Muon Power Supply Systems for Phase 2 Upgrade

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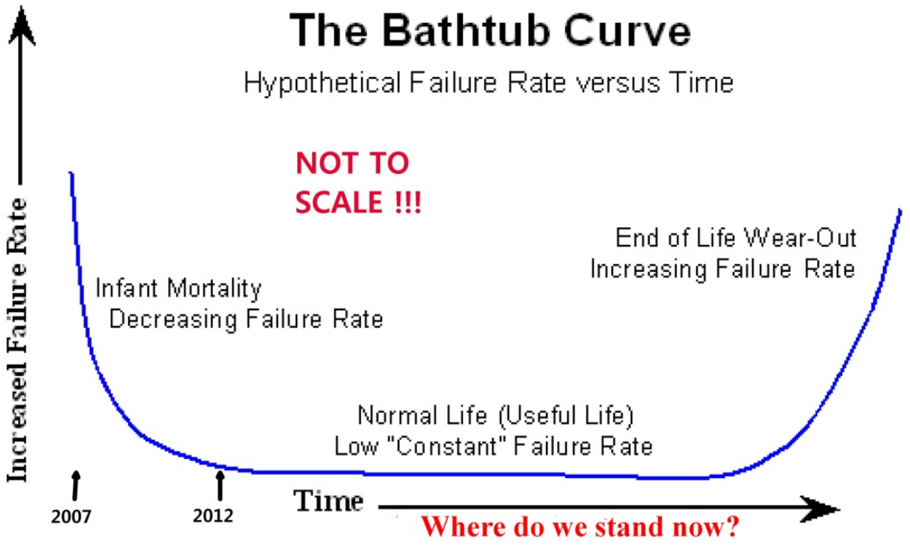
Main Motivations

- **Hardware obsolescence**
  - Design and components from first 2000's.
  - Difficulty of component replacement in ten years from now, mostly on the rad-hard types
  - Maintenance problematic: probably more expensive after the contract renewal in 2019 because of procurement of replacements
- **Limit of radiation performance**
  - HL-LHC goal is 3000 fb^{-1} by 2035. Qualification tests of the present system reached 1700 fb^{-1}, taking in account the new safety factors. The expected lifetime will last until 2030 only.
  - The bathtub curve cannot be precisely determined



Power Supply System Quantities

- The presently installed base in the LHC experiments for the two major companies is the following:

Experiment	Relative percentage
AB	10,3
ALICE	8,8
ATLAS	**18,9**
CMS	**51,9**
LHCB	6,8
TOTEM	0,8
ELECTRONICS POOL	2,3
PH	0,5

- CMS is by far the major user of commercial power supplies
- *An agreement with them concerning the replacement strategy is necessary to reduce as much as possible the production times and the costs*
- ***This agreement should be discussed by the respective Electronics Coordinators***

- The Power Supplies of the four ATLAS Muon technologies are distributed systems using about one thousand components, listed below:

LV modules	546
HV modules	418
Controls and monitoring	86
Primary power	58

- *RPC and TGC systems have the same architecture; MDT is sligthly different, not using primary power in rad-hard environment*

Replacement scenario

The baseline scenario is a long term replacement, starting at the beginning of LS3 and extending up to 2030 (hopefully) during the winter shutdowns.

The main advantages of this scenario are:

- Less problematic budget, spreading the costs among several years with a well planned delivery schedule;
- Use of the same cables and connectors already installed;
- Full hardware and software compatibility with the present systems

while the main disadvantages are:

- Less efficient use of the last generation communication protocols, reducing the nominal optimal performance;
- A possible increase of the total costs due to the compatibility constraint;
- A higher complexity of the DCS, which must manage two different system at the same time.

Needed R&D

The necessity of designing up-to-date power systems, also using new architectures, at least for part of them, will require a R&D program among the interested companies. What resources will be required by this R&D is not completely clear at the moment, but some assumptions can be underlined:

- This R&D will not start before the completion of the phase-1 R&D program (NSW for ATLAS Muons). This means that the results of the phase-1 R&D will be used for phase-2;
- in detail, the HV systems are not subject of a specific phase-1 R&D, the opposite is true for the LV system, for which a new architecture will be developed for the majority of the NSW detectors;
- The new systems developed under the phase-1 R&D will be designed to comply also with the phase-2 requirements. The R&D for phase-2 should last three or four years, mostly dedicated to adapt a general design to the different detectors in terms of mechanics, connectors and electrical performance, but not for the rad-hard and B-tol requirements;
- Only these last requirements will be developed with a common effort among the experiments and the companies, hopefully in a framework of written contracts establishing in advance the IP and the share of costs

Tentative Schedule

2017: ATLAS and CMS Electronics Coordinators call meetings to discuss and agree on a common replacement strategy;

2018 – 2020: R&D with the major companies to develop the new generation components;

2021 - 2022: tenders;

2023 – 2029: production;

2025 – 2026: installation and commissioning of the avaialble modules during LS3;

2027 – 2030: installation and commissioning of the remaining modules during the EYETS.

Conclusions

- Two main motivations lead to a full replacement of the Muon Power Supply systems from LS3 onward:
- CMS is the main user of these systems and an agreement with them is necessary to minimize delivery time and costs. The contacts should be leaded by the Electronics Coordinators;
- The Muon detectors have two different architectures, one used by RPC and TGC and the other by MDT. Used components are about one thousand;
- The baseline scenario for the replacement is the long term one, requiring a production spreaded over 6 – 7 years and a full backward compatibility

Back-up

Radiation and B-field validation

- The EASY3000 families were validated under radiation at several facilities in Europe (Louvain-La-Neuve: protons and neutrons, Uppsala: protons, Prospero: neutrons, Casaccia: gammas), up to the following limits:
  - Gammas – 140 Gy
  - Hadrons – 2 x 10^{11}/cm^2
  - Neutrons – 2 x 10^{12}/cm^2 1MeV equivalent

Corresponding to 10 years of LHC operating at 10^{34} cm^{-2}s^{-1} nominal luminosity in the regions where the modules are placed (UX15 balconies), with the exception of the SW and some part of the Barrel, where the TID is higher**, 186 Gy,** as reported in the LV and HV specifications for tenders

http://www2.pv.infn.it/~servel/atlas/mdt/hv-system_specs_en.pdf

http://www2.pv.infn.it/~servel/atlas/mdt/lv-system_specs_en.pdf

- Tests in B-field were performed at Cern by the E-Pool, and certified the families working up to 2kG without significant degradation in efficiency and electrical performance

Safety factors

- The previous doses and fluences were evaluated applying safety factors related to the simulation uncertainties, the low dose rate correction and the different production lot of the electronic components, as reported in the following table

	TID	NIEL	SEE
Safety factor simulation	3,5	5	5
Safety factor low dose rate	5	1	1
Safety factor production lot	4	4	4
Total safety factors	70	20	20

- In 2013 the Radiation Estimate Task-Force, comparing real radiation data with the simulations, recommended to decrease the simulation safety factors to 1.5 (TID) and 2 (NIEL and SEE), keeping the same factors for the rest