Bulk power for CMS 20170913

M. Hansen, CERN

S. Lusin, CMS TC / UW

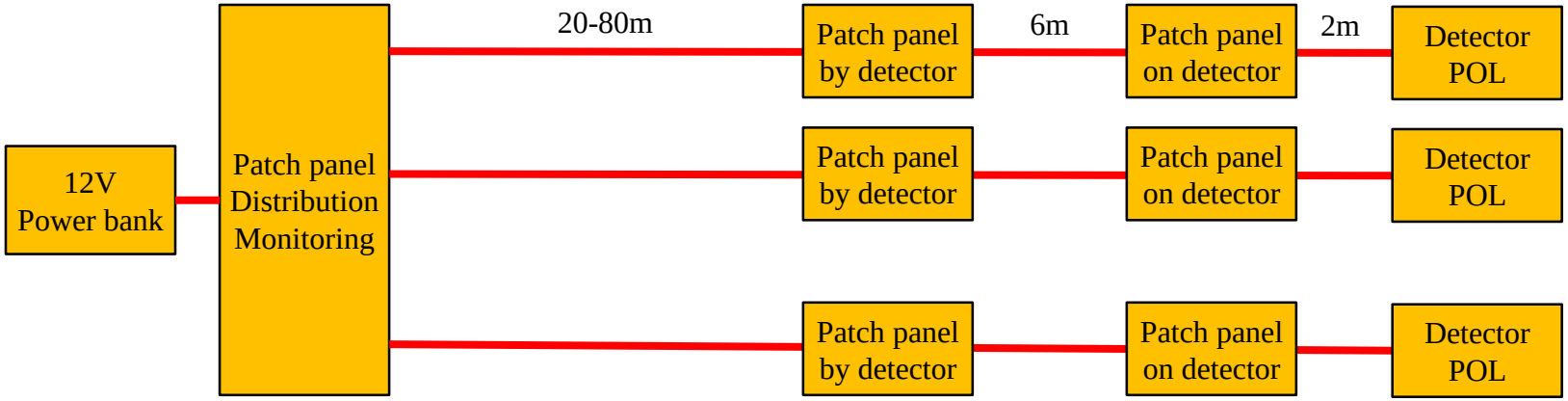
Bulk power system

- **Exploit the fact that we know our environment**
  - **Compare to initial construction**
  - **Allow smaller safety factors**

Bulk power system

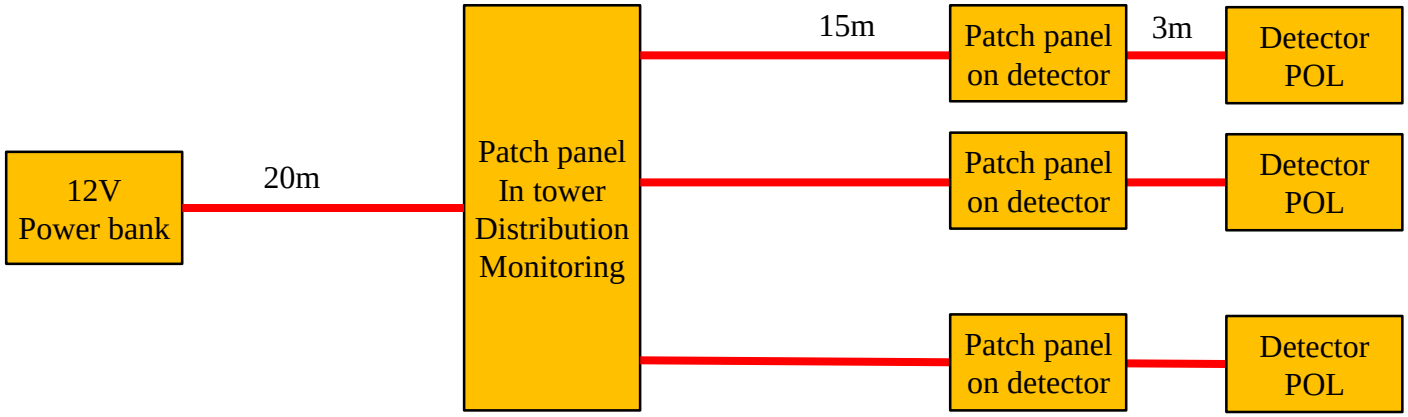
- **Tracker**
  - Will make use of DCDC converters in or close to the front end
  - Remote bulk supply
  - “Fine grain” power distribution, safety and monitoring
  - System will need some space in USC55 for controls
- **Barrel Calorimeters**
  - Similar to Tracker
- **Endcap calorimeter**
  - Under study; potentially different to barrel as supplied through cable chain or due to internal space limitations

Tracker



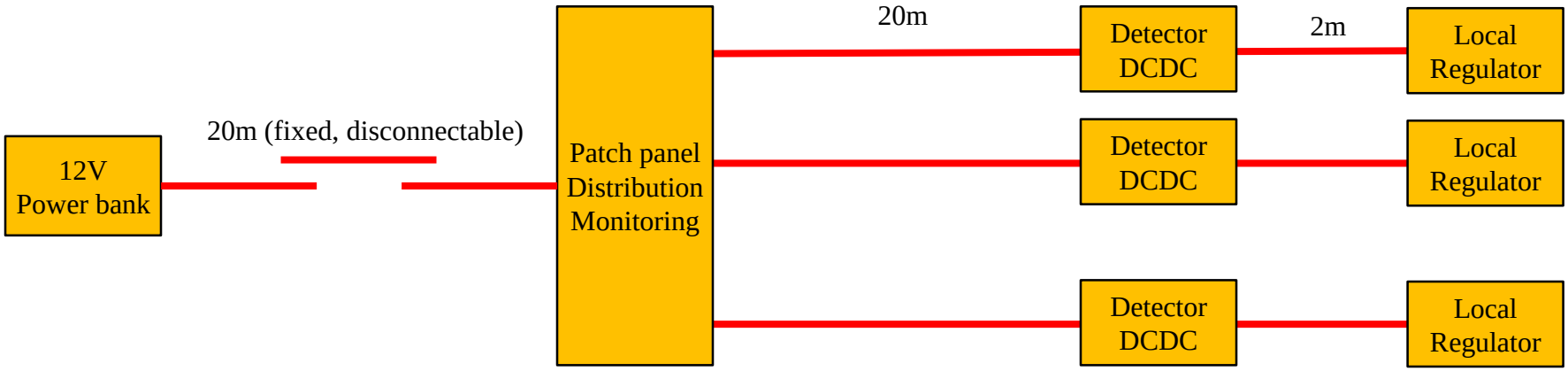
- **100kW**
- **This implementation**
  - **may, depending on the location of the active components, require radiation and / or magnet field qualified equipment**

Barrel Calorimeter



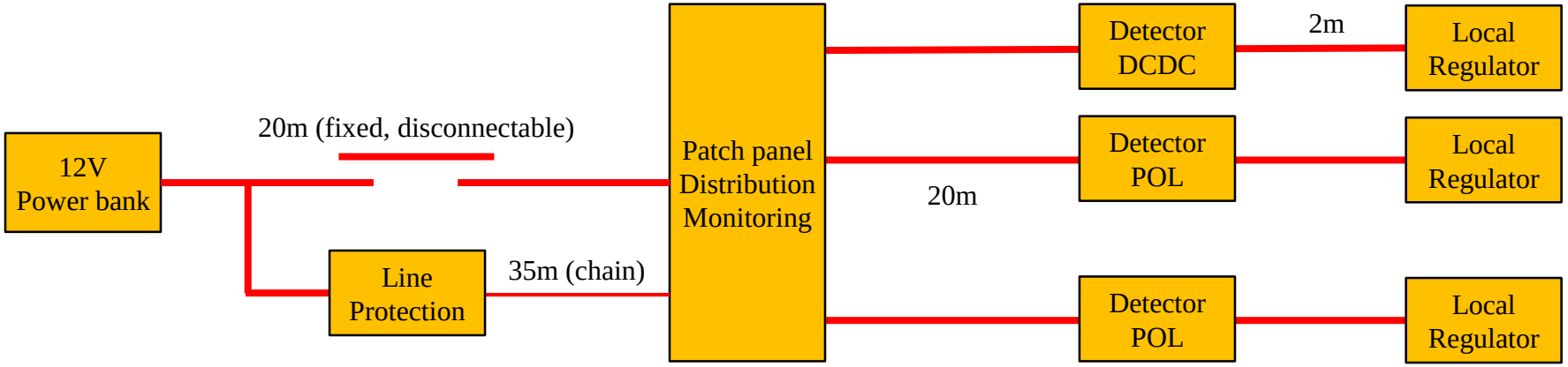
- **200kW**
- **This implementation**
  - **implies radiation and magnetic field tolerance qualification of the active equipment**

Endcap Calorimeter alt. 1



- **100kW + 100kW**
- **This implementation**
  - **Allows operation only in a discrete number of positions, e.g. fully closed and fully opened**

Endcap Calorimeter alt 2.



- **100kW + 100kW**
- **This implementation**
  - **Allows full operation in a discrete number of positions, e.g. fully closed and fully opened and partial operation, e.g. monitoring, in any position**

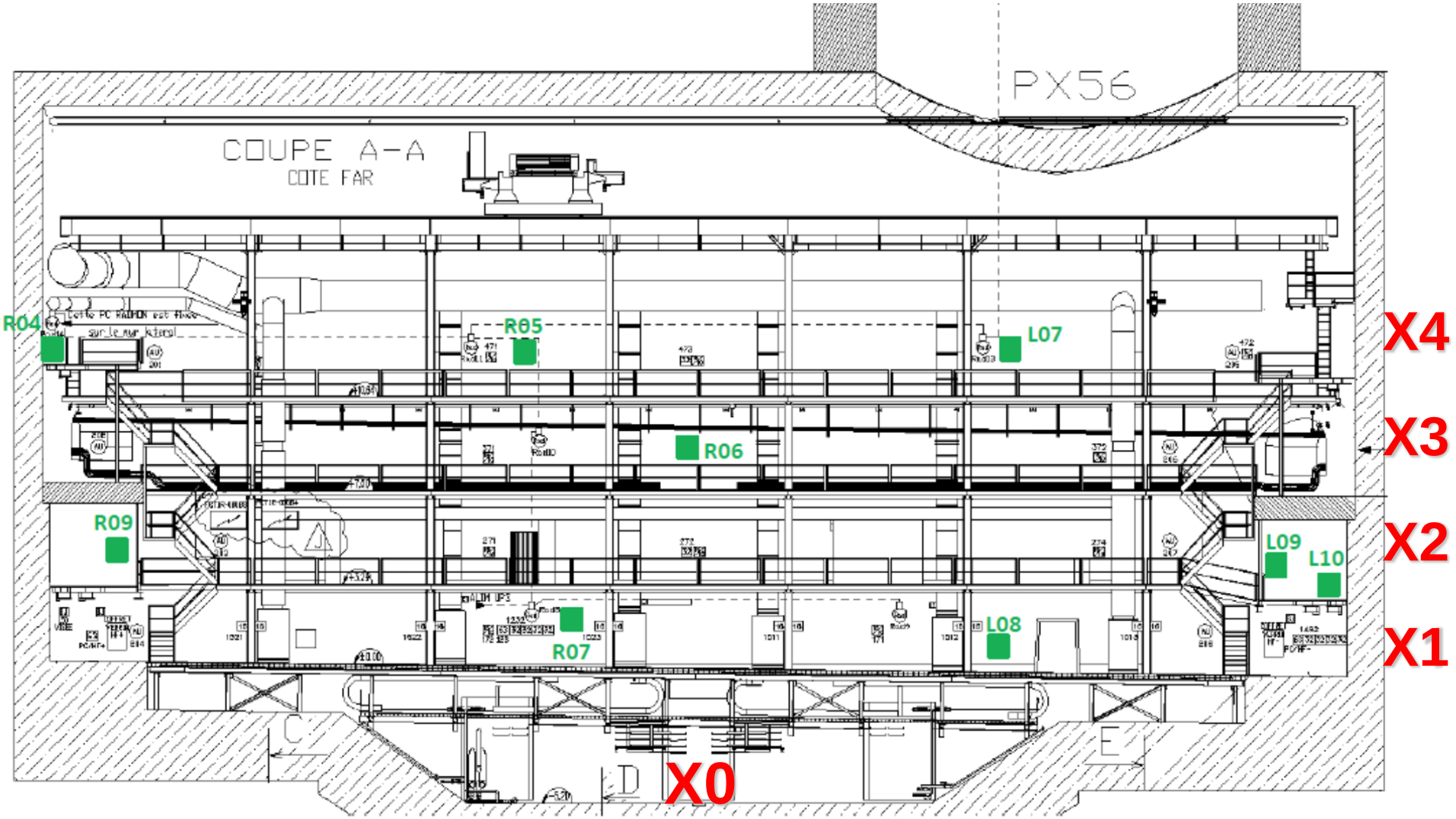
Requirements

- **Requirements**
  - About 12V; not much higher at any time
  - Modular
  - High availability: configured for n+1 or n+2 redundancy
- **Wishes**
  - Light and compact
    - ➔ To make carrying around less demanding
  - Affordable
    - ➔ Low cost would not hurt unless quality suffers
    - ➔ Generally means high volume COTS

Requirements

- **In addition…**
  - **Sufficiently magnetic field tolerant**
    - ➔ 200 Gauss < Fringe field in CMS cavern < 1100 Gauss
      - ⇘ 200 Gauss in X0 and balconies, 1200 in towers around the crack between YB and YE
    - ➔ Qualification procedure required
  - **Sufficiently radiation tolerant**

UXC55



M. Hansen, CERN, S. Lusin, UW/TC

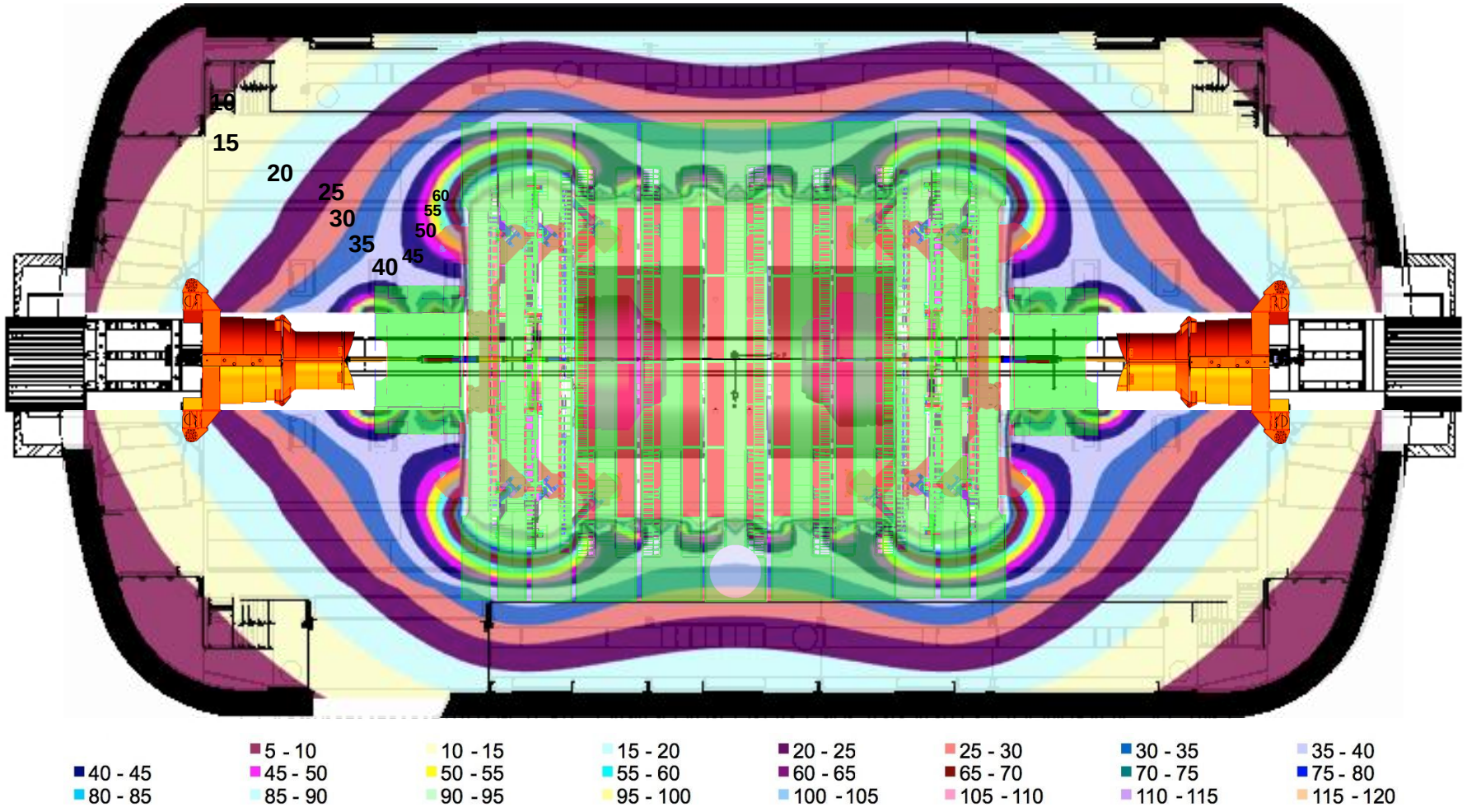
Radiation levels

- **Low total dose in X0**
  - **Estimation after 3000 fb-1:**
    - ➔ **Hadrons > 20 MeV = 2.1*108/cm2**
    - ➔ **1 MeV-equivalent neutrons = 6.7*109/cm2**
  - **Source: CMS BRIL**
- **Will have to deal with SEE**
  - **SEU, SEB**
  - **i.e. how do the PS fail following SE?**
- **What about X3/X4?**
  - **Will be determined after further simulation by CMS BRIL**

CMS magnet fringe field in UXC55 with 3.8T at IP

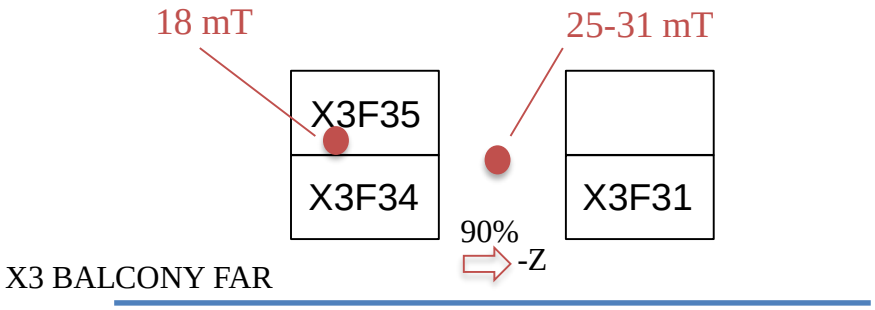
Scale in mT, from 0 to 120 mT, with 5 mT increment

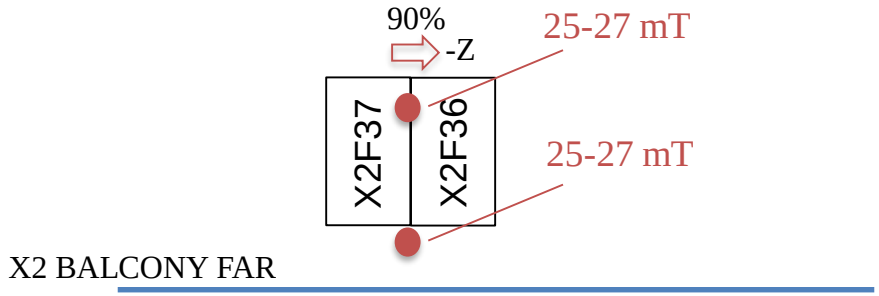
Horizontal mid-plane Y=0

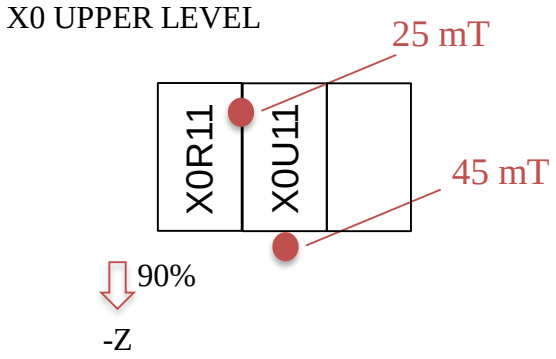


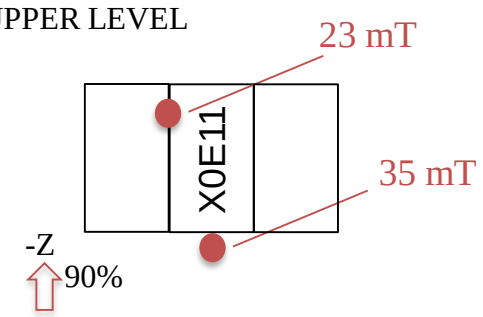
Prepared by B. CURE with data from V. KLYUKHIN
November 2010

Measurement of the fringe magnetic field (@3.8T)









X0 LOWER LEVEL: 21-27 mT

Nicola Bacchetta, Wolfram Zeuner May 19th 2016

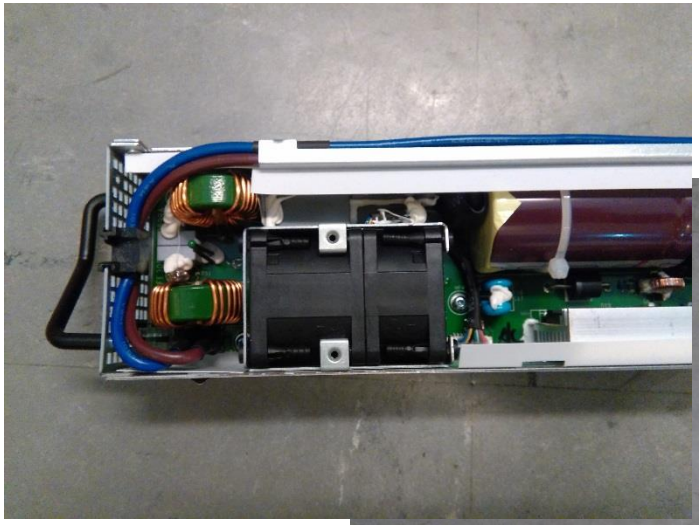
COTS Candidate / test engine

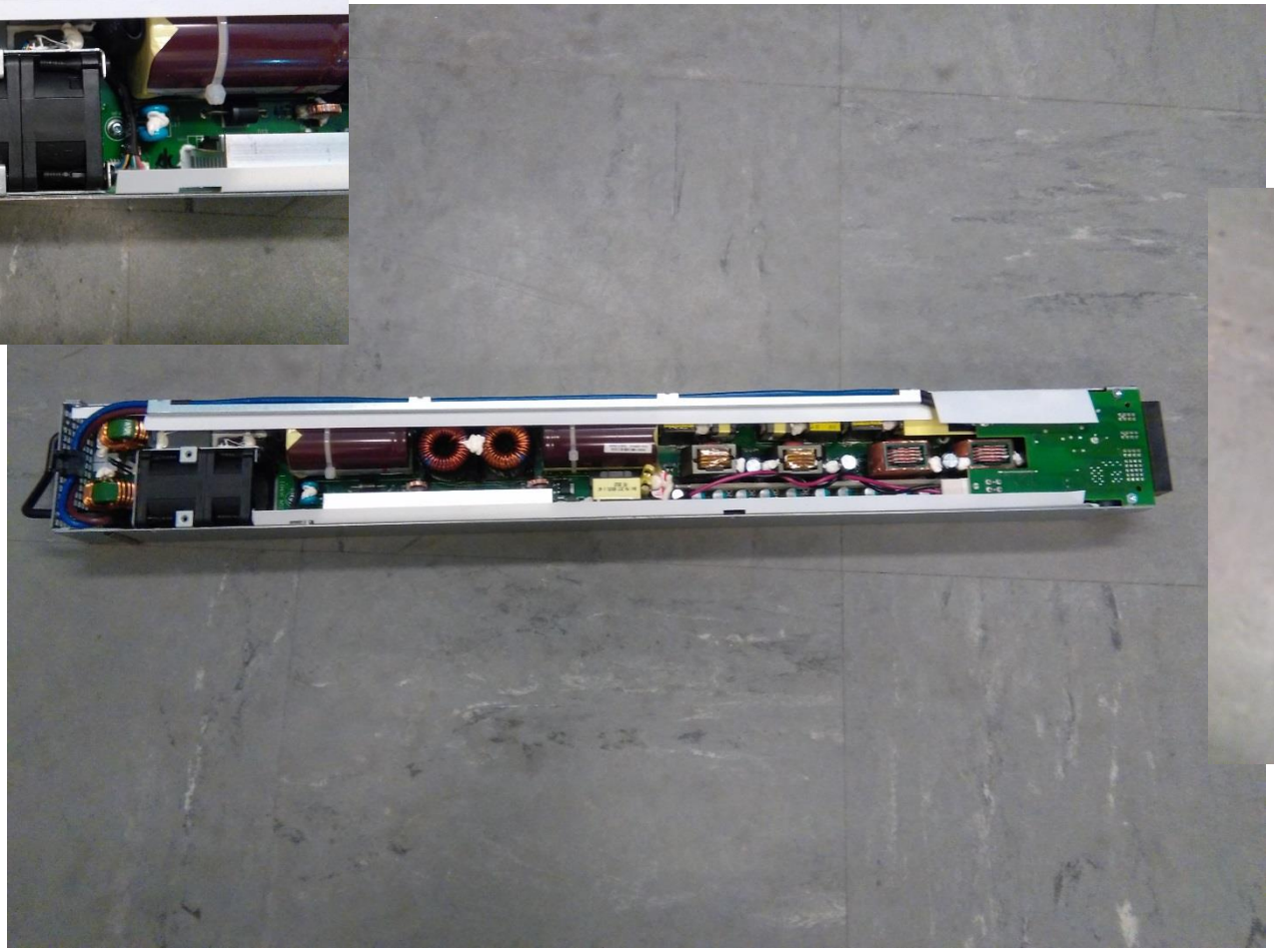
- PowerOne PFE3000-12-069RA
- 12v 3kW (244A), 94% efficient
- http://www.digikey.com/product-detail/en/bel-power-solutions/PFE3000-12-069RA/179-2714-ND/4439947
  - 31 in stock 20160429
  - 937USD for one, 8000 USD for 10 pc
  - Estimated product life beyond 10 years

PFE3000-12

S. Lusin

PFE3000-12





S. Lusin

Magnetic field test

S. Lusin

Magnetic field test

19 Oct 16

B-Field Testing of

Bel 3kW supply

PFE 3000 - 12 - 069RA 12V

load is ~ 100 in of
10 mm² wire
⇒ at ampacity limit

FW Bell
Gauss Meter
Model 4048

Wire heats up: current
takes ~ 10 min to
stabilize from cold
start

Horiz

B. field	P	KVA	KVAR	PF	DPF	I_{in}	I_o
0G	.77kW	.78	.14	.98	.99	3.44	59.0
119	.77	.77	.10	.99	.99	3.43	59.2
224	.76	.77	.10	.99	.99	3.43	59.0
333	.77	.77	.10	.99	.99	3.42	59.0
371	.78	.78	.10	.99	.99	3.45	59.2

~ 400 ⇒ supply unstable
goes into "current pulsing"
mode

On side

B	P	KVA	KVAR	PF	DPF	I_i	I_o
133	.77	.78	.10	.99	.99	3.48	59.8
255	.77	.77	.10	.99	.99	3.43	59.1
336	.76	.77	.10	.99	.99	3.42	58.9
476	.76	.77	.10	.99	.99	3.42	58.8
561	.77	.79	.10	.98	.99	3.48	58.8
615	.78	.79	.11	.99	.99	3.48	59.2

⇒ 600G already too much

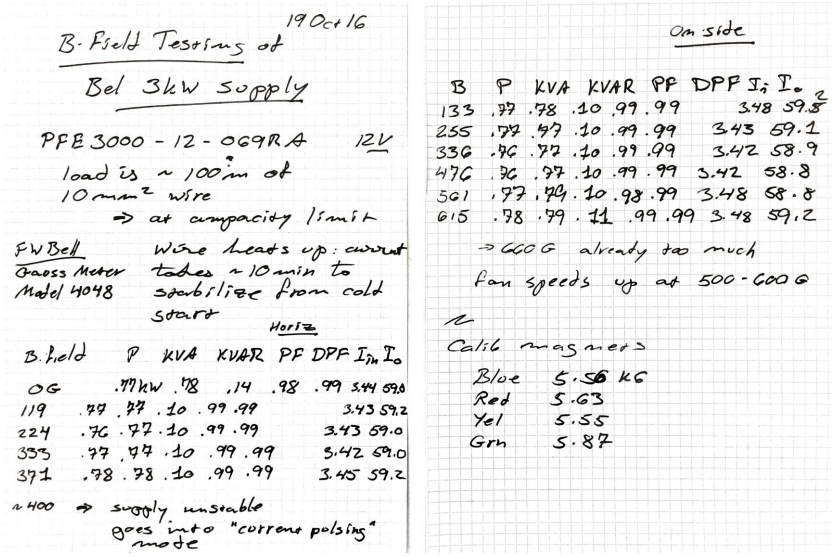
fan speeds up at 500 - 600G

Calib magnets

Blue	5.56 kG
Red	5.63
Yel	5.55
Grn	5.87

S. Lusin, B. Cure

Magnetic field test



19 Oct 16

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- **Bottom line**
  - **Tolerates 400g from side**
  - **Tolerates 600g from top**
  - **Tolerates 250g longitudinal**
    - ➔ **A different test in the M1 magnet at CERN**

S. Lusin, B. Cure

Front end power distribution

- **Finer granularity than a single bulk supply**
  - Line protection
  - Over/Under voltage protection
  - Voltage monitoring
  - Current monitoring
  - (Power monitoring)
- **Example COTS**
  - LM25066: System Power Management and Protection with monitoring through PMB (essentially I2C)
- **Backend could be an ELMB+ system**

Front end power distribution

- **Final development, production and maintenance by Industrial partners**
  - **Tuned to requirements for different users, e.g.**
    - ➔ **Trip current depending on cabling to detector**
    - ➔ **Combine LV and bias distribution for silicon trackers**

Plans

- **Demonstrate feasibility and reliability**
  - **Performed 3D magnetic field tolerance mapping in M1 magnet**
  - **Install demonstrator in UXC55 X0 lower floor for long term (B field) verification**
- **Mixed field radiation studies**
  - **@ Charm (CERN)**
  - **Need to determine how an SEE affects an n+1 or n+2 redundant power supply system**

Plans

- **Collaboration with industry for development of power distribution and monitoring system**
  - **Positive feedback from industrial partners, e.g. CAEN**
  - **Tuned to each subsystem**