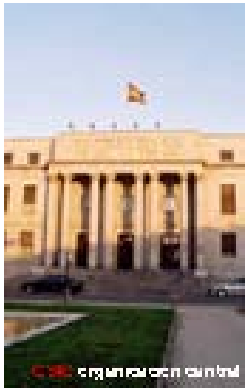
Search for New Physics using the CDF and ATLAS Experiments

Mario Martinez

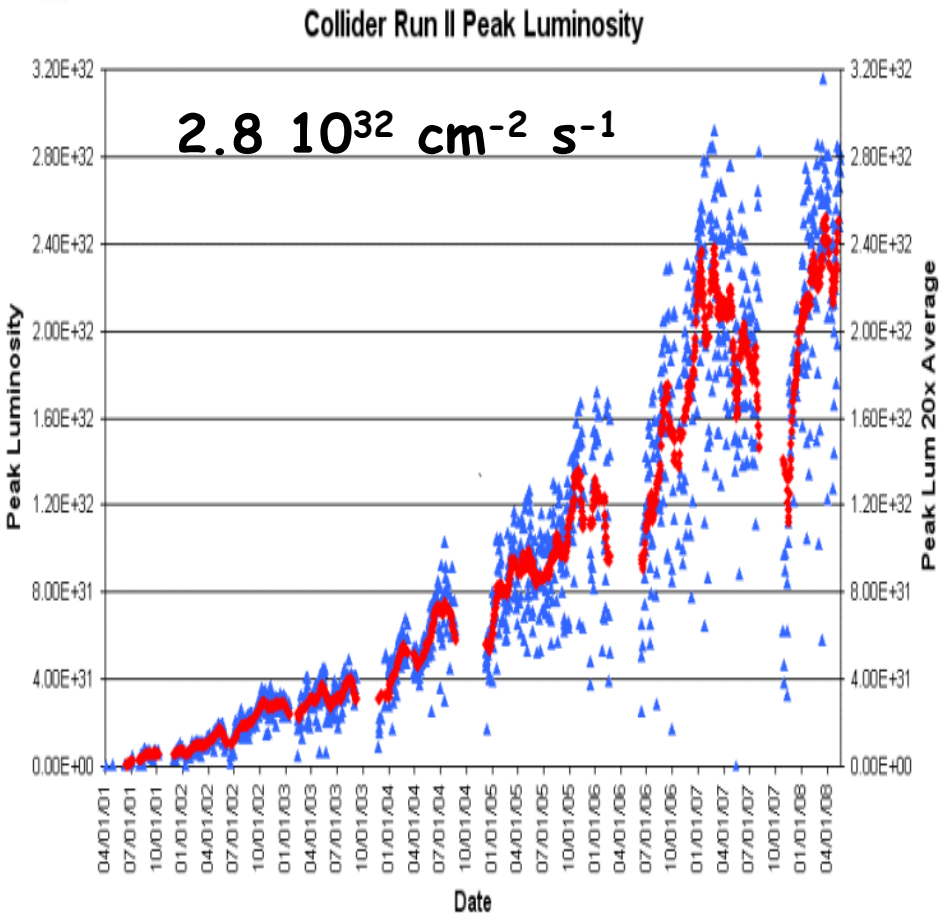
ICREA/IFAE-Barcelona

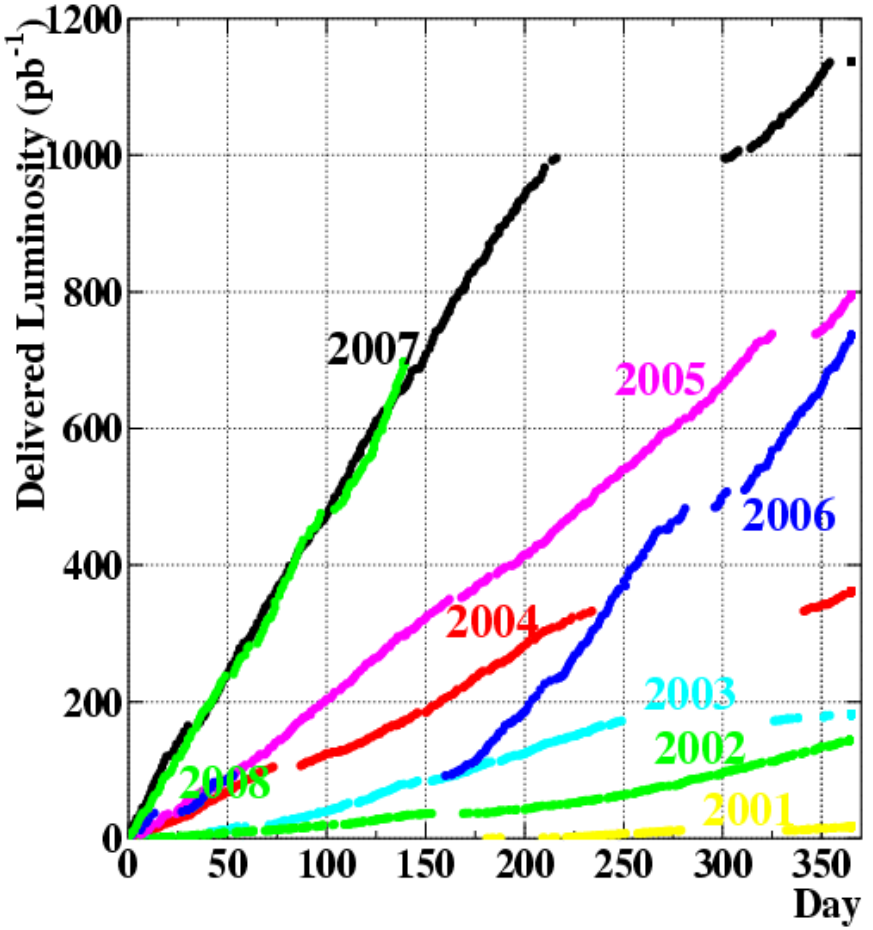


CSIC, Madrid, May 27th 2008


The Tevatron
Chicago
$\sqrt{s} = 2$ TeV
p
$\bar{p}$
CDF

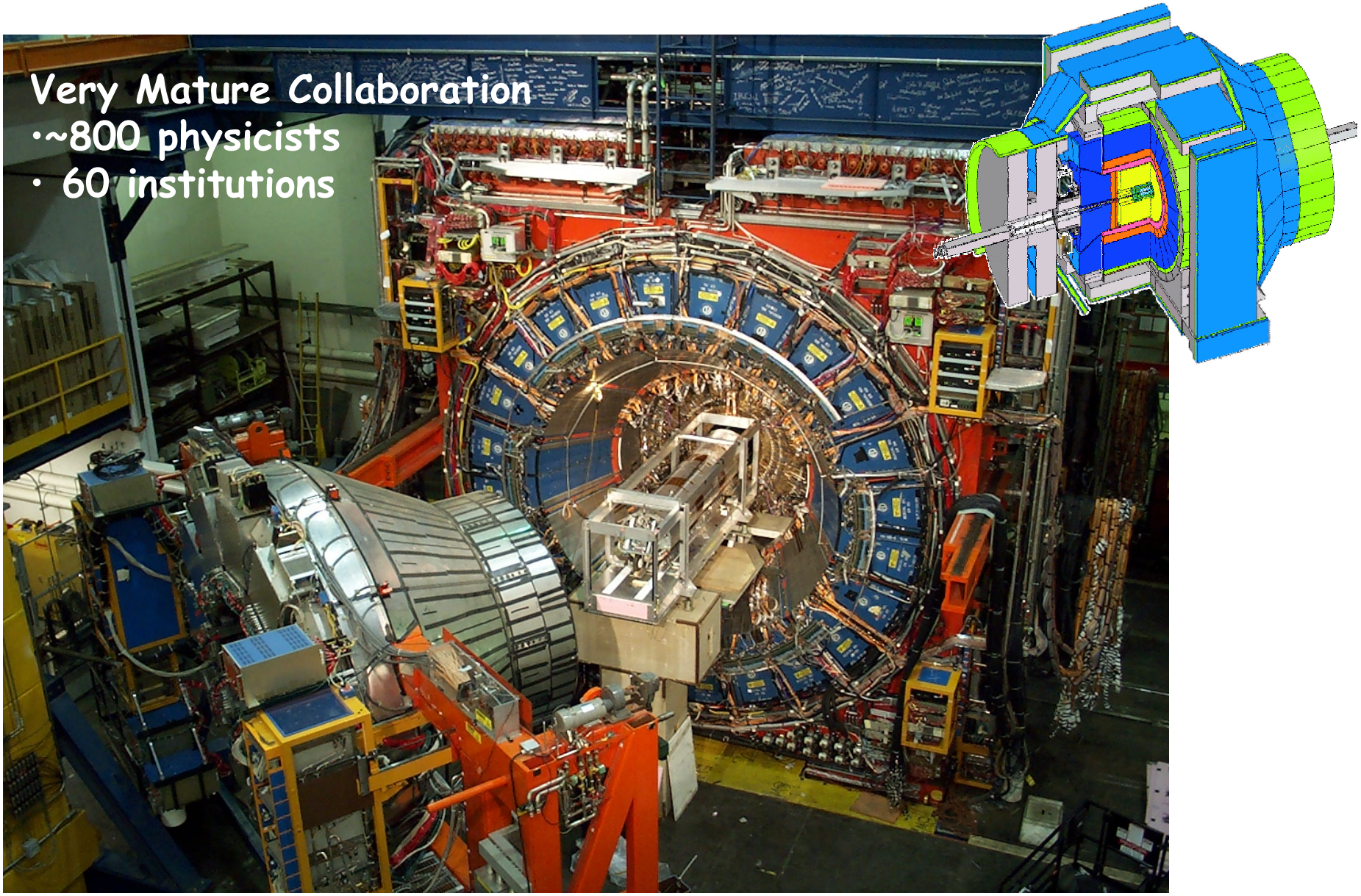
Tevatron Performance



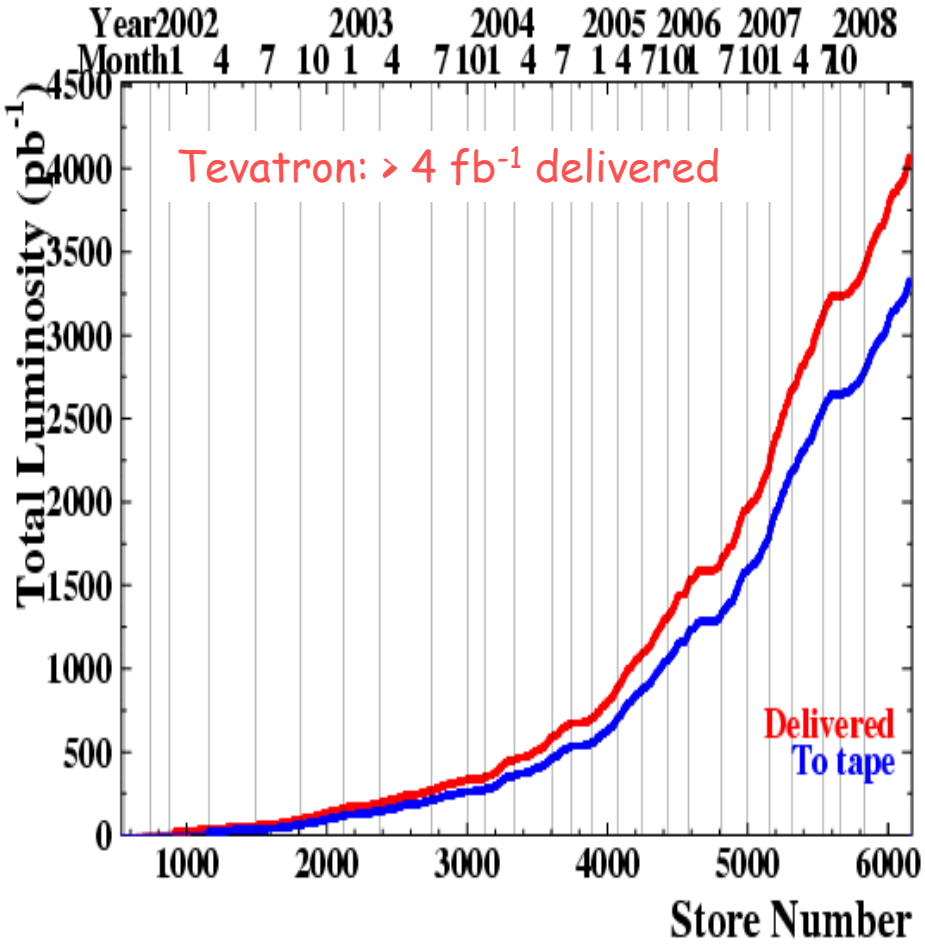


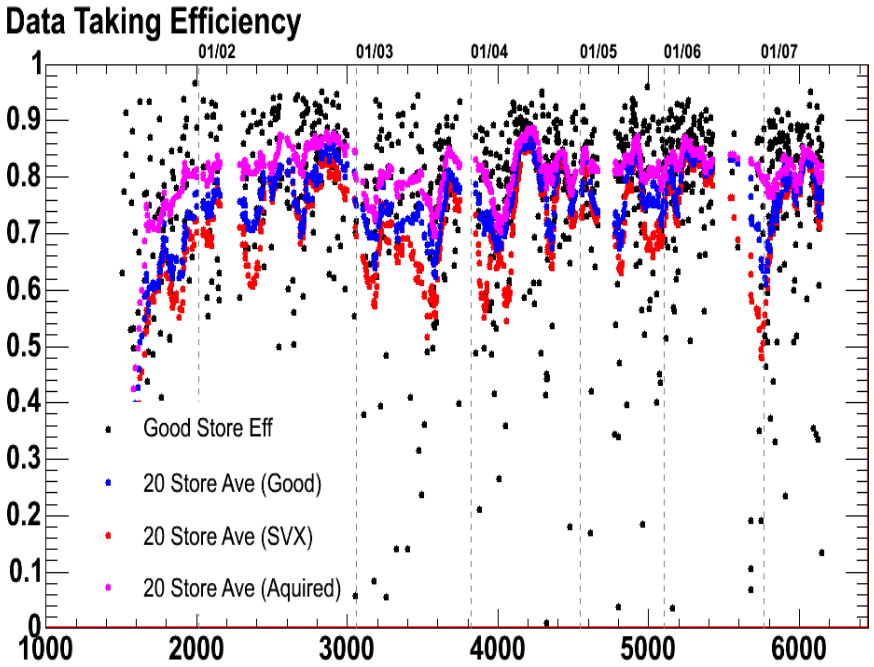
Tevatron delivered > 4 fb^{-1}
(6-7 fb^{-1} expected by end FY09)

CDF Run II Detector



CDF Run II Data





CDF: > 3.3 fb^{-1} on tape

CDF Averaged Eff. ~ 85%

DAQ runs with about 5% dead time
Rest from very careful operation
of detector's HV due to machine losses

CDF Physics Program

- Top Quark Physics
  - Cross Section
  - Top Mass
  - Single Top Production
  - ……
- EWK Precise Measurements
  - W Boson Mass and Width
  - FB Asymmetries
  - Triple Gauge Boson coupling
  - ……..
- Searches
  - Search for Resonance in DY processes
  - LQ Searches
  - SUSY & Extra Dimensions
  - Higgs
  - ……..

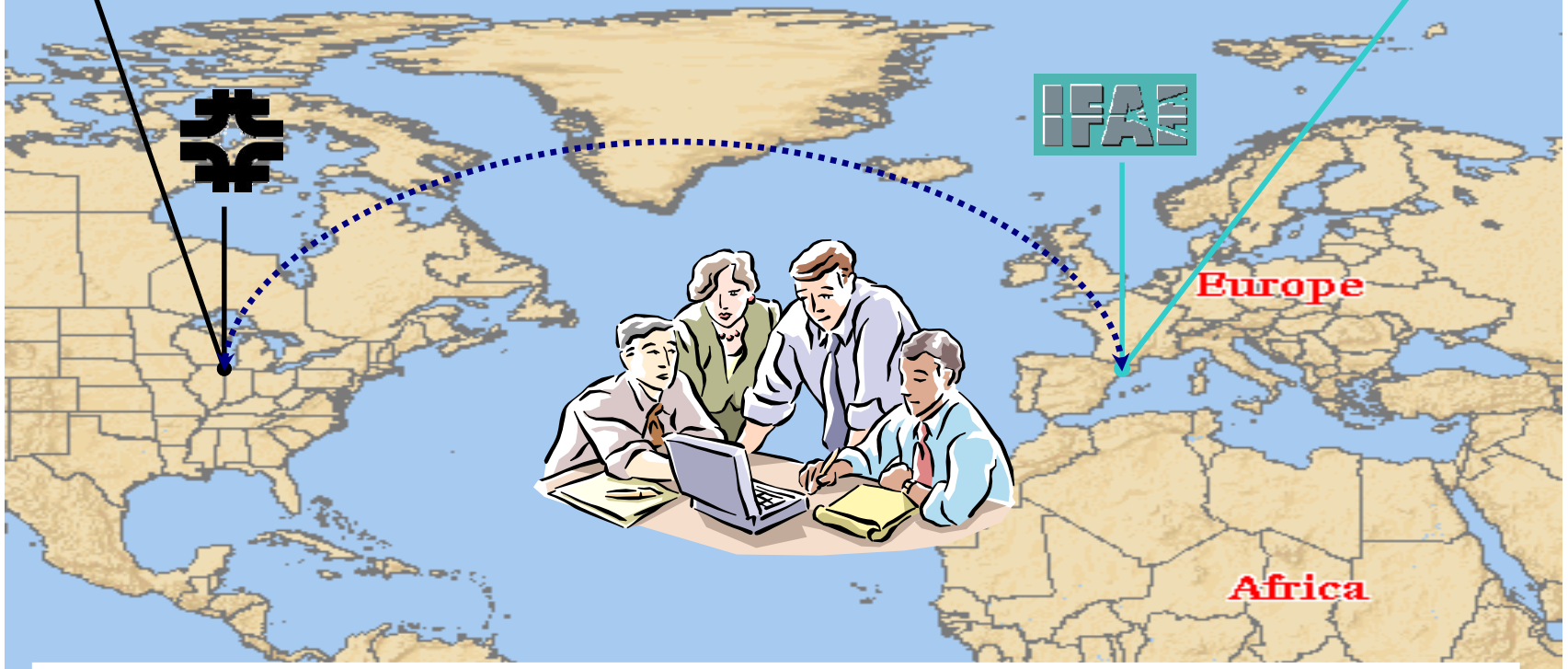
CDF Physics Program (cont.)

- QCD/Jet Physics
  - Inclusive Jet Production
  - B-jet Production
  - Boson + Jet(s) Physics
  - Jet Fragmentation
  - Underlying Event Studies
  - ……
- Heavy Flavor Physics
  - B Mixing / CP Violation
  - Rare B decays
  - Charm Physics
  - Hadron Spectroscopy
  - PentaQuarks Search

…CDF has a VERY RICH research program…
… ideal educational ground for LHC physics…

CDF at IFAE

IFAE JOINED CDF ON MAY 2003



IFAE Goals at CDF:

- Thesis for students with physics data
- Training on Hadron Collider Physics before the LHC
- CDF is a first-class experiment at the energy frontier

IFAE-CDF Commitments

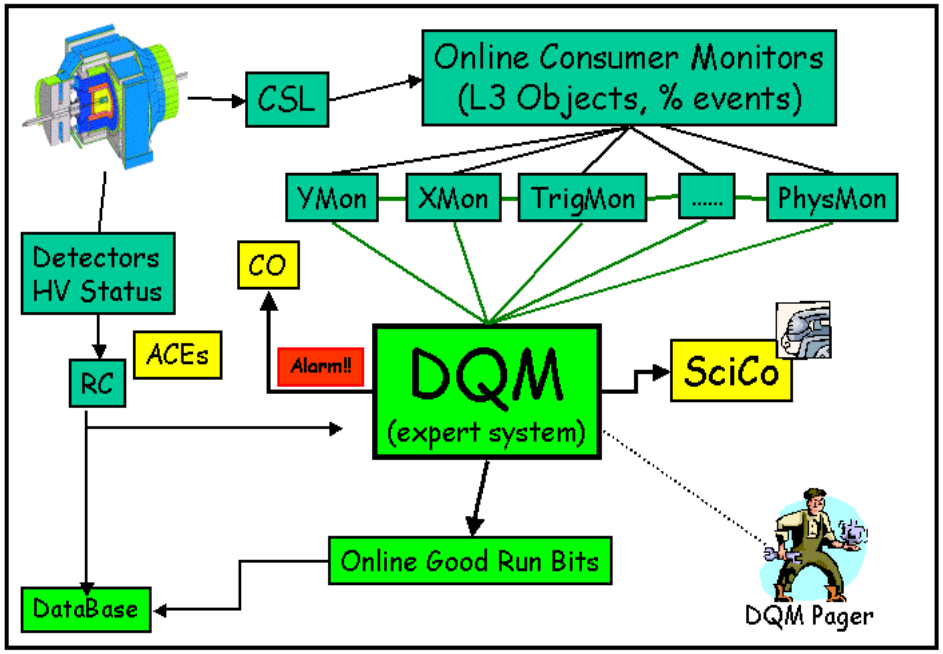
- IFAE group is leading the data quality monitoring effort in CDF and acts as Data Quality Manager (DQM)

- IFAE implemented global DQM Automated Systems to characterize the quality of the data with emphasis on the quantities relevant for physics analyses
  - **Online & Offline** DQM Automated Expert Systems
  - Maintenance of Good Run Lists (DQM Online+Offline diagnosis)
  - WWW documentation & Statistics

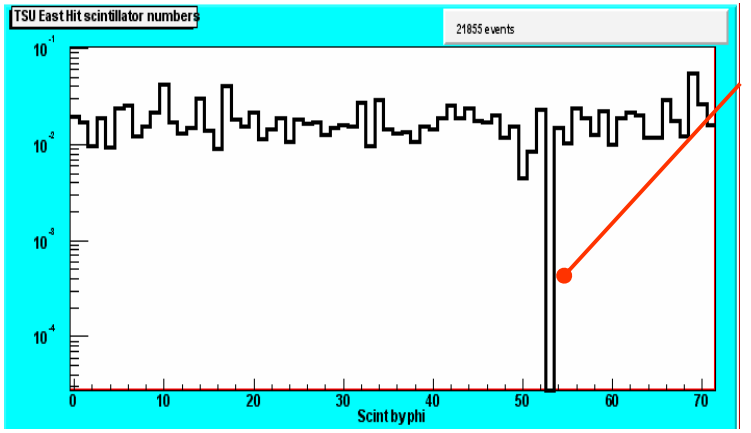
- IFAE is responsible of DQM Operation
  - Regular Reports to CDF
  - Online Support to Shift Crew operations (DQM contact person)

- IFAE charges & responsibilities were formally established in a **MoU** signed together with CDF and FNAL Directorate

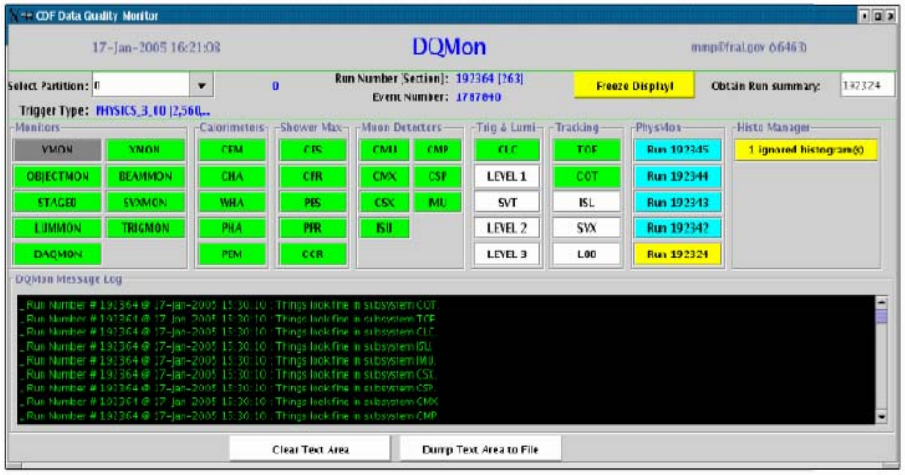
DQM Online Model for CDF



Online Monitors (C++ based)
produce online histograms to monitor
the basic performance of the different
sub-systems (occupancy levels, HVs)



dead
channel



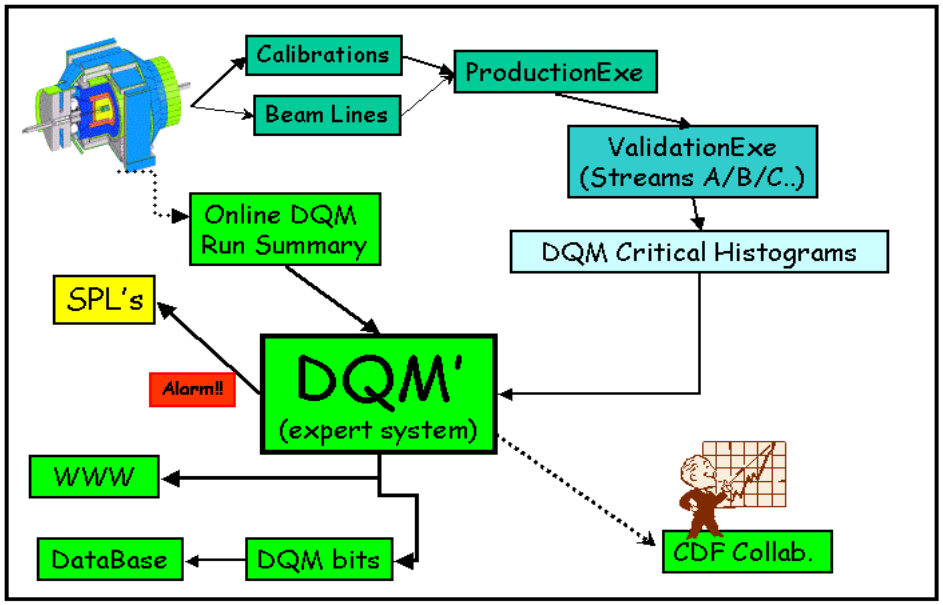
Expert System runs @ CDF control room

Monitors online histograms & status of
Consumers, HVs and Tevatron Beams

Alerts shift-crew in case of problems

-> Determines Online Good Run Status

DQM Offline Model for CDF

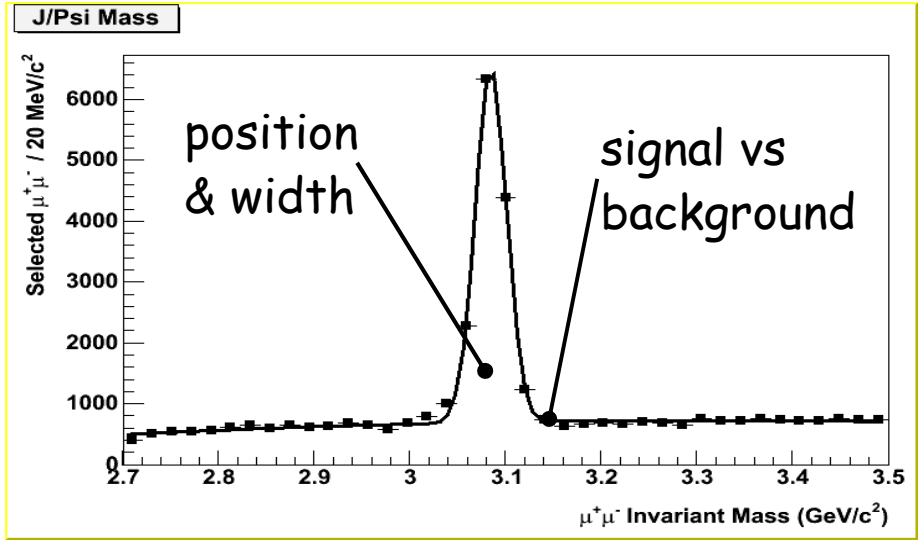


Latest calibrations and alignments are used to reconstruct high-level objects (electrons,. photons, jets, J/Ψ...) as they are employed in final physics analyses

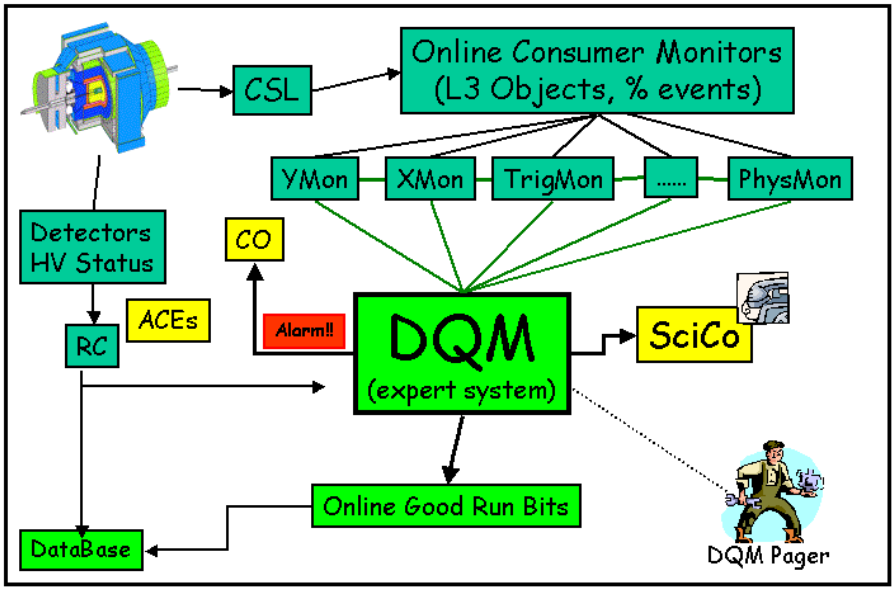
A number of **critical quantities** are selected, enough for DQM diagnosis

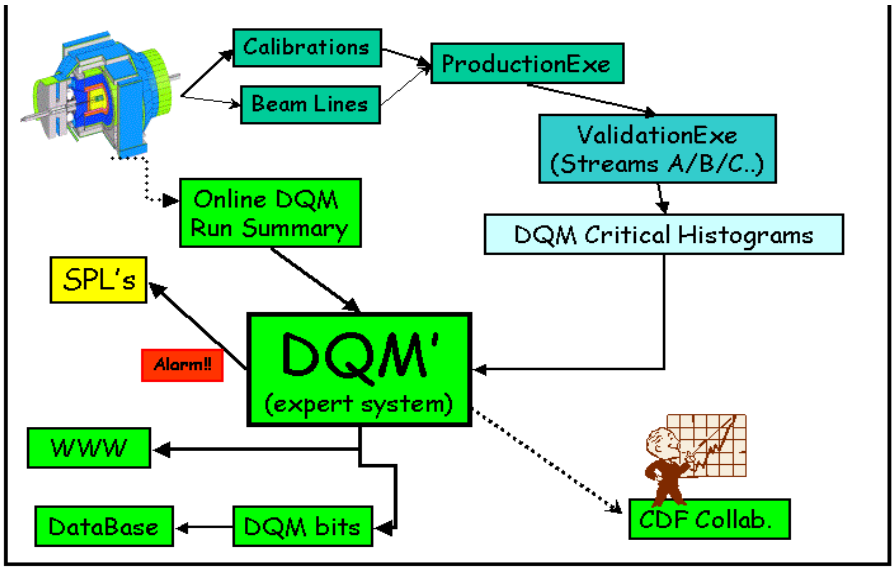
The **DQM expert system** implements the logic to automatically analyze the critical histograms and evaluate their quality

The errors detected (either due to raw detector quantities or caused by offline reconstruction codes) are promptly reported to **detector experts**



Status of DQM Project





DQM Online (maintained by 1 FTE)

- 100% Operational in 2005
- CDF shift-crew now relies on it

DQM Offline (maintained by 1 FTE)

- Expert System @ 100% in 2005
- System fully automatic and used to validate data & offline reconstruction software
- New versions of "good run" lists regularly delivered to CDF

IFAE-CDF Group (by Fall 2007)

Physicist	Position	% CDF	Based in	Other Experiments
M. Martinez (PI)	ICREA Research Prof.	80	FNAL/IFAE	ATLAS
M. D'Onofrio (PhD from U. Geneva)	JdC	100	FNAL	NONE
A. Attal (PhD. from UCLA)	PostDoc	100	FNAL	NONE
O. Salto	PhD. Student	100	FNAL	NONE
G. De Lorenzo	PhD. Student	100	FNAL	NONE
C. Deluca	PhD. Student	100	FNAL	NONE
M. Cavalli-Sforza	Research Prof.	50	IFAE	ATLAS
I. Korolkov	RyC	50	IFAE	ATLAS

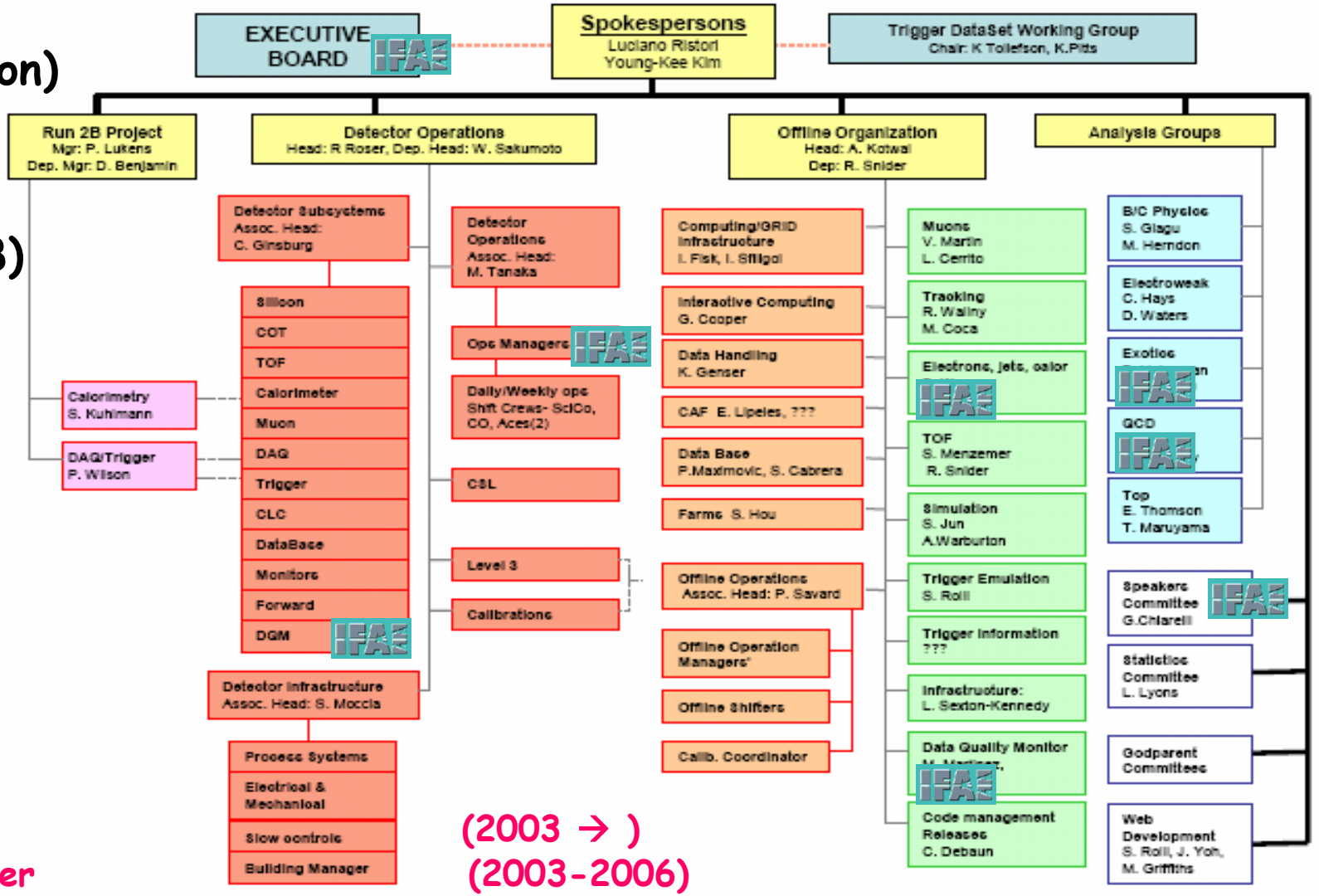
Former members

2 PhD. Theses in 2007

R. Lefevre	PostDoc	Now Staff Researcher at Clermont-Ferrand
X. Portell	(Ph.D on March 2007)	Now at Freiburg University
O. Norniella	(PhD. On March 2007)	Now at Urbana-Champaign

CDF Chart
(2004 version)

(2003-2008)



- DQM SPL (2003 →)
- QCD convener (2003-2006)
- Jets E-scale convener (2006-2007)
- SUSY Group convener (2007-2008)
- Ops Manager (Run Coordinator) (2007-2008)
- Speakers Committee (2007-2008)

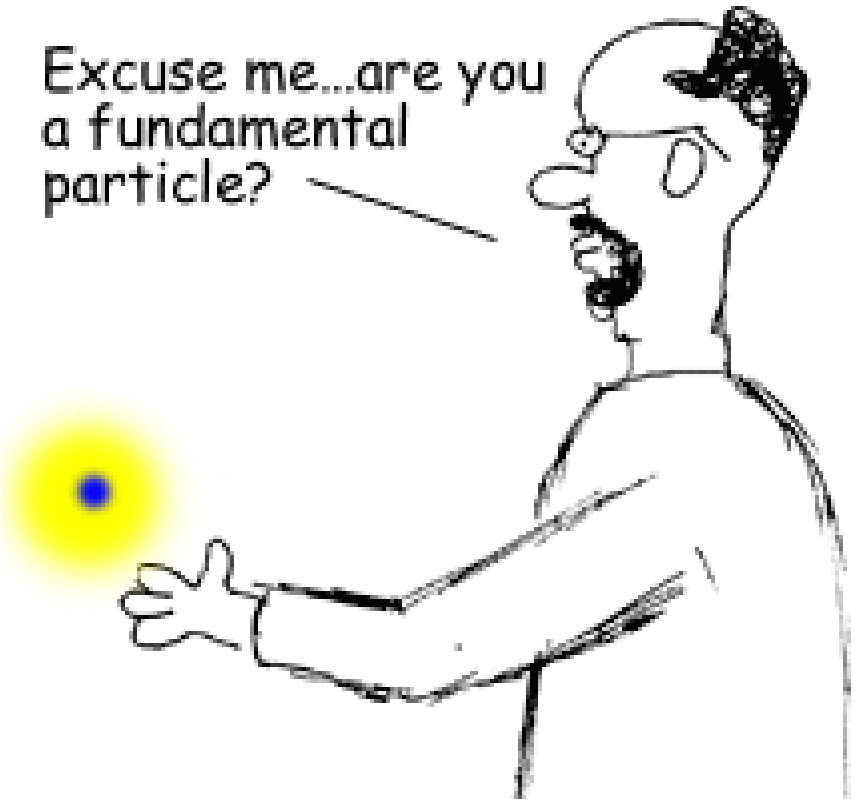
Very visible group in CDF

·One of us member of LHCC committee (2005 →)

May 30th - June 3rd 2005
CDF Collaboration Meeting

First time that CDF met outside USA….140 persons came

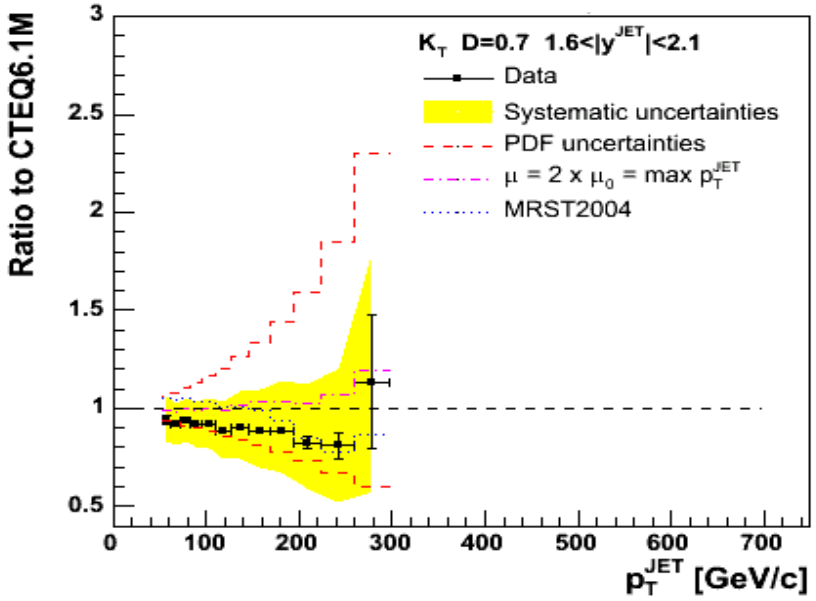
Physics Program

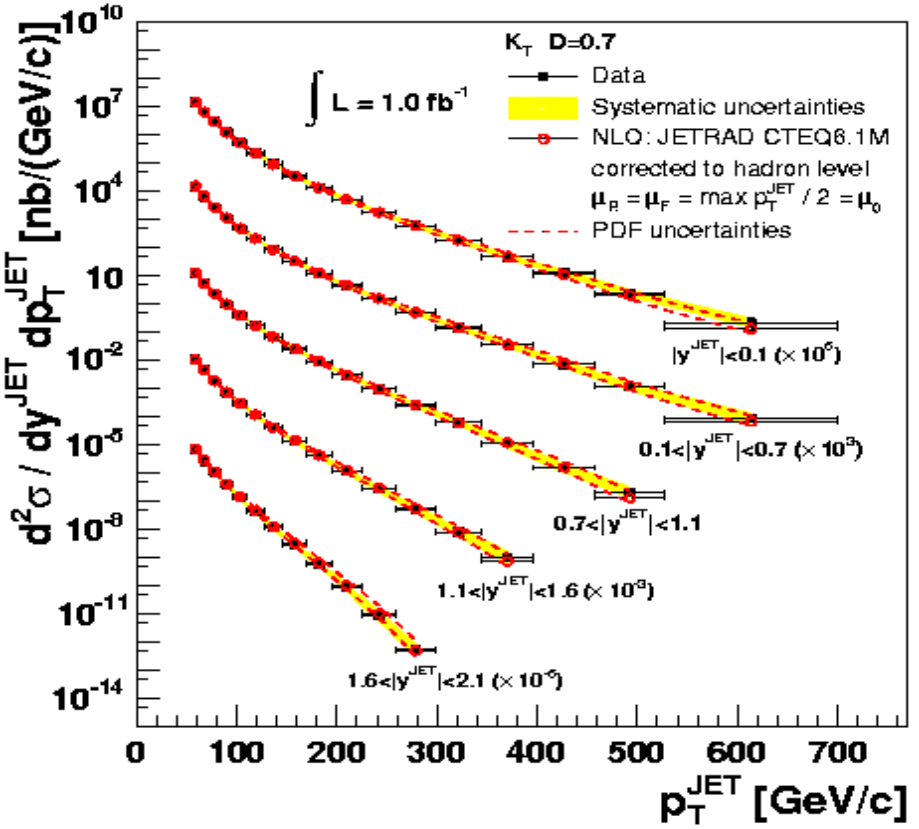


O. Norniella PhD. Thesis (March 2007)

Jet Production with K_T

- Inclusive K_T algorithm
- Stringent test of NLO pQCD over ~9 orders of magnitude (probing distances ~10^{-19} m)
- Constrains gluon PDF at high-x



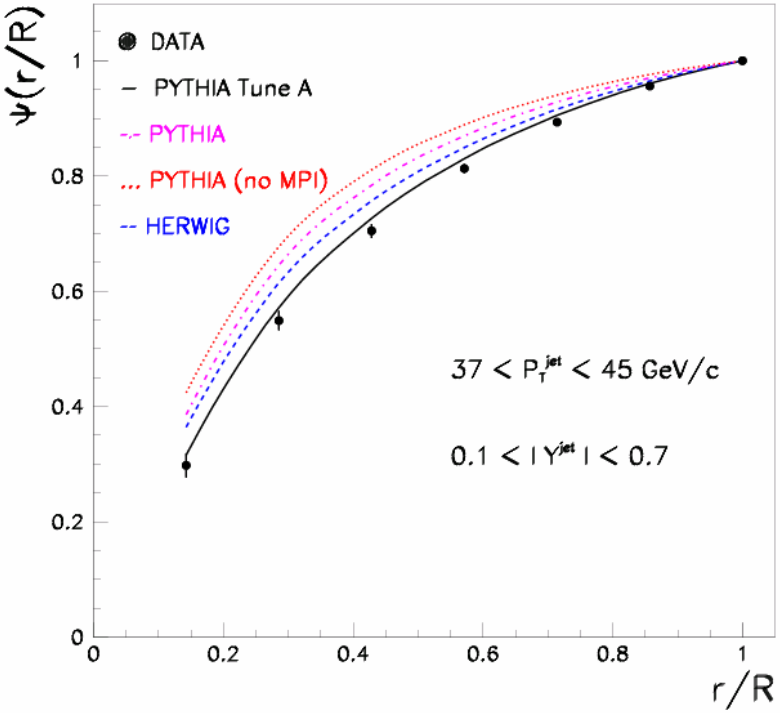


- Phys. Rev. Lett. 96, 122001 (2006)
- Phys. Rev. D75, 092006 (2007)

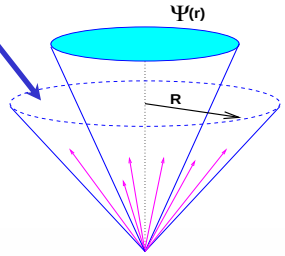
- PhD. Thesis being published as Monograph (VDM Verlag Dr. Müller & Co, Germany)

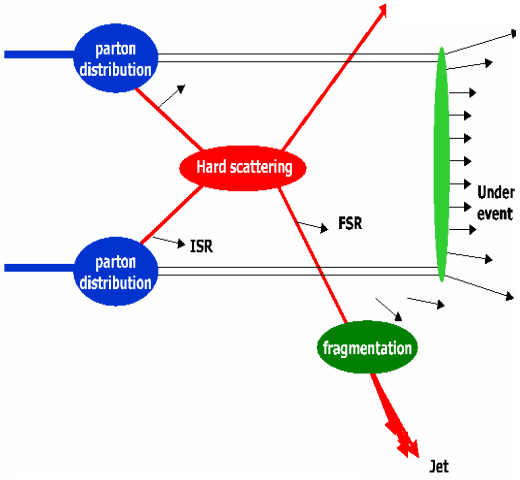
O. Norniella PhD. Thesis

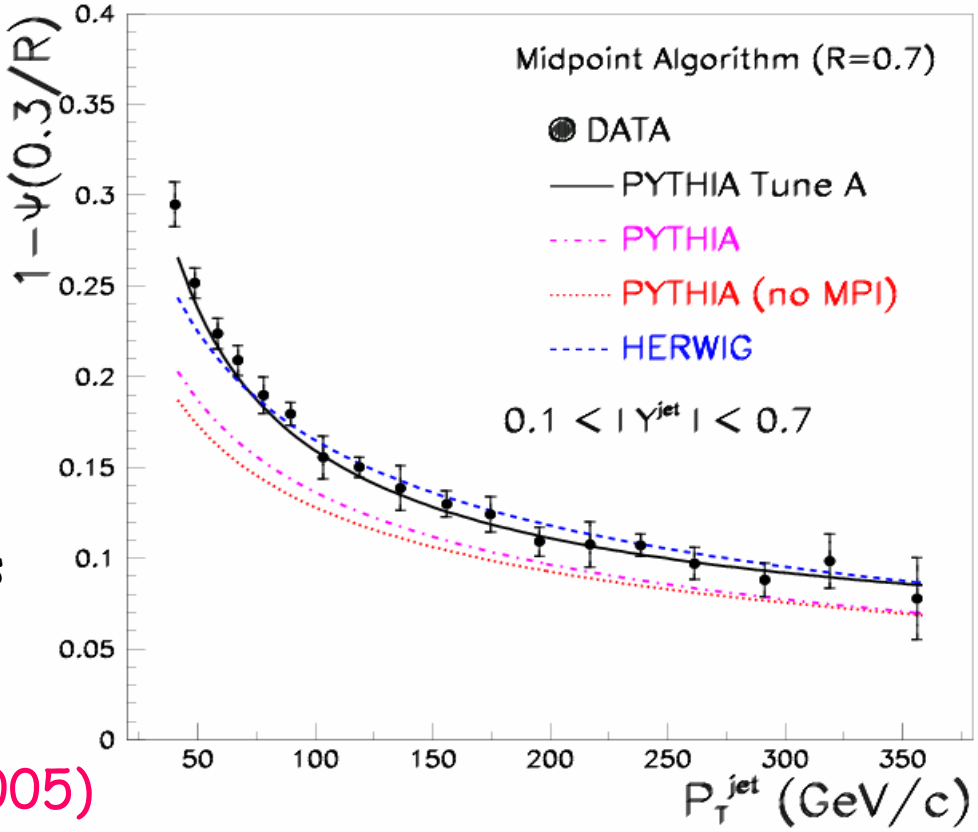
Jet shapes



$1-\Psi(r)$







PYTHIA Tune A describes the data
(enhanced ISR + MPI tuning)
→Used to compute non-pQCD factors

Published: Phys. Rev. D71 11 (2005)

IFAE @ FNAL TODAY

Fermilab Today

Thursday, July 1, 2004

Calendar

Thursday, July 1
3:30 p.m. DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over
THERE WILL BE NO ACCELERATOR PHYSICS AND TECHNOLOGY SEMINAR TODAY

Friday, July 2
3:30 p.m. DIRECTOR'S COFFEE BREAK - 2nd Flr X-Over

Hill Succeeds Ellis as Theory Head

Today, after more than a decade as head of Fermilab's Theoretical Physics Department, Keith Ellis will step down. Chris Hill, a theoretical physicist and 25-year Fermilab employee, will take over leadership of the department.

Keith Ellis

"Filling Keith Ellis'

Hill.

heory

ast

head of the department,

e Run II Physics

led the creation of the

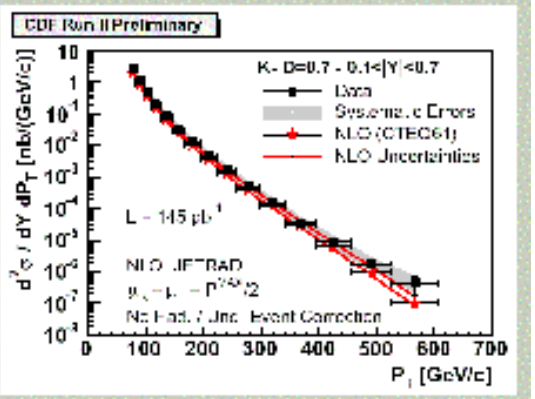
tier Fellows program

r theorists to Fermilab

Fermilab Result of the Week

Inclusive Jet Studies

How small is a quark?

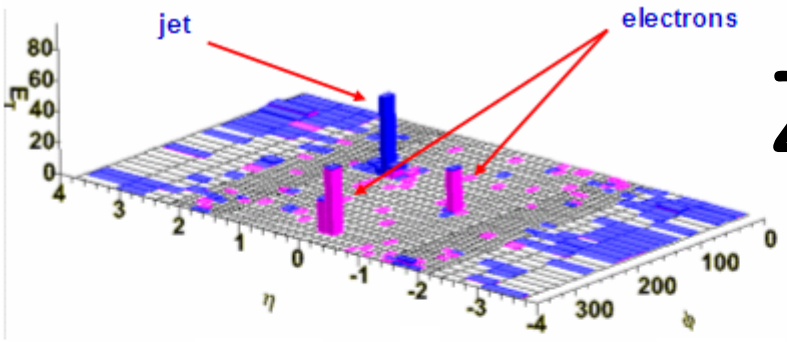


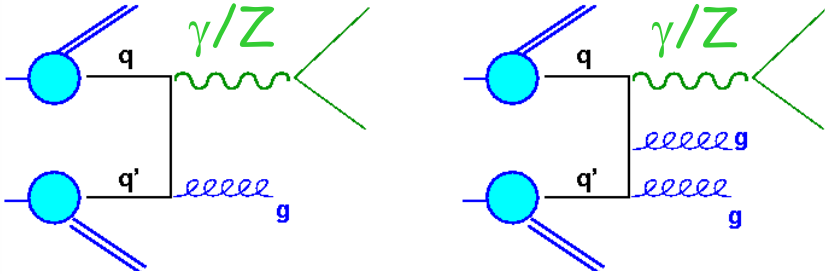
Measured inclusive cross section as a function of jet transverse momentum compared to NLO pQCD predictions. Jets are searched for using the longitudinally invariant Kt algorithm. The red band indicates the theoretical uncertainty. (Click on image for larger version.)

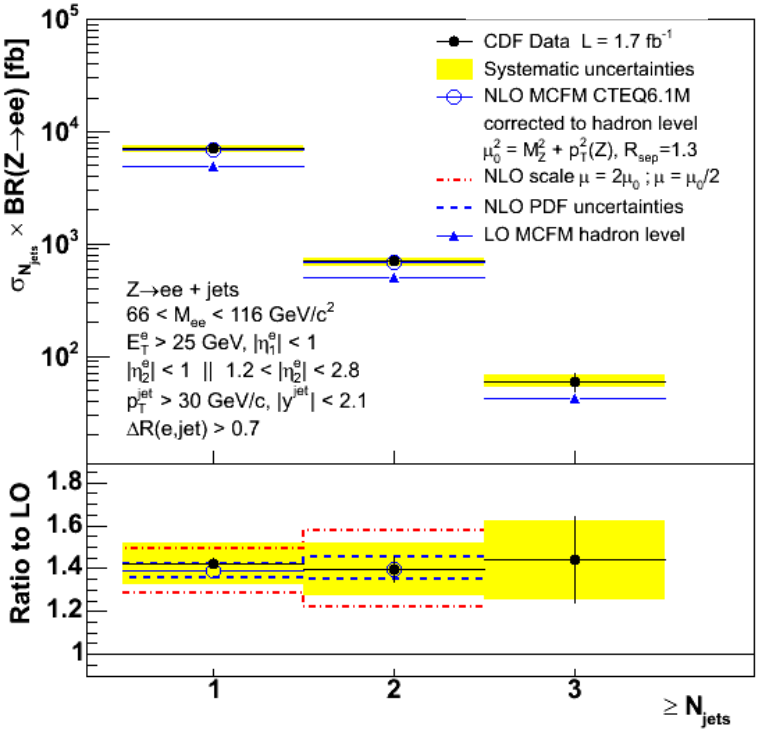
In 460 B.C. the Greek philosopher Democrito introduced the concept of "atom" to explain the nature of matter.

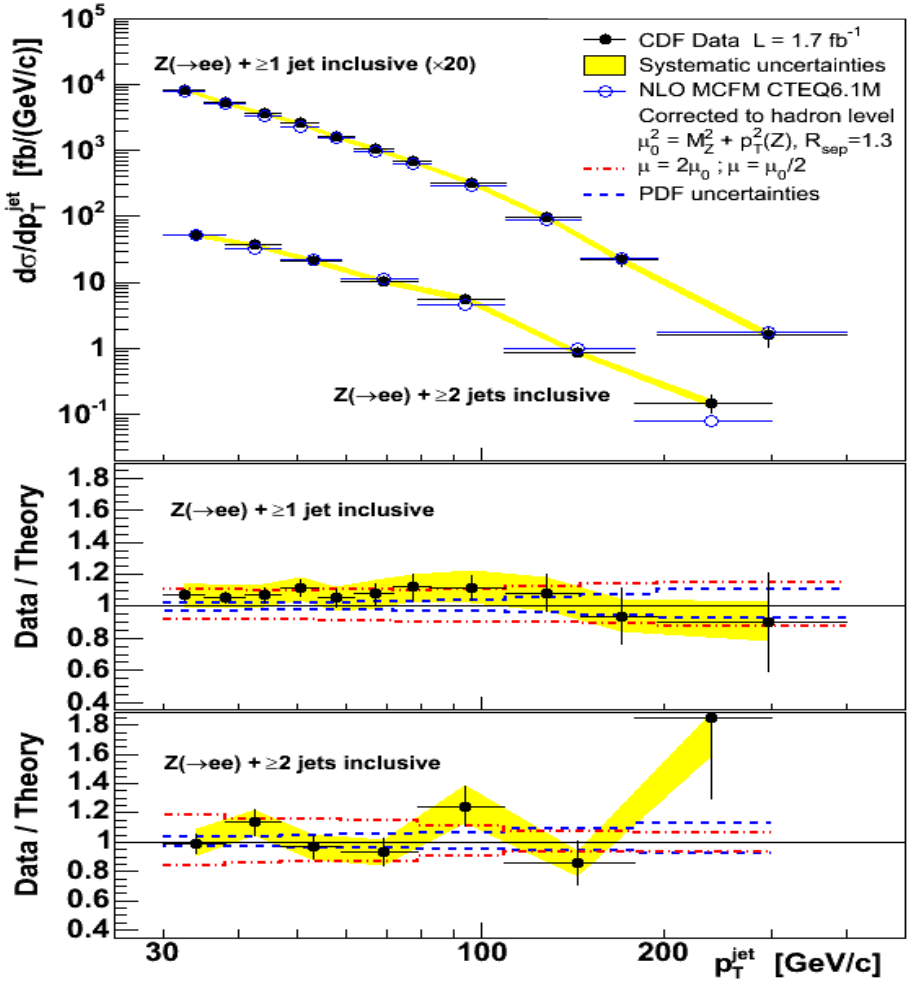
O. Salto PhD. Thesis (scheduled June 2008)

Z/γ*+jet(s) Production









Phys. Rev. Lett. 100, 102001 (2008)

Now studying also Z+QQ final states

IFAE@ FNAL TODAY

Fermilab *Today* Thursday, May 24, 2007

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endar

urs., May 24
0 p.m.
CPG ILC Physics and
tector Seminar -
I-10NW, West Wing
eaker: C. Milstene,
milab
e: Precision
asurement of the Stop
ss at the ILC
0 p.m.
eoretical Physics
minar - WH-3NW (NOTE
CATION)
eaker: D. Tucker-Smith,
liams College
e: Mixed-Sneutrino Dark
ter at the LHC
0 p.m.
RECTOR'S COFFEE
EAK - 2nd Flr X-Over
ERE WILL BE NO
CELERATOR PHYSICS
D TECHNOLOGY
MINAR TODAY

, May 25
0 p.m.
RECTOR'S COFFEE
EAK - 2nd Flr X-Over

Feature

FNAL and ANL collaboration meeting focuses on future

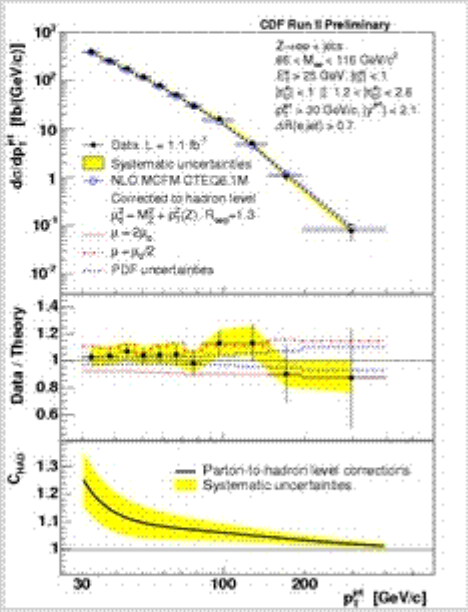
Last Friday's collaboration meeting between key Argonne and Fermilab employees allowed attendees to mingle during breaks. Argonne Director Robert Rosner is pictured second from the right.

Optimism and eagerness were pervasive last Friday as dozens of key members from Argonne National Laboratory and Fermilab listened to each other speak. More than 50 Argonne and Fermilab employees came together for a collaboration meeting last week to discuss the two institutions' opportunities for synergy and their plans for the future.

The meeting was the second for the two groups, who originally met at Argonne in

Fermilab Result of the Week

The strong, the weak and the invisible



Measured inclusive jet cross section in events where a Z boson is produced with jets. The top plot shows the number of jets as a function of the momentum of the jets, ranging from 30 to 400 GeV/c. The middle plot demonstrates the data agree well with theory, so that data/theory is approximately 1.

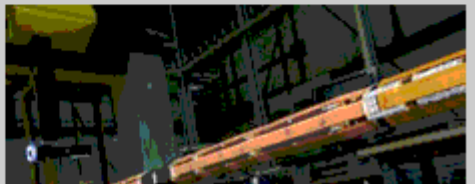
energy spectrum and jet multiplicity have been compared with predictions from Quantum Chromodynamics (QCD). The measurements indicate that QCD inspired models properly describe these events, creating confidence that new invisible particles produced with jets could be distinguished from the background.

CDF members involved in the analysis (from left) Mario Martinez, Monica D'Onofrio, Oriol Salto (IFAE-Barcelona).

Learn more

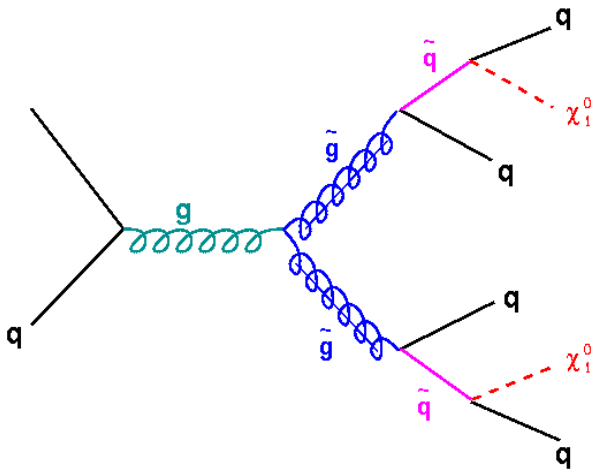
iSGTW

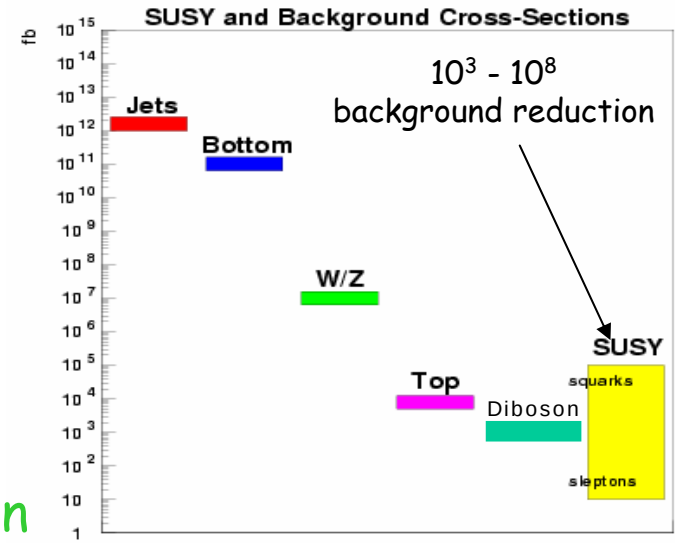
DZero: Doing Double Duty

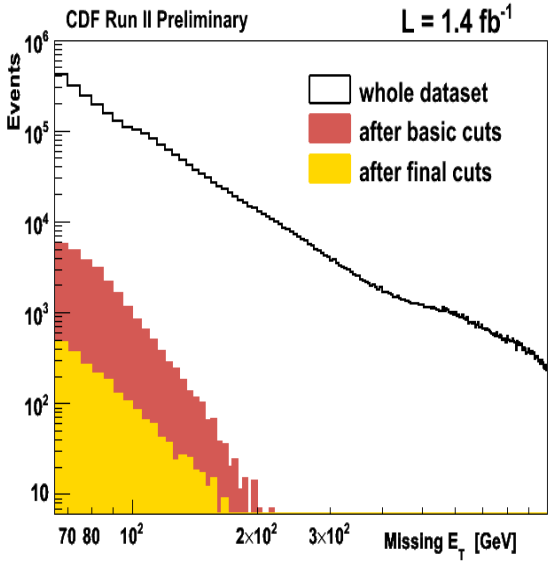


X. Portell PhD. Thesis (March 2007)
G. De Lorenzo M. Thesis (April 2008)

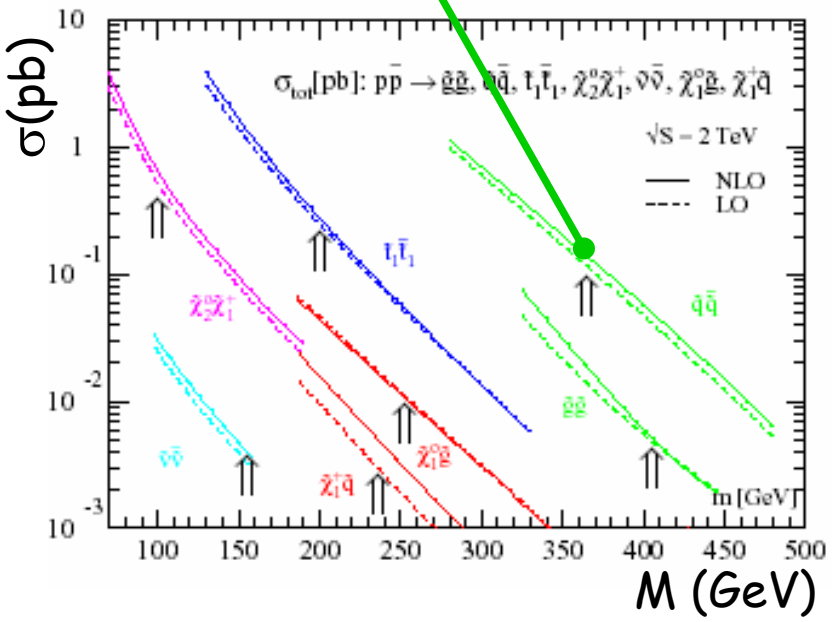
Squark/Gluino Search







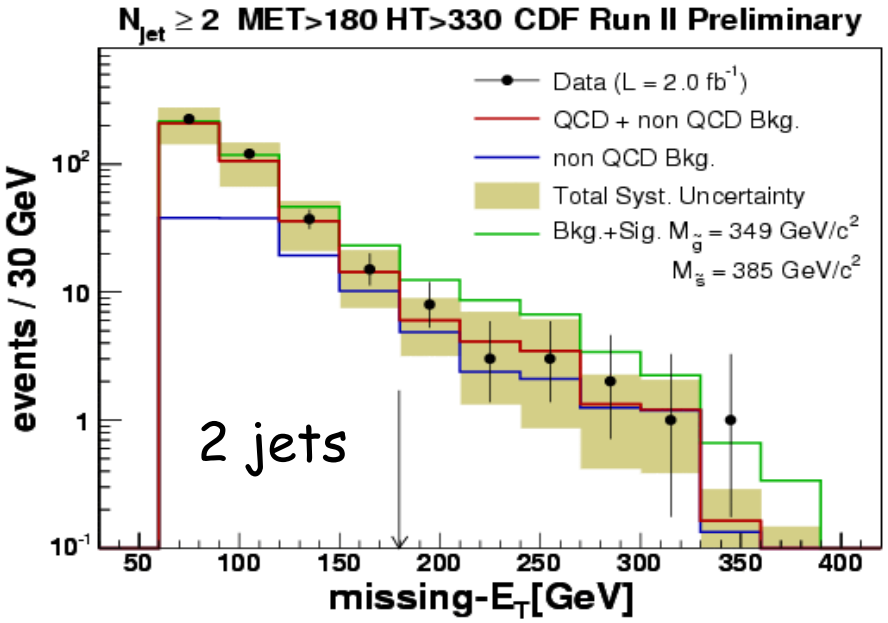
gluino/squark production at the energy frontier

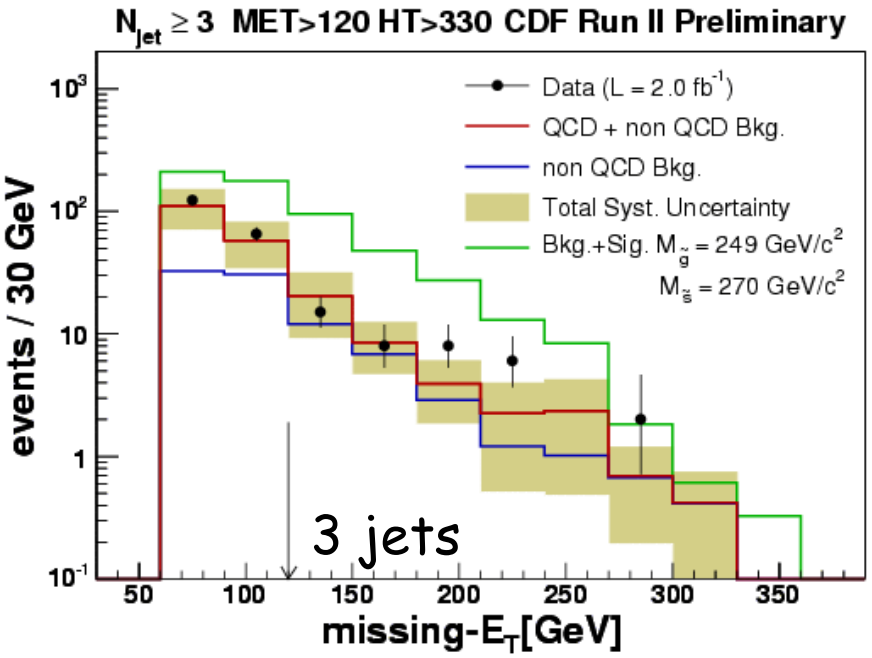


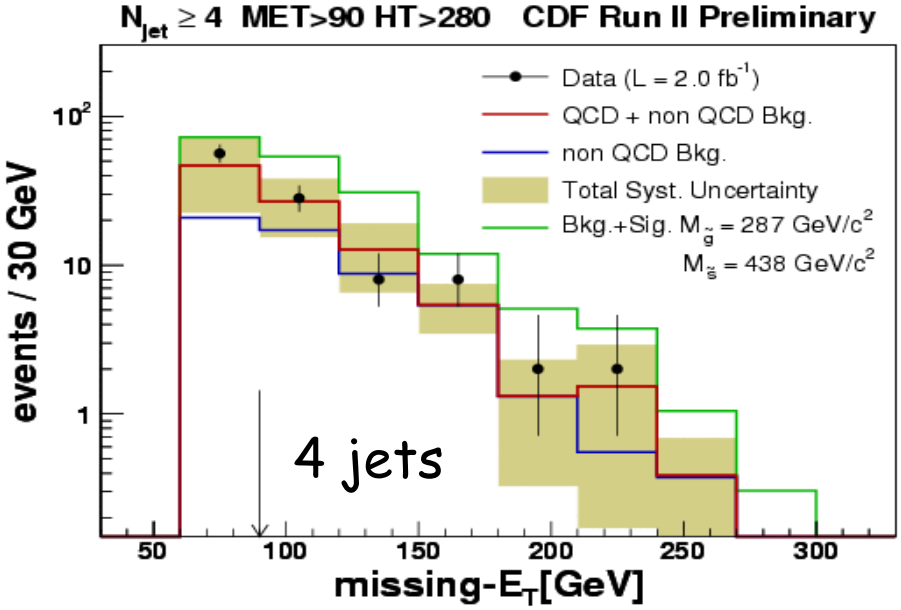
- Assuming R-parity conservation
- Signature: $\not{E}_T$ + jets
- Understanding of beam backgrounds
- Difficult…multiple SM backgrounds
  - Detector effects
  - top and Z->νν+jets irreducible
  - understanding of QCD & W/Z+jets
- Three analyses carried out with different jet multiplicities

Squark/Gluino Search

2 fb^{-1}





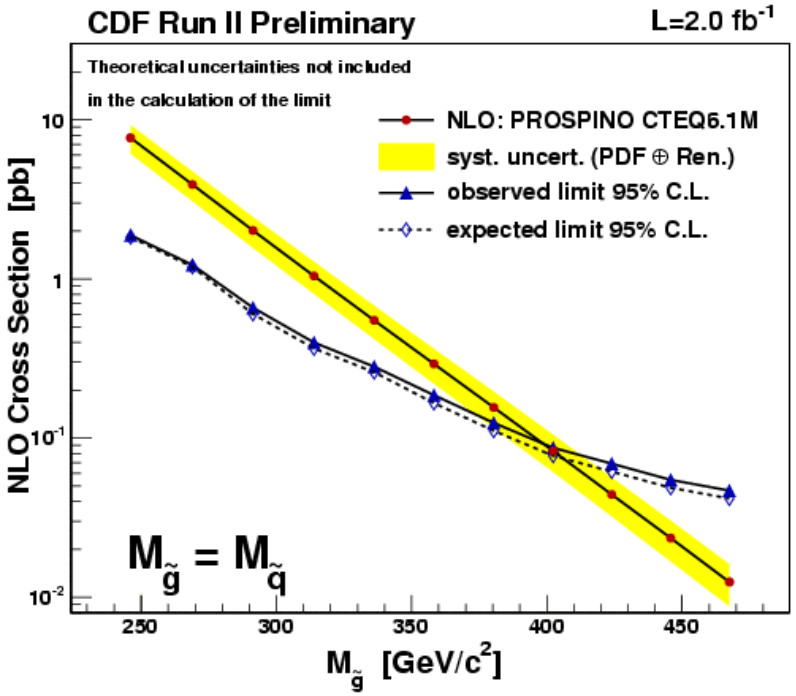


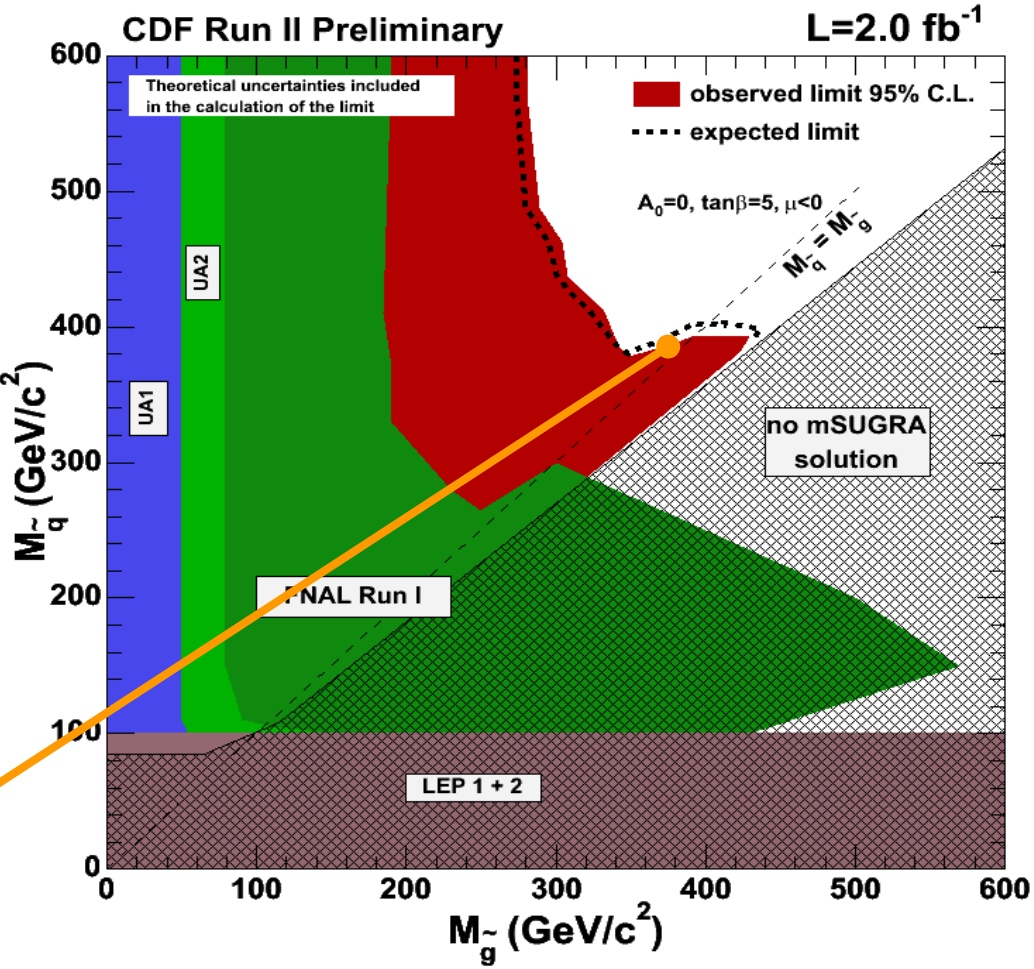
events in 2 fb^{-1}	DATA	SM Expected
≥ 4 jets	45	48 ± 17
≥ 3 jets	38	37 ± 12
≥ 2 jets	18	16 ± 5

Good agreement with SM predictions

Exclusion Limits

G. De Lorenzo PhD. Thesis (expected by 2009)





$\sigma < 0.1\,\text{pb}$ @ 95 % CL

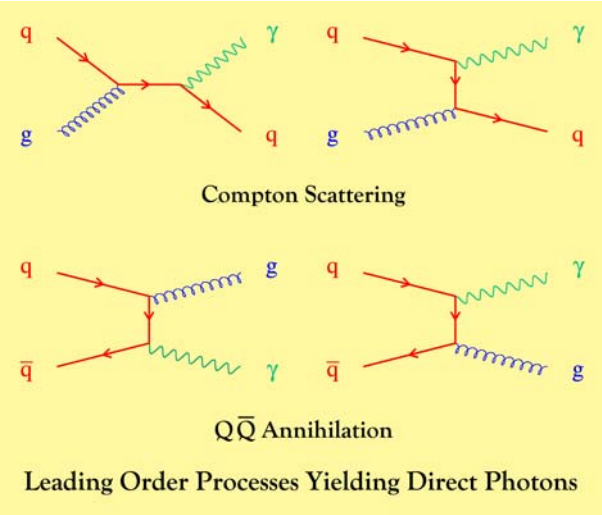
$M > 392\,\text{GeV}$ @ 95% CL

PRL draft now about to be submitted for publication

Analysis being complemented with a dedicated search for 3rd generation squarks → results by ICHEP08

High-P_T γ Production

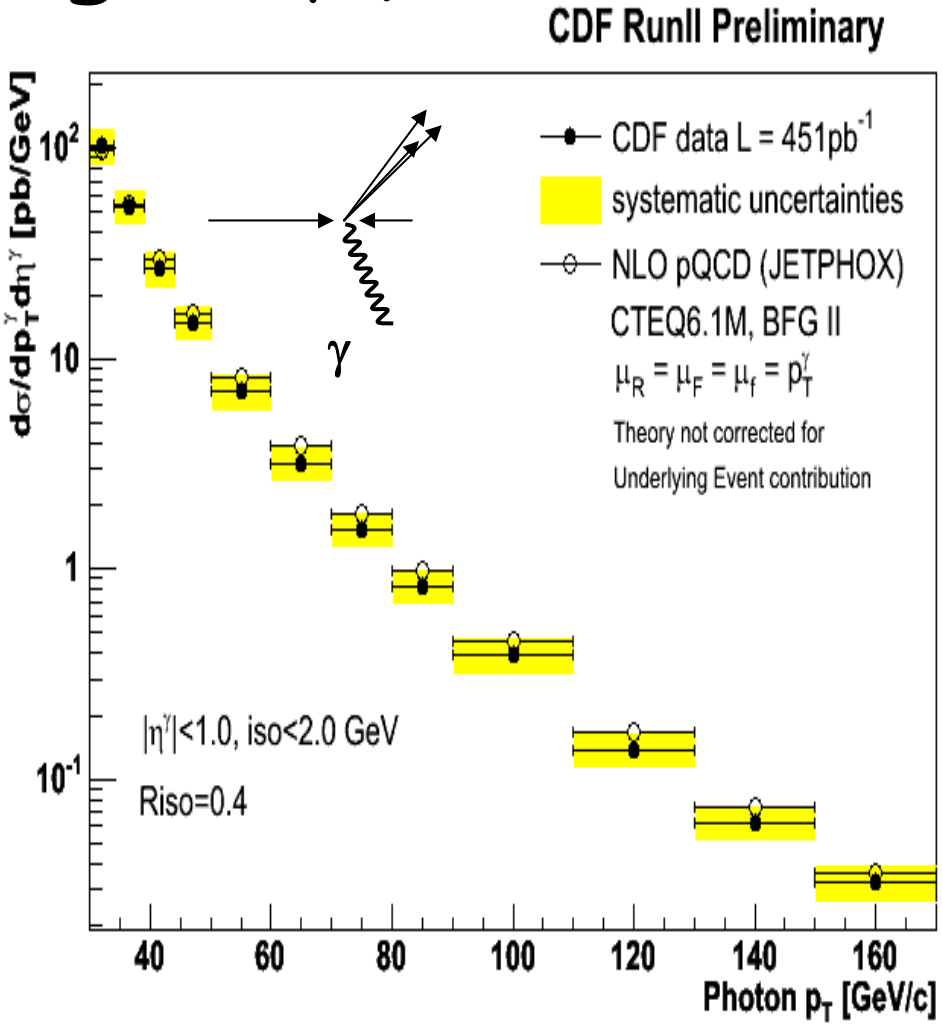
C. Deluca PhD. Thesis (expected by 2009)



Using prompt photons one can precisely study QCD dynamics:

- Well known coupling to quarks
- Give access to lower P_T
- Clean: no need to define "jets"
- constrains gluon PDF

Experimentally difficult because of large background from π^0 decays



First results presented at APS08
New 3 fb-1 result by ICHEP08

Talks in Conferences & Seminar (2006-2007)

- 1 Plenary talk at Lepton-Photon 2007 (Korea)
- 1 Plenary talk at Physics in Collision 2006 (Brazil)
- 2 Plenary Talks at La Thuile 06/07 (Valle d'Aoste)
- 1 Plenary Talk at HCP 06 (Duke)
- 2 Talks at SUSY06/07 (Irvine, Karlsruhe)
- 4 Talks at APS Conferences (Dallas, Florida)
- 2 Talks at EPS07 Conference (Manchester)
- 2 Talks at PHENO07 Conference (Madison)
- 2 Talks at DIS06/07 Workshop (Tsukuba, Munich)
- 1 Talk at QCD06 Conference (Montpellier)
- 2 Talks at IMFP06 Conference (Madrid)
- 1 Talk at Euro-GDR 07 SUSY Meeting (Brussels)

(CDF speakers at LP07)

24 talks

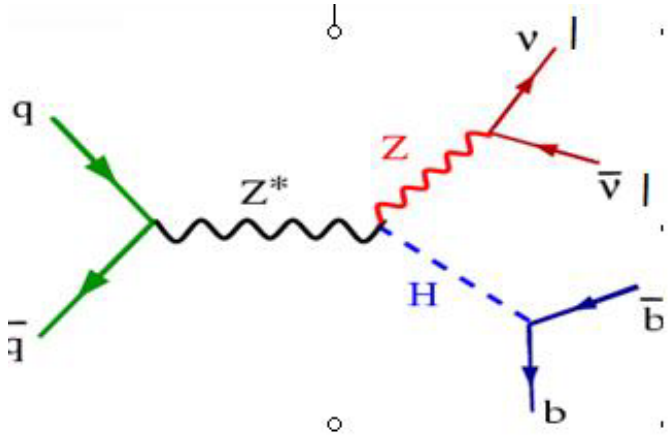
+

12 talks in CDF Collab. Meetings

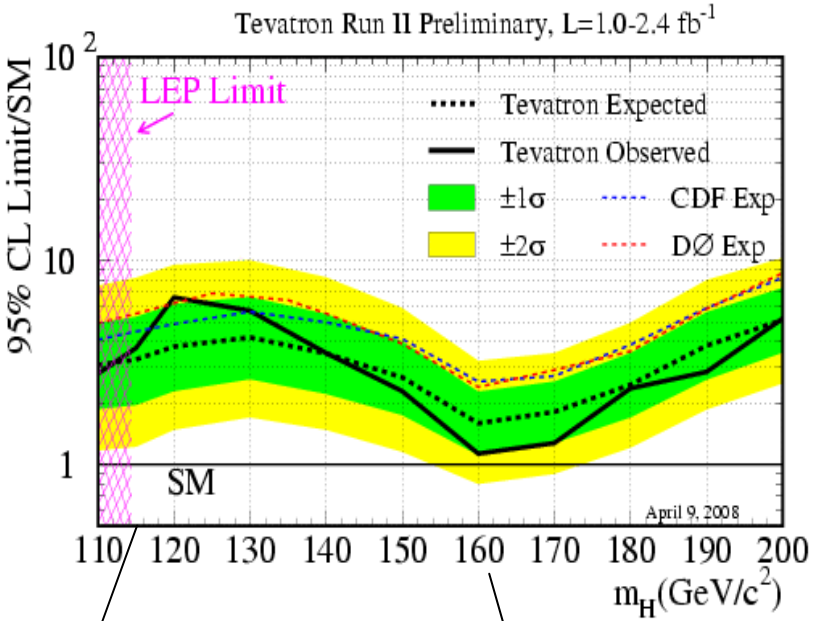
- 1 Invited Lunch Seminar at University of Chicago (Chicago)
- 1 Invited Lunch Seminar at Harvard University (Boston)
- 1 Invited talk at W&C Theory-Experiment Seminar (FNAL)

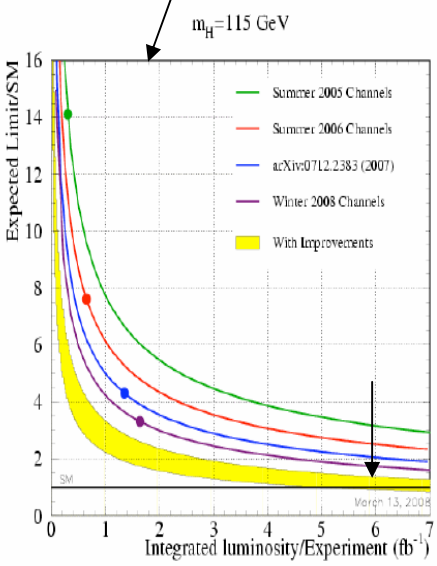
Notes on SM Higgs at CDF

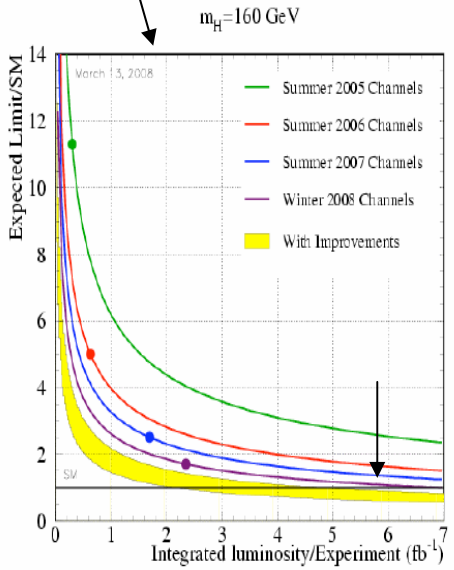
- Tevatron still has a window of opportunity for SM Higgs Physics in 2008-2010
- Our group would reach now the necessary critical mass to significantly contribute to this effort using full CDF dataset



- Expertise on Z+jets, b-tagging, boson+HFs, top, etc…
- A delicate balance between LHC startup in 2008/9 & the TeV/CDF performance







In Summary

We have left a clear footprint in CDF

- DQM project in CDF considered a success
- Consistent Physics Program
  (well recognized internationally)
- 2 PhD. Theses in 2007 (+1 PhD Thesis in 2008)
- Very visible inside CDF organization chart

- Tevatron expected to deliver 6-7 fb^{-1} by end FY009
- LHC scheduled to start operations this year

- Our group aims to complete its physics program in CDF
  - SUSY studies, prompt photon studies, Z+QQ, Higgs
  - 2 additional PhD. Theses expected by 2009

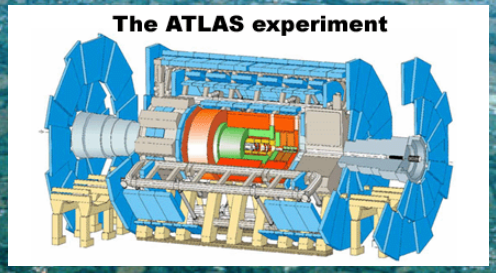
while we initiate an energetic involvement in ATLAS

The LHC

Summer 2008....

$\sqrt{s} = 14$ TeV

p p



10 persons well coordinated & trained in hadron collider physics that promise to play a relevant role in ATLAS at the LHC

Personnel (Summer 2008)

Independently funded

Physicist	Position	Based in	Experiments
M. Martinez (PI)	ICREA Research Prof.	IFAE/CERN	ATLAS/CDF
M. Cavalli-Sforza	Research Prof.	IFAE	ATLAS/CDF
S. Gristein (a)	ICREA Researcher	IFAE/FNAL	ATLAS/CDF
V. Sorin (b)	BdP*	IFAE/FNAL	ATLAS/CDF
M. D'Onofrio	JdC	CERN	ATLAS/CDF
A. Attal	PostDoc	FNAL	CDF
S. Camarda (c)	PhD. Student	IFAE/FNAL	CDF/ATLAS
O. Salto**	PhD. Student	IFAE	CDF
G. De Lorenzo	PhD. Student	IFAE	CDF/ATLAS
C. Deluca	PhD. Student	FNAL	CDF/ATLAS

Transition towards LHC happening

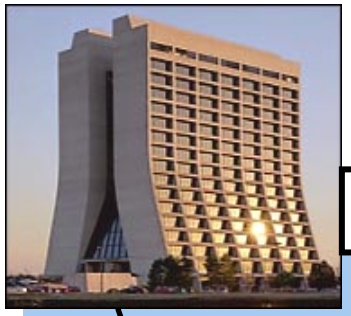
(a) Previously PostDoc in Harvard (CDF)
- Former CDF b-tagging convener, silicon SPL, now co-Head CDF Operations
- Expert on Boson+HF Production, top physics

(b) Previously PostDoc in Michigan State (CDF) (not in the proposed document)
- Expert on Trigger and top physics

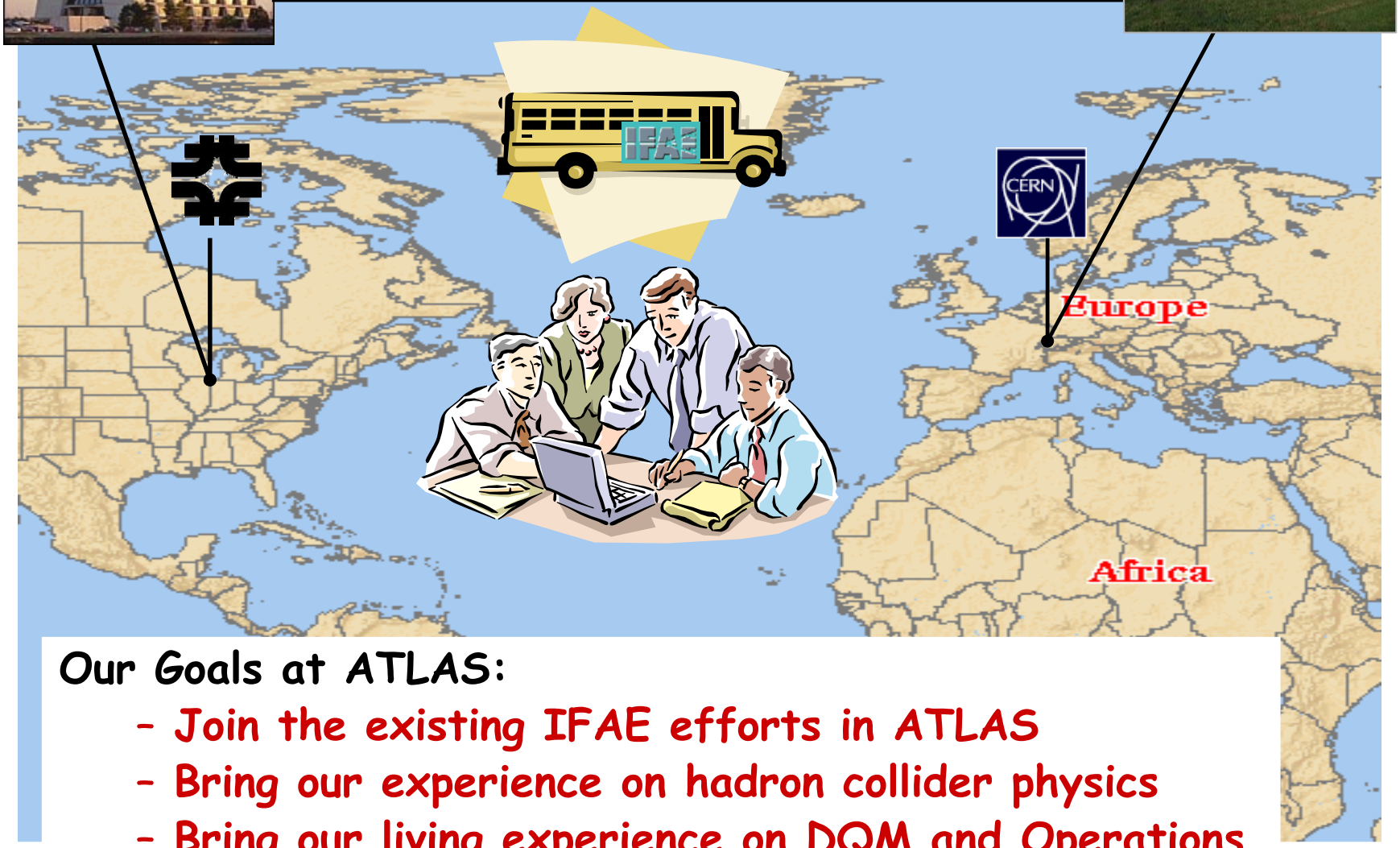
* Beatriz de Pinos

(c) Interested in Z+QQ and Higgs Physics

TeV4LHC



OUR GROUP IN CDF JOINS IFAE/ATLAS



Our Goals at ATLAS:

- Join the existing IFAE efforts in ATLAS
- Bring our experience on hadron collider physics
- Bring our living experience on DQM and Operations

TeV4LHC

- In 2008 members of our group are being invited to participate in ATLAS preparatory meetings for LHC Physics
  - 2 invited talks at Berkeley Workshop on Boson+jets Production (LBL, March 2008)
  - 1 invited talk at CERN´s Workshop on MC tools for BSM Physics (CERN, March 2008)
  - 1 invited HEP seminar at University of Chicago on SUSY searches (Chicago, April 2008)
  - 1 invited talk at ATLAS-France Workshop on Jets (Paris, June 2008)

- IFAE plays a leading role in ATLAS Monte Carlo studies on Z+jets CSC note (to large extent a follow up of our PRL work in CDF)

- One of us acts as internal referee of ATLAS CSC note on SM background for SUSY searches

Just a living example of the merging between great IFAE-ATLAS existing efforts and IFAE-CDF experience

Draft version 1.0

ATLAS CSC NOTE
W/Z+jets

March 20, 2008

W/Z + jets CSC Note

W/Z + jets CSC authors

Abstract

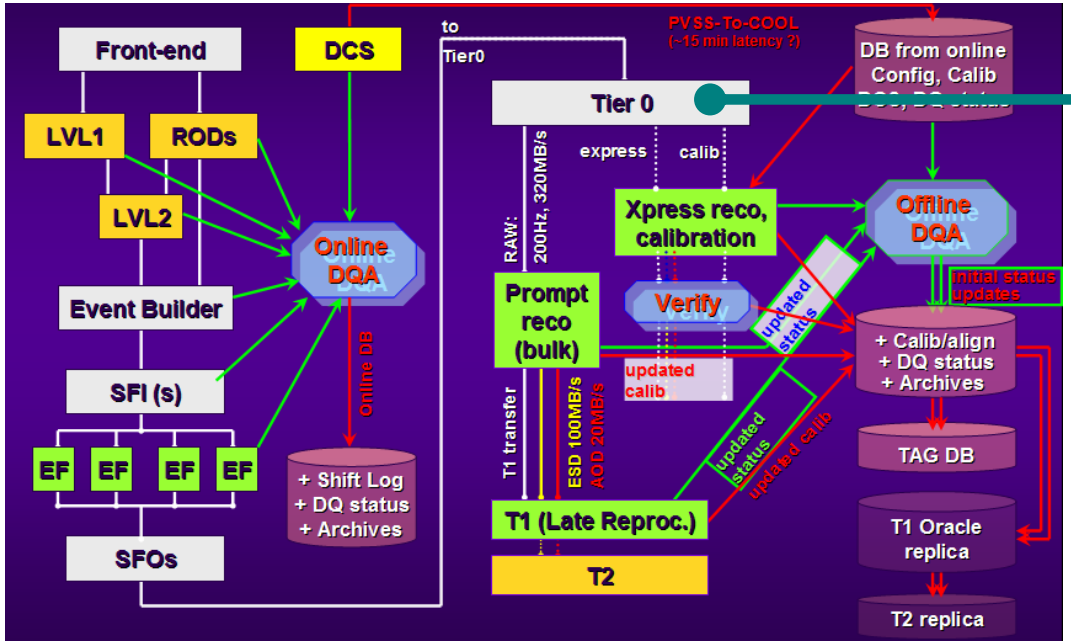
The production of a W or Z boson in conjunction with jets is an interesting process in its own right as well as a signal channel (and background) for many interesting standard model and beyond standard model physics signals. Final states with 2,3,4 or more jets accompanying a W/Z boson will be observable at the LHC and will serve as a crucial part of the ATLAS physics program. The variety of possible jet multiplicities allows for precision tests of jet reconstruction algorithms and techniques. In addition, the reconstruction of leptons and of missing transverse energy becomes more complex in the presence of a multi-jet final state. In this note, we will quantify the differences of lepton, missing transverse energy and jet reconstruction with respect to that observed in inclusive W and Z production.

The wide kinematic range for production of W/Z + jets allows serves as a testing ground for perturbative QCD predictions, both fixed order alone and in conjunction with parton shower Monte Carlos. As an example, the possible large rapidity separations between pairs of jets allows for tests for the applicability and importance of BFKL-type logarithms.

U. Blumenschein & E. Segura (IFAE-Barcelona)

→ Already involved in ATLAS where our Tevatron experience pays off

DQM at ATLAS



- The success of the DQM model at CDF inspired ATLAS (also CMS) to adopt very similar solutions for quality monitoring activities
- ATLAS Management very much welcomes our participation on the existing DQM efforts (most natural involvement in required ATLAS service work)
- Our group will initially focus on Tier0 DQM activities at CERN
- Since Fall 2007 two members of our group (M. D'Onofrio, MMP) actively participate on ATLAS DQM work & FDR activities….more by summer 2008

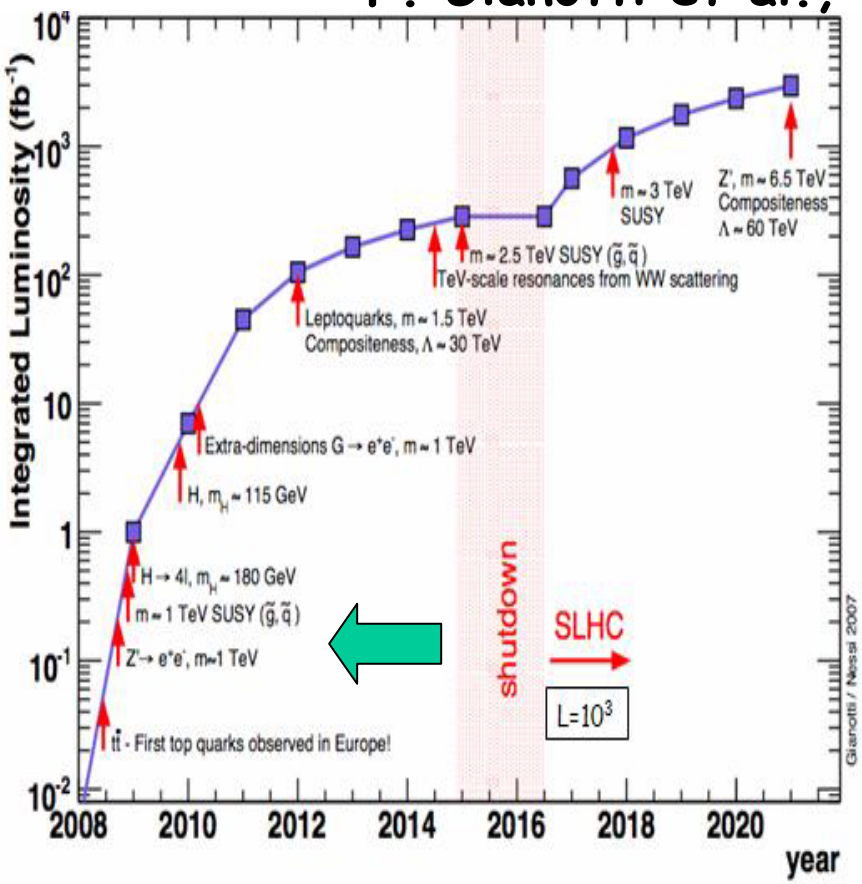
Initial Physics Program

- No surprise that our initial physics program at the LHC will be a natural continuation of our search activities in CDF (by construction)
  - Inclusive Jet Production and Quark Compositeness
  - Drell-Yan and Z+jets production
  - Search for Gluinos and Squarks
  - Top Physics
  - ….

→ some of the first analyses that will be carried out at the LHC as soon as the data becomes available…

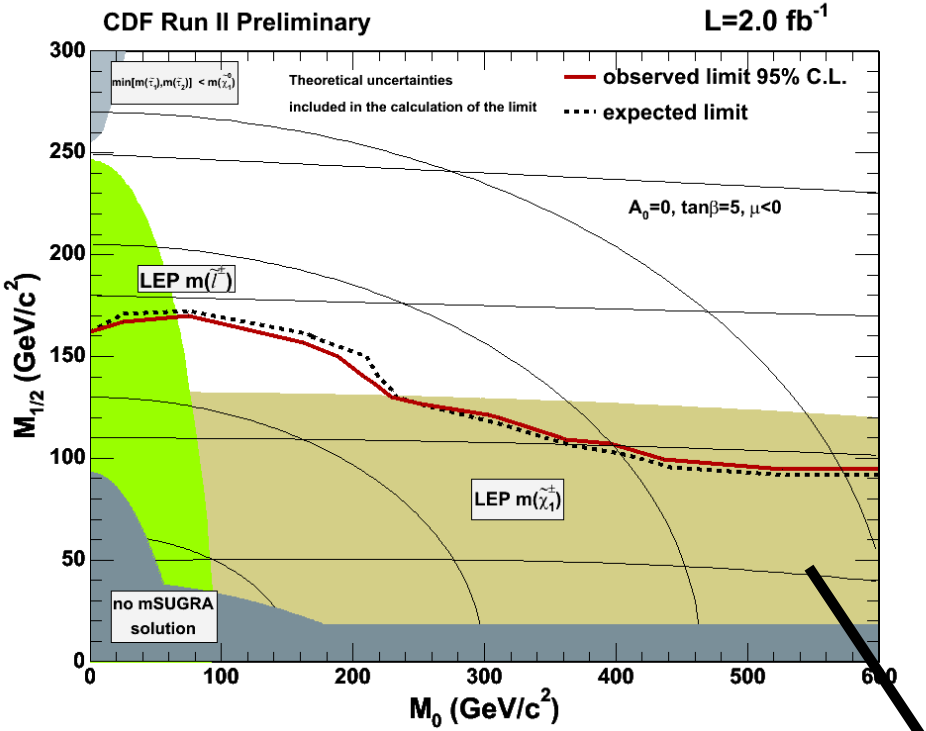
→ We merged efforts with the rest of IFAE-ATLAS group

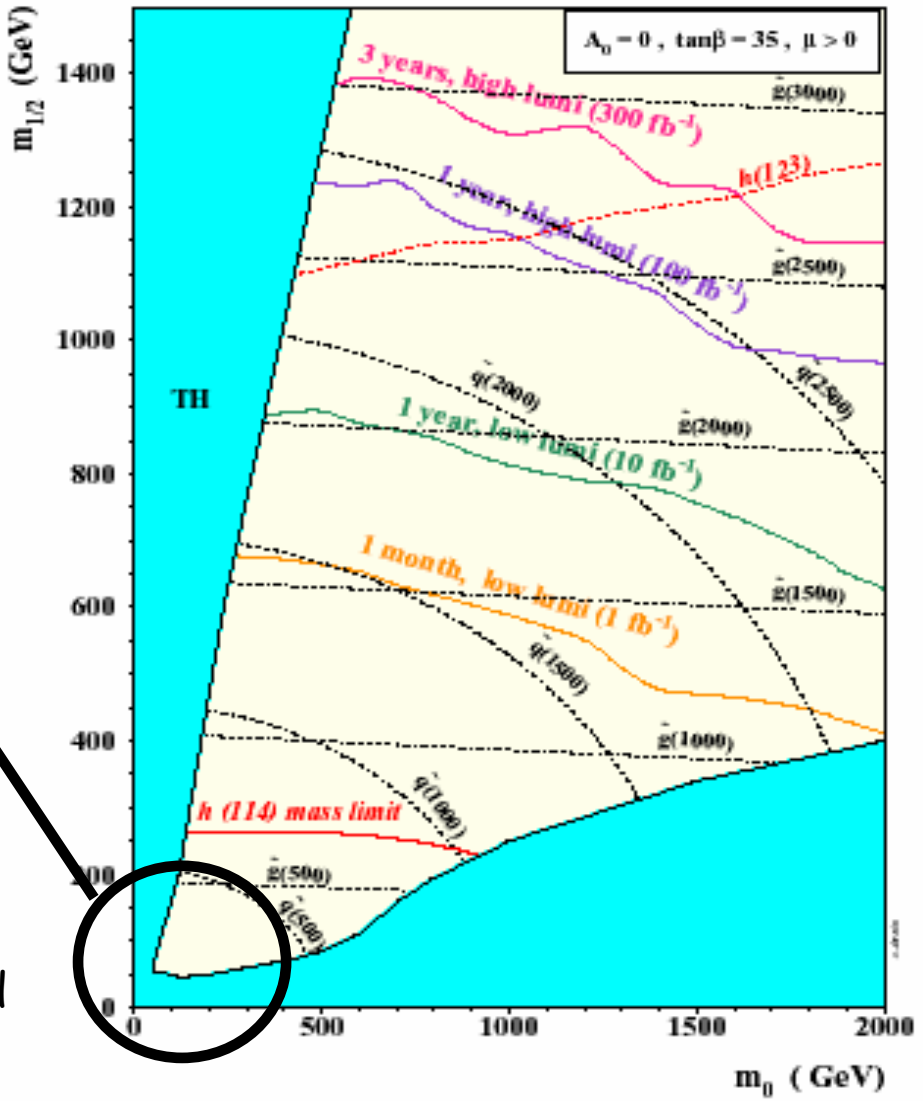
F. Gianotti et al.,



Follows expected lumi profile & understanding of physics objects in ATLAS vs time

SUSY Searches at the LHC





The LHC is built to discover SUSY
If there, we will find it relatively soon

But…we do not underestimate the commissioning phase and the work needed to understand the SM backgrounds (QCD-jets, top, Boson+jets….)

Computing

In CDF, keeping leadership on physics analyses
required adequate CPU & storage capabilities
(huge MC & data samples, NLO programs, endless SUSY scans..)

We built a small cluster in BCN (@ PIC) for CDF physics analyses

BCN DCAF @ PIC

Production CAF (Condor)

- 1 Server CAF -> Dual Xeon 2.4 Ghz
- 1 Server SAM -> Dual Xeon 2.4 Ghz
- 120 jobs in parallel (~300 kSI2k)
- ~24 TB of disk space (~12 TB at FNAL)
- A Technician takes care of it

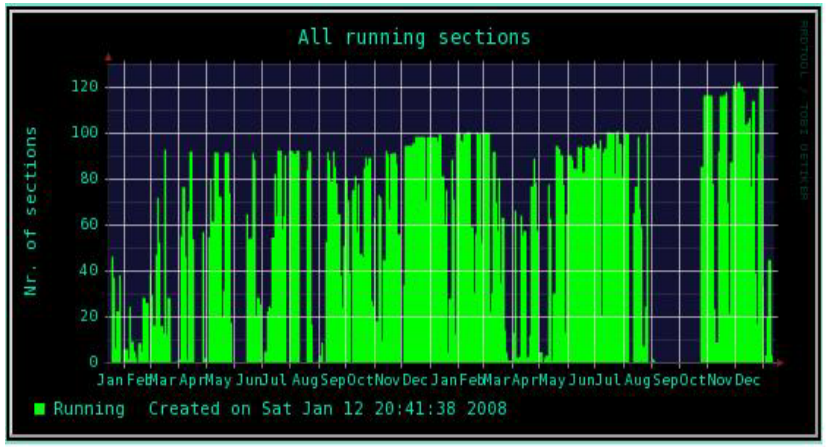
Modest in size but plays a fundamental role in all physics analyses of the group

→ CPU steadily increased thru years

Since almost 3 years the cluster is available to ALL CDF users…heavily used

Part of the hardware already 3-years old will require some replacement soon…

2-years period



Computing Needs for CDF/ATLAS

- Our physics analysis power will be determined by our "real" CPU and storage capacity
- Replacement & slightly increase of CPU & disk space necessary for CDF BCNCAF in 2009
- Tier1 and Tier2 LHC resources largely scheduled by Grid and ATLAS management
- Only about ~168 kSI2k from Tier2 devoted to physics analysis by 2009 (~430 kSI2k by 2011) assuming 50% of the resources assigned to IFAE
  - → as reported on March 08 Tier2 review
  - → clearly insufficient (see CDF numbers)
- We need a rather modest but highly available cluster for our ATLAS analyses (Tier3 like)
  - Analysis of data/MC root files
  - Generation of small Monte Carlo samples
  - Scan on parameter space (SUSY, etc..)
  - NLO and NNLO heavy calculations
- Investment/resources optimized by gradually redefining "CDF nodes" into "ATLAS nodes" (of course, we implemented same technology)

BCNCAF as seed for our Tier3 cluster

Budget

Notes on Budget (2009-2011)

- We present a **3-years project** to continue/complete our physics program in CDF and initiate an energetic activity on ATLAS together with the rest of the IFAE Group

- Essential to ensure the continuation of financial support for PostDocs on CDF/ATLAS to fulfill our commitments
  (we need **at the very least** to maintain the manpower level)

- Our physics analysis model relies on a steady increase of the available computing capabilities and an early definition of a Tier3-like cluster (consistent with increasing Tevatron luminosity and the arrival of the first ATLAS data in 2009)

- Our commitments and leadership on the physics analyses require a constant presence of manpower at Laboratories

Budget (I)

Personnel	Budget (€)	Comment
PostDoc Position	36.000	Essential for maintaining financial support for Alon Attal in 2009 (CDF based)
PostDoc Position	144.000	2 years, 2 positions (only replaces/continues existing manpower)
System Manager	36.000	critical to maintain software and operate DCAF @ PIC
TOTAL	216.000	

Budget (II)

Scientific Equipment	Budget (€)	Comment
30 nodes for CDF cluster at BCNCAF (10.8 kSI2k each)	60.000	Replace and/or increase cluster capacity for CDF analysis in 2009
15TB of disk on BCNCAF	15.000	Increase of Disk Capacity for CDF analyses en 2009
50 nodes for ATLAS cluster at BCNCAF (10.8 kSI2k each)	100.000	ATLAS Nodes to be installed in BCNCAF in 2009-2011
30TB of disk on BCNCAF	30.000	Disk space for ATLAS Physics Analyses and ATLAS DQM activities
Desktops (ATLAS)	14.000	Desktops at IFAE and CERN for ATLAS usage
RDSI/IP	9.000	FNAL-IFAE-CERN video connections
TOTAL	228.000	

IFAE-CDF Budget (III)

Trips/Per Diem	Budget (€)	Comment
Doctors Residents @ FNAL	36.000	1 year, 2 doctors
Doctors Residents @ CERN	72.000	2 years, 2 doctors
PhD. Students @ FNAL/CERN	108.000	2 years/student 3 students
Non-resident Doctors (trips to FNAL/CERN)	66.900	4 trips/year (~1 month duration) 3 doctors
TOTAL	282.900	

Budget (IV)

Running Costs Conferences	Budget (€)	Comment
CDF common funds	38.000	$6900/FTE/year (here we assume 50% dedication)
Communications in Conferences	45.000	Amount justified by CDF experience
TOTAL	83.000	

IFAE-CDF Budget (V)

Consumables *(fungible)*	Budget (€)	Comment
Desktops renovation in CDF in 2009	10.000	Renovation of some of PCs/Desktops in CDF
Miscellaneous	6.000	Small office expenses, etc…
TOTAL	16.000	

Summary Budget (3 years)

ITEM	Budget (€)	Fraction
PERSONNEL	216.000	26.2%
SCIENTIFIC EQUIPMENT	228.000	27.6%
TRIPS/PER DIEM	282.900	34.2%
RUNNING COSTS	83.000	10.0%
CONSUMABLES	16.000	2.0%
TOTAL	825.900	