# *GTeV: Gluon Physics at the Tevatron*

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# *GTeV: Gluon Physics at the Tevatron*

- A future experiment at the Tevatron
- 2009: CDF & D0 complete data taking
  - BTeV to run (if funded) 2009- ~ 2013 (?)
- Primary Goal of GTeV: QCD (perturbative & non-perturbative)
- Uses CDF or D0 detector as "core"
- Add precision forward and very forward tracking

# *Primary Goal: Understand Strong Interactions*

**Foci:**

**Gluon density g(x, Q2) at very low x**

saturation, unitarity, gluodynamics, non-perturbative frontier

**Pure Gluon jets**

profiles, content, color connection, gg compared to q-qbar jets

**Determine glueball spectrum**

Relates to pomeron trajectories, strings, lattice ...

**Measure exclusive** $\chi_c^0, \chi_b^0$

Relates to Higgs study at LHC

**Discover new exotic hadrons**

Hybrids, 4-quark, pentaquarks, ...

**Search for exotic fundamentals**

CP-odd H, Radions, gluinoballs ...

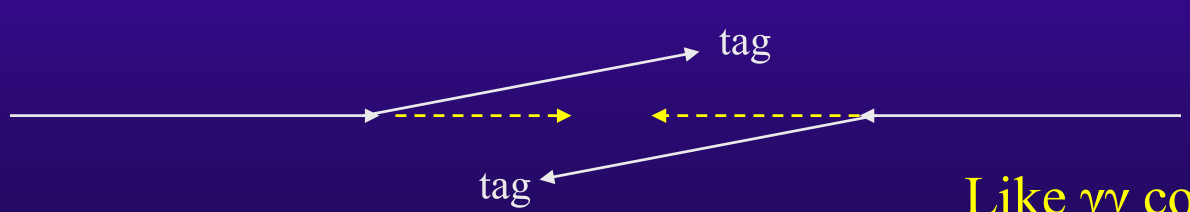
# Use Tevatron as Tagged Glue-Glue Collider

$$\sqrt{s_{gg}} = \sim 1\,\text{GeV} \Rightarrow \sim 100\,\text{GeV}$$

$\sigma_{\sqrt{s}} \sim 100$ MeV ⟵ (Stretch Goal)

Glueballs and Hybrids
New Exotic Hadrons
chi_c and chi_b states
Hunting strange exotic animals (radions, ...?

Everywhere: **Gluodynamics**, perturbative and non-perturbative issues




Like γγ collider in LC

# The REAL Strong Interaction

extended, strong coupling
non-perturbative

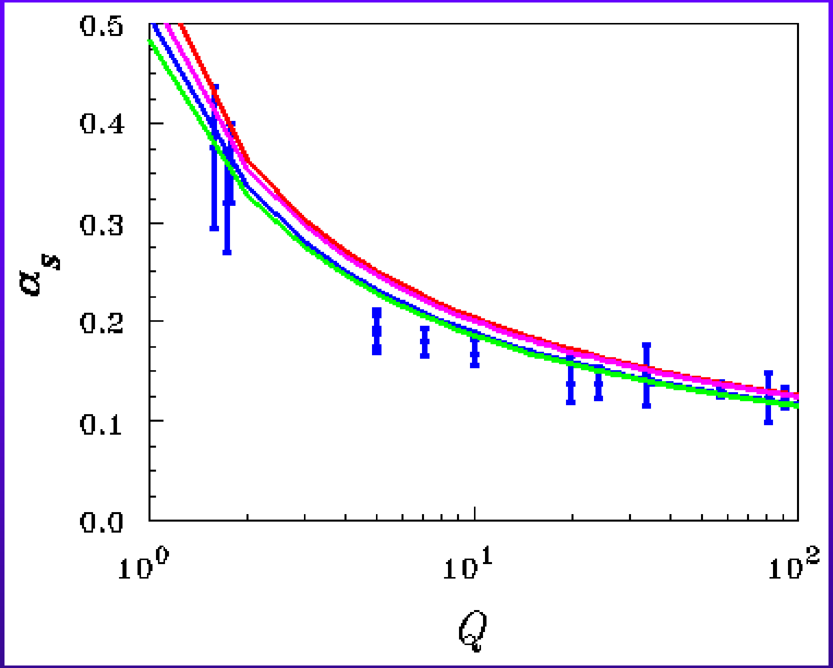
point-like, weak coupling
perturbative

Many approaches, none complete:

→ Lattice Gauge Theory
Small volume, hadron size

→ Regge Theory: Analyticity + Unitarity + Crossing Symmetry + Complex angular momenta

→ String models




**Want a complete understanding of S.I.**

$Q^2 = 0 \rightarrow \infty$

**Non-perturbative – perturbative transition**

Some of proposed program could be done now, except:

1) Do not have 2-arm forward p-taggers (dipole spectrometer)
2) Small angle ( < 3 deg) region now trackless
3) Limit on number of triggers
4) Bandwidth allocated small

**60 Hz → 250 Hz → > 1 KHz for 2009 [ $10^{10}$ /year]**

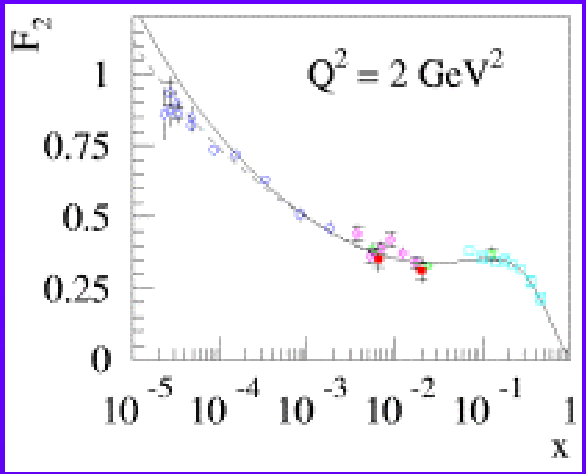
CDF, D0: NP QCD <~ 10%, other ~ 90%

**GTeV: QCD ~ 90%, other (?) <~ 10%**

& upgrade of forward and very forward detectors

# Probing Very Small x Gluons

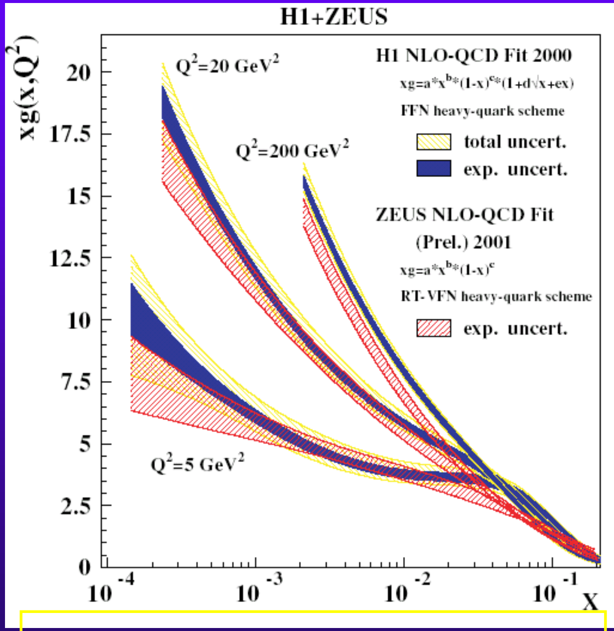
High parton densities
New phenomena (gluon saturation)
HERA measures q(x) to ~ 10^-5
g(x) by evolution, charm
GTeV : measure g(x) to ~ few 10^-5
(also x >~ 0.5) more directly




$$x_1 = \frac{p_T}{\sqrt{s}}\left(e^{y_1} + e^{y_2}\right) \quad ; \quad x_2 = \frac{p_T}{\sqrt{s}}\left(e^{-y_1} + e^{-y_2}\right)$$

e.g. $\sqrt{s}$=1960 GeV, $p_T$ = 5 GeV, $y_1 = y_2$ =4 ($2.1^0$)

$$\Rightarrow \qquad x_1 = 0.56,\ x_2 = 10^{-4}$$




Instrument $0.5^0 < \theta < 3^0$ region with tracking, calorimetry (em+had), muons, $J/\psi$
jets, photons ...

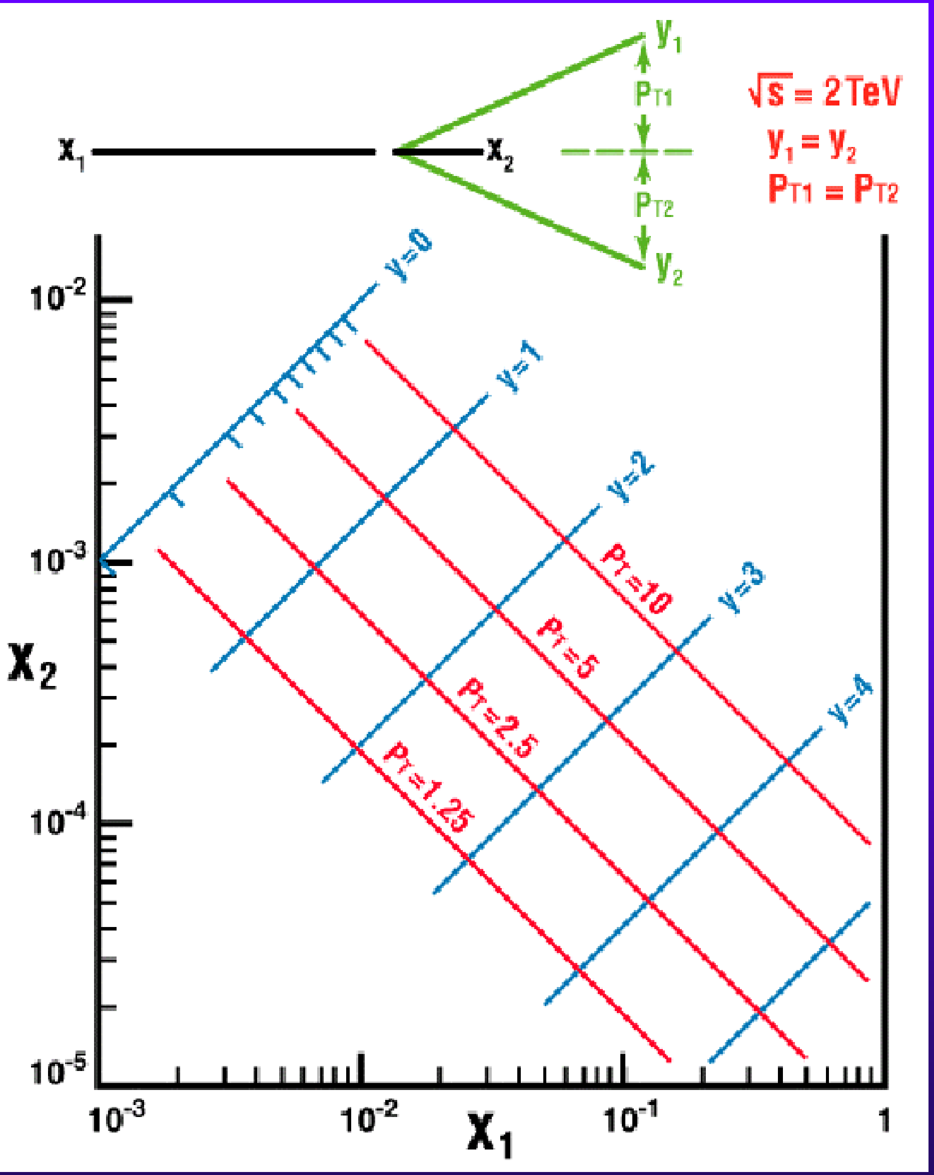
*@ Q2~ 1 GeV^2 <~ 0!?*

# *Low-x*

Mapping:

partons' $x_1, x_2$ to

jets' $y, p_T$ for $y_1 = y_2$




Forward $D\bar{D}$ probably best for lowest x gluons.

BTeV may do this.

# Gluon Jets

LEP(Z) ... ~ 10^7 q-jets, detailed studies

"Pure" g-jet sample: 439 events (OPAL), Delphi more but 80% "pure"

$e^+e^- \to Z \to b\,\bar{b}\,g$ g-jet contaminated at low-x

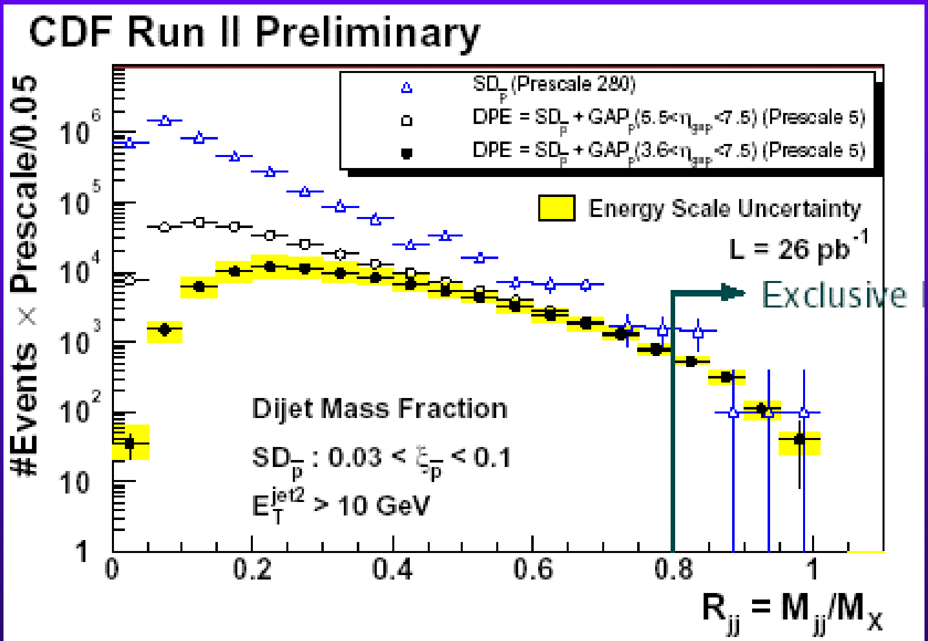
In $pp \to p$ JJ $\bar{p}$ with $M_{MM} \approx M_{JJ}$

(2 jets and ~ nothing else)

~ 99% pure g-jets

q-jets suppressed by Jz = 0 rule

**~ $10^5$ pure g-jets**

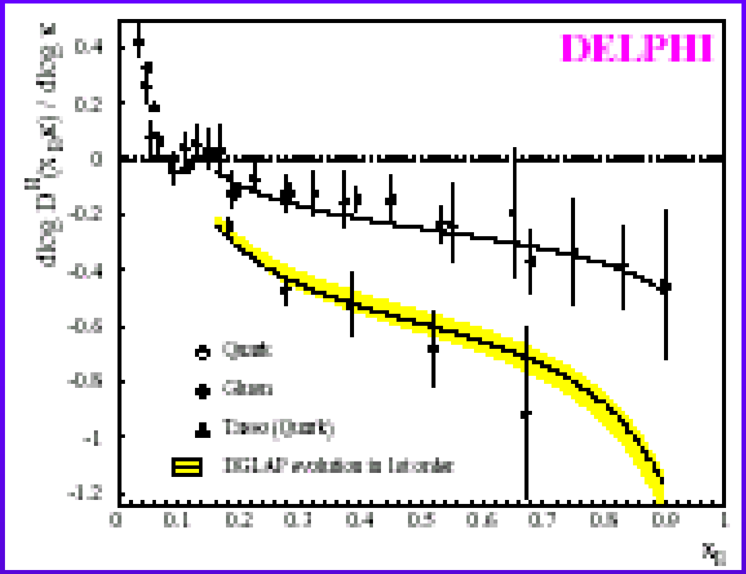



Fragmentation, scaling

color singlet back-to-back gg jets: DPE unique

# *Gluon Jets: Scaling violations in Fragmentation*

Gluon jet fragmentation and scaling violations different from quark jets.




Measure ~ pure gluon jet fragmentation from Q^2 ~ 400 GeV^2  to 10,000 GeV^2

For x ~ 1 ratio of log derivatives = ratio of g and q color charges: $\frac{C_A}{C_F} = \frac{9}{4}$

g-jets wider $\delta_g = \delta_q^{C_F/C_A = 9/4 = 2.25}$

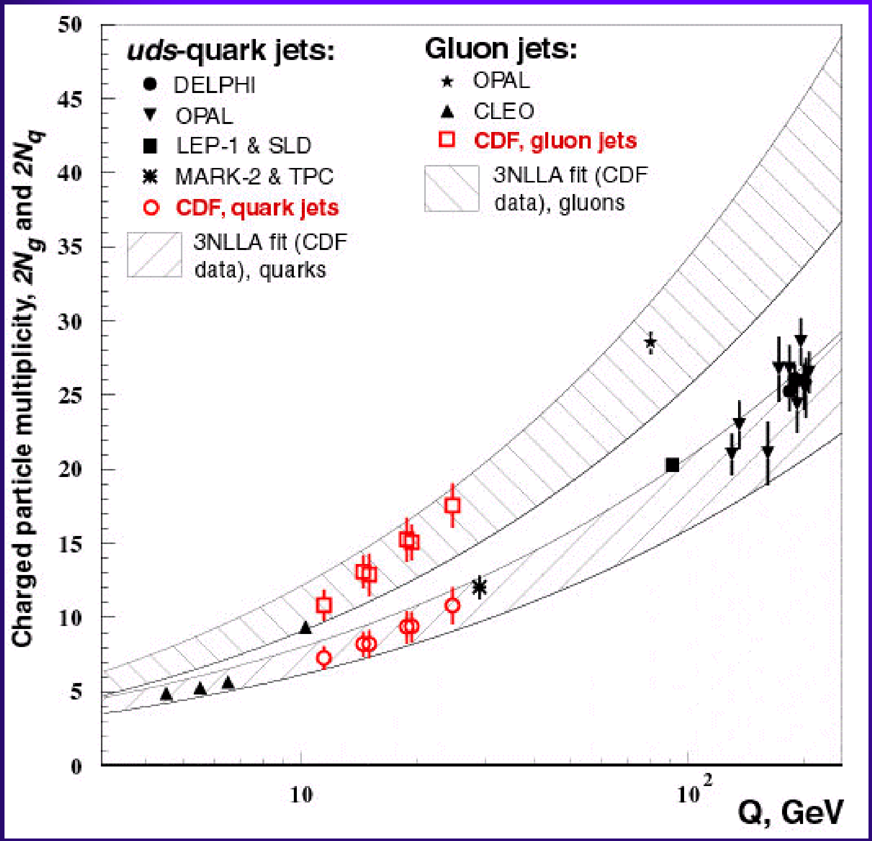
softer, higher n, larger n-fluctuations

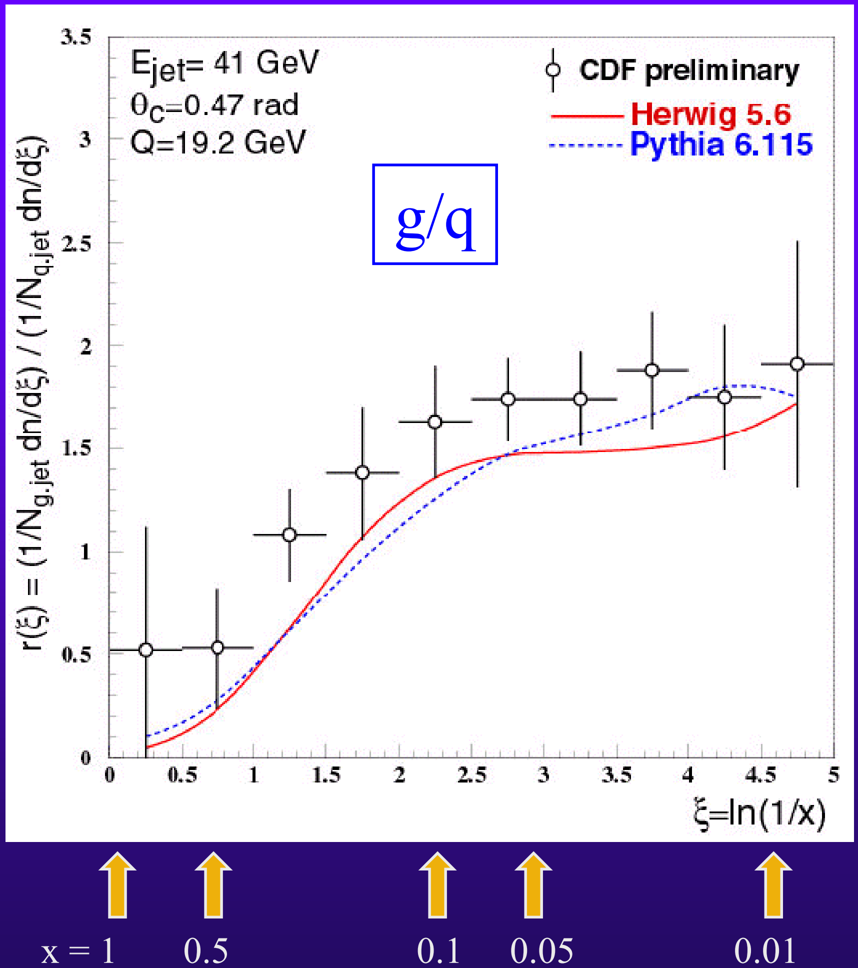
QCD uniquely defines color singlet back-to-back gg jets: DPE unique

# Gluon Jets: Purity and High Statistics

Comparing jet-jet and photon-jet **(CDF)**

CDF note 6809



# *Central Exclusive Production*

... or, diffractive excitation of the vacuum

> ***"It is contrary to reason to say that there is a vacuum or a space in which there is absolutely nothing."*** ***Descartes***

→ Virtual states in the vacuum can be promoted to real states by the glancing passage of two particles.

Charged lepton (or q) pairs : 2-photon exchange
Hadronic states : 2-pomeron exchange (DPE) dominates

Vacuum quantum number exchange.
Central states' quantum numbers restricted.
Measure forward p,pbar → missing mass, Q-nos.

Ideal for Glueball, Hybrid spectroscopy

| $I^G$ | $J^{PC}$ (DPE) | |
|---|---|---|
| $0^+$ | $0^{++}$ | ← |
| $0^+$ | $0^{-+}$ | Not at $0^0$ |
| $0^+$ | $1^{-+}$ | Not at $0^0$ |
| $0^+$ | $1^{++}$ | Not at $0^0$ |
| $0^+$ | $2^{++}$ | ← |

# *Gluonia and Glueballs*

## Hadrons G without valence quarks

Allowed in QCD – or, if not, why not ?

Some can mix with $q\bar{q}$ mesons

Some have exotic quantum numbers and cannot $J^{PC} = 0^{--}$, even$^{+-}$, odd$^{-+}$

Glue-glue collider ideal for production (allowed states singly, others in association GG', G + mesons.)

Forward $p\bar{p}$ selects exclusive states, kinematics filters Q.Nos :

Forward protons: $J^P = 2^+$ exclusive state cannot be non-relativistic $q\bar{q}$ ($J_z$=0 rule)

Exclusive central states e.g. $\phi\phi \to 4K, \pi\pi KK, D\bar{D}^*, \Lambda\bar{\Lambda}$, etc

Other processes:

- $\pi^- p \to [\phi\phi] + n$
- $J/\psi \to \gamma + G$ $\quad$ $e^+e^- \to J/\psi, \Upsilon + G$
- $p\bar{p}$ (low $\sqrt{s}$) $\to G$ + anything
- $gg \to G, GG, G$+anything

This one →

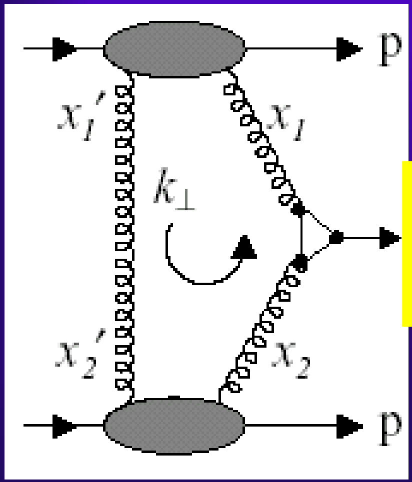
# Central Exclusive Production

gg fusion: main channel for H production.

Another g-exchange can cancel color, even leave p intact.

p p → p + H + p

Theoretical uncertainties in cross section, involving skewed gluon distributions, gluon k_T, gluon radiation, Sudakov form factors
→Probably $\sigma(SMH) \sim 0.2$ fb at Tevatron, not detectable, but may be possible at LHC (higher L and $\sigma \sim 3$ fb?)




u-loop : $\gamma\gamma$ c-loop : $\chi_c^0$
b-loop : $\chi_b^0$ t-loop: H

Theory can be tested, low x gluonic features of proton measured with exclusive $\chi_c^0$ and $\chi_b^0$ production.

Khoze,Martin,Ryskin hep-ph/0111078
Lonnblad & Sjodahl hep-ph/0311252
and many others

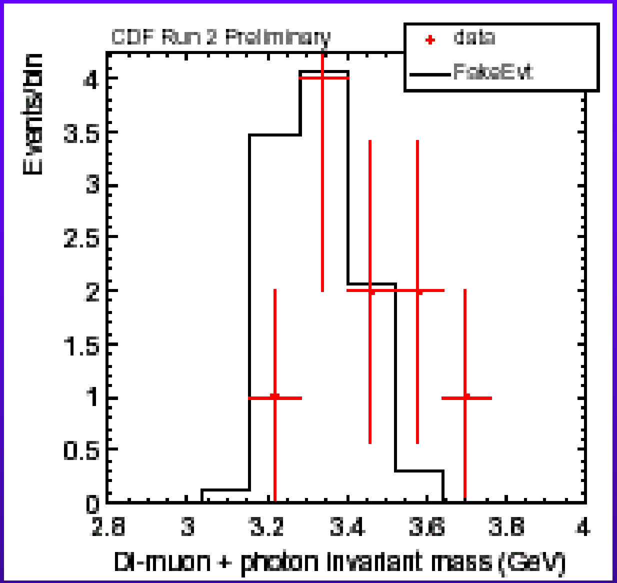
# Exclusive $\chi_c$ search in CDF : $p\,\bar{p} \rightarrow p \quad \chi_c \quad \bar{p}$

Predictions for Tevatron: Khoze, Martin, Ryskin ~ 600 nb
Feng Yuan ~ 735 nb (20 Hz at Tevatron!)

In reality: $BR(\chi_c^o \rightarrow J/\psi\,\gamma) \sim 10^{-2}$; $BR(J/\psi \rightarrow \mu^+\mu^-) \sim 6.10^{-2}$

No other interaction ~ 0.25; acceptance(trig) ~ $10^{-2}$

$\Rightarrow$ few pb (1000's in 1 $fb^{-1}$)

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$\sigma(p\,p \rightarrow p \quad \chi_b \quad p) \sim 120$ pb (KMR)

$\times(BR \rightarrow \Upsilon\gamma)\times(BR \rightarrow \mu\mu\gamma) \Rightarrow \sim 500/fb^{-1}$

Measuring forward p → central quantum numbers

$J^P = 0^+$ ; 2++ suppressed at t=0 for $q\bar{q}$ state

(Khoze,Martin,Ryskin hep-ph/0011393; F.Yuan hep-ph/0103213)

**If MM resolution <~ 100 MeV, exclusive test, resolve states**

# CP-Odd Higgs at Tevatron?

In SUSY can have CP-violation in Higgs sector
Higgses are CP-odd & CP-even mixtures
CP-odd component does not couple to W,Z
→Even if M ~ 40 GeV would not have been seen at LEP
Allowed regions ~ 20-60 GeV, tan beta ~ "few"
→Will not be seen by standard associated WH,ZH at Tevatron, LHC

Production through gg → top loop → H not suppressed
But b-bbar b/g large too.

Missing Mass resolution is critical !!
~ 250 MeV, then Low $\beta \Rightarrow$ Medium $\beta$ $\sigma_{MM} \approx 100$ MeV
(z,t) correction $\approx$ ?

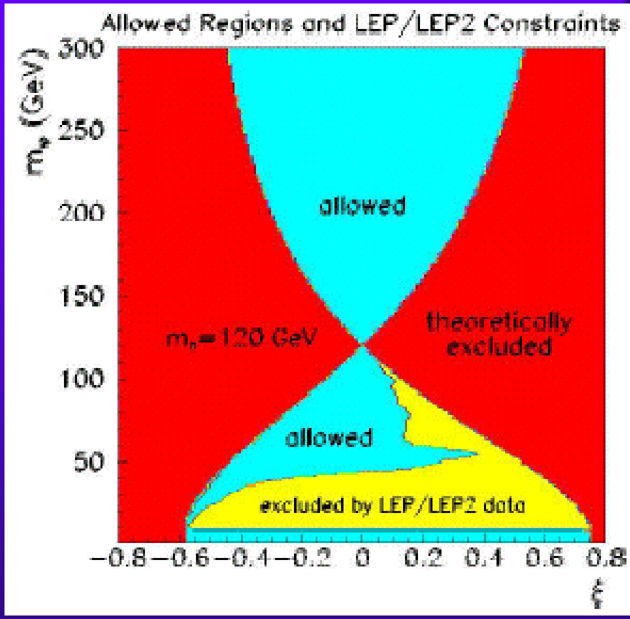
(30 ps timing in pots → where p,pbar are in bunches)

# *Radions?*

Randall & Sundrum: SM fields on 4D brane, gravity on another displaced in 5$^{th}$ dimension. Heirarchy problem solvable.

Quantum fluctuations in 5$^{th}$ dimension: tensor + scalar RADIONS
"Graviscalar"
Radions can be much lighter than O(TeV)
..... even ~ 20 GeV if parameters right.

Couplings similar to Higgs and can mix with h
But direct coupling to gluons allowed.
gg → r dominant at Tevatron
BR (r → gg) ~ 75%, (r → bb) ~ 25% low masses
Width ~ keV




Dominici et al.
hep-ph/0206192

ξ: mixing parameter with h

# *Light Gluinos and Gluinoballs*

A.Mafi and S.Raby hep-ph/9912436

Gluino $\tilde{g}$ could be lightest SUSY particle LSP
Does not decay in detector --- forms heavy hadrons
Can form $\tilde{g}\tilde{g}$ bound states "gluinoballs"
Expect a spectrum of excited states --- lightest is $\tilde{G}\ 0^{++}\ ({}^3P_0)$
25 GeV < $\mathcal{M}(\tilde{g})$ < 35 GeV not ruled out

Cross section for exclusive production at Tevatron sizeable:
Khoze, Martin and Ryskin hep-ph/0111078:

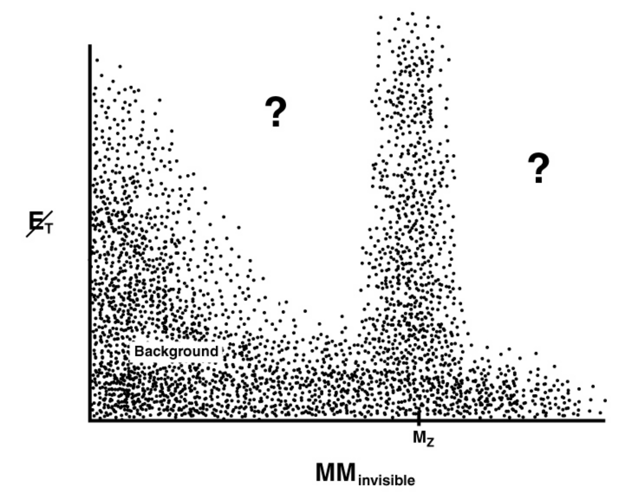
$$\sigma(p\bar{p} \to p + \tilde{G}(60\mathrm{GeV}) + \bar{p}) \approx 20\mathrm{fb}\ (\mathrm{Tevatron})$$

But S:B small : MM resolution !! Angular cuts, ...

# *Missing Mass!*

$$MM^2_{central} = (p_1 + p_2 - p_3 - p_4)^2 \quad (4 - \text{vectors})$$

$$MM^2_{invisible} = (p_1 + p_2 - p_3 - p_4 - \Sigma_{rest} p_i)^2$$




Peak at $M_Z$ for $Z \to \nu\bar{\nu}$

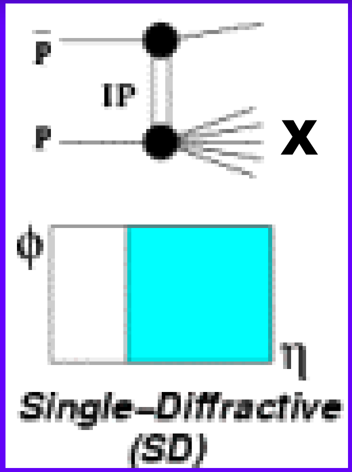
ET as 3rd axis?

Extreme case of rest of detector completely empty
No MM peaks "expected"
But threshold bump → pair production of e.g. LSPs
Needs measurement of all forward particles
Tracking + calorimetry + dipoles (?)

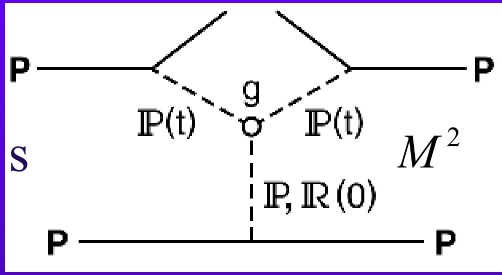
# Single Diffractive Excitation

$$\sigma_{inv} = \frac{m_0^2}{16\pi^2}\frac{1}{s}\sum_{iij} G_{iij}(t)\left(\frac{s}{M^2}\right)^{2\alpha_i(t)}\left(\frac{M^2}{m_0^2}\right)^{\alpha_j(0)} + \ldots$$

s-dependence at various fixed t, $M^2 \Rightarrow \alpha_i(t)$




System X can be soft (all low pT)
or hard (jets, W, Z).
HERA-Tevatron difference – universal screening?
Pomeron trajectory probably different for
hard and soft systems. Similar seen at HERA in

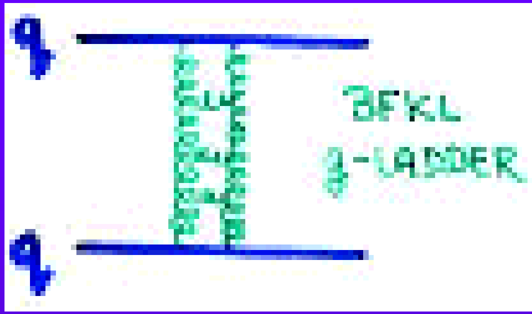



$\gamma^* p \rightarrow \rho \quad p$ (soft) and $\gamma^* p \rightarrow \psi/\Upsilon \quad p$ (hard)

Systematic study of trajectories, needs s-dependence
→ run at sqrt{s} = 630, 900, 1300, 1960 GeV
(~ log spacing, modest runs at lower sqrt{s})

# BFKL and Mueller-Navelet Jets

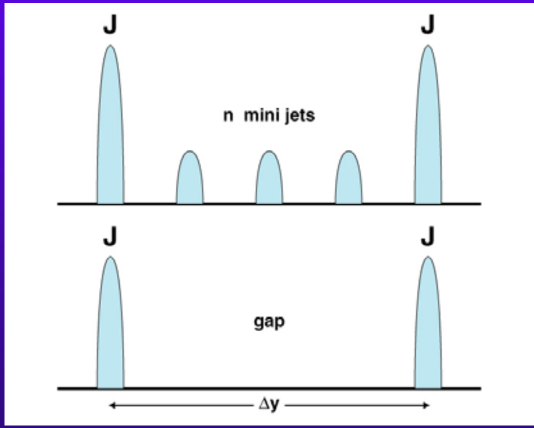
Color singlet (IP) exchange between **quarks**
Enhancement over 1g exchange – multiRegge gluon ladder
Jets with large y separation
n minijets in between (inelastic case)
large gap in between (elastic case)




Cross section enhanced $\left(\frac{s}{t}\right)^{\omega}$

$$\omega_{BFKL} = \frac{4N_c \ln 2}{\pi}\alpha_S \approx 0.5 \text{ for } \alpha_S = 0.19$$

$$\bar{n} \sim \omega \ln\left(\frac{s}{t}\right) \sim 3-4$$

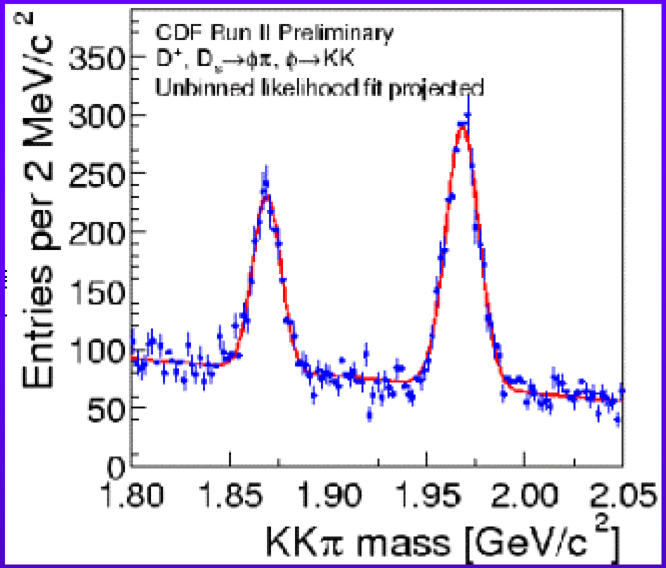



Measure fn($\eta$, $p_T$, $\sqrt{s}$, $\Delta\eta$)

Fundamental empirical probe of new regime:
non-perturbative QCD at short distances.

# *Non-Diffractive Events*

**Inclusive production of many hadrons (pT, y)**




$J/\psi$, $\chi^{0,1,2}$, $\Lambda_c$ ... $\Omega_{ccc}$ (!)

$B^{\pm}$, $B^0$, $\Upsilon^{',...''}$, $\Lambda_b$ --all B baryons

X(3872), pentaquarks and partners

Glueballs, hybrids, ...

11.6 pb^-1

**Search for new and rare states for hadron spectroscopy, lifetimes, production mechanisms ...**

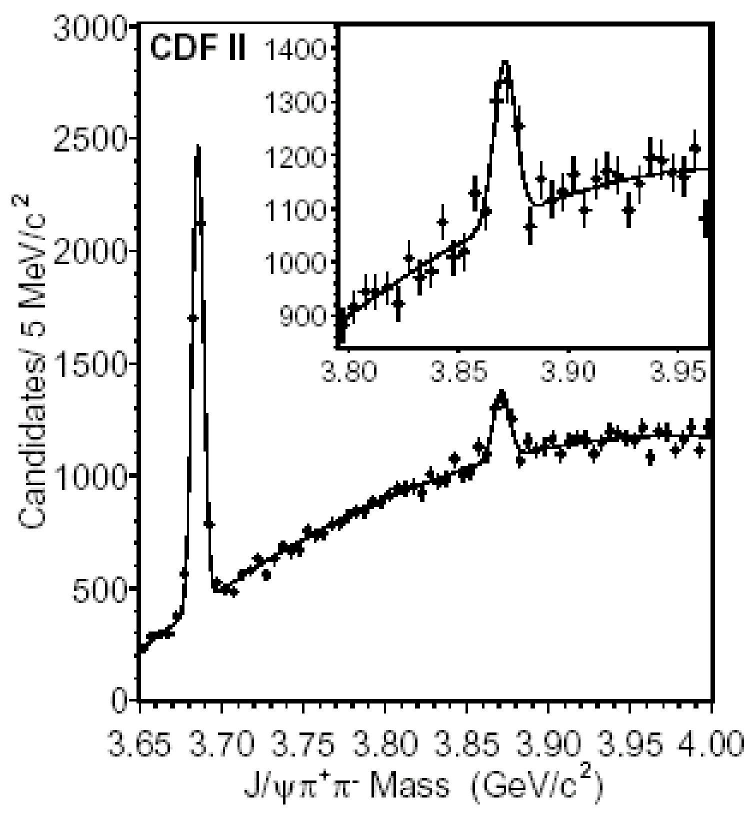
**Important for understanding NP QCD**

# *Hadron Spectroscopy: an example*

X(3872) discovered by Belle (2003)
Seen ~ 1 week after by CDF!
Relatively narrow

$$M_{X(3872)} - M_{J/\psi} - 2M_{\pi} = 495 \text{ MeV}$$

$$\Gamma < 3.5 \text{ MeV}$$




What are its quantum numbers?
Why so narrow? What is it?

$D\bar{D}^*$ "molecule" ? or $[\{cd\} \Leftrightarrow \{\bar{c}\bar{d}\}]$ state ?

If we see it in exclusive DPE:

$I^G J^{PC}$ (DPE)

$0^+0^{++} \Rightarrow$ favored

$0^+0^{-+}, 0^+1^{-+}, 0^+1^{++} \Rightarrow$ not at 0°

$0^+2^{++} \Rightarrow$ not $q\bar{q}$

Also, cross-section depends on “size/structure” of state.

# *Hyperons Y and heavy flavor baryons*

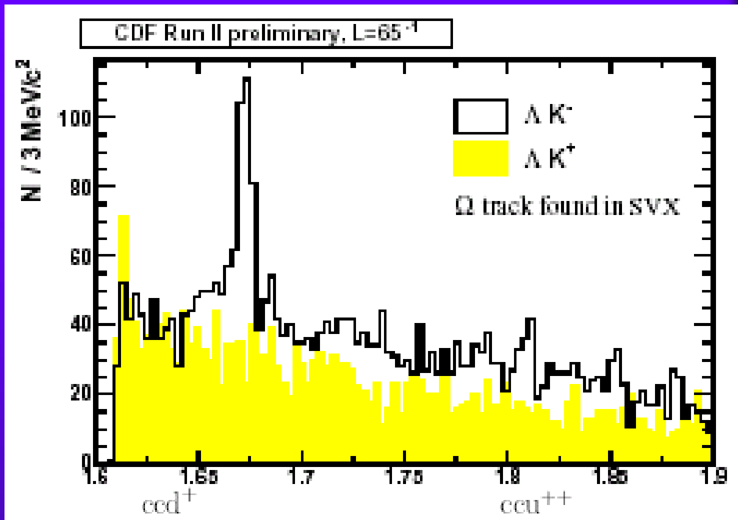
$\Lambda[uds]\ \Xi[dss]\ \Omega[sss] \Rightarrow \Lambda_c[udc]\ \Xi_c[dsc]\ \Omega_c[ssc] \Rightarrow\Rightarrow \Omega_{ccc}[ccc]$

Nice hyperon signals in Run 2 data
with 2-track trigger.
"High" p_T ... small acceptance.
Looking now in 0-bias data.

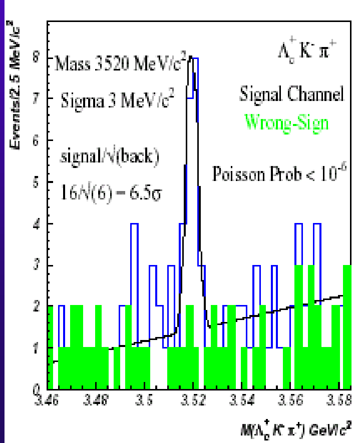
Best hope of finding most exotic states
Main competition is BTeV
Measure masses, lifetimes, BR's

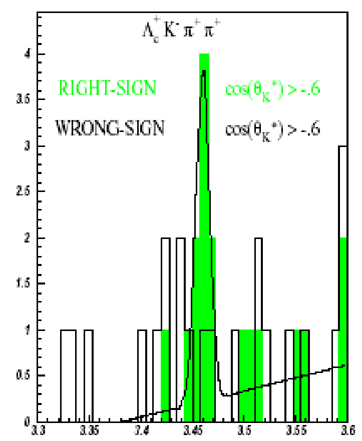
Pentaquarks: $\{ud\}\{ud\}\bar{s}$, $\{ss\}\{su\}\bar{d}$, $\{ud\}\{ud\}\bar{c}$, $\{ud\}\{ud\}\bar{b}$, etc

$\Omega^-$ and $\bar{\Omega}^+$ (




SELEX: doubly charmed baryons →



# *Stringy Hadrons*

*Topological mnemonics?*

Mesons, Hybrid, Glueball,
Baryon, Antibaryon

Baryonium: 2 types?

Exotics:
e.g. Pentaquarks

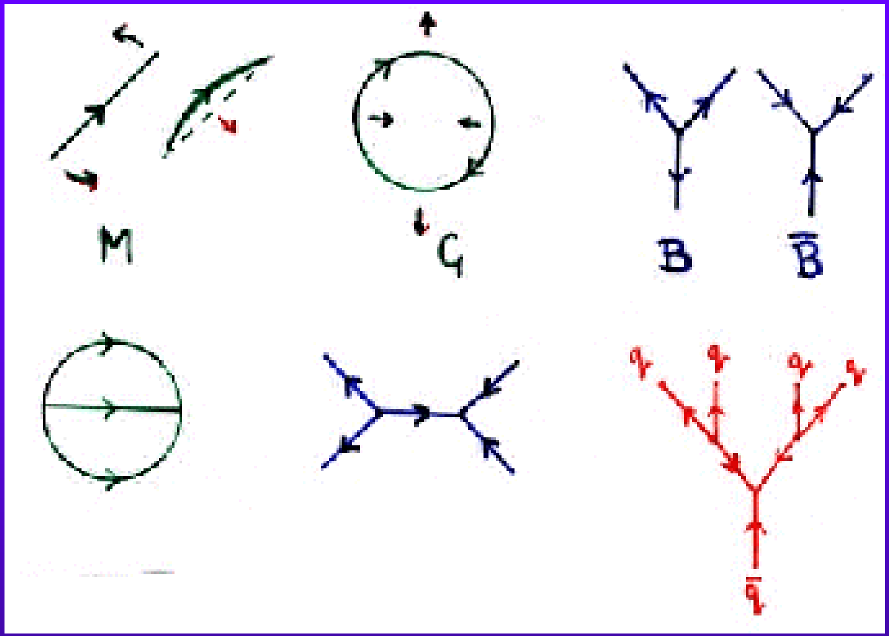
$\theta^+(1540) \rightarrow nK^+, pK^0$

$us\ \ us\ \ \ \bar{d} \rightarrow \Sigma^+K^0, \Xi^0\pi^+$

$ds\ \ ds\ \ \ \bar{u} \rightarrow \Sigma^-K^-, \Xi^-\pi^-$

$\theta_c, \theta_b = ud\ \ ud\ \ \ \bar{c}/\bar{b} \rightarrow pD^-, nD^0$ *etc*

Meson Hybrid Glueball Baryons




Baryonium Pentaquarks ?

# Exotic Baryons

There are many baryons with strange and charmed quarks.

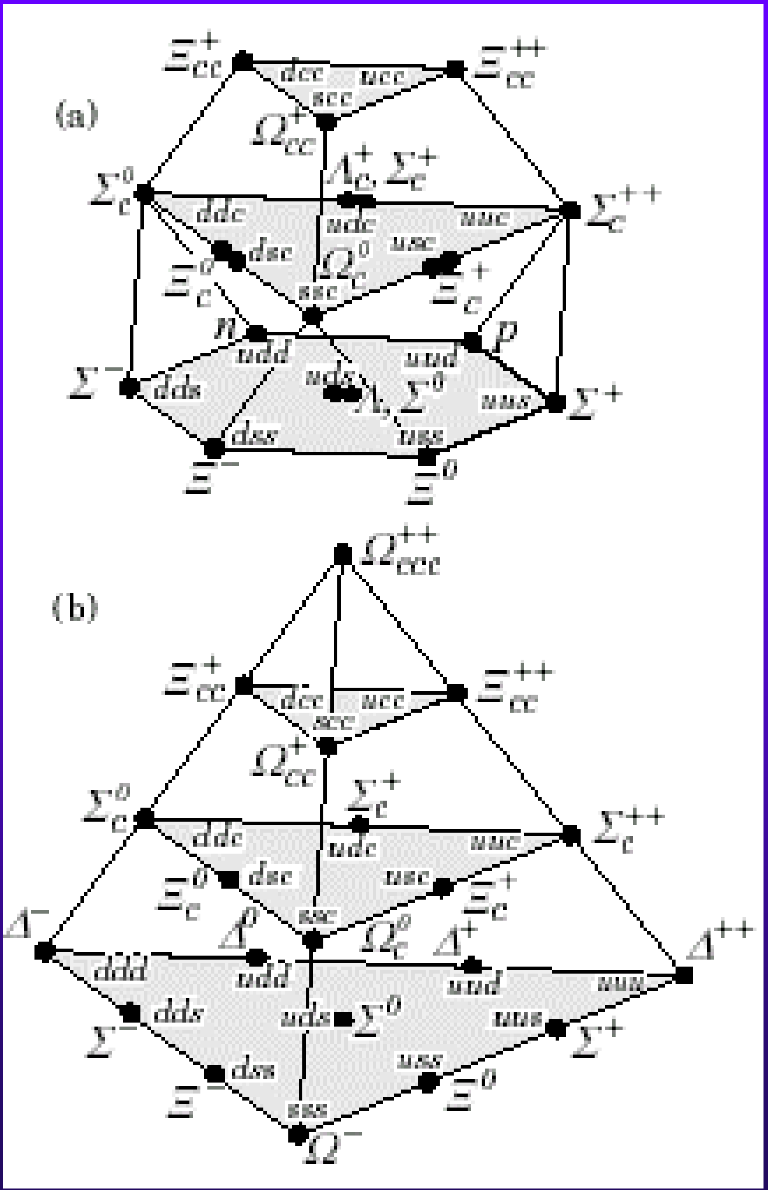
Many not yet seen (ccc)

To say nothing of the b's:
bcs, bbc, bbb

Can you think of any better way of producing and studying these than GTeV with 10^10?

Not just stamp collecting, hadrons test non-perturbative QCD (Lattice or otherwise)

**Even without b-hadrons:**



# ***Bjorken: Low pT is the frontier of QCD***

As pT drops from **200 → 100 → 50 MeV** what happens?
Larger distances: 1 f → 4 fm
How do gluon fields in protons “cut off” ?

Multiplicity distributions of very low pT particles, correlations, ...
Low-pT cloud in special events

[Runs with reduced field, Si-only tracking, etc
..................absorption and multiple scattering is the limit]

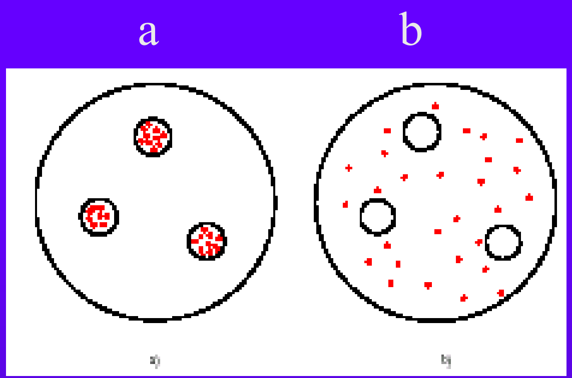
Large impact parameter, b collisions

RHIC AA can measure b, how can we? Diffraction at small t

# Multiple Parton Scattering

$f(x,Q^2) \rightarrow$ longitudinal structure of q,g/p

Transverse structure not studied at all!




Infinite sea of partons as x →0

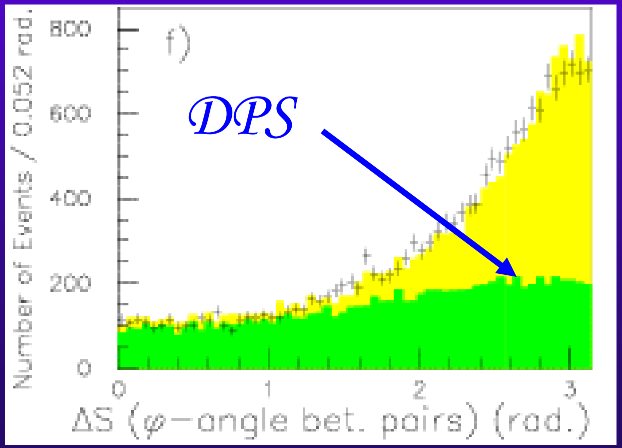
Cluster around valence quarks or uniform ?

x-dependent distribution ?

Correlations in nucleon wave function

Relates to proton decay

CDF →




DPS = double parton scattering:

pair-wise balancing

4 jets (or photon + 3 jets, or DY + 2-jets ...)

Minijets ~ 5-10 GeV

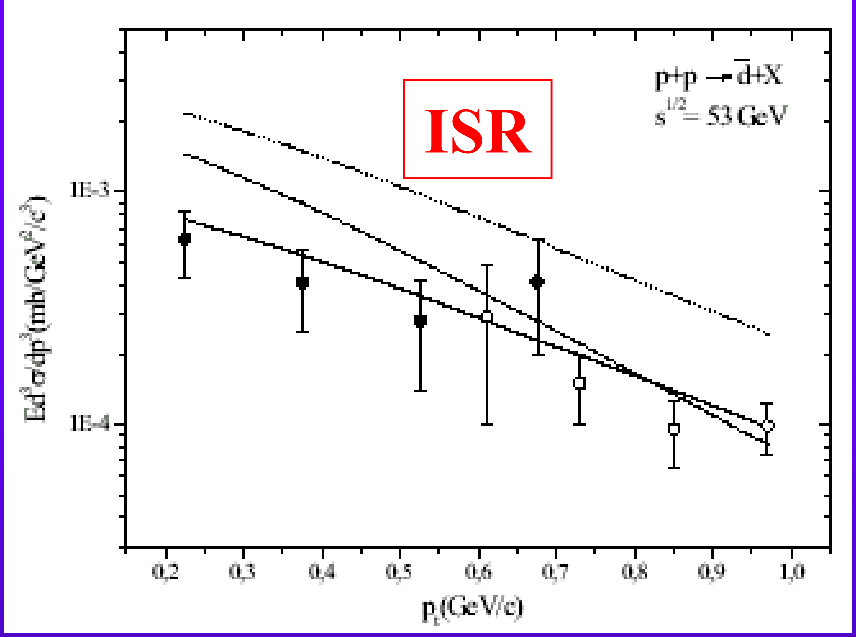
Results ("crude" from ISR, SPPS, Tevatron)

# *Antinuclei* ... just for fun?

$\bar{d}$ observed in pp $\sqrt{s}$=53GeV and in pA and AA

$\bar{t}$, anti-$He_3$ seen in beam (1974,Russian paper;

Na52 Pb-Pb: $10^6$ $\bar{p}$, $10^3$ $\bar{d}$, 5 $\overline{He}_3$, 0 $\bar{t}$ )




Coalescence model:
Overlap of wave-functions:

$$\bar{p}\,\bar{n} \rightarrow \bar{d}$$

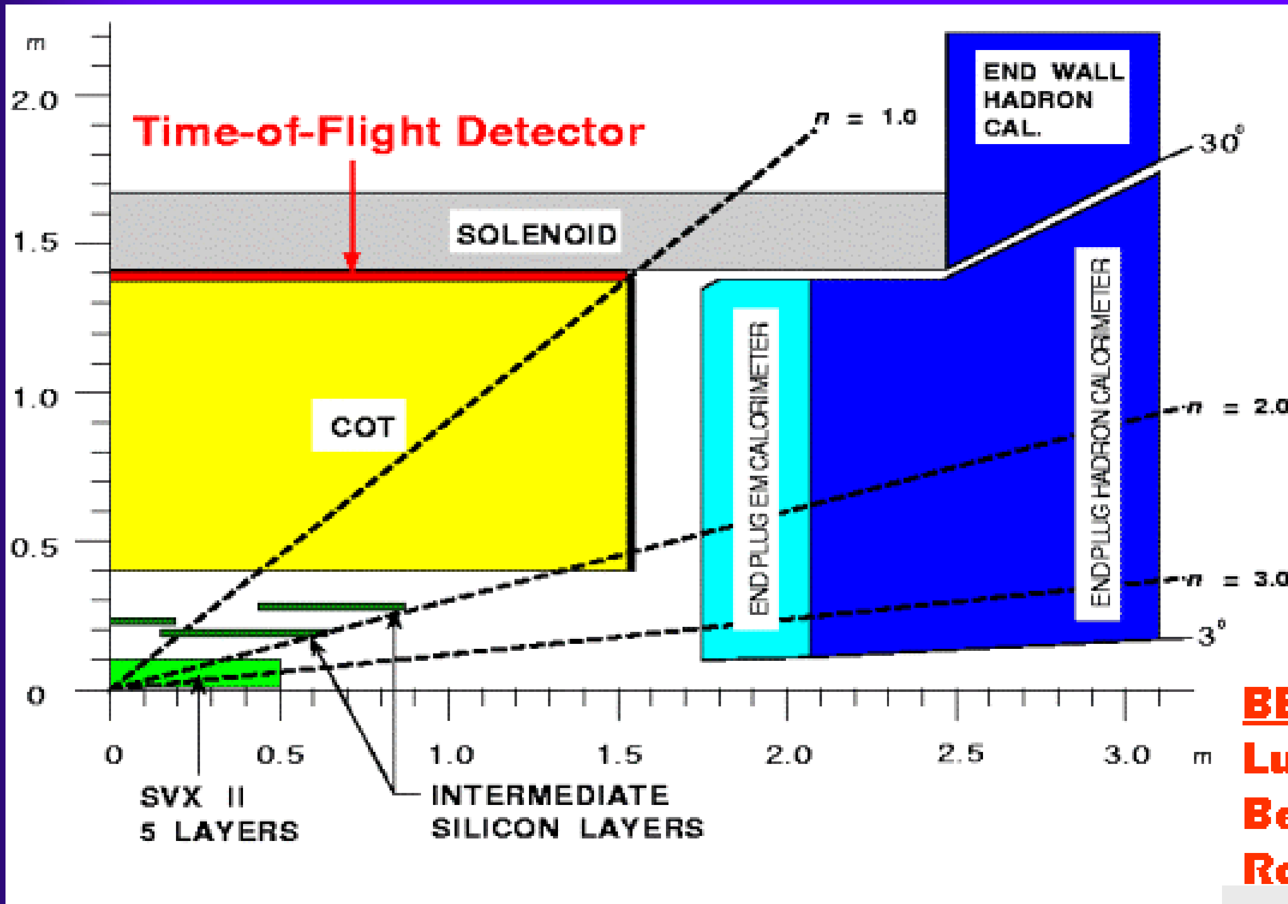
ISR:

$$\frac{\bar{d}}{\pi^-} = 7.6 \pm 2.3 \times 10^{-6} \quad \Rightarrow \sim 10^6\ \bar{d} \text{ in } 10^{10} \text{ events}$$

Exercise: understand multiple baryon formation in hadron collisions

Possible astrophysical interest: searches for antimatter in Universe (AMS) and in cosmic rays. This is the background

# *Detectors*

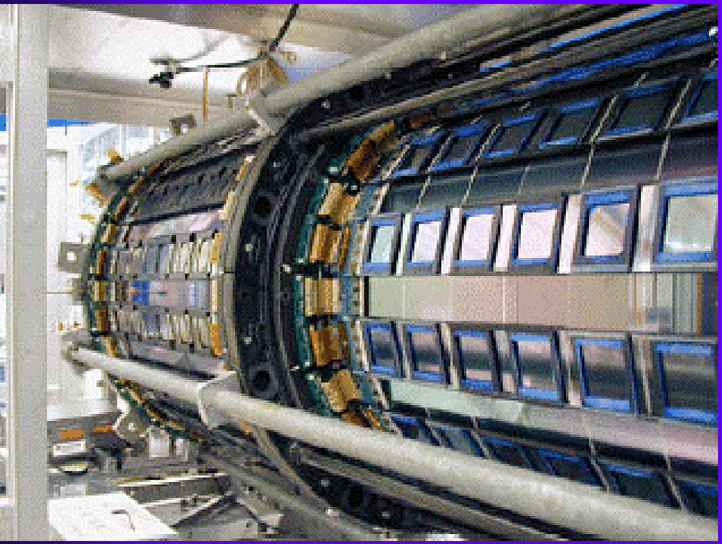


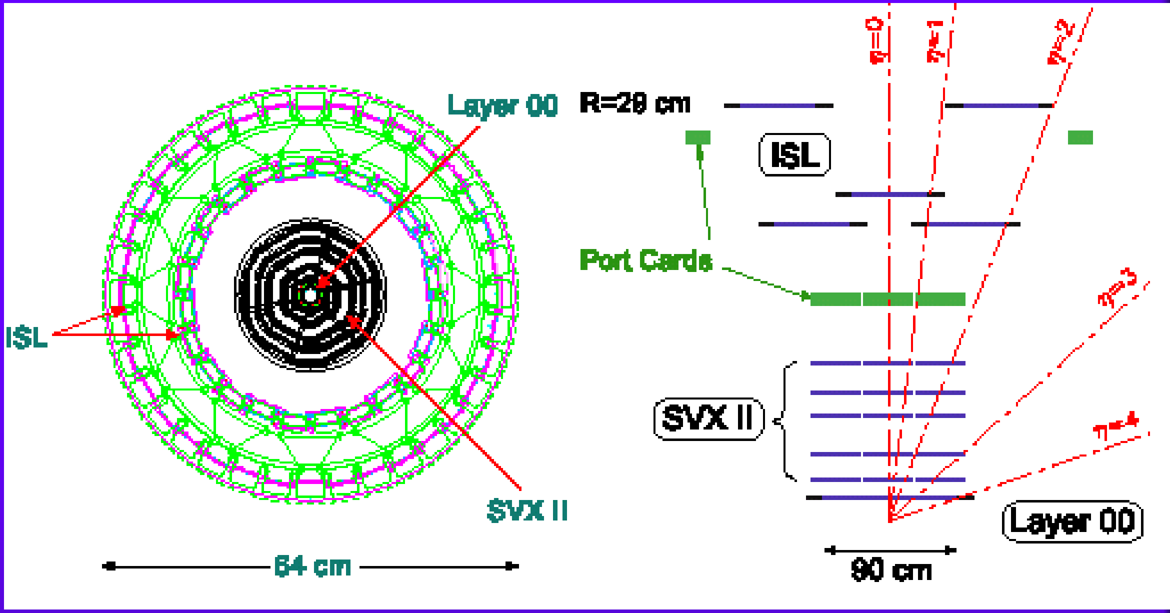

D0 an option
I focus on CDF
(tracking, hadron ID ...)

**BEYOND 3 deg :**
**Luminosity Counters**
**Beam Shower Counters**
**Roman Pots**
***MiniPlugs***

Add:
New pots very forward E&W: through quadrupoles + near (55m) + far (~160m?)
Other forward detectors (tracking, upgrade calorimetry e.g.) → **"Cone Spectrometers"**
New DAQ and trigger system → kHz
Silicon (certainly want it) ... hope it's still good (COT also)

# CDF Silicon VerteX Detector SVX



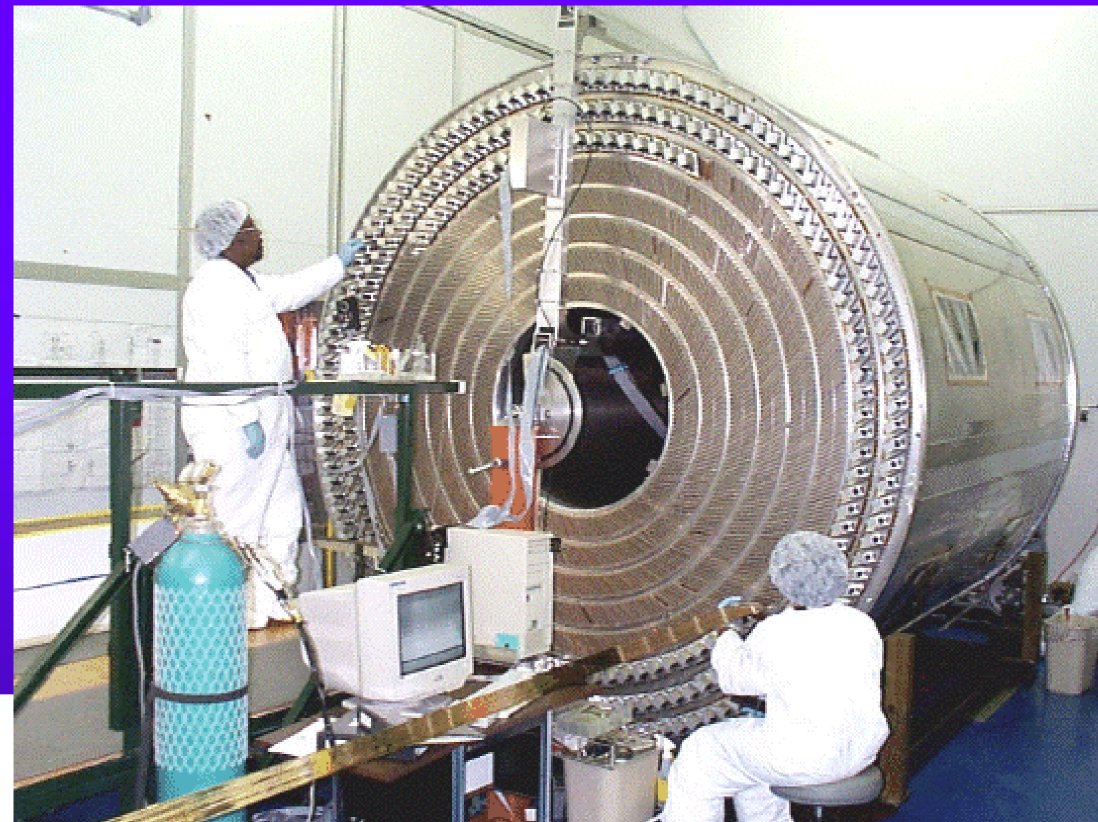


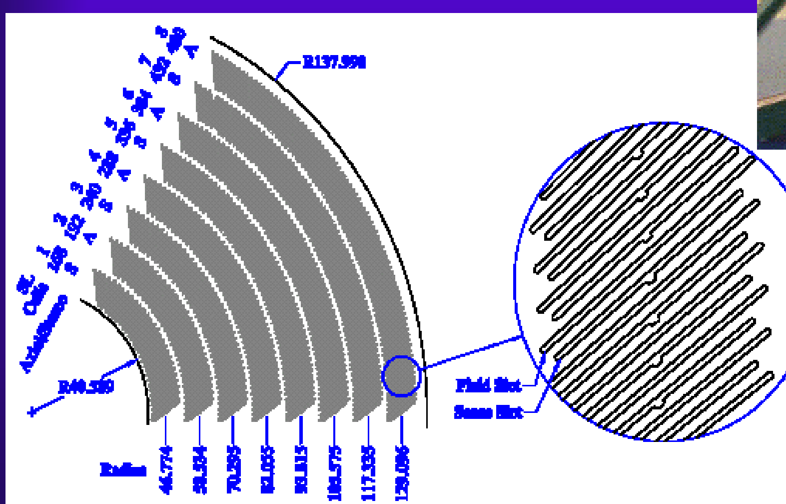

For beauty, charm, tau identification and measurement.
~ 720,000 strips, 25um with 50um readout
L00 : ~ 1.5 cm from x, R-phi view
SVXII: 3 double 90 deg layers + 2 double 1.2 deg layers
ISL : 1 or 2 double 1.2 deg layers.
Impact parameter resolution ~ 30 um @ 1 GeV/c

# CDF Central Outer Tracker (COT)

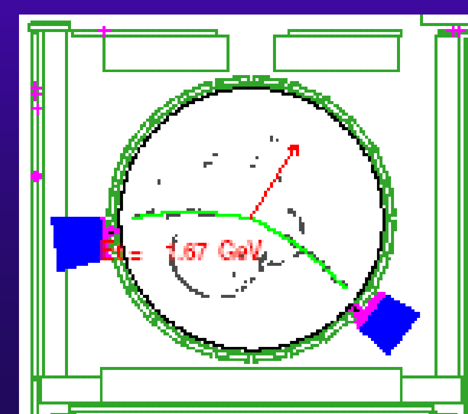
Drift chamber
3.1m in z, 0.34-1.32m in R
96 layers → 30,240 sense wires
40 um gold-plated tungsten
ADC & TDC each end
6 um Au-mylar field sheets

Resolution ~ 150 um/wire



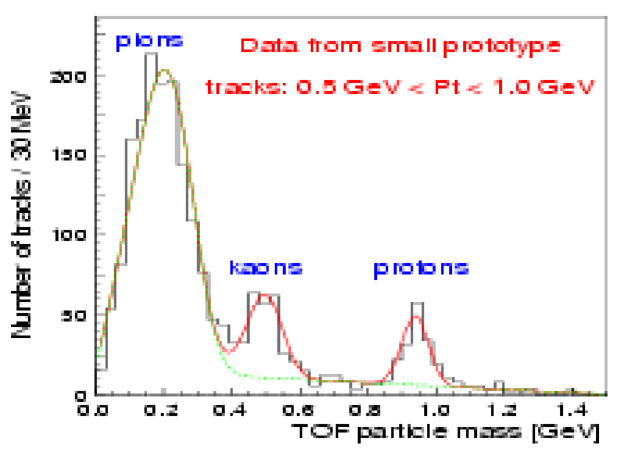


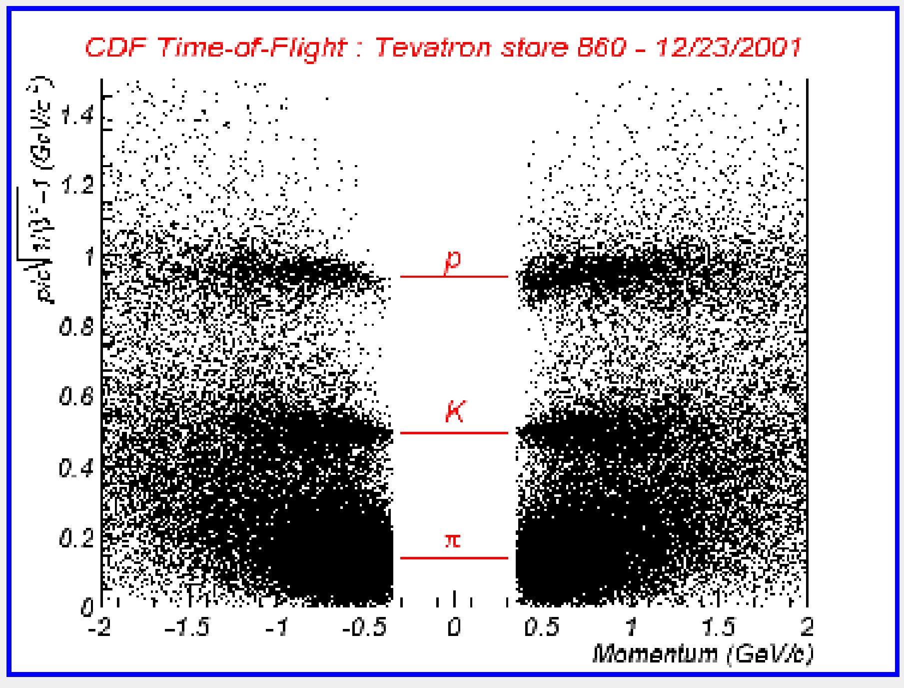

J/ψ γ
(*probably* $\chi_c$)



# Time of Flight Detector

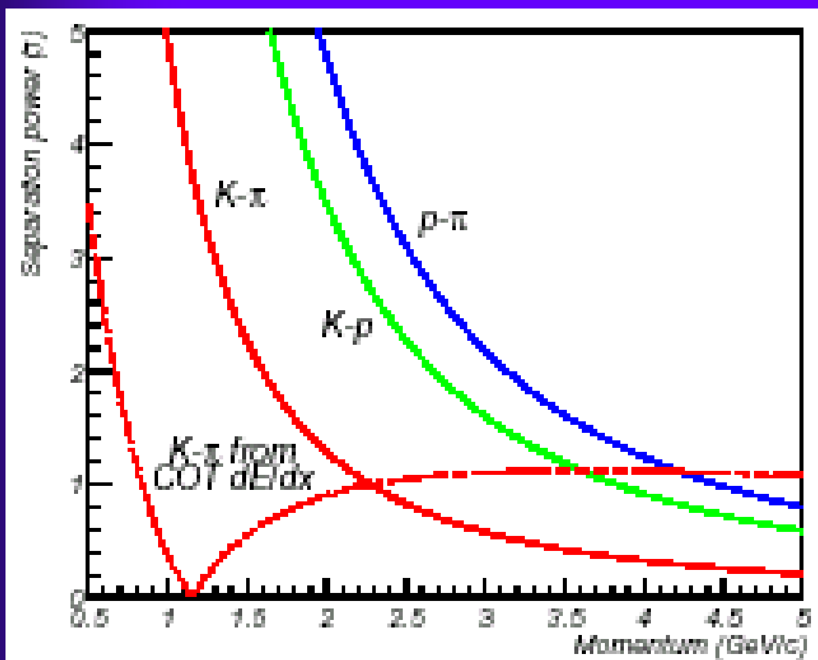
Surrounds Central Outer Tracker COT
140 cm ( ~ 4.7 ns) from beam.
216 scintillator bars, each ~ 4 cm x 4 cm
Both ends read out: time and pulse height
Design resolution = 100 ps
Design optimized for B physics, K-pi separation.

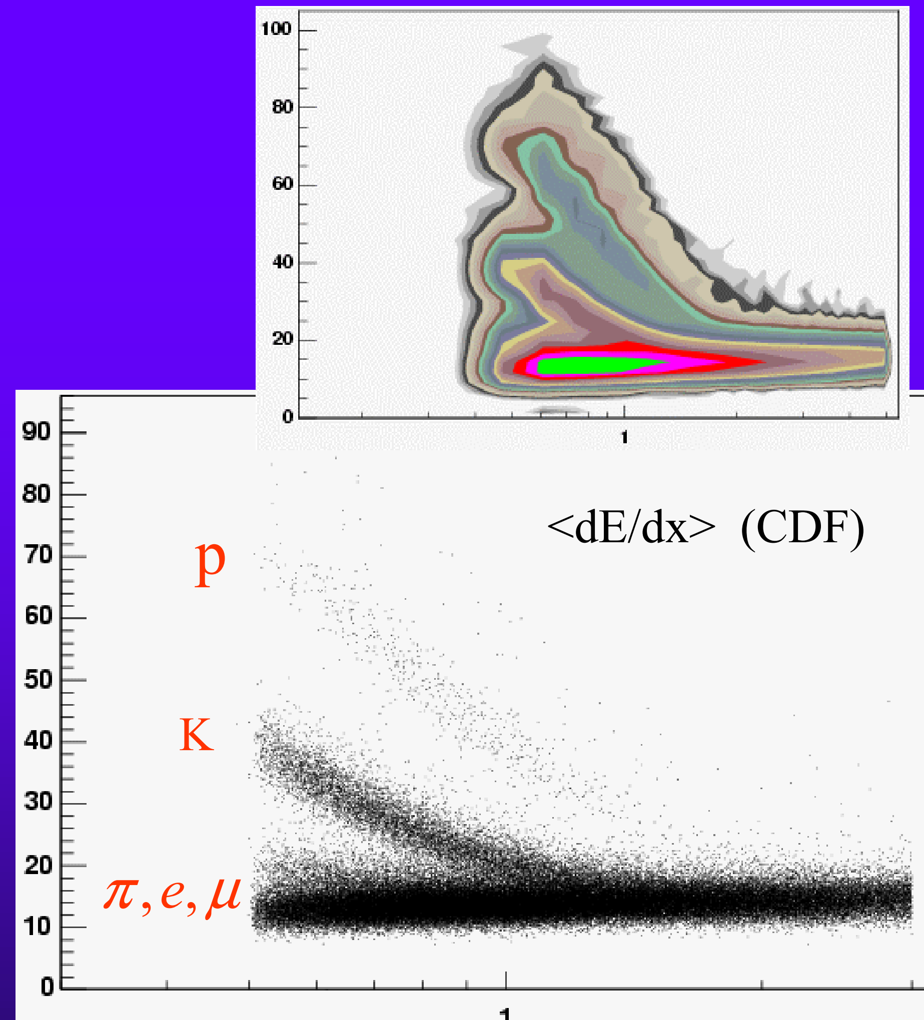


# COMPARISON of TOF and COT dE/dx

TOF Separation Power (sigma)




p (GeV/c)

Low p_T particles in range ~ 0.3 – 3.0 GeV/c, high identification probability

# *Calorimetry in CDF*

em: Pb-scintillator
had: Fe-scintillator
+ em shower position detector (strips)

"New" (Run 2) Plug

Central: 31x [3.2mm Pb + 5mm scint]
+ strip (2cm) chambers at 6 Xo
32x [25mm Fe + 10mm scint]

Plug: 22x [4.5mm Pb + 4mm scint]
+ sh.max : 5mm scint strips at 6 Xo
23x [50mm Fe + 6mm scint]

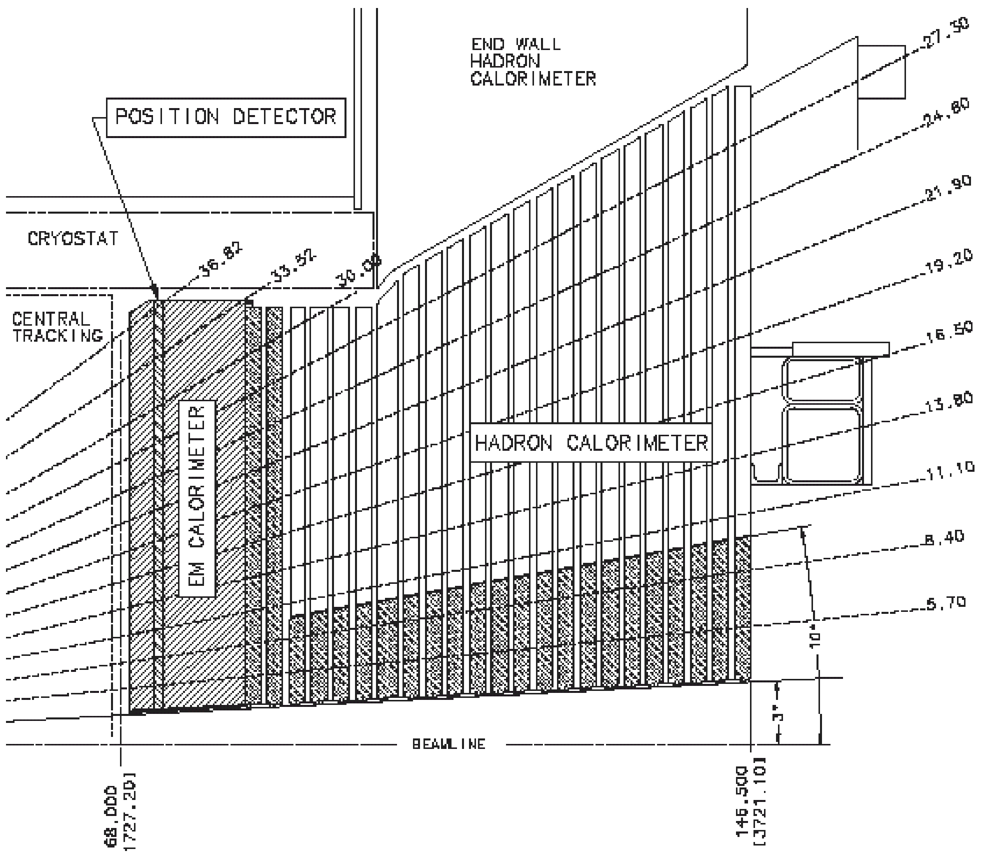
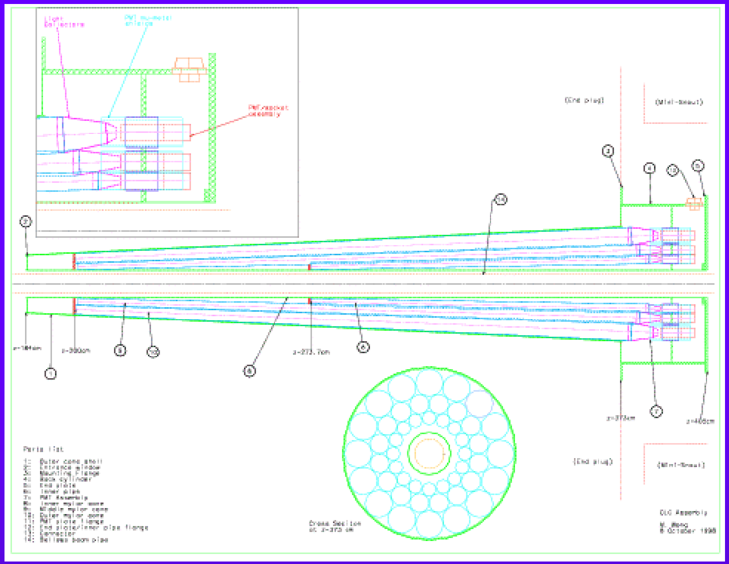



**Fig. 3:** The plug upgrade calorimeter.

# Below 3 degrees: (1) Cerenkov Luminosity Counters CLC

Al mylar cones with isobutane radiator and 1" Ham R5800Q PMT
48 each end in 3 rings of 16

$3.7 < |\eta| < 4.7$

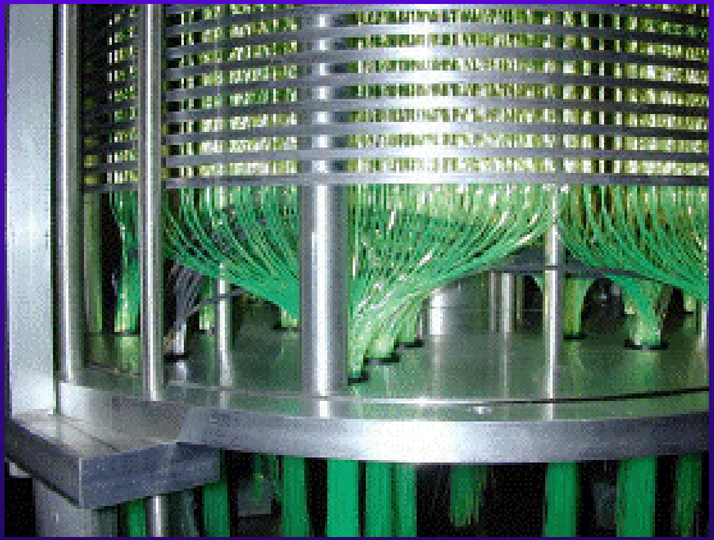


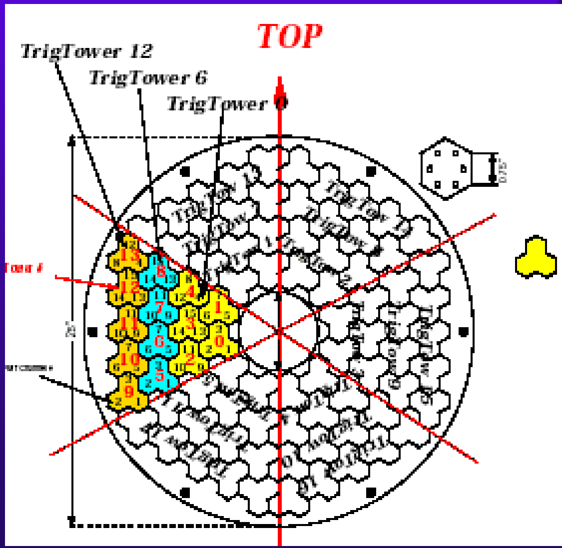
## (2) MiniPlug Calorimeters

36x [4.8mm Pb + 6.4mm Sc]
Liquid scint + wls fibers
18 Ham R5900 PMT each end

$32\ X_0, 1.3\ \lambda$

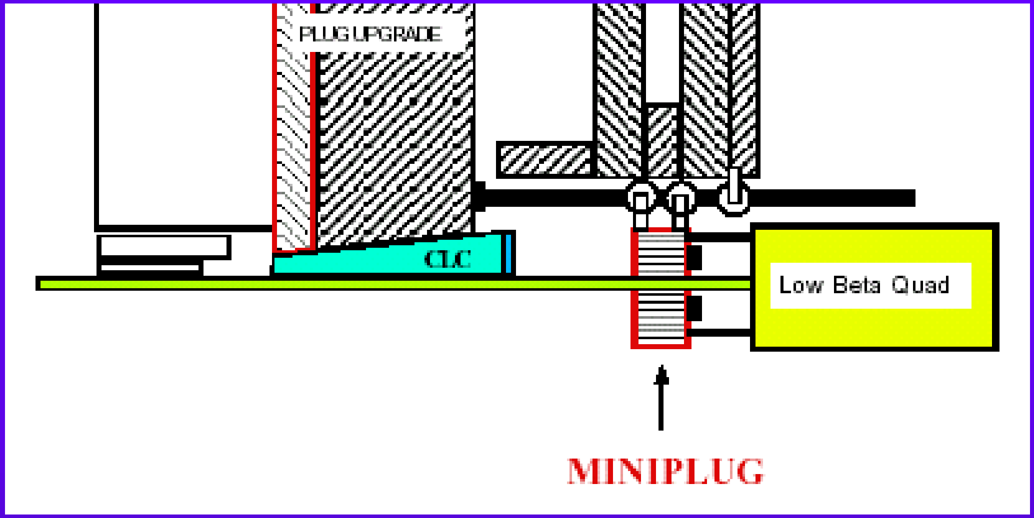
$3.6 < |\eta| < 5.2$





# *New Forward Region (0.5-3.0 deg): Cone Spectrometer?*

Now: 48 CLC counters + MiniPlugs



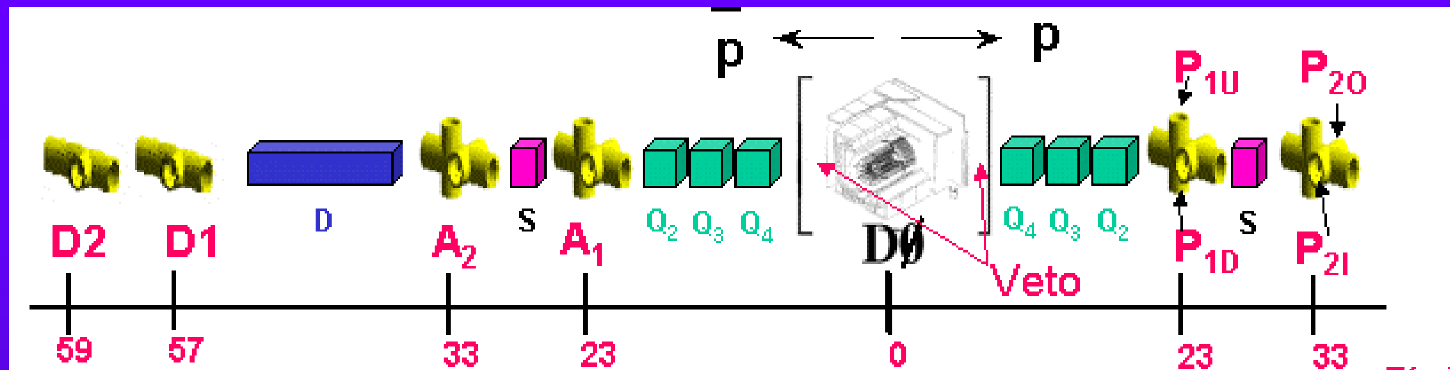

Can (remove Q1 and) push back ~ 2 m low-beta quads
Tracking e.g. GEM layers (50 um, 15 ns) over large area
Deeper Calorimeter (~8 int. lengths) high granularity, em/had
Possibility of forward dipoles (?) or toroid fields on calo iron
Upgrade motivation: Low-x with v.forward jets, J/psi?
(BFKL) J - minijets - J, J – gap – J and J + X + J ... etc

"Cone Spectrometers"

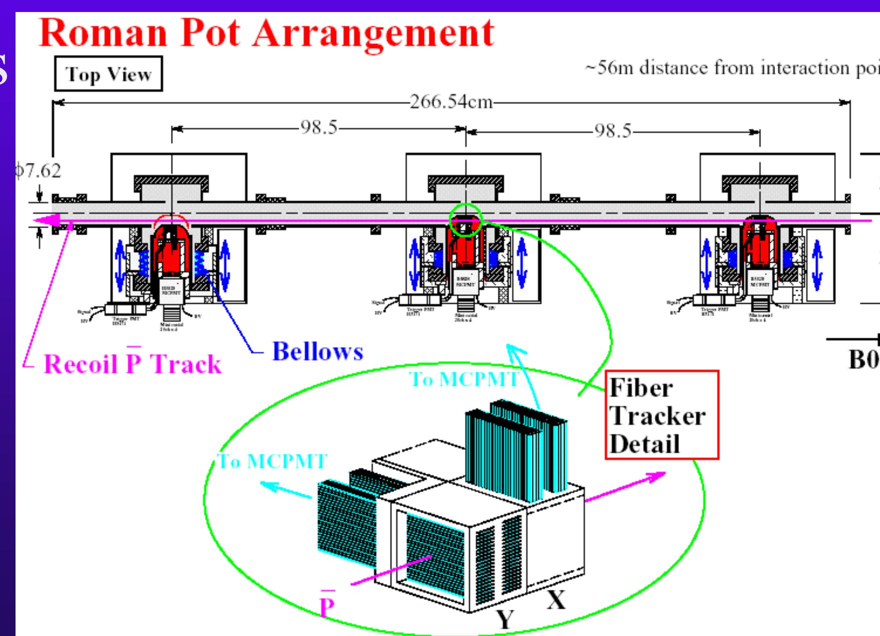
Jets, $\mu$, e, J/$\psi$, $\gamma$ ?

# *Very Forward: Roman Pots*

D0 has 8+8 quadrupole spectrometer pots + 2 dipole spectrometer pots
Scintillating fiber hodoscopes (~ 1mm)

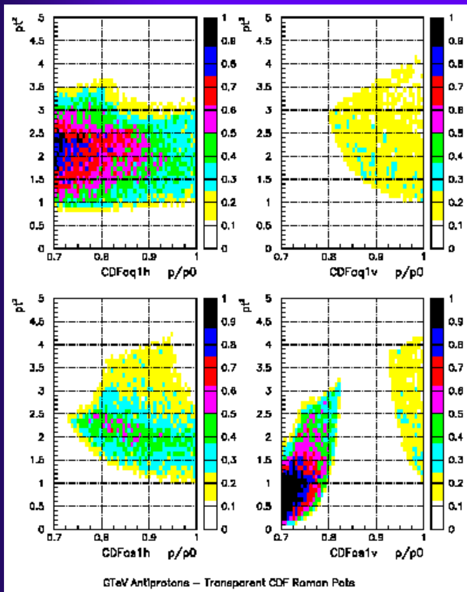


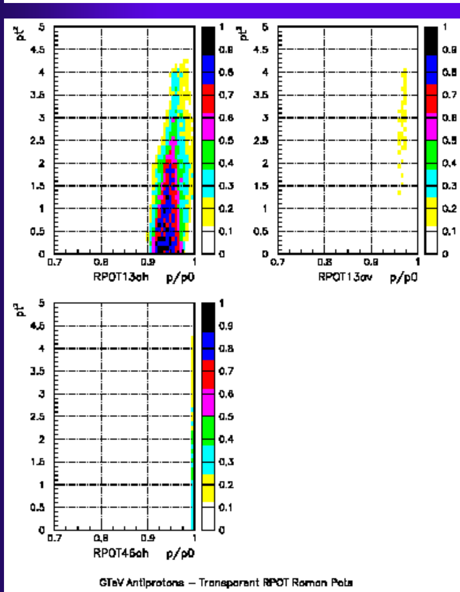

CDF has 3 dipole spectrometer pots
0.8 mm x-y fibers




GTeV: Quads + near + far dipoles
Silicon ustrips, pixels, trig scint
Quartz Cerenkov for ~ 30 ps TOF

# *Roman Pot Acceptances (pbar)*



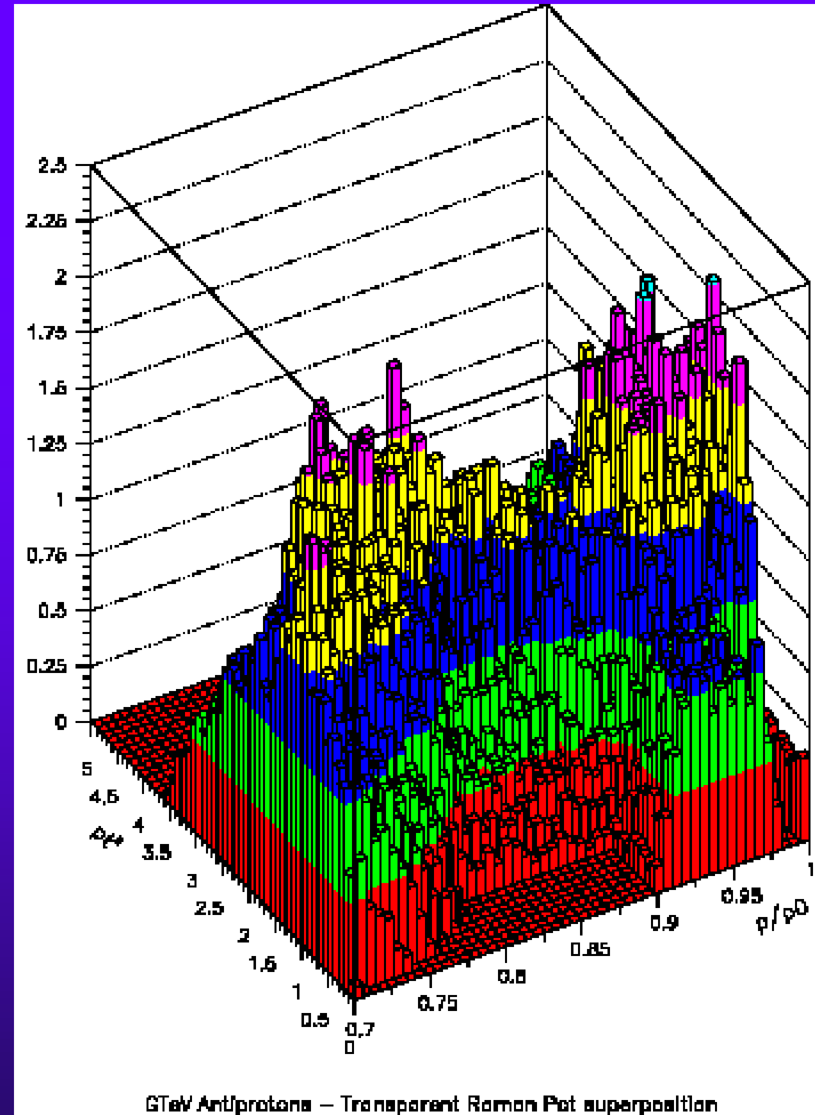




Q1h Q1v

Q2h Q2v

D55h D55v
{CDF}

D150h

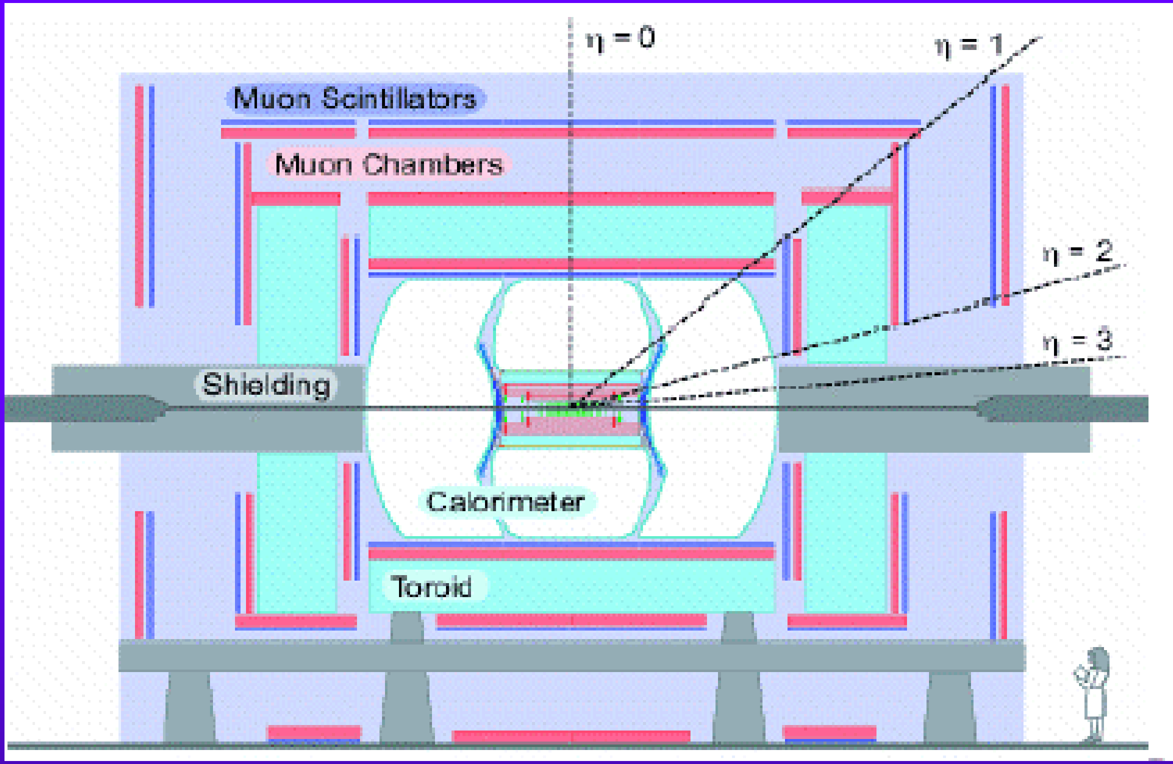



$\Uparrow \ p_T^2 \approx t : 0 \rightarrow 4 \ \mathrm{GeV}^2$

$\Rightarrow x_F : 0.7 \rightarrow 1.0$

Acceptance (all pots)

# Re-using D0 detector?




Add :

New/upgrade pots very forward E&W: quad + near (55 m) + far (160 m?)

New DAQ and trigger system → kHz

Forward ("cone") region probably not instrumentable

# ***Tevatron Issues***

Spaces for pots and their position: quad, near dipole, far dipole
**Replace 3 dipoles with 2 High Field dipole(s)** → ~ 4 m spaces
6.5 Tesla, same current, temperature! (Tech.Div or outside)

Momentum and Missing mass resolution. Limits? Medium-beta?
p-z correlation? stability, drifts
Instrumentation: precision (~ 10 um?) BPMs at pots

Co-existence with BTeV: Luminosity (~2 - 4 e31, also high?),
Beam-beam tune shift, Long-range tune shift,
Electrostatic separators, Luminosity lifetime, ...

# *Many Subjects not Covered*

**Just a few:**

**The cosmic ray connection:** very forward particle production

**Jet – gap - X – gap - Jet** ( low mass X) different from p—X---p ?

**Very soft photons** < 100 MeV, via conversions

**Bose-Einstein correlations:** directional, event type, high statistics

**Many other studies will be done,** as happens in CDF, D0 etc now.

# GTeV plan

Forming Working Groups, conveners.
Workshop at Fermilab May 20-22 :

***The Future of QCD at the Tevatron***

*http://conferences.fnal.gov/qcdws/*

CDF & D0 now → 2009
HERA, BNL, JLab, etc
BTeV, LHC beyond 2007
What is unique for GTeV beyond 2009?

Please come!

**Proposal** to PAC Spring 2005 (?)

| Working Groups | Topics |
| --- | --- |
| Physics | Low Mass Double Pomeron |
| | High Mass DPE & Higgs |
| | Jet-Gap-Jet Studies+BFKL |
| | Small-x g and g-jets |
| | Hadron spectroscopy |
| | Single Diffractive Excitation |
| | Exotics |
| | Cosmic Ray issues |
| | Event Generators |
| Detectors | Simulations with Detectors |
| | Cone Spectrometers |
| | Roman pots ("v.forward") |
| | Central detector |
| (DAQ & Trigger) | Triggers L1 L2 L3 |
| | kHz DAQ |
| | Computing on/off line, GRID |
| Tevatron | High Field Dipoles |
| | Orbit issues, beta, ES seps |
| | Roman Pot insertions |
| | BTeV-GTeV interaction |

# *Concluding Remarks*

There will be a vast amount of QCD physics still
to be done in 2009. Here I have only scratched the surface.
Unknown territory: discoveries likely.

The CDF and D0 detectors are great central detectors for this
program, suitably upgraded at modest cost:
DAQ, trigger, forward (few deg) and very forward (pots)
Not all ~1500 physicists on CDF and D0 want to go to LHC
We hope physicists come from DESY, BNL, JLab etc expts.

Tevatron running anyway for BTeV, so it's great value.

**Let's do it!**