The CDF Program for Run IIb

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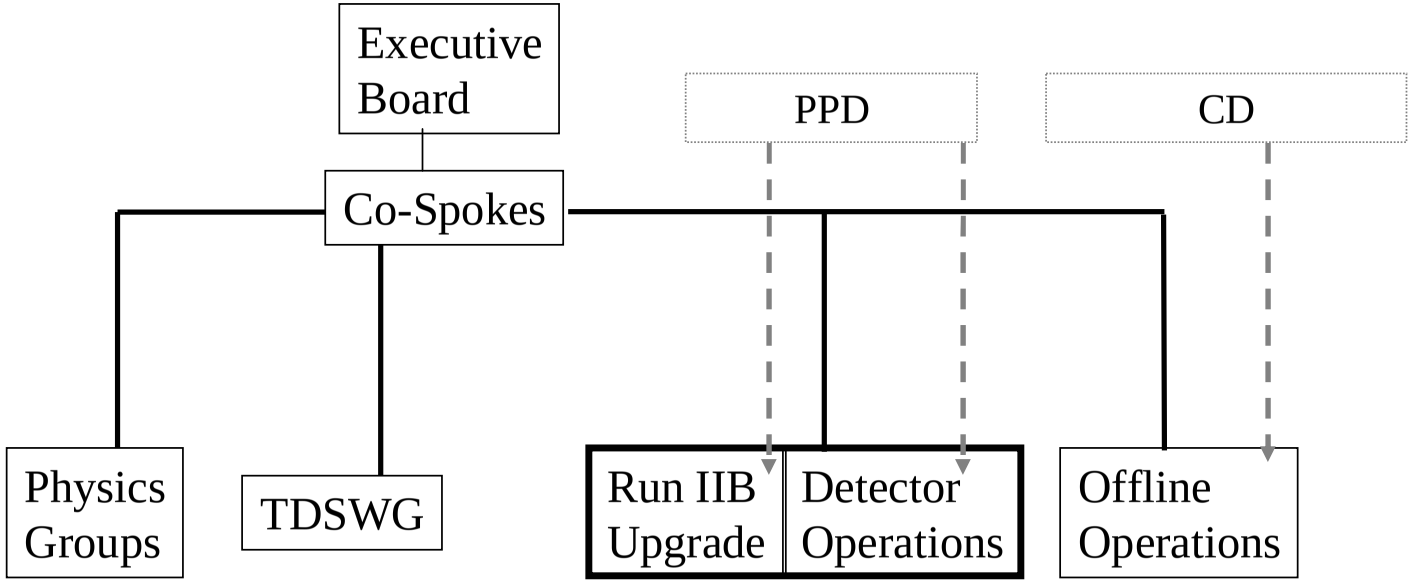
The Run IIb Specifications

- The current detector was designed/built based on “Run IIa specifications:
  - Maximum instantaneous luminosity of $2\times10^{32}cm^{-2}s^{-1}$.
  - Integrated luminosity of 2 fb^{-1}.
- We now consider the detector to have a longer, harder life.
- For Run IIb:
  - Maximum instantaneous luminosity of $5\times10^{32}cm^{-2}s^{-1}$.
  - Integrated luminosity of 15 fb^{-1}.
  - Make the changes needed in a 6 month shutdown.

Run IIb Strategy

- CDF's strategy for Run IIb was to consider detector modifications that would be required to maintain the detector's capabilities through the Run IIb conditions.
- A CDF internal review committee evaluated proposals, and supported a number of them:
  - Silicon replacement – radiation damage
  - COT, CPR replacement/modification – high occupancy
  - DAQ/Level 3, XFT, Track trigger – high trigger rates
  - CSX – possible aging of scintillator
  - EM Timing – motivated by SUSY searches

CDF Organization



Project leaders for Run IIb

- Project Manager
  - Pat Lukens (FNAL)
- Silicon
  - Nicola Bacchetta (Padova)
  - Brenna Flaugher (FNAL)
- Preradiator
  - Steve Kuhlmann (Argonne)
  - Joey Huston (MSU)
- DAQ/Level 3
  - Christoph Paus (MIT)
  - Frank Würthwein (MIT)
- CSX Replacement
  - Giovanni Pauletta (Udine)
- Stereo XFT
  - Richard Hughes (OSU)
- Track Trigger
  - Kevin Pitts (UI)
- EM Timing
  - Dave Toback (Tex. A&M)

Run IIb Strategy

- CDF's plan was presented to the PAC at their November, 2001 meeting.
- The plan was judged to be too big, too expensive
- The benchmark proposed by the PAC is different from the original CDF Run IIb strategy.
  - Originally: Maintain the detector
  - Currently: Justify based on the Higgs search
    - Specifically $WH \rightarrow l\nu b\bar{b}$ and $ZH \rightarrow \nu\bar{\nu}b\bar{b}$
- This implies a reduction of the CDF physics program for Run IIb.

Run IIb goals

- While CDF acknowledges the limitations in funding, the proposed single benchmark for the program is difficult to accept.
  - It ignores major parts of our physics program:
    - Supersymmetry, other exotics searches.
    - B physics beyond Run IIa
- CDF has always been a broad based experiment, with many diverse topics within our reach.

Paying for Run IIb

- After the PAC meeting, we received the funding profile from the lab available for Run IIb:

2002	2003	2004	2005
$2.5M	$2.8M	$2.8M	$1.0M

- The US total is $9.1M
- New installation date is Jan-July 2005.
- Funding available from Japan (in $, at $8.2/kYen)

2001	2002	2003	2004
$225K	$984K	$902K	$328K

- The Japanese total is $2.4M
- We are hoping for a contribution of ~$1M from Italy.

Run IIb Cost Estimates

Project	Cost	US	Japan	Italy
Silicon	$11,290,000	$8,837,000	$2,100,000	$353,000
Preradiator	$757,000	$324,000	$300,000	$133,000
Stereo XFT-Track trigger	$623,000	$623,000		
EM Timing	$399,000	$266,000		$133,000
CSX	$170,000	$28,000		$142,000
DAQ - Level 3	$2,060,000	$2,060,000		
Total	$15,299,000	$12,138,000	$2,400,000	$761,000

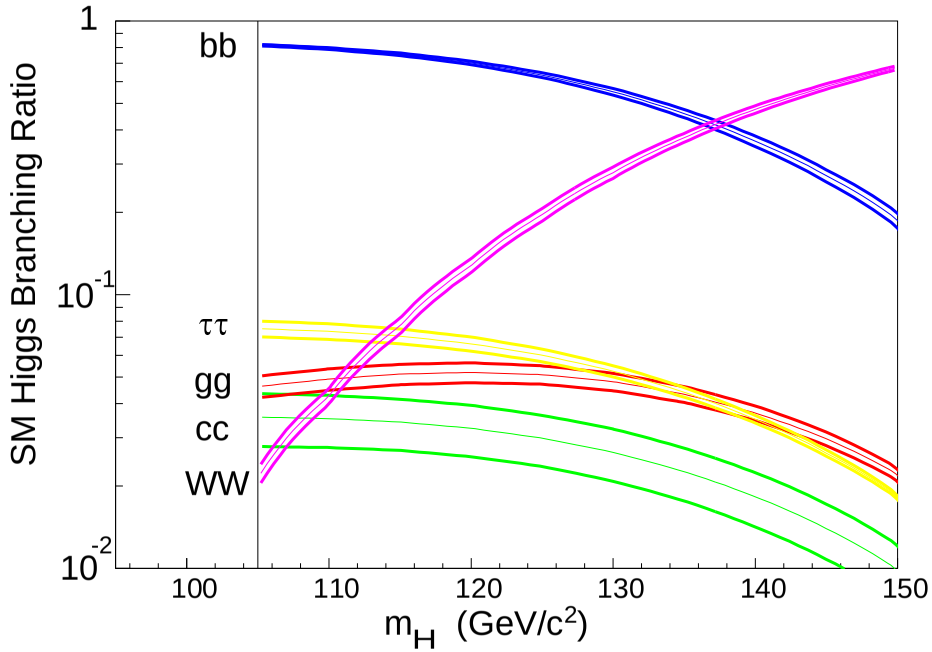
- Silicon estimates are updated since the PAC meeting
  - Contingency increased
- Others are the same
- Our problem is to take $12.1Mà $9.1M

Reducing the scope

- We plan to deal with the funding guidelines by removing three projects from the base plan for CDF Run IIb:
  - CSX replacement – This project is maintenance, and needs more work before we can understand the need.
  - Stereo XFT/track trigger upgrade – This project preserves bandwidth for hadronic B decay and some SUSY triggers. It does not serve the Higgs search.
  - Electromagnetic Timing – This project serves SUSY searches, but not the Higgs search.
- Three projects remain – silicon, preradiator, and the event builder.

Silicon project

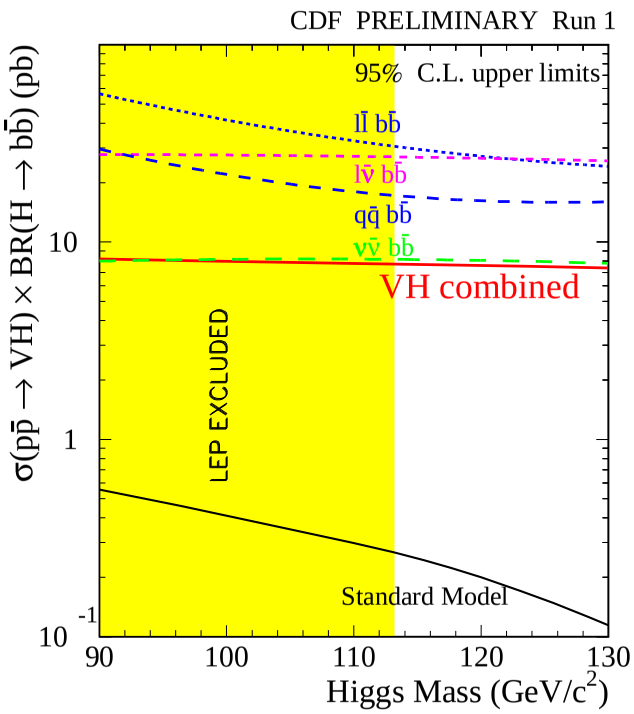
- The silicon detector to replace SVX II/L00 will be retained for Run IIb
- *bb* jets is the dominant branching ratio for a Standard model Higgs below 135 Gev/c^2.
- Tagging of *b* jets is only possible with a precision vertex detector.

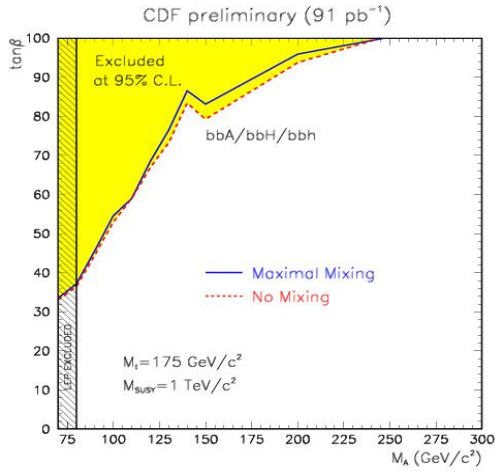


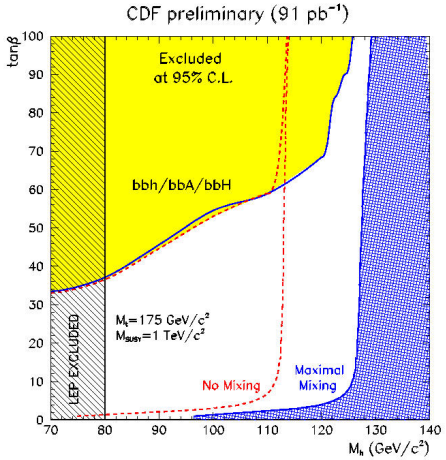
Higgs searches in Run I

SM Higgs, pp→VH associated production:

- l+ jets (≥1 btag)
- MET + jets (2 b-tag)
- multijets (2 btag)







MSSM Higgs, pp→φb $\bar{b}$ where φ=h,H,A

- at large tanβ $m_h \approx m_A$ (m_A < 125 GeV)
  - $m_H \approx m_A$ (m_A > 125 GeV)
- multijet sample + ≥ 3 b-tags
- Limits from Run I:
  - Min stop mixing: m_h (max) = 115 GeV
  - Max stop mixing: m_h (max) = 130 GeV

Central Preradiator

- The central preradiator replacement project will be retained for Run IIb
- This device will replace the existing preradiator – a gas chamber that will be overwhelmed with occupancy in Run IIb.
  - It should be noted that the central shower maximum chamber is also gas, and inaccessible.
- The preradiator is our only option for making this system more robust.
- Electron identification is crucial for the Higgs search.
  - Both high energy (W decay) and low energy (*b* tagging).
  - Jet energy resolution will be aided as well.
- Greater detail by Steve Kuhlmann in a later talk.

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	1243
Rate for L= 5*10 ^{32}(Hz)	622

Run IIb Reduction – consequences

- CSX replacement
  - These counters tag the crossing, to reduce the trigger rate due to out-of-time fakes
  - We had a trigger rate problem here in Run I
    - Shielding was added
  - Run II high luminosity rates aren't known.
  - A rate problem here would be serious – this is ~40% of our central muon coverage!
- EM Timing
  - Proposed to add timing to the electromagnetic calorimeters
  - This will eliminate backgrounds to photons due to cosmic rays.
  - Primarily useful for SUSY searches.
  - The $ee\gamma\gamma\not{E}_T$ event lacked time information in two of the objects in the event.

Run IIb Reduction – consequences

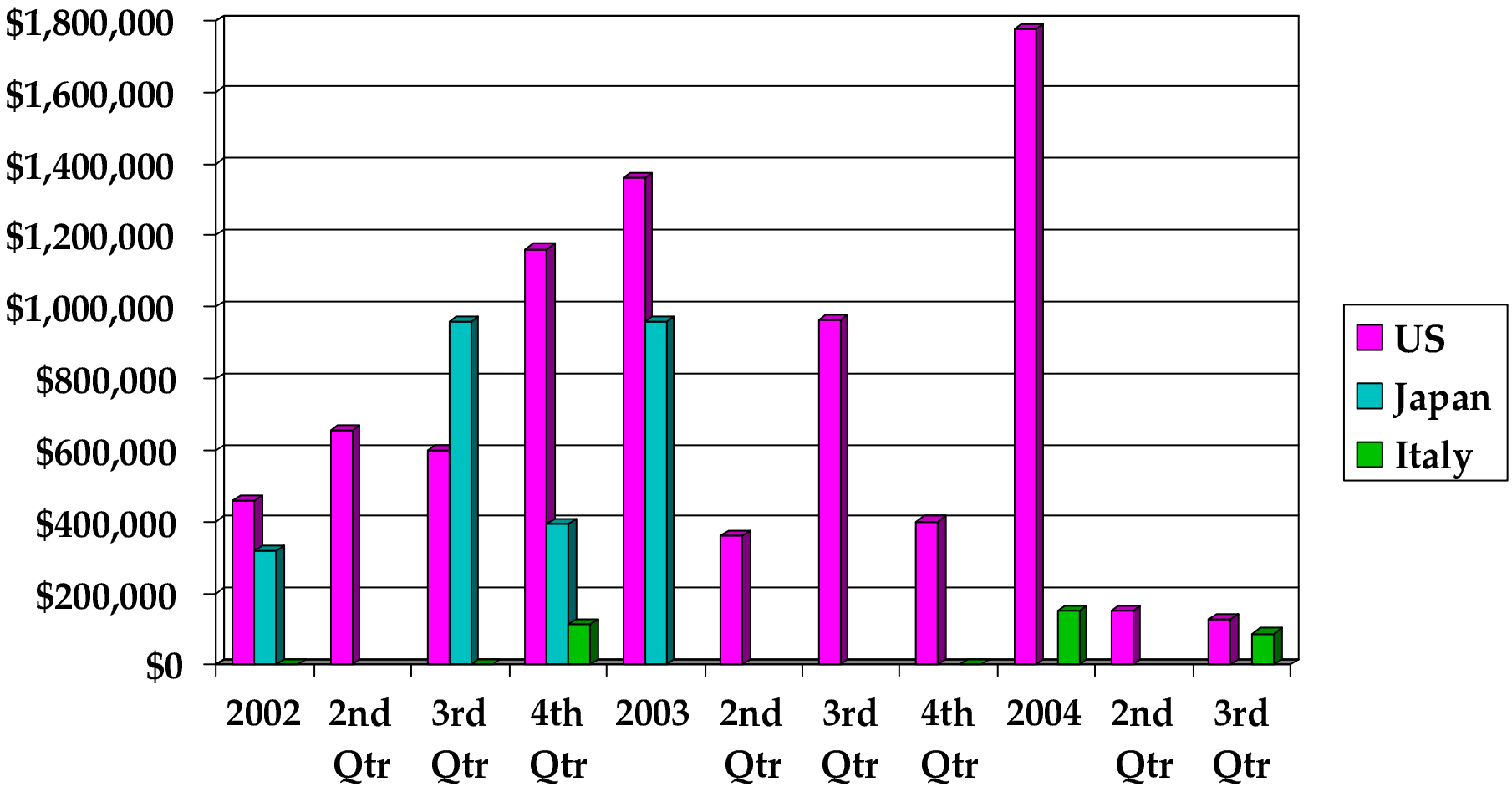
- Stereo XFT
  - Would provide
    - Crude mass calculation at the trigger level.
    - Rapidity segmentation for lepton triggers - all P_t
  - Reduces trigger rates for J/ψ, low mass SUSY triggers.
  - These measurements would suffer.
- Track trigger
  - Needed to preserve Level 1 bandwidth for hadronic B triggers ($B \rightarrow \pi\pi$, etc.).
  - The CDF program of CP violation studies in the B sector will be weakened.

Revised Cost Estimate

Project	Cost	Cost with Contingency	U.S. (with cont.)	Japan	Italy
Silicon Tracker	$8,043,800	$11,289,501	$8,666,501	$2,270,000	$353,000
Central Preradiator	$603,084	$757,009	$343,769	$280,000	$133,240
Data Acquisition	$414,000	$538,200	$538,200		
Total	$9,060,884	$12,584,710	$9,548,470	$2,550,000	$486,240

- Revised cost estimates still fall short of the specification - $9.1M (US).
- Silicon contingency is ~40% - higher than shown to the PAC, and consistent with their recommendations.

Funding profile for Run IIb Silicon detector (M&S)



Funding profile for silicon

- The funding profile is derived from the resource loaded schedule.
  - The large purchases are scheduled early.
  - Some large purchases have been broken into smaller lots, to smooth the profile
    - More of this will be needed (ie., sensor purchases) to cross fiscal year boundaries.
- Even with an installation of early 2005, there will be a conflict between the funding profile and the desire for “float” in the schedule.

Reducing Silicon Cost

- Three possible descoping options have been identified for the silicon detector. Details will follow in the later talks.
  - Replace 90° sensors with axial or small angle sensors
    - ~ $250K could be saved, possibly with loss of performance.
  - Descope Layer 1
    - ~$500K could be saved, with loss in performance.
  - Reuse the existing beam pipe
    - ~$300K could be saved

      Increased risk to the silicon installation

      Increased shutdown time (1-3 months?)

Reducing Costs

- We will remove the maintenance items from the Data Acquisition/Level 3 project.
- There is little way to save on the Central Preradiator project. The majority of US funds covers contingency and labor.
  - Moving the labor to other funding sources seems the only way to save here.

Conclusions

- The CDF Run IIb construction program has been modified in response to the PAC's recommendation and the laboratory's budget.
- Silicon
  - The silicon project has been simplified.
  - The silicon contingency has been increased.
- Preradiator
  - This remains as proposed.
- DAQ
  - Maintenance must be covered elsewhere.

Conclusions

- After taking these steps, our cost estimates are close to the budget available.
- Funding profile still needs to be modified somewhat.
- These steps will preserve CDF as a Higgs search experiment in Run IIb.
- Additional funding sources will be pursued for projects left off of our modified plan:
  - CSX replacement
  - Stereo XFT/Track trigger
  - EM Timing