DCH Summary

4th SuperB Meeting –

Elba, June 2012

G. Finocchiaro – M. Roney

Main Discussion topics

- Cluster counting: simulation studies

16:00	Intro and Cluster Counting Garfield Studies (I) (20')	Giuseppe Finocchiaro (*LNF*)
16:20	Cluster Counting Garfield Studies (II) (20')	Giulietto Felici (*LNF*)

- Cluster counting: experimental talks

16:40	Update on Cluster Counting studies (20')	Marcello Piccolo (*LNF*)
18:00	November '11 beam test data analysis and plans for August 2012 beam test (20') (Slides)	Christopher Hearty (*University of British Columbia/IPP*)

- Cluster counting: physics reach

09:10	FastSim studies of the impact of cluster counting (20')	Elisa Manoni (*PG*)

- Electronics + trigger

18:40	DCH preamplifier: input stage optimisation (20')	Jean-Pierre Martin (*University of Montreal*)
19:00	Update on DCH Trigger (20')	Paolo Branchini (*ROMA3*)

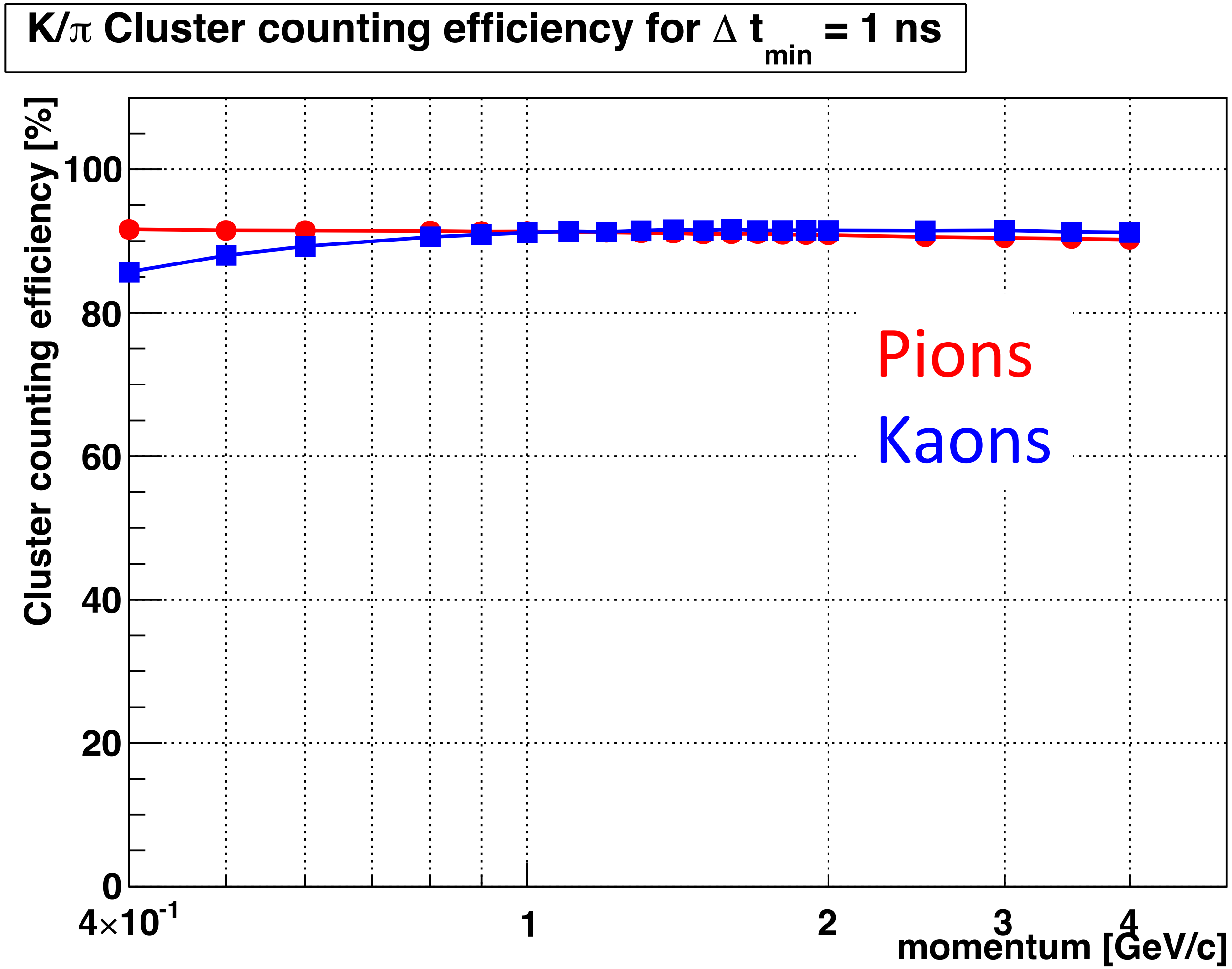
- Mechanics and integration

08:50	Update on DCH mechanics and integration (20')	Stefano Lauciani (*LNF*)

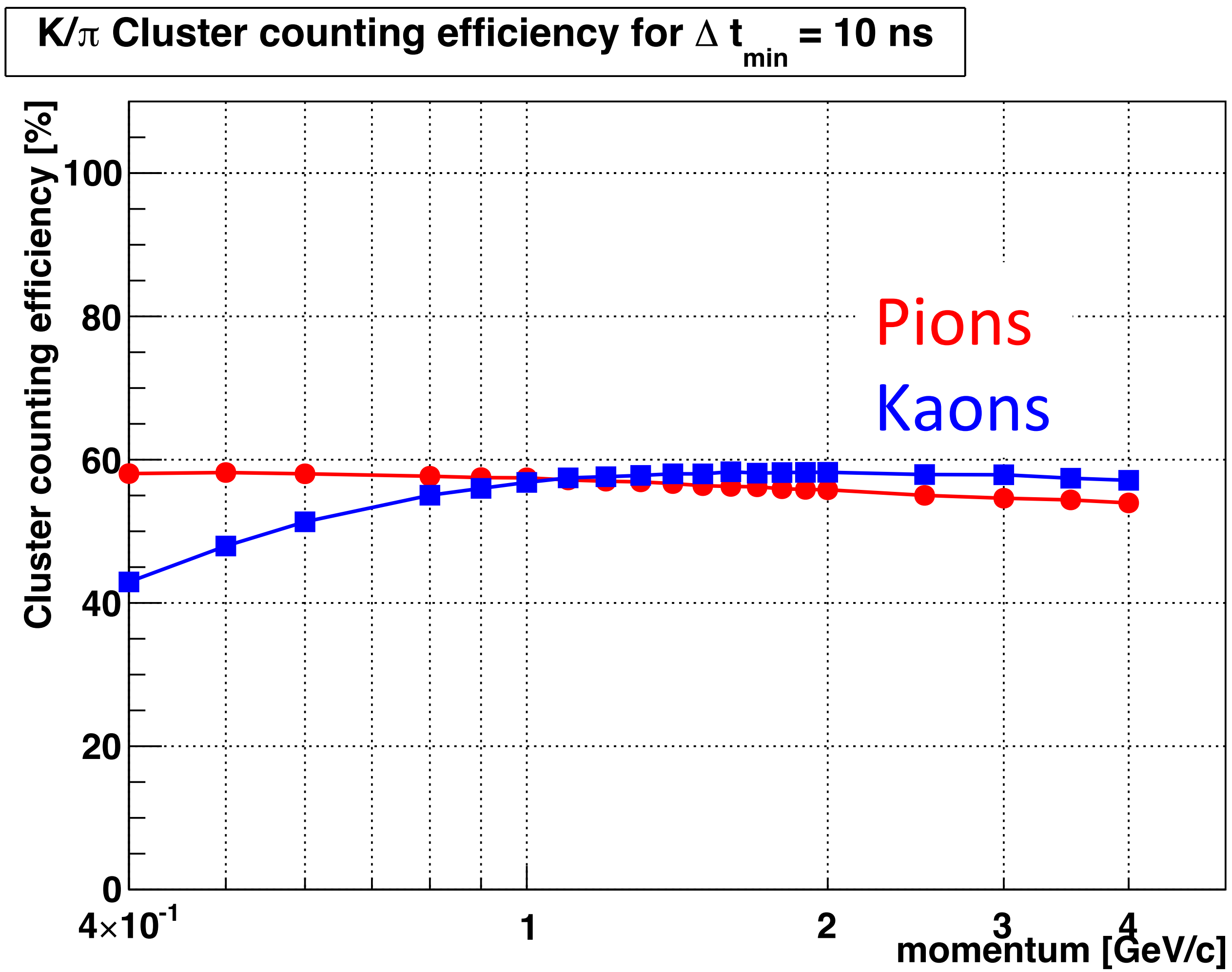
ε(cluster counting) vs. p for Δt_{min}=1ns

ε(cluster counting) vs. p for Δt_{min}=1ns

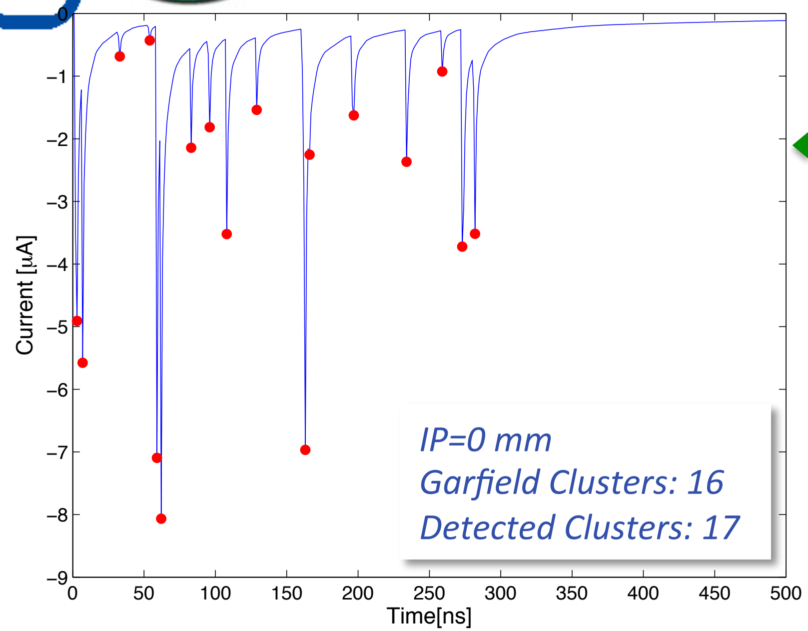
$\Delta t \equiv$ t(cluster # i) – t(previous found cluster)



ε(cluster counting) vs. p for Δt_{min}=1ns

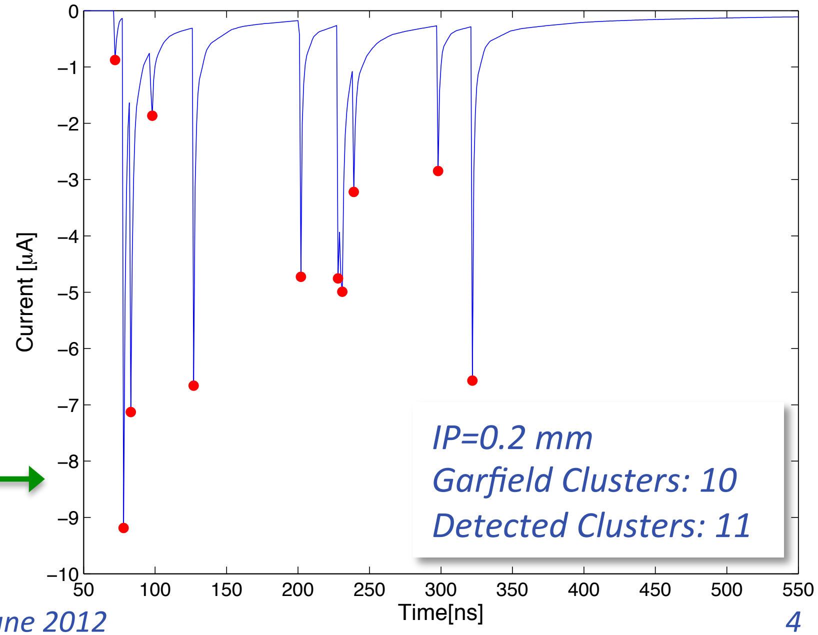


SNR = ∞ ; Detected clusters fluctuation (I)

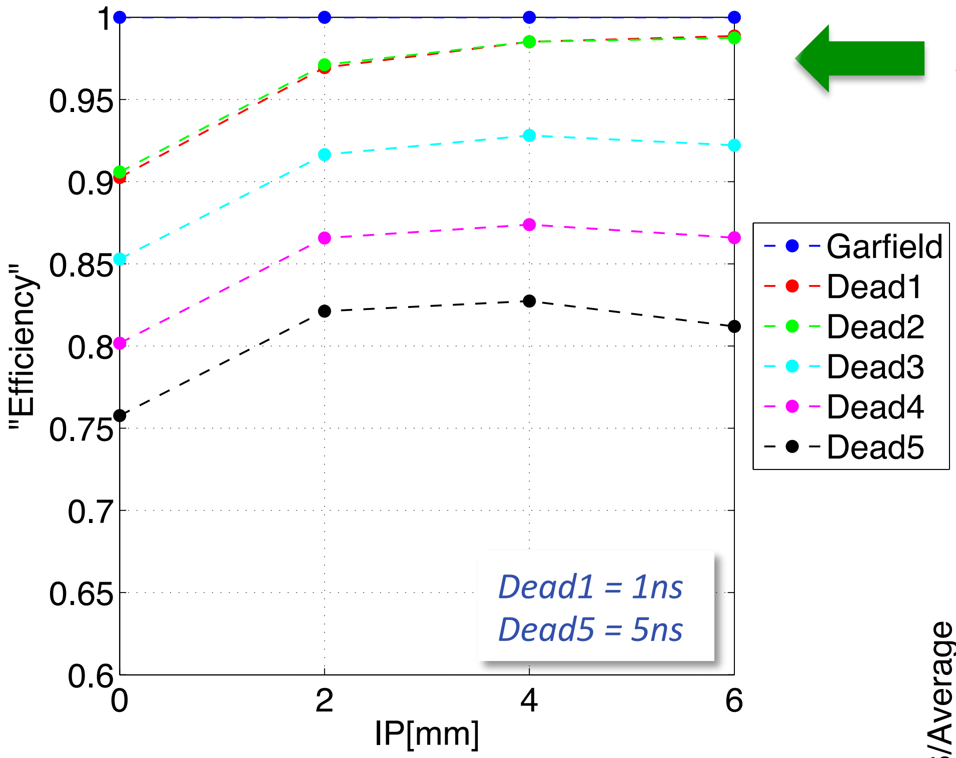


Ev#	Garfield	Detected
0	16	17
1	15	15
2	16	15
3	12	9
4	17	17
5	10	11
..	…	…

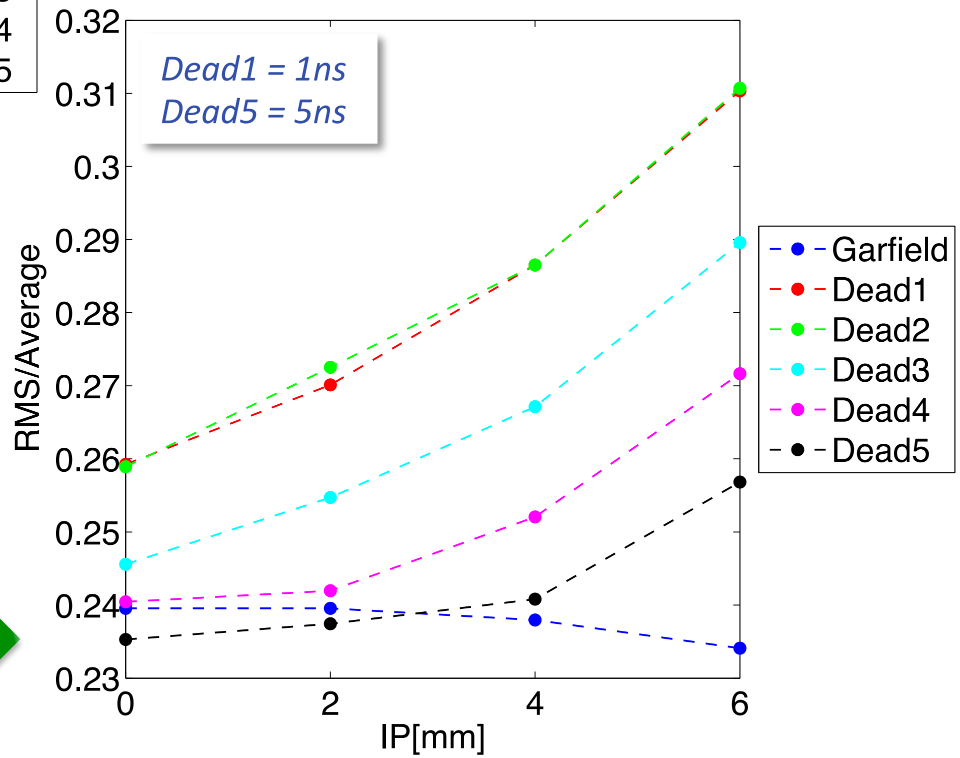
Ev#	Garfield	Detected
0	16	21
1	15	13
2	16	17
3	12	10
4	17	19
5	10	11
..	…	…



SNR = ∞ - “Efficiency” & “Quality Factor” vs Dead Time



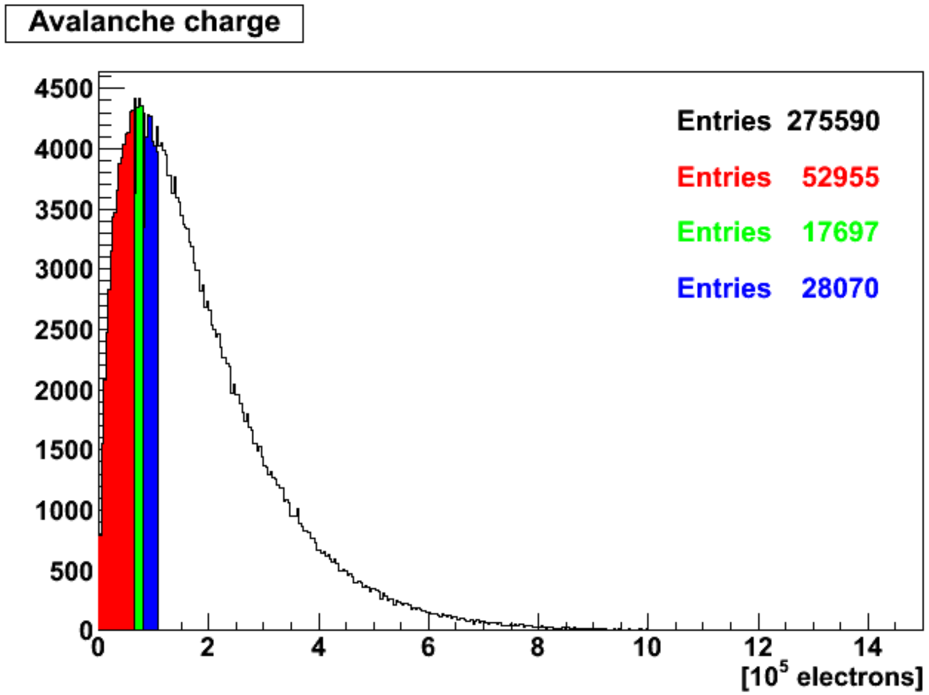
Detection “Efficiency” vs Dead Time



“Quality Factor” vs Dead Time

Signal-to-noise Ratio

- In addition to the rearming time of the counting algorithm, also the noise level must be taken into account
  - "any algorithm has a threshold"
- Example: charge in the electron avalanche
  - A Polya distribution with mean 1.8×10^5 and $\theta=0.6$



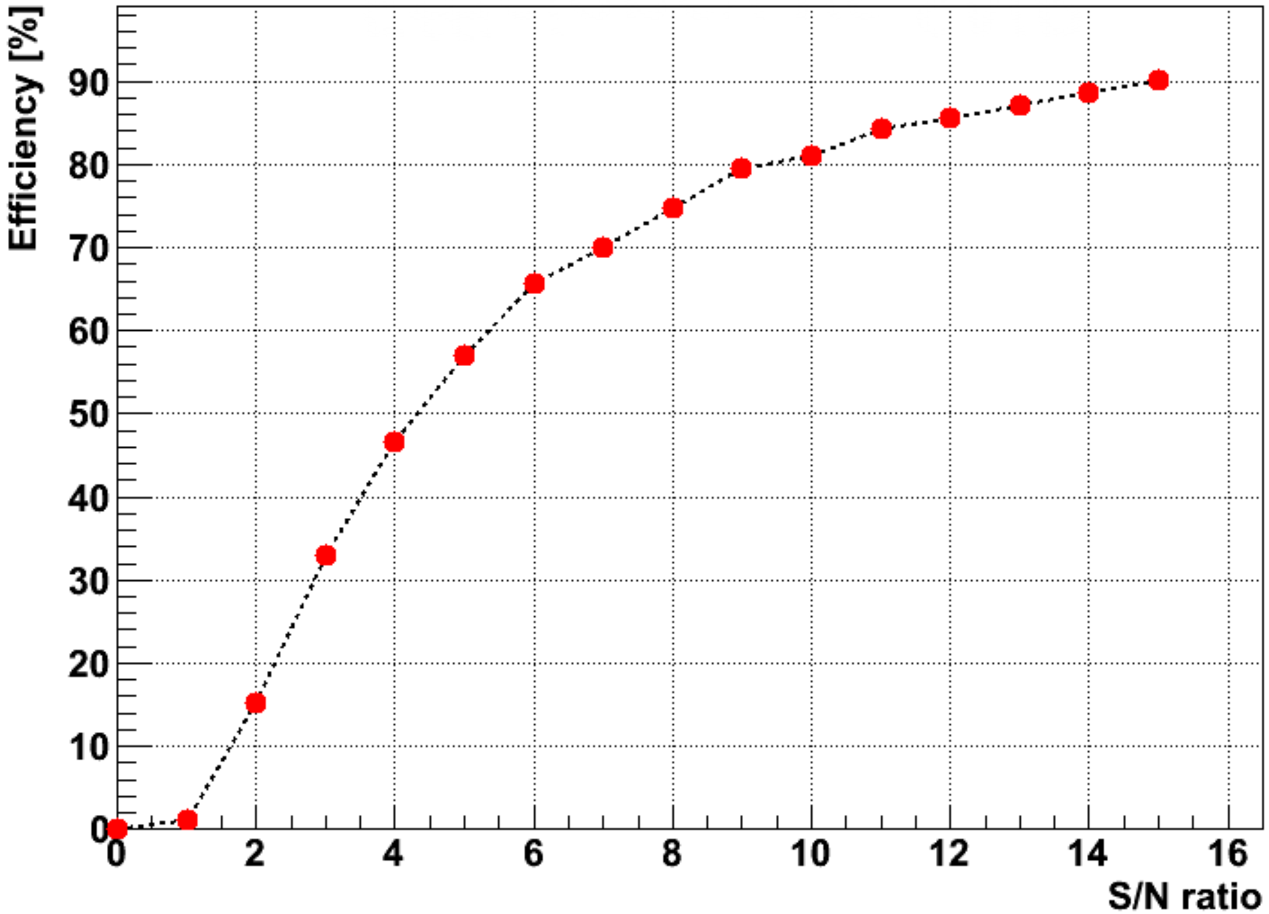
SNR=10 – ε = 81.1%

SNR= 8 – ε = 74.7%

SNR= 6 – ε = 65.6%

Threshold = 3.5 x RMS(noise)

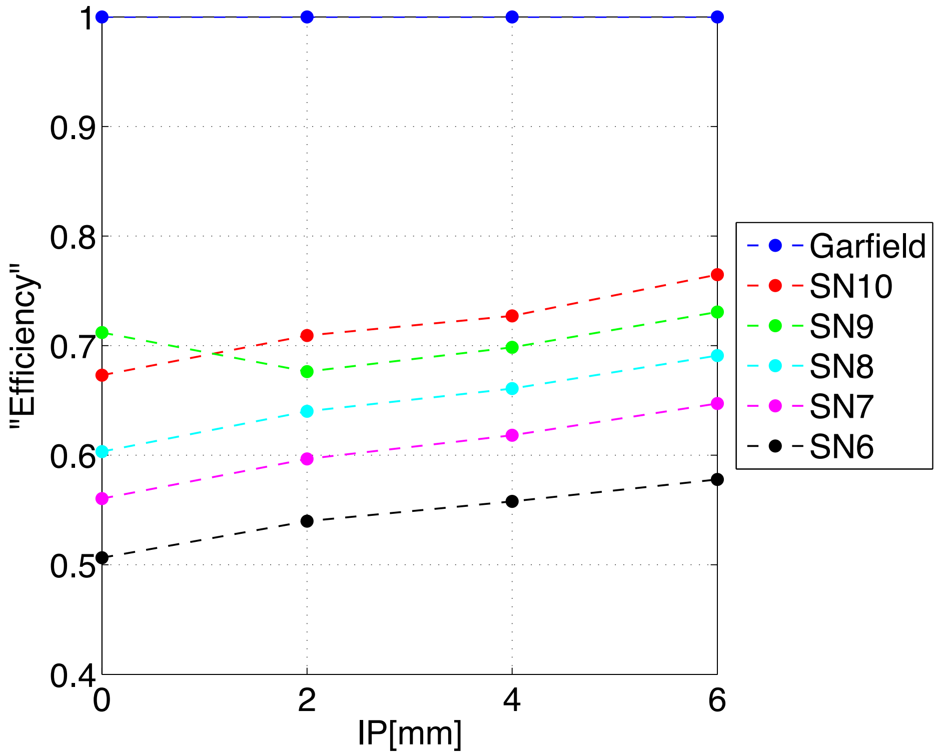
Efficiency vs SNR

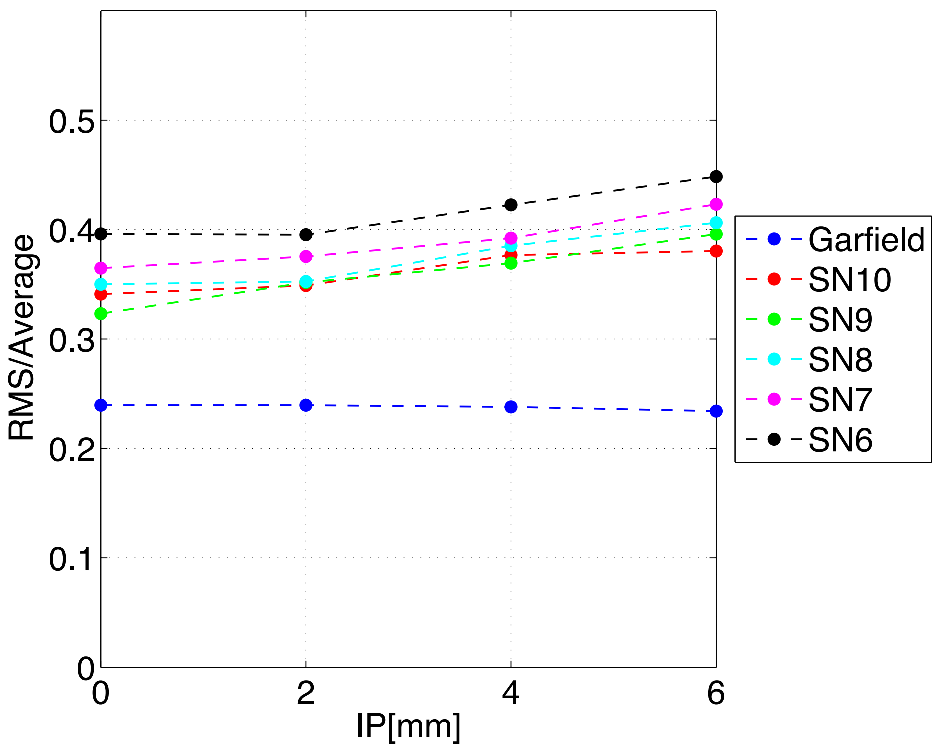


- Typical average single-electron amplitude in prototype 2: 20mV
  - typical RMS noise: 3.6mV ➪ **SNR ~ 5.5** (!!)

Detected clusters (efficiency & "quality factor") vs SNR

BW= ∞ ; 10kΩ transimpedance ; Noise; Dt=2 ns

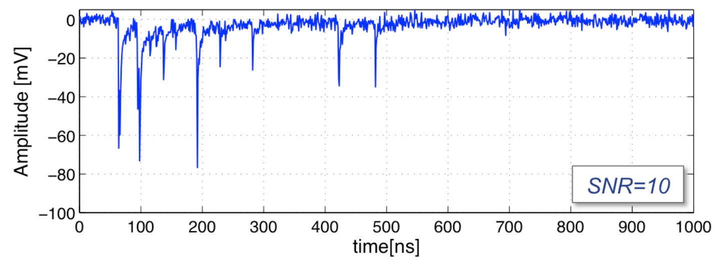




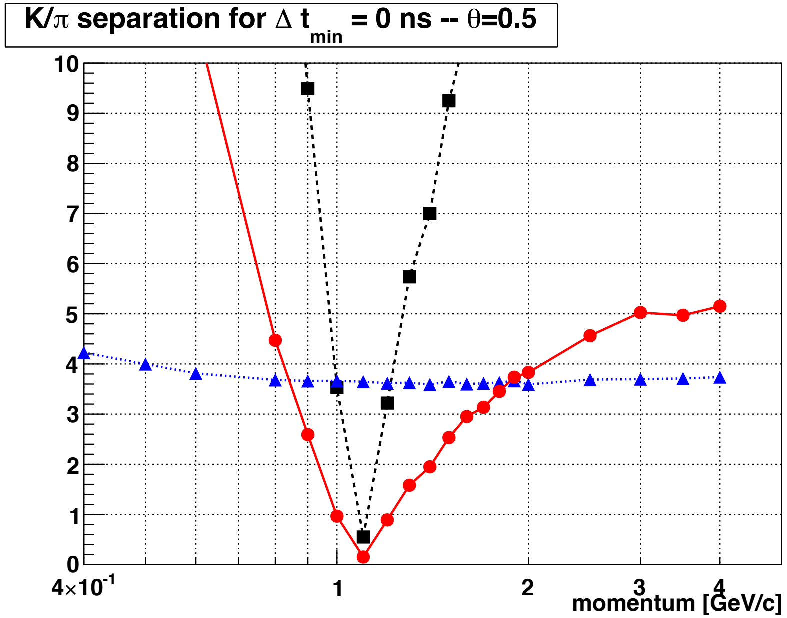
$$D = A_n - \left(\frac{A_{n-1} + A_{n+1}}{2}\right) \geq 4\sigma_d$$

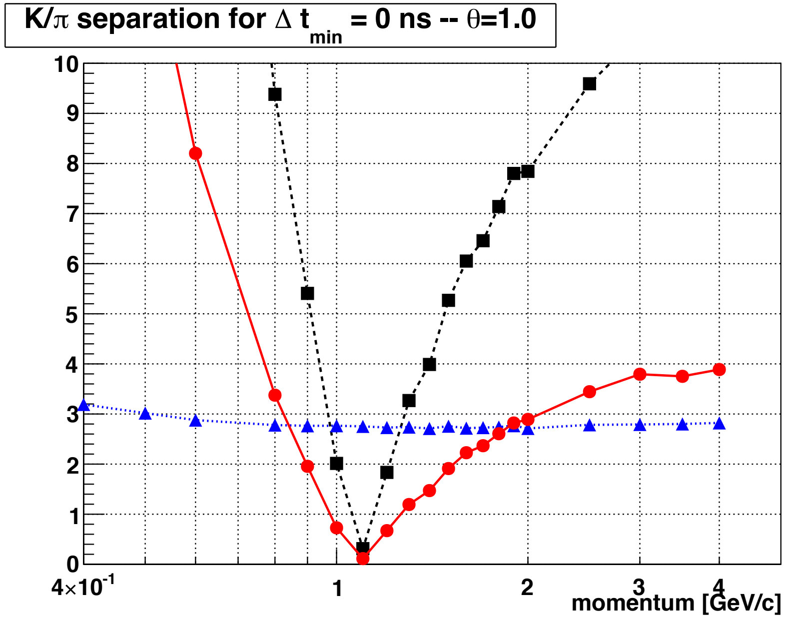
Peak Found Condition

Luigi Cappelli
on behalf of CLUTIM Group



K/π separation for ε=1

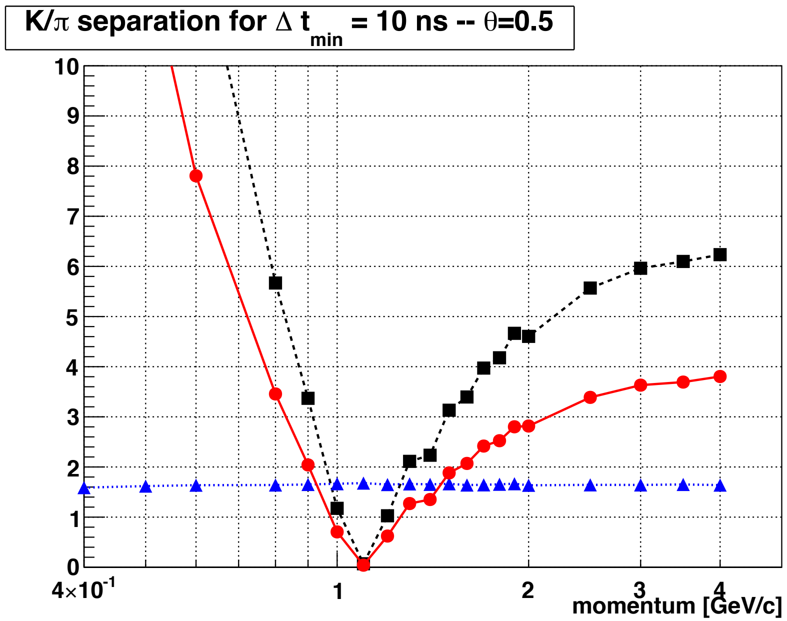


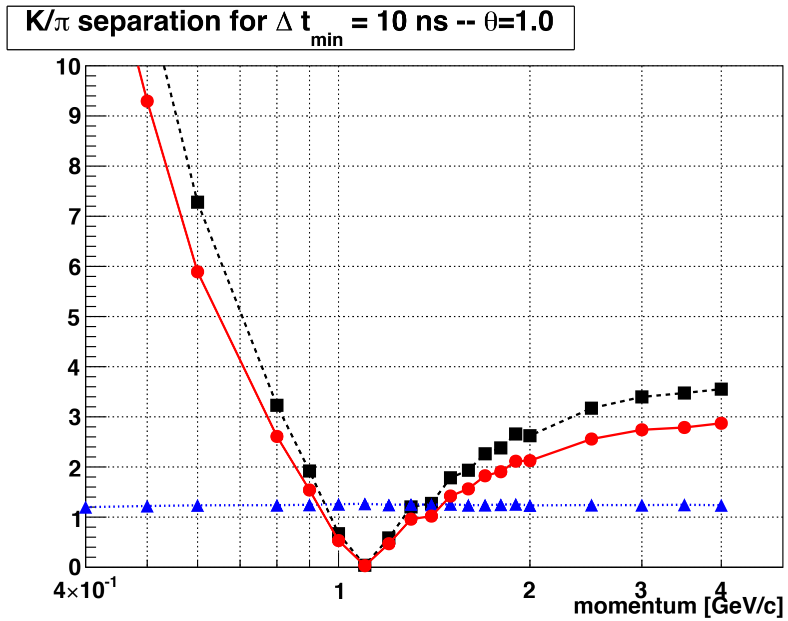


- Total track length normalized to a drift chamber with 40 layers of 1.2cm high rectangular cells
- $\langle \sigma \rangle \equiv (\sigma_K + \sigma_\pi)/2$
- separation ≡ $|N_K - N_\pi| / \langle \sigma \rangle$

■ $|N_K - N_\pi|/10$
▲ $\langle \sigma \rangle/10$
● separation

K/π separation for Δt_{min} = 10ns





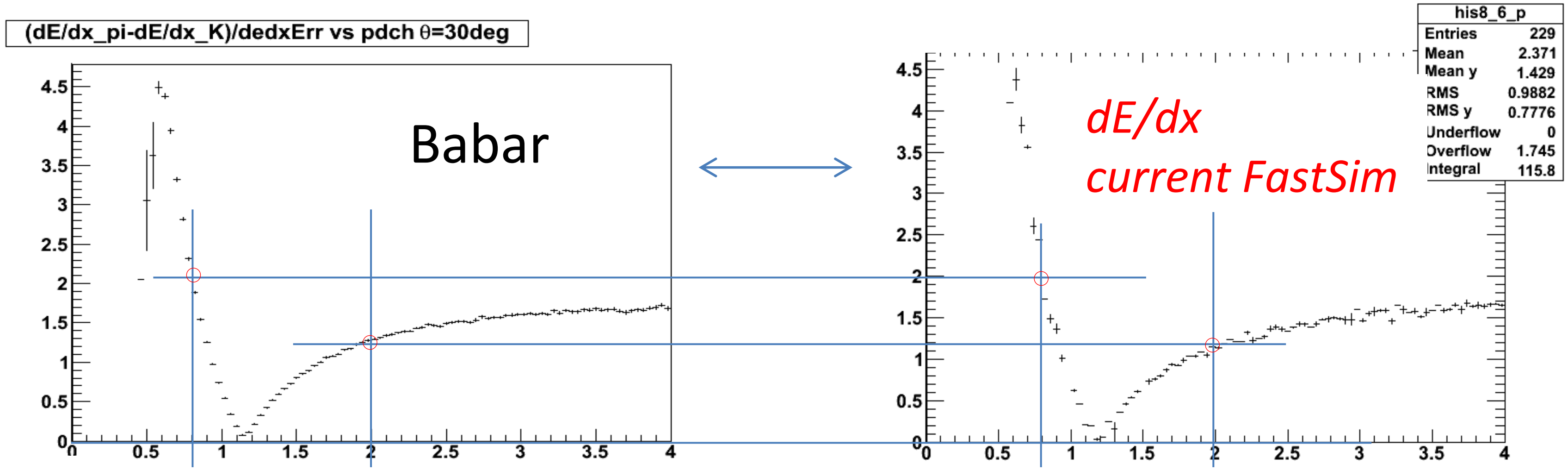
■ $|N_K - N_\pi|/10$

▲ $\langle\sigma\rangle/10$

● separation

K/π separation in FastSim

- Realistically model performance of cluster counting vs. dE/dx in `FastSim`

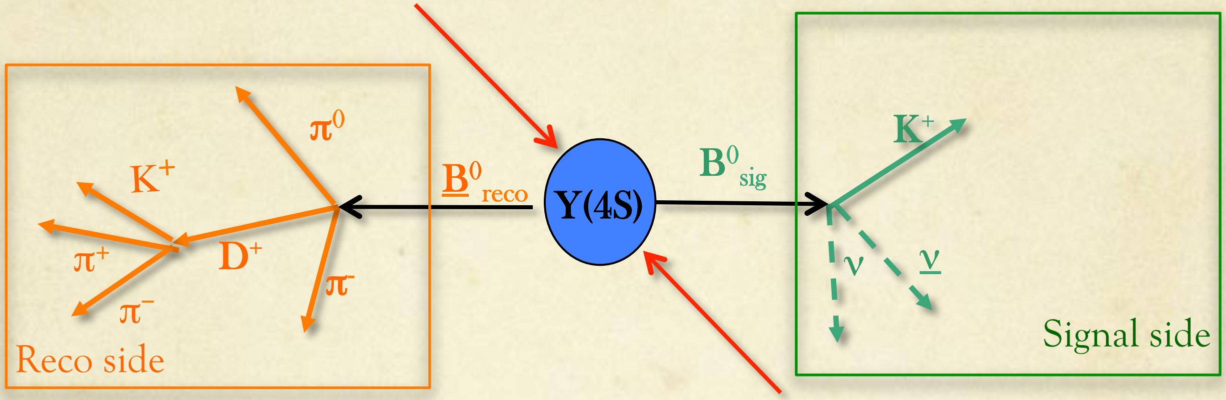


- Parameterize K/π separation from cluster counting as an improvement over conventional dE/dx
  - 1.3, 1.5, 1.7, 2.0 times better separation

Aim of the study

E. Manoni

- Test impact on physics of kaon PID selectors incorporating Cluster Counting in DCH, using $B^+ \rightarrow K^+ \nu\nu$ against Hadronic B_{reco} analysis



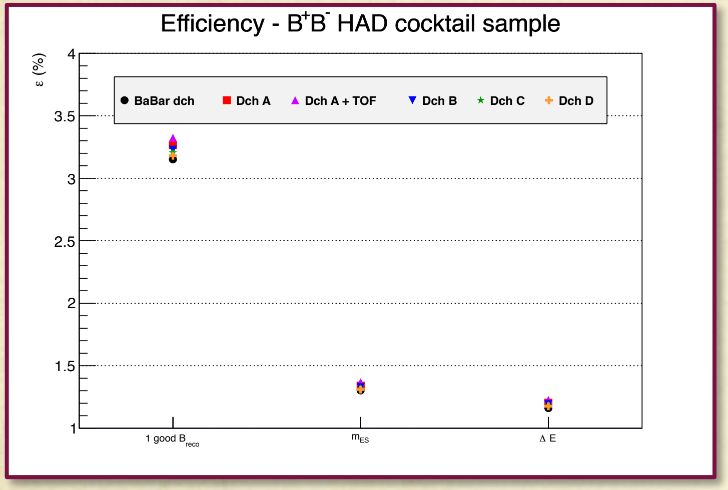
- Configurations for CC performances

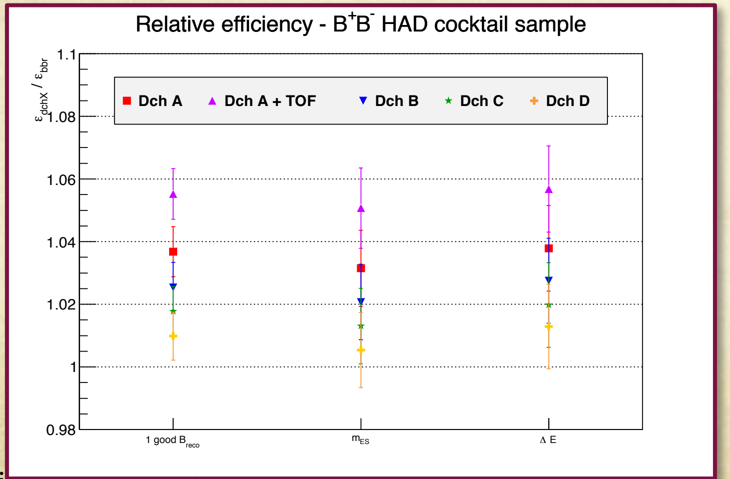
DCH bbr	DCH A	DCH A + tof	DCH B	DCH C	DCH D
0%	100%	100% + fwd tof	70%	50%	30%

Improvement with respect to the BABAR dE/dx performance *averaged over theta and p*

B^+B^- HAD cocktail sample efficiencies

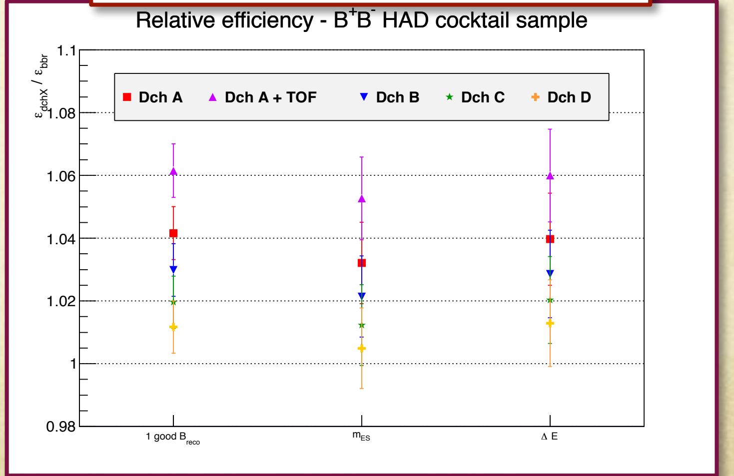
All B_{reco} modes





- K passing TightLHKaonSelection
- Best B_{reco} chosen according to smallest ΔE
- m_{ES} and ΔE selection

B_{reco} modes with at least 1 K (most of B_{reco} modes)



B^+B^- HAD cocktail sample efficiencies

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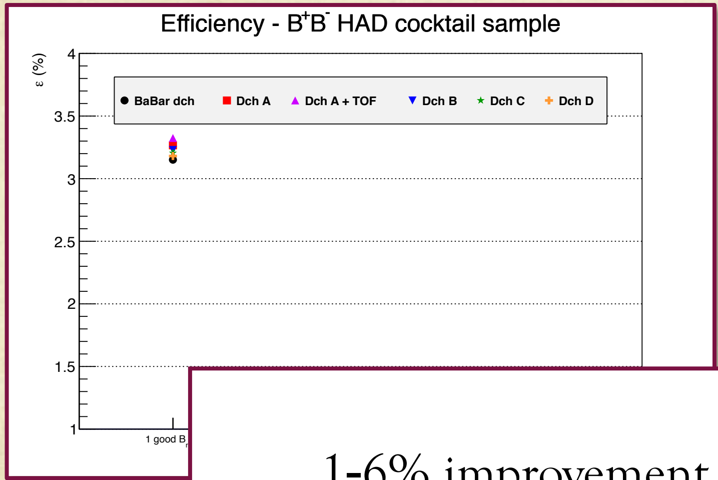
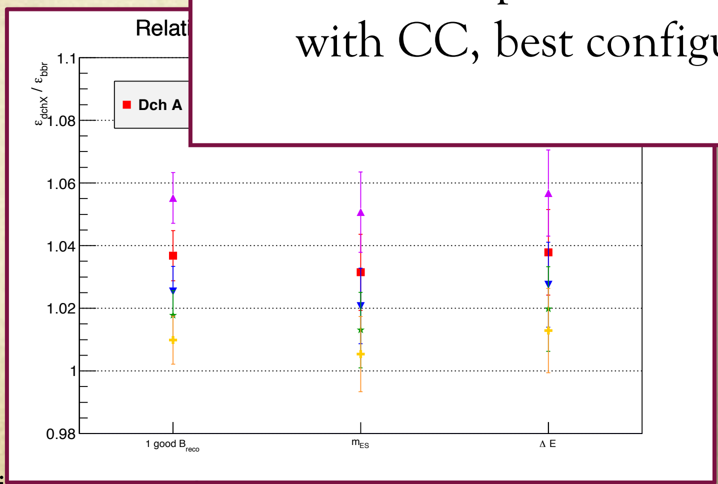
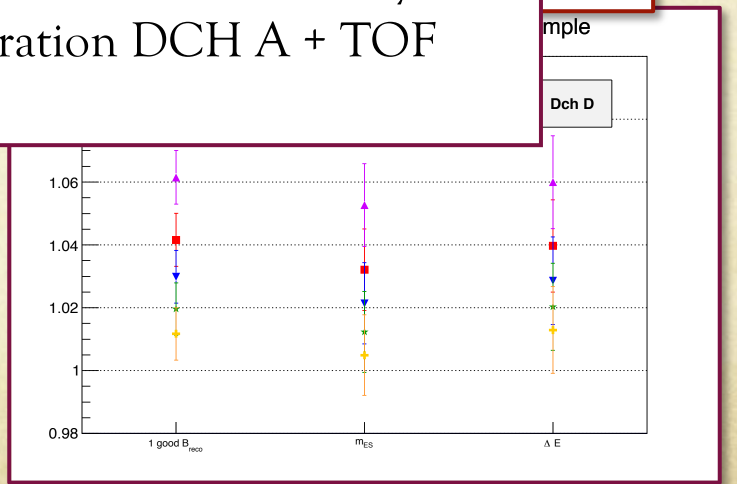


- K passing TightLHKaonSelection
- Best B_{reco} chosen according to smallest ΔE
- m_{ES} and ΔE selection

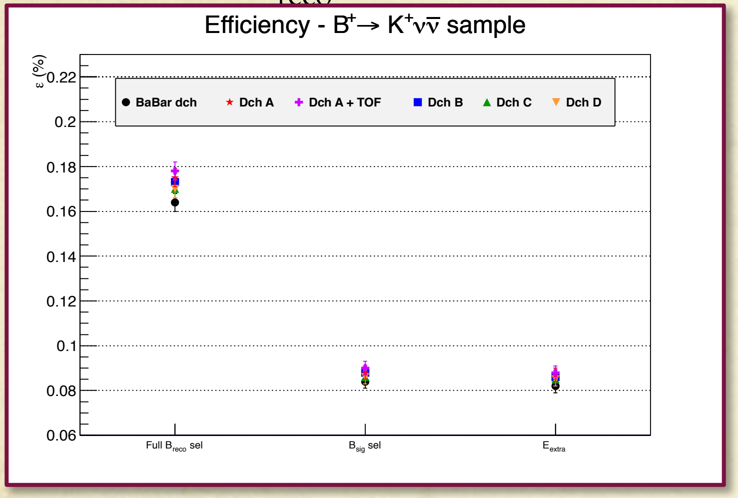
1-6% improvement in selection efficiency
with CC, best configuration DCH A + TOF



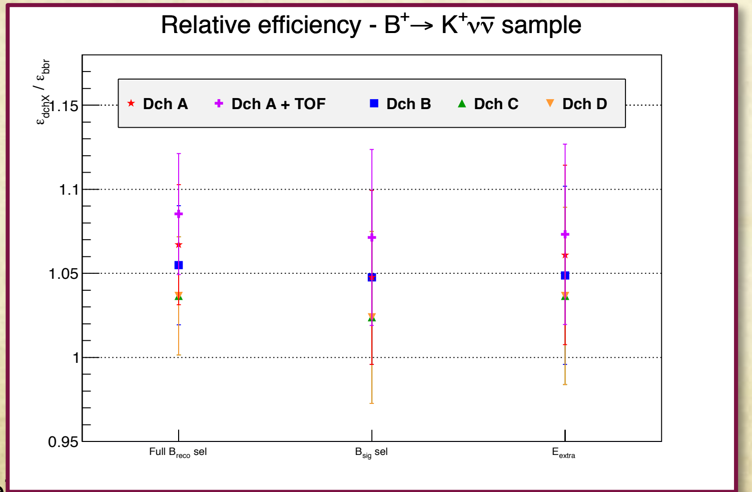


$B^+ \to K^+\nu\bar{\nu}$ signal MC efficiencies

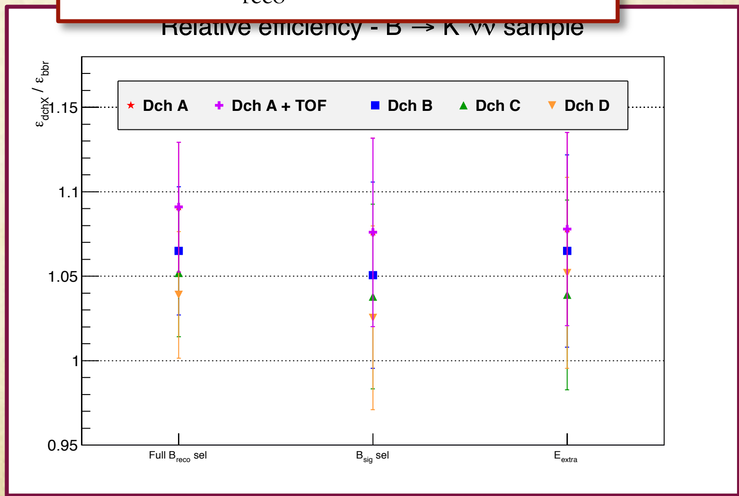
All B_{reco} modes



- Breco side selection
- 1 K passing TightLHKaonSelection and no extra tracks
- selections on p^*_K, $|\cos\theta_{miss}|$, E_{extra}



B_{reco} modes with at least 1 K (most of B_{reco} modes)



$B^+ \rightarrow K^+ \nu\bar{\nu}$ signal MC efficiencies

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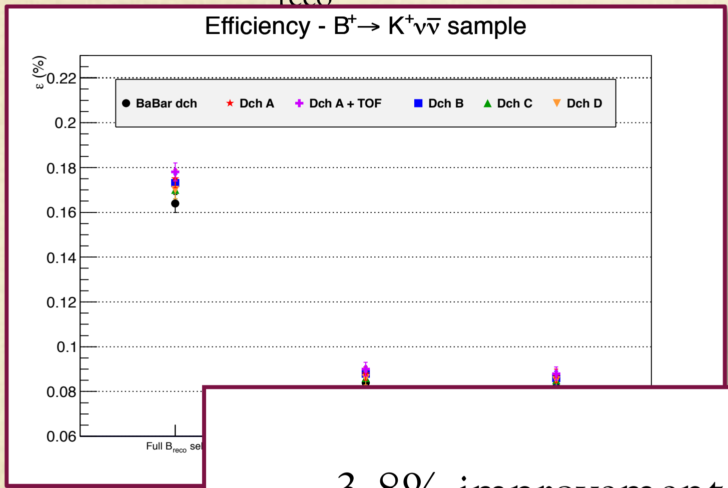

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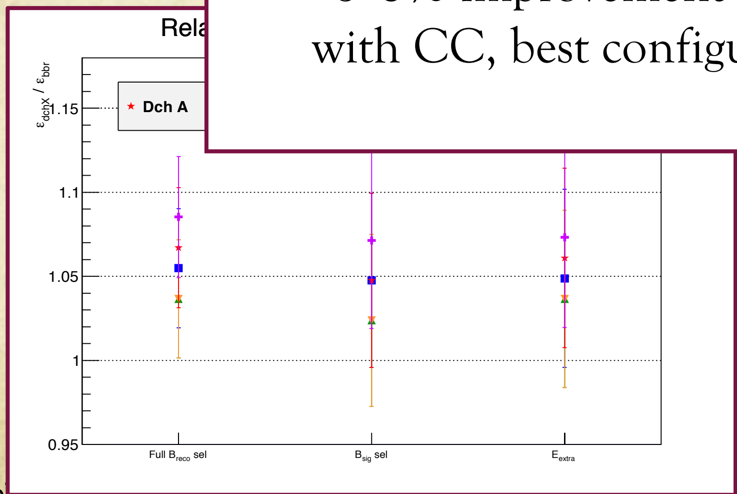
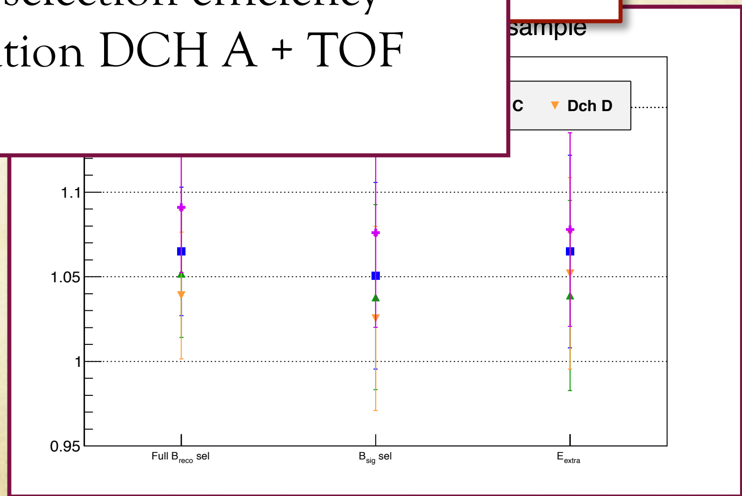
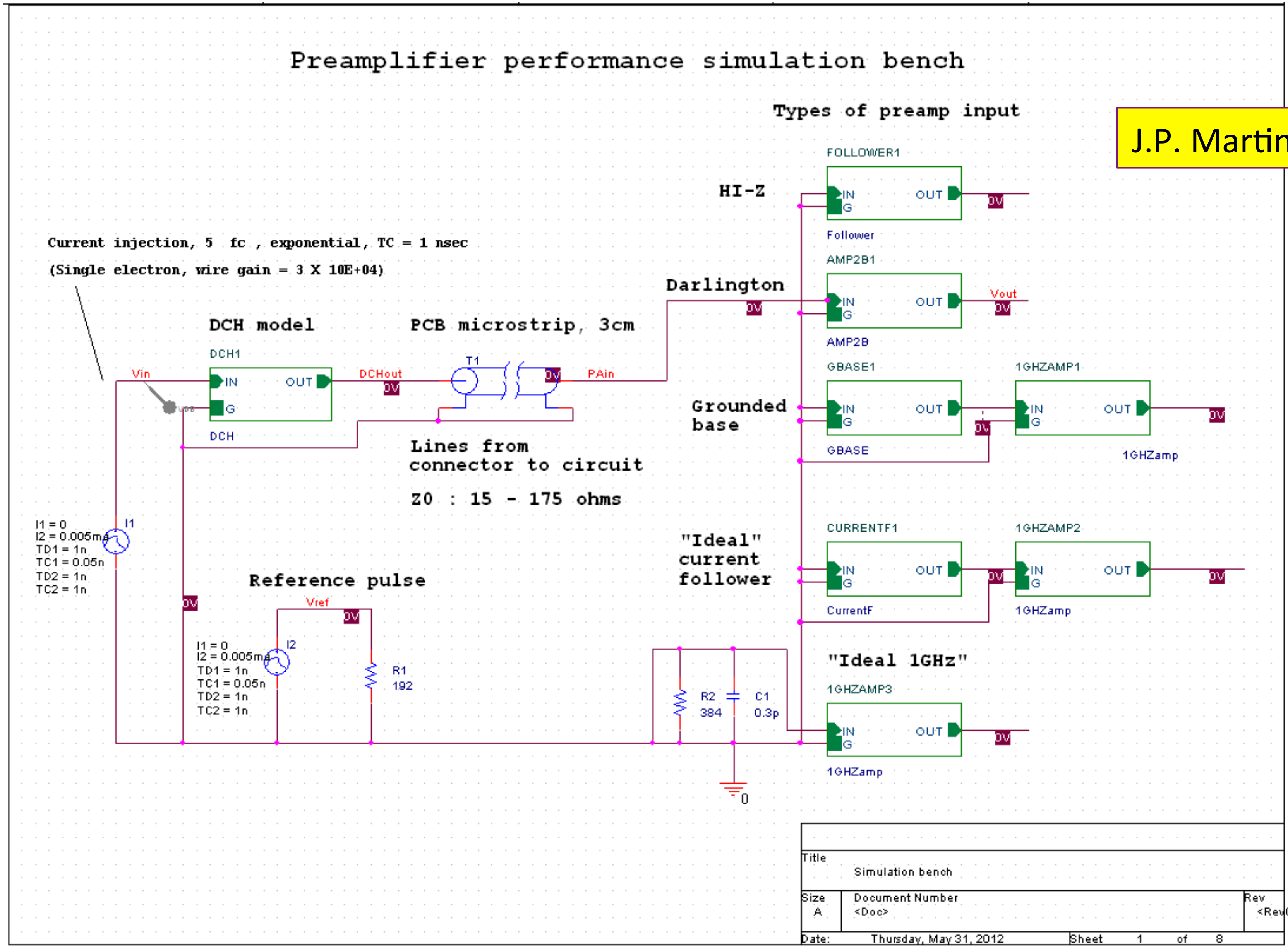




3-8% improvement in selection efficiency with CC, best configuration DCH A + TOF



Preamplifier performance simulation bench
Types of preamp input
FOLLOWER1
HI-Z
Follower
AMP2B1
Darlington
Vout
AMP2B
Current injection, 5 fc , exponential, TC = 1 nsec
(Single electron, wire gain = 3 X 10E+04)
DCH model
PCB microstrip, 3cm
DCH1
T1
Vin
DCHout
PAin
DCH
GBASE1
1GHZAMP1
Grounded base
GBASE
1GHZamp
Lines from connector to circuit
Z0 : 15 - 175 ohms
I1 = 0
I2 = 0.005mA
TD1 = 1n
TC1 = 0.05n
TD2 = 1n
TC2 = 1n
I1
CURRENTF1
1GHZAMP2
"Ideal" current follower
Reference pulse
Vref
CurrentF
1GHZamp
I2
R1
192
R2
384
C1
0.3p
"Ideal 1GHz"
1GHZAMP3
1GHZamp
Title
Simulation bench
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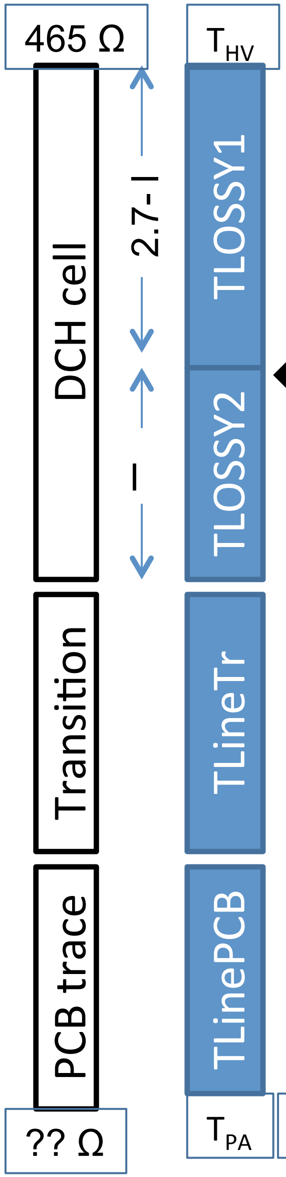
Date: Thursday, May 31, 2012
Sheet 1 of 8

J.P. Martin

MODEL ELEMENTS for the DCH



DCH cell:
Coax line approximation
Inner wire dia. : 25 microns
Outer diameter 15 mm.

Lossy transmission line parameters:
C = 8.68 pf/meter
L = 1279 nHy/meter
R= 250 ohms/meter
Z = 384 ohms

Current pulse injection, at l meter from the sense wire output

Section representing the crimp pin sockets, from the faceplate to the Motherboard PCB.
Modeled as a transmission line with 2 mm inner wire diameter and 15 mm OD. Z0 = 120 ohms, l = 1 cm

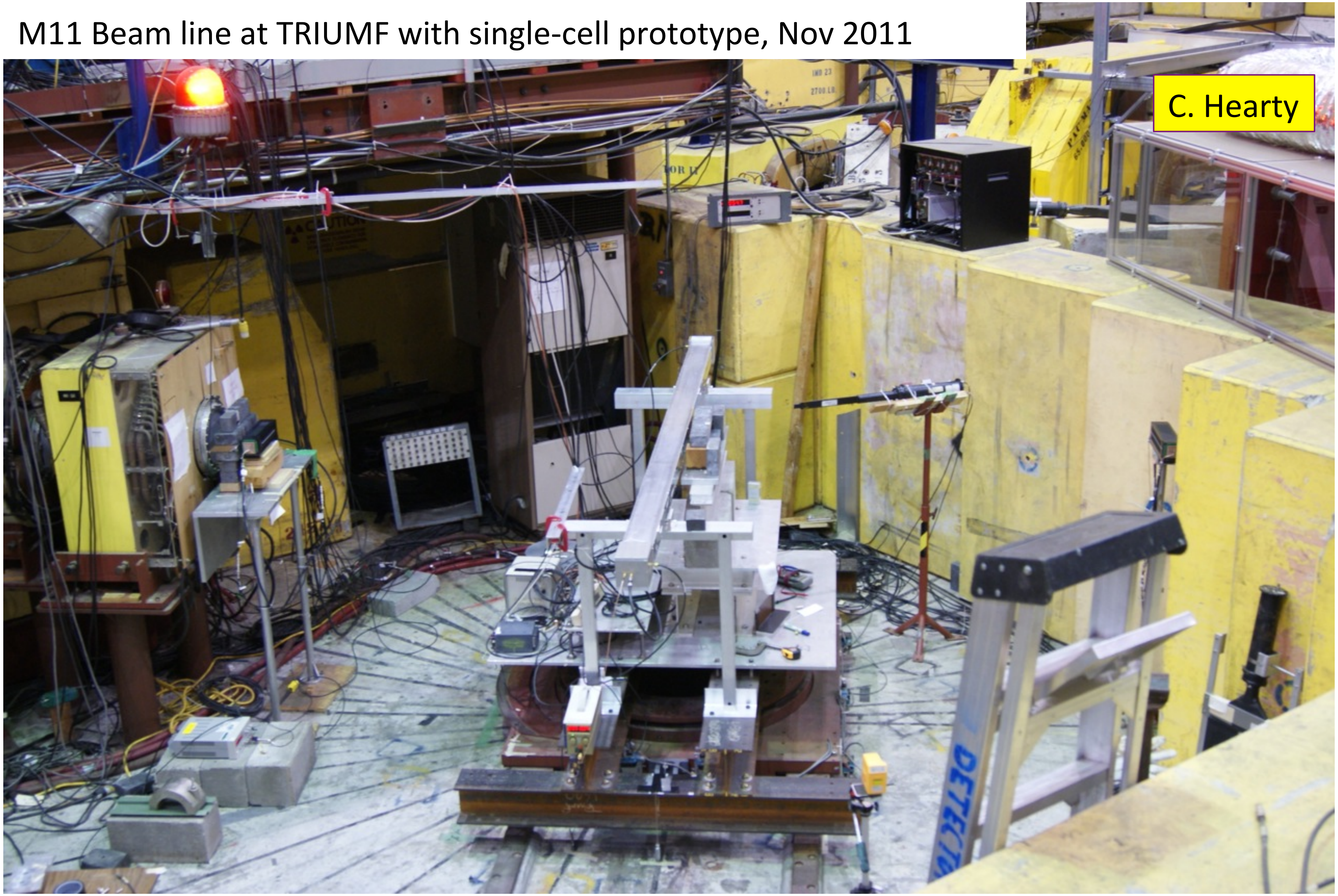
Section representing the PCB traces from the motherboard to the preamplifier Input.
Z0: tunable from 10 ohms to 175 ohms (line width, distance from GND plane)
l : up to 3 cm.

Ideal amplifier

Summary of the simulations

Scenario	Signal amplitude (millivolts)	Peaking time (nanosec.)	RMS noise (millivolts)	S/N
Ideal				
1A:Term. = Z0 chamber	0.396	0.44	0.029	4.30
1B: Term = stripline	0.291	0.40	0.028	3.50
1C: Term = stripline=transition	0.221	0.40	0.025	2.93
2: Term = 50 ohms	0.107	0.37	0.019	1.90
3: Current follower/50 ohms	0.116	0.36	0.037	1.06
Physical devices				
1A: Follower (384 ohms)	0.235	0.50	0.027	2.87
with 2 AD 8354 (4.2dB NF)	23.500	-----	4.300	1.82
1B: Darlington (175 ohms)	18.430	0.65	2.310	2.66
2: 50 ohms (2 AD8354)	10.700	-----	3.078	1.16
3: Grounded base transistor	0.098	0.39	0.039	0.83

M11 Beam line at TRIUMF with single-cell prototype, Nov 2011



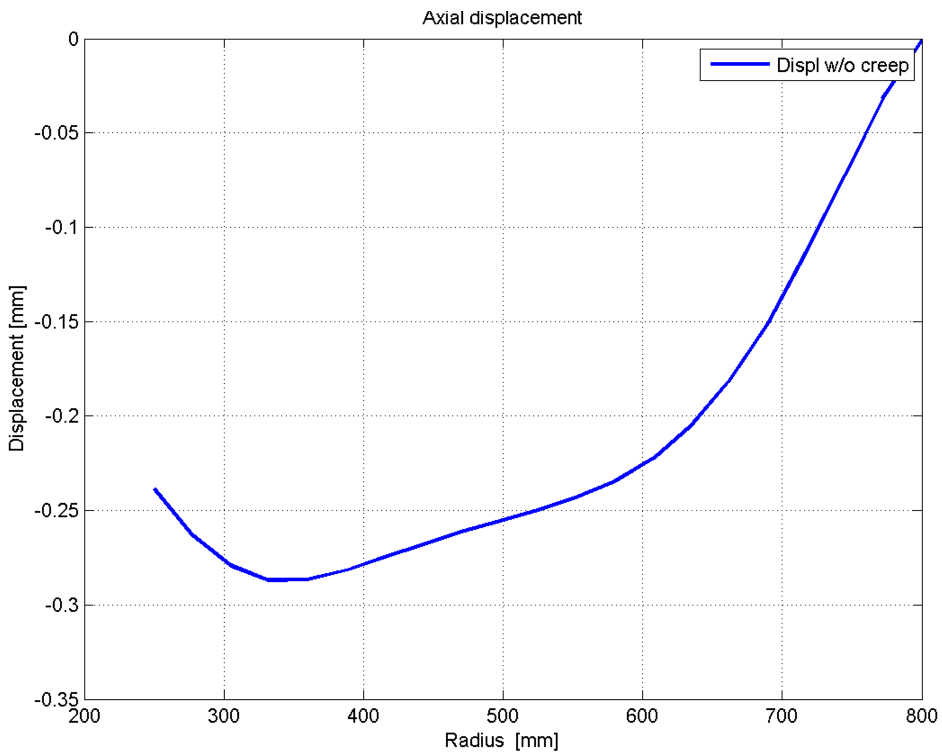
Goals for M11 beam test, Aug 2012

- Establish whether or not amplifier prototypes provided by JP Martin satisfy the requirements for cluster counting.
- Quantify the benefits of cluster counting compared to dE/dx
- Impact of sense wire diameter on PID performance
- Impact of analog cable choice on PID performance
- Impact of cable connectors on PID performance
- Impact of termination on PID performance
- Impact of gain on PID performance
- Normalization of current draw for aging calculations
- dE/dx data for Rocky So's thesis

Spherical Endplates - update of FEA

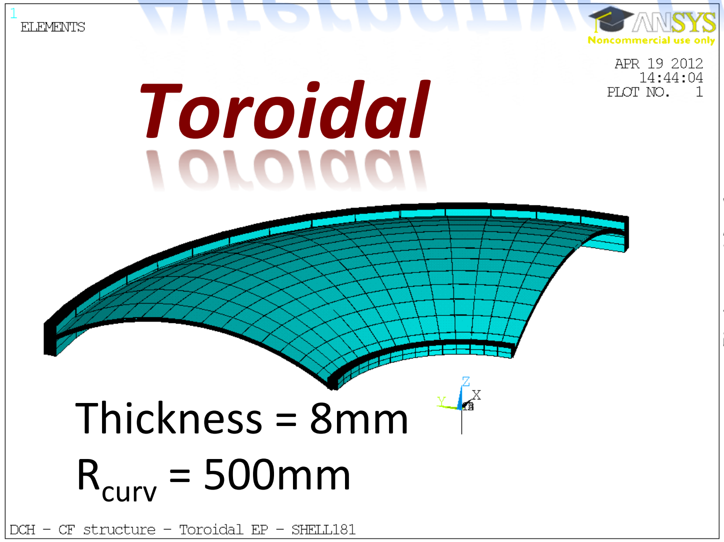
S. Lauciani

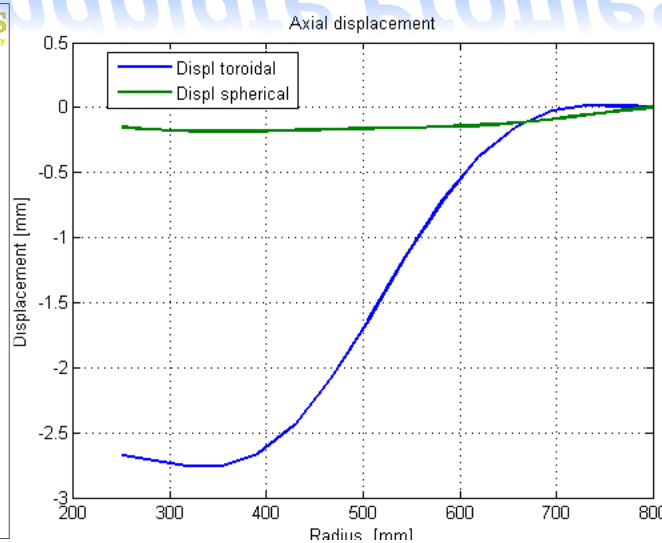
Wire type	Mat	d (mm)	N° Wires	Sag. (mm)	Avg length	T(gr)
Field	Aluminium	0.090	22914	0.2	2500	≈70
Sense	Molybdenum (AU coated)	0.025	7638	0.2	2500	≈21

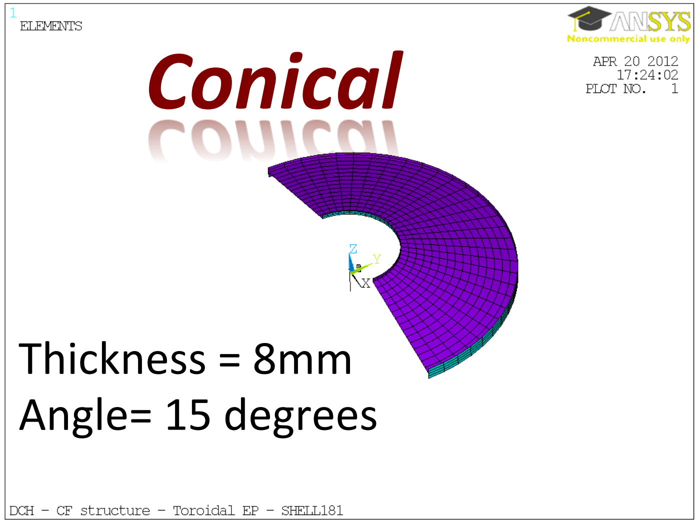


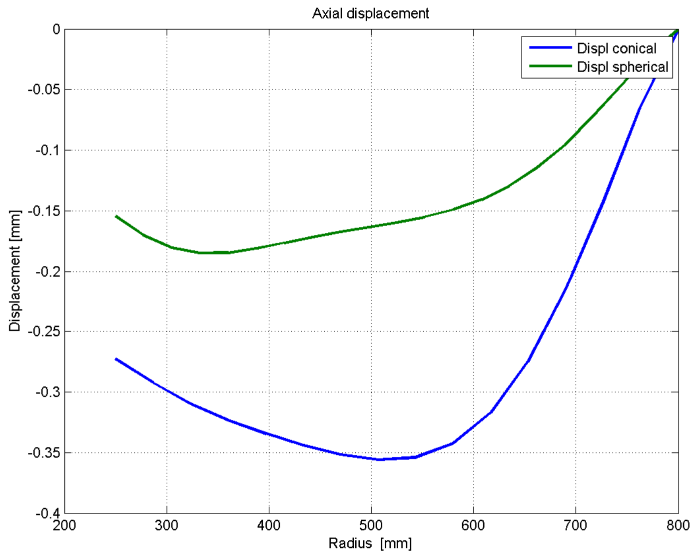
- Max displacement: 0.19mm → 0.28mm
- Total nominal load: 14268 N → 17631 N
- Total load after stringing: 13893 N → 16823 N (+20%)

Alternative Endplate Profiles



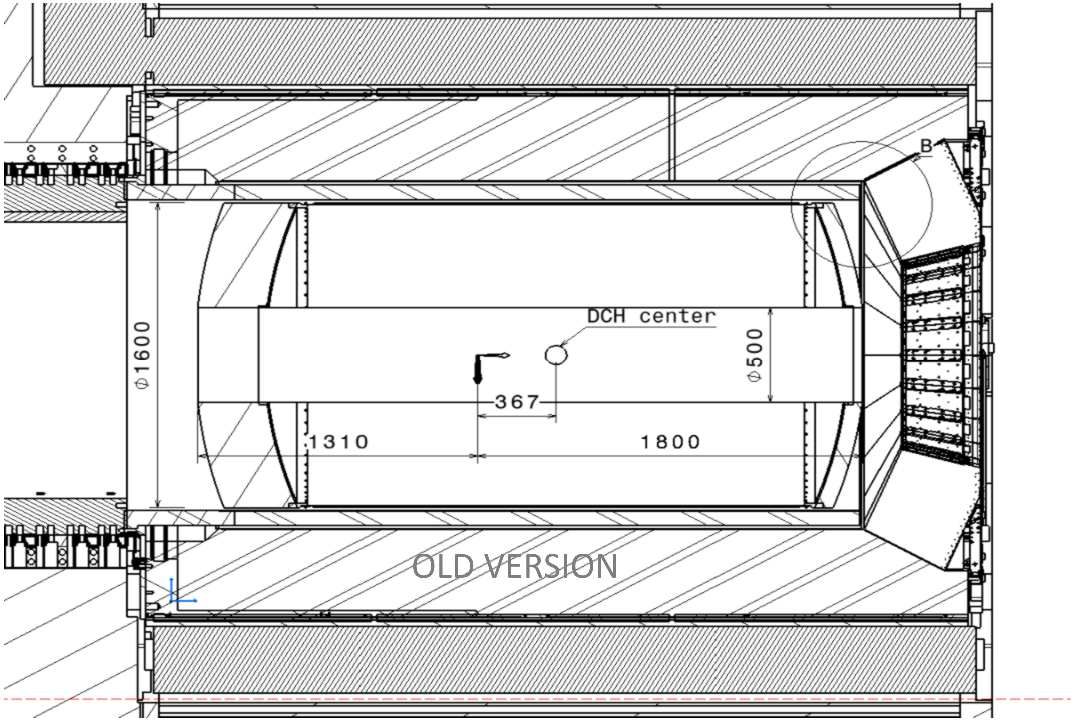


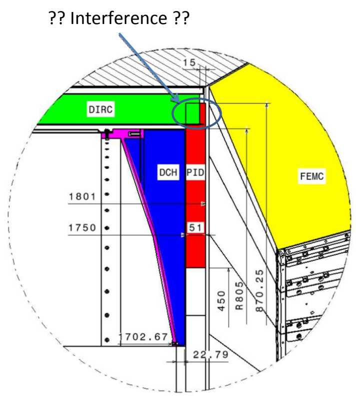




Integration

- R_{min} 250mm → 265mm (W shield)
- R_{max} 800mm → 809mm (as it was in *BABAR*)
- DCH length → Fully evaluate interplay with FTOF, FW+BW EMC, space needed for services and cables

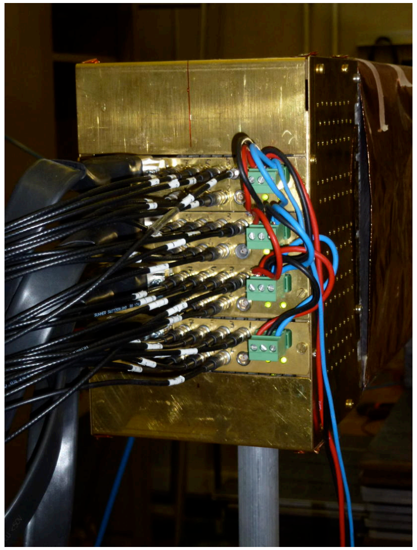




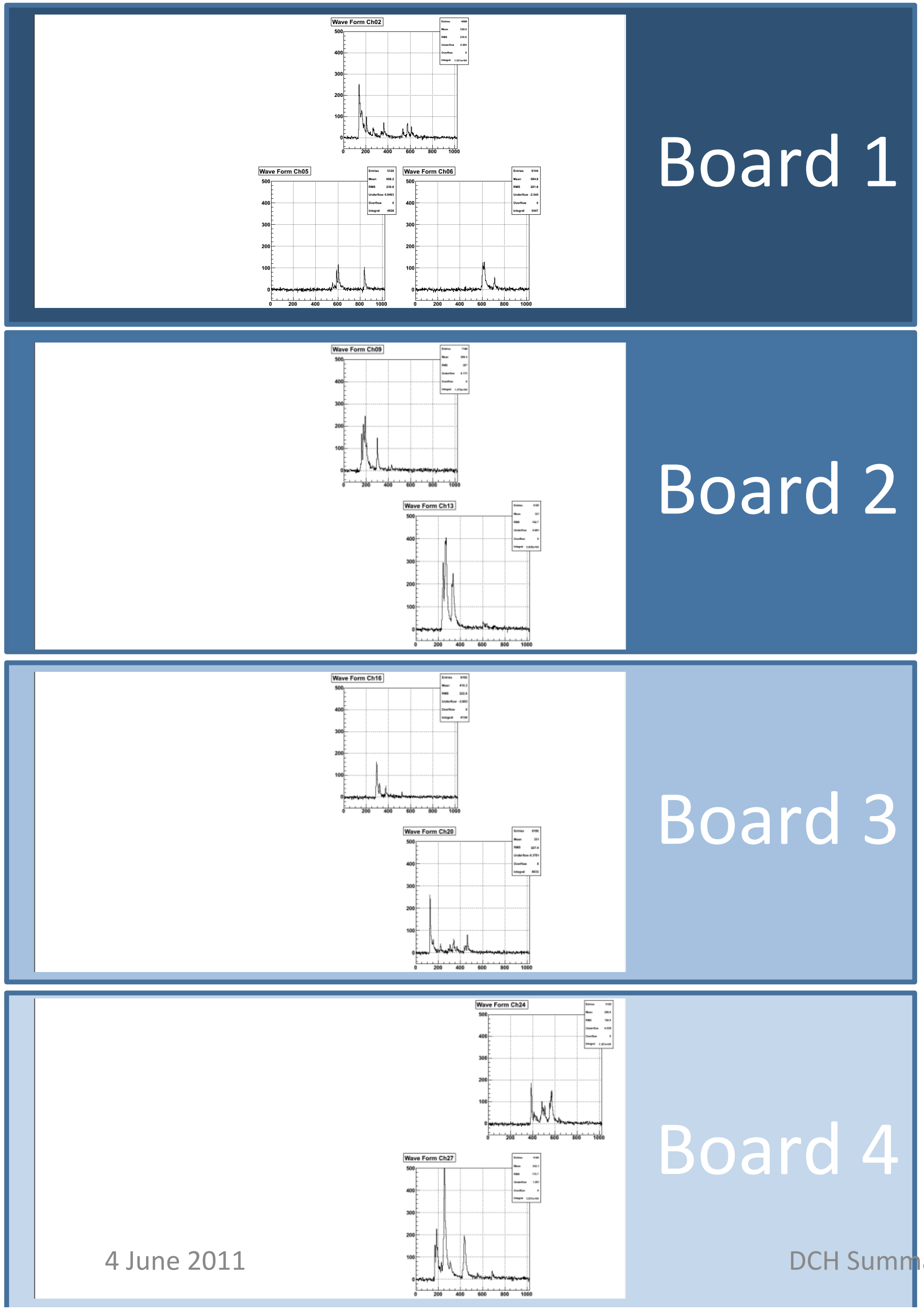
DCH trigger

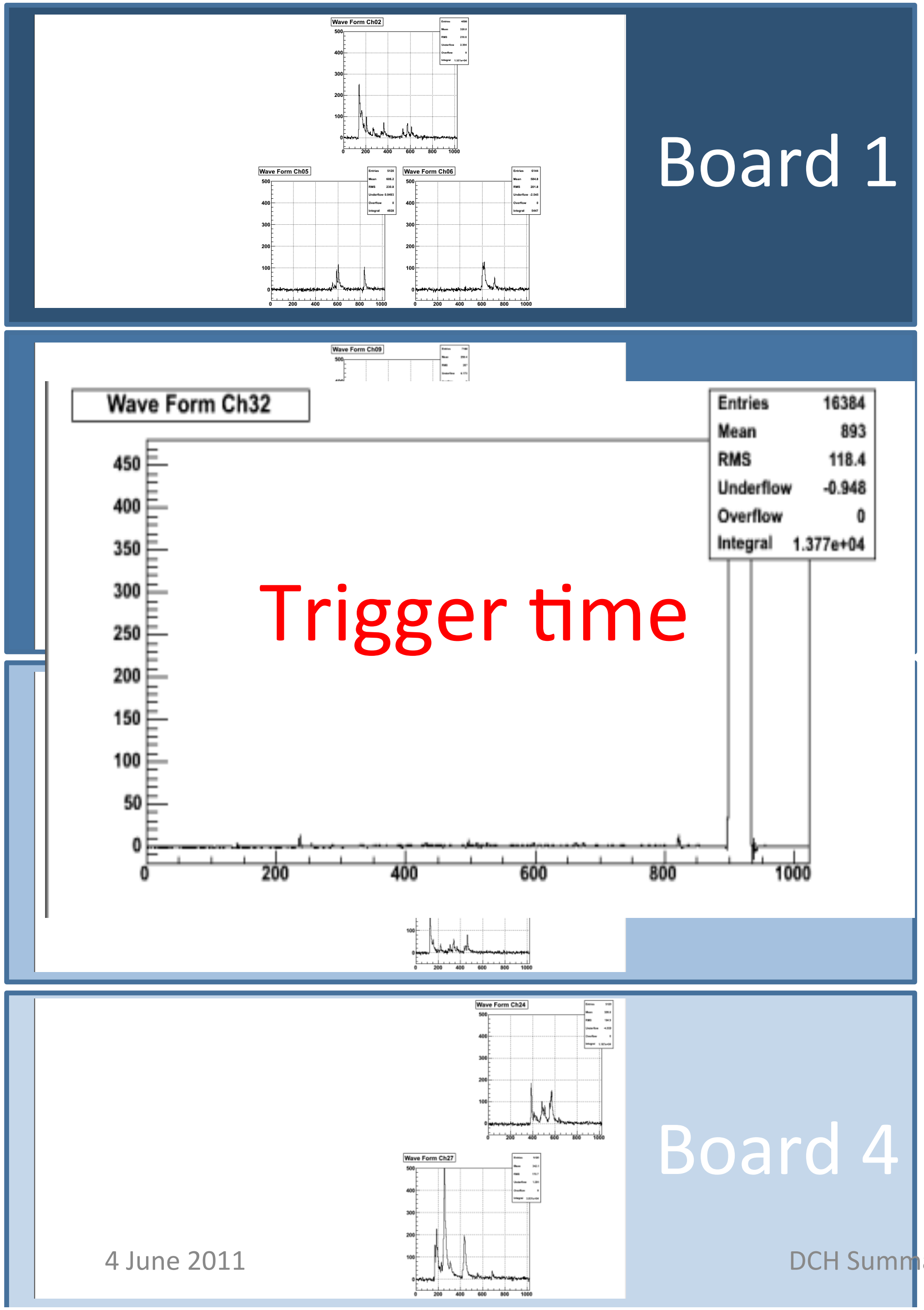
P. Branchini

- Based on track segment (TS), defined as 4 contiguous hits in neighbouring layers
- Drift signal is stretched by one drift time (500 ns) in order to allow for time coincidences
- Trigger is asserted whenever at least one TS is found
- Trigger time jitter is under study
- For the first time tested on prototype 2



Triggered track Example





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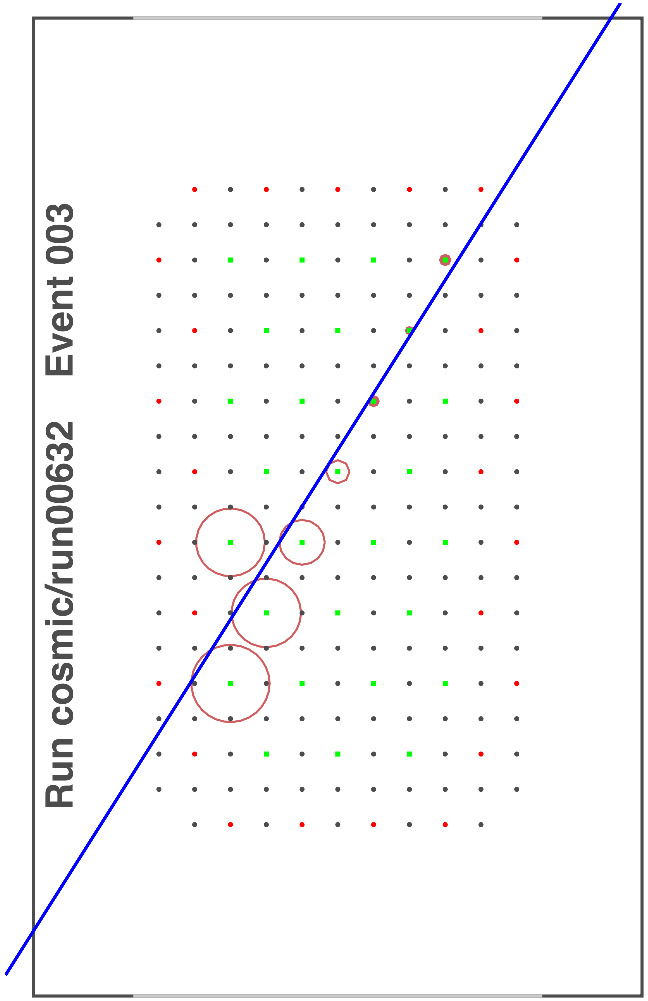
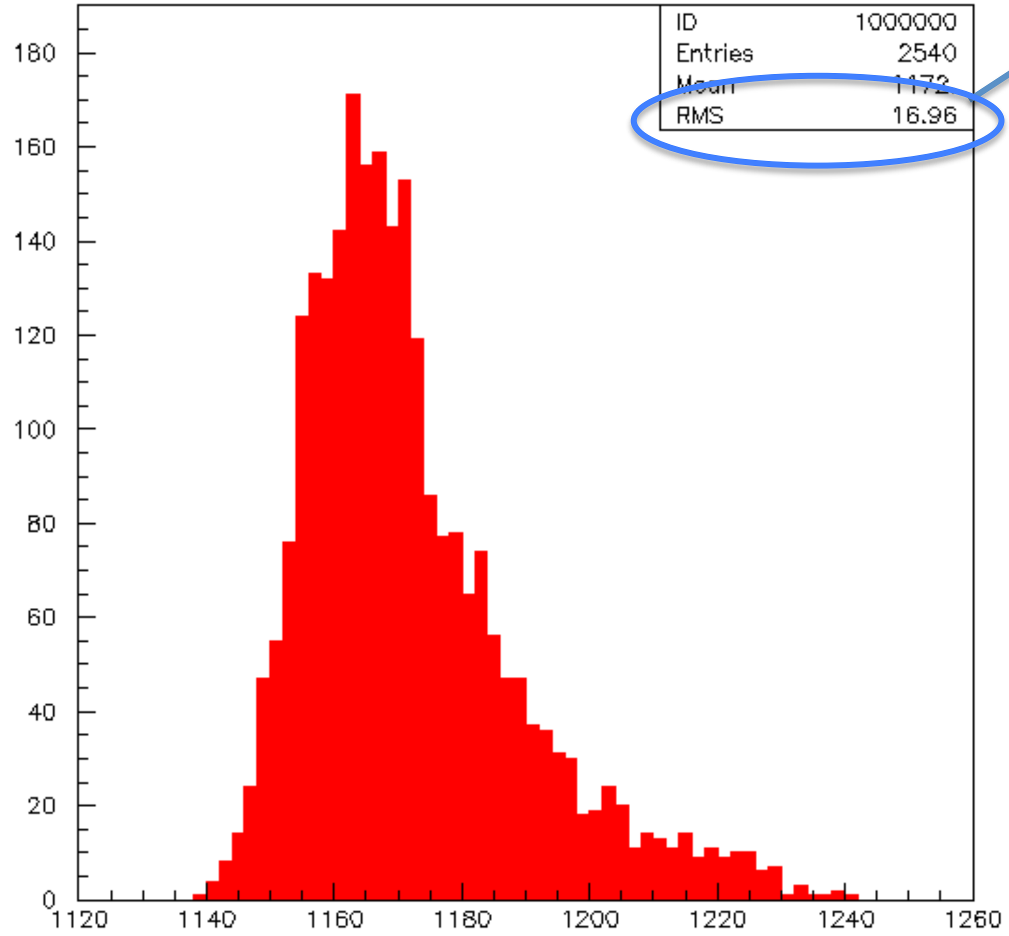


Timing resolution (cosmics)



t(track element) – t(scintillator)

17 counts x
3.2 ns ~ 54ns
(one 4-layer TS)

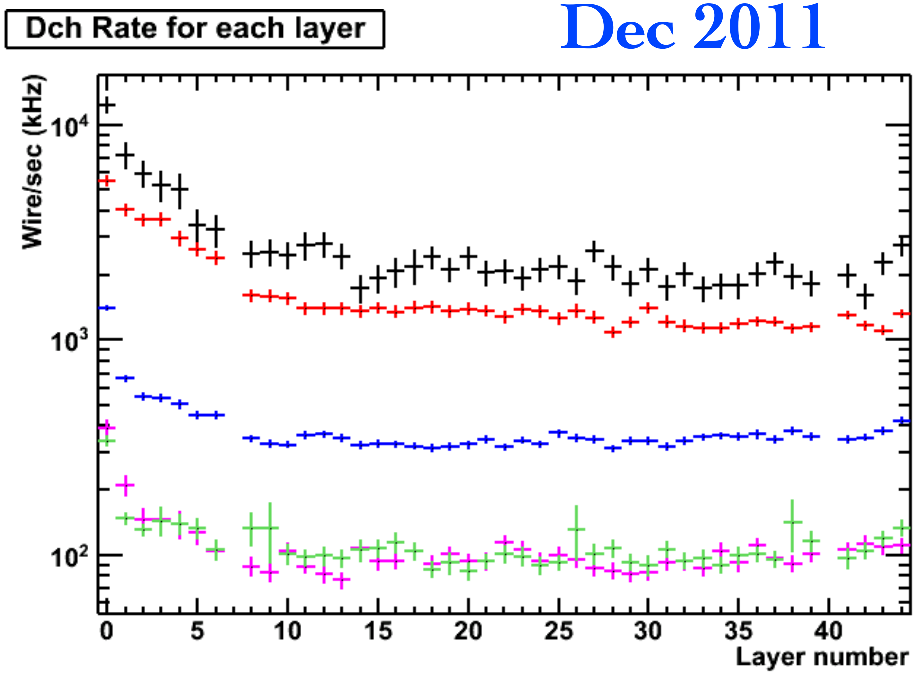
"Ultimate" t_{TRG} resolution from fit of common track t_0

DCH Rate (wire sec^{-1} per layer)

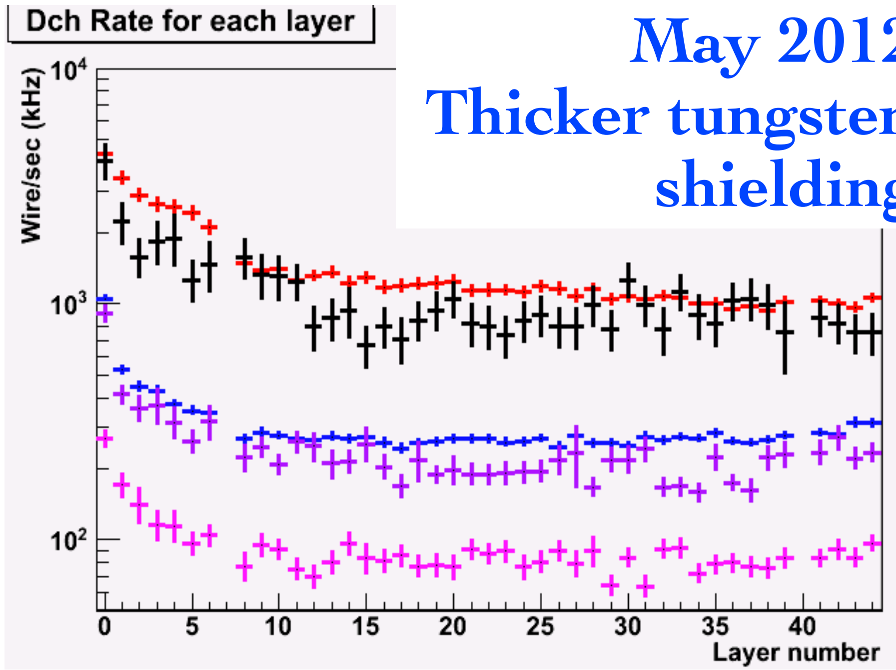
Contributions (Avg. rate)
Radiative Bhabha (2784 kHz)
2photons (1672 kHz)
Touschek LER (393 kHz)
Touschek HER (109 kHz)
Beamgas HER (114 kHz)

Contributions (Avg. rate)
Radiative Bhabha (1111 kHz)
2photons (1431 kHz)
Touschek LER (306 kHz)
Touschek HER (92 kHz)
Beamgas HER (xxx kHz)
Beamgas LER (244 kHz)

Dec 2011



May 2012
Thicker tungsten shielding



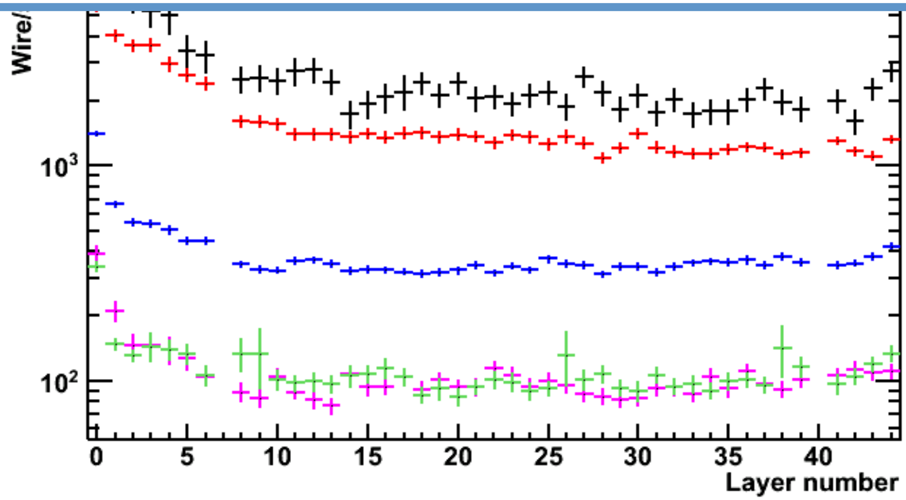
DCH Rate (wire sec^{-1} per layer)

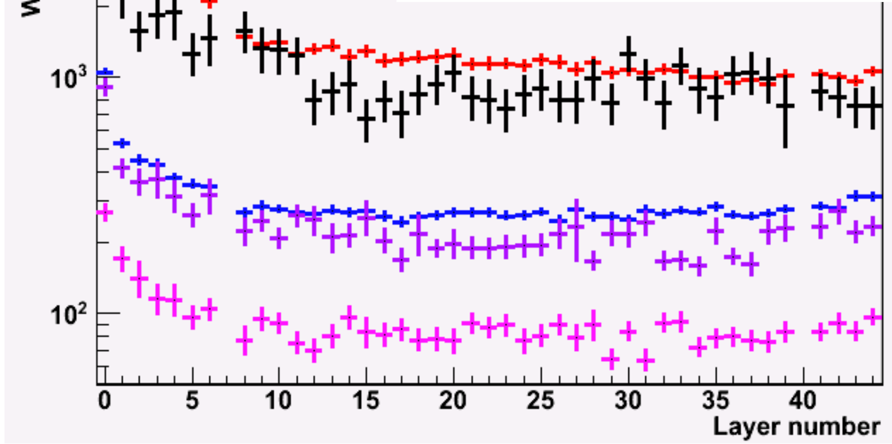
Normalization for DCH:
- 1μs time window
- ~200 cells in the 2 innermost superlayers
- ~124 →240 cells in the outer superlayers

➔ 4-2x10^{3}kHz (Rad-Bhabha + 2photons) are 0.5-1% occupancies

tions (Avg. rate)
Bhabha (1111 kHz)
(1431 kHz)
LER (306 kHz)
HER (92 kHz)
HER (xxx kHz)
LER (244 kHz)

May 2012
Thicker tungsten shielding





Summary and outlook

- Detailed simulation studies reproduce cluster counting efficiencies, and improvement over truncated-mean dE/dx, observed in data
  - Effect of minimum Δt between clusters and SNR
- First FastSim study with Breco and $K^{+}\nu\nu$
  - Refine increasing MC statistics
- First Implementation of DCH trigger on full-length 28 cells prototype
- Next "experimental" steps:
  - Increase the trigger rates by using longer counters, and the DCH itself as a trigger;
  - compare ionization loss at different momenta, by using varying absorber thickness and a combination of trigger and veto counters
  - Exploit effect of a variety of experimental conditions on PID performance
- Fully exploit integration of DCH with the rest of SuperB