

Searching for physics beyond the Standard Model in the decay $B^+ \rightarrow K^+ K^+ \pi^-$.

SN-ATLAS-2001-002

by

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- Theory
- Hadron identification and Analysis
- Branching ratio
- R-parity couplings
- Summary

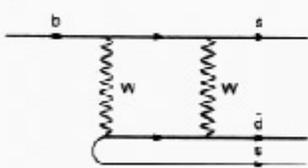
Theory

K. Huitu, C.-D. Lü, P. Singer and D.-X. Zhang, Phys. Rev. Lett. 81 (1998) 4313.

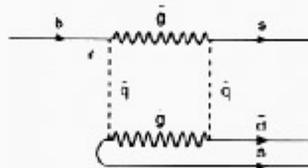
K. Huitu, C.-D. Lü, P. Singer and D.-X. Zhang, Phys. Lett. B 445 (1999) 394.

$B^+ \rightarrow K^+ K^+ \pi^-$ predicted Branching Ratios:

- SM: 10^{-11}
- THDM: 10^{-8}
- MSSM: 10^{-7}
- MSSM with R-parity violation: 10^{-4}



a) Standard Model

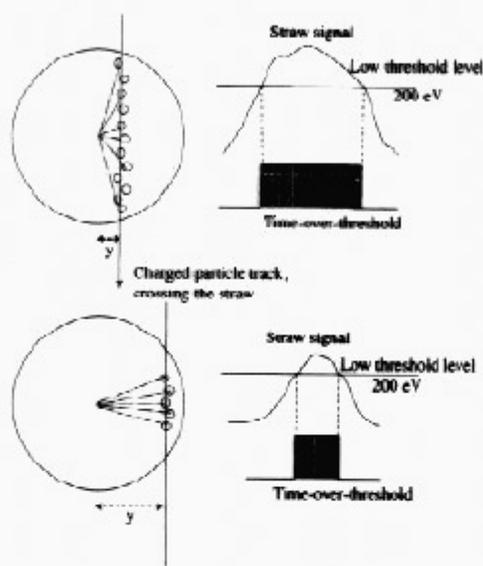


b) MSSM



c) MSSM with broken R parity

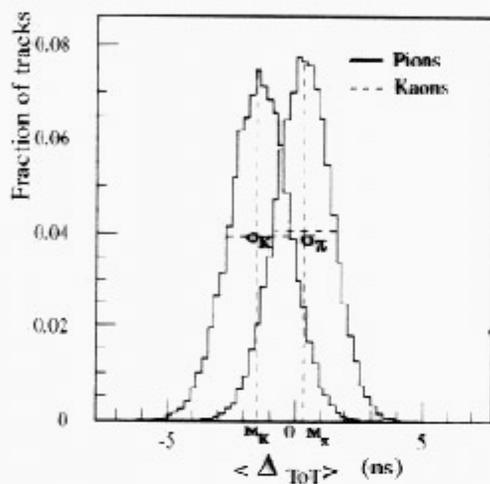
Hadron Identification based on Time-over-Threshold measurement



- ToT gives a partial information on dE/dx
- All straw hits on the track must be used to build up a dE/dx estimator

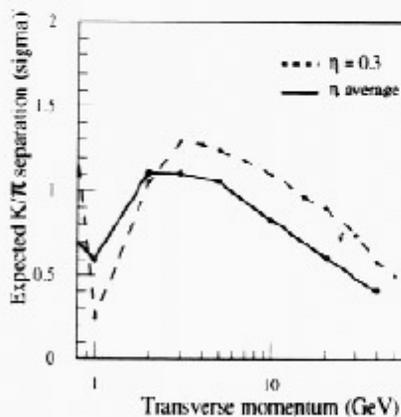
Technique explained in details in:
ATL-INDET-2000-021 by T. Åkesson *et al*
Submitted to Nucl. Instr. and Methods A.

ToT



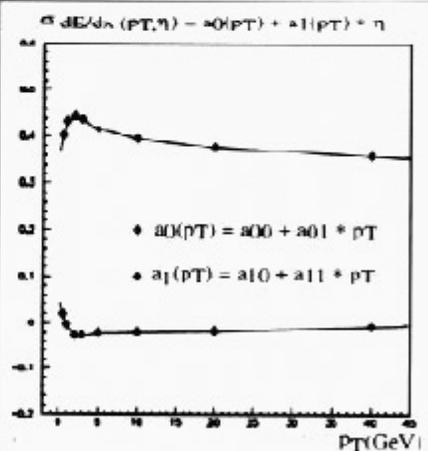
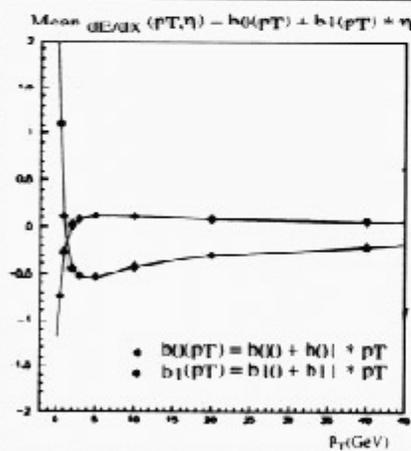
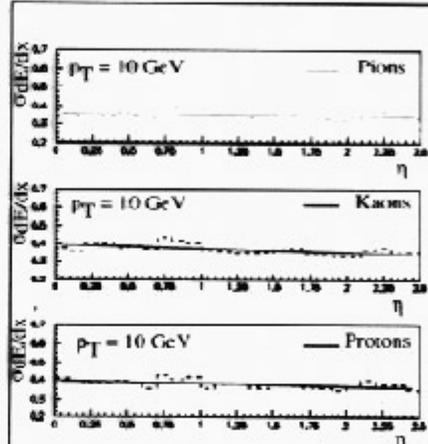
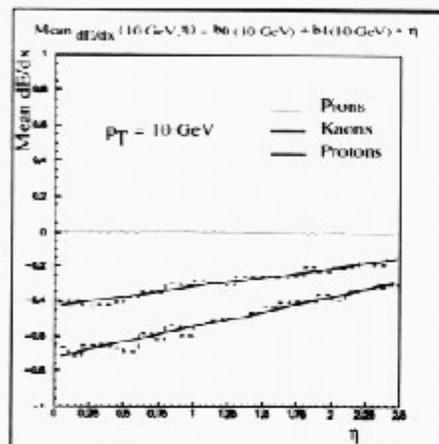
$$|\eta| = 0.3, p_T = 5 \text{ GeV}$$

K/ π separation



$$\text{Separation} = \frac{|M_K - M_\pi|}{\left(\frac{\sigma_K - \sigma_\pi}{2}\right)}$$

Parameterisation of dE/dx



Analysis

1. $p_T(\text{tracks}) > 1.5 \text{ GeV}$
2. $4 \text{ GeV} < M(\text{B}) < 6 \text{ GeV}$
3. $\chi^2(\text{triplet vertex fit}) < 2$
4. $p_T(\text{B}) > 10 \text{ GeV}$
5. Vertex detachment $> 0.1 \text{ mm}$
6. $\mathcal{P}(dE/dx) > 0.1$
7. m_{13}^2 and $m_{23}^2 > 2.5 \text{ GeV}^2$
8. $5.16 \text{ GeV} < M(\text{B}) < 5.45 \text{ GeV}$

Signal Reconstruction Efficiency: 11.6%

Background efficiency: $2.8 \cdot 10^{-4} \%$

Application to B^+ decay into $K^+K^+\pi^-$

For each particle (η , p_T) in any given triplet,
candidate for B^+ decay into $K^+K^+\pi^-$ calculates:

$$\left. \frac{dE_i}{dx} \right|_{ex} = \text{Mean} \left(\frac{dE}{dx} \right)$$

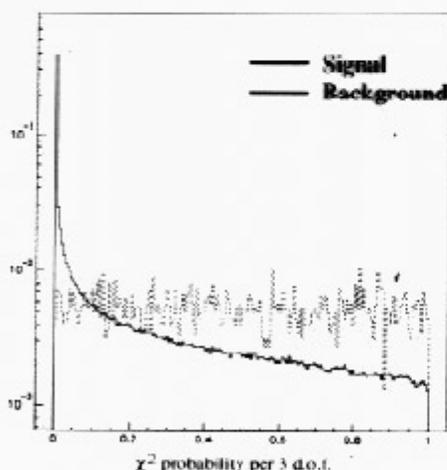
Expected w.r.t signal hypothesis:
Mean (dE/dx) pion for negative track
Mean (dE/dx) kaon for positive track

$$\left. \frac{dE_i}{dx} \right|_{actual} = \text{Mean} \left(\frac{dE}{dx} \right) + RND \cdot \text{Sigma} \left(\frac{dE}{dx} \right)$$

(in full simulation: dE/dx as measured by the detector)

$$\chi^2 = \sum_{i=1}^3 \left(\frac{\left. \frac{dE_i}{dx} \right|_{ex} - \left. \frac{dE_i}{dx} \right|_{actual}}{\sigma_i} \right)^2$$

χ^2 distribution



Results - Branching Ratio

Signal

$$N_{signal}^{obs} = \sigma(pp \rightarrow b\bar{b} \rightarrow \mu 6X) \cdot Br(b \rightarrow B^+) \cdot Br(B^+ \rightarrow K^+ K^+ \pi^-) \cdot \int \mathcal{L} dt \cdot \epsilon_{rec} \cdot \epsilon_{id}$$

$$\sigma(pp \rightarrow b\bar{b} \rightarrow \mu 6X) = 2.3 \mu\text{b}$$

$$Br(b \rightarrow B^+) = 38.9\%$$

$$\int \mathcal{L} dt = 30 \text{fb}^{-1}$$

$$\epsilon_{rec} = 11.6\%$$

$$\epsilon_{id}(\mu 6) = 0.85$$

$$\epsilon_{id}(\pi, K) = 0.90$$

Background

$$N_{bg}^{obs} = \sigma(pp \rightarrow b\bar{b} \rightarrow \mu 6X) \cdot \int \mathcal{L} dt \cdot \epsilon_{rec} \cdot \epsilon_{id}$$

$$\epsilon_{rec} = 2.8 \cdot 10^{-4}\%$$

Limits

$$Br(B^+ \rightarrow K^+ K^+ \pi^-) = 3.5 \cdot 10^{-7} \text{ @ 95\% CL}$$

$$Br(B^+ \rightarrow K^+ K^+ \pi^-) = 9.0 \cdot 10^{-7} \text{ for } 5 \sigma$$

Comparison to other experiments

-  $Br < 8.79 \cdot 10^{-5}$ @ 90% CL

-  $Br < 3.4 \cdot 10^{-7}$ @ 95% CL

-  **BABAR** and  **BELLE**
Only few events if $Br \sim \mathcal{O}(10^{-7})$

-  could set $Br < 8.1 \cdot 10^{-7}$ @ 95% CL

-  could set $Br < 4.1 \cdot 10^{-8}$ @ 95% CL

Results - Limits on R-parity violating couplings

The $b \rightarrow ss\bar{d}$ decay rate induced by the R-parity violating couplings was estimated in to be :

(K. Huitu, C.-D. Lü, P. Singer and D.-X. Zhang, Phys.Rev. Lett. 81 (1998) 4313.)

$$\Gamma(b \rightarrow ss\bar{d}) = \frac{m_b^5 f_{\text{QCD}}^2}{512(2\pi)^3 m_{\tilde{\nu}}^2} \left(\left| \sum_{i=1}^3 \lambda'_{i32} \lambda'^*_{i21} \right|^2 + \left| \sum_{i=1}^3 \lambda'_{i12} \lambda'^*_{i23} \right|^2 \right)$$

$$m_b = 4.5 \text{ GeV}$$

$$f_{\text{QCD}} = (\alpha_s(b)/\alpha_s(m_{\tilde{\nu}}))^{24/23} = 2$$

$$m_{\tilde{\nu}} = 100 \text{ GeV}$$

$$\tau_{B^+} = 1.65 \text{ ps}$$

$$\sqrt{\left| \sum_{i=1}^3 \lambda'_{i32} \lambda'^*_{i21} \right|^2 + \left| \sum_{i=1}^3 \lambda'_{i12} \lambda'^*_{i23} \right|^2} < 5.4 \cdot 10^{-5}.$$

Summary - SN-ATLAS-2001-002

- Hadron identification using ToT measurements in the ATLAS TRT is used.
- Feasibility of reconstructing the $B^+ \rightarrow K^+ K^+ \pi^-$ in ATLAS.
- An upper limit of $Br(B^+ \rightarrow K^+ K^+ \pi^-) = 3.5 \cdot 10^{-7}$ @ 95% CL can be set
Approaching Br predicted by MSSM and THDM scenarios.
- In the case of R-parity violation, ATLAS can set limits on the couplings.
- Combining all results, the LHC experiments can contribute significantly to the search and measurements of physics beyond the Standard Model using the $B^+ \rightarrow K^+ K^+ \pi^-$ decay channel.