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New generations of RF Amplifiers:
from system requirements to technologies

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System requirements (1)

From System requirements to Technologies….and not the opposite way

System requirements do include technical performance but are not limited to these performance

Systems requirements should cover system life time

Cost of a system is not limited to purchasing cost: it clearly include Life Cycle Costs (LCC)

- **Purchasing cost**
- **Maintenance cost**
- **System evolution cost**
- **Supplier support cost**
- **Spare part cost**
- **……**

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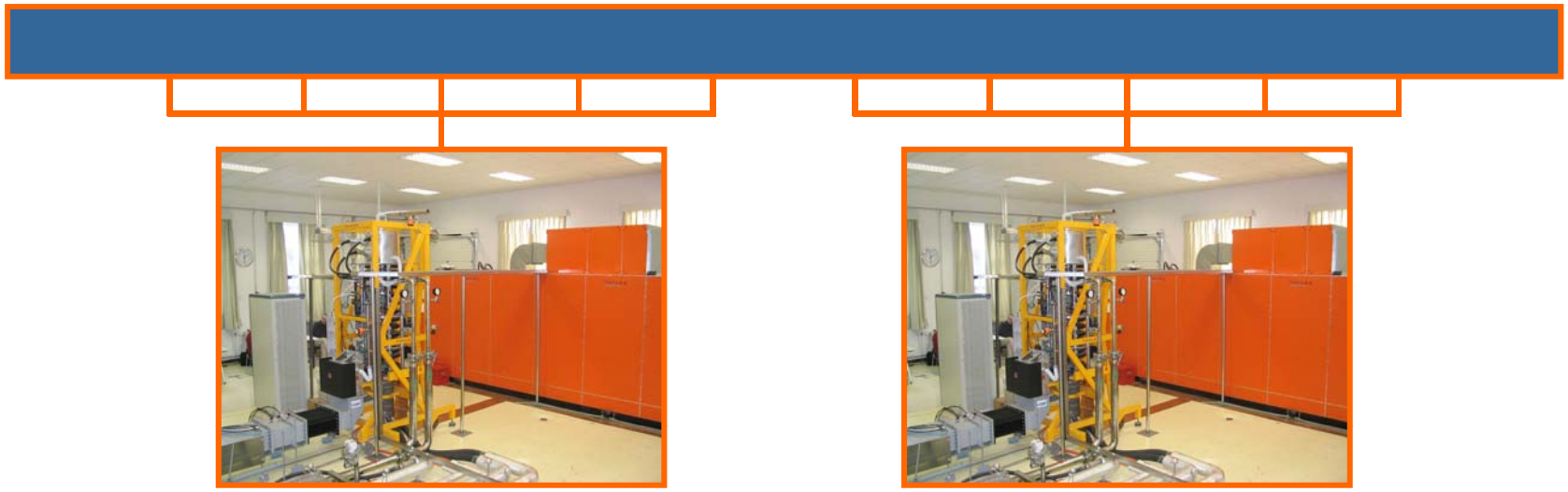
Systems Requirements

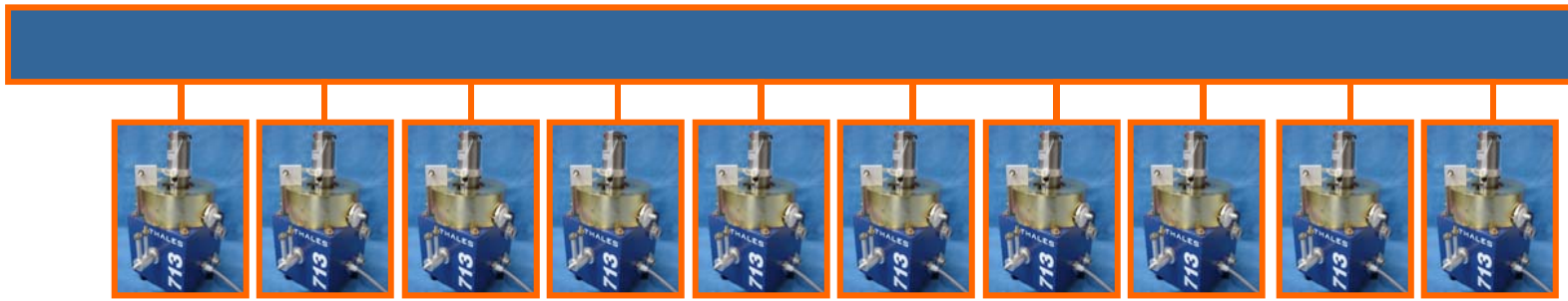
- Technical performance
- LCC including availability of spare parts over 2 or 3 decades
- System architecture
- System reliability
- System availability (fault tolerance, graceful degradation, maintainability, testability, …)

Architectures (1)



Large klystron based RF amplifiers

High power
Few items to maintain
Centralized architecture



Multi-IOT based RF amplifiers

Lower power at each stage
Easy replacement
Decentralized architecture with local control

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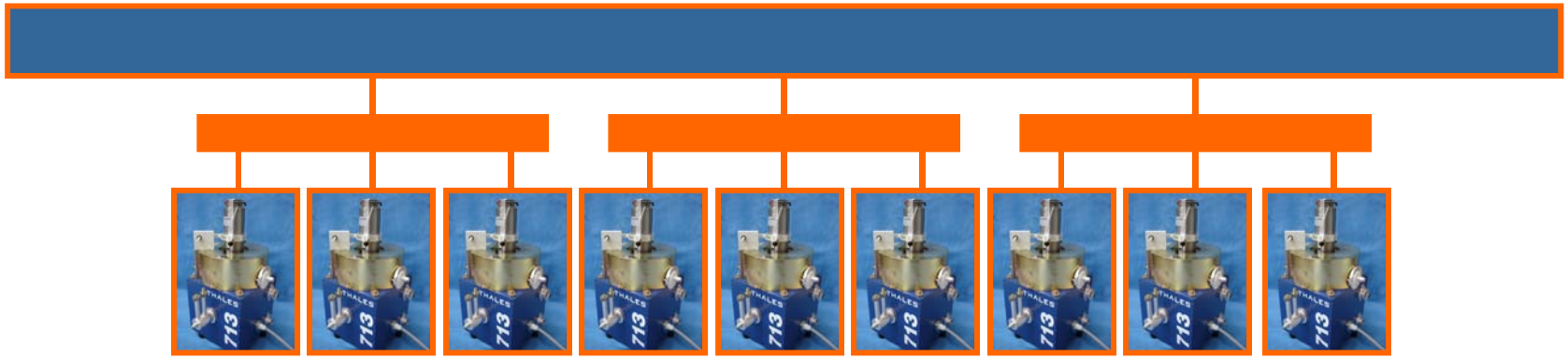
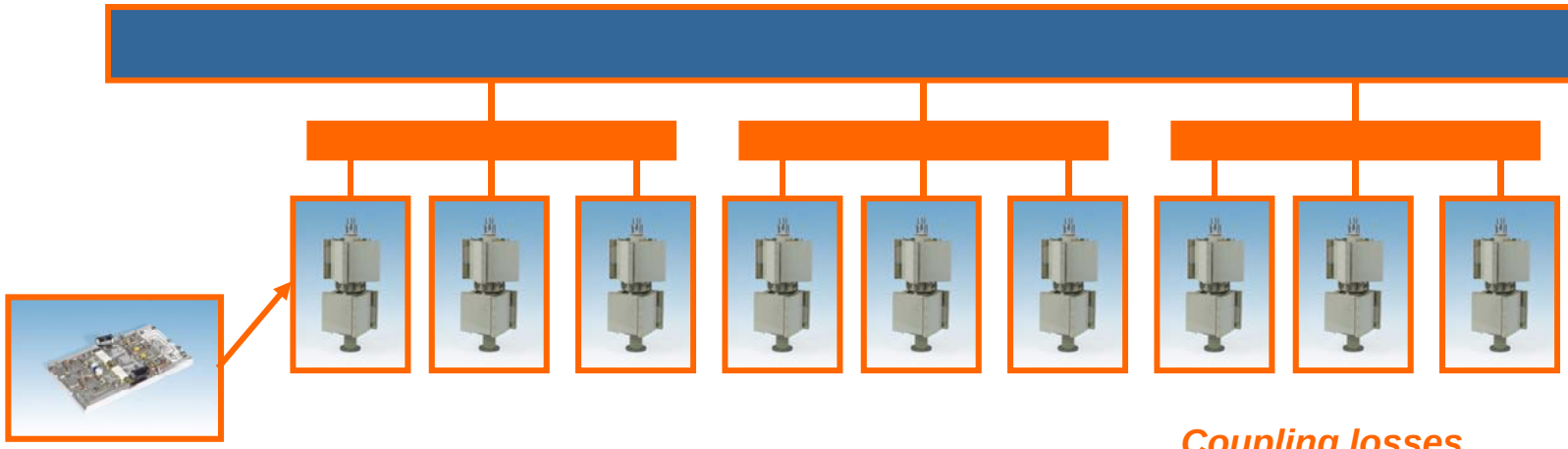
Architectures (2)



Multi-coupled IOT based RF amplifiers

Coupling losses
Graceful degradation
Easy replacement



Multi-coupled Solid State based RF amplifiers

Coupling losses
Low voltage
Obsolescence management

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Architectures (3)

- ✓ Architecture should not take into account technologies
- ✓ Architecture is strongly dependent on requirements
- ✓ Solid State vs. Electron Device architectures : really a debate ?

Solid State	Electron Devices
Low voltage	High voltage
Graceful degradation but coupling losses	Some possible graceful degradation
Obsolescence management	Few suppliers but existing (!!!)
Components not driven by science market	Ability to produce components some decades after system start
LCC (design evolution due to new components)	LCC

In both cases, experienced high power RF designers are mandatory !!!

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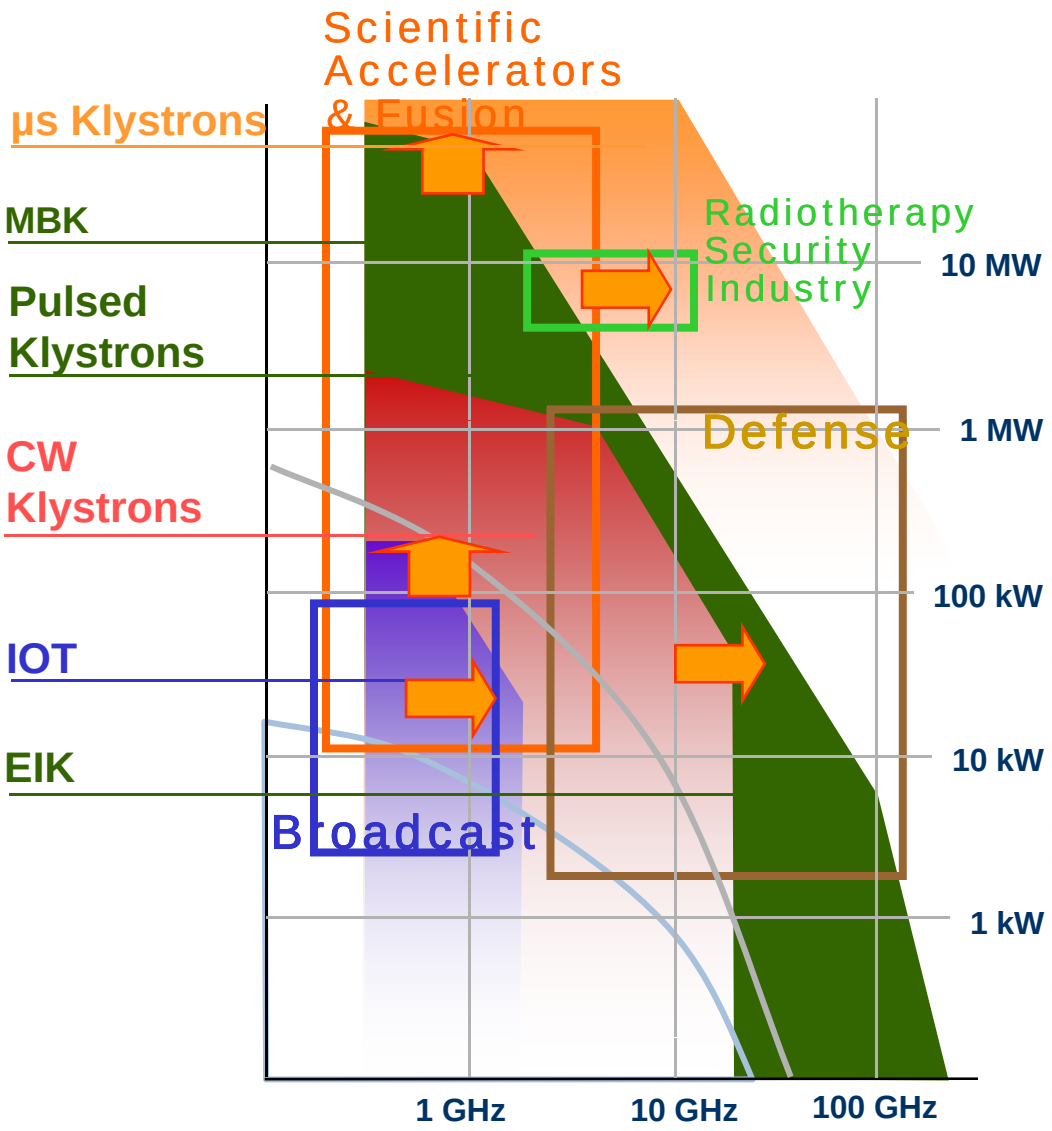
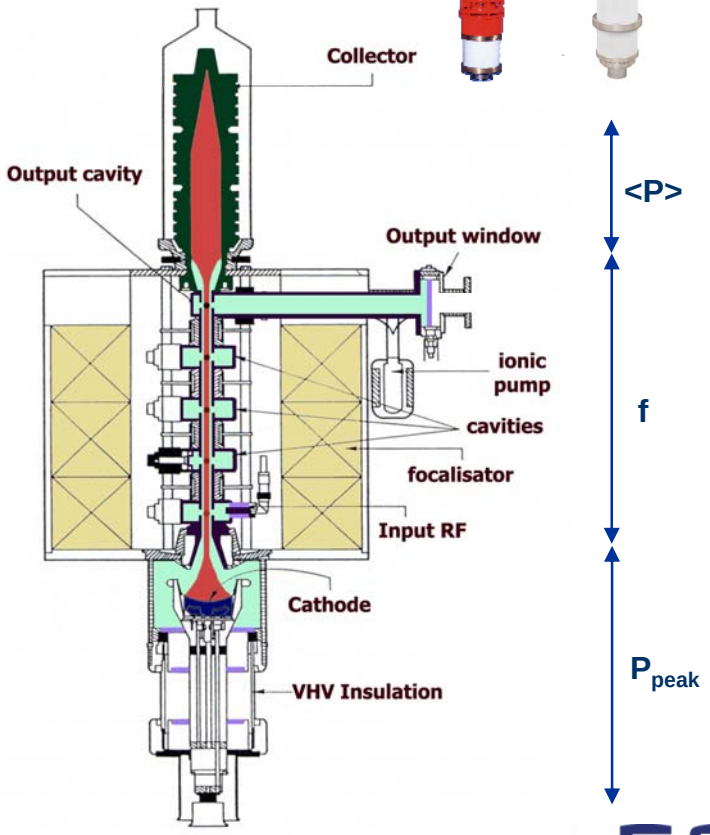
Electron device evolution - Klystrons & IOTs (1)

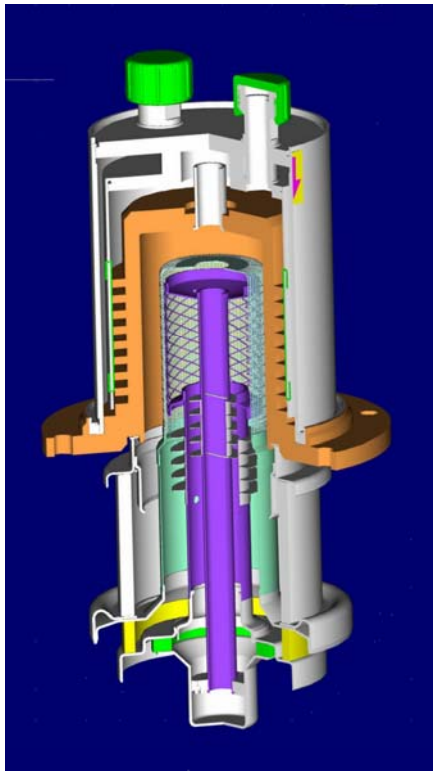


IOTs

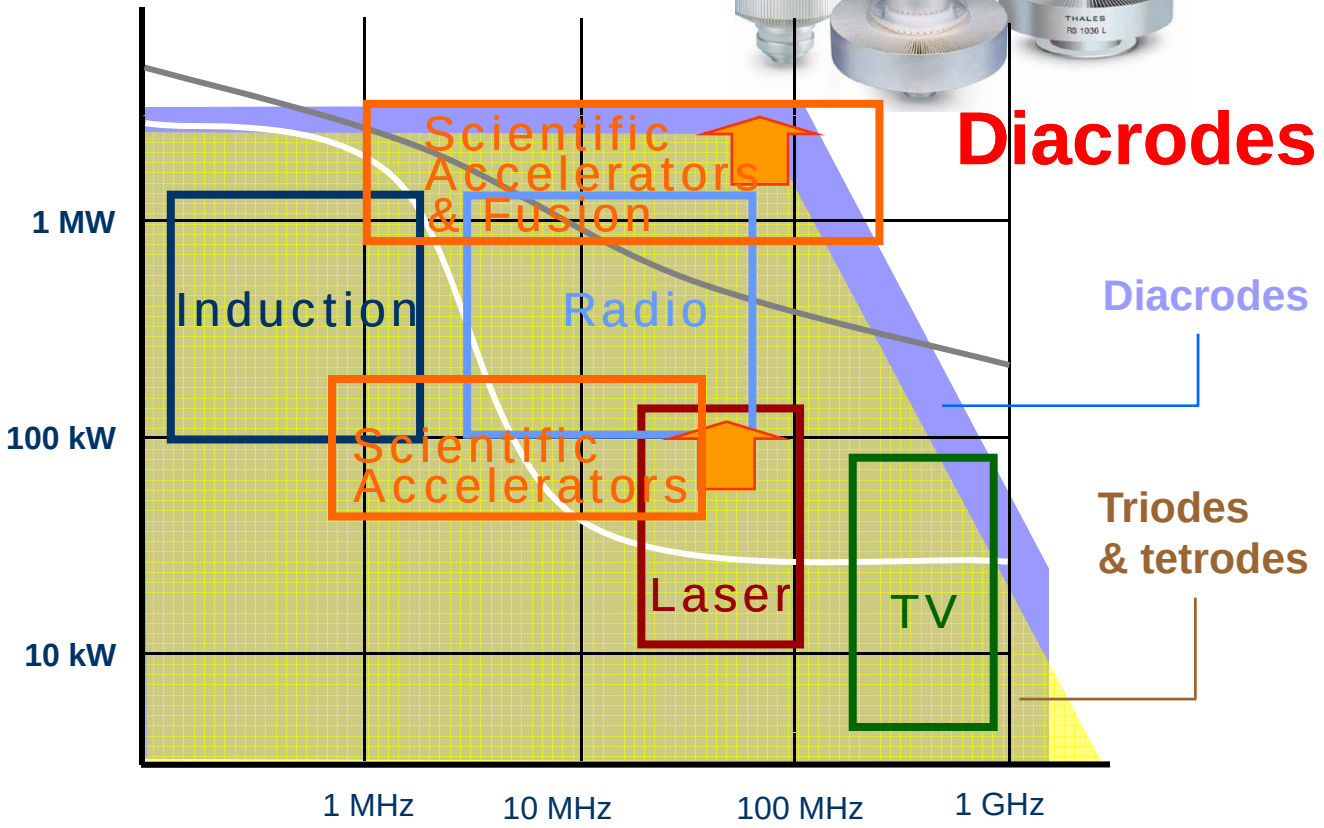
Klystrons



Electron device evolution – Triodes & Tetrodes (2)



Triodes & Tetrodes



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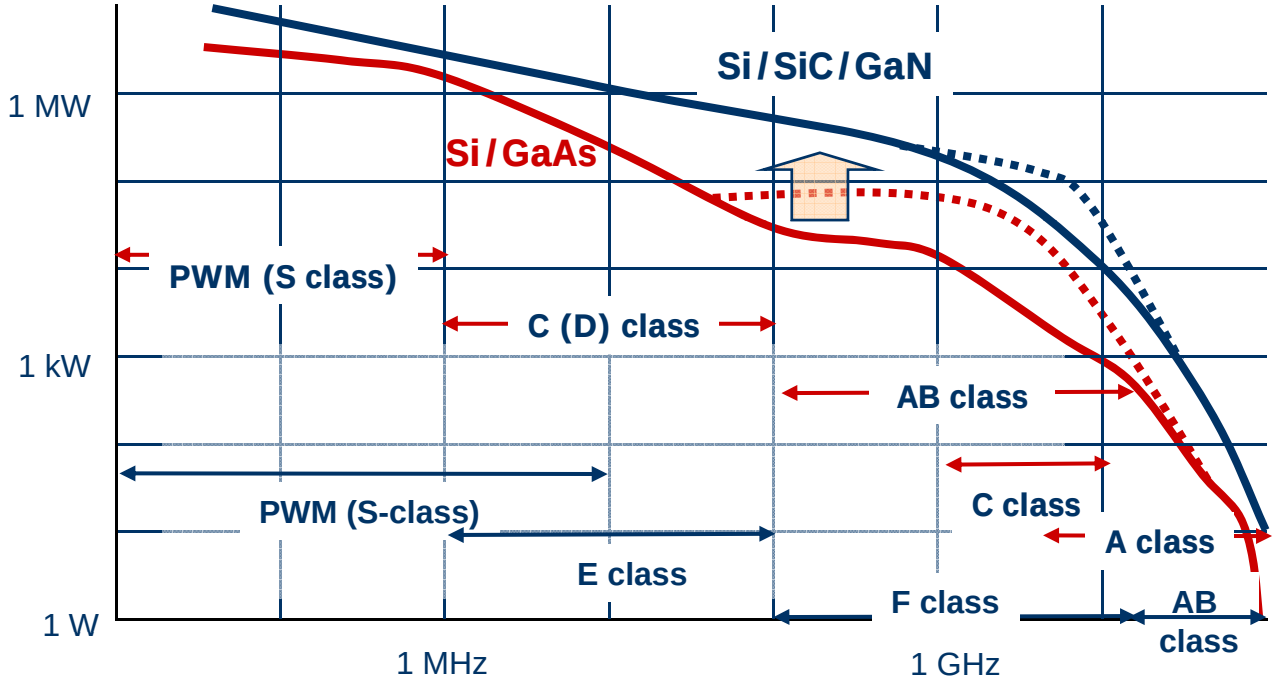
Electron device evolution – Solid State Device (3)

Solid State amplifiers



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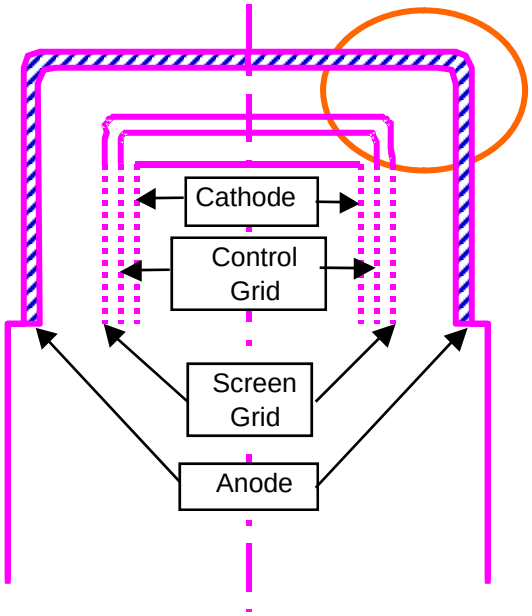
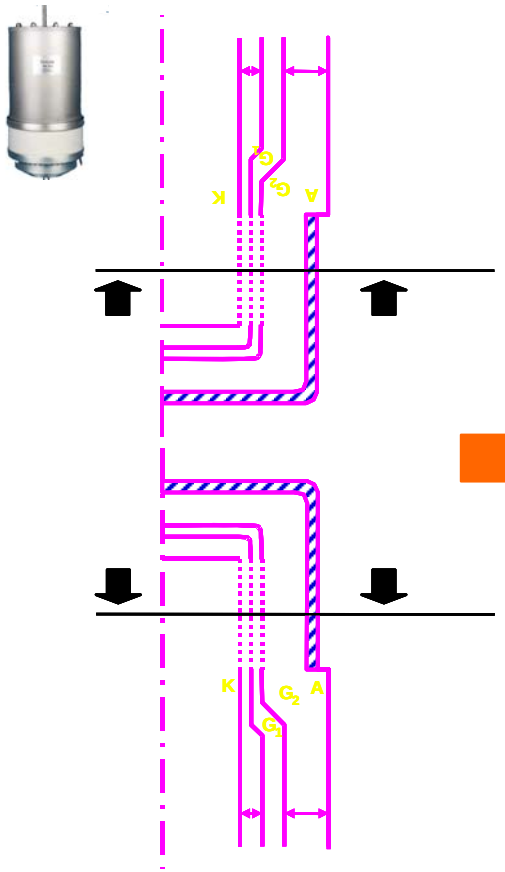
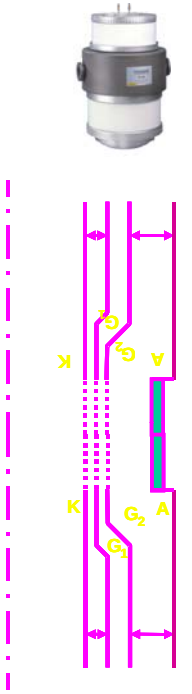
Diacrode - A major evolution for tetrode technology (1)

The end capacitance is mainly done in this area





Two tetrodes



One Diacrode

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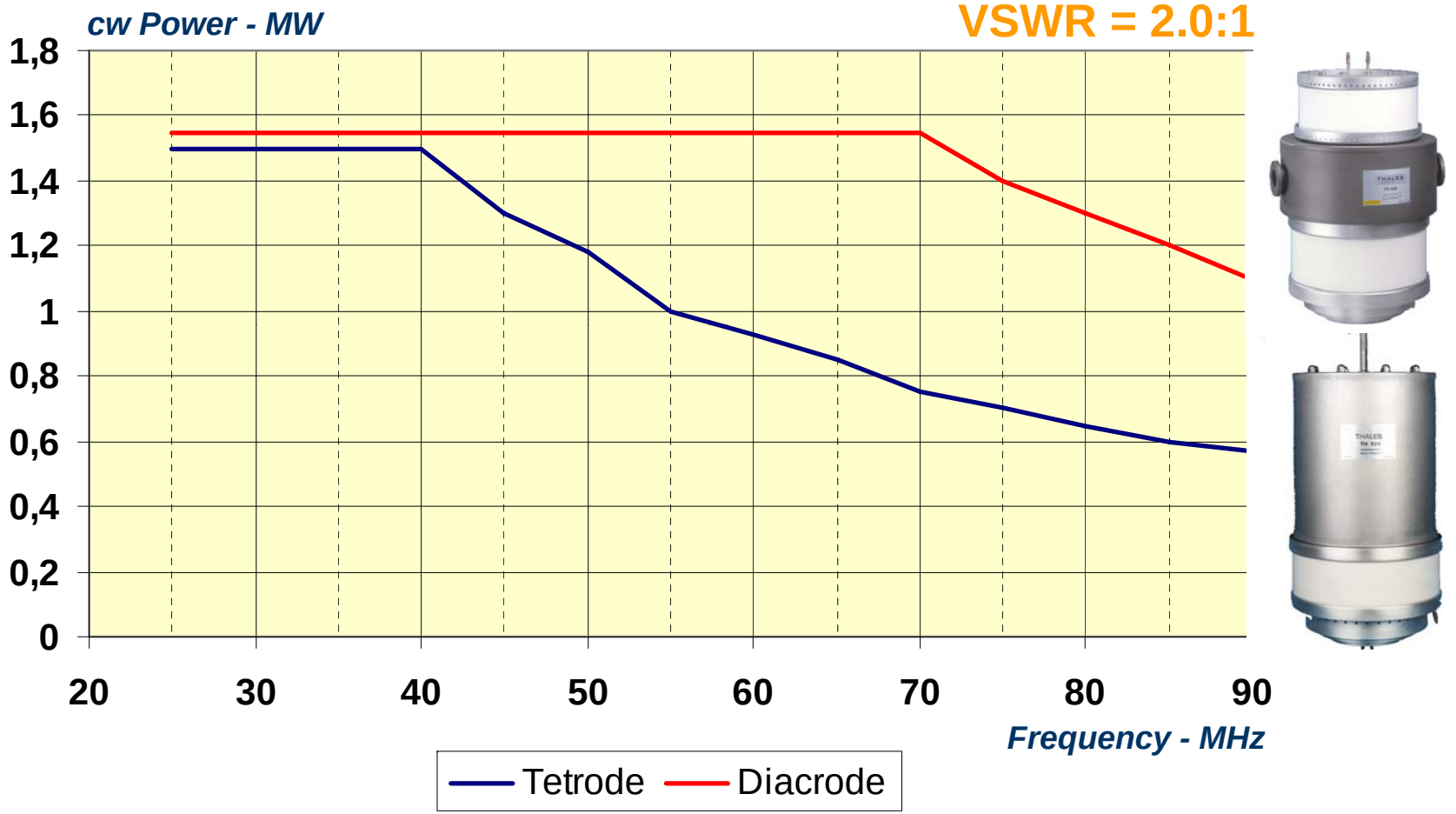
Diacrode - A major evolution for tetrode technology (2)



Both tubes with the same cathode

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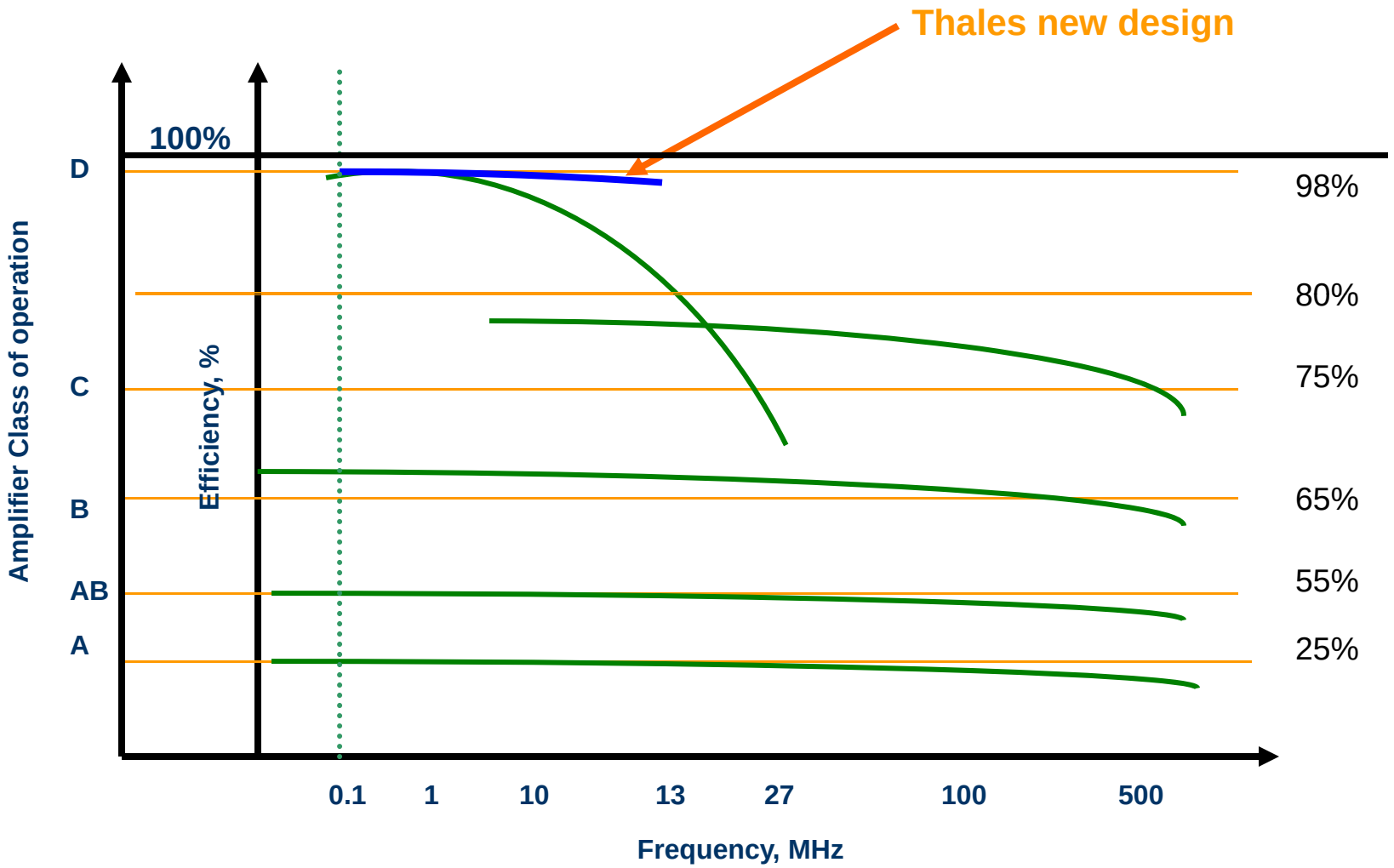
Solid State – Amplifier Class of Operation Impact (1)

Si MOSFET Technology



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Solid State – Amplifier structure Impact (2)

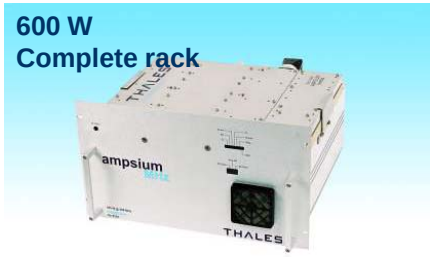
Si LDMOS Technology (low frequency)

Pallet

No required tuning or adjustment
90 % SMT technology
Last MOSFET technology
RoHS compliance

Case

Racks



In case of component technology evolution, Pallets are changing but not Case Interface and not Racks

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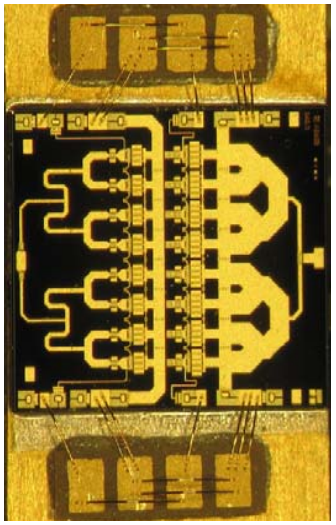
KORRIGAN : a GaN foundry for Europe

GaN TECHNOLOGY

- RF power density x 10
- Output power x 10
- Power added efficiency x 2
- Junction temperature > 250°C
- Voltage supply > 28V



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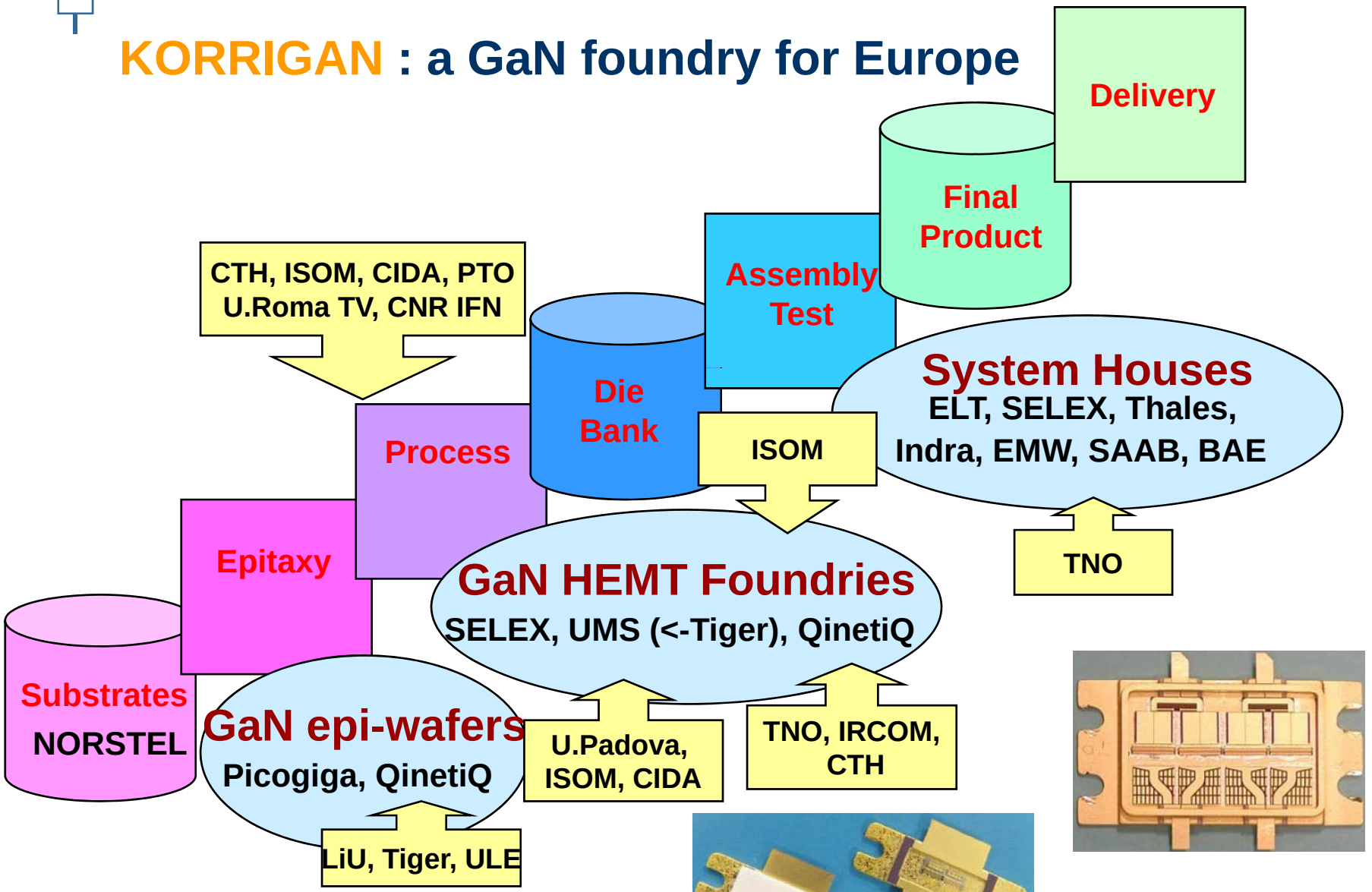
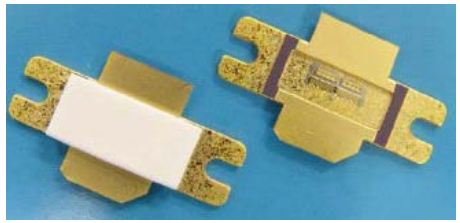
Solid State – GaN device for high frequency (4)

KORRIGAN : a GaN foundry for Europe





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IOTs – Modularity based design (1)

Diamond
TH793 IOTs
450-850 MHz
80 kW cw

TH713 IOTs
L band
16 kW cw

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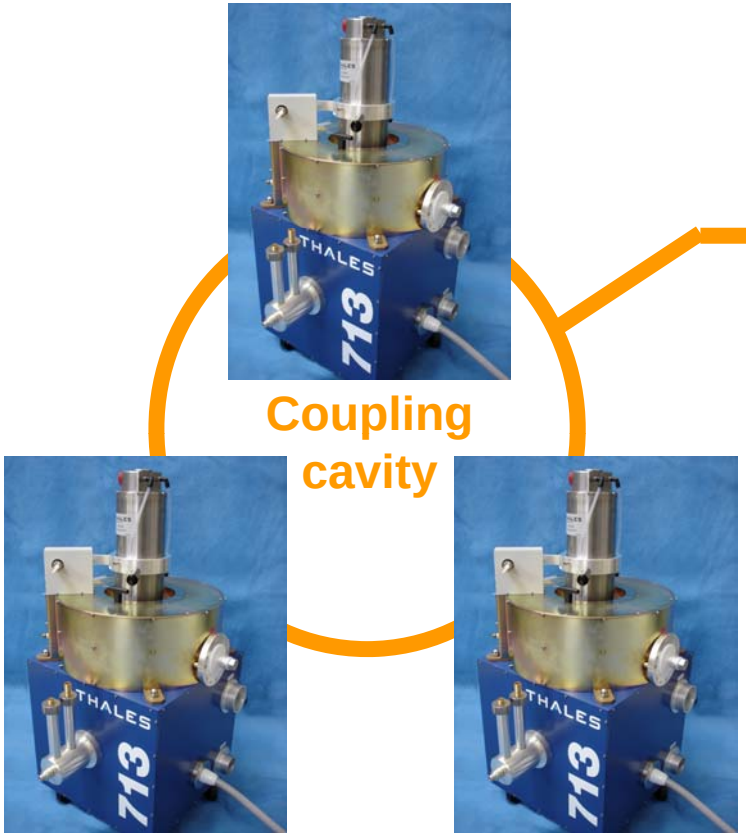
IOTs – Modularity based design (2)



Combined RF Output

Modularity allows for Fault tolerance through graceful degradation, due to the operation of each RF source at a lower power: in case of one source failure, two remaining can supply full power

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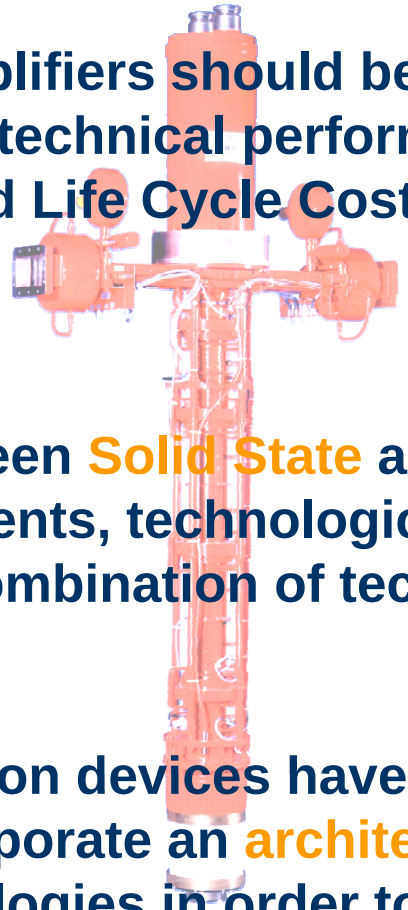
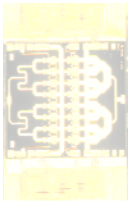
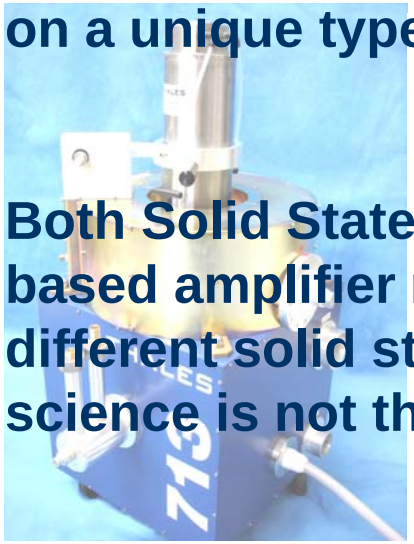
Conclusion





New generations of RF amplifiers should be defined by System Requirements that include technical performance but also system operation requirements and Life Cycle Costs (and not only Purchasing Cost)

There is not a debate between Solid State and Electron devices: based on system requirements, technological answers may be based on a unique type or on a combination of technologies



Both Solid State and Electron devices have evolutions. SSD design based amplifier must incorporate an architecture that allows to mix different solid state technologies in order to take into account that science is not the market driver