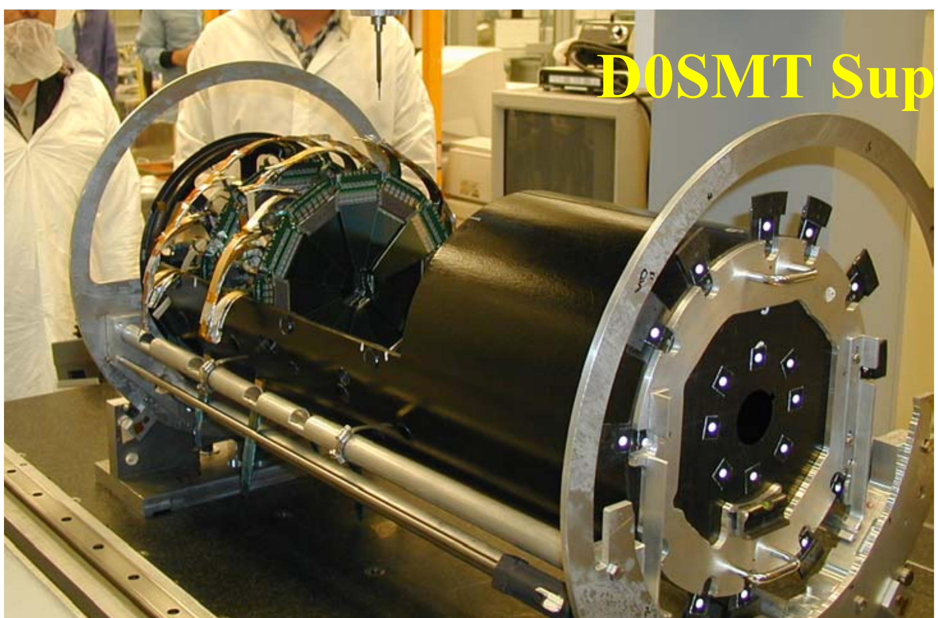
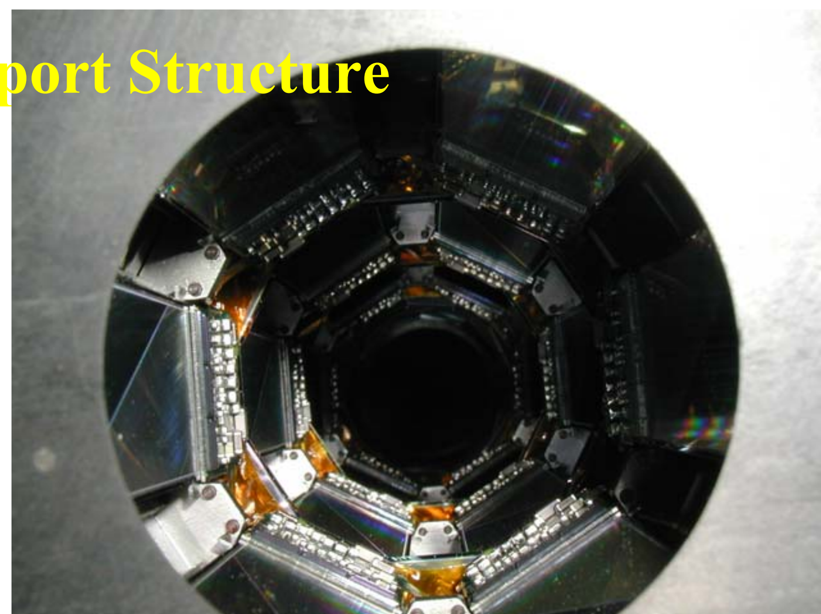
Layer 0 Project

DZERO proposes to install a detector *inside* the current inner layer. This detector will

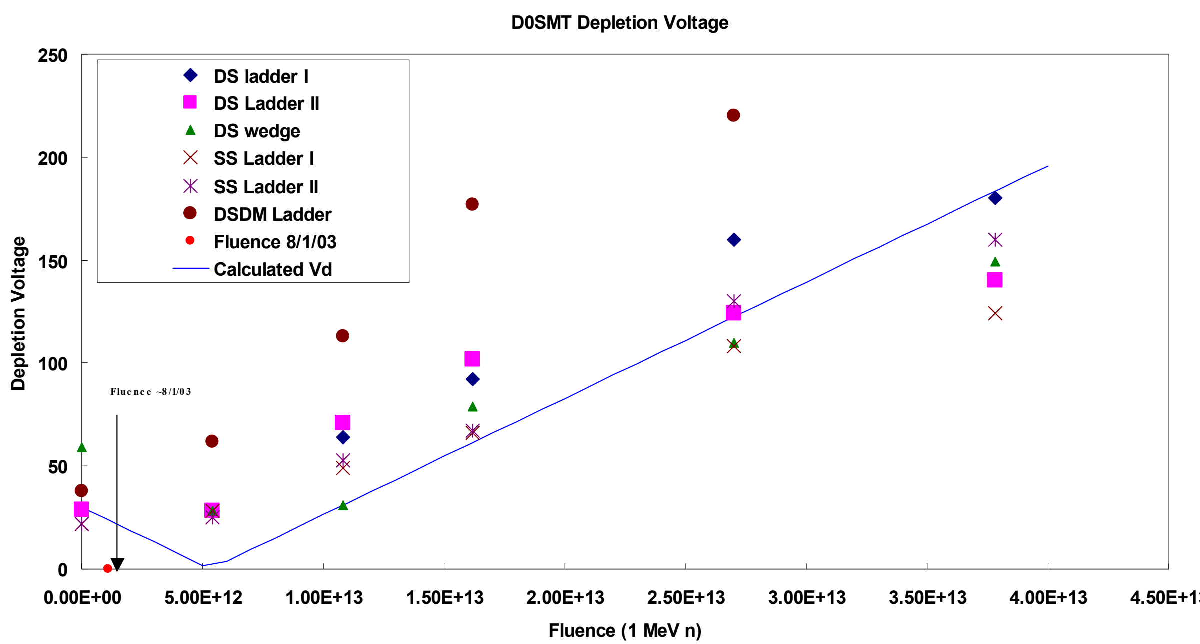
- Mitigate tracking losses due to radiation damage and detector failure
- Provide more robust tracking and pattern recognition for higher luminosities
- Improve impact parameter resolution





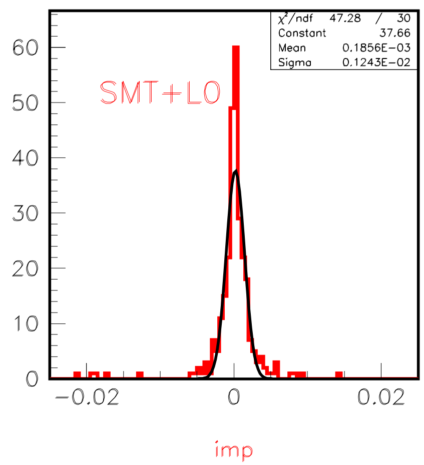
Layer 0 Motivation

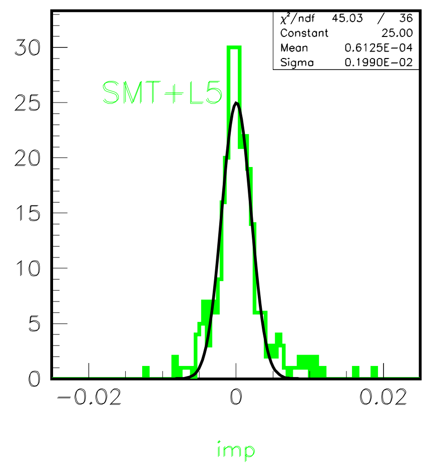
- We expect layer 1 Micron sensors to begin to fail at exposures of ~ 3-4 fb-1
- We are seeing continuing failures of readouts in the current detector (85-90% currently good)
  - Hard failures due to interior shorts/opens (1%)
  - SVX chip failures, readout problems (7%)
  - Bias or HV failures (1%)
  - Unstable HDIs – marginal timing and signal quality (6%) – many recoverable?
- Increased occupancy with higher luminosity, uneven TEV loading.

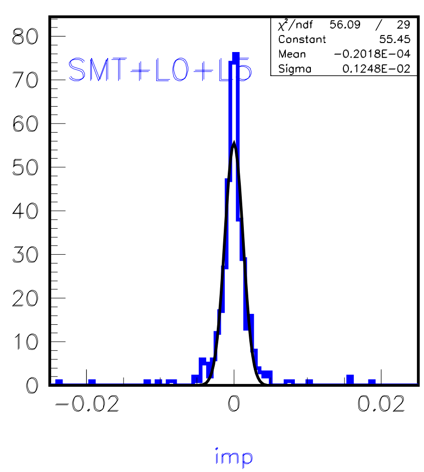


Layer 0 Physics Motivation

Results from early Run2b design studies: Impact parameter resolution - top events







- SMT+ L0:
  σ(IP) = 12.4 μ
- SMT+ outer layer
  σ(IP) = 20.0 μ
- SMT + L0 + outer layer
  σ(IP) = 12.5 μ

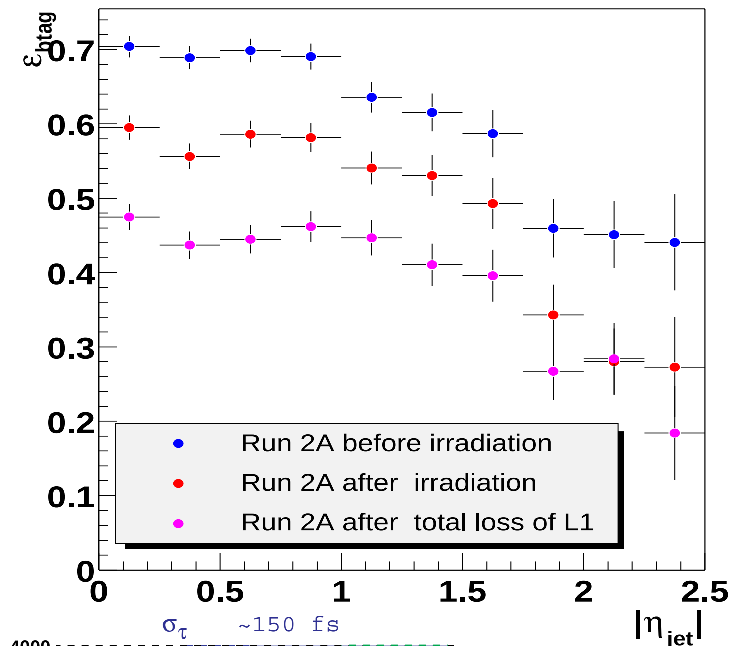
b-tagging efficiency per jet

	L0	L5	L0+L5
ε	47%	41%	48%

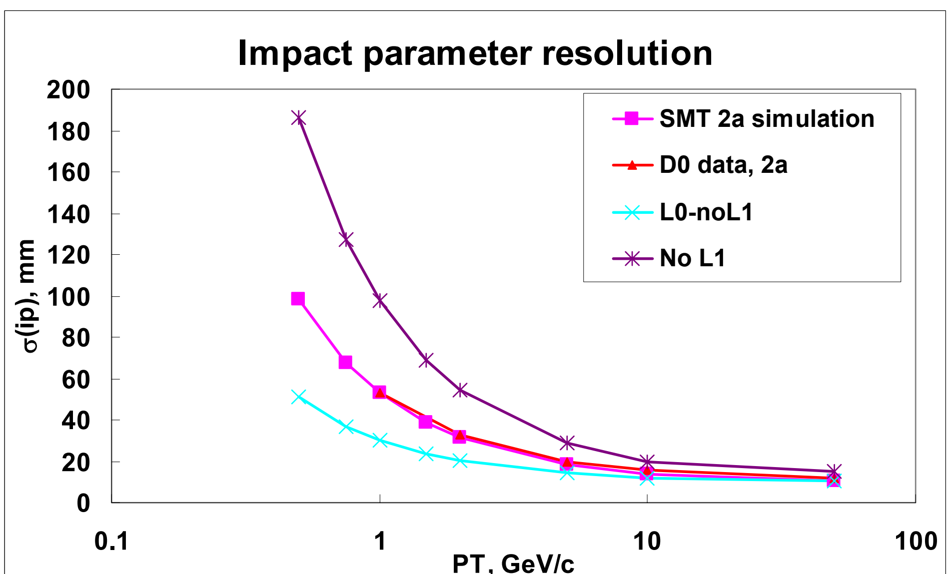
Relative increase of b-tagging efficiency is 15%

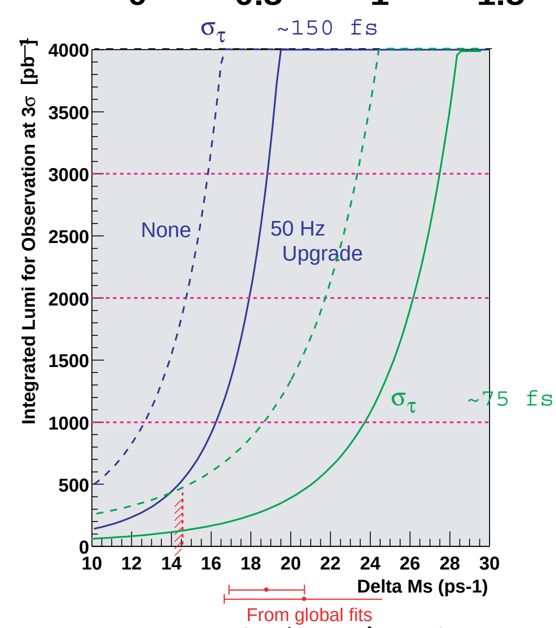
Layer 0 Motivation

- "after irradiation" effect studies:
  a) 10% hits are lost in outer layers
  b) 50% hit loss in L1 and F-disks
  c) "total loss" – a) + 100% hit loss in L1 and 50% in F-disks
- Different (improved tagging algorithm)



- Improvement in IP resolution,especially at low momentum due to analog cables

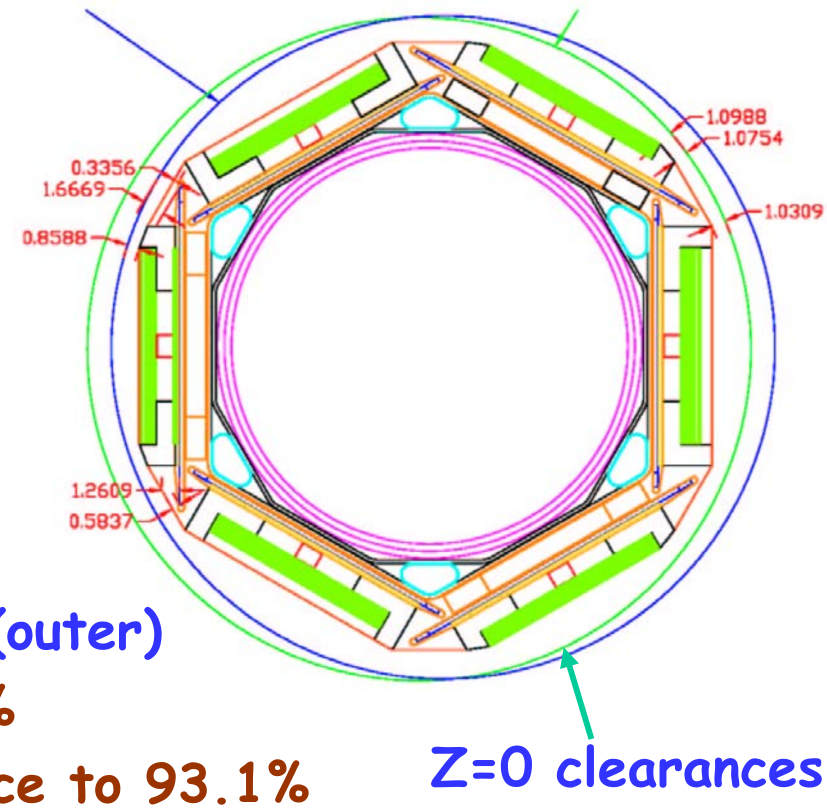




Bs mixing reach

Layer 0 Design

- Design – use as much of the Run2b R&D as possible
- Detector must fit in 22.8 mm SMT support structure opening
  - Six phi segments – match STT
  - Eight z segments 2x7,2x12cm
  - Analog cables – low mass
  - 48 HDIs x 256 channels
  - SVX4 chips (96)



- Replace at least outer H disks
- Sensor pitch – 71 μm (inner), 81 μm (outer)
  - Increases phi acceptance to 98.4%
  - Equal (71μm) pitch limits acceptance to 93.1%
  - Can be read out with one cable type
- *Check with HPK on cost and delivery*

Comparison with Run2b Layer0

Changes required by different geometries

	Layer 0	Run2b Layer 0
Sensors # Pitch(int, readout) Length	$6\ \phi \times 8\ z = 48$ (35/71),(40/81) 7, 12 cm	$12\ \phi \times 12\ z = 144$ (25/50) μm 7.7 cm
Analog Cables	4 lengths, <36 cm Double sensor pitch	6 lengths, <43.5 cm Double sensor pitch
Support	Six-sided nested structure (simpler)	Twelve-sided crenelated structure
Hybrids	Identical, use SVX4	
Junction cards, twisted pair and Digital cables	Identical design	
Adapter cards	Redesign to allow isolation of layer 0	

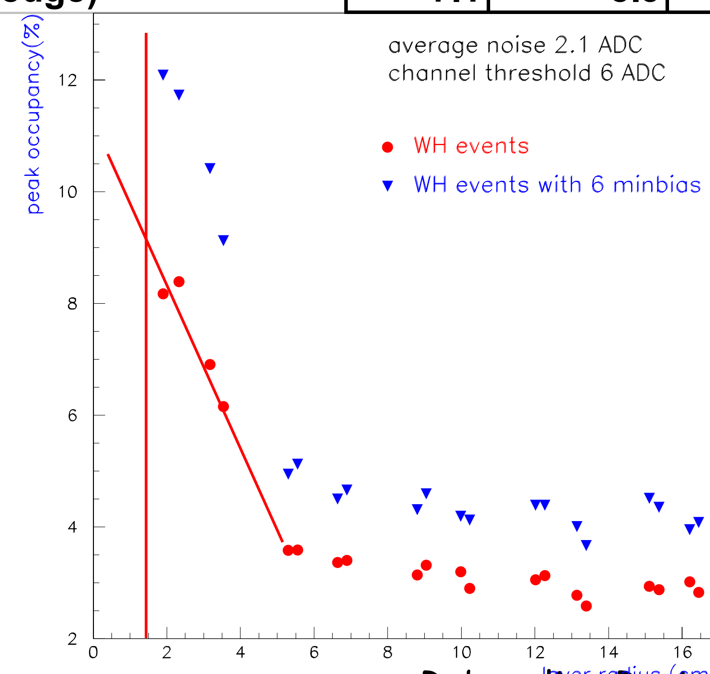
Layer 0 Performance

- Shorter than 2b detector- matches 2a
- Good signal/noise with shorter analog cables, detectors ~15:1
- Larger range of incident angles
  - Wide, small signal clusters

s/n at edge = 6.6/strip

- WH + 0 mb events: 7.0% shared clusters in L0
- WH + 7.5 mb events: 7.5% shared clusters in L0

	A	B	C	D
Detector length (cm)	7	7	12	12
Strip pitch (microns)	71	81	71	81
Active width (mm)	18.69	18.69	18.69	18.69
Radius (inner)	16.43	16.43	16.43	16.43
Max angle (radians)	0.52	0.52	0.52	0.52
L, effective (microns)	143.62	163.85	143.62	163.85
Analog cable length (cm	36	34	27	20
Total capacitance (pf)	21	20.3	23.85	21.4
Total noise(electrons)	1445	1414	1573	1463
S/N (normal inc)	15.9	16.3	14.6	15.7
S/N (edge)	7.1	8.3	6.6	8.0



Comparison with CDF L00

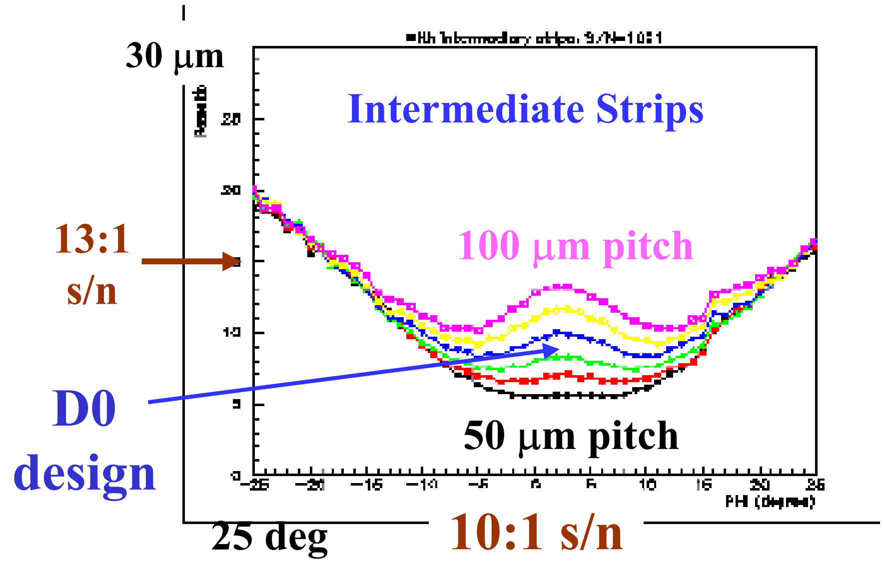
CDF is Just getting physics from L00 – details scarce

- Noise – fit pedestal on each event
- Occupancy – heavily ionizing tracks
- Alignment was difficult

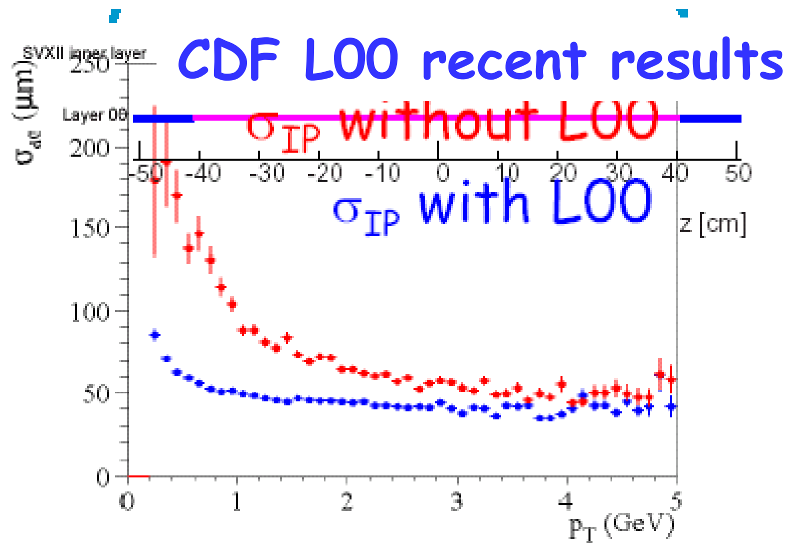
Our Layer 0 –

- At inner radius of 1.6 cm vs 1.3 for Layer 00
- Signal/noise 15:1 vs 10:1
- Length is 7 vs 14.8 cm
- Field is 2 T vs 1.4 T
- Very careful grounding
- Beam pipe radius larger

Occupancy is a concern – only ~65% of outer layer CDF tracks attached to clean single Layer 00 cluster



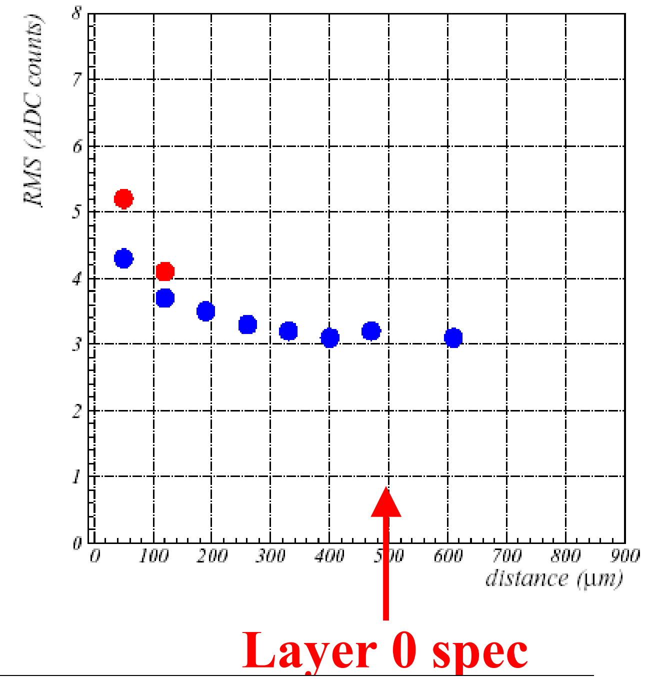
CDF Layer 00 studies of resolution vs pitch



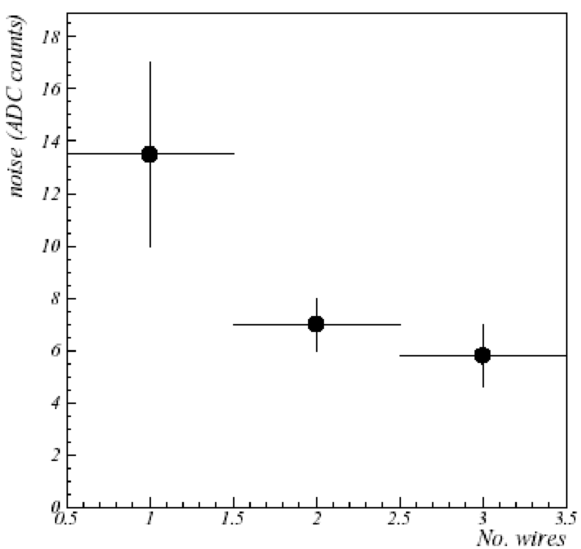
Grounding Studies

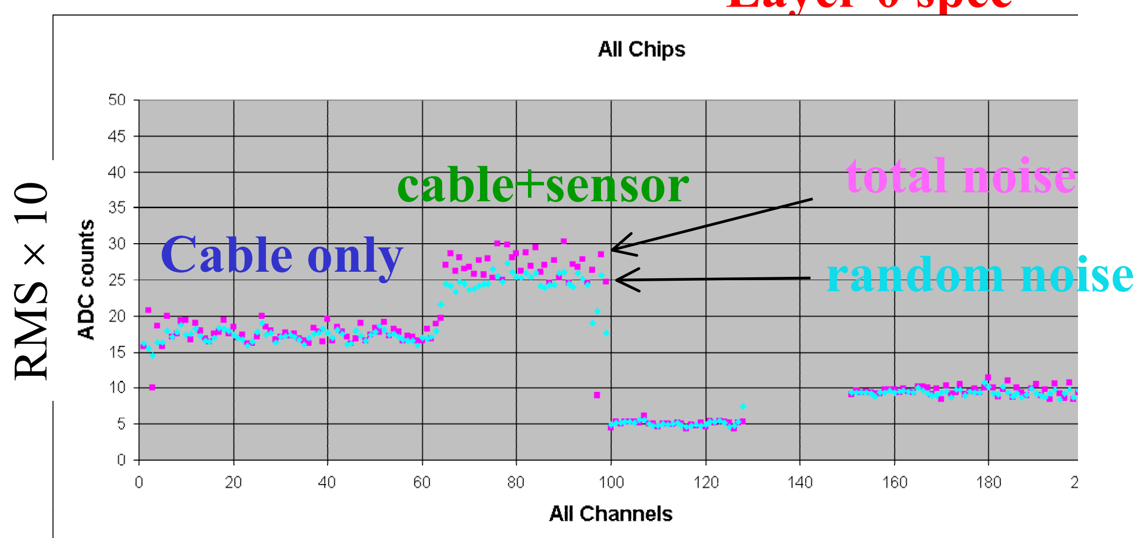
Set of detailed grounding studies:

- Sensor/analog cable can be coupled to the support structure capacitively Controlling proximity between detector and support structure is important



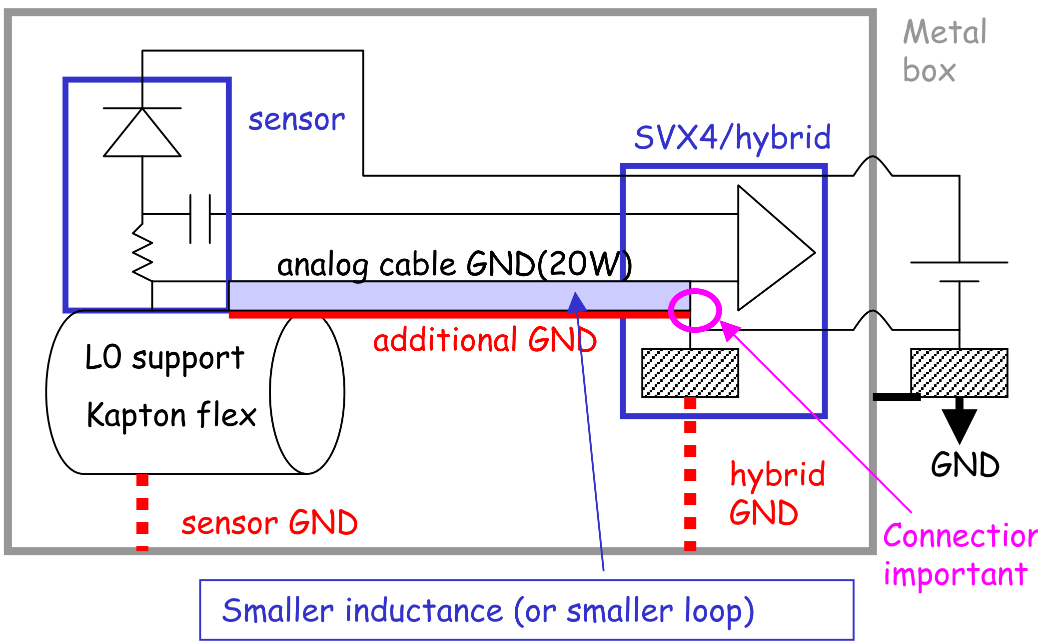
- Control inductance

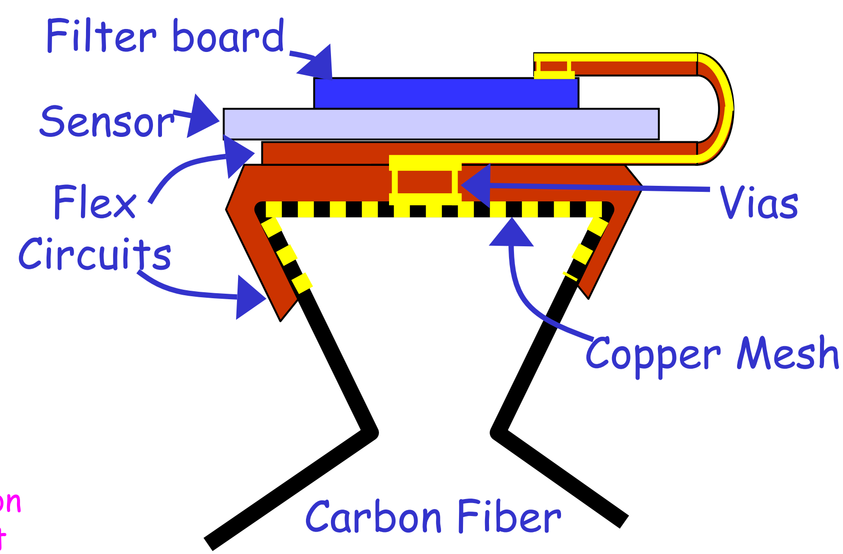




Grounding Scheme

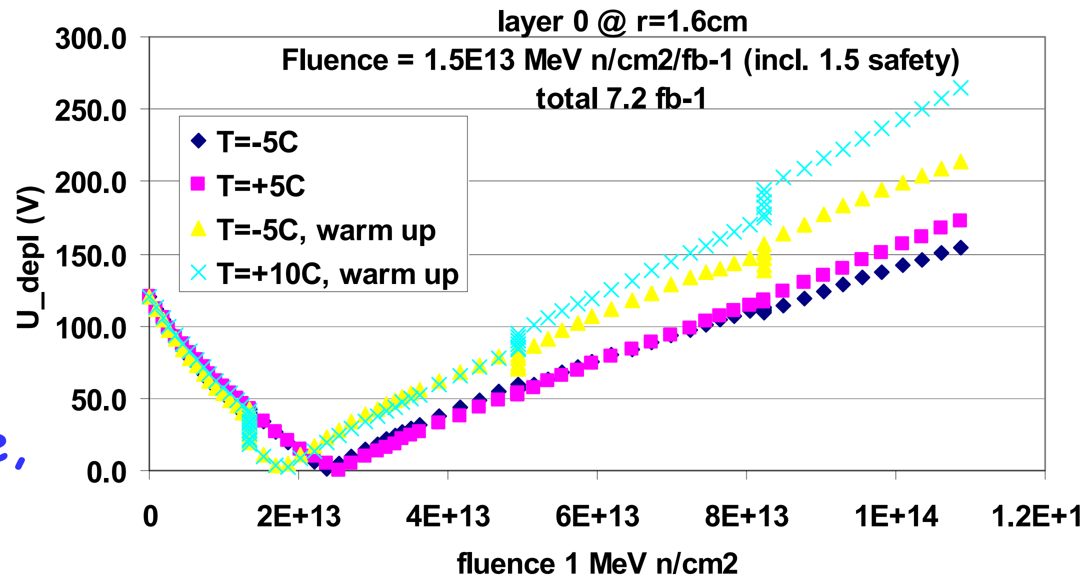
- Minimize inductance to carbon fiber ground plane
- Minimize load capacitance
- Use co-cured flex/CF support
- Limit coupling to beam pipe ~10Ω
- Isolate L0 and D0 grounds

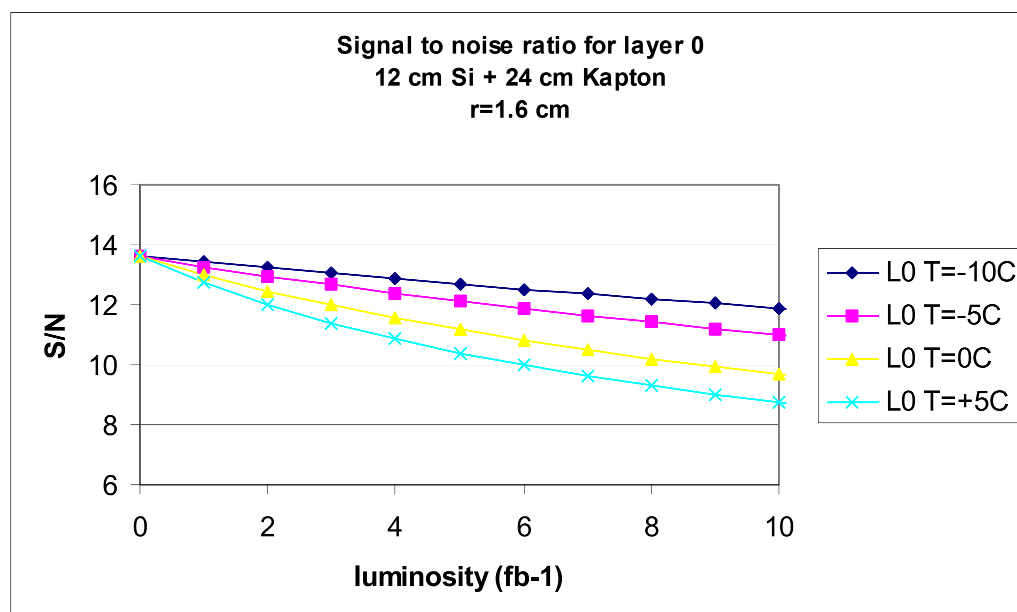




Layer 0 Sensors

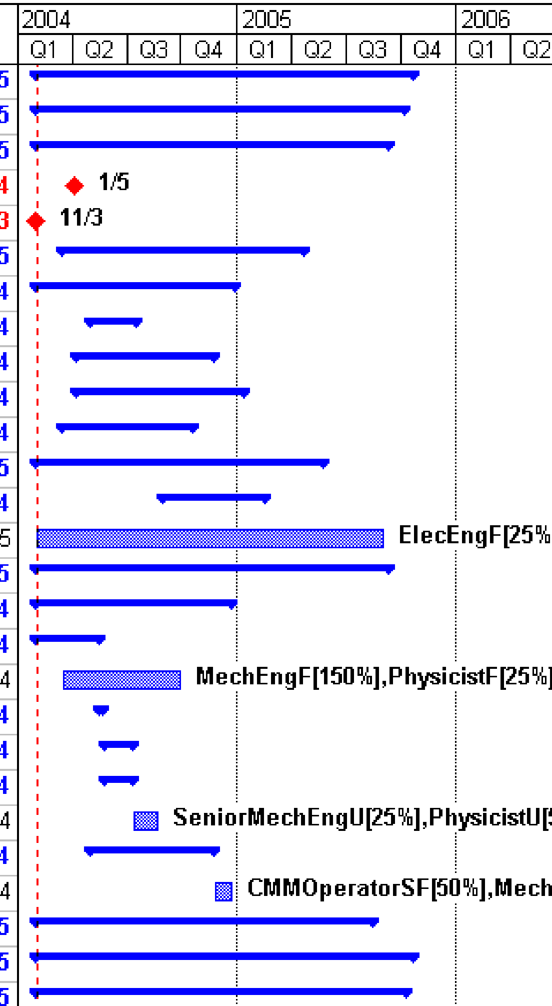
- Limited fluence – relaxed requirements on depletion voltage
- operating temperature<-5
- Should be able to design for Vmax of ~300V – can use existing infrastructure, smaller gaps between sensors
- Use Hamamatsu sensors similar to Run2b L0,1 design
- Prototypes probed and irradiated
- Passed Production readiness reviews





Schedule – Based on 2b schedule

ID	WBS	Task Name	Duration	Start	Finish
1	1.6	Layer 0 Silicon Detector	424 d	Mon 11/3/03	Thu 7/21/05
2	1.6.1	Sensors	415 d	Mon 11/3/03	Fri 7/8/05
16	1.6.2	Readout Electronics	395 d	Mon 11/3/03	Thu 6/9/05
17	1.6.2.1	SVX4 Chips Available	0 w	Mon 1/5/04	Mon 1/5/04
18	1.6.2.2	SASEQ Test Stands Available	0 w	Mon 11/3/03	Mon 11/3/03
19	1.6.2.3	Hybrids	265 d	Wed 12/17/03	Wed 1/19/05
40	1.6.2.4	Analog Cables	225 d	Mon 11/3/03	Wed 9/29/04
49	1.6.2.5	Flex Grounding Circuits	55 d	Mon 2/2/04	Fri 4/16/04
54	1.6.2.6	Digital Cables	160 d	Fri 1/9/04	Tue 8/24/04
64	1.6.2.7	Twisted-Pair Cables	195 d	Fri 1/9/04	Wed 10/13/04
74	1.6.2.8	Junction Cards	145 d	Wed 12/17/03	Tue 7/20/04
82	1.6.2.9	Adapter Cards	320 d	Mon 11/3/03	Wed 2/23/05
95	1.6.2.10	High-Voltage System	120 d	Tue 6/1/04	Wed 11/17/04
100	1.6.2.11	Readout Chain Integration	78 w	Mon 11/3/03	Thu 6/2/05
101	1.6.2.12	Full Chain Tests	395 d	Mon 11/3/03	Thu 6/9/05
108	1.6.3	Mechanical Design and Fabrication	220 d	Mon 11/3/03	Wed 9/22/04
109	1.6.3.1	Support Structures Design	65 d	Mon 11/3/03	Fri 2/13/04
117	1.6.3.2	Development and integration of design (FNAL)	26 w	Wed 12/17/03	Mon 6/28/04
118	1.6.3.3	Production Readiness Review	5 d	Mon 2/16/04	Fri 2/20/04
122	1.6.3.4	Final Fabrication Tooling	35 d	Mon 2/23/04	Fri 4/9/04
126	1.6.3.5	Final Quality Assurance Tooling	35 d	Mon 2/23/04	Fri 4/9/04
130	1.6.3.6	Produce preproduction samples for testing	6 w	Mon 4/12/04	Fri 5/21/04
131	1.6.3.7	Final Support Structures Production	145 d	Mon 2/2/04	Tue 8/24/04
139	1.6.3.8	Perform final article QA checks of support struct	4 w	Wed 8/25/04	Wed 9/22/04
140	1.6.4	Layer 0 Detector Modules	378 d	Mon 11/3/03	Mon 5/16/05
169	1.6.5	Final Detector Integration and Assembly	424 d	Mon 11/3/03	Thu 7/21/05
195	1.6.6	Silicon Project Administration	416 d	Mon 11/3/03	Mon 7/11/05



Costs

- Cost estimate – based on resource loaded schedule derived from Run2b project
- Assume 100% spares – small quantities
- Contingency 70%:
  - 100% for sensors – small quantities, HPK premium?
  - 50% for labor
  - 71% readout electronics and cables – adapter card isolation design
  - 50% mechanical design and fabrication

- ~ $800k available from NSF MRI grant - $730k now assigned to specific tasks (old numbers assume $650k)
- DOE holds most contingency and pays for FNAL labor

Costs

	FY 02 $ no G&A	M&S non-labor	M&S Labor	M&S Cost	Cont %	M&S Cont	Total M&S	FNAL Labor	Labor Cont %	Labor Cont	Total Labor	Total Cost (incl labor)	Cost + Cont
1	Layer 0 Silicon Detector	$573,805	$208,379	$782,184	73%	$573,426	$1,355,610	$535,847	50%	$267,923	$803,770	$1,374,921	$2,216,270
1.1	Sensors	$163,000	$1,200	$164,200	100%	$164,200	$328,400	$14,940	50%	$7,470	$22,410	$179,140	$350,810
1.2	Readout Electronics	$281,708	$117,840	$399,548	76%	$303,461	$703,009	$198,629	50%	$99,314	$297,943	$619,577	$1,022,352
1.3	Mechanical Design and Fal	$49,686	$89,339	$139,025	50%	$69,413	$208,438	$134,192	50%	$67,096	$201,288	$273,217	$409,726
1.4	Layer 0 Detector Modules	$16,711	$0	$16,711	75%	$12,503	$29,214	$74,076	50%	$37,038	$111,114	$90,787	$140,328
1.5	Final Detector Integration	$25,700	$0	$25,700	50%	$12,850	$38,550	$60,202	50%	$30,101	$90,303	$85,902	$128,853
1.6	Monitoring	$12,000	$0	$12,000	50%	$6,000	$18,000	$0		$0	$0	$12,000	$18,000
1.7	Software and Simulation	$0	$0	$0		$0	$0	$42,300	50%	$21,150	$63,450	$42,300	$63,450
1.8	Silicon Project Administrat	$25,000	$0	$25,000	20%	$5,000	$30,000	$11,508	50%	$5,754	$17,262	$71,998	$82,752

Reviewed last week

- assigned MRI resources to relevant tasks
- re-evaluated resource allocations
- total cost decreased by ~ $30k

Expect first procurements with MRI money soon

Schedule

- Assumes definition of all basic parameters Dec 15
  - Start of sensor, analog cable design and procurement
- No prototype phase for most components
  - Quantities small prototype = production
  - Run2b prototypes already complete for many items
  - Includes prototyping for adapter cards, supports
- Hybrids critical path – received new shipment last week – may be usable unchanged
- Six month sensor production – based on Run2b experience but will be critical path if ~2 months late. Sensor order date – March 19.
- ~1.5 year design/construction – Finish 7/21/2005

Risks

- Only one viable vendor for analog cables (Dyconex) – They expect an order (Run2b) from us soon
- Hammamatsu reaction to Run2b cancellation and small Layer 0 order – both schedule and technical risk if we go to other vendors
- Short design and construction schedule – labor costs will rise if schedule stretches out
- Space is tight – clearances were measured but errors are possible – survey before installation will be important
- Unexpected noise sources or physical damage to the detectors may be found in the final testing phase

Milestones

ID	Milestone	Date
112	Freeze Mechanical Parameters	12/16
9	Release Sensors for Production	3/19
24	Release Hybrids for Production	3/26
45	Release Analog Cables for Production	3/26
48	All Analog Cables Delivered and Tested	9/29
15	All Sensors Delivered and Tested	11/17
39	All L0 Hybrids Delivered, Stuffed, and Tested	1/19
94	All Adapter Cards Delivered and Tested	2/23
163	Silicon L0 Module Production Complete	3/24
191	Layer 0 Silicon Detector Ready to Move to DAB	7/21

Organization

- Level 2 – A. Bean (MRI PI), R. Lipton

  Level 3
  - Sensors – M. Demarteau, B. McCarthy
  - Electronics – A. Nomerotski, R. Sidwell
  - Mechanical – W. Cooper
  - Assembly – J. Fast

- Most (but not all) of the groups and individuals involved in Ru2b are continuing their commitments to layer 0. The role of the MRI groups has expanded and much of the M&S will be through MRI funds. *We have retained critical expertise in electronics, sensors and mechanical design.*

Layer 0 conclusions

This is an opportunity for the experiment and collaborators to utilize work done for 2b.

Layer 0 will materially improve the performance of D0, may be crucial in recovering tracking as the 2a detector degrades.

We know how to do this, and have the resources and manpower.