New 90 kW IOT for ALBA

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(Consortium for the Exploitation of the Synchrotron Light Laboratory)

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2. New IOT at 500 MHz, 90 kW-cw
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   b) Cavities Modifications
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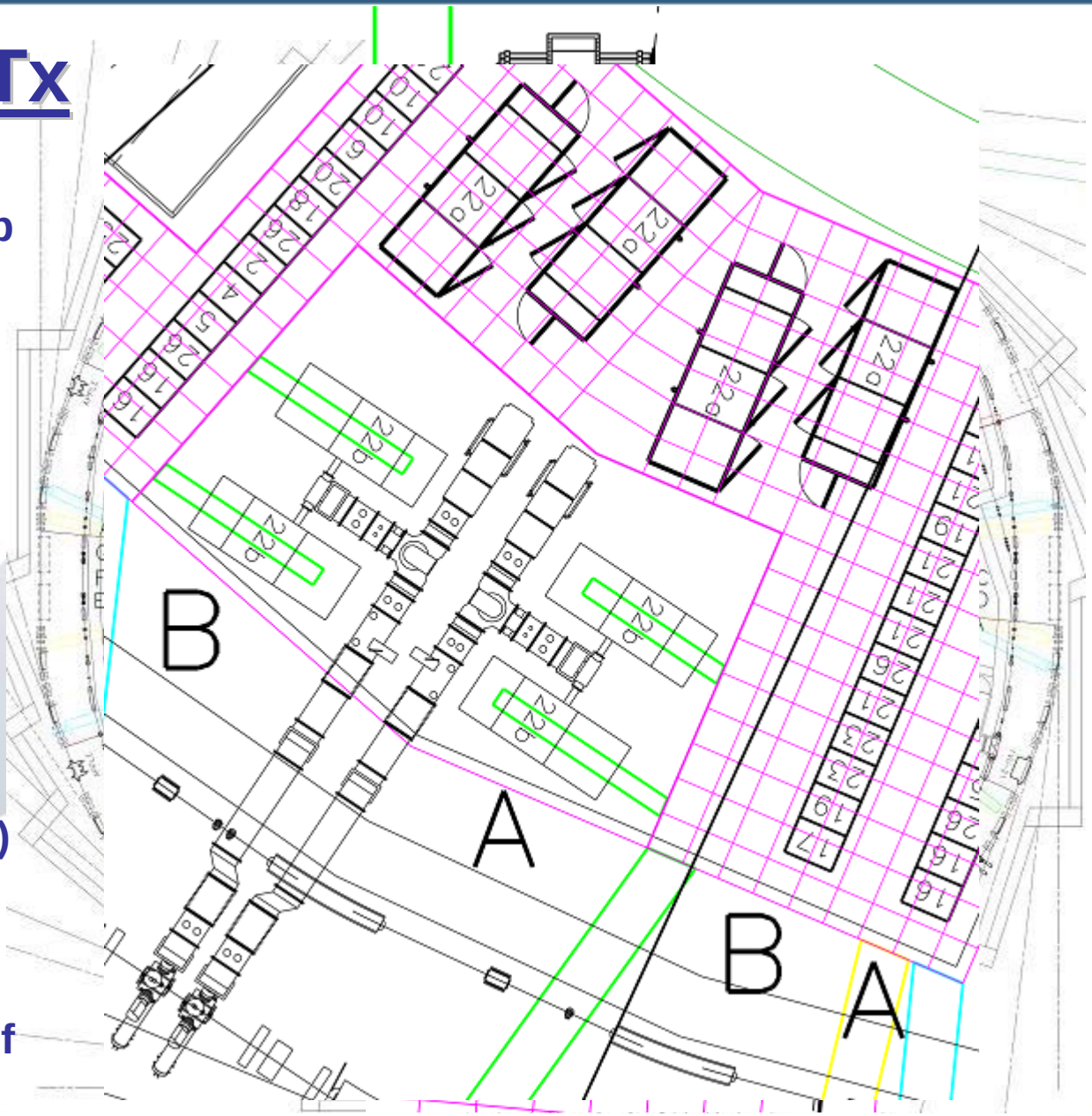
Introduction

ALBA RF Parameters:

	STORAGE RING	BOOSTER (at 3 GeV)
Frequency	499.654 MHz	499.654 MHz
RF total Voltage	3600 kV	900 kV
Beam Current	400 mA	2 mA
Total Beam Power	540 kW	1.3 kW
Losses (including IDs)	1300 keV/turn	627 keV/turn
Type of cavity	NC EU-Cav (DAMPY)	NC 5-cell
Number of cavities	6	1
RF Voltage per cavity	600 kV	900 kV
RF Power per cavity	150 kW	30 kW
RF Transmitter	2 x 80 kW	1 x 80 kW
Synchrotron frequency	9.3 kHz	8.6 kHz

The ALBA RF Tx

- 1 RF plant in the Booster (80 kW) + Lab
- 6 RF Plants in the SR (6 x 150 kW)
- Each SR Plant consists of:
  - 2 RF Amplifiers combined through CaCo
- The ALBA RF Tx:
  - HVPS (-36 kV, 3.3 A)
  - IOT (500 MHz, 90 kW cw)
- ALBA will have a total of 14 RF Tx



The ALBA RF Tx

- New RF Transmitter developed in collaboration between:

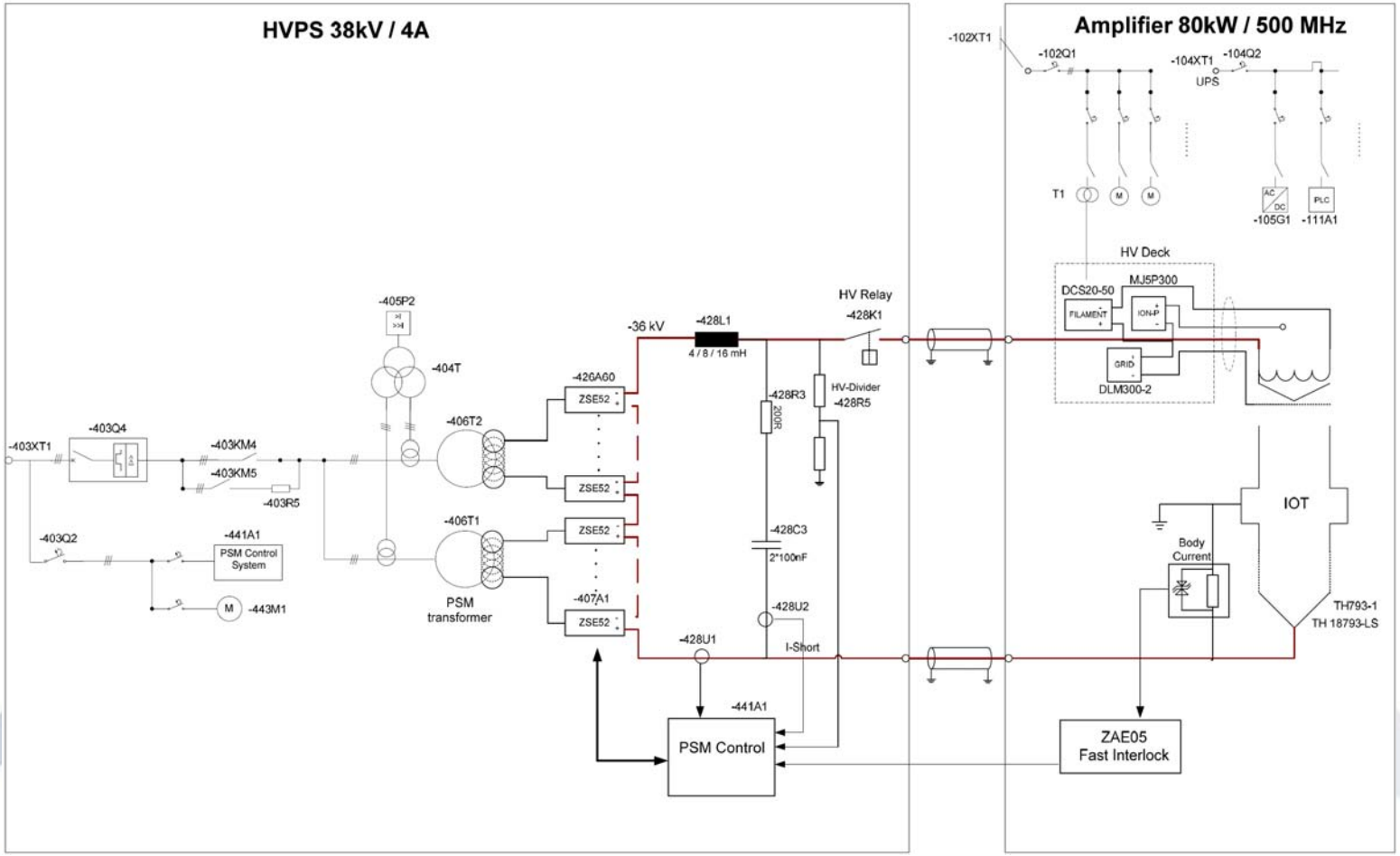
  - THOMSON Broadcast & Multimedia in Turgi (Switzerland)
    - ✓ Each IOT is powered by a single HVPS
    - ✓ HVPS based on Pulsed Step Modulators (PSM)
    - ✓ Variable Switching frequency [0.05 – 12 kHz]
    - ✓ Control system on PLC, interfacing with Tango

  - THALES Electron Devices in Thonon (France)
    - ✓ New IOT (TH793-1) operational at 500 MHz, 90 kW-cw
    - ✓ Adapted Output Cavity (TH18793 LS) to coax 6 1/8”
    - ✓ Bandwidth = 7 MHz
    - ✓ Tuning range = ± 5 MHz
    - ✓ Optimized cooling system

  - CELLS – ALBA in Cerdanyola (Spain)
    - ✓ CST-Microwave Studio Simulations
    - ✓ IOT improvements
    - ✓ Output cavity coupling loops

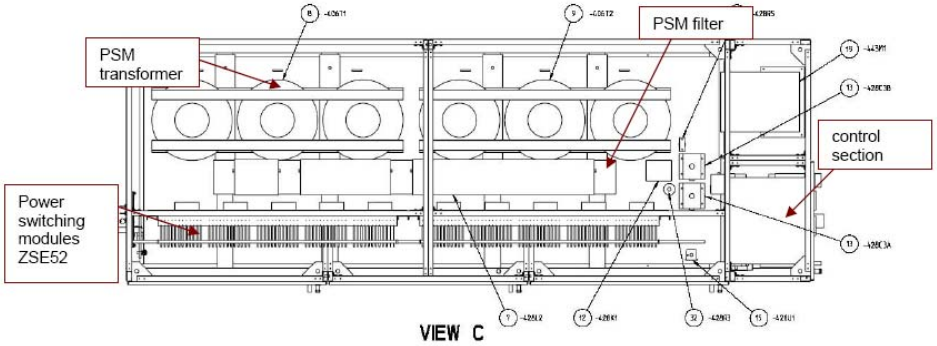
The ALBA RF Tx

- One HVPS per IOT, based on PSM technology (Pulsed Step Modulation):

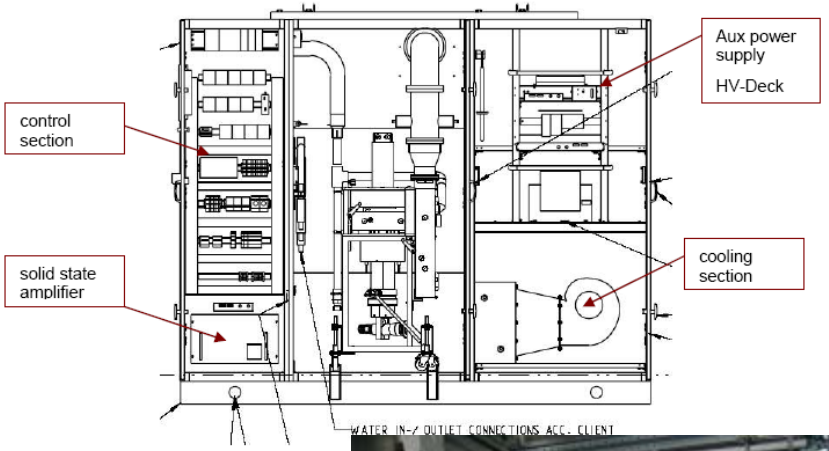


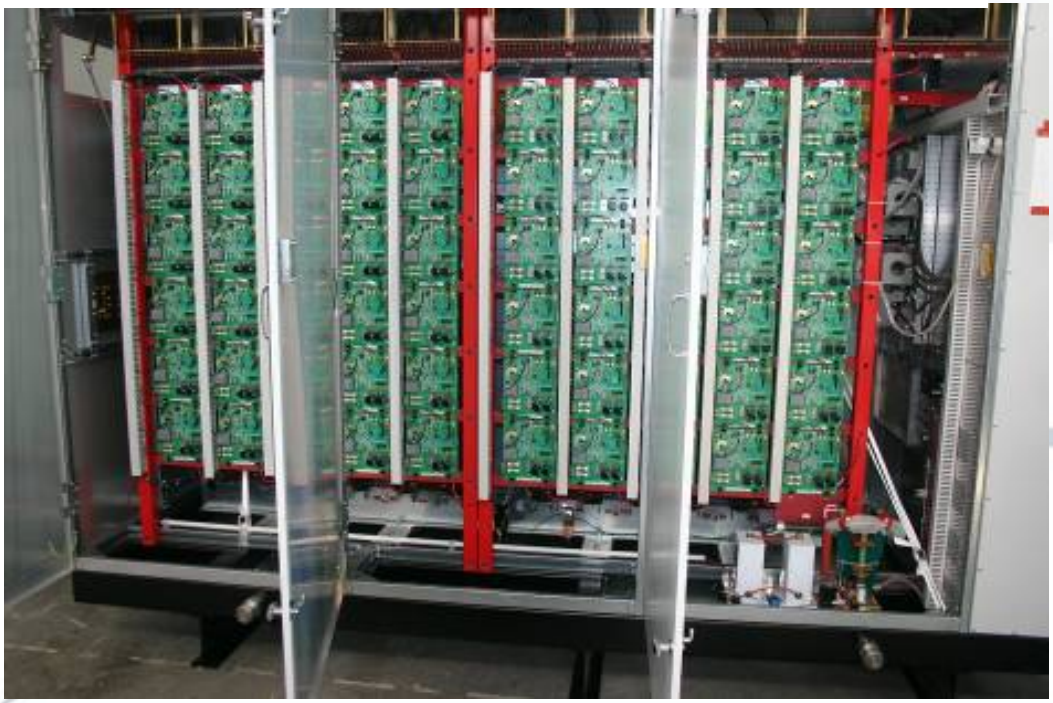
The ALBA RF Tx

HVPS cabinet



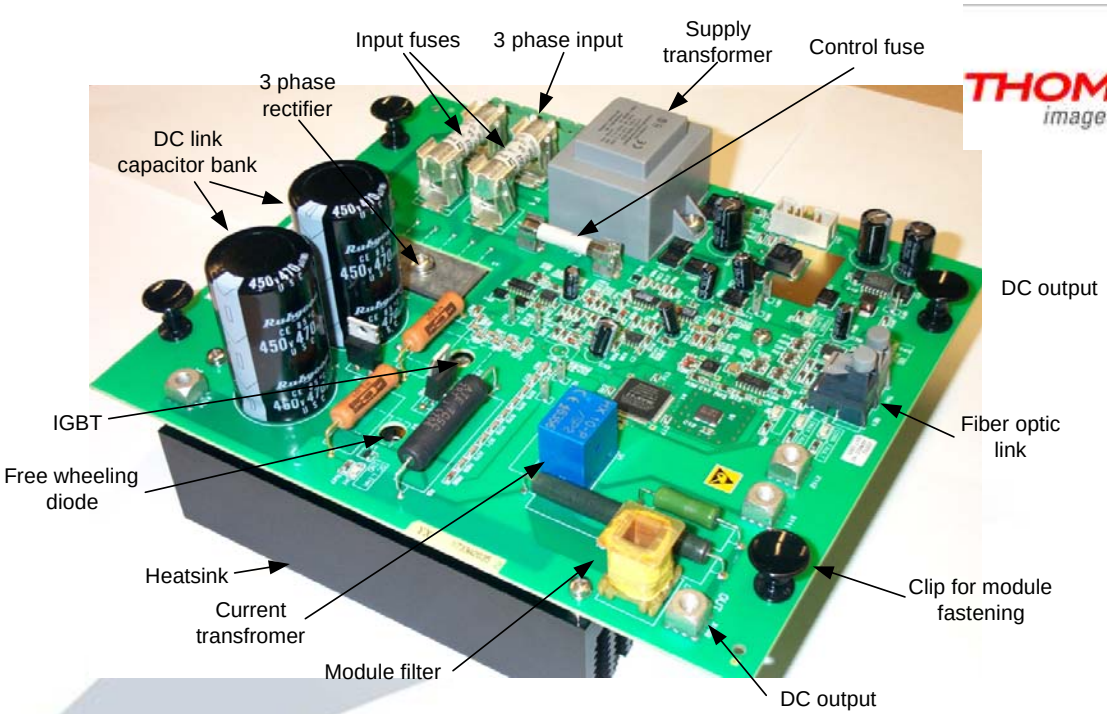
IOT cabinet





The ALBA RF Tx - HVPS

- New PSM module design and developed by THOMSON BM



- 60 modules switching at f = 1.67 KHz (modifiable via sw, 0.05 – 12 kHz)
- V_{out} = -38 kV and I_{out} = 4 Amps
- Redundancy: 700V per mod ➔ 52 modules are enough for -36kV (IOT)

The new IOT 90 kW-cw: TUBE

- **Tube Modifications (TED):**
  1. Bigger output window diameter
  2. Conical insulator between grid and anode

- **Advantages**
  1. Better suited for High Power cw operation
  2. Electric Field in the ceramic insulator decreased
  3. Losses also decreased
  4. Less stray electrons impinge on the tube

- **Drawback**
  1. Dedicated product for monofrequency applications

80 kW version (TV)

90 kW version (LS)

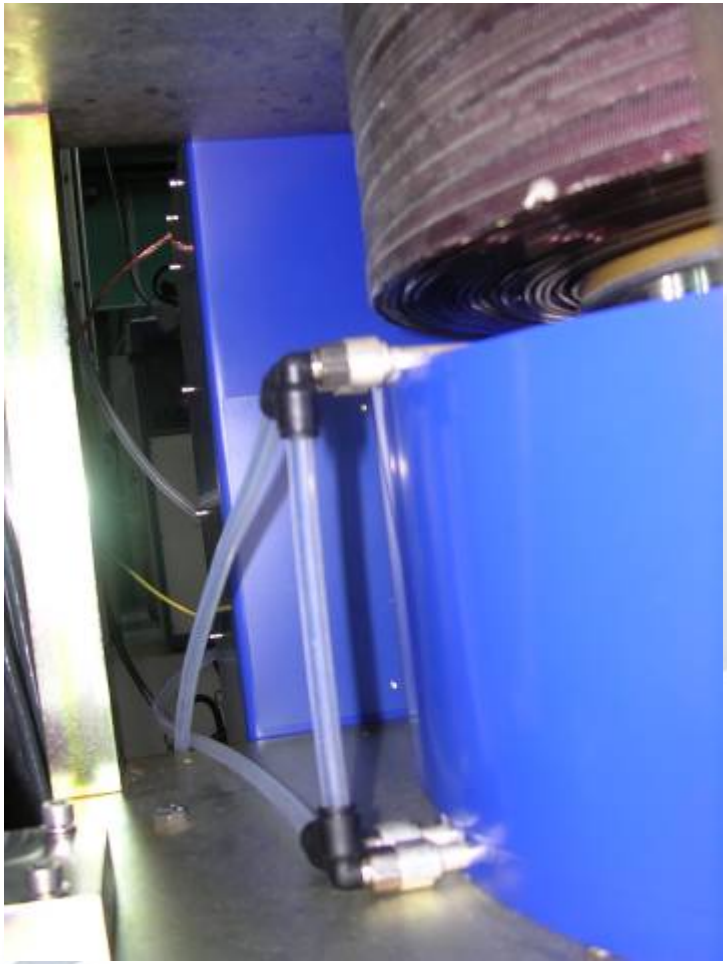
The new IOT 90 kW-cw: CAVITIES

- **Output Cavities Modifications (TED-CELLS):**
  1. Enlarge coax output coupling from 4-1/16” to 6-1/8”
  2. Redesigned primary cavity to house the new tube 90 kW
  3. Increase the secondary output cavity depth
  4. Add a post (resonance vs. harmonics)
  5. Second arc detector

- **Advantages**
  1. Cope with the higher cw power operation
  2. Simplified tuning devices in primary cavity

- **Drawback**
  1. Dedicated product (500 MHz)

The new IOT 90 kW-cw: CAVITIES



- **Other Modifications (TED-CELLS):**
  1. Modify accordingly the cavities coupling loops:
     - Output loop
     - Prim-sec cavity loop
  2. Water cooling added:
     - Primary cavity
     - Inter-cavity loop

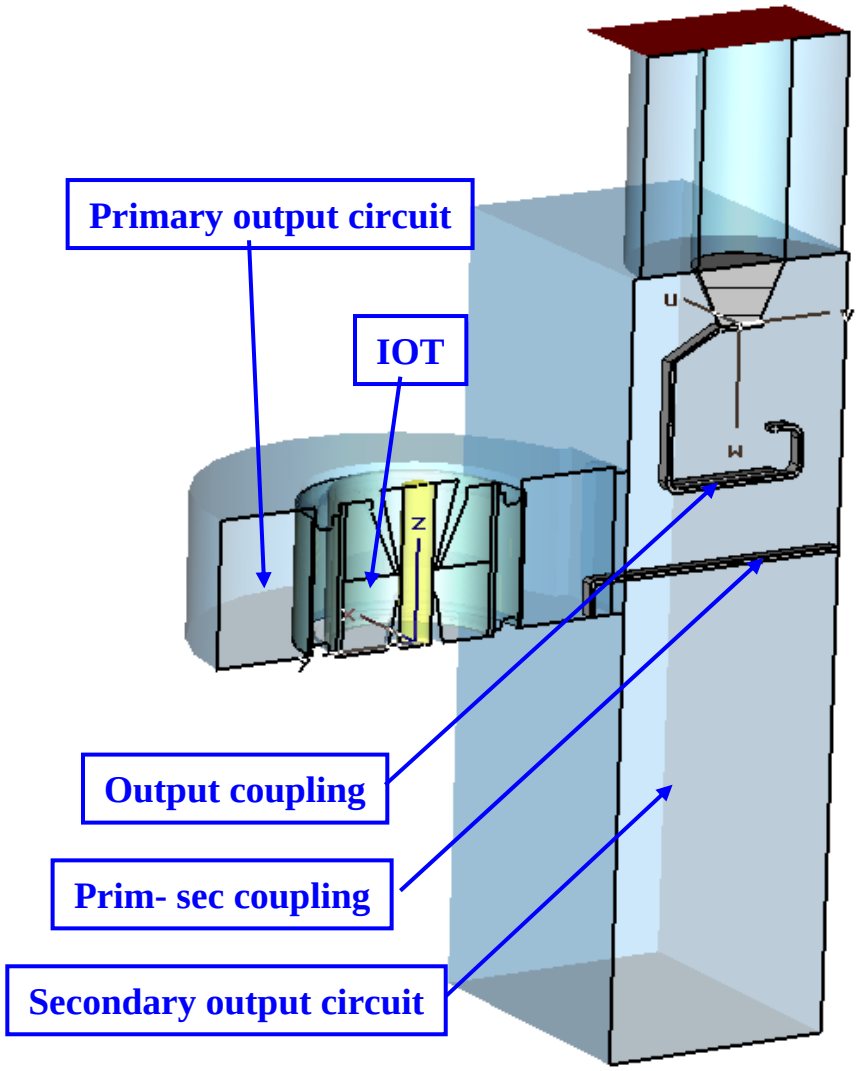
- **Advantage**
  1. Prevent thermal frequency shifts

- **Drawback**
  1. Add water cooling circuits in the RF Tx

The new IOT 90 kW-cw: SIMULATIONS

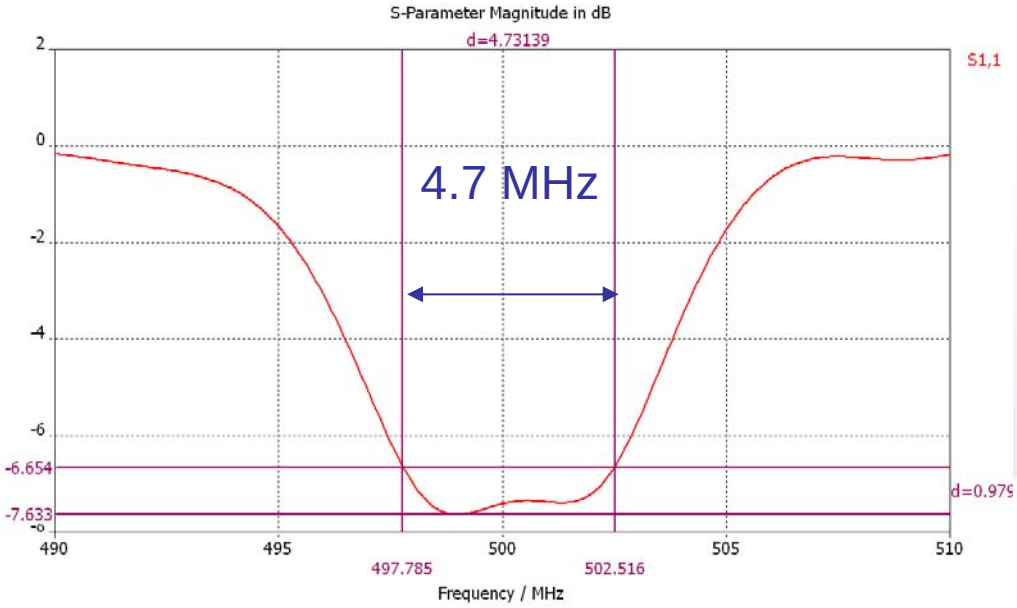
- **Cavity Simulations (CELLS):**

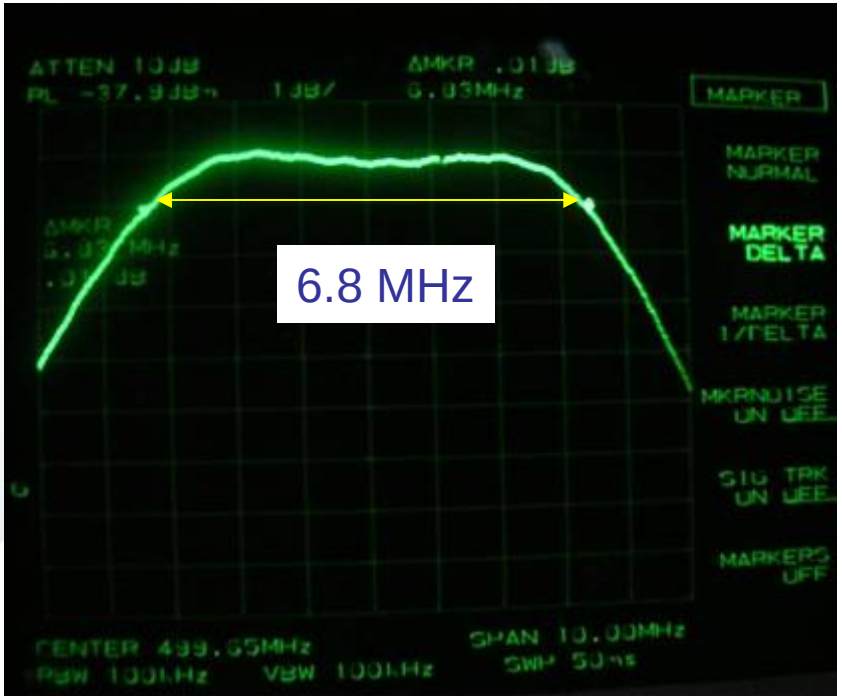
1. CST-Microwave Stutio ™
2. Output circuit simulated to obtain the cavities' dimensions and the coupling loops' dimensions
3. Conductive material in the drift tube gap to simulate the beam
4. Material conductivity adjusted in order to get the beam voltage at 90 kW
5. Bandwidth evaluation from the S_{11} parameter



The new IOT 90 kW-cw: SIMULATIONS

- **Computed BW compared to the measured one:**





The new IOT 90 kW-cw: FACTORY TESTS

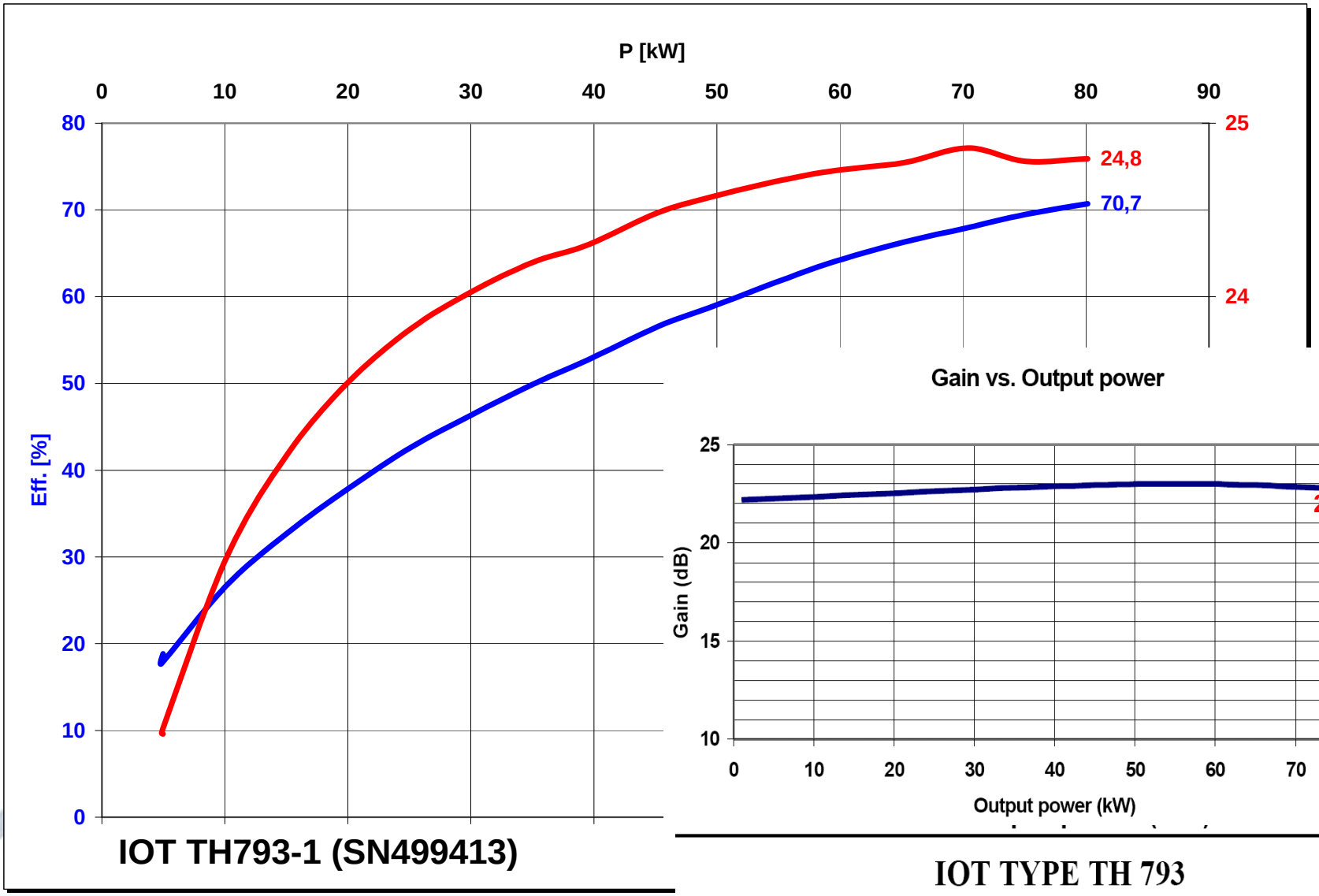
- Tested at 90 kW during ½ hour
- Duration test, at 80 kW, during more than 24 h, at TED premises
- Problem on IOT SN 499413 Ionic Pump, solved reconditioning it
- Bandwidth = 6.8 MHz; and Tuning capabilities = ± 5 MHz
- Efficiency and Gain measured as shown below

HV [kV]	Beam I [A]	Pout [kW]	Eff [%]	Gain [dB]
-36	3.18	80	69.9	23.8
-36	3.31	85	71.3	23.7
-37	3.42	90	71.1	23.9

- Harmonics at Dir-Coupler (6” coax output):

Pout [kW]	H2 [dB]	H3 [dB]	H4 [dB]	H5 [dB]
80	-37.5	-62.7	-52.2	-64.0

The new IOT 90 kW-cw: CHARACTERIZATION



The new IOT 90 kW-cw: Operating Hours

Item	IOT S/N	Type	Manuf.	in Transmitter	Since	Fil Hours	HV Hours	Until	Fil Hours	HV Hours	Filament Hours	HV Hours	*Comments*
IOT_A001	591095	TH793	TED	Tx01 - ANNA	08/Aug/2007	0	0	11/Dec/2007	150	106	**150**	**106**	*Considering also FAT hours. IOT returned back to TED*
IOT_A002	499413	TH793-1	TED	Tx01 - ANNA	12/Dec/2007	150	106	01/Oct/2008	334	258	**184**	**152**	
IOT_A003	499443	TH793-1	TED										*Spare Stored*
IOT_A004													
IOT_A005													
IOT_A006													
IOT_A007													
IOT_A008													
IOT_A009													
IOT_A010													
IOT_A011													
IOT_A012													
IOT_A013													
IOT_A014													
IOT_A015													
IOT_Annn													

TED THALES Electron Devices

TOTAL Hours

CONCLUSIONS

- The ALBA Tx (new IOT and PSM modules) working reliably in the ALBA RF Lab since December 2007
- HVPS is stable enough at full power 80 kW cw, even with pulsed power during cavity conditioning
- HVPS assures redundancy (2 modules failed during commissioning, keeping the HVPS operational)
- IOT safe operation at ALBA full power (80 kW): factory tested at 90 kW
- IOT bandwidth large enough
- IOT efficiency and gain have been improved with respect to the standard IOT

Acknowledgements

I would like to take this opportunity to thank:

THOMSON Broadcast & Multimedia – Jurgen Alex, Andre Spichiger, Jan Stahl

THALES Electron Devices – Pascal Ponard, Claude Bel, Guy Peillex-Delphe

CELLS - ALBA – Francis Perez, Michel Langlois

for their contributions to this new RF Transmitter.

Many thanks for your attention

To update and share (4 times per year?)

Item	Laboratory	Manuf.	Type	IOT S/N	f [MHz]	P [kW]	η [%]	G [dB]				Operating Until	Filament Hours	HV Hours	*Comments*
IOT_A001	ALBA	TED	TH793-1	499413	500	60	64	24,7				01/Oct/2008	**184**	**152**	*Still in operation*
IOT_A002	ALS	CPI			500	30								**10000**	*Several trips after shutdown periods: operate daily 3-4 h*
IOT_A003	BESSY-MLS	CPI			500	40									
IOT_A004	DIAMOND	TED	TH793		500	30									
IOT_A005	DIAMOND	TED	TH793		500	30									
IOT_A006	DIAMOND	TED	TH793		500	30									
IOT_A007	DIAMOND	TED	TH793		500	30									
IOT_A008	DIAMOND	e2V			500	30									
IOT_A009	DIAMOND	e2V			500	30									
IOT_A010	DIAMOND	e2V			500	30									
IOT_A011	DIAMOND	e2V			500	30									
IOT_A012	ELETTRA	TED	TH793		500	30								**5000**	
IOT_A013	ELETTRA	TED	TH793		500	30								**11000**	
IOT_A014															

Microsoft Excel Worksheet