Digital Control Links
Status and Plans

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5/11/03

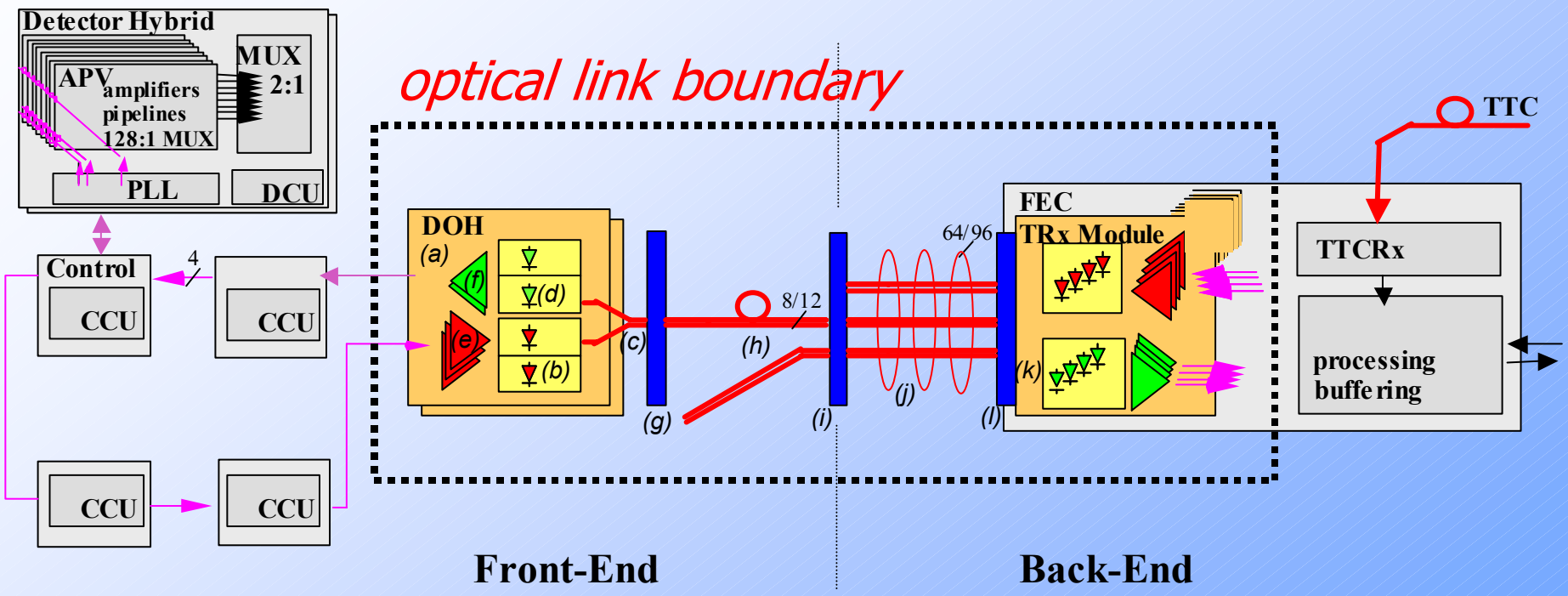
http://cms-tk-opto.web.cern.ch/cms-tk-opto/control/ESR/

Outline

- Overview of system
  - Functional requirements
  - Specifications
  - Components
  - Power budget and margins
  - Integration
- QA/Reliability
  - System tests
  - Radiation resistance
  - Pre-production qualification
  - Lot acceptance
- Procurement Status
  - Production Flow
  - Delivery schedules

System Overview

System overview

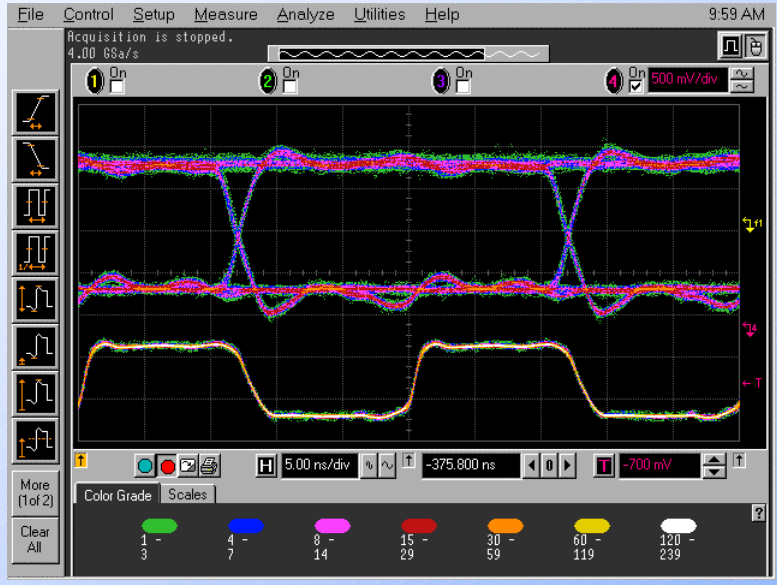


- Tracker 352 rings (includes 32 new TEC rings)
- ECAL 368
- Preshower 52
- Pixels 66
  - All with redundancy

Ref: LECC 2002
cms-tk-opto.web.cern.ch/

Functionality

- Digital link transmits
  - On clock line (@80Mbit/s)
    - 40MHz clock
    - Trigger
    - Resynch
    - Cal-request
  - On data line (@40Mbit/s)
    - Slow control data and tokens
    - Reset signal for front-end



Data

Clock

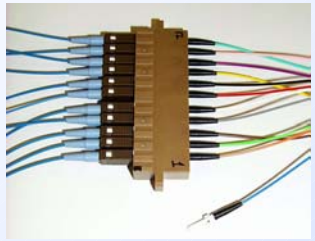
Digital Link System Specifications

Specification	*Min*	*Typ*	*Max*	*Notes*
Wavelength (nm)		1310		Same as analogue links
Speed (Mbits/s)	2		80	AC coupled
Bit-error-rate		10^{-12}		
Jitter (ns)			0.5	rms
Skew (ns)			2	Between fibres to/from same digital optohybrids
TRx Input/Output		±600mV		LVPECL input CML output into 100Ω
DOH Input/Output Voltage ranges		±400mV		LVDS, differential referred to Vss. Input impedence 100Ω, output should be terminated with 100Ω
Reset output from DOH	Active low			Reset output when no signal detected on DOH input data line for 10 clock cycles

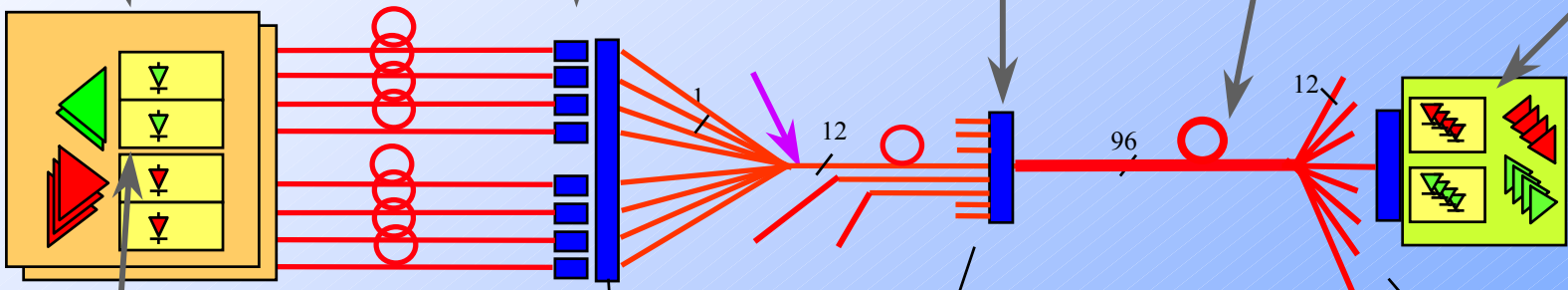
Development

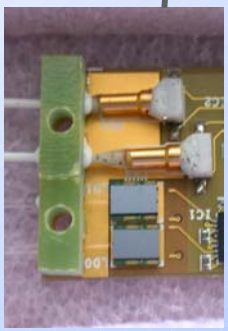
- Not so many optical channels in this system
  - ~7000
    - c.f. ~40000 analogue readout channels
  - Aim to minimize indirect costs of development and procurement effort
    - re-use analogue link components where possible
      - laser (low effic.), Laser Driver ASIC (LLD), Fibre, Cables and Connectors
    - Only a few unique parts for digital control link
      - Front-end: photodiodes, Receiver ASIC (RX40), digital optohybrid (DOH)
      - Back-end: Transceiver
  - Benefit from a lot of earlier work on analogue links: component development, qualification (functionality and radiation hardness), procurement
    - DOH also to be made at Kapsch, Vienna
      - Benefit from their experience with Analogue Optohybrid (AOH)

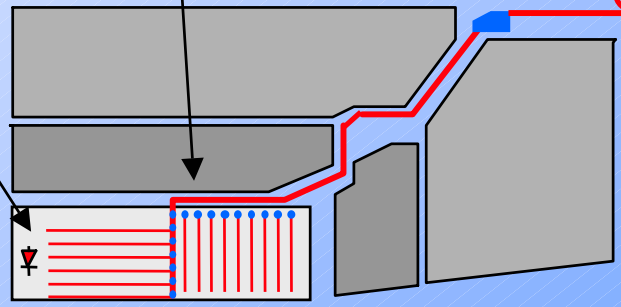
Components

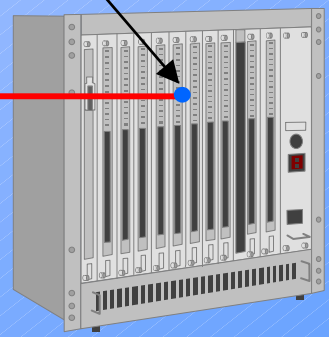


Cables/connectors
same as readout links

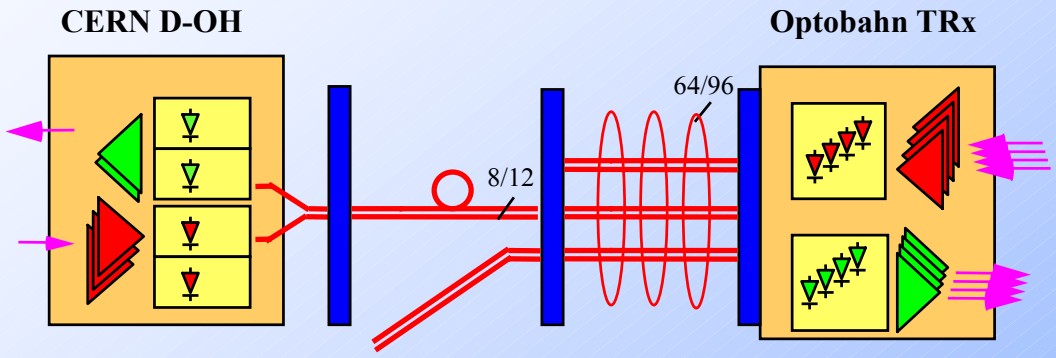








Functional reliability: Optical power budget



- Factors affecting power levels

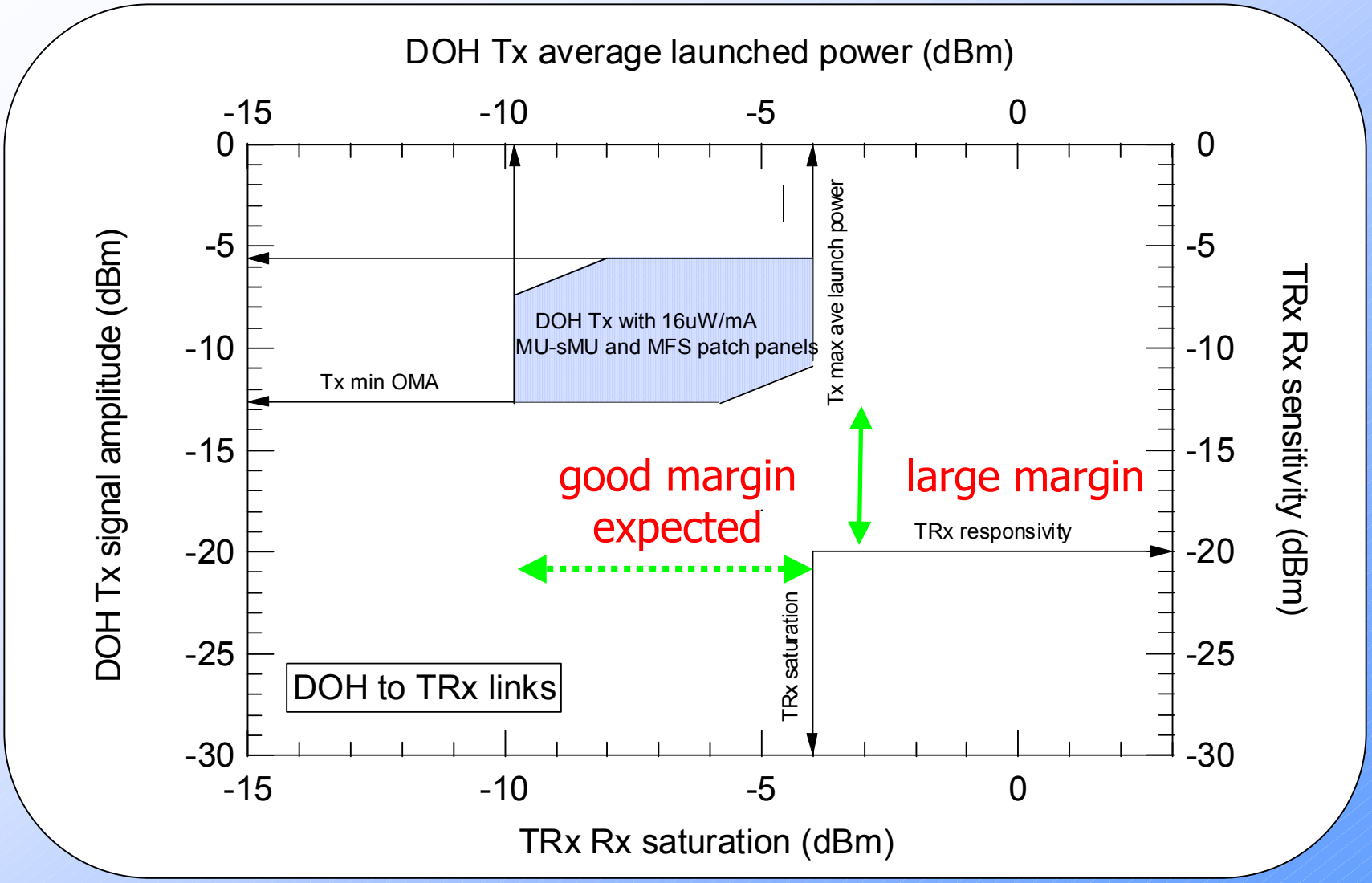
DOH to TRx

DC offset	Modulation (signal)
I2C dc bias setting (and laser threshold) Laser driver dc gain Laser efficiency Insertion loss + Attenuation	Input voltage amplitude I2C dc bias setting (and laser threshold) Laser driver gain Laser efficiency Insertion loss + Attenuation

TRx to DOH

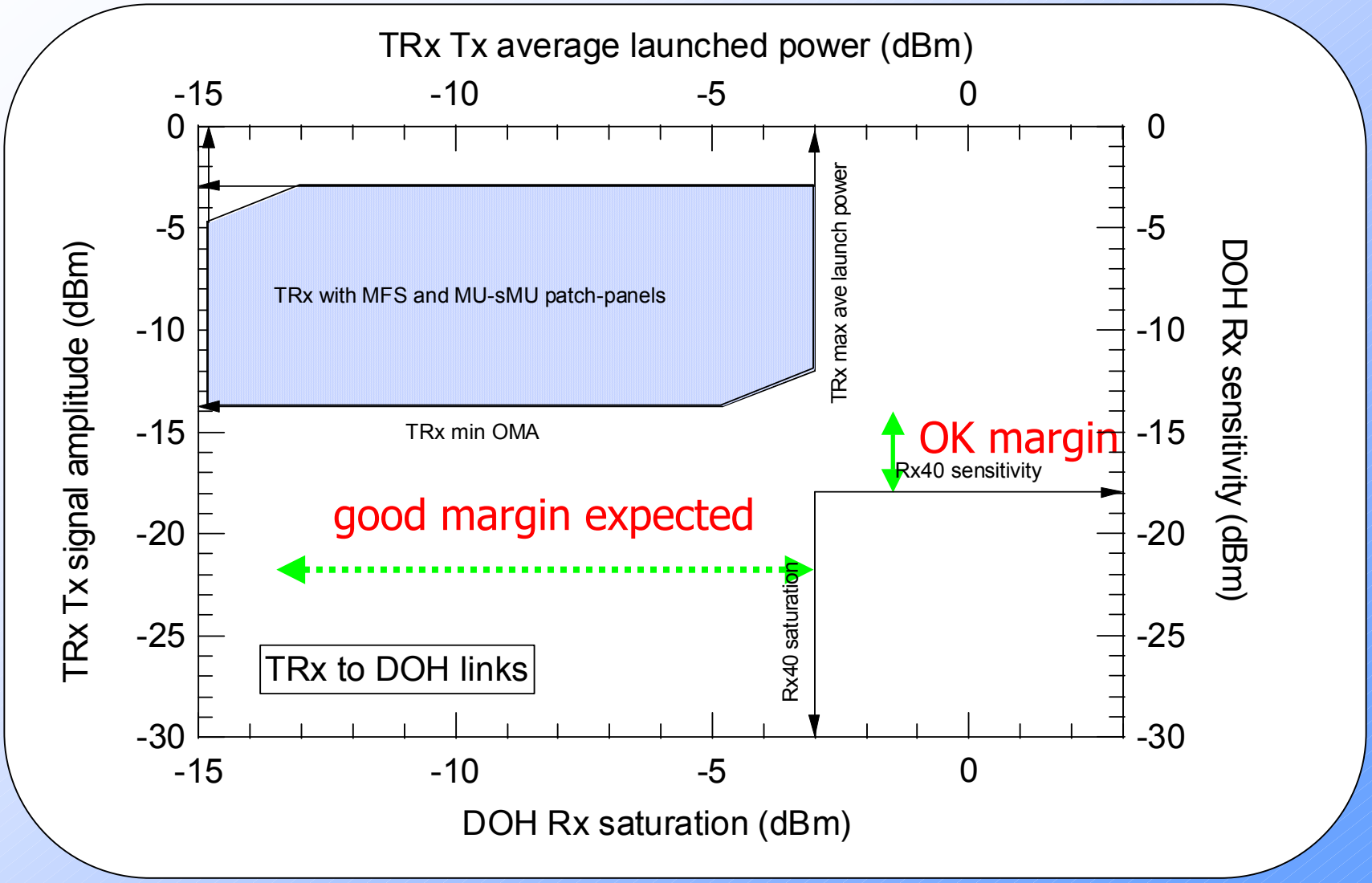
DC offset	Modulation (signal)
TRx laser efficiency Insertion loss + Attenuation	TRx laser efficiency Insertion loss + Attenuation

Power budget detail: DOH to TRx links



To avoid saturating TRx-Rx input, we have reduced laser efficiency (16uW/mA in place of 40uW/mA)

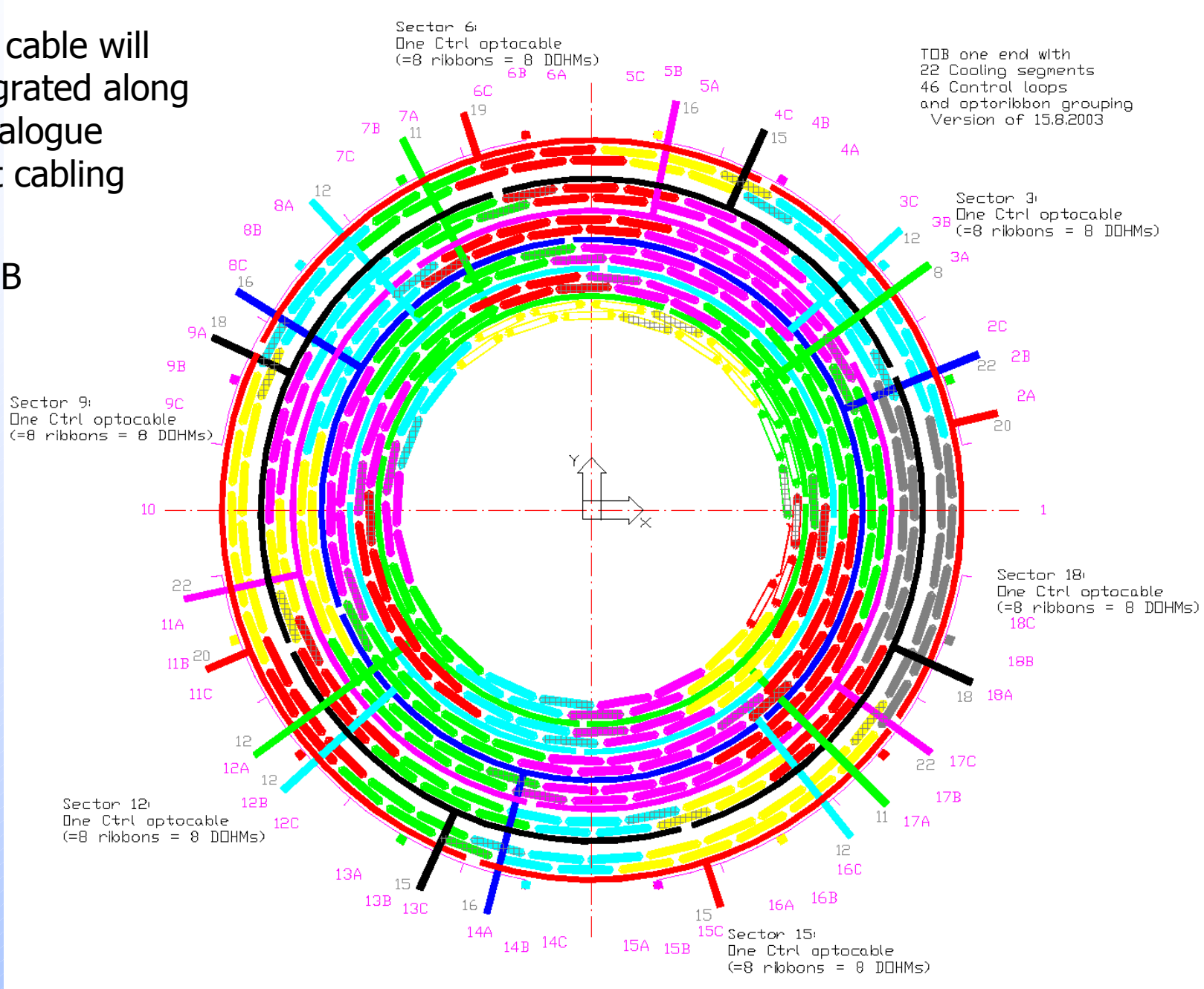
Power budget detail: TRx to DOH links



No problems from TRx to DOH

Integration - cabling

- Control cable will be integrated along with analogue readout cabling
- E.g. TOB



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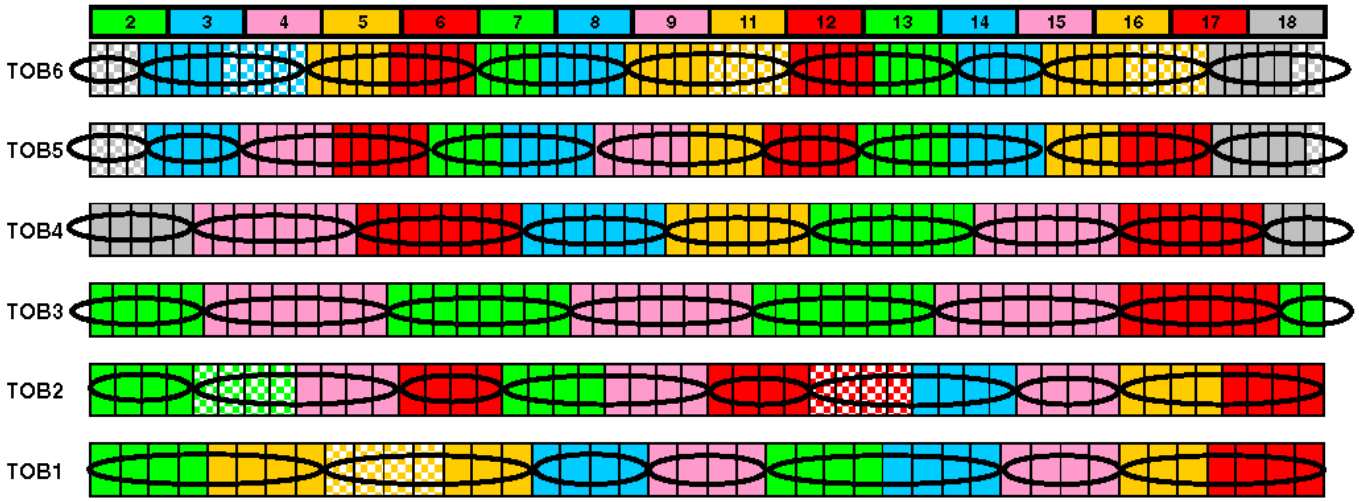
Plans

- TOB cabling continued



RODs / SECTOR

	2	3	4	5	6	7	8	9	11	12	13	14	15	16	17	18
TOB6		5+5		5	5	4	5		5+5	5	5	5		5+5		5+5
TOB5		5	5		5	4	5	5	4	5	5	5		4	5	5+4
TOB4			8		8		7		7		8		7		7	8
TOB3	7		8			8		8			8		8		7	
TOB2	4	4	4		4	4		4		4	4	4	4	4	4	
TOB1	4			4	4+3		4	4		4		4	4	3	4	
CTRL Ribbons:	8		8		8		8		8		6		8			

46 CTRL RIngs

CTRL RIngs	Bad FEDs	Cooling Groups	minMAX manifolds lenght	minMAX CTRL groups size
8	0	4	15 - 20	5 - 10
8	0	4	15 - 18	5 - 10
8	0	3	16 - 22	7 - 8
7	0	3	16 - 22	7 - 8
8	0	4	12	4 - 8
7	0	4	8 - 12	4 - 8

V V

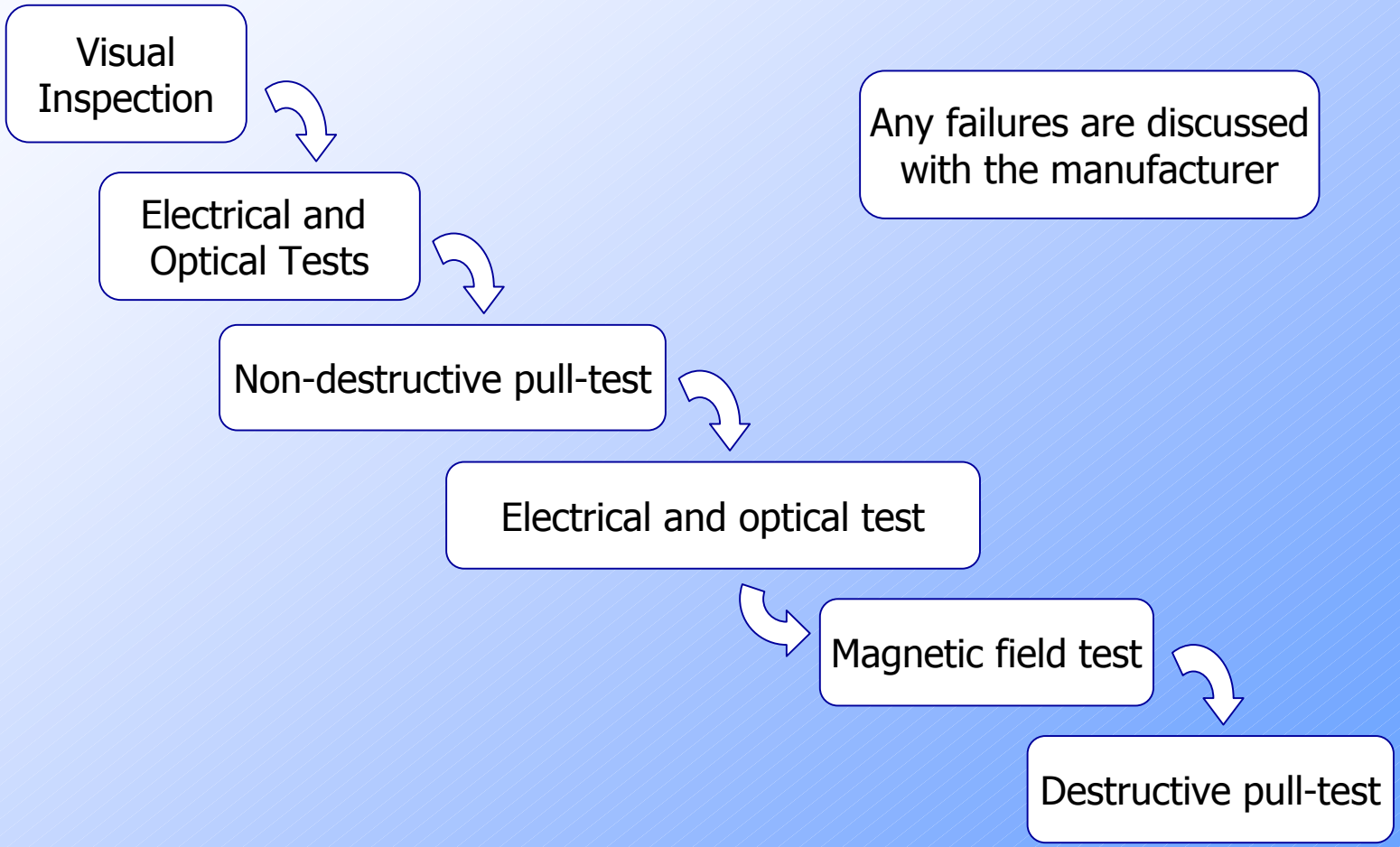
0	22

QA/Reliability Tests

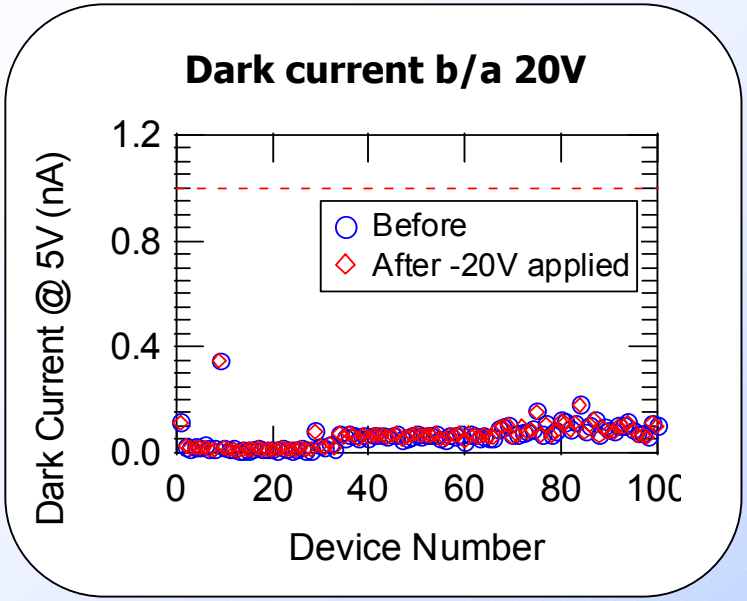
QA/Reliability

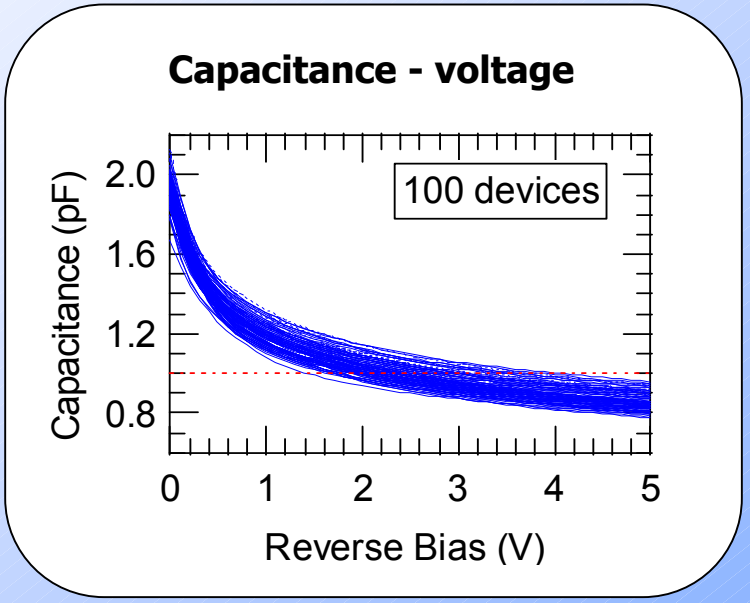
- Active components
  - Lasers – Qualification and AVT
    - Done already for analogue links – will not cover
  - Photodiodes – Qualification and AVT
    - Will present
  - Transceivers – Qualification
    - Will present
- Passive components
  - Fibres – Qualification and AVT
    - Done already for analogue links – will not cover
  - Cables and Connectors – Qualification and AVT
    - Ongoing for analogue links – will not cover
- System (Will present)
  - Eye patterns
  - Bit error rate (BER)

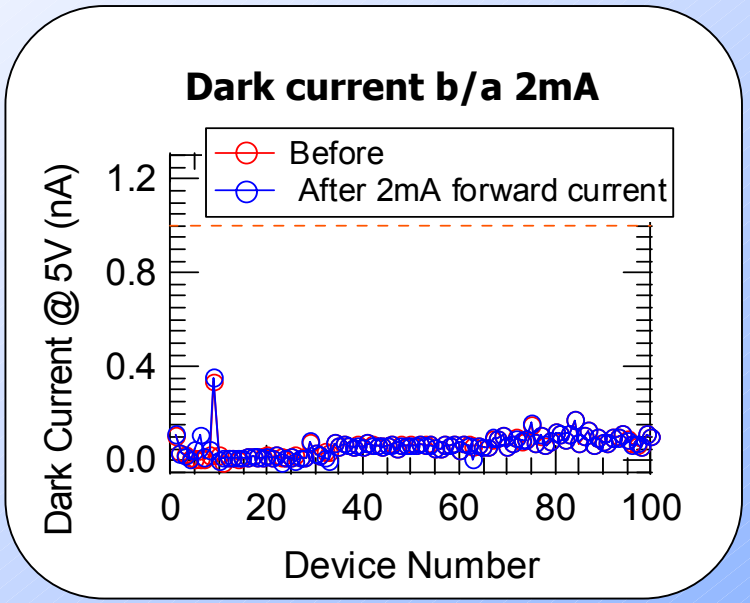
Qualification procedure - PINs

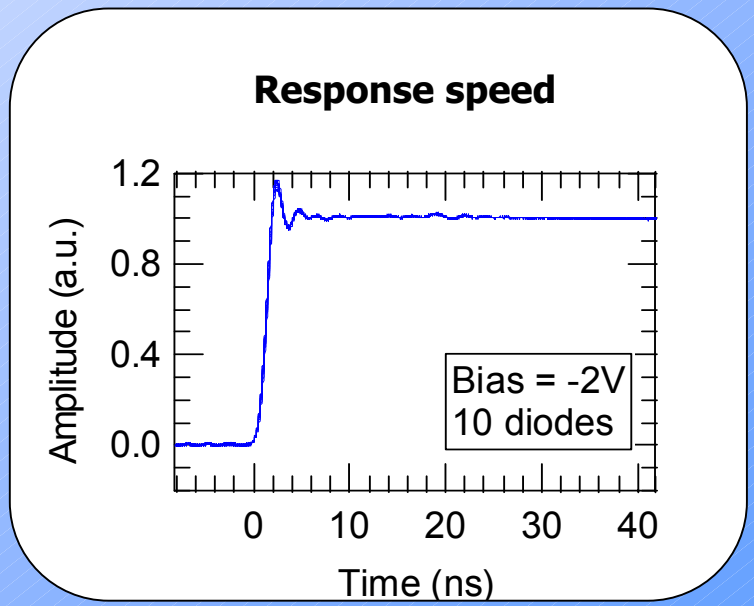


PIN photodiode qualification – optical/electrical



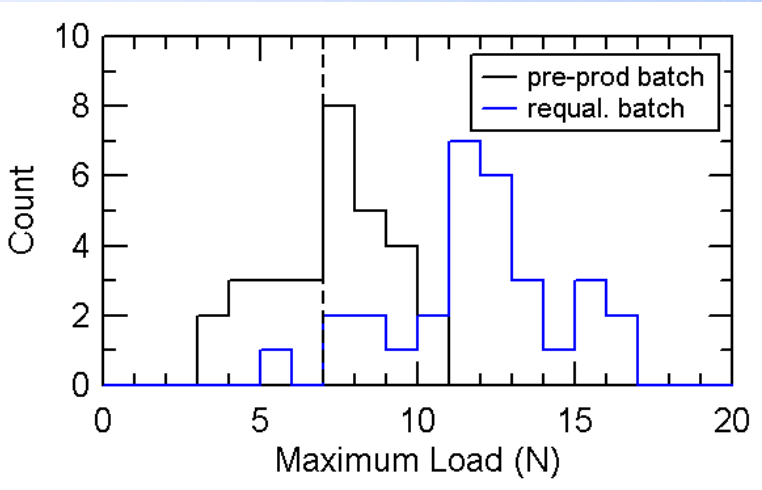


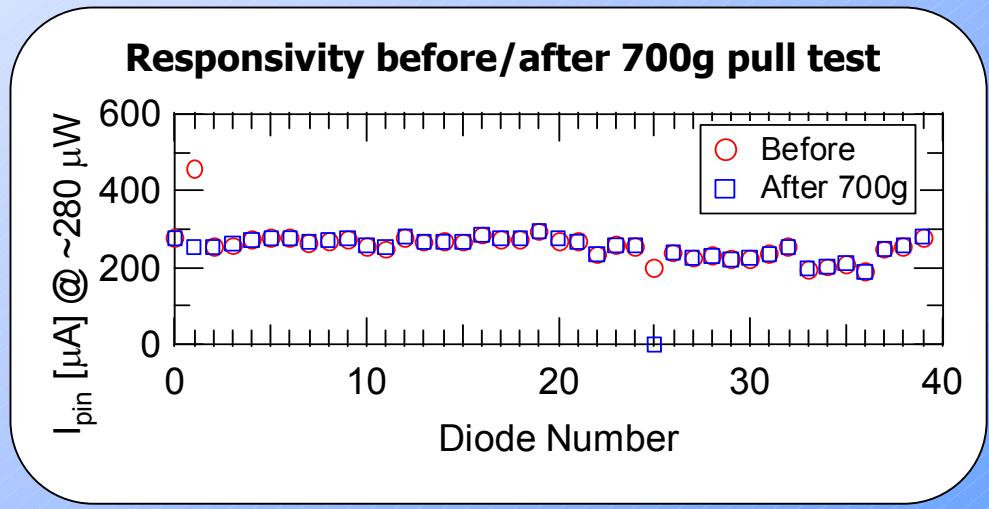




PINs with new gluing process

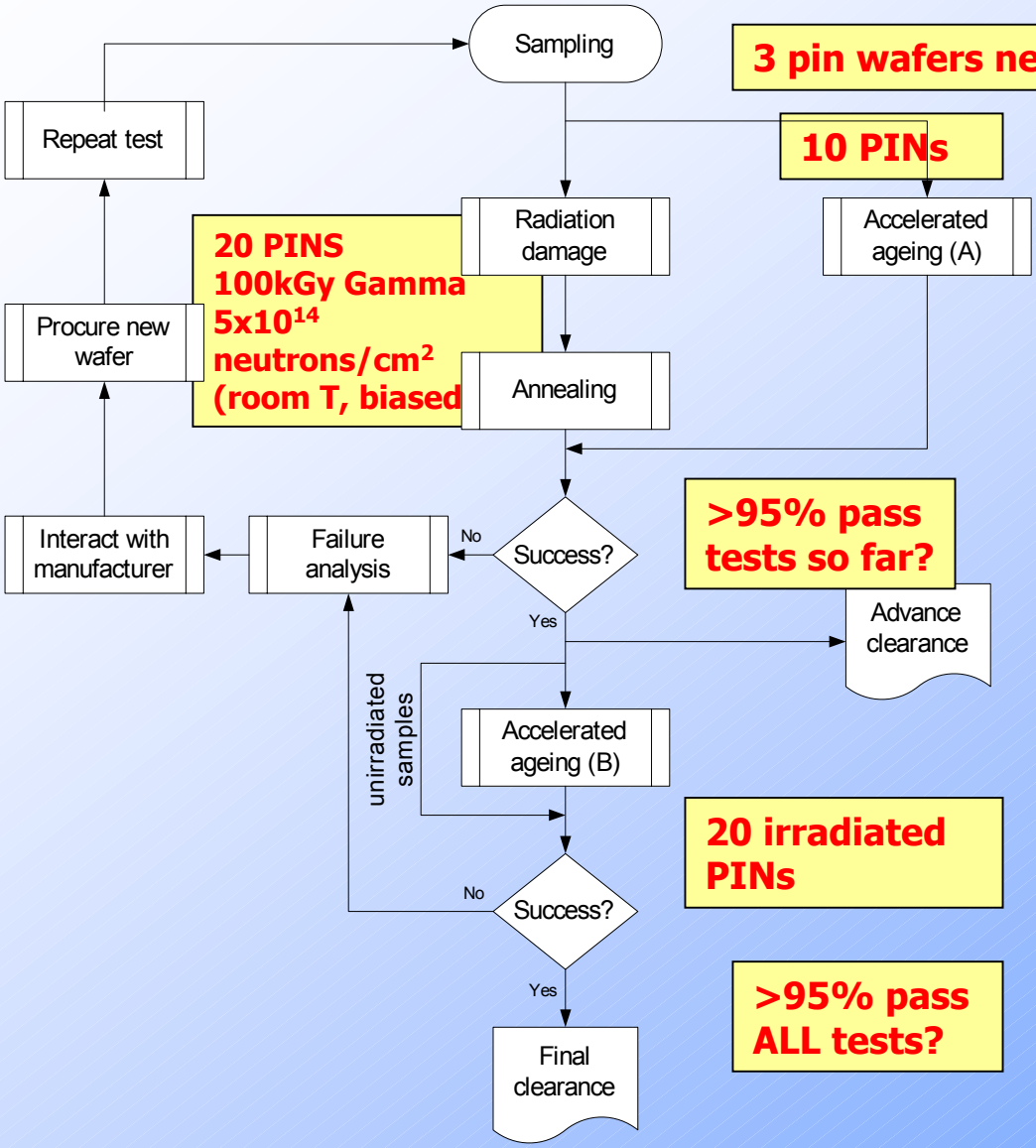
- First delivery for pre-production not strong enough
- Fermionics has changed their assembly process
  - essentially using more epoxy to provide tensile resistance >7N
- Re-supplied 50 devices
  - 40 pulled with 700g.
    - Only 1 failure
  - 30 parts destructively tested
    - Only 1 fails <7N





- These devices considered acceptable
  - Will test non-destructively samples from future series production

PIN AVT procedure for radiation resistance



Received AVT batch end of July

Irrad gamma 25/8, neutrons 28/8

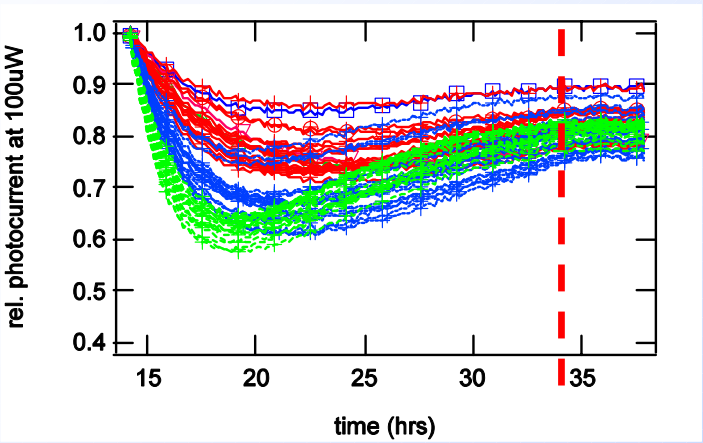
Annealing monitored until 16/9

Started aging step 10/10

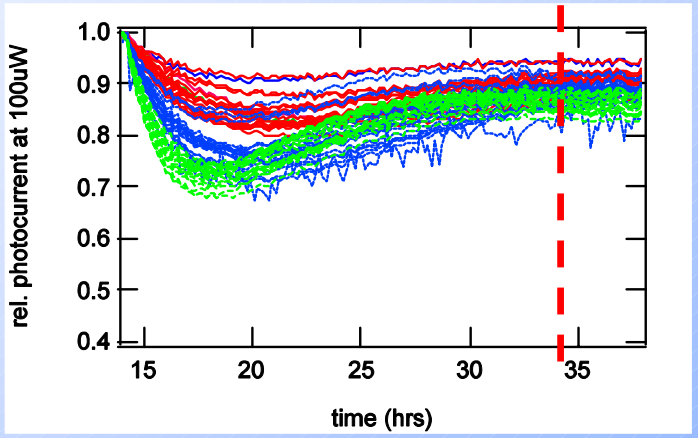
Will stop mid-November

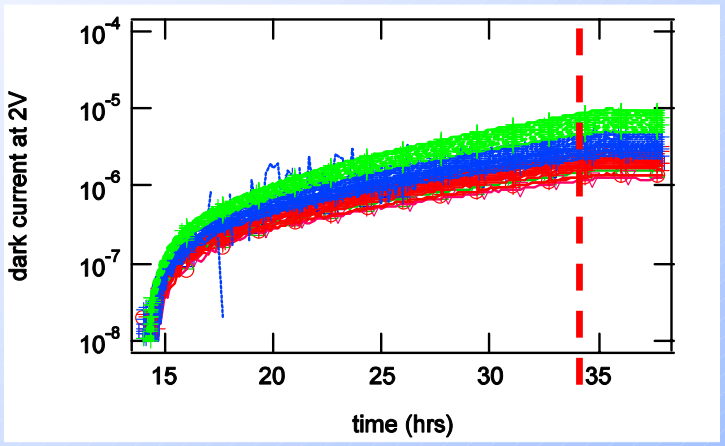
PIN AVT Neutron data

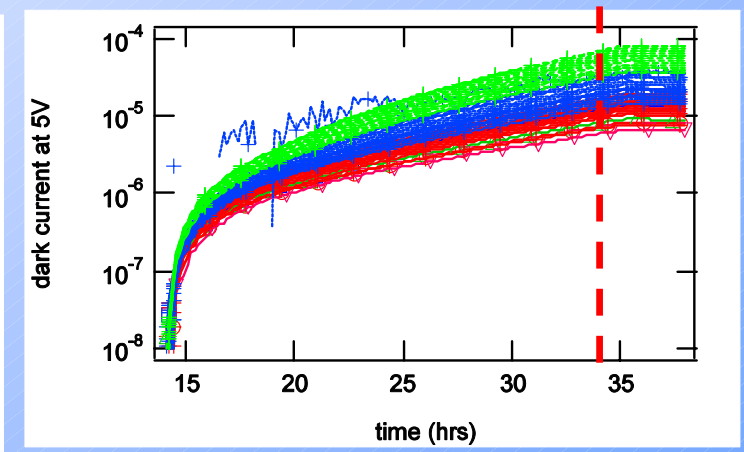
2V



5V

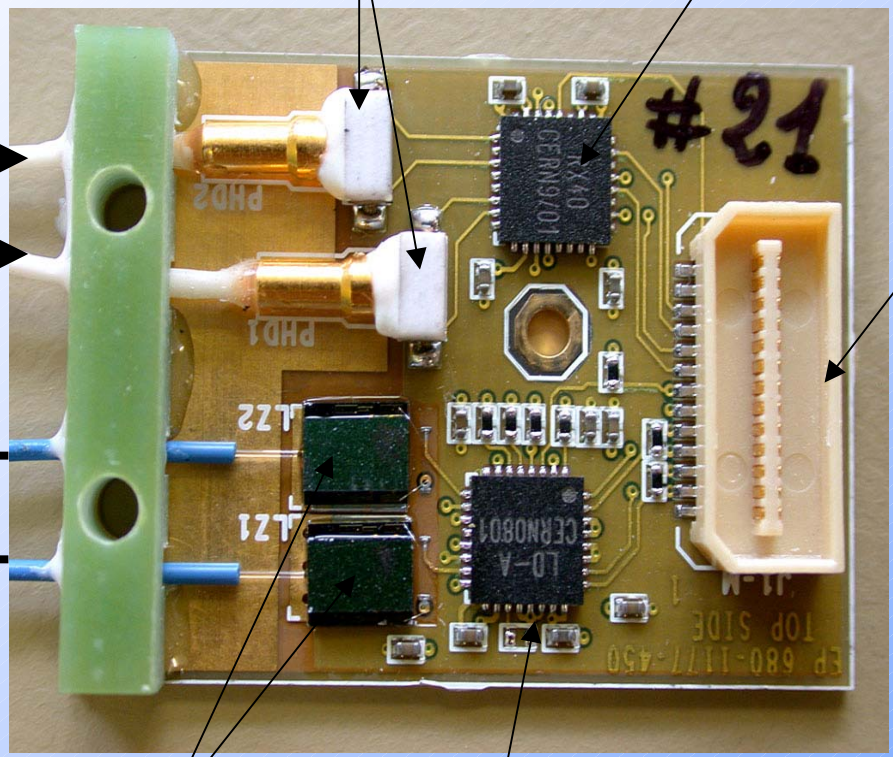




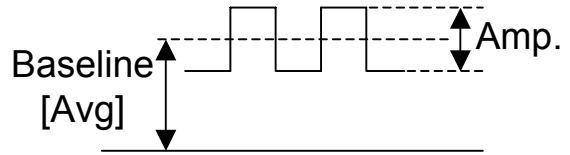


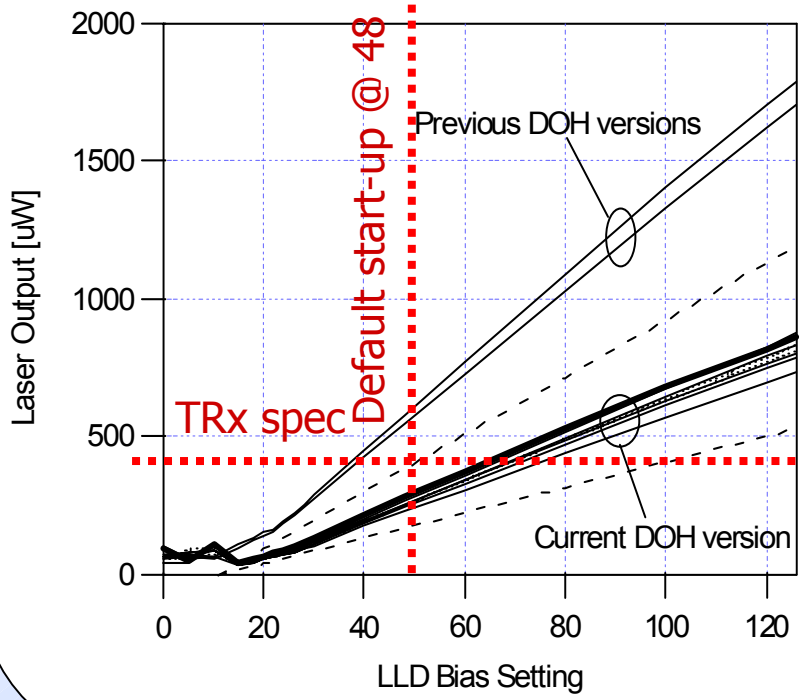
- Effects similar to those seen in past. Some variation between wafers.
- Fluence estimated to be in range of 0.7-1.4x10^{15}n/cm^2
- Devices probably sufficiently radiation resistant for CMS Tracker.

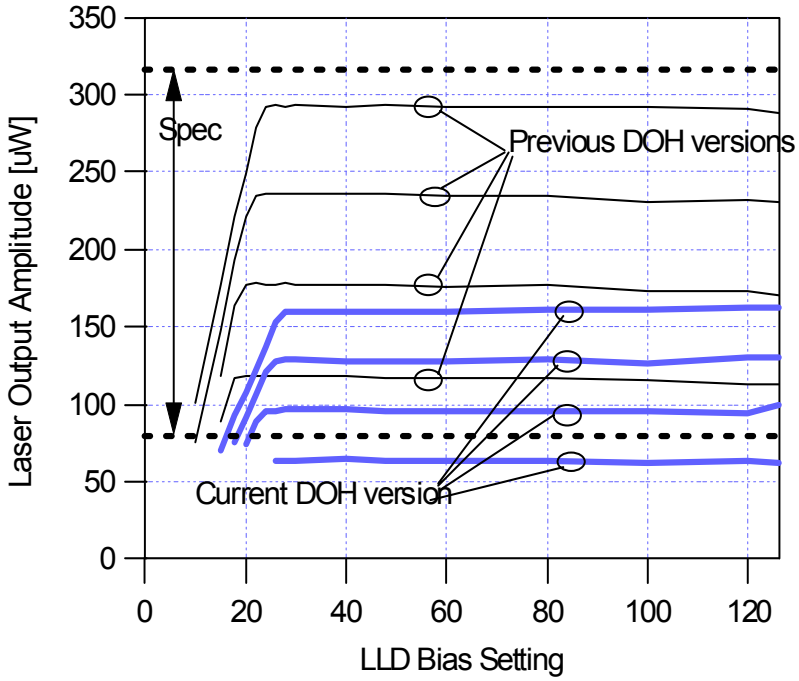
Digital Opto-Hybrid



New laser characteristics on v.4 DOH



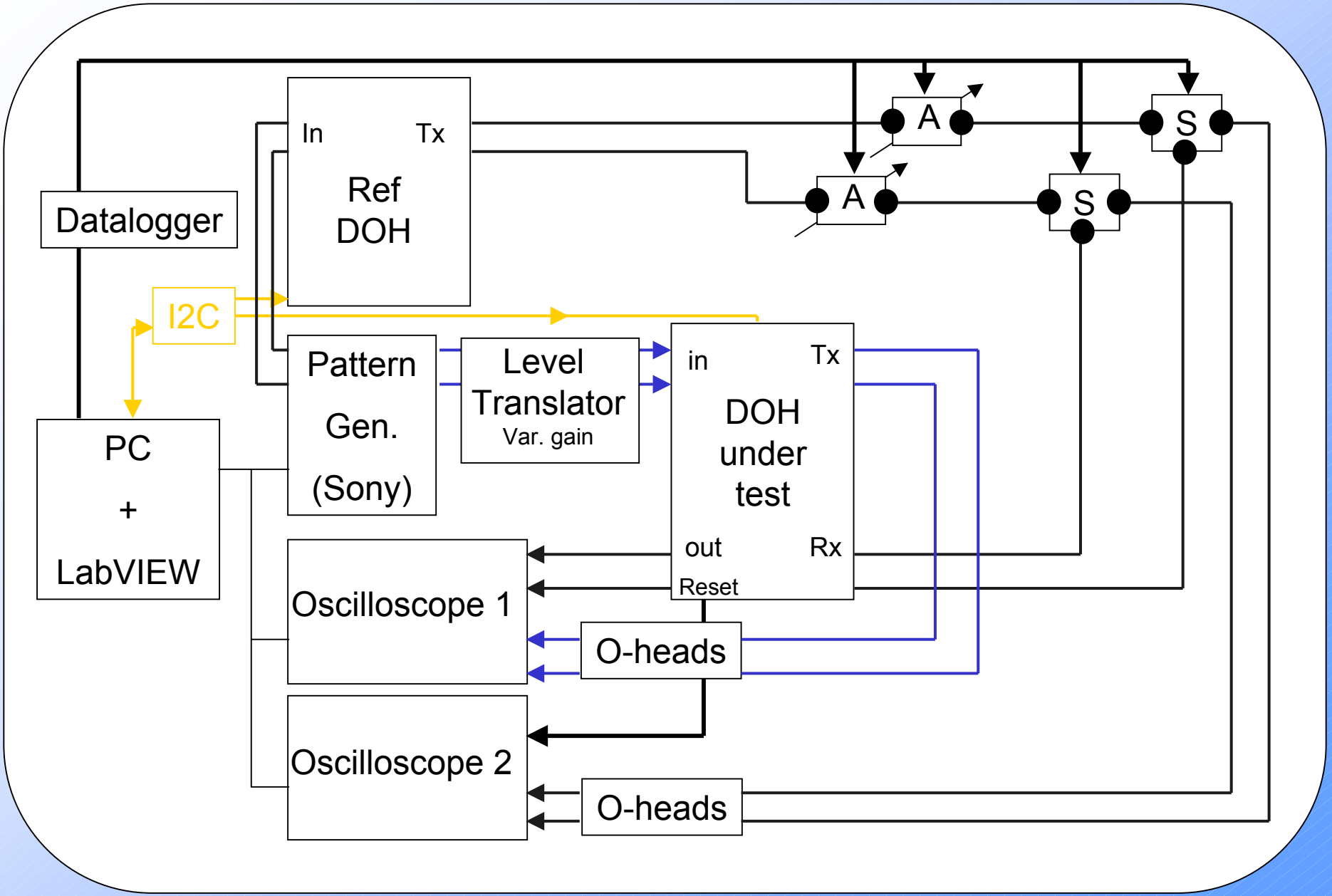




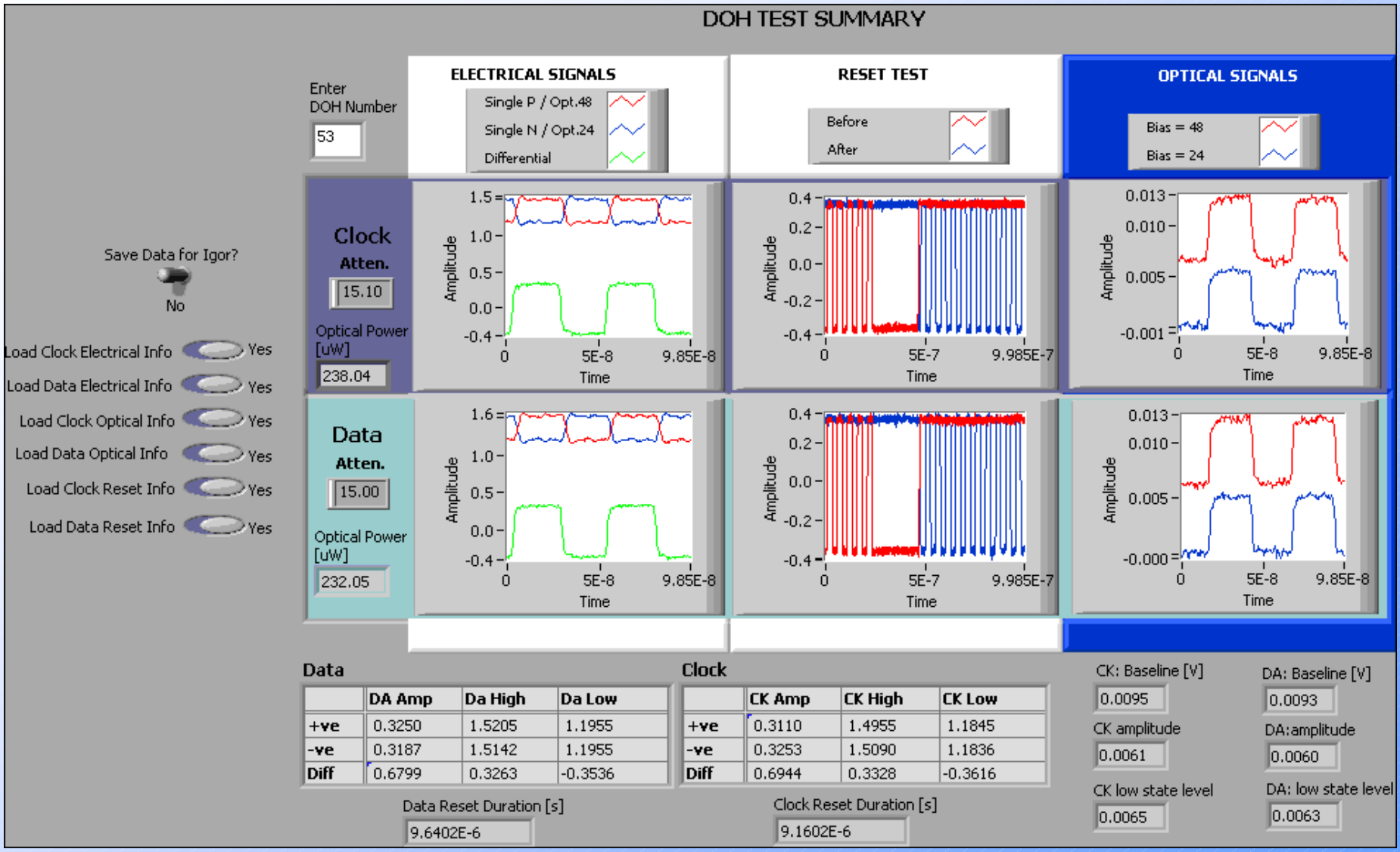
Default is highest gain

- Saturation of TRx at startup now unlikely with lower laser efficiency

DOH Test System, CERN



DOH Test setup Labview output



	DA Amp	Da High	Da Low
+ve	0.3250	1.5205	1.1955
-ve	0.3187	1.5142	1.1955
Diff	0.6799	0.3263	-0.3536

	CK Amp	CK High	CK Low
+ve	0.3110	1.4955	1.1845
-ve	0.3253	1.5090	1.1836
Diff	0.6944	0.3328	-0.3616

NGK Optobahn 4-way Backend transceiver module

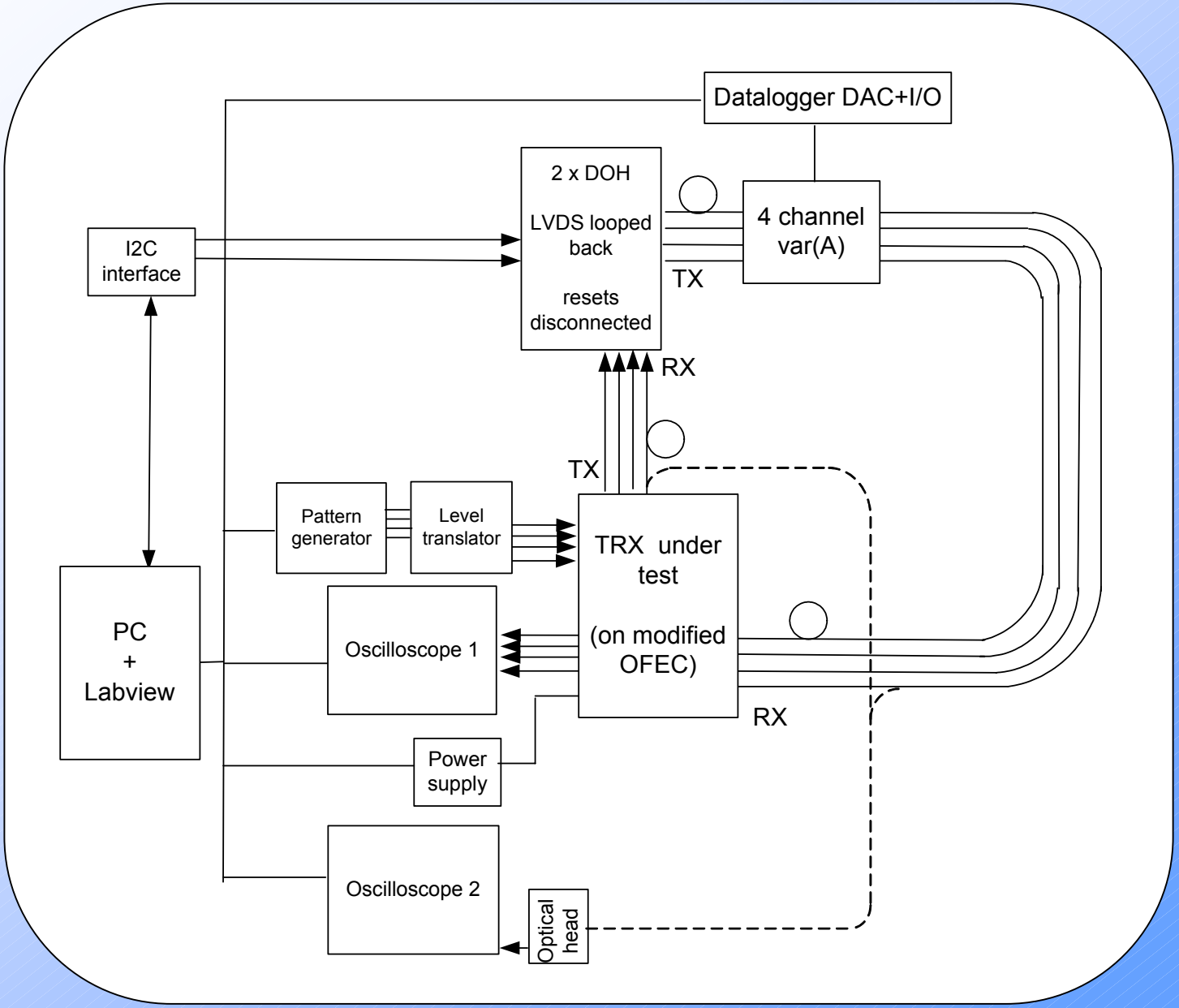
- Transceiver pre-production
  - 25 pieces
    - Received end August
  - Test Procedure and setup/software in place

4TRx module

m-FEC

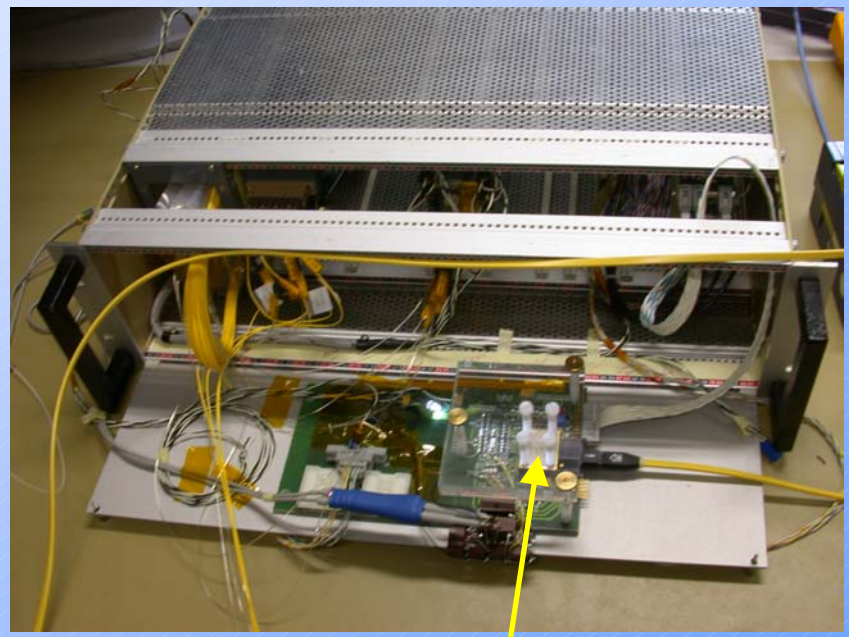
transceiver test-setup

- Transceiver test-setup



4TRx measurement setup

- Transceiver test-bench
  - very similar to DOH test-setup

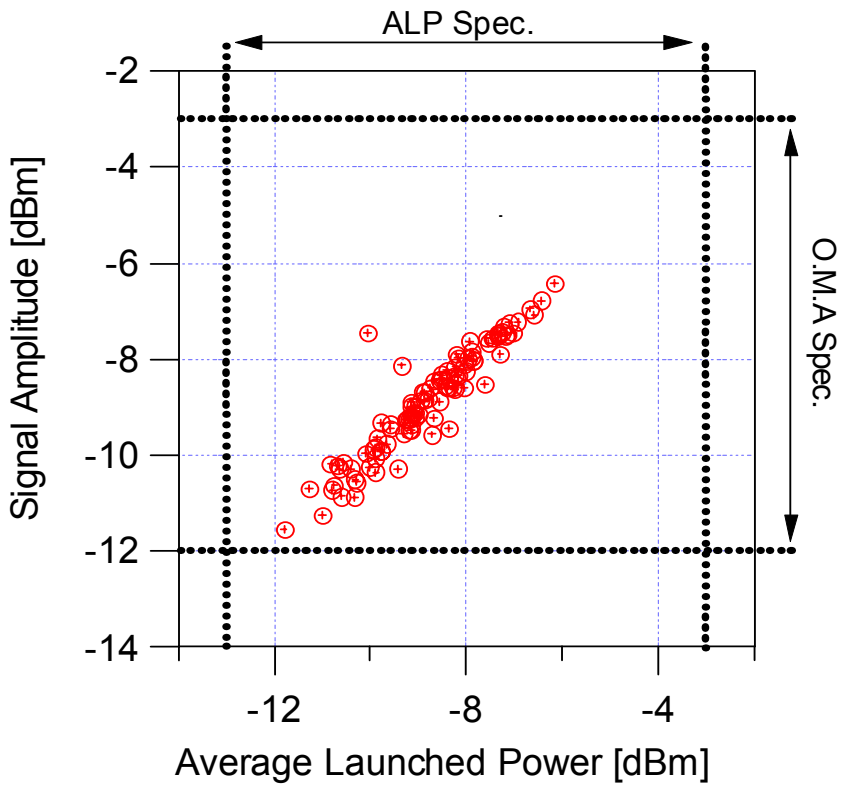


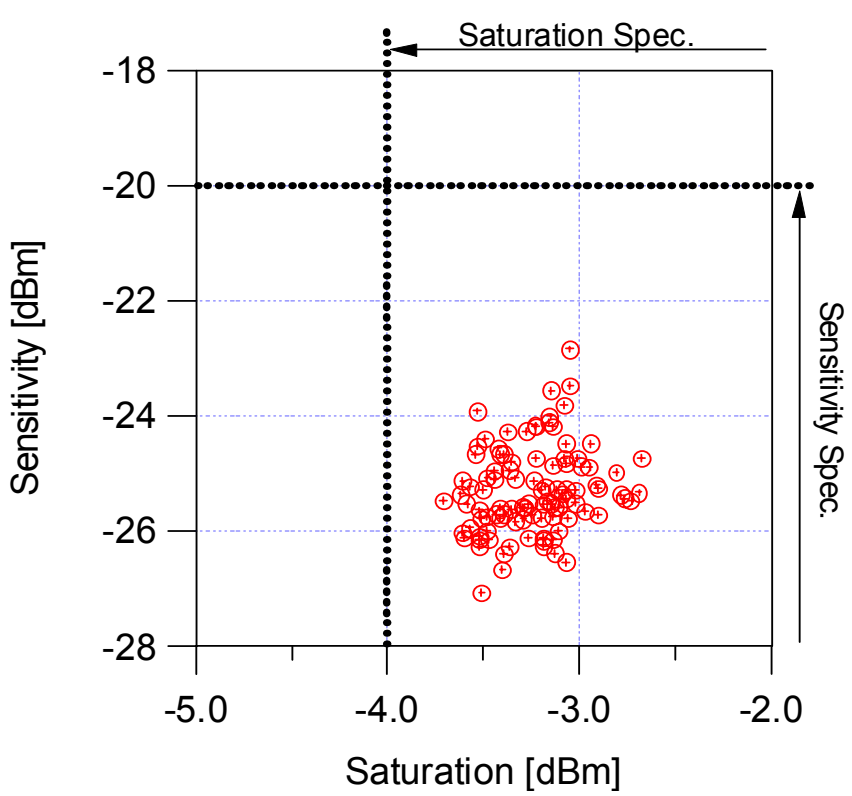
- Measured
  - Electrical output levels
  - Optical levels
  - Jitter and skew
  - Power consumption
  - Effect of variations in power supply
- ALL PARTS PASSED TESTS

Transceiver temporarily mounted on jig attached to modified O-FEC card

4TRx optical properties

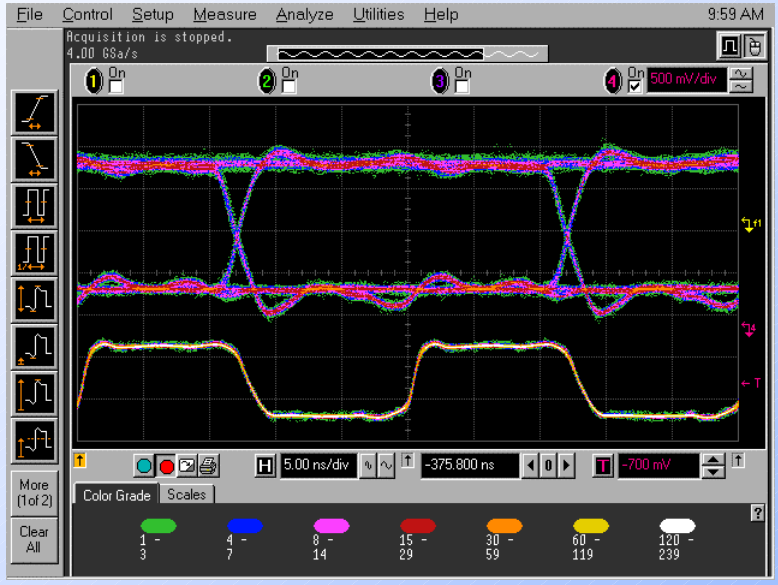
- Example of data from pre-production (25 pieces)





System signals

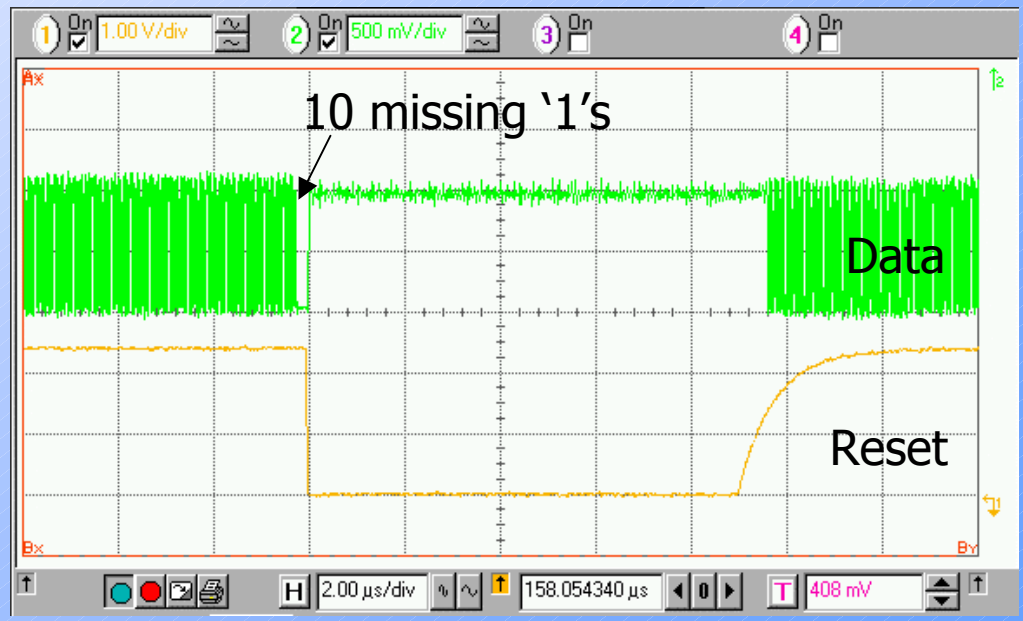
- Eye patterns



Data

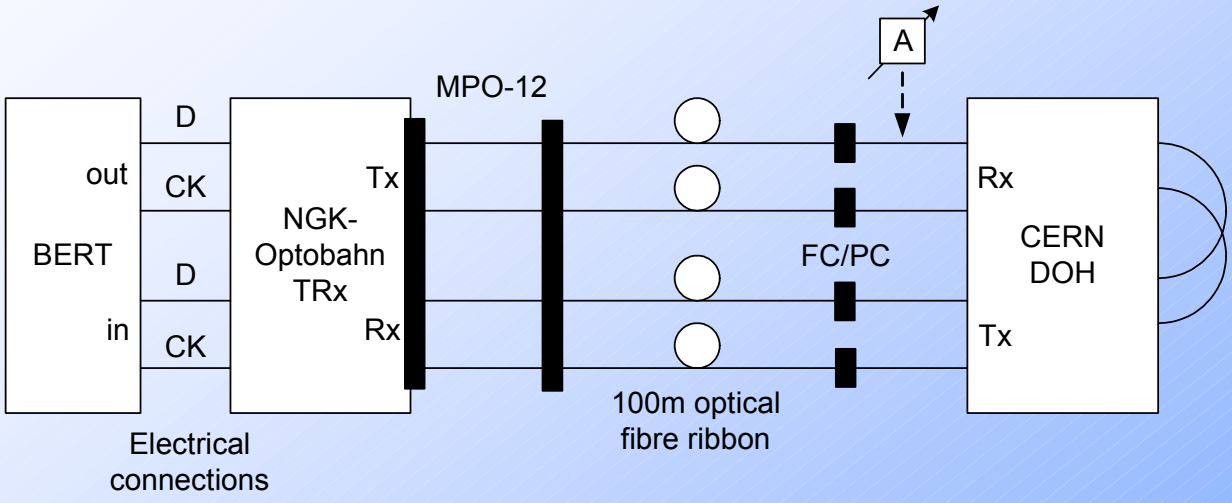
Clock

- Reset generation



Full link measurements

- Full link made with DOH, TRX, 100m cable + 3 'patch-panels'



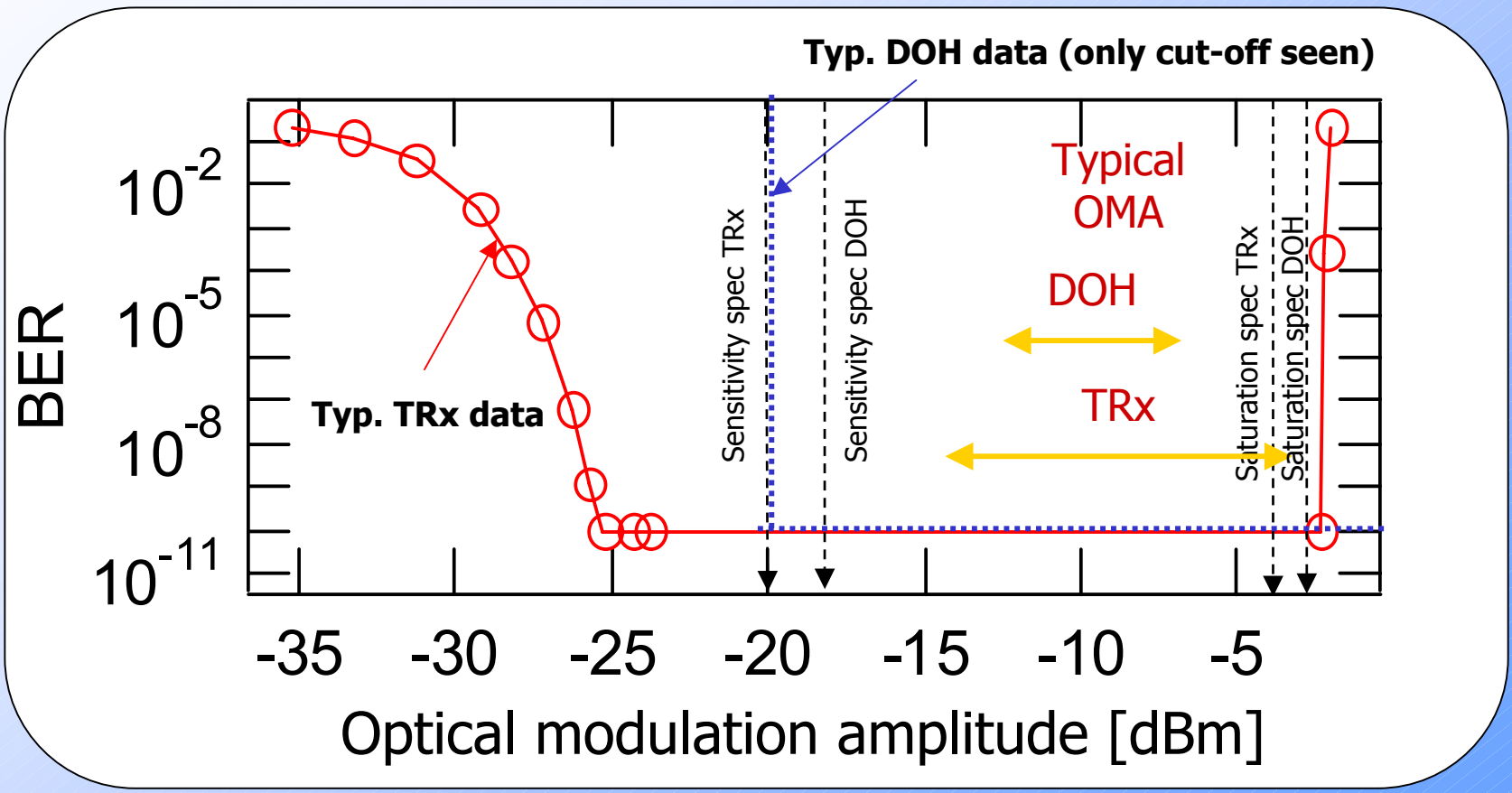
- Optical power margins measured in each channel
  - optical attenuation increased to point where errors occur or link fails

- From DOH to TRx	- From TRx to DOH
- Clock: ~17.5dB	- Clock: ~9.5dB
- Data: ~17.5dB	- Data: ~10dB

- Tested for 15 hours without any errors - BER < 3×10^{-13}

Illustration of Sensitivity & Saturation

- To illustrate the power budget and margins
  - consider BER vs average launched power

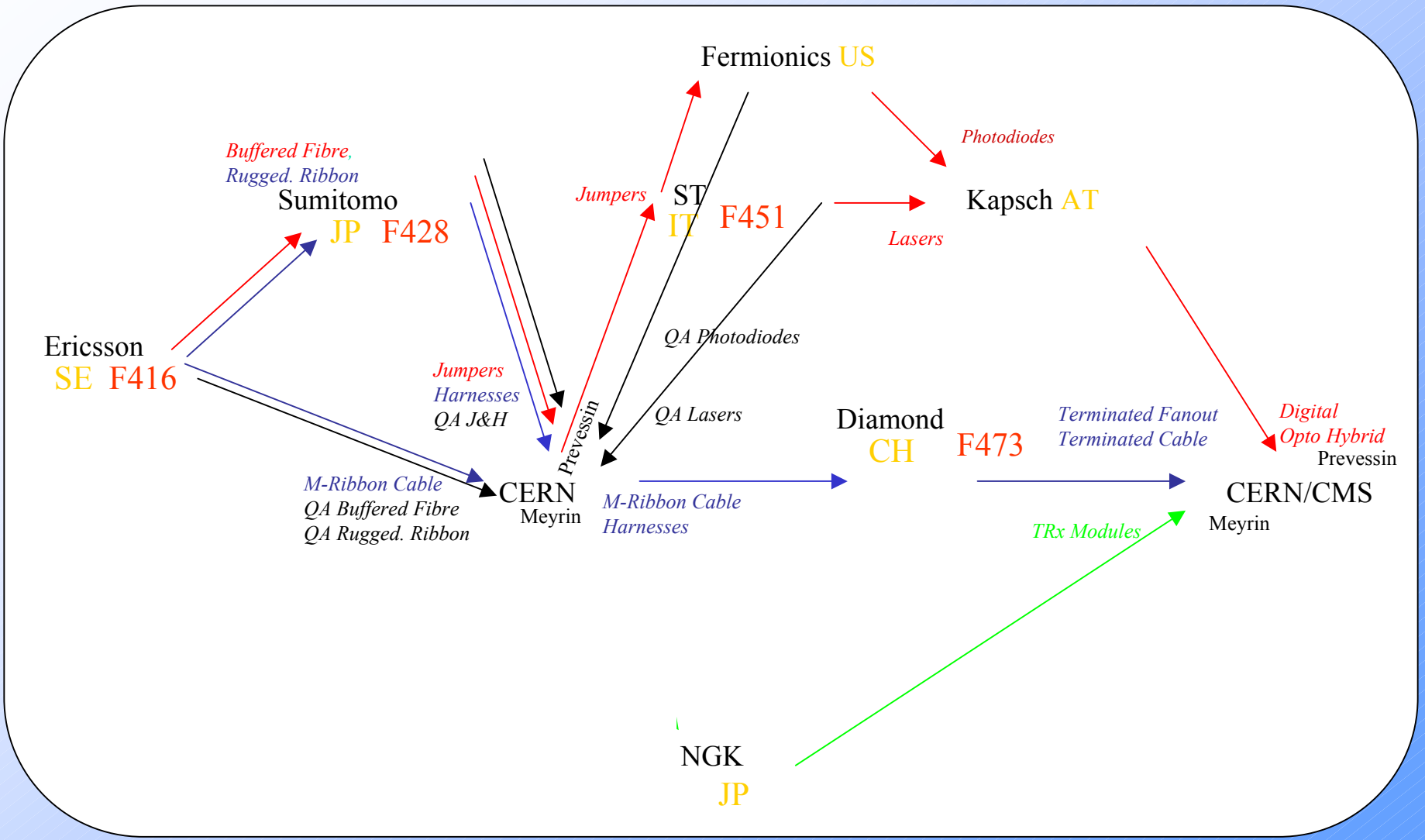


- BER lower limit due to short measurement period (3 minutes with 40MHz, PRS-7)

Production Status

Production flow

- Derived from analogue component flow + PINs, TRx, DOH.

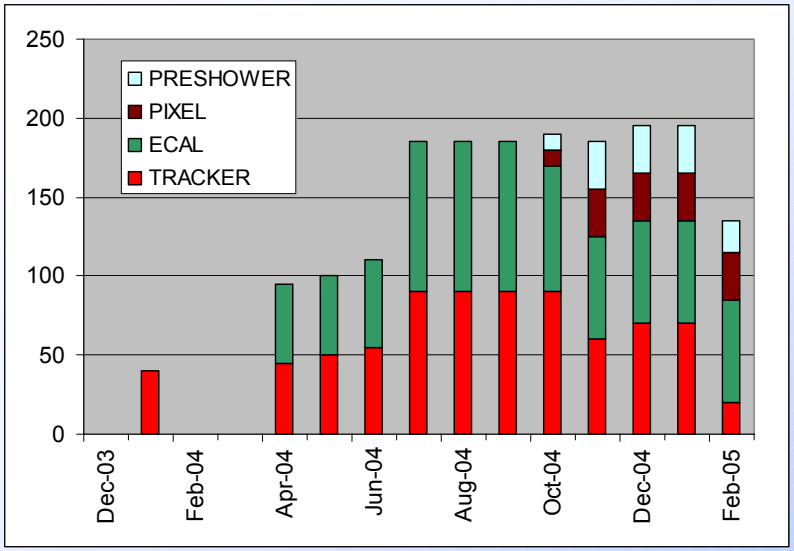


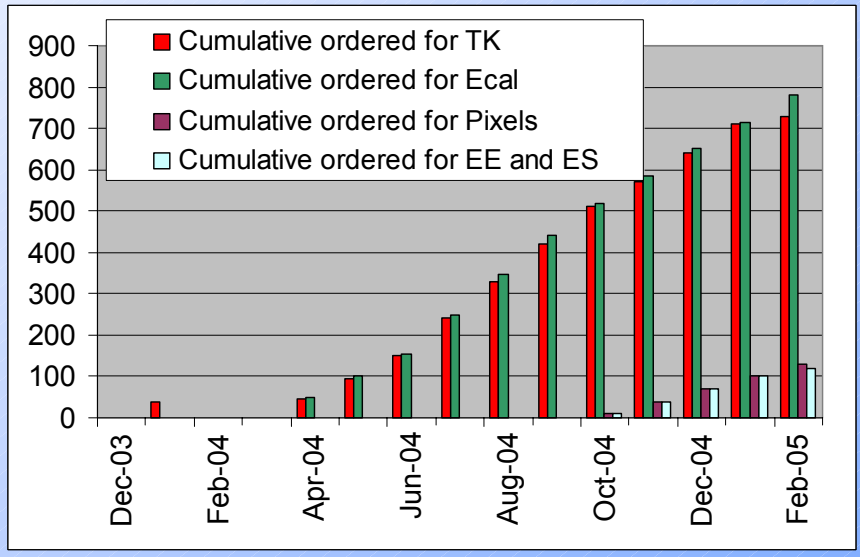
Production status

- DOH pre-production
  - Order now in place at Kapsch
    - Met 29/11 in Vienna
  - 40 hybrids to be delivered end January
    - All tested during assemblyusing CERN supplied setup
      - before/after mounting lasers and pins
    - Full qualification at CERN Feb-March
  - If sucessful, DOH series production starts in April 04.
  - Will irradiate v4 CERN hybrids in November/December 2003.
- TRx series production will start soon.
  - New TRx modules for ECAL order will be re-qualified.
- PIN series production will start soon.
  - AVT aging step almost finished.
- All test procedures prepared

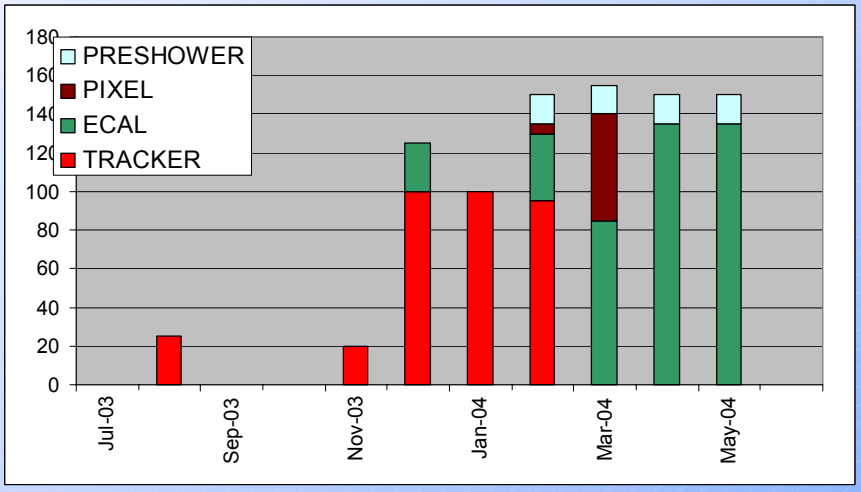
Delivery schedule

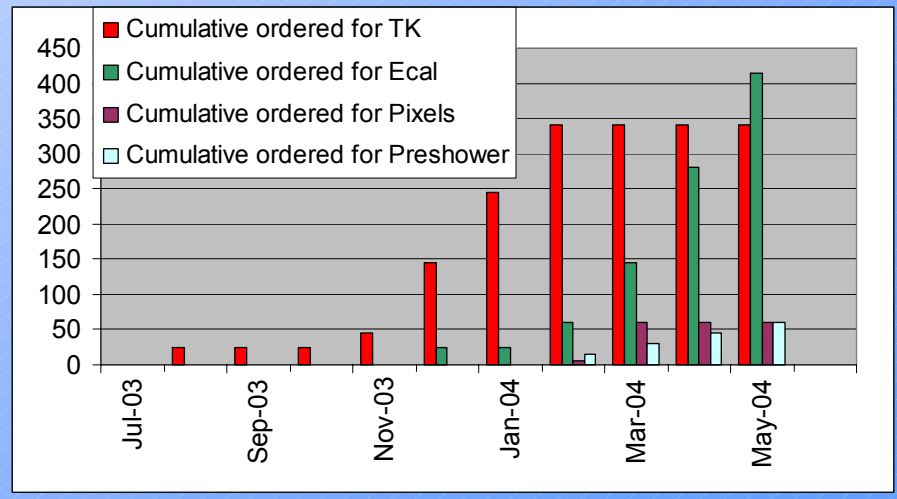
DOH





4-TRx





Conclusions

- Control link specs frozen earlier in 2003 PINs, DOH, TRx
  - Available on EDMS
  - Shares many parts/procedures with analogue readout links
- QA/test procedures and schedules written, test-equipment ready
- Cabling/integration/traceability in parallel with analogue readout links
- Procurement started for all parts specific to the digital control links
  - PIN photodiodes (Fermionics, USA)
    - Pre-Production Qualification complete
    - Advance validation test (AVT) almost complete
  - Lasers (ST, Milan)
    - Low efficiency lasers integrated into schedule. 100 parts made.
  - DOH (Kapsch, Vienna)
    - CERN Prototype Version 4 (Narrow – Pixel request) delivered/tested
    - Kapsch Order finalized.
  - TRx (NGK Insulators, Japan)
    - Pre-Production Qualification almost complete
    - Integration of TRX onto mFEC done
- Small number of 'final' links (~10) available now if needed for test-systems