Meenakshi Narain Memorial Symposium

Students and Mentorship

Ariel Schwartzman
SLAC

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Measurement of the $B^{\pm}$ Lifetime and Top Quark Identification using Secondary Vertex b-tagging

Ariel Schwartzman

Thesis Advisor: Ricardo Piegaia

Assistant Advisor: Meenakshi Narain

This dissertation presents a preliminary measurement of the $B^{\pm}$ lifetime through the full reconstruction of its decay chain, and the identification of top quark production in the electron plus jets channel using the displaced vertex b-tagging method. Its main contribution is the development, implementation and optimization of the Kalman filter algorithm for vertex reconstruction, and of the displaced vertex technique for tagging jets arising from b quark fragmentation, both of which have now become part of the standard DØ reconstruction package. These two algorithms fully exploit the new state-of-the-art tracking detectors, recently installed as part of the Run 2 DØ upgrade project. The analysis is based on data collected during Run 2a at the Fermilab Tevatron $p\bar{p}$ Hadron Collider up to April 2003, corresponding to an integrated luminosity of $60\,pb^{-1}$. The measured B meson lifetime of τ=1.57±0.18 ps is in agreement with the current world average, with a competitive level of precision expected when the full data sample becomes available.

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Acknowledgments

Working in the DØ experiment at Fermilab was a fascinating experience. I had the unique opportunity to work with exceptional physicists from whom I learned and shared the excitement of working in such a special place. This thesis is the result of the work of a great number of people and institutions and I am grateful to all of them.

First of all, I would like to express my gratitude to my thesis advisor Ricardo Piegaia. He gave the opportunity to work in Fermilab and provided guidance and support through my Ph.D. He spent an incredible amount of time helping me during the development of this thesis. Without his help and advice, this thesis would not have been possible.

I would like to thank my co-advisor, Meenakshi Narain. She is responsible for almost all the accomplishments in this thesis and I own her huge gratitude. She guided me through all my Ph.D giving me support, advice and a lot of work!. She has been not only a brilliant physicist, but also an extraordinary human being who did not hesitate to help and support me every time I asked for her advice.

I would like to thank Mark Strovink, who has been an example through my career. I am grateful for his support on my work, and his advice.

I want to express my gratitude to Greg Landsberg. Working with him was fascinating. Every discussion with Greg was a source of inspiration and new ideas.

I spent a significant amount of time working in the vertex and b-id groups and I

A New 3-Dimensional Cone Track-Clustering Algorithm

Ariel Schwartzman
Meenakshi Narain

July 3, 2001

The current simple cone algo
tracks is based on track p_T, η a
from different primary vertices n
resolution of the cluster and inc
purpose of this note is to present
simple cone algorithm and whic
bias tracks by forming clusters i
The result is a set of track-cluste
and, eventually, one or more low
vertices. This method is very u
secondary vertex finding

Secondary Vertex Reconstruction using the Kalman Filter

Ariel Schwartzman
Meenakshi Narain

September 29, 2001

Abstract

This note describes a method to reconstruct secondary and tertiary displaced vertices from b-quark hadronization with the purpose of b-jet identification. The algorithm is based on the Kalman Filter fitting technique and combines geometric and kinematics information to discriminate between b-decay and misreconstructed vertices. Its optimization on $t\bar{t}$ Monte Carlo events is described

Probabilistic Primary Vertex Selection

October 22, 2002

Abstract

This notes describes one of the problems of the primary vertex selection in RunIIa data reconstructed with 0 reco versions up to p11.13 which is the presence and selection of "splitted" vertices made of mostly 2 tracks with poor resolution coming from the hard interaction and proposes a new algorithm to solve it. In addition, a new probabilistic algorithm for Primary Vertex selection is introduced.

b-quark jet identification via Secondary Vertex reconstruction in DØreco p13 Software

Ariel Schwartzman
Meenakshi Narain

DØ Note 4081
Jan 11, 2003

Abstract

This note describes the performance of the secondary vertex tagger in event samples reconstructed with p13.0x.00 version of the DØsoftware. We only present a few updates relative to the study we previously carried out using DØreco version p11. A more detailed description of the algorithm and many more studies on characteristics of the *b*-quark jets in physics events using DØreco p11 version of the software may be found in document

`www-d0.fnal.gov/phys_id/bid/d0_private/certification/p13/secvertex/notes/D0note4081.ps`

- Joined DZero in 1999
- Worked with Meenakshi in the development of primary vertex reconstruction and the secondary vertex b-tagging algorithm for Run 2
- Fascinating journey led by Meenakshi's talent, physics knowledge and intuition, scientific vision, passion, and unlimited energy
- My interactions with Meenakshi defined me as a scientist

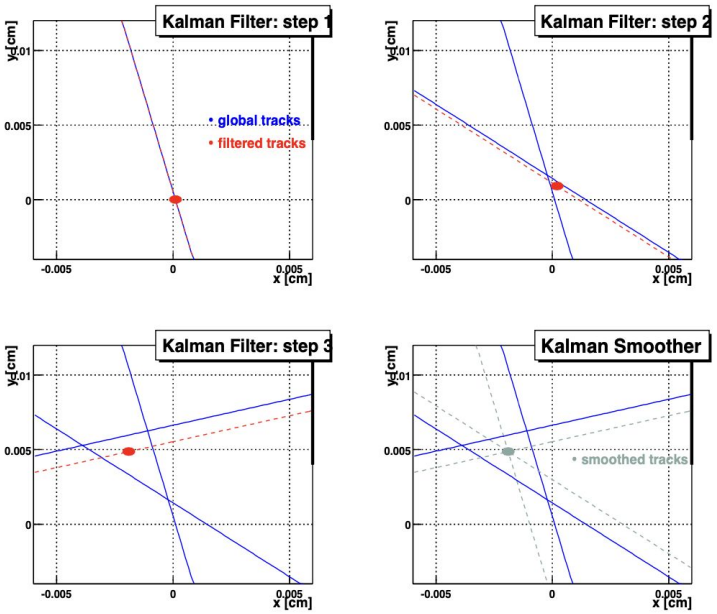


Figure 4.3: Example of 3-track vertex fit using the Kalman Filter

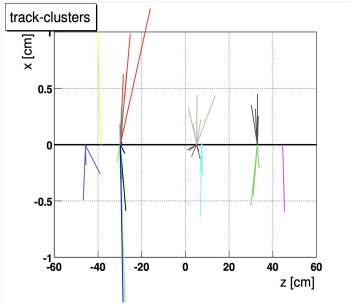
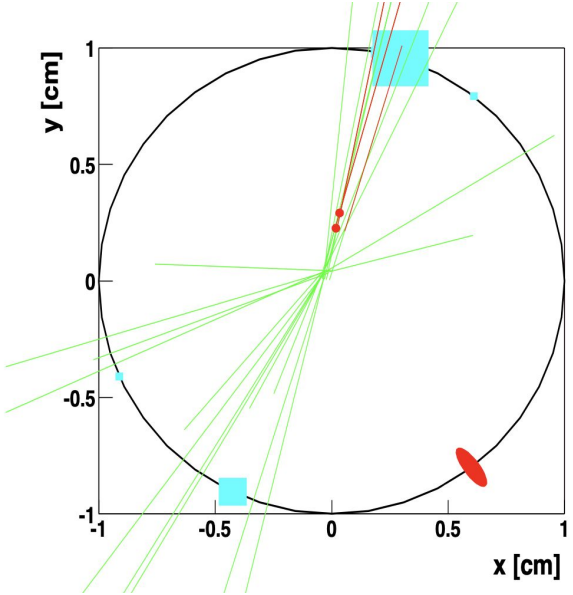


Figure 2: x-z view of 3d simple cone track-jets



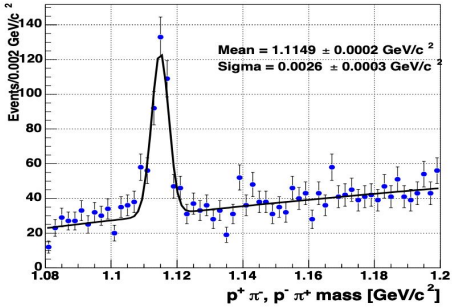
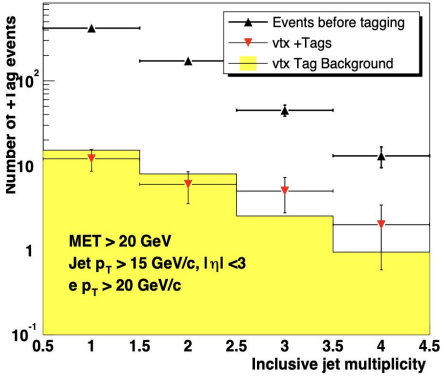


Figure 4.35: Invariant mass of Λ and $\bar{\Lambda}$ secondary vertex candidates for $prob(\chi^2) > 0.01$, $|IP/\sigma| > 3$, and collinearity> 0.9999.



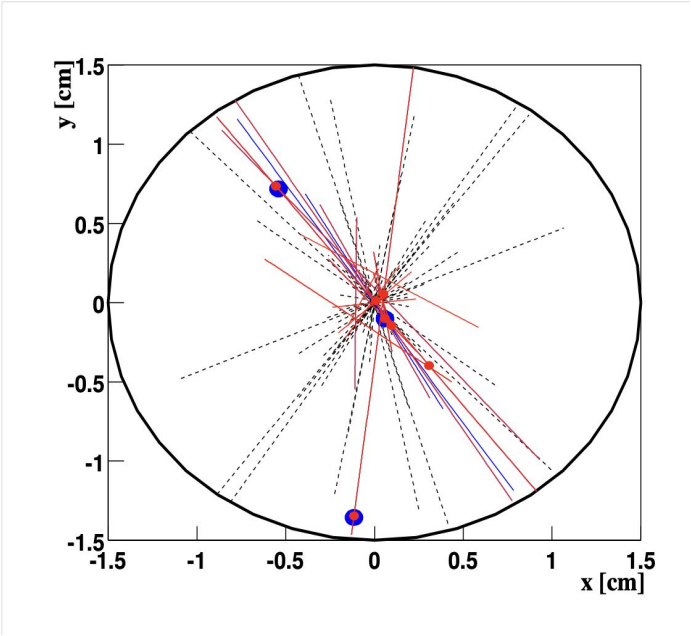


Figure 46: Vertex finding event display. In blue MC vertices, in red reconstructed vertices. Primary vertex tracks in black.

reco (3 tracks matched)	445 (0.64)
reco (2 tracks matched)	648 (0.93)
missed tracks	309
from primary vertex	233 (0.75)
fake tracks	1256
fakes in 3-track vertices	70 (0.06)
x resolution	121 *um*
y resolution	130 *um*

- Build-Up, position $\chi^2 < 5$

reco (3 tracks matched)	314 (0.45)
reco (2 tracks matched)	450 (0.64)
missed tracks	206
from primary vertex	167 (0.81)
fake tracks	1178
fakes in 3-track vertices	40 (0.03)
x resolution	140 *um*
y resolution	157 *um*

- Tear-Down, total $\chi^2 < 10$

reco (3 tracks matched)	396 (0.57)
reco (2 tracks matched)	589 (0.84)
missed tracks	302
from primary vertex	174 (0.58)
fake tracks	1688
fakes in 3-track vertices	79 (0.05)
x resolution	153 *um*
y resolution	119 *um*

	1 MC vertex	2 MC vertices
eff(1 reco vertex)	0.60	0.82
eff(2 reco vertices)	-	0.46

	1 MC vertex	2 MC vertices
purity(1 reco vertex)	0.52	0.35
purity(2 reco vertices)	-	0.20

1. Build-up

	1 MC vertex	2 MC vertices
eff(1 reco vertex)	0.55	0.77
eff(2 reco vertices)	-	0.43

	1 MC vertex	2 MC vertices
purity(1 reco vertex)	0.59	0.38
purity(2 reco vertices)	-	0.21

global vertex efficiency	0.50
global vertex purity	0.46
b-tagging efficiency	0.76
l-tagging efficiency	0.05

2. Tear-down

	1 MC vertex	2 MC vertices
eff(1 reco vertex)	0.41	0.62
eff(2 reco vertices)	-	0.19

	1 MC vertex	2 MC vertices
purity(1 reco vertex)	0.80	0.71
purity(2 reco vertices)	-	0.22

global vertex efficiency	0.36
global vertex purity	0.65
b-tagging efficiency	0.60
l-tagging efficiency	0.00

global vertex efficiency	0.59
global vertex purity	0.16
b-tagging efficiency	0.89
l-tagging efficiency	0.04

Next few tables show the parameters for the tear-down vertex-finding step:

	1 MC vertex	2 MC vertices
eff(1 reco vertex)	0.44	0.66
eff(2 reco vertices)	-	0.21

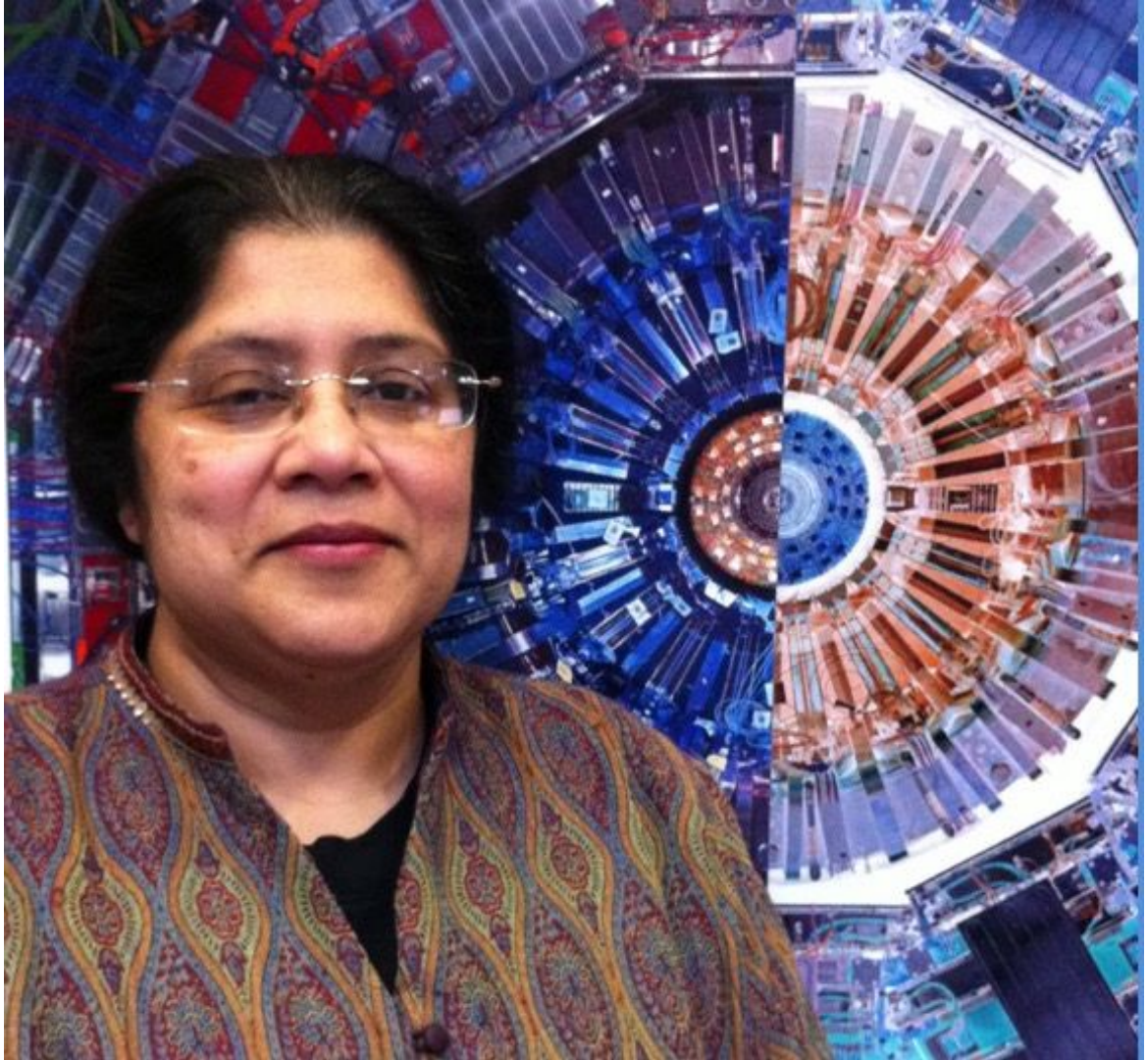
	1 MC vertex	2 MC vertices
purity(1 reco vertex)	0.76	0.68
purity(2 reco vertices)	-	0.22

global vertex efficiency	0.46
global vertex purity	0.26
b-tagging efficiency	0.68
l-tagging efficiency	0.01

The average vertex multiplicity per jet, for both algorithms, is shown in the table.

average MC vertex multiplicity per b-jet	0.63
average RECO vertex multiplicity per b-jet (build-up)	1.75
average RECO vertex multiplicity per l-jet (build-up)	1.30
average RECO vertex multiplicity per b-jet (tear-down)	1.09
average RECO vertex multiplicity per l-jet (tear-down)	1.05

Meenakshi taught me how to always reach an extremely detailed low level understanding.
Influenced the way I think and work.
She was constantly asking me for more tables and plots!



Meenakshi

Meenakshi had a profound impact on my whole scientific career. Her advice, kindness, passion, knowledge, and extremely high standards, continue to be stamped on me. She has influenced who I am and what scientist I am.

I first met Meenakshi 23 years ago. I was a new graduate student from the University of Buenos Aires who came to Fermilab to work on the DZero experiment. I joined DZero at a time where preparations for Run 2 were starting. My interest was to pursue a Run 2 thesis exploiting the brand-new silicon tracker capability to perform b-tagging, for which I joined the vertex group who was led by Meenakshi at that time.

Very quickly, we developed an extraordinary and very close working relationship on vertexing, then b-tagging, and finally on the first steps towards measuring the ttbar cross section with early Run 2 data. Even though I was a Buenos Aires student, Meenakshi “adopted” me as her own graduate student. She was always available to support me. During my time at DZero, and through this collaboration, Meenakshi taught me what it is to be a scientist.

These years as a graduate student at DZero were some of the most exciting and intense in my life. With Meenakshi we developed the primary and secondary vertexing algorithms, b-tagging using secondary vertices, and the software framework. We then worked on the commissioning and calibration of vertexing and b-tagging with early data, and finally on the application of these new tools to identify top quarks. When I arrived at Fermilab I could have not imagined achieving any of this. Meenakshi was fundamental to make all my work coherent towards a common physics goal.

Meenakshi and I discussed results, plans, and ideas on an almost daily basis. She constantly pushed me to get the best of me. I learned physics, how to work in a large collaboration, how to keep up with competition, and a way of thinking. She was also always thinking many steps ahead of the work we were doing. For example, she made me start working on various key aspects of top physics while we were still extremely busy commissioning the secondary vertex b-tagging algorithm. She always had the big picture of the broader field.

Meenakshi was extremely demanding, and that often meant working a lot. I remember many nights when I was working until very late hours and Meenakshi would call me to my office regularly to check on my progress, discuss new results, and make sure I had all the support I needed.

Meenakshi’s mentorship created an ideal working environment that inspired and motivated me throughout my whole Ph.D. Meenakshi’s strong personality was part of this magic. Meenakshi made me feel my work was important, valued, and the most interesting, unique, and exciting activity possible. **The joy of my work was not just the research itself (which was fascinating), it was the research I was doing with Meenakshi. She added an entirely new dimension, fueled by her passion, dedication, inspiration, and personality**.

When Meenakshi relocated to Boston, she invited me for three months so that I would be able to continue to work closely with her while she was teaching and unable to travel to Fermilab. Such dedication and commitment made a strong mark on me. I remember this time as an extremely exciting and intense period of my life. Meenakshi would ask me for tons of new tables to understand the impact of various parameters and I would rush to the student’s office at Boson to make them and interpret the results. Every time, these tables and detailed studies brought new light to the work we were doing and allowed us to constantly improve the secondary vertex b-tagging algorithm and introduce innovations. Meenakshi taught me how to approach research in an extremely systematic and detailed way, and always aiming at the highest quality. These lessons were deeply imprinted on me. **This way of thinking that I learned from Meenkashi has defined me as a scientist**.

Meenakshi always advocated for my work and pushed me in new directions. As a result of our strong collaboration, Meenakshi was officially appointed my thesis co-advisor and she and Ulrich later traveled to Buenos Aires for my thesis defense. These were also moments I will never forget.

Her mentorship did not end when I graduated. I reached out to Meenakshi every time I had career or work questions. Such continued support was invaluable. She would always be available for deep and insightful conversations and advice. **Meenakshi mentorship has been a lifelong commitment**.

What made Meenakshi an extraordinary mentor was that she was emotionally present all the time you discussed with her. This created an atmosphere of inspiration that generated ideas and motivation. You could see how Meenakshi was genuinely listening, trying to help and guide, and this human connection made all the difference. Ultimately, science is a human activity pursued by people, and it is the power of human connections that influences us in positive ways and advances our field.

Meenakshi’s mentorship has profoundly shaped my career and continues to influence it to this date. I will be forever grateful to have had the privilege to be one of Meenakshi’s students. She made me a scientist, and a better human being. **I will miss you greatly Meena.**