Crossing-angle-or-not physics implications

report from 19-01-04 phone-meeting

cold half-angle = 10, 4, 1, 0.3,…… 0 mrad

warm half-angle = 10, 4 mrad

technical issues	more IP tuning	optics design constraints
	crab-cavity req.	beam(strahlung) extraction
	SC mini-quad.	electrostatic separators
	backgrounds	collimation
	→ worse at 1 TeV	
physics issues evaluated	hermetic γγ veto (track impact par. dilution)	post-IP diagnostics for energy and polarization
	$\vec{B}$ and $\vec{P}$ not //	

no killer arguments either way → quantify impact

meeting agenda of the physics evaluation

http://www-flc.desy.de/bdir/meetingagenda190104.html

1.	Introduction, specification and context of study, meeting goals	10‘	P. Bambade/LAL
2.	Smuon and stau searches with small slepton-neutralino mass differences Implications for dark matter interpretation in co-annihilation scenarios	25‘	Z. Zhang/LAL
3.	Smuon and stau searches with small slepton-neutralino mass differences	20‘	U. Martyn/DESY

Tentative conclusion & further work concerning impact on slepton search capabilities

4.	Crossing angle and luminosity spectrum measurement	10‘	D. Miller/UCL
5.	News from the ALPCG SLAC Workshop	20‘	E. Torrence/Oregon
6.	Polarisation effects of the crossing angle	10’	K. Mönig/DESY
7.	Review of arguments for upstream / downstream polarimetry	15‘	G. Mortgat-Pick/Durham P. Schüler/DESY

Tentative conclusion & further work concerning impact on energy and polarisation

8.	Status of the detector background simulations Comparison of recent beamstrahlung pair calculations	20‘	K. Büsser/DESY
9.	Electron identification & veto in the LCAL / LumCAL Comparison with recent results from Takashi Maruyama	20‘	K. Kousnetzova/DESY
10.	Update on gamma-gamma to hadrons calculation	20‘	T. Barklow/SLAC

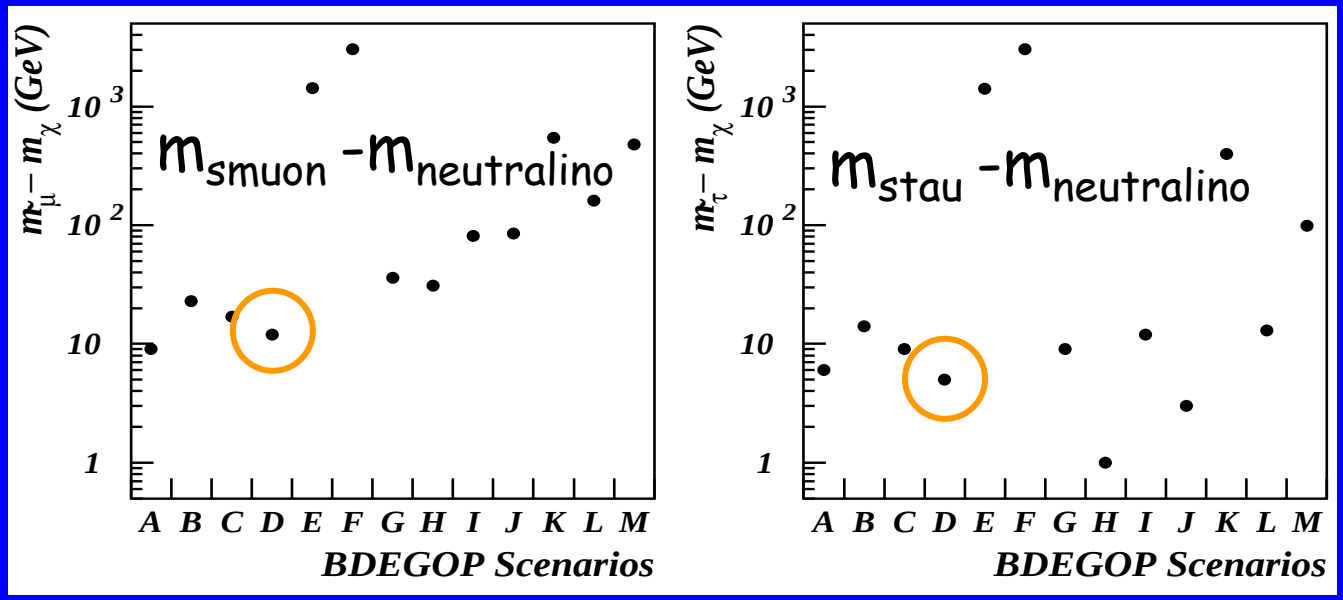
Tentative conclusion & further work concerning requirements on the background and very forward region

Conclude by LCWS04 - *strengthen international collaboration* (GLC)

SUSY dark matter motivation for low angle veto

- Some popular dark matter SUSY explanations need the LSP χ^0 to be quasi mass-degenerate with the lightest sleptons $\tilde{\tau}$, $\tilde{\mu}$,…

  → co-annihilation mechanism
- mSUGRA + new dark matter constraints from WMAP cosmic microwave background measurements point in this direction
- Scenario considered also relevant more generally in the MSSM



Acceptable solutions in mSUGRA

M. Battaglia et al.

hep-ph/0306219

efficient / hermetic $\gamma\gamma$ veto crucial for $\tilde{\tau}$ measurement

signal

$ee \rightarrow \tau\, \chi^0\, \tau\, \chi^0$

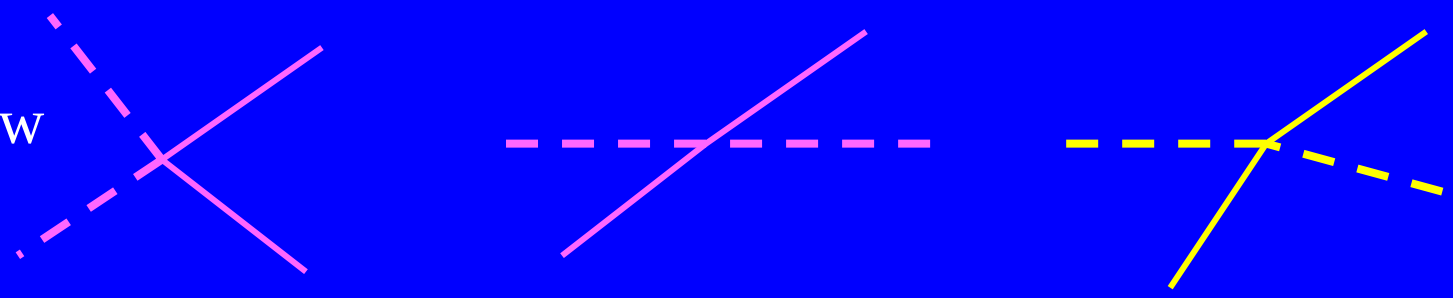
$\sigma \sim 10$ fb

major background

$ee \rightarrow (e)(e)\, \tau\, \tau$, $e\, (e)\, (\tau \rightarrow \mu)\, \tau$

$\sigma \sim 10^6$ fb

Transverse view



$\gamma\gamma$ veto crucial to detect sleptons in highly mass-degenerate SUSY scenarios $\rightarrow$ spectator e (~10mrad) , μ (~20mrad)

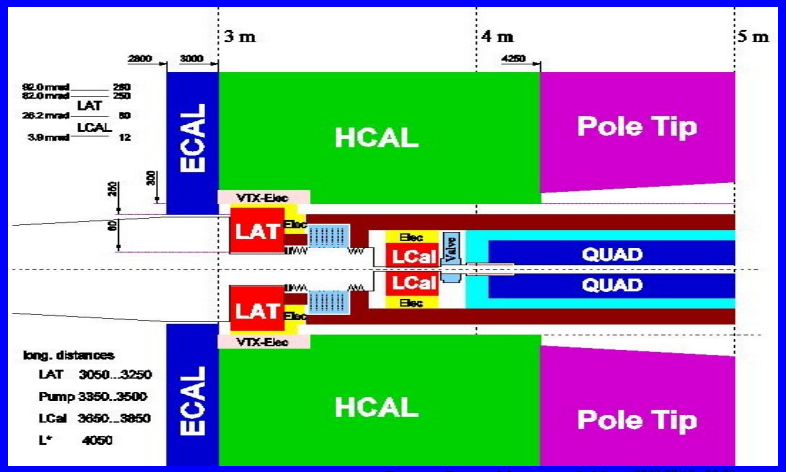
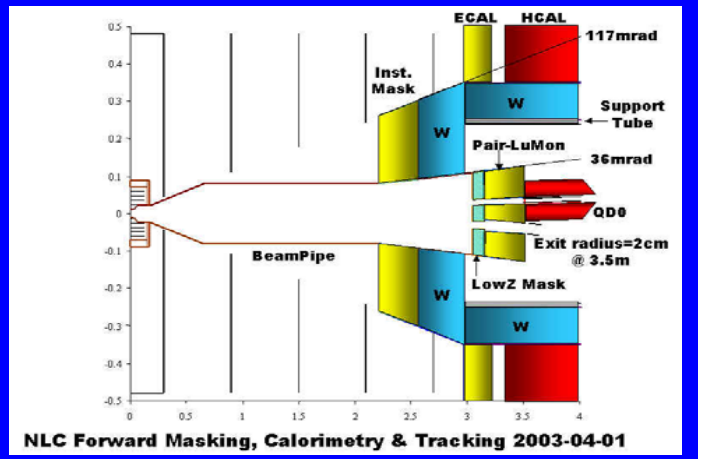
- Important LC channel, complementary to LHC

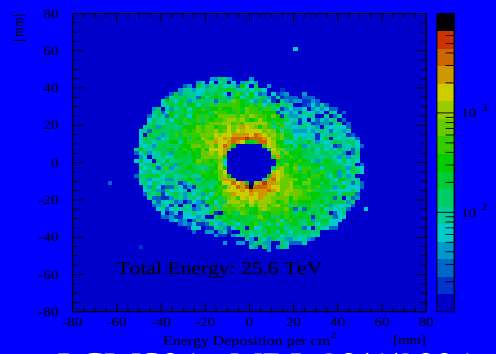
$\rightarrow$ talk by Z. Zhang

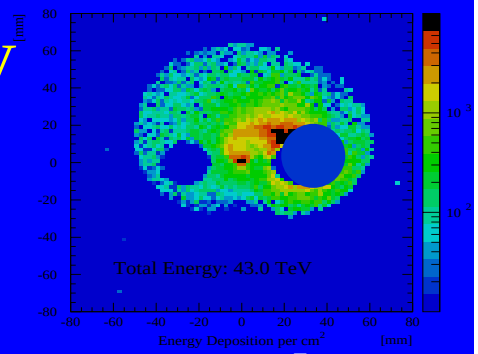
- Precise slepton masses $\leftrightarrow$ dark matter $\leftrightarrow$ constraints from Planck

(luminosity & energy strategy) (LC / LHC $\leftrightarrow$ cosmology)

Forward region geometries

	TESLA	NLC / JLC-X
bunch separation	337 ns	1.4 ns
IP geometry	head-on or crossing angle	crossing angle 20(7) mrad
forward region		
calorimetry at low angle 1. luminosity 2. veto	~ 25 TeV from e^+e^- pairs (~ 3 GeV)	~ 43 TeV × n bunches $\Delta t_{readout}$?

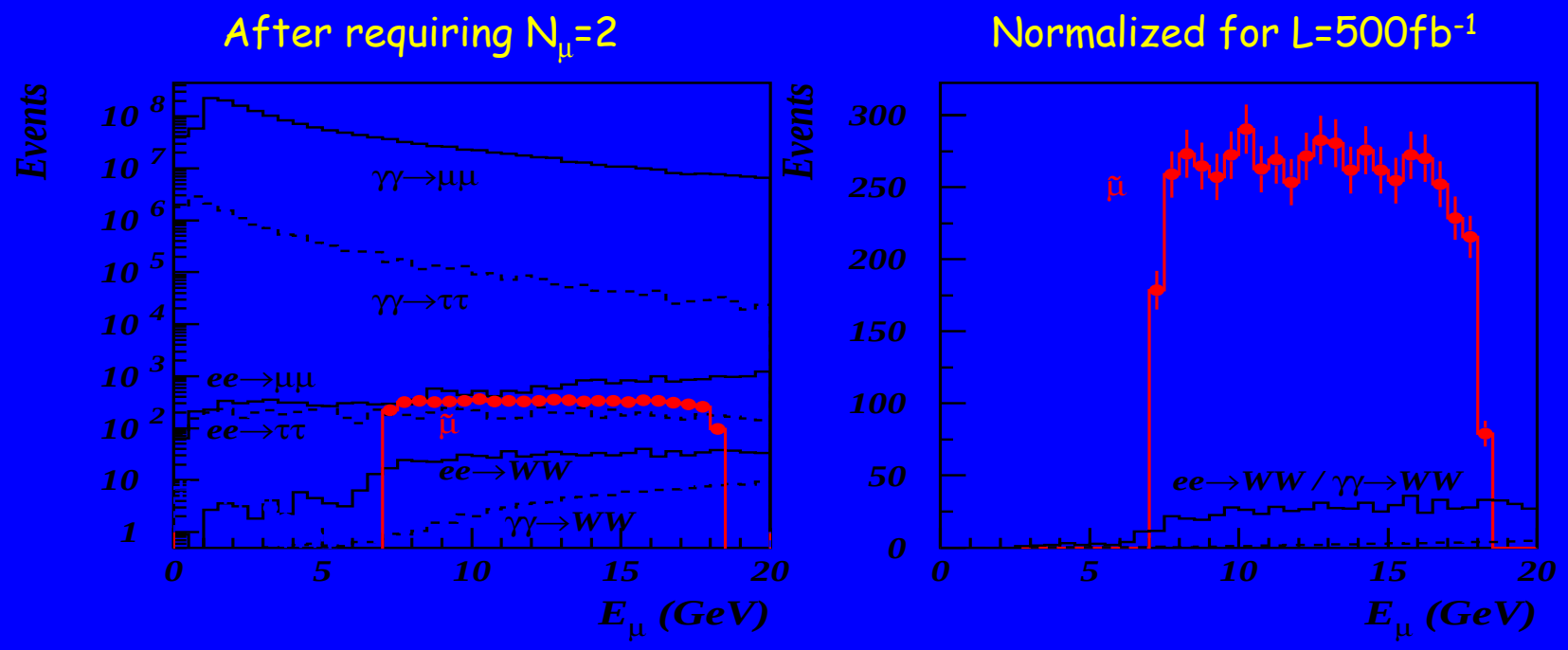




Preliminary $\tilde{\mu}$ result

from Z. Zhang

benchmark point D' with $\Delta m_{\tilde{\mu}-\chi}$ = 12 GeV



Same cuts OK for both head-on and crossing-angle collisions

signal efficiency ~ 80%

spectrum end-points preserved

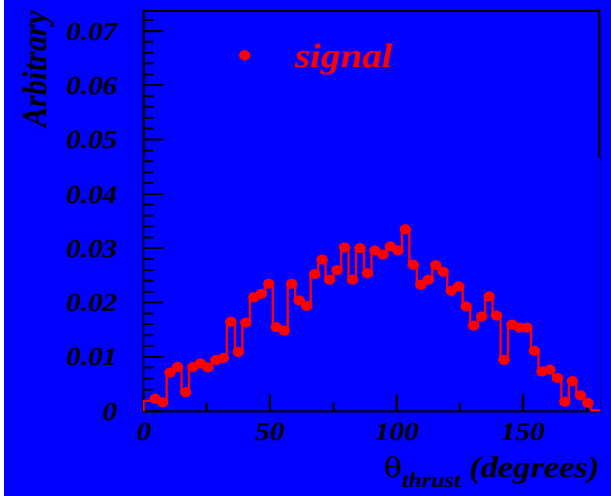
➔ $m_{s\mu}$ and m_{LSP} can be measured with precision for this benchmark point

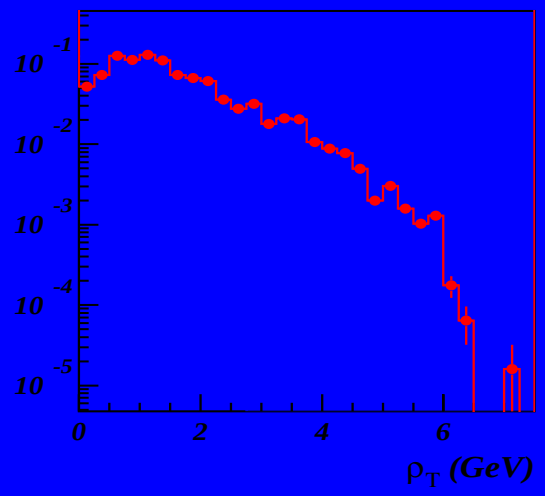
➔ more model-independent : smallest $\Delta m_{s\mu-\chi}$ detectable wrt to veto angle and quality ?

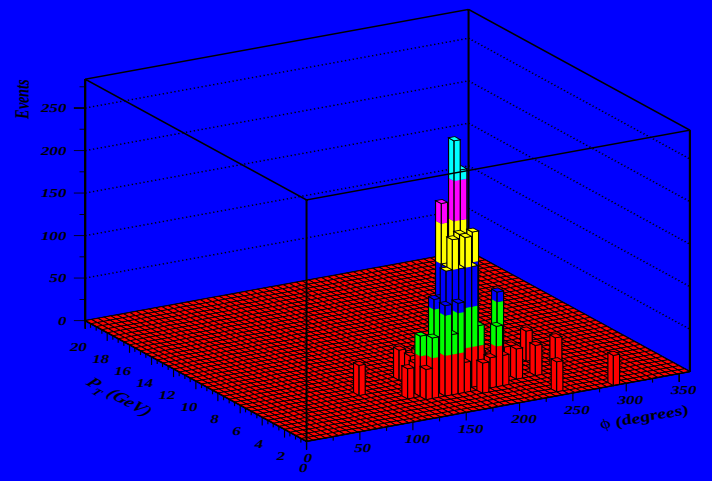
Preliminary $\tilde{\tau}$ result

benchmark point D' with $\Delta m_{\tilde{\tau}-\chi} = 5$ GeV

from Z. Zhang







Thrust axis angle in 3-dim

Σ P_T sum wrt thrust axis in the transverse plane

Azimuthal dependence in the transverse momentum

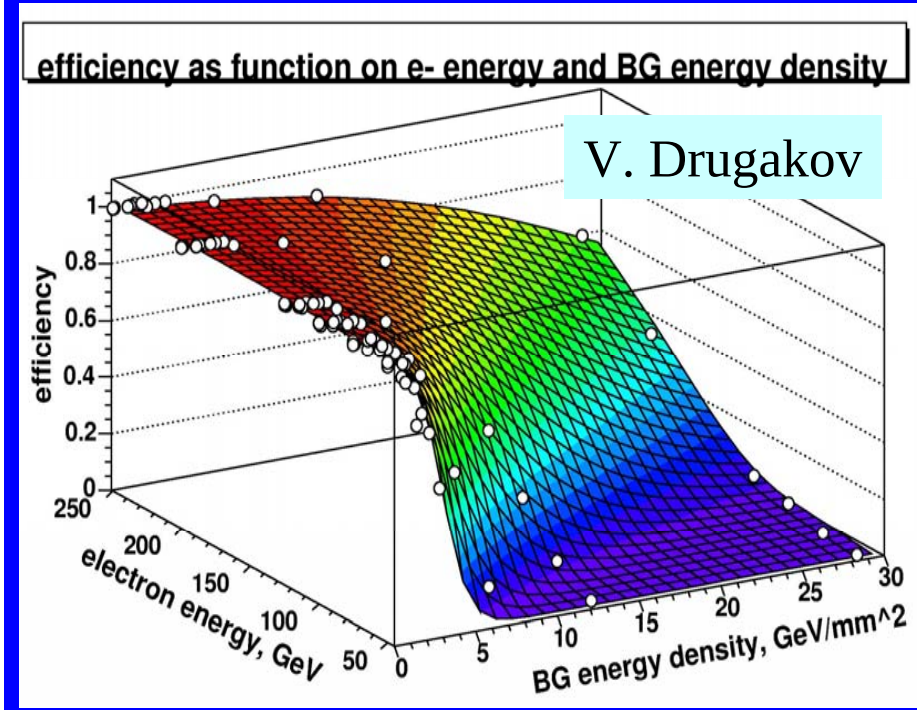
degradation visible but not huge

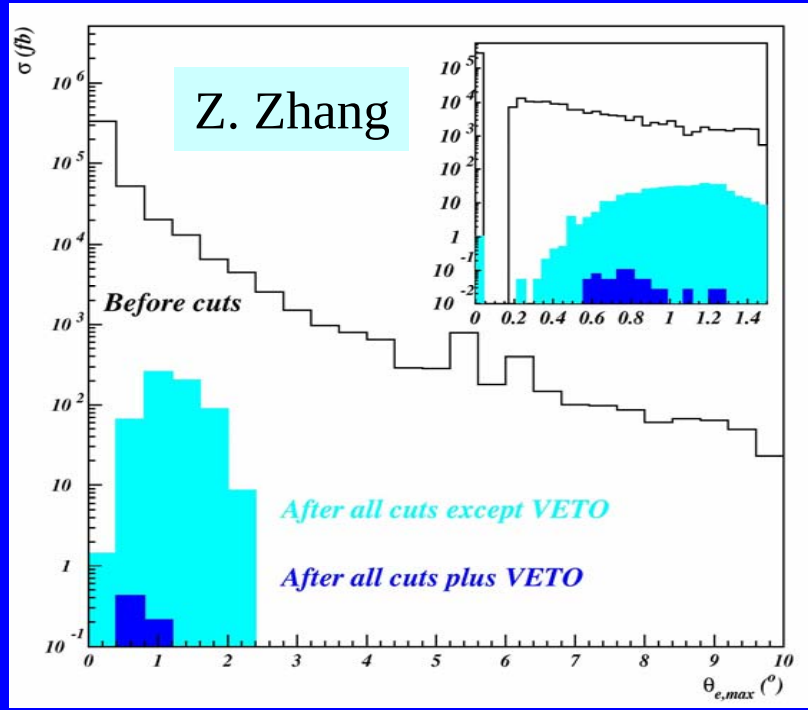
	head-on	crossing-angle
signal efficiency	~ 11 %	~ 8 %
S/B ratio	3.1 ± 1.3	2.4 ± 1.1

Caveat 1 : TESLA → electron veto efficiencies with beamstrahlung pairs from single bunch crossing ; warm LC will need fast read-out (R&D?) to avoid pile-up

Caveat 2 : some physics backgrounds still need to be fully included in the analysis

Importance of high veto efficiency (BeamCAL)





only one crossing
→ no pile-up

$ee \to \tau\, \chi^0\, \tau\, \chi^0$ $\quad$ $ee \to (e)(e)\, \tau\, \tau$

$\sigma \sim 10$ fb $\quad$ $\sigma \sim 10^6$ fb

analysis $\Rightarrow$ $\sigma \sim 1$ fb $\quad$ $\sigma \sim 600$ fb $\quad$ $\langle \varepsilon_{VETO} \rangle \sim 0.999$

analysis + veto $\Rightarrow$ $\sigma \sim 1$ fb $\quad$ $\sigma \sim 0.7$ fb $\quad$ S/N ~ 1

SLAC / ESA test beam proposal

Effect of crossing-angle on cms energy calibration

- Acollinearity angle of Bhabha events monitor the luminosity-weighted centre-of-mass spectrum in the presence of ISR and beamstrahlung

S. Boogart
D. Miller

$$\text{Reconstructed } \frac{\sqrt{s'}}{\sqrt{s}} = \sqrt{\cot\frac{\theta^*_+}{2}\cot\frac{\theta^*_-}{2}}$$

Desired precision :

~ few 10^{-4} - 5 10^{-5} for top & W masses

(10^{-5} - 10^{-6} to improve M_Z measurement)

No problems from a crossing-angle → the boost can be corrected exactly in the ultra-relativistic limit

T. Barklow

Steering and depolarisation from the solenoid with a 10 mrad crossing-angle

K. Mönig
(+ M. Woods)

- Solenoid B field not aligned to momentum ⇒ deflection ~ 0.4 mrad
  (assumes total length = 8 m, B = 4 T, E_b = 250 GeV)
- 100 % longitudinal polarisation ⇒ spin precession to IP ~ 115 mrad is known and can be corrected ⇒ $\Delta\mathcal{P}$ = 1- cos(0.115) = 0.7 %
- If measurement error of polarimeter $\Delta\mathcal{P}$ ~ 0.5 % ⇒ additional spin misalignment ~ 100 mrad ⇒ $\Delta\mathcal{P}$ = cos(0.115) – cos(0.215) = 1.6 % !
- Must include effects from fringe fields ⇒ $\Delta\mathcal{P}$ = 0.7 %

Physics requirement

G. Mortgat-Pick

new physics searches	SM tests @ HE	SM tests @ GigaZ
$\Delta\mathcal{P}$ ~ 0.5 %	$\Delta\mathcal{P}$ ~ 0.2 - 0.1 %	$\Delta\mathcal{P}$ < 0.1 %

⇒ extra vertical bends (+ some tuning) required to correct for both effects (M. Woods et al. are working on this)

Energy and polarisation calibration strategies

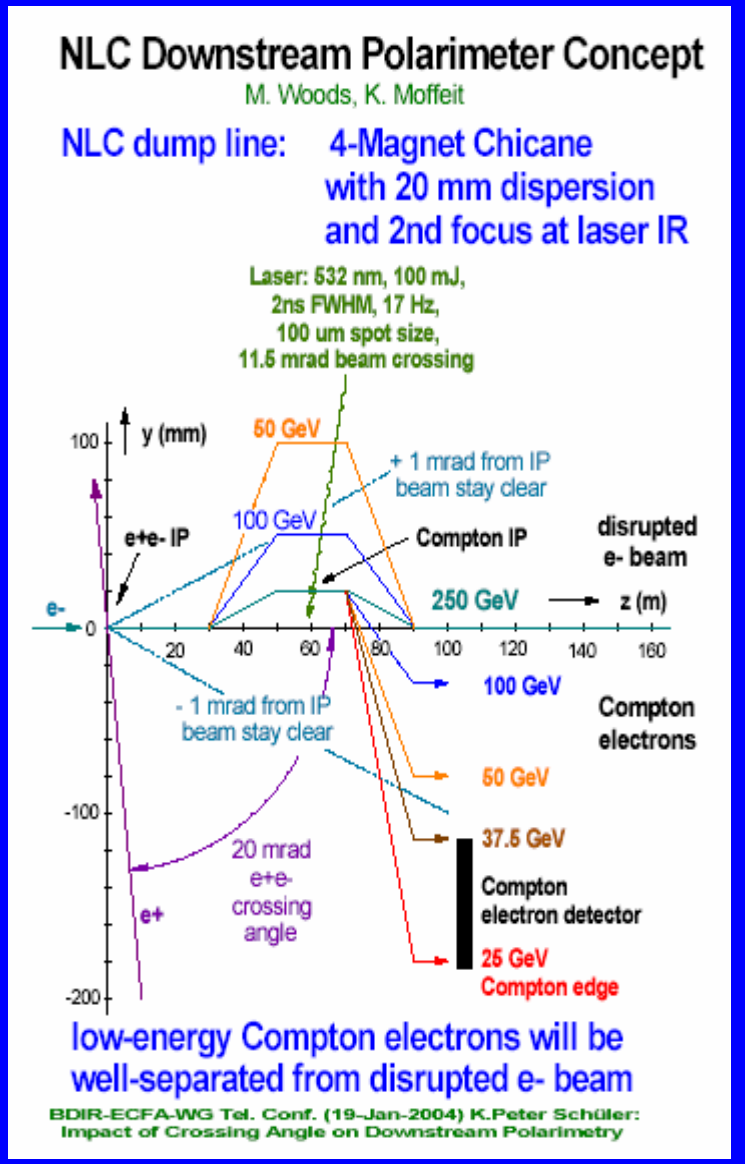
1. relevant lumi - wtd info from Bhabhas, $Z\gamma$, WW,… processes $\rightarrow$ needs statistics
2. pre-IP calibration needed to monitor incoming changes in E and P
3. post-IP very desirable to measure beam-beam effects and validate simulation

but quasi impossible with head-on collisions : how essential ?

Example : beam-beam depolarisation
1. spin precession in the magnetic field
2. spin-flip probability in beamstrahlung

total depolarisation $\sim 4 \times$ lumi - weighted

Nice bonus of crossing-angle but not major physics reason to choose to have one



Bottom-line on crossing-angle-or-not physics implications

Head-on quantifiably better for some aspects but crossing-angle attractive to enable good spent beam diagnostics (redundancy !)

Overall physics balance slightly in favor of head-on geometry but both are certainly acceptable for physics

Driving issues mainly on technical side → two main risk factors:

- head-on: constrained extraction potentially limiting the luminosity and/or energy performances, electrostatic separators
- crossing-angle: demonstration of very small quads, complications from crab-crossing tuning and requirements

TESLA can choose: head-on-or-not, magnitude of the crossing-angle...

Hybrid schemes combining virtues of both may be possible in TESLA

⇒ { 0.3 mrad vertical angle (Brinkman)
1 mrad horizontal angle (Napoly). }

R. Appleby

Not a LC technology choice driver - Background pile-up matters more