

# Magnet power supply system for J-PARC main ring upgrade

Yuichi Morita  
J-PARC/KEK

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- Introduction
- Present PS system
- PS system after upgrade
- Present status

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# J-PARC Main Ring (MR)

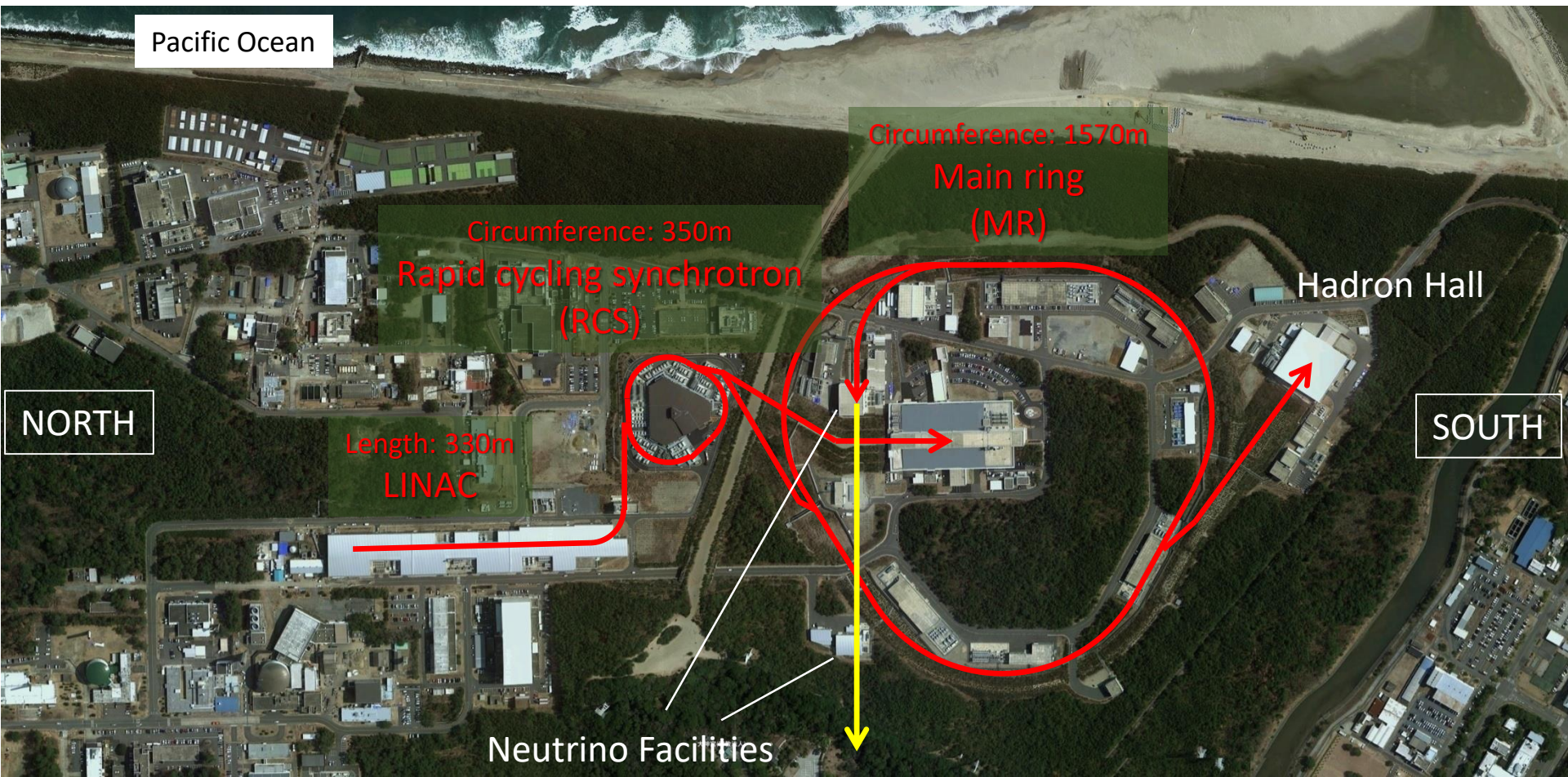
## Specifications

Proton synchrotron

2 experimental facilities (Neutrino, Hadron)

Acceleration: 3 GeV to 30 GeV, 3 GeV to 8 GeV

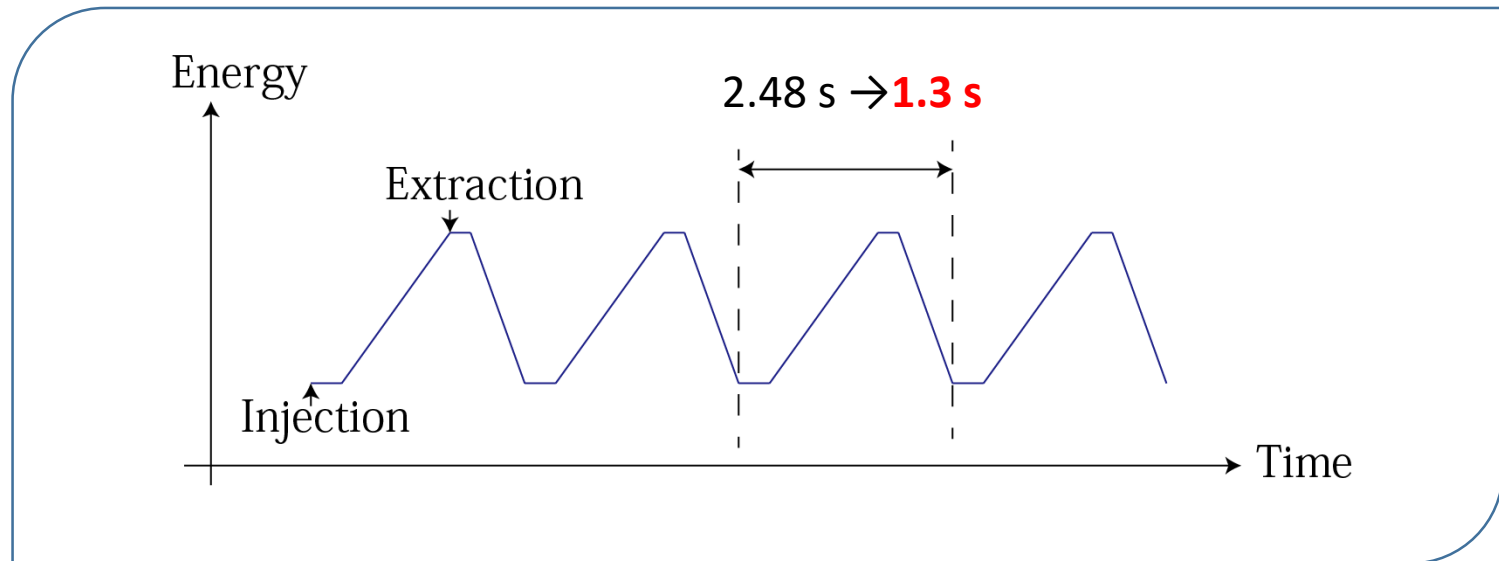
Beam power: 470 kW for Neutrino facility (present)



# Beam upgrade

In order to achieve the MR beam power of **> 750 kW**,

**the scheme of Increasing Repetition Rate is adopted.**



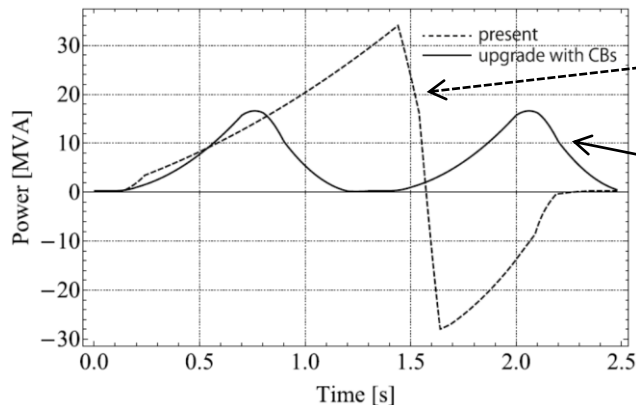
Required Performance of PS for MR Main Magnets

	Cycle [sec]	Output Current [A]	Output Voltage [kV]	Output Power [MVA]
Present PS	2.48	1600	3	5
New PS	<b>1.3</b>	1600	<b>~6</b>	<b>~10</b>

# List of MR Main Magnets and PSs

		Power Supply	Number of magnets	Total Inductance at 30 GeV [H]	Flat Base Current [A]	Flat Top Current [A]	Output Voltage [kV] 2.5 sec / 1 sec	
Large PS	B Magnets	BM1~6	16	1.47	190	1570	2.6 / 5.8	
		QFN	48	2.93	86	710	2.7 / 5.6	
	Q Magnets at Arc Sections	QDN	48	3.46	86	710	3.1 / 6.7	
		QFX	48	2.39	88	730	2.6 / 4.8	
		QDX	27	1.75	86	710	1.6 / 3.4	
Small PS	Q Magnets at Linear Sections	QFR	9	0.57	77	640	0.5 / 1.3	
		QDR	6	0.44	75	620	0.4 / 0.7	
		QFP	6	0.20	77	640	0.3 / 0.4	
		QFS	6	0.30	81	670	0.3 / 0.5	
		QDS	6	0.35	110	890	0.5 / 0.9	
		QFT	6	0.32	95	780	0.4 / 0.7	
		QDT	6	0.37	90	750	0.4 / 0.7	
		S Magnets	SFA	24	0.42	23	200	0.3 / 0.4
			SDA	24	0.41	19	160	0.2 / 0.3
			SDB	24	0.41	19	160	0.2 / 0.3

## Power variation at electrical system



2.48 sec cycle

~60 MVA (peak to peak)

1.3 sec cycle

w/o Capacitor Bank: > 100 MVA

Forbidden by electrical power company

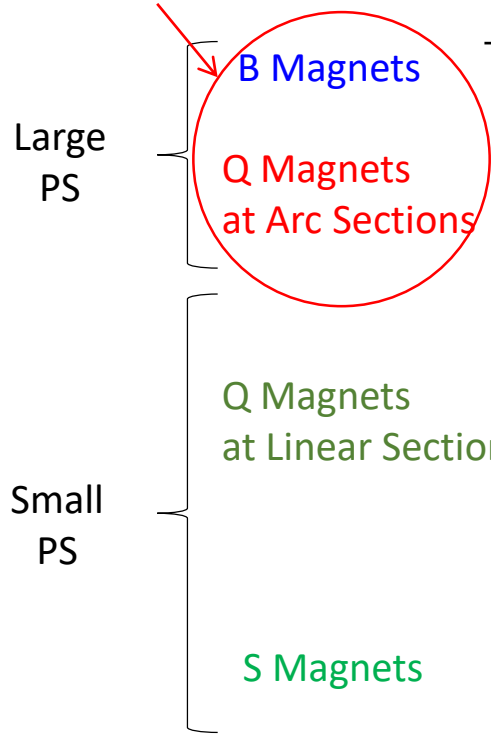


w/ Capacitor Bank: lower than the present value

B and Arc-Q magnets are the primary power variation sources.

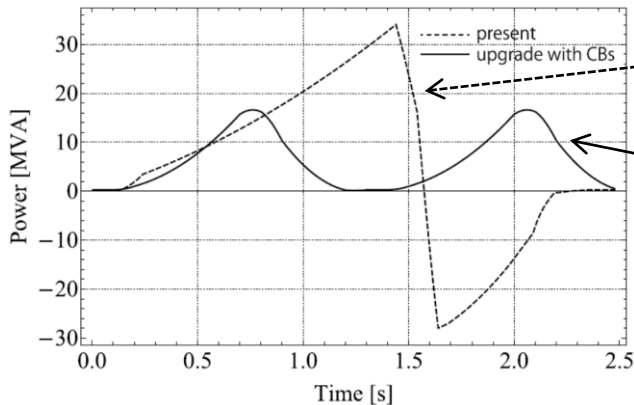
# List of MR Main Magnets and PSs

Capacitor banks will be installed.



Power Supply	Number of magnets	Total Inductance at 30 GeV [H]	Flat Base Current [A]	Flat Top Current [A]	Output Voltage [kV] 2.5 sec / 1 sec
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w/ Capacitor Bank: lower than the present value

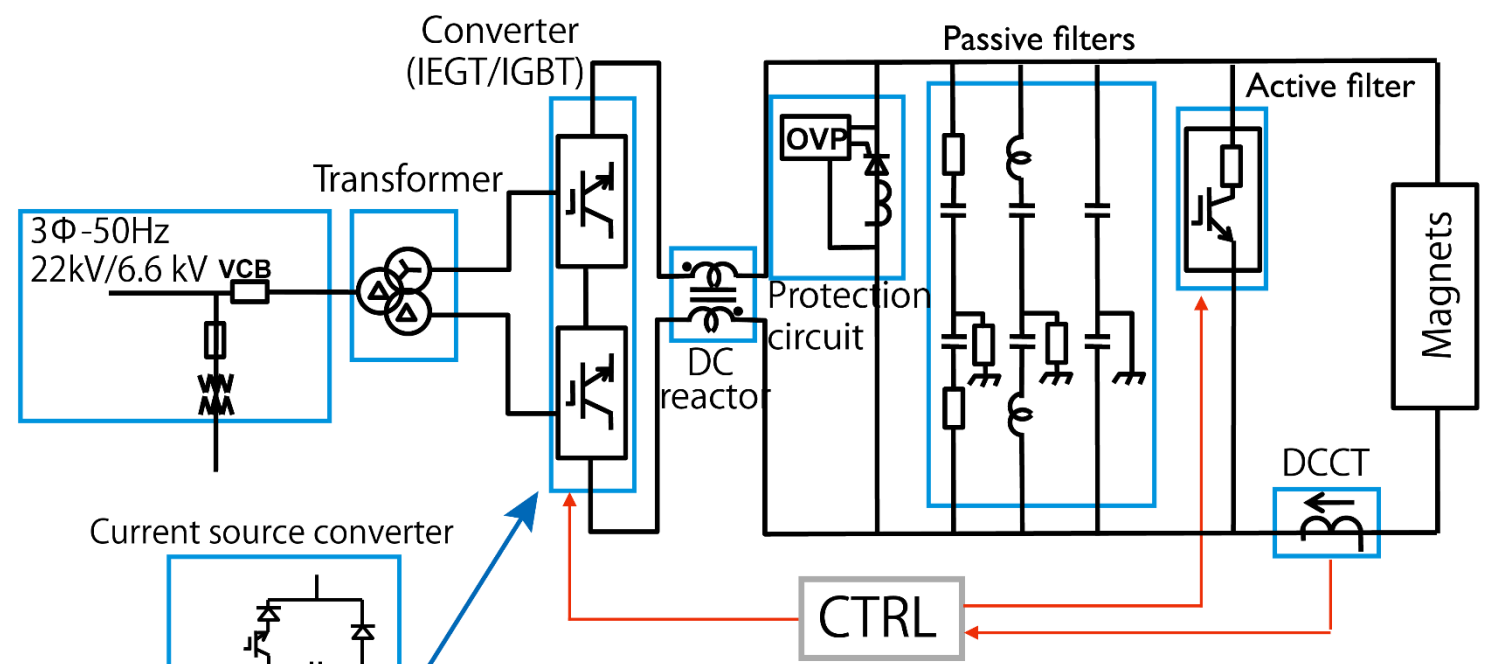


# Contents

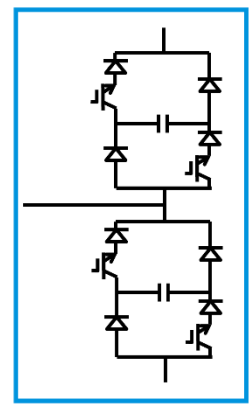
- Introduction
- Present PS system
- PS system after upgrade
- Present status



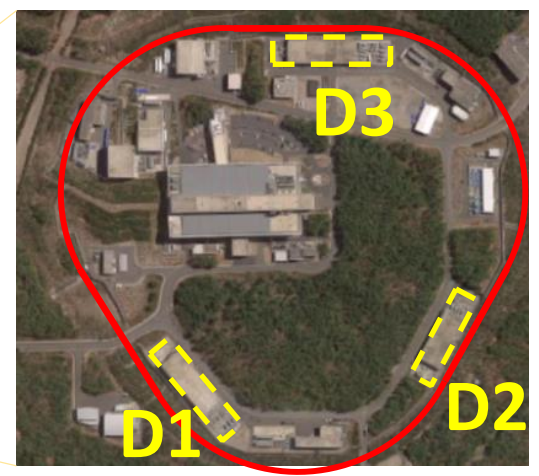
# Schematic circuit of PS



Current source converter



- > Current source converter
- > Hybrid passive and active filters



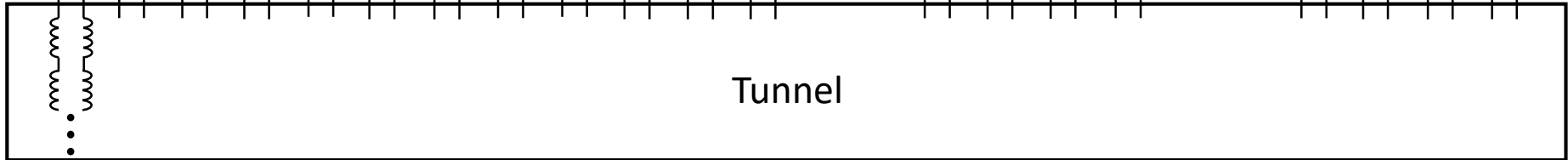
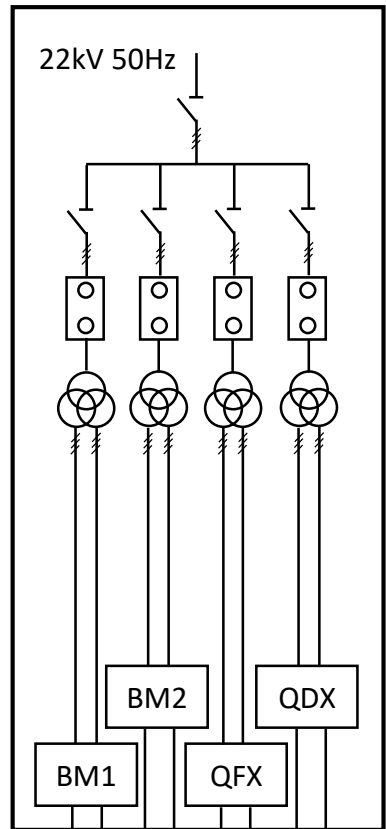
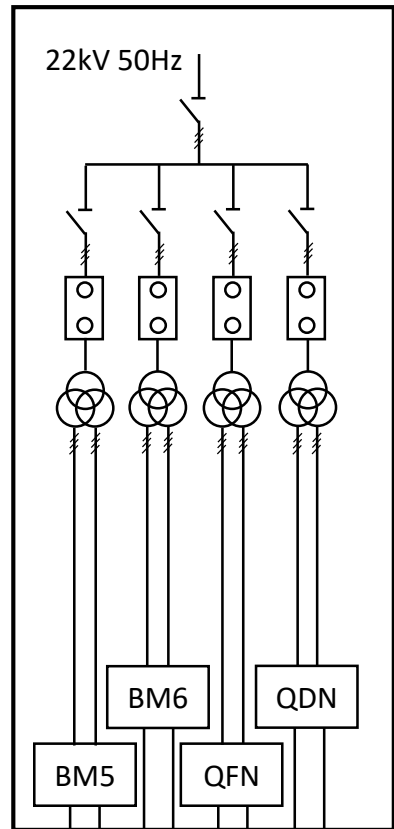
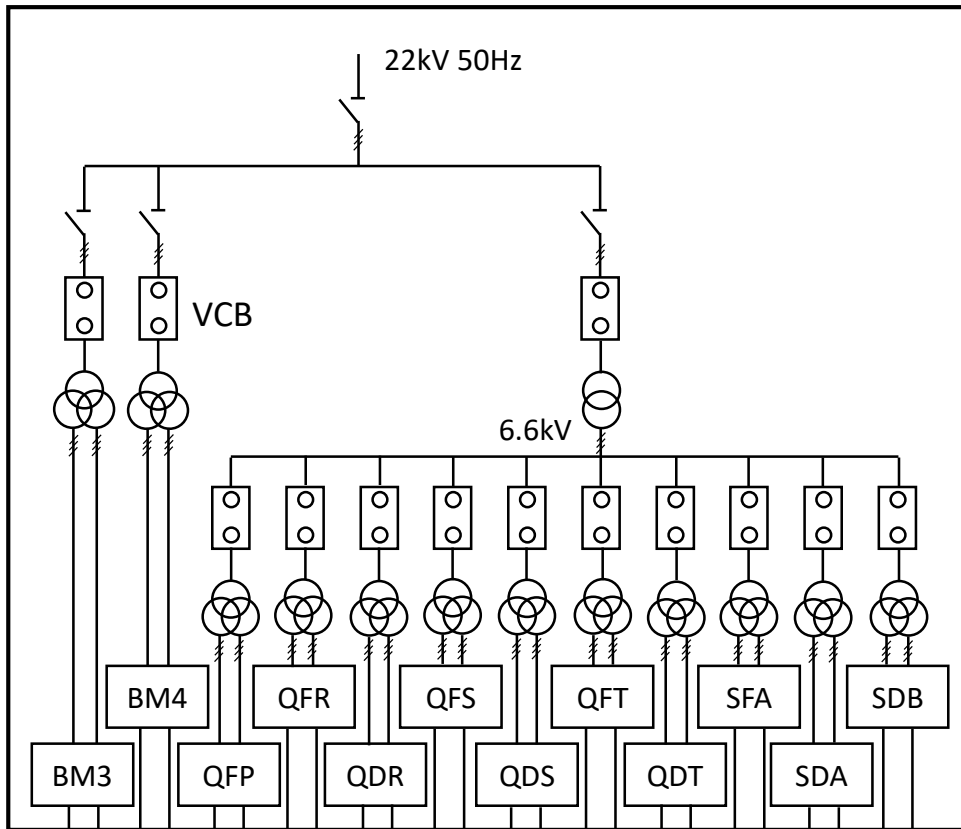
Three buildings for present PSs

# Electrical connection of PS system

D1

D2

D3

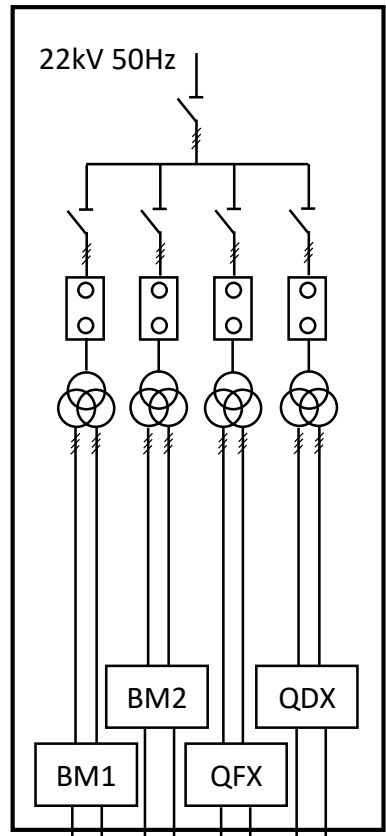
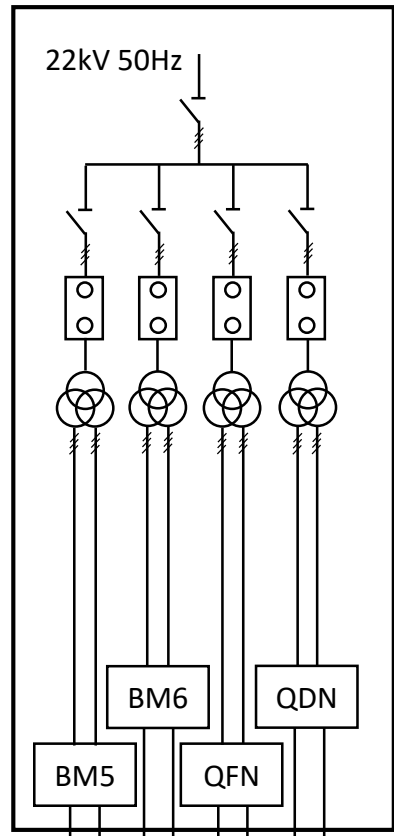
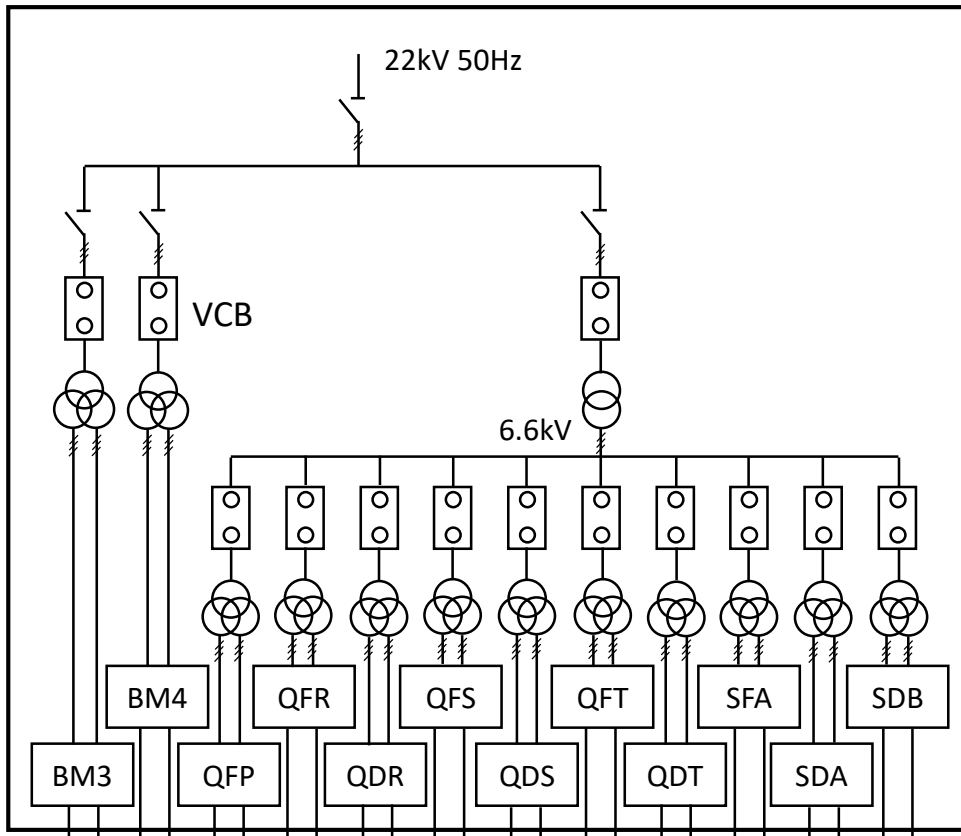


# Electrical connection of PS system

D1

D2

D3



- Large PSs are connected to 22 kV line.
- Small PSs are connected to 6.6 kV line. All of them are in D1.

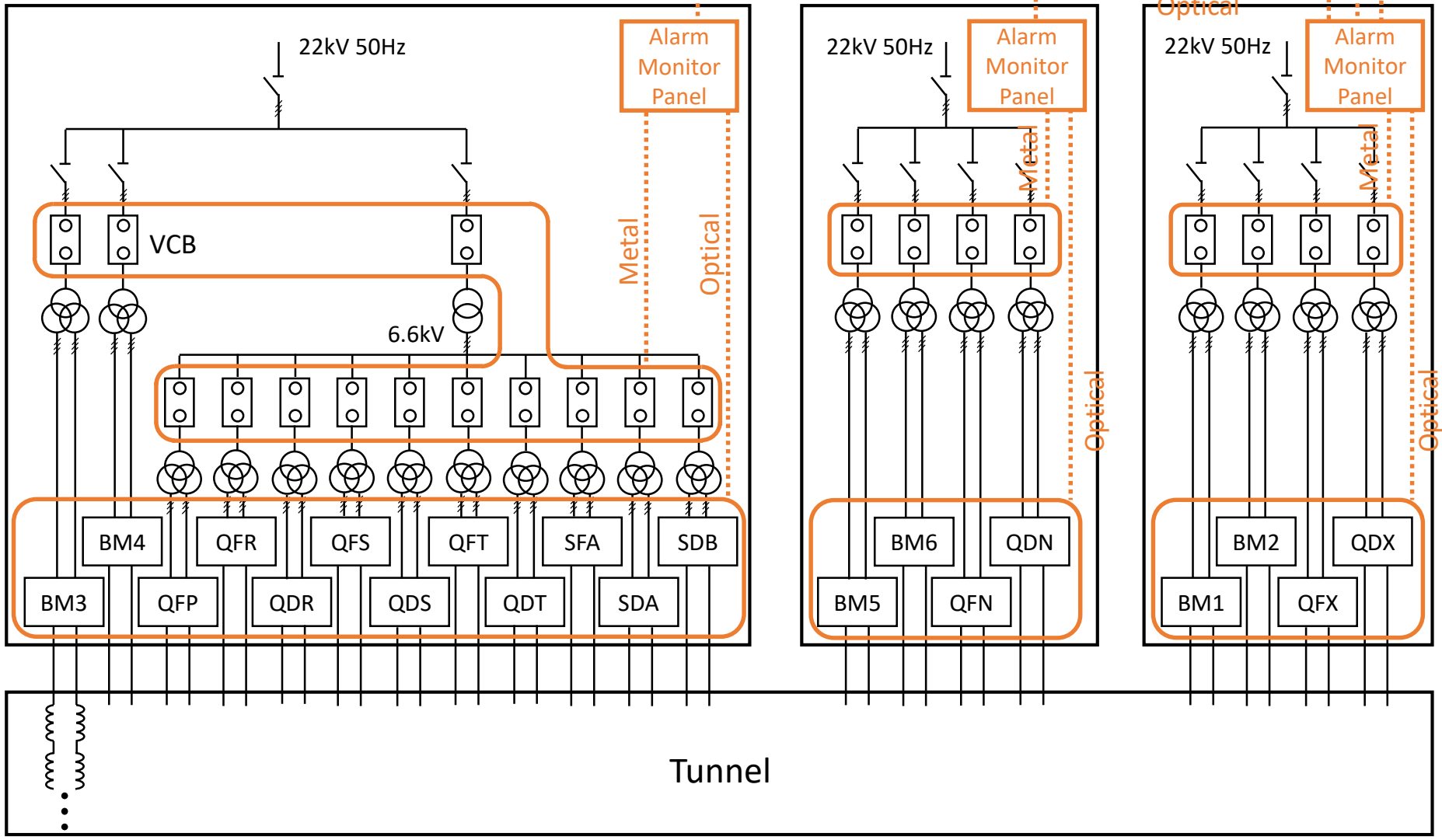
# Connection for control

Terminal

D1

D2

D3



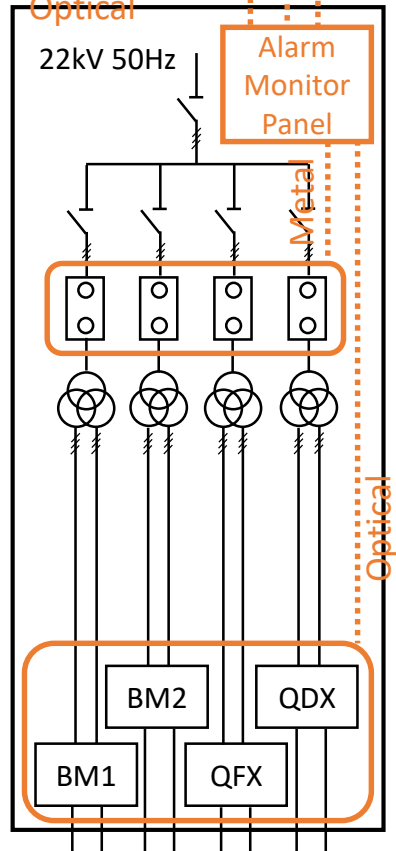
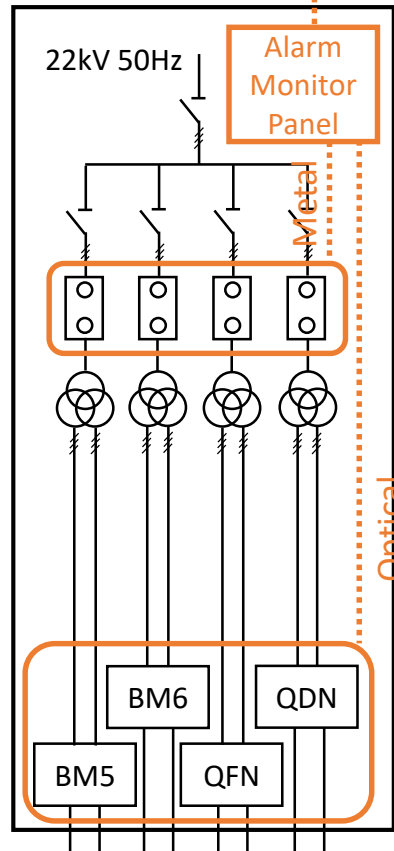
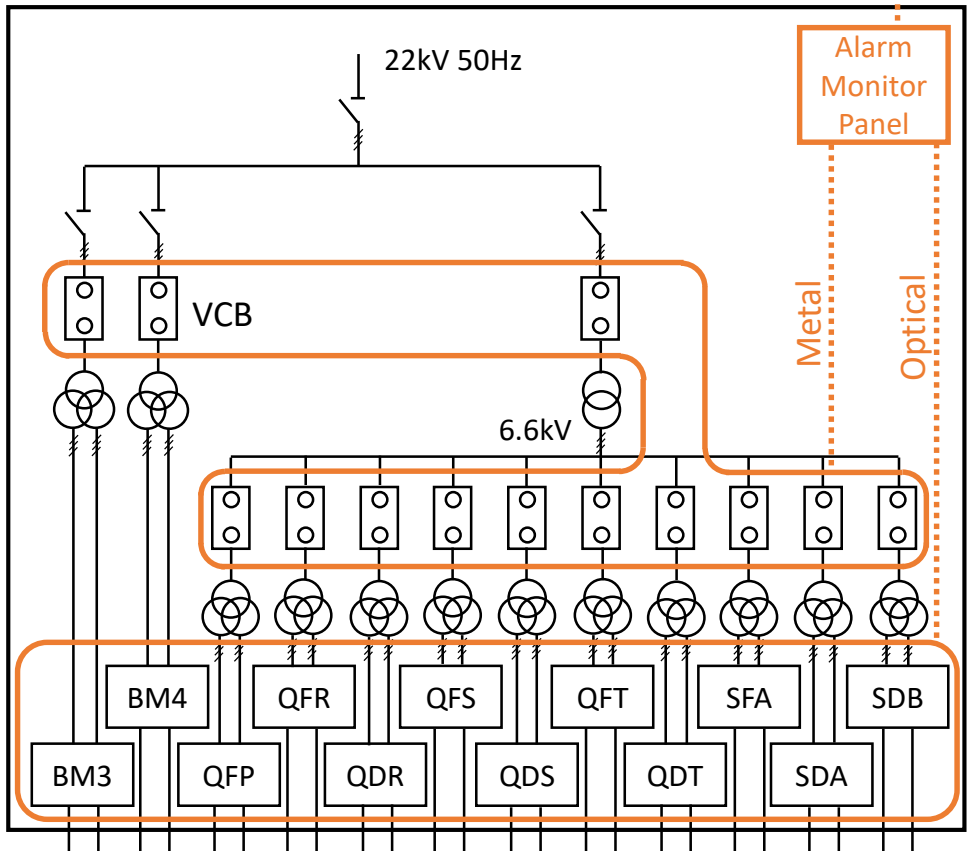
# Connection for control

Terminal

D1

D2

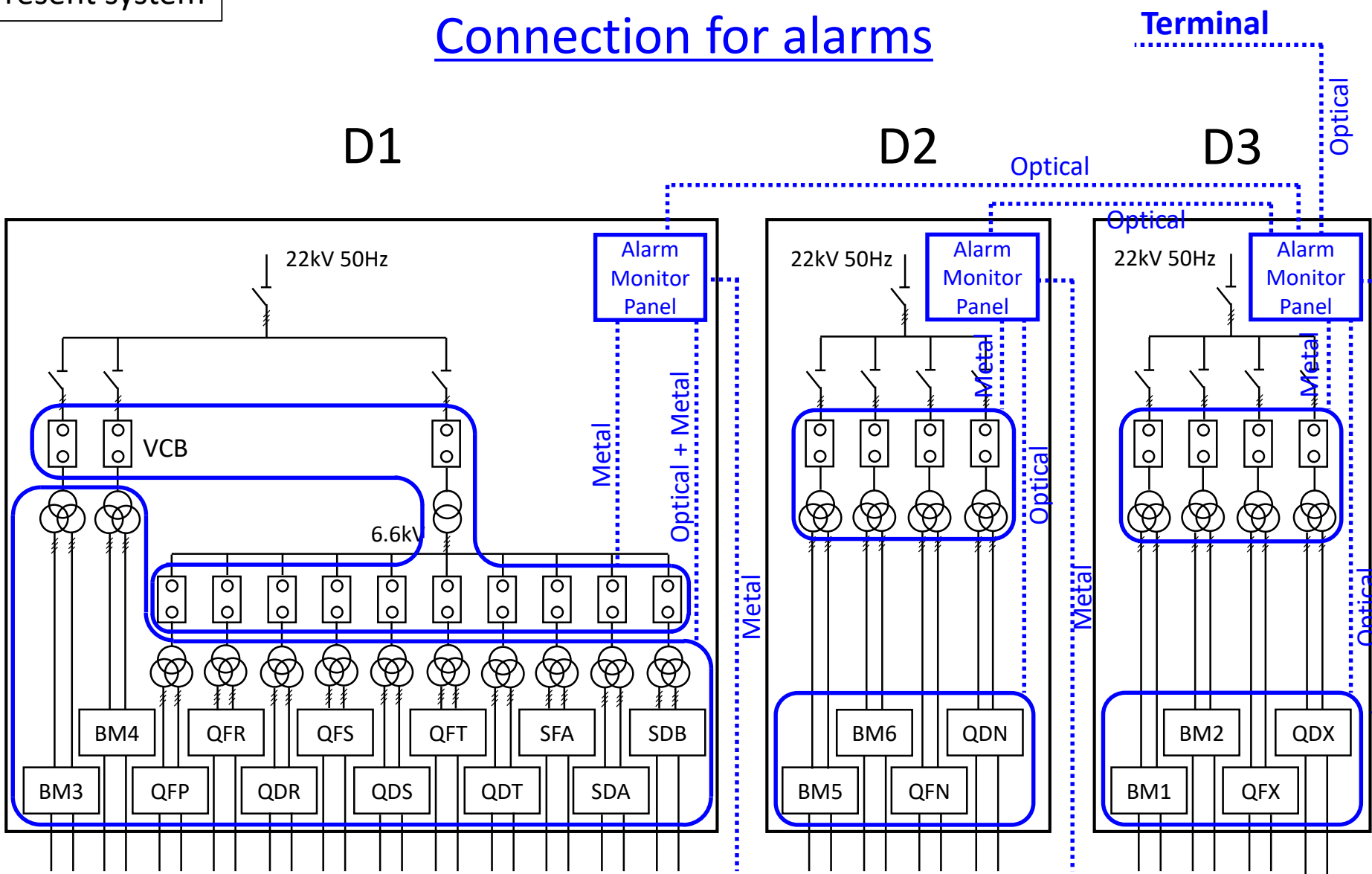
D3



- Alarm monitor panel exists in each building.
- Alarm monitor panels receive the commands from the terminal.
- Alarm monitor panels distribute the commands to the target PSs or VCBs.



# Connection for alarms

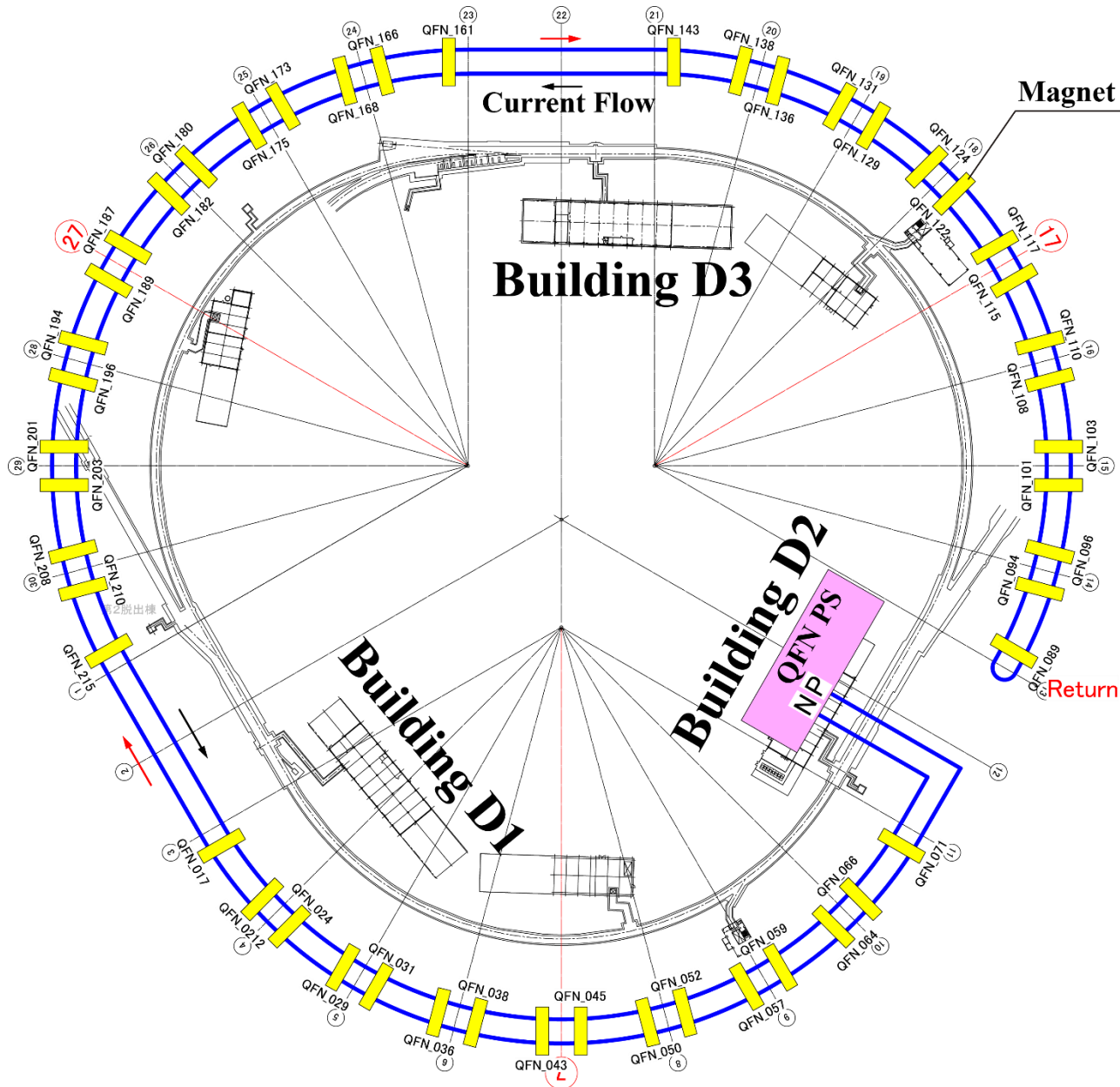


- Alarm monitor panels receive the alarm signals from the PSs, VCBs, transformers and magnets.
- The terminal can detect the alarms via the alarm monitor panels.
- Alarm information of magnets are shared among the three alarm monitor panels.

und



# Example of magnet distribution (QFN, 48 magnets)



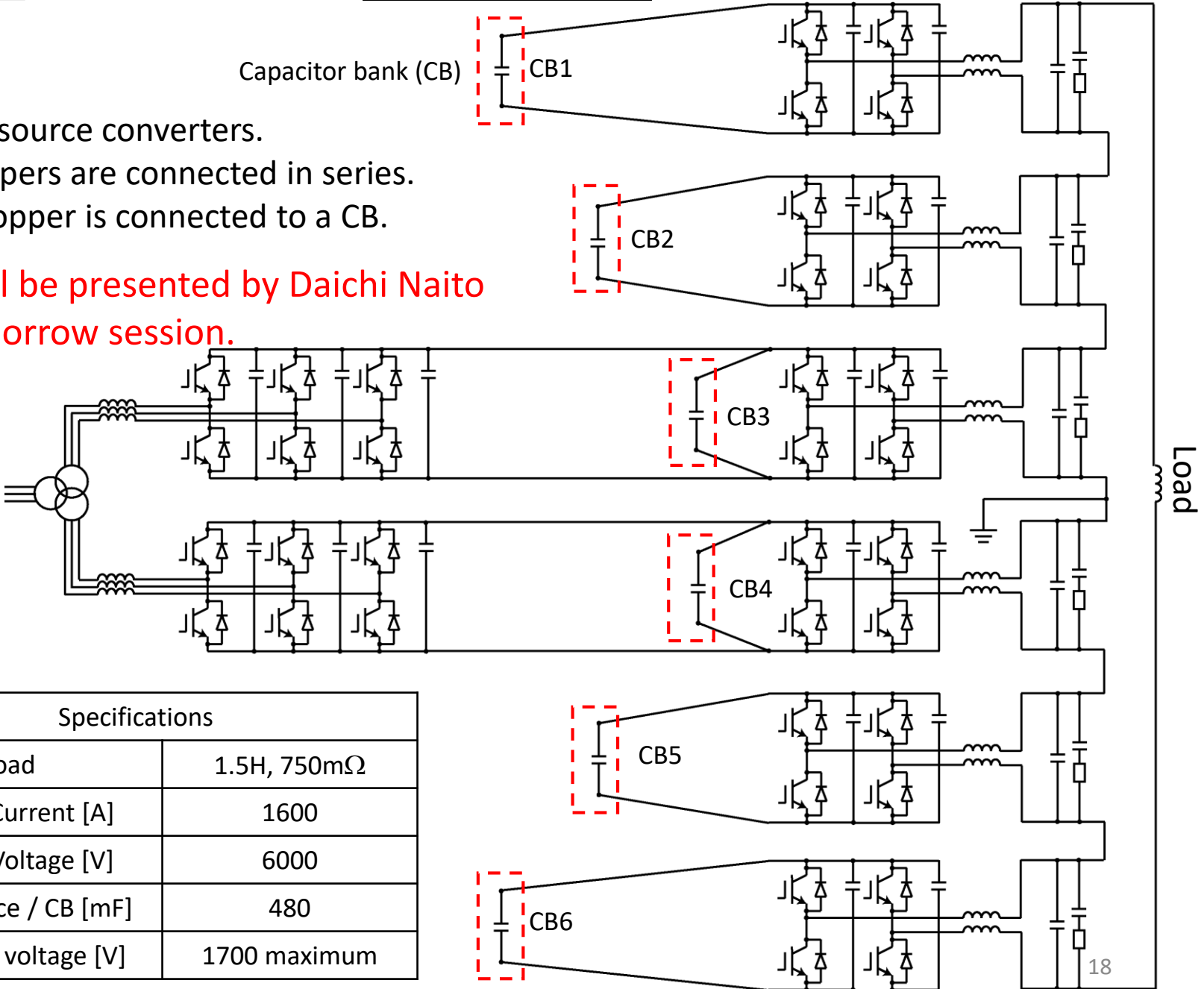
# Contents

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- PS system after upgrade
- Present status

# New PS for BM

- Voltage source converters.
- Six choppers are connected in series.
- Each chopper is connected to a CB.

Details will be presented by Daichi Naito in the tomorrow session.



Specifications	
Load	1.5H, 750mΩ
Output Current [A]	1600
Output Voltage [V]	6000
Capacitance / CB [mF]	480
Capacitor voltage [V]	1700 maximum

# New buildings for upgrade

Three new buildings were constructed.  
The constructions were completed last year.





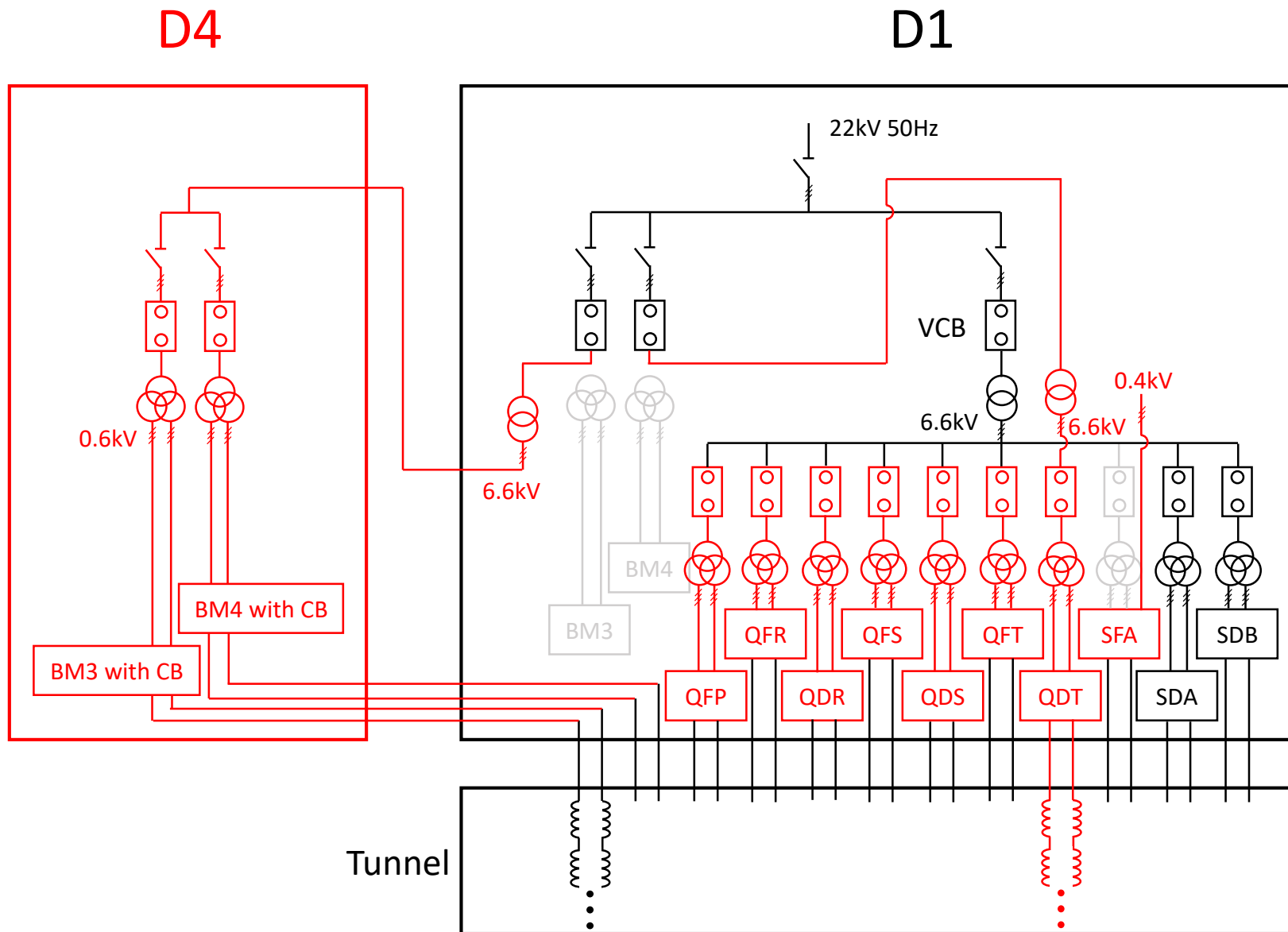
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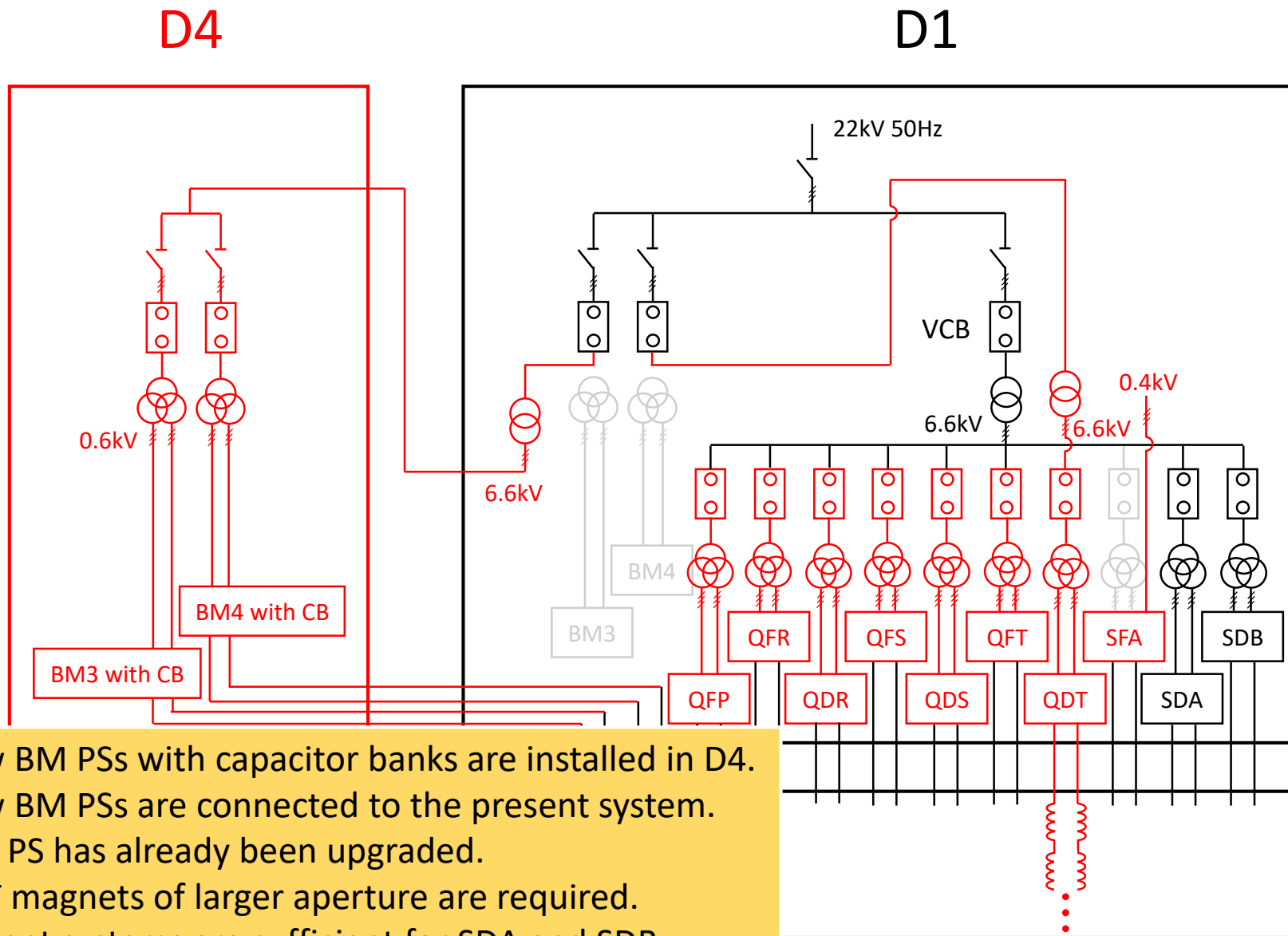


After upgrade

# Electrical connection of PS system



# Electrical connection of PS system

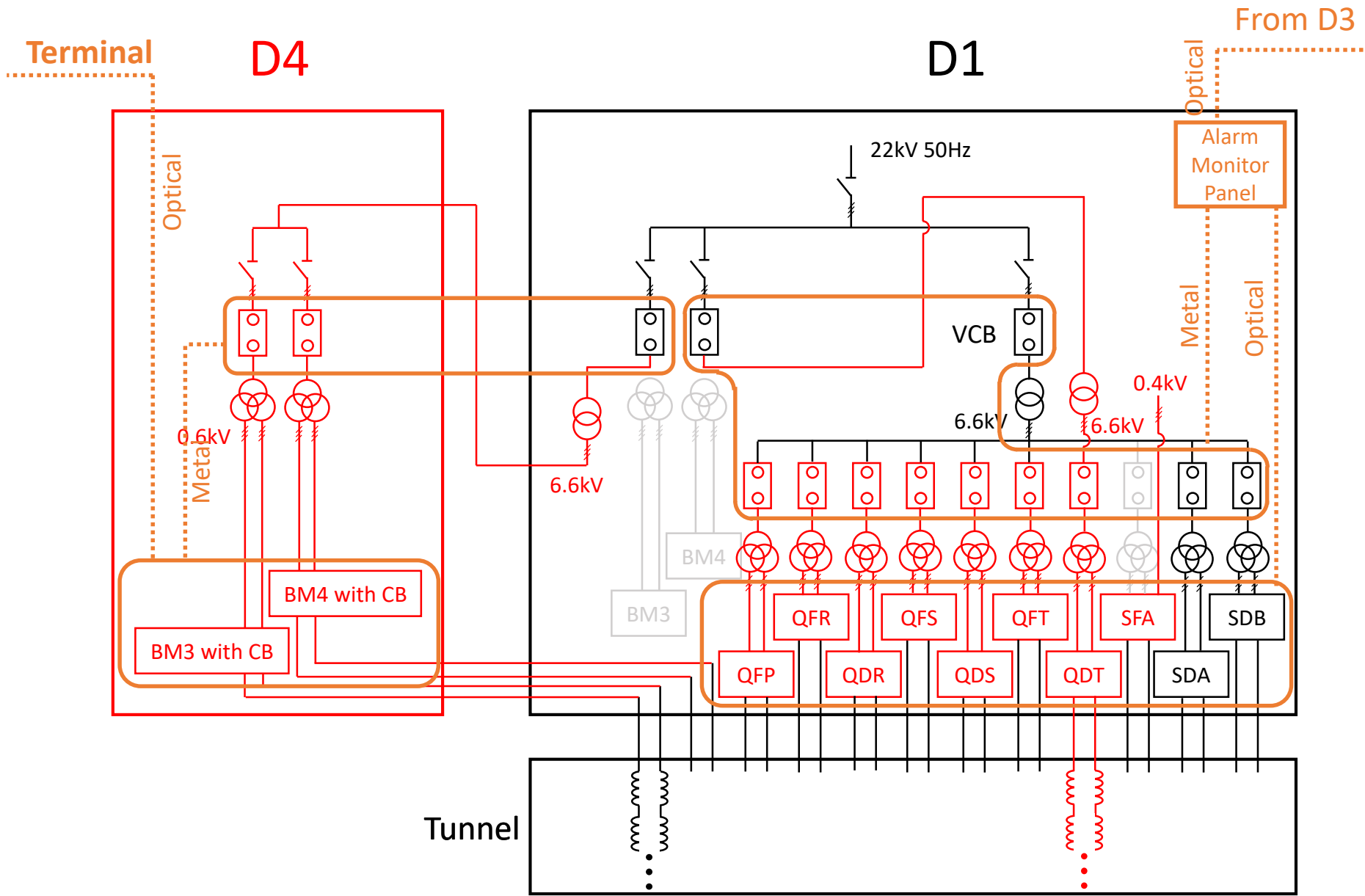


- New BM PSs with capacitor banks are installed in D4.
- New BM PSs are connected to the present system.
- QFR PS has already been upgraded.
- QDT magnets of larger aperture are required.
- Present systems are sufficient for SDA and SDB.

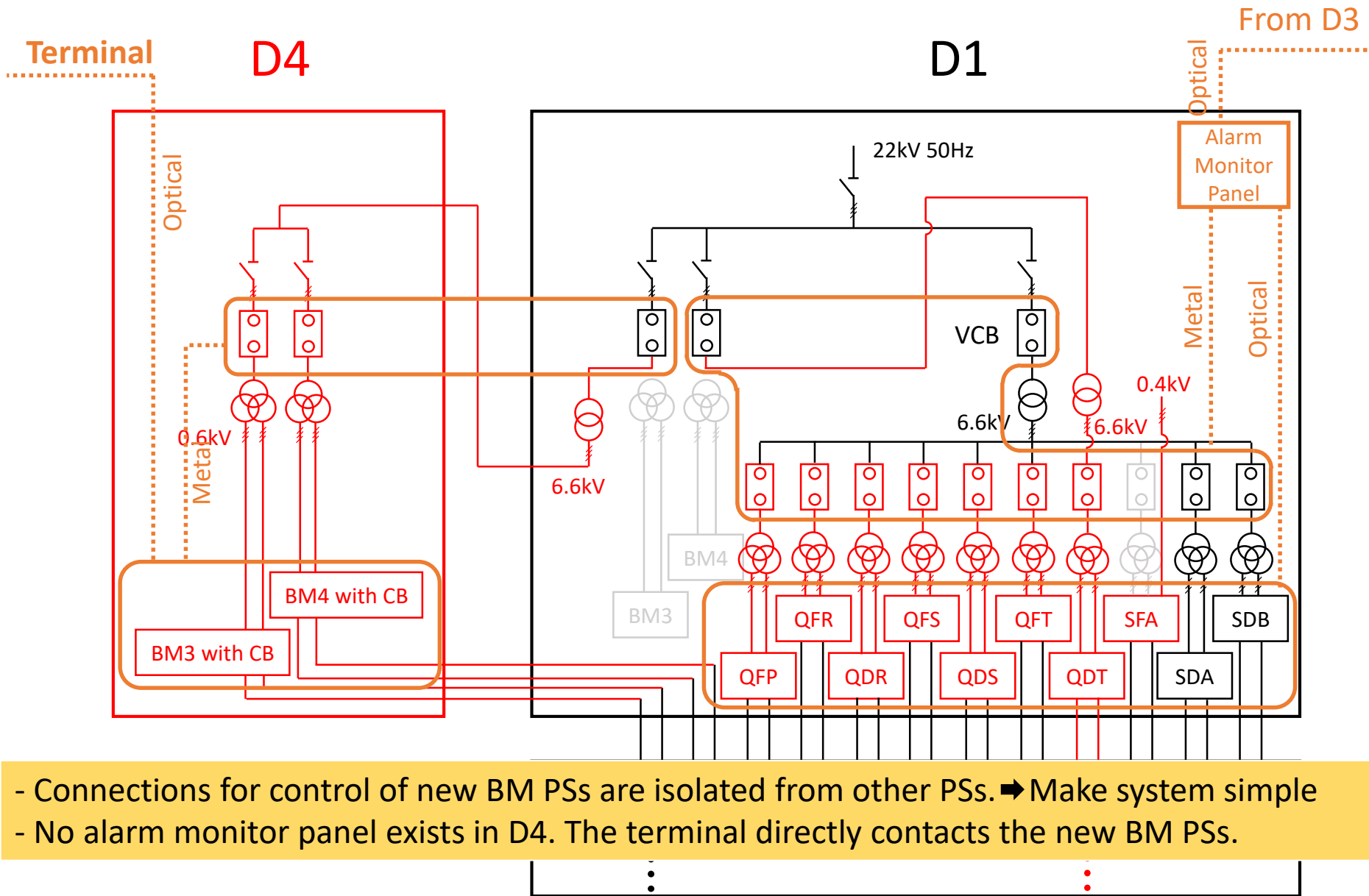


After upgrade

# Connection for control



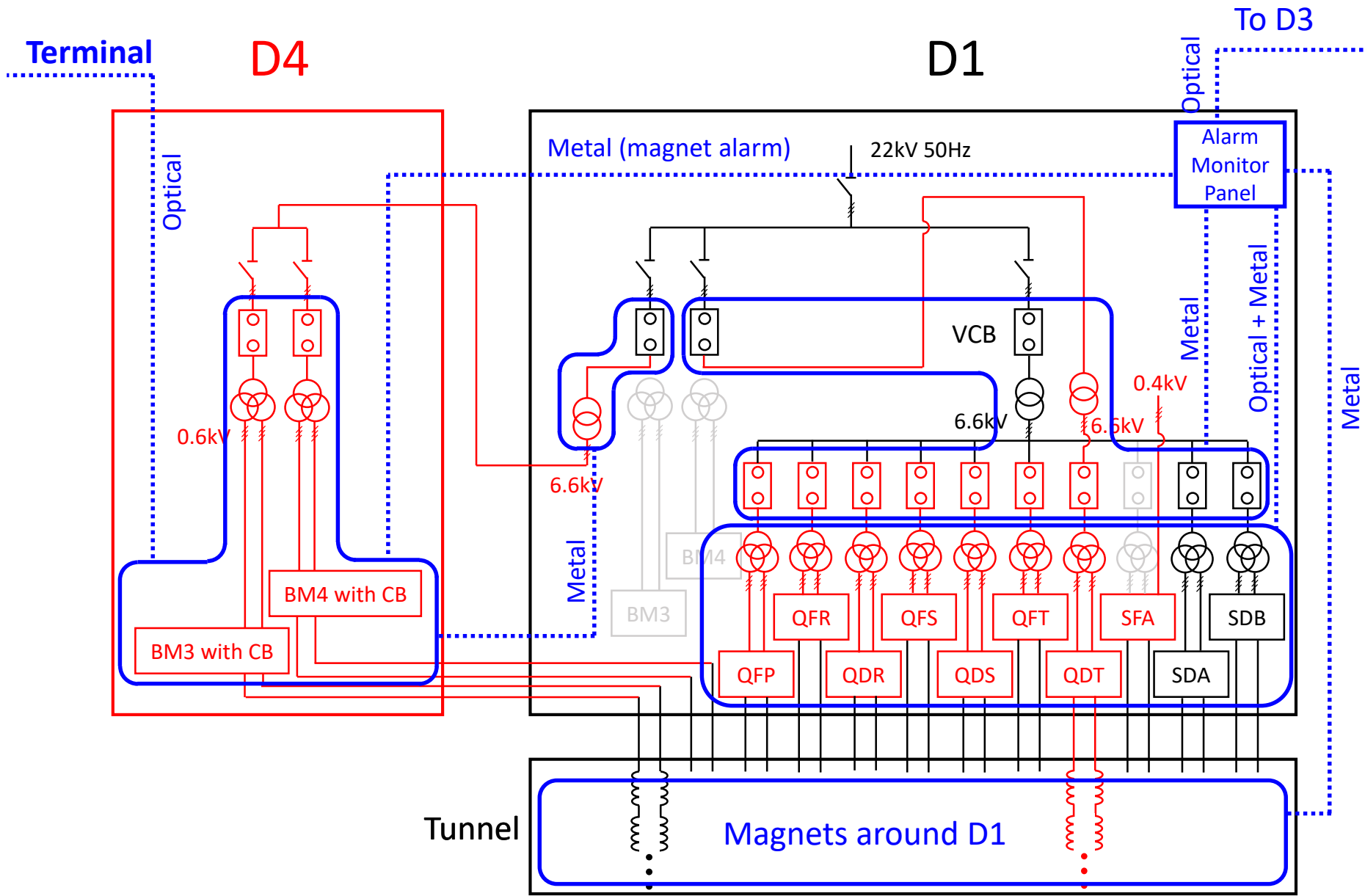
# Connection for control



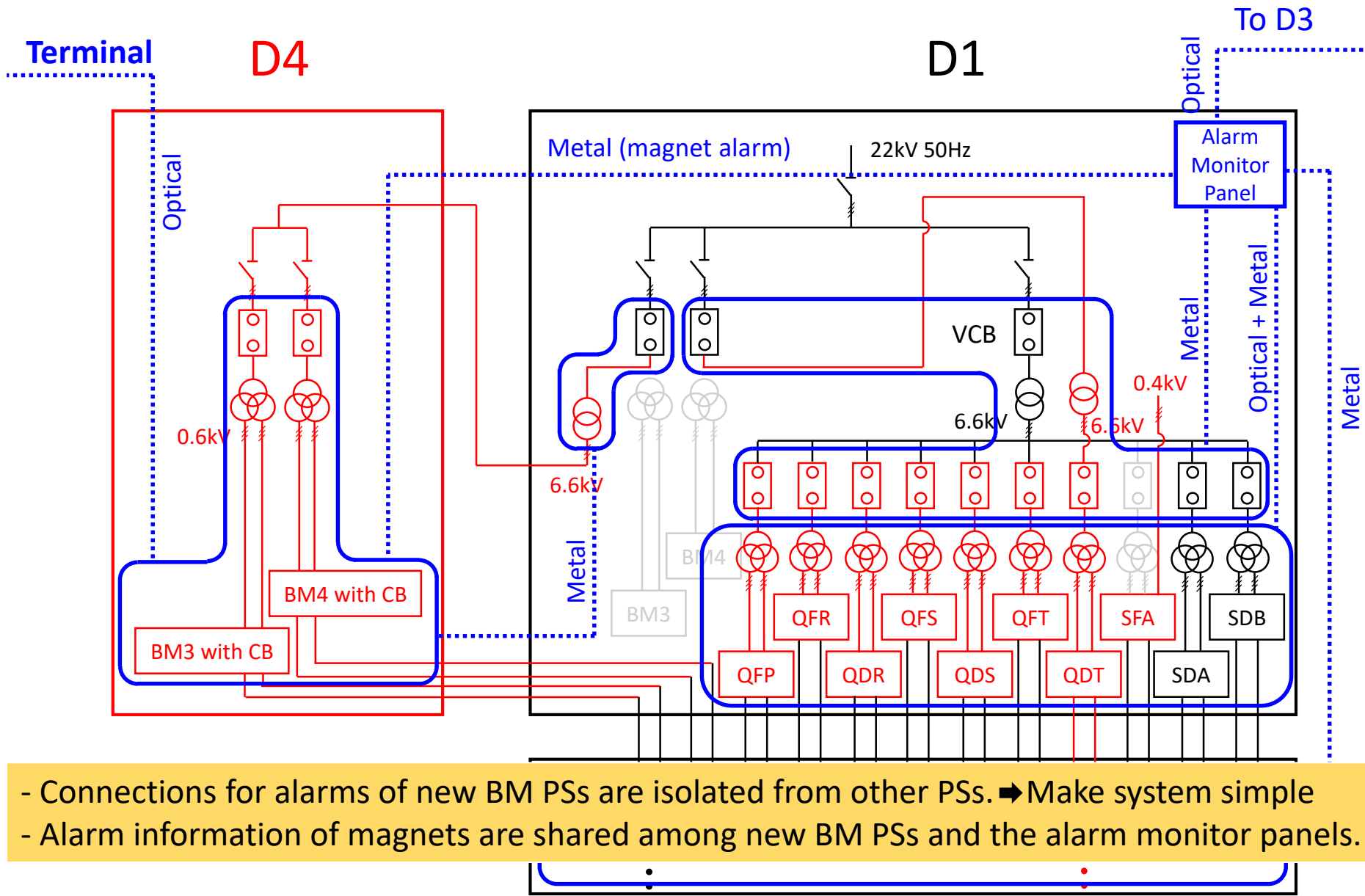
- Connections for control of new BM PSs are isolated from other PSs. ➔ Make system simple
- No alarm monitor panel exists in D4. The terminal directly contacts the new BM PSs.

After upgrade

# Connection for alarms



# Connection for alarms

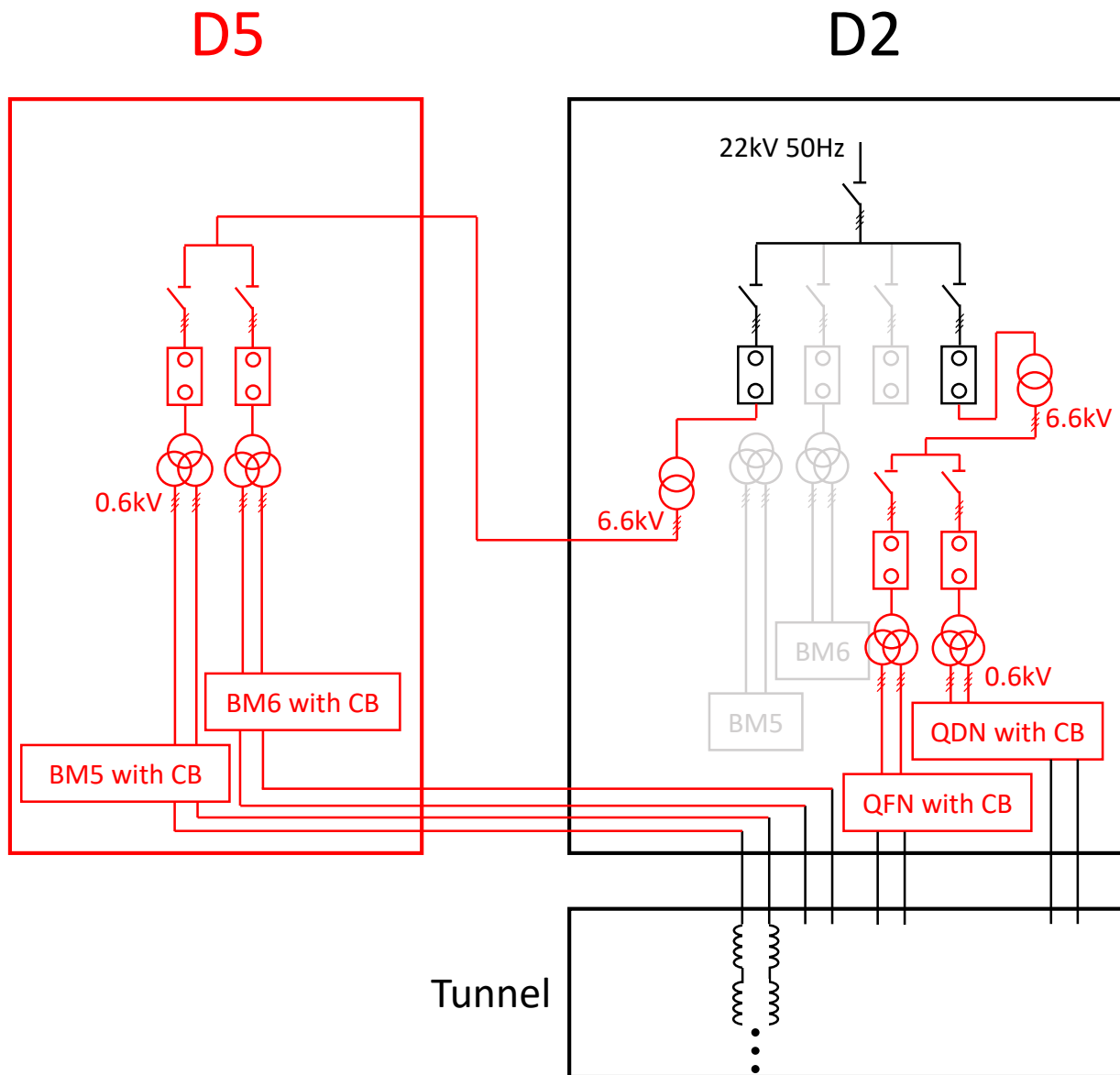


# New buildings for upgrade

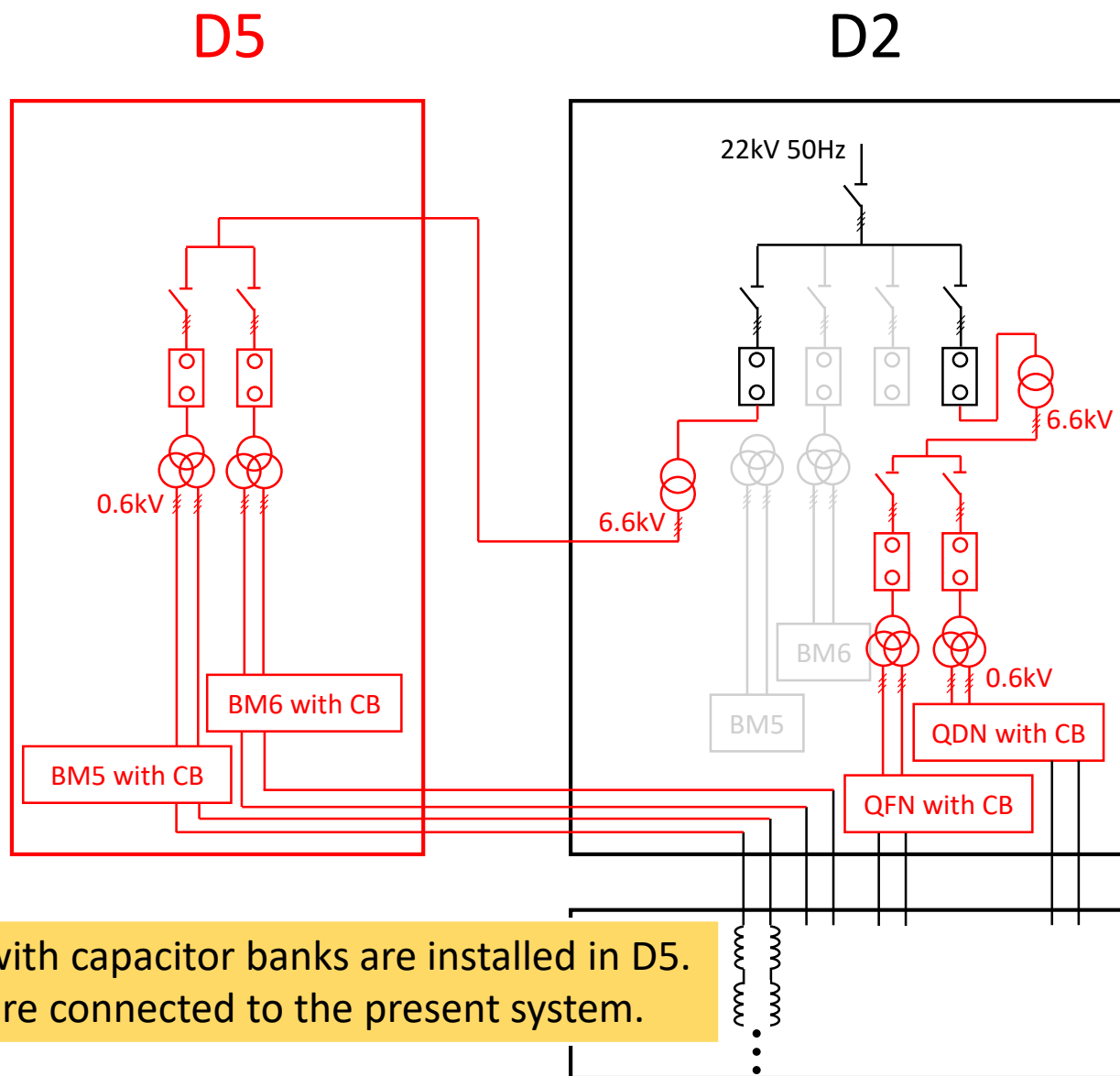
Three new buildings were constructed.  
The constructions were completed last year.



# Electrical connection of PS system



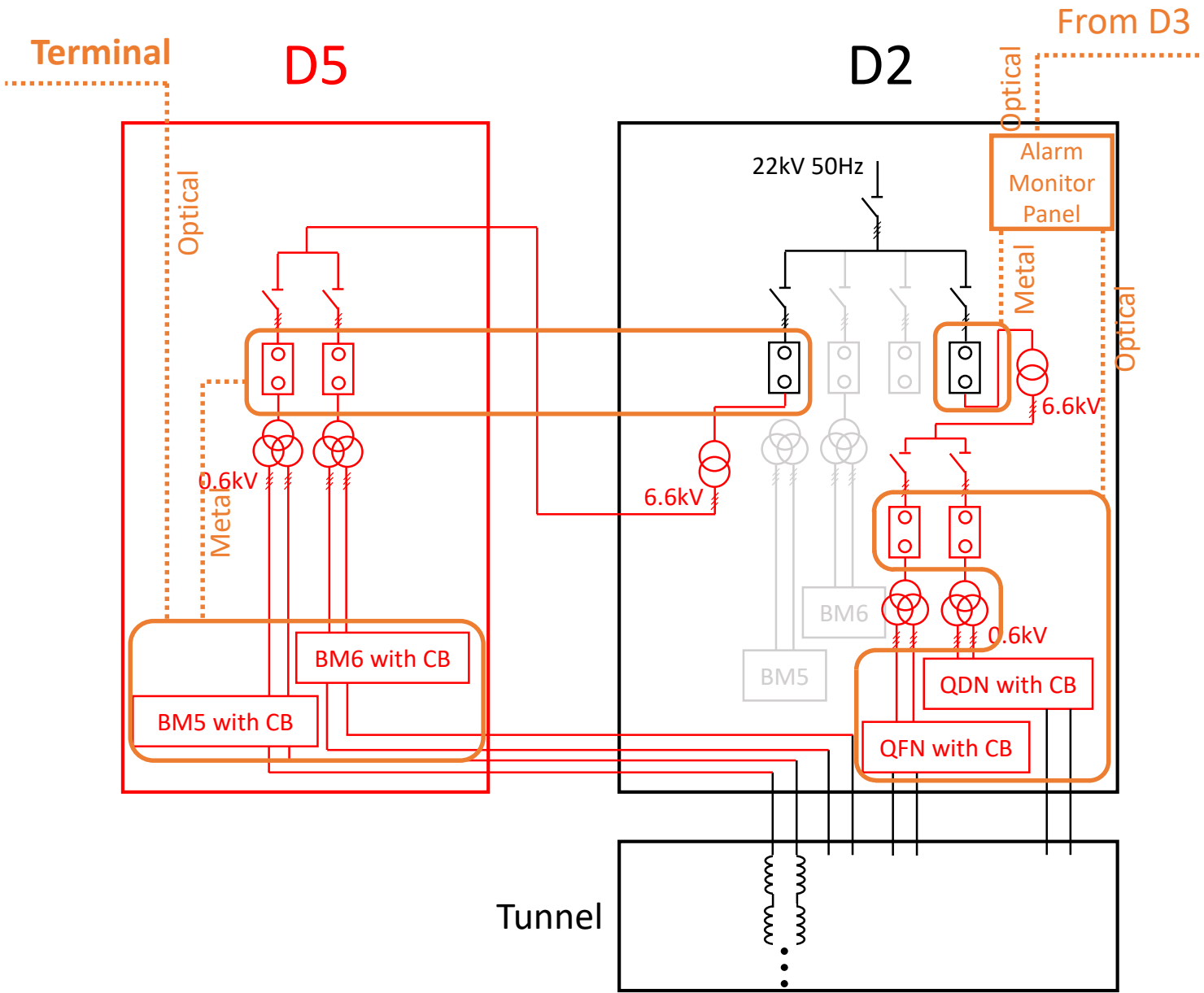
# Electrical connection of PS system



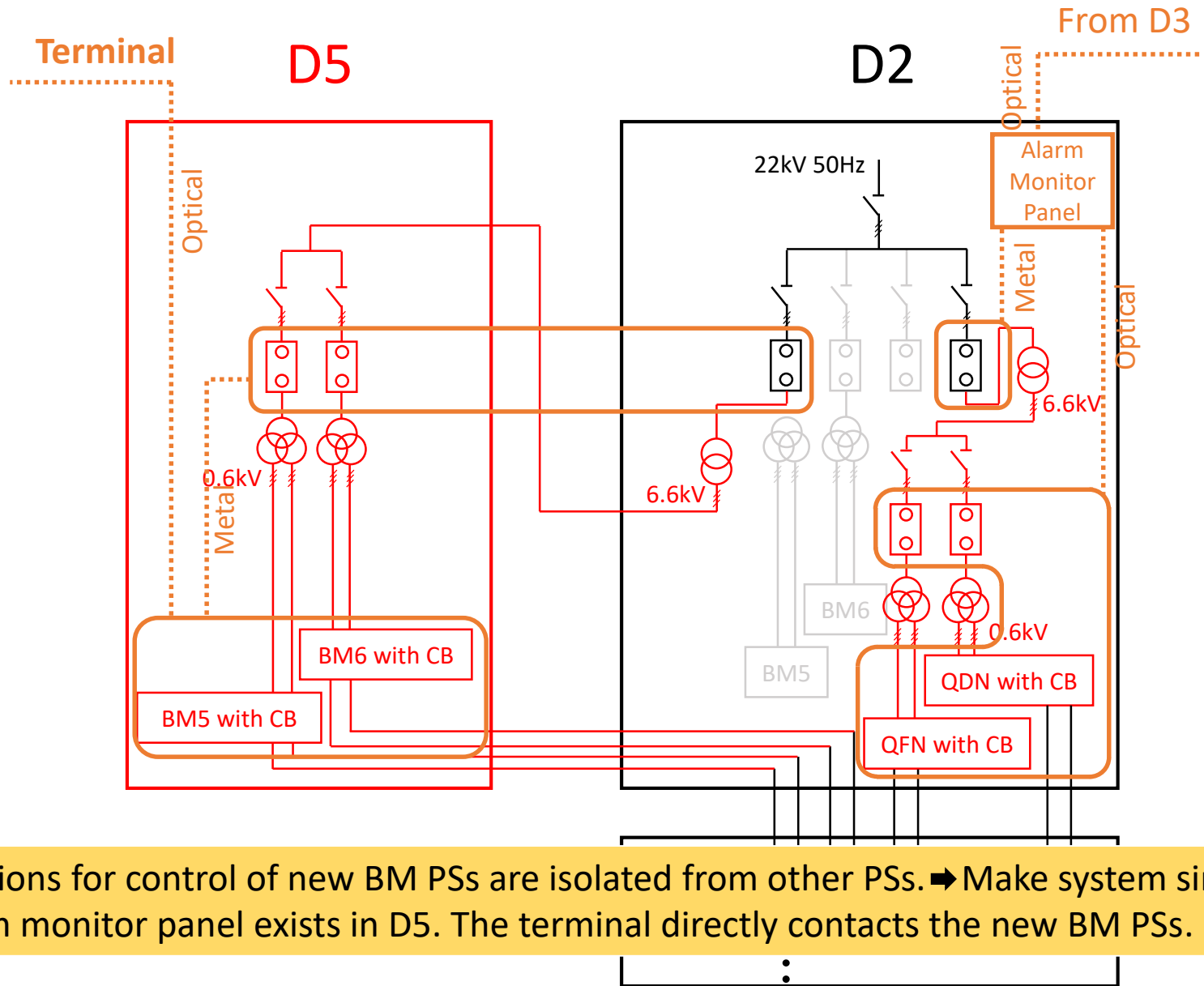
- New BM PSs with capacitor banks are installed in D5.
- New BM PSs are connected to the present system.



# Connection for control

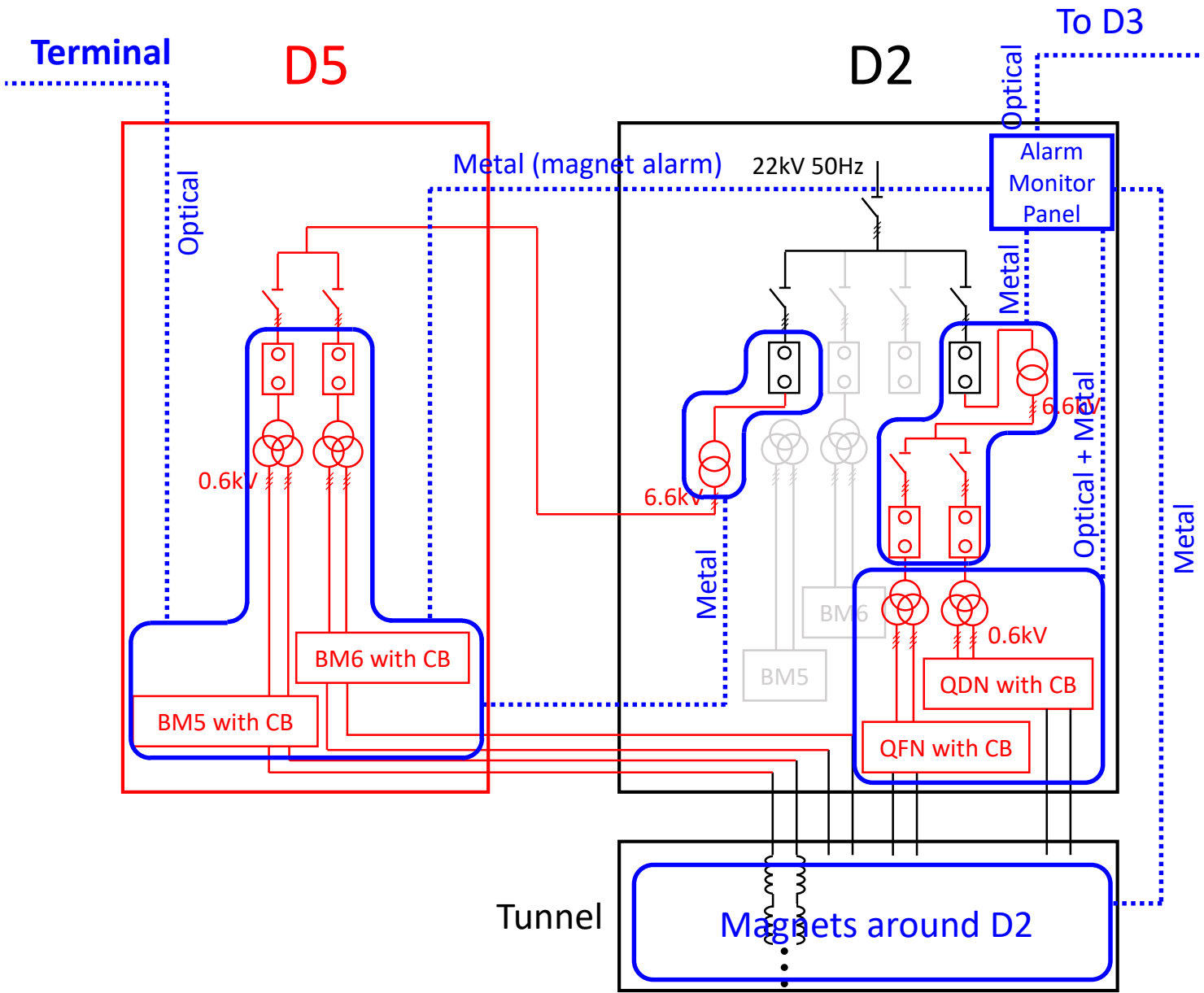


# Connection for control

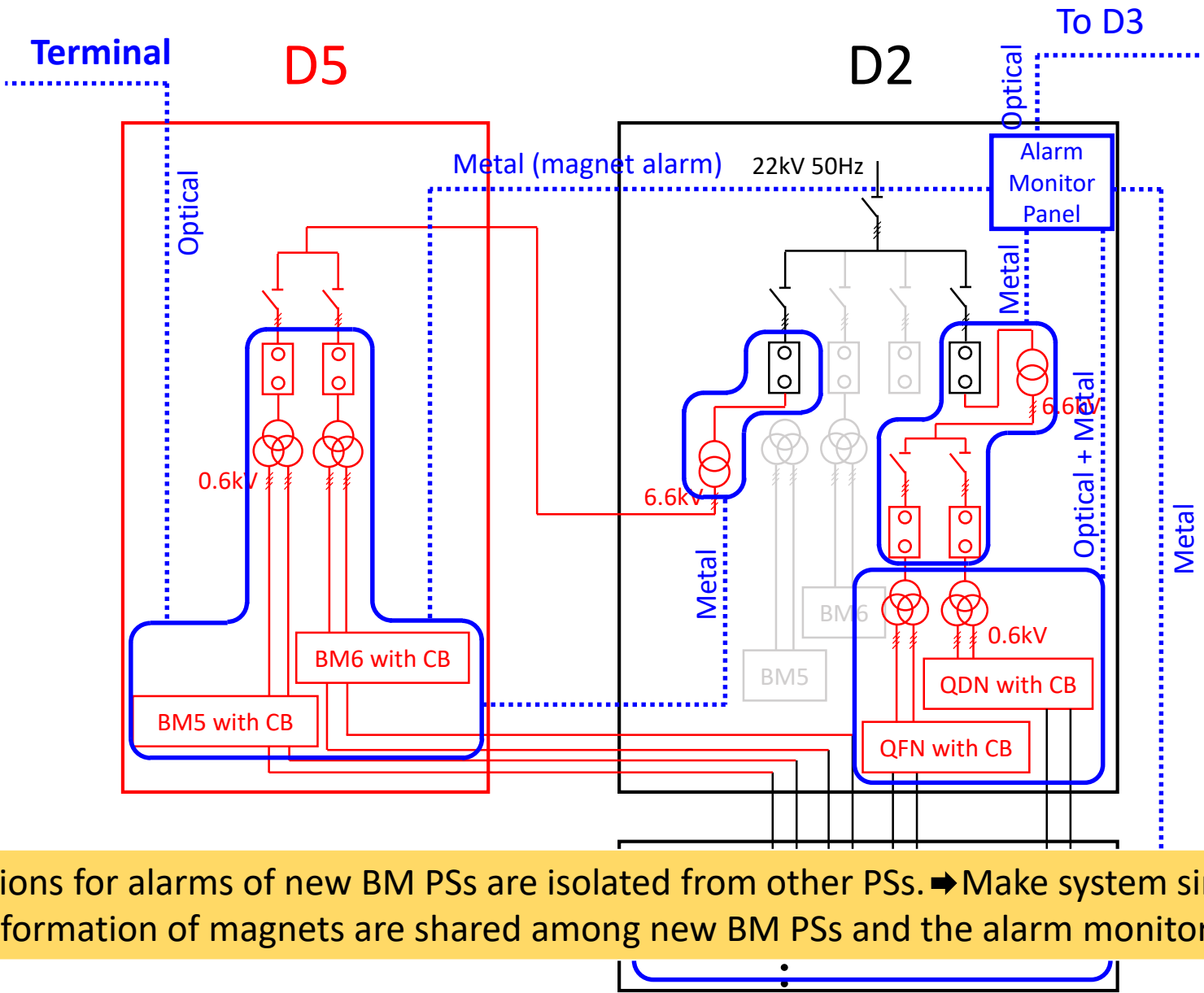


- Connections for control of new BM PSs are isolated from other PSs. ➡ Make system simple
- No alarm monitor panel exists in D5. The terminal directly contacts the new BM PSs.

# Connection for alarms

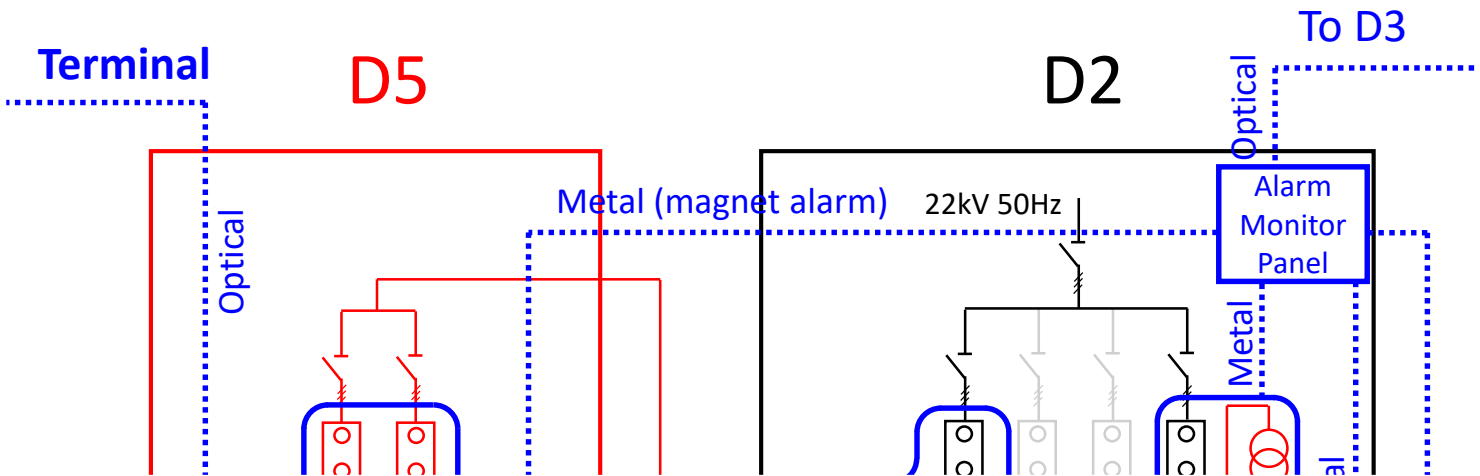


# Connection for alarms

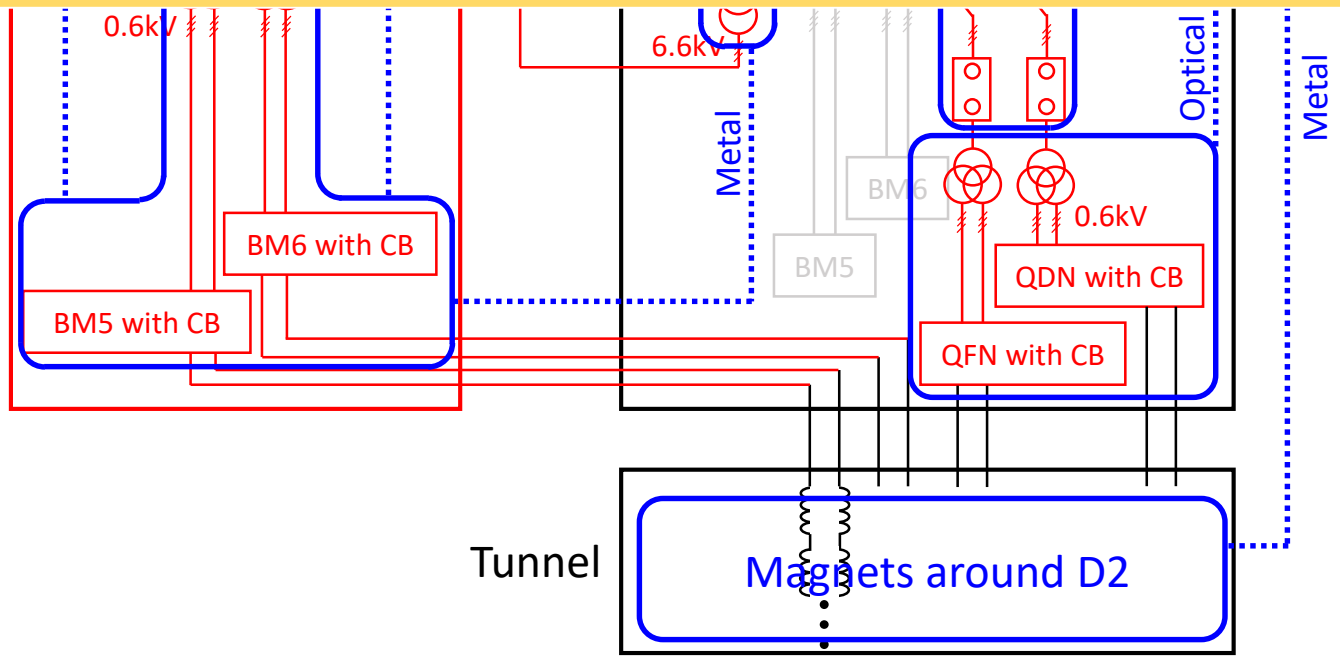


- Connections for alarms of new BM PSs are isolated from other PSs. ➔ Make system simple
- Alarm information of magnets are shared among new BM PSs and the alarm monitor panels.

# Connection for alarms



Configuration of D3 and D6 is almost identical to that of D5 and D2



# Contents

- Introduction
- Present PS system
- PS system after upgrade
- Present status

- Installed
- Partially installed

# Present status

Family		status
BM1	Converter	
	Capacitor Bank	
	Transformer	
BM2	Converter	
	Capacitor Bank	
	Transformer	
BM3	Converter	
	Capacitor Bank	
	Transformer	
BM4	Converter	
	Capacitor Bank	
	Transformer	
BM5	Converter	
	Capacitor Bank	
	Transformer	
BM6	Converter	
	Capacitor Bank	
	Transformer	
QFN	Converter	
	Capacitor Bank	
	Transformer	
QDN	Converter	
	Capacitor Bank	
	Transformer	

Family		status
QFX	Converter	
	Transformer	
QDX	Converter	
	Transformer	
QFR	Converter	
	Transformer	
QDR	Converter	
	Transformer	
QFP	Converter	
	Transformer	
QFS	Converter	
	Transformer	
QDS	Converter	
	Transformer	
QFT	Converter	
	Transformer	
QDT	Converter	
	Transformer	
SFA	Converter	
	Transformer	
SDA	Converter	
	Transformer	
SDB	Converter	
	Transformer	

Components that will be installed next January.

- Two sets of converters
- Three containers for CB

} The new QFR PS has been used for the beam operation since 2016.

~35% of the installation will be finished next January.

No technical issue is remained.  
The production of rest of PSs will start as soon as the budget is approved.

← Product was delivered in 2014.

} Present systems are sufficient.



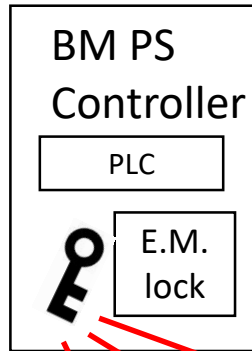
The end of slides

# Management for key of container

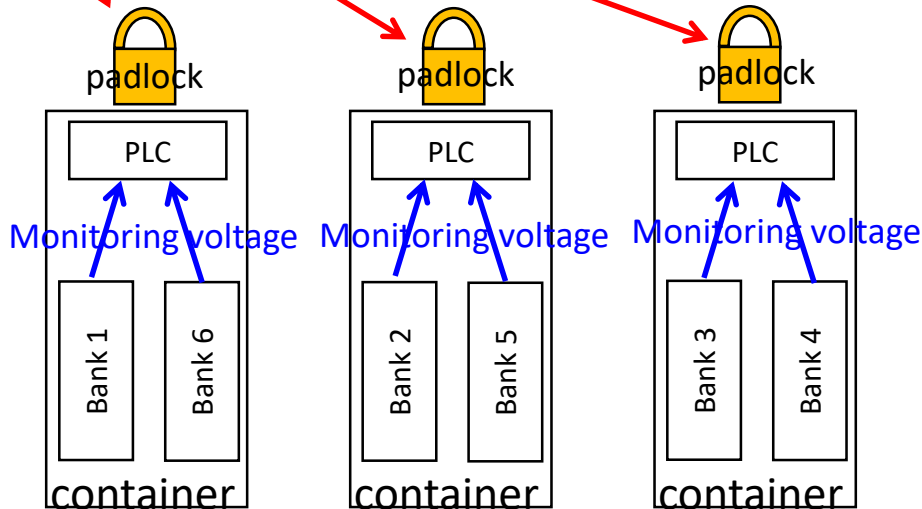
The conditions for the permission of the use of the key.

- The discharger "CLOSE" AND
- All of 6 banks complete the discharges (lower than 10 V). AND
- 5 minutes after the discharger closed.

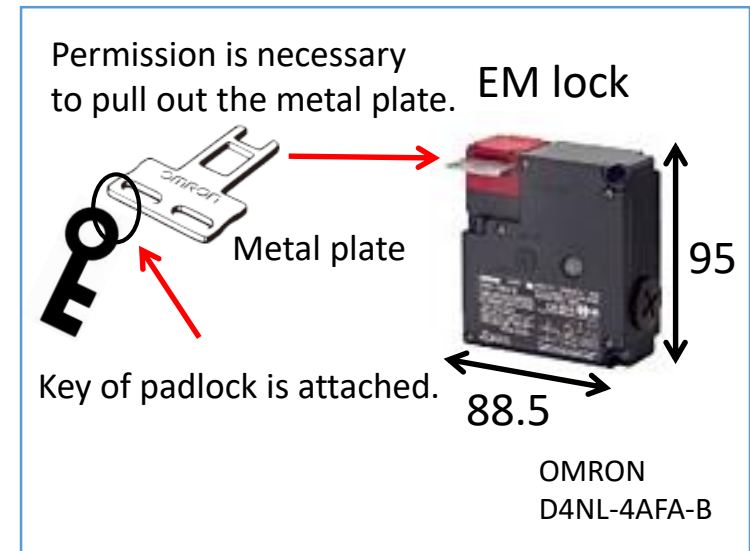
PLC monitors the conditions.



The key is common for the three containers.  
(It is not common among the different families.)



## Electromagnetic lock



All PLCs are connected with optical links each other. All voltages of 6 banks are included the management sequence.