Tevatron History

Mark Lancaster

"The main application of the work here is spiritual, if you will. It's because, in a philosophical sense, in the tradition of Democritus, we feel we have to understand, in simplest terms, what matter is, in order to understand who we are."

Robert R. Wilson, 1974

"Water to the Ropes"

The Tevatron's existence was born out of the "Main Ring" which had 126 bids but in the end reduced to the usual Berkeley vs BNL vs Argonne vs 5 newbies bidding war to build a new (200 GeV beam) National Accelerator.

Wilson was maverick and cheap ($250M) and delivered 500 GeV for less cash ….

Residents feared that the influx of physicists would ***"disturb the moral fiber of the community"***

PO Box 500 !

WEATHER
Cloudy Saturday and warmer, with high in lower 40s. See Page 54.

CHICAGO
SUN-TIMES

★ ★ ★ ★ ★
FINAL
TURF EDITION

©1966 by Field Enterprises Inc.

Vol. 19, No. 274 Phone 321-3000 SATURDAY, DECEMBER 17, 1966 80 Pages, 2 Sections—10 Cent

How Weston Won A-Site

By Tom Littlewood
Sun-Times Bureau

WASHINGTON—The Atomic Energy Commission chose Weston in the Chicago metropolitan area Friday as the location of the world's largest scientific instrument, a circular atom smasher three miles around.

The Illinois entry in DuPage County won a national competition for the site of the AEC's new high-energy physics laboratory.

At the heart of the laboratory is planned a 200-billion electron volt accelerator that will take eight years to build at a cost of possibly $375,000,000. The instrument will be designed to hurl tiny particles of matter at high speeds so that physicists can study the fundamental structure of the atom, the building blocks of the universe.

When completed, the laboratory will employ 2,300 scientists, technicians and others. It will cost an estimated $60,000,000 a year to run and is expected to stimulate the economy of the entire west suburban region.

All but four of the 50 states submitted more than 200 proposed sites. The AEC reduced the field drastically in September, 1965, and asked the National Academy of Sciences for further advice. Last March the academy screened out all but six finalists.

Glenn T. Seaborg, the AEC

Other stories and pictures on Pages 3, 4, 6 and 7.

Turn to Page 5

SPECIAL SECTION IN CENTER FOLD

Weston, selected as nation's atom-smasher capital, is easily accessible to O'Hare Airport, tollways, Argonne National Laboratory and major universities. (Sun-Times Map)

Holding a press conference in Weston, picked as site for the world's largest atom smasher, are (l. to r.) Matthew Molitor and Eugene Jones, village trustees; Arthur Therriault, village president, and State Rep. Lewis V. Morgan, chairman of Illinois Commission on Atomic Energy. (Sun-Times Photo)

THE WESTON FACTS

Here, at a glance, are the salient facts concerning Weston's 200-billion electron volt proton accelerator:

WHERE—Western Du Page County, near developing Du Page and Kane County communities.

COST—Up to $375,000,000, probably in more than one stage.

COMPLETION TIME—About a decade, with up to two years of planning and preliminary work and eight years of construction.

JOBS—The construction phase is expected to employ some 1,200 persons year around. The accelerator, when completed, is to have a staff of more than 2,000, with an affiliated visiting staff of up to 1,000. An unknown number of jobs would be created through spin-off industry that results from the presence of research installations.

IMPACT ON ECONOMY—Unlimited, but the accelerator is to have an annual operating budget of $60,000,000 and one official says 3,000 new workers means $17,000,000 more in bank deposits annually, $9,000,000 more in retail sales and 90 more retail establishments.

IMPACT ON COMMUNITIES—The same official estimates that 3,000 new workers means 9,000 more people, and 2,700 more schoolchildren.

Victory On The Lakefront

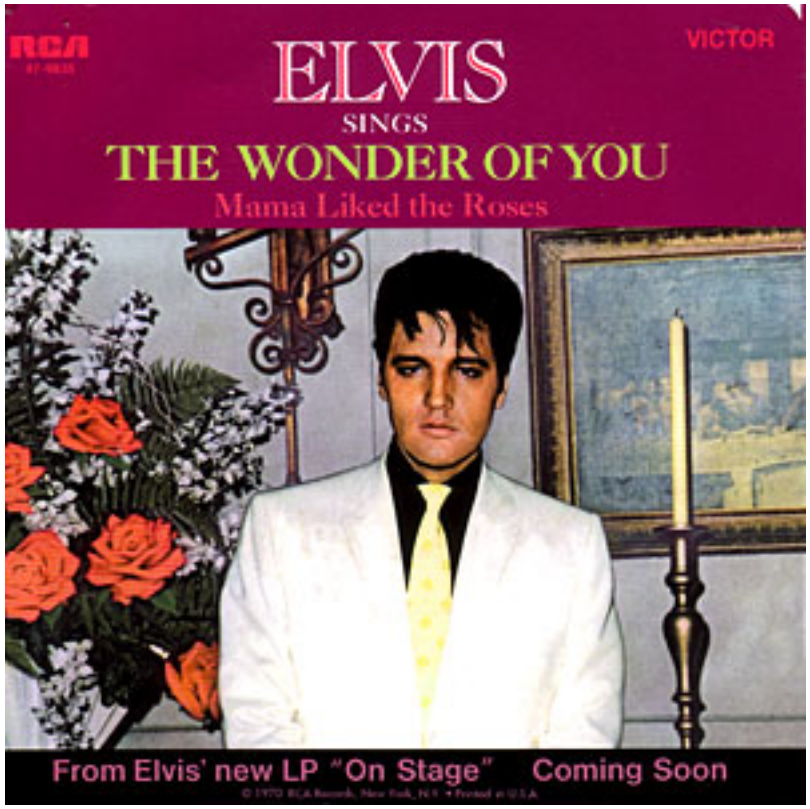
See Editorial On Page 25; McCormick Place Story On Page 2

Site selection stalled due to lack of "fair housing laws" in Illinois (and Michigan).

But in April 1968 congress passed a "fair housing bill" in part due to the political horse trading (to the Presidential level..) of $400M coming to Illinois..

Berkeley's view on collaborating..
"Give gladly your last drop of blood as you die !"

"In any conflict between technical expediency and human rights, we shall stand firmly on the side of human rights" : R. Wilson



Superconductivity *: "the elixir to rejuvenate accelerators and open new vistas to the future".*

The Doubler
The Saver
The Tevatron

A different Era

"The design process, and if carried out, the construction of the **Doubler**, builds upon our experience at NAL. We have **not** proceeded on the basis of deciding what is readily practicable, designing to that, adding up the cost and attempting the result.

Instead, we have set a cost goal and keep designing, redesigning, haggling and improving until we have done what we set out to do. Occasionally, we are forced to admit that we are not clever enough to achieve our cost goal and admit defeat, but not without a struggle"

1976

Key People : Tollestrup, Orr, Lundy, Edwards

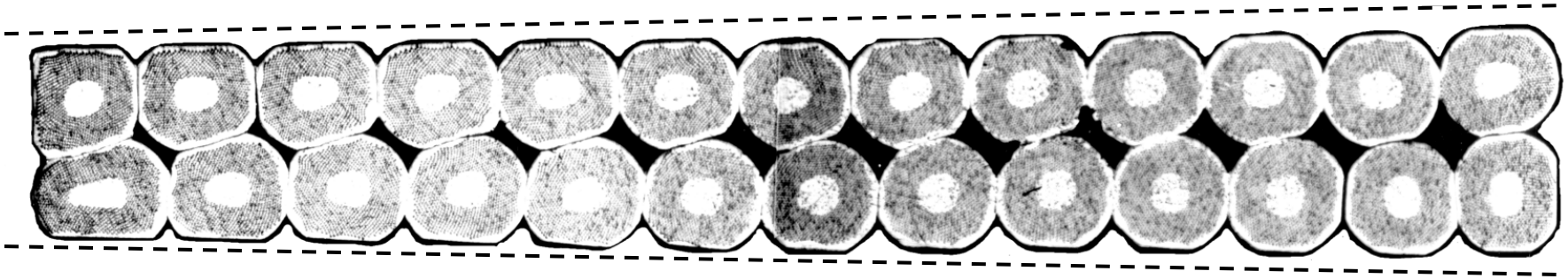
1989 National Medal of Technology recipients: (left to right) Alvin V. Tollestrup, J. Ritchie Orr, Richard A. Lundy and Helen T. Edwards. *Photo: Fermilab History and Archives Project*

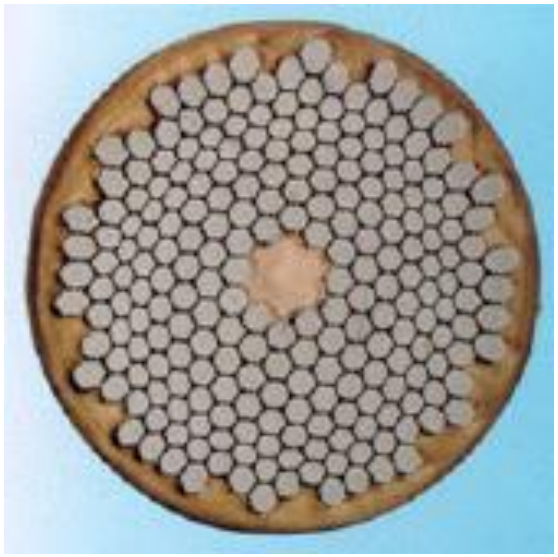
Alvin “Pumping Iron” Tollestrup

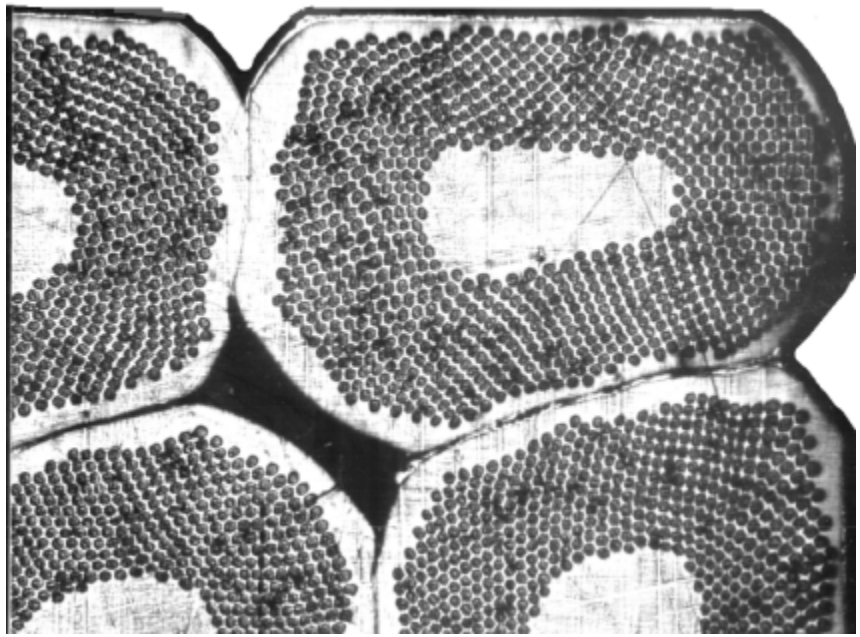
Ageless Alvin

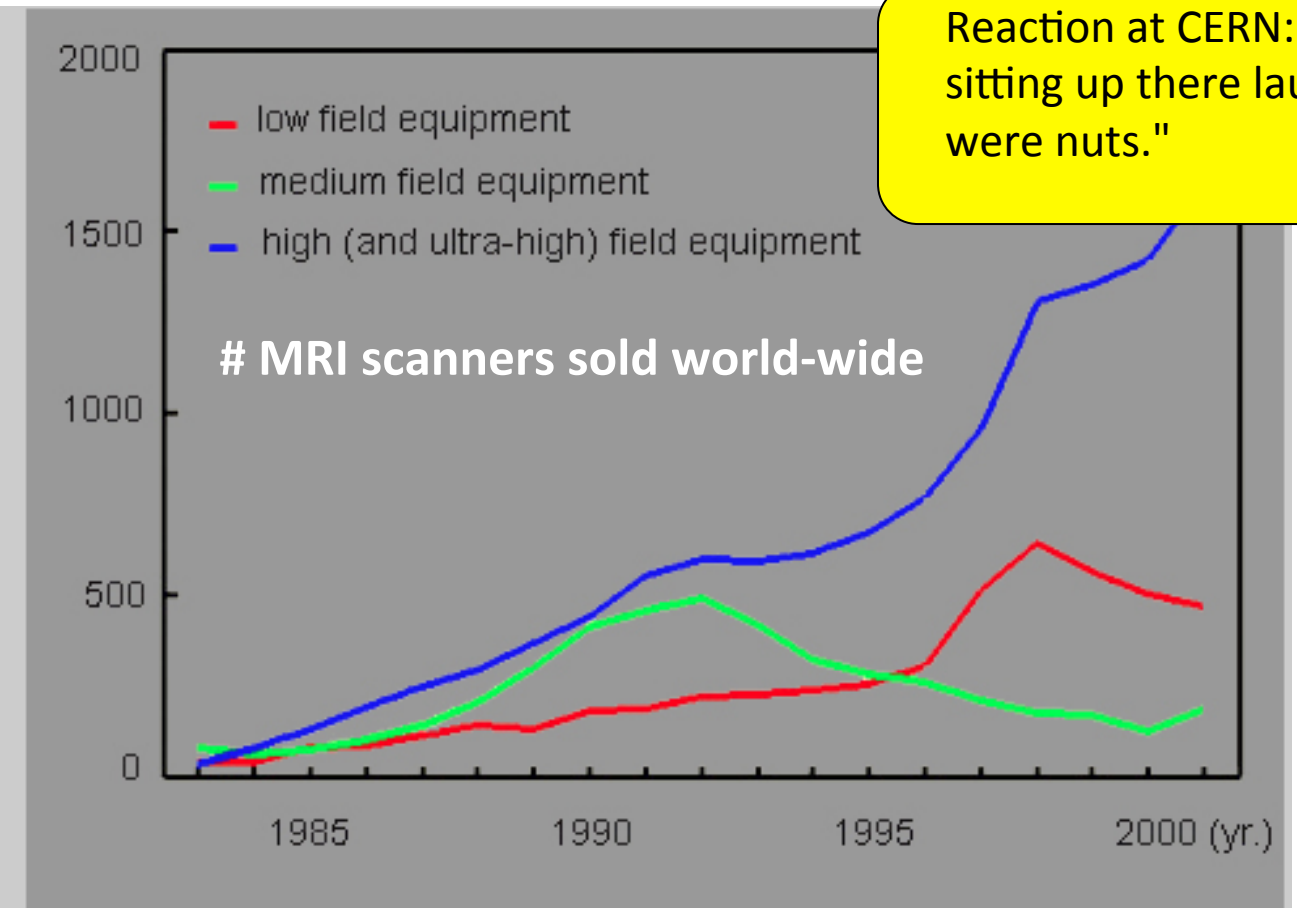
Rutherford Cable

densely packed/ quench resistant superconducting cable









Reaction at CERN: "a big room with these guys sitting up there laughing... they thought we were nuts."

Superconductors is now a $3.5B/year industry

FNAL : 95% of the niobium-titanium the world had ever produced.
Robert Marsh, the head of a major alloy supplier :
"every program in superconductivity that there is today owes itself in some measure to the fact that Fermilab built the Tevatron and it worked."

A potted history

1976 – 1978 magnet design

1978 – 1983 accelerator design/construction

1983 : 512 GeV p beam and pbar construction

: 400 GeV fixed target running started

1983 : Isabelle cancelled

1984 : 800 GeV proton beam

1985 : pbar source and 1st collisions (Oct 13) at 1.6 TeV

1986 (Nov) : collisions at 1.8 TeV

1987/1988 : CDF takes data (best Mz in 1989 for 3 weeks!)

1992 : D0 ready

1993 : SSC cancelled

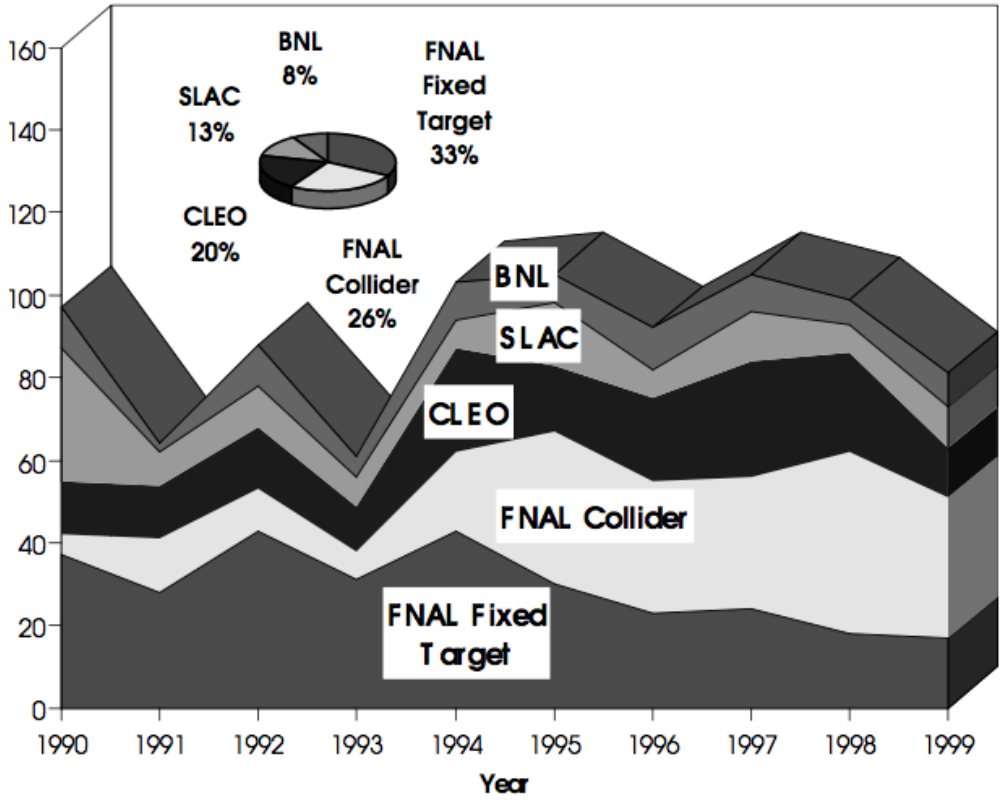
1992-1996 : Run-1

Run-2 : 1999 !!!

Fixed Target Running (in between collider running periods)

43 experiments : 1/3 of the US output in the 1990s (1 PhD from IC !)

Muon, Kaon, Hyperon, Neutrino interactions and production



E609 - The Structure of High P_T Hadronic Interactions

E683 - Photoproduction of High P_t Jets

E690 - Study of Charm and Bottom Production

E704 - Experiments with the Polarized Beam Facility

E705 - Charmonium and Direct γ Production at 300 GeV/c

E706 - Direct γ Production in Hadron Induced Collisions

E711 - Dihadron Production

E772 - The Quark-Antiquark Sea in Nuclei

Fixed Target Innovations

- 20 secs of beam every minute vs 1 sec every 15 sec (Main Ring)
- Use of micro-processors to extract beam from Tevatron (QXR system)
- Non trivial strings of s/c magnets to steer beam into different halls

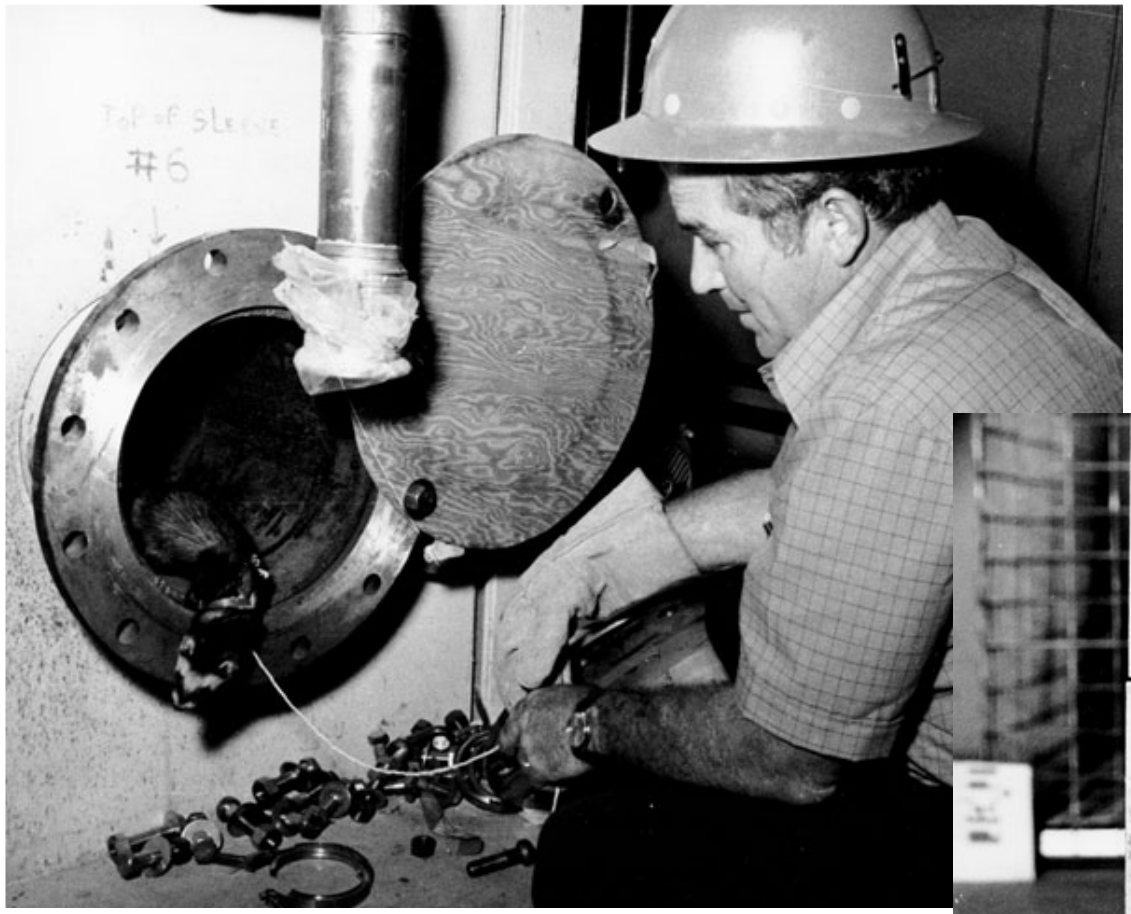
E691 experiment (studying charm in late 1980s) : **first Si micro-vertex detector** (based on original CERN R&D) : 10k charm vs 100.
9 silicon sensors all from the UK (Micron)…..

E715 **first large scale TRD** achieved e/pi separation of several thousand.

kTeV : CsI calorimeter with 0.75% energy resolution from
5-100 GeV photons and bespoke ASIC QIE now in Japan….

E605 : **Ring Imaging Cerenkov detector**
Offline computing farms e.g. E791 processed 50 Tb of data and the first large scale use of 8mm (and 2.5mm) magnetic tapes.

Fixed Target Innovations


#6

Fixed Target Physics : 300 papers

- Establishing QCD as the theory of the strong interaction
- Neutrino/EWK measurements (NuTeV/CCFR)
- First measurement (KTeV) of **direct** CP violation in the K-system(1999)
- Discovery of the tau-neutrino (DONUT in 2000)

So accelerator discovered new fundamental particle score is:

FNAL : 3 : b, top, tau-neutrino
CERN : 2 : W, Z
SLAC : 2 : tau, charm
BNL : 2 : charm, muon-neutrino
DESY : 1 : gluon

So USA 6 : Europe 3 …. or 6-4 if you believe the Higgsteria

Conception to birth of CDF was less than 8 years. D0 similarly quick.

Fermilab

Fermi National Accelerator Laboratory
P.O. Box 500 • Batavia, Illinois • 60510

Directors Office

December 13, 1976

Dear Colleagues:

On November 17 a meeting was held to discuss various possibilities for the organization of work on colliding beam experiments. After considering the ideas set forth in that meeting, I am proceeding to set up a Colliding Beam Experiments Department within the Research Division.

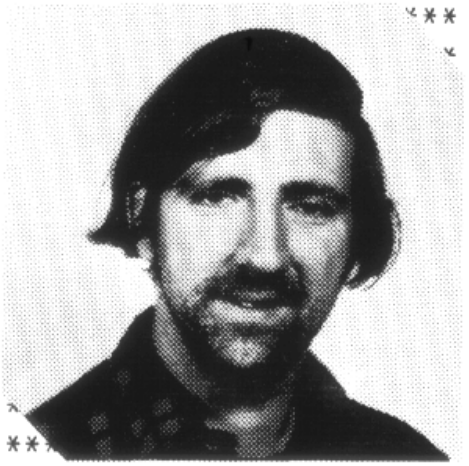
Fermilab

Colliding Beams Meeting

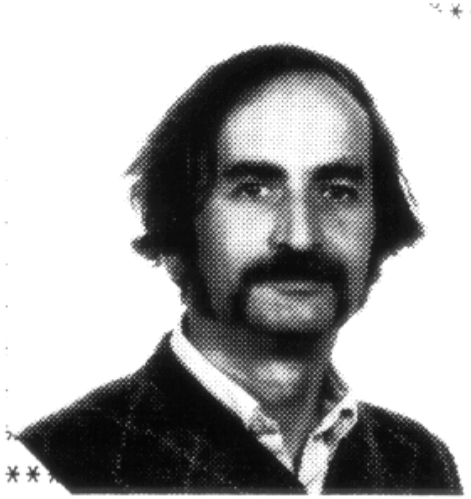
May 6, 1977

Present: J. Cronin, J. Walker, H. Frisch, A. Tollestrup, R. Loveless, I. Gaines, R. Diebold, D. Cline, C. Rubbia, C. Ankenbrandt, D. Johnson, A. Ruggiero, M. Shochet

1) R. Loveless said that Cadillac may not get in until Tuesday.



STEPHEN HAHN
STEVE
Senior Research Invest



LAWRENCE NODULMAN
LARRY

Fermilab

MINUTES OF THE COLLIDER DETECTOR MEETING

May 25, 1984

1. CDF has run out of money.

Fermilab

MINUTES OF THE COLLIDER DETECTOR MEETING

November 9, 1984

1. There will be a workshop to discuss upgrades to the CDF detector in early January.

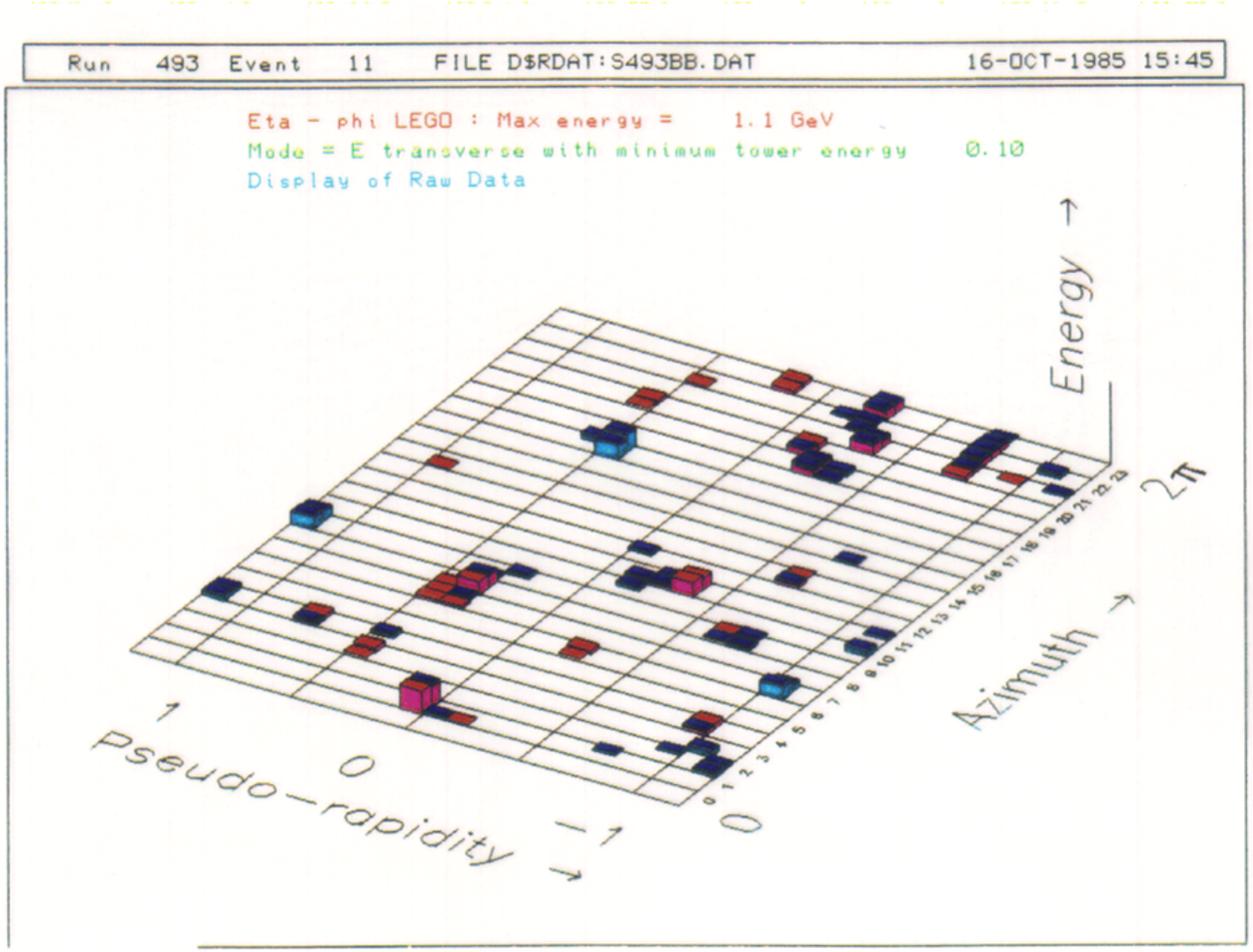
Fermilab

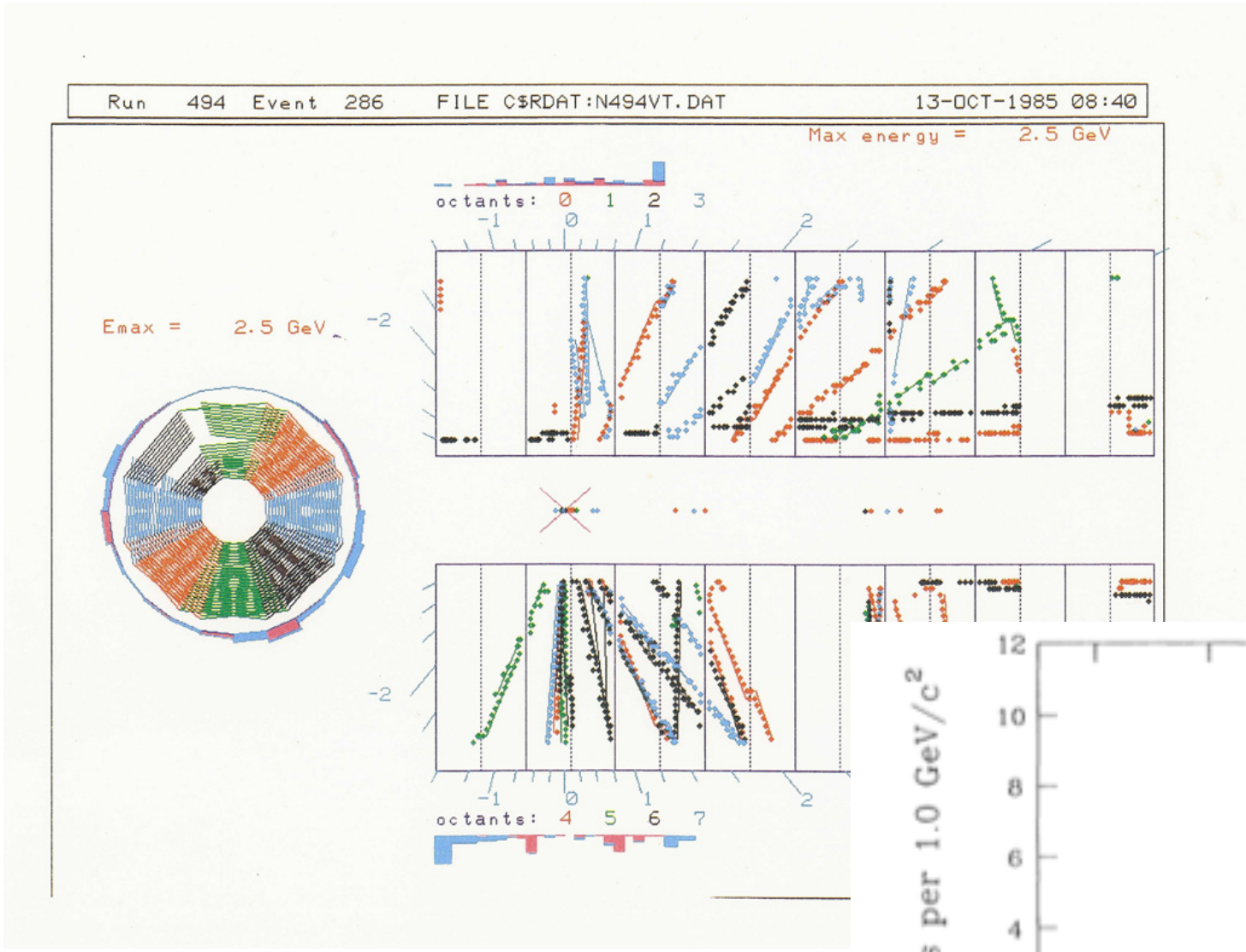
MINUTES OF THE COLLIDER DETECTOR MEETING

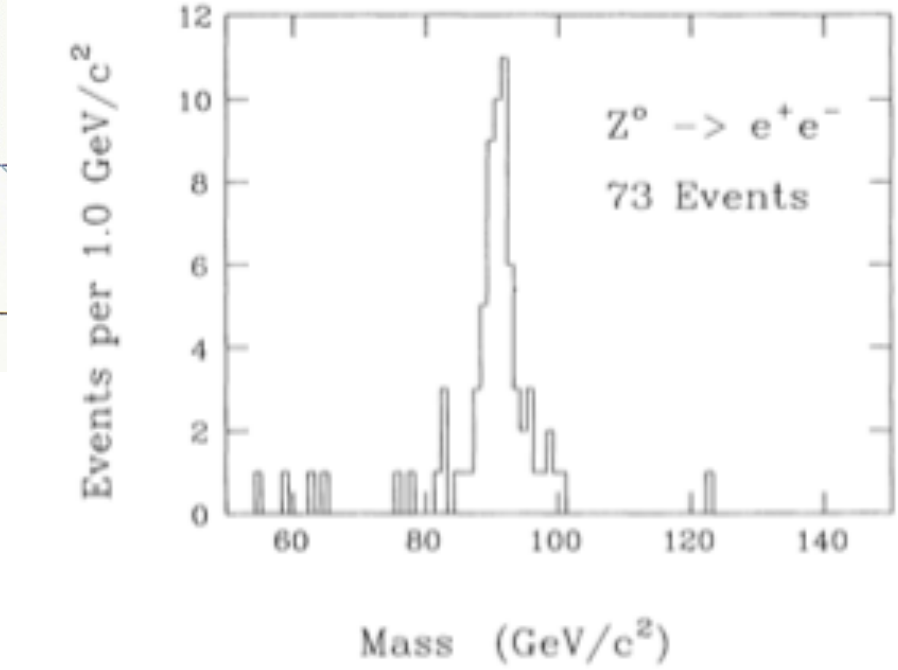
December 7, 1984

1. While in B0 people should watch out for falling objects. More formal safety procedures are under consideration.

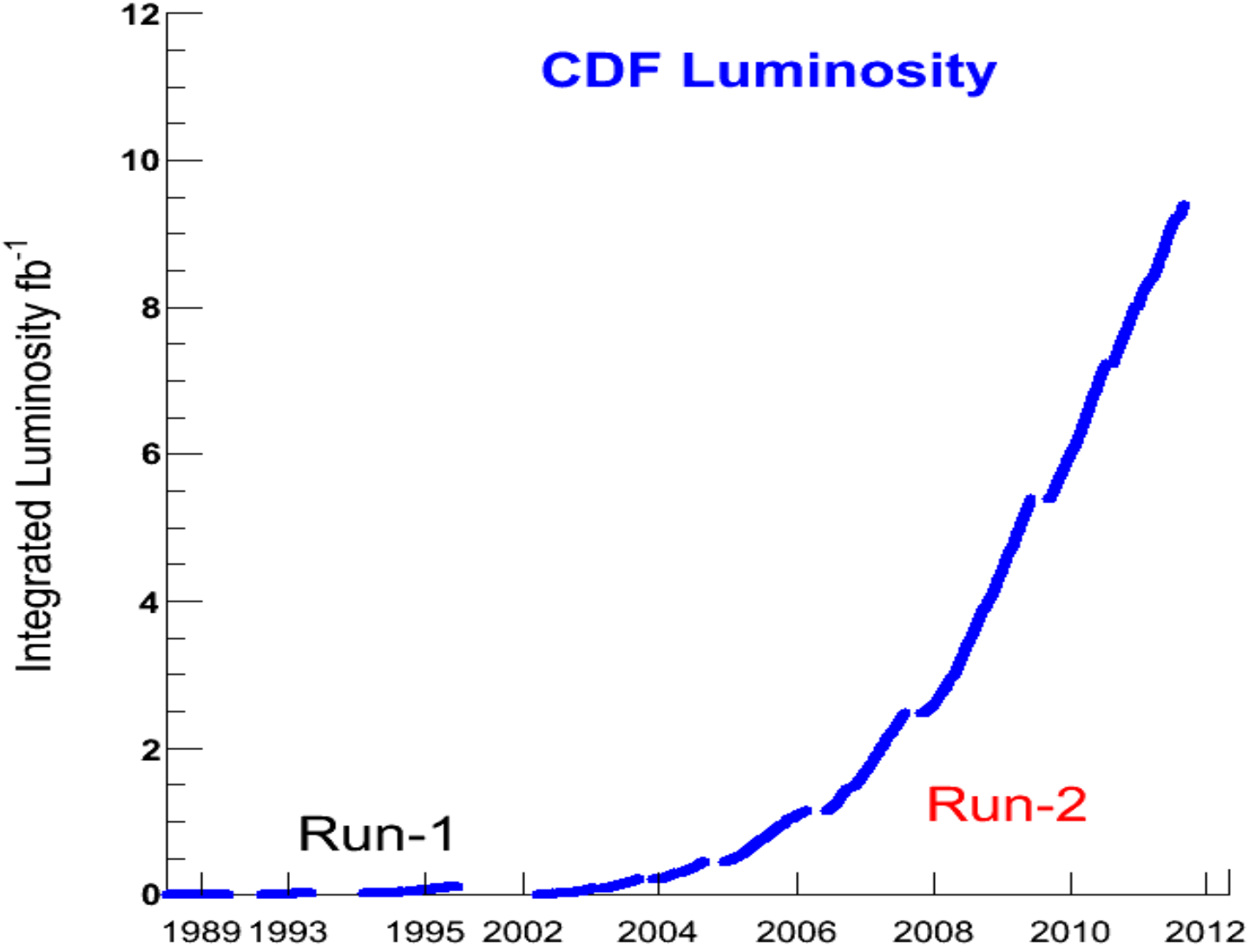
First “event” in 1985. CDF Collaboration : 180 members.

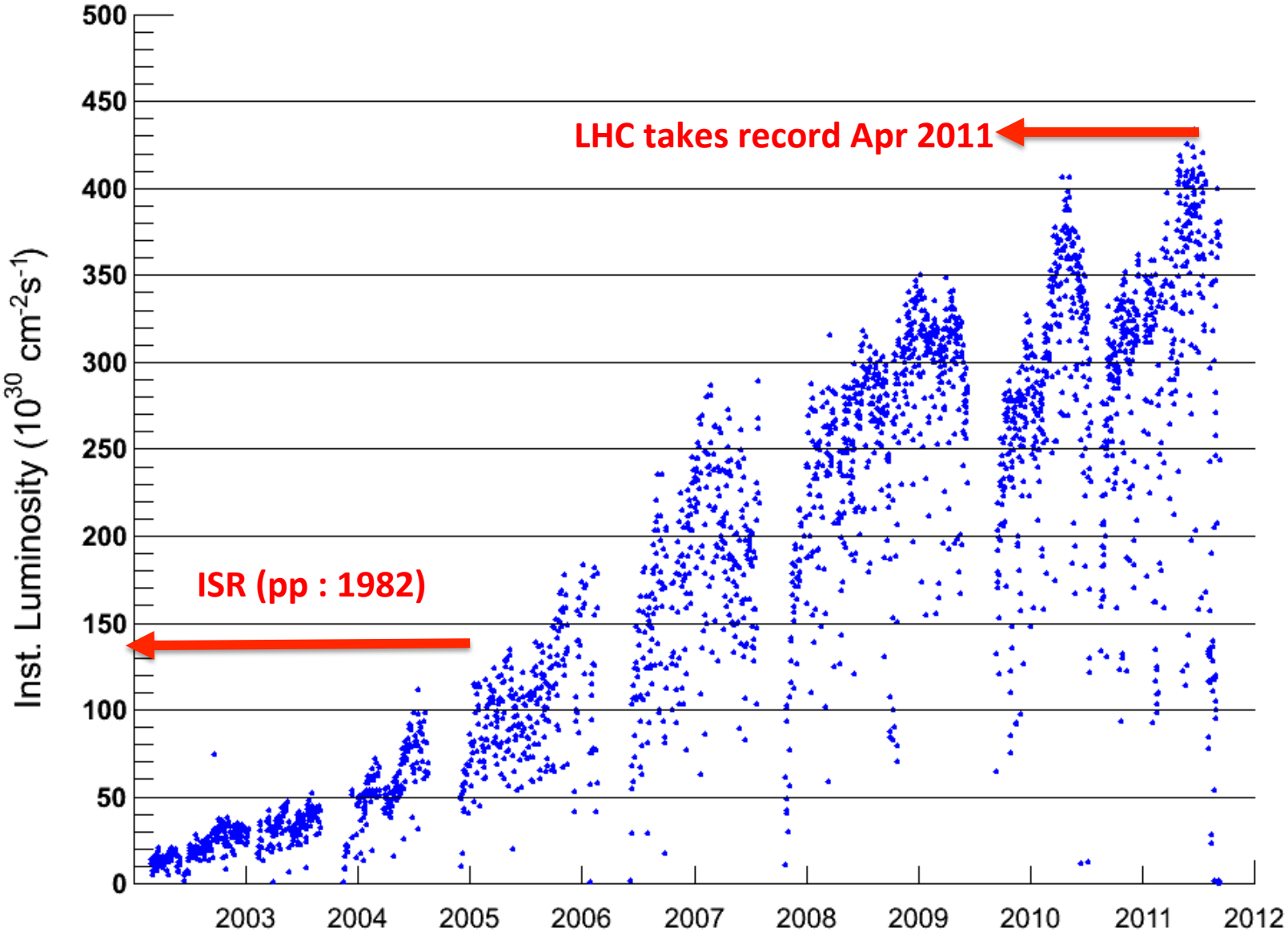



Run 494 Event 286 FILE C$RDAT:N494VT.DAT 13-OCT-1985 08:40
Max energy = 2.5 GeV
Emax = 2.5 GeV
octants: 0 1 2 3
octants: 4 5 6 7

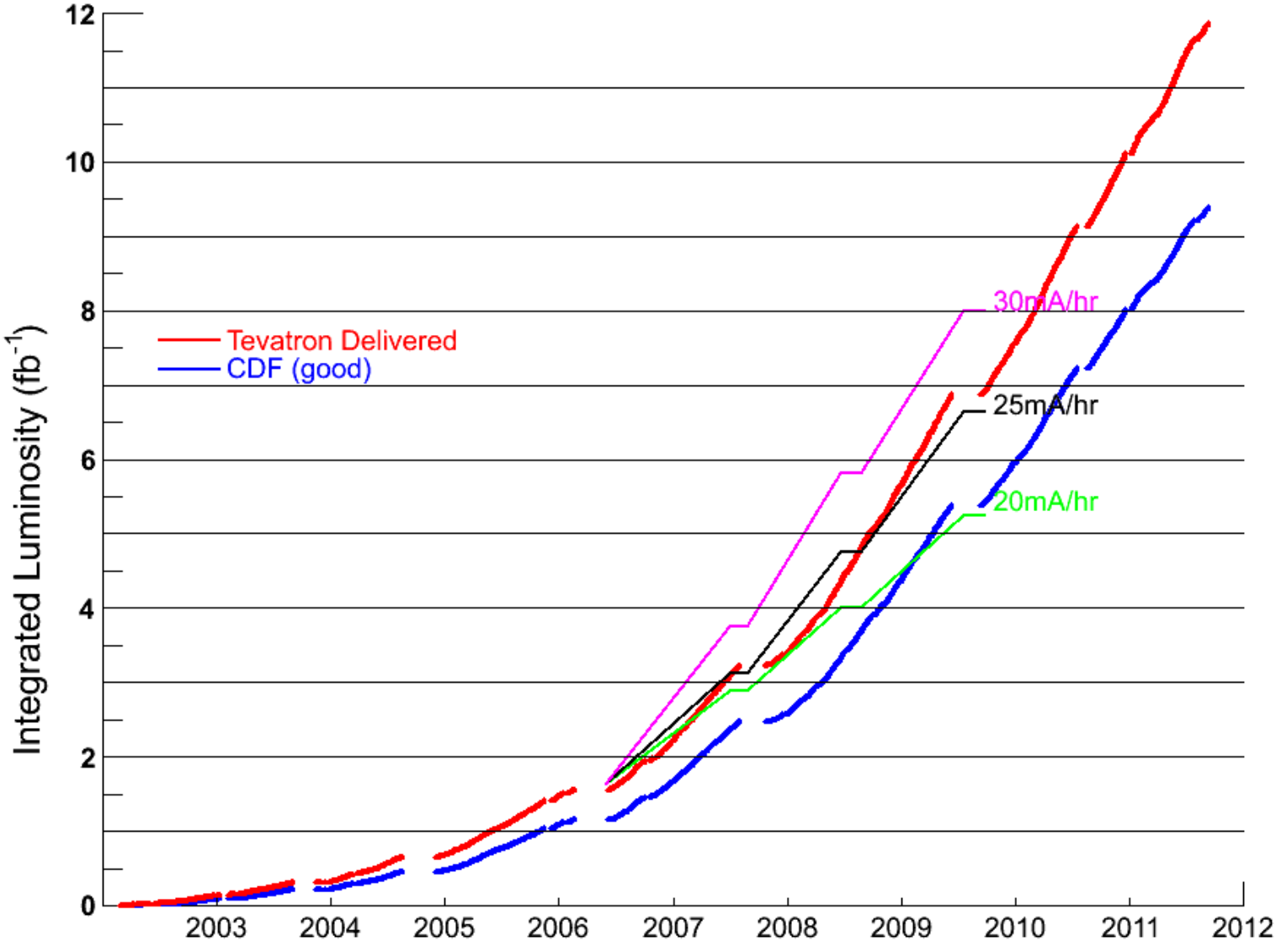

Z° -> e+e-
73 Events
Events per 1.0 GeV/c²
Mass (GeV/c²)

Tevatron Collider Luminosity



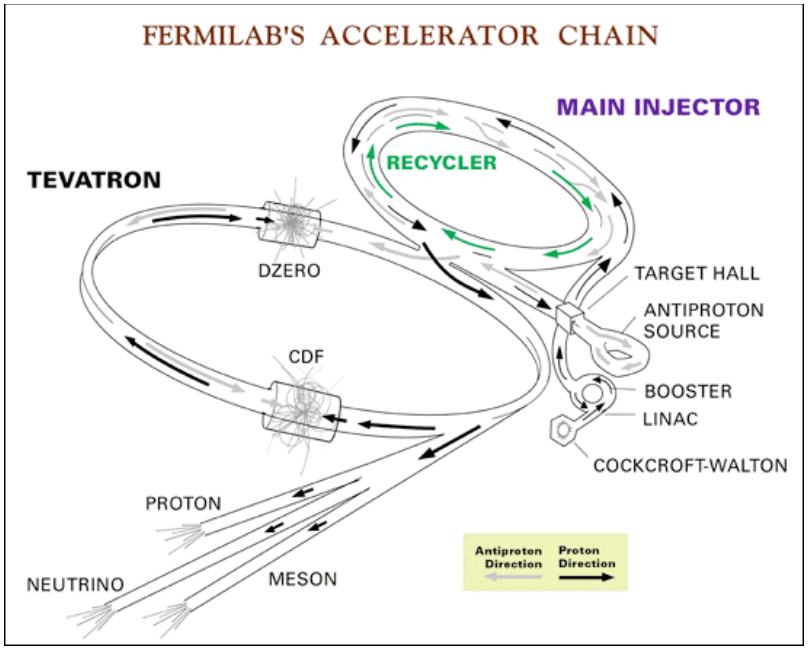

LHC takes record Apr 2011
ISR (pp : 1982)
Inst. Luminosity (10^{30} $cm^{-2}s^{-1}$)
500
450
400
350
300
250
200
150
100
50
0
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012

Base – Design – Optimistic



Factor of 10 improvement in luminosity was achieved over 5 years by:

Antiproton production : increased stacking rate and rate of transfer into recycler (less time in accumulator).
The recycler in the end didn't recycle !



FNAL produces 10^{15} anti-protons/year at a cost of approx $30M.

Time = O(1 billion) years.
Cost = 1000x world's GDP

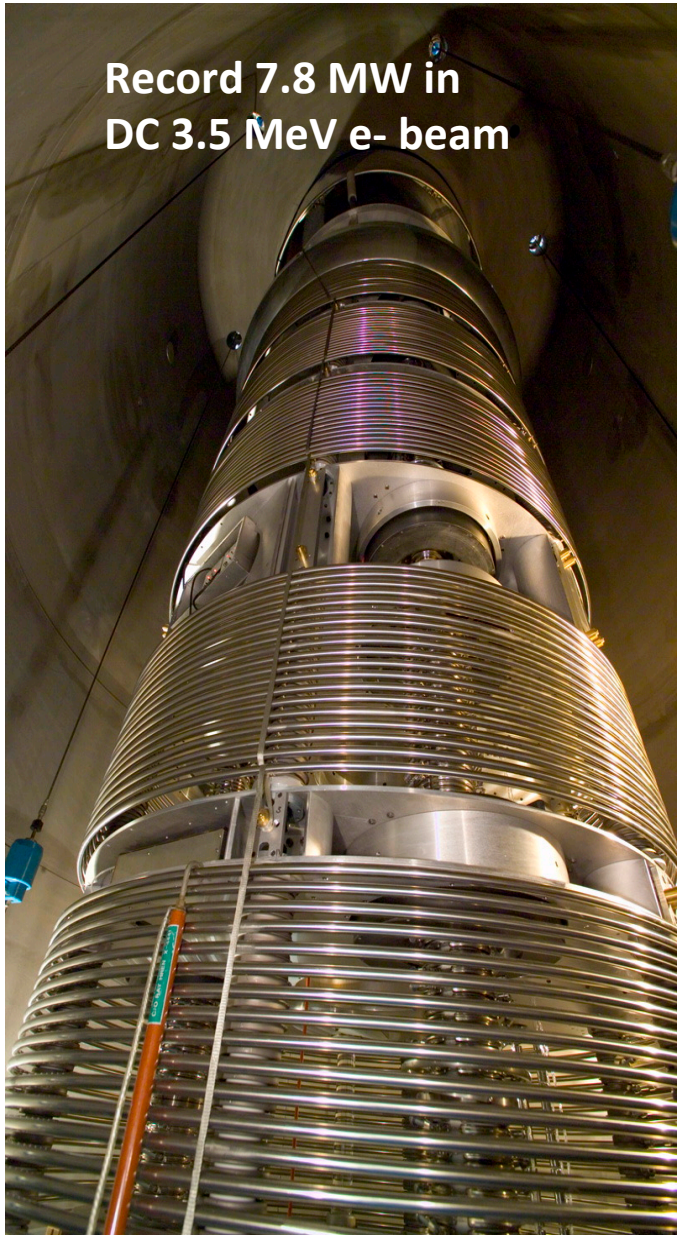
Slip-stacking protons : doubled # proton bunches in the main-injector for delivery onto anti-proton target.

Recycler e-cooling : stored and cooled pbars. Electron-cooling used for first time at high E (x 3 luminosity).

Tevatron beam position monitors : upgraded electronics/DAQ to 21st century & a culture that monitoring was important !

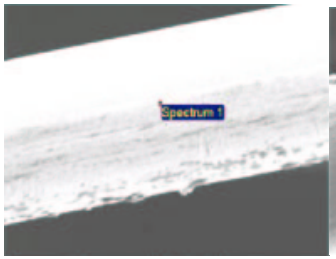
Premature ("parasitic") collisions : prevented by electrostatic separators to further separate beams as they orbit.

Luminosity optimisation : increasing initial luminosity is not the only way to maximise accumulated luminosity.

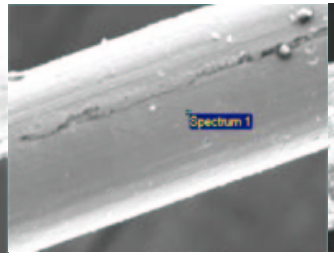


Detectors aged like fine wine with some luck

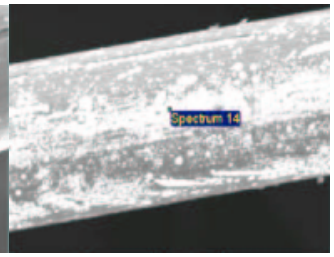
NEW WIRE

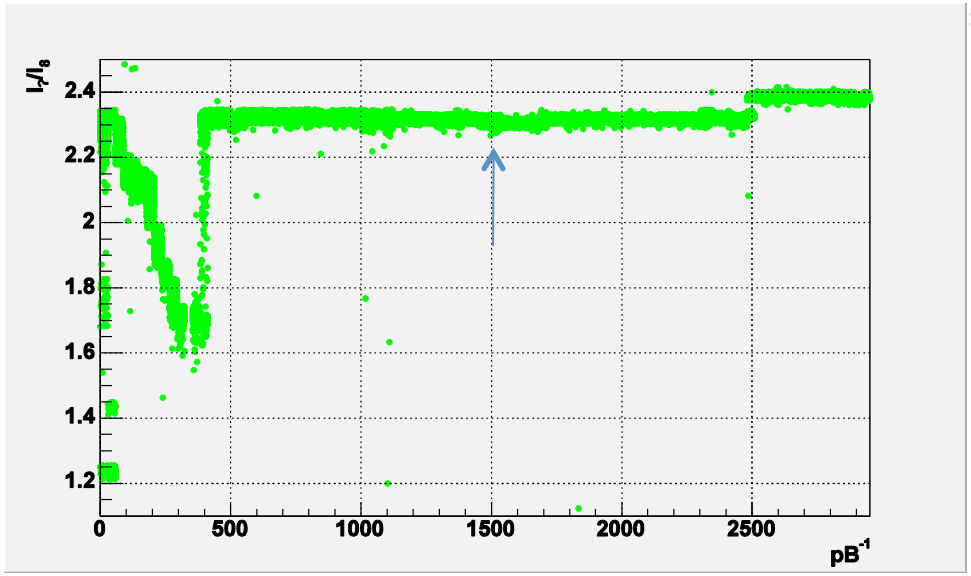


AGED WIRE

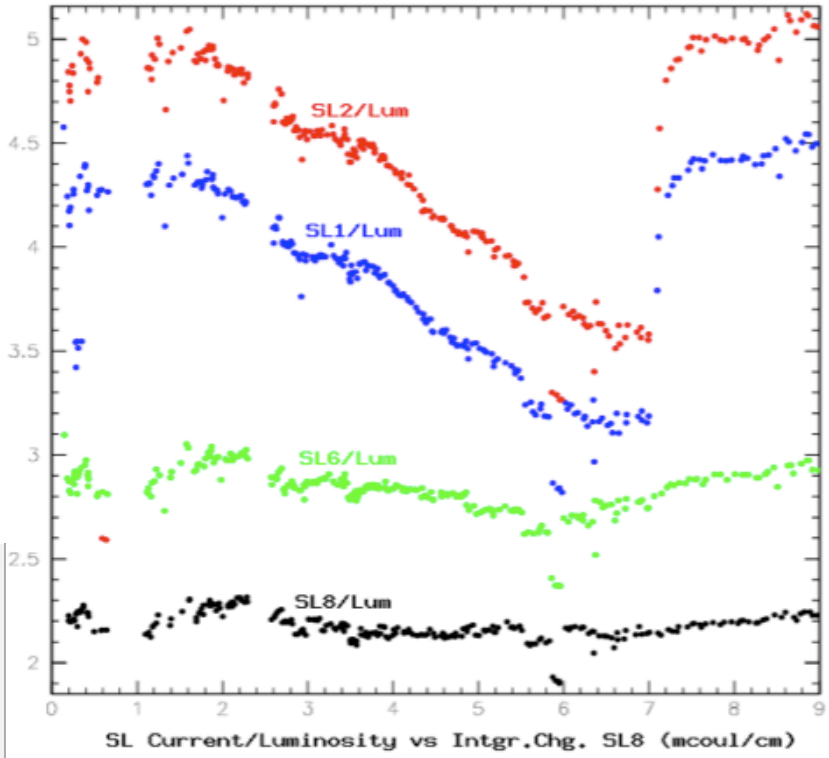


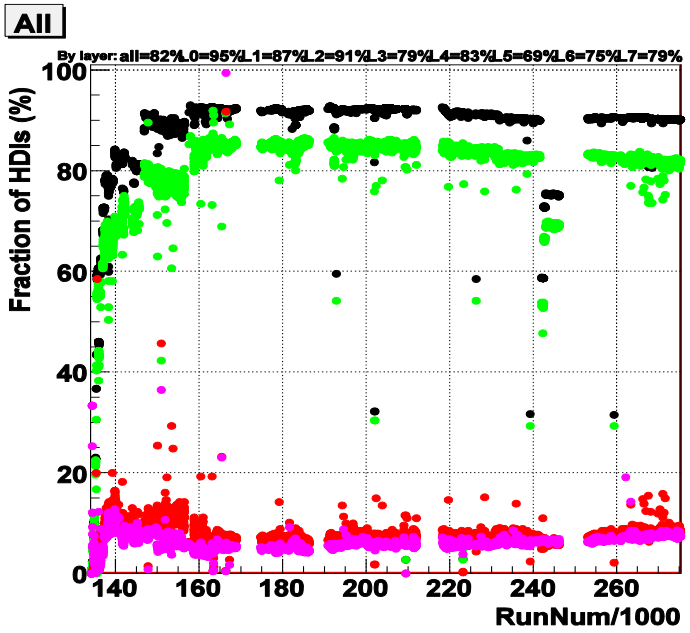
REVERSE AGED

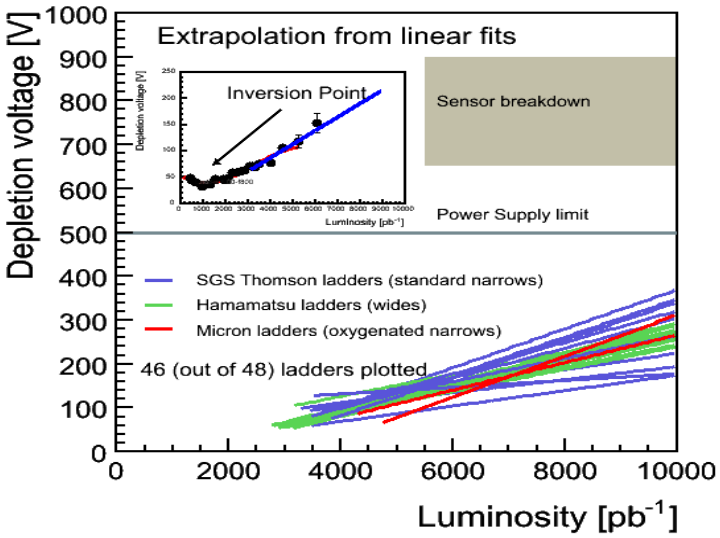


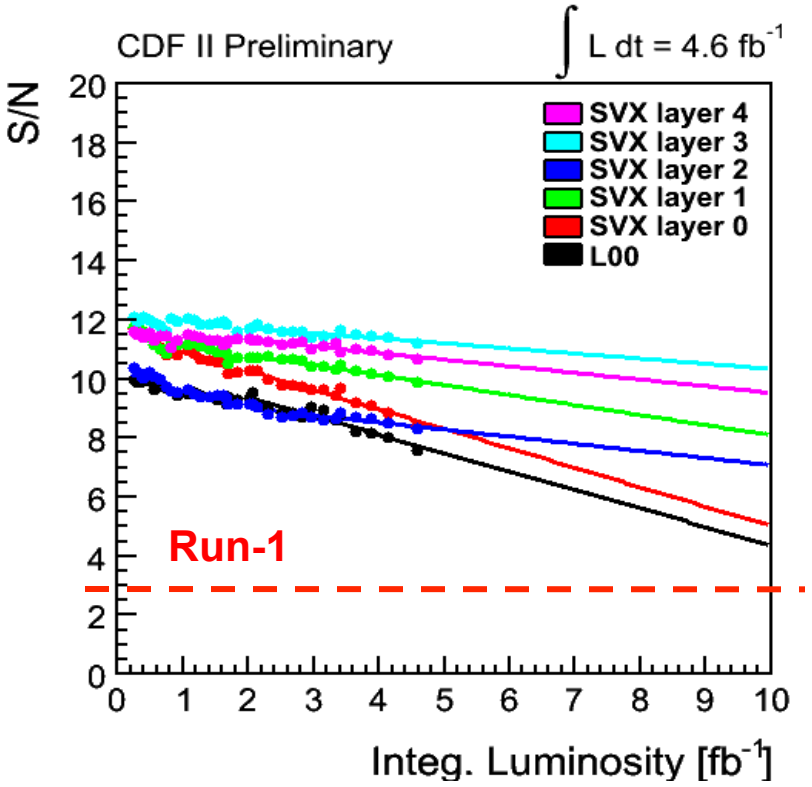


GAIN OF WIRES IN DRIFT CHAMBER VS TIME









In hindsight – not upgrading the silicon was a good decision !