FIP/2-5Ra

25th IAEA Fusion Energy Conference
St. Petersburg, Russia, Oct. 13-18 2014

Development of DC ultra-high voltage insulation technology for ITER NBI

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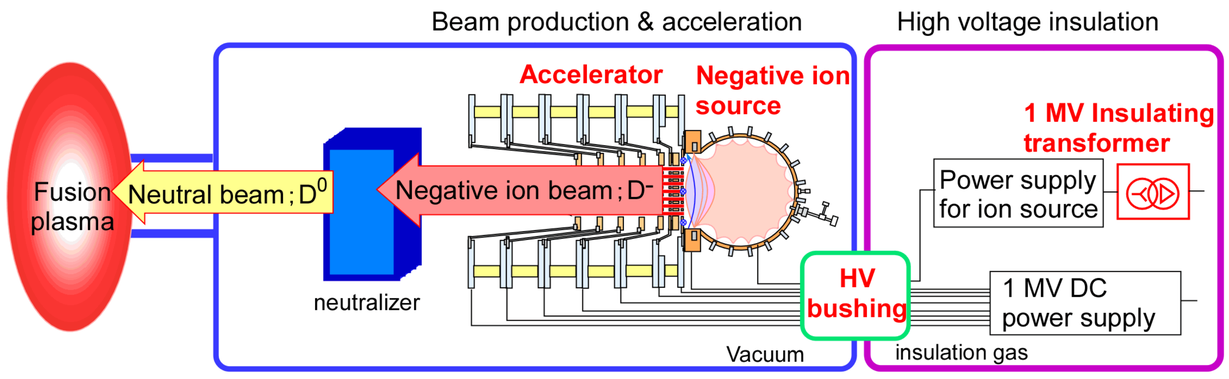
Summary of progress on NBI toward ITER and JT-60SA in Japan

	on or before FEC 2012	【on FEC 2014】
Items	***High voltage insulation***	
Insulating transformer	DC 500 kV, 10 s	**DC 1 MV, 3600 s**
HV bushing	Part test	1MV vacuum insulation design
	Long pule beam production & acceleration	
High current beam	13 A, 30 s	15 A, **100 S**
High energy beam	980 keV, 0.4 s	680 keV, **60 s**

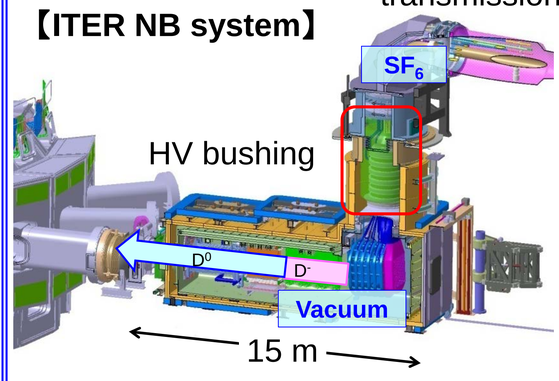
→A. Kojima, FIP/2-5Rb

Negative ion beam; D^-	ITER NBI	JT-60SA N-NBI
	1 MeV, 40 A, 3600 s	0.5 MeV, 22 A, 100 s

Neutral Beam Injector system



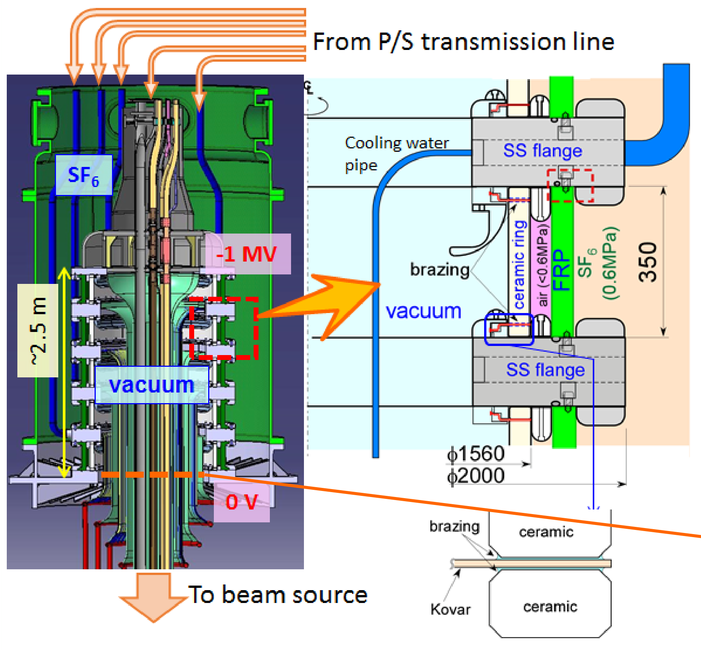
【ITER NB system】



- ■ Two NBIs in ITER
- ■ NBTF identical to ITER in Padova prior ITER operation
- ■ Procumbent for ITER NBTF in Japan ;
  - High voltage components of 1 MV PS (DC generators, 1 MV Insulating transformer, transmission line, HVD2)
  - HV bushing

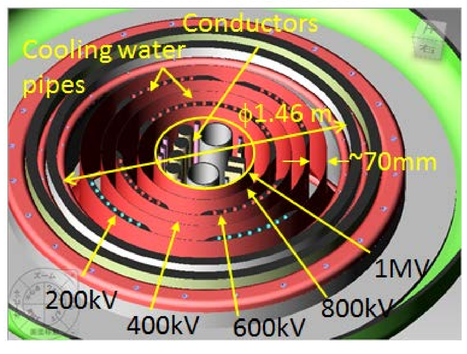
The procurement activities on ITER NBTF are in progress as scheduled in Japan.

Vacuum insulation design of the HV bushing



- •An insulating feedthrough to transmit 1 MV.
- •Tritium and vacuum boundary.
- •The world's largest ceramic ring is utilized as five-stage insulator (FEC2010).

Horizontal cross section



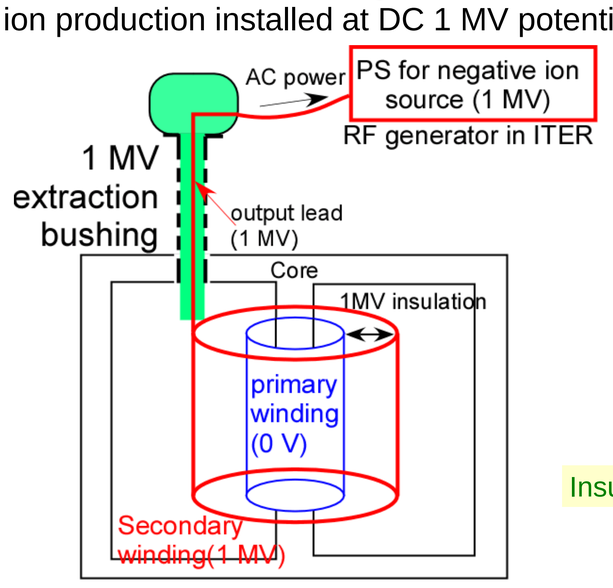
■All conductors and pipes at five different potentials (200 kV~1 MV), electrically shielded by five coaxial cylindrical screen (e.g. ϕ=500 mm, H=3.6 m), in a single vacuum space in order to minimize the tritium boundary.

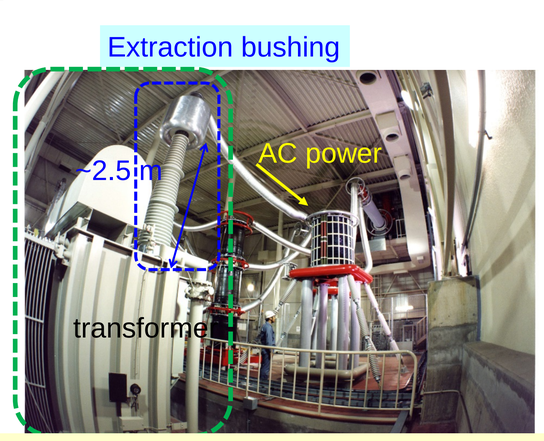
■Even with the world's largest ceramic ring (ϕ1.46 m I.D.), insulation distance of each gap is no more than around 70 mm.

(**Issue**) Voltage holding in large coaxial electrodes is not clarified in the field of vacuum insulation.

1 MV insulating transformer

【Function of the insulating transformer】To feed AC power to the PS for negative ion production installed at DC 1 MV potential.





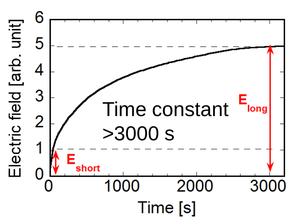
Insulating transformer on JT-60U (DC 500 kV, 10 s)

■ A bushing extracting output lead at 1 MV from the transformer to the air

(**Issue**) ϕ2 m, H=10 m insulator for 1 MV in ITER.

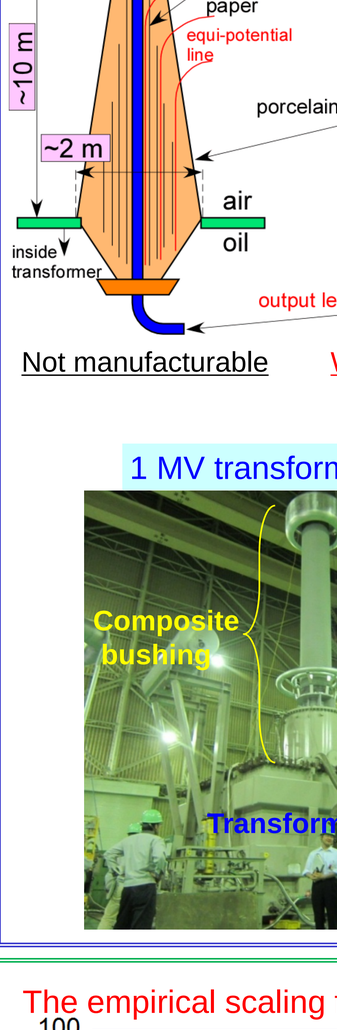
No existing manufacturing facility

■ Large insulation distance in transformer
- Five times due to long time constant
- Twice due to higher voltage in ITER



(**Issue**) Totally, ten times larger insulation distance. **Not acceptable in ITER.**

Condenser bushing

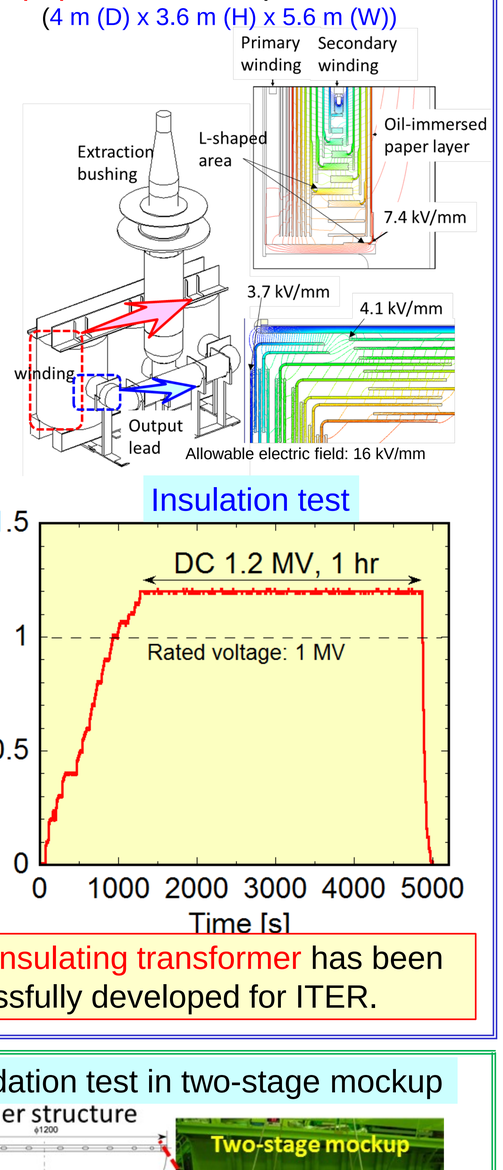


Not manufacturable

【New device】
Composite bushing

With manufacturable parts

Insulation structure with oil-immersed paper to be acceptable size
(4 m (D) x 3.6 m (H) x 5.6 m (W))



1 MV transformer mockup

Insulation test

The 1 MV insulating transformer has been successfully developed for ITER.

The empirical scaling for large electrode

Validation test in two-stage mockup

Stable insulation of 480 kV for 1 hr.
(including 20 % margin of rated voltage in ITER)

Vacuum insulation of the HV bushing for ITER has been ensured.