Powering requirements and constraints of the Mstrip-FTD detector

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OUTLINE

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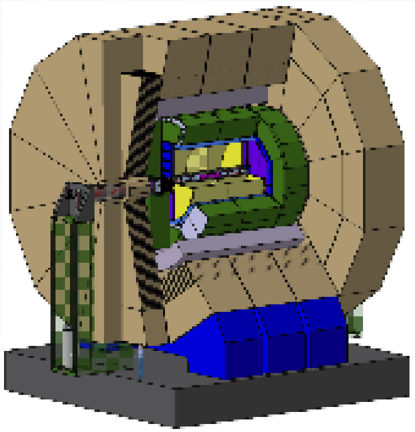
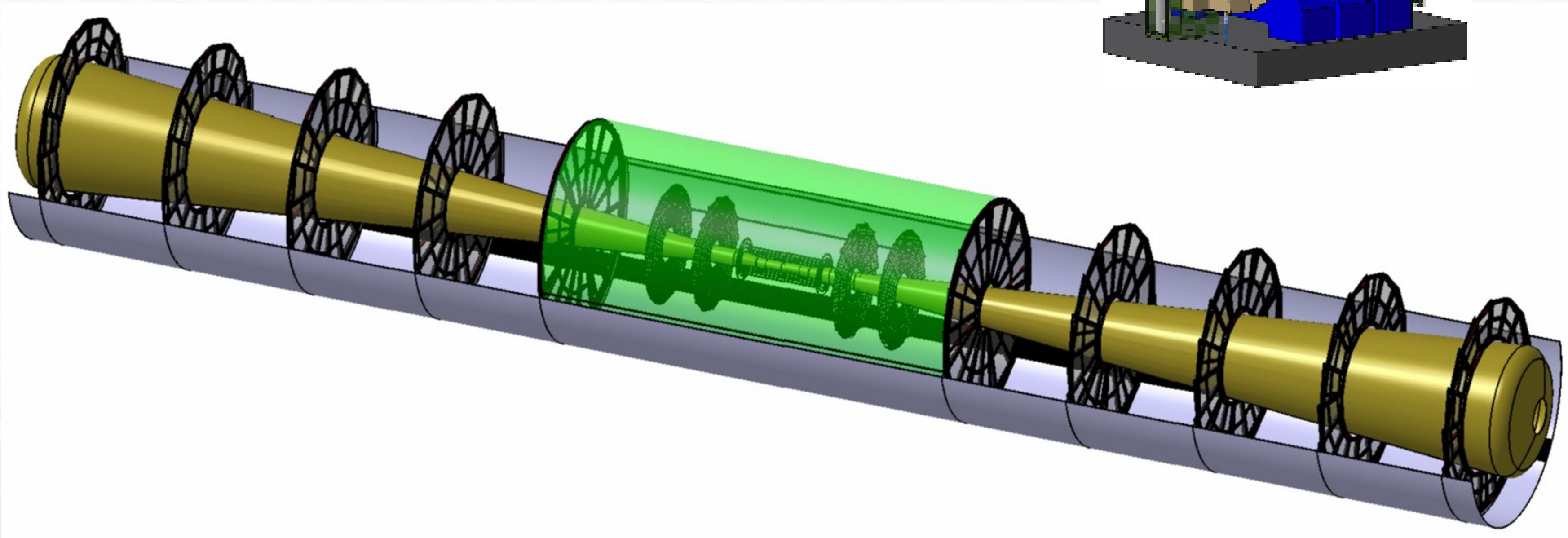
- 2. Power requirements
- 3 Main power design parameters
  - Transients
  - EMI
- 4. Powering schemes
  - Power scheme based on DC-DC converters
- 5. Conclusions

1. FTD detector

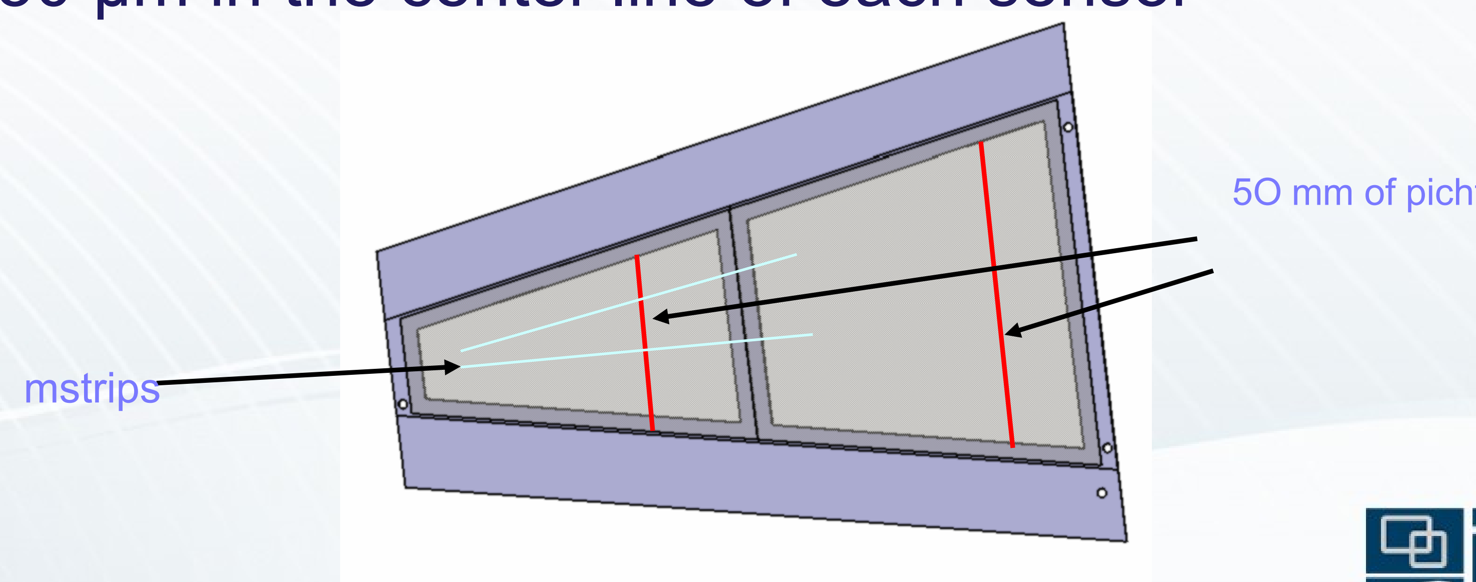
- The mstrip-FTD system is a silicon strip tracker located in the innermost part of the tracker region of the ILD.
- It constitutes of 10 disks.





1. FTD detector

- Each disk is constituted of 16 petals.
- Each petal has 2 modules
  - One on the top & One on the back
  - Total : 4 sensors per petal
- The sensors in a 6 inch Wafer
- Fine pitch sensors
  - 50 µm in the center line of each sensor



1. FTD detector

- The total number of strips is higher than a million
  - Non –uniform distribution

	MIDDLE PITCH									
FTD	FTD3		FTD4		FTD5		FTD6		FTD7	
	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT
Nº STRIPS PER SENSOR	2048	1280	2048	1280	2304	1536	2304	1792	2304	1792
TOTAL Nº STRIPS	212992		212992		245760		262144		262144	
TOTAL Nº STRIPS Strip-FTD			**1196032**							

2. Power requirements

- First estimation is based on some considerations:
  - FEE is based on new generation of Tracker systems.
    - 128 channel chip
    - Optical links.
    - Two operation voltages
      - 2.5V
      - 1.25V
- Power estimation based also on granularity issues.
  - First approach
    - 1 Power group per 4 petals
      - 4 Power groups per disk
      - FTD : 40 power groups

2. Power requirements

- Currents consumption of Strip - FTD

	MIDDLE PITCH									
FTD	FTD3		FTD4		FTD5		FTD6		FTD7	
	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT
Nº STRIPS PER Module (2sensors)	4096	2560	4096	2560	4608	3072	4608	3584	4608	3584
Chips per petal	52		52		60		64		64	
Optical links per petal	1		1		1		1		1	
I2.5 (A) per Petal	2.56		2.56		2.8		2.92		2.92	
I1.25 (A) per Petal	1.18		1.18		1.34		1.42		1.42	
I per petal	3.74		3.74		4.14		4.34		4.34	
I per disk	59.84		59.84		66.24		69.44		69.44	

TOTAL Mstrip- FTD Current	**649 A**

2. Power requirements

- Currents consumption of FTD per power group

	MIDDLE PITCH									
FTD	FTD3		FTD4		FTD5		FTD6		FTD7	
	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT	TOP	BOT
I2.5 (A) per PG	10.24		10.24		11.20		11.68		11.68	
I1.25 (A) per PG	4.72		4.72		5.36		5.68		5.68	
Power Groups	4		4		4		4		4	
TOTAL FTD Power groups			**40**							

3. Main power design parameters

- The amount of current required by Strip-FTD is around **650 A**
- The ILC accelerator has a duty cycle of 0.5%
  - 1 ms bunch train every 200ms
- If the power demanded by the FEE is synchronized to the bunch train, it helps to save energy
  - Energy dissipated will be lower
- The total Strip-FTD current demanded per bunch crossing (a peak current) is 650 A
  - Mean current 6.5 A. per cycle (no power–no bunch)
  - Max Current per power group lower than :
    - 12 A (1.25V) & 6A (2.5V)

3. Main power design parameters

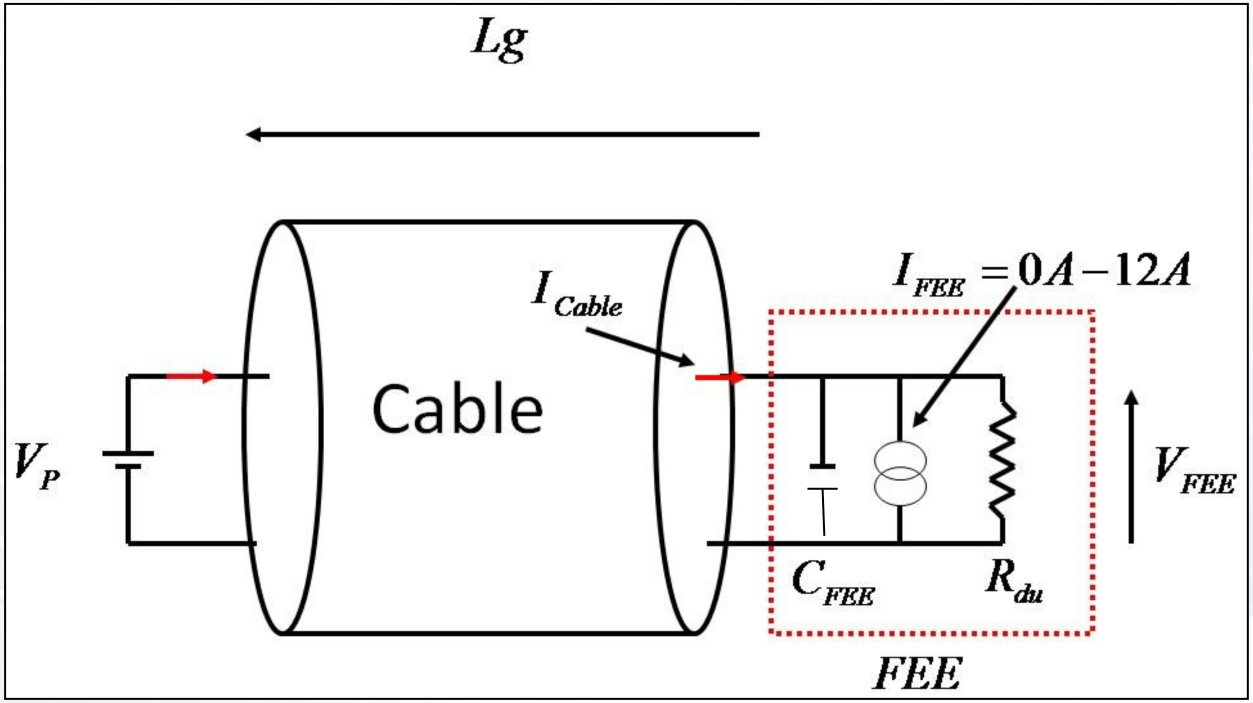
- However several important issues have to be considered during the design of the power system:
  - Transient phenomena
  - EMI phenomena
- All these phenomena have an impact in the design of the power supply distribution system
  - Topology
  - Cooling and material budget
- A very simple study has been carried out to define the implications of these issues in the design of the power system.
  - We have assumed FEE power off when no bunch

3.1 Main power design parameters: Transients

- The current variation per bunch crossing generates transients
  - Cable inductance
  - Cable resistance
- Transient characteristics depends on:
  - Cable length
  - Capacitors located at FEE level
  - Current variation amplitude
- A very simple power group has been analyzed
  - V=1.25V & I = 12 A

3.1 Main power design parameters: Transients

– Two analysis
  - **Cable length (Lg)** (local or remote powering)
    – 1 m & 50 meters
  - **Local capacitors (C_{FEE})**
    – 100 µF, 200 µF and 400 µF



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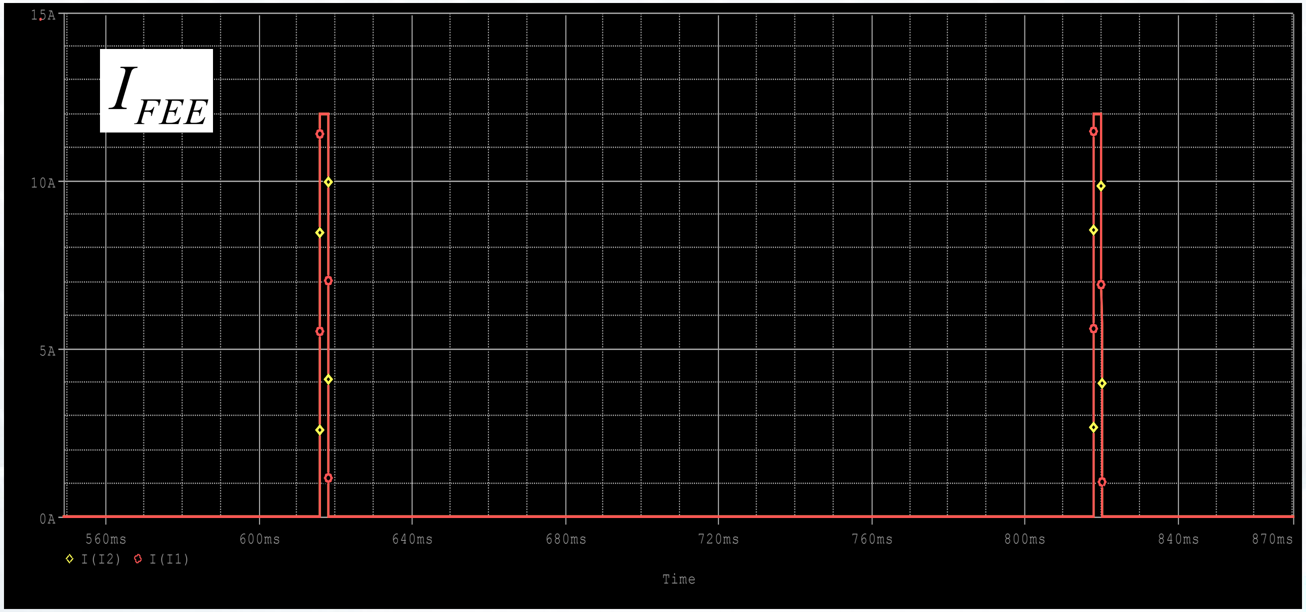
3.1 Main power design parameters: Transients

- **Cable length**
  - This analysis presents some implications of local or remote powering of the FEE
    - 1 m (red)
    - 50m (yellow)
  - We have considered no remote sensing
    - No regulation



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3.1 Main power design parameters: Transients

- **Voltage**
  - Long cable requires voltage compensation due to cable resistance
    - Complex power unit
  - Short cable do not need it

- **Cable currents**
  - Short cables has ringing effect due to small cable resistance.

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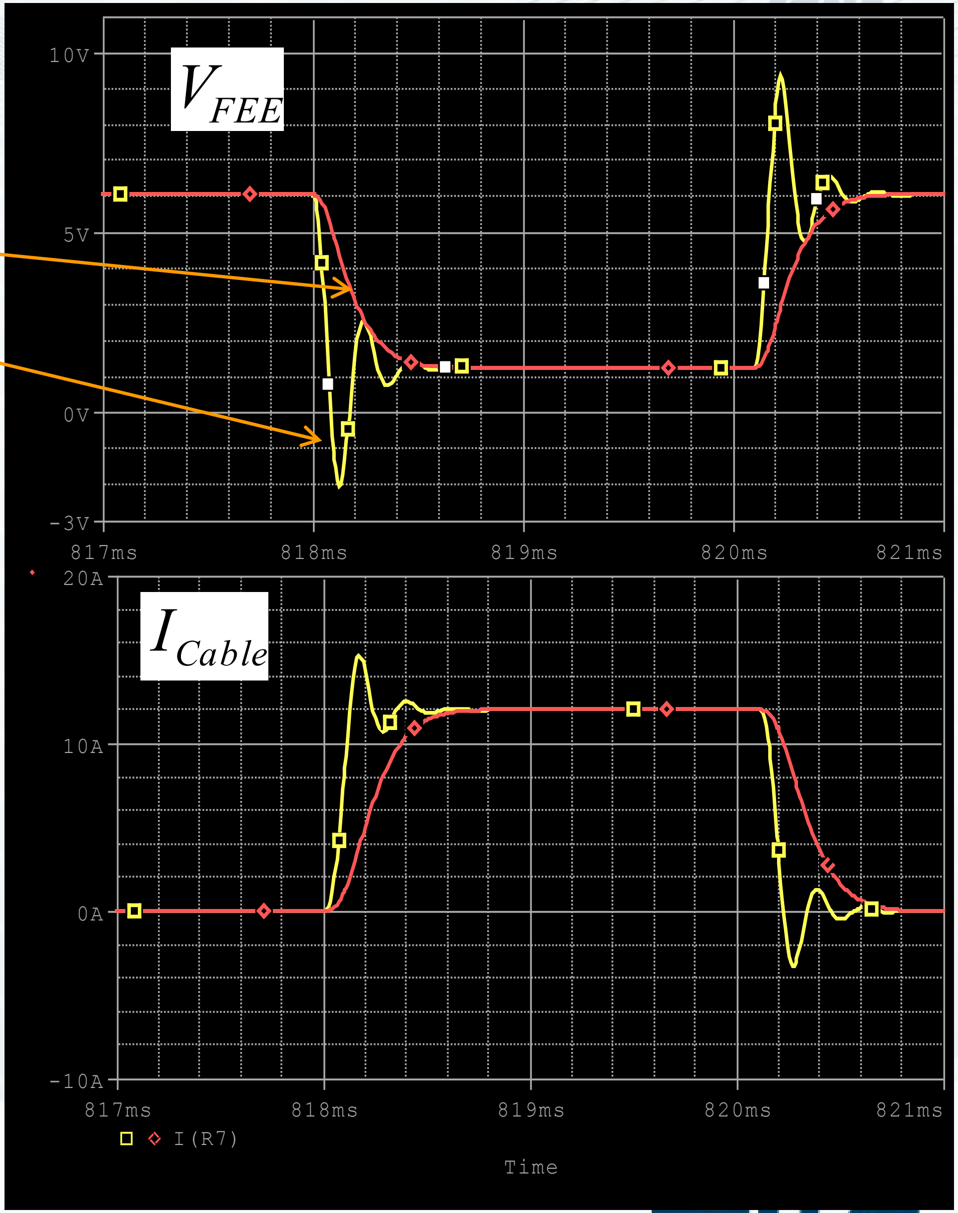
3.1 Main power design parameters: Transients

- **FEE capacitor**
  - Two cases
    - 100 μf & 400 μF
  - Cable length : 50m
- Low C values generates
  - Voltage dips
    - Important in the digital electronics
  - Overvoltage
    - Important in analogue electronics
- Both cases stabilization time similar
- High C Values
  - Reliability issues



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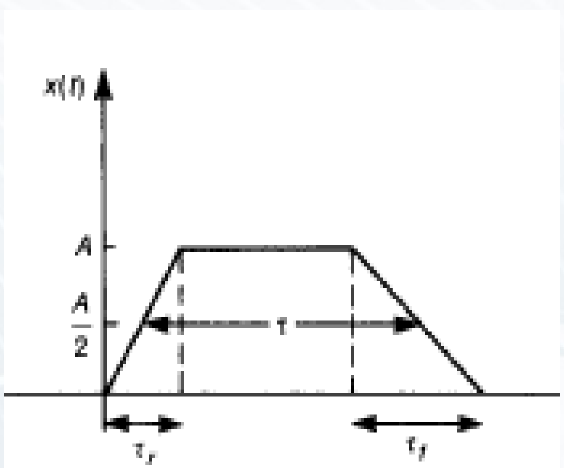
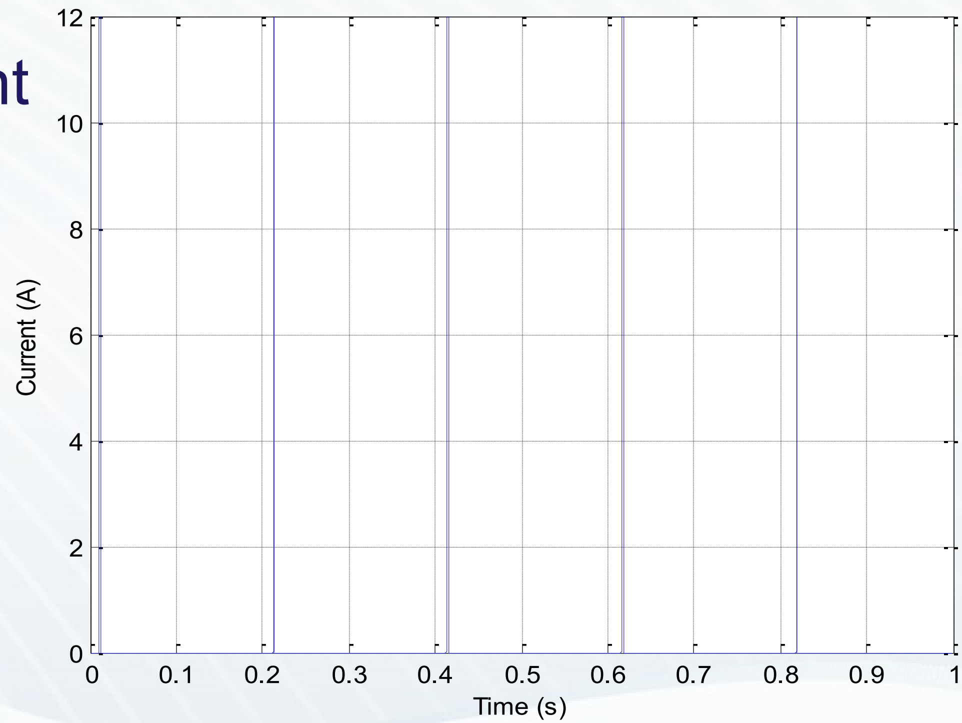
3.2 Main power design parameters: EMI

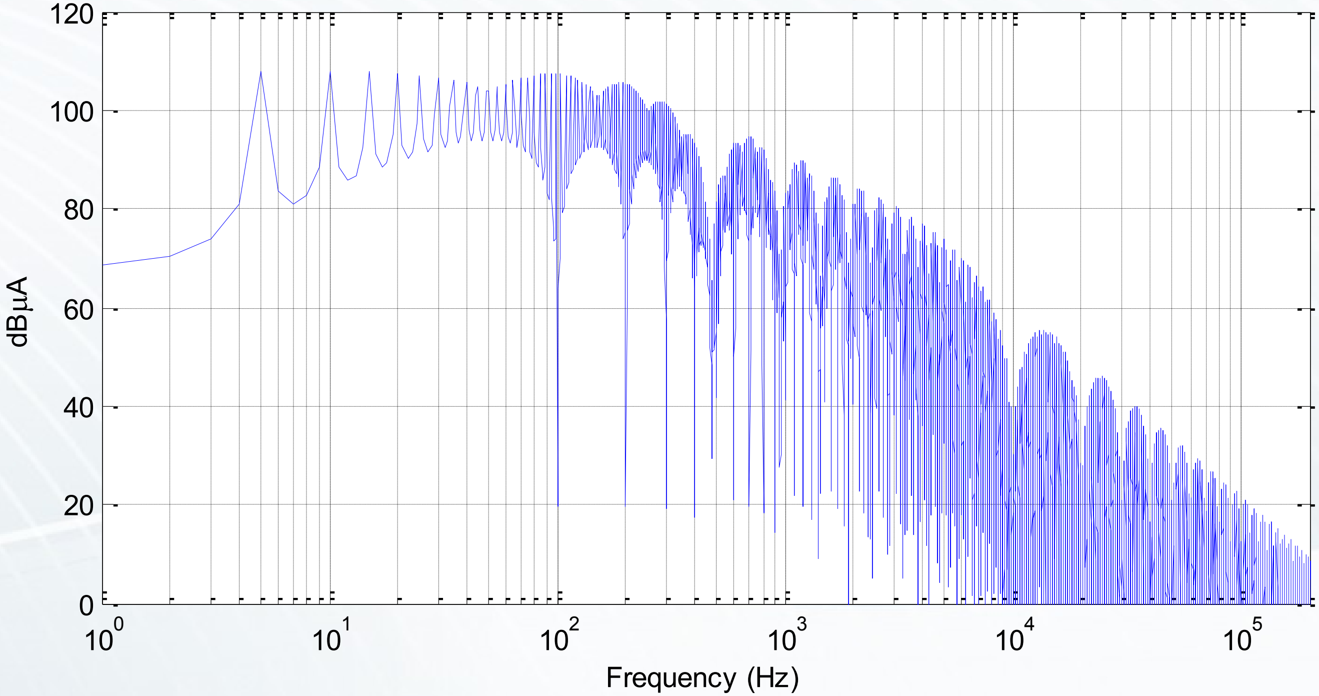
- The synchronization of the FEE power operation with the bunch crossing introduces a current periodic signal with a spectra content in the power supply system.
  - FEE became a noise source
- It will depend on:
  - Amplitude of the current
  - Duty cycle
  - Rise and fall time



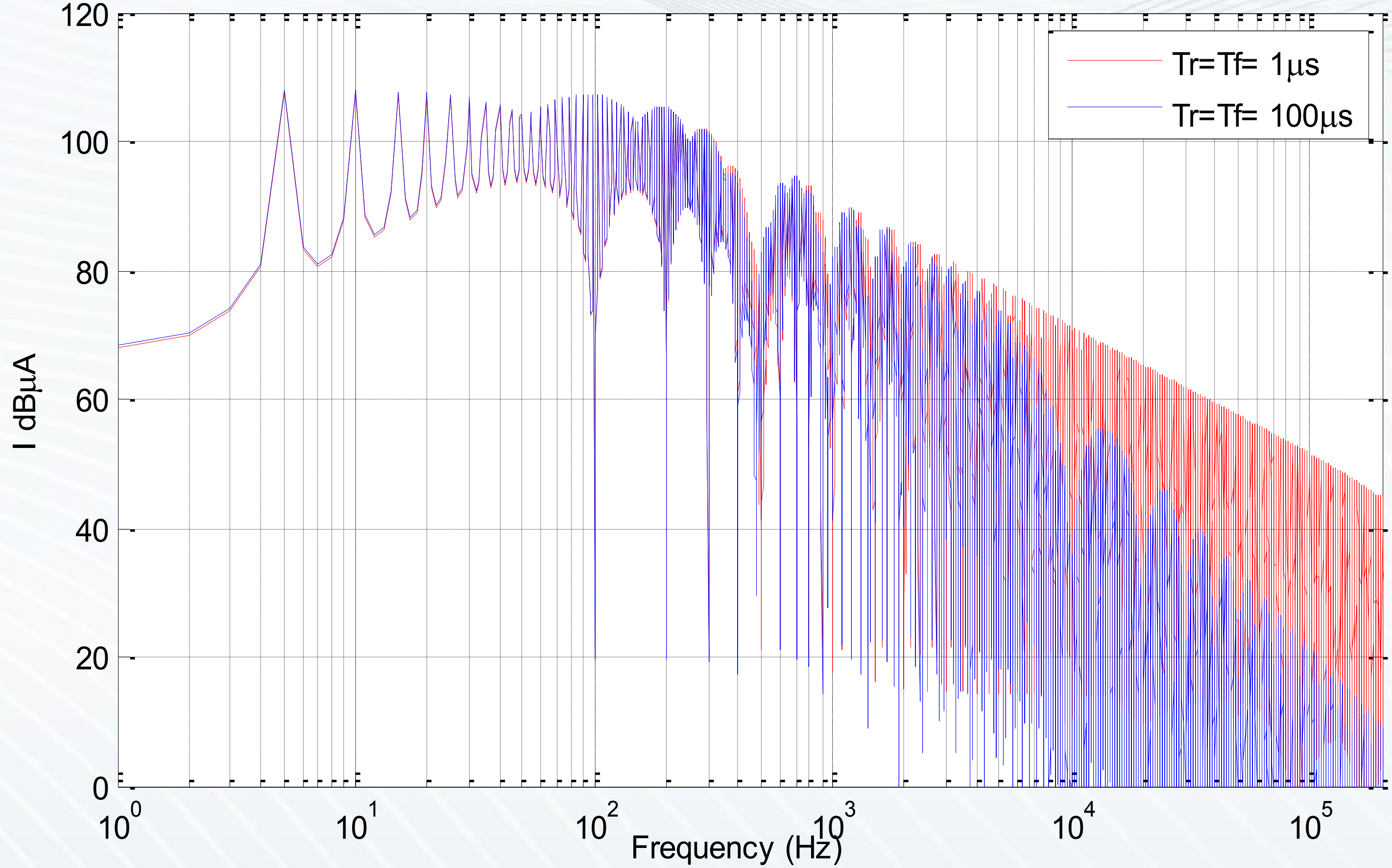


3.2Power supply distribution systems: EMI

- The spectra content varies between few Hz up to several hundreds of kHz
  - LF- Problematic due near field : Magnetic field
    - Every 5 Hz a pulsing magnetic field higher than 0.2 A each
      - Itotal = 40 x 0.2 A = 8 A
    - **It may cause mechanical problems**
      - Vibrations – wire bounding degradation



3.2 Power supply distribution systems: EMI

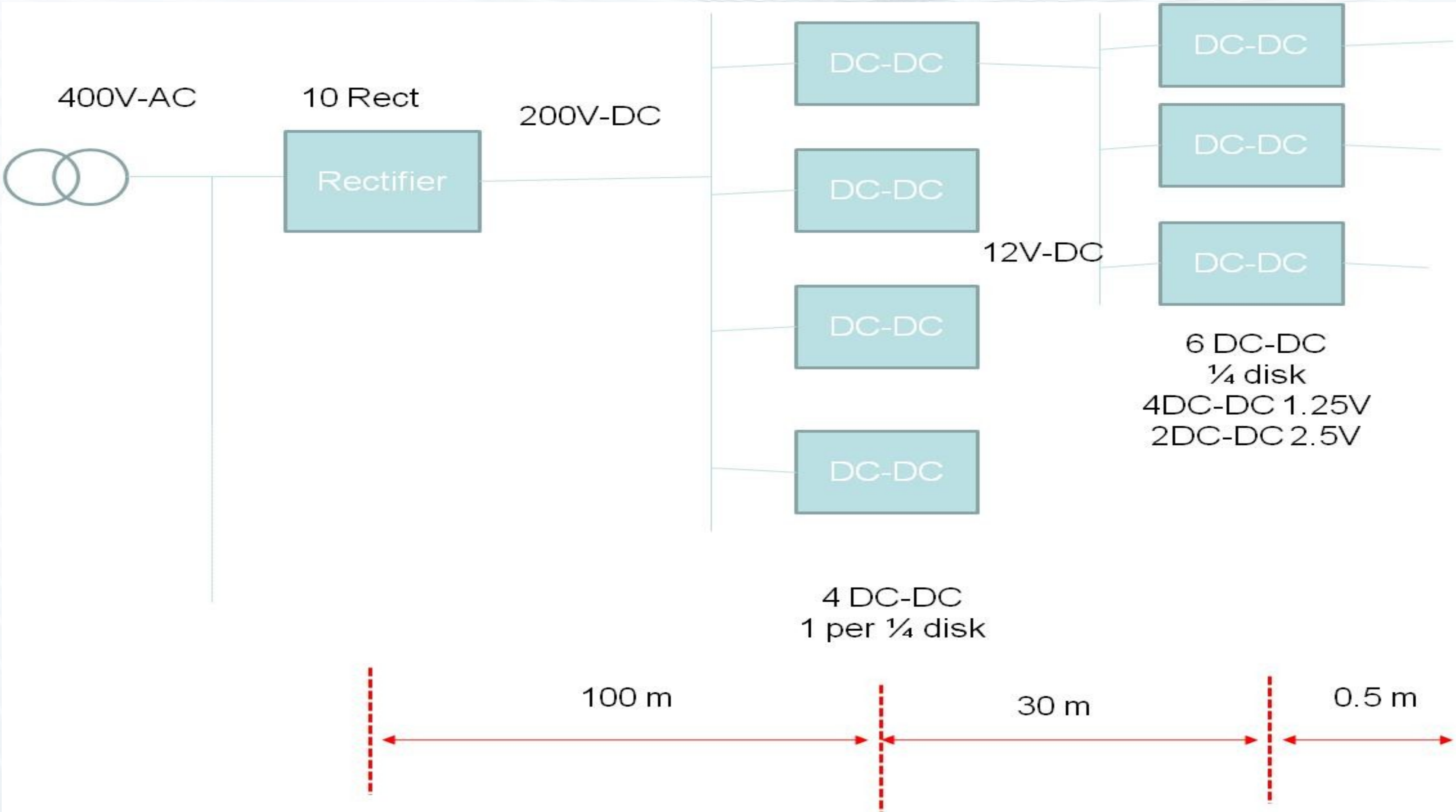


- Transition time Tr / Tf:
  - HF noise contribution increase if transition times decreases

4. Powering schemes

- There are several topologies that may be implemented in the FTD.
  - DC-DC based power distribution
  - Local LV RAD-hard regulators
  - Remote power supply
- Each of them has advantages and disadvantages
- we consider DC-DC as the first option of analysis:
  - To absorb transients associate to power pulsing system.
    - Keep transients locally at FEE level.
    - Low currents before DC-DC due to converter ratio
      - Low transients
  - Synergy with SLHC and new DC-DC hard-rad design.
    - HF noise & Rad issues

4.1 Powering schemes: DC-DC based Power System

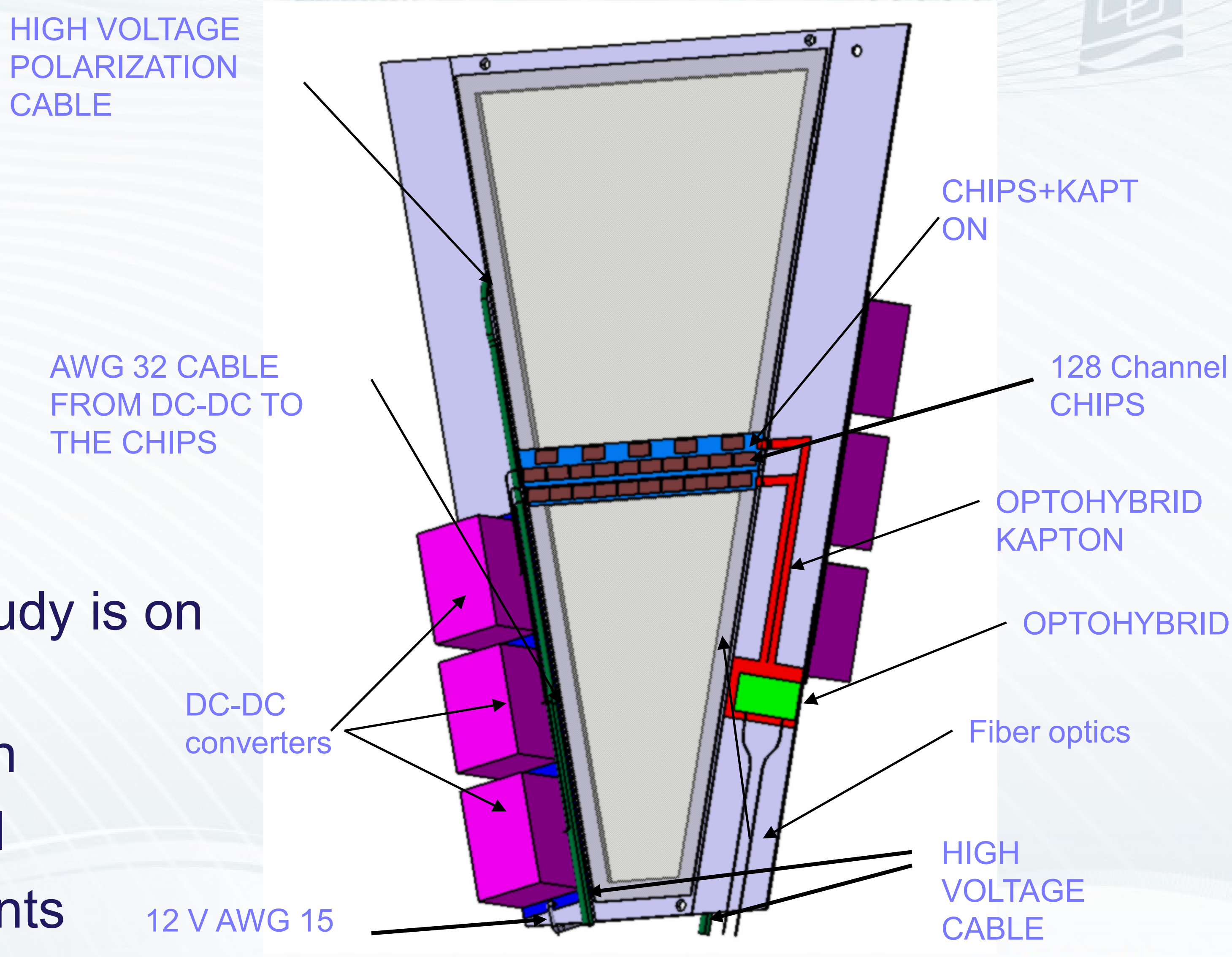


4.1 Powering schemes: DC-DC based Power System

- Power values per group:
  - Routing Inside each petal:
    - 6 DC-DC converters
      - 4 DC-DC (12V -2.5V)
      - 2 DC- DC (12V- 1.25V)
    - Max out current per DC-DC less than 3 A (low transients)
    - Short cabling – Less 1 meter (low voltage drop)
  - Outside petal
    - 1 DC-DC per power group
      - 200V – 12V
    - Max out current per DC-DC less than 3 A
      - Transients attenuated by the DC-DC
  - Outside experiment
    - 1 AC-DC per disk
      - 400V 50 Hz – 200V DC
    - Max current per cable less than 1 A

4.1Powering schemes: DC-DC based Power System

- Detailed study is on progress.
  - Location
  - Material
  - Transients



5. Conclusions

- The very first analysis of the power supply distribution system of Mstrip-FTD detector has be presented
  - Total current detector is around 650 A
- The power cycling of the FEE helps to decrease the power dissipation of FEE and cables
- However, It introduces two aspects that has to be considered during the design of the power supply distribution system.
  - Transients
    - Overvoltage or Voltage dips
  - EMI
    - LF noise (magnetic field)
- First analysis is focused on DC-DC based power distribution system
  - Analysis is still on going
    - It seems good option to keep transients locally