MSU Electronics for LArIAT

Carl Bromberg
Michigan State University

LArTPC electronics at MSU

Excellent Electronics Engineering at MSU – improving signal/noise at each stage below

Dan Edmunds

Bo – Warm amplifiers 3planes, 96 channels – tracks immediately (wire to disk)
Bo – Warm amplifiers 3planes, 144 channels – new feedthru, bias C/R in LAr
ArgoNeuT – Warm amplifiers, grid + 2 planes, 480 channels – bias C/R in LAr
Bo – COLD CMOS Hybrid amplifiers 3planes, 144 channels, Warm Receiver/Driver
Next step would be ASIC …

Dan Edmunds & Dean Shooltz

LAPD – Reconfigured COLD CMOS (LongBo 2m drift) + 1 prototype 16 ch. BNL ASIC

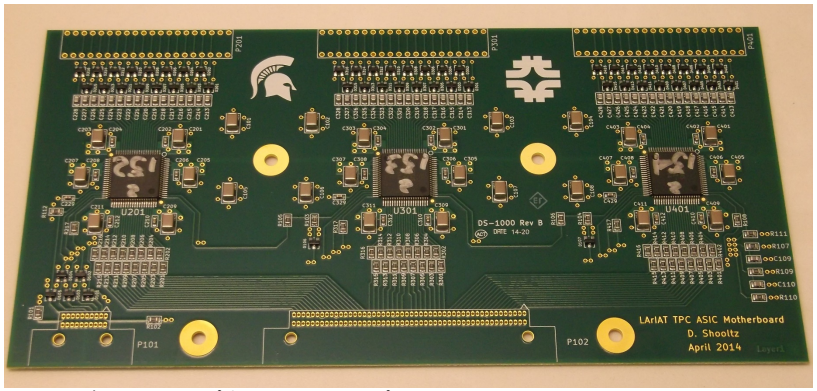
Dean Shooltz

LArIAT (ArgoNeuT TPC) Not feasible to reuse ArgoNeuT electronics (but cables OK)
- FNAL Neutrino Dept. arranged BNL FE ASIC (50 uBoone spares) for us
- 10 Cold Mother Boards (CMB), 3 ASICs/CMB, circuit layout similar to uBoone
- New feedthru – ASIC digital cont. + power + test pulse, ASIC analog out
- New Warm Receiver Driver card + Digital control + test pulse driver
- CAEN ADC – single ended input – D2S (differential to single ended) cards/crate
- Runs 1 & 2, now Run 3 in progress, all 480 ch. electronics operational

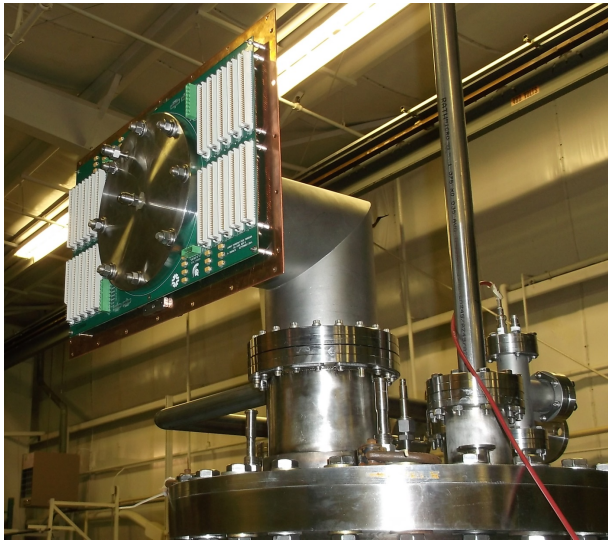
LArIAT Electronics

Cold Motherboard (48 ch)

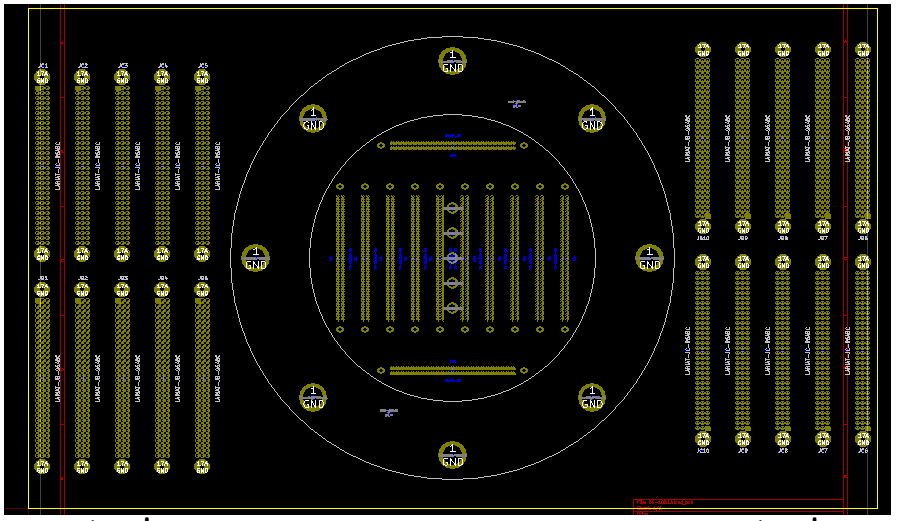
PC board connectors to wire planes



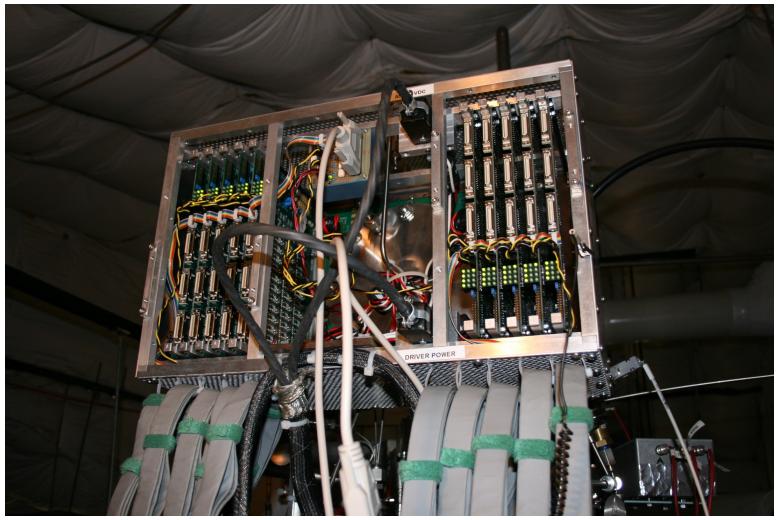
Power/Control* Analog Out



Digital/Test **Feedthru** Digital/Test



Analog Analog



Performance & Issues

Run I

Light System – coherent noise leaks – Shielding improved (got it <10% of stochastic noise)
WRD – cable driver chip (uBoone) w/low-pass filter had MHz oscillations, remove C
Grid Plane – Induction plane shadows. No Q-capacitor (ArgoNeuT missed it – Why? S/N !)
PMTs – neg. HV on photocathode near collection plane wires, so major signal distortions
ASIC serial data corruption – lowered impedance & reload each spill, acoustic wire motion

Most REPAIRED (or mitigated) by Run II

Run II

Beam Track Signal (~100 ADC counts = 50 mV) Very Low Noise (~1.4 counts = 0.7 mV)
Convert noise to electrons:

ASIC buffers off, we find 25mV/fC, 2us filter setting, yields 18 mV/fC
ASIC output -> CAEN ADC input = 0.91 (18mV/fC) = 16.4 mV/fC @ CAEN
0.7 mV: ENC = 270 electrons (reasonable for 0.5m wires +board capacitances)

Convert Beam track ionization to electrons: Basics (25 eV/ion, 2.2 MeV/cm, 1.4fC/mm)

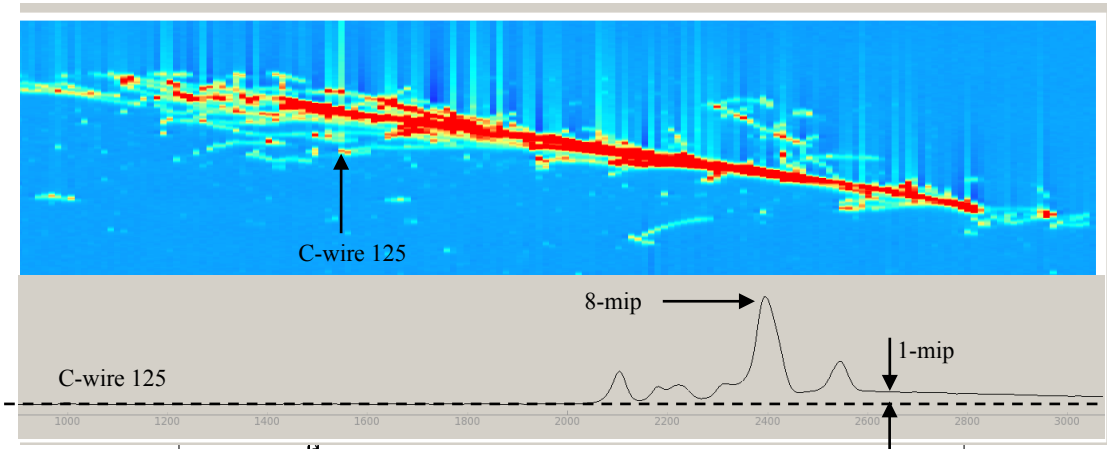
Drift field 500V/cm, tracks have 68% free ionization, 0.95fC/mm
Expected Signal = 0.95fC/mm * 4.6mm = 4.4fC , without attenuation
Beam tracks 50mV/16.4 mV/fC =3fC (0.5 ms electron lifetime?)

Run III In progress – 5mm then 3mm pitch should see signal and noise.

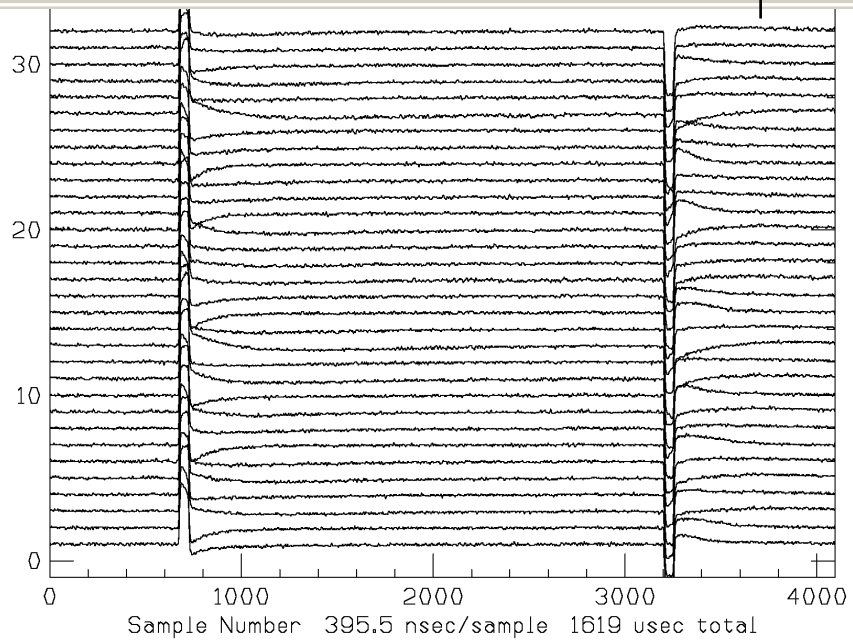
Due to excellent S/N, we found a major problem with cold FE ASIC chip.

FE-ASIC - baseline restoration problem

What are these streaks? Same FE ASIC as uBoone *did not see it initially*, and 35-ton



MSU Bench tests cold
Baseline problem has both signs and differs chip to chip!



BNL tracked this down and reports that increased transistor size in the ASIC pole-zero circuitry, has considerably reduced this baseline effect.

MSU enabling cold ASIC/FEMB testing (DUNE/SBN)

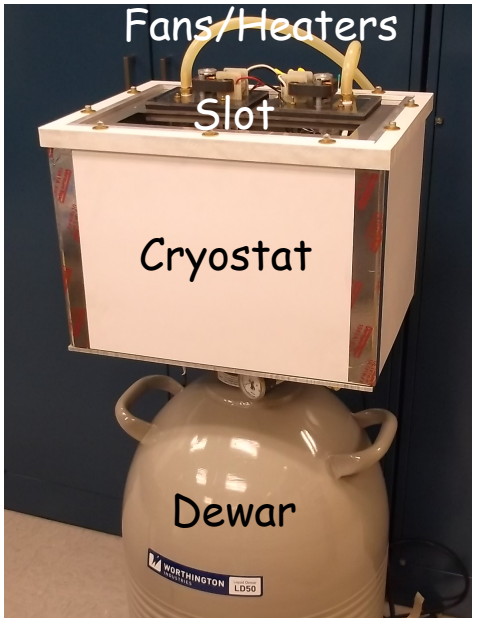
Cold Testing of 4 ASIC chips and/or full FEMBs

Avoid condensation at all costs (air carries dirt & contaminants).
Seal and purge with GN2
Slow (but not too slow) cool down to 77K to avoid thermal shock
Immerse in LN2 for full functionality testing
Remove from LN2 and slow (but not too slow) warm up while purging with GN2

Dean Shooltz Implementation

MSU providing 2 (perhaps 4) stations to BNL this month for such testing.

1) LN2 Dewar (below) filled once per day ~ 1 liter/cycle .
2) Electronics package lowered into slot and sealed in Cryostat
3) Purge cryostat with Dewar boil-off, with heaters & fans
4) Boil off valve closed, Dewar heated & LN2 rises into cryostat
5) Valve maintains LN2 below electronics while fans cool it
6) LN2 level raised to cover electronics – cold testing now
7) Valve opens allowing LN2 to drain back to Dewar
8) Heaters and Fans raise temperature while GN2 purging



Cycle takes ~15 minutes. **up to 16ASIC/hour/station**
up to 4 FEMB/hour/station

Want one?