The CDF Program for Run IIb

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CDF Talks to be Presented

- This talk:
  - Replacement of the Silicon Detector
  - Replacement of the Central Preradiator
  - Upgrade of the Event Builder
- Following Talk (Franco Bedeschi)
  - EM Calorimeter Timing
  - Trigger and Data Acquisition

Run IIb Strategy

- Since the November 2001 PAC meeting, the strategy for CDF's Run IIb program has evolved, reflecting the PAC's guidance.
- Justify upgrades based on the high P_T physics program (Higgs, SUSY, other heavy objects).
  - Where possible, use $WH \to l\nu b\bar{b}$ and $ZH \to \nu\bar{\nu}b\bar{b}$ as our benchmarks.
- In addition, laboratory has given us M&S cost guidance. Stay within $9.1M.

Focusing the project

- To stay within these limits, we have set priorities among the Run IIb subprojects.
  - Some will be deferred, until funding can be identified.
- Our program addresses specific weaknesses in the experiment that will arise in the Run IIb era.
  - Tracking
  - Lepton identification
  - Data acquisition

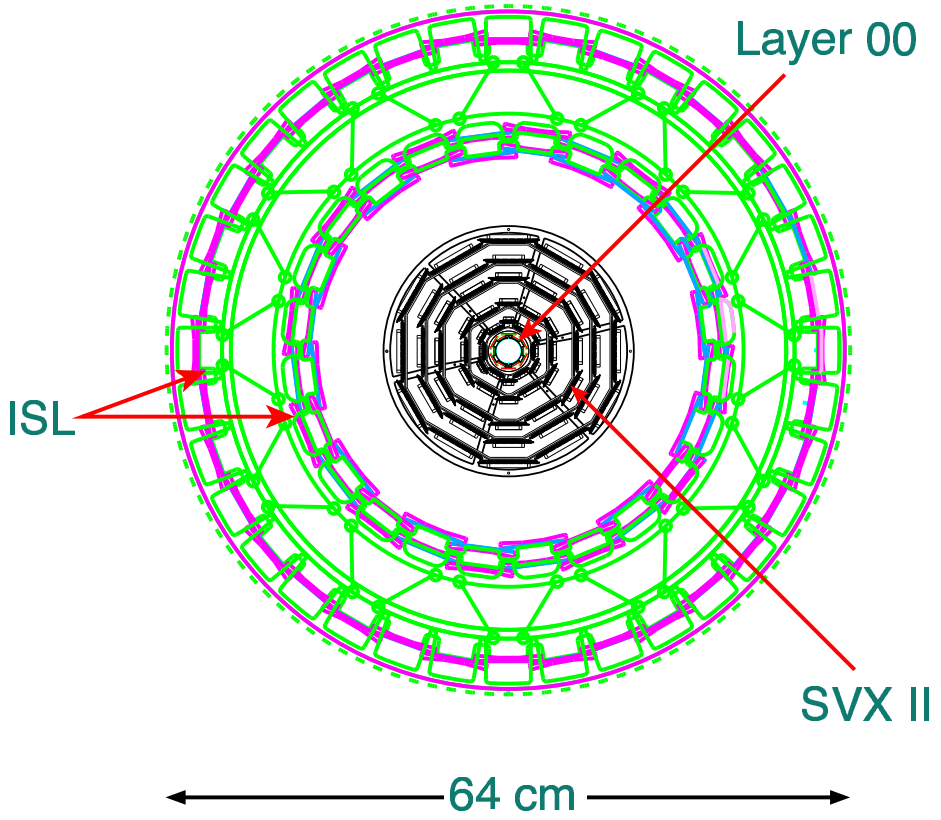
CDF's Run IIb Projects

- This talk describes three upgrades to the detector which 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

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

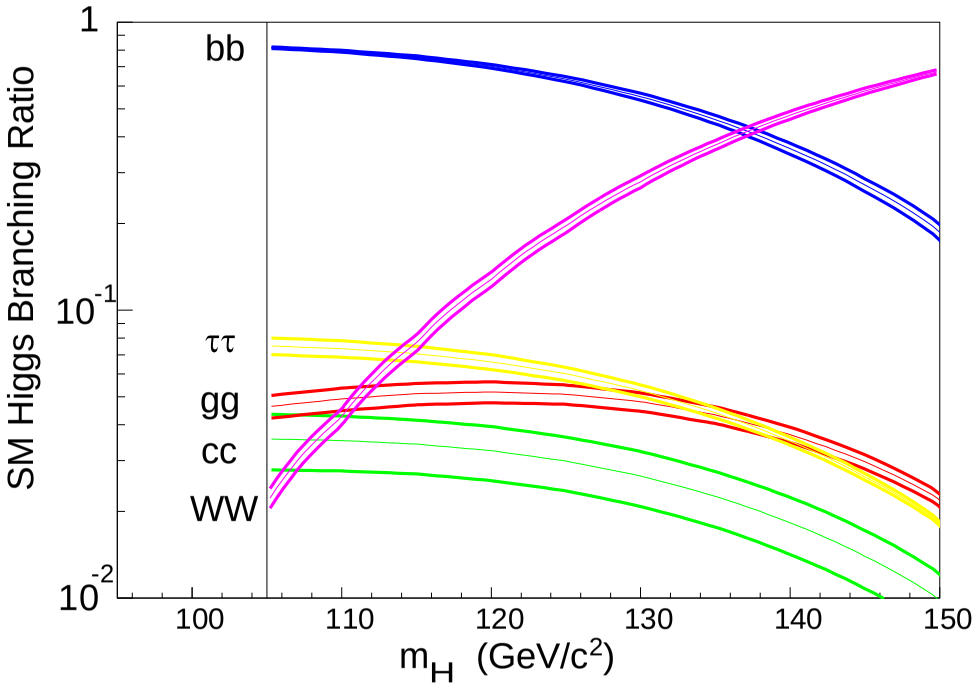
Layer	Lifetime (fb^{-1})
00	7.4
0	4.3
1	8.5
2	10.7
3	23
4	14



Silicon detector end view

Silicon Detector

- Why is a silicon detector important?
  - *bb* jets is the dominant branching ratio for a Standard model Higgs below 135 Gev/c^2.
- Tagging of *b* jets requires a precision vertex detector.
- This capability must be maintained for the Higgs searches of Run IIb.

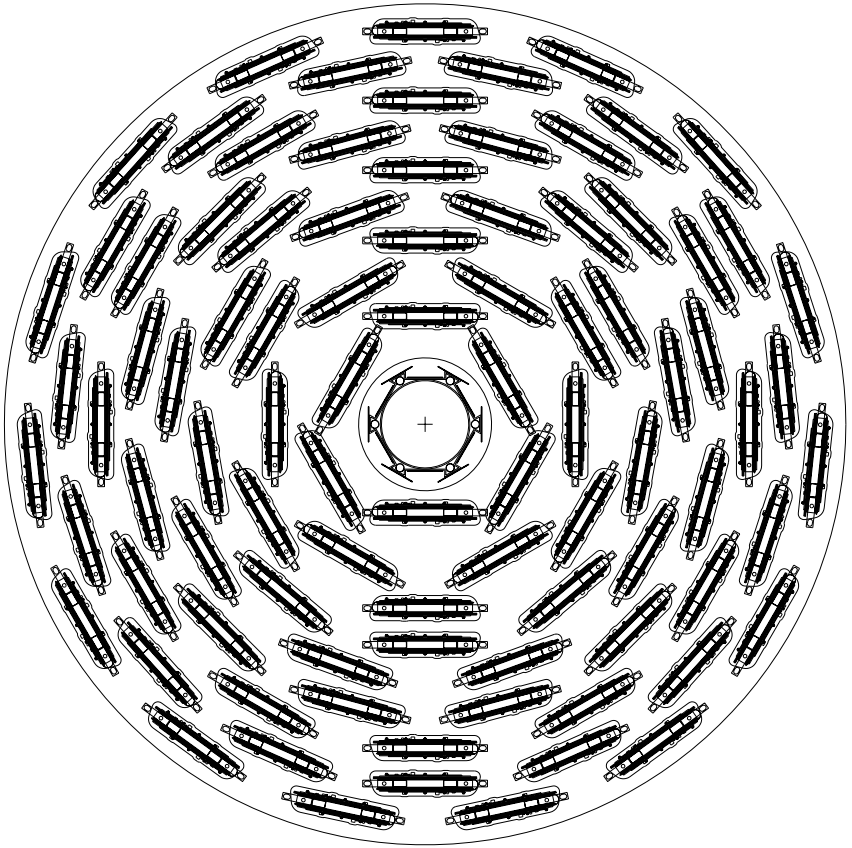


SVX Replacement

- The replacement silicon 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
- Developments since Nov. 2001 have simplified the design we propose to build.

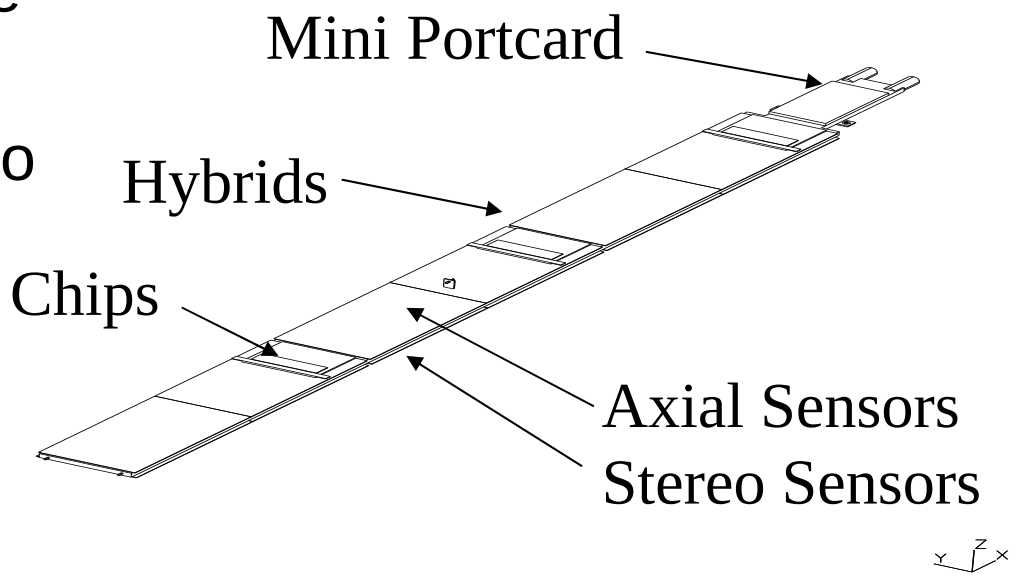
Silicon Detector - Run IIb

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



Silicon Detector - Run IIb

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



- Stave layout

Modifications since Nov.

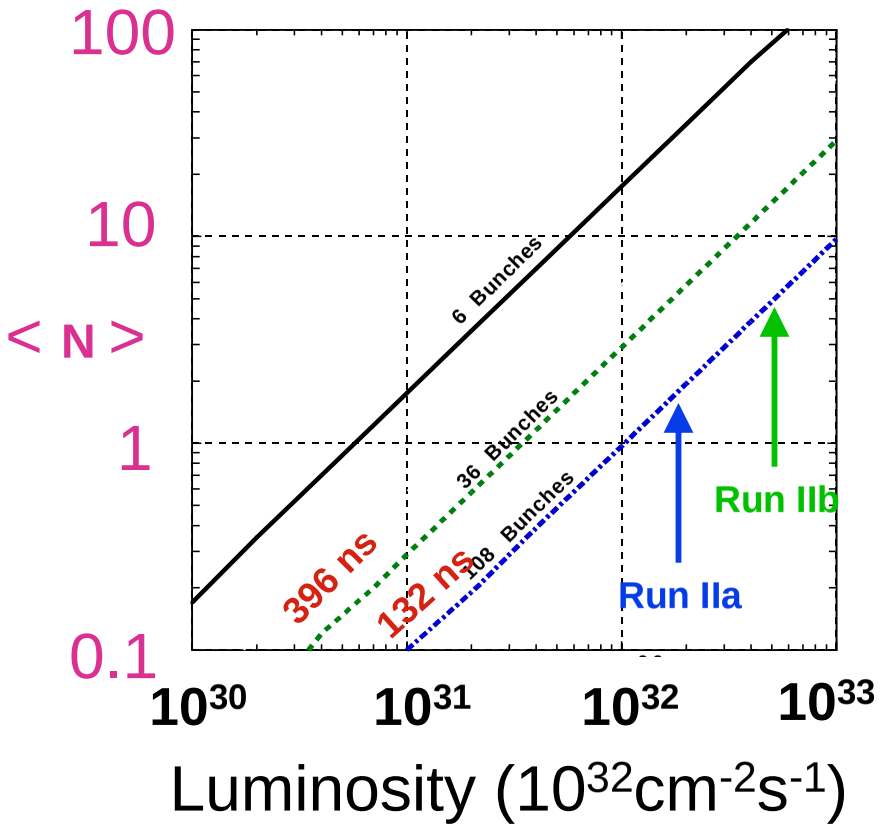
- Two important modifications have been made to the silicon detector design.
  - Both were listed as “descoping” options last fall.
- 90° layers have been replaced by axial and small angle stereo (1.2 °) layers.
  - Three 90° layers was not seen as sufficiently robust.
  - This was a trade off – resolution vs. pattern recognition.
  - The axial tracking is strengthened by additional layers

Modifications since Nov.

- Layer 1 will be built from the same staves used in layers 2-5.
  - Coverage will suffer, the strip spacing could be better.
- There is a significant saving in parts count.
  - No special hybrid, fixture, sensors, etc.
- Taken together, the two changes reduce the project cost by ~$1M.

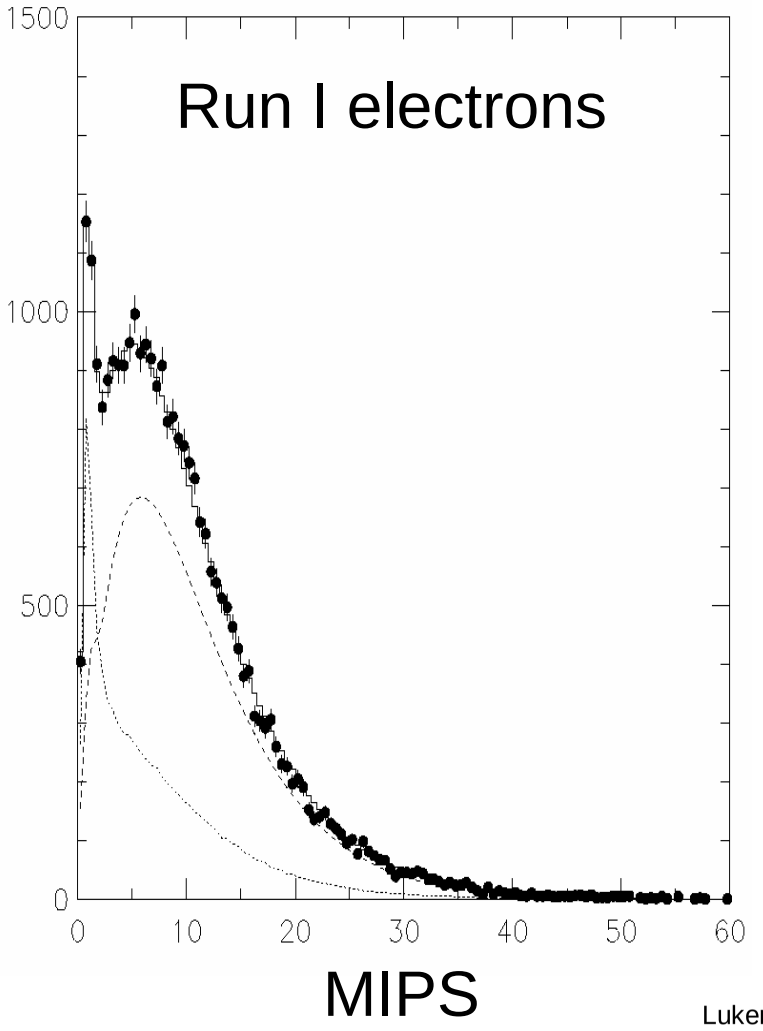
Central Preradiator

- The second Run IIb project for CDF is the Central Preradiator replacement
- Located on the front face of the central calorimeter
- The current device is a gas chamber
  - Charge must be collected over 4 beam crossings
  - Will contain data from ~20 interactions in Run IIb
- The rate will seriously compromise its usefulness.



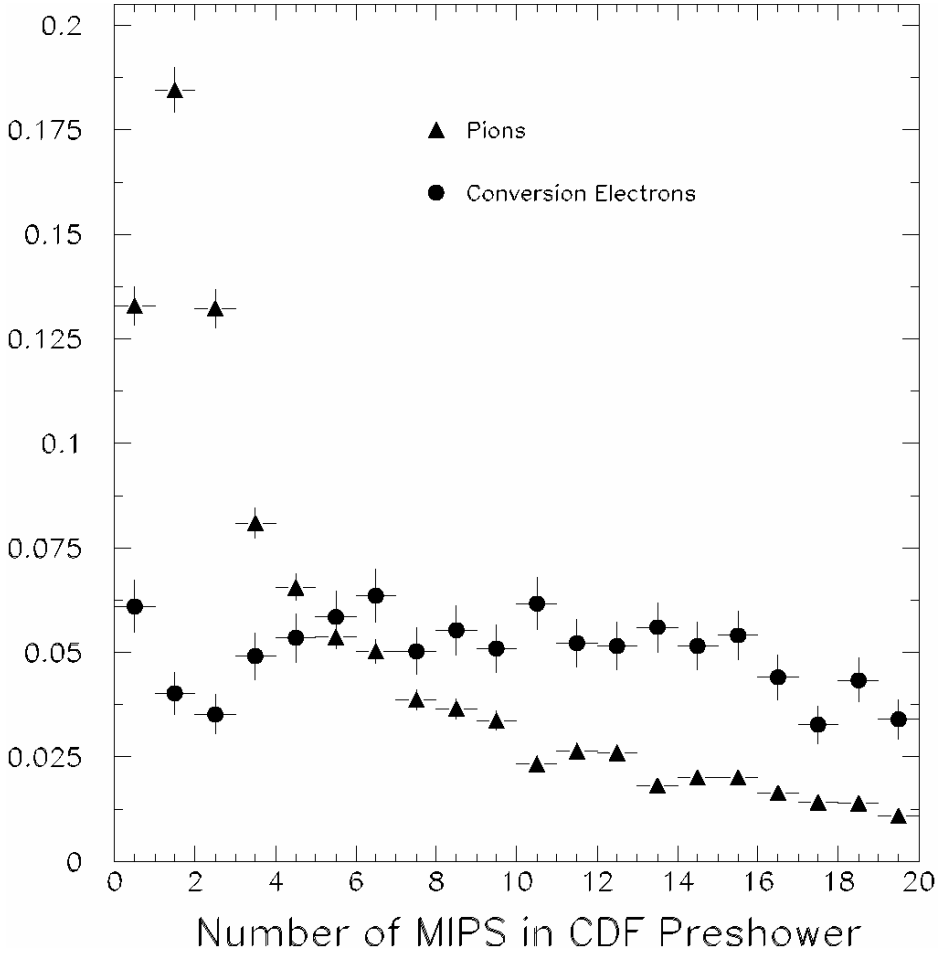
CPR for High P_T Electrons

- The preradiator provides an estimate of pion backgrounds to electrons
  - Can provide some rejection
- Note, the shower maximum chamber is also gas, and inaccessible
  - Preradiator is our only avenue to strengthen electron ID.



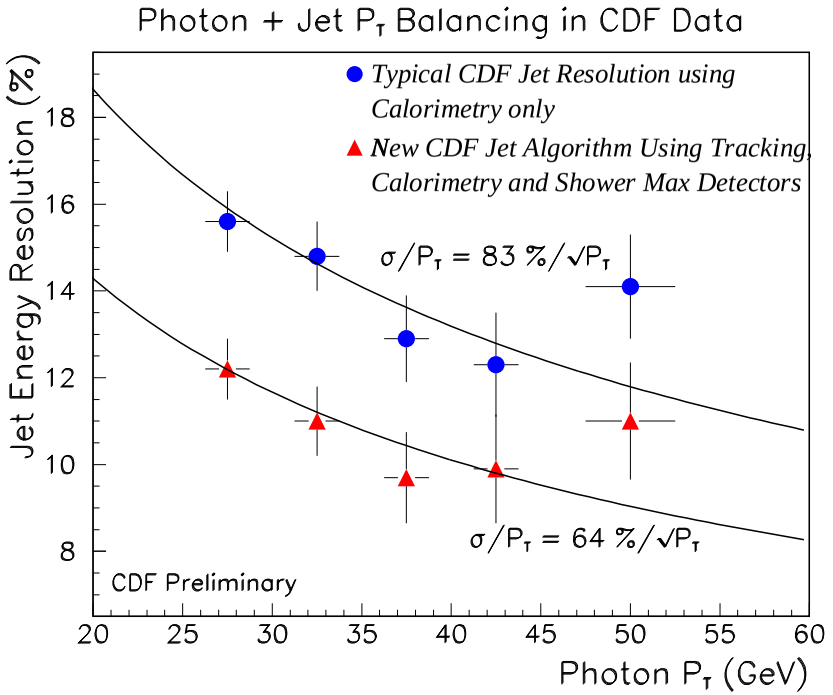
CPR for Soft *b* tagging

- Again, the ability of the CPR to discriminate between pions and electrons was used for tagging in Run I.
  - Ø 2 GeV particles from Run I
  - Ø CPR data was used to reduce π background



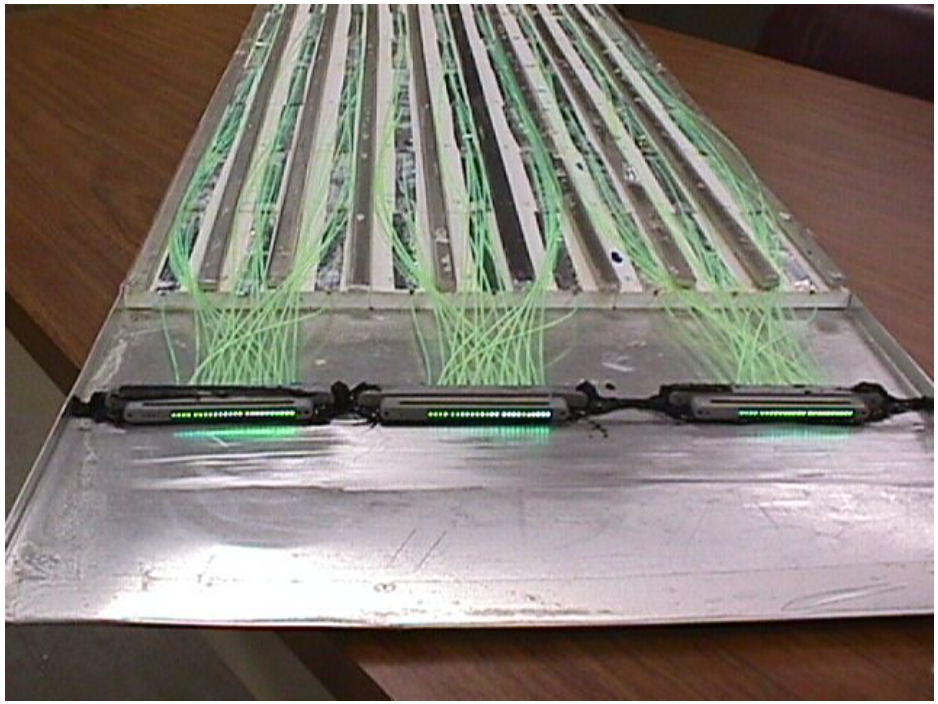
CPR for Jet resolution

- Some jet energy algorithms under study indicate that resolution can be improved by including CPR information.
- Jet resolution impacts Higgs sensitivity directly



Preradiator Replacement

- 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



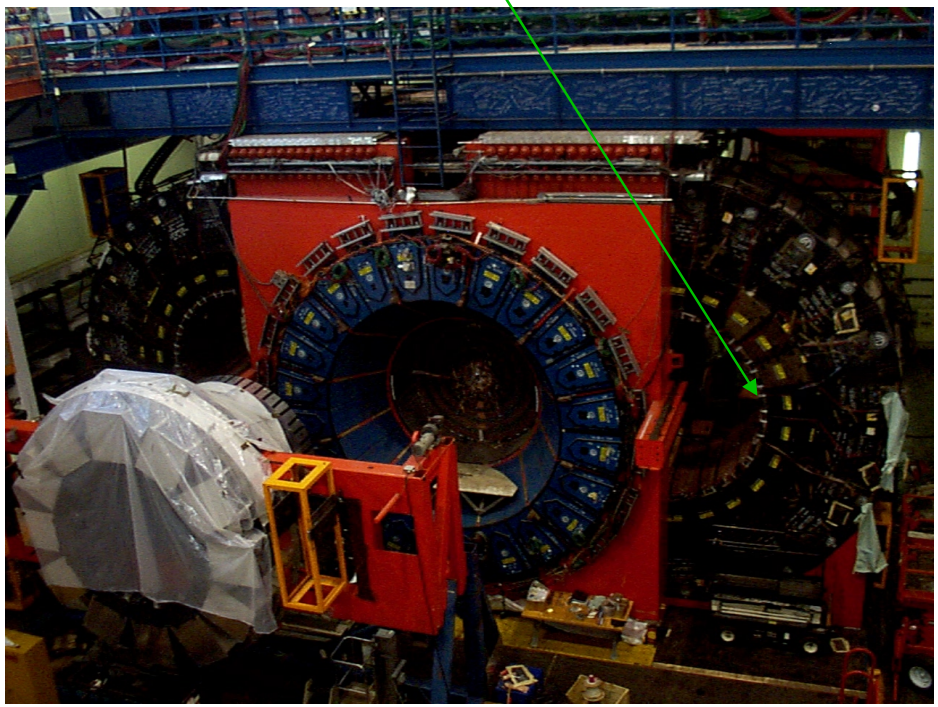
Preradiator Replacement

- CPR2 would be assembled at Argonne
- A year to build is thought to be ample, so schedule is not yet critical for Run IIb
- Still some R&D to do, to settle on details
- Electronics is reused, nothing new is needed
- 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.
- Installation can proceed within the ~8 weeks allowed
  - This does not compete with silicon detector installation for space.

Preradiator Installation

- Installation requires the calorimeter arches to be extracted
  - Not possible in collision hall
  - Assembly hall installation does not interfere with silicon.
- We think the CPR project should be retained
- It strengthens the high P_T program.
  - Large foreign contribution – U.S. cost is low

CPR location



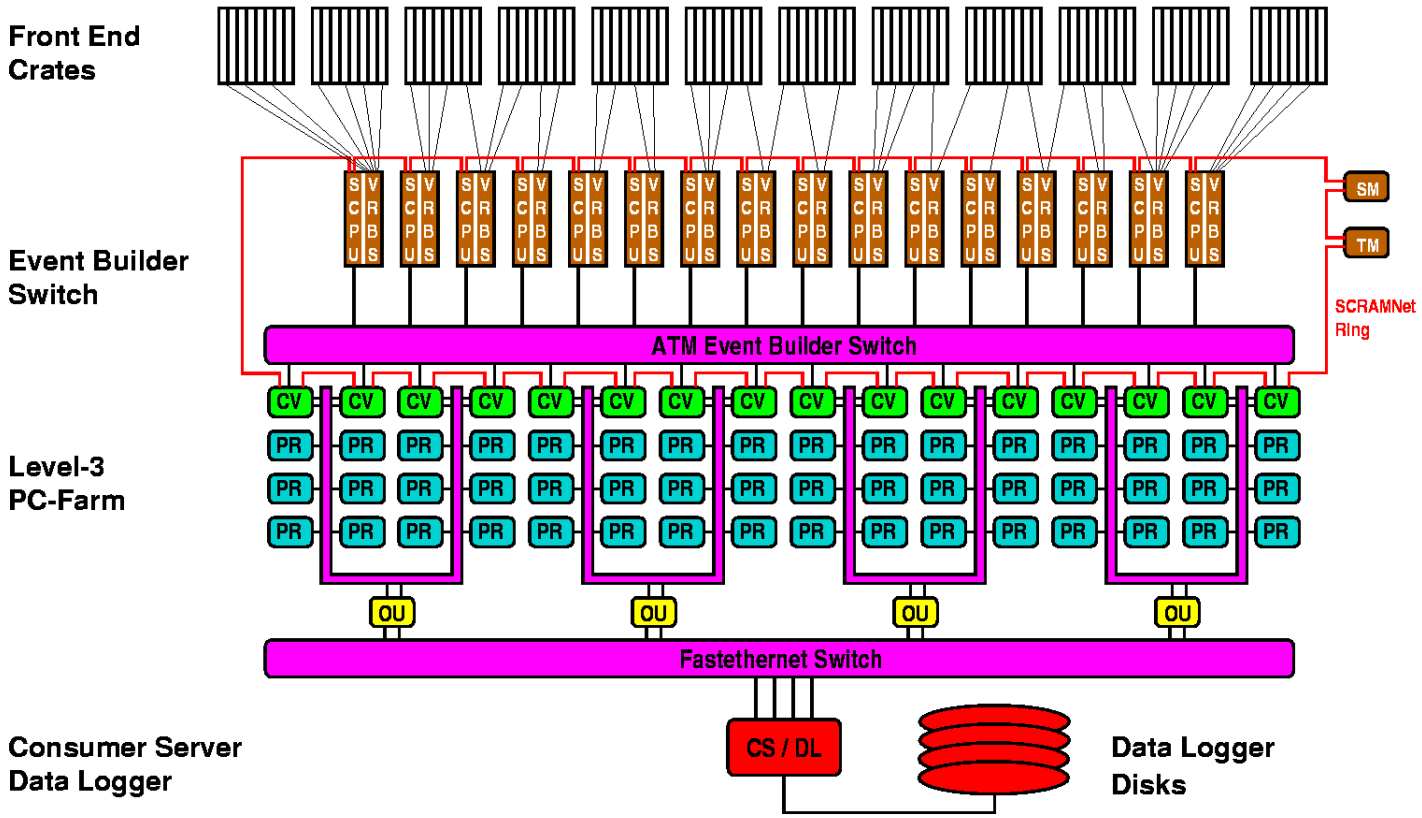
DAQ- Event Builder

- We also plan to retain the event builder upgrade, to increase our bandwidth into Level 3.
- 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.
- In addition, we must leave some “headroom” here.

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

Event Builder Overview

CDF Data Acquisition System: Engineering Run



Event builder installation

- The replacement system is specified to operate at 1000 Hz.
- 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.
- 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	$7,675,000	$10,495,000	$8,465,000	$1,685,000	$345,000
Central Preradiator	$690,000	$895,000	$426,000	$301,000	$168,000
Data Acquisition	$414,000	$538,200	$538,200		
Administration	$167,000	$217,000	$217,000		
Total	$8,946,000	$12,145,200	$9,646,200	$1,986,000	$513,000

- Changes since December technical review:
  - Simplified Layer 1 and dropped 90° layers
  - Improved estimates on many items
  - Added Administration, (travel, visitors, etc. …)
  - Added indirect costs where foreign money is used

Run IIb Scope

- We feel that the silicon detector, preradiator, and event builder satisfy the Higgs search test.
  - All are needed to maintain the high P_T program in Run IIb.
  - Our cost estimates for these are close to the lab guidelines.
- Additional projects presented last meeting will still be pursued – other sources of funds will be sought.
  - Franco Bedeschi will present these next.

Towards baselining

- Director's review is scheduled for 16-18 April.
  - We are trying to prepare as though this were the DOE baseline review.
    - Documentation is available at http://www-cdf.fnal.gov/upgrades/run2b/DIR_Apr02/DIR_Apr02.html
- DOE review scheduled for 25-28 June.
- We hope for baselining – Critical Decision 3 - by the end of summer
  - needed to achieve the installation goal of 2005.