Introduction to the practical afternoon courses on DSP/FPGA designs

CAS 2007-DSP

Hermann Schmickler (CERN)

contents

- What do we want to achieve with the courses
- Boundary conditions
- Original options
- The physics case: PLL betatron tune tracking
- Translation into the lab setup

- Familiarization with DSP and FPGA design during 8 hours
- Every student does within 16 hours (7 afternoons) 8 hours DSP and 8 hours FPGA designs
- No chance to learn the syntax of any detailed design tool
- Very different starting points of individual students

•Choice:
25 DSP workstations (PC plus evaluation board) +
25 FPGA workstations (PC plus evaluation board) +
MATLAB/Simulink as high level graphical design environment

The DSP master:

Maria-Elena Angoletta (CERN)

Room A

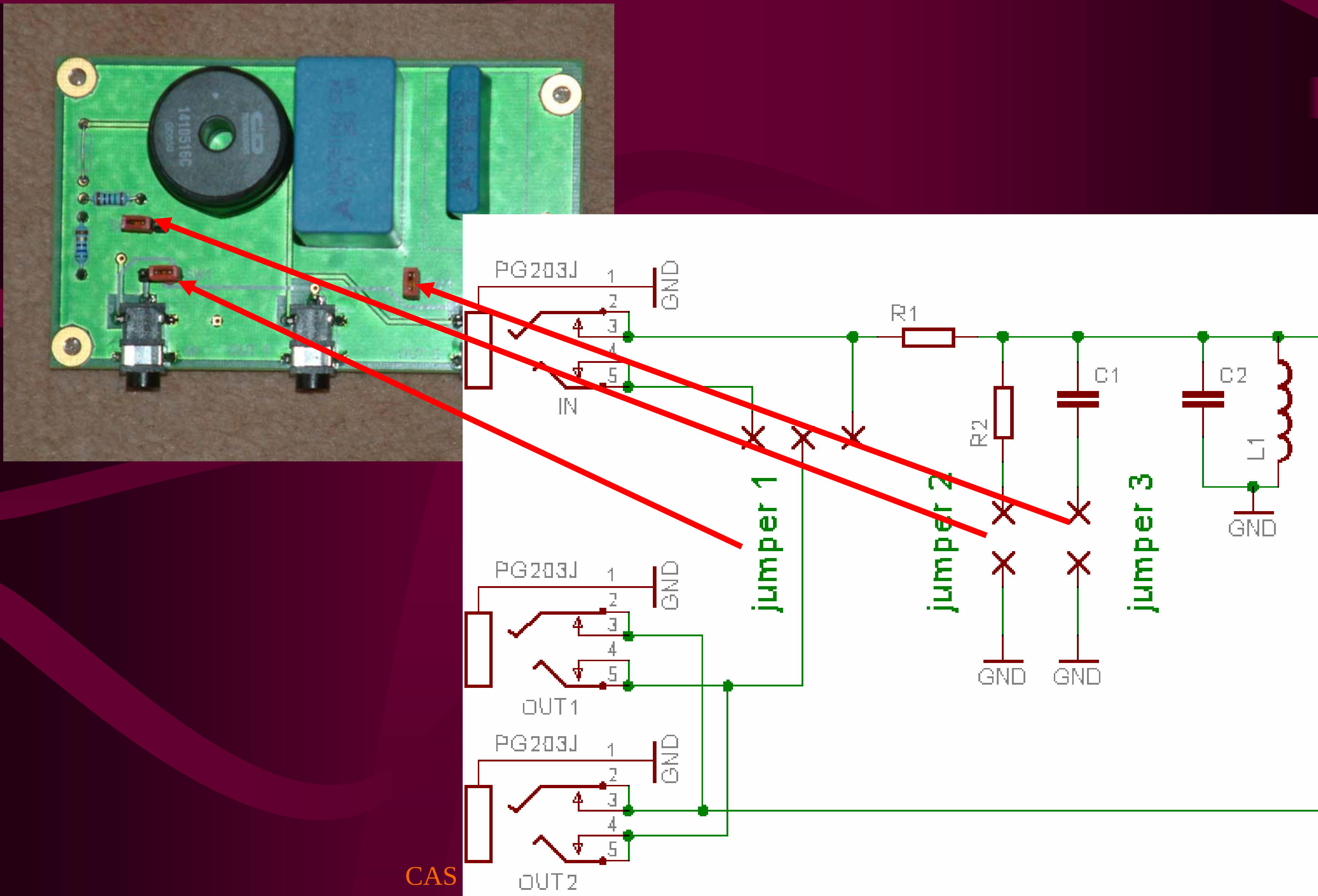
The FPGA master
Javier Serrano (CERN)

Room B

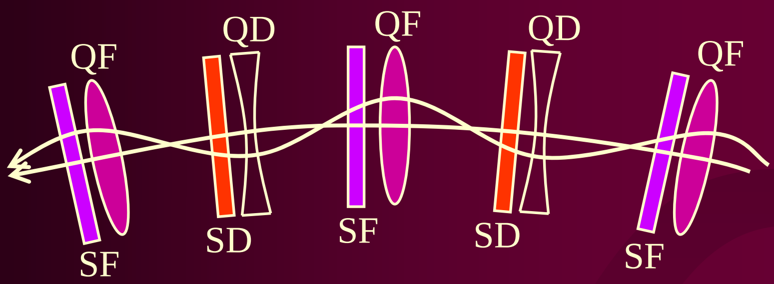
What possibilities for the lab?

- Hands on: Real physical input/output
- → Codec of DSP/FPGA cards
- Loudspeakers/headphones: no!
  No synthesizers, audio filters,
  speech recognition…
- Large synchrotrons (LEP, RHIC, HERA, LHC) have betatron tune within audio-bandwidth
- Decision to take as subject for the labs betatron tune diagnostics

The virtual accelerator (one plane only)



Measurement of Q (betatron tune)

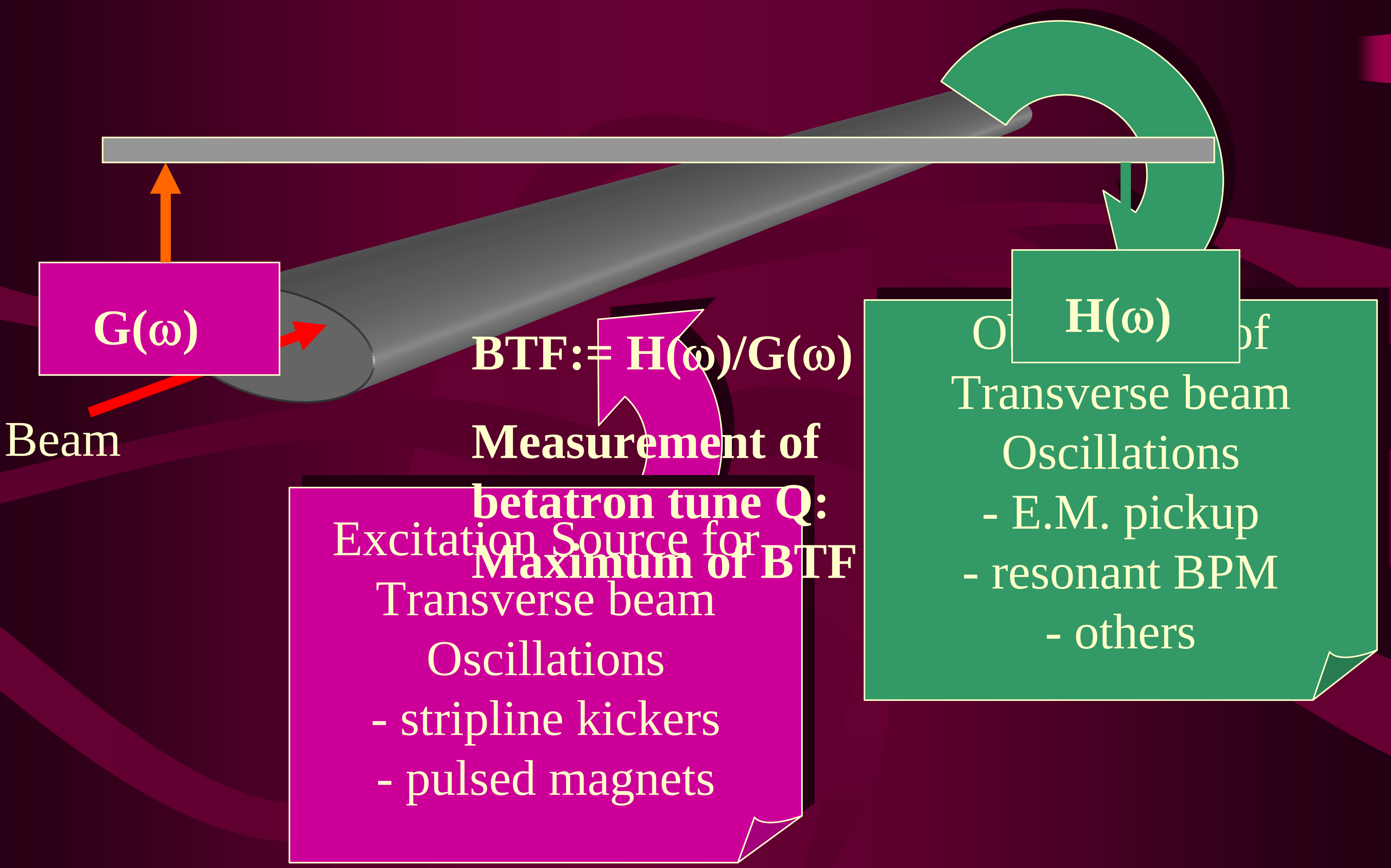


Characteristic Frequency of the Magnet Lattice

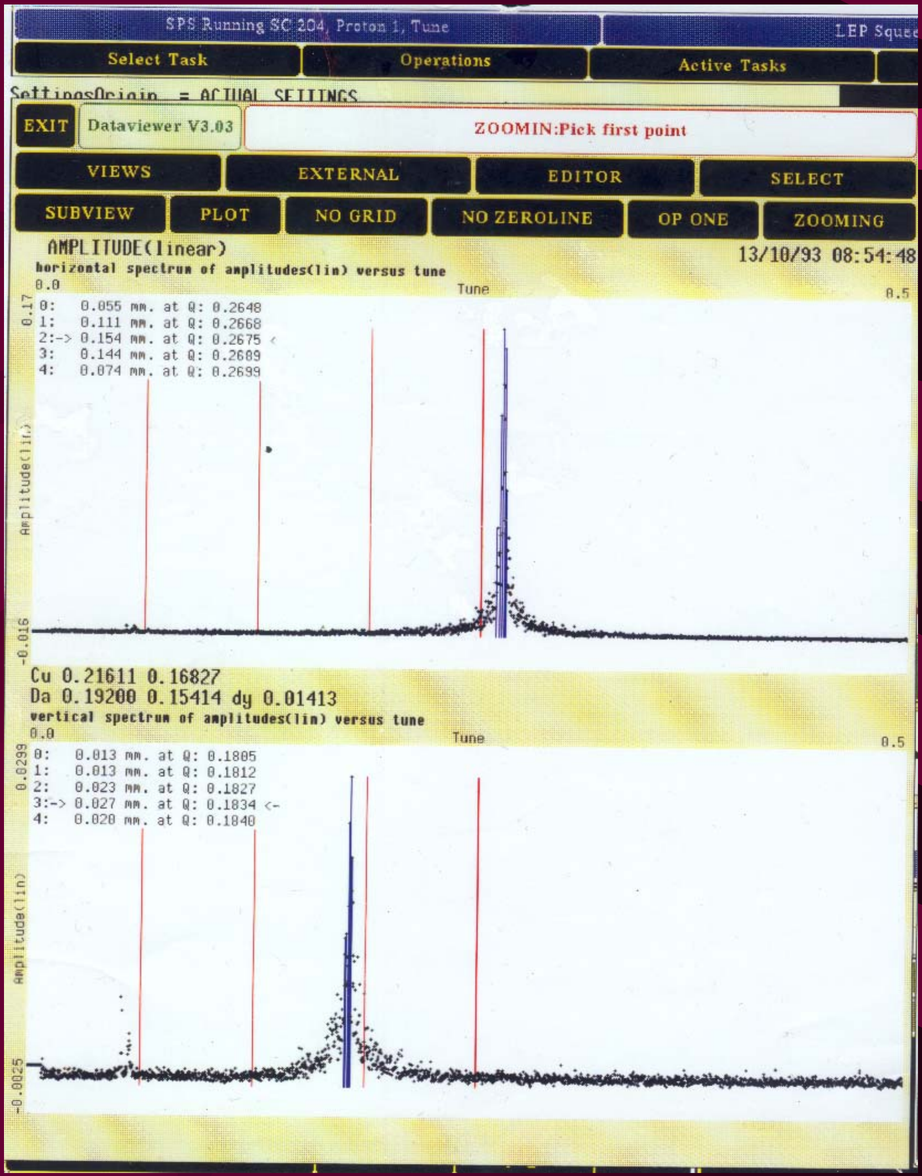
Produced by the strength of the Quadrupole magnets

- Q – the eigenfrequency of betatron oscillations in a circular machine
  - → One of the key parameters of machine operation
- Many measurement methods available:
  - → different beam excitations
  - → different observations of resulting beam oscillation
  - → different data treatment

Principle of any Q-measurement



Simple example: FFT analysis



G(ω) == flat
(i.e. excite all frequencies)

Made with random noise kicks

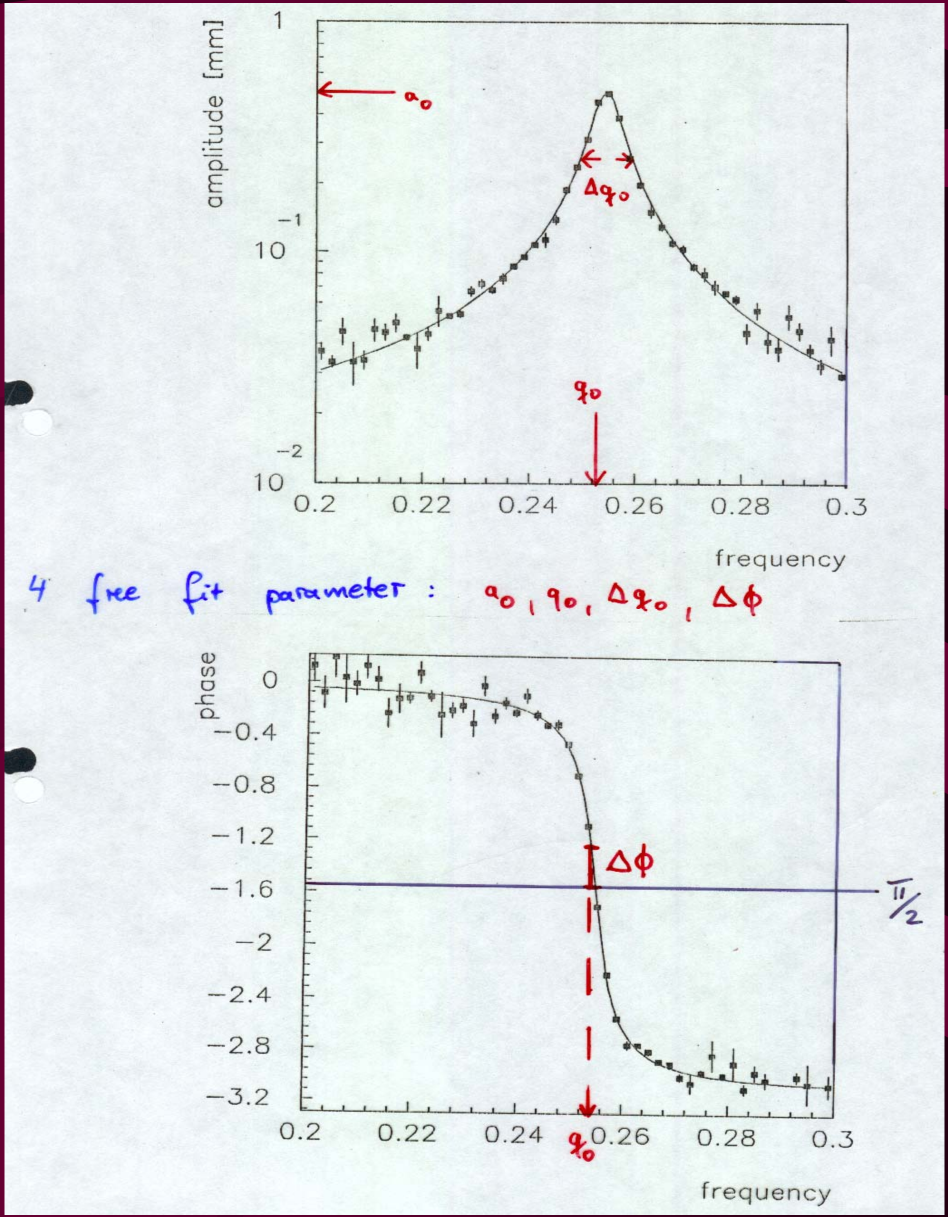
Measure beam position over many consecutives turns

apply FFT → H(ω)

BTF = H(ω)

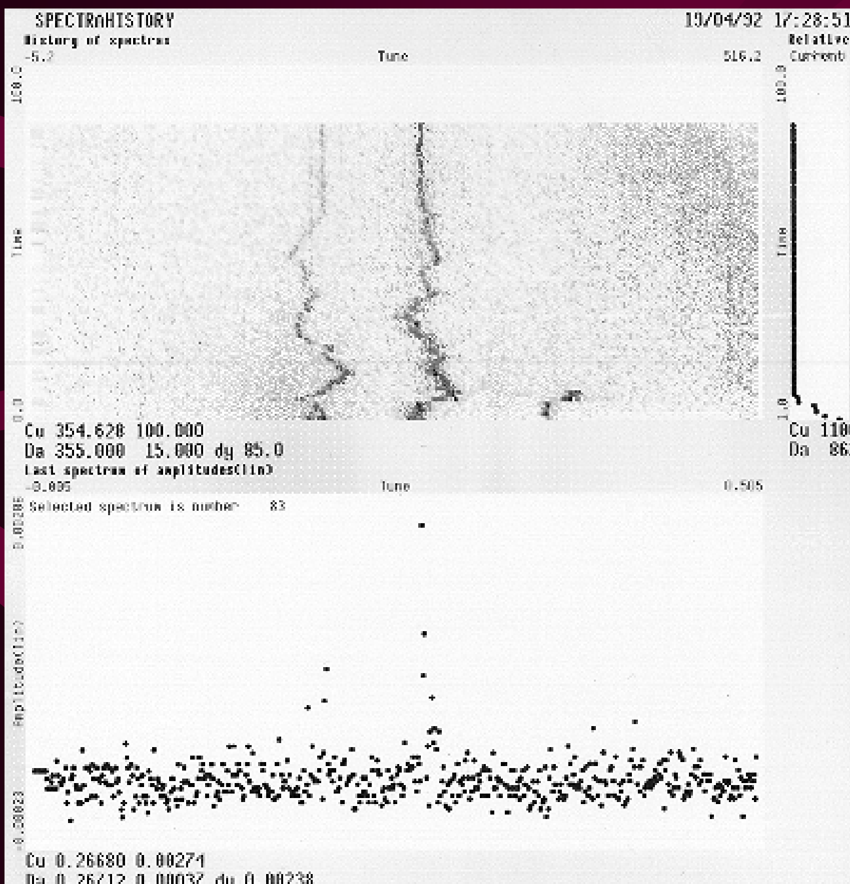
Network Analysis

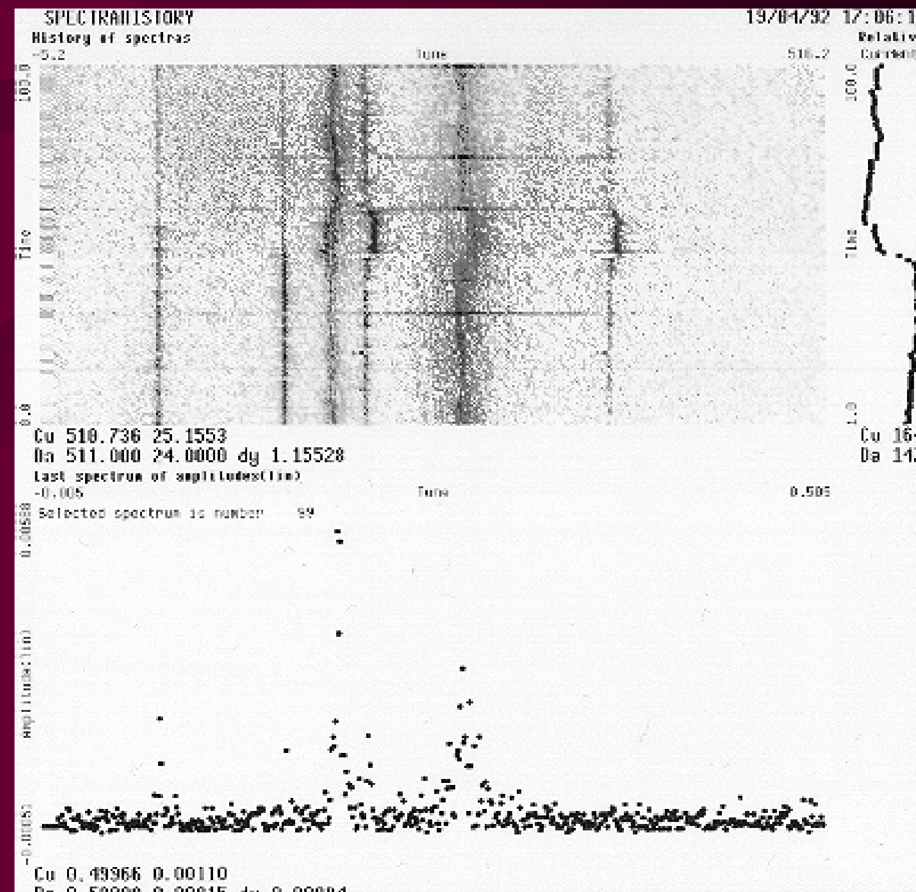
1. Excite beams with a sinusoidal carrier
2. Measure beam response
3. Sweep excitation frequency slowly through beam response



Time Resolved Measurements

- To follow betatron tunes during machine transitions we need time resolved measurements. Simplest example:
  - → repeated FFT spectra as before (spectrograms)





Principle of PLL tune measurements

This PLL system looks to the 90 deg. point of the BTF

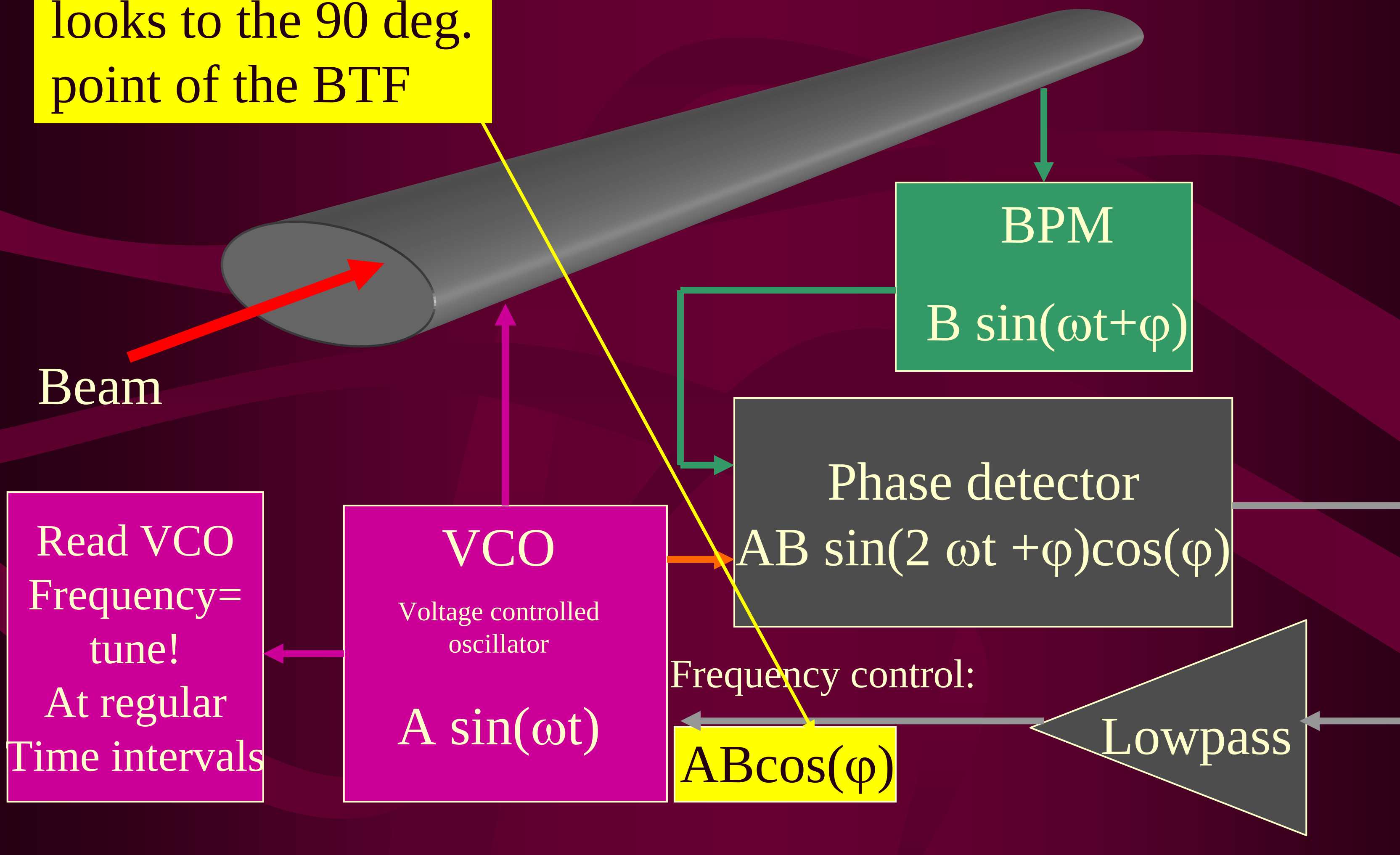
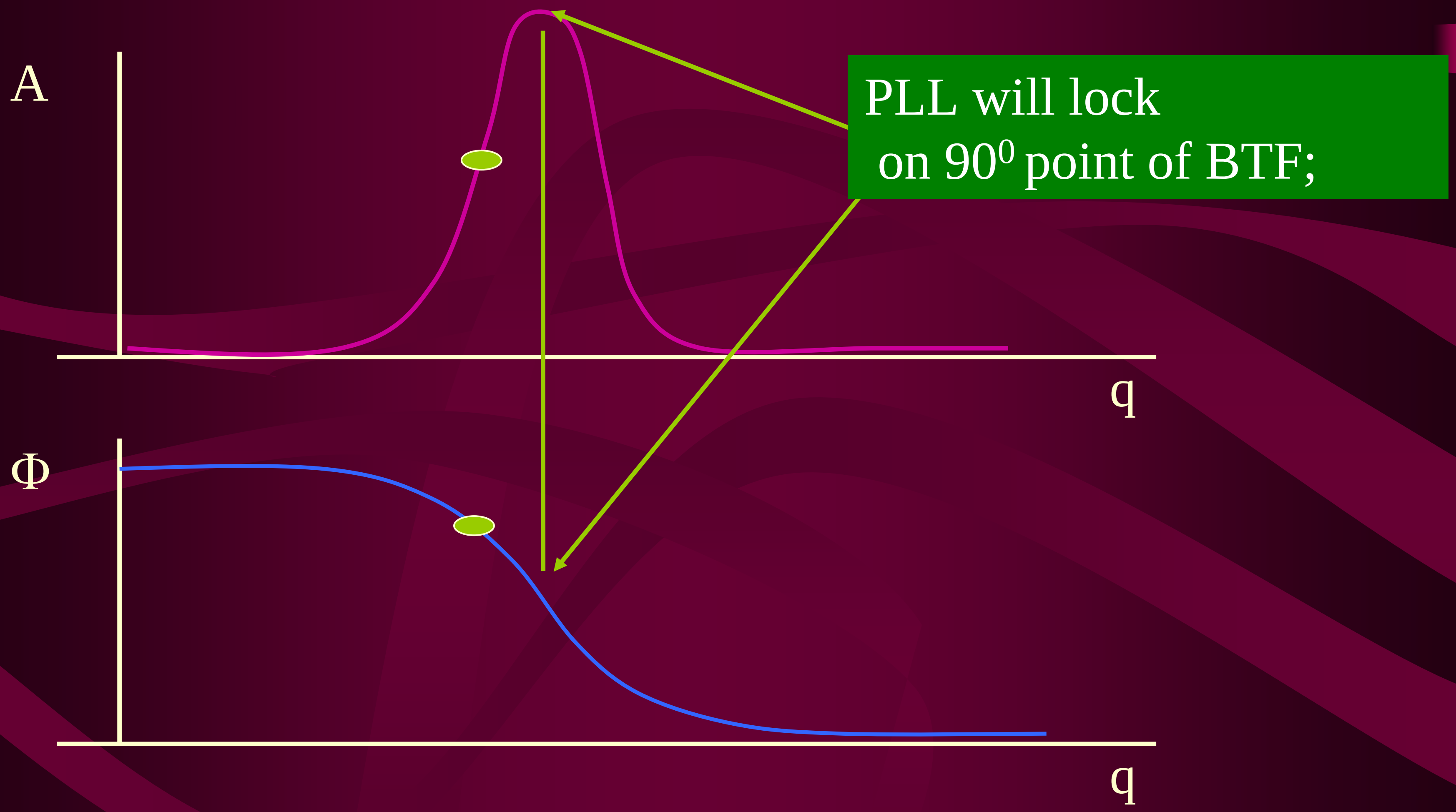
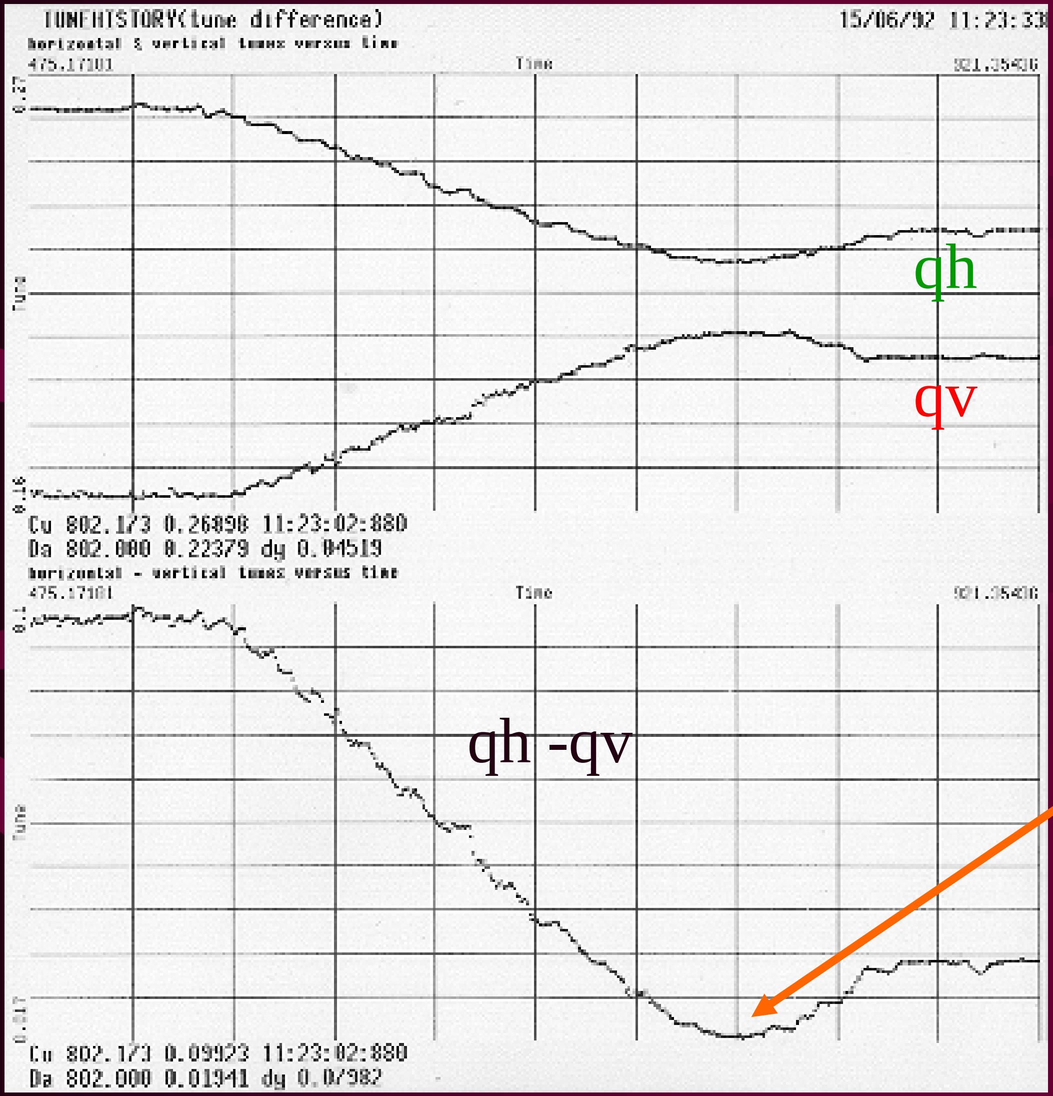


Illustration of PLL tune tracking



Example of PLL tune measurement



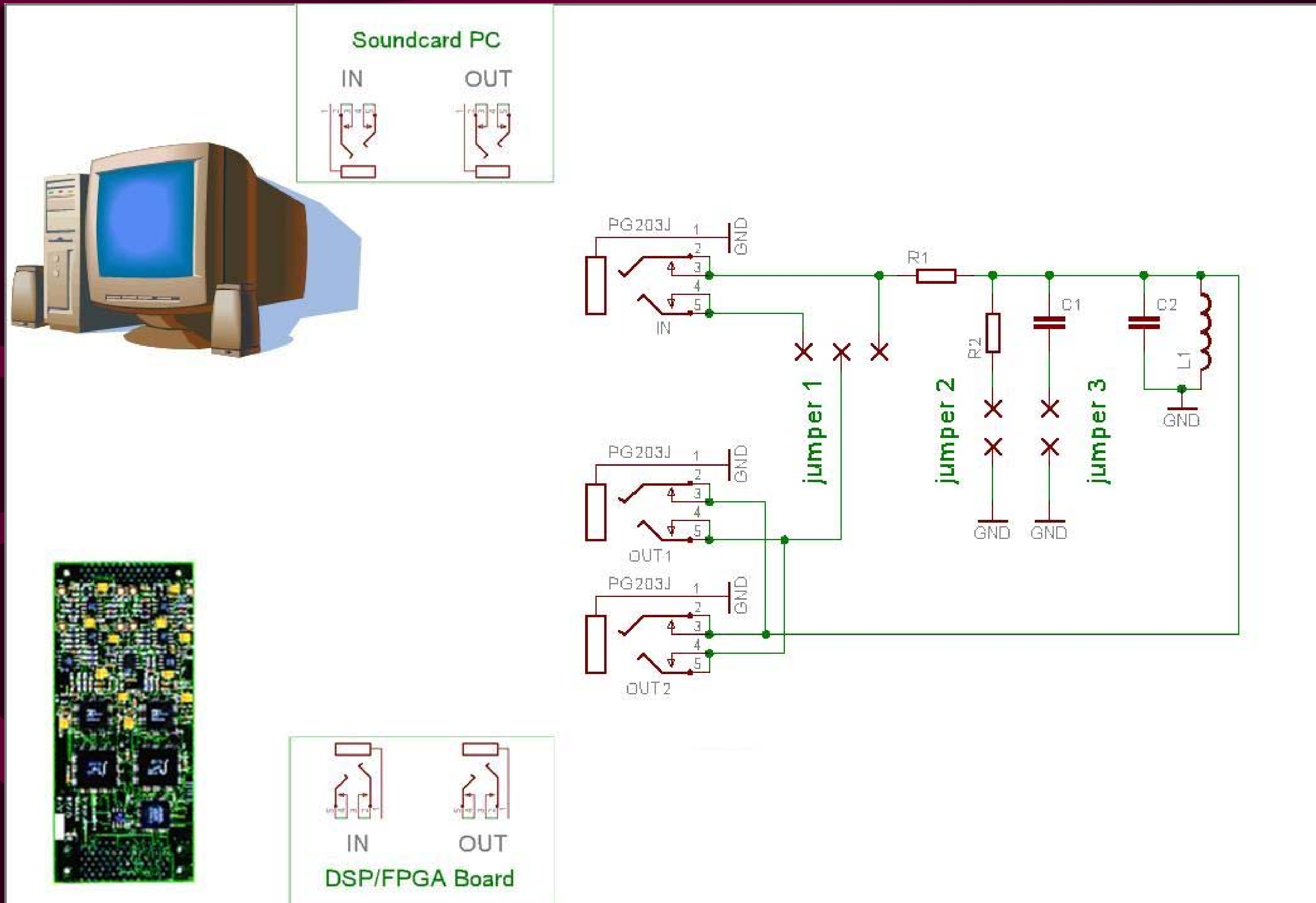
In this case continuous tune tracking was used whilst crossing the horizontal and vertical tunes with a power converter ramp.

Closest tune approach is a measure of coupling

Sequence of the exercises

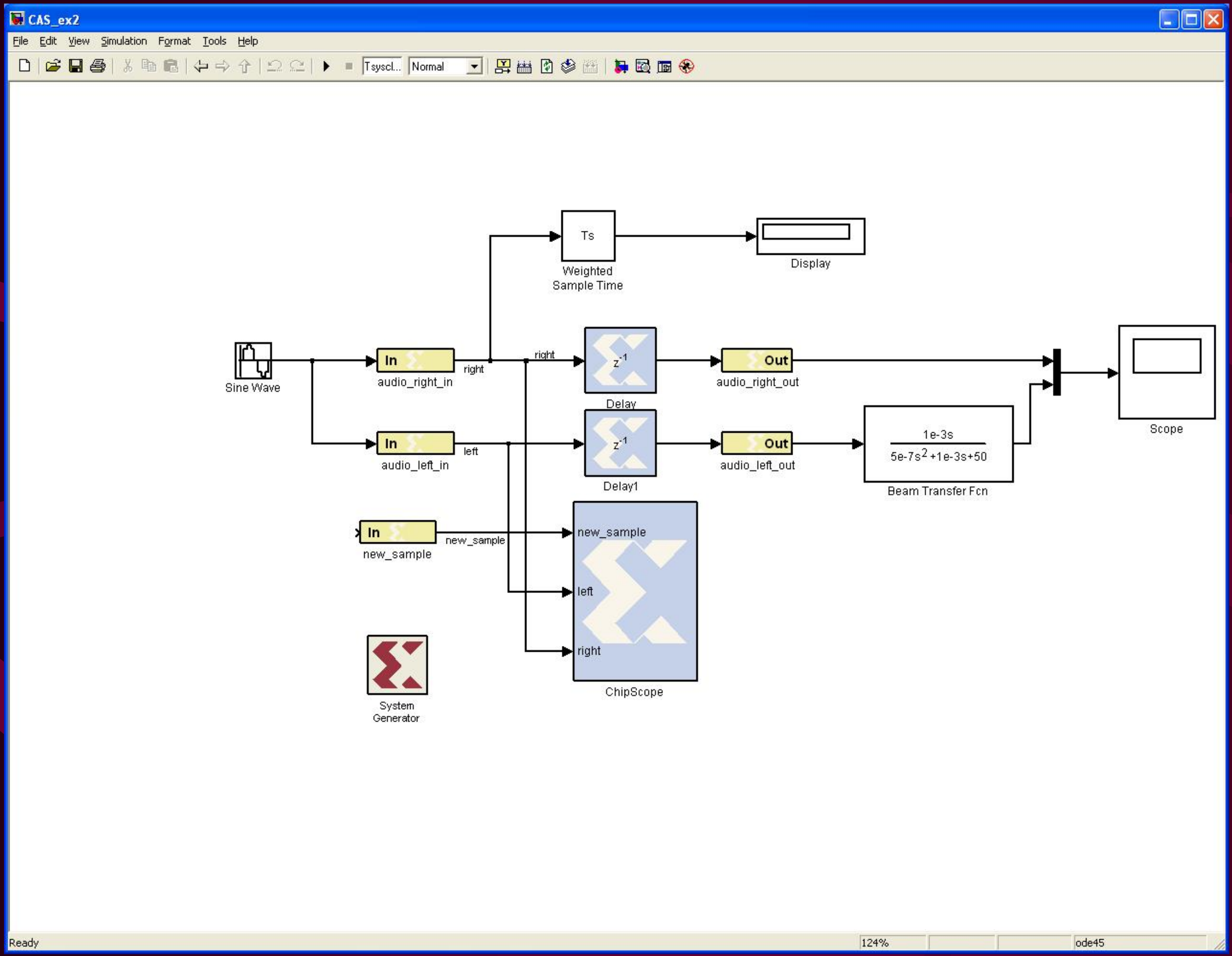
- 11 detailed exercises: printed booklet
- Objectives from
  - familiarization with the setup
  - measurement of BTF
  - NCO design
  - phase detection
  - closure of the PLL
  - amplitude regulation
- All exercises (designs) ready and tested
- Minimum expectation: students load ready designs and understand them
- Maximum expectation: students find the bugs in our designs and correct them

Lab setup



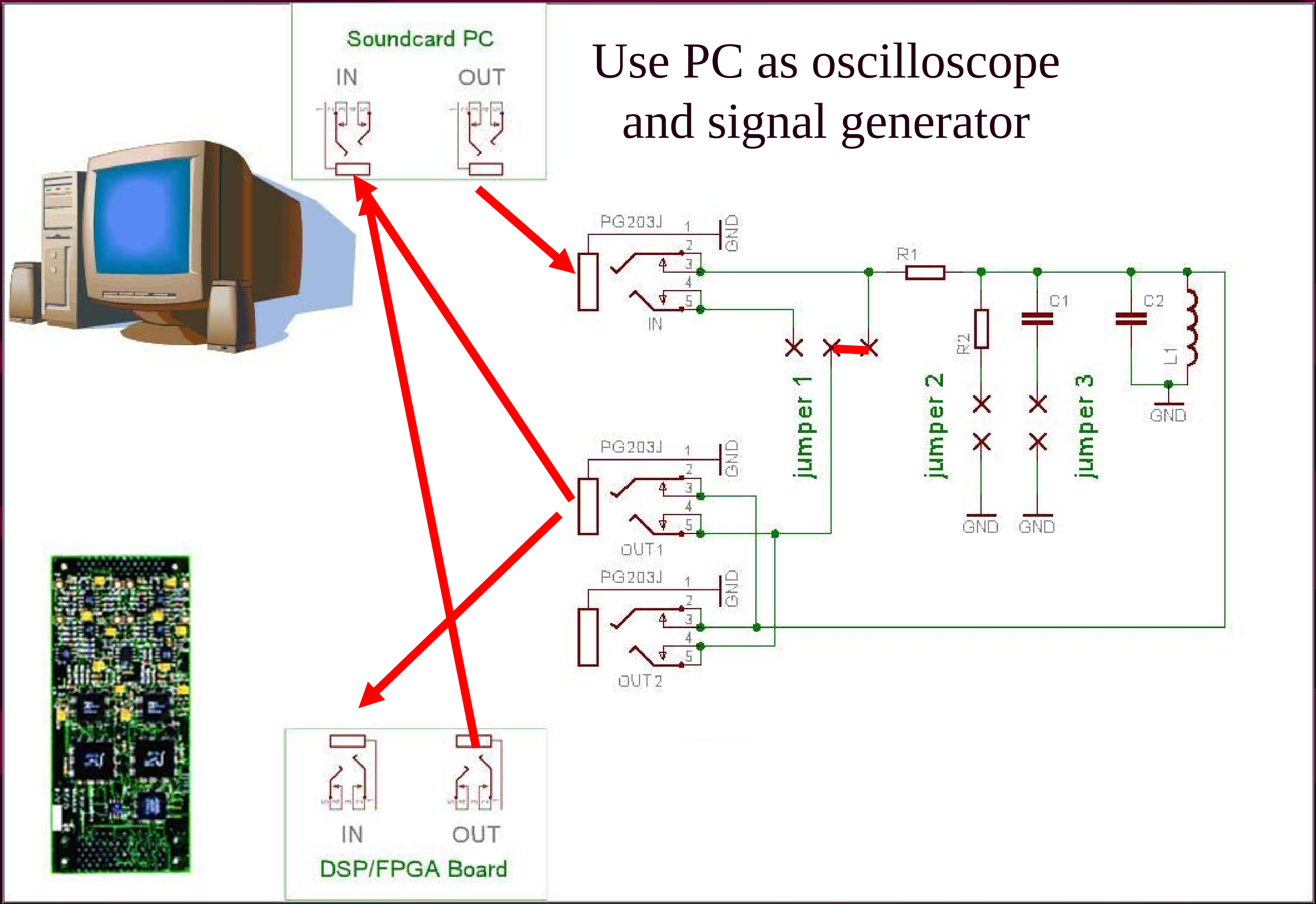
Soundcard PC
IN
OUT
PG203J
GND
IN
OUT1
OUT2
R1
R2
C1
C2
L1
jumper 1
jumper 2
jumper 3
IN
OUT
DSP/FPGA Board

Example: Exercise 2
« Measure BTF using the evaluation board »



Lab setup

Use PC as oscilloscope and signal generator



Practical instructions:

- No drinks/food/cigarettes in the labs please
- Get together in teams of two:
  Recommended: similar level of competence
- Labs are open in the evening: Everybody is invited to come back to his working place after dinner in order to play a little with the setup
- Now:
  define 48 + 48 students for FPGA/DSP courses