

FLASH-VHEE Project

Thales MIS
VHEE Daresbury

www.thalesgroup.com



Thales key figures



83,000
employees



68 countries
A global footprint



Intellectual property
portfolio including
21,000 patents



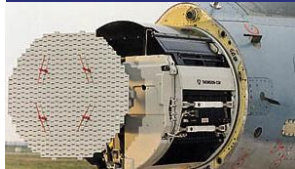
More than **40%**
of Thales employees
working in R&D

Microwave & Imaging Sub-Systems, multi-domaine expertise



DEFENSE & SECURITY

Protecting citizens and armed forces



Power transmitters for radar applications



Electromagnetic directed-energy weapons **for anti-drone warfare**



SCIENCE

Designing heating solutions for low-carbon energy and power to understand physics



Gyrotrons and Diacodes for plasma heating in nuclear **fusion reactors** (e.g. ITER)



Klystron electron tubes for **linear particle acceleration** (ex. LHC CERN)



SPACE

Promoting access to information, exploring space



Travelling wave tubes (TWT) and amplifiers for **communication satellites** (ex. Konnect VHTS)



Our tubes help transmit data collected during **exploration of the solar system**



HEALTHCARE

Promoting access to information and healthcare for all



X-Ray Detectors
Imaging Softwares

TRIXELL



Development of **portable X-ray systems**

Core components and systems offer

Unique know-how,
technology & components
with versatile applications
(science, medical,
accelerator, defense)



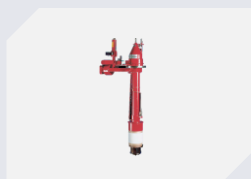
Gyrotron



Grid Tube



Klystron Science



Klystron RT

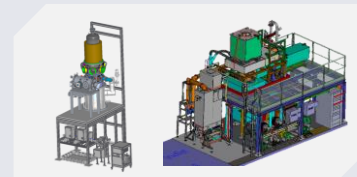


X-ray detector

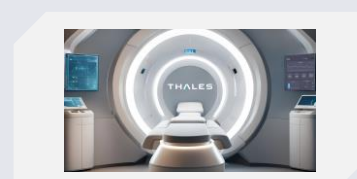


Imaging Solutions

Fusion plasma Heating system



LINACs



X-Ray Nomad system



Long since transitioned
from components to
sub-systems and
systems

Focus on systems with
unique know-how

SCIENCE

OUR SOLUTIONS

- Sources RF for particle **accelerators** and **fusion reactors**

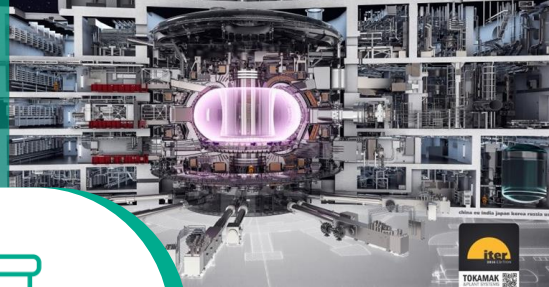
- **INNOVATIONS:**
Flashtherapy, Non-destructive testing, Green Chemistry

- **KEY PRODUCTS:**
Gyrotron, Klystron, multi-beam Klystron, grid tubes (Diode, Tetrode, Triode, IOT) & Cavities

- **KEY REFERENCES:**
Fusion : ITER (170GHz, 1 MW), DTT (170 GHz, 1 MW), W7X (140 GHz, 1,5 MW), CEA (105GHz, 1MW), General Atomics (117GHz, 1MW)

Particle Accelerators: CERN (400MHz, 300kW), ESS (704MHz, 1,5MW), DESY (1300MHz, 10MW), Soleil, Los Alamos (200MHz, 3MW), Brookhaven (500MHz, 300kW)

Big Science Instruments : EPURE, LMJ



MULTI BEAM
KLYSTRON



TÉTRODE



KLYSTRON



GYROTRON

**THALES, A LONG-STANDING PARTNER TO THE MOST PRESTIGIOUS
LABORATORIES AND RESEARCH CENTRES**

Thales MIS RF sources & particule accelerator supplier

> Thales combines engineering skills and control of industrial processes necessary for the design and success of a vhee machine

- Thales is mastering both RF sources and critical components for **particle accelerators** (CERN, ESS) and **particle therapy**.
- Thales masters system engineering, project management and support for complex accelerators including **electron accelerator**
- Thales has developed **turnkey custom LINAC solutions** for specific applications, including synchrotron injectors, with **beam energies >100 MeV** (ALBA, BESSY, SOLEIL).



RF SOURCES

Klystrons, grid tubes for science, & radiotherapy. From UHF to C band Up to 50MW



SCIENCE

Engineering and integration for complex subsystems for big science programs including ITER and LASER MEGAJOULE



SOLEIL

Synchrotron Soleil : Masters the design, key components and the different phases of the product lifecycle.



ALBA

Turnkey 100 MeV electron LINAC injector for ALBA (Spain)

HEALTHCARE

OUR SOLUTIONS



- **LEADER** : providing all system manufacturers with digital detectors and imaging software. Production of more than 15 000 detectors per year.
- **State-of-the-art solutions** to push technological boundaries for radiography, fluoroscopy and interventional applications
- **Expertise in medical certification: MDR, FDA**
- **Key partners:** Siemens, Philips, Canon, GE
- **70 years of experience** in radiology

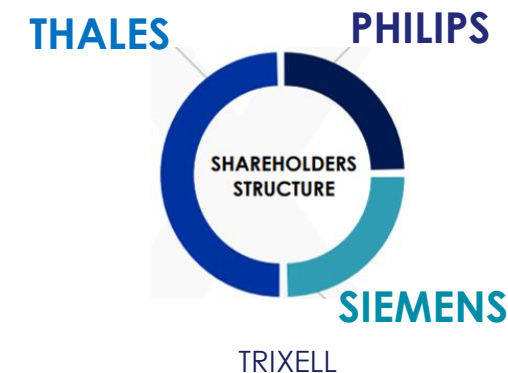
Made in **France**



DIGITAL DETECTORS



IMAGING SOLUTIONS



THALES, A LONG-STANDING PARTNER
TO ADVANCE RESEARCH IN RADIOLOGY

HEALTHCARE : Portable X-Ray Imaging System

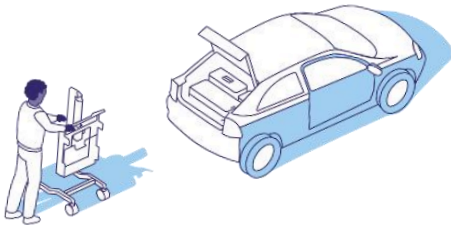
> Bring radiography closest to the patient

- ▶ End-to-End teleradiology service
- ▶ Cybersecured workflow
- ▶ AI service for computer aided diagnosis



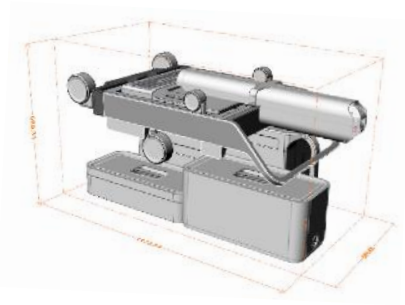
> Radiography anytime

- ▶ Easy & quick to assemble/disassemble
- ▶ Transported in a car trunk



> State of the art hospital grade image quality

- ▶ New generation portable detector
- ▶ Top Quality digital imaging & smart patient positioning



Thales experience in RF & X-ray detectors for radiotherapy & hadrontherapy



Science & Technology
Facilities Council

Manufacturer of S-band
klystrons (TH2100C &
TH2157) for CLARA



Since 2001, X-Ray
Detectors & Grid tubes
for Proteus One, Proteus
Plus & rhodotrons



Manufacturer of L & S-
band klystrons (TH1801,
TH1802, TH2104, TV2022)



Manufacturing of X-Ray
Detectors for
radiotherapy systems



Delivery of 1500+ S-
band 10MW klystron
for radiotherapy



Development and
manufacturing, installation &
commissioning of full amplifier
system (400MHz, 330kW CW)
for hadrontherapy system.
Manufacturing of UHF band
klystron



X-Ray detectors and
Imaging Solution for
protontherapy system
in development by
BdotMedical



Manufacturing of grid
tubes for Hadrontherapy
system developed by
GSI for Heidelberg (HIT),
Marburg (MIT) and
Siemens in Shanghai



Manufacturing of grid
tubes for Hadrontherapy
system developed by
MedAustron



Sumitomo
Heavy Industries, Ltd.



Manufacturing of grid
tubes for carbon
therapy facilities in
Japan

Critical provider of
X-ray detectors, Power
amplification, sub-
systems & accelerator
engineering for
radiotherapy &
hadrontherapy

THALES MIS legacy and synergies with FLASH VHEE

> Strong heritage & expertise

- Heritage and expertise on electron linacs for scientific and industrial applications with beam energies above 100 MeV (i.e. synchrotron injectors)
- Strong design skills in RF sources, components and sub-systems. Thales MIS has series production capabilities which offer broad synergies with electron linacs manufacturing
- Strong medical business with X-ray imaging solutions and development of medical systems

> Start of VHEE Flash project

- With the aim of exploring FLASH-VHEE
- Thales started feasibility studies of a VHEE FLASH accelerator
- Suitable for Flash irradiation treatment and compatible with a conventional clinical environment

Thales Flash strategy

> Flash platform >140 MeV

- ▶ Based on mature technology and off-the-shelf components
- ▶ Allows an accelerated approach for faster, more effective access to therapeutic needs
- ▶ Validate technologies while validating the clinical treatment plan and pre-clinical data
- ▶ Modular architecture: Large and flexible choice of parameter, modes for studies
- ▶ Meets the schedule needed for efficiency and speed to converge on the definition of the VHEE Flash therapeutic modality.

Thales' objective : From a platform for pre-clinical investigation of Flashtherapy to a viable European VHEE Flashtherapy medical machine

> Flash medical device

- ▶ Will have the maturity of a medical device and meet hospital constraints. Particularly in terms of space requirements and radiation protection, which probably implies dedicated technological developments.
- ▶ Focused on usability by hospital radiotherapy personals, thanks to determined choice of settings, based on pre-clinical data from platform(s), boosted by a modern approach to trials and data exploitation
- ▶ Regulatory compliance



THALES achievements since project start

> Evaluation of the actual need for a FLASH-VHEE system

- Specification of VHEE accelerator system in terms of **beam parameters** (current, frequency, ...)
- Investigation on the need of a **conformation systems** for VHEE-FLASH

> Design of a VHEE-FLASH platform

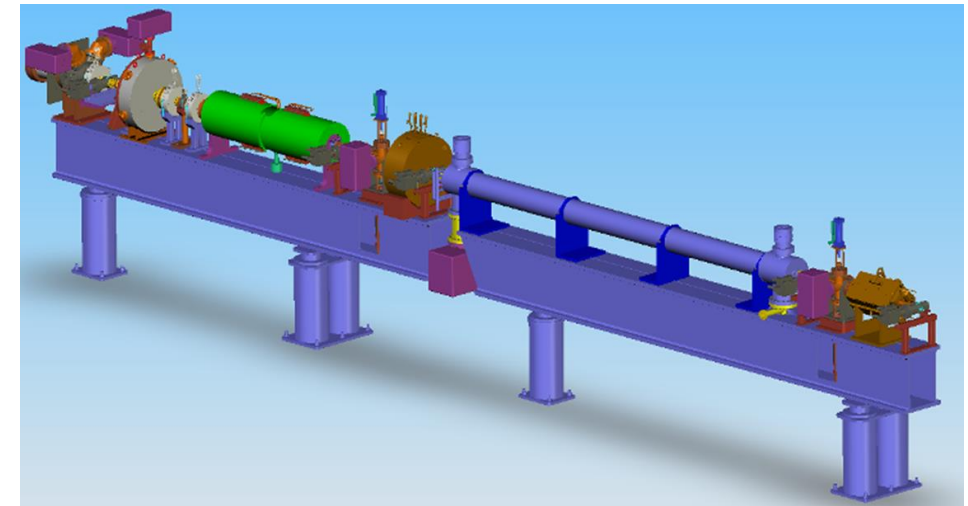
- Design of a **modular architecture**
- Test of mockups and prototypes to **validate critical technology bricks**
- Manufacturing of equipment's and sub-systems

> Radioprotection evaluation

- Characterize the secondary and prompt radiation released when operating these electrons beams.

Main advantages of Thales S-band platform approach

- > **Mature industrial RF sources**, high-power klystrons, modulators, accelerating structures and other components
- > **Readily available**, based on **mature technologies**, mass-produced
- > **Industrial advantages**: Lower complexity & reduced risks compared to higher bands
- > Based on **well-known Thales klystron**
- > **Historical Thales experience** in S-band accelerators for synchrotrons SOLEIL in France, ALBA in Spain and BESSY in Germany



Thales turn-key 100MeV LINAC for ALBA
Incl. 2 modulators 35MW, 3GHz klystrons

FLASH team

> FLASH-VHEE team:

- Brings together experts in accelerator physics, medical physics, radio frequency, as well as experienced engineers in their fields: project management, system integration, construction sites, quality, logistics, purchasing...

> Thales MIS has several industrial sites in France and Europe

> Thales FLASH team is based on Velizy (78) site, and hosts simulation and testing facilities, as well as klystron production plant

> With over 50 years of expertise in scientific research and the medical field, Thales MIS is also integrated within the scientific ecosystem of the Saclay plateau

- 10+ PhD students, post-doctoral researchers.
- Research partnerships with laboratories and universities (LOA, IJC Lab, CEA...)

