Flow, SAMPA Chips and Other Stuff: One Year of Ph.D. Studies

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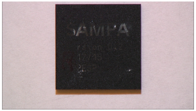
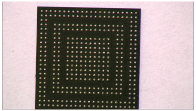
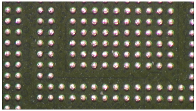
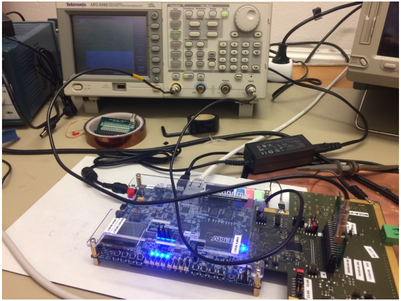
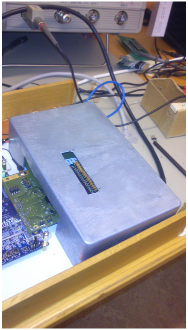
Who am I?

- Graduated from Engineering Physics in 2016
- Summer Student at CERN 2014
- Just completed first year of Ph.D. in ALICE

Outline of this talk

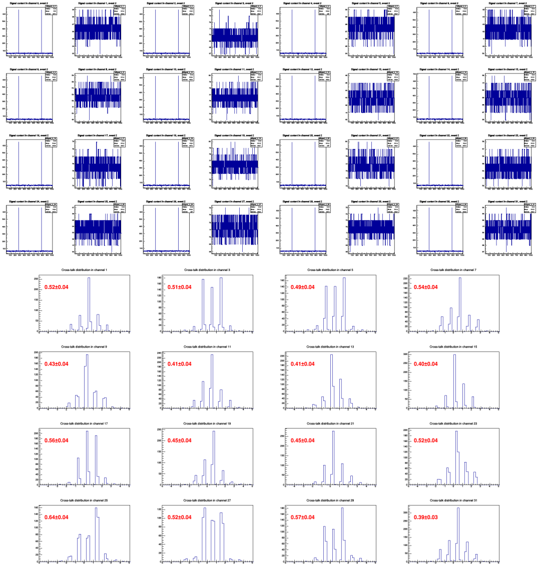
1. Testing of SAMPA chips (service task)
2. Analysis: measuring flow
3. Courses & teaching
4. Future plans
5. Some advice

SAMPA Chips

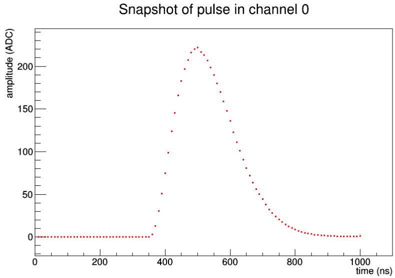
- New chips for the TPC upgrade
- Faster than current version
- Divided into 32 channels
- Many tests required

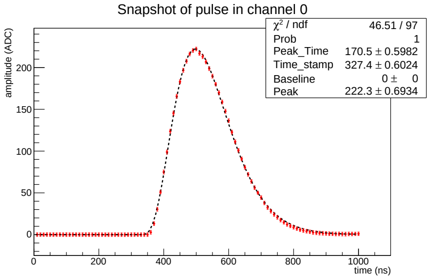
Cross-talk



- Several channels pulsed simultaneously: every second, third, all but one, only one...
- Cross-talk measured in non-pulsed channels, time-aligned with pulse
- Average taken over many events to suppress noise
- Result: cross-talk is acceptable

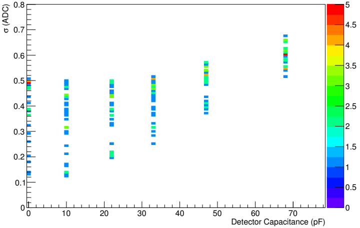
Pulse shape

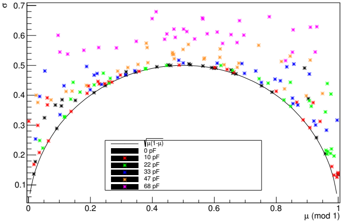


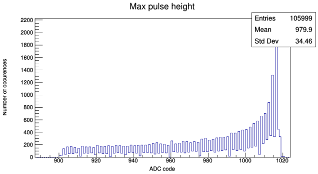


- Several different methods were tested
- Final approach: pulse train with slight phase shift between each pulse
- Reconstructed pulses look reasonable
- Gives measure of rise time and peak height, etc.

Issues

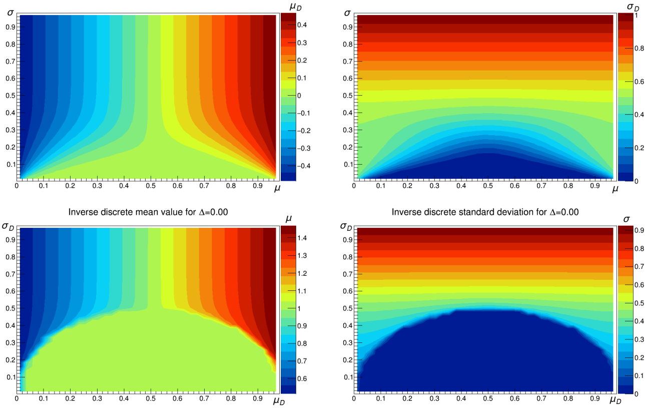






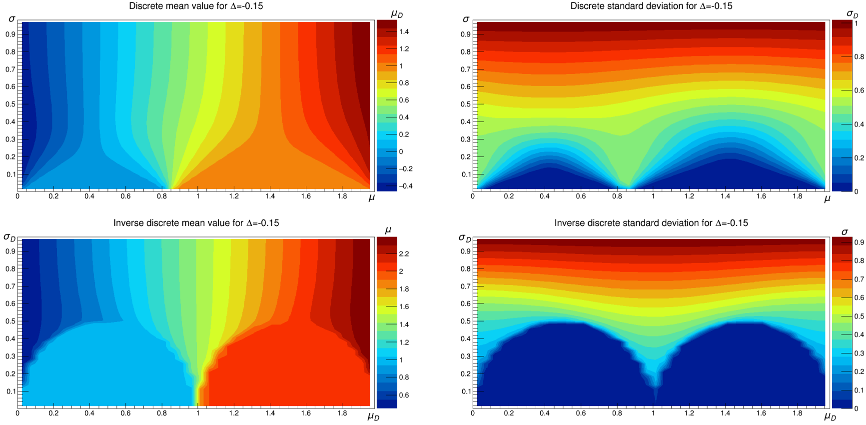
- Bit issues: in particular different counts in odd and even ADC bins (odd-even effect)
- Muon people want to use so low amplification that noise is below ADC resolution $\Longrightarrow$ correlation between μ and σ
- I looked into this using mathematical models (next slides)

Issues cont'd



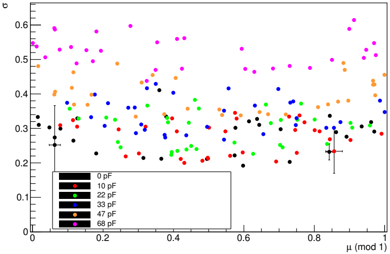
- Idea: $f : (\mu, \sigma) \to (\mu_D, \sigma_D)$ is invertible on $\mathcal{D}_f = [0, 1) \times \mathbb{R}_+$
- Measured values can be inverted to obtain correct analogue values

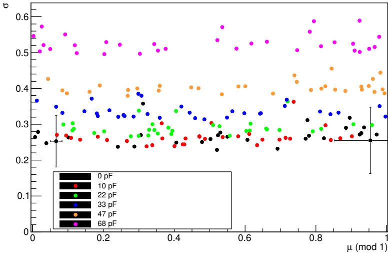
Issues cont'd



Also possible to include simple model for odd-even effect (unequal ADC bin width for odd and even ADC bins)

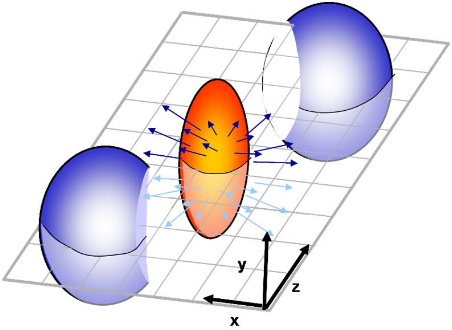
Issues cont'd - Results





- Left: without bit issues. Right: including odd-even effect
- Noise satisfies specifications in muon case
- Model for odd-even effect perhaps too simple

Flow



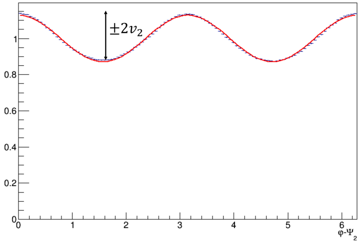
http://www.quantumdiaries.org/wp-content/uploads/2011/02/FlowPr.jpg

- System in thermal equilibrium, expanding with the pressure gradient (flow)
- Non-central collisions $\Longrightarrow$ asymmetric flow
- Studying this reveals properties of the QGP
- Events are divided into centrality classes

Elliptic flow, v_2

- Fourier decomposition:
  $$\frac{dN}{d\phi} \propto 1 + \sum_{n=1}^{\infty} 2v_n \cos\left(n\left(\phi - \Psi_R\right)\right)$$
- v_1 = direct flow (uninteresting)
- v_2 = elliptic flow (dominant)
- $n > 2$: require much data
- Problem: $\left(v_2^{meas}\right)^2 = \left(v_2^{coll}\right)^2 + \sigma^2 + \delta$, δ = non-flow

Track distribution vs. $\phi - \Psi_2$:

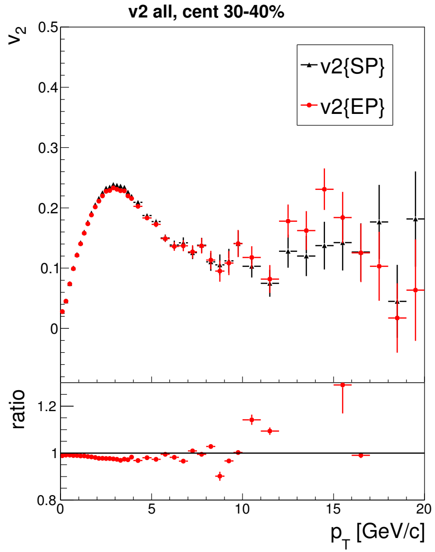


Methods

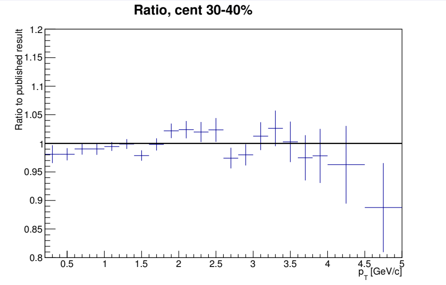
$$\frac{dN}{d\phi} \propto 1 + \sum_{n=1}^{\infty} 2v_n \cos\left(n\left(\phi - \Psi_R\right)\right)$$

- Two methods are used:
  1. Event plane method: Ψ_R is estimated from each event (introduces a bias)
  2. Scalar product method: v_2 is measured from two-particle correlations between two sub-events to eliminate Ψ_R
- A gap in detector acceptance is used to suppress non-flow - separates sub-events

First results (using data from 2013, 2.76 TeV)



Comparison with published results (scalar product)[a]:



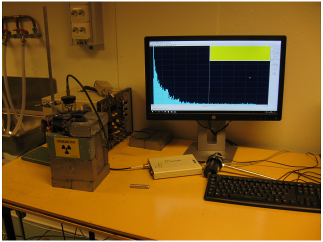
P-value: 0.15

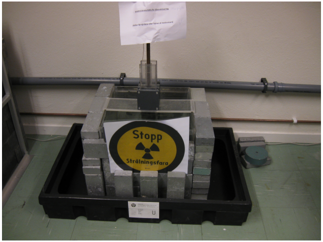
[a] PRL 107, 032301

Courses

- Dark Matter: Distribution, Detection, Origin and Production, 3 ECTS - *Special course offered at our division last year*
- Introductory Course for Ph.D. Students, 0.5 ECTS - *Mandatory course at Science faculty*
- Introduction to Quantum Field Theory, 7.5 ECTS - *Course for Master students given at Theoretical Physics during LP3; good theoretical background*
- Computational Tools and Recipes, 7.5 ECTS - *Given by COMPUTE once every few years. Lots of computing-related exercises. I still haven't finished it!*
- CERN School of Computing, 6 ECTS - *Computing-related summer school, given at a different place each year.* ***Strongly recommended!***

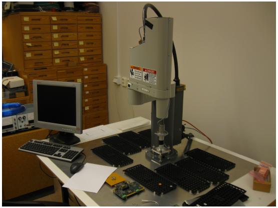
Teaching





- Lab supervision in 1st year physics together with Martin
- K3 lab: Neutron activation and half-life determination (in Swedish)
- Who wants to take over next year?

Future plans



- Start an own analysis study, co-supervised by Alex Dobrin, details not clear yet
  Ideas: continue Rickard's work with Event-Shape Engineering, Chiral Magnetic Effect in p-Pb, or who knows?
- Chip testing for new SAMPA version (will arrive October/November)
- Next teaching session
- Courses: *Learning and Teaching in High Education - Theory and Practice*, *Particle Physics Phenomenology*

Some advice

- Make a plan for your analysis as soon as possible
- Focus on a topic you find exciting
- Keep your eye open for interesting courses, summer schools and conferences
- Don't be afraid to ask more experienced colleagues for help and advice!

Summary

- I have mostly focused on chip testing (service task) and courses so far
- Resulted in study of how discretisation affects measurements of noise
- Analysis: Measured flow in Pb-Pb agrees reasonably well with published result
- Recommended summer school: CERN School of Computing
- Looking for lab partner in K3 lab next year
- Focus on analysis in future
- Advice: get started with your analysis early on

Thank you for your attention!