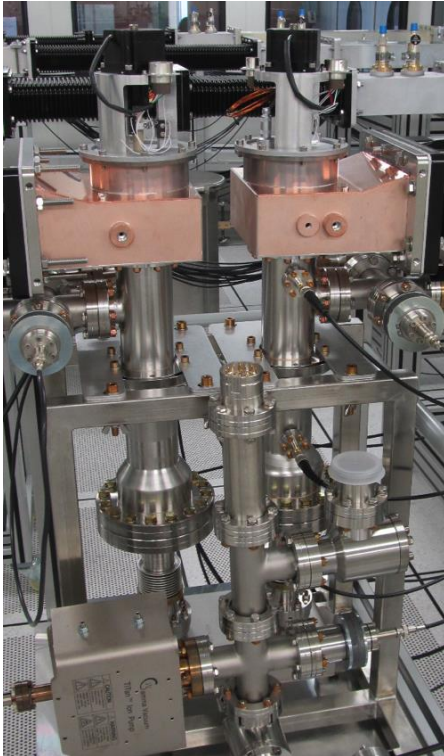


Development and Validation of Input Power Couplers for Superconducting Linacs

H. JENHANI/ W. KAABI/ E. KAKO



Pulsed Operation/1300 MHz

The European XFEL



Manufactured In Europe



CW Operation/175 MHz

LIPAc (IFMIF)



Manufactured In USA



CW Operation/1300 MHz

C-ERL & 3GeV ERL



Manufactured In Japan

Collaboration Groups



French Group

Hassen JENHANI

IRFU/CEA

Guillaume DEVANZ

IRFU/CEA

Walid KAABI

LAL/IN2P3/CNRS

Japanese Group

Eiji KAKO

KEK

Seiya YAMAGUCHI

KEK

Toshio SHISHIDO

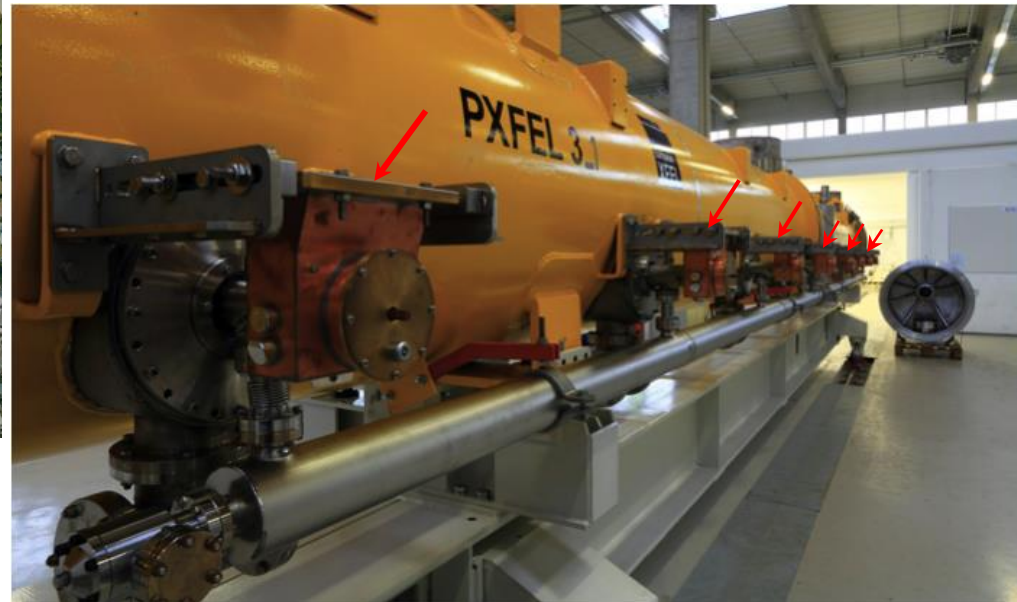
KEK

XFEL Power Couplers

The European XFEL is a facility that will generate ultra-short X-ray flashes, based on the free electron laser technology.



Electrons are accelerated in a 1.3 Km cold linac reaching up to 17GeV.



Linac composed of 100 Cryomodules, equipped with 8 couplers each → 800 Couplers needed

Production Monitoring at Companies

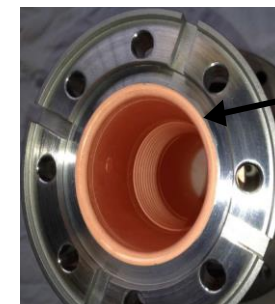
Manufacturer #1:



Brazing



Copper
plating



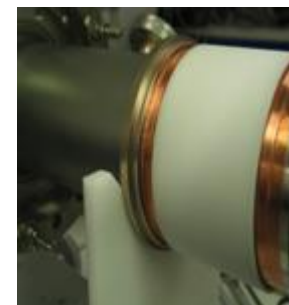
Inspection then
Shipment
Manufacturer #2



Assembly
by pair



Cleaning,
drying,
particles
counting



Ceramics TiN coating
Ceramics EB welding

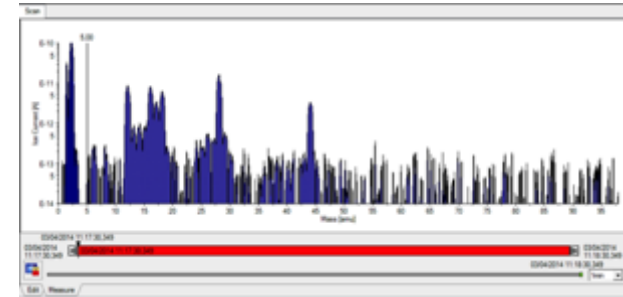
Power Couplers Preparation at LAL



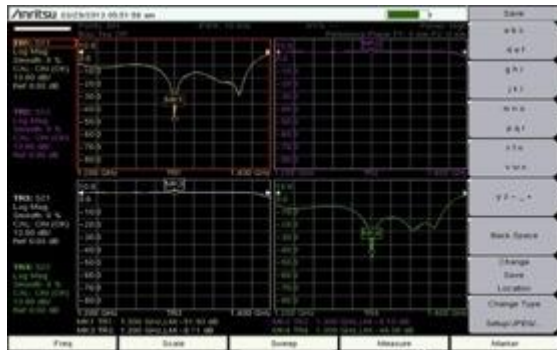
Leak test after reception



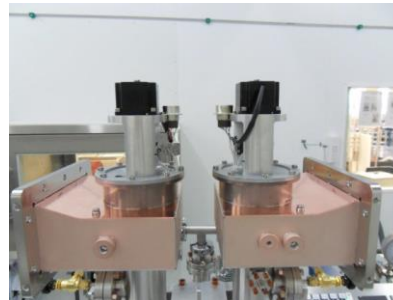
75h baking cycle at 130°C



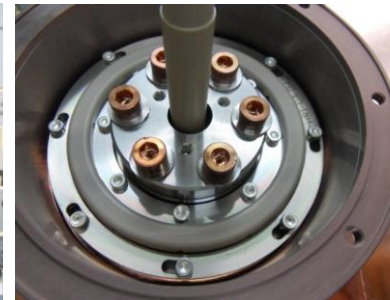
RGA spectrum recording



Antenna tuning



Actuators assembly



Capacitors assembly



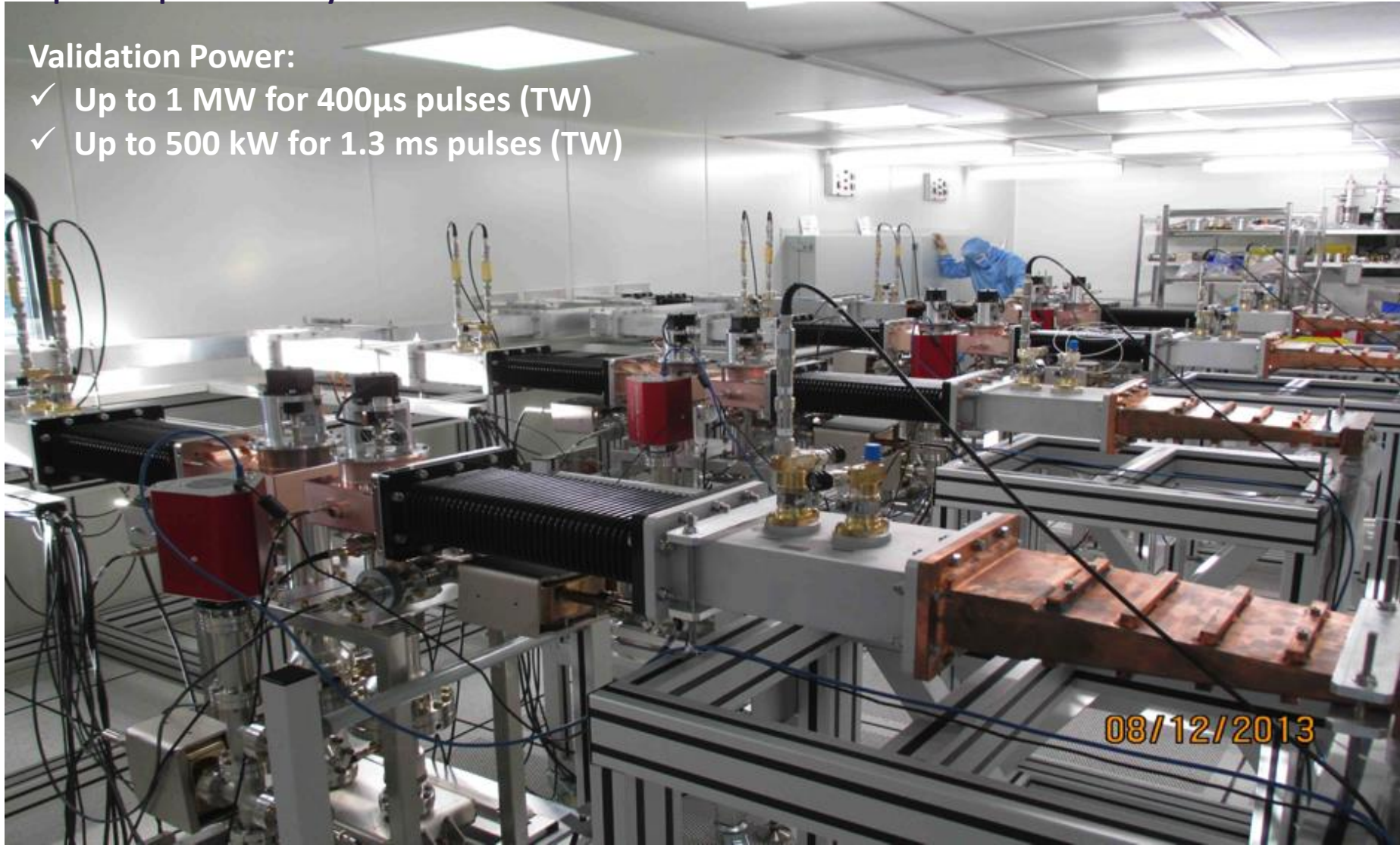
WGBs assembly

Power Couplers RF Conditioning at LAL

The ISO5 clean room, the RF facility and all the diagnostics are optimized to allow the conditioning of 8 couplers in parallel every week.

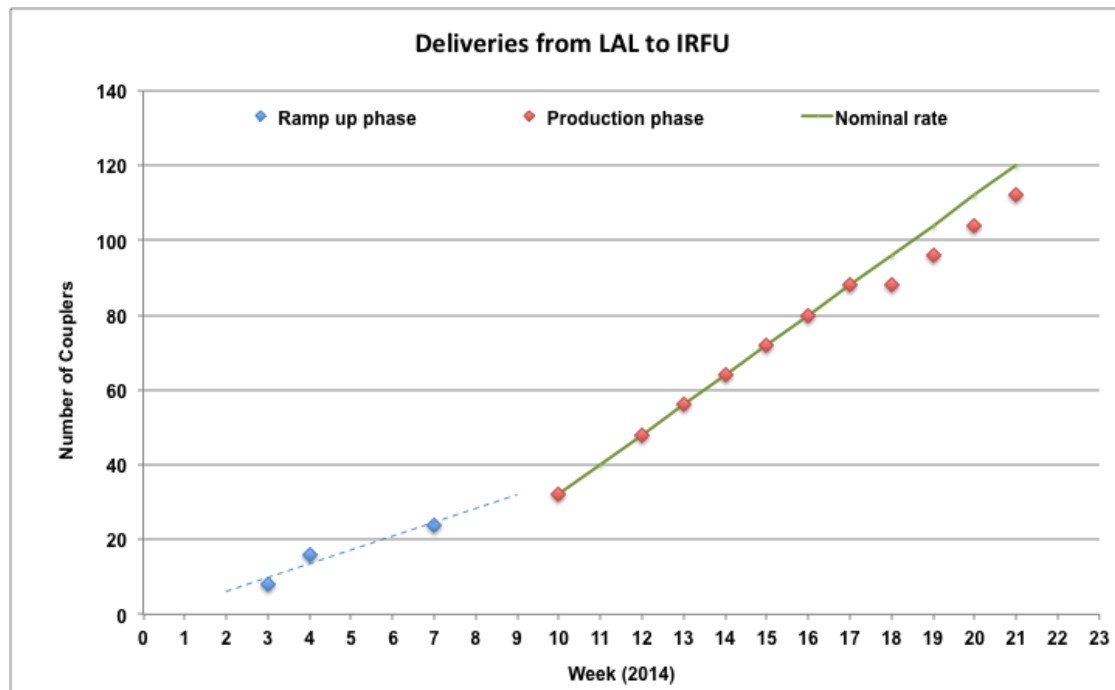
Validation Power:

- ✓ Up to 1 MW for 400 μ s pulses (TW)
- ✓ Up to 500 kW for 1.3 ms pulses (TW)



08/12/2013

Status of the XFEL couplers production

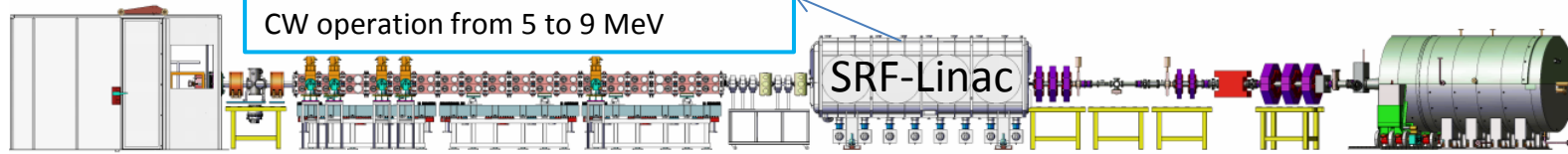


- **136 XFEL couplers** were already delivered to IRFU/CEA (17% of the need).
- The **nominal rate of 8 coupler/week** delivered from LAL to IRFU was reached beginning March 2014 (Week 10).
- According to the current delivery rate, the **last couplers will be delivered at last mid 2016**.
- The **copper plating quality still the real challenge** to be closely and continuously controlled.

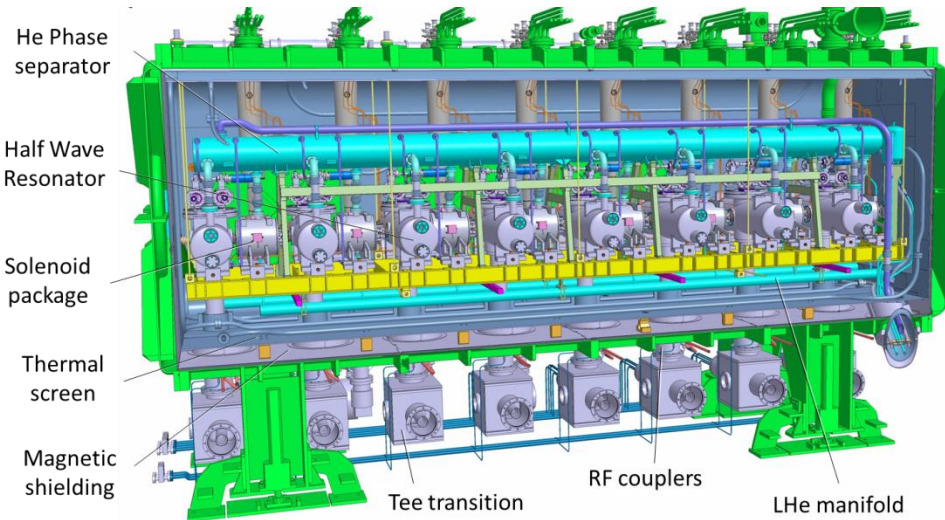
Power Couplers for LIPAc

Linear IFMIF Prototype Accelerator to be tested in Rokkasho - Japan

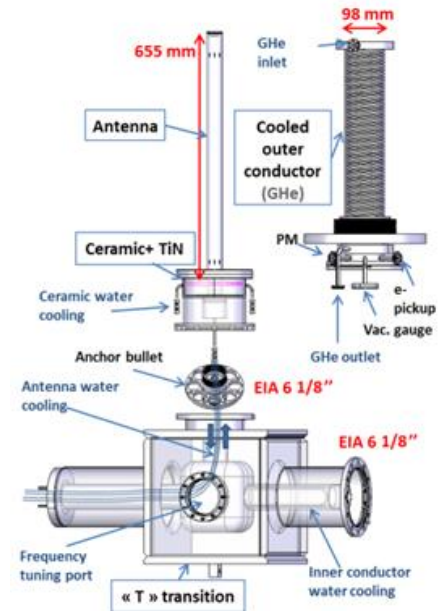
To Accelerate a 125 mA D+ beam in CW operation from 5 to 9 MeV



SRF-Linac Power Couplers



SRF-Linac : 8 Power Couplers are needed



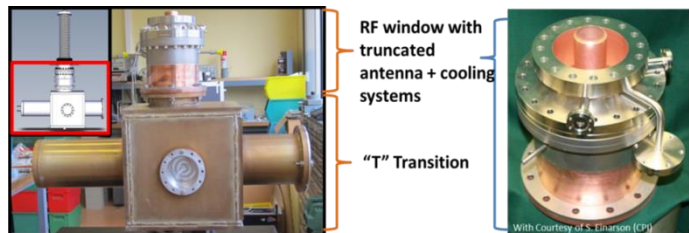
IFMIF Power Coupler

Power Specifications:

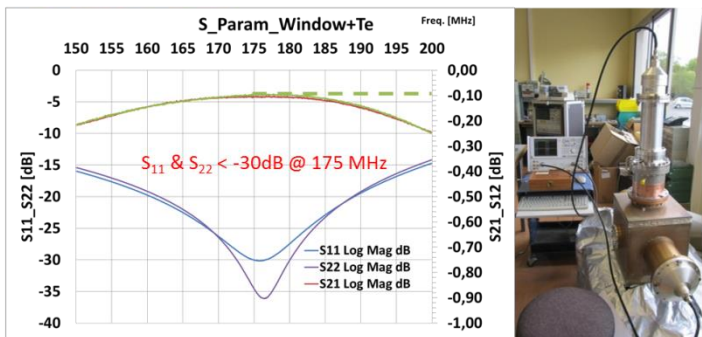
- Maximum nominal operating RF power **70 kW CW**
- RF power validation needs for the Power Coupler: **100 kW CW in Travelling Wave (TW) and Standing Wave (SW)**

Prototypes Manufacturing Control and Preparation

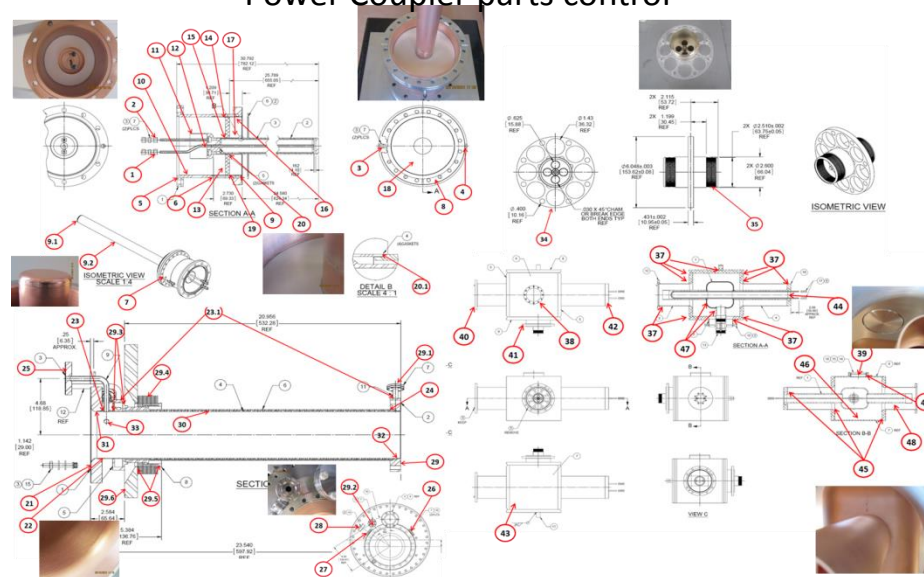
Manufacturing of representative parts for processes validation and RF measurements



RF measurements:



Power Coupler parts control



Power Couplers cleaning and assembly

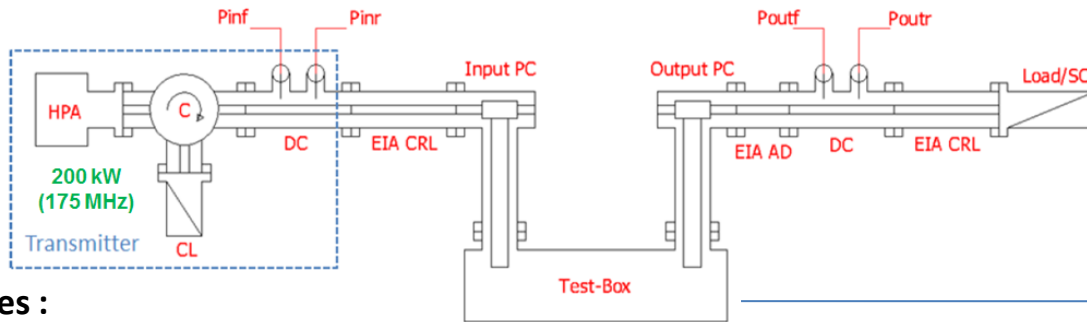


Coupler Prototype pair reception



RF Power Validation

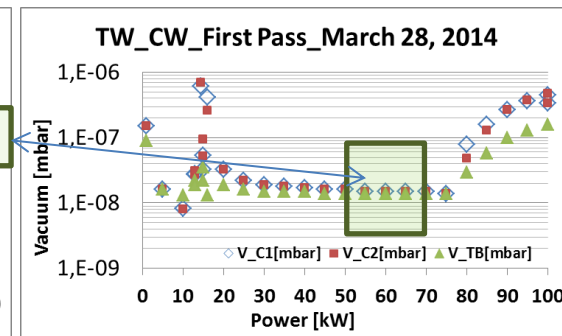
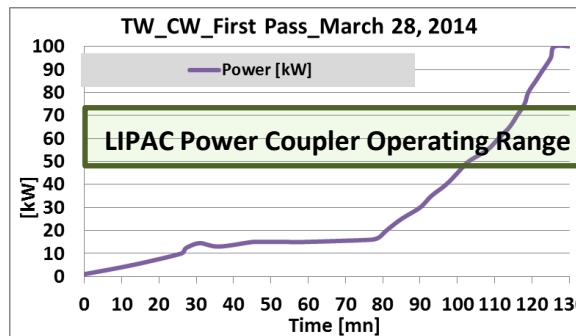
RF Power Test Stand : RF processing of a pair of input power @ RT (Thanks to collaboration with CIEMAT)



RF Power Validation Test Stages :

- ✓ Pulsed RF processing (0 → 100 kW) TW: from 20μs (2 Hz) to 400 ms (2Hz)
- ✓ CW RF processing up to 100 kW TW
- ✓ (Pulsed/CW) RF processing in SW mode with max E filed on ceramic windows 0 → 100 kW

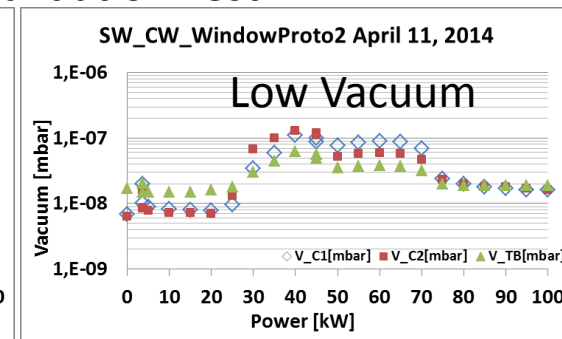
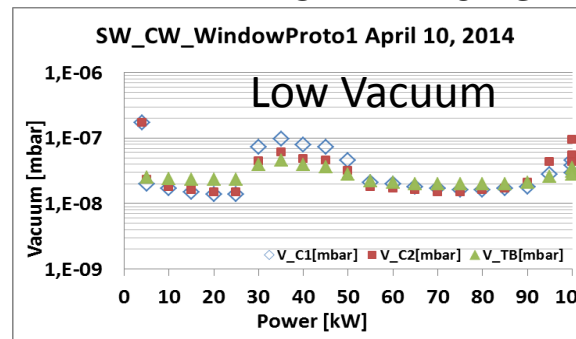
TW RF Power Validation Test



Test Results:

- Power validation objective has been reached
- Power Coupler behavior satisfactory
- For the operating power ranges: Low vacuum and no e-current measured at the end of the RF processing.

SW RF Power Validation Test

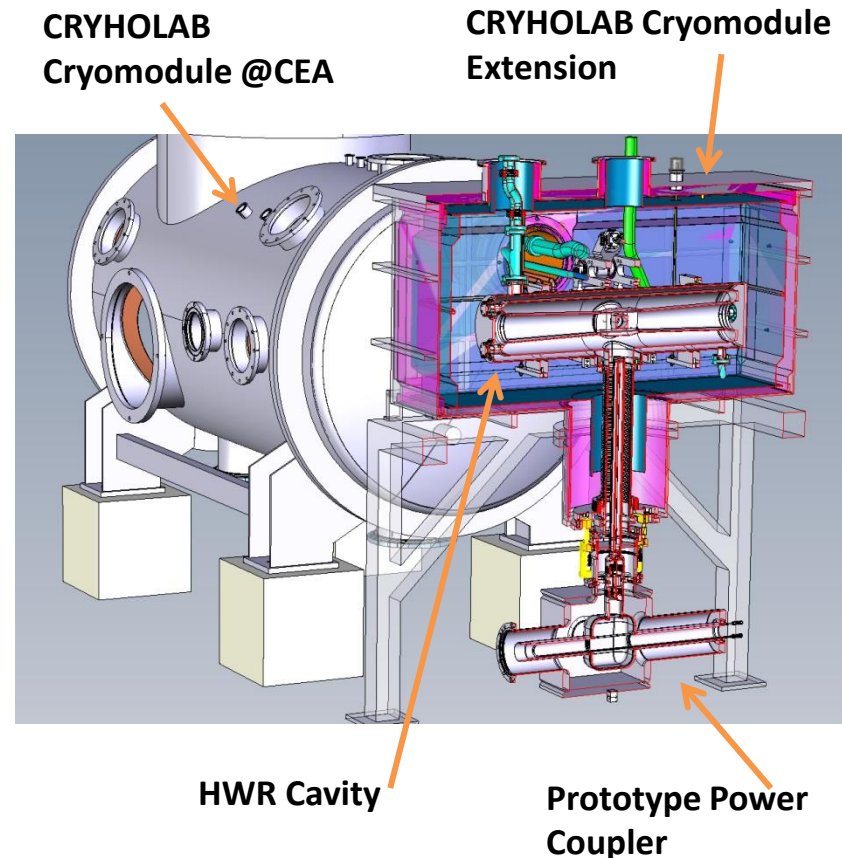


Current Situation:

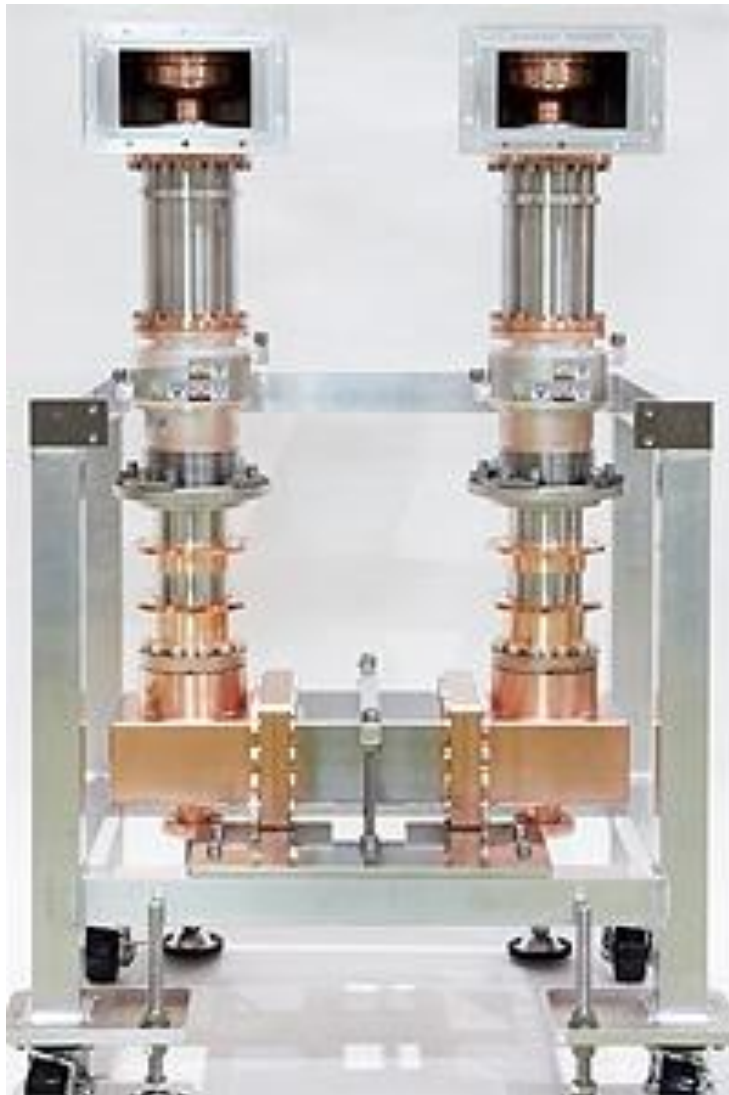
Two LIPAc Power Coupler Prototypes were manufactured and RF power tested @ RT
→ Approval for RF power operation up to 100 kW CW in TW and SW configurations: April 2014

Next stages:

- Complementary tests **up to 200 kW** (in pulsed mode): June 2014
- Manufacturing of **8 Series Power Couplers** for LIPAc: Starting in June 2014
- **Cold test** of one LIPAc **Prototype Coupler + HWR cavity** (Extension of an existing cryomodule (CRYHOLAB) to make the test possible)): May 2015
- First pair of the Series Power Couplers is expected for June 2015

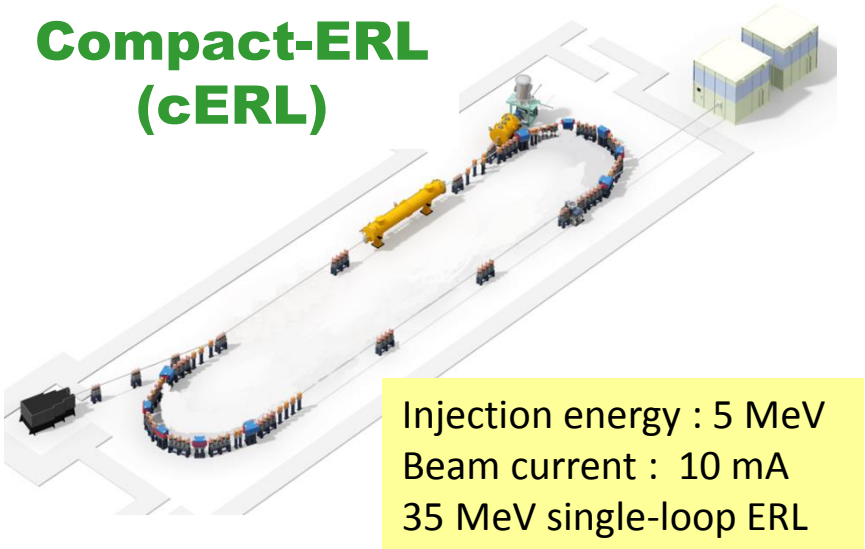


CW RF Input Couplers for ERL at KEK





Compact-ERL (cERL)

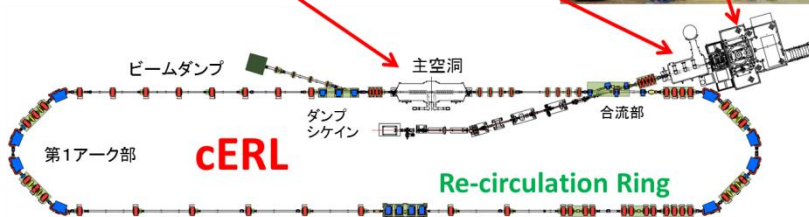


Injection energy : 5 MeV
 Beam current : 10 mA
 35 MeV single-loop ERL

Main-Linac Cryomodule

Injector Cryomodule

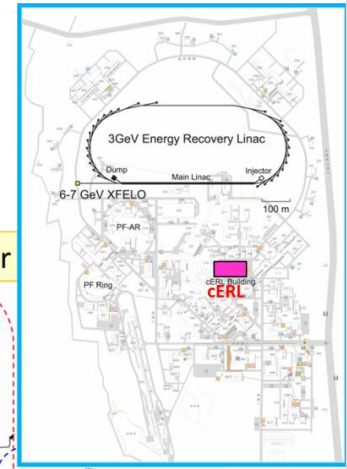
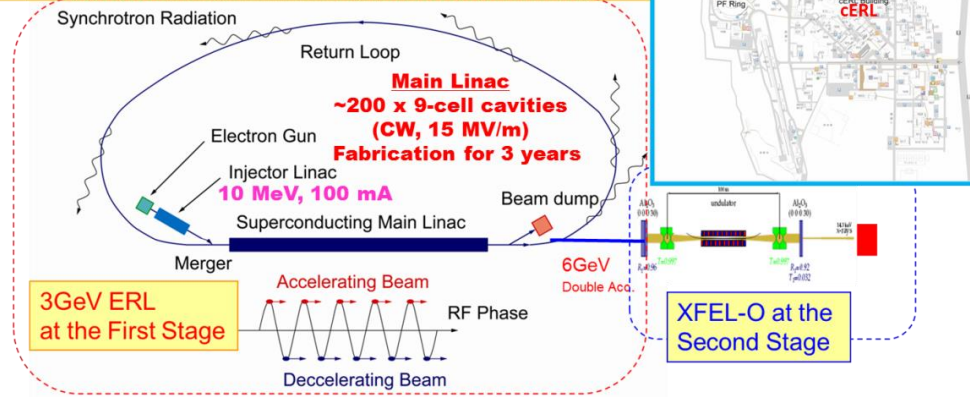
500kV DC-Gun



Future Light Source at KEK

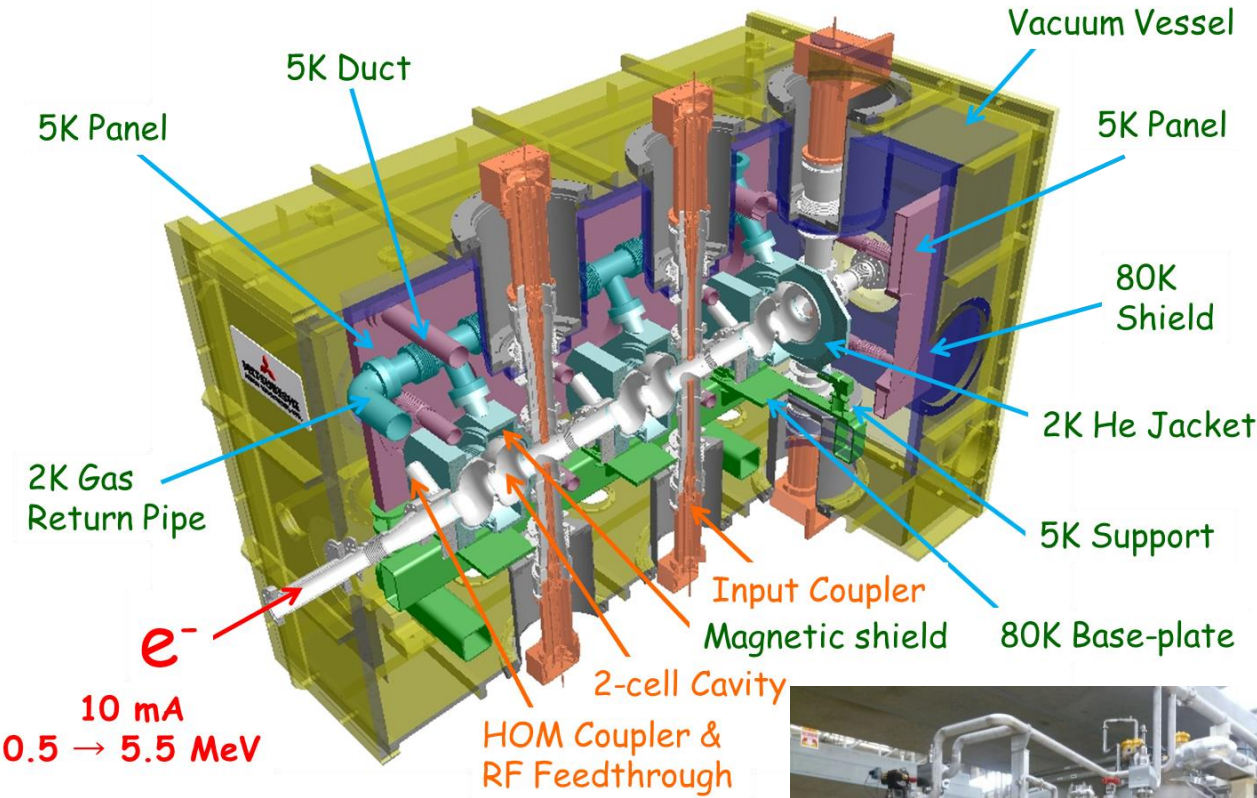
3GeV-ERL Project

3 GeV Energy Recovery Linac (ERL) and Oscillator



Injection energy : 10 MeV
 Beam current : 100 mA
 1st stage : 3 GeV single-loop ERL
 2nd stage : 6 GeV double-loop ERL

Injector Cryomodule for Compact-ERL



10 mA
0.5 → 5.5 MeV

2-cell cavity with
2 input couplers
and 5 HOM couplers

CW Input Couplers for cERL and 3GeV-ERL



	cERL	3GeV-ERL	3GeV-ERL
Beam current	10 mA	100 mA	100 mA
Injection energy	5 MeV	10 MeV	10 MeV
No. of 2-cell cavity	3	3	5
No. of input coupler	6	6	10
Operational accelerating gradient	7.3 MV/m	14.5 MV/m	8.7 MV/m
Required RF Power	8.3 kW/coupler	167 kW/coupler	100 kW/coupler
Loaded Q, (Q_L)	1.7×10^6	3.3×10^5	2.0×10^5

Assembly of cERL Input Couplers in Cryomodule



Two input couplers



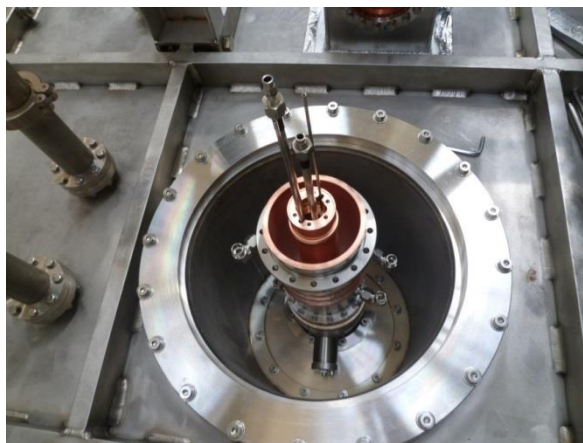
Inner conductors



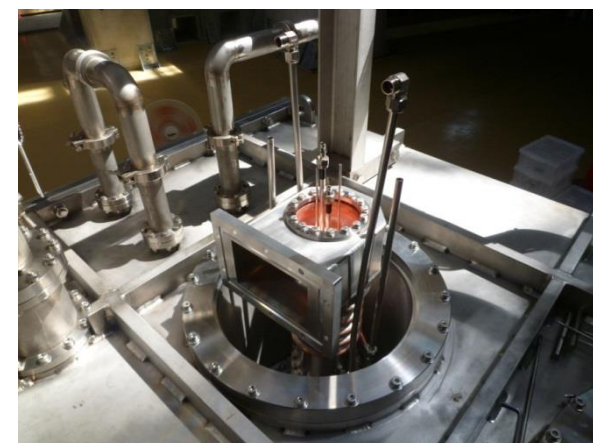
Outer conductors



Warm RF window

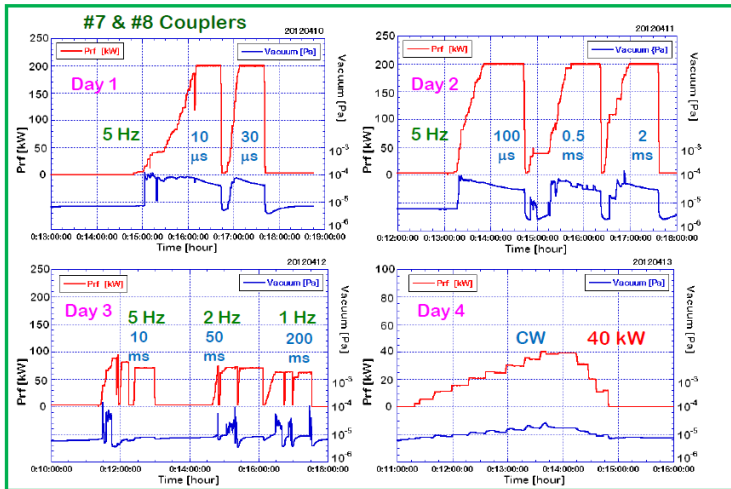


Coaxial RF line



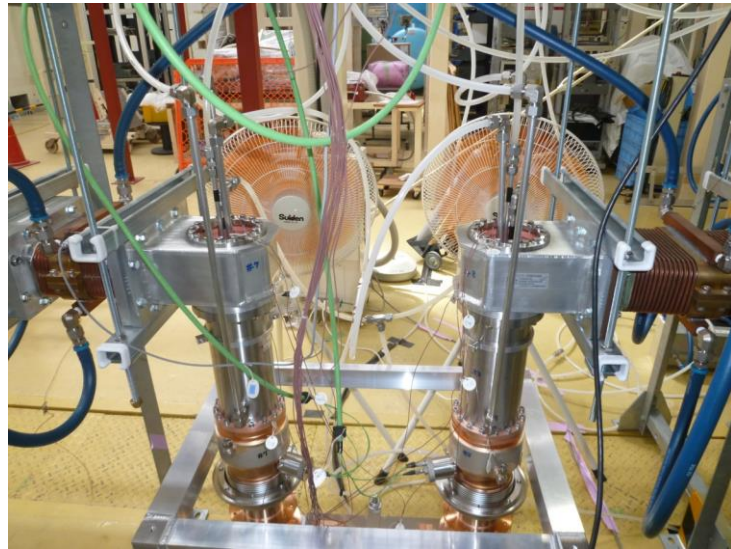
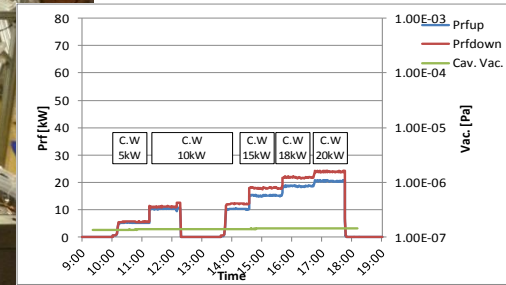
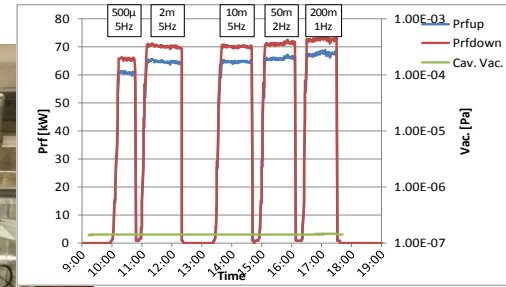
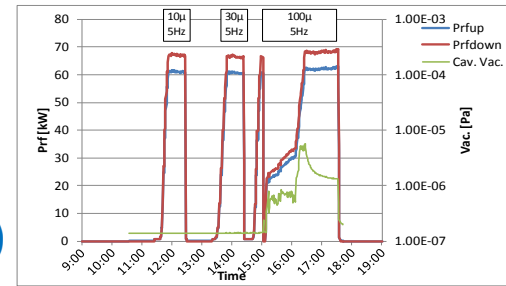
Doorknob RF transition

Conditioning of cERL Input Couplers



at Test-Stand
200 kW, <2ms, 5Hz (1%)
40 kW, CW

in Cryomodule at RT
70 kW, <0.2s, 1Hz (20%)
20 kW, CW





- **KEK injector CW couplers were conditioned;**
Test stand : 200 kW (pulse, 1%), **40 kW (CW)**
Cryomodule : 70 kW (pulse, 20%), **20 kW (CW)**
with beam : stable operation at **5 kW (CW)**
- **For the future 3-GeV ERL project;**
Fabrication and conditioning at test-stand of
CW 100 kW level couplers with **improved**
cooling capability are scheduled in this year.