DCH FEE

Off-Detector FEE crates/boards

(number & power requirement estimation)

&

On-detector electronics remarks

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Outline

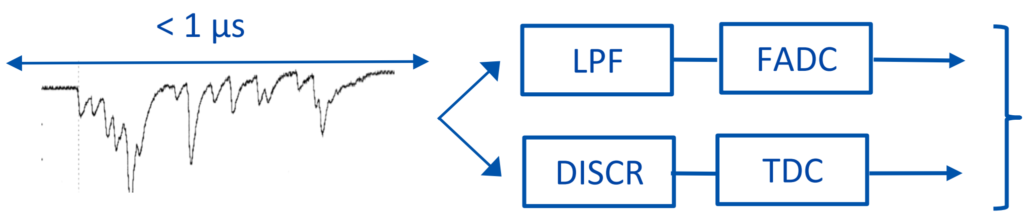
- OFF-DETECTOR CRATES/BOARDS ESTIMATION
  - Standard (BaBar like) DAQ
    - Basis of estimate (BoE)
    - Number of boards/crates counting
    - Power requirements estimation
  - Cluster Counting DAQ
    - Basis of estimate
    - Number of boards/crates counting
    - Power requirements estimate
- ON-DETECTOR ELECTRONICS REMARKS
  - Commercial, Off The Shelf (COTS) option (pros & cons)
  - Dedicated devices (ASIC) power requirement estimation.
    - Pre layout simulation of two preamplifiers based on Current Conveyors circuits
- CONCLUSIONS

Off-Detector : crates/board estimation

Off-Detector: BaBar-like DAQ BoE (I)

Measurements

- *First electron(s) cluster arrival time*
- *dE/dx by means of (preamplified) signal charge measurement (and truncated mean method)*



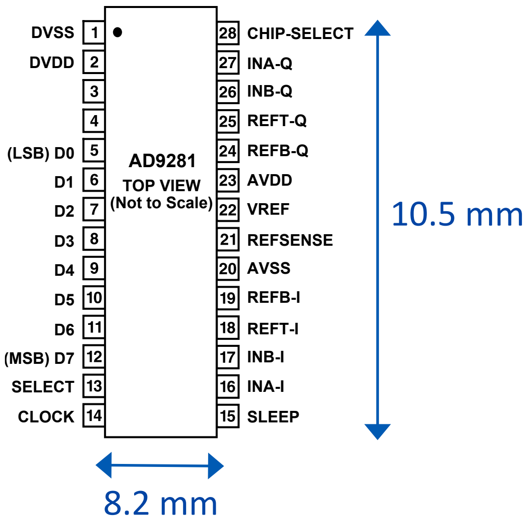
- *32 samples (8 bits) @ 28 MHz*
- *≈ 1ns time resolution over-threshold TDC values*
- ***Single event buffer size : 32 x 8 bits***
- ***5 events buffer provides ≈ 6 µs latency time***

Hardware (COTS)

- *1 ns multi-hit/multi-channels TDC can be implemented both in RAM-based and FLASH-based FPGA*
- *Multi-channels FADC + FPGA*
- *Fast discriminators*

Off-Detector: BaBar-like DAQ BoE (II)

2 channels 28 MHz FADC – Analog Devices



FEATURES
Complete Dual Matching ADC
Low Power Dissipation: 225 mW (+3 V Supply)
Single Supply: 2.7 V to 5.5 V
Differential Nonlinearity Error: 0.1 LSB
On-Chip Analog Input Buffers
On-Chip Reference
Signal-to-Noise Ratio: 49.2 dB
Over Seven Effective Bits
Spurious-Free Dynamic Range: –65 dB
No Missing Codes Guaranteed
28-Lead SSOP

+

Ancillary HW

- *2 channels comparator*
- *2 channels OA*
- *Passive components*

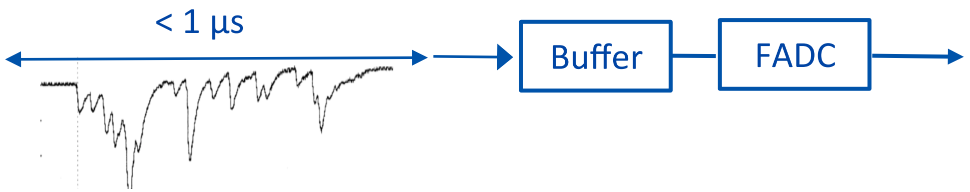
48 channels could be packaged in a single VME board together with dedicated logic for pipelines & DAQ & ECS interfaces

≈ 30 – 35 W
10 W ADC – 20/25 W (FPGA + OAs + comparators)

Off-Detector: Cluster Counting DAQ BoE (I)

Measurements

- *Electrons clusters arrival time (tracking propose)*
- *dE/dx by means of counting of detected clusters*



- *1000 samples (8 bits) @ 1 GHz*
- ***Single event buffer = 1000 x 8 bits***
- ***5 events buffer provides ≈ 6 μs latency time***

Hardware (COTS)

- *1 GS/s FADC*
- *High performances SRAM based FPGA*

Off-Detector: Cluster Counting DAQ BoE (II)

8 channels 1 GS/s Digitizer - CAEN

+ 5 V - 6.5 A
+12V - 0.2 A
-12V - 0.3 A

≈ 40 W

- 4/8 channels
- 10 bits 2 GS/s (interleaved) – 1 GS/s ADC

provides 8 inputs for A/D conversion @ 1 GS/s

Off-Detector: crates counting - Estimate

BaBar-like option

- DCH number of sense wires (guess): 9216
- Number of channels per board (guess): 48
- Power requirement/board : ≈ 30 - 35 W

Off-Detector boards: 192

VME crates (16 boards/crates): 12

Power Requirements: ≈ 6 - 7 kW

Cluster Counting option

- DCH number of sense wires (guess): 9216
- Number of channels per board (guess): 8
- Power requirement/board : ≈ 40 W

Off-Detector boards: 1152

VME crates (16 boards/crates): 72

Power Requirements: ≈ 46 kW

Signal Cables

Cluster Counting requires high frequency cables →larger diameter → more space to route the cables

Example :

- RG178/U : diameter ≈ 2 mm – attenuation ≈ 1.8 dB/m @ 1 GHz
- RG174/U : diameter ≈ 2,6 mm – attenuation ≈ 1.2 dB/m @ 1 GHz
- Mini coax : diameter ≈ 0.81 mm – attenuation ≈ 3 dB/m @ 1 GHz

Bonus : larger cables provide better shield against induced noise because the copper braid

Off-Detector: HV/LV crates

HV crates (I)

- DCH number of sense wires (guess): 9216
- 24 channels HV board
- Current resolution: 100 nA
- Sense wires per channel (average): 24

HV boards: 16

HV crates (16 boards/crates): 1

Power requirements: ≈ 2.3 kW

HV crates (II)

- DCH number of sense wires (guess): 9216
- 12 channels HV board
- Current resolution: 2 nA (20 µA)/ 20 nA (20 µA)
- Sense wires per channel (average): 24

HV boards: 32

HV crates (16 boards/crates): 2

Power requirements: ≈ 4.6 kW

LV crates

- On-detector FEE Power Supply crates : 2

On-Detector electronics remarks

COTS : Pros & Cons

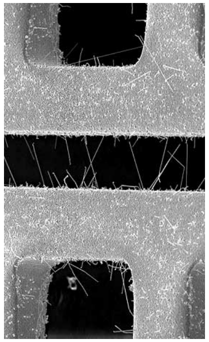
Pros

- high availability
- fast delivery
- low cost

Cons

- Consumer electronics have 2-3 year lifecycles
- Components are subject to the consumer electronics regulatory environment

  Example: To comply with RoHS, for example, commercial electronics manufacturers have had to move to lead-free solder → possible problem: tin whiskers (microscopic growth)

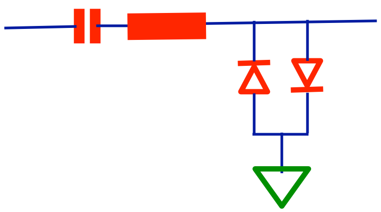


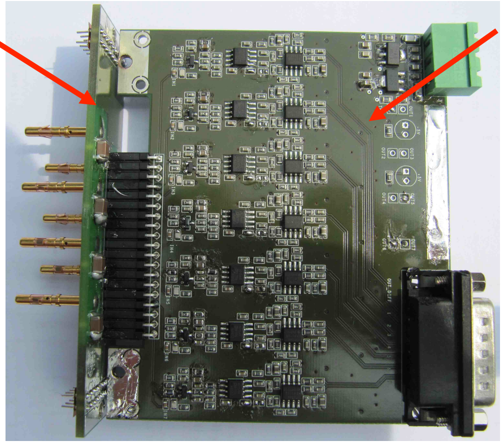
- Components are developed for consumer applications → some feature are redundant for our applications → power requirement

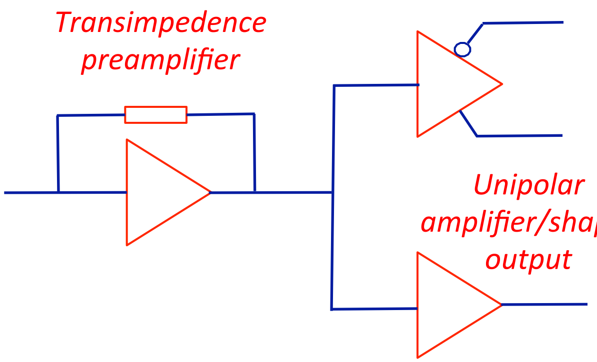
  Example: in OA DC offset must be low, while in most FEE chain different FEE sections are AC coupled

- Must be qualified to work in radiation-tolerant or radiation-hard environment

COTS FE example : Proto 2 DCH preamplifier

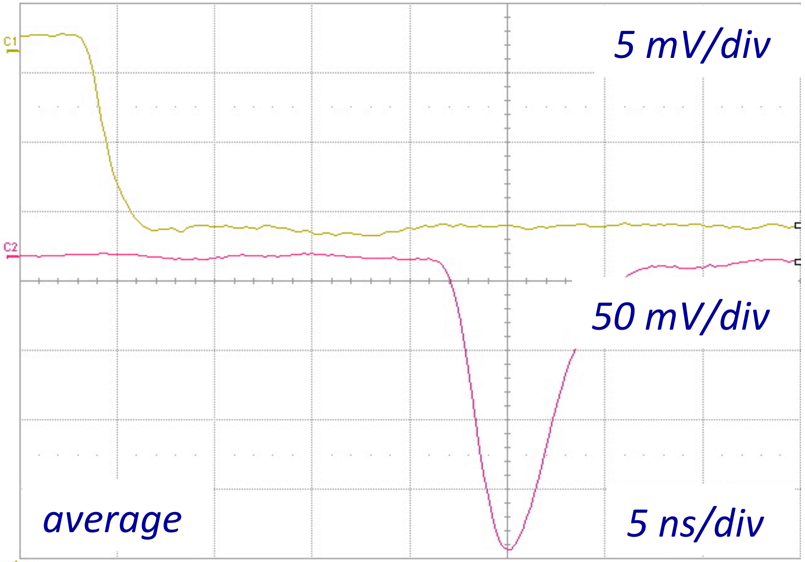






Preamplifier main features

- Number of channels : 7
- Zin ≈ 60 Ω
- Gain ≈ 8.8 mV/fC
- Noise ≈ 2500 erms @ 250 MHz BW
- Rise time ≈ 2.4 ns
- Unipolar & Differential outputs (50 Ω – 110 Ω)
- Test input
- Supply Voltage : + 7V (310 mA) - 7V (190 mA)
- Power Dissipation : 490 mW/ch



1.8 pF injecting capacitance

COTS FE example : Power Requirement Optimization

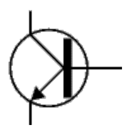
+ 5 V
1 mA } 5 mW

+ 5 V
25 mA } 125 mW

+ 5 V
15 mA } 75 mW

→ ≈ 210 mW

CB configuration



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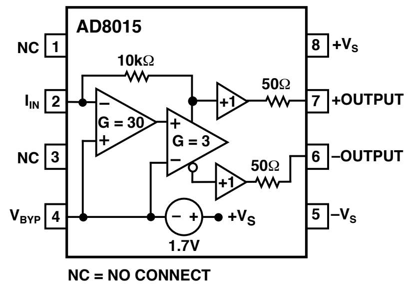

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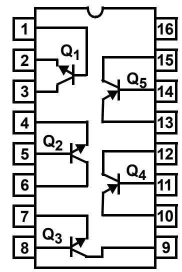


GBW product NPN ≈ 4 GHz @ 1 mA/Vce=5V
GBW product PNP ≈ 4 GHz @ 3 mA/Vce=5V

COTS On-Detector FE Power Requirement (≈ 250 MH BW)

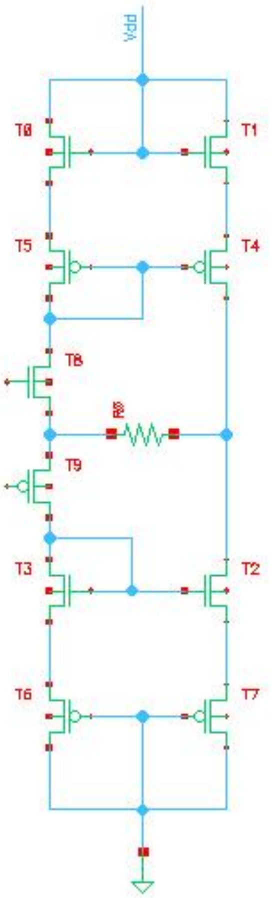
- DCH number of sense wires (guess): 9216
- Power requirement per channel : 210 mW

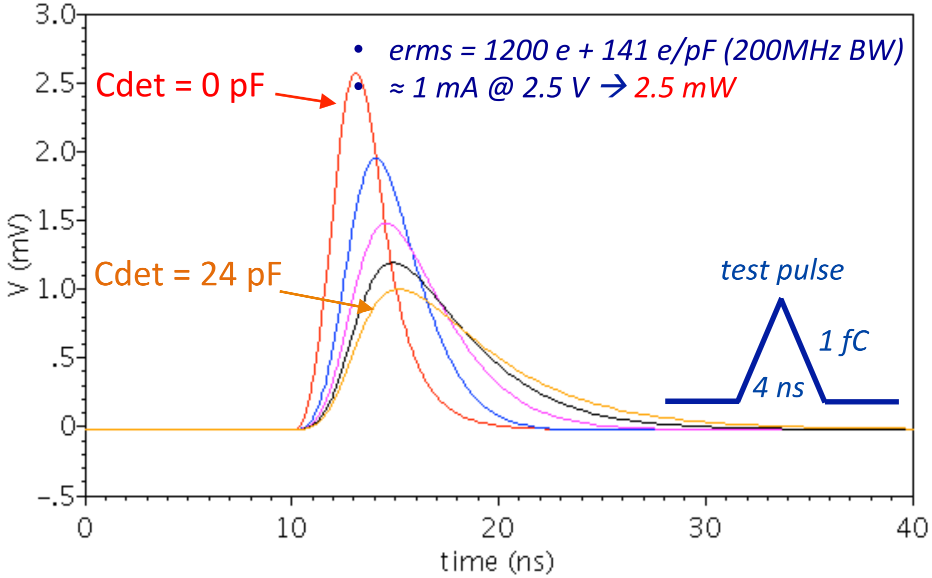
} Power Requirements: ≈ 2 kW

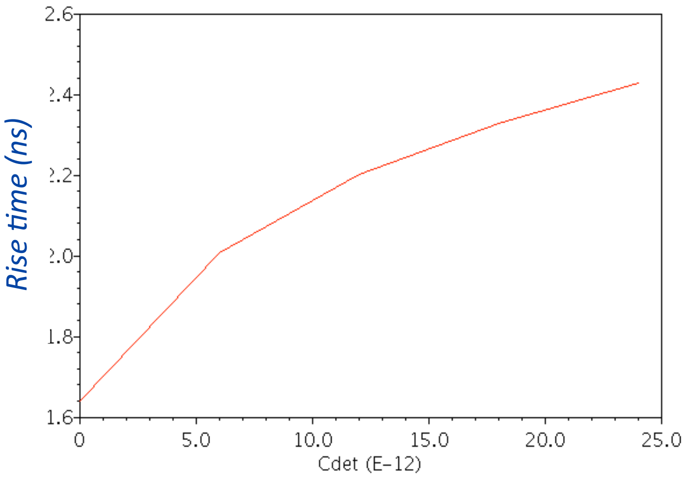
- Reducing the BW requirements → reduction in Power requirements
- Components MUST be qualified for radiation environment

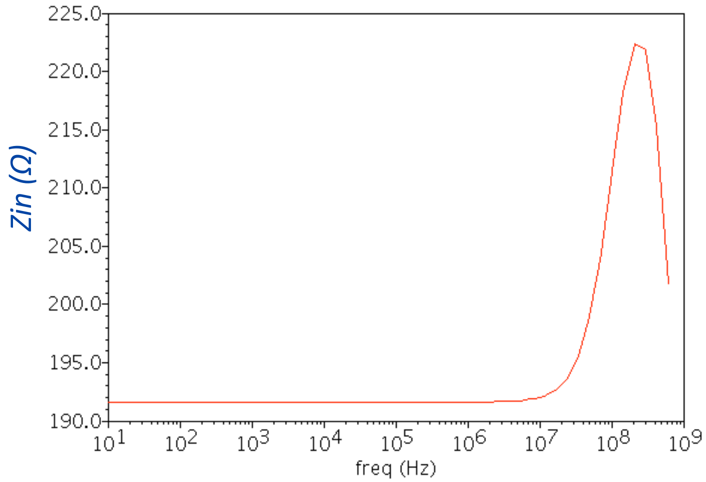
Dedicated device (ASIC) example 1 : Class AB CCII based on current mirrors

IBM 180 nm

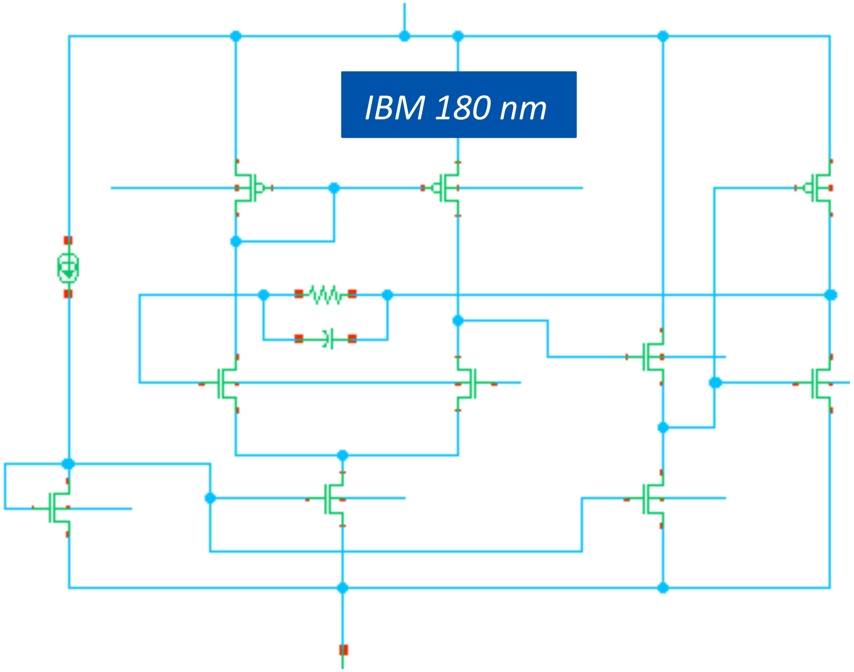


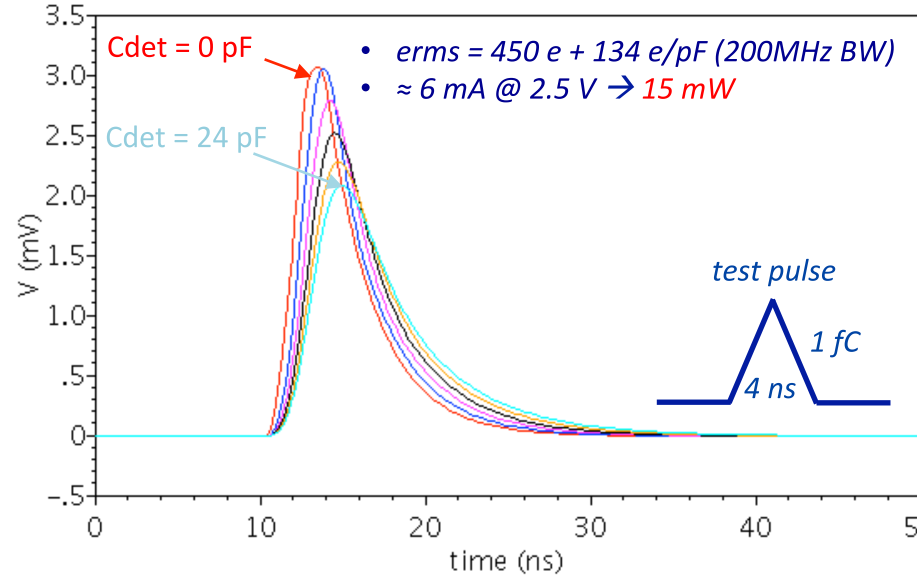


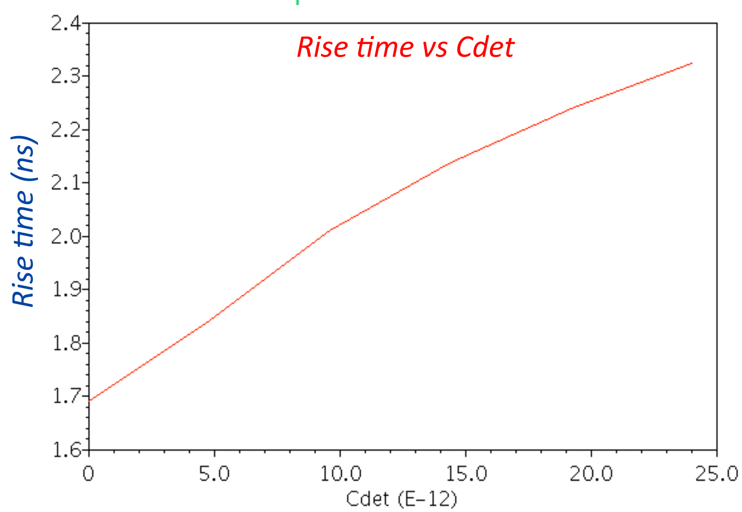


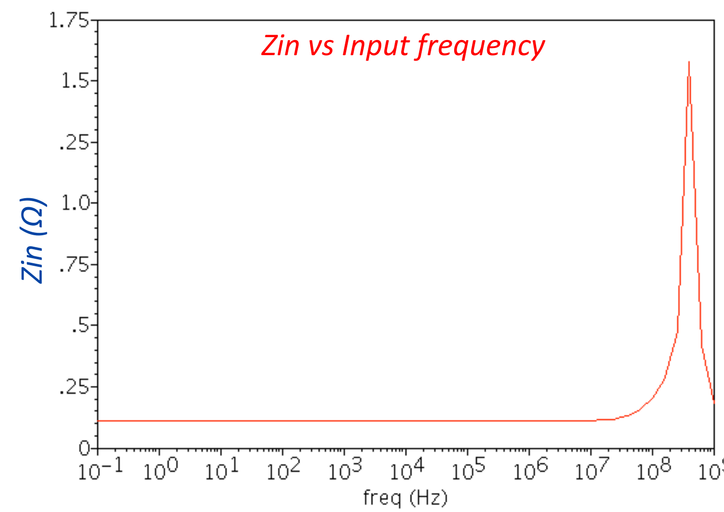


Dedicated device (ASIC) example 2 : Class AB CCII based on Differential Pair









Conclusions

ON-DETECTOR ELECTRONICS

The use of COTS electronics should be avoided because power requirements, PCB size, and radiation environment.

OFF-DETECTOR ELECTRONICS

Both boards/crates and total power requirements differs greatly for BaBar-like and Cluster Counting electronics (192/12/6 BaBar-like and 1152/72/46 Cluster Counting).

Cluster Counting FE remark: probably within a couple of years it will be possible to pack 16 - 1 GS/s digitizer, feature extraction logic and buffers in a single VME board, but at the present time the state of art are 8 - 1 GS/s channels in a (standard) VME board.

BaBar-like FE remark: 48 channels in a VME board is a (very) prudent estimation. A real one could be 64 (using micro coax or twisted pairs signal cables). In such a way the boards/crates counts would decrease to 144/9.

CLUSTER COUNTING REMARKS

The minimum BW required of about 200-250 MHz entails larger power dissipation on the end-plate (unfortunately FE is not distributed on both end plates) and high bandwidth cables. Unavoidably high bandwidth distributed system is more sensitive to noise.