LC Background Requirements

- Introduction: background sources @ the LC IP
- Detector tolerance levels
  - naive detector model
  - pain-threshold ‘guesstimates’
- ‘Some’ open issues
  - are the advertised tolerance levels reasonable? consistent?
  - muons
  - lost particles
  - synchrotron radiation
- Conclusions

W. Kozanecki, CEA-Saclay

Beam-Beam Interaction at the LC IP

Beams attracted to each other reduce effective spot size and increase luminosity

- $H_D \sim 1.4 - 2.1$

Pinch makes beamstrahlung photons:

- 0.9-1.6 γ/e^- with $E_\gamma \sim$ 3-9 % E_{beam}
- Photons go straight to the dump & are not a background source (at least by themselves)

Particles that lose a photon are off-energy

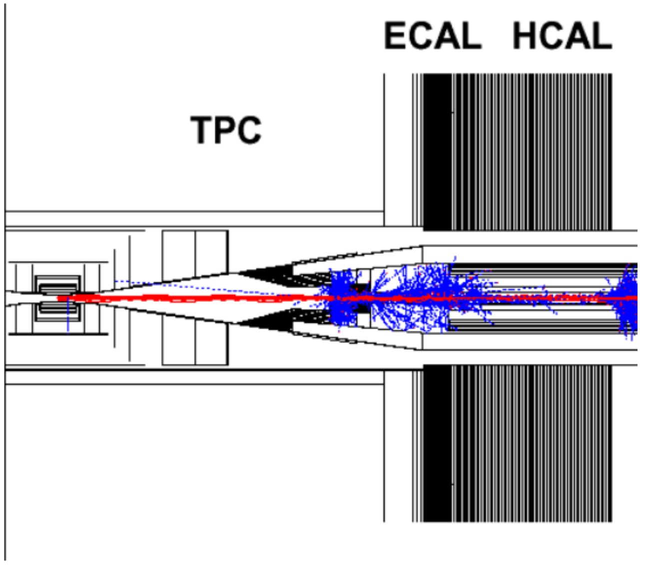
- Physics problem: luminosity spectrum
- Extraction line problem:
  - NLC 1 TeV design has 77 kW of beam with $E < E_{nom}/2 \Rightarrow$ 4kW lost (0.25% loss)

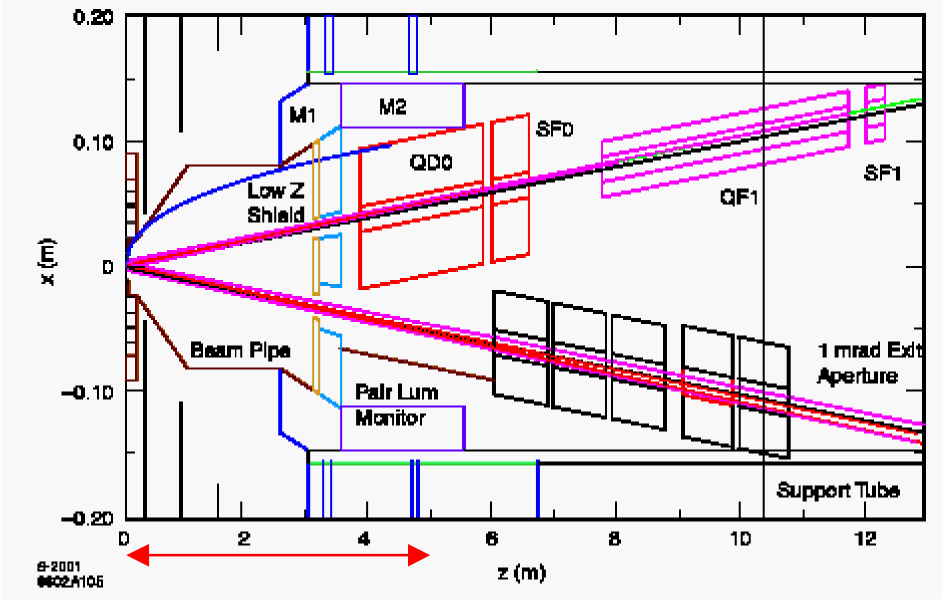
Photons interact with opposing e, γ to produce e^+e^- pairs and hadrons

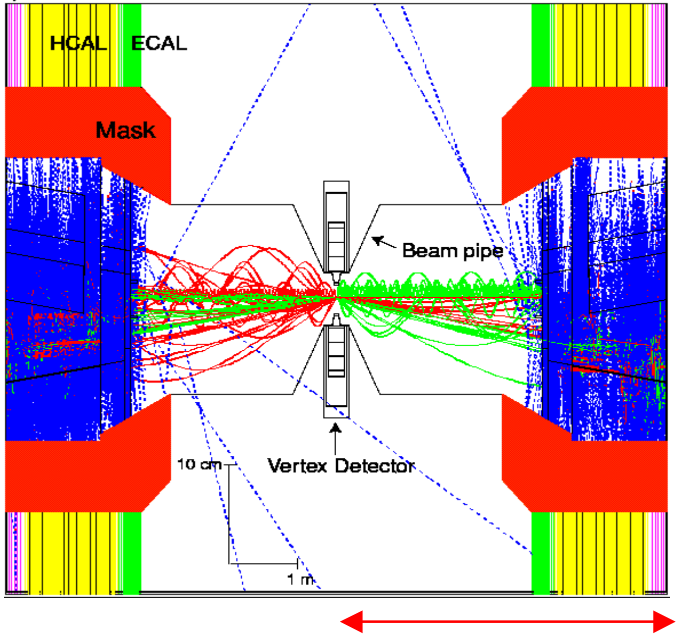
Background Sources

IP Backgrounds

- **Beam-Beam Interaction**
  - Disrupted primary beam
    - Extraction Line Losses
  - Beamstrahlung photons
  - e^+e^- pairs from beamstr., $\gamma\gamma$ interactions
  - $h^\pm$/n from beamstr., $\gamma\gamma$ interactions
- **Radiative Bhabhas ($e^+e^- \rightarrow e^+e^- \gamma$)**







Background Sources

IP Backgrounds

- **Beam-Beam Interaction**
  - Disrupted primary beam
    - Extraction Line Losses
  - Beamstrahlung photons
  - e^+e^- pairs from beamstr., γγ interactions
  - $h^{\pm}/n$ from beamstr., γγ interactions
- **Radiative Bhabhas ($e^+e^- \rightarrow e^+e^- \gamma$)**

Have been studied to death

Scale with luminosity

1. ***Transport them away from IP***
2. ***Shield sensitive detectors***
3. ***Exploit detector timing***

Machine Backgrounds

- **Muon production at collimators**
- **Direct Beam Loss ($e^{\pm}$ halo) near IP**
- **Synchrotron Radiation**
- **Collimator edge scattering**
- Beam-Gas
- Neutrons from dumps/extrct'n line

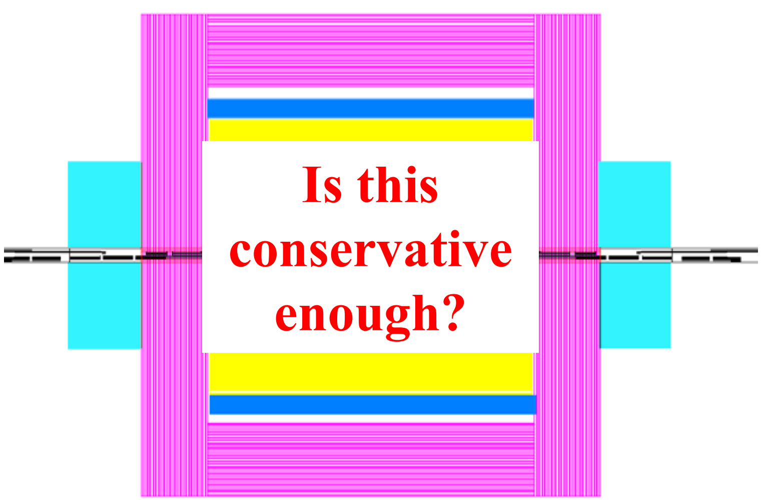
Our topic today

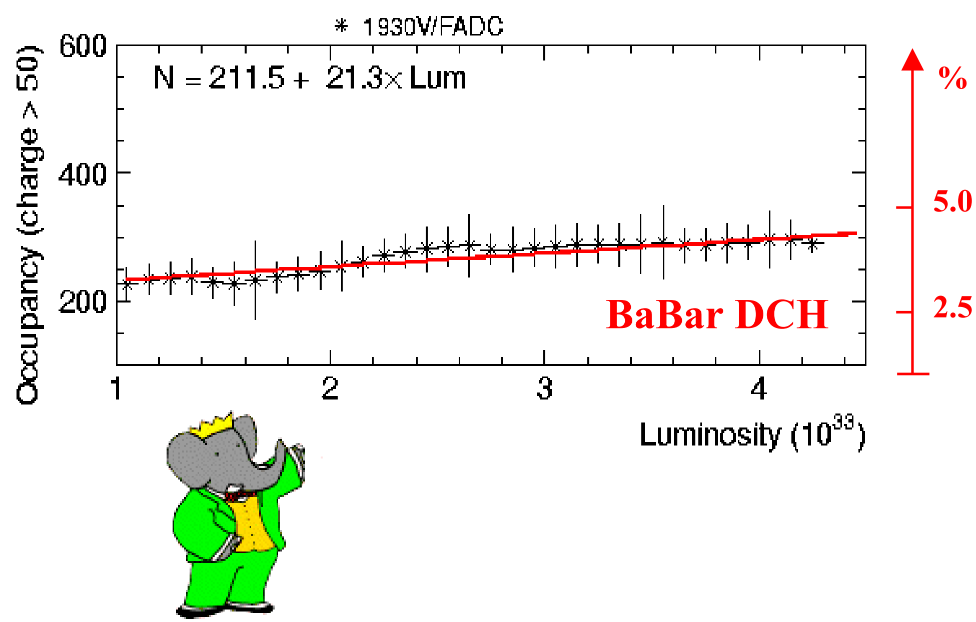
1. ***Don't make them***
2. ***Keep them from IP if you do***

A (very) naive detector-tolerance model

Subdetector	Tolerance criterion
Vertex detector	Rad. damage (worst-case: CCD's) : < 3 10^9 n cm^{-2} Occupancy: < 1% (hit density)
Time Projection Chamber	Occupancy: < 1% (hit density)
Calorimeter	'Occupancy': < 1% (MIPs), or about < 100 GeV
Muon system	< 1 per m^2

Generic LC detector





Detector-response model (*)

(*) As per R. Settles et. al., TESLA St Malo workshop

Subdetector	Granularity	Sensitivity window	Fract'l sensitivity
Vertex detector (Layer 1)	20 μ x 20 μ pixels = 2500 pixels/mm^2	50 μs (1 NLC train / 150 TESLA bunches)	Chgd trks: ε = 1.0 (4 pixels) γ: ε = 0.02 (4 pixels)
TPC	1.5 10^6 pads x 10^3 time buckets = 1.5 10^9 voxels		Chgd trks: ε = 1.0 (3 p x 200 r x 10 tb) γ: ε = 0.02 (3 p x 200 tb) n: ε = 0.01 (3 p x 200 tb) μ: ε = 1.0 (6 p x 1000 tb)
Calorimeter (excluding LAT/LCAL)	44,000 cells	~ 200 ns (or less?) (1 NLC train / 1 TESLA bunch)	E > 1 MIP (~ 250 MeV) Chgd trks: 1 MIP μ: 100 cells
Muon system	~ 1 cm x 5 m $\perp$ beam axis	1 NLC train / 1 TESLA bunch ?	Chgd trks: ε = 1.0

Background tolerance levels (*)

(*) *As per R. Settles et. al., TESLA St Malo workshop*

Unless otherwise stated, limits are expressed in # particles per sensitivity window (SW) (typically 150 bunches for TESLA, 1 train for NLC in VDET/TPC)

Subdetector	Chrgd tks	γ	n (~ 1 MeV)	μ	E
Vertex detector L1	6 mm^{-2}	300 mm^{-2}	3 10^7 mm^{-2}	-	-
TPC	2500 (!?)	1.25 10^6 a)	2.5 10^7	2500 (?)	-
Calorimeter	-	~ 40000 (E_γ~2.5 MeV)	-	1% $\Rightarrow$ 4μ [x10 b)]	400 MIPs (100 GeV?)
Muon system	leaking jets?	not an issue? c)	not an issue? c)	1 m^{-2}	leaking jets?

a) NLC uses ~ 10^5 γ / train as a typical upper limit
b) if the μ E deposition can be identified & subtracted in software
c) Tunnel shine can presumably be shielded out with a sufficiently massive concrete plug

Important notes

1. No generic answers – **depend strongly on subdetector technology**
2. Only guesstimates so far. Real answer **needs detailed simulations**, pattern recognition studies, understanding of background distribution....
3. 1% may sound overconservative...but we **need ~ x 10 safety** factor!

Background tolerance levels: collimation-related requirements

Subdetector	Chrgd tks	γ	n (~ 1 MeV)	μ	E
Vertex detector L1	6 mm^{-2}	300 mm^{-2}	*not a collimation issue*	-	-
TPC	2500	$1.25\ 10^6$	*not a collimation issue*	2500	-
Calorimeter	-	~ 40000 (E_γ~2.5 MeV)	-	4 (40?)	*not a collimation issue*
Muon system	*not a collimation issue*	-	-	1 m^{-2}	*not a collimation issue*

'Typical' requirements

- primary collimation efficiency must be good enough so that # μ's from secondary collimation system / FFS 'not dominant'
- no synchrotron-radiation (SR) photon hits beam tube /mask/SVT 'near IP'
- no (< 1) high-energy $e^{\pm}$ hits beam tube /mask/SVT 'near IP' (i.e. within the Final Doublet - or closer)

Some ‘personal worries’

- The ‘typical requirements’ above are
  - based on experience....

‘At SLD/SLC SR WAS a (THE?) PROBLEM’ ***(TWM et. al.)***

- SR from triplet WOULD have directly hit beam-pipe and VXD
- Conical masks were installed to shadow the beam pipe inner radius and geometry set so that photons needed a minimum of TWO bounces to hit a detector
- Quantitative measurements of background rates could be fit by a “flat halo” model where it was assumed that between 0.1% and 1% (in the early days) of the beam filled the phase space allowed by the collimator setting.

  - but somewhat arbitrary, and not yet supported by quantitative detector studies (to my knowledge)
- It is important for the LC detector community to put them on a more robust basis. In addition, I would like to suggest a few ‘sanity checks’...

Open issues & 'sanity checks'

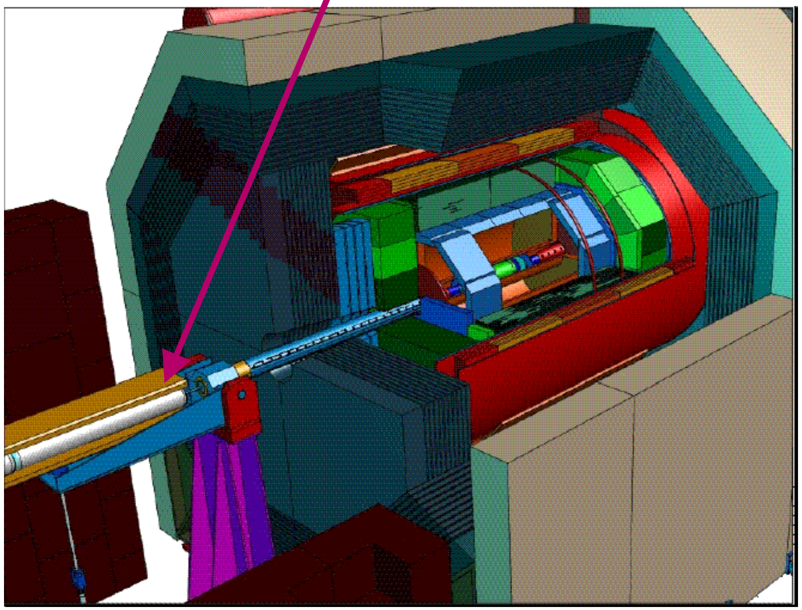
- **Muons**
  - Comparisons of muon yields (# $e^{\pm}$ lost / μ @ IP) at low & high c.m. energy (500 GeV vs. 800, 1000 or 3000 Gev) appear inconsistent across LC designs
  - Secondary $e^{\pm}$ energy cutoff (> 50 GeV in A. Drozhdin's code) may be too high to realistically model 'harmful' μ production
  - tunnel modelling (wrt μ transport): a huge job by itself....

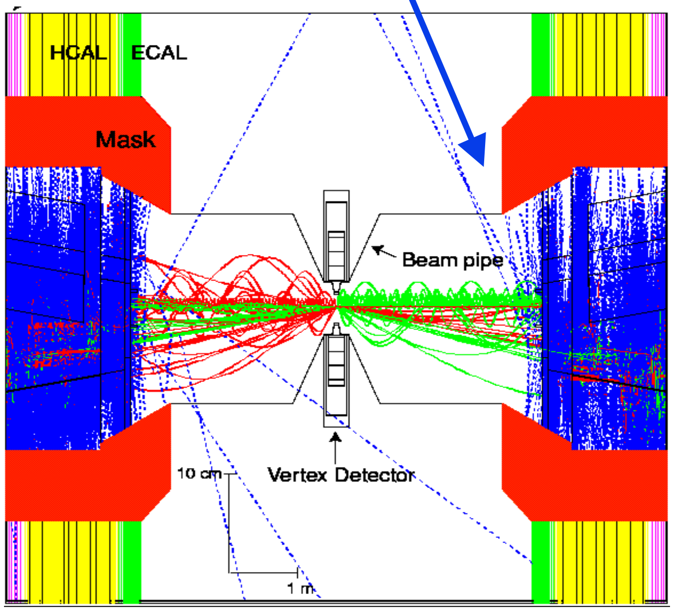
- **Electromagnetic debris: production & transport**
  - Is the showering in 'thin' machine elements (vacuum pipe, magnets) modelled with enough realism to be sure we are not overlooking potential problems?
  - High energy $e^{\pm}$ losses 'near' the IP:
    - what is reasonable tolerance level (TWM: 'a few ten per train"?)
    - how near is 'near' ?

    See more recent results in T. Markiewicz's talk later today

How far upstream of the IP do electromagnetic debris matter ?

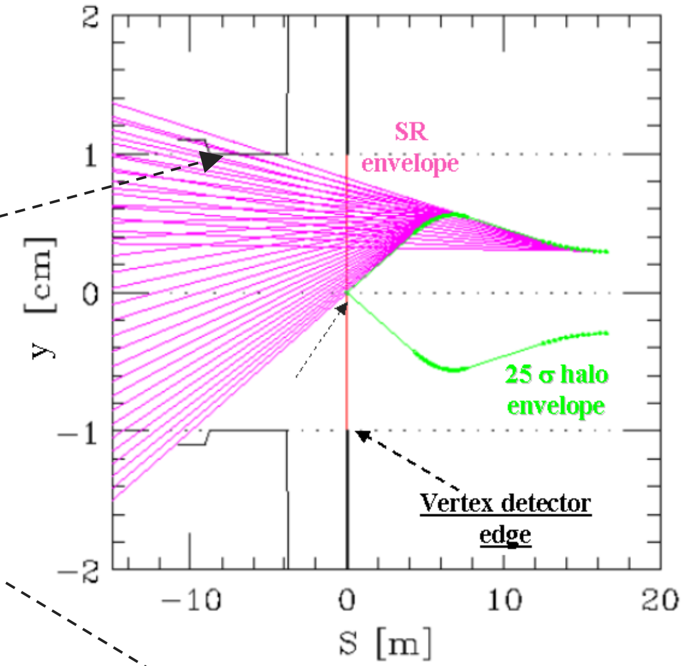
Can showers produced by full-energy e± 10-20 m from the IP on the *__incoming__* *__beam__* *side cause substantial backgrounds, in view of ?*

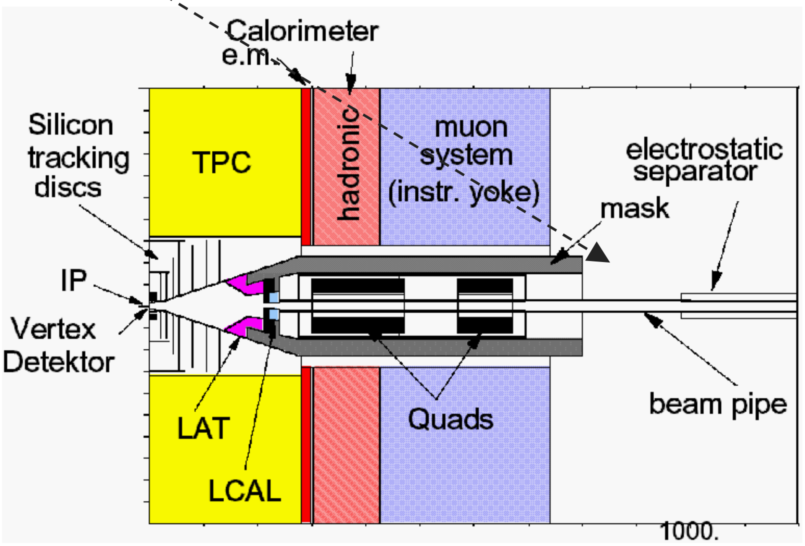




Open issues & ‘sanity checks’

- **Synchrotron radiation**
  - **Concerns**
    - **backscattering** from downstream aperture limitations
    - **edge- & tip-** scattering from upstream SR masks
    - impact of a **partially-shared beam line** on SR masking?
      - compatibility of stay-clear apertures (spent beam, pairs, beamstrahlung γ) with effective masking of incoming SR
    - any hidden alligators?
      - **consistency checks** between **independent** calculations **important** (e.g. TESLA TDR vs. A. Drozhdin’s results)

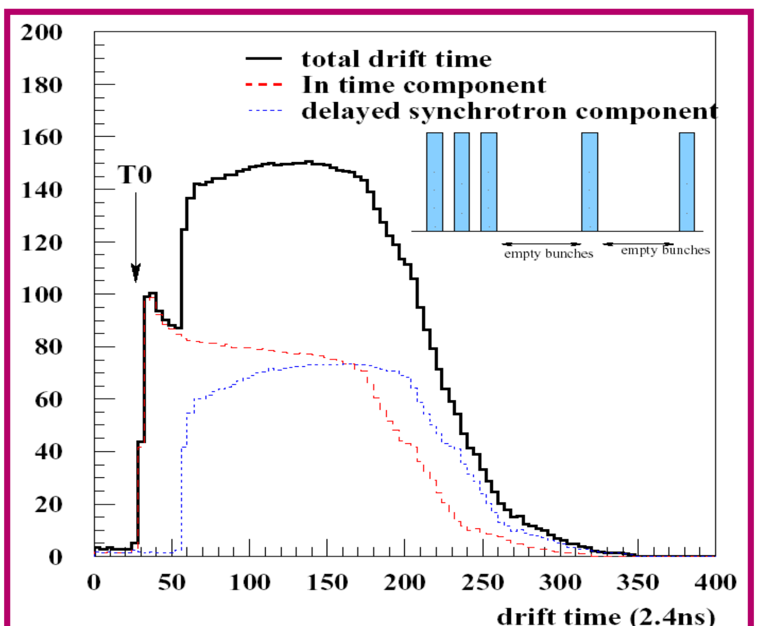




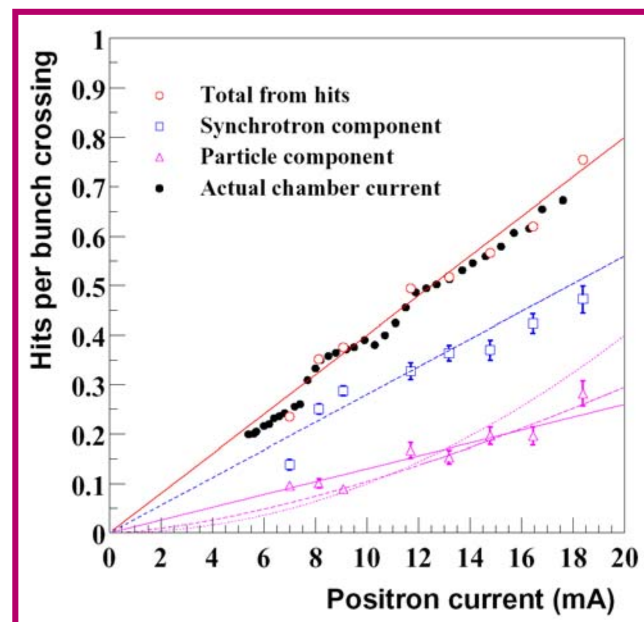
❍ Synchrotron radiation *(continued)*

◎ Lessons from existing detectors

- BaBar design: SR background dominated by tip-scattering
- BELLE: 'fried' their first VDET by a combination of
  - improperly masked incoming-beam SR (very soft X-rays from XYCORs)
  - hard SR backscattered from the first beam-pipe wall on outgoing side
- Zeus + H1: SR – much of it backscattered – absorbs a large fraction of their 'background budget'



Zeus CTD



Conclusions

- **Detector tolerance levels:**
  - well-understood & under control for beam-beam sources
  - still at the level of 'guesstimates' for incoming-beam backgrounds
    - detailed 'physics-performance' simulations are required to quantify what is acceptable
    - the '1 % occupancy limit' is probably adequate, at this stage, in most cases
- **Some open issues**
  - μ tolerance criteria need to be consolidated
  - how do we quantify the impact of incident high-energy $e^{\pm}$ losses inboard of the FD entrance?
  - back- & edge- scattering of SR photons
    - are known to be a (serious) problem in (some) existing detectors
    - need to be modeled promptly, so we can
      - develop effective masking schemes
      - avoid overconstraining the collimation-system design

Acknowledgements

- *'Somebody' twisted my arm to give this talk, in spite of my attempt at passing it on to a more competent 'victim'...*
- *There are people in this room who have worked on backgrounds at a future LC quite a bit more than I have*
- *A lot of the material in this talk (whether conceptual or graphical) was originally produced by*
  - **Tom Markiewicz (as well as some of his NLC colleagues)**
  - **Ron Settles (as well as some other conveners of the TESLA detector study groups)**