Report from MDI workshop at SLAC

Karsten Büßer

ILC@DESY Project Meeting
21th January 2005

87 Participants:

12 from Asia
24 from Europe
- 5 from DESY (HH: 2, Z: 3)

51 from the US
- 29 from SLAC

Program Overview

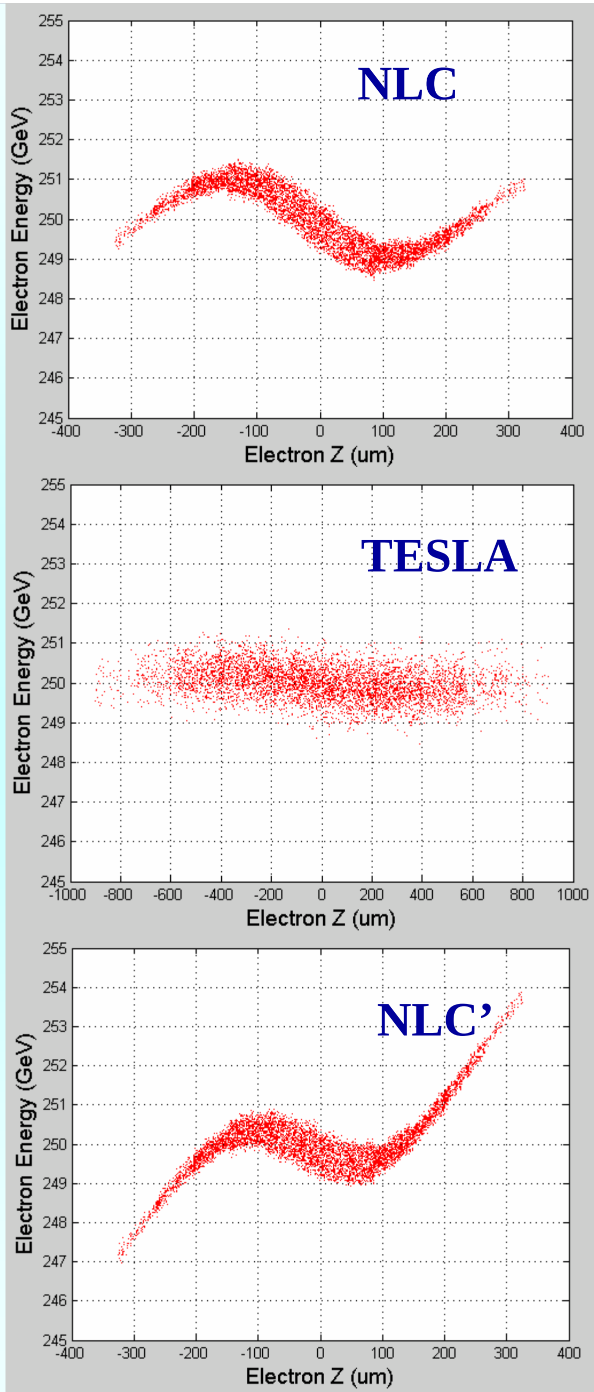
Main MDI topics ⇒ sessions

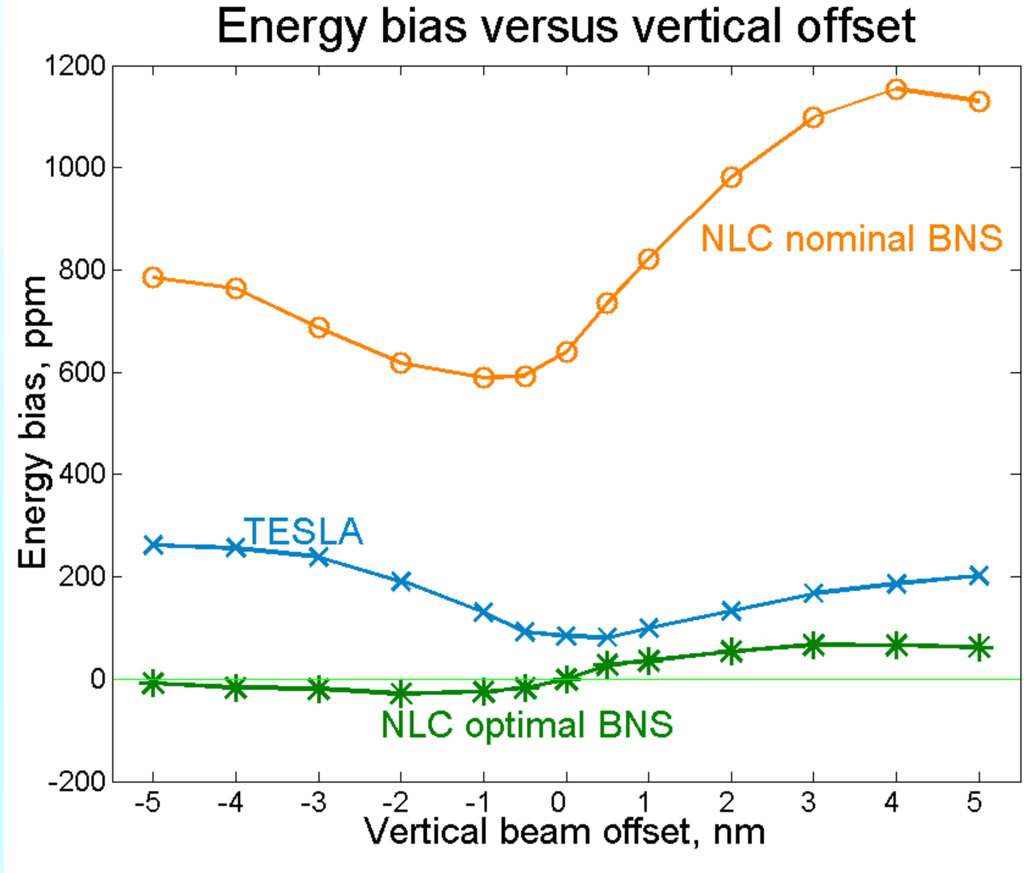
• Energy and luminosity spectrum	S. Boogart, K. Kubo
• Polarimetry	K. Moffeit, K. Mönig
• Very forward region	W. Lohmann, H. Yamamoto
• Backgrounds	K. Büsser, T. Maruyama
• IR layout, crossing-angles	T. Tauchi, A. Seryi
• Beam RF effects	M. Woods

Important connected topics ⇒ overview talks

• Physics options (+ other issues)	A. de Roeck
• Detector concepts	M. Oreglia
• Beam optics & collimation	S. Kuroda
• Luminosity optimization	P. Burrows

Energy and Luminosity Spectrum





Summary of E_{CM}^{bias}

LC Machine Design	$<E_{CM}^{bias}>$ ($\Delta y = 0$)	$\sigma(E_{CM}^{bias})$ ($\Delta y = 0$)	$Max(E_{CM}^{bias})$ vary Δy, η_y
WARM-500	+520 ppm	170 ppm	+1000 ppm
COLD-500	+50 ppm	30 ppm	+250 ppm
NLC'-500	0 ppm	10 ppm	+50 ppm

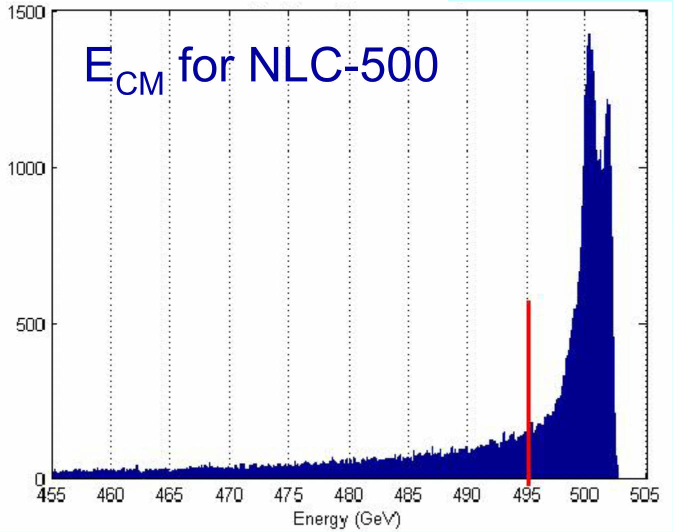
Definition of E_{CM}bias (Beamsstrahlung OFF)

$$E_{CM}^{Bias} = \frac{\langle E_1 \rangle + \langle E_2 \rangle - \langle E_{CM}^{lum-wt} \rangle}{\langle E_1 \rangle + \langle E_2 \rangle},$$

E_1 and E_2 are beam energies measured by the energy spectrometers. (ISR and beamstrahlung are turned off for this study.)

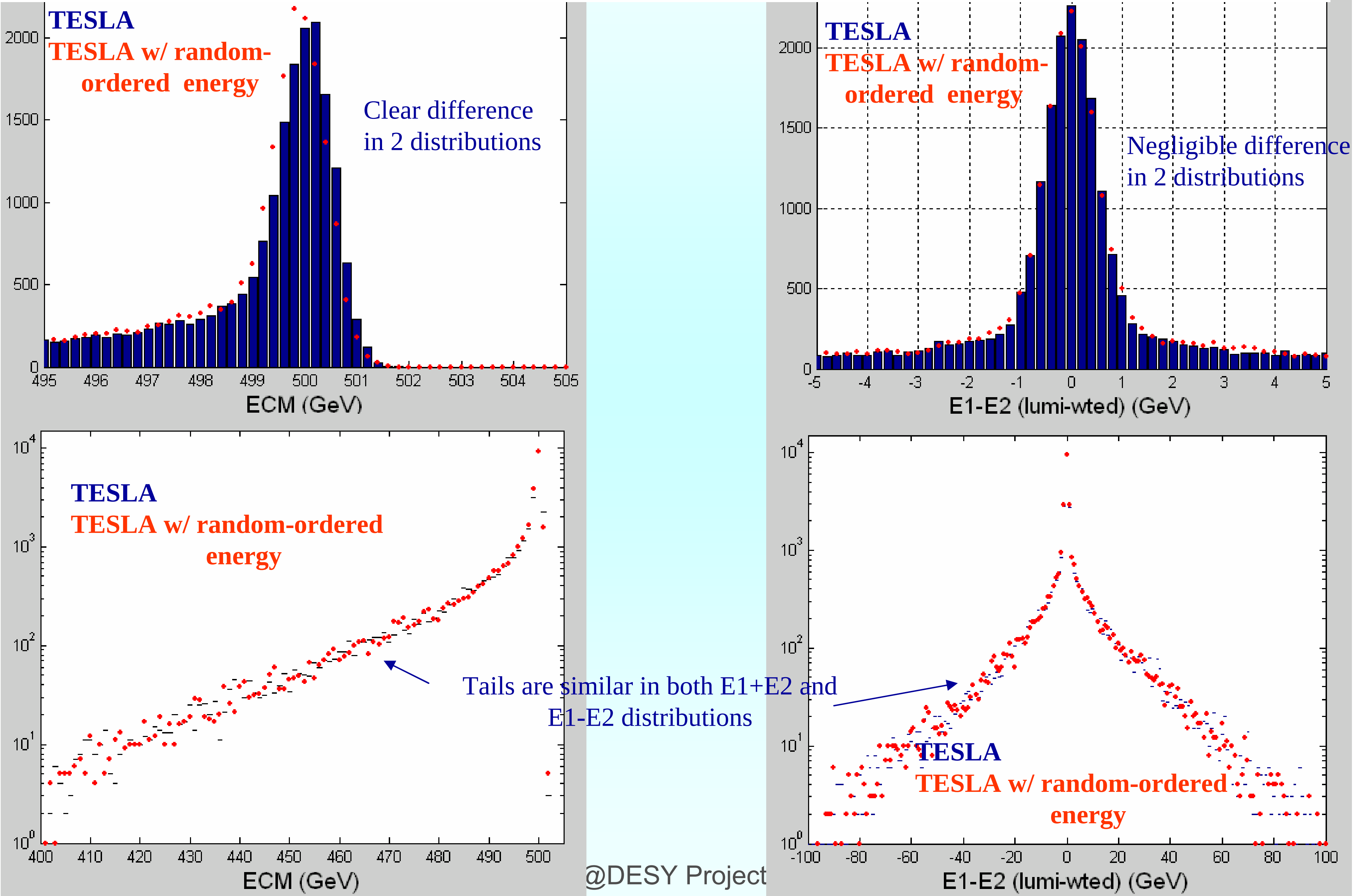
Definition of E_{CM}bias (Beamsstrahlung ON)

$$E_{CM}^{bias}\Big|_{BSon} = \left\langle E_{CM}^{lum-wt} \right\rangle\Big|_{unaltered}^{E_{CM} > Ecutoff} - \left\langle E_{CM}^{lum-wt} \right\rangle\Big|_{random\,E}^{E_{CM} > Ecutoff}$$



Vary cutoff energy from 480-495 GeV

Study of distributions for i) E_{CM} (cannot measure this)
ii) E1-E2 (closely related to Bhabha acolinearity)



Summary of E_{CM}^{bias} without Beamsstrahlung

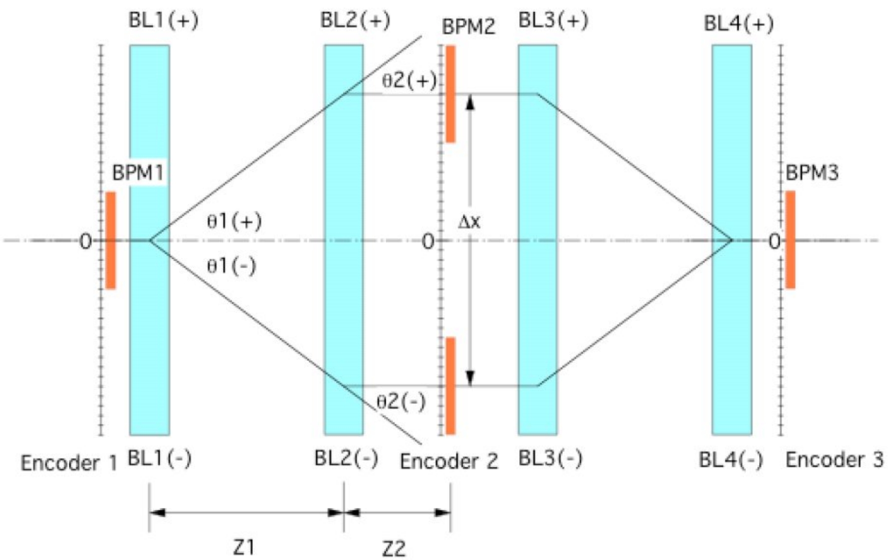
LC Machine Design	$\langle E_{CM}^{bias} \rangle$ ($\Delta y = 0$)	$\sigma(E_{CM}^{bias})$ ($\Delta y = 0$)	$Max(E_{CM}^{bias})$ vary Δy, η_y
WARM-500	+520 ppm	170 ppm	+1000 ppm
COLD-500	+50 ppm	30 ppm	+250 ppm
NLC'-500	0 ppm	20 ppm	<50 ppm

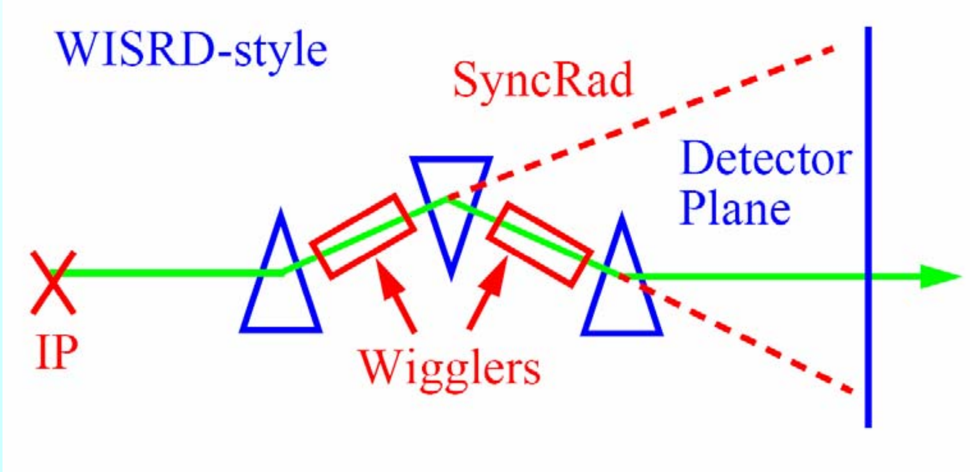
Summary of E_{CM}^{bias} in presence of Beamsstrahlung

LC Machine Design	$\langle E_{CM}^{bias} \rangle$ ($\Delta y = 0$)	$\sigma(E_{CM}^{bias})$ ($\Delta y = 0$)	$Max(E_{CM}^{bias})$ vary Δy, η_y
WARM-500	+960 ppm	150 ppm	+ 1120 ppm
COLD-500	+150 ppm	30 ppm	+350 ppm
NLC'-500	~0 ppm	20 ppm	<50 ppm

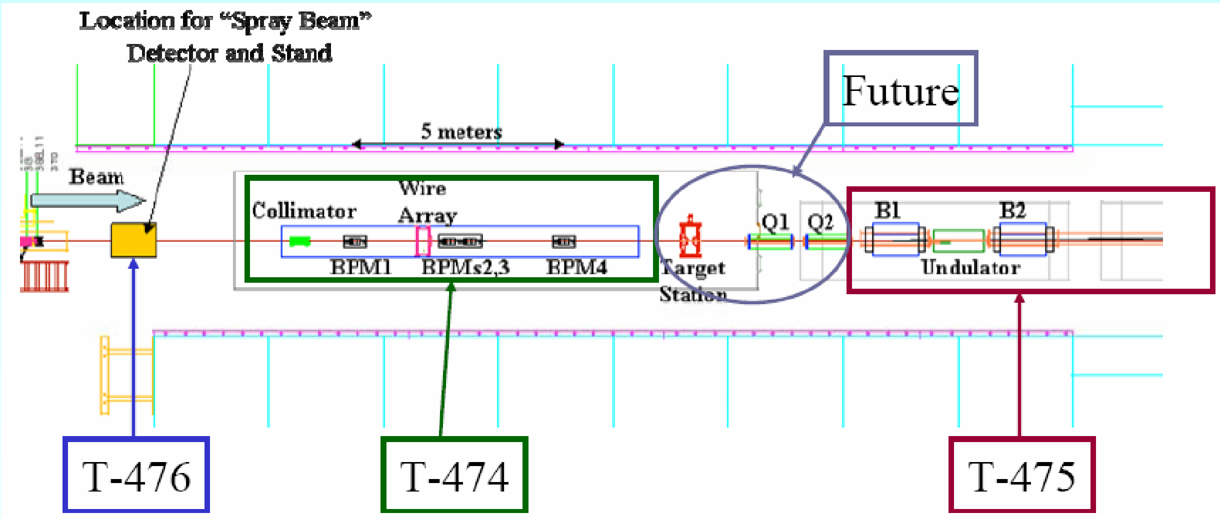
→ Energy spectrometers and Bhabha acolinearity alone are not sufficient to correct for this bias. Need beam dynamics modeling and other input from annihilation data, disrupted energy measurements, …

Energy Spectrometers





SLAC ESA Beamtests

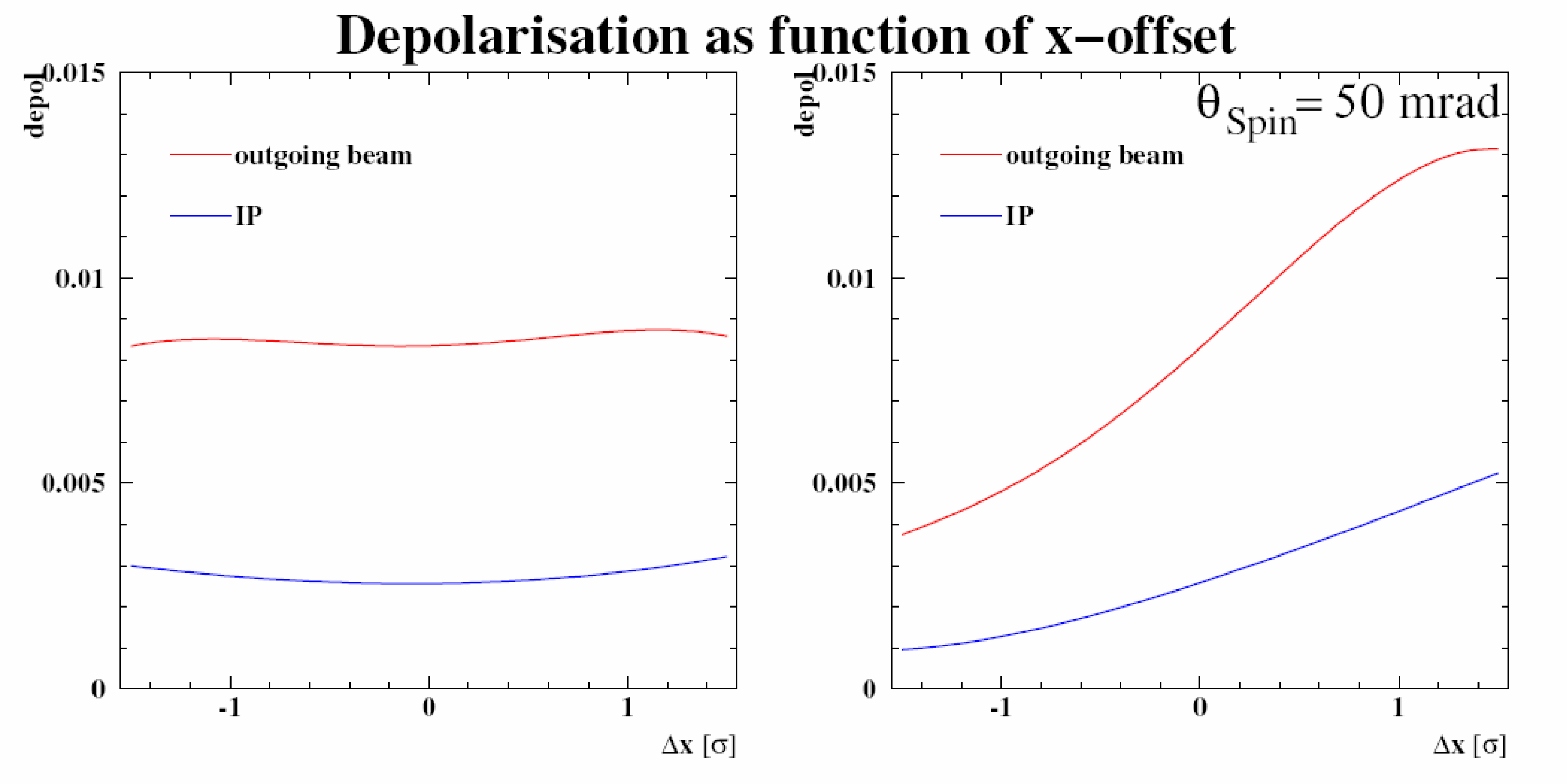


Polarimetry

Polarimetry

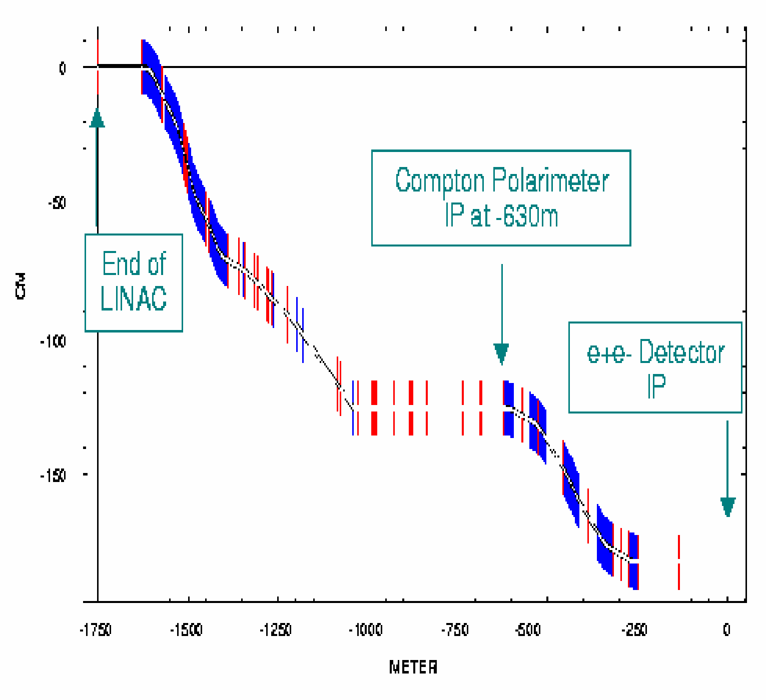
- 3 ways to measure polarisation: upstream, downstream, data
- issues to understand:
  - difference of incoming, outgoing and luminosity weighted polarisation
  - correlations between electron and positron polarisation
  - polarimeter corrections for data methods
- more concrete questions:
  - is downstream polarimetry with 2 mrad crossing angle possible?
  - if no, is upstream polarimetry enough?
  - can we believe CAIN for depolarisation?
  - do we understand the polarisation transport well enough?
  - backgrounds
  - light sources for different polarimeters (backgrounds, correlations)
  - switching between IRs, how, how often?
  - real designs
  - common issues with beam energy/lumi spectrum: correlations between beams, momentum-polarisation correlations

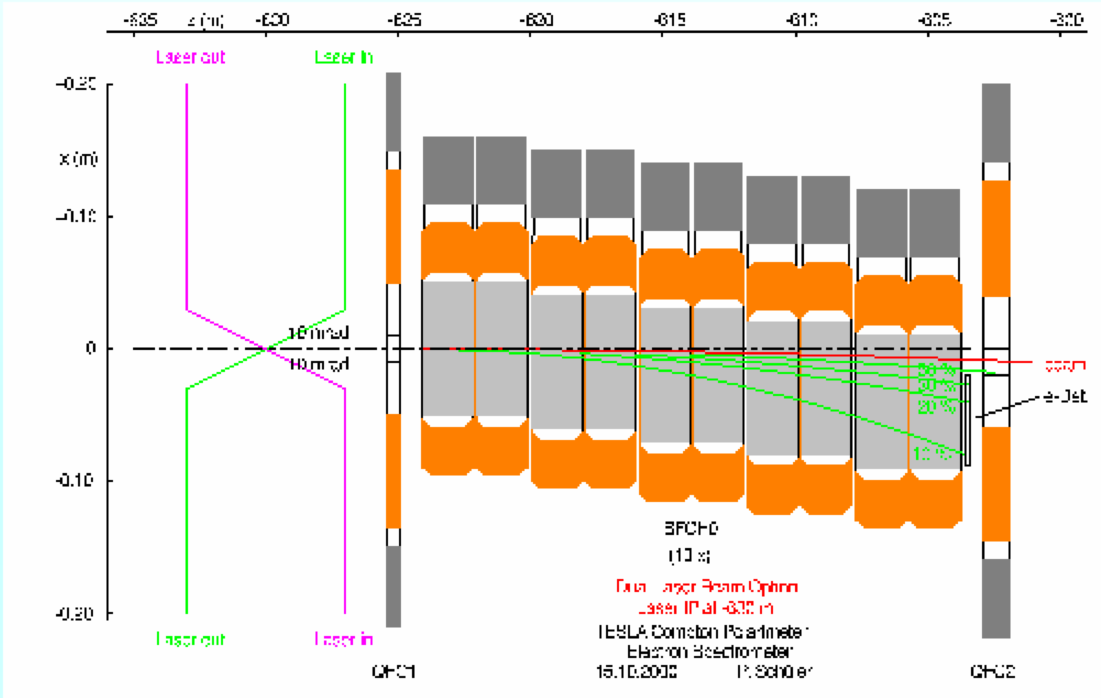
Depolarisation



Depolarisation for interacting particles: ~0.3%
Depolarisation for spent beam: ~1%

TESLA Design

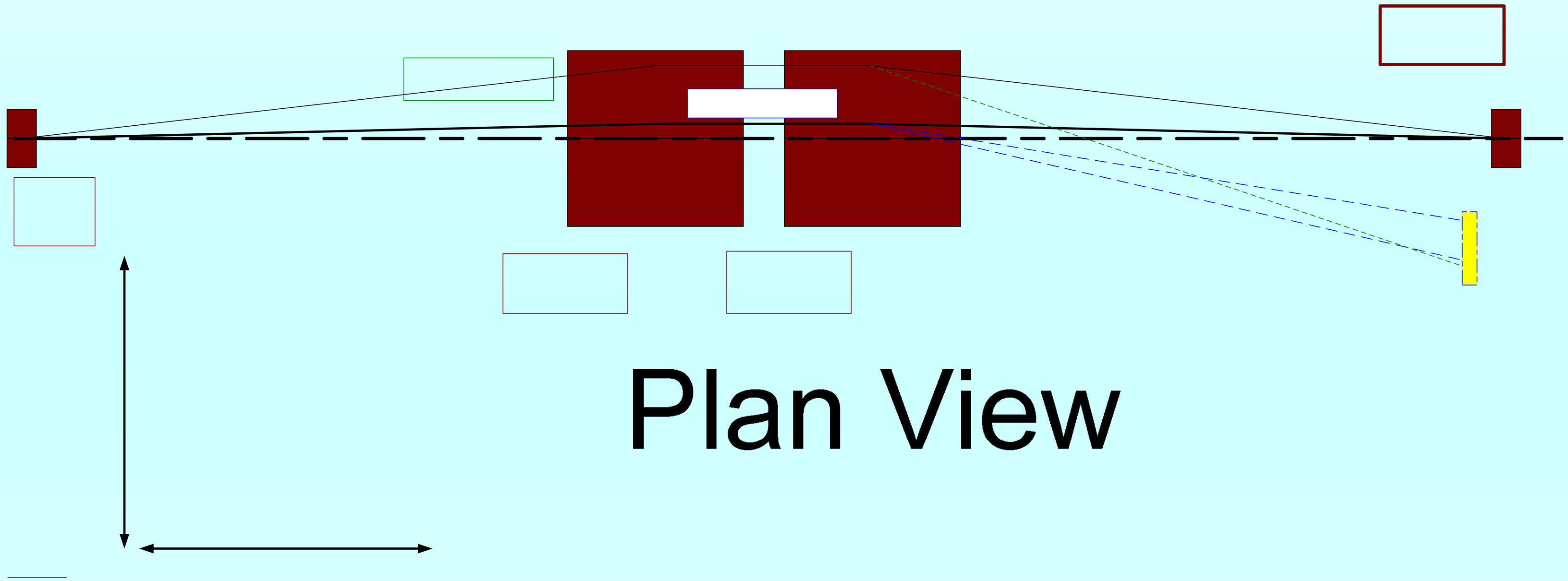




- Minimal space and no special magnets required
- Need to change laser wavelength for z-pole running

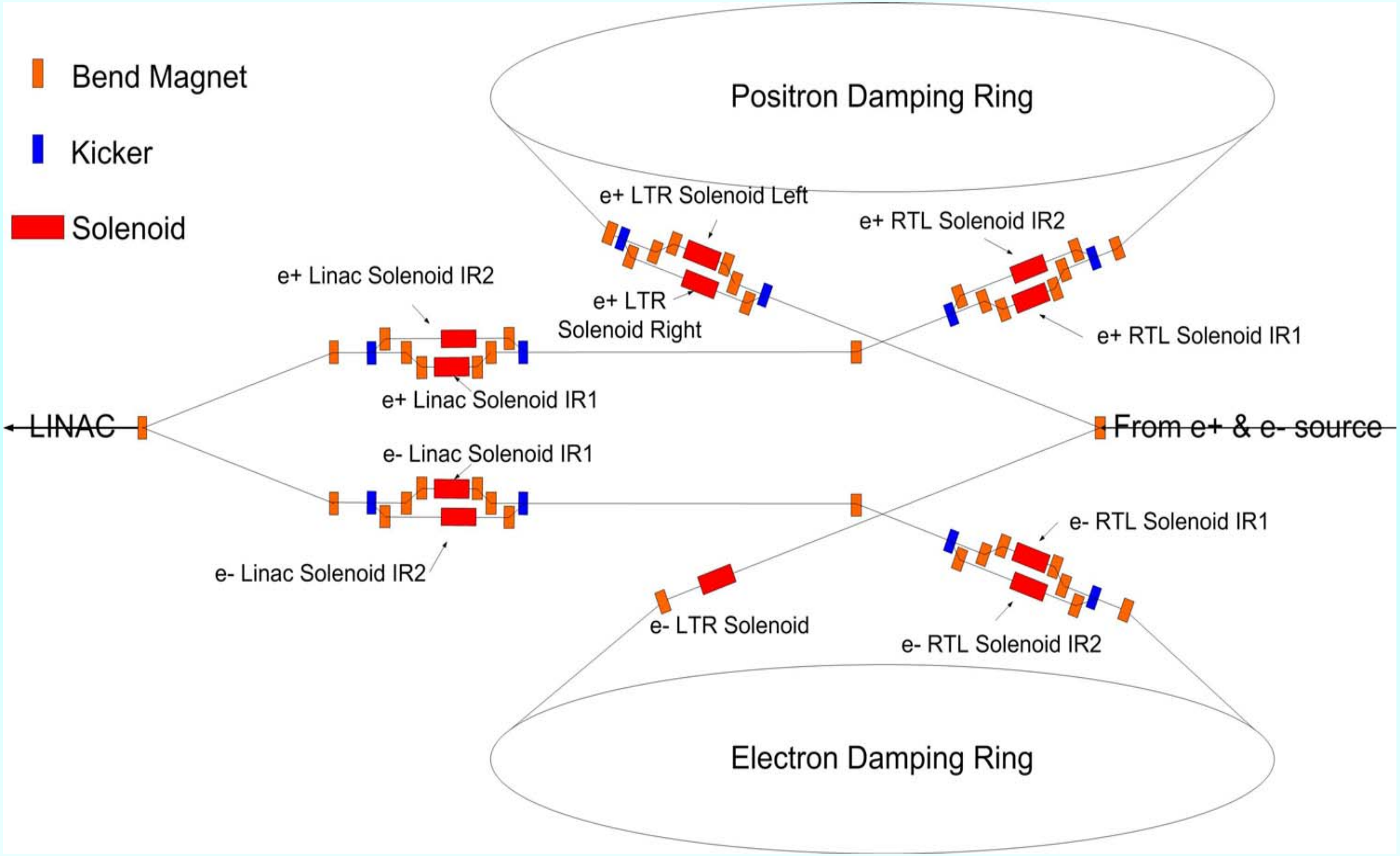
Chicance Polarimeter

Upstream
Polarimeter Chicane

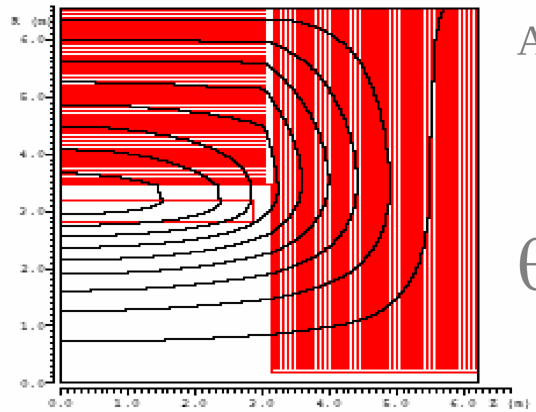


- Requires ~50 meters length
- Same B-field at Z-pole, 250 GeV and 500 GeV running
- Same magnet design as for upstream energy chicane
- Good acceptance of Compton Spectrum at all energies without changing laser wavelength

Polarisation at both IPs?

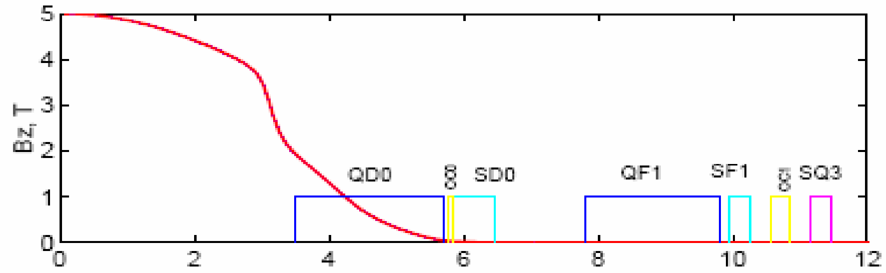


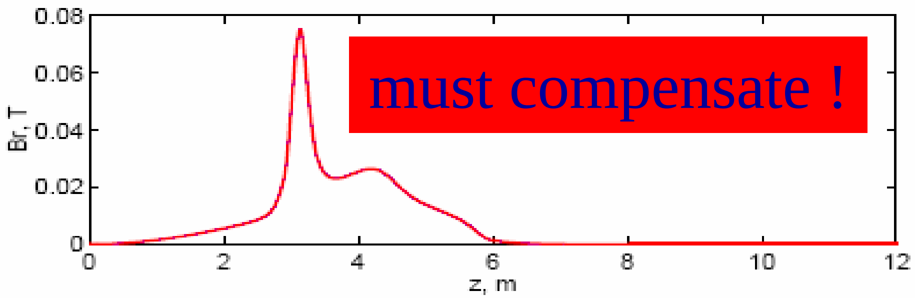
$\theta_c \neq 0 \Rightarrow$ solenoid steers + spin precesses

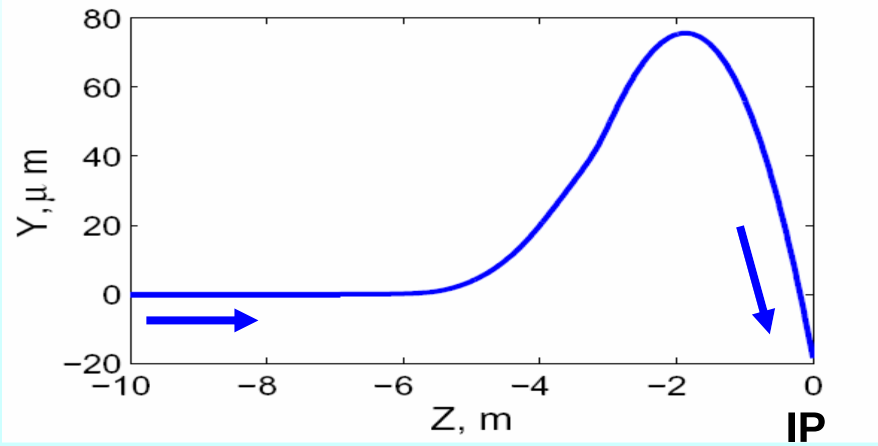


A.Seryi and B. Parker

$\theta_c = 20$ mrad







IP y angle ~ 100 μrad

IP y offset ~ - 20 μm

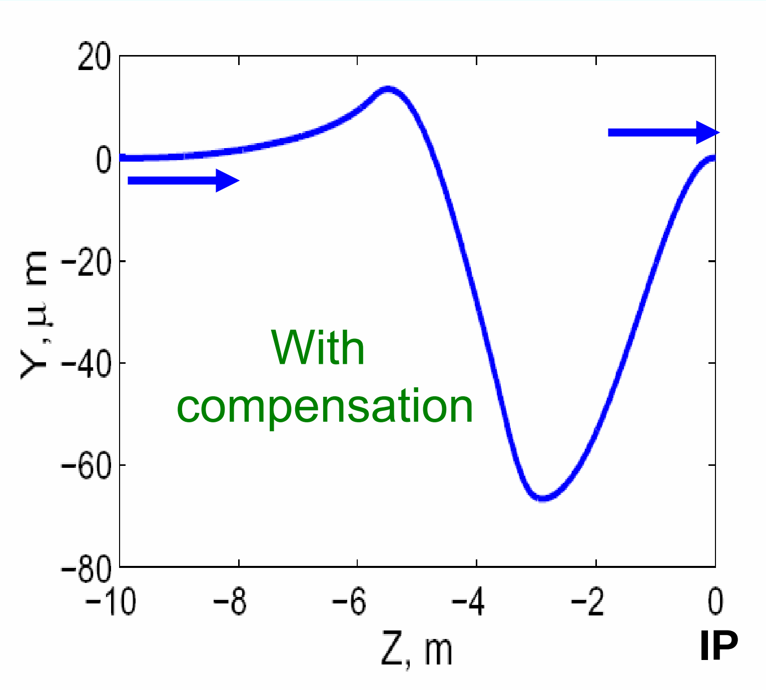
$\sigma(\theta_y)$ ~ 85 μrad $\sigma(y)$ ~ 3 nm

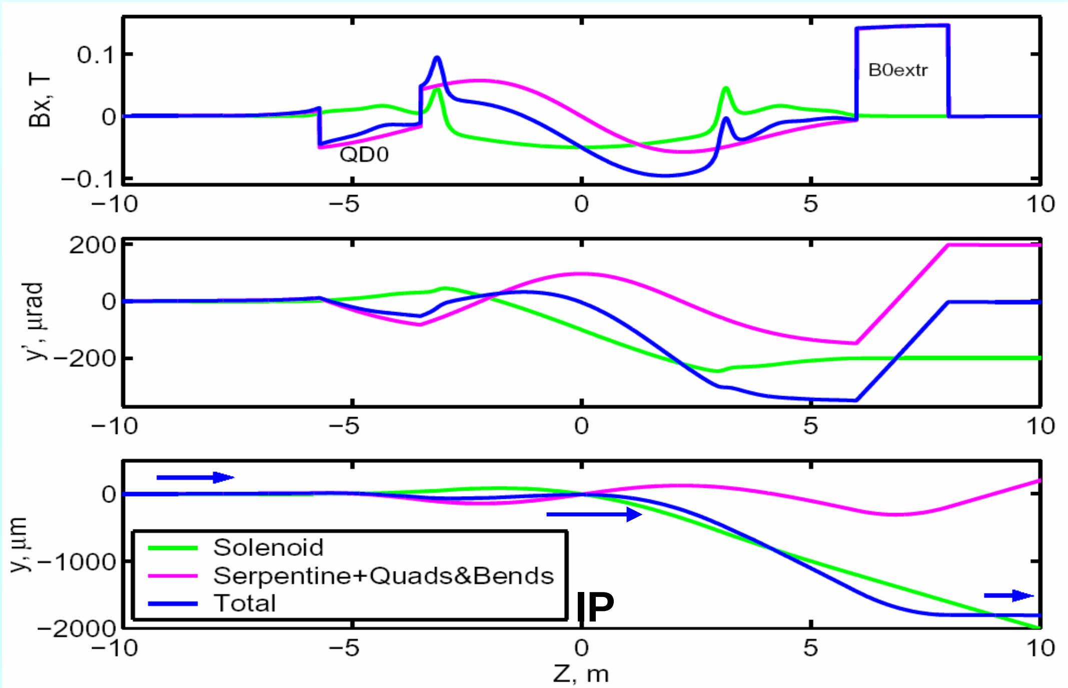
spin precession ~ 60 mrad

if uncorrected →

~ 0.2 % depolarization with perfect beams (or else larger)

Option for local correction with extra dipole fields within the detector + before + after





- Adds ~ 0.01 of B_z along x in detector
- TPC tracking → map B_z to 0.0005 to control distortions
- Larger backgrounds and steering of the spent beam

Very Forward Region

Forward Instrumentation

$L^* = 4m$

High precision Lumi measurement

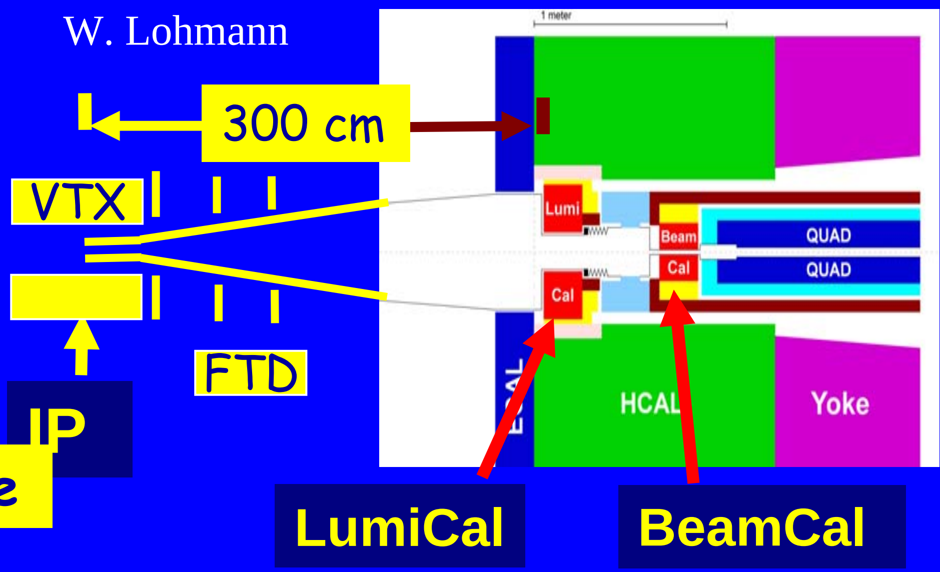
Physics wishes

$\Delta\mathcal{L}/\mathcal{L} \sim 2 \cdot 10^{-4}$

$$\frac{\Delta L}{L} = \frac{2 * \Delta\theta}{\theta_{min}}$$

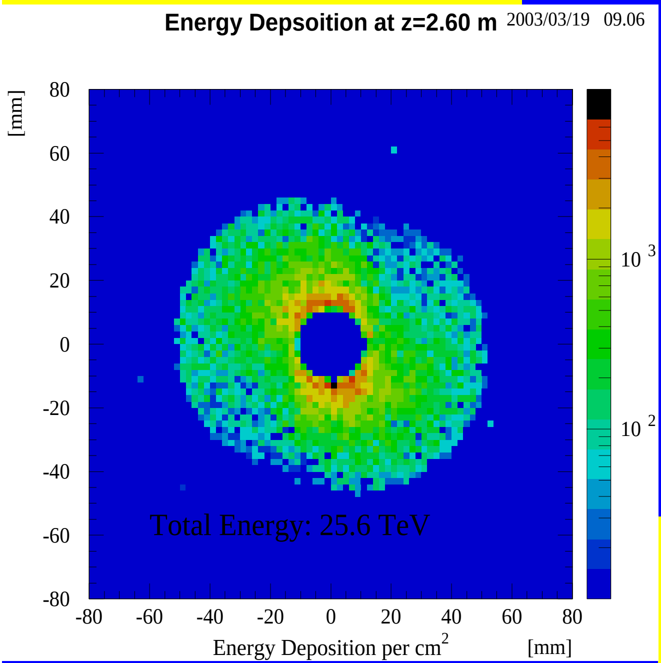
Bias in θ!

W. Lohmann

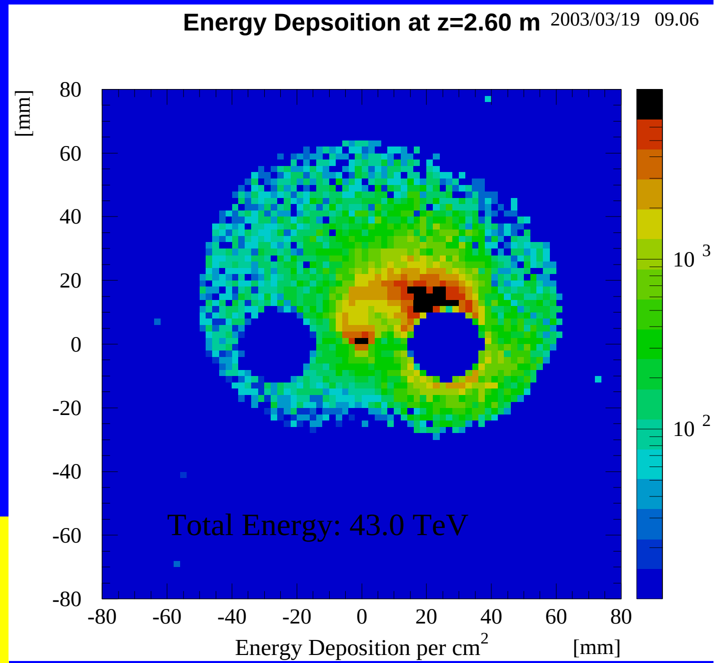


precision hardware → needs space

Beam diagnostics



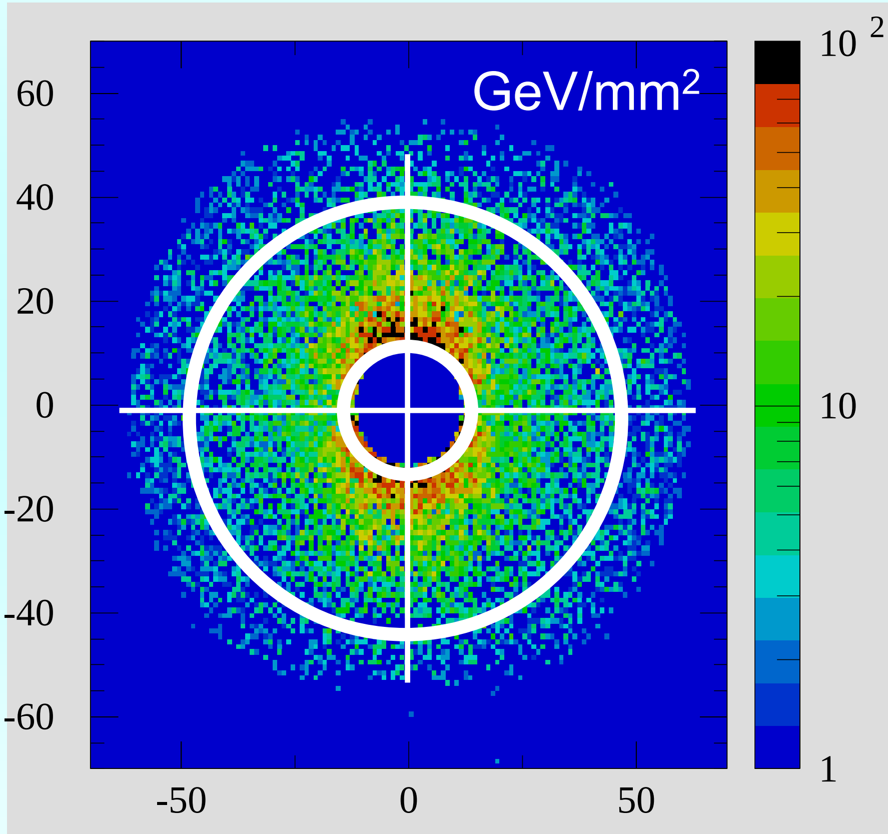
Large potential! More mutual understanding needed



Goal: Complex diagnostics system

Beamstrahlung Pairs

- Observables (examples):
  - total energy
  - first radial moment
  - thrust value
  - angular spread
  - E(ring ≥ 4) / Etot
  - E / N
  - left/right, up/down, forward/backward asymmetries

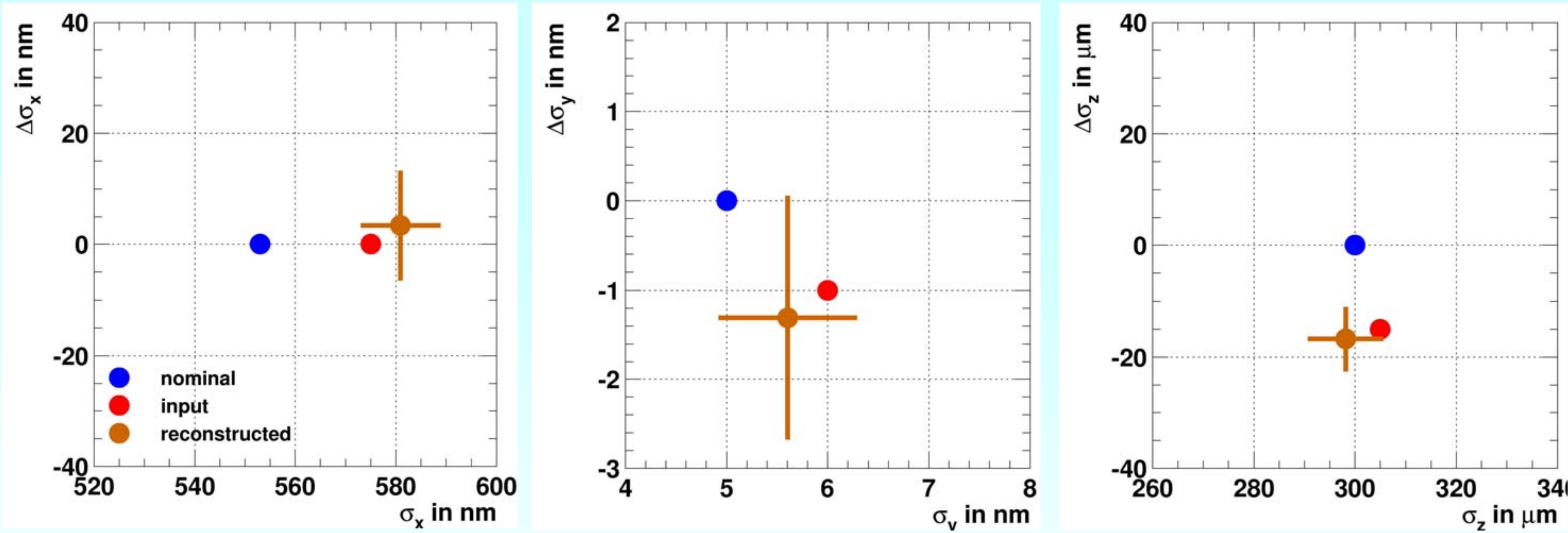


detector: realistic segmentation, ideal resolution
bunch by bunch resolution

Analysis

Test with non-nominal bunches:

	e^-	e^+	nom.
bunch size x:	575nm	575nm	553nm
bunch size y:	5nm	7nm	5nm
bunch size z:	290µm	320µm	300µm

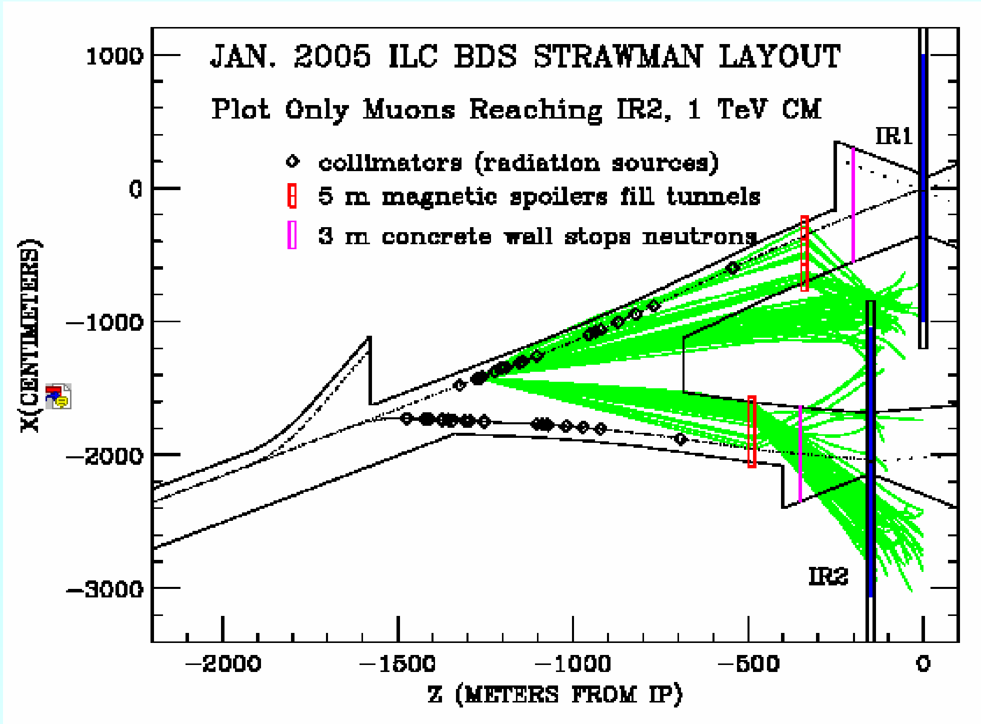


Backgrounds

Personnel Protection from Muons

Problem: Occupy one IR hall while beam is being delivered to the other IP

Shielding Condition	500 GeV CM (mRem/hr)	1 TeV CM (mRem/hr)
No shielding	0.9	1.5
18 m steel walls	0.03	0.12
5 m magnetic spoilers	<0.01	0.04



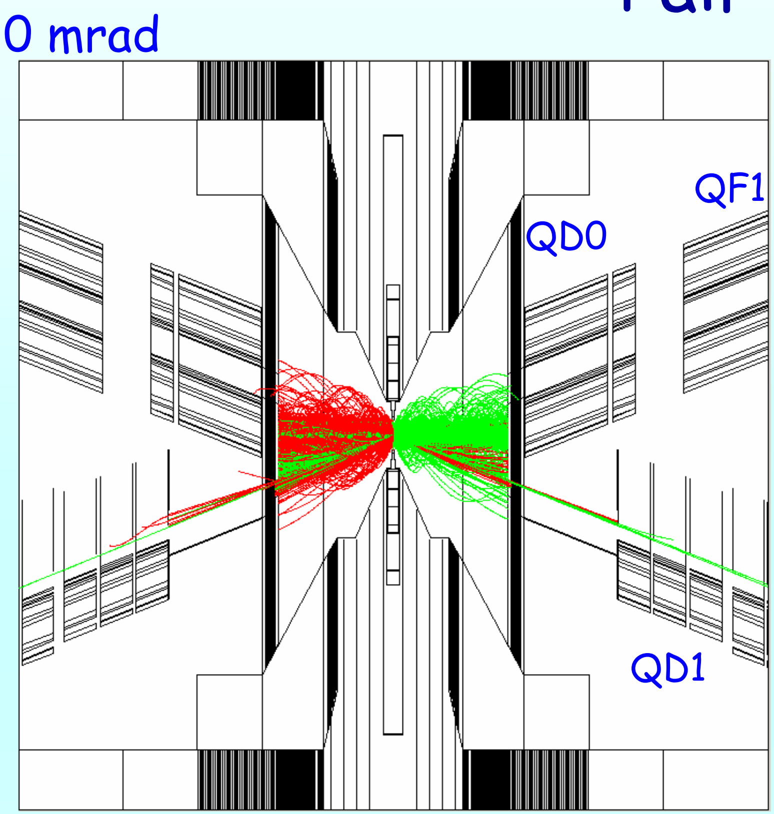
L. Keller

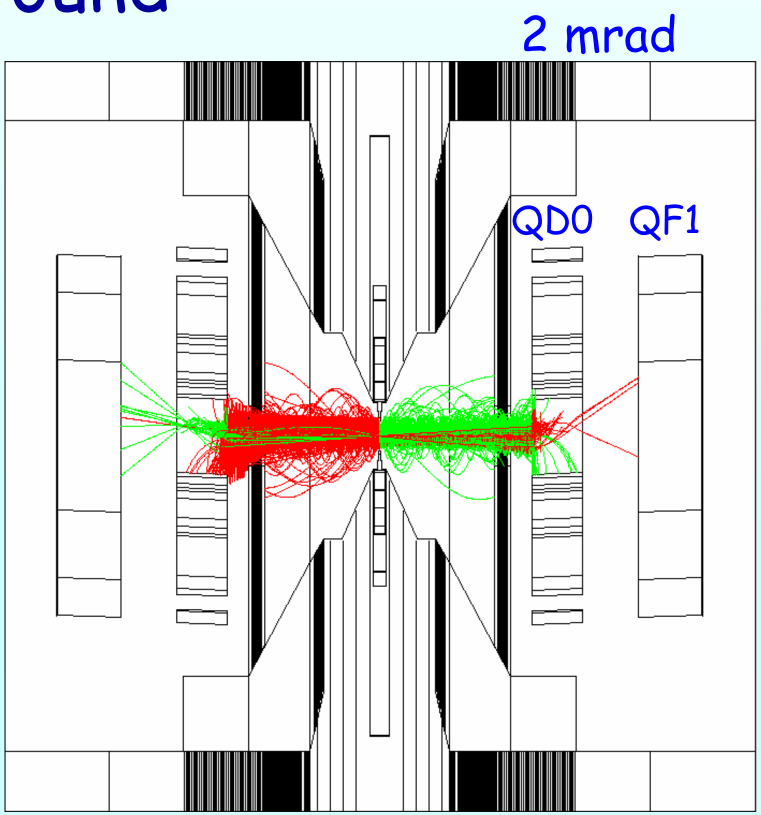
Hardware to keep the primary beam from entering an occupied IR

1. A series of protection collimators and stoppers such that all possible missteered beams are confined to a collimator or stopper.
2. All dipoles in the big bend and energy collimation sections locked off.

Pair Background

T. Maruyama



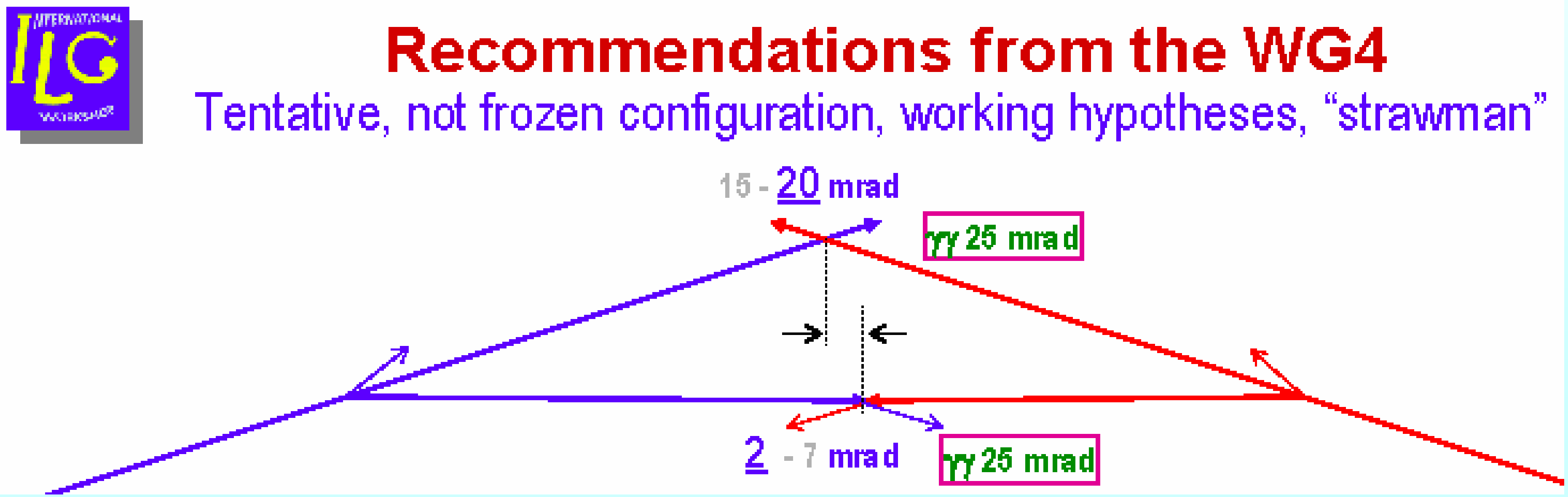


Conclusions

- Background seems tolerable for both crossing angle schemes
- KB: Backgorunds at 20 mrad are larger than in 2 mrad:
  - 15% in Vertex Detector
  - 50% in TPC
  - even more in FTDs (but on lower level)
  - Backgrounds are asymmetric at 20 mrad

IR Layouts, Crossing Angles

Strawman Model

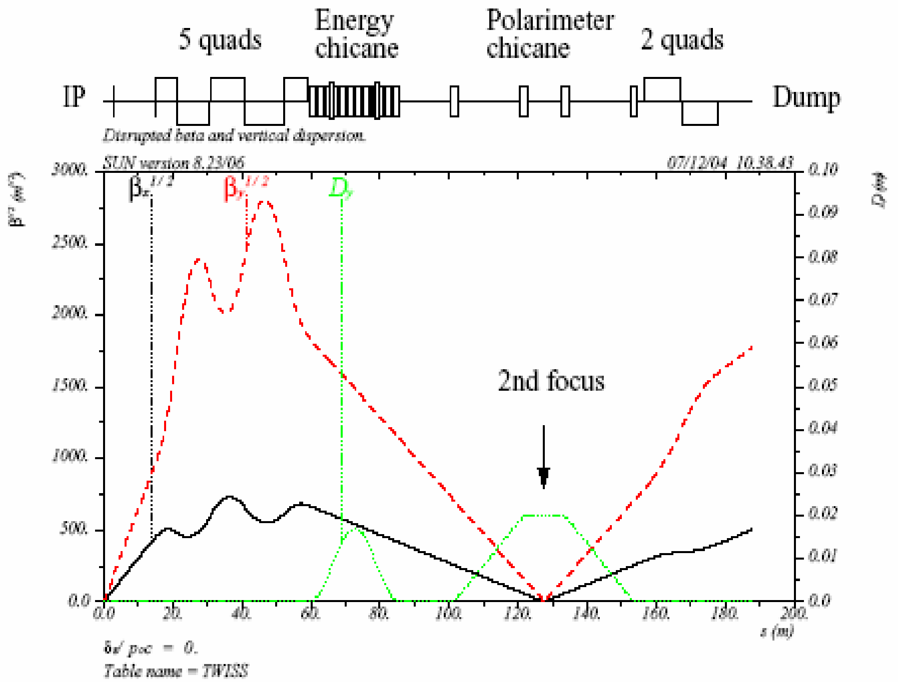


Discussion on angles between the Linacs was again hot:
- Multi-TeV upgradability argument is favoured by many
- Small crossing angle is dis-favoured by some

20mrad Extraction Scheme

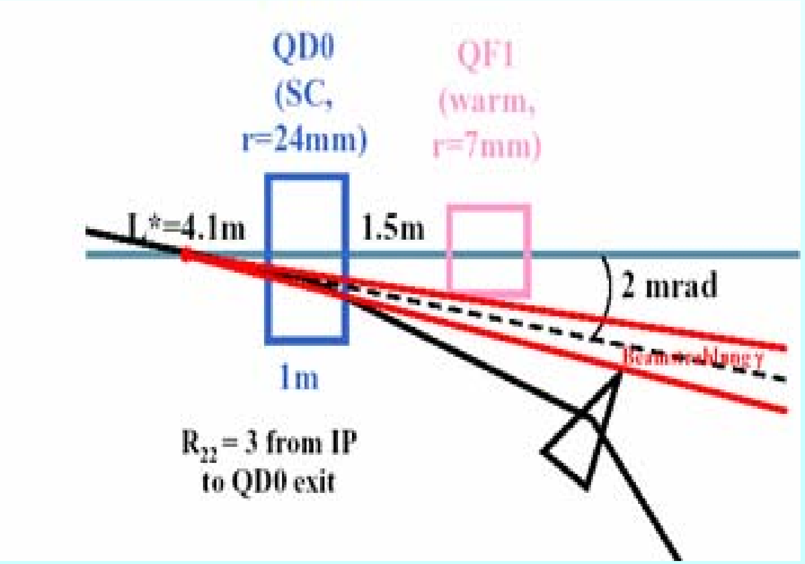
Y. Nosochkov et al.

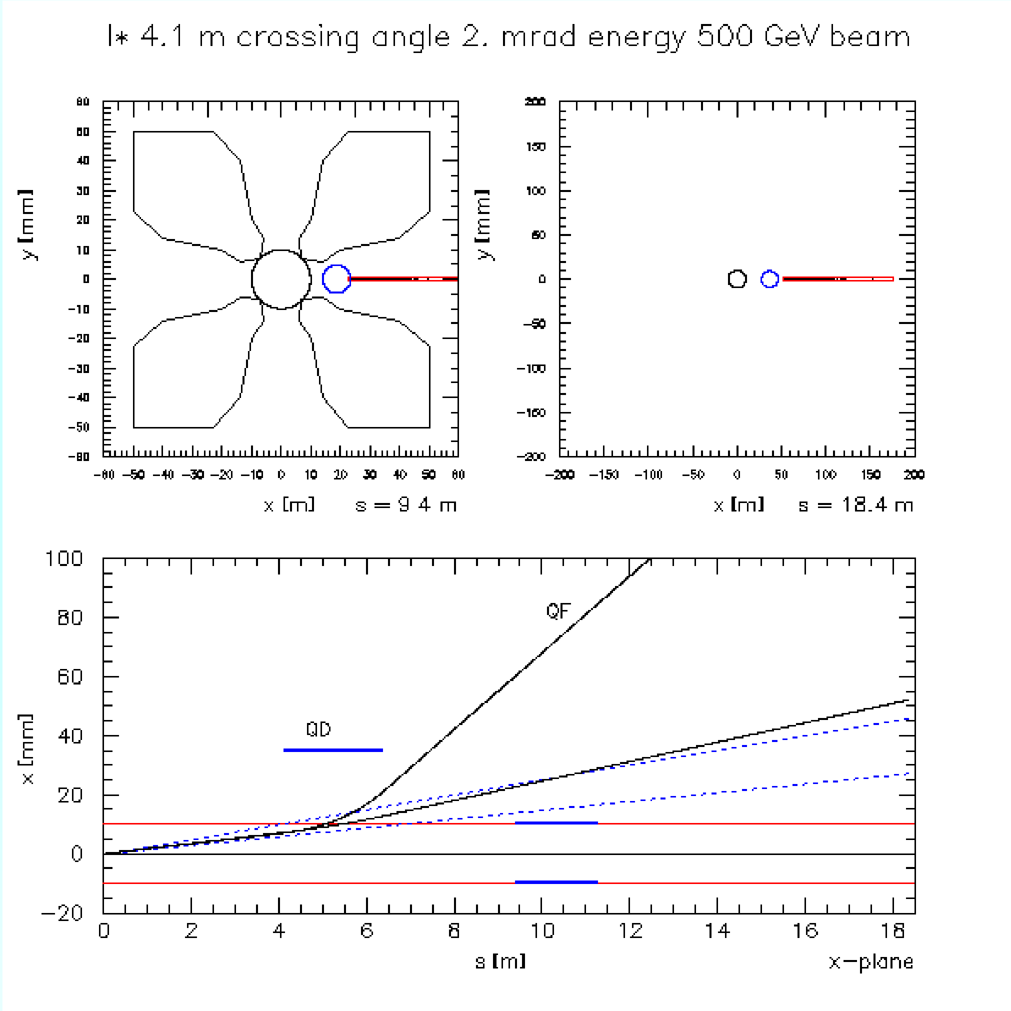
Beam optics



- L^{*}_{ex} = 15 m free space after IP (an 8 m option also exists).
- At the 2nd focus: η_y = 2 cm, $R_{12} = R_{34} = 0$, $R_{11} = -3.1$, $R_{33} = -2.4$.
- Dump is assumed at 188 m after IP, but its location may be changed.

2mrad Extraction Scheme



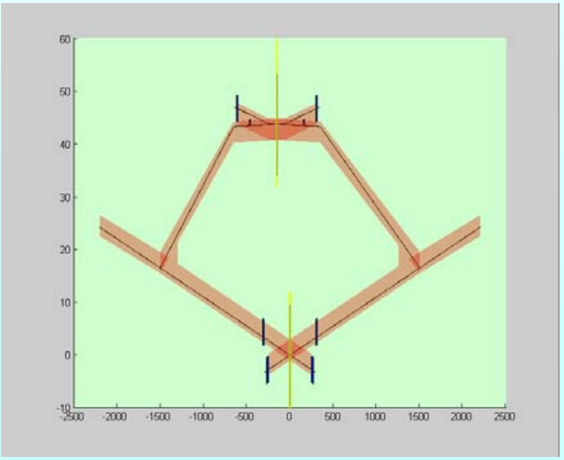


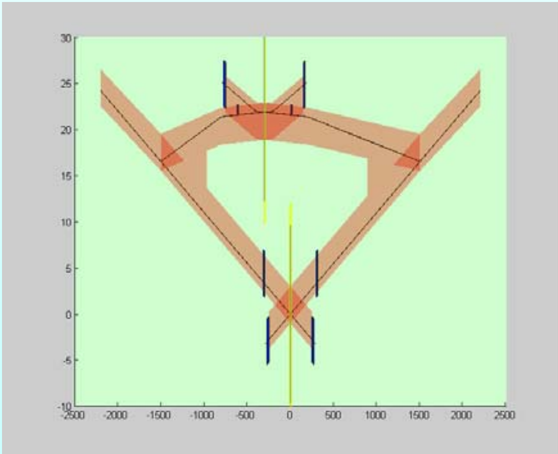
Under study:

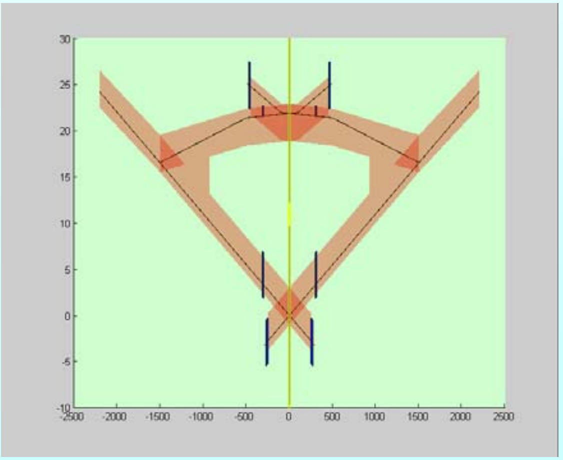
- Optics
- Spent beam losses in QD
- Beamstrahlung stay-clear in QF
- Diagnostics chicanes

R. Appleby et al.

Civil Engineering Issues

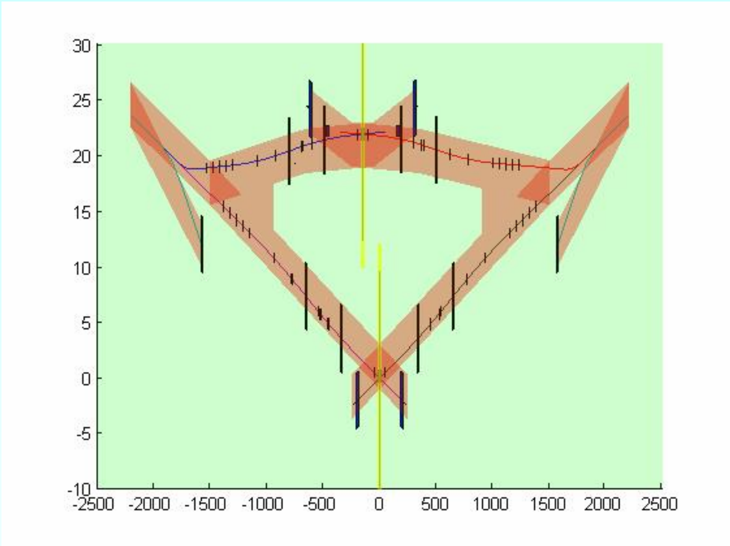




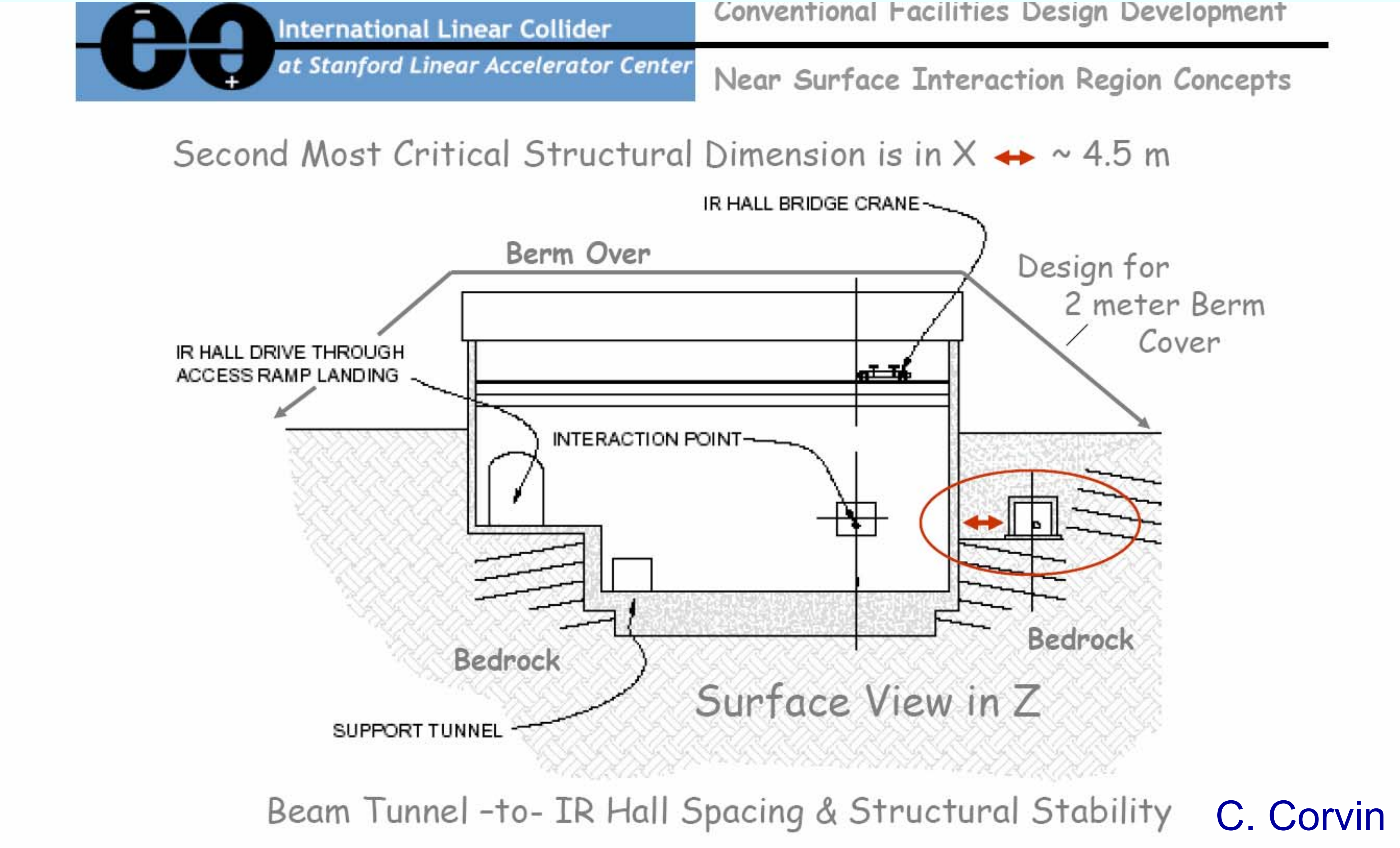


T. Markiewicz

MatLab Tool to study constraints from civil engineering



Civil Engineering Issues



C. Corvin

Beam RF Effects

Beam RF Effects

Significant impact on:

- RF shielding for beamline and detector components
- Detector design
- Signal Processing and DAQ architecture

	SLC	PEP-II e^+	ILC
Electrons/Bunch, Q	4.0×10^{10}	5.0×10^{10}	2.0×10^{10}
Bunch Length, σ_z	1 mm	12 mm	0.3 mm
Bunch Spacing	8 ms	4.2 ns	337 ns
Average Current	0.8 μA	1.7 A	50 μA
$(Q/\sigma_z)^2$ relative	92	1	256

Detector physicists MUST study this seriously together with the accelerator experts

Beam Test at SLAC ESA to further investigate this is proceeding:

- with SLD's VXD3 and with simpler beampipe
- strong desire for this from international vertex community
- can provide important information for VXD design and for signal processing/DAQ for all LC Detector systems

My personal conclusion

- MDI/BDIR working group is very active
- Some design issues are under heavy debate, e.g.
  - Small crossing angle
  - Multi-TeV upgradability
- Still a tendency to make recommendations without proper grounding to the physics/detector groups
- Next milestones:
  - LCWS2005 at SLAC: 18.-22. March 2005
  - BDIR workshop at RHUL: 20.-23. June 2005
  - Snowmass: 14.-27. August 2005
- Goal is to finalise all CDR relevant design issues at Snowmass latest