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# The CDF Program for Run IIb

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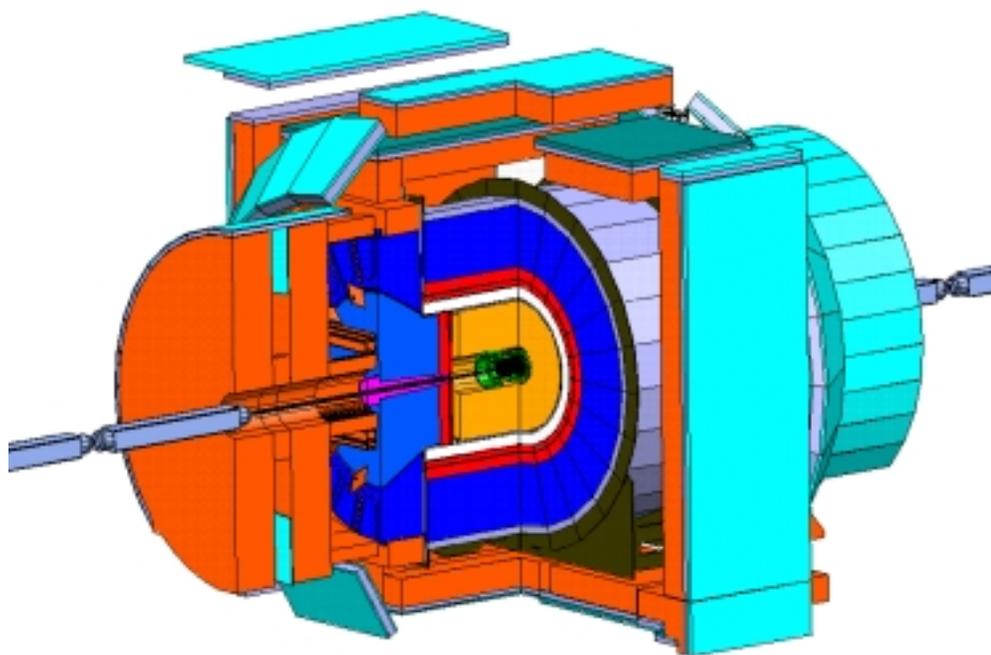
# Run IIb Strategy

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- 1 CDF's plan for Run IIb follows the guidance given by the Physics Advisory Committee (PAC) at their November, 2001 meeting.
- 1 Justify upgrades based on the Higgs search  
Specifically  $WH \rightarrow l\nu b\bar{b}$  and  $ZH \rightarrow \nu\nu b\bar{b}$
- 1 Our program addresses specific weaknesses in the experiment, that will arise in the Run IIb era.
  - Tracking
  - Lepton identification
  - Data acquisition



# CDF for Run II



- 1 The current detector was designed/built based on Run IIa specifications:
  - Maximum instantaneous luminosity of  $2 \times 10^{32} \text{cm}^{-2} \text{s}^{-1}$ .
  - Integrated luminosity of  $2 \text{fb}^{-1}$ .
  - Operation with 396 ns and 132 ns bunch spacing.
- 1 As in Run I, CDF's strength lies in its tracking system
  - Good momentum precision
  - Good vertex precision – b hadron identification



# The Run IIb Specifications

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- 1 We now consider the detector to have a longer, harder life.
- 1 Operating conditions for Run IIb:
  - Maximum instantaneous luminosity of  $5 \times 10^{32} \text{cm}^{-2} \text{s}^{-1}$ .
  - Integrated luminosity of  $15 \text{fb}^{-1}$ .
- 1 Not all portions of the detector can operate effectively in these conditions
- 1 The Run IIb project consists of replacements for key elements needed for the Higgs search.
  - Make changes needed in a 6 month shutdown in 2005.



# Higgs searches in Run I

## 1 Standard Model Higgs

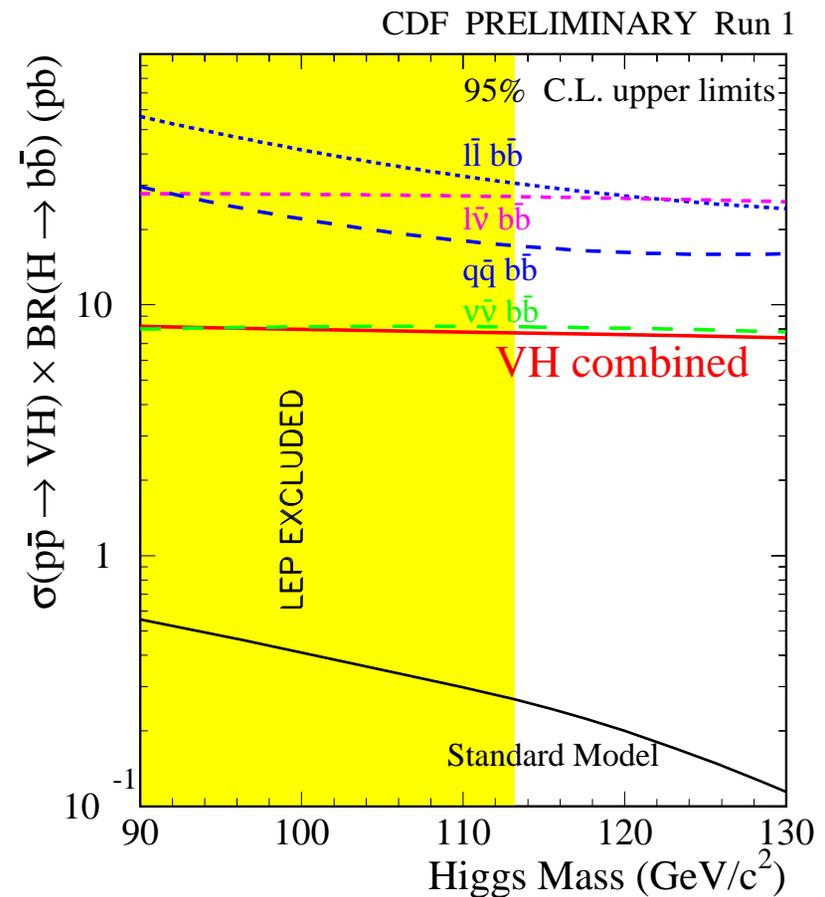
$$p\bar{p} \rightarrow VH$$

Lepton + jets ( $\geq 1$   $b$  tag)

Missing  $E_T$  + jets (2  $b$  tags)

Multijets (2  $b$  tags)

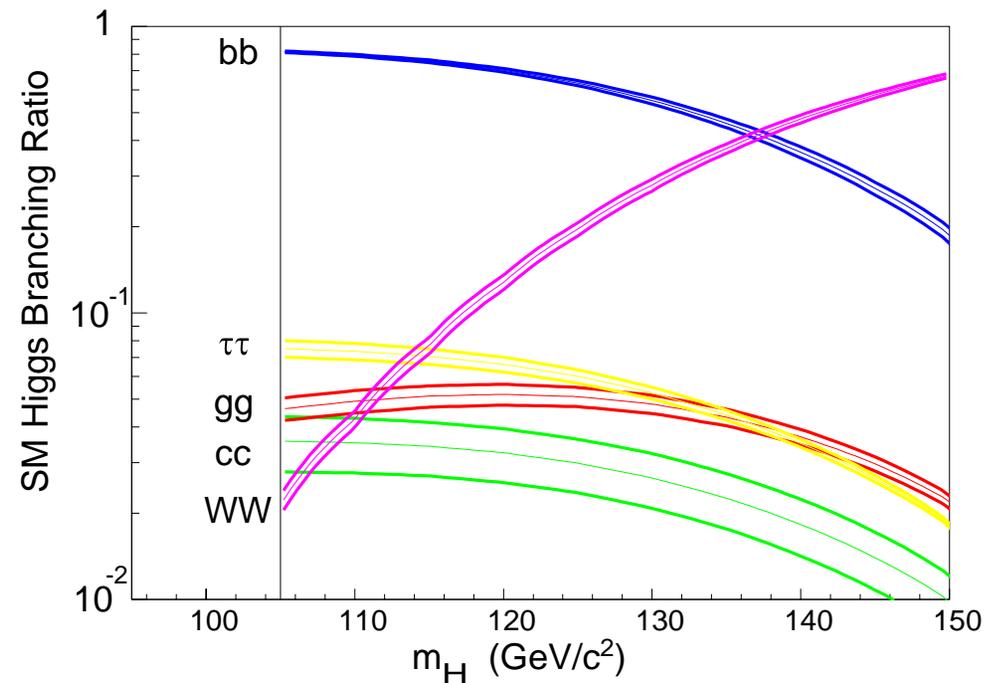
- 1 All channels require the ability to tag jets containing  $b$  quarks.





# b tagging

- 1 Why is tracking important?
  - bb* jets is the dominant branching ratio for a Standard model Higgs below 135  $\text{GeV}/c^2$ .
- 1 Tagging of *b* jets requires a precision vertex detector.
- 1 This capability is must be maintained for the Higgs searches of Run IIb.





# CDF's Run IIb Projects

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- 1 Three upgrades to the detector are required to maintain CDF as a viable Higgs search experiment for Run IIb:

Replacement silicon detector

- Current system cannot withstand the integrated luminosity

Replacement Central Preradiator

- Current system cannot withstand the instantaneous luminosity

Upgraded Event Builder

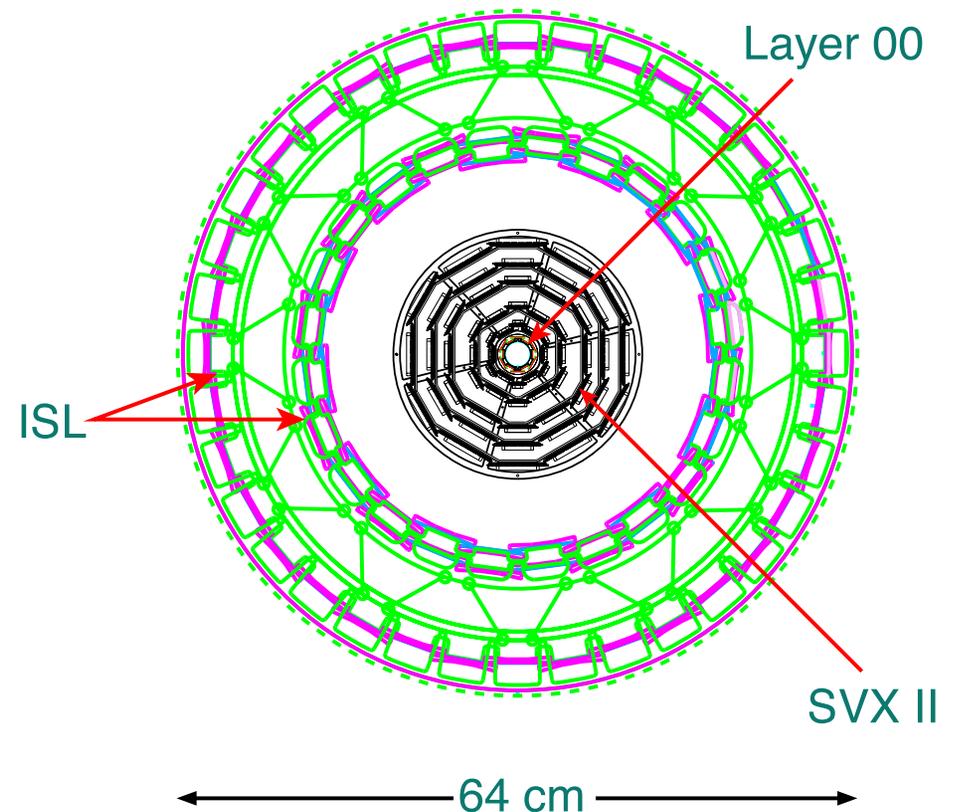
- Current system cannot withstand the instantaneous luminosity



# Run IIa silicon system

- 1 Radiation damage tests and rate measurements allow us to predict the lifetime of the SVXII.

Layer	Lifetime ( $\text{fb}^{-1}$ )
00	7.4
0	4.3
1	8.5
2	10.7
3	23
4	14



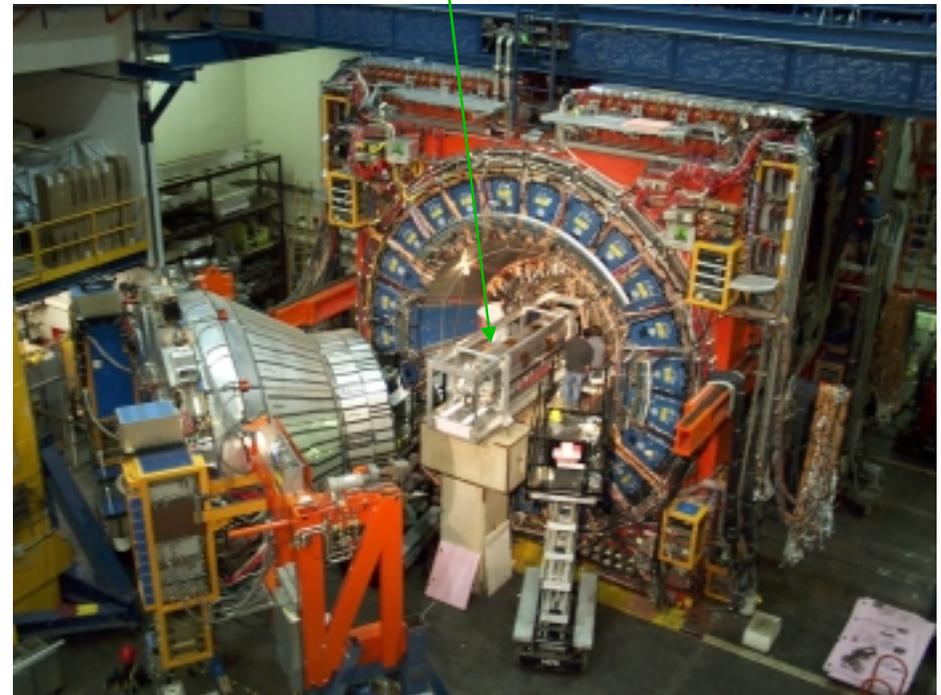
Silicon detector end view



# Silicon Installation

- 1 Silicon detector replacement
  - Space constraints require removal of the central detector from the collision hall
- 1 14 weeks are required for the detector to come out and return to the collision hall
- 1 The 6 month shutdown leaves only 12 weeks to work on the silicon system
  - The full silicon system (SVX II/ISL) must be removed and taken to the silicon facility

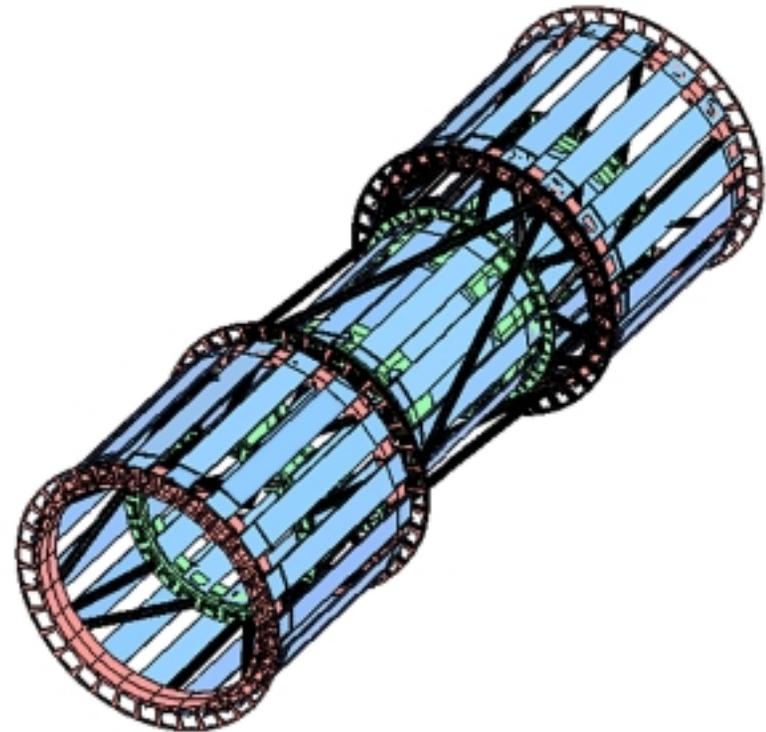
ISL positioned for installation (Jan. 2001)





# SVX Replacement

- 1 The inner six layers of the silicon system are tightly coupled mechanically.
  - Disassembly would be time consuming and very risky.
  - Also tight connection with the beampipe.
- 1 This motivates a complete replacement with a new detector
  - ISL is retained, but inner portion (SVX II) will be replaced.



ISL Space Frame



# SVX Replacement

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- 1 The replacement detector is being designed to be simple, and should be relatively quick to build.

Based on single sided detectors

Readout chip is common with D0, manufactured in a standard process.

One structure is used for most of the detector

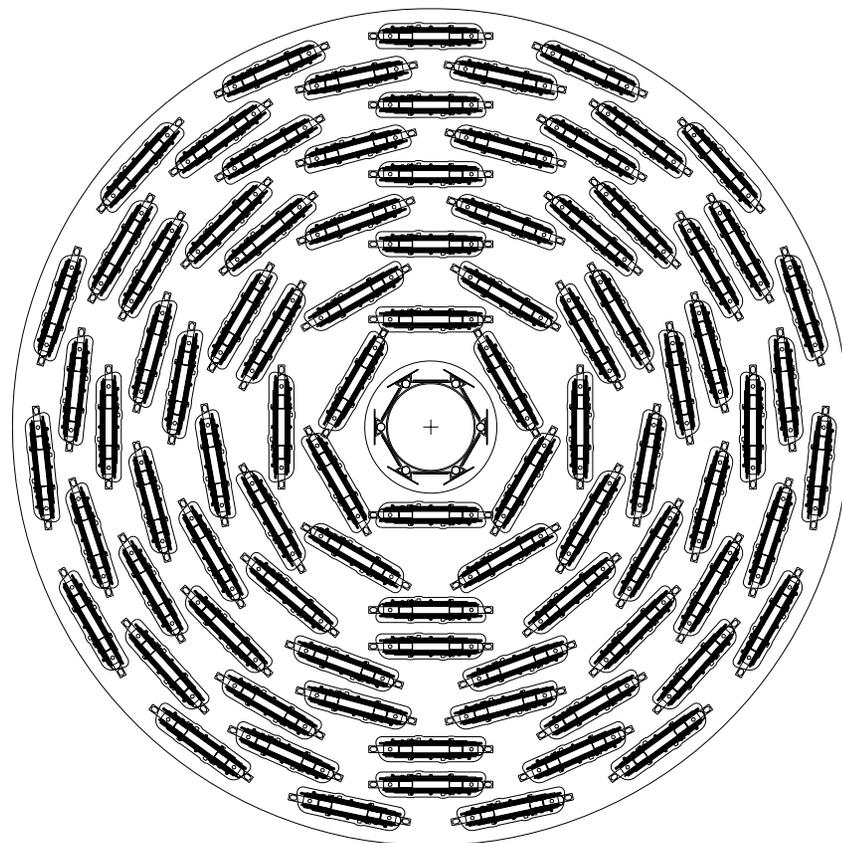
Compatible with existing systems

- Data acquisition
- Cooling



# Silicon Detector - Run IIb

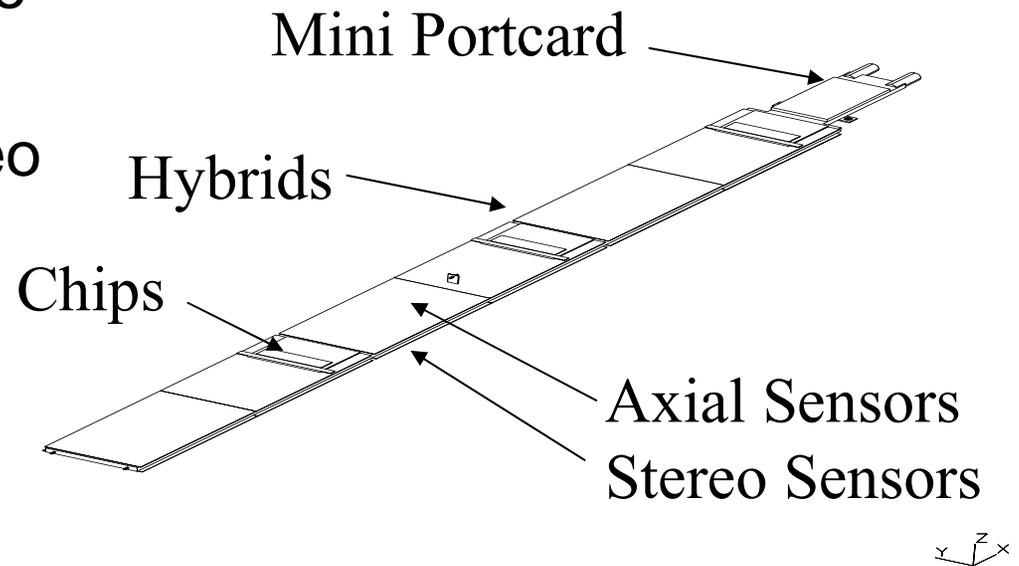
- 1 New detector is designed for quick construction
- 1 A basic module - the “stave” will be built
- 1 This structure will populate most of the detector volume
- 1 This gives the advantage of fewer parts than the current detector





# Silicon Detector - Run IIb

- 1 Single sided sensors will be used for Run IIb.
- 1 Axial and small angle stereo layers will be joined in a single structure – this is used for layers 1-5.
- 1 Layer 0 (innermost) will be axial only, and a different structure.



1 Stave layout



# Central Preradiator

- 1 The second Run IIb project for CDF is the Central Preradiator replacement
- 1 Located on the front face of the central calorimeter
- 1 The current device is a gas chamber
  - Charge must be collected over 4 beam crossings
  - Will contain data from ~20 interactions in Run IIb
- 1 The rate will seriously compromise its usefulness.
- 1 This detector is used to
  - Identify high  $P_T$  electrons
  - Tag  $b$ 's through soft electrons
  - Improve jet resolution
- 1 All these functions are needed for the Higgs search.
- 1 Furthermore, the shower maximum chamber is also gas, and inaccessible
  - Preradiator is our only avenue to strengthen electron ID.

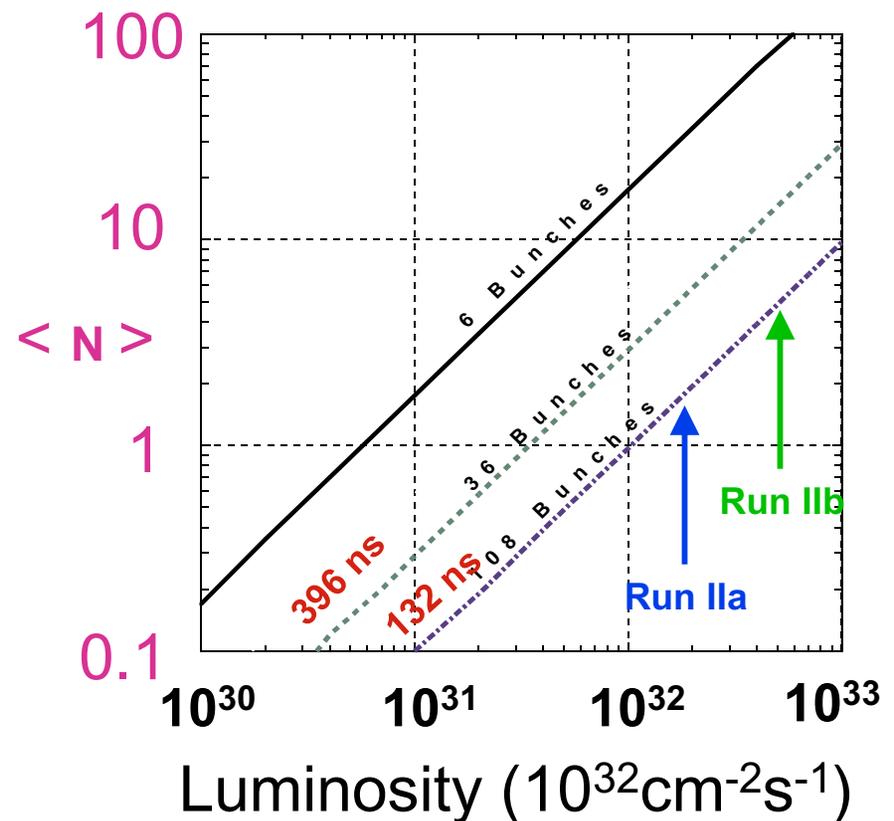


# Run IIb Instantaneous Luminosity

Run IIb conditions imply an average of  $\sim 5$  interactions per crossing.

The Central Preradiator will therefore contain data from 15-20 interactions.

Occupancy will be very high, reducing the usefulness





# Preradiator Replacement

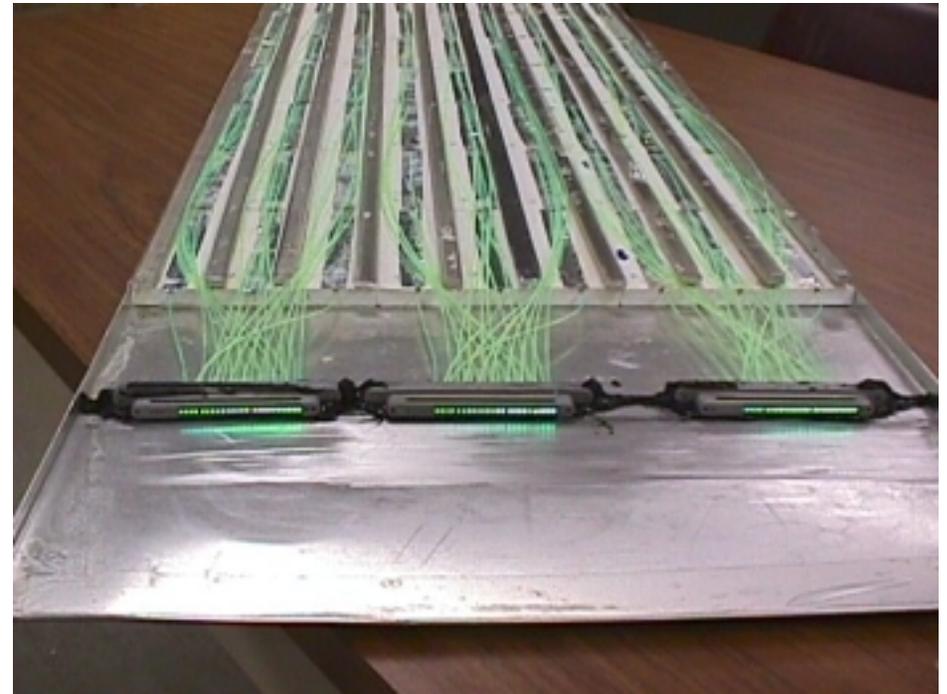
- 1 The preradiator replacement will take the place of existing CPR.

Replacement uses scintillator

- Minos excess is possible, used for the prototype
- Other approaches will be studied

Optical fiber readout, with 16 channel phototubes

- Same readout used in the plug calorimeter shower maximum detector, same phototubes





# Preradiator Replacement

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- 1 CPR2 would be assembled at Argonne
- 1 A year to build is thought to be ample, so schedule is not yet critical for Run IIb
- 1 Still some R&D to do, to settle on details
- 1 Electronics is reused, nothing new is needed
- 1 Significant foreign contributions are expected
  - We expect phototubes and bases to be provided by Japan.
  - We expect high voltage supplies to be provided by Italy.
- 1 Installation can proceed within the ~8 weeks allowed
  - This does not compete with silicon detector installation for space.



# Run IIb Projects tied to detector access

## 1 Central Preradiator replacement

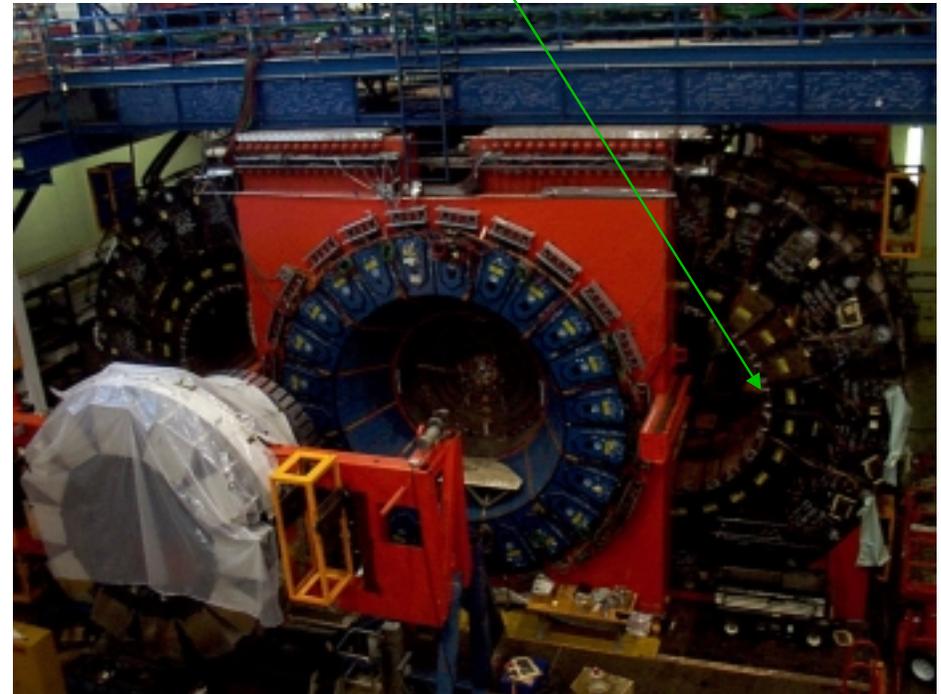
Existing gas chambers will be removed, and new replacement scintillator chambers installed

Installation requires the calorimeter arches to be extracted

- Only partial extraction is possible in the collision hall

Quite a few cables to dress.

CPR location





# DAQ- Event Builder

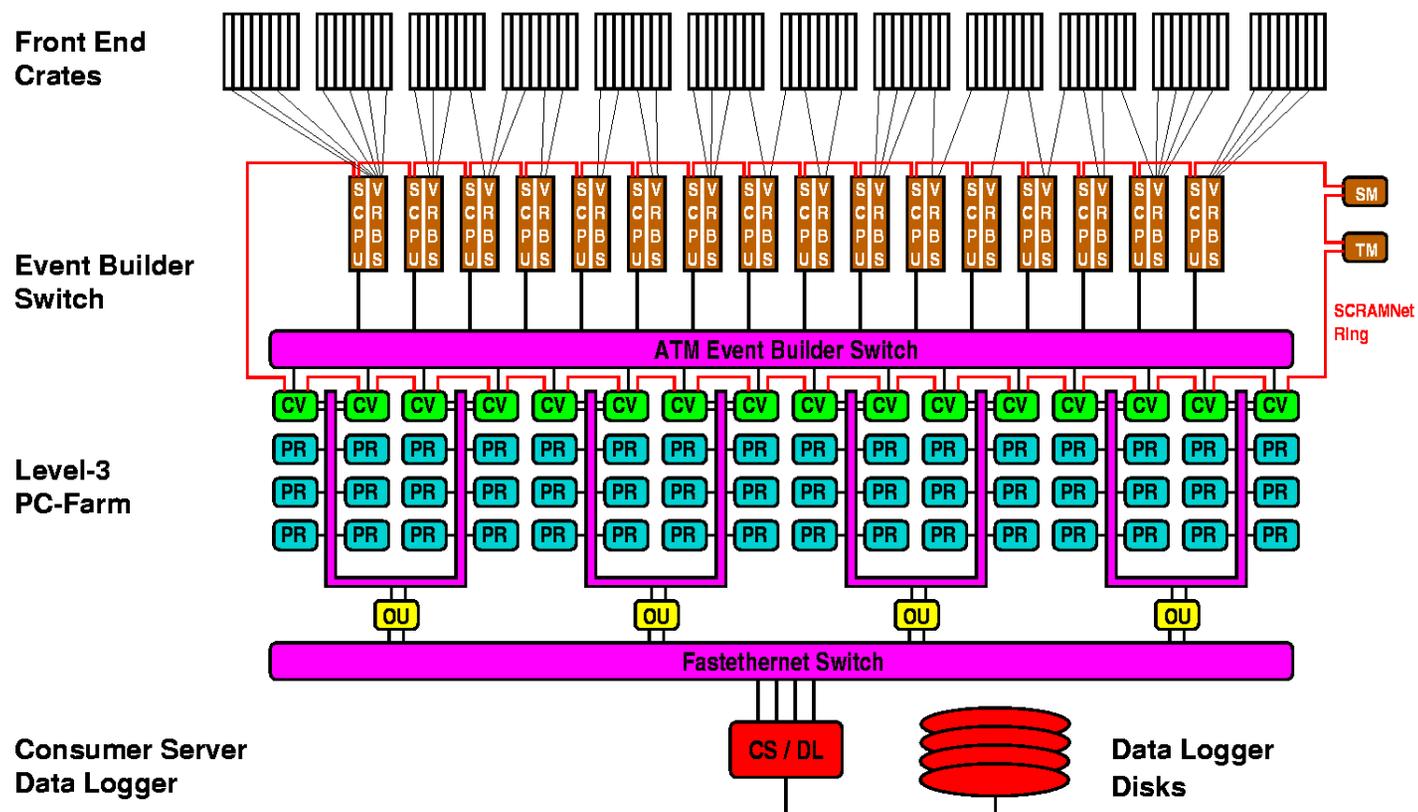
- 1 We also plan to retain the event builder upgrade, to increase our bandwidth into Level 3.
- 1 Our current system is specified to operate with a 300 Hz Level 2 accept rate.
  - Cutting our trigger table to the minimum set of Higgs search triggers gives us ~600 Hz in Run IIb.
- 1 In addition, we must leave some “headroom” here.

Level 2 Trigger	$\sigma(\text{nb})$
Minimum, no bias	25
Jets	190
High Et electrons	115
High Pt muons	200
MET + 2 jets, b tags	220
J/ $\psi$ $\rightarrow$ $\mu\mu$ , central	25
J/ $\psi$ $\rightarrow$ $\mu\mu$ , other	50
Multi jets/b tag	95
High Pt b jet	200
Di-tau	55
tau + MET	36
Z $\rightarrow$ bb	32
<b>Total(nb)</b>	<b>1243</b>
<b>Rate for L= <math>5 \cdot 10^{32}</math> (Hz)</b>	<b>622</b>



# Event Builder Overview

## CDF Data Acquisition System: Engineering Run





# Event builder installation

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- 1 The replacement system is specified to operate at 1000 Hz.
- 1 Installation occurs in the counting rooms, and can begin without interruption to operations
  - Final integration with the rest of the data acquisition can occur during the 6 month shutdown.
- 1 Labor for this will be provided by MIT
  - Same group is responsible for our current system.



# Current M&S Cost Estimate

Project	Cost	Cost with Contingency	U.S. (with cont.)	Japan	Italy
Silicon Tracker	\$7,177,000	\$9,832,000	\$7,616,000	\$1,870,000	\$345,000
Central Preradiator	\$680,000	\$872,000	\$459,000	\$280,000	\$133,240
Data Acquisition	\$414,000	\$538,200	\$538,200		
Administration	\$120,000	\$120,000	\$120,000		
<b>Total</b>	<b>\$8,391,000</b>	<b>\$11,362,200</b>	<b>\$8,733,200</b>	<b>\$2,150,000</b>	<b>\$478,240</b>

1 Changes since December technical review:

Added Administration, which clearly needs more (travel, visitors, ...)

Added indirect costs (16.6%) where foreign money is used (~\$500K)

Simplified Layer 1 and dropped 90° layers

1 The cost fits within the laboratory's guidelines for M&S.

1 Labor estimates are still in progress

1 We expect a total project cost of approximately \$28M.



# Next steps

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- 1 PAC Review next week 12-14 April.
- 1 Director's review is scheduled for 16-18 April.
- 1 Baseline review scheduled for 25-28 June.
- 1 The silicon schedule (procurement, construction) is critical.
- 1 We hope for baselining – Critical Decision 3 - by the end of summer  
needed to achieve the installation goal of 2005.