Large Instrument for Science and recent developments of high power microwave tubes at THALES Microwave & Imaging Sub-Systems

DITANET School Stockholm March 2011

TOPICS

- **Presentation of Large Instrument for Science (LIS), new department of THALES Microwave & Imaging Sub-Systems**
- **Recent developments of high power RF sources for Scientific Applications at RFM (Radio Frequency and Microwave department of THALES Microwave & Imaging Sub-Systems)**

Microwave & Imaging Sub-Systems / Main markets

Radio Frequency & Microwave sources

Traveling Wave Tubes, grid tubes, X-ray sources, klystrons, gyrotrons, space amplifiers, defense transmitters, atomic clock, ion thrusters

Space, telecoms, TV and radio Broadcast, defense, science, security/NDT

Large instruments

Design, development and integration of multi technology systems and sub-systems

Research and Defense infrastructures

Radiology

IIR, imaging units, flat digital detectors
Complete imaging solutions

Radiography, fluoroscopy, 3D dental imaging, veterinary, security/NDT

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RF & Microwave sources – Large Instruments

Communication
Space - Telecoms
Uplinks and downlinks
TV radio broadcast

Traveling Wave Tubes
Grid tubes
Space amplifiers
Ion thrusters
Atomic clock

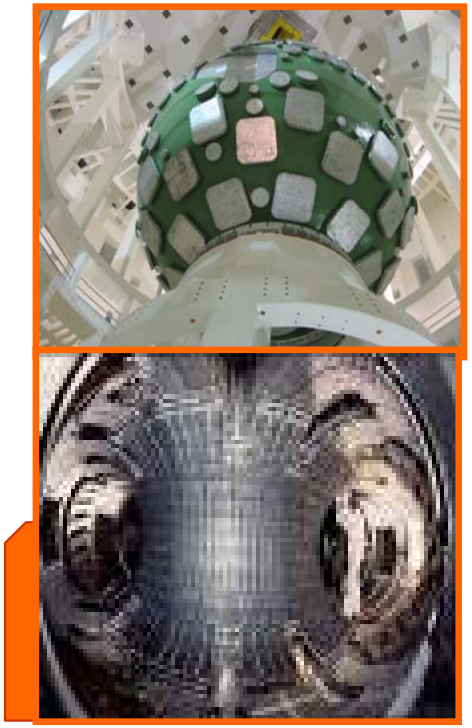
Defense
Radars
Counter-measures
Missiles
Datalinks

Traveling Wave tubes
Transmitters
Klystrons, CFAs,

Industry
Laser
Industrial heating
Sterilisation
Non Destructive Control

Grid tubes
X-ray tubes
X-ray detectors

Large Instruments
Light sources
Accelerators
Thermo-nuclear Fusion
High power lasers
Therapy



Power tubes and amplifiers – klystrons, gyrotrons, tetrodes…
Energy storage, couplers
Accelerators

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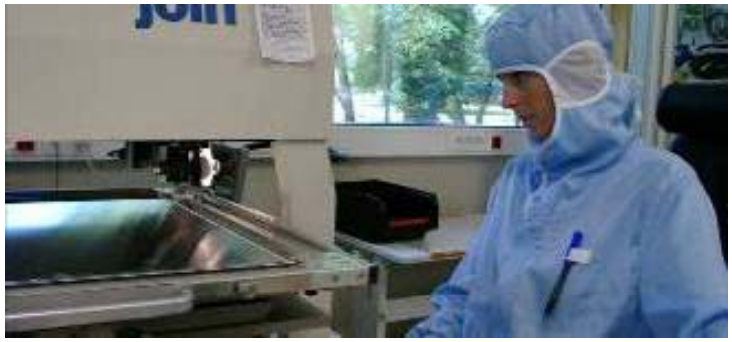
Microwave & Imaging Sub-Systems / Key figures



- 2009 turnover: 407 M€
- 10% **of turnover dedicated to R&D**
- 2 600 **employees**
- 40% **of managers, engineers and highly qualified technicians**
- 8 **industrial sites (Production, R&D)**
- 100 000 m² **industrial surface, including** 9 000 m² **clean rooms**
- 1 500 **clients**
- 13 **sales offices in the world**
- 167 **valid industrial patents**
- 2 000 **product references**

World # 1 for microwave & imaging sub-systems for professional applications

Large Instruments for Science

- Supply of turnkey, multi-technology systems and sub-systems
- Three main sectors

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Multi technology test facilities

- **Characterisation of equipments installed in submarine fluid circuits**
  - acoustic and functional performances
  - pumps, fans, gates and compressors endurance

- **Tests of launcher cryogenic engines**
  - Simulate atmosphere conditions during flight
  - Characterisation of the engine performances: thrust, consumption, vibrations, temperatures, …

- **Decoy test facility**
  - Allows to test comportment of decoys (trajectory, infrared signature) after firing them at a speed varying from 50 m/s to 250 m/s
  - Up to ten tests per hour

expertise in command/control, mechanics, fluids, cryogenics, vacuum, thermics

Systems and Specific Logistics Resources

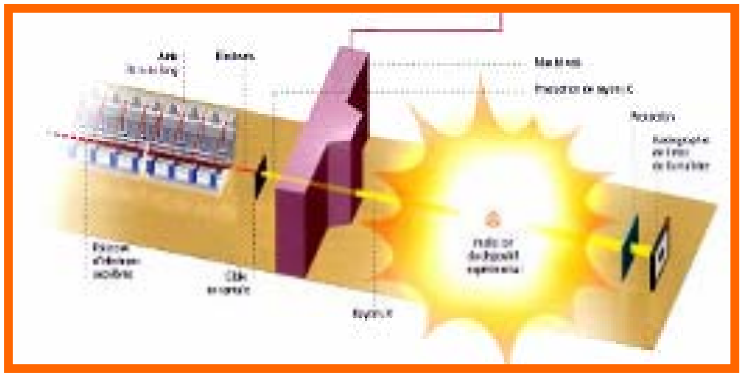
- **Specific aero transportable load conditioning equipment**
  - Design and turn key supply
  - Handling, lifting and weighting equipments included
  - Dedicated protection shelters
- **Automated parachute maintenance factory**
  - Design and turn key supply
  - Up to 130 000 maintenance operations per year
  - Productivity improved by a factor of 3
- **Missile assembly tools**
  - Design and turn key supply
  - Assembly of the pyrotechnic part of the French M51 missile
  - Manipulation of very heavy and fragile materials

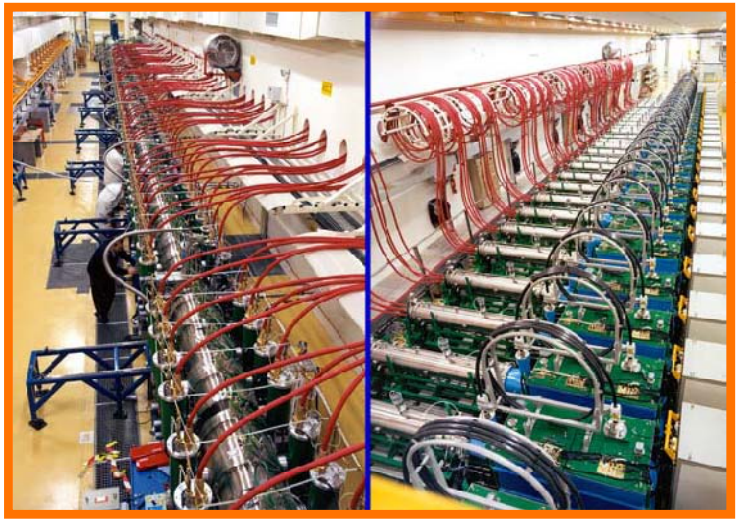
Know how in design and turn key supply of systems

Research Infrastructures

Linear induction accelerator for flash X Ray radiography AIRIX CEA France

- 4 MeV Injector
- Electron beam energy up to 20 MeV
- Electron beam current : 3,5 kA
- Pulse length : 60 ns
- HV generator 250 kV each





- Participation to the definition of prototype sub-systems
- Industrialisation files
- Accelerator turnkey supply
- Accelerator upgrade and transfer from one site to another

expertise in high voltage, particles dynamics and complex system integration

Research Infrastructures

MegaJoule Laser (LMJ) – CEA France
French Nuclear Simulation Program

- Experiment hall support structure, in particular of the experiment chamber
- Opto-mechanical interface between the evacuated chamber and laser lines
- Experiment chamber pumping system
- Gas and fluid distribution networks
- Plasma diagnostics: experience characterisation
- Energy bench supplying the HV pulses required for laser pumping

expertise in support structure, vacuum mechanics, critical heavy load handling, high voltage and high current generator, control/command

Research Infrastructures

Supply, on-site installation and conditioning of power transmitters including RF source, HV power supply and associated control/command (C/C)

SSRF (Shanghai – China)

BEPC II (Beijing - China)

TPS (Taipei - Taiwan)

PLS (Pohang – South Korea)

CNRS (Orsay - France)

HV power supply and C/C supplied by Thomson Broadcast (Suisse)

expertise in high RF power, high voltage power supply, control/command and complex system integration

Research Infrastructures

Couplers are RF components which need mastering technologies similar to the ones used for tubes: vacuum, welding and brazing assembly, RF, cooling,…

An additional technology : cryogenics

- **Successful diversification in 2010 thanks to the contact signed with CNRS (IN2P3) for the production of 670 1.3 GHz couplers to equip the XFEL accelerator in construction in Hamburg.**
- **Operation done in partnership with the German company RI Research Instruments**
- **Couplers are complex components requiring development skills mastered only by laboratories**
- **Thales offer limited to industrialisation works and series production**

Short to mid term offer

LMJ A MAJOR REFERENCE

All machines

- High constraint mechanical structures
- Instruments and Diagnostics
- Vacuum and fluid distribution networks
- Remote Handling
- Test benches

Particle accelerators

- Turnkey linear accelerators
- RF chain
- RF amplifier
- Cryomodule assembly
- RF superconducting couplers

Fusion reactors

- Complete heating systems
- RF amplifier

Recent developments of high power RF sources for Scientific Applications at RFM (Radio Frequency and Microwave department of THALES Microwave & Imaging Sub-Systems)

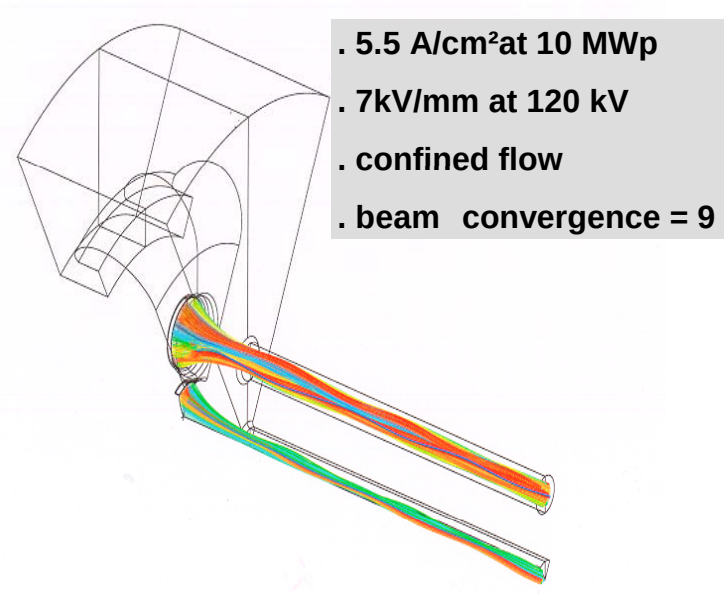
RECENT DEVELOPMENT OF HIGH POWER RF TUBES

Multi beam klystron for European XFEL (DESY) TH1802 1.3GHz 10MWp 150kWm 1.5ms

- Request of DESY for a high peak power (10MW), moderate voltage (120kV), long pulse (1.5ms), high efficiency (63%) electron tube operating at 1.3GHz and in horizontal position
- Performances not achievable simustaneously with a conventional klystron (single beam)
- Prototype successfully commissioned in 2010 at full specification
- Selection of tube suppliers under way by DESY (36 positions to be fullfilled)

RECENT DEVELOPMENT OF HIGH POWER RF TUBES

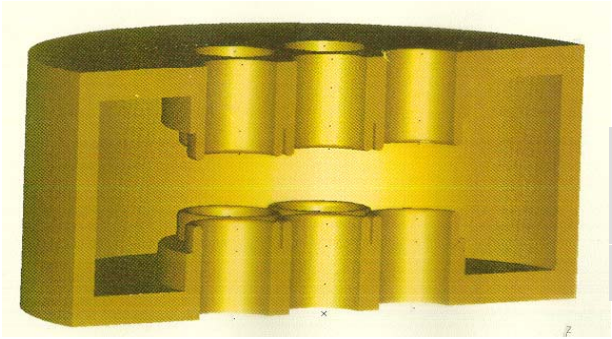
Multi beam klystron TH1802 for European XFEL DESY



. 5.5 A/cm²at 10 MWp
. 7kV/mm at 120 kV
. confined flow
. beam convergence = 9

design highlights

- 7 beams
- 6 cavities operating on fundamental mode
- specific solenoïd (with reduced defocussing radial field components)



. Toroïdal multi-gap cavity
. fundamental mode
. tunable cavities

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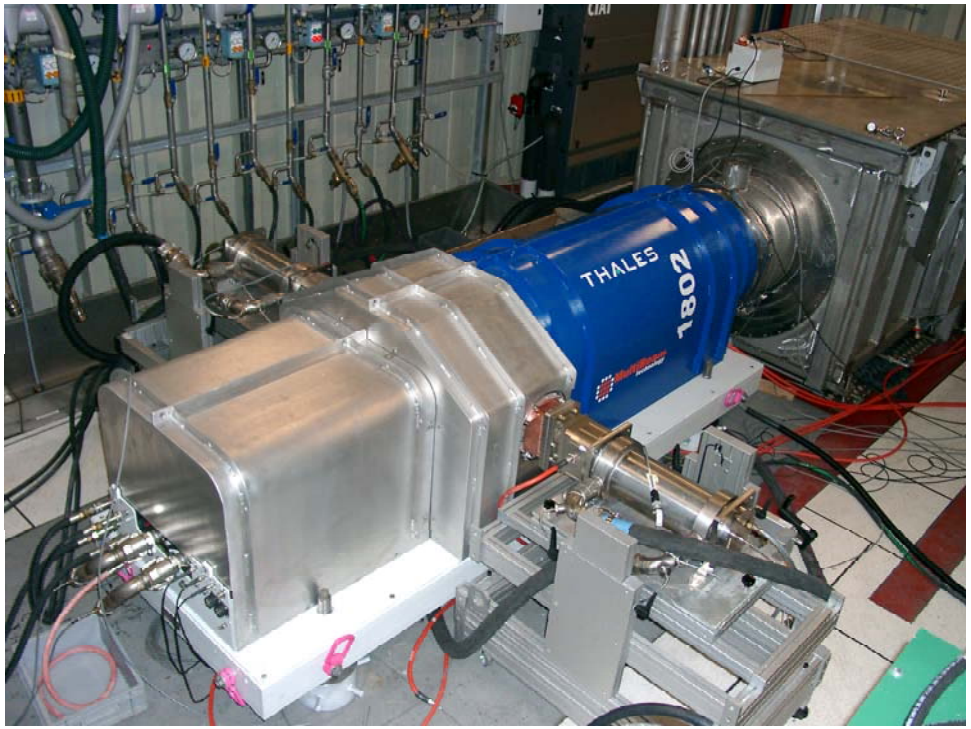
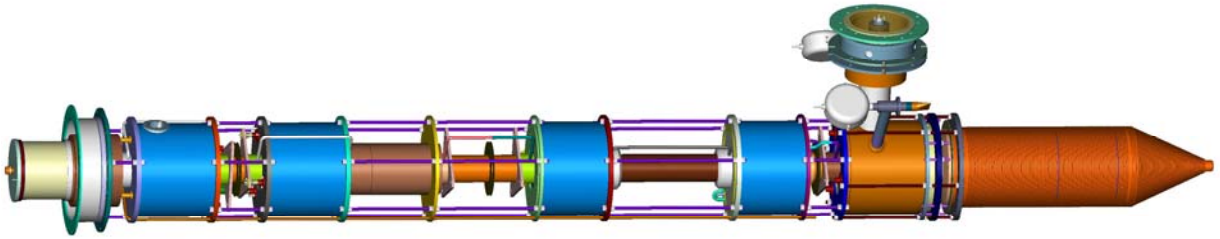


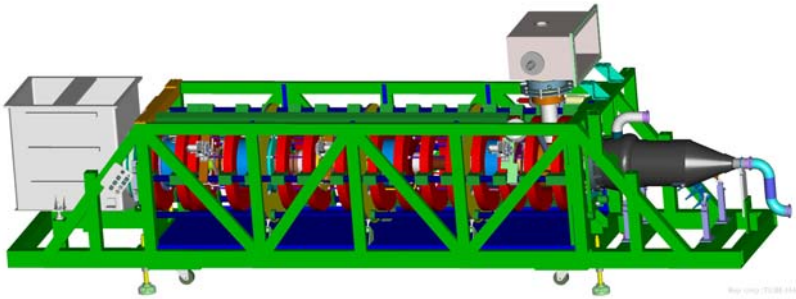
MultiBeam technology

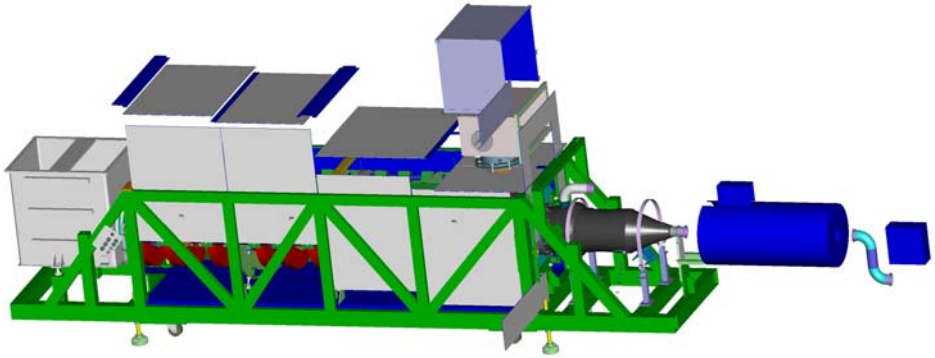
RECENT DEVELOPMENT OF HIGH POWER RF TUBES

UHF Klystron TH2179 for LINAC4 CERN
352 MHZ 3MWp 1.5ms

- 110 kV 50A efficiency 58%
- Built in electromagnet
- Built X-Ray shielding
- Length 5.5m Weight 4500 kg
- Horizontal position
- Development under progress







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RECENT DEVELOPMENT OF HIGH POWER RF TUBES

High power CW Klystron TH2103C for TORE SUPRA CEA
3.7 GHZ 700kW CW (Lower Hybrid Current Drive)

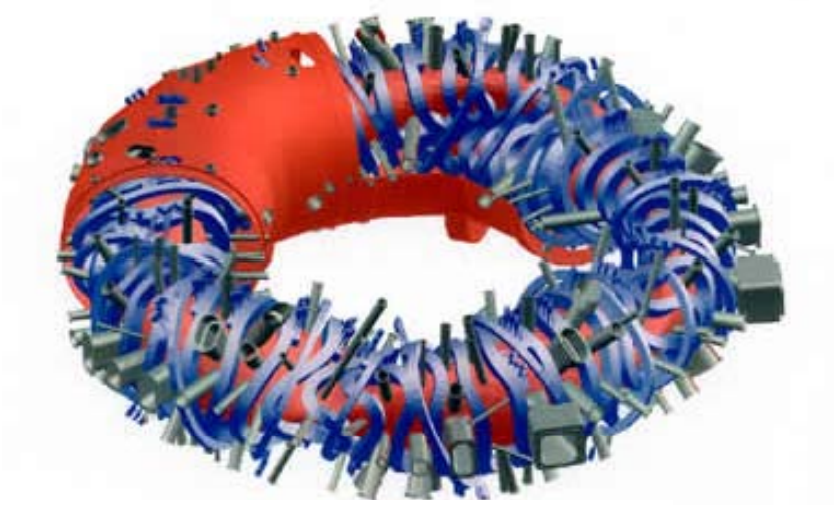
Extension of CEA power transmitter to 11.2 MW T= 1000s

- 75 kV 22A efficiency 45%
- 18 tubes delivered from mid 200_ to mid 2010
- 8 klystrons installed and commissioned on the first half generator at CEA Cadarache

RECENT DEVELOPMENT OF HIGH POWER RF TUBES

High power CW gyrotron TH1507 for W7-X stellarator IPP Greifswald 140 GHZ 900kW (Electron Cyclotron Heating)

- Production of 7 tubes (3/7 installed)
- Accelerating 90 kV
- Beam current 45A
- Efficiency 40% (depressed collector)
- Cavity magnetic field 5.7 Tesla
- Diamond window



RECENT DEVELOPMENT OF HIGH POWER RF TUBES

High power CW coaxial gyrotron TH1508 for ITER F4E 170 GHZ 2MW (Electron Cyclotron Heating)

- Coaxial gyrotron
- Accelerating beam voltage 90kV
- Beam current 80A
- Efficiency 42% (depressed collector)
- Average hollow beam radius (cavity) 10mm
- Cavity field 6.86 Tesla
- Diamond window
- Development under way

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THANK YOU