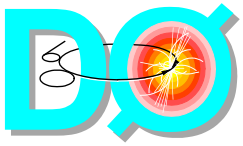

WBS 1.2.8:
AFE II/TriP Upgrade to the Central Fiber Tracker for DZero Run IIb

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for the
DZero Central Fiber Tracker Group

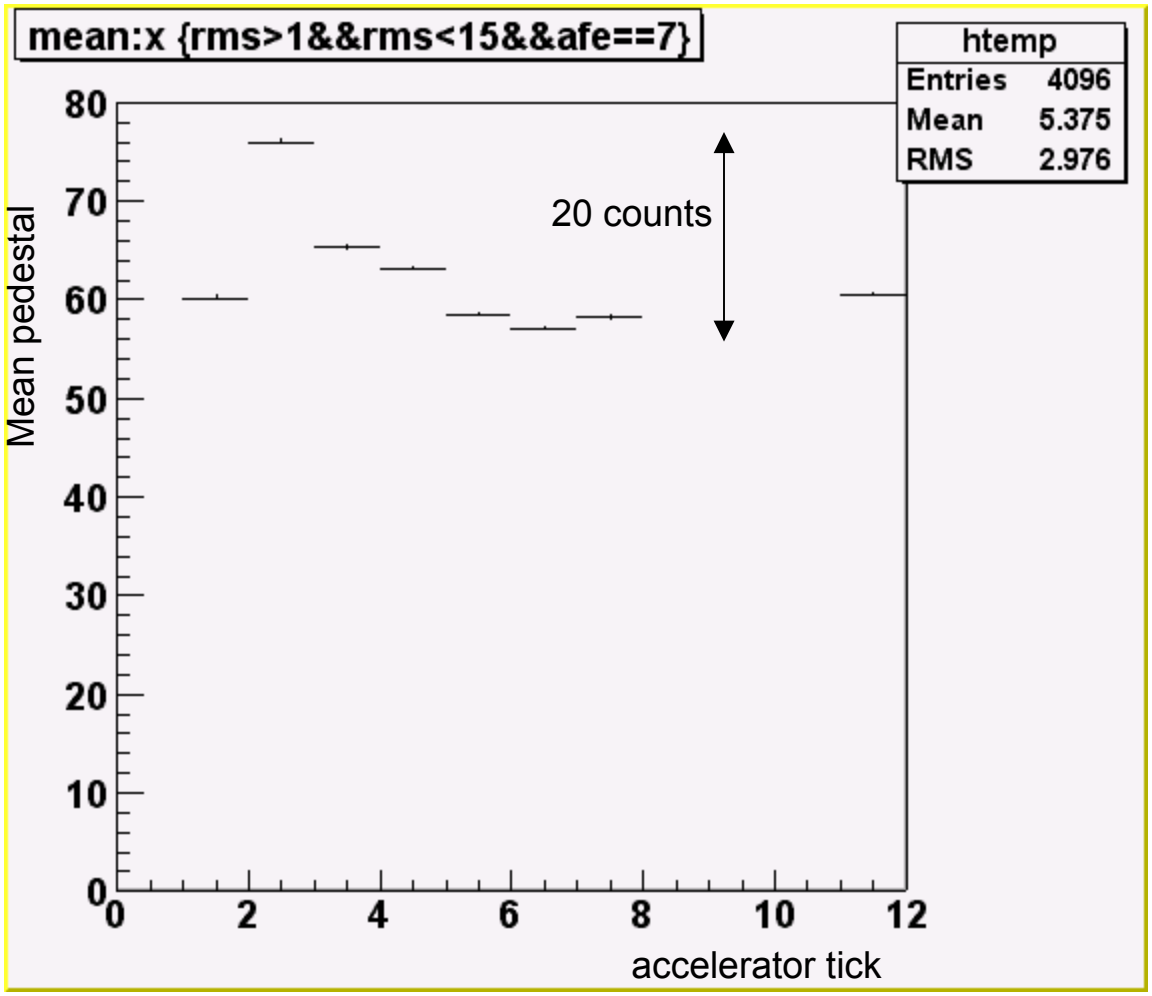
DZero Run IIb Rebaselining Mini-Review
November 5, 2003
Fermilab

AFE II

- Motivation to replace current analog front-end boards (AFE) for the CFT
  - Current operations
    - Problems with pedestal width and stability
      - Tick to Tick problems and problems within a tick
      - Can cause threshold setting increase of as much as 2 pe in order to keep noise rates under control
    - Threshold setting
      - Zero suppression (1 setting/64 ch – SVX) (Analog information)
      - Discriminator (14 or 18 channels per setting)
    - Maintenance
      - 200 boards
        - Although quite reliable – experience has shown D0 averaged one board replacement every 2 weeks
        - Ageing & SVXIIe (severe dependence on clock timing and shape)?
  - Data Size
    - SVX unused channel problem

SVX Pedestals vs. Accelerator Tick

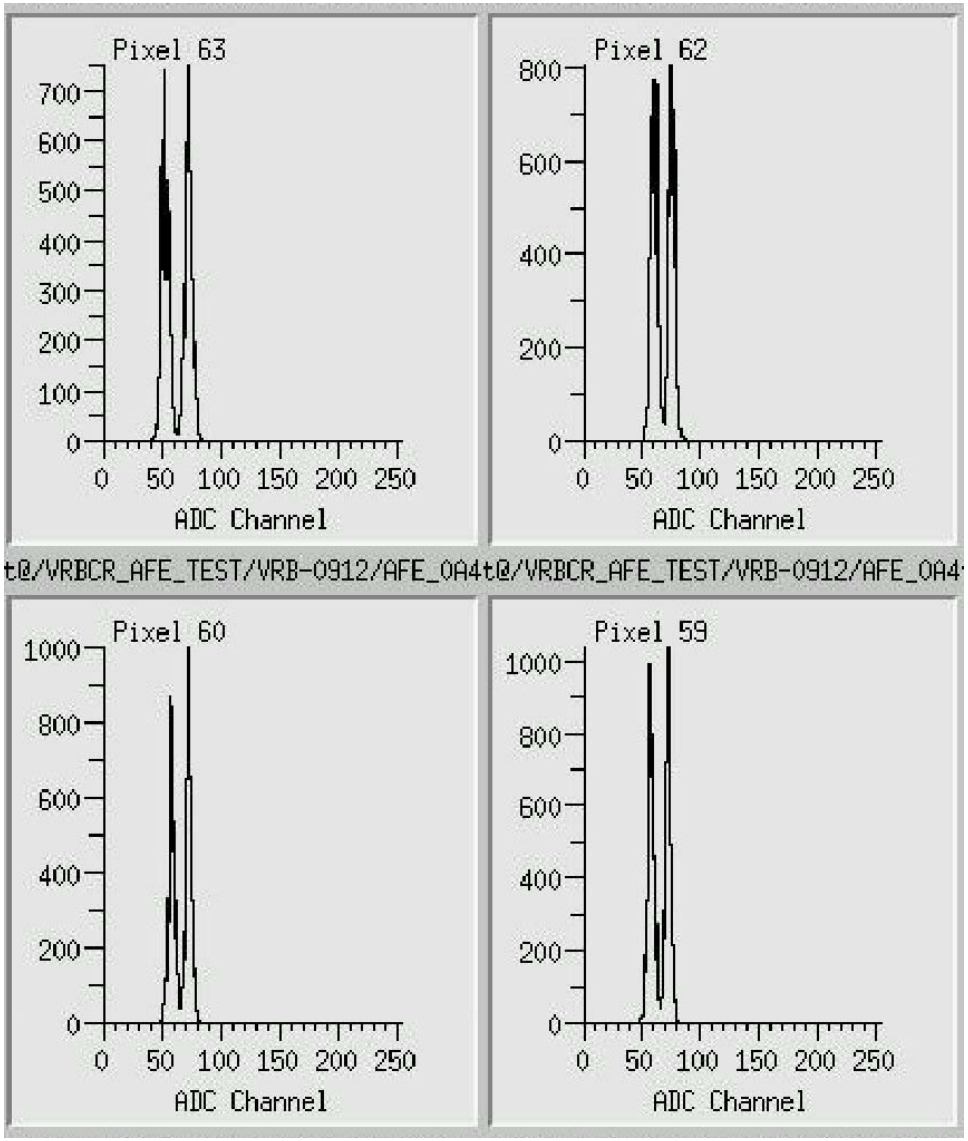
- Seen in all channels, effect is proportional to gain:



- Additional threshold cuts needed to suppress tick-dependent noise.

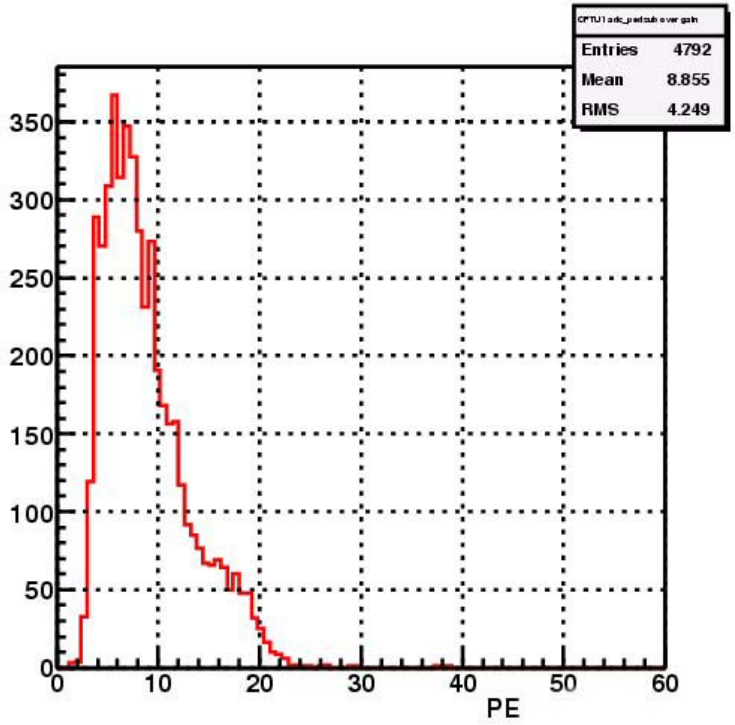
20 counts ≈ 1.5-2 pe

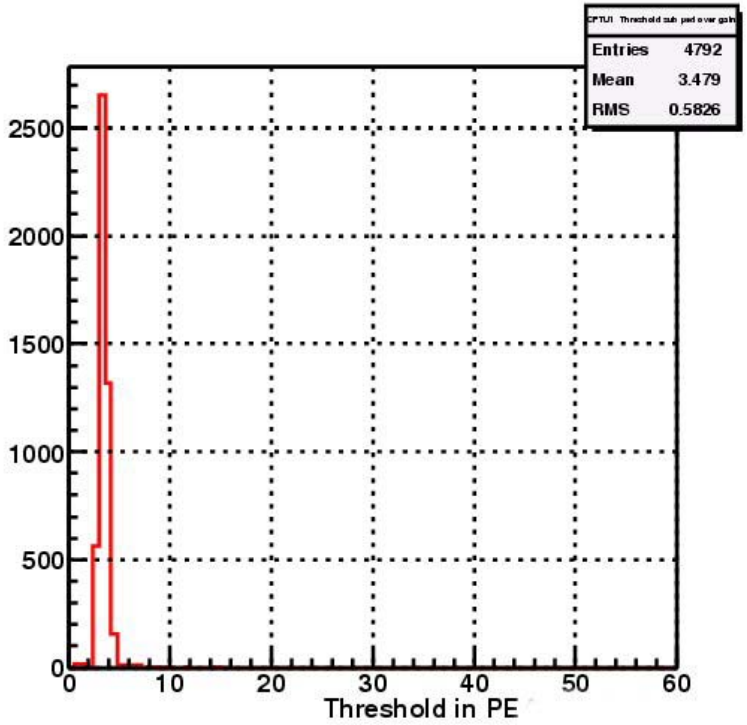
SVX "Split-Peds"



Pedestal splits/shifts as large as 40 counts have been observed.

Light Yield



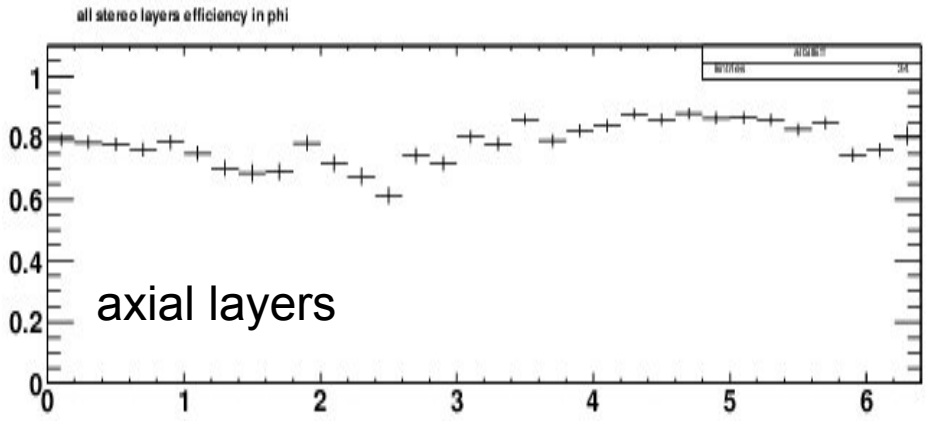


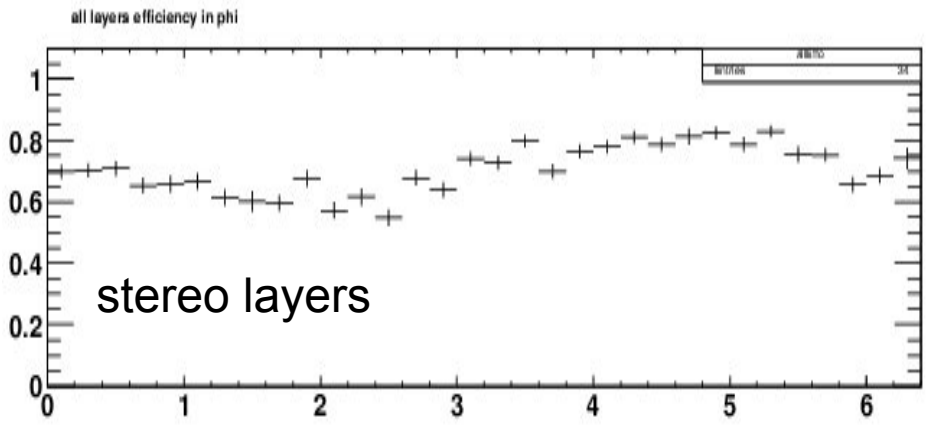
- In parts of the detector, thresholds as high as 3 pe are needed offline (for reco)
  - Effects cluster and thus tracking efficiency

Track Efficiency

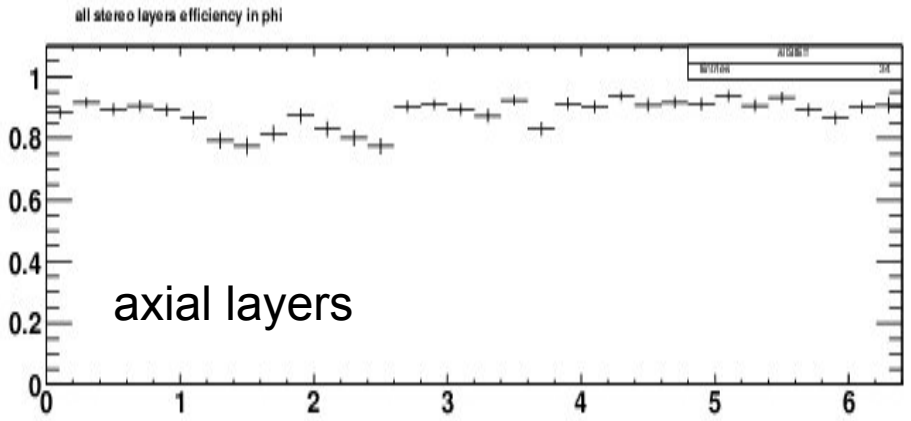
- **Track efficiency vs. ϕ with and without 20 ADC cut to suppress noise:**

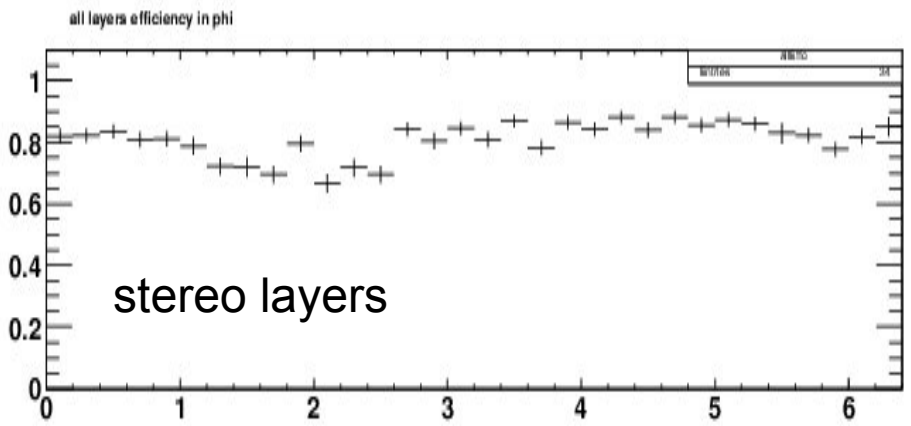
with cut:





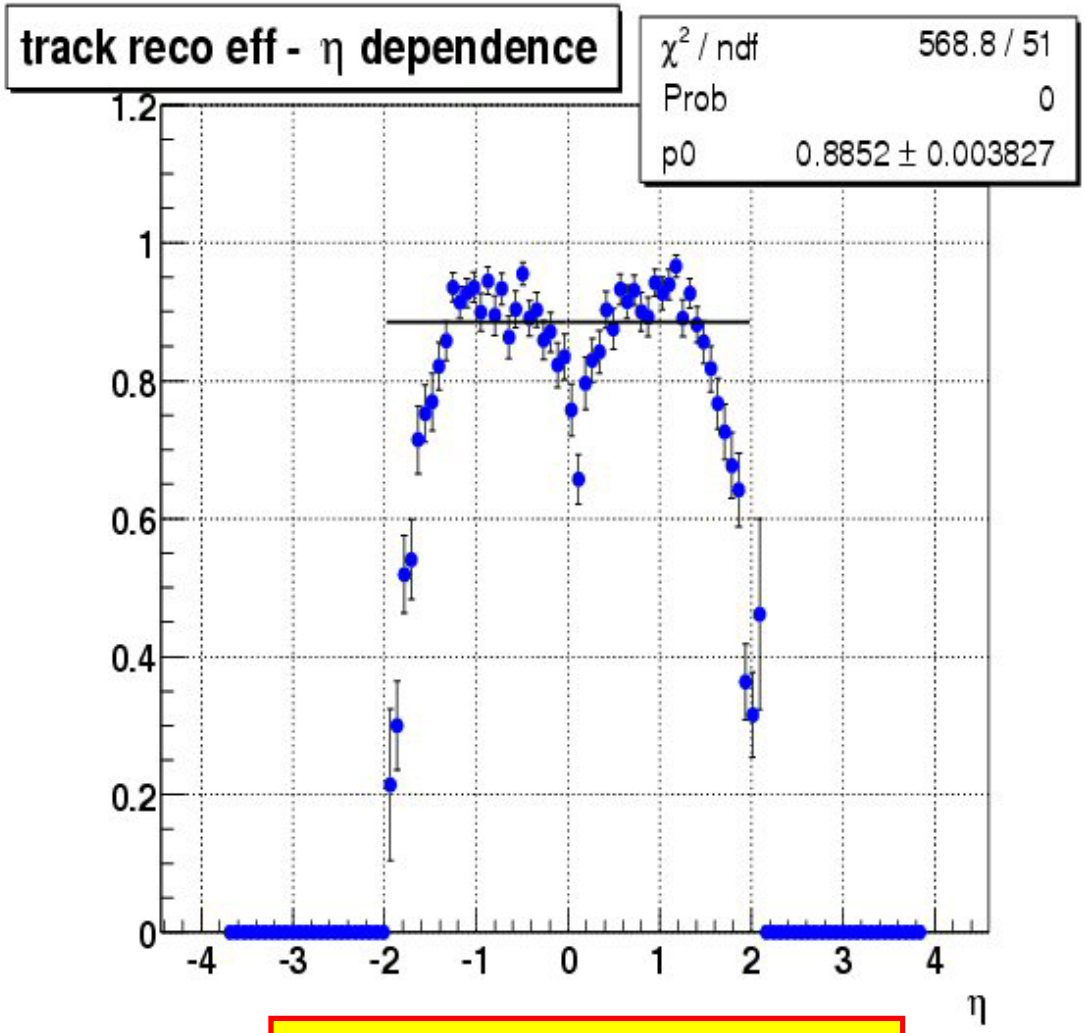
without cut:





Tracking Efficiency I

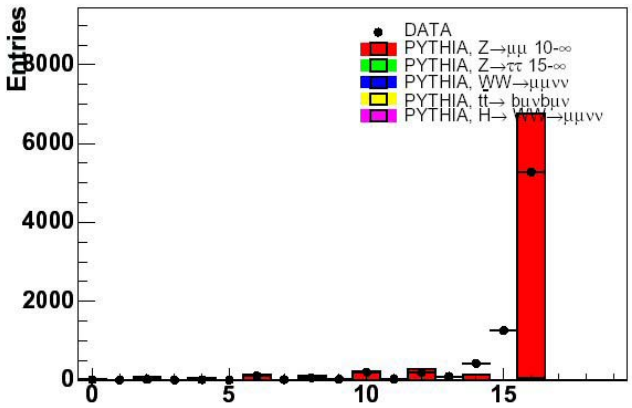
- Increased thresholds have obvious impact in tracking efficiency



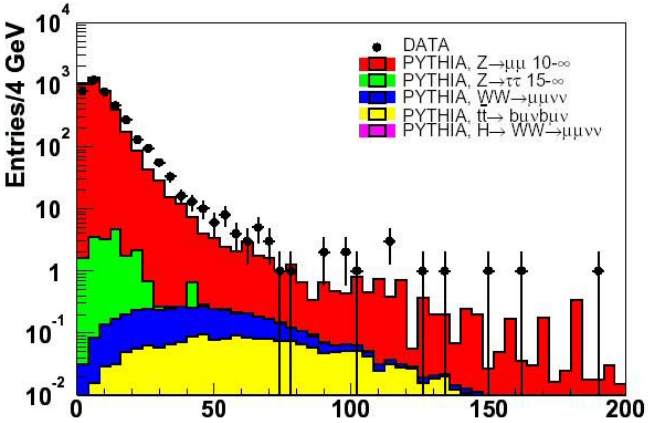
P13 – $Z \rightarrow \mu\mu$ data

Tracking Efficiency II

Track distributions (II)



Number of CFT hits of μ



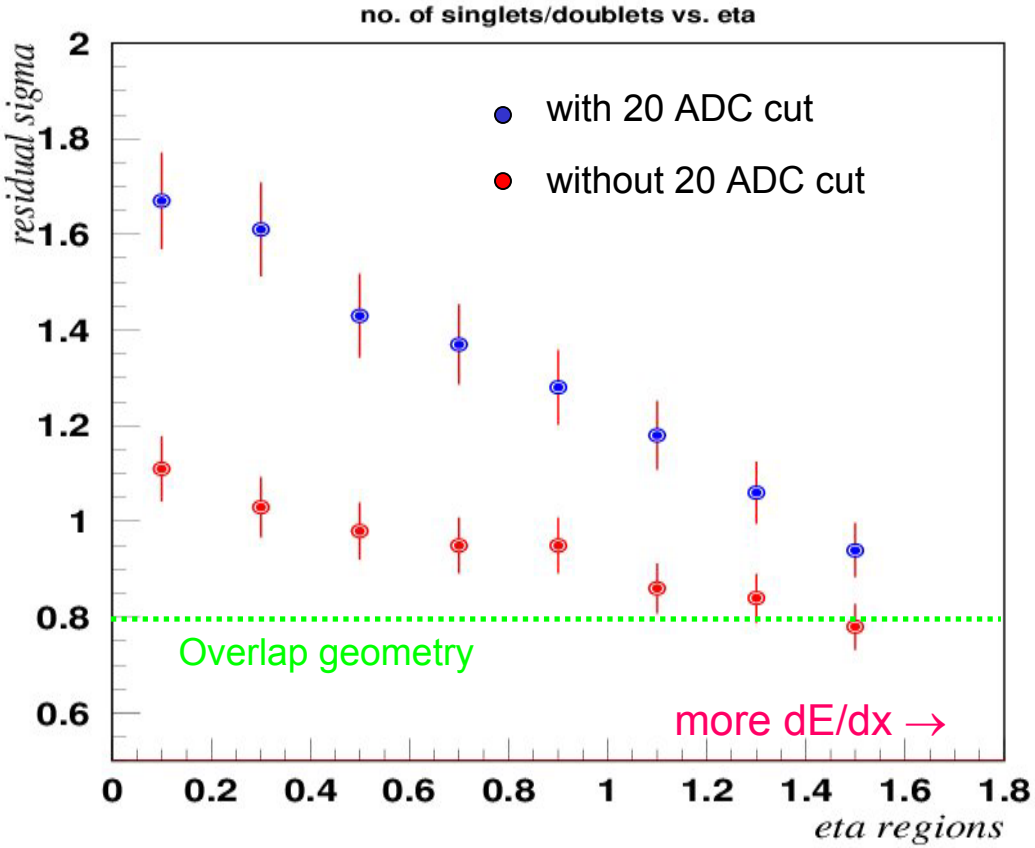
missing transv. Energy $\not\!\!E_T$
(without extra μ smearing)

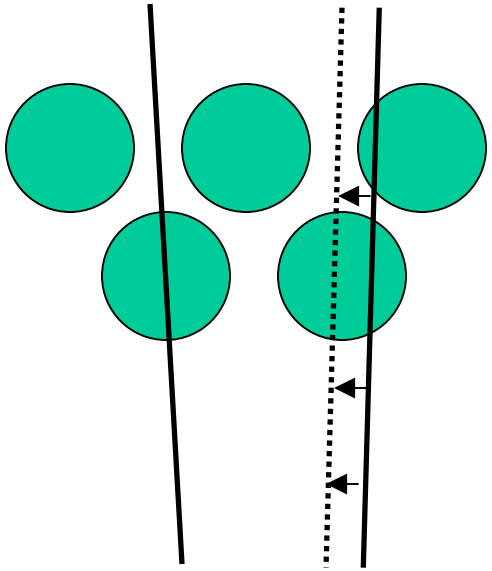
Dropped for now $N_{\text{hits}}^{\text{CFT}} \rightarrow$ increased eff.
Investigate effect on $\not\!\!E_T$

P14 – allows for more CFT misses – efficiency now > 95%

Single-hit resolution

- **Ratio of single-fiber clusters to double-fiber clusters on tracks:**





• loss of double-fiber clusters to threshold cuts shifts hit centroid
  - larger fit χ^2
  - worse p_T resolution

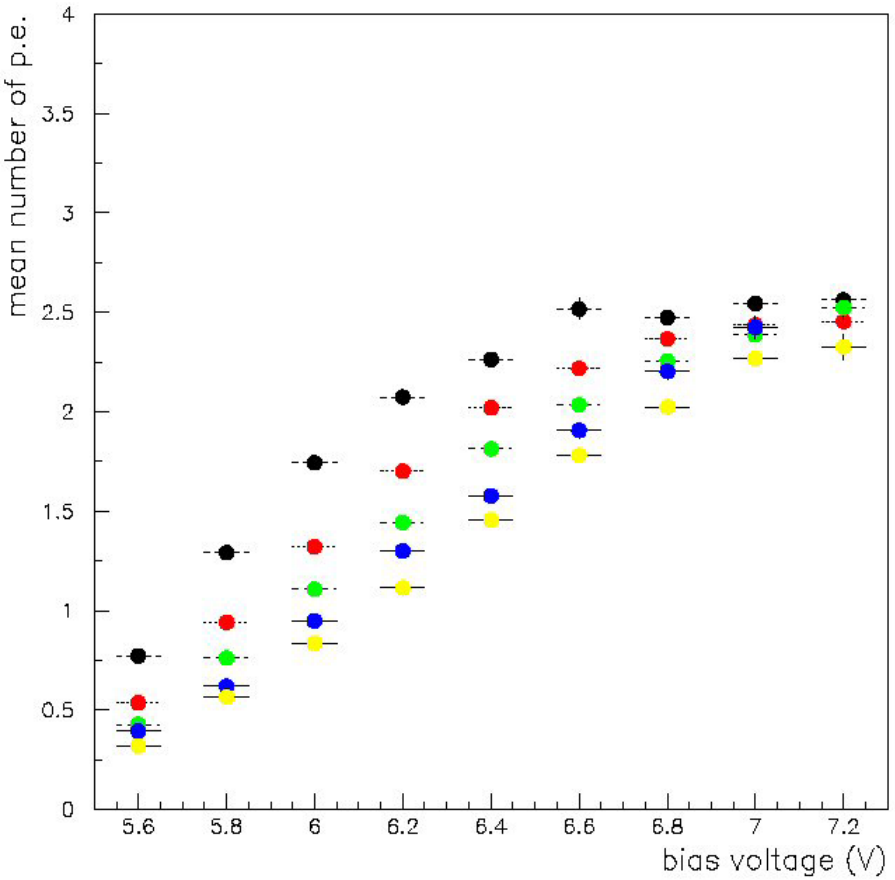
Fiber diameter: 800 μm

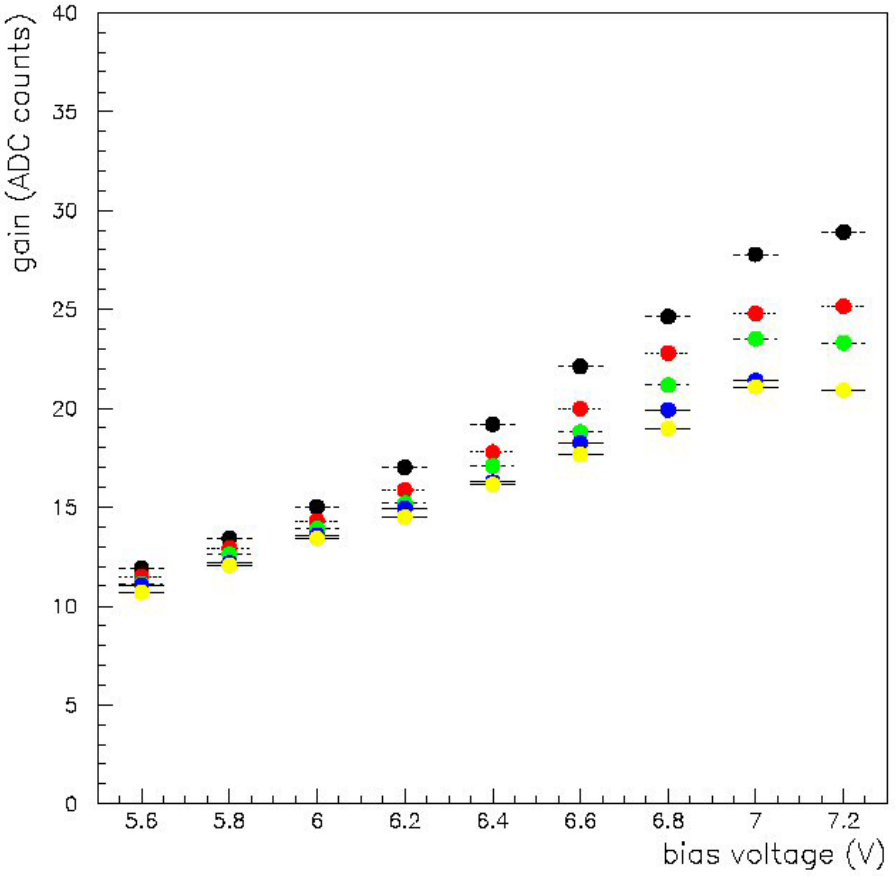
Single Hit resolution: ~90 μm

Luminosity Dependent Effects

- As luminosity goes up
  - VLPC QE and gain drop

0, 10, 20, 30, 40 % occupancy (expect close to 40% on inner layers at highest RunIIb L)



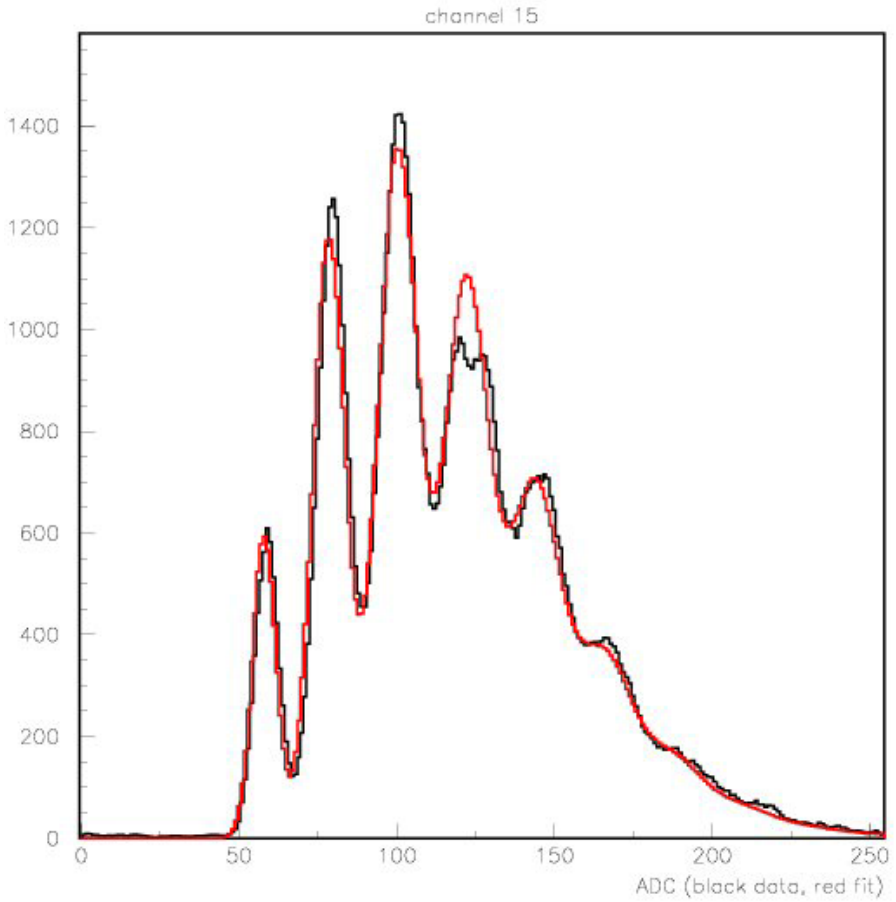


AFE II

- AFE II
  - Full New set of boards
  - No SIFT No SVX – Much simpler architecture
  - Will use instead
    - Trigger Pipeline Chip: TriP (or Trip*t more in a bit*)
      - Discriminators and analog pipeline
      - TriP chip submission was very successful – meets spec.
    - Commercial Flash ADCs + FPGA for analog information
    - Integrates completely with existing system
  - Expect
    - Improved Ped dispersion and stability
      - Lower and tighter threshold setting capability
        - Channel by Channel - analog
    - Improved reliability
    - Improved readout flexibility
      - Decreased deadtime
      - Multi-buffering possible
    - Added Functionality with new submission of TriP Chip - Trip*t*
      - z information from timing (≈ 2 ns rms)

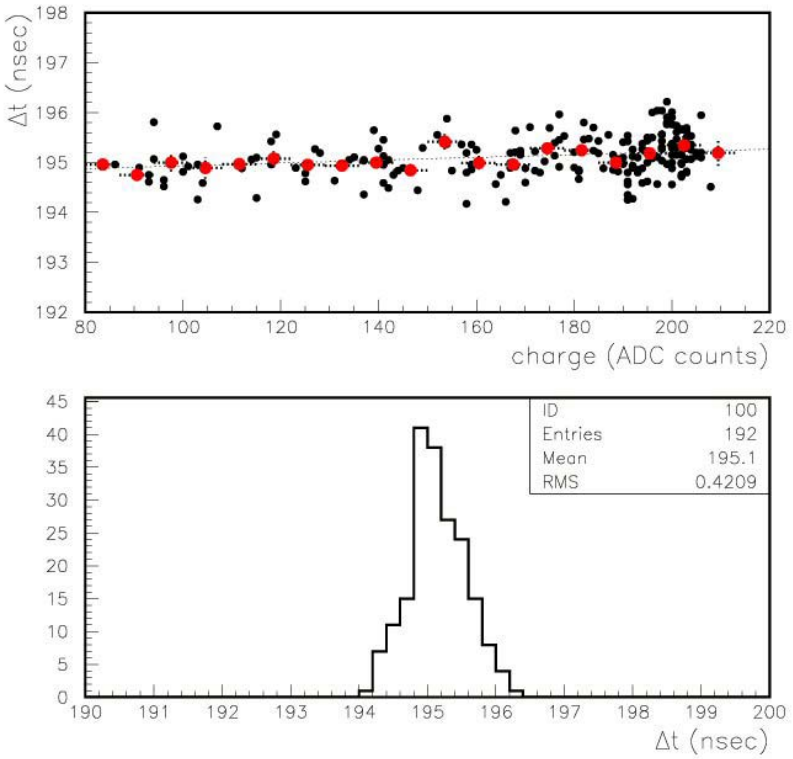
AFE II

- Preliminary measurements on TriP very promising
  - Noise at 1/5 pe rms
  - Threshold setting at 1.5 pe reliably
- Plot at right was obtained after 1 day of work on a TriP modified AFE board
  - To get this good, a plot with the AFE took about 1 month of dedicated work by the same people!



AFE II - TriP*t*

- With a rather simple modification to the TriP design – time stamp for hits can be obtained
- Current TriP
  - Electronics resolution was determined to be ≈ 400 ps
  - For 8 pe signal expect about 2 ns sigma
    - Z measurement – ≈ 30 cm
- Has impact on reco time and cluster splitting
  - In $Z \rightarrow \mu\mu$ +15 min bias MC
    - 40% reduction in reco time
  - Improvement in clustering algorithm utilizing z info also a possibility



400 ps intrinsic resolution

AFE II – Cost and Schedule

- **Cost M&S:**
  - Production cost M&S are based on quotes for parts and labor – contingency estimate is grounds up:

Cost Element	Qty Reqd	Unit cost	Net cost
Bare AFE Boards	250	$400	$100,000
Parts Costs	250	$800	$200,000
Assembly Charges	250	$600	$150,000
packaging TRIP chips	5,000	$5	$25,000
Flash ADCs	5,000	$8	$40,000
Xilinx Spartan II	2,500	$20	$50,000
P/S parts (regulators)	2,500	$20	$50,000
CPLD cost adjustment	4,000	-$10	-$40,000
fifo cost adjustment	2,000	-$10	-$20,000
analog support adjustment	4,000	-$10	-$40,000
Develop TRIP test fixture	3	$6,000	$18,000
New Vicor Modules	17	$300	$5,100
BASE COST ESTIMATE			$538,100
Chip submission			$100,000
NET COST ESTIMATE			**$638,100**

Note: Parts costs come from AFE I calculation. AFE II does not use some parts, thus the cost adjustments (negative $)

AFE II - Cost and Schedule

- **Manpower**
  - Manpower estimates are based on experience with AFE I and the assumption that the boards will be fully loaded by an outside vendor and tested (DC + basic functionality).
    - FTE technicians (electrical): 1.0 FTE (FY04) + 2.0 FTE (FY05)
    - FTG engineer (electrical): 0.5 FTE (FY04) + 1.0 FTE (FY05)
  - It is assumed that physicists manning shifts will perform high-level testing at DAB test stand and will commission the electronics.
  - Fully loaded project cost then becomes – 2.2M$
- **Schedule:**
  - Our current estimate is 18-24 months depending on second submission of Trip – (Trip*t*)
    - July-August 05 Installation and commissioning
  - We hope to have full AFE II prototypes (using current TriP) ready for test by end of the calendar year
  - We would like to start design mods for Trip*t* in December so that we could be ready for a March submission

AFE II – Other User

- As of November 3, the Muon Ionization Cooling Experiment (MICE) has received scientific approval from Rutherford Lab
- The collaboration has chosen to build two fiber trackers for the two spectrometers in the experiment
- MICE plans to build D0 type VLPC cassettes and will need AFE II
  - Prefers a version with timing
  - Exploring possibilities for early funding to help with development

Conclusions – AFE I status

- Although current D0 CFT tracking is working well
  - Required modification to tracking algorithm
- In order to achieve low (<1%) noise, thresholds set higher than optimal
  - Introduces hit inefficiency
- Current boards still require significant maintenance in order to keep them operating at their best
  - Spare parts may become an issue
- As luminosity (occupancy) increases tracking efficiency issues will become more acute
- Data volume, front-end-busy rate will also increase and the CFT readout may become limit at L1
  - Over taking Silicon system

Conclusions – Improvements with AFE II

- AFE II will
  - Improve noise floor and pedestal stability which will allow for consistent and reliable threshold setting at the level of 1.5 pe
    - Better hit efficiency and point resolution
  - Board construction is simpler, more robust
    - No MultiChip modules (MCM)
    - Mostly commercial parts/standard mounting techniques
    - Repairs/rework MUCH easier than in AFEI
  - Elimination of SIFT, SVXIIe, and MCM in readout should greatly reduce board maintenance load
  - Readout architecture much more flexible
    - Less deadtime
    - With additional memory, buffers can be added to greatly increase L1 capability
  - Added functionality of the Trip*t* (z information)
    - Large reduction in reco time
    - Possible improvement in cluster finding
      - Cluster splitting leading to additional improvement in track quality
- AFEII will improve our capability to maintain high-quality and stable operation as the Tevatron Luminosity increases in RunII. This will allow D0 to maintain excellent tracking performance