324- and 1296-bunch modes: User expectations and experiences

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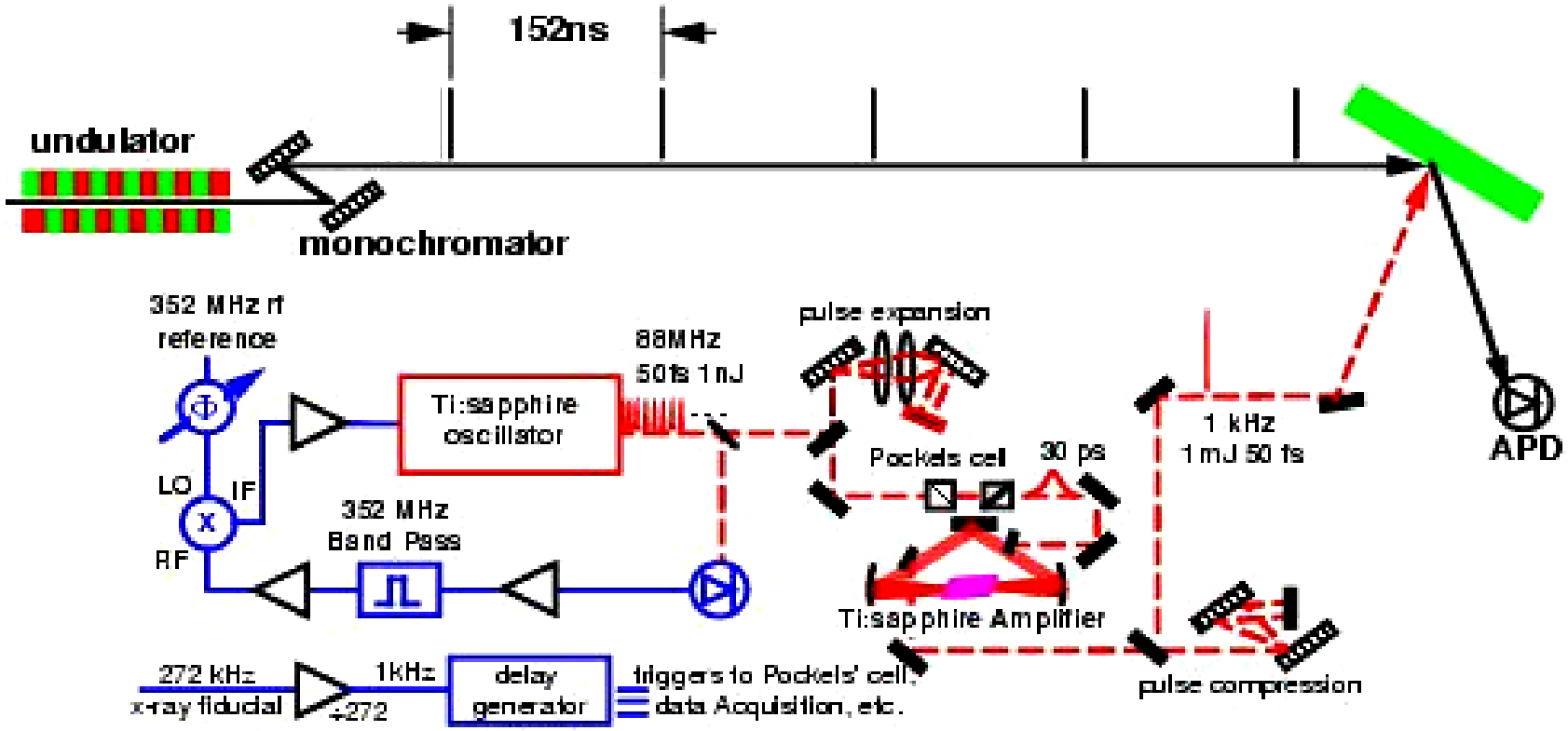
Typically, Peak Brightness is the Figure of Merit for Time-Resolved Research

- Pump-probe experiments limited by:
  - Repetition rate of the pump
  - Sample recovery time
  - Single shot x-ray brightness
- Hybrid singlet is the best
- 24 bunch mode suffices for some experiments
- Nobody wants more bunches in the S.R.!
- Today's talk: The exceptions to this rule

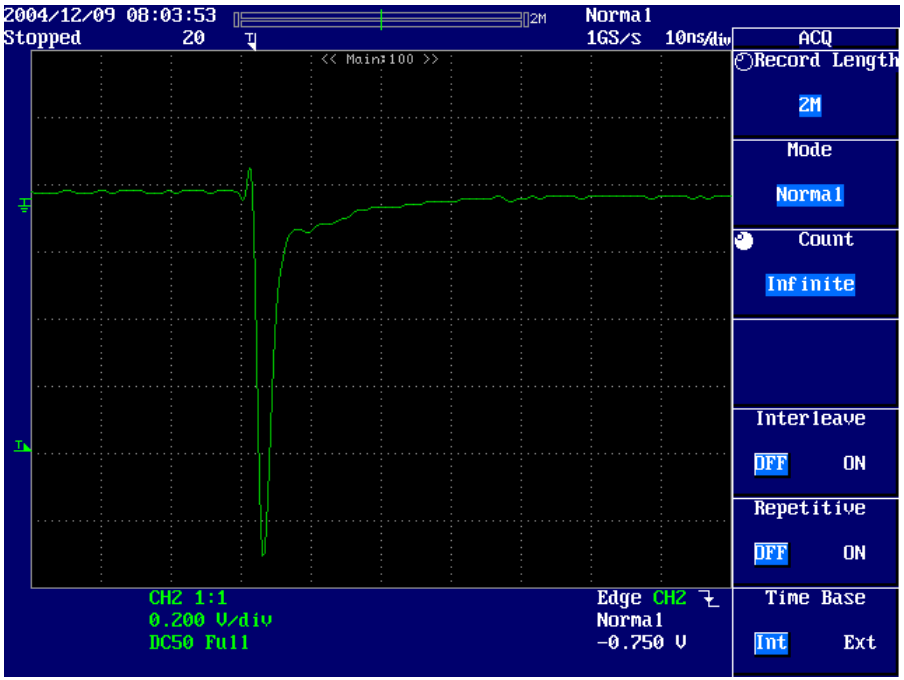
Pump-probe Time-resolved X-ray Diffraction

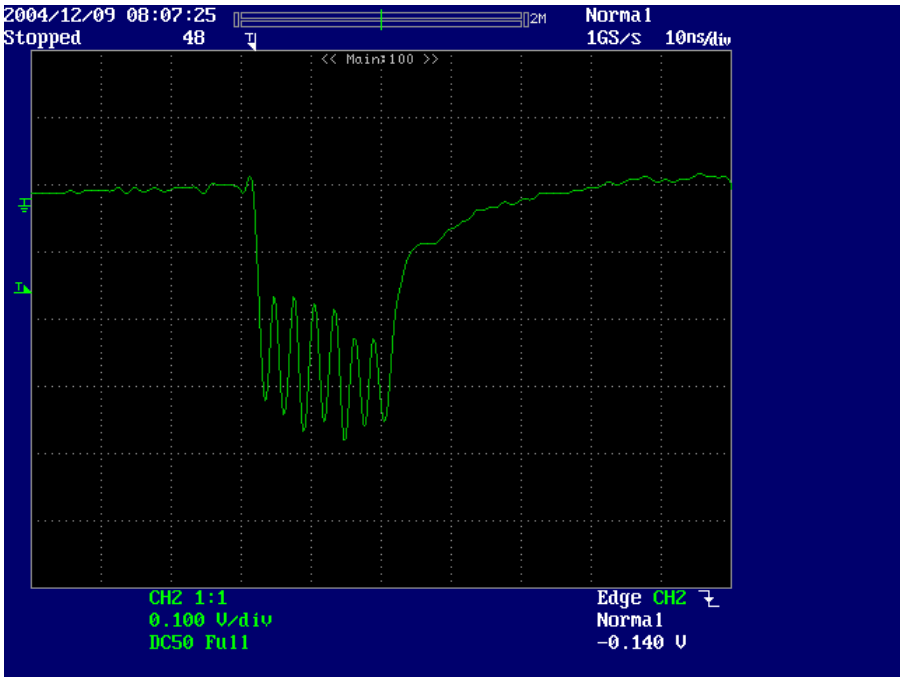


- uses “slow” detectors to study ultrafast dynamics*
- Temporal resolution limited by probe pulse: ~100 ps at synch.
- Pump-probe delay must be held fixed << the pulse duration.

**Detector must recover before the next x-ray pulse!*

Hybrid singlet x-ray measurement





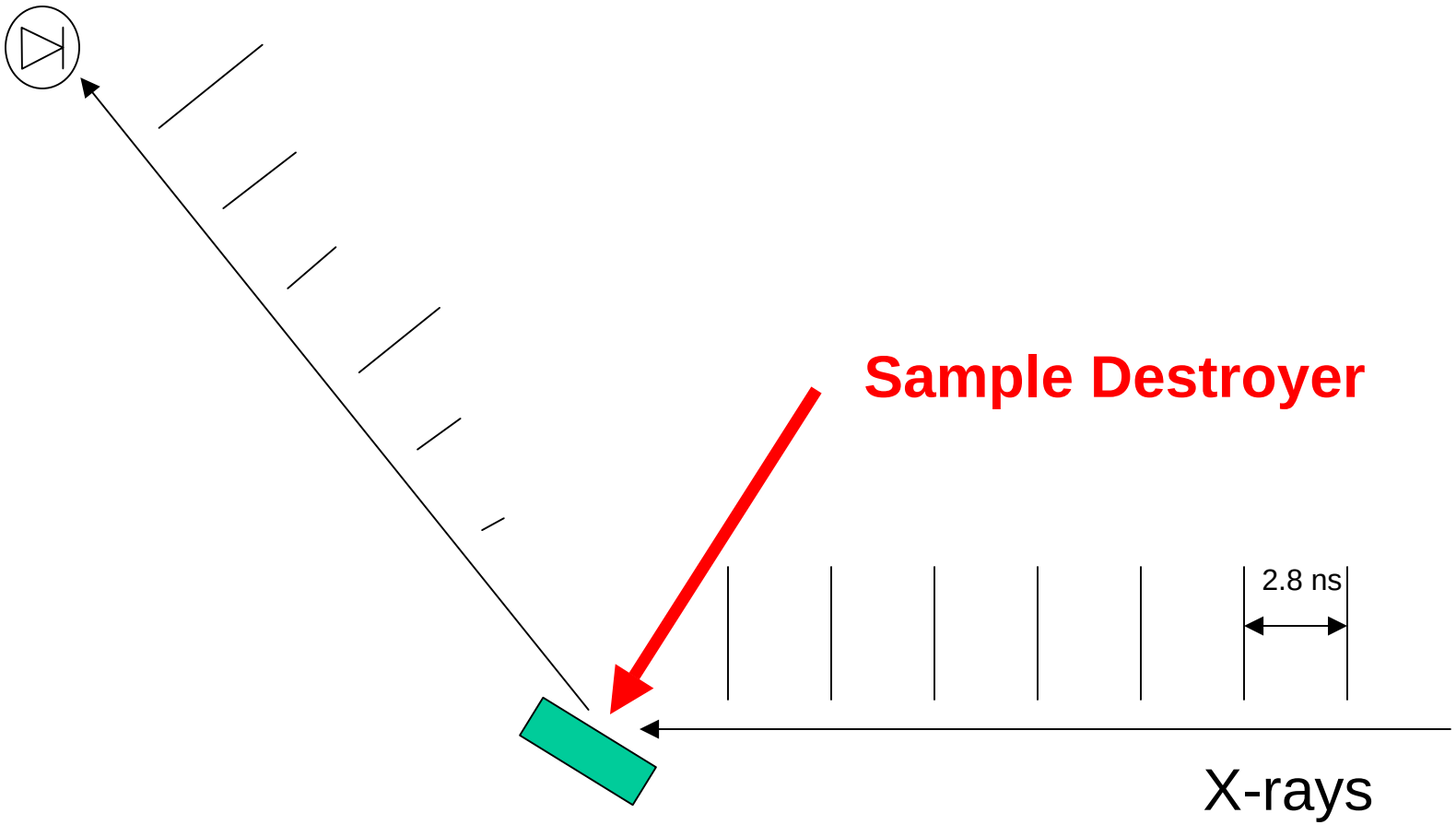
Judson Technologies InGaAs photodiode J22-18I-R250U1.7 (250 μm dia.) in direct beam (2.5 x 10^{12} ph/s) into ~ 1mm^2, 14 keV, directly into a FEMTO HAS-Y-2-40 2 GHz 40 dB transimpedance amplifier. Read out over a ~100 ft RG-223 cable into a 500 MHz Yukogawa 7200 oscilliscope and triggered using a ThorLabs 210 photodetector phase-locked fs laser beampath.

Bunch-to-bunch fluctuations in the 1296 fill pattern

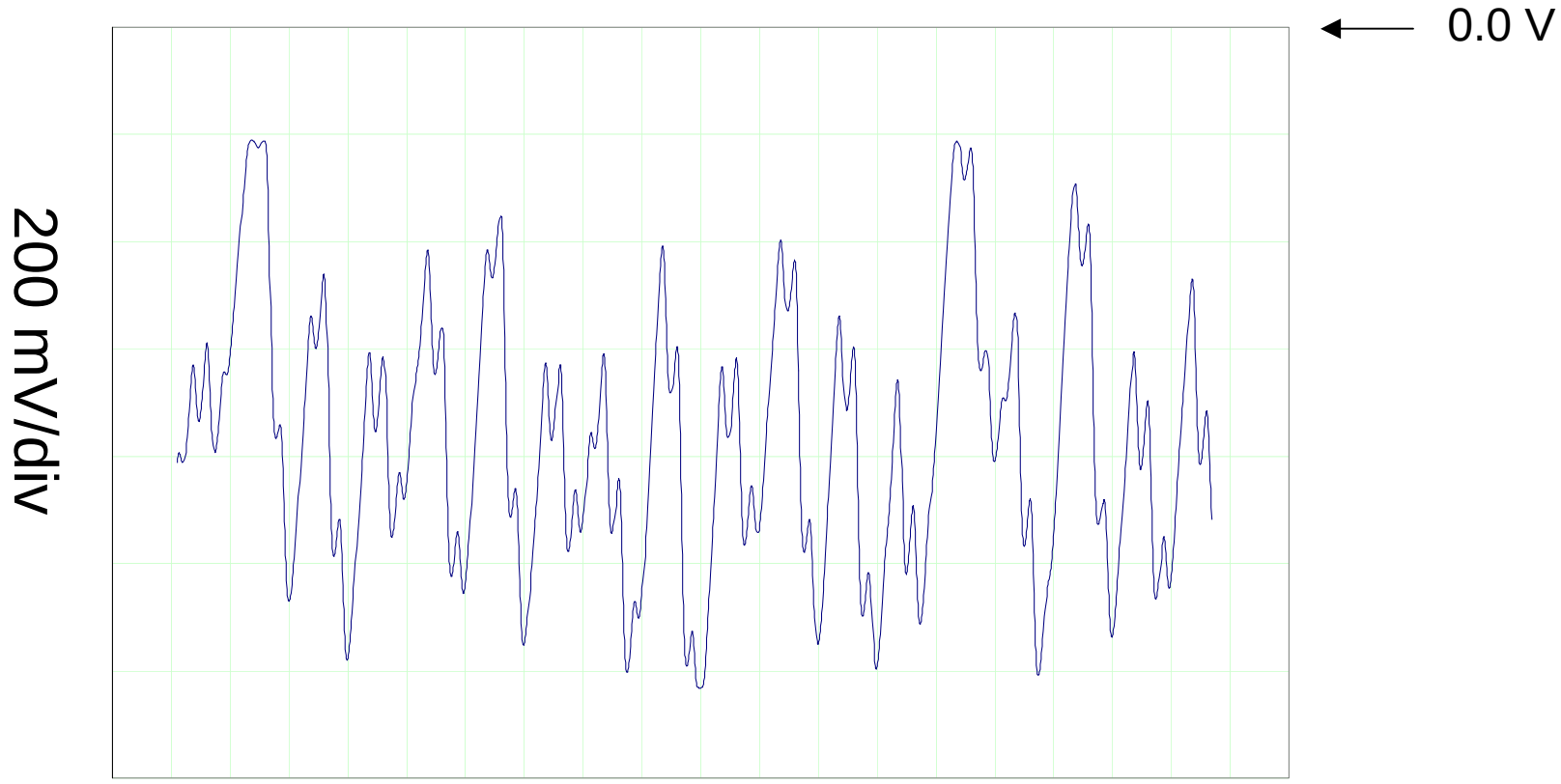
Eric Landahl, Jim Belak, Eric Dufresne, Bernhard Adams, Jan Ilavsky

TWG, April 2005

Stroboscopic diffraction using 1296 bunch mode

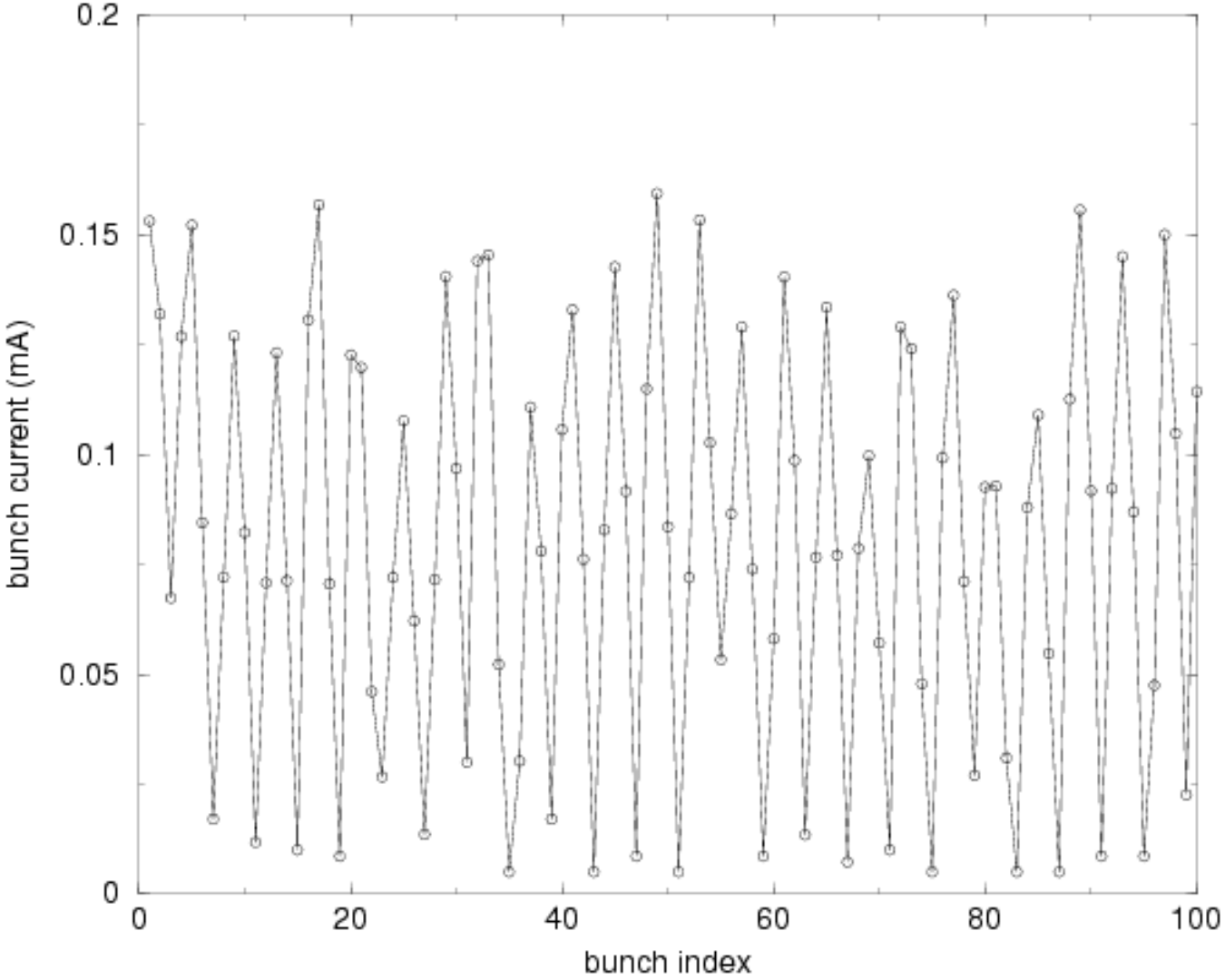


1296 bunch x-ray measurement



11.37 ns / div
(324 bunch separation)

1296 bunch mode
APS current monitor

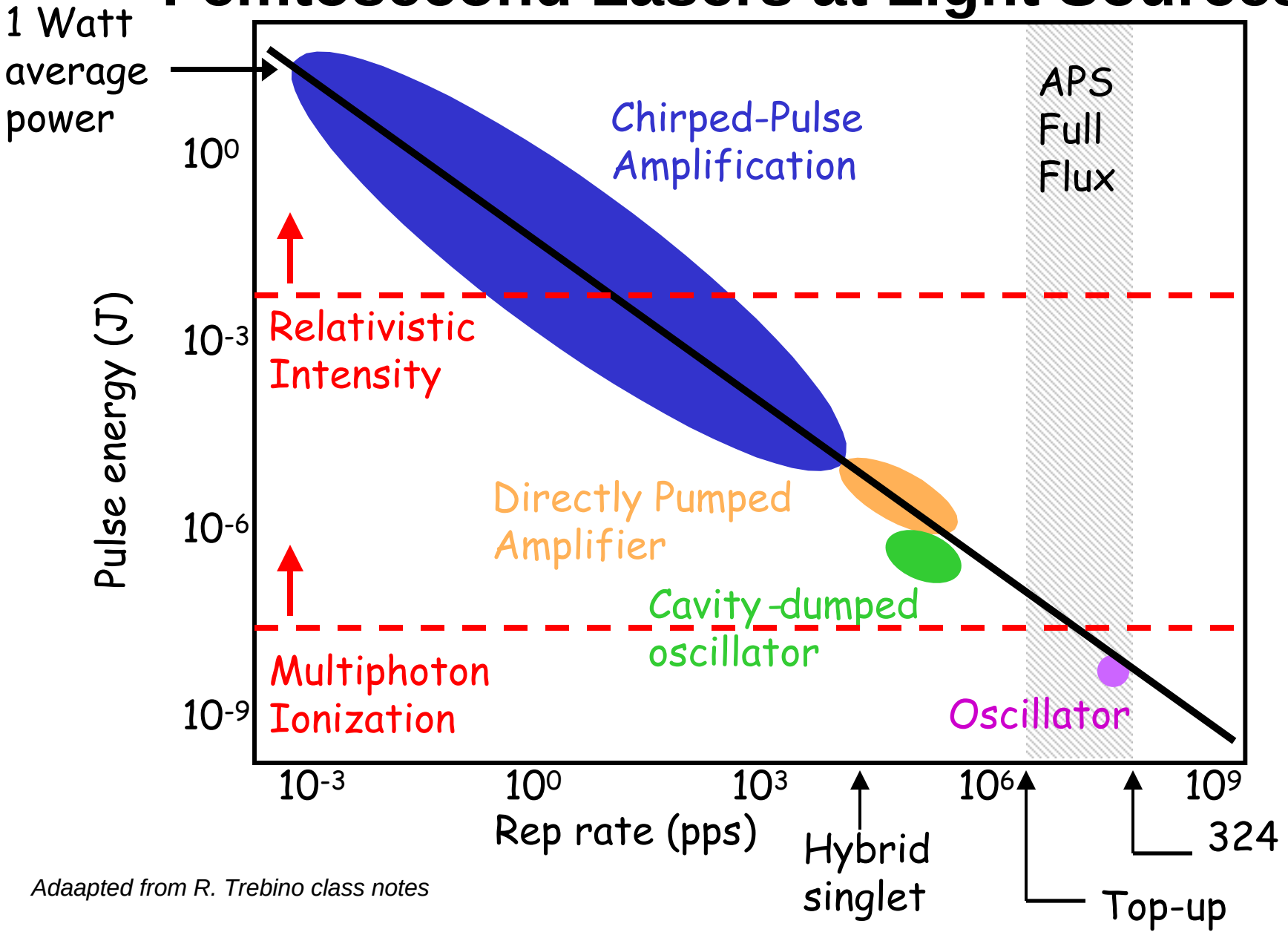


BNCHI:BunchCurrentWF This is an array of length 1296 with the bunch current per bucket.

324 bunch mode time-resolved experiments

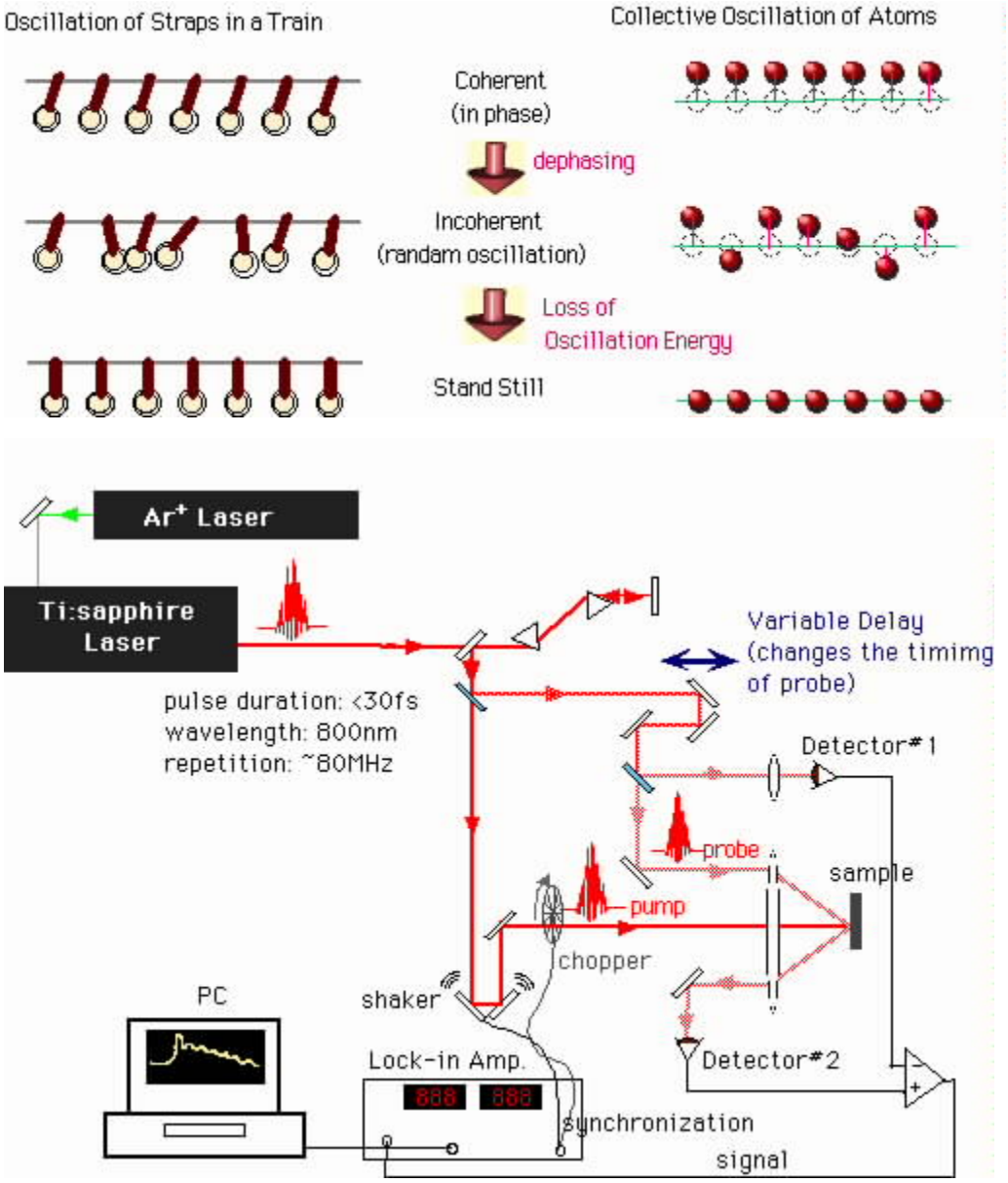
Various S7 and MHATT-CAT people

Pulse energy vs. Repetition rate: Femtosecond Lasers at Light Sources



Adaapted from R. Trebino class notes

Fs pump-probe experiments at 88 MHz



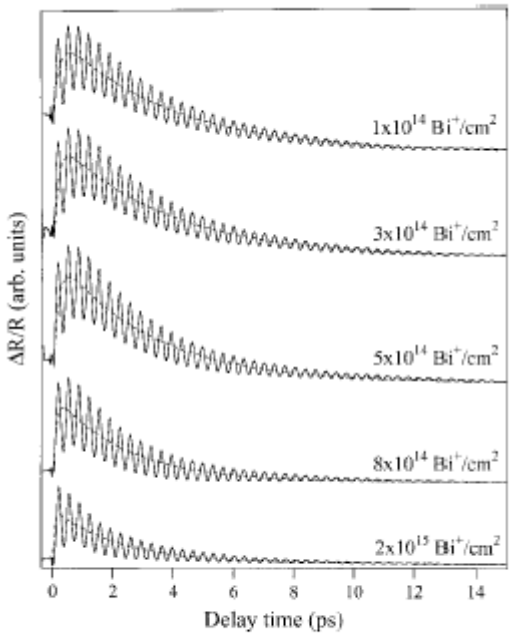


Fig. 3. Time-resolved reflectivity change for the bismuth films implanted at doses from 1×10^{14} to 2×10^{15} Bi^+/cm^2.

Ushida et al., 2002

Reflectivity data requires a model to separate electronic from structural contributions.

X-rays are needed!

Strategies for high repetition rate fs laser pump / x-ray probe experiments

- pm sensitivity, optical $\Delta R/R \sim 10^{-6}$
- Coherent x-ray diffraction (E. Dufresne)
- meV energy resolution (B. Adams)
- Diffuse scattering (D. Reis)
- Lock-in detection and spectroscopy (E. Landahl)

These efforts can also be frustrated by poor bunch purity and by uneveness in the fill pattern