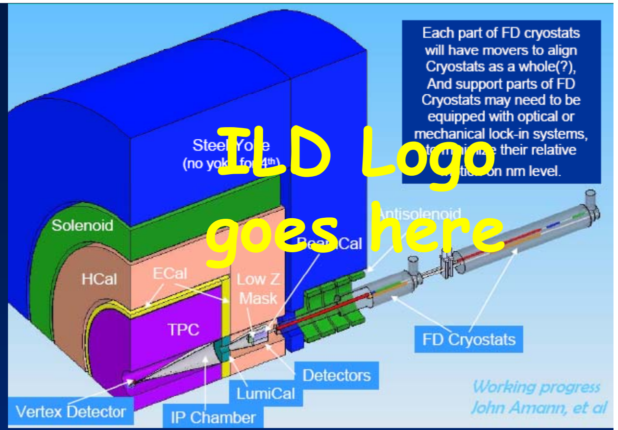
Worldwide Study of the Physics and Detectors for Future Linear $e^+ e^-$ Colliders



'Private' ILD-MDI meeting at LCWS2008

LC-TPC

Ron Settles MPI-Munich
MDI Questions for the TPC

Cables

LCTPC engineering model for LOI

- Size, weight, support, dead areas

2) Endplate thickness:

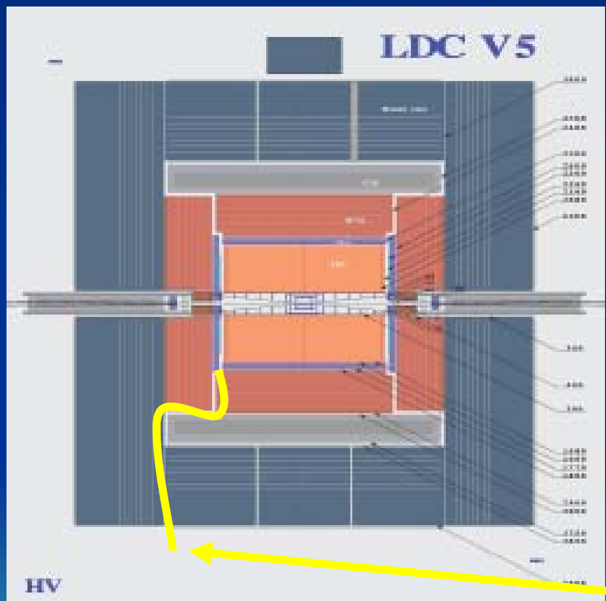
Proposal 2) on Endplate thickness:

=>X_{tpcendplate}/X_0 = 0.15

New Mokka list (** mark changes wrt old list):

dz (mm)	material	% X_0	
0.003	copper	0.02	gating
0.03	kapton	0.01	
0.003	copper	0.02	
1.964	TPC_gas	0.002	
0.003	copper	0.02	mpgd
0.03	kapton	0.01	
0.003	copper	0.02	
1.964	TPC_gas	0.002	
0.003	copper	0.02	mpgd
0.03	kapton	0.01	
0.003	copper	0.02	
3.964	TPC_gas	0.004	
0.05	copper	0.35	pads
2	g10	1.03	
0.5	silicon_2.33gccm	0.53	ROelectr
2	epoxy,etc	1.932	
1	kapton	0.35	
**2	aluminium	2.24	cooling
1	kapton	0.35	
**3	carbonfibre	1.59	stiffness
80.45	Air(0.85)+G10(0.15)	0.02 +6.22	air+ g10 space/ROboards
summa (new model)			
100mm		14.77 %X_0	

- Dead areas:
  - 10 cm in z at each endcap for "standard" electronics/cables (may be increased later)



- Space needed for φ ~ 1cm^2-cables here
  ~10^3 cables/side ⇒ **0.1m^2 cables/side**

How much bigger is the gap to allow mounting/dismounting??

Backgrounds

Status of ILD Detector MDI work

T. Tauchi,

LCWS2008, UIC, Chicago, 17 November 2008

Background - IR

es in Detectors

Sources :	pairs	disrupted beams/pairs	beam halo
Detector	Hits	Neutrons	Muons
VTX	1×10^4 hits/cm^2/train	1×10^{10} n/cm^2/year	-
TPC	4.92×10^5 hits/50μsec	4×10^4 n*/50μsec	$1.2 \times 10^3 \mu$/50μsec
CAL	1×10^{-4} hits/cm^3/100nsec	-	0.03 μ/m^2/100nsec

* : The neutron conversion efficiency is assumed to be 100% in the TPC.

1 hit in TPC consists of 5 pads(1mmx6mm) x 5 buckets(50nsec)

A muon creates 1 pad x 2000 buckets in parallel to the beam line.

A neutron creates 10 hits in TPC.

Above numbers shall be re-evaluated by ILD sub-detectors. Machine parameters : nominal and low-P as well.

Detailed studies by A. Vogel and Japanese colleagues

Let's check in ILD, too.

Neutrons

① Ron Settles 12.4.02

"Backgrounds-in-the detector" - Discussion

INTRODUCTION

- ILC-TRC (Loew panel) Report
  - compare energy & luminosity perf. of machine options Tesla, JLC, NLC, Clic
  - MDI wg → backgrounds big issue
    → machine phys. working hard on it (e.g. Table 7.1.6 in TDR)

② Ron Settles 12.04.02

(2) LOP "Limit of pain"

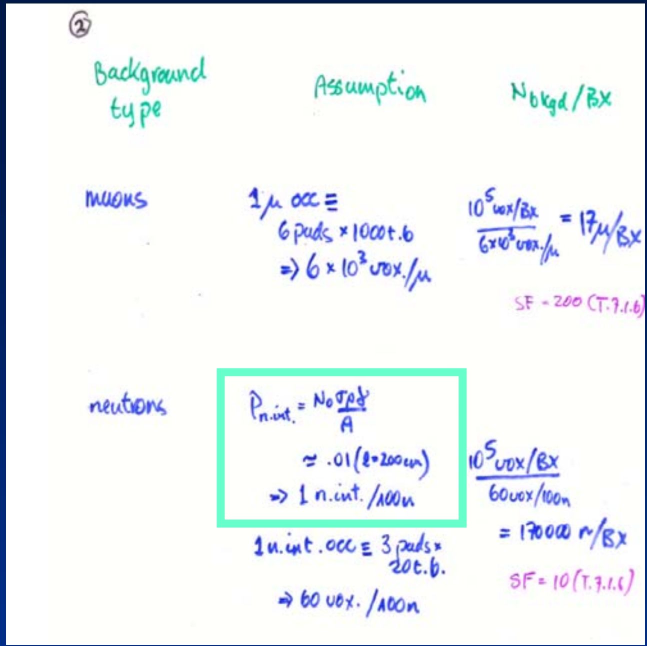
Background giving 1% occupancy

i.e. $\text{bkgd}/\Delta t_{s.d.} = \text{bkgd}/\text{BX} \cdot \text{No. BX}/\Delta t_{s.d.} = 1\%$

TPC

- Granularity/Size
  - 1.5×10^6 pads (2mm×6mm)
  - 1.5×10^9 voxels (1000 timebuckets)
  - $\phi_i \sim 330$ mm
  - $\phi_o \sim 1650$ mm
  - $L \sim 2 \times 2500$ mm
- Gas
  - Ar 5% CH_4 , $\sigma_n \simeq 18$ bn
  - $v_{drift} \sim 50\,mm/\mu s = 50\,\mu m/ns$
  - $\Delta t_{TPC} \sim 50\,\mu s \Rightarrow 150\ \text{BX}/\Delta t_{TPC}$
  - 1 timebucket (t.b.) = 50 ns = 2.5 mm
- 1% occ = $0.01 \times 1.5 \cdot 10^9 / 150$ BX

  ⇒ 10^5 voxels/BX may be occupied by background



…should be 1%?

Background - IR

Tolerances in Detectors

Sources :	pairs	disrupted beams/pairs	beam halo
Detector	Hits	Neutrons	Muons
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Detailed studies by A. Vogel and Japanese colleagues
Let's check in ILD, too.

Geant4 Simulations of Machine-Induced Background in a TPC

Primary Charges and Occupancies

Adrian Vogel
DESY FLC

LCWS, Hamburg, 2007-06-02

Particles in the TPC

- Particles entering the TPC (per BX)

	BERT	20% CH_4	BIC
Neutrons	142 ± 20	146 ± 25	138 ± 22
Photons	947 ± 57	955 ± 44	952 ± 49
Electrons	6 ± 13	6 ± 12	8 ± 13

- Particles created in the TPC (per BX)

	BERT	20% CH_4	BIC
Electrons	292 ± 130	303 ± 121	326 ± 149
Protons	2 ± 2	9 ± 4	2 ± 1

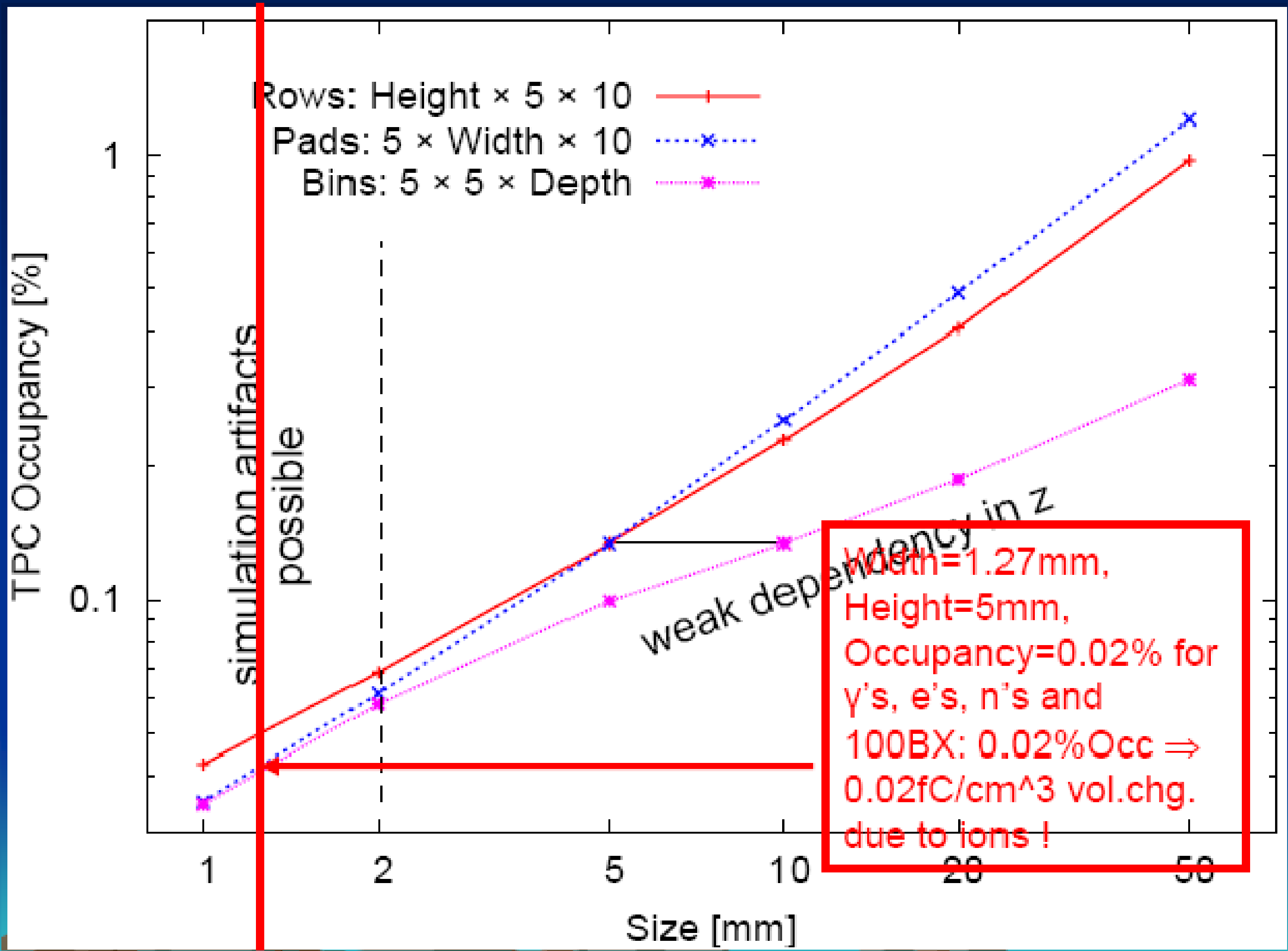
- Influence of neutrons is visible, but negligible

Adrian Vogel LCWS, Hamburg, 2007-06-02 17

Space Charge

2. LCTPC sensitivity to backgrounds

See talk#3 in opening session at Cambridge by Adrian Vogel:



Ion build-up

Three sources of space charge are (a) ion build-up at the readout plane, (b) ion build-up in the drift volume and (c) ion backdrift, when ions created in the gas amplification drift back into the TPC volume.

(a) Ion Build-up at the readout plane.

At the surface of the gas-amplification plane during the bunch train of about 3000 bunch crossings spanning 1 ms, there will be few-mm thick layer of positive ions built up due to the incoming charge, subsequent gas amplification and ion backflow. An important property of MPGDs is that they suppress naturally the backflow of ions produced in the amplification stage. Steps to minimize this backflow are described in Sec. 5.6, where a suppression to 0.25% is shown to be achievable. Thus this layer of ions will reach a density of a few tens of fC/cm^3, depending on gas gain and the background conditions during operation. Its effect will be simulated, but intuitively it should affect coordinate measurement only by a small amount since the drifting electrons incoming to the anode experience this environment during only the last few mm of drift. The TPC must plan to run with the lowest possible gas gain, meaning $\sim 1\text{–}2 \times 10^3$, in order to minimize this effect.

(b) Ion build-up in the drift volume.

In the drift volume, an irreducible positive-ion density due to the primary ionization will be collected during about 1s (the time it takes for an ion to drift the full length of the TPC). The positive-ion density will be higher near the cathode and will be a few fC/cm^3 at the estimated occupancy of $\sim$ 0.5%. The effect of the charge density will be established by our R&D program, but the experience of the STAR TPC[20] indicates that 200 fC/cm^3 is tolerable (Sec. 3.7(b)) and a few fC/cm^3 is well below this limit.

(c) Ion backdrift and gating.

Ion backdrift, gating

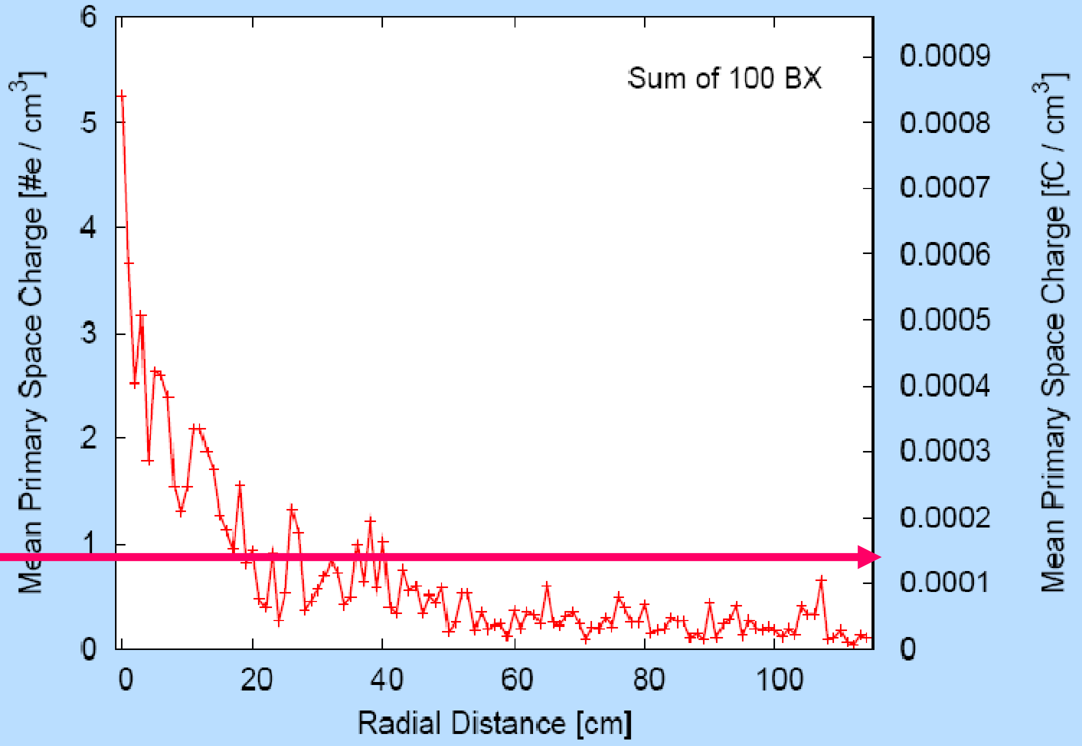
tolerable (Sec. 3.7(b)) and a few fC/cm^3 is well below this limit.

(c) Ion backdrift and gating.

The operational conditions at the linear collider – long bunch trains, high physics rate – require an open-gate operation without the possibility of intra-train gating between bunch-crossings should the delivered luminosity be optimally utilized. As already mentioned, MPGDs lend themselves naturally to the intra-train un-gated operation at the ILC since they can operate with a significant suppression of the back-drifting ions. In order to minimize the impact of ion drifting back into the drift volume, a required backdrift suppression of about 1/gasgain has been used as a rule-of-thumb, since then the total charge introduced into the drift volume is about the same as the charge produced in the primary ionization.

Not only have these levels of backdrift suppression not been achieved during our R&D (Sec. 5.6), but also this rule-of-thumb is misleading. Lower backdrift levels will be needed since these ions would drift as few-mm thick sheets through the sensitive region during subsequent bunch trains. The charge density in the sheets would be much higher than a few fC/cm^3 (Sec. 3.6(b)) since the volume in the sheets is $\sim$ 100 times smaller than that of the drift volume. How these sheets would affect the track reconstruction will be simulated to understand their influence, but since this backdrift into the drift volume can in principle be completely eliminated by a gating plane, a gate should be foreseen, to guarantee a stable and robust chamber operation. The added amount of material for a gating plane will be small (e.g., it was $< 0.5\% X_0$ average thickness for the Aleph TPC). The gate will be closed between bunch trains and remain open throughout one full train. This will eliminate the need to

Primary Space Charge



taking this
X 150 for
ions

Adrian Vogel LCWS, Hamburg, 2007-06-02 14

WP#30 Special discussion on ion effects
2 June 2007, 14:00-ca.17:00
Sem Room 1
DesyHH

-Space charge effects can be minimized by choosing a gas with large \omega\tau.

-The Star TPC review Oct.2006 estimates mean for us (large \omgea\tau) up to 200fC/cm^3 in the volume would give rise to about 10cm drift-electron dispacement over the full drift, and this is the magnitude of the B-field effects we have to correct.

-Back-of-the-envolope and the Tesla TDR estimates give 0.5% occupancy for nominal backgrounds and about one fC/cm^3 in the volume assuming 100e per occupied voxel. (Adrian at this meeting give more solid numbers based on sumulation, and his numbers are lower as seen below).

-In the sheet, the density might be as large as 100 fC/cm^3, but the sheet is thin next to the Gem/Micromegas plane so its effect should be small (must be simulated). In the volume, the sheets can be eliminated by gating between trains.

-The correction for space-charge and B-field (antiDID) of about 1 cm means measuring the effects to 2x10^-5, the tools for doing this are known (see the Beijing report); this order of correction was achieved by the Aleph TPC.

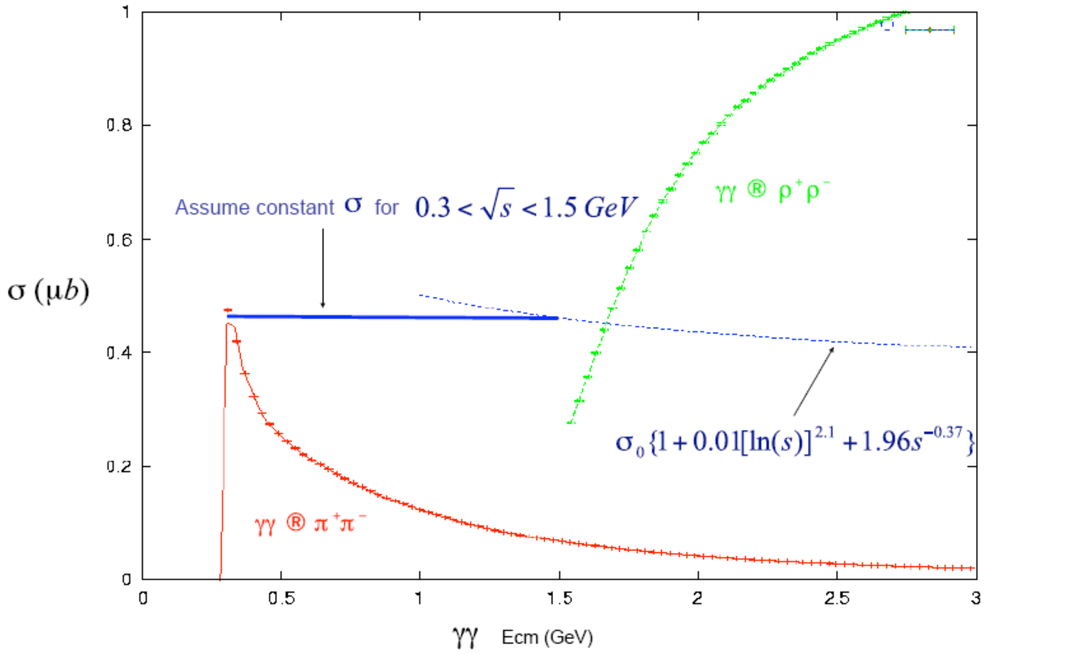
Muons

Minijet issue (T.Barklow, 2004) to be evaluated

i.e. primary positive ion effect in TPC - inner radius

e.g. mini-jets could be 750 events/train, 2 tracks/event (no Pt cut)

TPC Occupancy ~ .0001%



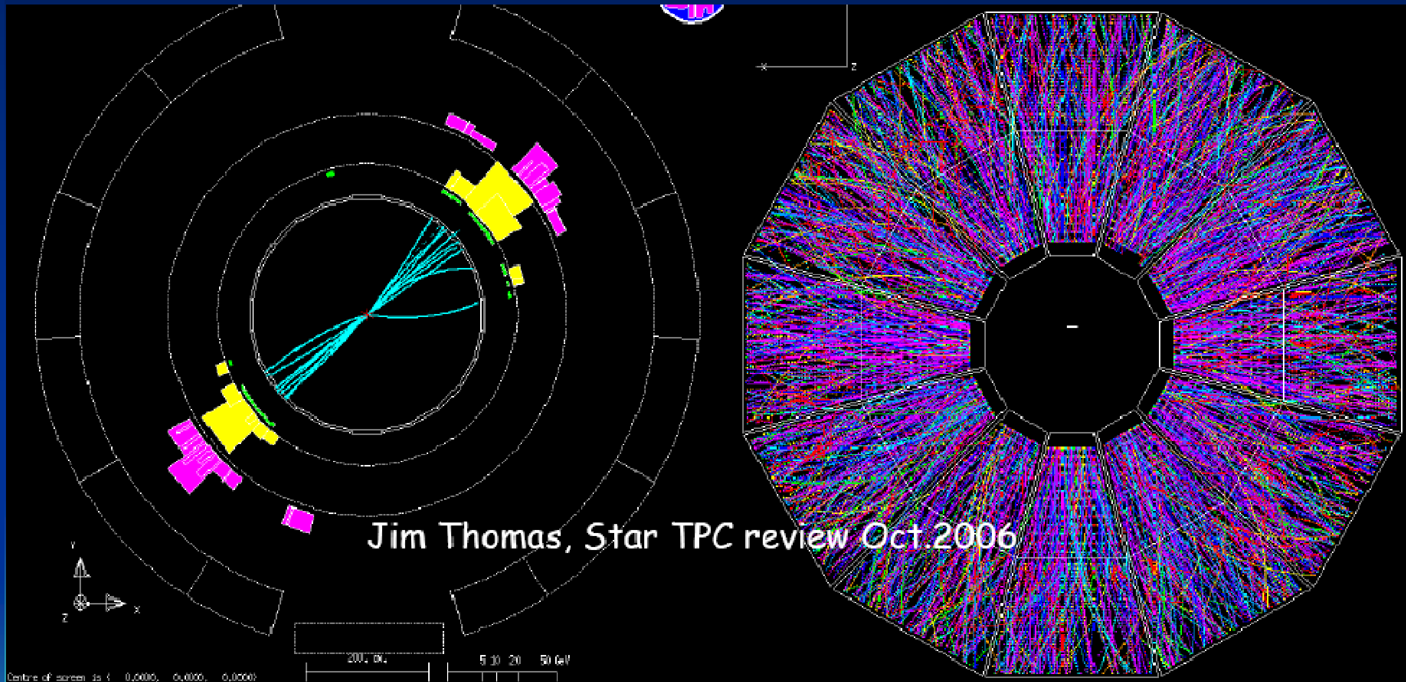
(2)

Background type	Assumption	N_{bkgd}/BX
muons	1 μ occ ≡ 6 pads × 1000 t.b. ⇒ 6×10^3 vox./μ	$\frac{10^5\ \text{vox/BX}}{6\times10^3\ \text{vox./}\mu}$ = 17 μ/BX SF = 200 (T.7.1.6)
neutrons	$P_{n.int.} = \frac{N_0 \sigma \rho \ell}{A}$ ≃ .01 (ℓ = 200 cm) ⇒ 1 n.int./100n 1 n.int. occ ≡ 3 pads × 20 t.b. ⇒ 60 vox./100n	$\frac{10^5\ \text{vox/BX}}{60\ \text{vox/100n}}$ = 170000 n/BX SF = 10 (T.7.1.6)

Jet Physics … it is easier to find one in e^+e^-

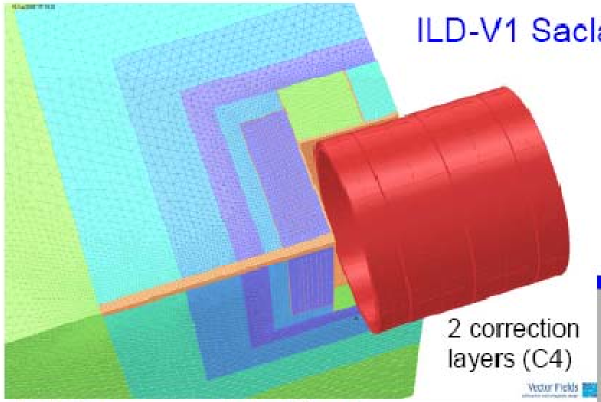
Jet event in e^+e^- collision

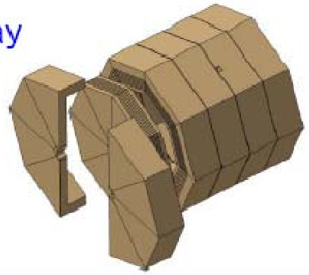
STAR Au+Au collision



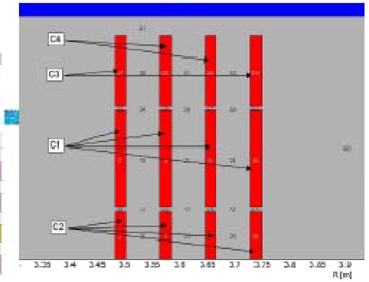
Magnet

ILD-V1 Saclay



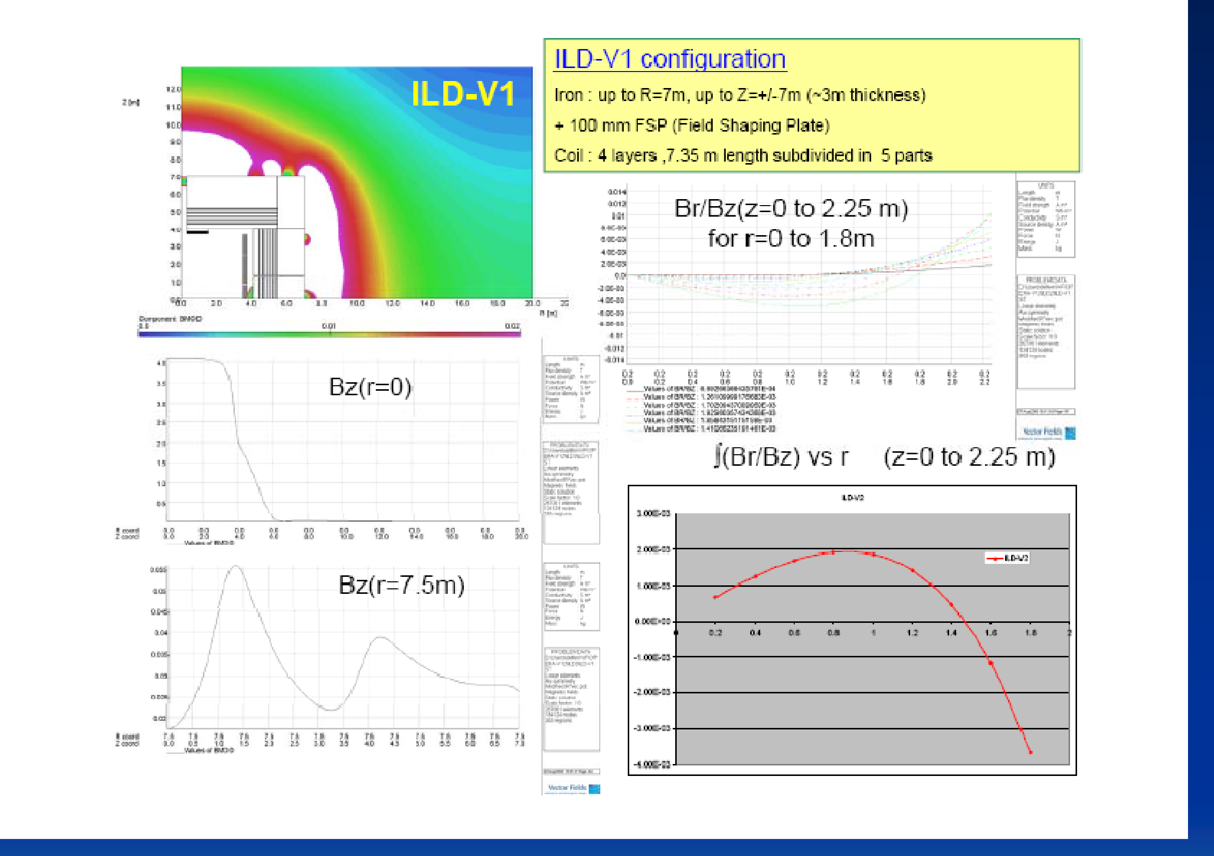


2 correction layers (C4)



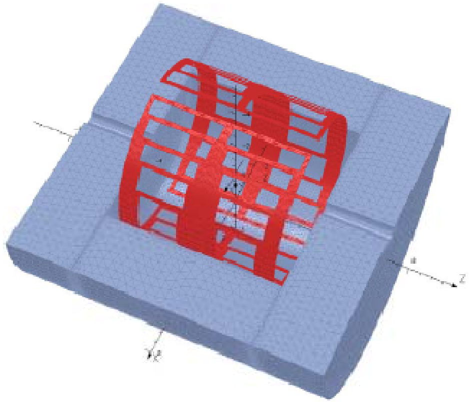
Current distribution :		2 correction layers		
12948	12948	12948	12948	12948
32136	12948	12948	12948	32136
32136	12948	12948	12948	32136
12948	12948	12948	12948	12948

	NI (MA)	J (A/mm²)	N (turns/layer)	I per turn (kA)	I correction (kA)	Length (m)
C1	1.29	40.0	100	12.9	0	1.65
C2	0.65	40.0	50	12.9	0	1.65
C3	0.95	40.0	73	12.9	0	1.21
C4	2.35	98.0	73	32.1	19.2	1.21


ILD-V1 configuration
Iron : up to R=7m, up to Z=+/-7m (~3m thickness)
+ 100 mm FSP (Field Shaping Plate)
Coil : 4 layers ,7.35 m length subdivided in 5 parts
ILD-V1
Bz(r=0)
Bz(r=7.5m)
Br/Bz(z=0 to 2.25 m)
for r=0 to 1.8m
∫(Br/Bz) vs r (z=0 to 2.25 m)

Anti-DID coil design

In case an anti-DID coil is needed, Brett Parker has started some conceptual design study



. Two dipole coils, anti-symetric with respect to the I.P.

. Proposal to wind the anti-DID coil outside the main solenoid coil (reduced field region)

. Field maps (3D) do not yet include the ILD solenoid

. $B_{anti\text{-}DID}$ ~ 0.65 T

CEA DSM Irfu - F. KIRCHER - [ILD Workshop, Cambridge, Sept 11-13, 2008] 22