RF SYNCHRONIZATION: GENERAL APPROACH AND FIRST EXPERIMENTAL TESTS

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OUTLINE

- **Introduction**
- **Experimental measurements on one DAΦNE Linac klystron**
  - ***Phase jitter***
  - ***Group delay***
- **Intra-pulse phase-lock bench measurements**
- **Conclusions**

SPARC PHASE STABILITY SPECIFICATIONS:

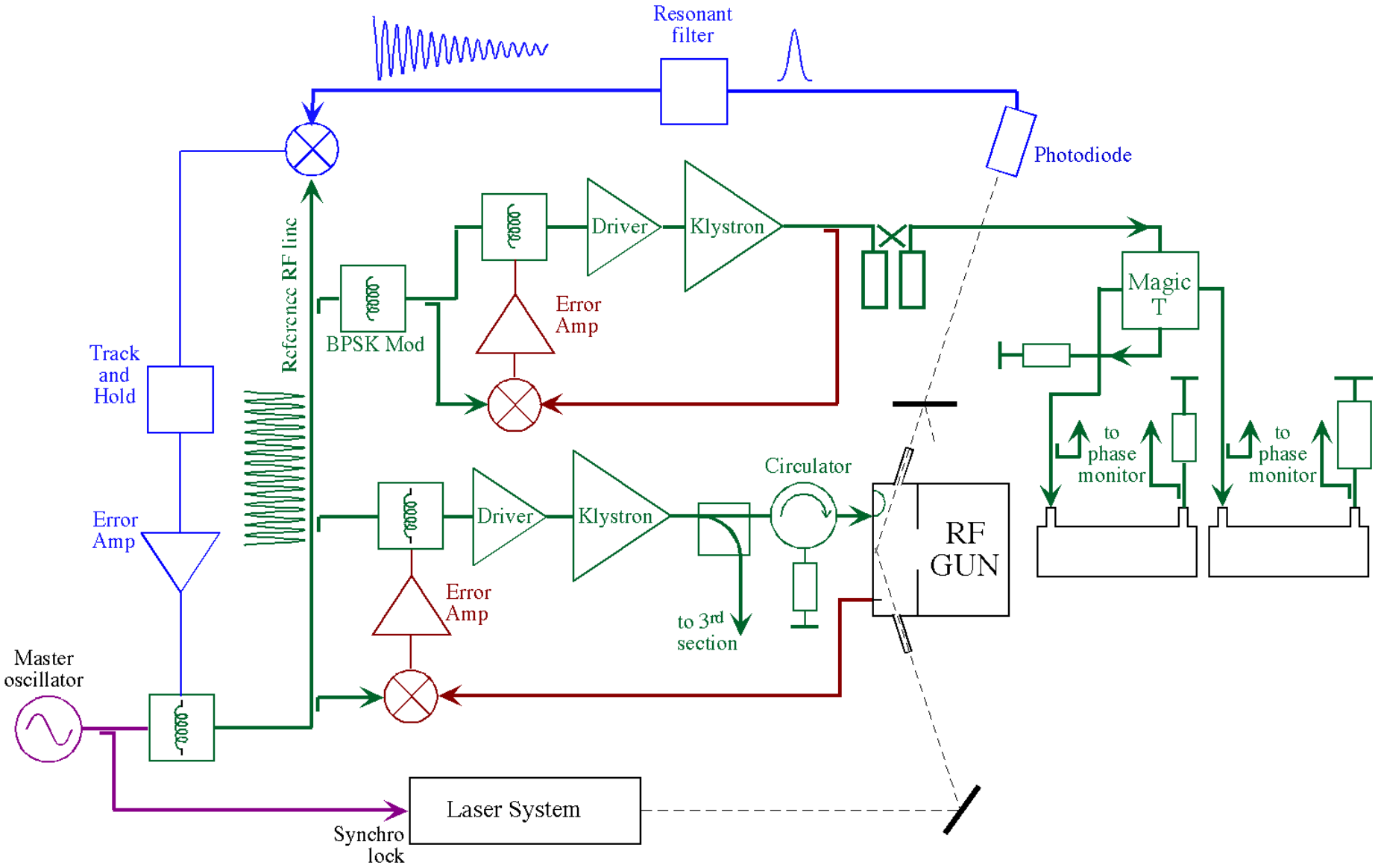
- **SPARC phase I:**
  ± 3° between the Laser pulse and the Linac RF
  (RF gun mainly)

- **SPARC phase II:**
  ± 0.5° between the Laser pulse and the Linac RF
  (RF gun and RF compressor mainly)

GENERAL APPROACH (Guidelines):

- **The phase of the Laser pulse respect to the Linac RF reference line will be continuously monitored and the "slow drifts" (i.e. the phase noise in a frequency band limited to _ of the Linac rep. rate) will be compensated (shifting the phase of the RF ref. Line seems the simplest way to do it).**
- **The "fast phase jitter" (i .e. the noise in a band larger than _ of the rep. rate) of the Laser pulse can't be compensated and must be kept inside the acceptable limits by specifications (1° requested to the manufacturer).**
- **All the Linac RF signals will be phase-locked to the RF ref. Line. The possibility of implementing an intra-pulse fast phase lock to correct the fast phase jitter introduced by the RF stations (klystrons + their drivers) is under study and looks feasible.**

SPARC RF SYNCHRONIZATION SYSTEM



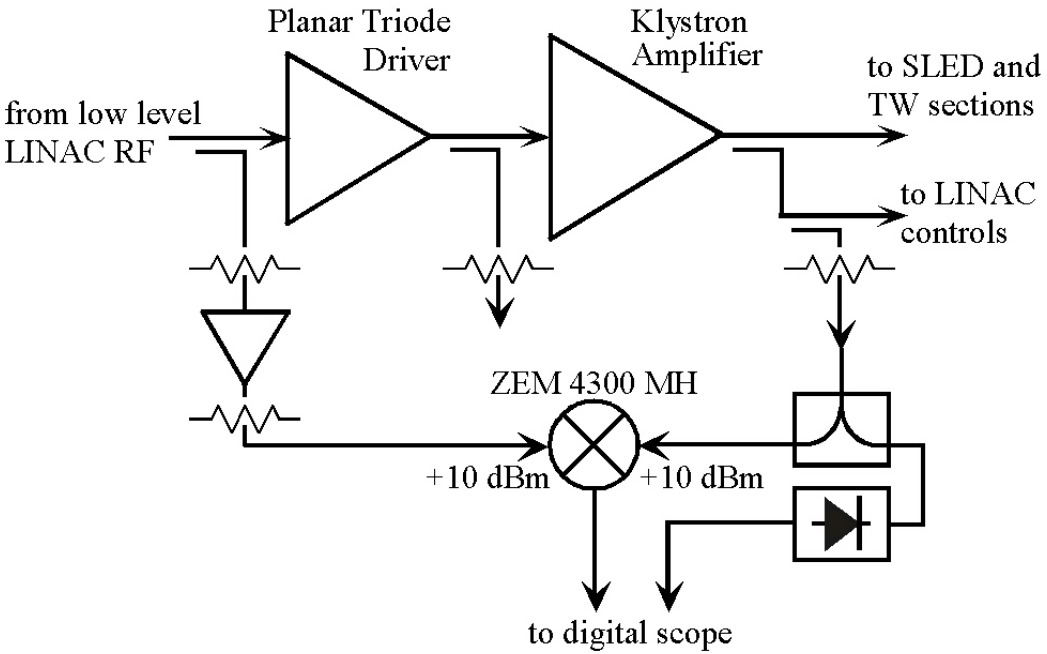
DAΦNE LINAC KLYSTRON MEASUREMENTS

- **The phase jitter at the output of one of the DAΦNE TH2128C Linac klystrons has been measured to figure out the amount of expected noise in the SPARC case and to gain some experience in this subject.**

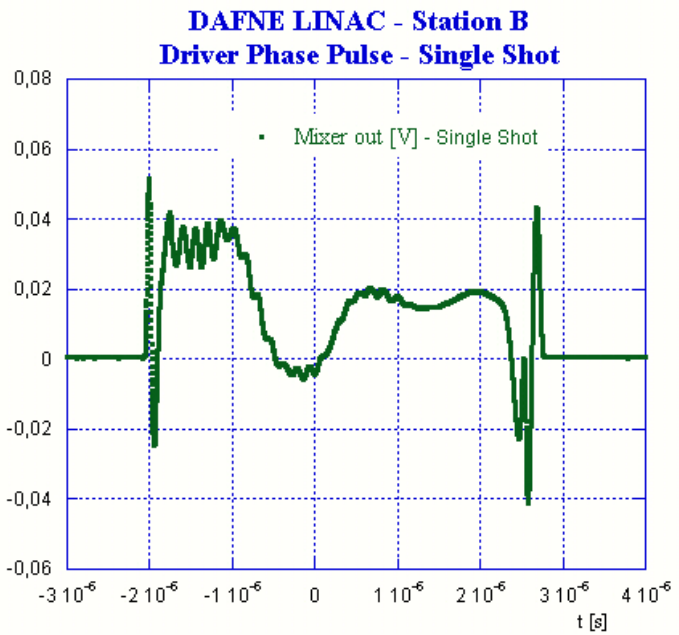
- **The bandwidth and the group delay of the TH2128C klystron (unavailable in the technical documentation!) have been measured since these values are crucial to define whether or not a fast intra-pulse phase-lock is feasible.**

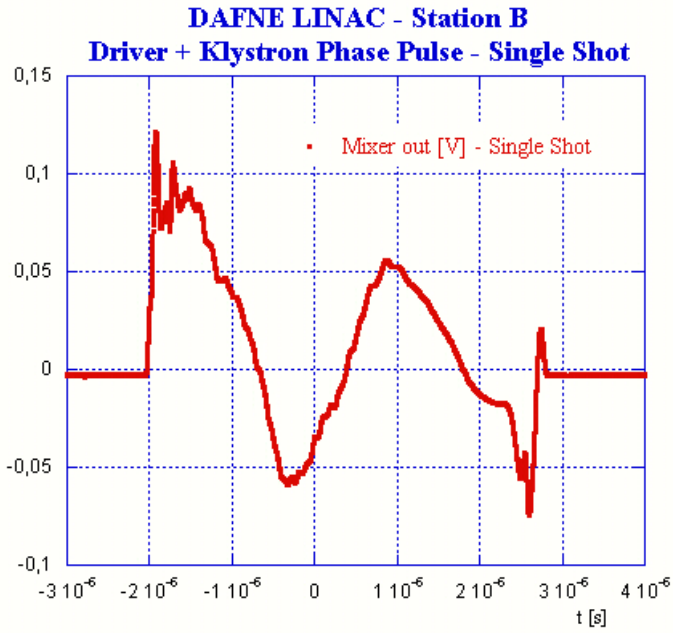
PHASE STABILITY MEASUREMENTS

DAFNE LINAC – STATION B
August 2003



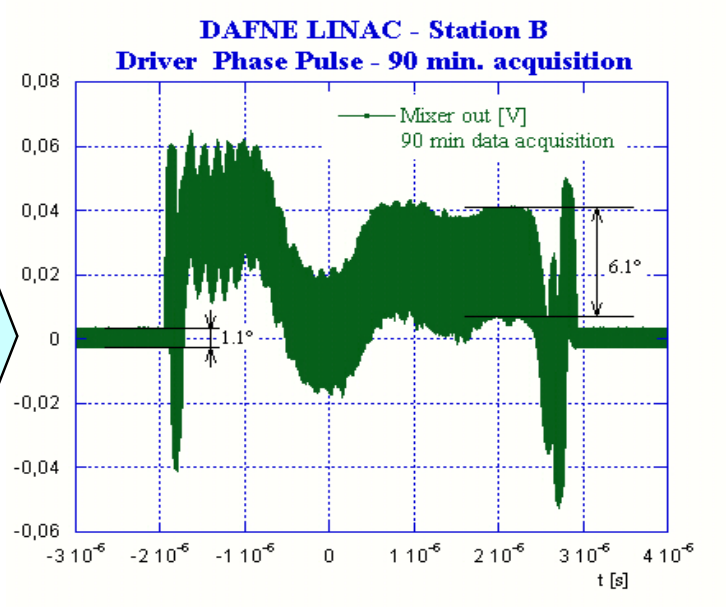
mixer sensitivity = 5.6 mV/Deg

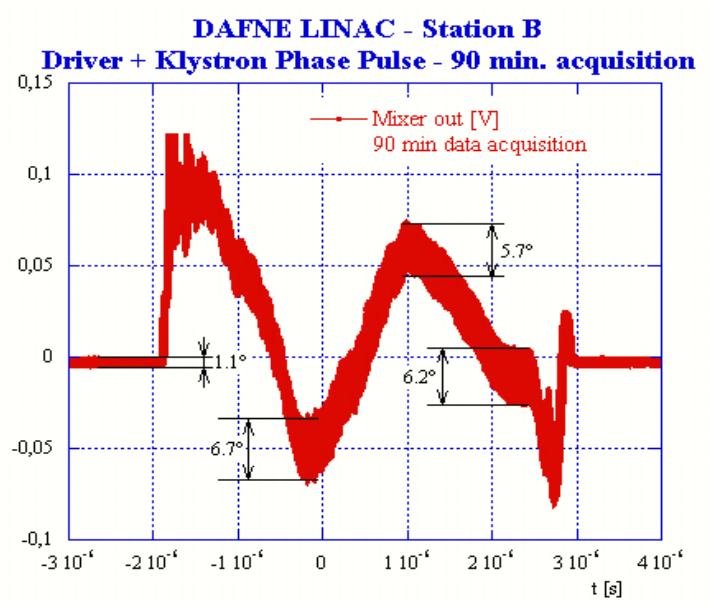




Long Term (90 min) phase variation:

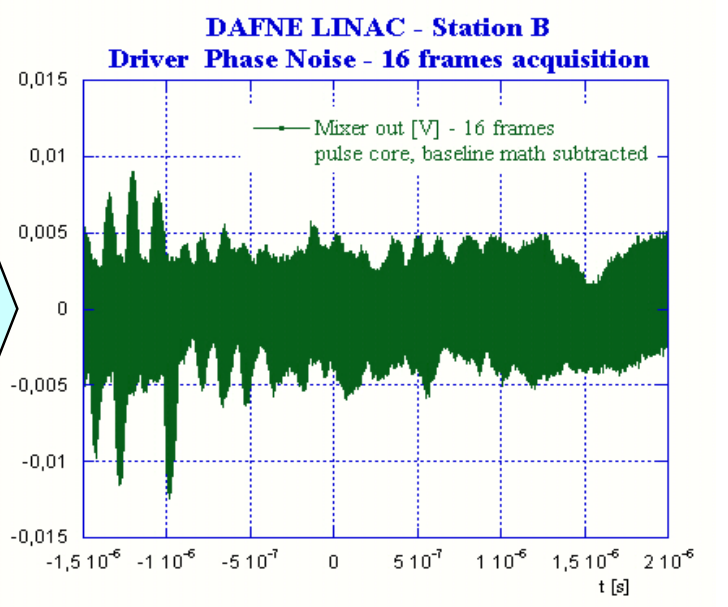
± 2.5°

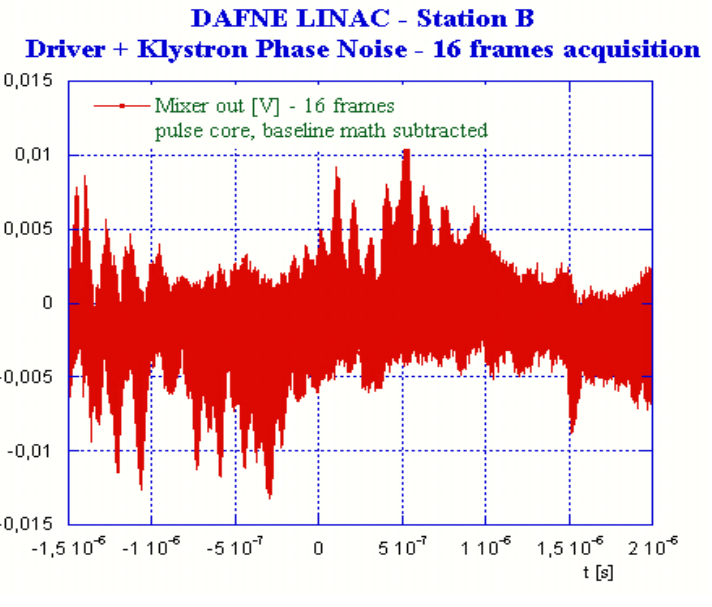




Short Term (16 shots) phase variation:

± 1°





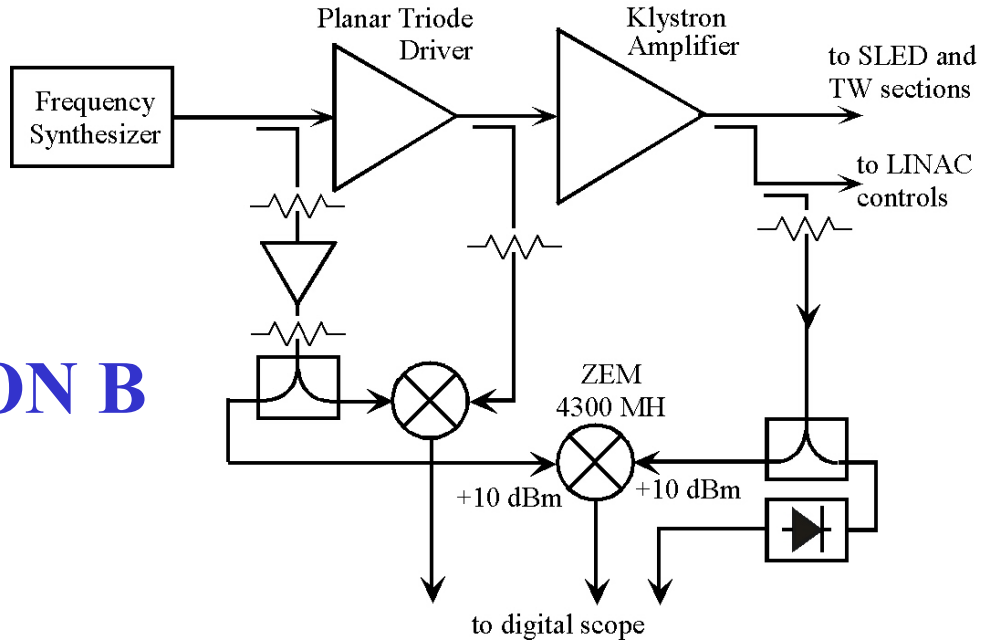
KLYSTRON PHASE NOISE MEASUREMENTS CONCLUSIONS

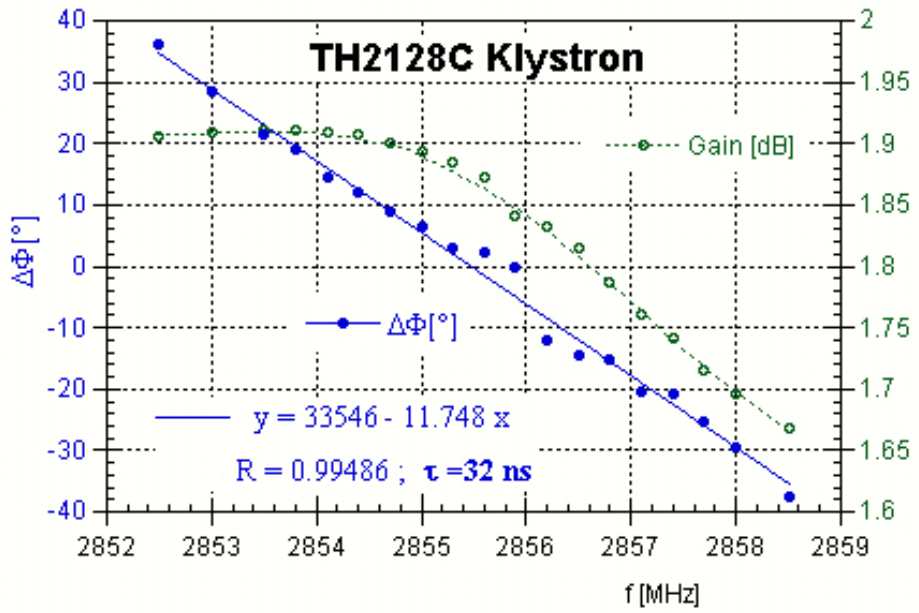
- **The measured phase jitter at the output of the Linac station-B klystron is about ± 2.5° in long term and and ± 1° in short term.**

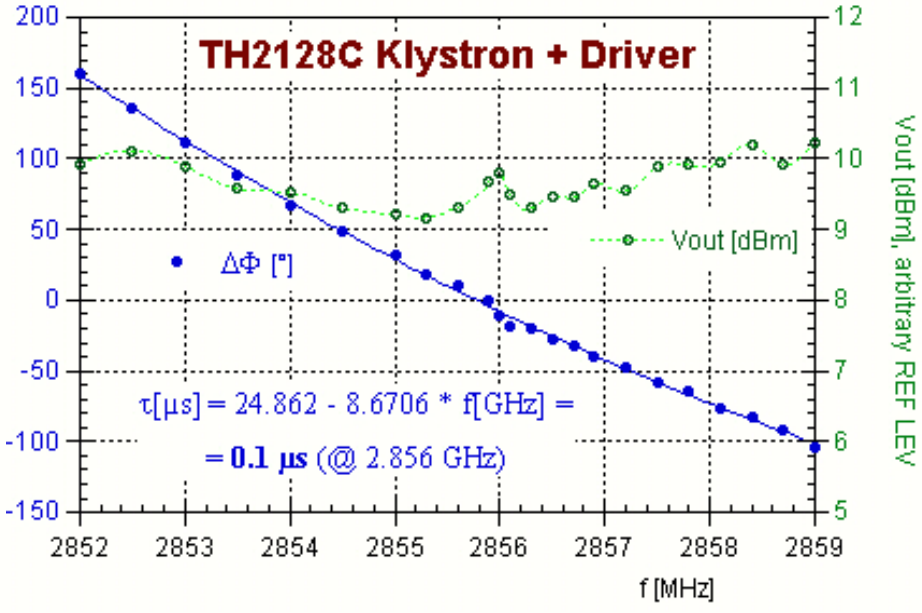
- **The main contribution seems to come from the driver amplifiers (planar triode technology). In the SPARC case the driver amplifiers will be of a different and better performing technology (pure class A, solid state) with tight phase jitter specification (1° rms). The expected phase jitter values of the SPARC RF stations are consequently lower.**

BANDWIDTH and GROUP DELAY MEASUREMENTS

DAFNE LINAC – STATION B
August 2003







TH2128C KLYSTRON GROUP DELAY MEASUREMENTS CONCLUSIONS

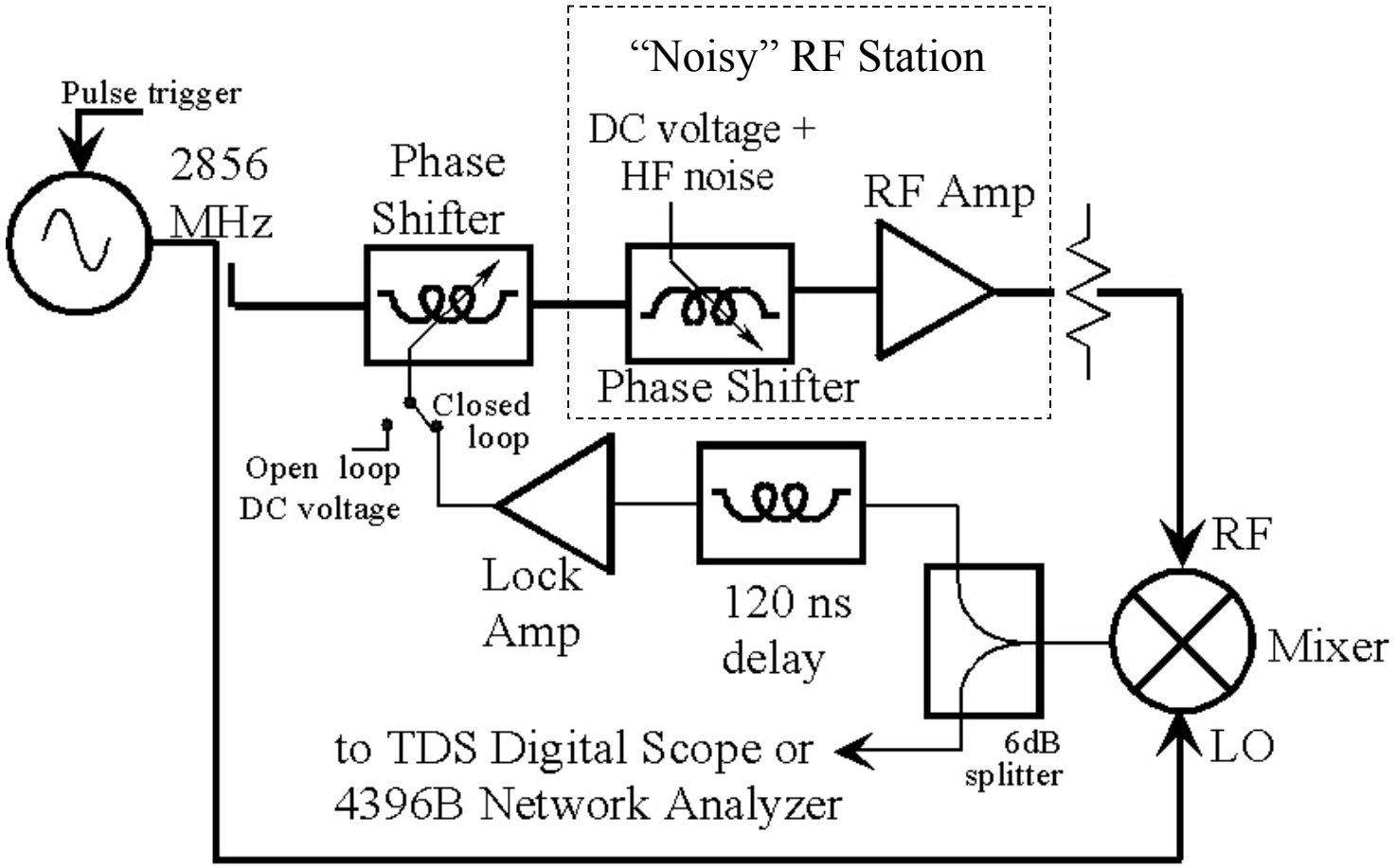
- **The TH2128C klystron bandwidth has been partially measured (too large input frequency deviation caused the station to trip).**

- **The measured band was sufficient to extrapolate the group delay value, that was ≈ 30 ns for the klystron alone and ≈ 100 ns for the whole station (including driver amplifiers and connecting cables). According to these measurements, a fast intra-pulse phase-lock control seems feasible.**

BENCH MEASUREMENTS OF A FAST INTRA-PULSE PHASE-LOCK CONTROL

An intra-pulse phase-lock system is under study to actively correct the fast phase jitter coming from the RF stations. Since the RF pulse is about 4.5 μs long, the rise time of such a system should be of the order of 1 μs, corresponding to a bandwidth of about 1 MHz. Consequently a fast phase modulator is needed, while the overall delay of the connections (including the group delay of the RF station) should be limited to ≈ 100 ns. The speed of the OpAmps manipulating the signal has also to be adequate.

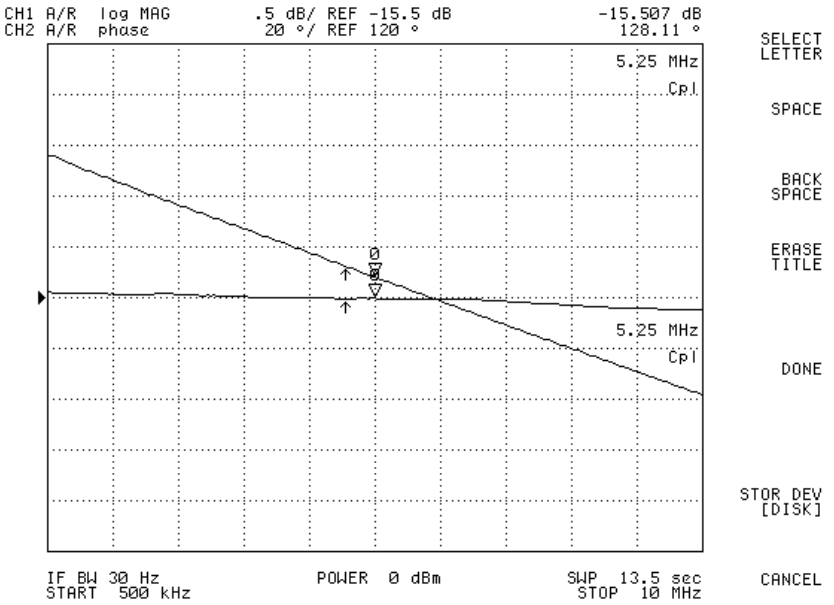
FAST PHASE LOCK FEEDBACK SYSTEM
Sketch of the Experimental Set-up

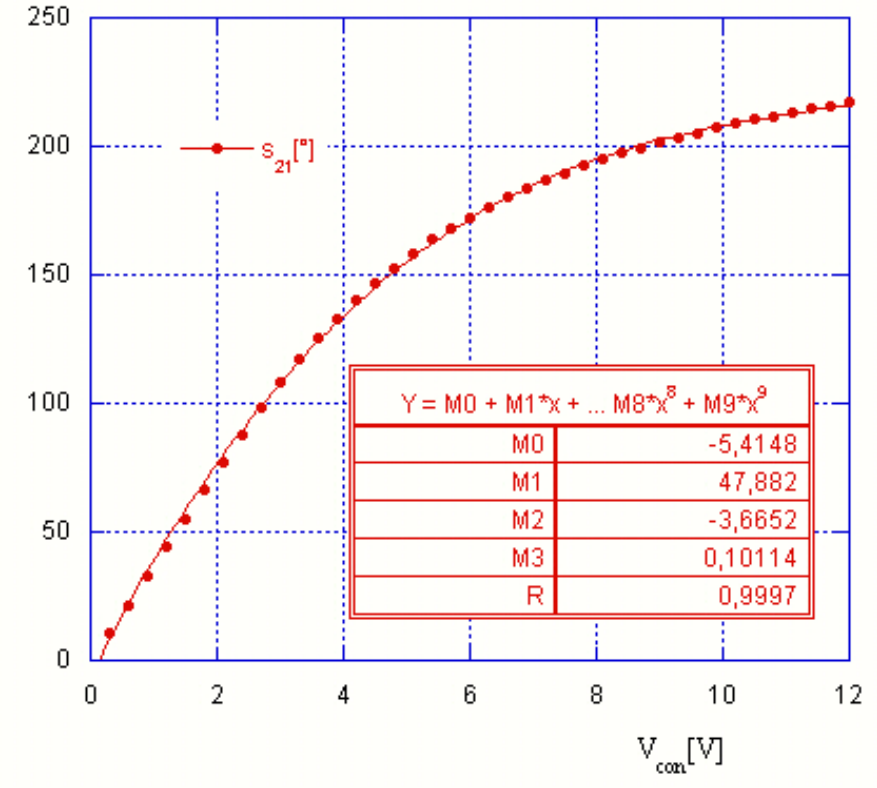


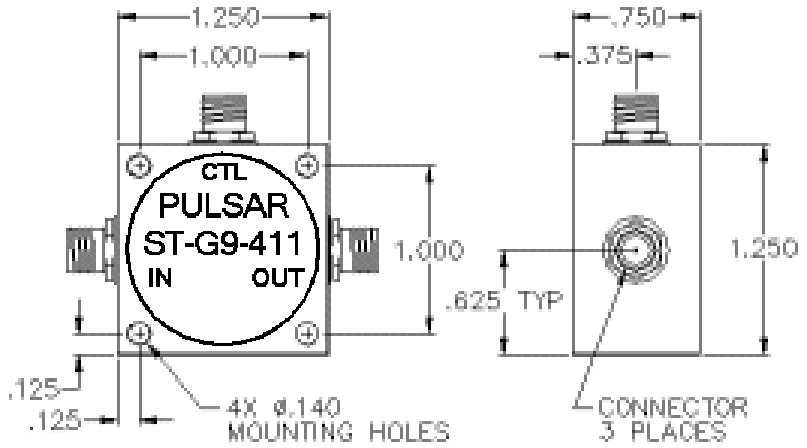
PULSAR ST-G9-411
Phase Shifter

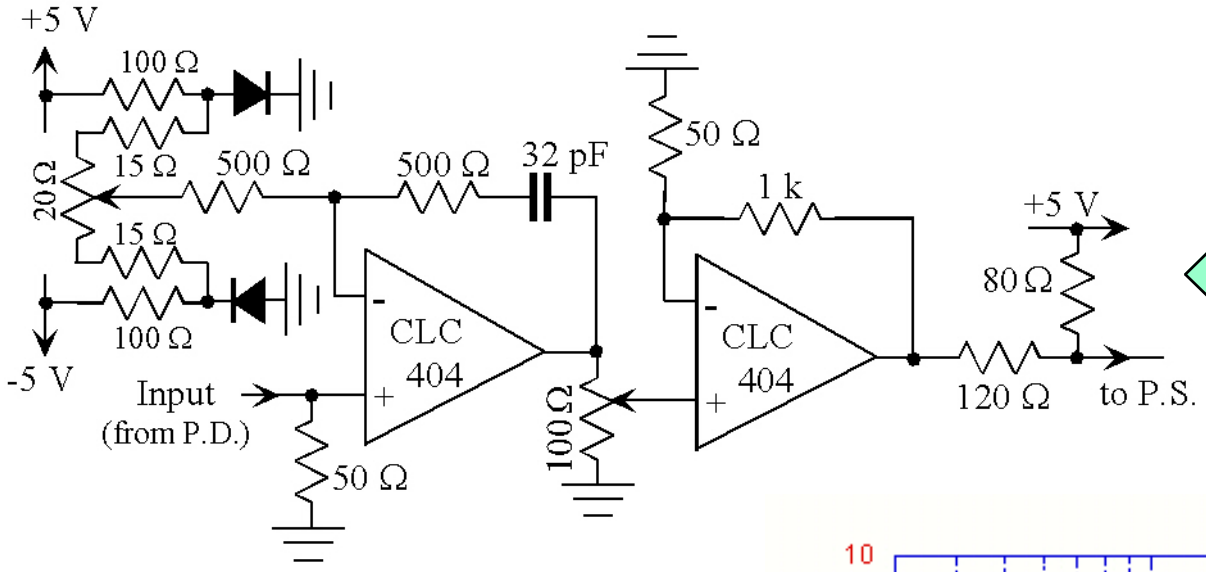
CALIBRATION

FREQUENCY RESPONSE



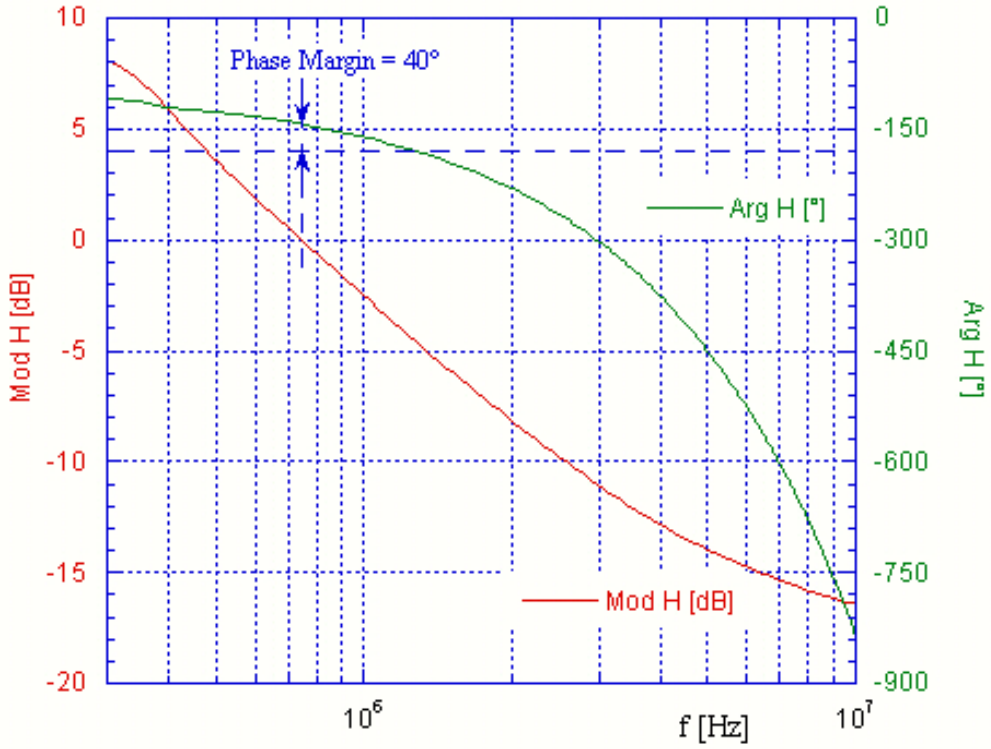




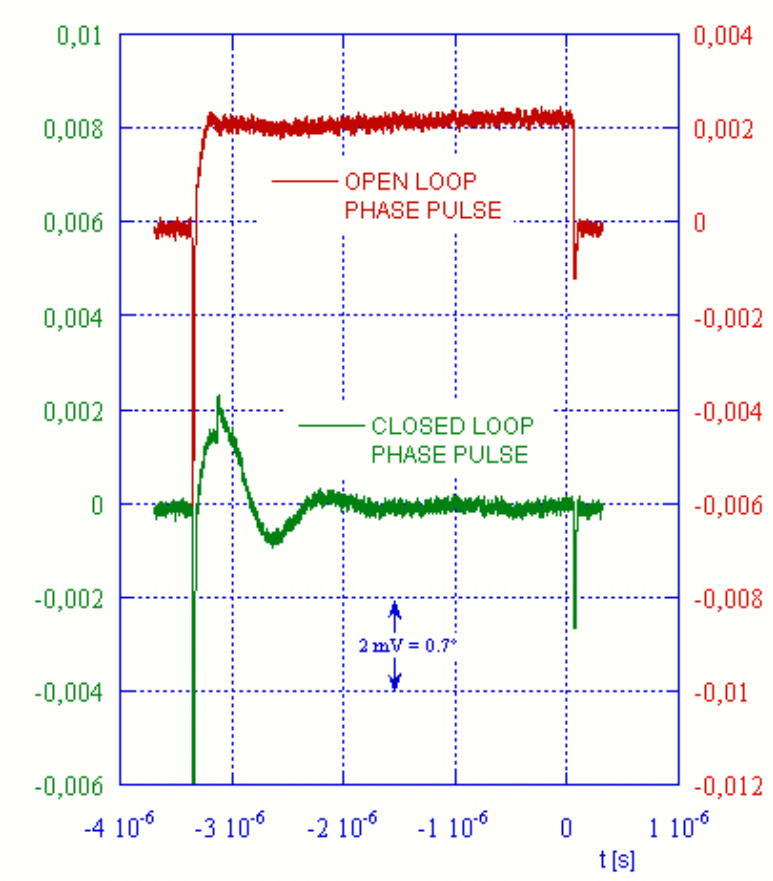


Lock Amp:
Circuit sketch

Fast Phase Lock
Feedback System:
Open Loop Gain
(amplitude and phase)

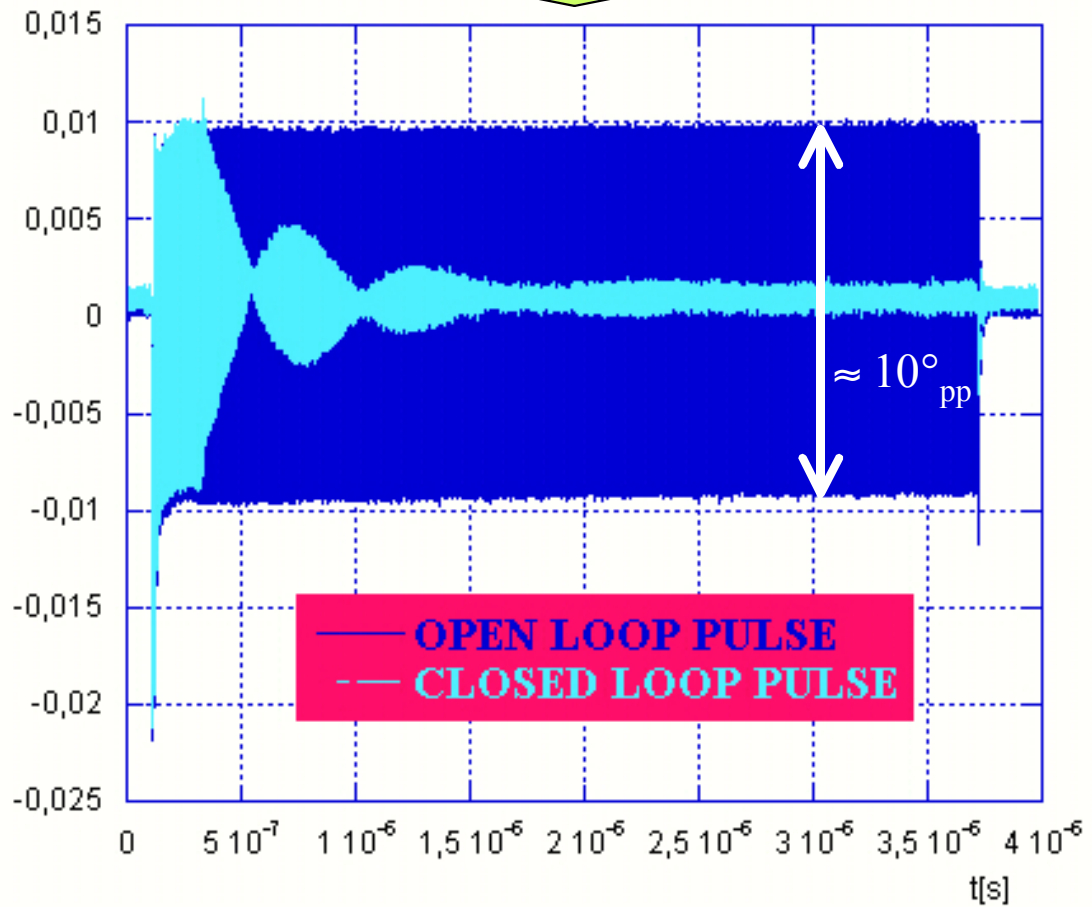


Open/Closed Loop Phase Pulses



Single shot
phase pulses

256 frames with ≈ 10°$_{pp}$,
10 kHz phase noise



CONCLUSIONS

- **A fast phase-lock system capable to reach the regime inside each RF pulse to correct the fast jitter of the SPARC RF stations seems feasible from bench experimental activities.**
- **The design of the whole low-level SPARC RF control, including all the RF synchronization electronics, will be completed by June 2004. A significant part of the needed devices is already in house. The remaining part will be ordered in the first half of this year.**