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## Liquid Argon TPC electronics development at MSU

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Work of  
Dan Edmunds - MSU engineer/hardware design  
Philippe Laurens - MSU engineer/DAQ software

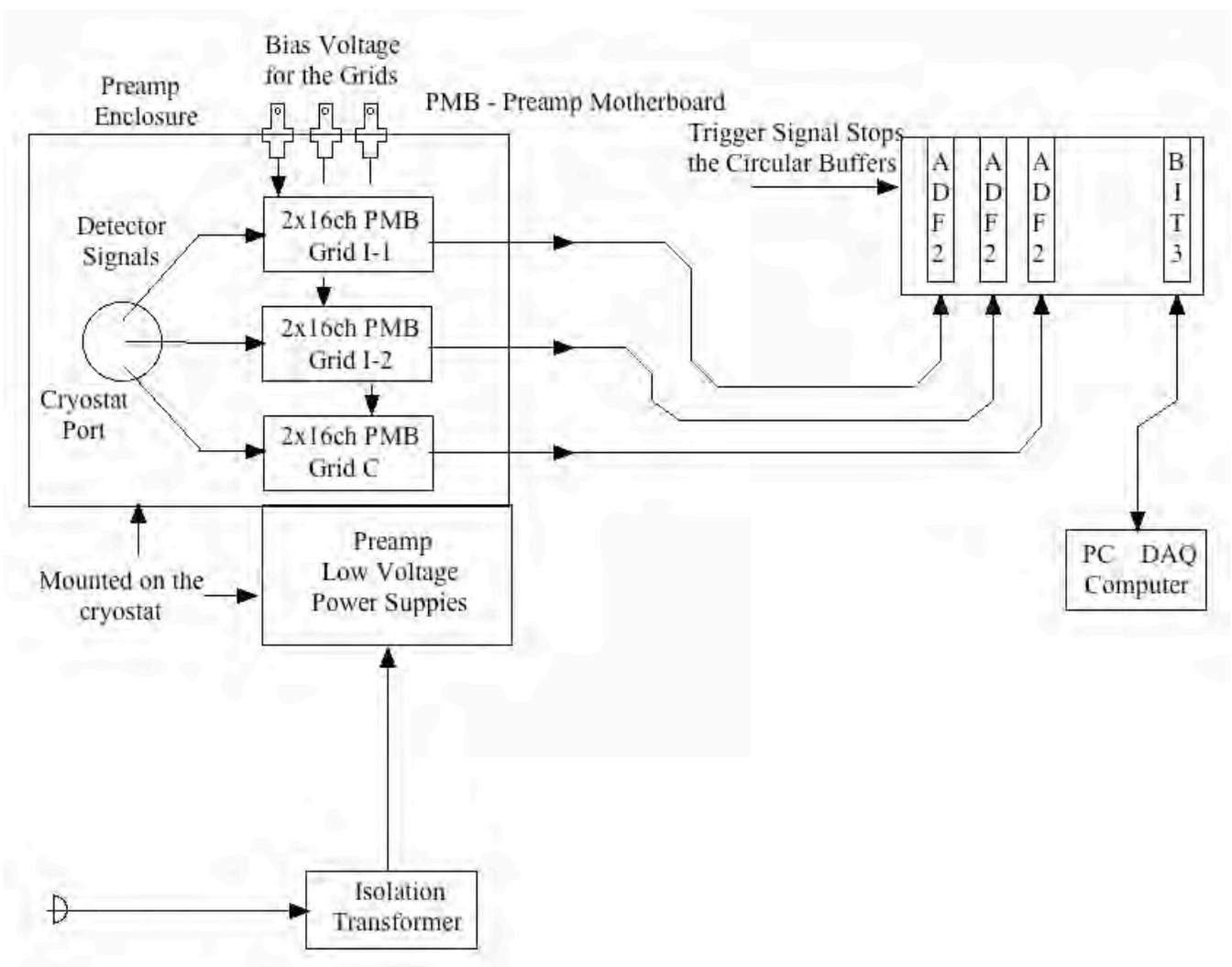
Carl Bromberg  
Michigan State University

## Program and Status

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- Goal is to develop DAQ electronics for a 15-50 kTon LArTPC
  - Careful study of ICARUS (2 x 300 Ton) electronics
    - Conclude that multiple FET front ends are unbeatable (warm)
    - ICARUS 10 year-old electronics design is obsolete and unavailable
    - Commercial electronics suppliers (e.g. CAEN) can be problematic
  - Develop an independent capability using modern components
    - Testing Run II D0 hybrid preamplifiers (not in use, many available)
    - MSU designed ADC-FPGA for Run II D0 trigger (2nd level spares)
    - Single channel tests with simulated signals - intrinsic noise under control
  - Made prototype preamp motherboards for a 96 channel TPC
  - Mounting a system on a cryostat in PAB for noise evaluation
  - Install TPC: See cosmic muon tracks in Argon before Spring 2007.
  - Afterward investigate COLD electronics: preamps, etc.
- A simple system (< 500 channels) for T962 should be feasible

# LArTPC DAQ hardware



# Hybrid preamplifier

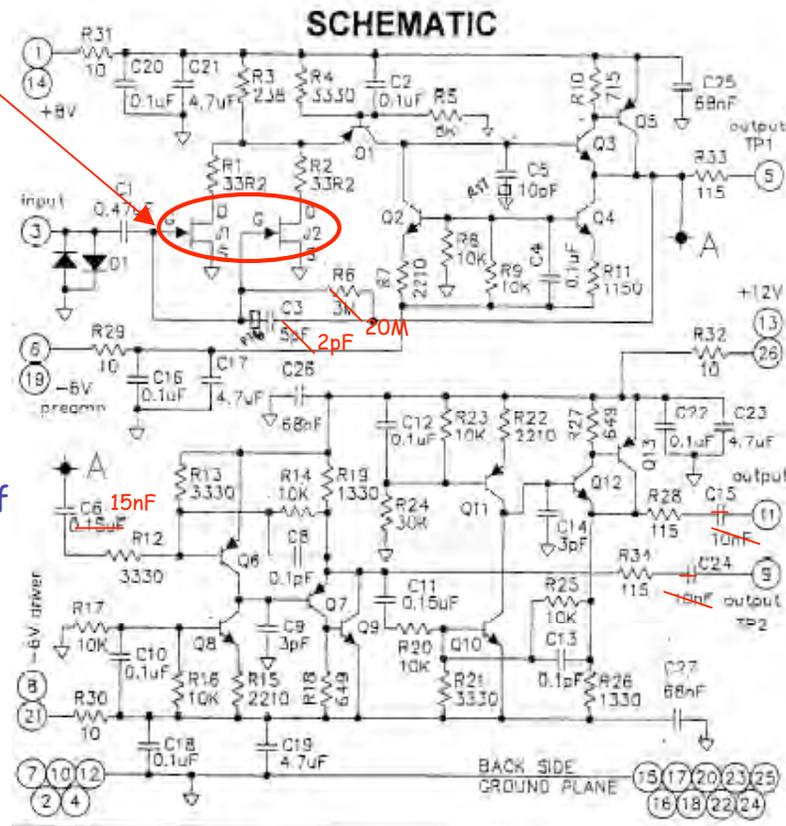
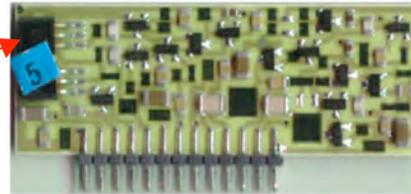
D-zero Run-II  
LAr preamp

Dual FET  
input stage

## Modifications

Increase gain to 0.5 mV/fC  
Increase RC to 40  $\mu$ s  
Note: Signals are  $\sim 3 \mu$ s

Will improve  
low freq. cut-off

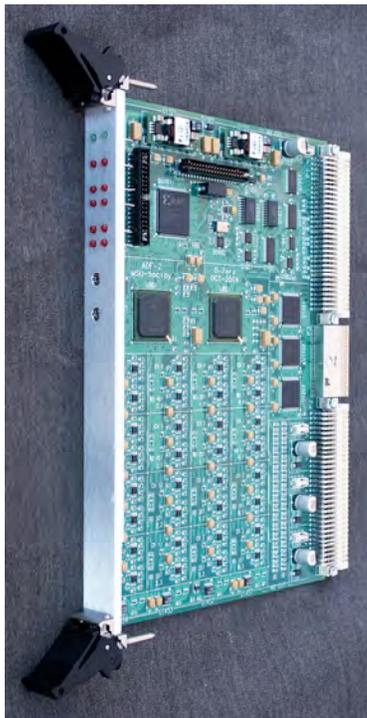


Output

Blocking now on preamp  
motherboard (PAB)

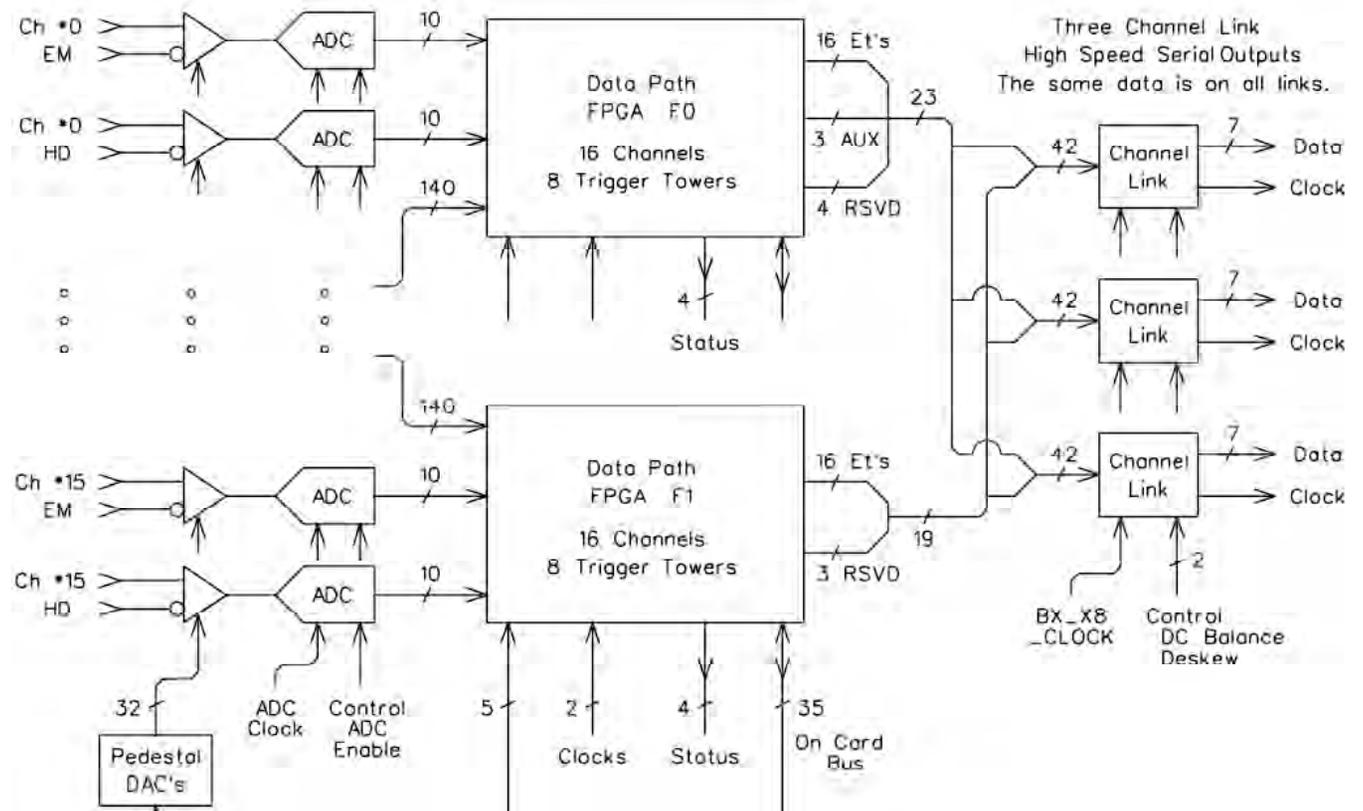
# Analog to digital conversion

D-zero Run-II  
ADF-2 card



FPGA data storage  
field programmable

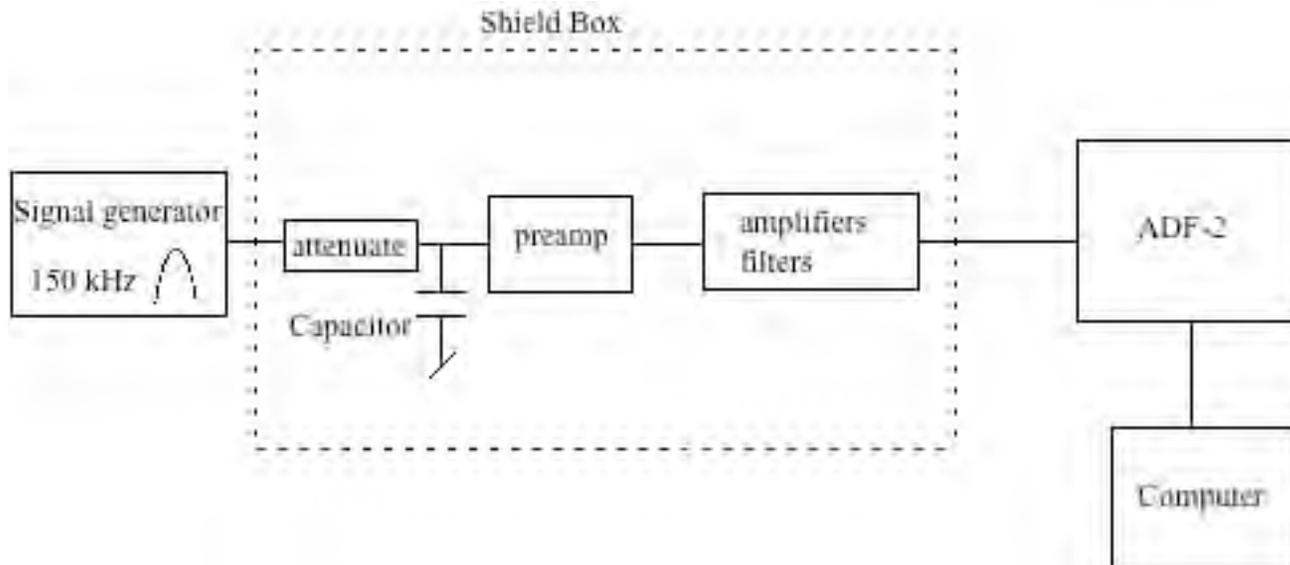
Example: 2048 samples  
@ 5 MHz (400  $\mu$ s total)



Designed and built at MSU by Dan Edmunds

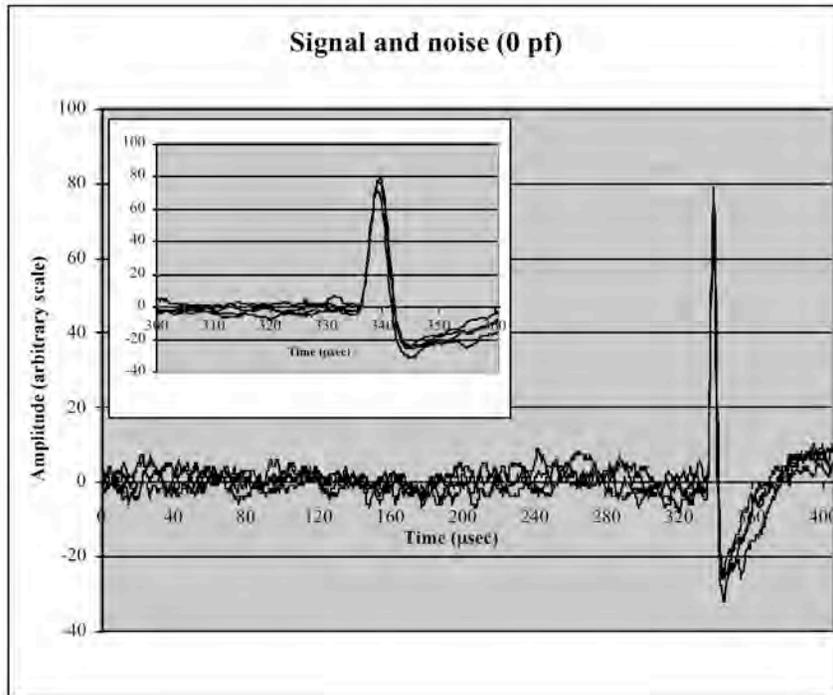
# Single Channel Test

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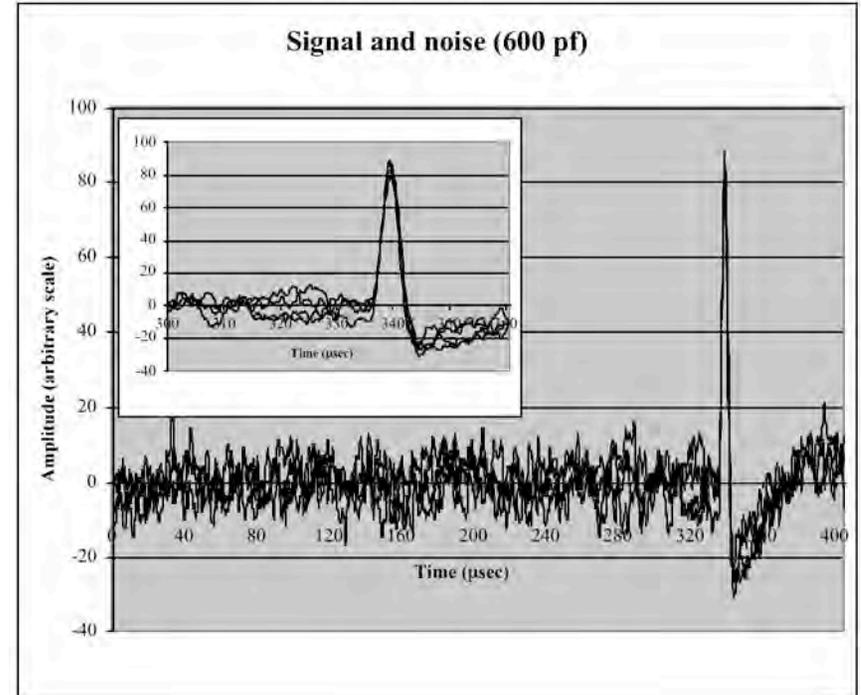


# 22,000 electron signal

Capacitance 0-pf



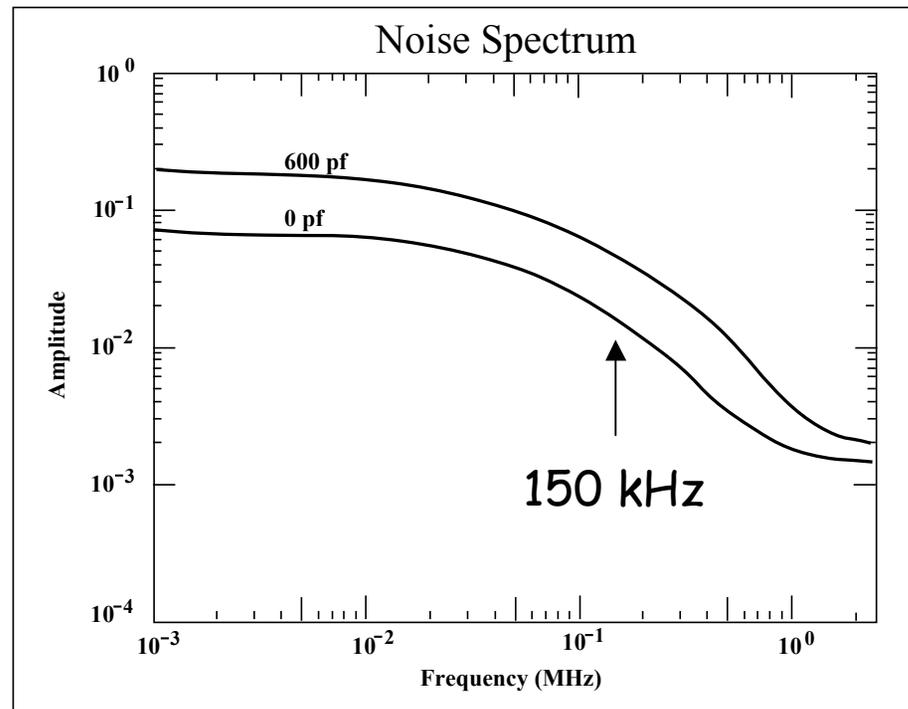
Capacitance 600-pf



Signal to noise can be estimated from these plots

# Noise spectrum

Noise relative to 22,000 electron signal



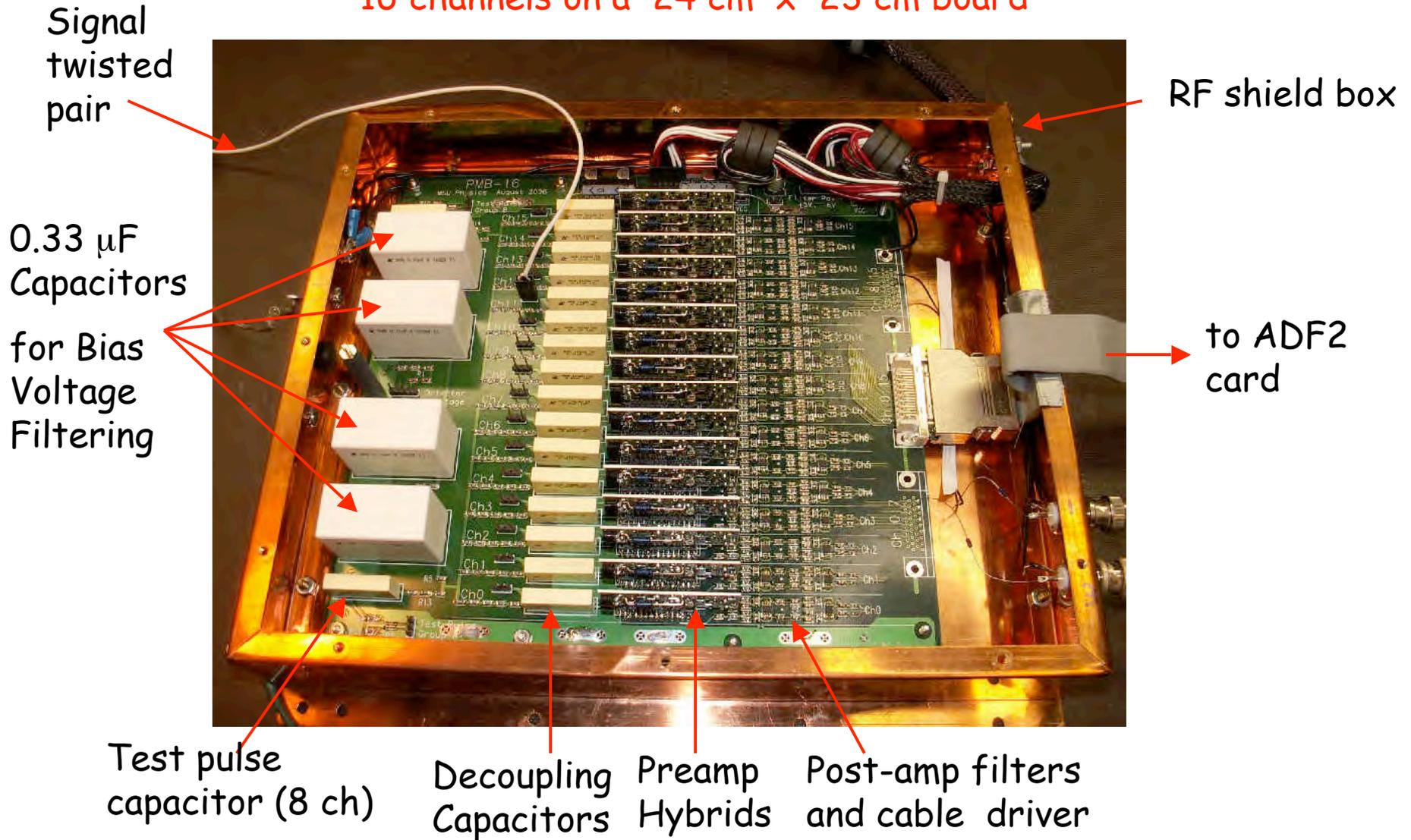
High pass & low pass filters are **not optimized**

Conclude that noise in these preamps is low enough for now.

Build a small system (~100 channels) based on these components

# Preamp Motherboard (PMB)

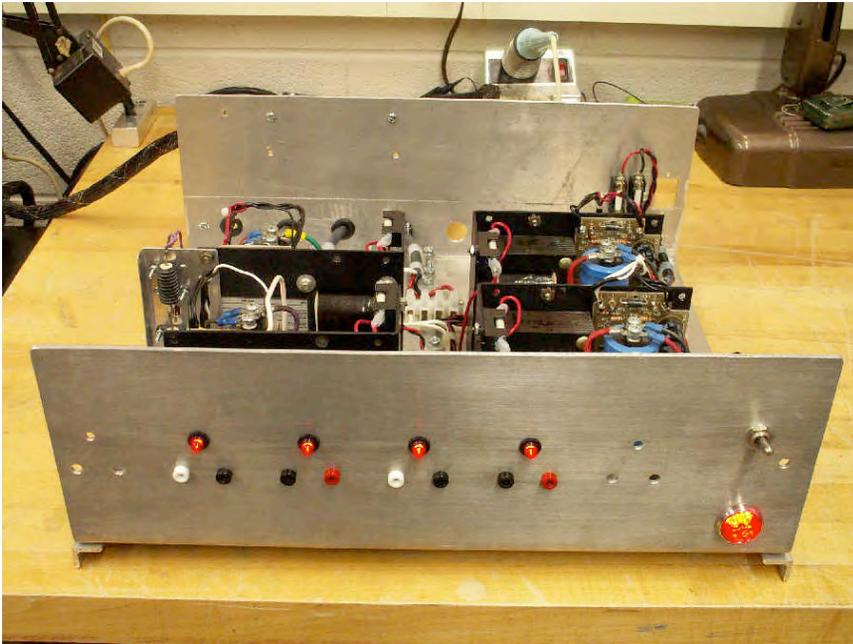
16 channels on a 24 cm x 23 cm board



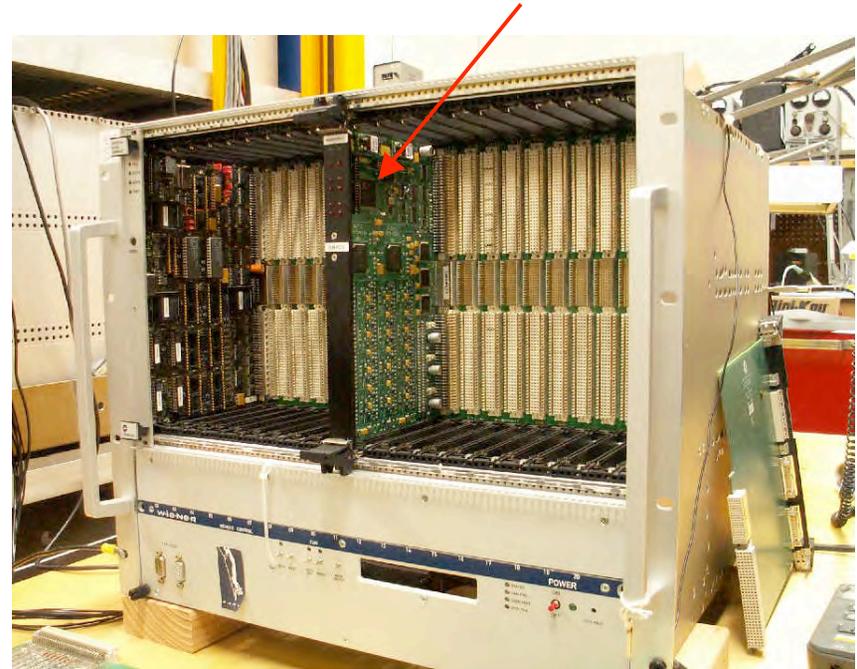
## Other hardware

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Preamp Power Supply



VME Crate with ADF2 card



# Documentation

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See - <http://www.pa.msu.edu/~edmunds/LArTPC/>

- Hardware is documented
  - Determine state-of-the-art in front end electronics
  - Tests of D0 preamplifier hybrids
  - Preamplifier modifications to optimize for LArTPC
  - Preamp motherboards <--> ADF2 channel mappings
  - Grounding and shielding principles employed
  - Much more
- Other reports available on <http://lartpc-docdb.fnal.gov/>
- DAQ software is ready for tests in PAB
  - Run Control
  - Raw data displays
  - Simple data format (ascii files)
  - Event selector - data plotting

## T962

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- Until tracks are seen and understood in PAB tests, there won't be time to invest in specifics for T962 electronics.
- The general principles of the design can be extracted nearly verbatim from existing documentation
- Dan has stated that there are LOTS of hybrids and sufficient ADF2 modules for < 500 channels, however, PAB tests may suggest modifications to improve performance.
- Dan must have **CZAR status** when it comes to anything connected to a region defined as electronics - DAQ.
- **Dan & Philippe are NOT free.** D0 has paid for MSU electronics engineering services (design and operations) since the mid 80's. LArTPC R&D has only recently obtained a fraction of these services.
- Dan Edmunds is held in the highest regard by FNAL both at Dzero and in LArTPC