Experience with prototype of a 1.3 GHz IOT for CW Studies

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Experience with 1.3 GHz IOT prototype for CW Studies

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HELMHOLTZ ASSOCIATION

DESY

Outline

1) Motivation
2) Specifications
3) First test
4) First breakdown
5) Second test
6) Modifications
7) Further investigations

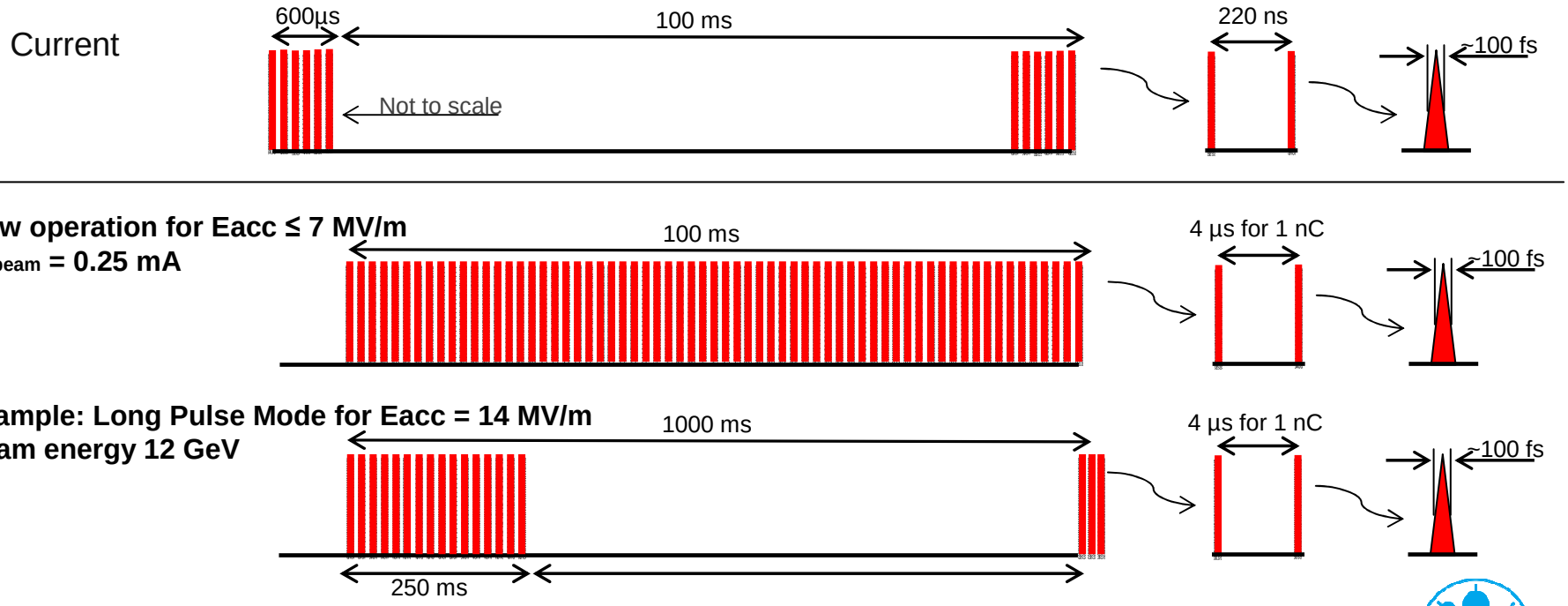
Motivation

XFEL facilities offer unique combination of the coherent photon beam properties:

- High peak brightness
- Short photon bursts (<100 fs)
- Short wave length (≤ 1 Å)

But their extremely low **Duty Factors** limit **flexibility in the time structure of photon beams**

Idea: Long pulse mode or CW- Operation gives more flexibility in Bunch patterns



Motivation

- FLASH / XFEL Klystron are not designed for CW operation
- CW as upgrade option
- Separate RF- system !?!
- Has to fit into the tunnel
- CW or long pulse mode are limited by HOMs cryoload

Specifications of IOT

Preliminary Specifications:

Parameters	Unit	Minimum	Nominal	Maximum
Frequency	[GHz]		1.3	
Output Power	[kW]		120*	
3dB- Bandwidth	[MHz]	8	10	15
Power Gain	[dB]	21	22	
Efficiency	[%]	60	65	
Beam Voltage	[kV]		46	50
Beam Current	[A]	3.5	3.9	4.5
RF- Drive	[W]		600	800
Grid Bias	[V]	-50	-100	-150

* For Prototype 60 kW should be reached

- Feb./2007: Ordering the prototype IOT (grid & cathode are standard components » minimum output power = 60 kW)
- Jun./2008: IOT shipped to DESY
- Jun./2008 to Dec./2009: Building test stand in DORIS- RF hall
- 2010 First test and modifications on hardware

First test in DORIS transmitter hall

HV- installations

Heater & Grid supply

Control cabinets

DESY 1.3 GHz, 60-120 kW IOT
Prototype Tube Test Performance

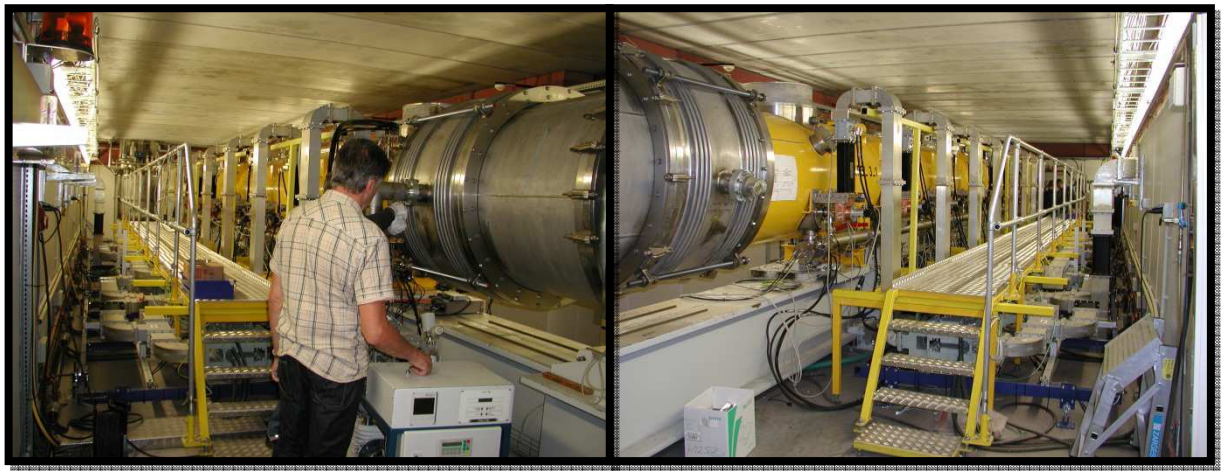
SERIAL NO.001R1	CPI Sep.2009	CPI Sep.2009	DESY @DORIS-NR Jan.2010
Drive Power	474 W	300 W	440 W (*)
Beam Voltage	48 kV	48 kV	48 kV
Beam Current	3.44 A	3.0 A	2.83 A
Beam Power	165 kW	144 kW	136 kW
Output Power (Meter via Dir.Cplr.)	85.3 kW	65.1 kW	60.3 kW
Output Power (Calorimetric via Water)	85.1 kW	64.7 kW	57.2 kW
Gain	22.5 dB	22.1 dB	22.1 dB
Efficiency	51.5 %	44.9 %	42.1 %

* max. available Drive Power

Moving to CMTB (Cryo Module Test Bench)

Crowbar | Control Racks | Heater, Grid- supply | IOT | IOT | Match Line and Connection- box

- Jan./2011to Jun./2011: Moving to CMTB with more compact infrastructure
- Jun./2011 to Sep./2011: Test operation on Flash/XFEL Test Module or on load



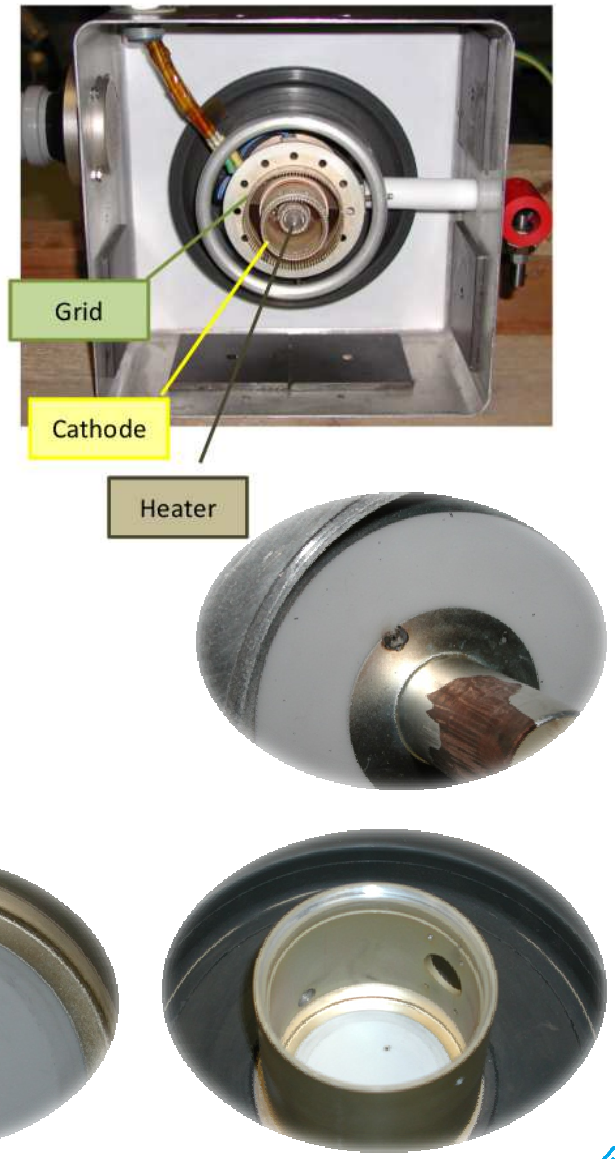
Test module (with 8 cavities)

First breakdown

September 2011:

- 2nd High power test after TTF- module testing
- No high voltage possible
- Sparking through insulating ceramics

- CPI knows this as a “weak point of design” and has spare part
- Whole connection box sent to CPI



Second test

March 2012:

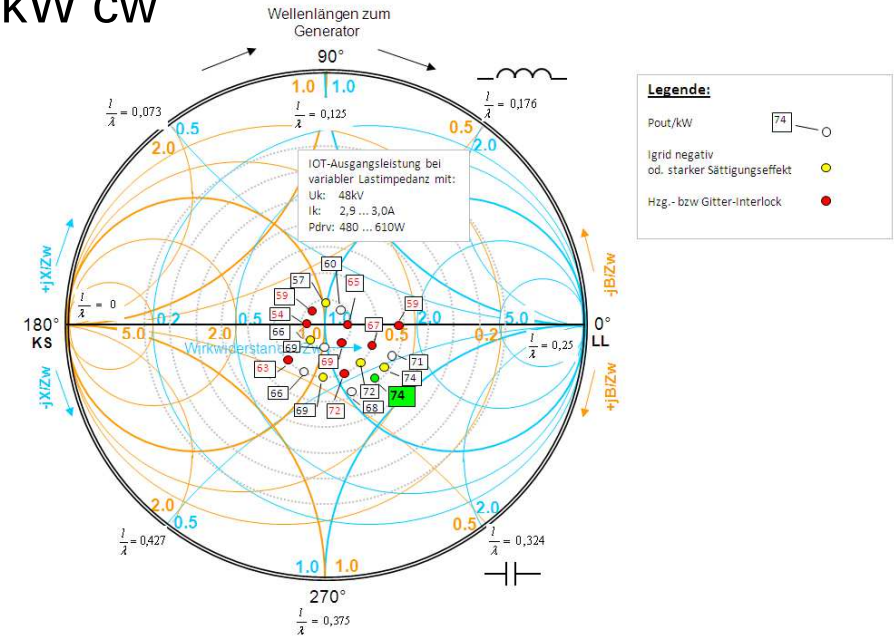
- After replacing ceramics only unstable operation possible
- Input circuit sensitive to mechanical forces
- Input circuit was mismatched
- Only 12 kW output power was “stable” possible
- Module tests with 12 kW (LLRF studies)

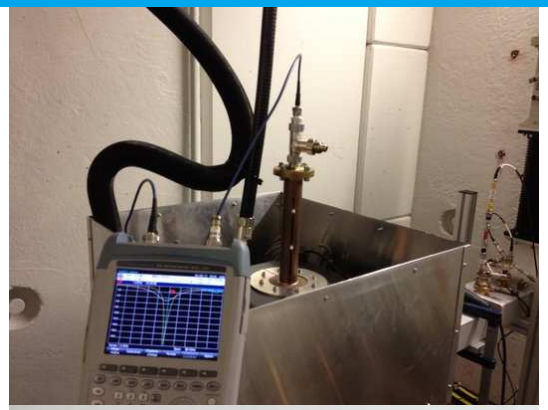
Modifications (1st part)

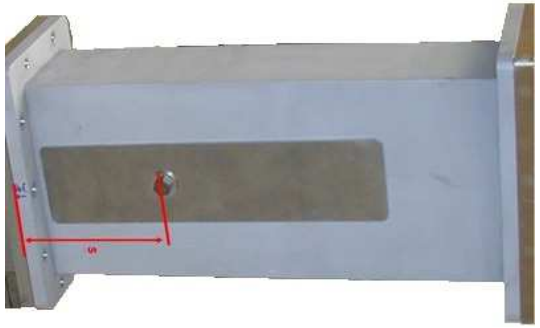
August 2012:

- Tighten the “Match Line” *(even if bad matched)*
- Matching the driver with slugs and Tee’s

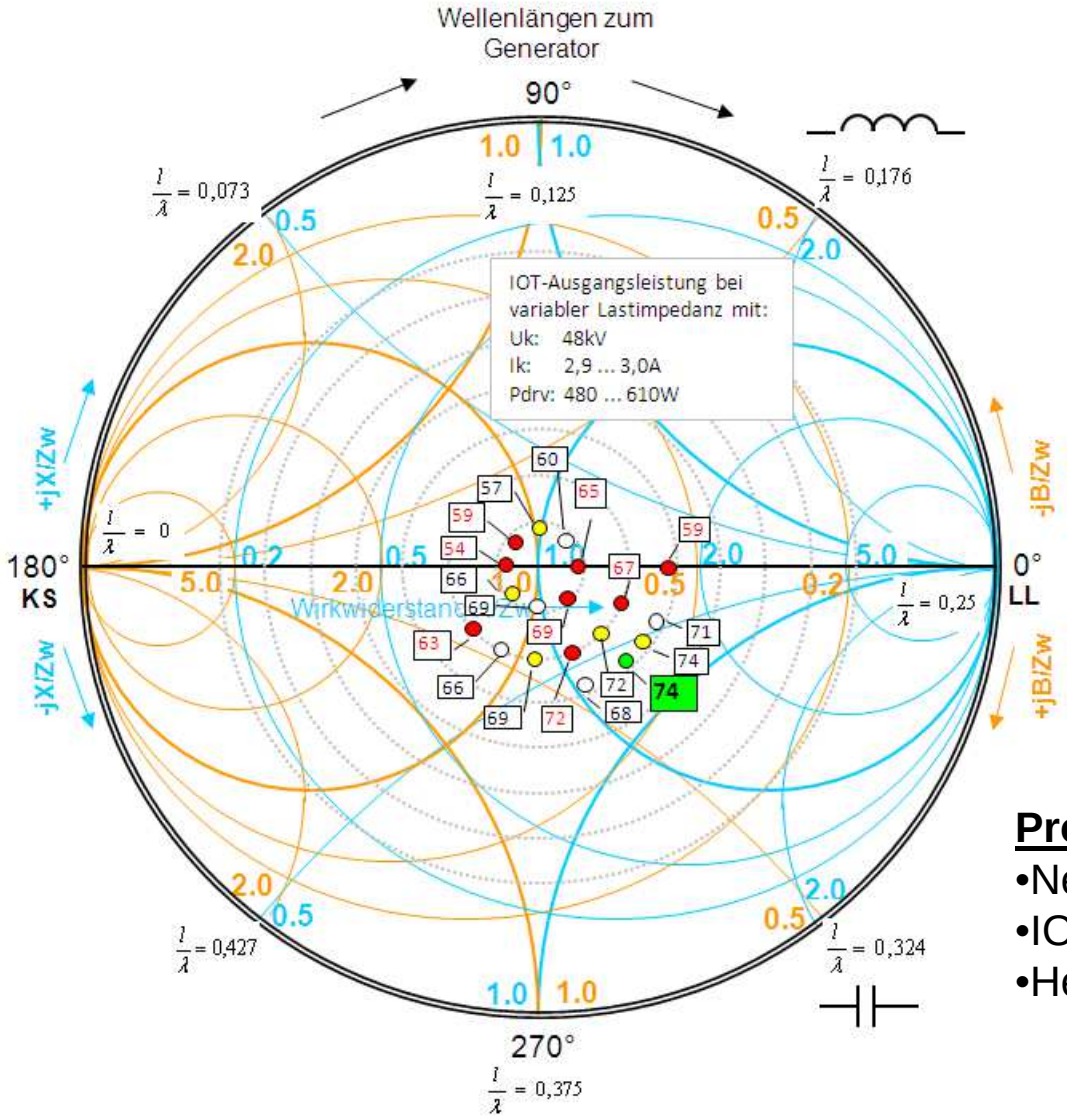
  (to get more power to the grid)
- Match / Mismatch output *(“Sliding wart waveguide“)*
- Up to 74 kW cw







Modifications (1st part)



Legende:

Pout/kW 74

Igrid negativ od. starker Sättigungseffekt

Hzg.- bzw Gitter-Interlock

- 3 constant reflections at different angels
- Finding stable operating points

Problems:

- Negative grid current
- IOT saturated
- Heater or grid- interlock

Modifications / Investigations (Future)

What are the next steps for this IOT:

- Miram check (under-heating curve)
- Tuning the „Match Line“ during operation

Timeline of IOT

- First ideas on 2005
- Mar./2006: Design proposal
- Feb./2007: Ordering the prototype IOT (grid & cathode are standard components » minimum output power = 60 kW
- Jun./2008: IOT shipped to DESY
- Jun./2008 to Dec./2009: Building test stand in DORIS- RF hall
- 2010 First test and modifications on hardware
- Jan./2011to Jun./2011: Moving to CMTB with more compact infrastructure
- Jun./2011 to Sep./2011: Test operation on cavities
- Sep./2011: broken ceramic » shipped to CPI
- Sep./2011: ordering 2nd Prototype (new cathode- and grid- design) » minimum output power = 85 kW
- Mar./2012: Operating reassembled IOT » not stable
- Aug./2012: Playing on output matching
- ….