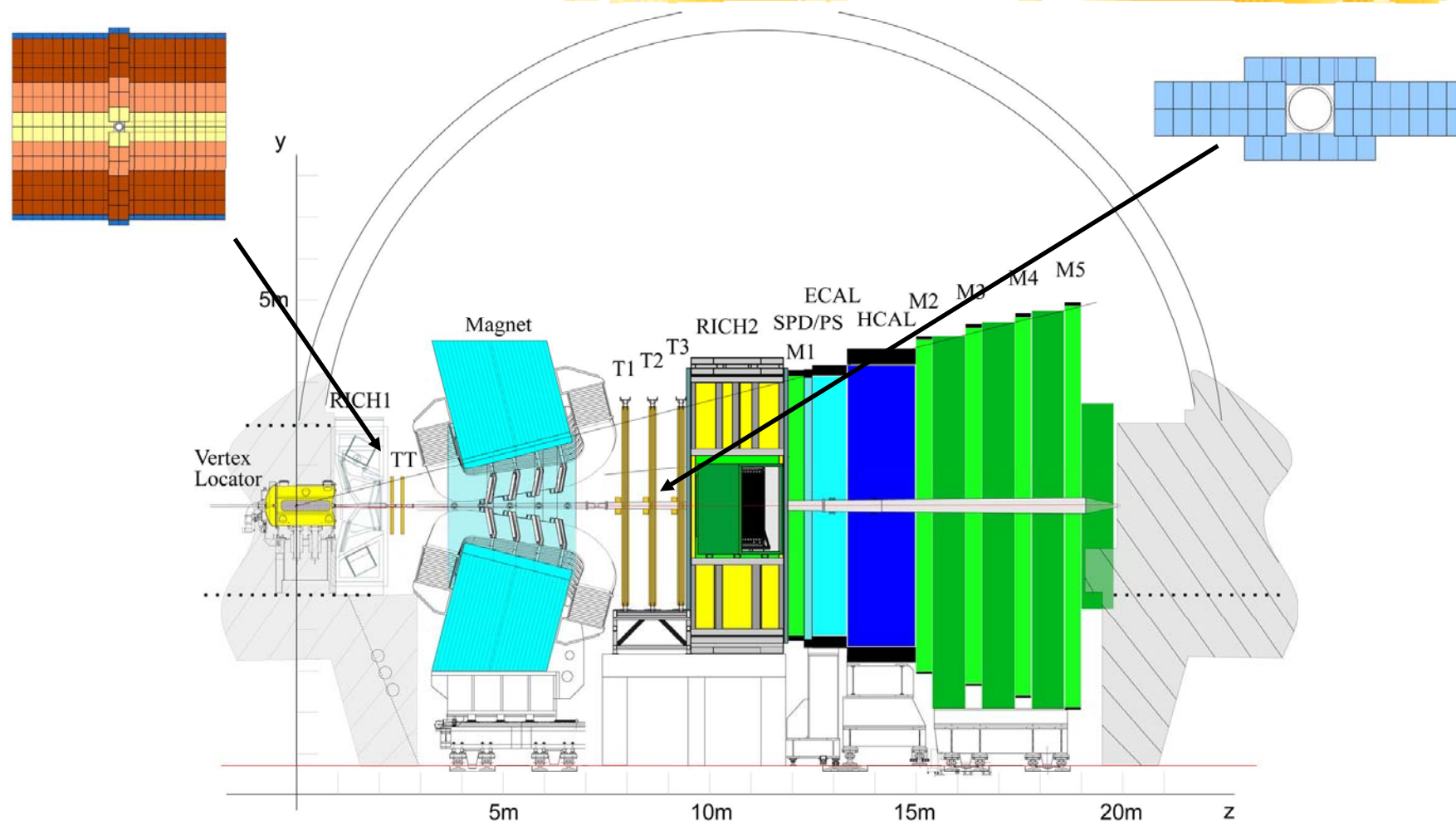




# The LHCb Silicon Tracker: Lessons learned (so far)





# Outline

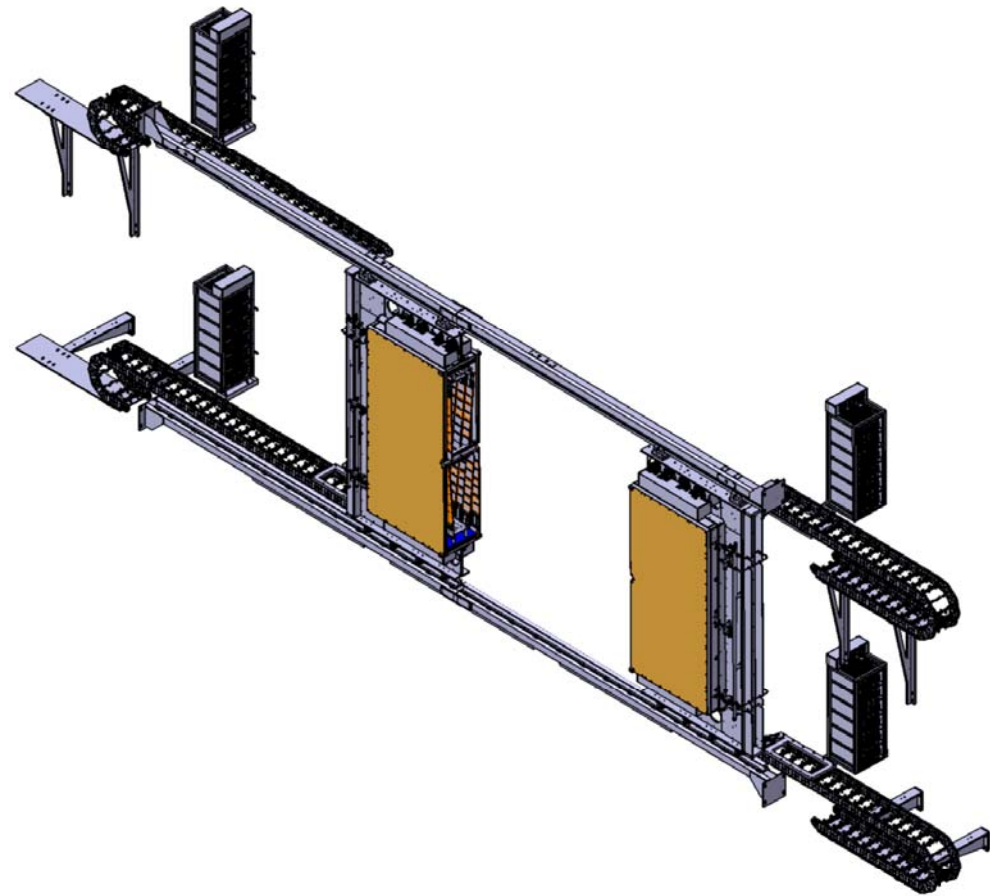
- Overview of the Silicon Tracker
- Module issues + Bonding
- Connectors + flexible prints
- Electronic design issues
- Conclusion + Outlook



# TT station in front of magnet



TWEPP08, Naxos

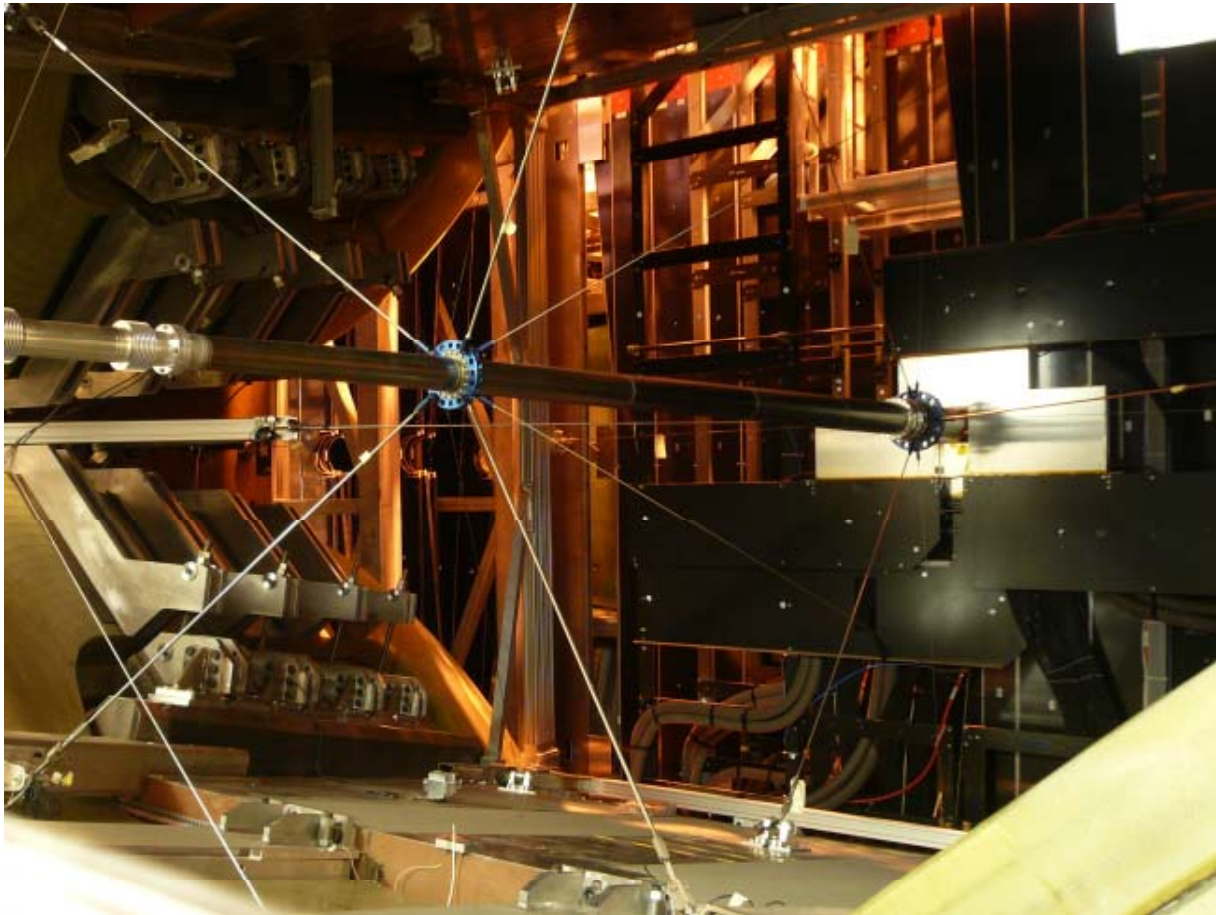


A. Vollhardt, Uni Zürich/Switzerland





# IT stations behind magnet



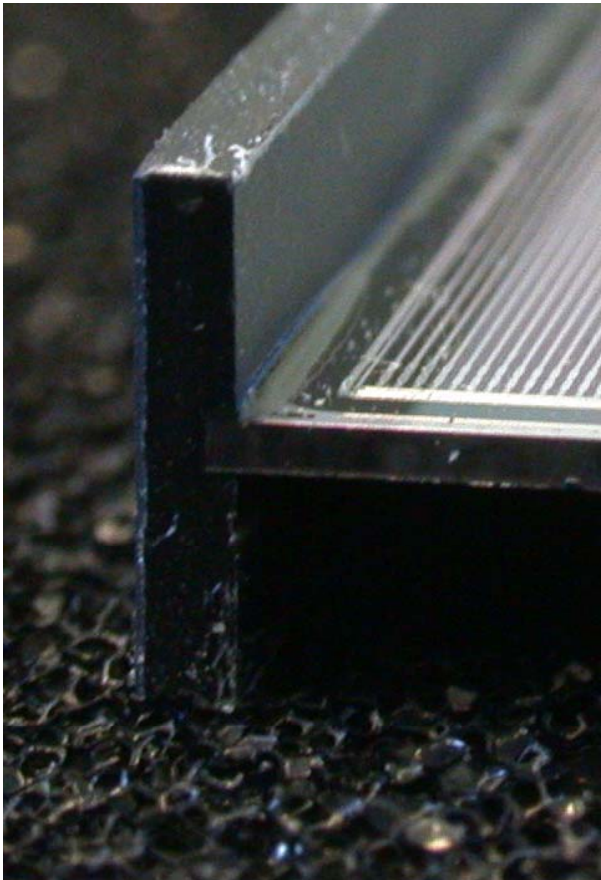


# Disclaimer

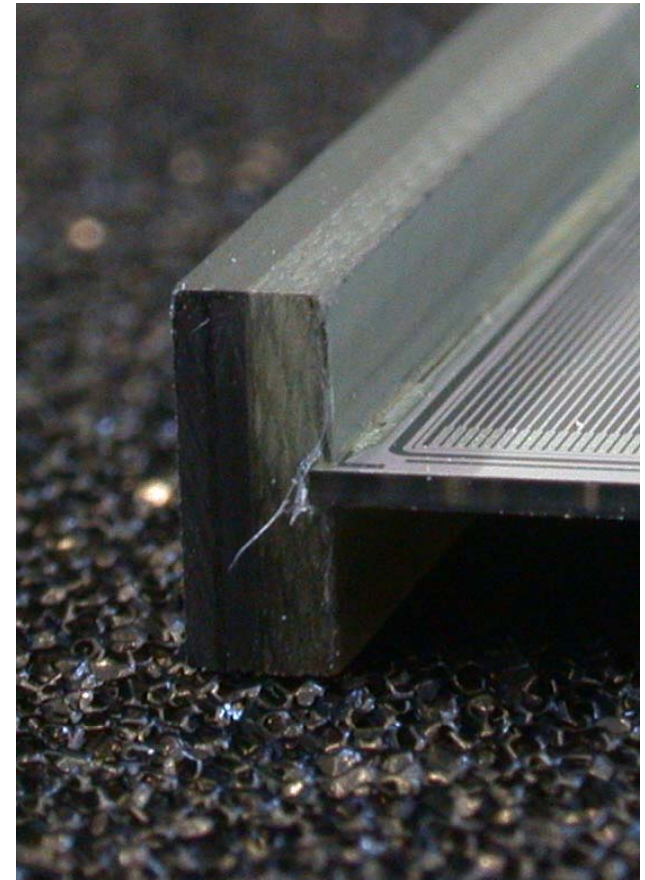
Any information presented in this talk is for the sole purpose of knowledge transfer and sharing the experience made during the commissioning of the LHCb Silicon Tracker. No responsibility for any mistakes shall be attributed to anybody by this presentation...

... except the ones I did myself ☺

# GFK/CFK sensor rails



- Parylene coated CFK rails to support sensor modules
- Lot of bias voltage breakthroughs
- CFK fibers not 100% covered, shorting sensor backside (bias) and guard rings
- Fix: use GFK/CFK sandwich

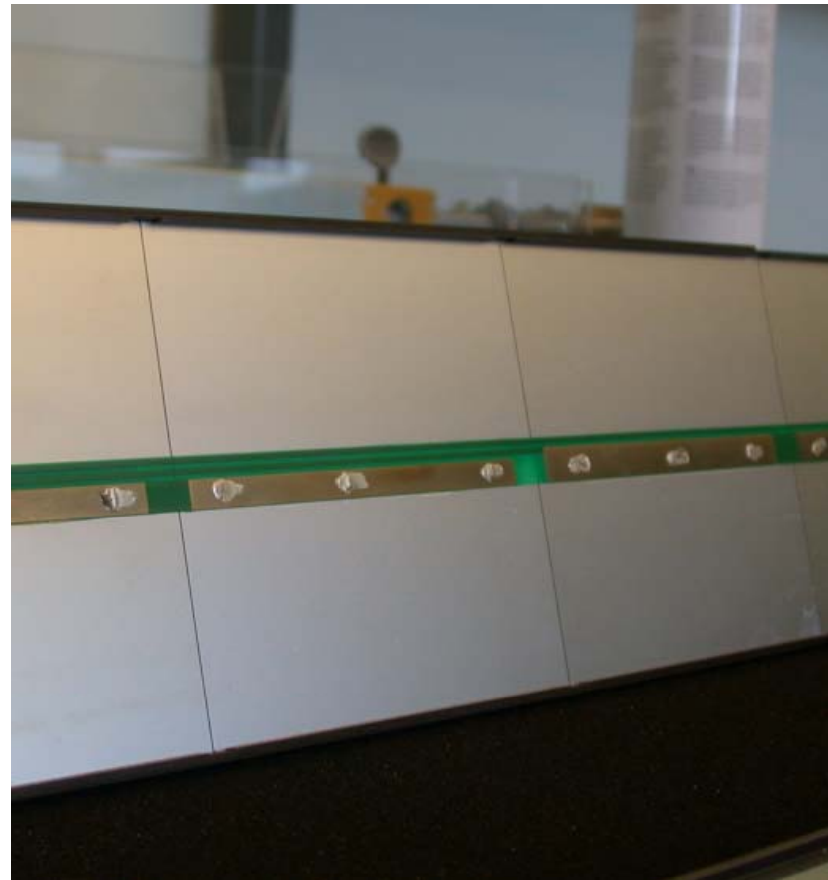






# Using conductive Glue

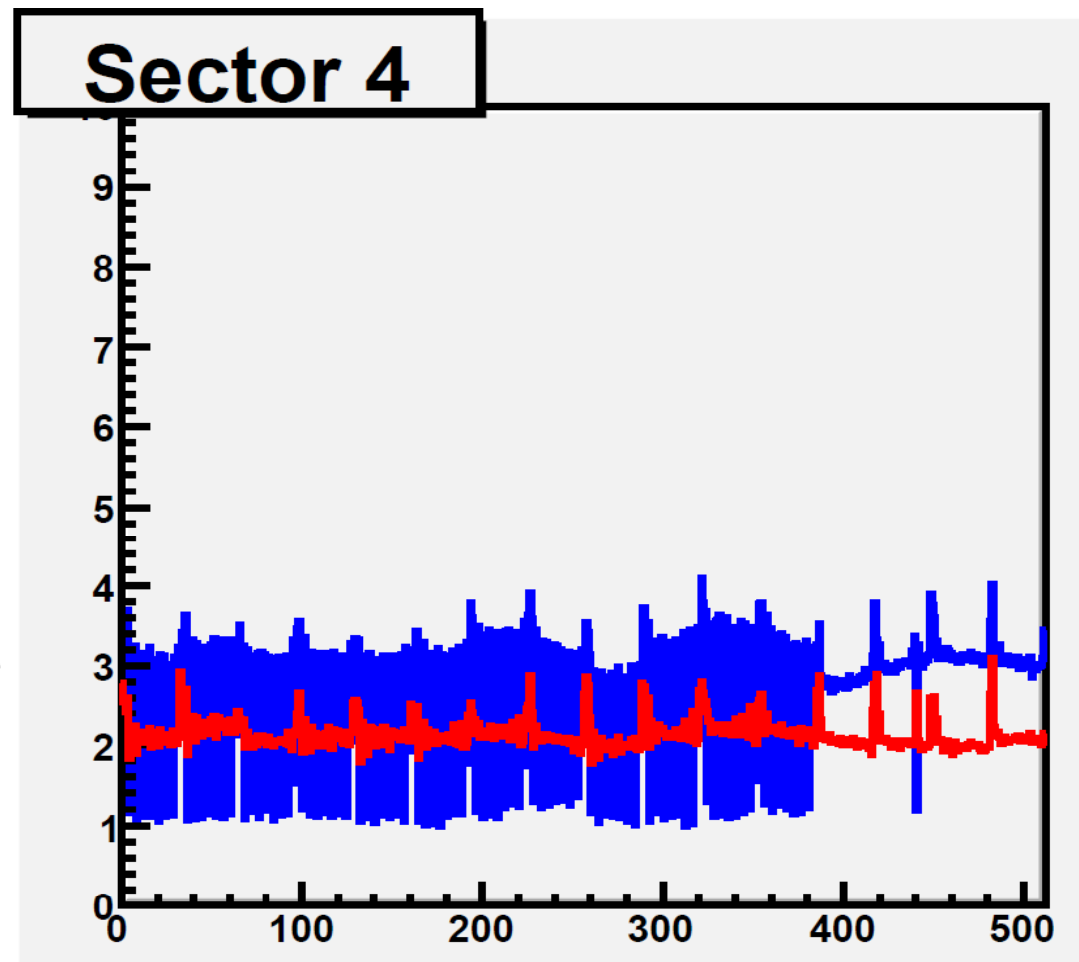
- Single compound silver glue (Ecolit) was used for connecting the sensor bias voltage on the back side and for grounding the kapton hybrid onto the copper ground plate
- The conductivity of the glue was decreasing over time -> bad grounding and unreliable bias connection
- Fix: Grounding was soldered  
Bias connection was bonded and sealed with glob-top





# 4<sup>th</sup> channel problem

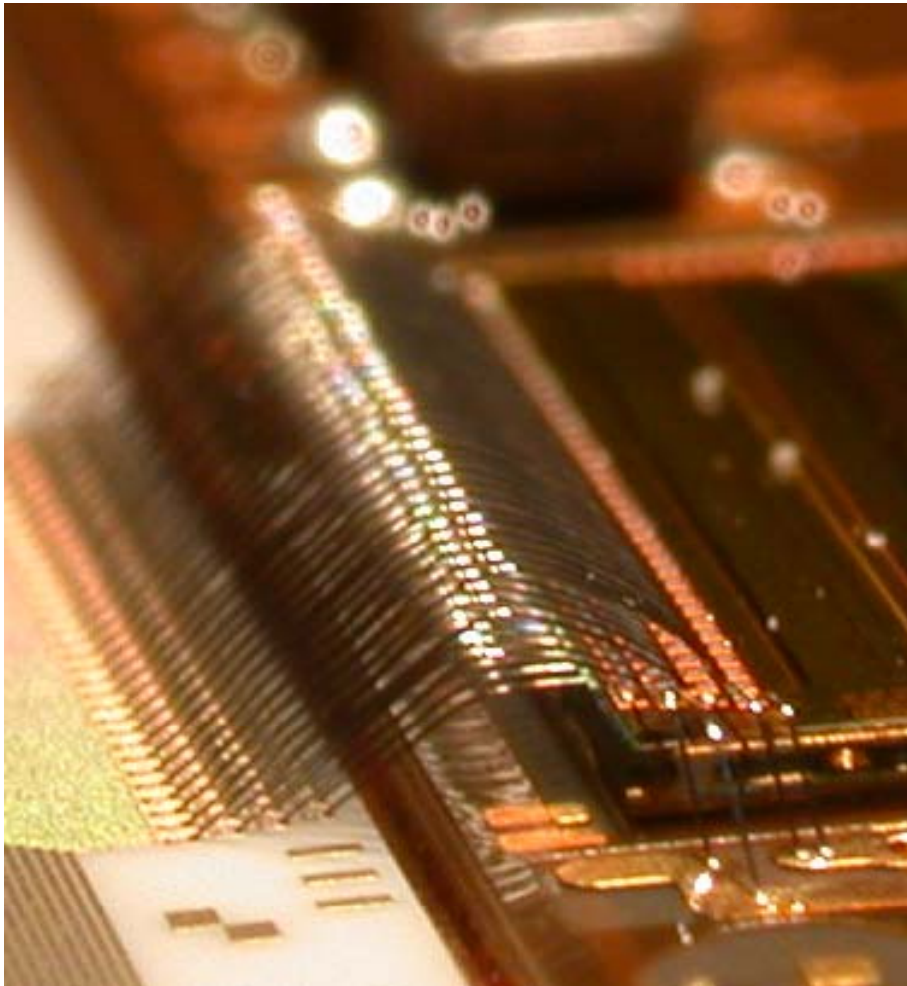
- Strange pattern seen after some weeks: low noise on every 4<sup>th</sup> channel
- Ca. 320 bonds in total (concentrated on 5 readout hybrids)
- Problem not seen in multiple burn-in tests in Lab (incl. few dozen temperature cycles)



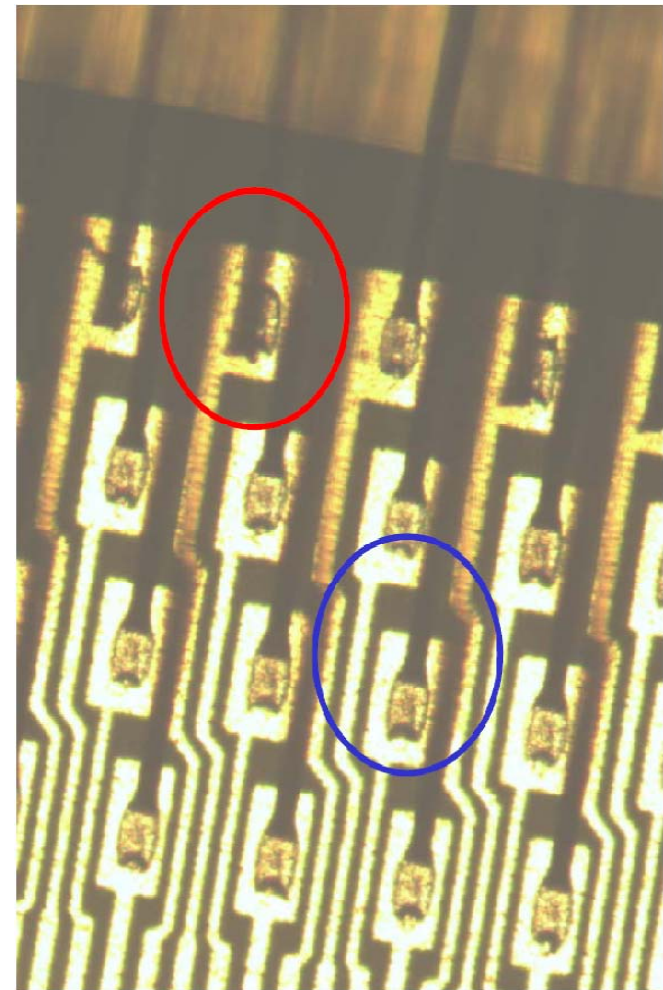




# 4<sup>th</sup> channel problem



TWEPP08, Naxos

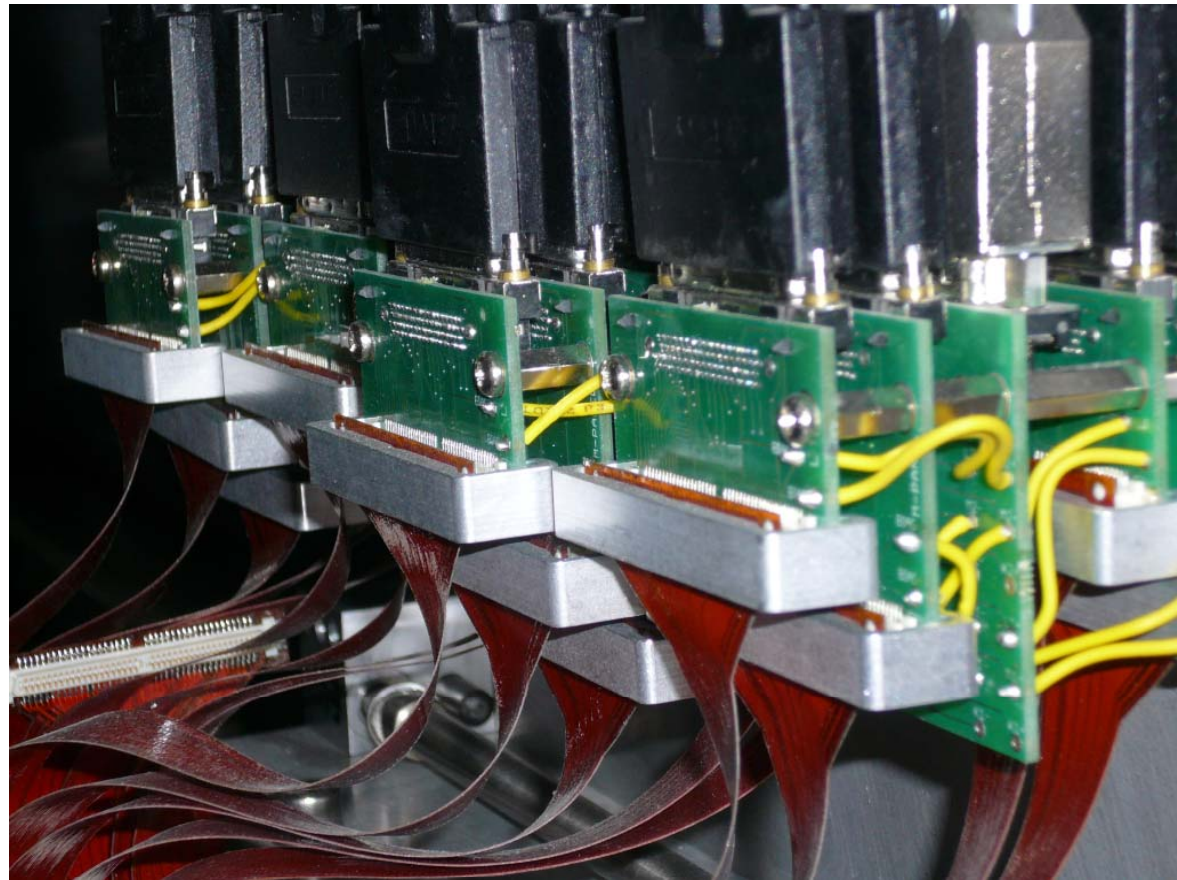


A. Vollhardt, Uni Zürich/Switzerland



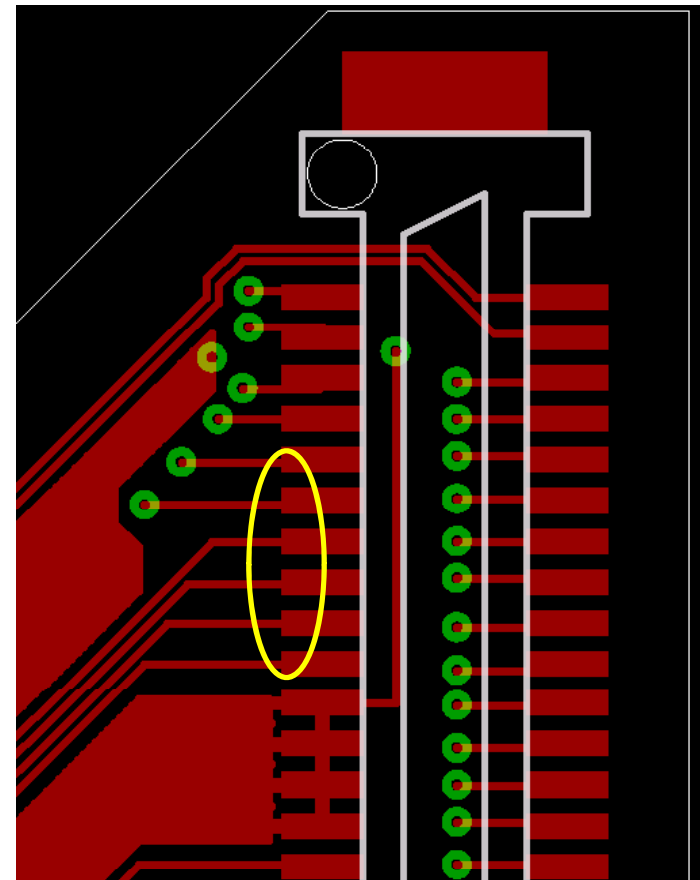
# High-Density connectors

- 80-pin connectors for insulation wall feedthrough
- One cable per readout hybrid, carries all signals/power/bias
- Kapton tension puts torque on mating interface, which can lead to unreliable contact
- Fix: Aluminum clamps to prevent connector rotation



# Kapton Flexcables

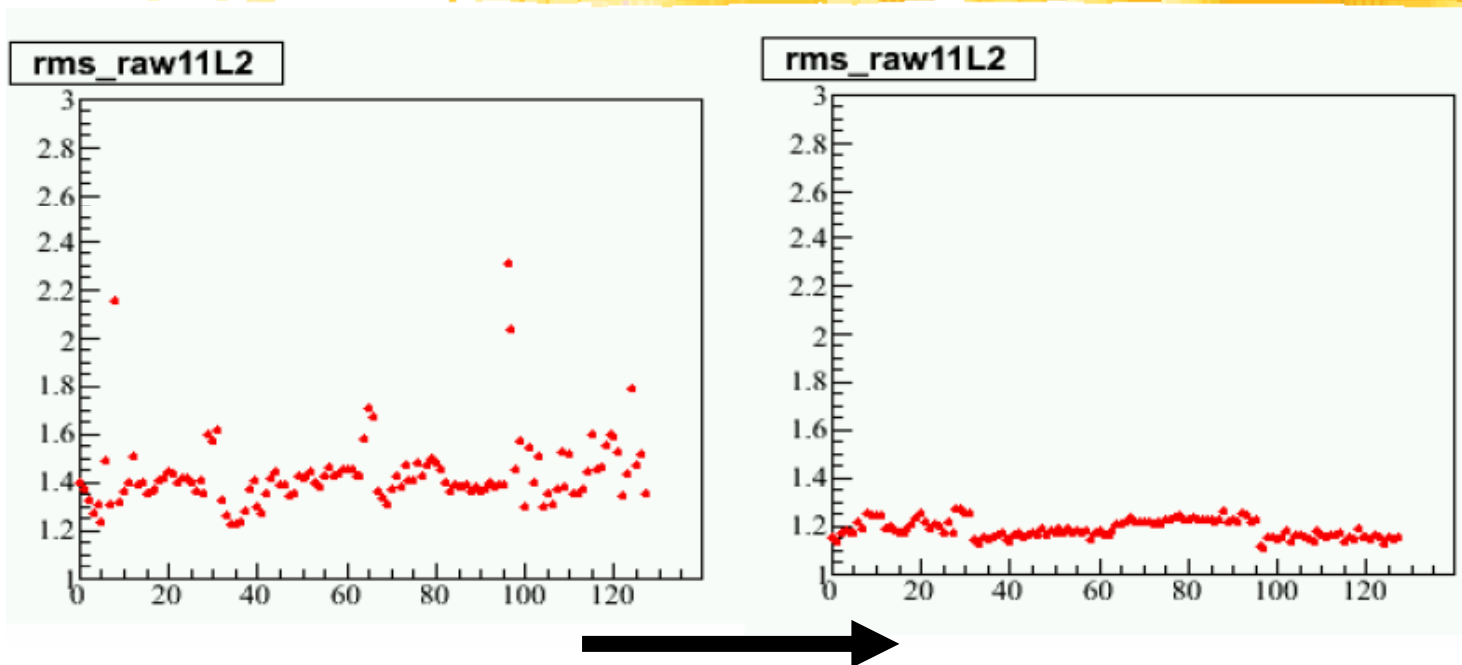
- Kapton Flexcables have open traces (6-7 cables of 280)
- Reason: hairline cracks at transition of solder joint to copper trace (solid-flexible)
- Almost impossible to repair, exchange is only option
- Lesson learned: keep trace wide beyond solder pad for some mm before thinning trace for the long run







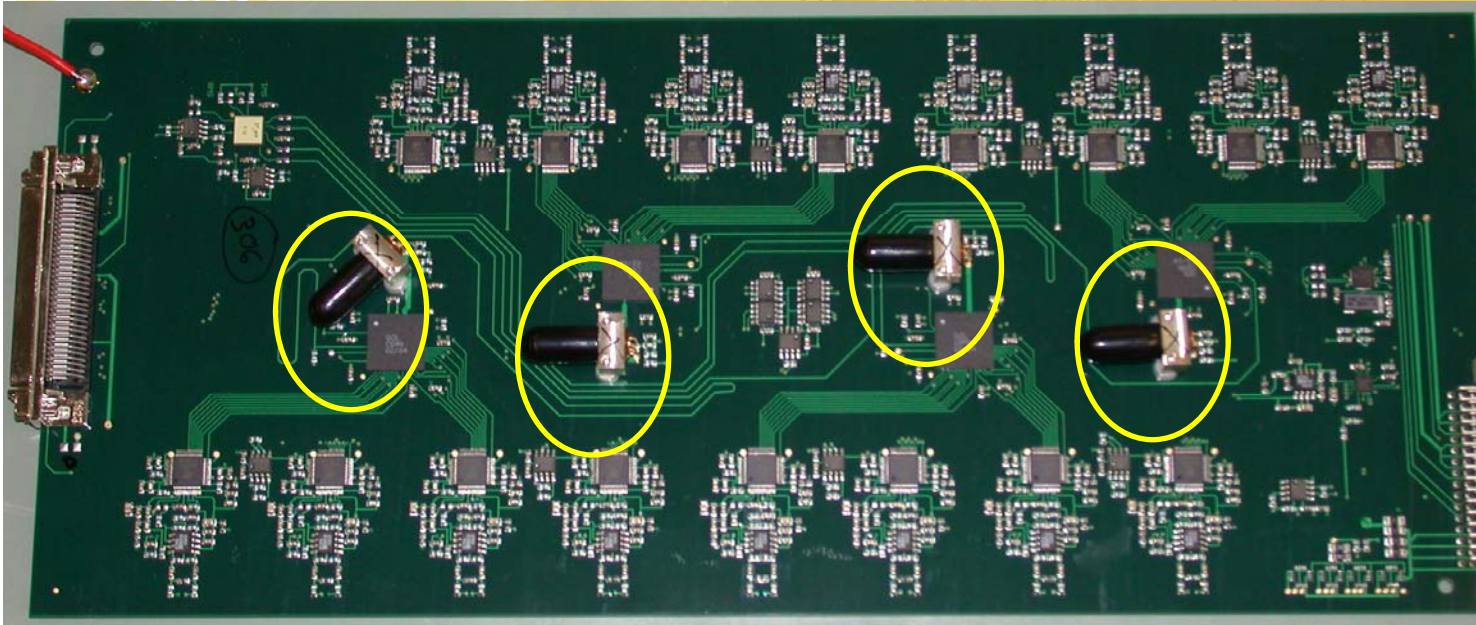
# Hunting noise: The ADC frequency response



- Analog input bandwidth of ADC 'changed' between 2001 and 2002 from 100 MHz to 1000 MHz
- Lowpass filter for out-of-band noise rejection missing!
- Fix: Adding 18 pF on an empty SMD pad did the trick...



# VCSEL Diodes

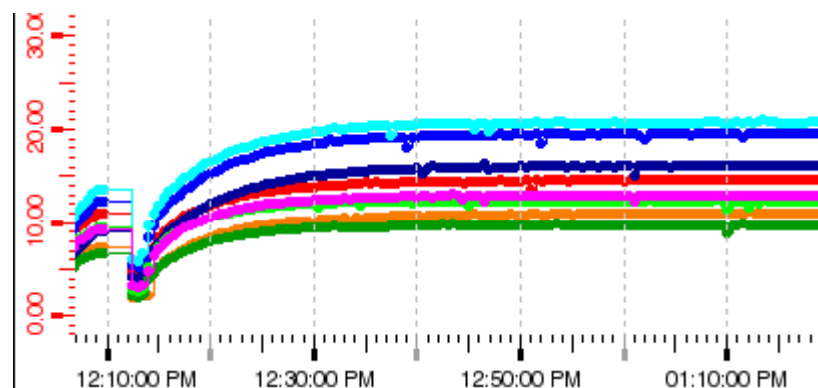
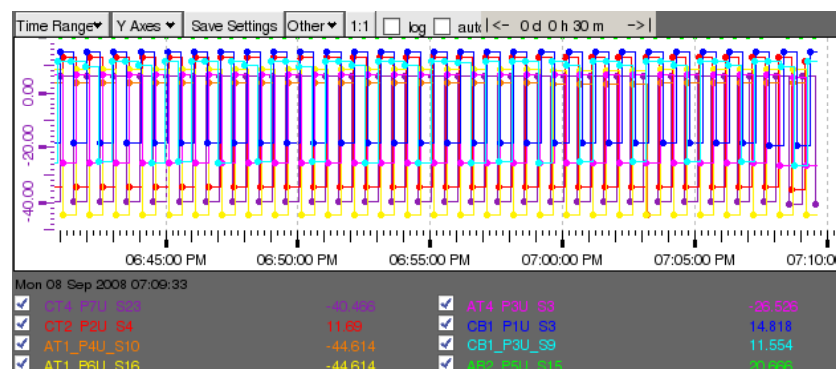


- Symptom: 30 % of laserdiodes with too little output power
- Preproduction diodes were hand soldered, Main production was wave soldered.
- Increased heat flux through fixation screws resulted in partial de-alignment of VCSEL diodes inside receptacle.
- Fix: find and exchange out-of-spec diodes.



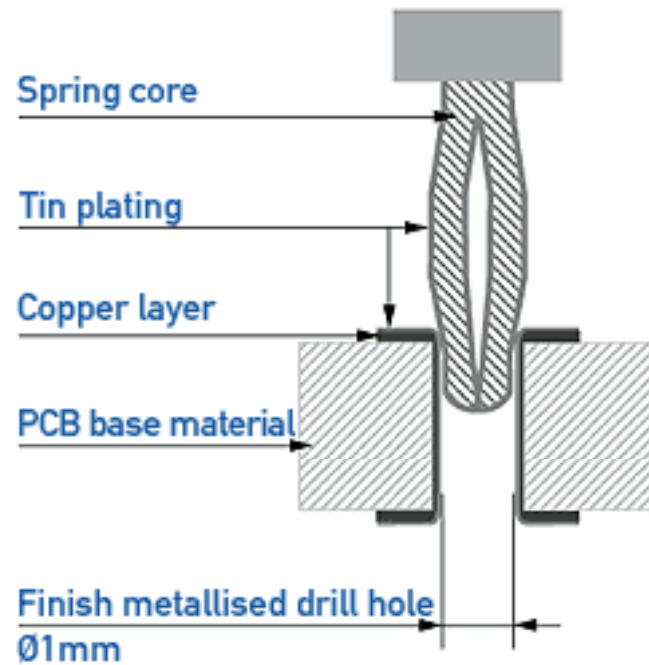
# Oscillating temperature readout

- Strange Temperature oscillations seen, traced back to DCUF slow control ADC
- Problem: voltage divider ratio for measuring regulator output designed wrong ( $>2.5V$  at DCUF input)
- Cause: voltage drop of cable calculated incorrectly
- Fix: change divider ration to reduce ADC input voltage

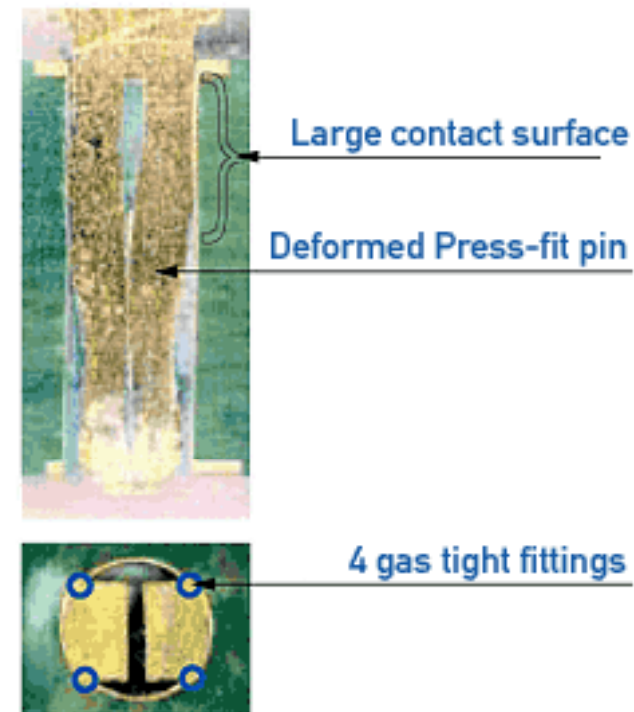


# Pressfit Connectors

Press-fit structure



Sectional view

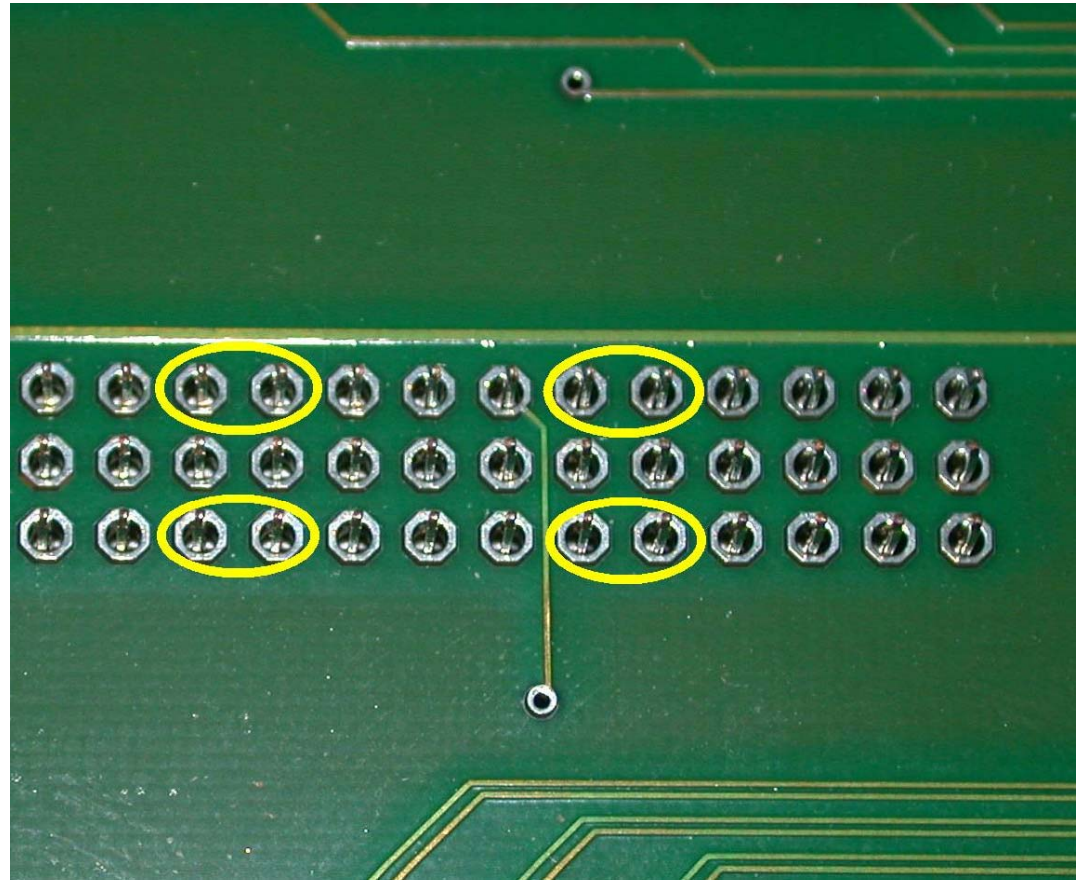


Picture courtesy of IMS Connector systems



# Pressfit Connectors

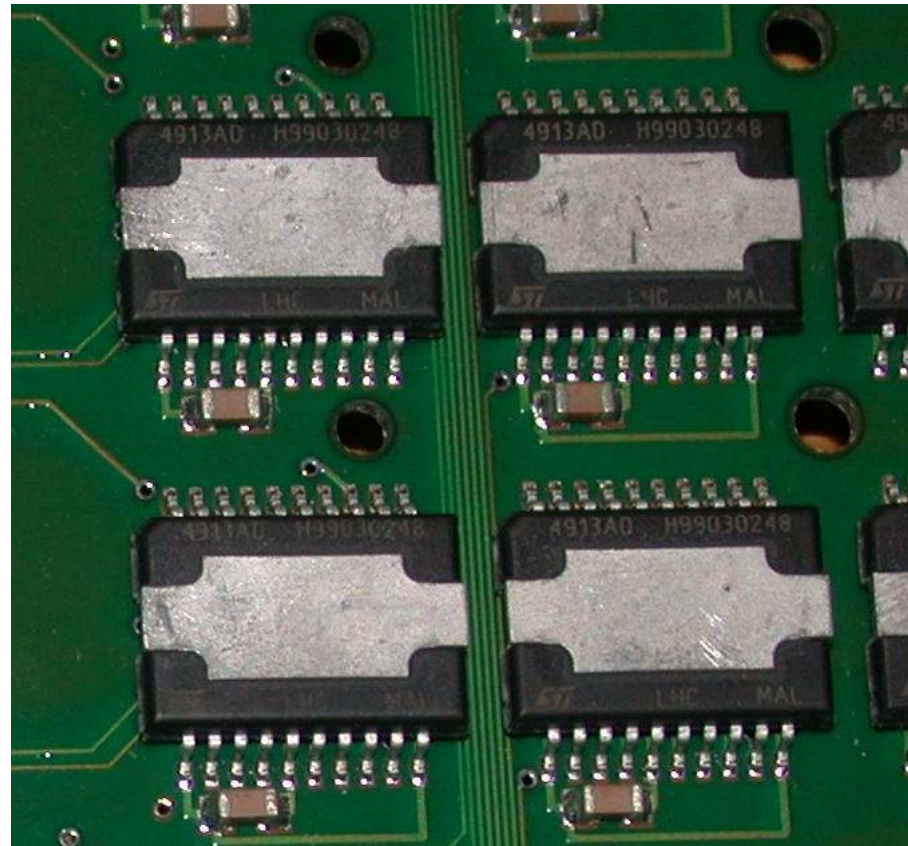
- Pressfit technology used for Box backplane connectors (DIN41612)
- Part of the pins got bent during delivery, rework by company
- Pin loses tension/reliability/contact
- Fix: all pins resoldered by hand





# Voltage Regulators

- All voltage regulators tested in test setup (24h burn-in)
- Some regulators failed to deliver rated current (1 Amp)
- Regulators signaled over-current condition
- Fix: Exchange of regulators (ca. 30 of 864)
- Was partially traced down to influence of long cables between regulator and load (8m) which were not part of the testsetup
- Still not completely understood



# Power line oscillations

- Symptom: some frontend electronic boxes draw less current when switching to max. L0 trigger rate compared to idle.
- Cause: power supply oscillations on the MARATON output going to the electronic Boxes (35m line length) (3Vpp @ 6V/20A !)
- Fix: add 1000uF electrolytic capacitor directly at low voltage terminal of electronics box





# Current status TT

	A-Side									C-Side									
TTb x	19	41	7	46	33	10	42	101	133	132	108	25	44	32	48	52	51	11	full module
	48	48	48	48	48	48	16	15		14	13	12	32	32	32	32	32	32	Tell1 number
	47	47	47	47	47	47	16	15		14	13	12	31	31	31	31	31	31	
	46	46	46	46	46	46	16	15	14	13	12	30	30	30	30	30	30	30	
	45	45	45	45	45	45	16	15	14	13	12	29	29	29	29	29	29	29	
TTb v	1	30	3	24	31	40	23	104	104	106	103	8	34	38	5	13	29	45	full module
	44	44	44	44	44	44	11	10		9	8	7	28	28	28	28	28	28	Tell1 number
	43	43	43	43	43	43	11	10		9	8	7	27	27	27	27	27	27	
	42	42	42	42	42	42	11	10	9	8	7	26	26	26	26	26	26	26	
	41	41	41	41	41	41	11	10	9	8	7	25	25	25	25	25	25	25	
TTa u	36	14	12	20	21	22	107	103		134	105	35	37	39	28	27	26		full module
	40	40	40	40	40	40	6	5		4	24	24	24	24	24	24	24		Tell1 number
	39	39	39	39	39	39	6	5		4	23	23	23	23	23	23	23		
	38	38	38	38	38	38	6	5		5	4	22	22	22	22	22	22		
	37	37	37	37	37	37	6	5		5	4	21	21	21	21	21	21		
TTa x	2	49	15	47	4	54	102	146		121	106	16	6	43	9	53	17		full module
	36	36	36	36	36	36	3	2		1	20	20	20	20	20	20	20		Tell1 number
	35	35	35	35	35	35	3	2		1	19	19	19	19	19	19	19		
	34	34	34	34	34	34	3	2		2	1	18	18	18	18	18	18		
	33	33	33	33	33	33	3	2		2	1	17	17	17	17	17	17		

- 0.2 % ripped bond wires
- 0.7 % high bias current (seems to work)

› 99% channels functional (- 6 optical links, to be replaced)



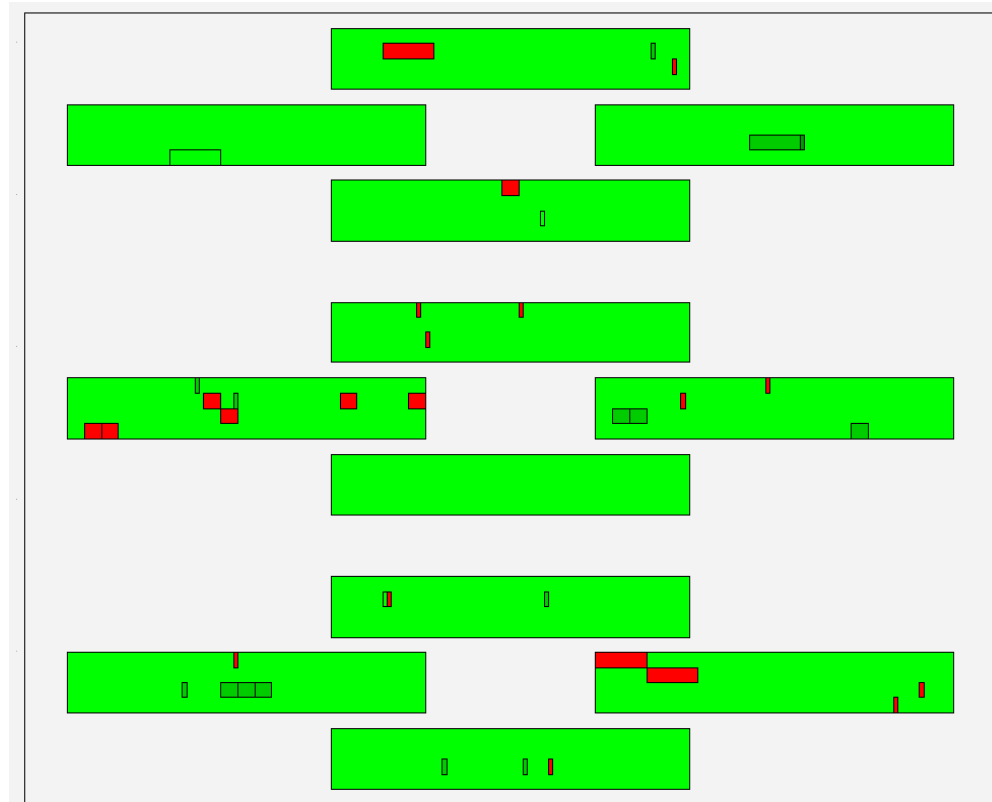
# Current status IT

various problems:

- broken cables
- broken fibers
- weak VCSEL diodes
- broken Digitizer Boards

Could not be fixed yet due to inaccessibility of IT stations compared to TT

All to be fixed in next shutdown!

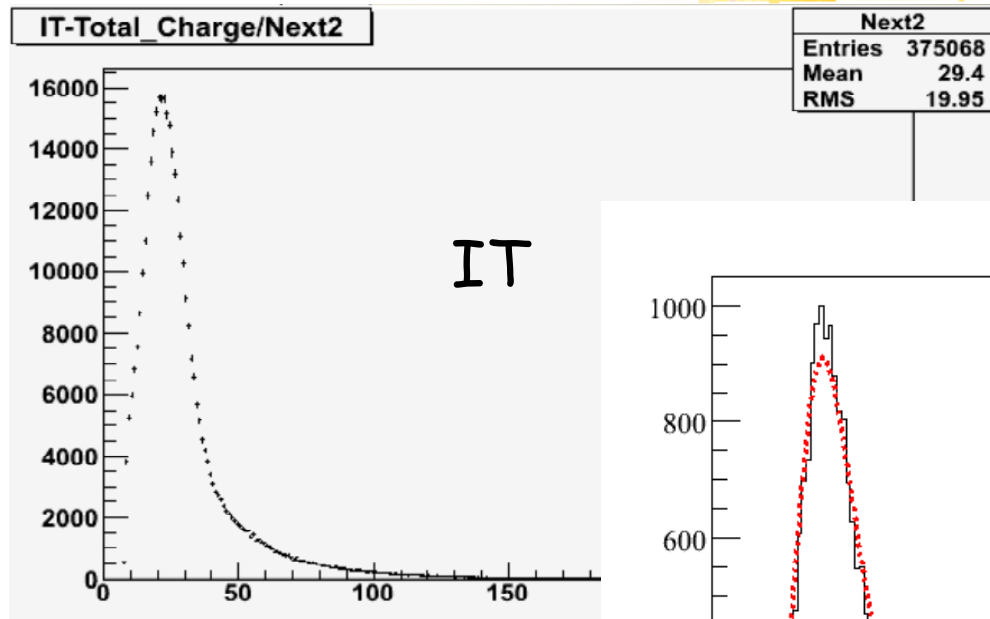


**~97% of the IT is fully functioning**



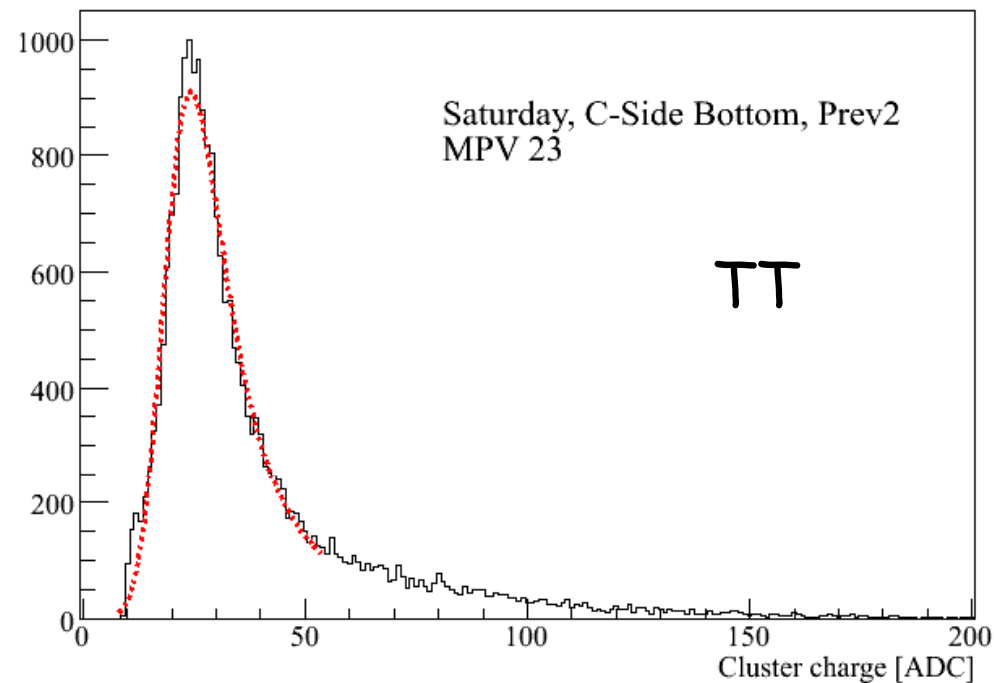


# First injection data



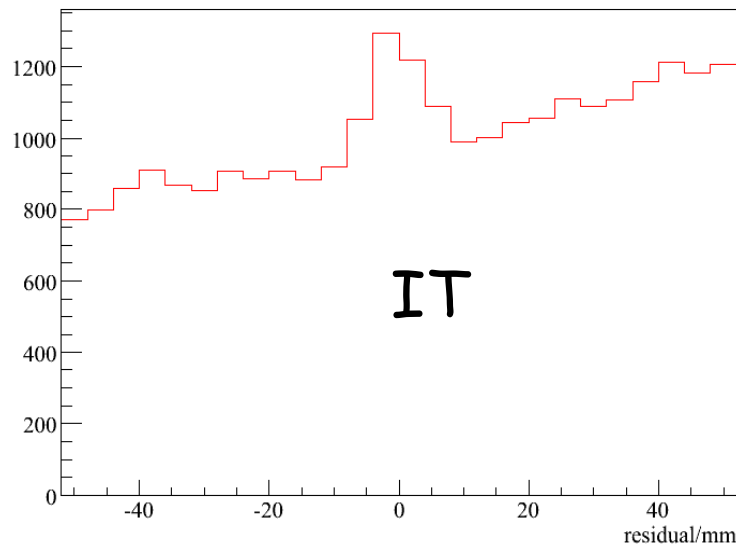
LHC on TED absorber  
Aug 23/24 for IT  
Aug 8/9 for TT

SNR within expected  
range



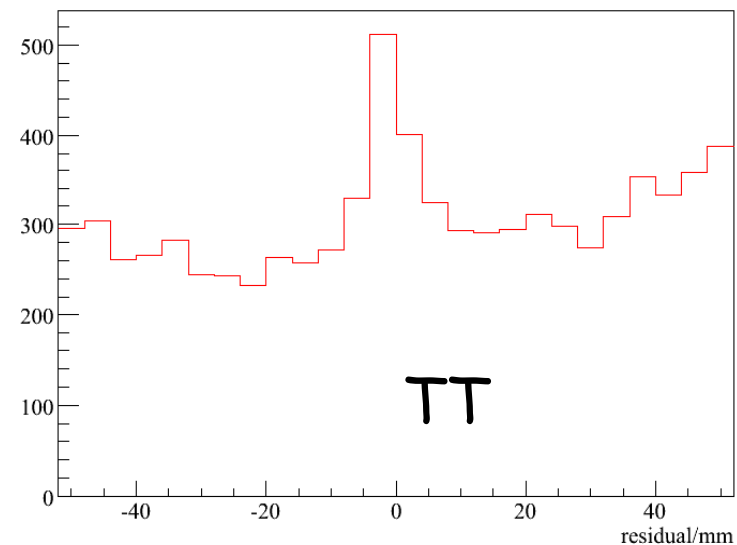


# First injection data



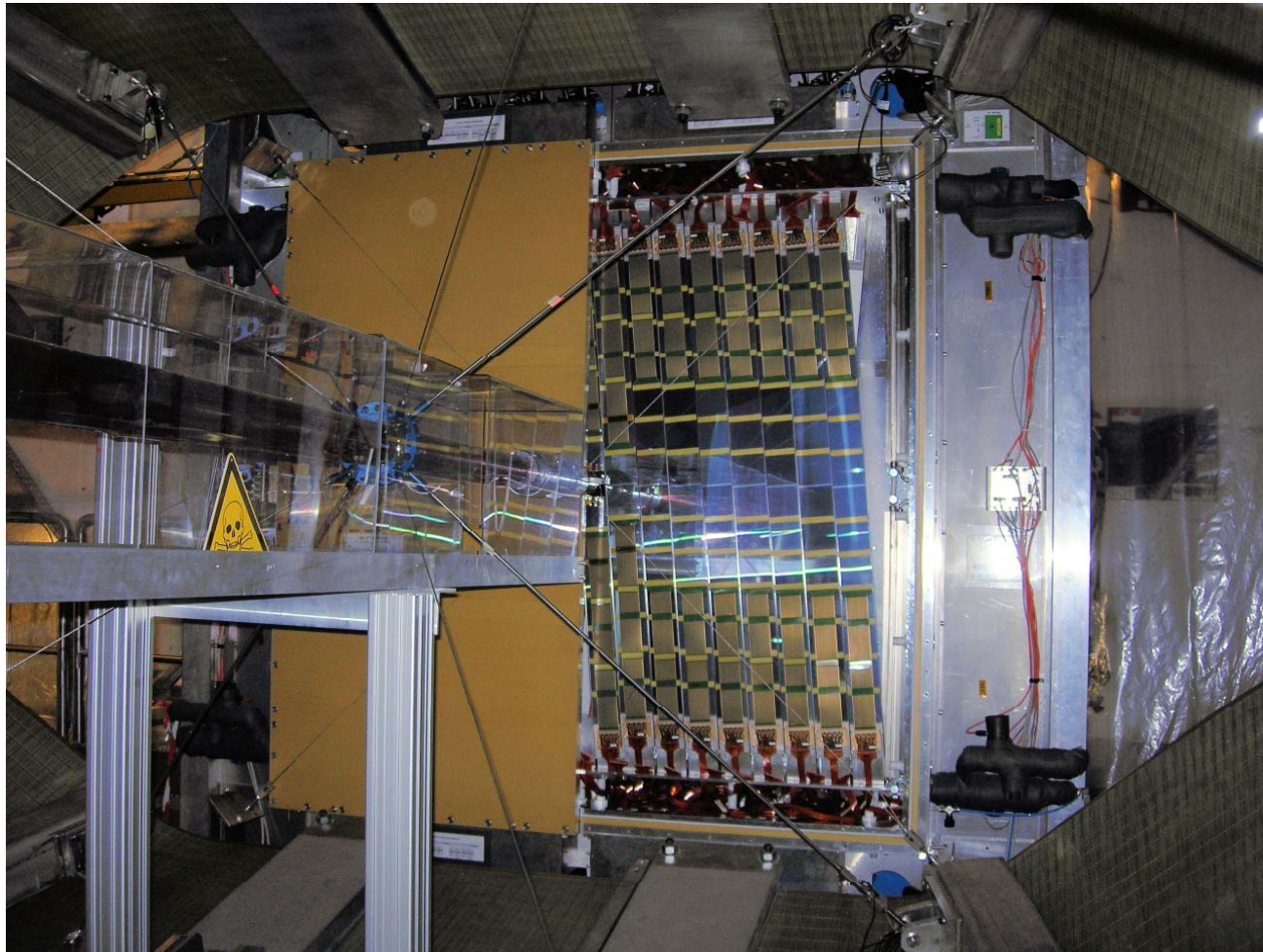
LHC on TED absorber  
Aug 23/24 for IT  
Aug 8/9 for TT

- Correlations between LHCb Vertex Locator and TT/IT stations
- Resolution limited by angular extrapolation from VeLo





# Conclusion + Outlook





# Conclusion + Outlook

- A lot of mistakes were done during the construction of the LHCb Silicon Tracker.
- Almost all problems understood and fixed, if accessible.
- TT >99% working, IT easy to push above 99% once hardware accessible.

Everything ready for great physics!