MDT System Performance Measurements

MDT Electronics PDR
February 22, 2001
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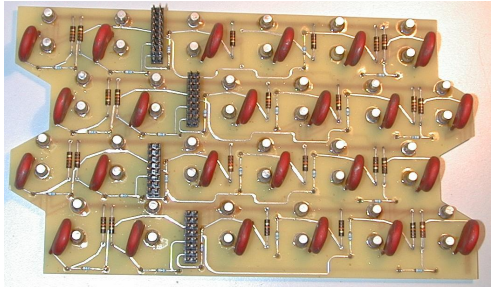
- Architecture for 10k−Channel Test
- Performance Measurements
  - HV Leakage Current
  - Noise Levels
  - Time Resolution
  - Cosmic Rays

MDT Electronics Prototypes
The 10k−Channel Test

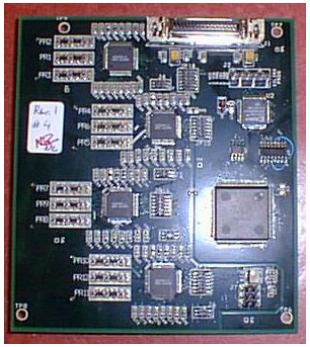
- Vertical slice of 10k−channel electronics
  - HV and Signal Hedgehog cards
  - ASD Mezzanine cards − Lite version (3x8 and 4x6 geometries)
  - CSM−0
- Goal:
  - Proof of principle with electronics close to final version
  - Test chamber production
- Status
  - Most Hedgehog cards produced
  - 25% of ASD Mezzanine cards produced
  - CSM−0 produced
  - Undergoing on−chamber tests on EIL1 Module−0

Prototype Electronics

Hedgehog Boards



Mezzanine Card



CSM−0

Final Electronics

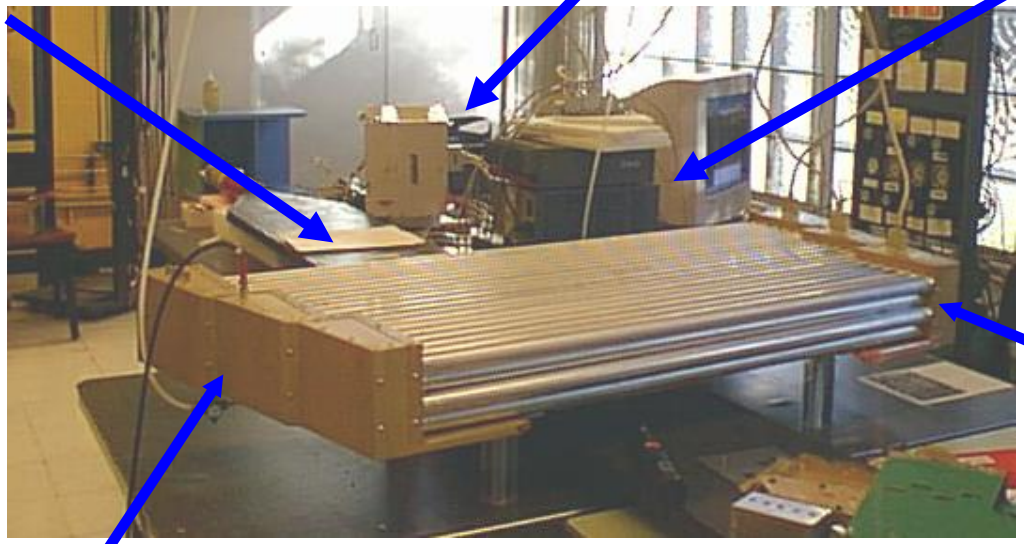
- Similar layout
- Different capacitors

- Octal ASD chip similar to Lite version
  - 8−channels per chip
  - Programmable
  - Bipolar (high rate) shaping
  - Wilkinson
- AMT−2 chip similar to AMT−1
  - Lower power
  - JTAG control

- Similar functionality
  - No event building
  - Clock from TTC
- On−chamber with new connector scheme
- Communicates upstream by optical fiber

Electronics Prototype Chamber

- Electronics was extensively tested during development on a small MDT chamber prototype (EIL1)



- 72 tubes
- 3 steps
- 4x6 geometry

- The integration test results shown are from this chamber and Module−0

BMC Module−0 Chamber

EIL1 Mod−0

Early FC prototype

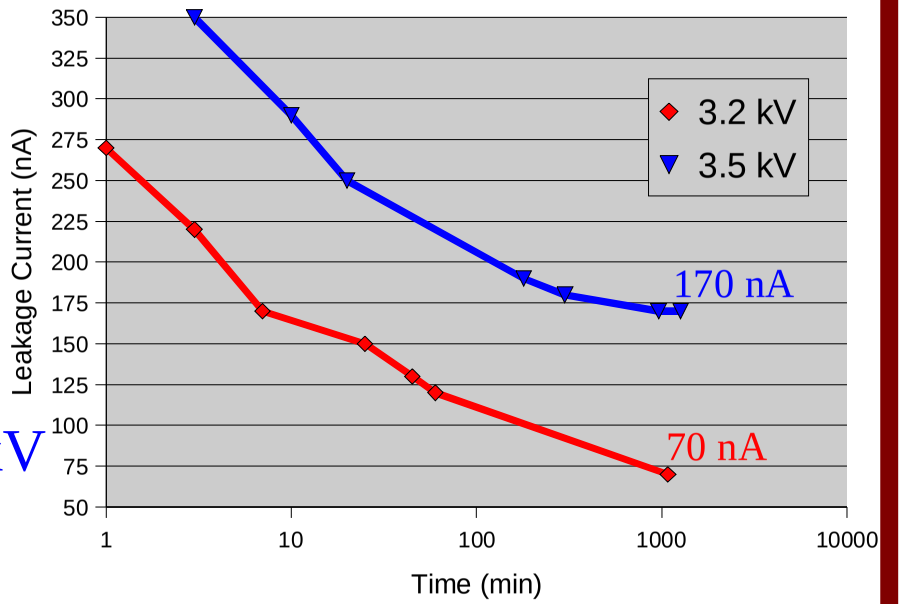
- 4x6 geometry
- 12 Mezzanine cards
- 288 channels

HV performance

Chamber with:

12 HV Hedgehog cards

12 Signal Hedgehog cards



Leakage current better than specifications (5 nA)

$I_{leak} <$ 3.0 nA per Hedgehog card @ 3.2 kV

(neglecting leakage current in the tubes)

Module−0 Readout side

Connectors

Kapton tape for electrical isolation

12 Mezzanine cards mounted

FC holes for connectors

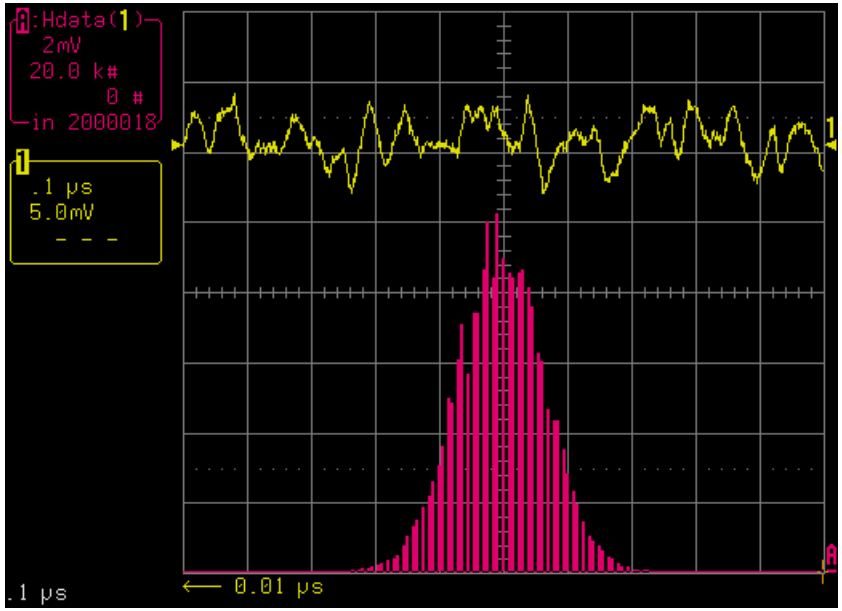
Thick metal braids connecting all metal parts of the chamber

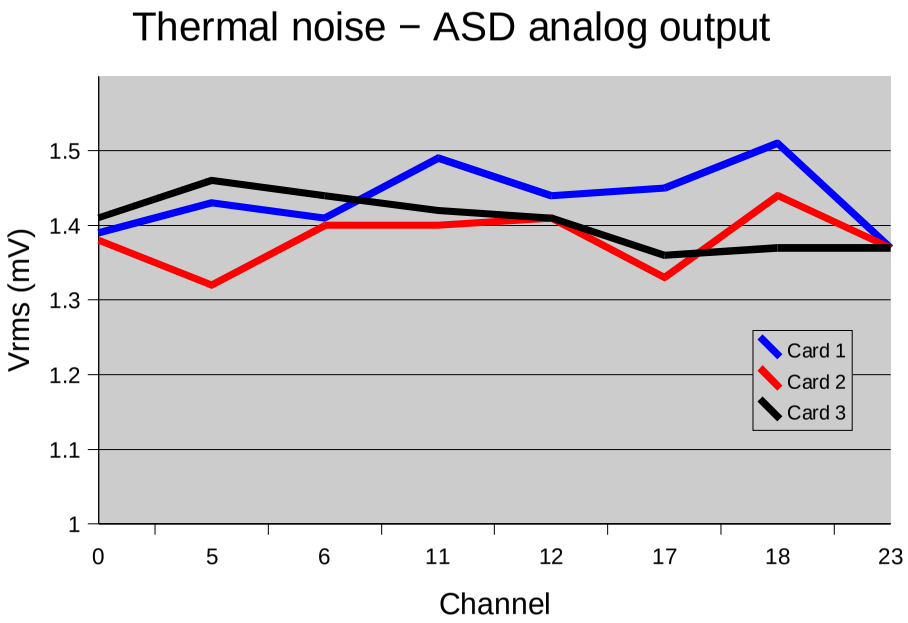
Twist/flat cable

- Unshielded Twist/flat cable radiates (40 Mhz) => used instead shielded printer cables

Thermal Noise

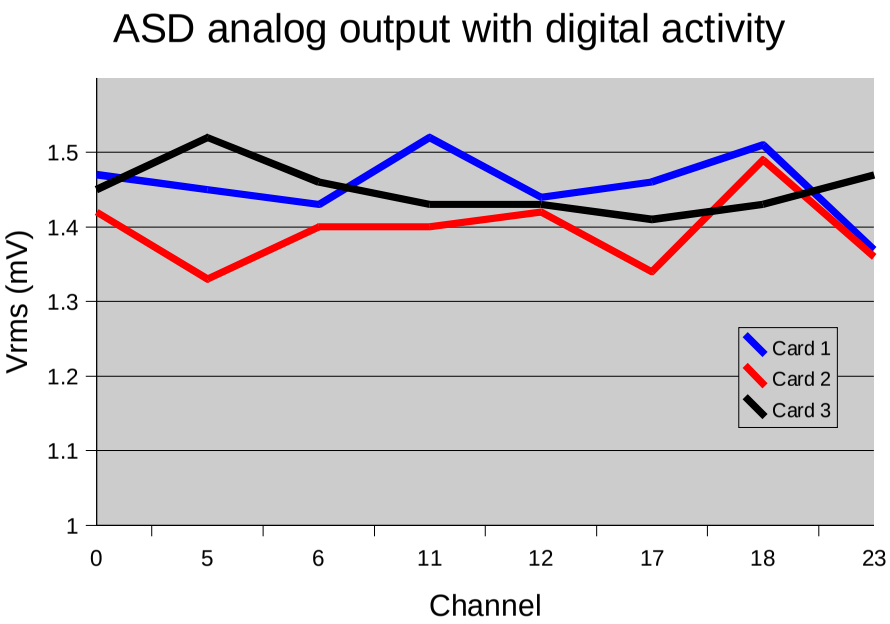
- Thermal noise ~ 6000 e^- rms ~ 4 p.e. ~ 1 fC ~ V_{rms} = 1.5 mV(through pad driver) (8:1 attenuation)
- On−chamber measurement
  - ASD analog output (without digital operations)
- 3 Mezzanine cards operating simultaneously

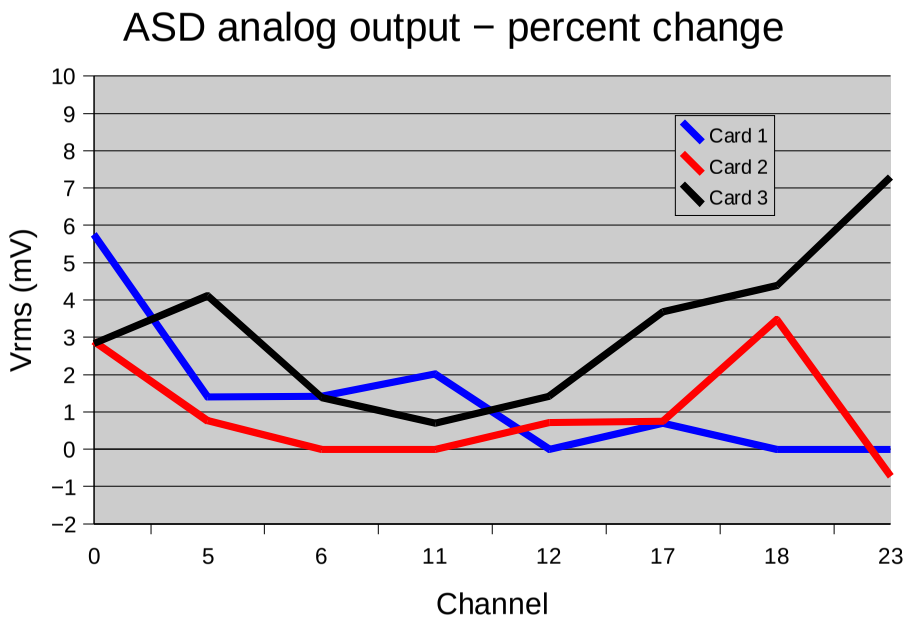




Thermal noise as expected from simulation

Digital noise feedthrough





No significant noise increase due to digital activity

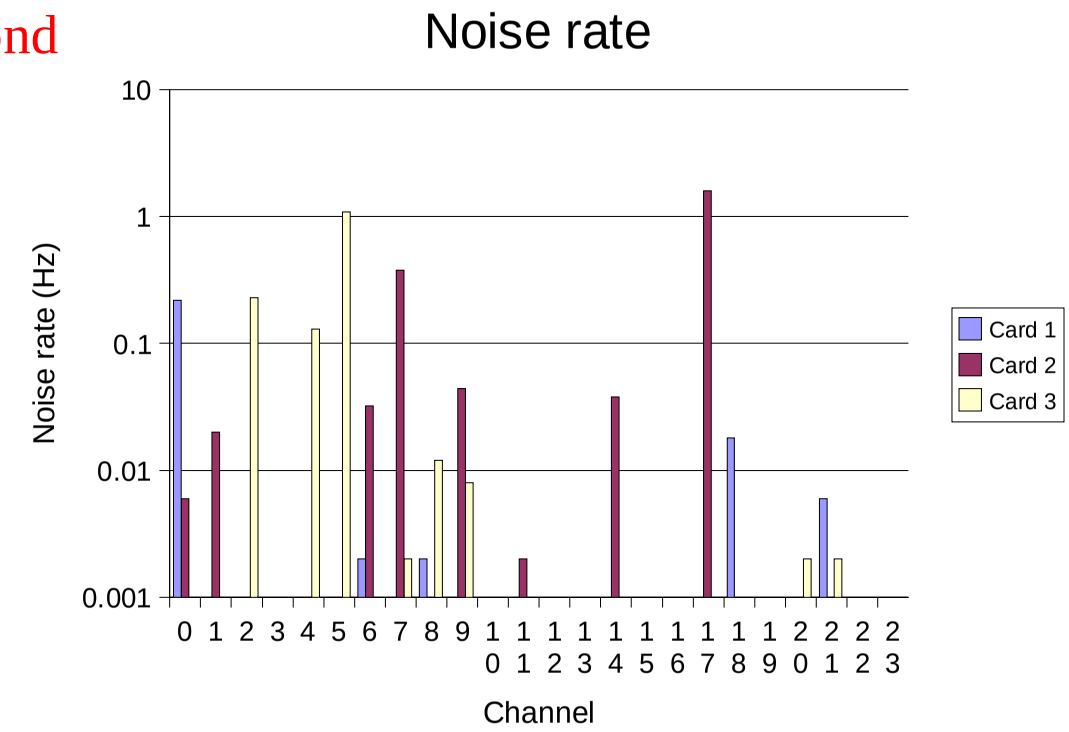
- Results similar for most channels
- 4 channels (out of 288) show 20% higher noise rate
- Work in progress

Noise rate with 12−cards

- Measured on Module−0 chamber
  - Both multilayers fully instrumented
  - 12 Mezzanine cards operating simultaneously
- Nominal Discriminator Threshold :
  - $5 \times \sigma_{noise} \sim$ 20 pe ~ 5 fC ~ V_{th} = 60 mV

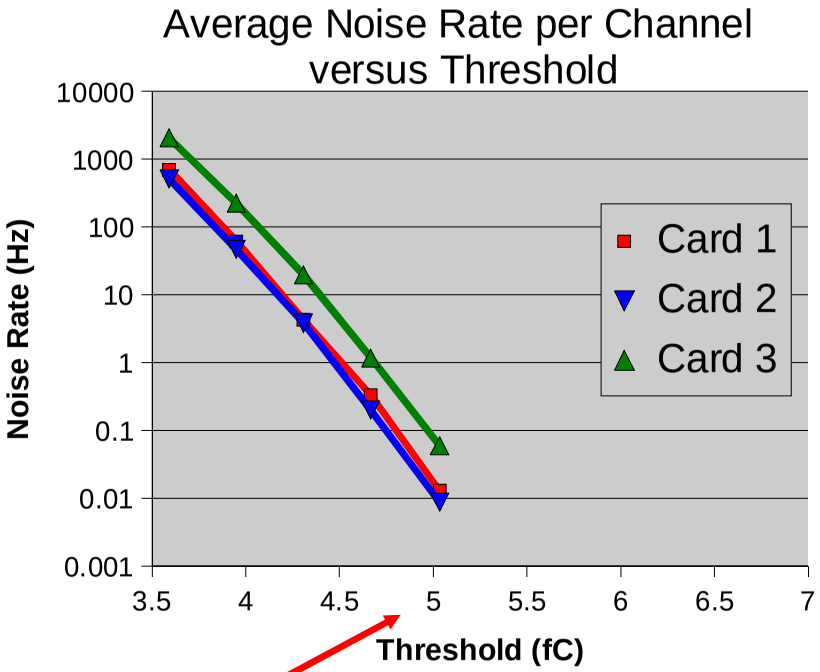
Number of hits per second measured by the CSM0

1 Hz →



Noise rate versus threshold

- Measured on Module−0 Chamber
  - Two multilayers fully instrumented
  - 12 Mezzanine cards operating simultaneously



V_{th} = 12 mV/ fC

Nominal threshold −V_{th}= 60 mV

Noise comments

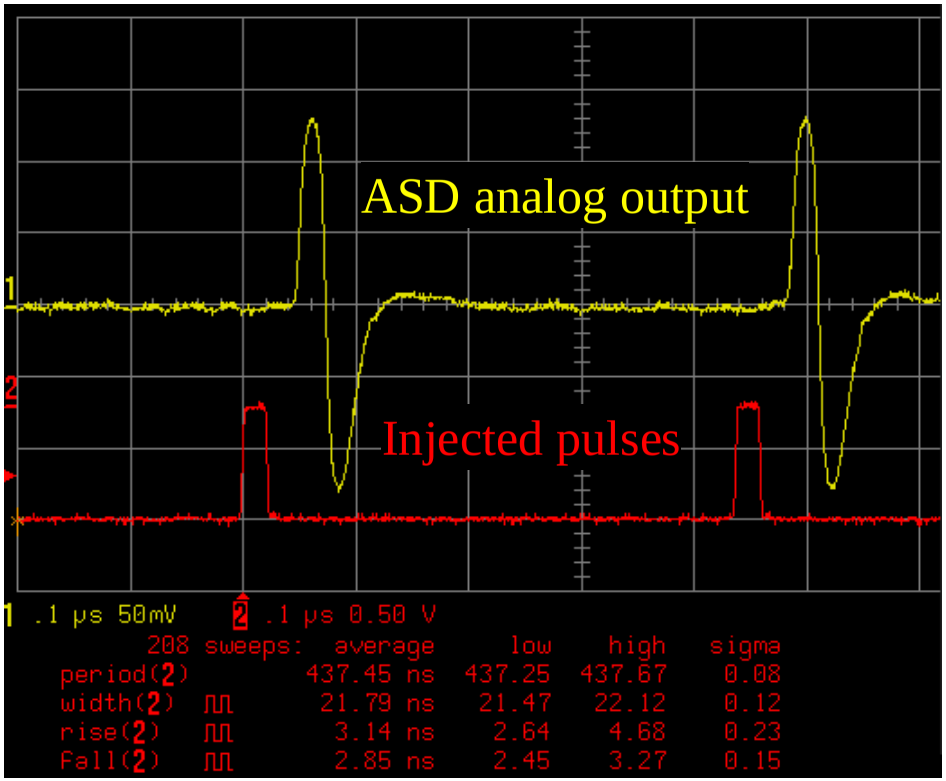
- Noise rates on 3x8 and 4x6 mezzanine cards are very similar
- Noise level depends strongly on grounding and cabling (not suprisingly!)
- Thermal noise is in agreement with specifications
- Digital noise feedthrough is small compared to thermal noise
- Most remaining noise rate comes from:
  - VME bus operation (this will not be present in the final CSM design)
  - Radiation from cables (40 Mhz clock) => shielded cables
- Noise rate is close to 0 at nominal threshold

Time Resolution

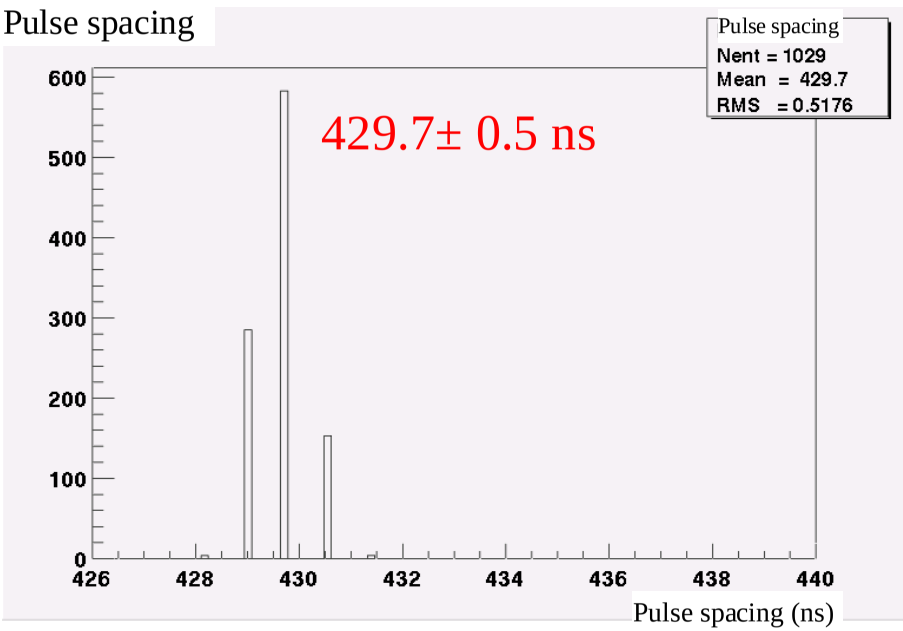
☞ TDC time measurement

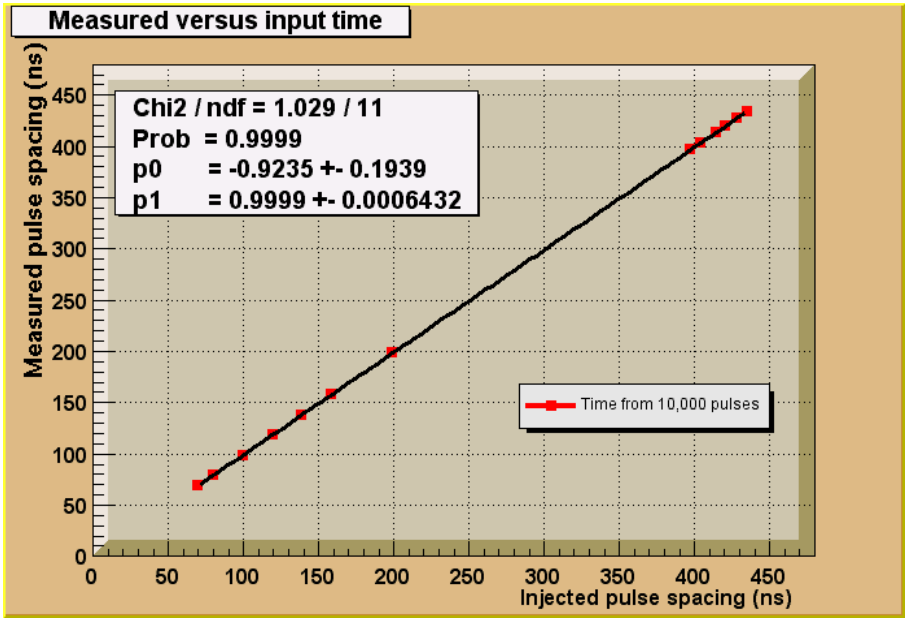
- Coarse = 25 ns/ bin (40 MHz)
- Fine = 0.78 ns/ bin (PLL)
- Resolution = 300 ps (rising edge)

- Inject 2 pulses per channel
  - Fixed time difference
  - 2 pF capacitor



Fine Time Measurement

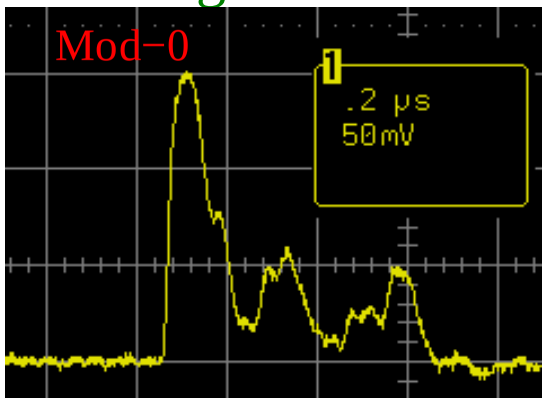


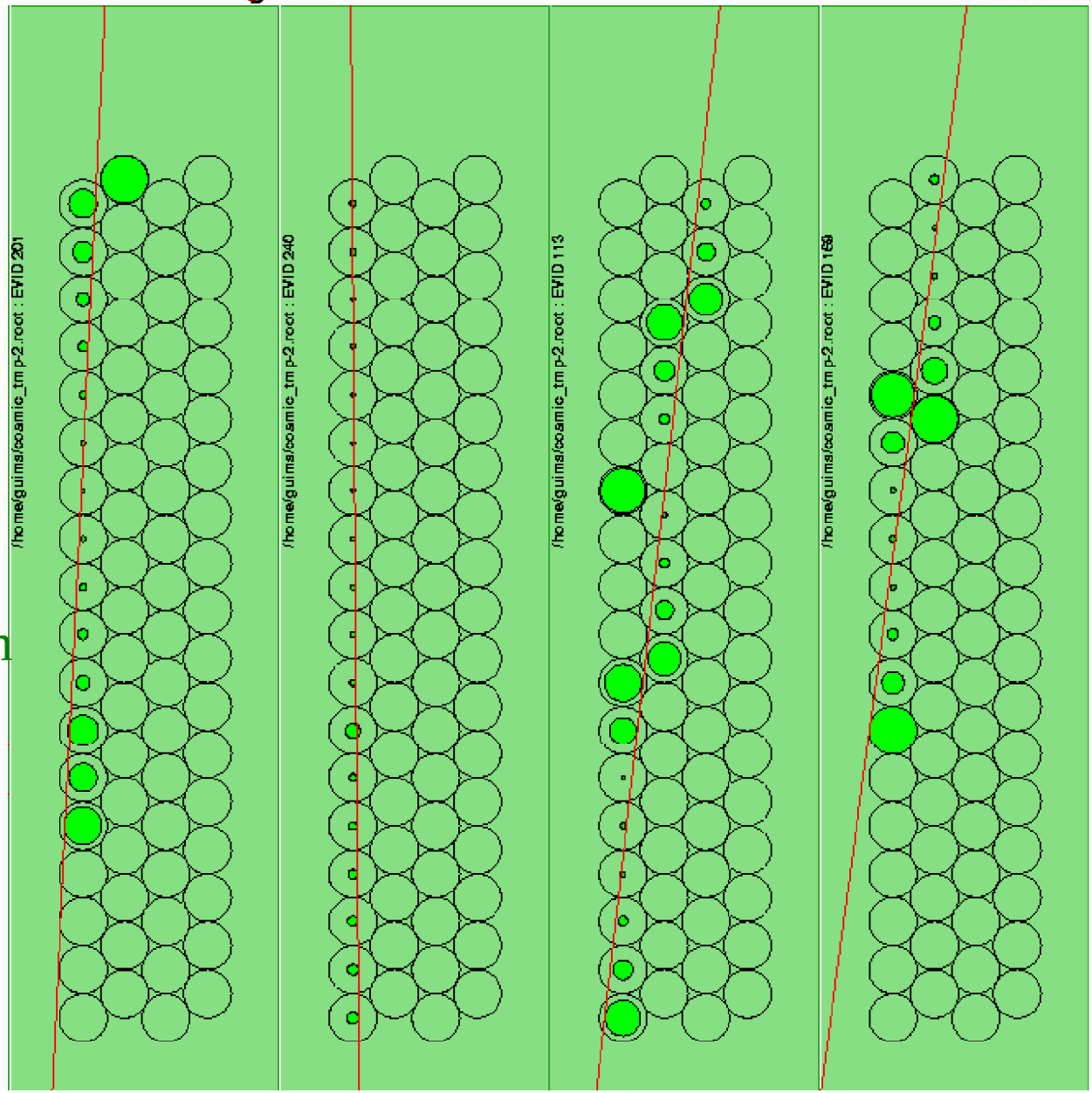


- Good time measurement is independent of:
  - Trigger rate
  - Cable length
  - LVDS common mode level

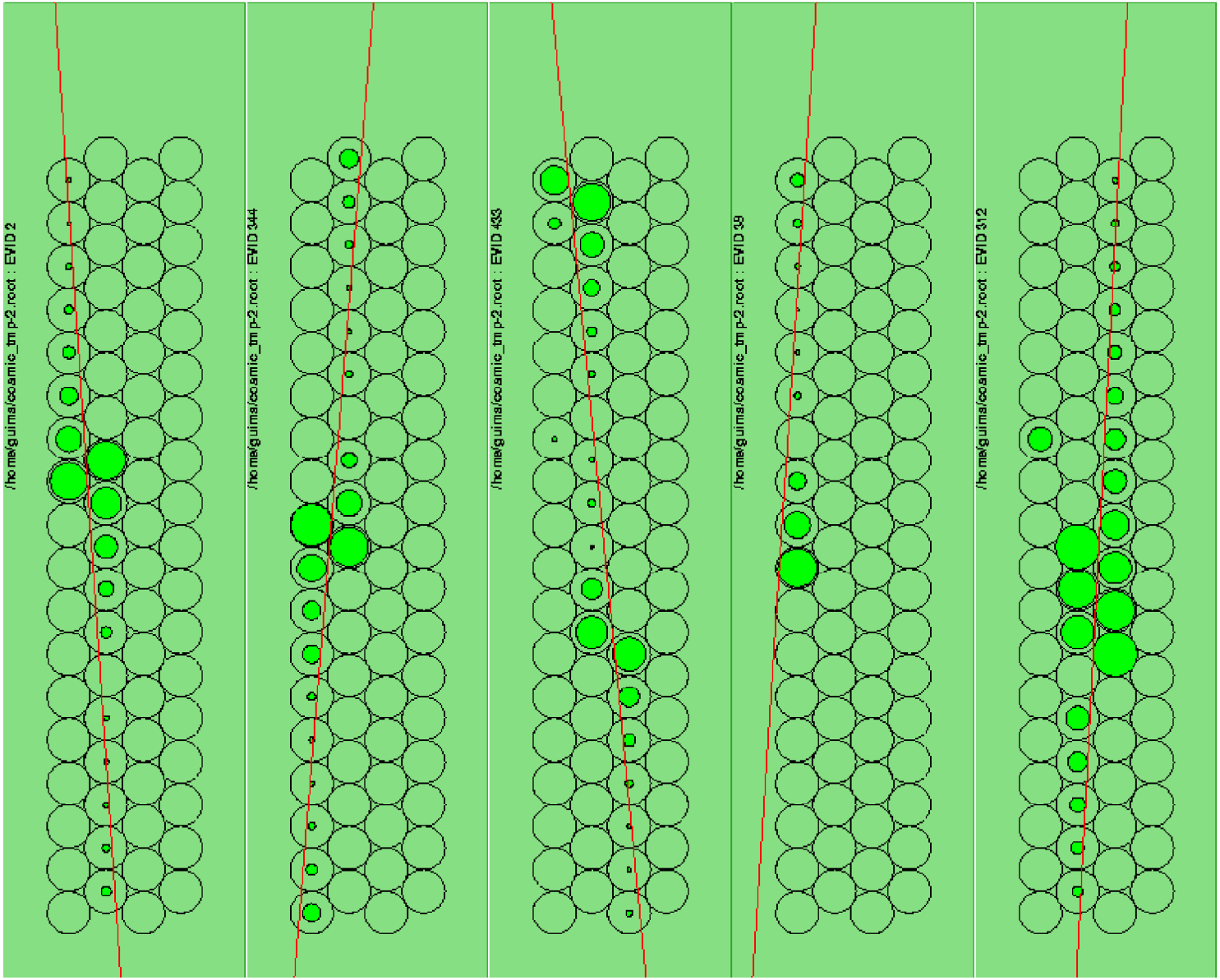
Cosmic rays with 3 cards

- Cosmic rays with the 72−tube chamber prototype
- Vertical position
- 3 Mezzanine cards
- CSM−0 triggered by scintillator telescope
- Gas pressure of 3 atm
- Voltage = 3.2 kV





More cosmic rays



Future Plans

- Continue studies on EIL1 Module−0 chamber
  - Finalize grounding, cabling and shield studies
  - Take cosmic ray data −> measure resolution

- Test electronics at larger scale in Module−0 Chambers
  - 10k−Channels of electronics is being delivered to several site
    - BMC, CERN, Thessaloniki, MPI Munich, Michigan, Rome, LMU, Pavia, Dubna, Frascati, Freiburg, Seattle, Protvino
  - CERN −> work has started on BIS chamber
  - Rome −> started testing a small number of cards)
  - Michigan, Munich −> start within a month

Future Plans (2)

- Learn about issues particular to the different chambers (grounding, cabling, low noise operation)
- Test CSM−TDC data link with up to 18 mezzanine cards simultaneously
- Take cosmic ray data and measure resolution
- Test operation of the system at high hit rates
  - BIS chamber in X5 area
  - Cosmic rays with high−rate gamma rays source by May
  - Muon beam in July

☞ Test of final electronics prototypes

- Octal Mezzanine card being designed
  - On−chamber testing will begin in April
- On−chamber CSM (non−VME version)
  - Cabling scheme and grounding issues

Conclusions

- Extensive integration on−chamber tests have been done on a small 3−card chamber prototype
- Initial tests on Module−0 chamber have started with good results
- Prototypes of all components have performed well
- System characteristics:
  - HV Leakage current better than specification
  - Noise level according to specification
    - Digital noise feedthrough is small
  - Good time resolution
  - Cosmic ray tracks observed

It works !!!!