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Backgrounds

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Background related Questions

- For each of your critical sub-detectors, what is the upper limit you can tolerate on the background hit rate per unit area per unit time (or per bunch)? Which kind of background is worst for each of these sub-detectors (SR, pairs, neutrons, muons, hadrons)?
- Can the detector tolerate the background conditions for the ILC parameter sets described in the Feb. 28 2005 document at www-project.slac.stanford.edu/ilc/acceldev/beamparameters.html? Please answer for both 2-mrad and 20-mrad crossing angle geometries. If the high luminosity parameter set poses difficulties, can the detector design be modified so that the gain in luminosity offsets the reduction in detector precision?
- What do you anticipate the difference will be in the background rates at your detector for 20 mrad and for 2 mrad crossing angle? Give your estimated rates in each case.

More questions

- What are your preferred values for the microvertex inner radius and length? If predicted backgrounds were to become lower, would you consider a lower radius, or a longer inner layer? If predicted backgrounds became higher, what would be lost by going to a larger radius, shorter length?
- What is your preliminary evaluation of the impact of local solenoid compensation (see LCC note 143) inside the detector volume, as needed with 20mr crossing angle, on the performance of tracking detectors (silicon, and/or TPC, etc).

Background Sources

IP Backgrounds

- Beam-beam Interactions
  - Disrupted primary beam
    - Extraction line losses
  - Beamstrahlung photons
  - e+e- pairs
- Radiative Bhabhas
- $\gamma\gamma \rightarrow$hadrons/μ+μ-

Machine backgrounds

- Muon production at collimators
- Collimator edge scattering
- Beam-gas
- Synchrotron radiations
- Neutrons from dumps/extr. line

Good; scale with luminosity

- Transport them away from IP
- Shield sensitive detectors
- Exploit detector timing

- Reliable simulations.

Bad,

- Don't make them
- Keep them from IP if you do

- Dominated by beam halo
- Dependent on assumptions

Three Detector Concepts

Subdetector	GLD	LDC	SiD
Vertex detector	Si pixel r1= 2.0 cm	Si pixel r1= 1.5 cm	Si pixel r1 = 1.4 cm
Tracker	TPC	TPC	Si strips
EM CAL	Scintillator-W	Si-W	Si-W
HAD CAL	Scintillator-Pb	Scintillator-Fe RPC/GEM-Fe	Si-W
Muon system	Scintillator	RPC	RPC
Solenoid	3 Tesla R = 3.5 – 4.5 m L = 8.9 m	4 Tesla R = 3 – 4.45 m L = 9.2 m	5 Tesla R = 2.5 – 3.3 m L = 5.4 m

Background tolerance levels

Three levels of criteria:

- Radiation damage
- Pile up
- Pattern recognition

Table is from W. Kozaneck (Collimation Task Force Workshop, SLAC, 2002)
GLD and SiD answers included.

Subdetector	Chrgd trks	γ	n (~ 1MeV)	μ	E
Vertex detector	6 / mm^2 100/mm^2/tr	300 / mm^2	3×10^9 cm^{-2}y^{-1} 1×10^{10} cm^{-2}y^{-1}	-	-
Si Tracker	0.2 /cm^2/BX	10 /cm^2/BX			-
TPC	2500	1.25×10^6	2.5×10^7	2500	-
Calorimeter	-	~40000	-		1MIPS/cm^2/train
Muon system	-	-	-	100/cm^2/s	

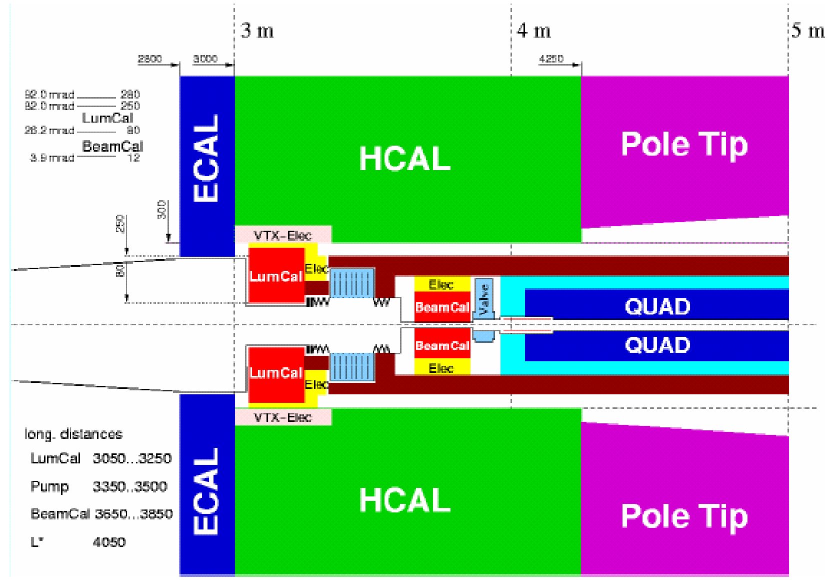
Background simulations

- Simulations from BDS to Dump
  - EGS4, Decay TURTLE, STRUCT, MARS, FLUKA, BDSIM, GEANT3, GEANT4
- Three detectors
- 10 ILC beam parameters
- 2 crossing angles
- Many background sources

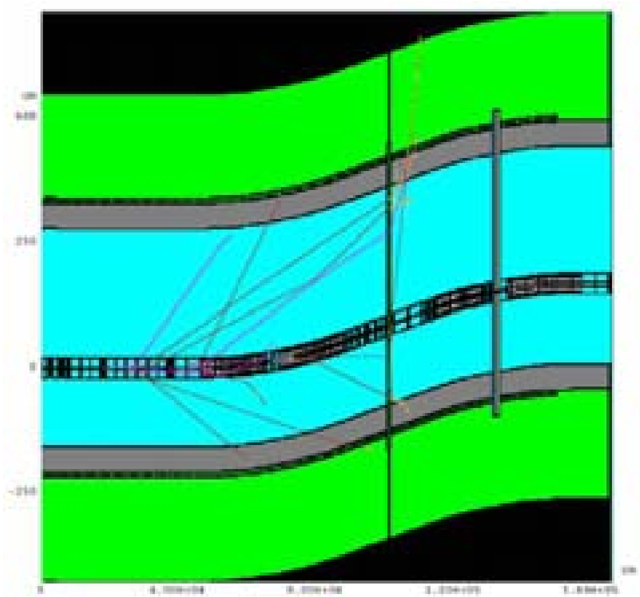
- Requires a tremendous amount of work to complete.
- A great deal of work has been done, but much more studies are needed.

Realistic geometries

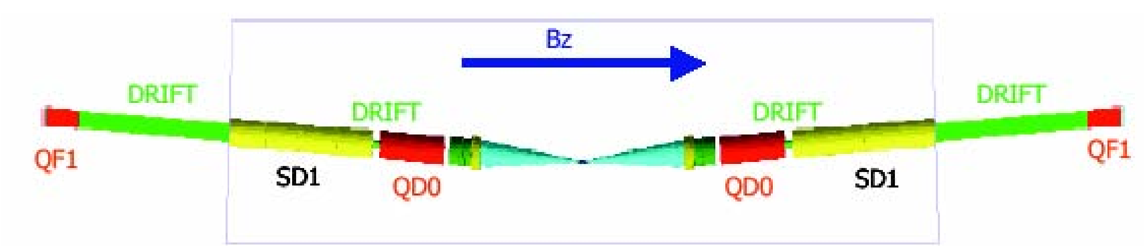
LDC model



MARS model of BDS

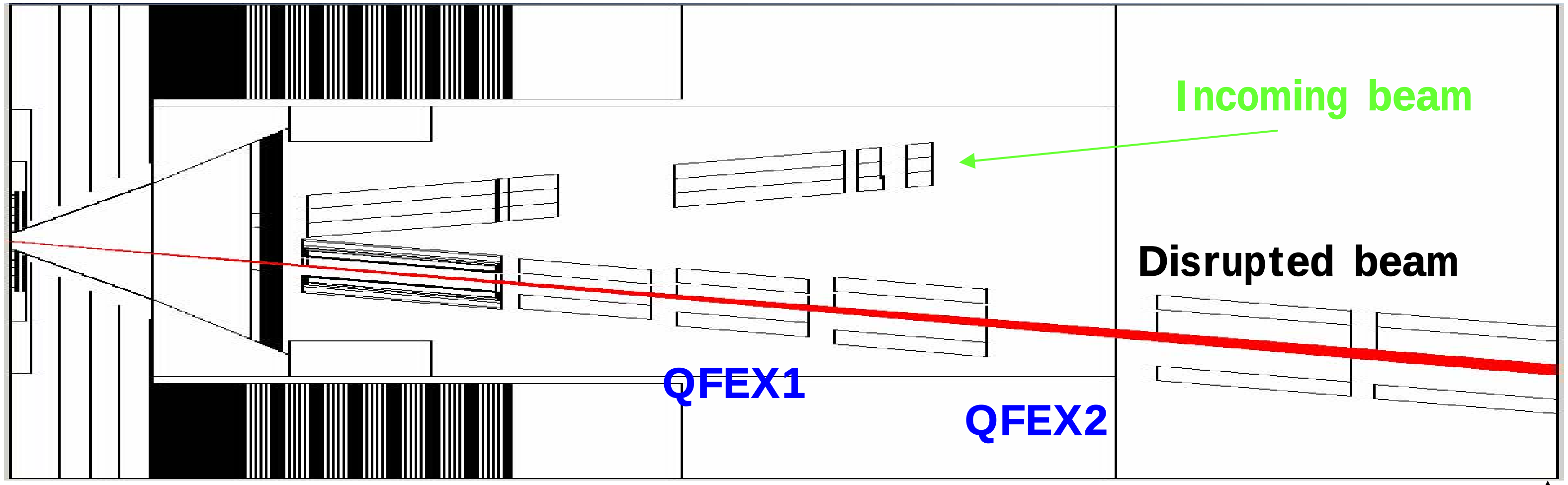


2mrad in BDSIM

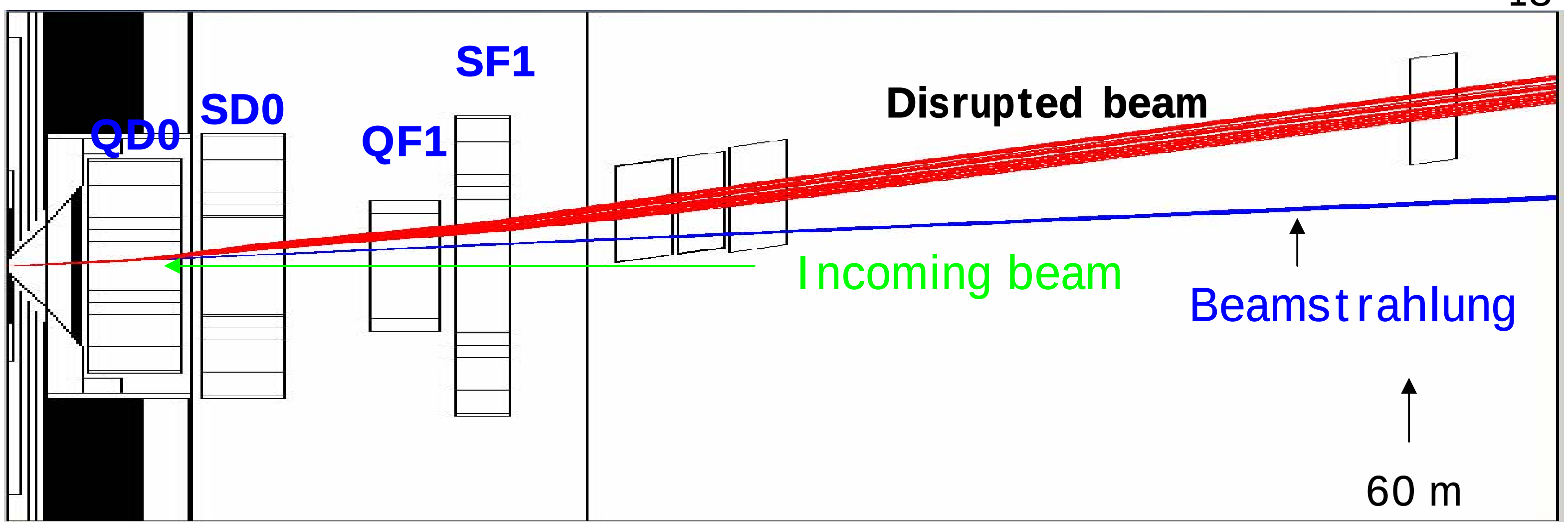


SiD in two crossing schemes

20 mrad



2 mrad



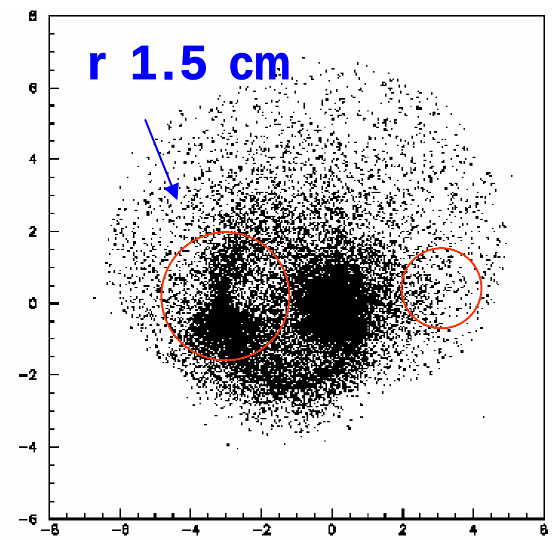
Pairs

- Dominant background
- Very dependent on Beam parameters
- Solenoid field strength
  - Solenoid compensation for 20 mrad
- VXD layer radius
- Far forward geometry

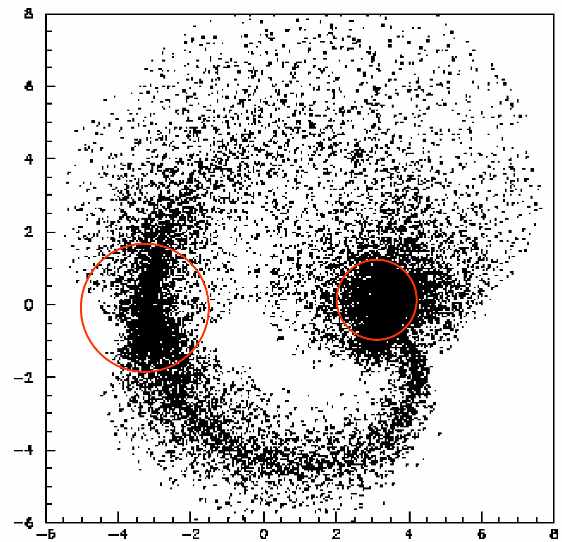
	Beam	# e+/e-/BX	Total energy
500 GeV	Nominal (N)	98 K	197 TeV
	Low Q (Q)	38	86
	High Y (Y)	104	191
	Low P (P)	232	709
	High Lum (H)	268	944
1 TeV	Nominal	174	1042
	Low Q	73	486
	High Y	229	1356
	Low P	458	4596
	High Lum	620	7367

Pairs at Z = 300 cm

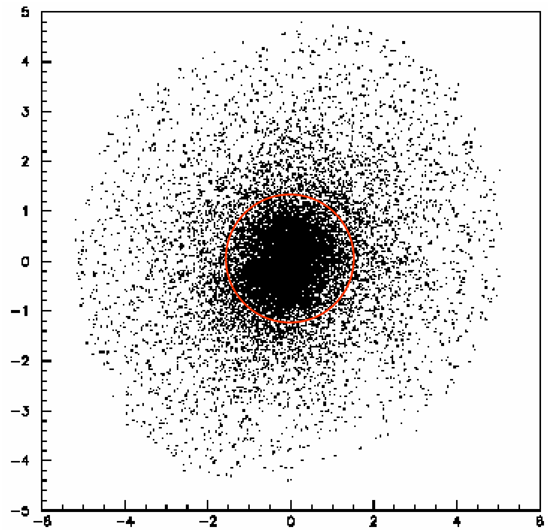
20 mrad
w/o compensation



20 mrad
w compensation



2 mrad



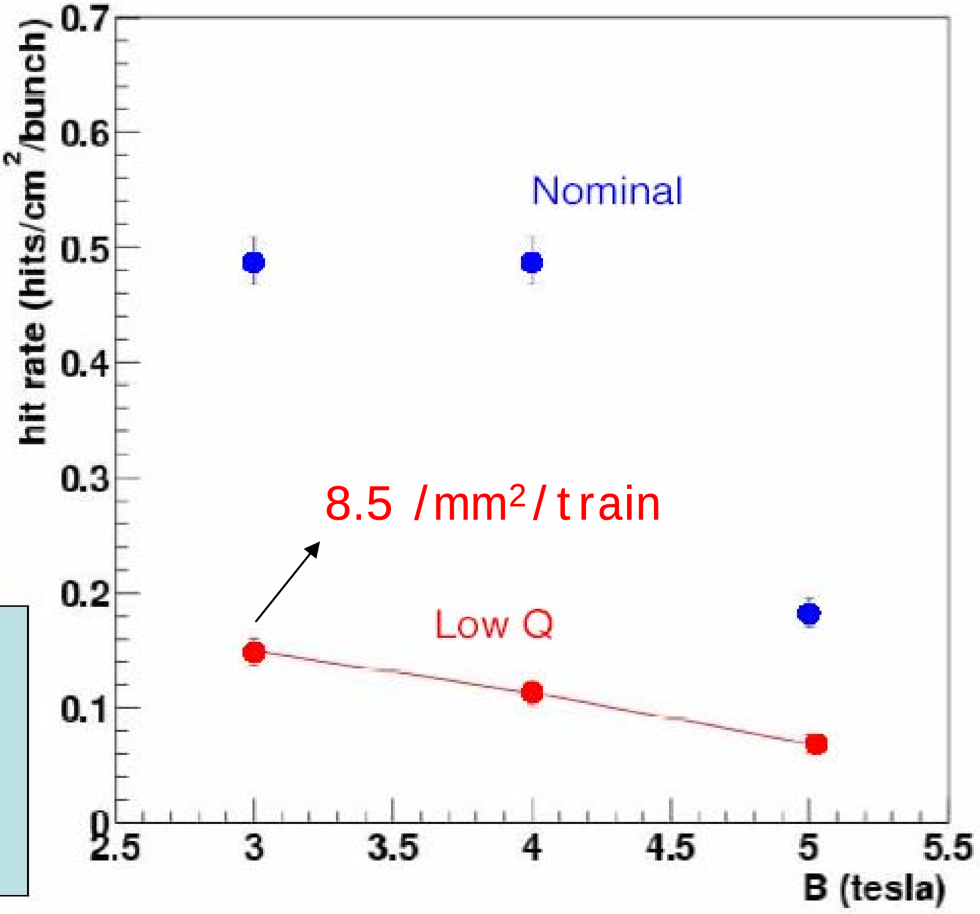
X (cm)

Solenoid field map is important.
SiD 5 Tesla $\rightarrow$3 Tesla @ Z= 300 cm
DID field

VXD hits GLD

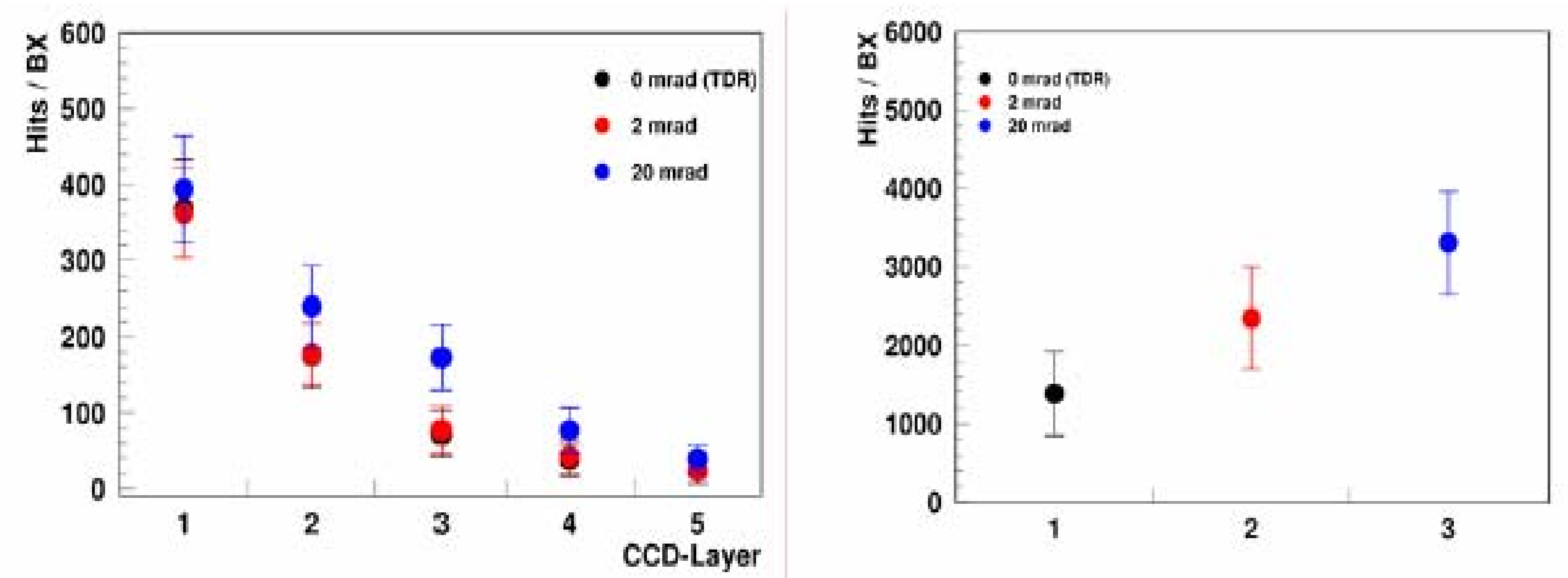
- Pair background hit rate on the 1st layer of the Vertex Detector (R=24mm)
- Simulation using CAIN and JUPITER
- Hit rate of the Low Q option is ~1/3 of the nominal option, as expected

Pair B.G. hit rate (/cm^2/bunch)		
B(tesla)	Nominal	LowQ
3	0.488	0.149
4	0.48	0.113
5	0.183	0.069



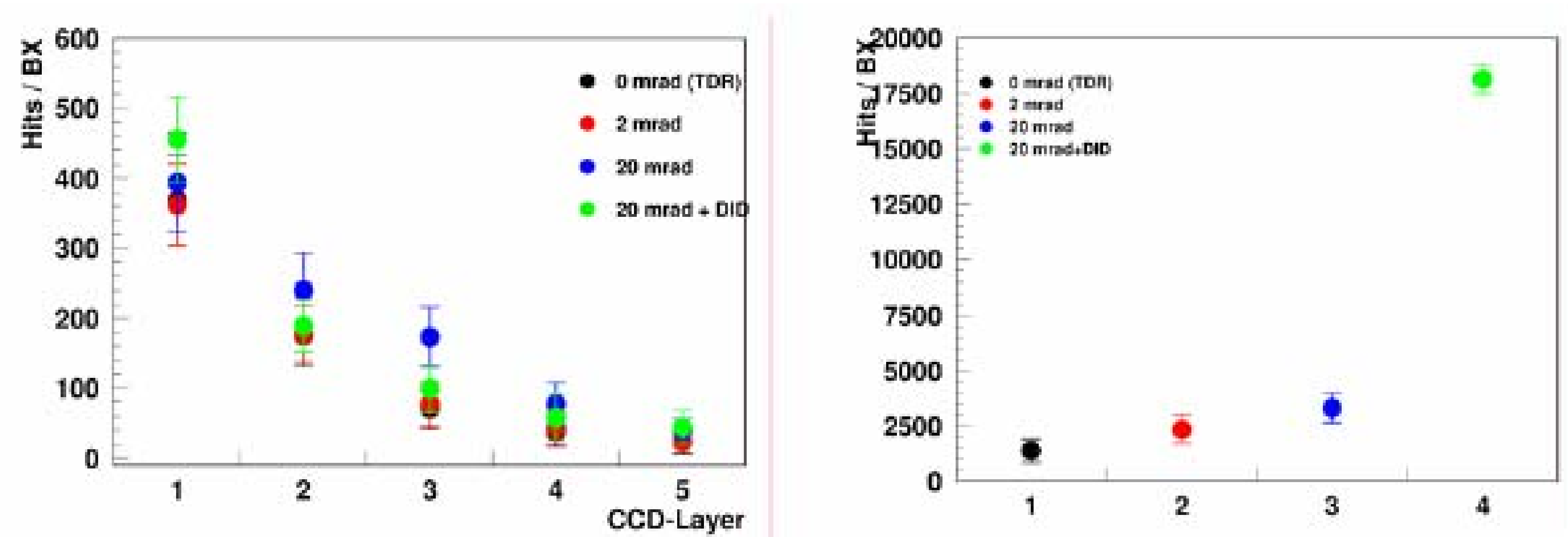
Crossing angle dependence LDC

TESLA Beam parameters



- VXD hits
  - No difference between 0 mrad and 2 mrad
  - Higher background in 20 mrad
- TPC hits
  - Twice as much in 2 mrad than in 0 mrad
  - Twice as much in 20 mrad than in 2 mrad

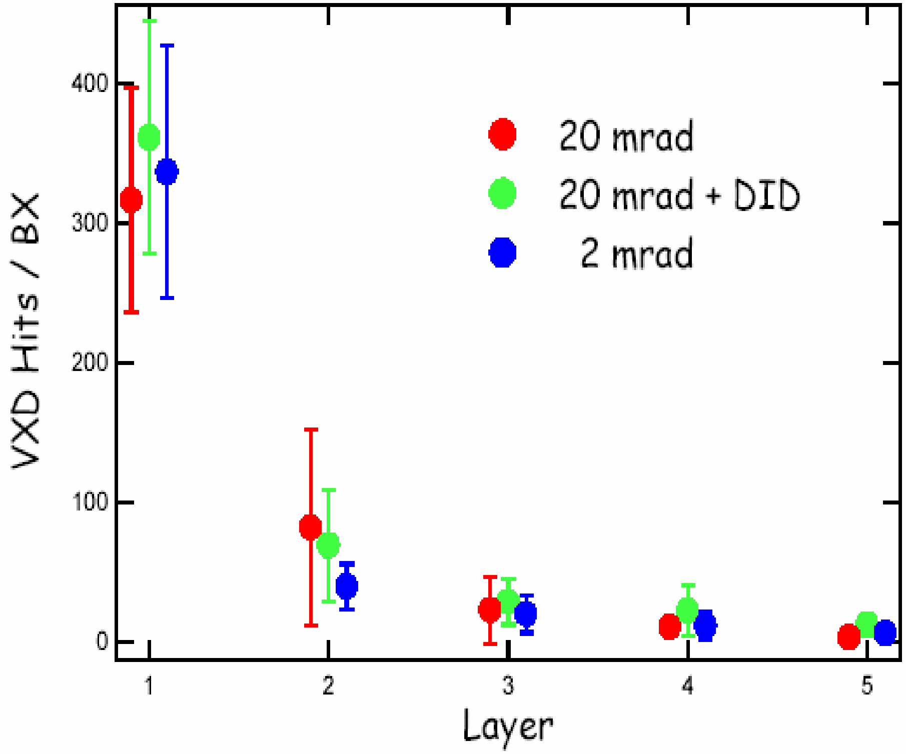
DID effect on VXD and TPC hits LDC



- VXD hits
  - DID field reduces vxd hits to 2 mrad level.
- TPC hits
  - Significantly more TPC hits

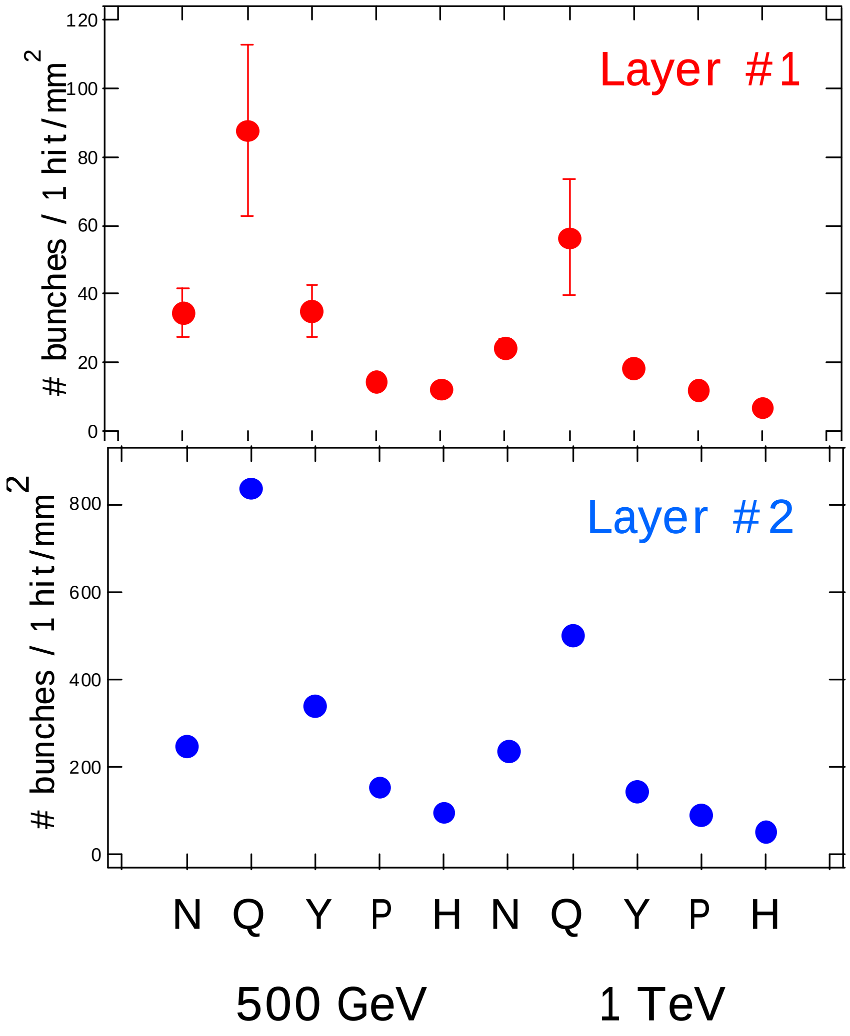
Crossing angle dependence SiD

ILC 500 Nominal



- Average and RMS from 20 BXs.
- 20 mrad and 20 mrad + DID will have more VXD hits than 2 mrad.
- But bunch-to-bunch fluctuation is larger than the crossing angle difference.

How many bunches to reach 1 hit/mm^2



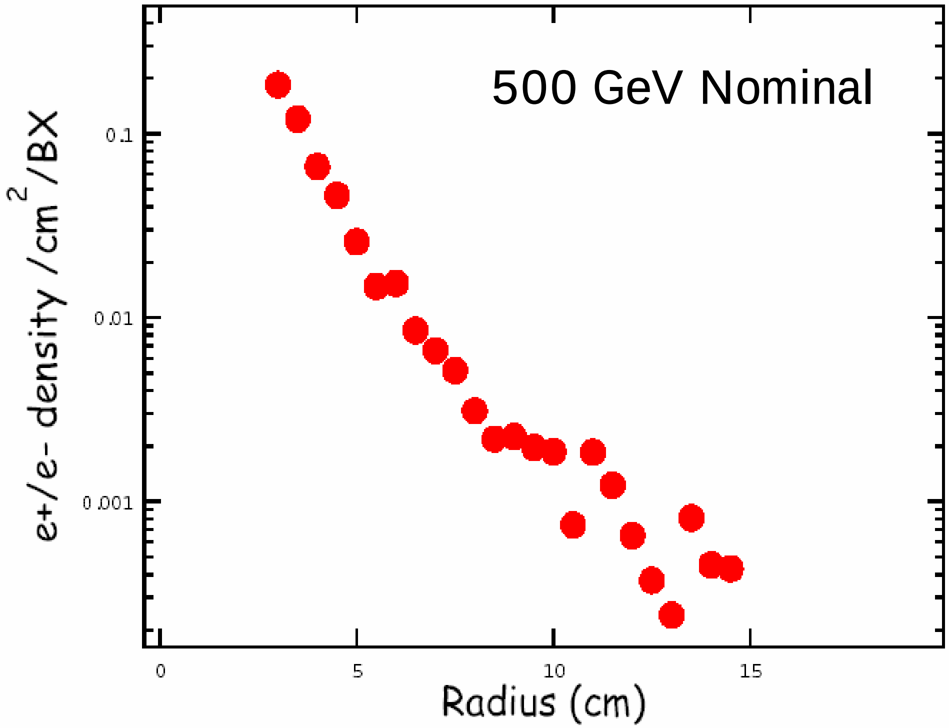
SiD

- One readout/train does not work for 25μm×25μm pixel detector.
- 5μm×5μm fine pixel detector can allow one readout/train for some beam parameters.
- Layer #2 can take x8 more bunches.

e+/e- density in Si Tracker

SiD

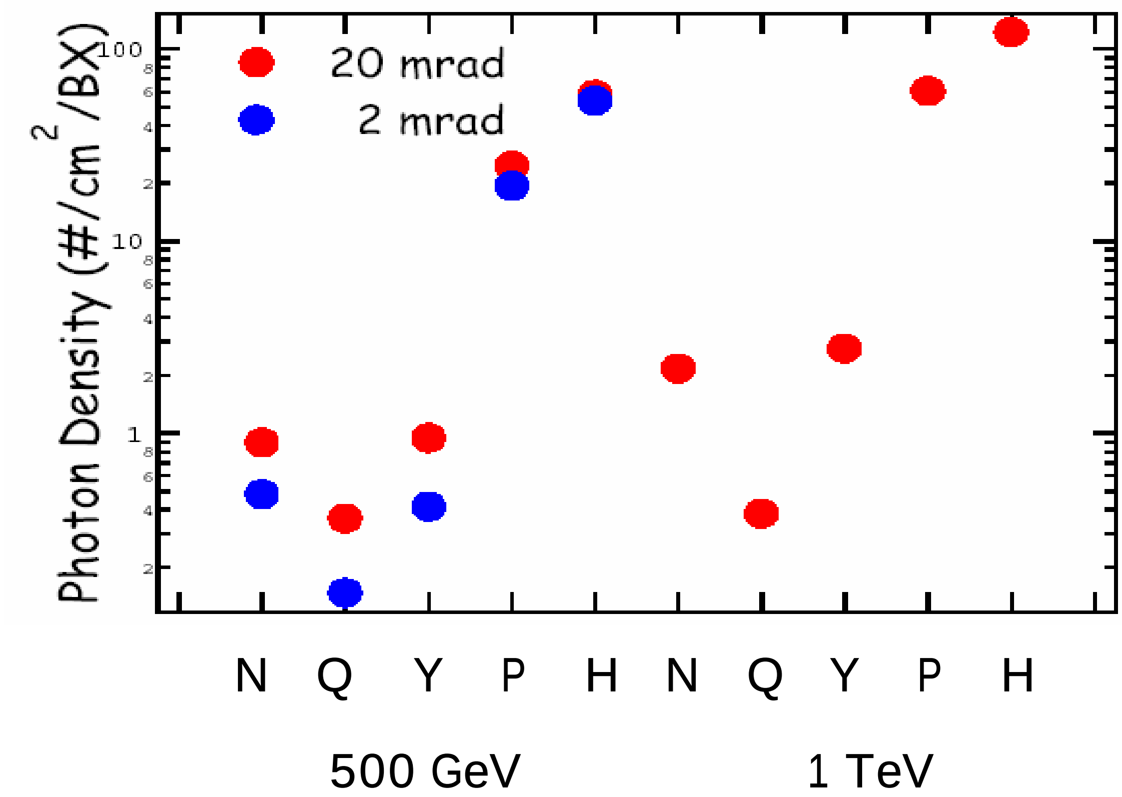
Forward Tracker Layer #1 hits



- Steep radial dependence
- Innermost region is at the tolerance level (0.2/cm^2/BX).

Photons in Si Tracker

SiD

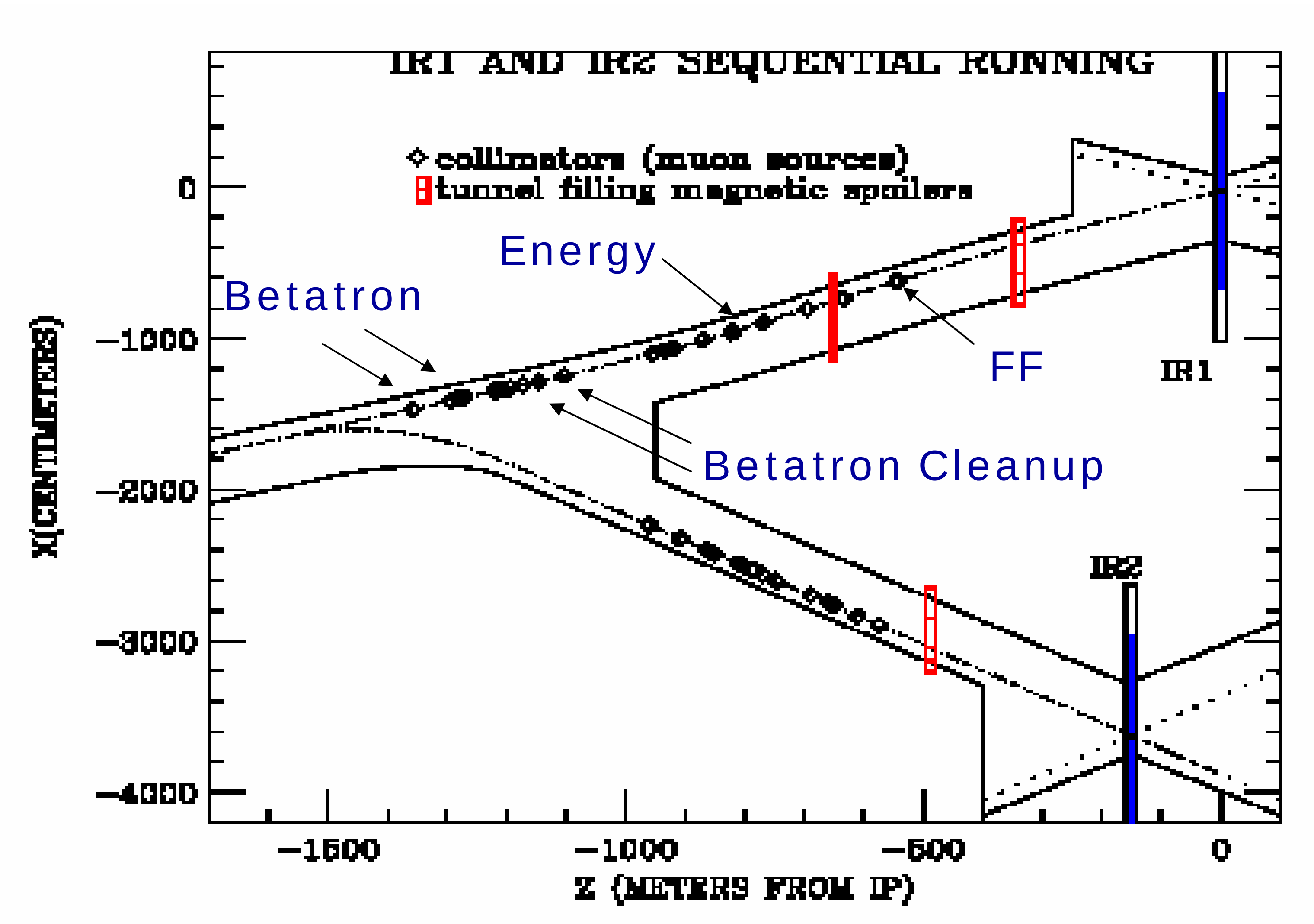


- Twice as many photons in 20 mrad than in 2 mrad
- More than the detector tolerance level for Low P and High Lum options

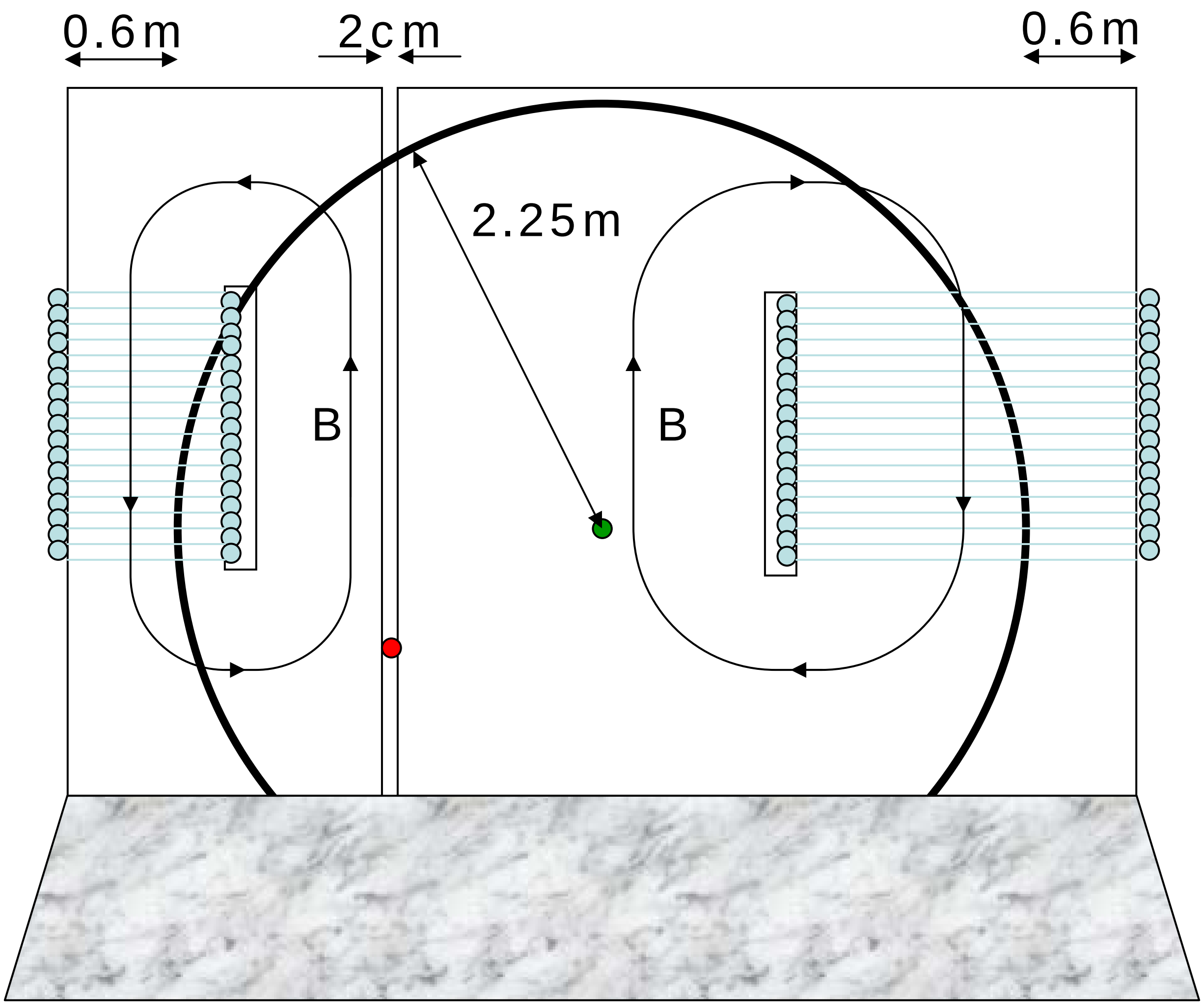
Muon background

Muons are generated at collimators: μ / e = 5×10^{-4}

Assume collimate 0.1% of 2×10^{10}/BX



9 & 18m Toroid Spoiler Walls

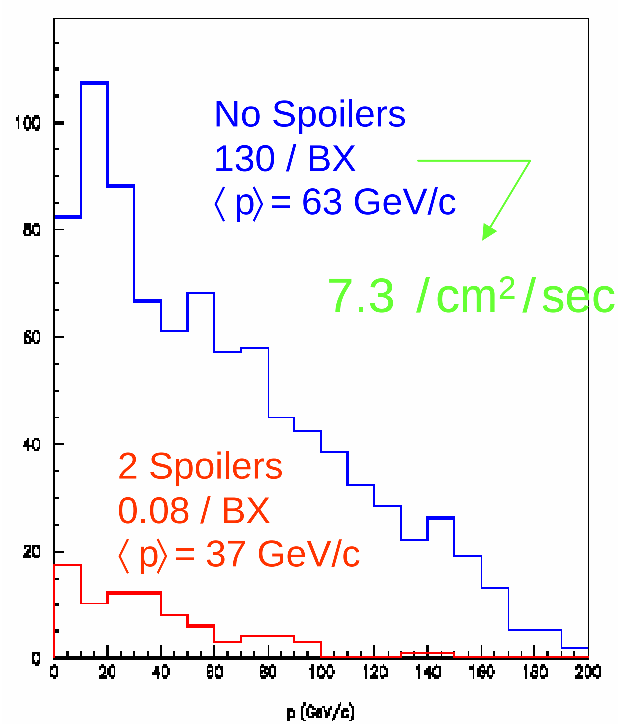


170 Tons/m

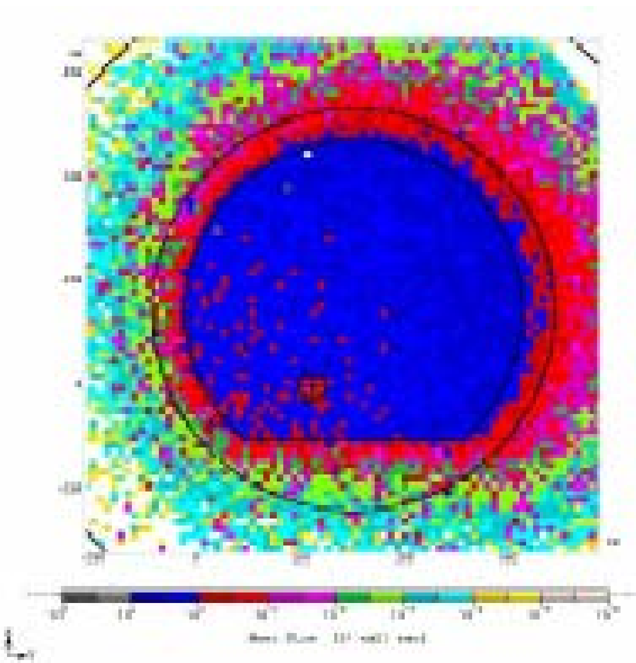
Design Constraints: Minimize gap & minimize stray field in beampipe

Muon distribution at 250 Gev/ Beam

MUCARLO (Keller)



MARS (Kostin)



< N > = 4.06 +/- 0.21 /cm²/sec

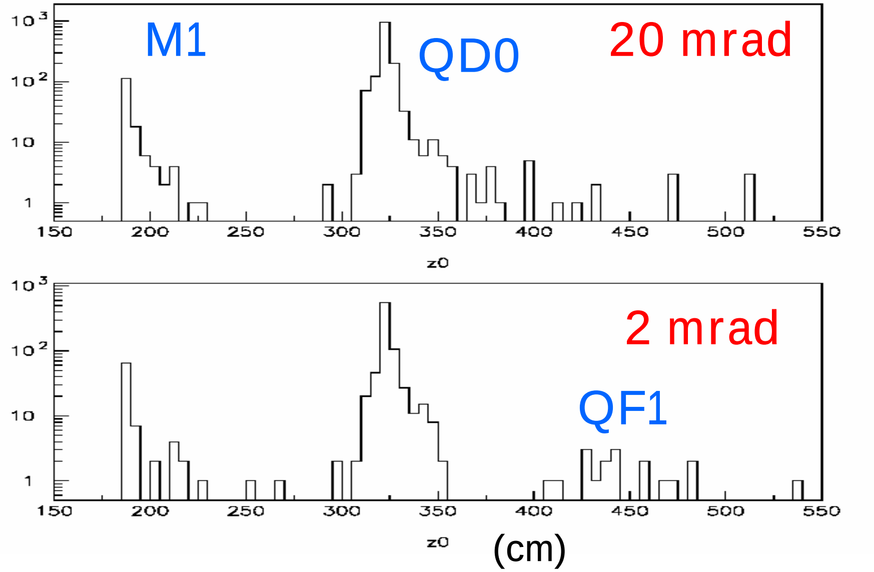
At least one spoiler is required to reduce the muon rate to < 1 Hz/cm²

500 GeV Beam: 144 / BX GEANT4-BDSIM (Blair)

Neutron Backgrounds in VXD

The closer to the IP a particle is lost, the worse

- 20 mrad
  - Pairs: 3.6×10^{8} $n_s/cm^2/yr$
  - Rad. Bhabhas: 1.1×10^{8} $n_s/cm^2/yr$
- 2 mrad
  - Pairs: 2.3×10^{8} $n_s/cm^2/yr$



- Neutron background is proportional to pair total energy.
  - Reach $1\times10^{10}/cm^2/yr$ for 1 TeV Low P and High Lumi options.

- Neutrons from the extraction line and beam dump
  - NLC era estimation $\sim1\times10^{8}/cm^2/yr$
  - Need updating calculations using the ILC conditions.

Neutrons in TPC   LDC

GEANT4 (Vogel)

	L*=4.05 m Stahl	L*=3.0 m TDR
Total neutrons per BX	333977	413286
Neutrons reaching TPC	517	10959
Bouncing neutrons	20%	20%
Total TPC hits	5361	9881

Only preliminary!

- simulation of one single BX – need more statistics
- how many hits are caused by neutron scattering?

Synchrotron Radiations (A. Drozhdin)

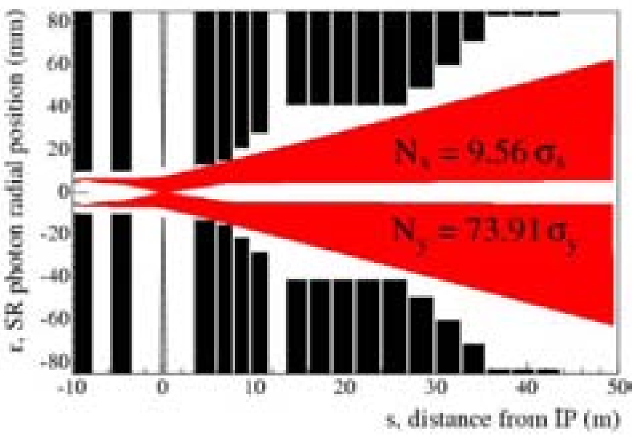
element	Mean energy GeV	Photons number per bunch	Photon energy per bunch GeV/bunch
synchrotron radiation from beam halo			
lost at PDUMP	0.752E-04	0.373E+07	0.280E+03
lost at MSK1	0.155E-03	0.115E+07	0.179E+03
lost at MSK2	0.300E-04	0.768E+05	0.230E+01
pass through IP	0.320E-02	0.422E+07	0.135E+05
bremsstrahlung photons from beam halo			
lost at PDUMP	0	0	0
lost at MSK1	0	0	0
lost at MSK2	0	0	0
pass through IP	0.140E+00	0.400E+03	0.561E+02
synchrotron radiation from beam core			
lost at PDUMP	0.740E-04	0.426E+10	0.315E+06
lost at MSK1	0.683E-04	0.464E+10	0.317E+06
lost at MSK2	0.305E-04	0.396E+09	0.121E+05
pass through IP	0.398E-03	0.383E+10	0.152E+07

Photon loss at PDUMP, MSK1, MSK2 and passed through the IP from beam halo for collimation at $8\ \sigma_x$ and $65\sigma_y$ and from beam core.

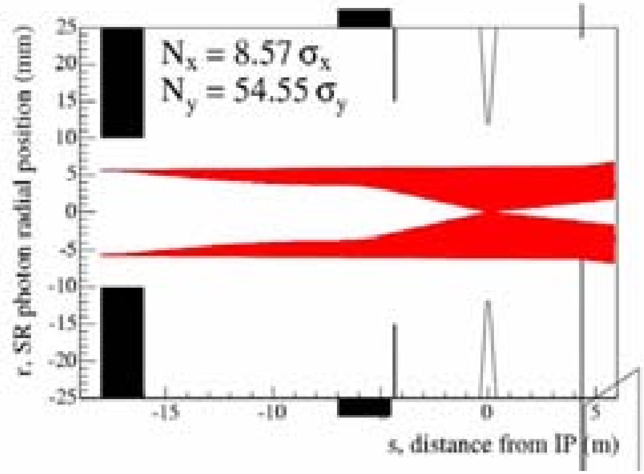
Collimation Depth

F. Jackson, J. Carter

20 mrad



2 mrad

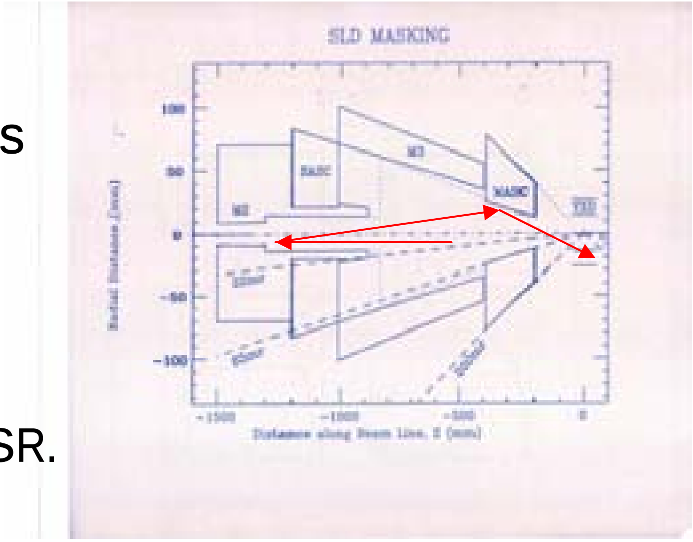


- Limiting aperture: r =12 mm (20 mrad), 15 mm (2 mrad)
- Spoiler gaps a_x = 1mm, a_y = 0.5 mm
- Tighter collimation for 2 mrad

Sync radiations can be very serious

At SLD/SLC, SR was the problem

- Conical mask completely shadowed the beam pipe and VXD.
- Mask was designed so that photons need at least TWO bounces to hit VXD.
- Two-bounce masking is not compatible with pairs.
  - Central detector is vulnerable to SR.



Require

- Complete analysis of SR from soft-bends and quads.
  - Gaussian core and beam halo
- Study
  - Repopulation of particles outside the collimation depth
  - Tip scatterings from upstream SR masks
  - Backscatterings from downstream apertures

Conclusions

- Detector tolerance levels need to be updated/expanded.
- Beam-beam pairs are dominant background
  - Very dependent on geometry, solenoid field strength, crossing angle, and beam parameters.
- Sync radiations are potentially very serious backgrounds.
  - We cannot assume beam collimation works perfectly.
  - We have to be conservative.
- Building realistic model is essential.
  - Detector geometry, magnets, tunnel, solenoid field map, magnet fringe field
- Simulation standards
  - Having many tools is good, but we need standards.
  - Repository
    - Optics
    - Detector description
    - Magnet geometries, field maps
    - Guinea-pig files, muons, beam-gas scattered particles
- Benchmarking and cross checking