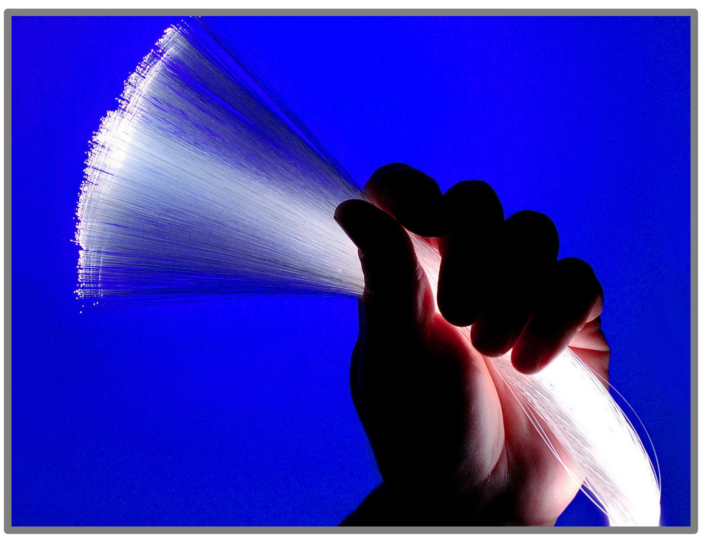
Fast Optical Switch for Data Communication Applications

- Overview -

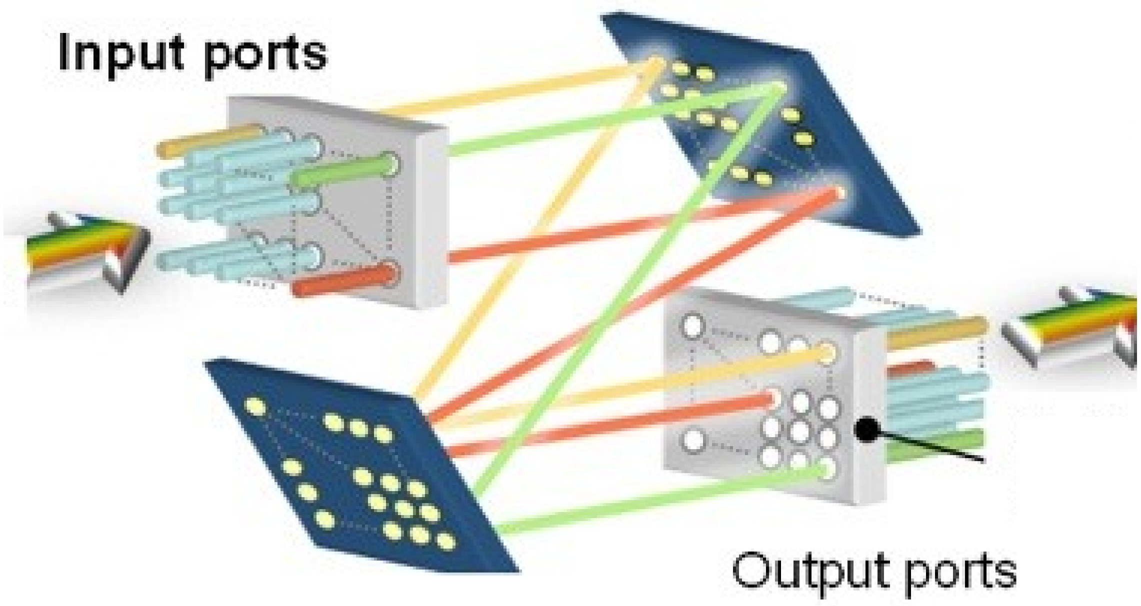
- Data communication networks around the world use optical fibers because of the large bandwidth.
- Data routing is done by switch devices that interconnect different fibers.
- “Old way” switch converted the optical signal to electric then back to optic
  - Too slow when rate increases → bottle neck.
  - Very high energy consumption.



- Optical switch -

Function:

- Directly connects <u>any</u> N input fibers to N output fibers (NxN)
- Rate agnostic

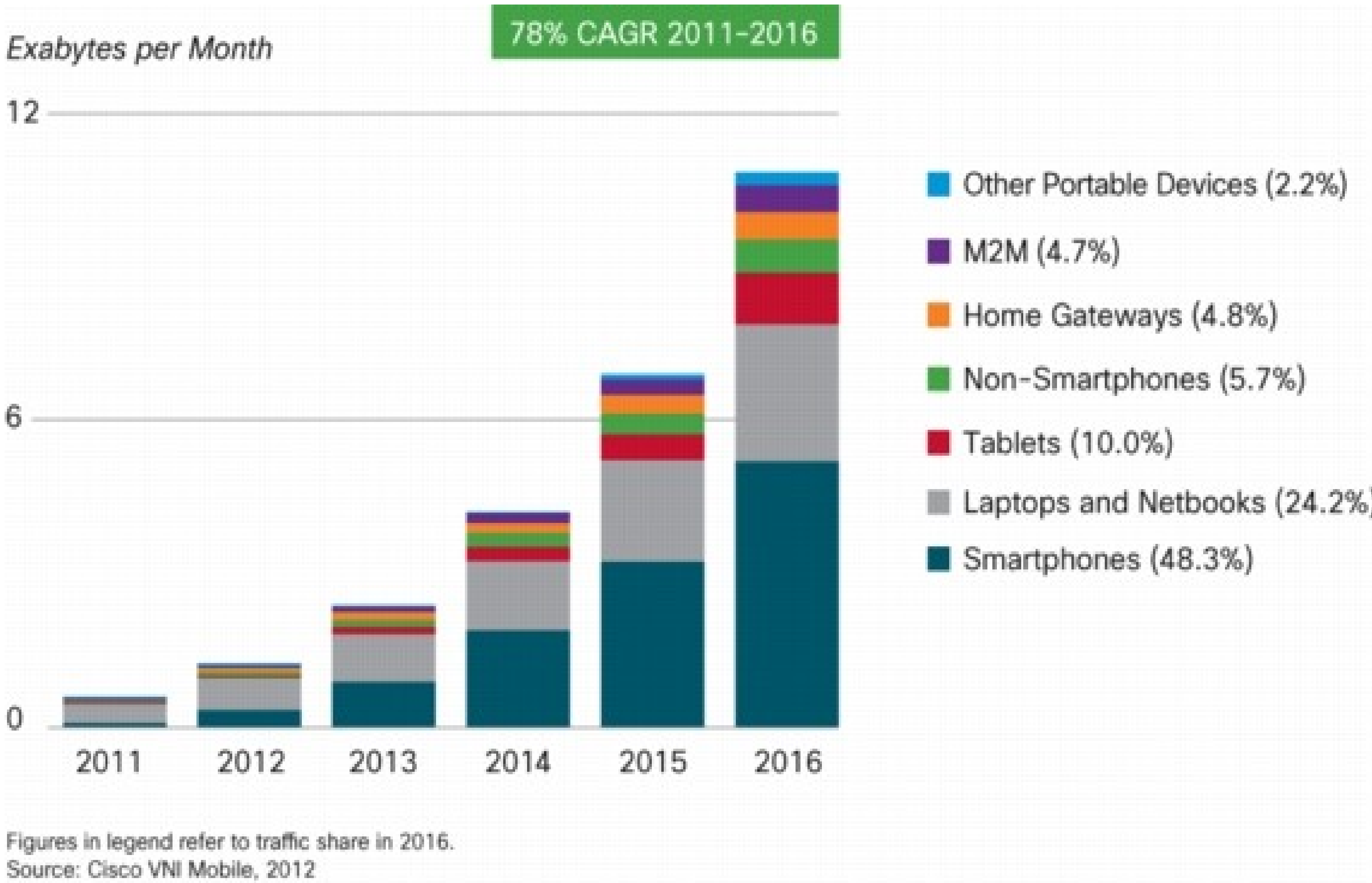


Usage:

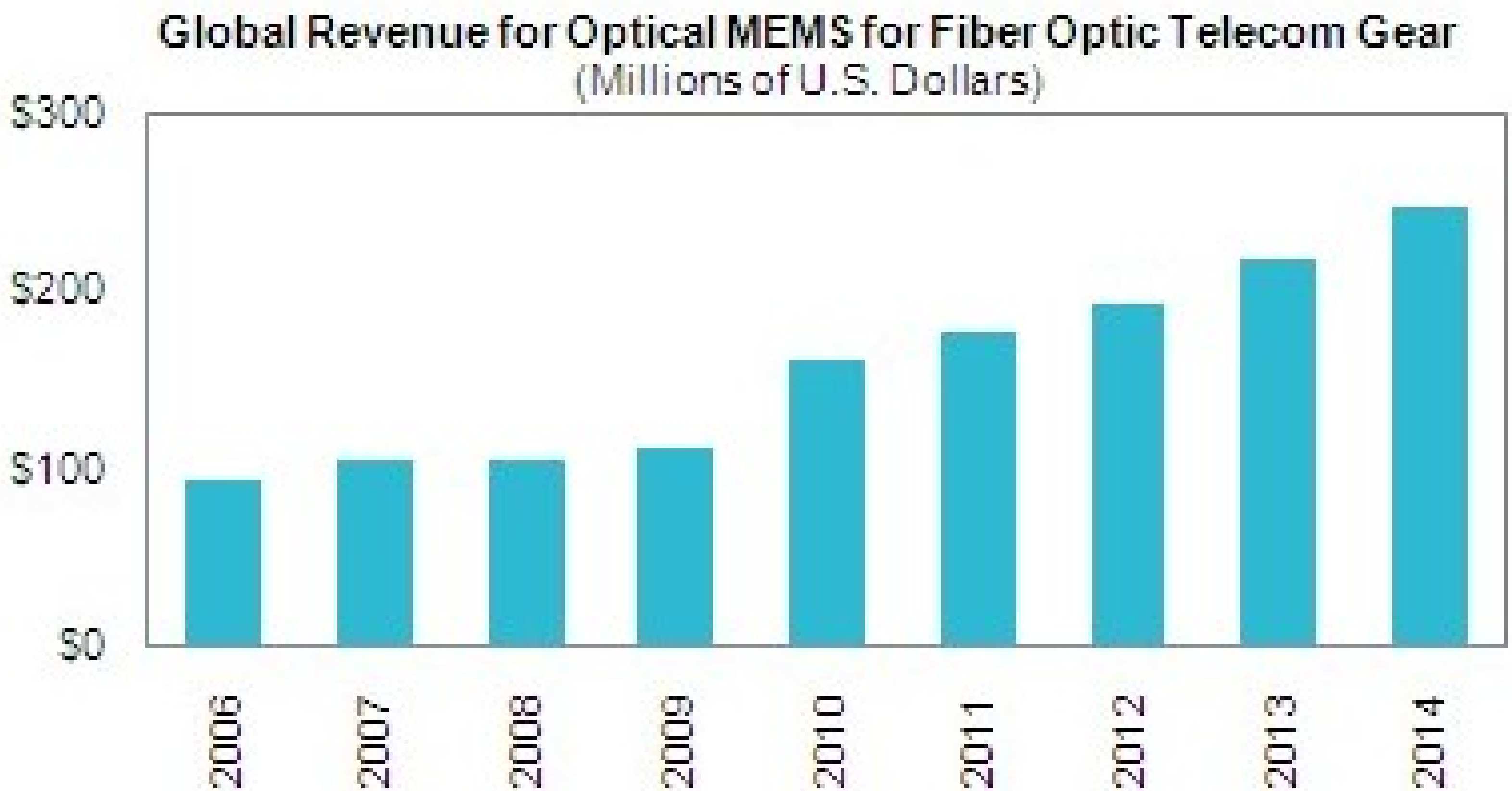
- Data centers
- ROADM
- Network aggregation

- Market Drivers -

- Exponential increase of the data traffic due to cloud computing, mobile devices (tablets, smartphones), social networking.

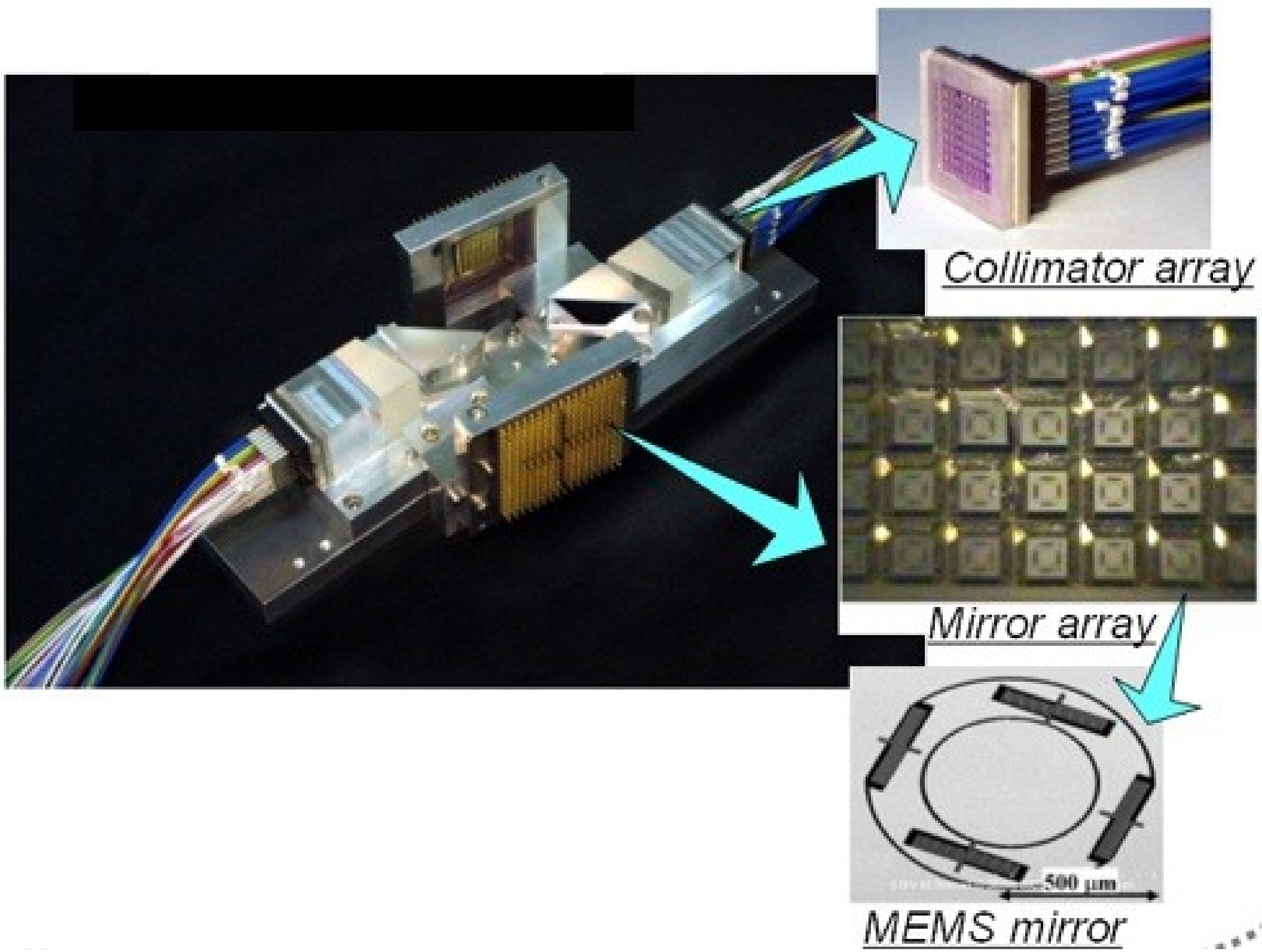


- Optical switch market share -



- Current technology -

- O-MEMS based
- Mirrors on gimbals mount
- Mirror reoriented to redirect the beam



- Current technology -

PROS

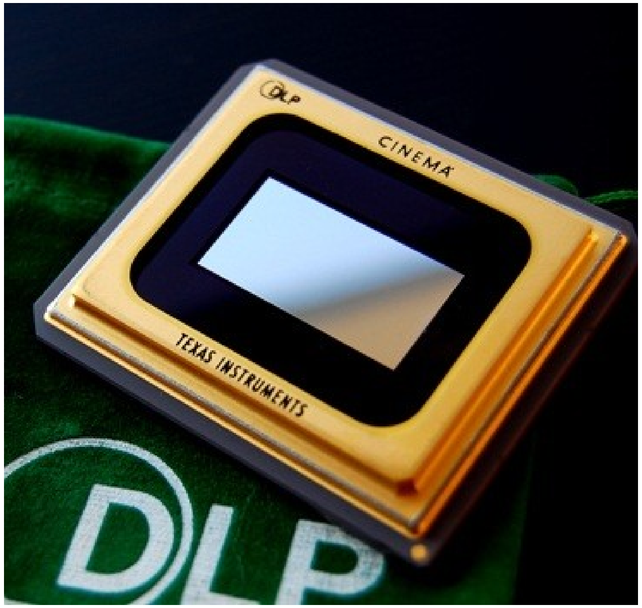
- Large number of port (320)
- Low insertion loss (3db)
- $300-$700 per port

CONS

- Custom made element
- Millisecond response time
- Sensitive to vibration
- Sensitive to input energy
- Sensitive to failure
- Hinge failure (small MTBF)
- Power consumption (45W)
- $300-$700 per port

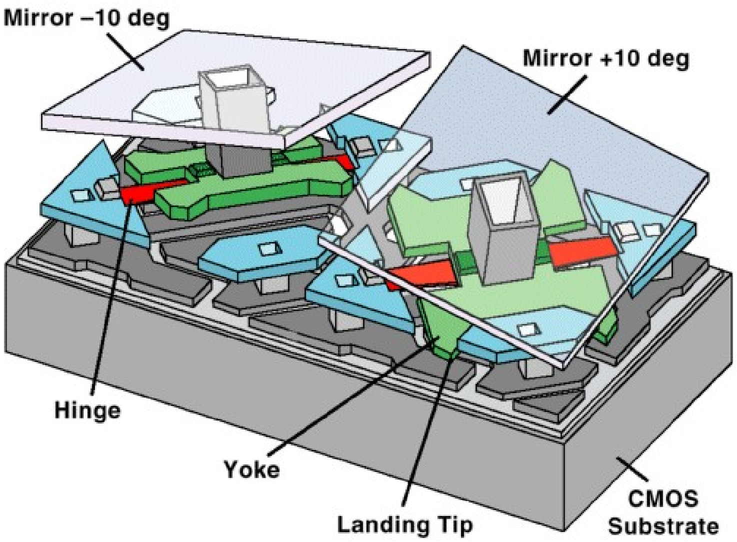
-Our Approach-

O-MEMS → DMD



- 12 μs switching time (vs 25 ms)
- Bistable (reduced power)
- Mass produced (cheap)
- Highly reliable (10^{12} flips)
- Large number of elements (1024x720)

- Used in projectors
- Television
- Medical/automotive display

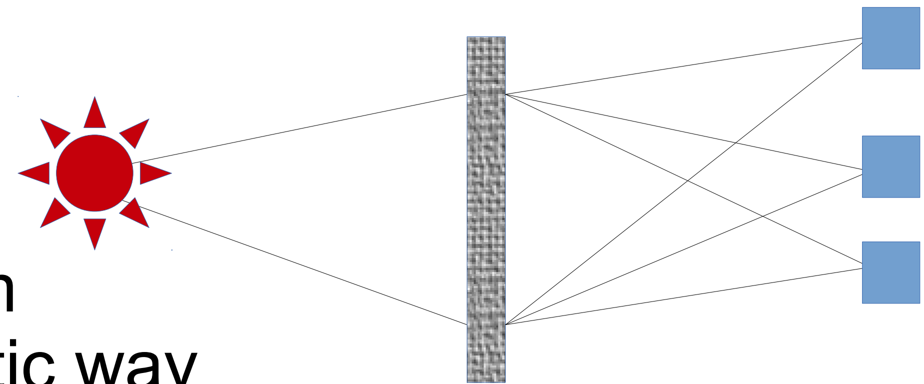


How do you steer a beam with a binary device?

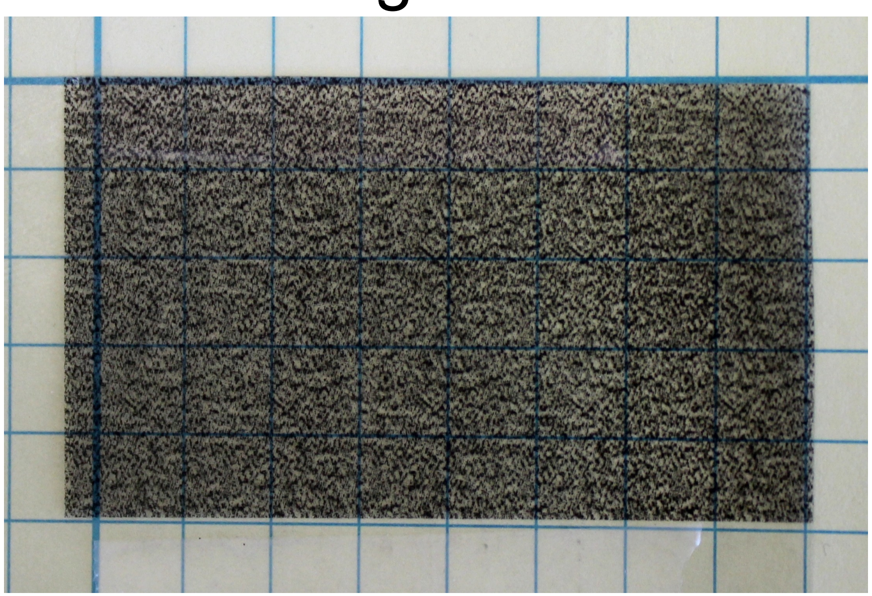
-Our Approach II-

Reflection → Diffraction

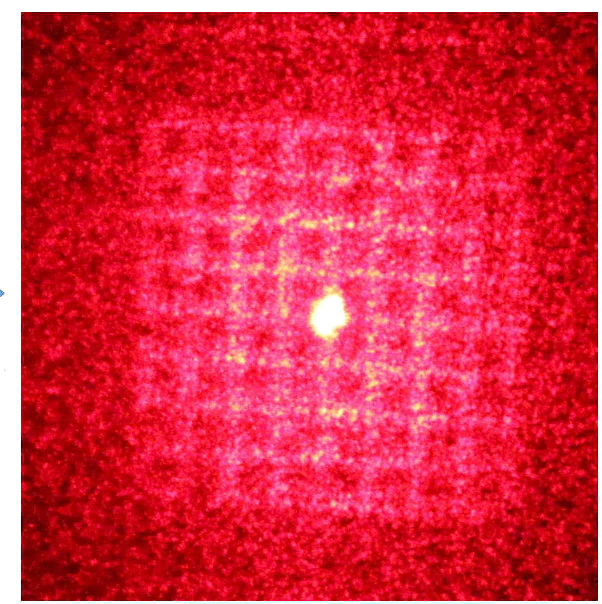
Holograms:
- Binary pattern
- Calculated by iterative Fourier transform
- Diffract light in deterministic way



Printed hologram



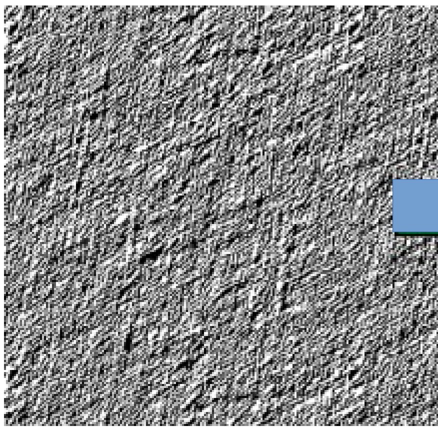
Diffraction



-Our Approach III-

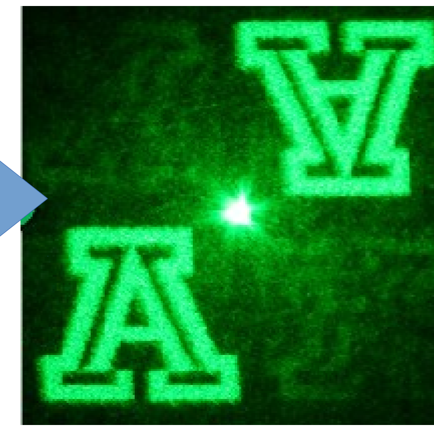
Reflection → Diffraction

Hologram



DMD

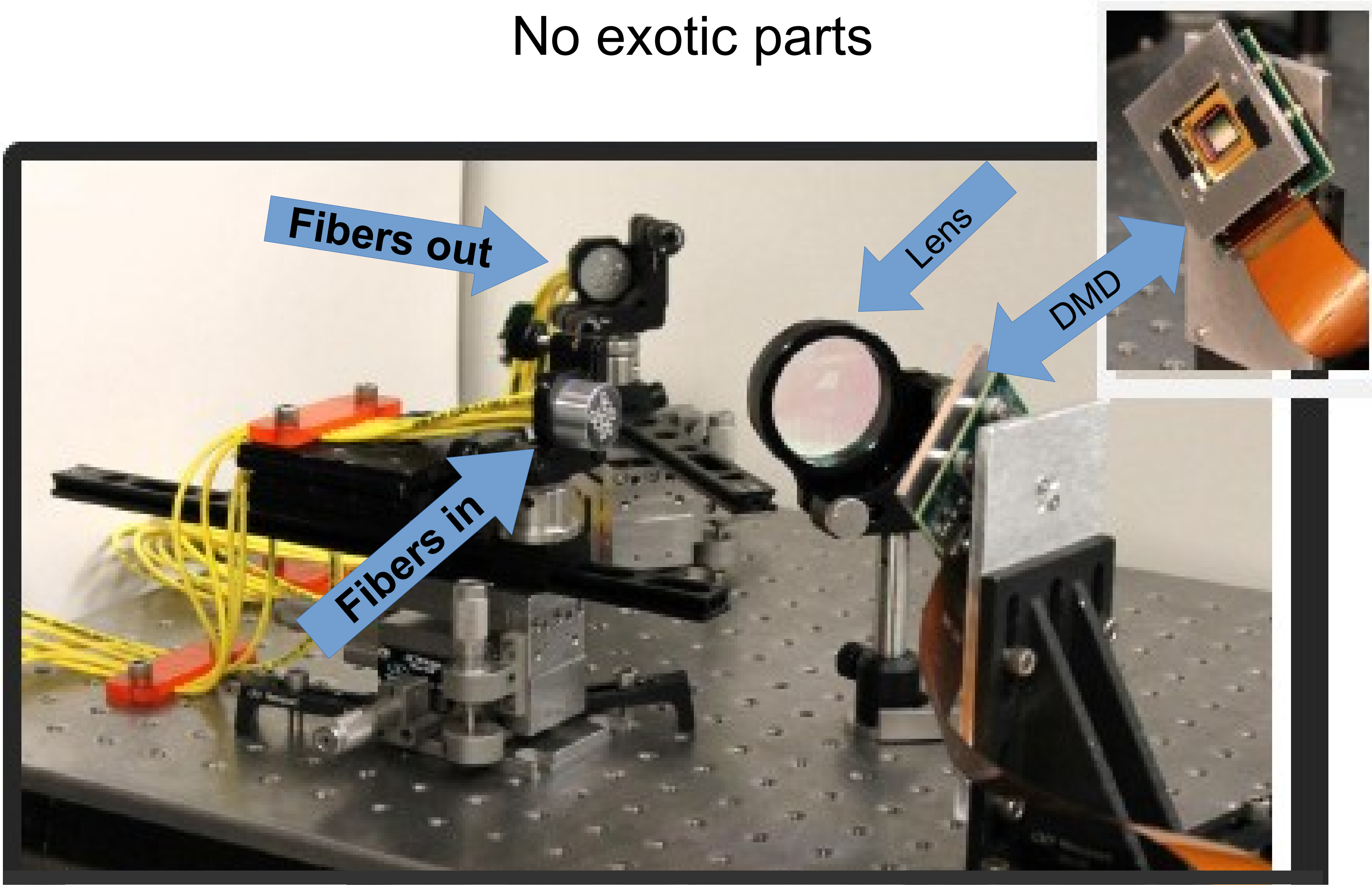
Diffraction



- Robust (distributed information)
- Scalable (thousand of ports)
- Handle beam power (distributed energy)
- True non-blocking (all ports accessible)
- Addition/division functions (ROADM)

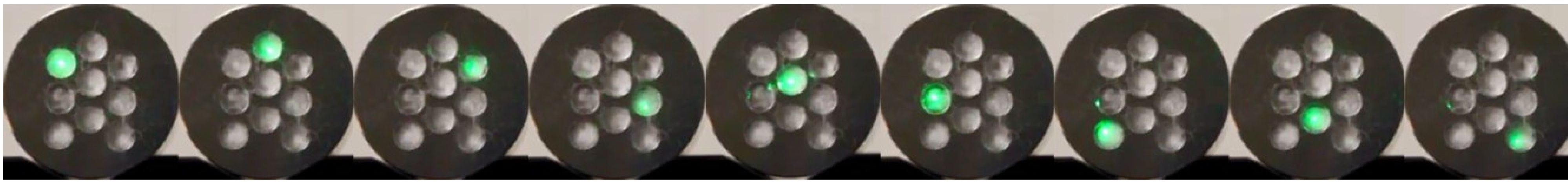
-Our Approach III-

No exotic parts

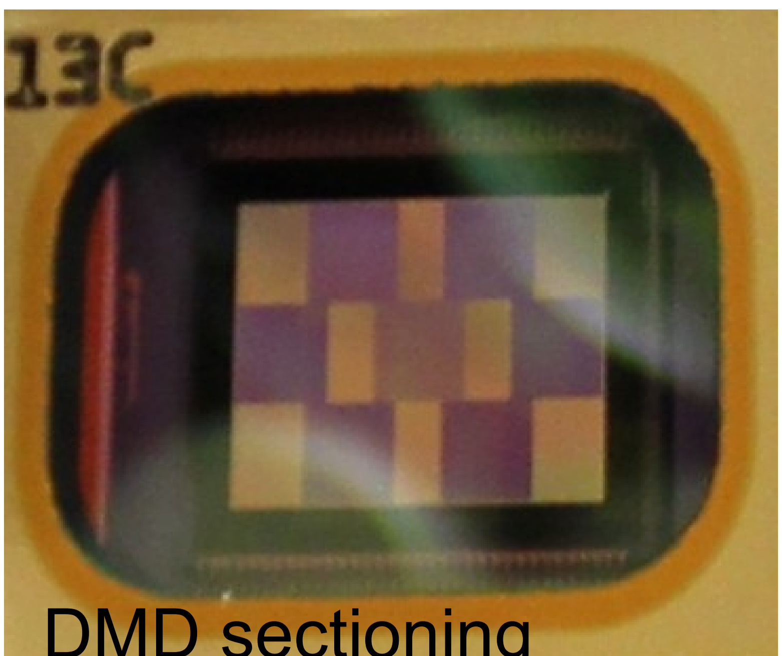


-Characterization-

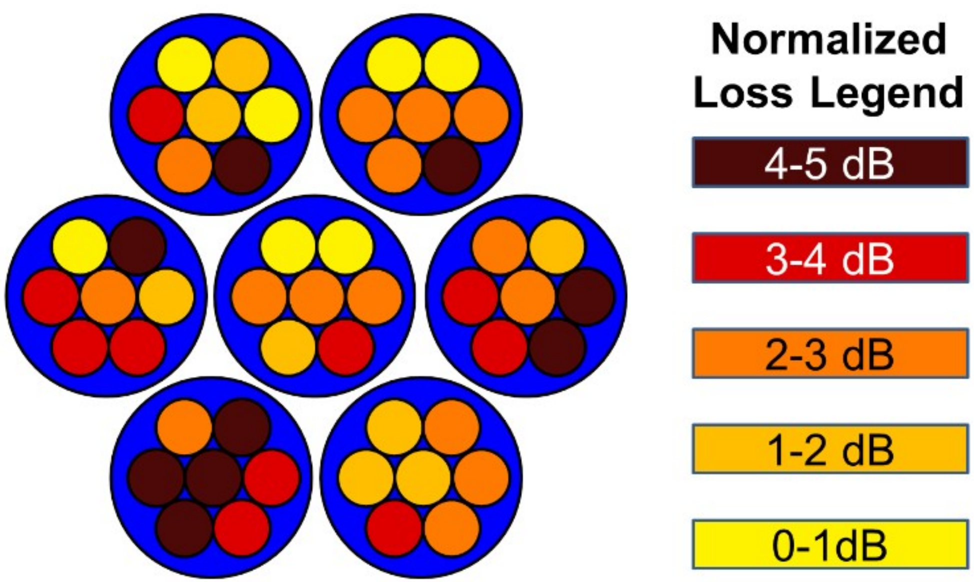
Non-blocking ✓



All ports accessible 9x9 visible / 7x7 IR

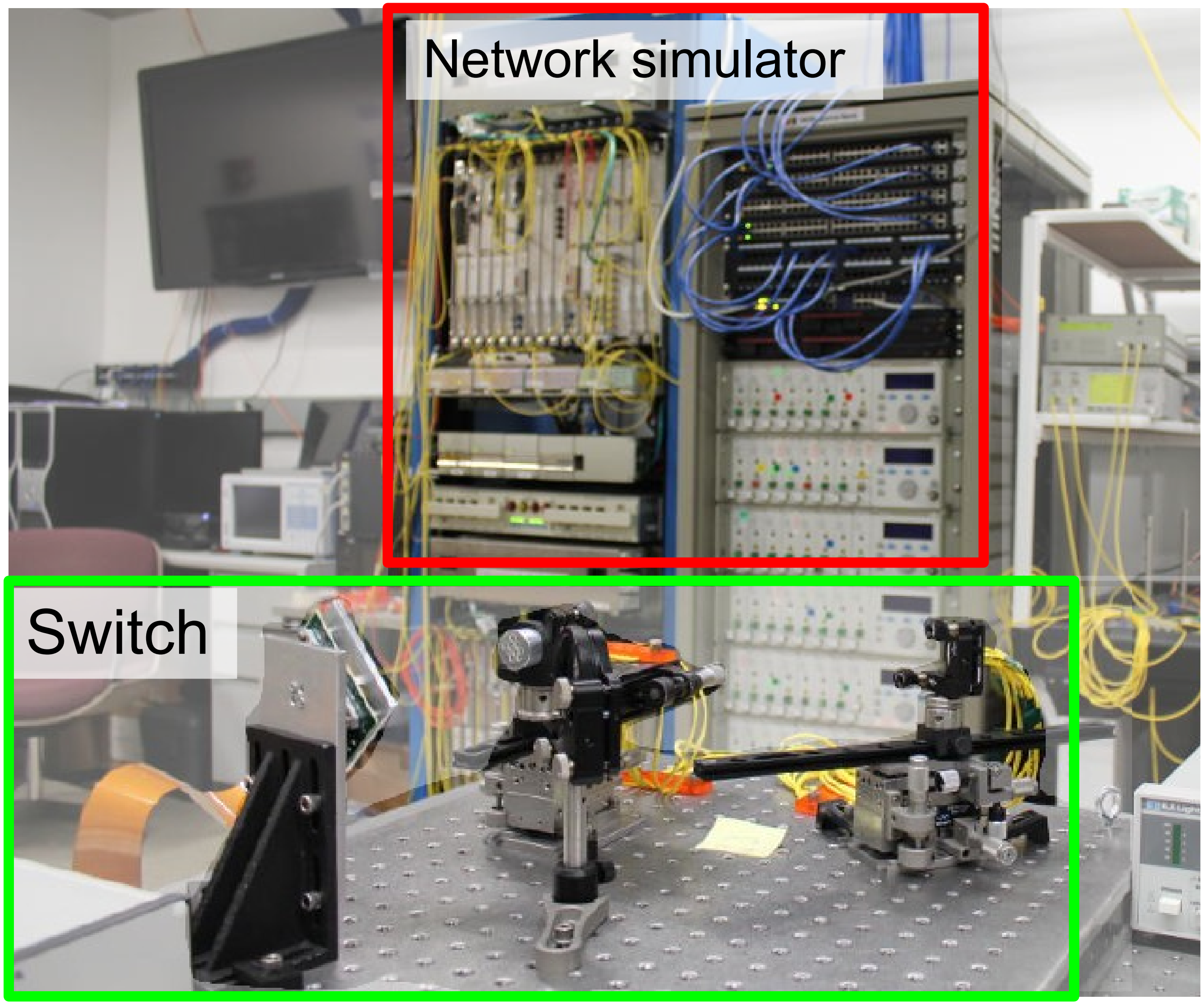


Loss map per port



-Characterization II-

Testbed insertion & video transmission ✓



- Tech Comparison-

Vendor	Technology	Port count	Loss	speed	Power	Reliability
Calient	3D MEMS	High	Low	ms	45 W	Low
CrossFiber	3D MEMS	Low (1x8)	Low	ms	1W	Low
Polatis DirectLight	Micro-actuatio n	Moderate	Low	ms	128W	Good
Nistica*	DMD wavelength switch	High	Low	µs	1W	High
UA	DMD Hologram	High	High Addressed in next phase	µs	1W	High

* The Nistica product is a wavelength switch (not space) using the DMD

Loss budget

50% Fiber injection

- Analysis of the injection condition
- Solution found (replacing lens)

50% Diffraction

- Binary amplitude grating 10% efficiency
- 8 level phase grating 90% efficiency
- Require a piston DMD

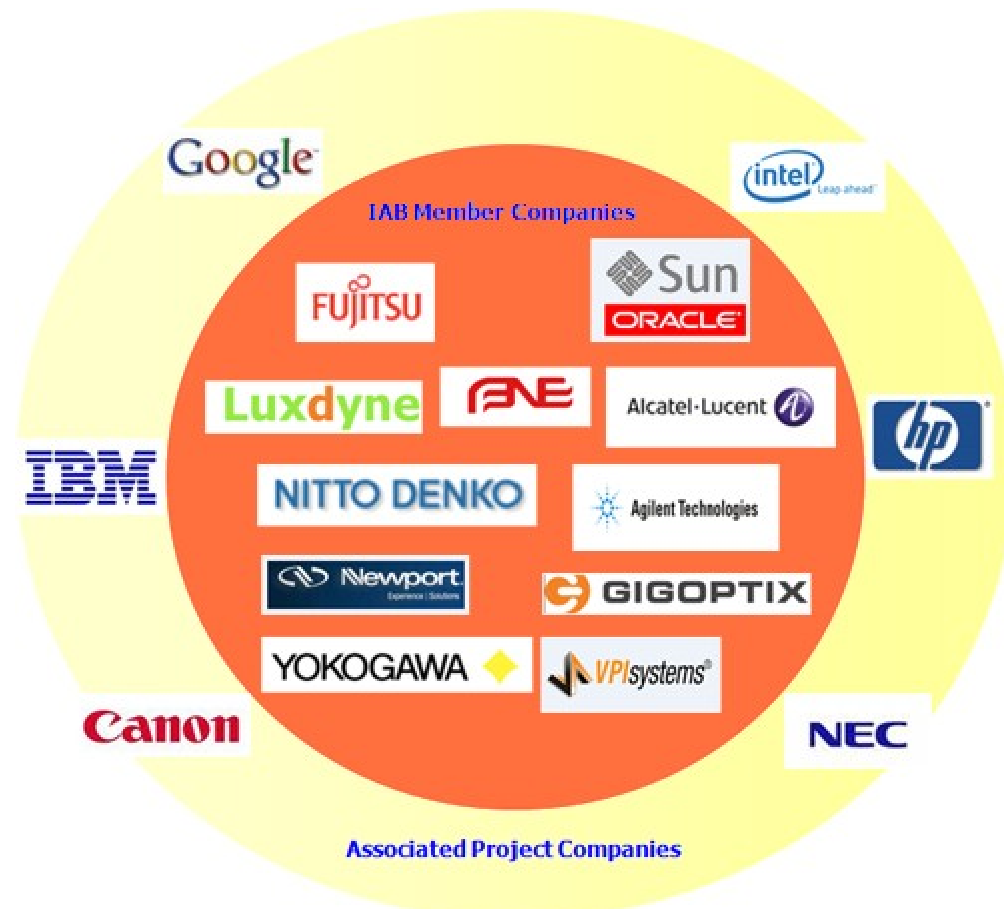
- Competitive Advantage -
- Commercial Appeal -

Disruptive technology !

- Faster (100x)
- Scalable (1,000s of ports)
- Robust (10^{12} mirror cycles)
- Cheaper per port (<$100)
- Low power consumption (1 Watt)

- Commercial significance -

- Bill-Of-Material → manufacturing cost <$100/port
- Preliminary Data Sheets
- Assessment of Packaging and Integration Options
- Interaction with
  - Texas Instrument
  - Fujitsu
  - Nistica
  - UCSD



Next steps

Metrics	Current	Phase 1	Phase 2
Ports count	7x7	30x30	128x128
OSNR [db]	>8	>10	>100
Insertion loss [db]	36	16	5
Homogeneity [db]	5	3	1
Repeatability [db]	N.A.	0.5	0.1
Cross talk [db]	<-73	<-100	<-100
Speed [μs]	50	12	5