

NA62 RICH

Test Beam Results

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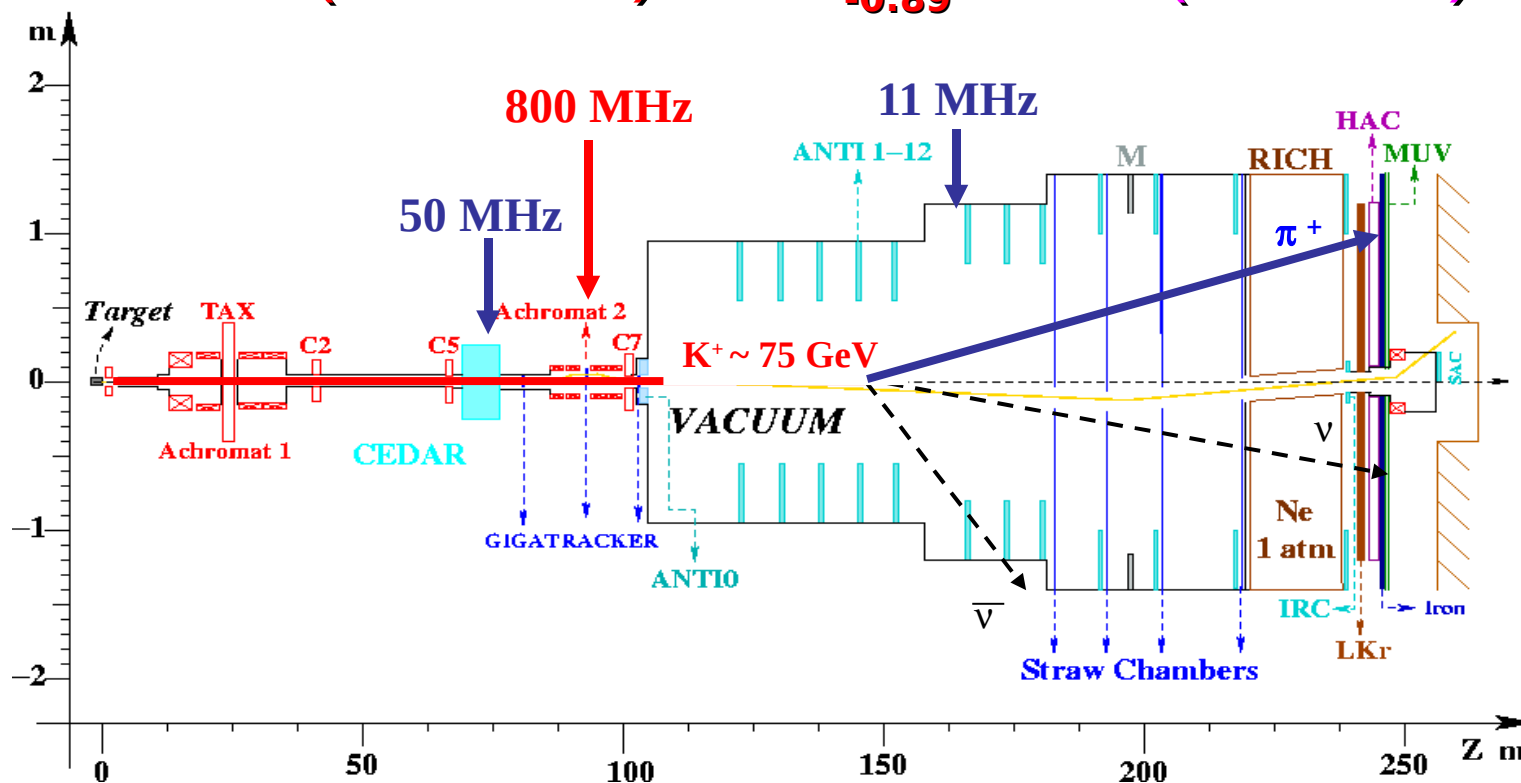
On behalf of
NA62 RICH Working Group

NA62

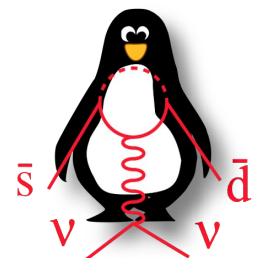


NA62: measurement of $K^+ \rightarrow \pi^+ \nu \bar{\nu}$

- Very clean theoretical prediction, sensitive to V_{td} , very sensitive to new physics (if measured at level of 10%: ~100 events)
- $BR(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = (8.0 \pm 1.1) \times 10^{-11}$ SM @ NLO
- E787/949: $BR(K^+ \rightarrow \pi^+ \nu \bar{\nu}) = 1.47_{-0.89}^{+1.30} \times 10^{-10}$ (3 events)

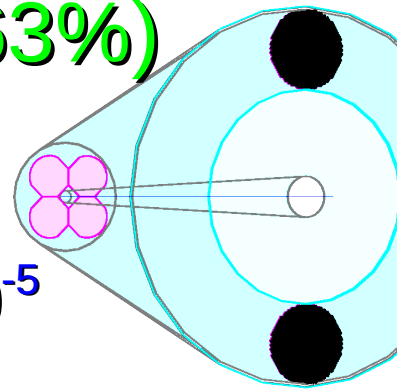


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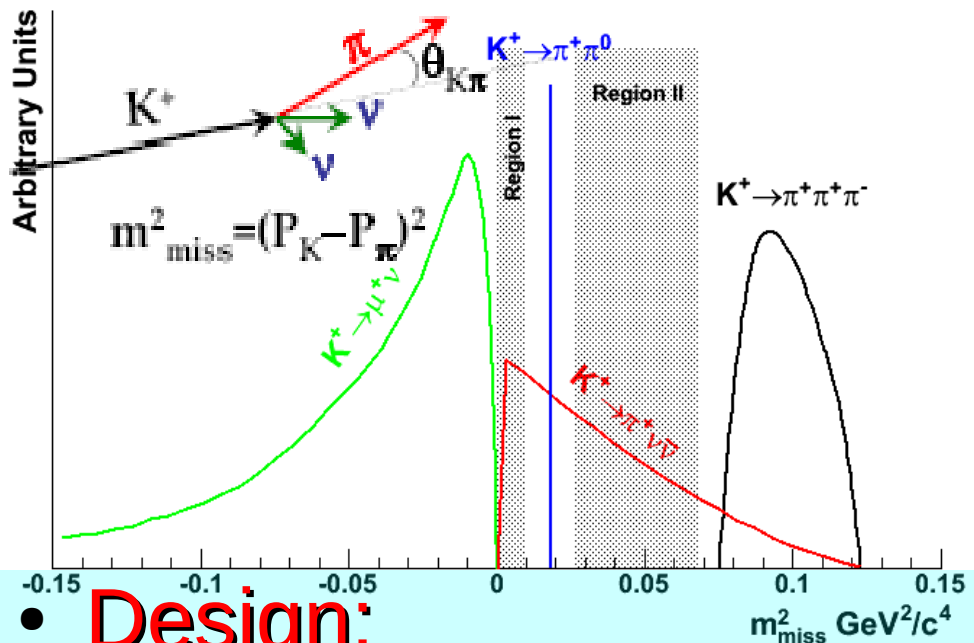


The RICH

- Main background
 $K^+ \rightarrow \mu^+ \nu$ (BR ~ 63%)

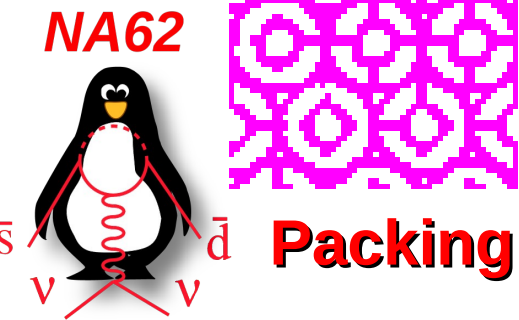
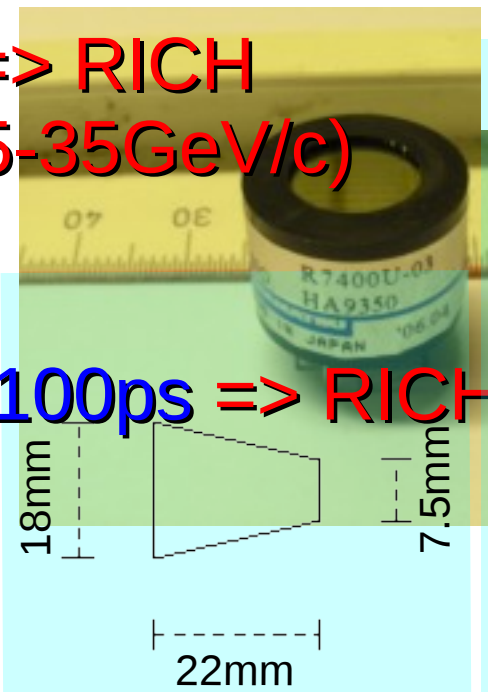


- Rejection $\sim 10^{-12}$
 - Kinematics $\sim 10^{-5}$
 - Vetoes $\sim 10^{-5}$
 - PID $\sim 5 \cdot 10^{-3} \Rightarrow$ RICH
 $(\pi-\mu \text{ at } 3\sigma \text{ } 15\text{-}35\text{GeV}/c)$



- Design:
 - Focal length $f \sim 17\text{m}$
 - Neon at 1 atm $\leftrightarrow P_\pi > 12\text{GeV}/c$
 - 2000 PM (Hamamatsu R7400U)
 - granularity 18mm

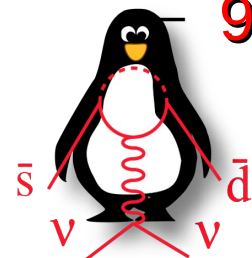
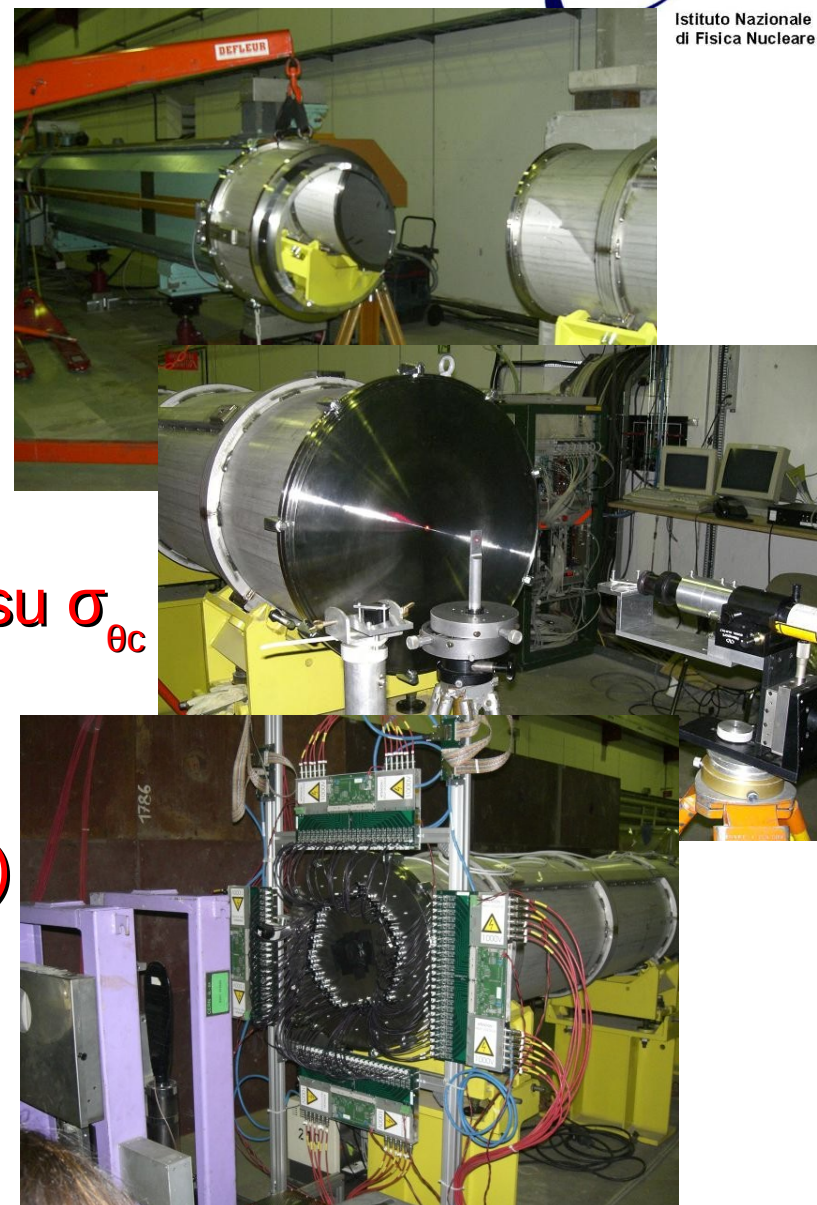
- Time K- π
 - Resolution $\sim 100\text{ps} \Rightarrow$ RICH



Winston's cone

• Aim: Prototype 96 (Fall 2007)

- Time resolution
- Hits multiplicity
- Features:
 - Mirror: $\Phi=50\text{cm}$, thickness=2.5cm, $f=17.01\text{m}$
 - 96 PM (Hamamatsu R-7400) \Rightarrow Bias su σ_{θ_c}
- Detector setup:
 - Test PM and Front-End (NINO based)
- Setup del TestBeam:
 - NA62
 - 96.2% π , 3.0% K, 0.8% p @200GeV

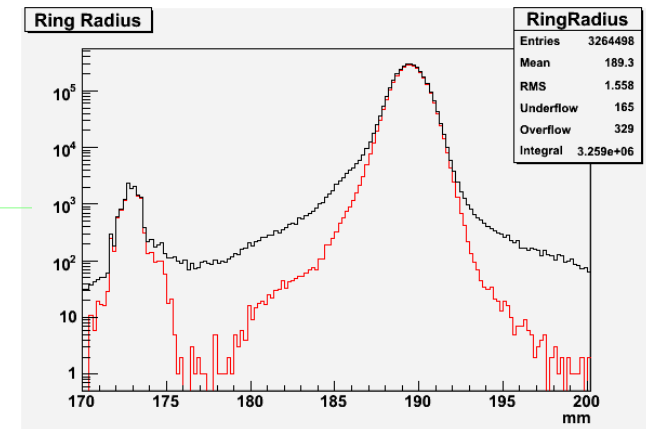
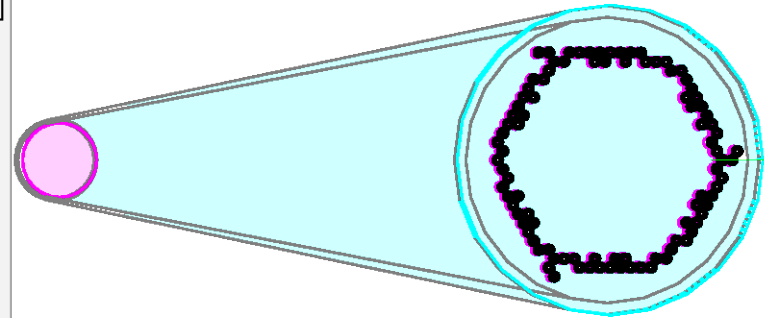
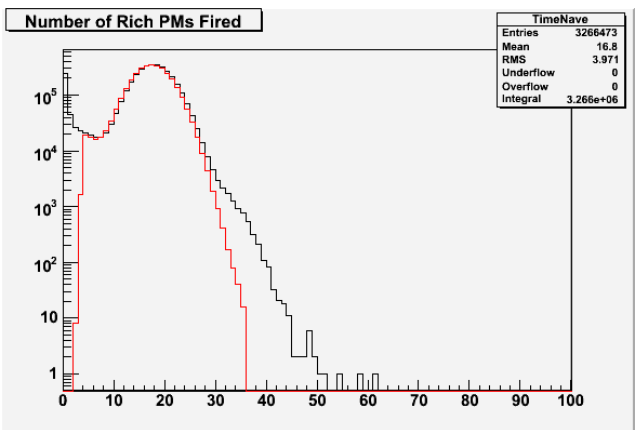
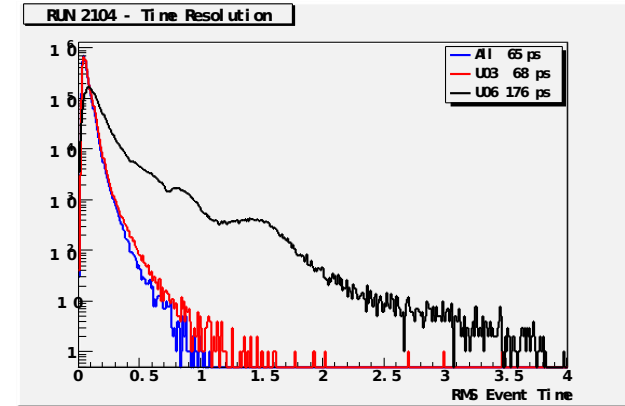


Test Beam Results

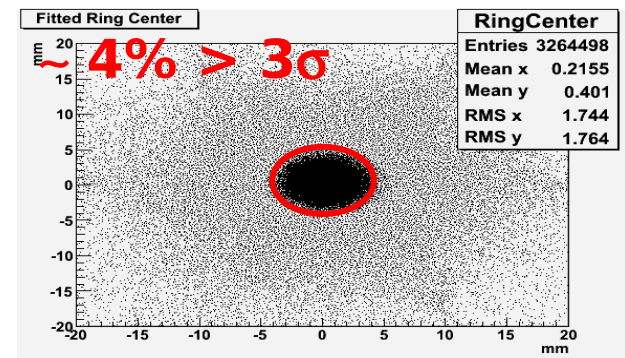
<http://dx.doi.org/10.1016/j.nima.2008.05.029>

- **Performance:**

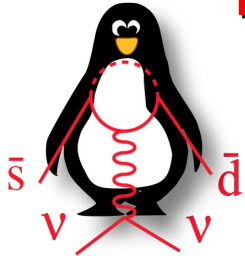
- Time resolution ~65ps
- $\sigma_{\theta_c} \sim 50\mu\text{rad}$ (bias)



- Track Angular resolution ~100μrad

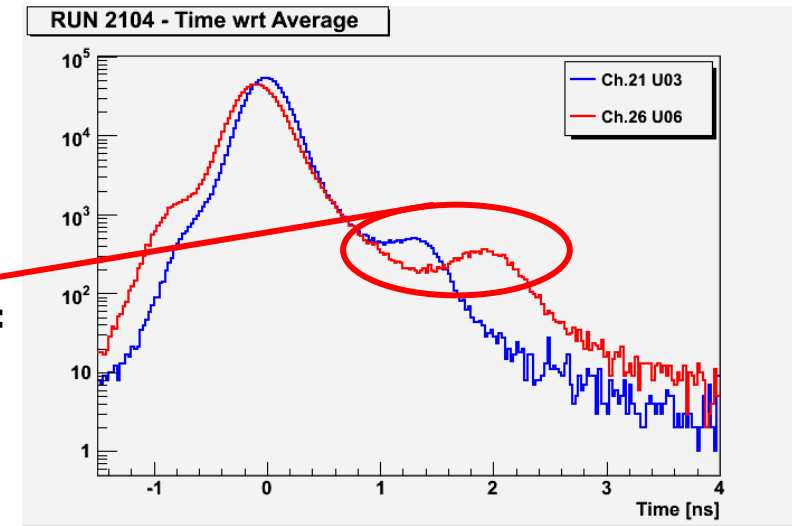
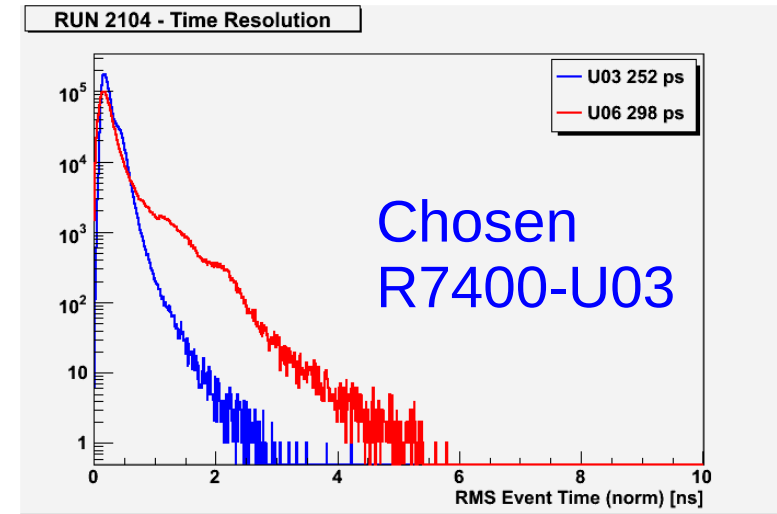


NA62 Hit PM multiplicity ~ 17

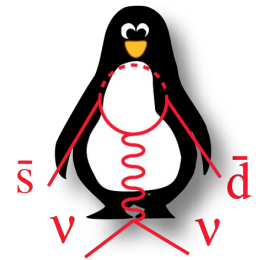


Test Beam Results (details)

- Comparison between PMs:
R7400-U03/R7400-U06
- Single PM time resolution
- Robustness tests:
 - Neon contamination up to 1%
 - Temperature variations
 - No relevant effect

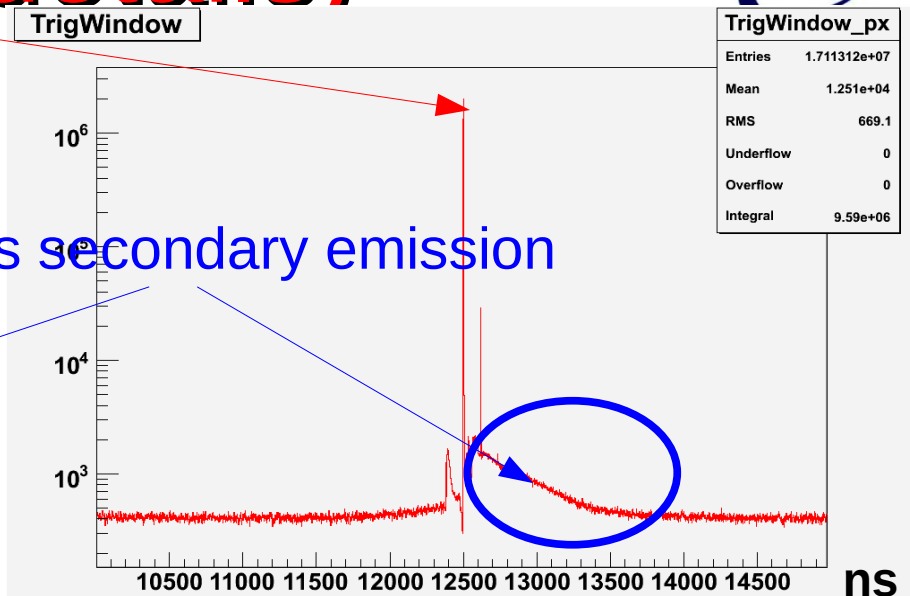
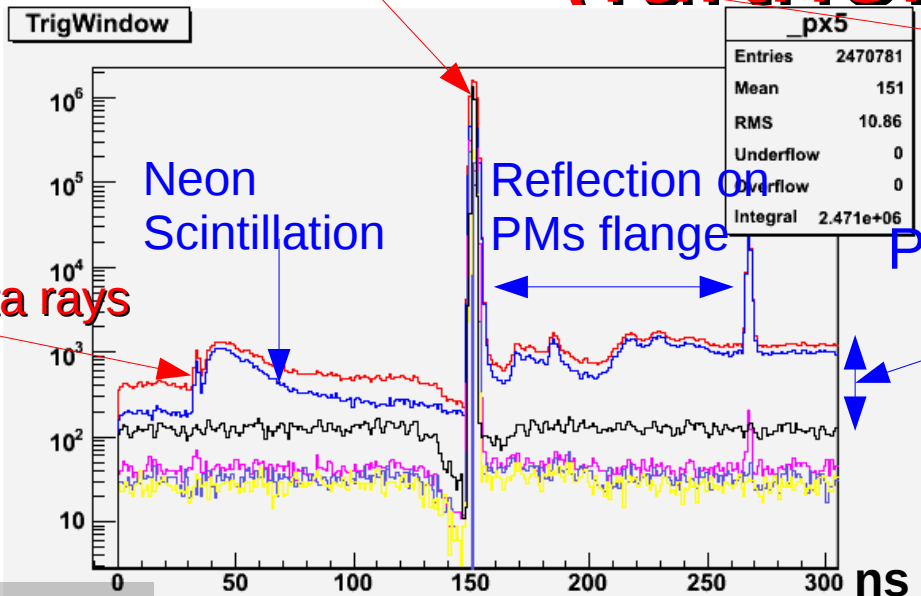


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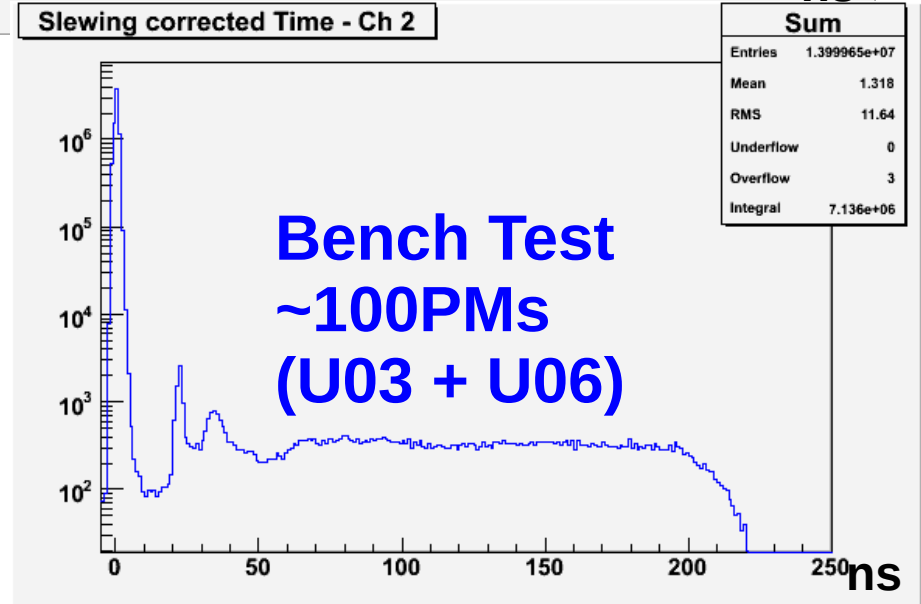
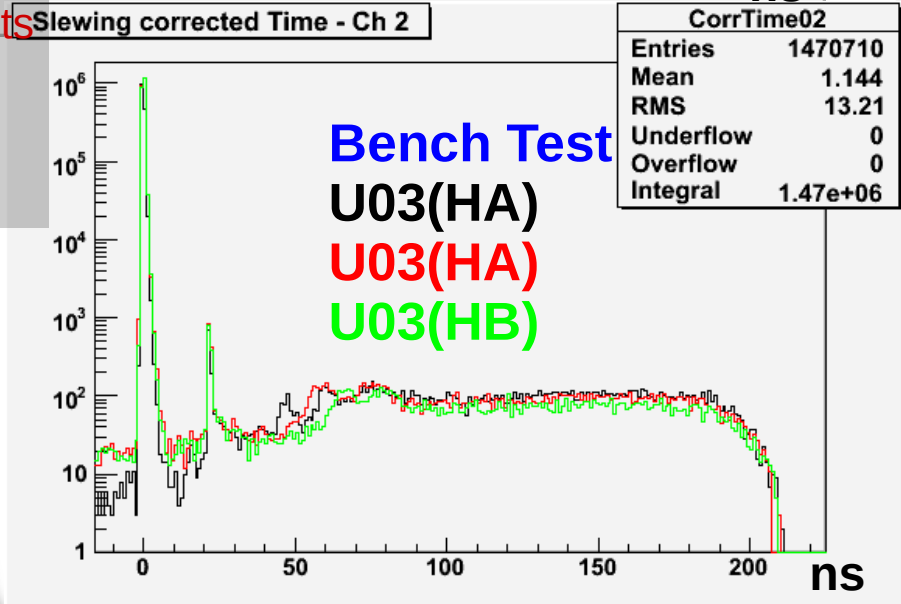
Test Beam Results (further details)

Time of the event
(arbitrary offset)

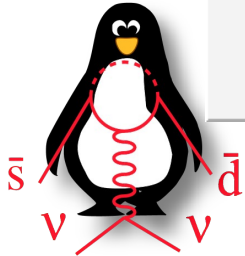


Delta rays

- all events
- 1 PM
- 2 PMs
- 3 PMs
- ≥4 PMs

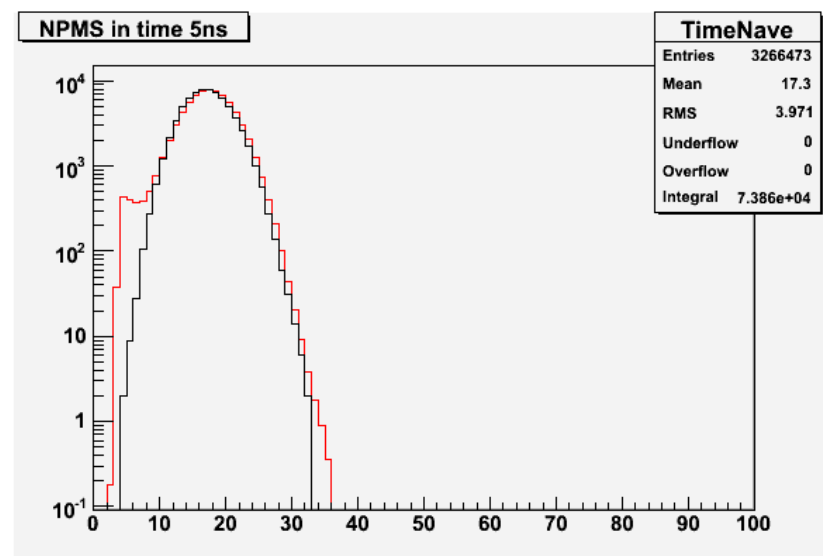
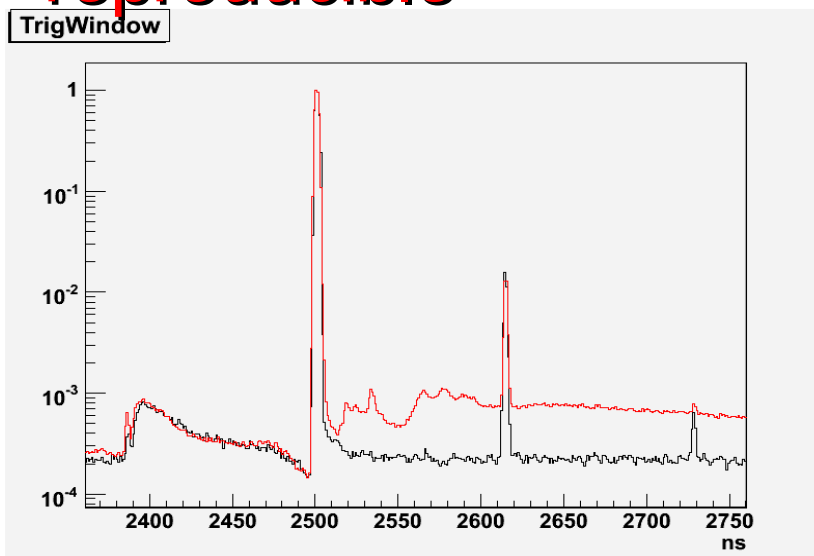
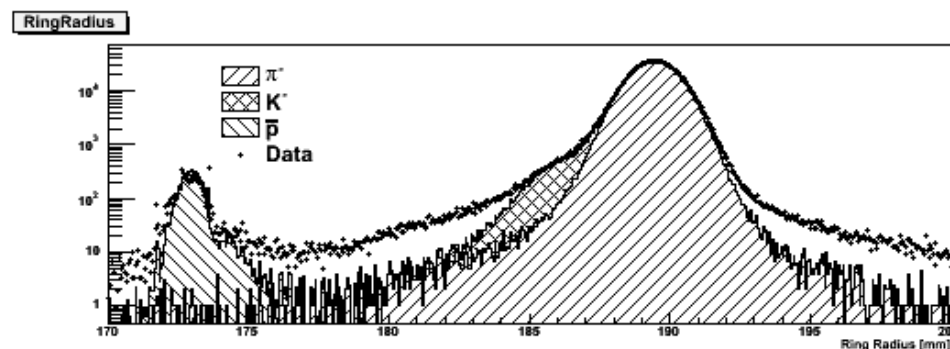
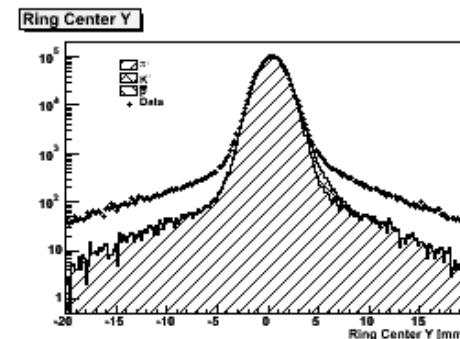
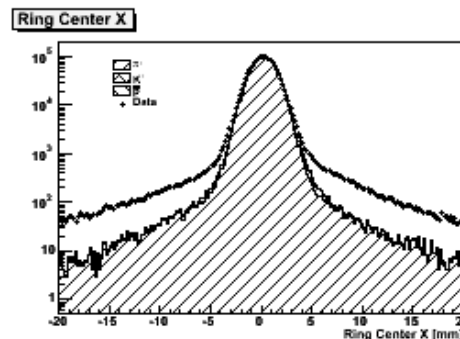


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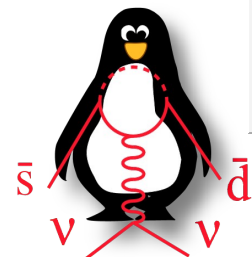


MonteCarlo

- Cherenkov related performance reproduced
- Higher order effects:
 - could be tuned better
 - PM's secondary emission not reproducible



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Prototype 414

- **Aim:**

- π - μ separation at 15-35 GeV/c
- Improvement of cooling and mechanical structure

- Test DAQ and Trigger by TELL1 (HPTDC)

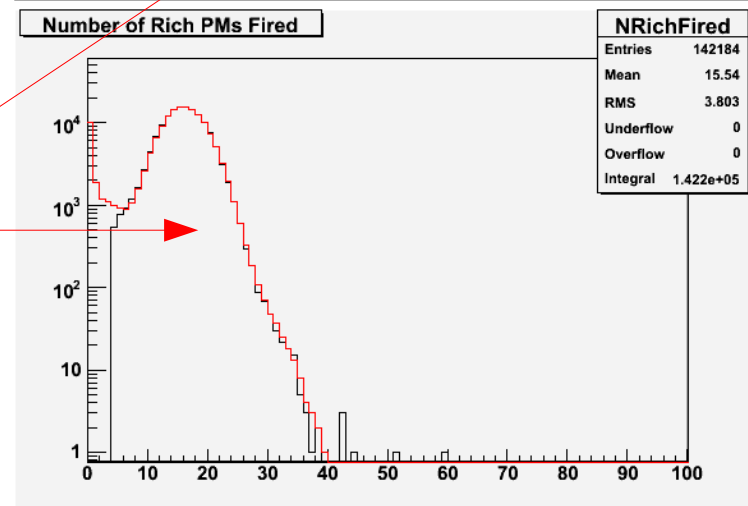
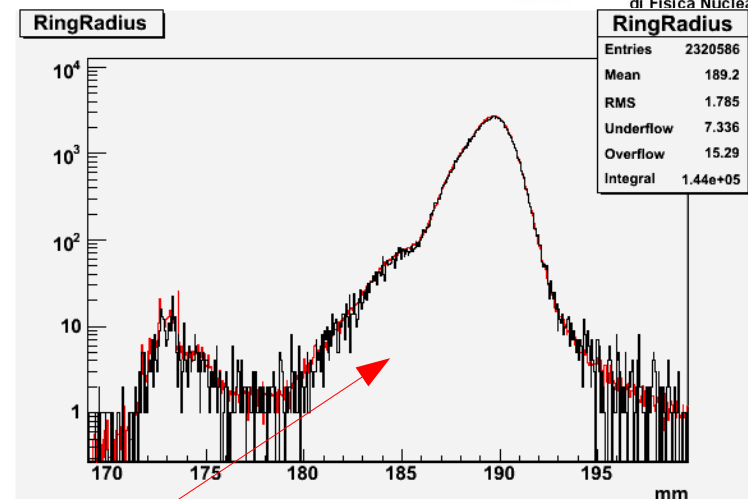
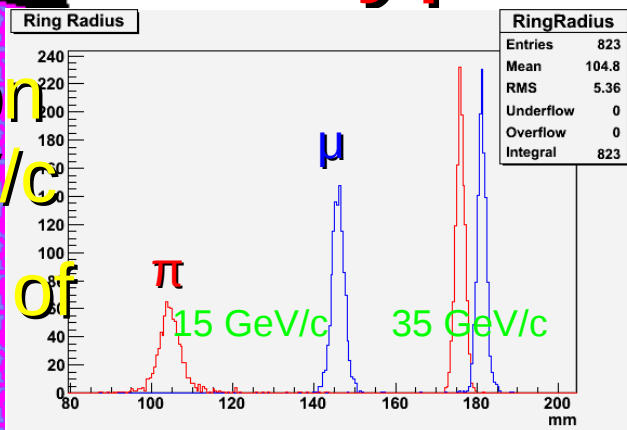
- **Features:**

- Added 318PM

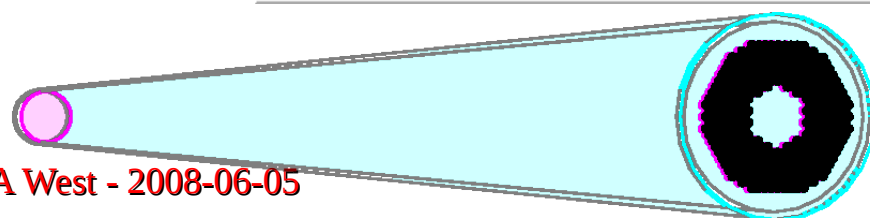
- **Status:**

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Design almost finalized



Offline application of trigger algorithm to data from TestBeam 2007



Summary

- Test of the first prototype (96PM):
 - Good results
 - Tool for MC validation
 - NIM paper accepted for publication
- Fall 2008: test of the second prototype (414PM) for π - μ separation

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SPARES

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Antonino Sergi - SORMA West - 2008-06-05

PMT Hamamatsu R7400U

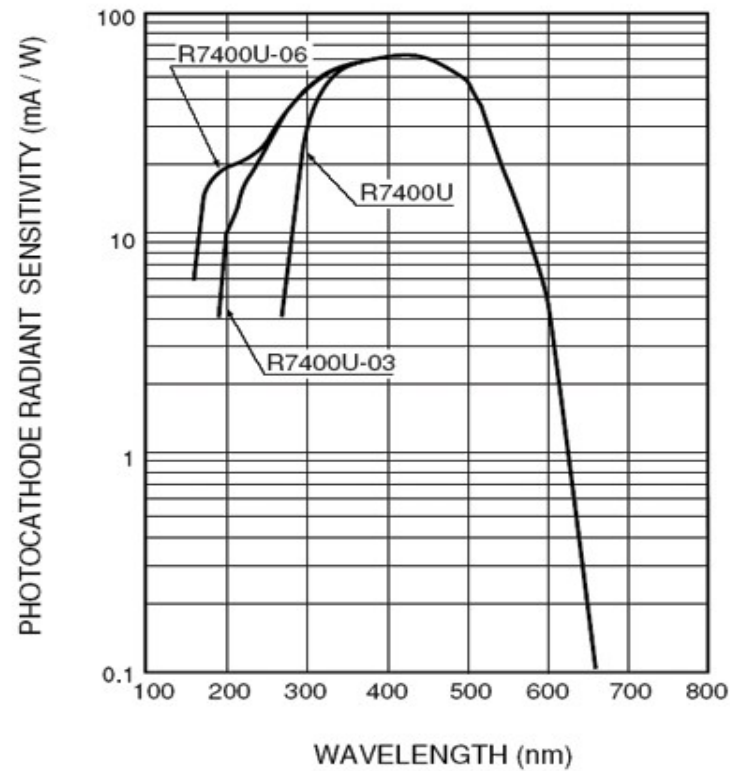
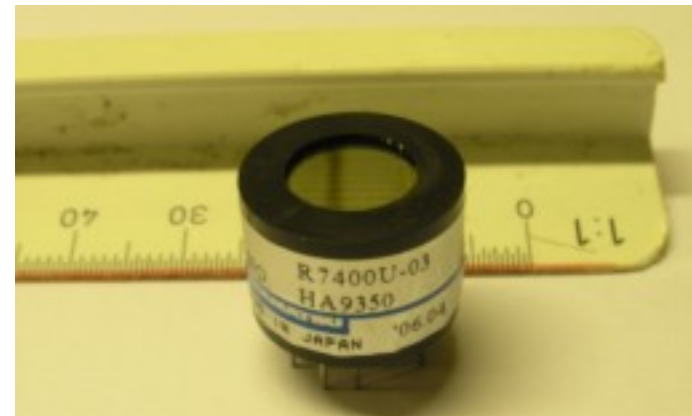
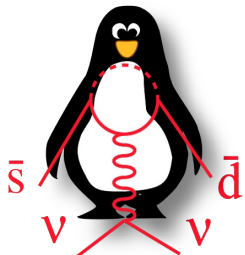
Hamamatsu R7400U PMT

- diameter 16 mm
- length 16 mm
- photocatode diameter 8 mm
- 8 stages
- Max HV 1000 V
- Gain@800V ~ $5-7 \times 10^6$
- λ peak ~ 420 nm
- t.t.s. 280 ps

Used:

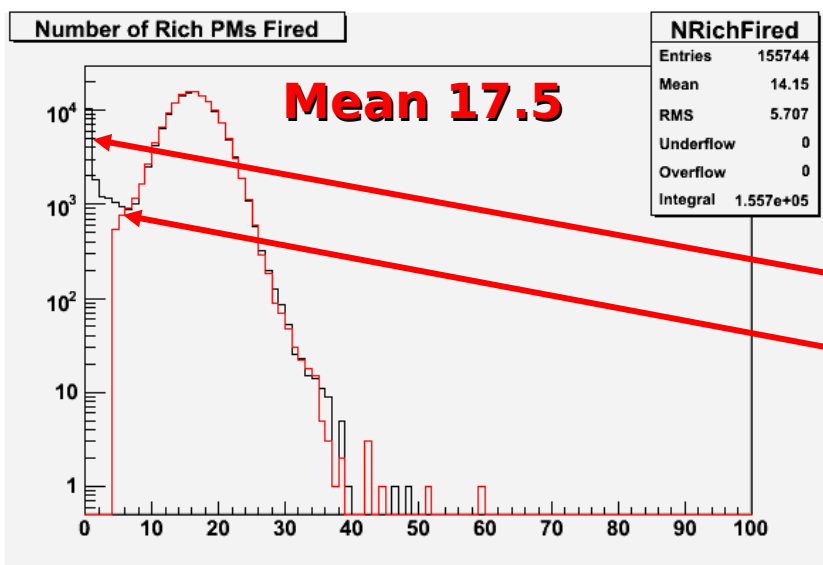
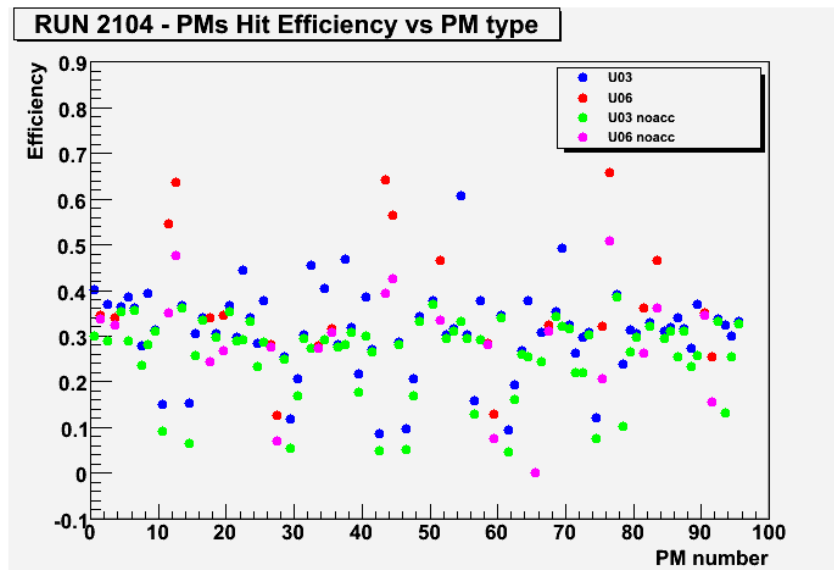
- R7400-U03: Bialkali, UV glass
- R7400-U06: Bialkali, quartz

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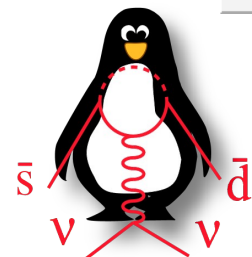
Efficiency

- PM "Efficiency" ~ 0.3 photoelectrons per PM
- Effect of Cuts
- $\lambda_1 \Rightarrow 0$ Hits (Prob $\sim 7\%$)

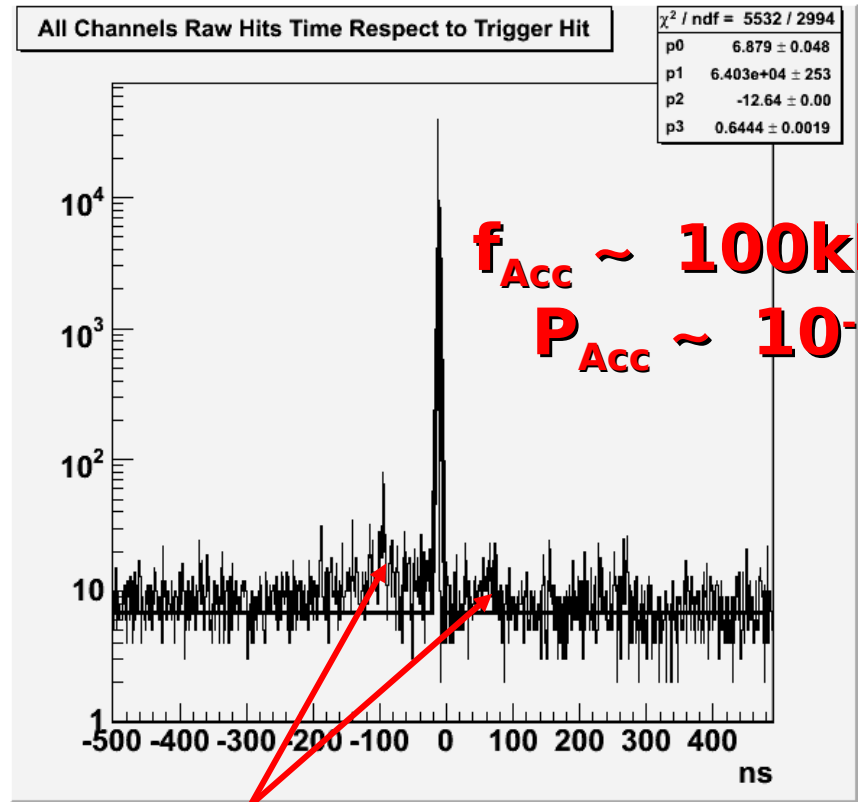
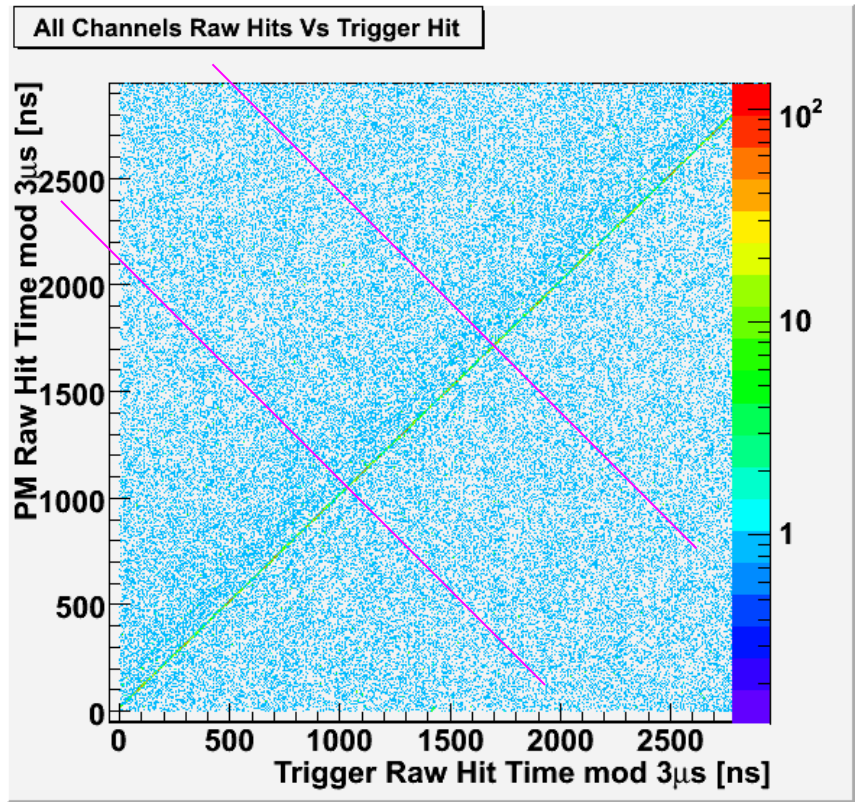
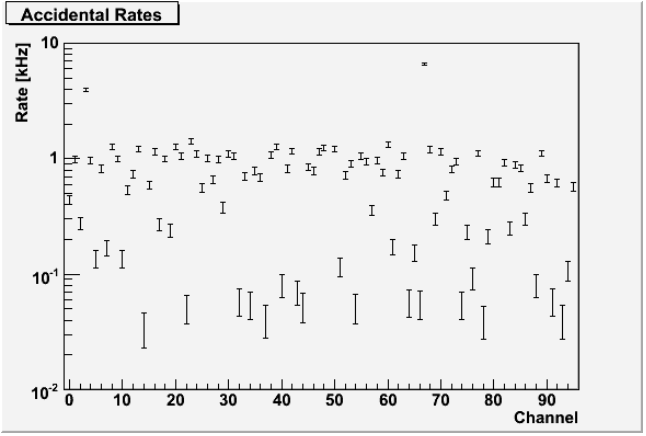


| Cut / Run | Standard (2104) | Dx +500 | Dx +100 | Dy +500 | Dy +1000 |
|-------------------------------|-----------------|---------|---------|---------|----------|
| 1 Trigger | .985 | .985 | .985 | .984 | .984 |
| Trig Time Wind | .996 | .996 | .996 | .996 | .996 |
| Nrich 2-35 | .927 | ---- | ---- | ---- | ---- |
| <Time> in 10ns | .996 | .927 | .884 | .925 | .885 |
| ≥ 4 PM in 1ns (Ring fit) | .984 | .820 | .259 | .795 | .255 |
| Good fit | .999 | .999 | .988 | .999 | .986 |
| Final | .891 | .745 | .222 | .721 | .218 |

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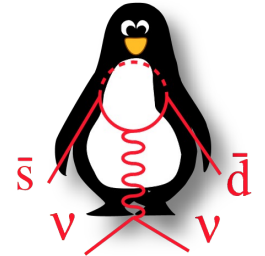
Accidentals



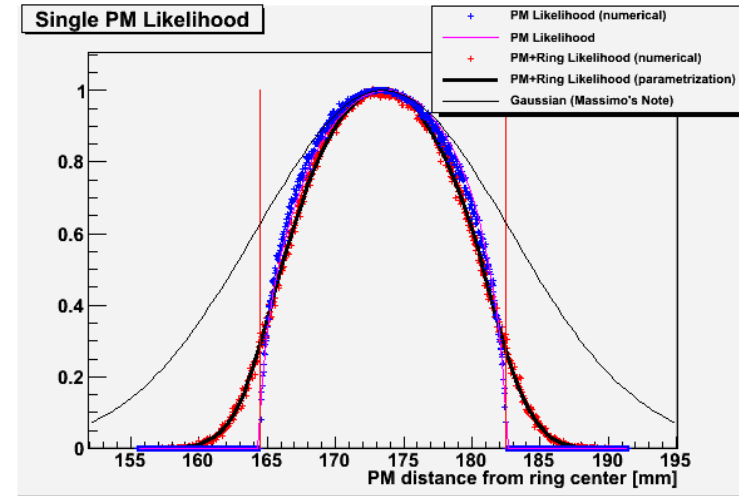
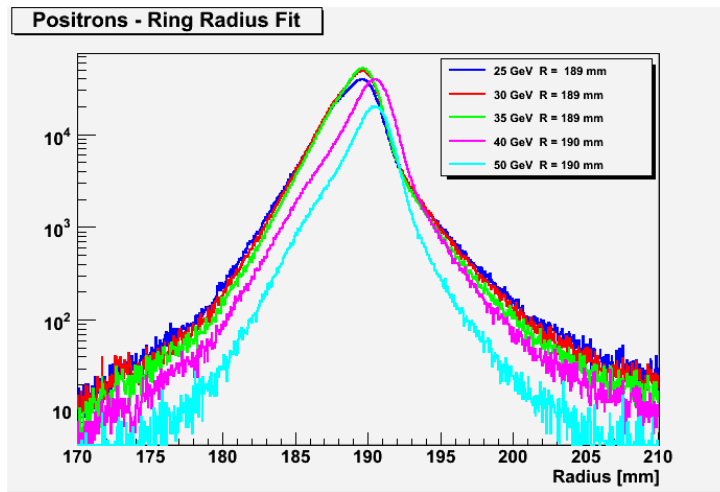
$f_{\text{Acc}} \sim 100\text{kHz}$
 $P_{\text{Acc}} \sim 10^{-3}$

Trigger (Low) Quality

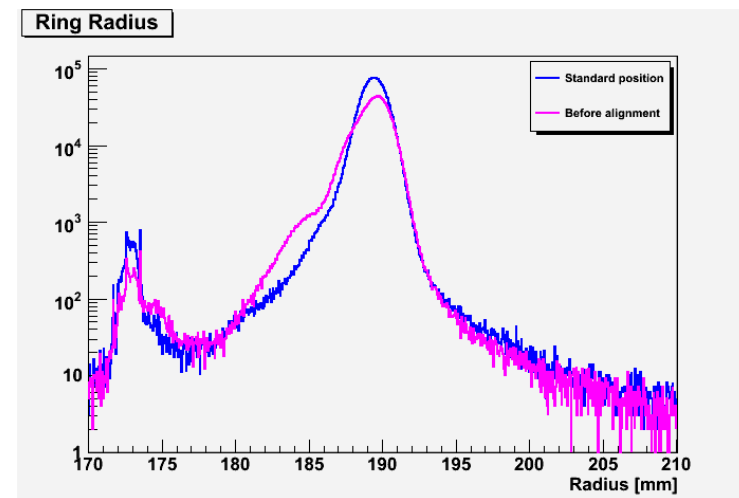
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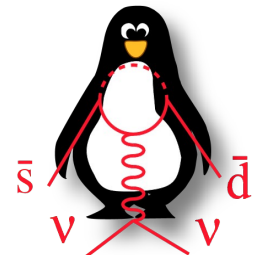
Ring Fit



- Positrons Run: Single Peak
- Bump in “Kaon Region” removed: Geometry/Fit artifact

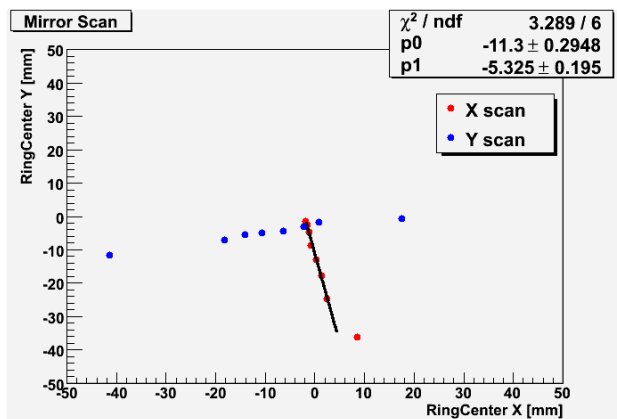


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Mirror Movements

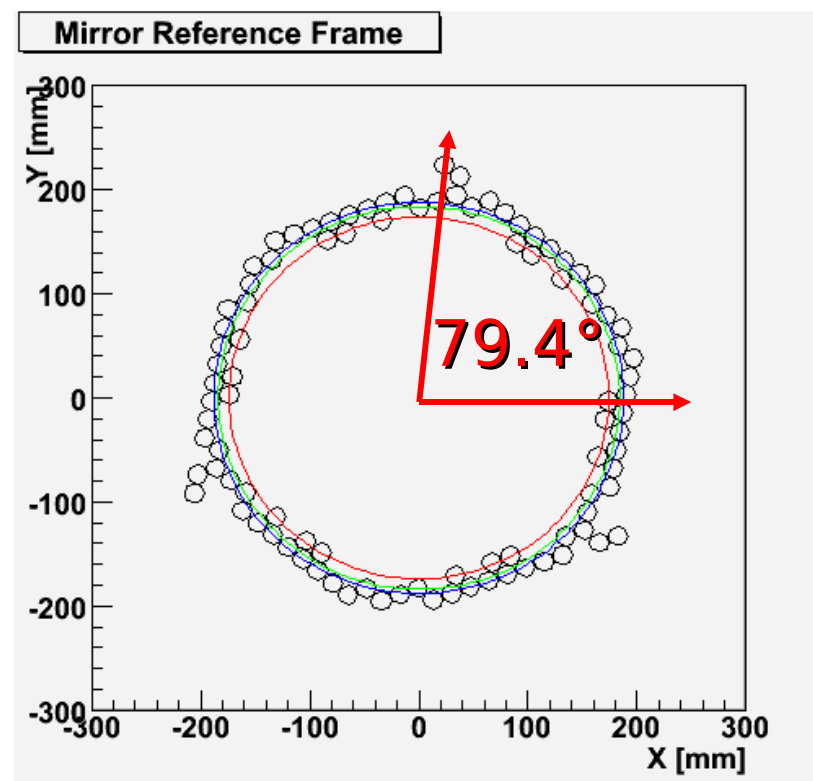
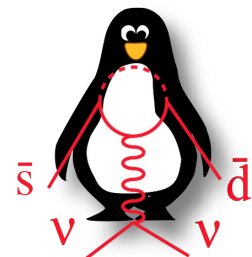
- Mirror orientation reproducibility



- Rotation angle between Mirror and PMs XY reference

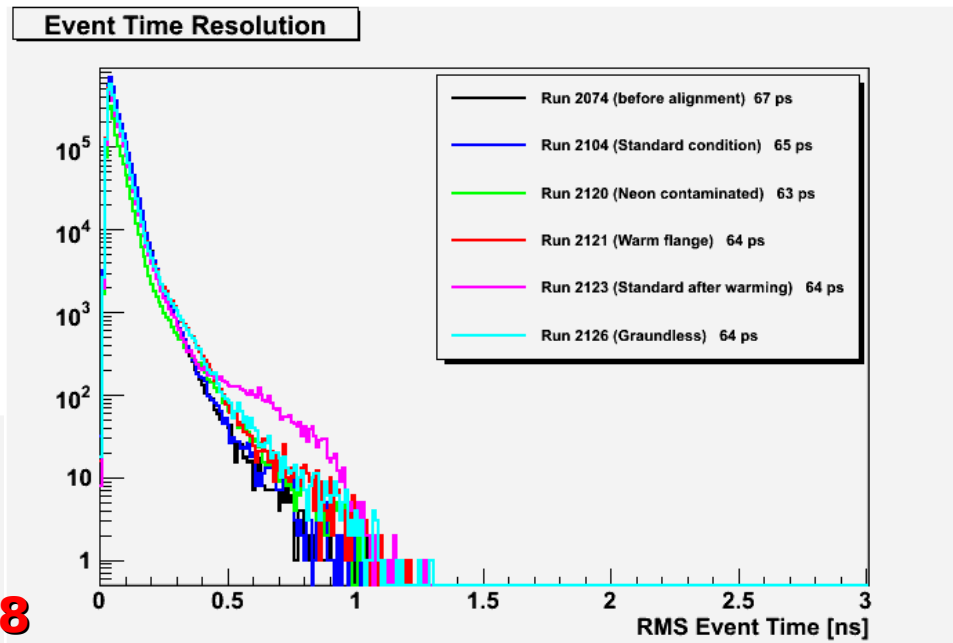
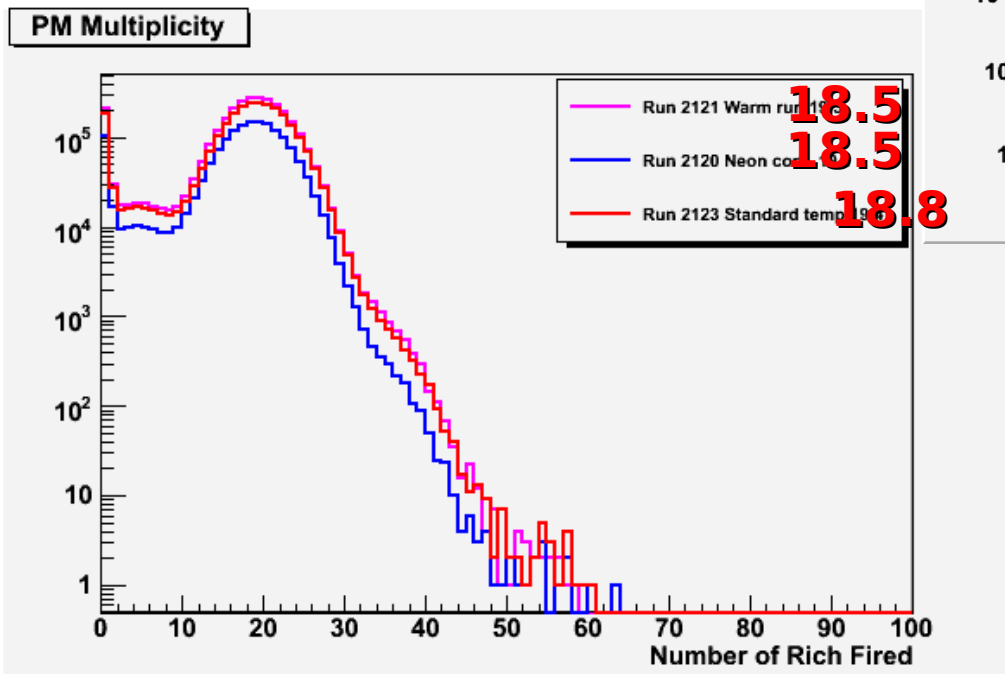
(~ 80°)

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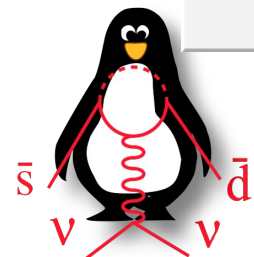
Robustness Tests

- Temperature
No visible effect on
“Cerenkov side”



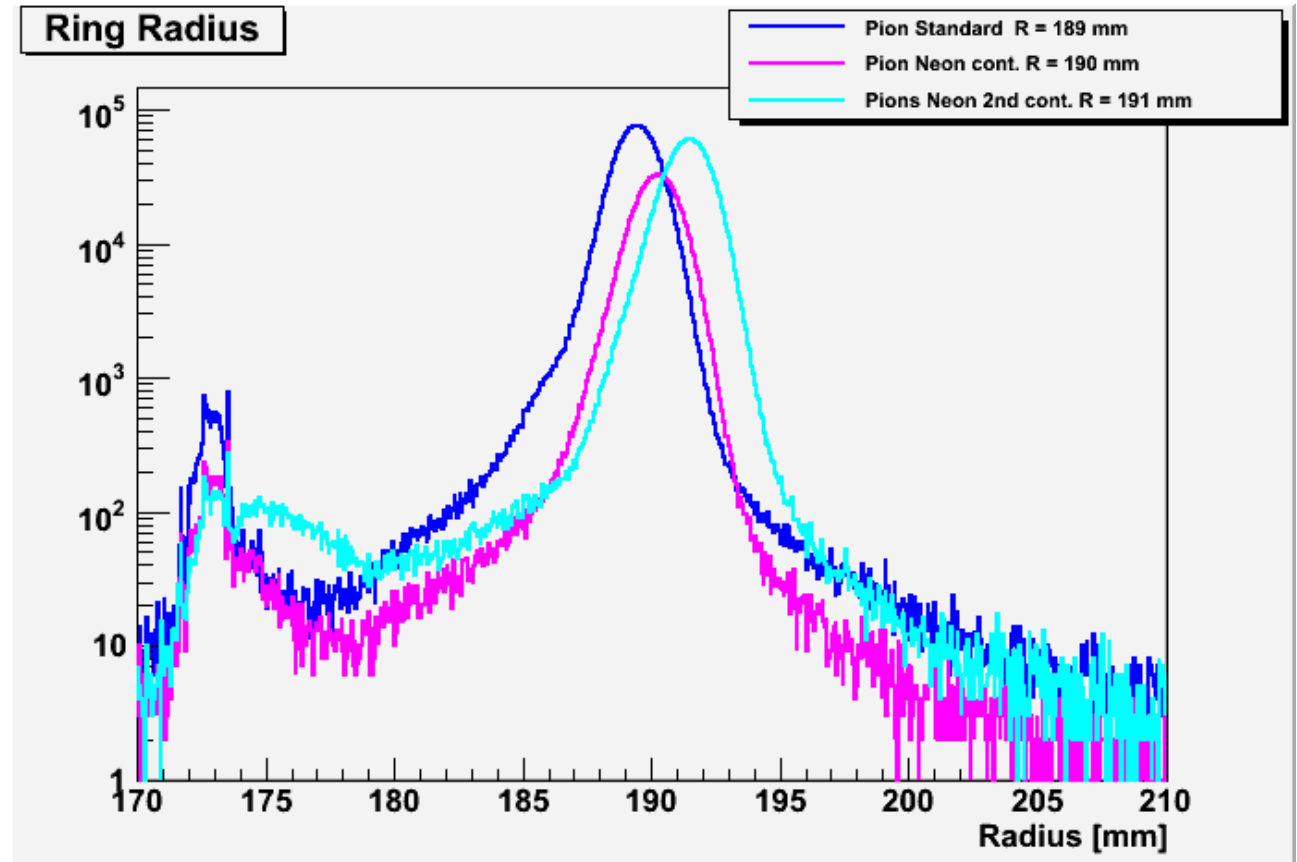
Neither on Time
Resolution

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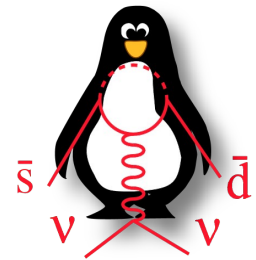


Robustness Tests (2)

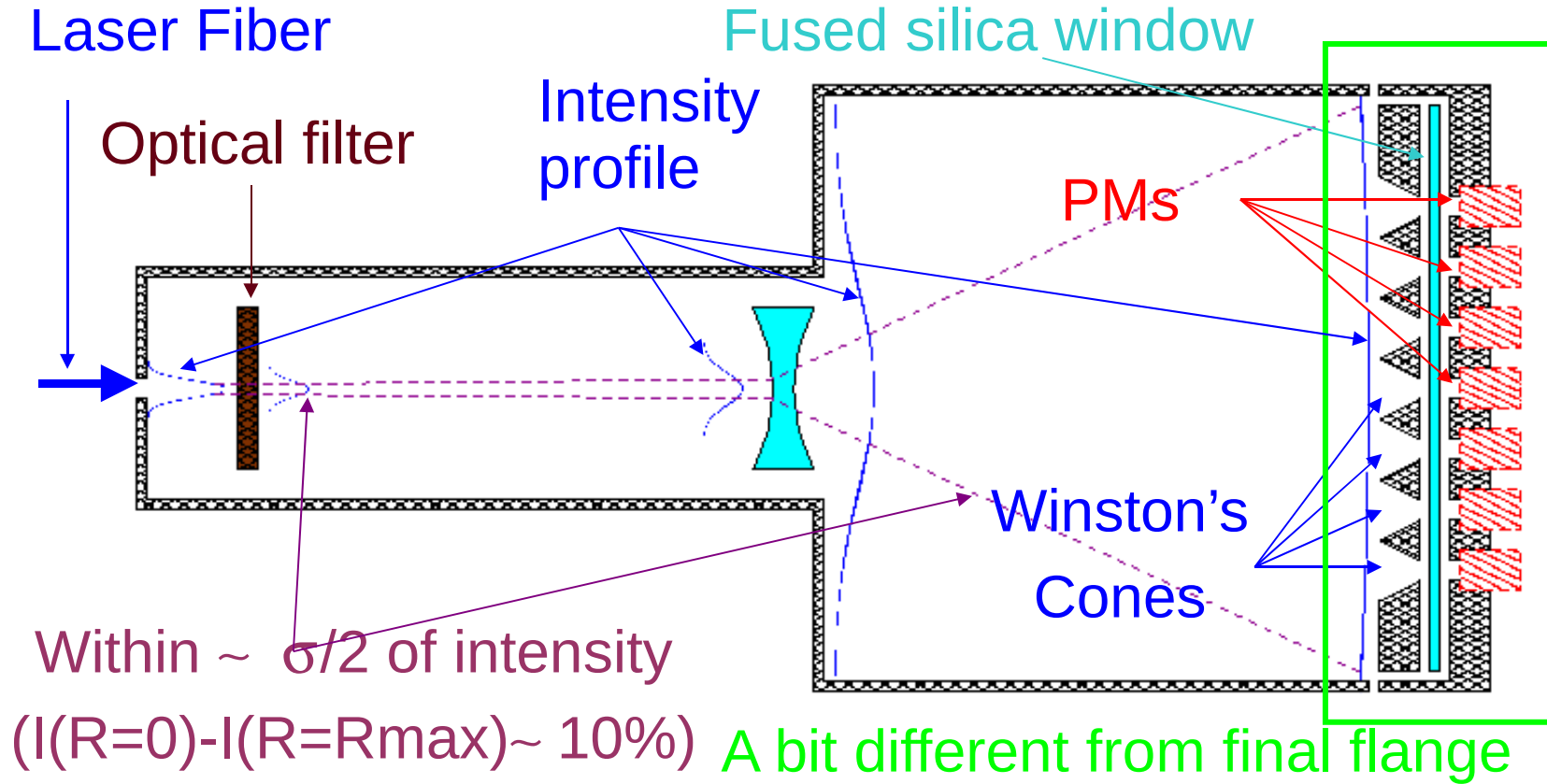
- Neon Contamination (N_2 0.5%+0.5%)



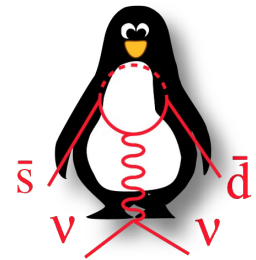
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Test Optics

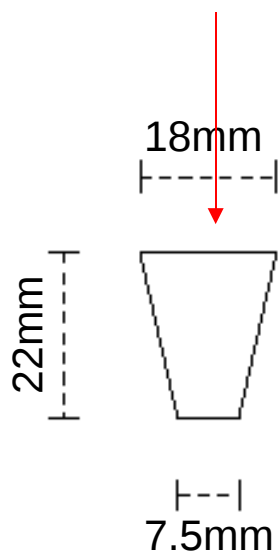


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Flanges

Within $\sim 1^\circ$
 from axis
 max $\sim 3\text{mm}$ gap
 without loosing
 efficiency



Fused silica window(s)

PMS

Winston's
 Cones

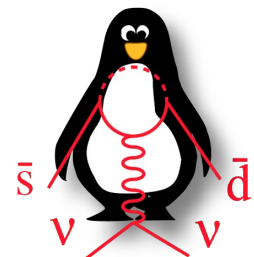
$\sim 7\text{mm}$ gap
 ($\sim 40\%$ loss)

$\sim 1.5\text{ mm}$ gap

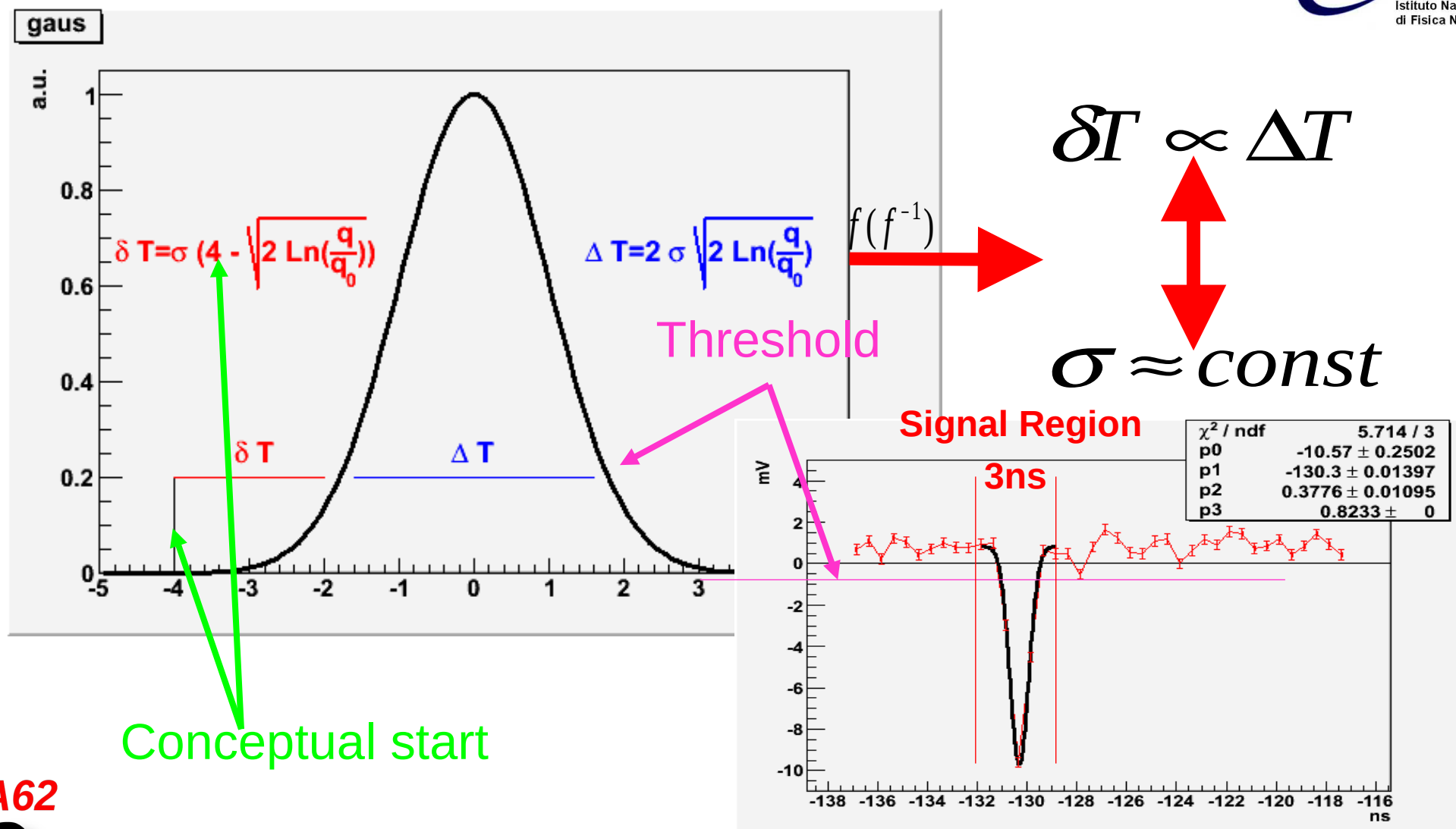
Perugia Lab

RICH TestBeam

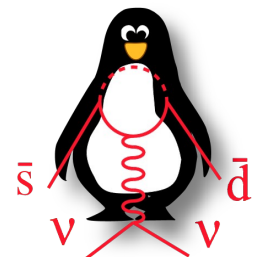
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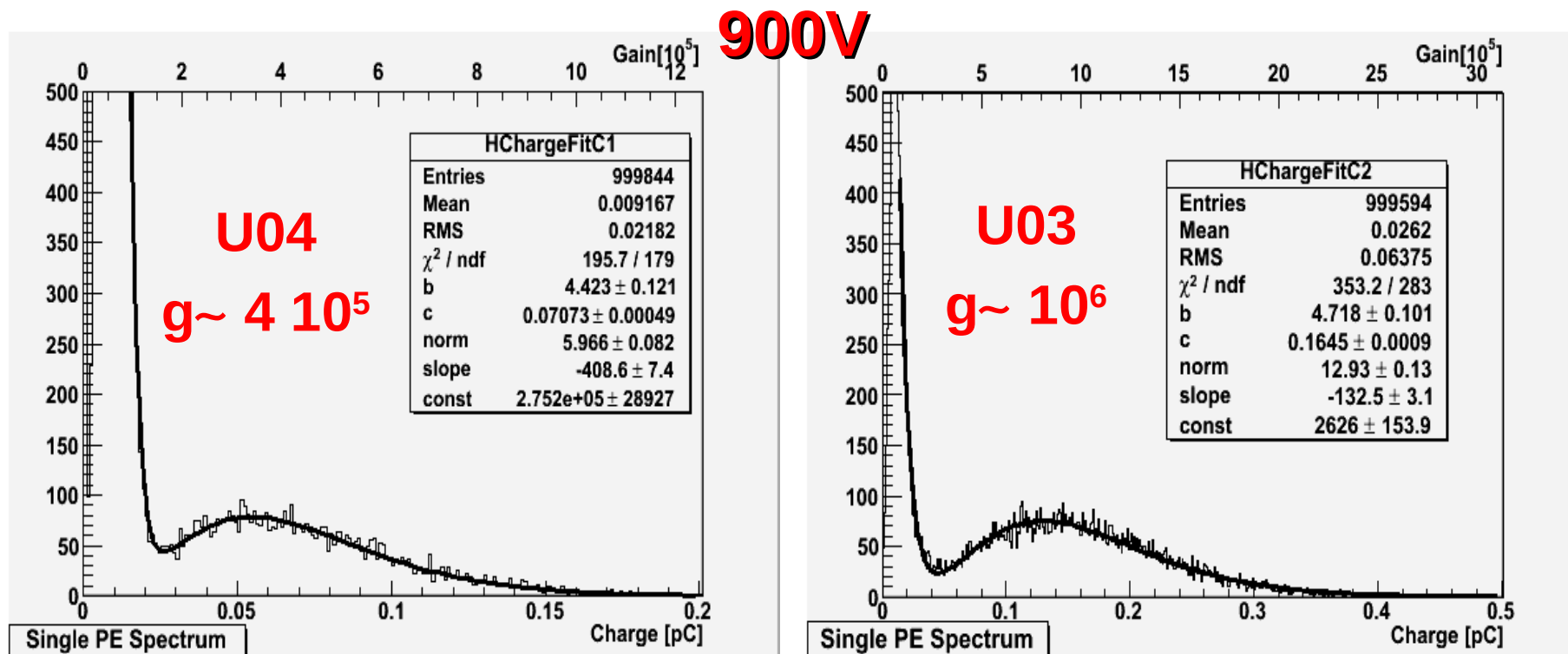
Analog signal parametrization



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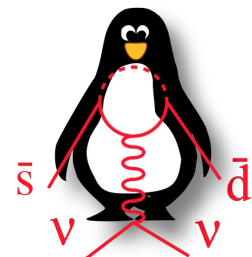


Single PE measurements



$$f(q) = \frac{\left(\frac{b}{c} - q\right)^b e^{-\frac{b}{c}q}}{x \Gamma(b)}$$

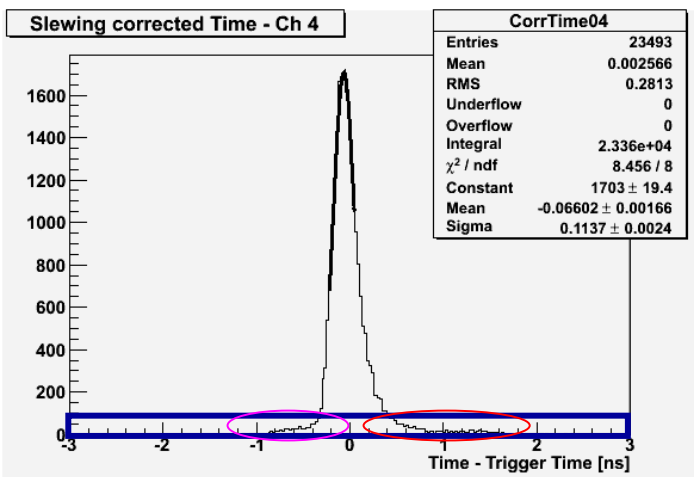
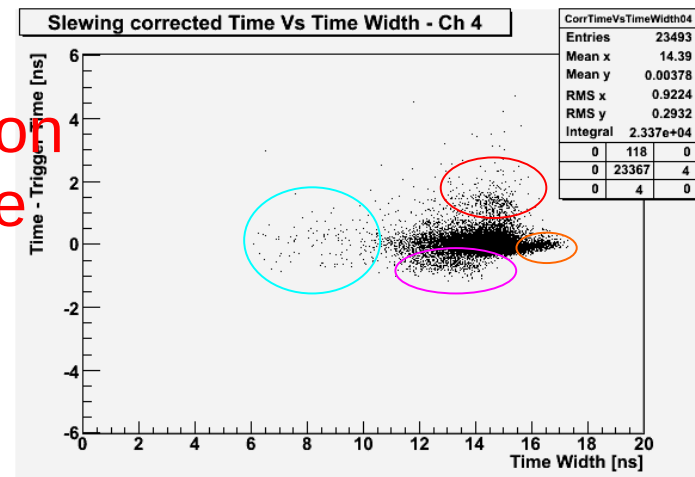
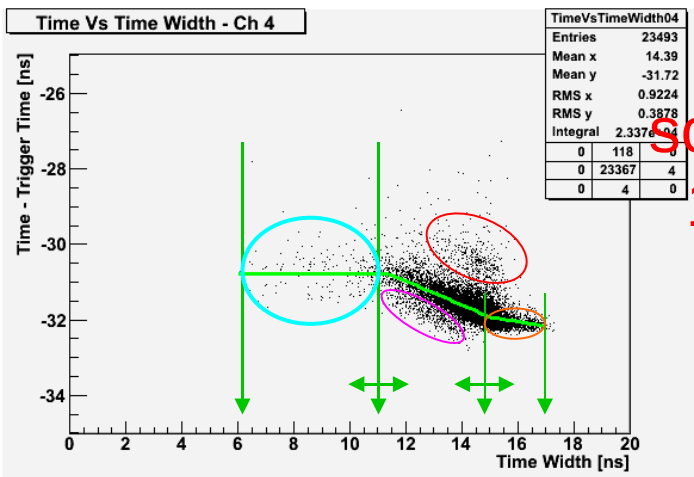
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Time resolution understandings

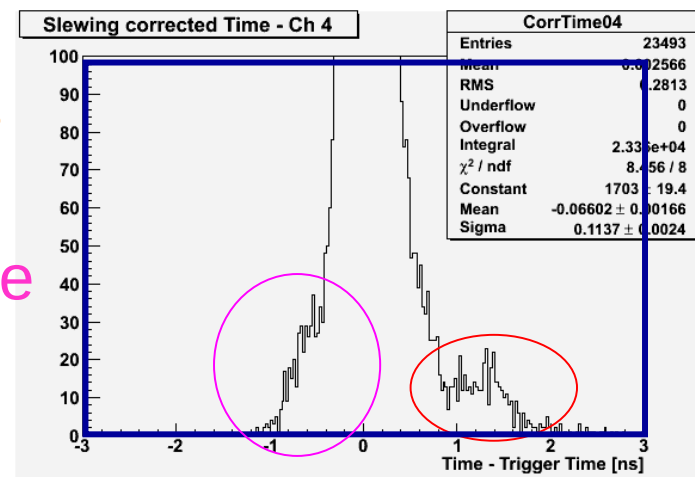
Laser specs + elastic scattering on 1st dynode

NINO stretch ineff

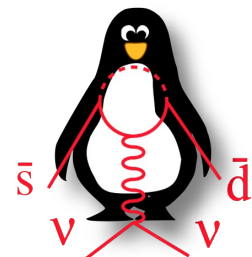


Restarts

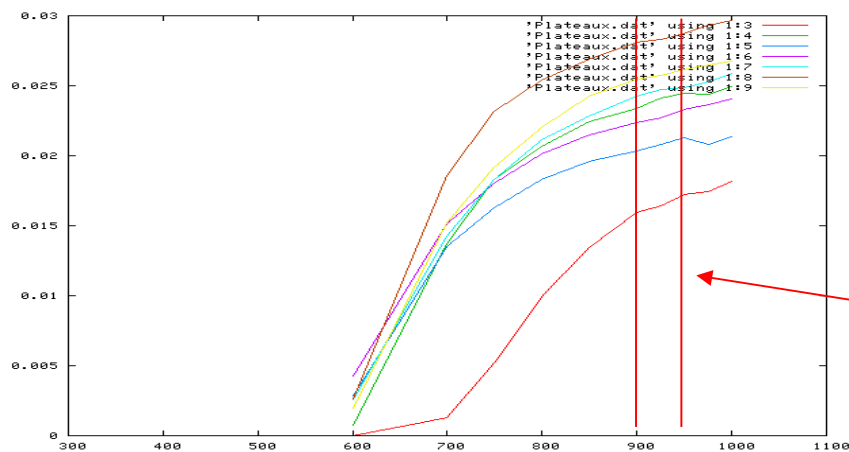
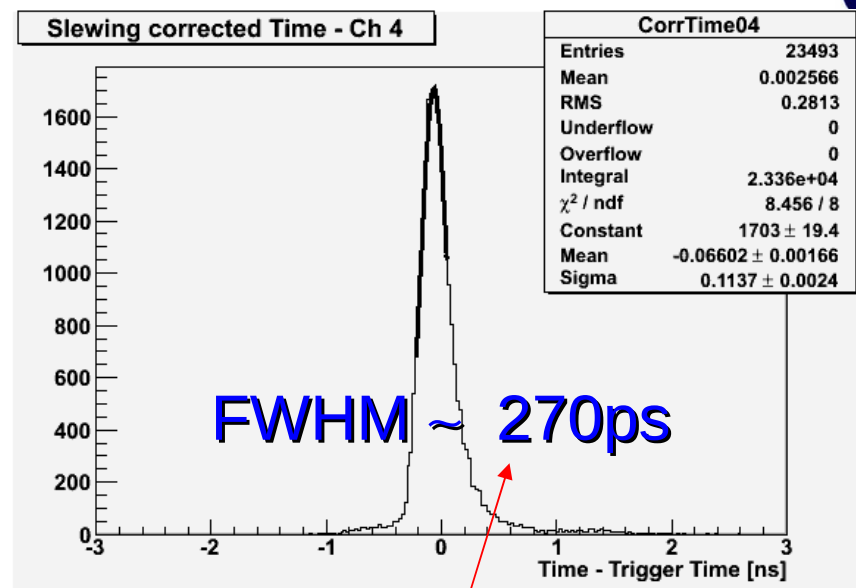
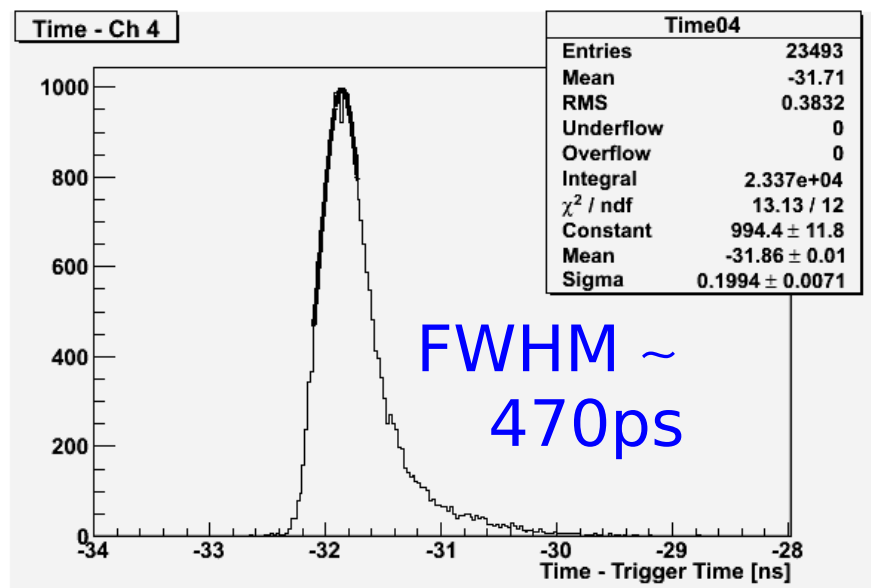
1st dynode PE



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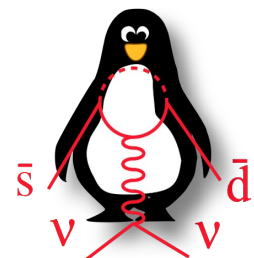


Time resolution for O(1-2) PE

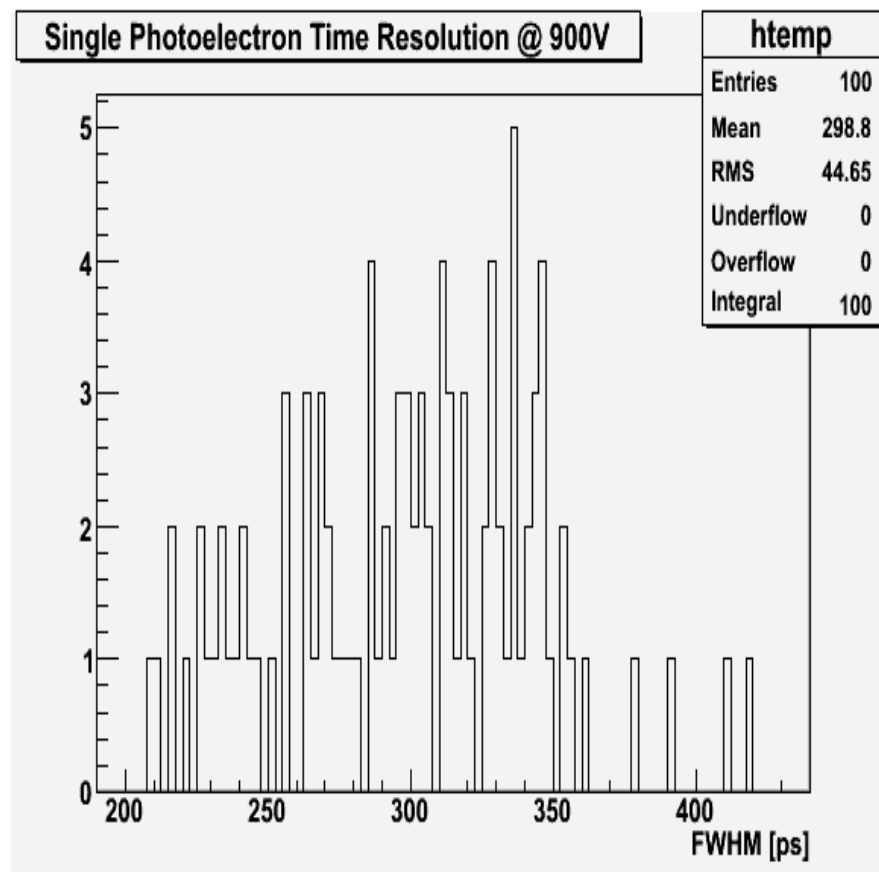
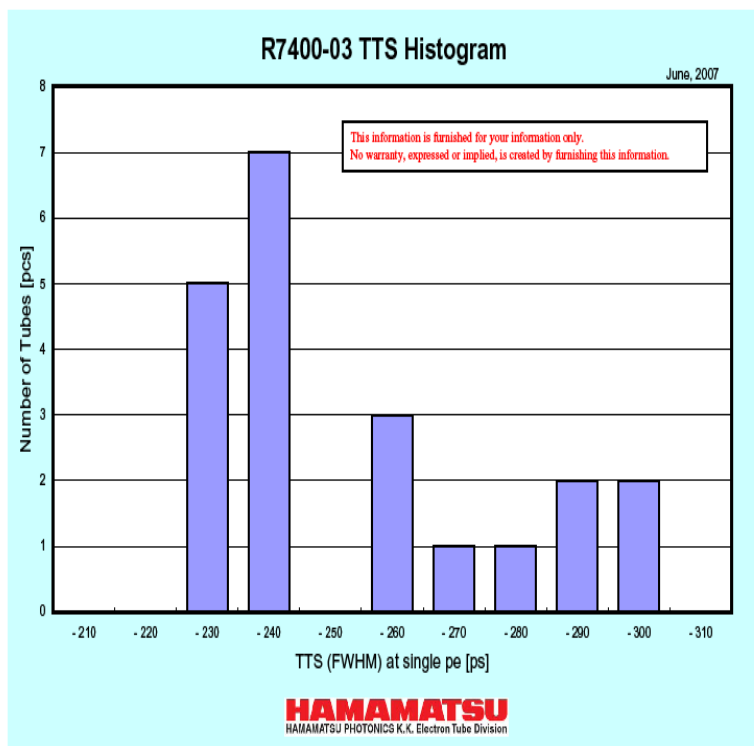


Electronics Contribution
~ 120ps

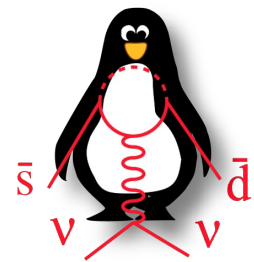
Suggested Working Voltage
900-950V



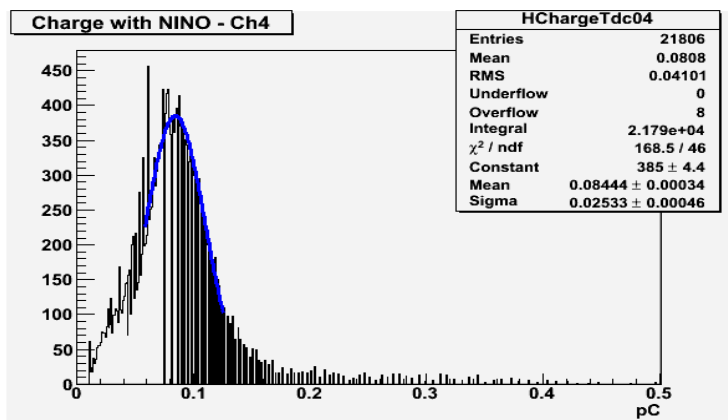
Time resolution for O(1-2) PE Results



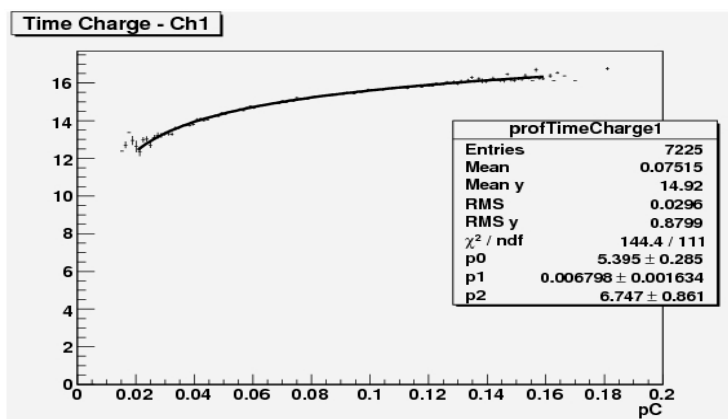
NA62



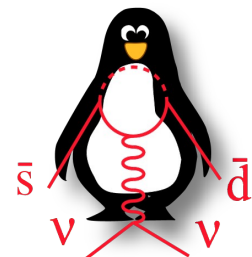
Charge Calibration Results



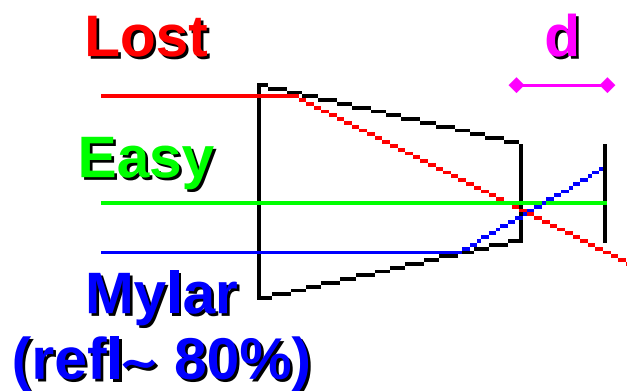
- Channel by channel
- Needs very clean input signal
- Gain estimate accuracy $\sim 10\%$
- Pulse height estimate without further electronics



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Winston's cones



- If $d < 3\text{mm} \Rightarrow 0\% \text{ Lost}$
- In tests $d = 7\text{mm} \Rightarrow 40\% \text{ Lost}$
- In the prototype $d < 2\text{mm}$
- Gain should be ~ 5
- Seen ~ 3 in tests (compatible with $40\% \text{ Lost}$)

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