

# **GEM UF/PNPI HV system**

**V. Barashko, A. Korytov, A. Madorsky, G. Mitselmakher  
University of Florida/Physics**

**N. Bondar, V. Golovtsov, P. Levchenko, L. Uvarov,  
S. Vavilov, S. Volkov  
St. Petersburg Nuclear Physics Institute (PNPI)**



# 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



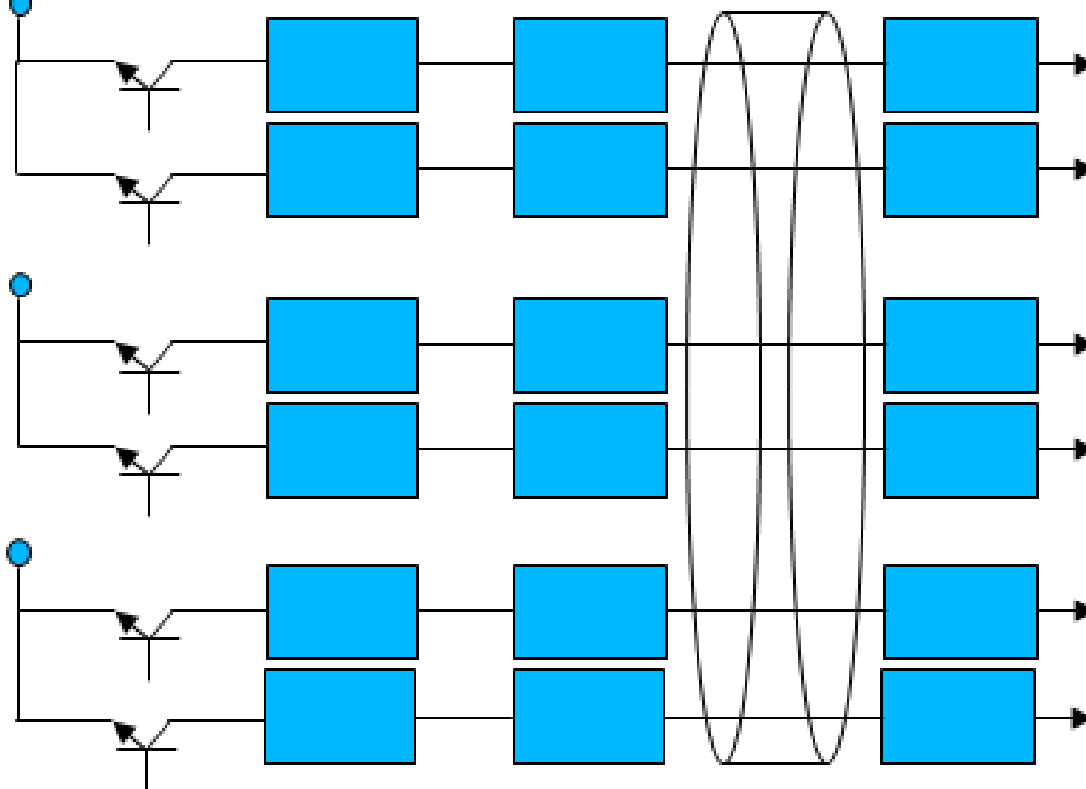
# Block schematics

HV power inputs

-3800V

-2600V

-1400V



↑  
Regulating  
transistors

↑  
Filters

↑  
Current  
sensors

↑  
Long  
cable

↑  
Filters  
In GEM



# 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

**Distribution board**



**Master board (left)**





# 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



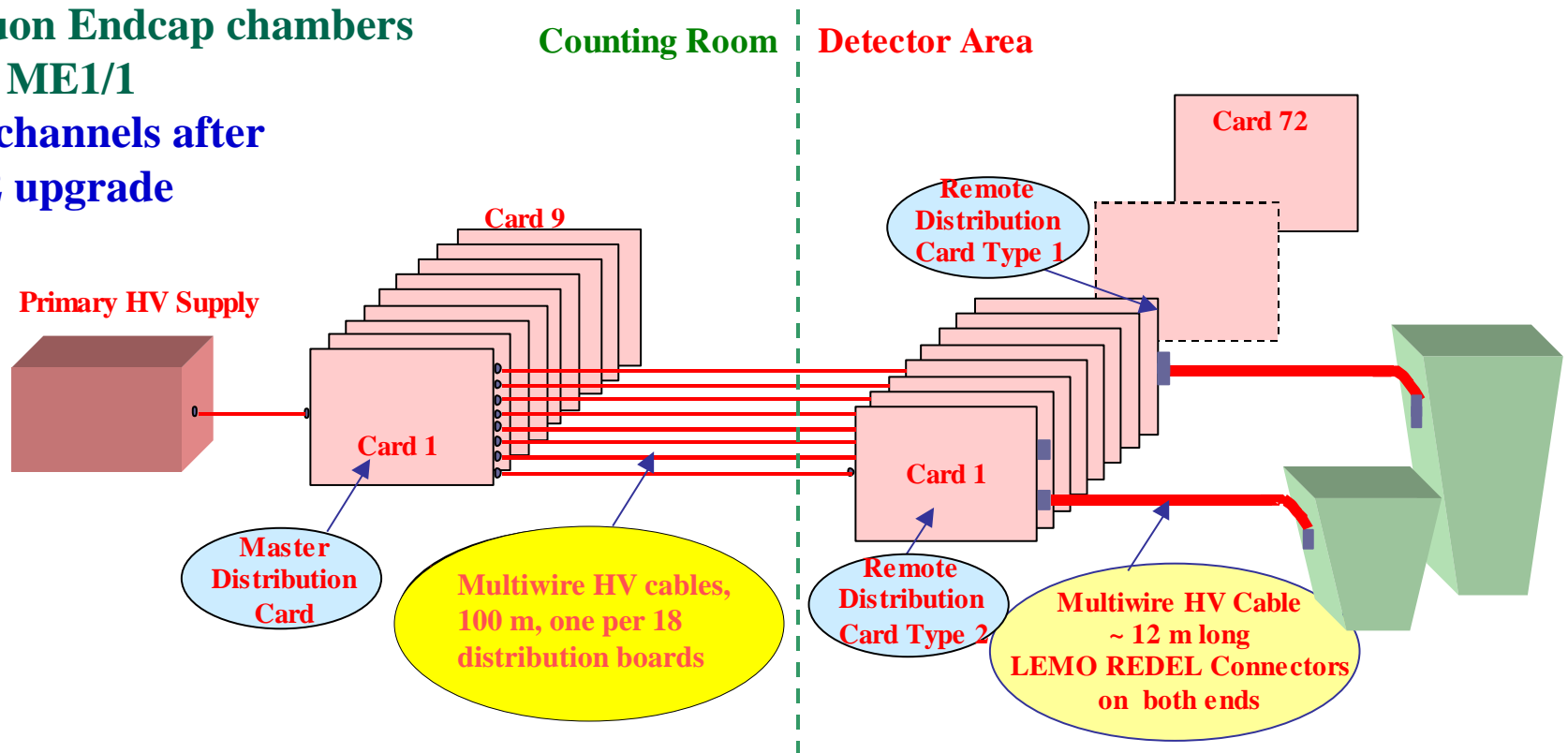
# Backup



# 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

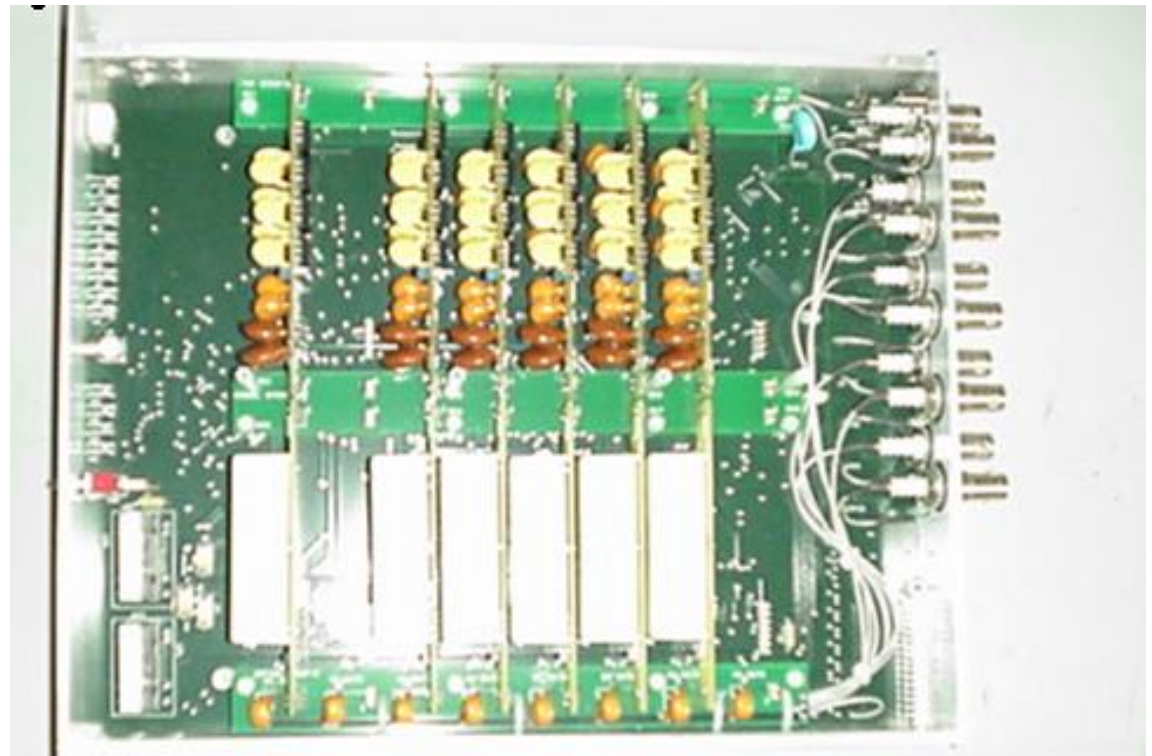
- Off the shelf unit
- Matsusada AU type
- Up to 5KV output
- 60 mA
- Control : RS-232
- Overcurrent protection
- Door switch
- Floating output





# 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

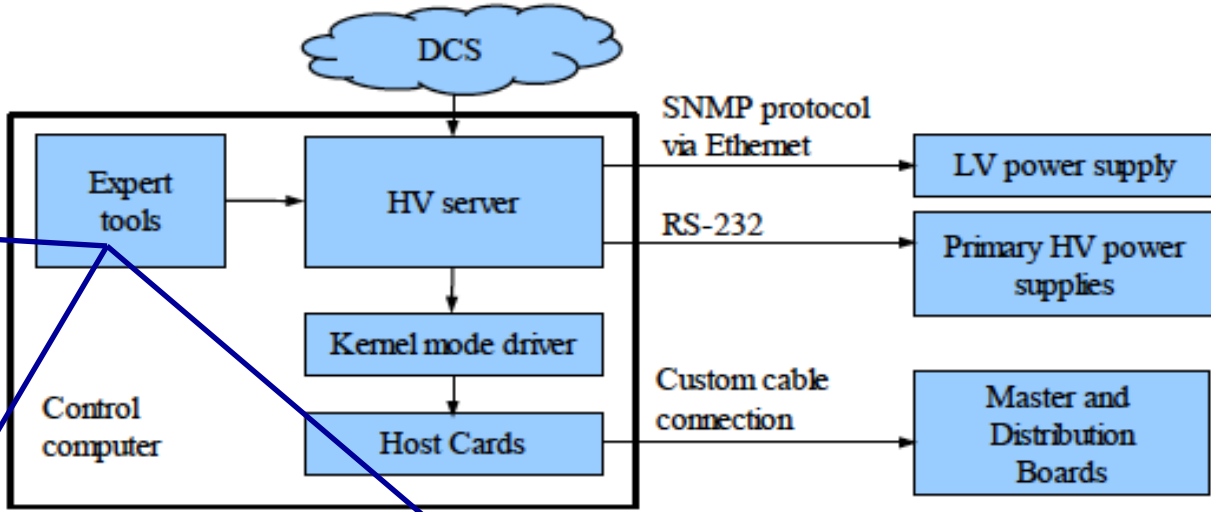
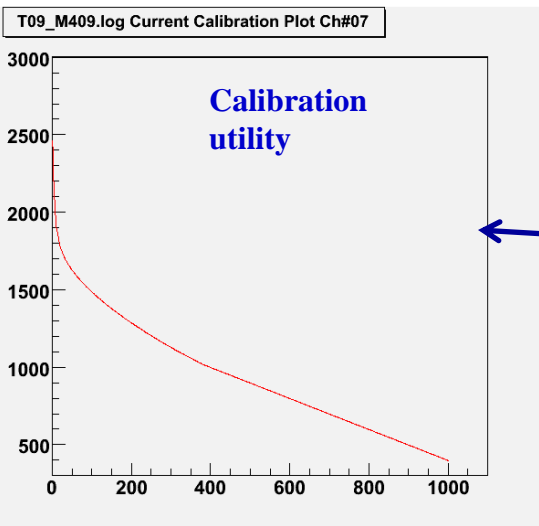


- Up to 38 channels
- Partial range regulators (~1KV down from input V)
- Each channel can be disconnected from load
  - ❖ Remote-blow fuse
- Up to 100 uA per channel
- Rad-hard, magnetic field-tolerant
- Located in UXC (CMS cavern), near disks
- On each channel:
  - ❖ Voltage and current limit programmable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





# Software



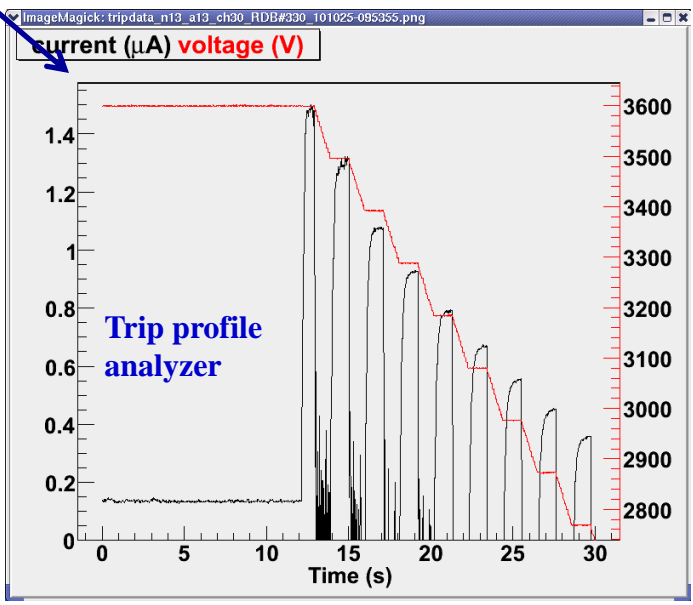
HVClient ver.1.2.18 - @IM DNS=desp1a11-01.250%

CSC Status for HD600

CSC Name	RDB	RDB Part	#Chars	#Chars On	Vset	Vmon min	Vmon max	Imon total	Imon min	Imon max	Stare	Status
ME+1/2/01	133	2	18	18	3598	3592	3600	0.0	0.0	0.0	ON	OK
ME+1/2/02	133	1	18	18	3598	3594	3600	0.0	0.0	0.0	ON	OK
ME+1/2/03	10	2	18	18	3598	3595	3590	0.0	0.0	0.0	ON	OK
ME+1/2/04	10	1	18	18	3598	3595	3598	0.0	0.0	0.0	ON	OK
ME+1/2/05	148	2	18	18	3598	3595	3590	0.0	0.0	0.0	ON	OK
ME+1/2/06	148	1	18	18	3598	3594	3598	0.0	0.0	0.0	ON	OK
ME+1/2/07	116	2	18	18	3598	3596	3600	0.0	0.0	0.0	ON	OK
ME+1/2/08	116	1	18	18	3598	3595	3601	0.0	0.0	0.0	ON	OK
ME+1/2/09	104	2	18	18	3598	3595	3598	0.0	0.0	0.0	ON	OK
ME+1/2/10	104	1	18	18	3598	3595	3590	0.0	0.0	0.0	ON	OK
ME+1/2/11	41	2	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/12	41	1	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/13	123	2	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/14	123	1	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/15	134	2	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/16	134	1	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/17	139	2	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK
ME+1/2/18	139	1	18	18	3598	3597	3600	0.0	0.0	0.0	ON	OK

Modules Status for HD600

Module	ID	#Chars	#Chars On	Vset	Vmon min	Vmon max	Imon total	Imon min	Imon max	Stare	Status
B	1	3500	IO	3659	3688.0	0.0	133.5	0.0	0.0	ON	OK
B	2	2500	IO	3689	423.6	0.0	130.2	0.0	0.0	ON	OK
B	3	3500	IO	3683	799.3	0.0	137.1	0.0	0.0	ON	OK
B	4	4000	3682	3686	820.4	107.3	135.3	0.0	0.0	ON	OK
B	5	4000	3683	3658	846.5	103.6	108.0	0.0	0.0	ON	OK
B	6	4000	3687	3695	1039.2	124.0	130.5	0.0	0.0	ON	OK
B	7	4000	3680	3726	920.7	107.6	122.2	0.0	0.0	ON	OK
B	8	3500	S	3659	790.2	0.0	115.6	0.0	0.0	ON	OK
B	9	2500	398	3686	762.2	0.0	113.1	0.0	0.0	ON	OK
B	10	1000	IO	3685	1011.1	0.0	122.7	0.0	0.0	ON	OK
B	11	3500	1457	3692	819.6	7.3	140.0	0.0	0.0	ON	OK
B	12	4000	3681	3683	1061.1	116.4	137.8	0.0	0.0	ON	OK
B	13	3000	IO	3689	759.3	0.0	119.1	0.0	0.0	ON	OK
B	14	4000	3688	3691	996.7	116.0	119.8	0.0	0.0	ON	OK
B	15	4000	3685	3690	853.5	104.4	110.9	0.0	0.0	ON	OK
B	16	3500	2597	3690	824.7	0.4	118.9	0.0	0.0	ON	OK



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



# 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