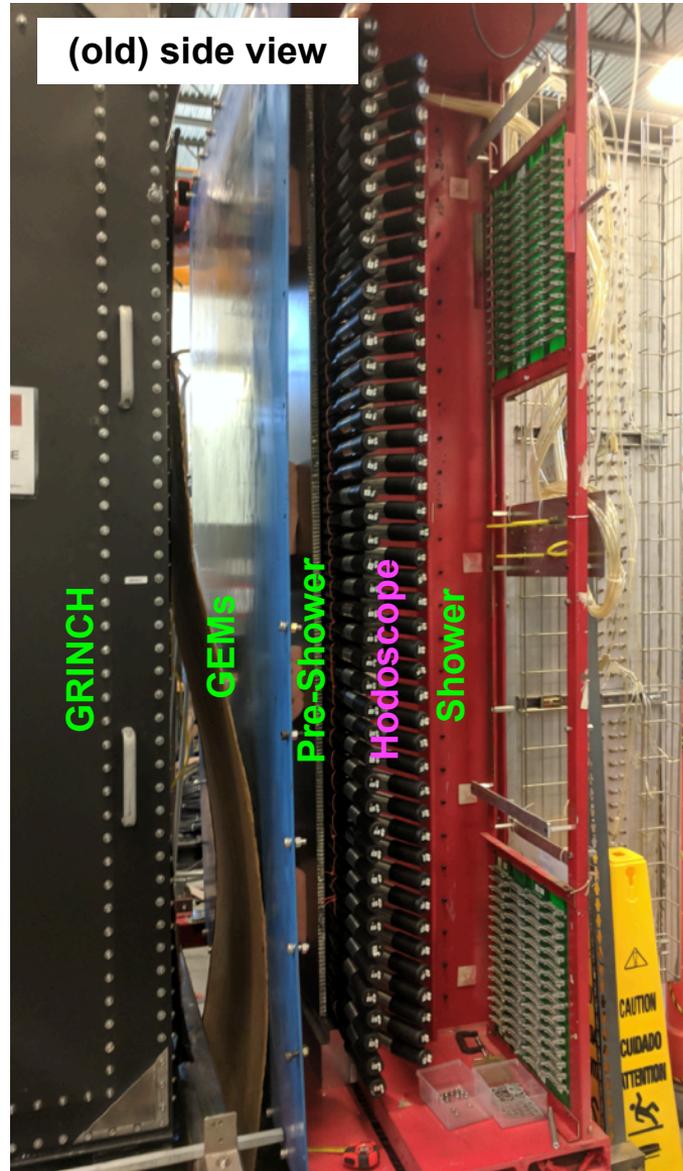
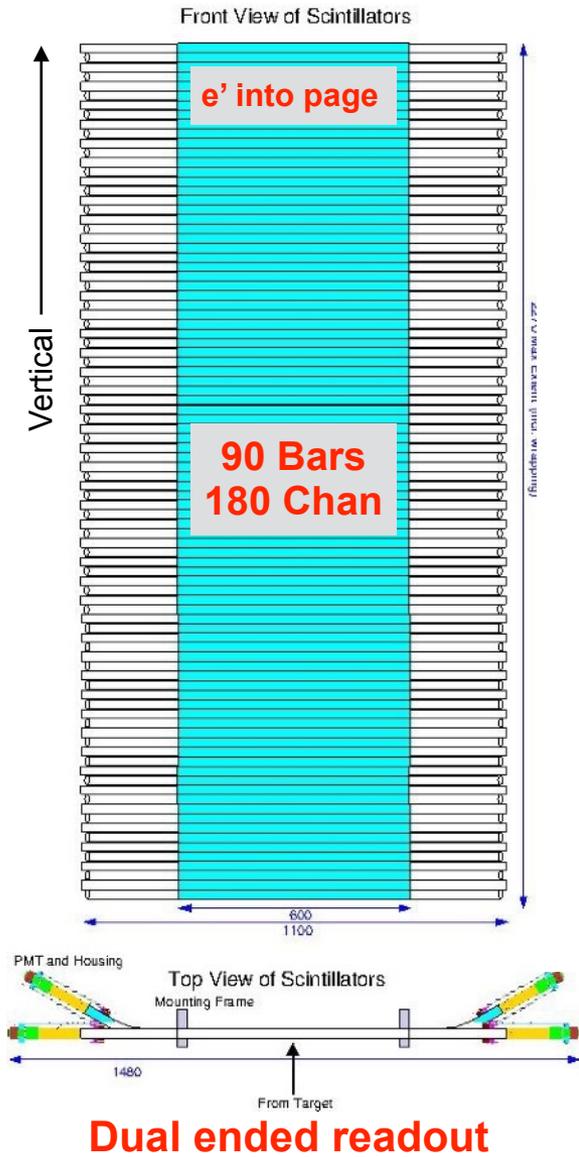


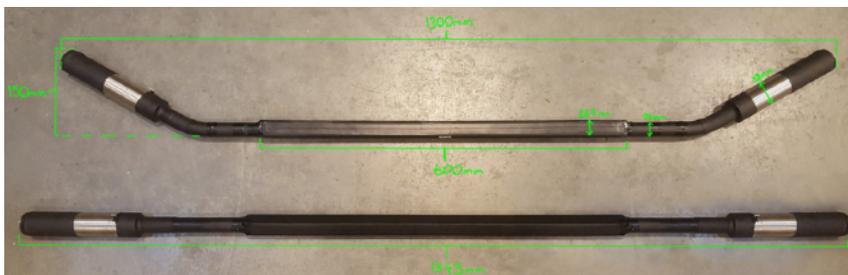
R. Montgomery on behalf of several
hodoscope colleagues and SBS Collaboration

SBS Review
Jefferson Lab
17/02/21

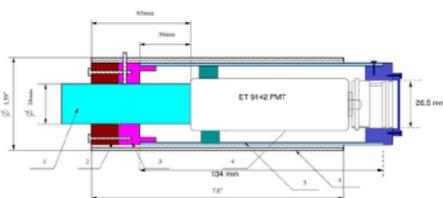




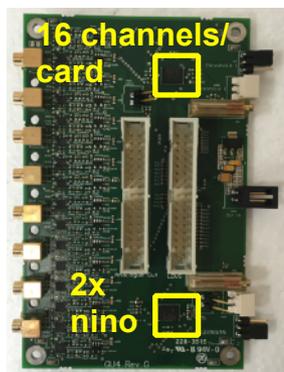
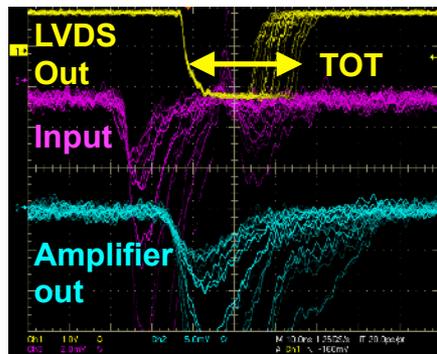
- Subsystem of BigBite
- Positioned between PS/SH
- 90 vertically stacked scintillator bars



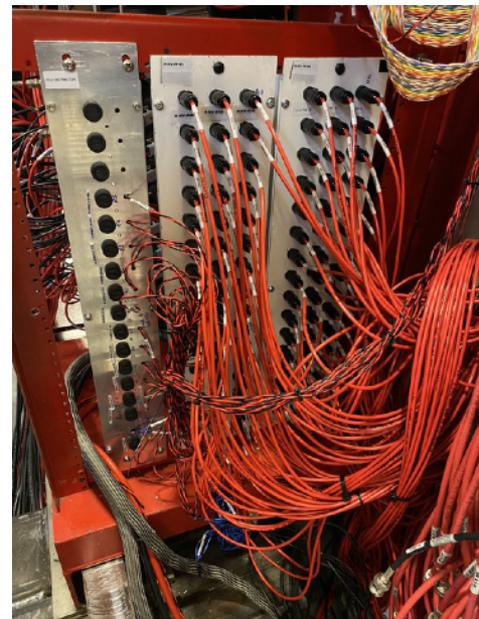
- **90 Scintillator bars**: Eljen Technologies EJ200 plastic, 600 x 25 x 25mm
- **180 Light guides (LG)**: Eljen Technologies UVT acrylic rods
- Dymax UV curable adhesive



- **180 PMTs**: Electron Tubes ET9124SB
- **180 custom bases**
- **180 PMT assemblies**: mu metal, Al housing, washer, base collar, light guide clamp, air inlet



- **180 1.5m co-ax**: PMT → FE
- **12 FE cards**: custom amplifier/discriminator cards based on NINO ASIC
- NINO → time-over-threshold (TOT) → rough amplitude info
- **180 LVDS to CAEN V1190A TDCs**
- **64 analogue to CAEN V792 QDCs (not for production running - commissioning only!)**



HV:

- 1 CAEN **SY1527LC mainframe**; 4 A1932A 48-chan HV distributors; 2 A1531 PSU
- **Individual channel control**
- 4 60m 52-chan **multiway cables** w/ braiding and 52-pin radial connectors
- 4 48-chan **distribution boxes** on BB frame
- 180 2m **cables** - distribution boxes to PMT

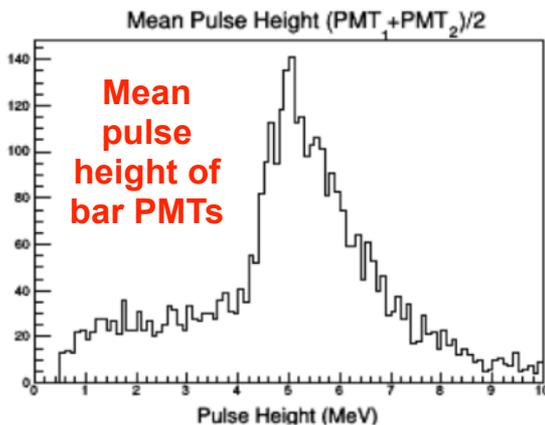
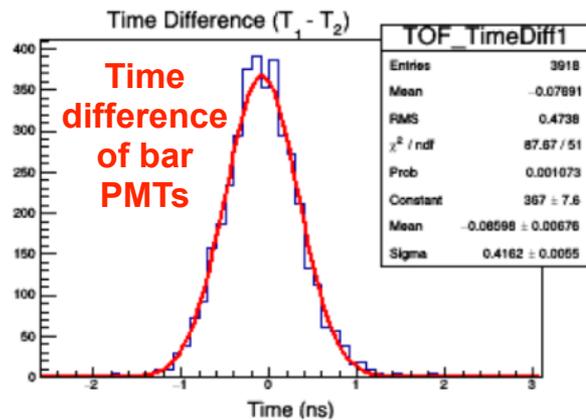
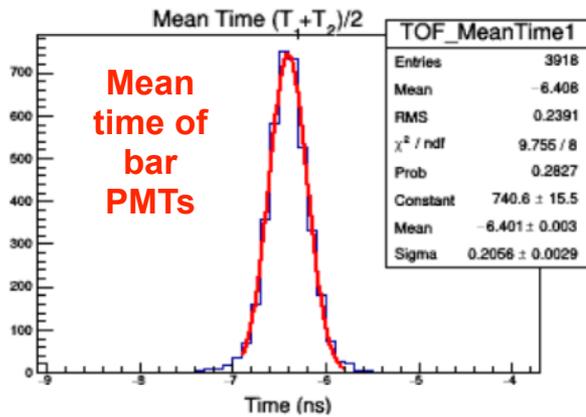
LV for NINO (likely to change, discuss later):

- 1 Agilent N5761A 19" 1U **PSU**
- 1 **distribution** panel on BB frame
- 1 **shielded pair** cables PSU to distribution panel (~10m)
- **Shielded pair** cables from panel to NINOs



Readout:

- 1 Wiener 6U VME 64x6023 crate
- 2 CAEN V1190A **multi-hit TDC**, 100ps, and Robinson-Nugent converters
- 2 V792 32 chan **QDC** - **only** for calibration and hardware de-bug



Purposes:

- High precision e' timing for 2-arm ($e, e'N$) measurements
- Coarse pulse height from TOT in TDC may help differentiate MIP from low energy background
- Hit position may assist high occupancy tracking

Specifications:

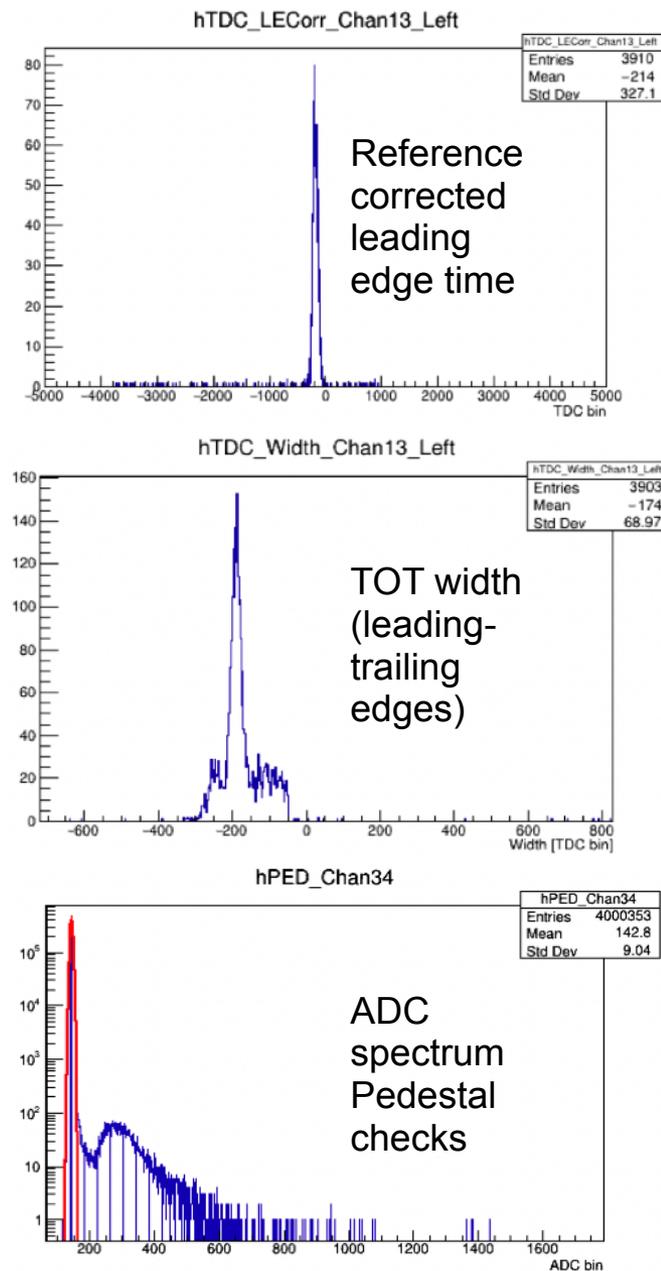
- Position independent timing from bar mean time.
Mean timing resolution $\sim 150\text{ps}$
- Bar time difference \rightarrow linearly correlated with position \rightarrow horizontal hit along bar. Time difference resolution $\sim 300\text{ps}$ \rightarrow 6cm position resolution
- Landau for MIP - peak well separated from noise
- High efficiency for MIP over all particle momenta analysed by BB
- Position dependence of PMT pulse heights should not exceed factor 2 and mean bar pulse height variation $\sim 11\%$ maximum along length of bar
- MHz operation capability for individual bars

- Reminder - by early 2020 majority of bars needed repair
- Summer 2020 meeting:
 - surface roughness tests at Glasgow, need for roughening
 - on-going repairs, design of bar support system, PMT assembly and mu metal changes at JLab by A Shahinyan, B. Wojtsekhowski, C. Long, W. Tireman
- **Since summer 2020:**
 - **repairs and final stacking** completed at JLab Jan 2021 (R. Marinaro, M. Satnik (W&M), B. Wojtsekhowski, C. Long)
 - **DAQ** set up at JLab (M. Jones, B. Moffit, A. Camsonne, R. Marinaro)
 - **start of detector commissioning with cosmics** Feb 2021

- Repairs for all bars:
 - bars & LG: cleaned in bath; roughened in jigs; glued in jigs
 - glue joint - only broke after soaking in alcohol bath and with ≥ 18 lbs
 - optical integrity - only $\sim 1\%$ loss relative to original smooth configuration
 - re-assembled PMT assemblies, attached to bars
 - re-wrapped bars; made light-tight; preliminary gain matched w/ oscilloscope
 - fitted support rods to each bar
 - re-stacked and re-cabled HV/LV
 - installed signal cables and patch panels from BB to weldment
 - checked electronics chains (HV, LV, NINO, signals)



Example raw distributions - still under study/preliminary



- DAQ running:
 - CODA3, ROC, PEB
 - 2 V792 ADCs (64 channel subset and commissioning only)
 - 2 V1190 multi-hit TDCs (all 180 channels)
 - Trigger from scintillator on top of array
- Data de-code and raw data analysis:
 - Modified SBSTimingHodoscope in SBS-Offline to decode raw data only
 - Modified V1190 and module classes in analyser hana_decode for leading/trailing edge TDC info
 - ROOT scripts for TDC and ADC viewing
 - reference corrected TDC, TOT, ADC pedestal fit/correction, signal fit
- Currently underway:
 - hardware de-bug (majority channels ok but some e.g. high pedestal widths and noisy TDC)
 - software developments
 - starting cosmics commissioning
- Next steps:
 - complete de-bug
 - ADC: all pedestals, NINO thresholds, calibrate TOT, gain matching
 - TDC: time walk correction

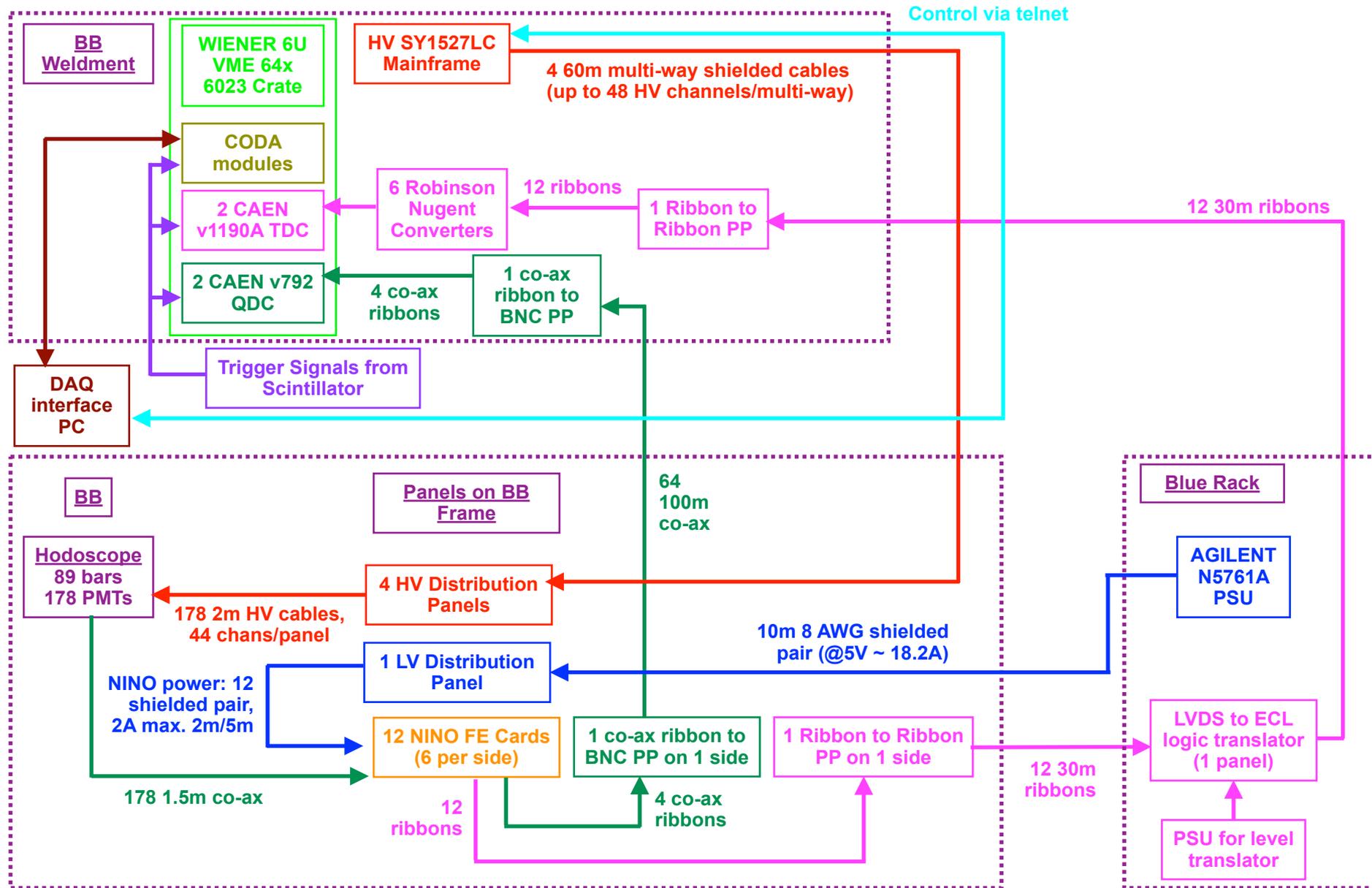
Status of Equipment 1/2

Item	Status
Detector Apparatus	
Scintillator bars/light guides	89 installed - missing 2 light guides for 90th (may have 2 curved in Glasgow, will check when access possible - would need repair)
PMTs, bases, PMT assemblies, mu metal	Installed
Front End	
12 NINO cards	Installed
Signal cables from PMTs to NINOs	Installed
Low Voltage for NINO (current set up in TEDf)	
AGILENT N5761A DC power supply	Installed
Low voltage cabling and distribution	Installed (10m shielded pair from power supply to BB, if using in Hall would need 1 longer and heavier gauge shielded pair)
Low Voltage NINO (proposed change for Hall)	
Power supply for NINO cards and distribution	Move to higher current power supply already procured for GRINCH and hodoscope NINOs. Share GRINCH distributor already on BB frame. For this, need longer shielded pairs to reach hodoscope and GRINCH NINO cards from distributor on both sides BB frame (to ensure correct voltages for all cards)

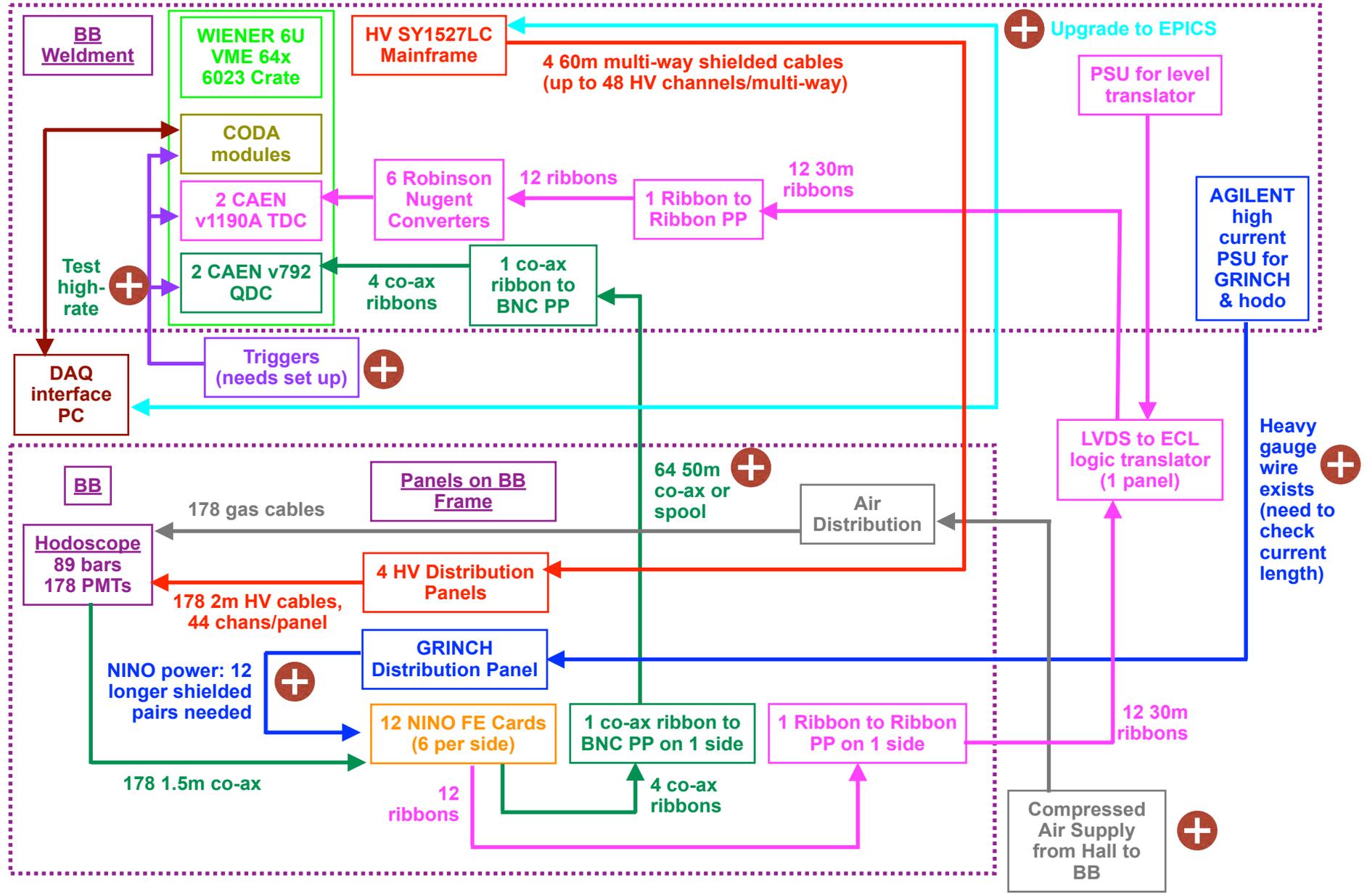
Status of Equipment 2/2

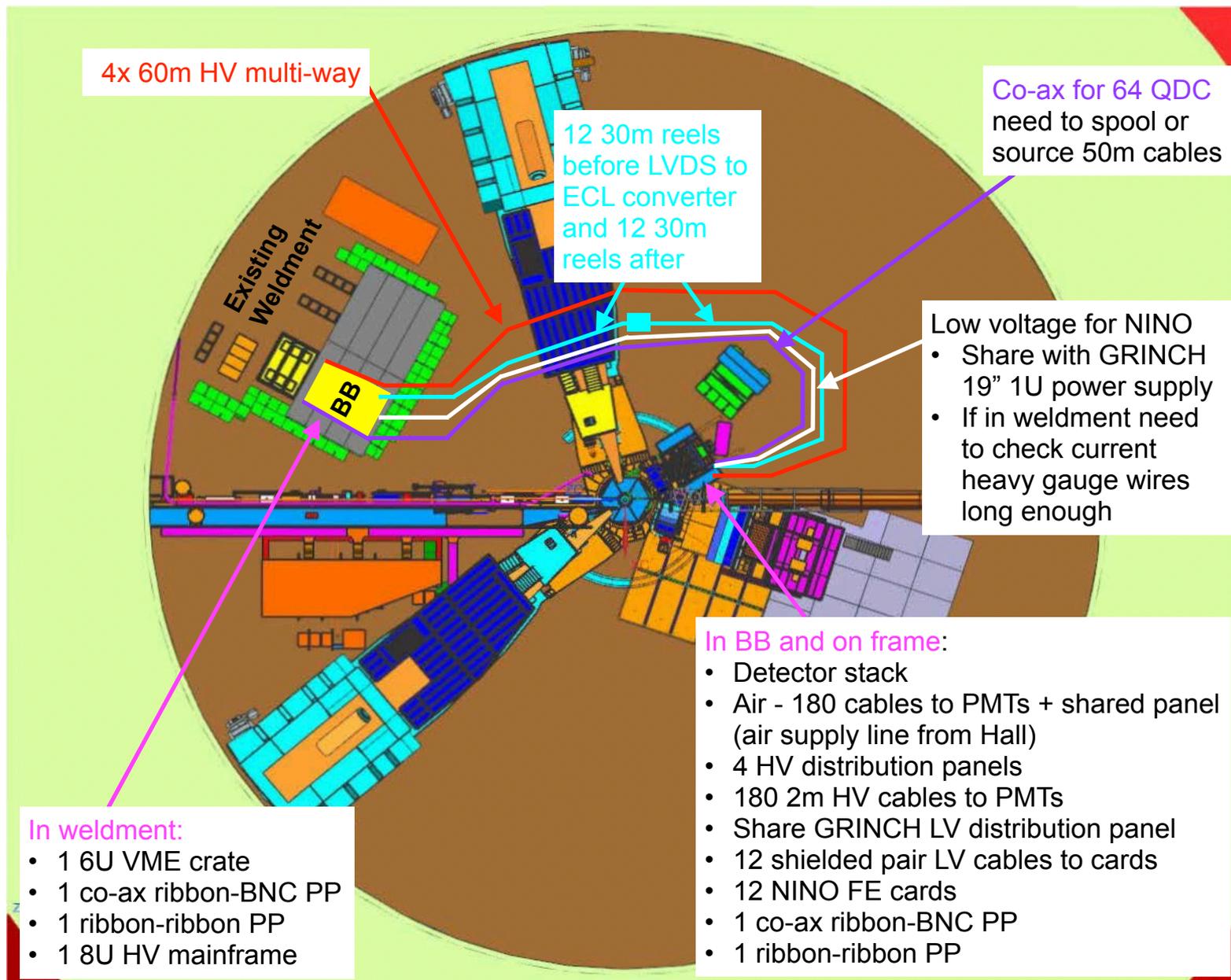
Item	Status
High Voltage	
CAEN SY1527LC mainframe ,2 A1531 primary PSU, 4 A1932AN HV distributors	Installed. Need to set up enhanced remote control (currently telnet and terminal via LAN with no logging of HV values)
Cabling and distribution	Installed
Signal Cabling and Patch Panels (PP)	
Cables/PP from NINO to QDC for 64 signals	Installed. Currently 100m co-ax from BB to weldment. Only need 50m. Source shorter cables or spool excess length (would need basket/space in existing basket)
Cables/PP from NINO to TDC for 180 signals	Installed. (Currently borrowing W&M power supply for logic translator, if possible continue borrowing or use Glasgow supply when move to shared high current supply for hodo/GRINCH)
VME readout and DAQ	
VME crate and readout modules	Installed
DAQ	Installed and running w/ CODA3. Need to test fast trigger and fast clear for V792 for commissioning in Hall (not production)
Compressed Air Flow	
Flushing PMTs with compressed air	To be done. Plans currently under way.

Current Equipment for Cosmic Testing (not to scale)



Changes needed for Hall (not to scale)



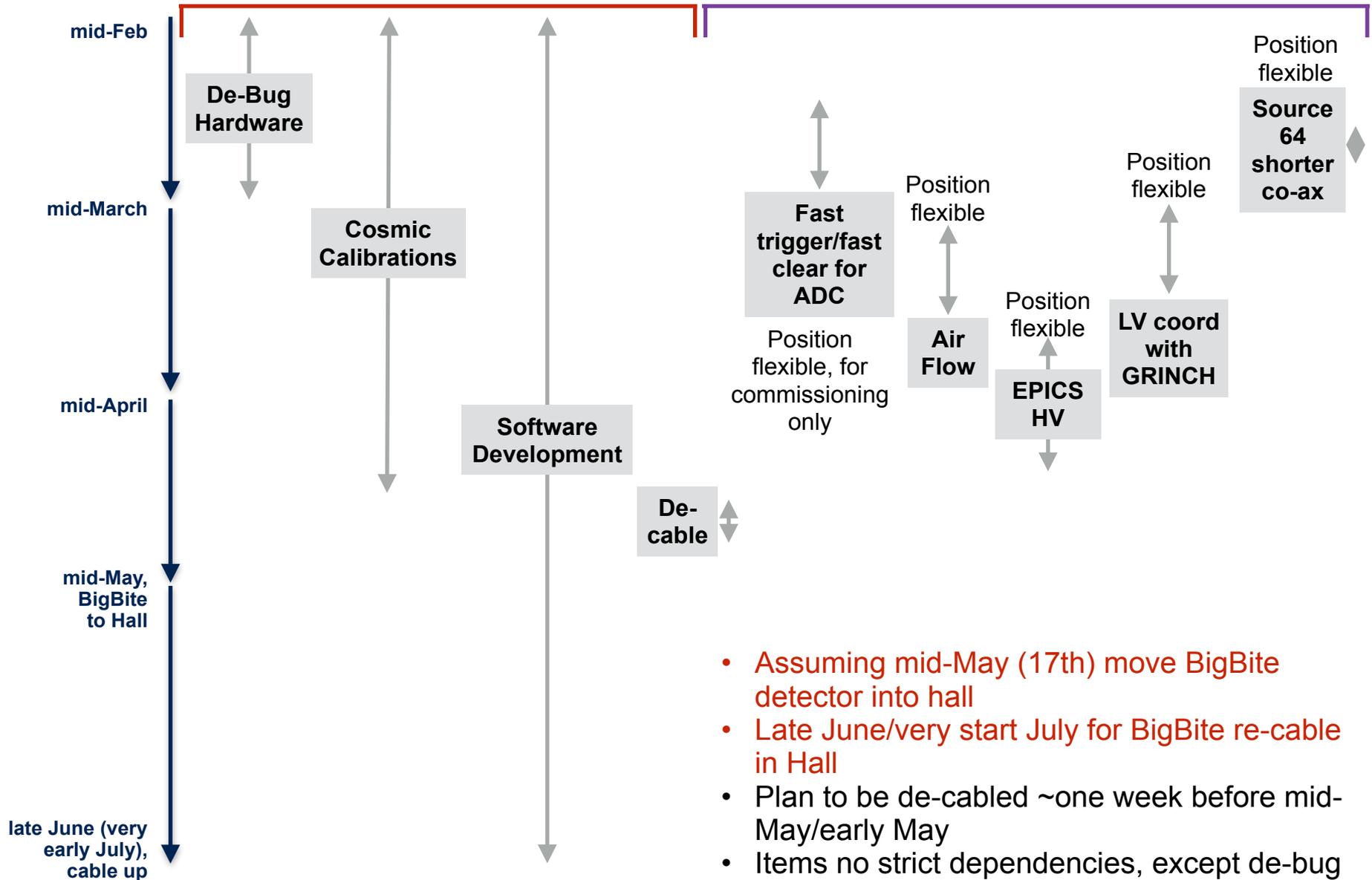


- Available from University of Glasgow and FTE fractions for hodoscope during GMn prep:
 - J. Annand (honorary), 0.1
 - A. Clarkson (technical support), 0.1
 - D. Hamilton (academic+research), 0.1
 - R. Marinaro (PhD), 1.0 (on-site)
 - R. Montgomery (research), 0.5
 - G. Penman (PhD), 0.2
- Everyone in UK except Ralph. Can travel when restrictions allow
- For GMn preparations support from staff/on-site users required/underway for (not FTE):
 - Set up fast trigger and fast clear for V792 (est 2 weeks)
 - Maximise rate capability of V792 for commissioning with low current beam
 - EPICS HV set up (est 3 weeks)
 - Remote control with logging of HV values and alarms
 - Co-ordinate with GRINCH low voltage set up (est 2 weeks)
 - Pressurised air install (similar need for other sub-systems with PMTs) (est 2 weeks)
 - Source 64 shorter (50m) co-ax for ADC or finalise basket space (est 1 day)

Plans for Move into Hall 1/4

General tasks underway

Shorter tasks needed for Hall set up



- Assuming mid-May (17th) move BigBite detector into hall
- Late June/very start July for BigBite re-cable in Hall
- Plan to be de-cabled ~one week before mid-May/early May
- Items no strict dependencies, except de-bug

- **De-bug hardware** (est time remaining 1 month, expect ready before move)
 - **underway** R. Marinaro (on-going local support from JLab BB staff (M. Jones, B. Wojtsekhowski etc) and remote as possible from Glasgow)
- **Cosmics calibration** (run until de-cable early May, expect ready for move)
 - **underway** by R. Marinaro (on-going local support from JLab BB staff, remote Glasgow)
 - Tasks for all channels:
 - pedestal check; check ADC signal; PMT gain matching; calibrating NINO TOT with ADC; NINO threshold; threshold studies (eg effect on TOT); TDC time walk correction calibration by TOT; mean time/time difference resolutions; coarse hit position reconstruction
 - (if access to ^{90}Sr source and safe mounting possible could do above easier/faster)
- **Software** for commissioning/shifts (est time remaining 4 months, expect ready for Hall cabling)
 - **underway** by R. Marinaro, R. Montgomery, D. Hamilton
 - working on building up SBSTimingHodoscope in SBS-Offline again
 - in addition to developing calibration software above, have to make shift-ready versions
- **Test fast trigger and fast clear for V792 ADC** (est time 2 weeks, expect ready for move)
 - A. Camsonne planning this. Can be done in parallel
 - Only for commissioning in Hall with beam, not production
 - Expect should work. If not backup is possible use of spare FastBus ADC (or FADC)

- **Set up shared LV with GRINCH (est time required 2 weeks, expect ready before move)**
 - **Underway.** High current supply procured by D. Higinbotham, T. Averett. Heavy gauge cables from supply to GRINCH distribution prepared (C. Long) - need to check length ok
 - Will need support for installation on BB (12 new shielded pairs from GRINCH distribution panel on frame to hodo cards)
- **Slow control for HV (est time required few weeks, expect ready before move)**
 - Can be prepared in parallel at any point, M. Jones planning this
 - EPICS libraries for HV exist in CLAS12/Hall B, need to install and test
- **Source & install 64 shorter co-ax for ADC (est time 1 day, expect possible before move)**
 - Need support on-site; can be done at any point
 - Otherwise require basket space reserved to spool excess length in Hall
- **Set up compressed air flow (est time required 2 weeks, expect ready before move)**
 - **Underway.** Common amongst systems with PMT. A. Shahinyan designing distribution suitable for BigBite sub-systems (hodo/PS/SH) and discussing parts with C. Long (based on A. Shahinyan's design for 2006 GEn experiment). Similar design should be ok for HCal.
 - Glasgow can help as required remotely (e.g. any CAD, ordering parts)

Equipment does not need moved in certain sequence

All cables should be removed first and stored safely for move (est time 1 week, plan completion early May to be ready before 17 May BB move)

- R. Marinaro on-site

Current idea:

- piggy-back on PS/SH plan for cable storage location during transport start June?
- see A. Tadepalli slides for details of their plan after discussion with J. Butler
- 64 long co-ax, 24 long ribbons (plus some shorter) plus 180 2m HV
- **Exception/particular care needed for HV multi-ways**
 - Stored on large wooden cable spools
 - Connectors delicate
 - Would be best if possible to reserve space on BB weldment (in crate?) during transit
 - Need to confirm



- Re-cabling signals and HV/LV electronics set up, including HV remote control, and compressed air connection
- **Set up cosmic trigger and DAQ**
- After equipment start-up:
 - **Re-check cosmic calibrations for all channels**
- Calibration procedure/software will be established from current running for:
 - Gain matching (ADC)
 - TOT calibration (ADC plus TDC)
 - NINO threshold setting (ADC)
 - Time walk correction calibration (TDC)
- For any step requiring ADC, plan is to cycle through 180 channels in subsets of 64 channels at a time, i.e. 3 data runs for one complete cycle
- Set up **trigger** for beam studies

Plans for Commissioning with beam

- With-beam runs required to **optimise TDC window width and position wrt trigger**
- **TDC calibration** could be desirable (although not essential)
 - correlate hodoscope hits with microstructure of CEBAF beam buckets (500MHz)
- With-beam calibrations:
 - Cross-check **NINO threshold** settings (ADC)
 - Cross-check **TOT calibrations** (ADC plus TDC)
 - Optimise **time-walk** correction parameters (need TDC only)
- NINO threshold and TOT calibrations will be checked for 64 channels only, to avoid Hall accesses (essential to cycle through all channels w/ cosmics before and inside Hall)
- (If time permits, g4sbs simulations before move to Hall could help anticipate any expected threshold differences in NINO threshold w/ cosmics vs e')
- **Ideal if runs for calibrations performed at relatively low e⁻ beam intensity**
 - **Any other requirements flexible (e.g. energy/reaction/sieve slits/triggers)**

Software

- Calibration/online monitoring/event display can be developed by Glasgow
- Input/advice from staff/collaboration remains essential (esp final integration in SBS-Offline)
- Many routines have been used in prototyping/sim files - need to adapt for new framework
- Current planned online data quality monitoring plots:
 - 180 channels
 - Leading edge (LE) TDC spectra (reference time and time walk corrected)
 - TOT
 - TOT vs corrected LE time
 - 90 bars
 - Mean time
 - Time difference
 - Reconstructed hit position in hodoscope local co-ordinates
- Additional calibration plots (for all channels, achieved by iterating in 64 channel sub-sets):
 - ADC spectra (for pedestals/NINO threshold setting)
 - Pedestal corrected ADC spectra
 - TOT against ADC

Dependence on other detectors

- Would be useful to correlate hodoscope hits with particle tracks from BB GEM, PS/SH

- University of Glasgow can prepare documentation
- Existing documents on wiki (<https://hallaweb.jlab.org/wiki/index.php/Docs>)
 - Technical specs; software requirements; electronics design; roughening report
 - How to & mapping for HV and LV with cosmics
 - Manuals for equipment
- “Live” info about operating test stand & performing cosmic analysis on wiki
- “Live” mapping of cosmics HV/LV/signals, status of runs, channel integrities during de-bug stage exists on shared drive from R. Marinaro for those working on cosmic stand

Underway:

- Detailed final set up description and cable mapping document
 - currently in preparation (G. Penman), will upload to DocDB

To-Do:

- “**how-to’s**” rely on procedures being (near) final. Once these are set, they will be written for (at least) the following and uploaded to DocDB:
 - HV with EPICS slow control
 - LV could be shared with GRINCH for Hall config
 - Online analysis and event displays
- Main points of **safety** for Hall will be standard risks with HV, LV, compressed air flow
 - Can start to write up but need direction/guidance for template/procedure and contacts

- Significant efforts over past year on repair of all bar elements and stacking/cabling
- DAQ for cosmics set up
- Detector checks, signal understanding underway and progressing
- Majority of channels look good, but once any existing noise etc resolved will move through calibration steps/tasks more strategically for all channels
- Software developments underway
- Documentation underway
- Should meet time frame before move to Hall