THE MUON HV SYSTEM

- Design
- Radiation issues
- Procurement plan

LHCb Muon System

- 5 Stations
- 1368 MWPC + 24 3-GEM
- 4416 gaps M2-M5
- 528 gaps M1
- 4944 gaps total

For safety reasons and operating convenience the ideal solution is to have 4944 channels For MWPC (redundancy, possibility of HV optimization)

Available systems (CAEN and UF/PNPI) not really universal

- in some regions (M1 and M2 inner part) I > 100 uA/channel (no UF/PNPI)
- the commercial system is too expensive to install it everywhere
- Different specs for 3-GEM

Decided for a mixed expandable system:

- UF/PNPI for M2-M5 R3-R4 (1536 → 3840 channels)
- CAEN remaining regions (1104 MWPC + 72 3-GEM)

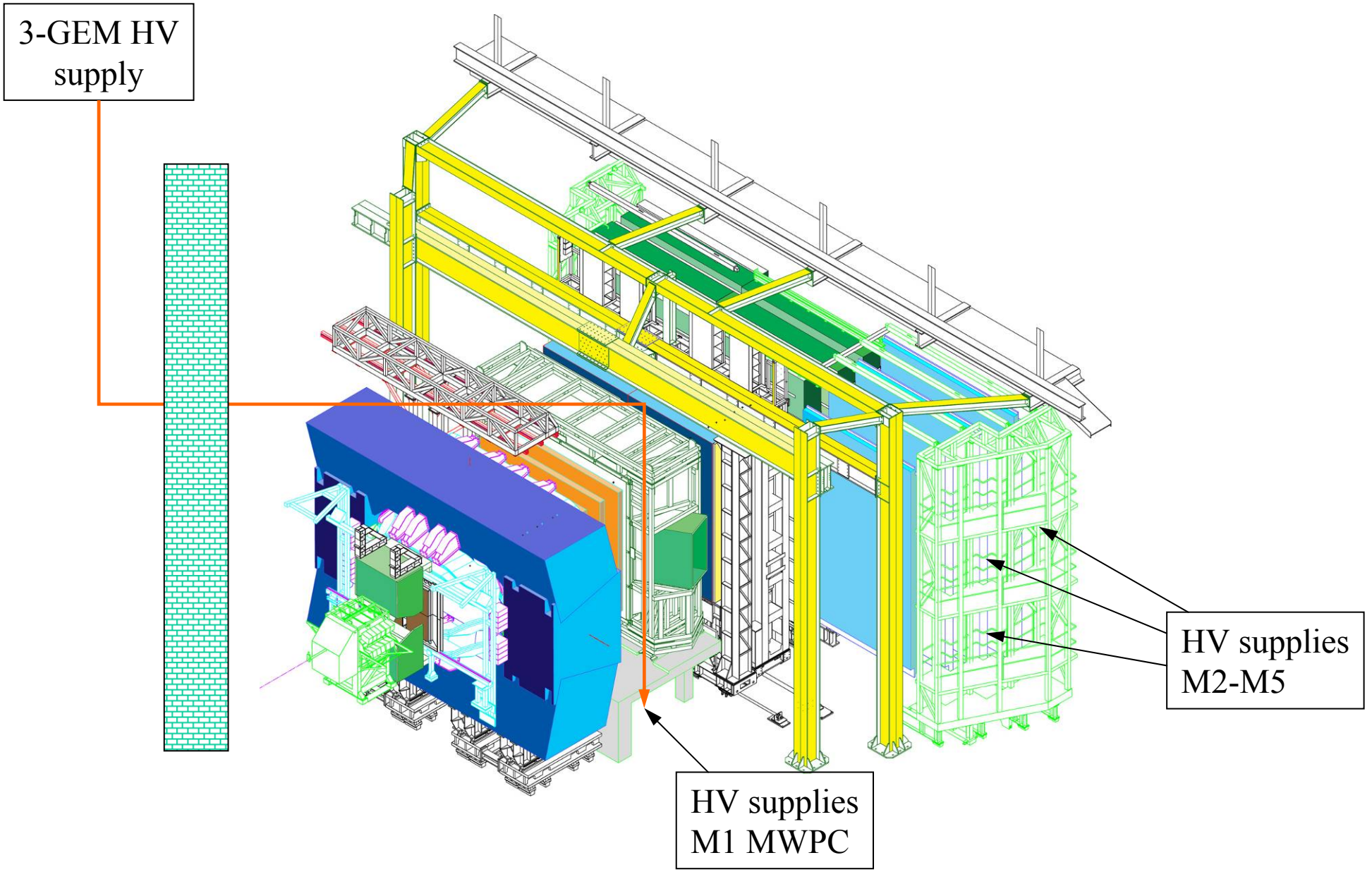
MWPC HV Power Supply requirements

a) Max voltage: + 3 kV
b) Voltage resolution: 10 V or better
c) Current per channel 230 μA at most (on M1R2)
d) Current resolution: 50 nA or better (to spot bad chambers)
e) Switch off of the single HV channel
f) Radiation hardness
(for systems inside the exp. area) 50 Gy

Currents in mA per gap

	M1	M2	M3	M4	M5
R1	GEMs	0.107	0.028	0.021	0.016
R2	0.228	0.078	0.015	0.010	0.009
R3	0.169	0.041	0.006	0.005	0.006
R4	0.068	0.010	0.004	0.002	0.003

Based on 5 10^{32} luminosity and safety factors (x2 in M1, x5 in M2-M5)


3-GEM HV supply
HV supplies M2-M5
HV supplies M1 MWPC

MWPC HV installed in two phases

- All cables are installed on detector since the beginning (4944 channels)
- In Phase 1 the R4 chamber gaps are grouped 1:4 (UF/PNPI system)

  ↳ The grouping is achieved via Patch Panels (1536 ch)

- For Phase 2 PNPI will provide additional 2304 channels
- The crates for the new PNPI channels will replace the Patch Panels

The CAEN system is fully installed from the beginning (1104 channels)

Responsibilities: CERN-PNPI (UF/PNPI) and INFN (CAEN Easy)

Customization

- HV modules are customized for our needs

  ↳ use of custom cheap HV connectors for M2-M5

Advantages of HV supplies on detector

No expensive long HV cables
Patch panels minimized (only in Phase 1)
↘ cheap connectors
Simpler cabling

For remote HV one needs

- many long (100 m) multiconductor (37-52) cables
- @ about 750 CHF per cable + connectors
- (Patch panel ass'y not included)
- > 100 kCHF overhead
- Space issue: more than 140 cables needed

The MWPC system in a nutshell

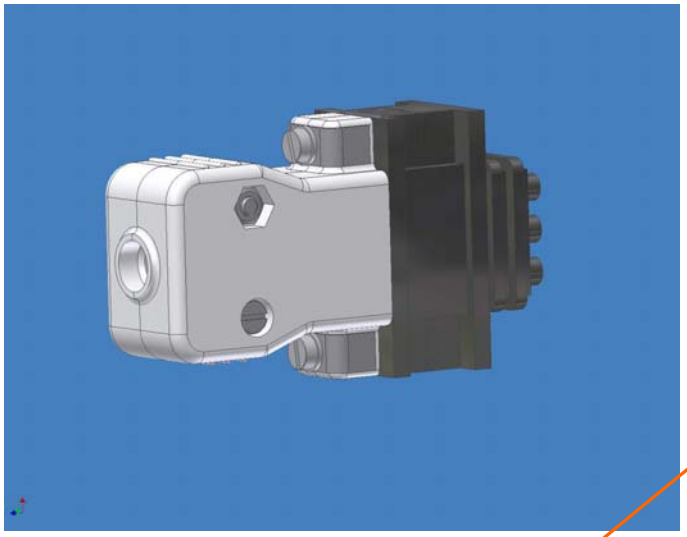
UF/PNPI
Master Modules (barrack)
Master HV and LV (barrack)
Distributor modules (detector)
1 Distributor 36 channels
1 crate 6U 9 distributors = 324 ch
HV supplied to distributors

CAEN
Branch Controller (barrack)
Master LV (barrack)
HV modules A3535P 32 channels (detector)
1 crate 6U 5 HV modules (M1)
1 crate 6U 7 HV modules (custom connectors M2-M5)

108 ↑ 44 needed

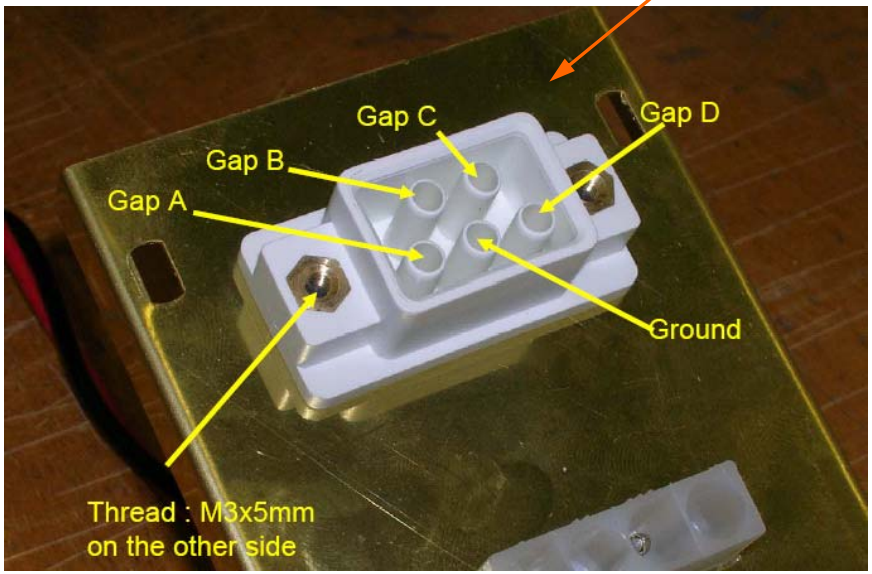
18 + 18 (M1) needed

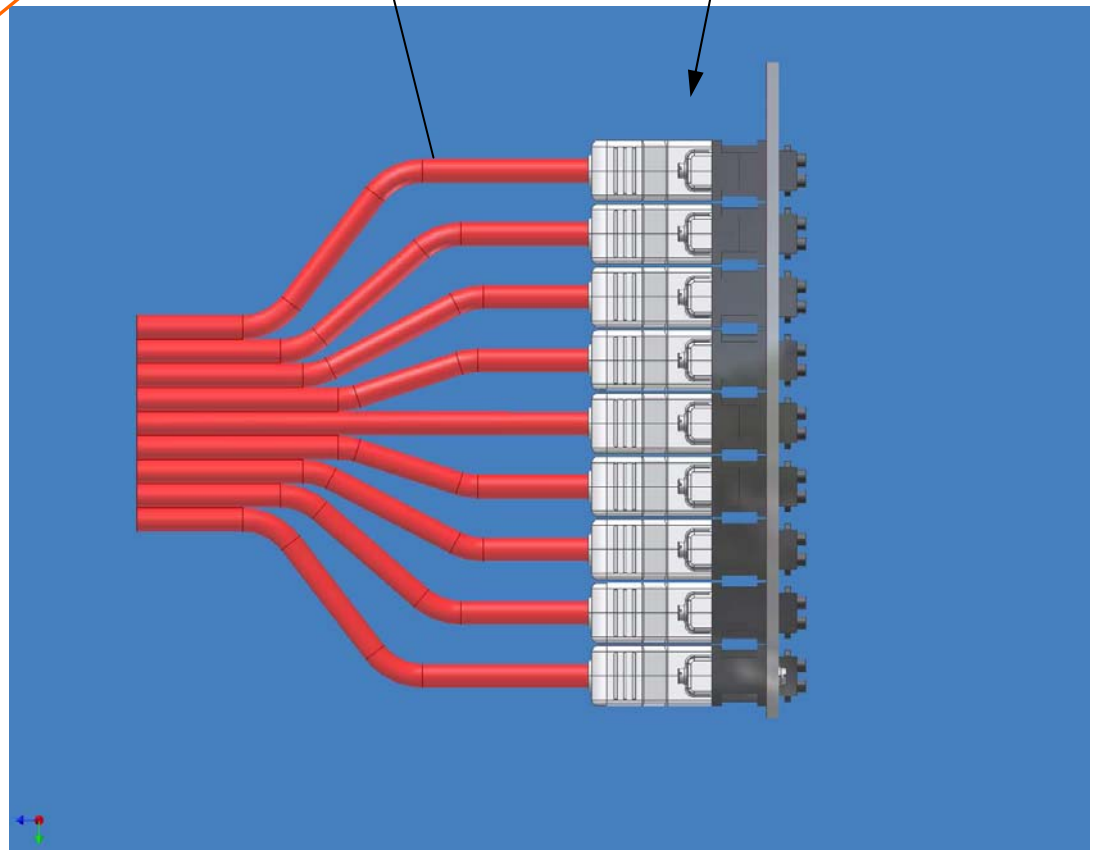
Both radiation-resistant

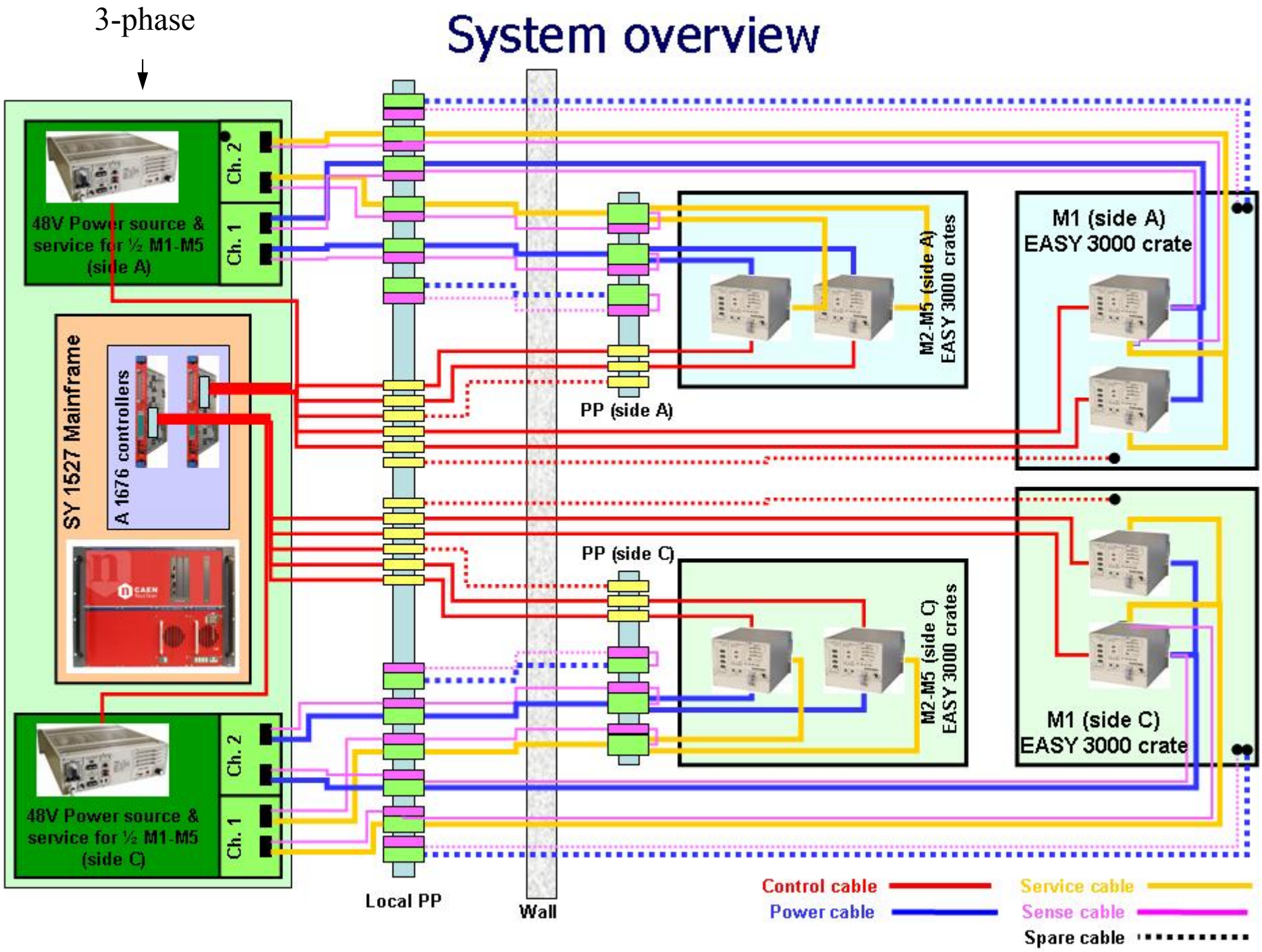


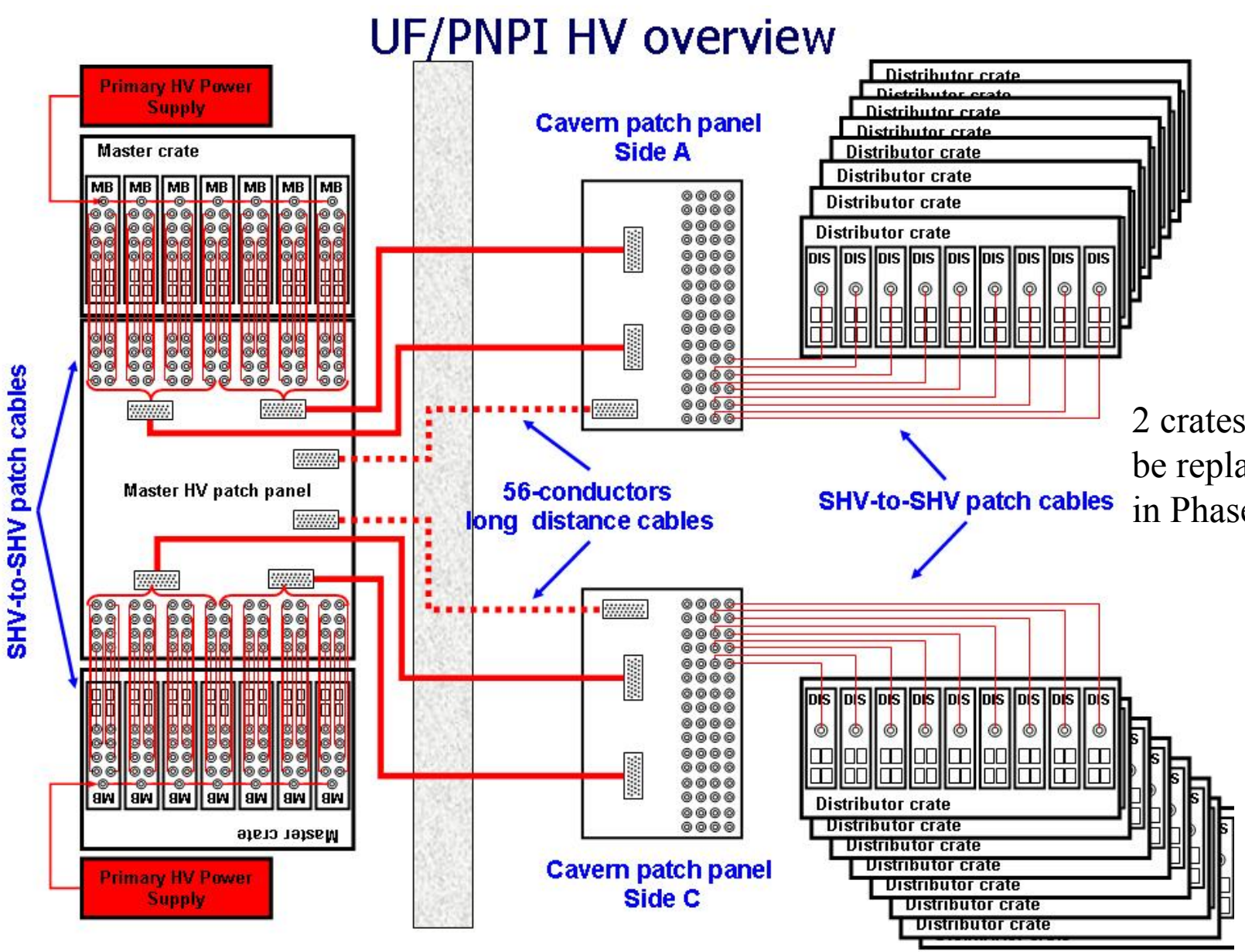
One cable
per chamber

UF/PNPI module
9x4 = 36 channels
CAEN Easy
8x4 = 32 channels



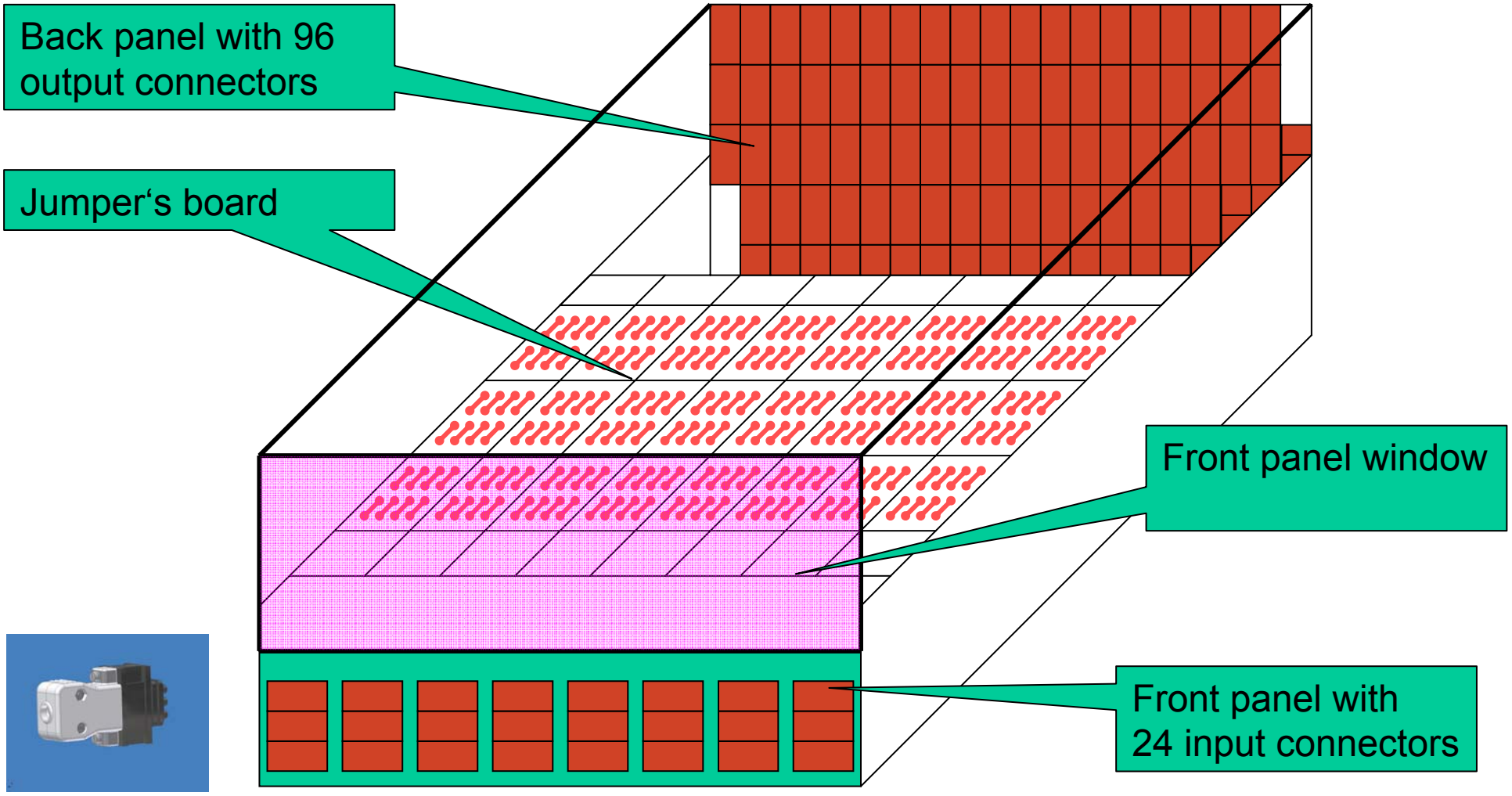



3-phase
System overview
48V Power source & service for ½ M1-M5 (side A)
Ch. 2
Ch. 1
SY 1527 Mainframe
A 1676 controllers
48V Power source & service for ½ M1-M5 (side C)
Ch. 2
Ch. 1
Local PP
Wall
PP (side A)
M2-M5 (side A) EASY 3000 crates
M1 (side A) EASY 3000 crate
PP (side C)
M2-M5 (side C) EASY 3000 crates
M1 (side C) EASY 3000 crate
Control cable
Power cable
Service cable
Sense cable
Spare cable


UF/PNPI HV overview
Primary HV Power Supply
Master crate
MB
Master HV patch panel
SHV-to-SHV patch cables
Cavern patch panel Side A
56-conductors long distance cables
SHV-to-SHV patch cables
Cavern patch panel Side C
Primary HV Power Supply
Distributor crate
DIS
2 crates per side will be replaced by PP in Phase 1

HV Patch panel .

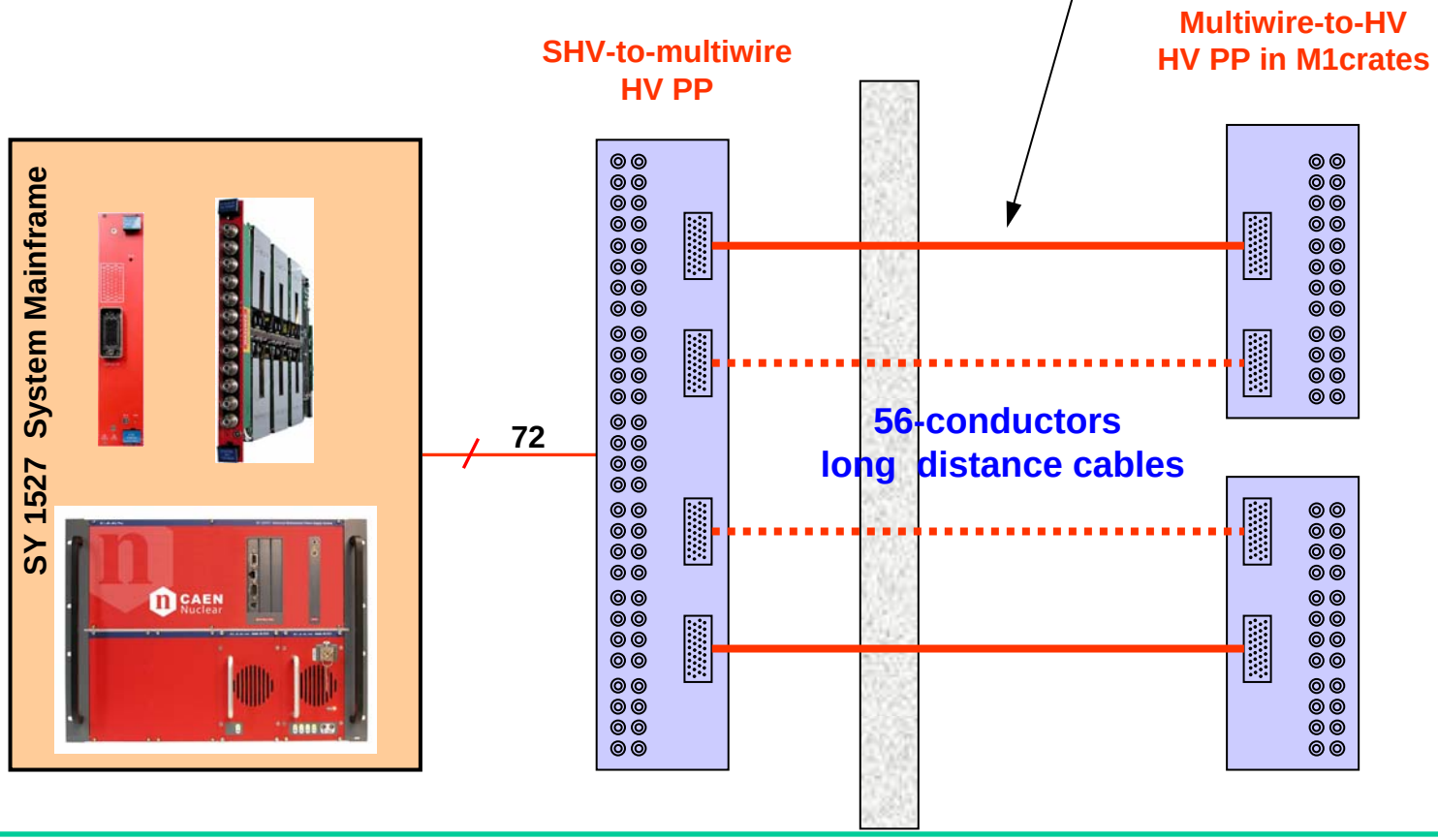
General view (EUROPA CHASSIS 6U)



3-GEM Overview

24 chambers
3 HV needed per chamber
High current for the voltage divider of the GEMs

4.5 kV at least
(solution exist with 18-cond)

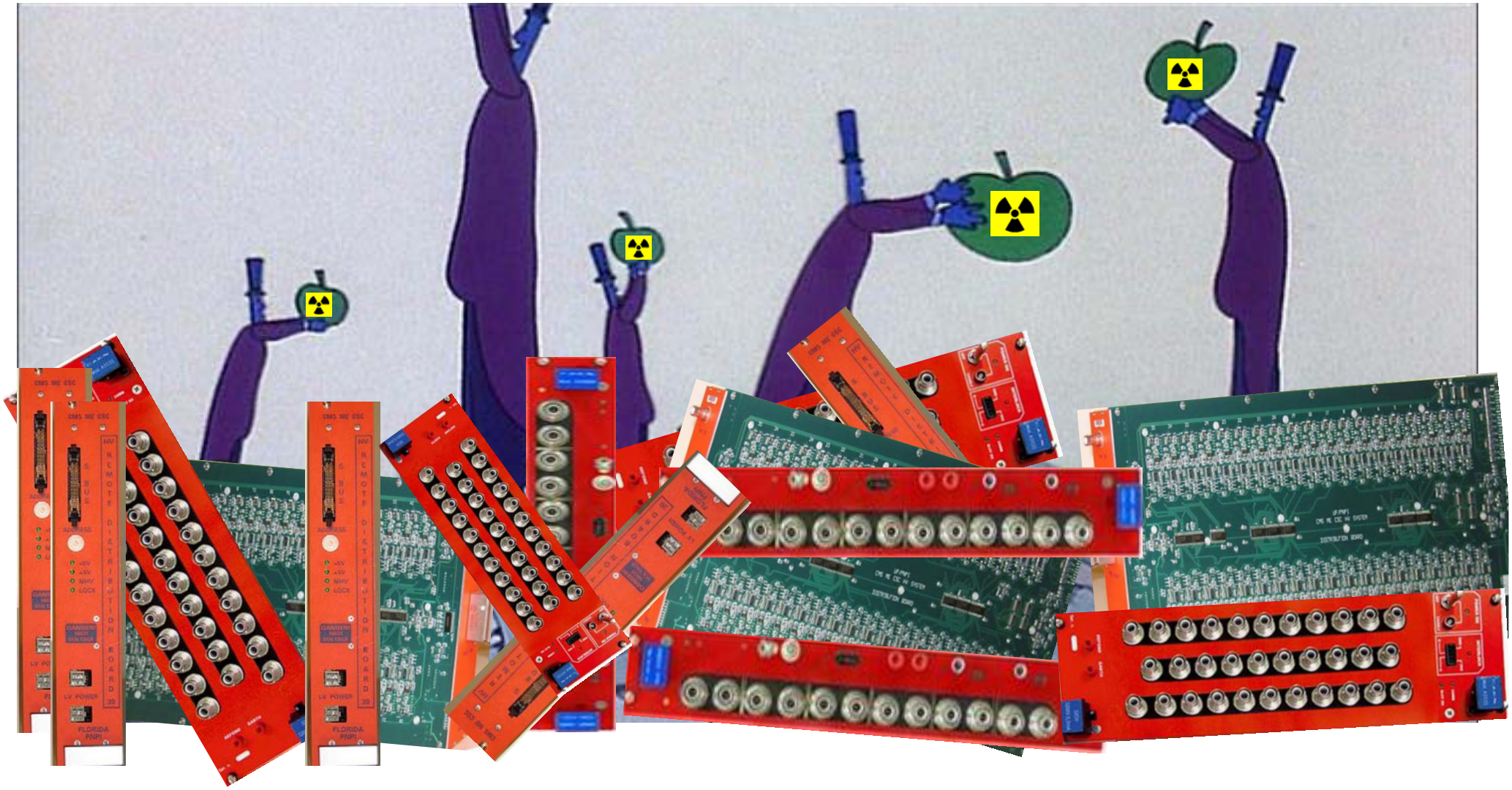


2x A1832
12 ch 6 kV

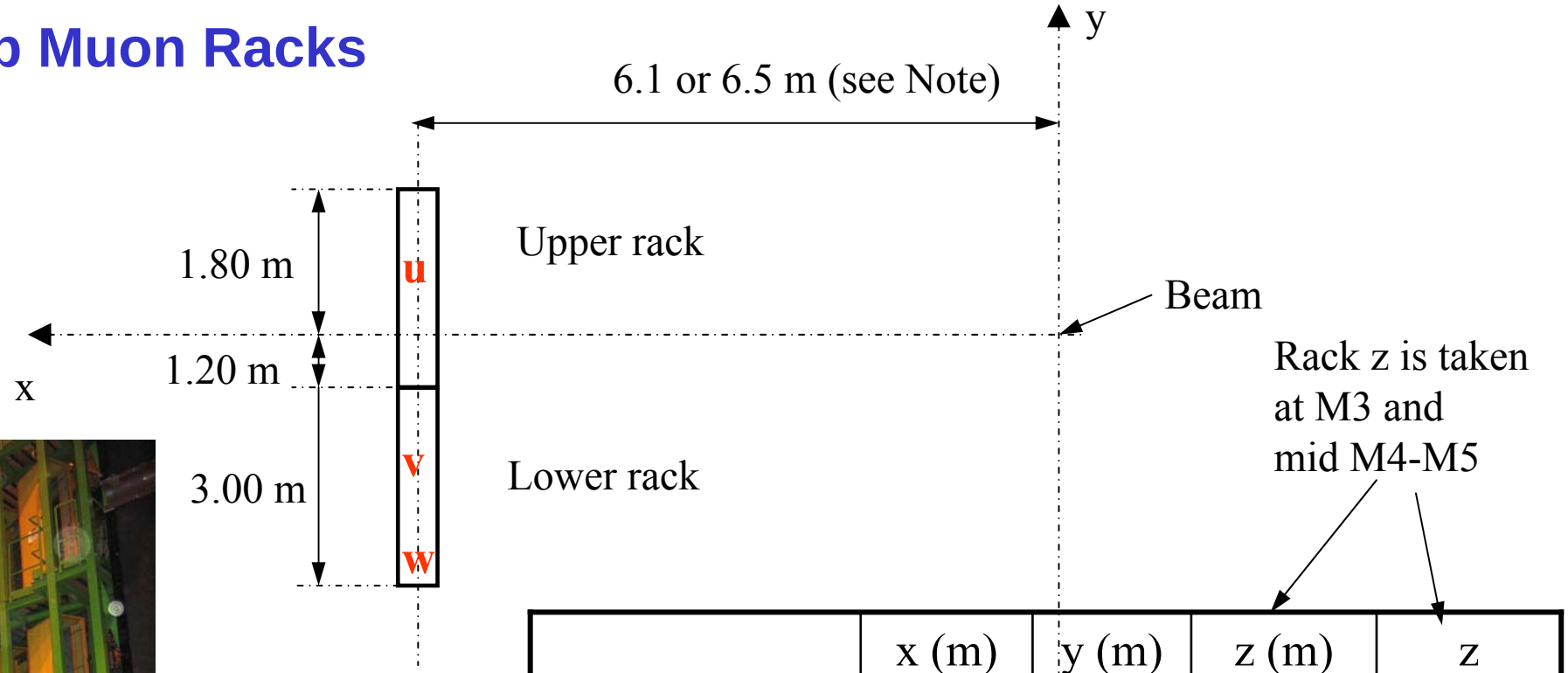
2x A1735
12 ch 1.5 kV
7 mA

1x A1733B
28 ch 3/4 kV

Radiation issues

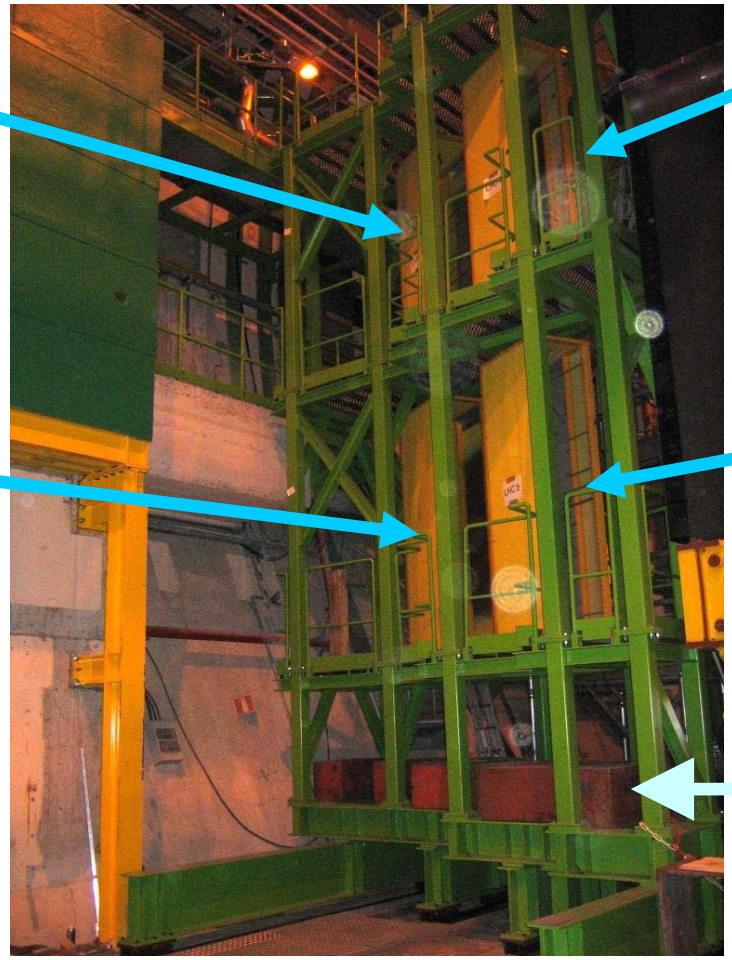


LHCb Muon Racks



	x (m)	y (m)	z (m)	z
I u	6.1	0.3	16.47	M3
I v	6.1	-2.7	16.47	M3
I w	6.1	-3.8	16.47	M3
II u	6.5	0.3	18.27	M4-M5
II v	6.5	-2.7	18.27	M4-M5
II w	6.5	-3.8	18.27	M4-M5

Note: 6.1 m for upstream (I) racks,
6.5 m for downstream (II) racks


Rack II u
Rack I u
beam
Rack II v and w
Rack I v and w
Iron counterweight

LHCb M1 Racks

Inside bunker

Bunker

- $-5 < x < 5$ m
- $7.4 < z < 11.8$ m

Radiation maps

- Maps from the LHCb background web page
- Used last numbers from Gloria for final bunker
- The M2-M5 maps go to x = 6 m max, we use this value
- Calculated for 1.6 10**15 collisions/10 years (80 mb x 2 10**32)
- Safety factor is 2 in maps. We multiply by 5 to get 10
- Use 1 MeV equivalent n for NIEL

At floor level we could consider to use the iron counterweight as extra shielding and include that in simulations if possible

Summary

Table gives 10 y upper limits in different locations with safety factor 10

	TID (Gy)	NIEL (n/cm2)	SEE (h/cm2)
I u	41	5.5 E11	4.1 E10
I v	30	4.5 E11	3.0 E10
I w	16	5.0 E11	1.7 E10
II u	24	5.0 E11	1.1 E10
II v	6	4.0 E11	0.9 E10
II w	7.5	4.5 E11	1.3 E10
Bunker average	2	2 E12	5 E10
Floor	15	8 E11	3 E10

Recommendations

- minimize use of the upper racks (u) and upstream racks (I)
- close to floor is not much better than the rest (but simpler to add shielding)

Our requirements (x10 safety factor in)

	TID (Gy)	NIEL (n/cm2)	SEE (h/cm2)
LHCb M2-M5 (*)	16	5-8 E11	1.7 E10
LHCb M2-M5 (**)	41	5-8 E11	4.1 E10
LHCb M1	2	2 E12	5 E10

(*) assume not worst locations (see previous table)
(**) worst locations (see previous table)

Summary of radiation tests

UF-PNPI

Tested on the UC Davis 20-Mev p accelerator successfully up to 50 Gy
The distributor boards use particularly simple circuitry (serial regulation) with almost no logic (PNPI will take care of maintenance)
The system was discussed by A. Madorksy (UF) and Jorgen and questions have been answered
We plan to update the documentation

CAEN Easy

A3535 OK up to at least 70 Gy "as is"
Critical components identified (PWM and EEPROM)
Tested end of March on A3512 (12 kV) successfully to 70 Gy (in 2h) or 200 Gy (in 2d)

☺ Contract with ATLAS legally binds CAEN to meet 145 Gy specs

Documentation is available via the Muon WEB page
http://lhcb-muon.web.cern.ch/lhcb-muon/electronics/electronics.htm

Easy tests summary (courtesy A. Lanza)

	Casaccia (01/06)	Uppsala (01/06)	Casaccia (03/06)
A3535 HV	1 ch DC/DC conv (naked) → 73 Gy	16 ch (different configs) 2 ch → 124 Gy, rest 147Gy (Controller shielded)	
A3540 HV	DC/DC → 134 - 165 Gy **PWM UCC3580** **Xicor EEPROM → 54 Gy**	DC/DC → 62 - 124 Gy **PWM UCC3580** (Xicor shielded)	
A3512 HV 12 kV			**Xicor** → 70 Gy (in 2h) → 200 Gy (in 2d)
A3486 48V			**Xicor** → 70 Gy (in 2h) → 200 Gy (in 2d)
EEPROM		→ 129 Gy Atmel EEPROM	**HN58C256 ok**
PWM		→ 171 Gy **PWM UCC3525**	

System Procurement

CAEN

A first order for CAEN Easy has been placed end 2005 – One A3535 received
A3486 delayed → we will probably switch to A3485 (non rad-hard) 48V supply
Purchase procedure for the rest is starting (order June-July, first modules September)

UF/PNPI

Main HV supply and board components ordered
Assembly and test will take place in PNPI
3 distributors modules in June
For the moment use borrowed Master Module

Cables

Ready to place order