12GHz Phase Monitor

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Energy and phase stability requirements in CLIC

- Drive beam phase jitter leads to luminosity drop.
- $\Delta\varphi$ at 1 GHz causes 12 $\Delta\varphi$ at 12 GHz!
- Requirement at 1GHz (order of magnitude):
  drive beam phase jitter <0.02° (3.5E-4, 50 fs)
  drive beam energy jitter <$\mathcal{O}$(1E-4)

(With a feed-forward, this may be relaxed by a factor 10!)

- Requirement at 12GHz (order of magnitude):
  drive beam phase jitter <0.2° (3.5E-3, 50 fs)
  drive beam energy jitter <$\mathcal{O}$(1E-4)

See: Erk Jensen, 4th CLIC Advisory Committee (CLIC-ACE)

- Drive beam gun
  - Beam current changes acceleration! $\frac{\delta V}{V} = -\frac{R}{V_0/I - R}\frac{\delta I}{I}$

    at full loading: $\frac{\delta V}{V} = -2\frac{\delta I}{I}$
  - Phase jitter from the source
- Sub-harmonic buncher
  - Flips phase every 244ns. Creates also systematic error at 2.05 MHz
- via klystron:
  - Voltage $\delta\varphi = -\frac{L}{\lambda}\left(V\left(2+V\right)\right)^{-3/2}\delta V$
  - Klystron body temperature: $\delta\varphi \approx 1^\circ \frac{\delta T}{K}$
  - Drive power $\delta\varphi \approx 2.3^\circ \frac{\log \delta P_{in}}{\mathrm{dB}}$
  - … filament current, magnet current, waveguides...

See: Erk Jensen, 4th CLIC Advisory Committee (CLIC-ACE)

Phase monitor development

Task 5. Drive Beam Phase Control

1. Design, build and test a low-impedance RF beam phase monitor with a resolution of 20 fs
2. Design, build and test an electro-optical phase ... n of 20 fs

Sub-task 1: CERN ... a conceptual design report of ... **er to the electromagneti** ... n of the monitor. **CERN wi** ... . INFN will ... lab. A final ... n will be test... or.

Sub-task 2: The ... . PSI will implement prototyp... electro optical detector and electronics. ... be tested in the existing facilities at PSI.

Fabio Marcellini, INFN
Beam Phase Monitor for CLIC and CTF3: pick-up design
WG3: 15-Oct-2009, 16:00
in 40-S2-C01

Overview of the Phase Measurement System at SLS/PSI
WG3:15-Oct-2009, 11:30
in 40-S2-C01

This Presentation

Ready for beam tests in 2012

A. Andersson 2009-10-14

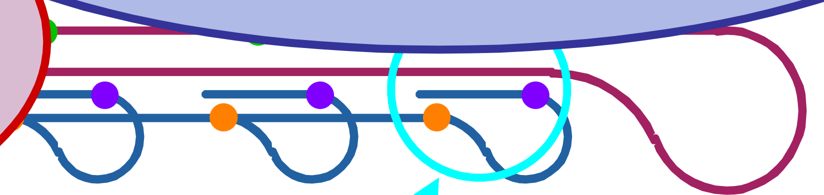
Timing Reference

Laser based timing distribution systems naking a lot of progress and can achieve femtosecond stability over a few kilometers

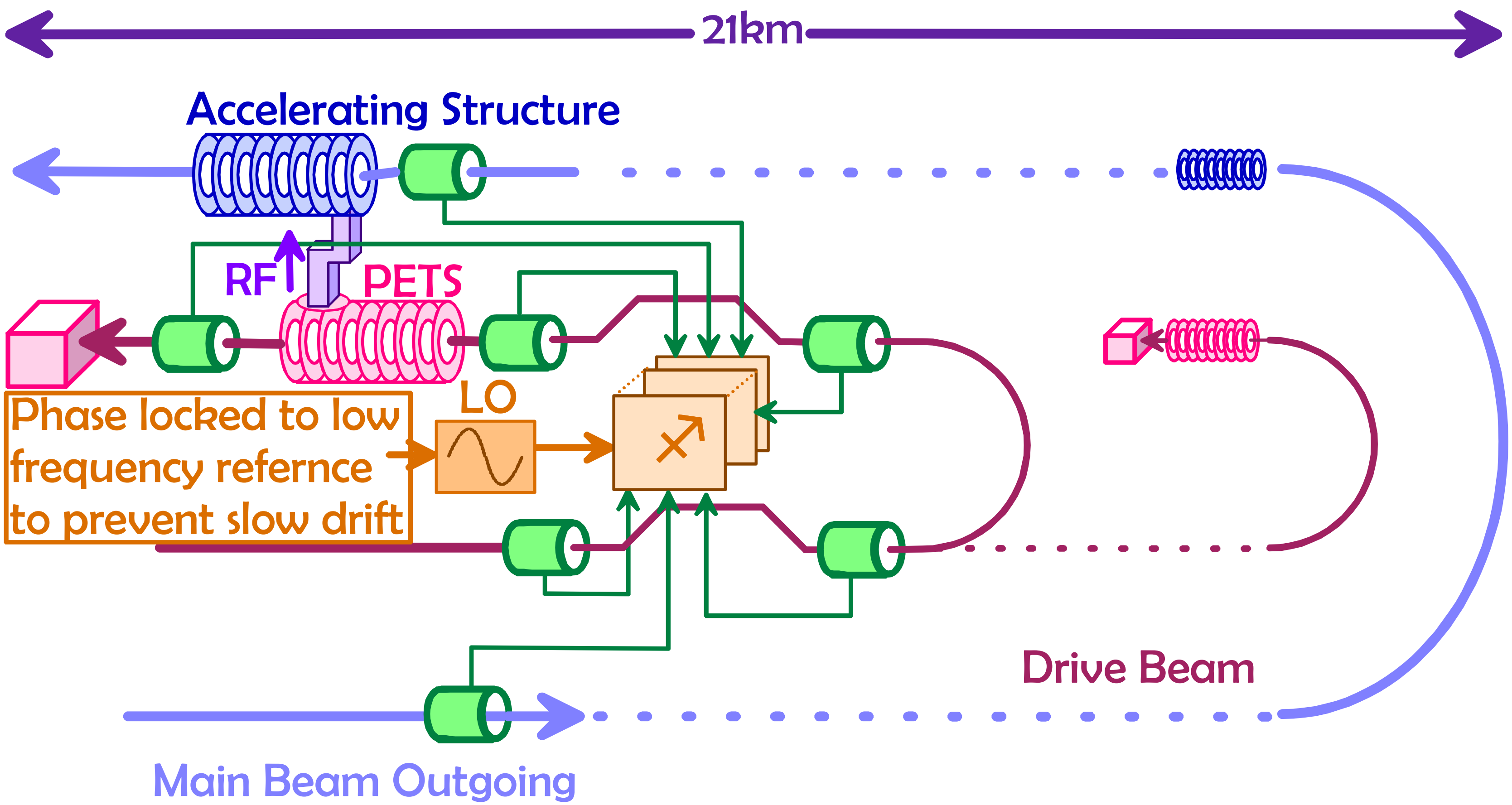
- Otherwise, the outgoing
reference at each turna
- A very stable local o
to

F. Ömer Ilday
Long distance Optical Fibers with fs resolution
WG3 :15-Oct-2009, 11:00
in 40-S2-C01

Matthias Felber
Femtosecond optical synchronization system for FLASH
WG3: 15-Oct-2009, 12:00
in 40-S2-C01



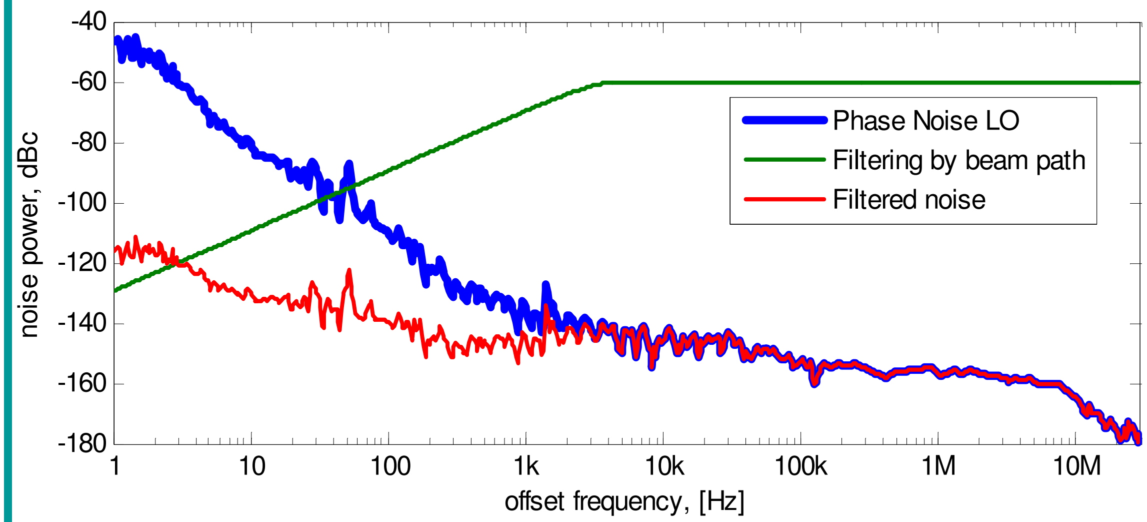
Phase measurements in CLIC



Local Oscillator

$\mathcal{O}$5k€

- We need an Local Oscillator with «23fs integrated phase jitter
- The beam path provides some noise filtering below 3kHz
- The system here seems to come in around ~4fs

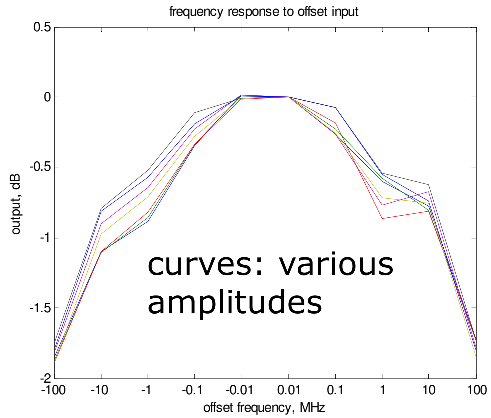


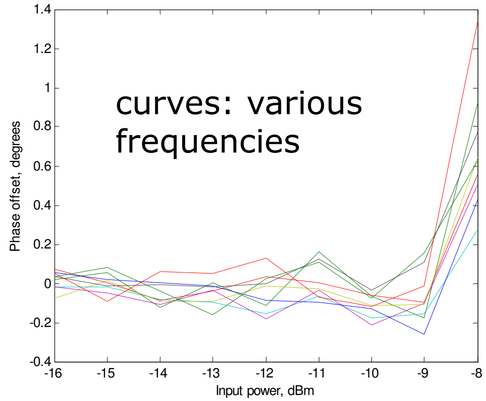
Electronics challenges

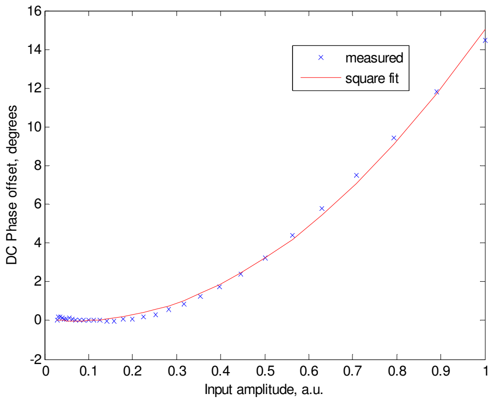
- Device non-linearities
- Phase detectors are inherently non-linear device
- Suppose a detector with an RF input consisting of a pure (sin) amplitude modulated signal. It has frequency components: f_0, f_0-f_m, f_0+f_m
- But all products of these are created at the input as well
- 2nd order: DC, $2f_0$, $2f_0$-$2f_m$, $2f_0$+$2f_m$, $2f_0$-f_m, $2f_0$-f_m, f_m, $2f_m$
- And 3rd, and 4th, and ...
- Which mix with the LO and all its harmonics: f_0, $2f_0$, $3f_0$…
- These are all weighted by complex coefficients that depend on device parameters and parasitics. Complex ⟶ AM-PM conversion
- And for an nth order product, on the amplitude V_0^n
- Thus, it is possible to find an operating point where the non-linear terms are small enough

Looking at a 12GHz mixer

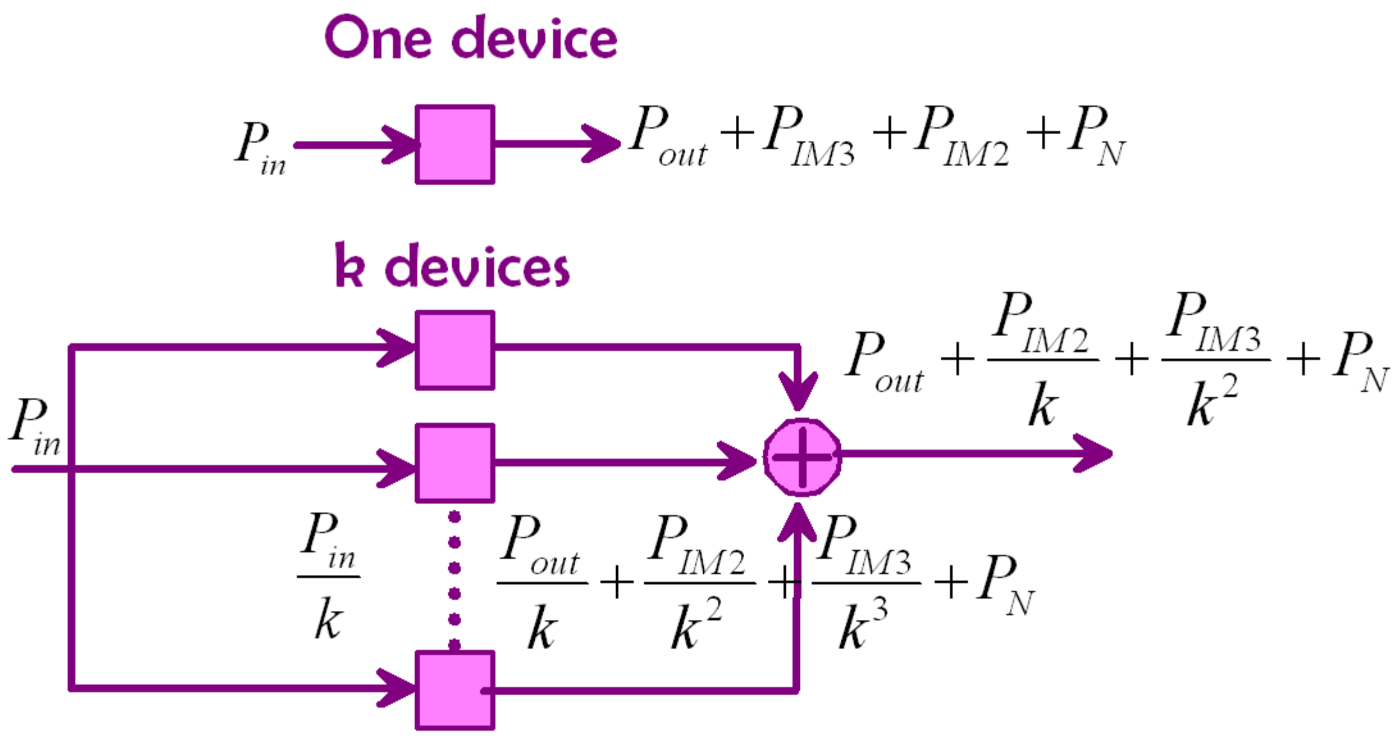
- Mixing to baseband directly from 12GHz to avoid long device chains
- The amplitude-squared dependant DC-DC term can be made small enough at low input levels
- It follows a square law as expected
- IF frequency response could be better







Managing non-linearities and noise



Conclusions

- An important topic for CLIC
- Electronics already realised and tested at 30GHz for similar requirements.
- Migration to 12GHz under way – similar and different approach
- Should have electronics prototype to bench test and to test with CTF3 signals from TBTS in 2010