Analysis of Endcap Muon Anode Front End data from US CMS test beam at CERN

(CMS Endcap Muon Anode Front End Electronics Project at CMU)

US CMS EMU meeting
Fermilab, Batavia, Il 60510
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- **Introduction**
- **Efficiency vs HV and Thresholds**
- **Time distributions**
- **Bunch Crossing Efficiency in Theta Scan Data at H2**
- **Recovery Time**
- **Conclusion**

New US CMS EMU Anode Front End Electronics Web page at CMU (www-hep.phys.cmu.edu/cms)

- **Chip and Card Description and Status (98,99)**
- **Cosmic Muon Test Stand (FNAL 98)**
  - results of data analysis
- **CERN 98 Test Beam**
  - results of data analysis
- **More (see Web page)**

Introduction

- **The features of Cathode Strip Chambers (CSC) front-end anode electronics:**
  - high efficiency bunch crossing identification (92% per station) within 25 nsec bunch crossing interval
  - muon trigger primitives for the Level 1 trigger
  - coarse measurement of muon hit radial position

- **Use of a coincidence** $>= 4$ **planes ON from 6 planes in each CSC station:**
  - reduces the large spread of CSC drift times (with a maximum of 50-70 nsec) to a level of < 25 nsec
  - the 2-nd arriving hit in time gives the best time mark of the bunch crossing and decreases an accidental overlap with random background hits

- **The main analysis goals:**
  - time resolution of signal from single plane anode, the 1-st, 2-nd, etc. anode signals from the 6 planes
  - the corresp. efficiencies in the gates of 20, 25 nsec
  - their dependence on HV, thresholds, angle of incident track and background rate

- **The data were taken:**
  - on the cosmic muon stand at Fermilab - May 1998 (analyzed in June)
  - on the CMS test beam at CERN - June thru August 1998 (first results in July - August)

- **Data were taken in two beam locations:**
  - H2 beam (calibration, HV, θ and ϕ scans)
  - Gamma Irradiation Facility (GIF) beam (HV, thresholds scans; anode and cathode trigger electronics tests, measurements with GIF 15 Ci Cs^{137} γ-source to simulate high intensity random background)
  - the beam is mostly 20-150 GeV μ

- **Beam PWC were used to predict the hit coordinate in P2 CSC**
  - only 3-4 channels/plane illuminated (Fig.1)
  - not good prediction from the beam PWC at GIF, easy to underestimate anode front end efficiency (Fig.2)
  - if taken care of (neighbour channels must be OFF) then reasonable tracking (Fig.3)

- **HV and threshold scan (GIF source OFF):**
  - additional grounding for ASD16 chips was made (allowed 1.5 times lower thresholds, oscillation free)
  - high efficiency ($> 95\%$) at HV which is 50 V above the nominal - good result for the first full scale prototype (Fig.4)
  - further improvements ($\sim$ 2-3 times lower thresholds) were in order and were done in the new submission (Nov. 18, 1998)

- **Anode Thresholds vs Cathode Pulse Amplitude**
  - select cathode hits regardless anode info (Fig.5, top, cathode ADC distributions, peaks at small ADC are noise)
  - select cathode hits when anode channels ON (Fig.5, bottom, cathode ADC distributions)
  - differential anode efficiency is bottom/top (Fig.6)
  - a way to control anode efficiency in fC if anode/cathode charge ratio is known (about 1.3)
  - a way to check correspondence of anode thresholds to cathode ADC dynamic range

- **Bunch tagging efficiency**
  - wide time distributions from ind. planes (Fig.7)
  - fit by two halves of gaussians with one and the same center and different σ (Fig.7-8) to see dependence on channel #, HV, pulse # etc
  - centers are different for some channel groups due to different cable lengths
  - small slewing time (see time means vs cathode ADC, Fig.9)
  - time distributions for the 1-st,2-nd etc arrivals are narrow (Fig.10-11), min. RMS for the 3-rd pulse (at incident angle of 25°)
  - HV scan at minimum threshold and software gate of 25 and 20 nsec (Fig.12)
  - tagging on the 2-nd hit in >= 4 hits from 6 has efficiency above 92% (baseline) at nominal HV=3.85 kV for the 25 and 20 nsec gates (Fig.12).

- **Bunch tagging efficiency vs incident angle**
  - efficiency is $> 95\%$ except region around $\theta = 15^\circ$ due to the largest RMS (Fig.13)
  - planes also show specific time distributions vs incident angle (Fig.14)

The Recovery Time of the Anode Front-end

- using the high background (photon) rate of the GIF (Fig.15, top)
- how close in time the muon can come to the background and still get a new output pulse
- measure the time difference between two pulses in one channel (Fig.15, bottom)
- the width of the pulse (110-115 nsec) is subtracted
- recovery time is between 0 and 50 nsec (left edge of the time difference distribution)
- double contribution for $0 < t < 250$ nsec since photon can come before or after muon

- **Conclusions**
  - the first full-size prototype anode front-end cards provide 92% efficiency for bunch crossing identification within 25 nsec gate
  - analysis of the CERN 98 data almost completed (15° anomaly to be understood - use of Si in analysis)
  - Bryan's puzzle, JTAG vs chip location correlation solved (chip feature, diff. thresholds at one and the same JTAG)
- **Plans**
  - analyse data from ASIC test stand (new chips are coming)
  - data taking and analysis of data from Fermilab Cosmic Muon Test Stand (full scale,all 4 cards on P2' chamber)
  - preparation for the CERN test beam 99 (new DAQ, new chips and cards, what and how to measure, lessons from the test beam 98)

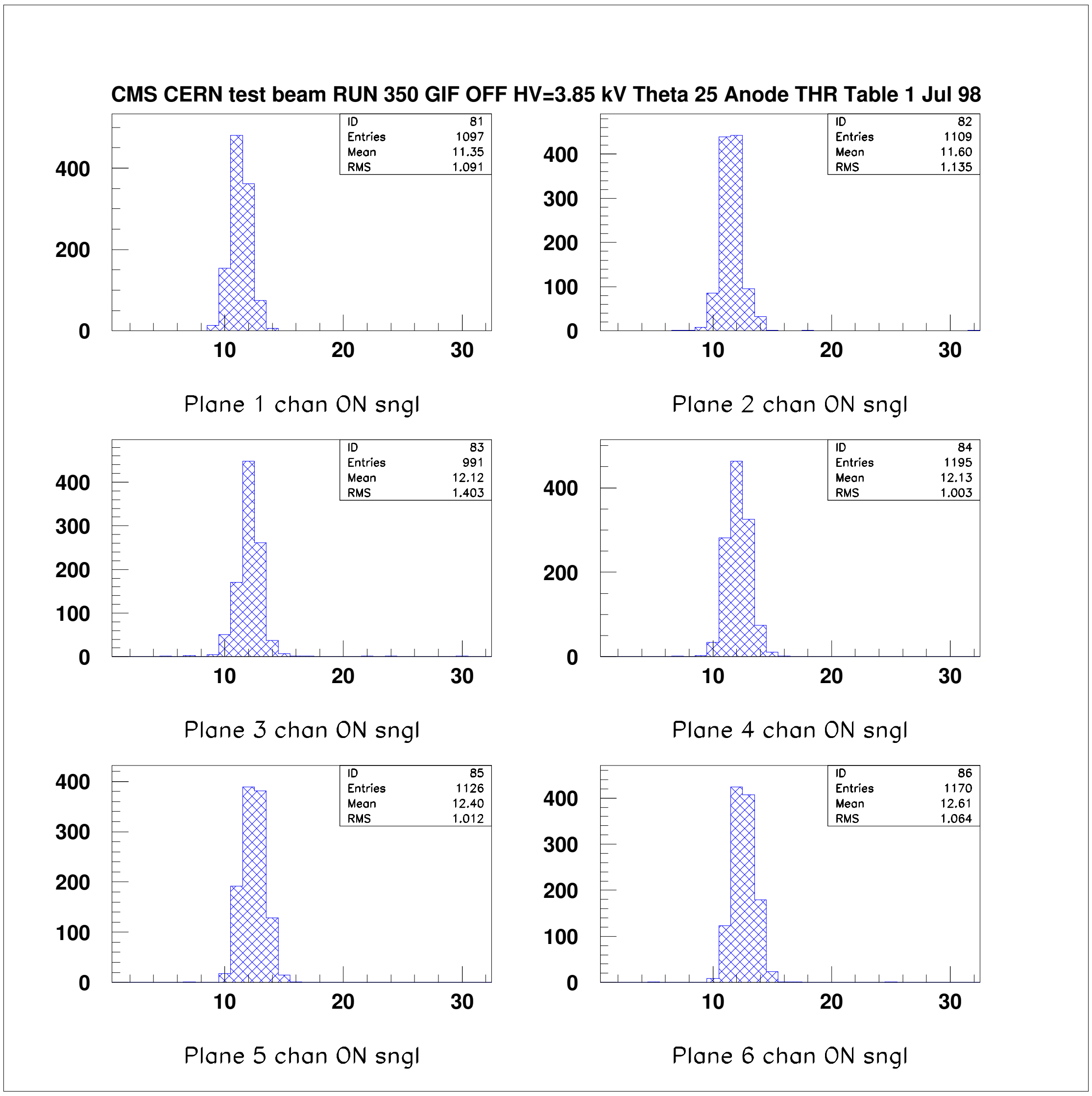

Figure 1: Beam profile in anode channels (GIF OFF)

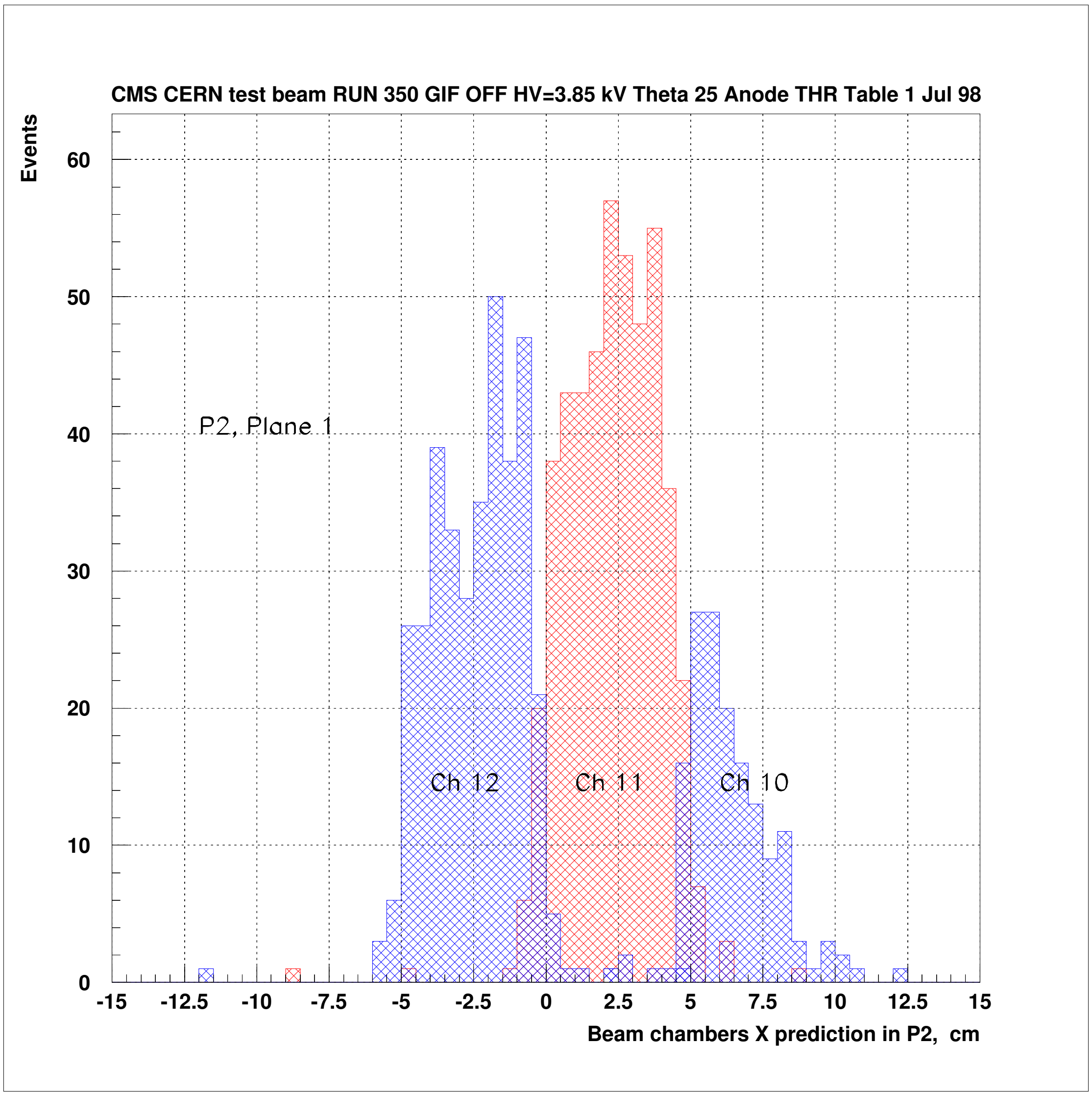

Figure 2: Beam PWC prediction (X) in P2 chamber and channels ON

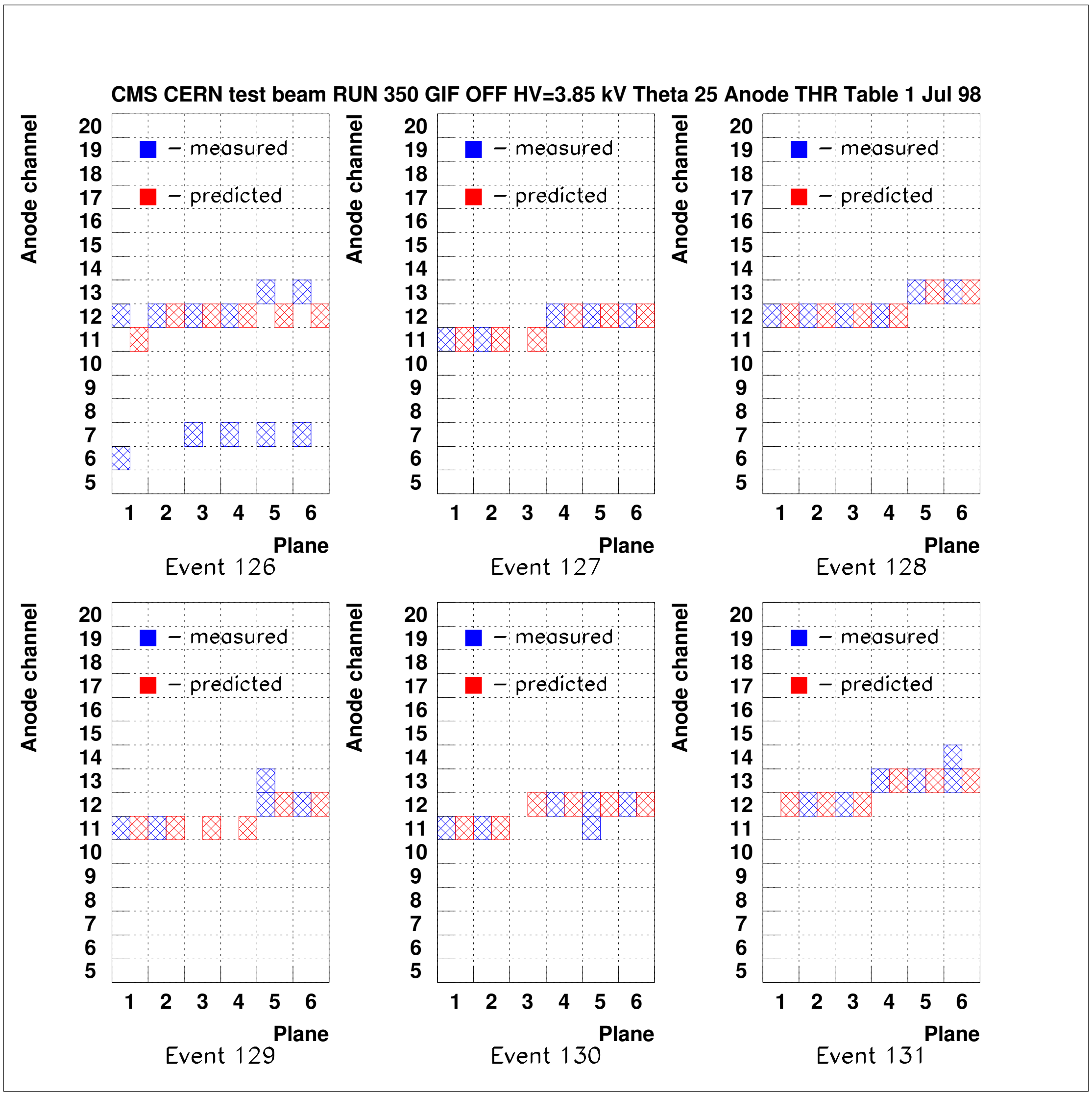

Figure 3: Event display for predicted and measured hits

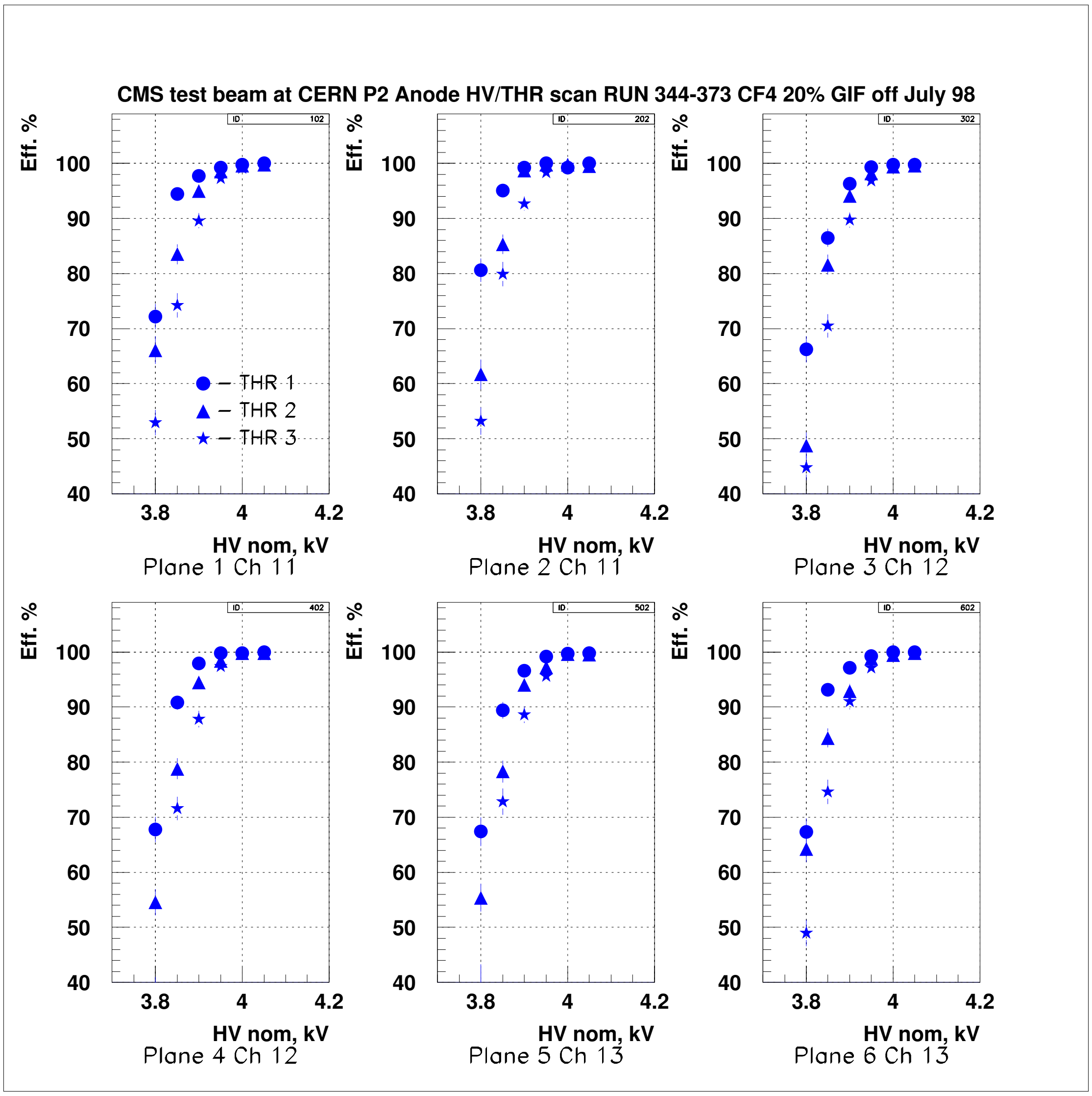

Figure 4: Anode efficiency at different thresholds (THR1-minimum) vs HV

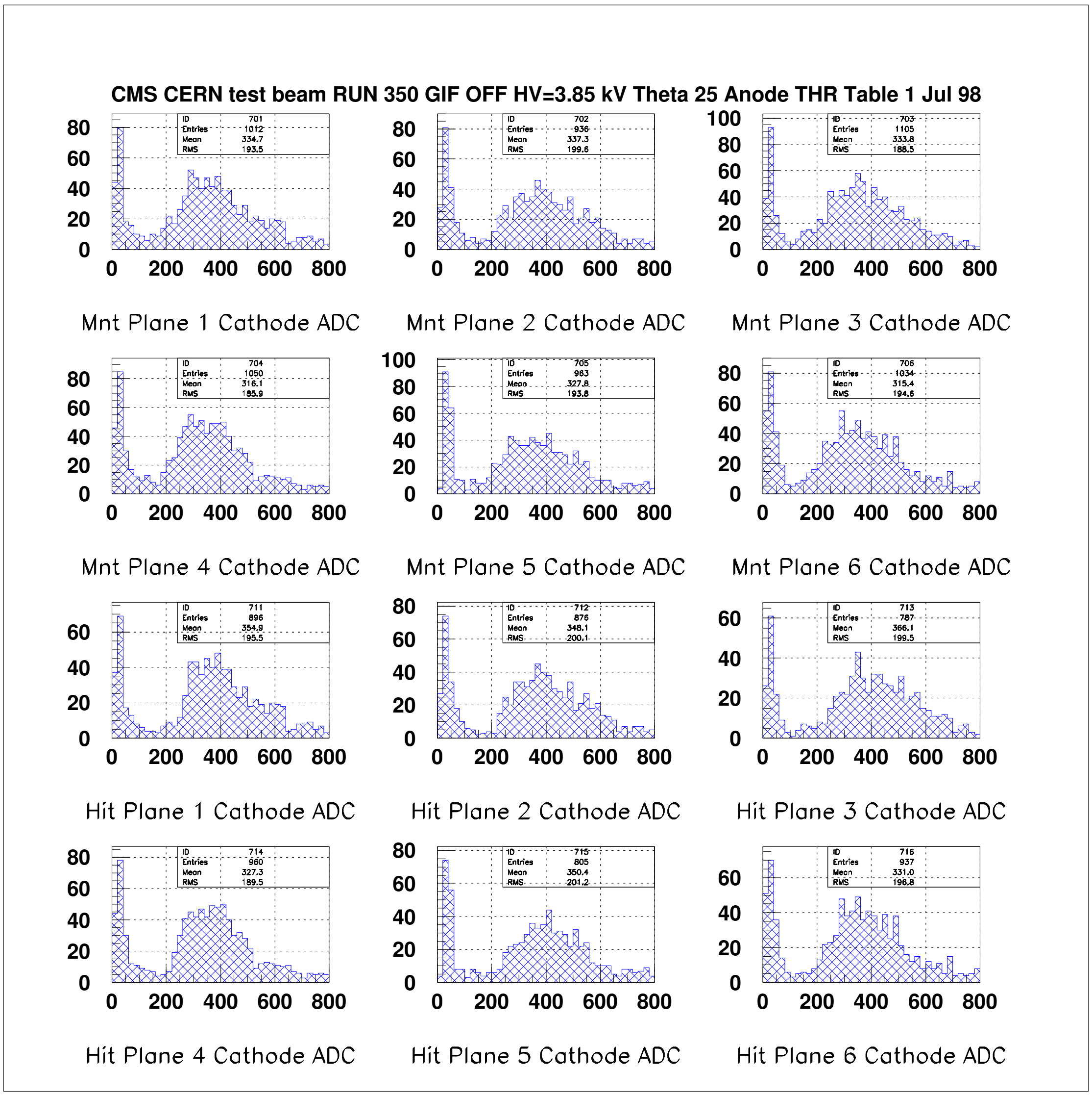

Figure 5: Cathode ADC distributions, regardless (6 top) and in coincidence (6 bottom) with anode hits

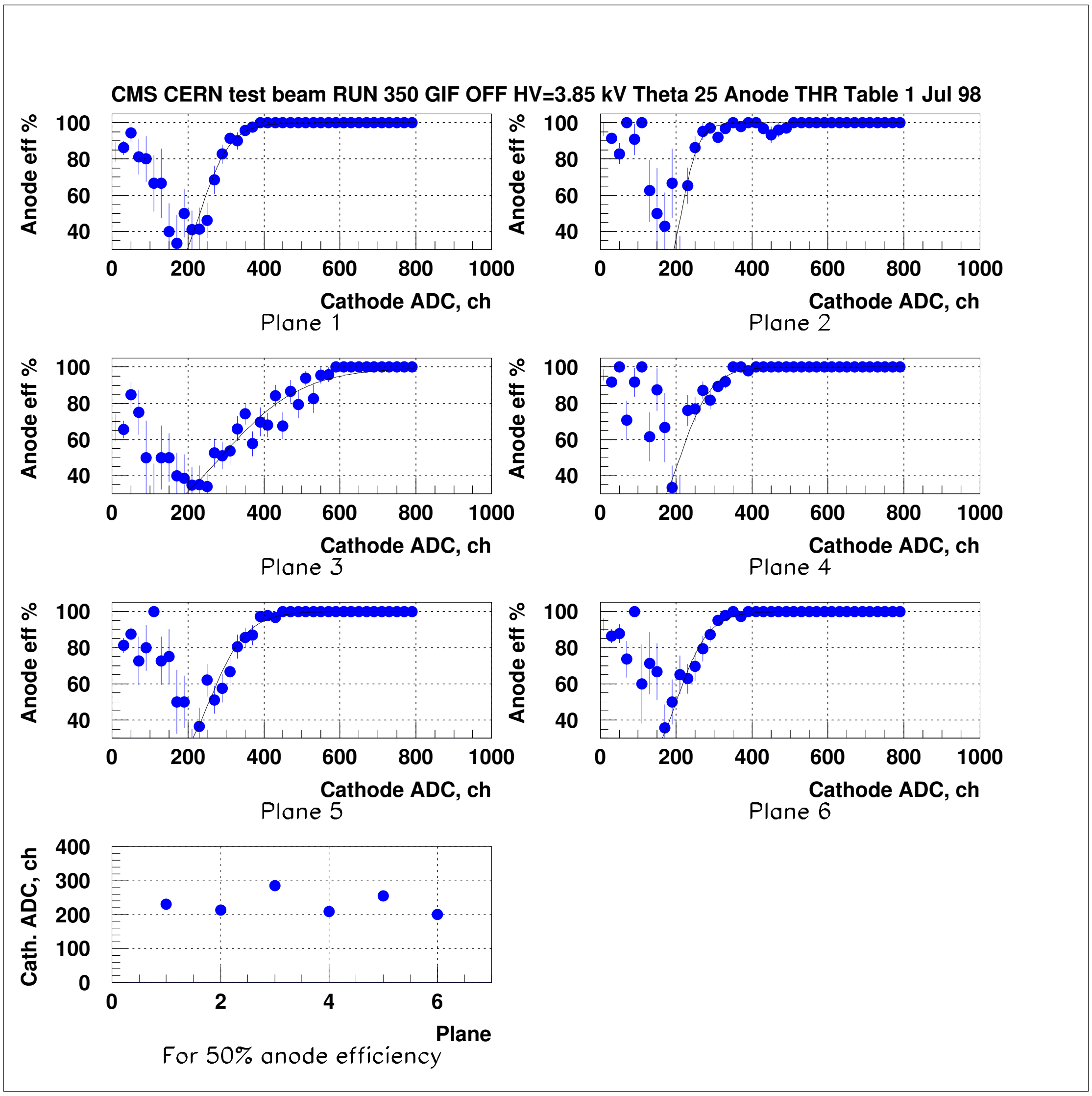

Figure 6: Differential anode efficiency vs cathode ADC

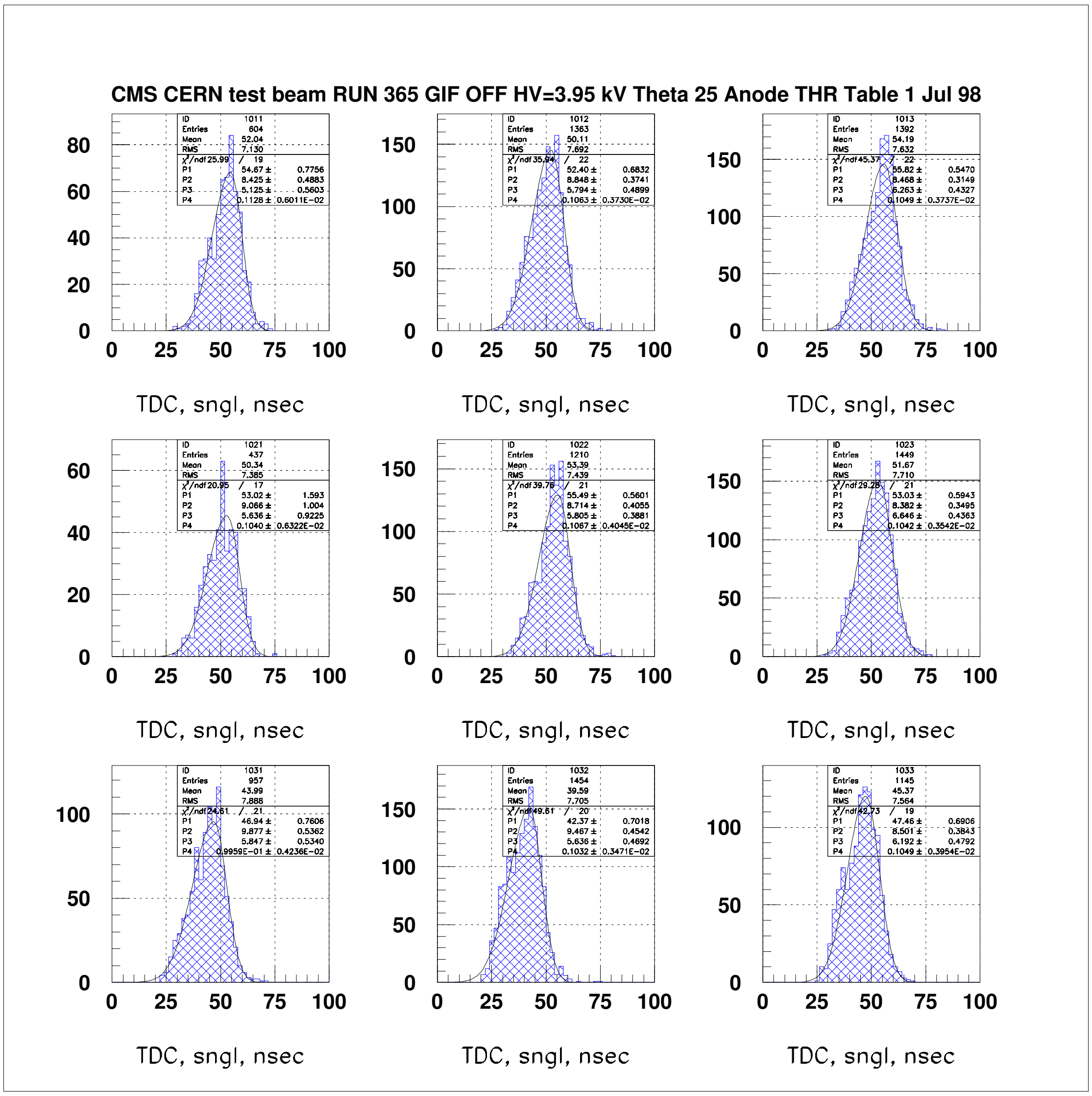

Figure 7: Time distributions from the P2 planes, shown are 3 channels from planes 1-3

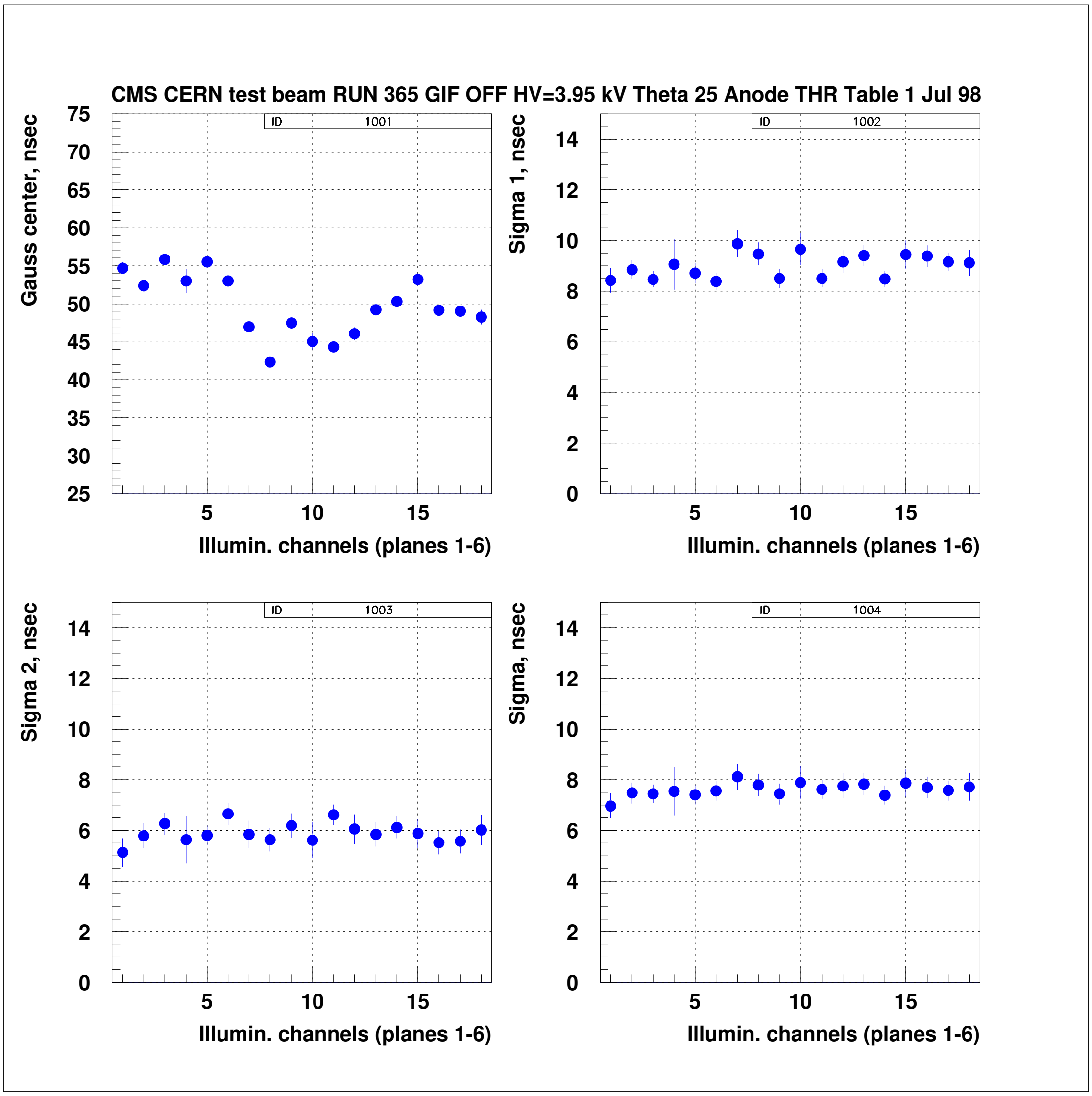

Figure 8: Fit parameters for individual anode channels, 3 ch/plane

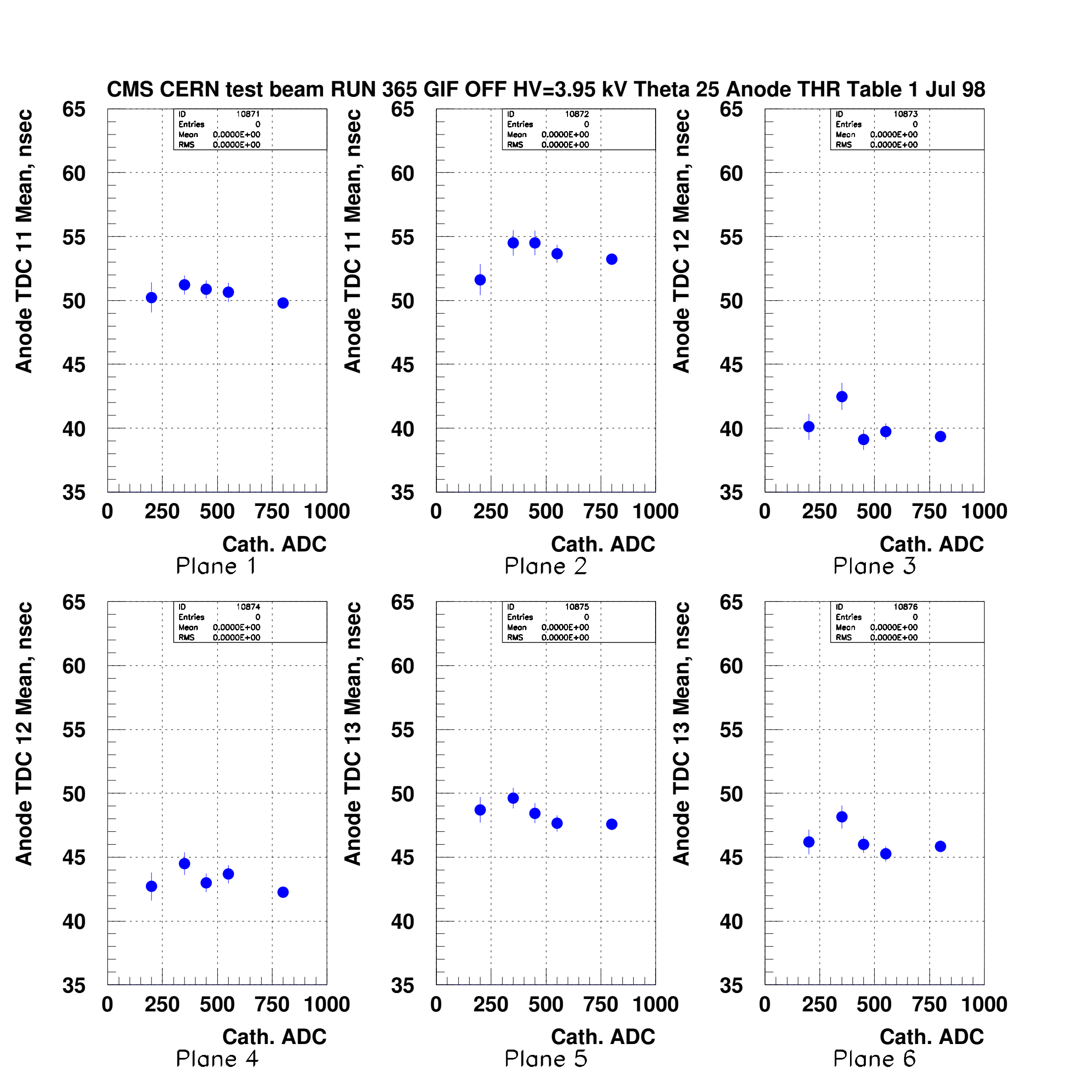

Figure 9: Slewing time - anode time dependence vs cathode ADC

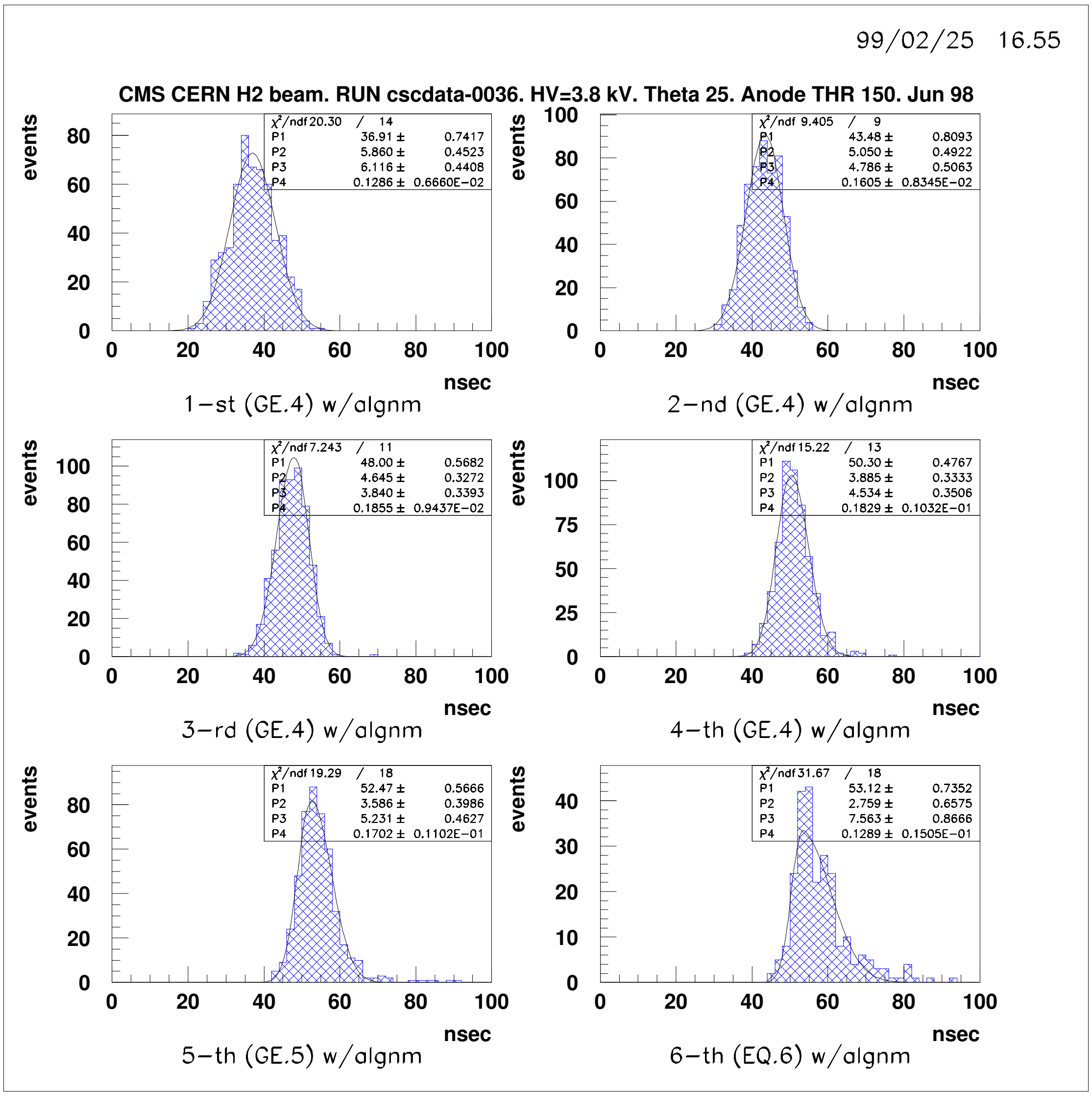

Figure 10: Anode time distributions for the 1-st, 2-nd etc arriving pulses

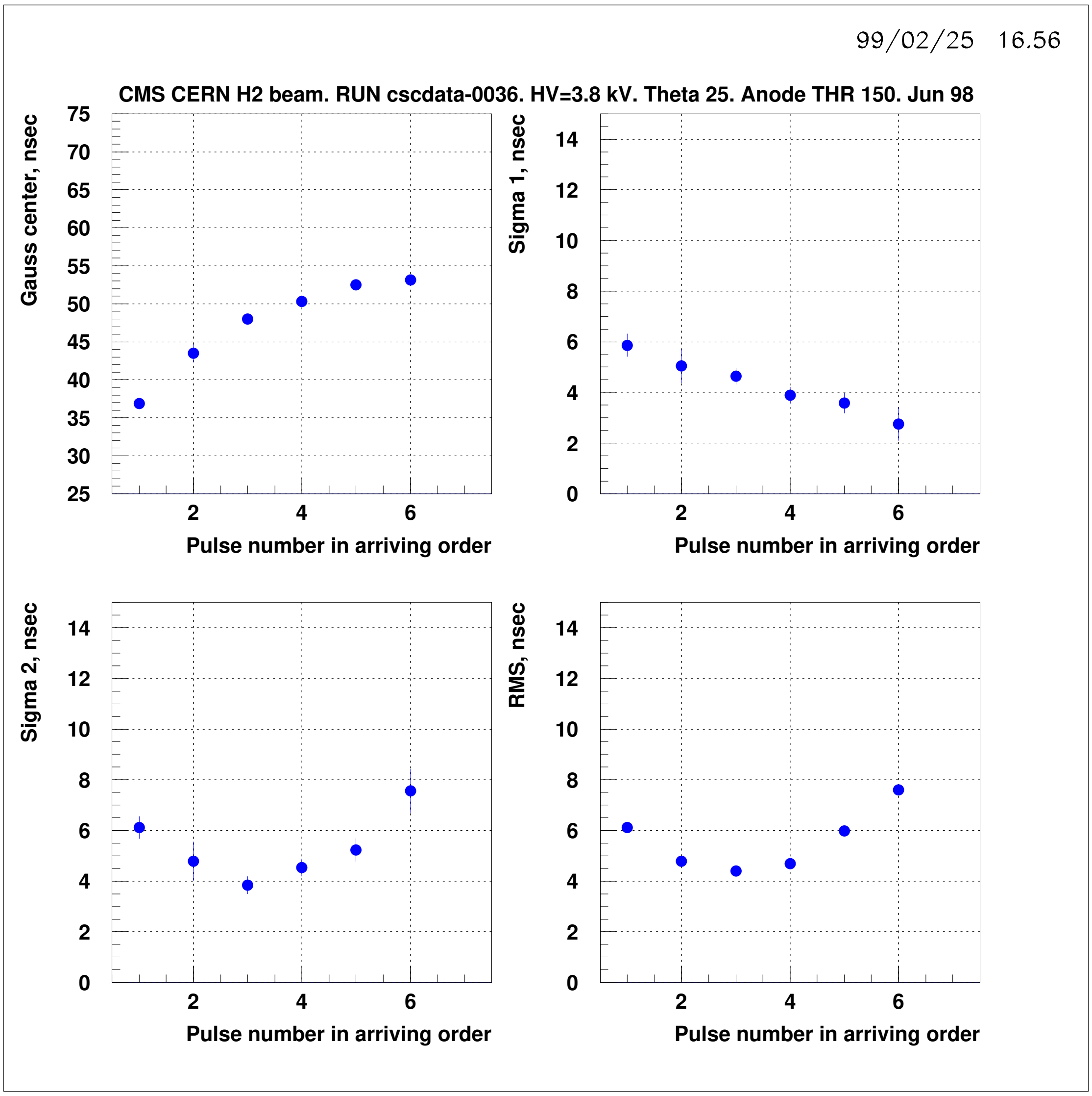

Figure 11: Fit parameters for the 1-st, 2-nd etc arriving pulses

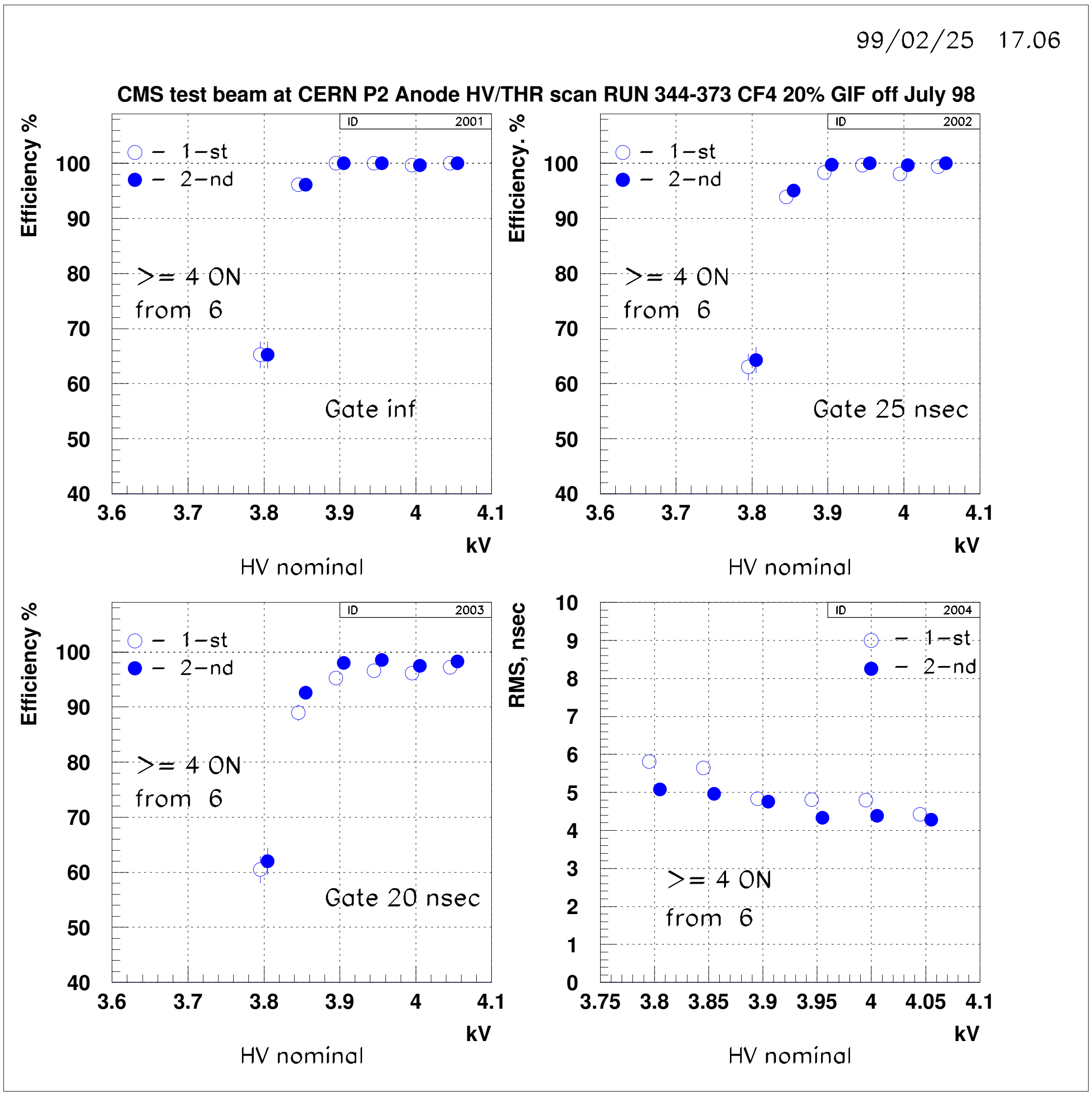

Figure 12: Bunch crossing identification efficiency with the help of the 1-st and the 2-nd arriving anode signals vs HV at different time intervals

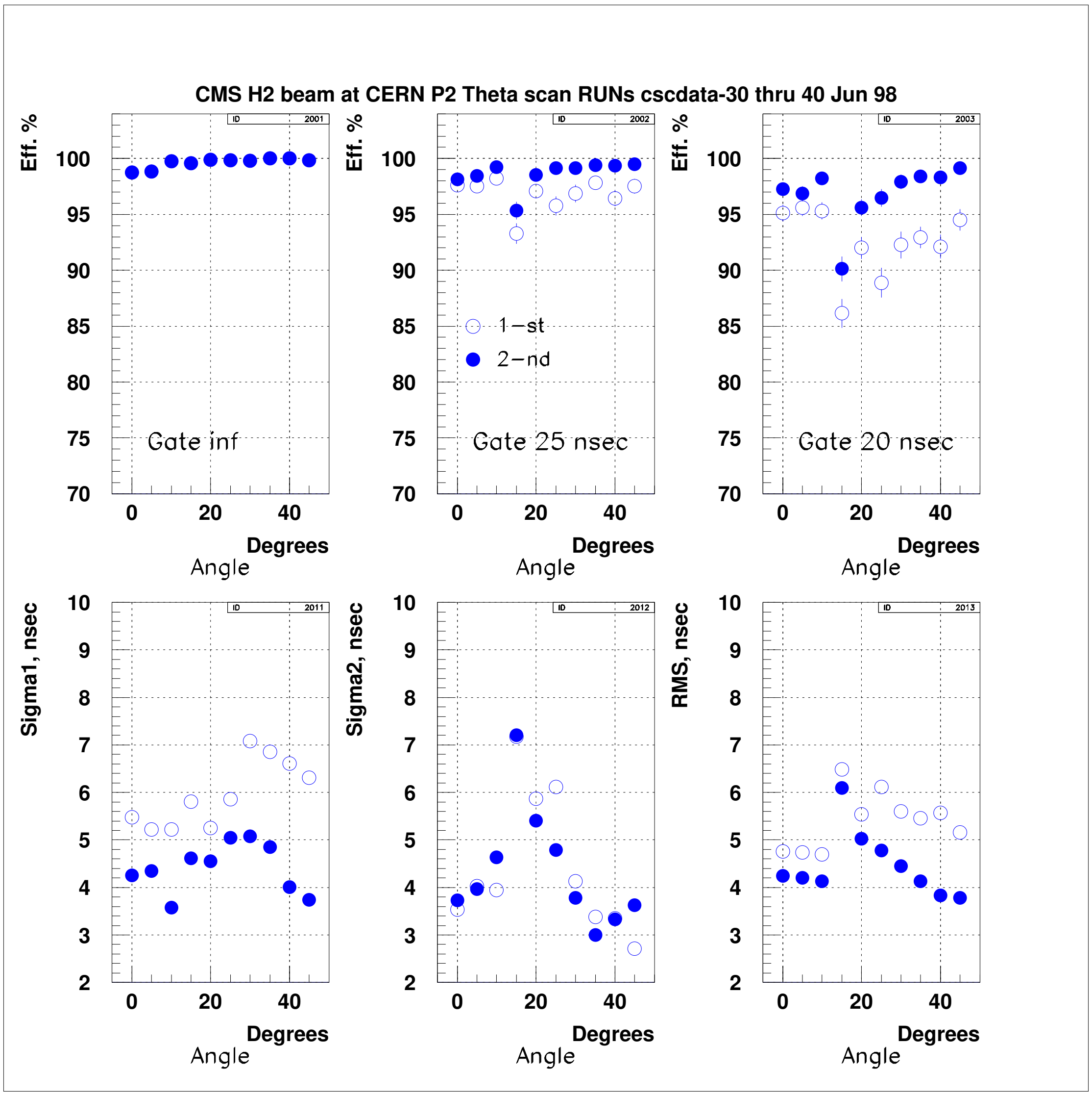

Figure 13: Bunch crossing identification efficiency for the incident tracks with different angles

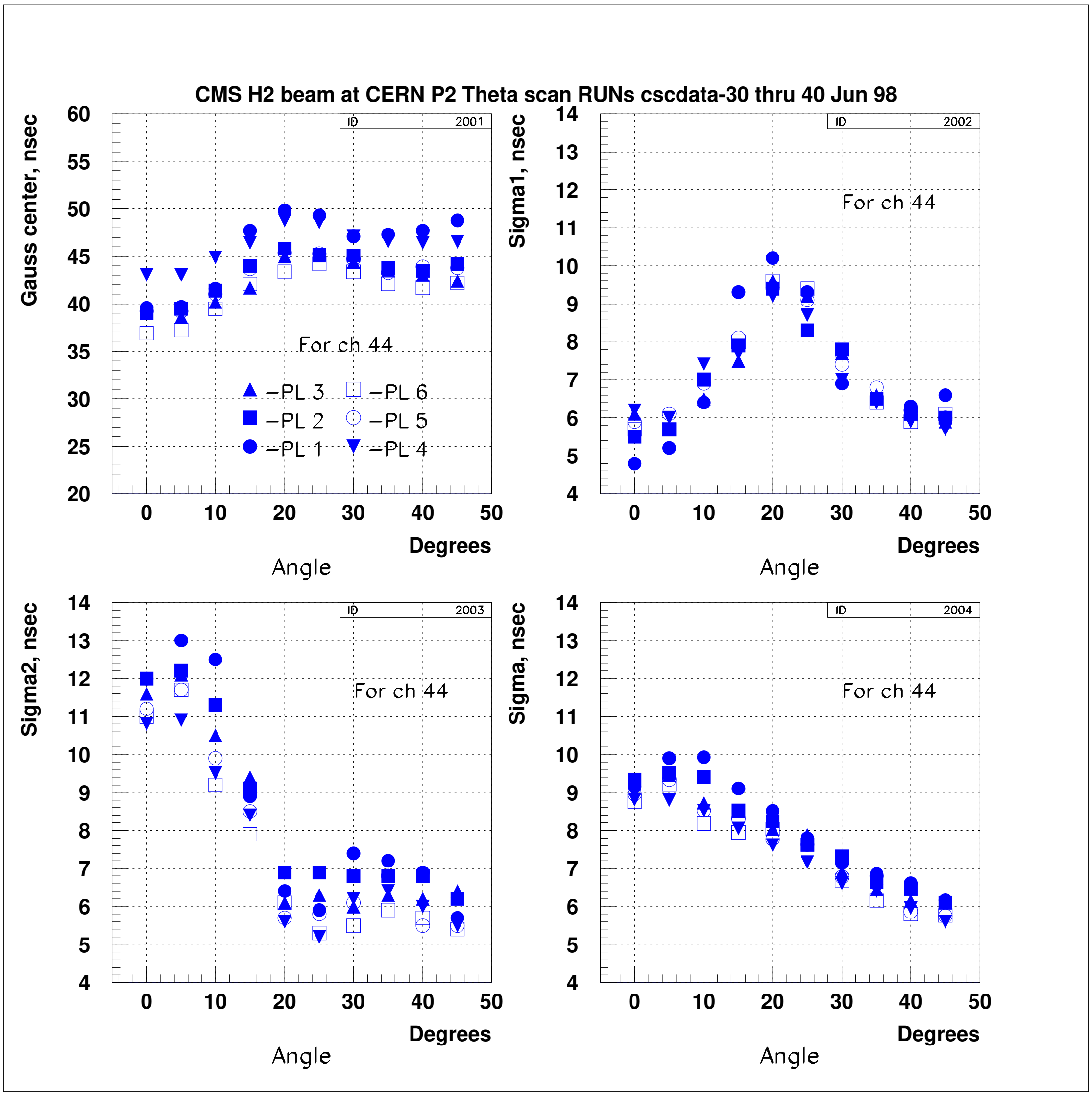

Figure 14: Fit parameters of the time distributions from individual planes of P2 vs angle of incident track

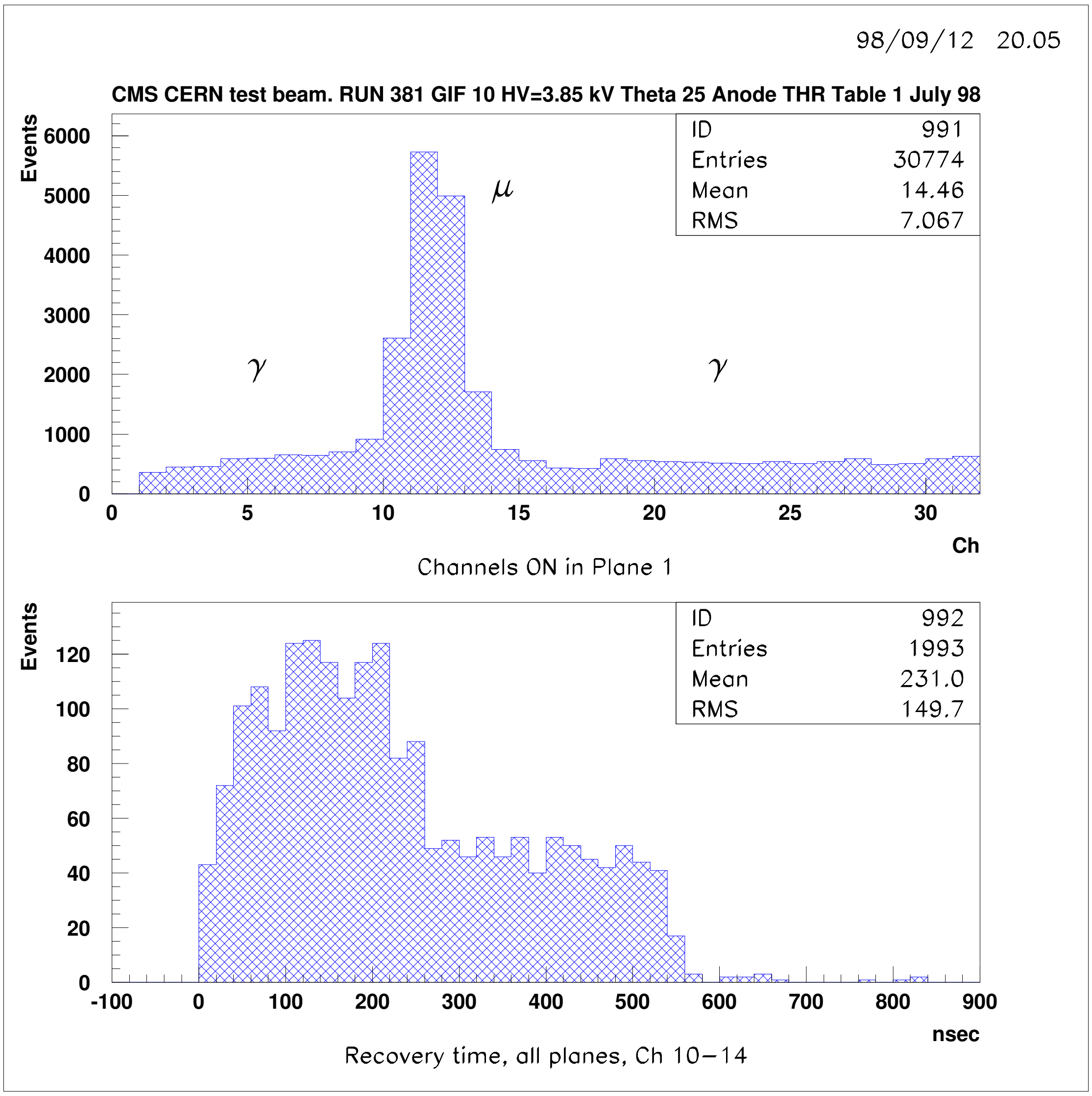

Figure 15: Recovery time of the anode front end channels at GIF