40G on UTP or Shielded Copper - Reality or Myth?

K G Hodge Brand-Rex

With contributions from Alan Flatman, LAN Technologies

Would these cabling types be able to support 40Gbps or 100Gbps technologies?

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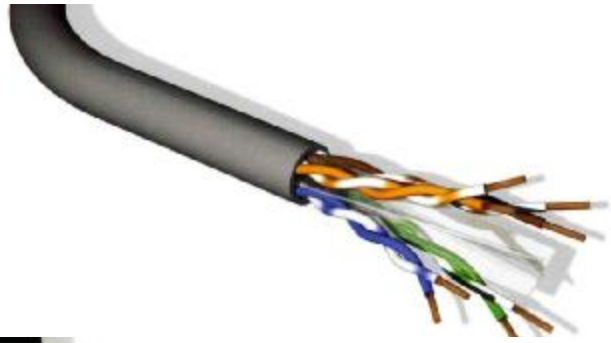
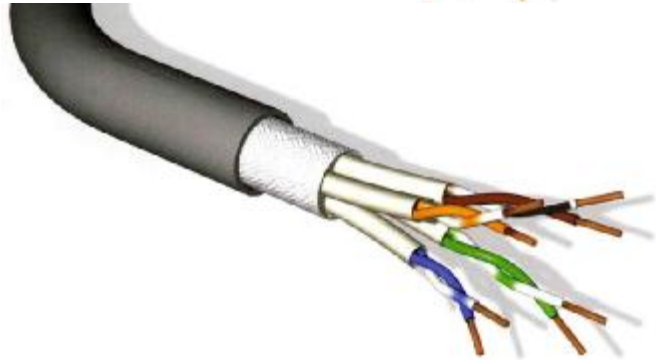
UTP



F/UTP

S/FTP



Current >10Gbps initiatives on Copper cabling

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Twinax:

- 40GBASE-CR4, 100GBASE-CR10 specified by 802.3ba
  - 8-twinax or 20-twinax cable assembly up to 7m
- 100GBASE-CR4 currently being developed by 802.3bj
  - 8-twinax cable assembly anticipated to be up to 5m

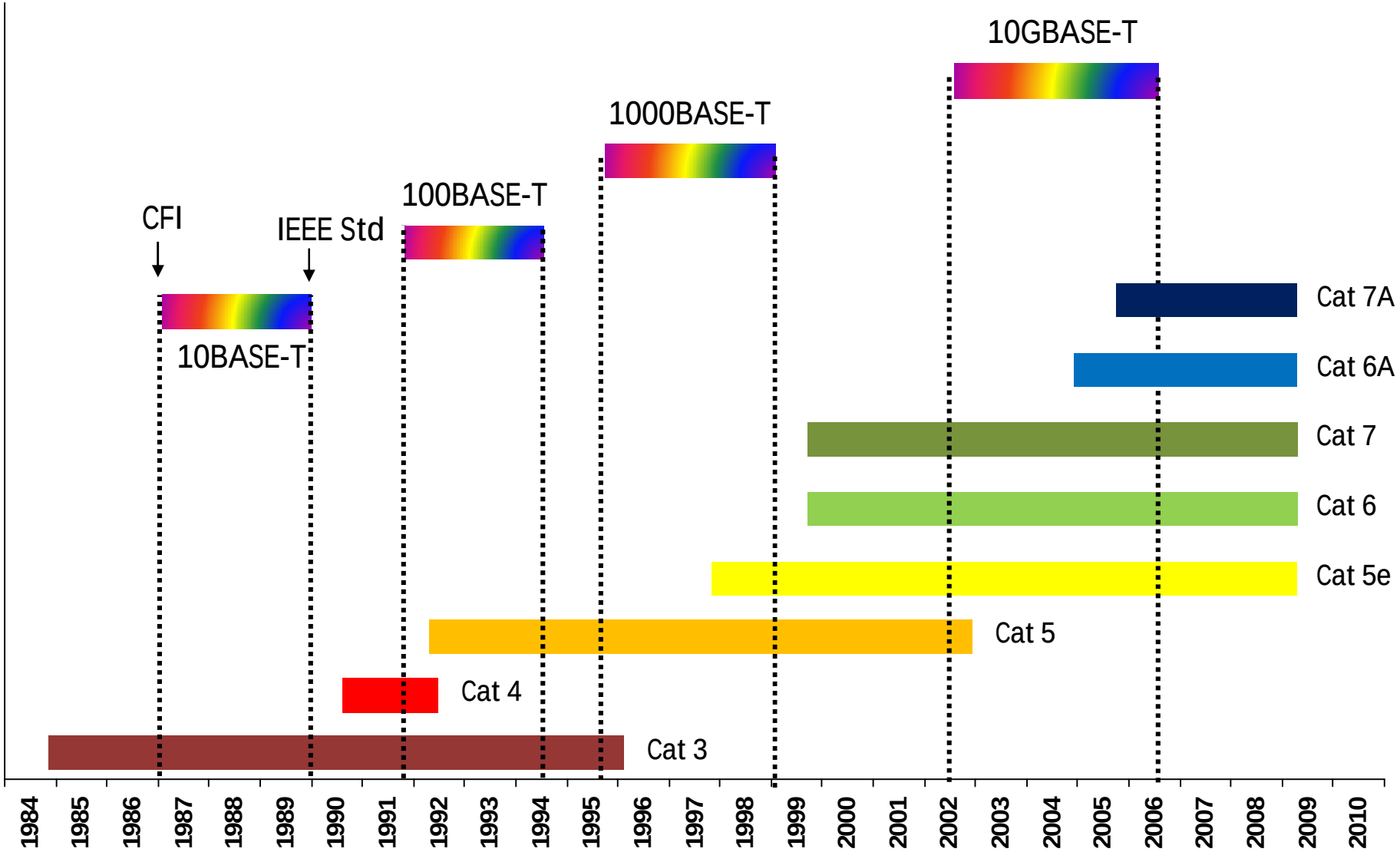
Electrical Backplane:

- 40GBASE-KR4 specified by 802.3ba
- 100GBASE-KR4 currently being developed by 802.3bj

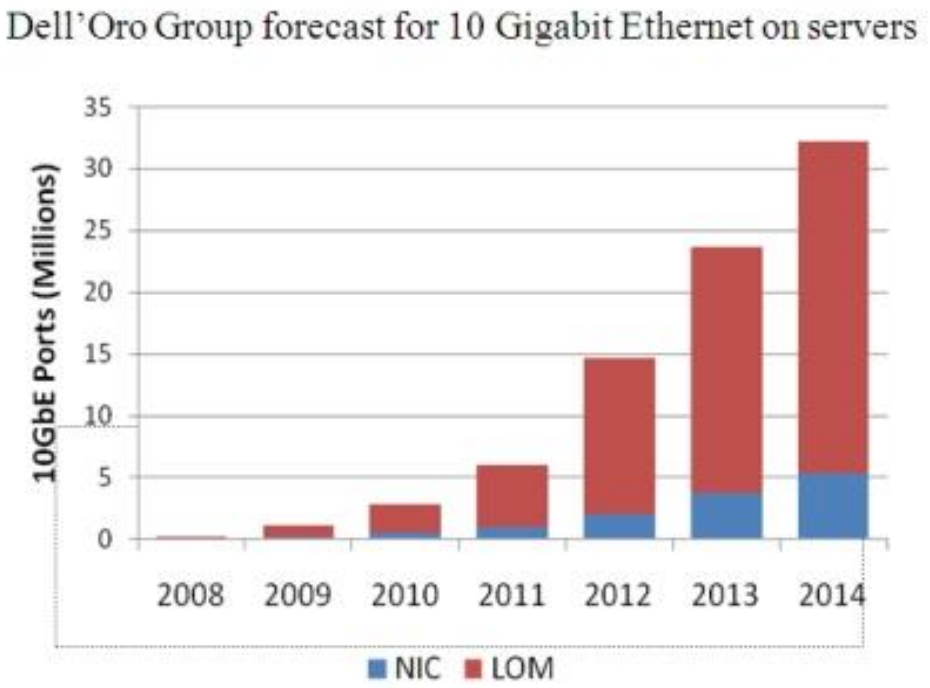
Twisted Pairs:

- 2-day workshop at Penn State University in Aug 2009
- contributions on technical feasibility, standardisation, market potential from industry and academia
- 4-pair Cat 7_A channel used with 2 modular connectors
  - 40G theoretical capacity shown up to 100m
  - 100G theoretical capacity shown up to 70m

Cabling Lifecycles & BASE-T technologies



The latest BASE-T technology:



Dell'Oro press - Dec 2010:

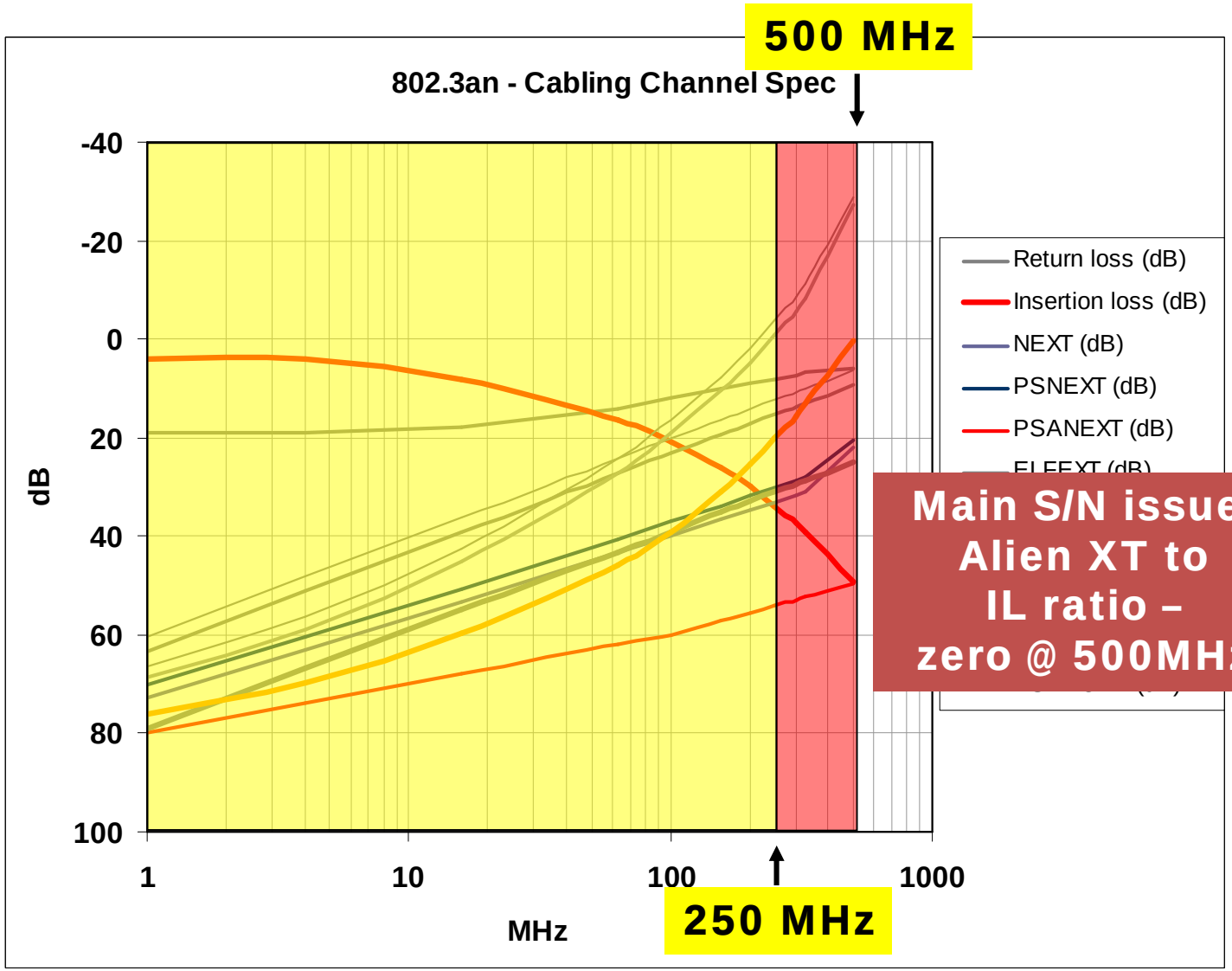
"Dell'Oro Group projects 10GBase-T chips used on sever motherboards will rise from about 5 million in 2011 to more than 25 million in 2014 .

Intel showed in September its Twinville chip that combines a two-port 10GBase-T physical layer chip from Teranetics along with Intel's media access controller. The 40nm chip consumes less than 10W, so it does not require a heat sink, and fits into a 25mm^2 package.

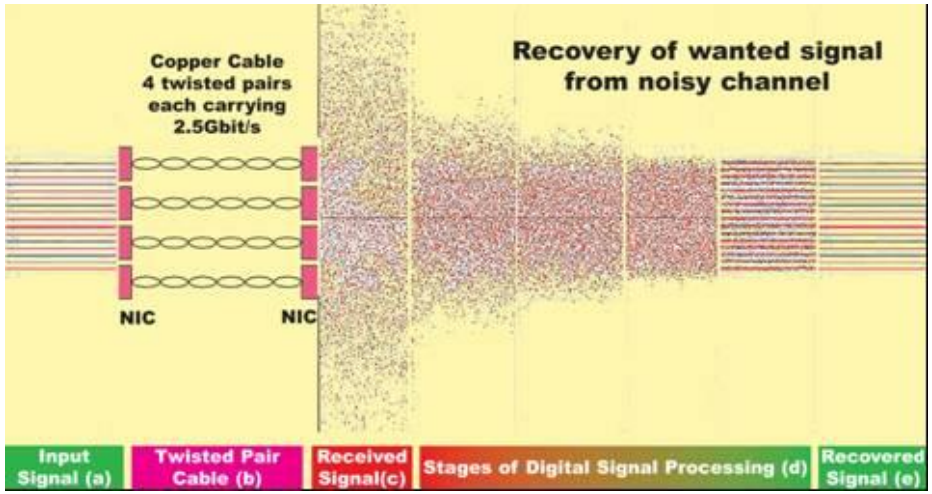
Intel's schedule is to launch it in tandem with its Sandy Bridge server processors in the second half of 2011"

10GBASE-T technology is growing

10GBASE-T


500 MHz
802.3an - Cabling Channel Spec
-40
-20
0
20
40
60
80
100
dB
1
10
100
1000
MHz
250 MHz
Return loss (dB)
Insertion loss (dB)
NEXT (dB)
PSNEXT (dB)
PSANEXT (dB)
Main S/N issue:
Alien XT to
IL ratio –
zero @ 500MHz

10GBASE-T signal integrity



Random noise sources = risk

Alien Crosstalk

- Bundled cables generate noise

EMI

- Interference from radiated & conducted emissions

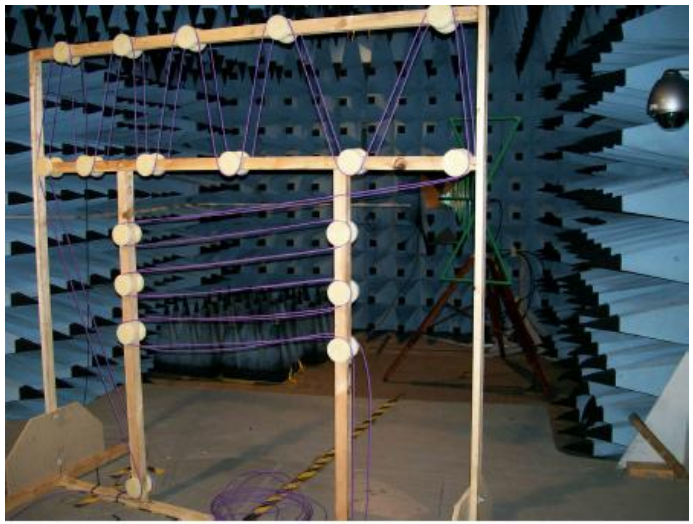


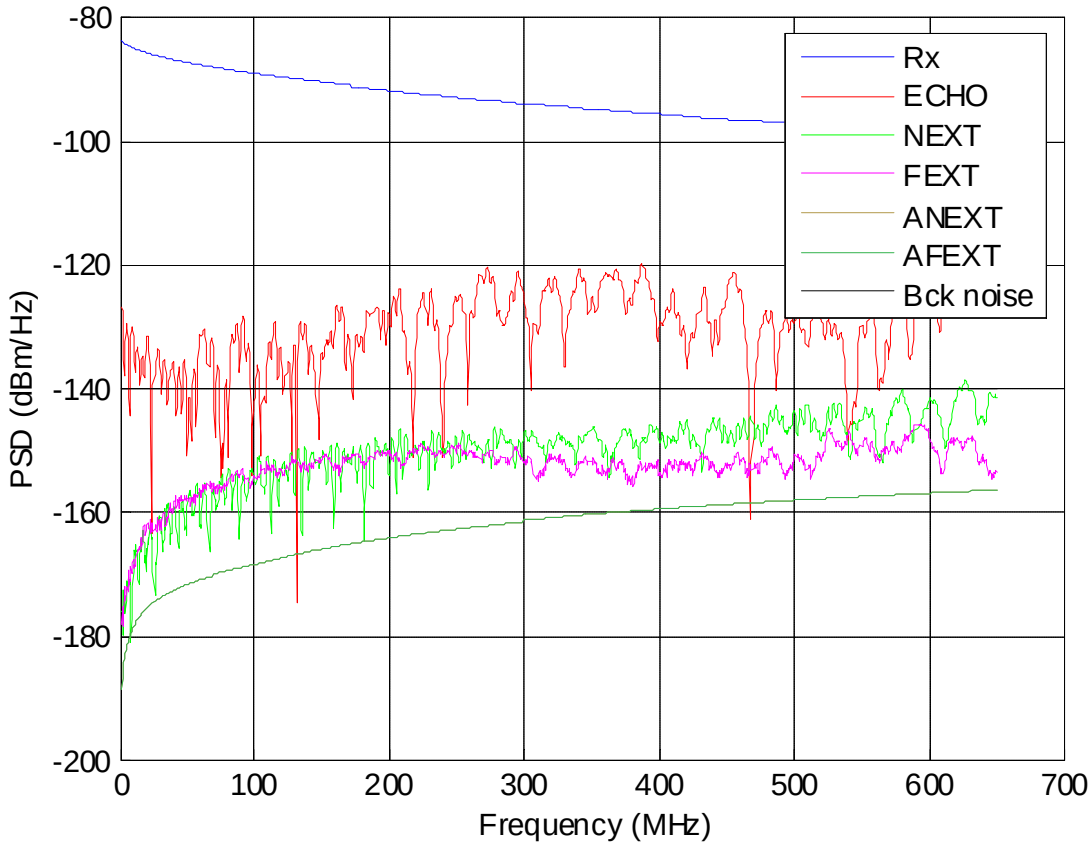
Photo 1. Radiated emission E field – Semi Anechoic Screened Room

Random (external) noise test summary

EMI, E1	10GBASE-T on the Cable Type*			
	Cat6 U/UTP	Cat6A U/UTP	Cat6A U/FTP	Cat6A S/FTP
Radiated Emmissions EN 55022 (30MHz-1GHz)	pass	pass	pass	pass
Immunity to radiated RF field EN61000-4-3 (80MHz-1GHz)	Transmit stops	Transmit stops	pass	pass
Immunity to conducted disturbance EN61000-4-6 (150KHz – 80MHz)	Transmit stops	Transmit stops	pass	pass
Immunity to fast transients EN61000-4-4 (noise on signal cable)	pass	pass	pass	pass
Immunity to fast transients EN61000-4-4 (noise on power cable)	pass	pass	pass	pass
Alien Crosstalk (6 round 1 bundles)	Transmit stops	pass	pass	pass

* Brand-Rex independent 3rd party testing of 1st generation 10GBASE-T devices

10G transmission line assessment



A short Class F/FA channel
-140 dBm/Hz Background Noise
Echo was identified as the Dominant Impairment

Source: CFI for 10GBASE-SH

10Gbps

- Is now growing in volumes
- UTP cabling transmission lines are:
  - Alien noise vs insertion loss limited
  - EMI limited in noisy environments
- Screened cabling:
  - Good S/N margins against alien noise
  - Protection against EMI
  - High performance transmission lines that are not XT limited – exhibiting limitations associated with Echo

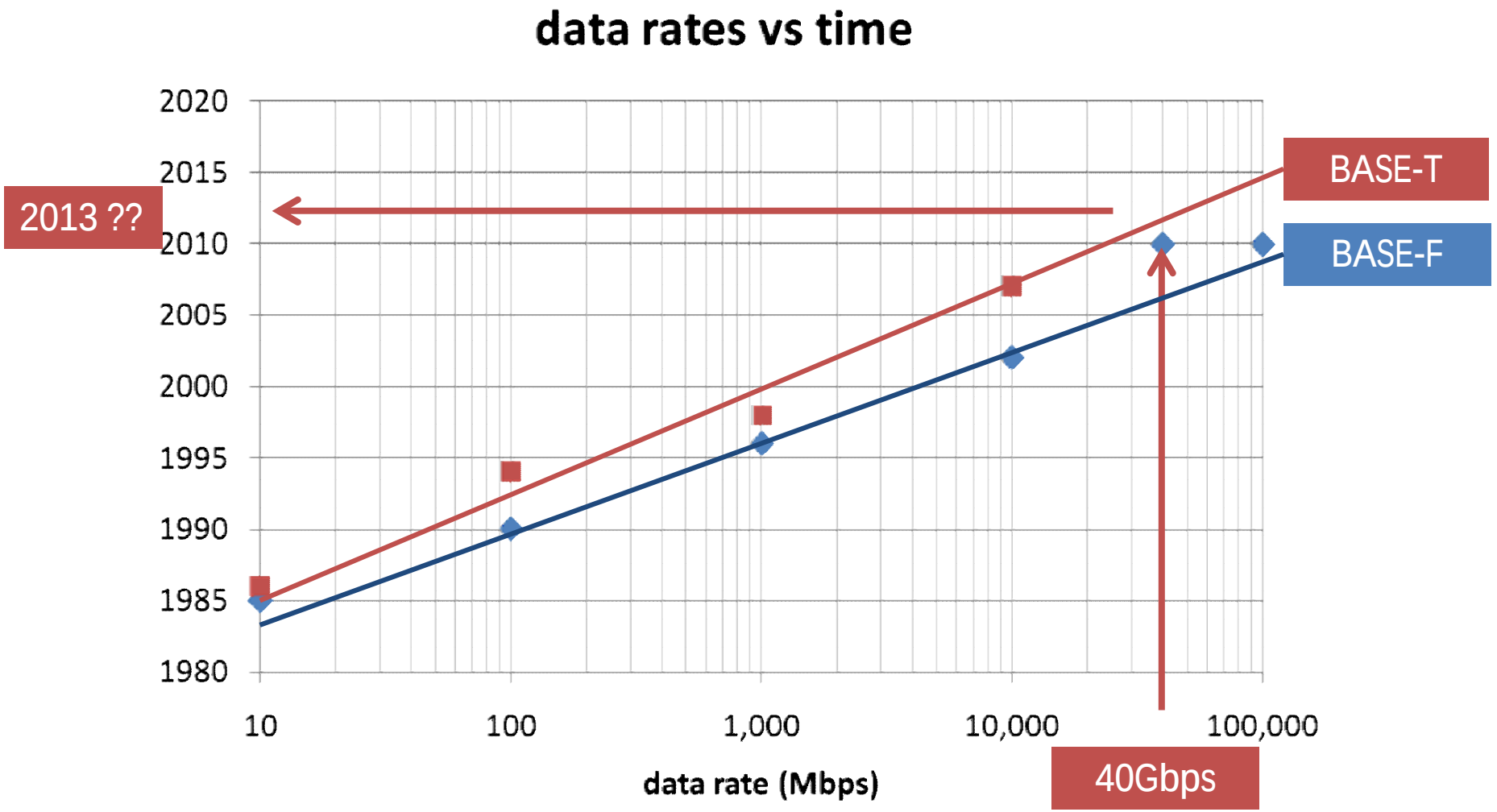
If 10GBASE-T is susceptible to noise – what about higher speeds?

40Gbps

40,000,000,000 bps

A 4Gb file transferred in 0.1s

Forecasting BASE-T speeds

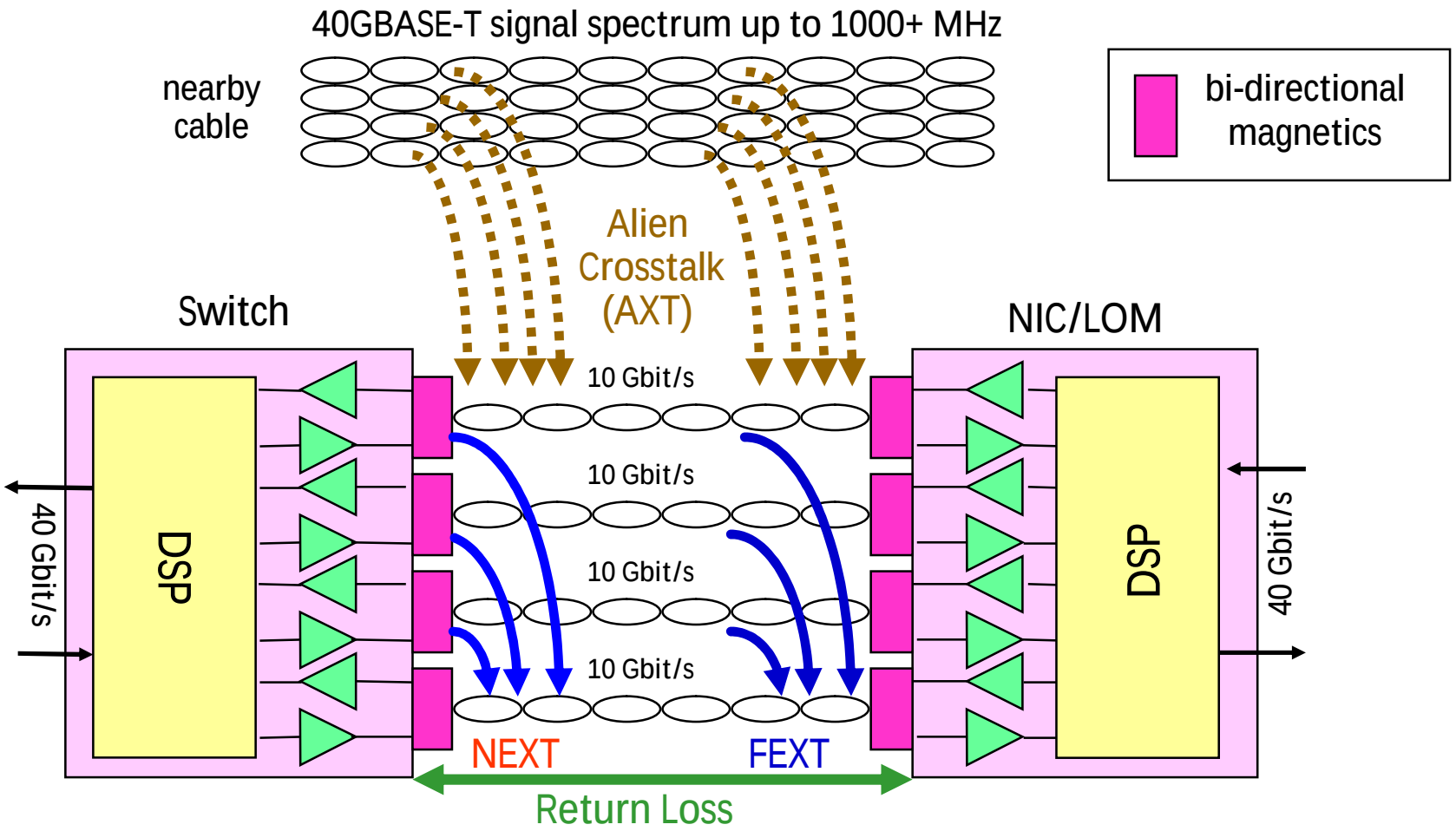


BASE-T transmission parameters

	10Mbps	100Mbps	1000Mbps	10Gbps
Silicon	Manchester	MLT-3	PAM5	128 DSQ
			Echo cancellation	Echo cancellation
			NEXT cancellation	NEXT cancellation
			FEC	FEC
				Power back off
				FEXT suppression

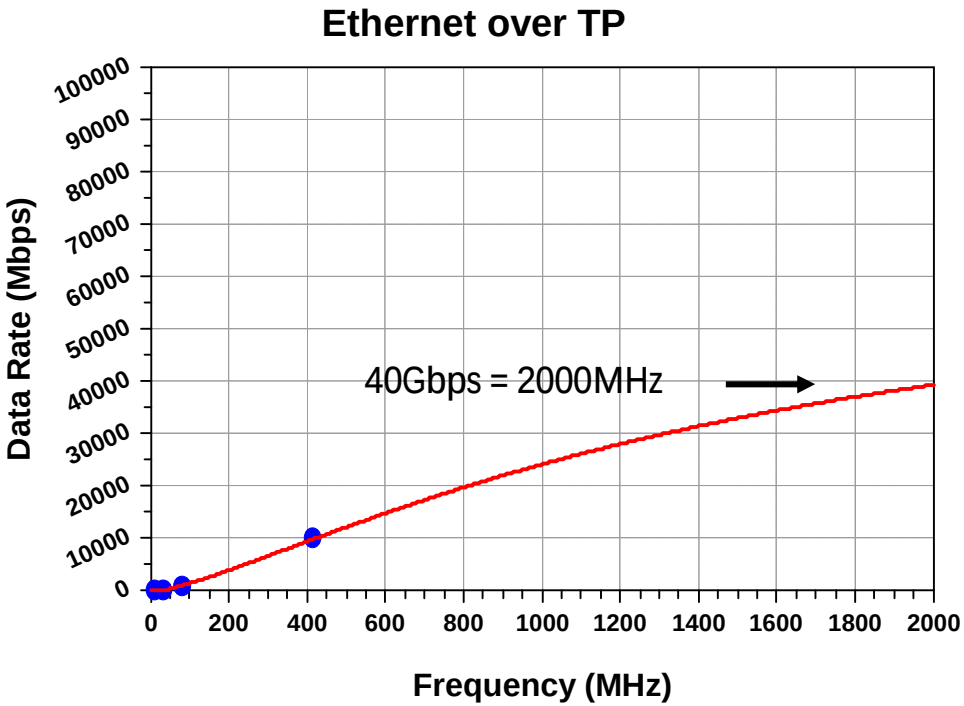
	Class C	Class D	Class D	Class EA
Cabling	Attenuation	Attenuation	Attenuation	Attenuation
	RL	RL	RL	RL
	NEXT	NEXT	NEXT	NEXT
			PSNEXT	PSNEXT
			PSFEXT	PSFEXT
				ANEXT
				AACR-F

40GBASE-T Transmission with bi-directional 4x10G



What spectrum would be required?

- "the imperative of self accelerating growth is limited by the environment", Morgan-Mercer-Flodin
  - BASE-T technology
    - 10Mbps 12.5MHz
    - 100Mbps 31.25MHz
    - 1G 80MHz
    - 10G 416MHz
    - 40G ≈ 2 GHz



NB. The Penn State team looked at 1GHz as an upper frequency

What are the critical cabling key characteristics

100m channel parameters (Basic transmission line)	Class EA UTP	Class EA Screened	Class F	Class FA
Upper Frequency	500MHz	500MHz	600MHz	1GHz
Attenuation @ 500MHz	49.3	49.3	49.3	46.7
RL @ 500MHz	6.0	6.0	8.0	8.0
NEXT @ 500MHz	27.9	27.9	52.4	53.6
PSACR-N @ 500MHz	-24.5	-24.5	0.1	3.9
PSACR-F @500MHz	6.3	6.3	29.6	30.4

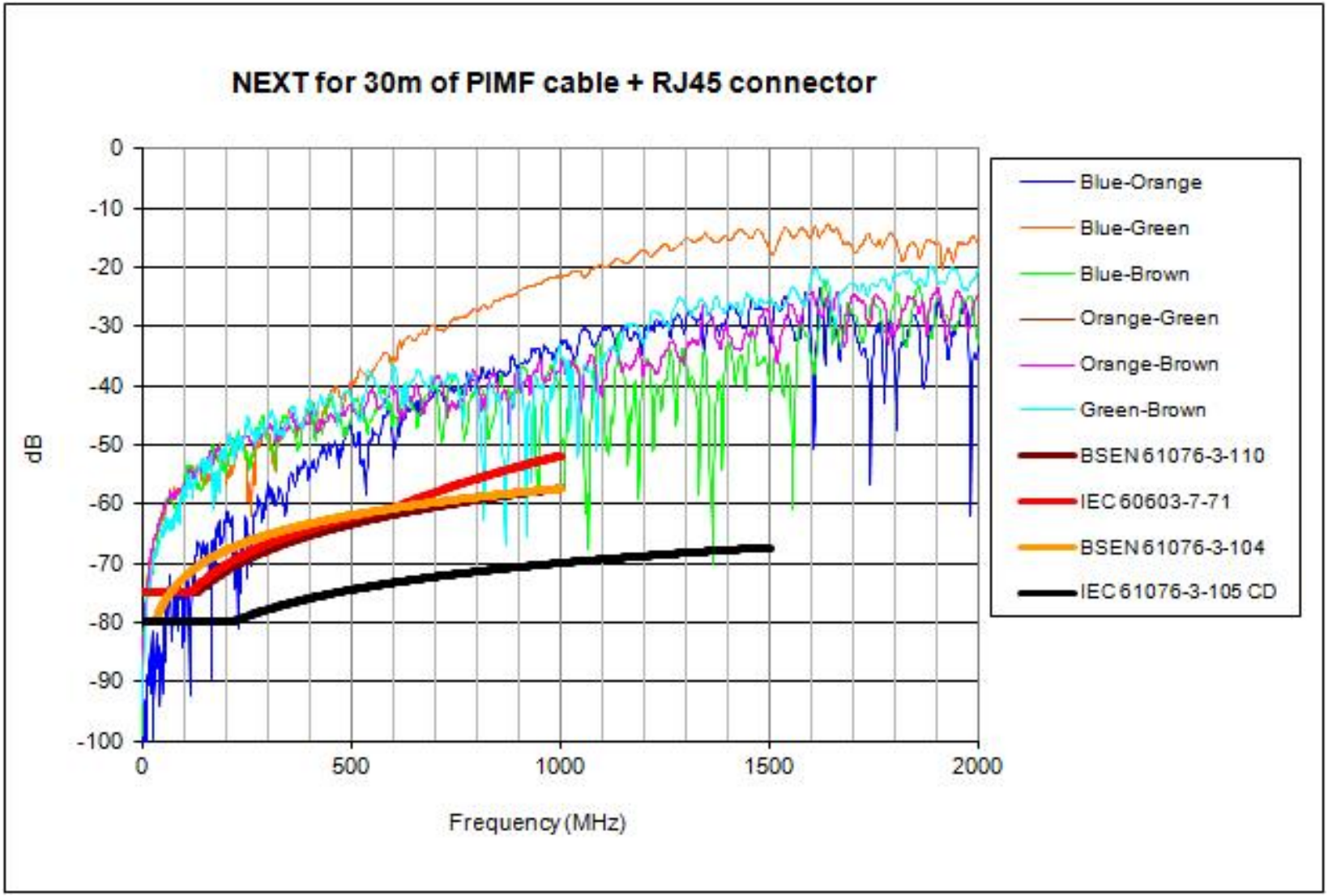
Parameters (External noise sources)	Class EA UTP	Class EA Screened	Class F	Class FA
PS ANEXT @ 500MHz	49.5	49.5	49.5	64.5
PS AACR-F @ 500MHz	23.0	23.0	23.0	38.0
Coupling attenuation @ 500MHz E1	-	26*	26*	26**
E2	-	36	36	36
E3	-	46	46	46

Ref : EN 50173-1:2011

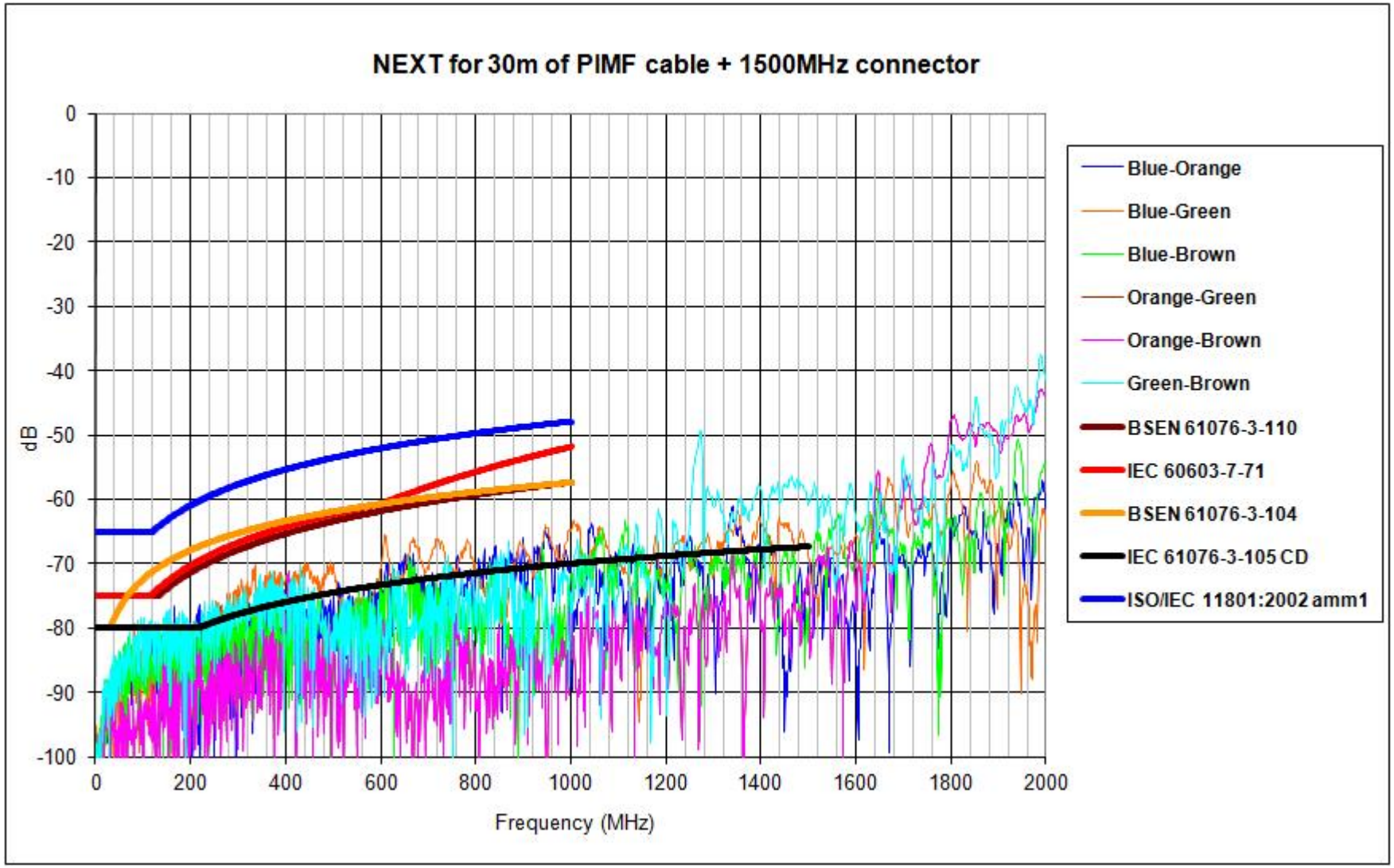
* 10dB rule

** 25dB rule

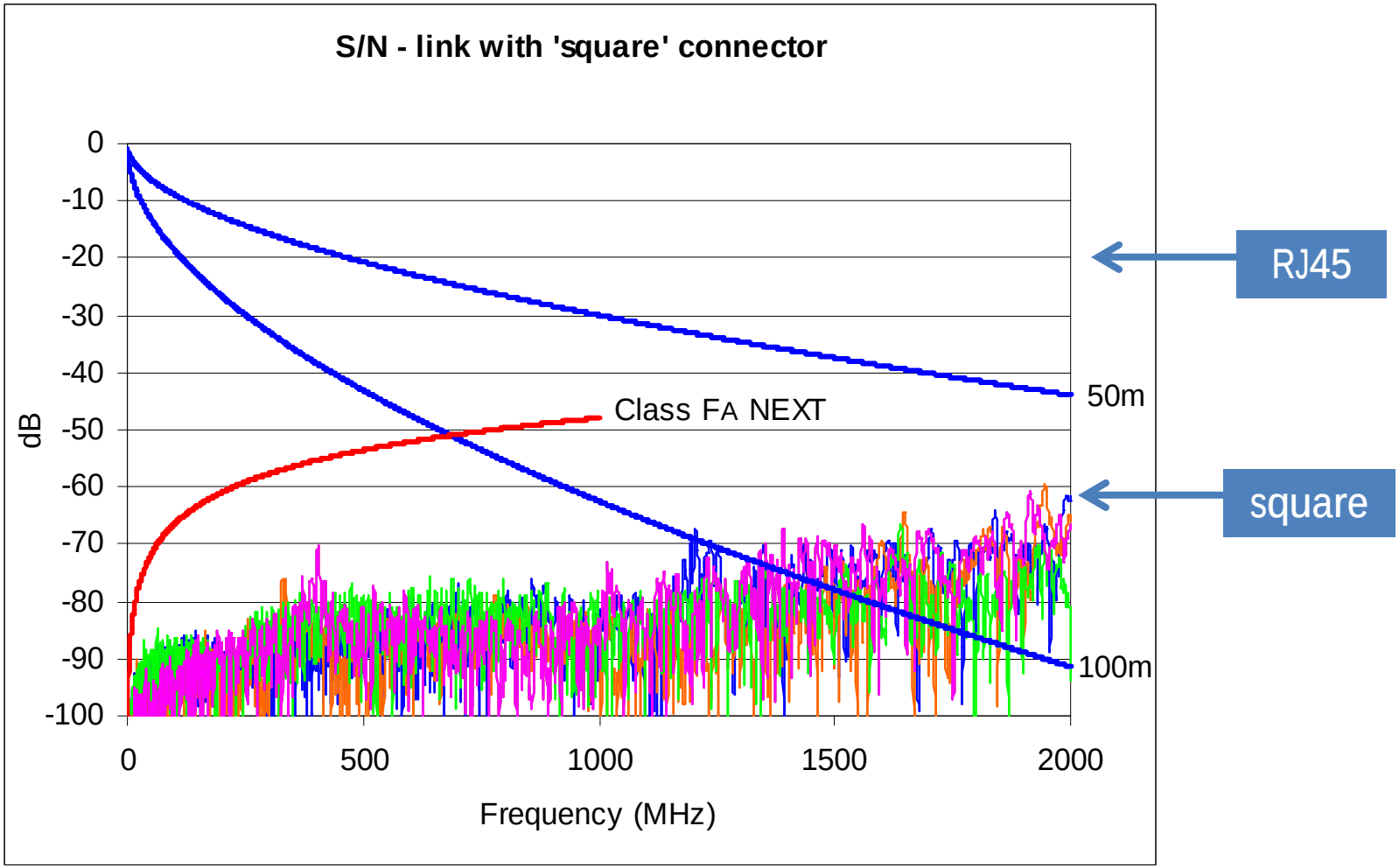
Measuring an RJ45 based channel to 2GHz



Measuring typical ‘square’ connector channels



Link Length S/N trade-off



What about testing?

Parameter	Reference testing	Installation testing
Return Loss	N	N
Insertion Loss	N	N
NEXT	N	N
ACR-F	N	N
DC unbalance	N	I
Prop delay	N	N
TCL	N	I
ELTCTL	N	I
Coupling attenuation	N	I
Alien NEXT	N	N*
AACR-F	N	N*

>>1GHz devices are not specified today

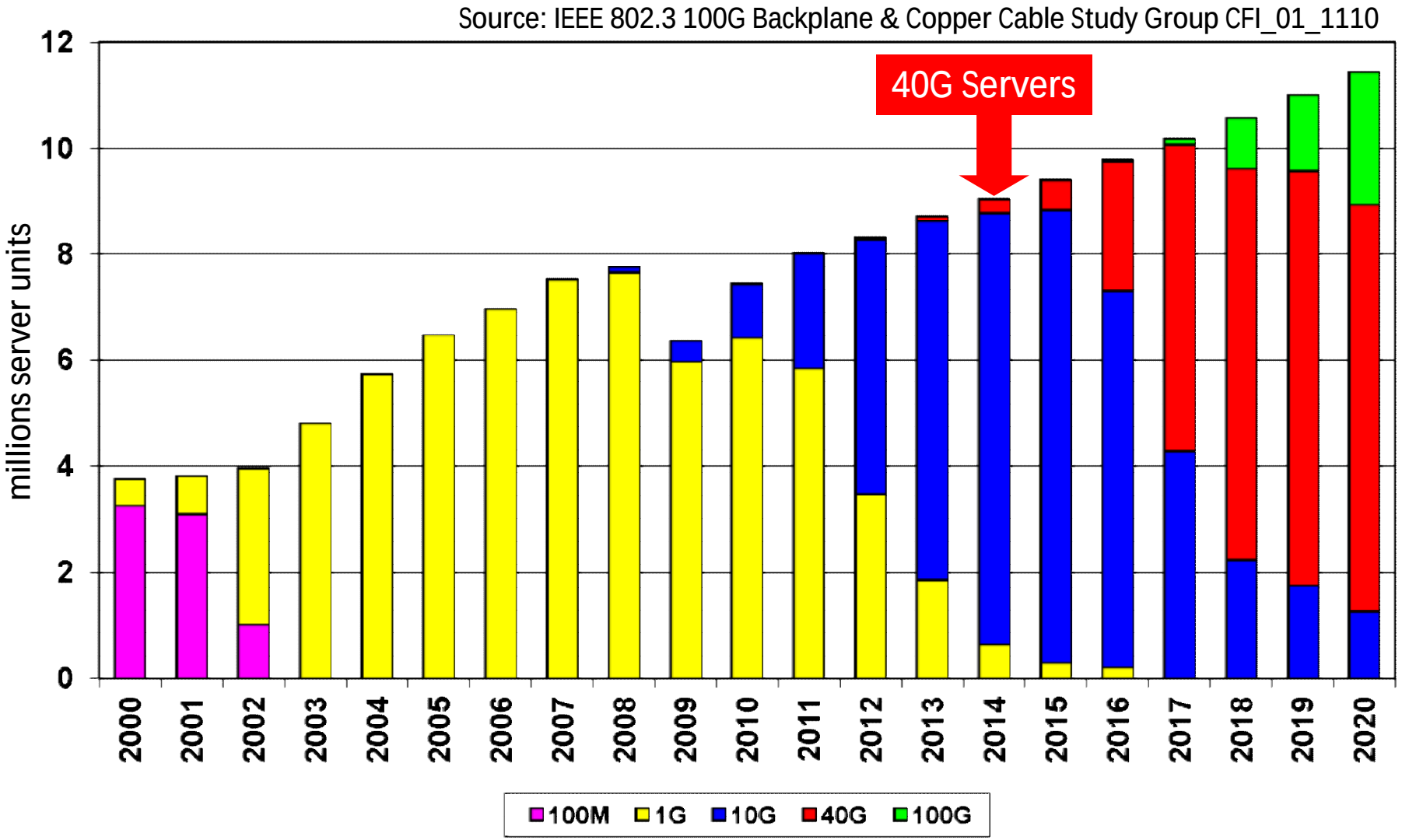
40Gbps technology

- UTP cabling
  - With standard RJ45 based connectivity – exhibits high levels of noise on the basic transmission line at higher frequencies
- Screened cabling
  - With square connectors – shows a +ve S/N ratio on the basic transmission line at higher frequencies
- Field testing
  - Is, at present, upper frequency limited for twisted pair products
- >10G technologies
  - More complex coding systems solve basic transmission line 'internal' noise issues
  - More complex coding systems may be more susceptible to external noise

The opportunity

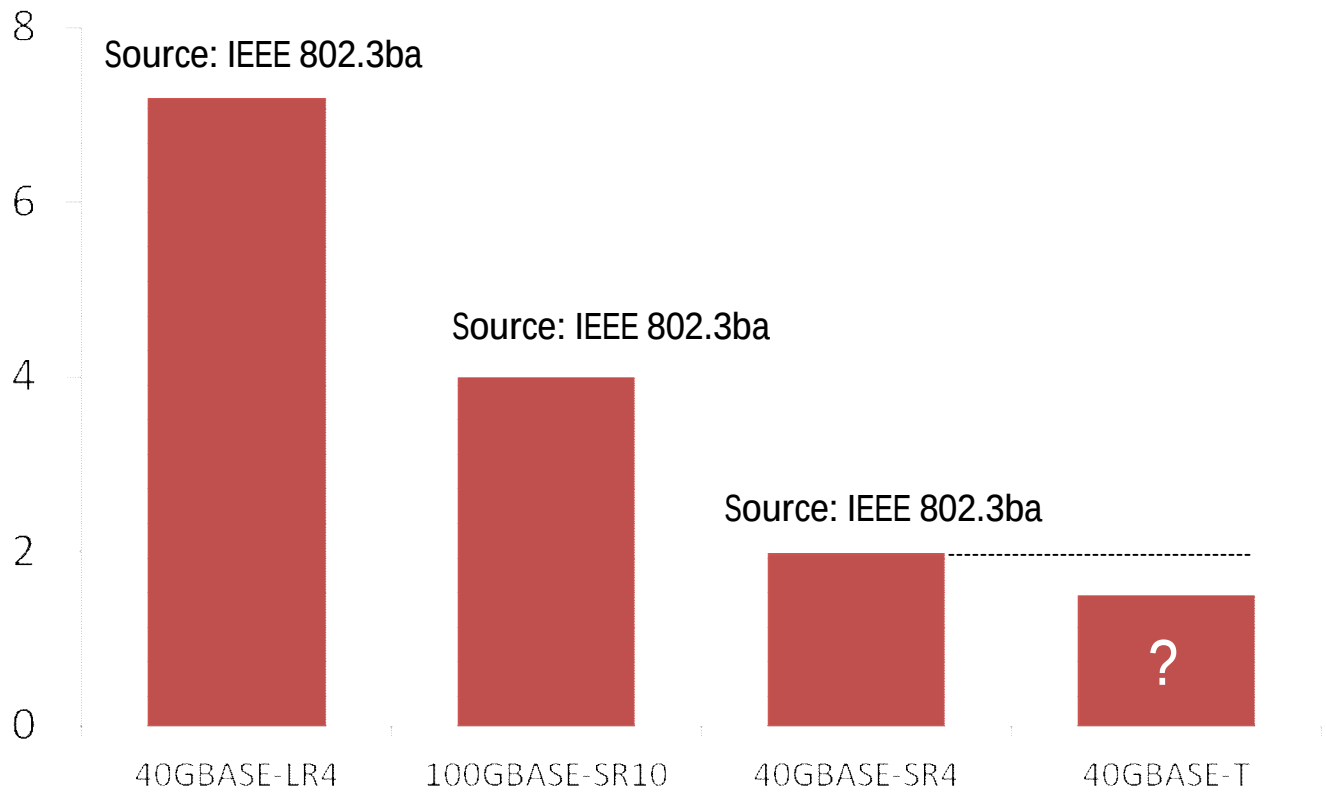
x.86 Servers by Ethernet Port Speed

Brand-Rex



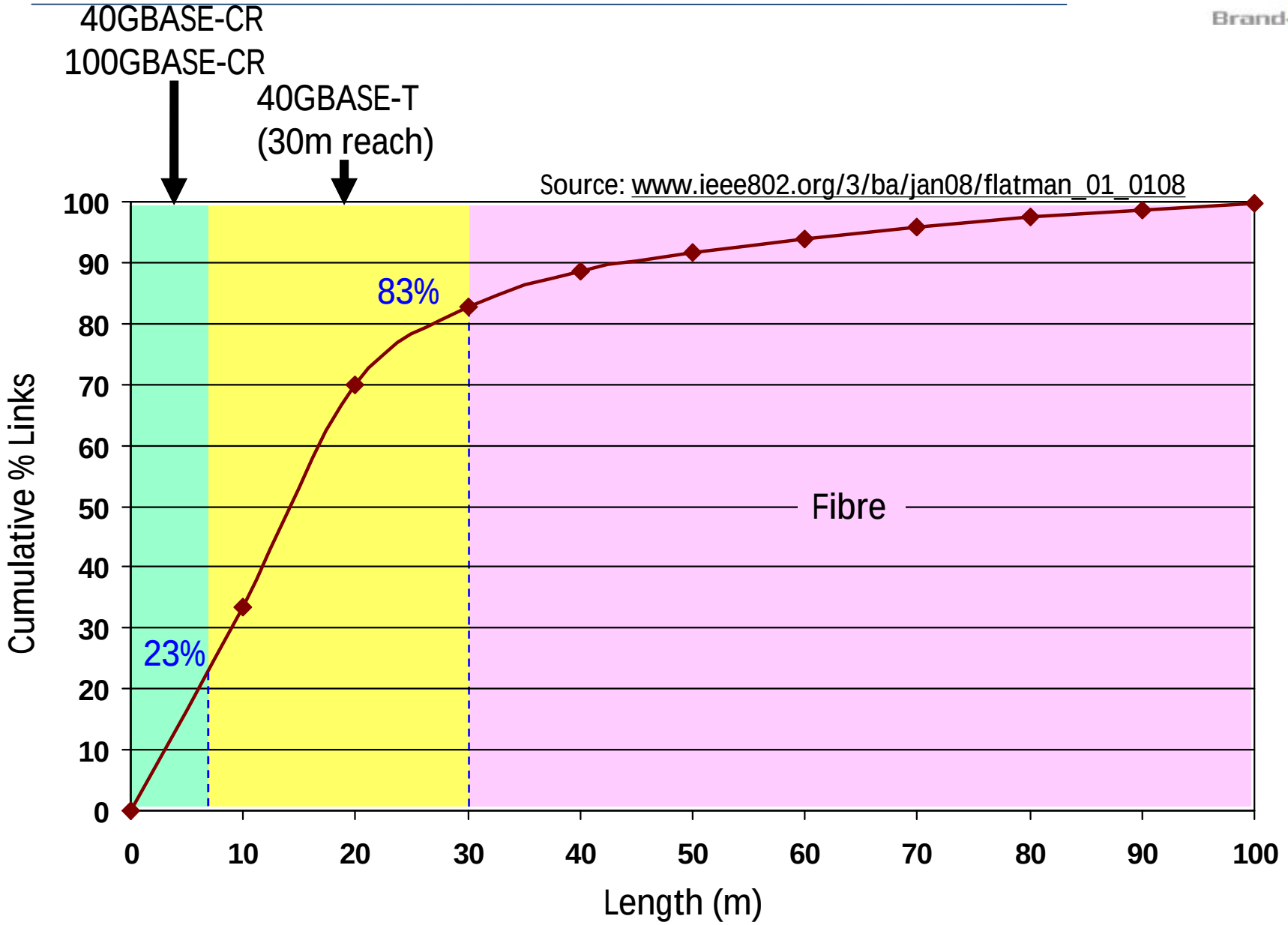
Transceiver Cost Estimates

(relative to 10GBASE-SR in 2010)

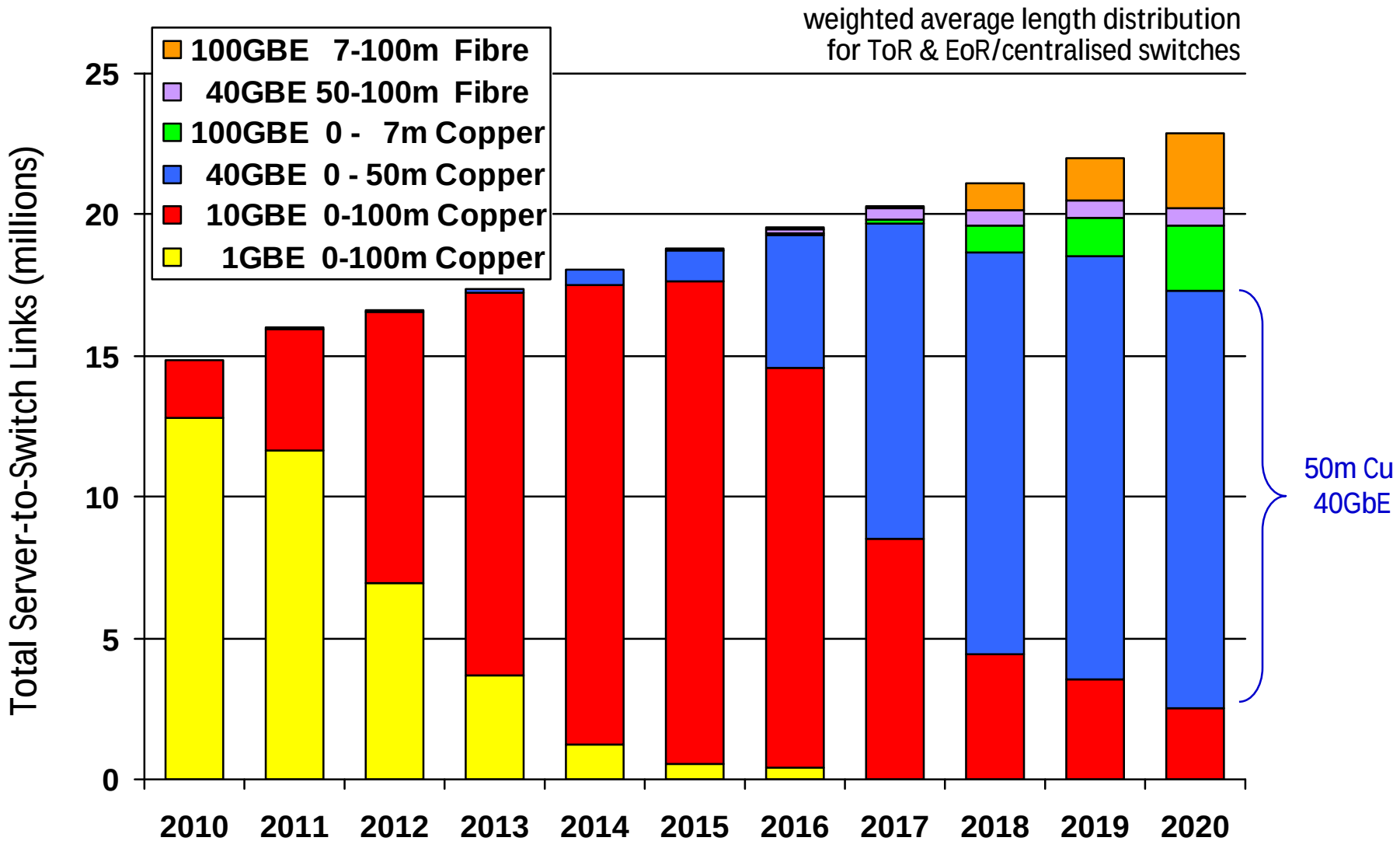


BASE-T transceivers must be cost effective

Data Centre Server-to-Switch Link Lengths for EoR/Centralised Switching



Server-to-Switch Data Centre Links based on 50m Limit for 40GBE & 100GBE



The potential solutions

Development options

	Existing Silicon	New Silicon
New Cabling	Not viable	Higher frequency Cat6A or Cat7A cabling & silicon development
Existing Cabling	Not an option	Cat7A & significant silicon development Cat6A & major innovations in silicon technology

Which cabling types will be preferred for 40Gbps or 100Gbps technologies?

Brand-Rex

UTP or Shielded?			
	OK transmission line with lowest resistance to EMI	OK transmission line with less resistance to EMI	Good transmission line but less resistance to EMI
	OK transmission line but less resistance to EMI	OK transmission line with good resistance to EMI	Good transmission line with good resistance to EMI
	OK transmission line but less resistance to EMI	OK transmission line with good resistance to EMI	Best transmission line with best resistance to EMI

40G on UTP or Shielded Copper - Reality or Myth?

- There is a logical and significant market opportunity for a 40G solution on twisted pair cabling
- Higher performance cabling offers the silicon designers certain advantages
  - Reduced complexity of electronics
  - Possibility of improved latency
- A 100m link is technically feasible
  - Shorter reach distances = reduced complexity/power/latency
  - Shorter distances will suffice for the majority of the DC market
- UTP or shielded?
  - S/FTP cabling has 25dB better NEXT than F/UTP or U/UTP solutions
  - Shielded cabling provides better protection against external interference
  - The pertinent question also includes.....RJ45 or square connector?