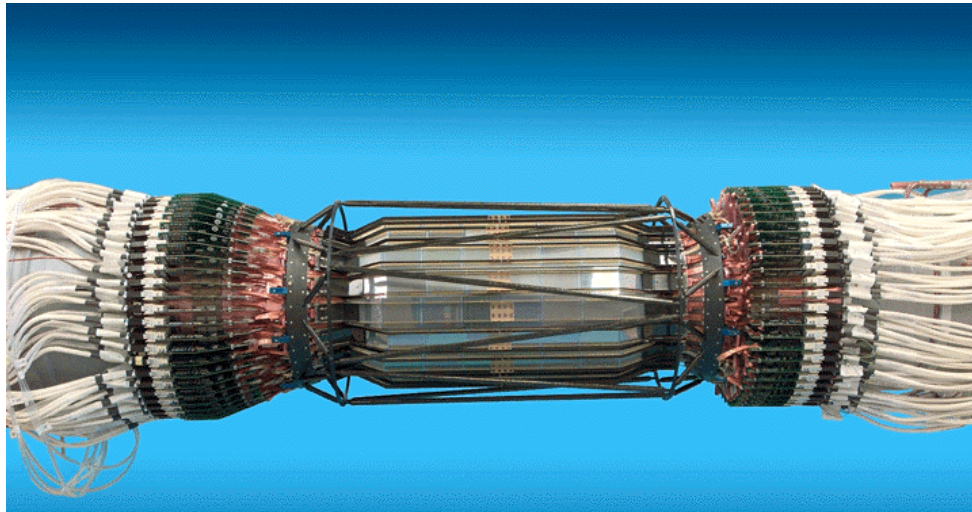


BaBar SVT



Claudio Campagnari - UCSB

Giuliana Rizzo - Pisa

Outline

- Requirements
- Detector Description
- Performance
- SVT spare construction project
- A look at the future

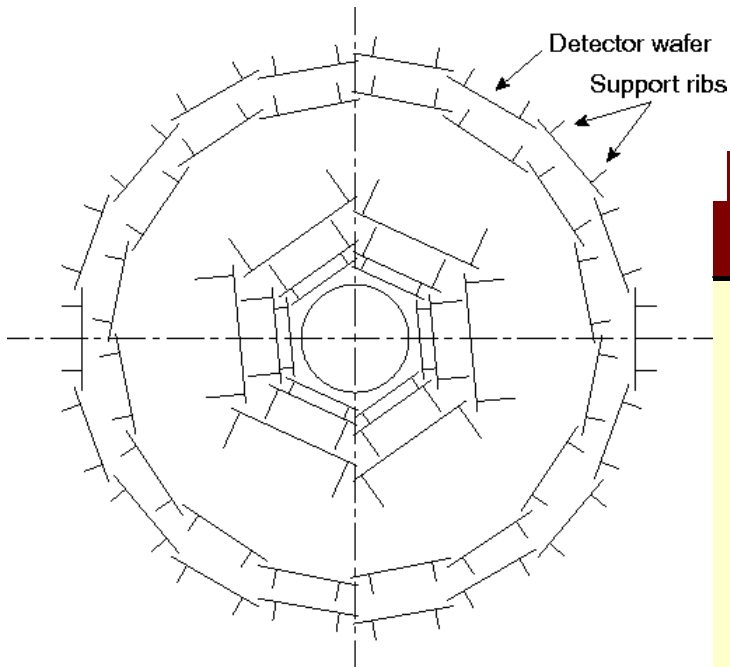
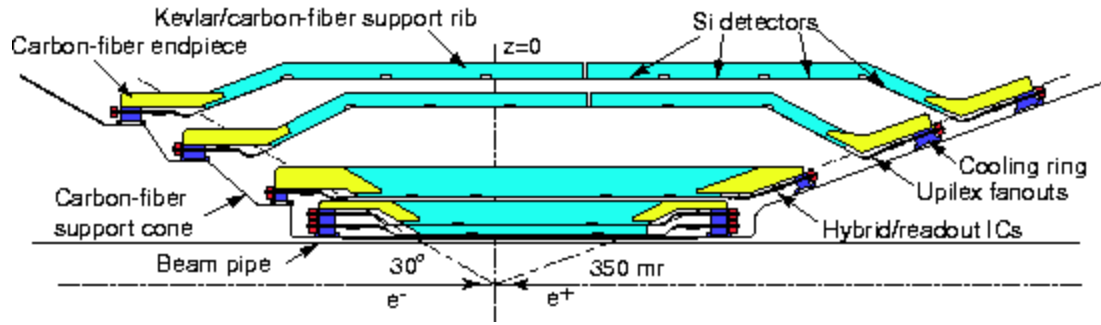
Main requirements (from TDR)

- Measure Δz to $\sim 125 \mu\text{m}$
 - translates into series of single hit resolution requirements
 - low mass support structure
- Good standalone pattern recognition
 - Slow π from D^* reconstructed in SVT only
- Radiation hard up to 2 Mrad
- Efficient

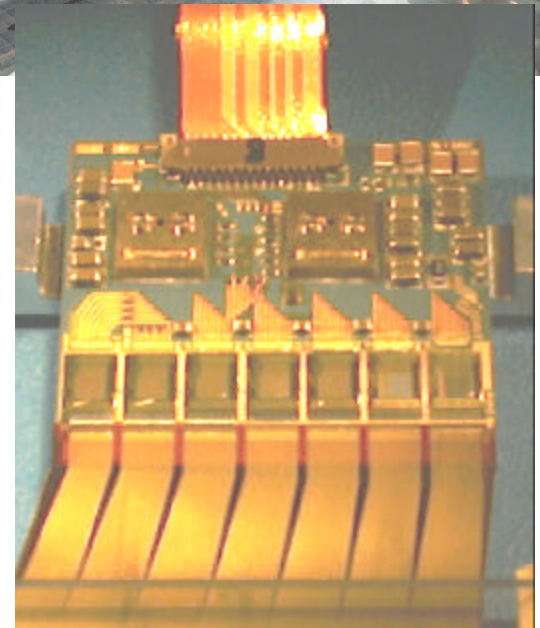
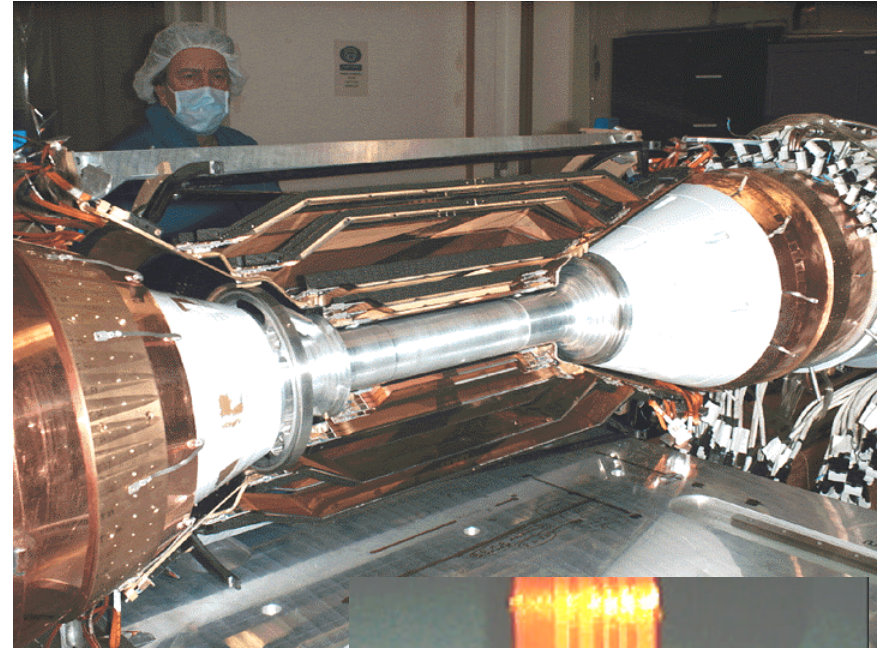
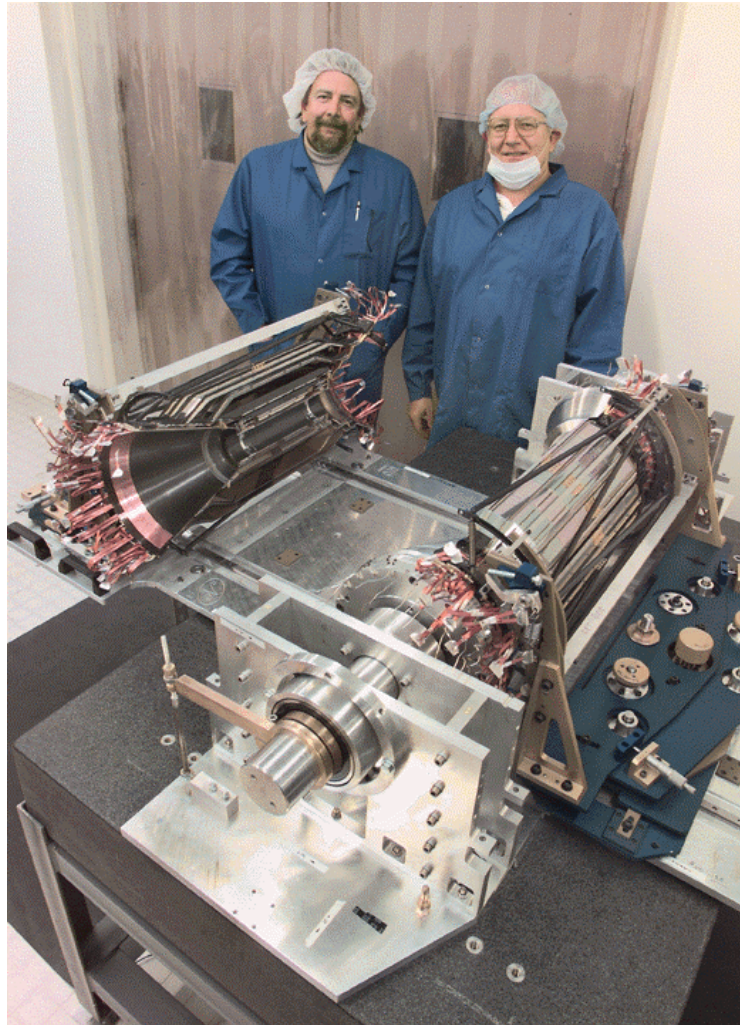
SVT characteristics

- Five layers, double sided
 - Barrel design, L4 and 5 not cylindrical
 - 340 wafers, 6 different types
 - Low mass Kevlar-Carbon Fiber support ribs
- Uplex fanouts to route signal to ends
- Double-sided AlNi HDI (104 of these)
 - Outside tracking volume
 - Mounted on Carbon Fiber cones (on B1 magnets)
- Atom chips
 - 1156 chips, 140K channels

BaBar Silicon Vertex Tracker



<i>Layer</i>	<i>Radius (mm)</i>	<i>Modules/ Layer</i>	<i>Wafers/ Module</i>	<i>F Pitch (mm)</i>	<i>Z Pitch (mm)</i>
1	32	6	4	50 or 100	100
2	40	6	4	55 or 110	100
3	54	6	6	55 or 110	100
4a	124	8	7	100	210
4b	127	8	7	100	210
5a	140	9	8	100	210
5b	144	9	8	100	210

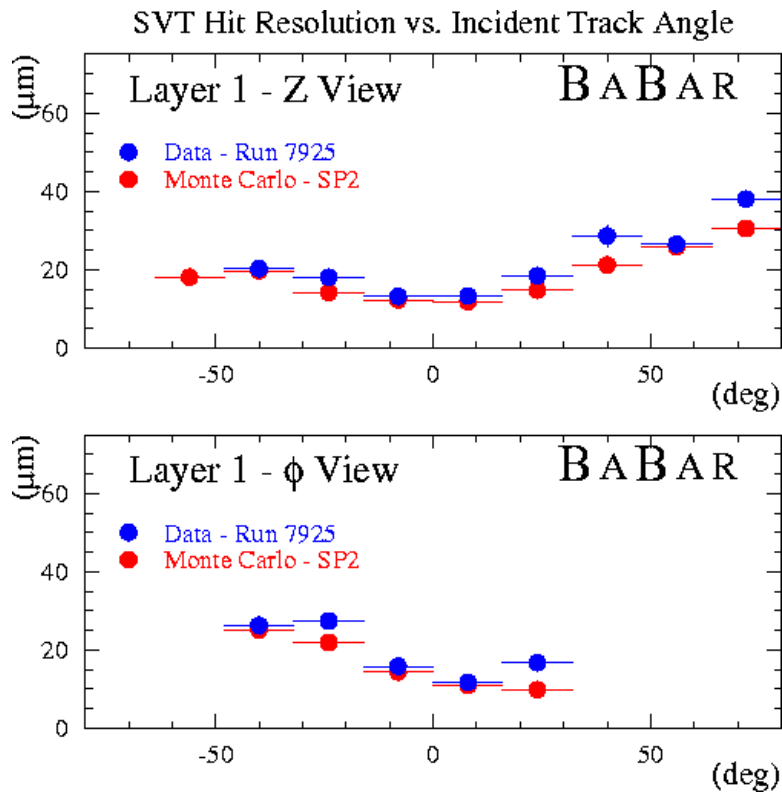


11 October 2000

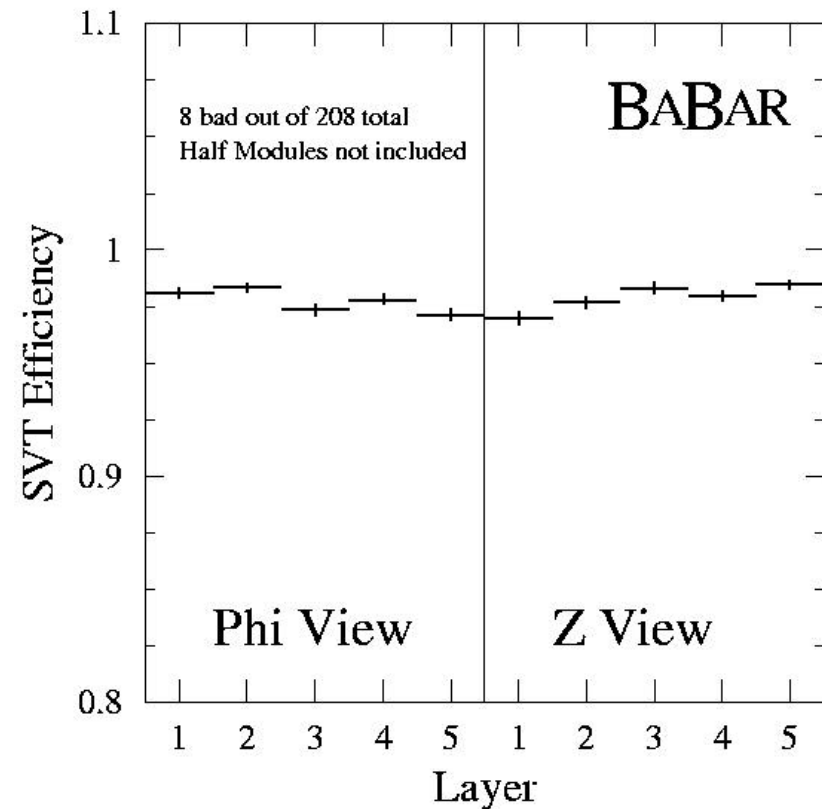
Gilchriese Review - BaBar SVT

6

Performance

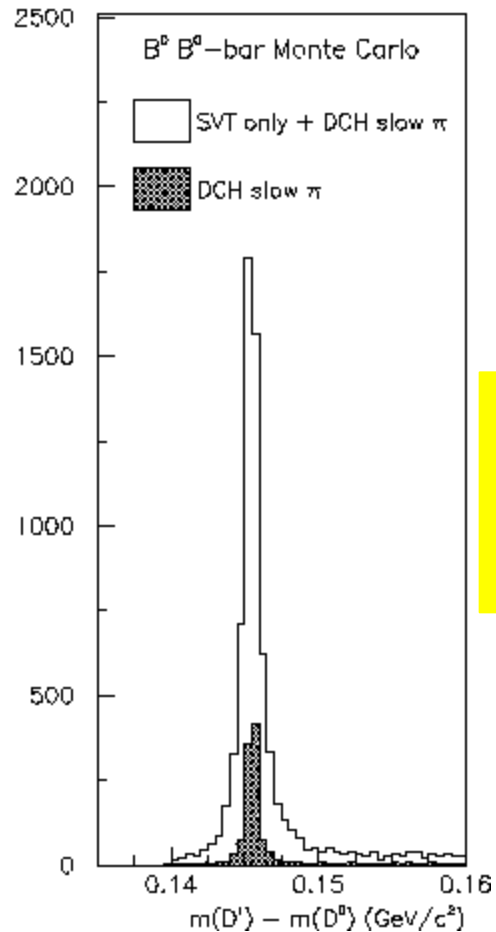
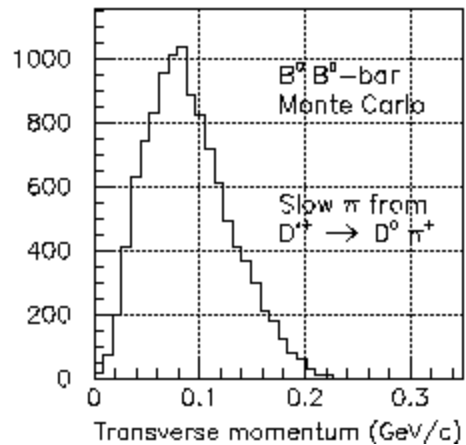
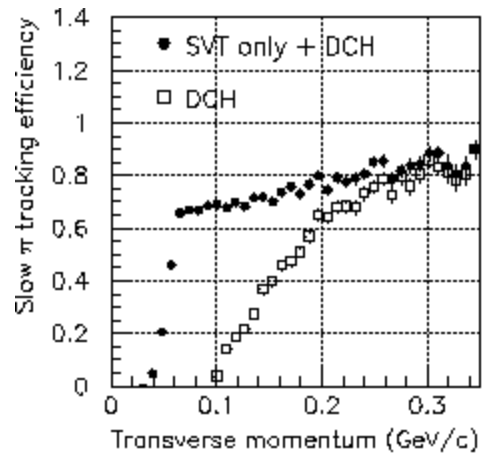


Resolution approaching
Monte Carlo expectation



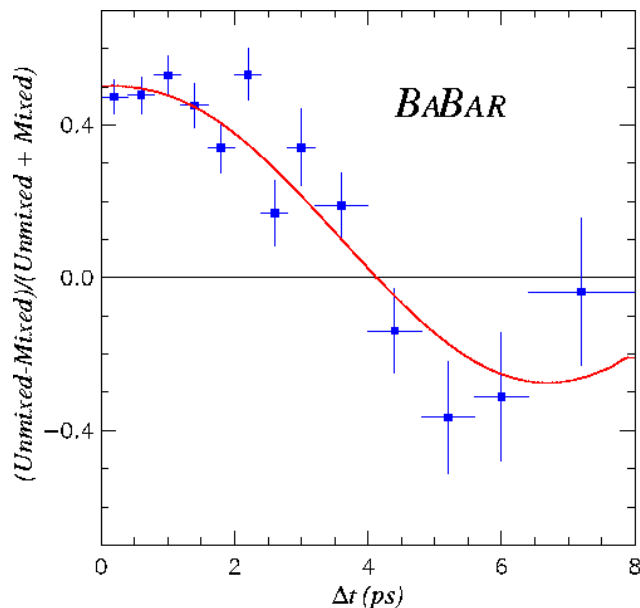
Excellent Efficiency

Performance (cont.)



Standalone SVT tracking works...

Highlights from Osaka Conference



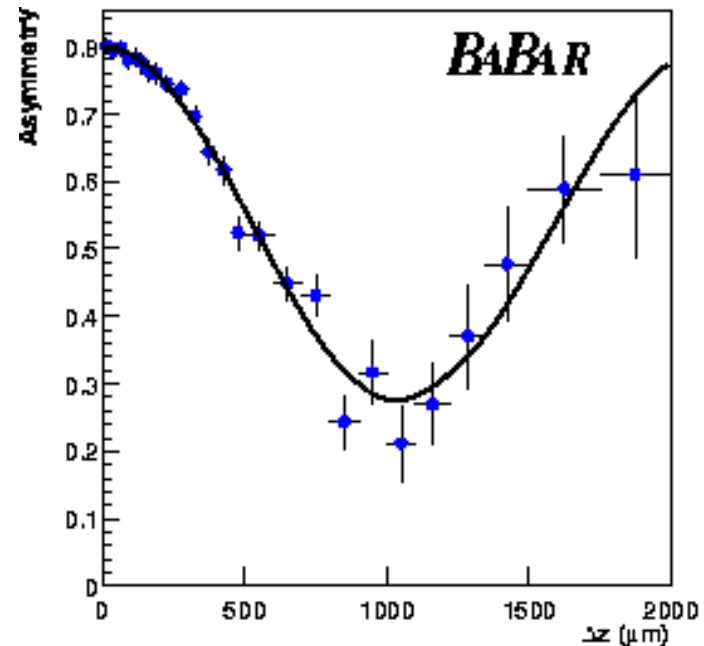
$$\Delta m_d = 0.515 \pm 0.031 \pm 0.018 \text{ ps}^{-1}$$

Mixing with fully reco B

Also:

$$\tau(B^0) = 1.506 \pm 0.052 \pm 0.029 \text{ ps}$$

$$\tau(B^+) = 1.602 \pm 0.049 \pm 0.035 \text{ ps}$$



$$\Delta m_d = 0.507 \pm 0.015 \pm 0.022 \text{ ps}^{-1}$$

Mixing with dileptons

$$\text{And } \sin 2\beta = 0.12 \pm 0.37 \pm 0.09$$

SVT spare construction

- Motivation
- Technical Issues
- Status and schedule
- Budget

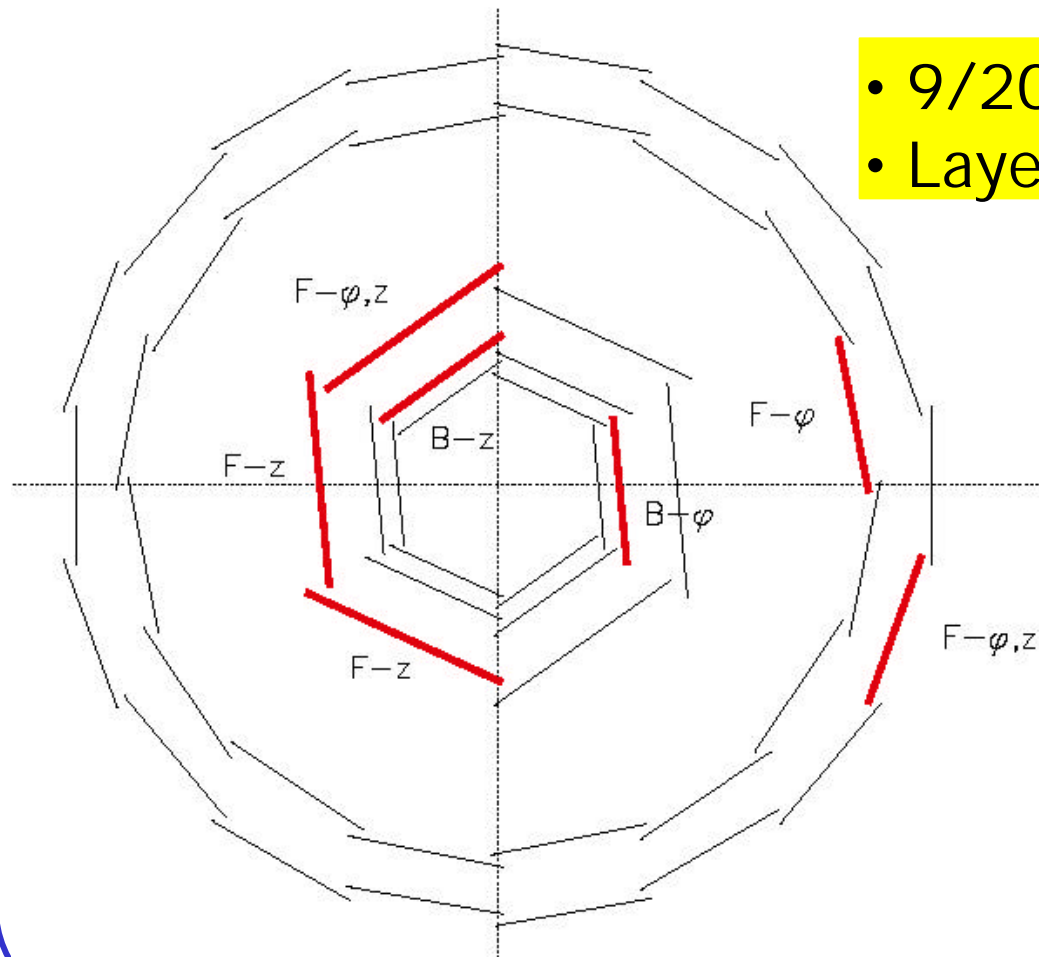
Glossary of SVT terms

- DFA (Detector Fanout Assembly):
 - Two or more wafers glued end-to-end with fanouts glued on both ϕ and z sides
- Half Module (also HDFA):
 - A DFA bonded to a hybrid (HDI)
 - 1/2 coverage in z
- Module:
 - Two HDFAs mechanically connected by ribs
 - full z coverage
- Sextant:
 - Layer 1 + Layer 2 modules (one mechanical unit)
- Tail:
 - 30 conductor kapton cable, connects HDI to data transmission system

Motivation

- Several (7) SVT half-modules died during installation on support cone (3/99)
- No time for replacement & not enough spares to do it
- Sept 99 new dead HM after magnet quench
 - few quenches since, no more problems
- Results from recent radiation tests and background extrapolations suggest to have more spare for L1-L2 horizontal plane replacement

Map of bad half modules



- 9/208 bad half module sides
- Layer 1 perfect

Spare Production Project

Layer	Problem Modules	Spare Needed	Module needed
Sextants (1/2)	2+1mp	2 (1)	4 (6)
Layer 3	3	2 (1)	4 (6)
Layer 4A	2	2	4 (8)
Layer 4B	0	2	2 (8)
Layer 5A	1	2	3 (9)
Layer 5B	2	2	4 (9)

This is ~ 50% of installed SVT

Institution involved

Item

Detector/Testing

Fanouts

Ribs,End Pieces

HDI

Atom chips

Tails

DFA

Bonding, Assembly

Data Transmission

Pin Diodes

Final Assembly

Institution

Pisa,Trieste

Trieste

UCSB

Pisa,Milano

LBNL,Pavia

Ferrara

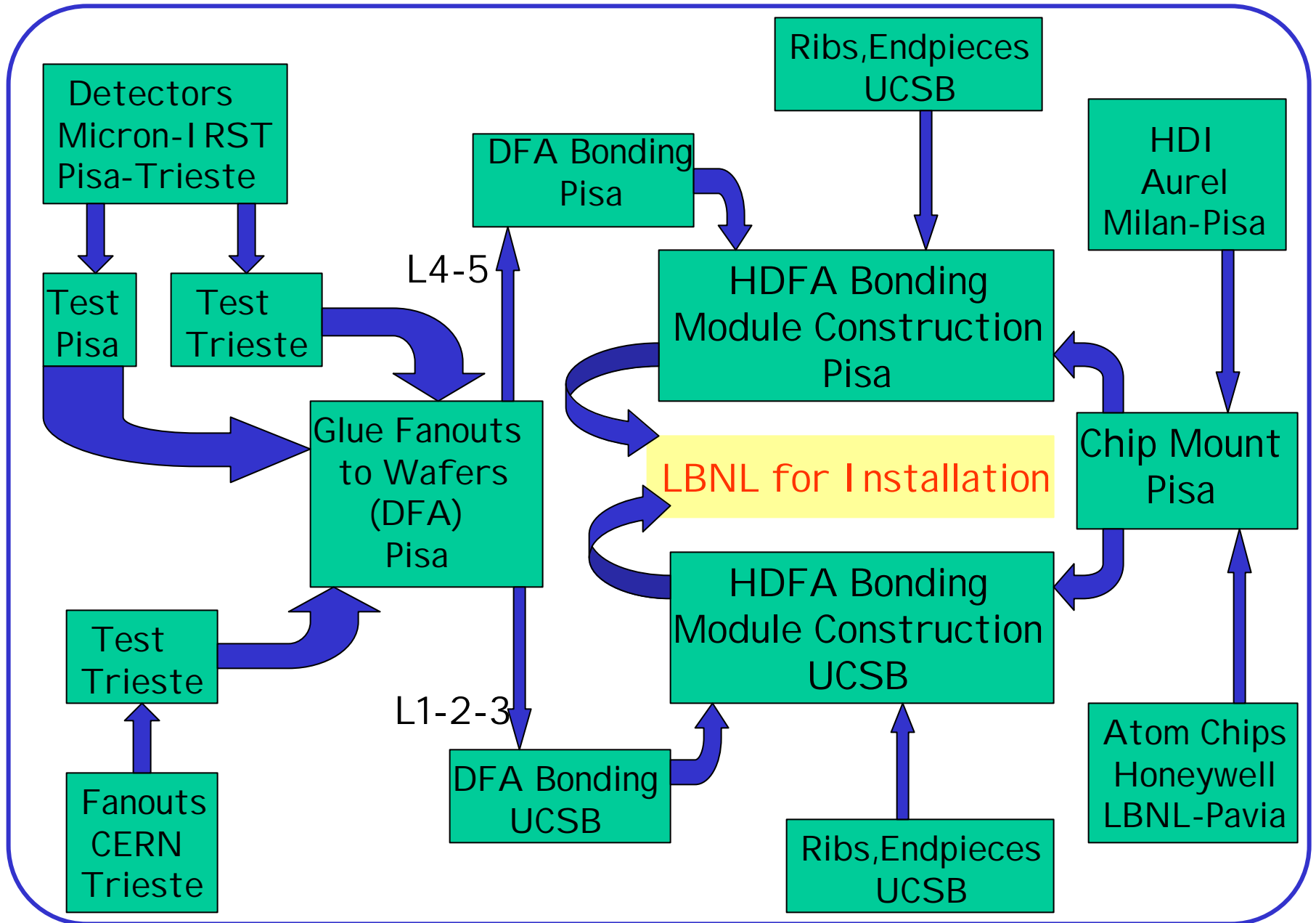
Pisa

Pisa,UCSB

UCSC

Stanford

LBNL (Pisa,UCSB...)



Technical Issues

- Well understood, since we are building *more of the same*
 - Manpower needs to be watched closely
 - Same people/groups that built SVT, but also doing other things (physics, operations...)
 - Looks OK, but still worry.....
- Honeywell yield issue in going from 4" to 6"
 - discussions with CDF group and Honeywell
 - problem was with vias between M2-M3 layers
 - added a process monitor bar
- Radiation hardness issues discussed later

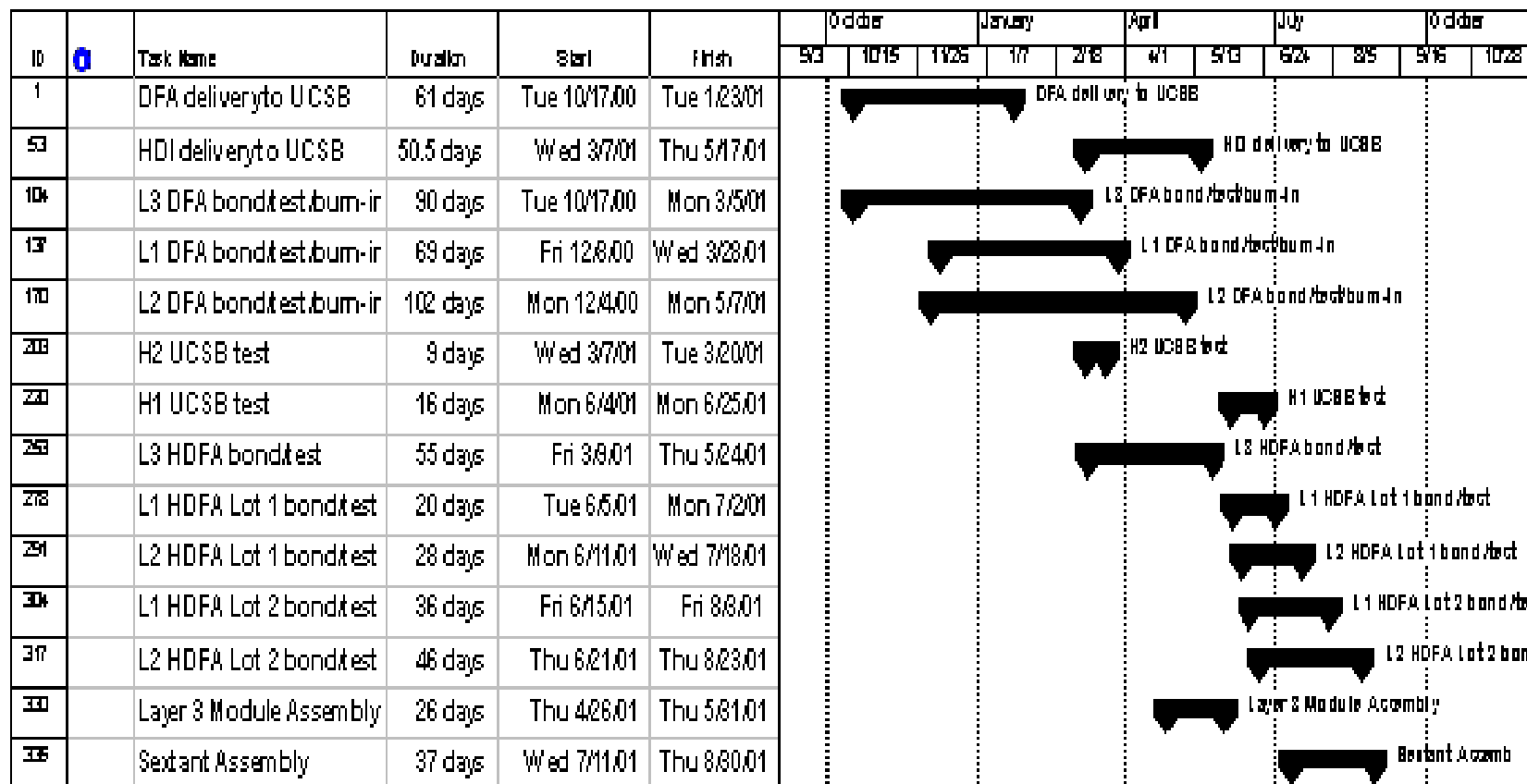
Schedule

- A detailed schedule has been developed based on experience from SVT construction
- Goal was to be ready for possible installation in Summer of 2002
- Present schedule shows completion at the end of 2001

(Unreadable) Italian Schedule

ID	Task Name	Duration	Start	Finish	Qtr 3, 2000				Qtr 1, 2001			Qtr 3, 2001			Qtr 1, 2002	
					May	Jul	Sep	Nov	Jan	Mar	May	Jul	Sep	Nov	Jan	
1	Detector Test/burn-in	138 days	Mon 9/11/00	Wed 3/21/01												
196	Fanout Production & Test	139 days	Mon 7/31/00	Thu 2/8/01												
225	DFA gluing (N-Forw/Backw)	139 days	Mon 9/25/00	Thu 4/5/01												
305	DFA bonding/scan/repair	75 days	Wed 1/3/01	Tue 4/17/01												
414	Atom Procurement	115 days	Mon 9/11/00	Fri 2/16/01												
419	HDI Passive Component Loading	10 wks	Mon 10/2/00	Fri 12/8/00												
420	HDI Fabrication	114.5 days	Mon 2/19/01	Fri 7/27/01												
703	DFA delivery to UCSB	70 days	Tue 10/17/00	Tue 1/23/01												
755	HDI delivery to UCSB	50.5 days	Wed 3/7/01	Thu 5/17/01												
808	L45 Module Assembly	102 days	Fri 7/27/01	Tue 12/18/01												

(Unreadable) US Schedule



Dates are completion dates

Readout IC

Submit IC
11 Sep 00

Hybrids

Model 1 - H1
Dec 00

Model 2 - H2
Dec 00

Model 3 - H3
Dec 00

Layer 1-2
Hybrids
17 May 01

Layer 3
Hybrids
7 Mar 01

Layer 4-5
Hybrids
27 Jul 01

Detectors

Detectors - L1
19 Dec 00

Detectors - L2
5 Dec 00

Detectors - L3
28 Oct 00

Detectors - L4
22 Dec 00

Detectors - L5
21 Mar 01

Fanout

Fanouts - L1
21 Nov 00

Fanouts - L2
10 Oct 00

Fanouts - L3
20 Sep 00

Fanouts - L4
20 Dec 00

Fanouts - L5
8 Feb 01

Detector-Fanout Gluing

DFA L1 - 23 Jan 01

DFA L2 - 27 Dec 00

DFA L3 - 14 Nov 00

DFA L4 - 6 Feb 01

DFA L5 - 5 Apr 01

Final Assembly

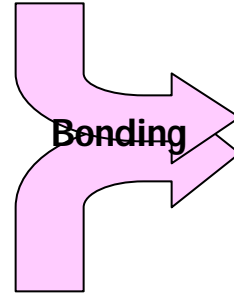
Sextant
30 Aug 01

Layer 3
31 May 01

Layer 4
22 Oct 01

Layer 5
18 Dec 01

Spares Avail
19 Dec 01



Spare Production Status

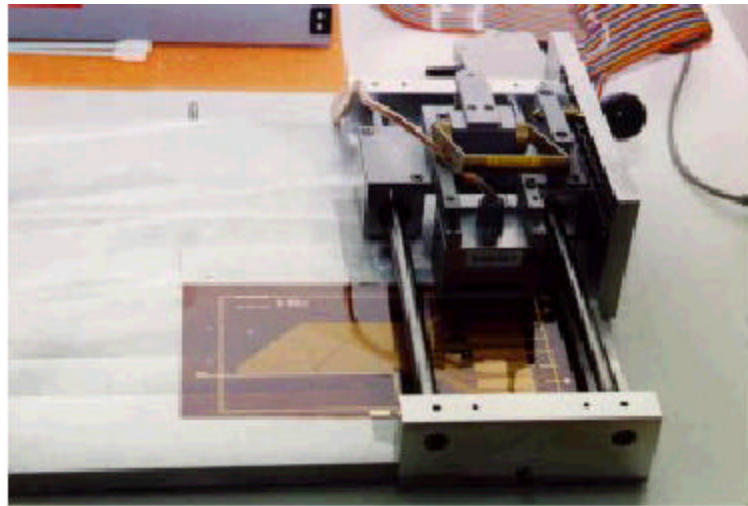
- Detectors:
 - L3: delivered and tested
 - L1-2: delivery end of October 2000
 - L4-5: 75% delivered, rest in October 2000
- Fanouts: L2-3-4-5 delivered, under test
- HDI : production October to December
- Atom chips: to be delivered at the end of 2000
- Tails: in hand - Mech. Pieces: in production
- Detector Fanout Assembly started in Sept.



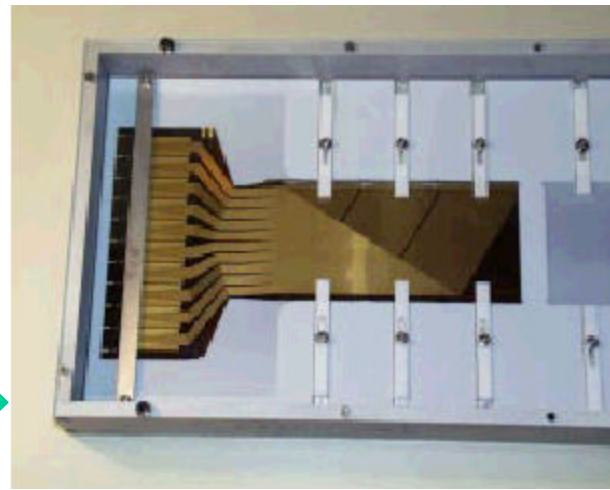
**New detectors
in "burn-in"
station (Pisa)**



**First Y2K DFA
(Pisa)**



**Fanout under test
(Trieste)**



I NFN Budget = 1043 ML

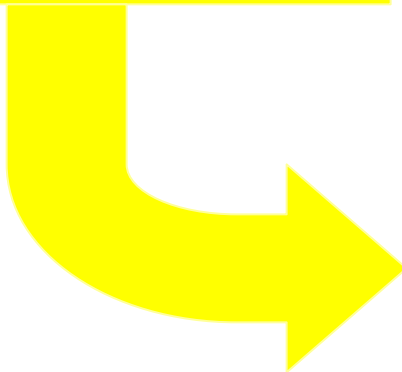
Detectors	591 ML
Fanouts	102 ML
HDI	42 ML
Tails	48 ML
Atom	260 ML
Total	1043 ML

- Does not include people, infrastructure modifications/improvements.
- Approved

US Budget = 1068K

- Includes engineering/tech/infrastructure
- FY00 : 541K (Atom chips 335K)
- FY01: 118K
- FY02: 409K (All installation, does not include PEPI I costs)
- MOAs between SLAC and institutions signed in FY 2000

Detailed breakdown
of US budget - as
included in MOAs
between SLAC and
US institutions



Item	Institution	FY00	FY01	FY02
Tech for ribs/endpieces	UCSB	10K	10K	-
Tech for bonding	UCSB	23K	30K	-
½ enginner	UCSB	27K	35K	-
Machine Shop Charges	UCSB	10K	10K	-
Surface Grinder	UCSB	6K	-	-
Laser Cutting	UCSB	10K	-	-
Power Supply crate	UCSB	-	10K	-
Probe Station Refurbish	UCSB	7K	-	-
Bonder Parts	UCSB	1K	1K	-
Bonder Maintenance	UCSB	2K	2K	-
DAQ Hardware	UCSB	-	10K	-
Atom Procurement	SLAC	335K	-	-
3 mo. elec. engineer	LBNL	35K	-	-
3 mo. elec. Tech	LBNL	24K	-	-
Supplies, test cards	LBNL	20K	-	-
Cables	LBNL	4K	-	-
Connectors	LBNL	13K	-	-
Crimping Tools	LBNL	2K	-	-
Retermination of cables	LBNL	-	-	70K
Electronics	LBNL	-	-	3K
Elec. Coordinator	LBNL	12K	-	12K
Matching cards, part	UCSC	-	5K	-
Matching card, labor	UCSC	-	5K	-
Clean Room Prep				
Engineer, 4 months	LBNL	-	-	52K
Tech. 2x3 months	LBNL	-	-	73K
Move mill	LBNL	-	-	5K
Installation				
Engineer, 4 months	LBNL	-	-	52K
Tech, 3x4 months	LBNL	-	-	140K
Pin diodes	Stanford	-	-	2K
Total		541K	118K	409K

SVT Removal and Reinstallation

- A major operation because of coupling with machine elements
 - First estimates, of order 5 month
- We will be ready by Summer 2002
- Exact time of intervention still needs to be decided

A look at the future...

- PEPI I luminosity is going to increase significantly beyond design value of $3 \cdot 10^{33}$
- Need to evaluate impact on SVT
 - Radiation damage
 - DAQ issues
 - Reconstruction issues

PEPI I Luminosity and BG Projections

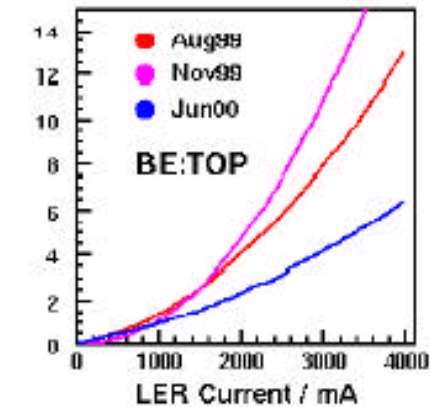
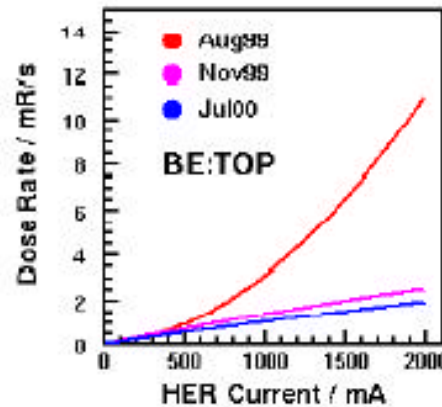
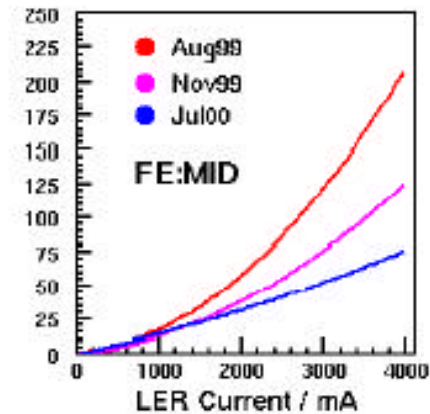
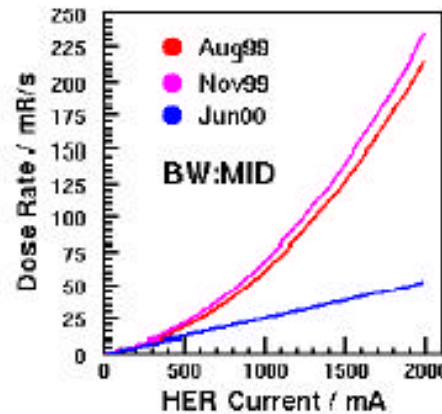
- Expected evolution of currents and lumi

Year	Her (mA)	Ler (mA)	Lum (10^{33})
2001	1000	2000	3 - 6
2002	1050	2600	6
2003	1200	3100	6 - 10
2004	1300	3600	15

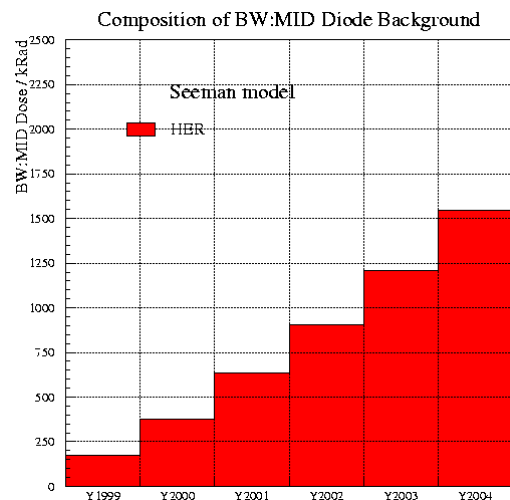
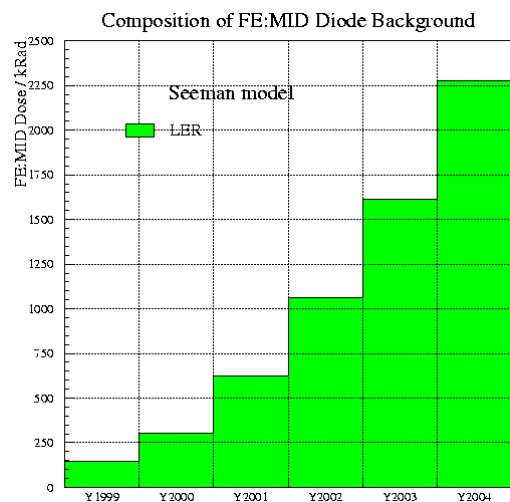
- SVT Radiation monitored by 12 diodes (6/end)
 - performed extensive studies of dose vs current/luminosity.....

Radiation Studies

- Radiation concentrated in midplane (of course)
- Doses ~ linear with current
- Only small improvements foreseen



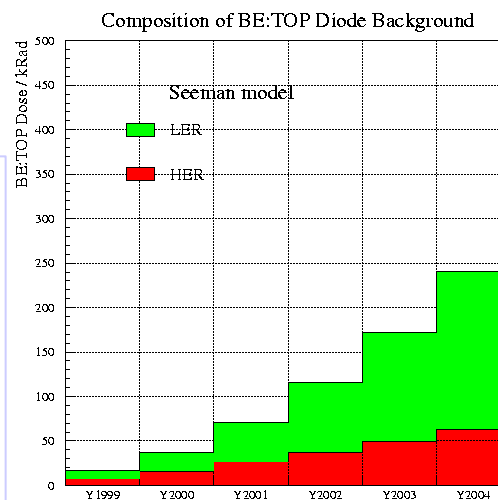
Projected cumulative doses



Worst-case MidPlane diodes,
1999-2004 (full scale 2.5 MRad)

Recall: spec up to ~ 2 MRad

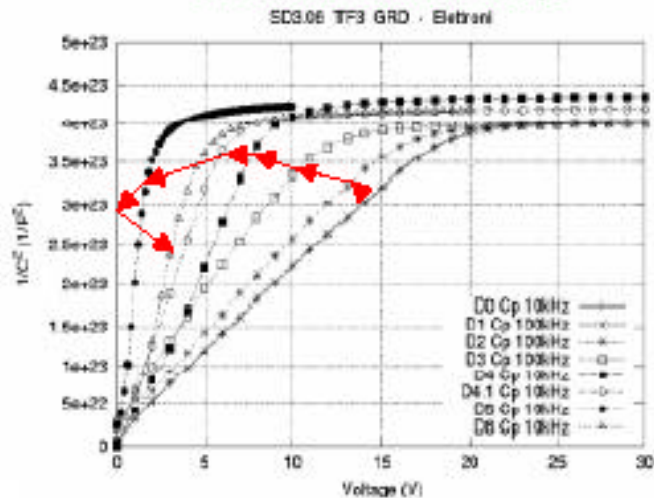
Typical non-
MidPlane diode
1999-2004
(full scale
0.5 MRad)



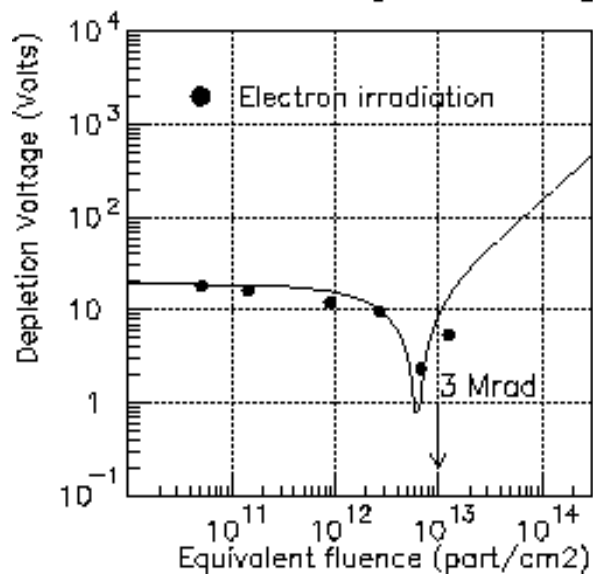
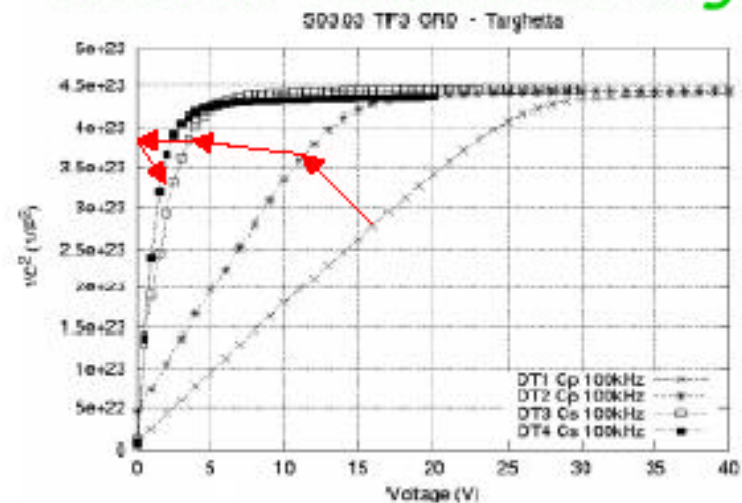
Detector radiation tests

- Electron beam from Elettra Linac (Trieste)
 - 900 MeV, pulsed at 10 Hz
 - 1.6 nC/pulse
- Two setups:
 - electron beam directly
 - electron beam on Cu target
- Type inversion at 1-2 Mrad (depends on initial dopant concentration)

electron beam



electron beam on Cu target



- C^{-2} vs V curve show inversion
- Results in ~ agreement with NIEL scaling hypothesis
 - this was not entirely obvious/expected
- Leakage current increase of order $2 \mu\text{A}/\text{cm}^2$
 - agrees with in-situ measurement

Detector Radiation Tests (Cont.)

- Electrical properties after inversion:
 - Strip isolation OK
 - Edge currents, no sudden increase, manageable
- Trying to find manpower to do a test of charge-collection efficiency
 - According to literature, should be OK, but...

Atom Chip Radiation Issues

- Previous tests, up to ~ 2 Mrad:
 - higher intrinsic noise (~ 20%)
 - lower gain (~ 5%)
 - lower DACs (~ 10%)
- New tests (in progress) to higher doses
 - use ^{60}Co source at LBNL
 - measure several chips in step of 1 Mrad
- Extra noise from detector leakage current not expected to be a problem

DAQ SW/HW and Reco SW

- DAQ
 - No special SVT issues
- Tested existing reconstruction SW with up to five times more BG than we have now
 - Pessimistic (too much BG in L3,4,5)
 - Benchmarks: ΨK_S and slow π from D^*
 - No change in vtx and mass resolution for CP mode
 - ~ 20% resolution loss in $D^* - D$ mass difference
 - ~ 15-20% loss of efficiency for both modes
 - Significant increase in CPU load

A look of the future (summary)

- Because of increased lumi/BG expect ~ 2-3 Mrad in midplane by ~ 2004
- Detectors in midplane will invert, but indications are that we'll be OK
- Further atom chip radiation test in progress - charge collection efficiency test if can find manpower
- Looked at DAQ and reco, no big surprises
- Timing of spare replacements need to be optimized

Conclusions

- The SVT is working quite well
- We have started construction of additional modules to
 - replace handful of malfunctioning ones
 - eventually replace radiation damaged modules in midplane, inner layers
- Modules will be ready before Summer 2002
- We are making a lot of progress in understanding high luminosity and high BG issues