Proceedings Trim Size: 11in x 8.5in
Text Area: 9.25in (include runningheads) x 6.6in
Main Text is 10/13pt

For Half-Title Page (prepared by publisher)

Publishers' page — (Blank page)

For Full Title Page (prepared by publisher)

PREFACE

The *Tenth International Conference on Recent Progress in Many-Body Theories* (RPMBT-10) was held at the University of Washington in Seattle, USA during the period 10–15 September, 1999. The present volume contains the texts of most of the invited talks delivered at the conference and a selection from among the many poster presentations.

The general format and style of the conference followed the accepted and well-developed pattern for the series, focusing on the development, refinement and important applications of the techniques of quantum many-body theory. The intention of the series has always been to cover in a broad and balanced fashion both the entire spectrum of theoretical tools developed to tackle the quantum many-body problem and their major fields of application. One of the main aims of the series is to foster the exchange of ideas and techniques among physicists working in such diverse areas of applications of many-body techniques as nuclear and subnuclear physics, astrophysics, atomic and molecular physics, quantum chemistry, complex systems, quantum field theory, strongly correlated electronic systems, magnetism, quantum fluids and condensed matter physics.

Quantum many-body theory as a discipline in its own right dates largely from the 1950's, and is hence in many senses already a mature subject. Despite this apparent maturity the field remains vibrant and active, vigorous and exciting, vital and important. Indeed, the successes, importance and vitality of the field have very clearly been recognized by the sharing of the 1998 Nobel Prizes in both Physics and Chemistry by the many-body theorists Robert Laughlin, Walter Kohn and John Pople. It is a source of great pleasure to all of us who work in quantum many-body theory that important achievements in our subject have been thus recognized at the very highest level. We were also especially delighted that two of these then most recent Nobel Laureates, Kohn and Laughlin, accepted invitations to deliver keynote lectures at RPMBT-10...

In any event, the Local Organizing and Programme Committees deserve great thanks in creating a well-run and productive meeting, with an exciting programme of talks and poster presentations. It is a pleasure to thank all of them for their hard work, especially Aurel Bulgac who, as Chairman, has led and guided them throughout.

R.F. Bishop
(Chairman, International Advisory Committee for the Series of International Conferences on Recent Progress in Many-Body Theories)

Manchester, U.K.
31 December 1999

ORGANIZING COMMITTEES

CONTENTS

FOR PROCEEDINGS EDITORS:
COMBINING CONTRIBUTIONS USING WS-PROCS11x85 MASTER DOCUMENT IN LATEX2e

First Author

World Scientific Publishing Co, Production Department,
5 Toh Tuck Link, Singapore 596224,
E-mail: wspc@wspc.com.sg

ws-procs11x85.tex is the master file to input all the papers from front matter, body and end matter files.

Keywords: Master file; LATEX; Proceedings; World Scientific Publishing.

1. Using WS-procs11x85

You can obtain these files from the following website: `http://eproceedings.worldscinet.com/pro_editors.shtml`, `http://www.wspc.com.sg/style/proceedings_style.shtml` and `http://www.icpress.co.uk/authors/stylefiles.shtml#proceedings`.

1.1. *Master File*

All the subdocuments are arranged in this master file in the following sequence:

```
\documentclass{ws-procs11x85}
\usepackage{ws-toc,ws-multind}
%necessary when used with multicols
\usepackage{multicol,float}
%necessary when used with \twocolumn
\usepackage{balance}
%to invoke author index
\makeindex{author}
\begin{document}
\titlepages
\input preface.tex
\cleardoublepage
\include organizers.tex
\mastertoc
%optional part title
%\part{Part Title}{}
\include{proc1}
\include{proc2}
%\part{Second Part}{}
\include{proc3}
%to print Author Index
\printindex{author}{AUTHOR INDEX}
\end{document}
```

2. Pagination

Pages i–iv are always the same and are prepared by the publisher. The pagination of the rest of the front matter depends on the length of the various sections (preface, organizing committee's text, contents). Each front matter section should start on an odd right-hand page. The following is an example of proceedings pagination:

(i) Front matter:

page i	—	half-title page, prepared by publisher
page ii	—	blank page
page iii	—	full-title page, prepared by publisher
page iv	—	copyright page, prepared by publisher
pages v–ix	—	preface text
page xi	—	organizing committees text
pages xiii–xx	—	contents text (TOC)

The first available front matter page is page v.

(ii) Body text:

odd page — First article, followed by remaining articles

(iii) Back matter (optional):

odd page — participants list

Back matter text must start on an odd page.

If the organization of the contributors' manuscripts is different from the above pagination guidelines, please e-mail the respective desk-editor for advice.

Contribution provided by an individual contributor:	Modified contribution, ready to get included in the master document:
%proc1.tex	%proc1.tex
\documentclass{ws-procs11x85}	%\markboth{A. Author}{Paper Title}
\usepackage{multicol,float}	\wstoc{Paper Title}{A. Author}
\begin{document}	
\title{PAPER TITLE}	\title{PAPER TITLE}
\author{A. AUTHOR}	\author{A. AUTHOR}
	\aindx{Author, A.}
\address{Institute of ...}	\address{Institute of ...}
\begin{abstract}	\begin{abstract}
We search for ...	We search for ...
\end{abstract}	\end{abstract}
\keywords{Keyword1; ...}	\keywords{Keyword1; ...}
\bodymatter	\bodymatter
\begin{multicols}{2}	\begin{multicols}{2}
\section{Introduction}	\section{Introduction}
String theory ...	String theory ...
\begin{thebibliography}{00}	\begin{thebibliography}{00}
\bibitem{t1} A. Sen, ...	\bibitem{t1} A. Sen, ...
\bibitem{t2} P. Horava, ...	\bibitem{t2} P. Horava, ...
...	...
\end{thebibliography}	\end{thebibliography}
%for BiBTeX users	%for BiBTeX users
%\bibliographystyle{ws-pro...}	%\bibliographystyle{ws-pro...}
%\bibliography{sample}	%\bibliography{sample}
\end{multicols}	\end{multicols}
\end{document}	\vfill
	\pagebreak

3. Preparing the Individual Contributions for Combining

The above highlighted changes should be made in all the contributions provided by the individual contributors before including them in the master document.

4. Master TOC

Each contribution must have `\wstoc{#1}{#2}` at the preamble to create the combined table of contents.

```
\wstoc{Article Title}{Author's Name}
```

5. Running Head

Preparation of the running head is optional. Each contribution must have `\markboth{#1}{#2}` at the preamble to set the running head.

```
\markboth{Author's Name on Even Page}
         {Article Title on Odd Page}
```

Table 1. This table shows how the author names should appear in the running head and TOC depending upon the number of authors contributing that paper.

No. of Authors	Author Names
1	L. Hatcher
2	I. A. Pedrosa & I. Guedes
3	B. Feng, X. Gong & X. Wang
4 and more	S. R. Choudhury *et al.*

For TOC and Running Heads, the author names should appear in initial and surname format, e.g. LEE HATCHER should be abbreviated as L. HATCHER.

6. Author Index

To create an "author" index, `\makeindex{author}` must be typed at the preamble of the master file, and `\printindex{author}{AUTHOR INDEX}` before `\end{document}`.

In text, the author index entries are marked with:

`\index{autor}{entry}` or `\aindx{entry}`

7. Compiling the Master File in LaTeX2e

To complete the job, compile your file as follows:

(1) latex ws-procs11x85
(2) latex ws-procs11x85
(3) bibtex proc2
(4) makeindex author
(5) latex ws-procs11x85
(6) latex ws-procs11x85

Note: Chapters using BIBTEX database should be compiled individually in 'bibtex'.

You can obtain these files from the following website:

References

1. L. Lamport, *LaTeX, A Document Preparation System.* (Addison-Wesley, Reading, MA, 1994), 2nd edition.
2. L. Lamport, *Make Index: An Index Processor For LaTeX*, (1987).

FOR PROCEEDINGS CONTRIBUTORS: USING WORLD SCIENTIFIC'S WS-PROCS11X85 DOCUMENT CLASS WITH LATEX2e

A. B. AUTHOR* and C. D. AUTHOR

University Department, University Name,
City, State ZIP/Zone, Country
**E-mail: ab_author@university.com*
www.university_name.edu

A. N. AUTHOR

Group, Laboratory, Street,
City, State ZIP/Zone, Country
E-mail: an_author@laboratory.com

This article explains how to use World Scientific's ws-procs11x85 document class written in LATEX2e. This article was typeset using ws-procs11x85.cls and may be used as a template for your contribution.

Keywords: Style file; LATEX; Proceedings; World Scientific Publishing.

1. Using Other Packages

The class file loads the packages `amsfonts`, `amsmath`, `amssymb`, `chapterbib`, `cite`, `dcolumn`, `epsfig`, `rotating` and `url` at startup. Please try to limit your use of additional packages as they often introduce incompatibilities. This problem is not specific to the WSPC styles; it is a general LATEX problem. Check this article to see whether the required functionality is already provided by the WSPC class file. If you do need additional packages, send them along with the paper. In general, you should use standard LATEX commands as much as possible.

2. Layout

In order to facilitate our processing of your article, please give easily identifiable structure to the various parts of the text by making use of the usual LATEX commands or by using your own commands defined in the preamble, rather than by using explicit layout commands, such as `\hspace`, `\vspace`, `\large`, `\centering`, etc. Also, do not redefine the page-layout parameters. For more information on layout and font specifications, please refer to our `Layout and Font Specification Guide`.

3. User Defined Macros

User defined macros should be placed in the preamble of the article, and not at any other place in the document. Such private definitions, i.e. definitions made using the commands `\newcommand`, `\renewcommand`, `\newenvironment` or `\renewenvironment`, should be used with great care. Sensible, restricted usage of private definitions is encouraged. Large macro packages and definitions that are not used in this example article should be avoided. Please do not change the existing environments, commands and other standard parts of LATEX.

4. Using WS-procs11x85

You can obtain these files from the following website: `http://www.wspc.com.sg/style/proceedings_style.shtml`, `http://eproceedings.worldscinet.com/authors.shtml` and `http://www.icpress.co.uk/authors/stylefiles.shtml#proceedings`.

4.1. *Input used to produce this paper*

```
%\documentclass[draft,square]{ws-procs11x85}
\documentclass{ws-procs11x85}
\usepackage{multicol,float}
\begin{document}
\title{FOR PROCEEDINGS CONTRIBUTORS: ...}
\author{A. B. AUTHOR$^*$ and C. D. AUTHOR}
\address{University Department, ...}
\author{A. N. AUTHOR}
\address{Group, Laboratory, Street, ...}
\begin{abstract}
This article...
```

```
\end{abstract}
\keywords{Style file; \LaTeX,...}
\bodymatter
\begin{multicols}[2]
\section{Using Other Packages}
The class file has...
...
\appendix{About the Appendix}
Appendices should be...
\bibliographystyle{ws-procs11x85}
\bibliography{ws-pro-sample}
\end{multicols}
\end{document}
```

The environment used to typeset this document in two column is `multicols` from `multicol` package. Contributors who are much familiar with `\twocolumn` command can follow the sample `ws-procs11x85-sample.tex`.

5. Sectional Units

Sectional units are obtained in the usual way, i.e. with the LaTeX commands `\section`, `\subsection`, `\subsubsection` and `\paragraph`.

6. Section

This is just an example.

6.1. *Subsection*

This is just an example.

6.1.1. *Subsubsection*

This is just an example.

Paragraph This is just an example.

Unnumbered Section

Unnumbered sections can be obtained by using `\section*`.

7. Lists of Items

Lists are broadly classified into four major categories that can randomly be used as desired by the author:

(a) Numbered list.
(b) Lettered list.
(c) Unnumbered list.
(d) Bulleted list.

7.1. *Numbered and lettered list*

(1) The `\begin{arabiclist}[]` command is used for the arabic number list (arabic numbers appearing within parenthesis), e.g., (1), (2), etc.
(2) The `\begin{romanlist}[]` command is used for the roman number list (roman numbers appearing within parenthesis), e.g., (i), (ii), etc.
(3) The `\begin{Romanlist}[]` command is used for the cap roman number list (cap roman numbers appearing within parenthesis), e.g., (I), (II), etc.
(4) The `\begin{alphlist}[]` command is used for the alphabetic list (alphabets appearing within parenthesis), e.g., (a), (b), etc.
(5) The `\begin{Alphlist}[]` command is used for the cap alphabetic list (cap alphabets appearing within parenthesis), e.g., (A), (B), etc.

Note: For all the above mentioned lists (with the exception of alphabetic list), it is obligatory to enter the last entry's number in the list within the square bracket, to enable unit alignment.

7.2. *Bulleted and unnumbered list*

The `\begin{itemlist}` command is used for the bulleted list.

The `\begin{unnumlist}` command is used for creating the unnumbered list with the turnovers hangindent by 1 pica.

Lists may be laid out with each item marked by a dot:

- item one
- item two
- item three.

Items may also be numbered with lowercase Roman numerals:

(i) item one
(ii) item two
    (a) lists within lists can be numbered with lowercase alphabets
    (b) second item
    (c) third item.
(iii) item three
(iv) item four.

8. Theorems and Definitions

The following environments are available by default with WSPC document styles:

Environment	Heading
algorithm	Algorithm
answer	Answer
assertion	Assertion
assumption	Assumption
case	Case
claim	Claim
comment	Comment
condition	Condition
conjecture	Conjecture
convention	Convention
corollary	Corollary
criterion	Criterion
definition	Definition
example	Example
lemma	Lemma
notation	Notation
note	Note
observation	Observation
problem	Problem
proposition	Proposition
question	Question
remark	Remark
solution	Solution
step	Step
summary	Summary
theorem	Theorem

Input:

```
\begin{theorem}
We have $\# H^2 (M \supset N) < \infty$ for
an inclusion $M \supset N$ of factors of
finite index.
\label{aba:the1}
\end{theorem}
```

Output:

Theorem 8.1. *We have $\# H^2(M \supset N) < \infty$ for an inclusion $M \supset N$ of factors of finite index.*

Input:

```
\begin{theorem}[Longo, 1998]
For a given $Q$-system...
\[
N = \{x \in N; T x = \gamma (x) T,
T x^* = \gamma (x^*) T\}\,,
\]
and $E_\Xi (\cdot) = T^* \gamma (\cdot)...
\label{aba:the2}
\end{theorem}
```

Output:

Theorem 8.2 (Longo, 1998). *For a given Q-system...*

$$N = \{x \in N; Tx = \gamma(x)T, Tx^* = \gamma(x^*)T\}\,,$$

and $E_\Xi(\cdot) = T^*\gamma(\cdot)T$ gives a conditional expectation onto N.

LaTeX provides `\newtheorem` to create new theorem environments. To add theorem-type environments to an article, use

```
\newtheorem{example}{Example}[section]
\let\Examplefont\upshape
\def\Exampleheadfont{\bfseries}

\begin{example}
We have $\# H^2 (M \supset N) < ...
\end{example}
```

For details see the LaTeX user manual.[1,2]

8.1. *Proofs*

The WSPC document styles also provide a predefined proof environment for proofs. The proof environment produces the heading 'Proof' with appropriate spacing and punctuation. It also appends a 'Q.E.D.' symbol, □, at the end of a proof, e.g.

```
\begin{proof}
This is just an example.
\end{proof}
```

to produce

Proof. This is just an example. □

The proof environment takes an argument in curly braces, which allows you to substitute a different name for the standard 'Proof'. If you want to display, 'Proof of Lemma', then write e.g.

```
\begin{proof}[Proof of Lemma]
This is just an example.
\end{proof}
```

produces

Proof of Lemma. This is just an example. □

9. Programs and Algorithms

Fragments of computer programs and descriptions of algorithms should be prepared as if they were normal text. Use the same fonts for keywords, variables, etc., as in the text; do not use small typeface sizes to make program fragments and algorithms fit within the margins set by the document style. An example with only the tabbing environment and one new definition:

```
\newcommand{\keyw}[1]{{\bf #1}}
\begin{tabbing}
\quad \=\quad \=\quad \kill
\keyw{for} each $x$ \keyw{do} \\
\> \keyw{if} extension$(p, x)$ \\
\> \> \keyw{then} $E:=E\cup\{x\}$\\
\keyw{return} $E$
\end{tabbing}
```

for each x **do**
  if extension(p, x)
    then $E := E \cup \{x\}$
return E

10. Mathematical Formulas

Inline: For in-line formulas use `\( ... \)` or `$ ... $`. Avoid built-up constructions, for example fractions and matrices, in in-line formulas. Fractions in inline can be typed with a solidus, e.g. `x+y/z=0`.

Display: For numbered display formulas, use the displaymath environment:
`\begin{equation} ... \end{equation}`.

And for unnumbered display formulas, use `\[ ... \]`. For numbered displayed, one-line formulas always use the equation environment. Do not use `$$ ... $$`. For example, the input for:

$$\mu(n,t) = \frac{\sum\limits^{\infty}_{i=1} 1(d_i < t, N(d_i) = n)}{\int\limits^{t}_{\sigma=0} 1(N(\sigma) = n) d\sigma}. \tag{1}$$

is:

```
\begin{equation}
\mu(n, t) = \frac{\sum\limits^\infty_{i=1}1
(d_i<t, N(d_i)=n)}{\int\limits^t_{\sigma=0}1
(N(\sigma)=n)d\sigma}. \label{aba:eq1}
\end{equation}
```

For displayed multi-line formulas, use the `eqnarray` environment. For example,

```
\begin{eqnarray}
\zeta\mapsto\hat{\zeta}& =
        &a\zeta+b\eta\label{aba:appeq2}\\
\eta\mapsto\hat{\eta}& =
        &c\zeta+d\eta\label{aba:appeq3}
\end{eqnarray}
```

produces:

$$\zeta \mapsto \hat{\zeta} = a\zeta + b\eta \tag{2}$$
$$\eta \mapsto \hat{\eta} = c\zeta + d\eta \tag{3}$$

LaTeX does not break long equations to make them fit within the margins as it does with normal text. It is therefore up to you to format the equation appropriately (if they overrun the margin.) This typically requires some creative use of an eqnarray to get elements shifted to a new line and to align nicely, e.g.,

$$\begin{aligned}(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 \\ + \frac{n(n-1)(n-2)}{3!}x^3 \\ + \frac{n(n-1)(n-2)(n-3)}{4!}x^4 \\ + \ldots n\text{th}.\end{aligned} \tag{4}$$

Superscripts and subscripts that are words or abbreviations, as in σ_{low}, should be typed as roman letters; this is done as `\( \sigma_{\mathrm{low}} \)` instead of σ_{low} done with `\( \sigma_{low} \)`.

For geometric functions, e.g. exp, sin, cos, tan, etc., please use the macros `\sin, \cos, \tan`. These macros give proper spacing in mathematical formulas.

It is also possible to use the AMS-LaTeX package,[2] which can be obtained from the AMS and various TeX archives.

11. Floats

11.1. *Tables*

Put tables and figures in text using the table and figure environments, and position them near the first reference of the table or figure in the text. Please avoid long captions in figures and tables.

Input:

```
\begin{table}[H] % always [H] in multicols
\tbl{... table caption ...}
{\begin{tabular}{@{}lcccr@{}}\toprule
ID & $m$ & $R^2$ & ...\\ \colrule
11 & 100 & 3135 & 1138 & $<98$ sec\\
...
15 & 100 & 3135 & ...\\\botrule
\end{tabular}}\label{aba:tbl1}
\end{table}
```

Output:

Table 1. ... table caption ...

ID	m	R^2	x_2	Times
11	100	3135	1138	$<$ 98 sec
12	100	3135	1138	$<$ 99 sec
13	100	3135	1138	$<$ 100 sec
14	100	3135	1138	$<$ 101 sec
15	100	3135	1138	$<$ 102 sec

By using `\tbl` command in table environment, long captions will be justified to the table width while the short or single line captions are centered. `\tbl{table caption}{tabullar environment}`.

For most tables, the horizontal rules are obtained by:

- **toprule** one rule at the top
- **colrule** one rule separating column heads from data cells
- **botrule** one bottom rule
- **Hline** one thick rule at the top and bottom of the tables with multiple column heads

To avoid the rules sticking out at either end of the table, add `@{}` before the first and after the last descriptors, e.g. @llll@. Please avoid vertical rules in tables. But if you think the vertical rule is a must, you can use the standard LaTeX `tabular` environment.

Headings which span for more than one column should be set using `\multicolumn{#1}{#2}{#3}` where `#1` is the number of columns to be spanned, `#2` is the argument for the alignment of the column head which may be either c — for center alignment; l — for left alignment; or r — for right alignment, as desired by the users. Use c for column heads as this is the WS style and `#3` is the heading.

For the footnotes in the table environment the command is `\begin{tabnote}<text>\end{tabnote}`.

Tables should have a uniform style throughout the proceedings volume. It does not matter how you place the inner lines of the table, but we would prefer the border lines to be of the style as shown in our sample tables. For the inner lines of the table, it looks better if they are kept to a minimum.

11.2. *Figures*

A figure is obtained with the following commands

```
\begin{figure}[H] % always [H] in multicols
\centerline{\psfig{file=fig1.eps,width=5cm}}
\caption{...caption here...}\label{aba:fig1}
\end{figure}
```

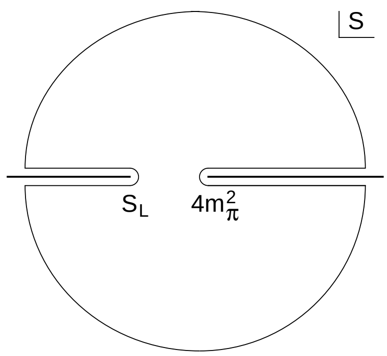

Fig. 1. ... caption here ...

The preferred graphics formats are TIF and Encapsulated PostScript (EPS) for any type of image. Our TeX installation requires EPS, but we can easily convert TIF to EPS. Many other formats, e.g. PICT (Macintosh), WMF (Windows) and various proprietary formats, are not suitable. Even if we can read such files, there is no guarantee that they will look the same on our systems as on yours.

Adjust the scaling of the figure until it is correctly positioned, and remove the declarations of the lines and any anomalous spacing.

We recommend the use of single column-wide tables and figures wherever possible. Tables and figures spanning two columns can be typeset with the following environments:

- `table*` and
- `figure*`.

Table 2. Comparison of acoustic for frequencies for piston-cylinder problem.

Piston mass	Analytical frequency (Rad/s)	TRIA6-S_1 model (Rad/s)	% Error[a]
1.0	281.0	280.81	0.07
0.1	876.0	875.74	0.03
0.01	2441.0	2441.0	0.0
0.001	4130.0	4129.3	0.16

[a] Sample table footnote.

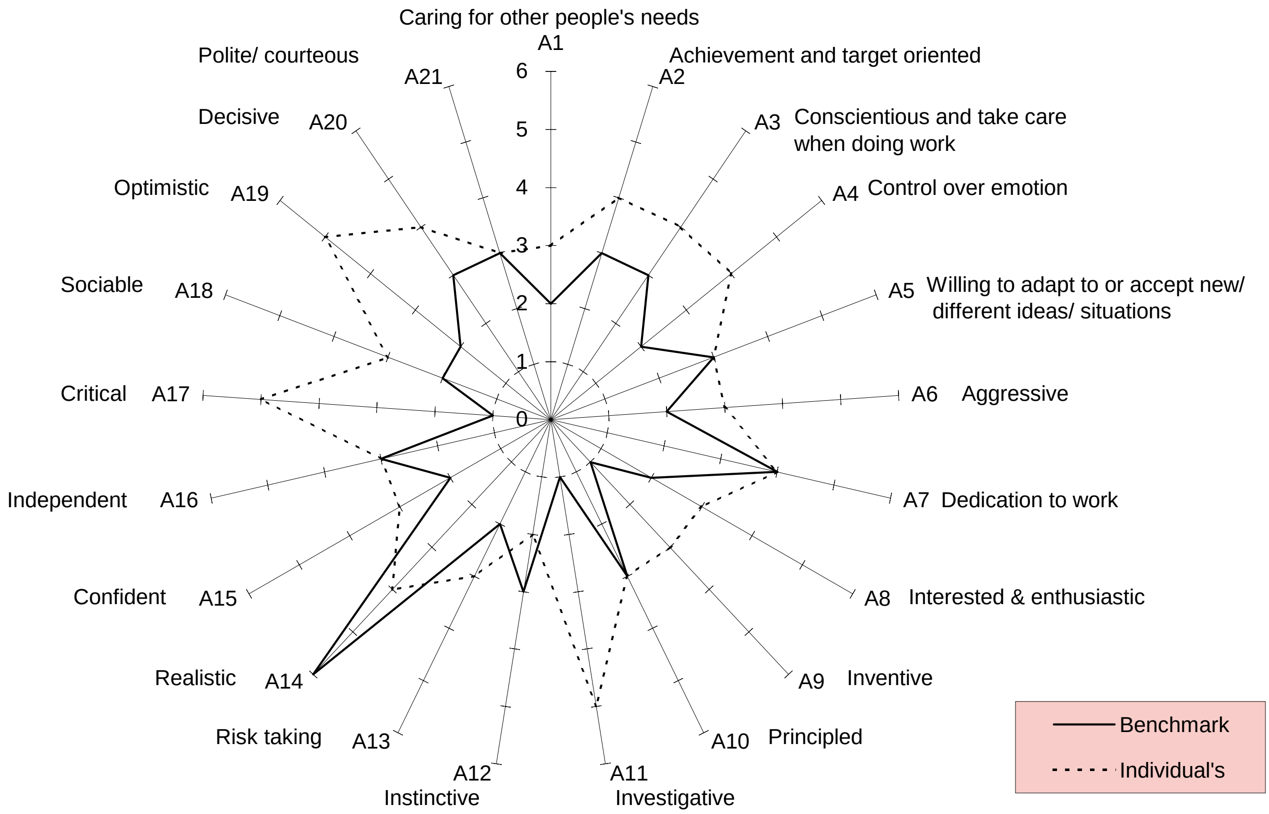

Fig. 2. The bifurcating response curves of system $\alpha = 0.5$, $\beta = 1.8$; $\delta = 0.2$, $\gamma = 0$: (a) $\mu = -1.3$; and(b) $\mu = 0.3$.

Table:

```
\begin{table*}
\tbl{Comparison of ...}
{\begin{tabular}{@{}cccc@{}}
\toprule
Piston mass & Analytical ...\\\colrule
1.0... \\
0.001...\\\botrule
\end{tabular}}
\begin{tabnote}
$^{\text a}$ Sample table footnote.\\
\end{tabnote}\label{aba:tbl2}
\end{table*}
```

Figure:

```
\begin{figure*}
\begin{center}
\psfig{file=procs-fig2.eps,width=6.6in}
\end{center}
\caption{The bifurcating ...}
\label{aba:fig2}
\end{figure*}
```

Table 3. Positive values of X_0 by eliminating Q_0 from Eqs. (15) and (16) for different values of the parameters f_0, λ_0 and α_0 in various dimension.

f_0	λ_0	α_0	Positive roots (X_0)							
			4D	5D	6D	7D	8D	10D	12D	16D
−0.033	0.034	0.1	6.75507, 1.14476	4.32936, 1.16321	3.15991, 1.1879	2.44524, 1.22434	1.92883, 1.29065	0.669541, 0.415056	—	—
−0.1	0.333	0.2	3.15662, 1.24003	1.72737, 1.48602	—	—	—	—	—	—
−0.301	0.302	0.001	2.07773, 1.65625	—	—	—	—	—	—	—
−0.5	0.51	0.001	—	—	—	—	—	—	—	—
0.1	0.1	2	1.667, 0.806578	1.1946 0.858211	—	—	—	—	—	—
0.1	0.1	10	0.463679	0.465426	0.466489	0.466499	0.464947	0.45438	0.429651	0.35278
0.1	1	0.2	—	—	—	—	—	—	—	—
0.1	5	5	—	—	—	—	—	—	—	—
1	0.001	2	0.996033, 0.414324	0.968869, 0.41436	0.91379, 0.414412	0.848544, 0.414489	0.783787, 0.414605	0.669541, 0.415056	0.577489, 0.416214	—
	0.001	0.2	0.316014, 0.275327	0.309739, 0.275856	—	—	—	—	—	—
	0.1	5	0.089435	0.089441	0.089435	0.089409	0.08935	0.089061	0.088347	0.084352
	1	3	0.128192	0.128966	0.19718, 0.41436	0.169063, 0.414412	0.142103, 0.414489	—	—	—

Very large figures and tables should be placed on a separate page by themselves. Landscape tables and figures can be typeset with the following environments:

- `sidewaystable` and
- `sidewaysfigure`.

Example:

```
\begin{sidewaystable*}
\tbl{Positive values of ...}
{\begin{tabular}{@{}cccccccccc@{}}
...
\end{tabular}}
\label{aba:tbl3}
\end{sidewaystable*}
```

12. Cross-references

Use `\label` and `\ref` for cross-references to equations, figures, tables, sections, subsections, etc., instead of plain numbers. Every numbered part to which one wants to refer, should be labeled with the instruction `\label`. For example:

```
\begin{equation}
\mu(n, t) = \frac{\sum\limits^\infty_{i=1}1
(d_i < t, N(d_i) = n)}
{\int\limits^t_{\sigma=0}1
(N(\sigma)=n)d\sigma}.
\label{aba:eq1}
\end{equation}
```

With the instruction `\ref` one can refer to a numbered part that has been labeled:

```
..., see also Eq. (\ref{aba:eq1})
```

The `\label` instruction should be typed

- immediately after (or one line below), but not inside the argument of a number-generating instruction such as `\section` or `\caption`, e.g.: `\caption{...caption...}\label{aba:fig1}`.
- roughly in the position where the number appears, in environments such as an equation,
- labels should be unique, e.g., equation 1 can be labeled as `\label{aba:eq1}`, where 'aba' is author's initial and 'eq1' the equation number.

[a]Sample footnote text.

Some useful shortcut commands.

Shortcut command	Equivalent TEX command	Output
In the middle of a sentence:		
`\eref{aba:eq1}`	Eq. (`\ref{aba:eq1}`)	Eq. (1)
`\sref{aba:sec1}`	Sec. `\ref{aba:sec1}`	Sec. 1
`\fref{aba:fig1}`	Fig. `\ref{aba:fig1}`	Fig. 1
`\tref{aba:tbl1}`	Table `\ref{aba:tbl1}`	Table 1
At the starting of a sentence:		
`\Eref{aba:eq1}`	Equation (`\ref{aba:eq1}`)	Equation (1)
`\Sref{aba:sec1}`	Section `\ref{aba:sec1}`	Section 1
`\Fref{aba:fig1}`	Figure `\ref{aba:fig1}`	Figure 1
`\Tref{aba:tbl1}`	Table `\ref{aba:tbl1}`	Table 1

13. Citations

We have used `\bibitem` to produce the bibliography. Citations in the text use the labels defined in the bibitem declaration, e.g., the first paper by Jarlskog[3] is cited using the command `\cite{jarl88}`. Bibitem labels should be unique.

For multiple citations, do not use `\cite{1}`, `\cite{2}`, but use `\cite{1,2}` instead.

When the reference forms part of the sentence, it should not be typed in superscripts, e.g.: "One can show from Ref. 3 that ...", "See Refs. 1 and 2 for more details." This is done using the LaTeX command: "`Ref.~\refcite{name}`".

14. Footnotes

Footnotes are denoted by a Roman letter superscript in the text. Footnotes can be used as

Input:

```
... total.\footnote{Sample footnote text.}
```

Output: ... in total.[a]

15. Acknowledgments and Appendices

Acknowledgments to funding bodies etc. may be placed in a separate section at the end of the text, before the Appendices. This should not be numbered, so use `\section*{Acknowledgments}`.

It is preferable to have no appendices in a short article, but if it is necessary, then simply use as

```
\appendix{About the Appendix}
Appendices should be...
```

```
\begin{equation}
\mu(n, t) = ...
\label{app:a1}
\end{equation}
\subappendix{Appendix Sectional Units}
Sectional units are...
```

16. References

References are to be listed in the order cited in the text in Arabic numerals. BIBTEX users, please use our bibliography style file `ws-procs11x85.bst` for references. Non BIBTEX users can list down their references in the following pattern.

```
\begin{thebibliography}{9}

\bibitem{jarl88} C. Jarlskog, in {\it CP
  Violation} (World Scientific, Singapore,
  1988).

\bibitem{lamp94} L. Lamport, {\it \LaTeX,
  A Document Preparation System},
  2nd edition (Addison-Wesley, Reading,
  Massachusetts, 1994).

\bibitem{ams04} \AmS-\LaTeX{} Version 2
  User's Guide (American Mathematical
  Society, Providence, 2004).

\bibitem{best03} B.~W. Bestbury,
  {\em J. Phys. A} {\bf 36}, 1947 (2003).

\end{thebibliography}
```

17. BIBTEXing

If you use the BIBTEX program to maintain your bibliography, you do not use the `thebibliography` environment. Instead, you should include

```
\bibliographystyle{ws-procs11x85}
\bibliography{ws-pro-sample}
```

where `ws-procs11x85` refers to a file `ws-procs11x85.bst`, which defines how your references will look.

The argument to `\bibliography` refers to the file `ws-pro-sample.bib`, which should contain your database in BIBTEX format. Only the entries referred to via `\cite` will be listed in the bibliography.

Sample output using `ws-procs11x85` bibliography style file:

BIBTEX database entry type	Sample citation
article	... text.[4–6]
proceedings	... text.[7]
inproceedings	... text.[8]
book	... text.[3,9]
edition	... text.[10]
editor	... text.[11]
series	... text.[12]
tech report	See Refs. 13 and 14 for more details
unpublished	... text.[15]
phd thesis	... text.[16]
masters thesis	... text.[17]
incollection	... text.[18]
misc	... text.[19]

Appendix A. About the Appendix

Appendices should be used only when absolutely necessary. They should come before the References.

Appendix A.1. *Appendix Sectional Units*

Where two or more appendices are used, number them alphabetically. Sectional units are obtained with the LATEX commands:

- `\appendix`
- `\subappendix`.

Unnumbered appendix sections can be obtained using `\section*`.

Table A1. Macros available for Table/Figures.

Environment name	Purpose
`figure`[a]	Single column figures
`figurehere`	Single column figures
`figure*`	Double column figures
`sidewaysfigure`	landscape figures
`table`[a]	Single column tables
`tablehere`	Single column tables
`table*`	Double column tables
`sidewaystable`	landscape tables
Horizontal rules for tables	
`\toprule`	one rule at the top
`\colrule`	one rule separating column heads from data cells
`\botrule`	one bottom rule
`\Hline`	one thick rule at the top and bottom of the tables with multiple column heads

[a] Always use with '[H]' placement option.

$$\zeta \mapsto \hat{\zeta} = a\zeta + b\eta \quad \text{(A.1)}$$

$$\eta \mapsto \hat{\eta} = c\zeta + d\eta \quad \text{(A.2)}$$

Number displayed equations occurring in the appendix in this way, e.g. (A.1), (A.2), etc.

Appendix B. Class options

The numbered citations can appear in two ways:

1. Superscript[1] `\usepackage{ws-procs11x85}` (default)
2. Bracketed [1] `\usepackage[square]{ws-procs11x85}`

The contributors are advised to consult the proceedings editor before choosing the citation style `square`.

Table B1. Macros available for use in text.

Macro name	Purpose
\title{#1}	Article Title
\author{#1}	List of all Authors
\address{#1}	Address of Author
\maketitle	Formats title page
\begin{abstract}	Start Abstract
\end{abstract}	End Abstract
\keywords{#1}	Keywords
\bodymatter	Start body text
\begin{multicols}[2]	Start two column
\end{multicols}	End two column
\section{#1}	Section heading
\subsection{#1}	Subsection heading
\subsubsection{#1}	Subsubsection heading
\section*{#1}	Unnumbered Section head
\begin{itemlist}	Start unnumbered lists
\end{itemlist}	End unnumbered lists
\begin{romanlist}	Start roman lists
\end{romanlist}	End roman lists
\begin{alphlist}	Start alpha lists
\end{alphlist}	End alpha lists
\begin{proof}	Start of Proof
\end{proof}	End of Proof
\begin{theorem}	Start of Theorem
\end{theorem}	End of Theorem
	See Page 6 for detailed list
\appendix{#1}	Appendix heading
\begin{thebibliography}	Start of numbered reference list
\end{thebibliography}	End of numbered reference list

References

1. L. Lamport, *LATEX, A Document Preparation System*, 2nd edn. (Addison-Wesley, Reading, MA, 1994).
2. *AMS, AMS-LATEX Version 2 User's Guide* (American Mathematical Society, Providence, 2004). `http://www.ams.org/tex/amslatex.html`.
3. C. Jarlskog, *CP Violation* (World Scientific, Singapore, 1988).
4. B. W. Bestbury, *J. Phys. A* **36**, 1947 (2003).
5. P. X. Deligne and B. H. Gross, *C. R. Math. Acad. Sci. Paris* **335**, 877 (2002).
6. J. M. Landsberg and L. Manivel, *Adv. Math.* **171**, 59 (2002), `http://www.url.com/triality.html`.
7. G. H. Weiss (ed.), *Contemporary Problems in Statistical Physics* (SIAM, Philadelphia, 1994).
8. R. K. Gupta and S. D. Senturia, Pull-in time dynamics as a measure of absolute pressure, in *Proc. IEEE Int. Workshop on Microelectromechanical Systems (MEMS'97)*, (Nagoya, Japan, 1997).
9. L. F. Richardson, *Arms and Insecurity* (Boxwood, Pittsburg, 1960).
10. R. V. Churchill and J. W. Brown, *Complex Variables and Applications*, 5th edn. (McGraw-Hill, 1990).
11. F. Benhamou and A. Colmerauer (eds.), *Constraint Logic Programming, Selected Research* (MIT Press, 1993).
12. D. W. Baker and N. L. Carter, *Seismic Velocity Anisotropy Calculated for Ultramafic Minerals and Aggregates*, in *Flow and Fracture of Rocks*, eds. H. C. Heard, I. V. Borg, N. L. Carter and C. B. Raleigh, Geophys. Mono., Vol. 16 (Am. Geophys. Union, 1972), pp. 157–166.
13. J. D. Hobby, *A User's Manual for MetaPost*, Tech. Rep. 162, AT&T Bell Laboratories (Murray Hill, New Jersey, 1992).
14. B. W. Kernighan, *PIC—A Graphics Language for Typesetting*, Computing Science Technical Report 116, AT&T Bell Laboratories (Murray Hill, New Jersey, 1984).
15. H. C. Heard, I. V. Borg, N. L. Carter and C. B. Raleigh, VoQS: Voice Quality Symbols, Revised to 1994, (1994).
16. M. E. Brown, An interactive environment for literate programming, PhD thesis, Texas A&M University, (TX, USA, 1988), pp. ix + 102.
17. G. S. Lodha, Quantitative interpretation of ariborne electromagnetic response for a spherical model, Master's thesis, University of Toronto (1974).
18. D. Jones, The term 'phoneme', in *Phonetics in Linguistics: A Book of Reading*, eds. W. E. Jones and J. Laver (Longman, London, 1973) pp. 187–204.
19. B. Davidsen, Netpbm (1993), `ftp://ftp.wustl.edu/graphics/graphics/packages/NetPBM`.

Top Quark Measurements at the Fermilab Tevatron

P. Azzi
I.N.F.N.-Sezione di Padova, Via Marzolo 8, 35100 Padova, Italy
E-mail: azzi@pd.infn.it

The top quark, discovered at the Tevatron in 1995, is a very interesting particle. Precise measurement of the top properties using large data samples will allow stringent tests of the Standard Model and offer a unique window on new physics. This report contains a review of the status of the current knowledge of the top quark as provided by the Run I results of the CDF and D0 experiments. A first look at various preliminary measurements obtained with data collected during Run II will also be presented.

Keywords: Keyword1; Keyword2

1. Introduction

The top quark is one of the building blocks of the Standard Model of Electroweak interactions as the partner of the bottom quark in the SU(2) isospin doublet of the third family of quarks. After having eluded experimentalists for many years, the CDF experiment found evidence for its existence in 1994[1] followed soon by its discovery by the CDF[2] and D0[3] experiments in 1995.

While the data set collected at the Tevatron $p\bar{p}$ collider during Run I ($\mathcal{L}_{int} = 110\,\mathrm{pb}^{-1}$) has been sufficient for the discovery of the top quark, it is still too small to allow stringent tests of the Standard Model in top enriched samples. The ensemble of available top measurements up-to-date is thus consistent with expectations, however Run I left us a few interesting discrepancies that will need to be addressed in Run II. The large Run II dataset will allow one to achieve a greater precision and probe possible deviations from the Standard Model in a significant way.

2. Top Production and Decay

At the Tevatron the top quark is produced mainly in pairs through the process $qq, gg \to t\bar{t}$ with a cross section of about 6.7 pb[4] for $m_t = 175\,\mathrm{GeV/c^2}$ and $\sqrt{s} = 1.96\,\mathrm{TeV}$. Within the Standard Model framework the top decays almost 100% of the time via $t \to Wb$. Therefore it is customary to classify the $t\bar{t}$ final states based on the W decays modes: dileptons ($\ell = e, \mu$), lepton+jets ($\ell = e, \mu$), all-jets and inclusive τ (hadronically decaying) final-state events.

Even if its production cross section is much smaller compared to other Standard Model background processes, top events have very distinctive signatures that guide the overall analysis strategy: given the large top mass the decay products (leptons, jets) have large p_T's and the event topology is central and spherical, and there are always two b jets in the final state. Excellent lepton identification, energy resolution and b identification capabilities are essential for a successful Run II top physics program. The full kinematical and heavy flavor characterization of top enriched data sets in terms of all the known Standard Model processes is important not only for precision measurements but also to test for any new phenomena.

3. The Run II Tevatron Collider and Detector Upgrades

For Run II the Fermilab accelerator complex underwent a major upgrade. As a result the Tevatron operates at a higher center-of-mass energy $\sqrt{s} = 1.96\,\mathrm{TeV}$, with a bunch crossing interval of 396 ns with a goal of $\mathcal{L}_{inst} = 33 \times 10^{31}\,\mathrm{cm^{-2}\,s^{-1}}$. By August 2003, the total integrated luminosity delivered by the Tevatron amounted to about $\mathcal{L}_{int} = 300\,\mathrm{pb}^{-1}$ with a typical $\mathcal{L}_{inst} = 3-4.5 \times 10^{31}\,\mathrm{cm^{-2}\,s^{-1}}$.

The CDF and D0 detectors underwent extensive upgrades for Run II motivated by the need to improve overall acceptance, secondary vertex capabilities and to cope with the upgraded Tevatron performance. CDF has retained its central calorimeter and part of the muon detectors, while it has replaced the central drift chamber (COT) and the silicon tracking system (L00, SVXII, ISL). New plug calorimeters and additional muon coverage allow CDF to extend lepton identification in the forward region. The most important upgrade of the D0 detector is the new tracking system which consists of a fiber tracker plus a silicon tracker immersed in a new 2 T superconducting solenoid. D0 has also improved the muon coverage and added new preshower detectors. Both CDF and D0 have new DAQ and trigger systems to cope with the shorter interbunch time.

3.1. *Silicon Detectors Upgrades and High p_T b-tagging*

The feasibility and the techniques of b hadron identification at hadron machines have been firmly established in Run I. The use of b-tagging has been crucial for top discovery and it is an essential piece of the Run II top and exotic physics program. Both CDF and D0 silicon detectors upgrades followed the same guidelines: provide good coverage of the long ($\sim 30\,\mathrm{cm}$) Tevatron luminous region, extend acceptance in the forward region, and with 3D reconstruction capabilities plus excellent impact parameter resolution achieve large signal efficiency and good background rejection.

The "silicon vertex" methods for identifying a b jet in a top event exploit the b hadron's long lifetime, large boost and significant charged track multiplicity of the decay. However, alternative methods ("soft lepton") that exploit the softer p_T spectrum and low isolation properties of b semileptonic decay modes are also employed successfully by CDF and D0.

4. Top Cross Section Measurement

Precise measurements of the $t\bar{t}$ production cross section and the branching ratios in all the decay channels provide a stringent test for the presence of new physics phenomena. Top-color and SUSY models predict not only alternative top production processes but extra decay modes that can alter the branching ratios of the various channels. The Run I top cross section measurements are summarized in Table 1. The goal for Run II ($\mathcal{L}_{int} = 2\,\mathrm{fb}^{-1}$) is to achieve a relative uncertainty of about 10% or less on $\sigma_{t\bar{t}}$, this will be possible not only through the increased detector acceptance and efficiencies but also because the main data driven systematic uncertainties (jet energy scale, ISR/FSR, ϵ_{btag}) will scale with the size of the control sample used for their determination.

4.1. *Run II Cross Section Measurement*

The first Run II measurements of $\sigma_{t\bar{t}}$ have been focused on the channels with the highest signal-to-background ratio, namely the dilepton and lepton plus jets (ℓ=e, μ). The results presented have been summarized in Table 2 and they are shown in Fig. 1 as a function of the center-of-mass energy.

Table 1. Summary table of Run I $\sigma_{t\bar{t}}$ measurements, $\mathcal{L}_{int} = 110\,\mathrm{pb}^{-1}$.

$\sigma_{t\bar{t}}$(pb) Channel	CDF measurement	D0 measurement
Dilepton	$8.4^{+4.5}_{-3.5}$	6.4 ± 3.4
Lepton+jets	$5.7^{+1.9}_{-1.5}$	5.2 ± 1.8
All jets	$7.6^{+3.5}_{-2.7}$	7.1 ± 3.2
Combined	$6.5^{+1.7}_{-1.4}$	5.9 ± 1.7

Fig. 1. Summary of $\sigma_{t\bar{t}}$ versus center-of-mass energy.

4.2. *Dilepton Channel*

This final state is characterized by the presence of two high p_T leptons (a reconstructed e, μ, τ or an isolated track), large missing transverse energy from the missing neutrinos and two or more central jets. The main sources of background for this channel come from other Standard Model processes with similar signatures (Drell-Yan $\gamma^*/Z^0 \rightarrow e^+e^-,\ \mu^+\mu^-$, $Z^0 \rightarrow \tau\tau$, $W^+W^-/W^\pm Z^0$) and processes with one real lepton and another object that fakes the second lepton. The dilepton event selection starts with two oppositely charged high p_T leptons, asking that one or both are well isolated from nearby track activity. Different techniques are employed in order to reduce the contribution from Z^0 events without reducing the signal acceptance. $\not{E}_T$ is required to be large given the two neutrinos from W decay and the presence of two central jets accounts for the two b's

Table 2. Summary table of Run II $\sigma_{t\bar{t}}$ measurements. CDF and D0 preliminary results.

Decay Channel	Method	$\sigma_{t\bar{t}}$(pb)	$\mathcal{L}_{int}$ (pb^{-1})	Experiment
Dilepton	$\ell\ell$	$8.7^{+6.4}_{-4.7}(stat)\ +^{+2.7}_{-2.0}\ (syst) \pm 0.9(lum)$	90 – 107	D0
Dilepton	$\ell\ell$	$7.6^{+3.8}_{-3.1}(stat)^{+1.5}_{-1.9}(syst)$	126	CDF
Dilepton	ℓ+track	$7.3 \pm 3.4(stat) \pm 1.7(syst)$	126	CDF
ℓ+jets	CSIP	$7.4^{+4.4}_{-3.6}(stat)^{+2.1}_{-1.6}(syst) \pm 0.7(lum)$	45	D0
ℓ+jets	SVT	$10.8^{+4.9}_{-4.0}(stat)^{+2.1}_{-2.0}(syst) \pm 1.1(lum)$	45	D0
ℓ+jets	topo	$4.6^{+3.1}_{-2.7}(stat)^{+2.1}_{-2.0}(syst) \pm 0.5(lum)$	92	D0
ℓ+jets	SMT	$11.4^{+4.1}_{-3.5}(stat)^{+2.0}_{-1.8}(syst) \pm 1.1(lum)$	92	D0
ℓ+jets	combined	$8.0^{+2.4}_{-2.1}(stat)^{+1.7}_{-1.5}(syst) \pm 0.8(lum)$	92	D0
ℓ+jets	SVX	$5.3 \pm 1.9(stat) \pm 0.9(syst)$	57	CDF
ℓ+jets	H_T	$5.1 \pm 1.8(stat) \pm 2.1(syst)$	126	CDF
Dilepton,ℓ+jets	combined	$8.1^{+2.2}_{-2.0}(stat)^{+1.6}_{-1.4}(syst) \pm 0.8(lum)$	90 – 107	D0

Fig. 2. Run II data H_T distribution of dilepton events compared to SM expectation (CDF).

Fig. 3. Run II data jet multiplicity distribution for dilepton events compared to SM expectation (D0).

from the top decay. Other kinematical and topological cuts (H_T, total energy of all the object in the event, $\Delta\phi(\not\!\!E_T, object)$) are finally employed in order to reduce the remaining backgrounds. The comparison of the remaining events after selection with the total Standard Model expectation (background plus signal) is shown in Fig. 2 and Fig. 3.

4.3. *Lepton Plus Jets Channel*

The lepton plus jets signature is characterized by the presence of one high p_T lepton and large $\not\!\!E_T$ due to the leptonic W decay plus three or more jets from the hadronically decaying W and the b jets. This final state suffers from large $W + jets$ background. However, kinematical and topological properties of the $t\bar{t}$ signal or its heavy flavor content (or both) provide a good separation from the background processes. In the kinematical approach, after the basic event selection, variables such as H_T, the scalar sum of all the objects' transverse energies in the event, or the aplanarity $\mathcal{A}$, a measure of the event shape, are found to be the most discriminant, see for example Fig. 4. A complementary approach is to exploit the heavy flavor content of signal events and the large b-tagging efficiency compared to the low fake rate. There are several b identification algorithms avail-

Fig. 4. Run II data H_T distribution for lepton plus jets events with at least four jets compared to SM expectations (CDF).

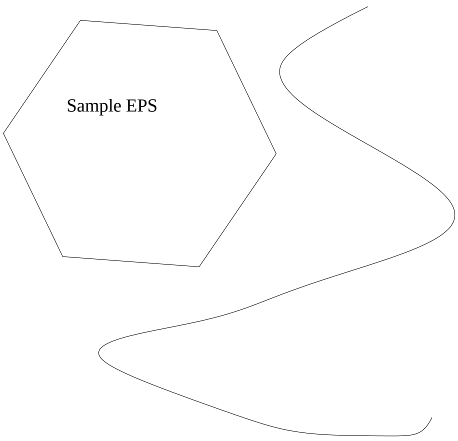

Fig. 5. Run II data jet multiplicity distribution in the lepton plus jets channel with a b-tagged jet compared with SM expectations (D0).

able at the moment, some employ the silicon vertex detector information, while another category focuses on the peculiar properties of leptons from b semileptonic decays. In Fig. 5 the jet multiplicity in $W+jets$ events is shown after the requirement of an identified secondary vertex: the points are the data compared to the background Standard Model expectation. The excess due to the $t\bar{t}$ signal is visible in the three or more jet bins.

4.4. *All Hadronic Channel*

The all-jets final state where both W decay hadronically is a very challenging signature of six central and energetic jets, swamped by a QCD multijet background of several orders of magnitude bigger than the

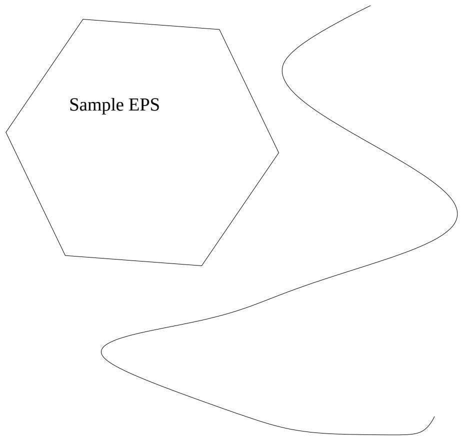

Fig. 6. Run I data $M(t\bar{t})$ distribution (CDF).

$t\bar{t}$ signal. However, in Run I both experiments succeeded in isolating the signal and measuring cross section and mass in this channel as well.[5,6] The D0 experiment has taken a first look at this channel in Run II repeating the Run I neural network analysis. A small excess of 78 events with a background of 68 ± 1.6 is found in $\mathcal{L}_{int} = 80.7\,\mathrm{pb}^{-1}$ of data, consistent with Standard Model expectations. The measurement of the cross section in this channel is in progress.

4.5. *Test for New Physics in $t\bar{t}$ Production*

Both CDF[7] and D0[8] have searched for $t\bar{t}$ resonances using the Run I data sample. Models with a dynamically broken EW symmetry (technicolor) predict a top-quark condensate, X, that decays to a $t\bar{t}$ pair. By searching for narrow $t\bar{t}$ resonances this limit becomes model independent, see Fig. 6. However, 95% CL limits have been placed on a leptophobic $Z' \to t\bar{t}$ with a large cross section for $m(Z') < 560\,\mathrm{GeV/c}^2$ by both CDF and D0, see Fig. 7.

5. Single Top Physics

In addition to pair production, single top quarks can be produced by weak interaction by a virtual W or through Wg fusion, with a total cross section of about $\sigma_{tX} = 2.9\,\mathrm{pb}$.[9] Single top production is interesting in its own right: a precise measurement of the cross section would provide a direct determination of $|V_{tb}|$ with a 14% uncertainty expected for $\mathcal{L}_{int} = 2\,\mathrm{fb}^{-1}$ of data. Moreover single top

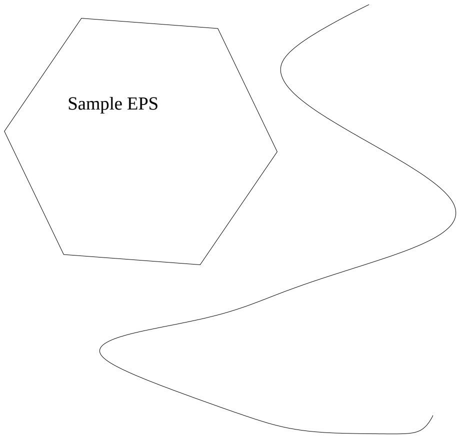

Fig. 7. Run I limit on a leptophobic $Z' \to t\bar{t}$ (CDF).

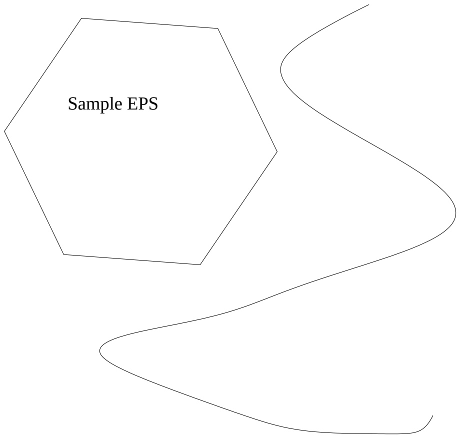

Fig. 8. H_T distribution for MC single top events compared to $t\bar{t}$ and $W + jets$ (CDF).

events have the same final-state experimental signature as the Standard Model Higgs associated production process ($HW \to b\bar{b}\ell\nu_\ell$). The extraction of a single top signal is more challenging than the pair produced case since there are fewer objects in the final state and the overall event properties are less distinct from the $W + jets$ background, see Fig. 8. In Run I searches for single top production (in the s- and t-channels separately and combined) were performed by both CDF[10] and D0.[11] The same search method has been applied by CDF on a Run II dataset of about $\mathcal{L}_{int} = 107\,\mathrm{pb}^{-1}$ and the preliminary result is still consistent with the Run I cross section limit, $\sigma_{tX}^{RunII}(comb) < 17.5\,\mathrm{pb}\,@\,95\%\mathrm{CL}$. The H_T distribution for the candidate events compared to Standard Model expectation for signal and background is shown in Fig. 9.

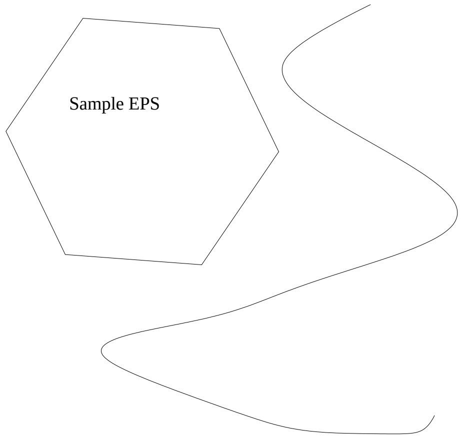

Fig. 9. Run II data (points) H_T distribution compared to the expected SM background plus $t\bar{t}$ and single top production (CDF).

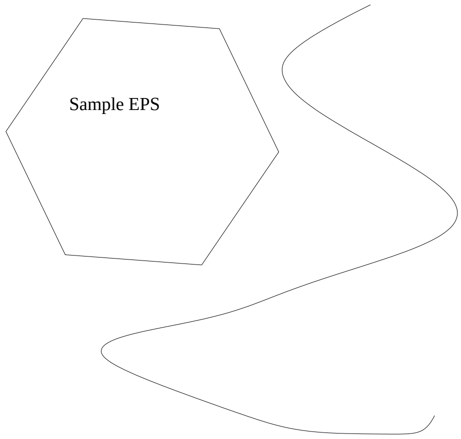

Fig. 10. Two dimensional (m_t,f_0) probability distribution of Run I lepton plus jets data (D0).

6. *W* Helicity in Top Decays

Since the top is the only quark that decays free without hadronizing, the decay products carry its polarization information. In the Standard Model the top quark decays only to longitudinal or left-handed W's, where the ratio is predicted to be about $f_0 = \frac{W_{long}}{W_{left}} = 70\%$ in the case of a $m_t = 175\,\mathrm{GeV/c^2}$. The helicity information is reflected in several kinematical properties of the decay products (W lepton p_T, $M(\ell b)$) that are traditionally used to extract an experimental measurement of f_0. However, D0 has performed a new measurement using the Run I datasets: $f_0 = 0.56 \pm 0.31(stat) \pm 0.04(syst)$ under the assumption of $m_t = 175\,\mathrm{GeV/c^2}$, see in Fig. 10 the two dimensional (m_t,f_0) probability distribution. The likelihood method used here makes better use of the event information thus greatly improving the statistical uncertainty. This method is used also in the measurement of the top mass and will be discussed more in Sec. 7.

7. Top Mass

The top quark mass is a fundamental Standard Model parameter that needs to be measured with the greatest possible precision. It is needed to determine the strength of the ttH coupling and it has a substantial effect on radiative corrections. In fact, an uncertainty of $2\,\mathrm{GeV/c^2}$ on the top mass would constrain the Higgs mass to 35%, see Fig. 11. It is not an easy task to achieve such a small uncertainty, but several experimental handles are available in Run II. On one hand the increased detector acceptance and large data sample will allow one to select purer samples less sensitive to systematic uncertainties: for instance requiring events with well measured jets (lowers the energy scale uncertainty) and two b-tagged jets (lowers the overall background). On the other hand, since most of the systematics are data driven, their uncertainty will scale approximately with $1/\sqrt{N}$, N being the number of events of the control samples themselves.

7.1. *Run I Measurement Summary*

Using the Run I dataset the CDF and D0 experiment have measured directly the top mass in channels (lepton+jets, dilepton and all hadronic) employing different methods and techniques. The results from the two experiments and their combination are summarized in Table 3. However, the single most precise measurement on the Run I data comes from the latest measurement from the D0 experiment in the lepton plus jets channel[12] of $m_t = 180.1 \pm 5.4\,\mathrm{GeV/c^2}$. The likelihood method employed for this measurement was originally proposed for the mass reconstruction in dilepton events[13−15] where the system is underconstrained for a simple kinematic fit. However, the technique is very useful also in the case of lepton plus jets events, since a better use of the event information effectively increases the statistical power of the data sample itself. Each event has an associated probability to be signal or background defined in terms of the matrix element information, and this probability is convolved with a transfer function that relates the object at the parton level to the object after reconstruction. The only background considered is $W + 4\,jets$, which makes up 80% of the total, and cleanup cuts are added to the data to further reduce the absolute background contribution. The remaining 22 events in $\mathcal{L} = 125\,\mathrm{pb}^{-1}$ of data are then used in a global likelihood fit to extract the top mass and the W mass (or the f_0 at the same time), as shown in Fig. 12. The large reduction in statistical uncertainty, corresponding to an effective increase of the data set by a factor 2.4, is mainly due to the more complete use of the event information.

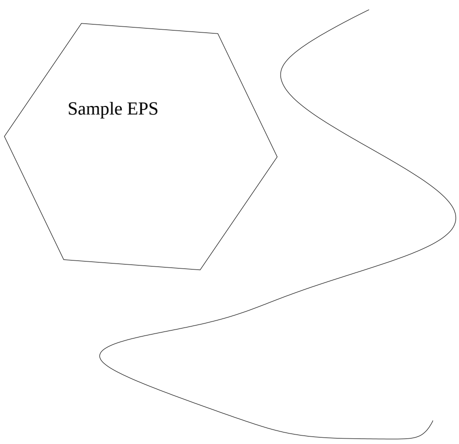

Fig. 11. The closed curves representing experimental measurements of m_t and m_W constrain the SM Higgs mass. The shaded band shows the allowed combinations of m_t and m_W for various m_H.

Table 3. Summary table of Run I m_t measurements.

m_t (GeV/c^2) Channel	CDF measurement	D0 measurement
Dilepton	167.4 ± 11.4	168.4 ± 12.8
Lepton+jets	175.9 ± 7.1	173.3 ± 7.8
All jets	186.0 ± 11.5	–
Combined	176.0 ± 6.5	172.1 ± 7.1
CDF+D0 Combined	174.3 ± 5.1	
Lepton+jets (New)	–	180.1 ± 5.4

7.2. *Issues for Precision Top Mass in Run II*

A precise measurement of the top mass combines cutting edge theoretical knowledge with state-of-the-art detector calibration. The highest contribution to the systematic uncertainty still comes from the jet energy scale. With the statistics available now the best calibration sample consists of events where a jet is re-

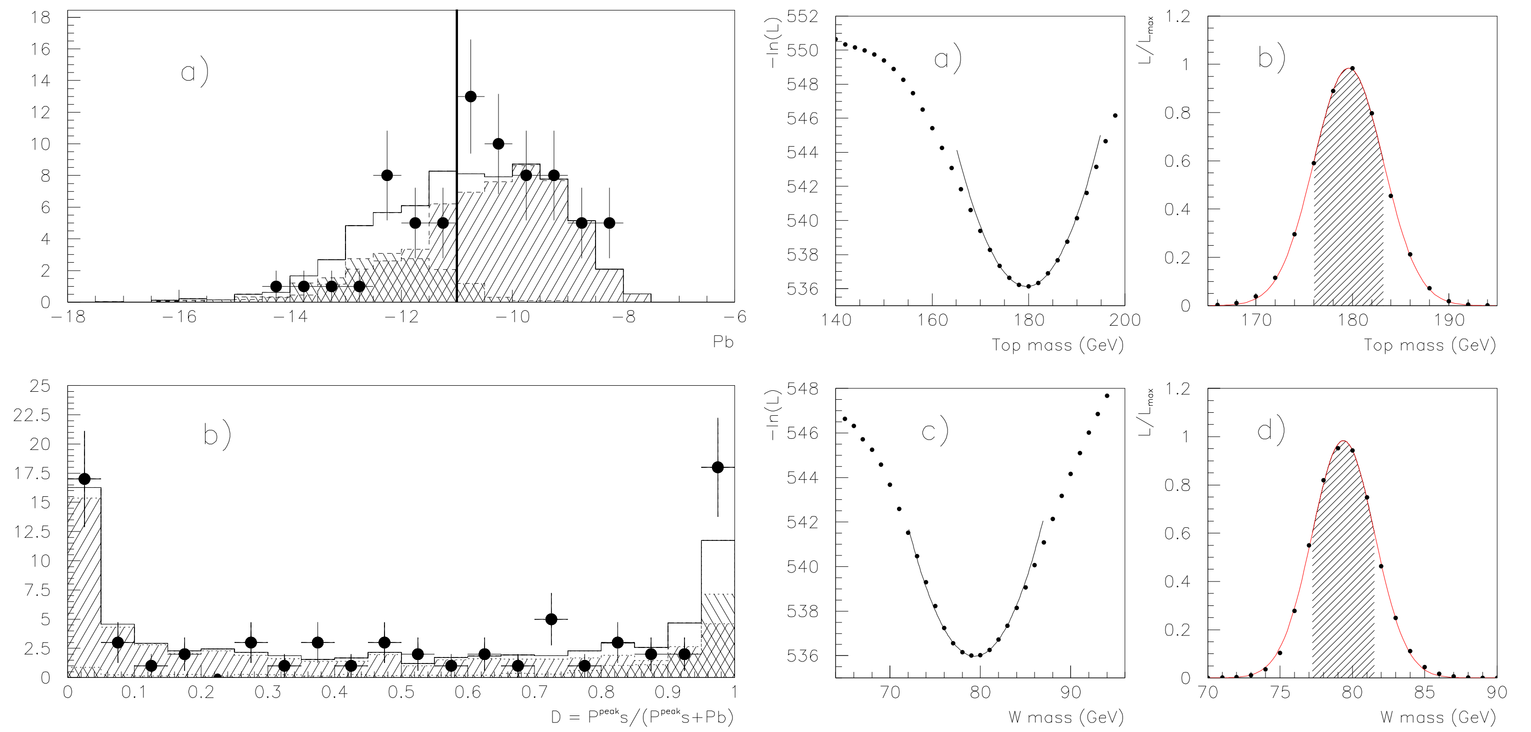

Fig. 12. New D0 Run I top mass measurement. Left: a) background probability distribution; b) ratio $P_{top}/(P_{bkg} + P_{top})$. Right: a) and b) fitted top mass value and its uncertainty; c) and d) fitted W mass when the top mass is fixed to its fitted value.

Fig. 13. Reconstructed m_t distribution in the lepton+jets channel with a b-tagged jet in Run II data (CDF).

Fig. 14. Reconstructed m_t in the dilepton channel in Run II data (CDF).

coiling against a well measured photon, with larger statistics the sample where a jet recoils against a reconstructed Z can be used. Finally the hadronic W in lepton plus jets events can provide an in situ calibration for the light quark jets, while the $Z \rightarrow b\bar{b}$ signal would be used for the heavy flavor ones. A large amount of data will allow one to not only reduce the systematics above but also to pick the best measured event categories with smaller backgrounds and that are less sensitive to systematics uncertainties. However, to achieve the ultimate precision excellent Monte Carlo generators implementing the latest theory knowledge and understanding of all the various effects (ISR, FSR, PDF's) plus an accurate detector simulation are essential.

While work is in progress on all these fronts, preliminary measurements of the top mass, still dominated by large systematic uncertainties, have been performed using the Run II data sample. In the lepton plus four jets channel with at least one secondary vertex b-tagged jet a value of $m_t = 177.5^{+12.7}_{-9.4}(stat) \pm 7.1(syst)\,\mathrm{GeV/c^2}$ is found using 22 candidate events shown in Fig. 13. In the dilepton channel a preliminary measurement of $m_t = 175.0^{+17.4}_{-16.9}(stat) \pm 7.9(syst)\,\mathrm{GeV/c^2}$, is obtained using 6 candidate events, shown in Fig. 14.

8. Conclusions

The top is still a very young particle and our current knowledge about its properties comes from the Run I Tevatron measurements. This accelerator and its two experiments, CDF and D0, are the place for top physics still for years to come. In Run II a data sample about 50 times the Run I statistics will be collected. It will be possible to achieve better precision in the measurements and perform significant tests of the Standard Model expectations. Maybe there will be surprises ahead... The first preliminary round of Run II measurements of the production cross section and mass covers already a variety of channels and very soon the uncertainties will start to drop. The two experiments are exploiting all their new upgraded detector features and a very exciting top physics program lies ahead.

Acknowledgments

I'd like to thank Keith Ellis and the LP2003 conference organizers for this great opportunity. I'd like also to thank my friends and colleagues Marumi Kado, Ela Barberis, Aurelio Juste, Jaco Konigsberg and Simona Rolli for their help in the preparation of this report.

References

1. F. Abe *et al.*, *Phys. Rev. Lett.* **73**, 225 (1994).
2. F. Abe *et al.*, *Phys. Rev. Lett* **74**, 2626 (1995).
3. S. Abachi *et al.*, *Phys. Rev. Lett.* **74**, 2632 (1995).
4. N. Kidonakis and R.Vogt, *hep-ph/0308222*.
5. F. Abe *et al.*, *Phys. Rev. Lett.* **79**, 1992 (1997).
6. D0 Collaboration, *Phys. Rev.* D **60**, 012001 (1999).
7. T. Affolder *et al.*, *Phys. Rev. Lett.* **85**, 2062 (2000).
8. V.M. Abazov *et al.*, *hep-ex/0307079*2003.
9. B.W. Harris *et al.*, *Phys. Rev.* D **66**, 054024 (2002).
10. D. Acosta *et al.*, *Phys. Rev.* D **65**, 091102 (2002).
11. V. Abazov *et al.*, *Phys. Lett.* B **517**, 282 (2001).
12. J. Estrada *for D0 Coll.*, *hep-ex/03/020312*002.

13. R.H. Dalitz and G.R.Goldstein, *Proc. R. Soc. Lond.* **A445**, 2803 (1999).
14. K. Kondo *et al.*, *J.Phys.Soc.Jap* **62**, 1177 (1993).
15. B. Abbott *et al.*, *Phys. Rev* D **60**, 052001 (1999).

AUTHOR INDEX