DCH Summary

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For the DCH group

XI SuperB General Meeting

LNF, 4 December 2009

Issues discussed in this meeting

- Backgrounds
- Geometry: Mechanical design
- Geometry: DCH length
- Cell and gas optimization
- Electronics: FEE & DAQ design
- Progress in Lab. work

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Backgrounds

Estimates presented @ SLAC Collab. Meeting in October have been updated

- Radiative Bhabha + pair production rate ~2%
  - average over the whole DCH
  - a few details in DCH geometry/cell layout need further adjustments (no big changes expected)
- Need to include other background sources (large angle bhabhas, Touschek ...)

DCH Backgrounds (cont.)

- What uncertainty (x5, x10)?
  - few % x 10 is not really comfortable…
  - Need more studies to convince ourselves that the numbers are credible
- Study dependence of background levels as a function of DCH structural design and amount and position of shielding

Large-angle Radiative Bhabha Cross Sections

Darren Swersky, McGill University

Part 1: Final Results

Table 1.1

$\beta\gamma$	θ_{min}(Lab)	$\cos\theta_{max}$(CM)	# electrons	σ(nb)	σ_F(nb)*
0.56	200mrad	0.943	4520	63.2±3.2	62.3
0.56	300mrad	0.875	1953	27.3±1.4	25.9
0.28	200mrad	0.966	7669	107.2±5.4	113.2
0.28	300mrad	0.924	3363	47.0±2.4	48.6
Reference**		$-0.922 \le \cos\theta \le 0.927$	3504	49	

- All calculations and cuts are performed by switching to CM frame
- 5% error assumed in calculation of σ

* Figures estimated by Giuseppe Finocchiaro using Babayaga generator

** See BaBar Note #503

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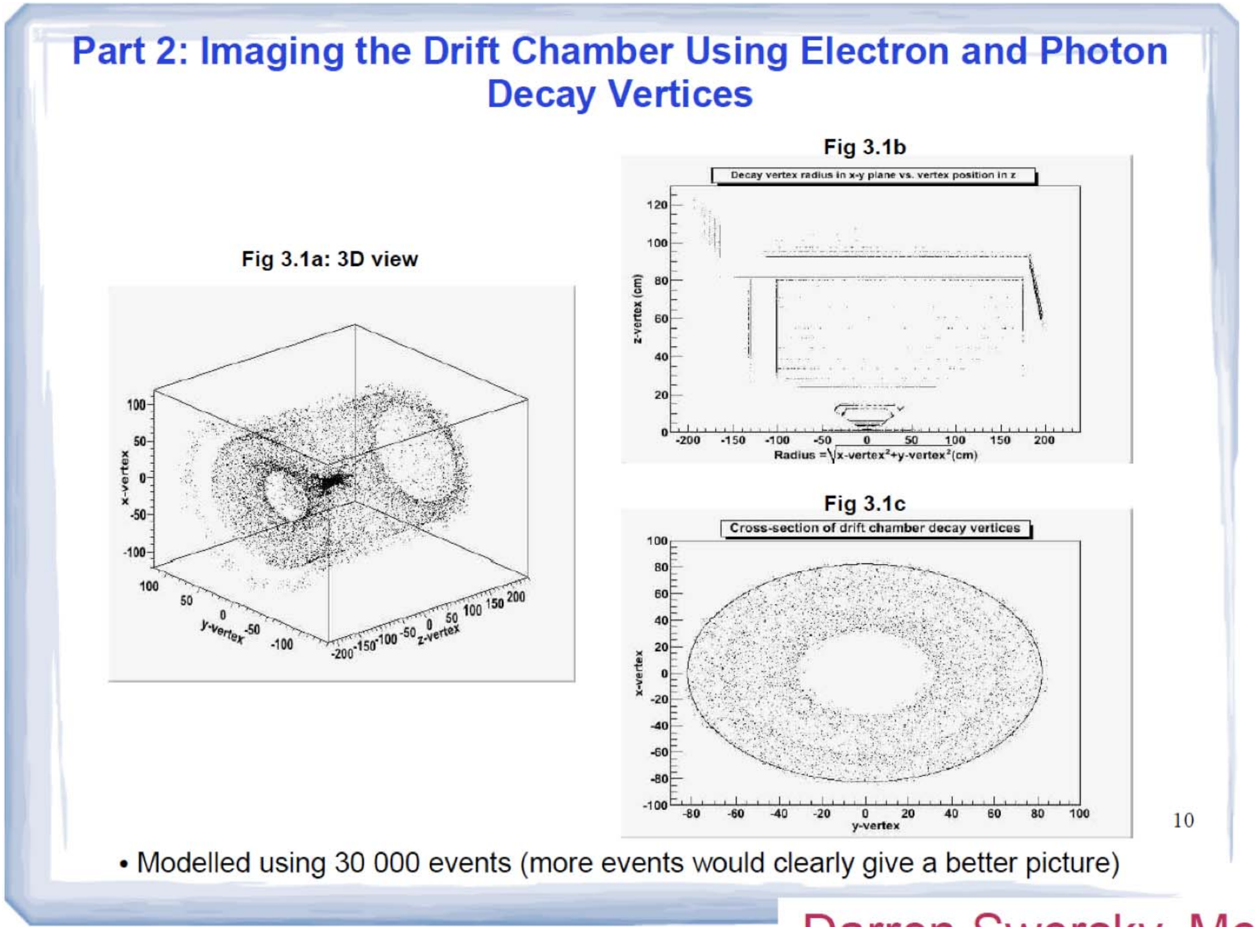
First FastSim study of Bhabha occupancy



Darren Swersky, McGill University

- Small-angle occupancy in this preliminary study (unfortunately) underestimated (plots require a reconstructed track)
- Want to understand if tapered endplates (see next slide) really needed

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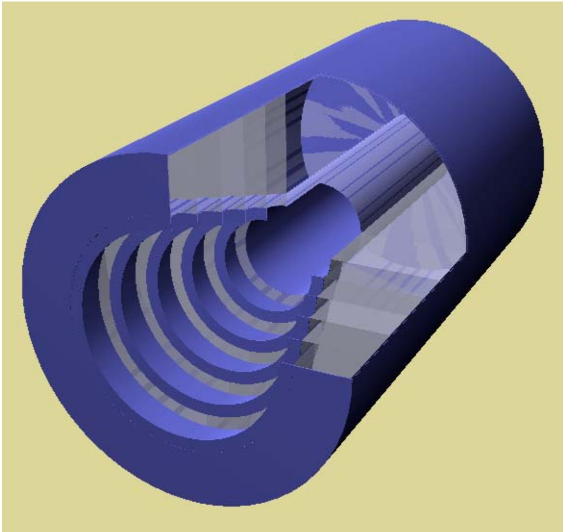
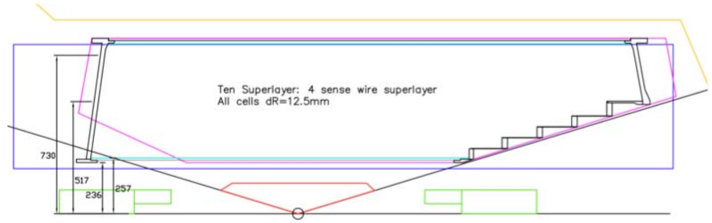
Varying the DCH design: stepped endplate

- A possible stepped endplate (a.k.a. “wedding cake”) design has been implemented in `gdml`





- Aside from stringing issues, one concern with this option is debris production from particles produces at the I.P. on localized material (the steps)
- Plan to study the effect of various bkg sources ASAP

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Drift cell optimization

- 1-liner drift cell design guidelines
  - ✓ uniformity ⇑ material ⇓ - obviously, contradictory ;(
- (As well-known) *BABAR* uses **hex** cells
  - ✓ "symmetric" and with low F:S ratio (2:1) but…
    - mandatory Super-Layer structure, with guard wires
    - 7104 sense 20μm∅, 704 clearing 120μm∅, 6400 guard 80μm∅, 14560 field 120μm∅
    - Overall material budget relatively high

Drift cell and gas optimization

- First attempt at a specific square-cell layout
  - 44 measuring layers
    - AA UV UV UV UV A (11 SL with 4 layers each)
    - h=12mm w=π×6mm (in first 8 A layers w=π×3mm)
    - 7696 sense 20μm∅, 1520 guard 80μm∅, 23088 field 80μm∅
- Lighter gas mixtures:
  - (as well known) BABAR used 80%He-20%iC_4H_{10}
  - KLOE uses 90%He-10%iC_4H_{10}
  - In (*) the use of 80%He-20%CH_4 in a large prototype chamber, obtaining 90μm spatial resolution, is reported

(*) NIMA436 (1999) 336

Drift cell-gas mixture comparison

PRELIMINARY

	$\rho(g/cm^3)$	$X0(g/cm^2)$	X0(m)
80%He-20%iC_4H_{10}	6.41E-04	51.2	798
80%He-20%iC_4H_{10}-hex	9.98E-04	29.0	291
80%He-20%iC_4H_{10}-sqr	8.78E-04	30.3	346
90%He-10%iC_4H_{10}	4.10E-04	56.8	1387
90%He-10%iC_4H_{10}-hex	7.67E-04	26.4	344
90%He-10%iC_4H_{10}-sqr	6.46E-04	27.4	424
80%He-20%CH_4	2.76E-04	63.0	2281
80%He-20%CH_4-hex	6.33E-04	24.1	381
80%He-20%CH_4-sqr	5.13E-04	24.7	481

- Potential for good reduction of pT measurement error , especially at low momentum
- Need for simulation work, operational experience (with low-CH_4 content mixture) and more detailed cell design

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DCH FEE - # of optical links

SuperB-DCH

SELF Servizio Elettronico Laboratori Frascati

OL - SuperB DCH vs BABAR DCH

BaBar DAQ/Trigger numbers

- 2.5 kHz L1 (average) trigger rate @ 10^{34}
- 7104 cells
- ≈ 10% occupancy
- DAQ ≈ 8 bytes/ch (average)
- Trigger ≈ 1 bit/ch @ 3.75 MHz

Super-B DAQ/Trigger numbers

- 150 kHz L1 (average) trigger rate
- ≈ 10000 cells
- ≈ 20% occupancy (1 μs time window)
- DAQ ≈ 8 bytes/ch (average)
- Trigger ≈ 1 bit/ch @ 7 MHz

OL Estimation according to the BW

DAQ → 150×10^3(L1 rate)$\times10^4$ (N. of cells)$\times0.2$(occupancy)$\times8$(N. of bytes/ev)$\times8$(1 byte = 8 bits) → 19.2 Gbits/sec (average)

TRIGGER → 10^4 (N. of cells)$\times7\times10^6$ → 70 Gbits/sec

OL Estimation according to the BABAR experience

BABAR DAQ/Trigger OL (1.2 Gbits/sec)

DATA
- 4 OL (layout requirement) ≈ 8 X L1 trigger rate requirement)

TRIGGER
- 24 OL

ECS
- Managed by DATA I/O modules (CAN standard)

Super-B DAQ/Trigger OL (2 Gbits/sec)

DATA
- 30 OL (including a x3 safety factor)

TRIGGER
- 35 OL (increase of sampling frequency & channels)

ECS
- 8 OL (layout driven)

G. Felici LNF SuperB Workshop – Dec 09

DCH FEE – 2 scenarios

SCENARIO 1

ONLY HV distribution and preamplifier boards located on the end-plate

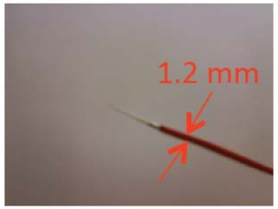
Pros :

- minimization of the material added to the end-plate
- reduction of the power dissipation on the end plate (no cooling required or low airflow)
- minimization of the radiation environment issue
- possibility of using commercial available devices for data conversion
- Full system reliability

Cons :

- 10k cables required to extract signals (either micro-coax or twisted)

Min: 1 mm FR4
Max: 1 mm FR4 + 440 µm copper + 3 mm ceramics



SCENARIO 2

Full FEE chain located on the end-plate

Pros :

- reduction of the number of connections between DCH and DAQ

Cons :

- two layers of boards plus shielding must be placed on the end-plate with not negligible increase of the material added to the end-plate (shielding is required as digital logic is continuously working for data conversion and serialization)
- power dissipation is increased and cooling is required
- to limit power dissipation dedicated radiation tolerant devices (ASIC) are required and ASIC design is a time consuming and expensive task.
- Power supply cables must delivery more current → bigger sections are required
- Reliability of the full system

Min: 2.6 mm FR4 + 280 µm copper
Max: 2.6 mm FR4 + 720 µm copper + 3 mm ceramics + cooling

DCH FEE – 2 scenarios

SuperB-DCH — Servizio Elettronico Laboratori Frascati (SELF)

DCH FEE Power Dissipation & Radiation Environment

BABAR

Super-B (Estimate)

DCH Power Dissipation

Component	Number	Total Power (W)
Front End Assemblies	48	1300
Data I/O Modules	4	100
Trigger I/O Modules	8	260

→ ≈ 1.7 kW

Radiation Environment

- Spartan 3 XC3S1500 → SEU (neutrons) ≈ 2kHz/cm2 estimated rate → FPGA must be reconfigured

→ 2/days

Material Budget

→ Nobody cares

On Detector FEE - Scenario1

- Pd < 300 W * (including some shaping/amplification)
- No cooling required (or low air flush)
- Radiation Environment : low sensitivity (no FPGA)
- Material budget: low

* In KLOE (12k channels) was 100W

On Detector FEE - Scenario2

- Pd ≈ 1.5/2 kW
- Cooling required
- Radiation Environment : large use of FPGA → SEU problems
- Material budget: high

- Option #1 requires bringing out (many) more signal cables. Can we find a route?
- Would there be space for a crate on the detector?

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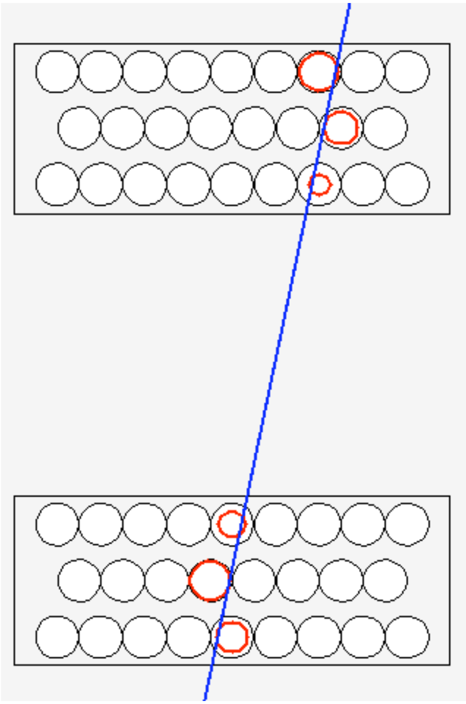
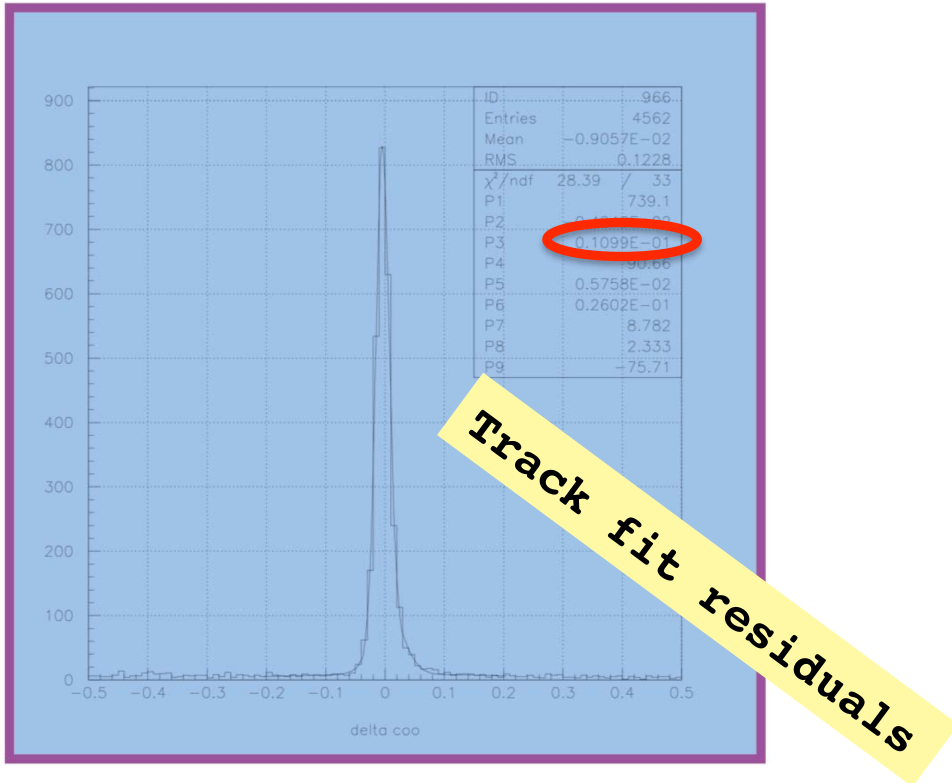
  - "baseline" (no cluster-counting) option
- Progress in Lab. work
  - including setup for first cluster counting studies

LNF Tracking telescope

REMINDER:

- ✓ Two identical assemblies of 26 tubes each
- ✓ Operated in LS mode
- ✓ 3 cm diameter, 100 μm wires
- ✓ 40%-60% Ar-iC_4H_{10} mixture
- ✓ Straight-line fit of cosmic-ray tracks



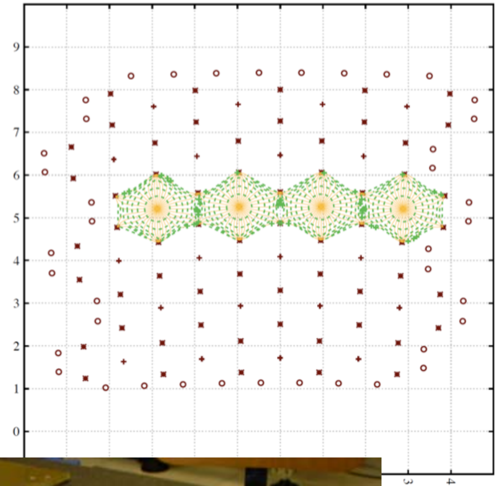


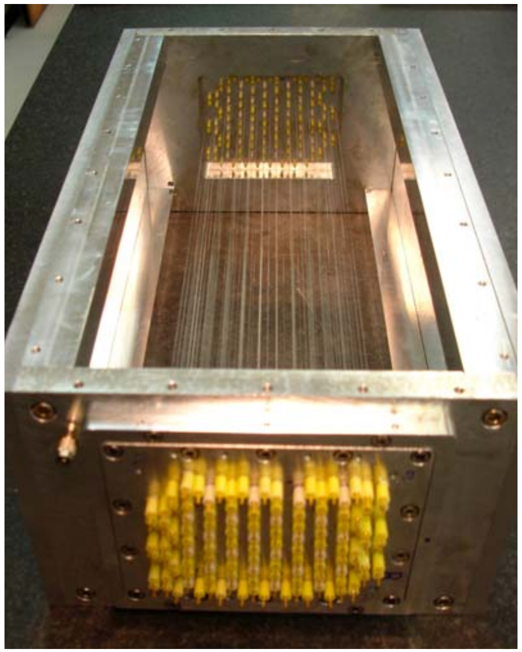
Middle layer of upper tracker – all tubes together ~100μm resolution

➔ **expected extrapolation accuracy on drift chamber prototype (between the two trackers) ~50μm**

DCH prototype 1

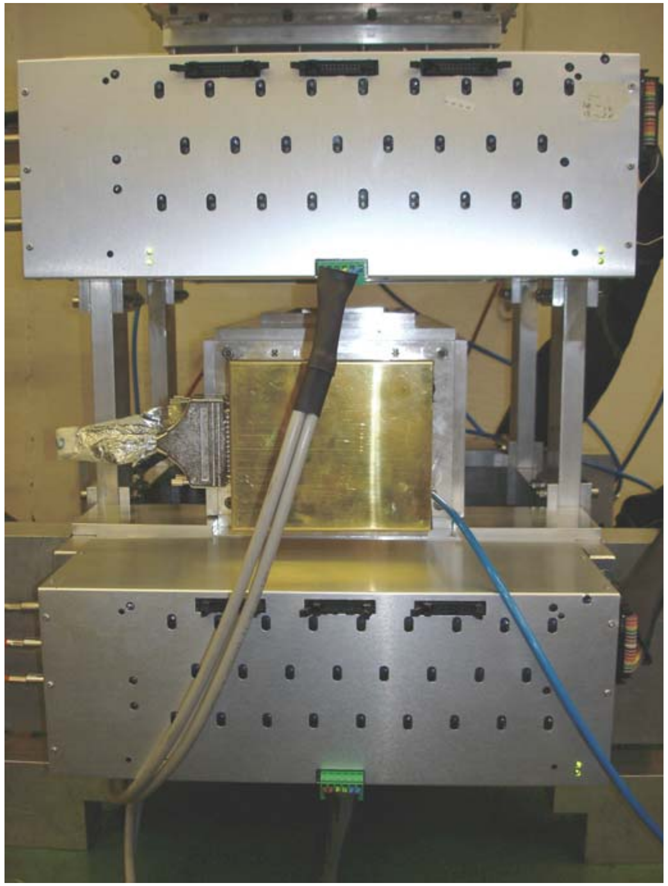
- 6x4 hexagonal cells à la BaBar
  - Guard wires guarantee uniformity of electric field among cells down to ~1%
  - Aluminized mylar windows on entrance-exit faces



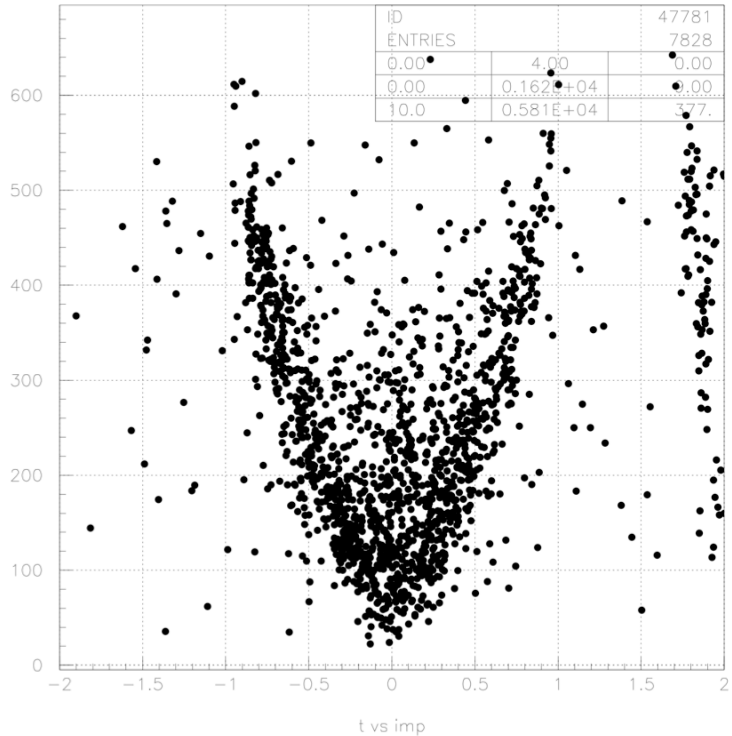


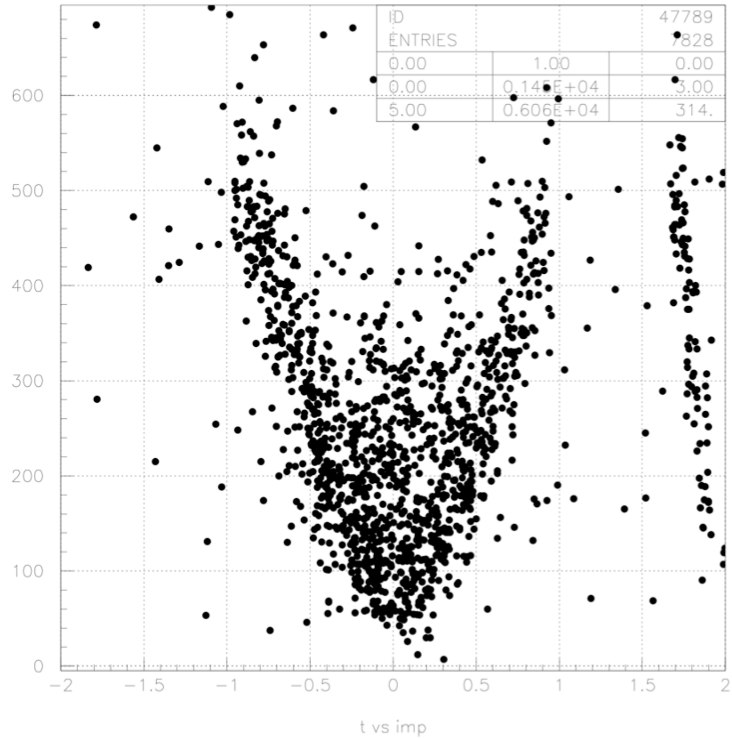
DCH prototype 1 (cont.)

- Readout electronics fully commissioned
- Using BaBar's 80%He-20%iC_4H_{10} gas now
  - volume is small, changing mixture is fast
- taking cosmic ray data now



(VERY!) Preliminary STRs

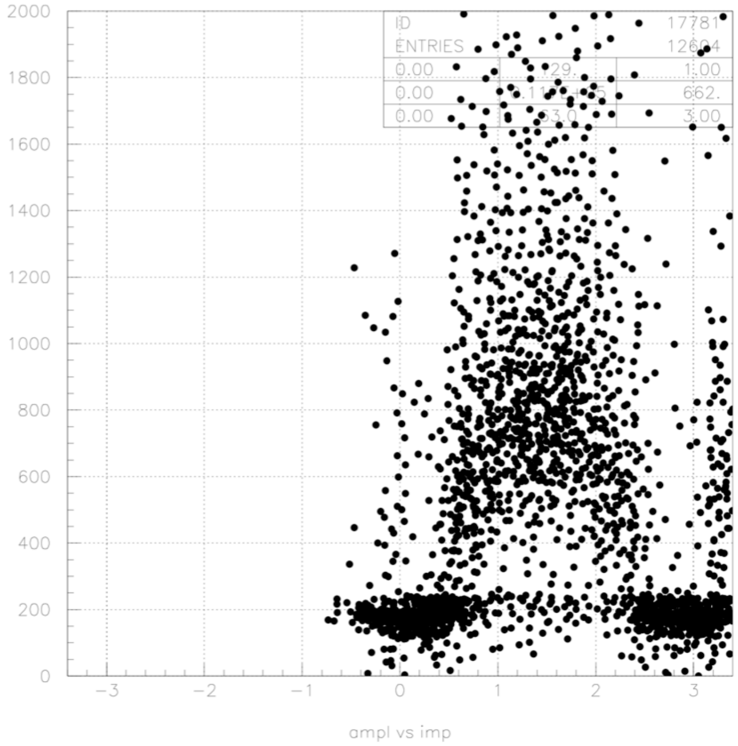


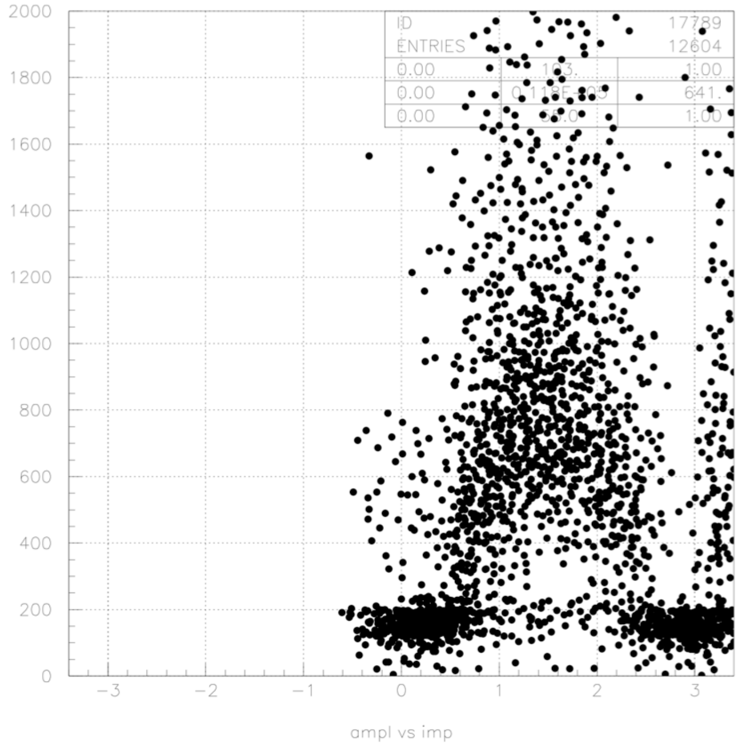


Almost no selection in these Space Time Relations

- Very loose χ^2 cut
- No constraint on amplitude (ADC reading)
- Expect to be able to clean up the above plots substantially

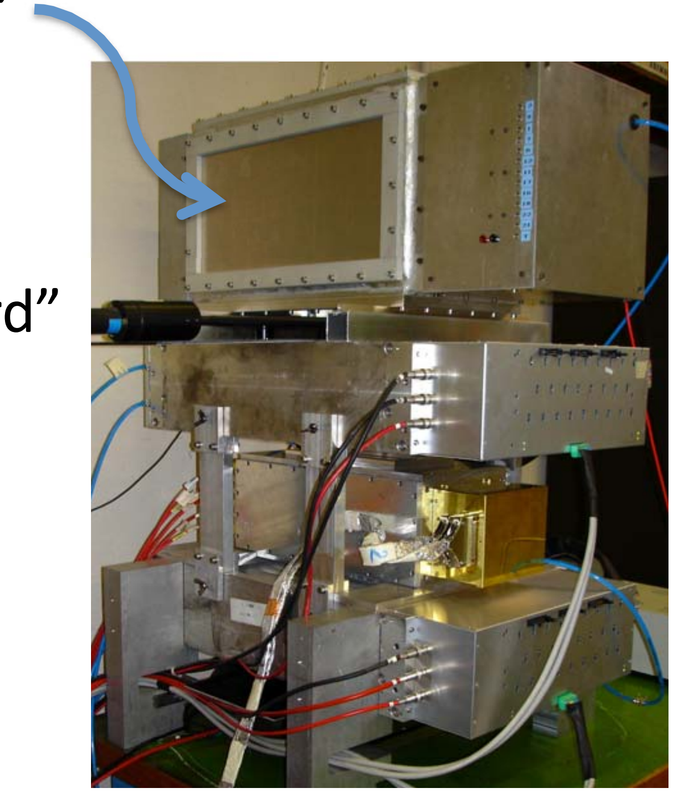
Charge vs. impact parameter - (VERY!) Preliminary





Waveform digitization

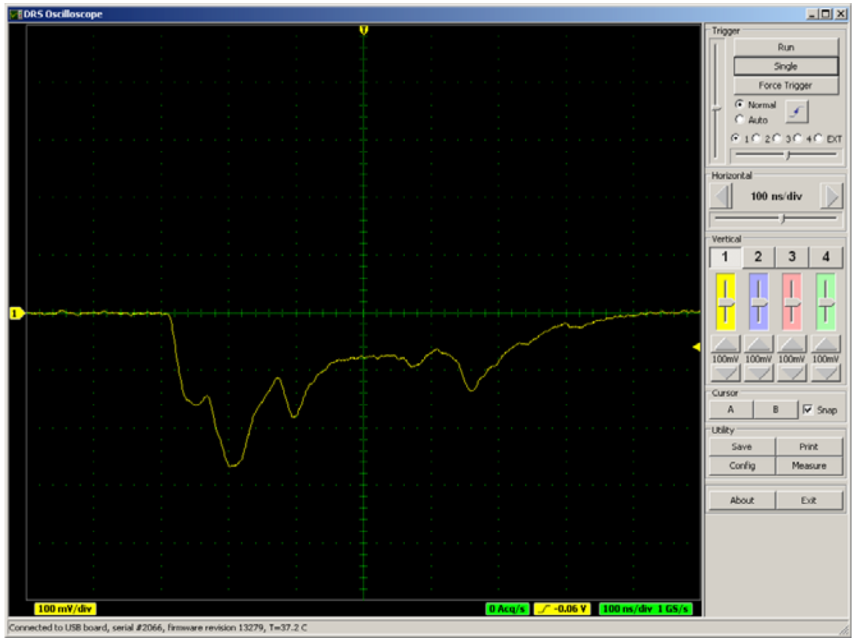
- Using old KLOE prototype (2:1 square cells), featuring higher bandwidth preamps than proto1
- Mounted on top of tracking telescope
- Read out through DRS4(*) “evaluation board”

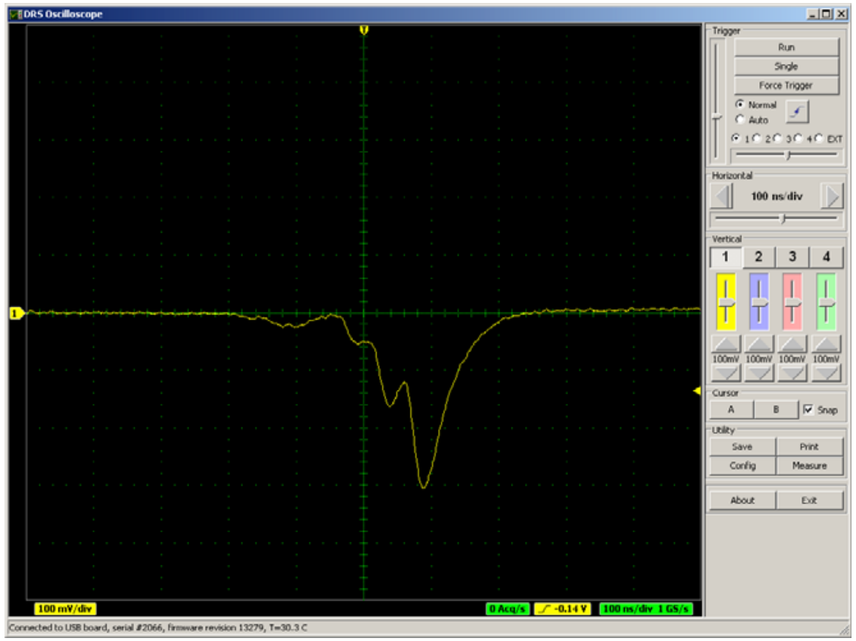


(*) A switched capacitor array (SCA) with 1024 cells, capable of digitizing eight analog signals with high speed (6 GSPS) and high accuracy (11.5 bit SNR) on a single chip (http://drs.web.psi.ch/)
[only 4 channels read-out with current version of firmware]

Waveform digitization

- 2 “random” examples, self-triggered (ext. trigger can be used instead)
  - left: SuperB proto 1, preamp. bandwidth ~100MHz
  - right: KLOE proto 0.2, preamp. bandwidth ~300MHz
- 1024 cells, 1GS/sec 100ns/div
- Work in progress to include digitized waveforms in the DAQ chain of tracking telescope
  - want to correlate recorded pulses with track impact parameter

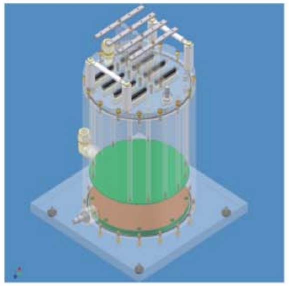


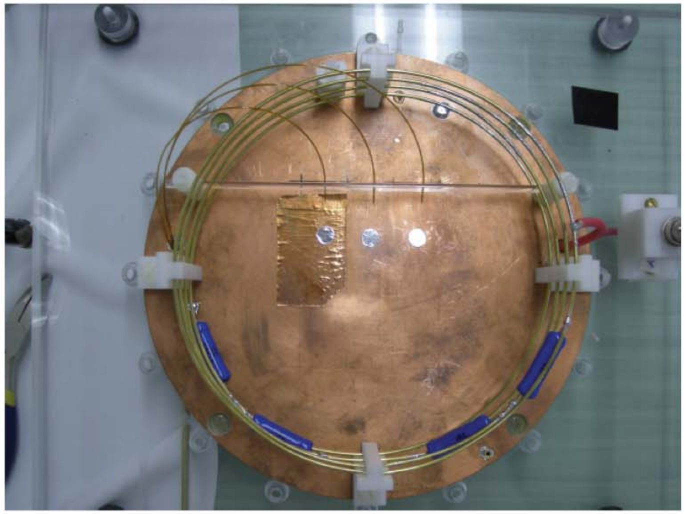


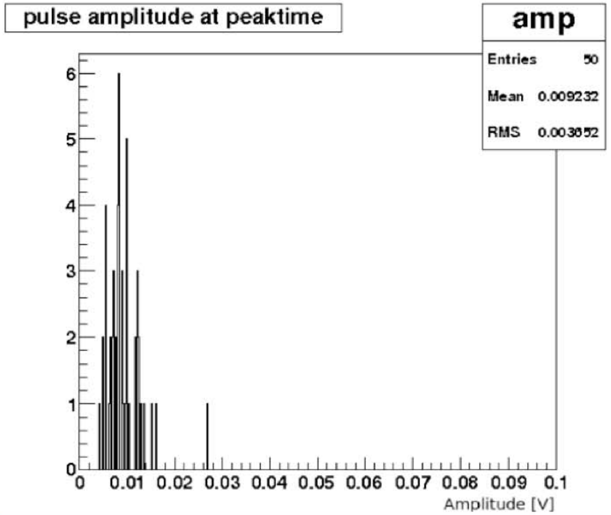
Lab activities @ UVIC

Gas Gain Studies

- Gas gain measurements made simultaneously with with the laser-photoelectron TPC setup.
- Uses Poisson fluctuations from the photoelectrons







Lab activities @ UVIC

Preparing for new prototypes

- last month have shipped the following

from SLAC and Princeton to TRIUMF

- BaBar feedthroughs
- connector boards
- Crimp tools
- W sense wire
- Al field wire (Au)

hypertronic connectors still to come from Colorado

Summary

- Despite limited manpower, a lot of progress since October meeting
- Hopefully fresh forces can start working on most critical items (background) soon