GEM
UF/PNPI HV system

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GEM HV system main features

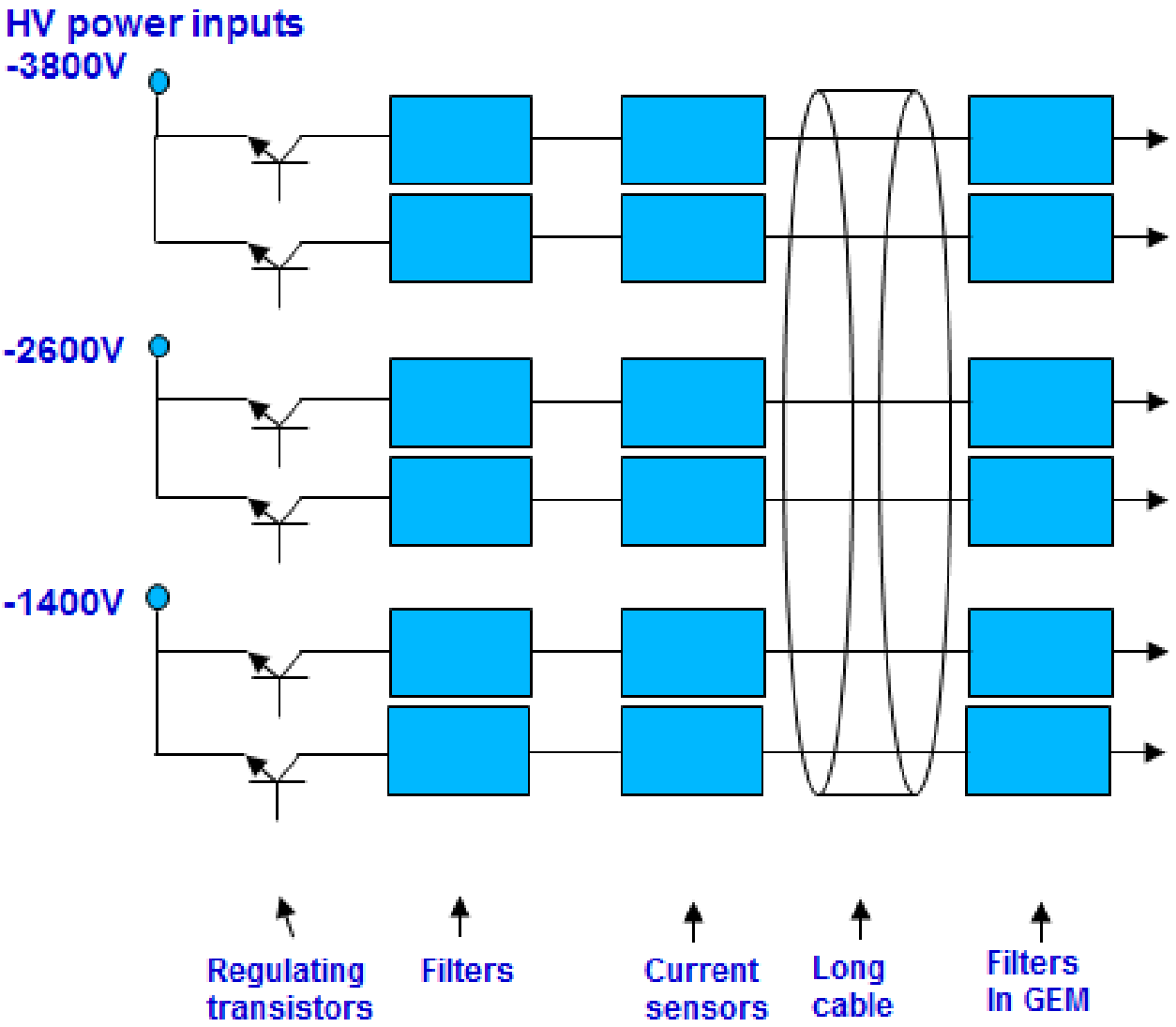
- Each voltage input powered from its own regulator
  - Voltages are individually adjustable
  - Voltages and Currents are measured on each channel
  - Over-, undervoltage, overcurrent protection on each channel
- Complex chamber protection scenarios possible
  - Example 1:
    - Voltage difference between any two foils must not exceed X volts.
  - Example 2:
    - In case of overcurrent on a segment, first reduce the voltage by X volts, wait for Y seconds, if overcurrent does not disappear, reduce voltage by Z volts, etc.
- GEM segment ganging will be needed to reduce channel count

Segment ganging options

- In order to reduce HV output count, segments on segmented layers have to be ganged in groups
- Each group is powered from one HV output
- Each segment in a group powered via its own resistor
- Maximum segment capacitance requirement still followed

Voltage (V)	All foil segments unganged	Ganging 9 + 9 + 9 + 9 + 11	Ganging 16 + 16 + 15	All 47 foil segments ganged together (baseline)
-3760	1	1	1	1
-2860	47	5	3	1
-2410	1	1	1	1
-2060	47	5	3	1
-1620	1	1	1	1
-920	47	5	3	1
-500	1	1	1	1
HV Outputs per chamber	145 (not realistic)	19	13	7
HV Outputs in system	20880 (not realistic)	2736	1872	1008

Block schematics



Prototyping plan

- Build the following modules:
  - One Distribution board
  - One Master board
- Status:
  - Distribution board: a few channels assembled and working
  - Buying parts for one complete board now
- Master board:
  - Buying parts now
  - Based on existing design

Master board (left)

Distribution board

Conclusions

- Prototyping in PNPI is in good shape
- GEM should create a target specification for its HV system

Important:

- If UF/PNPI system is selected, then:
- GEM chamber design has to be adapted for UF/PNPI HV system

Necessary changes:

- Because each segment group is powered from its own regulator:
  - Resistive divider should be removed
  - Each group of segments should be connected to its own HV wire
  - These wires should be attached to a multi-pin HV input connector
  - See table on page 2 for the HV pin count per chamber

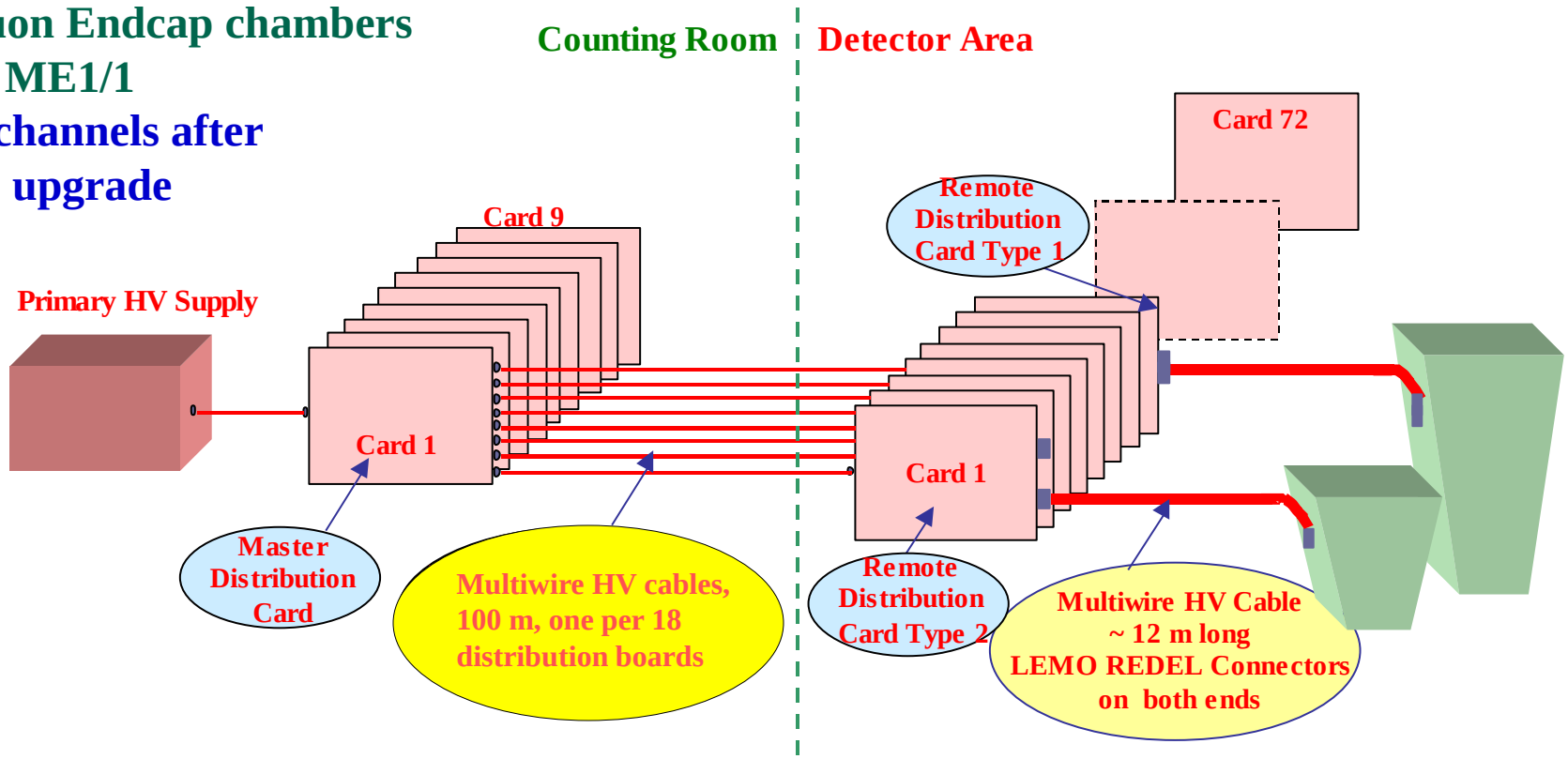
Test plan:

- Prototype will be ready in September-October 2014
- For a meaningful test, we'll need a chamber prototype designed as shown above
- UF can share the cost of such chamber prototype construction

Backup

UF/PNPI HV system architecture

All Muon Endcap chambers except ME1/1
11016 channels after ME4/2 upgrade



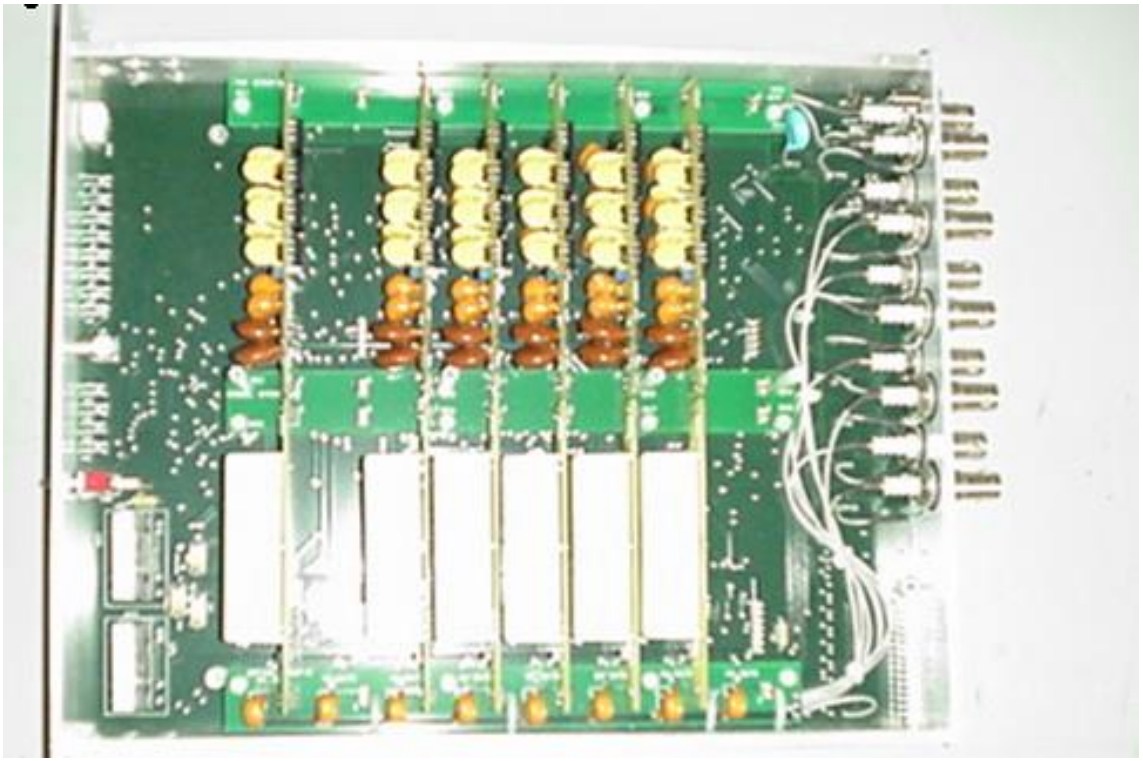
- **Primary HV power supplies: off the shelf**
- **Master board: One output per distribution board. Regulates voltage 0-4KV (VMAX), measures current on each output.**
- **Remote Distribution board: powers one large or two small chambers (36 outputs max). Regulates voltage 1KV down from VMAX, measures current on each output. Each output can be disconnected from HV if necessary.**

Primary HV Power supply

- Off the shelf unit
- Matsusada AU type
- Up to 5KV output
- 60 mA
- Control : RS-232
- Overcurrent protection
- Door switch
- Floating output

Master board

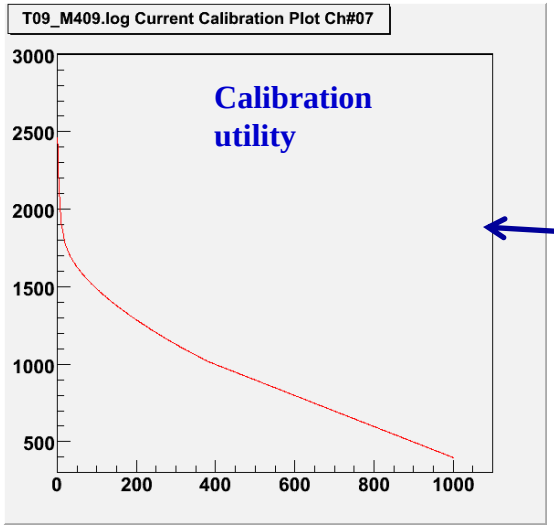
- 8 channels
- Full range regulators 0-4KV
- Up to 1.5 mA per channel
- NOT rad-hard
- Located in S1 (control room)
- Voltage and current measurement on each channel

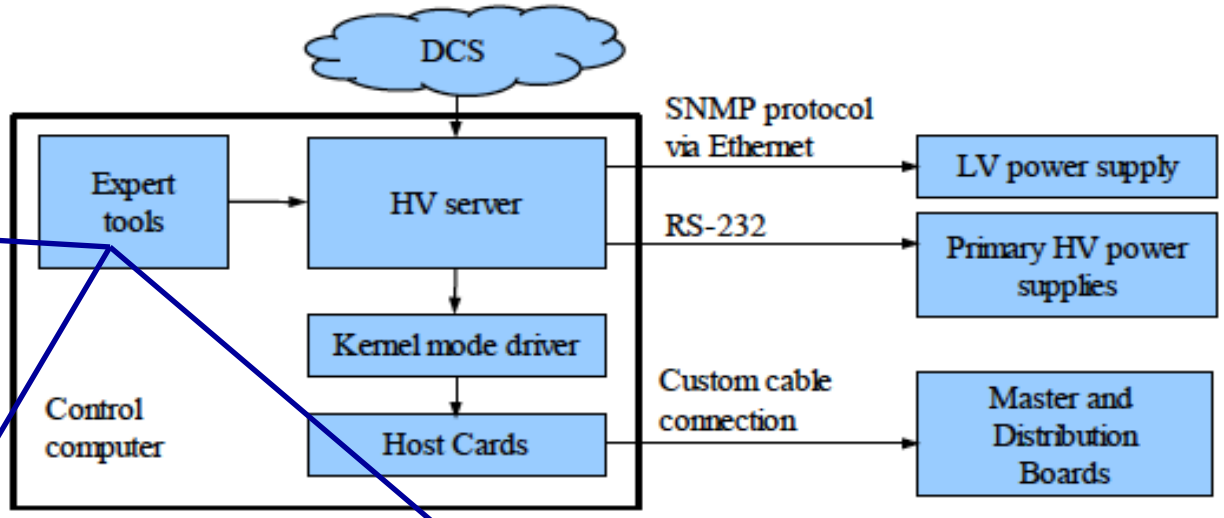


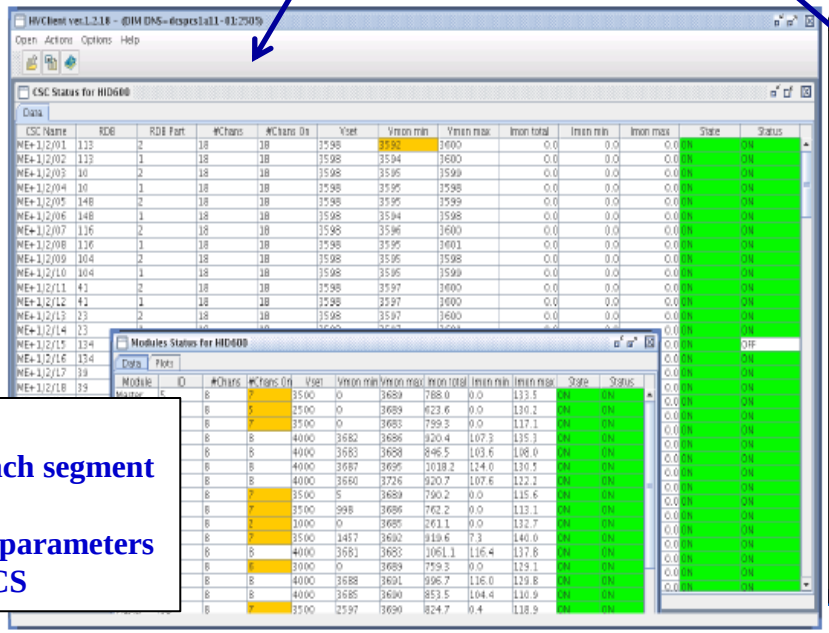
Distribution board

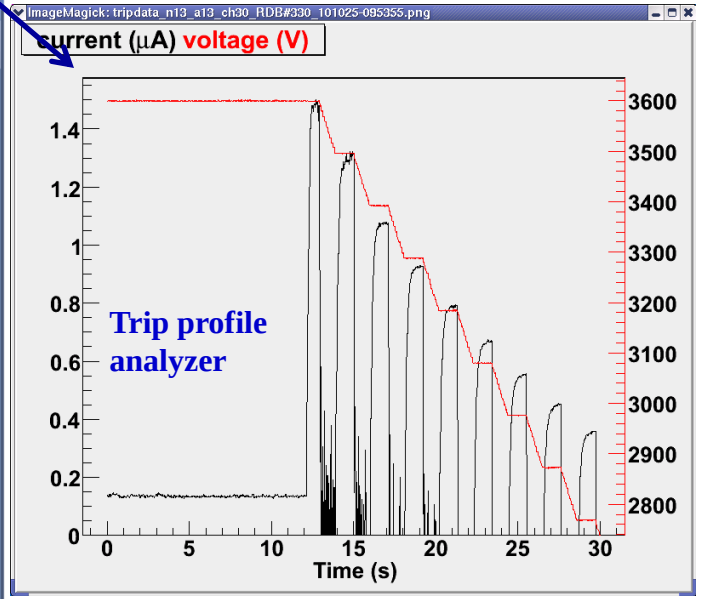
- Up to 38 channels
- Partial range regulators (~1KV down from input V)
- Each channel can be disconnected from load
  - Remote-blow fuse
- Up to 100 uA per channel
- Rad-hard, magnetic field-tolerant
- Located in UXC (CMS cavern), near disks
- On each channel:
  - Voltage and current limit programmable
  - Voltage and current measurement
- Voltage resolution:
  - ~1V
- Current measurement resolution:
  - 100 nA

Software









Expert GUI (Java)
Shows V and I on each segment in each chamber
Lets you control all parameters independently of DCS

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Safety

Purposes

- Safety of the personnel
- Protection of the end-loads
- Protection of system components

Fail-safe devices:

- Interlocks
  - All long cables
- Primary HV PS overvoltage protection
  - Remove PHVPS AC power in case of overvoltage
- Hardware watchdog
  - Monitors main control software loop activity
  - Turns PHVPS off if activity is missing for ~10 sec
  - Protects against:
    - software bugs
    - computer hardware failure
    - computer power cut-off
- Overvoltage and overcurrent protection on each output channel
  - All thresholds programmable
- Dead or disconnected board detection