CAEN Meeting
Power Supply for the future of LHC

Viareggio, 22/2/2016

Daniele Fasanella Summary Report

For CMS:

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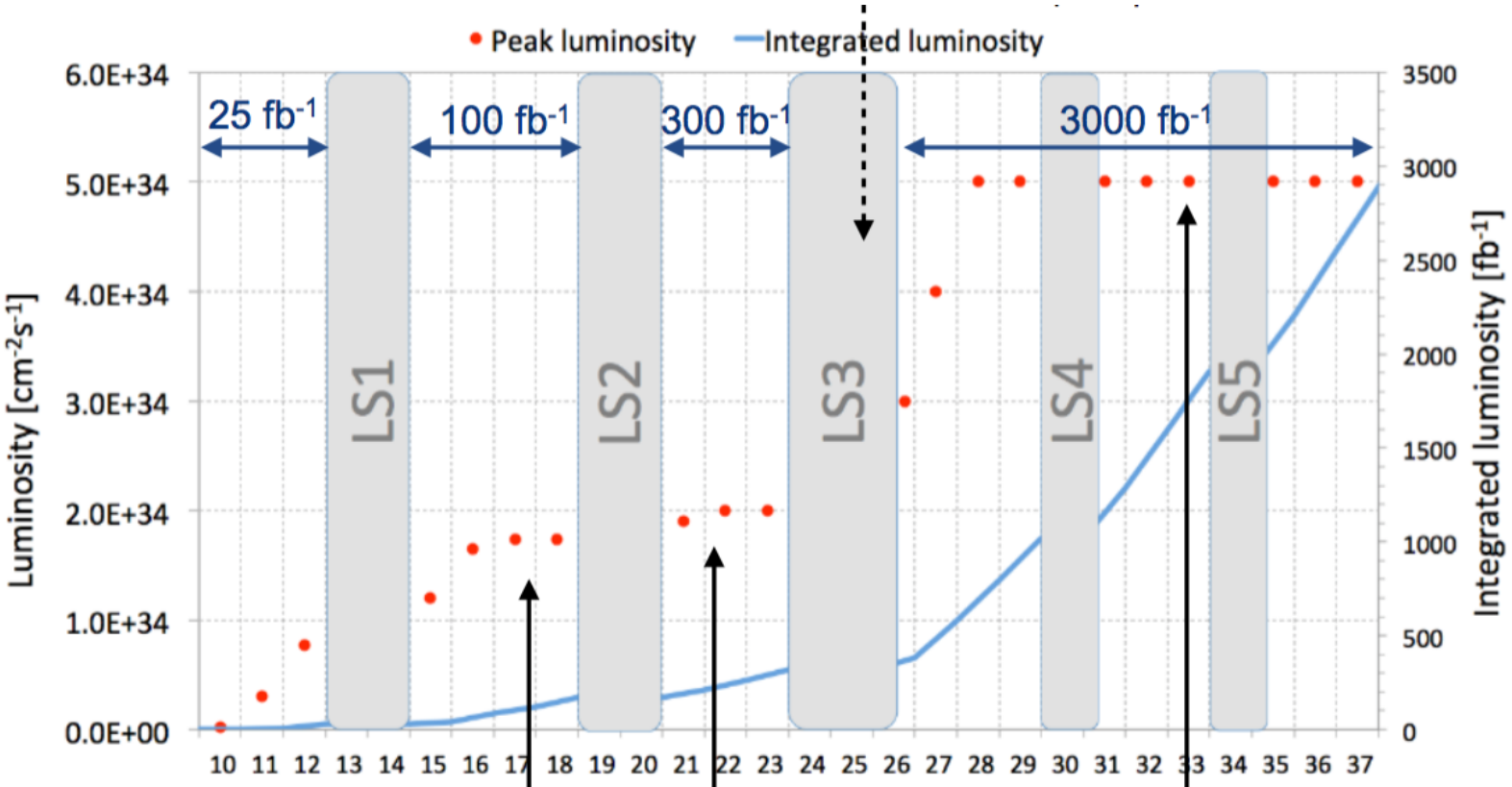
As we know we have a long way to go..



1.E34 Hz/cm2
Bx=25ns
PU~25-30

2.E34 Hz/cm2
Bx=25ns
PU~50

5.E34 Hz/cm2
(init~2E35 Hz/cm2)
Bx=25ns
PU~140-200

History of the EASY system

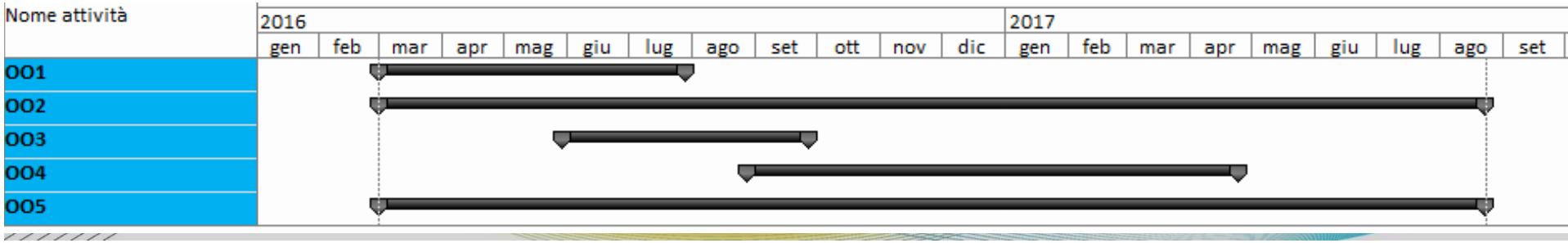
- R&D for HV and LV started in 1998-2003, but preliminary evaluation started in 1996
- Common requirements from LHC experiments
  - Reduce R&D costs
  - Reduce proliferation of different hardware and software
  - Reduce maintenance
- EASY was the solution
  - 21 slots per crate
  - 3 kW Maximum Output Power
  - Magnetic field tolerance: 5 kGauss
  - Radiation tolerance: $5*10^{10}$ p/cm^2 TD
    $2*10^{11}$ n/cm^2 TD
    15 kRad TID

NEOLITE Projects

- The EASY system was a success, but a lot of problem to produce all the boards in time in 2007-2008
- For HL-LHC CAEN wants to move ahead, to be ready in case needed
- Project 
  - Objectives
    New smart power supplies for hostile environments
  - Applications
    - High Energy Physics
    - Medical Physics (power supplies for MRI and PET)

Project description

- The project will last 18 months (March 2016- September 2017)
- 5 Objectives:
  1. Definition of the needed characteristics for the NEOLITE prototypes for some applications
  2. Study of materials, components, sensors for hostile environment
  3. Definition of the specifics for the NEOLITE prototypes
  4. Production of the prototypes
  5. Test and Demo of NEOLITE prototypes



- Partners: CAEN, INFN Firenze, INFN Pisa, University of Firenze, AGE SCIENTIFIC S.R.L., DESYS S.R.L.
- Total cost 1.880.000 Euros

Pilot Application for LHC

- LV Serial Powering for ATLAS-CMS Pixel Detectors
  - LV Channels “Radiation and Magnetic field tolerant”
  - Possibility of “Serial Powering” of “Feast DC-DC”
  - Implementation of communication with the load (Read-out ASIC from CERN, RD53)
  - Remote control with a new fast link technology retro-compatible with EASY branch controller
- During this pilot development, request and needs from all the LHC community will be studied
- Objective is to have in 2022-2023 a new family of LV/HV power supply to support the experiments up to 2035 and beyond.

ATLAS Muons Report

Agostino Lanza

ATLAS Muons

Two technologies for tracking:

- CSC – 70k channels
- MDT – 354k channels

Two technologies for trigger:

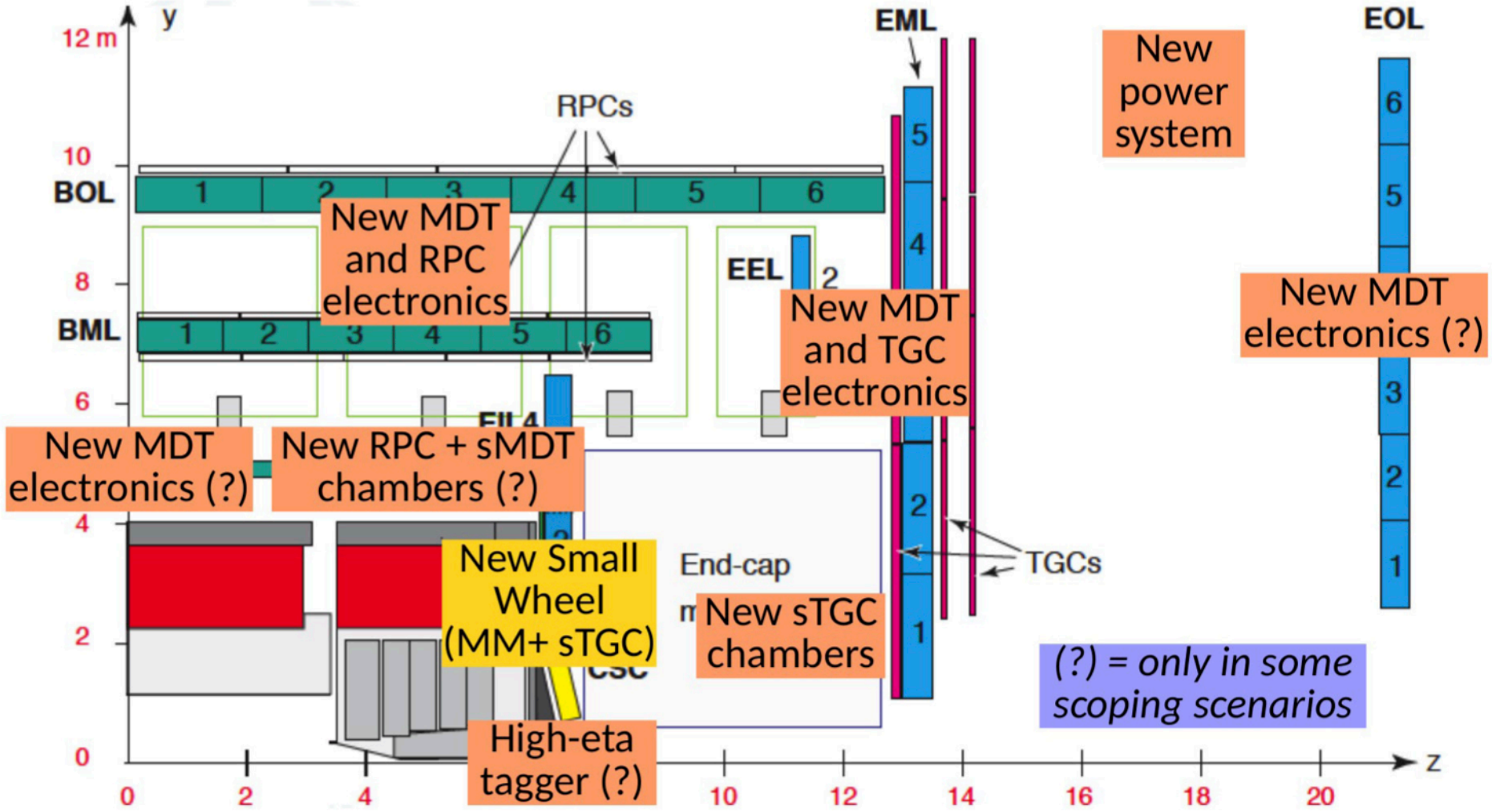
- RPC – 380k channels
- TGC – 440k channels

~ **1.3M channels** needing HV (**from 2.8 to 10k V**) and LV power (**122k W** delivered to the detectors), localized controls and monitoring, centralized DCS

❖ All power modules are installed in hostile environment for both radiation and B field

❖ CAEN Easy3000 system chosen for almost all technologies, for both HV and LV (only exception is CSC LV)

ATLAS Muons – Upgrade scenarios



R. Ferrari

ATLAS Muons – PS Replacement (1)

Radiation and B field validation for the EASY3000 families

- 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 > 20 MeV**
  - **Neutrons – 2 x 10^{12}/cm^2 1 MeV 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)

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

ATLAS Muons – PS Replacement (2)

Safety factors

- The 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 Total Ionizing Dose	**NIEL** Non Ionizing Energy Loss	**SEE** Single event effects
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.

ATLAS Muons – PS Replacement (3)

Decision for replacement

- LHC is planned to deliver 300 fb^{-1} up to the end of Run3 in 2022, reaching 3000 fb^{-1} in the ten years after LS3. Taking in account what seen before in terms of reduction of the safety factors on simulation, and the 25% higher TID for Muon Barrel and NSW, **the expected survival time of the present PS distributors is around 1700 fb^{-1}**. Speaking of time, they should stop working in **15 years from now**
- The increase of PS channels, **due to the upgrades**, will probably create a serious bottleneck to the DCS with the present systems. In order to take profit of the new communication protocol FlexRay, also the Branch Controllers on both the mainframe and the distributor sides must be replaced.
- Design of the EASY3000 was done in the early 2000's. So, the electronic components are phasing out from the market already now. Within 10 years many of them will be difficult to find, and the maintenance will become complicated.

ATLAS Muons – PS Replacement (4)

When

- With the known values of radiation it can be stated that **the Muons PS systems will not survive until the 2034, but should work until 2029**
- The cost of a full replacement (excluding the NSW) is very high, **so the replacement will happen during several years after LS3**

Requirements

- The new systems should derive from what will be used in the upgrades, at least for the LV
- They must be compatible with the existing PS systems, due to the long replacement time

ATLAS Muon Upgrades – NSW (1)

Phase 1 upgrade!! (But very important for the LV PS architecture)

Two technologies for both tracking and triggering:
- MicroMeGaS – **2.1M** channels
- sTGC – **322k** channels

LV power consumption:
- MicroMeGaS – **73k W**
- sTGC – **28k W**

HV in operation:
- MicroMeGaS - **<600 V**
- sTGC – **2.8k V** (like the TGC)

Baseline option for LV (both technologies):
- AC/DC generators on racks in cavern, delivering 24V or 48V
- Intermediate Second Stage (ICS) on the NSW rim, regulating the voltage to the FE at 11V (Feast DC/DC)

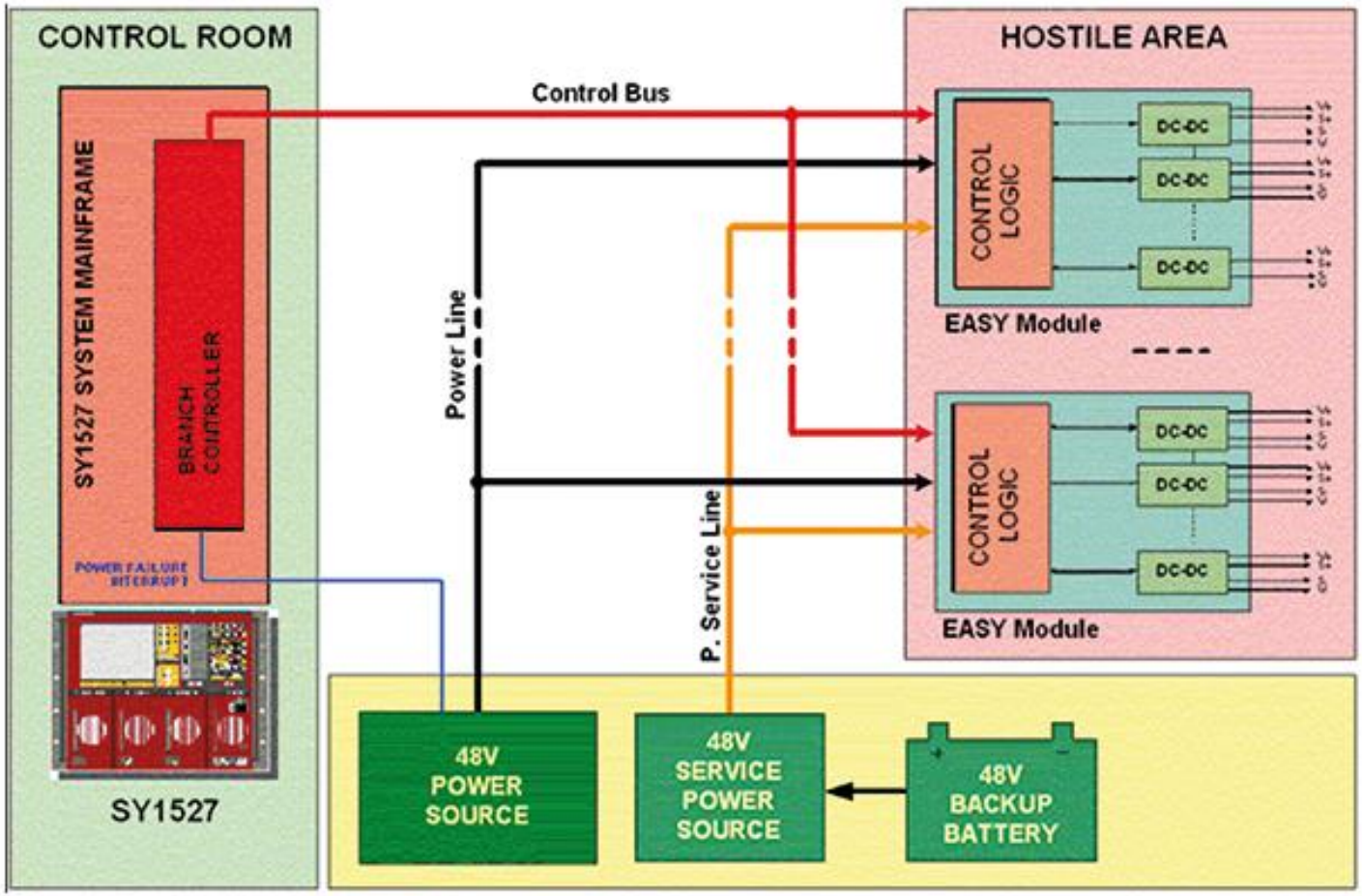
Baseline option for HV:
- MicroMeGaS – standard PS in USA15 (neither radiation nor B)
- sTGC – EASY3000 system (A3535P) on racks in cavern

Conclusion

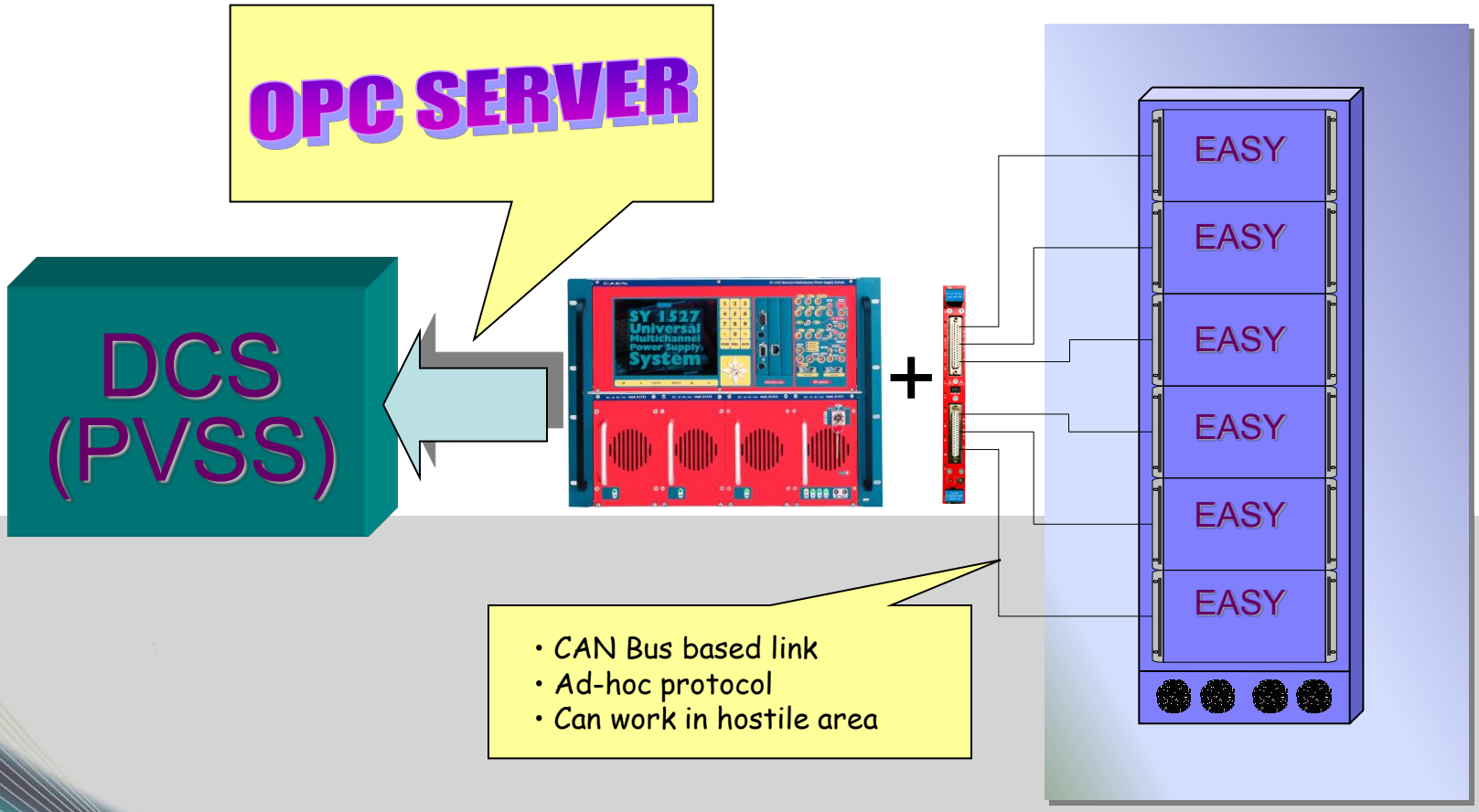
- **Reports from LHC experiments:**
  - For the new detector for the upgrade specific are still to be decided
  - For all the detector with no upgrades, difficult decision on how and when to act
    - general idea that the actual system will wear out in 10-15 years from now (if not by radiation, by aging of the components)
    - key importance to keep the actual infrastructure (for cost/difficulties of access)
- **From CAEN:**
  - The EASY system have been a success, for performances and maintnance
  - the NEOLITE project is a first step from CAEN not to arrive unprepared to the future of LHC projects
  - a new system backward compatible is foreseen, in order to give the possibility to partially change the existing systems and keep the sustituted parts for spares

Backup

Architettura EASY (I)



Architettura EASY (II)



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Moduli EASY- 1

Model	Ch. per module	Max Output Voltage per Ch.	Max Output Current per Ch.	Max Output Power per ch.	Width (slots)	Max Modules per Create	Max Channels per Crate	Hostile Area
A3006	6	±(4-16V)	6A	90 W	4	5	30	Yes
A3009	12	2-8V	9A	45 W	4	5	60	Yes
A3016	6	2-8V	16A	90 W	4	5	30	Yes
A3050	2	2-8V	50A	300 W	4	5	10	Yes
A3100	1	2-8V	100A	600 W	4	5	5	Yes
A3501 p/n	12	±100V	1mA	100mW	2	10	120	Yes
A3512 p/n	6	±12kV	1mA	12 W	3	7	42	Yes
A3535 p/n	32	±3.2kV	500µA	1.75 W	4	5	160	Yes
A3540 p/n	12	±4kV	1mA	4 W	2	10	120	Yes

and A4601F / A4601H / A4602 / A4603 – special boards for CMS Tracker/Pixel

Model	Description	Ch. per module	Input Range	Resolution	Width (slots)	Max Modules per Crate	Hostile Area
A3801	ADC	128	0 ÷ +10 V	15 Bit	2	10	Yes
A3801A	Temp. Sensor	128	-4 ÷ +125 °C	15 Bit	2	10	Yes

Model	Description	Ch. per module	Max Output voltage	Max Output current	Resolution	Width (slots)	Max Modules per Crate	Hostile Area
A3802	DAC	128	4 V	10 mA	12 Bit	1	10	Yes

Moduli EASY - 2

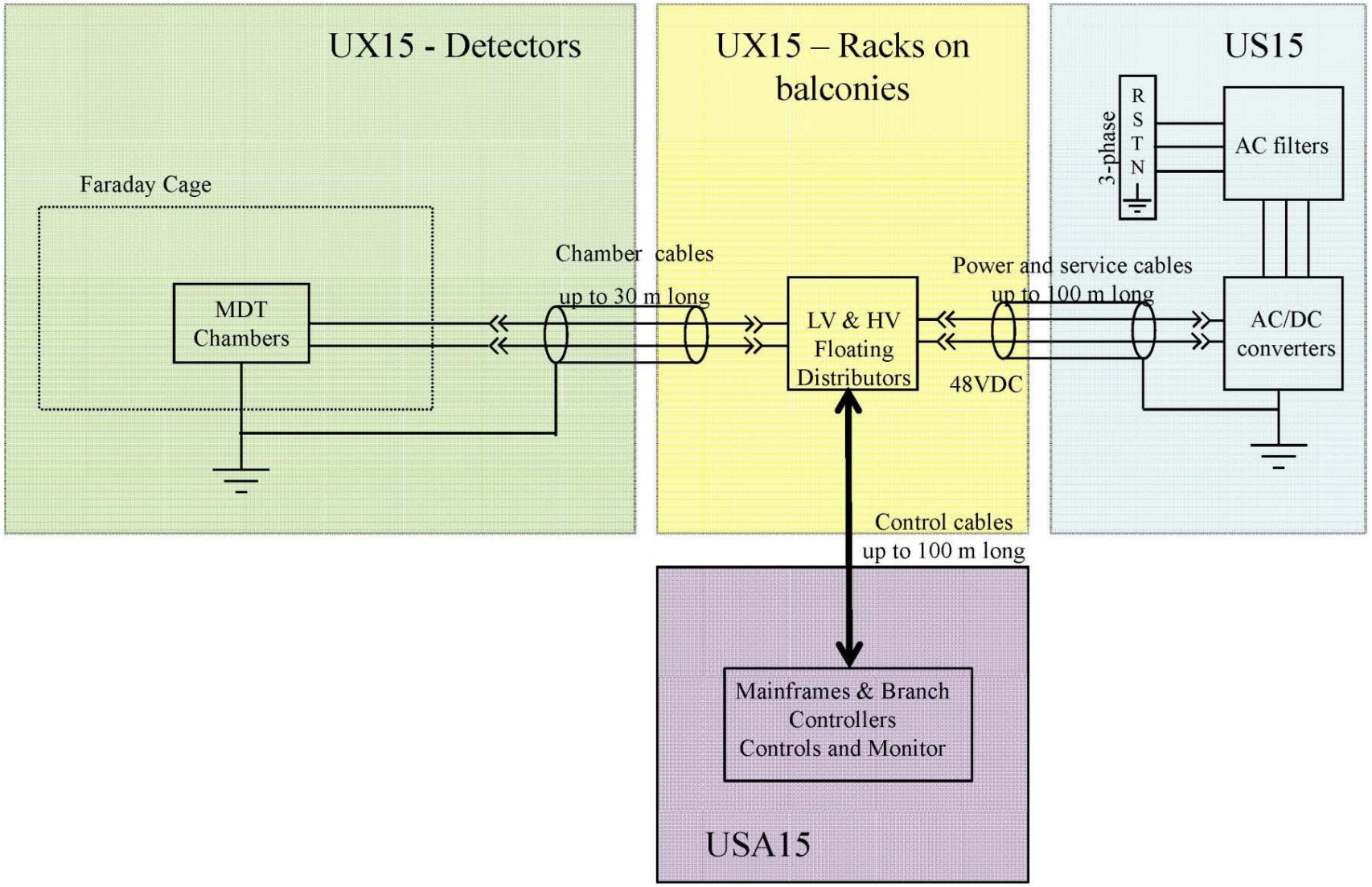
Model	Description	Output Control Line	Hostile Area
A1676A	Branch Controller	6	No

Model	Max Modules per Crate	Depth	Height	Width	Width (T.E.)	Hostile Area
EASY 3000 Crate	10	65 cm	6 U	19"	84	Yes
EASY 4000 Crate	9	65 cm	6 U	19"	84	Yes

Model	Description	Depth	Height	Width	Width (T.E.)	Hostile Area
A34FU	Fan Unit for EASY3000 (First Issue) and EASY4000	65 cm	2 U	19"	84	No
A3000F	Fan Unit for EASY3000 (Second Issue)	65 cm	2 U	19"	84	No

Model	Description	AC Input	DC Output	Max Output Power	Hostile Area
A3484	AC/DC Converter for EASY3000 and EASY4000	400V 3-phase	48V	2500W	No
A3485	AC/DC Converter for EASY3000 and EASY4000	400V 3-phase	48V	5000W	No
A3486	AC/DC Converter for EASY3000 and EASY4000	220/400V 3-phase	48V	2x2000/1x4000W	Yes

Present PS systems - MDT



Present PS systems – RPC and TGC