

# TPC Electronics Requirements

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# High level requirement (EB)

- SP-FD-2: system noise ( $< 1000 e^-$ )
- SP-FD-13: front-end peaking time ( $1 \mu s$ )
- SP-FD-14: signal saturation level ( $500k e^-$ )
- SP-FD-19: ADC sampling frequency ( $\sim 2 \text{ MHz}$ )
- SP-FD-20: Number of ADC bits (12)
- SP-FD-21: Cold electronics power consumption ( $< 50 \text{ mW/channel}$ )
- SP-FD-25: Non-FE noise contributions ( $\ll 1000 e^-$ )
- SP-FD-28: Dead channels ( $< 1\%$ )

# Internal consortium requirements

- SP-ELEC-1: number of baselines in the FE amplifier (2)
- SP-ELEC-2: gain of the FE amplifier ( $\sim 20$  mV/fC, adjustable)
- SP-ELEC-3: system synchronization (10 ns)
- SP-ELEC-4: number of FE channel per FEMB (128)
- SP-ELEC-5: number of oinks between the FEMB and the WIB (4 at 1.28 Gbps)
- SP-ELEC-6: number of FEMBs per WIB (4)
- SP-ELEC-7: data transmission speed between WIB and DAQ backend (10 Gbps)
- SP-ELEC-8: max diameter of conduit enclosing the cold cables in the APA vertical frame tube (2.5", 6.35 cm)

# ASIC and FEMB review

- That's not enough, we need more
- Example of requirements for the FE ASIC / ADC
  - Input capacitance to be updated (150pF instead of 220pF)
  - Maximum allowed clock jitter on the received clock
  - Maximum noise on power supplies (ripple vs frequency) and expected range of allowed PS
  - Minimum acceptable ENOB. Is 10 bits enough?
  - Double pulse resolution and settling time
  - Overload recovery (maximum recovery time vs overload)
  - Maximum acceptable crosstalk
- Currently no specifications for the FEMBs

# WIB and System Review

- Prepared 2 documents for hardware and firmware requirements for the WIB, need similar document for PTC
- Started to think / derive about requirements on low voltage power supplies and bias voltage supplies
- Example: maximum voltage ripples for FE amplifier power rail is  $O(2 \mu\text{V})$ 
  - There is no power supply that provides such a small ripple
  - Powering scheme foresees  $48 \text{ V} \rightarrow 12 \text{ V} \rightarrow 3.3 \text{ V} \rightarrow 2.5 \text{ V} \rightarrow 1.8 \text{ V}$ 
    - First two transitions done with buck converters, last two transitions done with LDOs
    - The voltage ripple of the power supply does not matter as much as the voltage ripple of the buck converters
    - LDOs provide all the rejection required to arrive at the specification for the maximum voltage ripple on the FE amplifier power rail

# Summary

- We will try to have updated hierarchy of requirements / specifications in time for next DOE review (July)
- There needs to be an understanding that some requirements will not be detailed at the level of
  - We have a parameterization of the physics reach of DUNE for oscillation physics / supernova physics / proton decay in term of the electronics noise and we have optimized the curve and decided to put a requirement at the level of XXX e<sup>-</sup>
  - There needs to be an understanding of how this information will be stored and how the hierarchy will be accessible
  - The answer “we have put everything in DOORS” is not a scientific one, it belongs to an apparatchik (see the following pages for explanation, I use this term because I like its negative connotation, which for me is related to “using the wrong person for a given task” and “giving a bureaucrat’s answer for a scientific question”)

# DOORS and hierarchy of requirements

- An hierarchy has been created between requirements in DOORS
- We cannot access DOORS directly, need to use column in spreadsheets generated by Nandhini (see documents under <https://edms.cern.ch/project/CERN-0000201829>)
- Example: noise requirement (ID2234) depends on ID269 (Signal over noise ratio) and ID343 (Deprecated)
  - But there are some funny things:
  - S/N requirement in ID269 is different from S/N requirement for ID2234
  - ID269 depends on ID315, which I could not find
  - Some of the requirements in the “Far Detector Science and Engineering Requirements” are out of data and not consistent with the requirements in “Far Detector EB held Specifications”
  - Hierarchy should go back all the way to P5 science requirements, but it doesn't, many links are not accessible / broken (this needs to be fixed for DOE review)

# DOORS and hierarchy of requirements

- Use of DOORS was the answer of LBNF management (not physicists) to the following recommendation from the October 2019 DOE IPR
  - 3. Distill the information contained in the TDR to reviewable summaries before the next IPR review. Examples of this information are: parameters tables, **detector and components flow-down requirements and goals**, phasing options and impacts on DUNE integral exposures, etc
- Putting everything in DOORS may make some people in the LBNF management (not physicists) happy but does NOT answer the recommendation from the review
- If you want to use DOORS you need to put a physicist in charge who understands how you go from P5 to the power rail on the FE amplifier, not an engineer with no background on physics, electronics



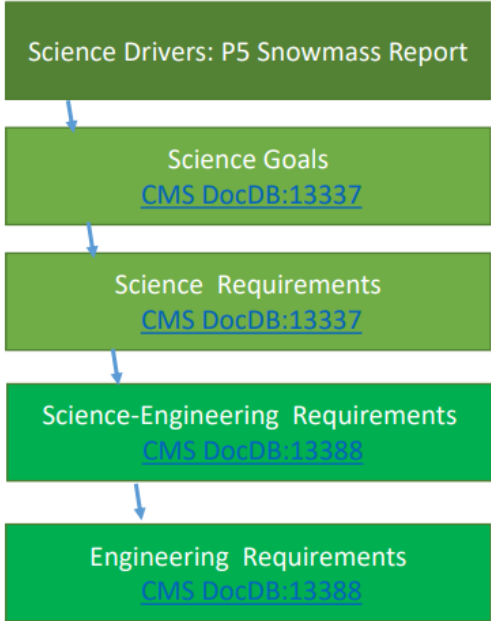
# What that recommendation really means

- Slide stolen from recent CMS HL-LHC review, ATLAS has similar slides in every presentation (we failed to do this....)



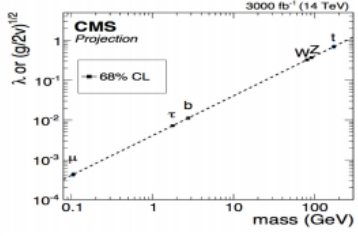
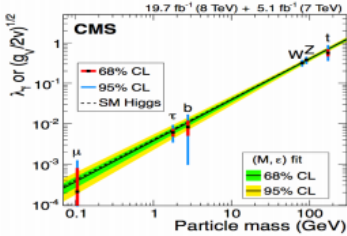
## Science → Design Flowdown

Charge #2,7



CMS-wide

Outer Tracker



Measure the Higgs Couplings (sci-goal-1)

Charged Particle Tracking Efficiency (sci-req-3)

Robust Track Reconstruction (OT-sci-engr-001)

Electrical Functionality (OT-engr-031)  
Dimensional Tolerance (OT-engr-038)  
Radiation Tolerance (OT-engr-007)