



Pulsed magnet

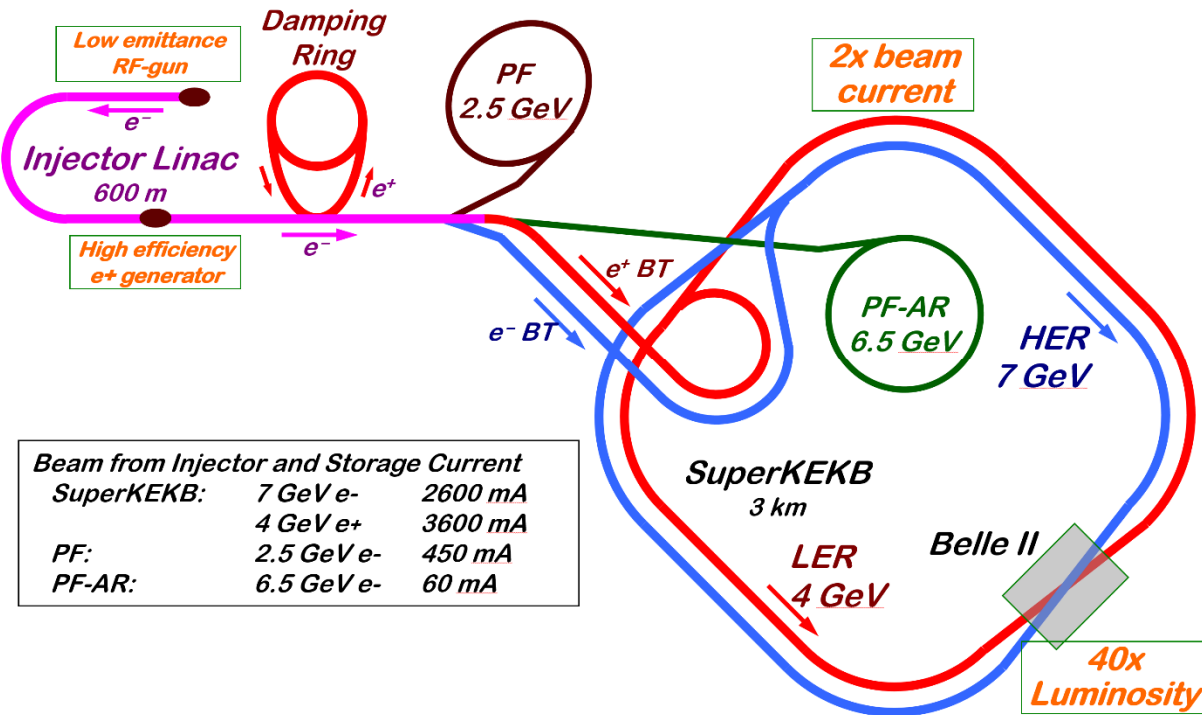
Y. Enomoto

Outline

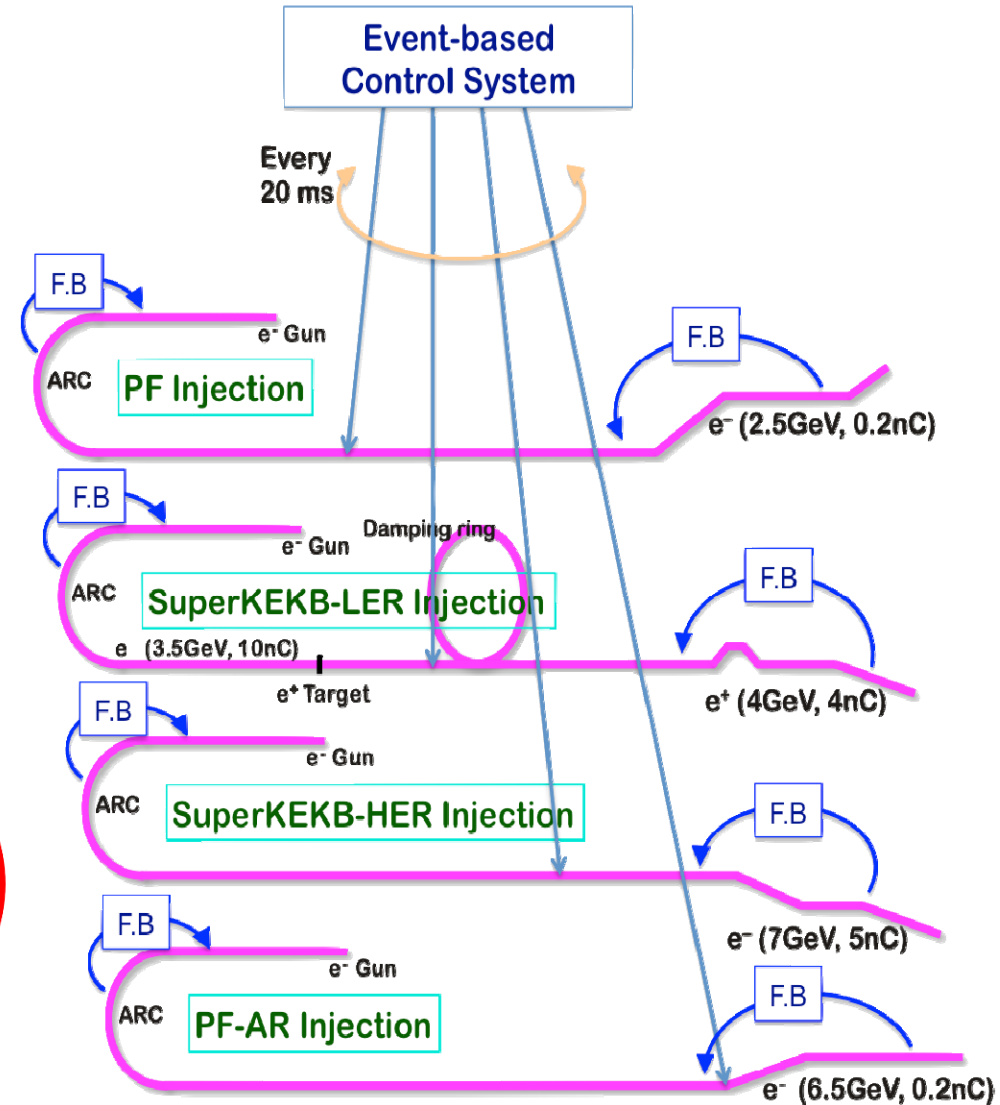
- Motivation
- Installation
- Technical features of pulsed power supply
- Present status
- Plan in FY2018
- Summary

Motivation

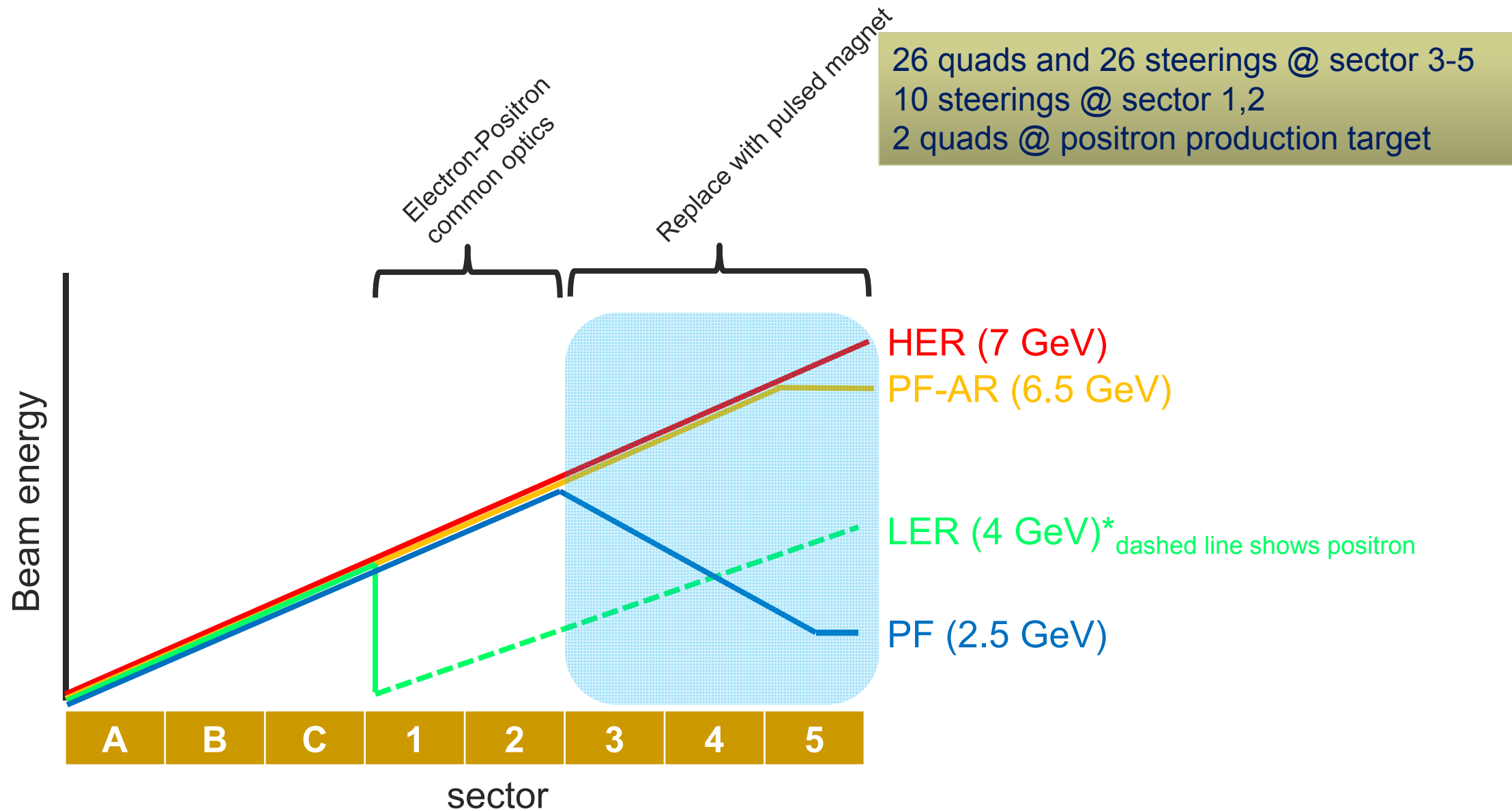
Shot by shot switch of injection destination to
 HER, LER (SKEKB)
 PF
 PF-AR



Beam from Injector and Storage Current		
SuperKEKB:	7 GeV e ⁻	2600 mA
	4 GeV e ⁺	3600 mA
PF:	2.5 GeV e ⁻	450 mA
PF-AR:	6.5 GeV e ⁻	60 mA

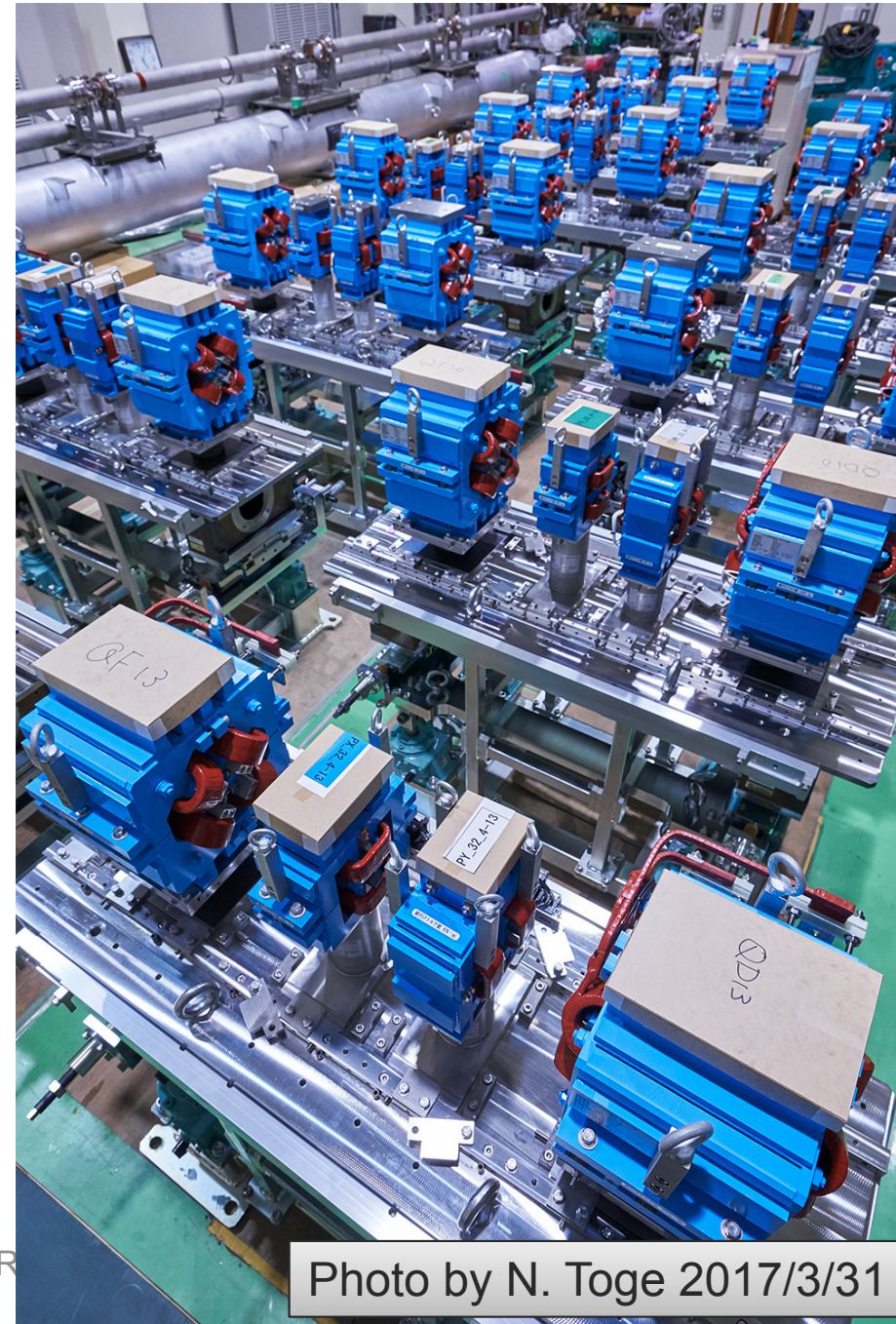


Magnet to be replaced

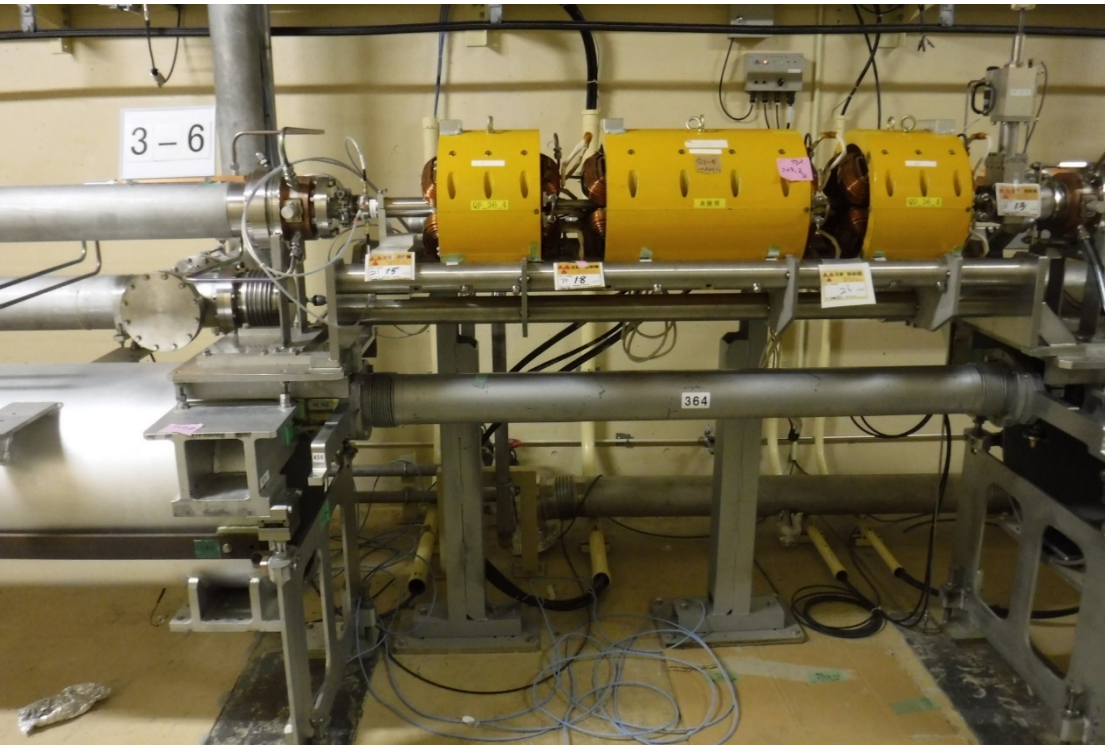


Installation 1

- New magnets were installed in summer 2017.
 - 64 magnets were replaced.
 - 99 working day.
 - PF was in operation till middle of May and restarted in October.
 - Careful preparation was important.
 - Not only magnet but
 - power supply
 - cooling water
 - cabling
 - support
 - control system
 - software...were renewed.



Installation 2



Old DC magnets
Q triplet



New pulsed magnets
QF
Horizontal steering
Vertical steering
QD

Installation 3

Standard pulsed power supply setup (1 set = 1 triple rack = 8 ch)

Power supply and interlock
for 2 x Quad + 2 x Steering

Power supply and interlock
for 2 x Quad + 2 x Steering

Control system



Installation work went well.
Long (one month) integrated tests were done in September.
→trouble free startup in October.

Technical features of pulsed power supply for quad magnet 1

- High efficiency
 - Stored energy in an inductance of the magnet are recovered to capacitors.
 - Total energy recovery efficiency 68.5% (measured).
- High precision and stability
 - Analog feedback of IGBTs.
 - 0.01% for 24 hours.

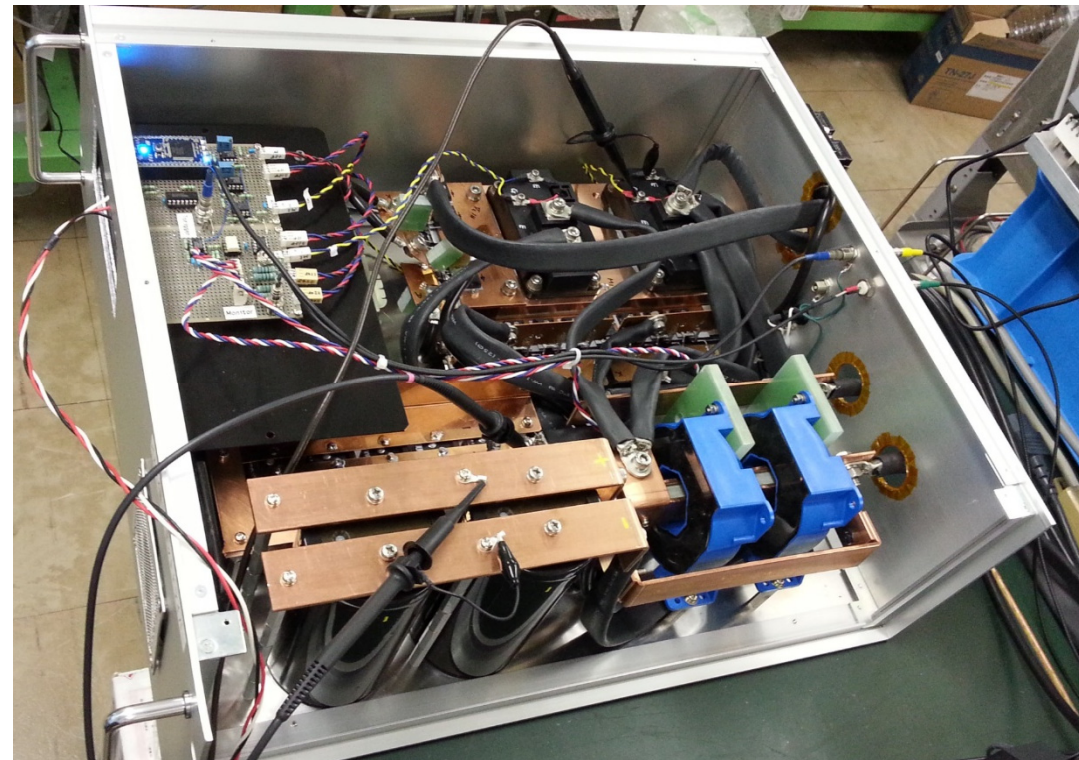
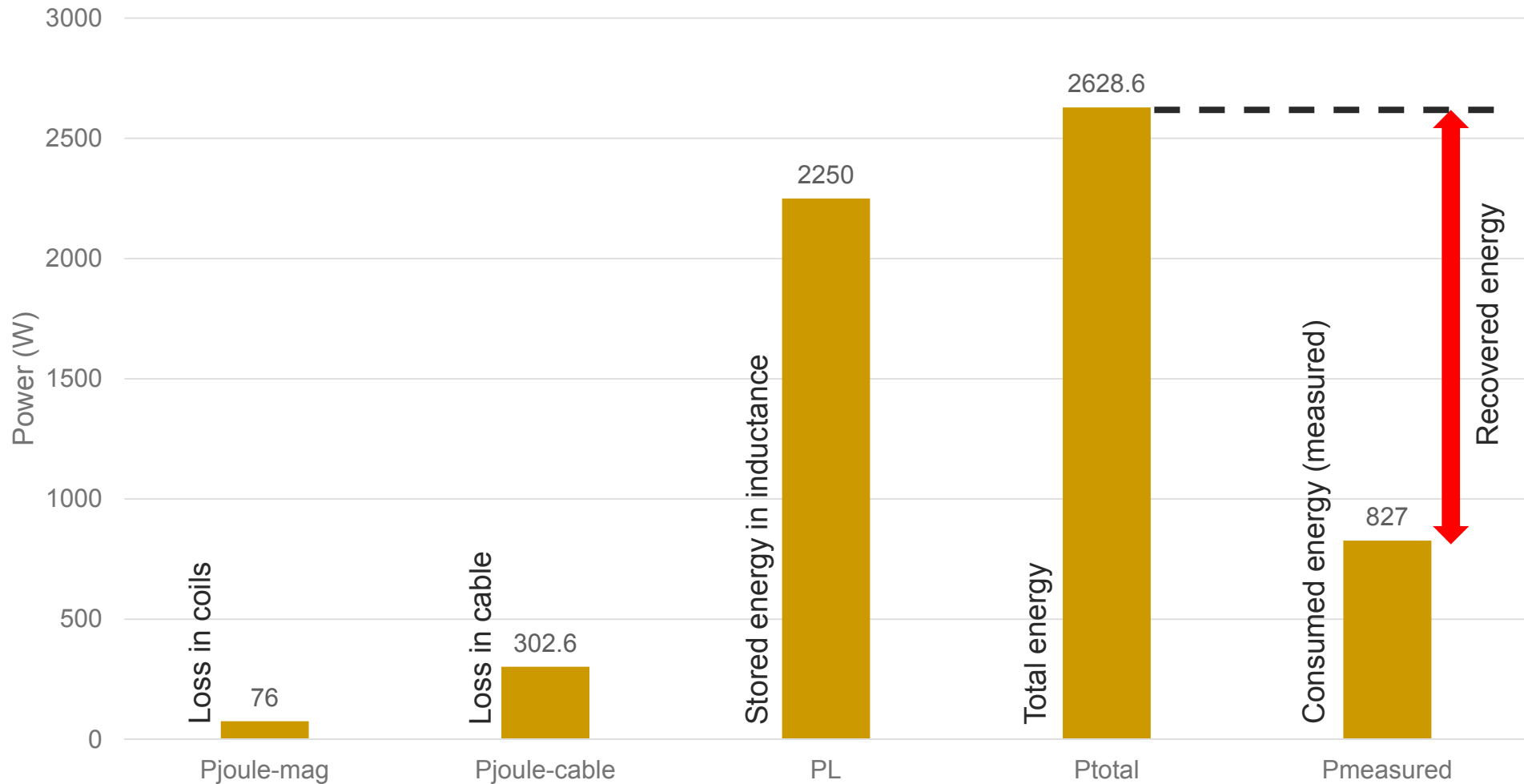


Photo of a prototype pulsed Q driver
Designed by T. Natsui

Technical features of pulsed power supply for quad magnet 2

Energy consumption balance

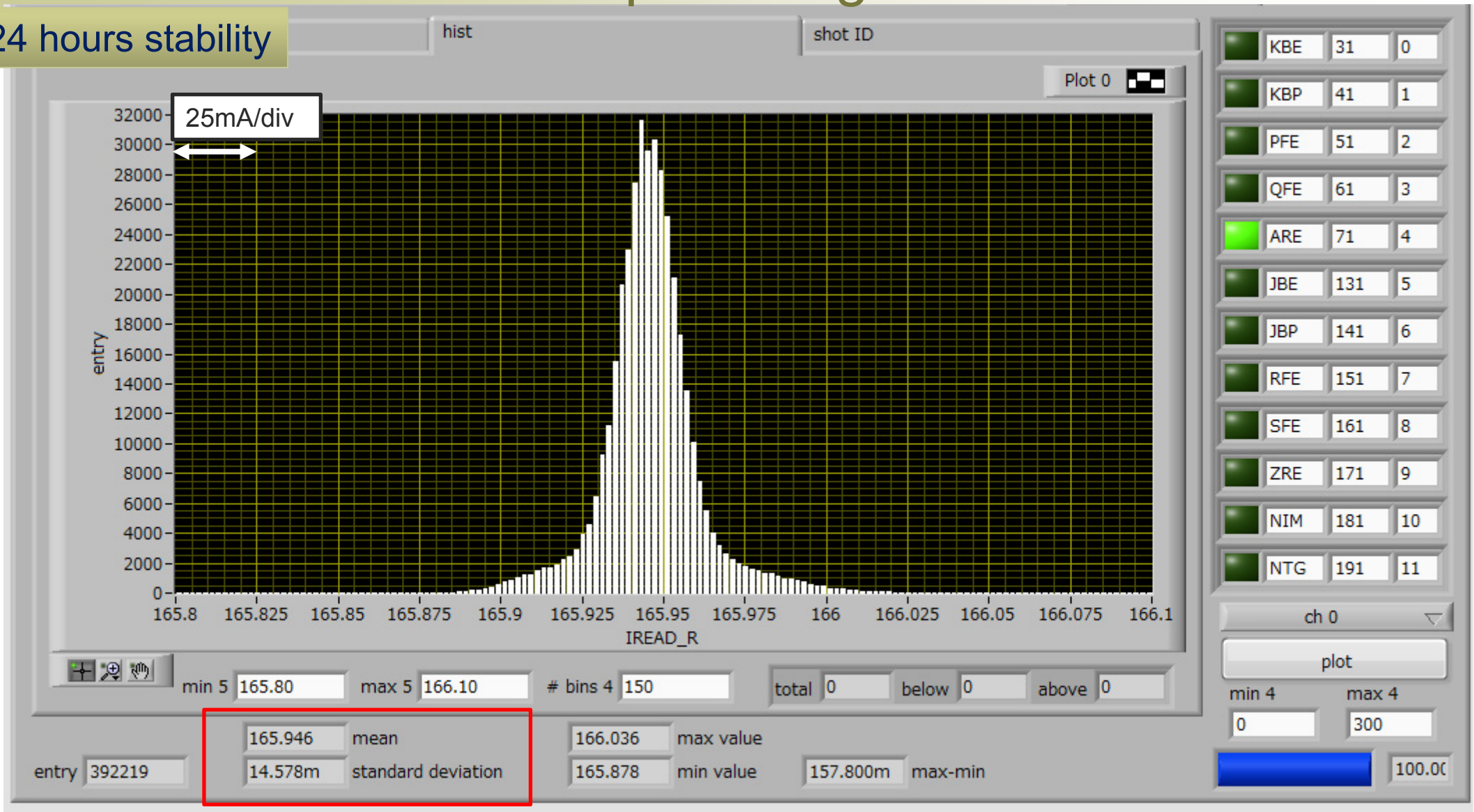
Q (50 Hz, 300 A) x 1



$$\text{Energy recovery efficiency} = 1 - P_{\text{measured}} / P_{\text{total}} = 68.5 \%$$

Technical features of pulsed power supply for quad magnet 3

24 hours stability

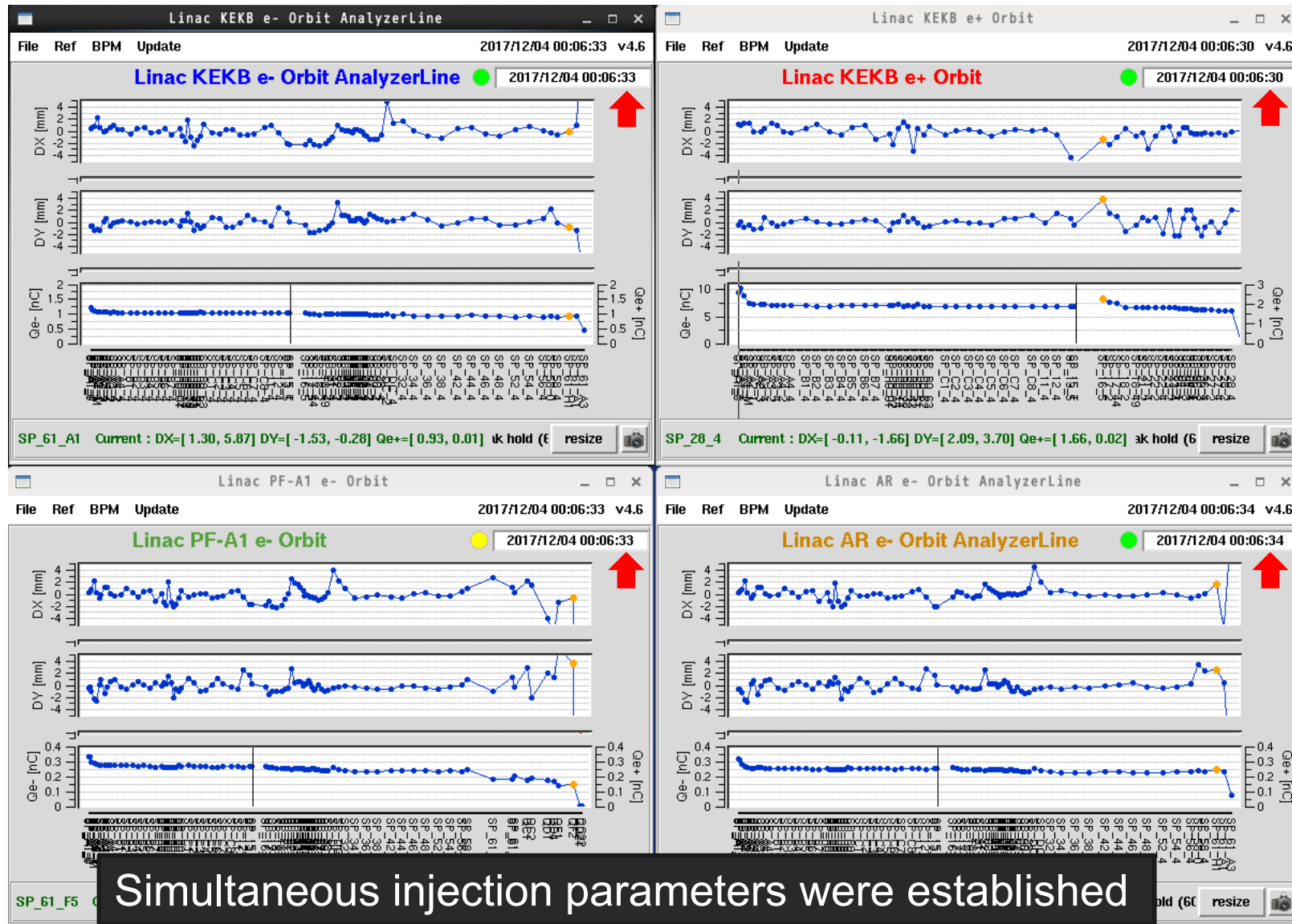


$$0.014578 / 165.946 = 0.01 \% \text{ (requirement } 0.1 \% \text{ @ } 330 \text{ A)}$$

PF_52_4

Present status

BPM data (orbit and charge) for 4 different rings



Plan in FY2018

- 2 bend magnets @ merging line.
 - Shot by shot switch of the RF / thermionic e⁻ gun.
- 4 quad and 4 steering magnets @ A sector .
 - To match the beam from the RF/ thermionic e⁻ gun.
- 8 steering magnets @ inlet and outlet of the arc section.
- 2 quad and 3 steering magnets @ 1 and 2 sector.
- Replace power supply and control system of old 11 steering magnets @ 1 and 2 sector.

23 magnets
34 power supplies
Will be installed in FY2018
→big quantity but ...

Plan in FY2018

2 bend magnet at merging line

Thermionic e^- gun

PF-AR
LER(for e^+ production)
PF

HER

RF e^- gun

Plan in FY2018

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	
sector	magnet名	magnetタイプ	マグネット設置時期	マグネット要廃入	開始	phase3電源システム	電源設置場所	使用条件	要採仕準設工事	分電盤	3相200V1次側電圧容量	要200V電圧工事	単相100V1次側電圧容量	要100V電圧工事	新電源設置時期	PXI制図	Interlock	冷却水必要流量	冷却水取水場所	流量計	水系統	貫通孔	キャリアー内ケーブル記録	備考	備考2	
A	PX_A1_22	新規	2018/夏	○	A1 アルミ架台	50V対応電源	ADF	既存x3	X	ExA-1(3)→A-A子分電盤(3)φ200V, ExA-1(3)→A-A子分電盤(4)3φ200V	40A	×	40A, ExA-1(3)→A-A子分電盤(4) 3φ200V 40Aからトランスで1φ100V/20Aを作る	×	2018/夏	2017-1	2018-6	20	?	?			A3-2	ビット内配線	-	-
	PY_A1_22	新規	○																							
	PB_A1_11	新規	○																							
	FB_AT_15	新規	○																							
	PF_A1_M	新規	○																							
	PD_A1_M	新規	○																							
	PX_A1_M	新規	○																							
	PY_A1_M	新規	○																							
	PF_A2_1	新規	○																							
	PD_A2_1	新規	○																							
B	PX_B8_41	新規	2018/夏	○	?	200V対応電源	BB裏側PLC.裏面一系中電源.裏中→表左	既存x2	X	ExB-2(4)3φ200V, (8)1φ100V	30A	○	30A	○	2018/夏	2018-2	2018-3	0				B6-1	南北は既存ラック利用東西、おろしラック新設B8-1付近におろしラック設置	-	-	
	PY_B8_41	新規		○																						
	PX_B8_42	新規		○																						
	PY_B8_42	新規		○																						
C	PX_C1_01	新規	2018/夏	○	?	200V対応電源	CA裏側増設x1既存電源はつめる	既存x1新規x1	×	ExC-1(4)3φ200V, (8)1φ100V	30A	○	30A	○	2018/夏	2018-3	2018-4	0				C2-3	ビット内配線	-	-	
	PY_C1_01	新規		○																						
	PX_C1_02	新規		○																						
	PY_C1_02	新規		○																						
1	PX_13_2	結	2018/夏	X	1-3-1 unit	200V対応電源	1EB	既存x3	X	Ex-New-BC2(4)3φ200V, (1)1φ100V	75A	○	20A	○	2018/夏	2017-2	2017-3	20				13-3	既存ケーブルラック利用既存配線と同じ経路	-	-	
	PY_13_2	結		X																						
	PF_13_5	PM32_4		既設											X											
	PD_13_5	PM32_4		既設											X											
	PX_13_5	結		既設											X											
	PY_13_5	結		既設											X											
	PQ_16_5x	新規		○																						
	PQ16_5x	新規		○																						
	PX_16_5	PX16_5		既設											X											
	PY_16_5	PY16_5		既設											X											
2	PX_17_2	PX17_2	2019/夏	X	1-7-1アルミ架台	200V対応電源	1DF	既存x3	X	Ex-New-1-D(2)→子分電盤(1)3φ200V, Ex-New-1-D(4)1φ100V	60A	○	20A	○	2017/夏	2017-3	2017-5	20				18-5	1次側電力ケーブルラックを通す1D筐体近くで東西方向ケーブルラック新設出力:南北は既存ケーブルラックおろしは既存ラックに平行して新設チャンネルブロックは取り外す	QF16_56と入れ替え?	-	
	PY_17_2	PY17_2		既設											X											
	PX_17_4	結		既設											X											
	PY_17_4	結		既設											X											
	PQ_17_4x	新規		○																						
	PQ17_4x	新規		○																						
	PX_18_2	PX17_2		既設											X											
	PY_18_2	PY17_2		既設											X											
	PX_18_4	結		既設											X											
	PY_18_4	結		既設											X											
2	PQ_18_4x	新規	2019/夏	○	1-8-1-4架台下流	200V対応電源	1DB	既存x3	X	Ex-New-1-D(2)→子分電盤(2)3φ200V, Ex-New-1-D(5)1φ100V	60A	○	20A	○	2018/夏	2017-4	2017-7	30				18-5	18-5	QF17_44と入れ替え?	-	
	PQ18_4x	新規		○																						
	PX_21_2	PX17_2		既設											X											
	PY_21_2	PY17_2		既設											X											
	PX_21_4	結		既設											X											
	PY_21_4	結		既設											X											
	PQ_21_4x	新規		○																						
	PQ21_4x	新規		○																						
	PX_22_4	PX17_2		既設											X											
	PY_22_4	PY17_2		既設											X											
2	PX_24_4	結	2018/夏	X	2-1チャンネル架台	200V対応電源	2EF	既存x3	X	Ex2-5(1)→子分電盤(2)3φ200V, Ex2-5(1)→子分電盤(1)3φ200V	60A	○	60A, Ex2-5(1)→子分電盤(1)3φ200V 60Aからトランスで1φ100V 20Aを作る	◎要トランス	2017/夏	2017-5	2017-9	20				24-4	ブラッター1台1-6へ移動再組1次側、出力ともにビット内配線	QF21_45と入れ替え?	-	
	PY_24_4	結		X																						
	PX_24_4	結		既設											X											
	PY_24_4	結		既設											X											
	PQ_24_4x	新規		○																						
	PQ24_4x	新規		○																						
2	PX_26_4	新規	2018/夏	○	2-2チャンネル架台	200V対応電源	2EB	既存x3	X	Ex2-5(1)→子分電盤(3)3φ200V, Ex2-5(1)→子分電盤(1)3φ200V	60A	○	60A, Ex2-5(1)→子分電盤(1)3φ200V 60Aからトランスで1φ100V 20Aを作る	◎要トランス	2018/夏	2018-4	2018-5	20				24-4	48_4から移動 48_4から移動	48_4から移動	加速管1m化が必要	
	PY_26_4	新規		○																						
	PF_28_4	PM32_4		既設											X											
	PD_28_4	PM32_4		既設											X											

Detailed plan has been made.
 Same system as that developed in 2017 will be installed.
 →not so much risk even though summer shut down time is 2 month shorter than that in 2017.

Summary

- High efficiency and high stability pulsed power supply was developed.
- 64 new pulsed magnets were successfully installed during summer in 2017.
- New system has been working without any serious trouble till now.
- Simultaneous injection parameter for 4 rings has been established.
- Installation of 23 magnets and 34 power supply system is planned in FY 2018.