

# Quaero

Making HEP Data Publicly Available

<http://quaero.fnal.gov/>

Motivation

Data

Algorithm

Examples

Bruce Knuteson

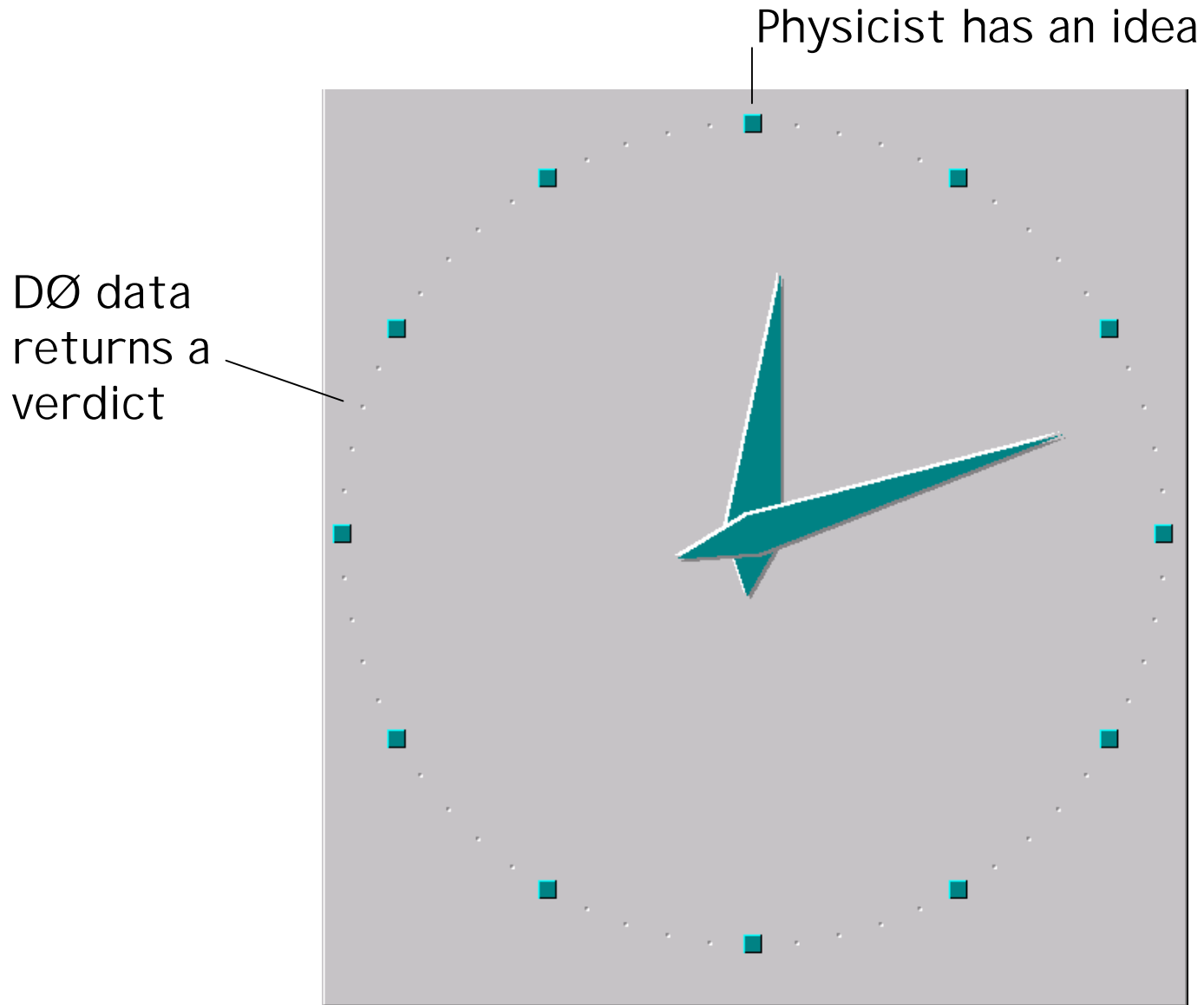
University of Chicago / CDF

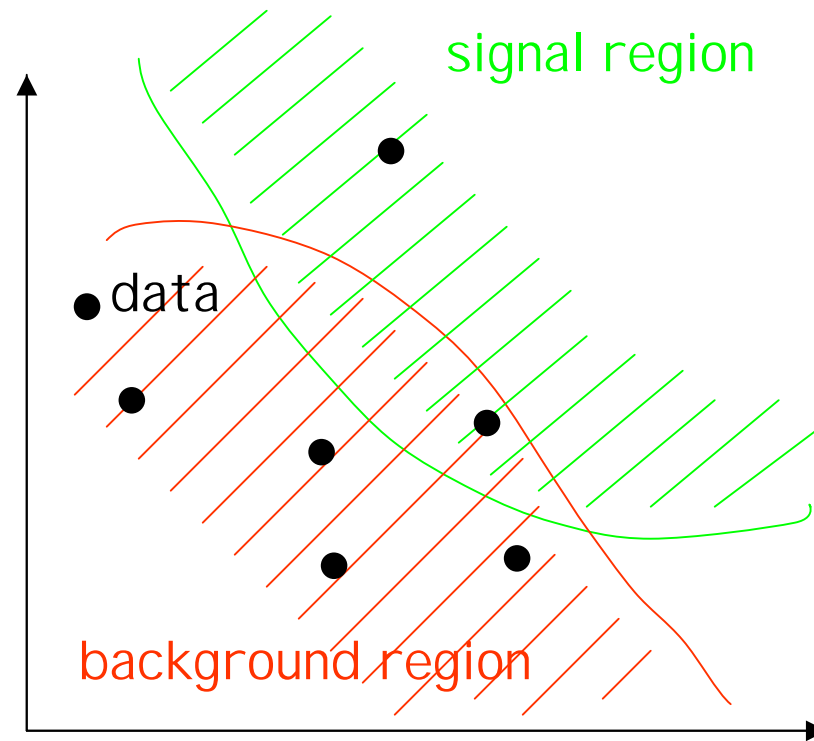
UC Berkeley / LBNL / DØ

# Motivation

# Time

<u>January 1999</u>	<u>February 1999</u>	<u>March 1999</u>	<u>January 2000</u>	<u>February 2000</u>	<u>March 2000</u>
Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
<u>April 1999</u>	<u>May 1999</u>	<u>June 1999</u>	<u>April 2000</u>	<u>May 2000</u>	<u>June 2000</u>
Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
<u>July 1999</u>	<u>August 1999</u>	<u>September 1999</u>	<u>July 2000</u>	<u>August 2000</u>	<u>September 2000</u>
Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
<u>October 1999</u>	<u>November 1999</u>	<u>December 1999</u>	<u>October 2000</u>	<u>November 2000</u>	<u>December 2000</u>
Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30	Su Mo Tu We Th Fr Sa 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31





How does one choose a set of cuts without bias?



The screenshot shows the Wired News website interface. At the top left is the logo "WIRED NEWS" in a red and green pixelated font. To the right are navigation links: BUSINESS (with a dollar sign icon), POLITICS (with a building icon), WIRE SERVICE (with a globe icon), CULTURE (with a gear icon), TECHNOLOGY (with a gear icon and highlighted in red), and TOP STORIES (with an upward arrow icon). Below the navigation is a search bar with the text "LOOK FOR" on the left, a search input field containing "Wired News", a dropdown arrow, and a "GO" button. Underneath the search bar are links for "Print this", "E-mail it", and "Set E-mail Alerts". The main content area features the article title "Secrets of the Atom Revealed" in bold black text, followed by the author "By Jeffrey Benner" in blue text. Below that is the date "2:00 a.m. July 27, 2001 PDT" in red text. The article text begins with "You can find a lot of information on the Web, but you just couldn't find a decent picture of the subatomic universe online. Until now. Scientists at the [Fermilab](#) in Illinois, home to the world's most powerful atom smasher, announced Wednesday that data collected during the last big round of experiments into the depths of the atom is now available online."

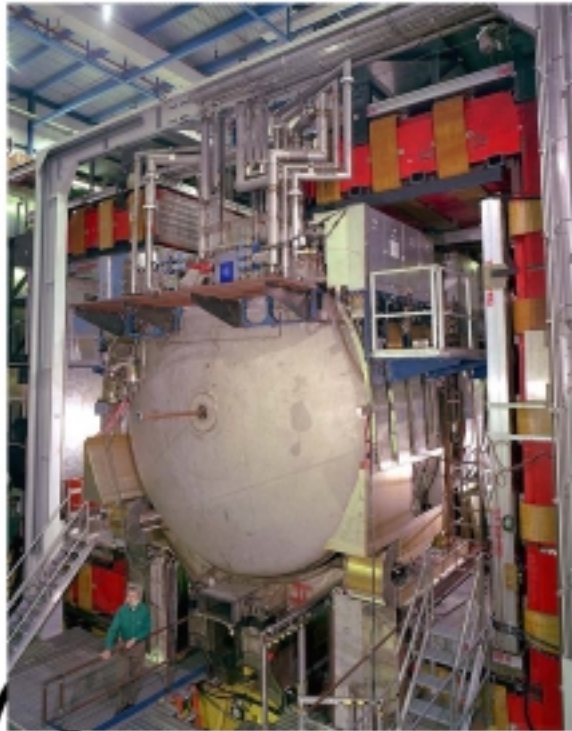
# Search for New Physics Using Quaero: A General Interface to DØ Event Data

DØ makes a subset of Tevatron Run I data publicly available

hep-ex/0106039

## Search for New Physics Using QUAERO: A General Interface to DØ Event Data

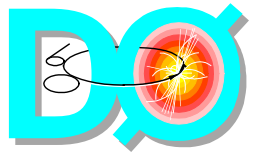
V.M. Abazov,<sup>20</sup> B. Abbott,<sup>22</sup> A. Abdesselam,<sup>21</sup> M. Abolins,<sup>24</sup> V. Abramov,<sup>20</sup> B.S. Acharya,<sup>117</sup> D.L. Adams,<sup>42</sup> M. Adams,<sup>20</sup> S.N. Ahmed,<sup>28</sup> C.D. Alexander,<sup>20</sup> G.A. Alves,<sup>2</sup> N. Amos,<sup>40</sup> E.W. Anderson,<sup>40</sup> Y. Arnaud,<sup>2</sup> M.M. Baarmand,<sup>24</sup> V.V. Bahintsev,<sup>26</sup> L. Babicharia,<sup>22</sup> T.C. Bacon,<sup>20</sup> A. Baden,<sup>43</sup> B. Baldin,<sup>27</sup> P.W. Balm,<sup>20</sup> S. Banerjee,<sup>17</sup> E. Barberis,<sup>20</sup> P. Barlinger,<sup>44</sup> J. Barrwin,<sup>2</sup> J.F. Bartlett,<sup>27</sup> U. Baurier,<sup>12</sup> D. Bauer,<sup>23</sup> A. Beau,<sup>24</sup> M. Begel,<sup>44</sup> A. Belyaev,<sup>24</sup> S.B. Bedi,<sup>14</sup> C. Bernadi,<sup>12</sup> I. Bertrand,<sup>27</sup> A. Besson,<sup>2</sup> R. Beuselinck,<sup>22</sup> V.A. Bezrukov,<sup>20</sup> P.C. Bhat,<sup>27</sup> V. Bhatnagar,<sup>12</sup> M. Bhattacharjee,<sup>22</sup> G. Blazey,<sup>20</sup> S. Blossing,<sup>24</sup> A. Boshnain,<sup>27</sup> N.I. Bojko,<sup>20</sup> F. Borcharding,<sup>27</sup> K. Borz,<sup>20</sup> A. Brandt,<sup>22</sup> R. Breedon,<sup>21</sup> C. Briskin,<sup>29</sup> R. Brook,<sup>24</sup> C. Brodijmann,<sup>27</sup> A. Bruce,<sup>27</sup> D. Buchholz,<sup>40</sup> M. Bruchler,<sup>20</sup> V. Buzaschar,<sup>24</sup> V.S. Burdakov,<sup>20</sup> J.M. Butler,<sup>20</sup> J. Camilleri,<sup>24</sup> W. Carvalho,<sup>2</sup> D. Casey,<sup>24</sup> Z. Castlun,<sup>44</sup> H. Castilla-Valdez,<sup>14</sup> D. Chakraborty,<sup>29</sup> K.M. Chan,<sup>24</sup> S.V. Chelmshev,<sup>20</sup> D.K. Cho,<sup>24</sup> S. Choi,<sup>24</sup> S. Chopra,<sup>20</sup> J.H. Christensen,<sup>27</sup> M. Chung,<sup>20</sup> D. Class,<sup>20</sup> A.R. Clark,<sup>20</sup> J. Cochran,<sup>26</sup> L. Conroy,<sup>40</sup> B. Connolly,<sup>20</sup> W.E. Cooper,<sup>27</sup> D. Coppage,<sup>44</sup> S. Crépeau-Renaudin,<sup>2</sup> M.A.C. Cummings,<sup>20</sup> D. Cutts,<sup>20</sup> G.A. Davis,<sup>24</sup> K. Davis,<sup>29</sup> K. De,<sup>40</sup> S.J. de Jong,<sup>20</sup> K. Del Signore,<sup>27</sup> M. Demarban,<sup>20</sup> R. Demina,<sup>40</sup> P. Demina,<sup>20</sup> D. Denin,<sup>27</sup> S.P. Denisov,<sup>20</sup> S. Deniz,<sup>44</sup> H.T. Diehl,<sup>27</sup> M. Diesburg,<sup>27</sup> G. Di Loreto,<sup>44</sup> S. Doolan,<sup>49</sup> P. Draper,<sup>40</sup> Y. Ducoen,<sup>12</sup> L.V. Dudkin,<sup>20</sup> S. Dussling,<sup>21</sup> L. Duflot,<sup>14</sup> S.R. Dugad,<sup>2</sup> A. Duperrin,<sup>12</sup> A. Dyshkant,<sup>20</sup> D. Edmunds,<sup>24</sup> J. Ellison,<sup>24</sup> Y.D. Elvira,<sup>27</sup> R. Engelmann,<sup>20</sup> S. Eno,<sup>47</sup> C. Eppley,<sup>20</sup> P. Ermolov,<sup>20</sup> O.V. Ershin,<sup>20</sup> J. Estrada,<sup>14</sup> H. Evans,<sup>20</sup> V.N. Evdokimov,<sup>20</sup> T. Fahland,<sup>20</sup> S. Faber,<sup>27</sup> D. Fain,<sup>20</sup> T. Farber,<sup>24</sup> F. Filthart,<sup>20</sup> H.E. Flak,<sup>27</sup> Y. Fislyak,<sup>20</sup> E. Flatum,<sup>27</sup> F. Fleuret,<sup>20</sup> M. Fortner,<sup>20</sup> H. Fox,<sup>40</sup> K.C. Frazer,<sup>24</sup> S. Fu,<sup>40</sup> S. Fusa,<sup>20</sup> E. Gallas,<sup>20</sup> A.N. Galyaev,<sup>20</sup> M. Gao,<sup>40</sup> V. Gavrilov,<sup>20</sup> R.J. Gemlik II,<sup>20</sup> K. Genser,<sup>27</sup> C.E. Gerber,<sup>20</sup> Y. Gerbstein,<sup>40</sup> R. Gilman,<sup>20</sup> G. Glzhar,<sup>44</sup> B. Gómez,<sup>2</sup> C. Gómez,<sup>47</sup> P.I. Gonzalez,<sup>20</sup> J.L. González Solís,<sup>12</sup> H. Gordon,<sup>20</sup> L.T. Goss,<sup>20</sup> K. Goussier,<sup>27</sup> A. Goussiou,<sup>20</sup> N. Graf,<sup>20</sup> C. Graham,<sup>47</sup> P.D. Grannis,<sup>20</sup> J.A. Green,<sup>40</sup> H. Greenlee,<sup>27</sup> S. Grinstein,<sup>2</sup> L. Gross,<sup>20</sup> S. Grünendahl,<sup>27</sup> A. Gupta,<sup>17</sup> S.N. Gurbulev,<sup>20</sup> C. Gutierrez,<sup>27</sup> P. Gutierrez,<sup>42</sup> N.J. Hadley,<sup>42</sup> H. Haggarty,<sup>27</sup> S. Hagopian,<sup>24</sup> V. Hagopian,<sup>24</sup> R.E. Hall,<sup>20</sup> P. Hanke,<sup>40</sup> S. Hansen,<sup>27</sup> J.M. Hauptman,<sup>40</sup> C. Hays,<sup>20</sup> C. Hebert,<sup>44</sup> D. Hedlin,<sup>20</sup> J.M. Heinmiller,<sup>20</sup> A.P. Heinson,<sup>24</sup> U. Heintz,<sup>40</sup> T. Heuring,<sup>20</sup> M.D. Hildreth,<sup>43</sup> R. Hirosky,<sup>20</sup> J.D. Hobbs,<sup>24</sup> B. Hoeslisen,<sup>2</sup> Y. Huang,<sup>20</sup> R. Illingworth,<sup>20</sup> A.S. Ito,<sup>27</sup> M. Jaffré,<sup>12</sup> S. Jain,<sup>17</sup> R. Jank,<sup>20</sup> K. Johns,<sup>20</sup> M. Johnson,<sup>20</sup> A. Jonckheere,<sup>27</sup> M. Jones,<sup>20</sup> H. Jöresden,<sup>27</sup> A. Juste,<sup>20</sup> W. Kahl,<sup>20</sup> S. Kahn,<sup>20</sup> E. Kajfasz,<sup>12</sup> A.M. Kalinin,<sup>20</sup> D. Karmanov,<sup>24</sup> D. Karmgard,<sup>40</sup> Z. Ke,<sup>4</sup> R. Keboe,<sup>44</sup> A. Khanov,<sup>44</sup> A. Khachatryan,<sup>40</sup> S.K. Kim,<sup>12</sup> B. Klima,<sup>27</sup> B. Knubson,<sup>20</sup> W. Ko,<sup>21</sup> J.M. Kuhl,<sup>12</sup> A.V. Kuznetsov,<sup>20</sup> J. Kotzke,<sup>20</sup> B. Kothari,<sup>20</sup> A.V. Kotwal,<sup>20</sup> A.V. Kozlov,<sup>20</sup> E.A. Kozlovsky,<sup>20</sup> J. Krane,<sup>40</sup> M.R. Krishnaswamy,<sup>17</sup> P. Krivkova,<sup>2</sup> S. Krzywdzinski,<sup>20</sup> M. Kubantsev,<sup>44</sup> S. Kuleshov,<sup>24</sup> Y. Kulik,<sup>44</sup> S. Kunori,<sup>47</sup> A. Kupco,<sup>2</sup> V.E. Kuznetsov,<sup>24</sup> C. Landsberg,<sup>40</sup> W.M. Lee,<sup>24</sup> A. Leflat,<sup>20</sup> C. Leggett,<sup>20</sup> P. Lehner,<sup>27</sup> J. Li,<sup>20</sup> Q.Z. Li,<sup>20</sup> X. Li,<sup>4</sup> J.C.R. Lima,<sup>20</sup> D. Lincoln,<sup>27</sup> S.L. Linn,<sup>20</sup> J. Linnemann,<sup>24</sup> R. Lipton,<sup>27</sup> A. Lucotte,<sup>2</sup> L. Luedtke,<sup>20</sup> C. Lundstedt,<sup>20</sup> C. Luo,<sup>40</sup> A.K.A. Maciel,<sup>20</sup> R.J. Madarac,<sup>20</sup> V.L. Malyshev,<sup>20</sup> V. Manankov,<sup>24</sup> H.S. Mao,<sup>4</sup> T. Marshall,<sup>43</sup> M.I. Martin,<sup>20</sup> R.D. Martin,<sup>20</sup> K.M. Mauritz,<sup>40</sup> B. May,<sup>40</sup> A.A. Mayurov,<sup>43</sup> R. McCarthy,<sup>20</sup> T. McFahen,<sup>27</sup> H.L. Malozemov,<sup>20</sup> M. Merkin,<sup>20</sup> K.W. Merritt,<sup>27</sup> C. Miao,<sup>40</sup> H. Miettinen,<sup>20</sup> D. Mihaleva,<sup>20</sup> C.S. Mishra,<sup>27</sup> N. Mokhov,<sup>27</sup> N.K. Mondal,<sup>17</sup> H.E. Montgomery,<sup>27</sup> R.W. Moore,<sup>24</sup> M. Mostafa,<sup>1</sup> H. da Motta,<sup>2</sup> E. Nagy,<sup>12</sup> F. Nang,<sup>20</sup> M. Namin,<sup>40</sup> V.S. Narasimhan,<sup>27</sup> H.A. Neal,<sup>20</sup> J.P. Negret,<sup>2</sup> S. Negrini,<sup>20</sup> T. Nunnemann,<sup>27</sup> D. O'Neill,<sup>24</sup> V. Oguri,<sup>2</sup> B. Olliver,<sup>20</sup> N. Oshima,<sup>27</sup> P. Padley,<sup>20</sup> L.J. Pan,<sup>40</sup> K. Papageorgiou,<sup>20</sup> A. Paris,<sup>27</sup> N. Parashar,<sup>40</sup> R. Partridge,<sup>20</sup> N. Parua,<sup>20</sup> M. Paterno,<sup>44</sup> A. Patwa,<sup>44</sup> B. Pawlik,<sup>20</sup> J. Perkins,<sup>40</sup> M. Peters,<sup>20</sup> O. Peters,<sup>20</sup> P. Pétrouff,<sup>12</sup> R. Pietsch,<sup>1</sup> B.G. Pope,<sup>24</sup> E. Popple,<sup>40</sup> H.B. Prosper,<sup>20</sup> S. Protopopescu,<sup>20</sup> J. Qian,<sup>20</sup> R. Raja,<sup>20</sup> S. Rajagopalan,<sup>20</sup> E. Ramirez,<sup>27</sup> P.A. Rapplis,<sup>27</sup> N.W. Reay,<sup>40</sup> S. Reucroft,<sup>40</sup> M. Reid,<sup>12</sup> M. Ripstein,<sup>40</sup> F. Rizatdinov,<sup>40</sup> T. Rockwell,<sup>40</sup> M. Rocco,<sup>27</sup> P. Rubinov,<sup>27</sup> R. Ruchti,<sup>43</sup> J. Rutherford,<sup>20</sup> B.M. Sakslev,<sup>20</sup> C. Sajot,<sup>2</sup> A. Santoro,<sup>2</sup> L. Sawyer,<sup>40</sup> R.D. Schamberger,<sup>40</sup> H. Schellman,<sup>40</sup> A. Schwartzman,<sup>1</sup> N. Sen,<sup>20</sup> E. Shabalina,<sup>20</sup> R.K. Shivpuri,<sup>40</sup> D. Shipilov,<sup>40</sup> M. Shupe,<sup>20</sup> R.A. Sidwell,<sup>40</sup> V. Simak,<sup>2</sup> H. Singh,<sup>24</sup> J.B. Singh,<sup>24</sup> V. Sirotenko,<sup>27</sup> P. Slattery,<sup>24</sup> E. Smith,<sup>20</sup> R.P. Smith,<sup>27</sup> R. Snihur,<sup>40</sup> C.R. Snow,<sup>20</sup> J. Snow,<sup>27</sup> S. Snyder,<sup>20</sup> V. Sorin,<sup>1</sup> M. Szwed,<sup>20</sup> N. Sotnikova,<sup>20</sup> K. Soustruznik,<sup>2</sup> M. Souza,<sup>2</sup> N.R. Stanton,<sup>40</sup> C. Steinbreck,<sup>20</sup> R.W. Stephens,<sup>27</sup> F. Stichelbant,<sup>20</sup> D. Stoker,<sup>20</sup> V. Stollin,<sup>24</sup> A. Stone,<sup>40</sup> D.A. Stoyanova,<sup>20</sup> M. Strass,<sup>20</sup> M. Strodink,<sup>21</sup> L. Stubbe,<sup>27</sup> A. Sznajder,<sup>2</sup> M. Talby,<sup>10</sup> W. Taylor,<sup>20</sup> S. Tentiado-Repond,<sup>20</sup> S.M. Tripathi,<sup>20</sup> T.C. Trippe,<sup>20</sup> A.S. Turean,<sup>20</sup> P.M. Tuts,<sup>20</sup> P. van Gemmeren,<sup>27</sup> V. Varney,<sup>20</sup> R. Van Kooten,<sup>41</sup> N. Varelas,<sup>20</sup> L.S. Vertogradov,<sup>20</sup> F. Villaverde-Segnier,<sup>10</sup> A.A. Volkov,<sup>20</sup> A.P. Vorobiev,<sup>20</sup> H.D. Wahl,<sup>20</sup> H. Wang,<sup>40</sup> Z.-M. Wang,<sup>20</sup> J. Warhad,<sup>40</sup> C. Watts,<sup>20</sup> M. Wayne,<sup>40</sup> H. Weerts,<sup>24</sup> A. White,<sup>20</sup> J.T. White,<sup>20</sup> D. Whiteson,<sup>20</sup> J.A. Wightman,<sup>40</sup> D.A. Wijngaarden,<sup>20</sup> S. Willis,<sup>20</sup> S.J. Wimpenny,<sup>24</sup> J. Womersley,<sup>27</sup> D.R. Wood,<sup>40</sup> R. Yamada,<sup>27</sup> P. Yamin,<sup>20</sup> T. Yasuda,<sup>27</sup> Y.A. Yatsunenko,<sup>20</sup> K. Yip,<sup>20</sup> S. Youssef,<sup>20</sup> J. Yu,<sup>27</sup> Z. Yu,<sup>40</sup> M. Zanahria,<sup>2</sup> H. Zhang,<sup>43</sup> Z. Zhou,<sup>40</sup> M. Zolotarev,<sup>24</sup> D. Zieminska,<sup>40</sup> A. Zieminski,<sup>40</sup> V. Zutshi,<sup>20</sup> E.C. Zverev,<sup>20</sup> and A. Zylberstejn<sup>12</sup>





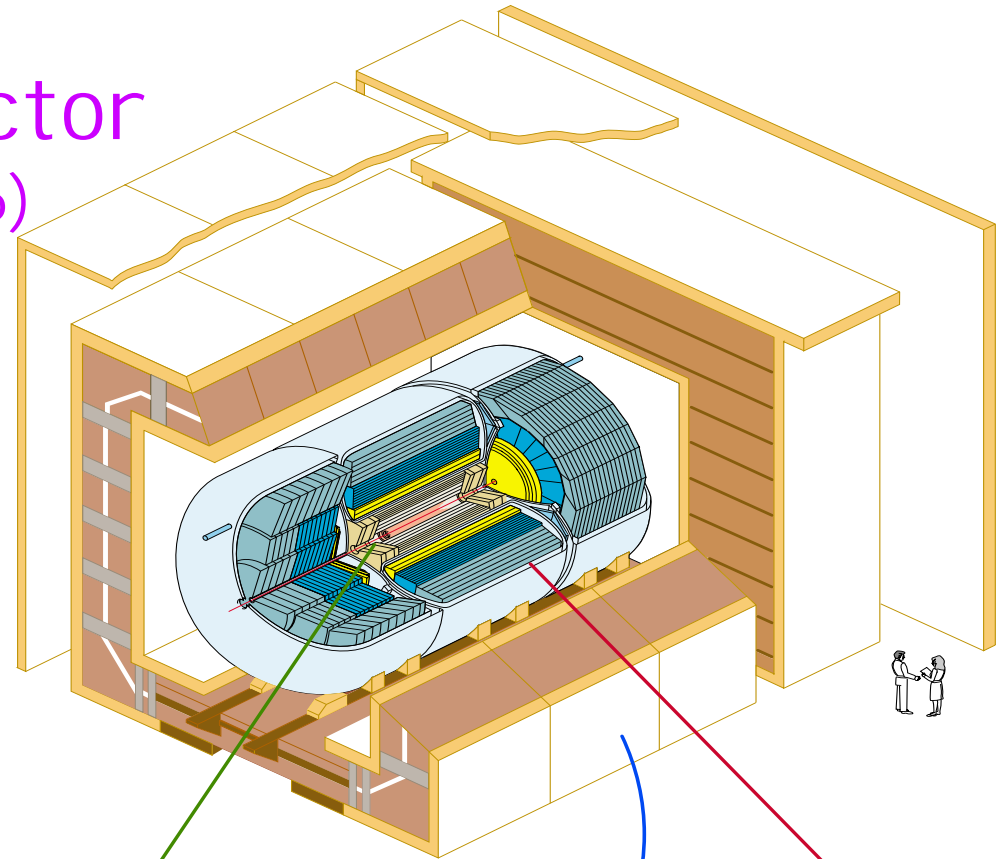


Motivation  
Data  
Algorithm  
Examples



# Run I detector (1992-1996)

- Multipurpose detector
  - central tracking
  - muon spectrometer
  - U-LAr sampling calorimeter
- No central magnetic field
- Excellent electromagnetic and hadronic calorimeters



## TRACKING

$\sigma(\text{vertex})=6 \text{ mm}$   
 $\sigma(r\phi) = 60 \mu\text{m}$  (VTX)  
= 180  $\mu\text{m}$  (CDC)  
= 200  $\mu\text{m}$  (FDC)

## DØ Detector

## MUON

$|\eta| < 3.3$

$\frac{\delta p}{p} = 0.2 \oplus .003p$

## CALORIMETRY

$|\eta| < 4$

$\Delta\eta \times \Delta\phi = 0.1 \times 0.1$

$\sigma(\text{EM}) = 15\%/\sqrt{E}$

$\sigma(\text{HAD}) = 50\%/\sqrt{E}$

We have chosen 3 well-understood final states:

Final State	Selection criteria	$\epsilon_{\text{ID}}$	$\int \mathcal{L} dt$
$e\mu$	$p_T^{e,\mu} > 15 \text{ GeV}$ $ \eta_{\text{det}}^\mu  < 1.7$	0.30	$108 \pm 5 \text{ pb}^{-1}$
$e\cancel{E}_T 2j$	$p_T^{e,j_{1,2}} > 20 \text{ GeV}$ $\cancel{E}_T > 30 \text{ GeV}$ $p_T^{e\cancel{E}_T} > 40 \text{ GeV}$	0.61	$115 \pm 6 \text{ pb}^{-1}$
$ee 2j$	$p_T^{e_{1,2},j_{1,2}} > 20 \text{ GeV}$	0.70	$123 \pm 7 \text{ pb}^{-1}$

$\epsilon_{\text{ID}}$  is the efficiency of identification requirements

additional jets are identified if  $p_T^j > 15 \text{ GeV}$  and  $|\eta| < 2.5$

Our background estimates come from a mishmash of sources:

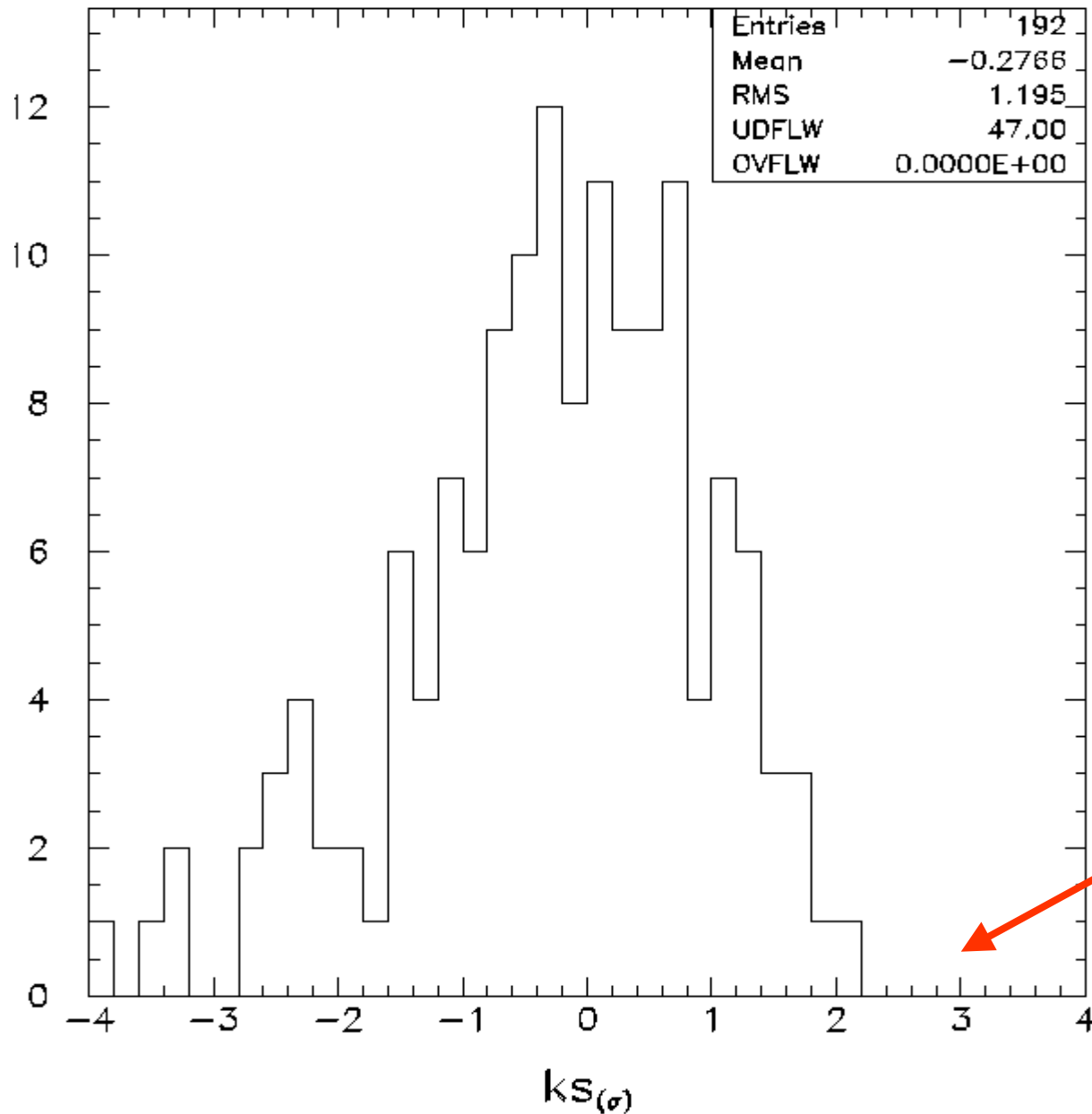
Final State	Standard model backgrounds				
	multijets	$W$	$Z$	$VV$	$t\bar{t}$
$e\mu$	data	data	ISAJET	PYTHIA	HERWIG
$e\cancel{E}_T 2j$	data	VECBOS	—	PYTHIA	HERWIG
$ee 2j$	data	—	PYTHIA	PYTHIA	—

Systematic errors vary among the final states we consider, but roughly:

Systematic uncertainties

jet modeling	15%
trigger / lepton ID eff	10%
cross sections	10%
“faking” probabilities	10%
luminosity	5%

These uncertainties are incorporated into the cross section limit



We analyzed 192 different distributions in these final states, including:

- transverse momenta
- invariant masses
- angular separation

and computed the Kolmogorov-Smirnov statistic for each.

Agreement is observed in all distributions

The data and background estimates have each been used in previous analyses:

- $e\mu$ 
  - Top quark cross section PRL 79 1203 (1997)
  - Scalar top PRL in collab. review
  - Sleuth PRD 62 92004 (2000)
- $e\cancel{E}_T 2j$ 
  - Leptoquarks PRL 80 2051 (1998)
  - Sleuth PRL 86 3712 (2001) PRD 64 12004 (2001)
- $ee 2j$ 
  - Leptoquarks PRL 79 4321 (1997)
  - Sleuth PRL 86 3712 (2001) PRD 64 12004 (2001)

# Data

---

These data and backgrounds are well understood



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Motivation  
Data  
Algorithm  
Examples

# Quaero

## A General Interface to DØ Data

[PRL](#) [Manual](#)  
[Examples](#)

**Signal**

**Final State:**  **Smear?**

**Pythia Input:**

**Signal File:**   **xsec:**  pb

**View**  **Search**

**Backgrounds:**  **(nj)**  **W(nj)**  **Z(nj)**  **VV(nj)**  **tt(nj)**

**Variables**

**Constraints:**

**Variables:**

v1

v2

v3

**Requestor**

**Name:**

**Institution:**

**Email:**

**Brief description of model:**

[Help!](#) - [Bug history](#) - [DØ](#) - [Fermilab](#) - [Author](#)

## 1) The signal Monte Carlo is processed

- (events are generated using Pythia, if requested)
- events are smeared with a fast detector simulation
- selection criteria are applied for desired final state
- particle identification efficiencies are considered

### This gives

- total number of expected signal events in final state
- Monte Carlo signal events as they would look in the detector

The parametrized detector simulation is simple but sufficient:

- Partons are clustered and merged into jets
- Energies are smeared according to measured resolutions

$$e/\gamma: \quad \delta E/E = 15\%/\sqrt{E} \oplus 0.3\%$$

$$\text{jets:} \quad \delta E/E = 80\%/\sqrt{E}$$

$$\mu: \quad \delta(1/p) = 0.18(p-2)/p^2 \oplus 0.003$$

(Resolutions depend loosely on pseudorapidity)

## Why do we believe the fast detector simulation?

PRL 75 1028 (1995)	PRL 75 1034 (1995)	PRL 78 3634 (1997)
PRL 78 3640 (1997)	PRD 56 6742 (1997)	PRL 79 1441 (1997)
PRD 57 3817 (1998)	PRD 58 051101 (1998)	PRD 58 31102 (1998)
PRD 60 72002 (1999)	PRD 62 52005 (2000)	PRD 62 71701 (2000)
PRL 75 1456 (1995)	PRD 60 52003 (1999)	PRD 61 72001 (2000)
PRD 61 32004 (2000)	PRL 84 2792 (2000)	PRL 77 3309 (1996)
PRD 58 12002 (1998)	PRL 80 3008 (1998)	PRD 58 92003 (1998)
PRL 80 5498 (1998)	PRD 62 92006 (2000)	PRL 84 222 (2000)
PRL 81 524 (1998)	PRL 86 1156 (2001)	...

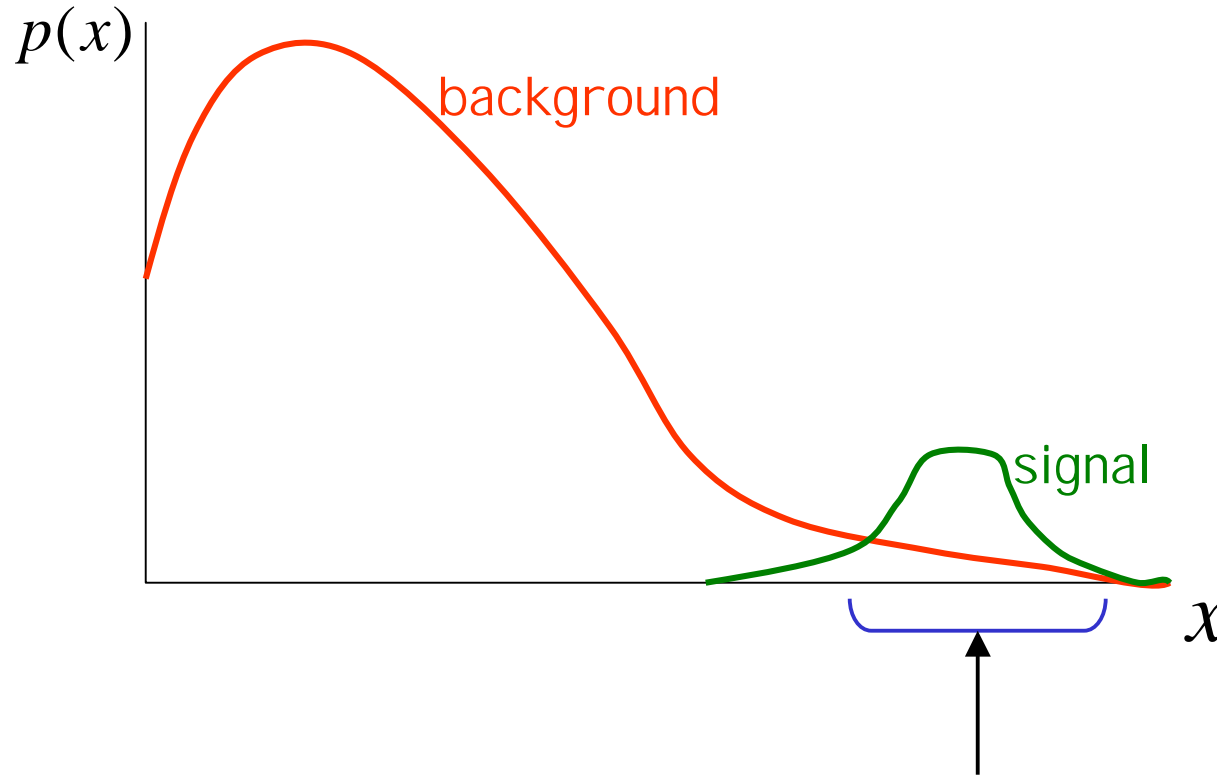
These publications cover a variety of analyses

gauge boson couplings

W/Z production

searches for new physics

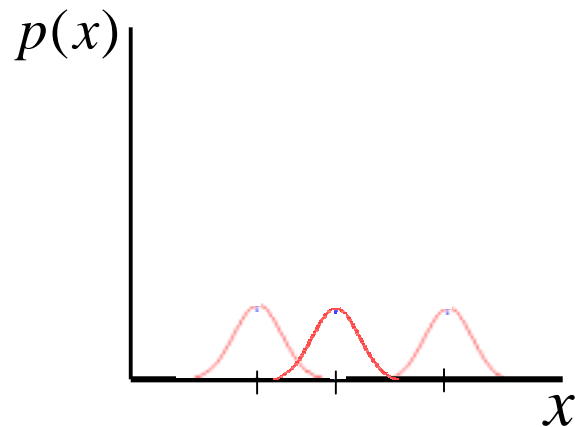
Note also the difference between signal and background:



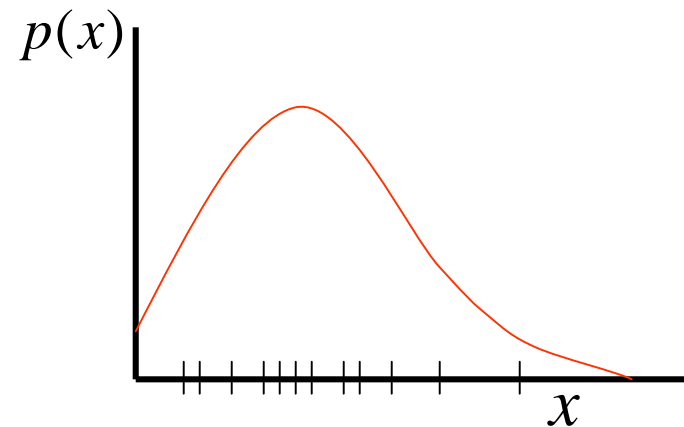
The region that we are interested in generally lies in the *tail* of the background, but in the *bulk* of the signal

(Correct modeling of the background tails is relatively more important than correct modeling of the signal tails)

- 2) An optimal region is chosen in the variables provided
- a) Estimate signal and background densities using kernels



1) place "bumps of probability" around each Monte Carlo point



2) sum these bumps into a continuous distribution

$$p(x) = \sum_{i=1}^N \text{gauss}(x - x_i)$$

The multivariate generalization is immediate

b) Define a *discriminant*

$$D(x) = \frac{p(x | s)}{p(x | s) + p(x | b)}$$

and choose a cut on  $D(x)$  that minimizes

*the 95% CL cross section limit you would expect to set assuming the data contains no signal.*

We call  $1/\text{this quantity}$  the “sensitivity”

Note that so far we have made no use of the data



- 3) Comparing number of observed events in the data to expected bkg, set 95% CL cross section limit on signal
- 4) Result is returned by email



Total elapsed time  $\approx$  1 hour

**From:** quaero@fnal.gov  
**Subject:** Quaero Request #29

$$W_R \rightarrow t\bar{b} \rightarrow e\cancel{E}_T 2j$$

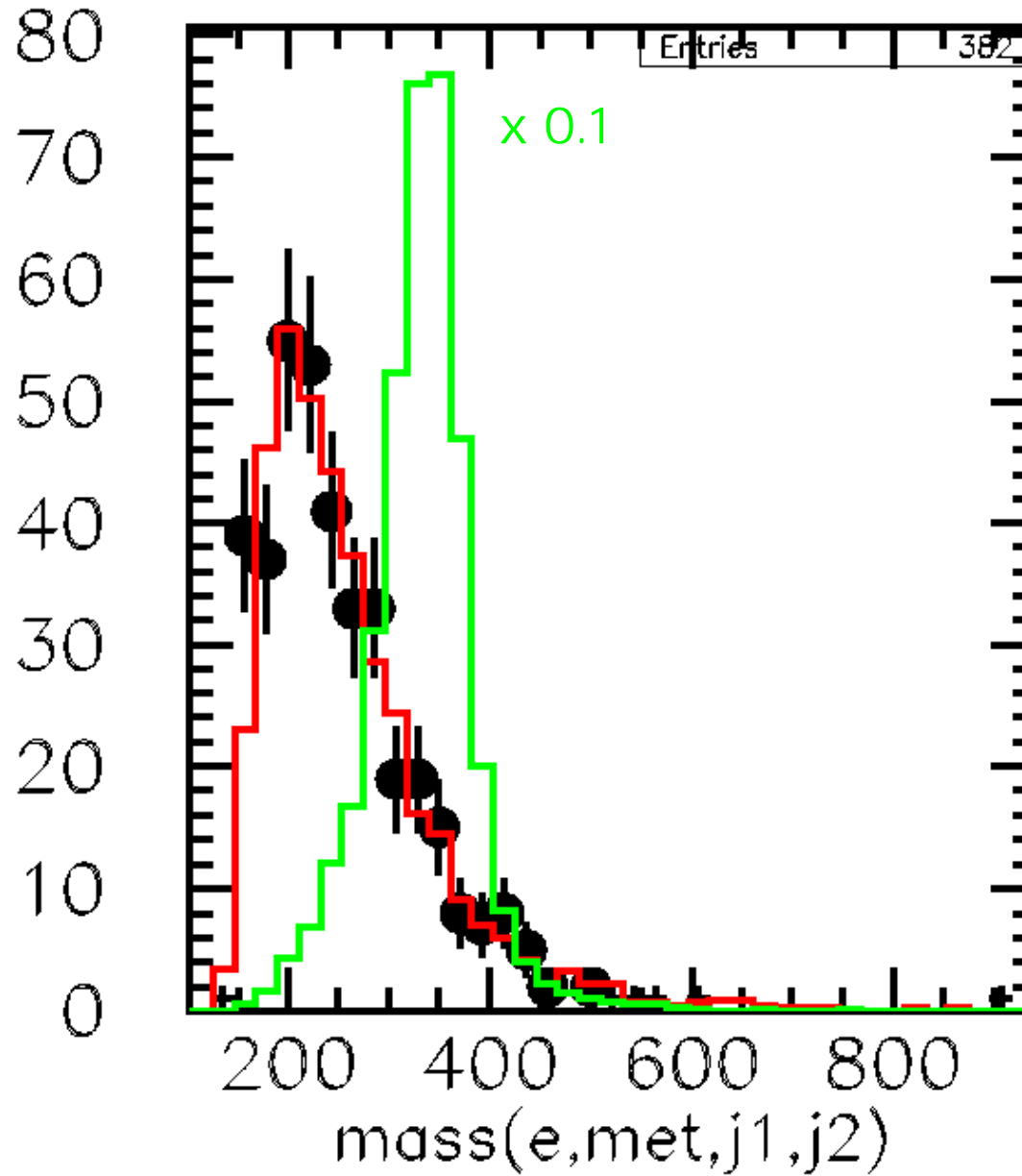
## Result

**Pythia cross section x branching ratio = 1.68 pb.**

**Upper limits on the cross section to this process at confidence levels of 50%, 90%, and 95% are found to be 0.8 pb, 1.8 pb, and 2.1 pb, respectively. Maximal sensitivity (0.73 pb<sup>-1</sup>) is achieved in a region of variable space with 17.6 signal events expected, 32.7 +- 7.1 background events expected, and 36 events observed in the data.**

## Plots

**Plots of the variables that you used are available for viewing at <http://quaero.fnal.gov/quaero/requests/plots/29.ps>. The red curve is the expected background; the green curve is your signal multiplied by a factor of 10; the black dots are D0 data.**



There are a number of ways Quaero could be implemented



Don't

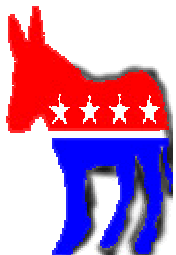
Keep Quaero as an internal tool

Make data available with limited scope and internal review

Restrict those who are allowed to use Quaero

Review all Quaero results before releasing them

Make data available with general scope and more limited internal review



"Put the data out there"

Make data available to all with no internal review

Many variations on these themes

We chose to make data available with general scope and limited internal review

## Quaero Policy

- Any "interesting" Quaero result will be reviewed by a **DØ Quaero Review Board**.
  - A Quaero result is "interesting" if an excess of data over background of more than 2.0 standard deviations is found.
  - If an interesting result is found, the requestor is notified that his request is under review, and the result of the request is sent to the review board.
  - If a fault is found the fault is rectified, the request is re-run, and the new result is sent to the requester (along with an explanation).
  - If the "interestingness" is not deemed to be due to any fault, the result is sent to the requester.
- In all cases the requester is free to publish the Quaero result in his or her own paper, so long as Quaero is referenced. The appropriate citation, including the Quaero request log number and request date, is included in the email with Quaero's result.

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Motivation  
Data  
Algorithm  
Examples

## Examples

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You're presumably thinking

"Surely this can't be as good as a real analysis . . ."



If so, think again!

Using Quaero, you can analyze the following in a day:

# Examples

#1

## Standard Model $WW \rightarrow e\mu E_T$

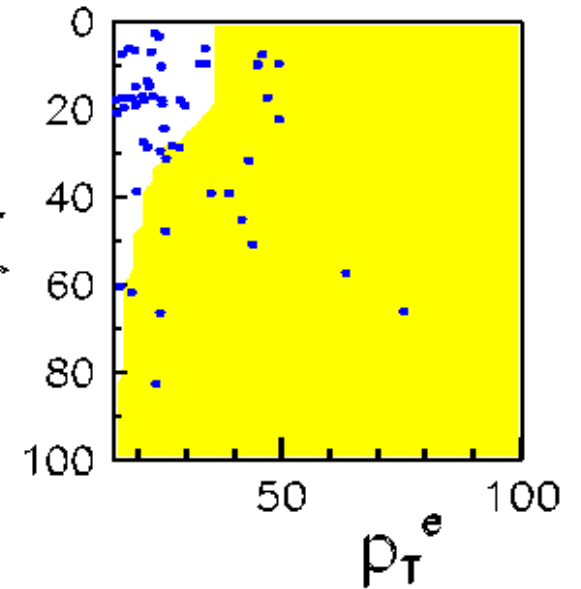
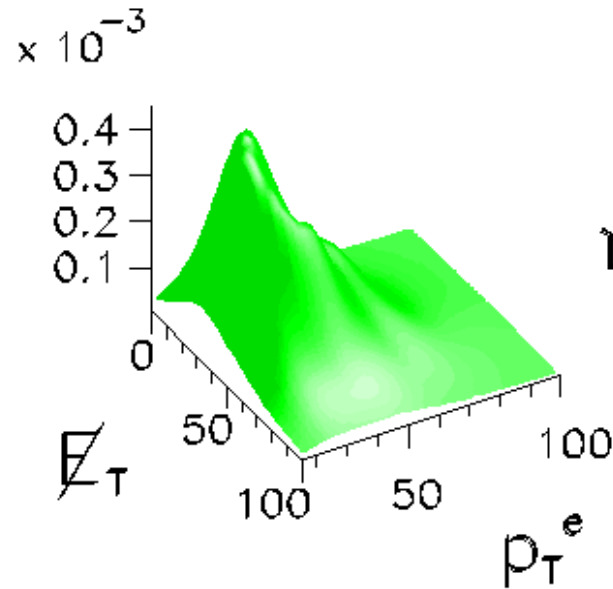
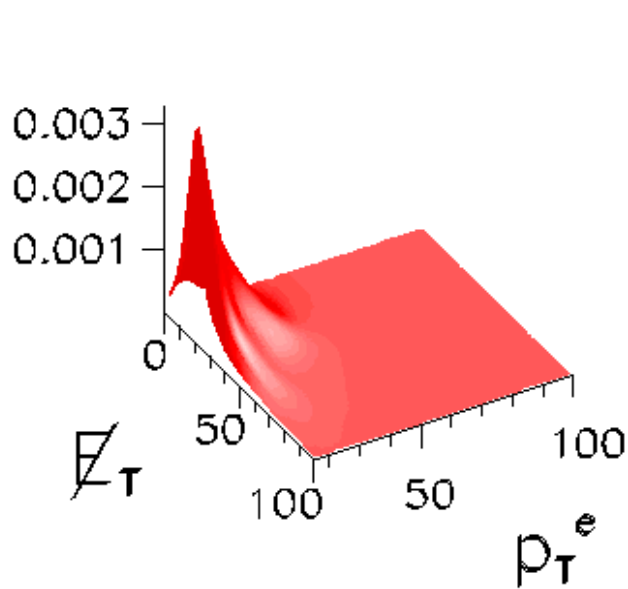
Variables	
Constraints:	<input type="text"/>
Variables:	<input type="text"/>
v1	<input type="text" value="e_pt"/>
v2	<input type="text" value="met_pt"/>

$\epsilon_{sig}$	14%
$\hat{b}$	$19.0 \pm 4.0$
$N_{obs}$	23
$\sigma^{95\%} \times \mathcal{B}$	1.1 pb

Background density

Signal density

Selected region





Standard Model  $ZZ \rightarrow eejj$

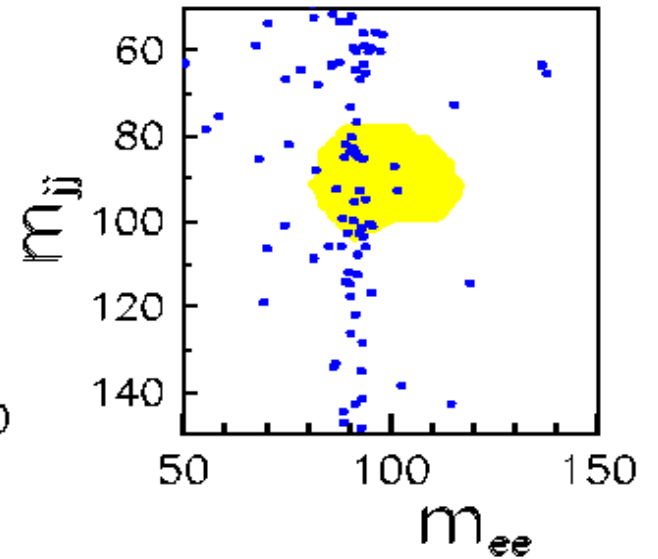
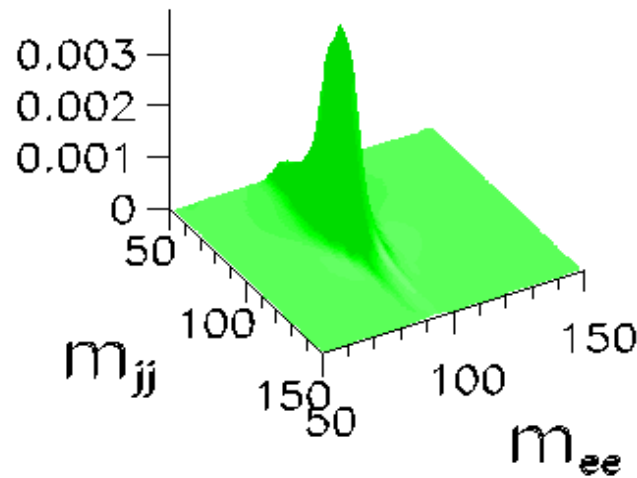
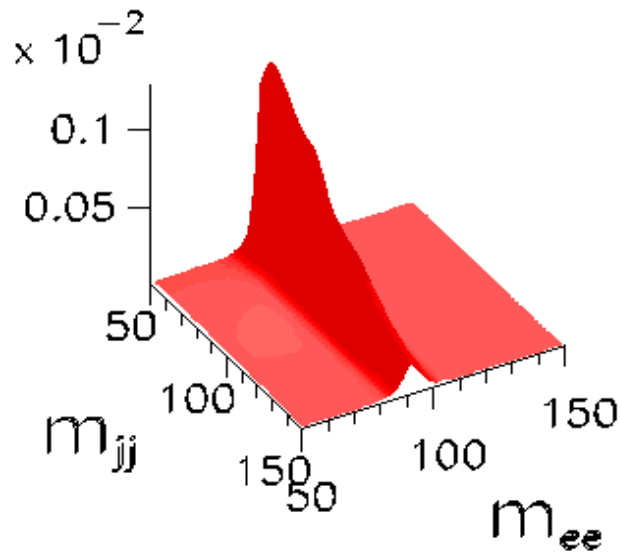
Variables	
Constraints:	<input type="text"/>
Variables:	
v1	<input type="text" value="mass(e1,e2)"/>
v2	<input type="text" value="mass(j1,j2)"/>

$\epsilon_{sig}$	12%
$\hat{b}$	$19.7 \pm 4.1$
$N_{obs}$	19
$\sigma^{95\%} \times \mathcal{B}$	0.8 pb

Background density

Signal density

Selected region



Standard Model  $WW \rightarrow e\mu\cancel{E}_T$

$$\text{Predicted } \sigma \times \mathcal{B} = 0.17 \text{ pb}$$

$$\text{Limit } \sigma^{95\%} \times \mathcal{B} = 1.1 \text{ pb}$$

Standard Model  $ZZ \rightarrow ee 2j$

$$\text{Predicted } \sigma \times \mathcal{B} = 0.05 \text{ pb}$$

$$\text{Limit } \sigma^{95\%} \times \mathcal{B} = 0.8 \text{ pb}$$

These processes are currently at the edge of the Tevatron's sensitivity

CDF, "Observation of  $W^+W^-$  production . . . ." PRL 78 4536 (1997)

5 events observed on a background of  $1.2 \pm 0.3$  events  
in all dilepton final states ( $ee, e\mu, \mu\mu$ )

# Examples

#3

Standard Model  $t\bar{t} \rightarrow e\mu\cancel{E}_T 2j$

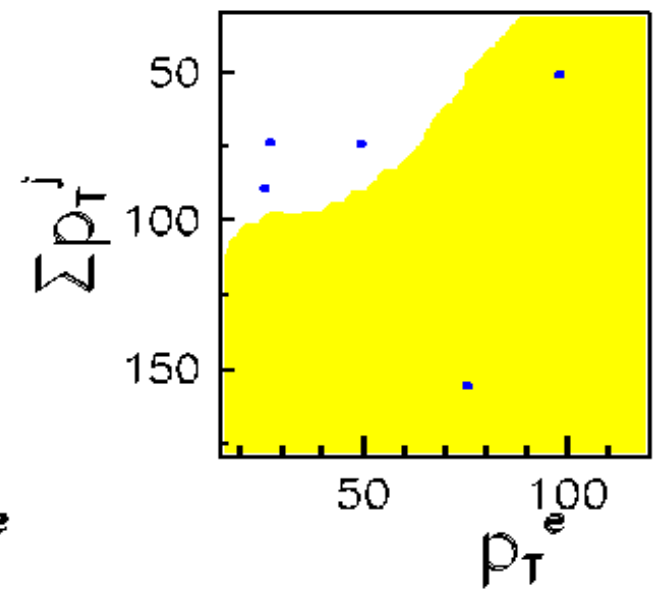
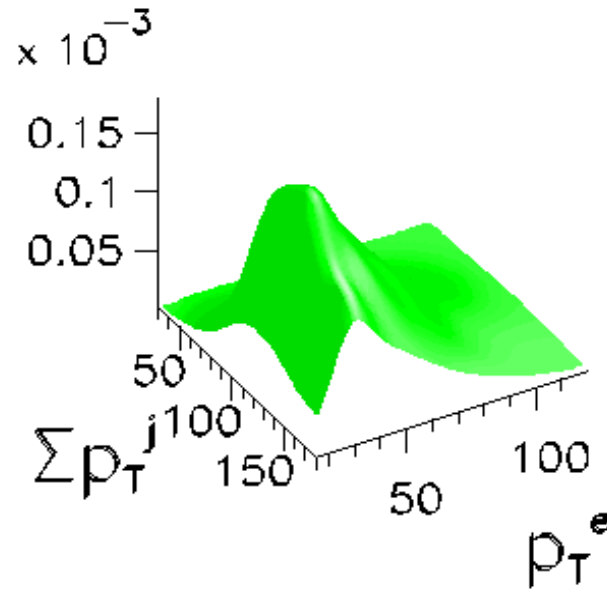
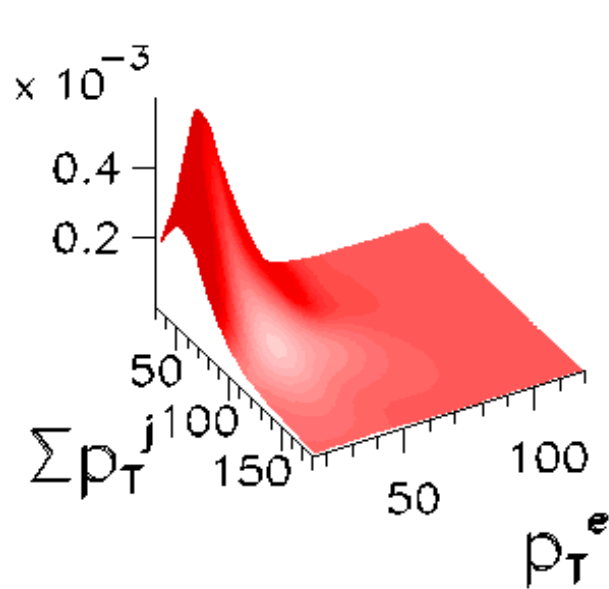
Variables	
<u>Constraints:</u>	$j2\_pt > 15$
	<u>Variables:</u>
v1	$e\_pt$
v2	$j1\_pt + j2\_pt + j3\_pt$

$\epsilon_{sig}$	14%
$\hat{b}$	$0.6 \pm 0.2$
$N_{obs}$	2
$\sigma \times \mathcal{B}$	$0.14^{+0.15}_{-0.08}$ pb

Background density

Signal density

Selected region



# Examples

#4

Standard Model  $t\bar{t} \rightarrow e\bar{e}\tau^+ 4j$

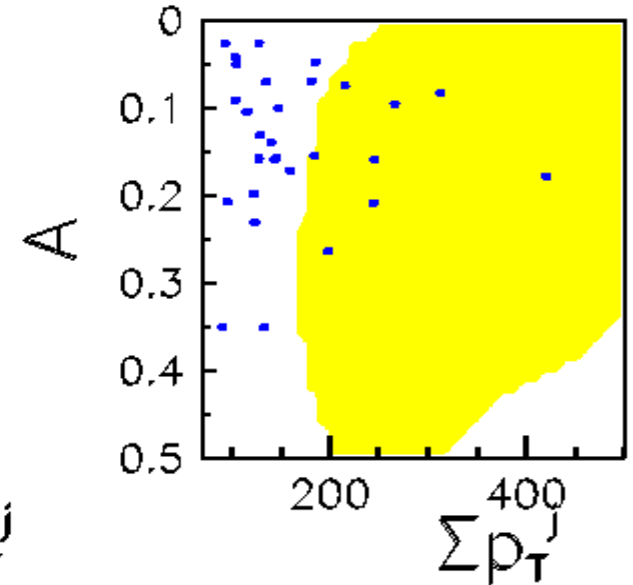
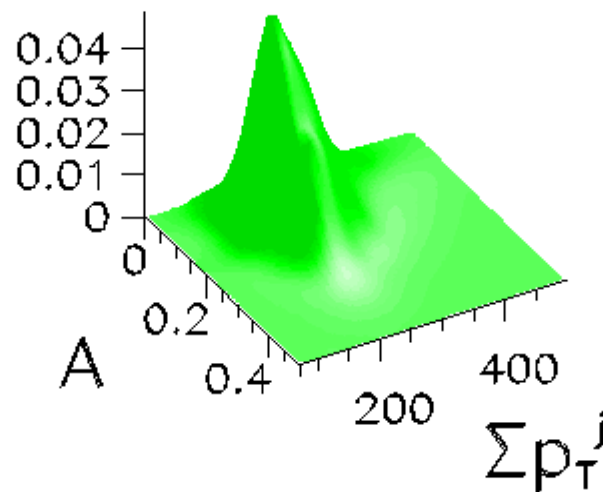
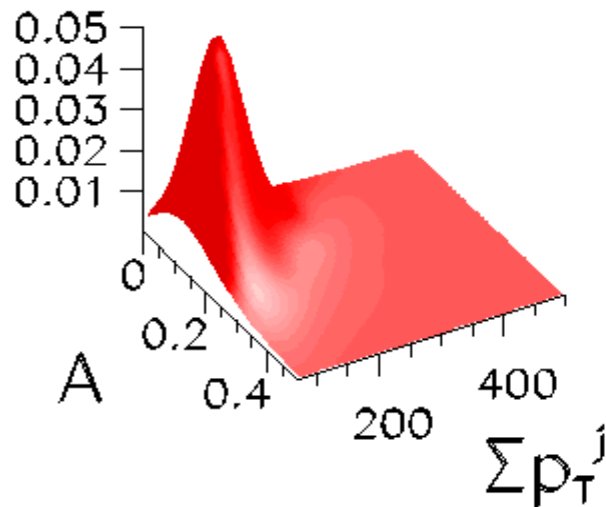
Variables	
<u>Constraints:</u>	$j4\_pt > 15$
<u>Variables:</u>	
v1	$j1\_pt + j2\_pt + j3\_pt + j4\_pt + j5\_pt$
v2	$aplanarity()$

$\epsilon_{sig}$	13%
$\hat{b}$	$3.1 \pm 0.9$
$N_{obs}$	8
$\sigma \times \mathcal{B}$	$0.39^{+0.21}_{-0.19}$ pb

Background density

Signal density

Selected region



DØ PRL (1997, 125 pb<sup>-1</sup>)

in dileptons (ee, eμ, and μμ):

2.1σ (5 events with 1.4 expected)

in lepton+jets (e+jets and μ+jets):

2.6σ (19 events with 8.7 expected) w/o b-tag

3.6σ (11 events with 2.5 expected) w/ b-tag

We have used

- ½ of the dilepton sample (eμ) only
- ½ of the lepton+jets sample (e+jets) only
- no b-tagging

$\sigma \times \mathcal{B}$  is consistent with previous measurements

# Examples

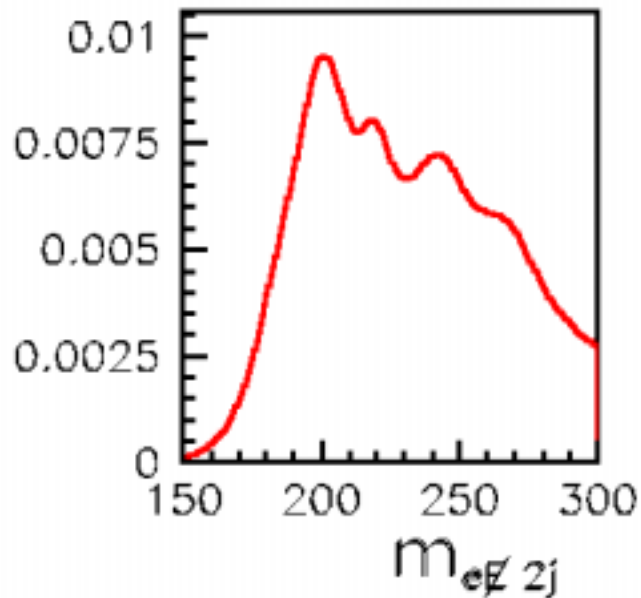
#5

SM Higgs  $\rightarrow WW \rightarrow e\cancel{e}_T 2j$

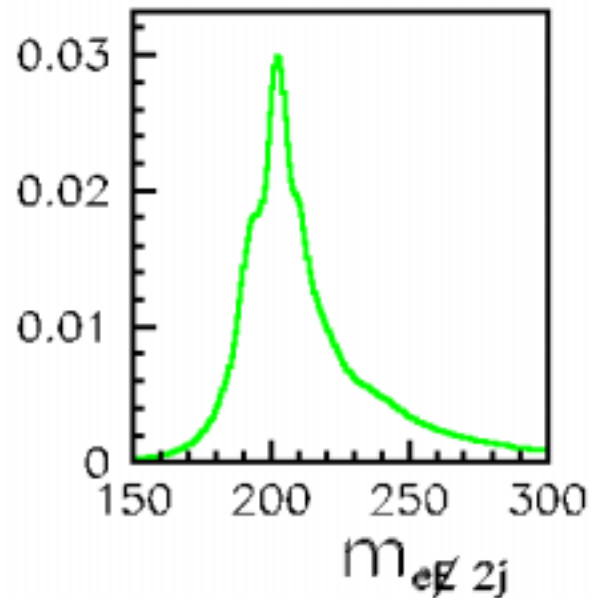
Variables	
<u>Constraints:</u>	<code>ChiSqdConstrainWW(e,met,j1,j2)&lt;100</code>
<u>Variables:</u>	
v1	<code>mass(e,met,j1,j2)</code>
v2	

$\mathcal{E}_{sig}$	7%
$\hat{b}$	$66.0 \pm 13.8$
$N_{obs}$	69
$\sigma^{95\%} \times \mathcal{B}$	4.4 pb

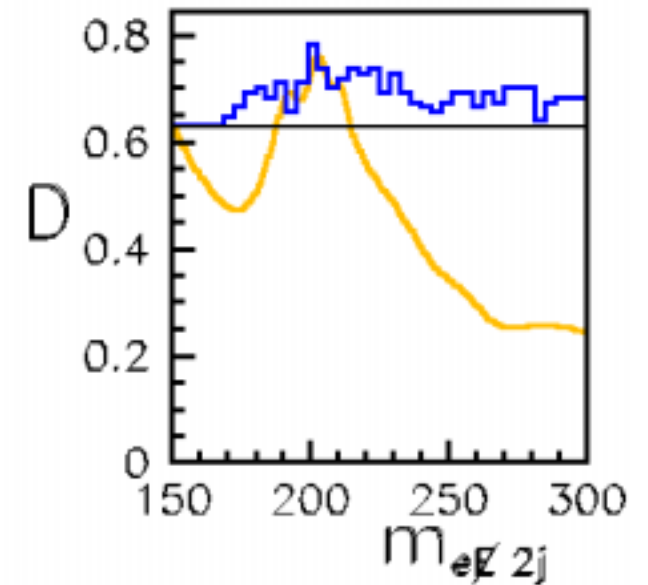
Background density



Signal density



Selected region



SM Higgs  $\rightarrow$  ZZ  $\rightarrow$  ee 2j

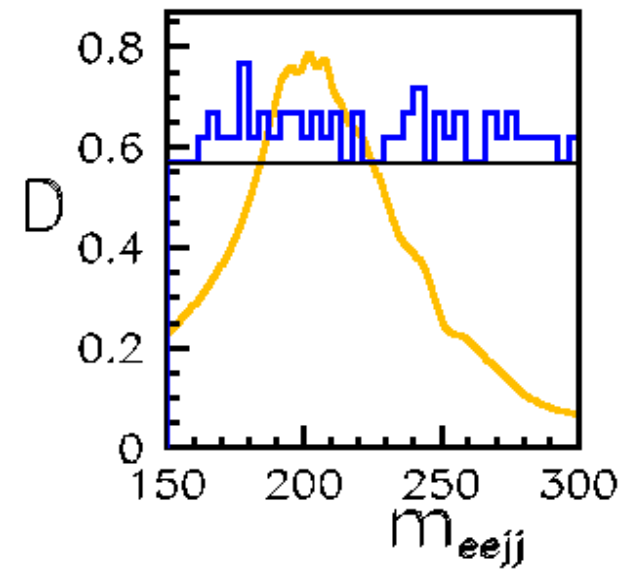
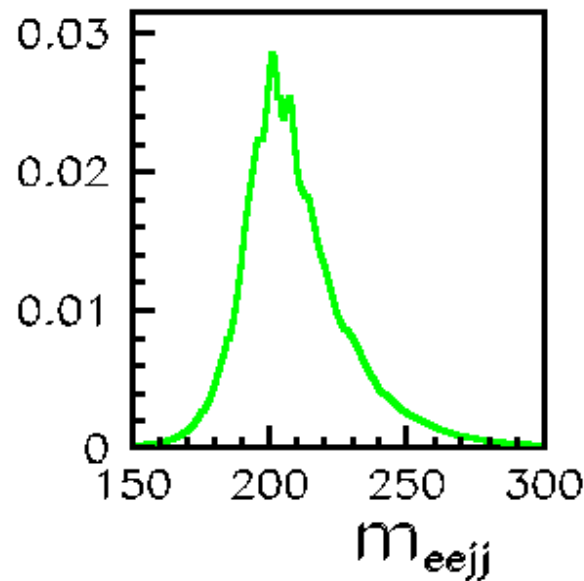
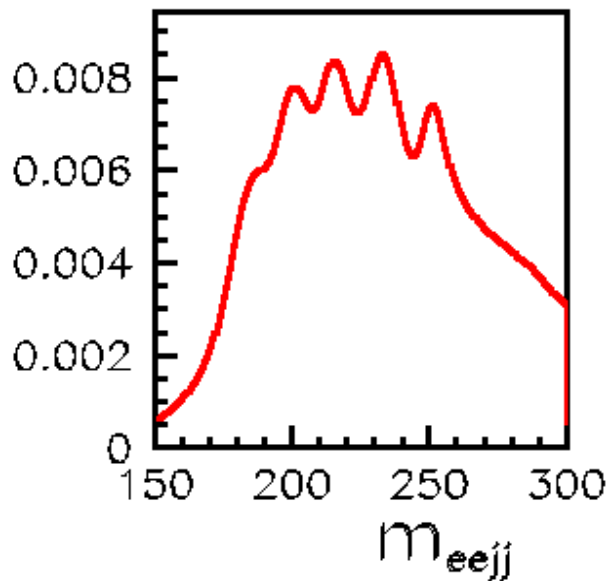
Variables	
<u>Constraints:</u>	ChiSqdConstrain(j1,j2,Z)<20
	<u>Variables:</u>
v1	mass(e1,e2,j1,j2)
v2	

$\mathcal{E}_{sig}$	15%
$\hat{b}$	$17.9 \pm 3.7$
$N_{obs}$	15
$\sigma^{95\%} \times \mathcal{B}$	0.6 pb

Background density

Signal density

Selected region



# Examples

#7

$$W^* \rightarrow Wh \rightarrow e\cancel{E}_T 2j$$

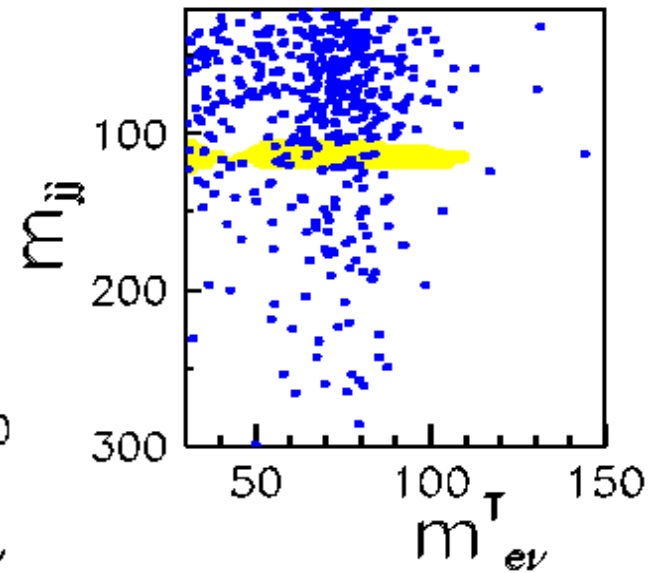
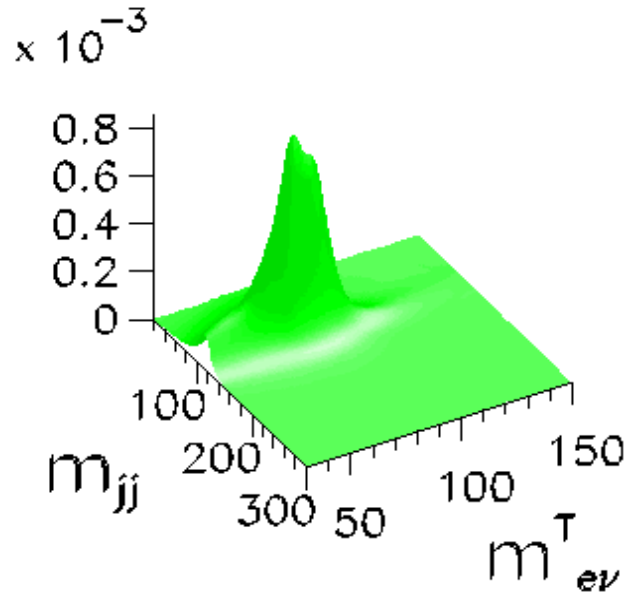
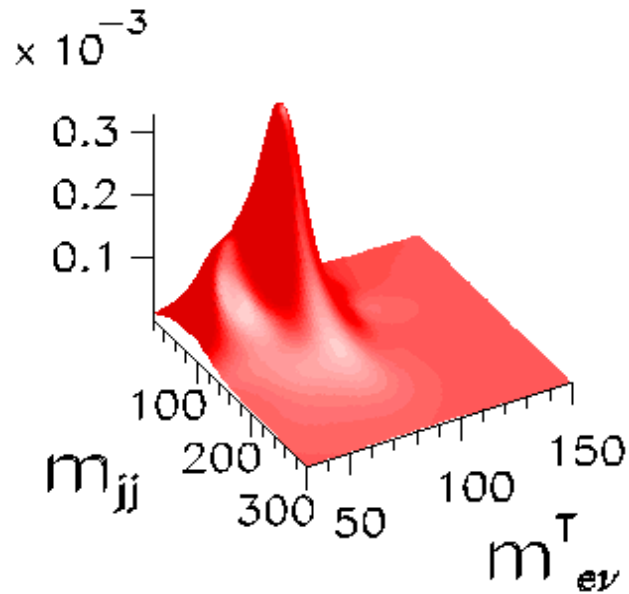
Variables	
Constraints:	
Variables:	
v1	transversemass(e,met)
v2	mass(j1,j2)

$\mathcal{E}_{sig}$	8%
$\hat{b}$	$37.3 \pm 8.2$
$N_{obs}$	32
$\sigma^{95\%} \times \mathcal{B}$	2.0 pb

Background density

Signal density

Selected region





# Examples

#8

$$Z^* \rightarrow Zh \rightarrow ee 2j$$

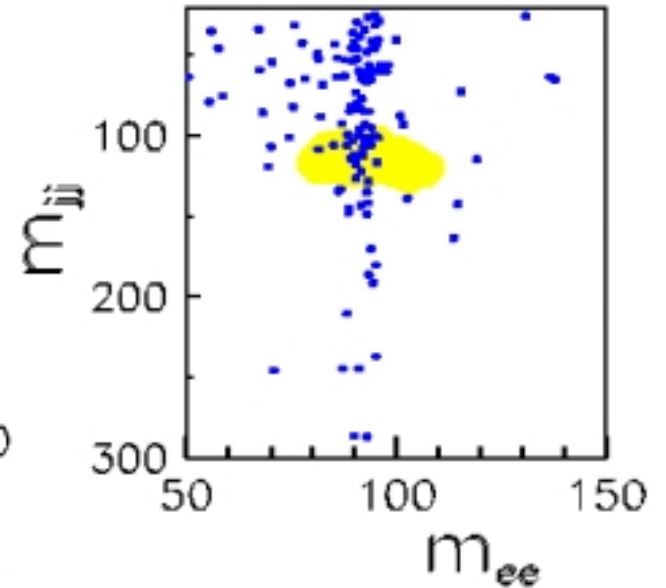
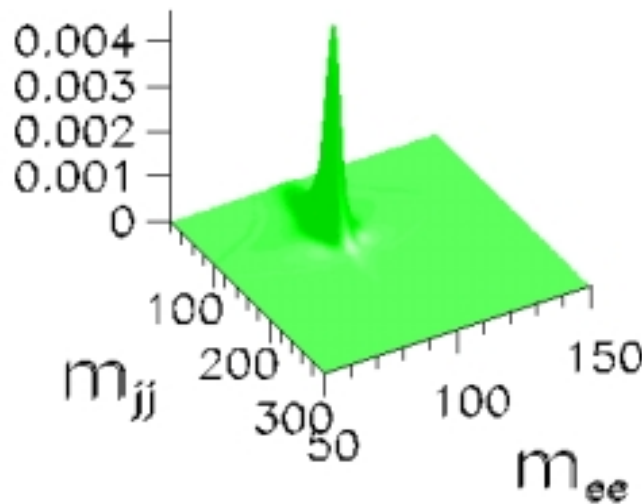
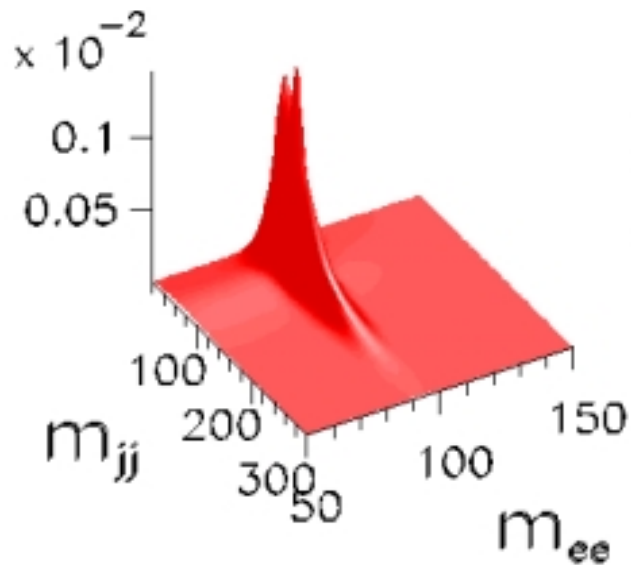
Variables	
<u>Constraints:</u>	<input type="text"/>
	<u>Variables:</u>
v1	<input type="text" value="mass(e1,e2)"/>
v2	<input type="text" value="mass(j1,j2)"/>

$\epsilon_{sig}$	20%
$\hat{b}$	$19.5 \pm 4.1$
$N_{obs}$	25
$\sigma^{95\%} \times \mathcal{B}$	0.8 pb

Background density

Signal density

Selected region



**Heavy Higgs** ( $m_h=200$  GeV)

Standard Model  $h \rightarrow WW \rightarrow e\cancel{\nu}_T 2j$

Predicted  $\sigma \times \mathcal{B} = 0.0047$  pb

Limit  $\sigma^{95\%} \times \mathcal{B} = 4.4$  pb

Standard Model  $h \rightarrow ZZ \rightarrow ee 2j$

Predicted  $\sigma \times \mathcal{B} = 0.0005$  pb

Limit  $\sigma^{95\%} \times \mathcal{B} = 0.6$  pb

factor of  $10^3$  —  
no surprise here

In fact, our search has been more general:  
 $X \rightarrow WW \rightarrow e\cancel{\nu}_T 2j$   
 $X \rightarrow ZZ \rightarrow ee 2j$

**Light Higgs** ( $m_h=115$  GeV)

Standard Model  $W^* \rightarrow Wh \rightarrow e\cancel{\nu}_T 2j$

Predicted  $\sigma \times \mathcal{B} = 0.011$  pb

Limit  $\sigma^{95\%} \times \mathcal{B} = 2.0$  pb

Standard Model  $Z^* \rightarrow Zh \rightarrow ee 2j$

Predicted  $\sigma \times \mathcal{B} = 0.0023$  pb

Limit  $\sigma^{95\%} \times \mathcal{B} = 0.8$  pb

nothing expected,  
nothing seen

# Examples

#9

$$W' \rightarrow WZ \rightarrow e\cancel{E}_T 2j$$

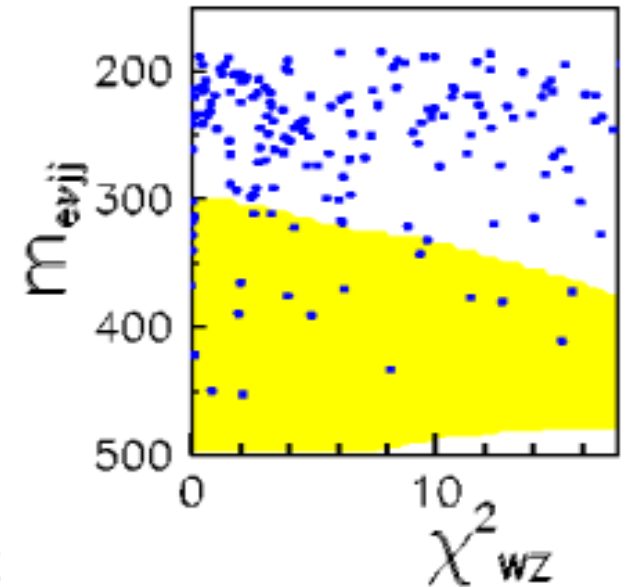
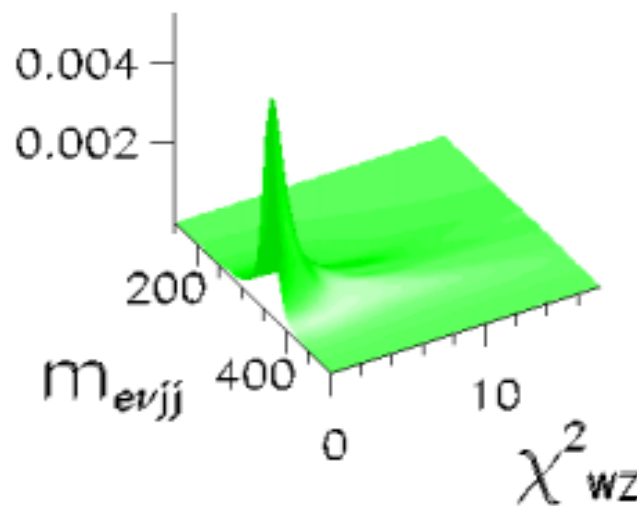
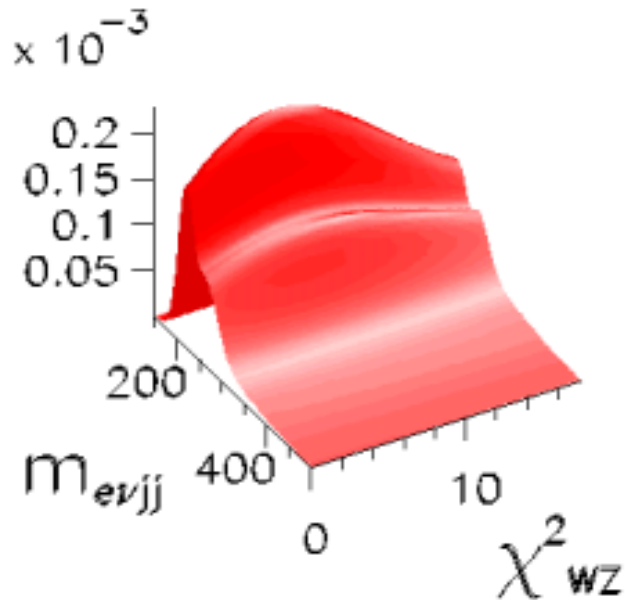
Variables	
Constraints:	
Variables:	
v1	ChiSqdConstrainWZ(e,met,j1,j2)
v2	mass(e,met,j1,j2)

$\mathcal{E}_{sig}$	23%
$\hat{b}$	$22.7 \pm 5.2$
$N_{obs}$	27
$\sigma^{95\%} \times \mathcal{B}$	0.7 pb

Background density

Signal density

Selected region



# Examples

#10

$$Z' \rightarrow t\bar{t} \rightarrow e\cancel{e}_T 4j$$

**Variables**

Constraints: `(j4_pt>15)&&(ChiSqdConstrain(e,met,W)<10)`

Variables:

v1 `mass(e,met,j1,j2,j3,j4)`

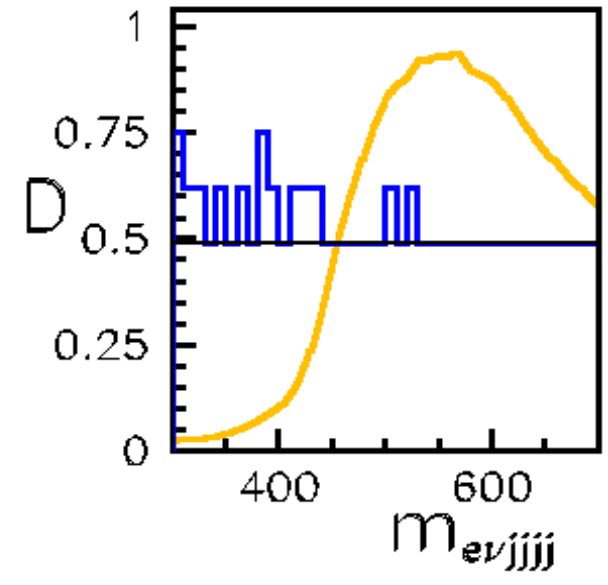
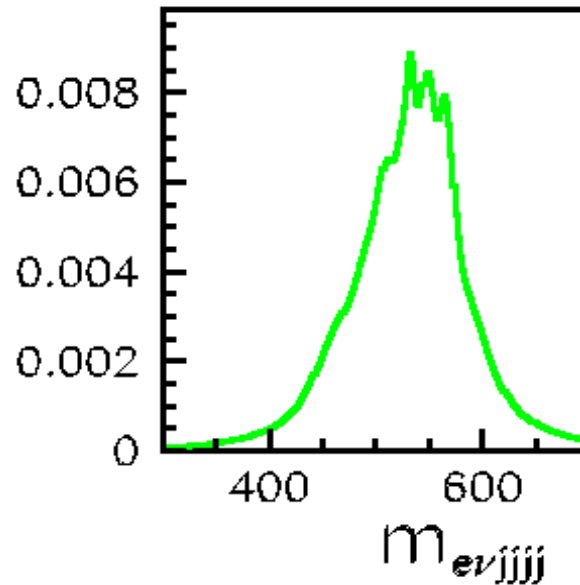
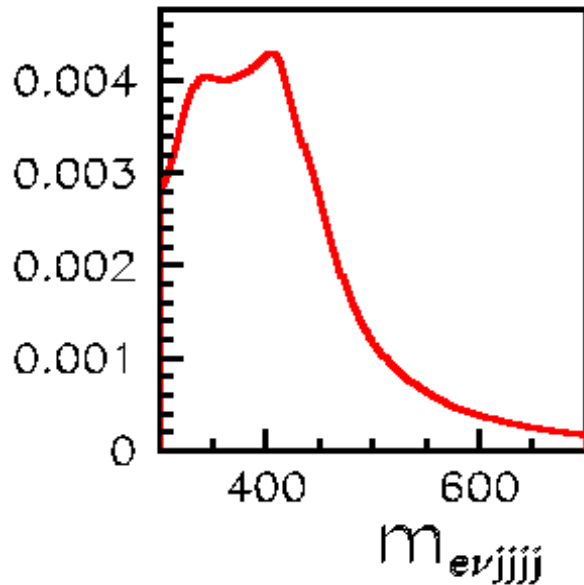
v2

$\mathcal{E}_{sig}$	14%
$\hat{b}$	$3.8 \pm 1.0$
$N_{obs}$	2
$\sigma^{95\%} \times \mathcal{B}$	0.3 pb

Background density

Signal density

Selected region



$W' \rightarrow WZ \rightarrow e\cancel{E}_T 2j$

“Extended gauge model” [Altarelli et al., Z. Phys. C 45 109 (1989)]

mass(W')	$\sigma^{95\%} \times \mathcal{B}$ (Quaero)	$\sigma^{95\%} \times \mathcal{B}$ (CDF)	$\sigma \times \mathcal{B}$ (theory)
200	3.4 pb	6.6 pb	0.65 pb
350	0.7 pb	2.0 pb	0.13 pb
500	0.2 pb	0.5 pb	0.02 pb

[CDF, hep-ex/0108004]

$Z' \rightarrow t\bar{t} \rightarrow e\cancel{E}_T 4j$

Standard Model (Z-like) couplings assumed

mass(Z')	$\sigma^{95\%} \times \mathcal{B}$ (Quaero)	$\sigma^{95\%} \times \mathcal{B}$ (CDF)
350	1.1 pb	-
450	0.9 pb	0.65 pb
550	0.3 pb	0.45 pb

Results are consistent with  
(and competitive with)  
previous measurements.

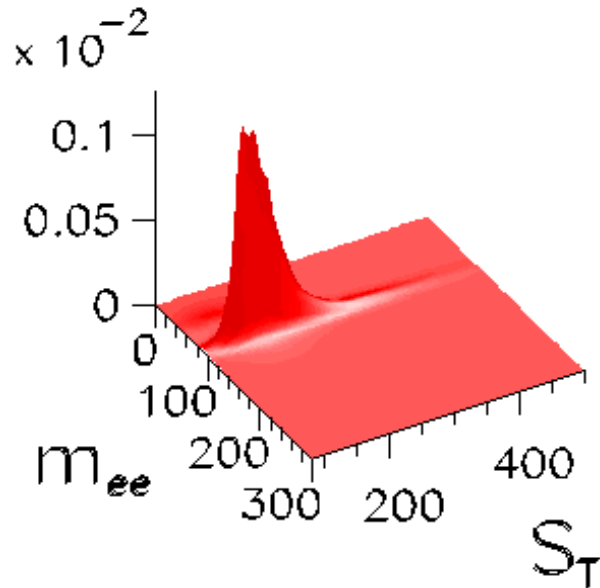
[CDF, PRL 85 2062 (2000)]

Leptoquarks  $\rightarrow ee 2j$

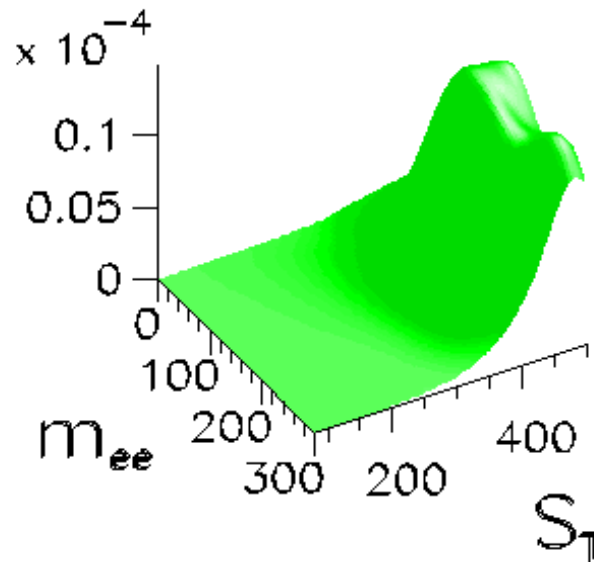
Variables	
<u>Constraints:</u>	
<u>Variables:</u>	
v1	$e1\_pt + e2\_pt + j1\_pt + j2\_pt + j3\_pt + j4\_pt$
v2	$mass(e1,e2)$

$\mathcal{E}_{sig}$	33%
$\hat{b}$	$0.3 \pm 0.1$
$N_{obs}$	0
$\sigma^{95\%} \times \mathcal{B}$	0.07 pb

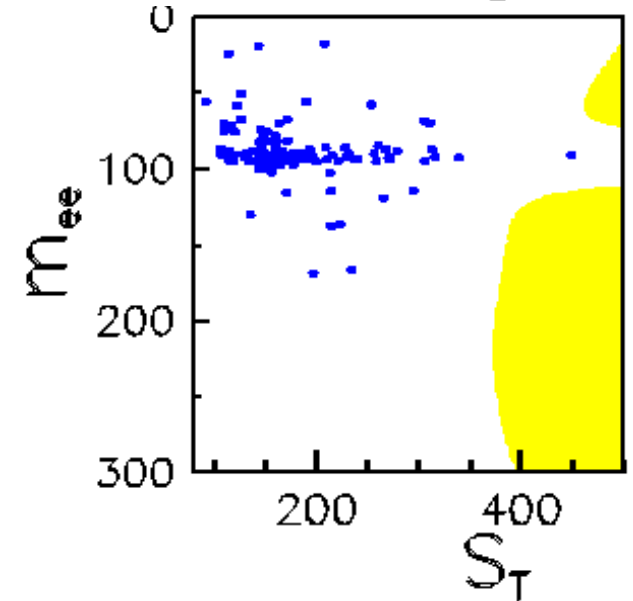
Background density



Signal density



Selected region



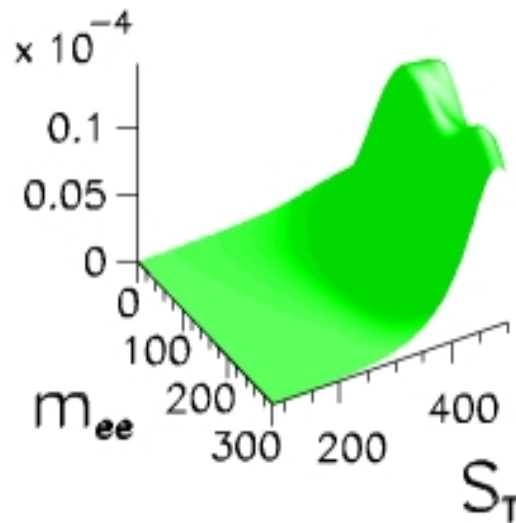
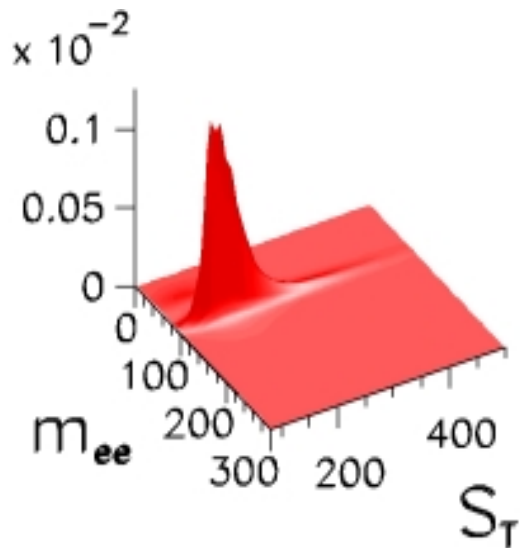
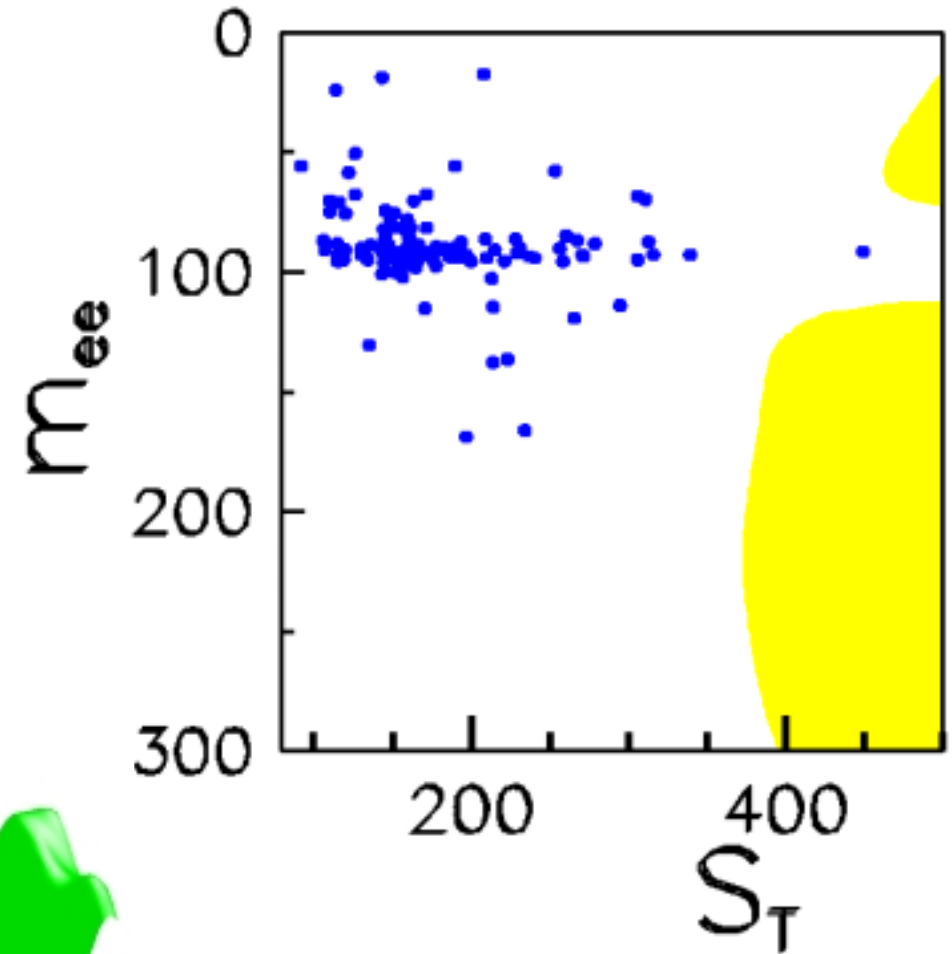
Leptoquarks  $\rightarrow ee 2j$

Quaero

$$\hat{b} = 0.3 \pm 0.1$$

$$\epsilon_{sig} = 0.33$$

$$\sigma^{95\%} \times \mathcal{B} = 0.07 \text{ pb}$$

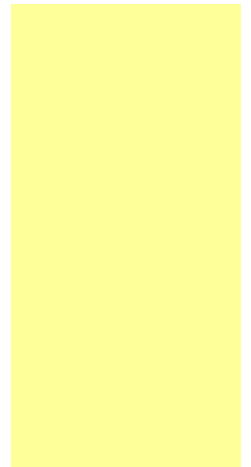


Previous

$0.4 \pm 0.15$

0.35

$0.07 \text{ pb}$



Nearly identical results

(to be overlayed)



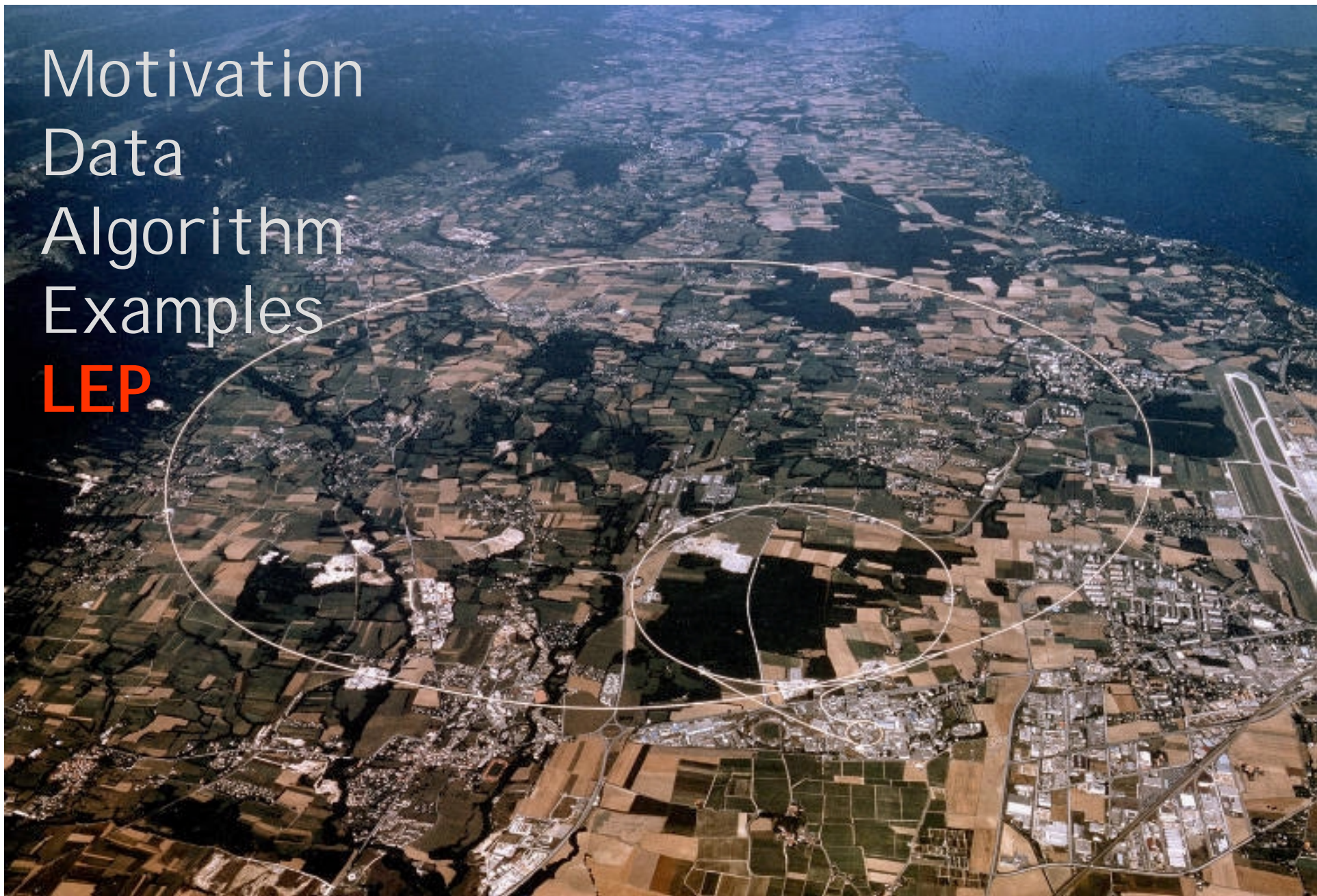
## Examples

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Quaero performs as expected in 11 of 11 sample analyses

Motivation  
Data  
Algorithm  
Examples

**LEP**



# Quaero

A General Interface to LEP Data

[Aleph](#)    [Delphi](#)    [L3](#)    [Opal](#)

## Signal

[Pythia Input:](#)

[Signal File:](#)   [xsec:](#)  pb

## Requestor

Name:

Institution:

Email:

Brief description of model:

[Help!](#) - [Bug history](#) - [CERN](#)

## Current challenges:

### 1) Archiving data

Can we archive ~~HEP~~<sup>LEP</sup> data in a meaningful way?

### 2) Combining results from various final states

What do the data *as a whole* say about a particular model?

### 3) Combining results from various experiments

Can we do this consistently and correctly, with minimal headache?

### 4) Precision measurements

Can Quaero do measurements, in addition to searches?

### 5) Systematic errors

Can we allow an arbitrarily sophisticated treatment of systematics?

Any experiment wishing to use Quaero needs to provide 4 things:

- ▶▶ Data
  - Object 4-vectors
- ▶▶ Backgrounds
  - Object 4-vectors
- ▶▶ Systematic errors
  - Sources of error & effect on 4-vectors
- ▶▶ Detector simulation
  - (and reconstruction, if necessary)

## Event format:

```

eventType
weight{err/mag,...}  sqrt(s){err/mag,...}
e+  E{err/mag,...}  cos( $\theta$ )   $\phi$ 
e-  E{err/mag,...}  cos( $\theta$ )   $\phi$ 
b   E{err/mag,...}  cos( $\theta$ )   $\phi$ 
b   E{err/mag,...}  cos( $\theta$ )   $\phi$ 
uncl  m{err/mag,...}  E{err/mag,...}  cos( $\theta$ )   $\phi$  ;

```

Data event:

```
data 1 190.0
e+ 45.2 +0.11 0.21
e- 47.3 -0.05 3.56
b 46.0 -0.16 1.71
b 48.2 -0.02 4.90
uncl 0.44 3.3 +0.07 3.97 ;
```

## Background event:

ZZ	0.0041{1/0,12/0.0002,0201/0.0001}	190.0		
e+	45.2{0221/1.4}	+0.11	0.21	
e-	47.3{0221/1.5}	-0.05	3.56	
b{0211/j/0.001}	46.0{0222/3.6}	-0.16	1.71	
b{0211/j/0.05}	48.2{0222/3.7}	-0.02	4.90	
uncl	0.44{0222/0.07}	3.3{0222/0.32}	+0.07	3.97 ;



Instead of returning cross section limits, Quaero will return a single number:

$$\mathcal{L}(\mathcal{H}) = \frac{p(\mathcal{D}|\mathcal{H})}{p(\mathcal{D}|\text{SM})},$$

where  $\mathcal{H}$  is the hypothesis being tested.

(Further manipulation of this quantity is then straightforward)

Will this new algorithm actually work in practice?

We'll see . . .

# Conclusions

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- **Quaero** is a method for making HEP data publicly available
  - Perform the analysis automatically
  - Results within the hour
- **Quaero** has been used to publish DØ Run I data
  - [hep-ex/0106039](http://hep-ex/0106039), submitted to PRL
  - <http://quaero.fnal.gov/>

