Status of the π^+ analysis from the xSAL detectors

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understanding the nucleon

- Connect the observed properties of the nucleon with the theoretical framework provided by QCD
- measurements of pion photoproduction at low-energies
  - involves an explicit rearrangement of the quarks in the nucleon
  - comparison of experimental results with theory provides important test of the different models

understanding the nucleon

a number of different approaches

- low-energy theorems
- dispersion relations
- chiral perturbation theory
- partial-wave analyses
  - MAID
  - SAID

chiral perturbation theory ChPT

- method to solve QDC in nuclear regime
  - pion & nucleon as appropriate degrees of freedom
  - known symmetries restrict the form of the possible interactions
    - calculations are tractable

- ChPT has been used to predict s- and p-wave contributions to pion photoproduction
  - need to test these against measurements

beyond the s-wave ….

- above threshold, p-waves quickly dominate

- ChPT calculations:

  p-wave terms for $\gamma\ p \rightarrow p\ \pi^o$

  are different than for $\gamma\ p \rightarrow n\ \pi^+$

- would like to compare theory and experiment for p-waves for both neutral and charged channels

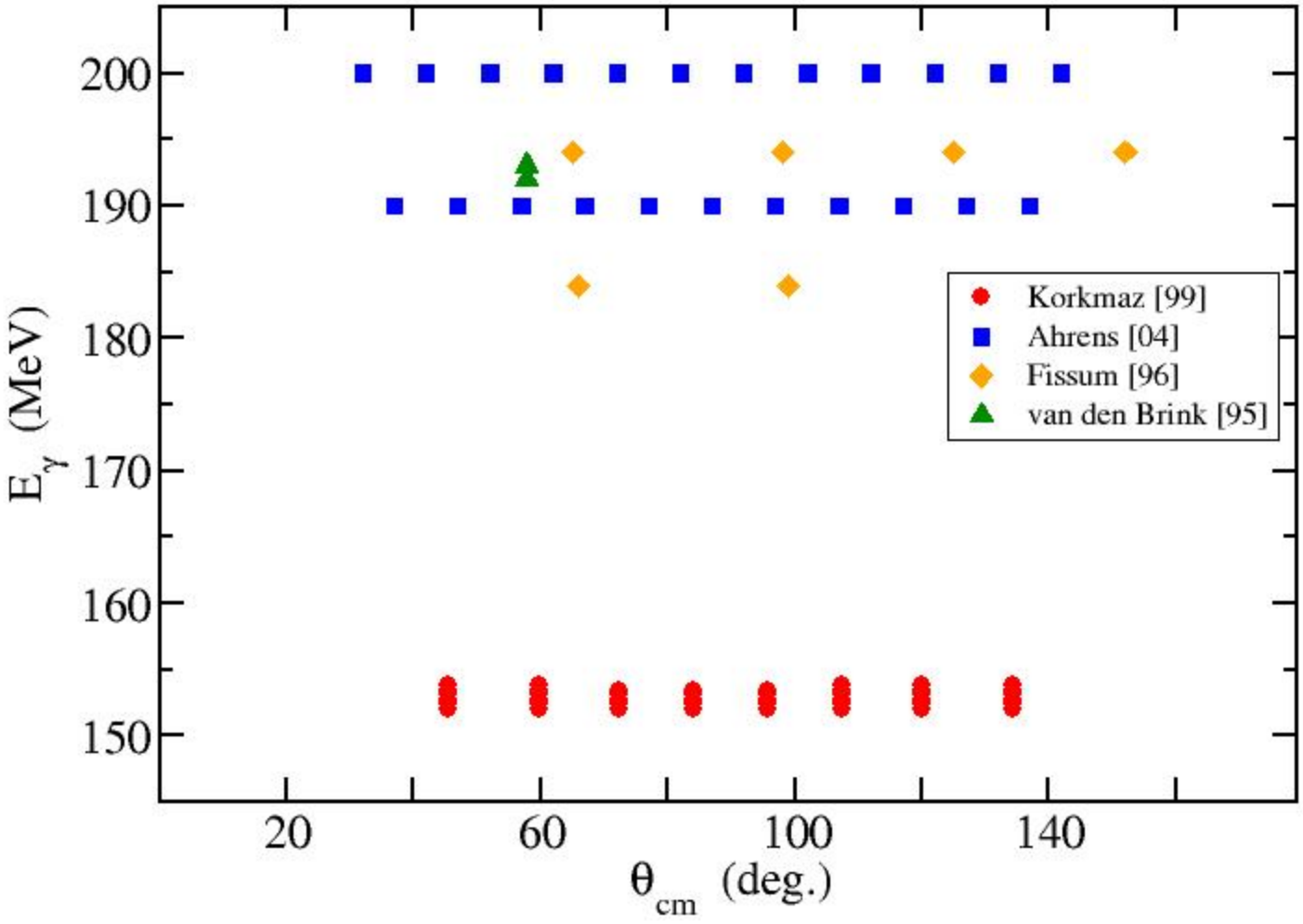
beyond the s-wave ….

- explicitly including the p-wave terms, the differential cross section can be expressed as:

$$\frac{d\sigma}{d\Omega} = \left(\frac{q}{k}\right)\left[A(E_\pi) + B(E_\pi)\cos(\theta) + C(E_\pi)\cos^2(\theta)\right]$$

- reliable determination of A, B and C requires high-quality measurements of cross sections which cover a large energy and angle range

existing data for $\gamma + p \rightarrow n + \pi^+$



(γ,π^+) program @ MAX-lab

- There is a need for new, precision data on $\gamma + p \rightarrow n + \pi^+$ in the energy range between threshold and the Δ-resonance

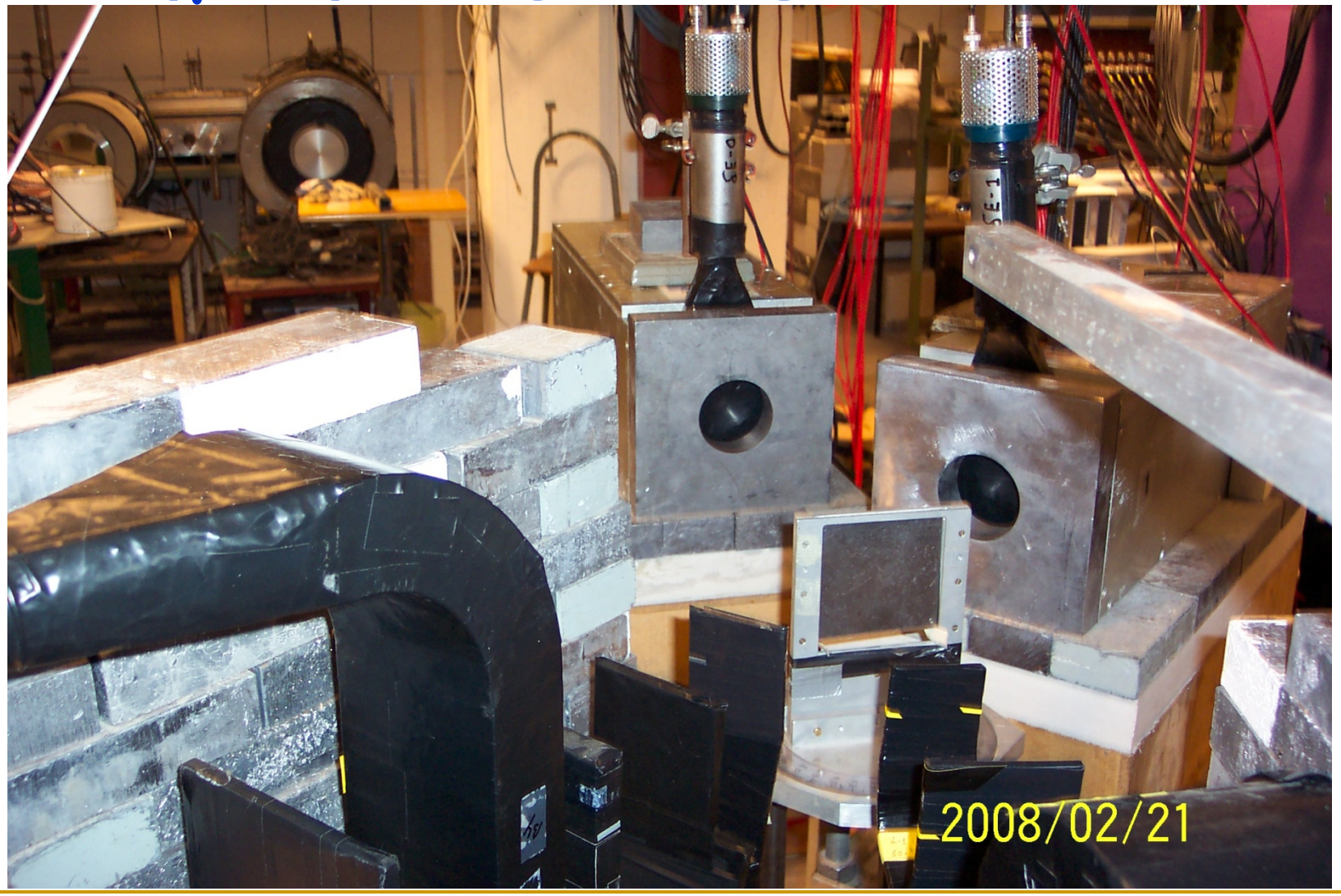
- MAX-lab's photon tagging facility is the only place such measurements will be done

(γ,π^+) program @ MAX-lab

February 2008 run

- Upgraded xSAL telescopes
  - Smaller E counters (better matched to π energy)
  - New ΔE counters
- E_e =194 MeV $\rightarrow$ E_γ = 167.24 – 179.96
- solid targets (C, CH_2, CD_2)
  - C for background subtraction
  - CD_2 for energy calibration using D(γ,p)n

(γ,π^+) program @ MAX-lab



(γ,π^+) with the xSAL counters

- trigger
  - ΔE-E coincidence
  - Σ-threshold (ΔE+E)
    (to eliminate background electron events)
- data acquisition
  - long- and short-gate ADC
    - look for $\pi \rightarrow \mu$ decay in long-gate ADC
  - TDC started by "delayed" E-signal
    - look at time distribution for $\pi \rightarrow \mu$ candidate events

(γ,π^+) beamtime in 2008

February 2008 run

- Some Problems
  - issues with tagger focal plane TDCs
    - ribbon cables, TDC units, ECL fan-out units
  - switch from CAMAC to VME system during run
    - different time range for new modules

- bottom line:
  - true timing peak outside TDC range
  - cannot make use of prompt timing cut in analysis

(γ,π^+) beamtime in 2008

- Some More Problems
  - pedestal drifts for short-gated QDC unit
    - likely introduced by a linear FIFO added to electronics
    - produced broad or double-valued pedestal peak
  - impacts selecting $\pi \rightarrow \mu$ decay from the QDC data

- bottom line:
  - cannot reliably identify π events

pedestal analysis (2008)

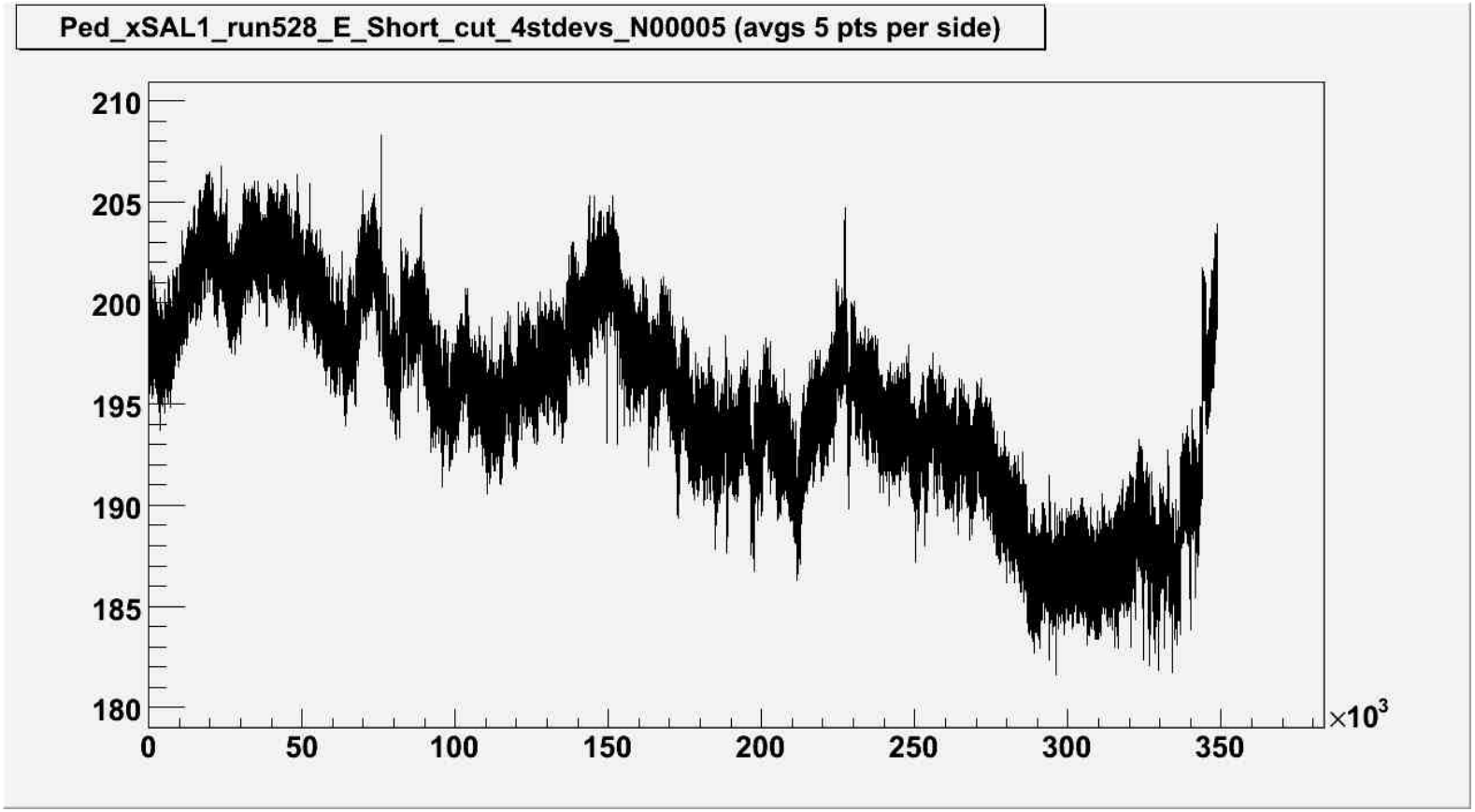
- if pedestal drifts are slow and smooth
  - calculate average pedestal for some set of events
  - use this value to correct nearby events

- Heather Brightman (UMass Dartmouth)

  MS thesis project
  - determine if pedestals can be corrected
  - apply correction to data

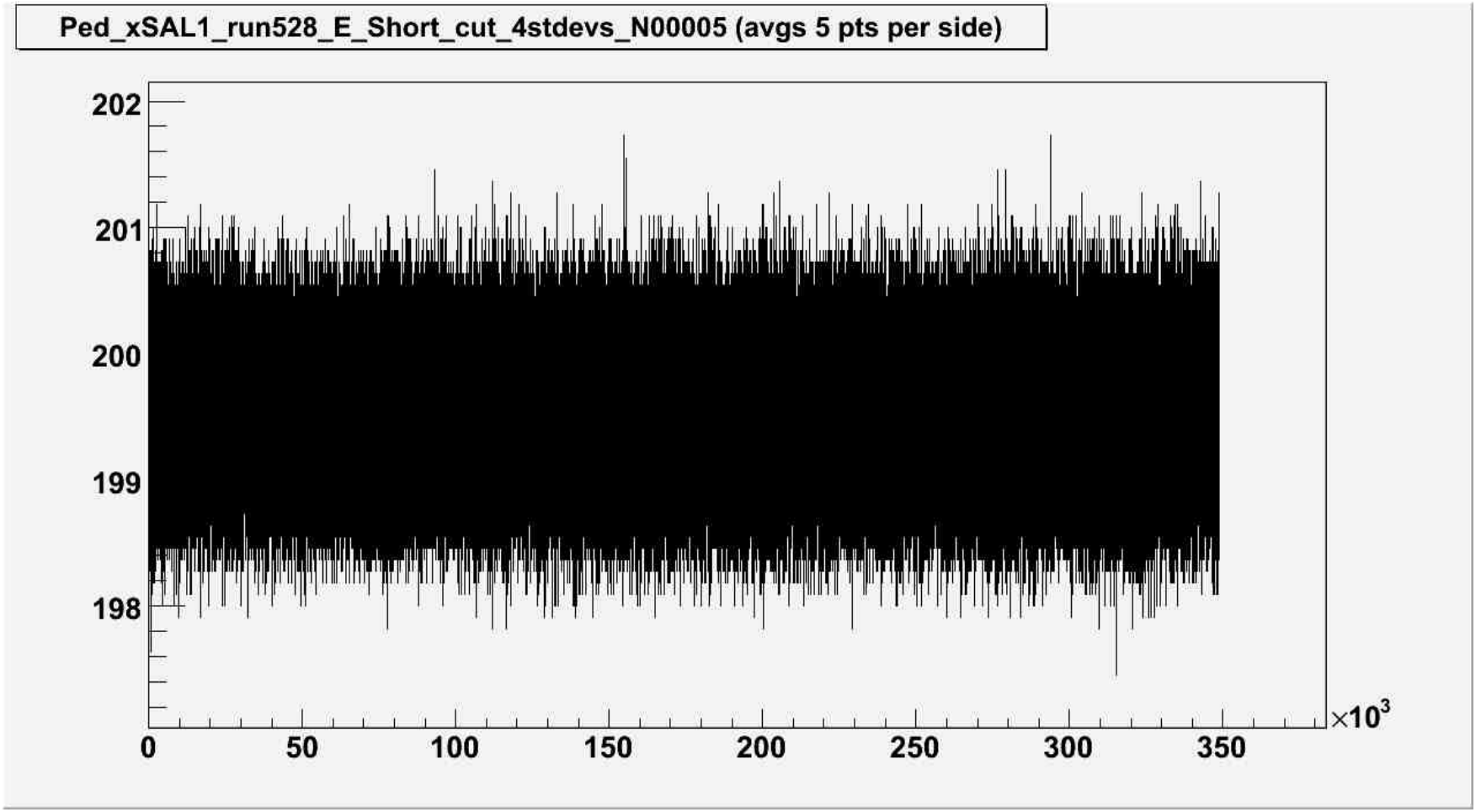
pedestal analysis (2008)

- pedestal value across a single run



pedestal analysis (2008)

- "corrected" pedestal for single run



pedestal analysis (2008)

- Heather's analysis:
  - uses averaging of 5 events on "either side"
  - significantly reduced width of pedestal
  - comparable to the "good" QDC data

  - Results in an event-by-event correction to data

NOT IDEAL !!

(γ,π^+) production run

June 2009 run

- pre-production set up in March & April

- debug/understand tagger focal plane
  - reliably indentify prompt peak in TDC spectrum

- setup/debug xSAL trigger & DAQ electronics
  - replace FIFO with passive splitter
  - resolves pedestal issues

(γ,π^+) production run

June 2009 run

- Highly successful
  - 3 independent detector systems
    - xSAL & RANGE (plastic scint. telescopes)
    - CsI+SSD
  - Compare analyses as “cross check”

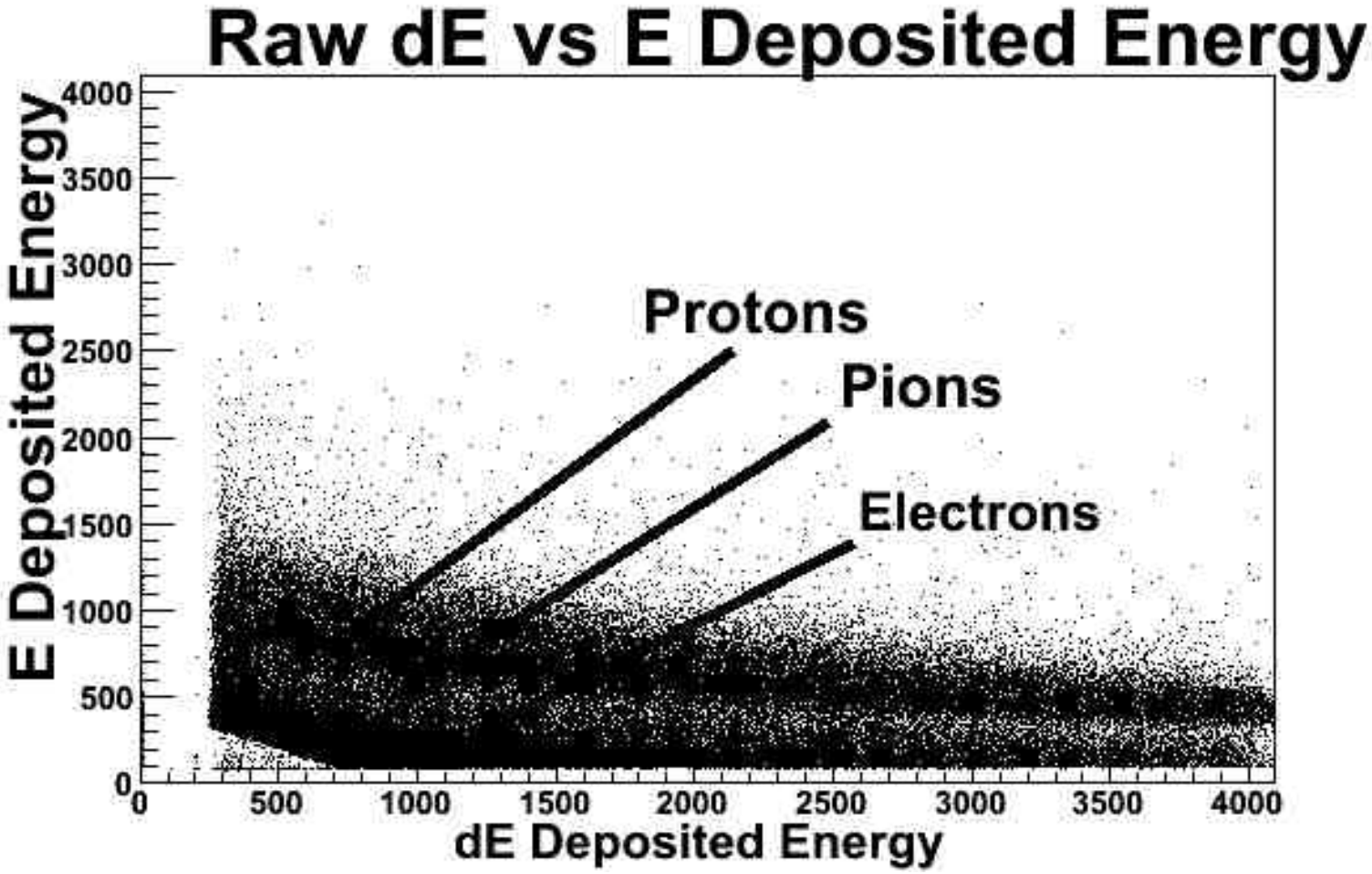
- solid targets (C, CH_2, Ta)
  - C, CH_2 for π^+ from proton
  - Ta for π^+ from heavy-A nuclei

(γ,π^+) production run

June 2009 run

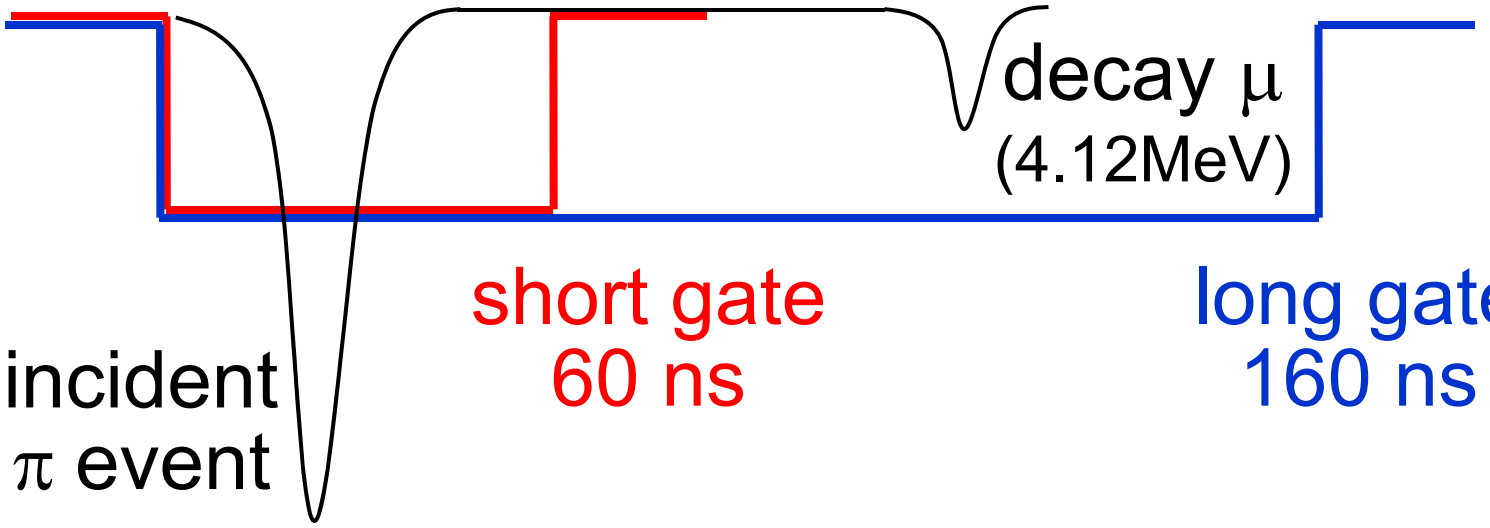
- US student participation
  - 1 graduate (Luke Myers, Illinois)
  - 3 undergraduate from UMassD & GW
    - supported by US NSF *International Research Experience for Students (IRES)* funding
  - tagging efficiency (Matty Litwack)
  - particle identification in xSAL counters (Colleen Allen & Jason Lemrise)

π^+ identification in xSAL



π identification

- π → μ decay

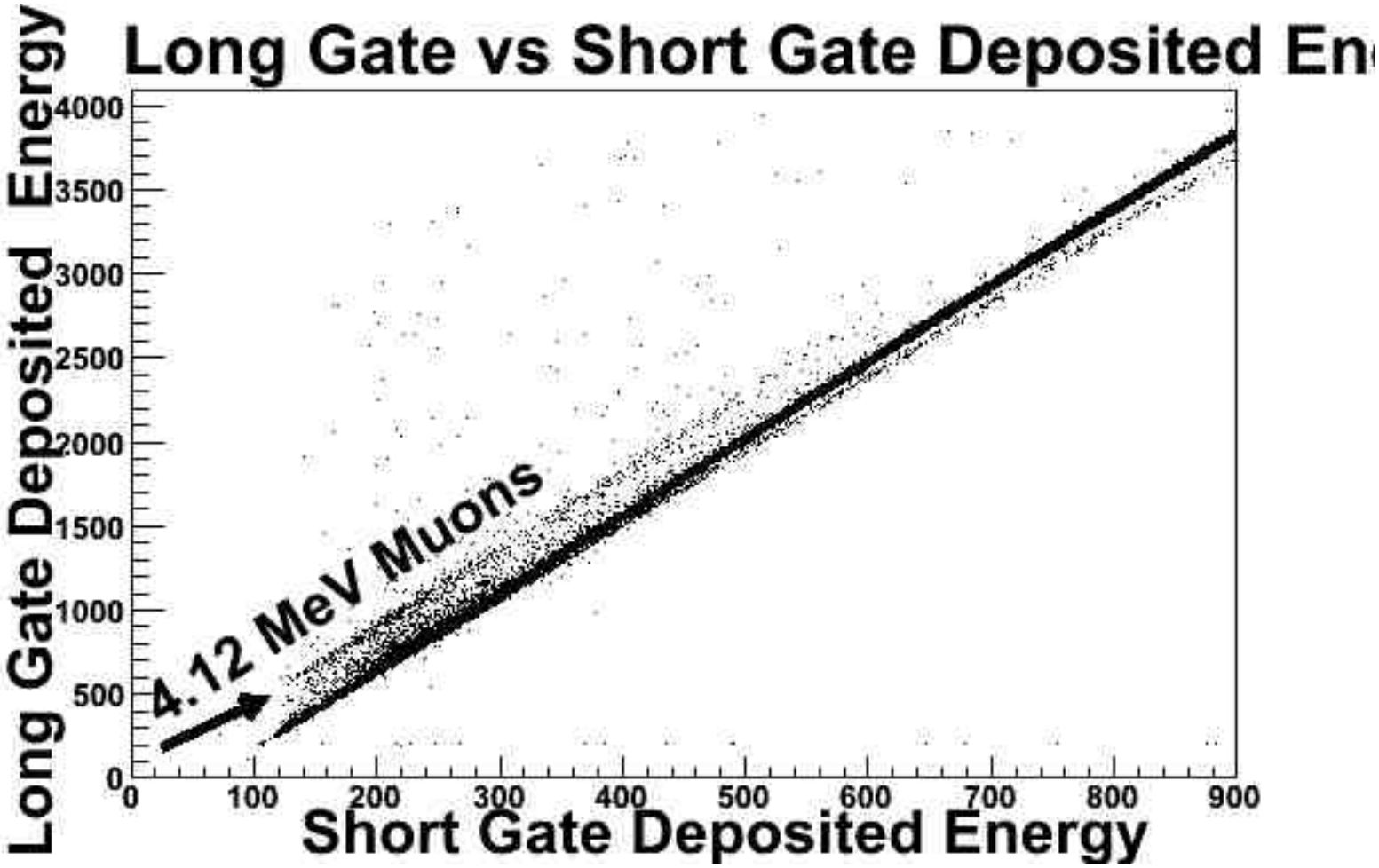


non- π events -- same energy in long/short gates

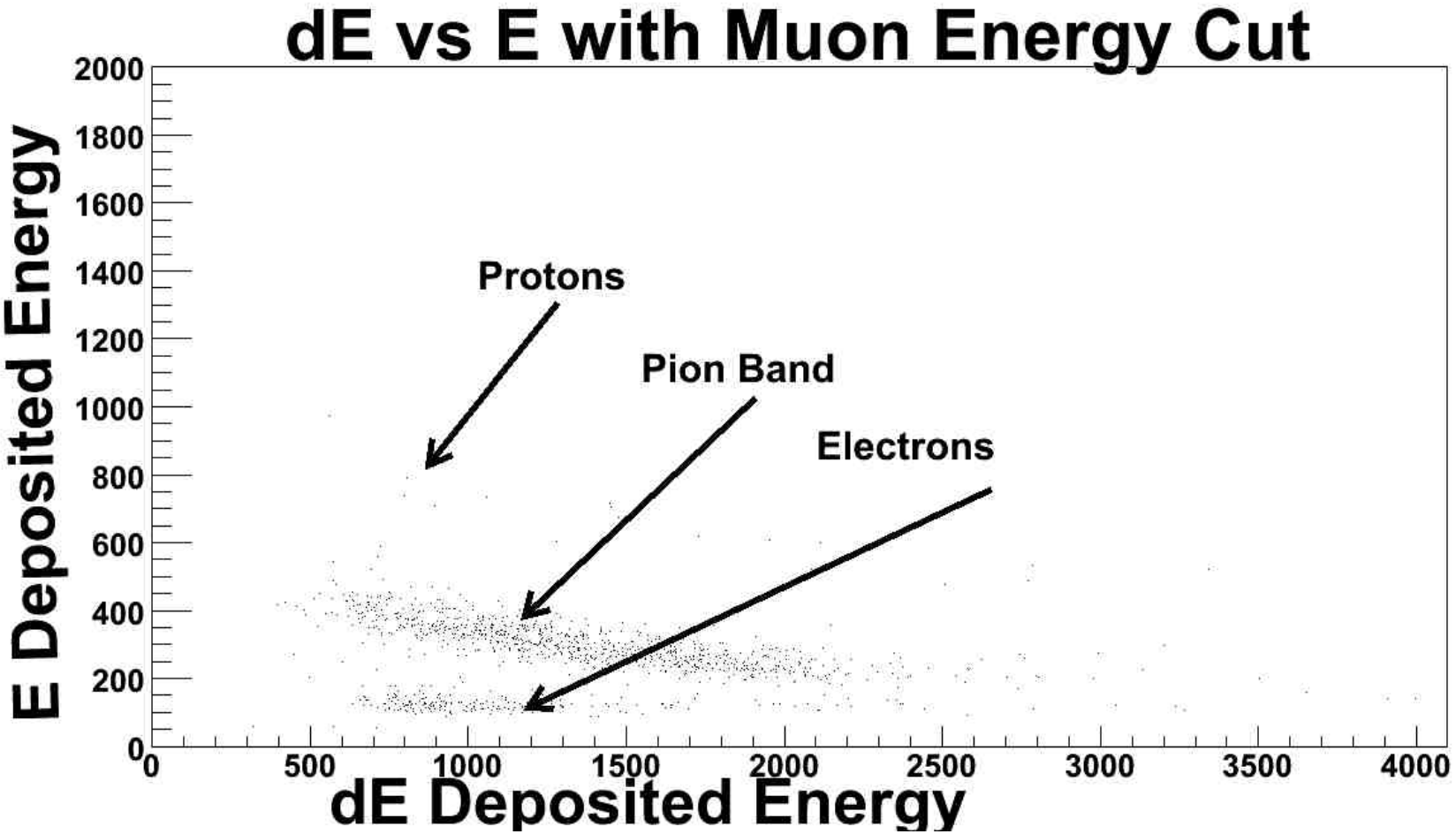
π events -- +4.12 MeV in long gate

plot of long vs. short will show offset for π events

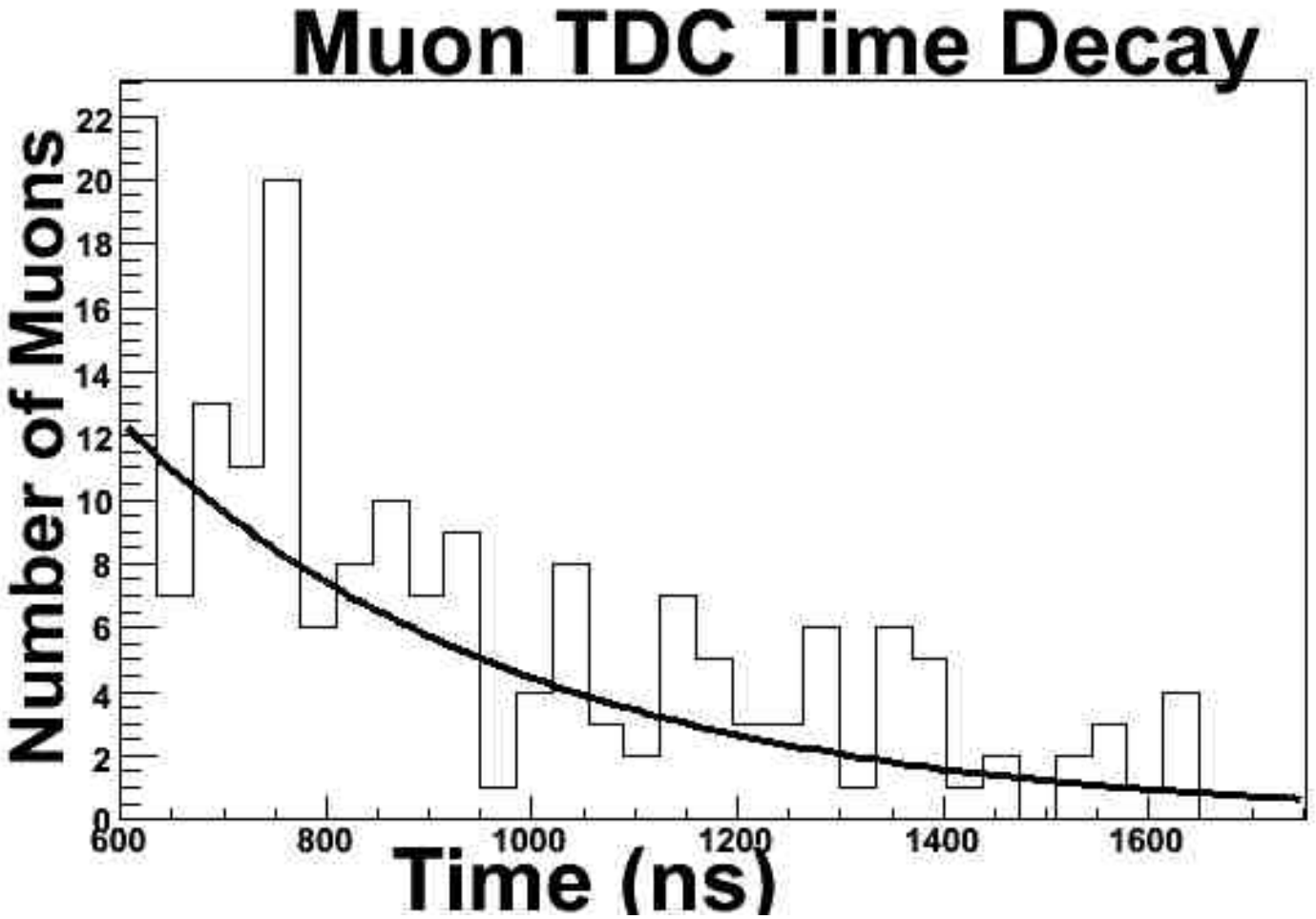
π^+ identification in xSAL



π^+ identification in xSAL



π^+ identification in xSAL



decay time = 26 ns matches $\pi \rightarrow \mu$ decay

π^+ analysis (xSAL)

optimizing analysis cuts for pion ident.
(Colleen Allen's undergrad. thesis project)

- create 1-d "PID value" for events & fit this to determine yield corrections
  - π events lost by analysis cuts
  - background events misidentified as π
- give reliable, well understood yield determination

π^+ analysis (xSAL)

- will have pion yields by end of year
- combine with photon flux (Matty's work)

- first cross-section for (γ,π^+) from MAX-lab in early 2010

- based on observed events rate
  - need more statistics for $\gamma p \rightarrow \pi^+ n$ channel

(γ,π^+) program @ MAX-lab

anticipated energy/angular coverage