



# Status of Multibeam Klystrons

*Vladimir Vogel, Stefan Choroba*

- Status of vertical MBK
- DESY klystron test stand
- Toshiba tube, result of testing
- Thales tube, result of testing
- CPI tube, result of testing
- Preparation for horizontal MBK
- Plans

**January 19, 2007**



## Vertical MBK Klystrons status

### Toshiba,

June 8 - October 12

10.4 MW, 1500 uSec, 10 Hz, 116.1 kV,  
efficiency ~ 66%

***klystron test stand, DESY***

### Thales,

Prototype, 20,000 hours operation since May 2000, will be modified

tube #3 at operation ***FLASH***, from march 2006. (total running time 5250+2100 hours)

tube #1 at operation in ***PITZ Zeuthen*** until November 2006, now in ***klystron test stand, DESY***

tube #2 under reconstruction

tube #4 full tested at ***klystron test stand DESY*** (250 hours), now in operation ***PITZ, Zeuthen,***

tube #5 new tube with modification, will come to DESY in February 2007

### CPI,

test underway, last data

9 MW, 300 uSec,

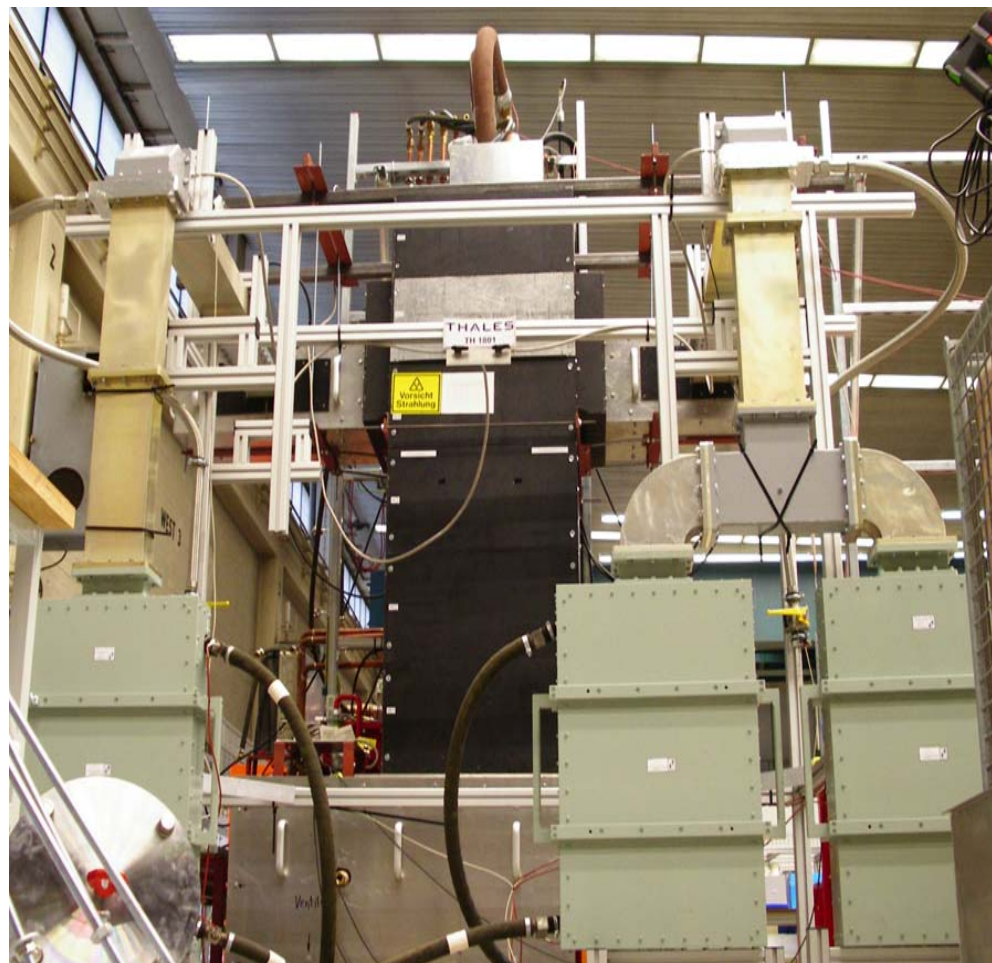
8.1 MW 1.3 mSec,

***klystron test stand, DESY***



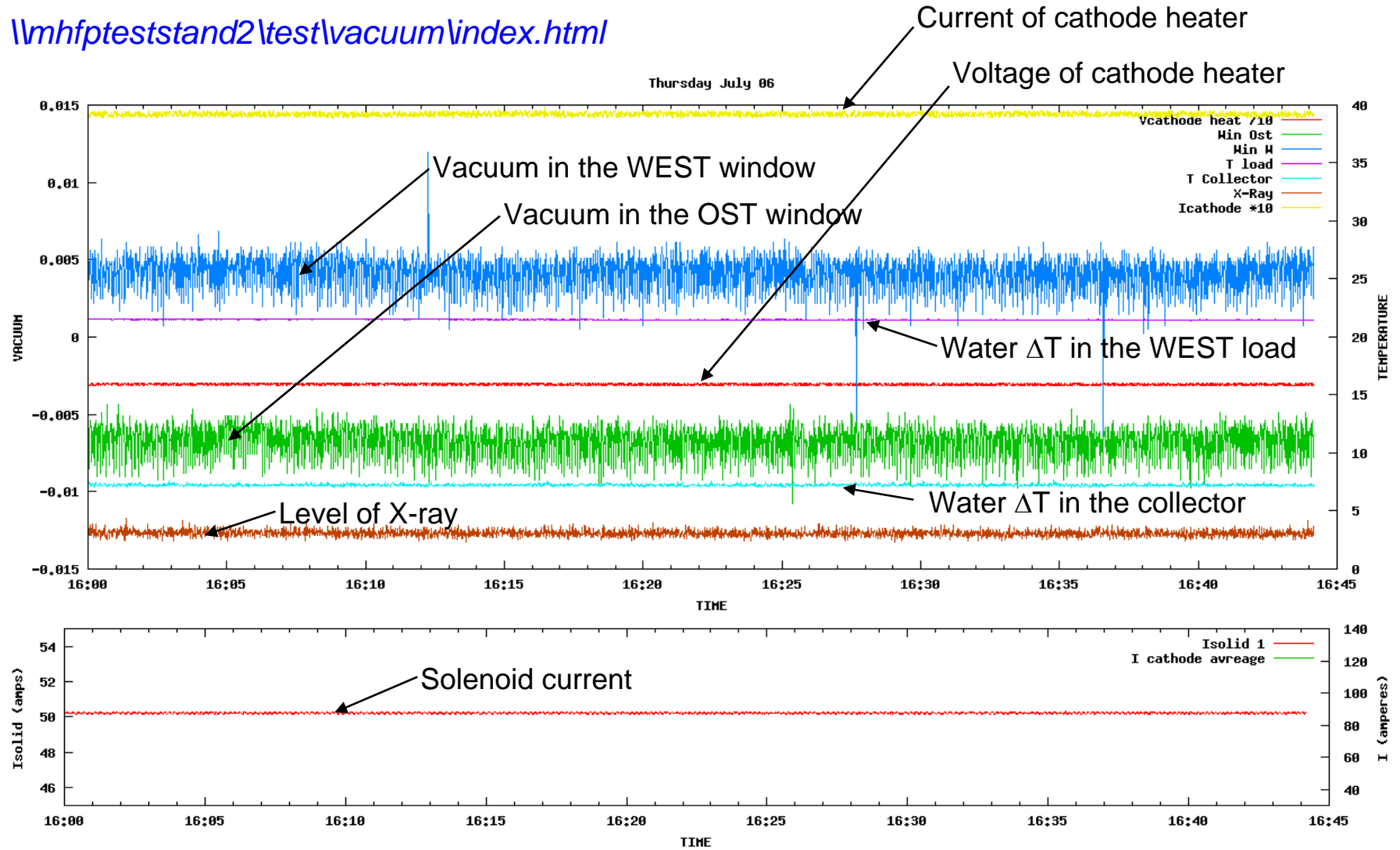
## Klystron test stand, DESY

Modulator (PPT)  
Pulse transformer (ABB)  
Waveguide WR650,  
SF6 up to 1.4 bar  
Calorimetric loads (Ferrite)  
Directional couplers (DESY)  
RF Amplifier AMP86-1.3s  
X-ray measurement system  
Data storage system base on PCI  
boards



Thales sn#1 at test stand, January 2007

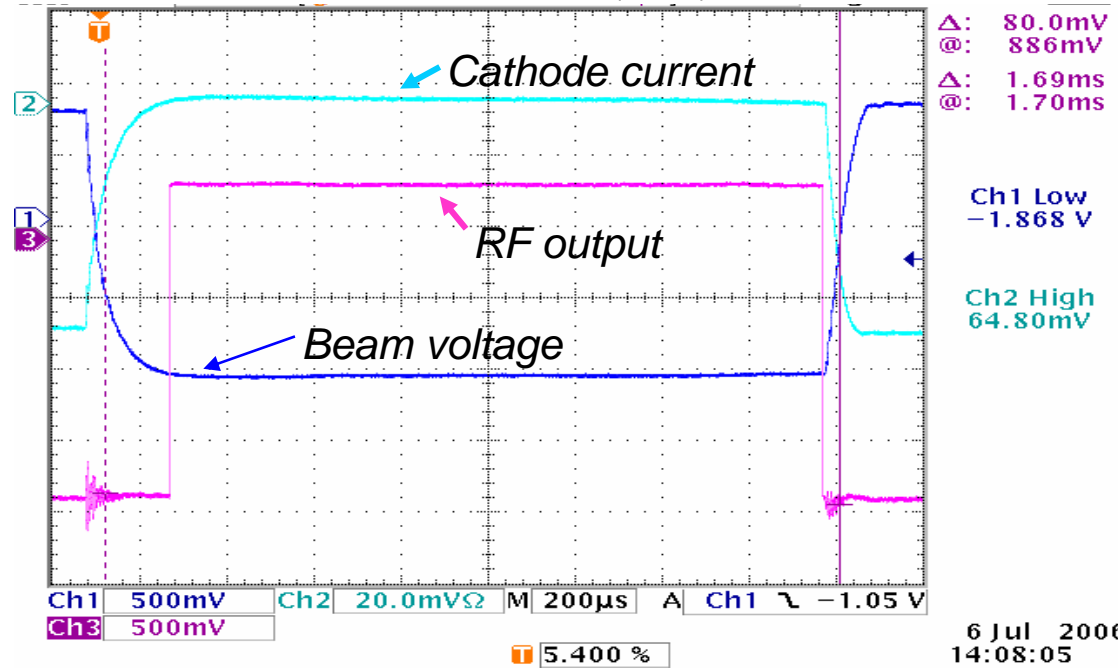
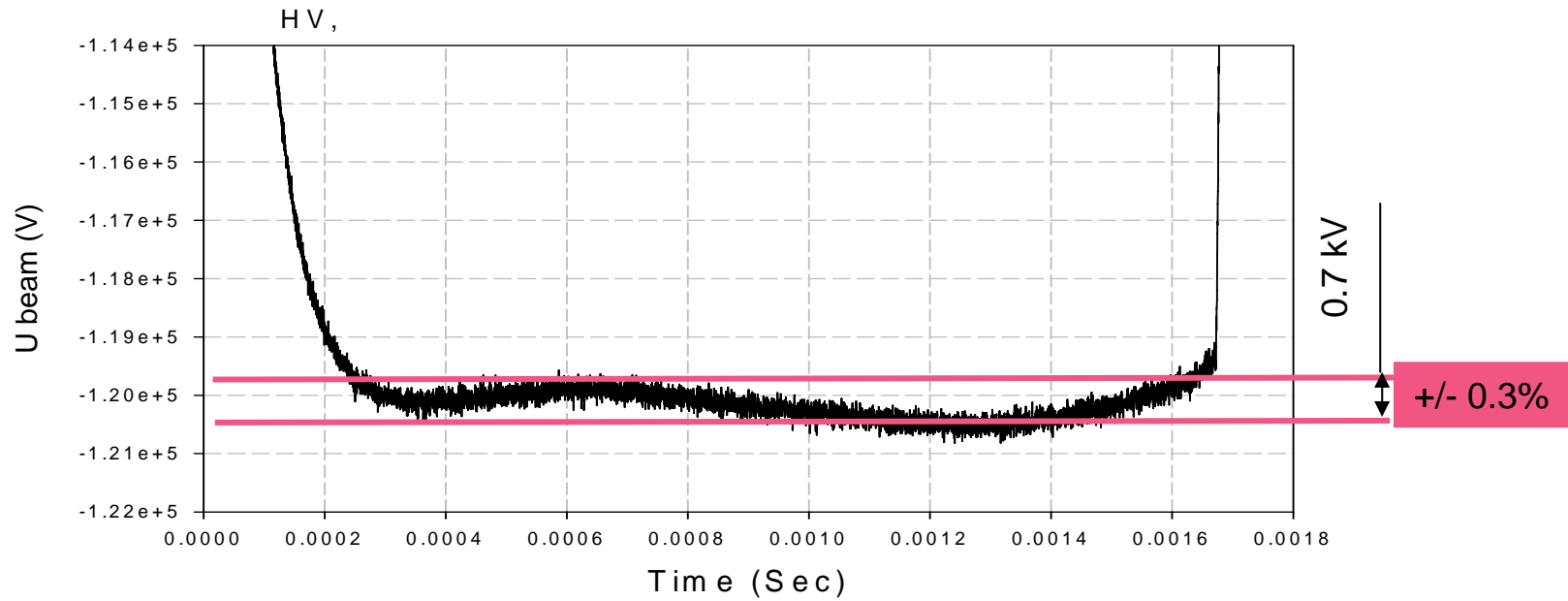
<\\mhfteststand2\test\vacuum\index.html>



Status screen of the Klystron test stand



# Cathode voltage



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6 Jul 2006  
14:08:05

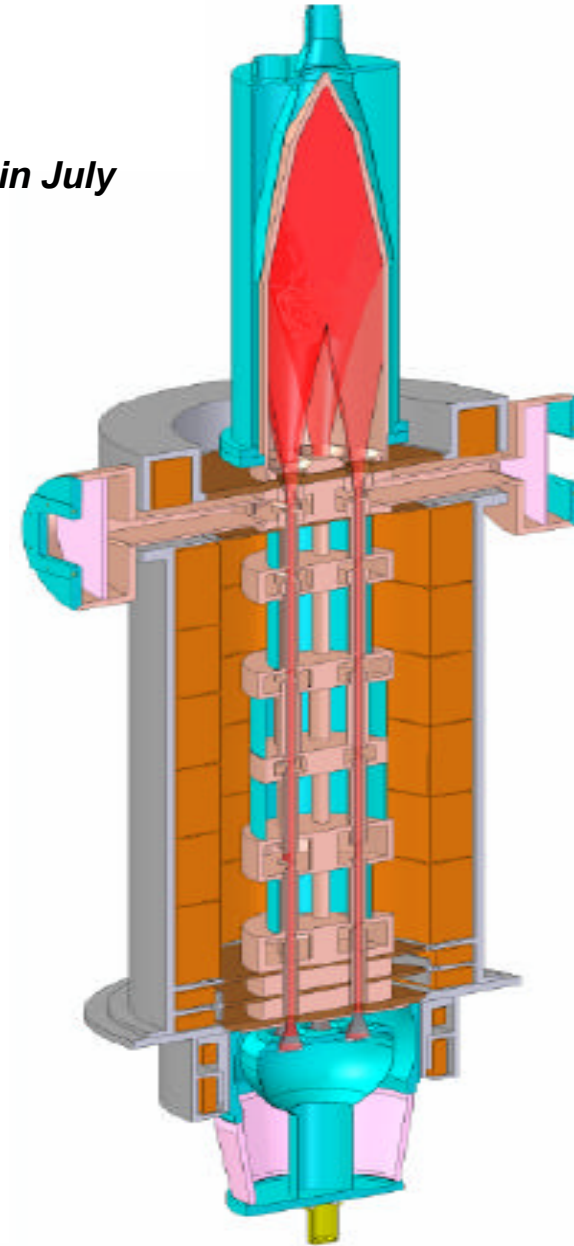


# Toshiba MBK E3736

*in cooperation with KEK, contract started in July  
2003*

## Design Features

- 6 beams, M type cathode (38 mm diameter)
- Cathode loading (2.1 A/cm<sup>2</sup>)
- Cathode electric field (6 kV/cm)
- Single beam  $\mu$ -perveance (0.56 A/V<sup>3/2</sup>)
- 6 Ring shape cavities (TM010)
- Second harmonic cavity
- Two common cathode coils
- Matching coils
- Solenoid power 3.6 kW (only one P/S)
- Tube length 2290 mm



### THE TOSHIBA E3736 MULTI BEAM KLYSTRON

S. Miyake, A. Yano (Toshiba Electron Tubes & Devises Co., Ltd. , Japan)

S. Kazakov, A. Larionov, V. Teryaev (BINP, Russia)

Y. H. Chin (KEK, Japan)

January 19, 2007



# Test History

- Klystron was tested successfully up to 10MW peak, 1ms, 10Hz in Nov. 2004 at Toshiba
- Modulator required modification for operation at full pulse width
- A leak was detected near the klystron collector after the test. The tube was opened, the leak sealed and a new gun installed.
- Test continued at Toshiba in Autumn 2005
- The klystron achieved 10.8MW, 1.5ms and 10Hz, efficiency 68%, but with high gun arcing rate.
- After opening of the tube, the gun was modified and the tube has been tested at Toshiba again.
- March 2006, AT. The klystron achieved 10.4MW, 1.5ms and 10Hz, efficiency 67%, U<sub>h</sub>v=115 kV, I<sub>cathode</sub> = 135 A.



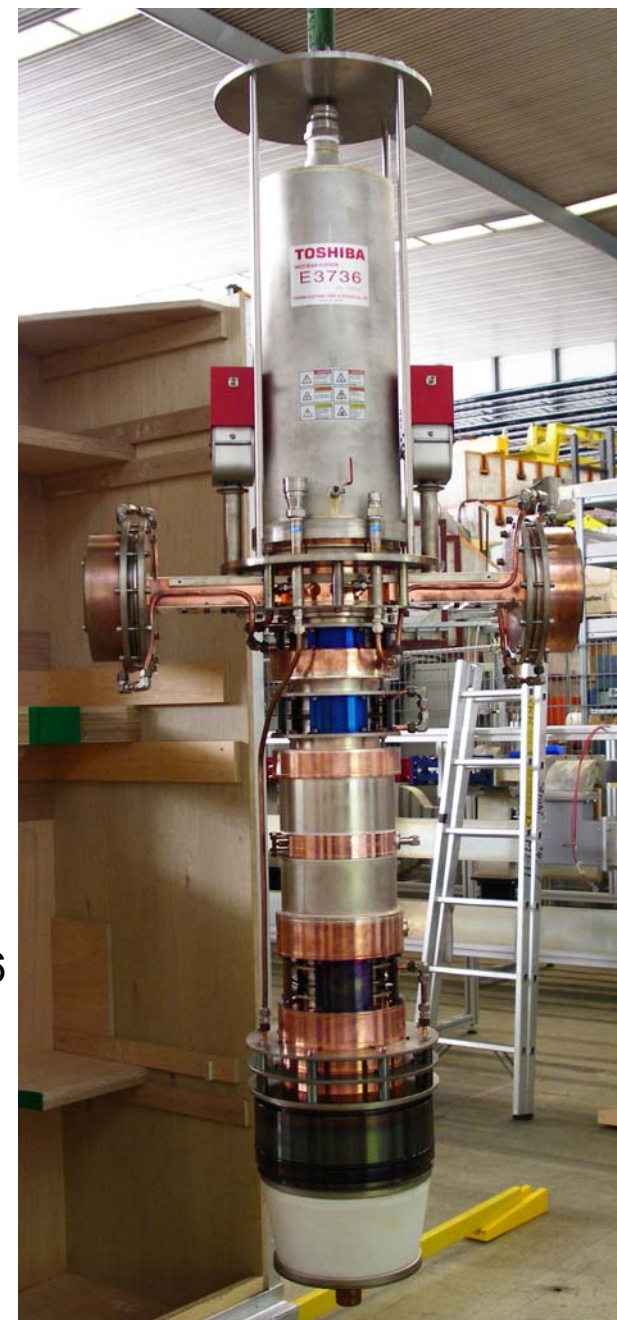
# Toshiba MBK TEST

DESY, HAMBURG

*June – October, 2006*

- Start installation: June 8, 2006
- Filament setting: June 14,
- Modification of tube socket June 16
- U<sub>hv</sub>=115kV, I=134A, Th<sub>v</sub>=1.7mS, 10pps June 19,
- RF 10MW, Tr<sub>f</sub>=1.5mS, 10pps, 150 kW June 20,
- 24 hours test July 4-5
- Remove from Test stand October 12, 2006
- Total time of operation on the test stand 750 hours

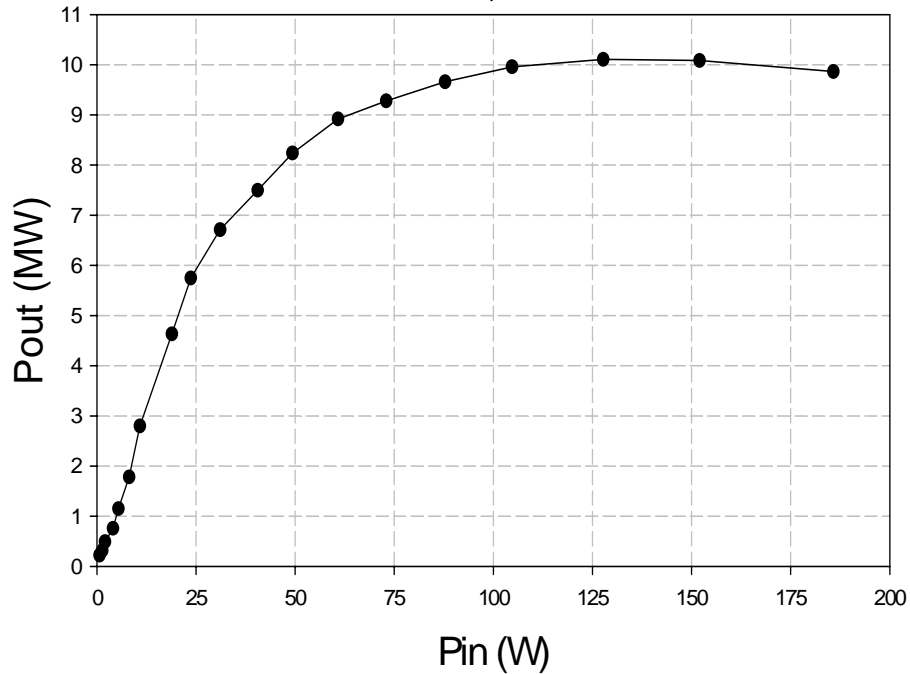
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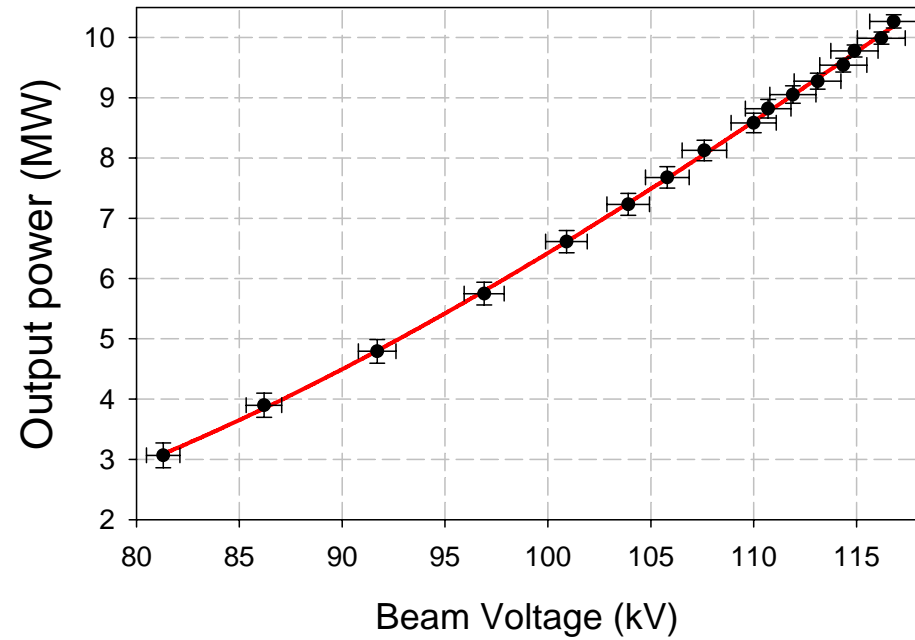


Toshiba MBK, June 2006  
 $U = 115,8 \text{ kV}$ ,  $I = 134 \text{ A}$ ,  $\text{Trf} = 1500 \mu\text{S}$



Dependence of output power vs input power

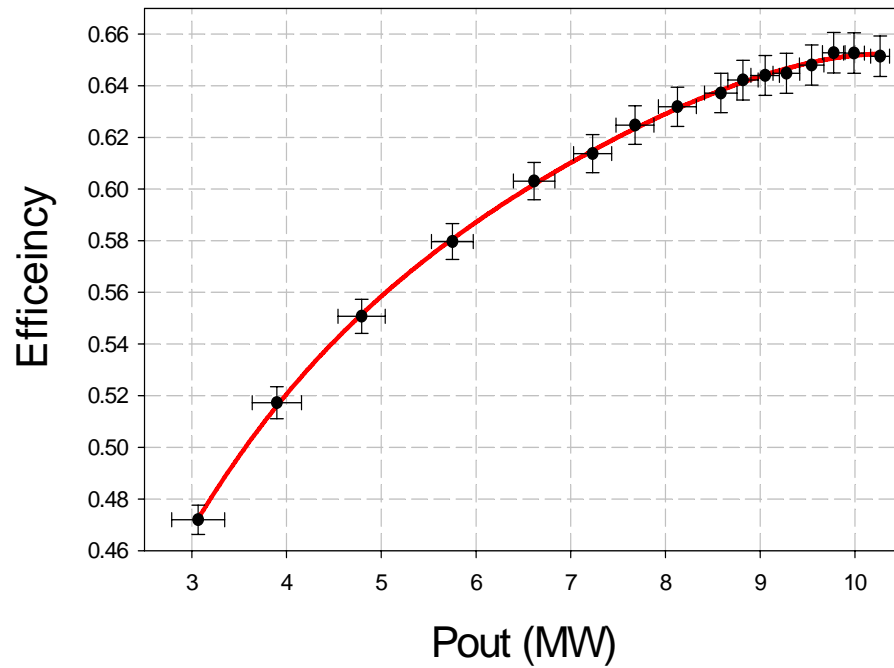
Toshiba MBK (saturation mode)



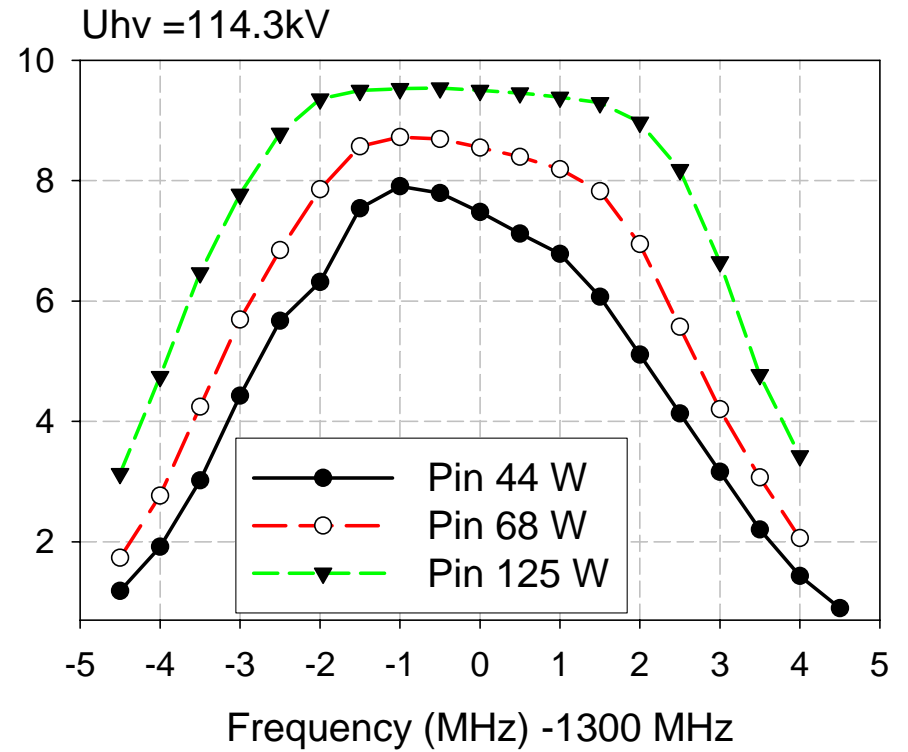
Dependence of output power vs beam voltage



Toshiba MBK June 22, 2006



Dependence of efficiency vs output power



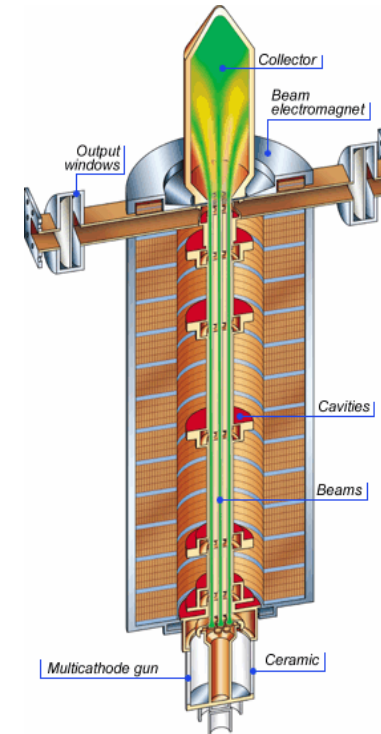
Tube bandwidth



# THALES MBK TH1801

## Measured performance

Cathode Voltage:	117kV
Beam Current:	131A
Number of Beams:	7
Cathode loading:	5.5A/cm <sup>2</sup>
Efficiency:	65%
Gain:	48.2dB
Solenoid Power:	6kW
Length:	2.5m

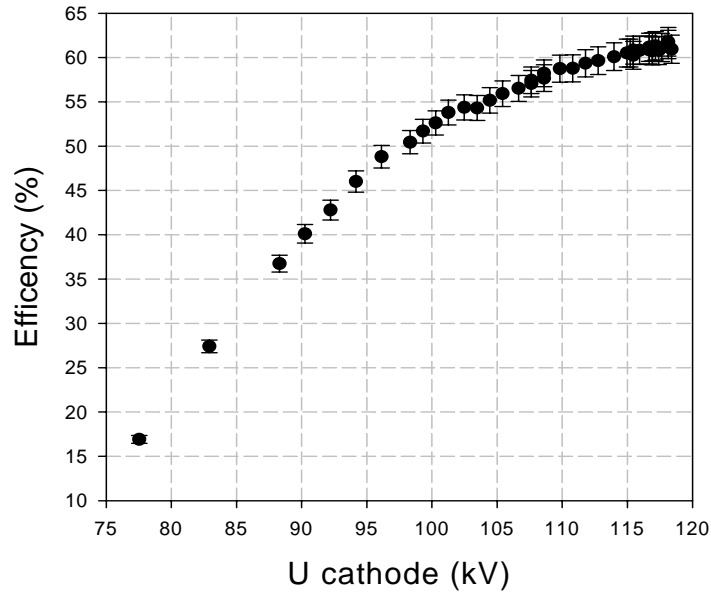


10 MW/1.5ms, L band multi beam klystron  
*C. Bearzatto, A. Beunas, G. Faillon, 1998*

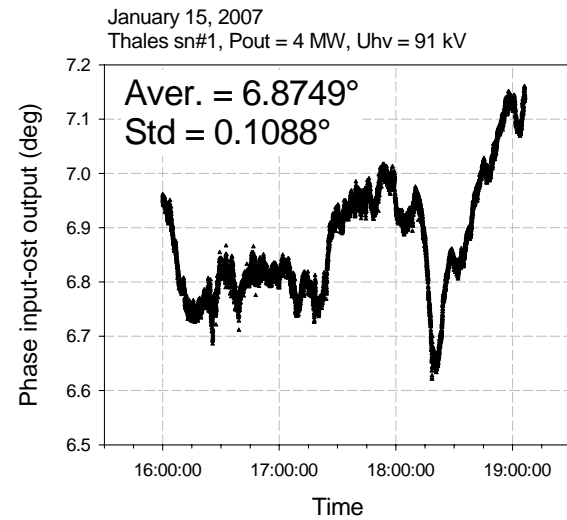
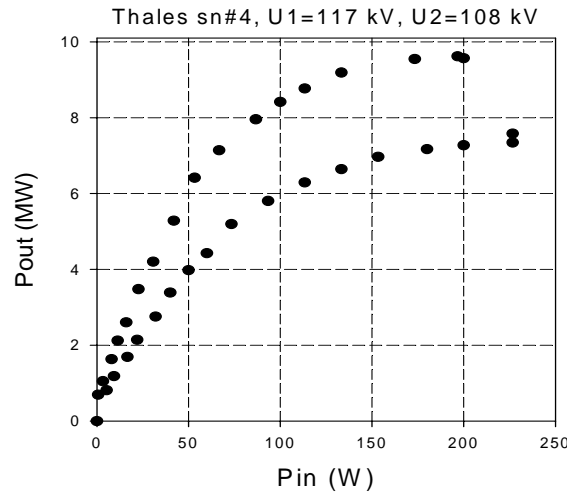
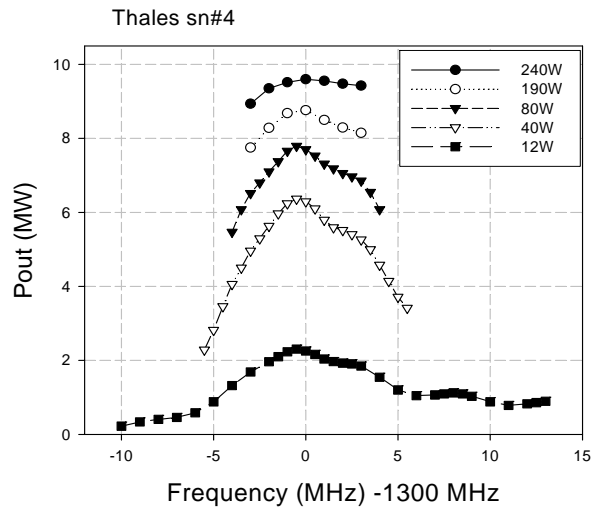
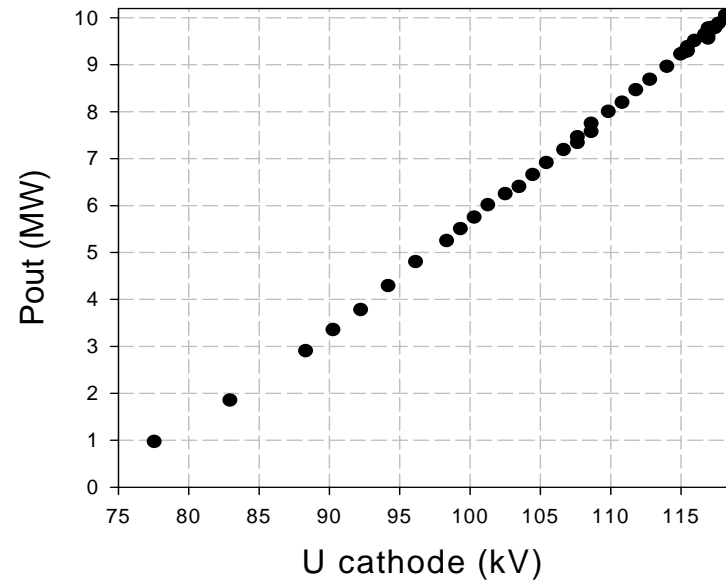


# Thales sn#4, Test stand, October-November 2006

Thales sn#4, (saturation mode)



Thales SN#4, November 2006



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# CPI VKL -8301 test underway

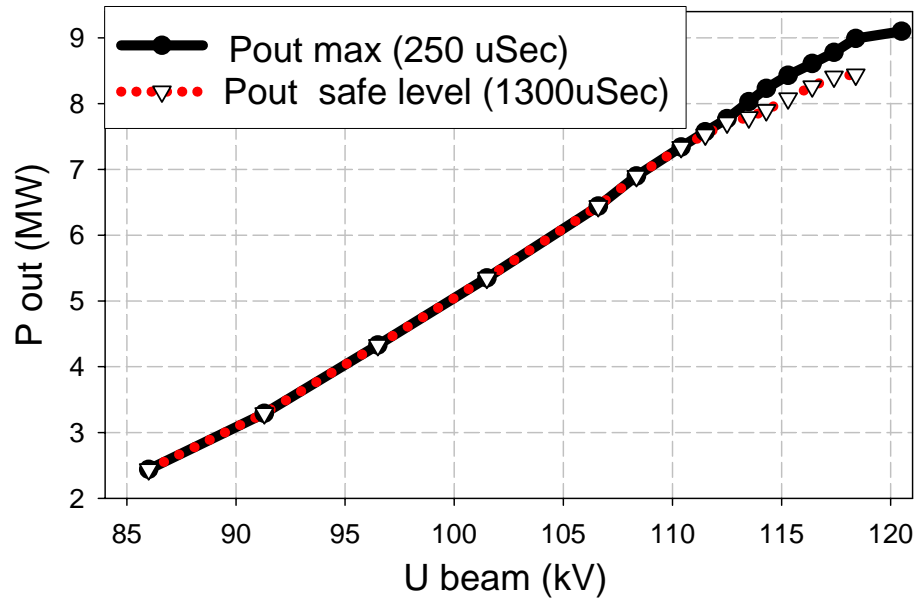
## Design Features:

- 6 beams
- HOM input and output cavity
- Cathode loading:  $<2.5\text{A/cm}^2$

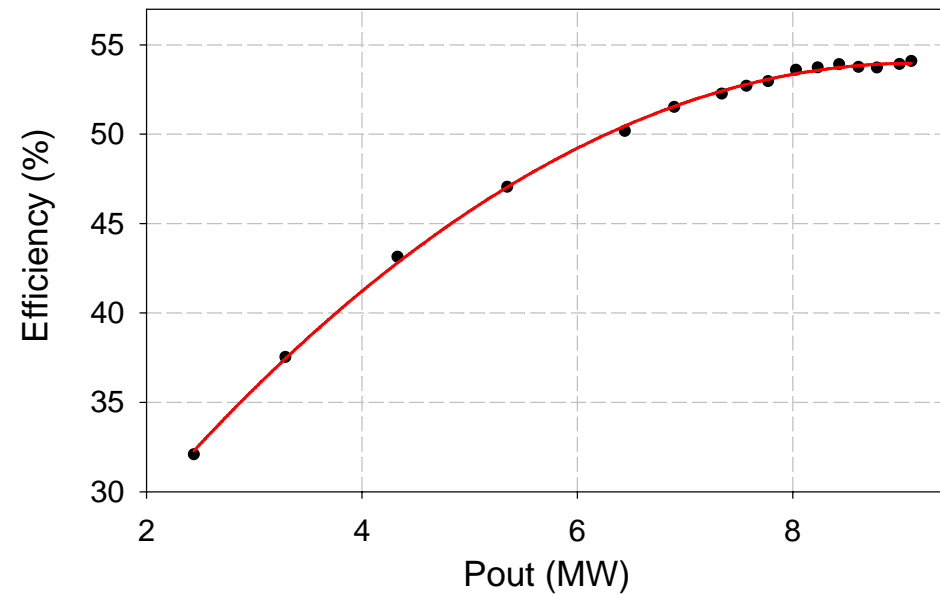


since August 2005  
test stand DESY

CPI, 9 - 19 September 2005



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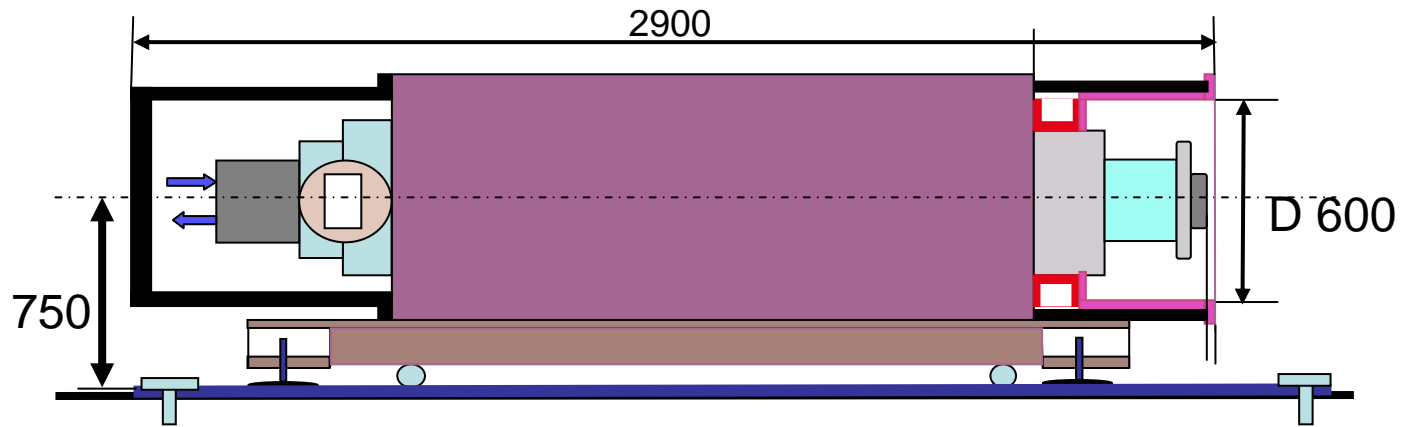




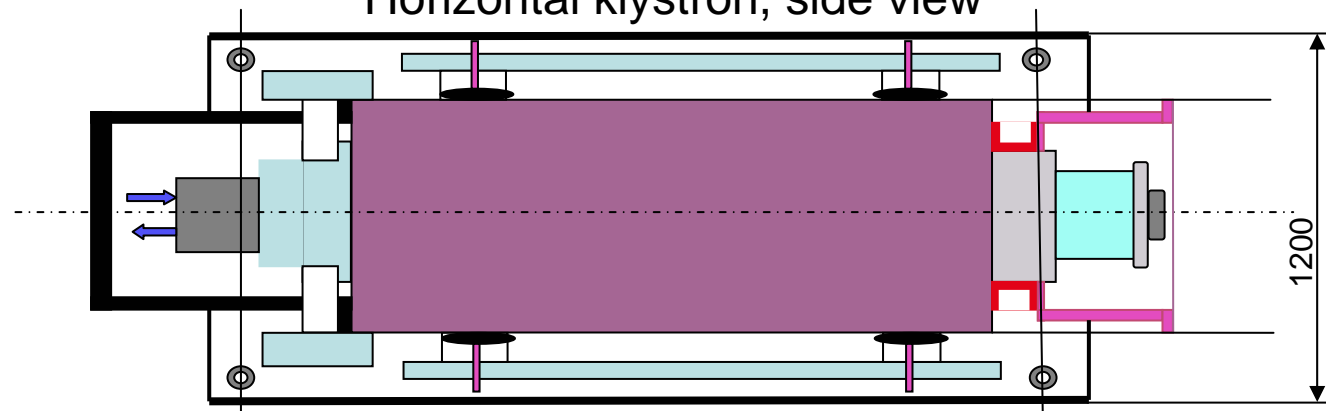
# Horizontal MBK for XFEL

DESY works with three company to design klystron Interface to transformer tank and tunnel layout.

*In March 2008 we expect the first horizontal MBK.*



Horizontal klystron, side view

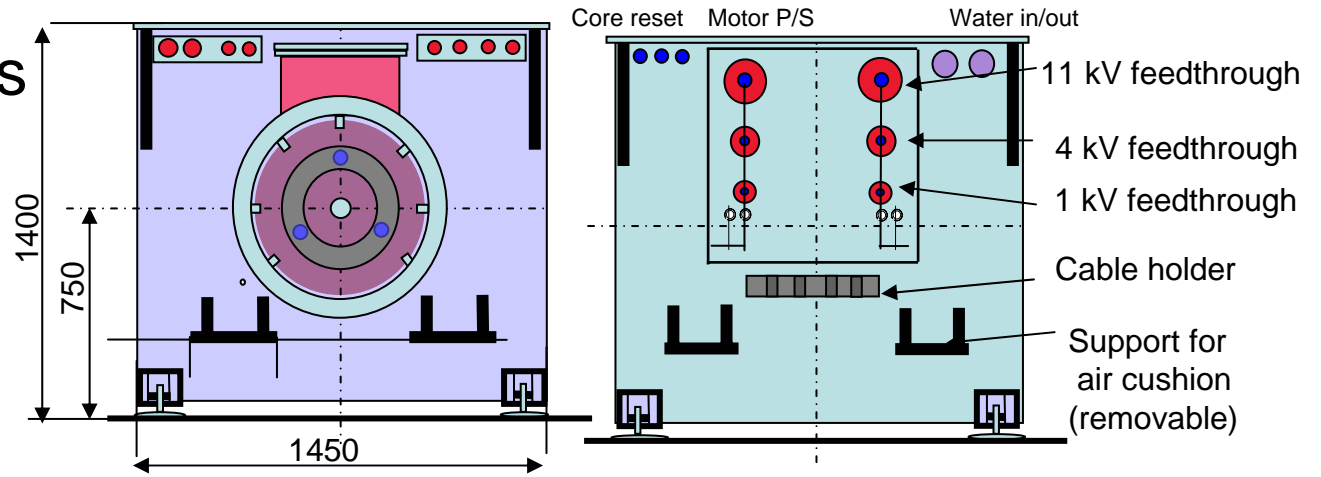


Top view

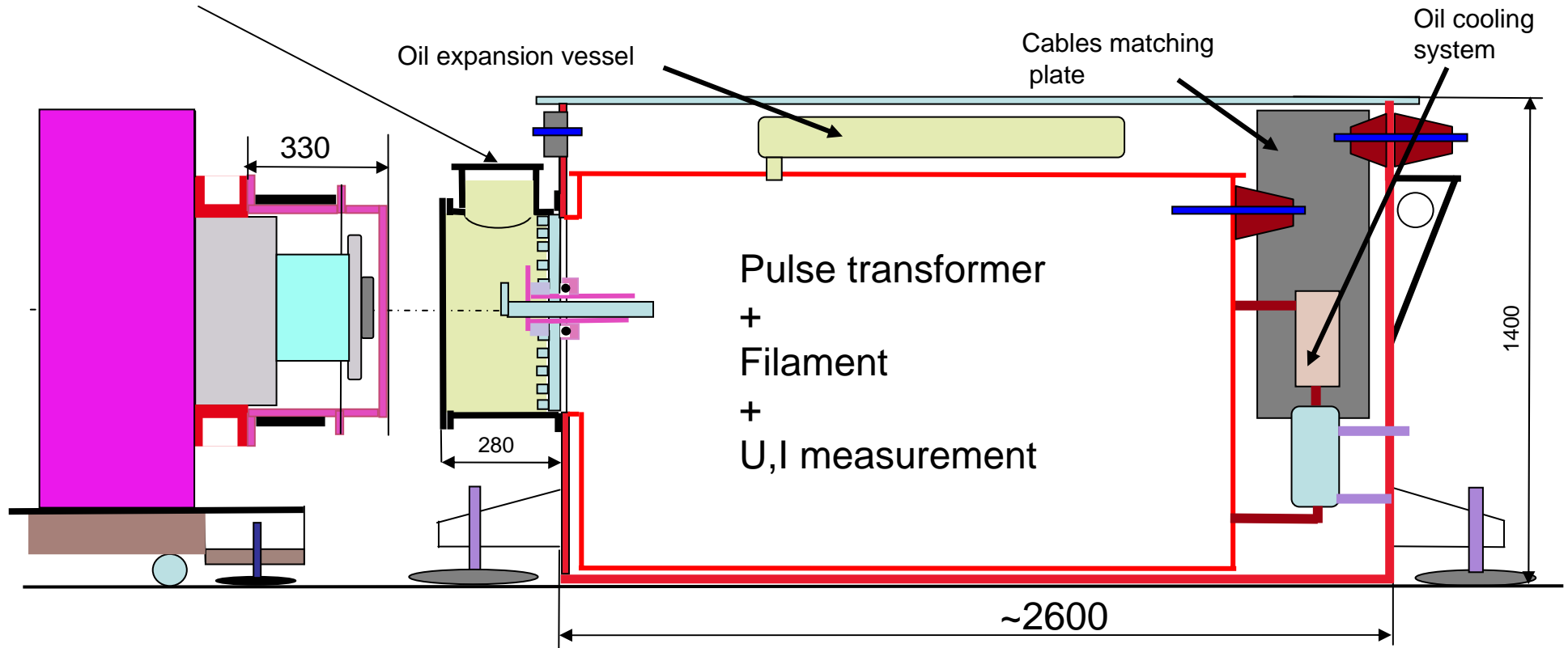




# Double tanks



Tank hatch for filament connection

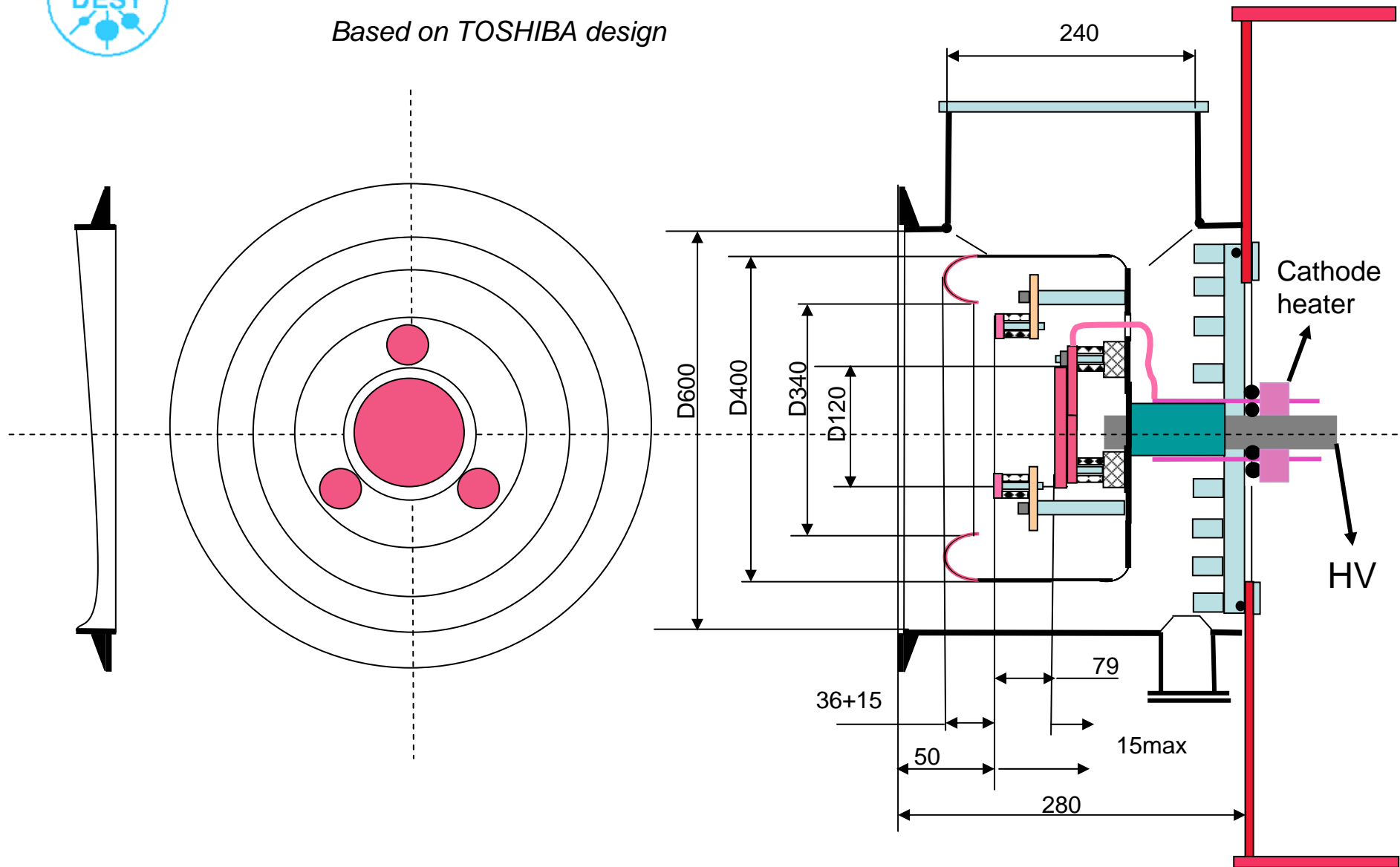


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# Tube socket

Based on TOSHIBA design



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# Cable connection between klystron and pulse transformer

We have a plan to design it in cooperation with BINP, Novosibirsk

Klystron gun insulator

Tube socket

Water cooling pipes

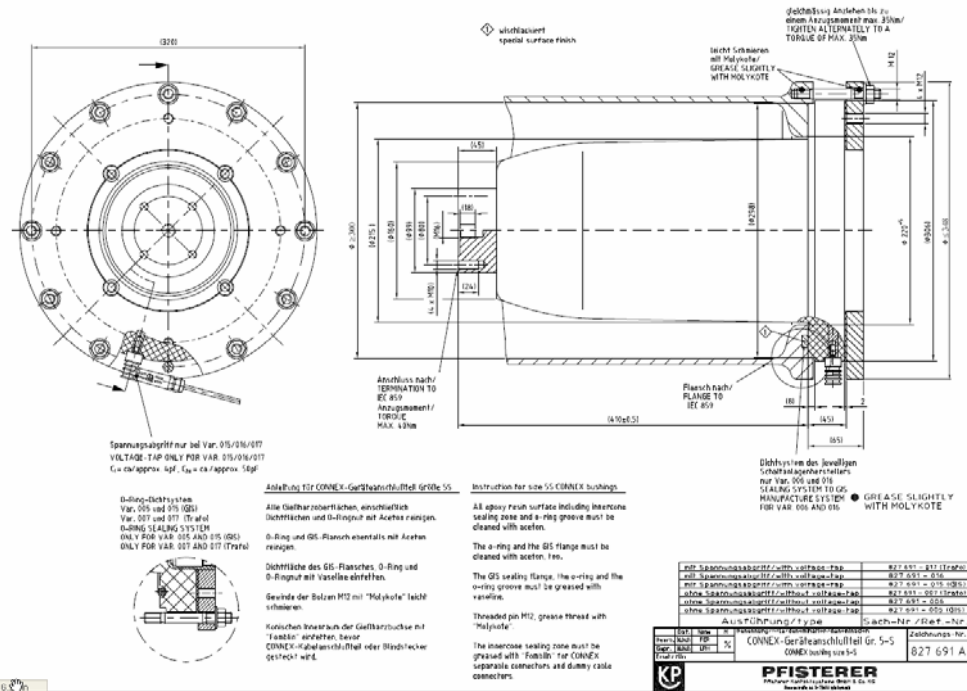
150 kV insulator (Oil)

HV cable

Cathode heater transformer

700

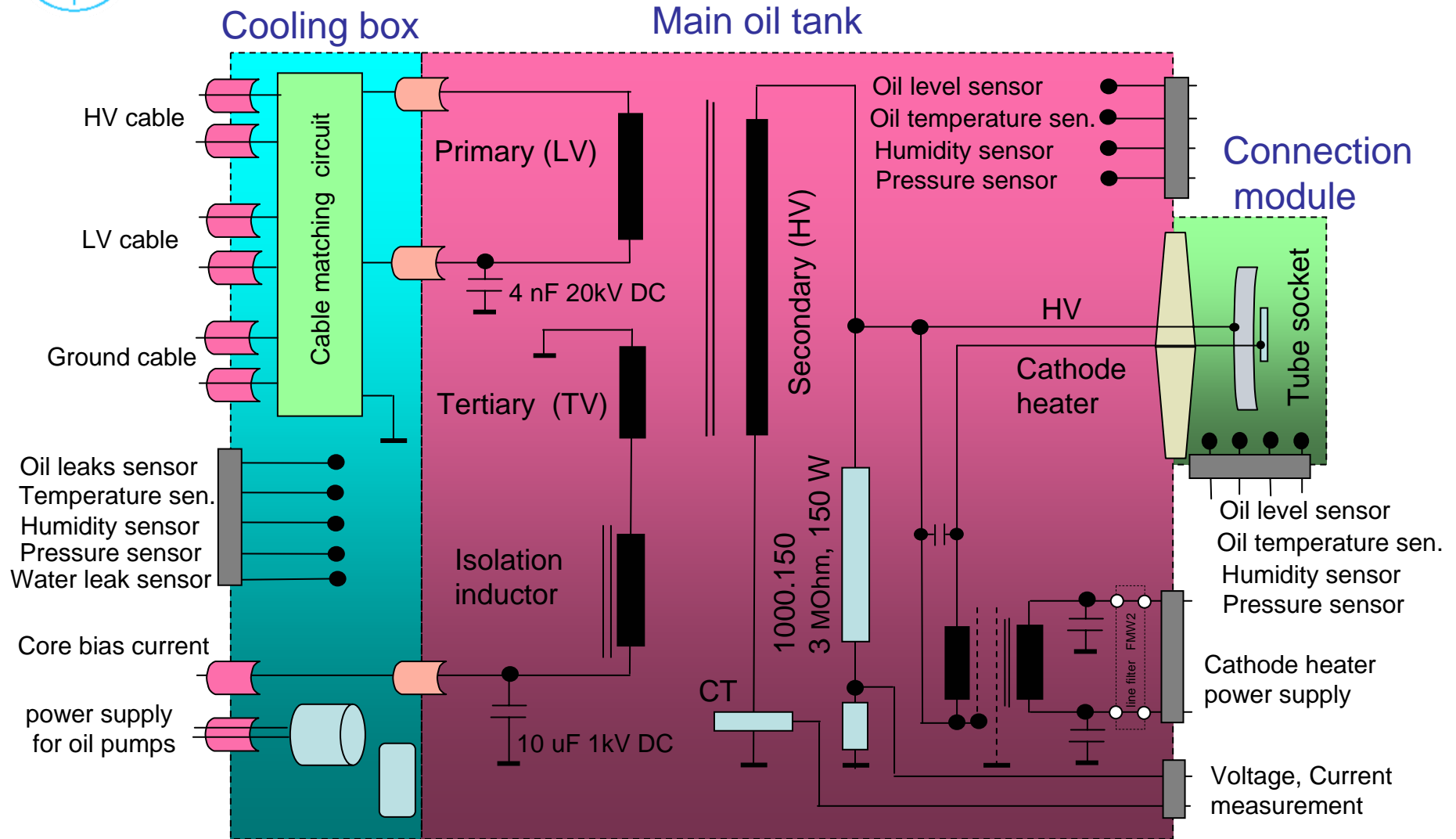
# Connection module





# Pulse transformer 10kV / 120kV, for Horizontal MBK

will be available in 2009





# Plans

- Thales sn#5 and sn#6 test
- Preparation for horizontal MBK test using existing (ABB) pulse transformer.
- HV cable connection test.
- Continue the investigation of phase, output power and perveance stability of MBK.
- Studying of dependence of a level of breakdown in RF components and windows of klystrons from filling of waveguides.
- Studying the fast klystron protection system against RF breakdown.