PAUL SCHERRER INSTITUT

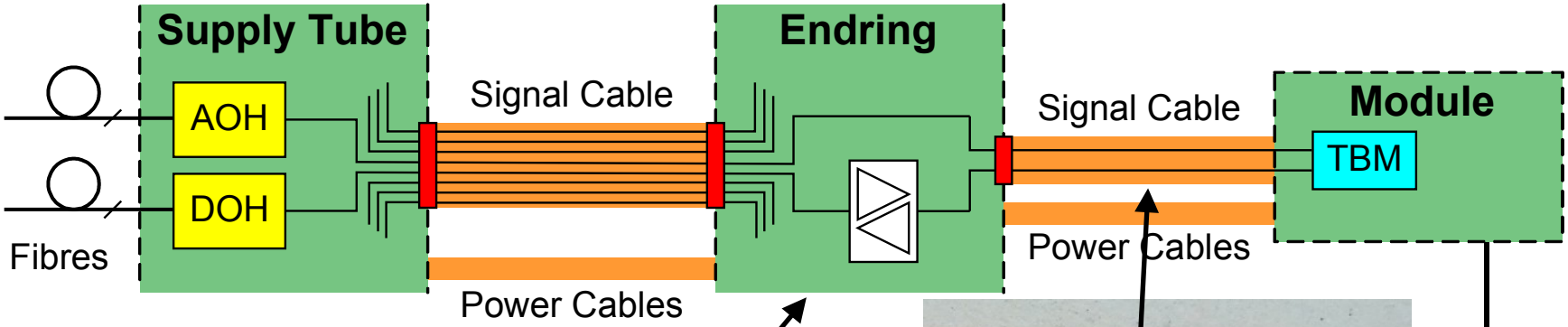
Low Power Links for CMS pixel upgrades

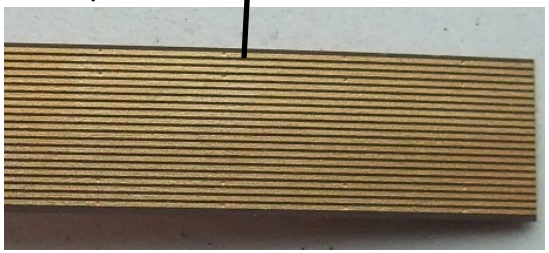
W. Erdmann for the PSI Pixel Group

ACES 2009

04 March 2009

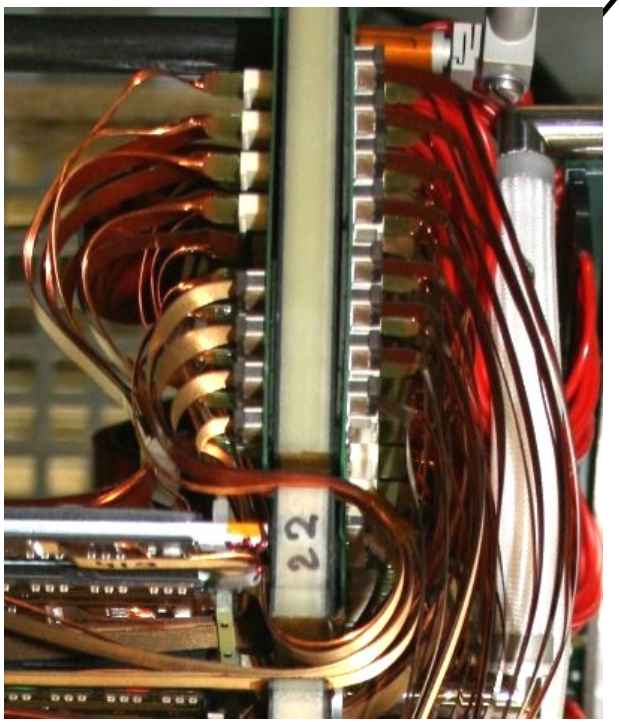
Existing Data Link in CMS Pixel Detector

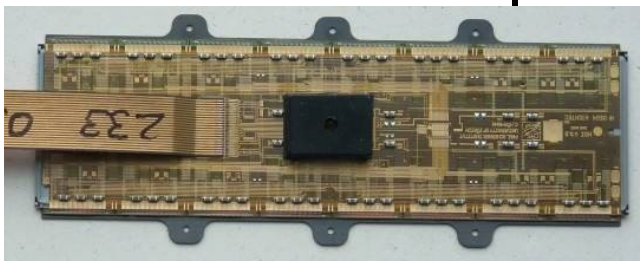




Kapton cable with 21 traces and ground plane

analog + digital signals





Existing Pixel Barrel

- first approach: standard LVDS everywhere
- dropped, because of
  - power consumption
  - unacceptable cross-talk digital → analog signals
- adapt links
  - intra-module: unterminated LVDS-like
  - low voltage swing differential "LCDS" (80 mV , 33 Ohms)

Goals for the pixel upgrade

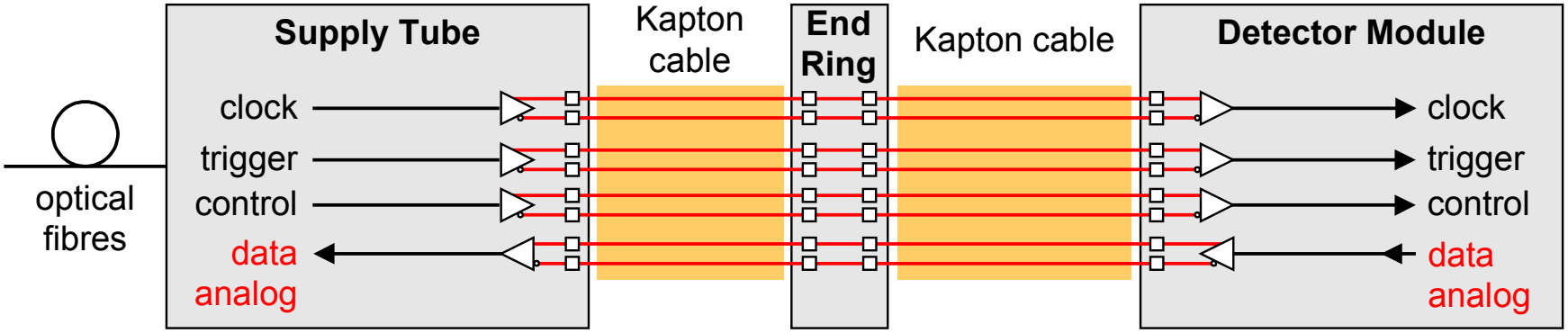
- reduce material in the tracking region
  - move auxiliary electronics further out in z
  - get rid of connectors at the endring
  - low mass cable
- transmit more channels through the same number of optical fibers
  - analog →high speed digital

1..2 m long, flexible cables/ribbons

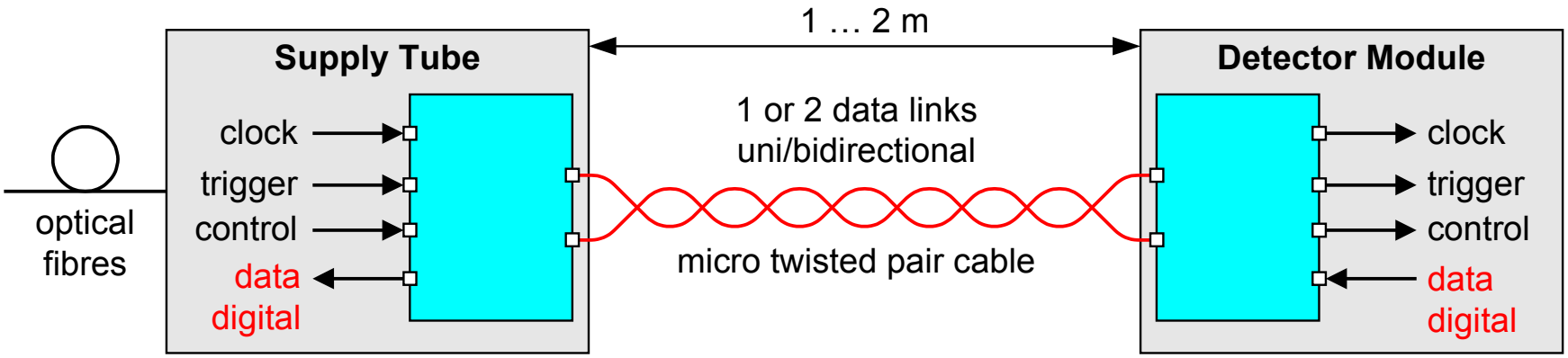
Kapton cables not longer suitable, → micro twisted pair

Comparison to a possible new Concept

Existing System in CMS Pixel Detector

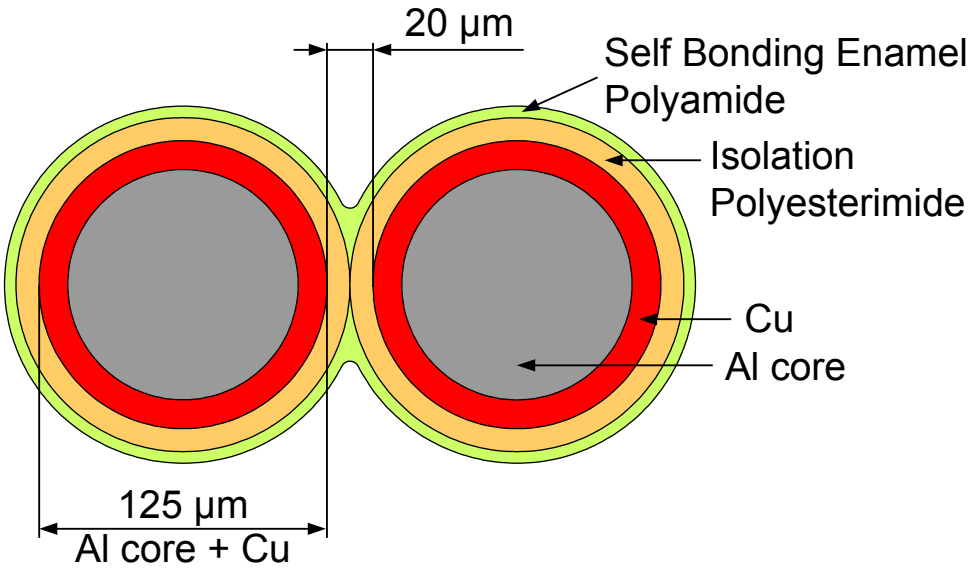


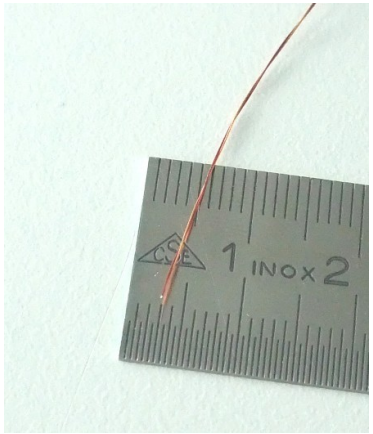
New Concept



Micro Twisted Pair Cable

cross section





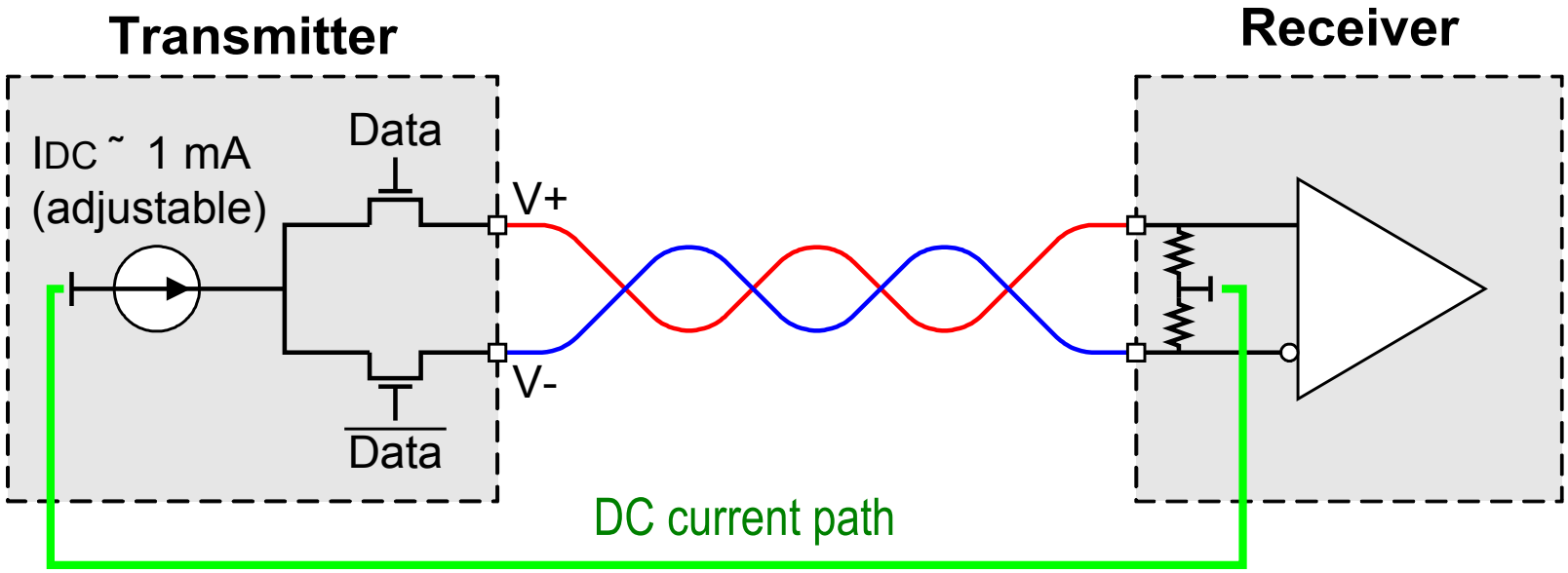
First Choice:

- twisted pair self bonding wire
- 125 µm wire diameter (4um Cu)

Electrical characteristics:

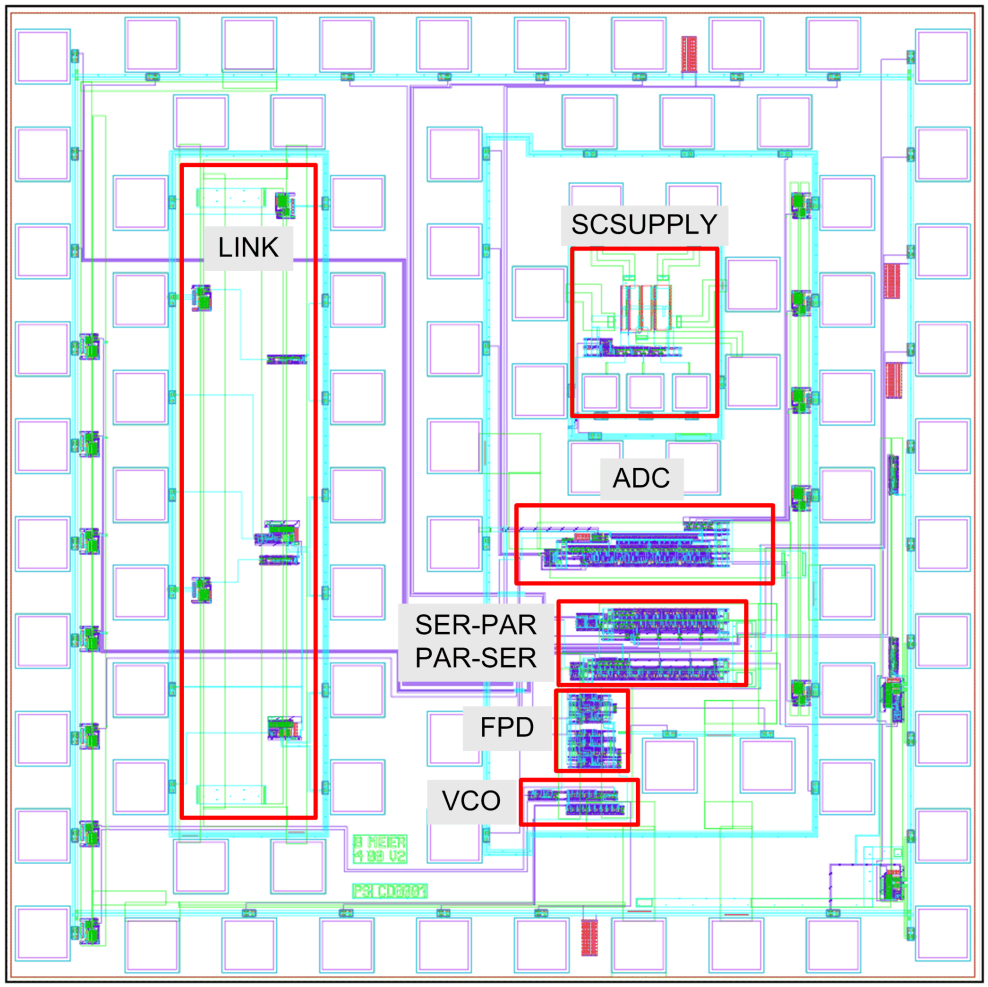
- Impedance: 50 Ohms diff. (low)
- v = 2/3 c_0 (5 ns/m)
- C = 100 pF/m, L=250 nH/m

Data Link



- Differential Current Driver (LCDS) from CMS Pixel with adjustable levels
- rise time < 400 ps
- DC loop closed over power lines

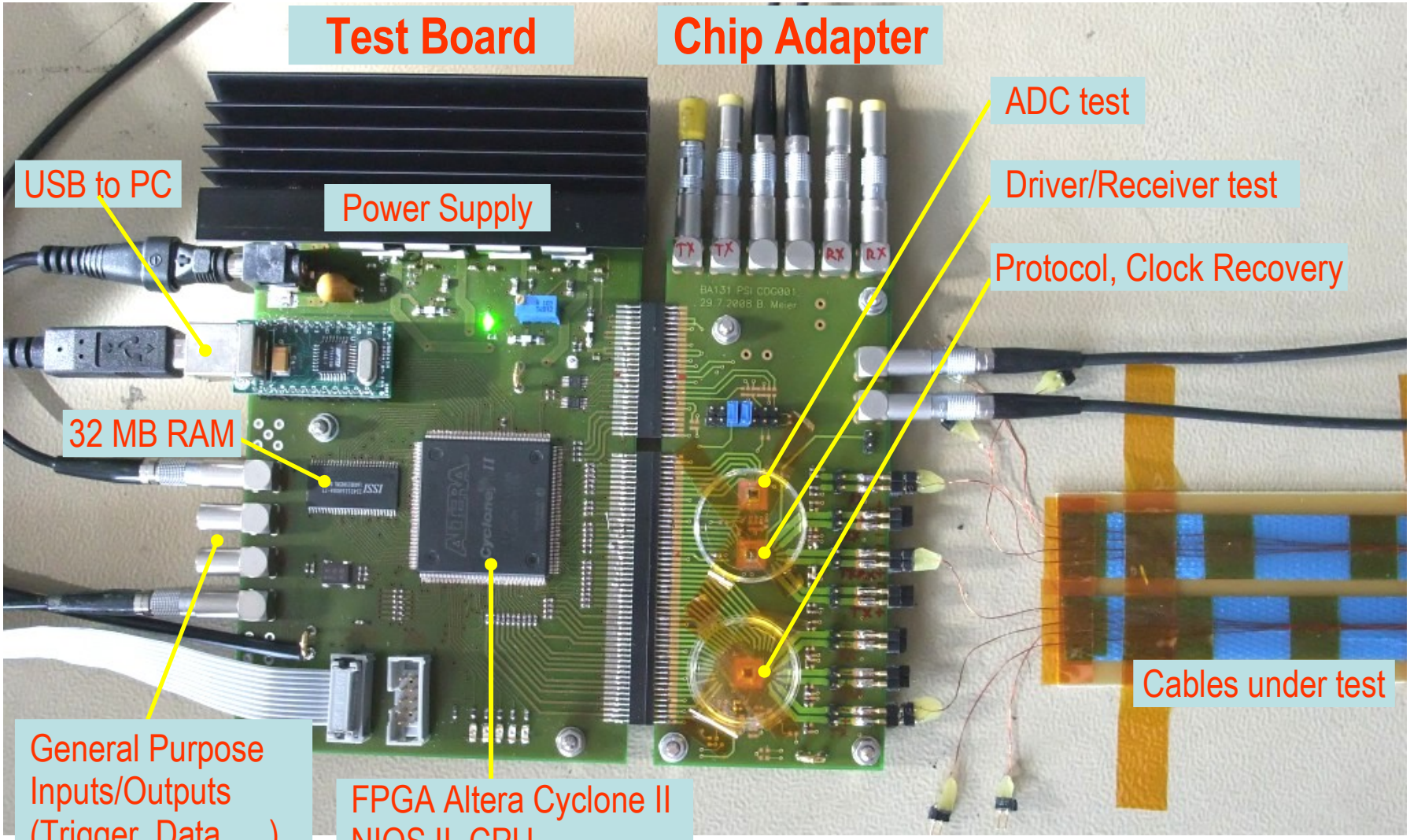
Test Chip Layout



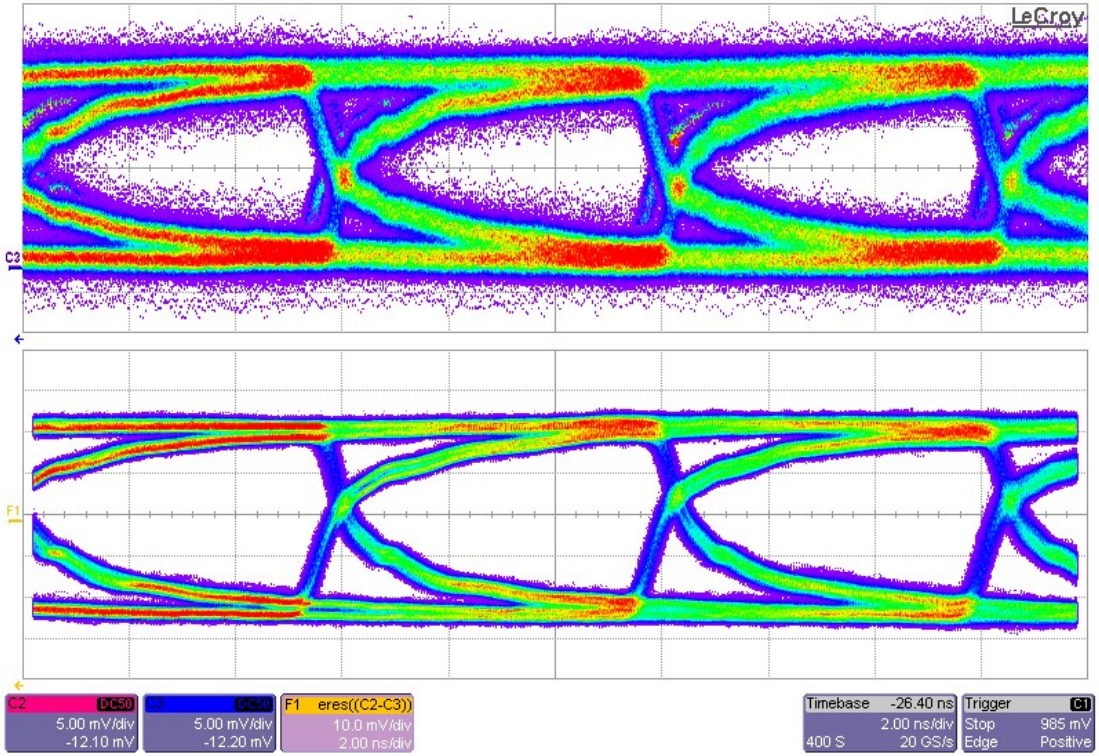
Design of a first test chip
(PSI Chip Design Core Team)

- Size: 2 x 2 mm
- Technology: 250 nm CMOS IBM same as CMS Pixel ROC
- CERN MPW submitted in April 2008
- modified design submitted to UMC 250 nm, February 2009

Chip Test System



Eye Diagram at 160 Mbit/s

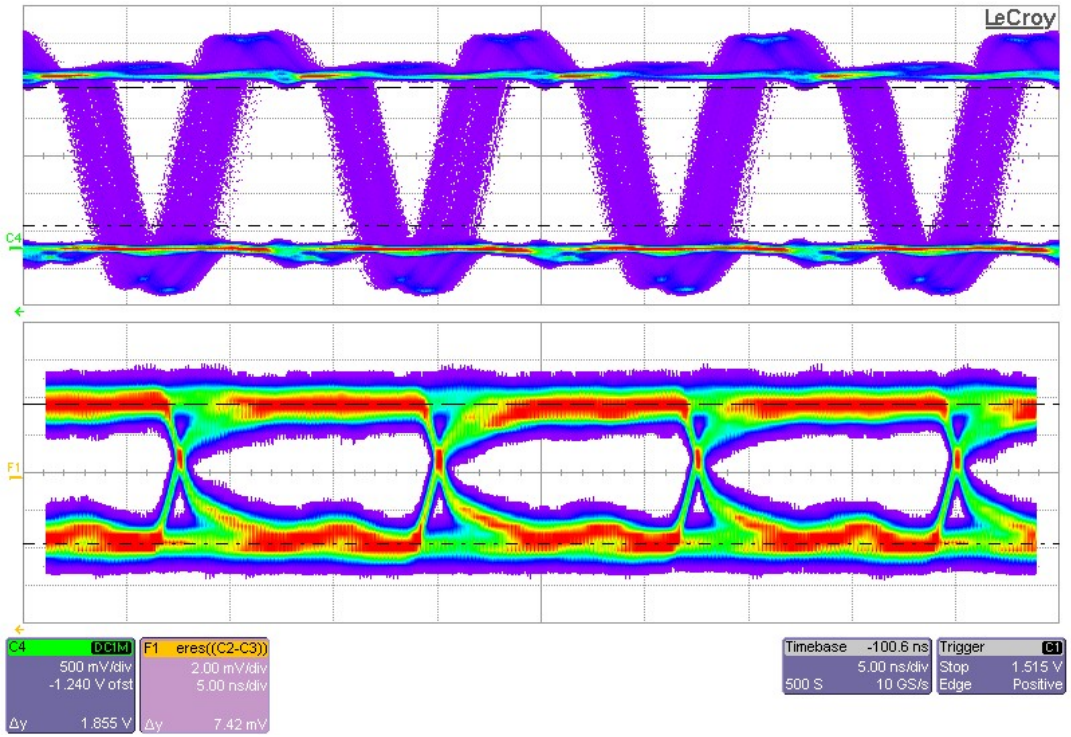


V+ and V-

V_{diff} = 45 mV

- Line length: 2 m
- agrees with lossy transmission line simulations

Bit Error Rate Measurements



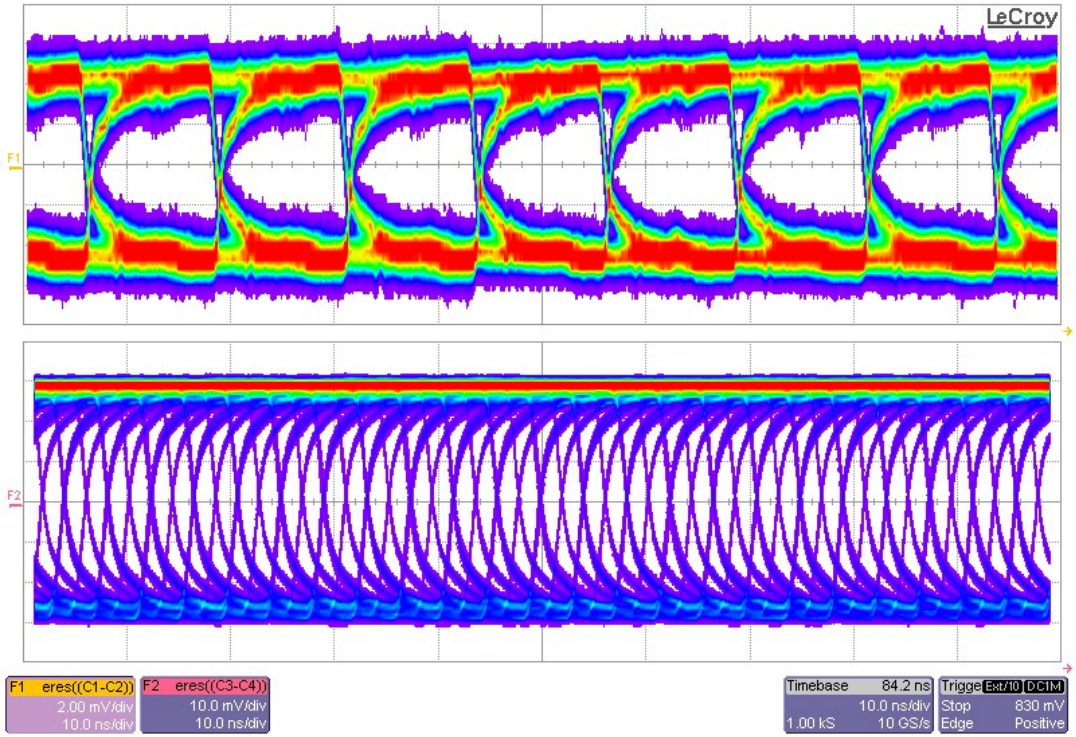
Receiver output signal

V_{diff} = 7.4 mV @ 80 Mbit/s

Scope bandwith limited to 1 GHz

- 80 Mbit/s and 160 Mbit/s
- Bit Error Rate < 10^{-11}
- receiver problem (time asymmetry)
  → amplitude at receiver > 35 mV needed @ 160 MHz

Crosstalk



V_{diff} = 9 mV @ 80 Mbit/s

Scope bandwith limited to 1 GHz

parallel line signal (asynchronous)

V_{diff} = 56 mV

- 80 Mbit/s and 160 Mbit/s (with higher level)
- No difference in bit error rate visible with/without disturbing signal
- very robust for crosstalk (twisted cable, high capacitance cables
- Bundling of multiple unshielded cablese appears possibl

studies with ribbons

Bundle 16 twisted pairs

Flat ribbon, 4 mm wide

too stiff when glued everywhere

better when “stiched”e

alternative: braided

very flexible

5-10% more material

connectivity?

Conclusions, Outlook

- low mass, low power lind for an upgrade pixel detector
- Less than 10 pJ per bit (2m)
- 160 Mbit/s is ok
- expect 320 Mbit/s with new revised design
- crosstalk levels allow bundling the unshielded cable
- ribbons under study

	new Data Link	CMS Pixel
Supply	2 V	2 V
Driver Current	0.4 mA (V_{diff}=20 mV_{pp})	2 mA
Receiver Current	0.2 mA	0.2 mA
Total Power per Link	1.2 mW	4.4 mW
Bitrate per Data Link	160 Mbit/s (320 Mbit/s)	100 Mbit/s (2.6*40)