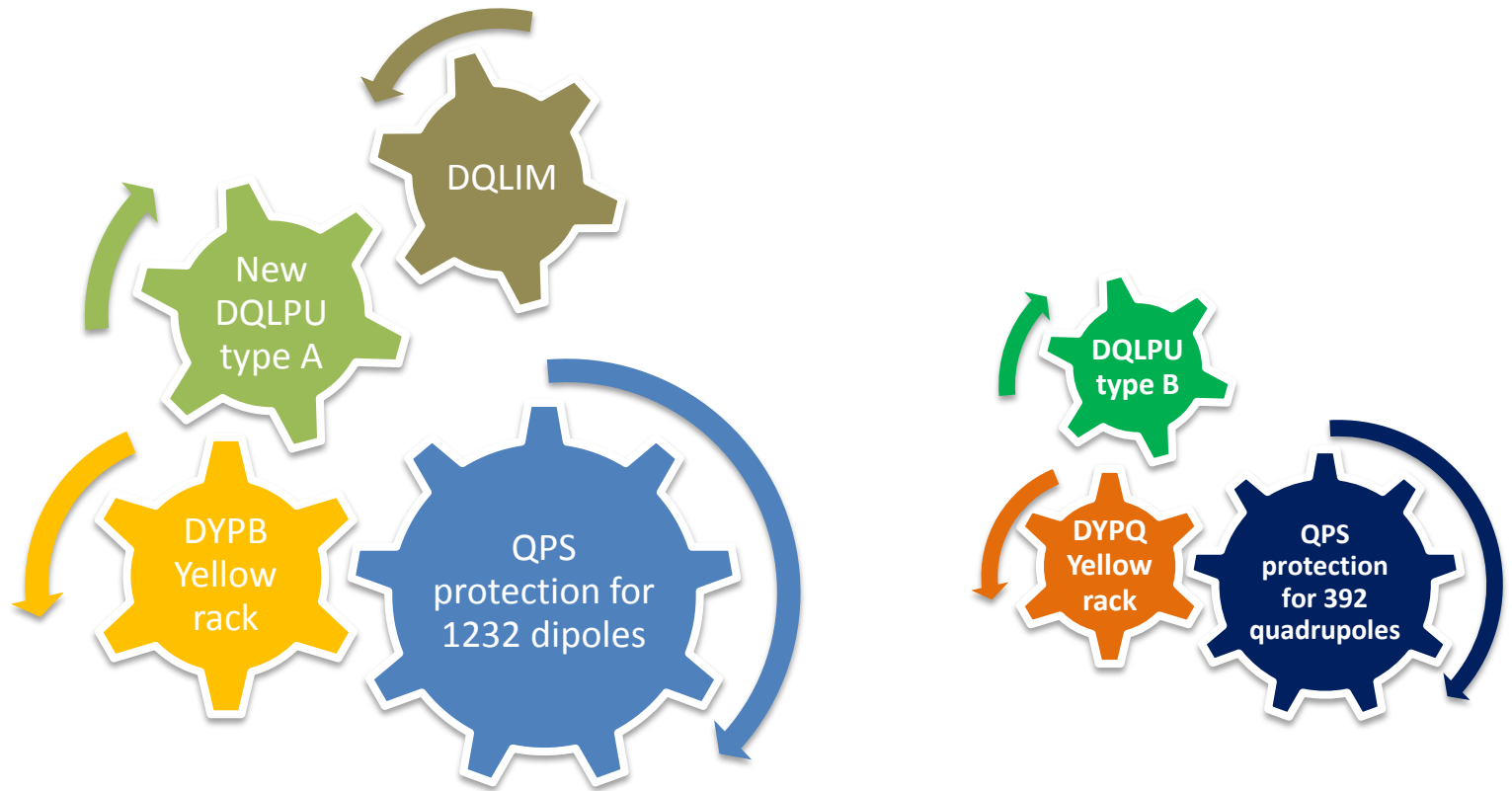# *LS1:* "Yellow racks" activities.

Protection of 1232 dipoles and 392 quadrupoles

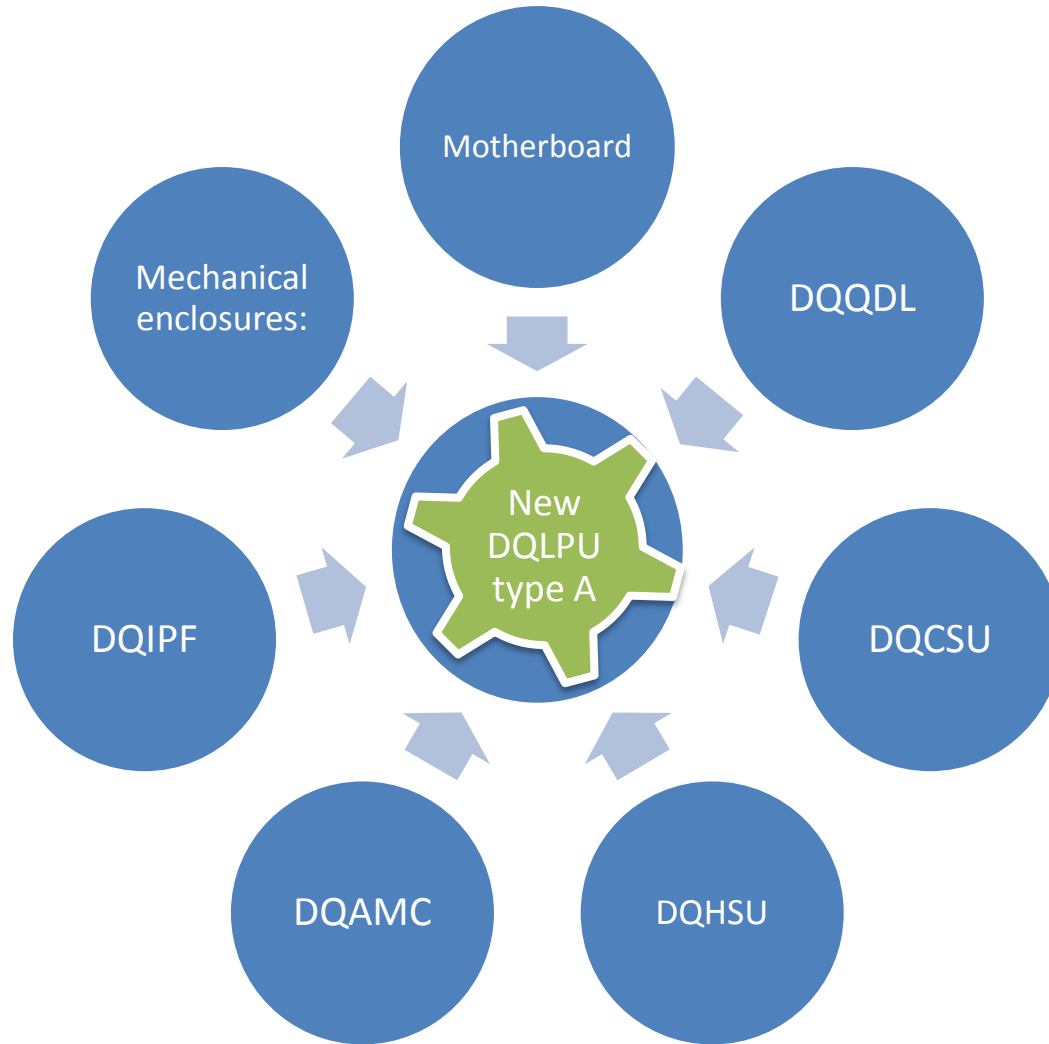# Scope and duties concerning the "yellow racks"

- Ensure the protection of the 1232 dipole magnets and 392 quadrupoles of the LHC machine by deploying a new upgrade of the quench protection.
- Studied and produced electronics and mechanics for new DQLPU type A
- Conducted and performed complete tests of new equipment and new functionalities, such as:

  - ✓ enhanced quench heater supervision
  - ✓ new fully redundant linear power supplies (DYPB)
  - ✓ new fuse in DQHDS.
  - ✓ Remote commands,…

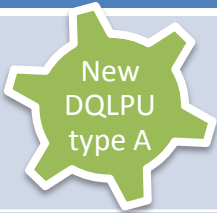- Refurbished fip connection of 392 quadrupoles + updated firm

Connections between «Yellow racks»

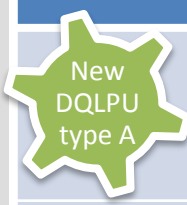# Connections with DQLPU type A (main development)

TE-MPE-EP

CRATE ENCLOSURES

New DQLPU type A	RESSOURCES		+	-
	IN (MPE) USED/NEEDED	OUT		
Mechanics (kits delivered)	x1 / x2: study, design	Design: x1 EM Protos: Atos Contract: purchase services Other company→ production	**+ : Price** **- : No real choice:** agreement with an unbalanced country. **New product: no experience** Had to **follow-up** every step the company since the beginning, in the end a sample was just copied. **Failure:** Surface treatment not as required, quality, precision, dimensions (thickness, depth ≠6mm, poor quality plastic hinges, very late delivery of the last spares. Only **after acceptance**, we had to provide a plan detailed to explain everything.	
Assembly		2 people AGH	OK, **very good** progress, efficient and clever work	No time to assemble all of the crates
Burndy connectors	x1: geometry, orders		Directly soldered on pcb	**Delay** for huge quantities →asked for **equivalent**, but **price!**
Harting connectors	x1: new design	Harting x1 EE	Good collaboration /interaction: **top quality** Directly soldered on pcb	**New product**→longer delay

ELECTRONIC BOARDS

New DQLPU type A

	RESSOURCES		+	-
	IN (MPE) USED/**NEEDED**	OUT		
Motherboard	x1.2 / **x1.5**	EM: fin.+ prod.	New design, direct connectors	Finalisation: **clearance rules changed** from MPE to EM: HV withstands problems
DQQDL (Local detector)	x1: tests / **x1.3 repair**		Re-used from initial crates. New firmware	**Missing 50** : had to repair old ones.
New DQQDL	x1: tests x1: rework	EM: rework	50 tested	200 boards **reworked** due to a missing wire and wrong resistor values. New version **not compatible**.
DQHSU (heaters supervision unit)	x1: design x1 /**+x1 for components**	EM: fin.+ prod.		**Relays** from «Arrowtronic» **not able to be soldered**: a mess! (broker?) Had to find new supplier in emergency
DQCSU (monitoring unit)	x1 / **x2**	EM:fin+ prod.		Launched under **pressure** →HV test forgotten →1 bad lot of pcb.
DQAMC (communication)	x1 / **x2 for repair or new design**		Re-used from old crates	**Missing 20**→ Had to be taken from new crates (No time for new production)
DQIPF (WorldFip interface)	x1: design **/ x2 for details**	EM:fin+ prod.	Programming from outside (gain of time)	Space between board and front panel had to be adapted. Connectors, screws, etc.

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TESTERS

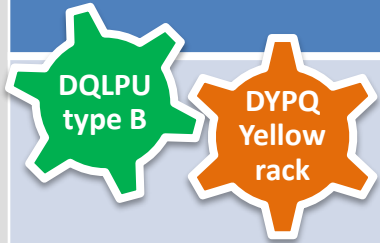|	RESSOURCES		+	
New DQLPU type A / **DYPB Yellow rack**	IN (=MPE) USED/**NEEDED**	OUT		
Connections tester	x1 **/ x2 : study, programming, design** x1 **/ x1.5 : use**		OK	
Crate functional tester	1p-4 months : study, programming, design 1p-3 months : design, building x1 : use	x1p-3 months : design, building	OK On time Faster	Study: **more specifications** and more feedback needed. **Synchronisation** with worldfip Eliminated data from DQAMC
Yellow racks functional tester See report: 234 errors	x1 : building x1.5 **/ x2 : use** x1: patches for DYPQ	x1 EE : building	AVG per shift: at least 11, usually 12 OK	Few problems with **gateway**. Starting tests delayed due to humidity (HV): heating switched off. UPS **cables too rigid→fragile**. **+6 days** due to DYPQ back from tunnel.
Cscm crate tester	x1 : making run, teaching x1 / **x2 : use, developing interface, preparation of crates**	**2 p. no tech. knowledge**		Under **pressure**, timing too tight. **New tester** to be tuned. **New interface** needed.
DQQDL tester: interlocks and threshold	x1: development x1: use		OK	Wire wrap → bad contacts, repaired several times →New pcb

Report about the 1232 yellow rack functional tester

234 problems:

- Divers:128:
    - Offsets values
    - X37 DQQDL
    - X4 DQCSU
    - X5 DQHSU
    - X3 DQAMC
    - X30 power cycles (repeated 2 or 3 times and ok)
    - X15 post mortem data
    - X50 interlocks
- Cables:28 (not connected, wires swapped, pin default, bad connections)
- DQHDS: 28 changed, 30 other problems with cables
- DQLIM: 20 problems

QUADRUPOLES

DQLPU type B / DYPQ Yellow rack	RESSOURCES		+	-
	IN (MPE) USED/NEEDED	OUT		
Taking DYPQ crates from tunnel and returning them.	x2 / **x3**			**Cables disconnected** from the Crawford box: had to be connected back afterwards (not planned)
Change Fip connectors on DYPQ (new patches)	x1: design	2 people AGH	OK. **Clever work**. (Reliability of connections Right screws UNC or Metric)	**Modification** on patches: holes had to be en
Programming and test of DQQDL	x1: new pcb for tester x1: use	x1: use (intern)	**OK**. (New firmware, test of interlocks, threshold and discrimination time)	
DQAMC programming, preparation	x1.5 / **x2**		OK. **Programmed in advance** in 281: saved time.	Errors due to **shifting of addresses** (difference between position and magnet protected but **not systematically**) **3 missing crates** Yellow DYPQ racks very dusty

TE-MPE-EP

COMMISSIONING

DYPB+DYPQ QPS protection	RESSOURCES		+	-
	IN (MPE) USED/NEEDED	OUT		
Interlock tests	x1 / **x2**		**Last sector**: fully automated	Constant **manual supervision needed**: **schedule too tight** Timing requested per sector: **8 to 9 hours** DYPQ:4x49 interlocks DYPB: 2x154 boards nQPS: 14x52 interlocks
Close current loops in tunnel	x1 / **x2**		Only few DQQDL to be replaced. Quick check thanks to monitoring	**Many cables not connected**, difficult to reach, remain behind magnet or on the wall behind them.
UPS1/UPS2 tests	x1 / **x2**			**Many cables not properly connected** on DQLPUS: many **pins bent** on Harting Q12, bad insertion of UPS connectors .
Interventions after ELQA tests	x1 / **x1.5**			Some nQPS patches missing. Not properly marked and placed.
DYPQ	x1 / **x2**			**New interlock cables** still in plastic packaging with tie wraps and **not connected** after previous team. A few **ripped cables** or connectors not seen or **not reported**.

COMMISSIONING (continued)

| WHAT?	RESSOURCES		+	-
	IN (MPE) USED/NEEDED	OUT		
Picking up DQCSU and returning	x2 / **x3**			**Tracking**: two sectors forgotten
Rework DQCSU	x1 / **x2**		OK	
Programming DQAMGS	x2 / **x3**			
Change DQQBS with mDQQBS (cscm)	X3 / **x5**			**Pressure** to change boards from one sector to another due to lack of boards.
Programming DQAMC	x2		**External programming** but difficult to download when on (must be switched off two times due to big capacitors)	Programming station **misplaced (not returned)** and then found.

A few illustrations of unexpected events

Programming station misplaced and then found after LS1

Patch missing
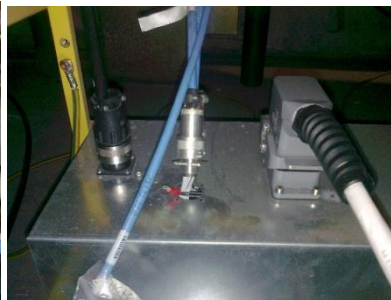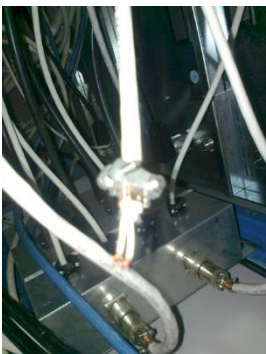
Additional tests

hinges

Lift/mad/pad

AS-702
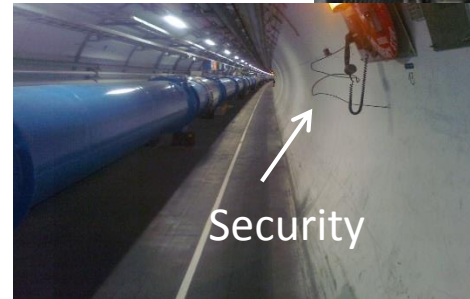
Security

Pins bent

connectors

Cables not connected

Concrete lessons learned and recommendation from LS1 to increase probability of getting a reliable machine.

- Better to choose a **company that masters a requested product and has demonstrated experience** (mechanical enclosures, components suppliers). If not possible, **more ressource** must be found in advance.
  Ex: I visited racks made by this company in Cern: looked good, even proposed in EDH.
- More advanced **preparation**, more information, clearer **specifications** must be **dispatched** (why were all DYPQ cables disconnected?)
- More **motivated, experienced and «well cared for» people needed** in the tunnel (Ex: should not lose a good person with two years experience).
- Real slots of time have to be found to **teach external ressources**.
- Not meetings necessarily, but at least a person dedicated to **taking note of what has been done** is needed (impossible to memorise and remember everything).
  Ex: forgot two sectors of DQCSU: people were sure that other people already did it before…

Concrete lessons learned and recommendation from LS1 to increase probability of getting a reliable machine (continued).

- Use knowledge and **expertise of people more efficiently**.
  - Ex: - **Too many wrong connections** (many pins bent, cables) remained and had to be identify by experts.
    - With more time or more ressources, we could have had time to **investigate more fundamental issues** or to do more tests (ex. nqps remote power cycle).
- Too many cables left without connection, because it was too difficult, too long or due to timing! **Should have been reported**. Don't underestimate that. It leads to wasting of time afterwards! = **Quality insurance missing**.
- In order to minimize the number of problems, **one sector should have been fully tested and declared as "good" before the deployment to the rest of the machine**, preferably not s 6-7.
  Ex: keep only the latest version of firmware in boards.
- Before disconnecting any cable, systematically **put a label** on it.

Conclusions

- Generally for LS1, **too many tasks were requested** to comply with a good organization and to have a fully tested working reliable equipment.
- Nevertheless, the **challenge** was overcome.
- Would have been **better to visit, discuss, and give clear instructions** to the outsourced company beforehand, by a expert.
- Take into account our well-noted ressources in order to define and **discuss with the whole team** the workload, not overestimate these capabilities, we are not supermen.
- As already started, we have to continue to think about LS2, and **prepare** right now everything we can in advance.
- Decisions must be made asap.

Conclusions (continued)

- Really take care of the level of knowledge of the teams involved in our equipment: investing time in **teaching would ultimately save time**. Too many wrong connections (many pins bent, cables) could have been avoided this way. Especially **if one sector was fully commissionned** at first and report all the problems encountered would be a **real advantage**.
- Priorities: security, quality, **work in a hurry cannot be a solution**.
- More time to **thoroughly test one device**.
  Ex: Proposal: develop in collaboration a specific «acid tester» to test the limits of a new device (EMC Testing - Transient Immunity, RF Immunity).
- For LS2 (or sooner), is there really no way to **leave wifi ON in the tunnel** and turn it off during exploitation? (even G4 is far from optimum).
- Having **another person other than the developer** could be an advantage to test a new device.
- Keep **testers** operational (**maintenance**).
- Having a **tracking** system for defective boards would be helpful.

Thank you !