Physics Case and ILC polarized Positron Source Plans

- Motivation
- Physics cases for polarized beams
- Status e+ sources at linear collider
- Conclusions

LINEAR COLLIDER COLLABORATION

Required features at LHC & ILC

⇒ In order to reveal the structure of the underlying (new) physics:

- ⋆ high energy desirable to reach the scale of new physics
- ⋆ high luminosity needed to get sufficient statistics
- ⋆ high level of experimental flexibility needed
- ⋆ high precision measurements needed to get access to the quantum structure

→ *need to be prepared for the unexpected !*

⇒ Spin and polarization physics is important

→ access to quantum properties, structure of couplings, etc.

⇒ How to exploit spin effects in particle reactions?

initial particles		short-living, intermediate states		final particles
e+ e-	→	fermion1 + fermion2	→	quarks, leptons
↓		↓		↓
beam polarization		*spin correlations*		*polarization of top, τ*
LC, today only		*LHC, LC: CP e.g.*		*LC, partially LHC*

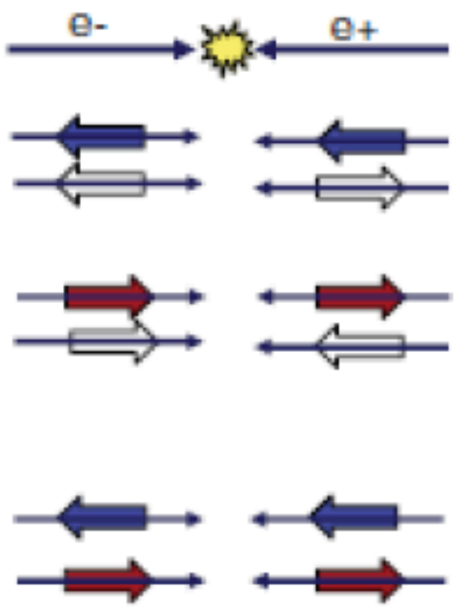
Statistical arguments

- Effective polarization

$$P_{eff} := (P_{e^-} - P_{e^+})/(1 - P_{e^-}P_{e^+})$$
$$= (\#LR - \#RL)/(\#LR + \#RL)$$

- Fraction of colliding particles

$$\mathcal{L}_{eff}/\mathcal{L} := \frac{1}{2}(1 - P_{e^-}P_{e^+}) = (\#LR + \#RL)/(\#all)$$



P_{e-}	P_{e+}	h_{e-}	h_{e+}	cross section
-1	0	-1	+1	σ_{LR}
		-1	-1	σ_{LL} → 0
+1	0	+1	-1	σ_{RL}
		+1	+1	σ_{RR} → 0
-1	+1	-1	+1	σ_{LR}
+1	-1	+1	+1	σ_{RL}

½ of events do not react !

⇒ Enhancing of $\mathcal{L}_{eff}$ with $P(e^-)$ and $P(e^+)$!

Statistical arguments

- Effective polarization

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$$= (\#LR - \#RL)/(\#LR + \#RL)$$

- Fraction of colliding particles
$\mathcal{L}_{eff}/\mathcal{L} := \frac{1}{2}(1 - P_{e^-}P_{e^+}) = (\#LR + \#RL)/(\#all)$

Colliding particles:

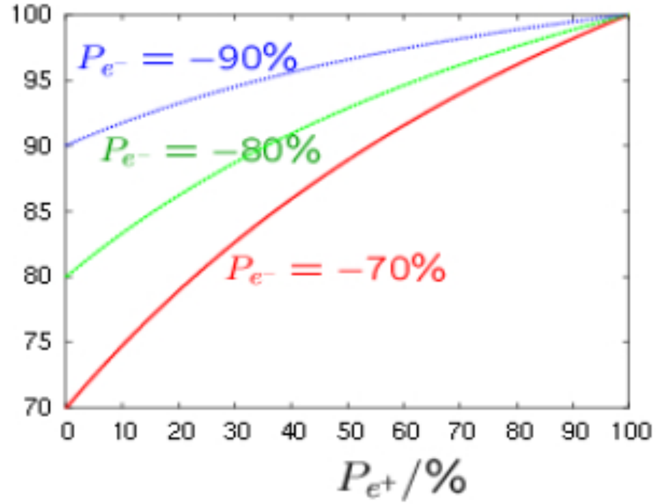
	RL	LR	RR	LL	P_{eff}	$\mathcal{L}_{eff}/\mathcal{L}$
$P(e^-) = 0$, $P(e^+) = 0$	0.25	0.25	0.25	0.25	0.	0.5
$P(e^-) = -1$, $P(e^+) = 0$	0	0.5	0	0.5	-1	0.5
$P(e^-) = -0.8$, $P(e^+) = 0$	0.05	0.45	0.05	0.45	-0.8	0.5
$P(e^-) = -0.8$, $P(e^+) = +0.6$	0.02	0.72	0.08	0.18	-0.95	0.74

$\Rightarrow$ Enhancing of $\mathcal{L}_{eff}$ with $P(e^-)$ and $P(e^+)$!

Impact of P(e+)

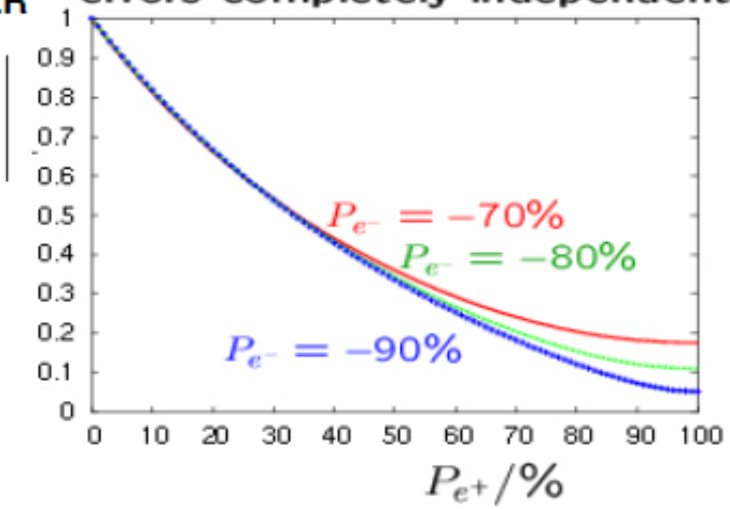
- **Statistics**

P_{eff} /%



- **And gain in precision**

$\sim \Delta A_{LR}/A_{LR} = \left|\frac{\Delta P_{eff}}{P_{eff}}\right|$



- (80%,60): P_{eff} = 95% — (90%,60%): P_{eff} =97% — (90%, 30%): P_{eff} =94 %

  $\Delta A_{LR}/A_{LR}$ = 0.3 — $\Delta A_{LR}/A_{LR}$ = 0.27 — $\Delta A_{LR}/A_{LR}$ =0.5

  gain: factor~3 — factor>3 — factor~2

- **NO gain with only pol. e- (even if '100% ') !**

Main benefits of simultaneous e^+ polarization?

- **Better Statistics: Less running time/operation cost for same physics**
  - higher rates, lower background, higher analyzing power for chosen channels

- **Lower Systematics**
  - key role for reduction of systematics originating from polarization measurement

- **More Observables**
  - Four distinct data-sets: opposite-site polarization collisions plus like-sign configuration ⟶ unique feature of ILC (including transversely but also unpolarized configurations!)

Why are polarized beams required?

- **Important issue: measuring amount of polarization**
  - limiting systematic uncertainty for high statistics measurements
  - Compton polarimeters (up- /downstream): envisaged uncertainties of $\Delta P/P=0.25\%$
- **Adding positron polarization required:**
  - Substantial enhancement of eff. luminosity and eff. polarization and independent observables
  - handling of limiting systematics and access to in-situ measurements
  - more observables available including options of transversely polarized beams
  - Windows to new physics already at low energy!
- **Physics impact: Higgs-Physics, WW/Z/top-Physics, New Physics**

Literature: polarized e+e- beams at a LC (only a few examples)

- LCC-Physics Group: 'The role of positron polarization for the initial 250 GeV stage of ILC', arXiv: 1801.02840
- G. Moortgat-Pick et al. (~85 authors) : `Pol. positrons and electrons at the LC', Phys. Rept. 460 (2008), hep-ph/0507011
- G. Wilson: `Prec. Electroweak measurements at a Future e+e- LC', ICHEP2016, R. Karl, J. List, LCWS2016, 1703.00214
- many more (only few examples): 1206.6639, 1306.6352 (ILC TDR), 1504.01726, 1702.05377, 1908.11299,2001.03011, …
- G. Moortgat-Pick, H. Steiner, `Physics opportunities with pol. e- and e+ beams at TESLA, Eur.Phys.J direct 3 (2001)
- T. Hirose, T. Omori, T. Okugi, J. Urakawa, Pol. e+ source for the LC, JLC, Nucl. Instr. Meth. A455 (2000) 15-24

Why are polarized beams required?

- Please remember: excellent e- polarization ~78% at SLC:
  - led to best measurement of $\sin^2\theta=0.23098\pm0.00026$ on basis of $L\sim10^{30}\ cm^{-2}s^{-1}$
- Compare with results from unpolarized beams at LEP:
  - $\sin^2\theta=0.23221\pm0.00029$ but with $L\sim10^{31}cm^{-2}s^{-1}$

➡*Polarization essential for suppression of systematics!*

Beyer,List Spin21

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Polarization measurement

- **Compton polarimeters: up- and downstream**
  - envisaged uncertainties of $\Delta P/P=0.25\%$ (at polarimeters!)
  - But that's is not enough for IP!
- **Use collision data to derive luminosity-weighted polarization**
  - single W, WW, ZZ, Z, etc.: combined fit

$$P^{-}_{e\pm} = -\,|P_{e\pm}| + \tfrac{1}{2}\delta_{e\pm} \qquad P^{+}_{e\pm} = \;\; |P_{e\pm}| + \tfrac{1}{2}\delta_{e\pm}$$

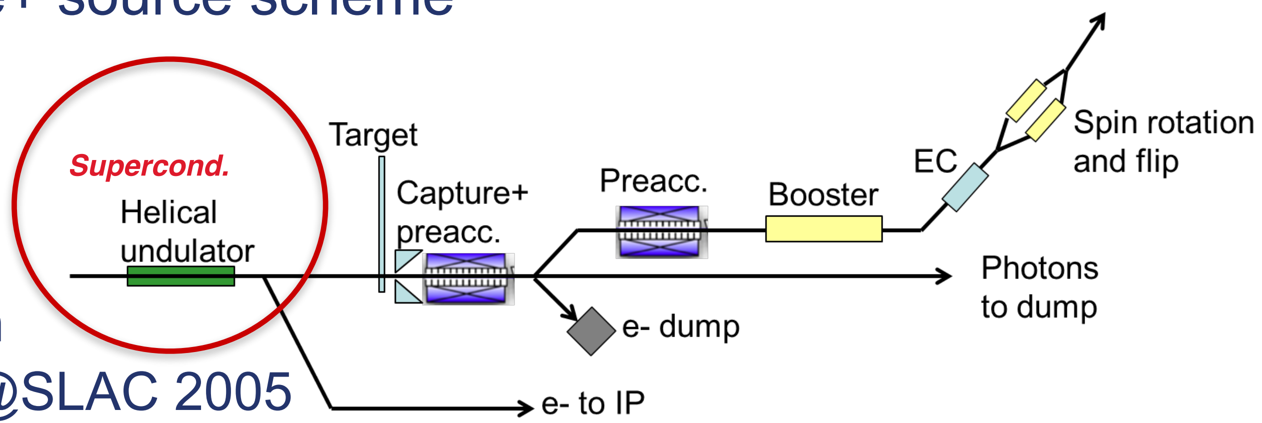
Karl, List,1703.00214

  - helicity reversal is important
  - non-perfect helicity-reversal can be compensated
  - 0.1% accuracy in $\Delta P/P$ is achievable at IP!
  - *NOT achievable without Pe+!*

Remember: even if no Pe+ (SLC! dedicated experiment at SLACs Endstation A), the P_{e+}~0.0007 had to be derived a posteriori for physics reason!

TDR baseline layout of the e+ source

- The polarized e+ source scheme



Principle tested with
E-166 experiment @SLAC 2005

G. Alexander et al., NIMA 610 (2009), G. Alexander et al., Phys.Rev.Lett.100 (2008)

- ILC e+ beam parameters (nominal luminosity)

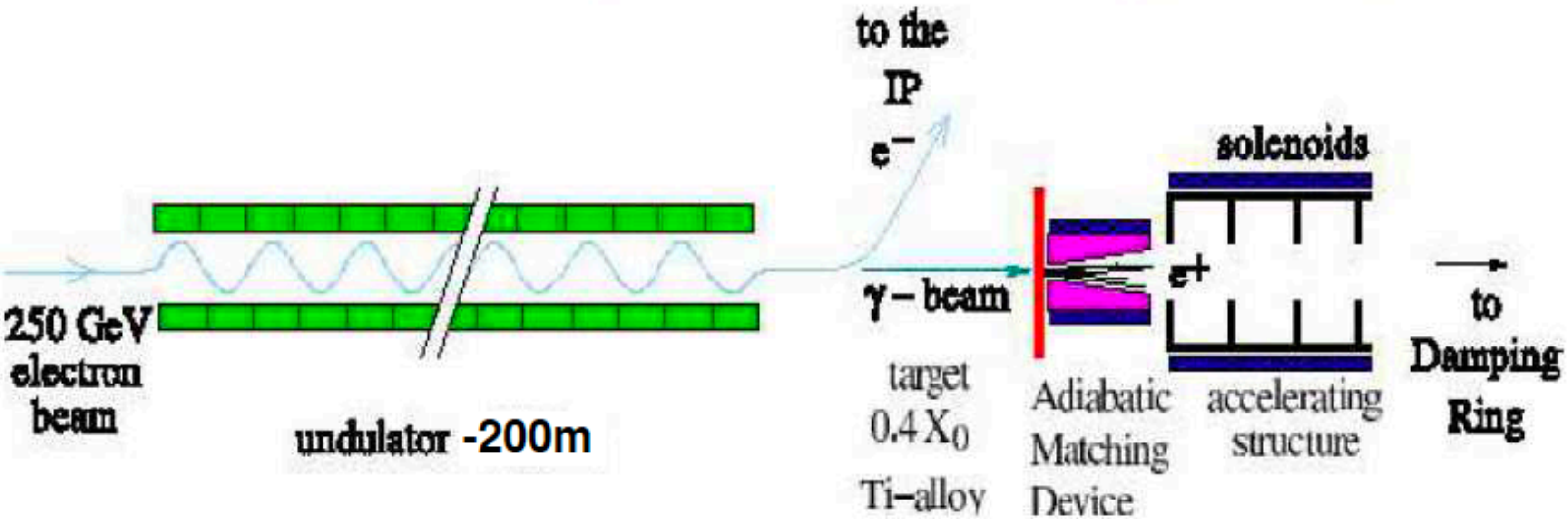
Number of positrons per bunch at IP	2×10^{10}
Number of bunches per pulse	1312
Repetition rate	5 Hz
Positrons per second at IP	1.3×10^{14}

That's about a factor 100 more compared to SLC!

– Required positron yield: Y = 1.5e+/e- at damping ring

Short overview: e^+ sources at ILC

- Conventional source: e- scattering in target → pair production → e+
- Undulator-based scheme: polarized e+ via circularly polarized photons



→ deviation of e- beam via helical magnetic field in undulator

→ radiated circularly polarized photons onto thin target, pair production

→ e+ yield and polarization depends on beam energy and undulator length

Short overview: e^+ sources at ILC

	SLC	ILC (RDR)	CLIC
e+/bunch	3.5×10^{10}	2×10^{10}	0.64×10^{10}
Bunches/ pulse	1	2685	312
Pulse rep rate	120	5	50
e+/s	0.042×10^{14}	2.6×10^{14}	1×10^{14}

➢ **in general: demanding challenges for the e+ source!**

- **Beam polarization status: at cms=250 GeV: $P(e^-)$~80-90%, $P(e^+)$~30%**
  =350,… ,500 GeV: $P(e^-)$~80-90%, $P(e^+)$=40% (60% with collimator)

(with chosen undulator parameters for cms=500 GeV)

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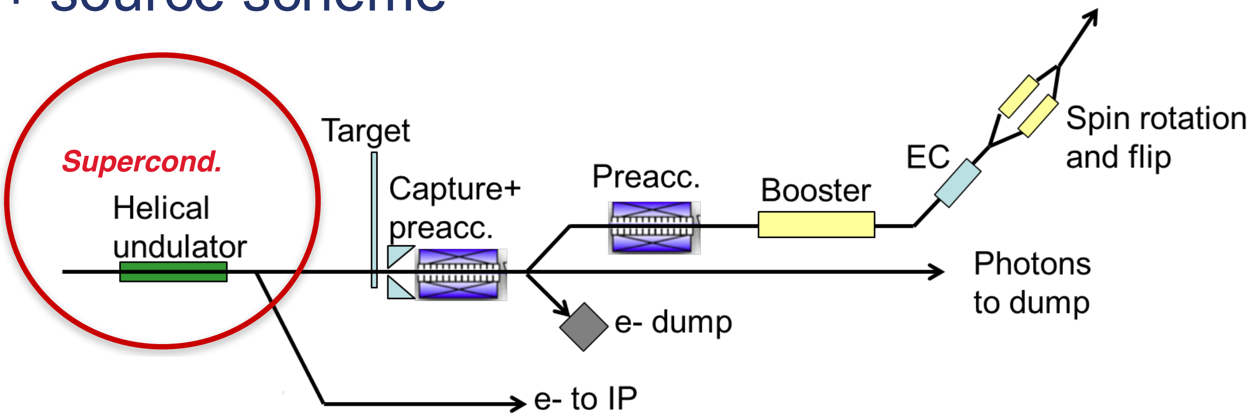
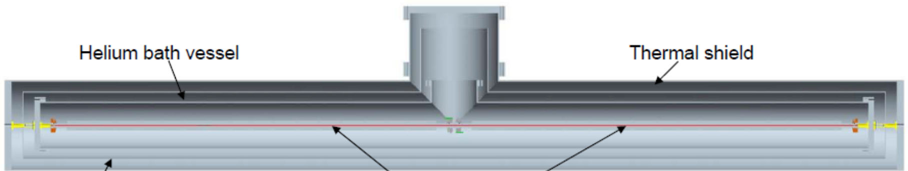


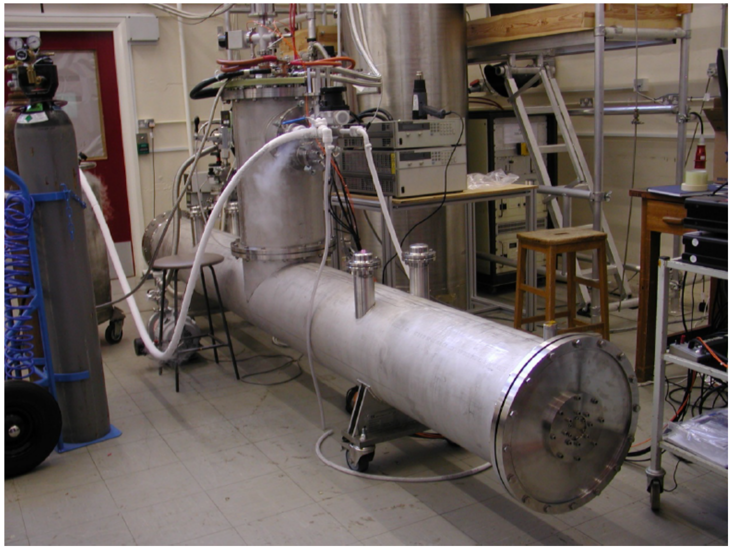
Work package	Items
WP-5: Undulator	Simulation (field,errors, alignment)
WP-6: Rotating target	Design finalization, partial laboratory test, mock-up design
	Magnetic bearings: performance, specification, test
	Full wheel validation, mock-up
WP-7: Magnetic focusing system	Design selection (FC, QWT, pulsed solenoid, plasma lens), with yield calculation
	OMD with fully assembled wheel

Undulator technology - Status

- Parameters
  - Undulator period, λ_U =11.5mm
  - Undulator strength K ≤ 0.92 (B ≤ 0.86T); $K \sim B \cdot \lambda_U$
  - Undulator aperture 5.85mm
- 4m prototype built and tested (UK)
  - Cryomodule, contains 2 undulator modules of 1.75m length each

D.Scott et al.,Phys. Rev. Lett. 107, 174803 (2011)





- ILC TDR (2013):
  - Max 231m active undulator length available (132 undulator modules in 66 cryomodules]
  - Quadrupoles every 3 cryomodules → total length of undulator system is 320m

Progress since TDR

K. Alharbi, PhD 2022
S. Riemann, GMP

- **Detailed ILC undulator simulations performed:**
  - realistic fields, masks and power deposition, misalignments
- **Undulator operation: experience with long undulators**

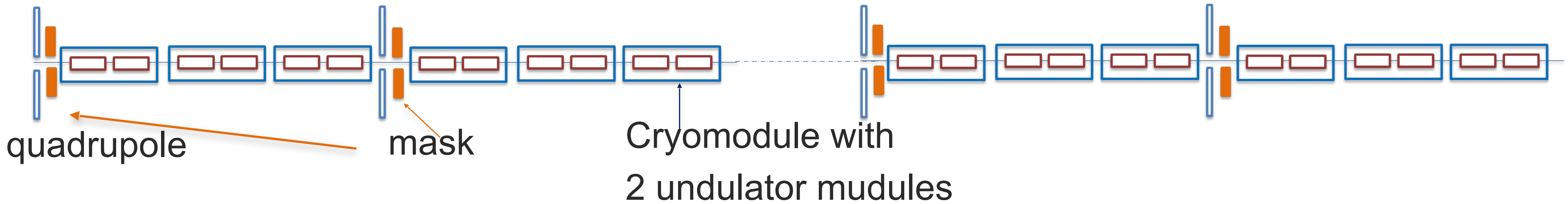
W. Decking/XFEL
LCWS21

  - XFEL: 91 undulators with 5m length each
  - energy loss due to particle loss negligible small (unmeasurable)
  - beam alignment up to 10-20 microns for 200 m (undulator length), remeasured every 6 months
  - during beam operation: beam trajectory controlled better than 3 micron with both slow and fast feedback systems
- **Stable operation and alignment experience**
  - Beam requirements at XFEL more challenging than at ILC due to FEL requests of photons
  - Tolerances of IlC undulator more relaxed than for XFEL!
- **Result: no operation&alignment issues for ILC undulator**

WP5 Undulator: Simulation (field errors, alignment)

Alharbi, Thesis 22

- Misalignments:
  - beam spot increases slightly, yield decreases slightly (see A.Ushakov, AWLC18)
- Realistic undulator with B field and period errors
  - Beam spot size increases slightly
  - Polarization decreases slightly
- Synchrotron radiation deposit in undulator walls
  - Masks protect wall to levels below 1W/m
  - ILC250: power deposition in ’last’ mask near undulator exit: ~300W



- Finalize undulator line (quadrupoles, masks,…)
- Simulation of e+ yield and polarization including realistic undulator tolerances and misalignment

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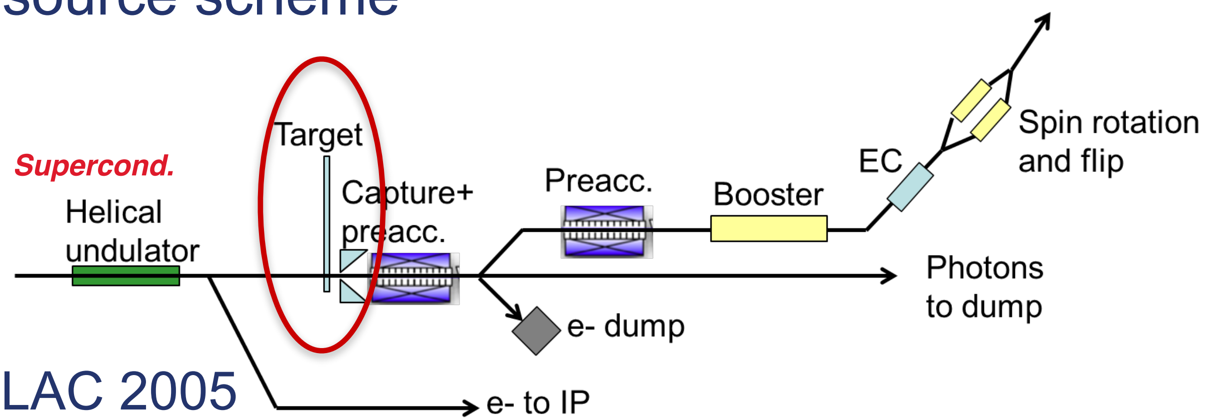

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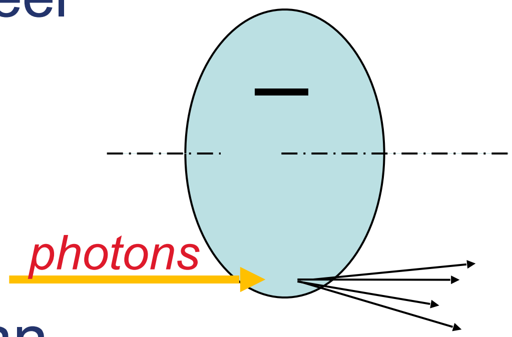
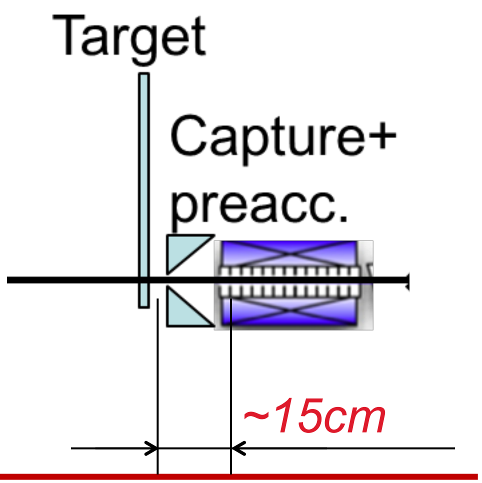
The positron target

- Is located ~240m downstream the undulator end
- 62 kW photon beam ⇔ about few 10^{16} photons/second
- Only few % of the photon beam power is deposited in the target
- Target is designed as 1m wheel
  material: Ti6Al4V
  spinning in vacuum



- The e+ are collected with an Optical Matching Device (OMD):
  - Maximum magnetic field (≥1T) about ~1cm from target exit to achieve high e+ yield



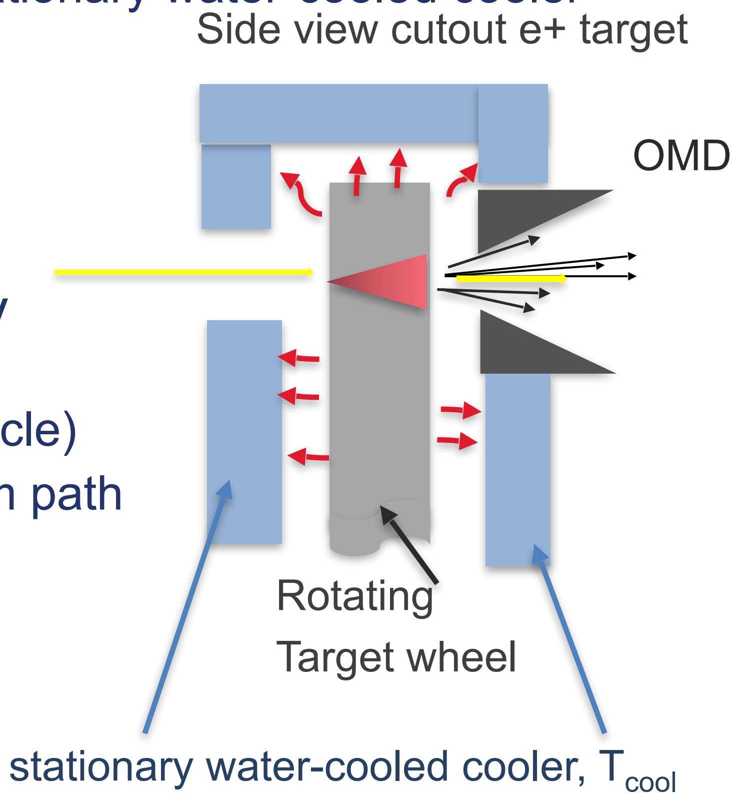
Cooling of the target wheel

- Water cooling (TDR design) does not work
- Few kW heat deposition can be removed with thermal radiation:
  - heat radiates from spinning target to a stationary water-cooled cooler

$$P \sim \sigma \varepsilon A \left(T_{radiator}^4 - T_{cool}^4\right)$$

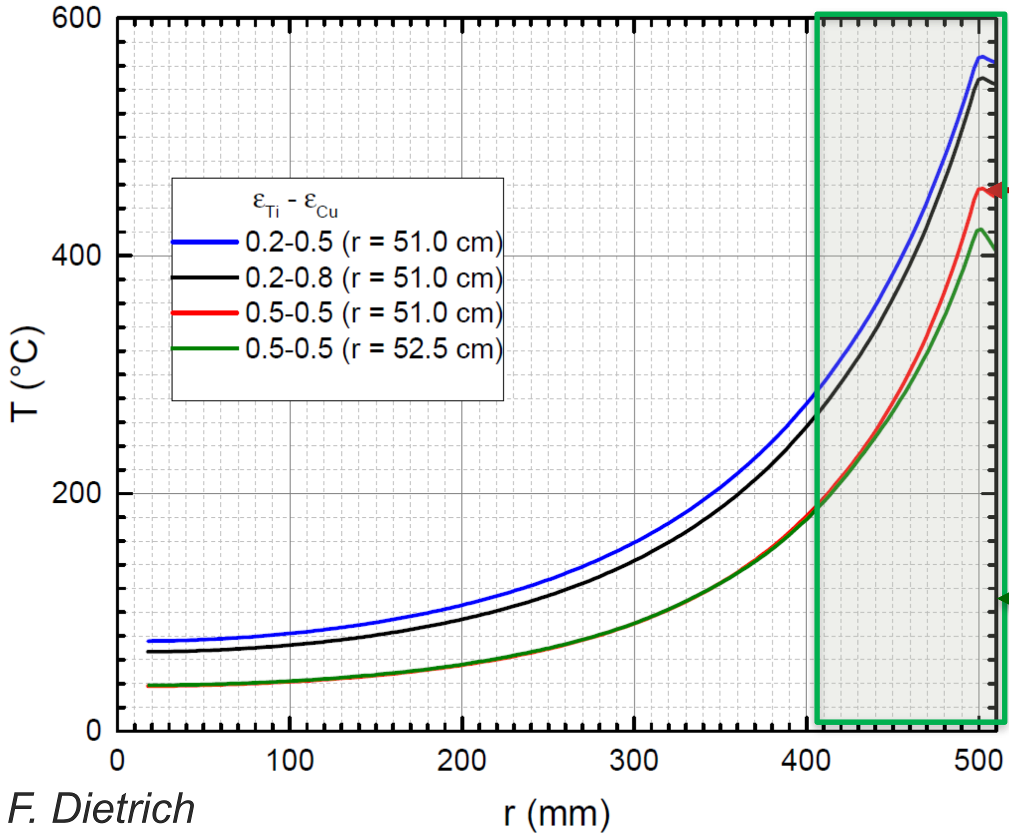
ε = effective emissivity

- Ti alloys have low thermal conductivity (λ = 0.06 – 0.15 K/cm/s)
  - heat propagation ~ 0.5cm in 7sec (load cycle)
  - heat accumulates in the rim near to beam path



Temperature distribution in target

Average temperature in Ti6Al4V wheel as function of radius r for different surface emissivity of target and cooler (Cu); Target wheel assumed as disk



F. Dietrich

Photon beam impact at r=50cm

Deposited power = 2kW

ε_{eff}= 0.33 for $\varepsilon_{Ti} = \varepsilon_{Cu}$=0.5

$T_{ave} \leq 460^\circ C$

max average temperatures can be decreased for larger wheel radius

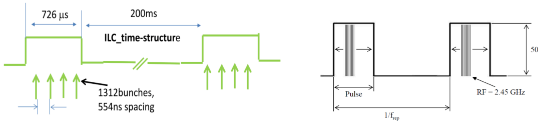
Main cooling power from area with r_0 ±5cm

Studies (FLUKA, ANSYS) show that such spinning disk stands heat and stress load

Progress since TDR: Target material

- **Target Material Tests at Mainz Microtron (MAMI) using e-**
  - **Goal: electron-beam on ILC target materials, generating cyclic load with same/ even higher PEDD at target than expected at ILC**
  - **Several successful tests performed on Ti-Alloy**
  - **Further tests foreseen in 22 with other materials and higher instantaneous load**
  - **Sophisticated target analyses with laser scanning also synchrotron diffraction methods performed**

Target Tests:	ILC e+ target	MAMI
Beam particles	photons	electrons
Average energy	7.5…40MeV	14 MeV, 3.5MeV
ΔT_{max} /pulse	60-120K	50-350K
Max energy deposition density in target	~60J/g	~50-200J/g
Eff. pulse length on material	25-55µs	1-5ms
Eff. pulse rep rate on material	0.17 Hz	1Hz …120Hz
Displacement per atom (dpa)	~0.3-0.5 per year	~0.33/24h (14MeV) ~0.22/24h (4MeV)

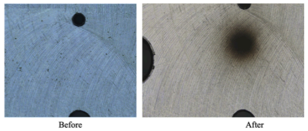


A. Ushakov et al., IPAC2017

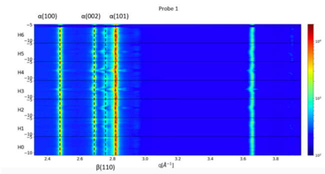
Results of diffraction method:

- used in transmission as well as reflection geometry
- Phase transitions between α- and β-phase in Ti-alloy observed
- only for 'cw-mode target' phase transition significant
- Targets applicable for future HEP experiments
- Results published in Bachelor thesis

Target before and after radiation:



α/β phase transitions in Ti-6Al-4V:



T. Lengler, BThesis 2020

- **Result: ILC undulator target will stand the load**

Progress since TDR

- Target tests at MAMI
  - Demonstrate the robustness of the target material against cyclic load at high temperatures
  - Result: No target damage for ILC undulator target

- Cooling of target wheel
  - The initial TDR-Undulator target (water cooled spinning in vacuum) was revisited:
    - Cooling by thermal radiation, thus avoiding a vacuum tight rotating seal (organic oil and iron powder).
    - Wheel completely, hermetically sealed in UHV-vacuum.
    - Rotating axis supported by contactless, maintenance free magnetic bearings.

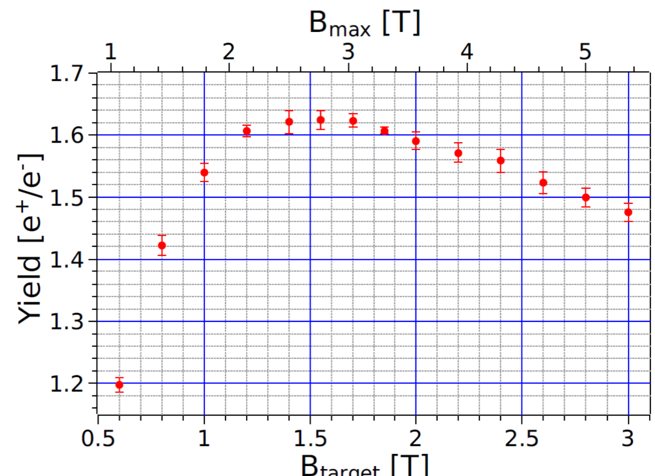
OMD: Pulsed solenoid

Talk C. Tenholt, later

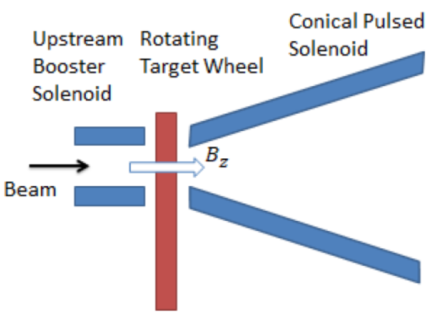
Idea:

Pulsed B field at target

- increases e+ yield
- Increases load at target only slightly



P. Sievers, POSIPOL18, LCWS19



Peak magnetic field	5.2 T
Field at target	3 T
Field at target with upstream booster coil	4 T
Stress due to magnetic field	$\leq$ 40 MPa
Beam induced effects at entrance of the solenoid, r=1 cm	PEDD 13 J/g
Average beam power deposition	600 W/cm^3
Thermal stress	$\approx$ 100 MPa
displacement per atom (dpa)	0.15/5000 h

Current detailed simulation (M. Mentink 1/21, G. Loisch&C. Tenholt 21/22):

- with COMSOL including Eddy currents, dep. power, masks etc.
- Yield (M. Fukuda, 10/21): matches ILC requirements!

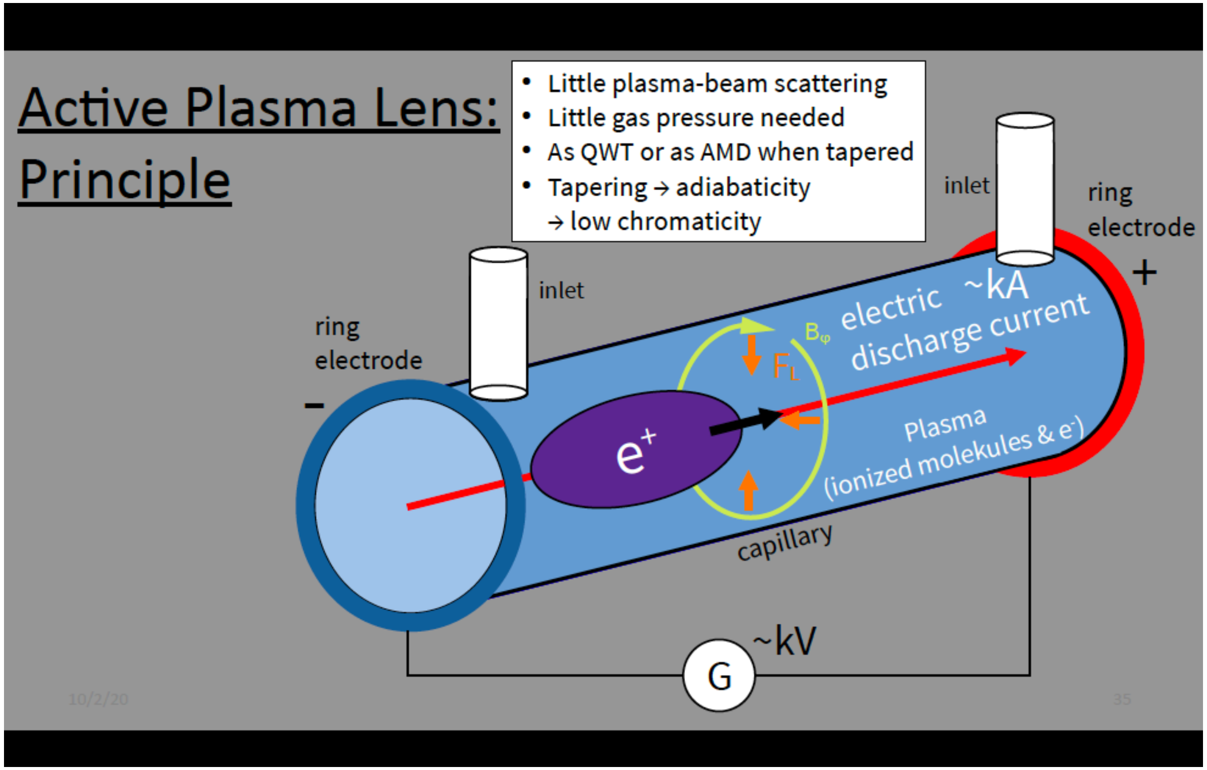
Fukuda/Loisch/Sievers/Tenholt, ILCX 10/'21

Talk G. Loisch, later

Further OMD Design: Plasma Lens

Idea: Plasma Lenses *K. Flöttmann, C. Lindström*

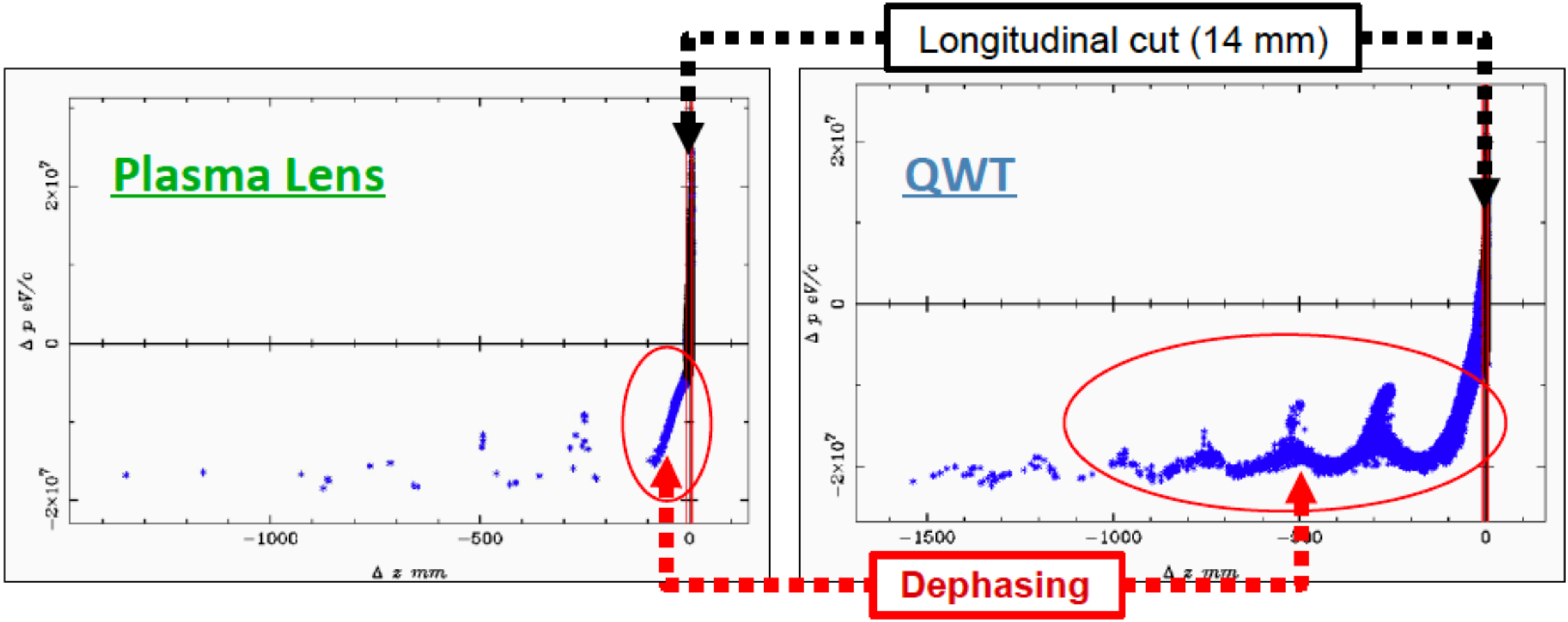
- increases e+ yield but Increases load at target only slightly
- advantages in matching aspects



M. Formela, N. Hamann, IPAC21

Dephasing Advantage of the Plasma Lens

The azimuthal magnetic field of the plasma lens leads to a sinusoidal trajectory (helical for QWT), which results in an effectively shorter path and therefore smaller longitudinal spread, the so called dephasing.



M. Formela, N. Hamann, IPAC21

Simulations with ASTRA

Optimization Results of Tapered Active Plasma Lens as OMD

41.7% captured e^+ within DR energy acceptance of .75% (14 mm long. Cut)
→ ~50% improvement over ILC's current proposed OMD (QWT) design

Optimized Parameters at I_0 = 3000 A

	Symbol	Optimal Value
PL Length	z_{max}	6 cm
Opening Radius	R_0	3.8 mm
Tapering Order	n	1
Tapering Strength	g	136 m^{-1}
PL-SWT distance	d	1 cm
SWT Phase	φ_0	220°

Tapered PL cavity profile: $R(z) = R_0(1+gz)^n$

Captured Yield Stability of the Opimum

		Captured Yield Deviation for deviations in optimized parameter by	
Parameter	Symbol	-10% offset	+10% offset
PL Length	z_{max}	-0.3% yield	-0.2% yield
Opening Radius	R_0	-0.1% yield	-1.1% yield
Tapering Strength	g	-0.2% yield	-0.3% yield
Current strength	I_0	-1.5% yield	+1.2% yield
PL-SWT distance	d	+0.2% yield	-0.2% yield
SWT Phase	φ_0	-0.5% yield	-0.4% yield

2021-05-09 IPAC2021 5

➡funded project 21-24, started at Hamburg, see talk G. Loisch

Summary

- Polarized $e^{\pm}$ required to fulfill physics promises!
- Undulator-based positron source mature design
    - offers in addition polarized e+ !!!
- Lots of progress since ILC TDR
    - Operating experiences XFEL
    - Target tests
- News on OMD
    - Pulsed solenoid design
    - Plasma Lenses (new technology)
- More collaborators welcome!
    - all WP, but in particular for WP6!

Active platform for mature design and new technologies!

Further Physics Examples

Case	Effects	Gain
SM:		
top threshold	Improvement of coupling measurement	factor 3
$t\bar{q}$	Limits for FCN top couplings reduced	factor 1.8
CPV in $t\bar{t}$	Azimuthal CP-odd asymmetries give access to S- and T-currents up to 10 TeV	$P^T_{e^-} P^T_{e^+}$ required
W^+W^-	Enhancement of $\frac{S}{B}$, $\frac{S}{\sqrt{B}}$	up to a factor 2
	TGC: error reduction of $\Delta\kappa_\gamma$, $\Delta\lambda_\gamma$, $\Delta\kappa_Z$, $\Delta\lambda_Z$	factor 1.8
	Specific TGC $\tilde{h}_+ = \mathrm{Im}(g_1^R + \kappa^R)/\sqrt{2}$	$P^T_{e^-} P^T_{e^+}$ required
CPV in γZ	Anomalous TGC $\gamma\gamma Z$, γZZ	$P^T_{e^-} P^T_{e^+}$ required
HZ	Separation: $HZ \leftrightarrow H\bar{\nu}\nu$	factor 4 with RL
	Suppression of $B = W^+\ell^-\nu$	factor 1.7
SUSY:		
$\tilde{e}^+\tilde{e}^-$	Test of quantum numbers L, R and measurement of $e^\pm$ Yukawa couplings	P_{e^+} required
$\tilde{\mu}\tilde{\mu}$	Enhancement of S/B, $B = WW$ $\Rightarrow m_{\tilde{\mu}_{L,R}}$ in the continuum	factor 5-7
HA, $m_A > 500$ GeV	Access to difficult parameter space	factor 1.6
$\tilde{\chi}^+\tilde{\chi}^-$, $\tilde{\chi}^0\tilde{\chi}^0$	Enhancement of $\frac{S}{B}$, $\frac{S}{\sqrt{B}}$	factor 2–3
	Separation between SUSY models, 'model-independent' parameter determination	
CPV in $\tilde{\chi}^0_i\tilde{\chi}^0_j$	Direct CP-odd observables	$P^T_{e^-} P^T_{e^+}$ required
RPV in $\tilde{\nu}_\tau \to \ell^+\ell^-$	Enhancement of S/B, $S/\sqrt{B}$	factor 10 with LL
	Test of spin quantum number	

Further Physics Examples

ED:		
$G\gamma$	Enhancement of S/B, $B = \gamma\nu\bar{\nu}$,	factor 3
$e^+e^- \to f\bar{f}$	Distinction between ADD and RS modes	$P^{\mathrm{T}}_{e^-} P^{\mathrm{T}}_{e^+}$ required
Z′:		
$e^+e^- \to f\bar{f}$	Measurement of Z' couplings	factor 1.5
CI:		
$e^+e- \to q\bar{q}$	Model independent bounds	P_{e^+} required
Precision measurements of the Standard Model at GigaZ:		
Z-pole	Improvement of $\Delta \sin^2\theta_W$	factor 5–10
	Constraints on CMSSM space	factor 5
CPV in $Z \to b\bar{b}$	Enhancement of sensitivity	factor 3

- **Many new physics examples**
- **Beam polarization always provides 'physics gain'**
- **Crucial sensitivity to coupling structures**
- **Still further new studies ongoing……..**

L_{eff} and P_{eff}

- More concrete: If only LR and RL contributions: only 50 % of collisions useful

effective luminosity: $L_{\rm eff}/L = \frac{1}{2}(1 - P_{e-} P_{e+})$

This quantity = the effective number of collisions, can only be changed with P_{e-} and P_{e+}:

here:

With $\mp$80%, $\pm$30%, the increase is 24%

With $\mp$80%, $\pm$60%, the increase is 48%
With $\mp$90%, $\pm$60%, the increase is 54%

In other words: *no P_{e+} means 24% more running time (!)*
and
10% loss in P_{eff} = 10% loss in analyzing power!

Quite substantial in Higgs strahlung and electroweak 2f production !

L_{eff} and P_{eff}: further example

- Charged currents, i.e. t-channel W- or ν-exchange (A_{LR}=1):

$$\sigma(\mathcal{P}_{e^-}, \mathcal{P}_{e^+}) = 2\sigma_0(\mathcal{L}_{\rm eff}/\mathcal{L})[1 - \mathcal{P}_{\rm eff}]$$

In other words: ***no P_{e+} means 30% more running time needed !***

Quite substantial in Higgs production via WW-fusion!

Statistics Suppression of WW and ZZ production

WW, ZZ production = large background for NP searches!

W^- couples only left–handed:
$\rightarrow$ WW background strongly suppressed with right polarized beams!

Scaling factor= $\sigma^{pol}/\sigma^{unpol}$ for WW and ZZ:

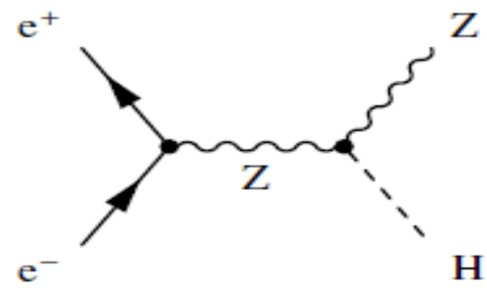
$P_{e^-} = \mp 80\%$, $P_{e^+} = \pm 60\%$	$e^+e^- \rightarrow W^+W^-$	$e^+e^- \rightarrow ZZ$
(+0)	0.2	0.76
(−0)	1.8	1.25
(+−)	0.1	1.05
(−+)	2.85	1.91

'No lose theorem': scaling factors for signals&background

	S	B	S/B	$S/\sqrt{B}$
Example 1	$\times 2$	$\times 0.5$	$\times 4$	$\times 2\sqrt{2}$
Example 2	$\times 2$	$\times 2$	Unchanged	$\times\sqrt{2}$

Process: Higgs Strahlung

$\sqrt{s}$=250 GeV



- $\sqrt{s}$=250 GeV: dominant process
- Why crucial?
  - allows model-independent access!
  - Absolute measurement of Higgs cross section σ(HZ) and g_{HZZ}:
    crucial input for all further Higgs measurement!

  - Allows access to H-> invisible/exotic
  - Allows with measurement of Γ^h_{tot} absolute measurement of BRs!
  - If no P(e+): 20% longer running time!…..*~few years and less precision!*

Higgs Sector @250 GeV

- **What if no polarization / no P_{e+} available?**
  - Higgsstrahlung dominant $\sigma_{pol}/\sigma_{unpol} \sim (1-0.151\,P_{eff}) * L_{eff}/L$

    With P_{e+}=0%: $\sigma_{pol}/\sigma_{unpol} \sim 1.13$

    With P_{e+} = 30% $\sigma_{pol}/\sigma_{unpol} \sim 1.51$ (about 33% increase comp. to 0%)
  - Background: mainly ZZ (if leptonic), WW (if hadronic)

S/B:	1.14 (+,0)	4.35 (+,0)
	1.20 (+,-)	12.6 (+,-)
$S/\sqrt{B}$:	0.99 (+,0)	1.95 (+,0)
	1.22 (+,-)	3.98 (+,-)

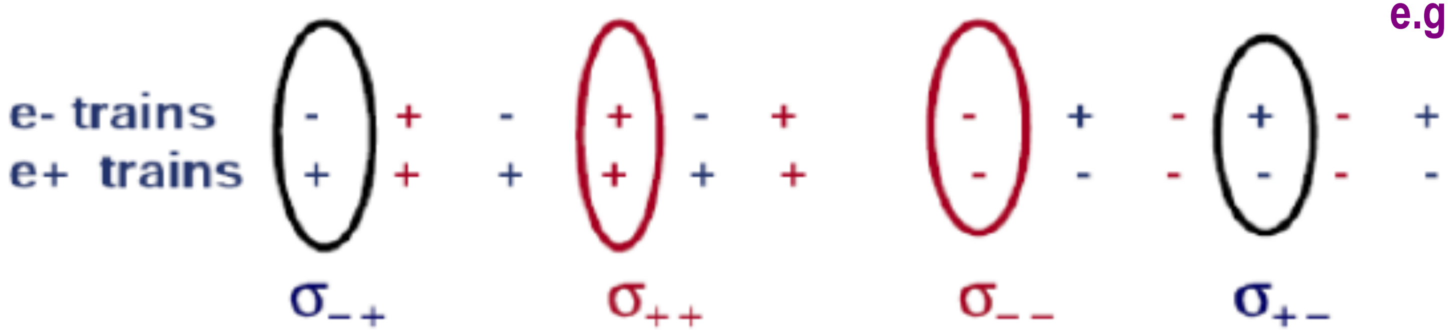
➢ *Loss if no P_{e+} :* ~20% ~ factor 2

- **Physics Panel used both beams polarized! P_{e+} is important …**

Caution: helicity flipping is required

- Gain in effective lumi lost if no flipping available

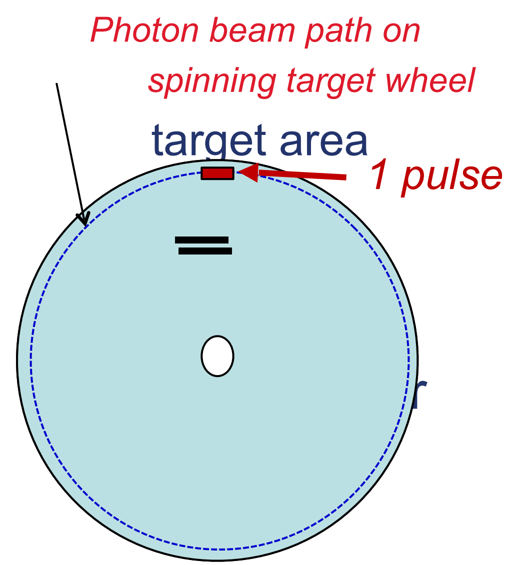
e.g. S. Riemann



  - 50% spent to ‘inefficient’ helicity pairing (most SM, BSM)
  - Similar flip frequency for both beams ~ pulse-per-pulse
- Gain in ΔP_{eff} remains, but flipping required to understand:
  - Systematics and correlations P_{e-} x P_{e+}
- Spin rotator before DR and spinflipper in set-up for baseline!
  - done!

The positron target

- Photon beam hits wheel at 1m diameter, spinning in vacuum with 2000rpm (100m/s tangential speed) → distribute the heat load
  - One pulse with1312 (2625) bunches occupies ~7 (~10)cm
  - Every ~7-8sec load at same target position
  - in 5000h roughly 2.5×10^6 load cycles at same

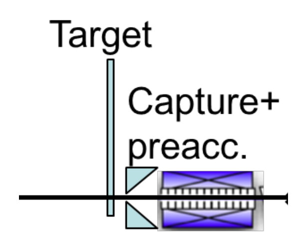


- ILC250, GigaZ: E(e-) = 125GeV
  - Photon energy is O(7.5 MeV);
  - target thickness of 7mm to optimize deposition and e+ yield
- Target cooling

S. Riemann, P.Sievers

  - T^4 radiation from spinning wheel to stationary water cooled cooler
    - Peak temp in wheel ~550˚C for ILC250, 1312bunches/pulse
      ~500˚C for GigaZ, 1312bunches/pulse

      assuming the wheel is a full Ti alloy disk (~simple design solution).



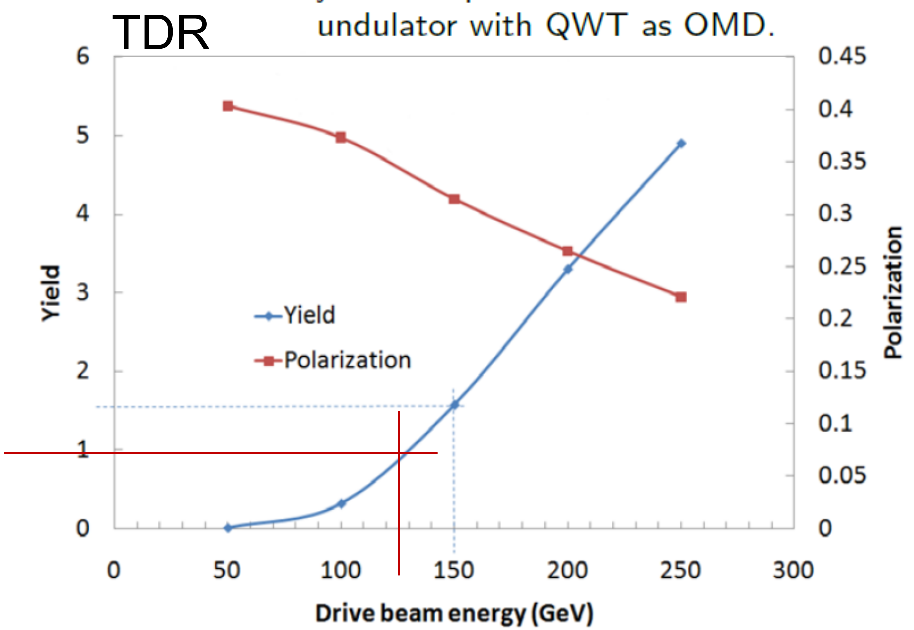
Rotating wheel design

- Material:
  - material tests with load similar as expected at ILC were done using the e- beam at Microtron in Mainz → Ti alloy will survive load cycles for ≥1 year
  - To be continued to study strength against high cyclic peak load at high T (luminosity upgrade)
  - Include alternative alloys with high T and high strength
- Target geometry
  - Optimize temperatures, stresses, thickness etc. while maintaining the required e+ yield
  - Study influence of eddy currents (heating, drag forces) caused by B field at target from OMD
  - Studies to be done with ANSYS, COMSOL,…
- Lab test of target sector to confirm cooling performance
- Drive and bearing
  - Magnetic bearing for vacuum-tight spinning wheel

Positron yield

- Electron energy 125GeV (126.5GeV to compensate loss in undulator)
- Photon energy is O(7.5 MeV)

Simulation results of positron source yield and polarization for 231 m RDR undulator with QWT as OMD.



- yield is ~1e+/e-
  for E(e-) = 125GeV

Need to optimize/improve the e+ capture

Upgrade to higher energies

No problem for nominal luminosity: PEDD and max temperatures do not exceed limit, target thickness could be optimized

Electron beam energy	GeV	126,5	175	250
Active undulator length	m	231	147	
Undulator K		0.85	0.66	0.45
Photon yield	γ/e-	393	157	76.1
Photon energy (1st harmonic)	MeV	7.7	17.6	42.8
Average photon beam power	kW	62.6	45.2	42.9
Distance target – middle undulator	m	401	500	
Target (Ti6Al4V)thickness	mm	**7**	14.8	
Average power deposition in target	**kW**	**1.94**	**3.3**	**2.3**
Photon beam spot size on target (σ)	mm	1.2	0.89	0.5
Peak Energy Deposition Density (PEDD) in spinning target per pulse	**J/g**	**61.0**	**42.4**	**45.8**
Polarization of captured positrons	%	29.5	30.8	24.9