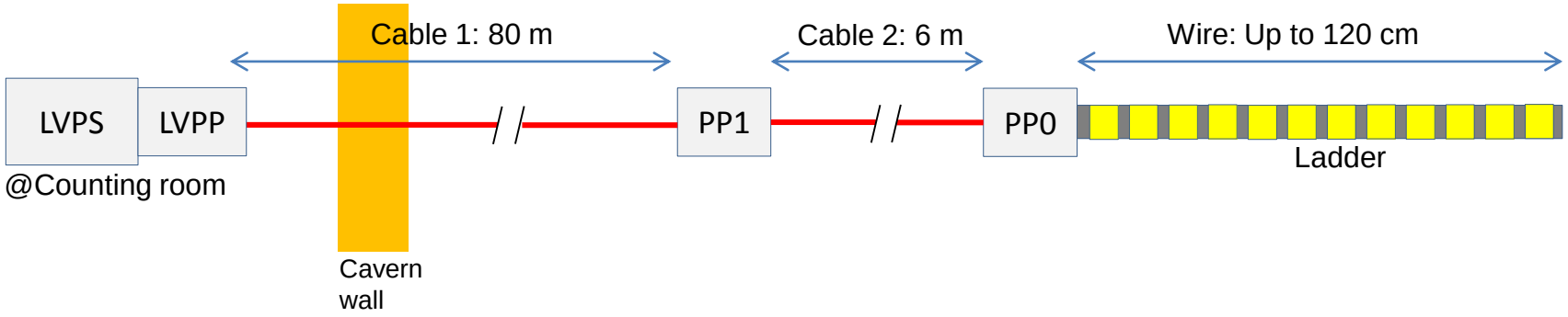
Options for LV production and distribution

From common project study to CMS OT use case

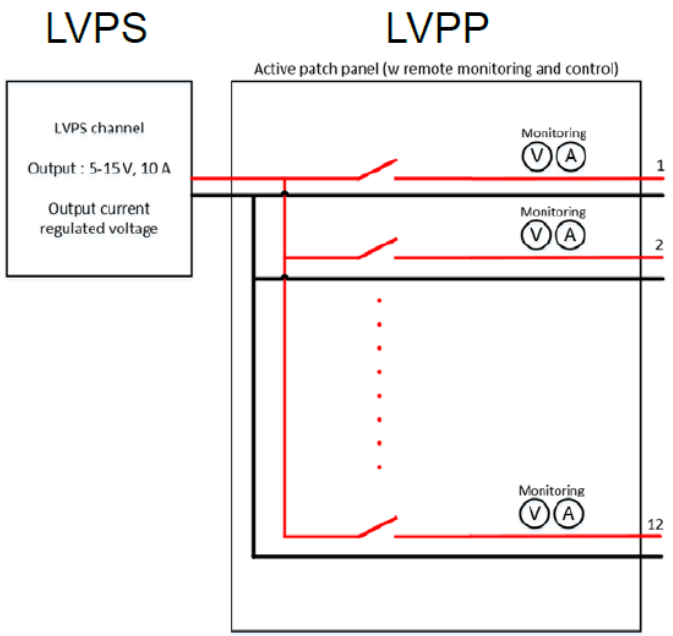
Common Project

Reminder: Originally proposed distribution scheme and demonstration target



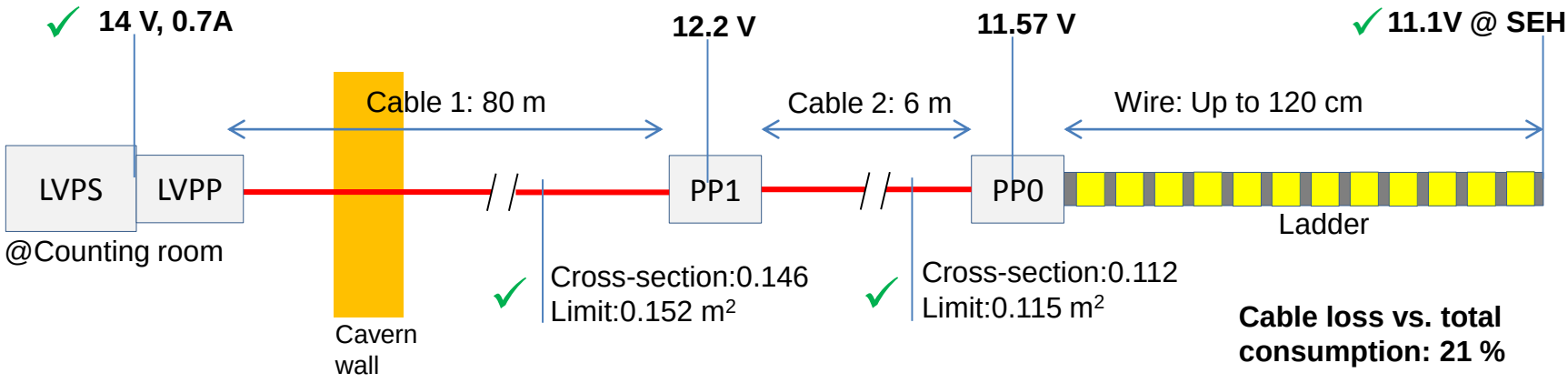
3 distinct building blocks considered

- LVPS
  - ❑ In counting house
  - ❑ Output range: 15V max, 15-20A max
  - ❑ Relaxed noise/ripple characteristics TBC
  - ❑ Regulation mode TBD and tested
- LVPP
  - ❑ 12 out. channels, max: 15V/2A
  - ❑ 0.7A per channel
  - ❑ Minimum control: Imon. and ON/OFF
- Cabling
  - ❑ Overall max Vdrop: 3V
  - ❑ Cross section constraints
  - ❑ Material budget from PP1 onwards



Design

Based on custom cables designed by and procured from Habia Cables



- ✓ 1 single cable / ladder (from PS to PP0) including LV, HV and returns
- ✓ Cross section limits respected
- ✓ Cabling extended from PP1 to CR
- ✓ Voltage drop from LVPS to POL DC/DC converter limited to 3V
- ✓ Aluminum wires between PP1 and modules
- ✓ Shielding: Al film with drain wire (PS to PP0)
- ✓ 2 multi-purpose pairs included

See poster by V. Bobillier
https://indico.cern.ch/event/608587/contributions/2614651/contribution.pdf

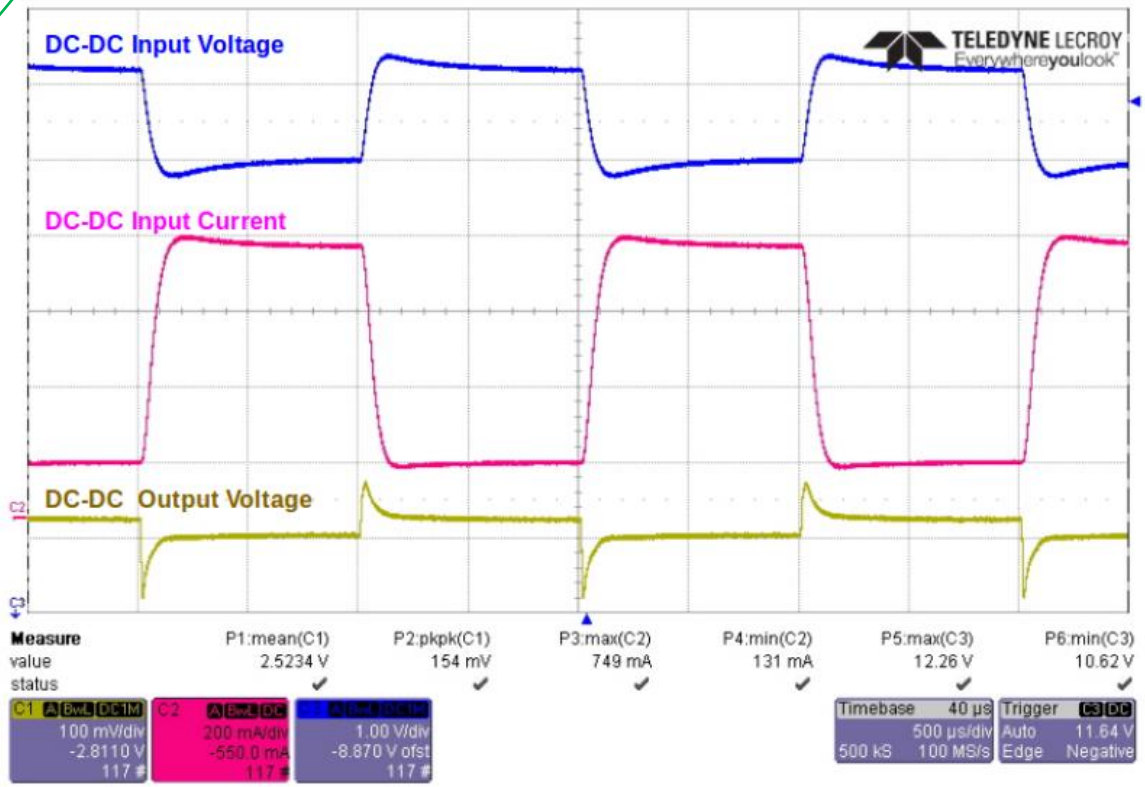
Feasibility Demonstration (1)

Based on custom Habia Cables and COTS LVPS

- Power supply output voltage: 12.37V
- Load in transient mode
- Current settings at load: 0.5A - 2.5A
- Frequency : 500Hz
- Slew Rate : $5A/\mu Sec$

Input Voltage (Max.)	12.26 V
Input Voltage (Min.)	10.62 V
Input Voltage Mean	11.44 V
Input voltage Peak to Peak	1.64 V
Input Current (Max.)	749 mA
Input Current (Min.)	131 mA
Output Voltage Mean	2.52 V
Output Voltage Peak to Peak	154 mV

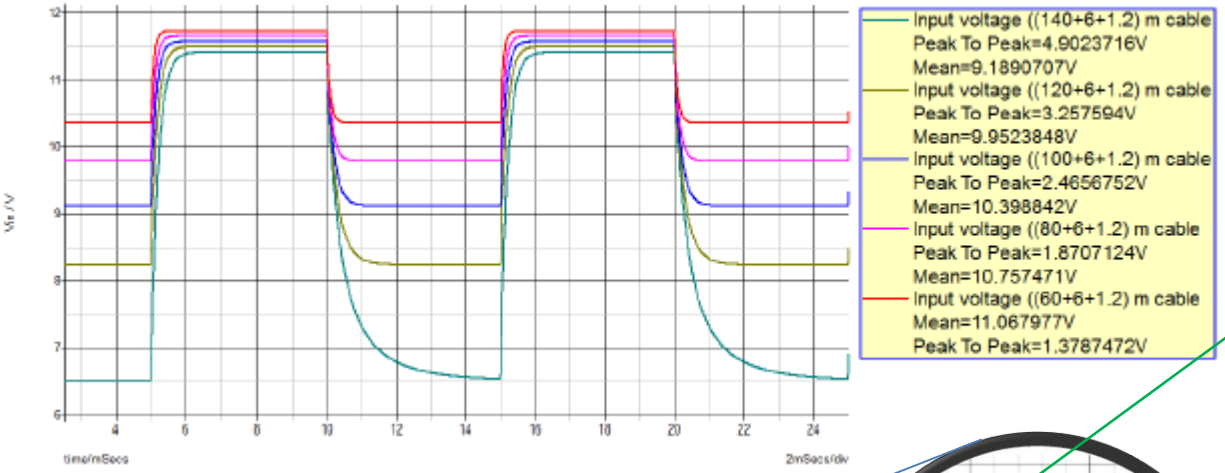
Max input voltage well within DC/DC converter operating range, cable mostly resistive



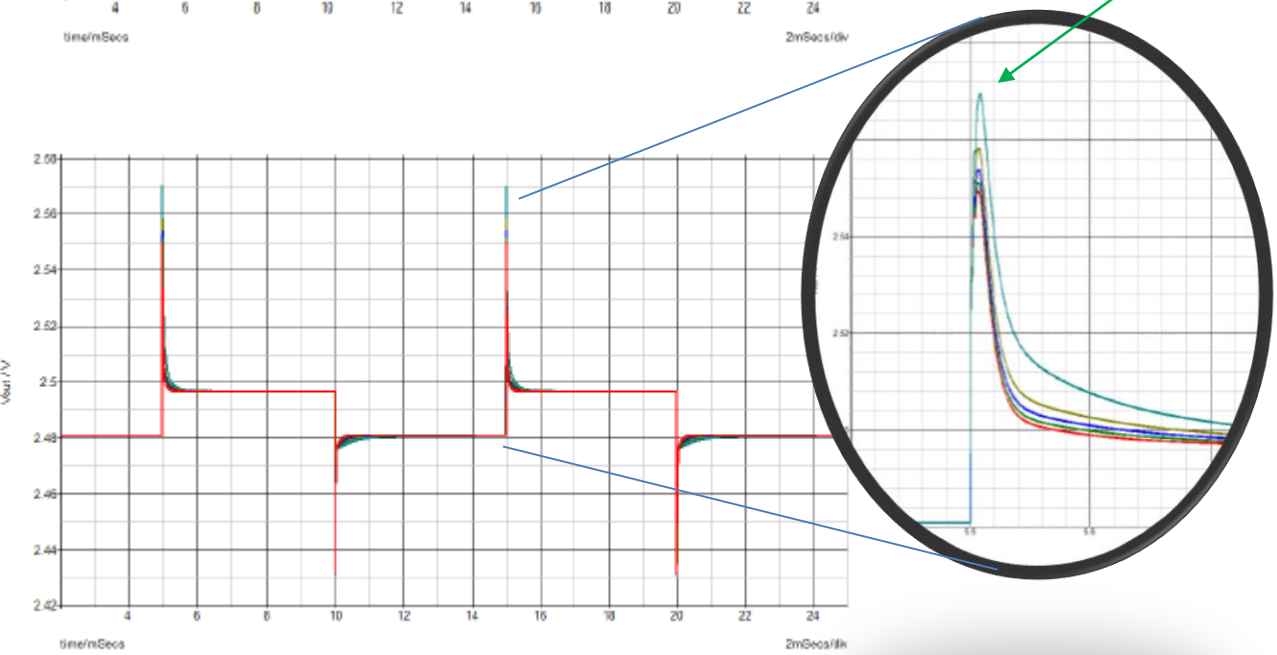
Despite large input swing, DC/DC converter performs well

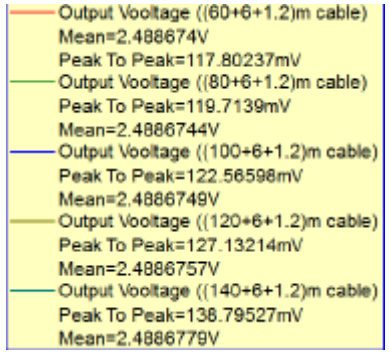
Feasibility Demonstration (2)

Simulation of longer cable lengths: is inductive behavior observed?



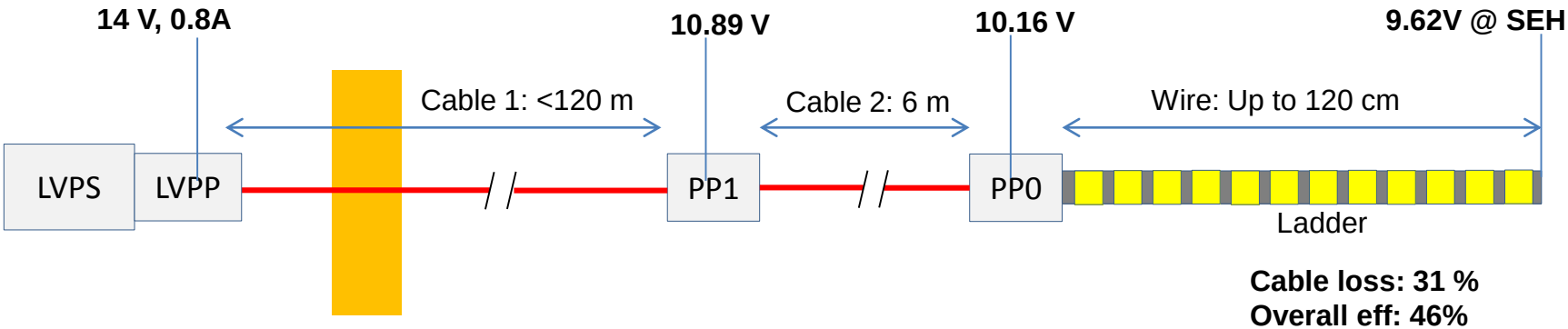
No inductive behaviour observed at DC/DC input up to 140m.
DC/DC converter output overshoots by ~70mV





Use case in CMS outer tracker

Implementation Options in CMS OT



Cable loss: 31 %
Overall eff: 46%

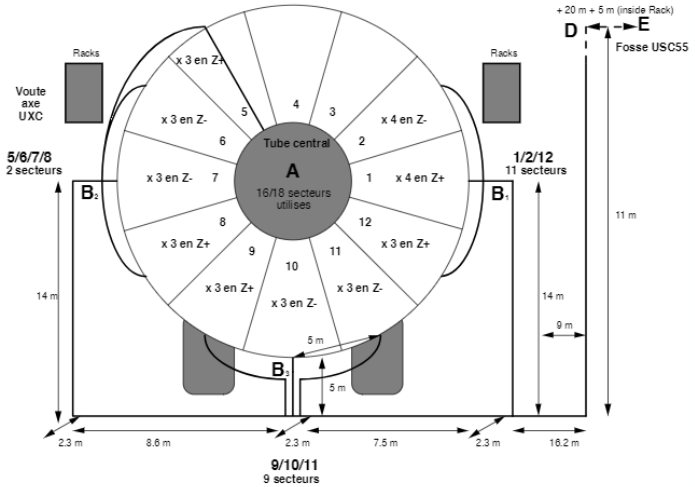
- ***Option 1**: As originally proposed, Lcable1<120m (was 80m)*
  - *the cable length, the space in USC and the cable channel availability seem to be problematic, especially considering the emerging needs of other detectors*
  - *NB: has not been confirmed by dedicated analysis*

Length from USC much dependent on the actual location in USC
FAR side more distant (~ 20 m) than NEAR side

2.3. Récapitulatif des longueurs de câbles pour les deux solutions

	1	2	3	4	5	6	7	8	9	10	11	12
1												
2	85.5 m	*90.4 m*										
3	86.0 m	*90.4 m*										
4	86.7 m	*90.7 m*										
5	87.6 m	*91.3 m*										
6					120.5 m	*116.3 m*						
7					120.3 m	*115.7 m*						
8					120.5 m	*115.4 m*						
9							*110.5 m*	116.3 m				
10												
11							*110.5 m*	115.4 m				
12							*111.0 m*	115.4 m				
13									90.3 m	*90.7 m*		
14									90.5 m	*90.4 m*		
15									91.0 m	*90.4 m*		
16											*90.3 m*	90.7 m
17											*90.5 m*	90.4 m
18											*91.0 m*	90.4 m

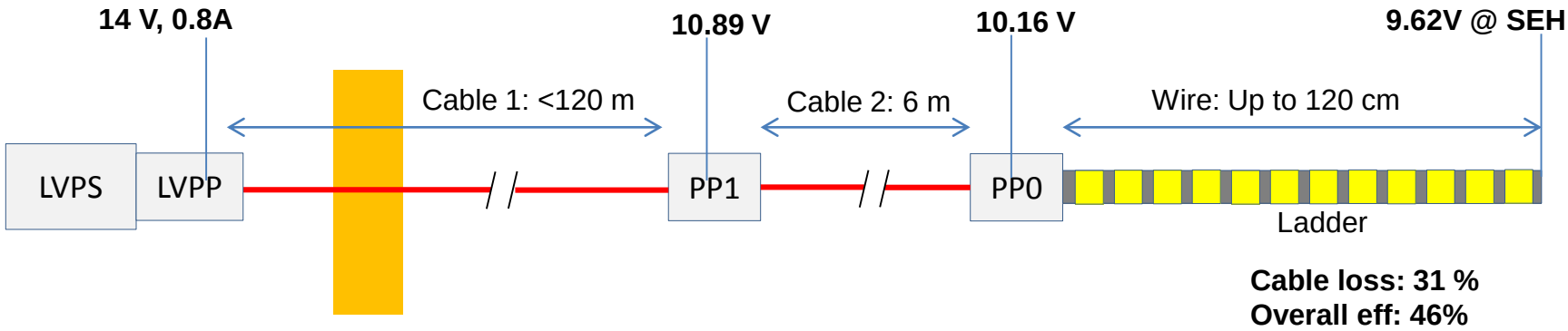
Tableau 6 : longueurs des câbles avec alimentations dans la salle de comptage



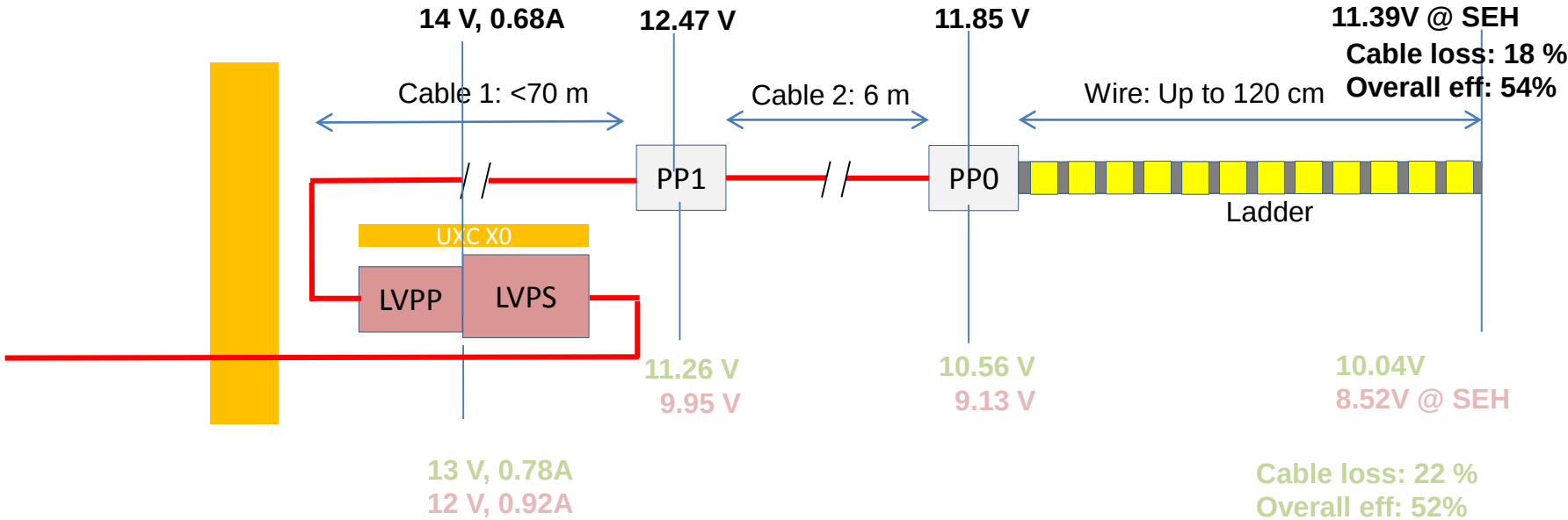
UXC

Implementation Options in CMS OT

- **Option 1: As originally proposed**

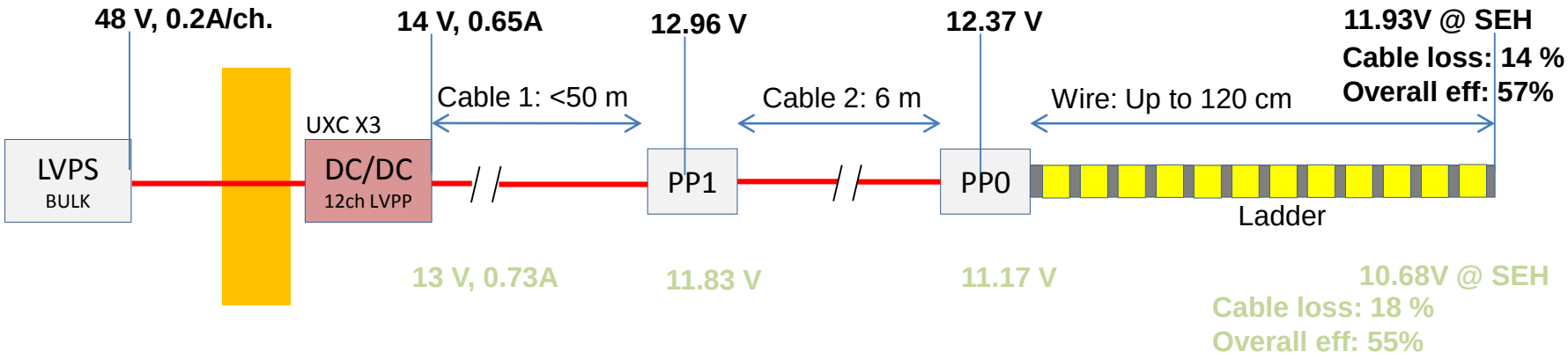


- **Option 2: Shortening Cable 1 length (assume -50m length reduction)**
  - **Room UXC-X0 provides shielding from radiation but the stray field is <500G**

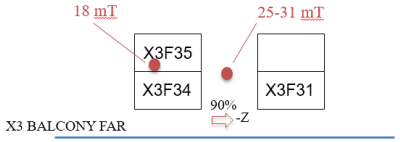


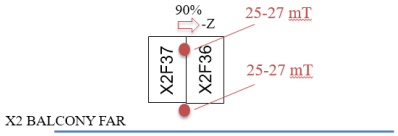
Implementation Options in CMS OT

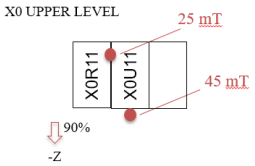
- **Option 3**: Introducing an intermediate DC/DC converter stage
  - Improves supply efficiency and reduces footprint on USC floor space
  - Development of rad and magnetic field tolerant power supply module is required
    - TID<10Gy, B<500G

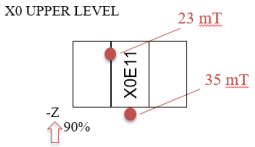


Measurement of the fringe magnetic field (@3.8T)









X0 LOWER LEVEL: 21-27 mT

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Implementation Options in CMS OT

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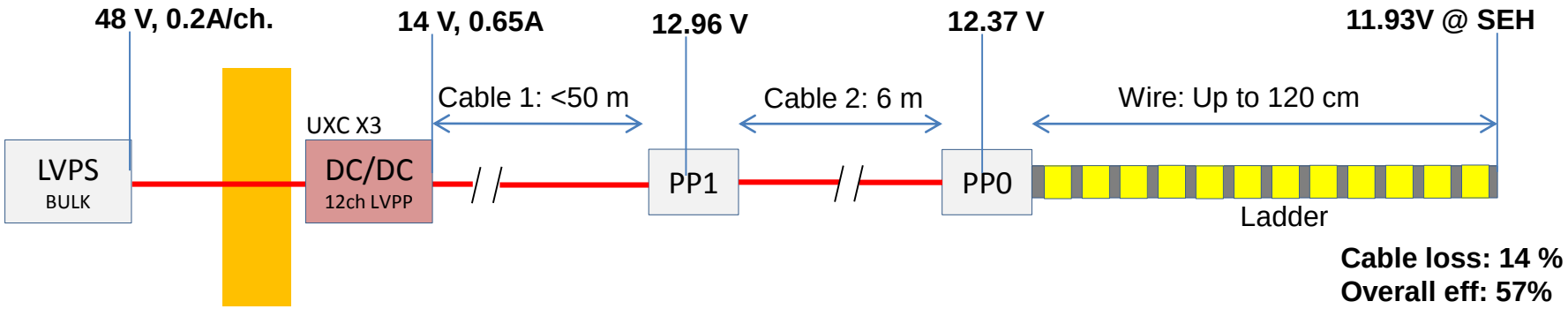
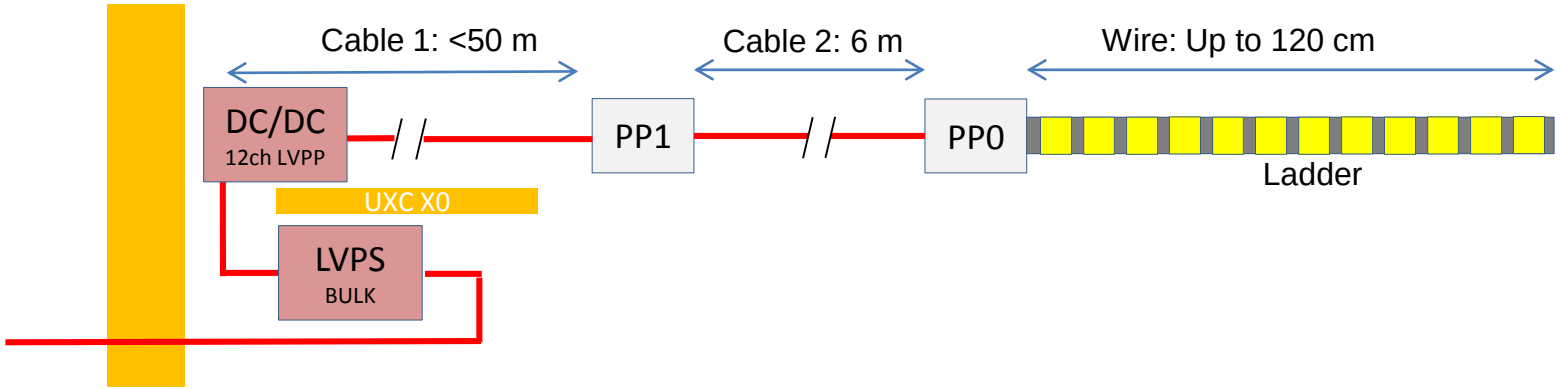
    - TID<10Gy, B<500G

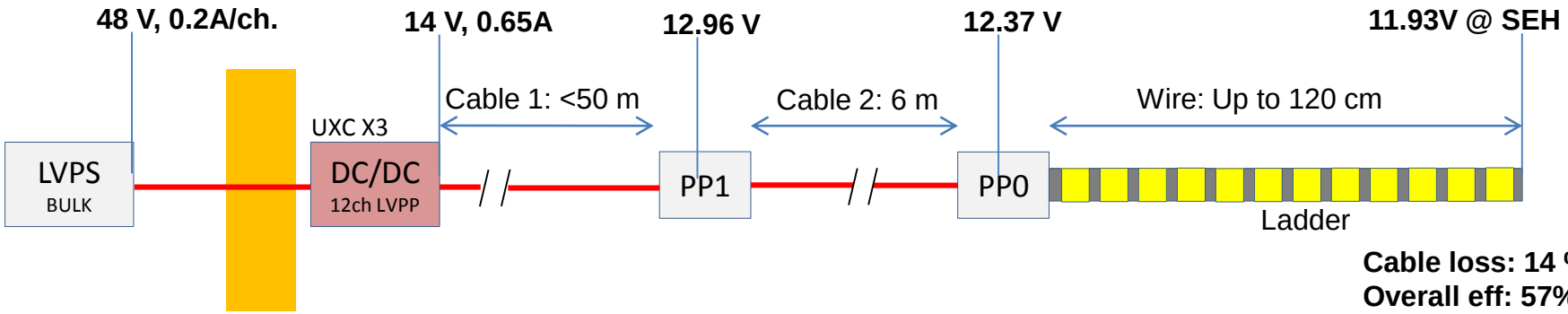


- **Option 3b**: Completely relaxes impact on USC
  - not much different from option 2 (cable 1 is shorter) while more complex

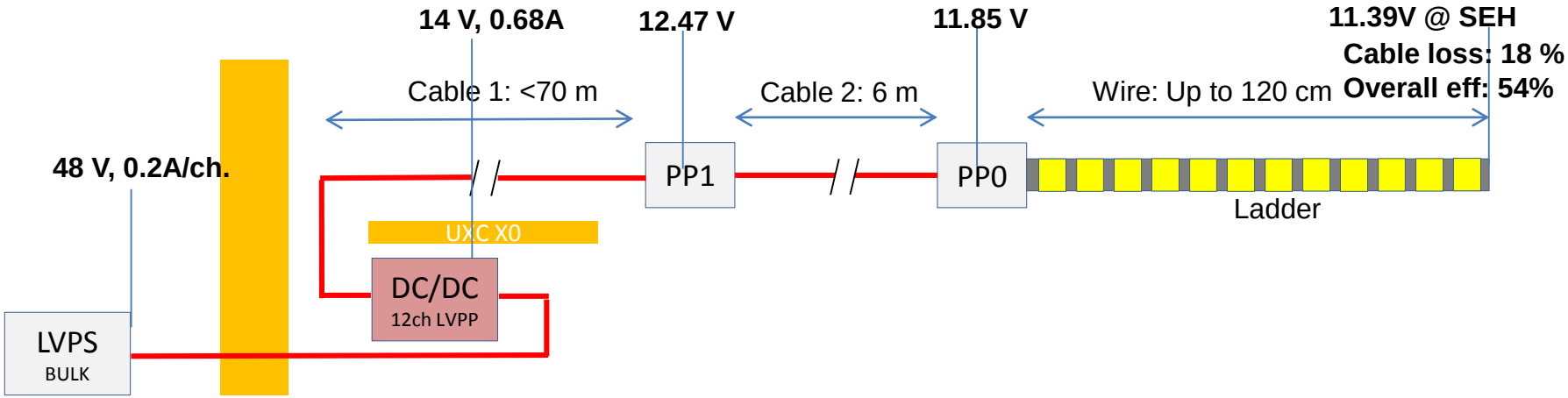


Implementation Options in CMS OT

- **Option 3: Introducing an intermediate DC/DC converter stage**
  - Improves supply efficiency and reduces footprint on USC
  - Development of rad and magnetic field tolerant power supply module is required
    - TID<10Gy, B<500G



- **Option 3c: Shielding DC/DC module**
  - Relaxes radiation tolerance constraint, but stray field is still <500G



Tentative Requirements (1):

- *Bulk LVPS*
  - *12-14V (options 1 or 2)*
    - *Pmax=300W (P=150Wmax in operation, i.e. 50% nominal loading)*
    - *Iout max 20A*
    - *+/- 50V floating range*
    - *Remote on/off and thresholds control (OPC, SNMP or equivalent)*
      - *Adjustable OVV and OVC thresholds*
    - *<200mVpp ripple&noise*
    - *1% line and load regulation*
    - *Bfield < 500G (if installed in UXC-X0, option 2)*
    - *Connects to distribution LVPP*
      - *14 channels*
      - *Iout max 1.5A per channel (Imax=0.8A in operation)*
      - *Per channel on/off control and current monitoring*
      - *OVV (?) and OVC protection*
  - *48V (options 3, 3b or 3c)*
    - *P=300W*
      - *Excluding possible HVPS need*
    - *Iout max 6A*
    - *<600mVpp ripple&noise*
    - *1% line and load regulation*
    - *Remote on/off and thresholds control (OPC, SNMP or equivalent)*
      - *Adjustable OVV and OVC thresholds*
    - *Bfield < 500G (if installed in UXC-X0, option 3b)*

Tentative Requirements (2):

- *DC/DC Converter*
  - *Vin: 48V*
  - *Vout: 10-14V*
  - *Pmax=300W (P=150Wmax in operation, 50% nominal loading)*
  - *Iout max 1.5A per channel (Imax=0.8A in operation)*
  - *+/- 50V floating range*
  - *Remote on/off and thresholds control (OPC, SNMP or equivalent)*
    - *Adjustable OVV and OVC thresholds*
  - *14 channels*
    - *<200mVpp ripple&noise*
    - *1% line and load regulation*
    - *OVV (?) and OVC protection*
    - *Vmon, Imon, on/off control*
  - *Interlock with HVPS to be discussed*
  - *Bfield < 500G (if installed in UXC-X0, option 3 or 4)*
  - *TID < 10Gy (if installed in UXC-X3, option 3)*