CDS tutorial

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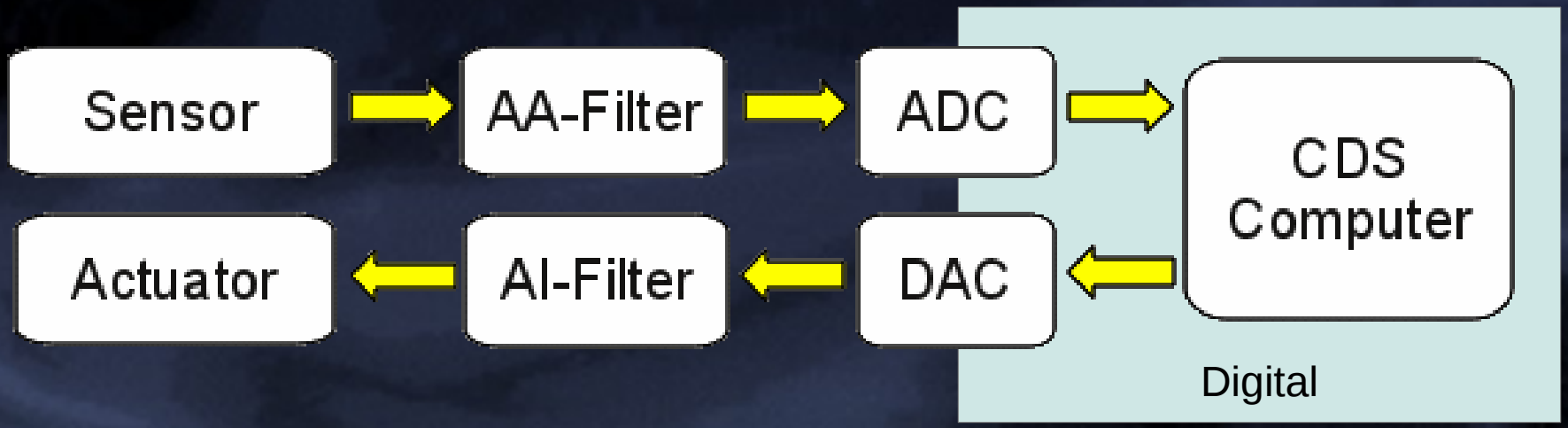
Overview

- Digital control
- LIGO control and data system (CDS)
  - Basics
  - User interaction
- Digital filters
- CDS tools
- Examples

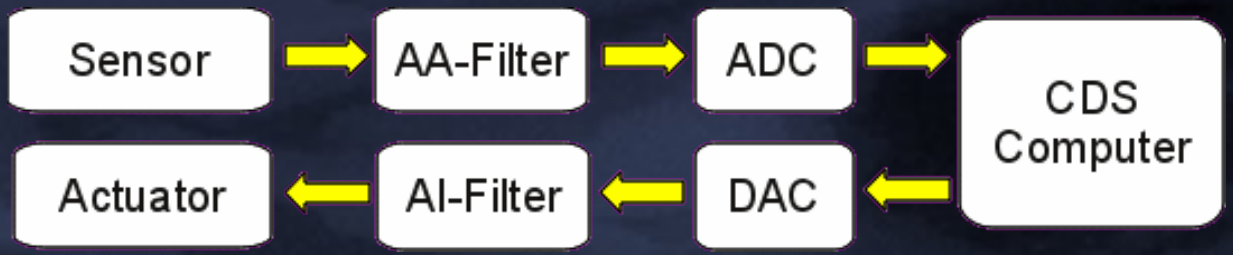
Digital control

- Analog signal conditioning
  - $f_{Signal} < f_{Nyquist} = ½ f_{Sampling}$
- Control loop with digital filters
  - Bandwidth limitations
  - Signal/noise limitations



CDS control bandwidth

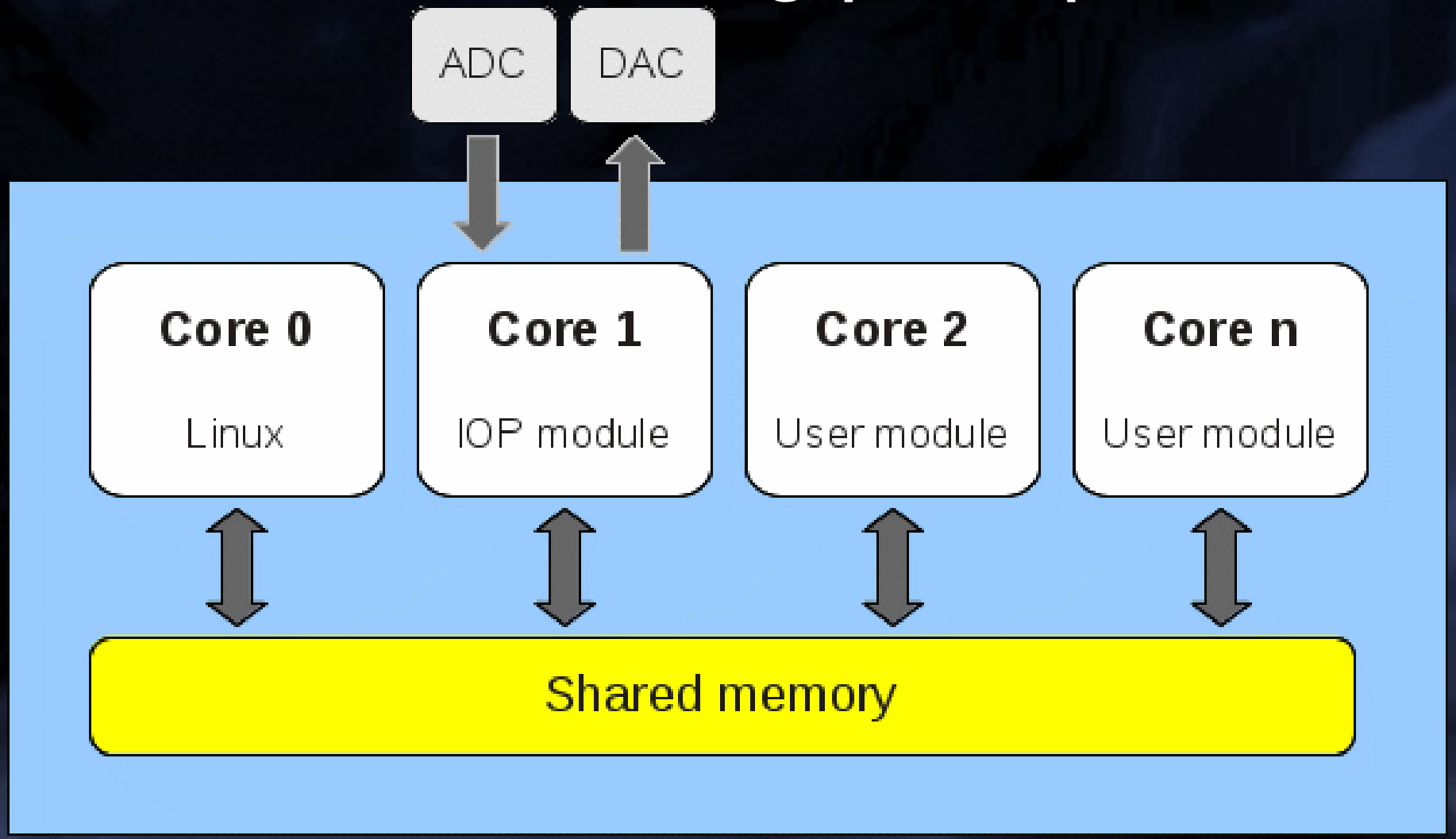
- $f_{Sampling}$ = 64 kHz (2^{16}Hz)
- Signal latency $t = t_{AA} + t_{ADC} + t_{CDS} + t_{DAC} + t_{AI}$
  - $t_{AA} = t_{AI}$=40µs
  - $t_{ADC} = t_{DAC}$=10µs
  - t_{CDS}= 16..24µs (timing system dependent)
- 1 / t = 1 / 120µs = 8.3kHz = f
- Control bandwidth ≈ f / 10 ≈ 1kHz



LIGO CDS

- Development @Caltech (Bork, Ivanov)
- Standard PC hardware (multi-core, fast networks)
- Linux operating system
- Commercial 16/18bit ADCs/DACs
- Custom filters (LIGO or AEI design)
- Scalability
- Large user base

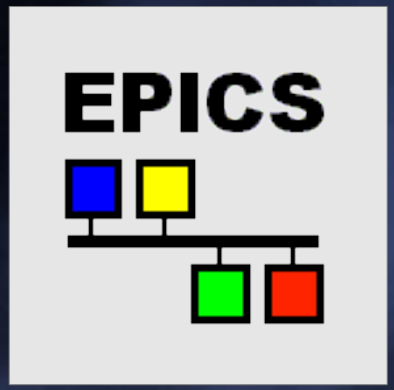
CDS working principle



- Control loops in user modules
- Modules individually (un)loadable

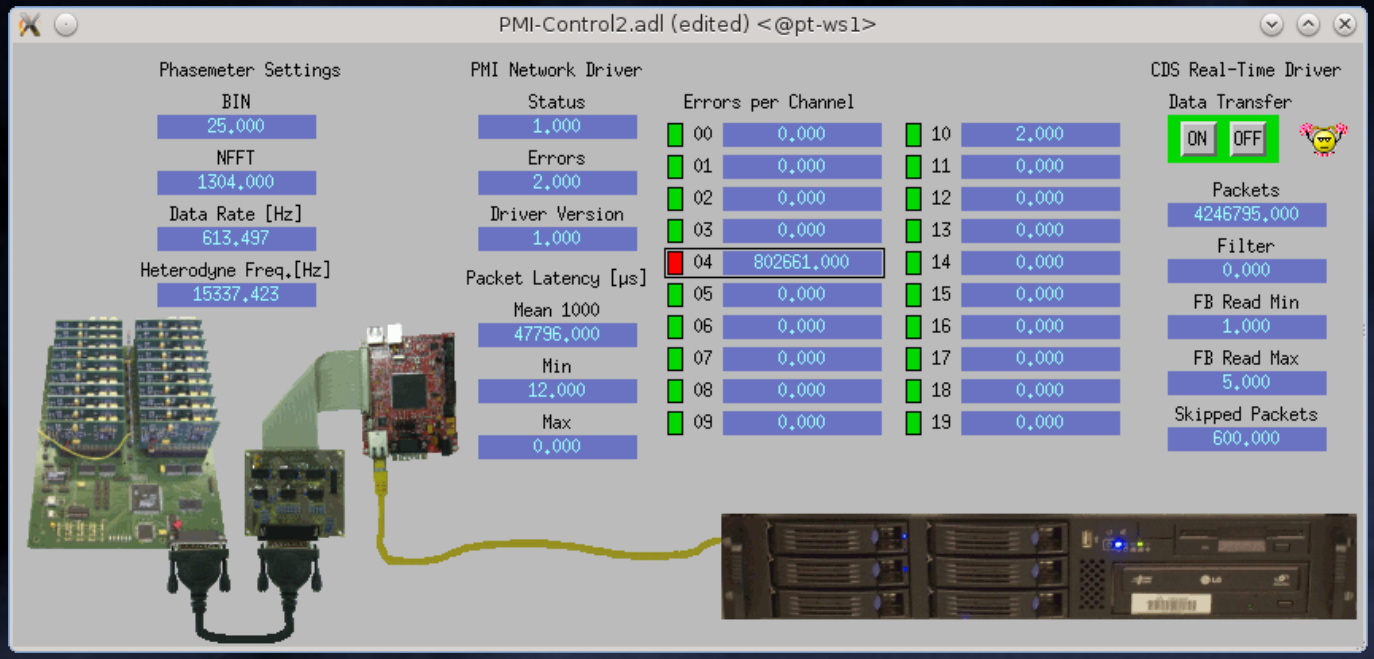
User modules

- Run @2, 4, 16, 32 or 64kHz
- Communication between modules

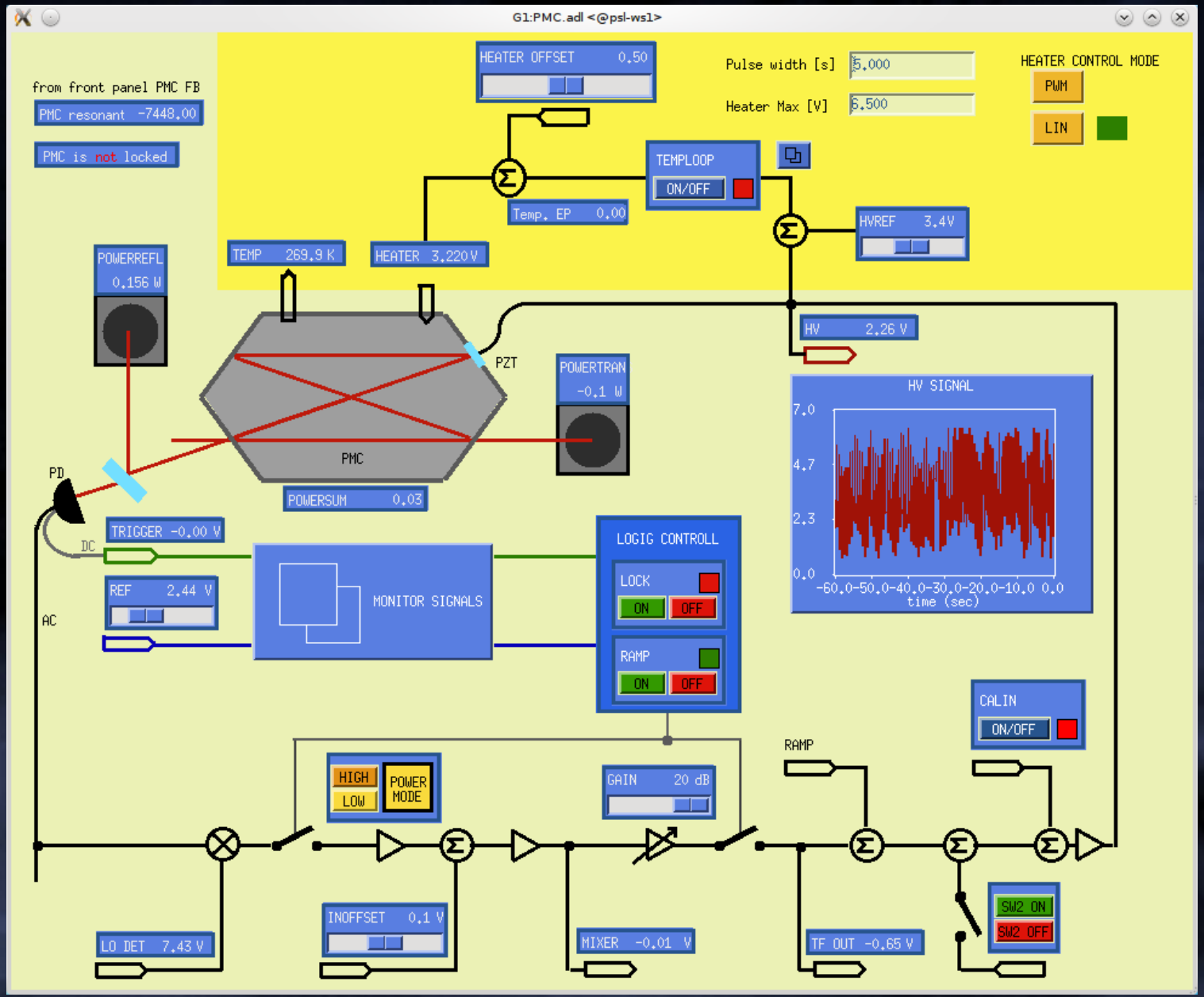


- Remotely controllable via EPICS channels
- Experimental Physics and Industrial Control System
- EPICS channels over network @16Hz
- MEDM graphical user interface (customizable)

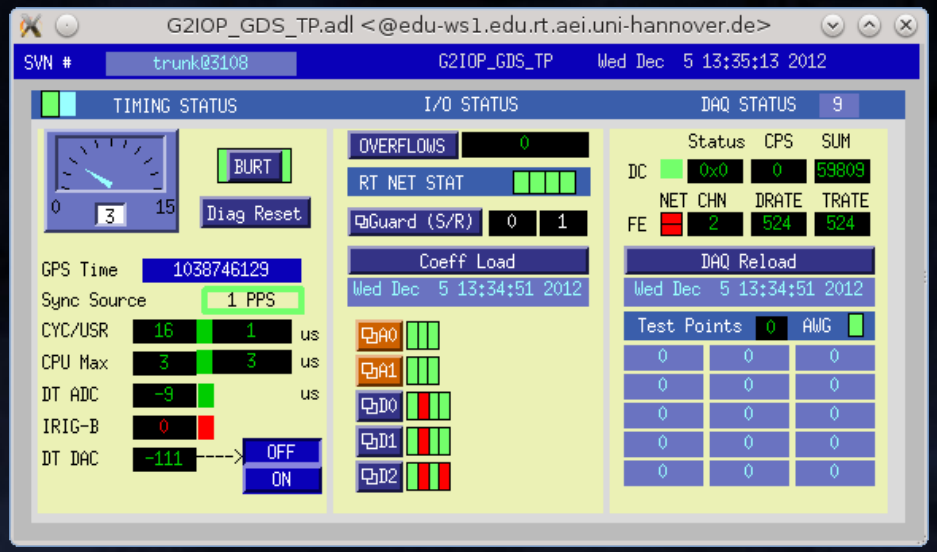
MEDM screens

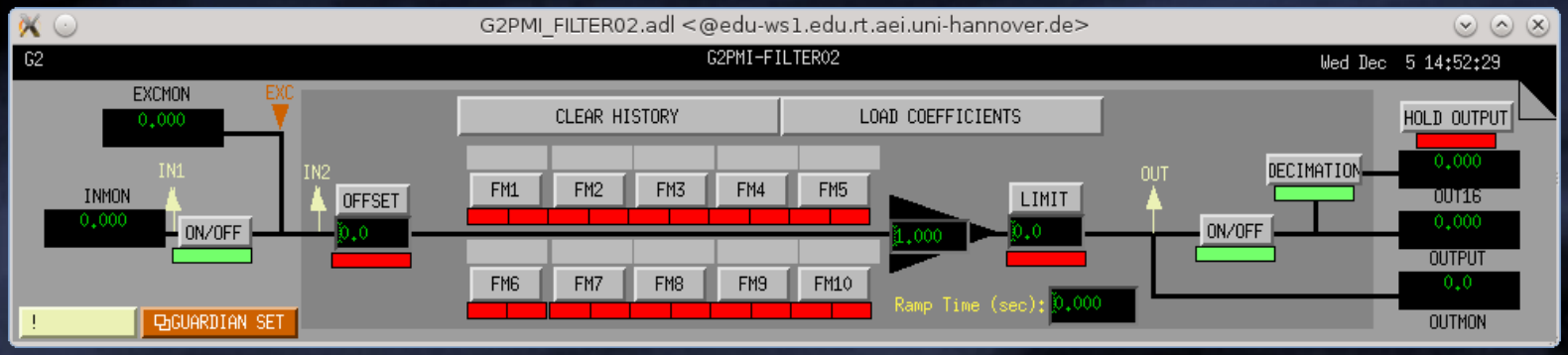


MEDM screens (2)



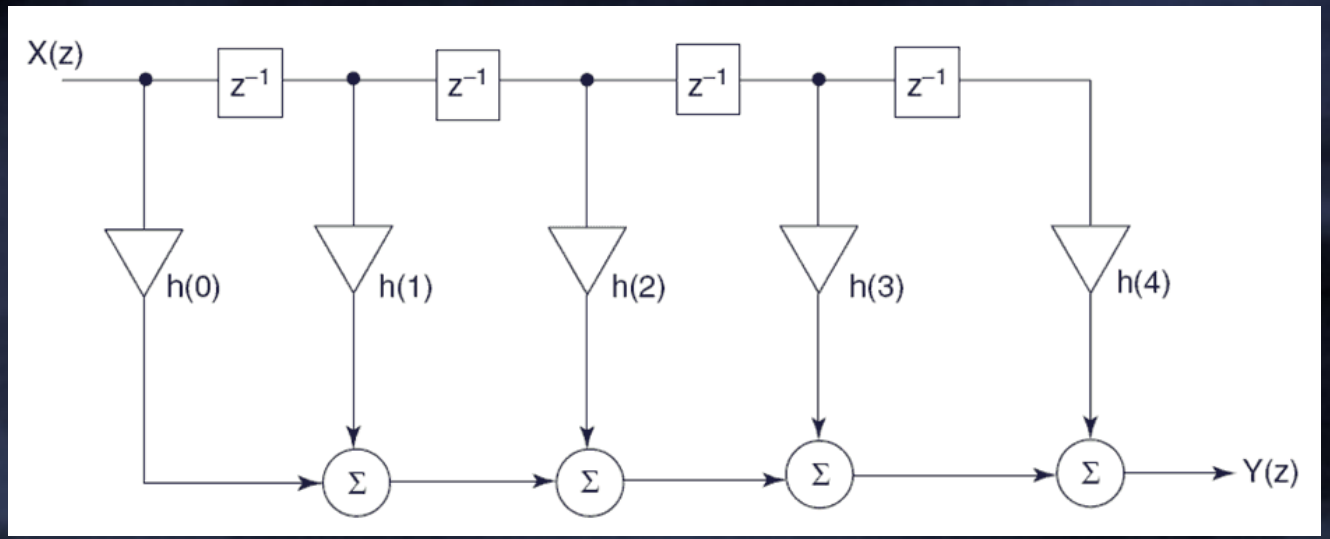
MEDM screens (3)





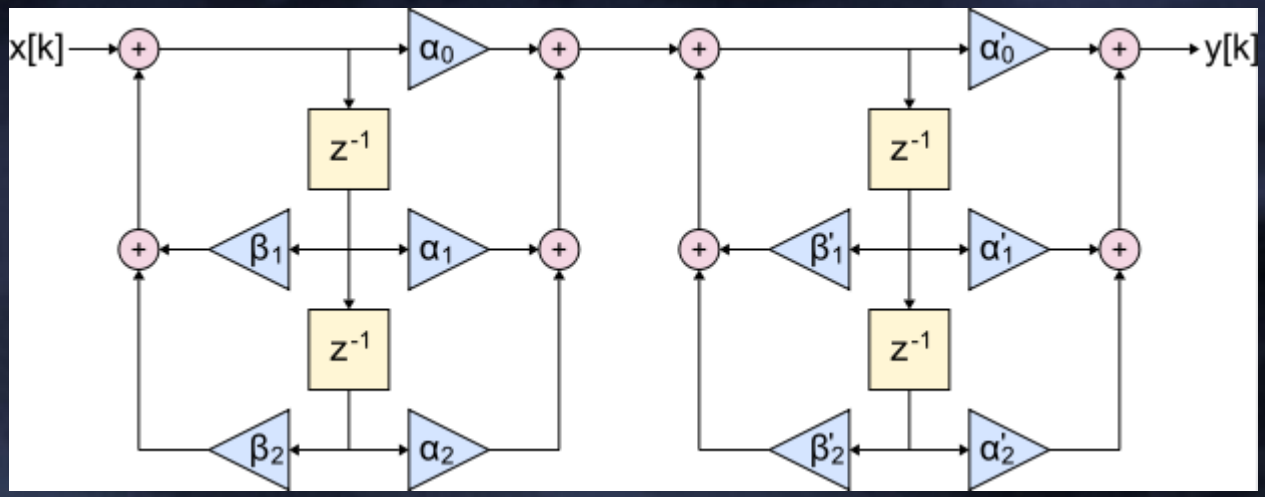
Digital filters: FIR

- CDS: Finite impulse response with ≦512 taps
- Computational heavy
- For 2kHz or 4kHz loops
- Coefficients defined in modelName.fir
- Nobody uses it (C-code instead)



Filters: IIR

- Infinite impulse response filter
- CDS implementation: second order sections
- Up to 10 SOS
- Coefficients from z-domain transfer function
- Matlab and tools help

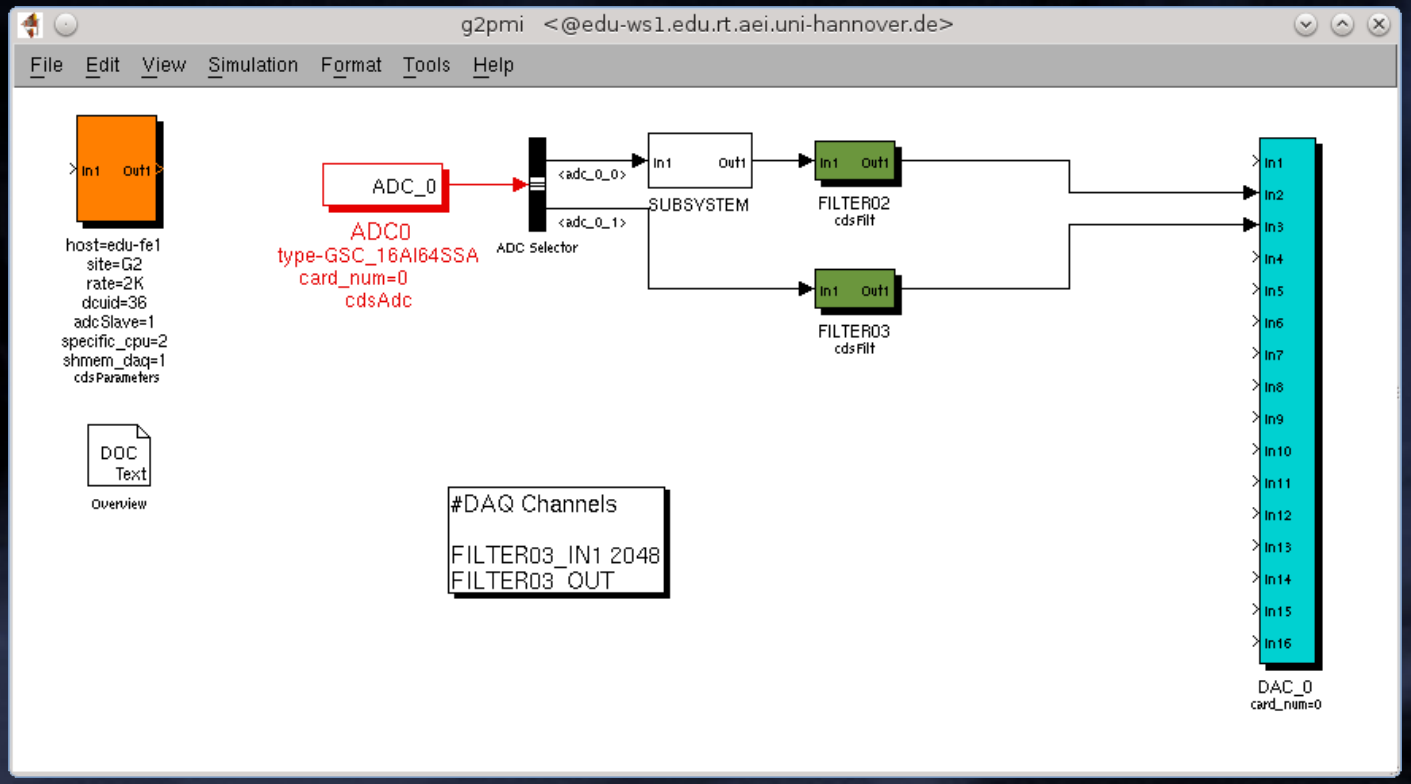


Tools, tools, tools

- Many useful tools – little documentation
- Select channels to record: daqconfig
- Look at time domain data: dataviewer
- Filter development: foton
- Spectrum analyzer: diagnostics test tool (DTT) – diag / diaggui
- Many tools are part of the global diagnostic system (GDS)
  https://www.lsc-group.phys.uwm.edu/daswg/download/software/source/
- Many user scripts available

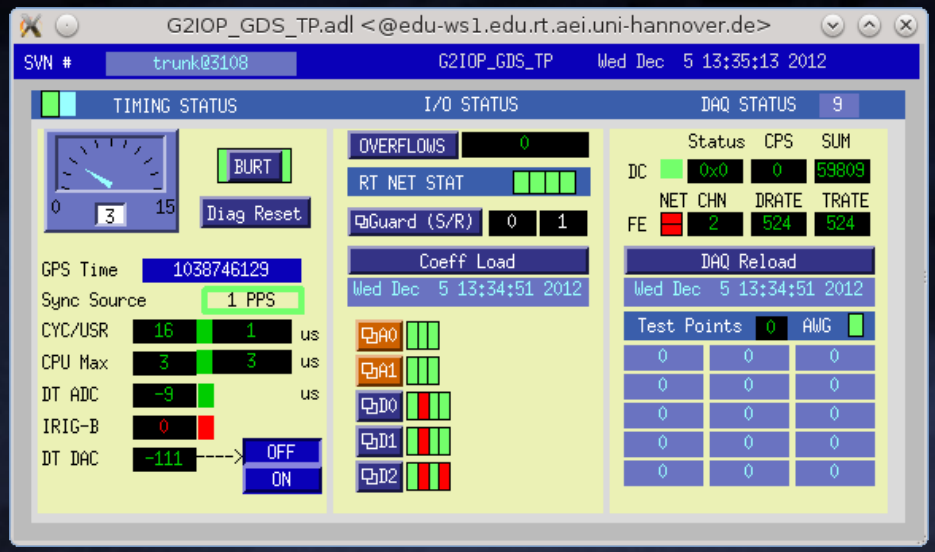
Tutorial (1)

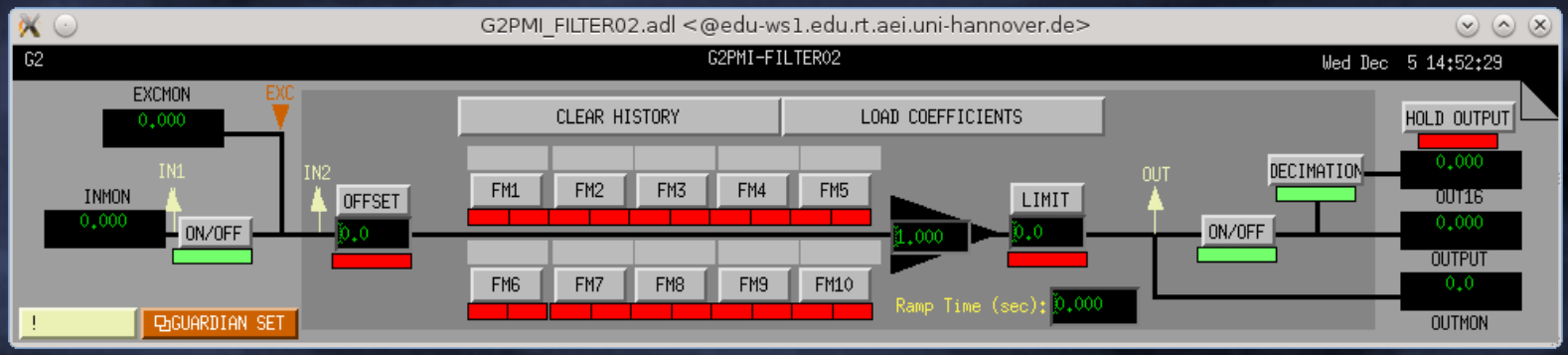
- Matlab: g2pmi.mdl



Tutorial (2)

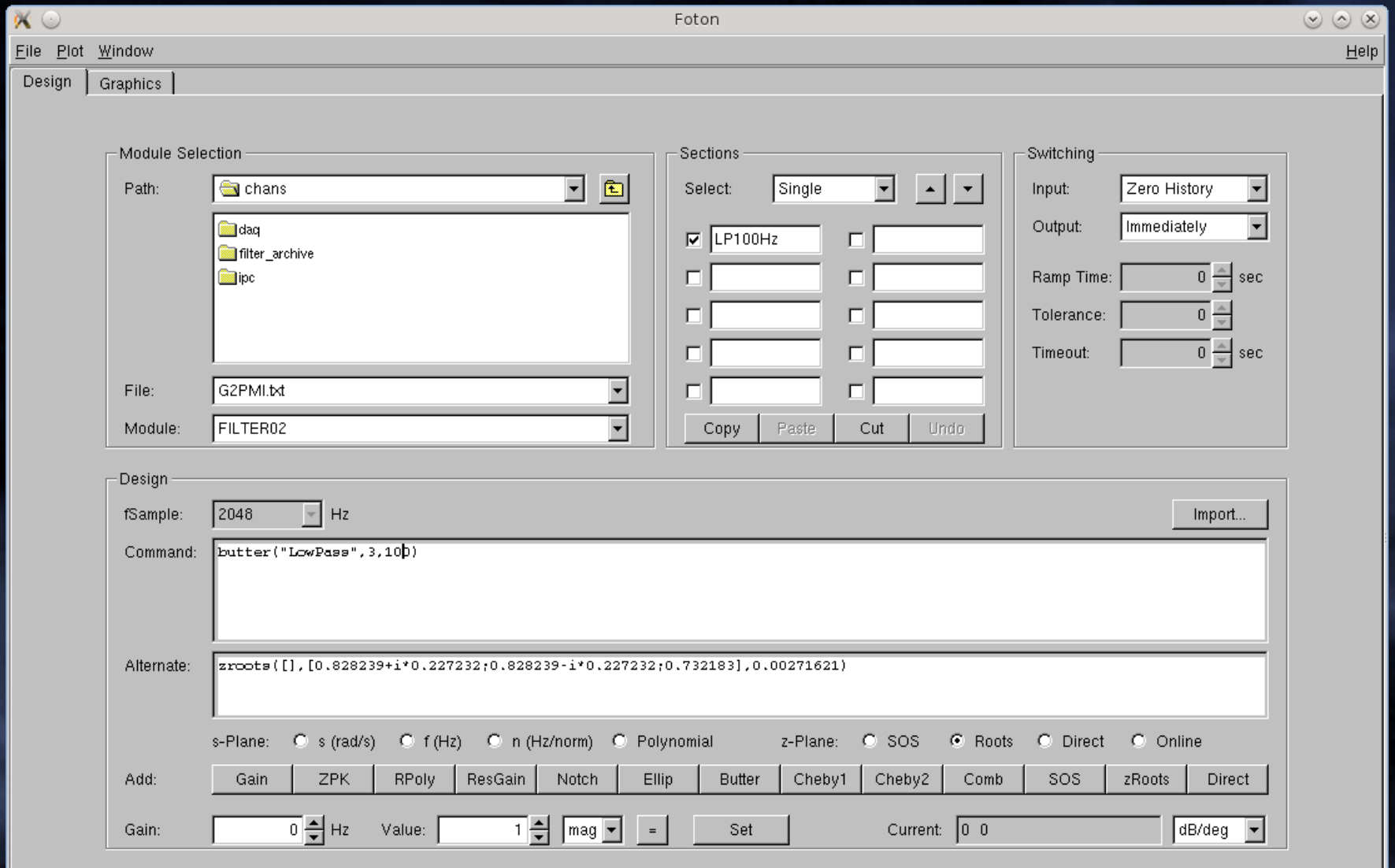
- MEDM: GDS_TP screens
- MEDM: pmi FILTER02, FILTER03





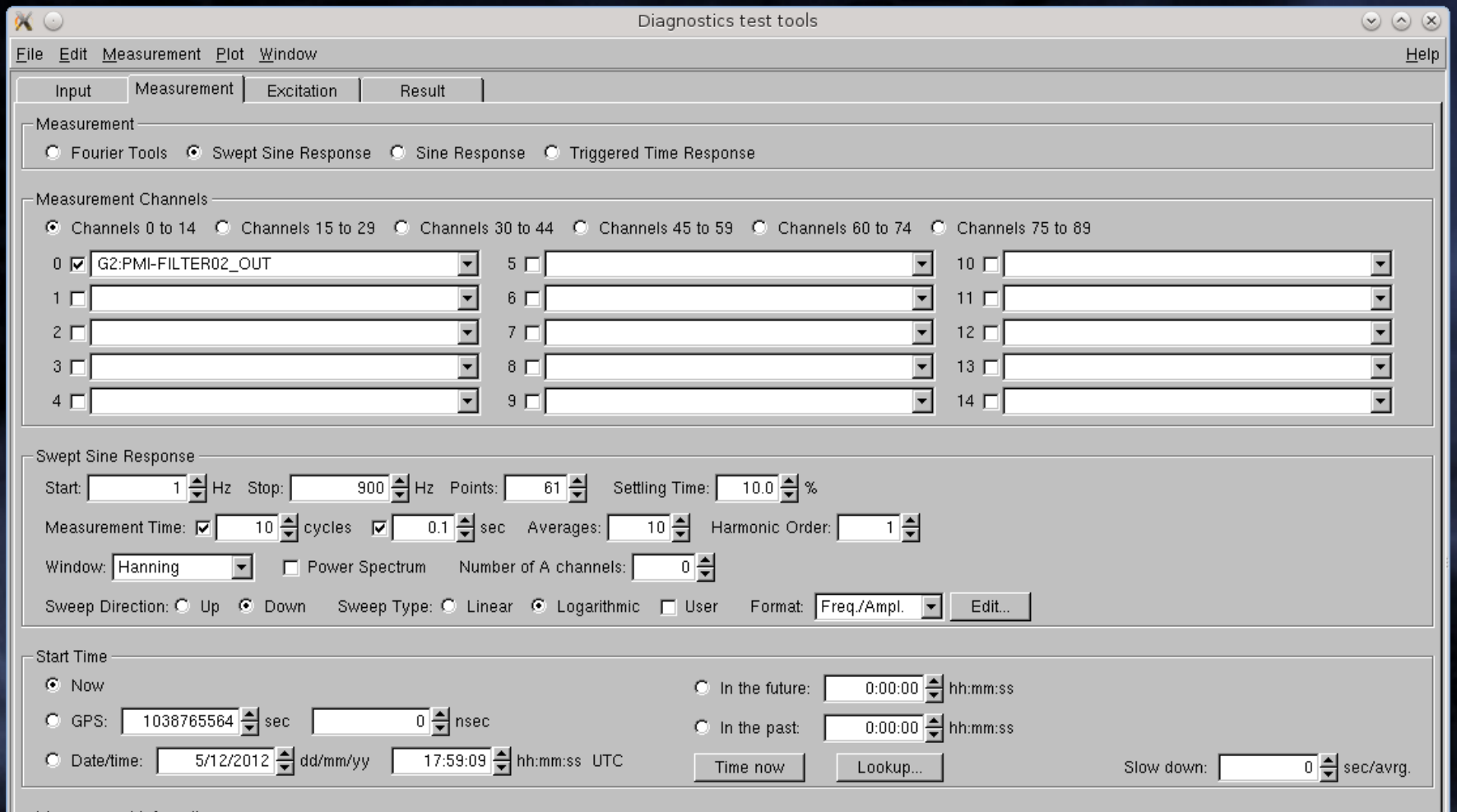
Tutorial (3)

- Filter design with foton



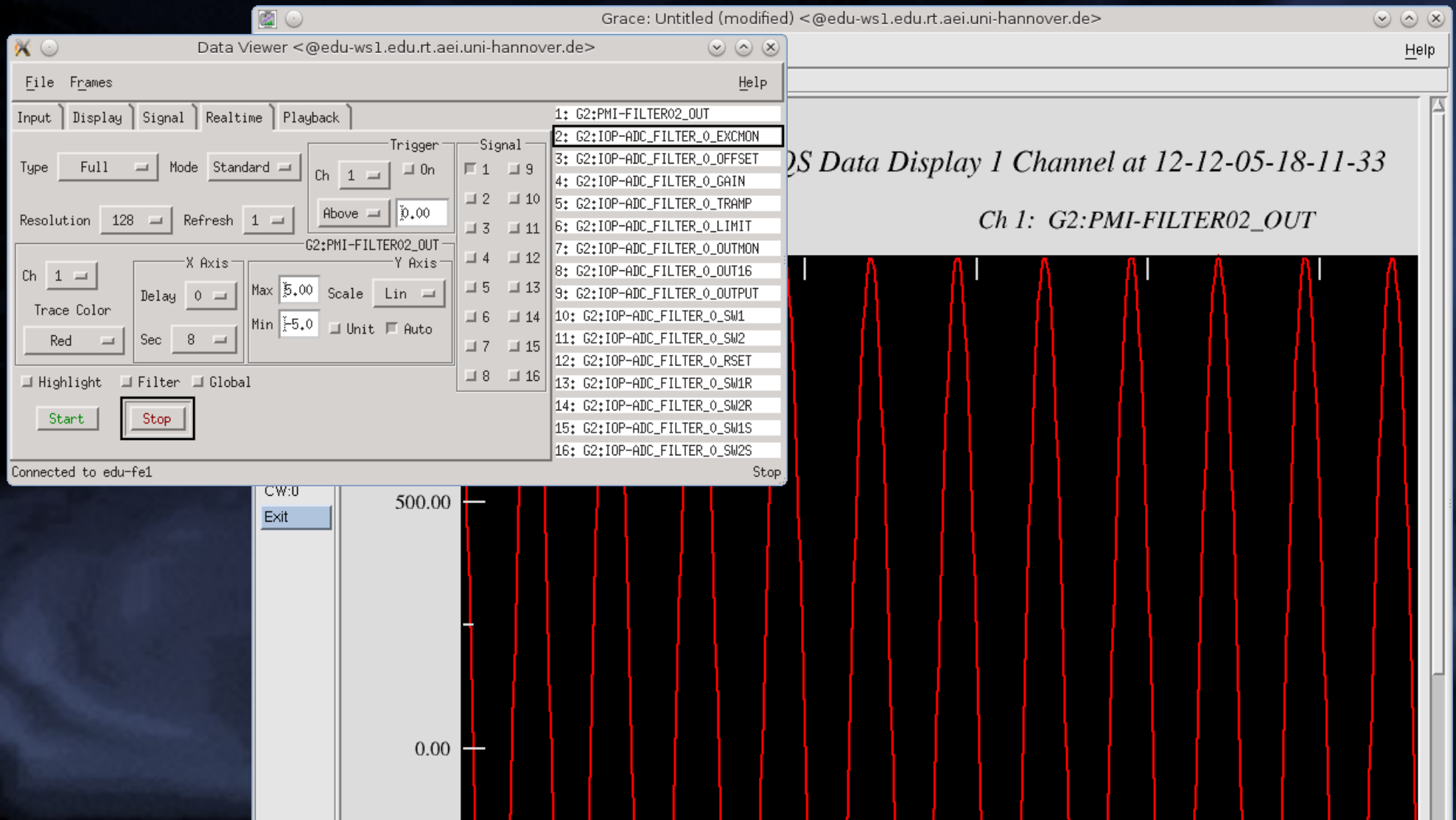
Tutorial (4)

- Measuring transfer functions with diaggui
- Old manual: LIGO T990013-v1



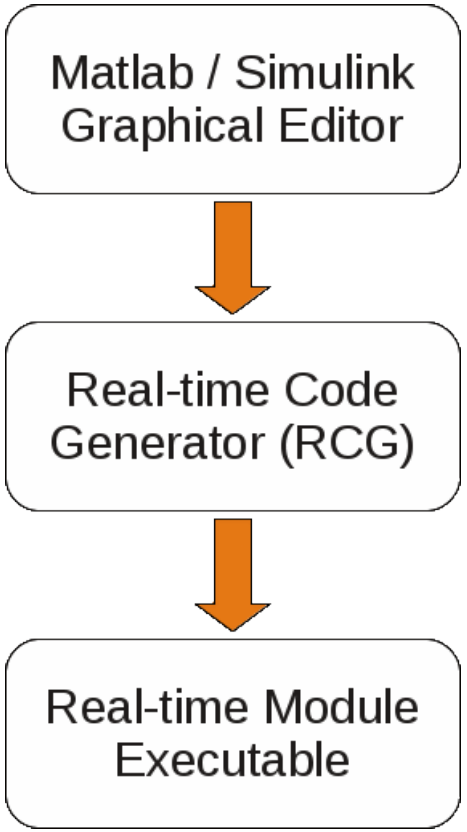
Tutorial (5)

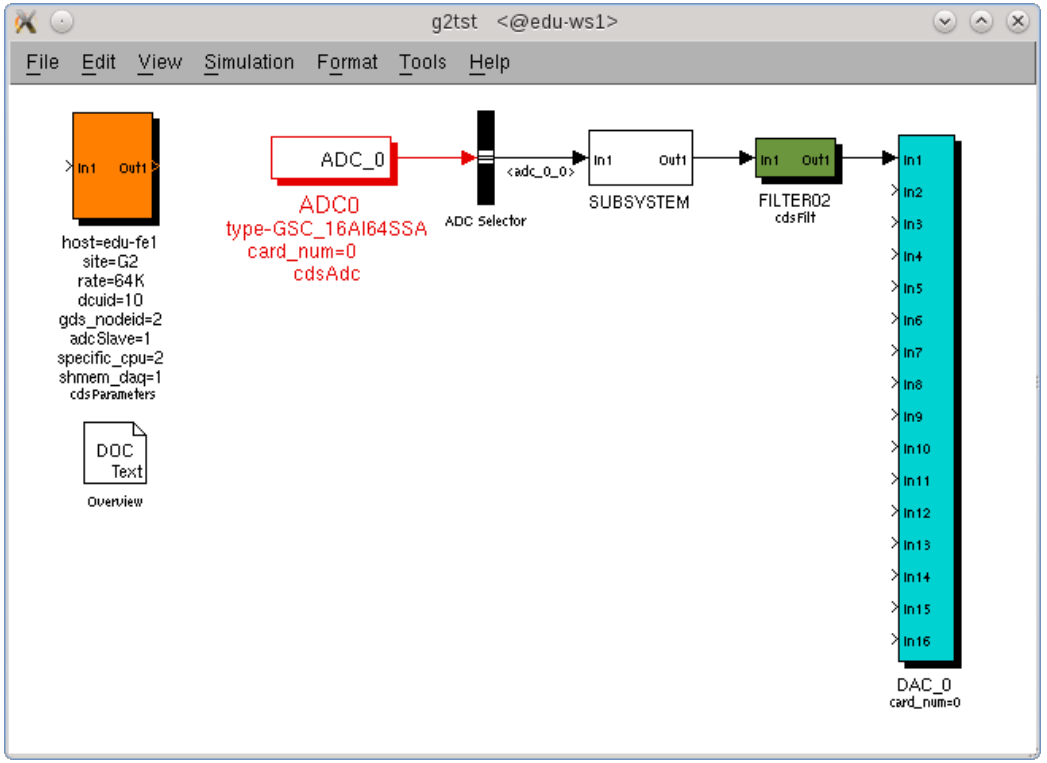
- Viewing live data with dataviewer



Thank you

CDS: from model to module



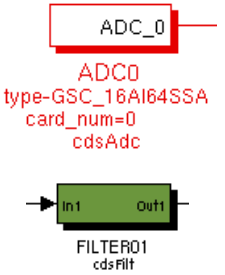


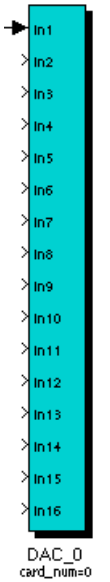
- Simulink is used just as a graphical editor
- RCG: mdl file → C code → Kernel module

The CDS_PARTS library

- CdsParameters specific to the CDS

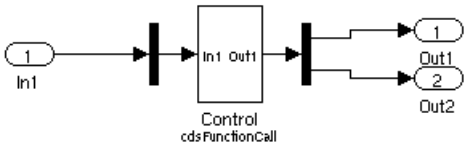
- ADC/DAC channels for analog input/output
- Filter with online changeable transfer functions





- Logic elements (switch, add, ...)
- External control with EPICS GUI

- CdsFunctionCall for custom C code



- LIGO-T080135-v4 RCG Application Developer’s Guide

Digital vs. analog filters

- Digital: reproducible, no aging, changeable on the fly, system scalable
- Con: limited bandwidth, system complexity
- Cost (10k€+), P[W], your metric