# Operational experience of the Upstream Tracker of LHCb

Giorgia Tonani on behalf of the LHCb collaboration

VERTEX 2023 - 32nd International Workshop on Vertex Detectors







### **LHCb** experiment

Run 3 goal: collect **more** data to improve the **physics** results  $\rightarrow$  L = 2 10<sup>33</sup> cm<sup>-2</sup> s<sup>-1</sup>

Not efficient with Run 1-2 detector, main limitation: LO hardware trigger

#### → BRAND NEW LHCB:

software trigger, detector upgrade, change of readout electronics 90% of the detector channels upgraded

100% replacement of readout electronics

 100% new DAQ & online system @ collision rate

Giorgia Tonani

**VERTEX 2023** 

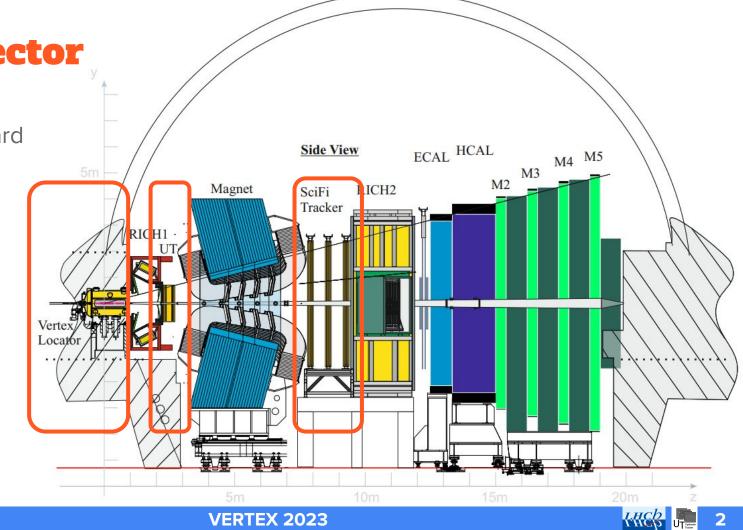


## **LHCb detector**

Single-arm forward spectrometer

Pseudorapidity range:  $2 < \eta < 5$ 

Tracking system



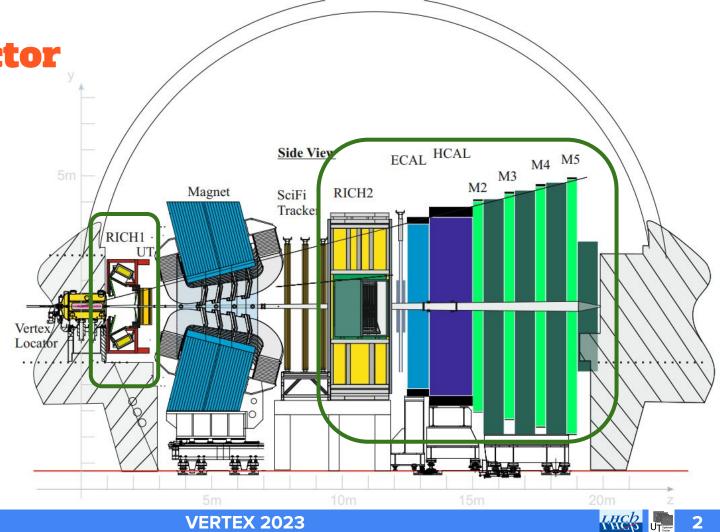
## **LHCb detector**

Single-arm forward spectrometer

Pseudorapidity range:  $2 < \eta < 5$ 

Tracking system

Particle identification system



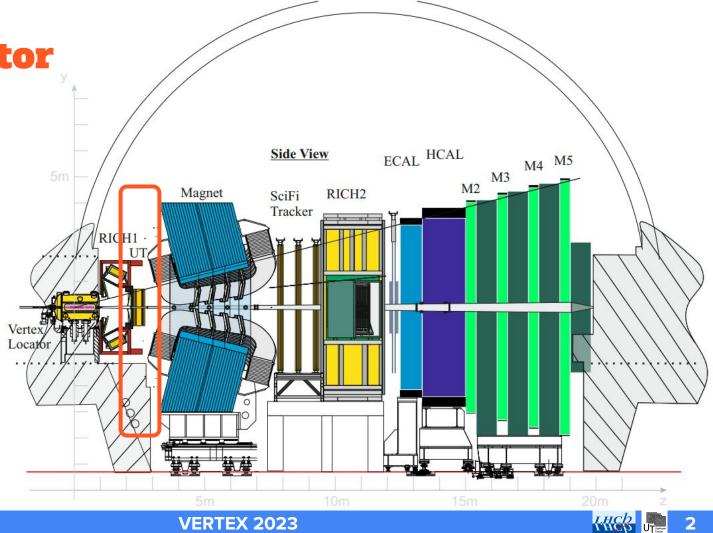
### **LHCb detector**

Single-arm forward spectrometer

Pseudorapidity range:  $2 < \eta < 5$ 

Tracking system

Particle identification system

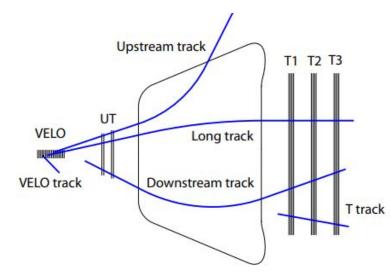


### **Upstream Tracker (UT): importance in LHCb**

• Track reconstruction: UT fundamental to improve the **momentum resolution** of Long tracks

 Ghost rate reduction: factor 2 improvements, essential for the software trigger

• Long lived particles reconstruction decaying after the VELO (e.g.  $\Lambda$ ,  $K^0_{s}$ )







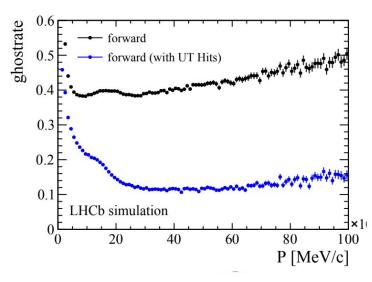
### **Upstream Tracker (UT): importance in LHCb**

• Track reconstruction: UT fundamental to improve the **momentum resolution** of Long tracks

• **Ghost rate** reduction: factor 2 improvements,

essential for the software trigger

• Long lived particles reconstruction decaying after the VELO (e.g.  $\Lambda$ ,  $K^0_{s}$ )



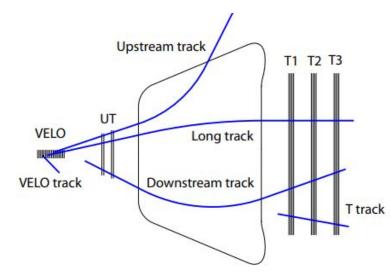


### **Upstream Tracker (UT): importance in LHCb**

• Track reconstruction: UT fundamental to improve the **momentum resolution** of Long tracks

 Ghost rate reduction: factor 2 improvements, essential for the software trigger

• Long lived particles reconstruction decaying after the VELO (e.g.  $\Lambda$ ,  $K^0_{s}$ )







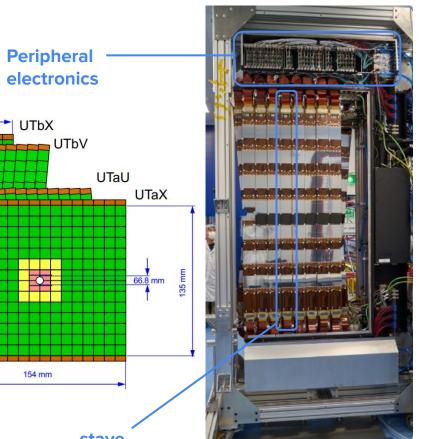
- Silicon strip detector
- **4 layers** with vertical and stereo (+/- 5 deg) orientation
- divided in **2 sides**: A-side and C-side

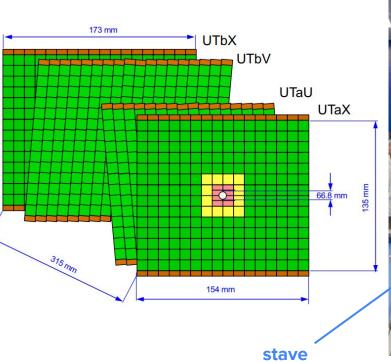
**Giorgia Tonani** 

organized in 68 staves



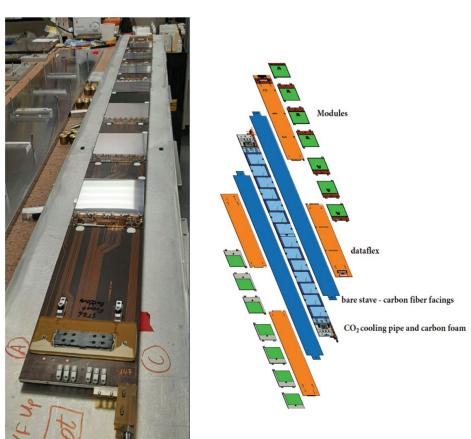
The LHCb Upgrade (arxiv.org)





#### Stave:

- 99.5mm x 1640mm (width x length)
- carbon fiber structure with thermal and structural foam in between
- S-shaped titanium **cooling pipe**
- 4 Flex Cu- Kapton cables, power and data distribution
- Single stave can host 14 or 16 modules, on both sides

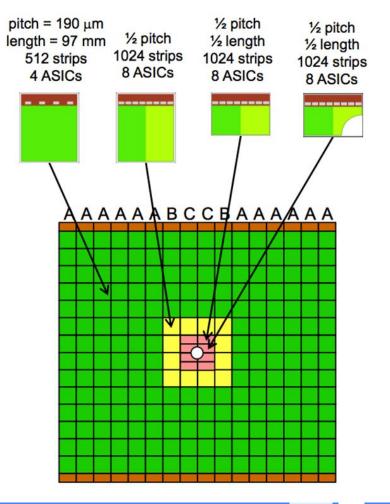


#### **Modules**



- silicon micro strip sensors (A-Type: p-in-n; B-, C-,
   D-type: n-in-p)
- Hybrids: VERA (4 ASICs), SUSI (8 ASICs)
- Front-end ASIC (SALT) glued and bonded to hybrid flex
- Ceramic stiffener (PBN): good thermal

conductivity and electrical insulation



#### **Giorgia Tonani**

**VERTEX 2023** 

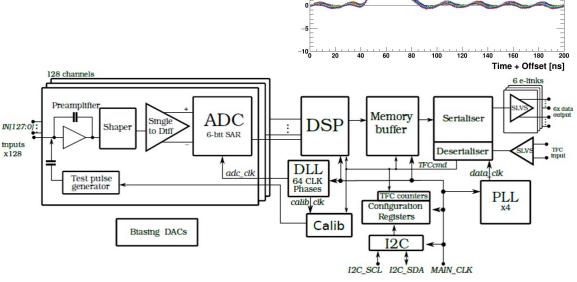
#### Silicon ASIC for LHCb Tracking

#### <u>(SALT):</u>

• CMOS 130 nm

technology

- 128 channels / ASIC
- 6 bit ADC / channel



Signal Height [LSB]

- Digital Signal Processing (DSP): pedestal and common mode noise subtraction, zero-suppression, data formatting, spillover correction
- peaking time~25 ns, S/N~20, input C=12 pF, power dissipation/channel < 6mW

#### Giorgia Tonani

#### **VERTEX 2023**



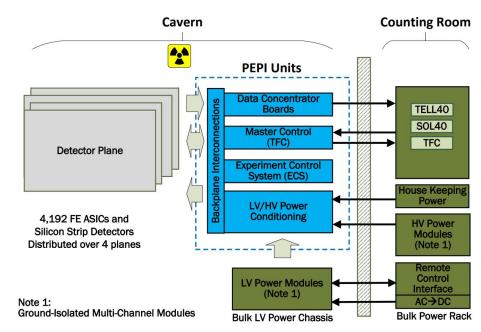
Chip 1

### **Peripheral electronics**

Periphery electronics processing interface (PEPI) to read out and control the detector:

- 24 backplanes
- 24 pigtail power breakout boards (P2B2s)
- 248 data and control boards (DCBs)





The **GBTx**, mounted on the DCBs, implements bidirectional **links** between the **detector** and the **counting room** 









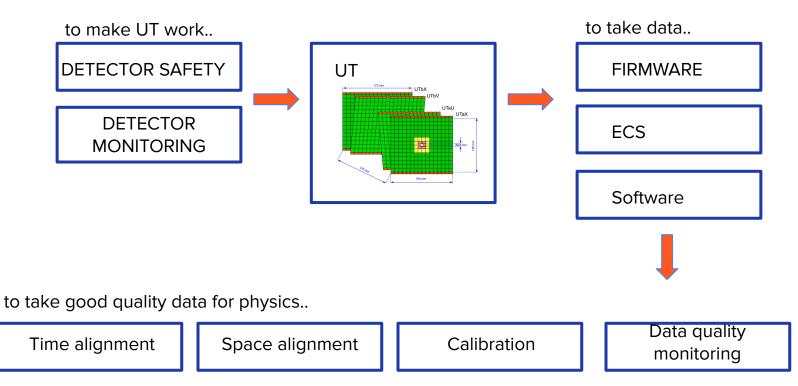






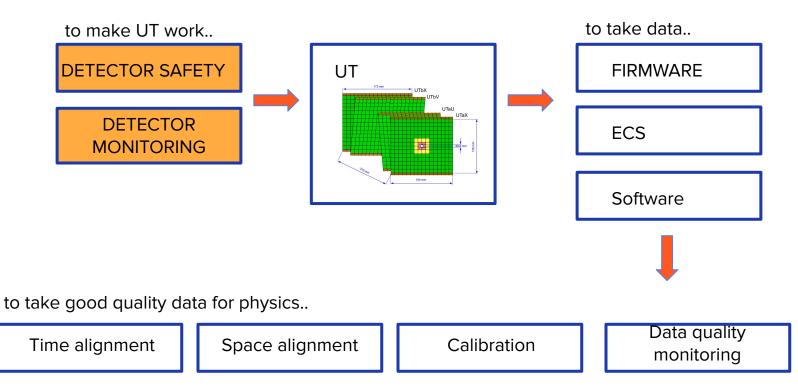


### UT path to collect physics data...





### **UT path to collect physics data...**







### **Detector safety**:

- **Humidity** inside the box
- **Temperature** of the **electronics**
- Stave temperature
- Current and Voltage

(high and low voltage)

#### Alarms

- exploiting sensors
- monitoring, warning the shifter
- action taken by expertes

UTaX_C			max UT 11.96		T max UTA	2.55	Tm	ax UTC 22.96	٦
UTaU C	L				1_11111				
					C-side aX	(-laver			
UTbV_C	A-side top	-	_		c-side da	(-layer	C-side top		
UTbX_C	ELMB status:	WORKS	Trends	_			ELME	status: WORKS	Tr
C-side Inlet									
	Start Sto	pp	Humidities			0	Start	Stop	Hu
	5.86 Hum_1, % -30.8.	1 Dewpoint 1	in.	-0		0-	5.60 Hum	1, % -30.16 Dewpoint	
C-side Outlet		benpont_1	Dew Points					Line [Boild ] Benpoint	De
	5.68 Hum_2, % -31.1.	2 DewPoint_2	tr,				5.21 Hum	_2, % -30.93 DewPoint_2	
k	5.75 Hum_3, % -31.0.	1 DewPoint 3	Temperature				5.34 Hum	3, % -30.67 DewPoint 3	1.0
			-						
UTaX A	3.94 T[C]		E.				5.45 T[C]		
UTUN_A					Q	)			
UTaU_A	A-side bottom ELMB status:	WORKS					C-side bottom	status: WORKS	
UTbV A		Inorato	Trends						Tr
UIDV_A	Start Sto	an	Humidities	-0		0-	Start	Stop	Hu
UTbX_A			m						F
A-side Inlet	6.61 Hum_1, % -29.6	5 Dewpoint_1					5.91 Hum	_1, % -30.28 Dewpoint_2	
in.	5.45 Hum_2, % -31.69	9 DewPoint_2	Dew Points				6.08 Hum	2, % -29.98 DewPoint 2	Dev
	Contraction of Contract	z	Ŀ,				, and the second	and a start of the	
A-side Outlet	6.26 Hum_3, % -30.24	4 DewPoint_3	Temperature				6.13 Hum	_3, % -29.89 DewPoint_3	Tem
tri	3.77 T[C]		m.				4.52 T[C]		1

- **DSS** All the switches and sensors installed and active, DSS panel working
- thermal switches + sensors
- regulated to operate in a range
- action taken by DSS

#### **Giorgia Tonani**

**VERTEX 2023** 

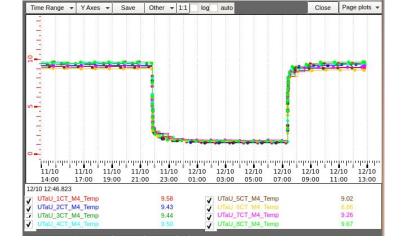


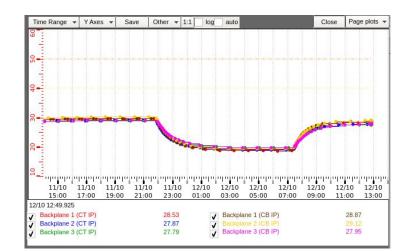
# **Cooling system**

- 1. **module** cooling: bi-phase CO<sub>2</sub>
  - a. manifolds connect to the cooling tube of the stave
  - b. single tube for each stave
  - c. sensor design temperature: -5°C

→ current setpoint temperature 0°C, need to optimized the box sealing to reach design temperature (during YETS)

2. **peripheral electronics** cooling: demineralized/mixed water



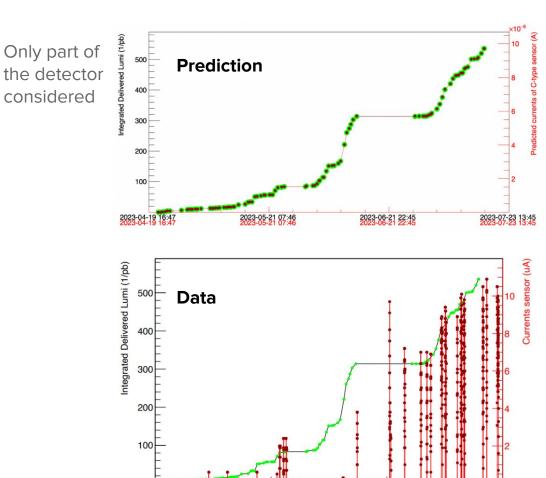


## **High voltage**

- High voltage for sensors depletion
- Monitoring panel in place: scan of the current over time

 $\Delta I = \alpha * \Phi * V$ 

- Total Fluence  $\Phi$
- Damage rate α
- Sensor volume V



05-21 07:46

2023-

#### **Giorgia Tonani**

**VERTEX 2023** 

2023-04-19 16:47 2023-04-19 23:43



2023-07-23 13:45

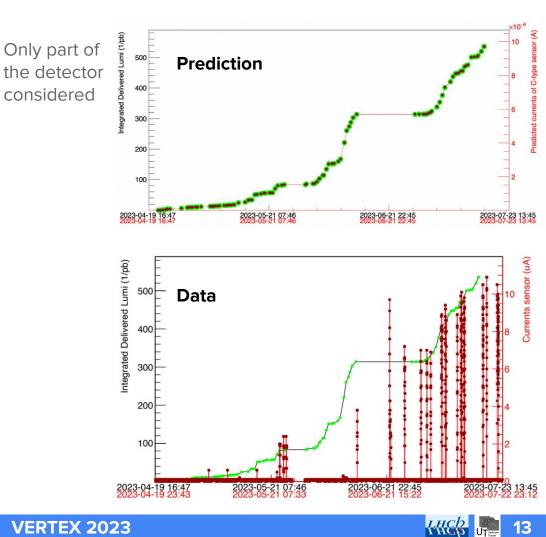
2023-06-21 22:45

# **High voltage**

Good agreement between data and prediction:

no additional current in the detector -> monitoring for the UT wellbeing

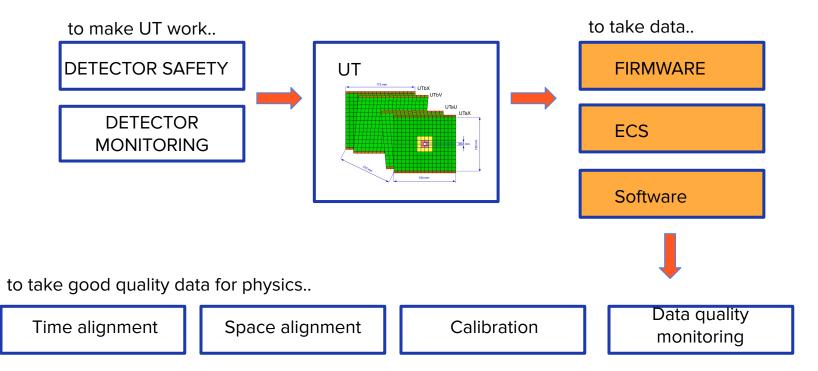
extend to higher luminosity to predict **annealing** 



#### **Giorgia Tonani**

**VERTEX 2023** 

### UT path to collect physics data...







#### **Giorgia Tonani**

mode

#### **Readout of the detector** possible with PCIe40 cards hosting

Intel Arria 10 **FPGA**: transforms the data from ASIC to PCIe format

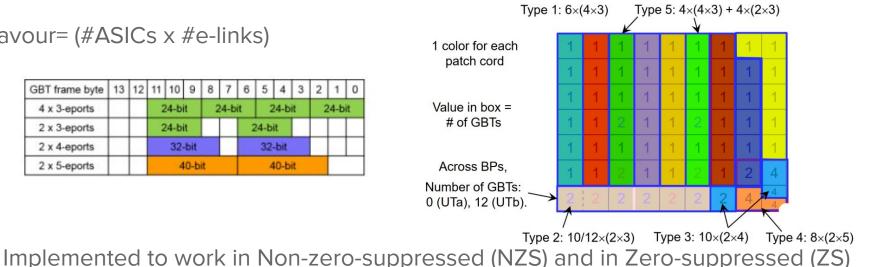
**5 flavours**, design to cope with different occupancies and to minimize the cost 

**VERTEX 2023** 

flavour= (#ASICs x #e-links)

Firmware

GBT frame byte	13	12	11	10	9	8	7	6	5	4	3	2	1	0
4 x 3-eports			24-bit		24-bi		it	t 24-b		it		24-b	it	
2 x 3-eports			24-bit				1	24-bit						
2 x 4-eports			32-bit					32	-bit					
2 x 5-eports			40-b		it .			4	10-b	it				







- Developed a complete Experiment Control System: configure and control the back-end and front-end electronics
- One panel for each part of the detector, organized in a **tree structure**
- Can be used as **debugging tool** for synchronization checks

		UT: TOP			- ×				UTA., TELL40: TOP		-
ruch	System	State	Auto Pilot	Wed 27-Sep-2023	16:12:38	Inch	System		State	Wed 27-Sep-2023	16:12:3
<b><i>Hicp</i></b>	ur	HLINNING - D	0## -	inoot	4	rncp	UTA_TELL40		navana - 🖀 🛦	root	
Sub-System	State	Run Info				Sub-System	State				
UT_HV	RAMPING READY -	Run Number:	Activity:			uatel\$40_011	RUNNING	- 1	Enable / disable stuff		
UT_DCS	READY -	277512	Professionautrate	Settings		uatel\$40_012	RUNNING	- 1	Disable children	Enable children	
UT_DAI	NOT READY -	Run Start Time:	Trigger Config:			ustel\$63_013	BUMPERS	- 1			
UT DAQ	RUNNING - E	27-Sep-2023 16:11:21	mgger comig.	Settings	2	uatel\$40 021	BUNNING	- 1	Disable Children in ERROR state	Enable Children in ERROR state	
UT_Runinfo	RUNNING - V					ustel340_022	RUNNING	- 11	Disable TELL40 devices	Enable TELL40 devices	
UT_TFC	maning -	Run Duration: 000-01-14	Time Alignment:			ustel\$40_023	RUNNING	• 1	CONTRACTOR CONTRACT	LINE TELEVO GENCES	
UT_EB	RUNNING - B					uatel843 031	RUNNING	- 1	Disable TELL40 devices in ERROR state	Enable TELL40 devices in ERROR state	
UT_Monitoring	mununs - B	Nr. Events:	Max Nr. Events:			uatel\$43_032	REPUBLIC	- 1			
		808'335	Elan, timited (	Events	5	uatel\$40_033	RUNNING	- 1	Exclude UT devices	Enable UT devices	
		Step Nr: To Go:	Automated Run		rt at	ustel140_041	RUNNING	- 11	Disable UT devices in ERROR state	Enable UT devices in ERROR state	
		0 0	C Step Fine wit	Steps 0	1.000	uatel\$40_042	RUNNING	- 7	In Endrary House	AT BOOMS SLEEP	
		Input Rate:	Output Rate:	Dead Time:		usteli40_043	RUNNING	- 4	- UT stuff		
		12.10	1 16 1	100%		uatel940_051	RUNNING	• 1			
		TY.	1	a		uatel340_052	RUNNING	- I.	PRBS	Decoding Counters	
		III	1.	-50%		ustell40_053	BLANNING	- 1	RaReady	Data Processing Counters	
		V I	Y I		202	uatel880.001	RUNNING	- 7		Transference Statistics	
		0.00 M/s	0.00 kHz	0.00 %		uatel\$40_062	BURNING	- 1	RESET ECS REGS	Status	
	EB Rates	Data Destination:	Data Type:		utomatic	uatel343_063	RUNNING	- 2	Report FE	Bypens	
						uabel\$40_071	BUNNING	- 11	and the second se	uppass	
TFC Control TELLA	as - UT Elog	File: https://www.file.com/	0277512		tun DB	uate840_072	RUNNING	- 11	Set RegASIC_ID	Do more stuff?	
Sub-Detectors:	0					uatel340_073	BUNNING	- 7			
BURNING - PUNNING	N					uate/40_081	BLINNING	- 1			
	-					uatel\$40 082	RUNNING	- 7	- Enable / disable flavours		
						uatel140_083	RUNNING	- 7			
						uatel340_091	RUNNING	- 7	Disable 4x3	Enable 4x3	
						uate(140_092	BUNNING	- 1	Disable 2x3	Enable 2x3	
Messages:						uatel\$40 093	RUNNING	- 1			
27-Sep-2023 16 11:21 - UT ex	eculing action GO FC executing action START_TR	COFR				uate(940_101	BUNNING	- 1	Disable 2x4	Enable 2x4	
27-Sep-2023 10 11:24 - UT in					Close	ustel+40_102	RUNNING	. 1	Disable 2x5	Enable 2x5	
ucte840_103	ITUNING - V		101 3		and the second	uatel\$40_103	RUNNING	- 1	Distant Ling	Come etc	
sicte640_111	RUNNING - V	Disable (x3		Enable Jx3		uatel402_111	RUNNING	- 1	Disable (x3	Enable Jx3	
uctell40_112	RUNNING - 🖌	-				uatel\$60_112	RUNNING	- 1			
ucte840_113	RUNNING .	-				watel\$40_113	RUNNING	- 2	-		
ucte840_121	RUNNING - 🗸					uatel140_121	RUNNING	- 1			
ucte640_122	mununo - V					uatel140_122	RUNNING	. 1			
ucteli40 123	RUNNING - V					untel103 123	RUNNING	- 1			
ucte040_131	RUNNING - V					uatel\$40_131	RUNNING	- 7			
uctedid0 132	RAMING + 2					ustellet 132	RINNING	- 10			

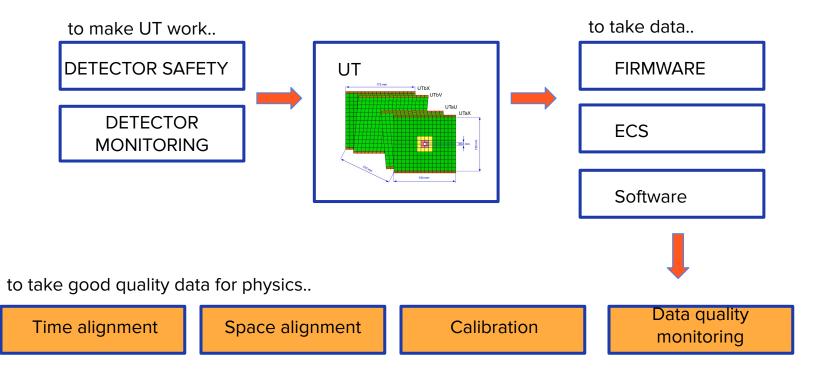
Operating the detector with 92% of the ASICs enabled due to known power issues (to be recovered during YETS to run with 99% of the ASICs)

#### Giorgia Tonani

#### **VERTEX 2023**



### UT path to collect physics data...





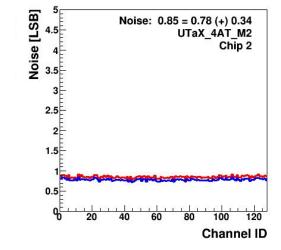


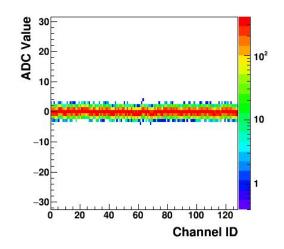


### **Performance studies**

**Characterization** of the **hybrids** in the early stage of the commissioning to illustrate the **behaviour** of the **detector** 

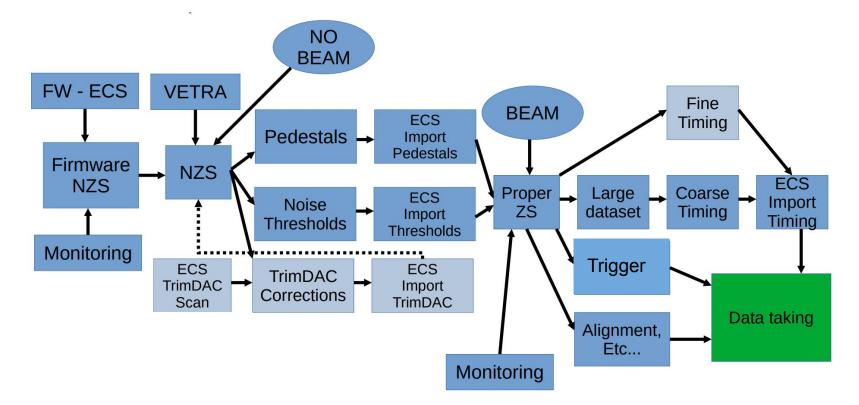
- Data collected in **bypass mode** (data not serialized by TELL40)
- Tests performed **before and after the installation**: good agreement of noise and bad channels
- Constant values of noise and pedestals during the installation time
- 0.16% of all the channels analysed are tagged as **bad channels** (0.07% pedestal shift, 0.09% high noise)







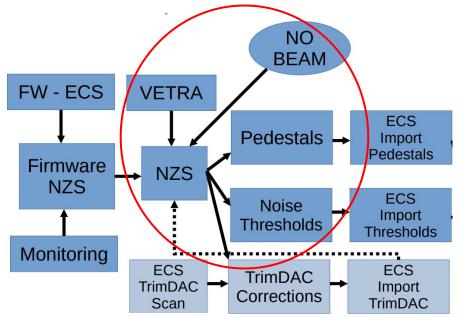
### Path to the data taking







### Path to the data taking



#### **Calibration**

 Development of software to run automated detector

#### calibrations

- Pedestals and thresholds
   computed exploiting End of Fill
   calibration runs (no LHC beam,
   only NZS data)
- Detector **parameters updated** automatically (ECS)
- Precise knowledge of the noise needed to run in ZS mode



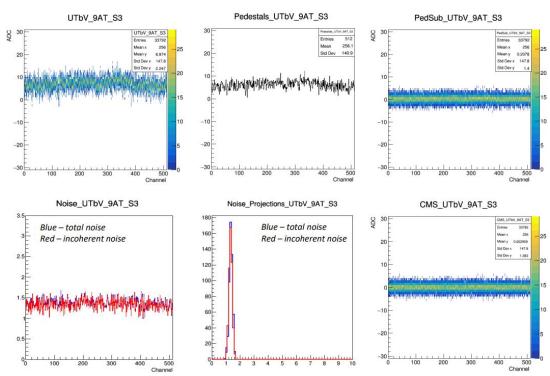
Mo

### **Offline calibration**

- Dedicated software package (VETRA), part of the LHCb software project
- Analysis of the decoded readout and compute sensors parameters:
  - Pedestal
  - Total noise
  - Coherent noise
  - Incoherent noise
  - CMS data monitoring

#### Preliminary results:

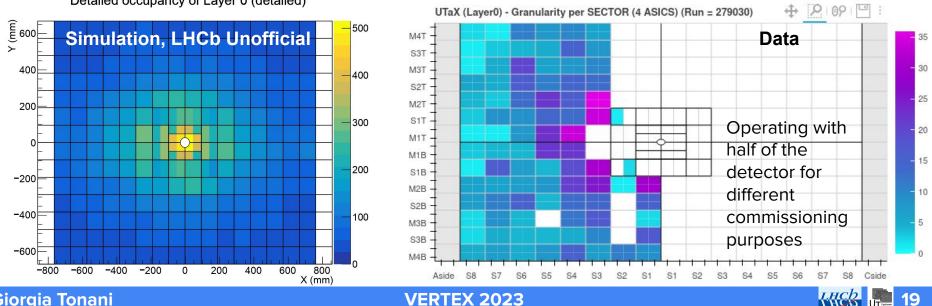
- observed the variation of pedestals across the layer
- uniform incoherent noise in the detector
- $\circ$  noise check after pedestal subtraction
- agreement with the early performance studies



**VERTEX 2023** 

# **Online monitoring**

- Monitoring in place: small sample of the captured data sent to computer farm to monitor in real time
- Crucial for the commissioning phase: basic information e.g. hits per sensor, errors information, analogue response. More plots to be added at the need

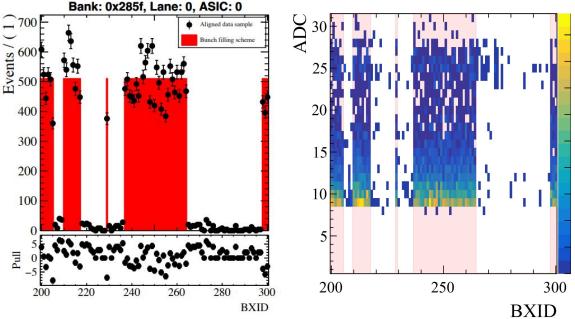


Detailed occupancy of Layer 0 (detailed)

# **Time alignment**

Goal: match the UT hits with the bunch filling scheme of the LHC

Fit a linear regression model: minimization of Residual Sum of Squares



20

- The ZS bank decoder has to provide "Number of hits" vs. "BXID" histograms for each ASIC using the
- First a global alignment, then performed for every ASIC
- No need for dedicated TAE runs
- Ongoing studies on data with ion run, waiting for calibration to perform coarse time alignment

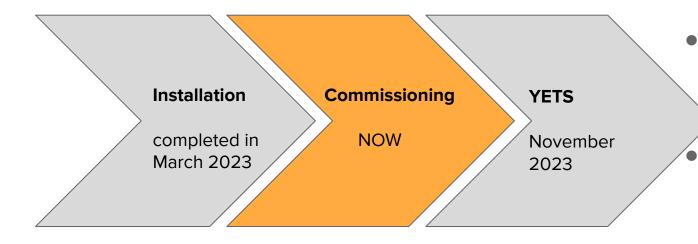
### **Current** status

Commissioning phase started in March 2023

- **Detector alignment** developed for one degree of freedom on MC
- **Decoder** ready to be used in the trigger
- Many **surveys** performed to check the status of the detector
- **Data taking** ongoing in local during the ions runs
- Faced issues in the integration of UT in the rest of the infrastructure:
   desynchronization with experiment clock → commissioning slowed down→
   affected the data taking stability → made significant progresses, learnt how to
   operate
- Working to guarantee **continuity** in the **data taking**



### **UT timeline**

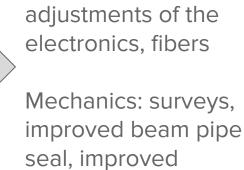


**VERTEX 2023** 

Categories:

- 1. recover loss of efficiency in data taking
- 2. guarantee detector safety
- 3. operation

#### **Giorgia Tonani**



Repairs and

approach

mechanism







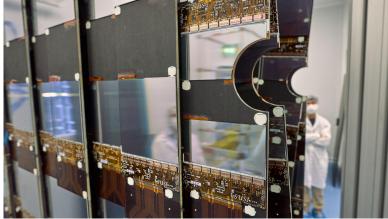






### **Summary**

- Installation completed successfully in March
- **Detector performance** matches specifications
- Analysing the **first commissioning data**
- Working to ensure **stability** in the data taking (5 flavour firmware)
- YETS plan to recover 99% of the detector efficiency
- Work in progress to have UT in the global LHCb data taking



#### Giorgia Tonani

**VERTEX 2023** 

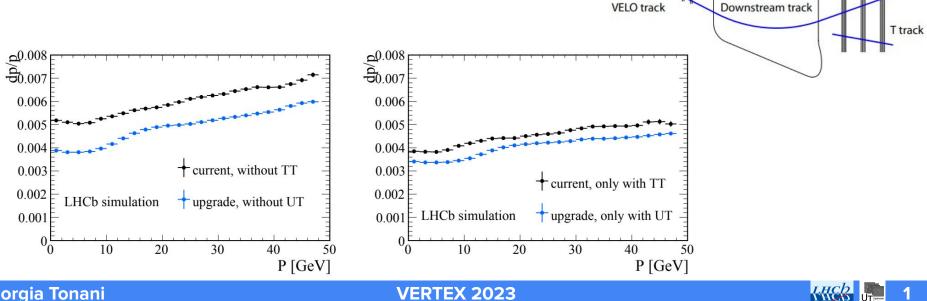


# Thank you



## **Upstream Tracker: importance in LHCb**

Track reconstruction: UT fundamental to improve the momentum resolution of long tracks



Upstream track

Long track

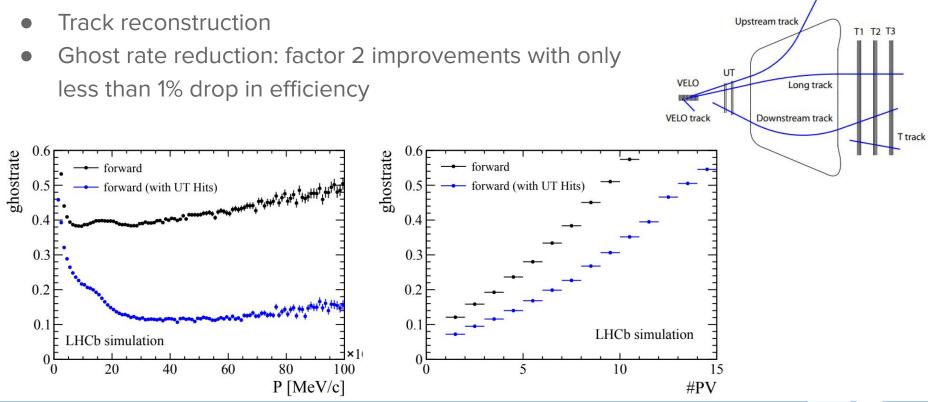
UT

VELO

T1 T2 T3

**Giorgia Tonani** 

## **Upstream Tracker: importance in LHCb**

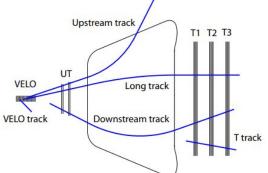


**Giorgia Tonani** 



## **Upstream Tracker: importance in LHCb**

- Track reconstruction
- Ghost rate reduction
- Long lived particle reconstruction decaying after the VELO



	Current LHCb [%]	Upgrade	LHCb [%]
	$\nu = 2$	$\nu = 3.8$	$\nu = 7.6$
Ghost rate	19.5	15.3	20.3
Reconstruction efficiency			
VELO + UT(TT)	80.9	86.7	84.5
VELO + UT(TT) p > 5 GeV	90.7	96.2	94.4
VELO + UT(TT) + not Long	66.6	69.6	67.9
VELO + UT(TT) + not long p > 5 GeV	89.2	94.5	93.2

# **High voltage**

High voltage cables for sensors depletion

Monitoring panel in place:

- access to each channel
- sensor name
- voltage per sensor
- current per sensor
- V/I per sensor

7	Object		State								F	ri 14-Jul-2023 14:47:06
LHCb	UTA_HV_IPX_AT		OFF - V								root	
гнср		_	OFF - 4								root	<u>د</u>
Sub-System	State											
UTaX_AT_HV13_CAEN-4-6	OFF	- 🗸	- Status									
UTaX_AT_HV14_CAEN-4-7	OFF	- 🗸										OPC Server Satus
UTaX_AT_HV15_CAEN-4-8	OFF	- 1	0.00 [uA]	0.00 [uA]	0.00 [uA]	[Au] 00.0		RED: NOT OK				
TaX_AT_HV16_CAEN-4-9	OFF	- 1										Display
aX_AT_HV17_CAEN-4-10	OFF	- 1										O Sensor
aX_AT_HV18_CAEN-4-11	OFF	- 1	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.30 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]		Partition
JTaX_AT_HV1_CAEN-5-0	OFF	- 1										O Voltage [V]
JTaX_AT_HV2_CAEN-5-1	OFF	- 1										Current [uA]
TaX_AT_HV3_CAEN-5-2	OFF	- 1	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.30 [uA]	0.30 [uA]	0.30 [uA]	0.00 [uA]		○ V/I
TaX_AT_HV4_CAEN-5-3	OFF	- 1										Redraw
TaX_AT_HV5_CAEN-5-4	OFF	- 1										
TaX_AT_HV6_CAEN-5-5	OFF	- <	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.30 [uA]	0.00 [uA]	0.30 [uA]	0.00 [uA]	0.00 [uA]		Overview
TaX_AT_HV7_CAEN-5-6	OFF	- 🗸										
TaX_AT_HV8_CAEN-5-7	OFF	- 1										Enable channels
TaX_AT_HV9_CAEN-5-8	OFF	- 1	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]						
TaX_AT_HV10_CAEN-5-9	_	- 1	0.00 [UA]	0.00 [UA]	0.00 [UA]	0.00 [UA]		Disable channels				
TaX_AT_HV11_CAEN-5-10		- 1										Get included devices
TaX_AT_HV12_CAEN-5-11	OFF	- 🗸	0.00 [	0.00 [	0.00 (	0.001.41	0.00 ( . 1)	0.001.41	0.001.41	0.00 (		Det included devices
			[Au] 00.0	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]		What you want?
												I-V curves
										0.00 [uA]	Current monitoring	
			0.00 [uA]	0.00 [uA]	0.00 [uA]	0.20 [uA]	0.20 [uA]	0.00 [uA]	0.00 [uA]	0.00 [uA]	Select HV board Disp	ay
										0.00 [UA]	UTHV:CAEN/uacaen01/b	ard05/channel008. *

Messages





# **High voltage**

I - V curves

- Single sensor scan
- List of sensors scan
- Scan all sensors that belong to a subsystem

Scan of the current over

time

00						UTA_HV_IF	X_AT: TOP						
LHCb	Object UTA_HV_IPX		State	✓ ▲								Fri 14-Jul-2023	14:49:36
Sub-System	Sta	ite											
UTaX_AT_HV13_CAE	EN-4-6 OF	F -	Status										
UTaX_AT_HV14_CAE	N-4-7 OF	F	3									OPC Server Sal	
UTaX_AT_HV15_CAE	IN-4-8 OF	F -	0.00 [u		0.00 [uA]	[Au] 00.0		0.00 [uA]	0.00 [uA]	[Au] 00.0		C RED: NO	
UTaX_AT_HV16_CAE	N-4-9 OF	F - 1	a   P	0		X I-V c	urves					- Display	
UTaX_AT_HV17_CAE	N-4-10 OF	F * .		Individual I-V sc	an —								
UTaX_AT_HV18_CAE	N-4-11 OF	F * .	0.0	Select the sensor	to perform the	e I - V curve				00 [uA]		<ul> <li>Sensor</li> <li>Partition</li> </ul>	
UTaX_AT_HV1_CAE	N-5-0 OF	F - 1					Informa	tion				Voltage [V]	
UTaX_AT_HV2_CAE	N-5-1 OF	F - 1			•							Current [u/	
UTaX_AT_HV3_CAE	N-5-2 OF	F - 1	0.0							00 [uA]		○ V / I	
UTaX_AT_HV4_CAE	N-5-3 OF	F - 1		Start measur	ements							Redraw	
UTaX_AT_HV5_CAE	N-5-4 OFI	F - 1											
UTaX_AT_HV6_CAE	N-5-5 OF	F -	0.0	-I-V of all sensors						00 [uA]		Overview	
UTaX_AT_HV7_CAE	N-5-6 OF	F -		This scan pe						10 [UM]		Overview	
UTaX_AT_HV8_CAE	N-5-7 OF	F -		I-Vs in all sen			Inform	nation				Enable chan	nels
UTaX_AT_HV9_CAE	N-5-8 OF	F -		belong to this	quadrant								
UTaX_AT_HV10_CAE	EN-5-9 OF	F - 1	0.0	Start measur	ements					00 [uA]		Disable chan	nels
UTaX_AT_HV11_CAE	N-5-10 OF	F 7 5											
UTaX_AT_HV12_CAE	N-5-11 OF	F T	4									Get included d	evices
			0.0						Quit I-V scan	00 [uA]		what you wa	antr
									Quit I-v scan				
										00 [uA]	- Current monitoring	I-V curve	s
			0.0		www.taket				MANN LUNA			Display	
										0.00 [uA]	UTHV:CAEN/uacaen		el008 *
										a 11	Le minore in dataen	a a sour do sy cridini	

Messages

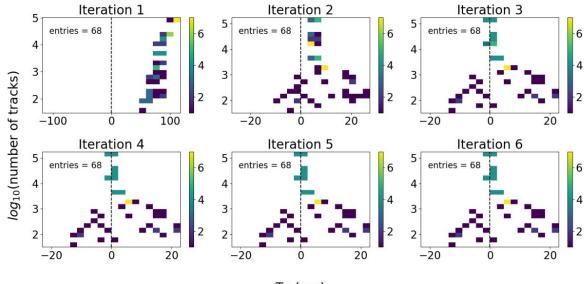


Close

# **Space alignment**

Implementation in DD4hep:

 after simulation and digitisation, with sub-detectors at the design position: no misalignment



Tx (μm)

- Run Alignment software with some initial misalignment in UT
- Expect **Alignment** to correct the misalignment after a few iterations using pure tracking (no constraints applied) : obtained after 4 iterations
- 10<sup>4</sup> tracks needed to reach good results
- Single degree of freedom (DOF), multiple DOFs studies ongoing



# **Cooling system monitoring**

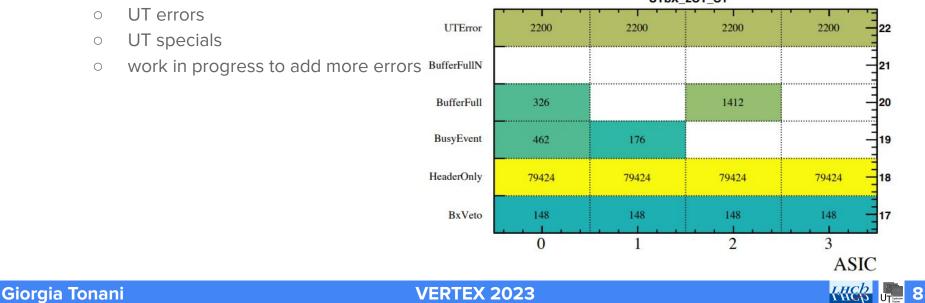
**Online** temperature monitoring of manifold, backplanes and modules

Monitoring of temperature and humidity **trend** in **time** (useful during commissioning)

view of UT monitoring		2							
UTaX_C	Status OPC server Server status	Running	Start/Stop OPC Server		T_max UT 23.39	T_max U	TA 13.39	T_max l	JTC 12.95
UTaU_C	Connection status	Connected							
UTbV_C	UTaX_C			C-side	aX-layer				
UTbX_C		c	O2 manifold 3.18	– Backplane –			Destudents		
-side staves inlet	Backplane	UTa_CT1	28.95	Backplane	UTa_CT2	28.37	Backplane UTa_CT3	28.20	
	UTaX_1CT_M4	UTaX_2CT_M4	UTaX_3CT_M4	UTaX_4CT_M4	UTaX_5CT_M4 9.75	UTaX_6CT_M4 9.52	UTaX_7CT_M4	UTaX_8CT_M4	
-side staves outlet	UTaX_1CT_S2W								
je.	UTaX_1CT_M1E	UTaX_2CT_M1	E						
	12.20 UTaX_1CT_S1E	10.31 UTaX_2CT_51E							
UTaX_A	7.52	9.49	-						
UTaU_A	UTaX_1CB_S1E 7.68	UTaX_2CB_518							
UTbV_A	UTaX_1CB_M1E 12.95	UTaX_2CB_M10 7.60	E						
UTbX_A	UTaX_1CB_S2W								
-side stave inlet	UTaX_1CB_M4	UTaX_2CB_M4		UTaX_4CB_M4	UTaX_5CB_M4	UTaX_6CB_M4	UTaX_7CB_M4	UTaX_8CB_M4	
	9.52	9.27	8.36	9.52	21.38	8.60	8.62	8.53	
A-side stave outlet	Backplane	UTa_CB1	29.12	васкріане	UTa_CB2	29.45	Backplane UTa_CB3	28.20	
ir.	Temperatures st	aves 1 and 2							
	1	<b>^</b>							
umidity system									
lumidity system									
OP Margins									
ackplanes ——									
In.									

## **Online monitoring**

- Monitoring in place: small sample of the captured data sent to computer farm to monitor in real time
- Adding plots to help the commissioning phase: basic information i.g. errors information



## Firmware data format

### Input data:

								No	rmal	Data	a pad	cket								1					
23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0		
	BXID [12b]											Parity	0		# Hits[6b]						HIT XXX CH_XXX [63]				
HIT XXX (cont)											HIT YYY									HIT ZZZ					
CH	_XXX[2	0]		VA	L_XXX	5b]				CH	I_YYY	[7b]				VA	L_YYY	[5b]		CH_ZZZ [63]					

### Output data:

### Example of a normal event

	E	ent Hea	ders & F	lags		LANE 5					LANE 4				LANE 3					LAN	VE 2			LAN	NE 1		LANE 0			
16b 16b		16b	16b		16b		16b		10	16b		16b		16b		16b		16b		16b		16b		16b		5lb	16b		16b	
8b 8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8b	8
	Event 0 Header			н	it1	н	10			Hito		HI1		Hito		Hitt		Hito		Hits		Hito		Hit1		HI				
																	н	it2	н	113	н	t2			H	12				
																					H	t4								

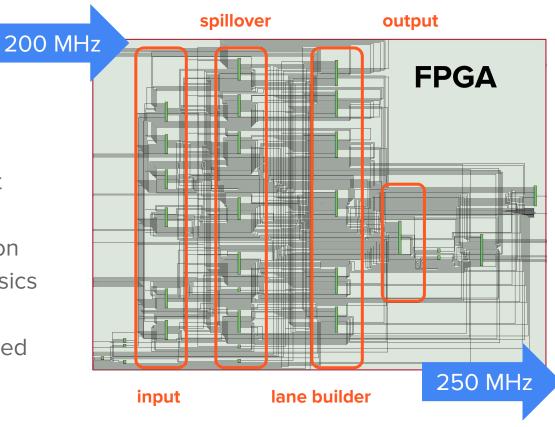




### **Firmware**

### Functionalities

- 1. flavour independence output data format
- 2. spillover correction application
- merging the information all asics in a flow (one output)
- 4. tag different data type received

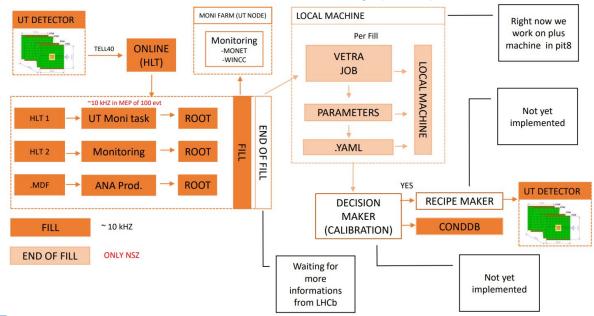


Status: implemented to work in Non-zero-suppressed (NZS) and in Zero-suppressed (ZS) mode



### **Calibration**

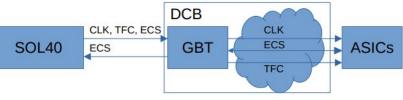
- Development of software to run automated detector calibrations
- **Pedestals** and **thresholds** computed exploiting End of Fill calibration runs (no LHC beam, only NZS data)
- Detector parameters updated automatically (ECS)







## **Desynchronization issue**



Biggest problem during commissioning: random lost of ASICs configuration

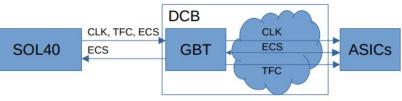
Unstable clock signal received from the ASICs, related to the TFC sequence:

TFC sequence quiet for a relatively long time + a single command bit activated + GBT loses synchronization with the SOL40 board which sent the clock

GBT not able to send a valid signal back to the SOL40 card  $\rightarrow$  both the FEC in the GBT and in the SOL40 are activated  $\rightarrow$  clock signal GBTs deliver to the ASICs is disturbed  $\rightarrow$  confuse the ASICs and put them in a state of which they can not recover on their own



## **Desynchronization issue**



UT not the only detector seeing this effect on the GBT chip, other detectors using it have reported similar problems.

Palliation strategy was found: if at least 1 of the 8 bits of the TFC command is asserted at all times, then the GBT suffers many less losses of synchronization

In the UT the SNAPSHOT bit has been sacrificed for this purpose: by activating it in every event, the command becomes useless, but the situation improves enough that it allows us to take some data for commissioning.

The reason why this works is theorized to be related to signal DC balance, but it is not fully understood or proven. It is not a complete cure either, as errors become much less frequent but still happen. Several improvements are currently being studied. We hope the situation will be enhanced in the future.

### Giorgia Tonani



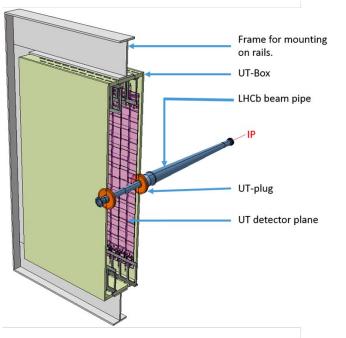
## **UT box deformation**

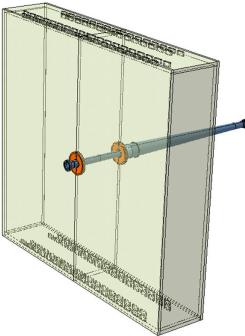
UT box deformation → not properly closed → higher temperature

→ decreased humidity, nitrogen leakage

Surveys and monitoring of the sensors behaviour:

possible to run at 0°C





YETS: stop the Nitrogen leakage with a beam pipe seal + surveys

### **Giorgia Tonani**





UT 15