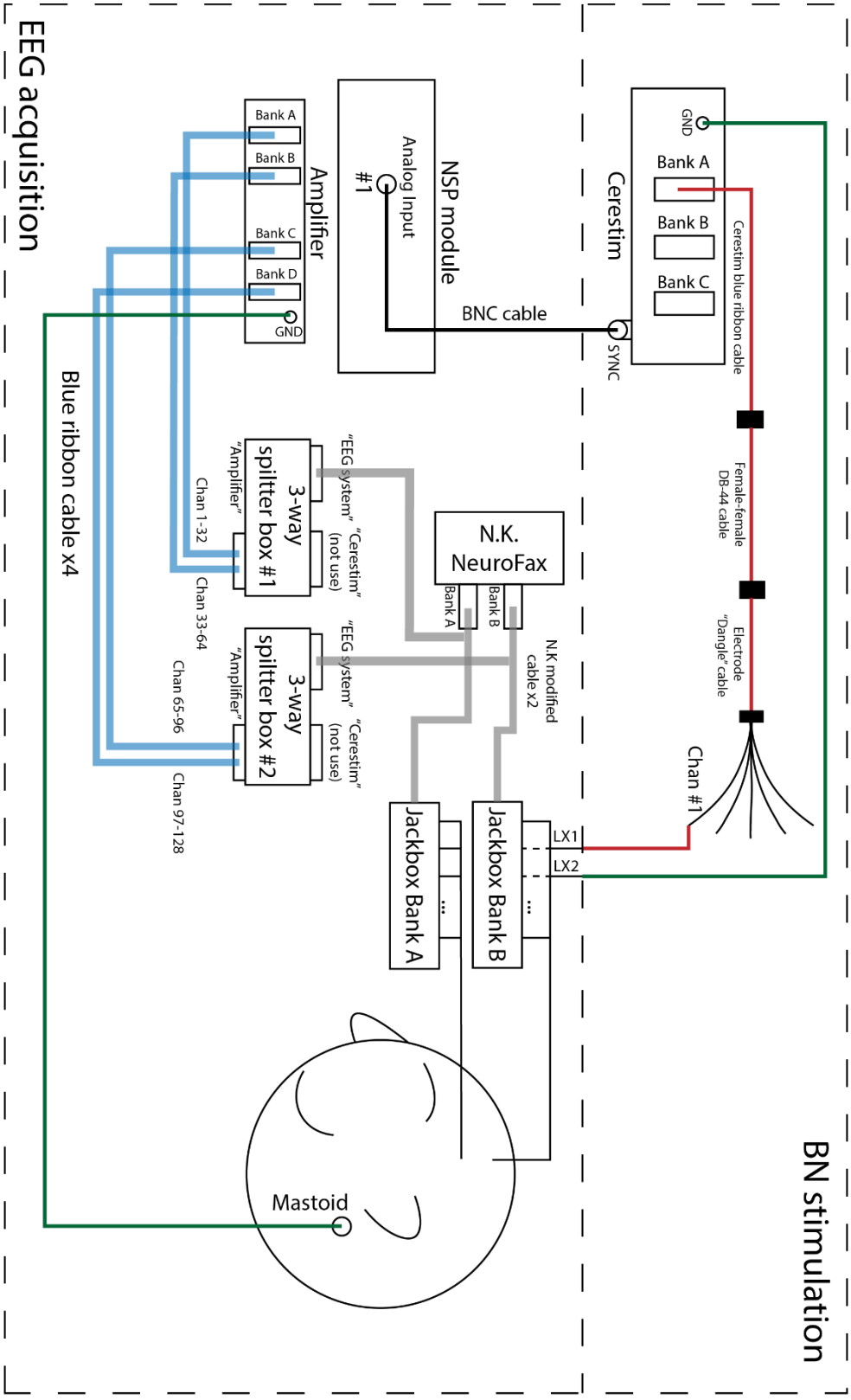
Version 0.1

By David Wang July 2021

Hardware setup:

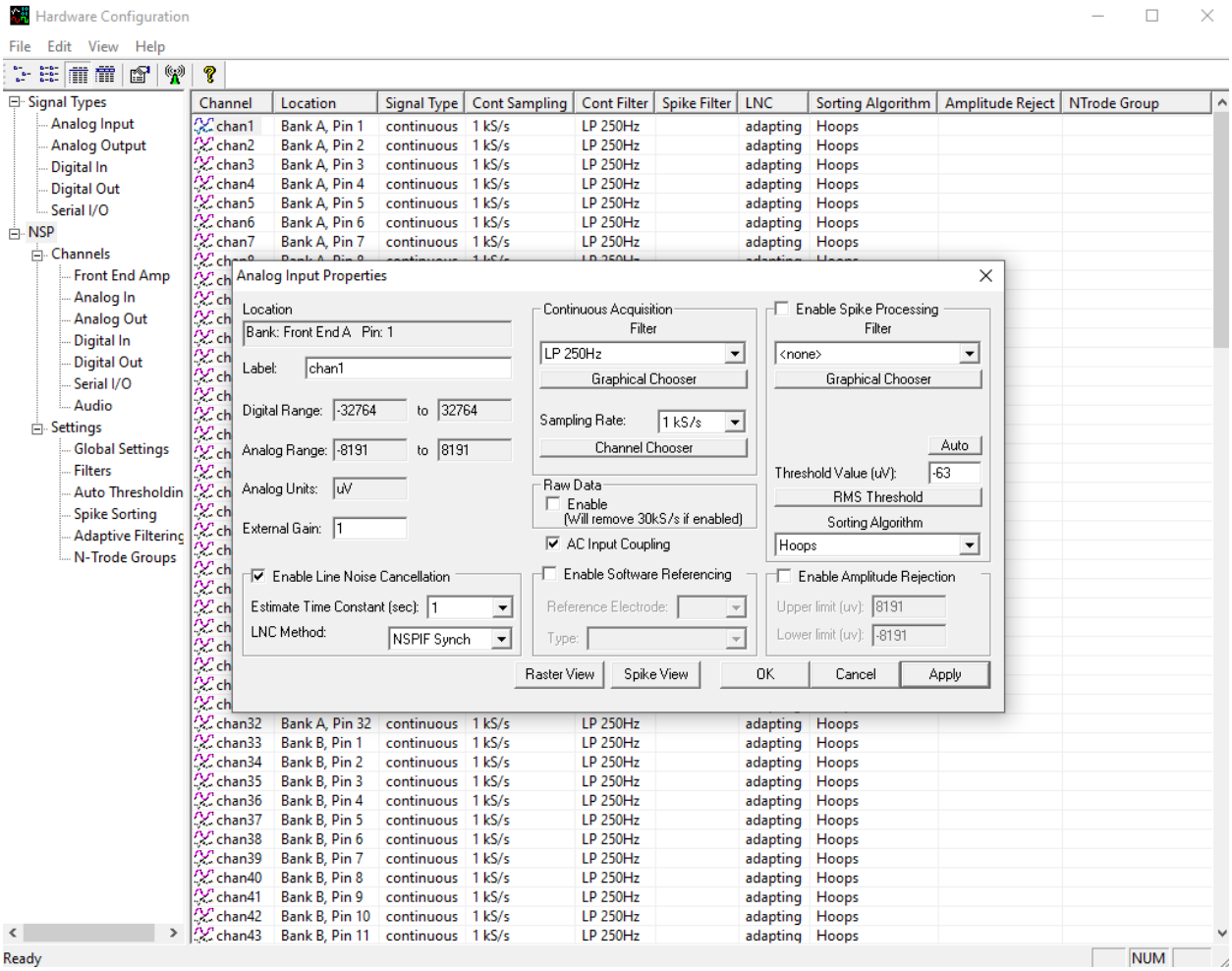
1. Set up EEG acquisition:
   a) Swap out the N.K. cables in between the N.K NeuroFax and Jack-boxes with modified N.K. cables for bank A and B.
   b) Connect the modified N.K. cables (2 DB44 connectors for each bank) to the "EEG system" ports of 3-way splitter boxes.
      - N.K Bank A 1st DB44 – "EEG system" port #1 - #32 (upper) on the "1-64" splitter box.
      - N.K Bank A 2nd DB44 – "EEG system" port #33 - #64 (lower) on the "1-64" splitter box.
      - N.K Bank B 1st DB44 – "EEG system" port #1 - #32 (upper) on the "65-128" splitter box.
      - N.K Bank B 2nd DB44 – "EEG system" port #33 - #64 (lower) on the "65-128" splitter box.
   c) Connect 3-way splitter boxes ("amplifier" ports) to the amplifier via blue ribbon cable.
      - Amp bank A – Chan #1 - #32
      - Amp bank B - Chan #33 - #64
      - Amp bank C - Chan #65 - #96
      - Amp bank D - Chan #97 - #128
   d) Set up ground on patient's mastoid then connect it to the ground port (GND) on amplifier.
2. Set up BN stimulation:
   a) Connect female-female DB44 cable to the Cerestim blue ribbon cable (wrapped in pink color) bank A.
   b) Connect electrode "dangle" cable to the other end of female-female DB44 cable.
   c) Unplug the electrode connector of stimulation site (LX1 for left PCC stimulation) from the jackbox, then connect it to the dangle cable channel #1 via a jumper connector. **Stim electrode (LX1) and the dangle #1 should have no contact with the jackbox.**
   d) Unplug the adjacent electrode of stimulation site (LX2) from the jackbox, then connect it to the ground port (GND) on the back of Cerestim. **This adjacent electrode (LX2) and the GND should have no contact with the jackbox.**
3. Connect the SYNC port on Cerestim to NSP analog input #1 via BNC cable for sync pulses. Make sure BNC cable fits properly on both ends.

BN_stim hardware diagram:



Software setup:

1. NSP central (Normally would not need electrode referencing, see troubleshooting section for excessive stimulus artifacts). A global Central configuration file is located**:** **C:/Blackrock Microsystems/BlackRock_Scrip/BRStim.ccf**



   a) For digital channel #1-#128
      - Enable line noise cancellation. LNC method: NSPIF sync, estimate time constant: 1s
      - Continuous Acquisition: LP 250 Hz
      - Sampling rate: 1kS/s
      - Disable Spike processing <None>
      - Disable channel referencing.
   b) For analog input #1:
      - Continuous Acquisition: <None>
      - Sampling rate: 30ks/S
      - disable rest of features
2. Matlab BN stimulation scripts (matlab scripts are located in **C:/Blackrock Microsystems/BlackRock_Scrip/** folder)

a) Connect cerestim to PC: open and run script "Cerestim_connect.m"
b) Open BN stimulation script "BlackRock_BN_stim_2f.m". Set subject number and session number

```
Subject = 'UT999';      % Subject Number, UT999 for testing
SessionNum = 0;         % Test Session Number. If a session is interrupted,
                        % please start with a new session number. (Same in BlackRock Central)
```

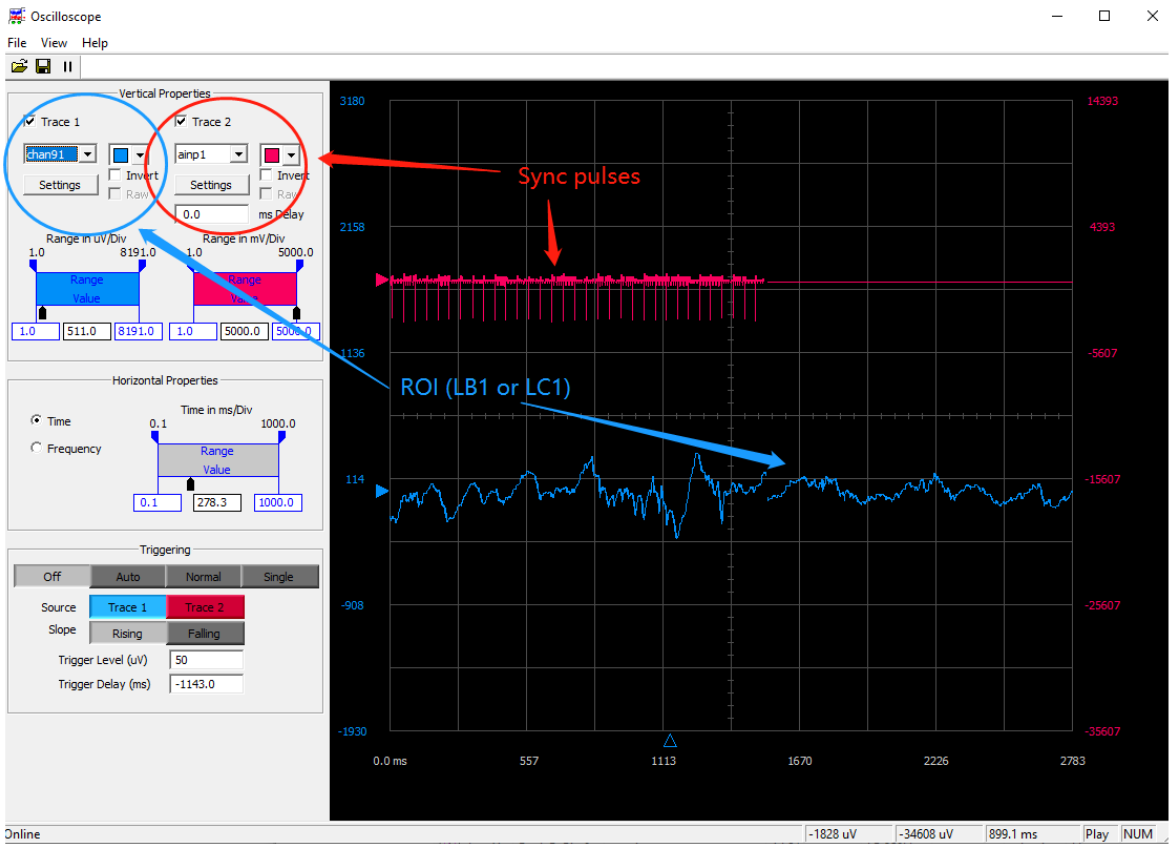
c) Use **2000 (2 mA) for HighAmp** and **1000 (1 mA) for LowAmp** for session_0
Use **3000 (3 mA) for HighAmp** and **1500 (1.5 mA) for LowAmp** for session_1

```
HighAmp = 2000;          % Amplitude for high current pulses, in uA
LowAmp = 1000;           % Amplitude for low current pulses, in uA
LowFreq = 100;           % Freuqnecy 1 for stimulation pulse, 100Hz
HighFreq = 150;          % Freuqnecy 2 for stimulation pulse, 150Hz
```

3. Stimulating and recording: start NSP recording in Central, file storage, then run the Matlab BlackRock_BN_stim_2f.m script.

Monitoring during the session:

Open the oscilloscope panel on Central, select the LC1 or LB1 Channel for Trace 1 and ainp1 (analog input #1) for Trace 2. You should be able to see LC1/LB1 EEG times-series in blue color and sync pulses in pink color.

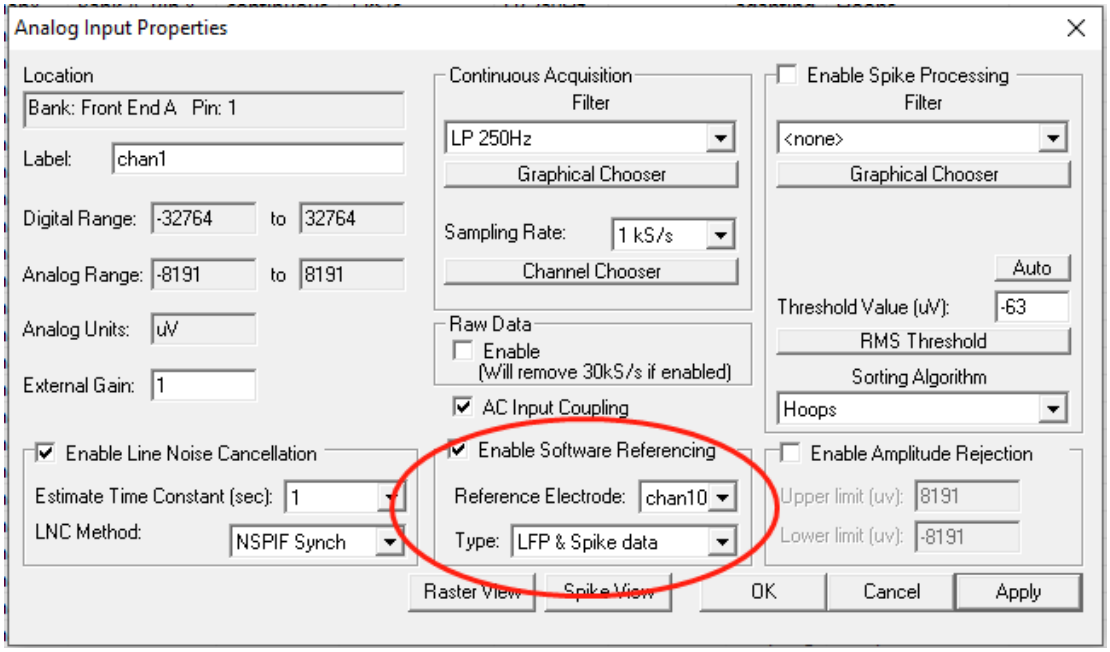


Note: It is a good chance to investigate if hippocampal EEG (from LB or LC contacts) has stimulus artifacts. A clean should look like the one in the example figure.

Troubleshooting:

1) Stimulation artifact leakage: if you see excessive high frequency artifacts in LB/LC channels during stim, it may indicate:
    - Poor stimulating circuitry: check dangle #1 and LX1 electrode connection and their connection should be completely away from the jack box. (i.e. once they are connected, no connector should be plugged back in the jackbox LX1 electrode socket). Same for the LX1's adjacent channel (LX2), make sure LX2 is directly connected to the GND on the back of Cerestim.

- Poor grounding: Also make sure the mastoid is connected to the GND on the amplifier and the connection is solid.
- Improper/no filtering: Make sure LP 250Hz filtering is enabled for Continuous Acquisition.
- If none of the above procedures helps reduce stim artifacts, try enable the referencing using "**BR_stim_10thRef.ccf**" configuration file (under the same folder path) for Central. Be sure to tweak the reference electrode if necessary. A bipolar (within the probe) referencing scheme would be helpful (e.g. LB1- LB10, LB2-LB1, LB3-LB2, LB4-LB3, … , LB10-LB9).



2) Absence of sync pulses: if you don't see sync pulses in the oscilloscope panel, it may indicate:
   - Stimulation script is not running: check the matlab script and make sure it is running. Scripts stops automatically after preset number of events (default 90 events, ~15mins).
   - Poor BNC cable connection: make sure the BNC cable has a snug fit on both ends. Swap out with another cable if necessary. Sync pulses should have a peak amplitude of ~4000uV at the beginning of each stim event.
   - Note that the oscilloscope is not 100% in real-time so wait a couple of seconds before any operations. If both channels on the oscilloscope are spotty and looking weird, switch to another channel and switch back. (This is a known software issue of Central)
3) Unable to connect Cerestim to PC. Error messages when running Cerestim_connect.m script.
   - This often happens when Cerestim is not turned off previously.
   - Turn off the Cerestim by firmly pressing the power button on the front panel of Cerestim, wait a couple of second, then firmly press the power button again for rebooting. Repeat a few more times if necessary.

Scripts and configuration files are found in **C:/Blackrock Microsystem/BlackRock_Script/** folder. EEG Data and BN sequences generated by the script are stored in **C:/data/UTXXX** folder. Feel free to contact David Wang (David.Wang@UTsouthwestern.edu) for further assistance.

Blackrock Binary-Noise (BN) Stimulation Instruction (BR_stim paradigm)

w/ micros and headstage

Hardware setup:

The main hardware setup remains the same as in ordinary blackrock BN stim paradigm w/o micro wires.

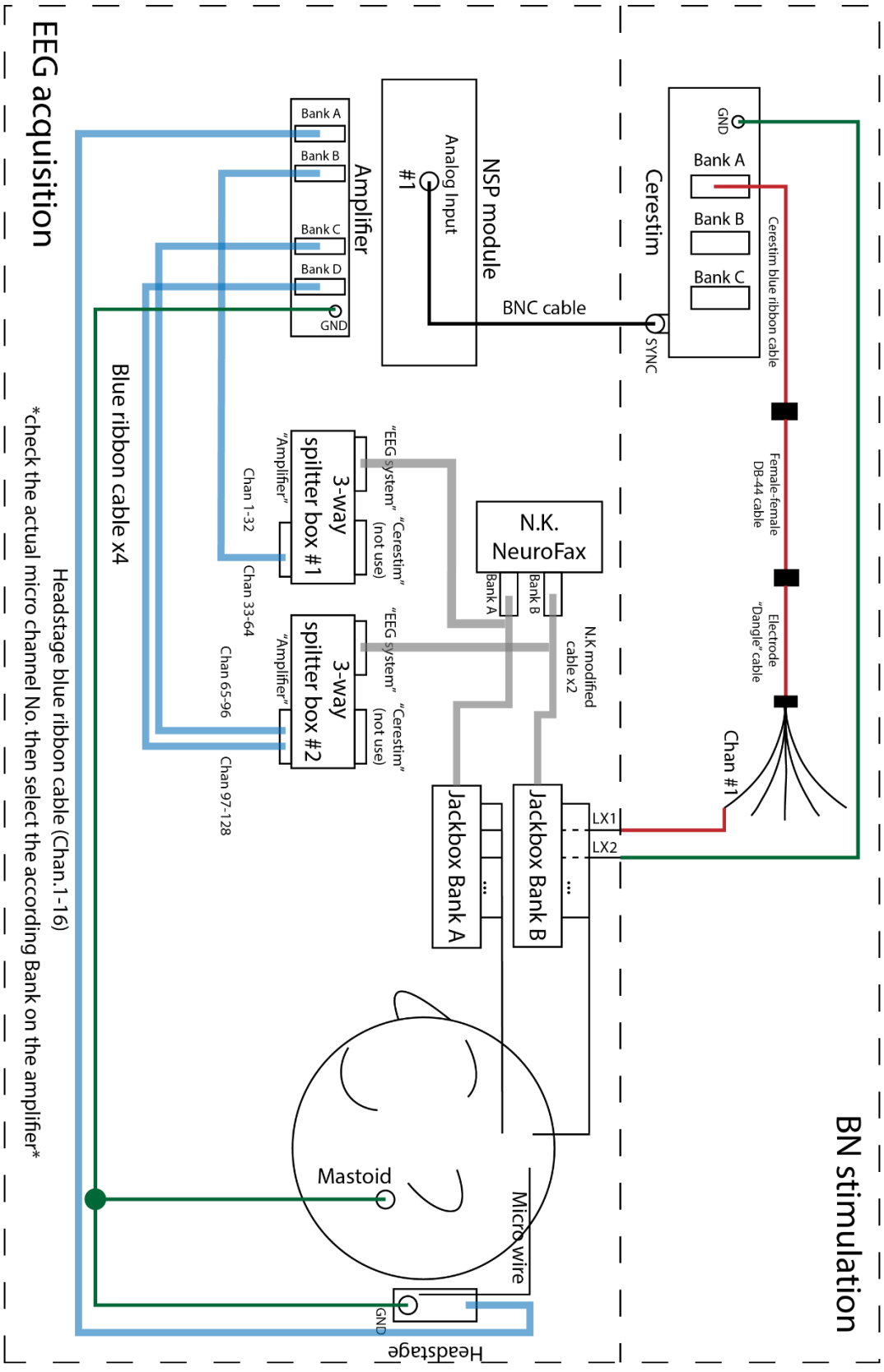
1. Set up EEG acquisition:
   Follow step a), b) and c) in page 1.
   d) Set up headstage on patient and ground. Grounding is different from AR micro setup. Use electrode jumper connector to connect GND on head stage, the mastoid, and the GND on the amplifier all together (No Z-port on the jackbox required).
   e) Connect 3-way splitter boxes ("amplifier" ports) to and the headstage the amplifier via blue ribbon cable.
   Note: Be sure to check the electrode numbers for micros and use the according bank of the amplifier for micros (e.g., if the electrode numbers are 1-8, use Bank A on the amp).
   - Amp bank A – Chan #1 - #8 are micros, #9-#32 are blank.
   - Amp bank B - Chan #33 - #64
   - Amp bank C - Chan #65 - #96
   - Amp bank D - Chan #97 - #128

   Special case: if the ROIs (LB/LC electrodes) are close to micro sites (with in the same 32-channel bank), use another bank with least amount of ROIs for headstage and stay true channel number for LB/LC channels. For example, RB (micros) channels are #1-#10, LC channels are #21-#30. Use Bank A (1-32) on the amp for LC, and Bank D for RB micros, if Bank D doesn't have many ROIs.

   Experimental: the other half of the blue-ribbon cable (NOT the same as splitter box-to-Amp blue ribbon cable) of the headstage is not in use, and it fits the port on the splitter box. This makes it feasible to collect data from 16 more channels. However, noises and artifacts seem inevitable with this type of setup. Not recommended for now.

2. Set up BN stimulation: remains the same as in page 1.
3. Sync pulses: remans the same as in page 1.

BN_stim w/ micros hardware diagram:



Software setup:

1. NSP central: load global configuration file C:/Blackrock Microsystems/BlackRock_Scrip/BRStim.ccf . Then, ONLY select micro channels for ARmicro configuration. For example, if micro channels are 1-8, set 1-8 as such:
    - Enable line noise cancellation. LNC method: NSPIF sync, estimate time constant: 1s
    - Continuous Acquisition: <None>
    - Sampling rate: 2kS/s
    - Enable Raw Data
    - Enable Spike processing: HP 250 Hz
    - Disable channel referencing for now. Note: most likely micro channels need channel referencing, especially during the last few days of patients' stay. Check the spike clusters in the Spike Panel, adjust threshold accordingly (~-30 uV to ~ -65 uV). If LFPs are too noisy, try bipolar referencing (1-8, 2-1, 3-2, 4-3, …, 8-7).
2. Matlab BN stimulation scripts: remains the same as in page 3.
3. Stimulating and recording: remains the same as in page 4.

Monitoring during the session:

Mainly remains the same as in page 5. Keep an eye on micro channels via the spike panel or the oscilloscope. It is normal to see stim artifact leakages in micro channels and consistent count of spikes due to the artifacts.

Troubleshooting:

Mainly remains the same as in page 5. Other than technical issues, one critical point of micro data in the BN-stim paradigm is that artifacts can not be eliminate completely because new frequency components are introduced to EEG/LFP signals due to the random switching of two stim frequencies and amplitudes. So far, the best way to investigate micro responses to the stimulation is to use fixed-amp stimulation paradigm instead of BN-stim. This can be simply done by using the same value for LowAmp and HighAmp the same value for LowFreq and HighFreq in BlackRock_BN_stim_2f.m script (2mA and 100Hz are recommended).