

Experimental Validation of an X-Band LLRF Prototype for High-Gradient Linear Accelerators

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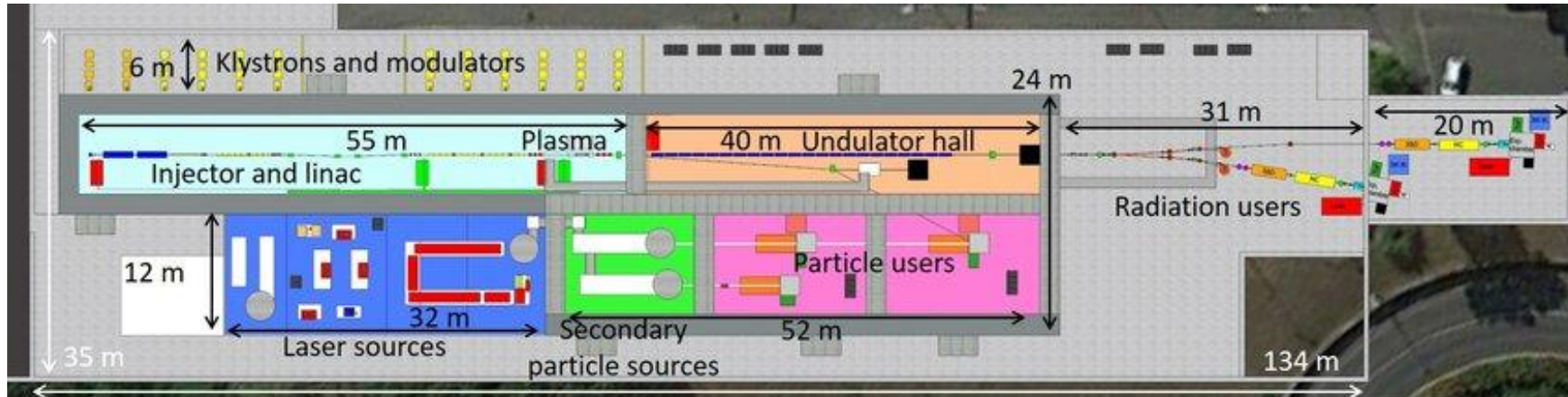
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Motivation

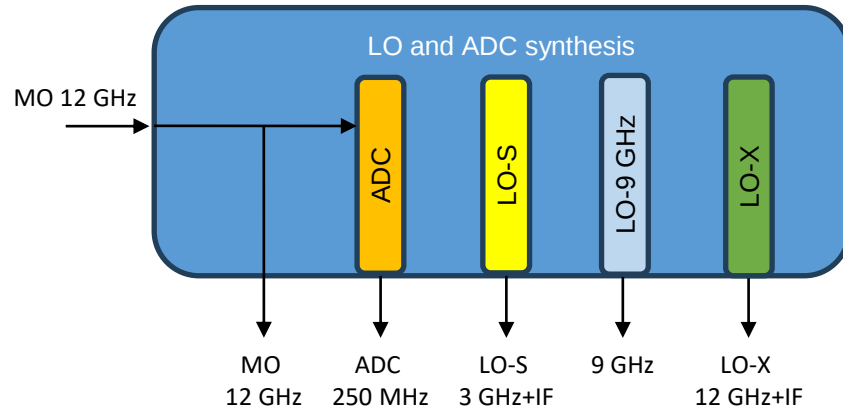
- EuPRAXIA aims to develop a **compact, high-performance** FEL facility based on X-band linacs and plasma accelerators
- Designed to significantly **reduce** the **size** and **cost** of future accelerator facilities compared to conventional technologies
- Challenge of controlling RF parameters (amplitude and phase) at **high frequencies** and for very **short pulses** (~ 100ns).
- **Development** of an X-Band LLRF **prototype** system in the the context of **EuPRAXIA-DN**.



Reference: [EuPRAXIA SPARC LAB](#)

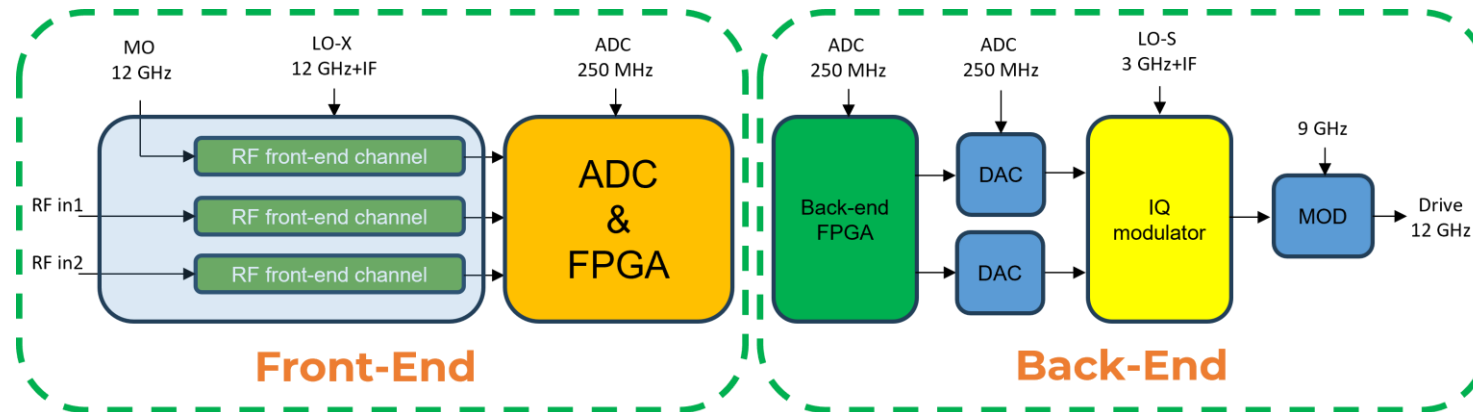


Prototype Block Diagram



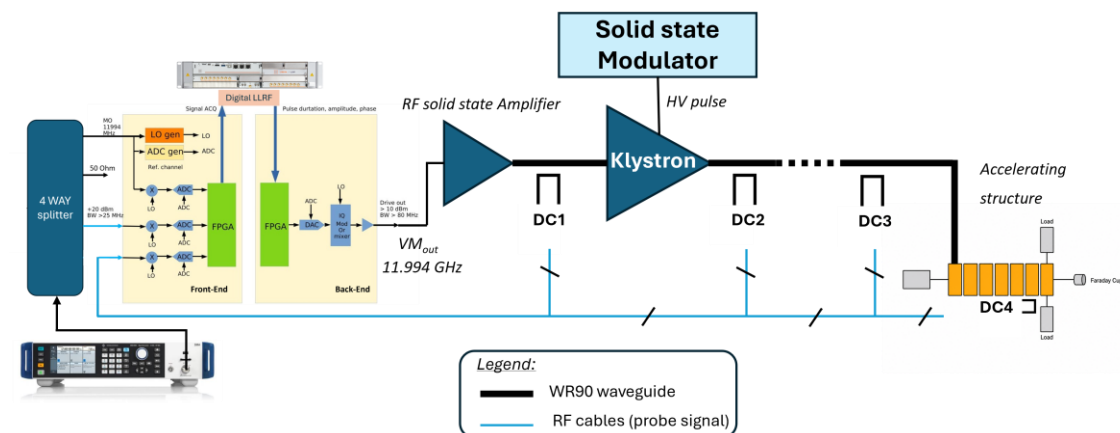
Development approach for the prototype:

- **Single stage** down-conversion
- **Double stage** up-conversion
- **Open loop prototype** (separate front-end and back-end systems)

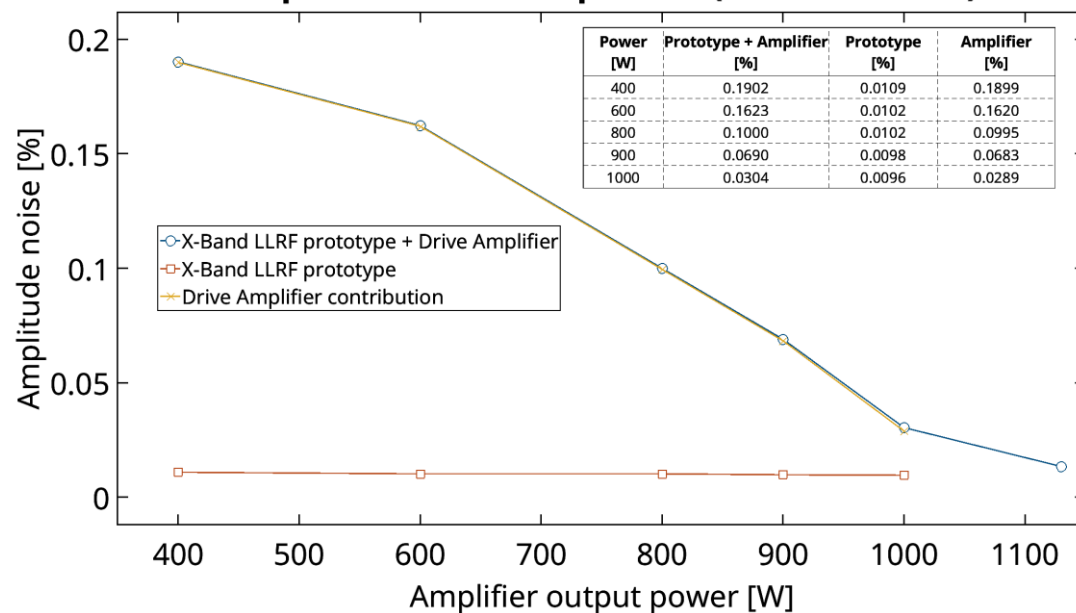


Drive Amplifier Tests at TEX Facility - INFN

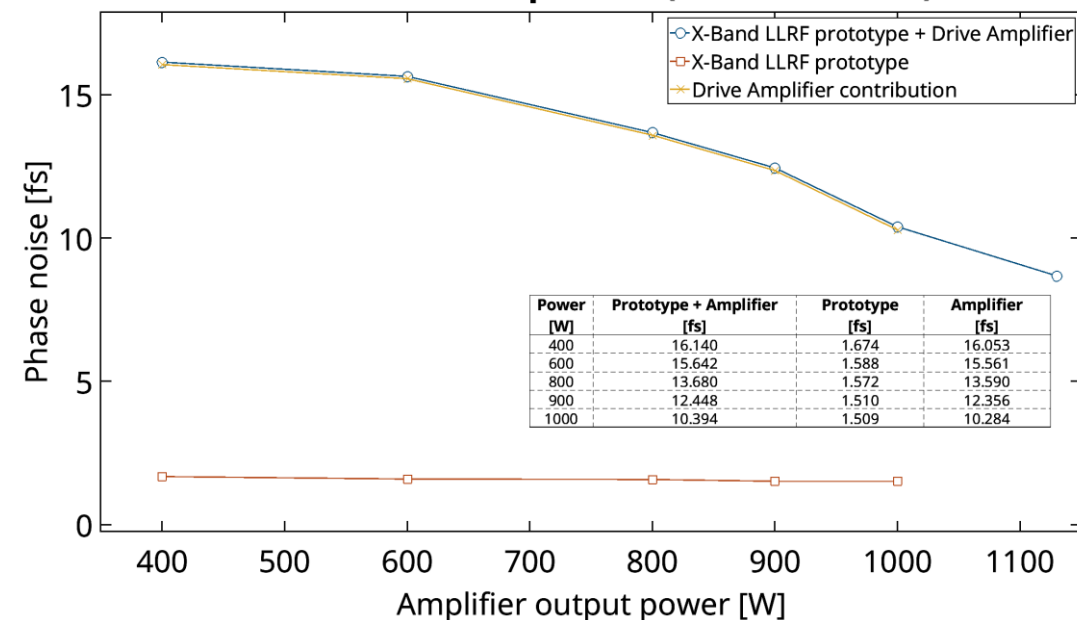
- No of Pulses : 6000 @ 50 Hz
- Pulse averaging window: 700ns
- Amplifier output: 400W $\rightarrow$ 1.1kW (saturation)



Amplitude noise comparison (700 ns window)

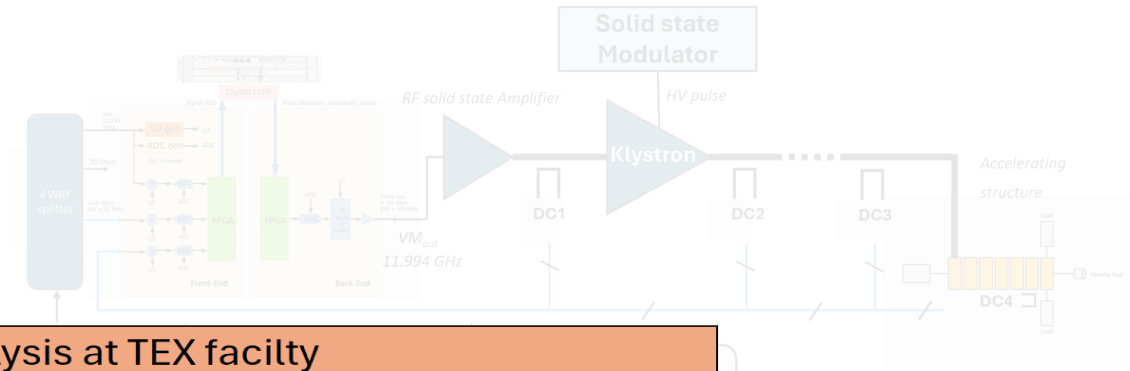


Phase noise comparison (700 ns window)

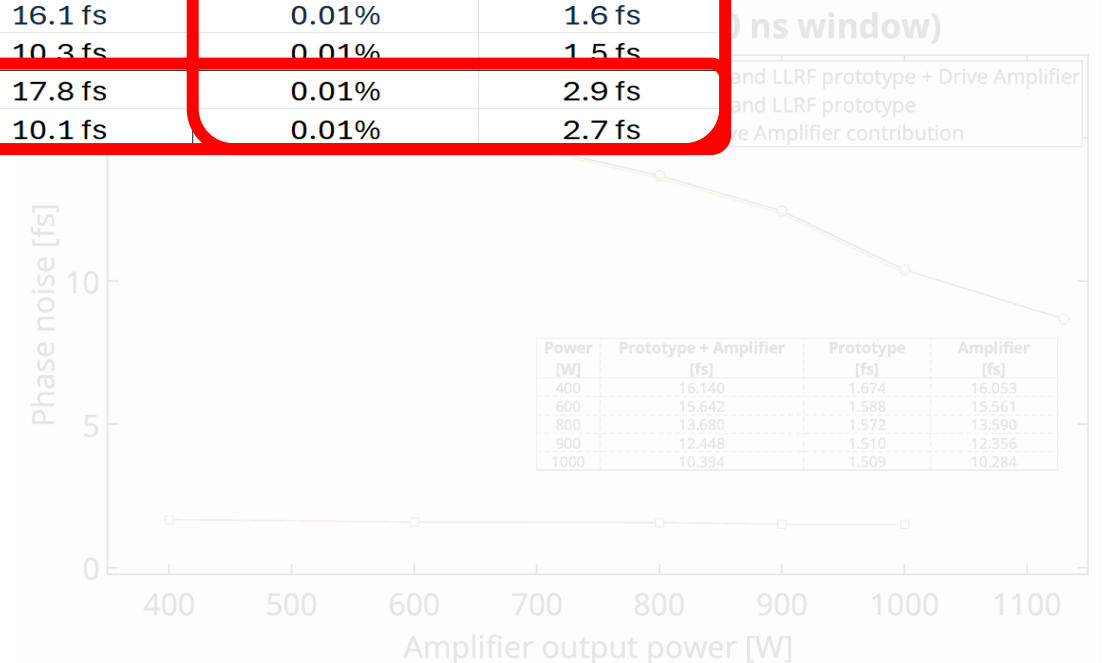
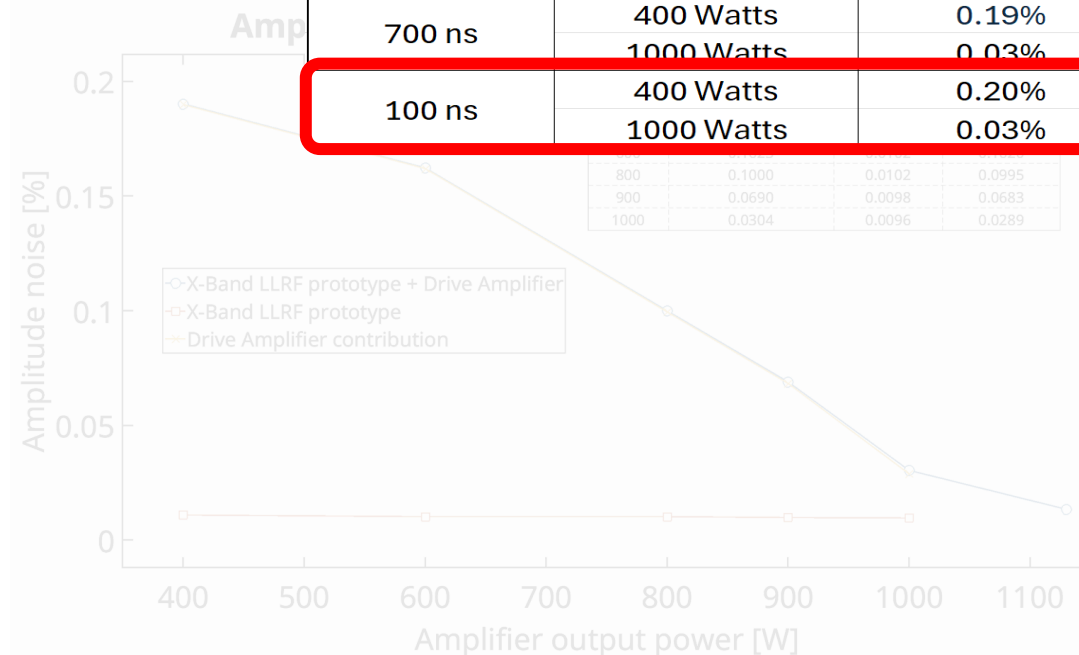


Drive Amplifier Tests at TEX Facility - INFN

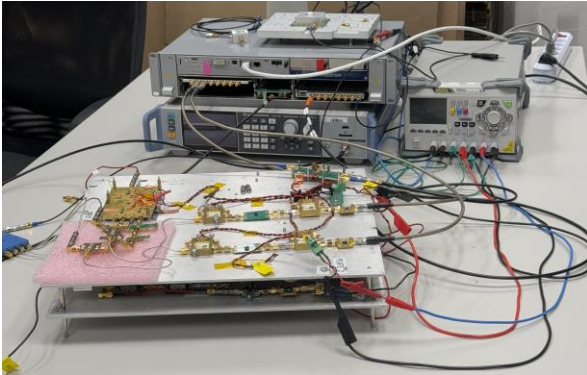
- No of Pulses : 6000 @ 50 Hz
- Pulse averaging window: 700ns
- Amplifier output: 400W → 1.1kW (saturation)



X-Band LLRF Prototype Analysis at TEX facility					
Pulse Length	Amplifier Output Power	Prototype + High Power Amplifier		Prototype Contribution	
		Amplitude Noise	Phase Noise	Amplitude Noise	Phase Noise
700 ns	400 Watts	0.19%	16.1 fs	0.01%	1.6 fs
	1000 Watts	0.03%	10.3 fs	0.01%	1.5 fs
100 ns	400 Watts	0.20%	17.8 fs	0.01%	2.9 fs
	1000 Watts	0.03%	10.1 fs	0.01%	2.7 fs



Project Overview:



LINAC'2024



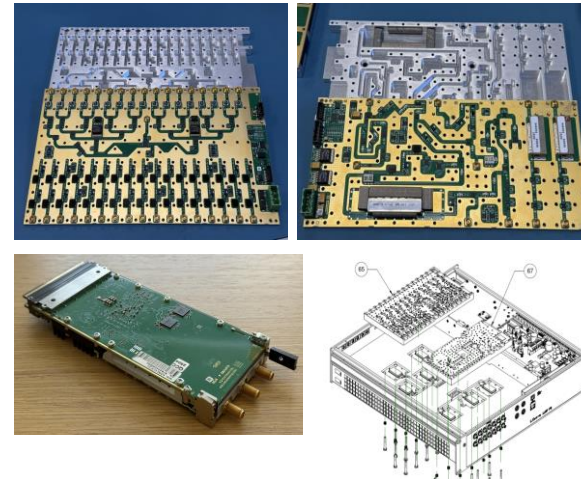
**VALIDATION – TEX facility
2025-2026**

IPAC'2025

LLRF'2025



**DESIGN & DEVELOPMENT
2023-2024**



LINAC'2026



INDUSTRIALIZATION - 2026



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