Neutron and Photon Backscattering from the ILC Beam Dump

Siva Darbha

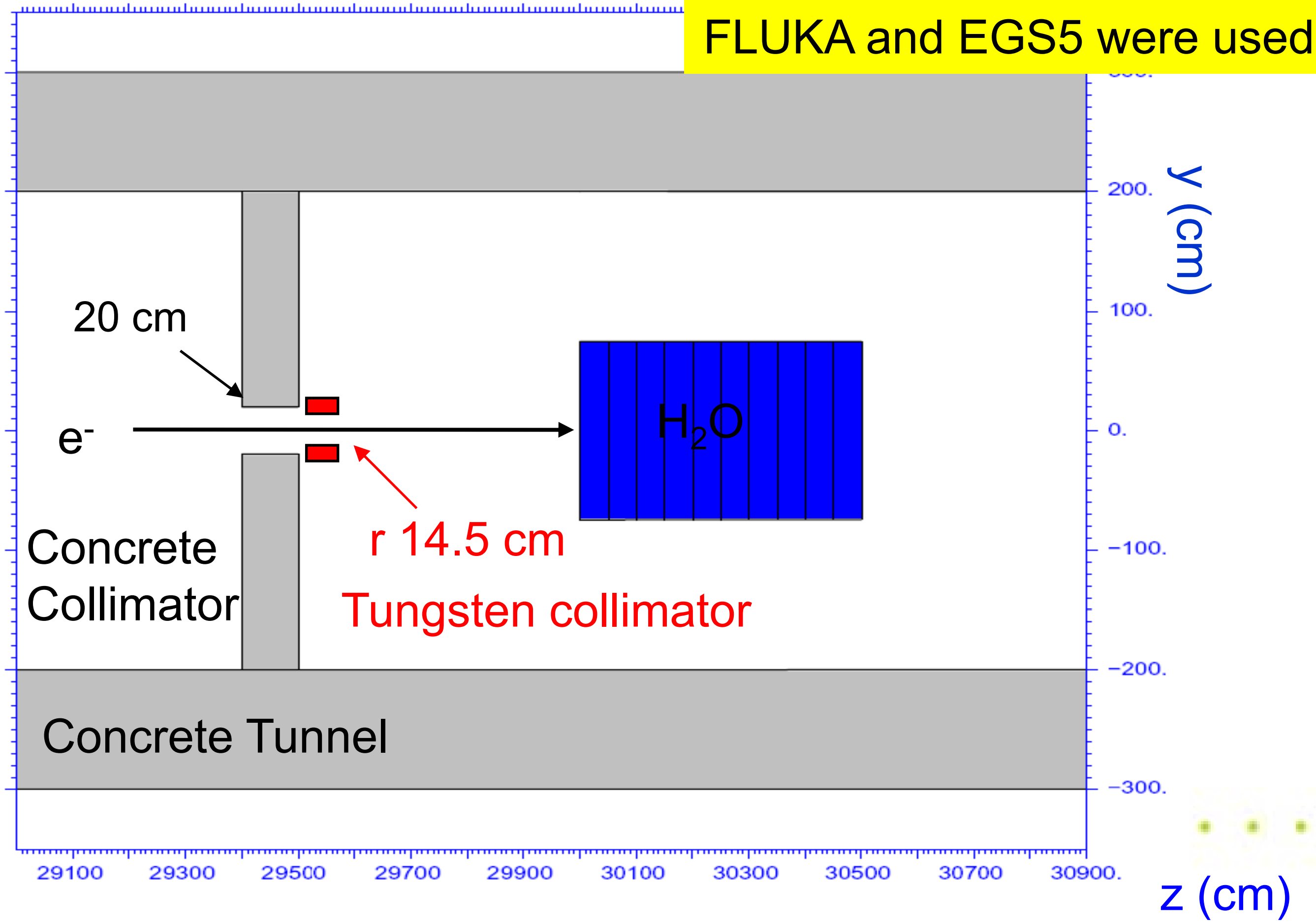
Lewis Keller and Takashi Maruyama

(SLAC)

Extraction Line and Water Dump

- The IP has a direct line-of-sight from the beam dump.
- Neutrons and photons produced at cosθ ~ -1 will reach the IP, and no shielding is possible.
- What is the IP flux?

FLUKA was used for neutrons.
FLUKA and EGS5 were used for photons.



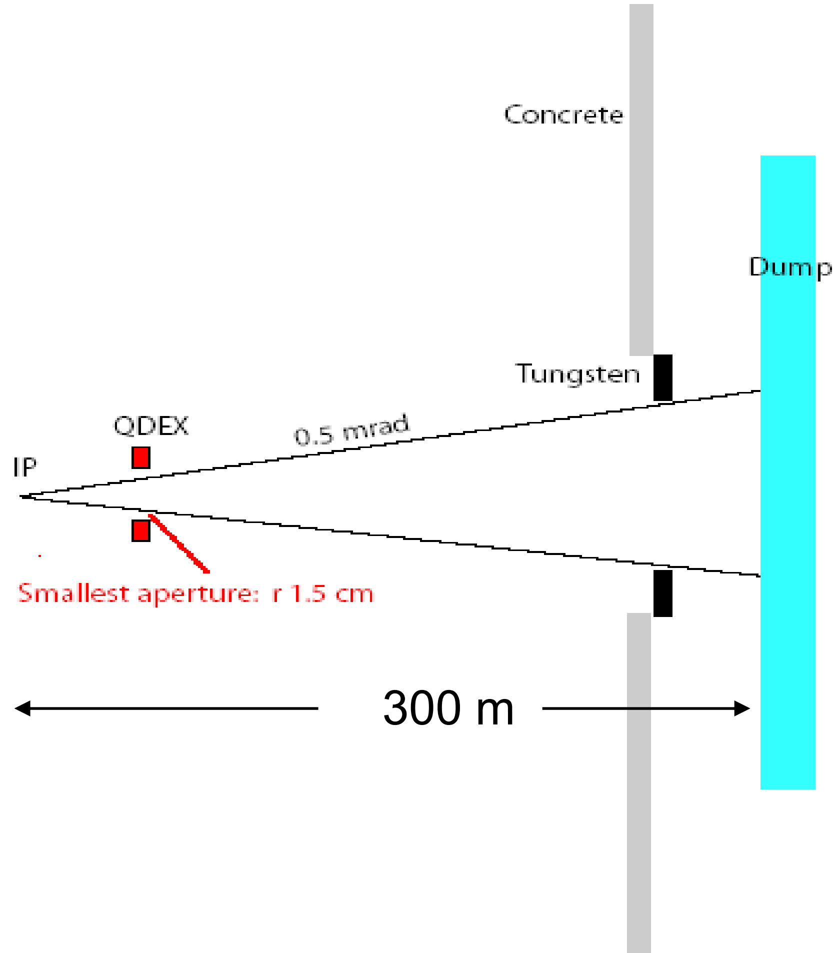
Brute force simulation takes forever

- Neutrons coming out of the dump:

  0.016 n's / 250 GeV e-

  3.2×10^{8} n's / BX

  1.3×10^{20} n's / year
- Solid angle of the smallest aperture: 10^{-9}
- If we want ~10 n's reaching the IP, we need 10^{10} n's at the dump and 6×10^{11} 250 GeV e-.
- 250 GeV e- full simulation takes ~10 sec.
- Use FLUKA's biasing techniques
- Calculate the IP fluence averaging over 2 m radius.



Particle Biasing

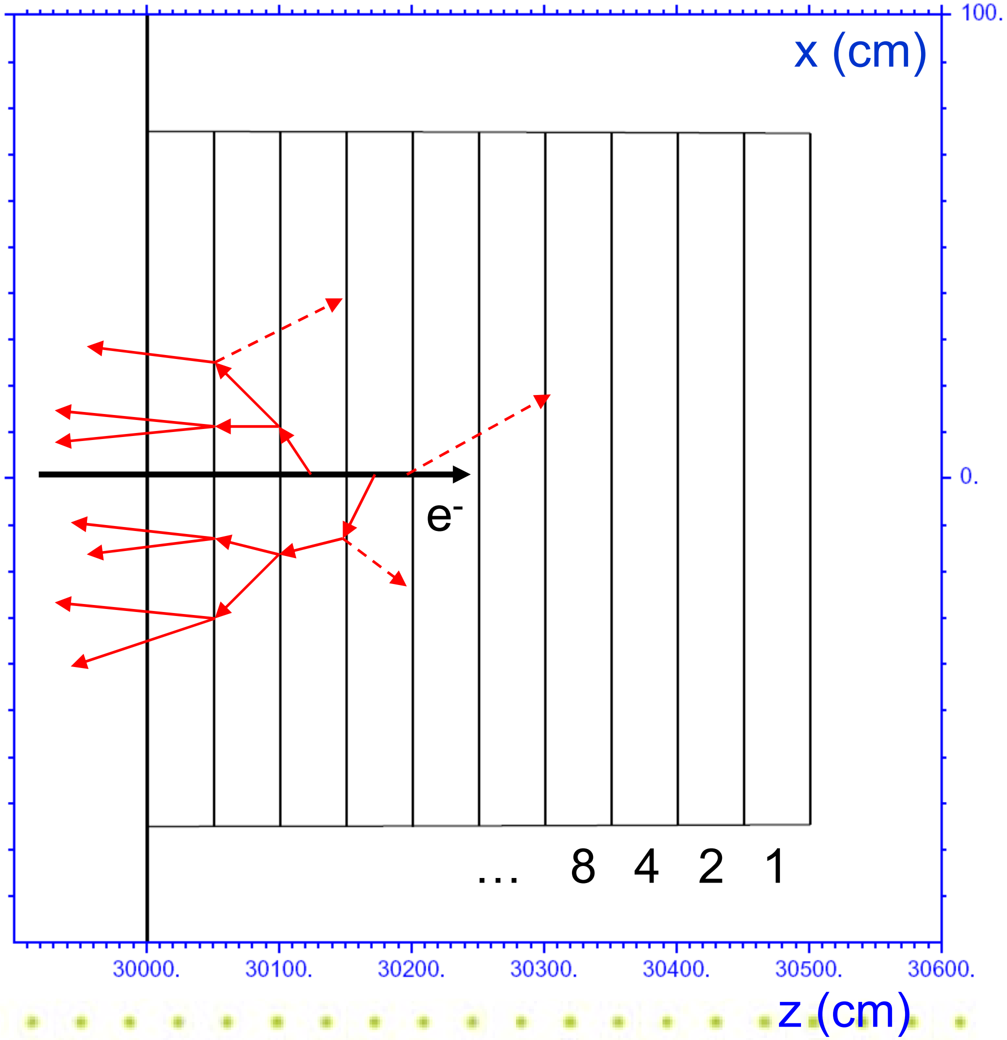
- Three types of biasing were used:
  1. Leading particle biasing
     - simulating a full EM shower requires long CPU time
     - to save time, take only the most energetic secondary and adjust the particle weight
     - applied to e^+,e^-, and γ's < 2.5 GeV
  2. Photonuclear interaction length

     $\gamma A \rightarrow n + X \qquad (\sigma, \ell)$

     - #n produced proportional to $\ell\sigma$
     - σ was increased by a factor of 50
     - 'weight' associated with each n produced from this was decreased by a factor of 50 to compensate

Particle Biasing (continued)

3. Splitting/Russian roulette
   - Dump divided into 10 regions
   - Each region given a factor of 2 larger importance
   - As e^+, e^-, or γ crosses a boundary, their number is increased or decreased on average by the ratio of importances on either side of the boundary
   - 'weight' is adjusted accordingly



Computation Time

6000 incident e^-			n total 'weight'		n total number	
Run #	Type of Bias	CPU time	At z=300m	At z=0*	At z=300m	At z=0*
1	None	23 h 35 min	82	2	82	2
2	LPB	1 h 36 min	102.9	0	87	0
3	Interaction length	6 h 46 min	103.4	0.78	5008	49
4	Splitting/RR	6 h 22 min	96.4	1.09	16619	117

* IP scoring plane with 20 m radius

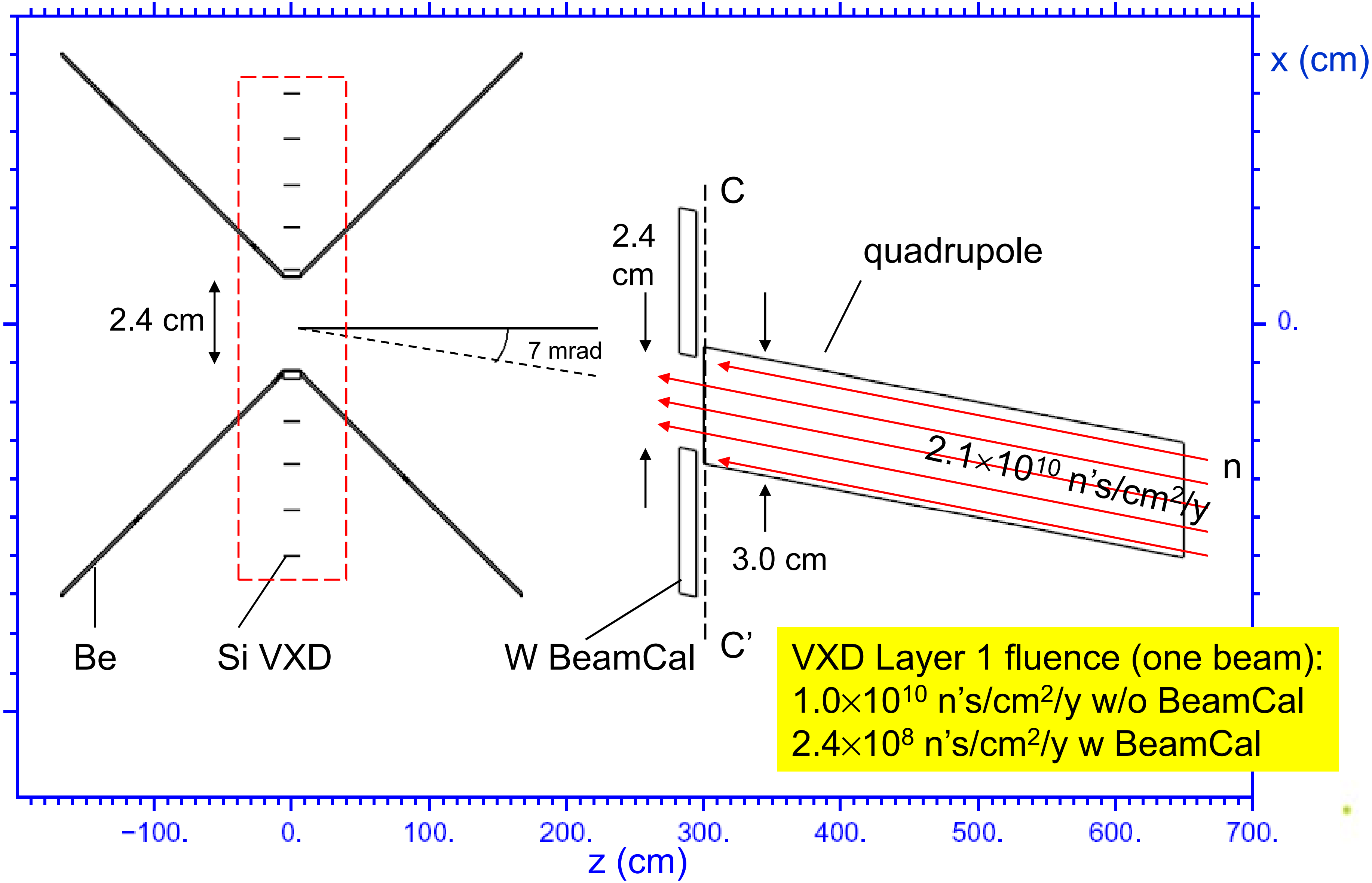
Neutron Fluence at IP

	n's/cm^2/year at IP (z=0)	
	Mean (10 runs)	RMS
No tunnel or collimator	4.8×10^{10}	0.9×10^{10}
Tunnel and Collimator	2.1×10^{10}	1.3×10^{10}

10^{10} n/cm^2 at the VXD would cause displacement damage to CCD Si detectors

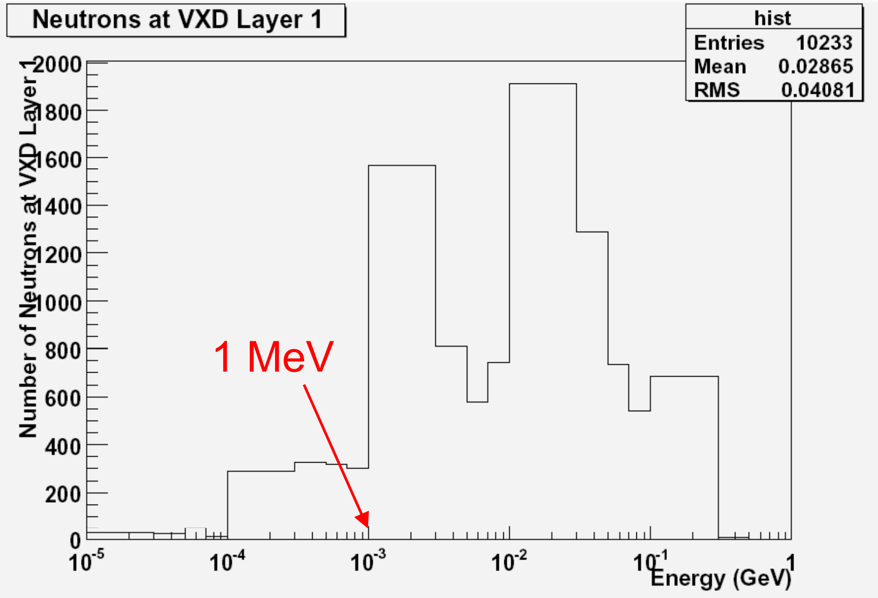
However, not all neutrons that reach the IP will hit the inner detector

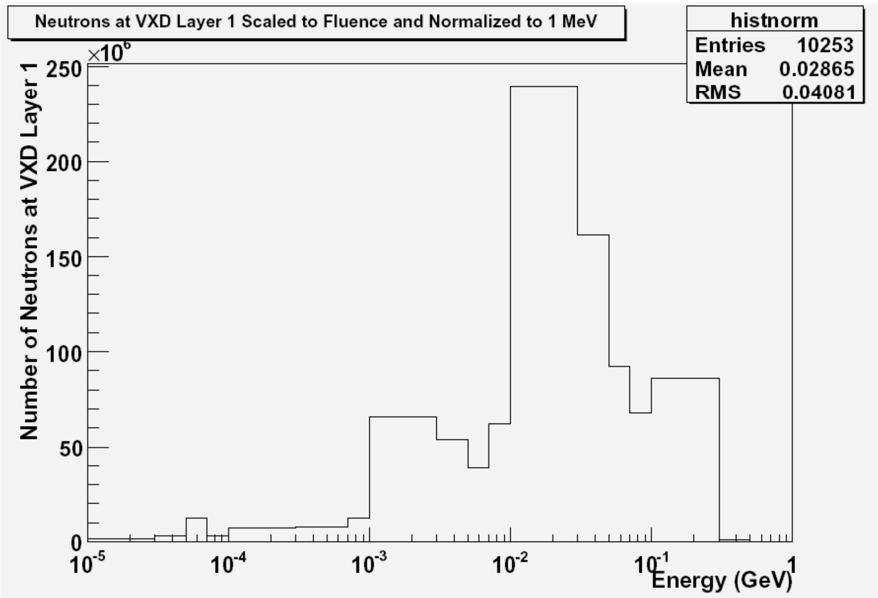
SiD Vertex Detector



VXD Layer 1 fluence (one beam):
1.0×10^{10} n's/cm^2/y w/o BeamCal
2.4×10^{8} n's/cm^2/y w BeamCal

1 MeV Neutron Equivalent Fluence





- However, the amount of displacement damage done to CCD Si detector by neutrons is a function of neutron energy
- When relative damage to Si is considered, normalized to 1 MeV, the fluence is: 5.3×10^8 n/cm^2/year
- When e$^+$ beam is considered also, value is doubled to 1.1×10^9 n/cm^2/year
- A value of 10^{10} n/cm^2 would damage the CCD Si detector by this measure

WHITE SANDS FAST BURST REACTOR

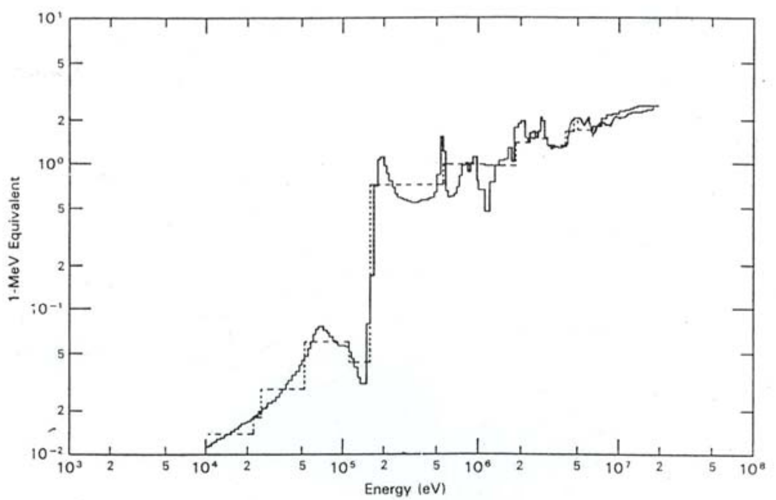
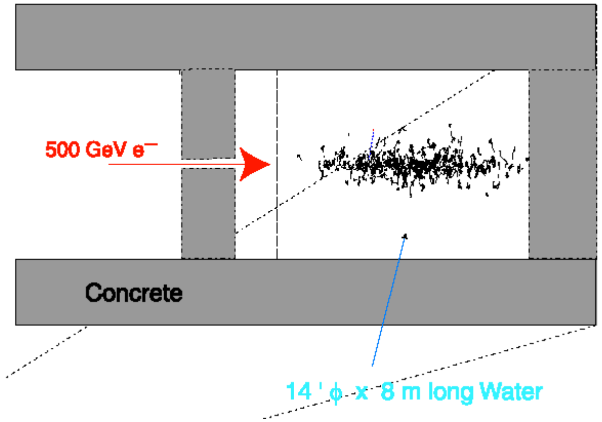


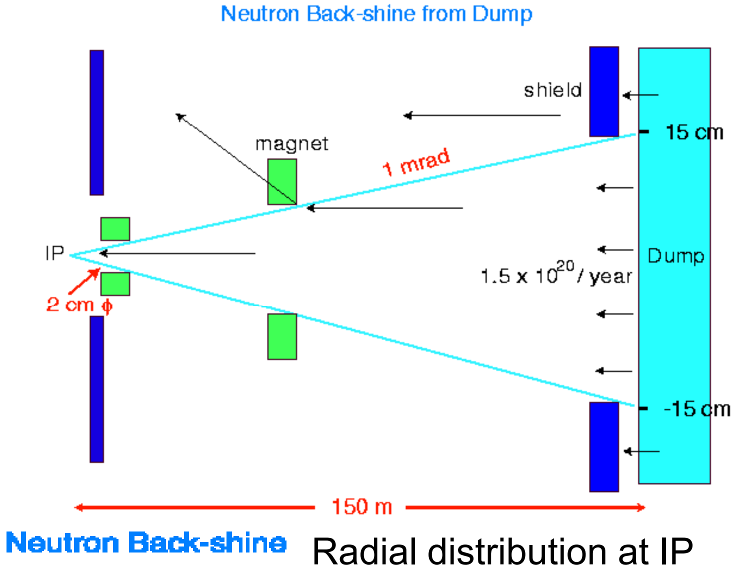
Fig. 3. Silicon displacement kerma as a function of energy. The fine-group histogram is the tabulated kerma values from Ref. 13. The broader group histogram is the function used in this work.

T. M. Flanders and M. H. Sparks, *Nuclear Science and Engineering*, 103, 265, 1989.

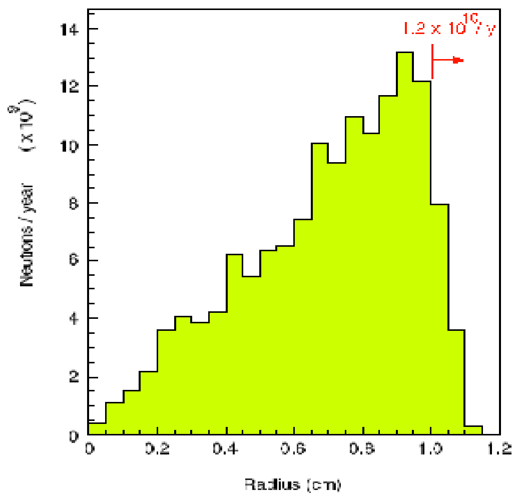
Is the neutron fluence gone up?

NLC day estimation





Radial distribution at IP



Neutron fluence at IP: 4.6×10^{10} n's/cm^2/y (same)

Neutrons at VXD layer 1@1.2 cm:
2×10^{8} n's/cm^2/y (two dumps)
This fluence was smaller due to the smaller aperture.

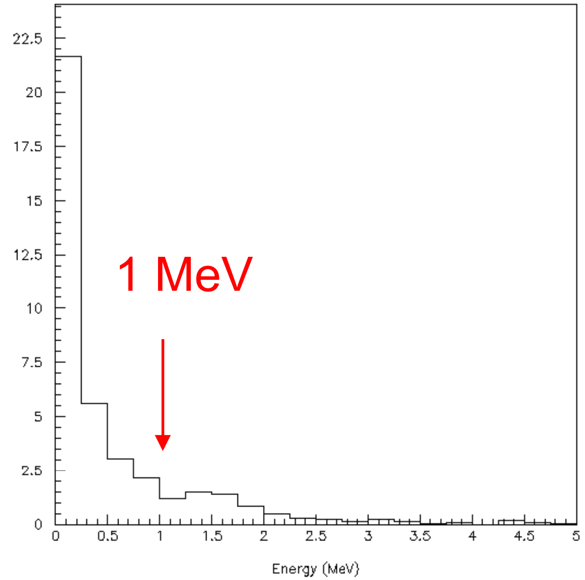
1-MeV equivalent fluence was never calculated.

Neutrons from Pairs

ILC 500 GeV Nominal

	n's/cm²/year	1-MeV eq. fluence, n's/cm²/y
DID	1.7×10^9	6.8×10^8
No DID	1.5×10^9	5.9×10^8
Anti-DID	1.0×10^9	4.1×10^8

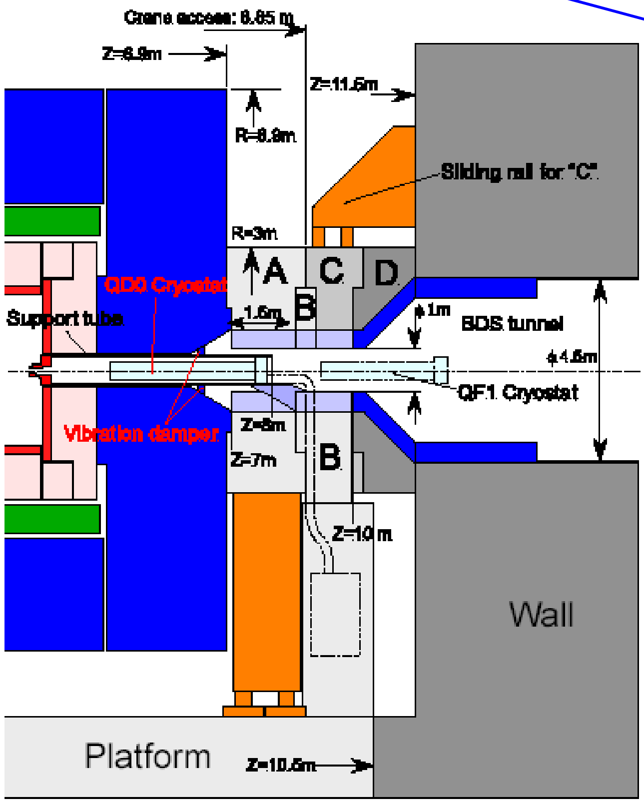
Neutron energy spectrum



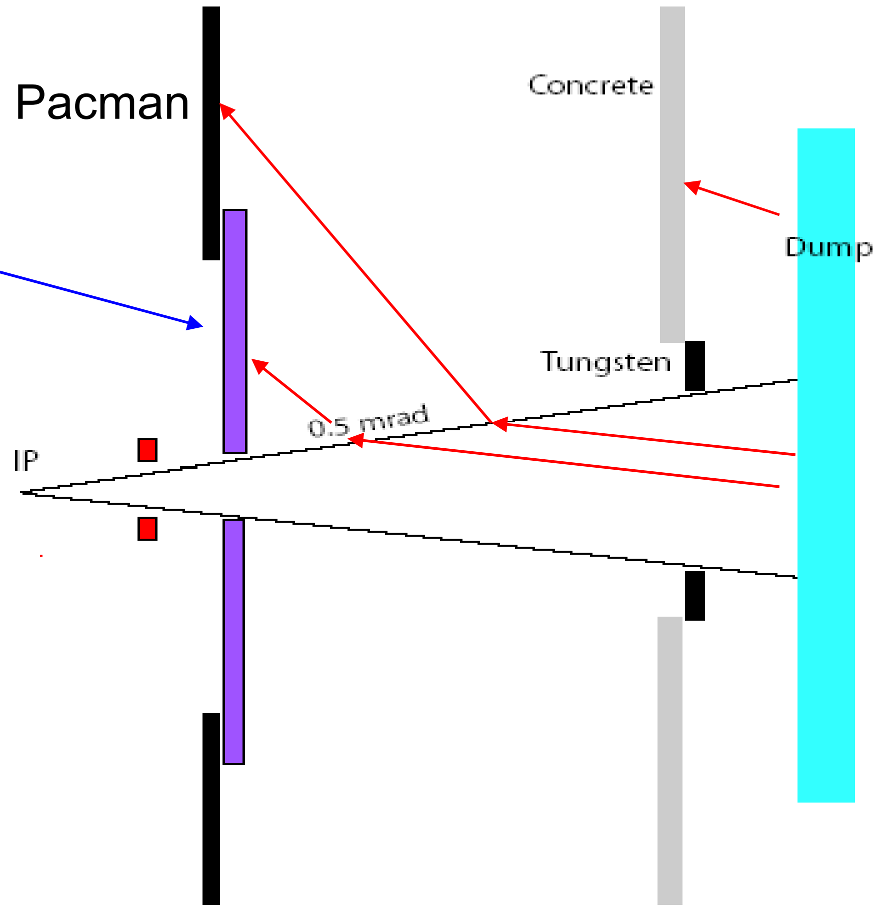
1-MeV equivalent neutron fluence from Pairs comes down.

Detector Shield

Pacman is a good shield.
But Pacman has 1 m$^{\phi}$ hole.
neutrons into this hole
is 1.3×10^{15} n's/ year.
Need additional shield.



Tauchi



Photons from the dump

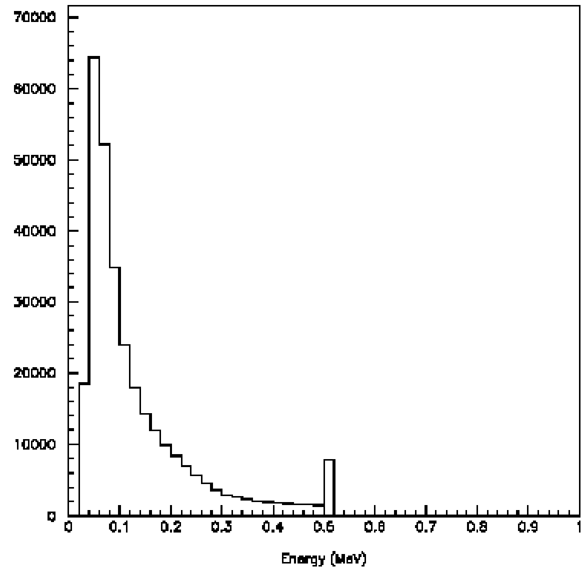
Photons coming out of the dump:

2.0 photons / 250 GeV e-

Photon fluence at the IP:

	Photons/cm^2/BX at IP (z=0) (one dump)
No tunnel or collimator	30.
Tunnel and Collimator	13.

Energy spectrum



Photons from the dump are negligible compared to photons from the pairs.

Conclusions

- 1-MeV neutron equivalent fluence from the beam dump is estimated to be 1.1×10^{9} n's/cm^2/year at the SiD VXD detector.
- Including the pair neutrons, the total 1-MeV neutron equivalent fluence is 2×10^{9} n's/cm^2/year.
- Photon backscattering from the dump is negligible.