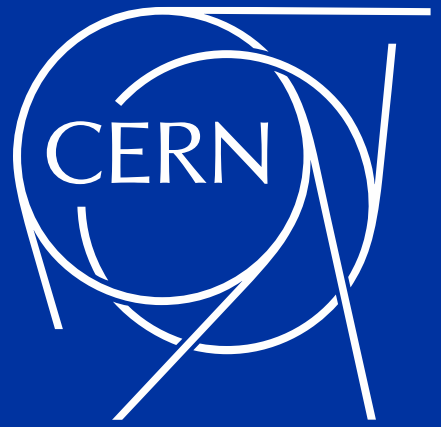


Experience with UQDS and EDAQ in the SM18 test benches and plans

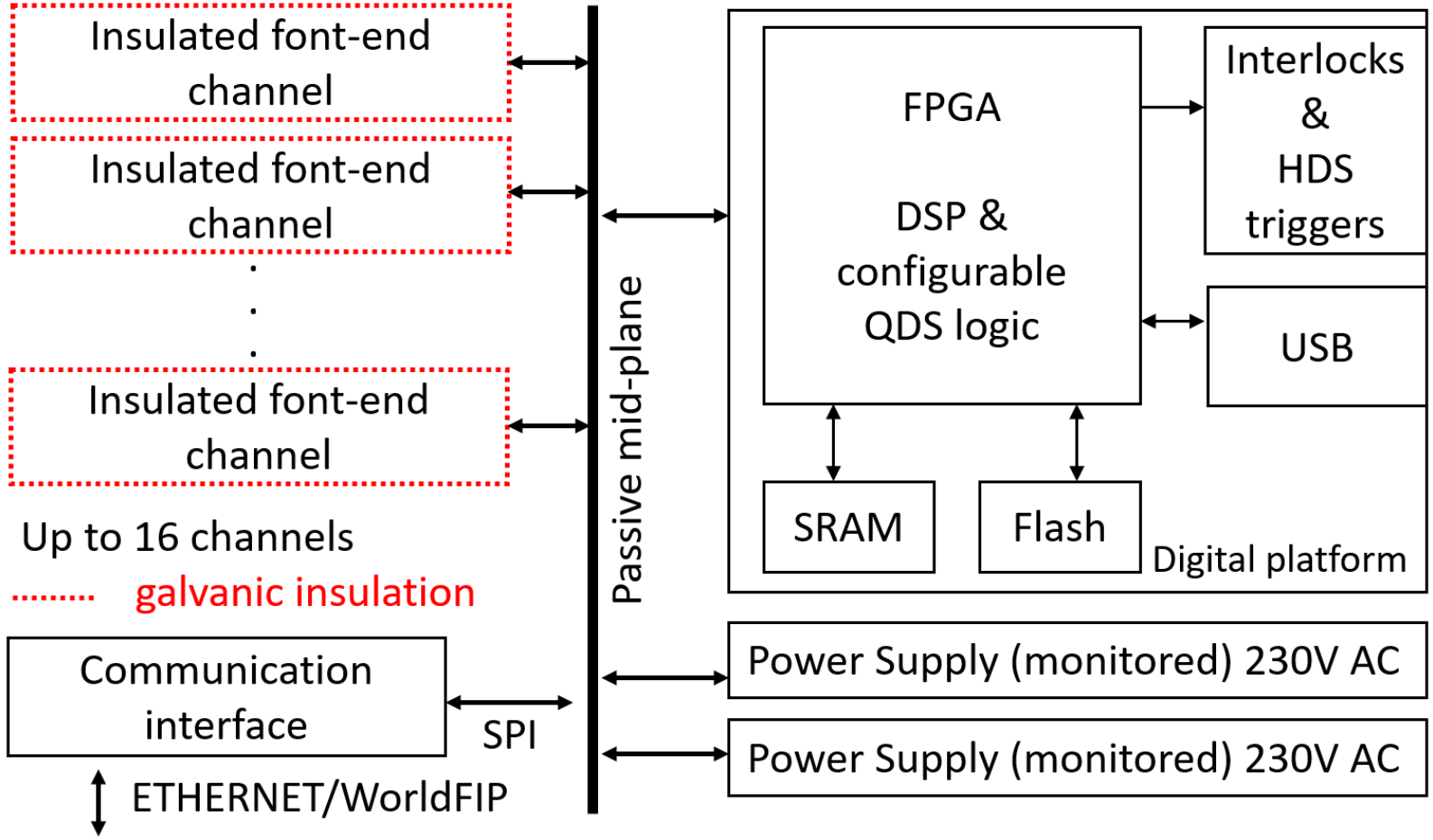
Jens Steckert, Jelena Spasic, Tomasz Podzorny, Guzman Martin, Reiner Denz & colleagues – TE-MPE-EP
Marc-Antoine Galilee – TE-MPE-CB
Thanks to Piotr Koziol, Stian Juberg and the SM18 Teams

Outline

- **UQDS overview**
- **EDAQ overview**
- **Cluster F1 & Cluster F2**
  - System Layout F1
  - UQDS firmware for F1 overview
- **Operational experience**
  - Experience in F1
  - Experience with UQDS in SM18
- **Summary**

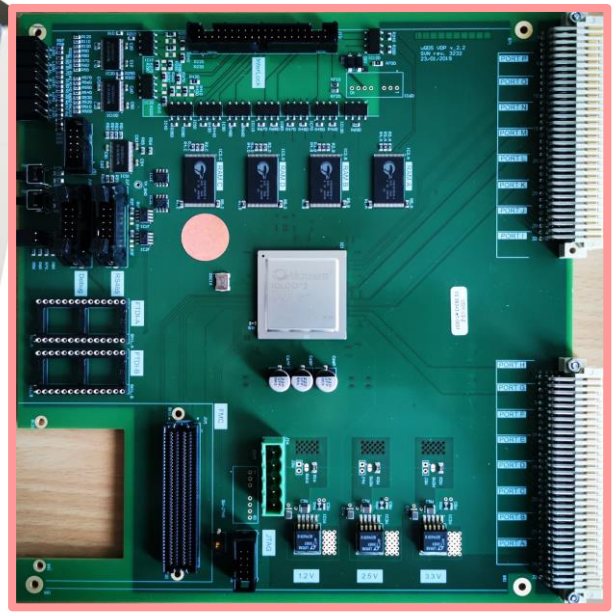
Universal Quench Detection System – UQDS

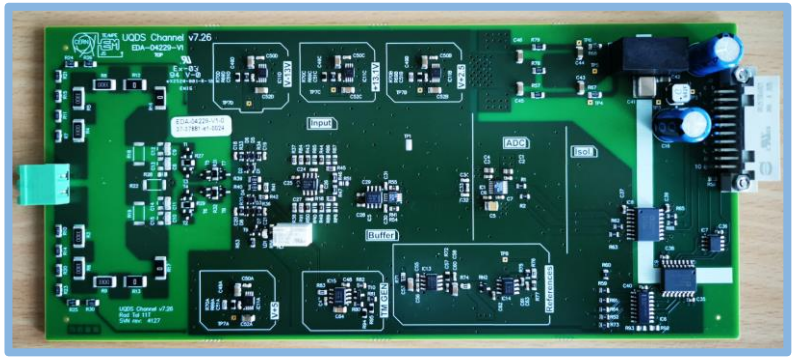
- **Modular, generic system**
- **Central FPGA performing all logic based on IGLOO2**
  - Advanced signal filtering
  - Dynamic setting of quench detection parameters for efficient operation
- **Analog front ends digitize signals and provide galvanic isolation**
- **Redundant power supplies, diode coupled and monitored**
- **Passive mid-plane**
- **Controls interface – WorldFIP or EDAQ**



- **UQDS is the baseline for HL-LHC – the first full deployment will be the IT-string project**

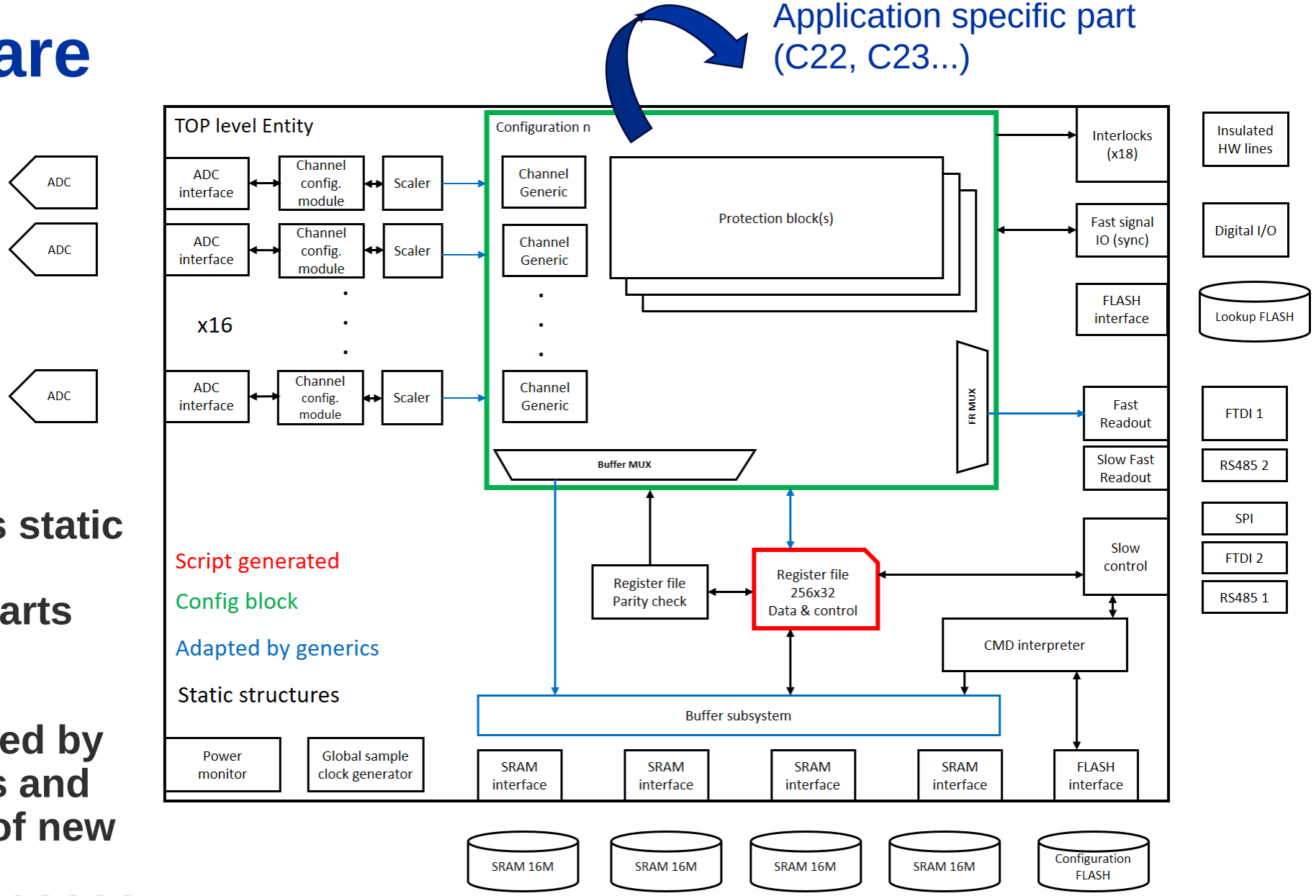
UQDS





Parameter	Value
Resolution (20-bit ADC)	105 nV/LSB .. 48 uV/LSB
ADC speed	Up to 1 MS/s
Analogue bandwidth @ gain	120 kHz @ G=1 100 kHz @ G=9 50 kHz @ G=45 7 kHz @ G=450
Active input voltage range	+/-50 mV (G=450) .. +/-22.5 V (G=1)
Max differential input voltage	1 kV/1 s
Galvanic insulation	2.5 kV/20 min, 5kV/1min

FPGA Gateware



Modular approach:

- **Basic infrastructure is static**
- **Application specific parts adapted to each case**
- **Some code is generated by scripts to avoid errors and speed up generation of new blocks**

EDAQ

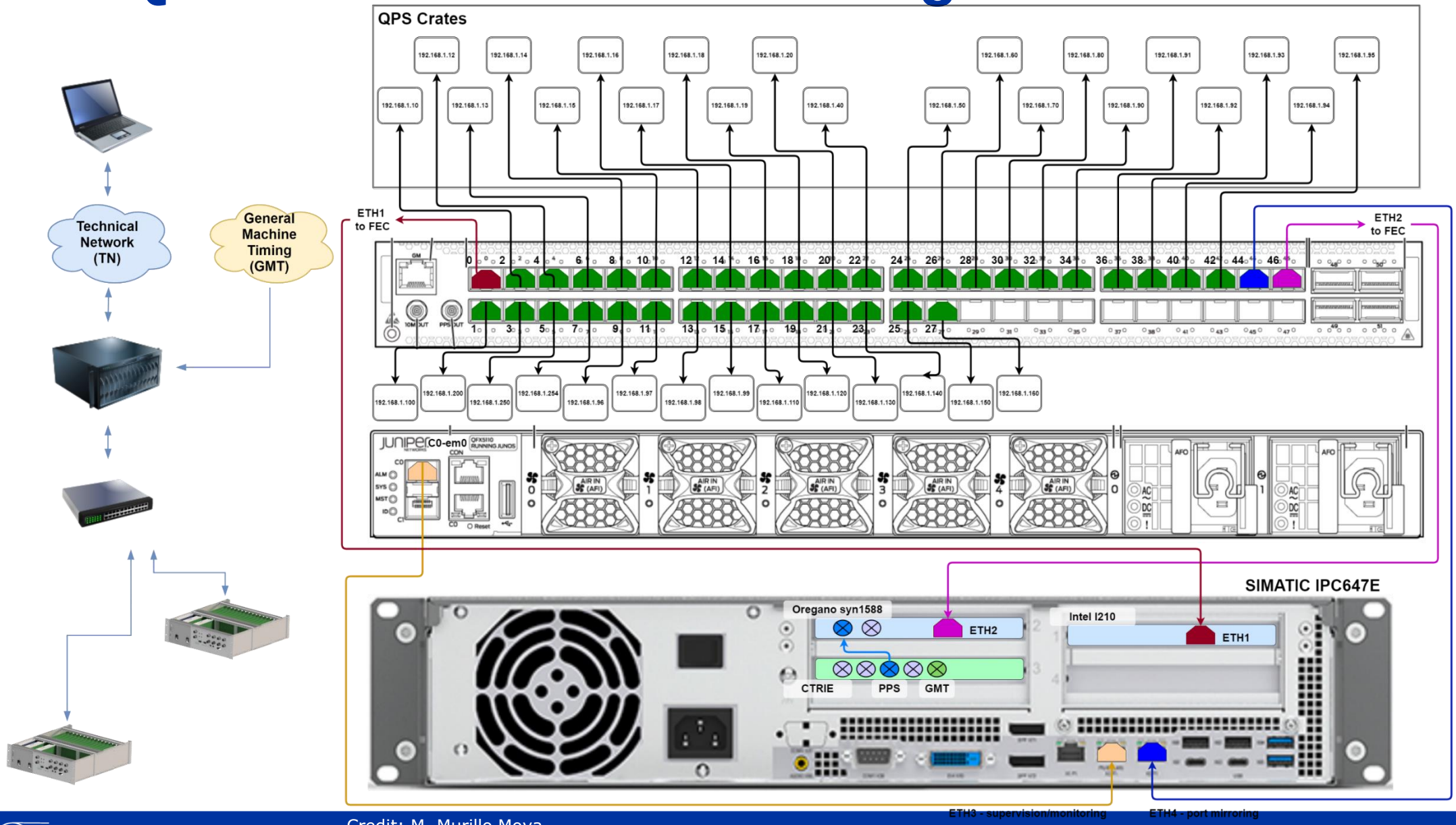
Communication and time synchronization system developed by MPE-EP to replace the outdated WorldFIP field bus by a modern ETHERNET based system

Key features:

- Data transmission rate of 10Mbit/client (WorldFIP was limited to ~960 bytes/s)
- Timing synchronization << 1ms (~1us)
- Full integration into FESA (Front End Server Architecture)
- Full integration to CERN controls system:
  - NxCALS (Logging) → 10Hz continuous
  - Post Mortem (transmission of high resolution data after system had triggered)
  - FESA API (get and set commands allow controls by third party applications
- Fast logging: up to 10kHz continuous logging **NEW**
- Possibility of fast readout with ~300kHz

EDAQ controller for UQDS

EDAQ infrastructure and configuration



Clients (UQDS)

Switch

Front end server

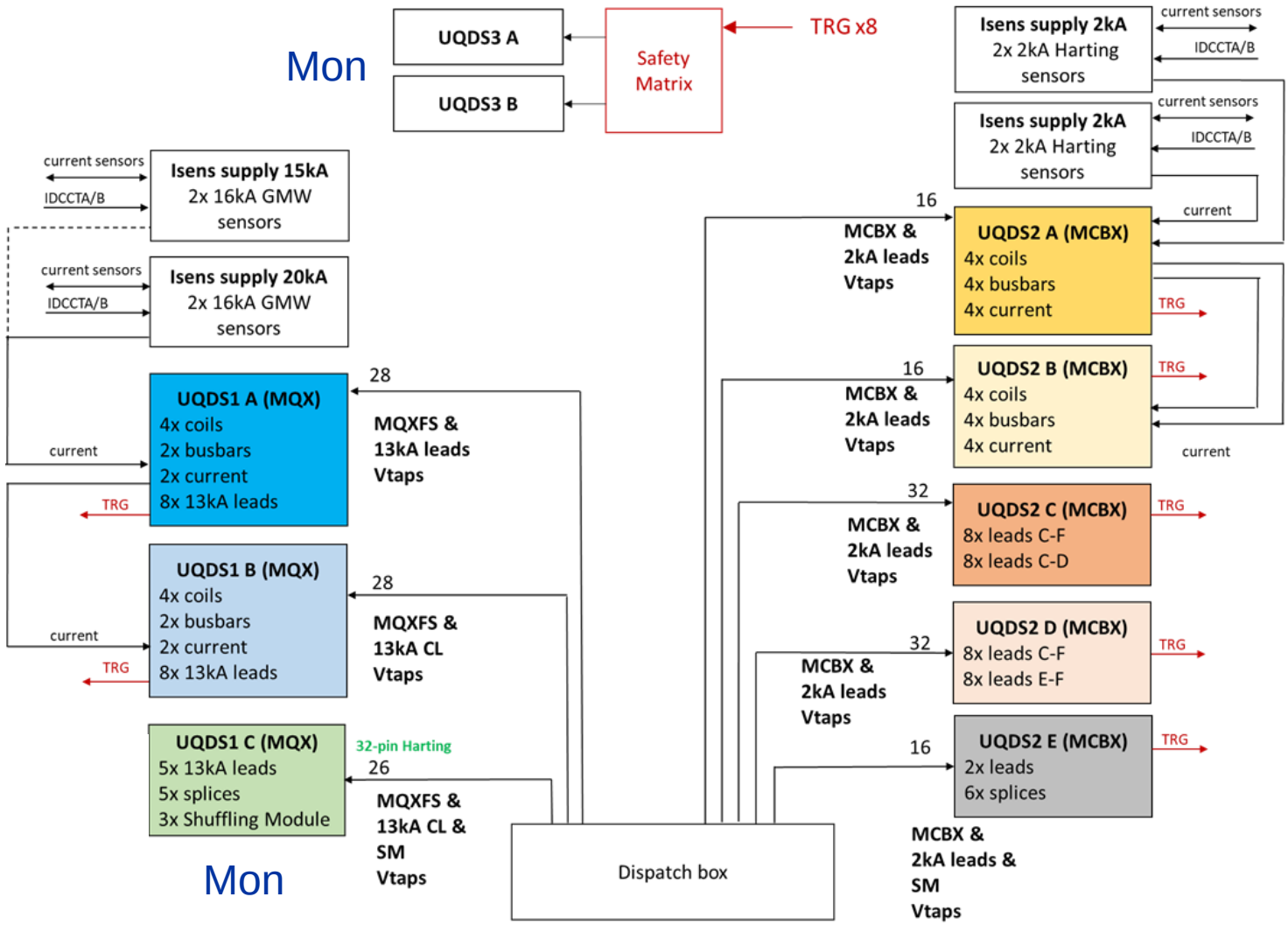
Credit: M. Murillo Moya

SM18 Cluster F1 & F2

- **Cluster F in SM18 was upgraded to provide a modernized test bench for HiLumi magnets and the superconducting link**
- **Quench detection, test bench protection and data acquisition is provided by UQDS + EDAQ**
- **F1 system size: 10x UQDS & 1x PDSUv1**
- **F2 system size: 20x UQDS**
- **Cluster F1 is commissioned and waiting for the first MQXF magnet**
- **Cluster F2 will be commissioned after F1 and will be used to test the super conducting link.**

Cluster F1 QDS block diagram

- **UQDS is used for:**
  - Magnet protection
  - Testbench protection (Current leads, bus-bars etc.)
  - Monitoring (additional signals)
- **Magnet protection systems are redundant and interlocking, monitoring systems are not**
- **Monitoring crates will record post mortem when protection crates trigger**
- **Current sensors are connected via dedicated powering and connection boxes**



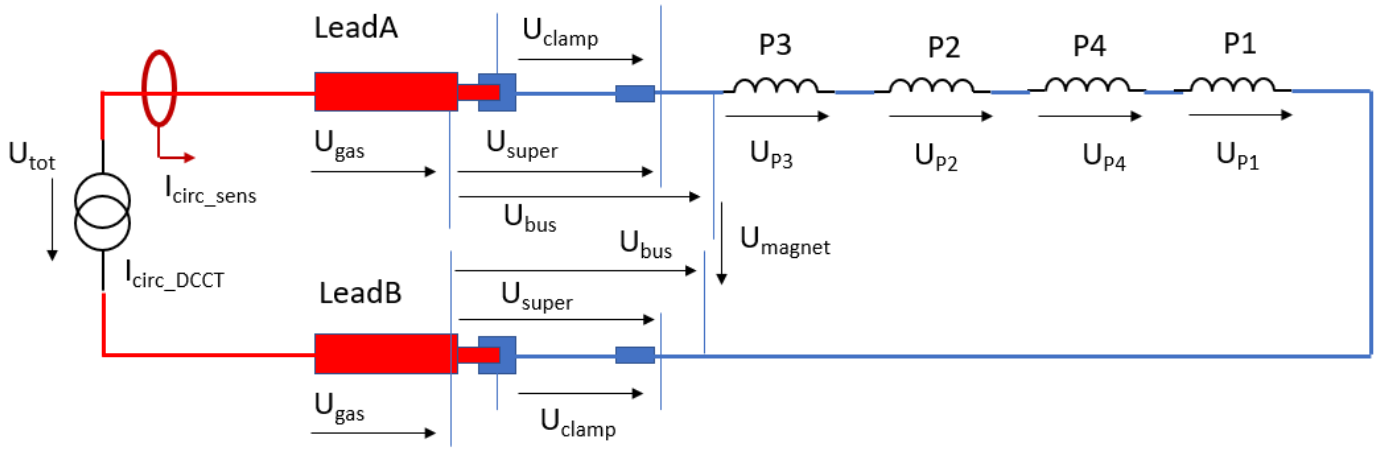
Cluster F1 & F2 UQDS installation

- 10 systems for F1
- 20 systems for F2
- Current sensor boxes

UQDS firmware for F1

- **C22**
  - Protection of MQX magnet and test bench
  - Implements protection algorithm for MQXF magnets already used in SM18 earlier
  - Additional Test bench protection channels for current leads
  - 27 signals at ~20kHz in Post Mortem (75k points)
- **C23**
  - Protection of MCBX corrector magnets and test bench
  - Implements hybrid (comparison and L*di/dt) algorithm used in SM18 in cluster D earlier.
  - 31 signals at 9.6kHz in Post Mortem (65k points)
- **C24**
  - Generic firmware with 16 channels implementing 16 absolute thresholds
  - Used for test bench protection and additional monitoring

Firmware architecture (example C22)

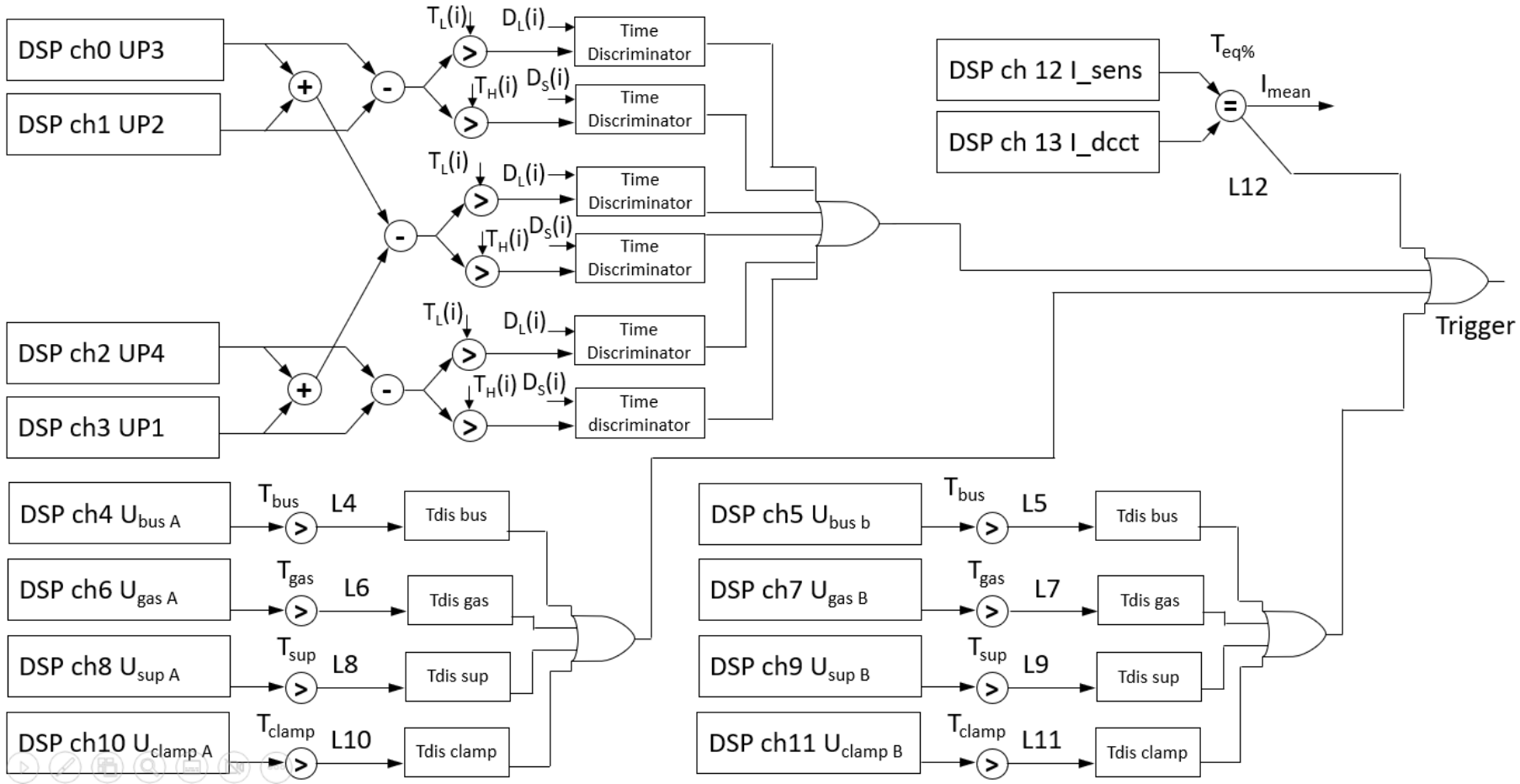


C22 Block diagram

DSP ch 14 U_{tot}

DSP ch 15 U_{magnet}

Low gain channels, supervision only

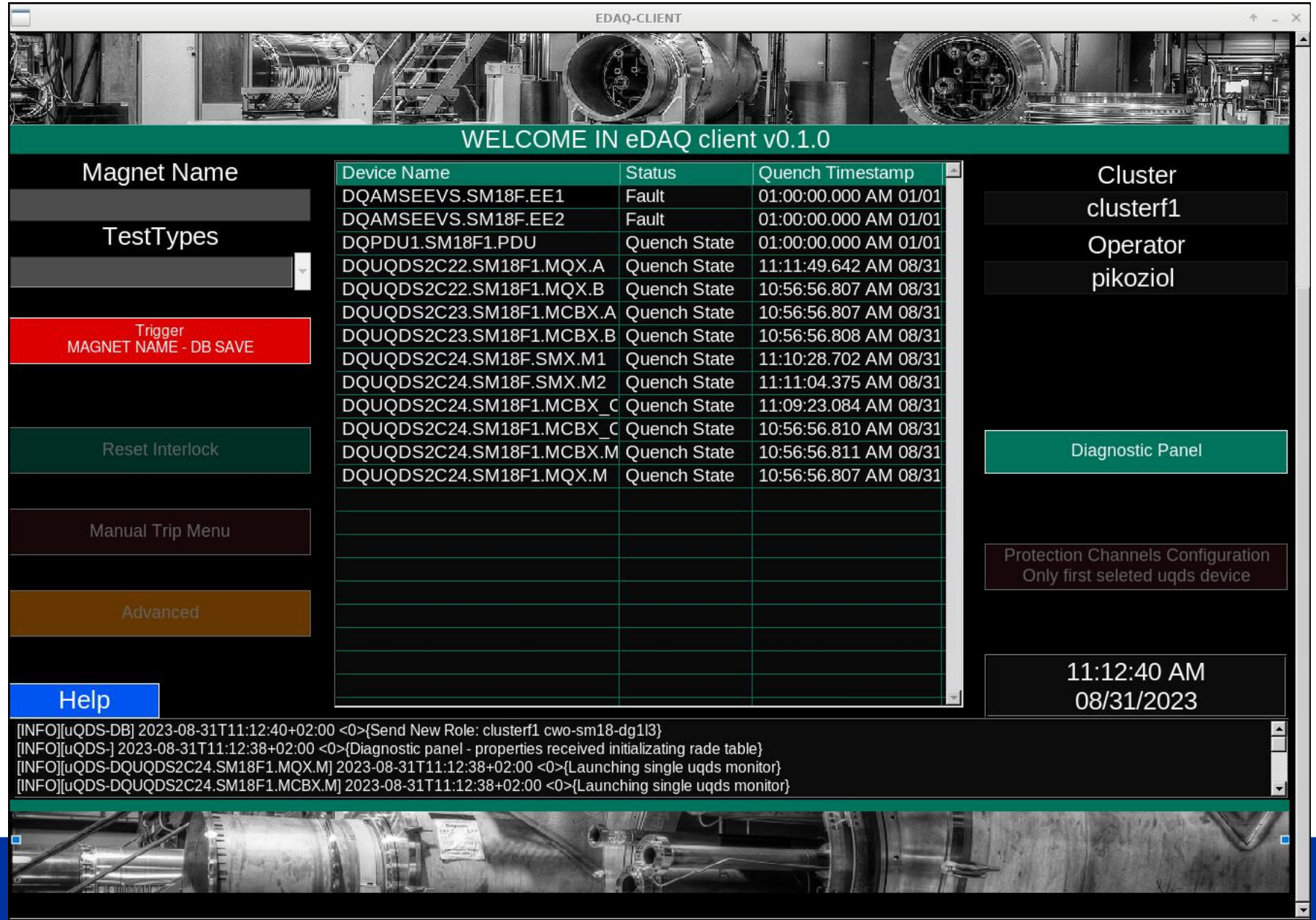


Cluster F1 controls GUI

- Developed by BE-CEM-MTA
- Allows the basic control of the UQDS crates via the EDAQ stack and FESA
- Gives the test bench operators a graphic user interface
- Thresholds and discrimination times can be changed by the TB operators
- Tested during cluster F1 commissioning

Cluster F1 controls GUI

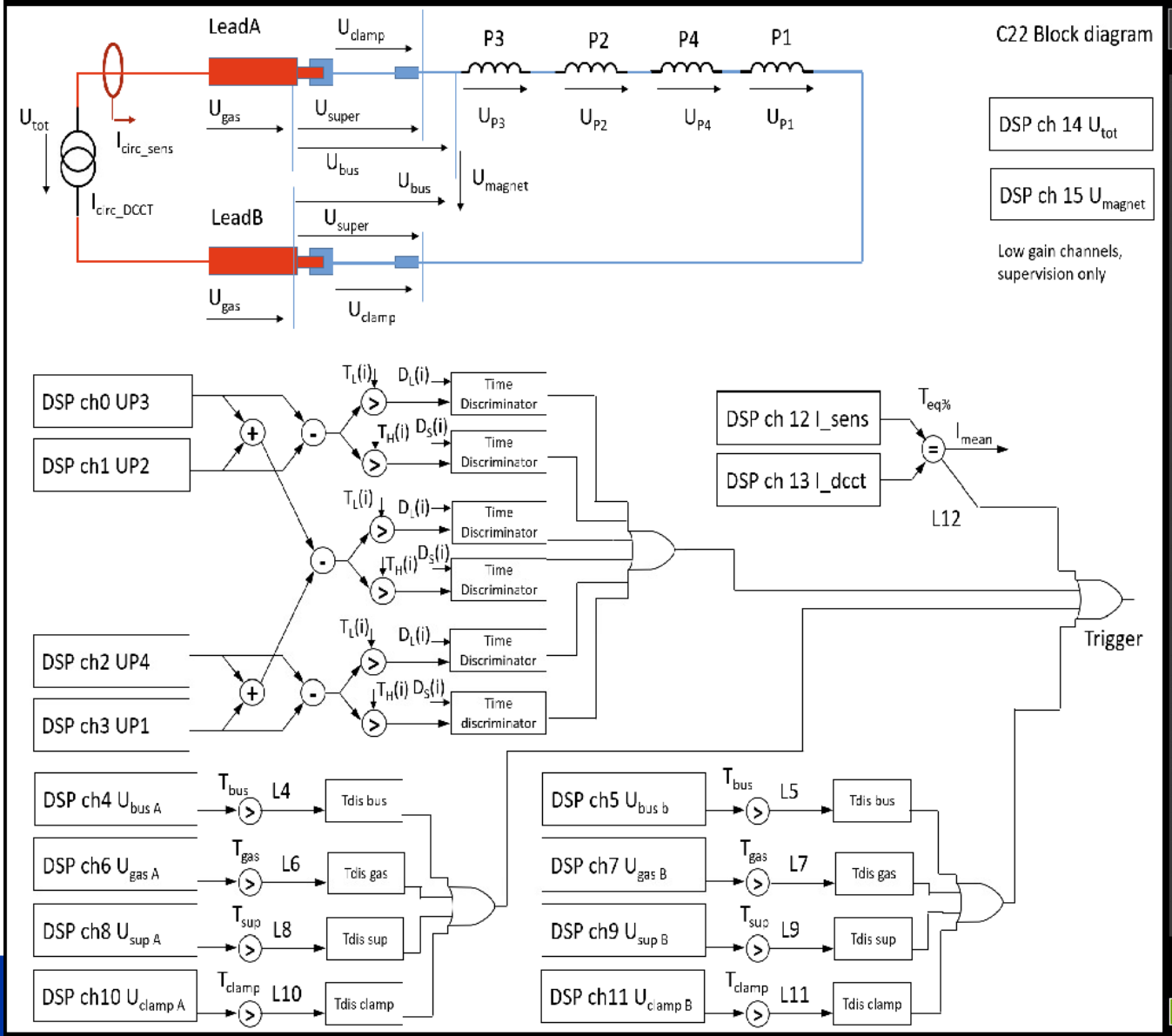
Screenshot: Piotr Koziol



Cluster F1 controls GUI

Screenshot: Piotr Koziol

EDAQ-CLIENTs



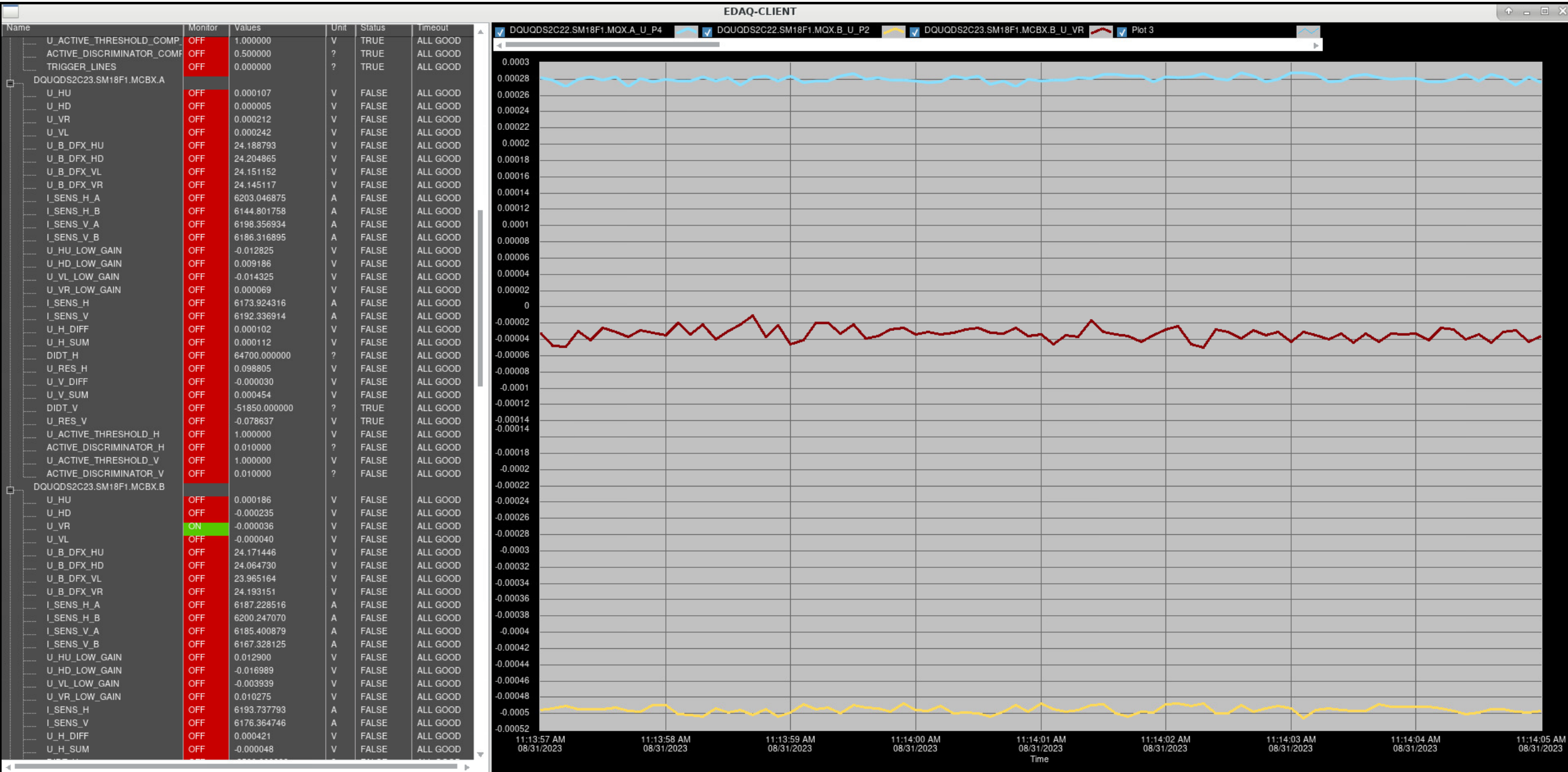
DQUQDS2C22.SM18F1.MQX.B::::CONNECTED TO:::::DQUQDS2C22.SM18F1.MQX.A

Descriptions	Values - To Overwrite	Feedback	Feedback Redundand
Current level 1 for Dyn Thres & Disc	0	0	0
Current level 2 for Dyn Thres & Disc	3000	3000	3000
Current level 3 for Dyn Thres & Disc	8000	8000	8000
Current level 4 for Dyn Thres & Disc	12000	12000	12000
Dyn thres. Comp 0 for I level 1	0.99999997	0.99999997	0.99999997
Dyn thres. Comp 0 for I level 2	0.99999997	0.99999997	0.99999997
Dyn thres. Comp 0 for I level 3	0.99999997	0.99999997	0.99999997
Dyn thres. Comp 0 for I level 4	0.99999997	0.99999997	0.99999997
Dyn discr time Comp0 for I level 1	0.5	0.5	0.5
Dyn discr time Comp0 for I level 2	0.5	0.5	0.5
Dyn discr time Comp0 for I level 3	0.5	0.5	0.5
Dyn discr time Comp0 for I level 4	0.5	0.5	0.5
Dyn thres. comp1 for I level 1	0.99999997	0.99999997	0.99999997
Dyn thres. comp1 for I level 2	0.99999997	0.99999997	0.99999997
Dyn thres. comp1 for I level 3	0.99999997	0.99999997	0.99999997
Dyn thres. comp1 for I level 4	0.99999997	0.99999997	0.99999997
Dyn discr time Comp1 for I level 1	0.5	0.5	0.5
Dyn discr time Comp1 for I level 2	0.5	0.5	0.5
Dyn discr time Comp1 for I level 3	0.5	0.5	0.5
Dyn discr time Comp1 for I level 4	0.5	0.5	0.5
Fixed threshold for Lead busbar	20	20	20
Fisxed disrcimination for Lead	0.1	0.1	0.1
Fixed threshold for Lead copper part	0.099999979	0.099999979	0.099999979
Fixed discrimination for Lead copper	1	1	1
Fixed Threshold for Lead	0.009999986	0.009999986	0.009999986
Fixed discrimination for Lead	0.05	0.05	0.05
Fixed Threshold for Lead clamp	0.009999986	0.009999986	0.009999986
Fixed discrimination for Lead clamp	0.01	0.01	0.01
Limit of current difference	0.1002609	0.1002609	0.1002609
Offset of current equivalence	256.69139	256.69139	256.69139
	0	0	0

Trigger Update - Check CRC (~30sec) - Save to flash - Reset Crate

Cluster F1 controls GUI

Screenshot: Piotr Koziol

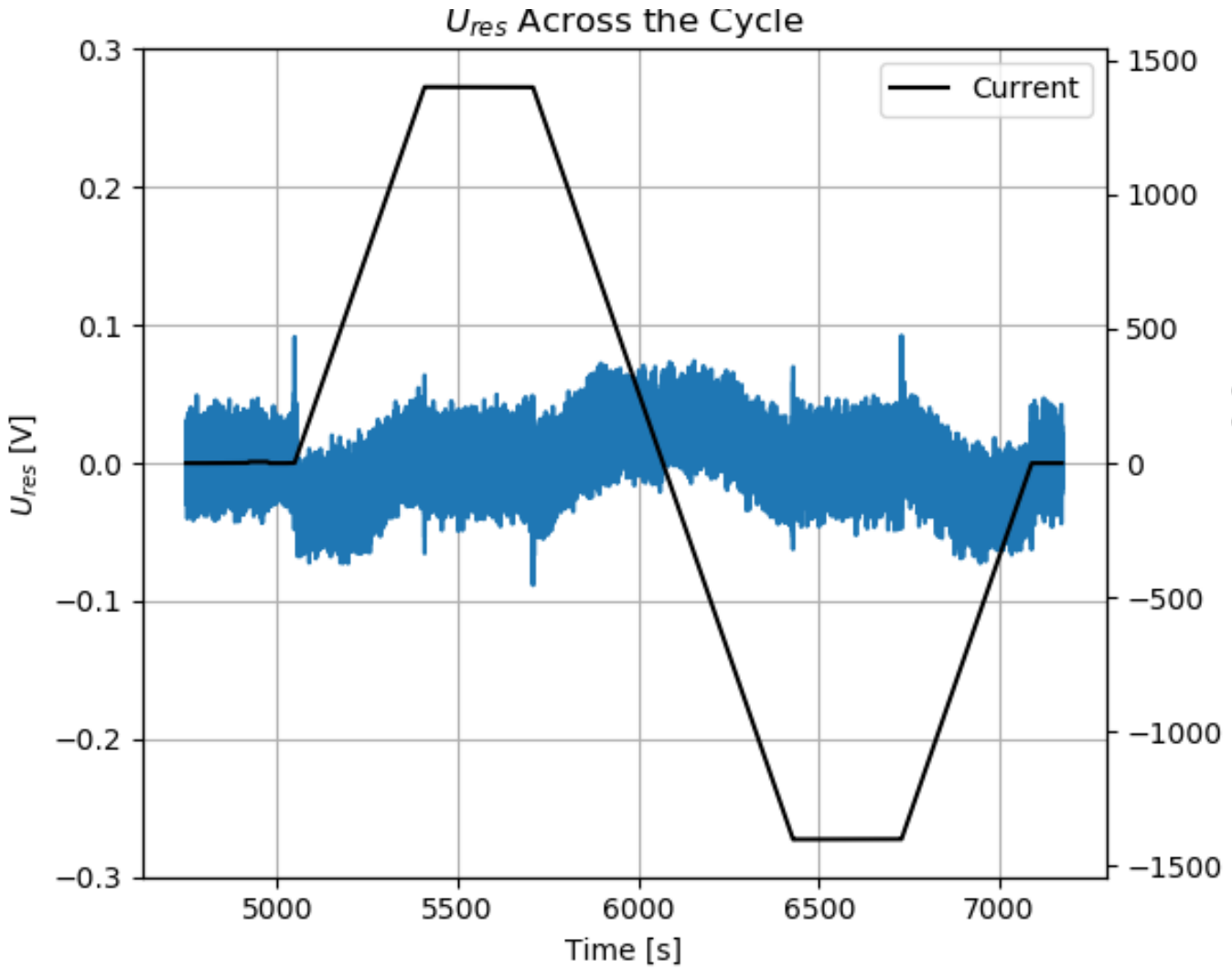


Experience with UQDS & F1

- **So far, UQDS was active during cluster F1 commissioning**
- **Shuffling module issues, delayed the production phase of F1**
- **Integration of EDAQ and UQDS took some time but is solved**
- **Fast logging option to be implemented in second phase**
- **Parameter configuration of UQDS needs some attention to ensure integrity of the system**
  - We have to make sure that each UQDS crate is properly configured and “locked” by internal checksum
  - Configuration management needs still action from experts and TB crew to be able to keep a record of settings → Room for automation !
- **In general experience is very good and we look forward to see the first magnet being tested !**

Other installations of UQDS in SM18 (no EDAQ)

- UQDS is in us
  years
- Table on the l
  installed syst
- QDS specialis
  (remote) oper
- By following t
  magnets we l
  specifics and
  QD algorithm
- So far UQDS
  representativ
  families



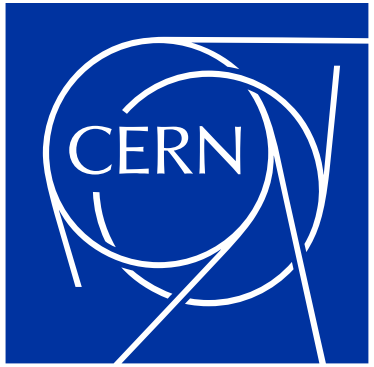
XF/MCBX magnets
(MBRD)
BRD test
BX or MCBRD test one monitoring crate)
re acoustic sensors equired)

Experience with other installations in SM18

- **Except cluster F the UQDS installations are not included in CERN controls infrastructure (no EDAQ)**
- **This requires relatively intensive expert coverage to operate as there is no official GUI available (only development GUI for experts)**
- **Biggest challenge for more sensitive algorithms (L* di/dt) is the noise coming from power converters as well as low current operation (necessitating I dependent settings)**
- **Another (yet unknown) noise source is also coupling in a lot of measurement systems in SM18. EMC user forum is informed and we'll launch a campaign with D. Valuch to identify the source of that noise.**
- **Using UQDS on (prototype) magnets in SM18 is an extremely valuable test bed for the final LHC units. → STRING will be final test for algorithms and systems**

Summary/Plans

- **Hardware installation and commissioning of cluster F1 system completed**
- **Hardware installation of F2 systems completed (still commissioning pending)**
- **EDAQ integration completed**
- **User GUI delivered by BE-CEM and working**
- **Configuration management to be more automated**
- **Possibility to extend EDAQ + GUI integration on other UQDS installations in SM18**
- **F1 & F2 UQDS+EDAQ installations are the blueprint for STRING QDS installation**



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