INSTRUMENTATION
TECHNOLOGIES

LIBERA

Reference Master Oscillators and Distribution Systems

Borut Baričević

WWW.I-TECH.SI

Libera Workshop, May 2022

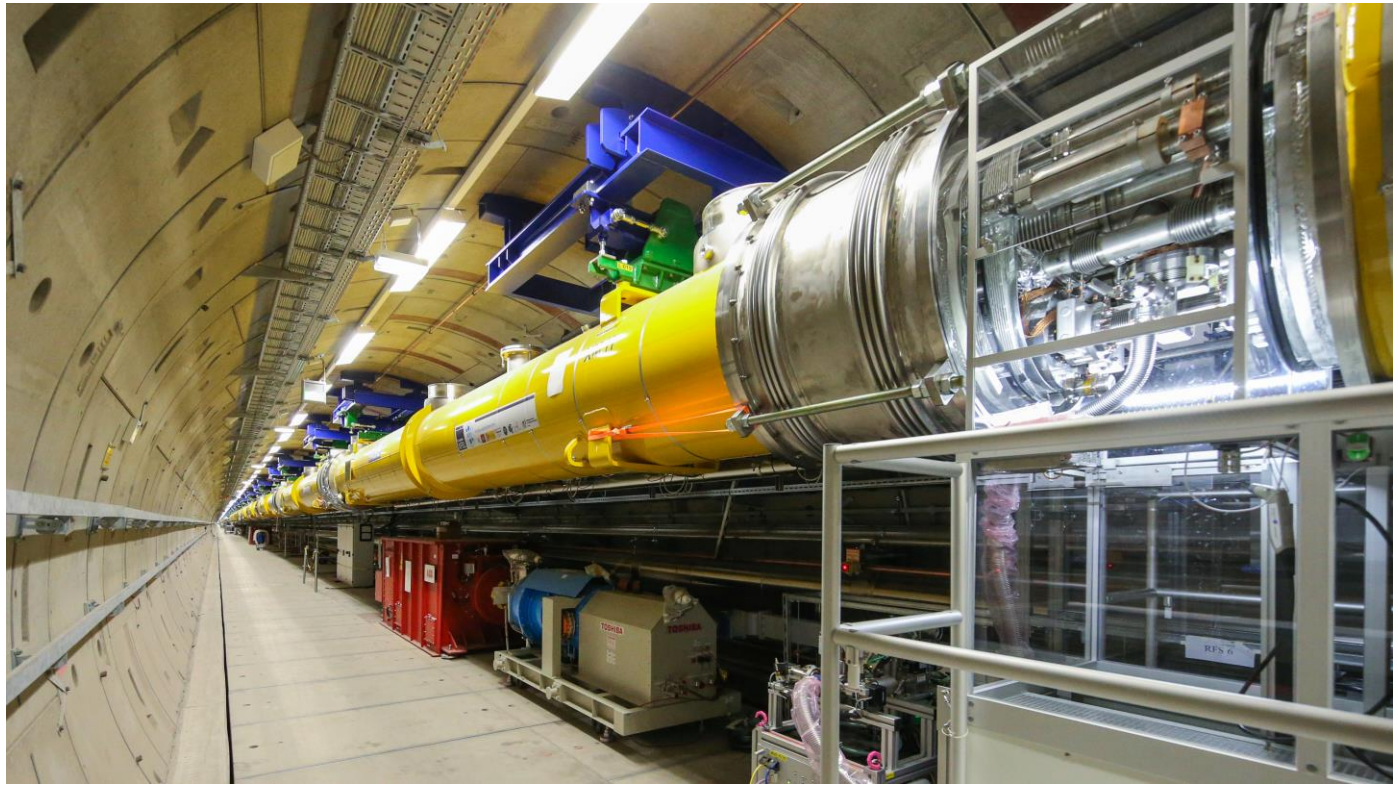
Outline

- Particle accelerator Master Oscillator introduction
- Libera building blocks overview
- Applications
- Recent developments

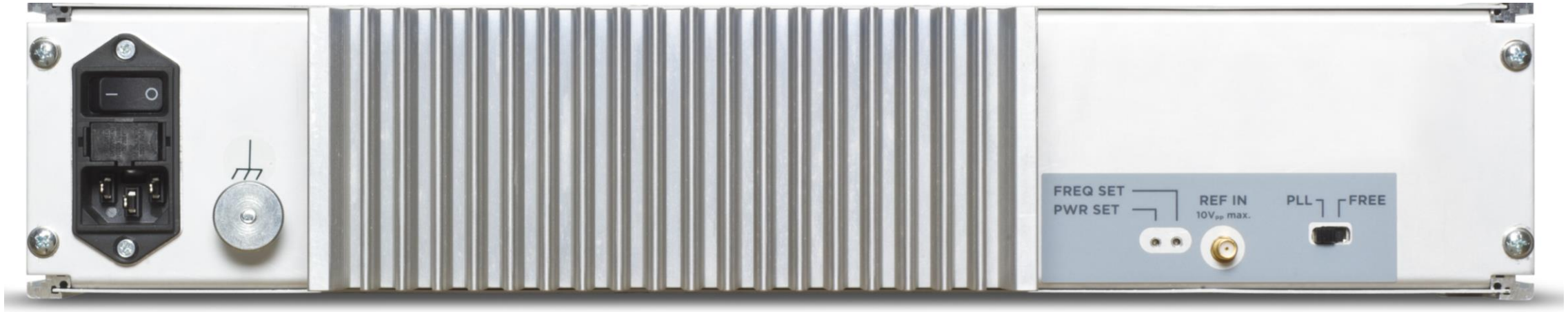
Introduction

Alternating gradient accelerators require:

- Synchronization of components with respect to a common phase reference (RF cavities, diagnostics…)
- Low jitter phase reference signal generation
- Stable distribution of the reference signal at spread locations. (low drift)
- Coherent generation of multiple frequencies from the same reference signal.
- Frequency tuning and continuous frequency sweep capabilities.
- Applications:
  - FELs
  - Synchrotron Light Sources
  - Particle therapy accelerators
  - Heavy particle linear accelerators



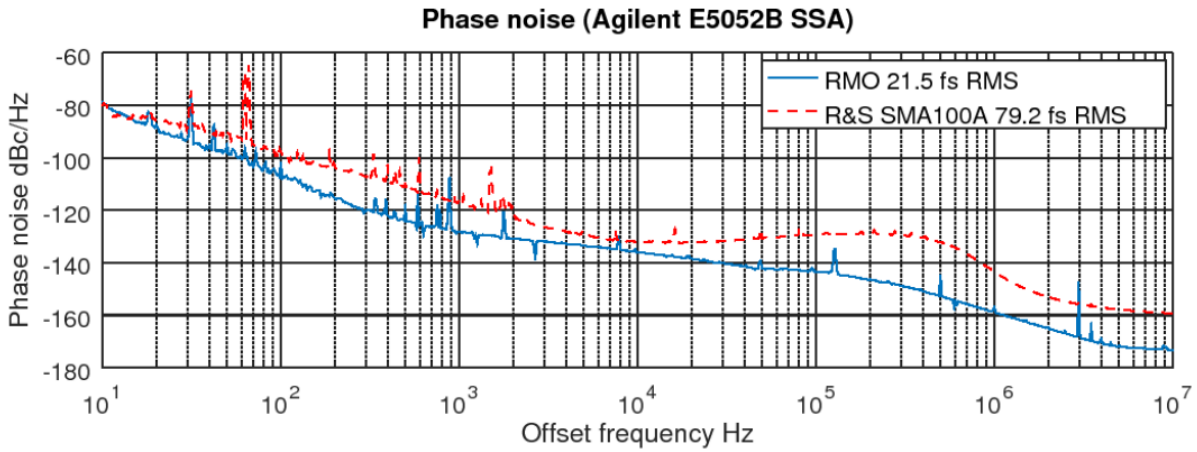
First generation Libera RMO (MO signal generation)

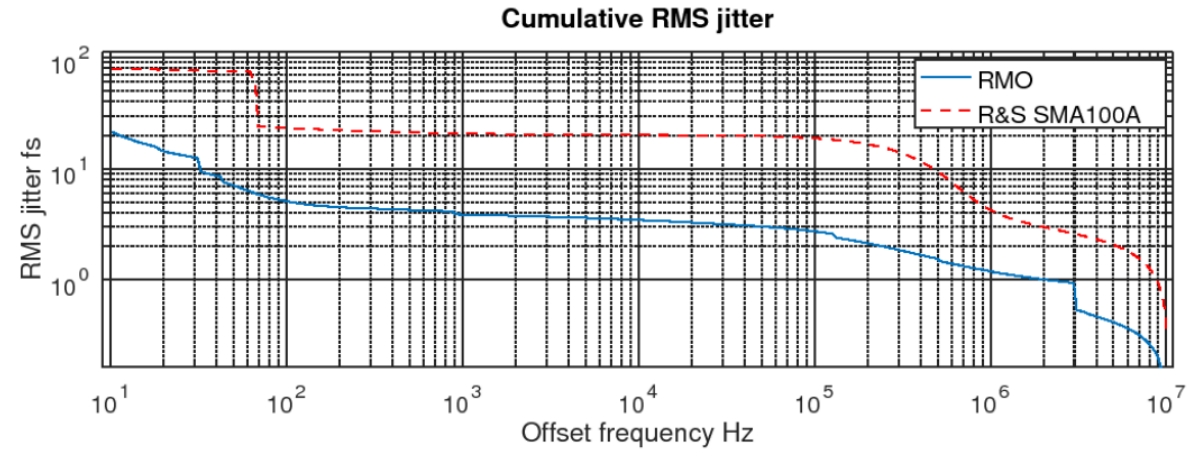


First generation Libera RMO features

Key features:

- Very low jitter: < 30 fs (10 Hz to 10 MHz)
- PLL locked OCXO based Reference Master Oscillator with frequency multiplication stages
- 4 RF outputs, up to +18 dBm
- Passive cooled design with temperature stabilized output RF splitter

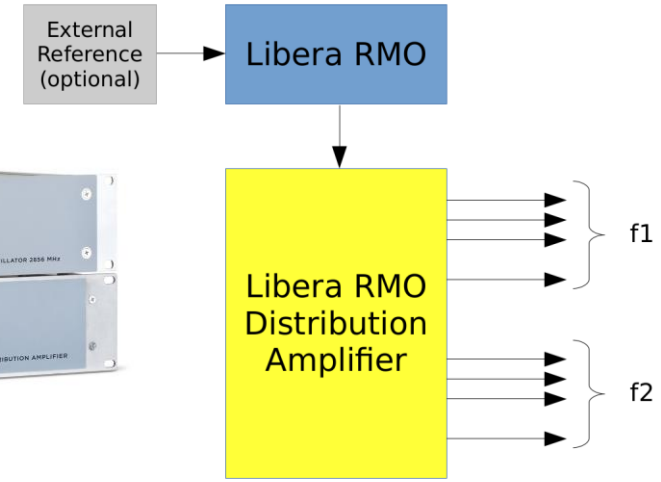




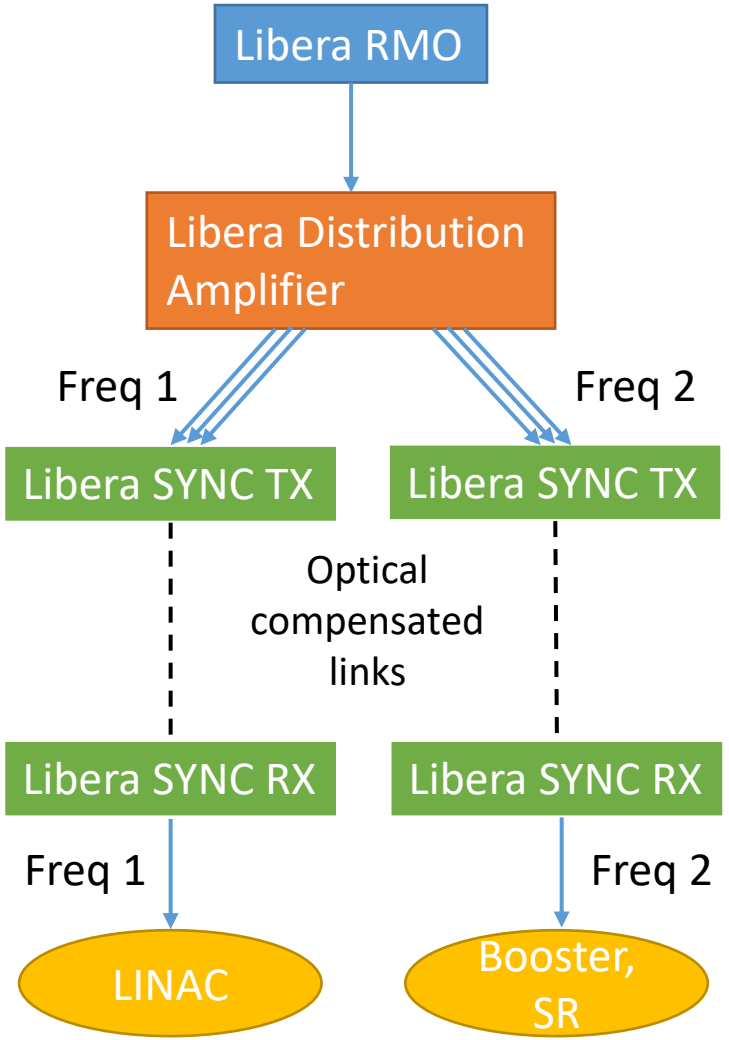
The Libera RMO Distribution Amplifier (MO distribution)

Key features:

- Active RF splitter to distribute the RMO signal to multiple users (up to 16 RF outputs)
- Low drift temperature stabilized design (based on Libera Sync and Libera LLRF TSRF)
- Low added jitter
- Possibility to generate output signals at multiple frequencies (harmonically related).

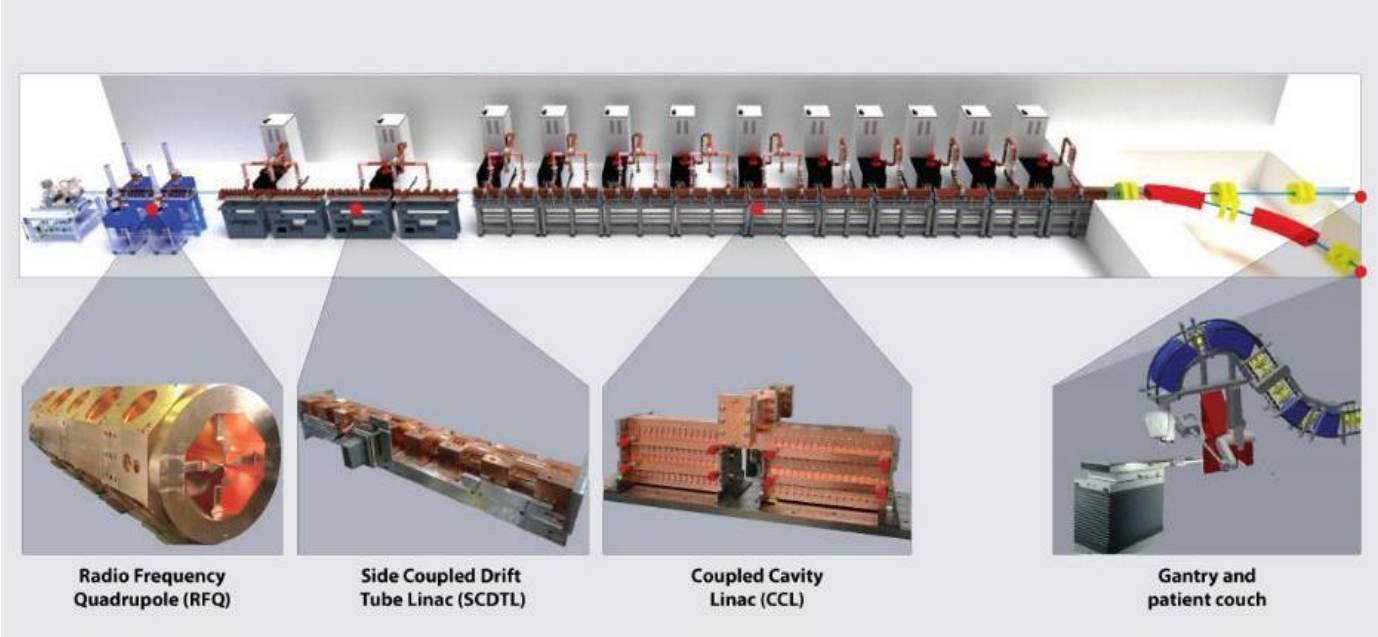


The MO generation and distribution building blocks



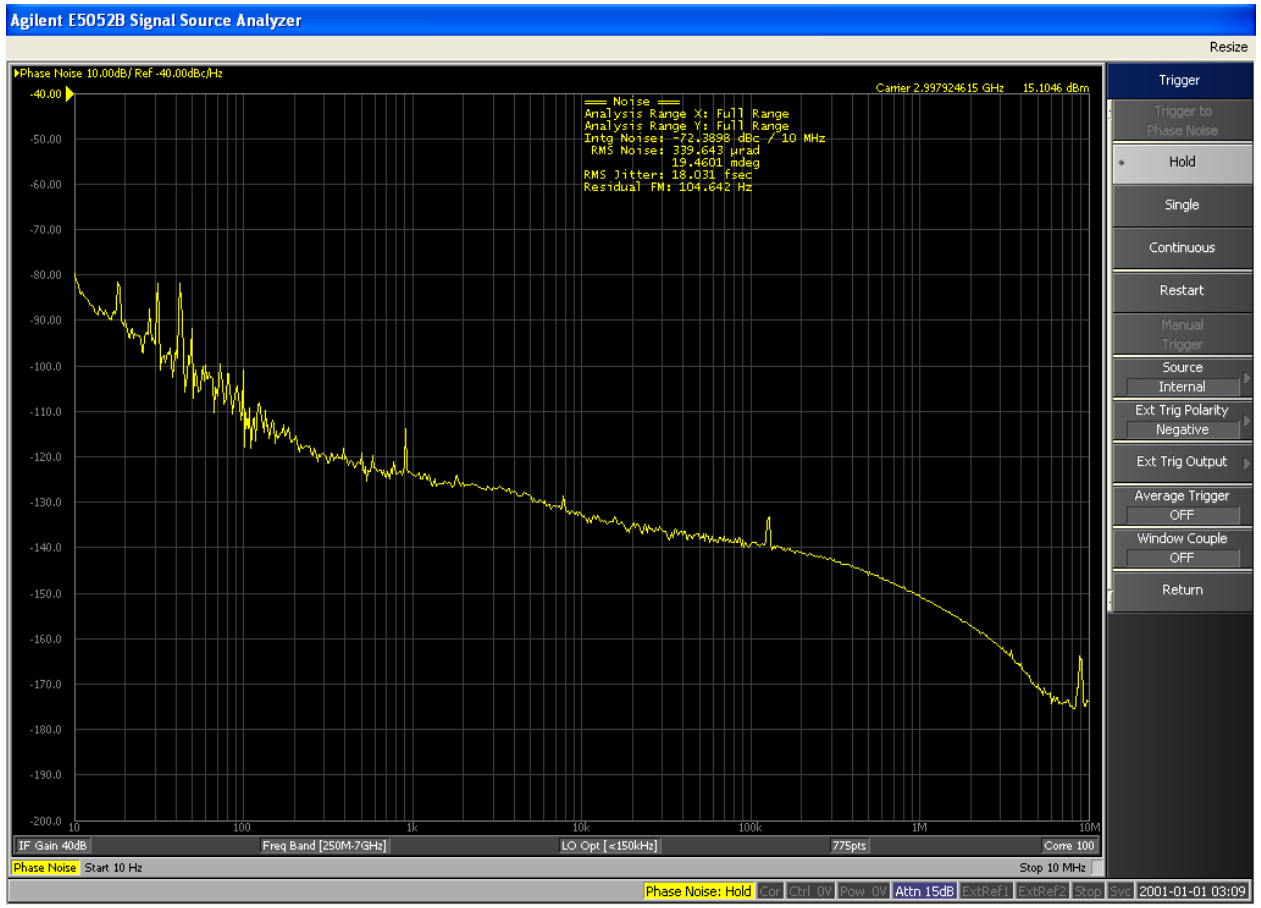
AVO proton therapy and other heavy particle applications

- Compact linear proton therapy accelerator based on 13 RF stations (LIGHT) (a 750 MHz RFQ and 3 GHz SCDTL and CCL structures)
- Libera RMO and Libera RMO DA are used to distribute the MO reference to each RF station, including the 750 MHz reference derived by the 3 GHz reference.
- Other heavy particle application would require MO frequency to be dynamically tuned to compensate the RFQ detune.

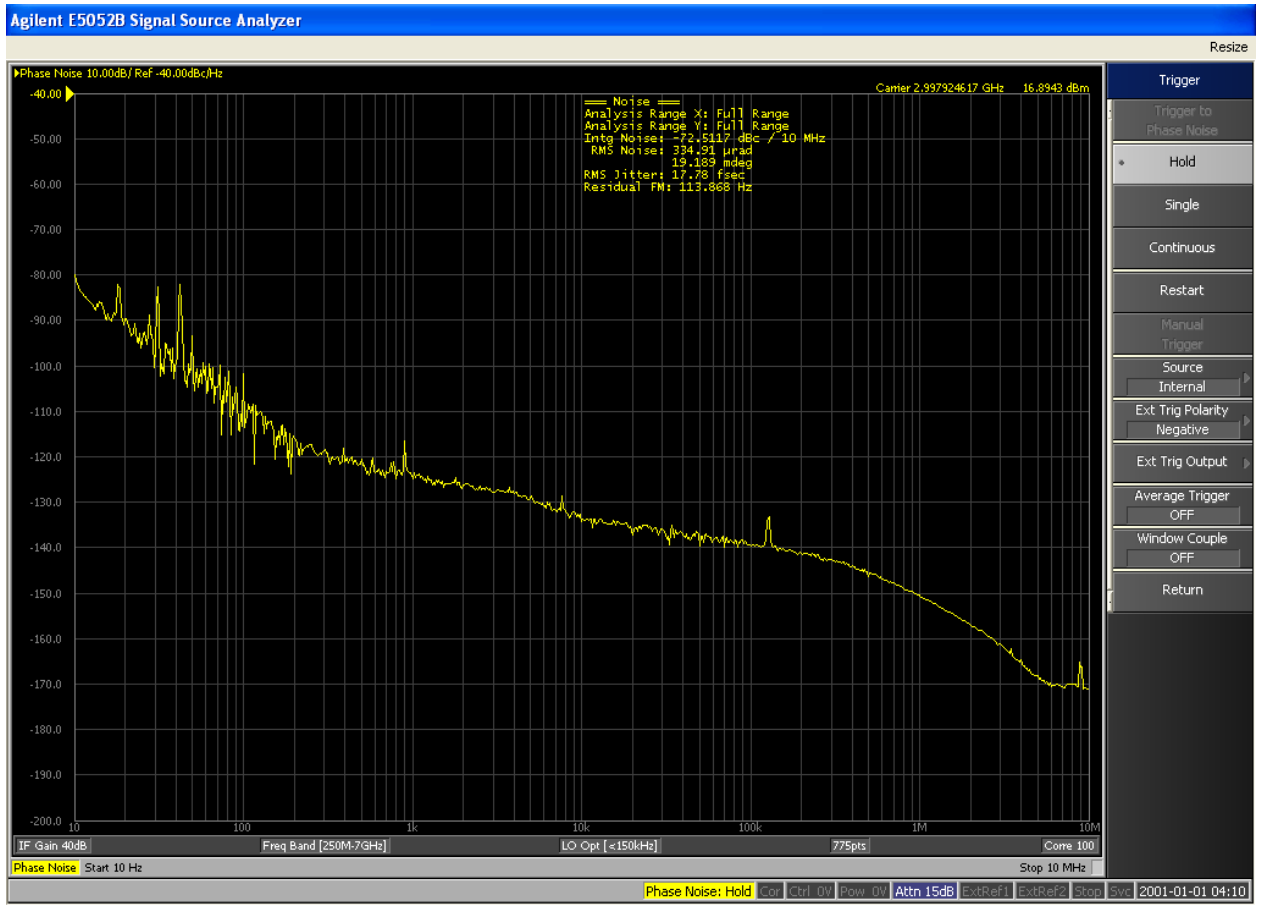


ADAM
an ADVANCED ONCOTHERAPY company

Libera RMO jitter performance 1/2

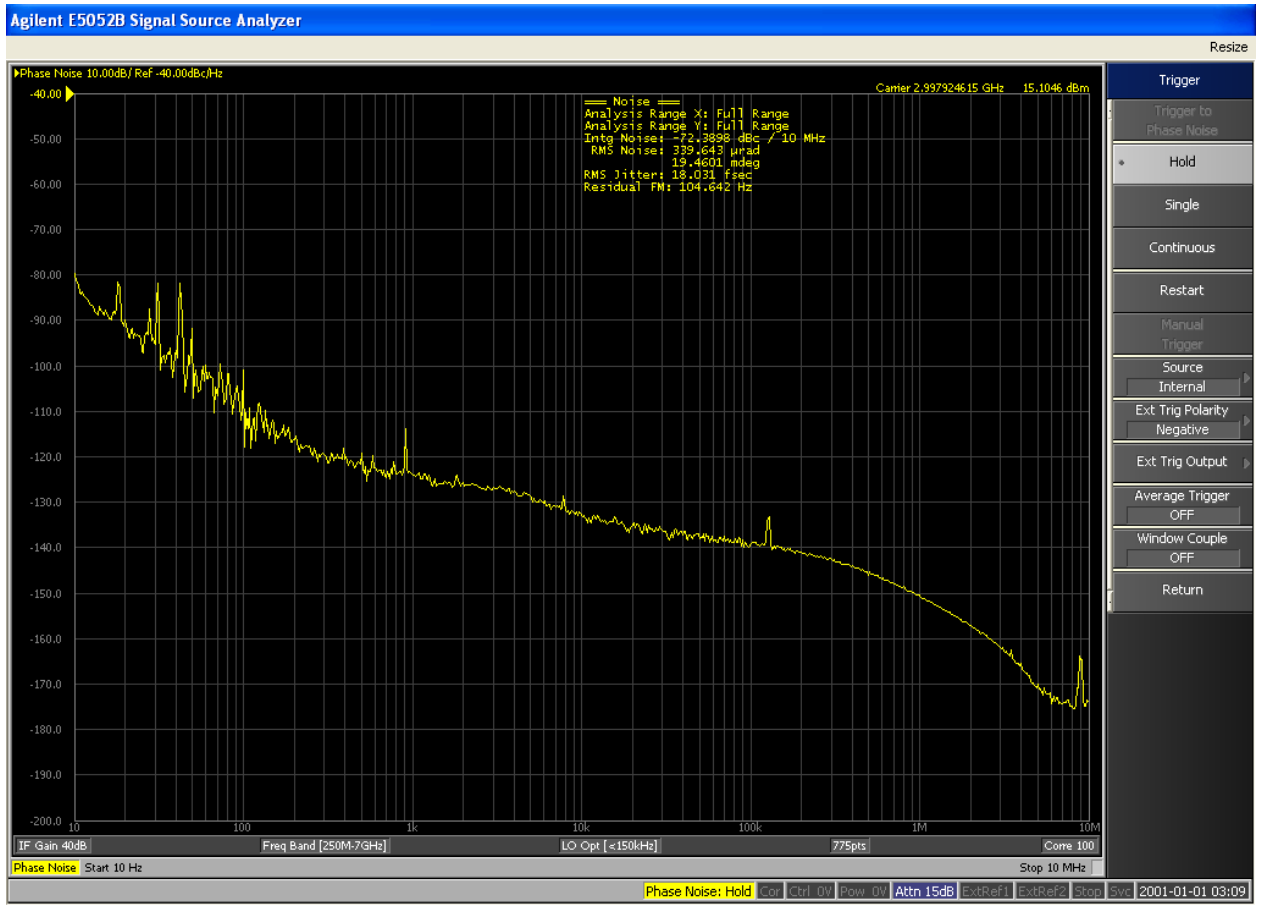


Libera RMO output (3 GHz) 18.03 fs

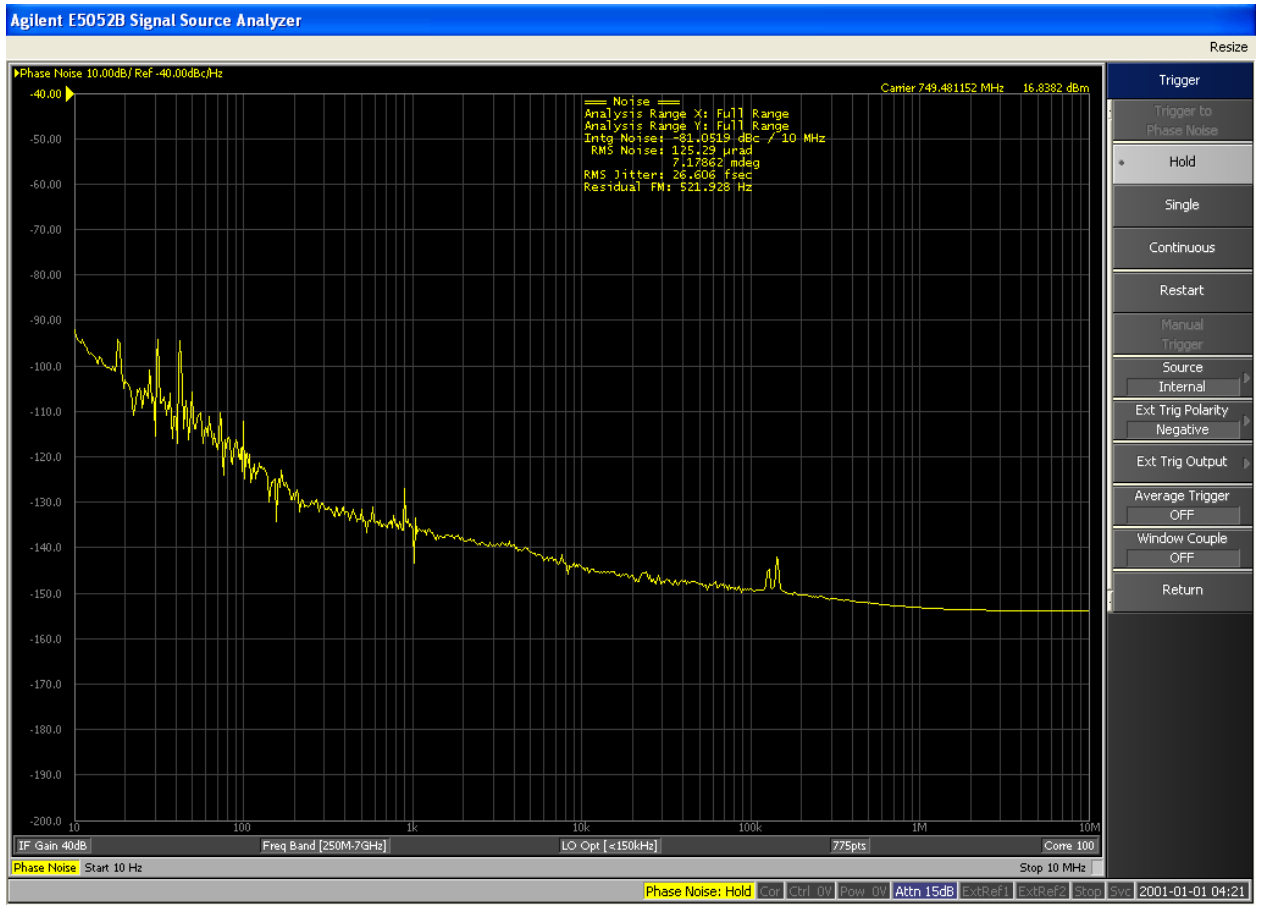


Libera RMO DA output (3 GHz) 17.78 fs

Libera RMO jitter performance 2/2



Libera RMO output (3 GHz) 18.03 fs

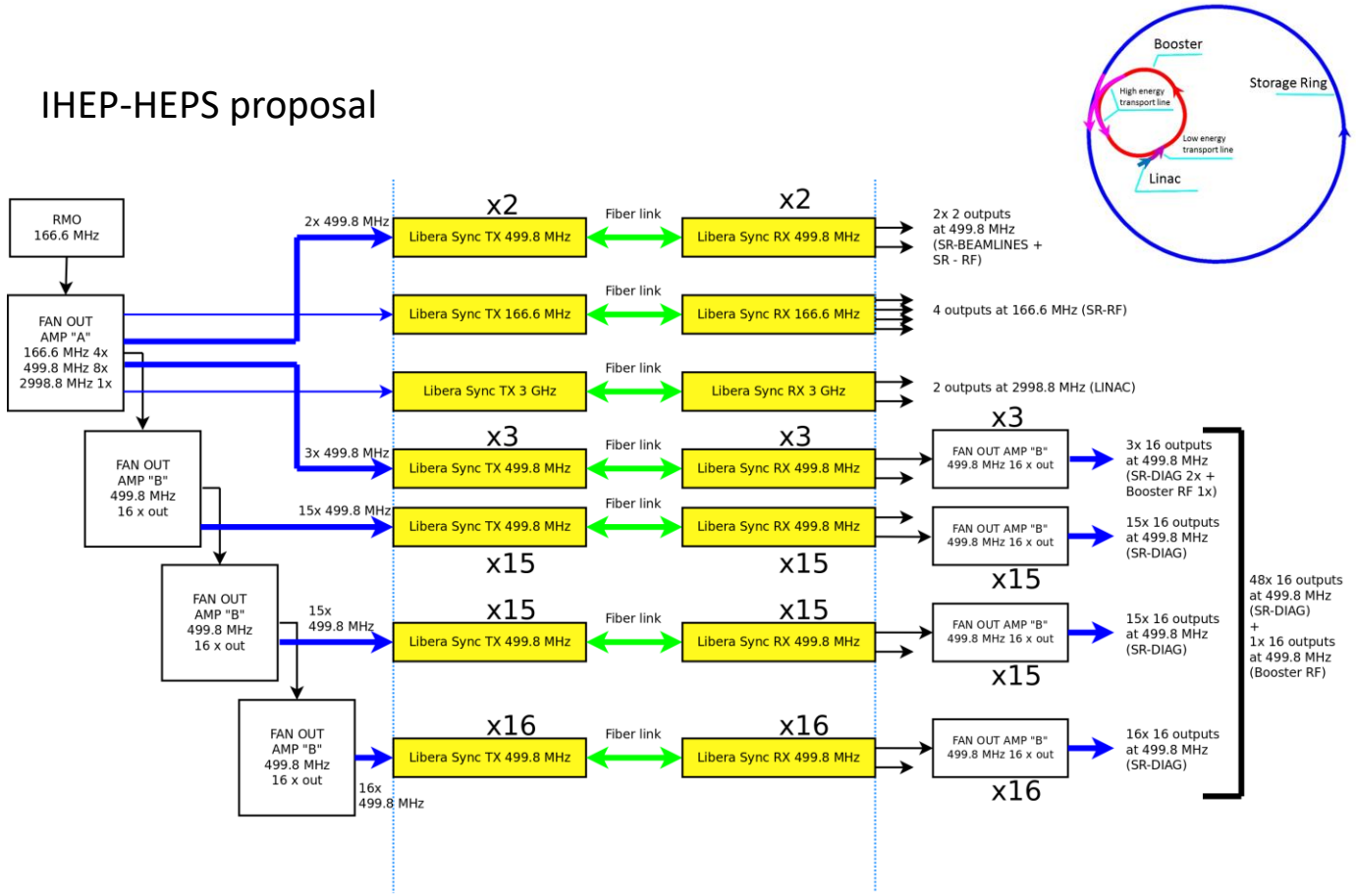


Libera RMO DA output (750 MHz) 26.6 fs

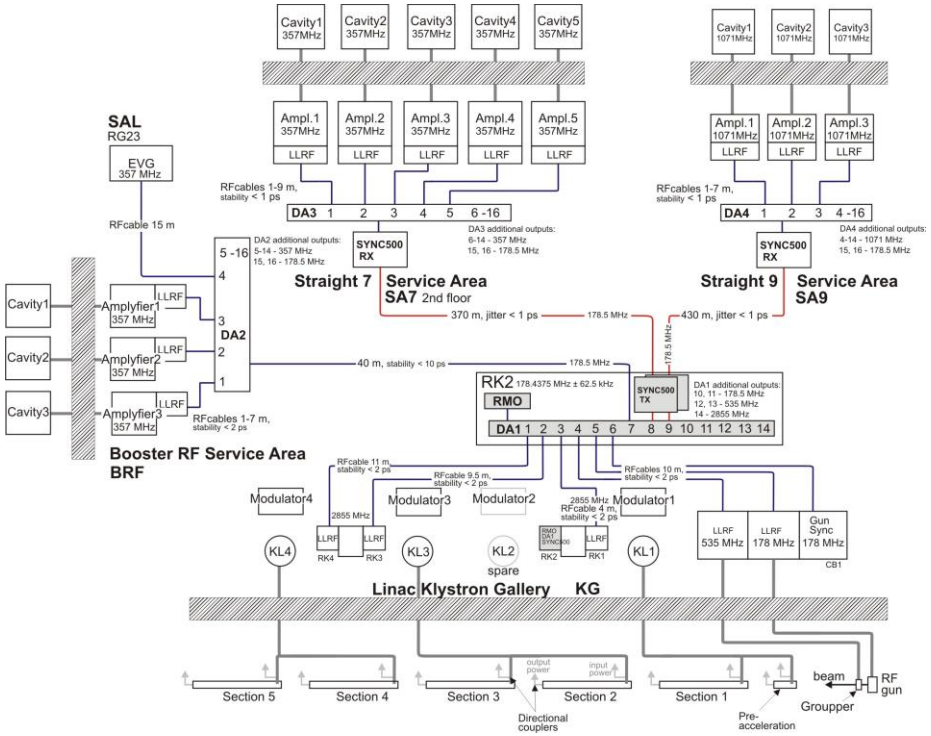
Applications: Synchrotron Light Sources

- LINAC, booster and synchrotron subsystem would need a common reference
- Multiple frequencies need to be generated and distributed to remote users at distant locations
- There is the need to continuously tune the reference frequency to track the changes in the rings

IHEP-HEPS proposal

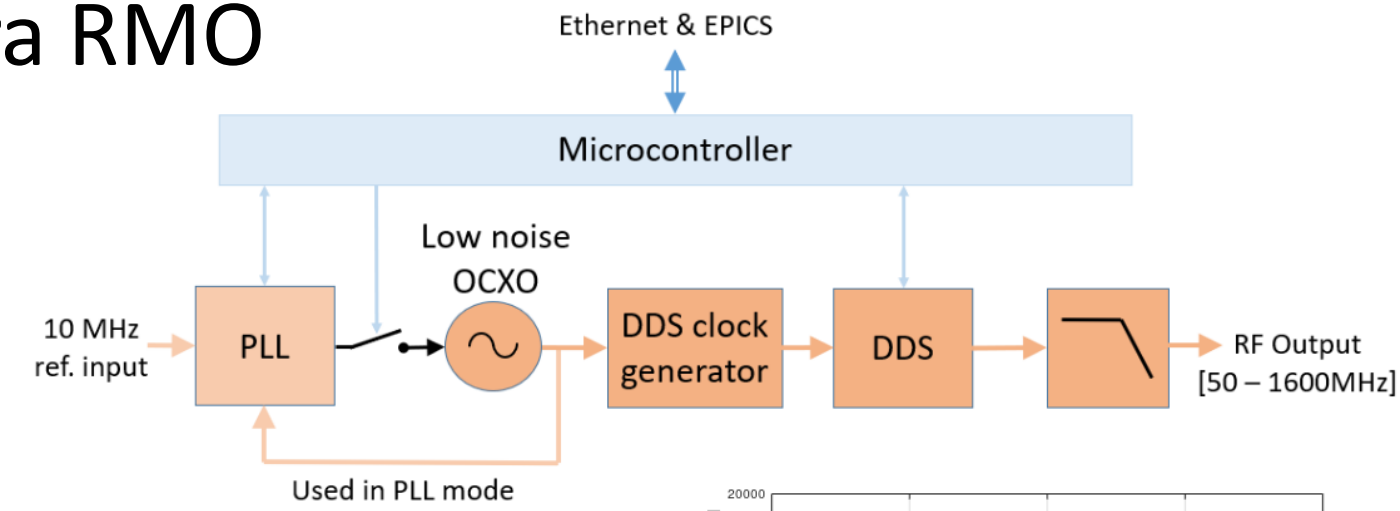


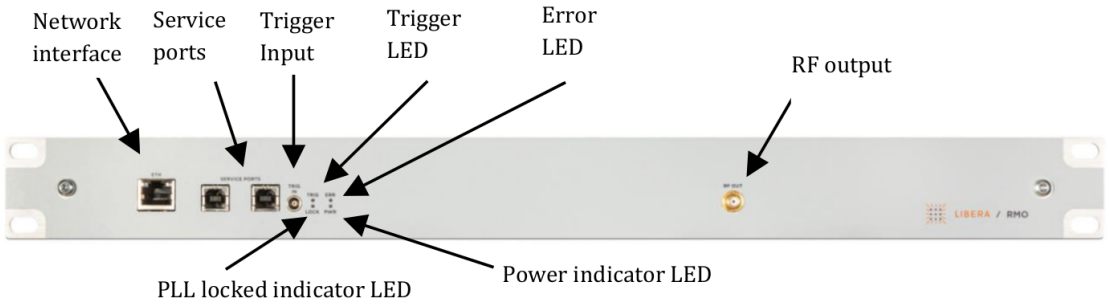
SKIF project at BINP

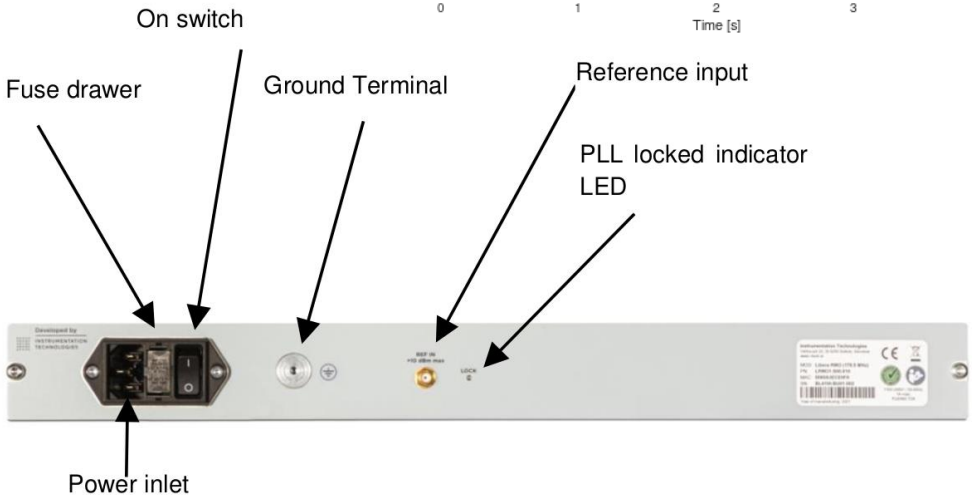


New generation of Libera RMO

- PLL locked based OCXO design upgraded with a DDS (Direct Digital Synthesizer)
- Improved frequency tuning range
- Frequency sweep capability and continuous phase transitions.
- Remote control over Ethernet with the possibility to be upgraded with an EPICS IOC.
- External triggering option to synchronize frequency adjustment time to avoid RF pulses.
- Different output stages and frequency ranges supported.
- Typical jitter: ~50 fs (10 Hz – 10 MHz)

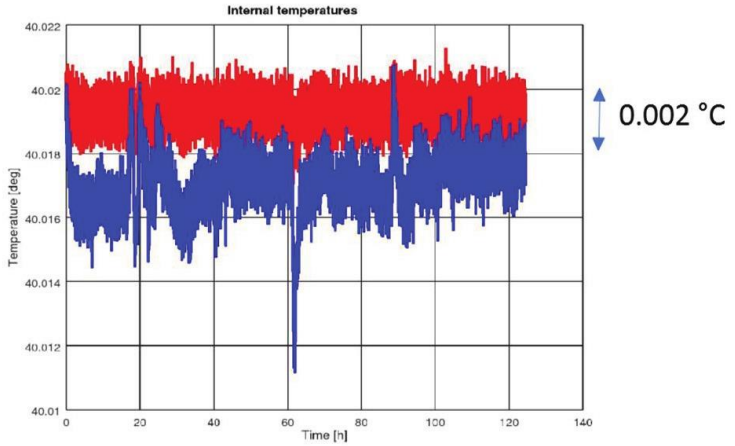


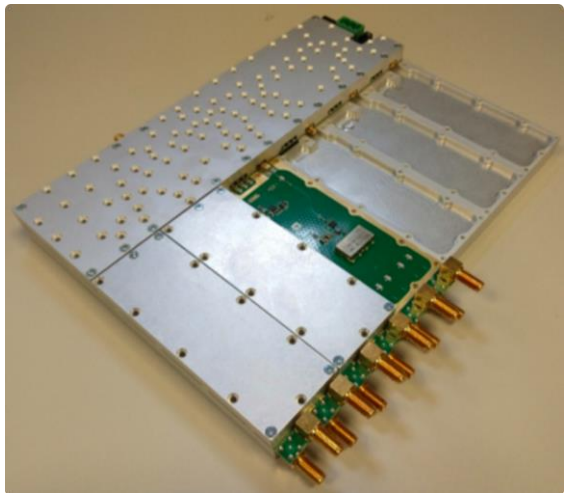


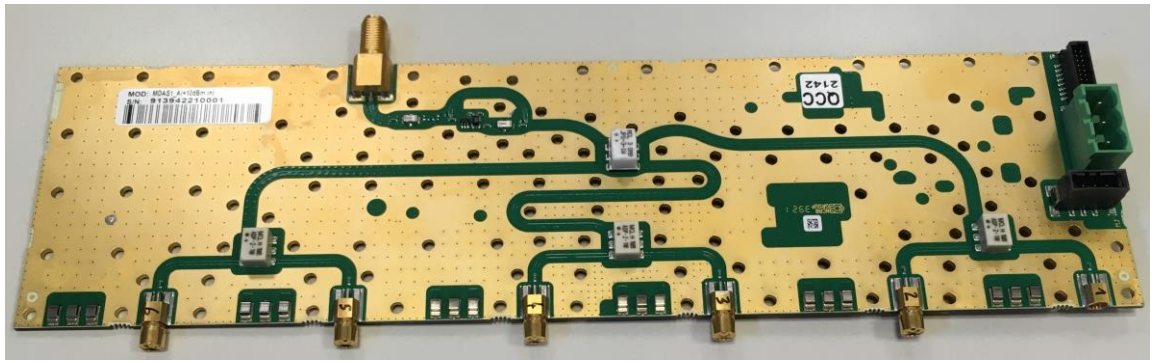


New generation modular Libera RMO DA

- Modular temperature stabilized design to simplify the frequency customization
- Low jitter design
- Each module can generate a different frequency and provide 4 output channels
- Supporting up to 24 output channels







Thank you!
Questions?

www.i-tech.si

borut.baricevic@i-tech.si

Libera RMO

Libera RMO DA

Libera Sync