Initial conclusions with 324-bunch fill

- Detected nearly every bunch at 87 Mhz (limit is 88.04 MHz) with beamline opened up. S/N improvement is

$$\sqrt{\frac{324}{23}} \sim 3.7$$

- Detected ~15 MHz bunch rate with *typical* experimental setup, corresponds to resolving ~1/6 bunches

- Current APD discr. threshhold set too high (~50 ph/bunch), can reduce to resolve every bunch

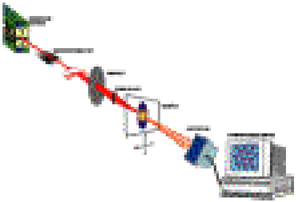
- Current APD pulse-pulse period is ~3 ns, can be pushed to resolve every bucket. Scalers currently limited to 40, 250 MHz

- Orbit was right on, low emittance was great, ~100 h lifetime!

X-ray Microscopy Group (Sector 2)

X-ray microscopy

- Transmission
- Fluorescence
- Tomography
- Microdiffraction

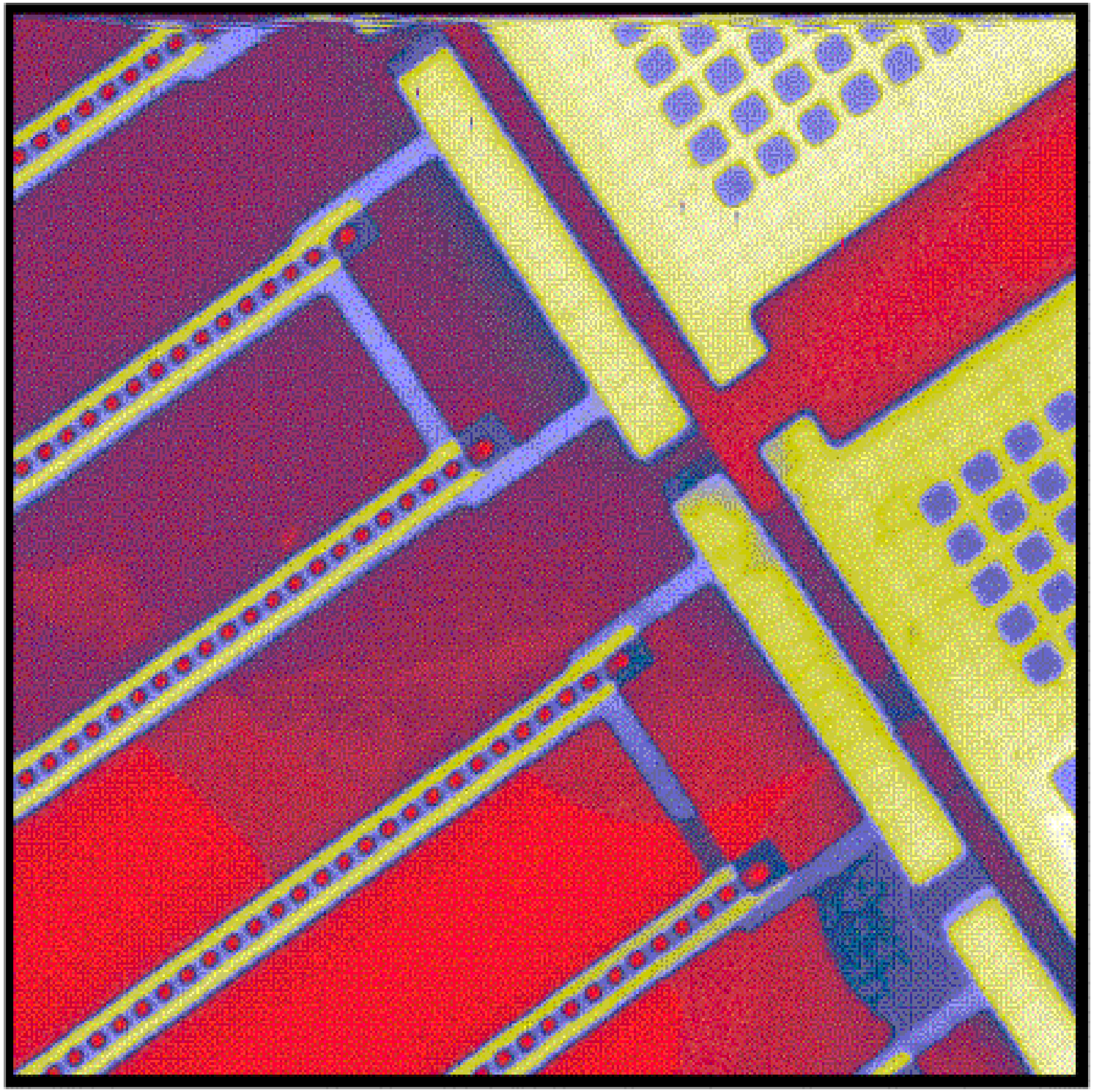


Sample Intel chip

Sample: Intel chip

50 µm x 50 µm fly-scan
50 nm x 50 nm pixels
2 ms/pixel dwell

1 + 1*22 bunch mode
Counts/pixel ~ 9000
RMS noise/pixel ~ 110
Shot noise limit ~ 95



Transmission microscopy

- Position-based "on-the-fly" scanning is routine
- Use multiscannel scaler, acquire in hardware min. overhead
- Scan speed — 100 µs/pixel — stepper stage
  50 µs/pixel — piezo stage
- Source brilliance — 3×10^{19} ph/s/mm^2/mrad^2/0.1% BW
- Flux in nanofocus — $\sim 10^9$ ph/s/0.1% BW
- Target — 10 µs/pixel

10^9 ph/s $\Rightarrow$ 1% stats/pixel (S/N = 100)

Counting statistics

- Average bunch rate and S/N

oper. mode	filled buckets	<bunch rate>	<S/N>
standard	23	6.25 MHz	2500
hybrid	59	16.0 MHz	4000
but, adj. buckets harder to resolve, so		2.4 MHz	1500 is typical
If 324 filled buckets, expect		88 MHz	~9400

- S/N gain with many bunches:

$$\sqrt{\frac{N_{\text{many-bunch}}}{N_{\text{few-bunch}}}}$$

- Actual gain depends on detector sensitivity and speed

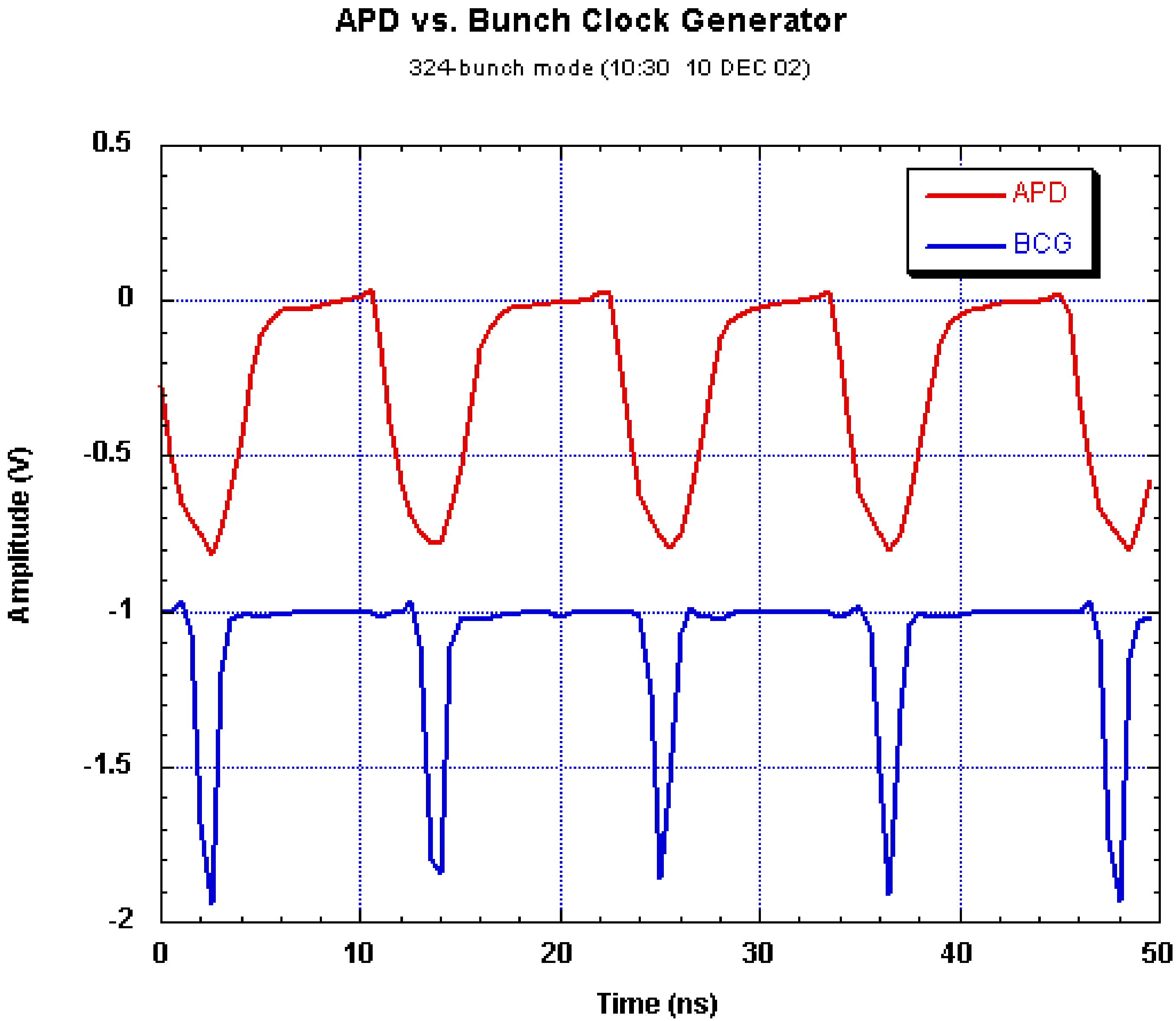
Countable photons per bunch

- Photons/bunch in focus (10^9 ph/s) and bunch stats/pixel (10 μs dwell)

filled buckets	<bunch rate>	ph/bunch	stats/pixel
23	6.25 MHz	160	12.6%
59	16.0	63	7.9
324	88.0	11	3.4
648	176	5.7	2.3
1296	352	2.8	1.7

- Problem: how to "see" every photon?
  - resolve instantanous charge/photon (photons/bunch)
    - distribute 100 mA into more bunches (many-bunch mode)
    - do PHA with counting detector (fast MCA, multiple discriminators, etc.)
    - photon resolution is limited by detector energy resolution
  - resolve average charge/photon (photons/dwell)
    - do charge-integration with current-mode detector (fast charge-amplifier)
    - photon resolution is limited by amplifier noise

APD vs. Bunch Clock Generator



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