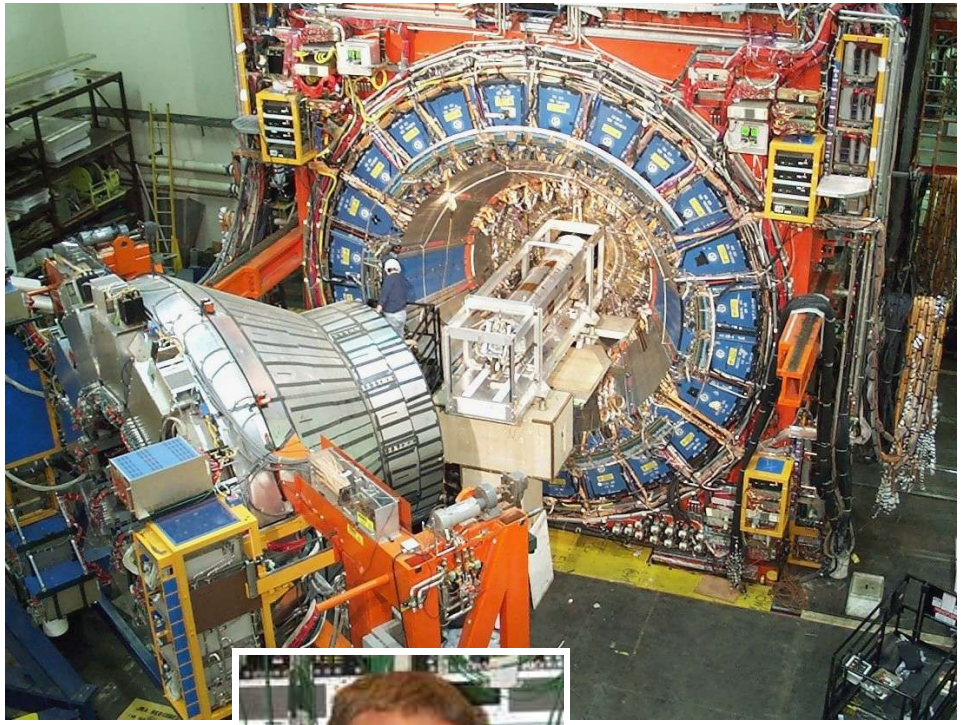
Career Review



- Time Line
- Zeus :: STT
- ALTA :: Cosmic Rays
- ATLAS :: LUCID Prototype
- CDF :: Exclusive Interactions
- Next ...

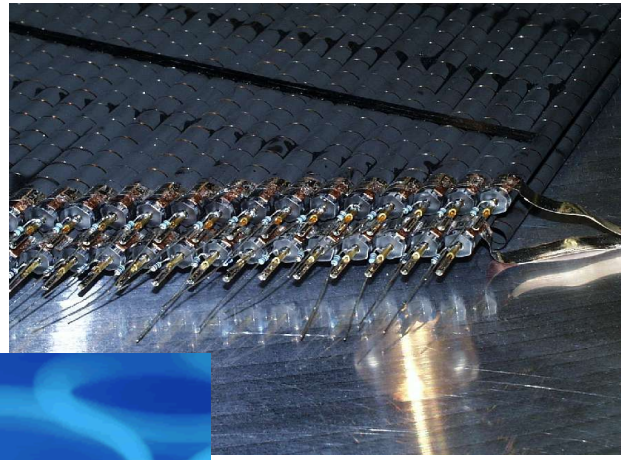
Andrew Hamilton, MSc., PhD. Candidate

University of Alberta

Time Line

Oct 1996

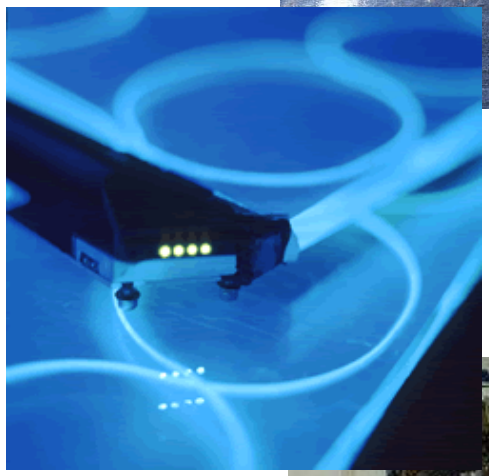
BSc at *York University*
Supervisor: *Sampa Bhadra*
Thesis: *Efficiency of Drift Chamber*
Other: *Zeus STT Construction*



Apr 2000

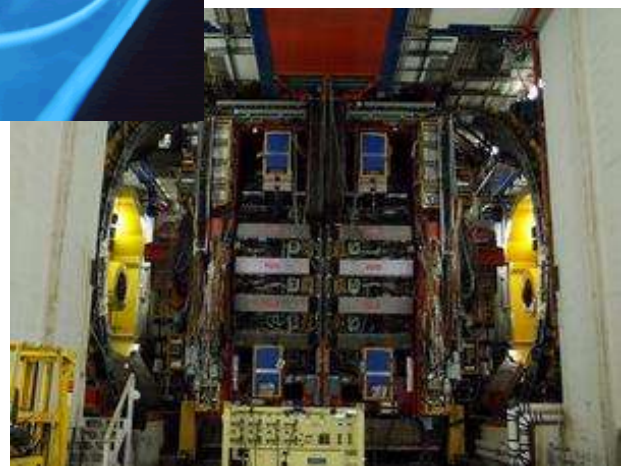
Jan 2001

MSc at *University of Alberta*
Supervisor: *John McDonald*
Thesis: *ALTA Cosmic Rays*



Sept 2002

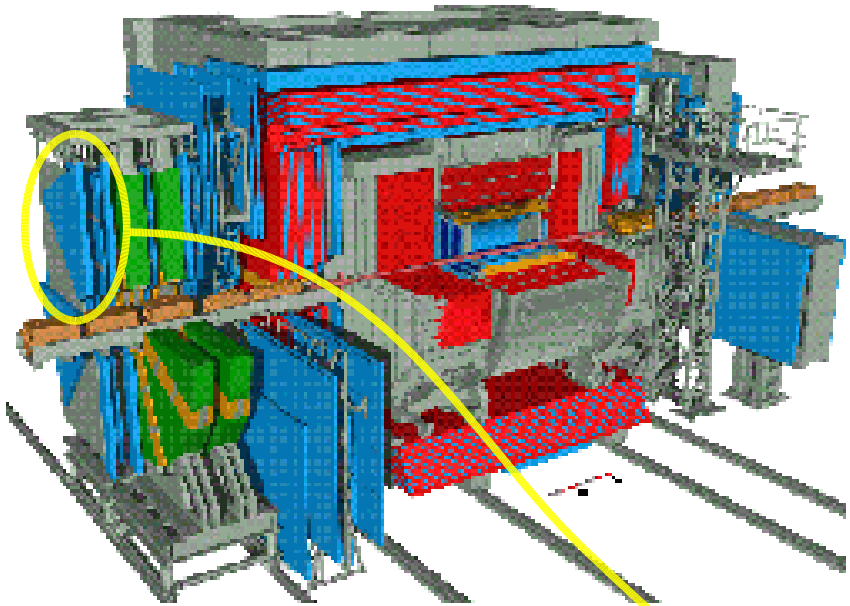
PhD at *University of Alberta*
Supervisor: *James Pinfold*
Thesis: *CDF Exclusive Interactions*
Other: *LUCID prototype*



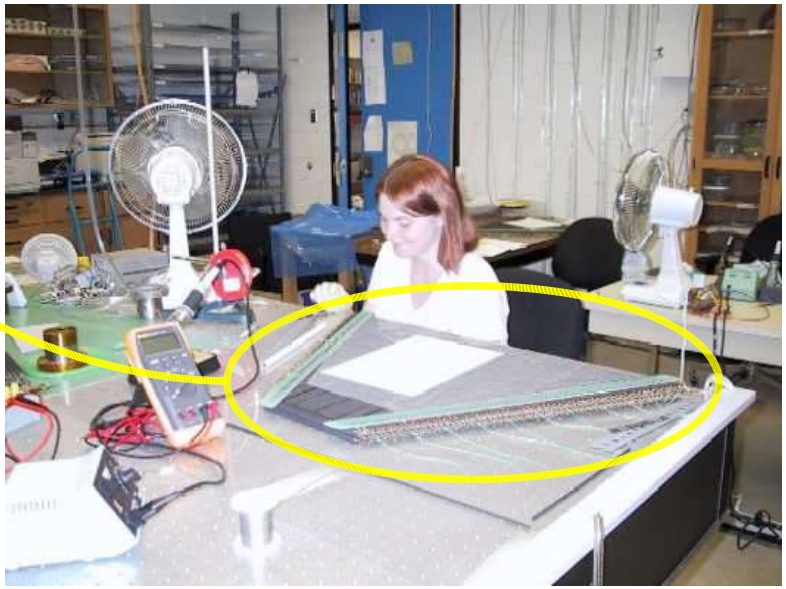
Zeus :: Straw Tube Tracker

(Apr. 1999 – Apr. 2000)

Zeus :: Straw Tube Tracker



- 16 of 48 sectors built at York
- 192-266 straws per sector
- 50 micron wire to be strung
- readout wires soldered
- gas manifolds installed



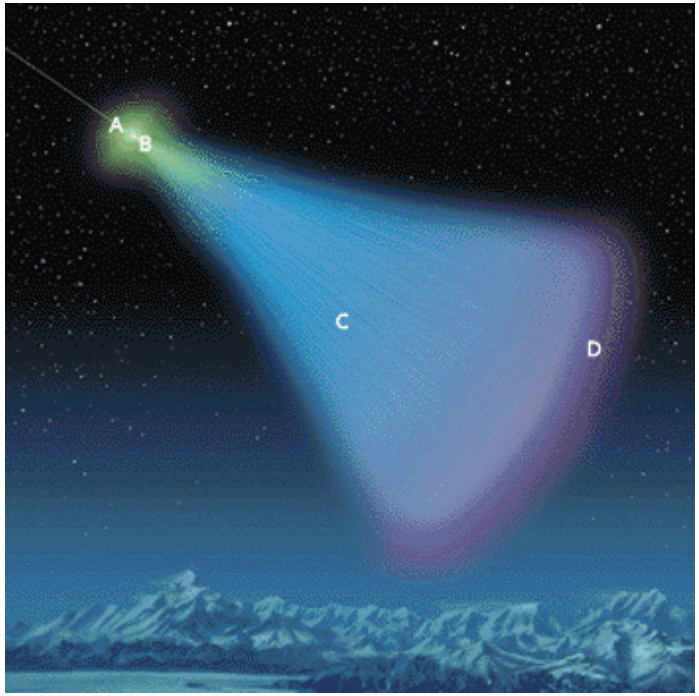
Tests done:

- ***wire tension***
- pressure
- dark current
- source test

ALTA :: Cosmic Ray Experiment

(Jan. 2001 – Sept. 2002)

ALTA :: A Cosmic Ray Experiment



ALTA: Alberta Large area Time coincidence Array

- search for temporal and spatial correlations in cosmic air shower arrival time (and UHECRs)
- large outreach program with high schools, like *NYSCPT*, detectors installed at high schools

- three scintillators installed in equilateral triangle, ~10m
- relative time and pulse height read out with custom electronics
- absolute time recorded with GPS

ALTA :: MSc Thesis

MSc thesis work:

- calibration of energy measurement
- measurement of angular resolution
- measurement of GPS time resolution
- software algorithms to search for temporal and spatial correlations

Presented work at:

- Snowmass 2001 "SALTA Workshop"
- 2002 Western Regional Nuclear and Particle Physics Conference

Victor Hess, played by Jeff Wilkes, at Snowmass 2001

Published Papers:

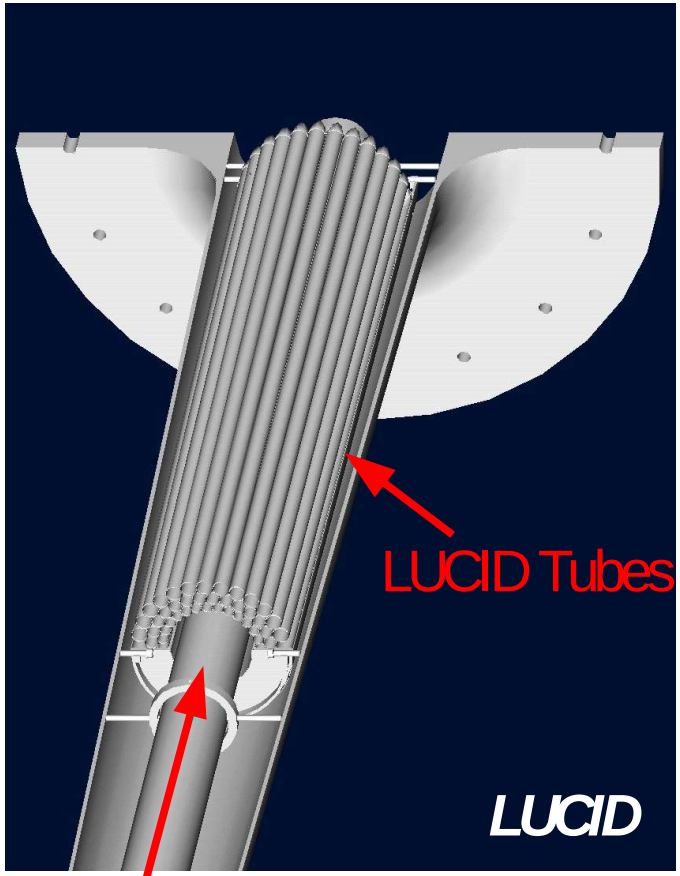
- W. Brouwer, et.al., "*ALTA Electronics Systems*", NIM A 539 (2005) 595-605
- W. Brouwer, et.al., "*ALTA GPS Timing Sytems*", NIM A 493 (2002) 79-89

ATLAS :: LUCID Detector

*(Sept. 2002 – present)**

**this a side project, not part of my thesis*

ATLAS :: LUCID Detector



LHC Beam

ATLAS IP

LUCID: Luminosity Using Cerenkov Imaging Detector

- 200 aluminized carbon tubes
- each tube 13-23mm diameter, 1.5m long
- C_4F_{10} (or isobutane) gas radiator
- Winston cone light collection
- quartz fiber light transport

Location:

- $5.4 < |\eta| < 6.1$
- $z_{front} = \pm 17$ m

based on CDFs Cerenkov Luminosity Counter

ATLAS :: LUCID Prototype

I set up the LUCID prototype cosmic ray test:

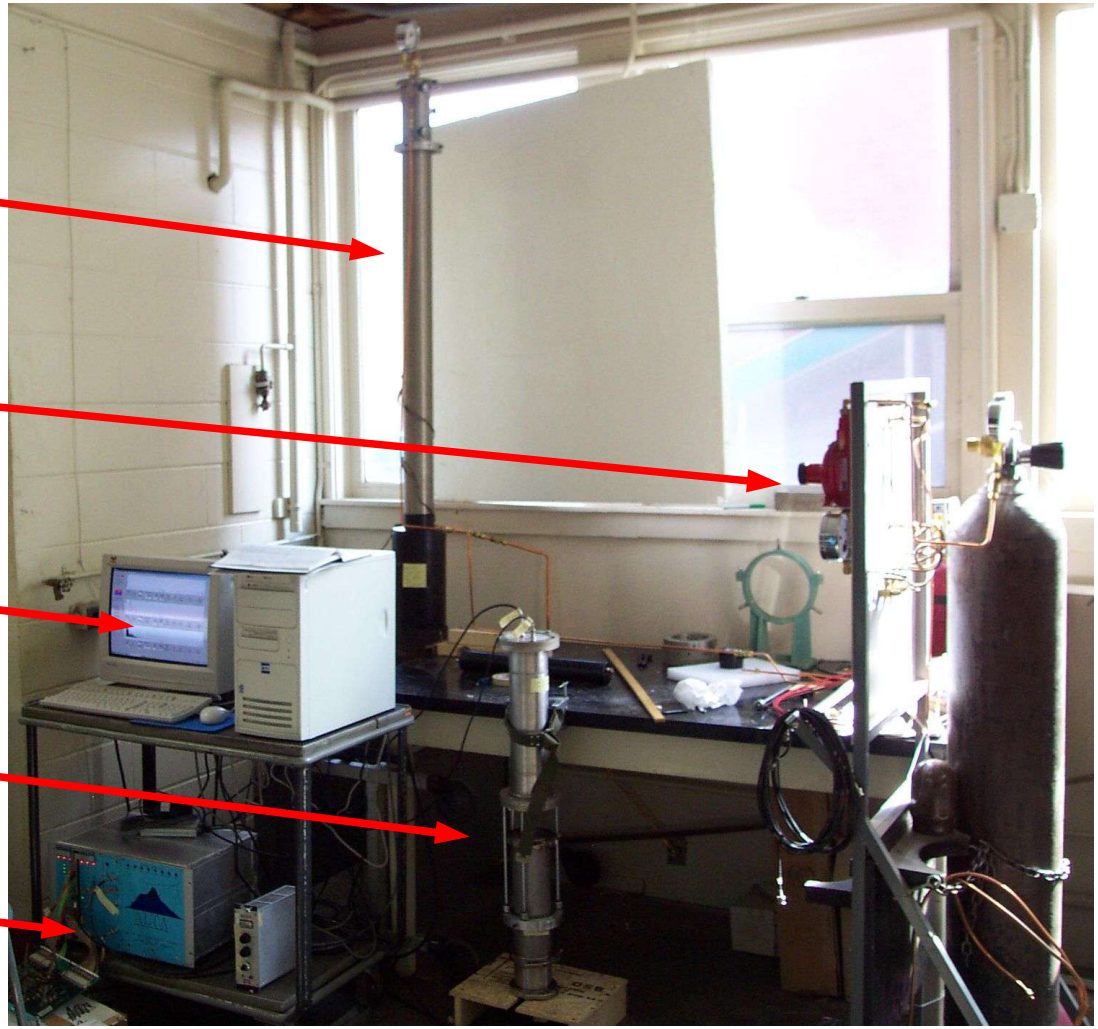
gas tight tube
(LUCID prototype inside)

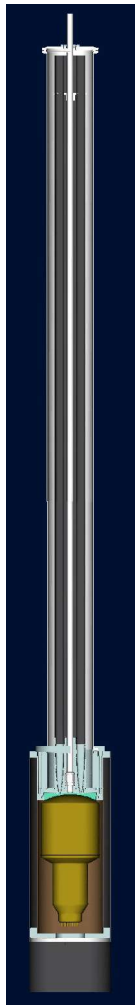
gas system
(isobutane, argon)

Data storage and
monitoring

trigger scintillators

DAQ and HV

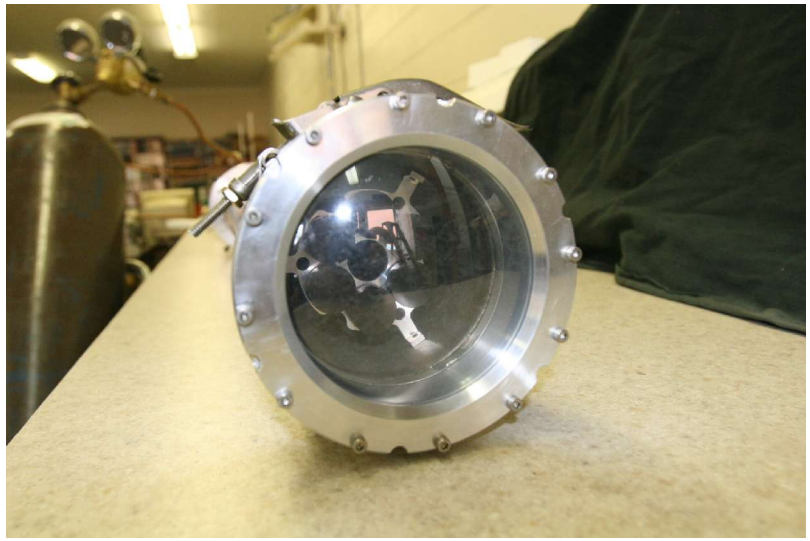




ATLAS :: LUCID Testbeam

- I wrote an MOU to get LUCID into the Fermilab testbeam
- Funding issues made it impossible, testbeam done at DESY in November 2005

MT6B area of Meson Test Beam Facility at FNAL



Front window of LUCID prototype gas vessel, ready for testbeam at 3 bar

CDF :: PhD Thesis

(Sept. 2002 – present)

CDF :: First, stuff that's not physics

Elected as a member of Fermilab's Graduate Student Association (Oct 2004 to Oct 2005)

- acquired 35 bikes for Fermilab visitors and residents
- organized the New Perspectives 2004 conference

Fermilab Today

Monday, July 26, 2004

Calendar

Monday, July 26

THEORETICAL ASTROPHYSICS SEMINARS WILL RESUME IN THE FALL

3:30 p.m. DIRECTOR'S COFFEE BREAK

Bicycles Help Fermilab Village Residents Get Around

w Hamilton helped secure the funds for 5 bicycles. (Click on image for larger on.)

easant as the rural life in Fermilab's

Safety Tip of the Week

Buzz, Bu Yellowja

It won't be lo harbingers o around picn The females that can be repeatedly only modest provocation them off.

It is not unus to encounte wasps and

Article in Fermilab Today on bicycle acquisition

news story

February 4, 2005

The ultimate deconstructionist

Andrew Hamilton peers at the building blocks of matter

by Richard Cairney
Folio Staff

Fermilab's control room (left) is powered by an incredible amount of computer hardware, but it's still only enough to analyse 75 of the 1.7 million particle collisions that occur every second. Right, Andrew Hamilton.

Article in University of Alberta paper on my work

www.ualberta.ca/~publicas/folio/42/11/11.html

New Perspectives Poster

CDF :: Timeline of PhD Work

Sept 2002 — Classes at University of Alberta

Jan 2003 — Move to FNAL

service: - *database monitoring & software development*
- *Sept to Nov 2003 month ACE shift (DAQ & Monitoring in CDF CR)*

physics: - *low multiplicity trigger study*
- *Aug 2003 invited to (attended) A. Zichichi HEP summer school*

Jan 2004 — More classes at University of Alberta

May 2004 — Back at FNAL

physics: - *change focus to exclusive diphoton interactions*
- *Aug 2004: DIFF_DIPHOTON trigger installed*
- *Oct 2005: first ~300 pb^{-1} of DIFF_DIPHOTON data fully processed*
- *May 2005: attended CTEQ summer school on QCD*

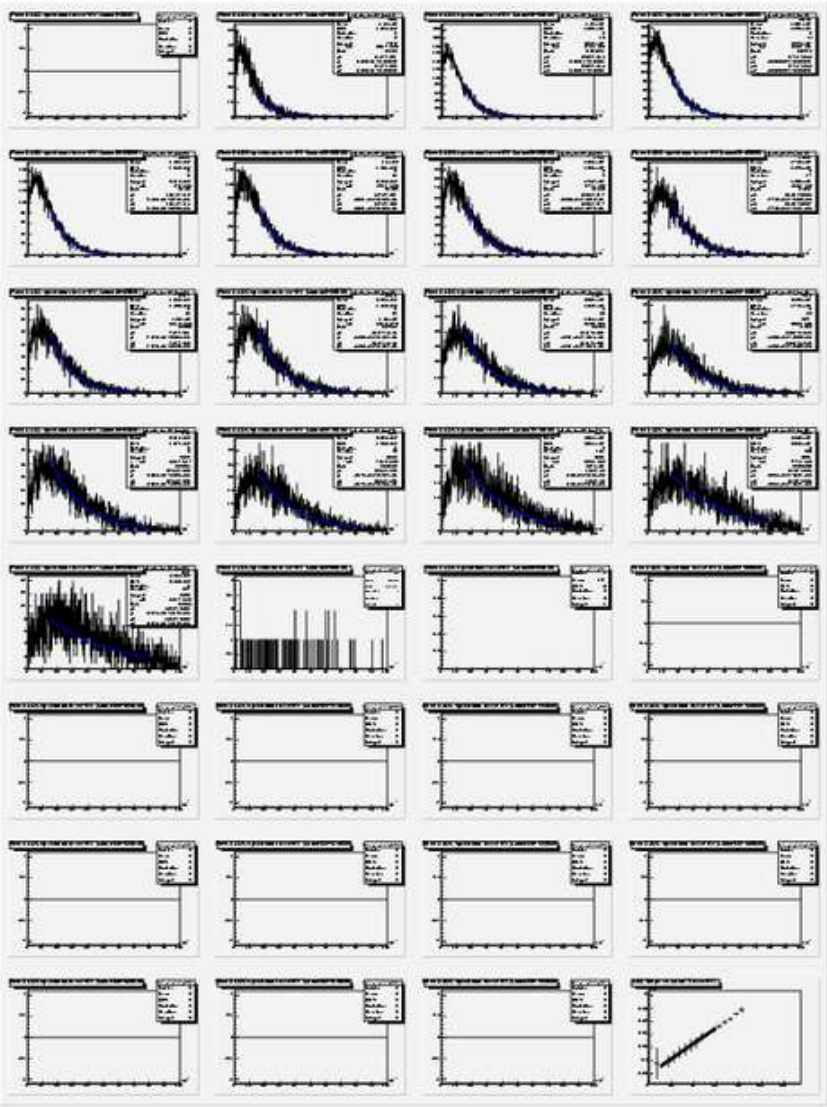
service: - *Miniplug calorimeter calibration*
- *Roman Pot and Beam Shower Counter hardware maintenance*

Jan 2006 — J1 visa expired, move to Toronto

physics: - *complete exclusive e^+e^- and $\gamma\gamma$ analyses (thesis)*

service: - *MiniPlug calibration*

CDF :: Recent Service Work



Miniplug Calorimeter Calibration

$$\frac{\text{slope Energy (MC)}}{\text{slope ADC (data)}} \times \text{ADC counts} = \text{Energy}$$

calibration is a function of inst. luminosity

BSC and Roman Pot Hardware Maintenance

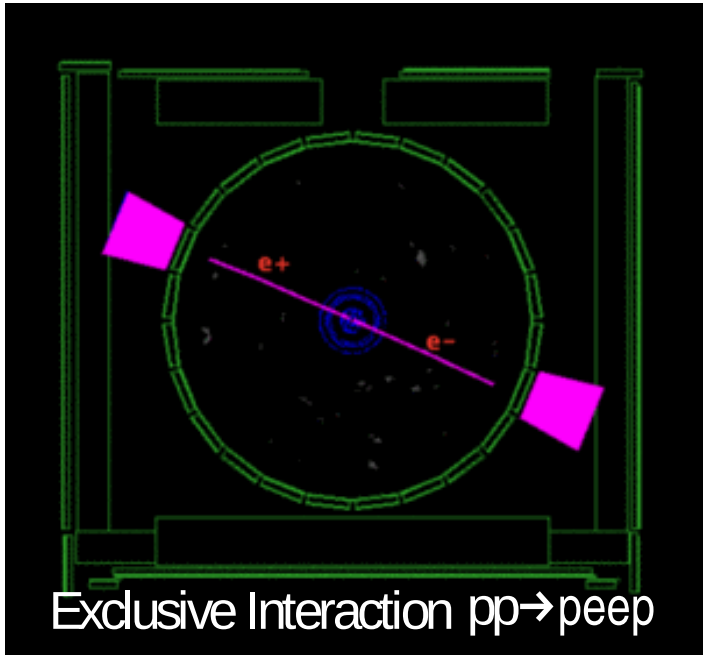
M. Convery, et.al., *"Energy Calibration of the Miniplug Calorimeter"*, CDFNOTE 7913, (2005)

CDF :: Thesis Analysis

My thesis analysis is composed of ***2 first observations*** in hadron collisions.

pp→peep

pp→p$\gamma\gamma$p



Exclusive Interaction pp→peep

The work was presented at:

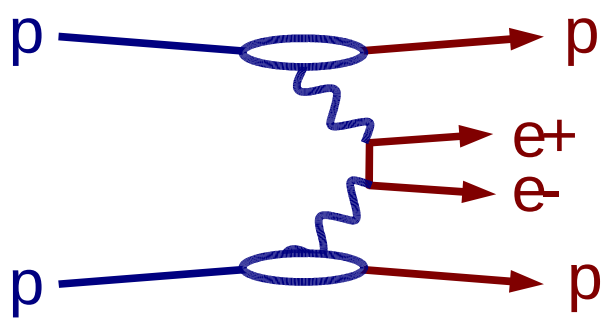
- Forward Physics at the LHC (Manchester, Dec 2005)
- Forward Physics at the LHC (Manchester, Dec 2004)
- Small-X and Diffraction (Fermilab, Sept 2003)

It is summarized in the following CDF notes:

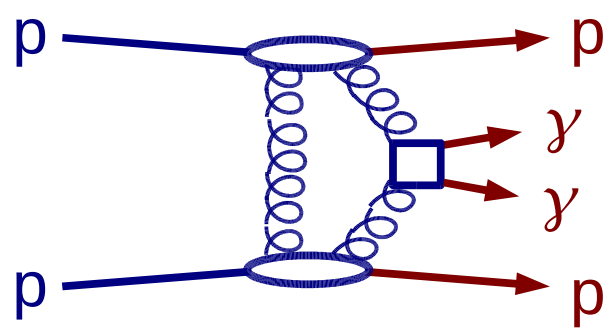
- A. Hamilton, *"Evidence of Exclusive Photon Pair Candidates"*, CDFNOTE 7931 (2005)
- A. Hamilton, *"Evidence of Exclusive Electron Pair Candidates"*, CDFNOTE 7930 (2005)
- A. Hamilton, *"Estimating Effective Luminosity for Rapidity Gap Physics"*, CDFNOTE 7556 (2005)
- A. Hamilton, *"Upper Limit on Exclusive DPE Diphoton Cross Section"*, CDFNOTE 7368 (2004)

Exclusive Interactions

Exclusive Interaction: An in-elastic interaction in which both proton and (anti-)proton escape without dissociating.

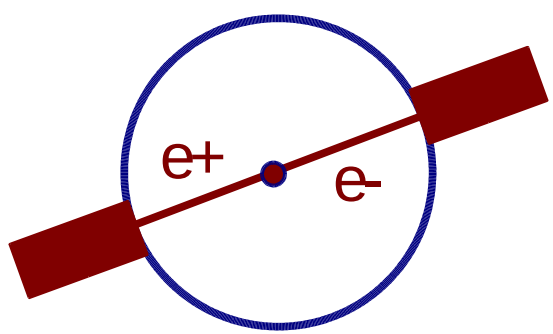


pp→peep

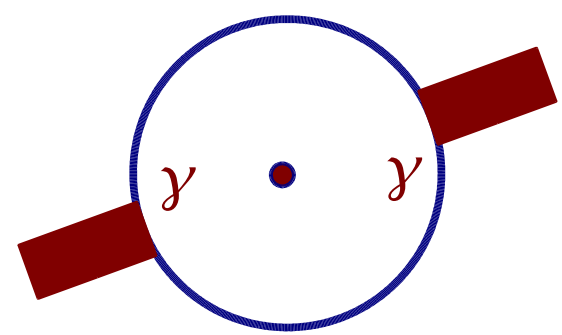


pp→pγγp

Fundamentally different production mechanisms (QED vs. QCD), while their detector signatures are nearly identical, *yet* easily distinguishable.



CDF rϕ-view

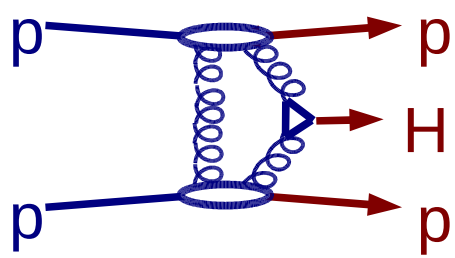


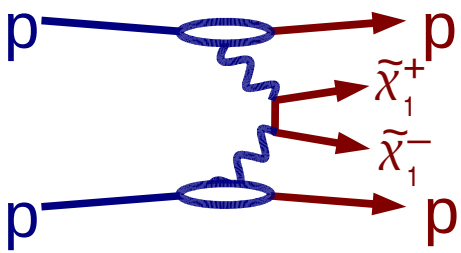
Motivation

Can exclusive interactions be used to search for new physics at LHC?

Advantages of exclusive interactions (if protons are tagged):

- mass of central system known by missing mass of outgoing protons
- spin selection ($J^{PC}=0^{++}$) of central system in QCD mediated interactions





Examples of specific measurements:

- exclusive SM Higgs: better mass resolution, QN determination, H→bb BR
- in some beyond SM scenarios exclusive Higgs gives high S:B ratio
- QED interactions may be able to help measure luminosity at LHC
- mass determination for any SUSY particle that couples to photons
- channel independent 'bump' hunting in pp missing mass spectrum

Forward proton detectors must be installed to make this possible with LHC pile-up.

Tevatron

$p\bar{p}$ collisions @ $\sqrt{s} = 1.96 \ TeV$

$\mathscr{L}_{inst} = 20 \text{ to } 160 \times 10^{30} \text{ cm}^{-2} \text{ s}^{-1}$

$\overline{\Delta t}_{bunch} = 580 \text{ ns}$

radius = 1 km
36 bunches

$\sigma_{inel} = 60 \text{ mb}$

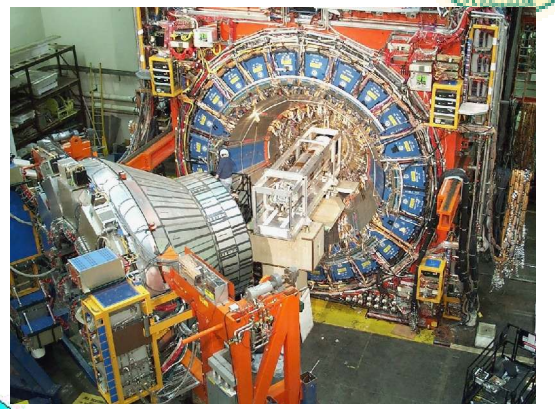
$\overline{n} = \sigma_{inel} \ \mathscr{L}_{inst} \ \overline{\Delta t}_{bunch}$

~ 1 to 6 interactions per crossing

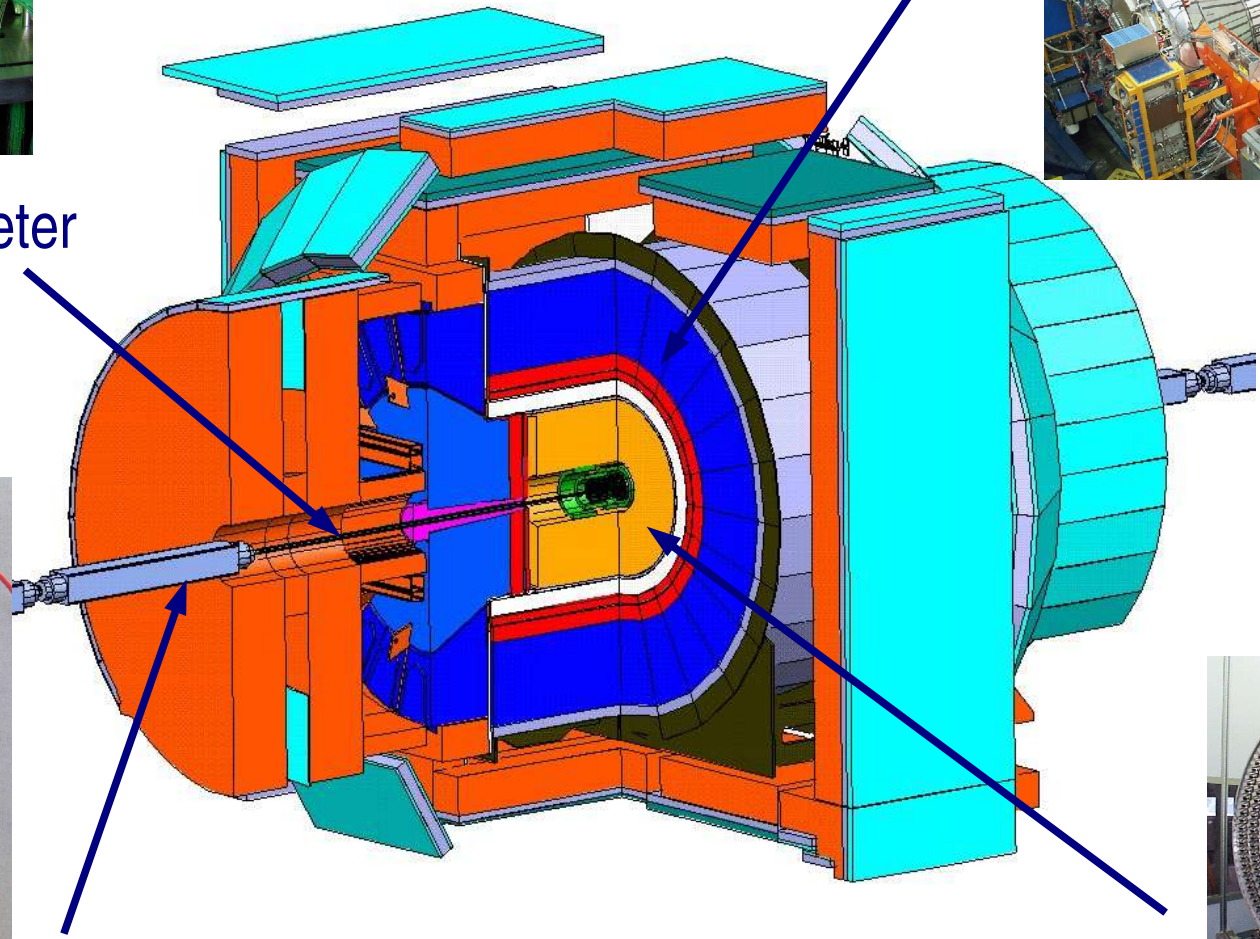
very important when searching for exclusive states without proton taggers

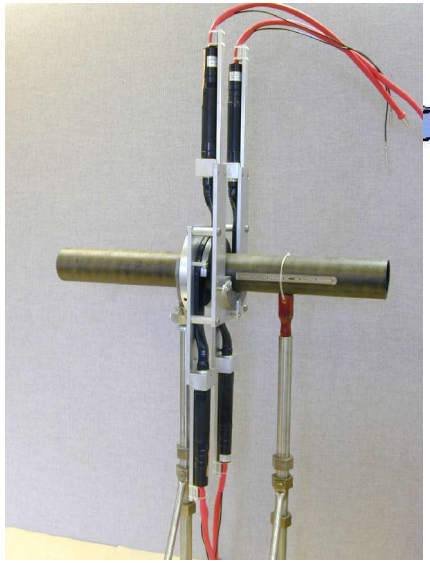
CDF II Detector

Plug and Central Calorimeters
$|\eta| < 3.5$

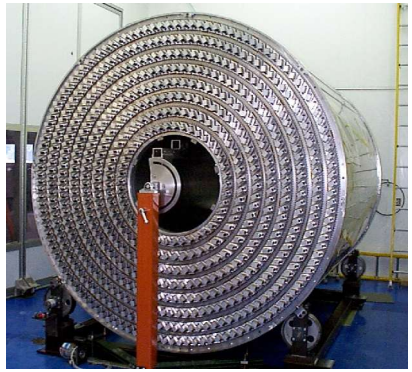


MiniPlug Calorimeter
$3.5 < |\eta| < 5.5$





COT Tracker
$|\eta| < 1\ (2)$



Beam Shower Counter $5.5 < |\eta| < 6$

Analysis Methodology

Data Collection:

- Trigger: east+west BSC veto and 2 EM towers with $E_T > 4$ GeV
- Running period: 7 December 2004 to 19 July 2005
- Total luminosity 325 ± 26 pb^{-1}

Event Selection:

- apply EM object cuts (require 2 EM objects)
- apply exclusive cuts to all towers outside EM objects
- apply tracking cuts to EM objects to distinguish e from γ

EM object cuts

- $E_T > 5.0$ GeV
- $|\eta| < 1.0$
- had/em<0.055+0.00045*E
- CES fiducial
- CES $\chi^2 < 20.0$

Exclusive cuts

- Central E_T < 200 MeV
- Low Plug E_T < 100 MeV
- Mid Plug E_T < 100 MeV
- Fwd Plug E_T < 70 MeV
- Mini Plug E_T < 10 MeV
- BSC ADC < 300 counts

Tracking cuts

e
- n tracks = 1
- track $p_T > 1.0$

γ
- n tracks = 0

Efficiency

Efficiency to trigger, reconstruct, and identify both e's (or γ's):

$$\varepsilon_{ee/\gamma\gamma} = 0.6 \pm 0.1$$

Efficiency for ee pair to not Bremsstrahlung into 2 separate CDF EM objects:

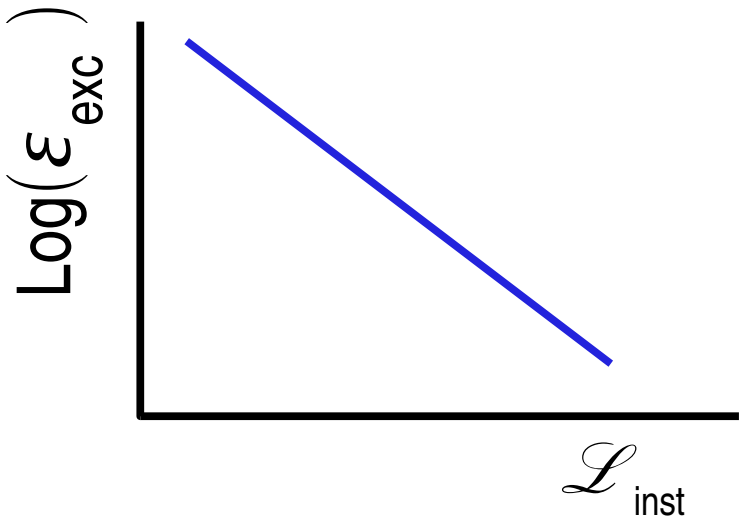
$$\varepsilon_{fsr} = 0.7 \pm 0.1$$

Efficiency for $\gamma\gamma$ pair to not convert into 2 separate CDF EM objects:

$$\varepsilon_{conv} = 0.9 \pm 0.1$$

Effective Luminosity

Concept:



$$\varepsilon_{exc} \simeq e^{-\sigma_{inel}\mathscr{L}}$$

ε_{exc} is the probability that the detector is in a state that can observe an exclusive interaction (no pile-up, beam halo, noise etc)

Effective luminosity: $\mathscr{L}_{eff} \equiv \int \varepsilon_{exc}\, \mathscr{L}_{inst}\, dt$

Calculated from zerobias data: $\mathscr{L}_{eff} = 40 \pm 10\ \mathrm{pb}^{-1}$ ← replaces $\int \mathscr{L}\, dt$

Expected Number of Events

$pp \rightarrow peep$: $N_{expected} = 9 \pm 3$ events

$\sigma_{LPAIR} = 582 \pm 4$ fb

$\mathscr{L}_{eff} \; \varepsilon_{ee/\gamma\gamma} \; \varepsilon_{fsr}$

$\sigma_{KMR/ExHume} = 40 \pm (\times 3)$ fb

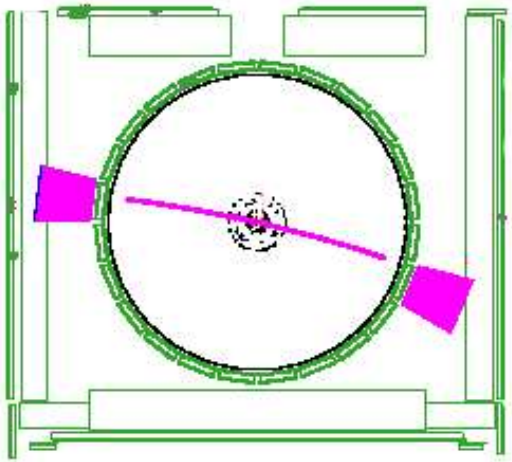
$\mathscr{L}_{eff} \; \varepsilon_{ee/\gamma\gamma} \; \varepsilon_{conv}$

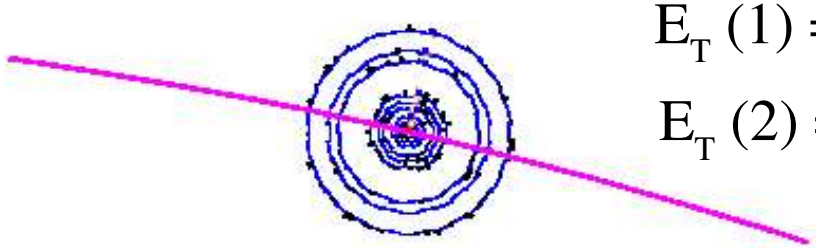
$pp \rightarrow p\gamma\gamma p$: $N_{expected} = 1^{+3}_{-1}$ events

CAUTION: *Backgrounds have not been subtracted. While they are expected to be small, estimates have not yet been made public.*

Any ee Candidate Events?

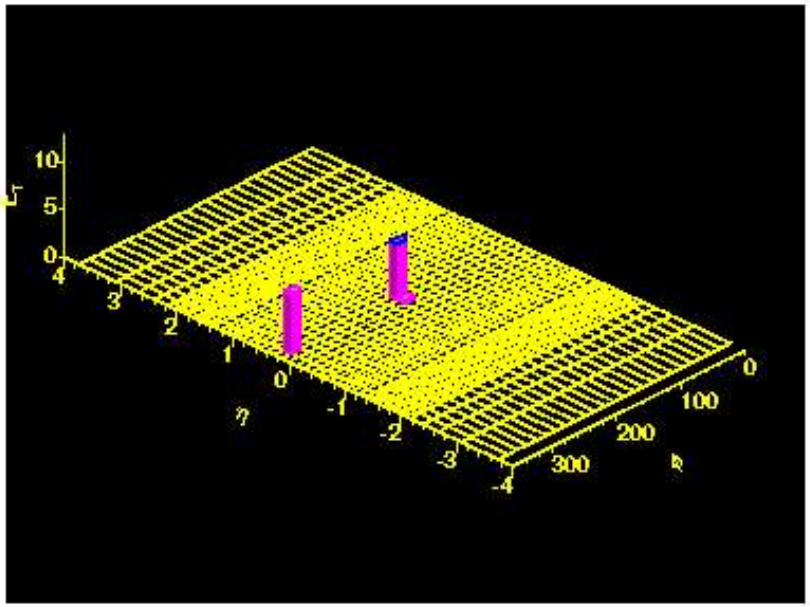
10 ee candidate events!

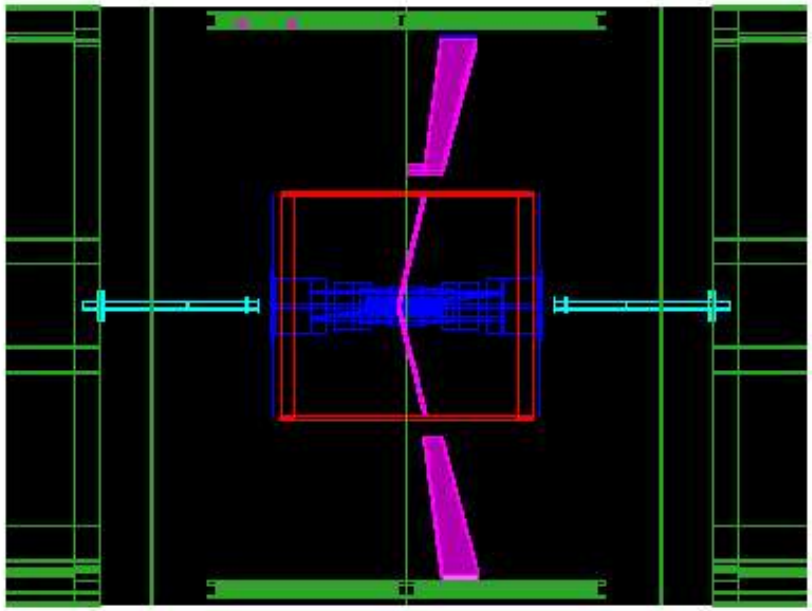




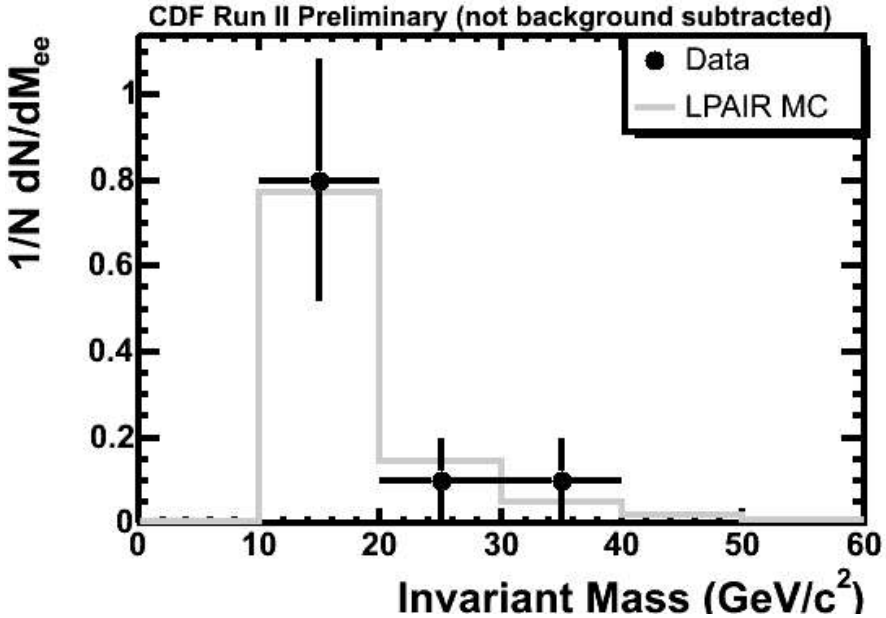
E_T (1) = 6.1 GeV

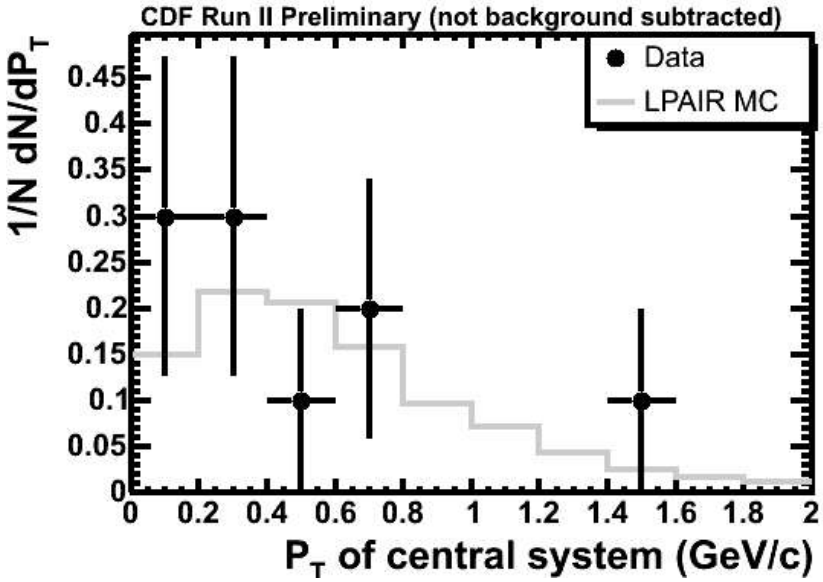
E_T (2) = 6.0 GeV

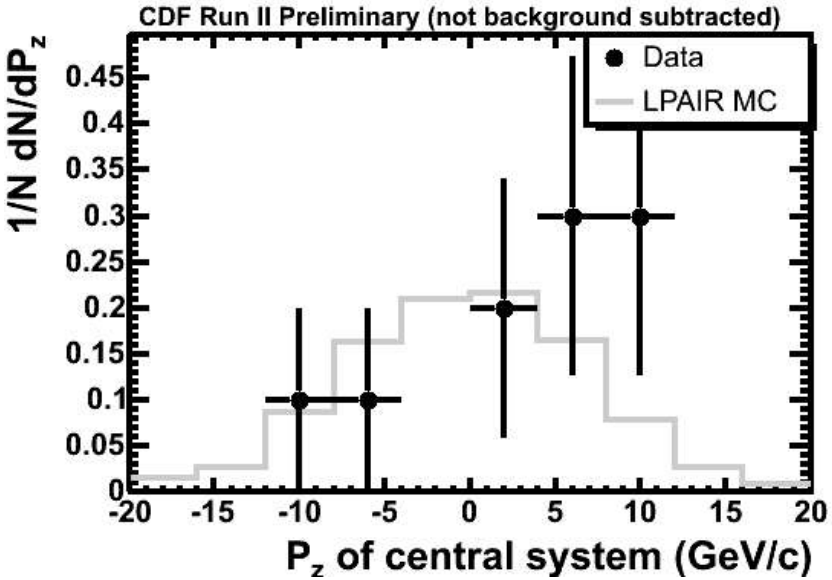




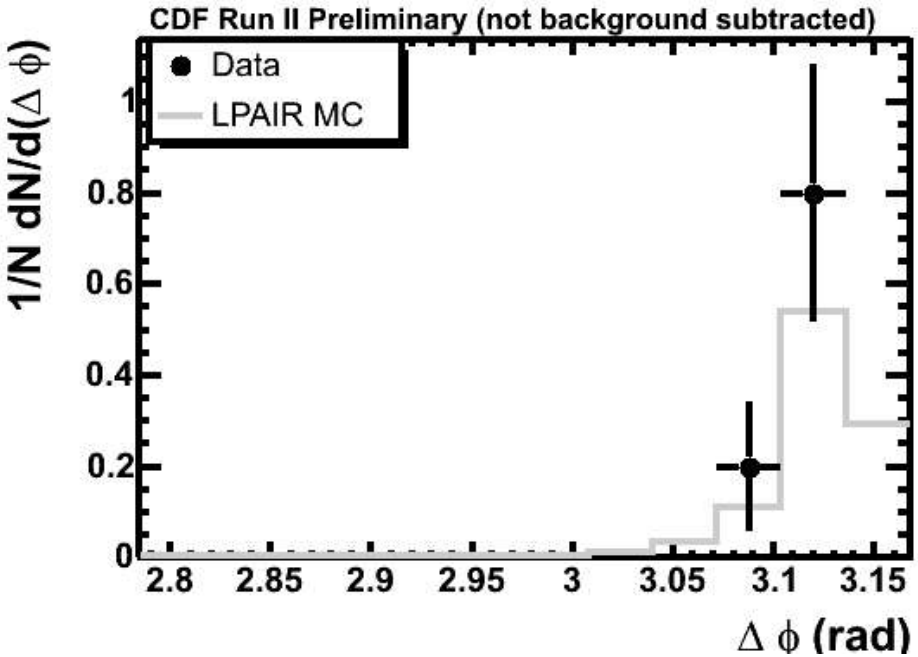
ee Candidates vs. LPAIR MC





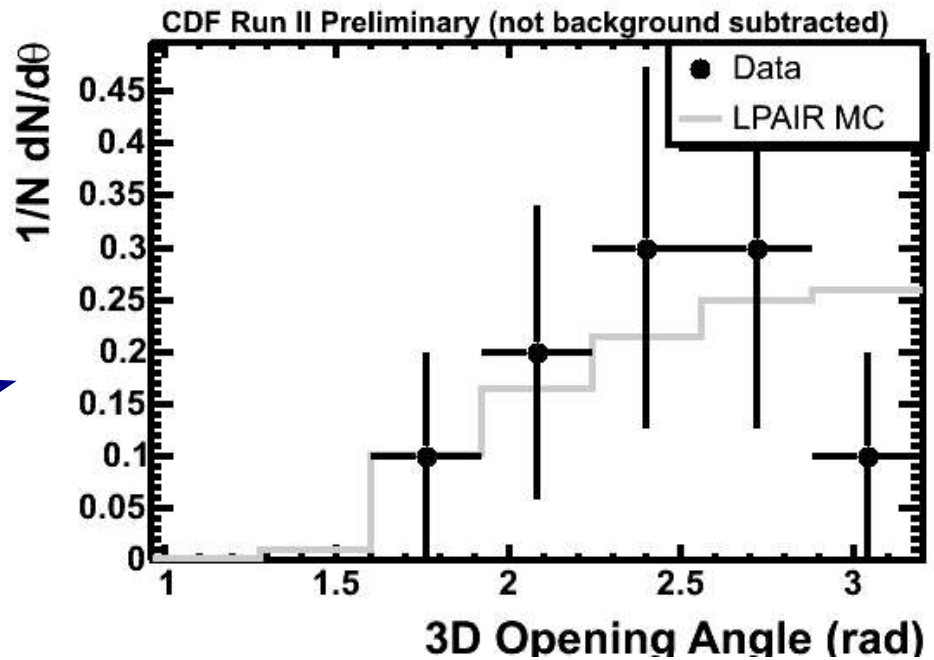


ee Candidates vs. LPAIR MC

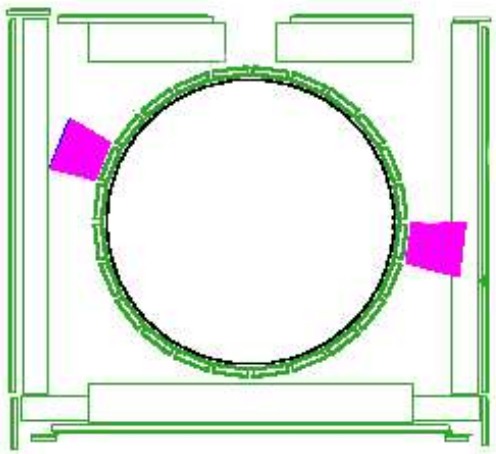


back-to-back in ϕ

not collinear



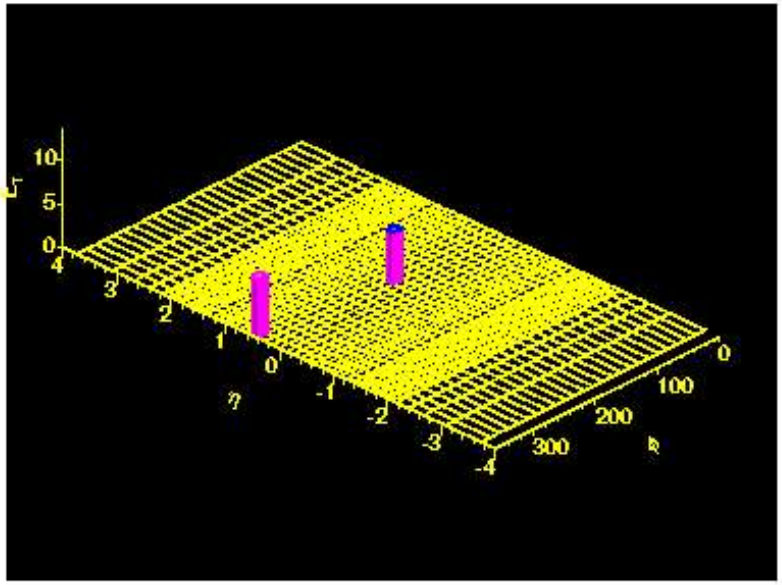
Any $\gamma\gamma$ Candidate Events?

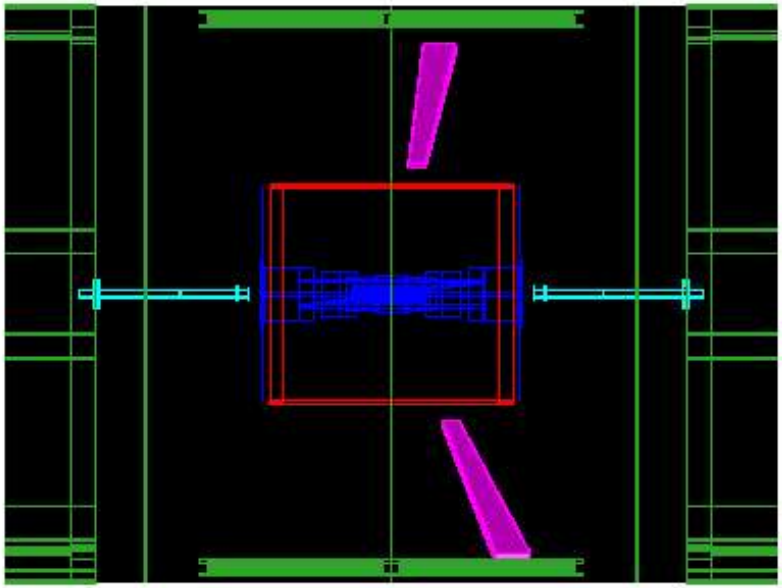


3 $\gamma\gamma$ candidate events!

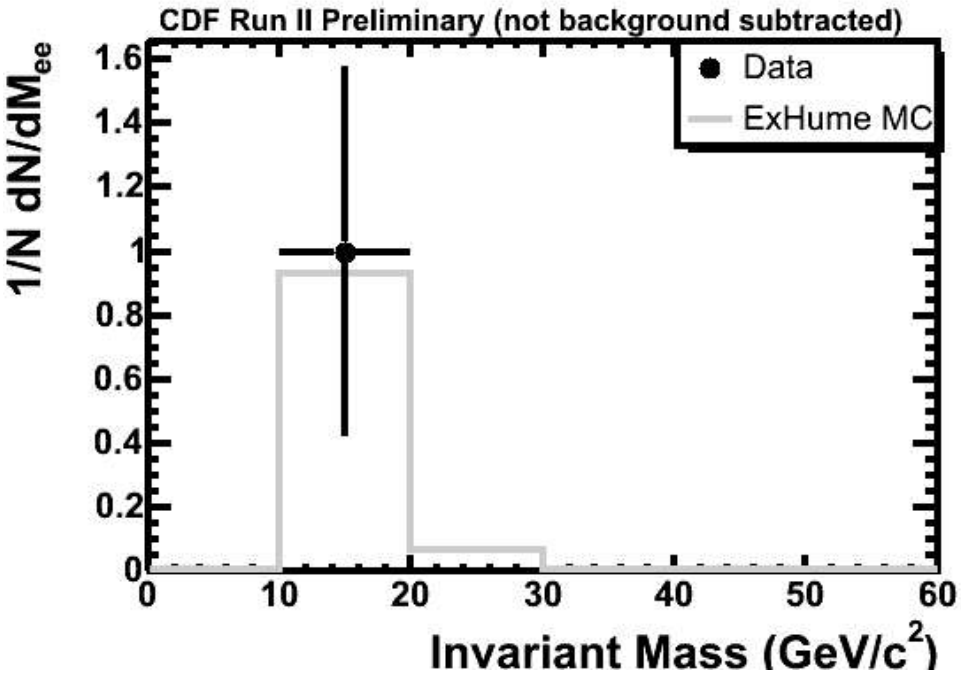
E_T (1) = 6.8 GeV

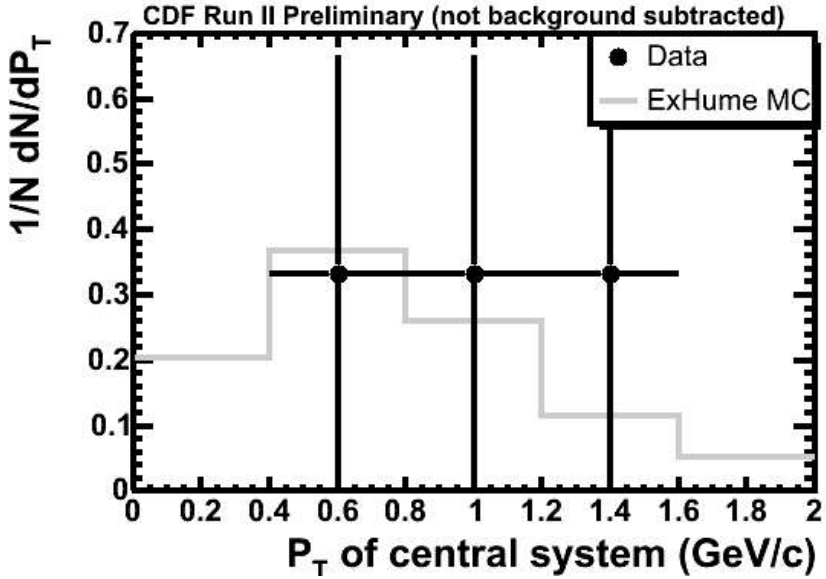
E_T (2) = 5.9 GeV

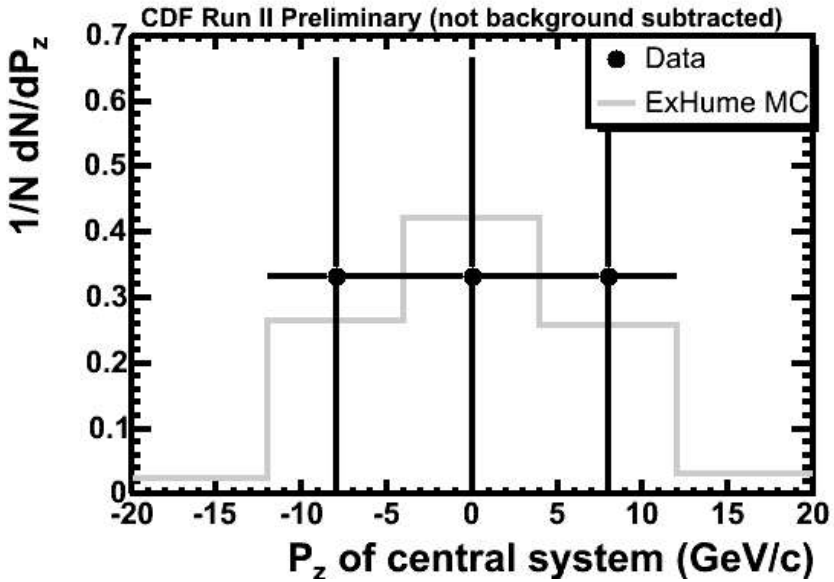




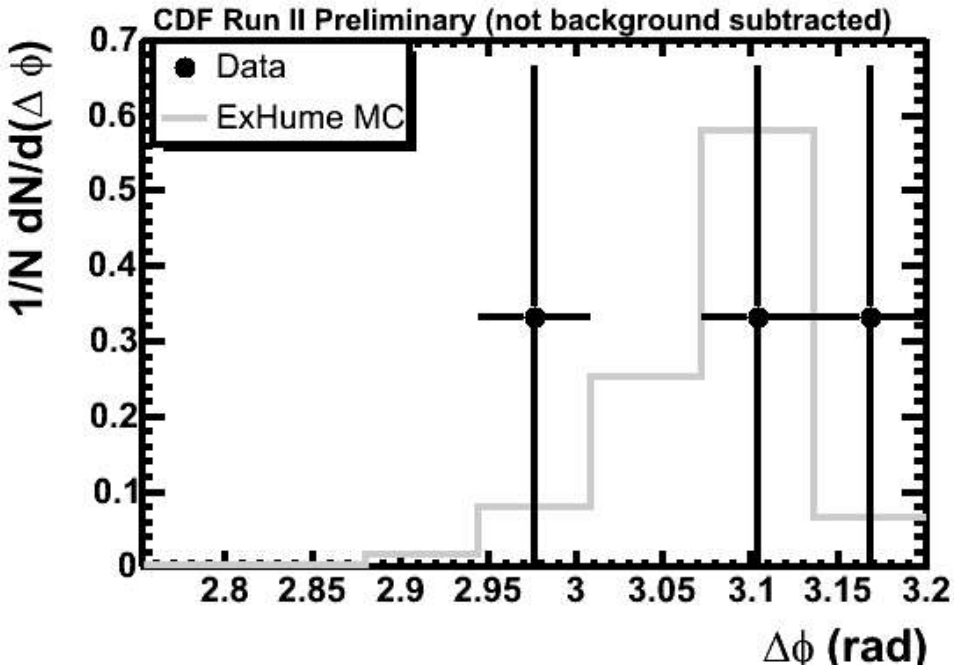
$\gamma\gamma$ Candidates vs. ExHume MC



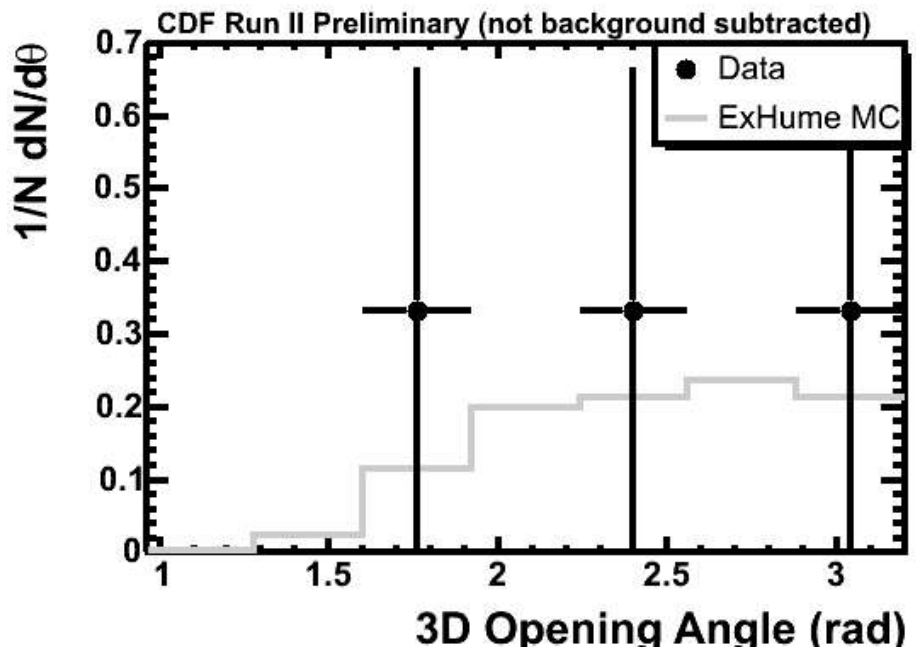




$\gamma\gamma$ Candidates vs. ExHume MC



lower ϕ resolution (no track)



Summary of Analysis

Conclusions:

- Found 10 events which appear consistent with pp→peep
- Found 3 events which appear consistent with pp→p$\gamma\gamma$p
- These "agree" with theoretical calculation

To Do:

- 'bless' the background estimates
- add another 100pb^{-1} (maybe 200pb^{-1})
- complete thesis (~3 months)

Next Presentation:

- I'll be summarizing the CDF diffractive physics program, including updates of this work, on Feb. 3 at the CDF Collaboration Meeting.

ATLAS :: My Physics Plans

Plans for ATLAS Physics

I want a physics result in my postdoc, must be done in the 2008 commissioning run.

Considerations:

- must use working detectors
- must have high cross section
- prefer it to be useful even if no new physics is discovered

Current Candidates:

- $Z' \rightarrow l^+l^-$: An "easy" search with $Z \rightarrow l^+l^-$ as a backup if no new physics, lots of competition?
- W+jets / Z+jets : More difficult than $Z' \rightarrow l^+l^-$, but not too sensitive to JES since some cancellation of uncertainties. If no new physics, still interesting as QCD background.
- $pp \rightarrow p\mu\mu p$: A simple search (if proper trigger exists), very useful for exclusive higgs and luminosity. New physics may be hidden by small cross section, and forward proton taggers will not be installed in time, so no pile-up is essential.