A1

Status of KEK STF-HLRF

S. Fukuda

KEK

Slide 1

A1 Administrator, 9/27/2007

Stuffs of HLRF&LLRF(RF group in KEK Linac team)

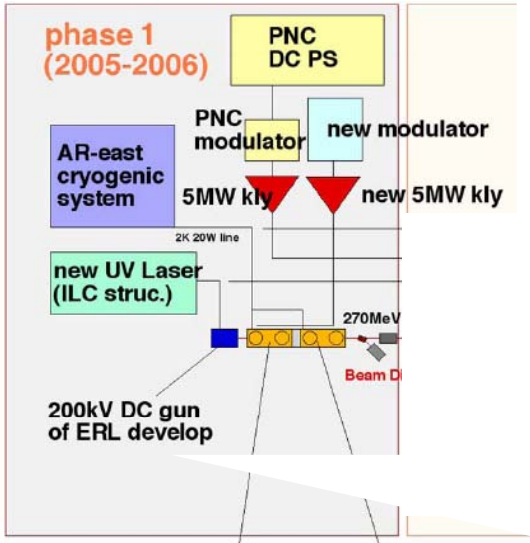
Leader S. Fukuda

Modulator M. Akemoto, T. Shidara, H. Honnma, H. Nakajima
Klystron (S. Fukuda), S. Matsumoto, M. Yoshida,
Power Distribution
(S. Fukuda), T. Takenaka, K. Nakao, S. kazakov (now in Yale) ,
H. Matsushita
LLRF & Operation
S. Michizono, Y. Yano, T. Matsumoto, T. Miura, H. Katagiri

Contents of this talk (Topics of LLRF are not included)

- STF Plan
- Progress from 2006 to 2007 (Klystron, Modulator, PDS)
- Preparation for Phase-1
- Summary

STF(KEK Superconducting RF Test Facility)



STF (Superconducting RF Test Facility)

STF-0.5(Under progress)

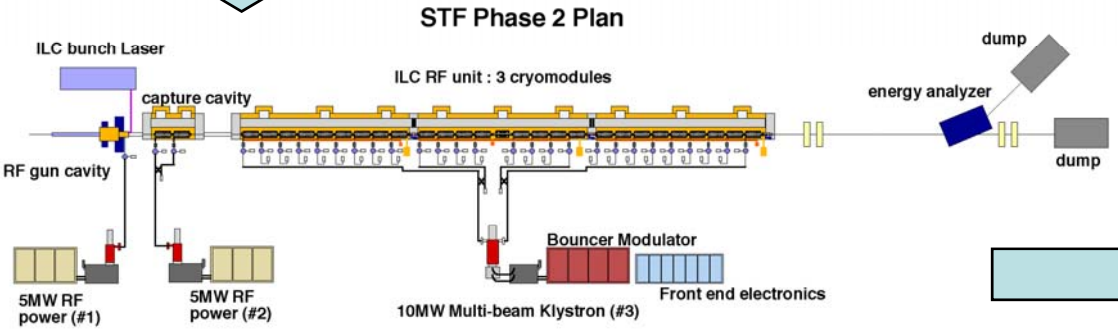
One 35MV/m-cavity in a 5m-long Cryomodule

+

One 45MV/m-cavity in a 5m-long Cryomodule

STF-1.0 (2007-2008:Delaying)

Configuration See left figure Necessary Infrastructures for STF (including EP, CP …) will be introduced.



Required RF Components

STF-1.0 (1.3GHz,L-band)

- 5MW Klystron x 2
- Pulse Modulators
  - for 5-MW Klystron & for 10-MW Klystron
- Power Distribution System (PDS)
  - for 8-Cavity System
- LLRF (Analogue control, Digital control)

STF-2.0

- 10MW MBK
- Pulse Modulator
- PDS for 26-cavity system
- LLRF

STF-Phase 3.0

Progress from 2006 to 2007

- **STF・ No1　RF-Source**
  - **Reinforcement of modulator from Power Nuclear-reactor Corp (PNC)**
    +5MW Klystron from JHP -
  - **Operation and evaluation of No1 RF Source and improvement**
  - **Evaluation of RF Conponents mainly from past projects:**
    Dummy Load,Circulator, hybrid etc.
  - **Processing of the couples**
  - **Coupler test for the STF-0.5**
    (Cryomodule with a35MV/m cavity+another with 45MV/m cavity)
  - **Evaluation of LLRF**
  - **RF feed to STF-0.5 System**
- Construction and evaluation of PDS for STF- 1.0
- **STF・ No2　RF-Source**
  - **-New Pulse Modulator (by Nichicon)**
  - **Collaboration with Company –Pulse modulator using IEGT SWs.**

Relating work with ILC

- **Co-procurement (US& Japan) of 10MW MBK**
- **Design and evaluation of Baseline Configuration Design (BCD)**

Used at JHP

表 1 Specification of Modulator

New Tube

Item	Unit			
Modulator No		Phase-I-1	Phase-I-2	Phase-II
Klystron		TH2104A	TH2104C	MBK
Kl;ystron output power	MW	5/<3.5		
Klystron applied voltage	kV	140/132	130	115
Klystron beam current	A	107/95	96	132
Pulse width(70%-70%)	ms	1700	1700	1700
Rise time	ms	200	200	200
Pulse flat top(90%-90%)	ms	1370	1370	1370
Flatness within pulse duration	%	0.5	0.5	0.5
Repititiom	Hz	5	5	5
duty		0.0085	0.0085	0.0085
Step-up Ratio of PT		1 : 6	1:12	1:12
Pimary Voltage	kV	23.3/22.0	10.8	9.58
Primary Current	A	642/570	1152	1584
Primary Impedance	Ω	36/38	9.4	6.05
Peak Power of Modulator	MW	15/12.5	12.5	15.2
Average Power of Modulator	kW	128/106	106	129
Vendor of modulator		MELCO	Nichicon	

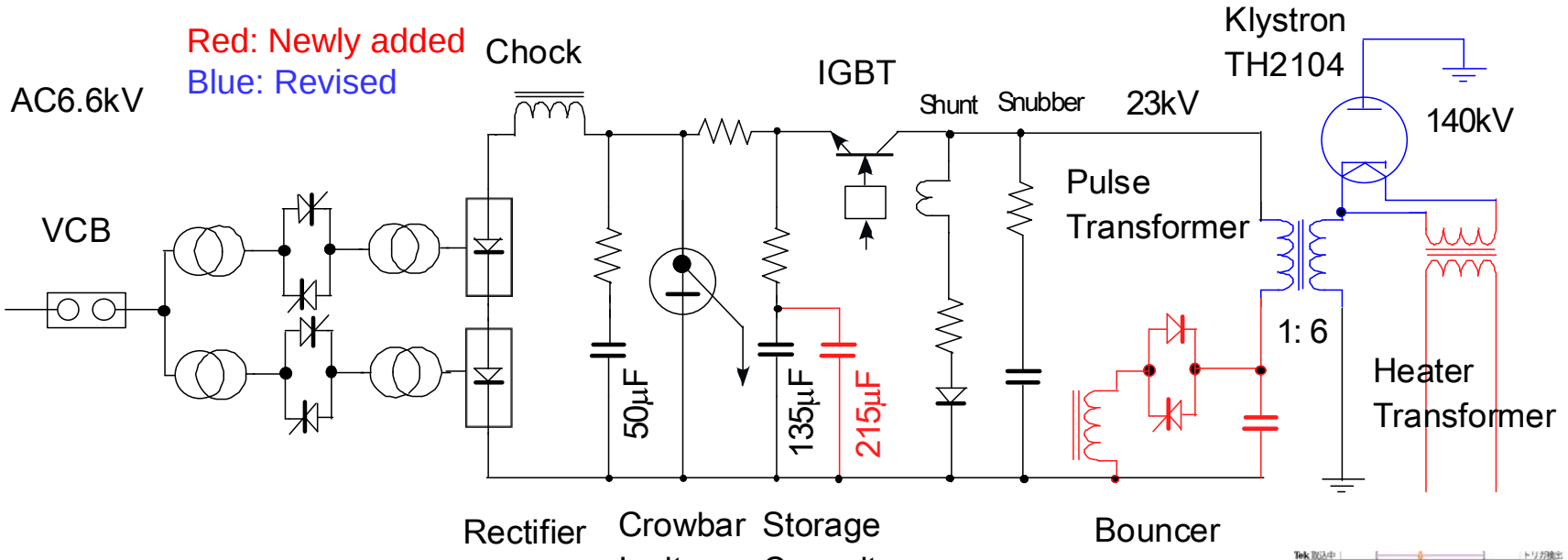
Used at PNC

HLRF KOM S.Fukuda

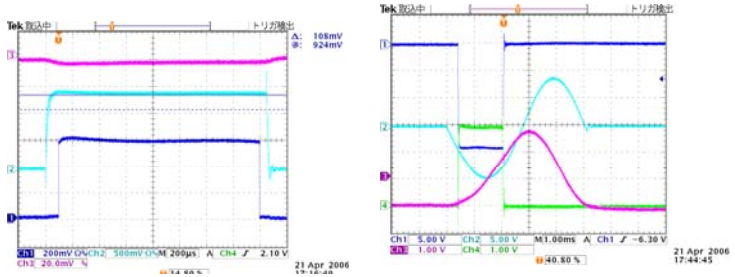
New Modulator

No.1 Modulator (MELCO)

Reinforced Modulator from PNC:Units distributing Type



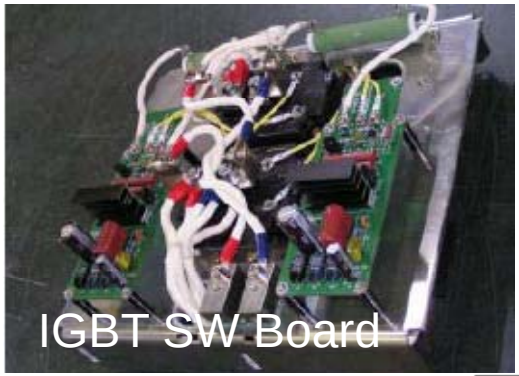
RF does not reached up to 5MW without adding IGBT stages

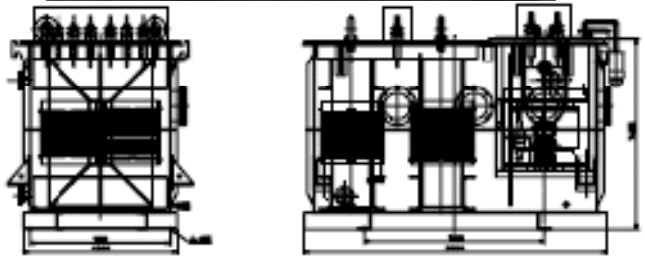


Waveform of Bouncer circuits

No.2 Modulator (Nichicon)

Budget of FY2006, Under evaluating, All-in-one-cabinet type modulator mating to the ILC spec.





Pulse-transformer

Modulator Specification

Possible to use

5MW Single beam klystron and

10MW MBK

5MW (136kV,100A, 1.5ms pulse width)

10MW(120 kV,140A, 1.5ms pulse width)

Step-up ratio of Pulse-transformer=1:15

(Different from ILC-BCD slightly)

Corresponding primary rating

5MW(9.07kV,1500A,pulse width of 1.5ms)

10MW (8.0kV,8000A,pulse width of 1.5ms)

Repetition of 5pps

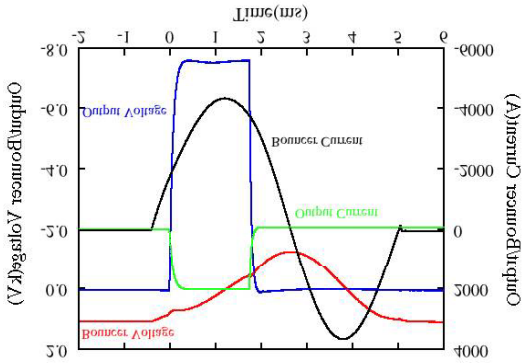
Pulse sag of less than 15 %

(Sag compensation by bouncer circuit)

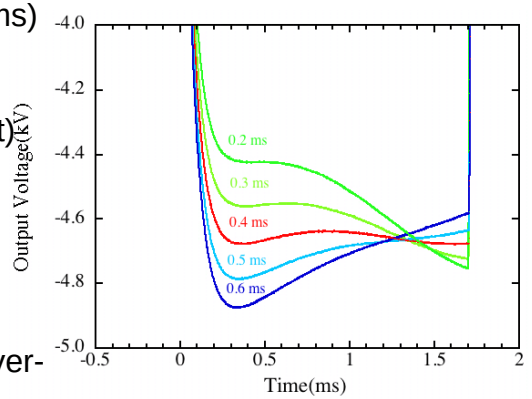
Pulse generation by IGBT SW

(IGBTs are chosen to be same as the No.1 modulator . Circuits are differnt)

In order ro protect SWs for the over-current, double interlock system are employed. Test was done normally.



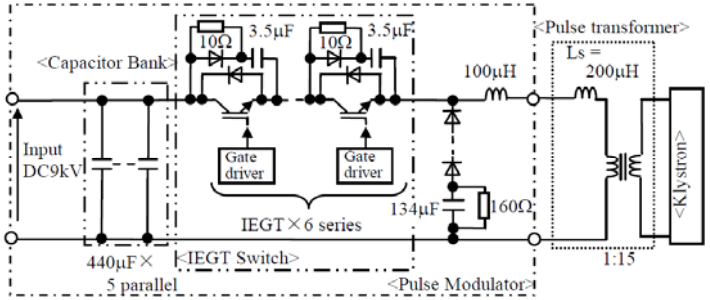
Output pulse waveform and timing with the bouncer operation



Variation of flat-top

IEGT Modulator with collaboration study
(Mitsubishi-Toshiba Corp-TMEIC/KEK)
All-in-One-Cabinet Modulator using IEGT

Item	Specification
Output Voltage	120kV
Output Current	140A
Kly. Equivalent load	857Ohm(Secondary)
Pulse width	1.7ms
Pulse flatness	+-0.5%
Max. Energy fo the kly. At the arcing	less than 20J
Step-up ratio of PT	1:15

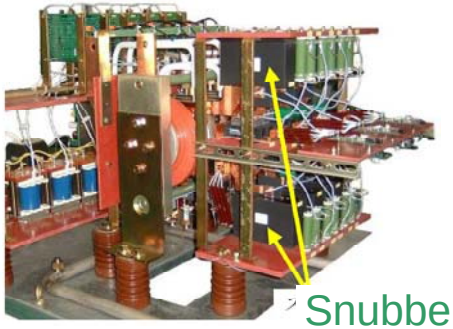


Circuit of modulator

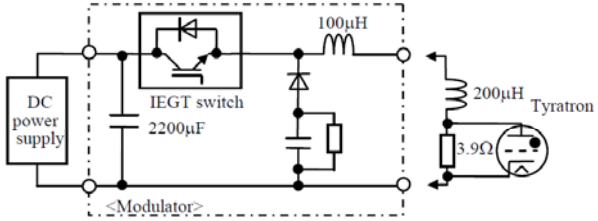
Pulse modulator using IEGT SW
(Injection Enhanced Gated Array)
（Collaboration with TMEIC）

Pulse parts were tested in KEK with the combination of Nichicon Power supply And successfully operated. KEK.

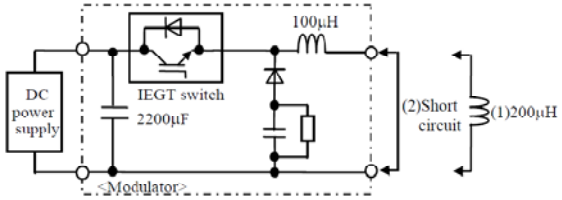
Fast SW-off for the over-current, and sudden shut-off under the continuous Running are successfully tested.



IEGT SW



Long-run and sudden shut off circuit



Fast off circuit for over-current

Slide 8

A2 Administrator, 9/27/2007

Outcomes and problems for STF Modulator

Outcomes

- **Technology for the semiconductor SW long-pulse high-power modulator is evaluated to be established in Japan after the manufacturing of No.1 modulator (MELCO), No.2 modulator (Nichicon) and TMEIC modulator.**
- **Sag compensation technology using the bouncer circuit for the high-power modulator is also established in Japan. (First demonstration in Japan)**
- **Fast SW off and protection circuit are studied successfully.**

  Double protection methods when load is shorted (KEK)

  ->IGBTs are quickly off when the over-current exceed threshold value of A.

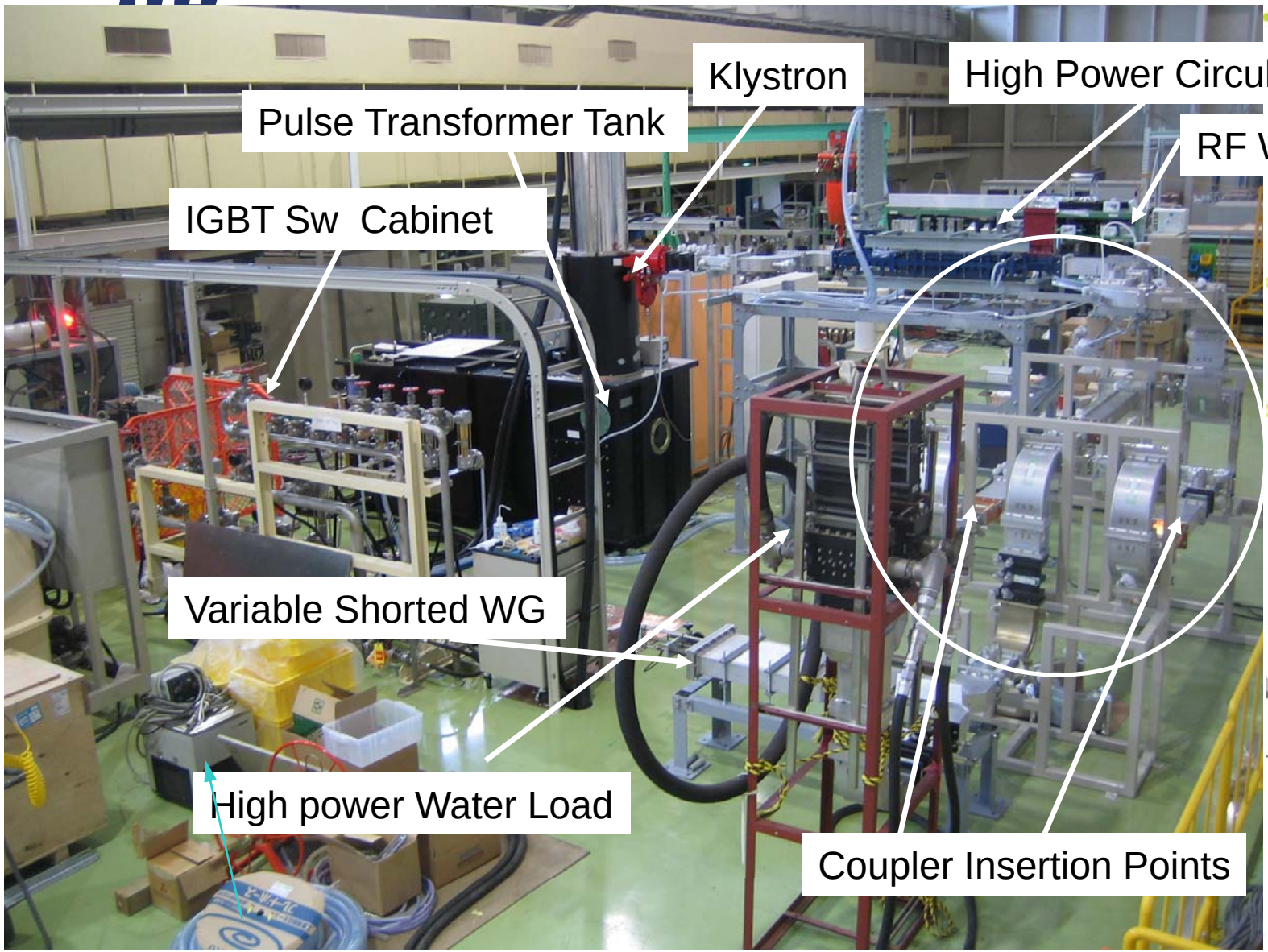
  ->Crawbar circuit are on if the over-current exceed threshold value of B (>A).

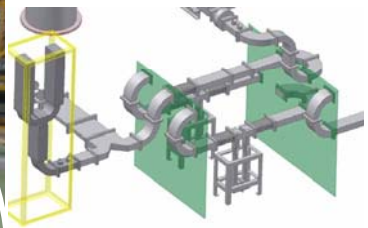
Problems

- **No1 modulator (MELCO) :** Due to the double protection methods mentioned above, **we could not obtained the maximum required voltage for 5MW** without increase the IGBT stage; MELCO requested the big money and we abandoned the reinforcement.

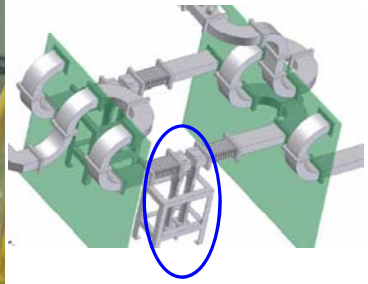
  Reinforcement of old system gave us the **anxiety of maintaining the old components** such as PLC, transistors etc.
- **No2 modulator (Nichicon) :**Some parts required the improvement. More compact pulse-transformer is desirable.

Test stand: STF No1 Area Photo





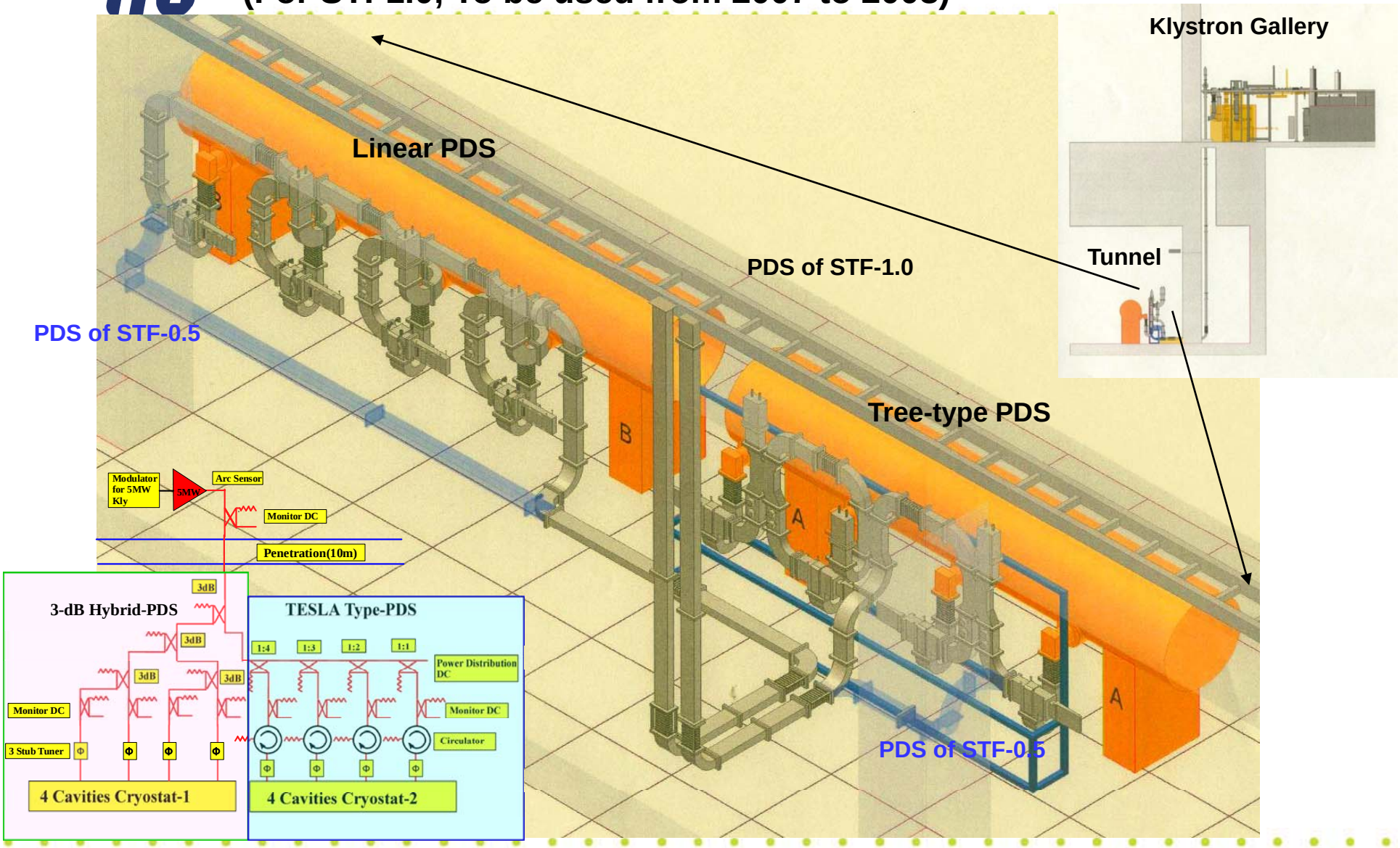
Layout of Klystron output and components test



Layout for Coupler test

Power Distribution System

(For STF1.0, To be used from 2007 to 2008)



Current status of PDS for STF-0.5 and STF-1.0

STF-0.5 45MV/m Cavity side

STF-0.5 35MV/m cavity side

Installed couple to Cryomodule for the test of

Tree-like PDS (Front)

Linear PDS

Assembled PDSs in KG and waiting for the evaluation test

Development of RF WG Components

For STF-1.0, so many waveguide components are come from PNC and JHP. For STF-2.0 we are considering to introduce the new WG components. We aim for using the domestic WG components to prepare for the coming ILC construction. Some R&D works are also planed.

Already manufactured components

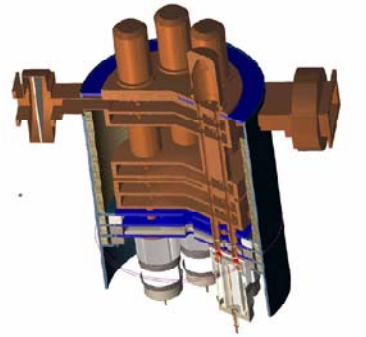
- L-band WR-650 straight aluminum waveguide
- Flexible waveguide with highly flexibility
- Y-junction circulator competitive with Russian products (both performance and price)
- High-power 3-dB hybrid with variable tap-off
- Study of the welding of WR650 for ILC installation
- LLRF: Arc detector for the interlock

To be done for R&D work

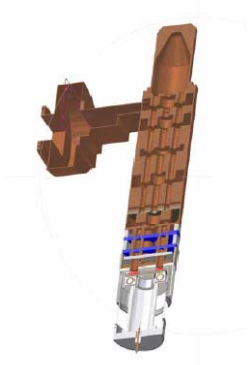
- Cheap phase-shifter and/or Cheap Qex tuner
- Cheap window (separating from the pressurizing and normal section)
- Search the possibility to eliminate the circulator to feed the power to many cavity systems
- Hybrid waveguide components (all in one waveguide components)
- ->Development of the cheap WG components mate for the requirement of ILC.

Some R&D Results

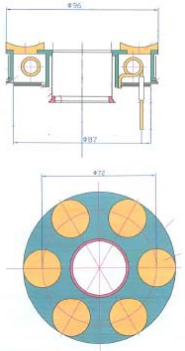
- Super MBK



Overview



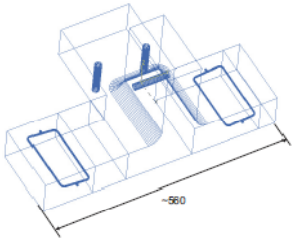
1/6 Model

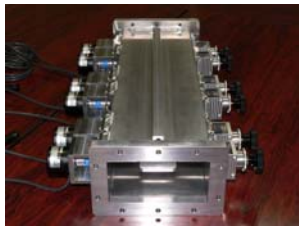


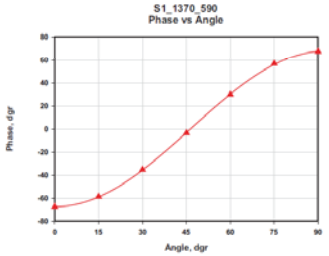
Ordered MBK Cathode

- Exotic phase-shifter

designed by S. Kazakov







- Welding R&D
- 500kW Circulator made by NKK

Summary

- **Modulator:**
  - **No.1 Modulator:**
    - Voltage sag of +-0.85 and RF sag of +-4% are achieved employing bouncer circuit. More flatness on RF is achieved by LLRF FB.
    - RF power of 2.5 MW is fed to coupler and tested.
    - More power-up requires the increase of IGBT stages and not available due to the budget limit.
  - **No.2 modulator:**
    - All-in-one-cabinet modulator .Basic test performance was finished.
    - Klystron test is under going.
  - **Collaboration work with TMEIC for IEGT Modulator was successfully performed.**
- **Klystron**
  - 2 TH2104 klystrons are available in the STF.
  - Two klystrons will be operated in each
  - **10MW MBK (Toshiba) was co-procured by US and Japan. Soon delivered to SLAC and tested.**
- **RF System:**
  - Coupler evaluation test was finished.
  - Coupler processing for the STF-0.5 was finished.
  - 2 PDSs are waiting for the test and the evaluation at the off-line position.
  - Various new WG components are designed and ordered.
- **LLRF: LLRF are developed and evaluated at the STF station.**