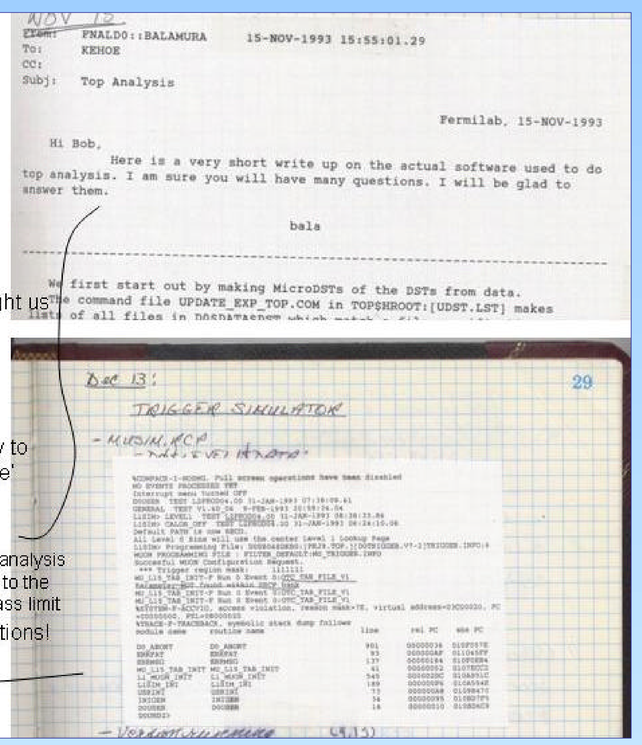
A Quark in the Life of a Student

R. Kehoe
Then student at Notre Dame, now Ass't Prof at SMU

Getting Started

- An unlikely student
  - Started on SSC
  - Cancellation brought us to D0
- started a QCD color coherence analysis
  - But got opportunity to work on Run 1b 'ee' channel
  - In late '93
    - Learn from '1a' analysis that contributed to the 131 GeV top mass limit
  - Not without frustrations!



NOV 12
From: FNALD0::BALAMURA 15-NOV-1993 15:55:01.29
To: KEHOE
CC:
Subj: Top Analysis

Fermilab, 15-NOV-1993

Hi Bob,

Here is a very short write up on the actual software used to do top analysis. I am sure you will have many questions. I will be glad to answer them.

bala

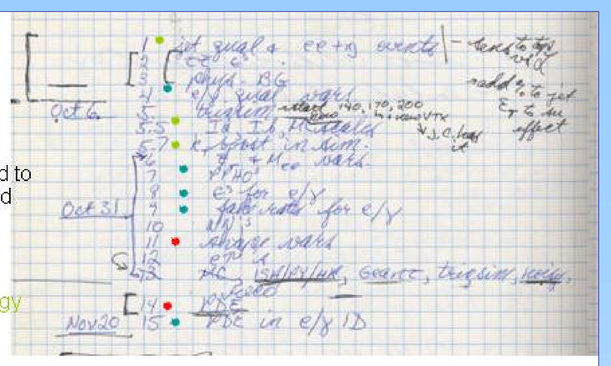
We first start out by making MicroDSTs of the DSTs from data. The command file UPDATE_EXP_TOP.COM in TOP$ROOT:[UDST.LST] makes

Dec 13:
TRIGGER SIMULATOR
- MUSIM.RCP

29

Optimization

- Many ingredients were studied to obtain maximum efficiency and luminosity, and minimum background
  - Electron ID
  - Jet cuts, quality and energy scale
  - Use of main-ring data
  - New variables or kinematic selections
- On right is shown logbook entry from Sep. where these efforts are planned out for this analysis
  - Later edits (in black) where this list was gone back to and modified
  - Many of these affect the other channels too, of course

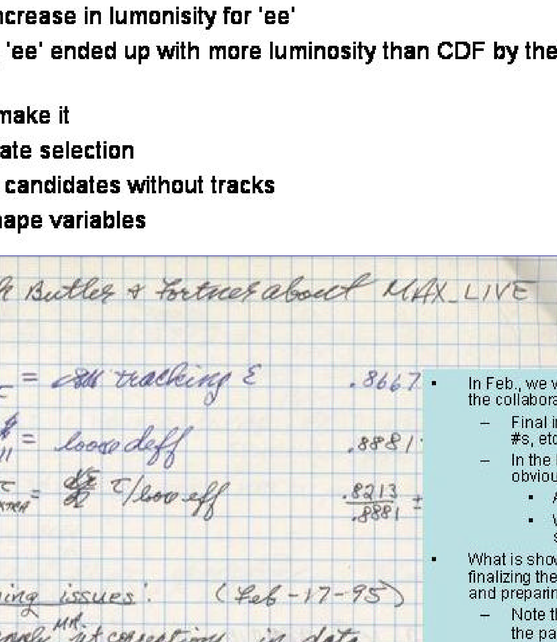


1994 was a very busy time,

This was the first time in my research or academic career when I realized I could really make a contribution. So many interesting things were going on at D0, and I was very happy to have the chance to be part of them. I myself was thoroughly unconvinced of the existence of the top quark, and the arguments and discussions at D0 in late 1993 thru early 1995 were extremely formative for me. I am grateful circumstance put me there.

Early Work

- The top group was dealing early on with the knowledge that top was heavy
  - In latter '93, I was doing trigger simulation studies to tighten triggers to lower rates
  - There was a lot of debate about event 417 (the Run 1a 'emu' event)
    - What did it mean about top?
    - What could be said about the top mass based on this event
    - I came to my own judgment of where the 'overinterpretation' of the data lie: I did not believe one dilepton event was capable of answering the dilemma
- I had been working on jets, and became convinced they were the key to effectively identifying high mass top
  - I was encouraged to follow my hunches, but a very clear standard was always clear from the postdoc I worked with (M. Narain)
- The dilepton effort became increasingly clustered around a few people: R. Hall, J. Bantly, J. Cochran, M. Narain…
  - Our meetings were informal, in a corner office, no talks
  - I did not socialize outside of work much with these guys, but they were the group I lived most with for the next year
    - For some reason, JC called me 'Senator'; I countered by calling him 'Imperator'
    - Jim has an 'interesting' sense for his password choices! ;)



152
OPTIMIZATION

HERWIG 2TTJJx	465	100	100	100	100	100	100	100	100
PYTHIA 2TTJJx	578		—	—	—	—	—	—	—
WWEEx	2488		.45	.30	.25	1.10	.95	1.00	
ISAJET 120_01	1626		.78	.52	.35	1.07	0.90	0.98	
130x	1992		.81	.60	0.40	1.05	0.95	0.99	
MO_V1213.x	2232		.82	0.69	.55	1.06	0.90	0.98	
152x	2002		.87	.72	0.57	1.04	0.95	1.01	
140	1892		.89	0.78	0.66	1.05	0.94	1.00	
170_01	526		.91	0.85	0.69	1.02	0.98	0.99	
180_01	2012		.93	0.86	0.75	1.03	0.94	0.99	
200_01	2084		.94	0.87	0.80	1.05	0.96	1.00	
WWEEJJx	4178		.56	.30	0.17	1.10	0.90	0.98	
2EEJJx	8225		.80	.40	.20	5.00	0.20	.40	
2EEx	9970		1.00	0	0	2.00	1.00	1.00	
2TTJJx	462		0.50	0	0	2.00	1.00	1.00	
2TTx	1998		1.00	1.00	1.00	1.00	0.70	0.70	
fake			0.55	0.30	0.16	1.34	0.74		

Backgrounds in 23.4 pb⁻¹
Zee .02 (.04 ii)
Zττ .07 (.04 ii, .02 Mμ)
WWee .03 (.005 in ii)
QCD .02
fake .18
(0.06 ii)

Taking Stock

By late 2004, much of the basic work to design an optimized analysis was done, or converging rapidly

However, there are many steps to producing a final analysis
- We still hadn't seen most of our data
- Simulation samples were continually improved
- Cuts, analysis methods, particle ID were still in flux

Early 2005, the Top Group moved into a very effective and efficient gear to bring this all to a conclusion.
- I remember this as a phase transition to a very business-like, aggressive and methodical set of meetings and discussions about what selections to keep, methods were viable, luminosity was useful
- A LOT of WORK!!!

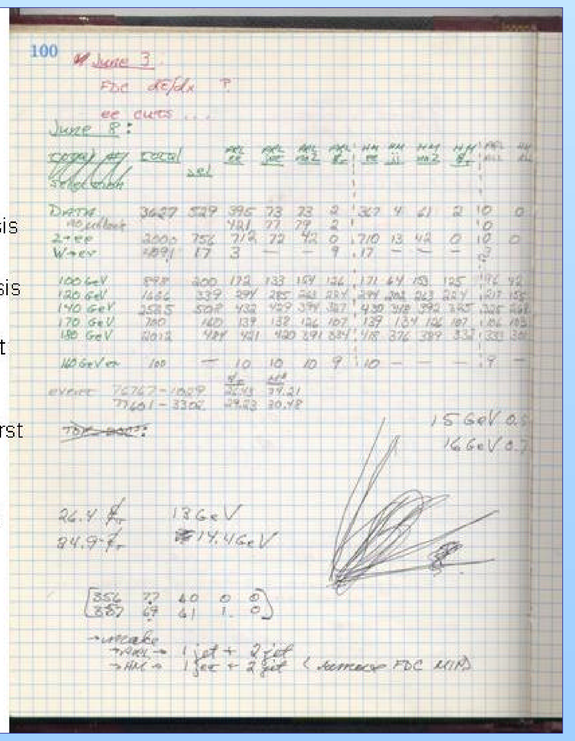
To the left, a logbook table giving optimization results for 'ee' in preparation for defending this analysis
- Note, we still did not have all of our data (only 23.4 pb-1!!!) that we would analyze and discuss (which was 48 pb-1?)
- What is shown in the table are the 'relative' efficiencies for various backgrounds and signal simulated samples for different choices of cuts.
  - The bottom row indicates what cut was changed

What Survived?

- **The optimized kinematic selection for high mass top**
- **Improved electron ID**
- **Use of MainRing data, except when both in-time particles and out-of-time particles were simultaneously present**
  - **A 25% increase in lumonisity for 'ee'**
  - **Actually, 'ee' ended up with more luminosity than CDF by the end of Run I**
- **What didn't make it**
  - **Multivariate selection**
  - **Electron candidates without tracks**
  - **Event shape variables**

The Mission:

- We knew top was heavy
  - Devise 'high mass' analysis
  - "HM" in columns to right
  - Compared to 'PRL' analysis
    - The 131 GeV limit
  - "HM' could have tighter jet cuts and electron ID cuts
- What is shown at right is the first pass at a tuned 'high mass' analysis
- Signal masses: 100, 120, 140, 170 and 180 GeV
- Z->ee background estimate



100
June 3
FDC dE/dx P
ee cuts . . .
June 8:

Data	3627	529	396	73	23	2	367	4	61	2	10	0							
2+ee	3000	756	719	72	42	0	710	13	42	0	10	0							
Wee	1891	17	3	—	—	9	17	—	—	—	3								
100 GeV	598	400	172	133	109	126	171	64	103	125	172	42							
120 GeV	1462	339	294	285	263	284	294	261	263	284	207	155							
140 GeV	2585	502	432	459	399	387	430	348	392	395	328	261							
170 GeV	780	160	139	132	126	107	139	134	106	107	126	103							
180 GeV	1012	484	461	420	391	384	418	376	369	332	330	301							
160 GeV ee	100	—	10	10	10	9	10	—	—	—	9	—							

event: 76767-19629 (2243, 39.21)
77661-33302 (4923, 30.48)

15 GeV 0.5
16 GeV 0.7

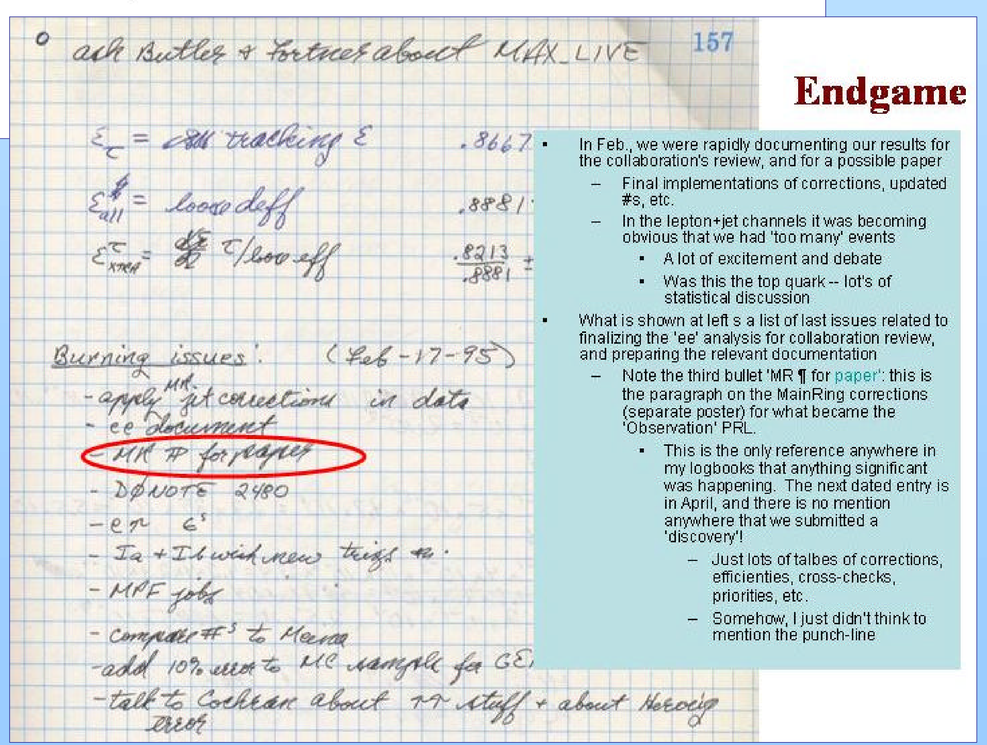
26.4 fb 13 GeV
84.9 fb 14.4 GeV

BSC	77	40	0	0
BBT	67	41	1	0

→ uncaks
→ TRIAL → 1 jet + 2 jet
→ HM → 1 jet + 2 jet (increase FDC MIN)

Endgame

- In Feb., we were rapidly documenting our results for the collaboration's review, and for a possible paper
  - Final implementations of corrections, updated #s, etc.
  - In the lepton+jet channels it was becoming obvious that we had 'too many' events
    - A lot of excitement and debate
    - Was this the top quark -- lot's of statistical discussion
- What is shown at left s a list of last issues related to finalizing the 'ee' analysis for collaboration review, and preparing the relevant documentation
  - Note the third bullet 'MR ¶ for paper': this is the paragraph on the MainRing corrections (separate poster) for what became the 'Observation' PRL.
    - This is the only reference anywhere in my logbooks that anything significant was happening. The next dated entry is in April, and there is no mention anywhere that we submitted a 'discovery'!
      - Just lots of talbes of corrections, efficienties, cross-checks, priorities, etc.
      - Somehow, I just didn't think to mention the punch-line



ask Butler + Fortner about MAX_LIVE 157

$\varepsilon_{\not\!\!E_T} = \not\!\!E_T$ tracking ε .8667
$\varepsilon^{\not\!\!E_T}_{all} = \not\!\!E_T$ loose eff .8881
$\varepsilon^{\not\!\!E_T}_{MAX} = \not\!\!E_T$ tight/loose eff .8213/.8881 =

Burning issues: (Feb-17-95)
- apply MR jet corrections in data
- ee document
- MR ¶ for paper
- DØNOTE 2480
- eπ ε's
- Ia + Ib with new trigs ??
- MPF jobs
- compare ¶'s to Herwig
- add 10% error to MC samples for GEANT
- talk to Cochran about ¶¶ stuff + about Herwig error