Origins of G.fast and its Role in future FTTH deployments

Rob F.M. van den Brink - TNO

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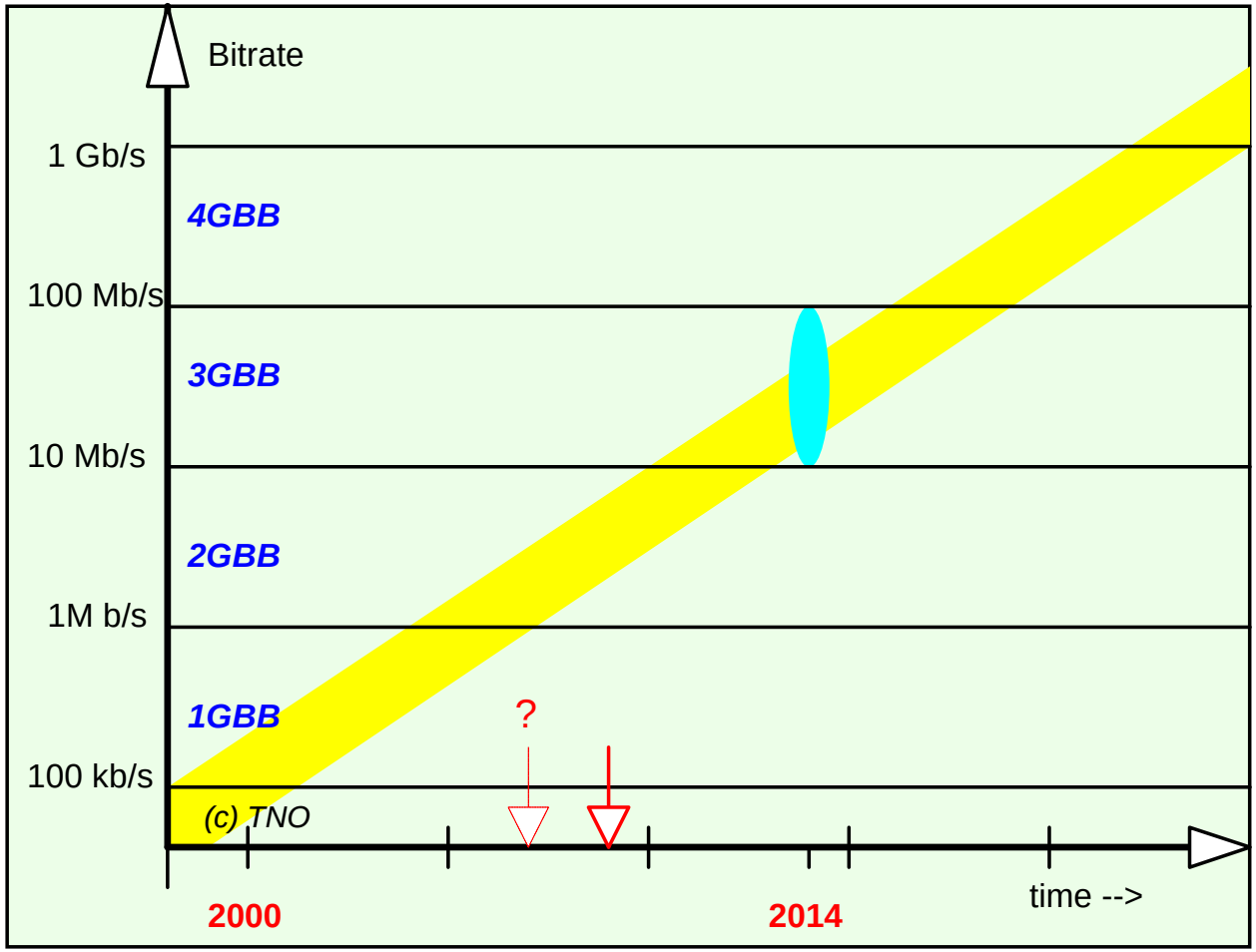
1. And suddenly there was G.fast ….. ????



Higher bitrates?

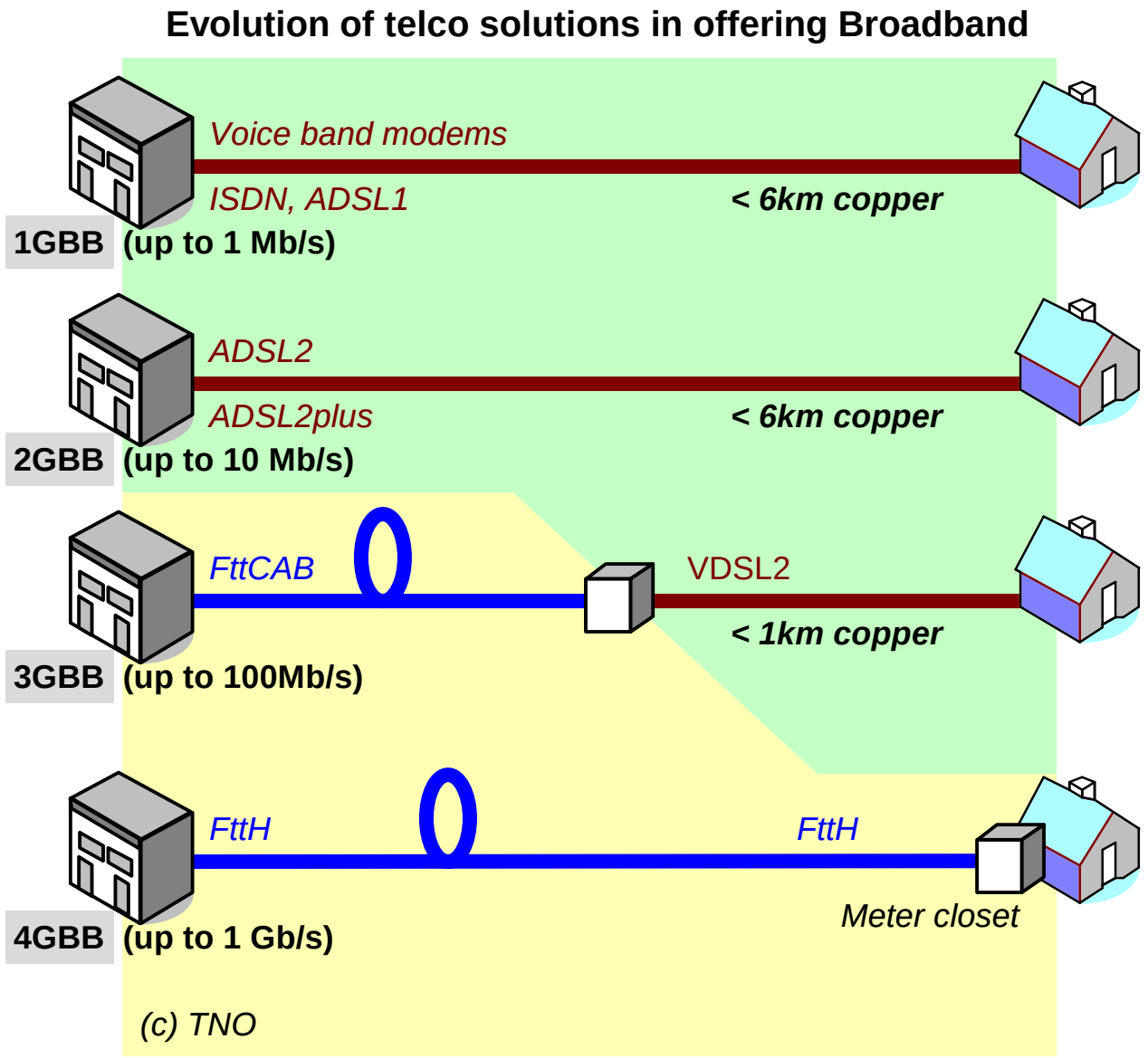
à The demand for it keeps growing

1. And suddenly there was G.fast ….. ?

2007: FP6 project MUSE, Task Force 2:

- BT, TNO, Ericsson, ULUND, …
- Discussion: What comes after VDSL?
  - VDSL: 35 Mb/s up to 800m (with vectoring!)
  - VDSL: 80 Mb/s up to 400m (with vectoring!)
  - VDSL: 125Mb/s at zero meter
  - VDSL with vectoring & Bonding: increase to190%
- Discussion: will it be (full) Fiber to the Home?

1. And suddenly there was G.fast ….. ?



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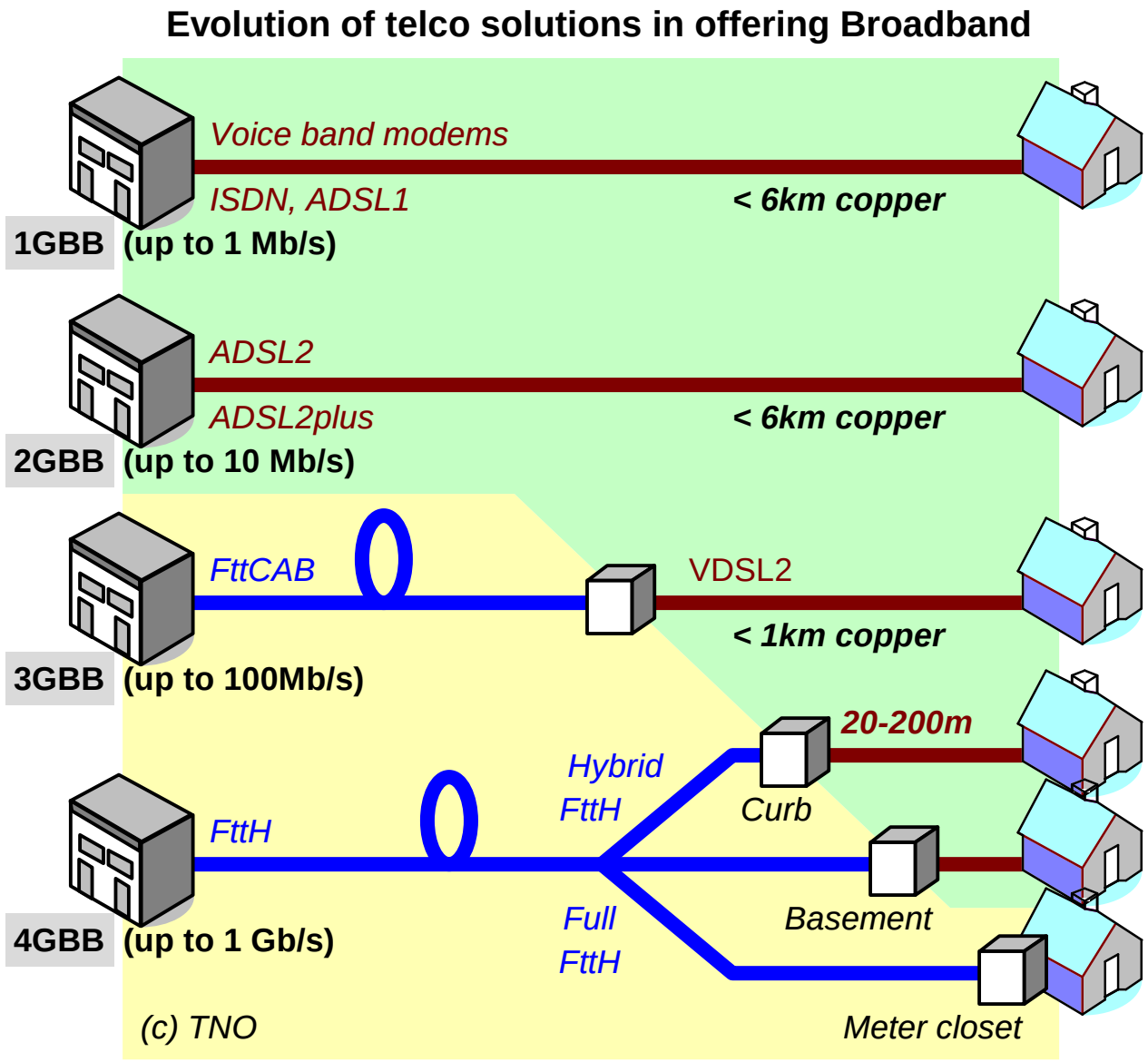

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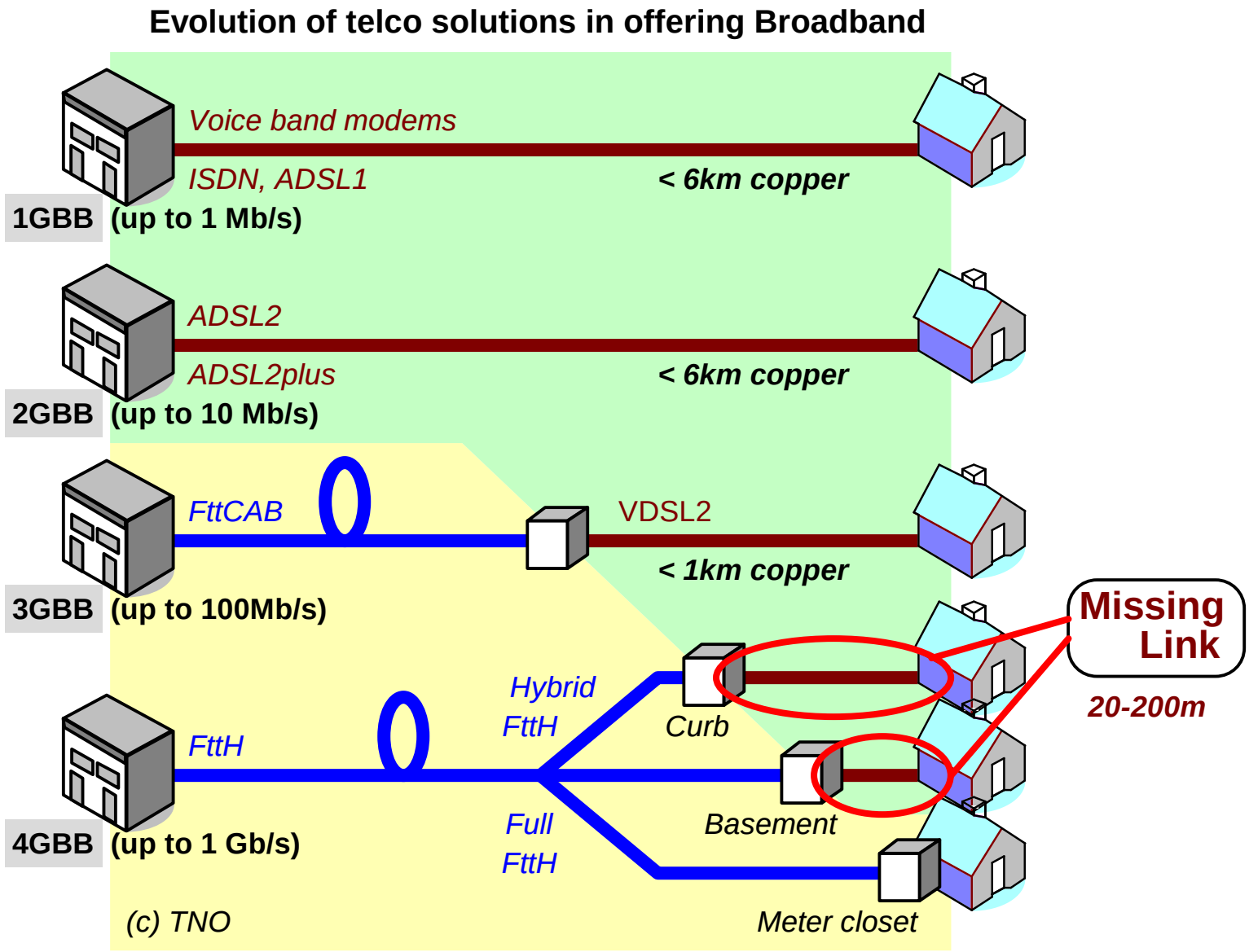


1. And suddenly there was G.fast ….. ?

2008: FP7 project proposal "Omega DSL":

- BT, TNO, Ericsson, ULUND, …
- Discussion: up to 1 Gb/s via 20-200m telephony cabling?
  - What are the techno-economic drivers for it?
  - Is it technically feasible via copper?
  - Can we transmit >100MHz via telephony wiring?
  - Can we initiate a world-wide standard for it?
  - Can we bring the industry into motion?
  - Aren't we not too late for that?
- The next generation BroadBand requires up to 1 Gb/s !!

1. And suddenly there was G.fast ….. ?

2009-2012: Celtic project "Enabling 4GBB"

4GBB everywhere

4GBB Consortium members:

BT

Telefónica Investigación y Desarrollo

&

TURK TELE KOM

TNO innovation for life

POLITÉCNICA "Ingeniamos el futuro"

LUND UNIVERSITY

ERICSSON

EURAB Elektronikutveckling i Rosvik AB

MARVELL

TELNET Redes Inteligentes

upZide

Partners participating part of the project

Actelis Networks

SIDSA

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

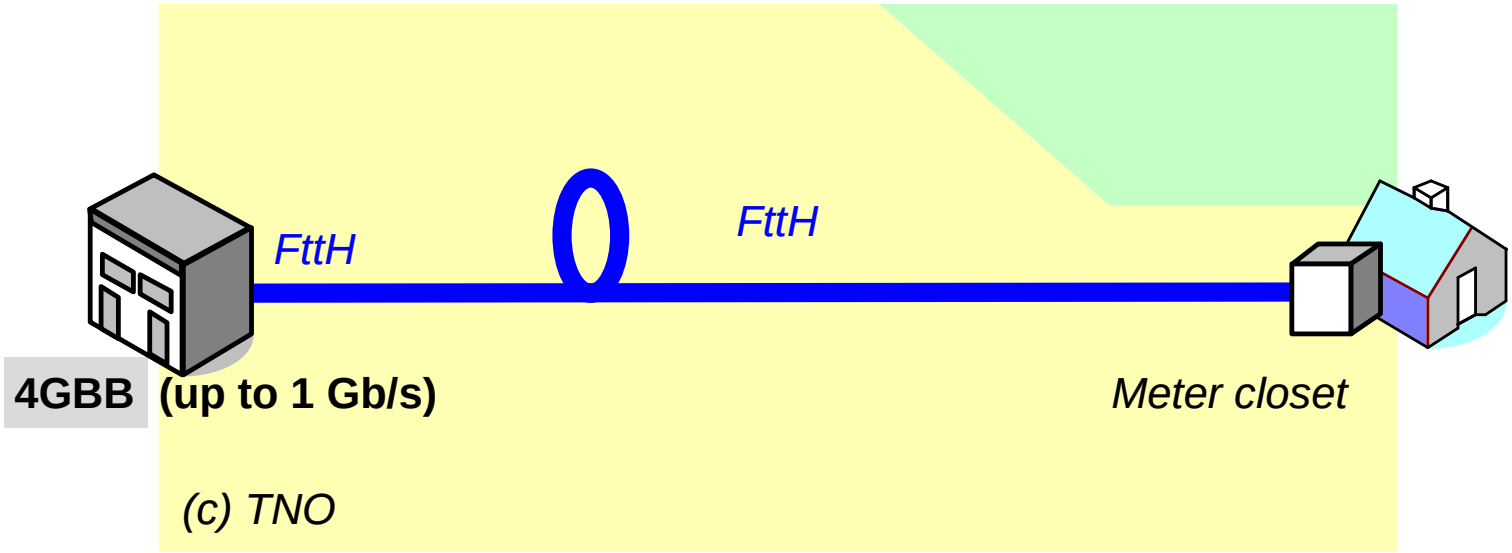
tecnalia Inspiring Business

THE UNIVERSITY OF EDINBURGH

Question in 2009

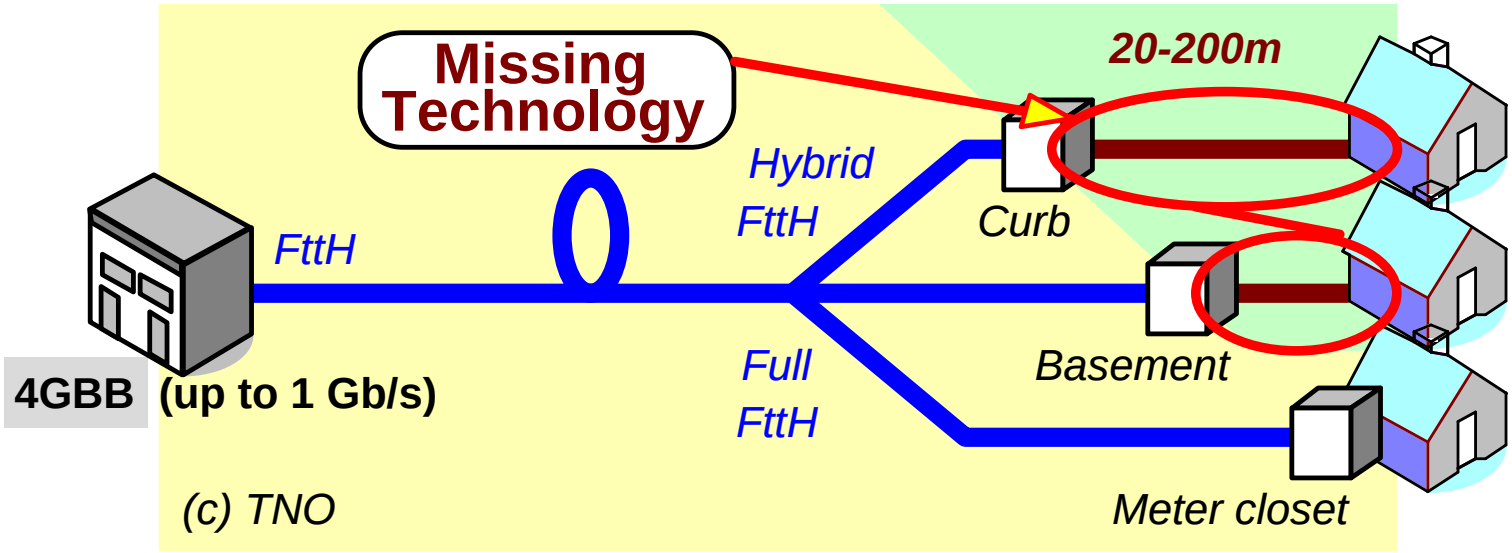
Why copper
if you can bring
1 Gb/s via fiber as well?

2. Techno-economic drivers for DSL beyond VDSL



2009: Only one flavor of FTTH available
à “into the Home”

2. Techno-economic drivers for DSL beyond VDSL



Multiple flavors of FTTH needed

à into the Home à "Full" FTTH

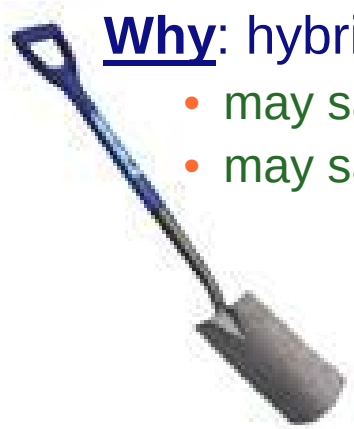
à upto the Home à "Hybrid" FTTH

2. Techno-economic drivers for Hybrid FTTH

Hybrid FTTH is complementary to Full FTTH

à into the Home à "Full" FTTH

à upto the Home à "Hybrid" FTTH



Why: hybrid has possible techno-economic advantages

- may save costs for digging/installation when copper can be reused
- may save installation time, so faster roll-out

2. Techno-economic drivers for Hybrid FTTH

Digging and drilling:

- **Too expensive**
- **Not allowed in historical areas**
- **Inconvenient in shopping area**

2. Techno-economic drivers for Hybrid FTTH

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2. Techno-economic drivers for Hybrid FTTH

Digging and drilling:

- **Too expensive**
- **Not allowed in historical areas**
- **Inconvenient in shopping area**

Hybrid FTTH (with G.Fast) brings opportunities

- **Less digging and drilling**
- **Shortens installation time**
- **Does not disturb customers**
- **Allows for self-install in premises (No appointment needed)**
- **Postpones huge investment**

Cost effective compared to Full FTTH!

2. Techno-economic drivers for Hybrid FTTH

Example use case #1 – Dense areas

Quick-win

Hybrid FTTH reduces the amount of digging / drilling

- Digging in historic city centers is a problem
- Digging in busy shopping streets is a problem

2. Techno-economic drivers for Hybrid FTTH

Example use case #1 – Dense areas

Quick-win

Hybrid FTTH reduces the amount of digging / drilling

Tomorrow: TNO presentation on Amsterdam case study !

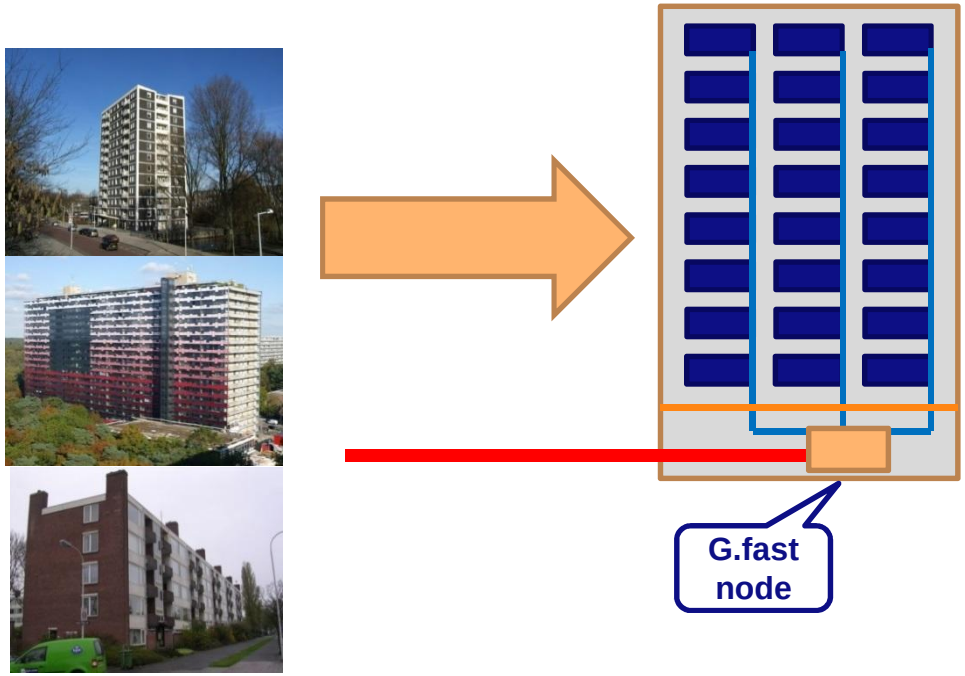
- Digging in historic city centers is a problem
- Digging in busy shopping streets is a problem

2. Techno-economic drivers for Hybrid FTTH

Example use case #2 – High rise buildings

Quick-win

In the past considered as the ideal ***Full*** FTTH scenario



- Full FTTH in practice far more complicated then aimed
- Drilling in floors of all stacked meter closets, all in one day!
- “Not in my Home” and “Not at Home” problems

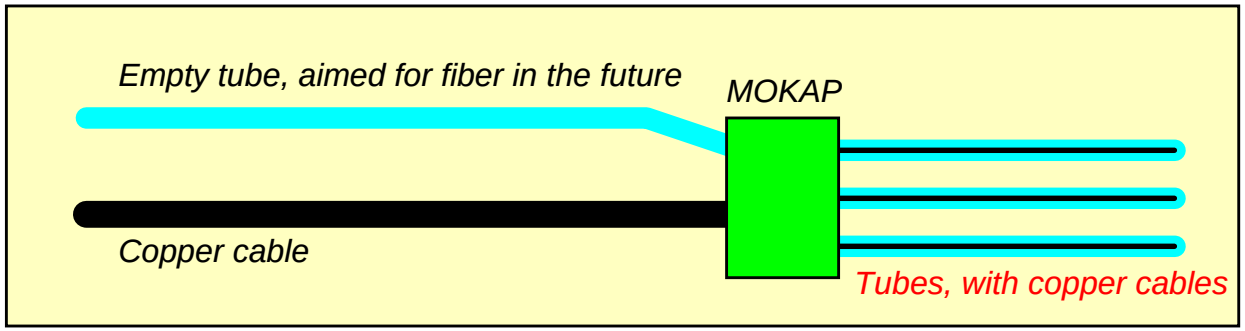
2. Techno-economic drivers for Hybrid FTTH

Example use case #3 – “Flashnet”

Quick-win

“Flashnet” was aimed at the ideal ***Full*** FTTH scenario

Roughly 300 000 connections scattered all over the Netherlands



- Aimed for replacing copper by fiber in the future
- But in practice it does not work that easy

2. Techno-economic drivers for Hybrid FTTH

Example use case ##– many others (country specific)

- **From street poles** (BT)
- **Single Fiber extension** (Orange)
- **Mobile back hauling** (Ericsson)
- etc

Expected deployment strategy:

- A mix between Hybrid and Full FTTH
- Use ***Hybrid*** FTTH where attractive
- Otherwise stay with VDSL, migrate to Full FTTH or skip

broadband forum

Various operators communicated their use-cases in BBF

BT

swisscom

orange

france telecom

TELECOM ITALIA

Deutsche Telekom

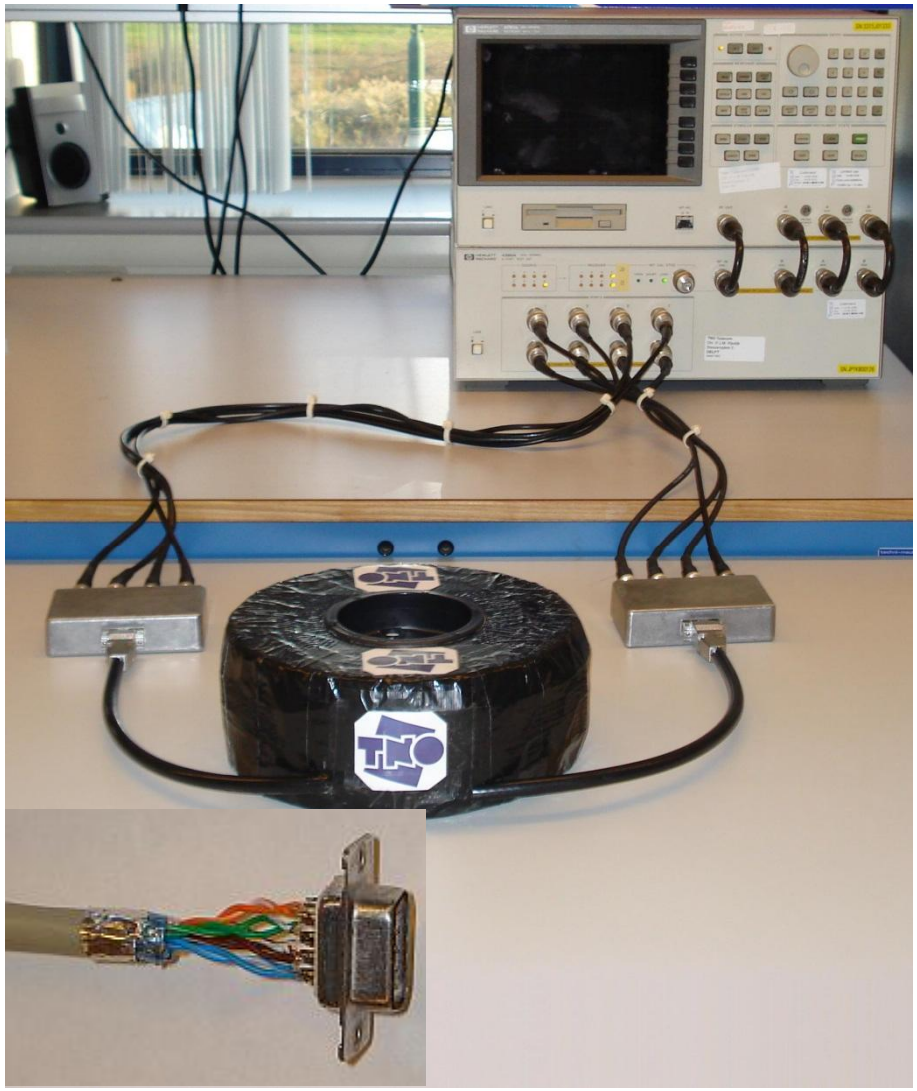
at&t

中国电信 CHINA TELECOM

Question in 2009

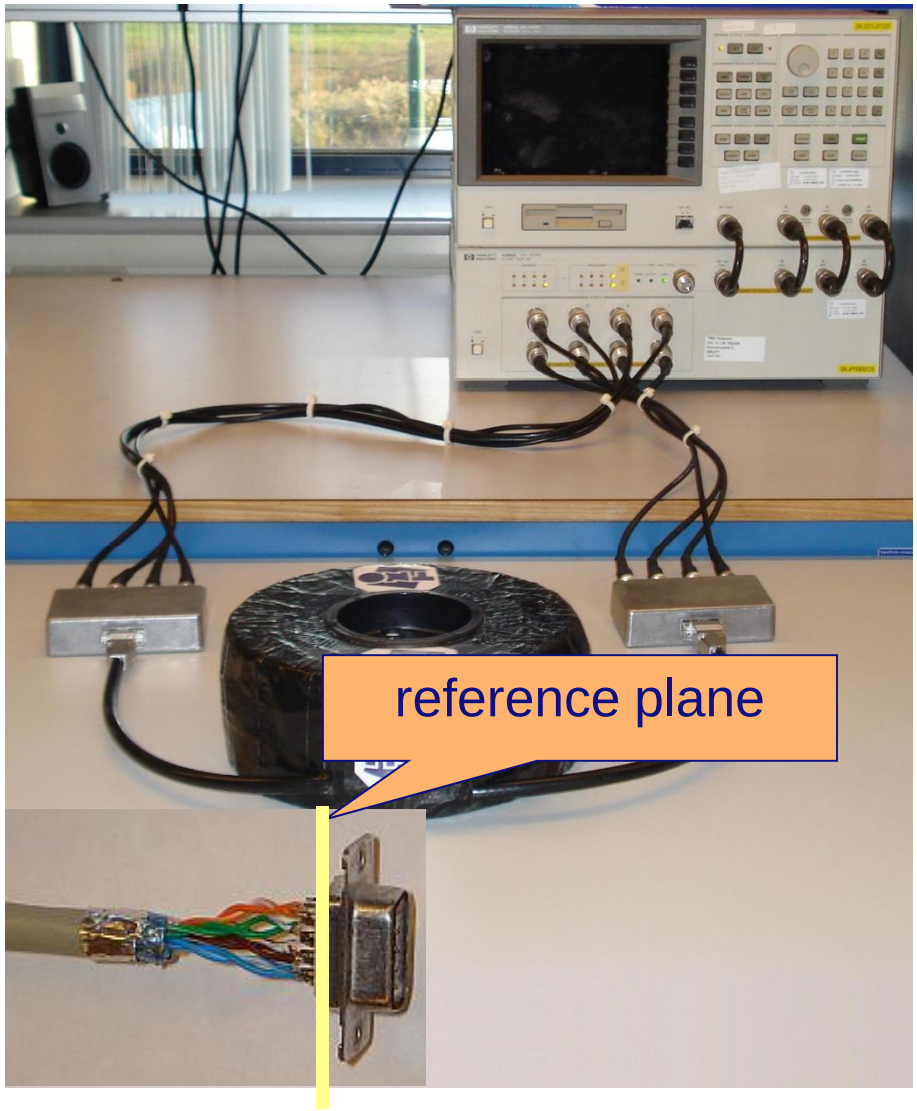
Can we transport
up to 1 Gb/s
via telephony wiring?

3. Multiport cable measurement setup, up to 500 MHz



Measurement setup

3. Multiport cable measurement setup, up to 500 MHz

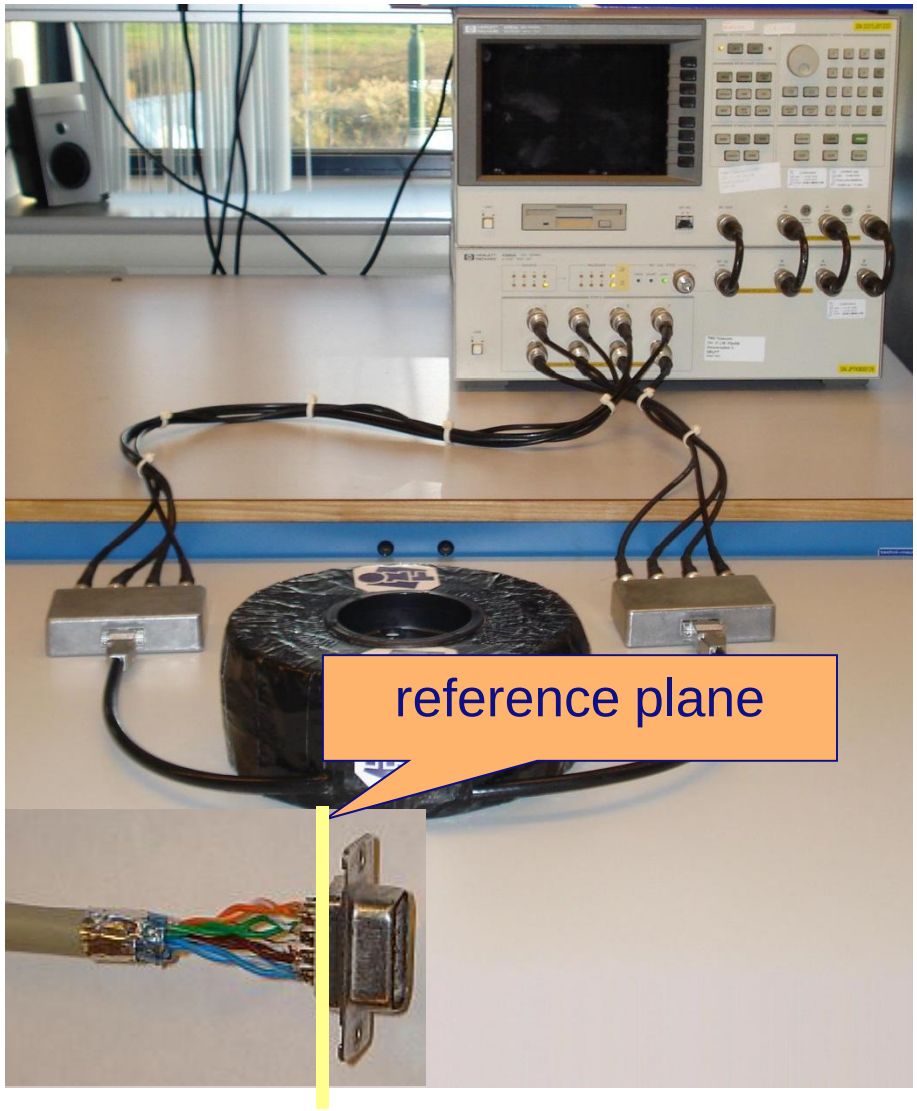


Measurement setup

Key problem:

Instrument does not measure what I would like to know!

3. Multiport cable measurement setup, up to 500 MHz



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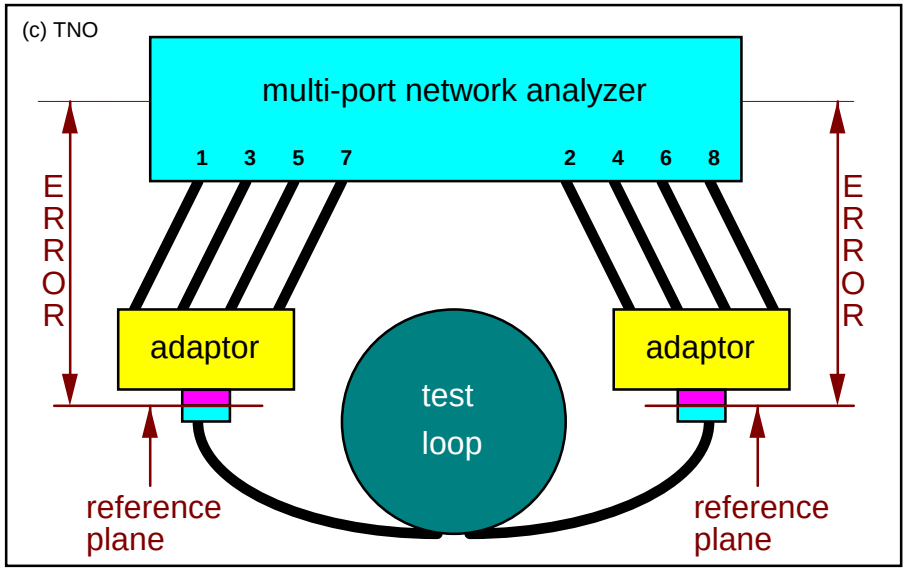
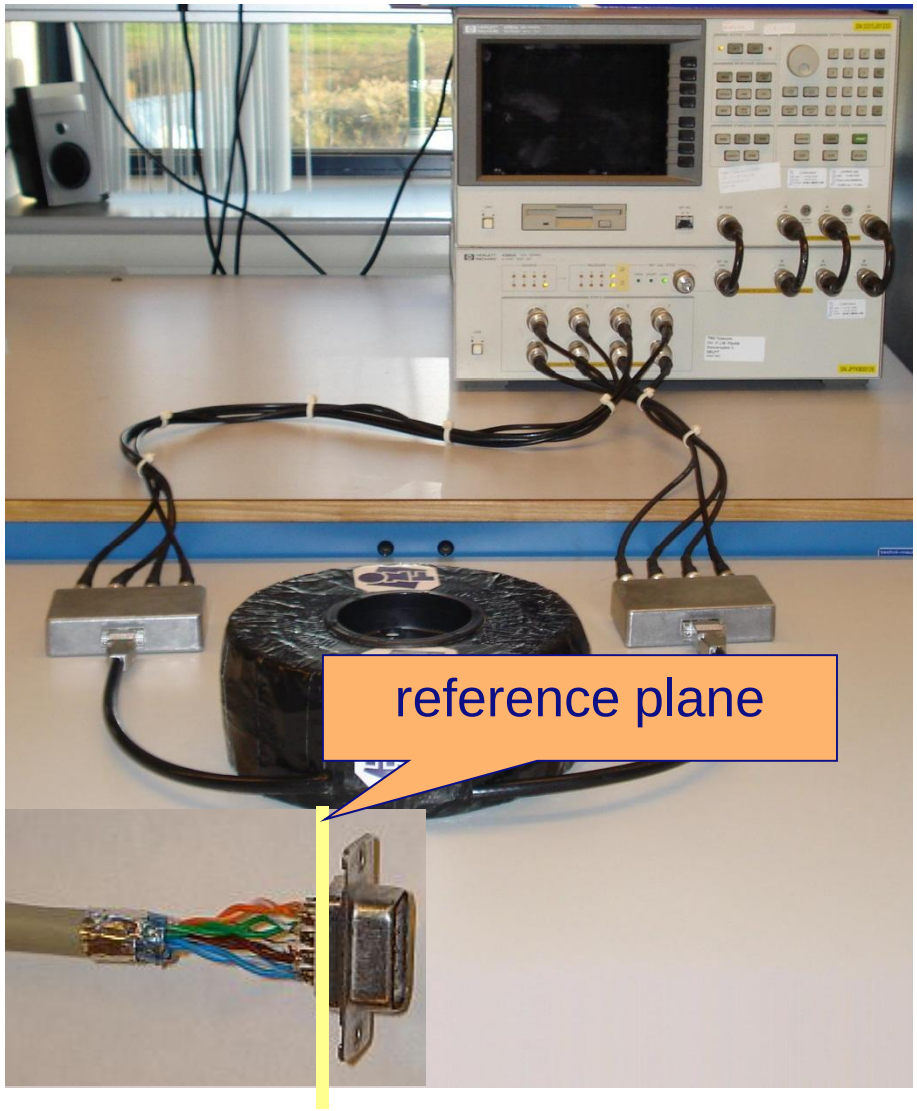
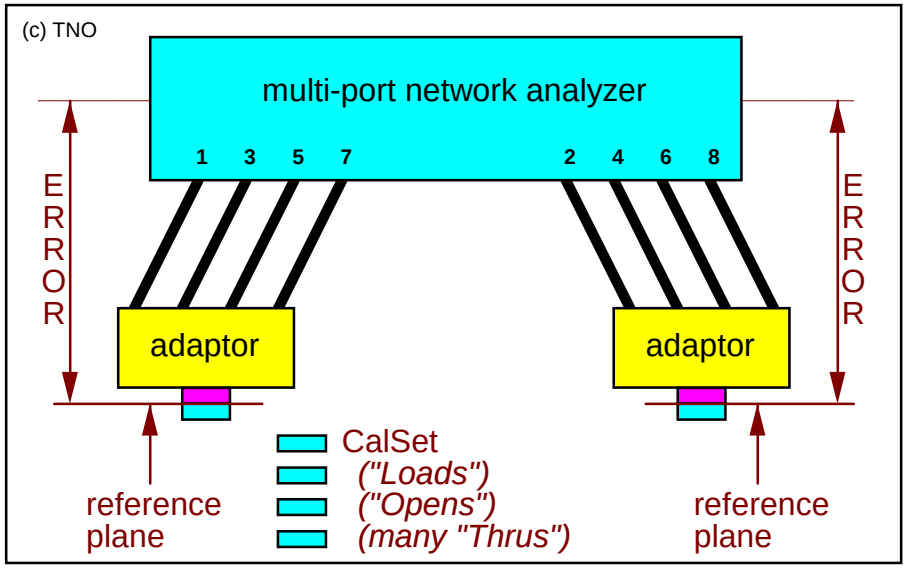


schematic diagram

3. Multiport cable measurement setup, up to 500 MHz



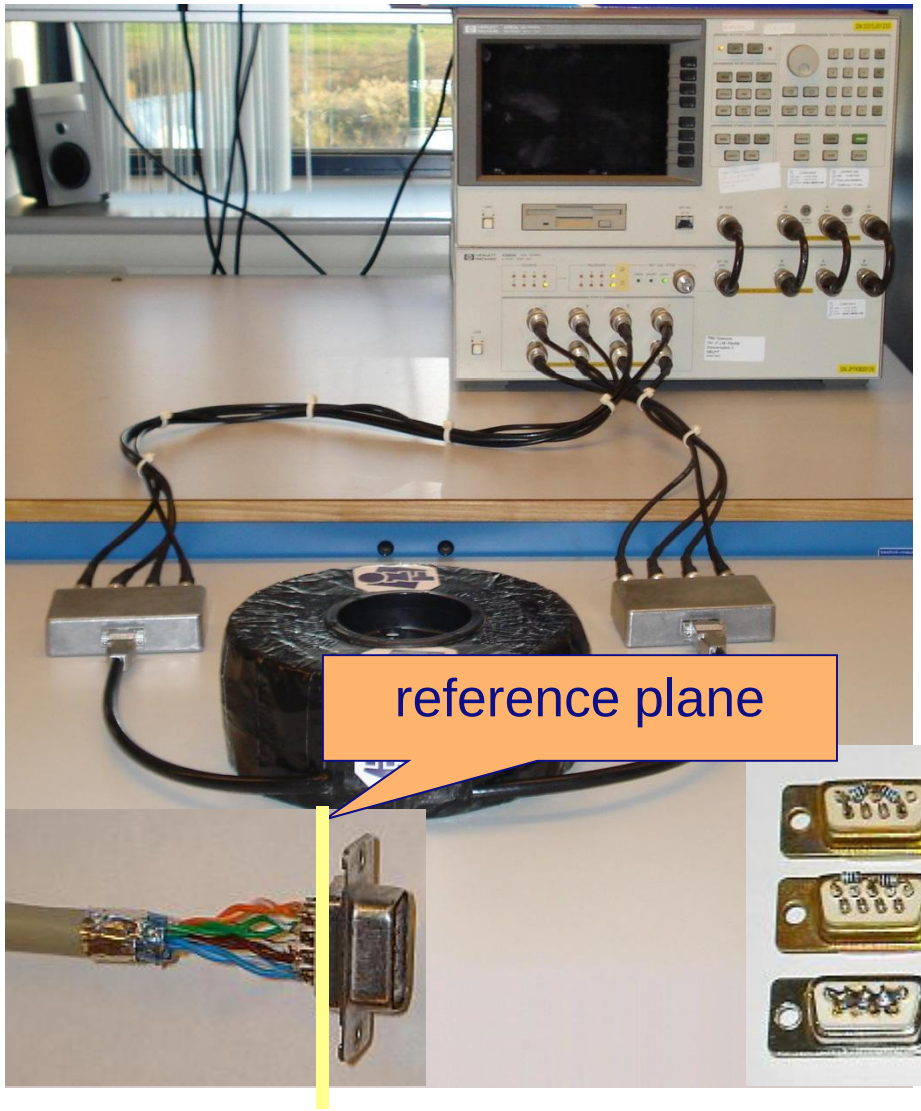
Measurement setup

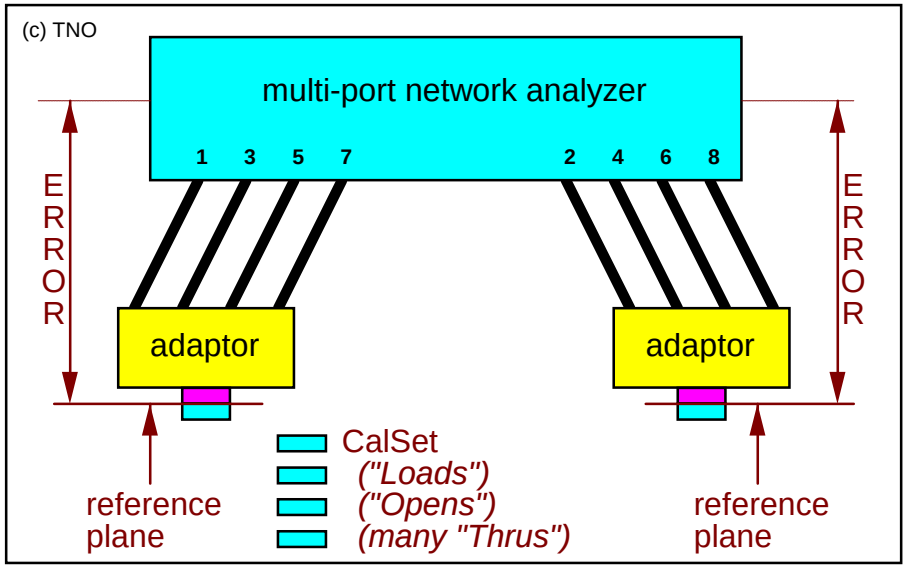


use known networks to measure the errors, and to correct for it via software post-processing …

solve 140 equations
to find 48 unknown
(for each frequency)

3. Multiport cable measurement setup, up to 500 MHz



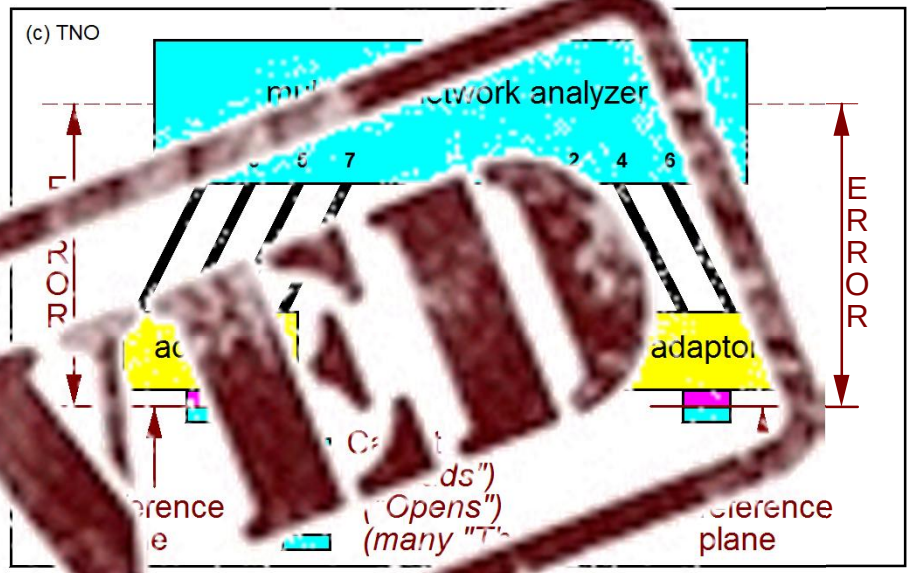


use known networks ….

Measurement setup

calibration set, for error correction

3. Multiport cable measurement setup, up to 500 MHz



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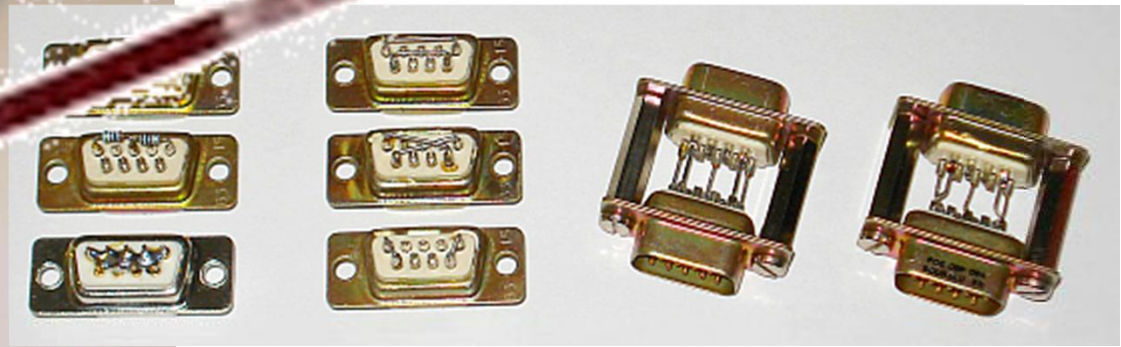
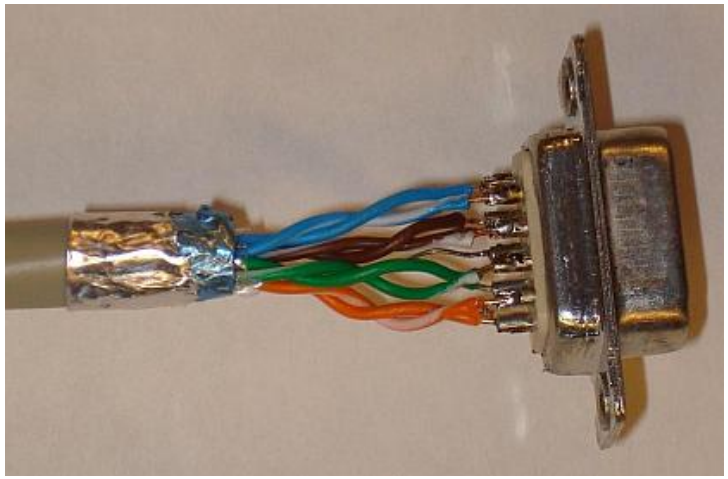


Measurement setup

calibration set, for error correction

4. Characterizing the copper environment

- CAT5-quality
- 4 twisted-pairs
- shielded
- intended for Gb Ethernet networks



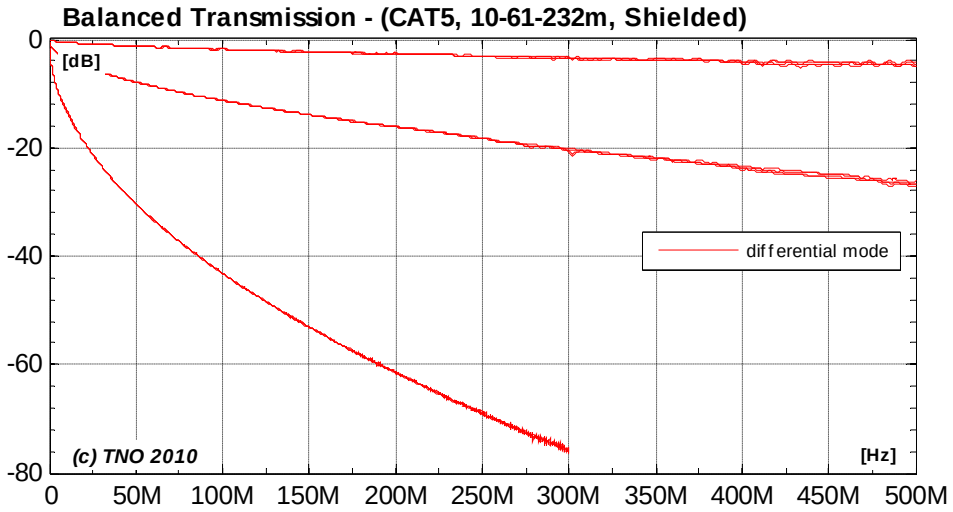
232m, CAT5, 4 twisted-pairs

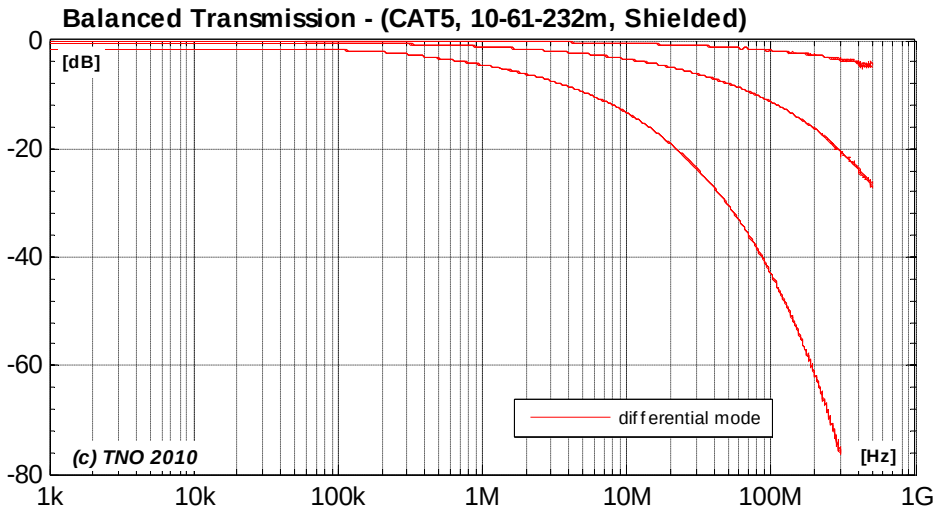
61m, CAT5, 4 twisted-pairs

4. Characterizing the copper environment

Balanced Transmission:

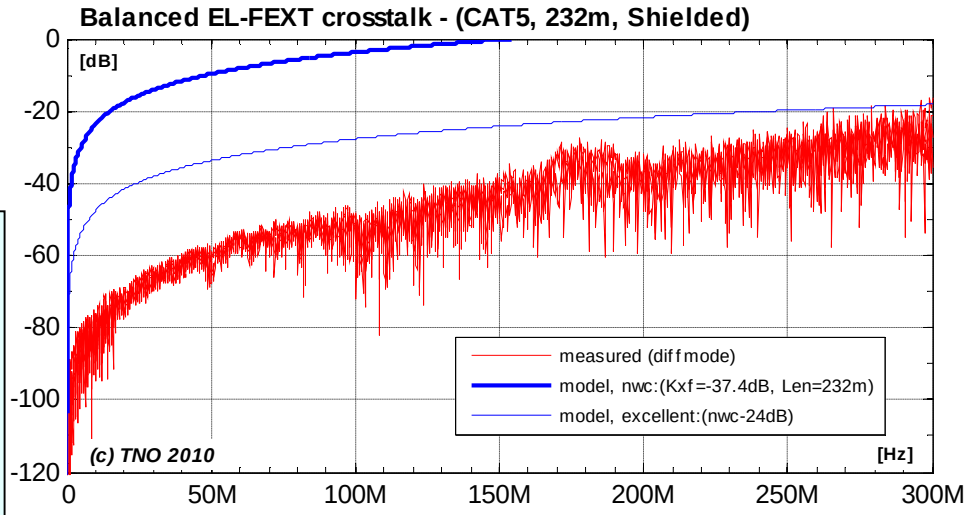
5.7 dB / 100m @ 10MHz
18.6 dB / 100m @ 100MHz





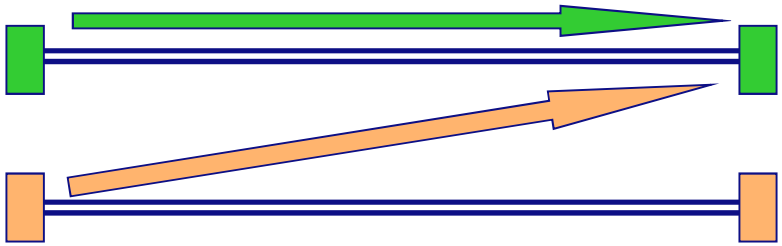
4. Characterizing the copper environment

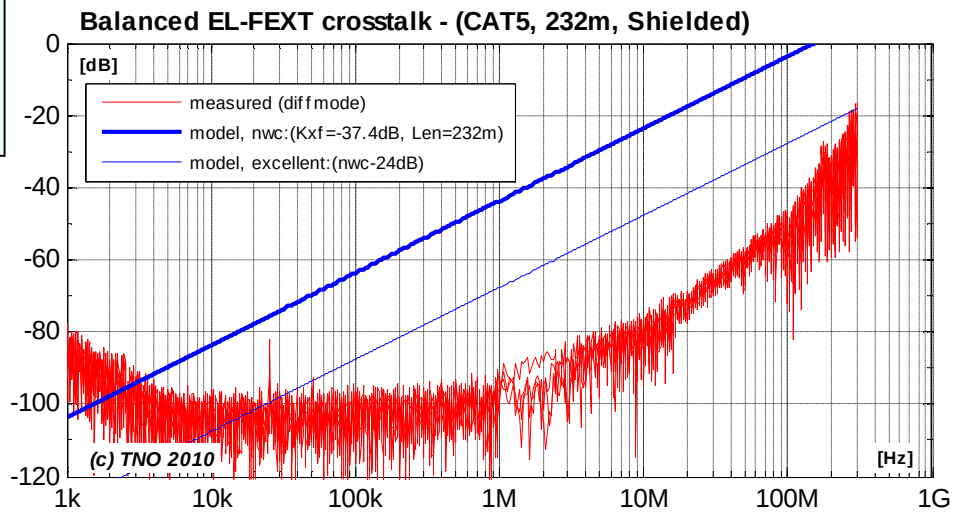
Balanced EL-FEXT Crosstalk:
much better then “excellent”



Theoretical bitrates (in 2010):
use of VDSL2, 30 MHz spectra:
use of 2 bonded pairs (“quads”)
use of classic simulation models
- 50m **à** >500 Mb/s
- 200m **à** >460 Mb/s

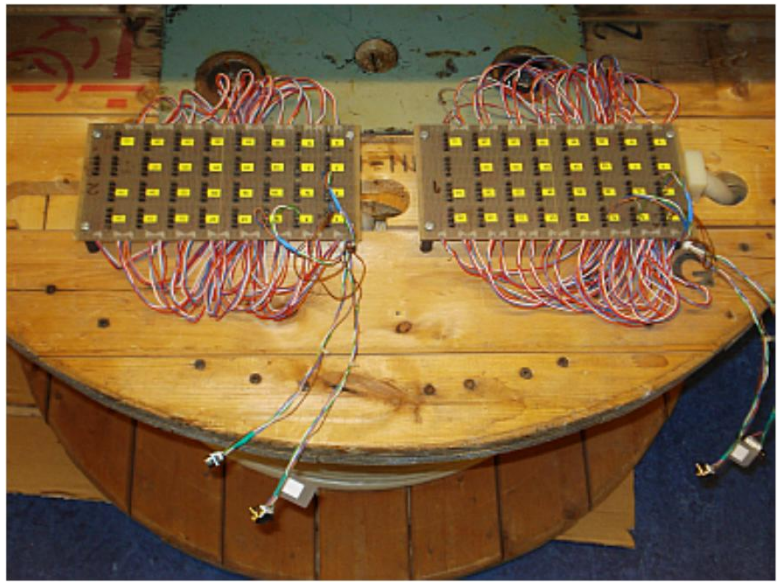
more with dedicated DSL / G.hn



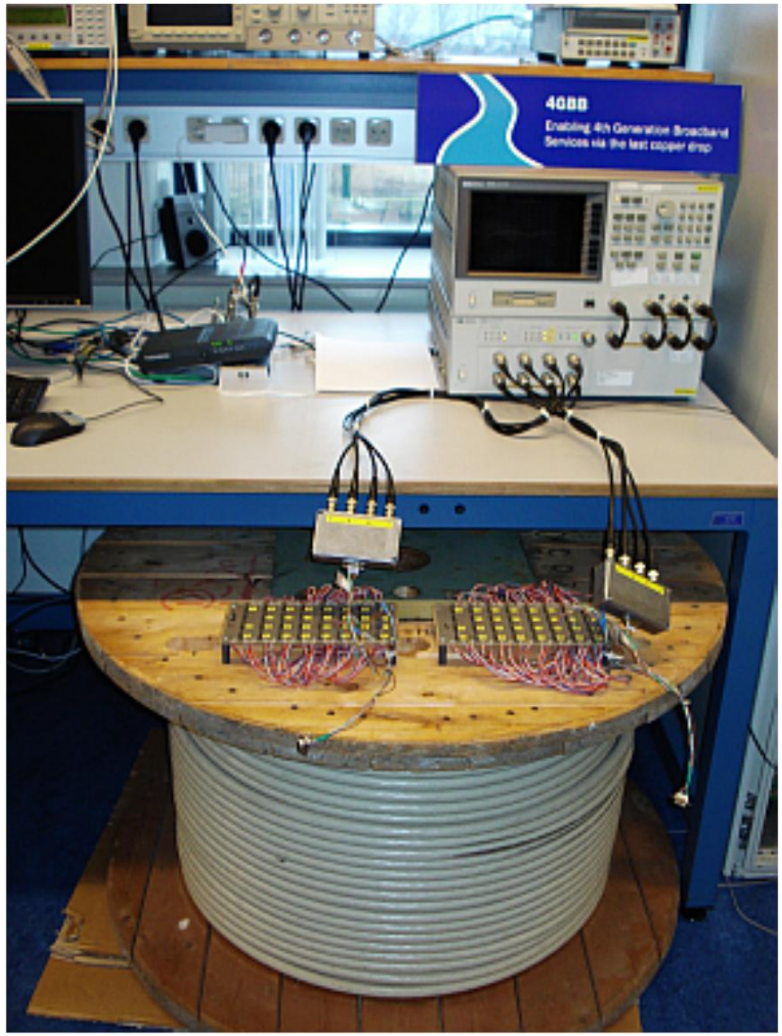


4. Characterizing the copper environment

- 30 twisted-quads (2×2 pair)
- shielded
- telephony wiring for buildings



interconnection with measurement setup

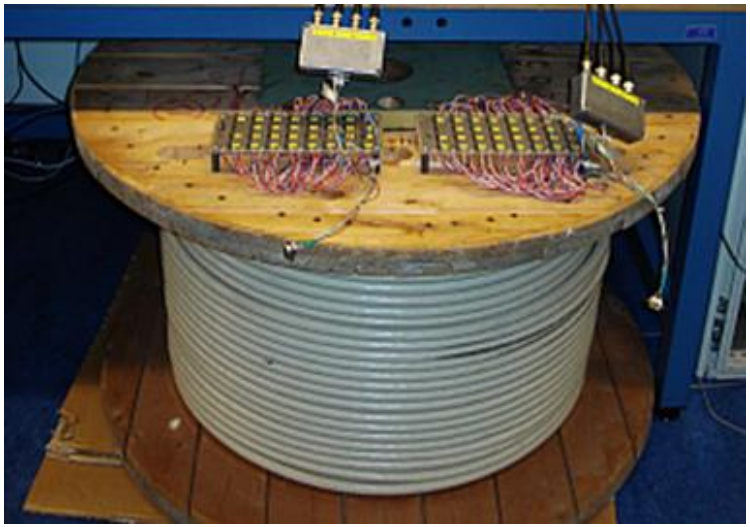


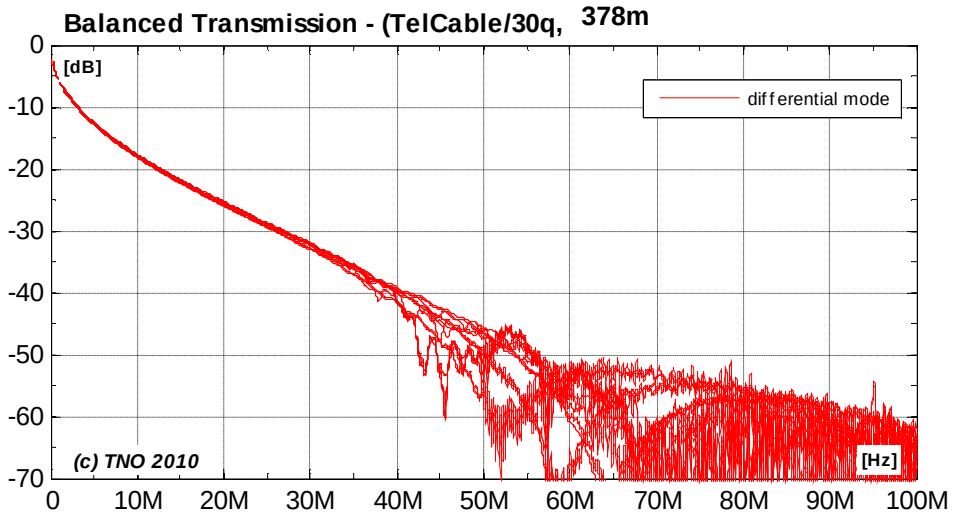
525m on a drum

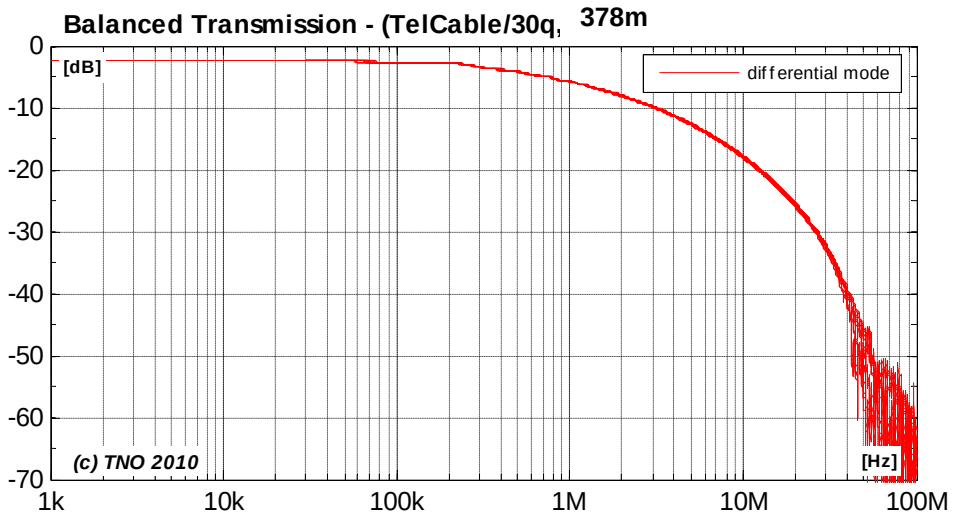
4. Characterizing the copper environment

Balanced Transmission:

3.5 dB / 100m @ 10MHz
13 dB / 100m @ 100MHz

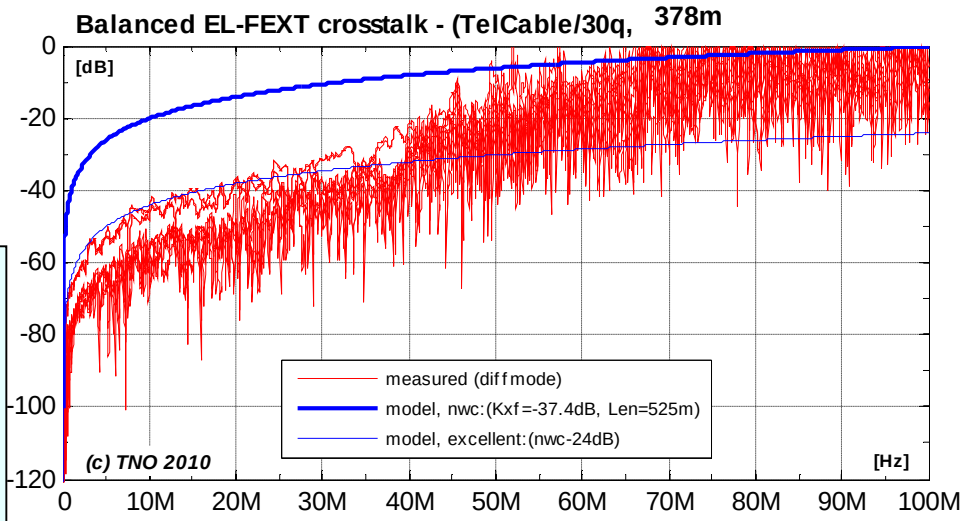






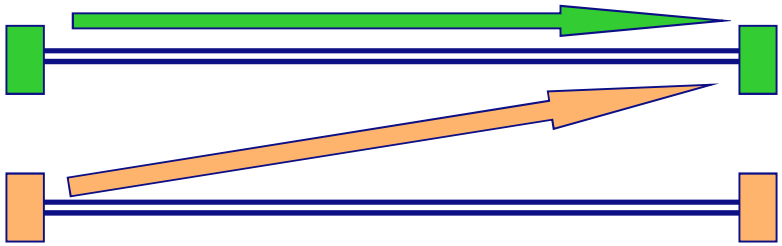
4. Characterizing the copper environment

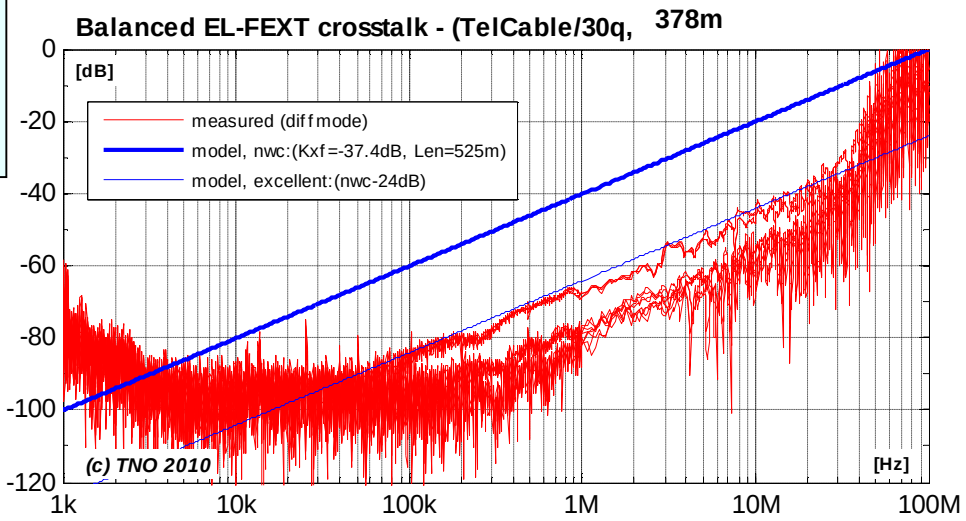
Balanced EL-FEXT Crosstalk:
"excellent" quality



2010 thoughts on bitrates:
use of VDSL2, 30 MHz spectra:
use of 2 bonded pairs ("quads")
use of classic simulation models
- 50m **à** >350 Mb/s
- 200m **à** >280 Mb/s

more with dedicated DSL / G.hn





4. Characterizing the copper environment

- fully untwisted
- fully undefined “telephony wiring”
- unshielded
- found in consumer shop “GAMMA”
- 25m

gamma

Lammenschansweg 130
2321 JX LEIDEN
+31 71 5315147

Klantenkaart: 2611008608819

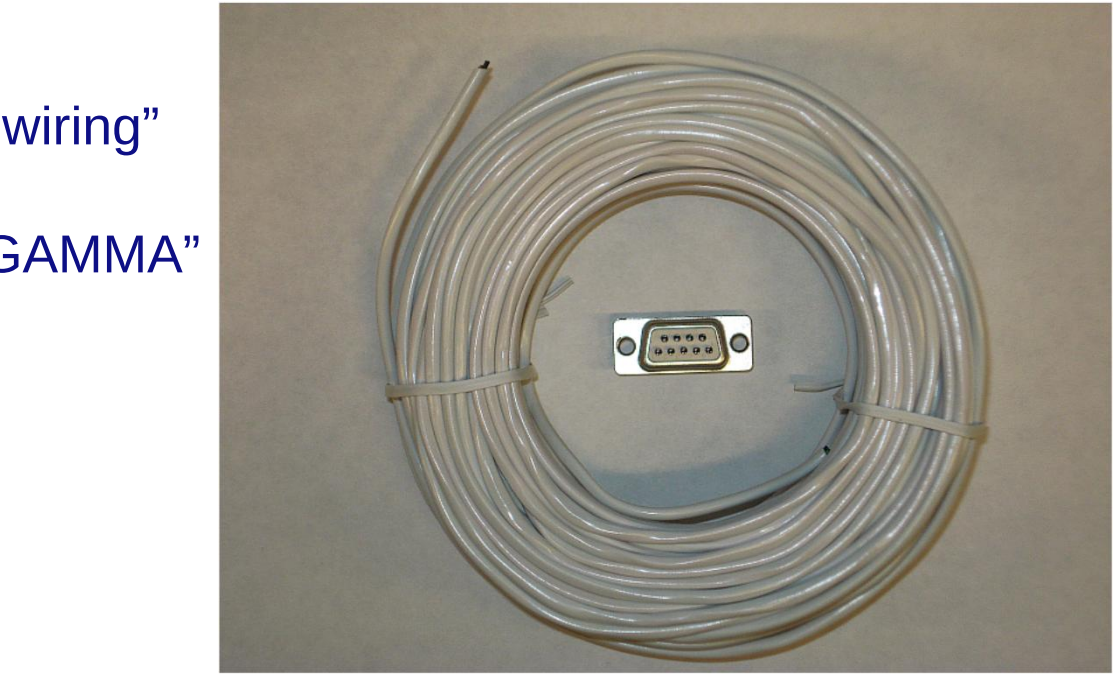
AANT	OMSCHRIJVING		PRIJS	BEDRAG	BTW
1	HOEK ALUMINIUM	25X25X2MM 1M	4,79	4,79	1
4	TELEFOONDRAAD ROND	4X0,5MM 25M	5,99	23,96	1
1	GAMMA BIG SHOPPER		1,00	1,00	1
1	BERKEN MULTIPLEX	15MM 122X61CM	18,49	18,49	1

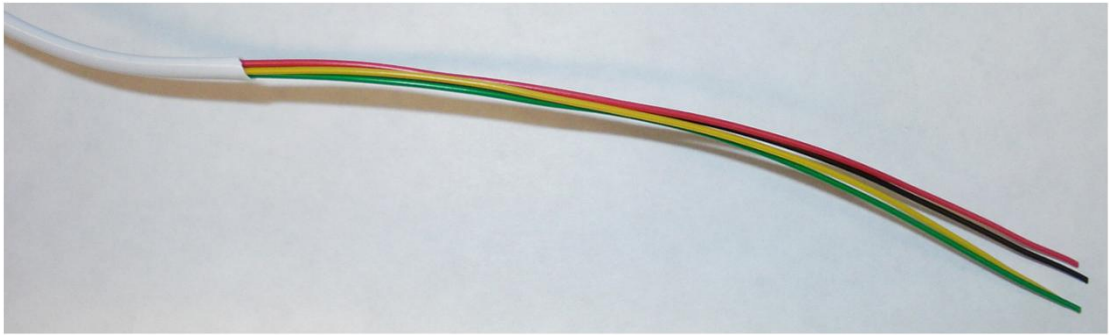
7 Totaal 48,24
Pin 48,24

BETAALAUTOMAAT
Datum 27/01/10 Tijd 16:09:23
Kassanr YM8106 Referentie 01091441

Totaal 48,24 EUR

Tlv 0315638842
BANK Bet kenmerk 027AUT
Acquirer identifier: 67300110
U HEEFT BETAALD
TOT ZIENS



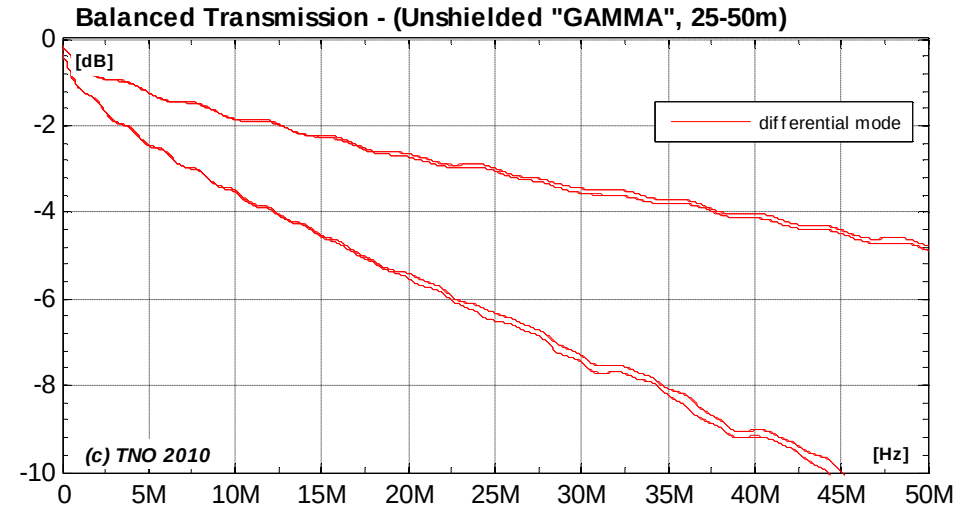


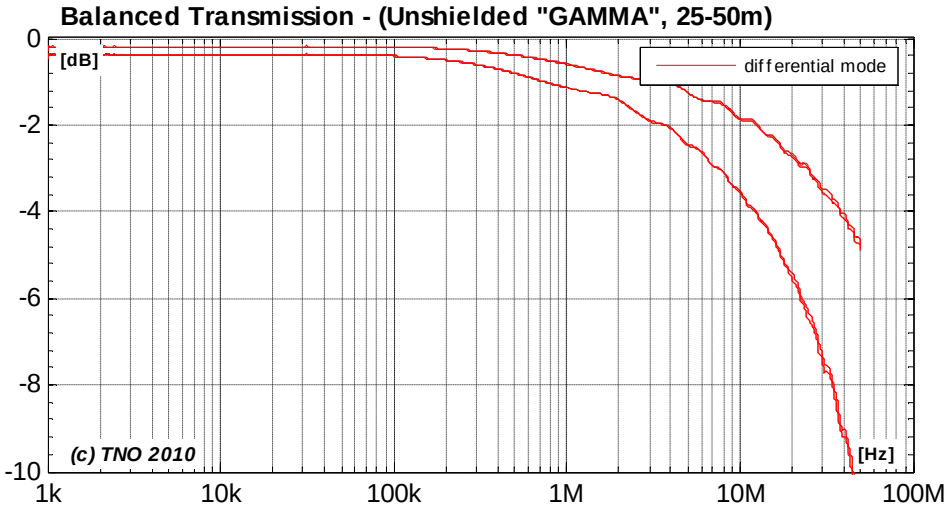
25m or 25+25m spread-out on the floor

4. Characterizing the copper environment

Balanced Transmission:

7 dB / 100m @ 10MHz
40 dB / 100m @ 100MHz

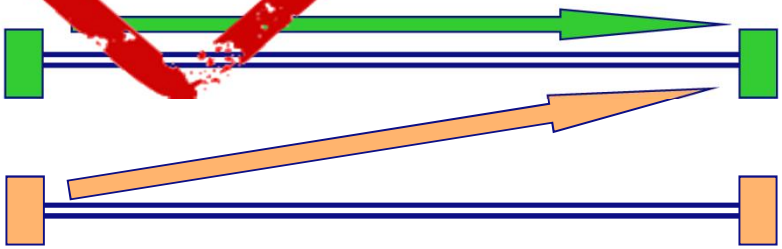


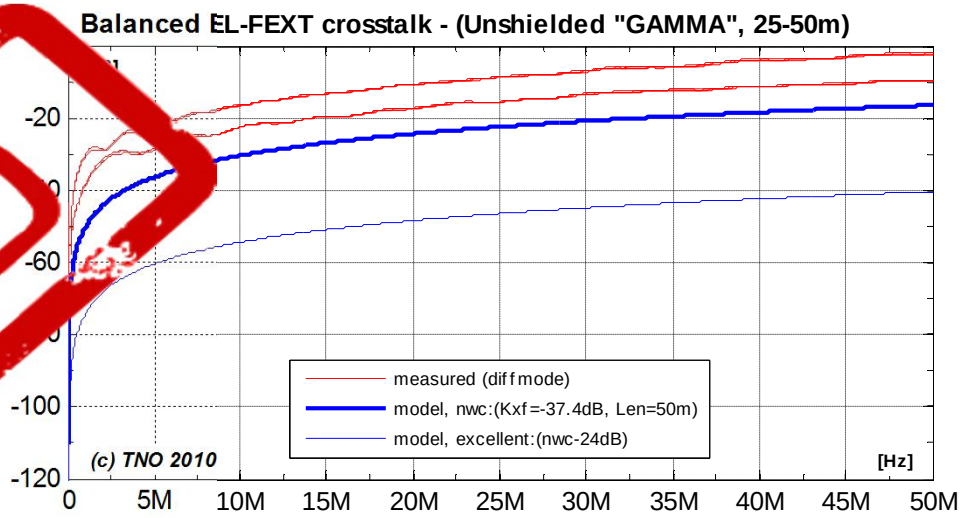


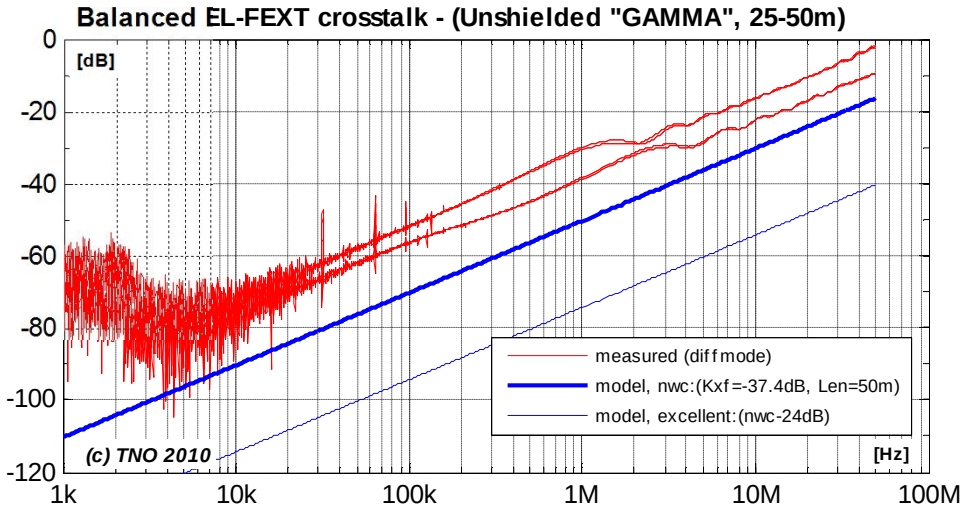
4. Characterizing the copper environment

Balanced EL-FEXT Crosstalk:
"bad" quality

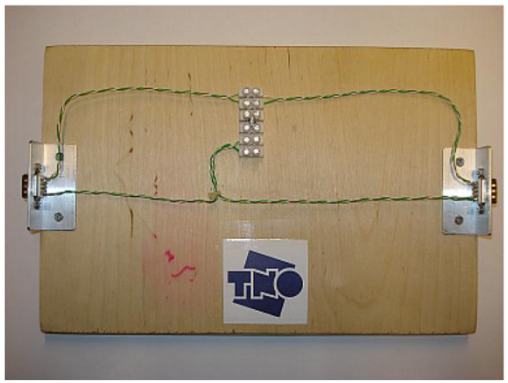
REJECTED

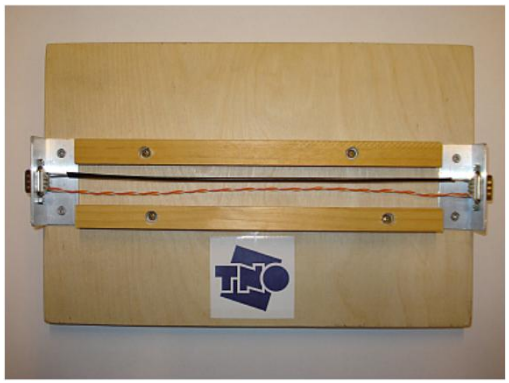




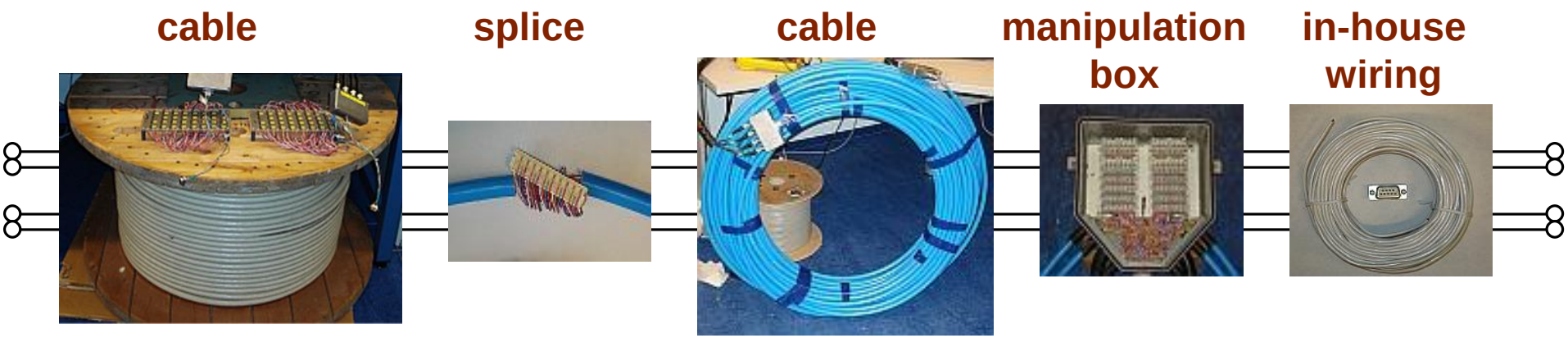


4. Characterizing the copper environment

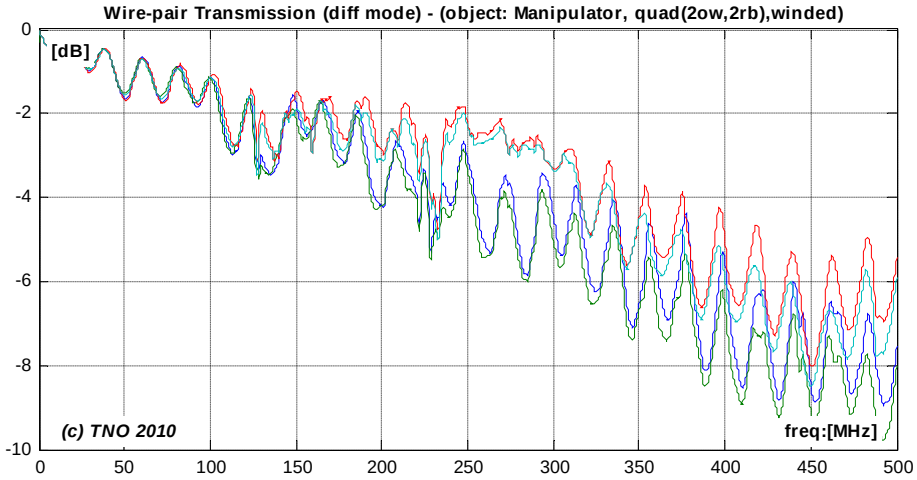


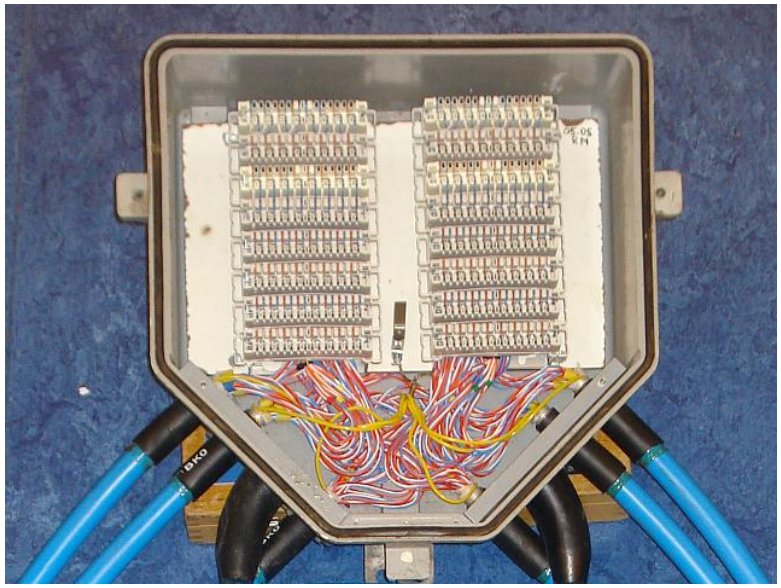


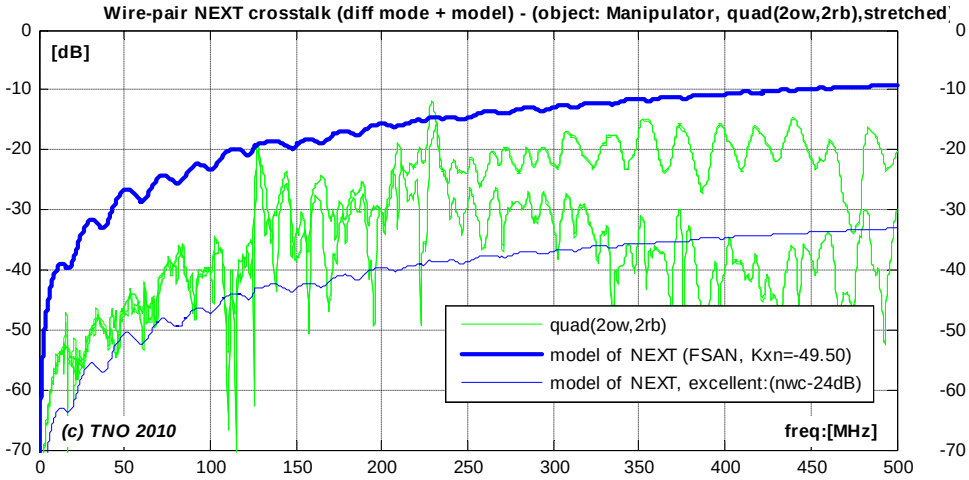
All kinds of obstacles
- Splices
- Manipulation boxes

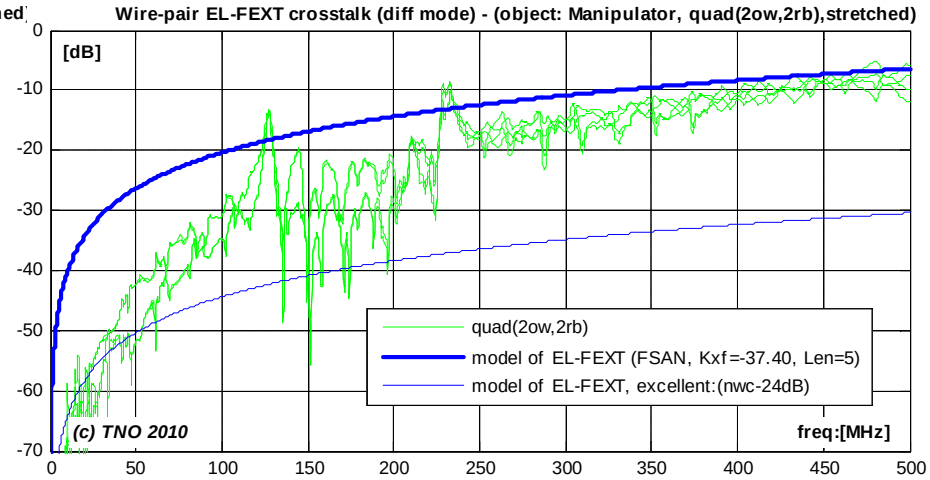


4. Characterizing the copper environment









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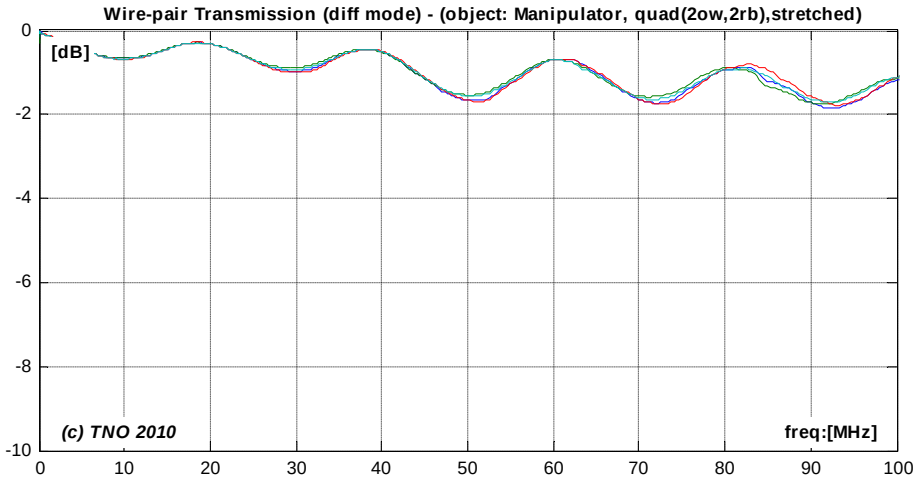
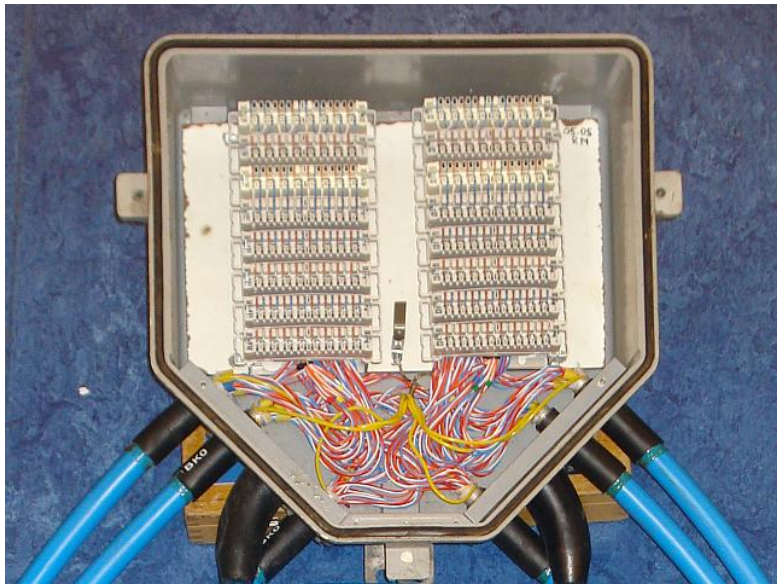
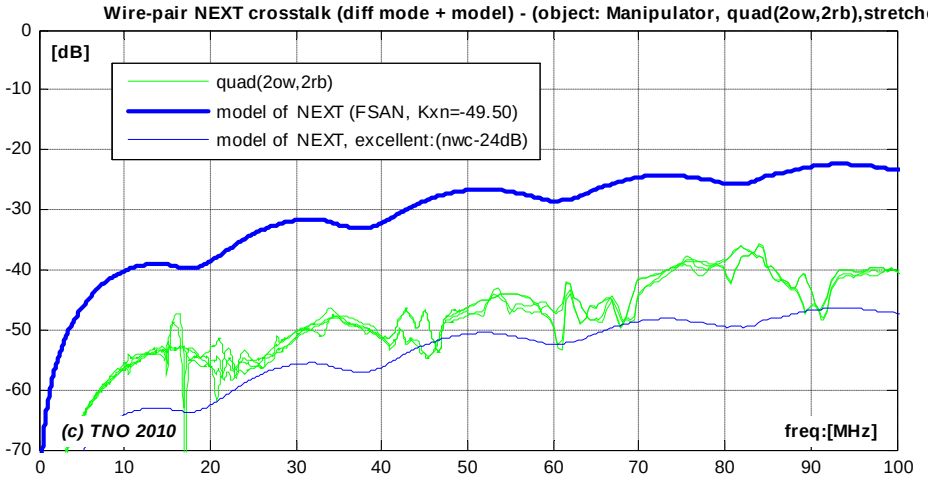
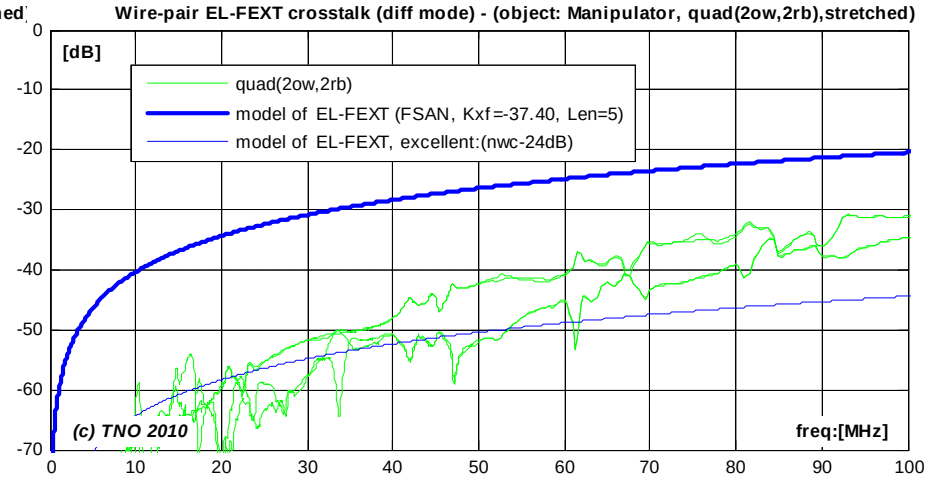
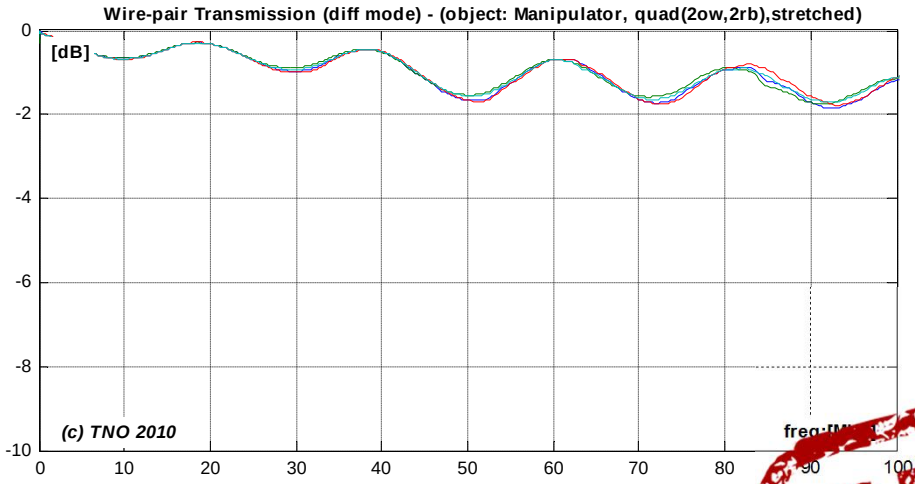




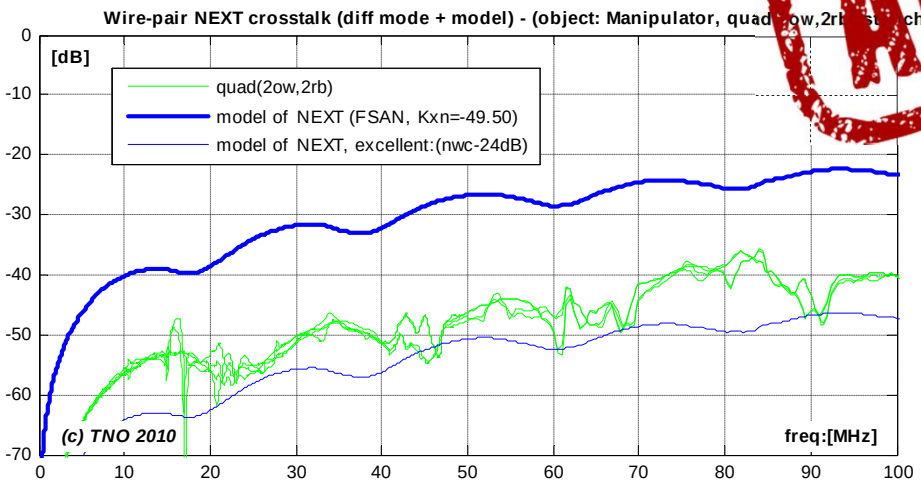


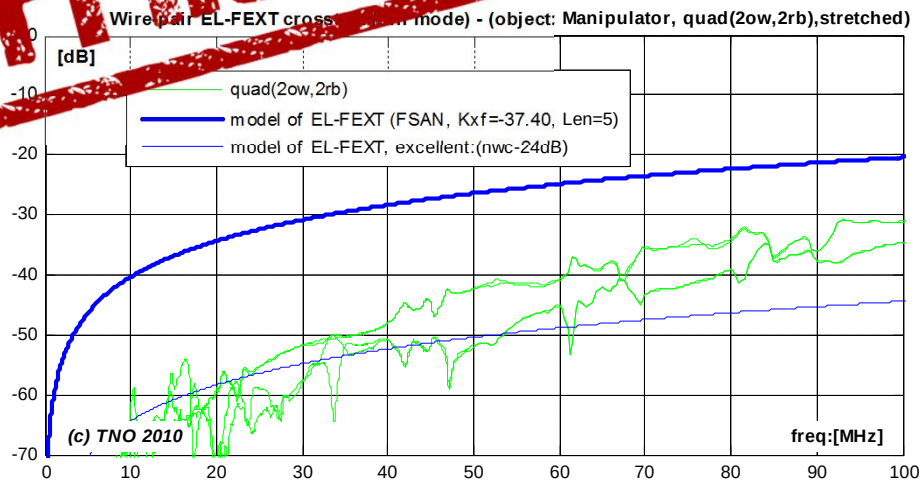


4. Characterizing the copper environment



APPROVED





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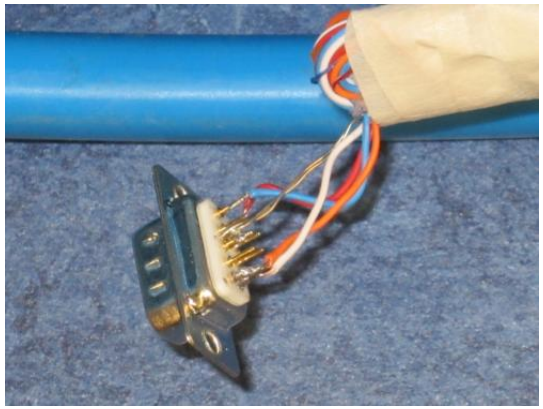
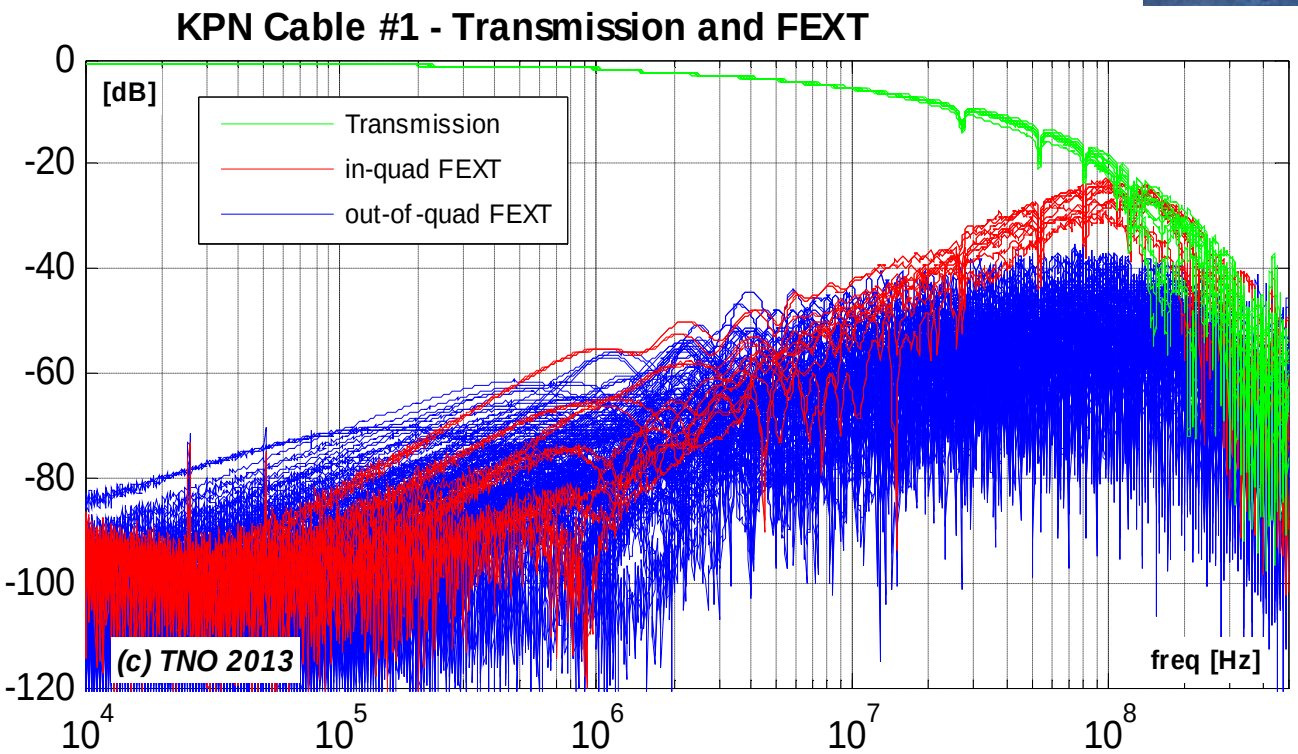


Bulk measurements

- Spread in cross talk
- Difference between in-quad and out-of-quad



4. Characterizing the copper environment

Discovery of new crosstalk behavior

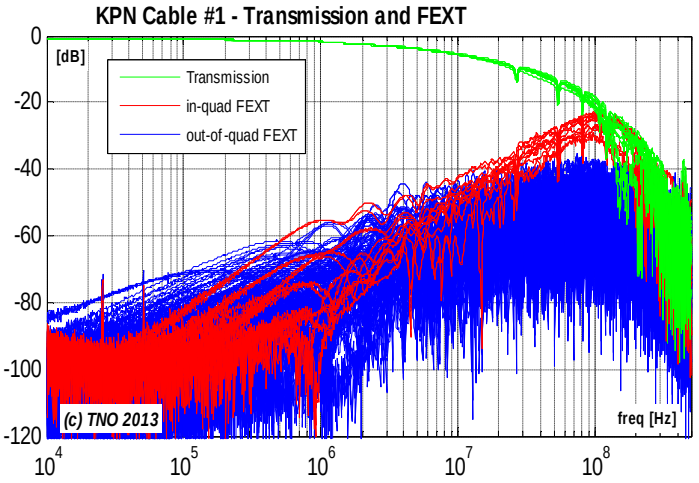
- Dual-slope of EL-FEXT
- HF crosstalk is higher than assumed
- Simple dual-slope model

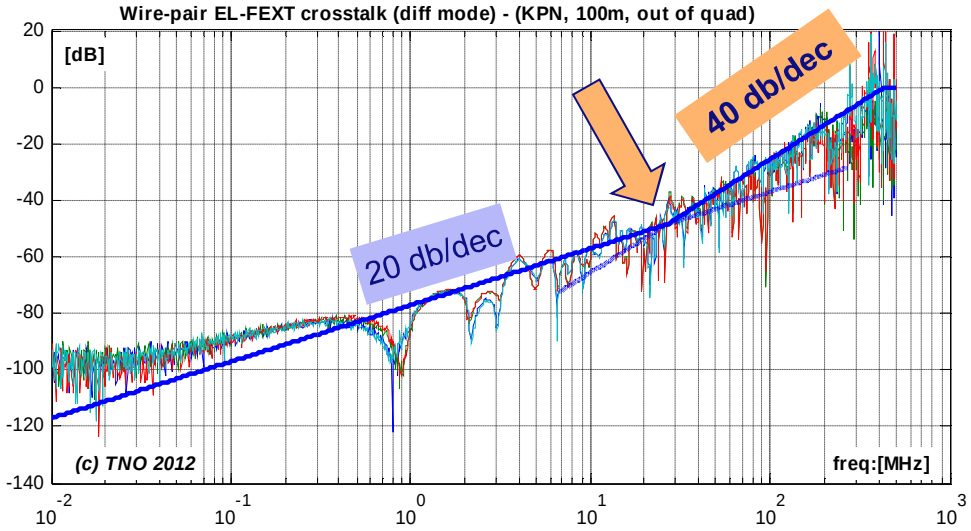
(*Contributed to ITU-T SG15*)

Introduction of new cable models

- Suitable for hundreds of MHz
- Causal by nature
- Replaces legacy BT model

(*Contributed to ITU-T SG15*)





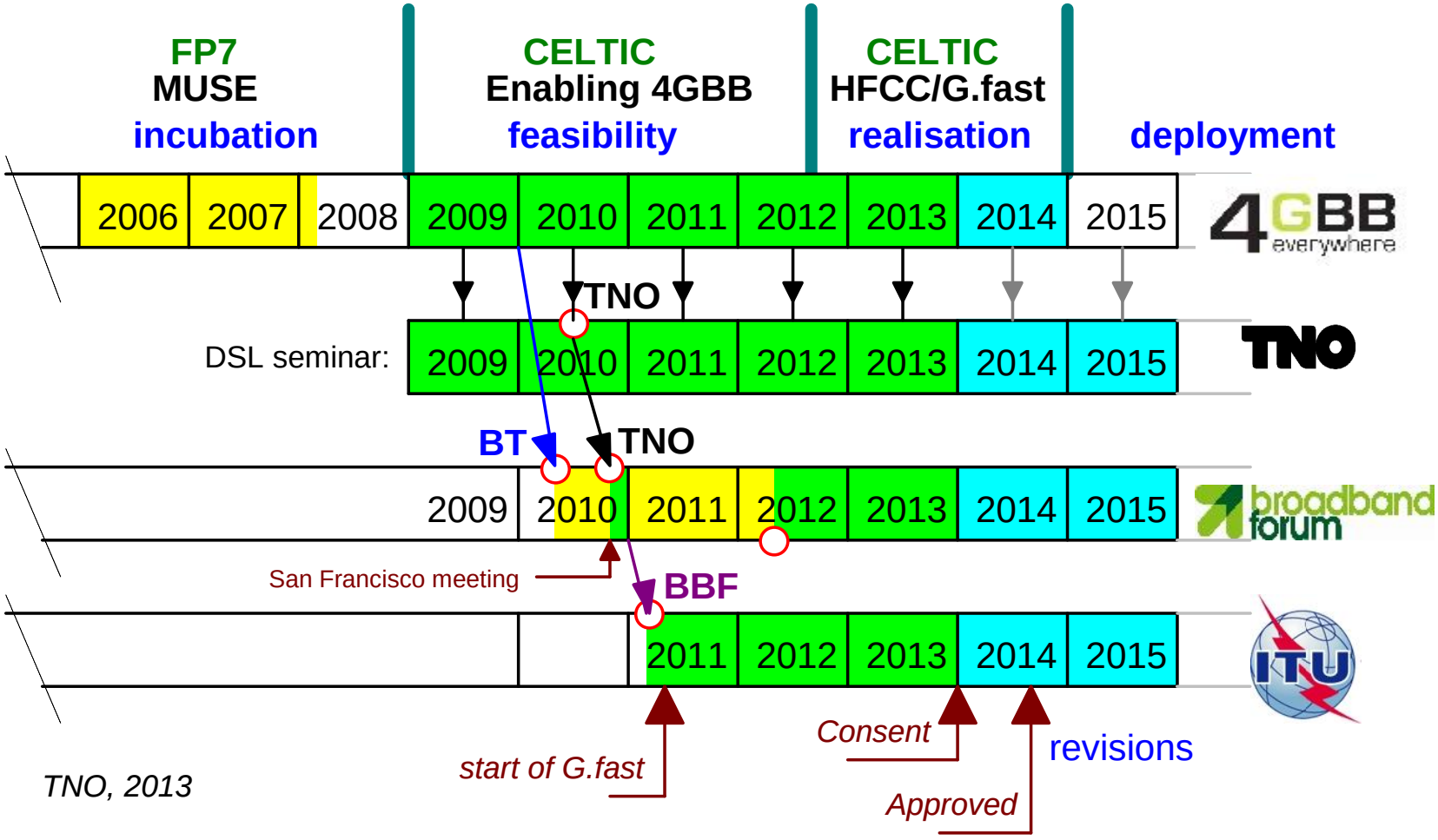
Questions in 2009

Can we initiate a standard?

Can we bring the industry into motion?

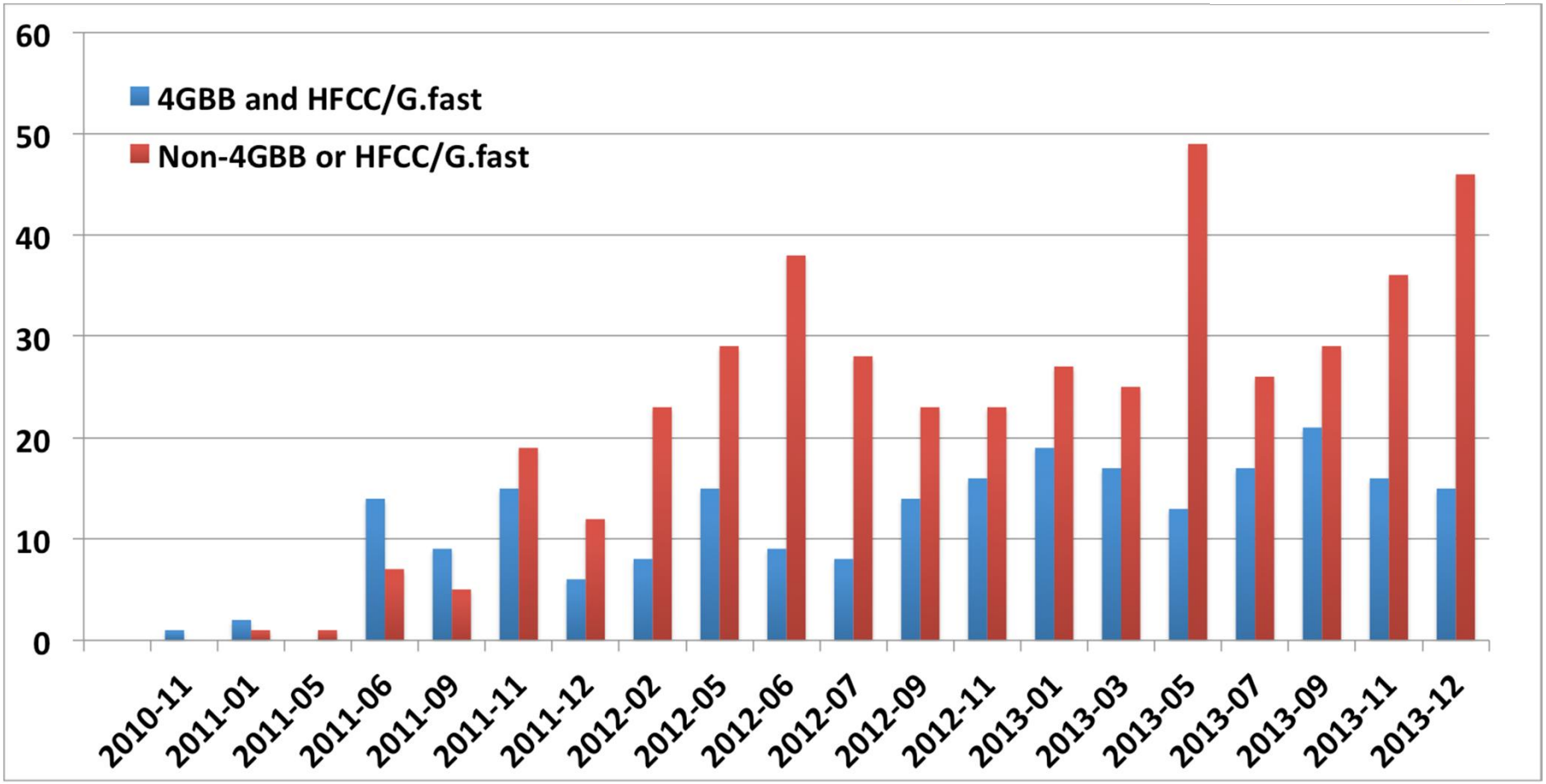
5. The making of Hybrid FTTH with G.fast

Initiation of the G.fast standard



5. The making of Hybrid FTTH with G.fast

G.Fast contribution to ITU-T
from 4GBB consortium members



5. The making of Hybrid FTTH with G.fast

Bringing the industry into motion for Hybrid FTTH with G.fast

… And suddenly there was G.fast ….. !

2009-2012: Celtic project “Enabling 4GBB”

2013-2014: Celtic project “HFCC/G.fast”

Current 4GBB Consortium members:


TNO