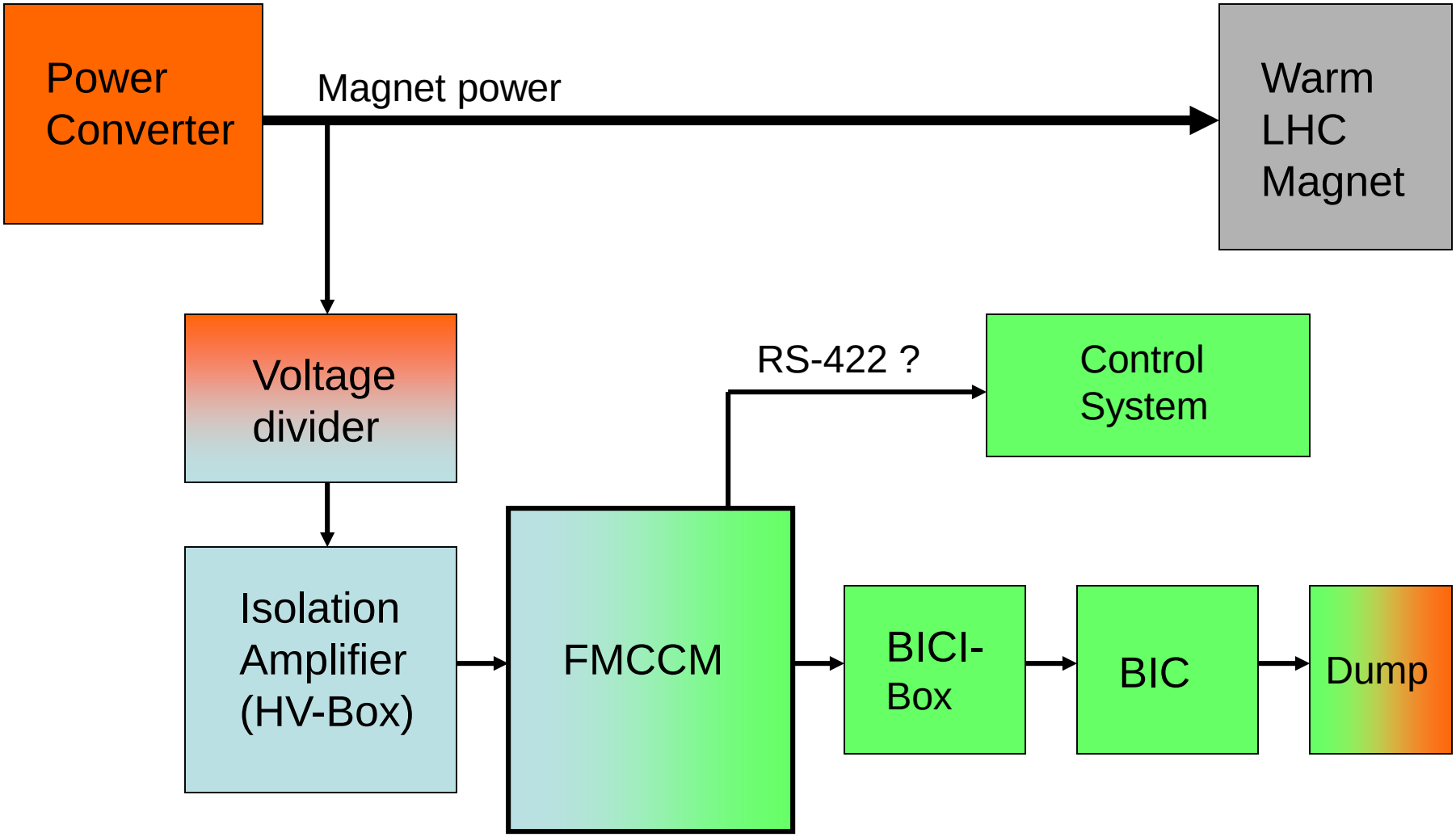
Tests of the FMCCM at CERN

- FMCCM = Fast Magnet Current Change Monitor
- Tests were made on different test benches for D1 magnet (dipole) and MSE (Extraction Septum)
- Power converter filters were different from real filters
- Only one magnet, not many magnets in series

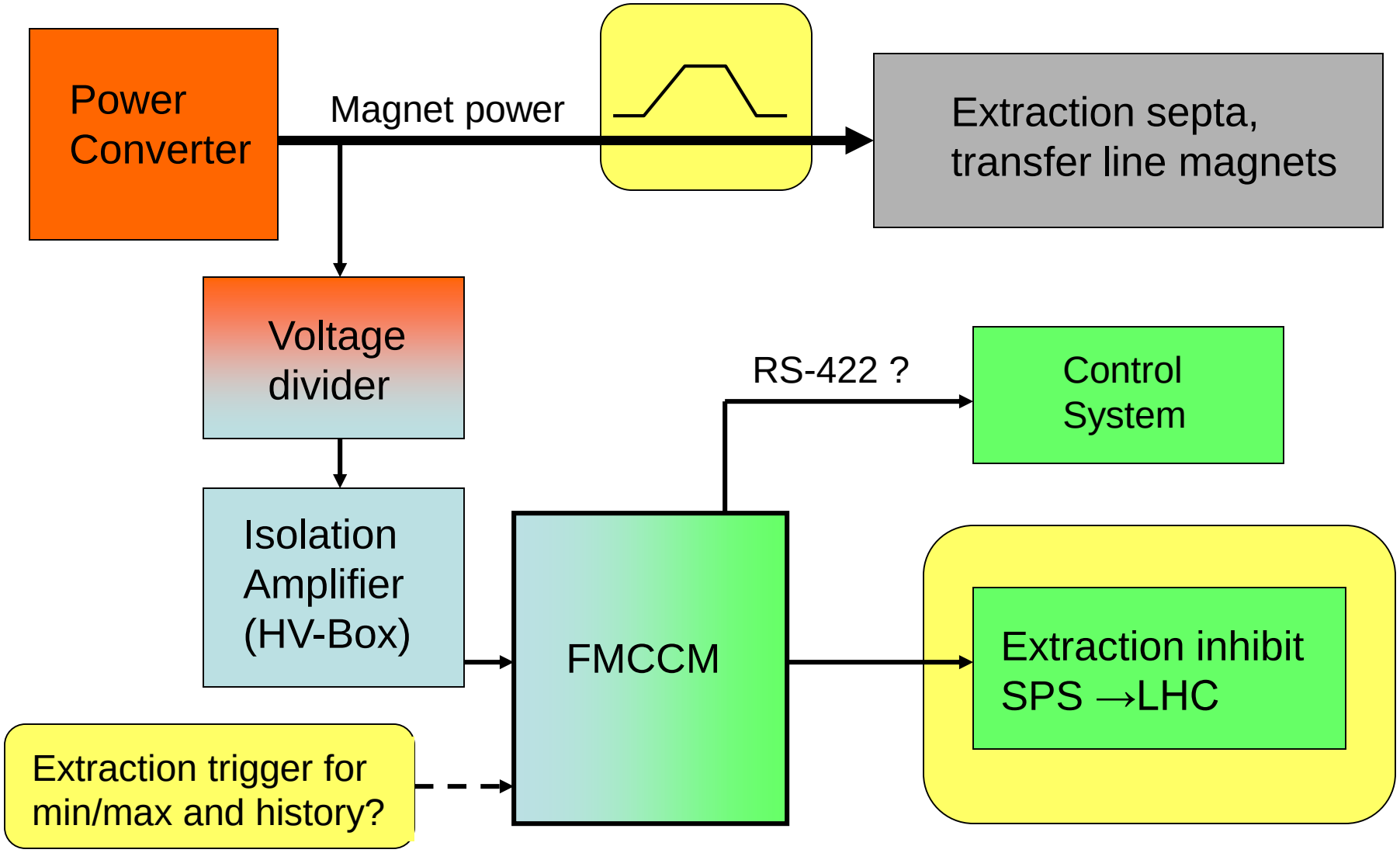
Tests done

- Test of reaction times
- Tests of power converter ripple
- Test if the simulated field changes are similar to the real magnetic field changes for different time domains
- Test of eddy current effect
- Test of minimum possible threshold
- Comparison between different principles: DCCT, Hall Probe, Current simulation
- Short test of noise sensitivity
- Impact of magnet heating effects for pulsed magnets
- Extrapolation of the results from the test benches for the real machine (less power converter ripple)

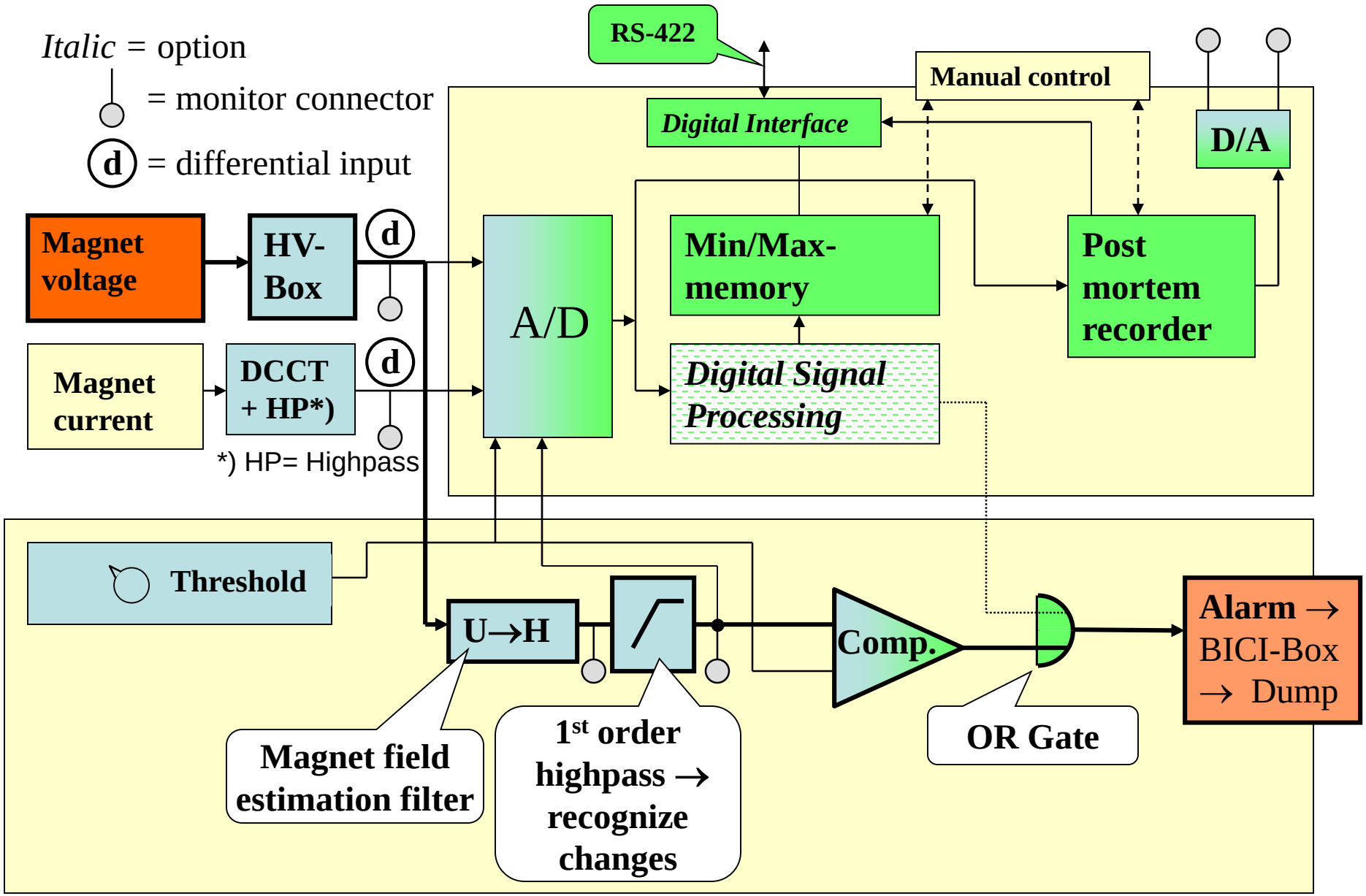
FMCCM for LHC magnets



FMCCM for extraction line

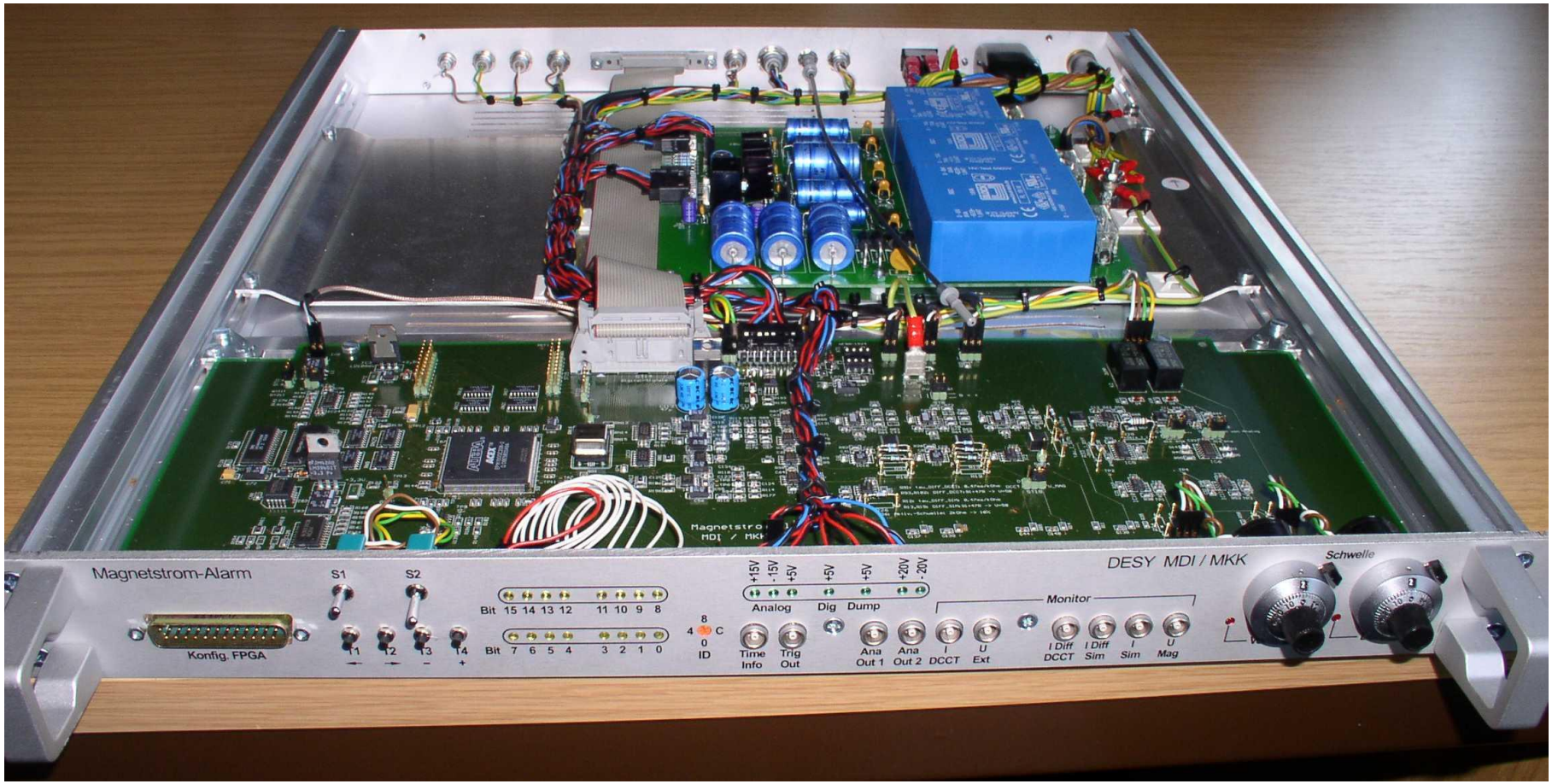


FMCCM: signal flow (simplified)



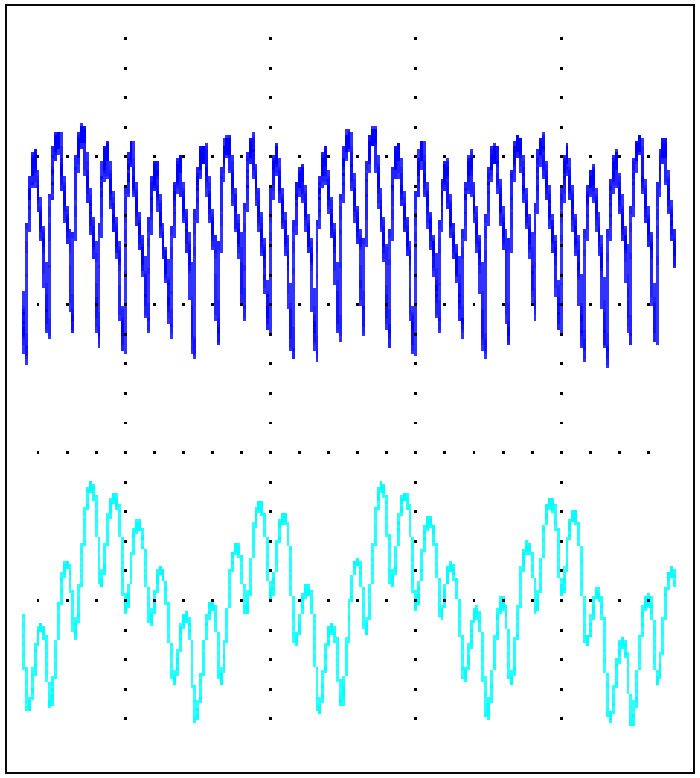
FMCCM *)

*) Fast Magnet Current Change Monitor



Ripple of Power Converter

MSE Test Setup

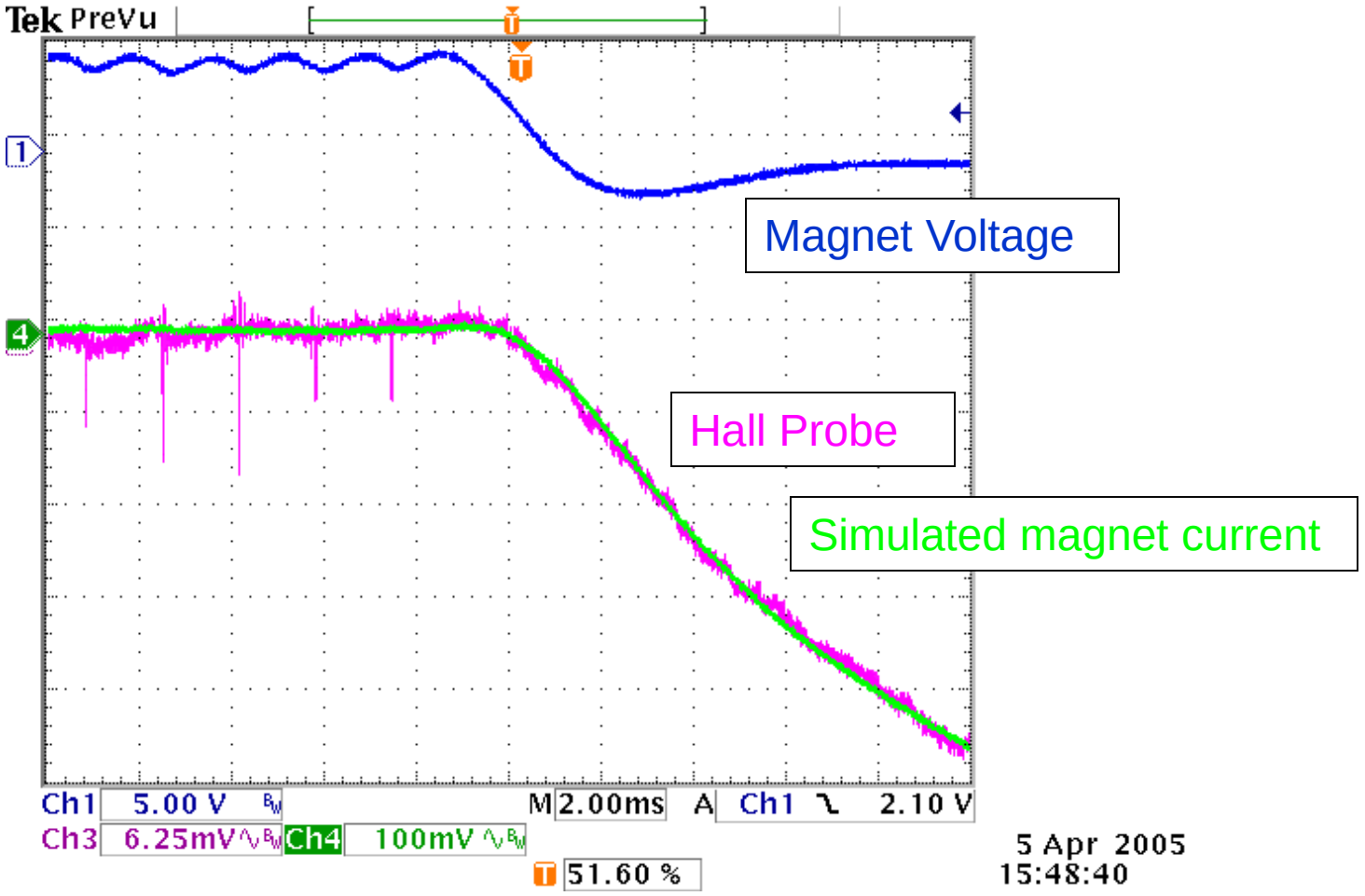


Voltage Ripple:
25% p-p, mainly
on 600Hz

Current Ripple:
0.5% p-p, equally
distributed to **50Hz**
and 600Hz

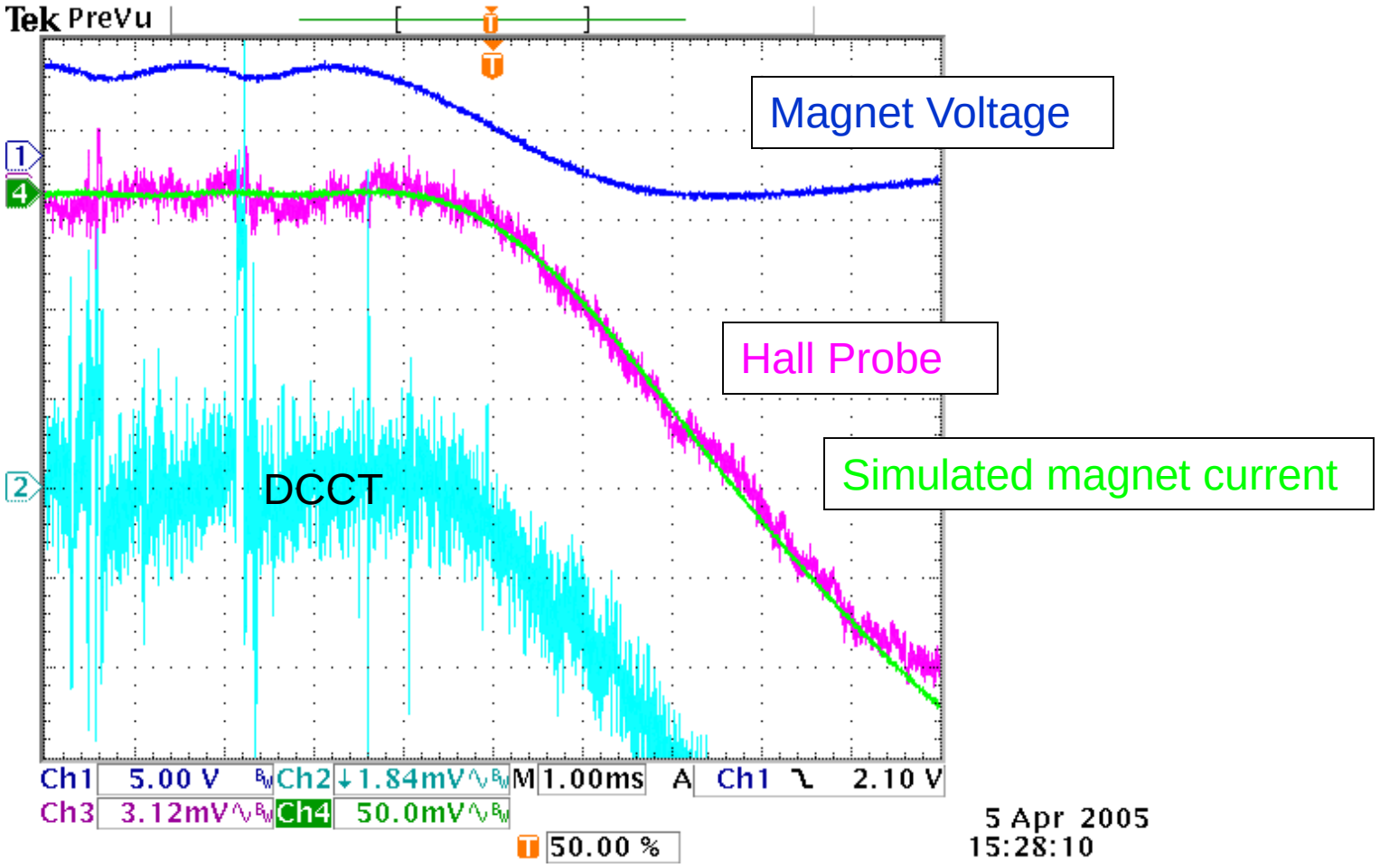
Simulated current tracks magnetic field

Switch off D1 magnet



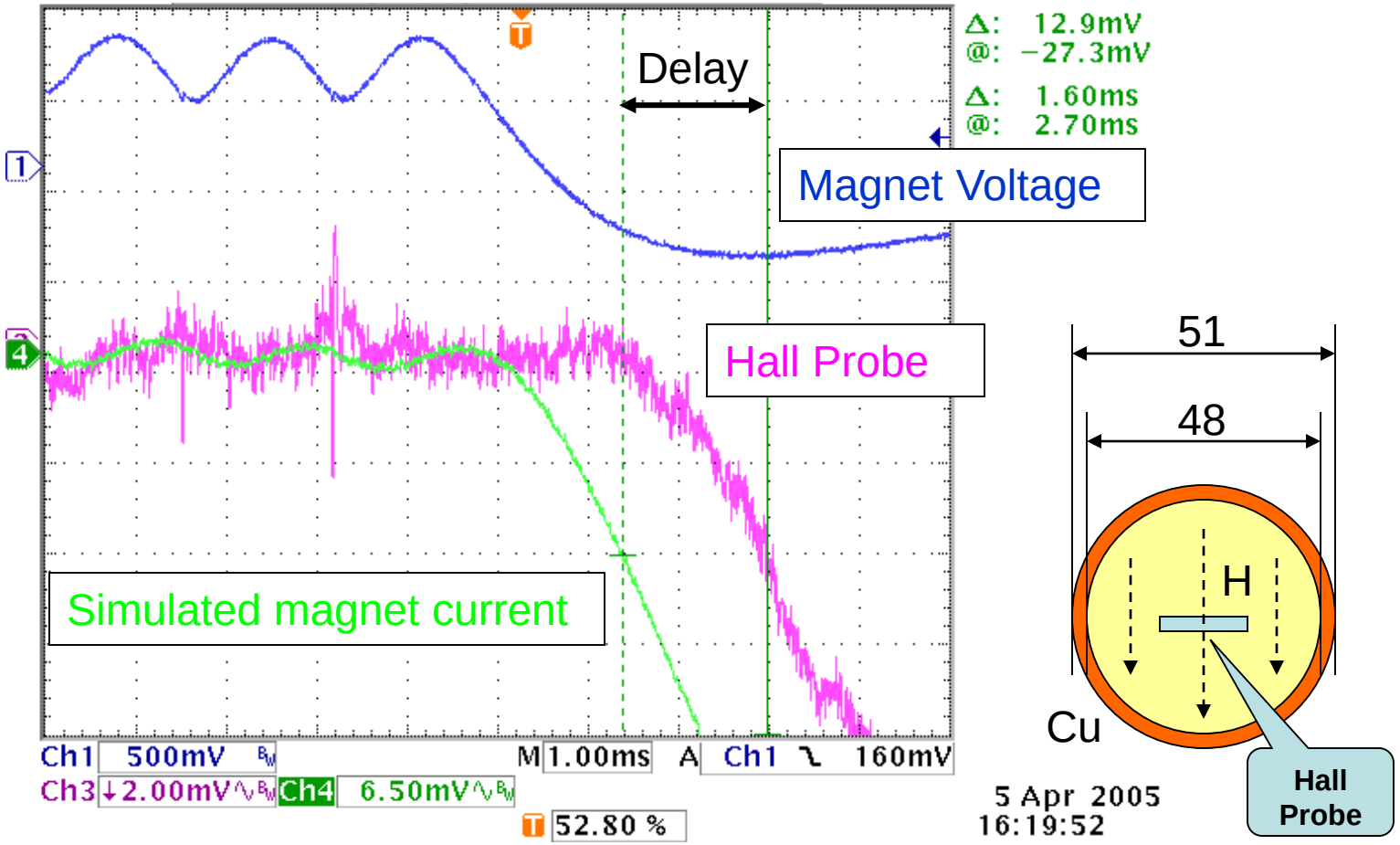
Noise comparison

Switch off D1 magnet



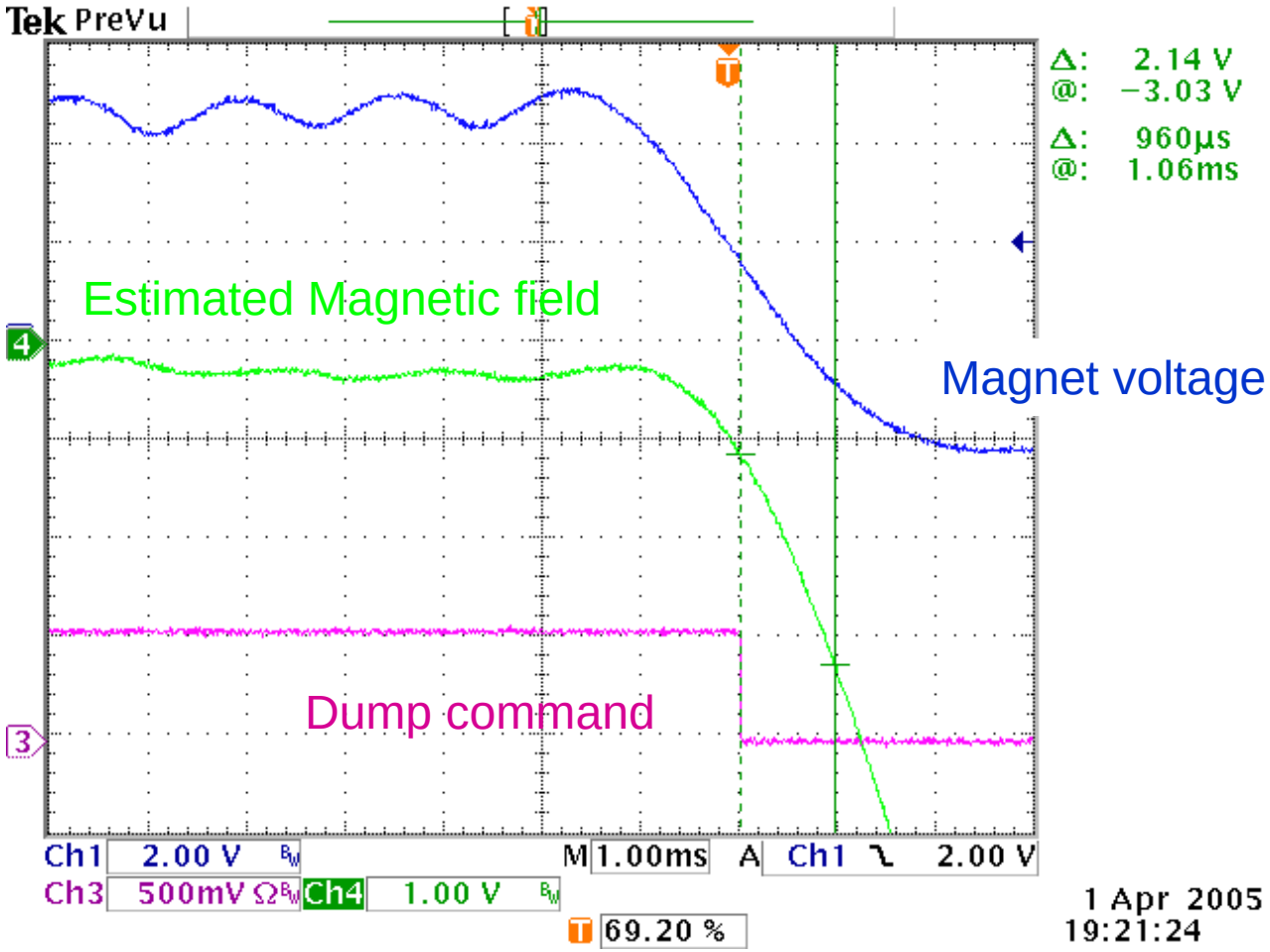
Delay by eddy currents

D1 magnet switched off, Hall Probe in copper tube

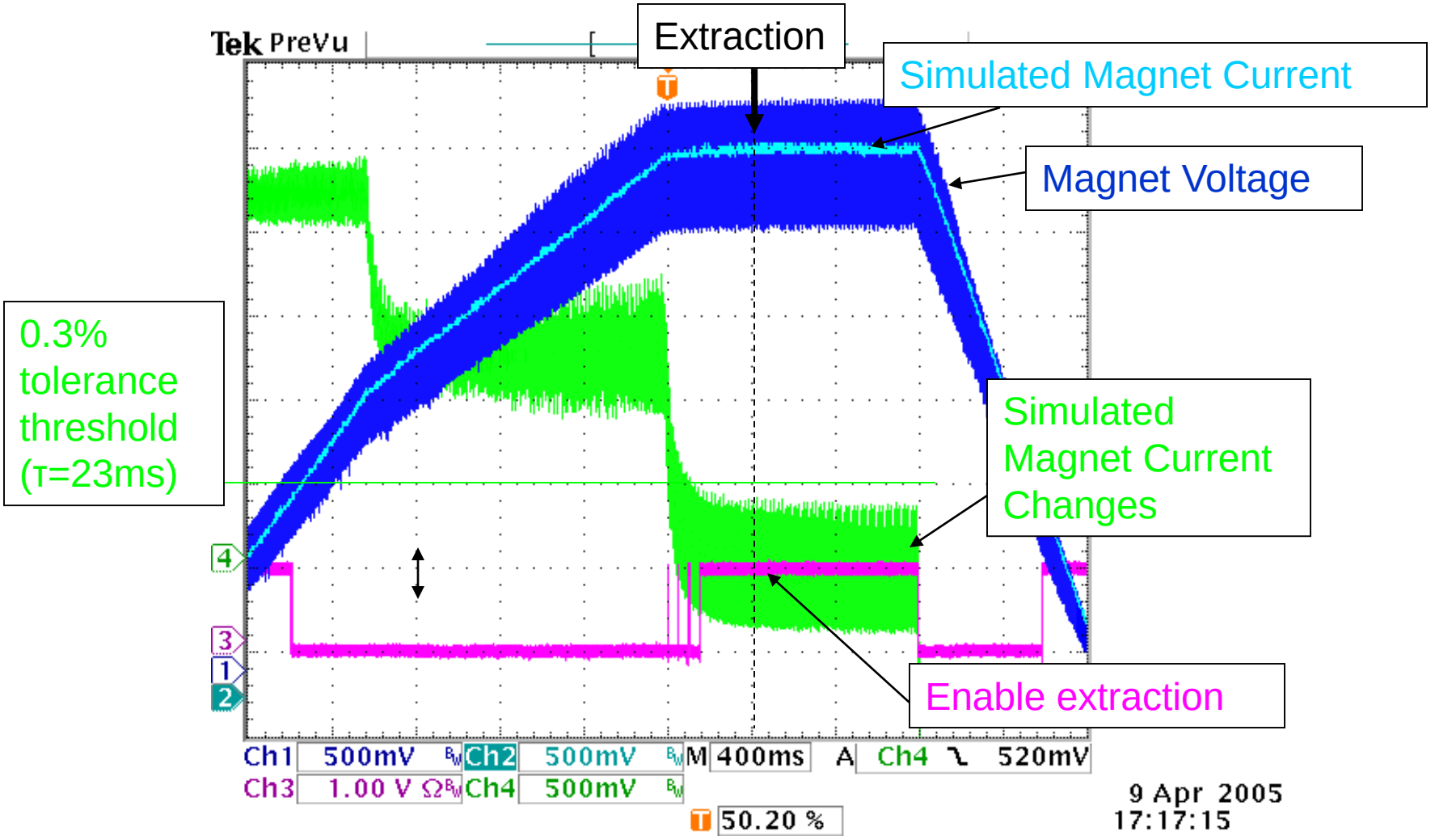


Reaction time: D1 power off

Time at D1: Recognition until damage

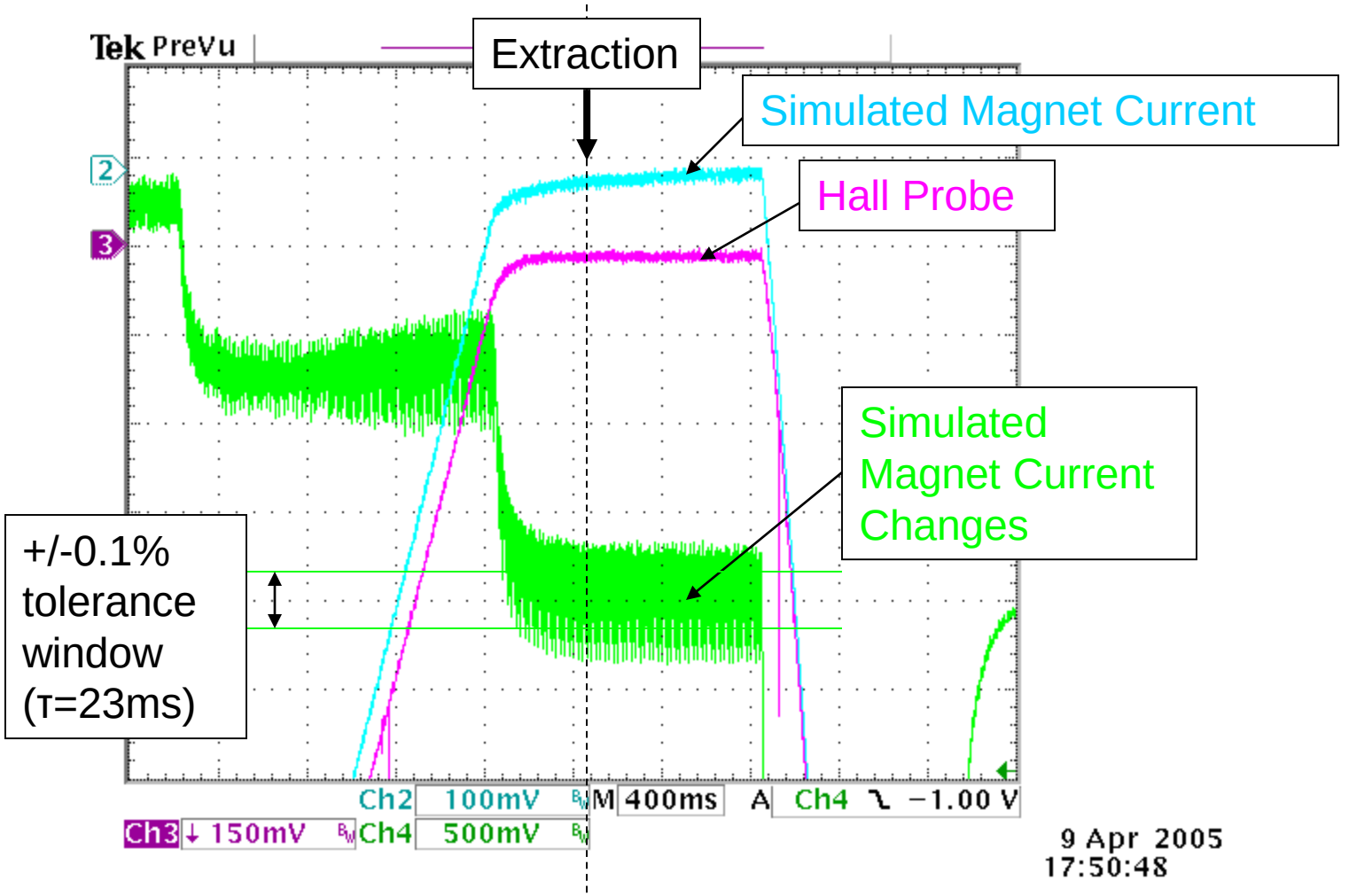


Extraction inhibit



Temperature effect

Sim. Mag. Current drifts upwards due to 12..15C(?) Temp. change during flat top



Different demands for D1 and MSE

	D1:	MSE:
Transients:	… can create “false beam dumps” – very annoying	… will only inhibit extraction for one cycle – no problem
History buffer:	… triggered only after fast current change – normally not the case	… triggered at every extraction
Sensitivity:	… limited by power converter ripple and “false beam dump” probability	… limited by power converter ripple and temperature rise during pulse

Control system interface

Main commands:

- Read history buffer (different for continuous and pulsed magnets)
- Read min/max values (different for continuous and pulsed magnets)
- Read threshold
- Activate dump/inhibit output

Proposed RS-422 Interface:

- Command: 1 character + 3 parameters + checksum
- Data: 2 byte header + integer values + checksum

What next ?

To do soon

- Decision: Use FMCCM for LHC magnets and / or injection?
- If yes: Use same hardware as DESY?
- If yes:
  - Decision who will produce it
  - Decision who will test it
  - Decision about control system interface (RS-422? Protocol?)
  - Decision if EMC test necessary
  - Decision who will design and produce the control system interface hardware (daughterboard or external connector? Modify rear panel to include interface connector?)
  - Decision who will design the interface inside the FPGA
  - Decision who should define the console screen layout and functions
  - Decision who will do the commissioning
  - Definition of the responsibilities, interfaces
  - Define Milestones

To do after decisions

- Implement RS-422 protocol:
  - Byte Serializer / De-serializer with start/stop/parity bit generator/checker
  - Checksum generator and checksum checker
  - State machine for command receiver and answer message generator
- Modify history buffer:
  - Different trigger points, different resolution, different recording length (cont.: 8000, pulsed: 4000) and different data creation (cont.: sample, pulsed: min + max) for continuous and pulsed magnets.
  - Min/Max-Generation for history buffer of pulsed magnets.
  - Add control system access to data
- Recognition if continuous or pulsed magnet
- Recognition of serial number if desired
- ADC offset compensation
- Meetings / Mails with software people
- Test software to check remote control
- Design RS-422 daughterboard, check layout, check prototype
- Documentation for hardware and FPGA functionality

Open questions

- Ripple specification for MSE magnet: 4E-4: peak or peak-peak?
- Ripple specification for D1 magnet
- Water cooling for pulsed magnets: timing behavior?
- Avoid undershoot of magnet voltage at switch off?
- Equalize thyristor firing to decrease 50 and 100 Hz ripple?
- Give extraction trigger to FMCCMs for pulsed magnets for remote minimum / maximum check?

Alarm delay of power converters

- At least for the few power converters connected to the FMCCM, in the case a power converter shuts down because of an internal recognized failure, the power converter itself should issue a dump / inhibit command **before** the FMCCM can recognize the magnet current decrease. This increases the safety and will result in more detailed dump origin and less complex dump sequence analysis.

Remember:

- The minimum / maximum recognition must be different for continuous and pulsed magnets
- The impedance of the dump/inhibit loop must be low enough to avoid unnecessary additional delay – value has to be specified
- If a trigger for the history buffer for MSE is desired, the interface must be defined.