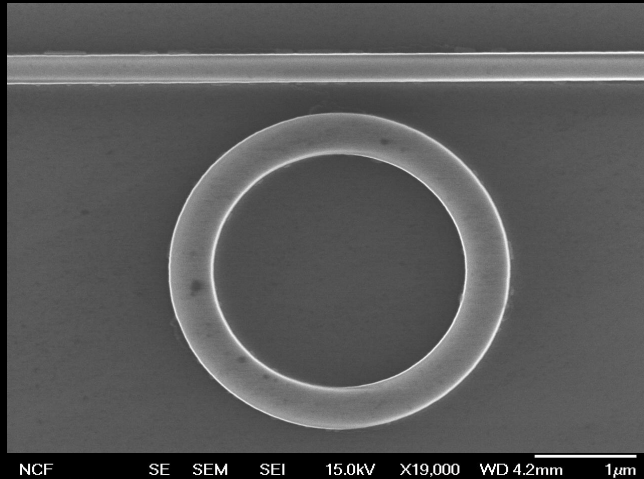


Optics and Disaggregation

Alan Mickelson

Two Questions

What
Optics?



What
Disag?



20 cores/server

50

servers

Per
rack

Warehouse

Scale

Computers

10k

racks

per
WSC

250 MW/WSC

70% of internet traffic

22%
growth
per
year

WSC's
and
Internet

1.8%
of
US
power

Problem

Too much power
for growth

Solution

Eliminate Servers:
Disaggregate

1<optimal (memory/
core)<1000

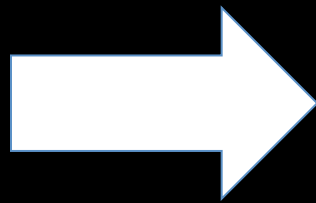
memory
wall

Why
Disag

miniaturization

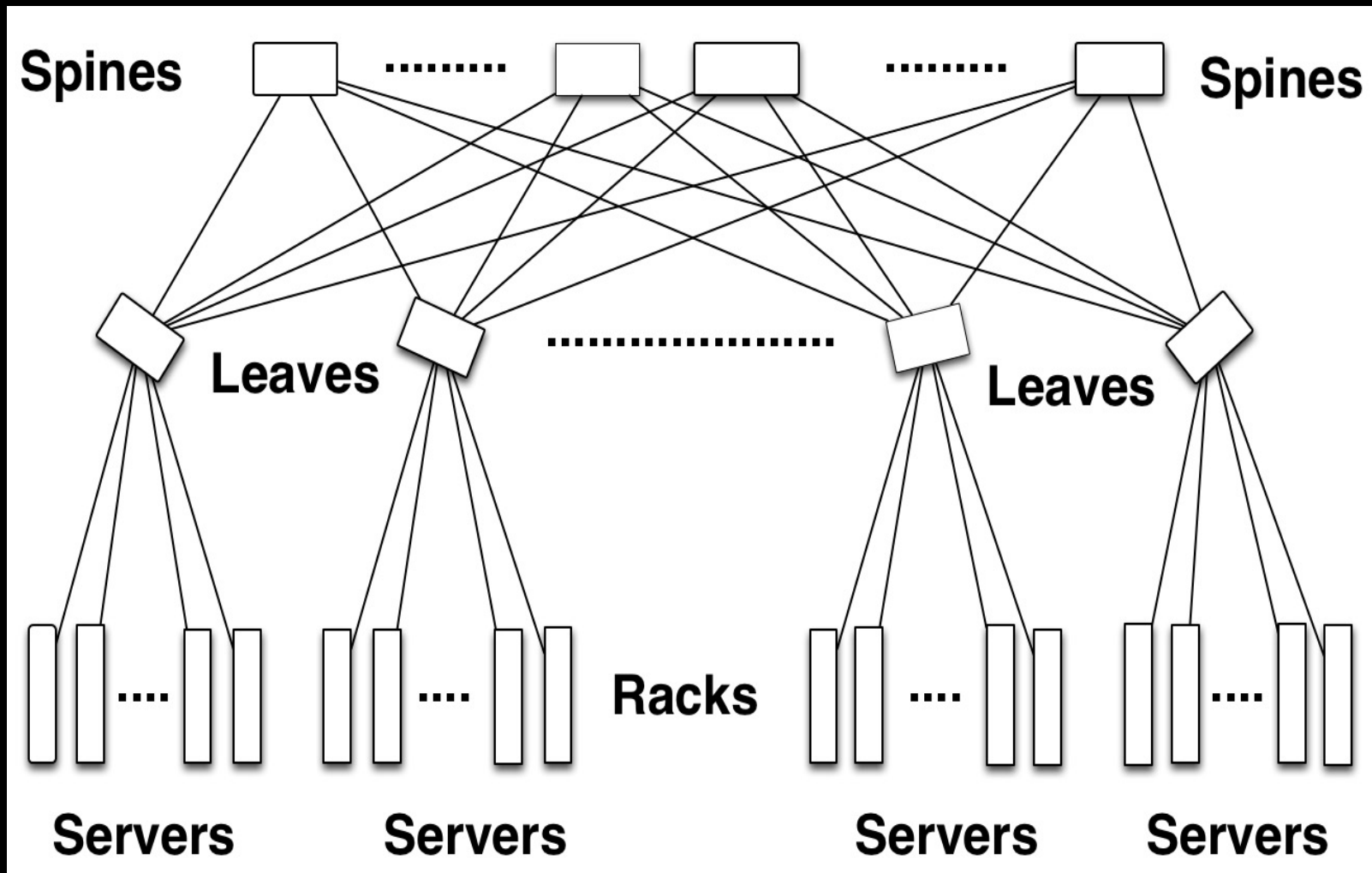
Disaggregation

Rack:
one
output
per
server:
50
servers



Board:
1000 cores
interconnected
with memories

Optics in Today's WSC's



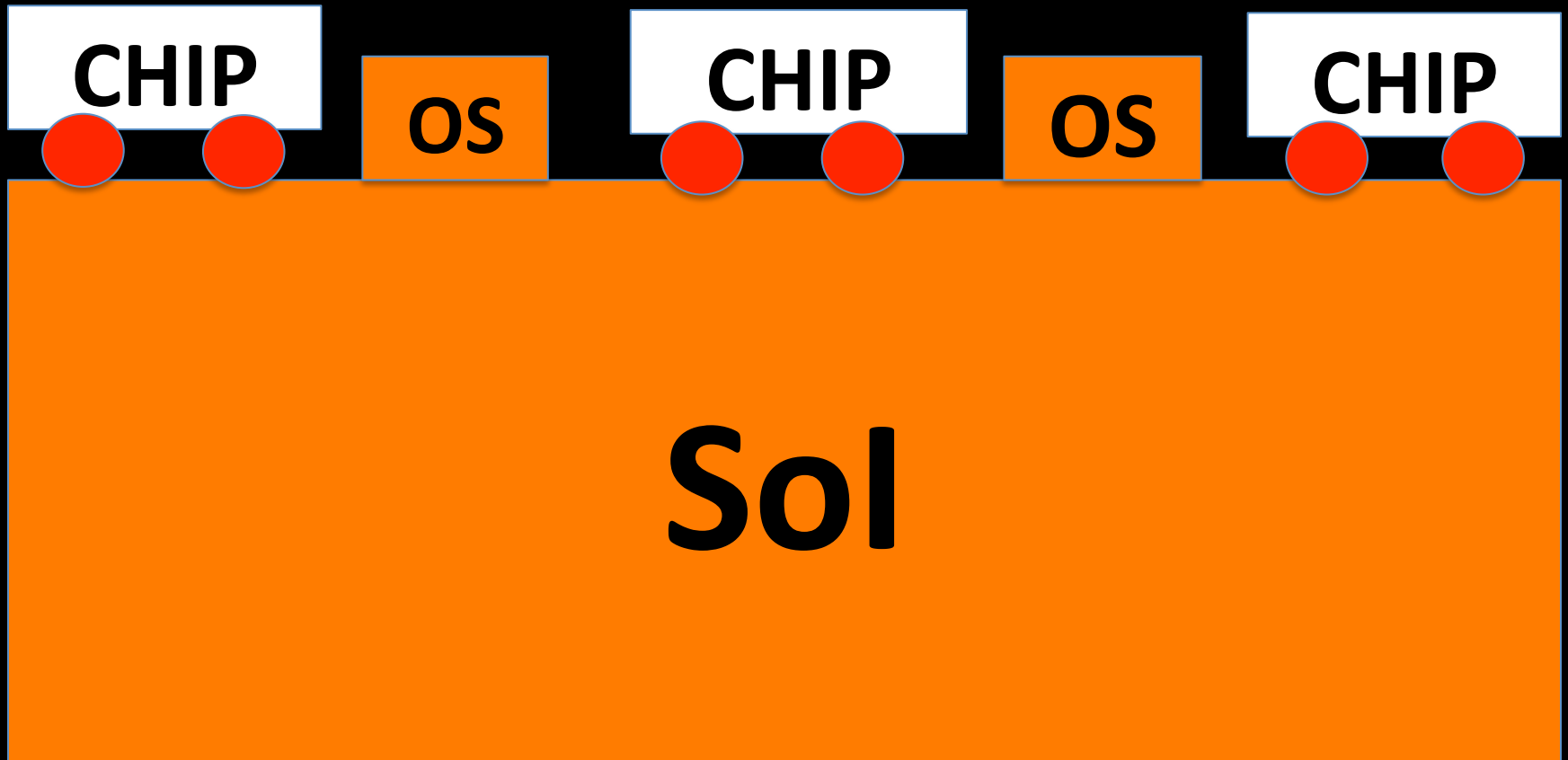
Solution

Disaggregate
With
Optics

Question

Optical
Power
Draw?

Sandwich



A (Partial) Chip(let)

Core

DRAM

Core

DRAM

Core

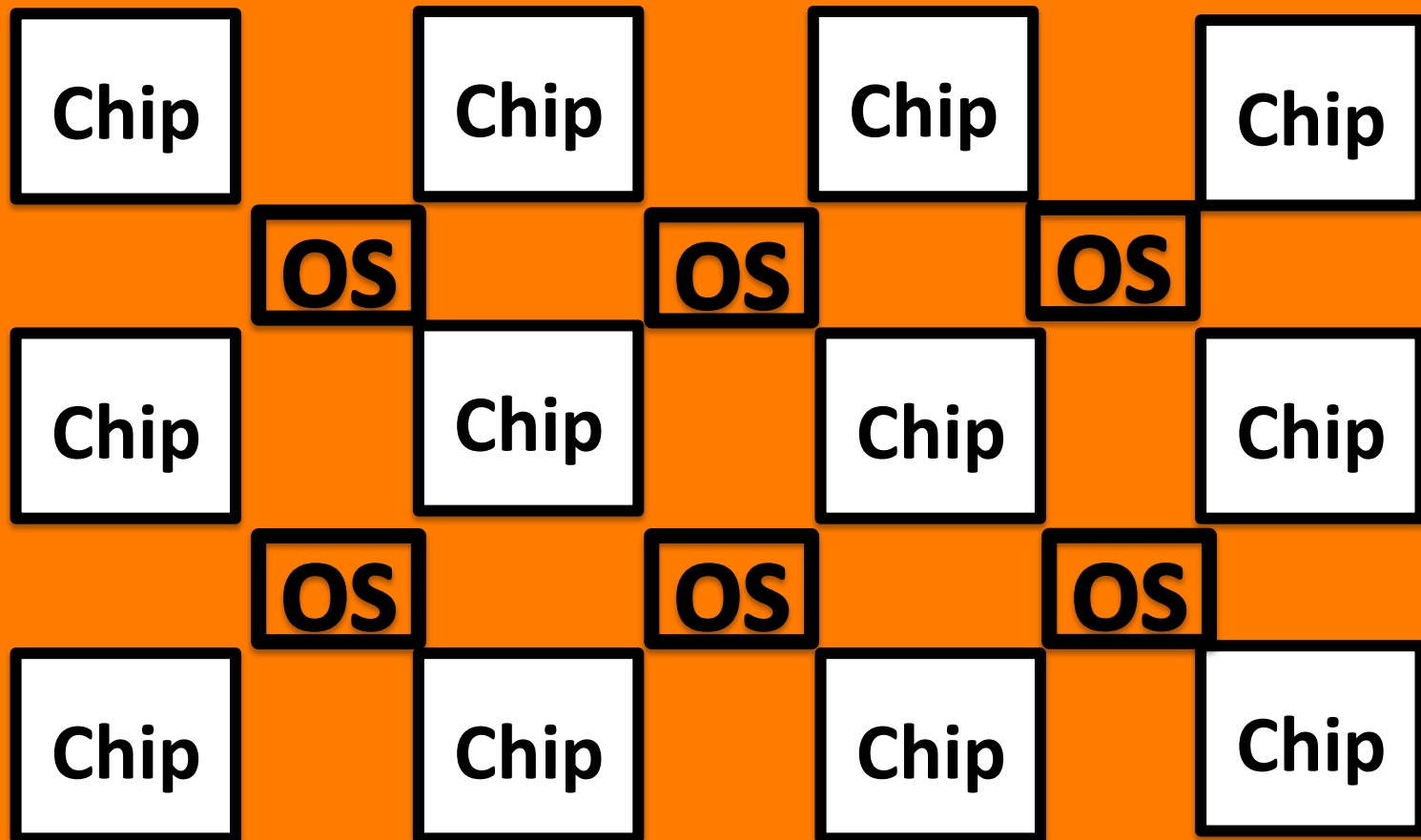
DRAM

Core

DRAM

Core

A (Partial) Rack



4 DRAMS/Core

80 lines/DRAM

of Interconnects

1 BUS between Cores

250 400 mW SLEDs

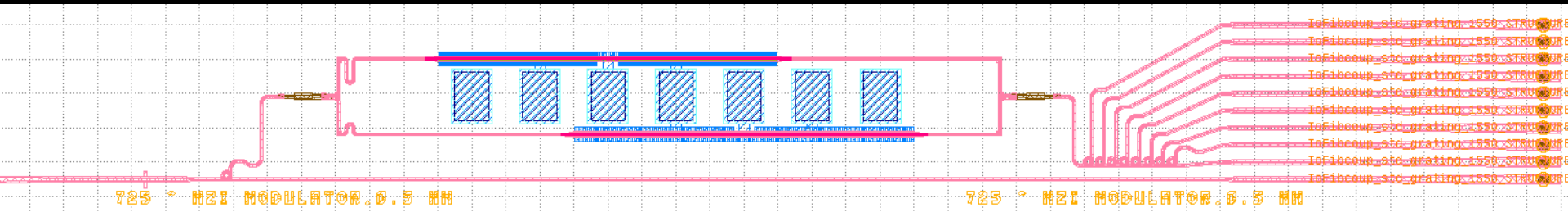
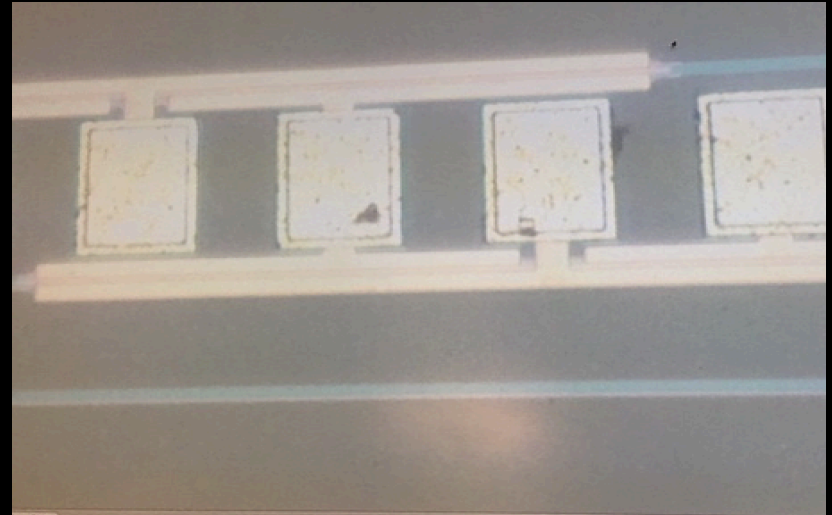
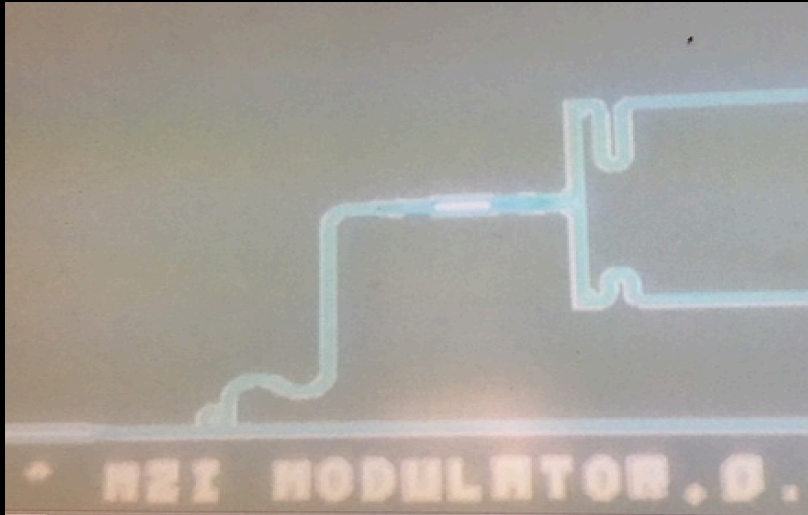
320,000 Intercons
requires

320,000 modulators

320,000 detectors

Do the modulators
and detectors fit?

A Modulator



1 mm x 0.1 mm

Modulator

0.1 mm x 0.05 mm

Minimized

0.01 mm x 0.05 mm

Detector

Modulator Area

0.05 mm²/mod

x 320 mods/core

=1.6 mm²/core

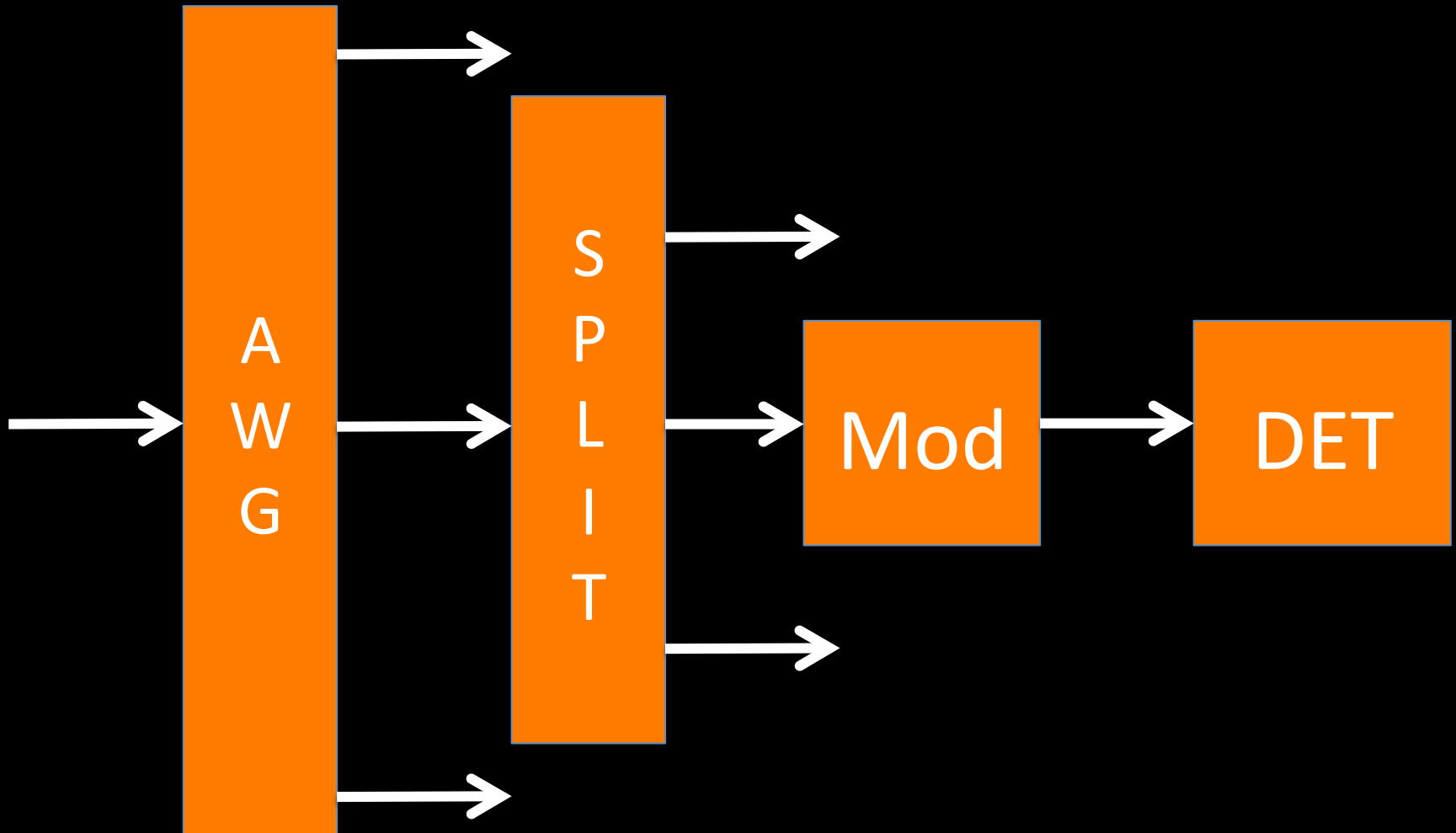
Core

Area

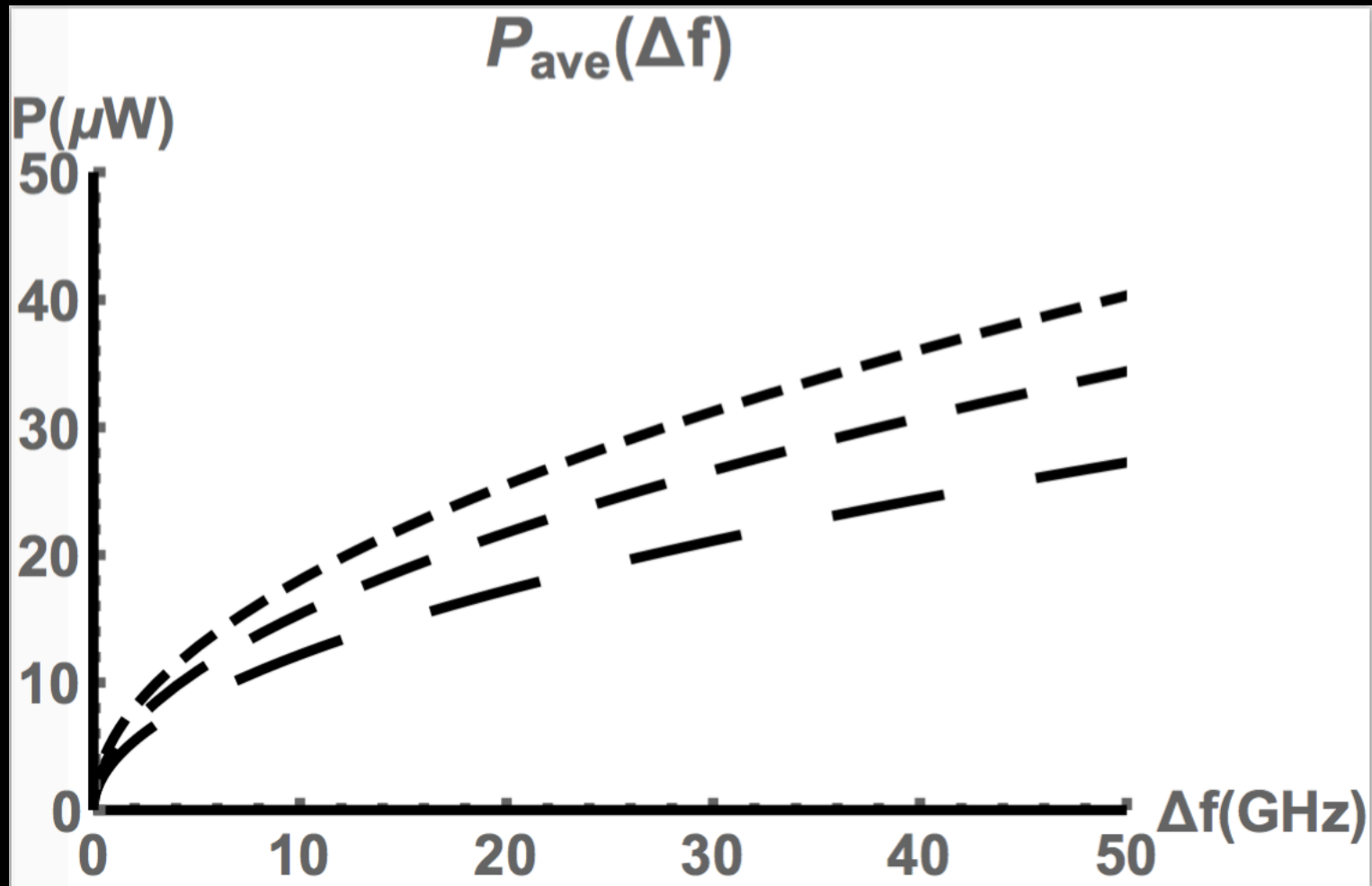
1.5 mm x 1.5 mm

=2.25 mm²

Optical Loss Budget

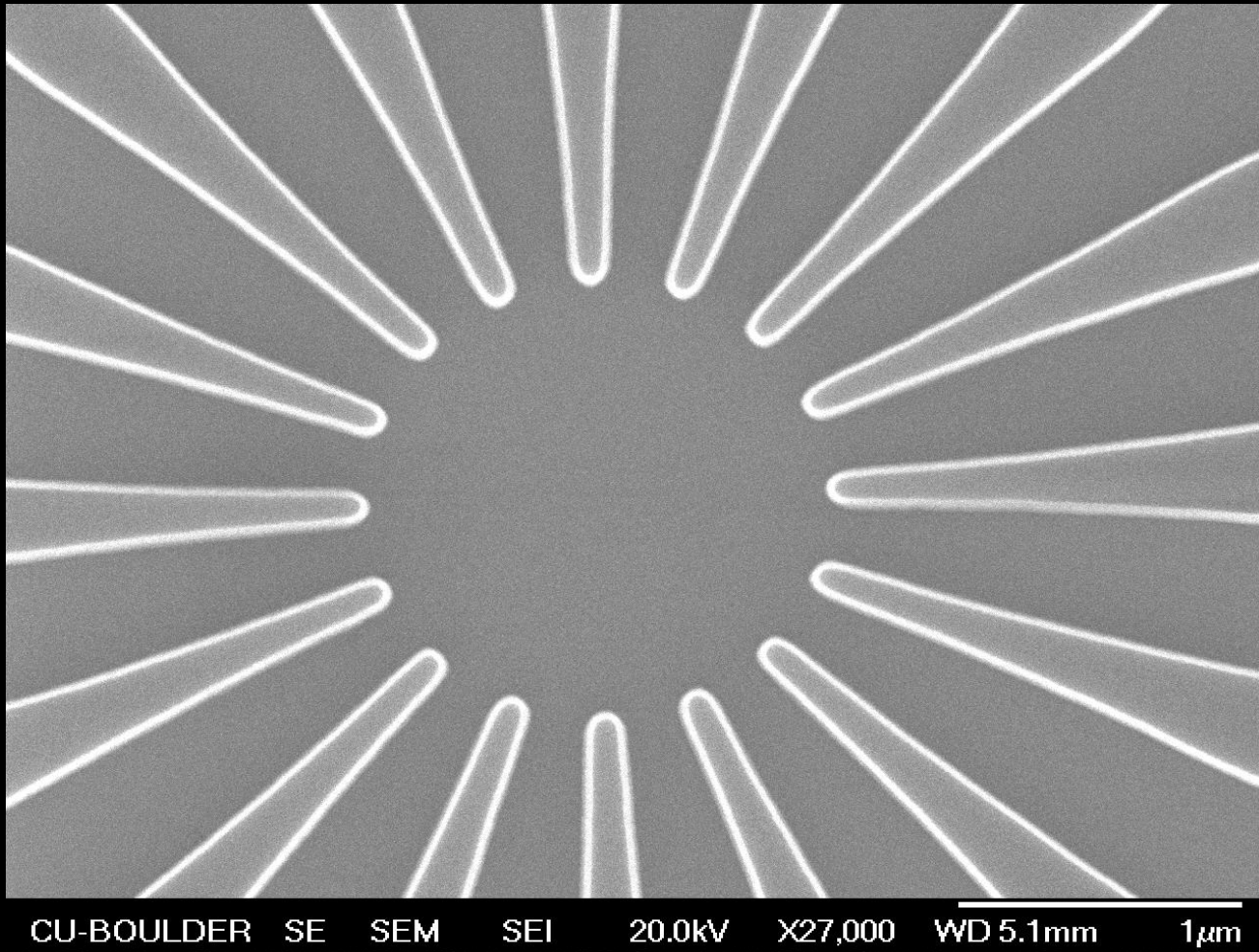


Average Required



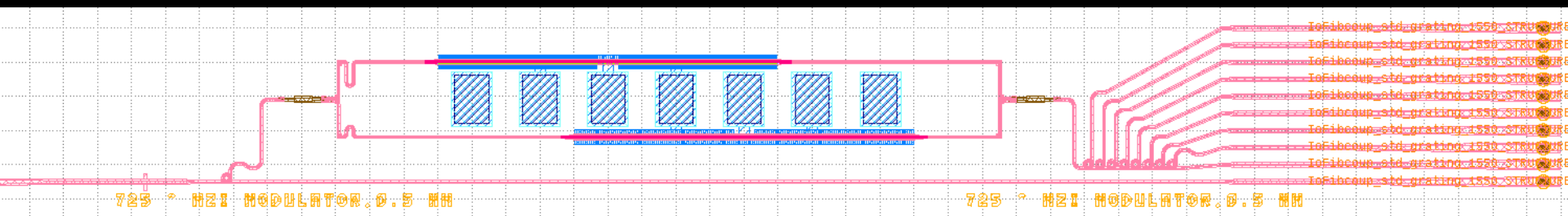
Detector Power

Splitting



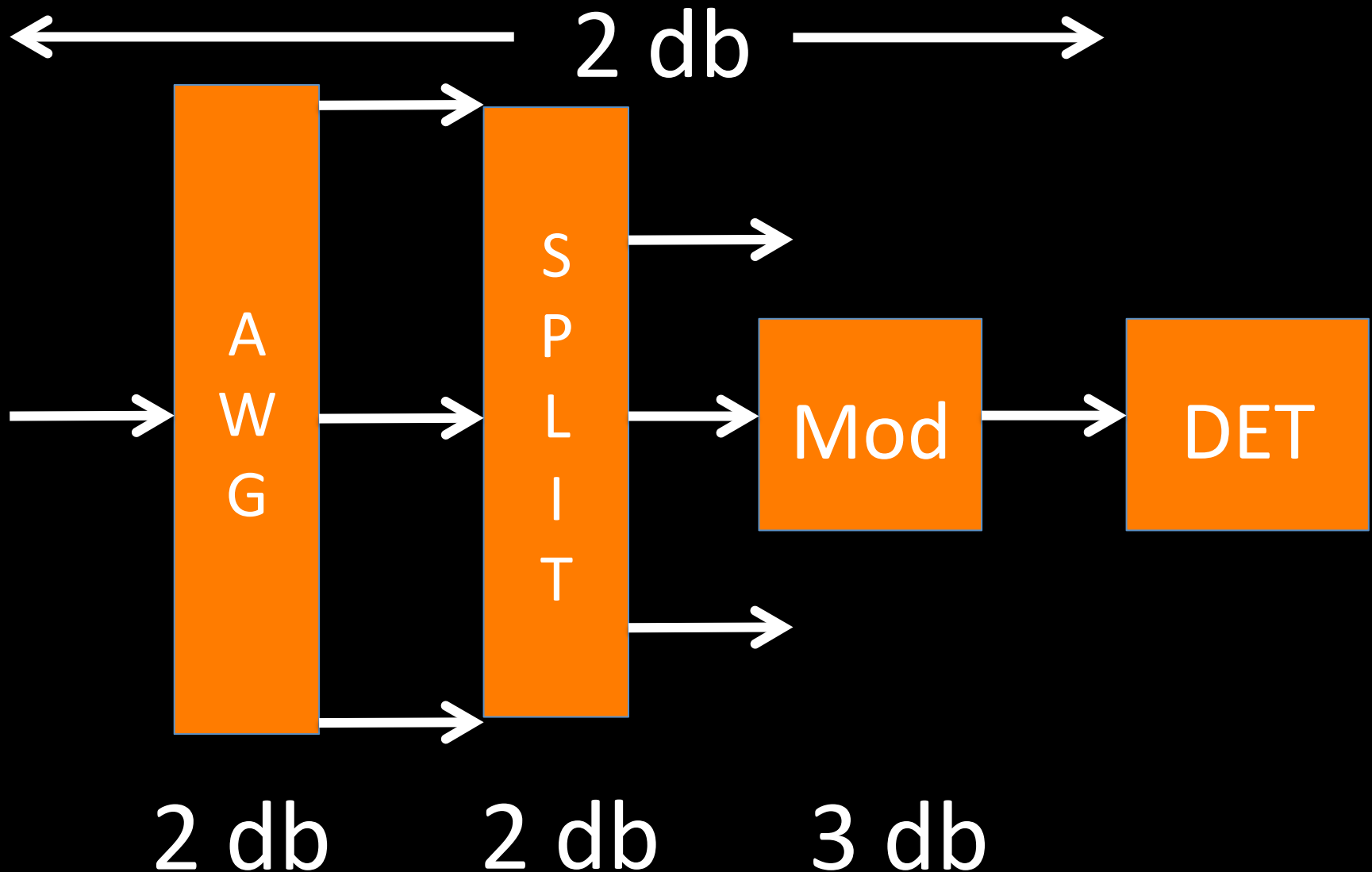
1 x 16 100 nm BW 2 dB insertion

A Modulator



$$\frac{P_{\text{opt}}|_{\text{in}}}{P_{\text{opt}}|_{\text{out}}} = -3\text{dB}$$

Optical Loss Budget



9 dB =

Loss Budget

2 (AWG) + 2 (splitter)
+ 2 (propagation)
+ 3 (modulator)

$$40 \mu\text{W} \rightarrow 320 \mu\text{W}$$

Power Budget

90% wall plug SLED

$$320 \mu\text{W} \rightarrow 360 \mu\text{W}$$

$$360 \mu\text{W} \times 3.2 \times 10^5$$

$$\approx 100 \text{ W}$$

Total Power
Budget

$$100 \text{ W} = 250 \times 0.4 \text{ W}$$

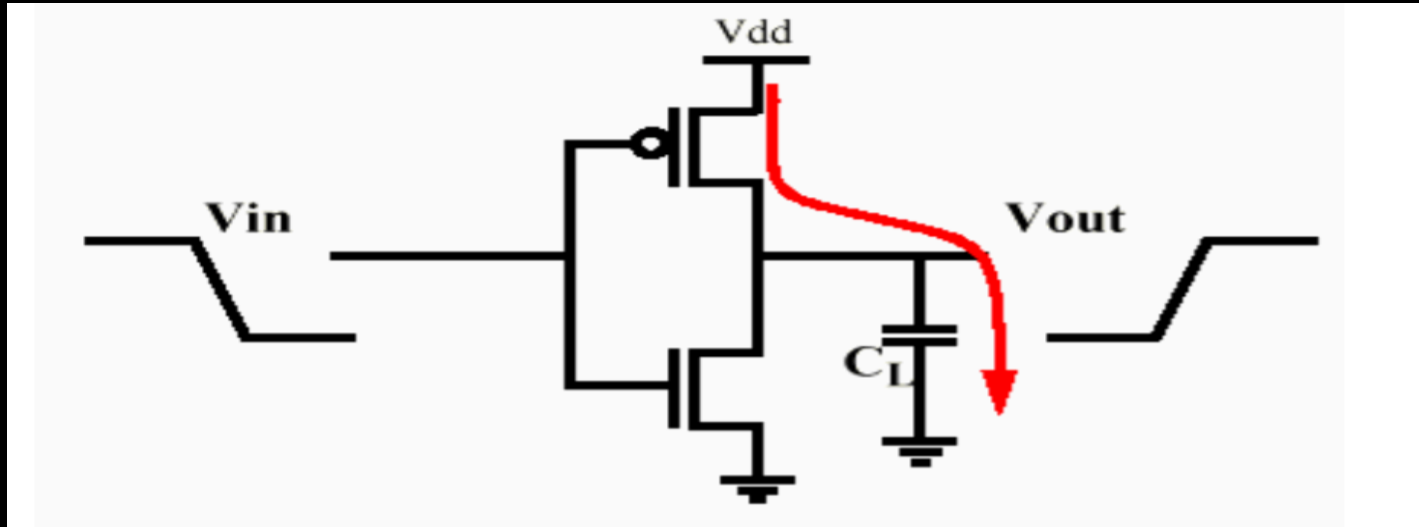
Drivers

Electrical

Power

TIA's

Modulation



$$P_e = \frac{1}{2} \left(\frac{C_L V^2}{2} \right) \Delta f$$

At 10 fJ/bit

Estimating $P(\text{drive})$

$$P_e \approx 10 \text{ fJ } 50 \text{ Gbps}$$

$$\approx 500 \mu\text{W}$$

10 fJ/bit

is not fundamental

Actual Driver/TIA

$P(\text{TIA}) \ll P(\text{driver})$

$$P_{OI} \approx 0.1 \text{ W/core}$$

OI needs HI

Summary

$$P_{OI}(\text{WSC}) \approx 1 \text{ MW}$$

$$P_e \geq P_{opt}$$

Conclusions

Ol is
viable

Ol not
panacea