New high power klystrons for particle accelerators

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High power pulsed TH 1801 multi beam klystron

Background : **MBK Technology**

Klystron with n low current beams bunched in n separate drift tubes, all travelling through the same cavities

⇨ High overall perveance

⇨ Low operating voltage
⇨ Low individual beam perveance

High power pulsed TH 1801 multi beam klystron

Background : Advantages of MBK

Lower operating voltage compared to conventional klystron

- ⇨ large pulse duration
- ⇨ improved reliability (risks of arcing are reduced)
- ⇨ simplification of HV supply and HV insulation
- ⇨ reduction or supression of x-ray shielding
- ⇨ reduction of dimensions and weight

High interaction efficiency achievable
Large bandwidth

High power pulsed TH 1801 multi beam klystron

Objectives :

Design, manufacturing and test of a new MBK for use at Tesla test bench facility (Desy Hamburg)

Frequency	1300	MHz
Peak output power	10	MW
Pulse width	1.5	ms
Average power	150	kW
Beam voltage	115	kV
Efficiency	70	%

This *high power-high efficiency-long pulse combination* is not achievable with a conventional klystron

typical L- band klystrons	20 MW	100 µs	42 %	210 kV
	10 MW	250 µs	44 %	185 kV
	5 MW	2 Ms	44 %	120 kV

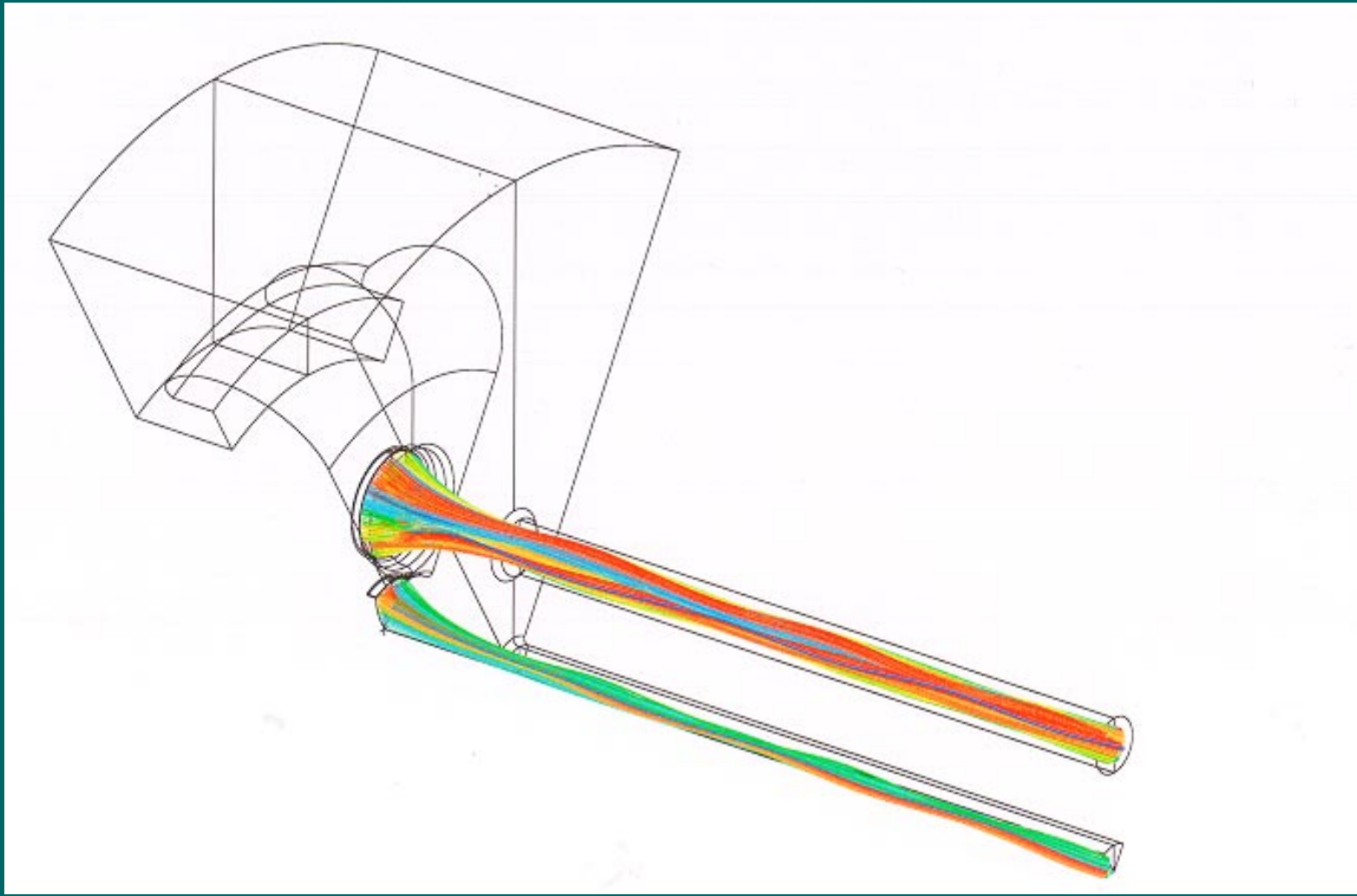
High power pulsed TH 1801 multi beam klystron

Main design parameters :

- 7 Low perveance beams (0.5 µPerv) 110 kV 18.2 A
- Common diode multicathode gun :
  - Low cathode loading
  - Low beams convergence
  - E_{max}xV product compliant with long pulse duration
- Constant focusing magnetic field (2 to 2.5 Bb)
- 6 Cavities operating in fundamental mode
- 2 output waveguides WR650
- common grounded collector

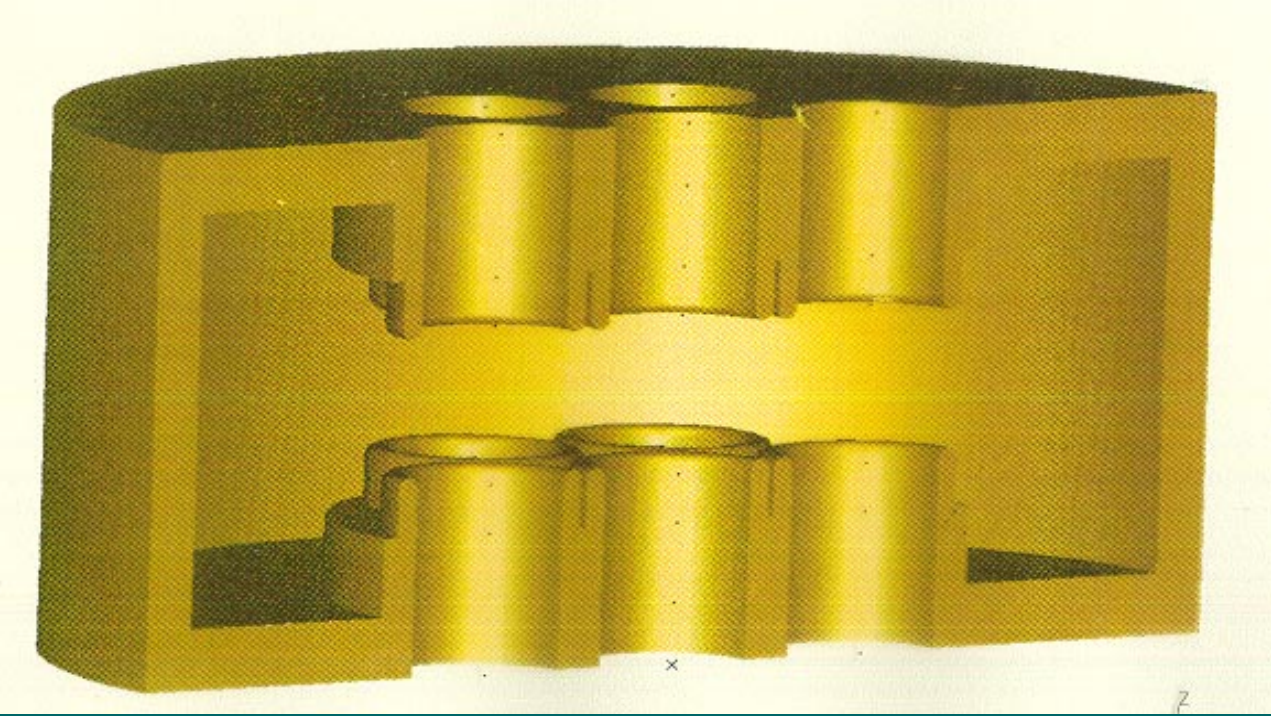
TH 1801

Electrons trajectories

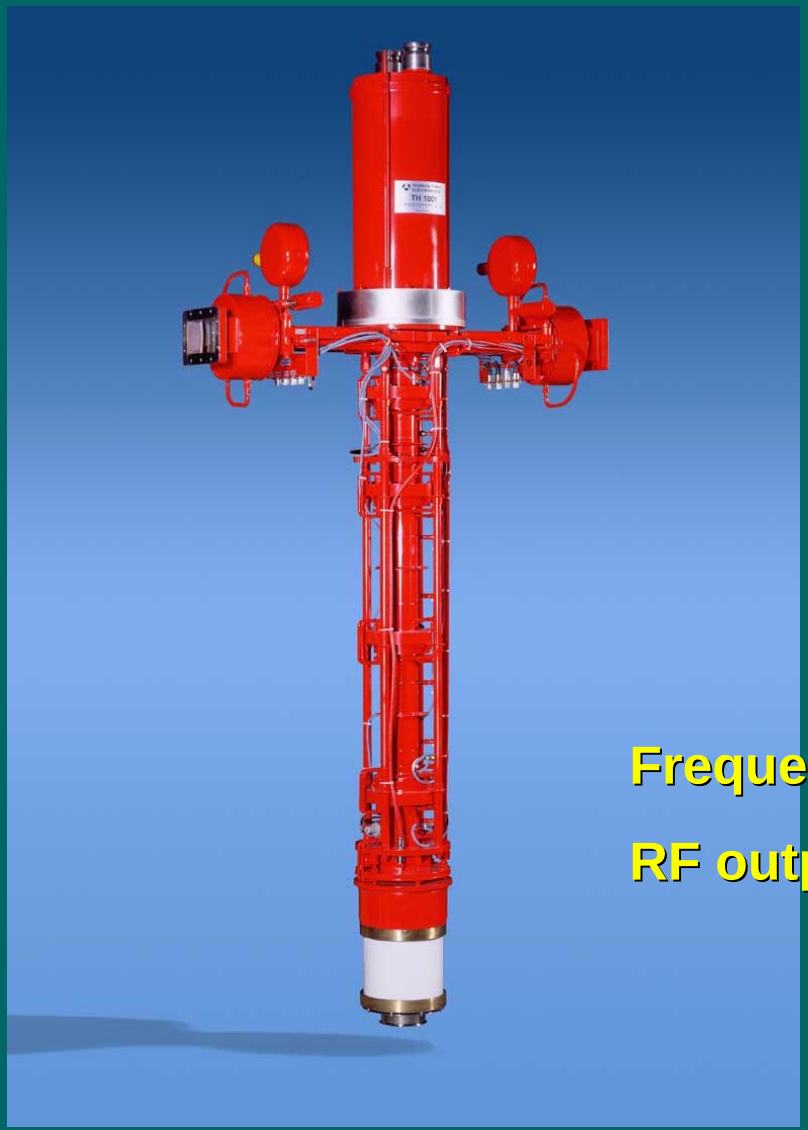


TH 1801

Multi gap cavity



TH 1801



Frequency: 1,300 MHz

RF output peak power: 10 MW

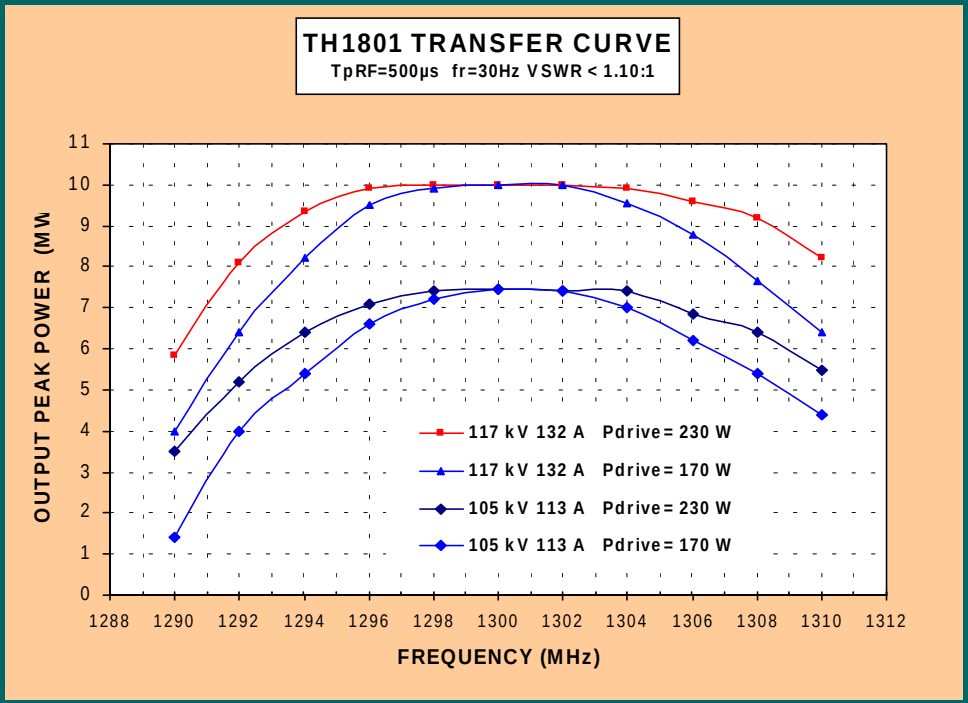
High power pulsed TH 1801 multi beam klystron

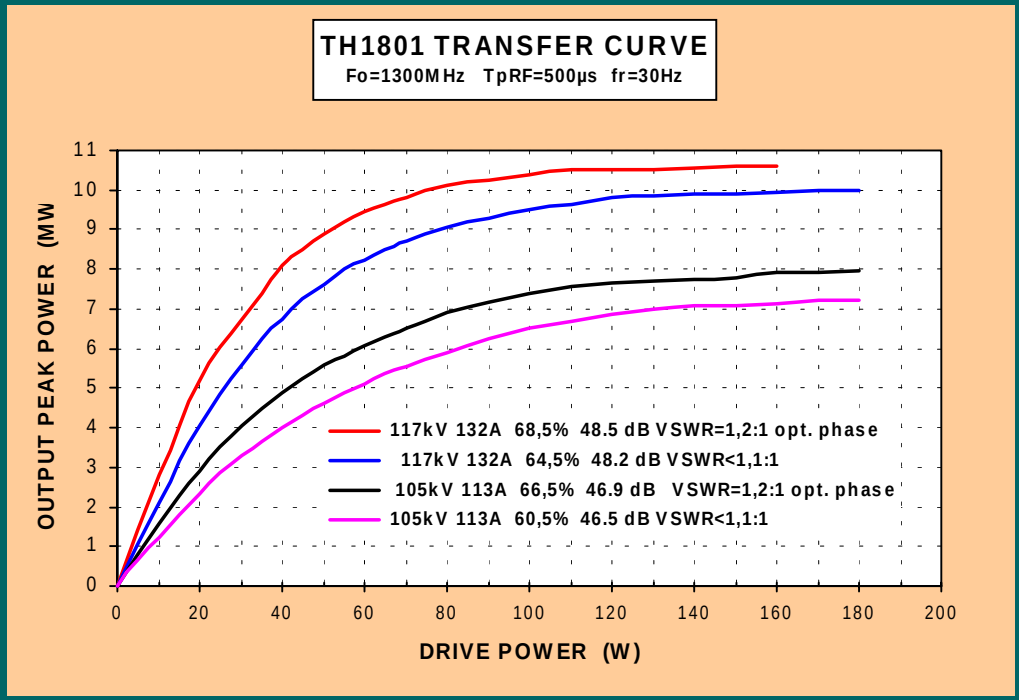
TEST RESULTS OF THE PROTOTYPES

	1997	1998		1999	
Beams voltage	116	115		117	kV
Beams current	132	133		132	A
Perveance	3.34	3.41		3.3	µperv
RF Pulse width	400	510		500	µs
Repetition frequency	10	30		30	Hz
VSWR	1.10	1.10	1.10	1.2 (opt.Φ)	
Output peak power	10	10	10	10.6	MW
Output mean power	40	152	150	159	kW
Efficiency	65	65.4	64.5	68.5	%
RF instabilities	yes	yes	no	no	
Gain	47	48	48	48.5	dB
Bandwidth (-1dB)			18		MHz
Body power	4.2	5.1	2	2.7	kW
Solenoid power				6	kW
Heater power				360	W

TH 1801

transfer curves





High power pulsed TH 1801 multi beam klystron

Conclusion :

The multi beam klystron is an alternative solution to generate long pulse high RF peak power with a good efficiency

We have already performed 10 MW peak power in 500 µs RF with an efficiency of 65 % at 117 kV beam voltage

The tests of the prototype on a 1.5 ms long pulse modulator are scheduled in the next months at desy

2 additional TH 1801 are under construction for TTF and will be delivered in 2000

New challenge : MBK as the prime RF power source for CLIC accelerator

TTE is carrying out a paper study concerning the faisability of a MBK with the following performances :

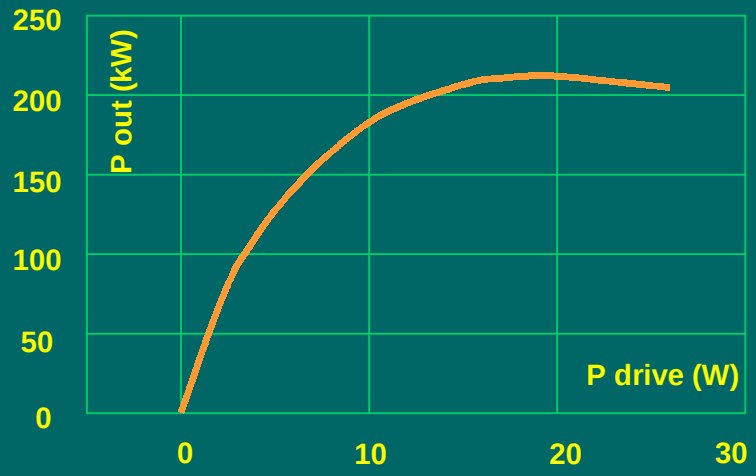
Frequency	MHz		937	
Beams voltage	kV	212 - 230		
Beams current	A	292 - 333		
Pulse duration	µS		100	
Output peak power	MW	40	Min 50	Obj.
Output mean power	kW	400	Min 500	Obj.
Efficiency	%	65	Min 70	Obj.

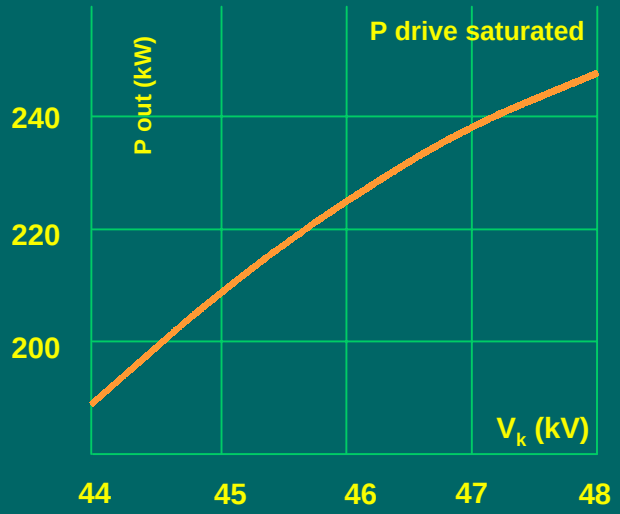
HIGH POWER CW TH 2161 KLYSTRON

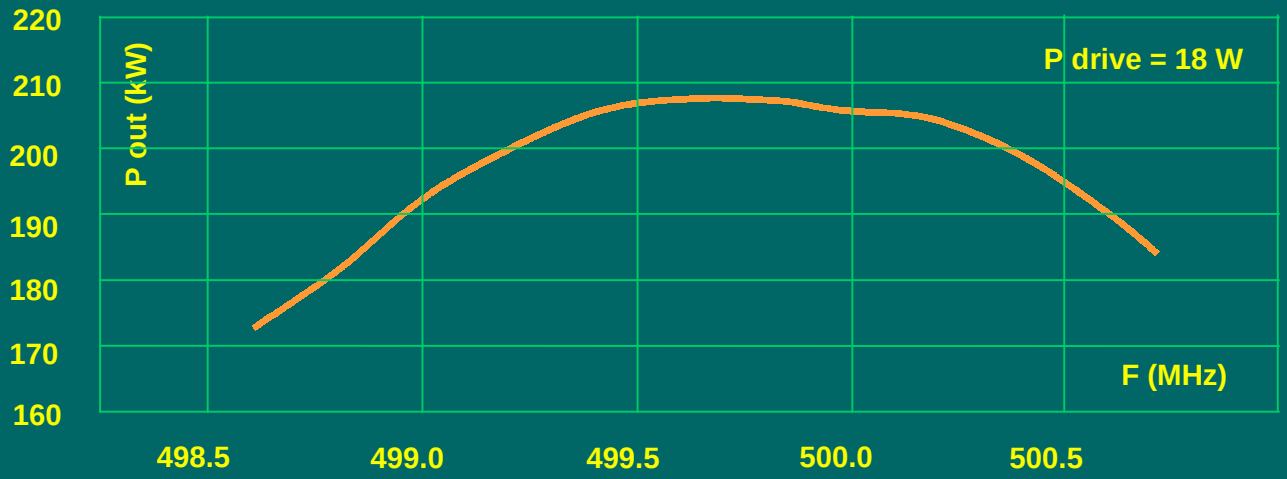
Operating frequency	500	MHz
RF output power	250	kW CW
Efficiency	60	% typ.
Gain	40	dB min.

- Modulating anode
- 5 integrated cavities
- Air isolated electron gun
- Hypervapotron cooled collector
- RF output on WR1800 waveguide

TH 2161 : Test results







F_0 = 499.65 MHz

V_k = 45 kV ; V_a = 28 kV ; I_k = 7.5A

P_{rf} =208 kW; P_d = 18W

P_{body} = 208 kW ; P_{cav} = 2.8 kW

Efficiency = 61% ; G = 40.6 dB

V_k = 50 kV V_a = 30 kV I_k = 8.5 A

P_{rf} = 262 kW P_d = 15 W

Efficiency = 61.6% ; G = 42.4 dB

TH 2161

Outlines & dimensions