EUROPEAN SPALLATION SOURCE

Brief update on the ESS RF Systems

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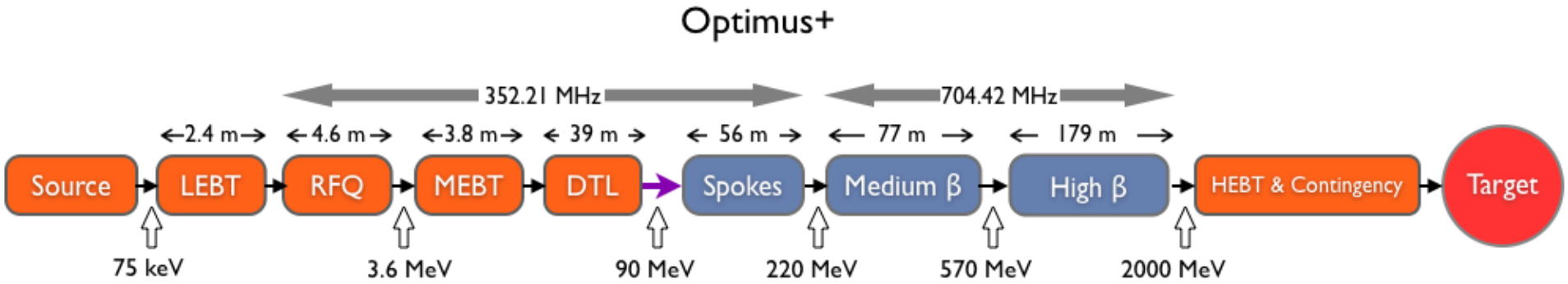
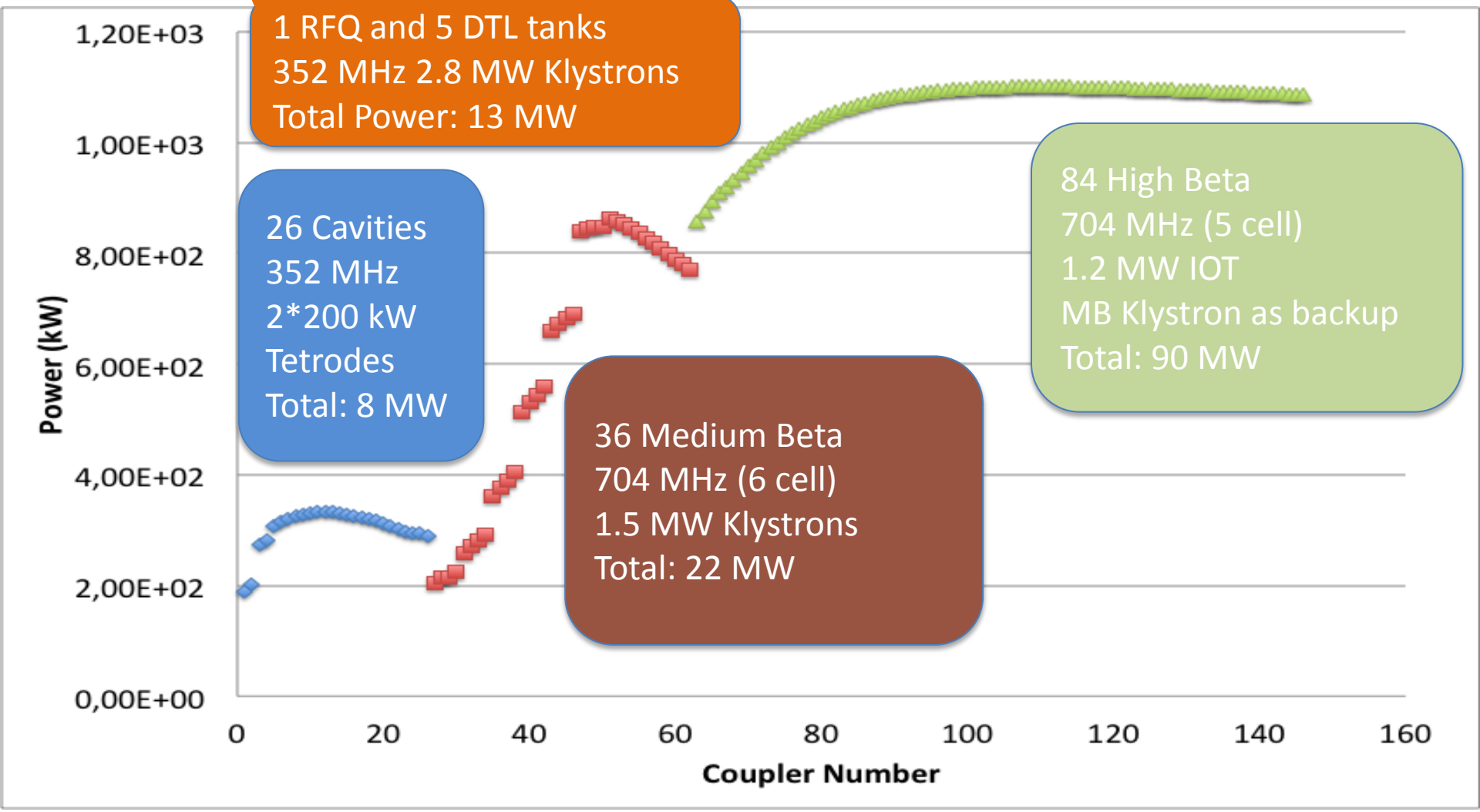
Linac Design Choices

- User facilities demand high availability (>95%)
- The linac will be mostly (>97%) superconducting
- Front end frequency is **352 MHz** (CERN Standard)
- High energy section is at **704 MHz**
- ESS will limit the peak beam current below **62.5 mA** (was 50 mA)
- Linac Energy of 2 GeV - **125 MW** peak power.



The ESS Superconducting Power Profile

> 150 cavities/couplers

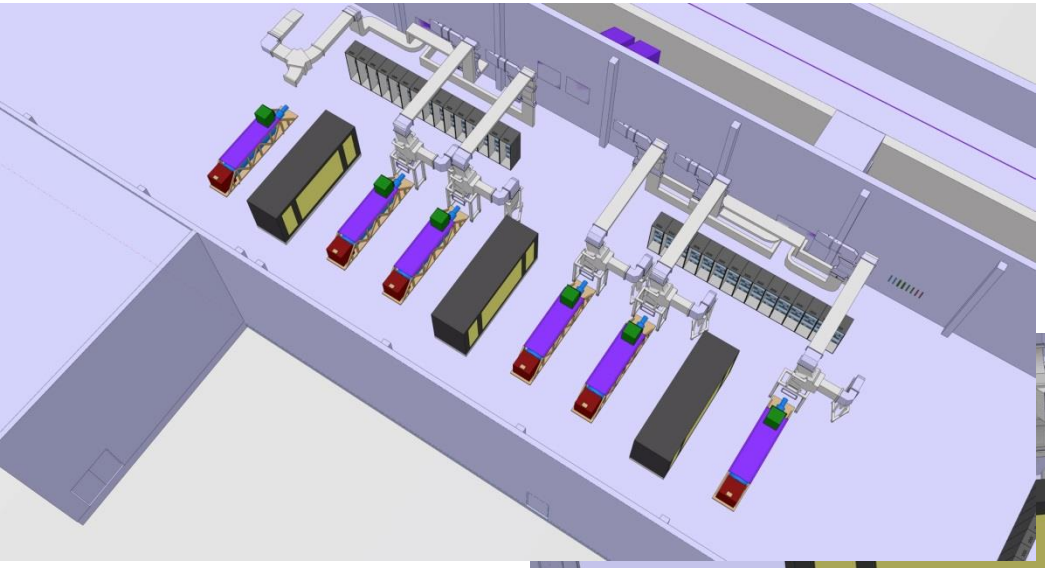


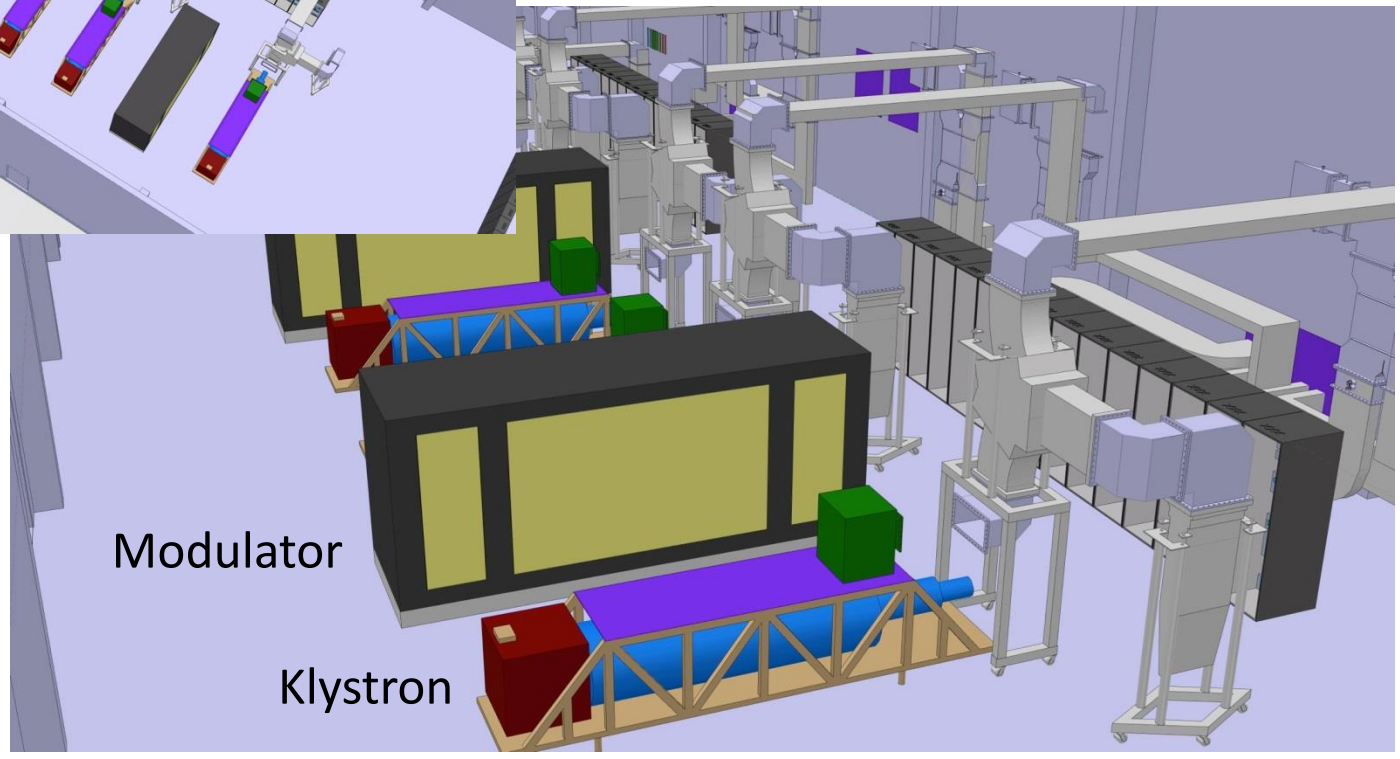
Total High Power RF: 133 MW peak (4% duty) plus overhead

RF distribution for the RFQ and 5 DTLs Layout being finalised

One 2.8 MW for RFQ
Five 2.8 MW klystrons for DLT

Power split to two couplers per DTL tank
CPI – VKP-8352B
Thales – TH2179

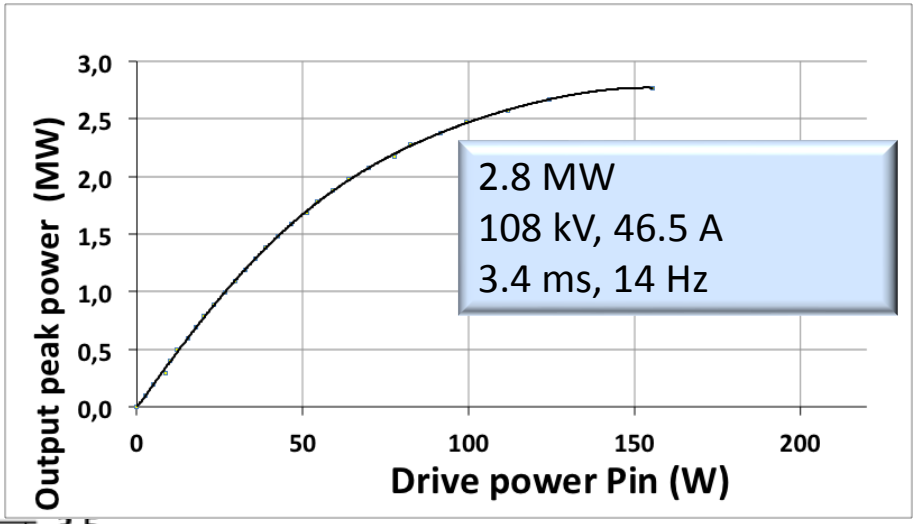


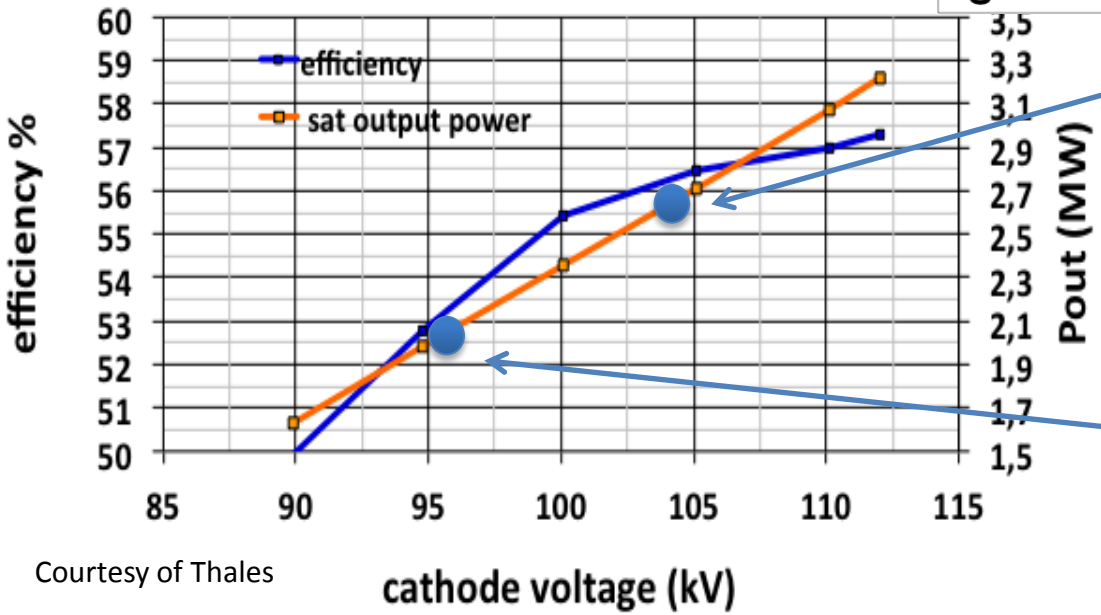


2 Klystrons per modulator

Possible RFQ and DTL Power Source

Investigating option to operate at lower voltage for lower power operation



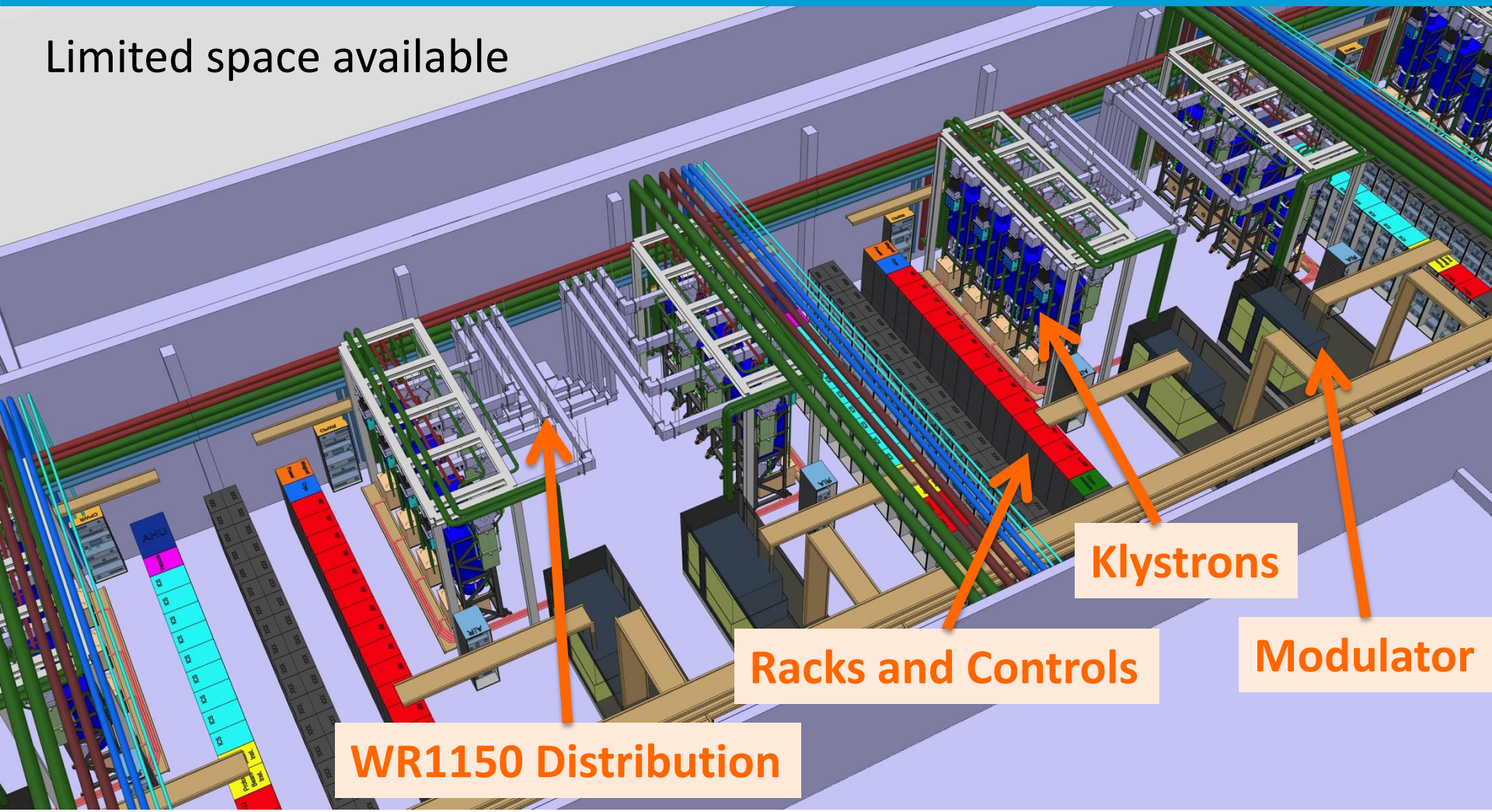


Courtesy of Thales

DTL:
Saturation efficiency = 55%
Beam efficiency = 46%
Full voltage efficiency = 41%

RFQ:
Saturation efficiency = 52%
Beam efficiency = 43%
Full voltage efficiency = 31%

Elliptical (704 MHz) RF System Layout

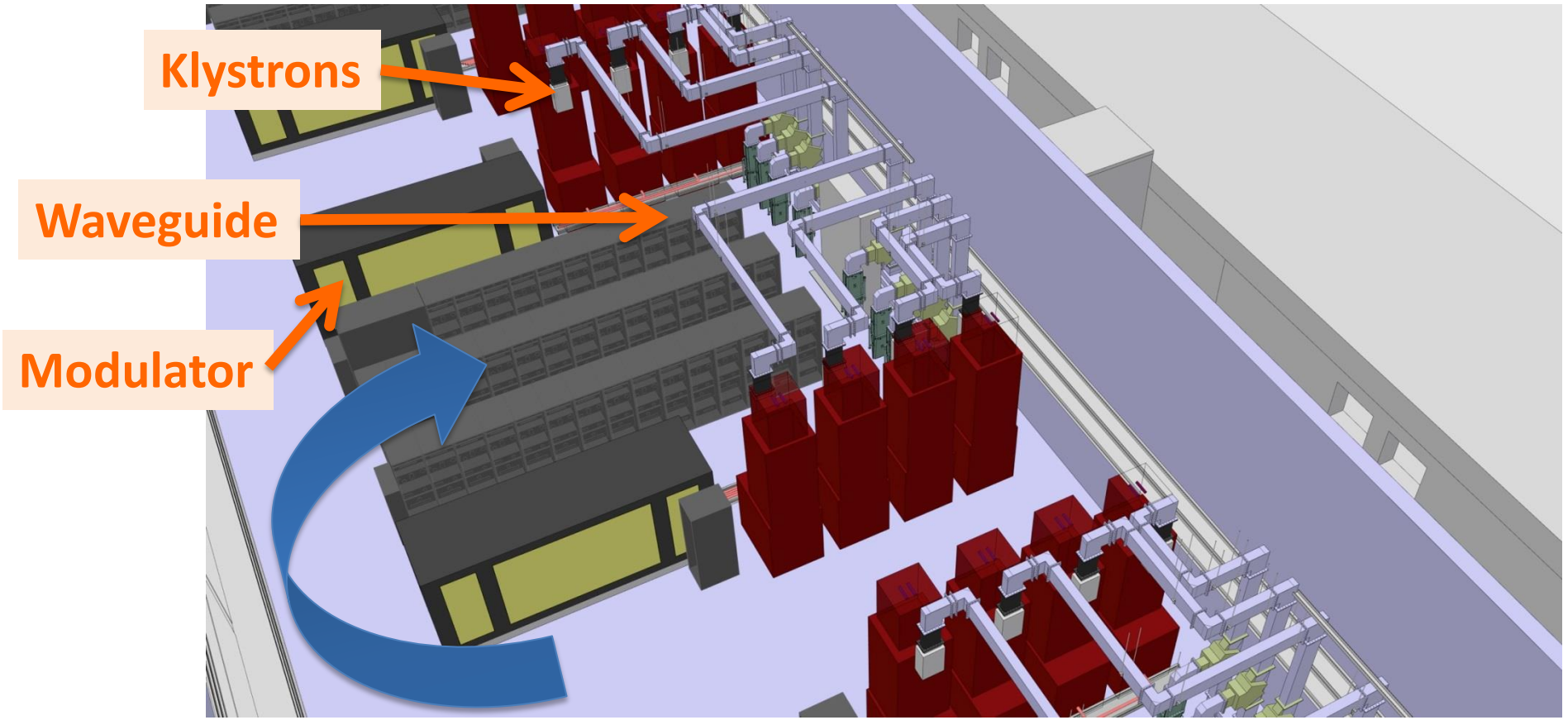


4.5 Cells of 8 klystrons for Medium Beta

10,5 Cells of 8 klystrons (IOTs) for High Beta

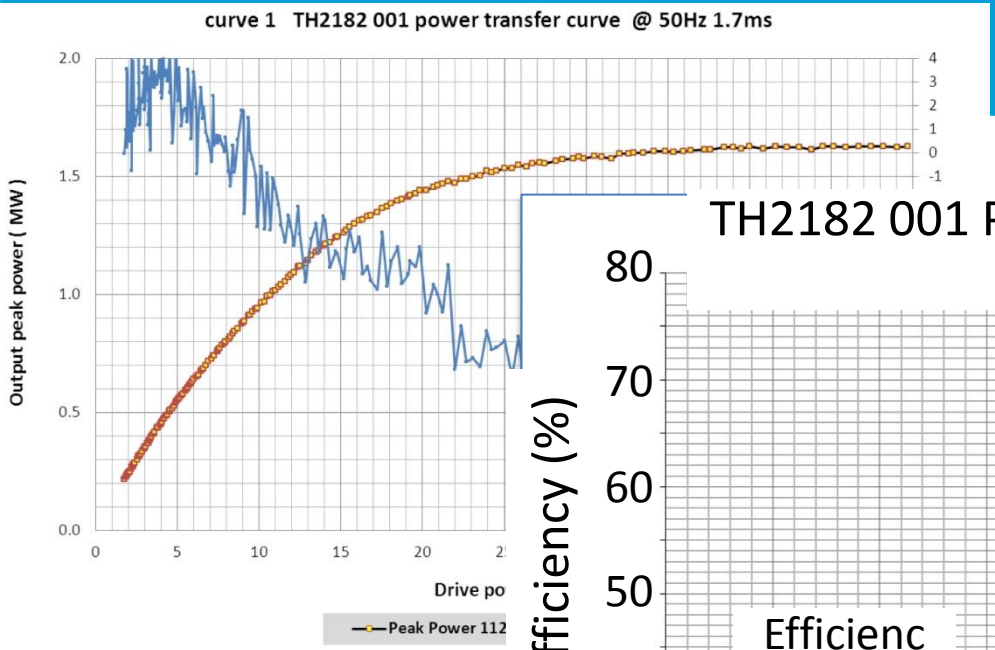
Elliptical (704 MHz) RF System Layout

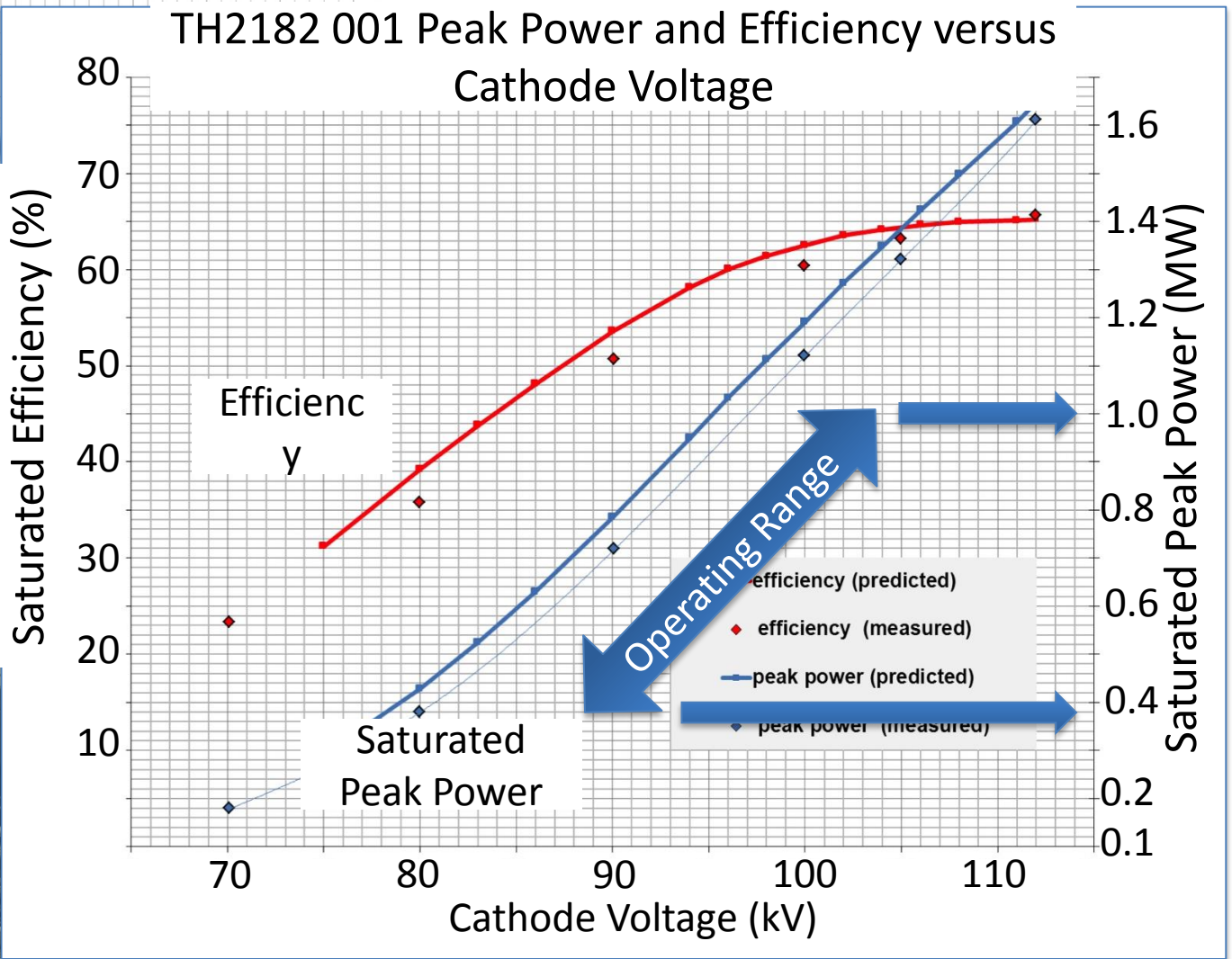
(but two weeks ago it may have changed)



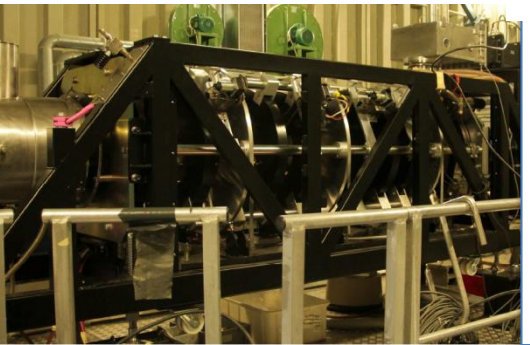
Racks moved to allow the cables to follow the route of the waveguide

704 MHz Klystron (Thales) factory tests



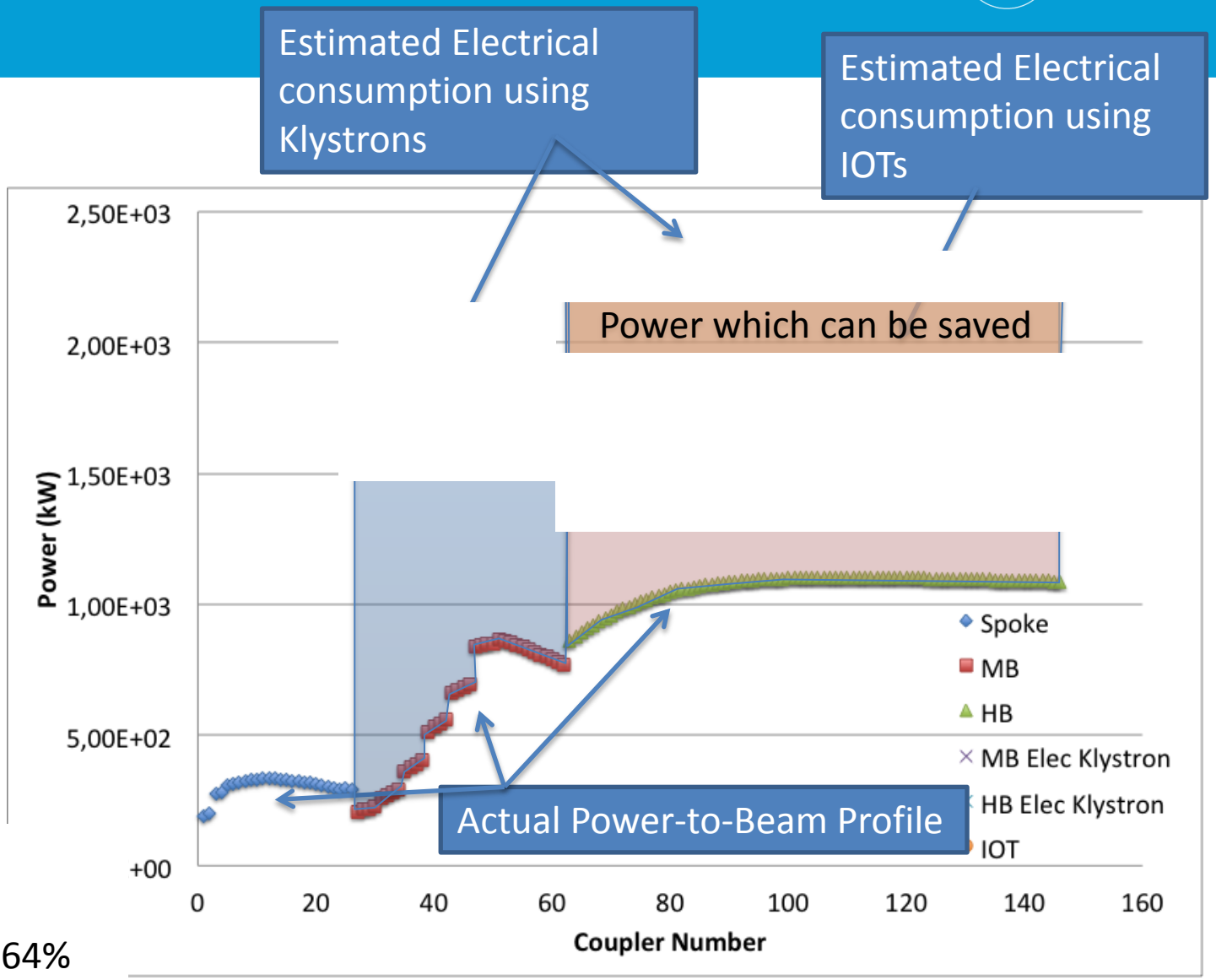


Courtesy of Thales and CERN



An RF Source for a Proton Linac

Each marker is an RF Source



Assume 25% overhead
Modulator η= 93%
Klystron saturation η = 64%
IOT η = 65%

An IOT for ESS

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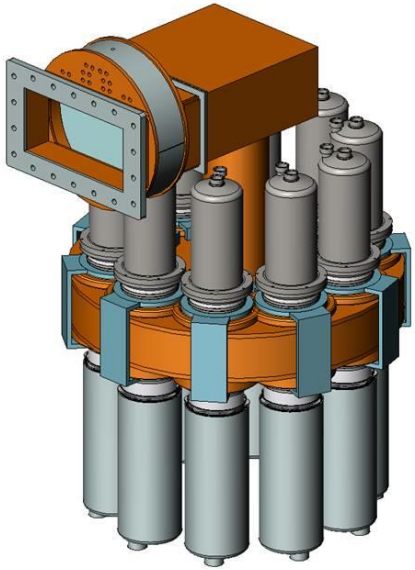
Parameter		Comment
Frequency	**704.42 MHz**	**Bandwidth > +/- 0.5 MHz**
Maximum Power	**1.2 MW**	**Average power during the pulse**
RF Pulse length	Up to 3.5 ms	Beam pulse 2.86 ms
Duty factor	Up to 5%	Pulse rep. frequency fixed to 14 Hz
Efficiency	Target > 65%	
High Voltage	Low	Expected < 50 kV
Design Lifetime	> 50,000 hrs	

Work is being carried out in collaboration with CERN

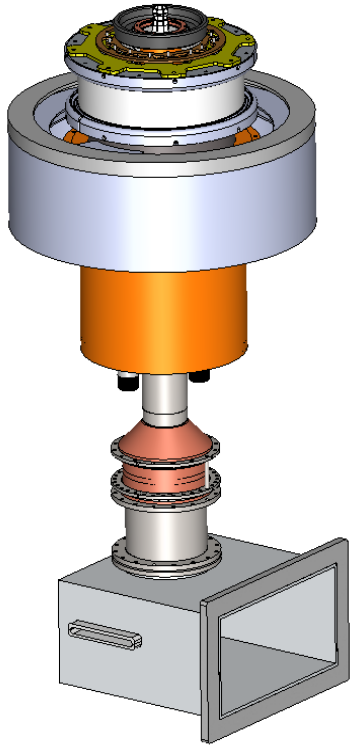
- ESS to procure prototypes
- CERN to make space and utilities available for testing

Target: Approval for ESS series production in 2017/18

1.2 MW Multi-Beam IOT



- ESS launched tender for IOT prototypes
- Tender replies received and contracts about to be signed for two IOTs
- Delivery in 24 months
- Site acceptance at CERN followed by long term soak test
- ESS > 3 MW saved from from high beta linac = 20 GWh per year



Pre-tender
CPI Cartoon

L3 Electron Devices

Summary of Key Parameters for the ESS High Power Devices

	Klystron 352 MHz	Tetrode* 352 MHz	Klystron 704 MHz	IOT 704 MHz
Peak output power (MW)	2.8	400	1.5	**1.2**
Frequency (MHz)	352.21	352.21	704.42	**704.42**
Gun	Diode gun	Filament	Diode gun	**Gridded Gun**
Pulse length (ms)	4	3.5	4	**3.5**
Rep. rate (Hz)	Up to 14	Up to 14	Up to 14	**Up to 14**
Maximum Beam Voltage (kV)	115	18	115	**50**
Efficiency at nominal output power	≥ 55%	> 65%	> 60%	**> 65%**
- 1dB Bandwidth (MHz)	≥ +/- 1	≥ +/- 3	≥ +/- 1	**≥ +/- 1**
Gain (dB)	≥ 40	>15	≥ 40	**≥ 20**