

# **HVM\_CMS**

## **Multi-channel Power Supply System**

### **UF/ PNPI**

#### **Abstract**

A current approaching of High Voltage Distribution and Monitoring System (hereafter named HVM\_CMS) is described. The system allows current and voltage monitor on each output. The primary HV power supply feeds the HV distribution boxes via long distance cables. The number of cables is minimized, since HV distribution boxes are placed just close to detector. The system allows linear voltage regulation on each distributed output.

## 1. Introduction

The HVM\_CMS system is the fully equipped version of power supply system, which represent US\_CMS latest proposal in the matter of high voltage power supplying. This system is under design for EMU chambers of CMS experiment according to MOU between PNPI and US\_CMS [1].

The specific features of HVM system are:

- Custom design;
- Allows I monitor on each output with less than 100 nA precision;
- Allows V monitor on each output with  $\pm 1V$  precision;
- Three levels of HV regulation
  - System level. Up to 2582 channels can be common regulated within 4000 V in  $\pm 1$  V step
  - Chamber level. Up to 36 channels can be common regulated within 4000V in  $\pm 1V$  step
  - Segment level. Each individual channel can be independent regulated within 2000V in  $\pm 1$  V step
- 19"- wide, 6U –high euro-mechanics racks for HV distribution boxes;
- Remote readout, control and supply;
- Extremely low cost.

Fast, accurate set-up and monitoring of system parameters (12-bit resolution on Voltages and Currents) is available for each host interface. The parameters can be controlled either via PC motherboard links or via Ethernet. Programmable handling of parameters and errors is available as well. Channel trip control is performed via HVM\_CMS serial bus. A sophisticated trip handling software allows to control and correlate trip conditions. The problematic channel can be even disconnected by remote control of burn-through fuse.

## 2. Short System Description

The HVM\_CMS system overview is shown in Fig.1.

The Mainframe and Distribution Box are the basic parts of the entire system. The Mainframe is located in counting room. The Distribution Box placed just near detector.

The Mainframe is housed in a 19" rack and hosts three main sections:

- the Primary High Voltage Power Supply;
- the Master Linear Regulator and Monitor;
- the Host Processor.

The Primary HV Power Supply is able to feed up to eight independent Distribution Boxes. The system level of the voltage regulation and monitoring is available for the Primary HV Power Supply. The Master Linear Regulator and Monitor both useful to provide the chamber level of the voltage regulation and monitoring. It also provides a fan-out from 1 HV input to 72 HV outputs. The Host Processor includes all interface facilities for the internal and external system communication. It allows the data to be readout from the system and control constants to be downloaded to the system. The remote Distribution Boxes are able to generate the programmable high voltages to the chamber segments, thus the segment level regulation and monitoring is available. Each Distribution Box is providing the fan-out from 9 inputs to up to 324 high voltage

outputs. There are the Fuses, which can be burned through using remote command to have the problematic segment completely disconnected.

A block scheme of the HVM\_CMS System is shown in Fig.2. There are Primary HV Power Supply, LV Power Supply, Host Processor, Host Card, Master Distribution Card and eight Remote Distribution Cards.

### **2.1. Primary HV Power Supply**

The Primary HV Supply is an industrial unit, which is developed as rack mount option. It allows different options depending on the number of channels. The total current is calculated as  $n \times 40 \mu\text{A}$ , where  $n$  – number of channels per Primary HV Supply. The voltage regulation and monitoring is provided by the Host Processor control using USB-CPIB adapter. The minimum system configuration consists of the Primary Power Supply, one Master Distribution Board and one Remote Distribution Board.

### **2.2. Host Processor**

The Host Processor is developed on the standard PC Motherboard. The system parameters can be controlled and monitored either via traditional built-in links (USB, RS232) or via Ethernet. The high-speed PCI Bus is developed to provide the system interface to the Distribution Cards.

### **2.3. Host Card**

The Host Card includes the system interface facilities. The PCI Interface performs all communications between Internal Bus and PCI Bus. The Buffer Memory is used for data buffer to be read-out from Serial Bus to Internal Bus and list of constants to be downloaded to Serial Bus. The Sequencer performs all control actions for electronics circuitry of the Distribution Cards. The Serial Bus Interface performs all communications between Internal Bus and Serial Bus. Up to 16 Distribution Cards can be connected to one Serial Bus controlled by Host Card.

### **2.4. Master Distribution Card**

The Master Distribution Card is able to control and supply up to eight independent Remote Distribution Cards. The Master Distribution Card delivers eight groups of high floating voltages conventionally called Master High Voltage (MHV). Each MHV delivers a positive high voltage in range from 0 to 4000V (1.5 mA max output current). The output voltage and output current can be fixed and monitored by I/ V ADC. The value of output voltage can be regulated using 12-bit DAC and Linear Regulator. The DC/ DC Converter is used to adapt the primary LV input to operating voltage of module. The Fuse Control provides the actions for remote fuses to be burned through if necessary. The Serial Bus Interface connects the Master Distribution Card to Serial Bus for all necessary control, downloading and readout.

### 2.4.1. Master Distribution Card Main Characteristics Table

Max Output High Voltage	4000V
Max Current (HV Channel)	1.5 mA
Voltage Ripple	< 50 mV
Voltage Monitor Accuracy (HV Channel)	$\pm 1V$
Voltage Set Accuracy (HV Channel)	$\pm 1V$
Current Monitor Accuracy (HV Channel)	<100nA
Packaging	240 mm wide 6U-high mechanics

### 2.5. Remote Distribution Card

The Remote Card has two modifications. The first one (Type A) delivers 30 independent high floating voltage outputs. The second (Type B) delivers 36 independent high floating voltage outputs. Output voltages are linearly programmable with 12-bit resolution within 2000 V.

The output voltages and output current can monitor with 12-bit resolution. The Fuses can be burned through using special Serial Bus command.

The DC/ DC Converter adapts the input LV (12V) to operating voltages ( $\pm 5V$ ) of card.

#### 2.5.1. Remote Card Main Characteristic Table

Max Output Voltage	4000V
Max Current (short circuit)	100 $\mu A$
Voltage Ripple	< 10 mV
Voltage Set Resolution	12 bit
Voltage Monitor Resolution	12 bit
Current Monitor Resolution	12 bit
Packaging	520 mm wide 6U-high mechanics

## 2.4. Distribution Box Communication

The Distribution Box Communication is shown in Fig.3.

There is Mainframe consisting of Host Processor Unit, Master HV Power Supply and 6U mechanics Chassis containing one Master Distribution Card. The Distribution Box located close to detector may contain either nine Remote Cards Type 1 or nine Cards Type 2.

### 2.4.1. Master HV Power Supply

There is Matsusada high voltage power supply model AU-5\*120. This is low profile and lightweight rack-mountable option. The output adjustable voltage is 5kV and output power is 600W. The USB- GPIB Adapter is used for Master HV Power Supply control and monitor. It allows the primary HV value to be regulated in full range.

### 2.4.2. Host Processor Unit

The Host Processor Unit housed in IPC-610F chassis optioned by switching LV Power Supply in a single fan-cooled chassis. The IPC-610F is a PC/ AT-compatible computer designed for HVM\_CMS June 2003

industrial application. This rugged all-steel chassis meets with the EIA RS-310C 19" rack-mount standard. The low power supply PS-300 ATX provides 300W output rating for output voltages +3.3V, ±5V and ±12V. The motherboard involves VGA, Ethernet and six PCI slots. One local monitor using the VGA and one remote using Ethernet can be equipped. The software supervisor SCADA is attracted. The PCI slots may be occupied by Host Cards to provide up to six independent serial buses. Each independent serial bus ganged up to sixteen cards.

### 2.4.3. 6U mechanics Chassis

The 6U mechanics chassis is used for Master Distribution Cards installation. Up to nine cards may be installed there to provide up to 72 high floating voltage outputs to eight distribution boxes. One output of Master Distribution Card meets with one input of Remote Distribution Card to be fan-out either to 30 or to 36 outputs.

### 2.4.4. Distribution Box

The Distribution Box located close to detector is the same 6U mechanics chassis. Up to nine Remote Distribution Cards may be installed there to provide either up to 270 (Type 1) or 324 (Type 2) high floating voltage outputs to the chamber segments.

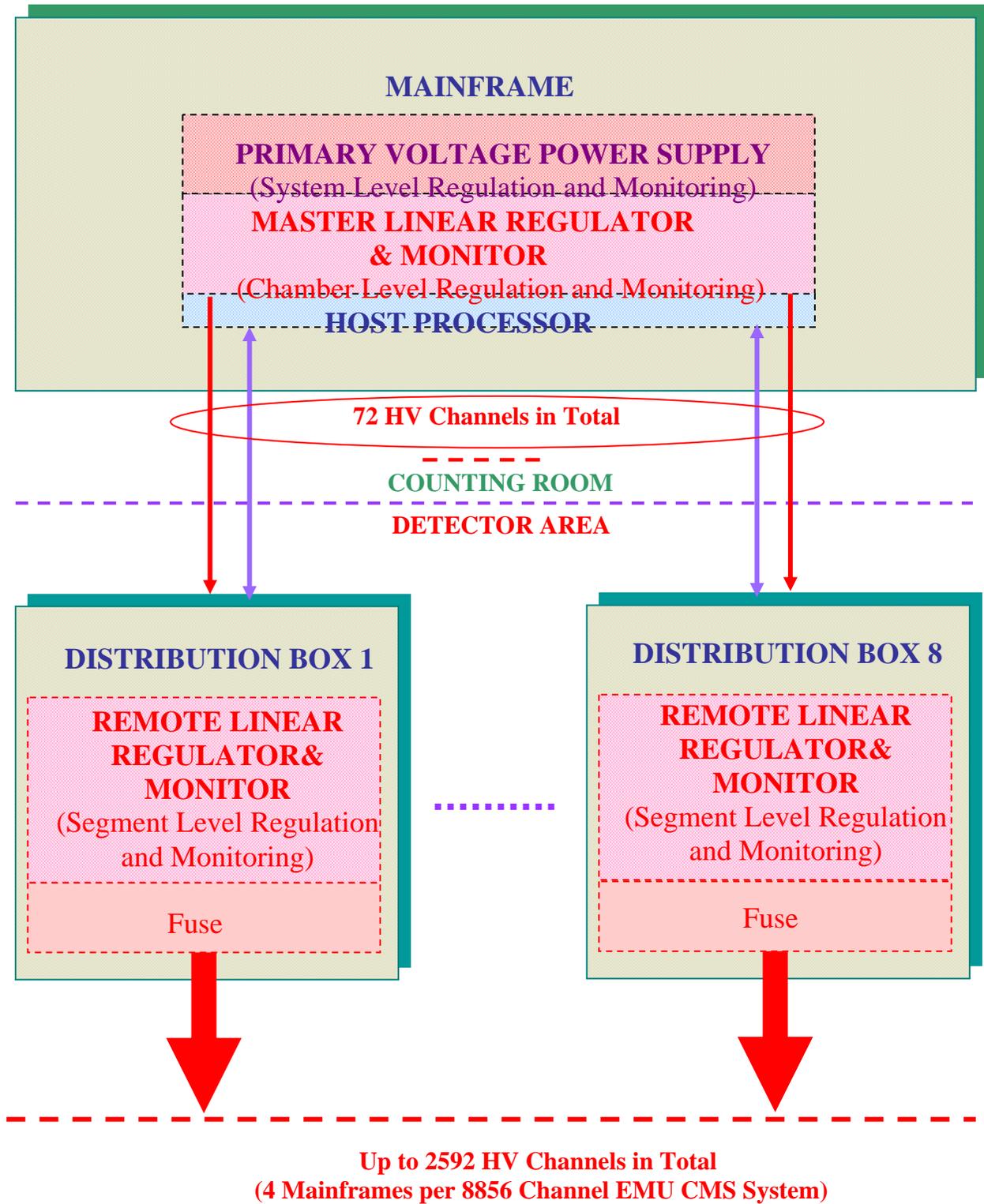
## 2.5. HVM System Approaching

The HVM system approaching for 8856 channels of EMU CMS chambers is shown in Fig.4.

Four rack mount Mainframes are located in counting room. They include four primary HV Power Supplies, four Host Processor Units, twenty-four Host Cards and thirty-four Master Distribution Cards. Thirty distribution boxes are located close to chambers. They include 270 Remote Cards. There are 270 HV cables and 24 readout cables laid out from counting room to close to detector area. The distribution boxes provide 342 multi-wire HV cables (8856 leads) to chamber segments.

## 2.6. Miscellaneous System Parameters

Individual channel turn-off (trip) speed	Less or equal to 10 ms from time of overload condition
Radiation hardness	0.5 Krad $2 \cdot 10^{11}$ n/cm <sup>2</sup>
Connection to SCADA	Yes
Current measurement limits	0 to 100 $\mu$ A
Current measurement resolution	2 nA for current up to 1 $\mu$ A, 100 nA for larger currents
Total output current	40 $\mu$ A x number of channels
Trip level setting step	100 nA
Maximum input voltage, V max	4000 V
Voltage regulation, common for plane	0 to 4000 V
Voltage regulation, each segment	(V max – 2000V to V max)
Voltage regulation step	± 1V
Voltage measurement resolution	± 1V
Ripple and noise	10 mV p-p
Rate of ramp-up, ramp-down	5 to 400 V/sec



*Fig. 1. HVM System Overview*

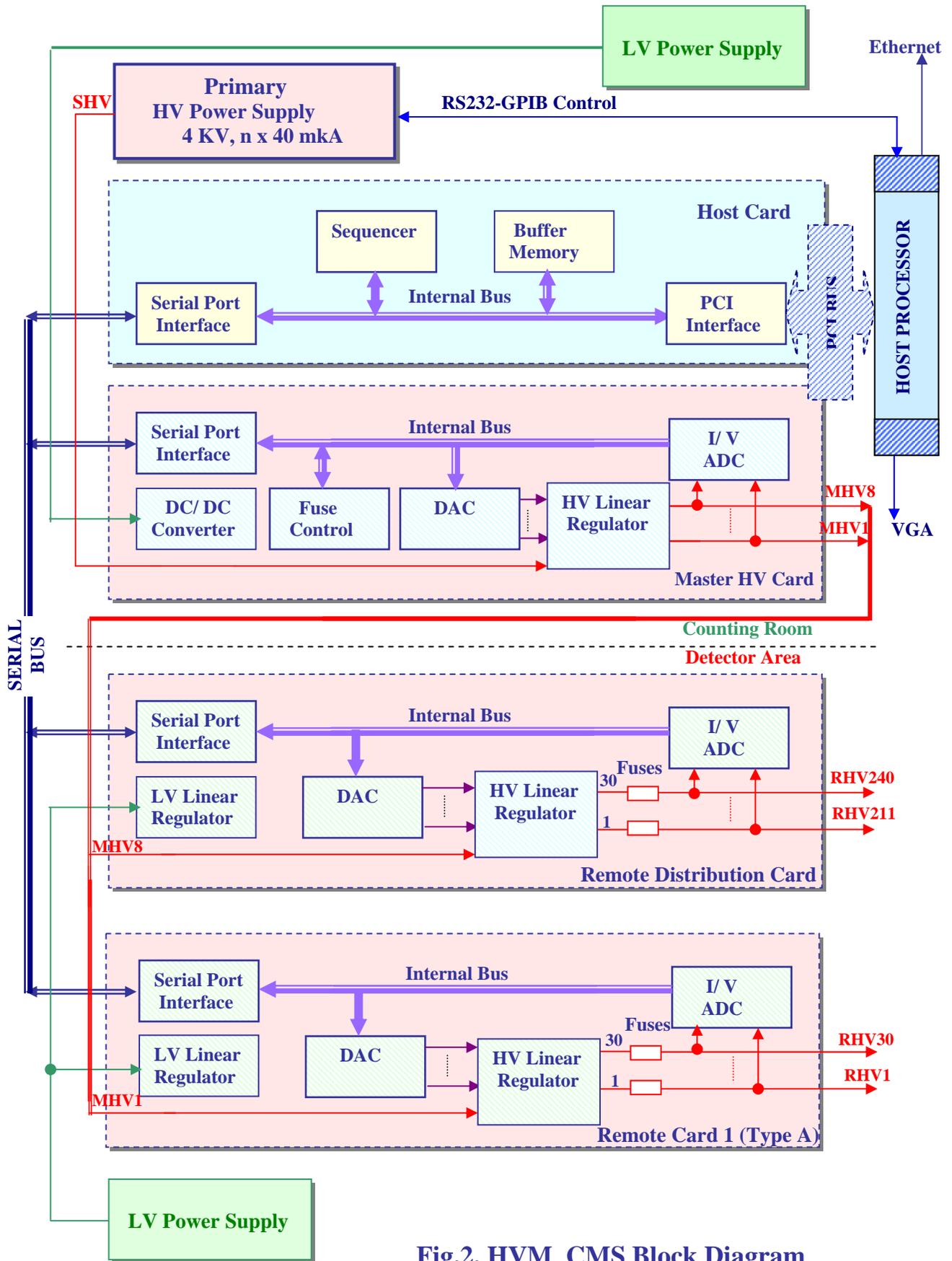
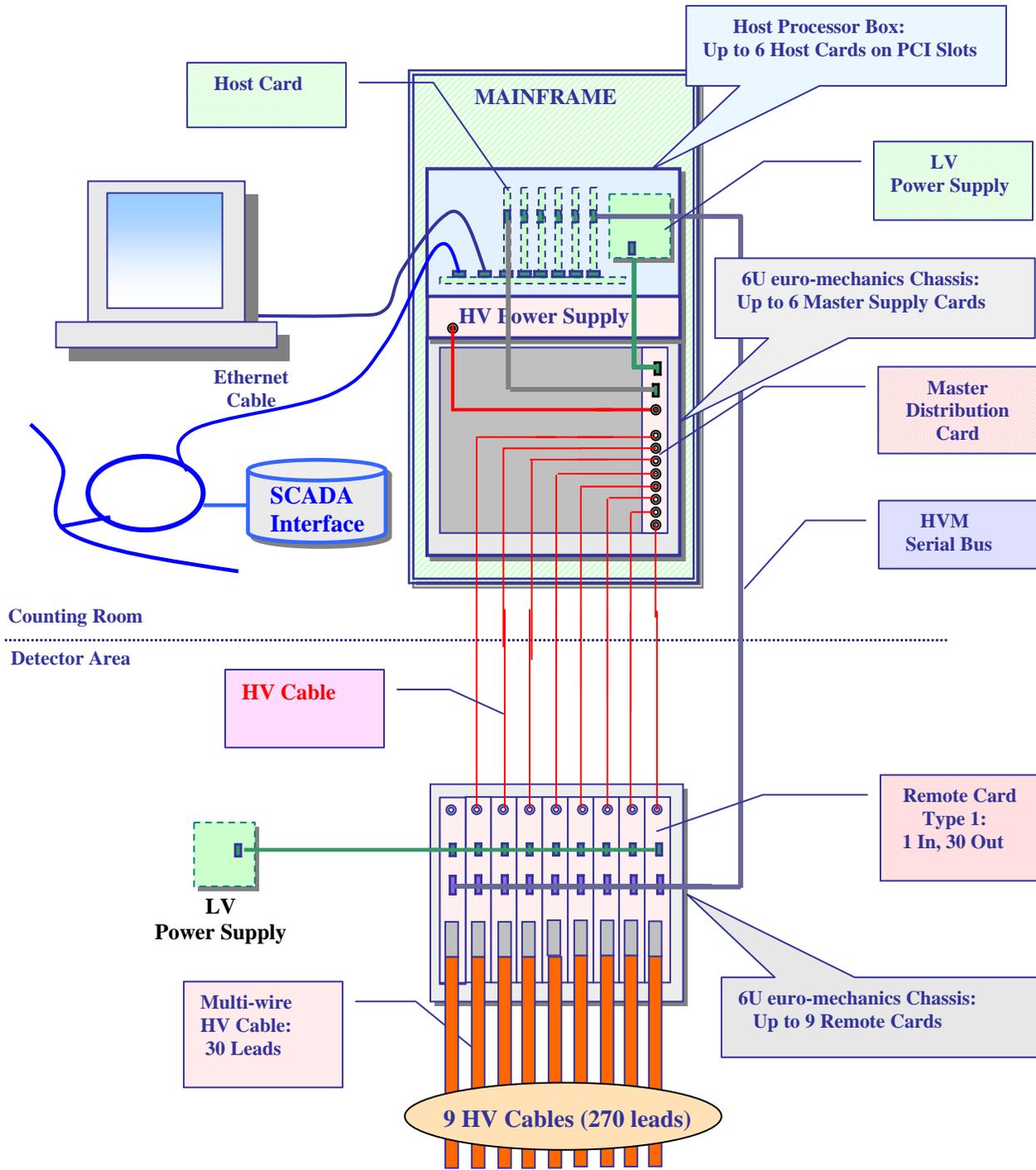
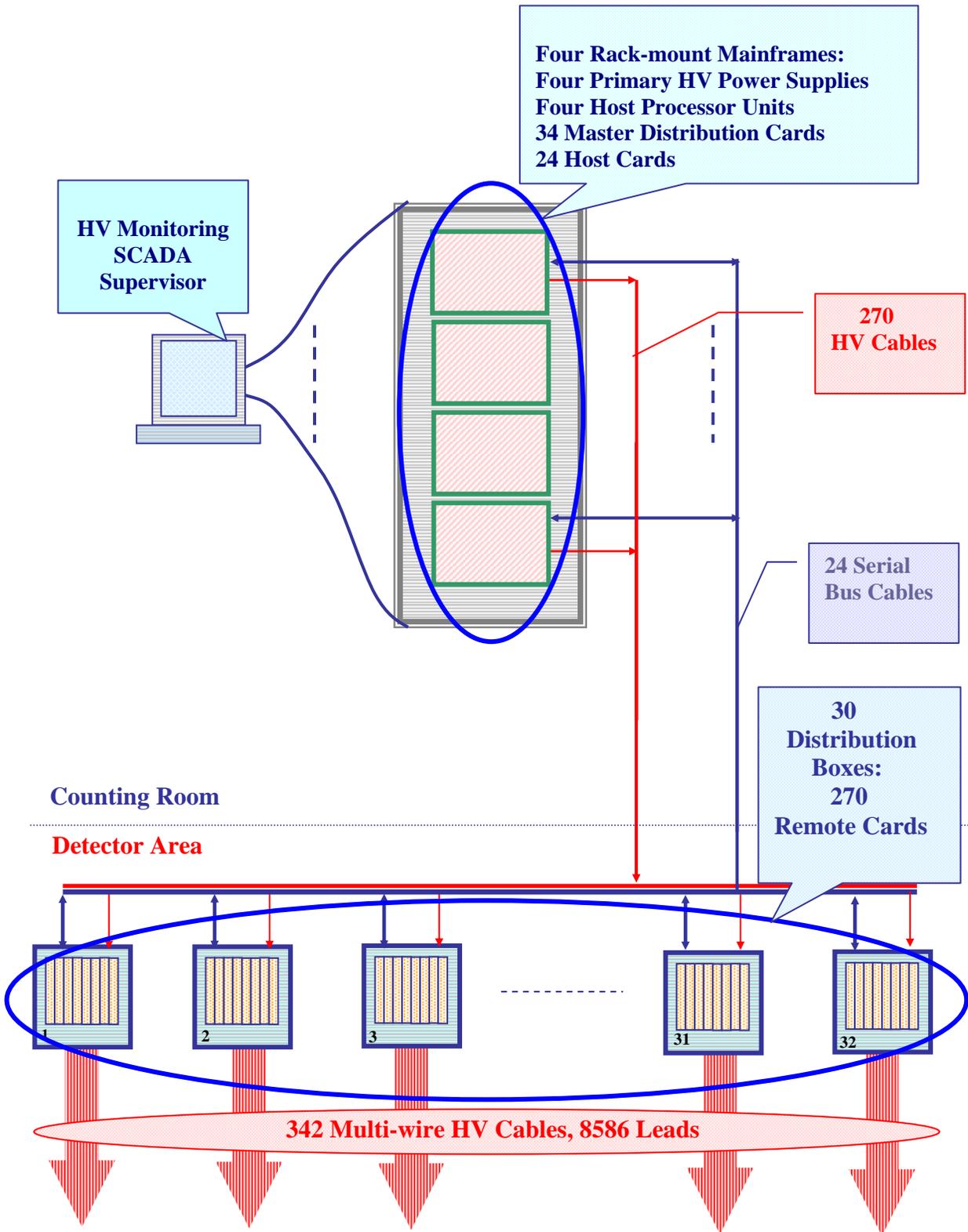


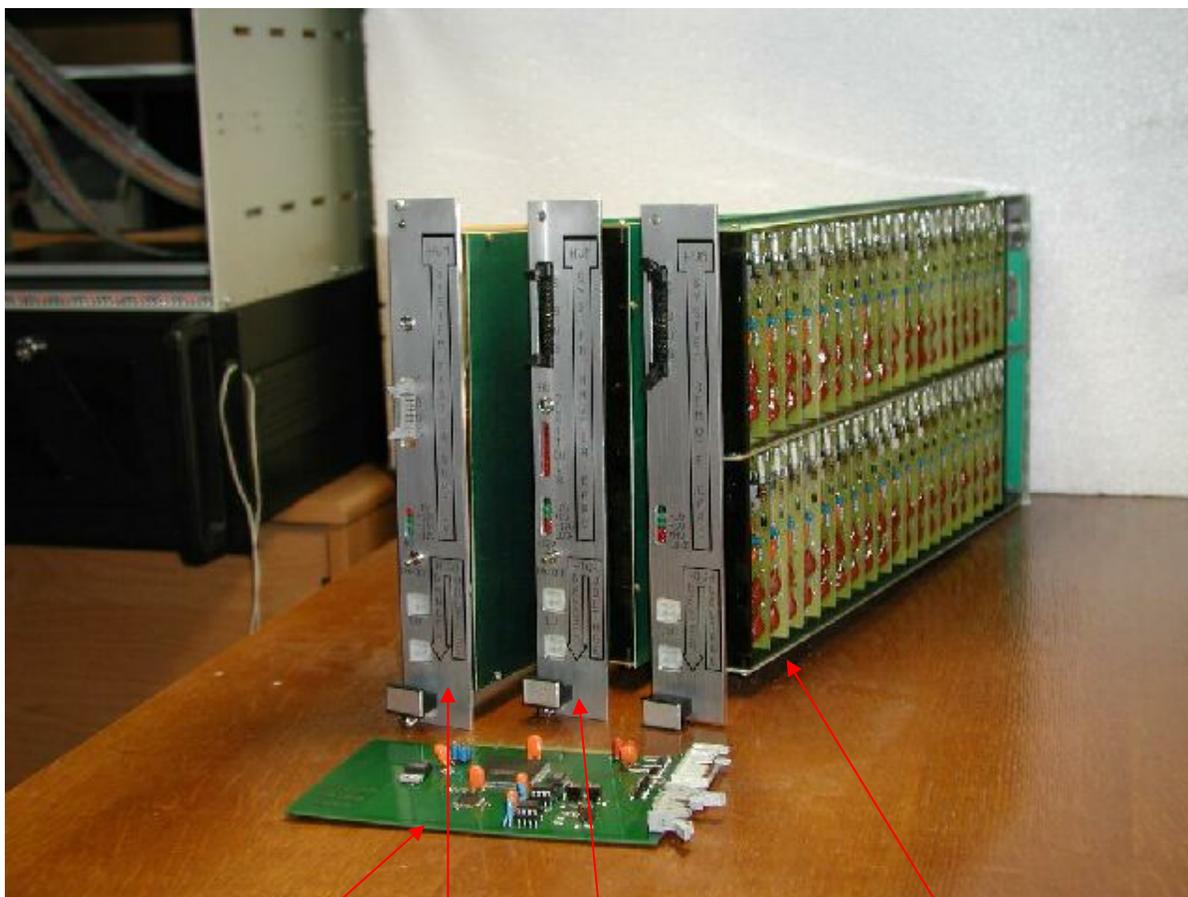
Fig.2. HVM\_CMS Block Diagram



*Fig.3. HVM Distribution Box Communications*



*Fig.4. HVM System Approaching (8208 Channels)*



**HOST CARD**

**REMOTE CARD**

**MASTER SUPPLY CARD**

**HV POWER SUPPLY\***

**\* HV Power Supply is the module for small size system especially. The total current is 2.5 mA.**





**HV POWER SUPPLY  
CONTROLLED BY HOST  
CARD**

**HOST PROCESSOR UNIT  
IPC - 610F CHASSIS  
HOST CARD IS INSTALLED  
ON PCI SLOT INSIDE**

**MASTER DISTRIBUTION CARD,  
REMOTE DISTRIBUTION CARD  
CONTROLLED BY HOST CARD**