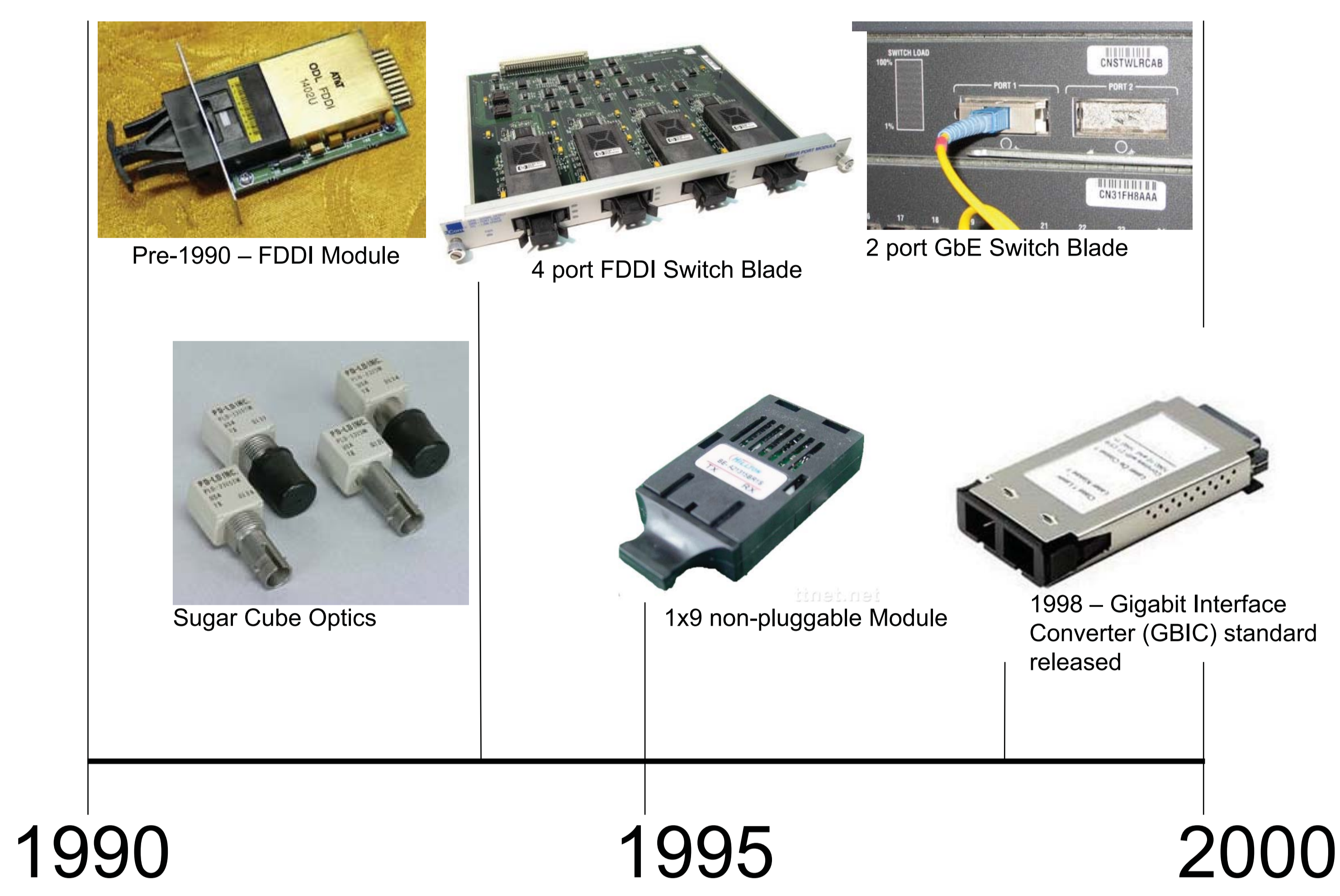


# A Roadmap of Ethernet Optics

## Early Ethernet Optics



## Ethernet is Mostly Copper

While hundreds of millions of Ethernet ports ship every year, only tens of millions of Ethernet modules ship every year.

10GBASE-T expected to ship over 1 million ports in 2014.

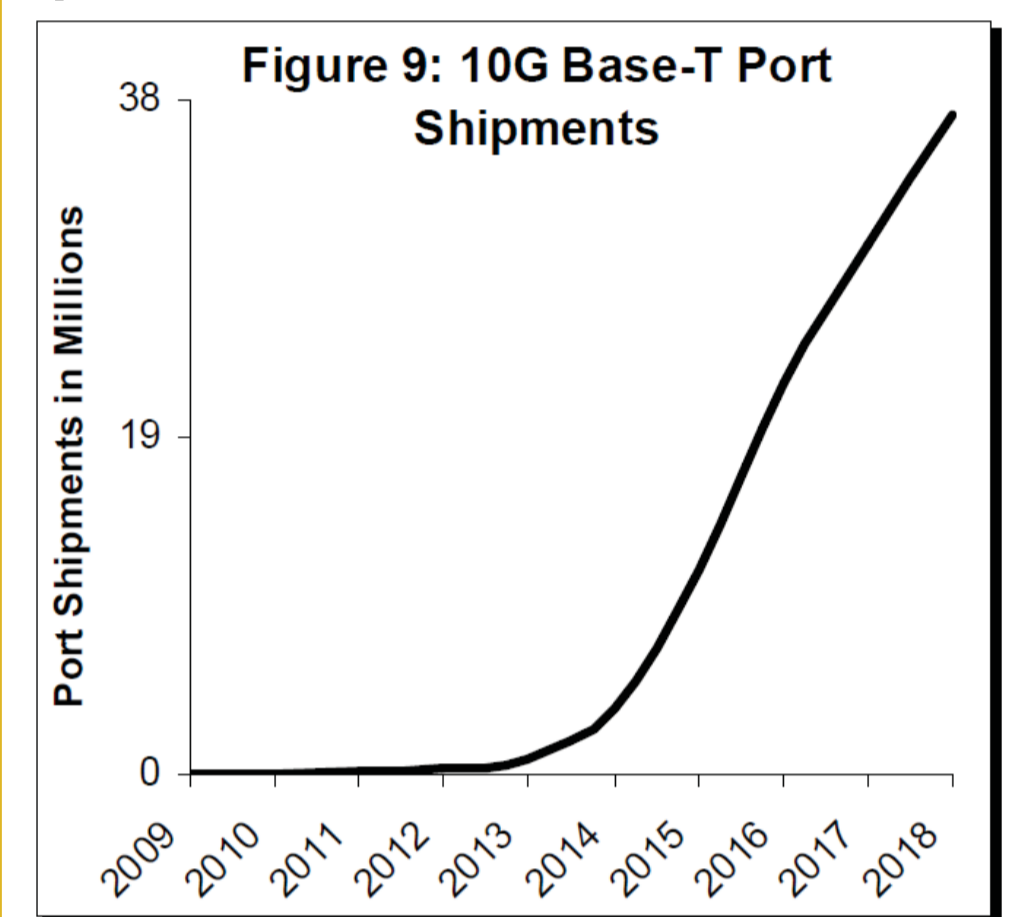
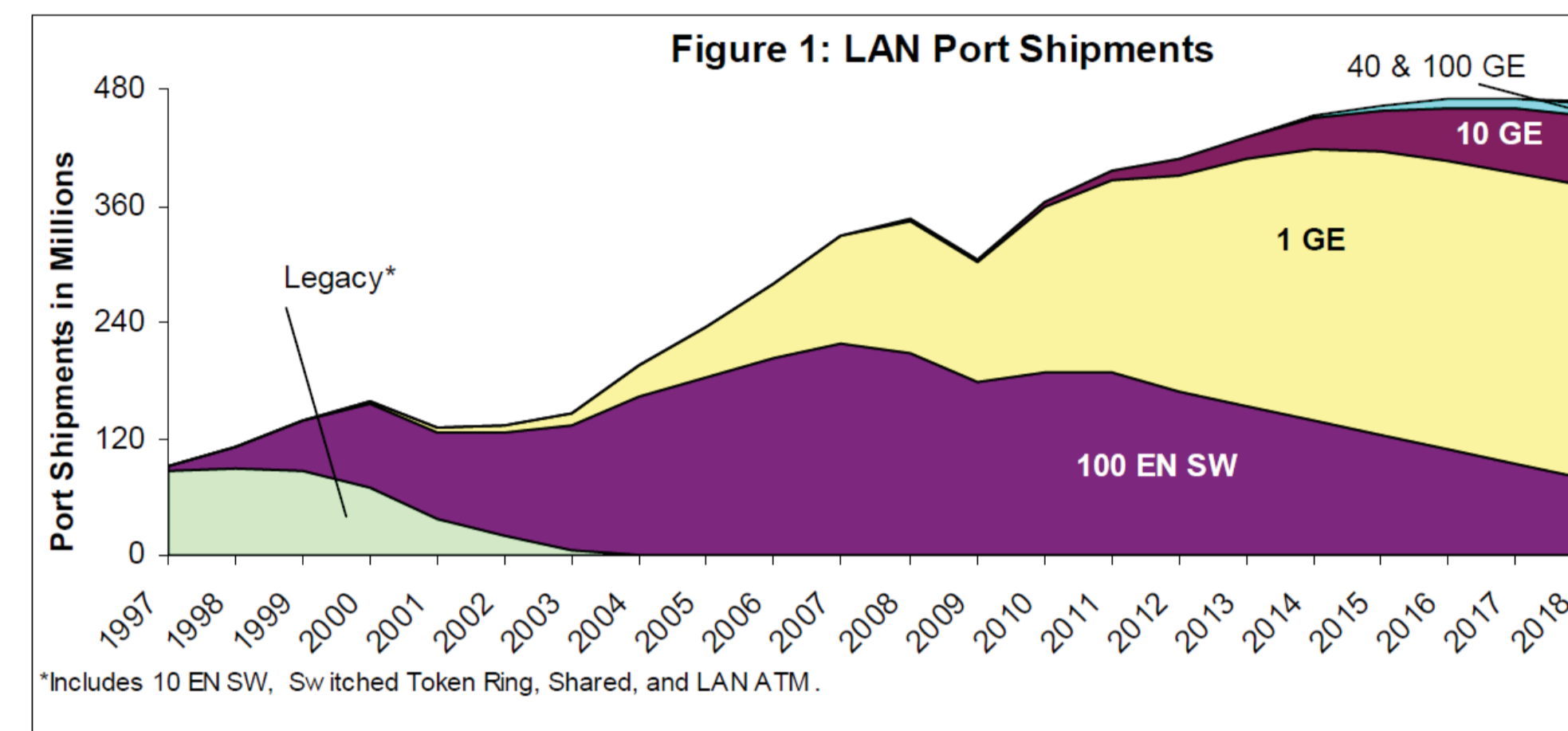


Figure 5: 1 GE Port Shipments (in 000s)

	2012	2013	2014	2015	2016	2017	2018
Copper	208,271	240,577	266,943	279,474	286,858	291,207	293,873
Fiber	14,322	11,495	13,014	11,877	10,407	8,765	7,040
Total	222,593	254,072	279,958	291,351	297,265	299,973	300,913
% Copper	94%	95%	95%	96%	96%	97%	98%

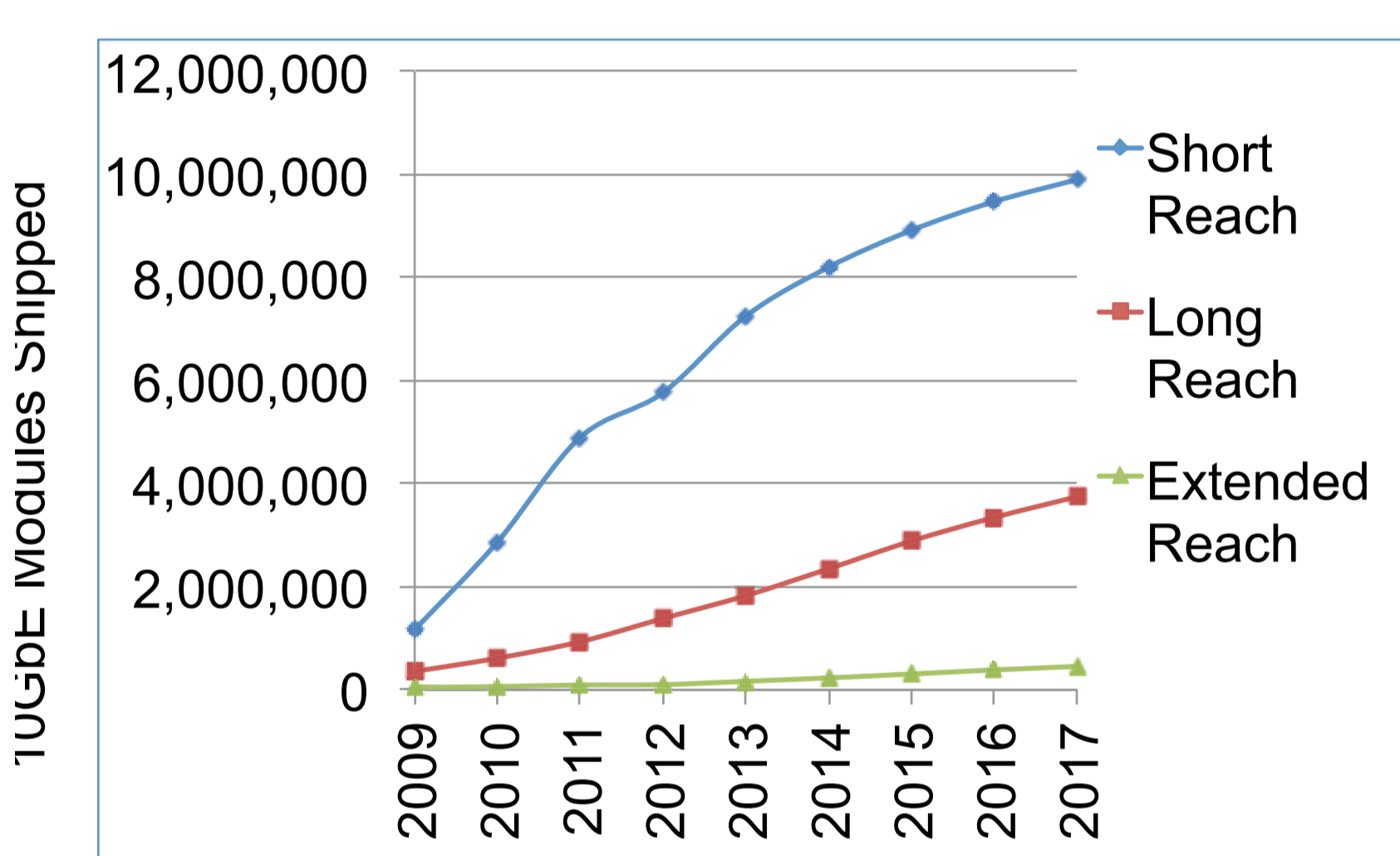
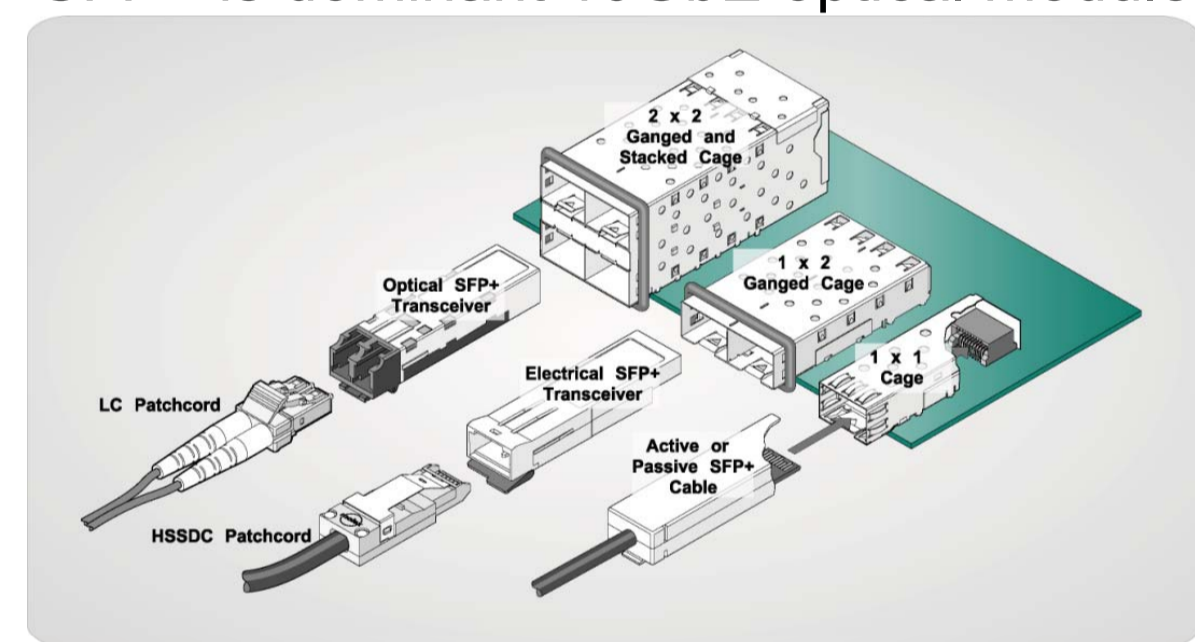
Figure 8: 10 GE Port Shipments (in 000s)

	2012	2013	2014	2015	2016	2017	2018
Copper	6,846	13,018	21,109	31,210	41,486	50,019	58,758
Fiber	8,923	9,341	9,113	11,558	13,271	15,120	14,716
Total	15,769	22,359	30,223	42,768	54,757	65,138	73,475
% Copper	43%	58%	70%	73%	76%	77%	80%

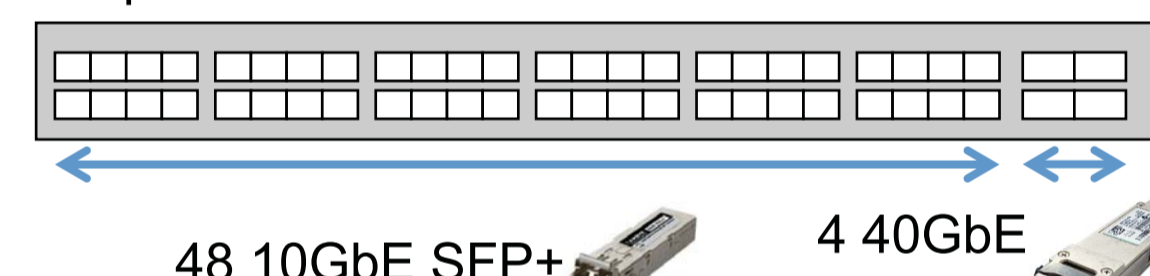
Source: Dell'Oro Ethernet Switch Forecast 2014-2018

## 10GbE Ships Over 10M

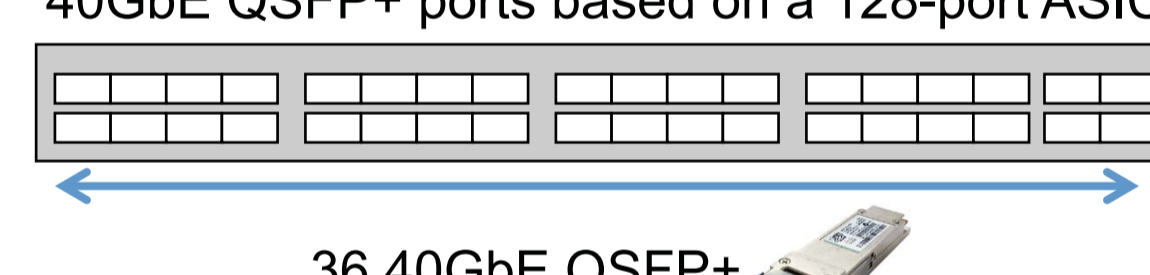
SFP+ is dominant 10GbE optical module



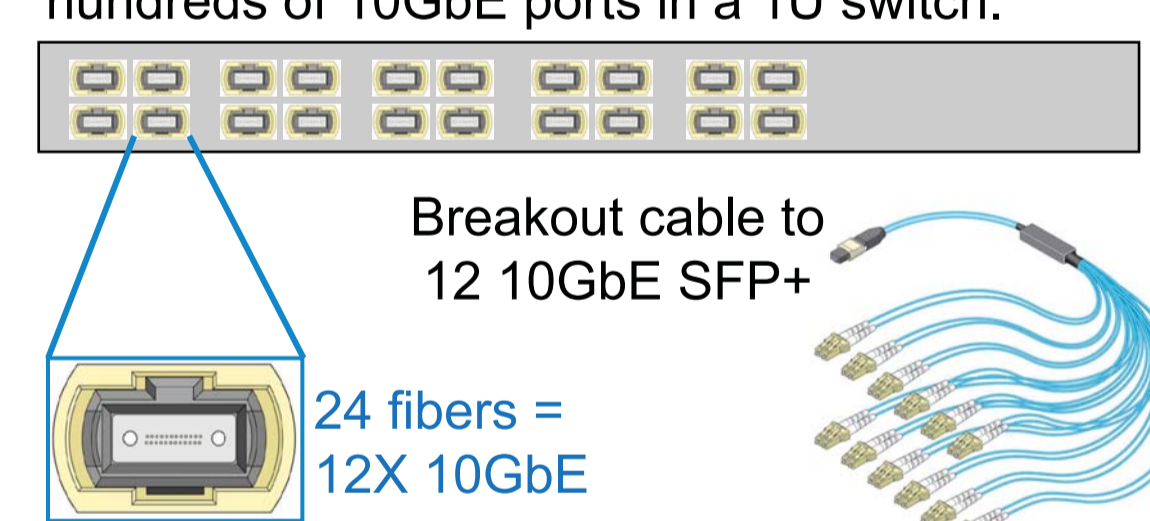
A common 1U switch design is 48 10GbE SFP+ as well as 4 40GbE QSFP+ based on a 64-port ASIC.



Soon, many switch designs will use up to 36 40GbE QSFP+ ports based on a 128-port ASIC.

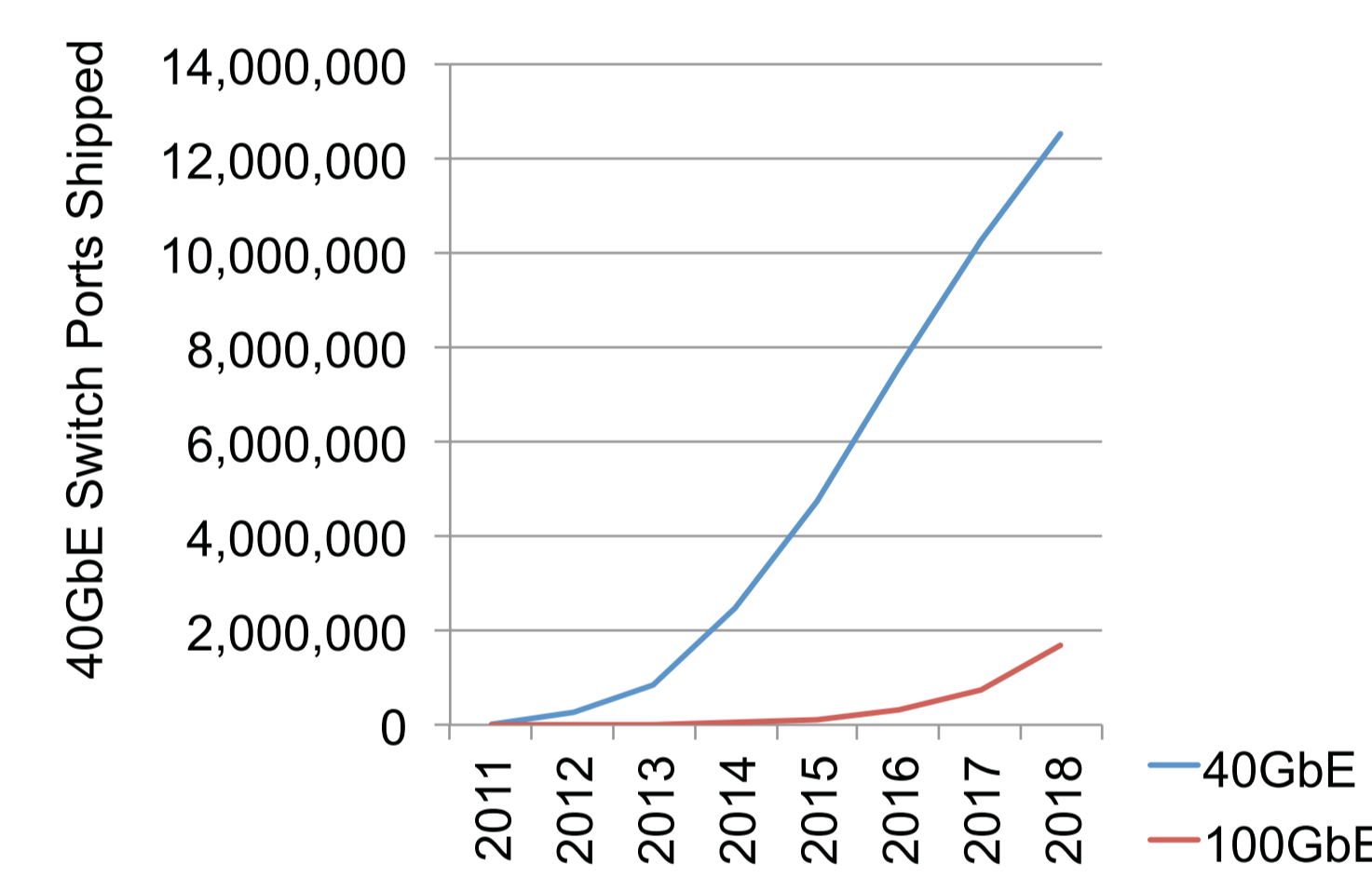


Embedded optical modules will enable hundreds of 10GbE ports in a 1U switch.



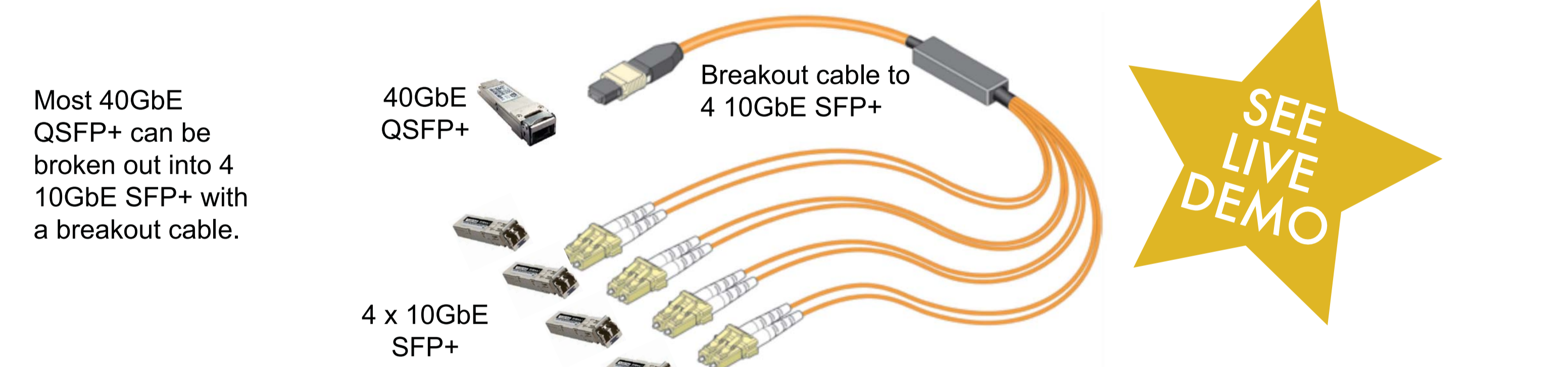
Source: LightCounting Forecast Database 2013-2017

## Over 2M 40GbE Ports Ship



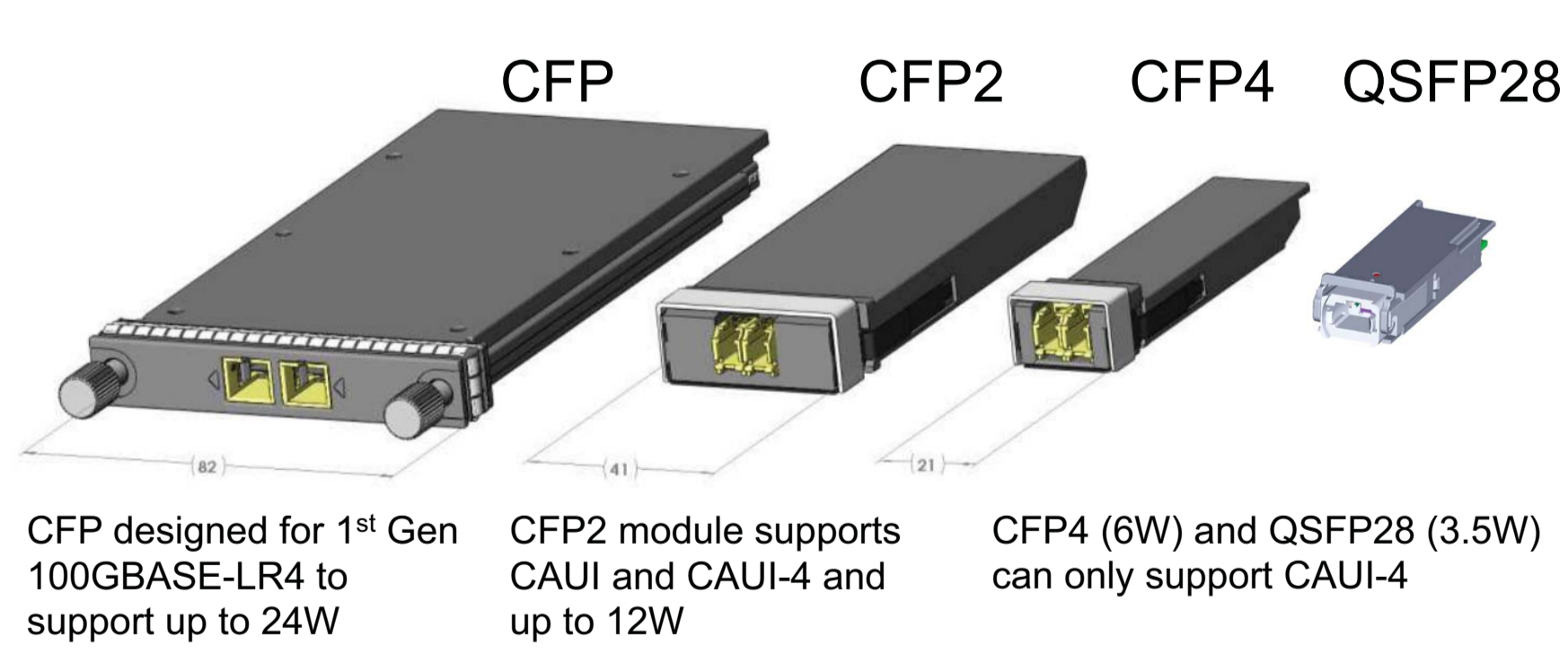
QSFP+ dominant form factor for 40GbE with estimates of over half the ports being used at breakout ports to 4X10GbE.

40GbE SFP+ could become low cost, serial 40GbE solution but no standard is being developed for this yet.



Source: Dell'Oro Ethernet Switch Forecast 2014-2018

## 100GbE Optics Roadmap



CFP designed for 1st Gen 100GBASE-LR4 to support up to 24W

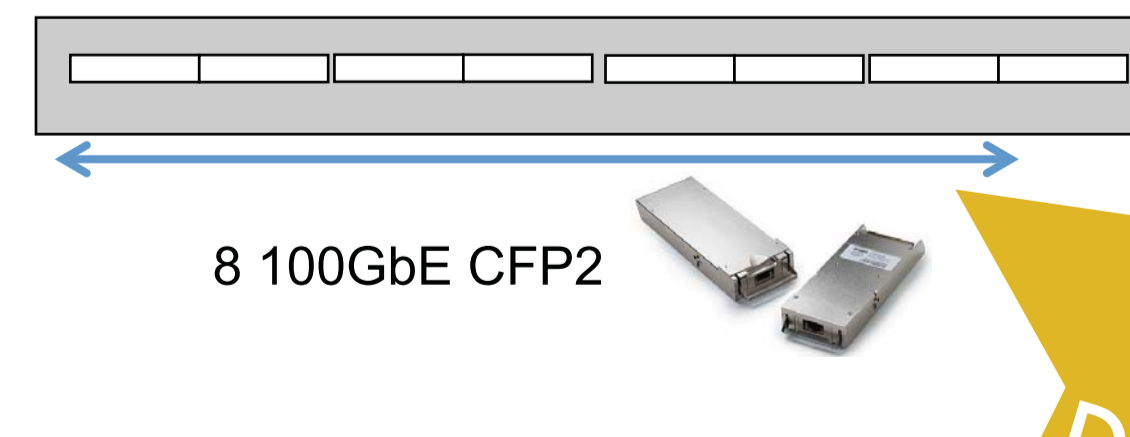
CFP2 module supports CAUI and CAUI-4 and up to 12W

CFP4 (6W) and QSFP28 (3.5W) can only support CAUI-4

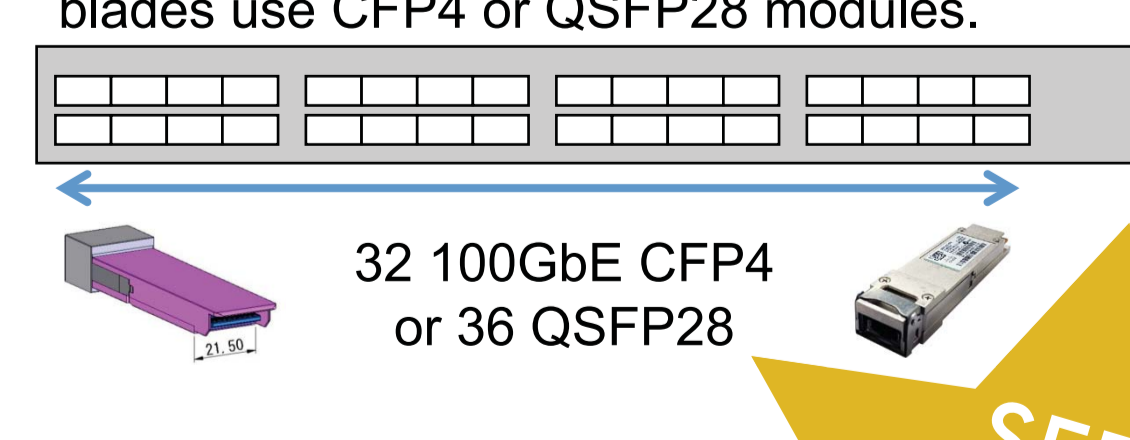
First generation 100GbE switch and router blades used CFP Module.



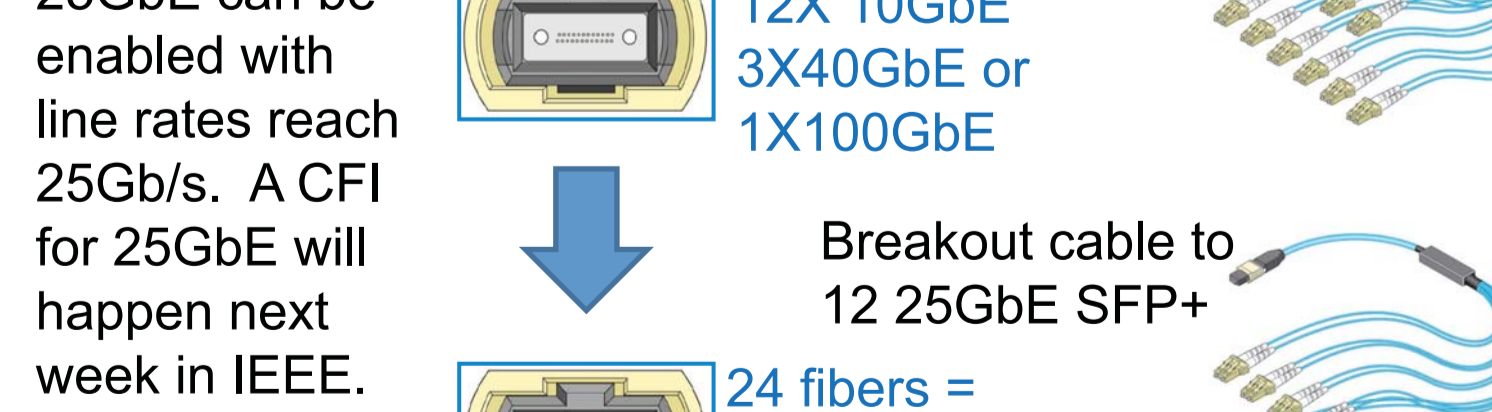
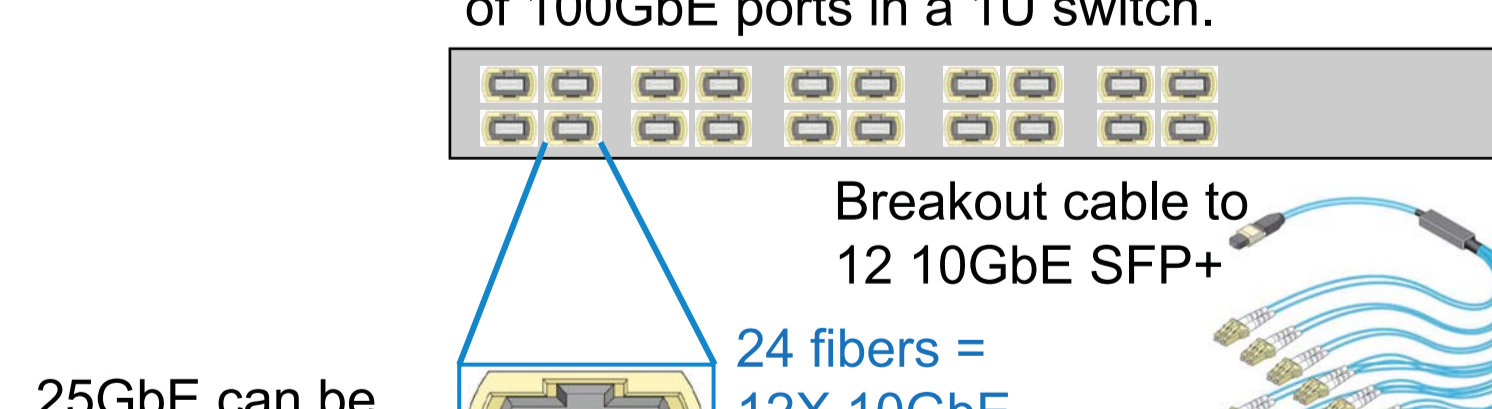
Second generation 100GbE switch and router blades use CFP2 modules.



Third generation 100GbE switch and router blades use CFP4 or QSFP28 modules.



Embedded optical modules will enable tens of 100GbE ports in a 1U switch.

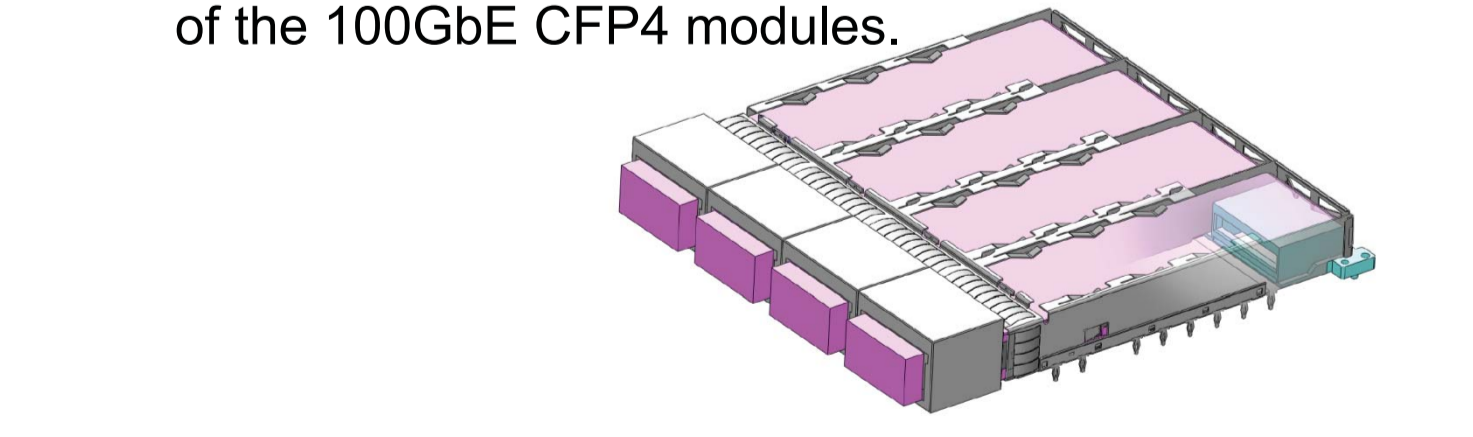


25GbE can be enabled with line rates reach 25Gb/s. A CFI for 25GbE will happen next week in IEEE.

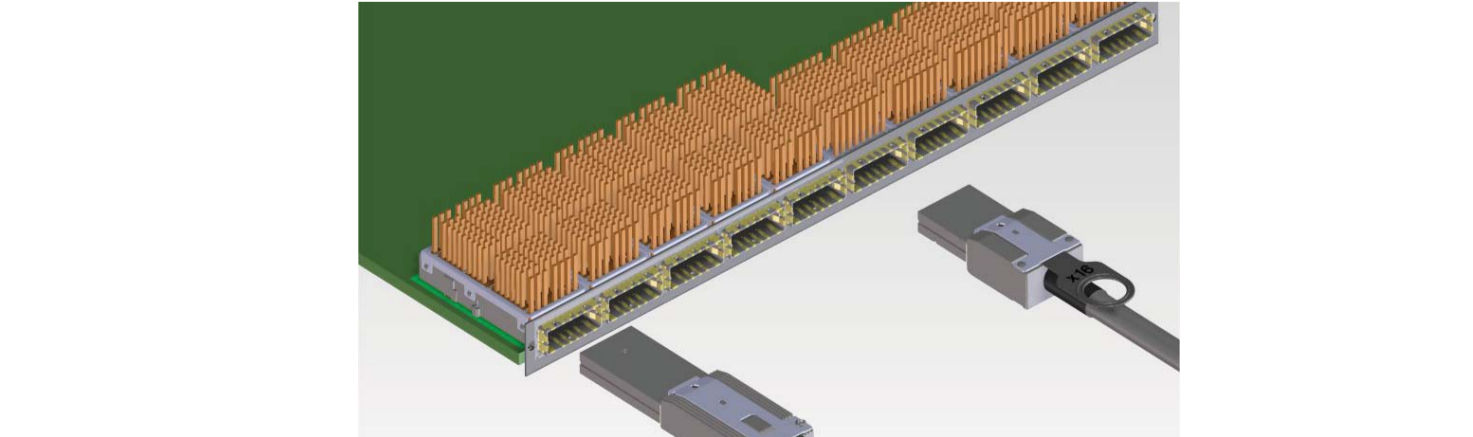
## 400GbE Optics Roadmap

The 400GbE Study Group should become the 400GbE Task Force after next week's IEEE meetings. There are a few options for first generation 100GbE optical modules. Some likely candidates include:

- 4 CFP4 modules – this approach would enable the re-use of the 100GbE CFP4 modules.



- CDFP Modules – this approach is being defined by the CDFP MSA and will likely only support distances within data centers. Find out more at [www.cdfp-msa.org](http://www.cdfp-msa.org).



- CD-CFP? – The CFP MSA is considering to standardize a 400G module that will probably be smaller than a CFP, but larger than a CFP2.

The 400GbE Study Group has set a number of reach objectives including:

- At least 100 meters over multimode fiber
- At least 500 meters over single-mode fiber
- At least 2 kilometers over single-mode fiber
- At least 10 kilometers over single-mode fiber

The standard for 400GbE is expected to complete in 2017 and multiple generations are expected. Here are some possible generations of 400GbE:

	Electrical Interface	Multimode Fiber Interface	Single-Mode Fiber Interfaces
1st Gen	16X25 Gb/s	16 pairs of fibers to 100 meters	8 λ at 50G or parallel SMF
2nd Gen	10X40 Gb/s or 8X50 Gb/s	8 or 10 pairs of fibers to 50 meters	4 λ at 100G or parallel SMF
3rd Gen	4X100Gb/s	Is it possible? We'll see after 2020...	1 λ at 400G or parallel SMF

**Beyond 400GbE**

While there is talk of Terabit Ethernet, the road to Terabit speeds will likely be built with 100Gb/s serial lanes. Data centers are mainly running at 10G now and will run at 25G soon. Next stop will be 40G and 100G is still a long ways out. If you know how to make low-cost, 100G serial lanes, please send an email to: [president@ethernetalliance.org](mailto:president@ethernetalliance.org).