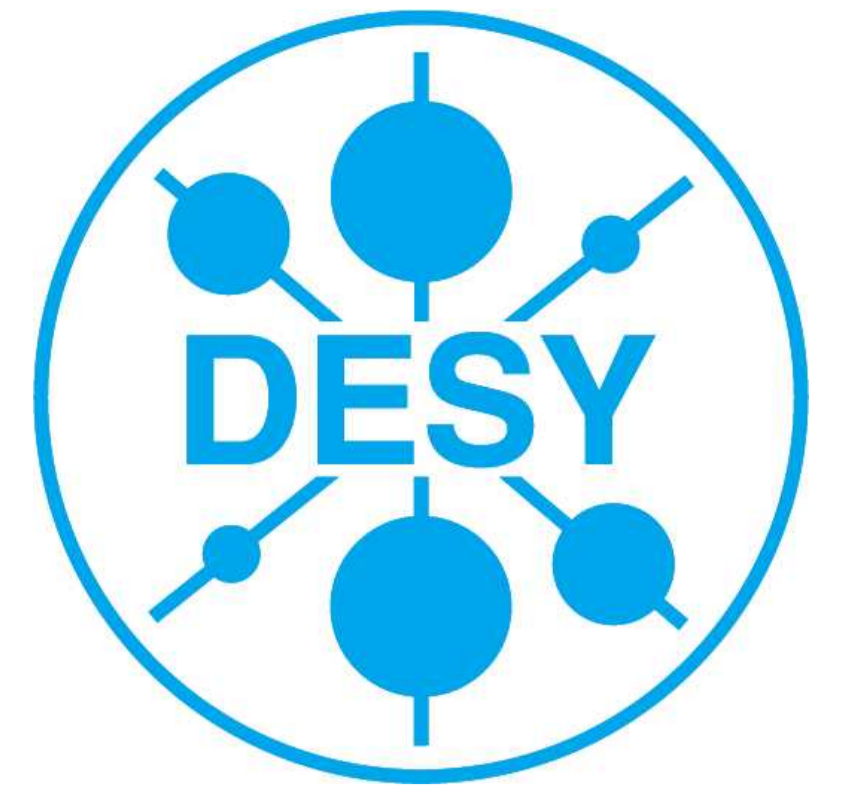


# The LLRF System for REGAE.

(Relativistic Electron Gun for Atomic Experiments)

M. Hoffmann, F. Ludwig, K. Czuba, M. Felber, O. Hensler, W. Jalmuzna, H. Kay, D. Makowski, L. Petrosyan, J. Piekarski, K. Rehlich, I. Rutkowski, H. Schlarb, C. Schmidt,



## System Overview

Requirements to achieve 10 fs stabilization:  
Phase Stability: 0.01 deg @ 3 GHz  
Gradient Stability: 10<sup>-4</sup>

Beam Parameters:  
• Energy: 5 MeV  
• Charge: < 1pC  
• Arrival Time Jitter: < 10 fs

RF Gun:  
• 1 1/2 cell  
• 110 MV/m  
• on-crest

Buncher Cavity:  
• 4 cell  
• 40 MV/m  
• 90° off crest

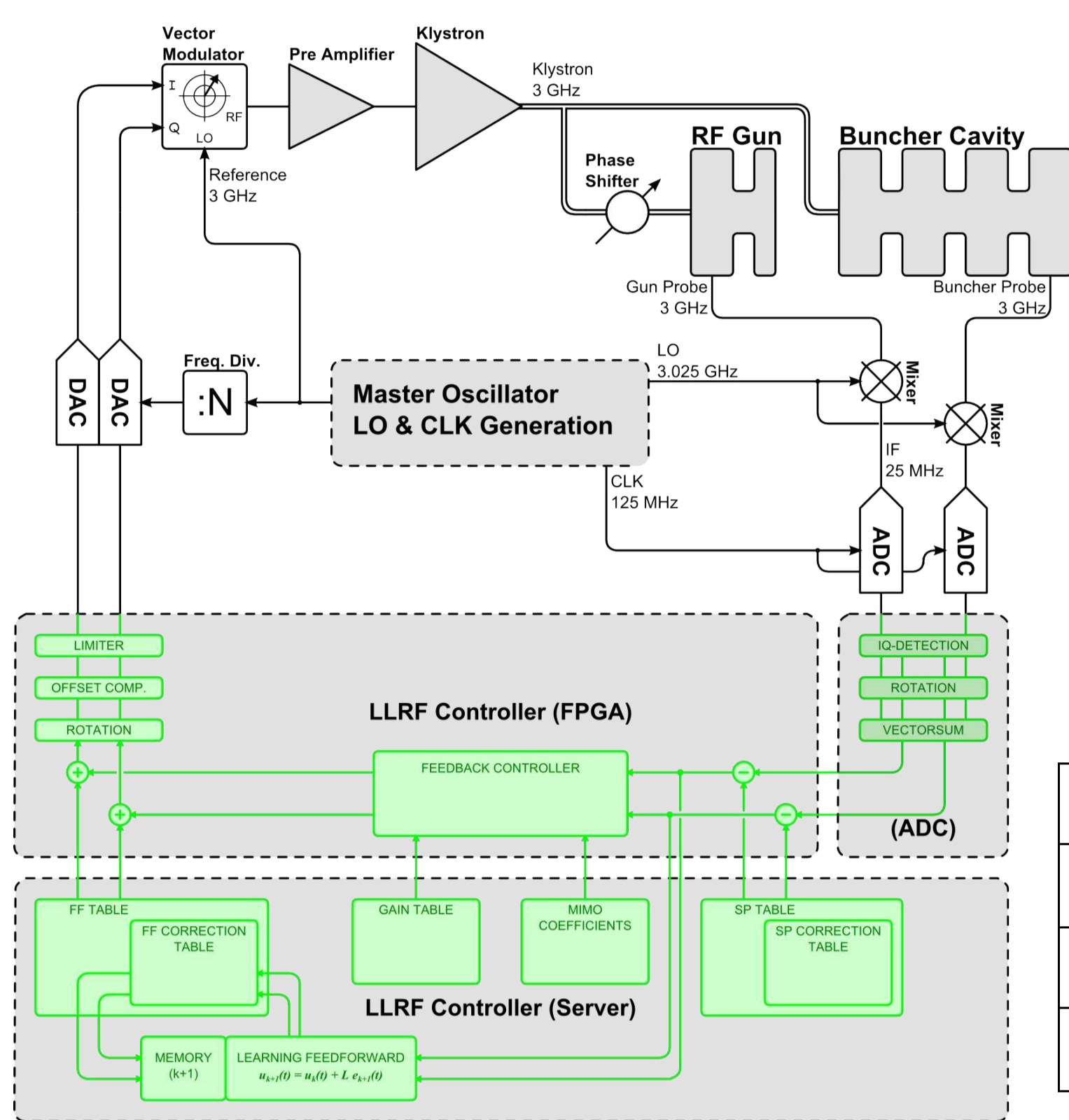
RF Parameters:  
Fundamental Frequency: 3 GHz, S-Band

Power Distribution:  
• Klystron: 24 MW  
• RF Gun: 17 MW  
• Buncher: 6 MW

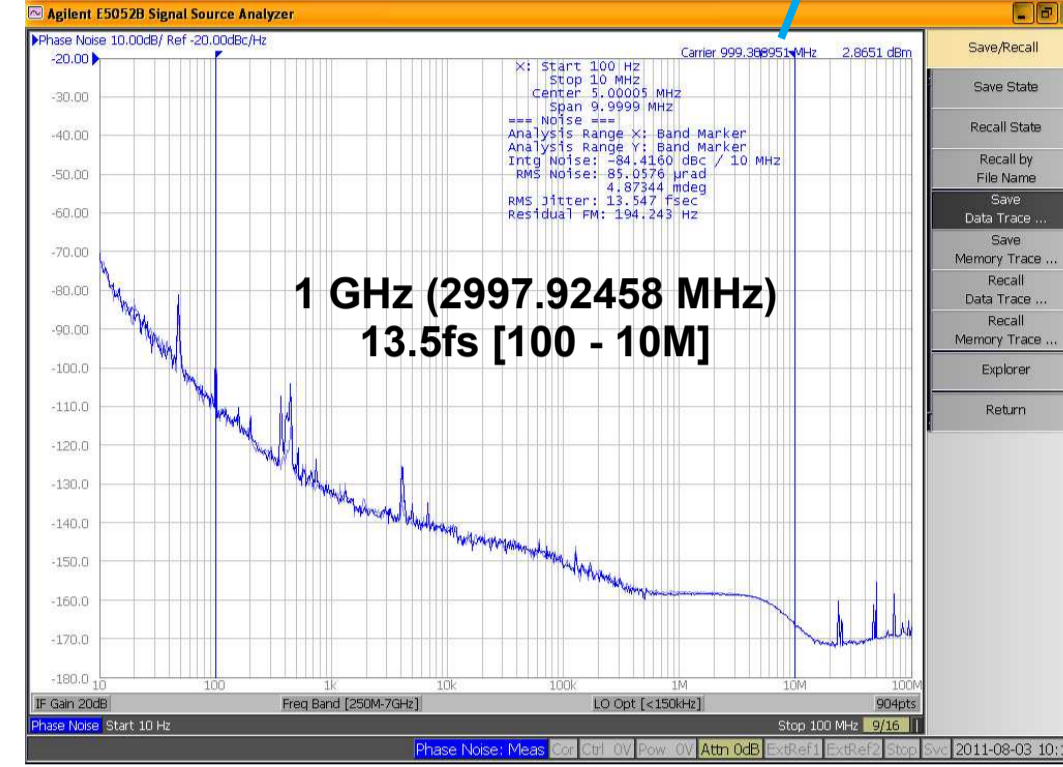
Pulse Repetition Rate: 50 Hz  
Pulse Length: 6 us (max.)

Tolerances:

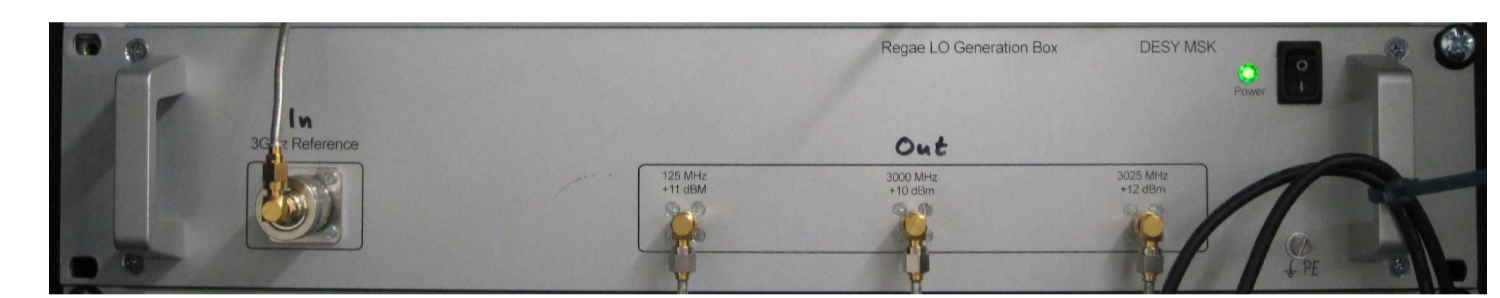
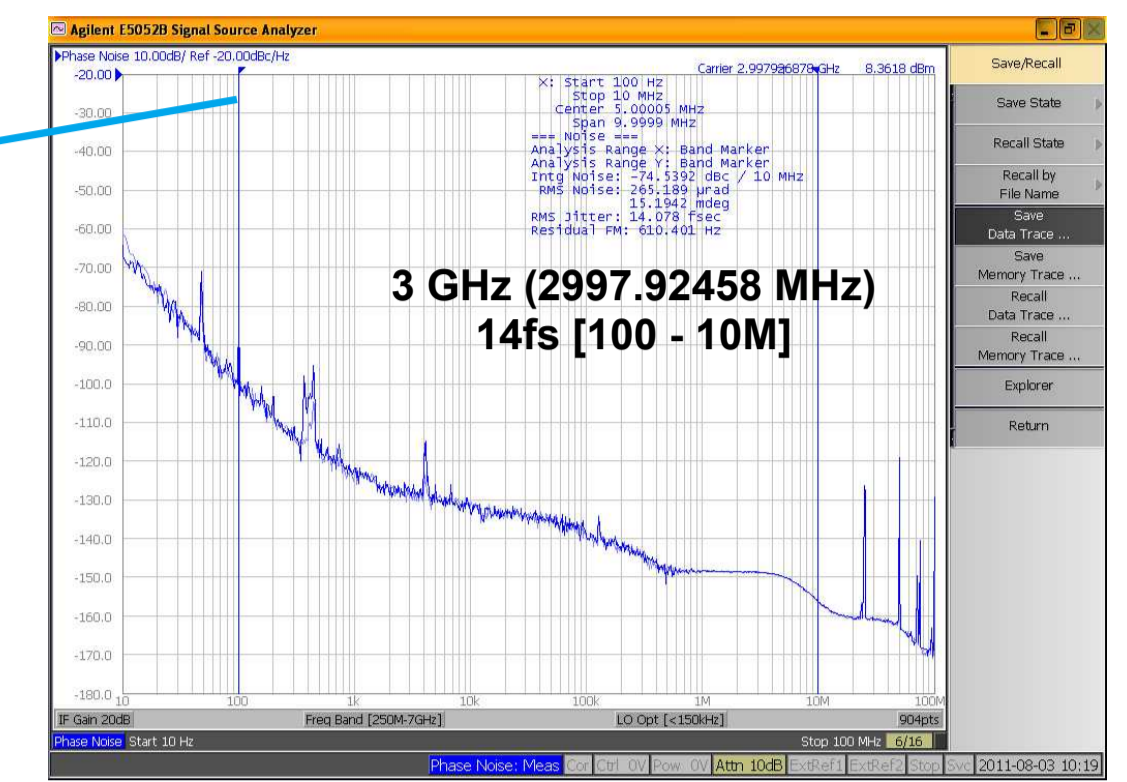
Gun phase	$\Delta t = 100$ fs/deg $\Delta E = -14$ keV/deg
Gun gradient	$\Delta t = -938$ fs/mV $\Delta E = 22$ keV/mV
Buncher phase	$\Delta t = -1286$ fs/deg $\Delta E = 5.3$ keV/deg
Buncher gradient	$\Delta t = 25$ fs/mV $\Delta E = 1.5$ keV/mV



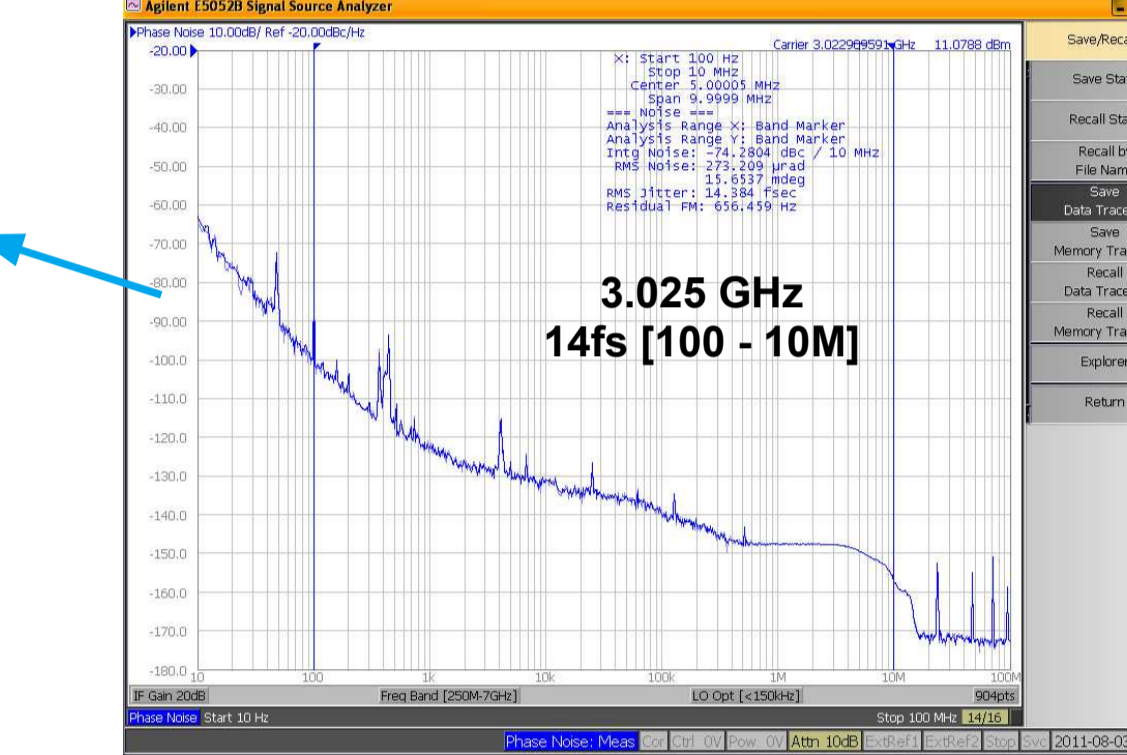
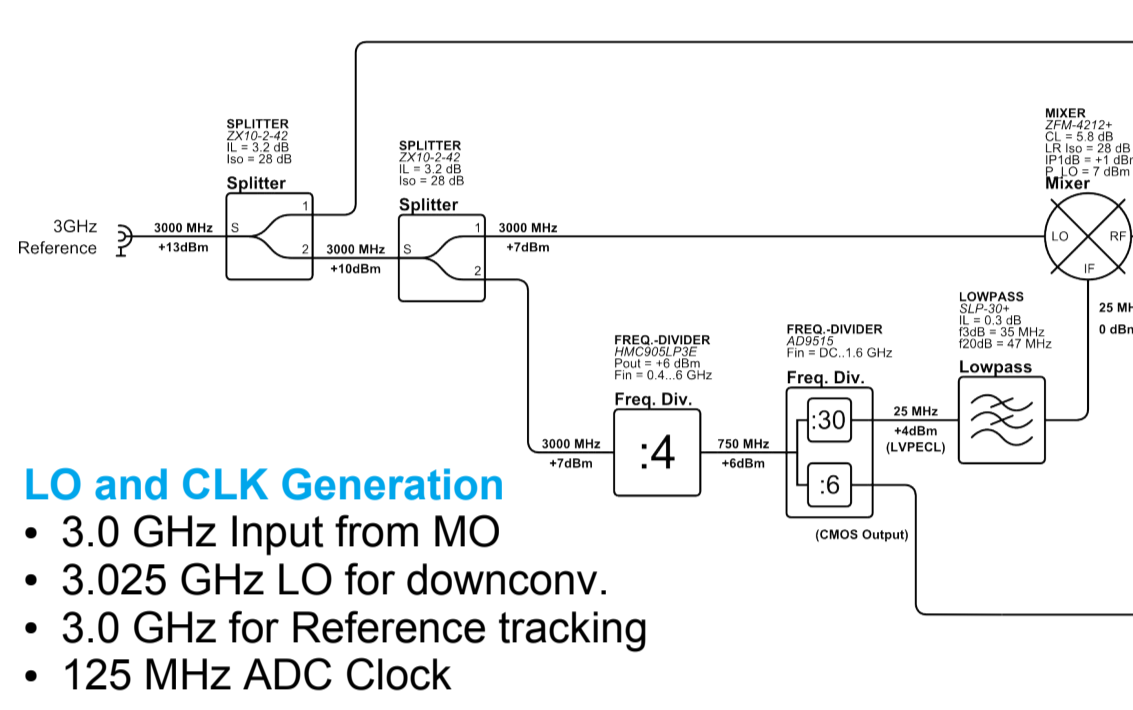
## Master Oscillator & LO Generation



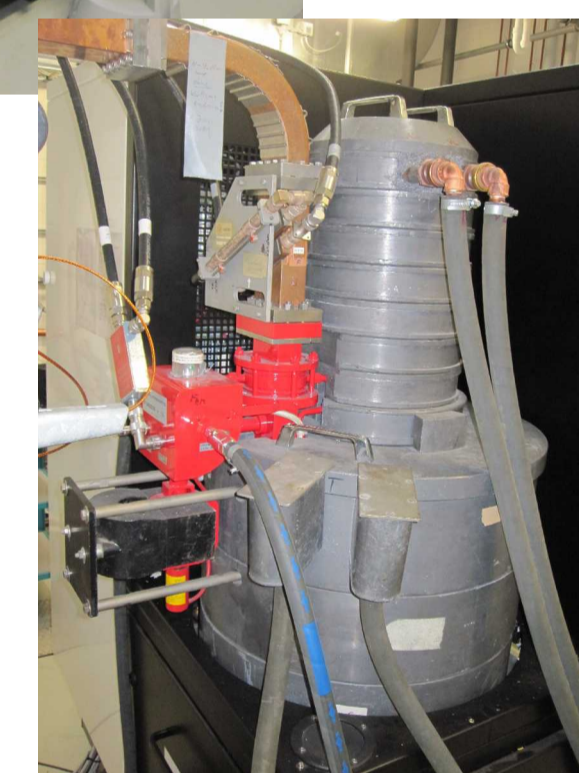
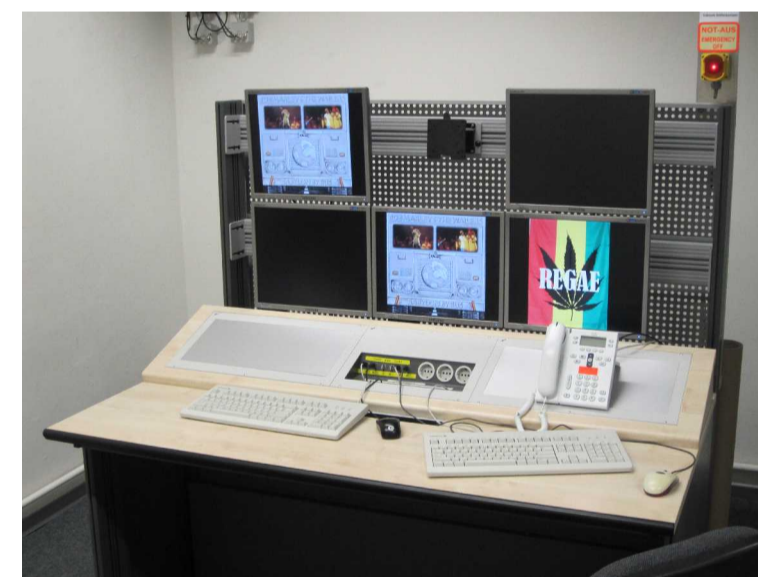
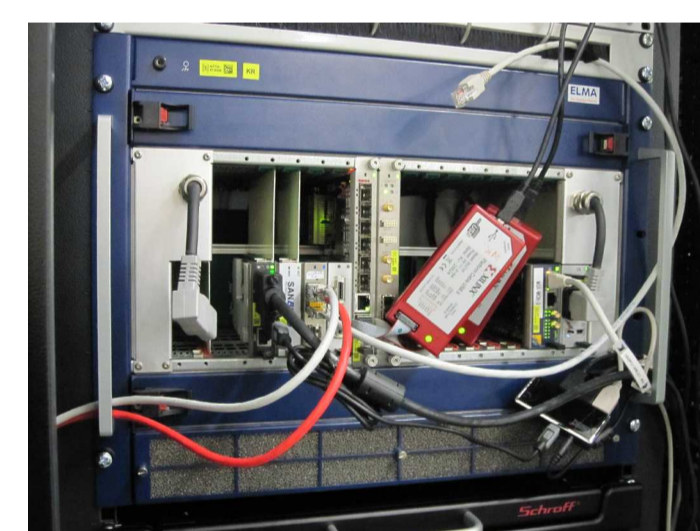
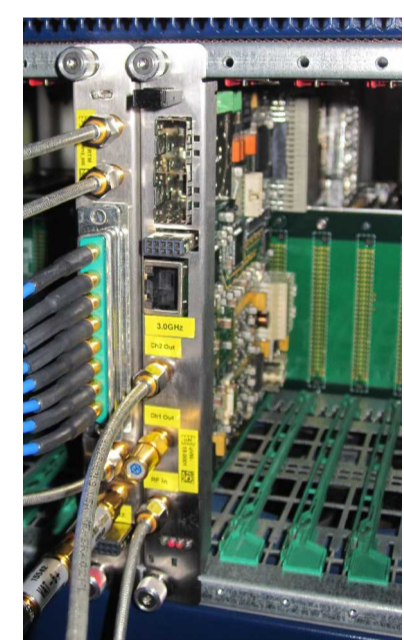
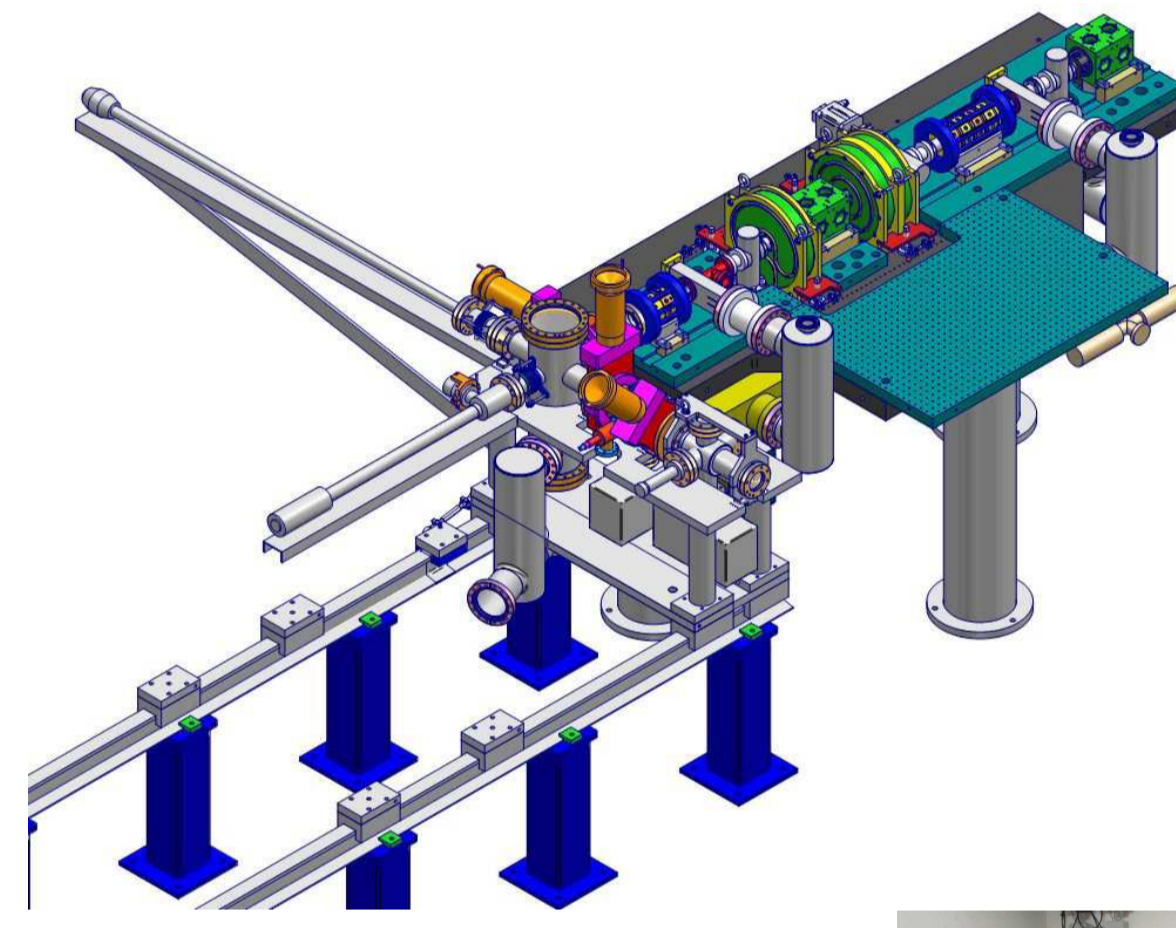
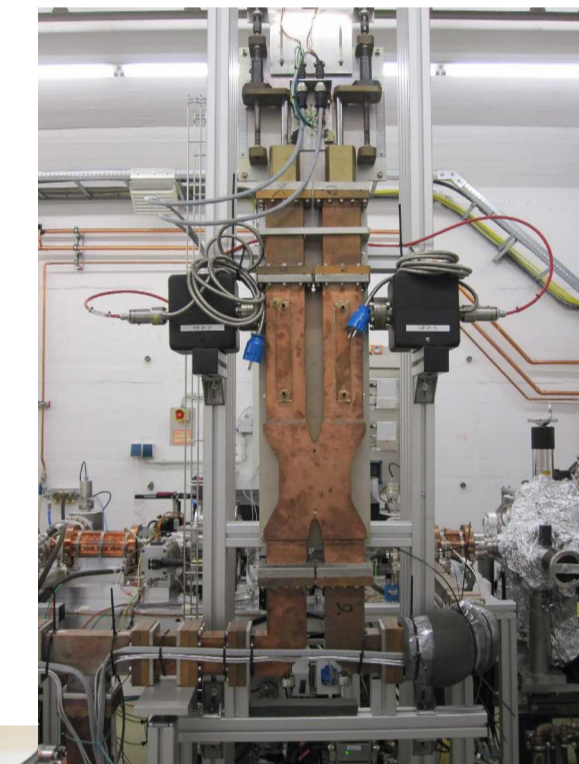
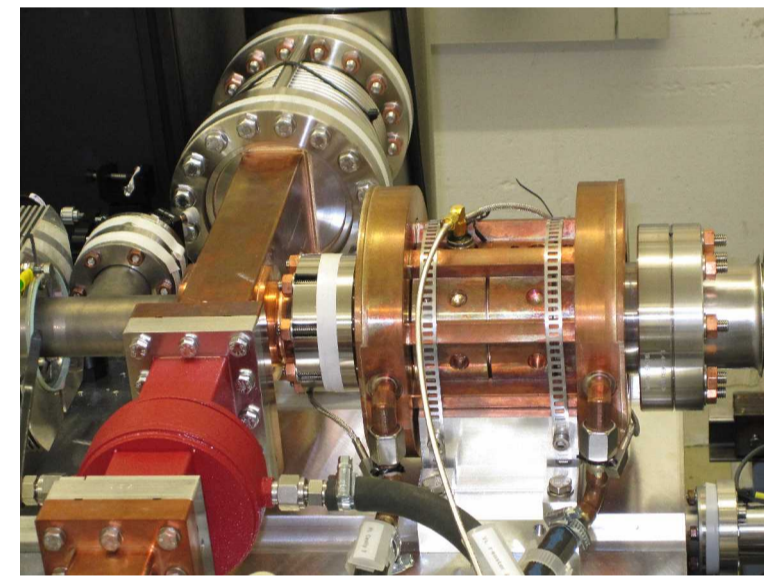
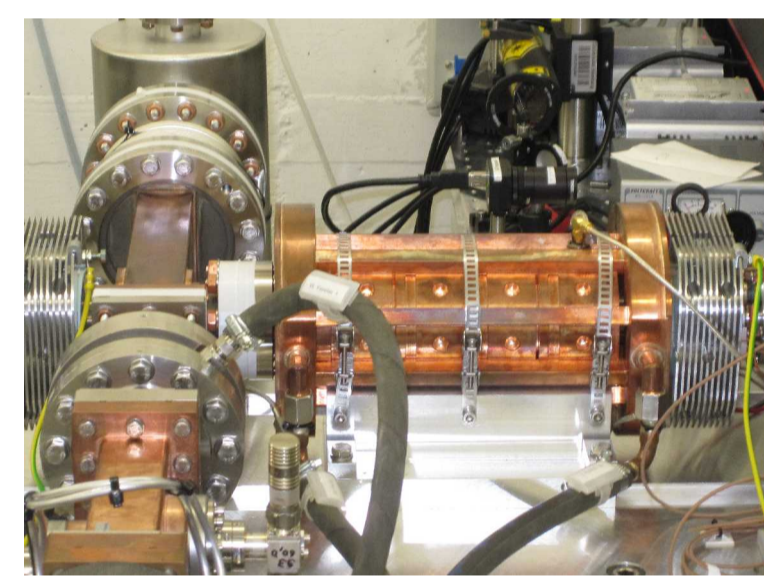
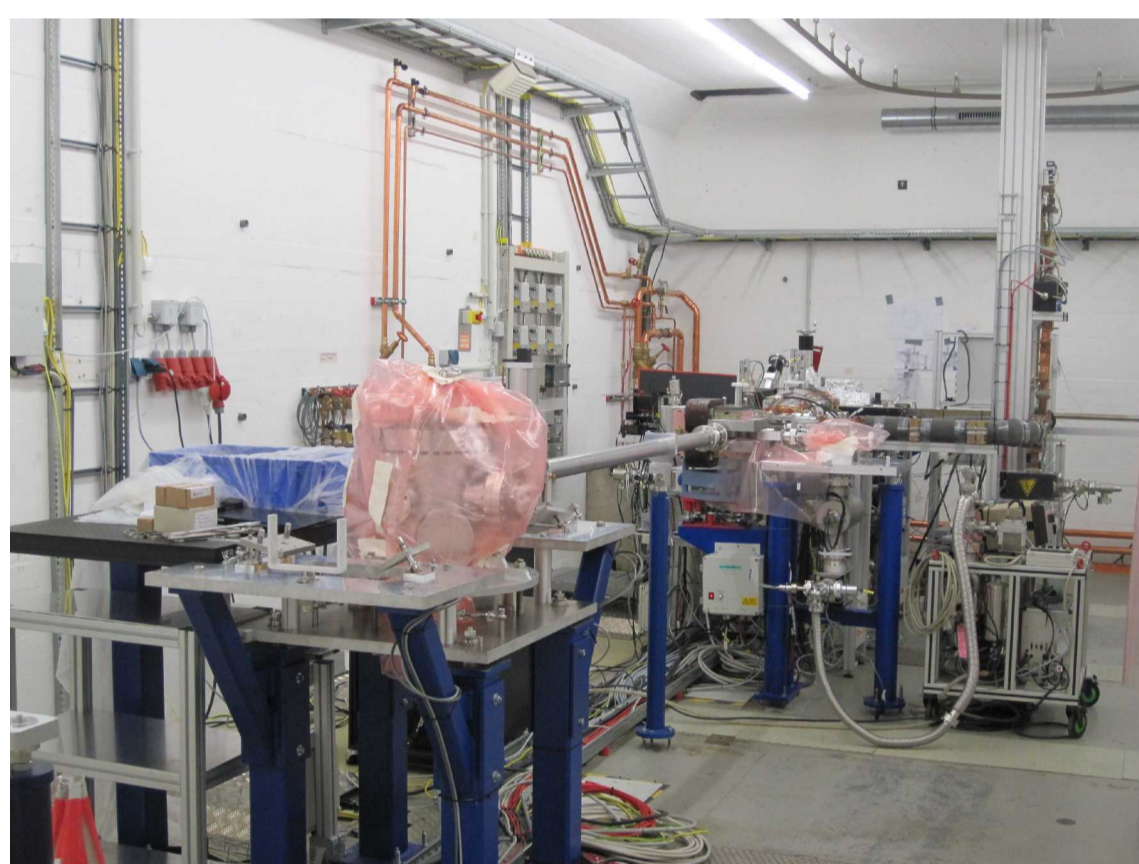
- MO Output Signals:
- 3 GHz (2997.92458 MHz)
  - Reference Signal
  - Vector Mod. LO
  - LO Generation Box
  - 1 GHz
  - Timing System
  - 83 MHz
  - Laser Synch. Backup



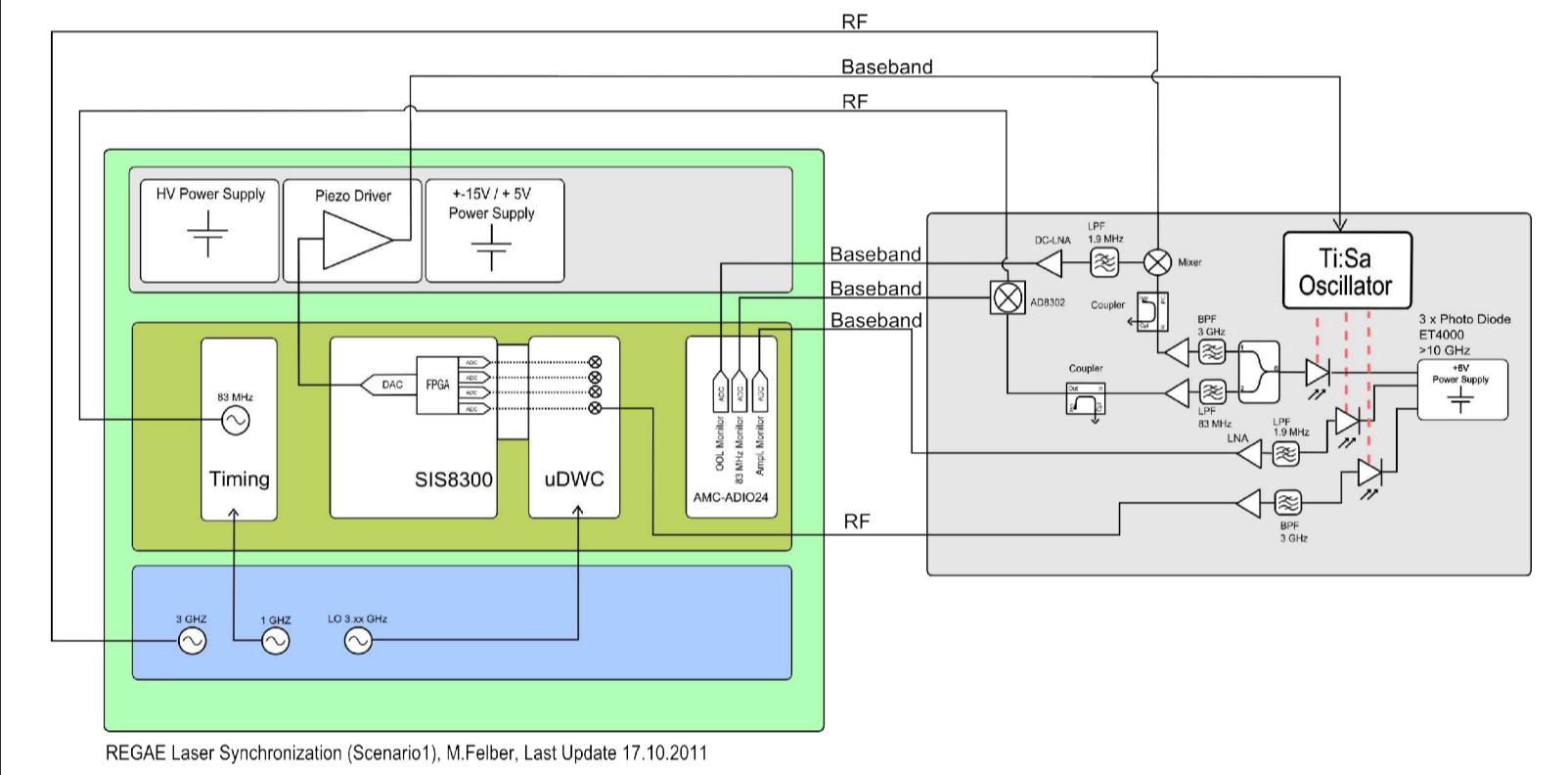
- LO and CLK Generation
- 3.0 GHz Input from MO
  - 3.025 GHz LO for downconv.
  - 3.0 GHz for Reference tracking
  - 125 MHz ADC Clock



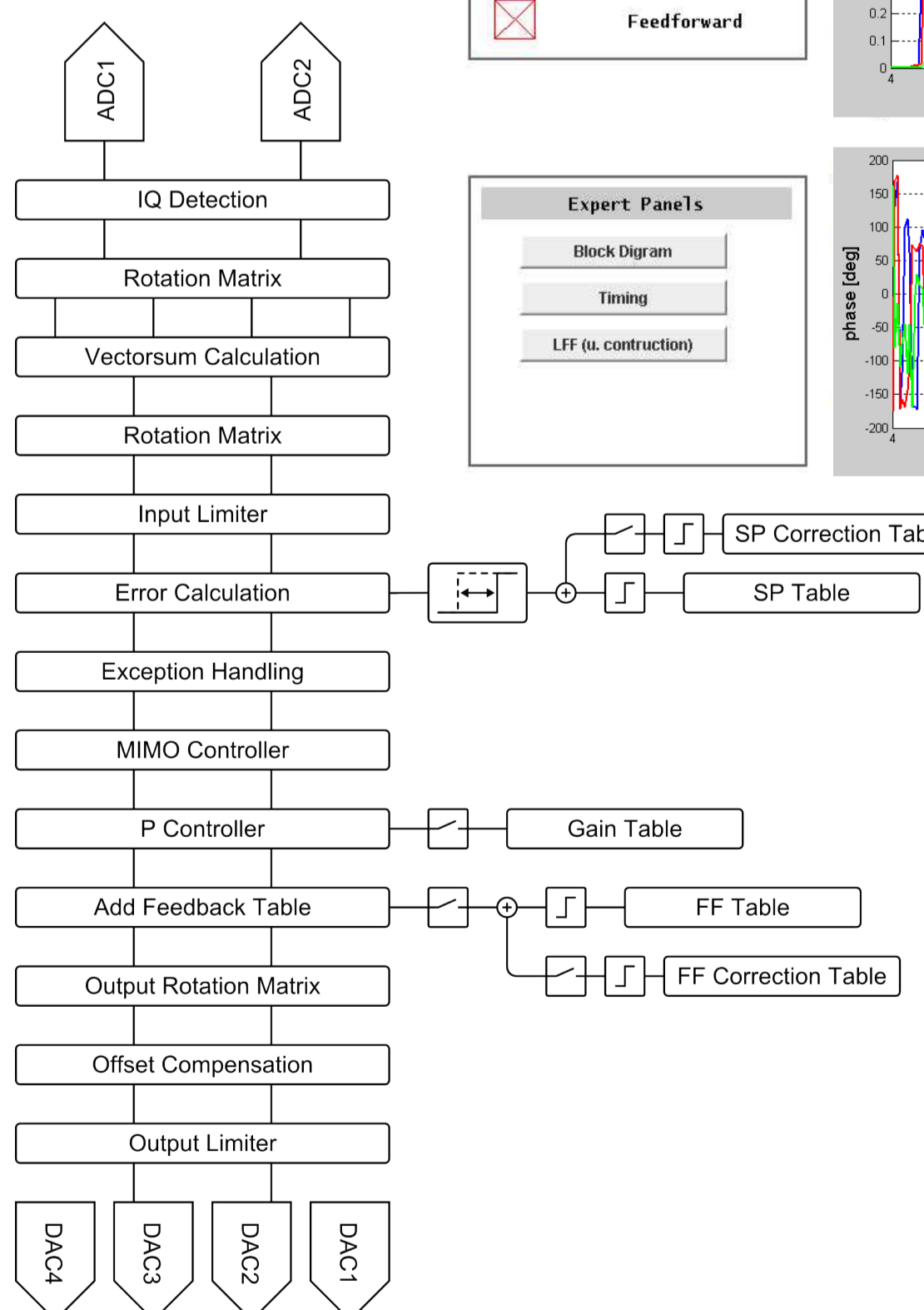
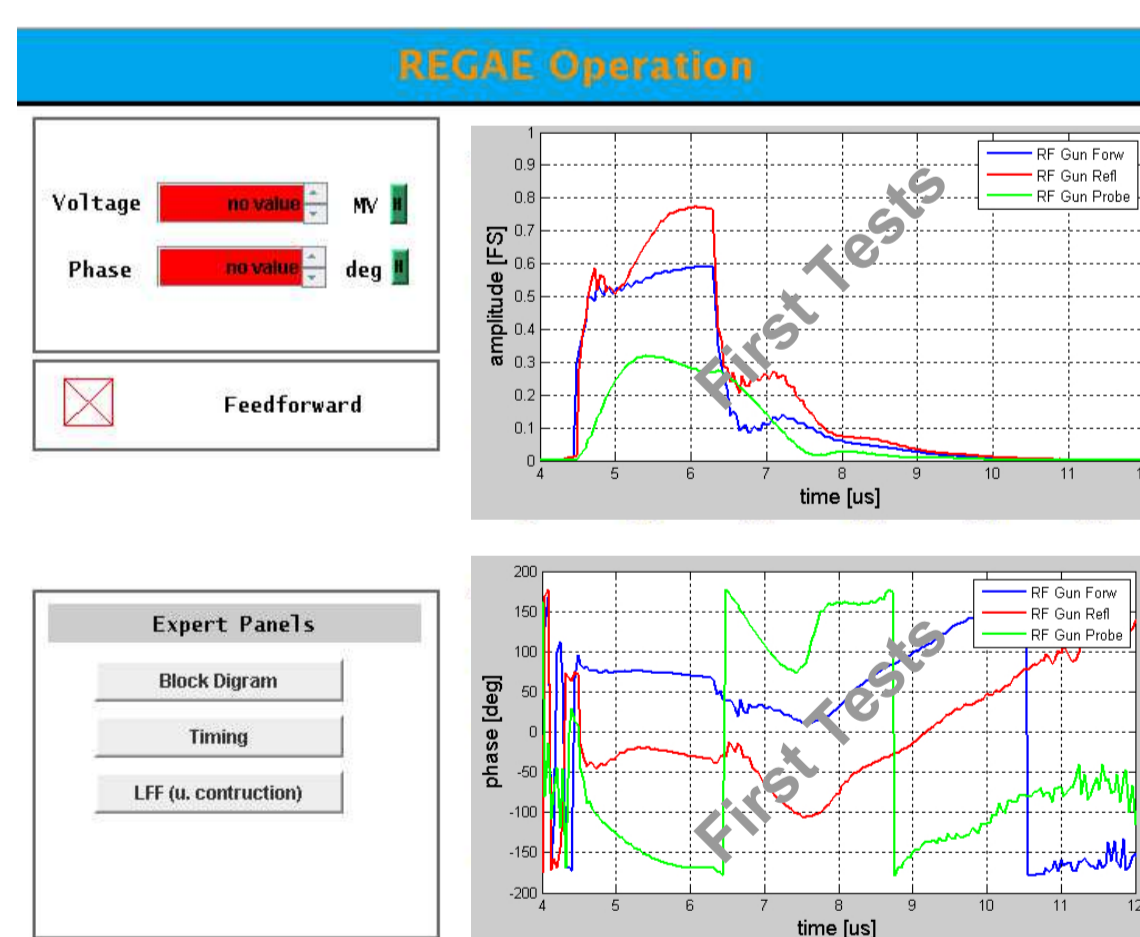
## Installation Overview



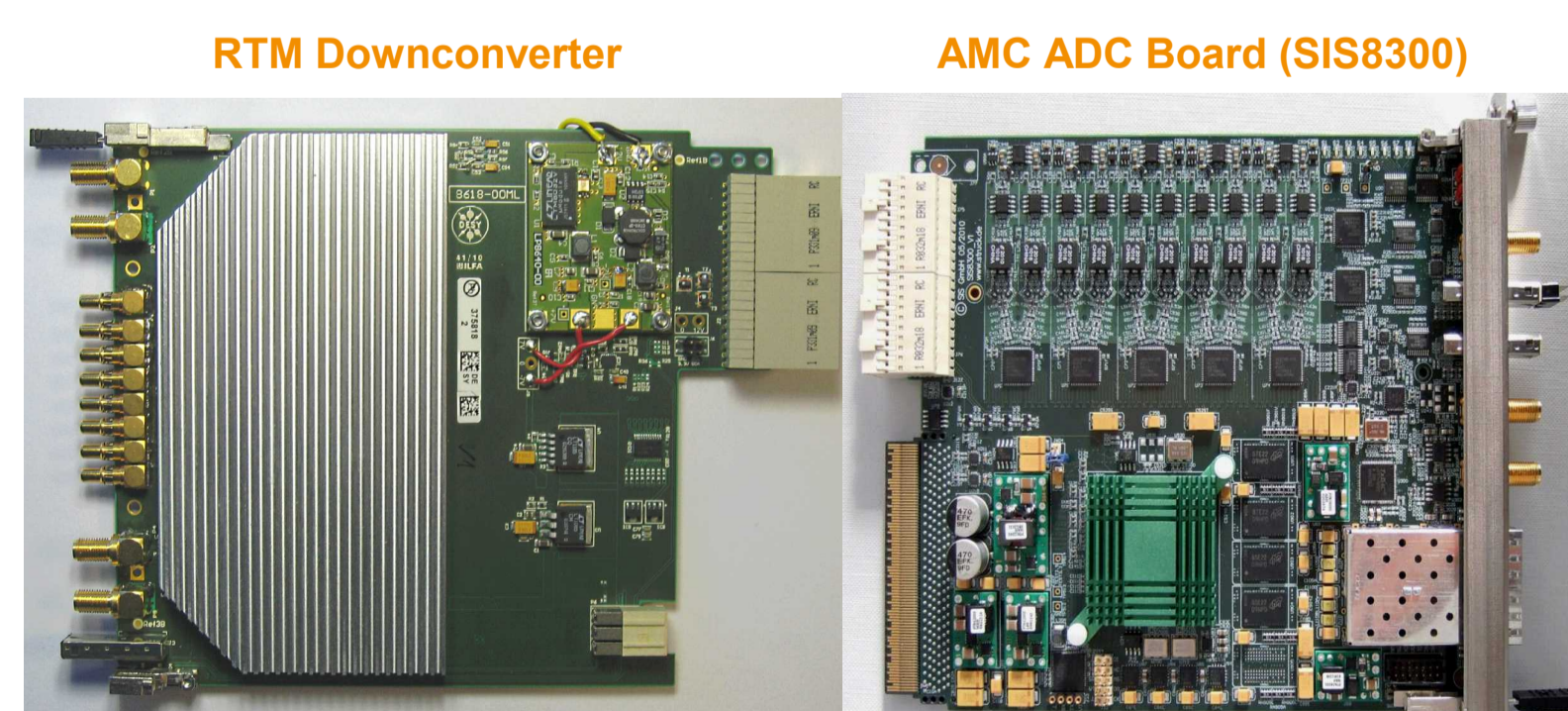
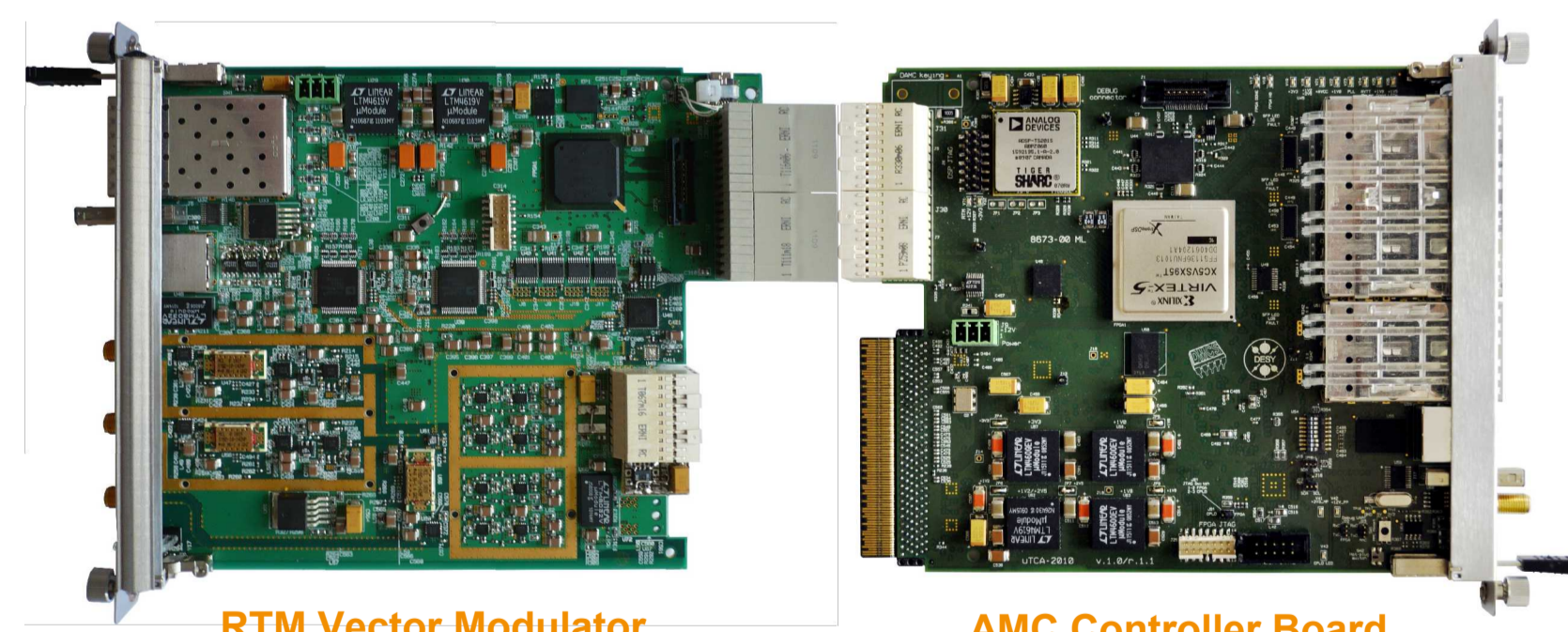
## Laser Synchronization



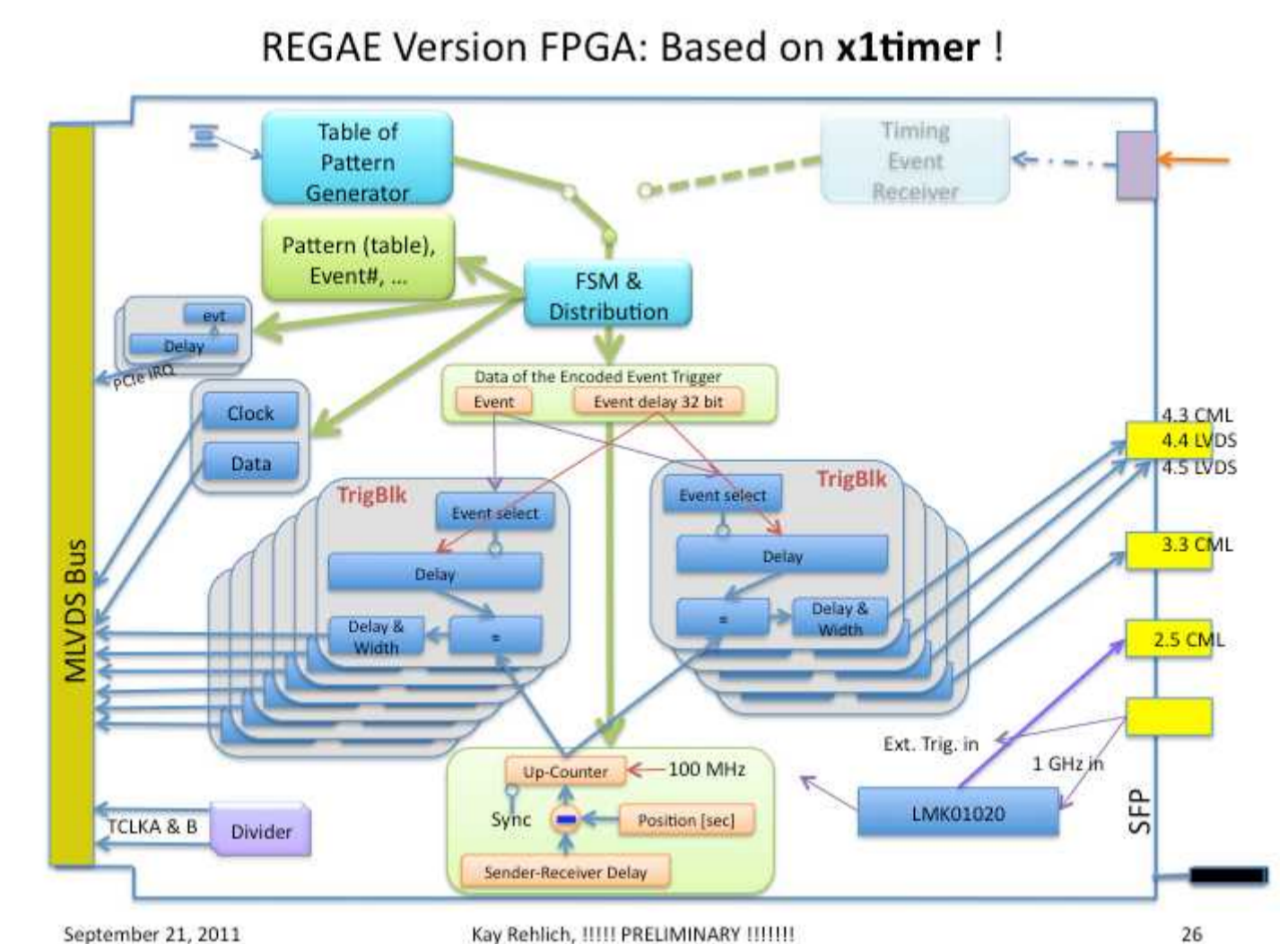
## LLRF Controller



## uTCA LLRF Hardware



## Timing System



- Trigger and CLK Signals from the x1timer
- Modulator Trigger
  - PreAmp Trigger
  - RF Gate
  - Diagnostic
  - 83 MHz Clock (Laser Synch)

TRIGGER	Delay in fs	Duration in fs	Name
TRIG1	0	1000	
TRIG2	0	1000	
TRIG3	2000	2000	
TRIG4	0	1000	
TRIG5	0	1000	
TRIG6	0	1000	