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Maintenance Strategy of the PEFP Proton Linear Accelerator

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PEFP, KAERI

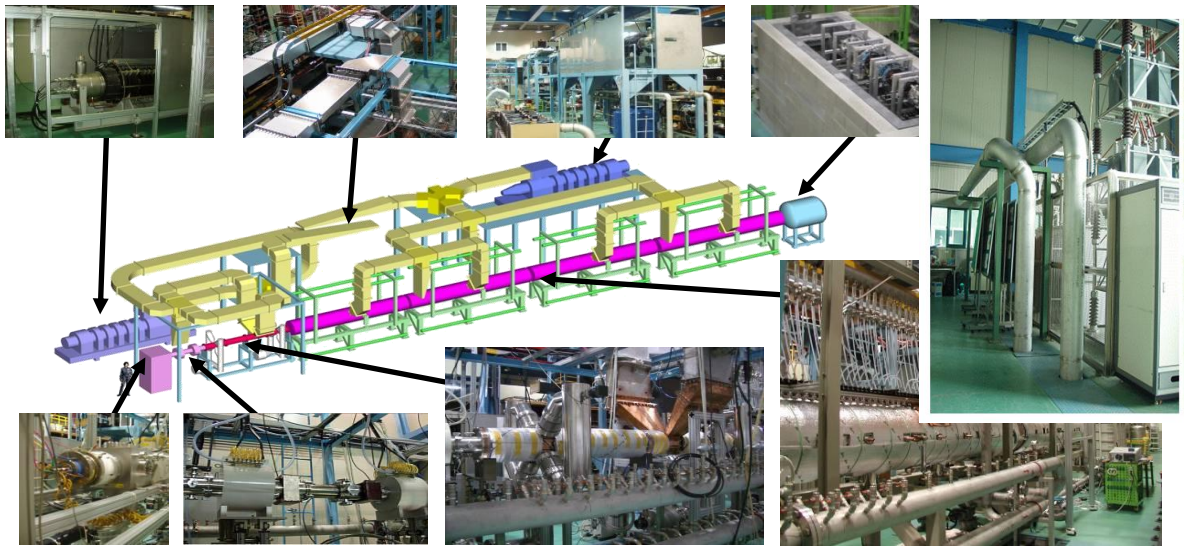
Contents

What we have

- Facilities
  - 20MeV proton accelerator
  - Auxiliary parts for the accelerator
  - Electrical power station
  - Cooling station
- Experiences on 20-MeV machine
  - installation,
  - operation,
  - maintenance


Electrical power system utilities

Klystron (RFQ) Waveguide Klystron (DTL) Target Station Beam Profile

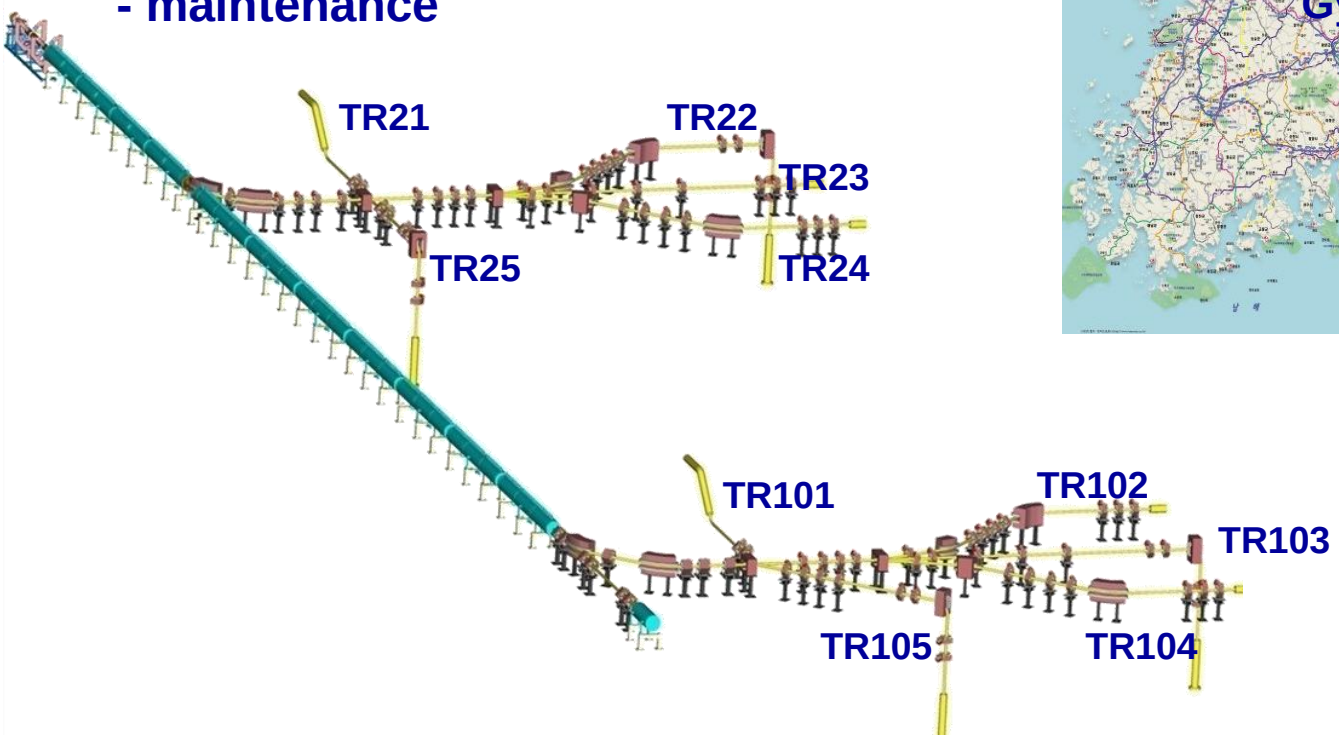



Cooling utilities

Ion Source LEBT 3 MeV RFQ 20 MeV DTL

What we have to do

- Installation at Gyeongju site
  - Disassembly of 20MeV linac
  - Packing and transportation
  - Installation
- After installation,
  - commissioning
  - operation
  - maintenance



I. What we have, what we have to do

II. 20-MeV experiences

III. 100-MeV plans

IV. Summary

Installation

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- **Experience on the heavy but carefully treated parts**

- DTL tank

- Alignment

- Klystron

- Supporting structure

- Modulator

Packing and Transportation

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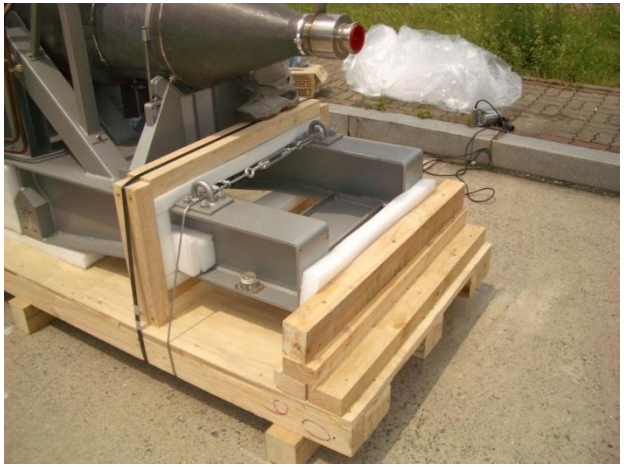
- Experience on the heavy but carefully treated parts
  - Klystron : Return of the spare klystron to factory
  - DTL tank (?) – DT alignment



Packing and Transportation

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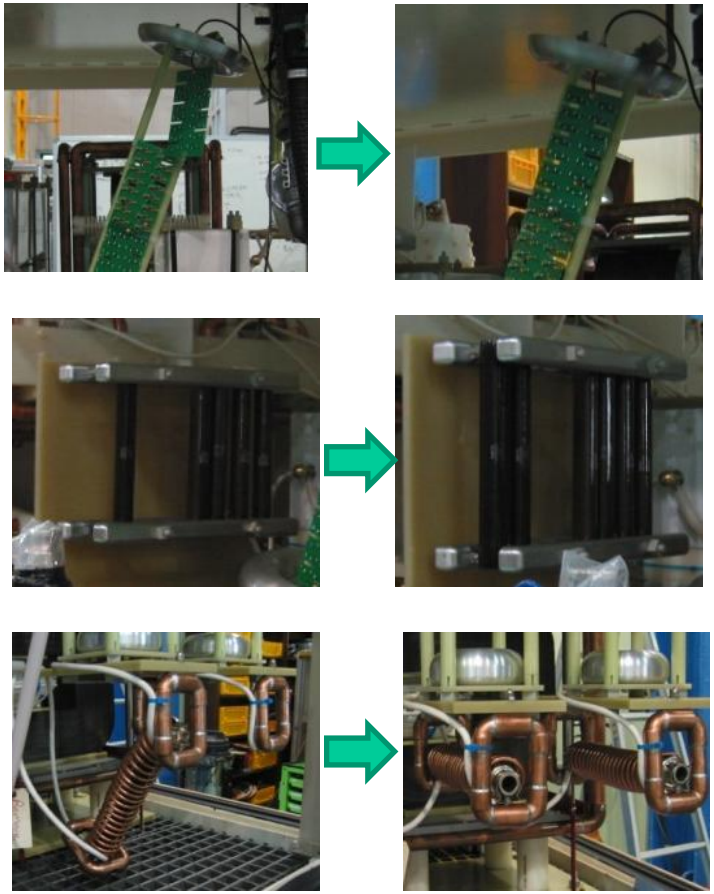
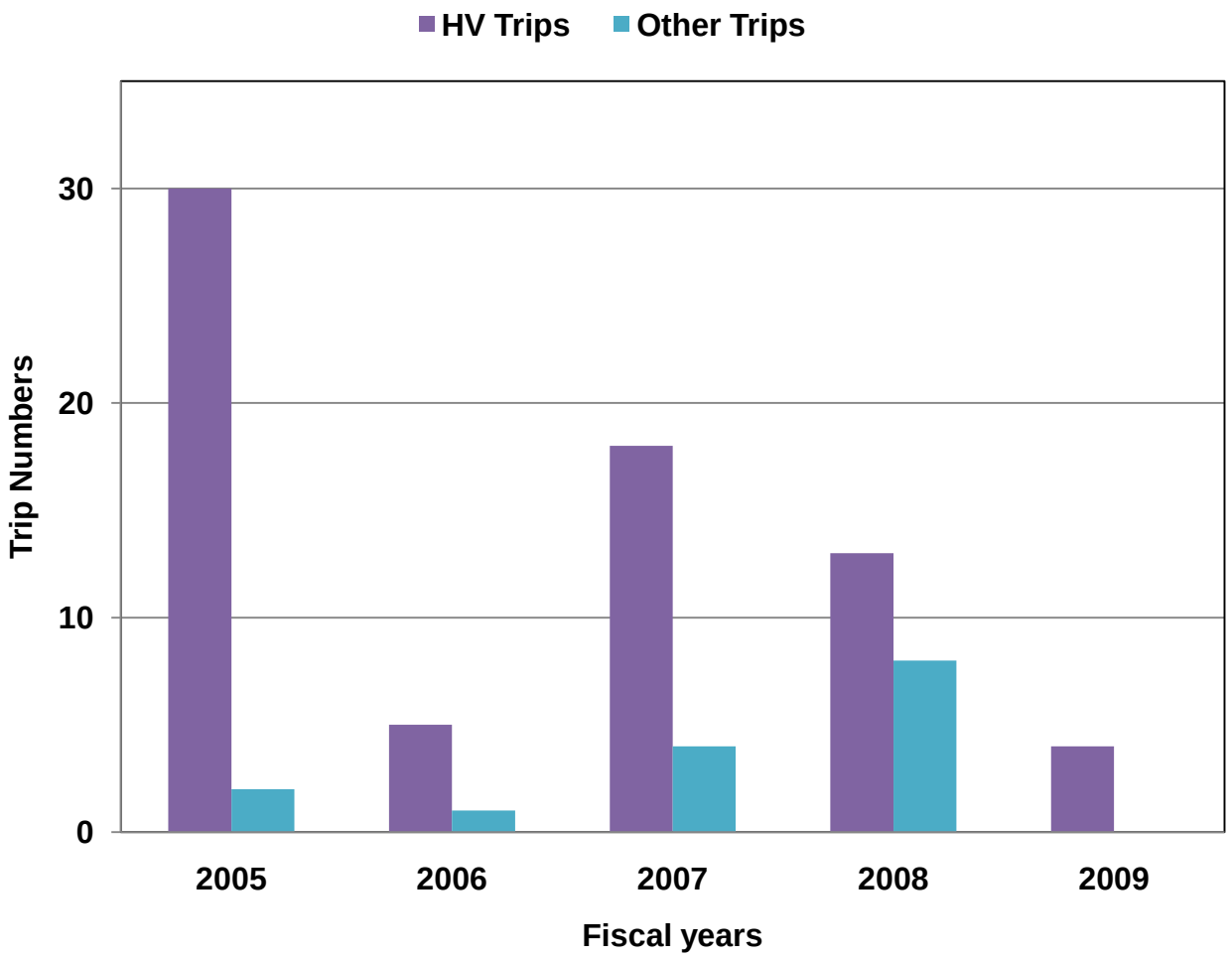
- **Inspection of parts inside oil tank after the delivery**
  - **find to the damaged components**

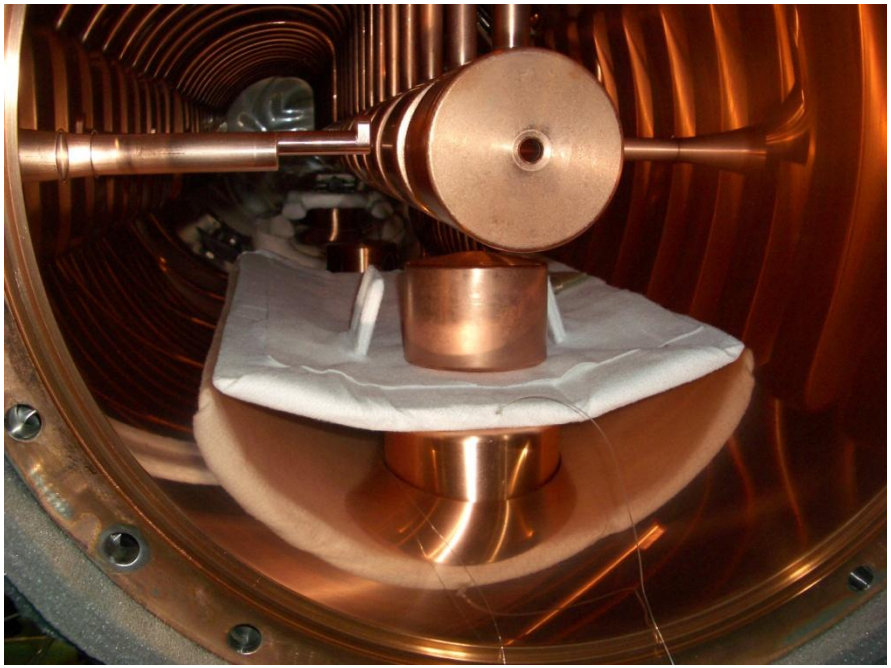


Maintenance Statistics

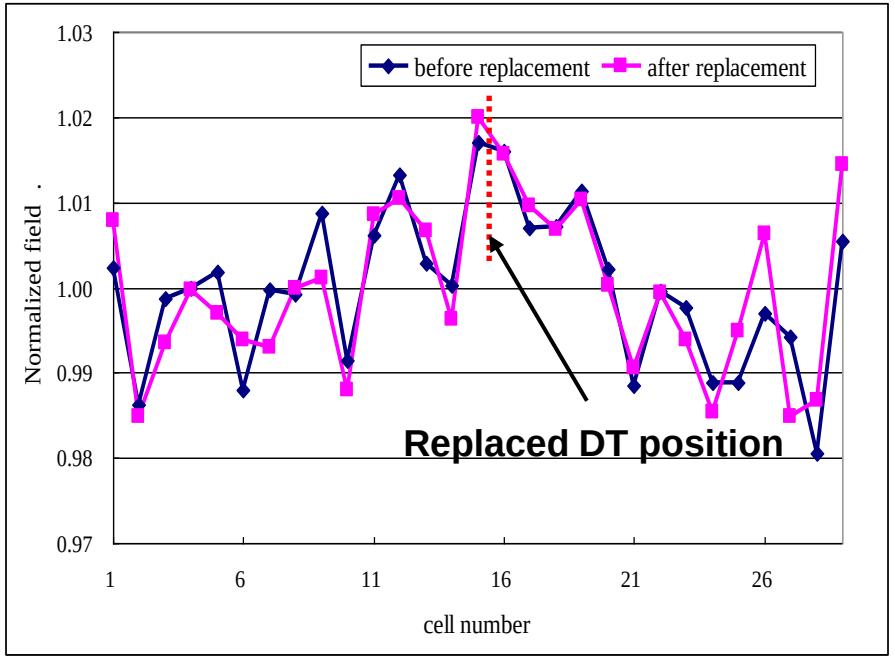


DT Replacement

- Reason
  - Electromagnet failure at tank 3 HE / tank 4 LE side end plate
  - Vacuum leakage at tank 4 / 15th drift tube
  - On line replacement of the DT
- Check after replacement
  - Field profile variation < 1%
  - Resonant frequency compensation using wall temperature < 2 deg. C



Drift tube replacement



Field profile before and after replacement

Vacuum System – Commissioning stage

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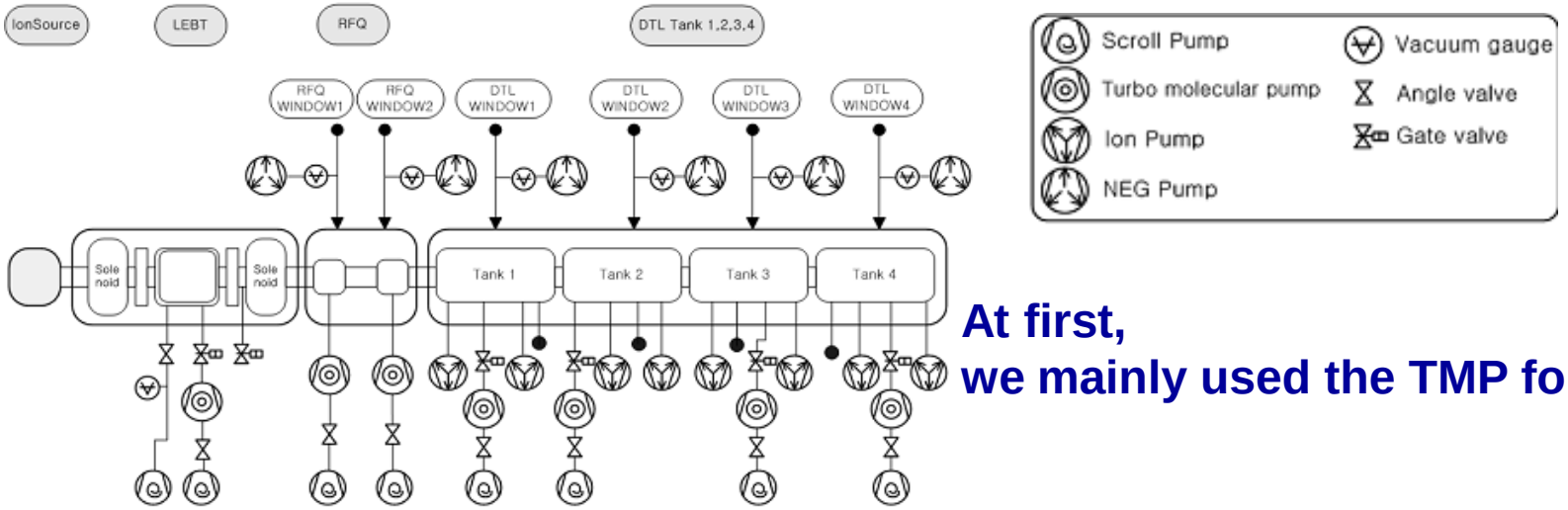
- **Vacuum system components of 20 MeV Proton Linear Accelerator**

Pump	Comp.	Model	Pumping speed	Seal	Flange	No.
Scroll Pump	Varian	Triscroll 300	250L/s	Viton O-ring	NW25	5
	Iwata	ISP-500B	500L/s	Viton O-ring	NW40	3
TMP	Leybold	T1600	1600L/s	Copper	CF250	1
	Osaka	TG1300MCAB	1300L/s	Copper	CF200	2
	Varian	TV301 NAV	280L/s	Copper	CF8"	4
NEG Pump	Saes getters	CapaciTorr B 1300-2 MK5	1300L/s	Copper	CF8"	6
Ion Pump	Varian	Vaclon Plus 300	300L/s	Copper	CF8"	8



At first,
we mainly used the TMP for DTL tank

Vacuum System – Operation stage

- Change of the vacuum system operation from commissioning stage (2007)
  - TMP fails
  - Regular maintenance of the scroll pump
- Operation method
  - At initial evacuation, use a TMP (1 TMP/DTL tank)
  - At normal operation,
    - use ion pumps as main pump (2 ion pump/DTL tank)
    - gate valve close, turn off the TMP

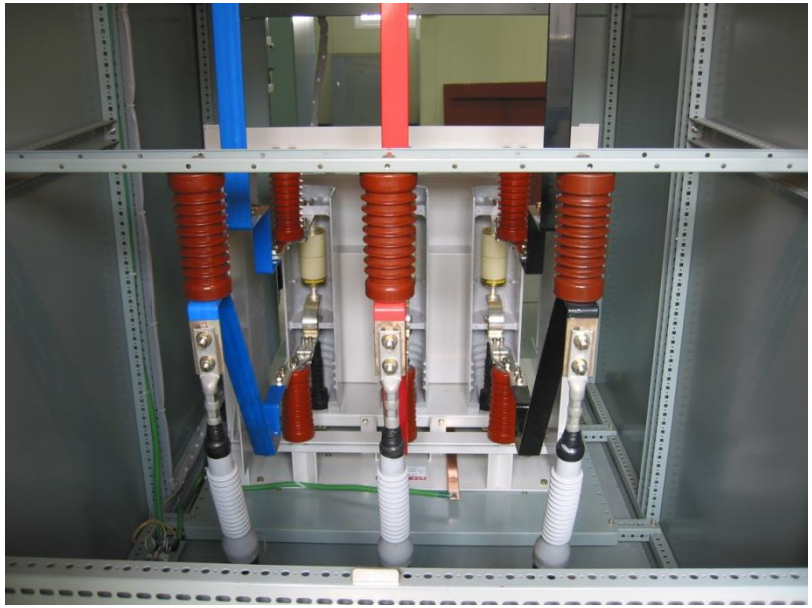
TMP:
Blade broken

Scroll pump:
Replace of tip seal and bearing

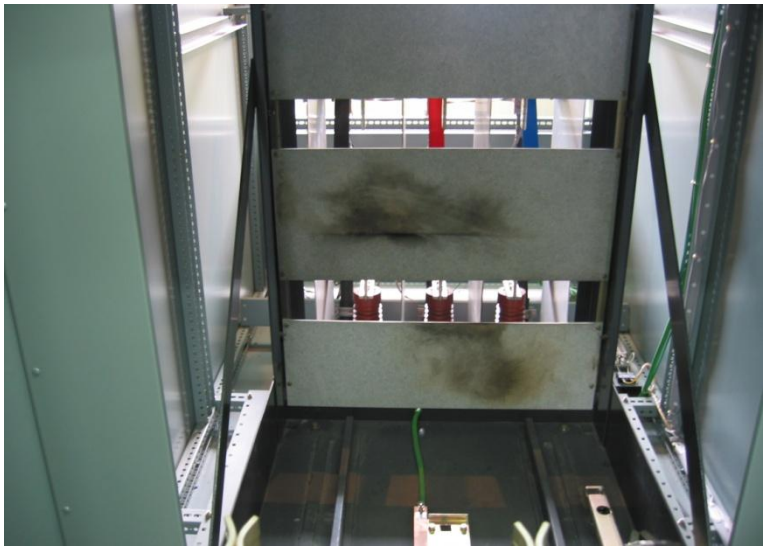
Electrical Power Station

- 22.9kV, 8MVA capacity
- VCB at the electrical power station
  - 8 years since manufacture
  - Coronal discharge at the VCB (June, 10, 2007)
- The number of permitted operation is within the limit, but the old causes problem

VCB and its bus bar



Newly installed one

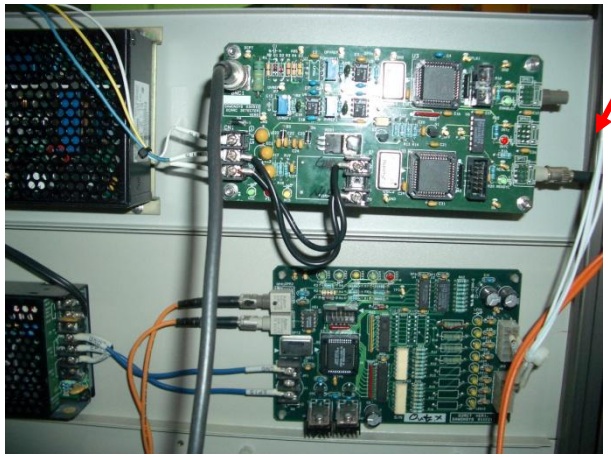


FRP barrier

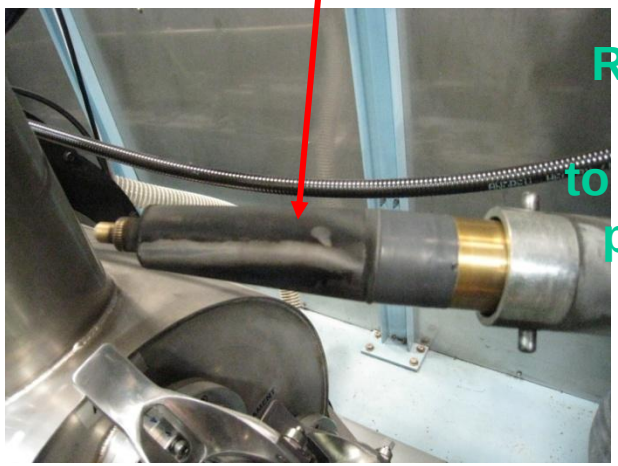
High Voltage DC Power Supplies

- -100kV, 20A, <20J : 2 sets
- Arc energy limiting device : crowbar (RFQ), opening switch (DTL)
- Trips of the high voltage DC power supplies caused by
  - Malfunction of the protection circuit (DTL , 2005)
  - Crowbar trip due to the klystron arcs (RFQ, 2007~ 2008)
    : high voltage connectors of the inside and outside the oil tank

	2005	2006	2007	2008	2009	2010
Number of Trip	30	5	18	13	-	-



Change the circuit
to optical (DTL case)



Change the connector and re-adjust
the inside connector (RFQ case)

Replace the systems
with modulator
to check the modulator
performance at 2009

Installation of the Modulator

- Valve direction of the cooling circuit

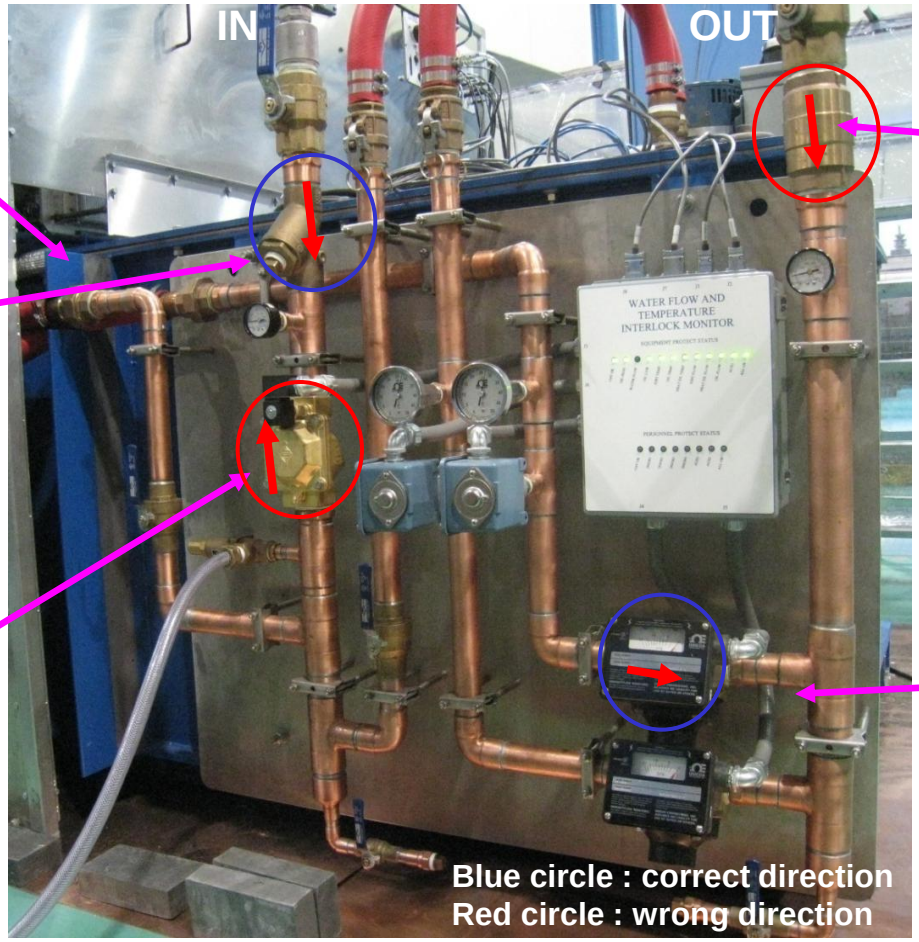
- After installation of the cooling circuit, we could not operate the cooling circuit

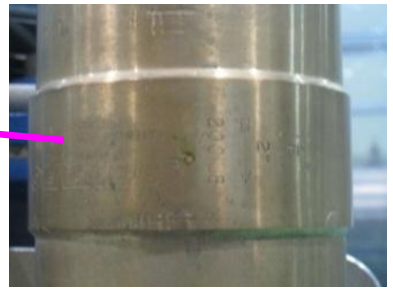
- The directions of the check valve and solenoid valve were reversed

Seal

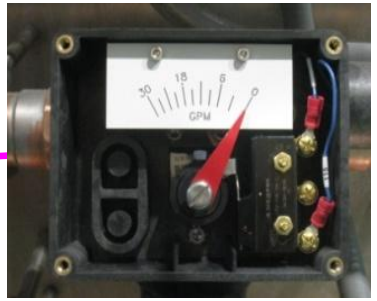
Strainer

Solenoid valve





Check valve



Flow meter

Installation of the Modulator

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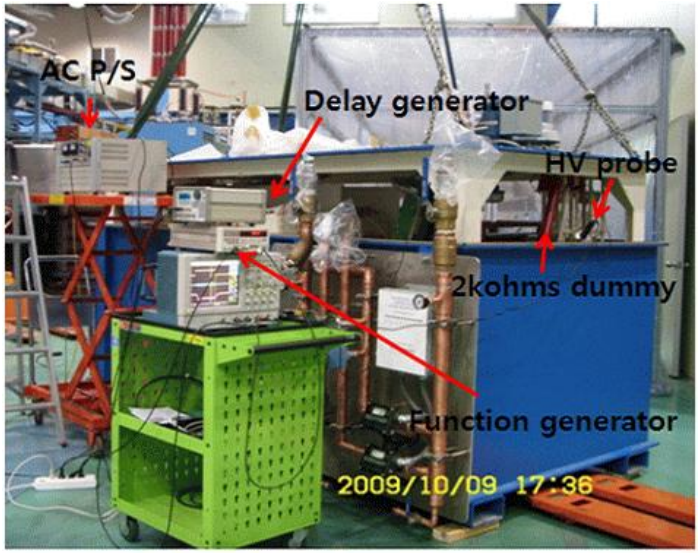
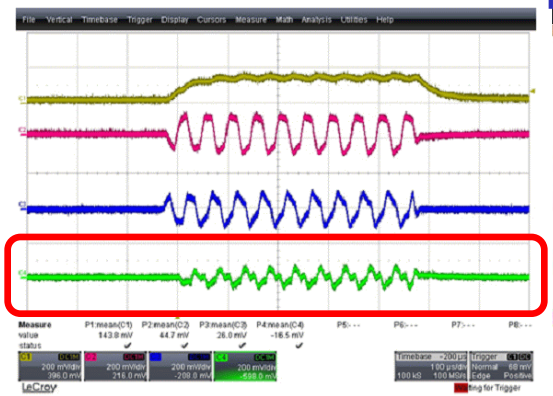
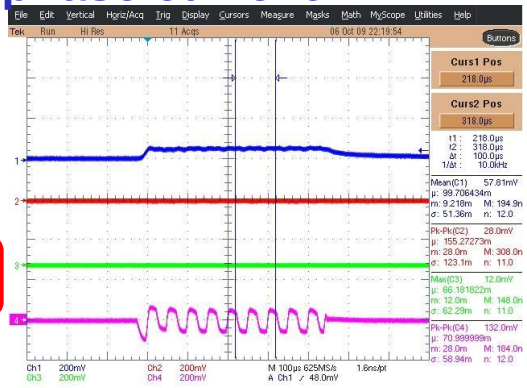
- Inspection and test for the finding of the strange pulse

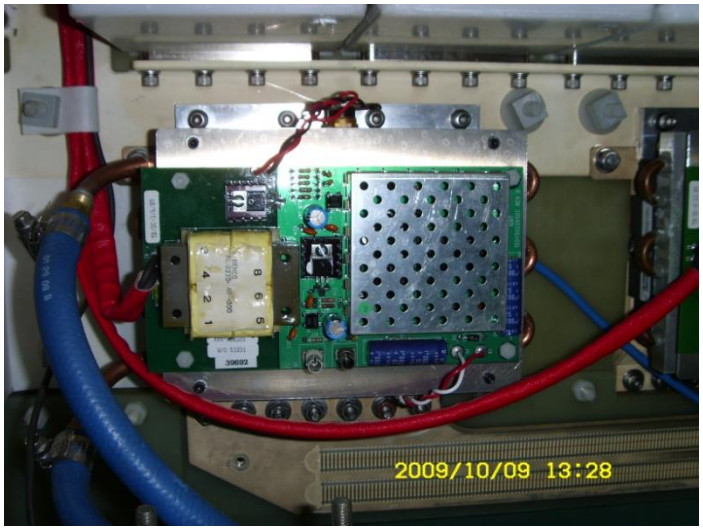


- C-phase of the CH4 is the strange pulse
- Ch 1: HVCM output voltage,
  Ch2&Ch3&Ch4 : A&B&C phase current

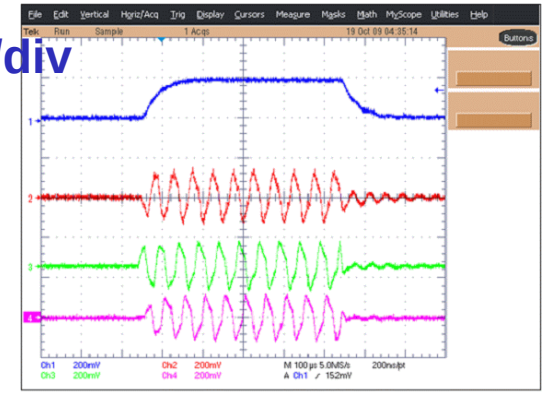




- Test after exchange the IGBT board



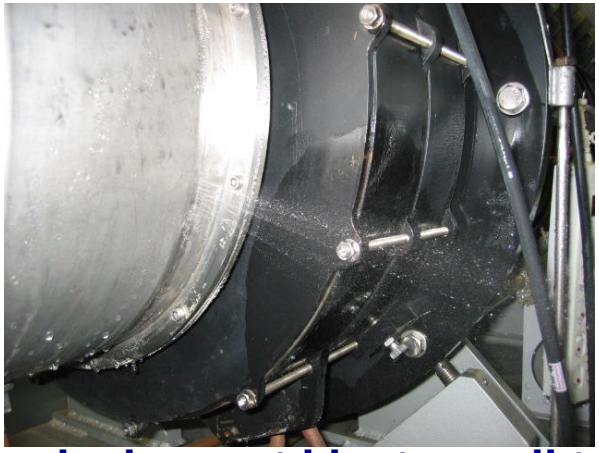
- HVCM output voltage : 7.5kV
- SCR voltage : 150V
- pulse width : 100us/div



Cooling System

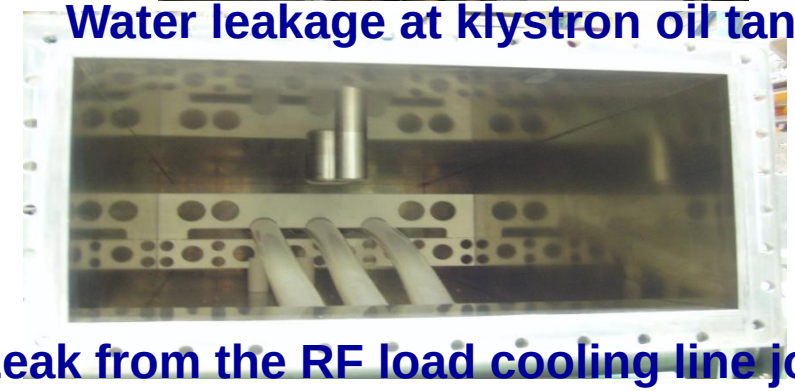
- 2MW, 6000lpm, 5bar : 2 sets
- Need regular maintenance – pump, heat exchanger, de-ionizer
- Problem : water leakage occurs many times
  - DTL DT cooling line
  - Klystron oil tank
  - RF load cooling circuit

Cleaning of the heat exchanger plate



Water leakage at klystron oil tank

De-ionizer filter

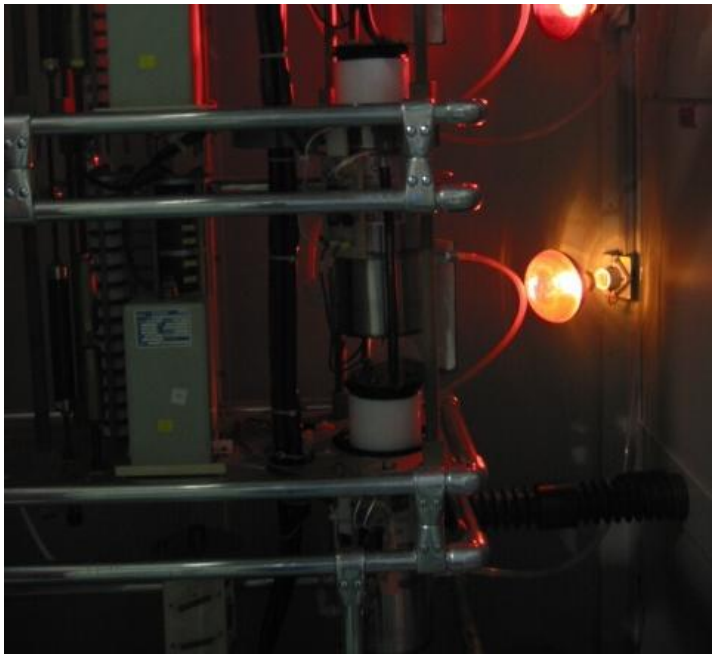


Leak from the RF load cooling line joint

Example of the Spare Parts

- Keep spare ignitron switches as a crowbar switch of the HVPS
  - Original one : glass sealed type
  - Spare parts : ceramic sealed type
    : New but unused for 6 years
- There was a problem for the unused new ignitron
  - Vacuum degradation and lost of the high voltage hold off capability
  - Disadvantage of the ceramic sealed type
- Need policy to choose the proper number, and storage period of the spare parts

Glass sealed type



Ceramic sealed type

I. What we have, what we have to do

II. 20-MeV experiences

III. 100-MeV plans

IV. Summary

Scheduled Maintenance

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- Regular maintenance period
  - August at summer season
  - Dec. ~ Jan. at winter seaon

- Make maintenance list, and do as the list

- List examples
  - Vacuum system
    Scroll pump, ion pump regen., NEG regen.
  - High voltage components
    Insulation oils, silica Gel, keep clean
  - Cooling system
    Grease, heat exchanger plate, DI system
  - Alignment of the system

Unscheduled Maintenance

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- Prepare spare part to reduce the down time
  - Disadvantage : Many important parts should be imported
  - Need to decide the number of spare part
  - Need to consider the unused period
  - Need to consider the delivery time
  - Need to consider the possible rental service

  - It is necessary for us to get advice from other experienced lab.

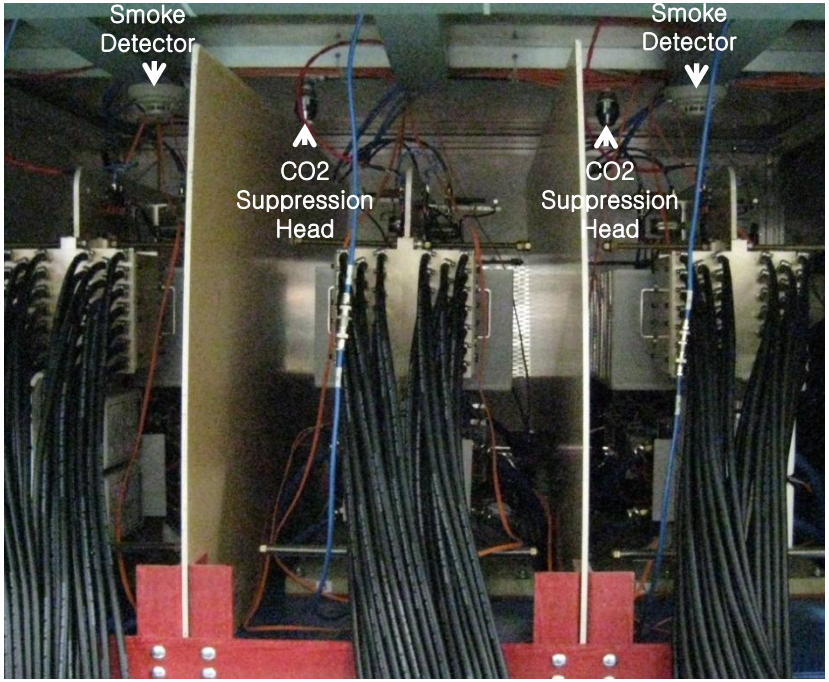
- Set up the possible fault scenarios and install MPS

- Long delivery items
  - Klystron
  - Modulator
  - etc.

Example of the MPS

- **Modulator**
  - **-105kV, 5.8MW peak, 9% duty, 1.5ms long, 60Hz**

- **CO2 system of the modulator as MPS**
  - **- Thank to the recommendations from the SNS**



Example of the Spare Parts

PEFP Proton Engineering Frontier Project

- **Spare part list of the modulator**
  - **Proposed by the manufacturer**
  - **Decide items, number based on the strategy**

Description	Price	Quatity	Delivery Time	Dynapower	Vendor
IGBT Switchplate Assembly				o	
Rogowski Coil Main					
IGBT, 1200A,3300V					o
IGBT Driver Board				o	
IGBT Fibler Optic Cables					o
IGBT gate bypass cards					
Modulator Differential Line Driver					
HV Boost Transformer				o	
Twinax Cable Terminations					
Twinax Cable Terminations					
Rogowski Integrator Box					
Oil Filter					o
Fan Filter					
Oil Pump Motor, 1 1/2 hp, 3500RPM					o
Safety Enclosure Fan					o
Oil Level Switch					o
3Ph 30A, Y Female Recepticle					
3Ph 20A, Y Female Recepticle					
3Ph 20A Y Male Recepticle					
Dessicant Breather Assembly					
Rectifier Card Assembly				o	
Energy Storage Capacitor				o	
IGBT bypass 10 uF 4kV caps				o	
IGBT 10 uF 2kV caps				o	
1800 pF 160 kV resonating caps					
900 pF 160 kV resonating caps				o	
500 pF 180 kV output caps				o	
50 kV resonant rectification caps				o	
.03 uF doubler caps				o	
DSP Control Chassis				o	
Dynamic Fault Detection Chasis				o	
HV connector assemblies				o	
Switchplate Handling and Installation fixture					

HVCM unit

Description	Price	Quatity	Delivery Time	Dynapower	Vendor
FUSE, 1.00A, 250V					o
FUSE, 200E AMP, 5.5KV					o
PILOT LIGHT, AMB					o
PILOT LIGHT, GRN					o
DIODE, 1010A, 5600V, DISC, 58MM					o
THYRISTOR, 2100A, 4200V, DISC, 7.7MM					o
H/F GATE DRIVE, 6 PUL, REV				o	
FIRING CKT LOGIC, 6/12 PLS				o	
INTERFACE, ZFCT				o	
REGULATOR, SWTCHR, REV B MO				o	
CURRENT IMBALANCE DETECTOR				o	
ISOLATOR, DIFF, HIGH PRECISIONRE				o	
H/F GATE DRIVE, 6 PUL, REV D 10K				o	
FUSE, 7.00A, 250V					o
SWCH, THRM, L-185, NC RED					o
SWCH, THRM, 356F, NC,PEPI					o
XFMR, CNTR, 500VA, 3300:110,50/60				o	
VALVE, BALL, 1-1/4, UNION, CPVC					o
METER, DIG PAN, 3-1/2, 20VDC					o
CNTR, 200A, 6.6KV, SF6,110VAC COIL					o
CURR SENS, 500A					o
ISOLATOR, DIFF, HIGH PRECISION RE					o
BRACKET, MOUNT, 1INCH					
VARISTOR, 1700VRMS, 6000J, BB					o
CAP, 0.82MFD, 3300VDC					o
RES, OHM, 15.00 190W, NON-IND					o
PROG CNTL, SLC500, POWER SUPPLY					
PROG CNTL, SLC500, PROCESSOR					
PROG CNTL, SLC500, 7 SLOT RACK					
PROG CNTL, SLC500, 12KFLASH					
PROG CNTL, SLC500, 16 AC IN, 120V					
PROG CNTL, SLC500, 8NO, 3A/120VAC					
PROG CNTL, SLC500, 16 RLY OUT					
PROG CNTL, SLC500, 8DC IN, SINK					
MOUNTING BOARD, 4 POSITION					
INPUT MOD, 5V LOG, 2.5-2.8Vin					
CNTR, 400A, 5KV, 120/230/50/60/DC					o
HT EXCH, W/A, 5291CFM, 3HP					o
SWCH, FLOW, 1.25 BODY, 20GPM					o
PWR SPLY, +/-15V, 1.5A, CA SE BB					o
FUSE, 15A, 250V					o
FUSE, 4.50A, 250V					o

SCR unit

Summary

PEFP Proton Engineering Frontier Project

- We experienced on
  - transportation
  - installation
  - operation
  - maintenance

  in the 20 MeV proton linear accelerator

- We will plan
  - make maintenance list, and do as the list for scheduled maintenance
  - prepare spare part to reduce the down time

    for the unscheduled maintenance
  - consider to buy the spare part
  - set up the possible fault scenarios and install MPS

    in the 100 MeV proton linear accelerator