Areal RF Station

A. Vardanyan, L. Hakobyan, H. Avdishyan,
H. Davtyan, H. Poladyan

Yerevan 16.07.2013

RF System

- The AREAL RF system will consist of 3 RF stations:
- Each RF station has 1 klystron, HV modulator, a low-level RF system, preamplifier and an interlock and control system.
  - 1 station is required for RF Gun
  - 2 (or 1 station) stations – for accelerating section(s) operation
  - LLRF systems which control the amplitude and the phase of the RF
  - RF power 7 MW in peak at 3 GHz
  - Interlock and control system

Acharyan 31, 0040, Yerevan, Armenia Tel / FAX (+374-10) - 629806

The Required Operation Parameters

• Peak power	6	MW
• Gradient	17	MV/m
• RF pulse duration	3.8	µs
• Repetition rate	1-2	Hz

RF Power Source

• Frequency	3	GHz
• RF Pulse Duration	3.8	µs
• Repetition Rate	1-2	Hz
• Cathode Voltage	190 - 200 kV	
• Beam Current	95 - 105A	
• HV Pulse Duration	3.8	µs
• RF Peak Power	7	MW

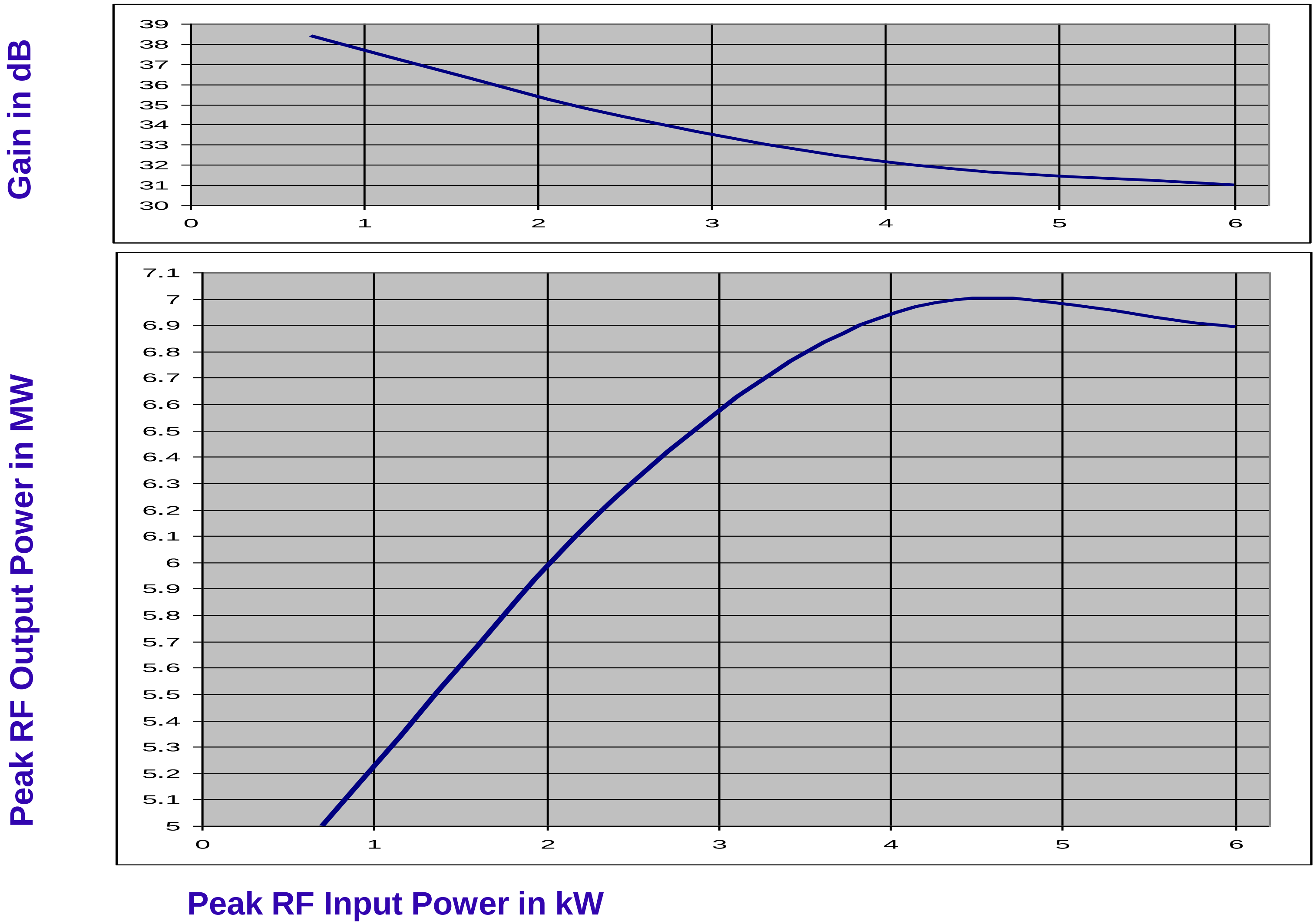
K211 Klystron Parameters

• Output Power peak	7 MW
• Efficiency	40 %
• Gain (min. dB)	31
• Beam voltage	200 KV
• Beam peak current	92A

KY211 Klystron Main Parameters

- Water and Air Cooling   For Operate Rate (50Hz)
- Water flow to body   3.64   l/min   *min*
- Water flow to collector   20.5   l/min   *min*
- Resistance of cooling water   50   kOhm cm   *min*
- Air flow to output window 85   l/min   *min*
- Cooling Air pressure   2.1 kg/cm^2 *min*

KY211 Klystron Main Parameters



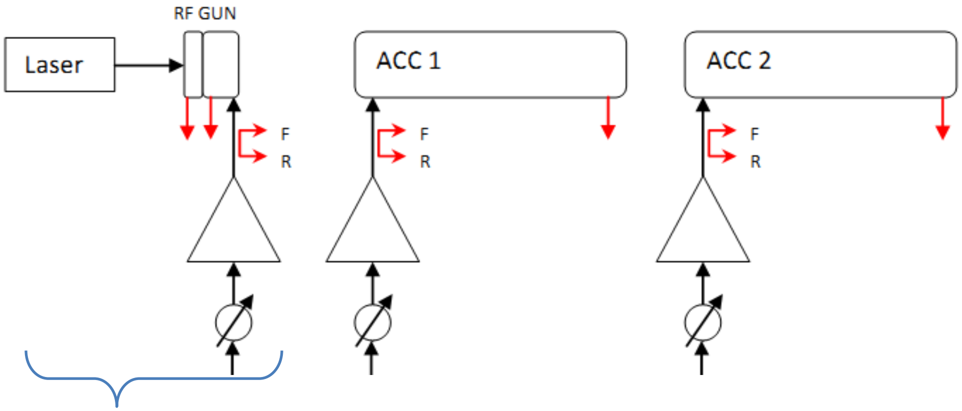
Acharyan 31, 0040, Yerevan, Armenia Tel / FAX (+374-10) - 629806

Low Level Radio Frequency Control

Characteristics of Signal/Probes:

- Phase stability 0.1 deg@3GHz
- Amplitude stability 0.1%
- Amplitude dynamic range 40 dB
- Ready to be integrated into the EPICS control system

The LLRF system ordered by I-Tech LIBERA.



1st stage.

RF Control System

Requirements for the RF control system

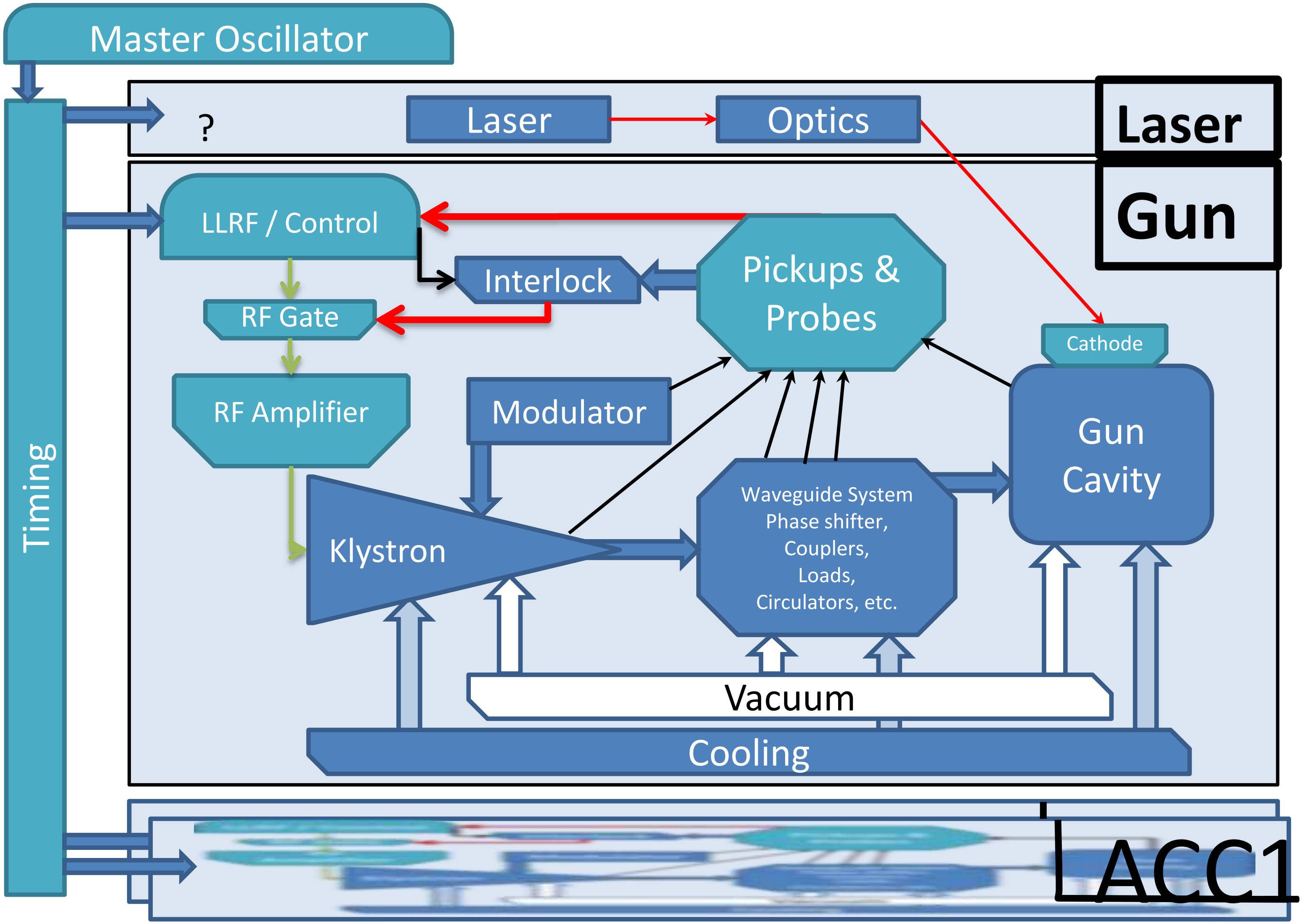
- Phase and amplitude stability of the accelerating field during 2 μs flat-top RF pulse
  - Field amplitude control 0.1%
  - Phase control 0.1°
- A frequency and phase stable master oscillator for RF reference signals to measure the cavity fields

The RF control system will provide:

- Remote control for all RF components
- An opportunity to change the necessary parameters such as waveguide tuners, phase shifters, etc.

Acharyan 31, 0040, Yerevan, Armenia Tel / FAX (+374-10) - 629806

Control System Block Scheme Overview

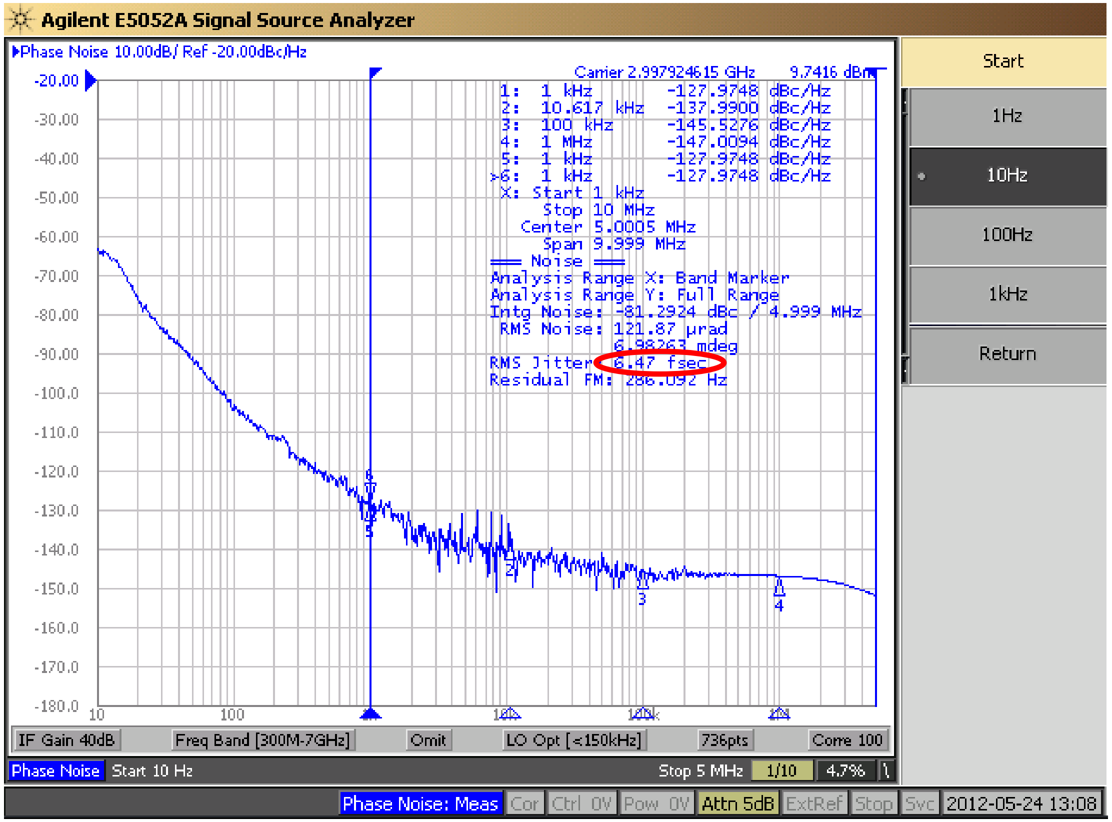


Master Oscillator

The Master oscillator designed by InWave AG according to our requirements.

- **Frequency ports:**
  - 1x 1Hz 1x 9MHz
  - 1x 2Hz 1x 81MHz
  - 1x 9MHz 1x 250MHz
  - 1x 81MHz2x 90MHz
  - 1x 125MHz 2x 10MHz (Secondary)
  - 1x 250MHz 1x 10MHz (main)
  - 2x 500MHz
  - 1x 1GHz
  - 2x 3GHz

The Measurement Results



The picture describes RMS phase Jitter 6.47 fsec !

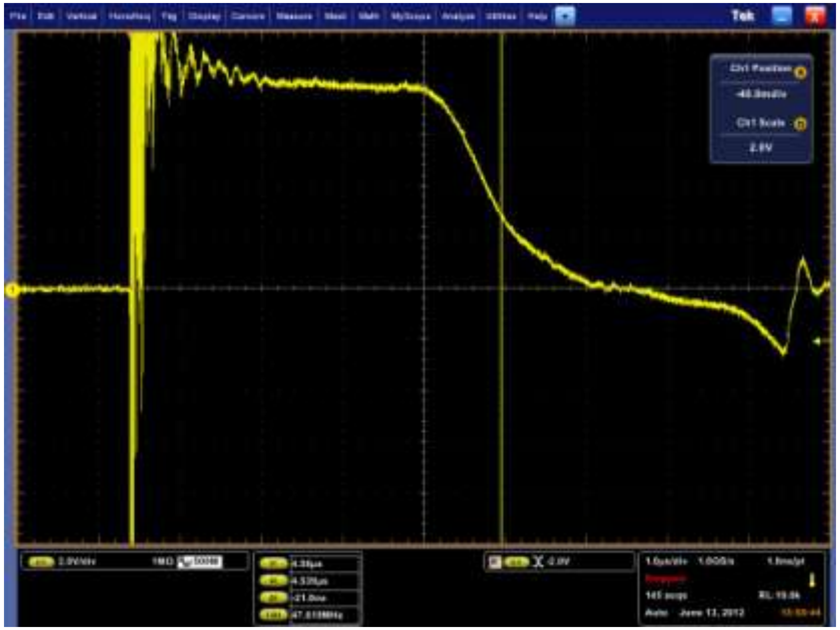
The Location of RF Equipment

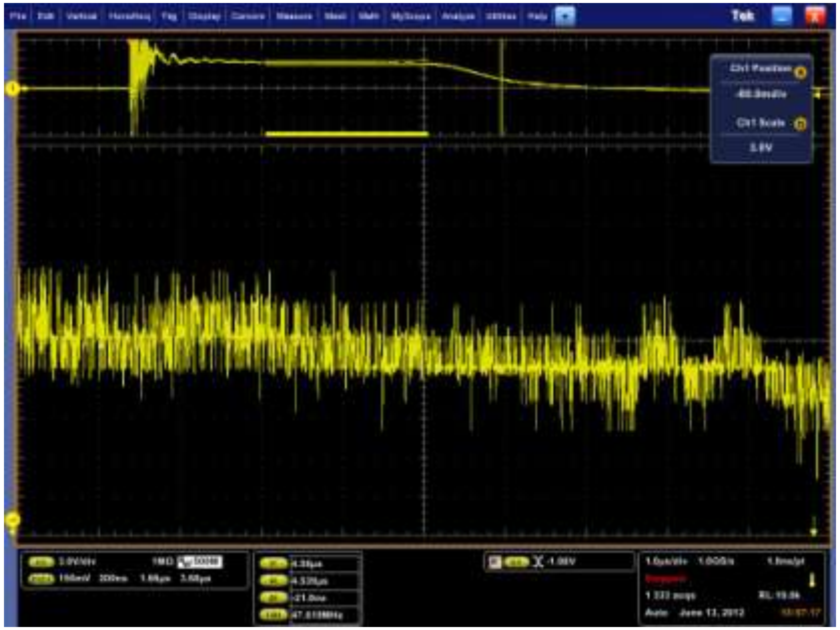
RF Test stand

- **Modulator (HV pulse power source)**
- **HV pulse modulator**
- **1:18,2 pulse transformer in an oil tank.**
- **The nominal pulse duration is 3.8 µs.**
- **Requirements to the flat top ripple**
  - should not exceed ±1%.
  - The pulse-to-pulse stability better than ±0.5%.

Measurements

K211 Modulator

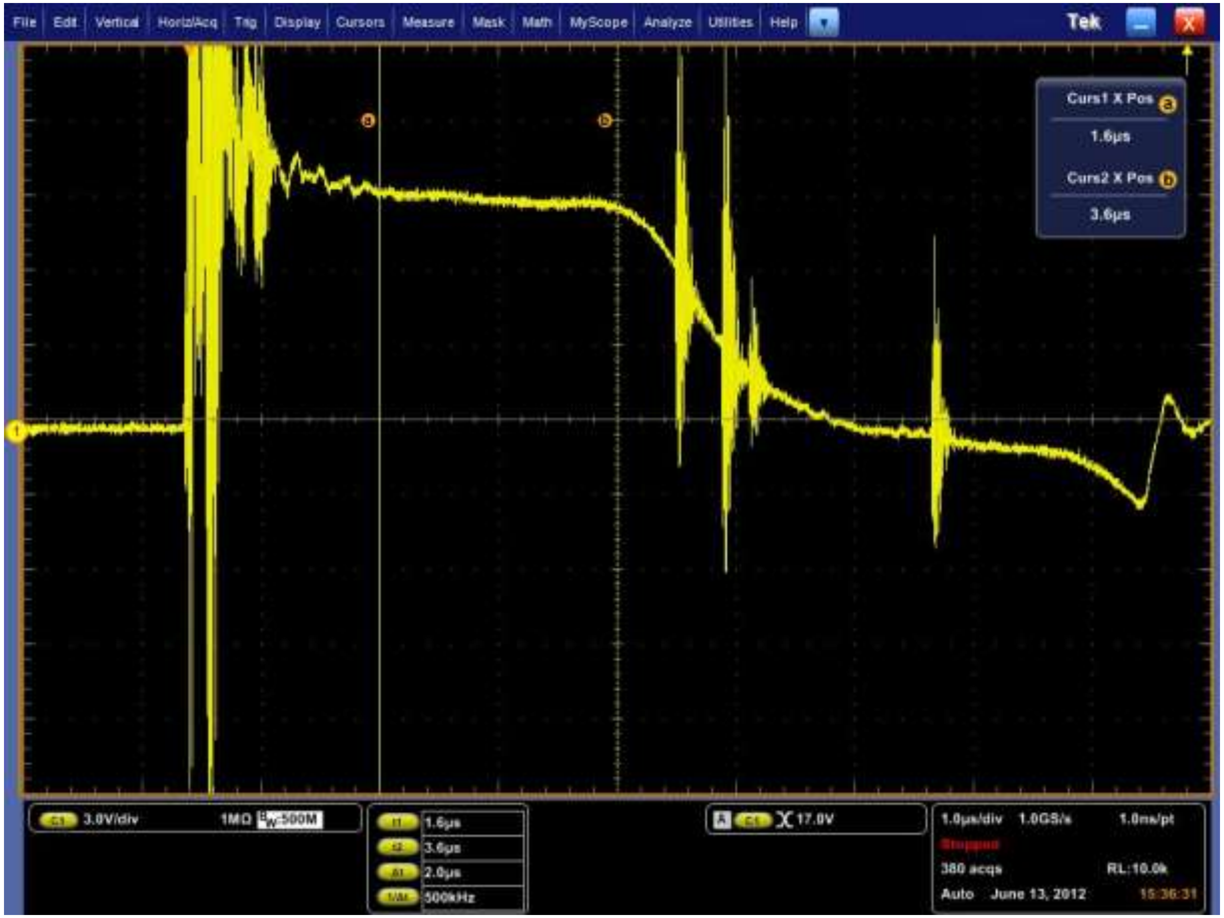




Amplitude flatness ~ 1.2%

Measurements

K211 Modulator



> 200 kV

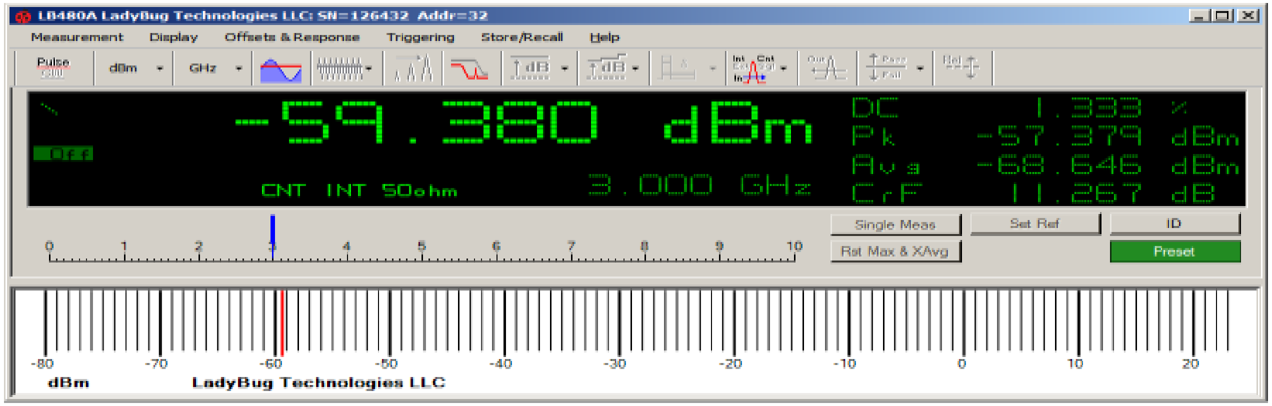
Equipment

LB480A Pulse Profiling USB PowerSensor

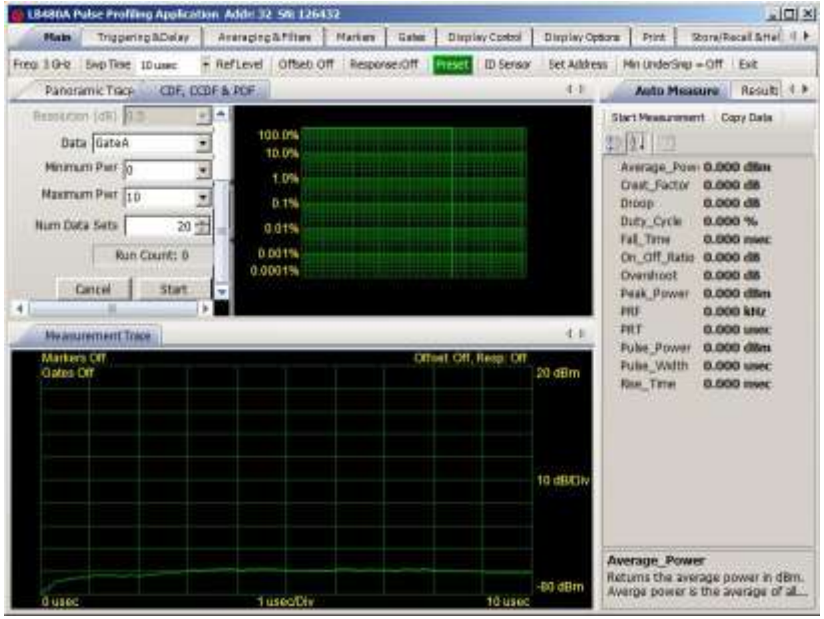
Specifications

50 MHz to 8 GHz (functional to 10 GHz)
- 60 dBm to +20 dBm
1.95% Total Error

Equipment



Power Meter GUI



Pulse profiling GUI

Power Meter Measurements	10 MHz
Pulse Profiling (standard)	100 kHz
Time resolution	0.1 us
10 % to 90% Rise Time	~100 ns

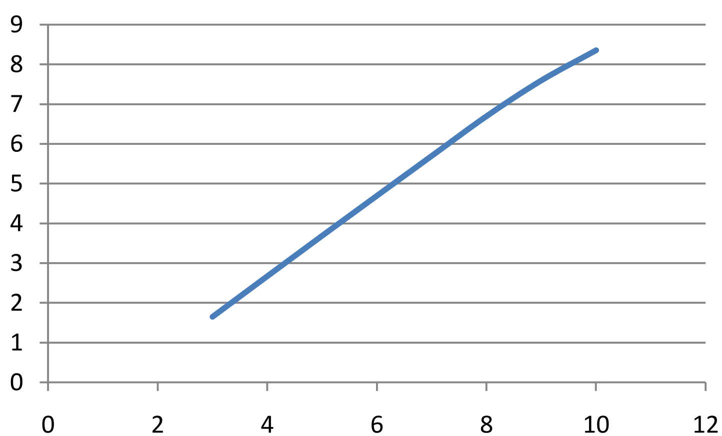
(-70 to -20 dBm pulse measured @ 4 GHz)

10 % to 90% Fall Time	~100ns

(-70 to -20 dBm pulse measured @ 4 GHz)

Equipment

Power Amplifier output (+24dB Att.)



TESTREPORT FOR MICROWAVE UNIT

PA3G-142.0000.1

INWAVE

Option : Non

Microwave Unit Ser.No. 002 Test Temperature: 22 °C

Measured with :

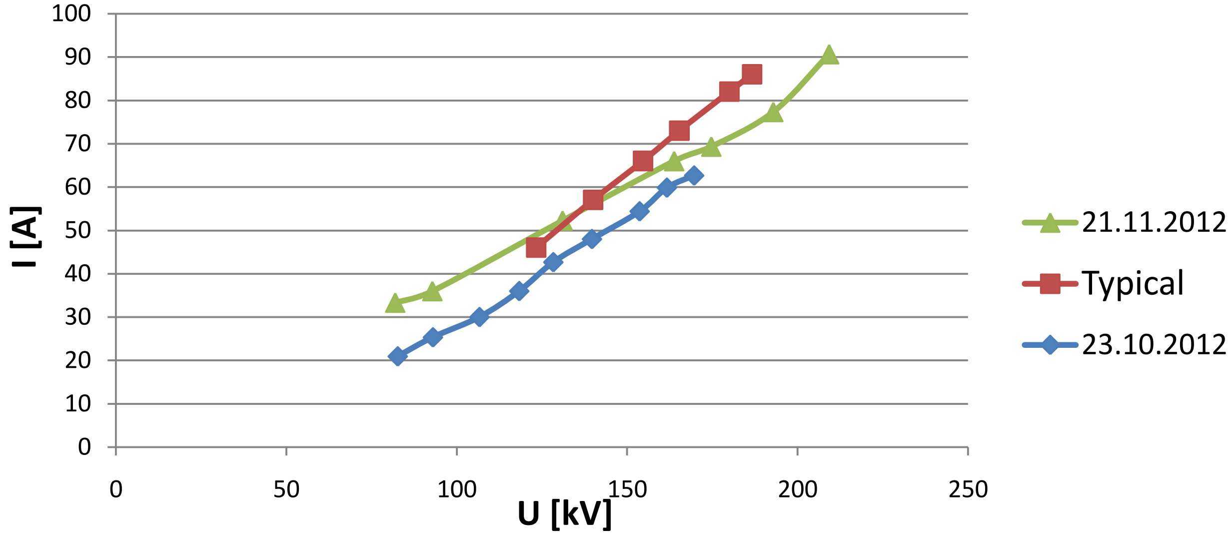
Power Meter HP 437B Poersensor HP 8481A

RF-Generator Marconi RF Test Set 6203B

Attenuator 25W 20.2 dB Weinschel Type 35-20-34

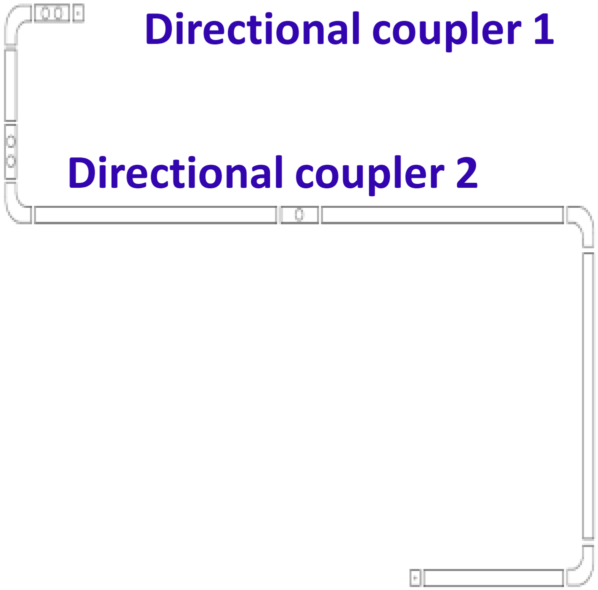
INPUT Power dBm		Attenuator dB	Measured Power dBm	Output Power dBm	Gain dB		Supply Voltag V	Current A
11.00	dBm	20.20	14.48	34.68	23.68		12.00	1.5
10.00	dBm	20.20	13.80	34.00	24.00		12.00	1.3
9.00	dBm	20.20	13.02	33.22	24.22		12.00	1.25
8.00	dBm	20.20	12.15	32.35	24.35		12.00	1.14
7.00	dBm	20.20	11.25	31.45	24.45		12.00	1.02
5.00	dBm	20.20	8.99	29.19	24.19		12.00	0.84
3.00	dBm	20.20	7.00	27.20	24.20		12.00	0.7

Klystron V-A Characteristics



A [A]	V [kV]
33.(3)	81.9
36	92.82
52.2(6)	131.04
66	163.8
69.(3)	174.7
77.(3)	192.9
90.(6)	209.3

S-parameters



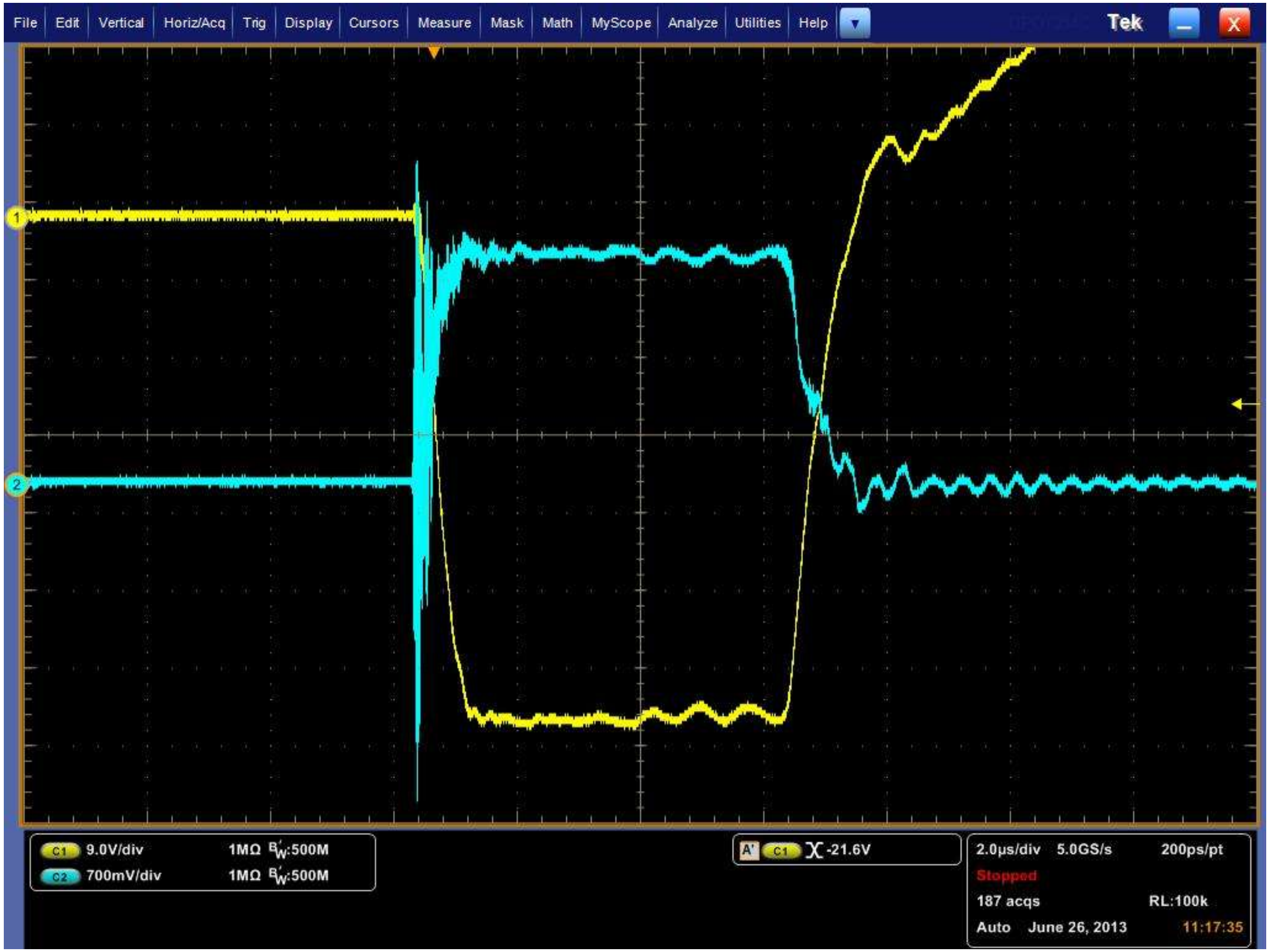
Directional coupler 1

Directional coupler 2

Directional coupler 1		Directional coupler 2	
S11	-17,78 dB	S11	-19,316 dB
S12	-0,615 dB	S12	-0,613 dB
(FW) S14	-76,8 dB	(FW)S14	-76 dB
(REF) S23	-76,8 dB	(REF)S23	-73,2 dB

Acharyan 31, 0040, Yerevan, Armenia Tel / FAX (+374-10) - 629806

TH2436 Modulator V-A Measurements



TH2436 Modulator V-A Measurements

After adjusting modulator coils we get +/- 1%

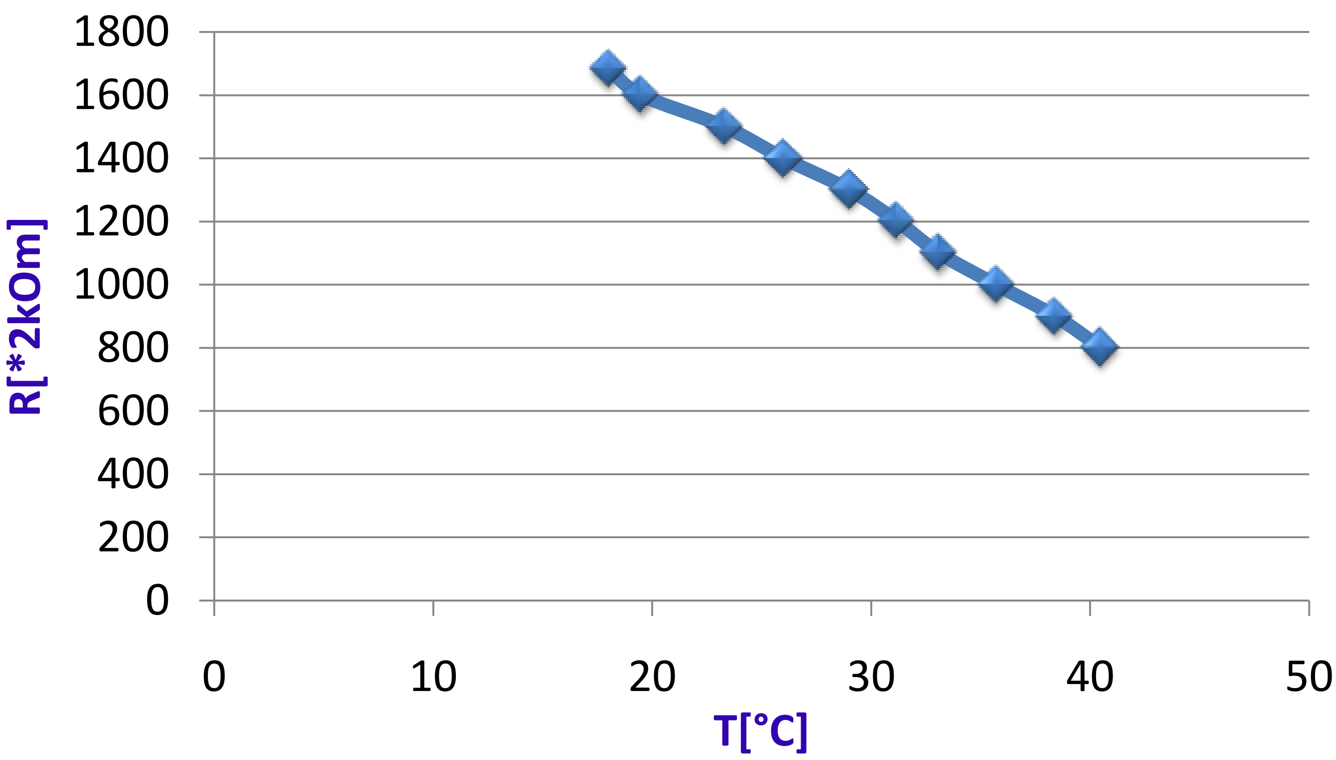
Net Stability Measurements

Network
±2.4V/330V
0.7%

Measurements

PS
12V out
±380mV/12V
1.5%

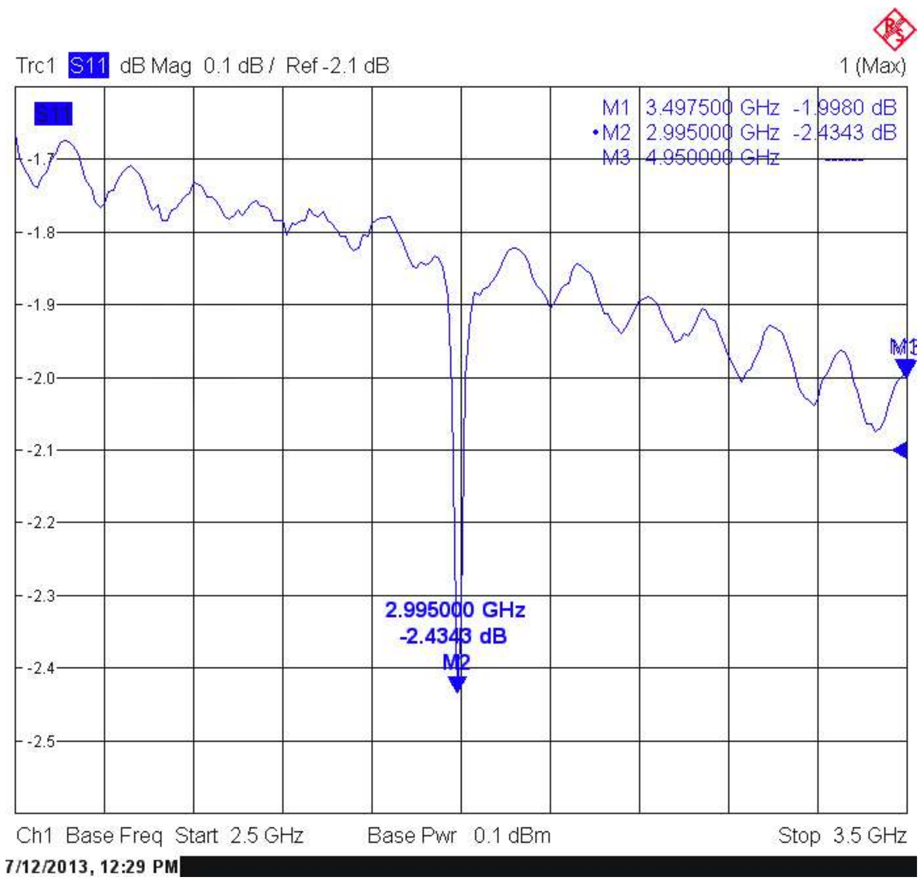
Solenoid and Body Thermocouple Calibration



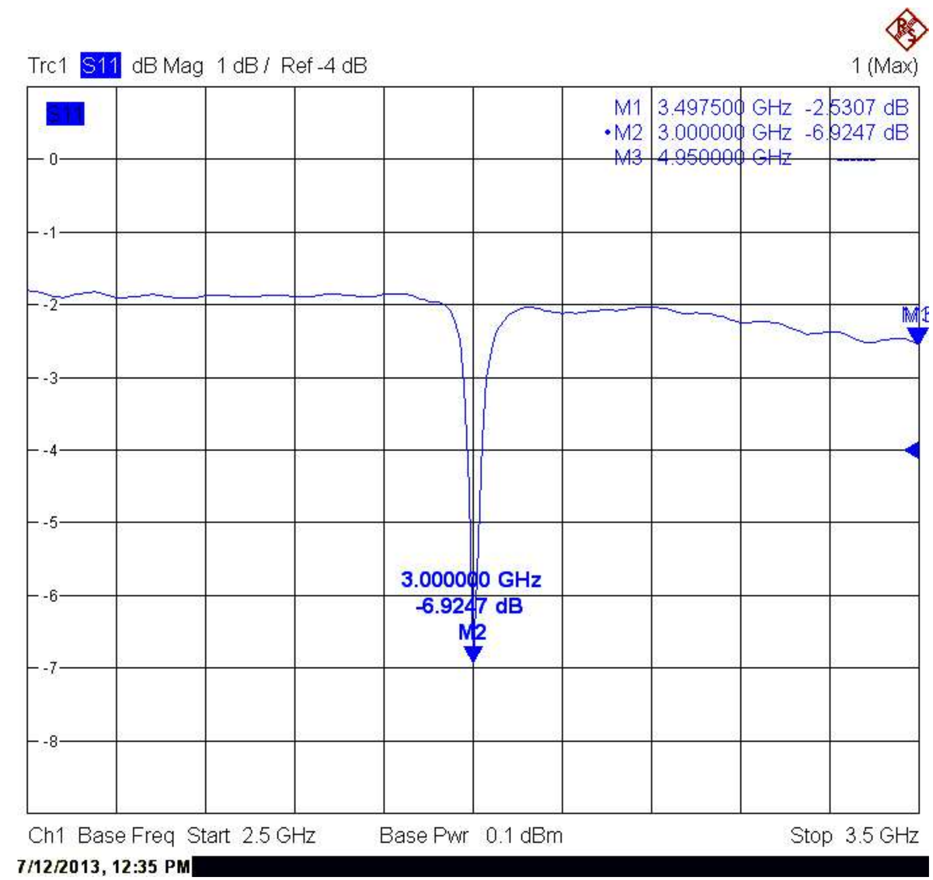
Date of measurement 22.10.2012

t=28°C

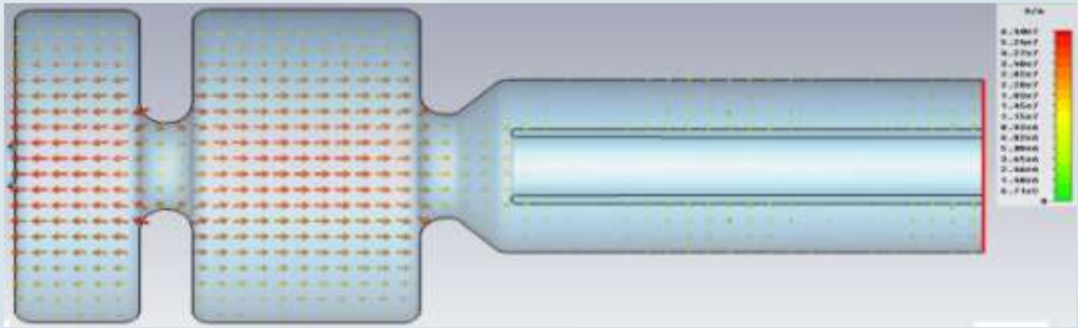
K211

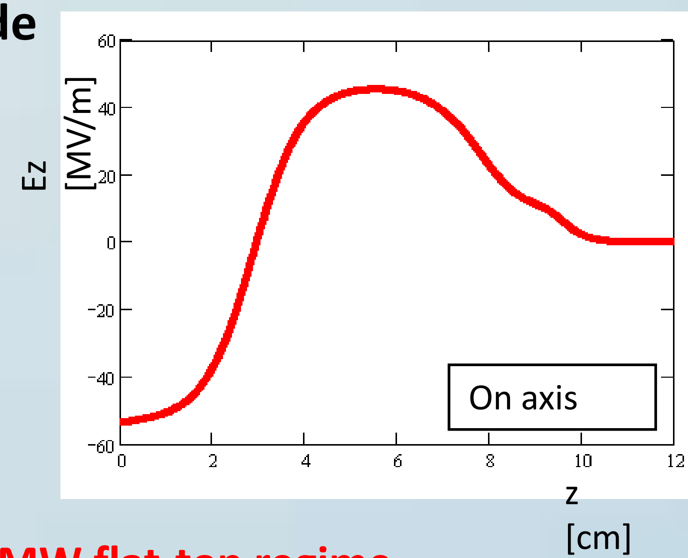


YK1110



Resonant TM010 mode

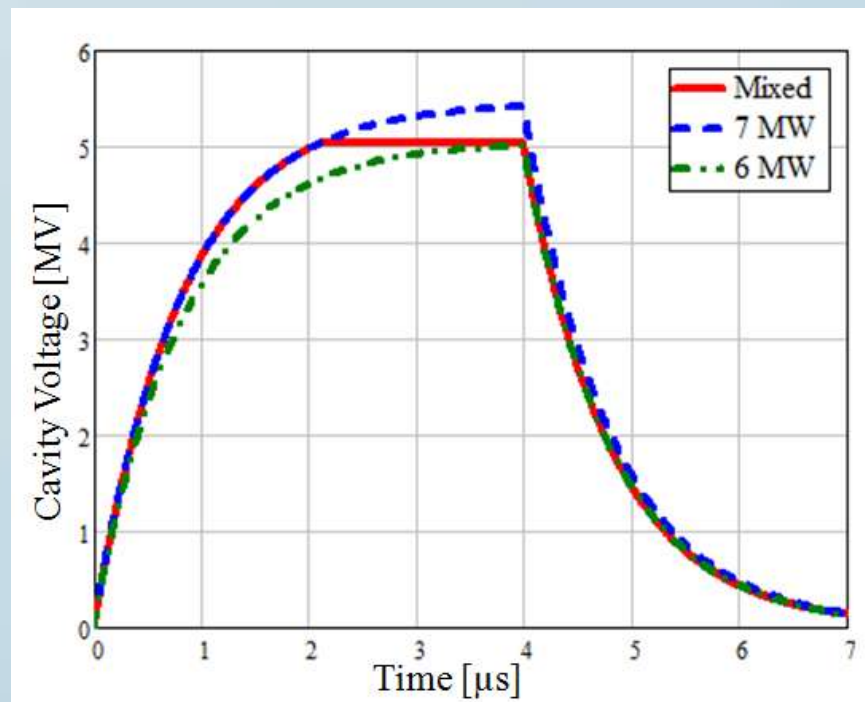




π – mode
freq. – 2.99646 GHz

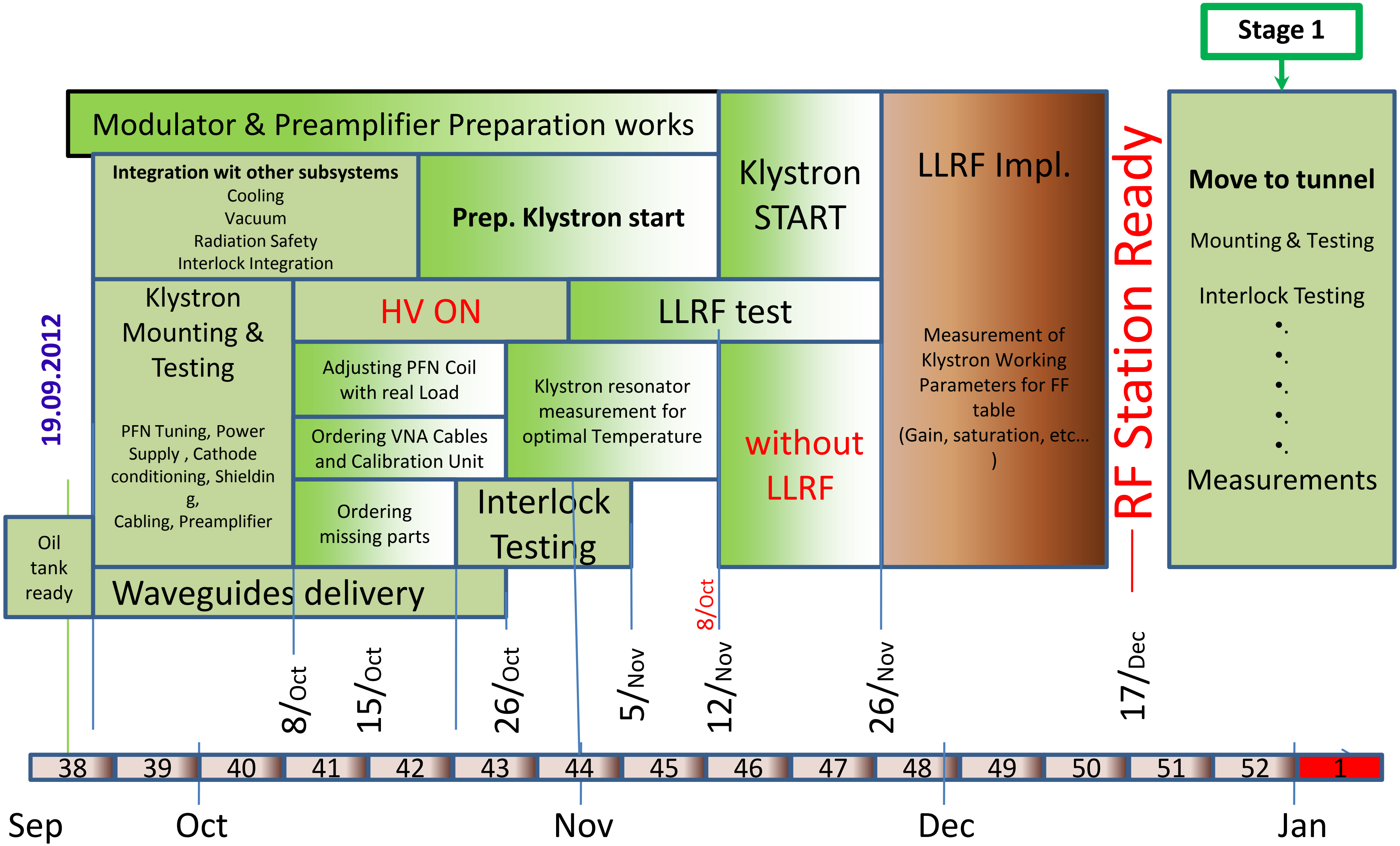
Cavity parameters for TM 010 resonant mode	
Frequency – f [GHz]	2.99646
Unloaded quality factor – Q_0	15292.34
Shunt impedance – $R_{sh}=V^2/(2P_d)$ [MΩ]	2.1174765
R_{sh}/Q_0 [Ω]	138.4665
External quality facor – Q_e	15434.52
Loaded quality factor – $Q=(1/Q_0+1/Q_e)^{-1}$	7681.55
Coupling factor – $\beta=Q_0/Q_e$	0.99
Natural filling time (loaded/unloaded) – $\tau=2Q/(2\pi f)$ [μs]	0.816

6 MW flat-top regime



A. Tsakanian

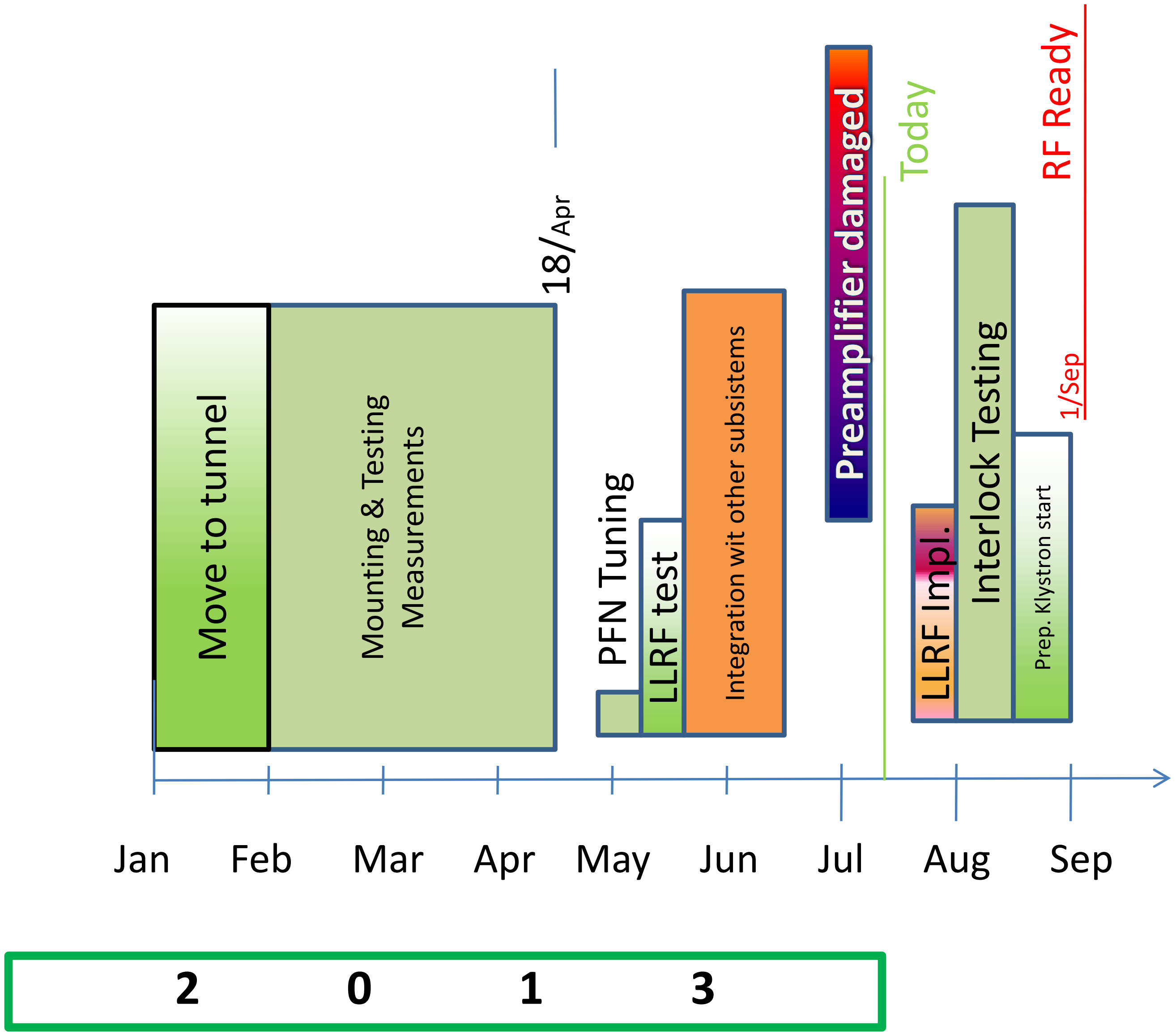
Klystron Start Preparation Works



2 0 1 2

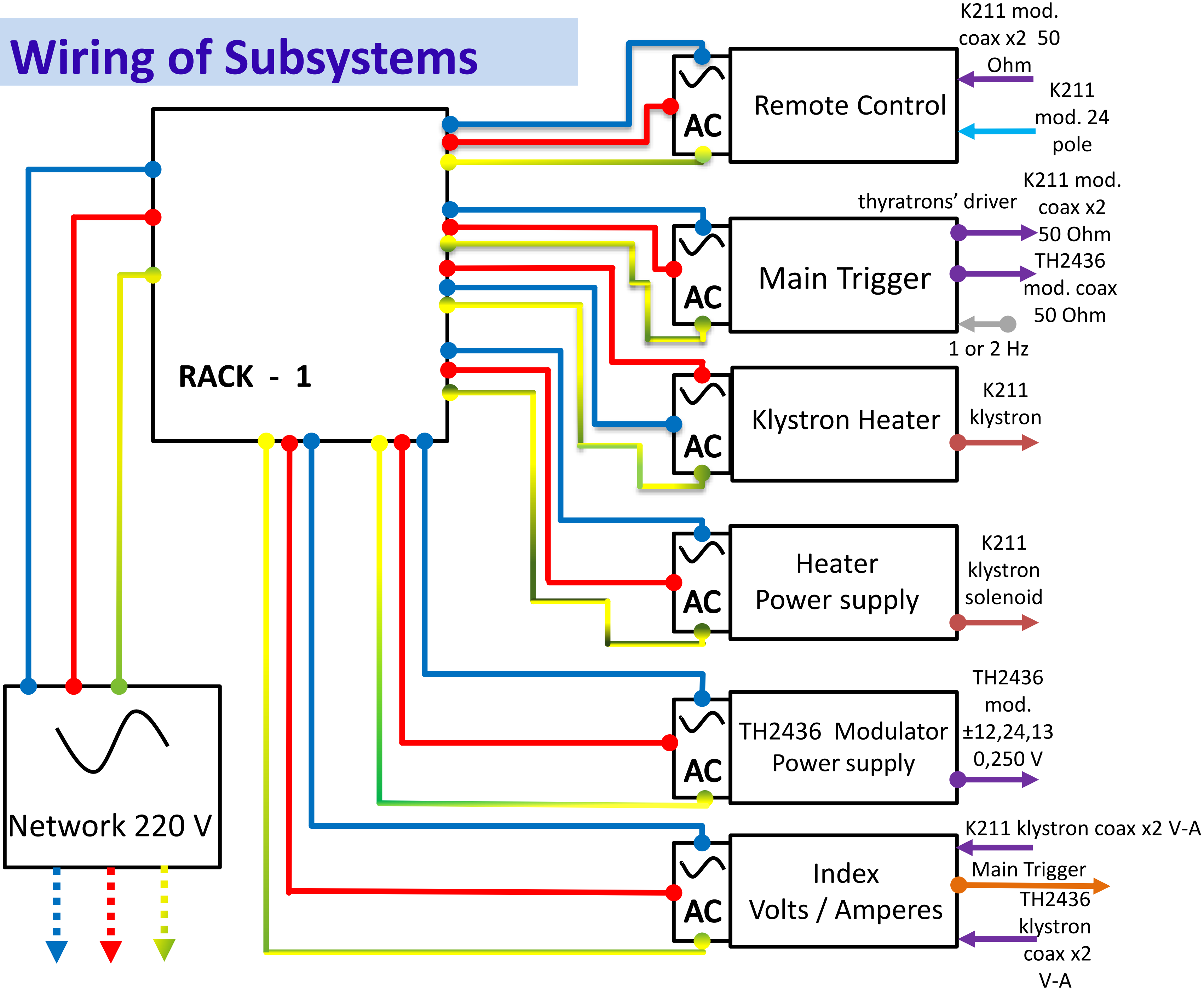
Presented on 19.09.2012

Stage 1

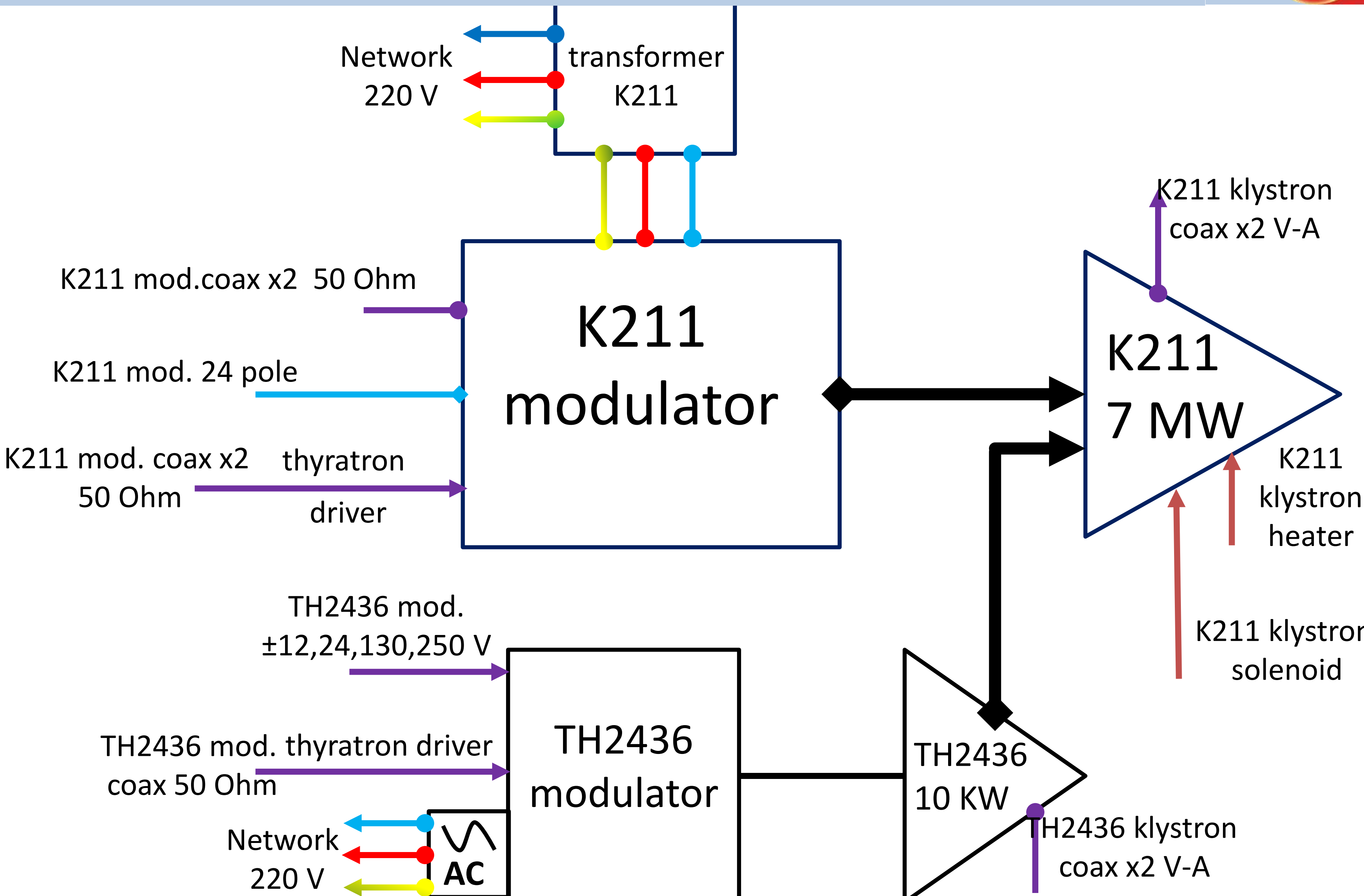


Acharyan 31, 0040, Yerevan, Armenia Tel / FAX (+374-10) - 629806

Wiring of Subsystems



Wiring of Subsystems



Conclusion

- The majority of the tasks defined for our group were performed according to the schedule. The critical issue remains the problem of timing which we plan to solve via simple time delays.

- An important problem we haven't yet paid enough attention to is the automatic synchronization of the laser and RF, which at the first phase we plan to perform manually.

- The analog interlock system is implemented and tested which will protect the accelerator and the RF station.

- An additional digital interlock system for the RF system is required. The Digital Interlock System (based on programmable logic devices) will be implemented after the LINAC first stage completion and upon necessity it can be easily modified during operation.

Thank You for Attention!!!