

Serial Powering of CMS Inner Tracker

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15.10.2018

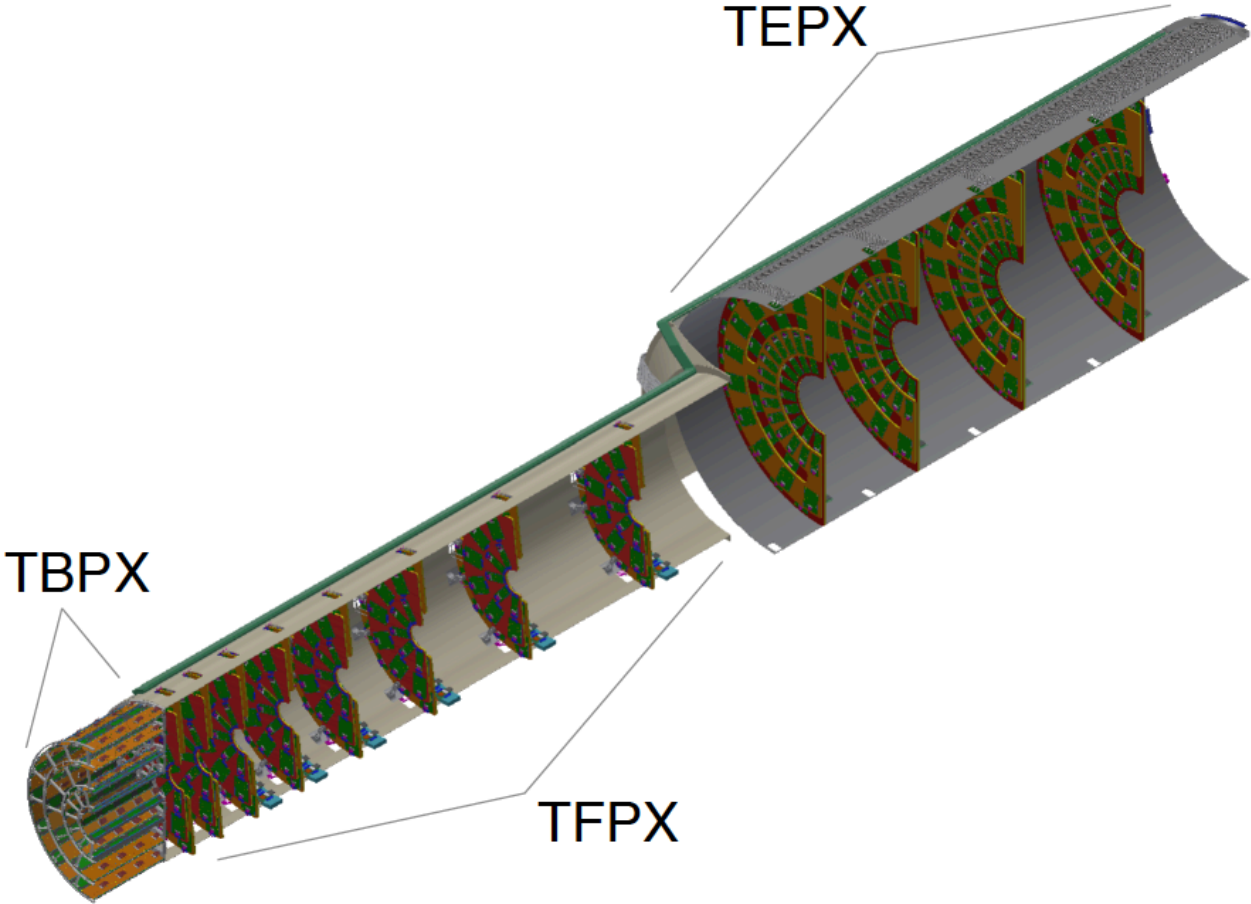
OUTLINE

- CMS SP PARAMETERS
- GEOMETRY
- SERIAL POWER CHAINS PER SUBDETECTOR
- SERVICES OVERVIEW
- THERMAL ASPECTS/ LOCAL

SERIAL POWER CMS PARAMETERS

- System designed based on the following initial parameters:
 - Nominal current 2.0A @Vin =1.4V
 - Max 1.0W/cm²
- Max length of a chain: 11 (increased recently)
- Average length of a chain: 8
- High voltage distribution: Parallel to SP chains
- Current overhead: 25%
- Other considerations: Optomodules not shared among SP chains
- All modules powered in series.
 - Double chip modules: 4A per chain
 - Quad chip modules: 8A per chain
- All studies done so far assumed planar sensors
 - Starting now the discussion on SP for 3D sensors (not many around for tests)
- No auxiliary protection:
 - Relying on whatever is integrated on the chip (undershunt, overvoltage protection etc)
- On detector services: CO2 cooling _ CuAl wires

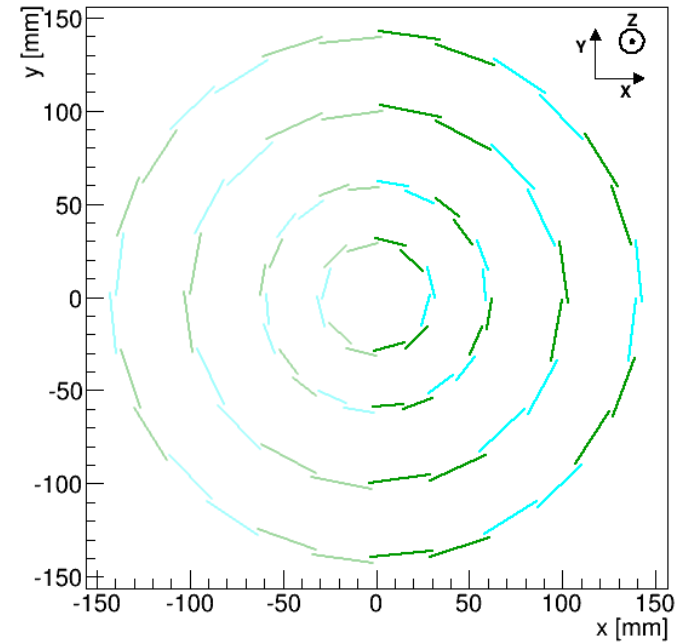
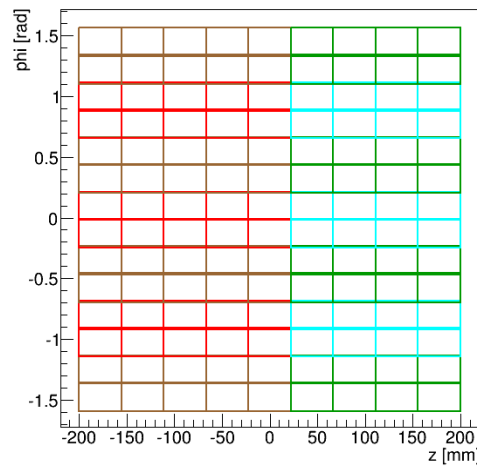
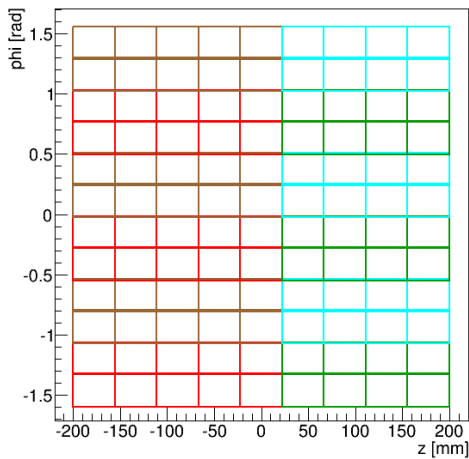
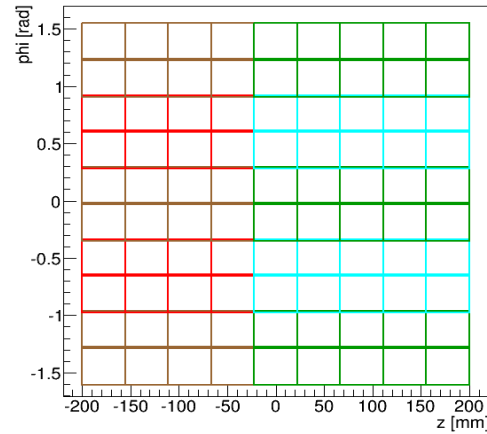
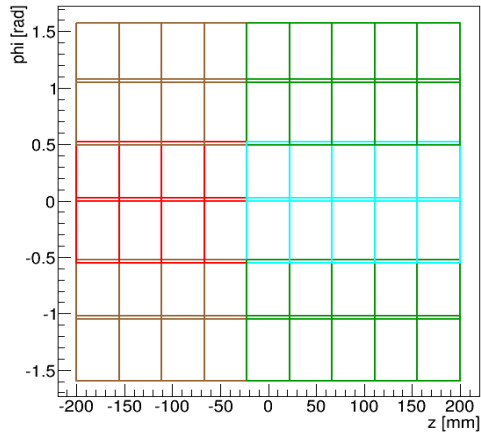
CMS Inner Tracker



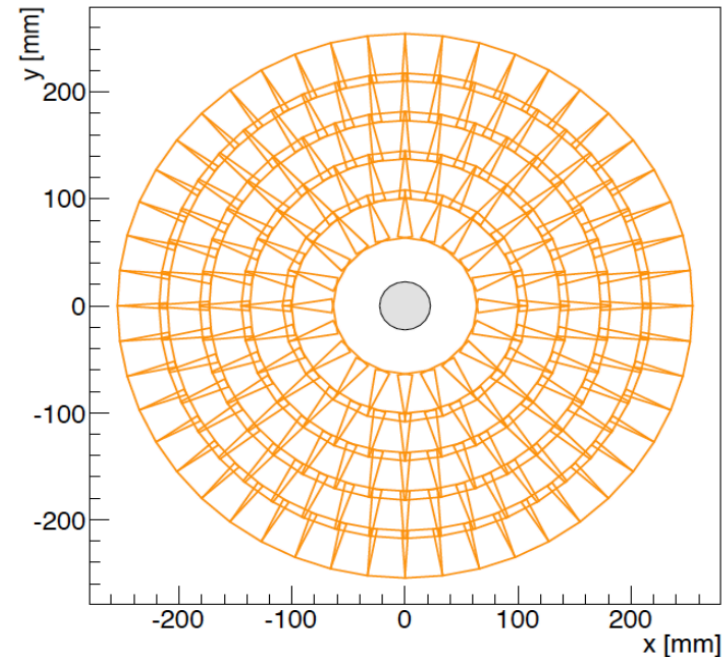
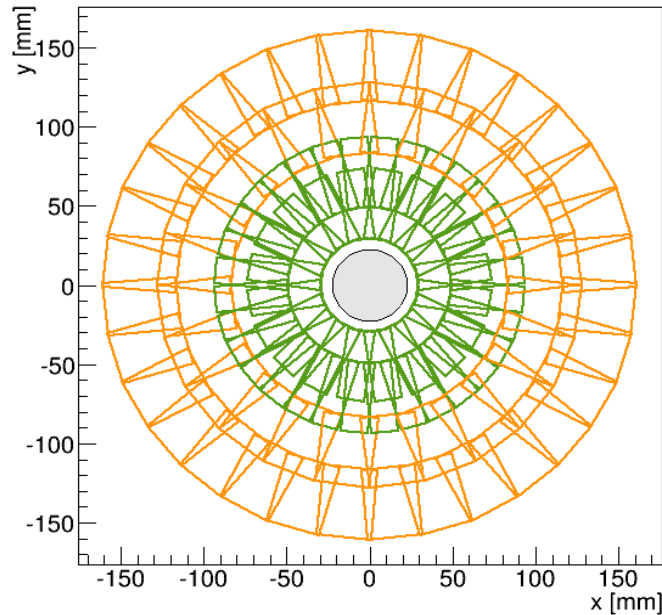
Pixel Barrel (TBPX)

1 serial power chain/ 2 ladders:

SP chains of 8 or 10 modules (depends on Z+/Z-, Layer)



Forward (TFPX) & Extension (TEPX) Pixel geometry: 1 serial power chain/side/ring (except for TEPX R5) SP chains of 5-11 modules



	Module type	Modules	Front side of Dee	Back side of Dee
Ring 1	1x2	20	5	5
Ring 2	1x2	32	8	8
Ring 3	2x2	24	6	6
Ring 4	2x2	32	8	8

	Module type	Modules	Front side of Dee	Back side of Dee
Ring 1	2x2	20	5	
Ring 2	2x2	28		7
Ring 3	2x2	36	9	
Ring 4	2x2	44		11
Ring 5	2x2	48	12	

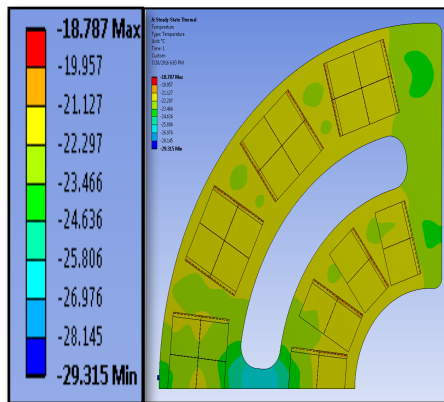
Statistics

		SP	SP	SP	Number of modules per SP chain	
		Chains	Chains	Chains		
		1x2 modules	2x2 modules	SUM	Z+	Z+
TBPX	L1	3		3	10	8
	L2	6		6	8	10
	L3		5	5	10	8
	L4		7	7	8	10
	SUM	9	12	21		
TFPX	R1	2		2	5	
	R2	2		2	8	
	R3		2	2	6	
	R4		2	2	8	
	Odd Dee	2	2	4		
	Even Dee	2	2	4		
	Disk	4	4	8		
	SUM	32	32	64		
one face of a TEPX Dee	R1		1	1	5	
	R2		1	1	7	
	R3		1	1	9	
	R4		1	1	11	
	R5		2	2	6	
TEPX	Front Face		4	4		
	Back Face		2	2		
	Dee		6	6		
	Disk		12	12		
	SUM		48	48		
QUARTER OF TBPX+TFPX		41	44	85		
QUARTER OF TEPX			48	48		
QUARTER OF IT		41	92	133		
ONE END OF IT		82	184	266		
ENTIRE IT		164	368	532		

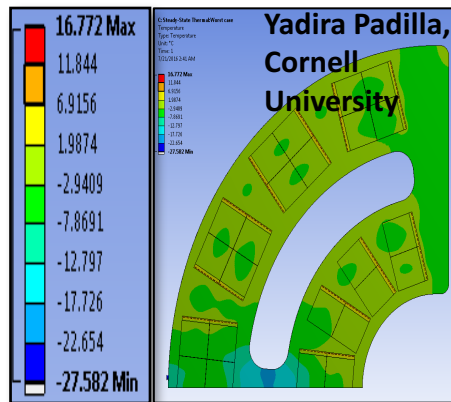
Thermal aspects:

- CO₂ pipes always below SLDO hotspot
- Close collaboration with mech. engineers for optimization of cooling, incl. failure scenarios

Normal operation



1.5x nominal power and pixel arrays shut-down



Location	ΔT [°C]
Quarter of an endcap disk structure	10.5
ROC Pixel area	2.5
LDO, Shunt, Periphery	3.7

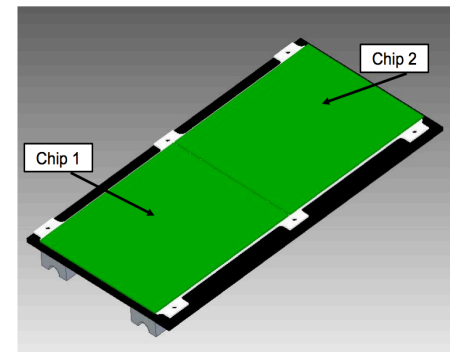
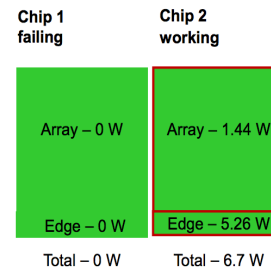
Location	ΔT [°C]
Quarter of an endcap disk structure	44.4
ROC Pixel area	5.1
LDO, Shunt, Periphery	26.0



CMS Phase 2
INFN Perugia – UNIPG Department of Engineering



Chip failure – Chip 1 failing

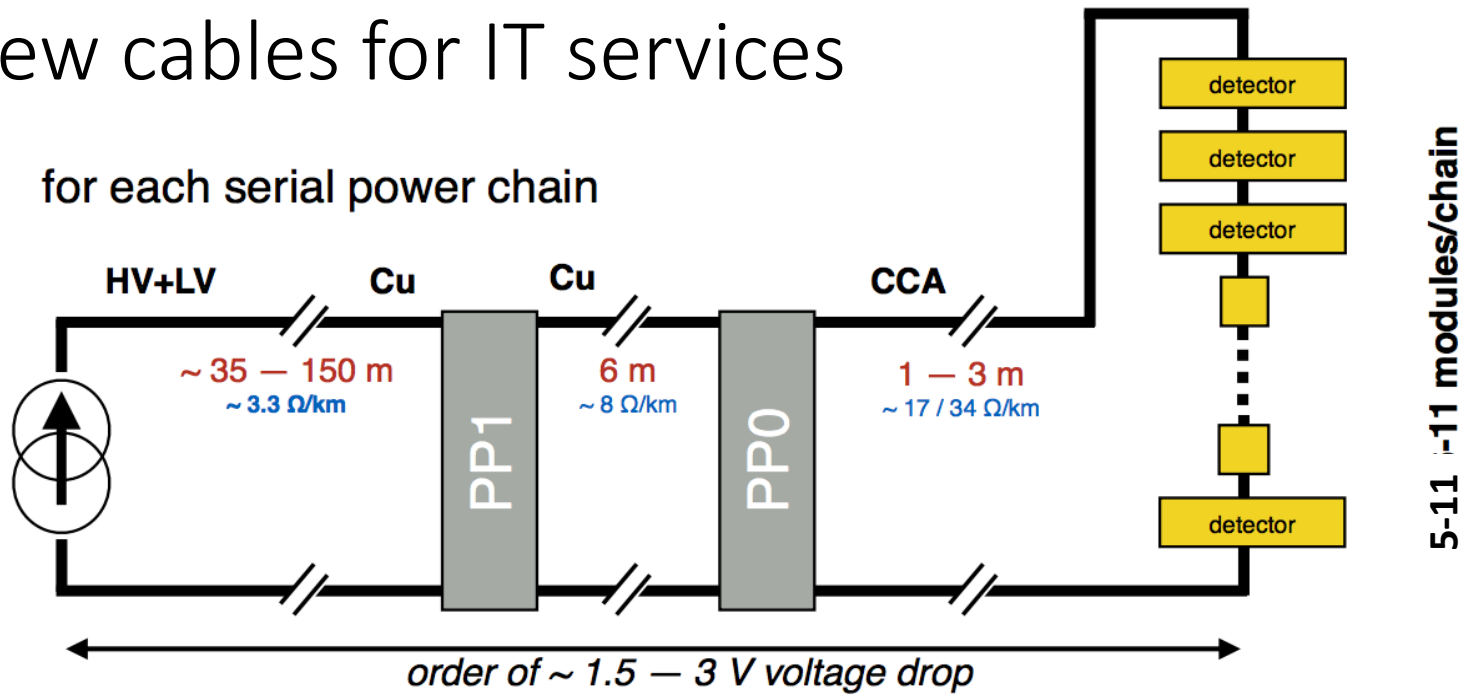


11/10/2018

11

F. Bianchi

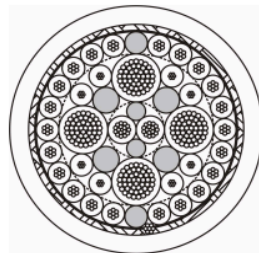
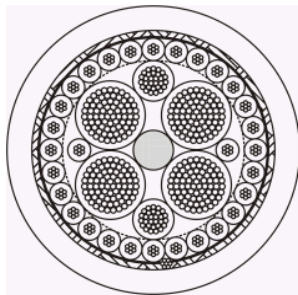
New cables for IT services



1 cable → 2 power chains

Cable 1: $\varnothing = 15.3 \text{ mm}$

Cable 2: $\varnothing = 13.4 \text{ mm}$













• Prototype cables available:

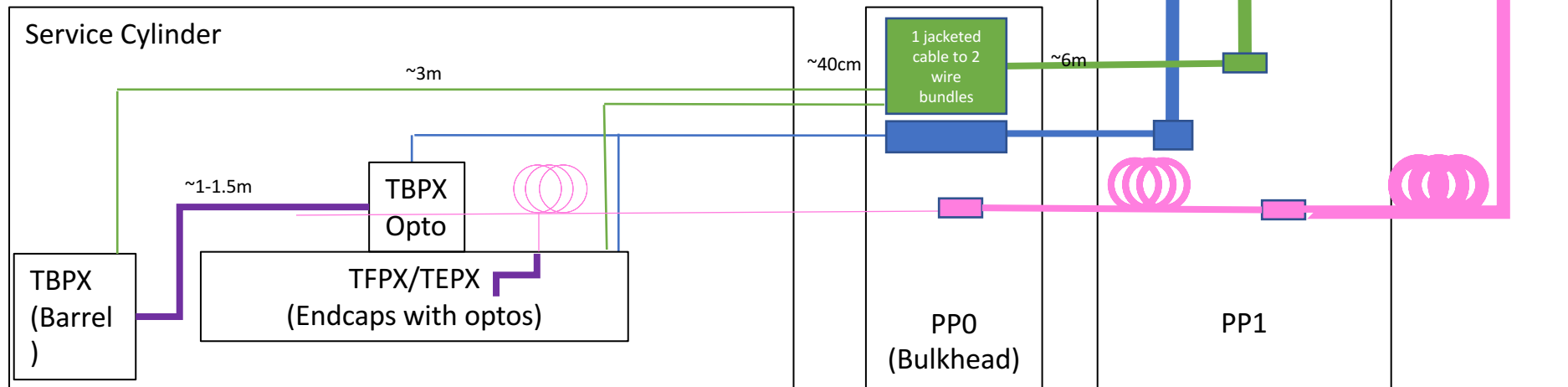
- 4 LV conductors
- 22 HV wires
- 8 env. wires (T,H)

	SP Chains	Power	SP Chains	Power	SP Chains	Power
	1x2 modules	Cables	2x2 modules	Cables	TOTAL	Cables
TBPX	9	5	12	6	21	11
TFPX	32	16	32	16	64	32
TEPX			48	24	48	24
QUARTER OF IT SUM	41	21	92	46	133	67
ENTIRE IT	164	84	368	184	532	268

CMS IT Services channels redesigned











Current Scheme

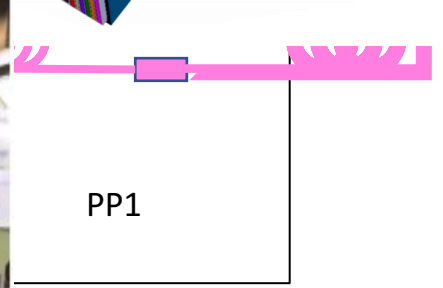
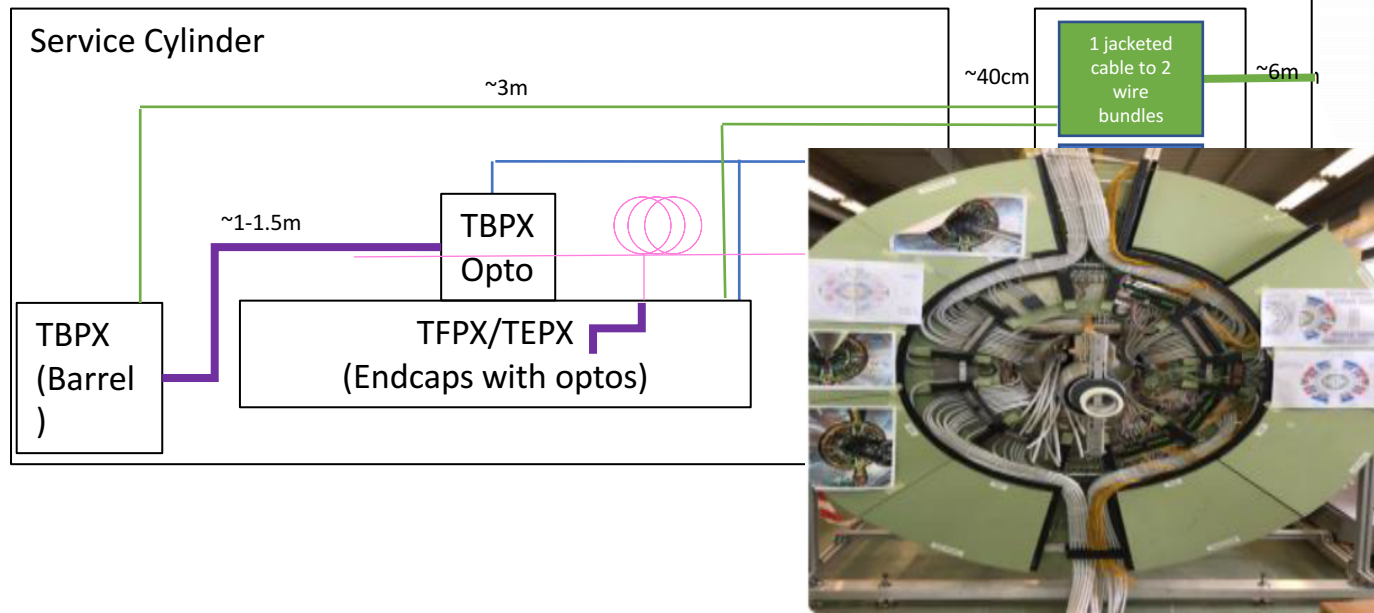
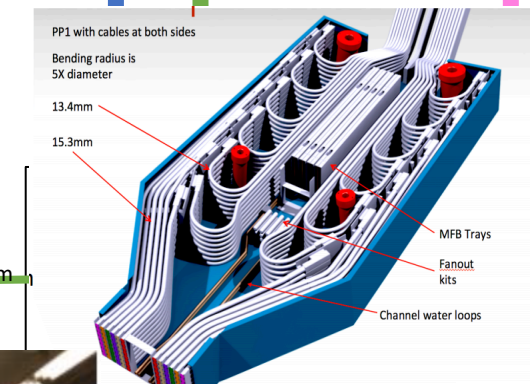
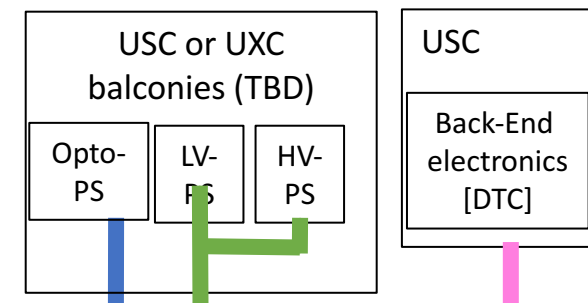
-  CuAl wires in bundles (1 SP chain/bundle:LV+HV+1Tsens)
-  $\Phi 13.4$ mm Cu multiservice cable
-  $\Phi 15.3$ mm Cu multiservice cable (2 SP chains:LV+HV+2Tsens+preheat)
-  CuAl wires OptoLV
-  $\Phi 13.4$ mm Cu OptoLV cable
-  $\Phi 15.3$ mm Cu OptoLV cable
-  Electrical link
-  Fibres
-  Multifibre bundles MFB (6 channels)
-  Multifibre cables MFC (12 bundles= 72 channels)



CMS IT Services channels redesigned

Current Scheme

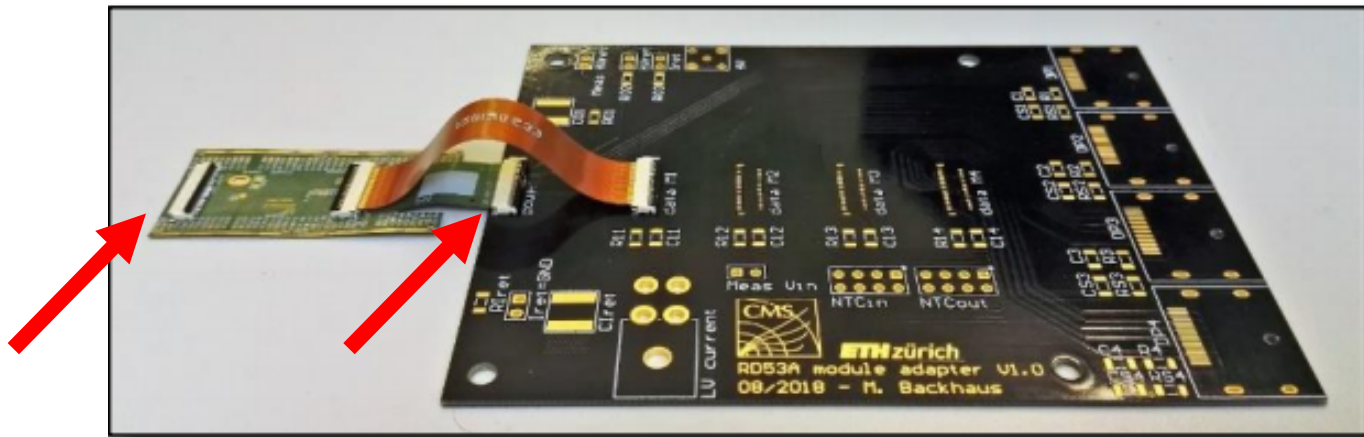
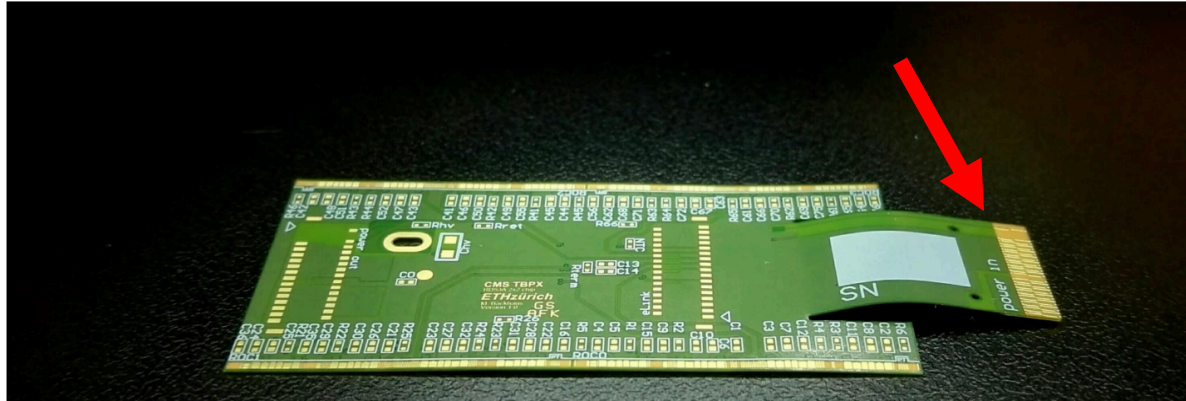
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-  CuAl wires OptoLV
-  $\Phi 13.4$ mm Cu OptoLV cable
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-  Fibres
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-  Multifibre cables MFC (12 bundles= 72 channels)



Serial power connection to modules (M. Backhaus)

ETH zürich

TBPX 2x2 RD52A HDI



Next steps for optimization of CMS SP :

- High voltage distribution
 - Planar
 - Sensor
- Deciding on headroom combined with
 - Offset and Rext optimization
- Minimization of decoupling capacitors and ext. resistors per module
- Protection scheme for overvoltage?
- Validation of SP scheme with RD53A modules