Polarized Positron Sources at Future Linear Collider Designs (ILC, HALHF,CLIC)

- **Motivation**
- **Status ILC positron source**
- **Undulator Source for CLIC**
- **Upgrade for HALHF e+ design**
- **Conclusion**

G. Moortgat-Pick, M. Formela, N. Hamann, D. Lott, T. Lengler, G. Loisch,
S. Riemann, P. Sievers, C. Tenholt, M. Trautwein, G. Yakopov

Motivation

Immediate need for

- *Higgs sector high precision measurements*
- *Top quark high precision measurements*
- *Electroweak high precision measurements*
- *New `windows' for detecting BSM physics effects (CP violation, DM,…)*

➡ *exploit complementarity of pp and e+e- colliders*

with stages: $\sqrt{s}$=Z-pole, WW, 250, 350, 550, >1000 GeV and polarized beams

➡ *would cover precision & energy frontier simultaneously*

LCvision, C. Balazs, arXiv: 2503.19983

Offer

- *an high Lumi e+e- Linear Collider, upgradeable to new technologies!*

➡ *powerful positron sources required*

➡ *focus today…*

Remember the past: physics gain of polarized beams

- **Past experience:**
  - **excellent e- polarization ~78% at SLC:**
  - **led to best single measurement of $\sin^2\theta=0.23098\pm0.00026$ on basis of $L\sim10^{30}\ cm^{-2}s^{-1}$ (~600000 Z's)**

- **Compare with results from unpolarized beams at LEP:**
  - **$\sin^2\theta=0.23221\pm0.00029$ but with $L\sim2\times10^{31}cm^{-2}s^{-1}$ (~ 17 million Z's)**

➡ **Polarization essential for suppression of systematics**

➡ **can even compensate order of magnitude in luminosity for specific observables!**

➡ ***Polarized e- sources well under control, why in addition polarized e+ required.....?***

Short reminder: why are polarized e$^{\pm}$ needed?

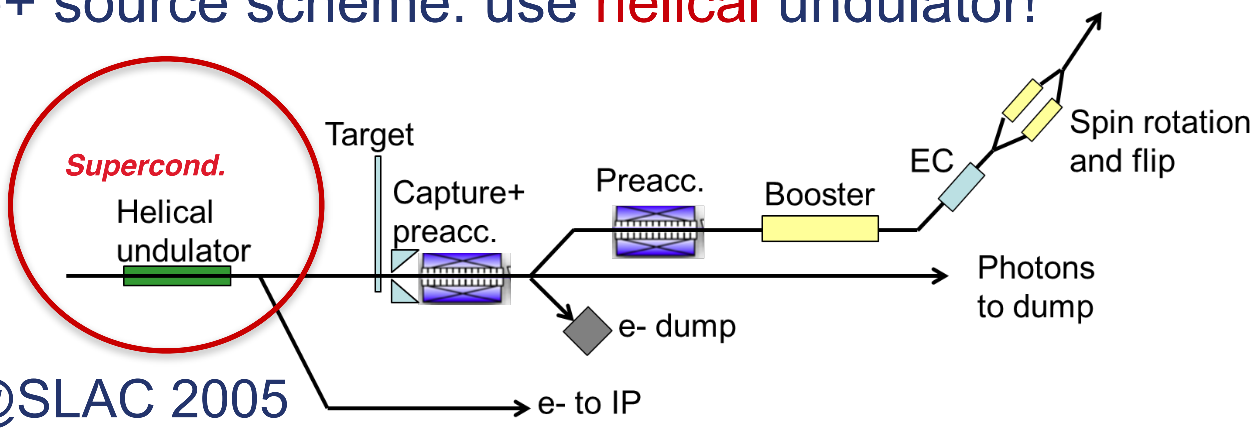
- **Important issue: measuring amount of polarization**
  - **limiting systematic uncertainty for high statistics measurements**
  - **Compton polarimeters (up- /downstream): envisaged uncertainties of ΔP/P=0.25%**
- **Advantage of adding positron polarization:**
  - **Substantial enhancement of eff. luminosity and eff. polarization**
  - **new independent observables**
  - **handling of limiting systematics and access to in-situ measurements: ΔP/P=0.1% achievable!**
  - **Windows to new physics (couplings, chirality, interaction structures)!**
- **Substantial physics impact: EWPO, 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,…*

Most mature LC design: ILC

- The polarized e+ source scheme: use helical undulator!



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

Overview positron requirements

	rep rate/Hz	#bunch/pulse	#e+/bunch	#e+/pulse	#e+/s
SLC	120	1	$5x10^{10}$	$5x10^{10}$	$6x10^{12}$
ILC/Tesla	5	1312	$2x10^{10}$	$2.6x10^{13}$	$1.3x10^{14}$
CEPC	100	1	$2x10^{10}$	$2x10^{10}$	$2x10^{12}$
CLIC	50	312	$4 x10^{9}$	$1.2x10^{12}$	$6x10^{13}$
HALHF	10000	1	$2\text{-}3x10^{10}$	$2\text{-}3x10^{10}$	$2\text{-}3x10^{14}$

➡ HALHF: More challenging e+ request as ILC

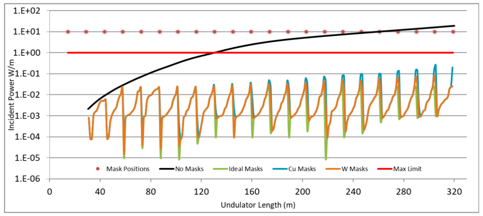
➡ Adaption of ILC e+ source for HALHF

Operation of the Undulator

- **Undulator in operation@XFEL:**
  - **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!**
- **Precise simulations based on XFEL&UK prototype:**
  - **realistic fields, mask system, power deposition**

  for at GigaZ, ILC250, ILC500

ILC250

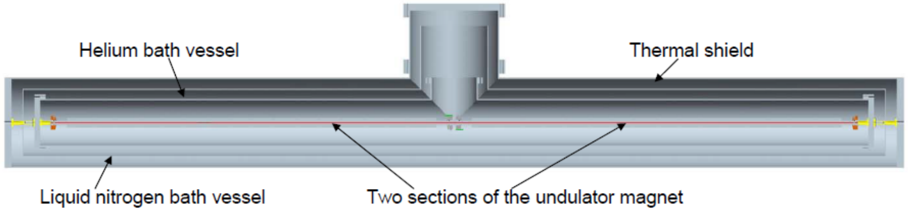


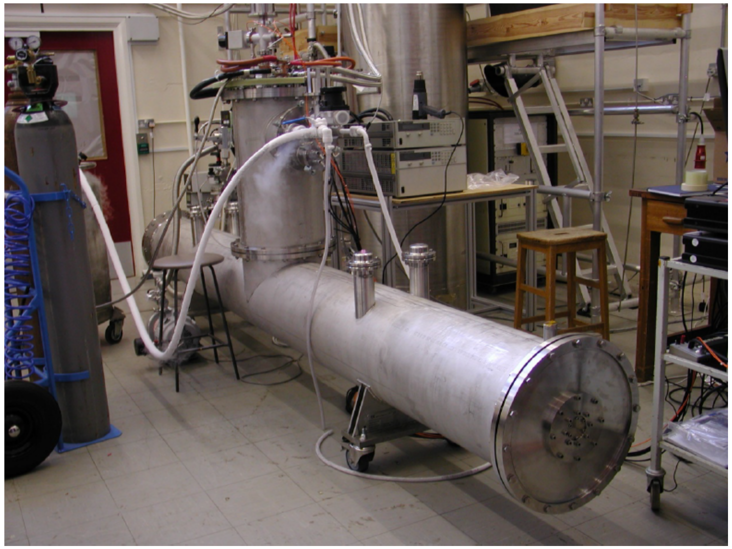
- **Results: no operation&alignmenta&heat issues**

ILC 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)





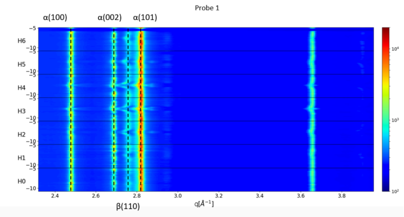
- ILC TDR (2013):
  - Max 231m active undulator length available (132 undulator modules in 66 cryomodules]
  - Quadrupoles every 3 cryomodules → total length of undulator system is 320m

Target System

- **Target Specifications:**
  - **Titanium alloy, 7mm thick (ILC250: 0.2 X_0), 14mm (ILC500), diameter 1m**
  - **Rotating at 2000 rpm (100 m/s tangential speed) in vacuum**
  - **Photon power ~60 kW, deposited power ~2 kW**
  - **Radiation cooling**
- **Status target material tests up to 2024**
  - **Target load tests at MAMI Beam**
  - **Multiple annual PEDD loads & thermal loads on target**
  - **In addition: dilatometer tests, different target thicknesses, etc.**
  - **Precise target analyses with synchrotron diffraction & scanning methods**

T. Lengler, D. Lott

α/β phase transitions in Ti-6Al-4V:



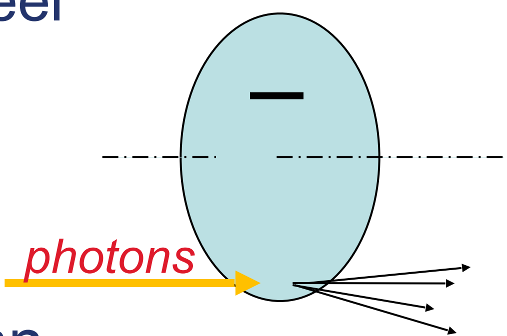
➡ det. of phase parameter

- **Results: no damage, ILC target will stand the load !**

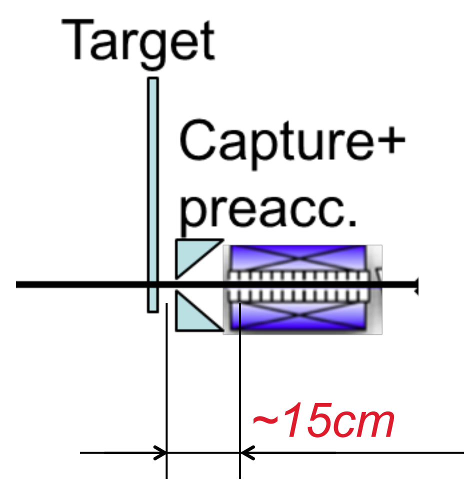
➡ ***Specifications will be matched!***

The ILC 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

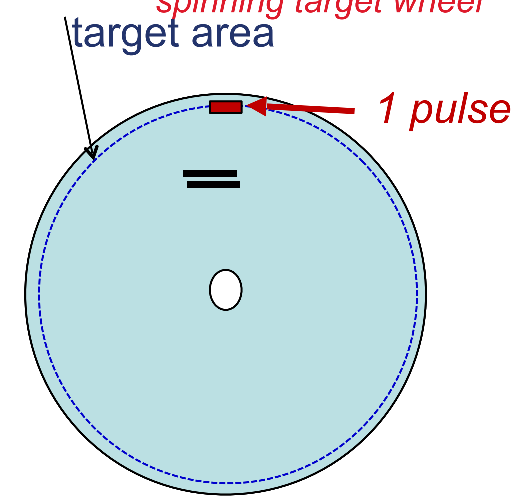


- The e+ are collected with an
  Optical Matching Device (OMD):
  - Maximum magnetic field (≥1T)
    about ~1cm from target exit to achieve
    high e+ yield
  - Pulsed Solenoid
  - Future Technology: Plasma lenses



The positron target

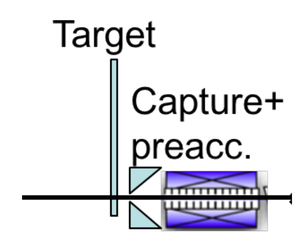
- Photon beam hits wheel at 1m diameter, spinning in vacuum with 2000rpm (100m/s tangential speed) → distribute the heat load
  - One pulse with1312 (2625) bunches occupies ~7 (~10)cm
  - Every ~7-8sec load at same target position
  - in 5000h roughly 2.5×10^6 load cycles at same



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

- Target cooling
  - 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

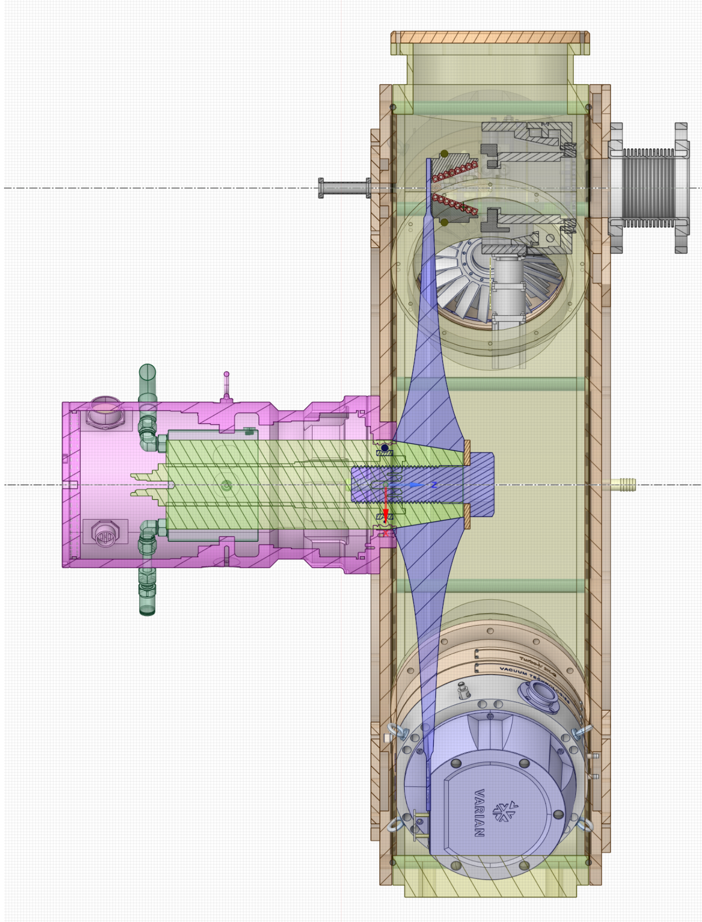
    assuming the wheel is a full Ti alloy disk (~simple design solution).



Target System

- **Status Protyping Rotating Wheel and Cooling**
  - Radiation cooling allows use of magnetic bearings
  - Standard component to support elements rotating in vacuum
  - Allows long time operation at high rotation speed without maintenance
  - Often used as Fermi-choppers in Neutron Physics and Spallation Sources
  - Technical specifications of ILC Wheel updated (P. Sievers, S. Doebert, G. Yakopov)
  - mechanical drawings and already LOI agreement exchanged with SKF Magnetic Bearings (Canada)
- **Results: currently close discussion with SKF**

➡ ***No technical issues expected, specifications will be matched!***



Grigory Yakopov '25

Cooling of the target wheel

S. Riemann, P. Sievers

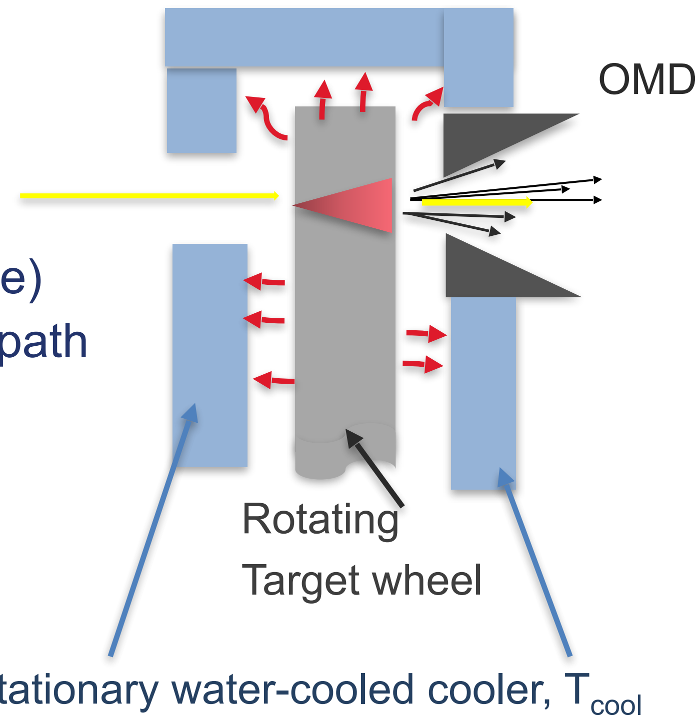
- Few kW heat deposition can be removed with thermal radiation:
  - heat radiates from spinning target to a stationary water-cooled cooler

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

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

Side view cutout e+ target

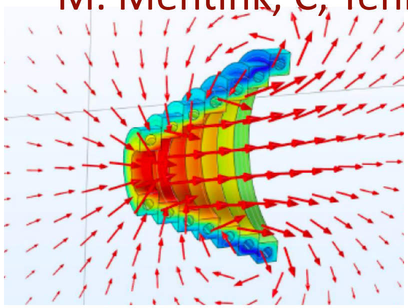


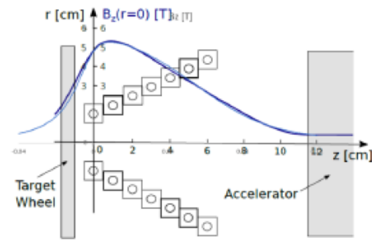
Magneting focussing and e+ capturing

- **Baseline Design OMD: Pulsed solenoid**
  - **Detailed simulations of winding, eddy currents magnetic shielding**
  - **Yield of e+ (OMD&capture Linac): 1.64-1.81**

Fukuda, 2021

M. Mentink, C, Tenholt, G. Loisch, 2021





C. Tenholt 2021

	Beamloss Power				Positron Yield	
	@dogleg	@booster	@EC	@DR	@capture (|Z|<7mm)	@DR
QWT	0.677 kW	0.014 kW	4.01 kW - 5.56 kW	13.15 kW - 14.3 kW	1.07	**~1.1**
Pulse solenoid w/o shield	0.927 kW	0.055 kW	5.86 kW - 7.93 kW	17.39 kW - 16.01 kW	1.81	**1.91**
Pulse solenoid with shield	0.871 kW	0.064 kW	5.58 kW - 7.90 kW	17.73 kW - 16.24 kW	1.64	**1.74**

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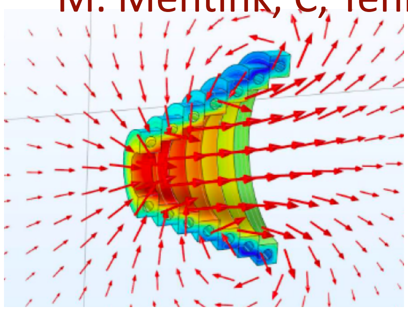
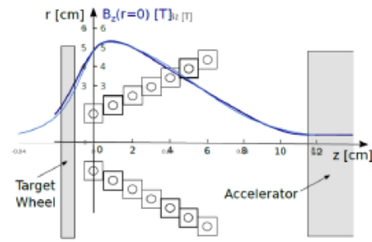
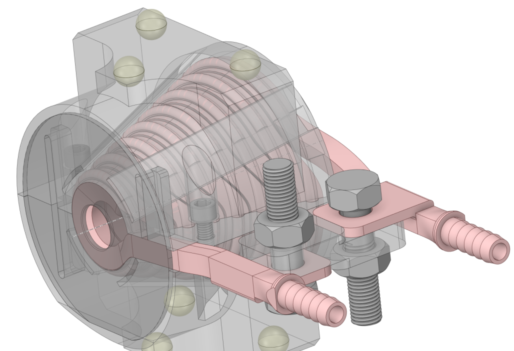






G. Yakopov 2023

- **Status Protyping Pulsed Solenoid**
  - **ITN initiative: manufacturing drawings&construction at DESY/UHH**
  - **Close ahead series of prototypes measurements**
  - **Comparison of field measurements with simulations**
  - **Several runs with different pulse modes/currents planned**
- **Results: expected soon and in time with protptype wheel**

Hamann, Yakopov ‘25

Undulator system adaptation for $\sqrt{s} \geqq 1$ TeV Designs

- **Undulator parameter set for ILC1000 exist**
  - **Higher drive beam energy, higher K**
  - **Start-to-end tracking can be done**
- **CLIC**
  - **Design down by Wei Gai exists, already shown at IPAC 2010**
  - **Update of parameters under work with new automatized tools**
- **H(ybrid)A(symmetric)L(inear)H(iggs)F(actory) Design**
  - **Higher drive beam: 375 GeV**
  - **Automatized simulation code for optimized parameter sets**
  - **Needs 2-3 times more positrons than ILC**
  - **Parameter sets with yields of 3-4 feasible, still under work!**

- **Results: polarized e+ also feasible for higher energy LC options**

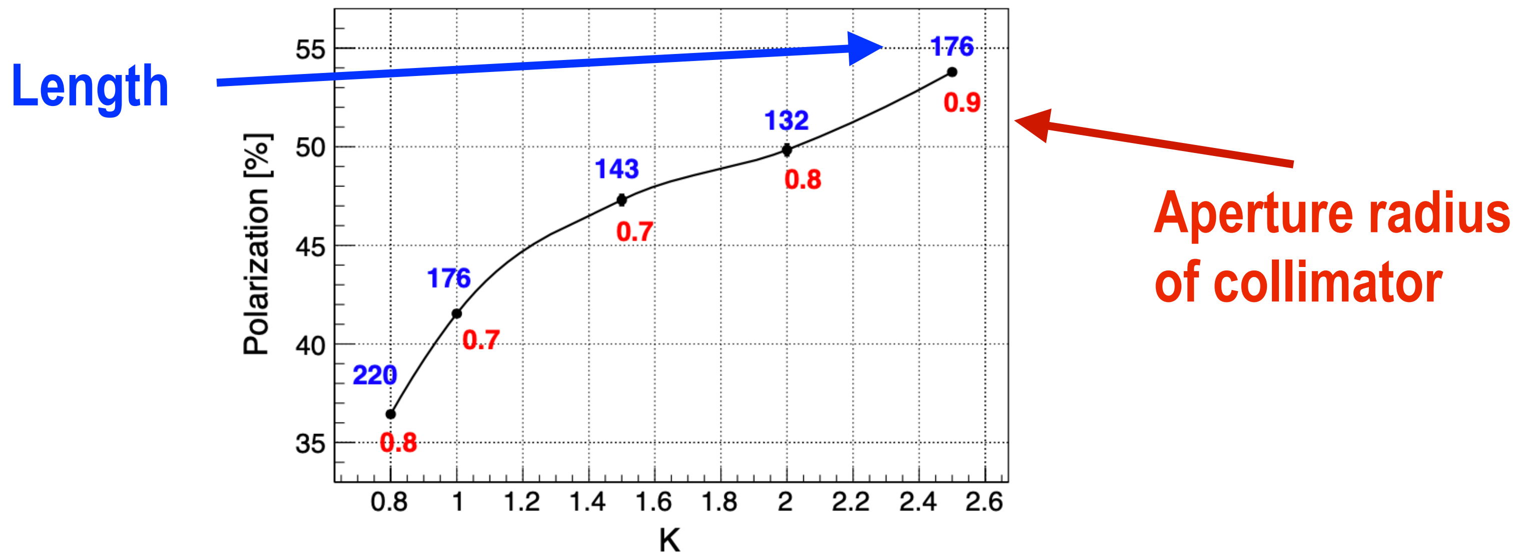
➡ ***Simulations and Concepts for $\sqrt{s} \geqq 1$ TeV Designs exist already!***

1TeV upgrade: Polarization@Und$_{E(e-)=500\ GeV}$

Goals: high #e+@DR, high P(e+)>30%, target lifetime~1y

Ushakov ea 1301.1222

- **K = 2.5, period λ=43 mm, higher harmonics, higher yield**
- **Apply photon collimator:**



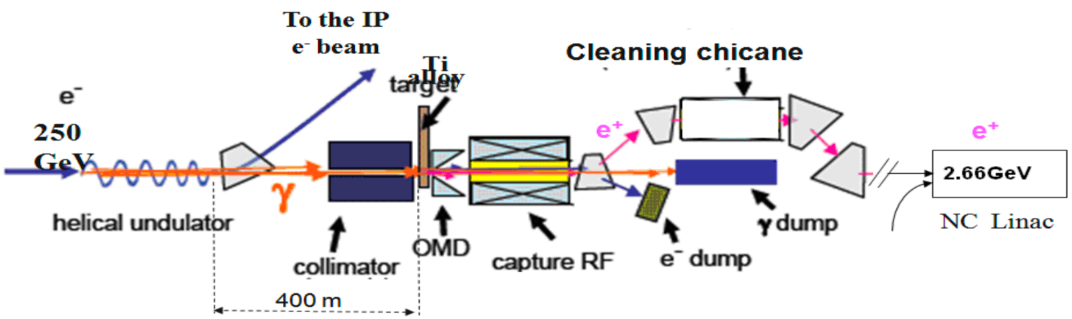
- **High P(e+) achievable: ~54%**

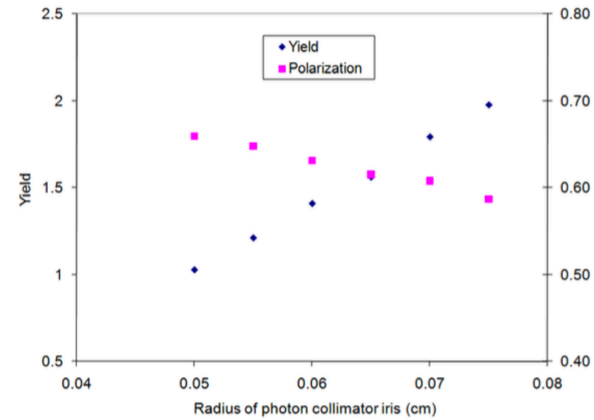
➡ **capture & target issues have to be addressed, but now more know-how on OMD (PS, etc.)**

Recap Undulator system for CLIC

- Drive beam e-=250 GeV:

W. Liu , W. Gai ea
IPAC 2010





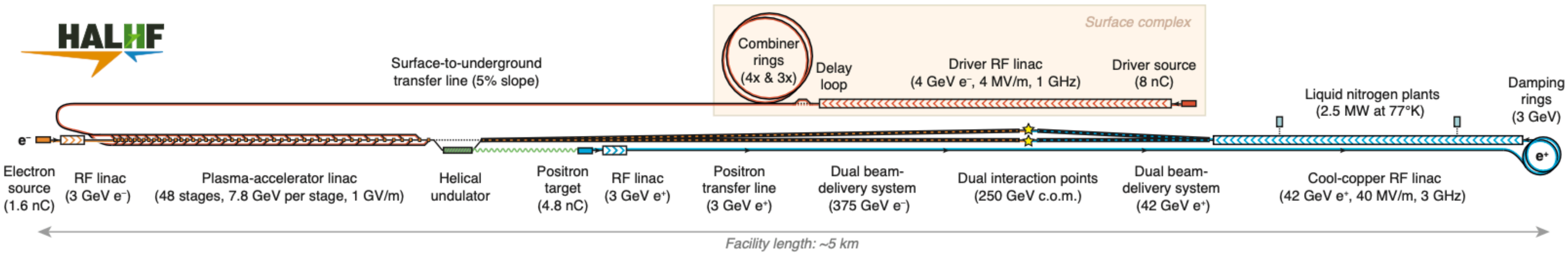
- Undulator period, λ_U =11.5mm
- Undulator strength K ~ 0.9 (B ~ 1T); K ~ B·λ_U
- Undulator length 127 m,
- Photon collimator 0.7 mm with distance to target 400m

➡ P(e+)~60%

- ***Updated parameters including acceptance of (pre-)damping ring under work***

H(ybrid)A(symmetric)L(inear)H(iggs)F(actory) Design

B. Foster, R. D'Arcy, C.A. Lindstrom



E. Adli et al, arXiv: 2503.19880, 2503.23489

Positron Source:

- **Undulator-based source: mature for ILC parameters**
  - **e- drive beam: 375 GeV from PWA**
  - **higher physics potential**
- **Higher yield required**
  - **optimized simulations ongoing**

M. Trauwein, M. Formela, N. Hamann

Some basics: just as an overview

Basic formula for photon spectrum of Helical Undulator given by Kincaid (1978) [3]:

K. Alharbi

$$\frac{dW}{d\omega} = \frac{N_p\, q^2\, K^2\, r}{\epsilon_0\, C} \sum_{n=1}^{\infty} \left(J_n'(x_n)^2 + \left(\frac{a_n}{K} - \frac{n}{x_n} \right) J_n(x_n)^2 \right) u(a_n)^2$$

$N_p = period\ number,\ \ n = harmonic\ number,\ \ r = \frac{\omega}{2\gamma^2\omega_0},\ \ a_n = \frac{n}{r} - 1 - K^2,\ \ x_n = 2Kra_n,\ \ J_n = \text{Bessel function}$

Photon number [4]: $N_\gamma \propto \frac{K^2}{\lambda_u} * L_u$,

K is the deflection, K = 0.0934 $B_o\lambda_u$.

λ_u is the undulator period.

B_o is B-field on axis.

L_u is the undulator active length = $N_p\lambda_u$.

The relationship between the energy of the electron beam (E_e) and the 1st harmonic cutoff energies of the photon spectrum (E_1):

$$E_1 \propto \frac{E_e^2}{\lambda_u(1 + K^2)}$$

The upper half of the energy spectrum at any order n is emitted into a cone of angle:

$\theta \approx \frac{1}{\gamma}\sqrt{1 + K^2}$, γ is Lorentz factor.

Simulations with CAIN

M. Trautwein et al.

Implementation of collimator at K=2.5, λ_u=4.3cm

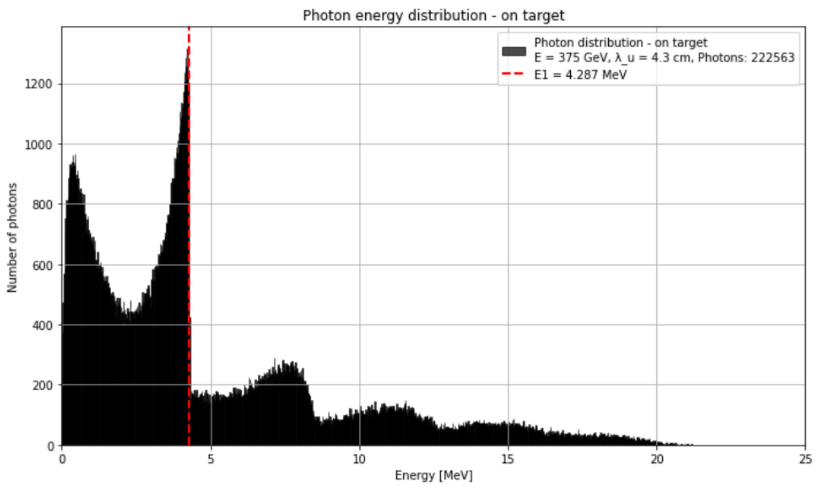


Fig. 3: Photon energy distribution without collimator

#Photons: 222,563

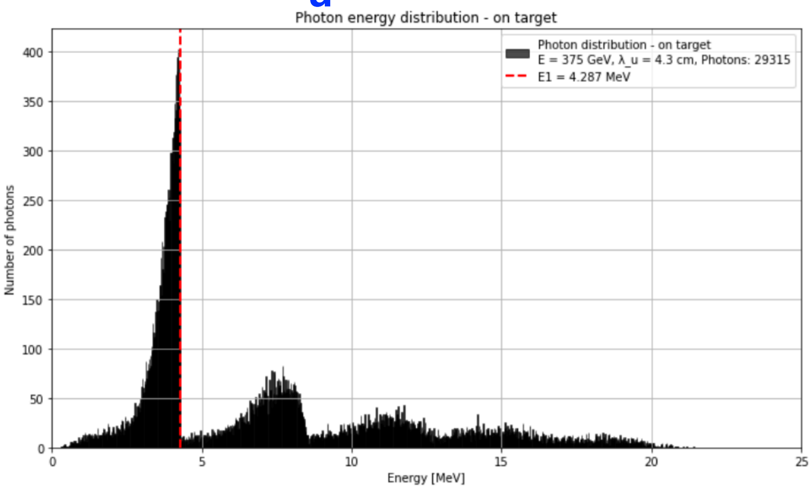


Fig. 4: Photon energy distribution with collimator (R=0.8mm)

#Photons: 29,315

HALHF-Parameters: E=375 GeV, ε_x=90 μm, ε_y=0.32 μm, σ_z= 0.04 mm

- Photon collimator required
- High yield and polarization required
- Optic matching device: adapt pulsed solenoid

Simulations with CAIN

M. Trautwein et al.

Implementation of collimator at K=2.5, λ_u=4.3cm

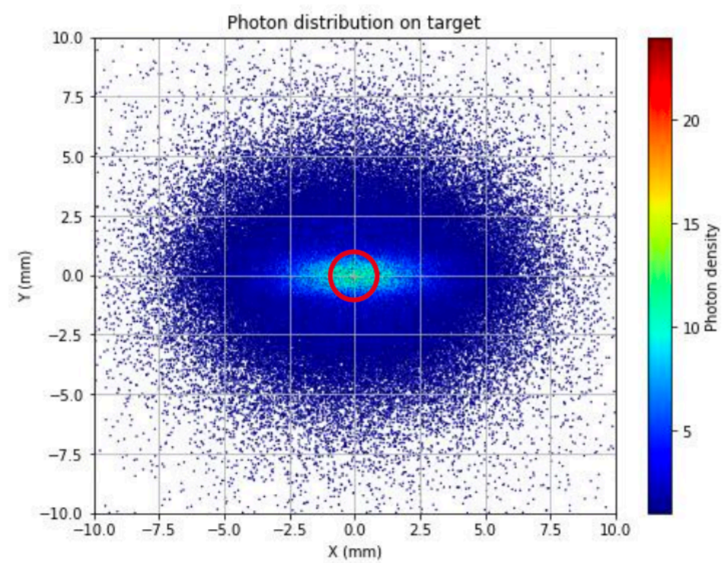


Fig. 5: Photon distribution on target without collimator

#Photons: 222,563

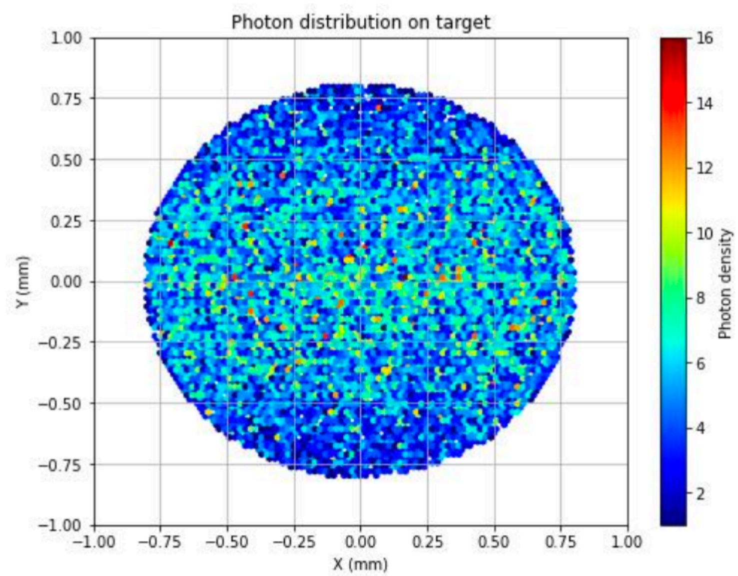


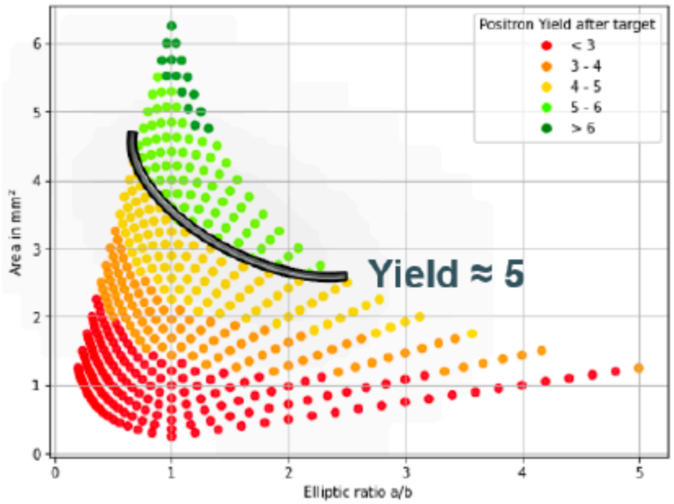
Fig. 6: Photon energy distribution on target with collimator (R=0.8m

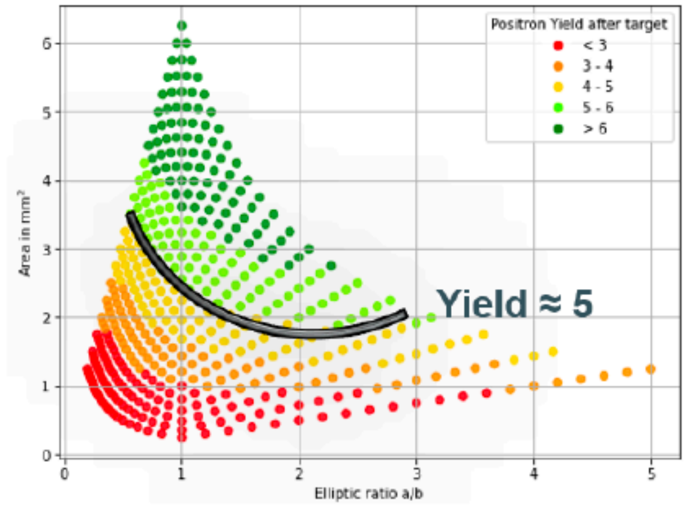
#Photons: 29,315

- Photon collimator required: still thoughts on geometry
- High yield and polarization required
- Optic matching device: adapt pulsed solenoid

Simulations with CAIN

Implementation of collimator at K=2.5, λ_u=4.3cm





Yield	Photon Pol.	Parameter	Period	Length	Field	Collimator	
e^+/e^- [1]	P [1]	K_u [1]	λ_u [cm]	L_u [m]	B [T]	a [mm]	b [mm]
7.1	**0.811**	3.0	2.5	241.5	1.28	1.5	1.0
8.2	**0.762**	2.5	2.5	231	1.07	1.5	1.0
9.4	**0.780**	2.0	2.0	252	1.07	1.5	0.5

M. Trautwein

- Still higher yields achievable
- Optimization for undulator parameters (K, λ_u , etc)

Conclusions

Polarized positron sources@ILC from GigaZ to >500 GeV:

- **Simultaneous e+ polarization allows best control of systematics, higher statistics, best physics results**
- **ILC undulator-based source mature and feasible**
- **prototype work on pulsed solenoid and rotating wheel ongoing**

Polarized positron sources@CLIC*:*

- **recap of parameters, simulation update under work, yield requirements matched**

HALHF plans (~8 km whole device….)*:*

- **new technology (PWA) in combination with SRF**
- **adapt e^+-based ILC undulator parameters for HALHF e- beam of 375 GeV *(instead of 125 GeV for ILC250)***
- **challenge: more e+ at IP needed than e+@ILC!**

Polarized positron sources for future LC are feasible, optimize physics and involve and combine new technologies!

GigaZ operation

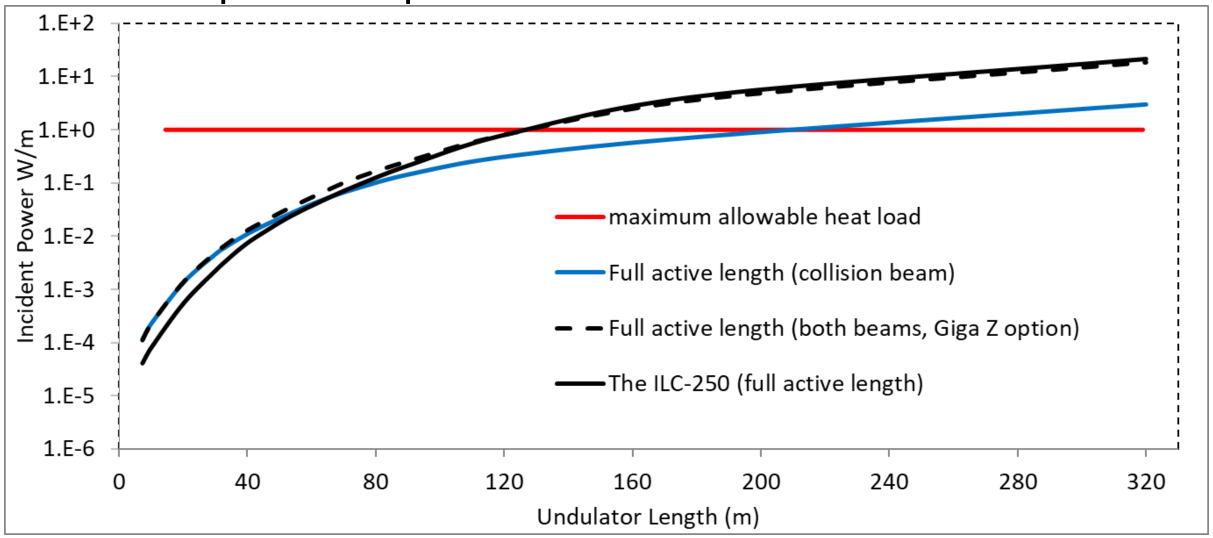
- Parameters for GigaZ operation

  Yokoya-san, 1908.08212

Parameters	e^+ production	collision	Unit
Final beam energy	125	45.6	GeV
Average accelerating gradient	31.5	8.76	MV/m
Peak power per cavity	189	77.2	kW
Beam pulse length	0.727	0.727	ms
RF pulse length	1.65	1.06	ms
Repetition rate	3.7	3.7	Hz

- Incident power at undulator walls: Compare GigaZ and ILC250

power deposition in wall without masks



K. Alharbi
S. Riemann

➡ Incident power at GigaZ below /comparable with ILC250

➡ Mask protection will also be sufficient for GigaZ running

OMD Design: Pulsed Solenoid

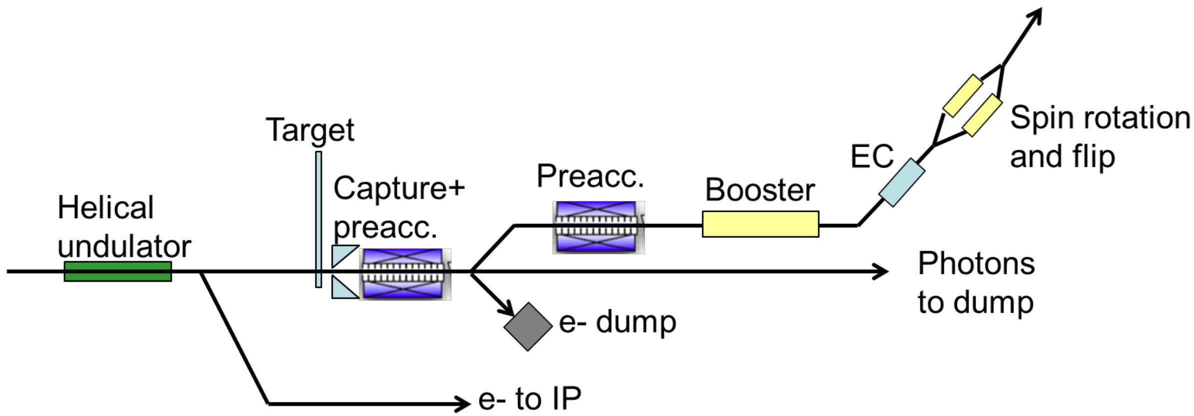
'Baseline': Pulsed Solenoid

- Yield of e+ (OMD&capture Linac): 1.64-1.81 Fukuda-san, 2021
- Within ITN initiative: manufacturing drawings at DESY G. Yakopov 2023
- Planned: prototype will be sent and tested at CERN

C. Tenholt 2021

	Beamloss Power				Positron Yield	
	@dogleg	**@booster**	**@EC**	**@DR**	**@capture (|Z|<7mm)**	**@DR**
QWT	0.677 kW	0.014 kW	4.01 kW - 5.56 kW	13.15 kW - 14.3 kW	1.07	**~1.1**
Pulsed ´solenoid w/o shield	0.927 kW	0.055 kW	5.86 kW - 7.93 kW	17.39 kW - 16.01 kW	1.81	**1.91**
Pulsed solenoid with shield	0.871 kW	0.064 kW	5.58 kW - 7.90 kW	17.73 kW - 16.24 kW	1.64	**1.74**

Focusing System for Undulator Scheme

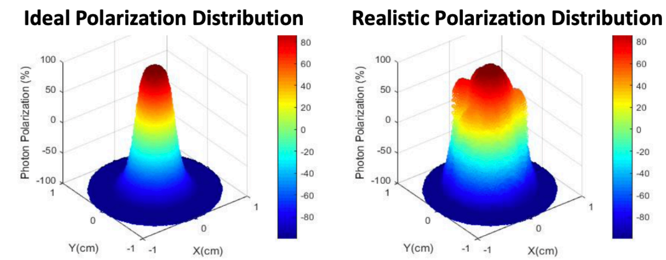


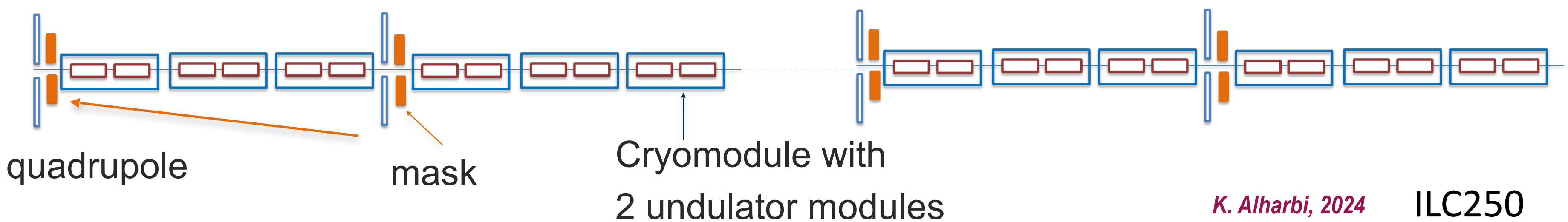
- The critical item for the undulator scheme is the magnetic focusing system right after the target
- Possible candidates are: (a) Pulsed solenoid, (b) Plasma lens
- The strongest candidate is (a) pulsed solenoid.
- R&D items ongoing:
    - Detailed simulations for (a) (already on-going)
    - Principal design & engineering for a prototype pulsed solenoid
    - Plans: Field measurements with 1kA (pulsed and DC) and with 50kA both in a single pulse mode and finally with pulse duration of 5ms at 5 Hz
    - Prototype plasma lens (funded study on-going, see Niclas talk)

Undulator: Simulation (field errors, alignment)

- Misalignments: *see A. Ushakov, AWLC18*
  - beam spot increases slightly, yield decreases slightly
- Realistic undulator with B field (K) and period (λ) errors
  - provides beam size, polarization, target load
  - impact depends on K-value!
- Synchrotron radiation deposit in undulator walls
  - Masks protect wall to levels below 1W/m
  - ILC250: power deposition in 'last' mask near undulator exit: ~300W

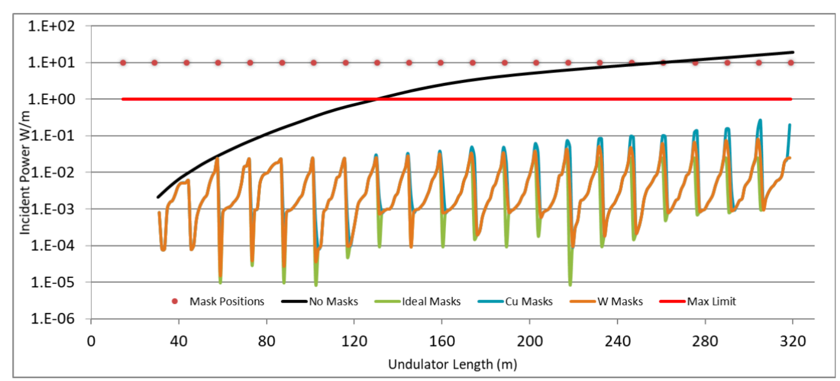
K. Alharbi, 2024





K. Alharbi, 2024 ILC250

- *Result: Masks substantial but sufficient in all cases!*
- Studied for ILC250, ILC350, ILC500 and GigaZ !



Analyses of ILC targets

- **History: target material tests at Mainz Microtron (MAMI) using e-**
  - **Strategy: electron-beam on ILC target materials, generating cyclic load with same/ even higher PEDD at target than expected at ILC**
  - **Numerous successful tests performed on Ti-Alloy, W** **A. *Ushakov et al.***
  - **target analyses with both scanning and synchrotron diffraction methods**
- **Ongoing: (final) tests, analyses and publication**
  - **test runs at MAMI until 9/24** **T. Lengler et al.**
  - **dilatometer tests: disentangling target damage originating from thermal vs radiation load**
  - **α- and β- phase of Ti-alloy depend on T, have different mechanical properties**
  - **Tested: fast and cyclic stress in the range of $T=300^0$-800^0C**
  - **variation of T_{max} as well as different heating/cooling rates of 25^0C/s-100^0C/s**

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

Analyses of ILC targets

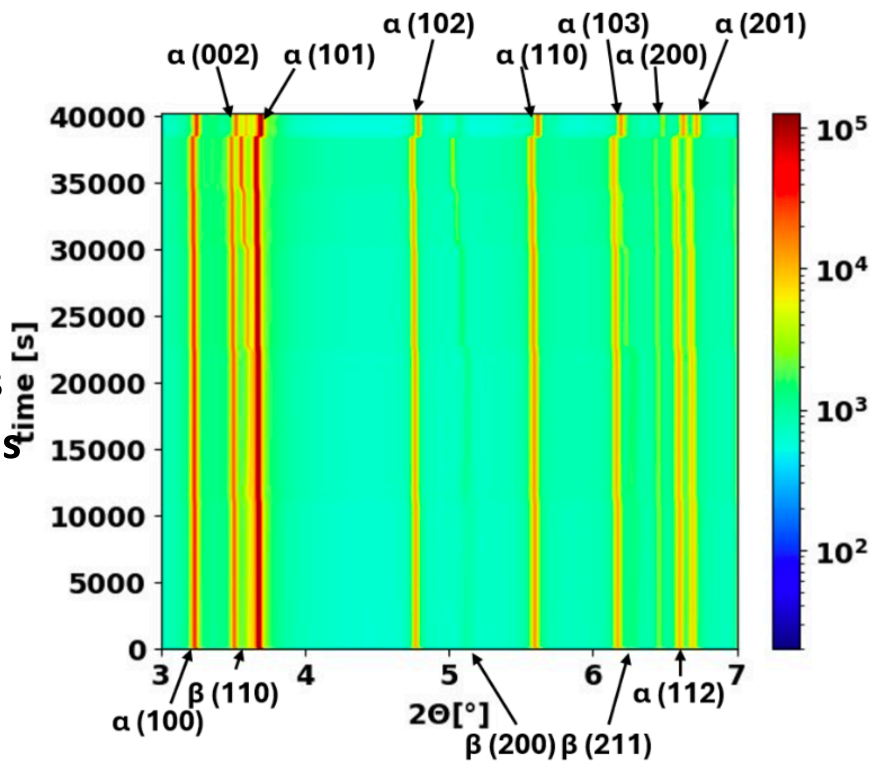
- **History: target material tests at Mainz Microtron (MAMI) using e-**
  - **Strategy: electron-beam on ILC target materials, generating cyclic load with**

Example:

- **step-wise heating**
- **peaks measured of both phases**

- **IPAC 24 Paper on radiation damages on e+ source materials**

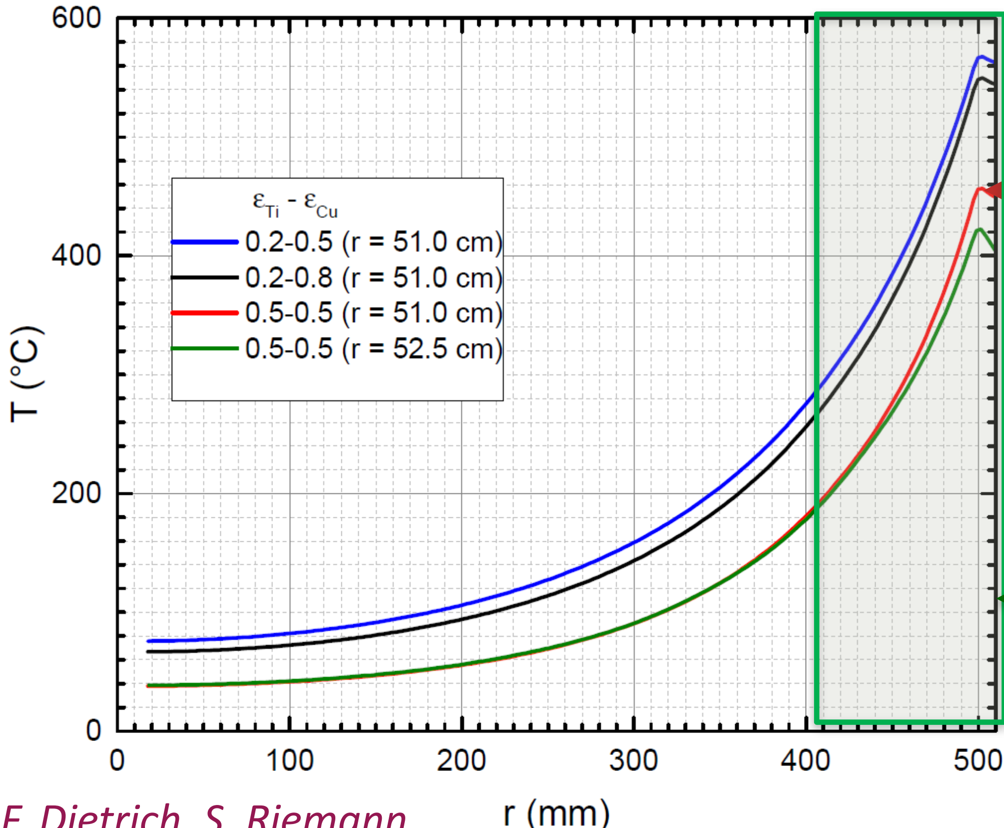
T. Lengler



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

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



Photon beam impact at r=50cm
Deposited power = 2kW

ε_{eff}= 0.33 for ε_{Ti} = ε_{Cu}=0.5
$T_{ave} \leq 460^{\circ}C$

max average temperatures can be decreased for larger wheel radius

Main cooling power from area

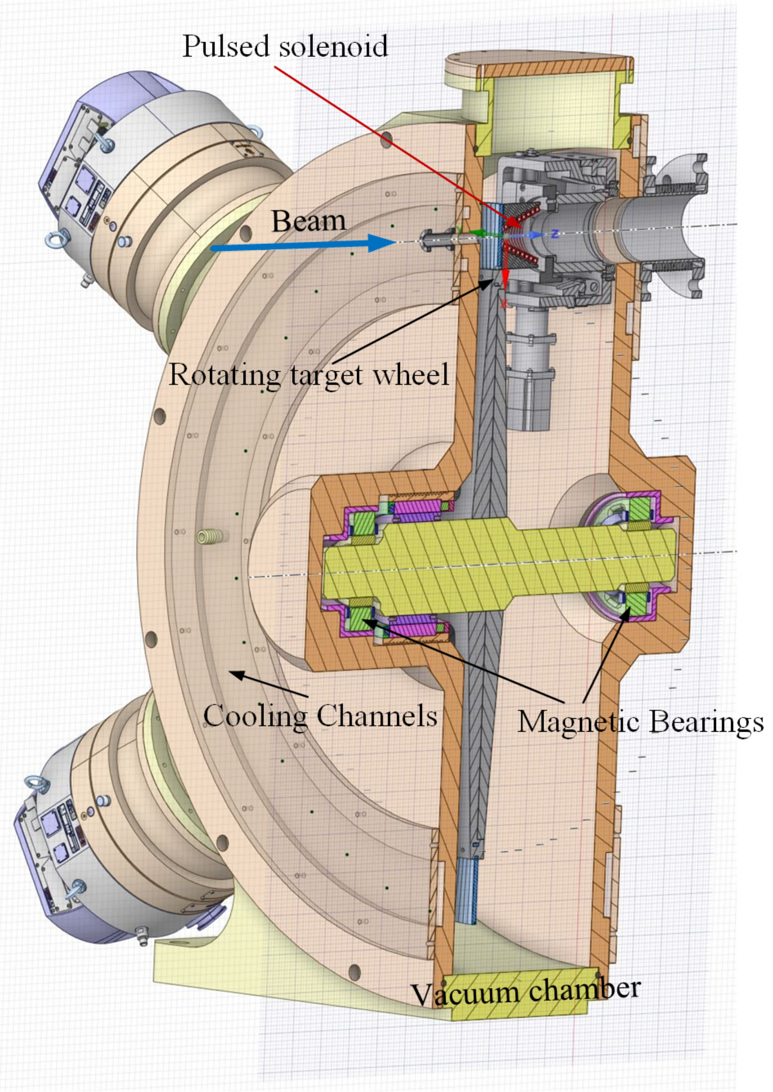
F. Dietrich, S. Riemann

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

Grigory Yakopov

Cross-section of the vacuum chamber with rotation target wheel, magnetic bearing system, and pulsed solenoid

Diameter of wheel: 120 cm, 2000 rpm
Tangential velocity at r=50 cm: 100 m/s
The mass of the wheel 50 kg (without shaft)
Ti-alloy target 7mm thickness
The repetition rate of the beam pulses is 5 Hz
Heat input around the wheel is about 2 kW
Thermal radiation cooling from both sides of the target



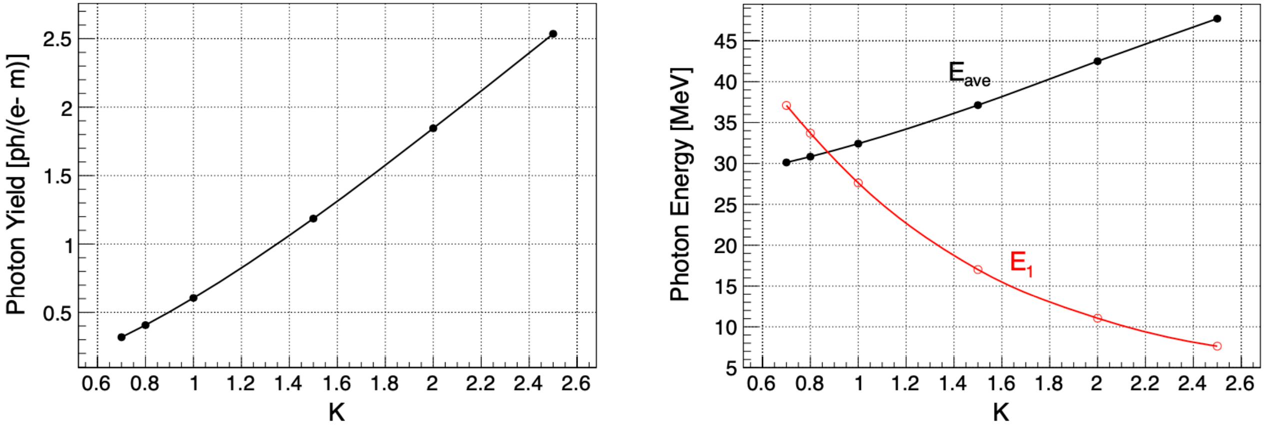
ILC Undulator with E(e-)=500 GeV

Goals: high #e+@DR, high P(e+)>30%, target lifetime~1y

Proposal: Use new undulator parameters

Ushakov ea 1301.1222

- ➡ **e.g. higher K = 2.5, period λ=43 mm**
- ➡ **leads to more higher harmonics, higher yield,**



- ➡ **higher γ_{ave} energy and higher energy spread**
- ➡ **larger γ spot size**
- ➡ **e+ capture more difficult…..but more know-how on (PS, PL) now!**

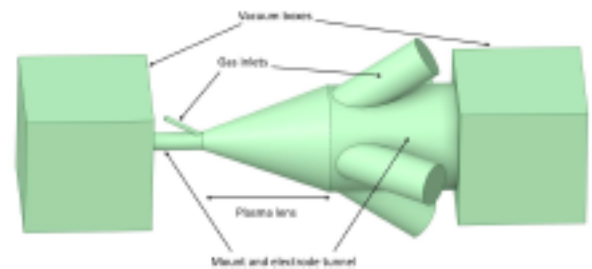
see IPAC 24

OMD Design: Plasma Lens

‘Future’: Plasma Lenses

- increases e+ yield but increases load at target only slightly
- advantages in matching aspect
- downscaled prototype designed and produced

Formela, Hamann, Loisch



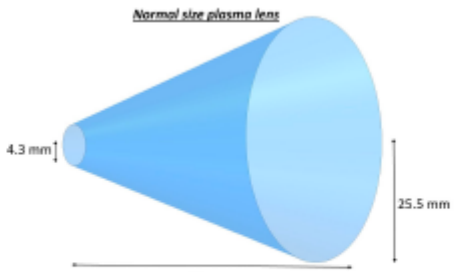
Plasma lens parameters

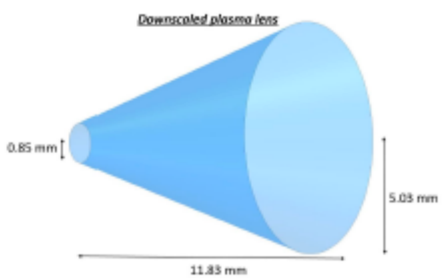
Normal size

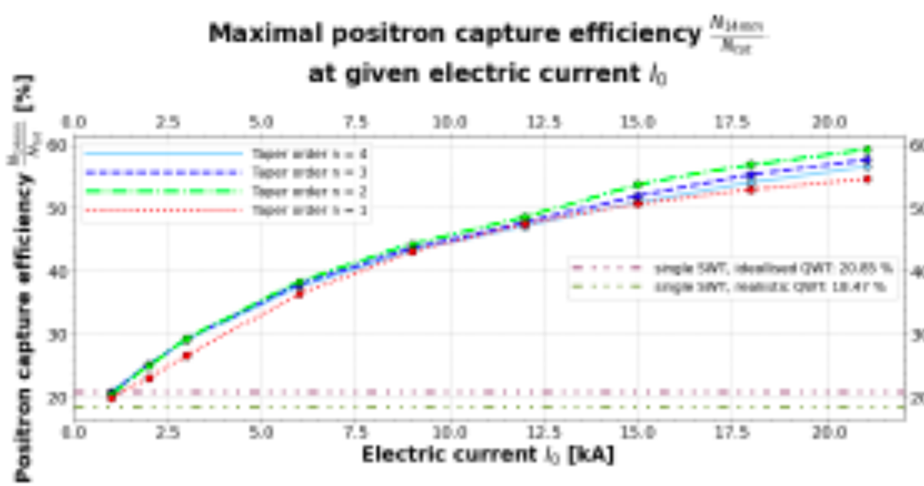
- Starting radius: 4.3 mm
- Exit radius: 25.5 mm
- Taper strength: 0.082 mm⁻¹
- Length: 60 mm
- Taper order: 2
- Total current: 9000 A
- Phase of SWT: 225 deg

Downscaled

- Starting radius: 0.85 mm
- Exit radius: 5.03 mm
- Taper strength: 0.416 mm⁻¹
- Length: 11.83 mm
- Total current: 350 A







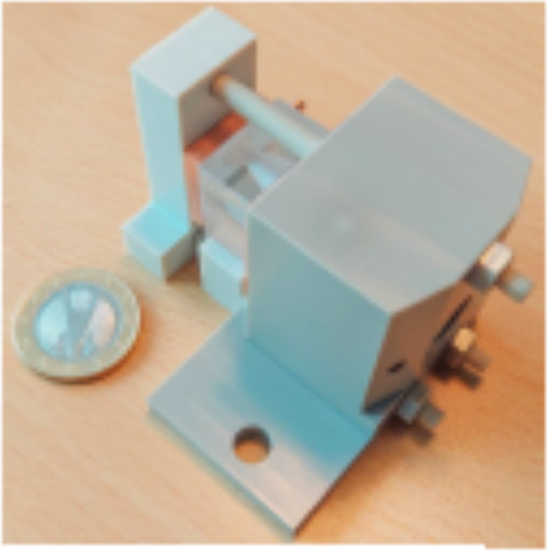
see IPAC 24

OMD Design: Plasma Lens

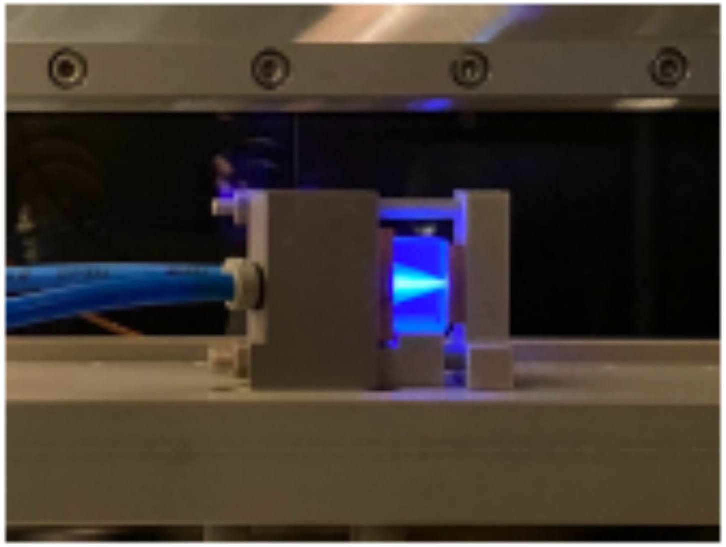
Formela, Hamann, Loisch

Prototype design

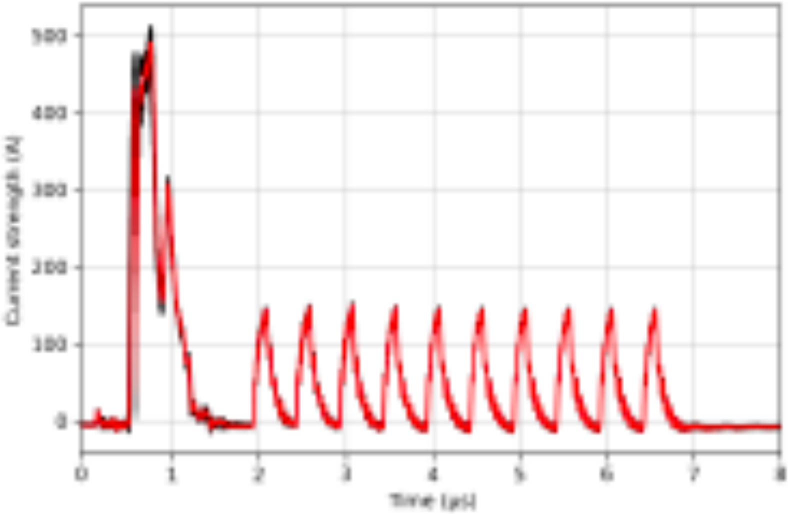
- Principle: lens is pressed in between mounts with threaded rods and sealed with O-rings
- Mounts made out of PEEK
- Electrodes made out of copper
- Plasma lens made out of sapphire block



Finished Prototype



Produced plasma



Ingoing current measured

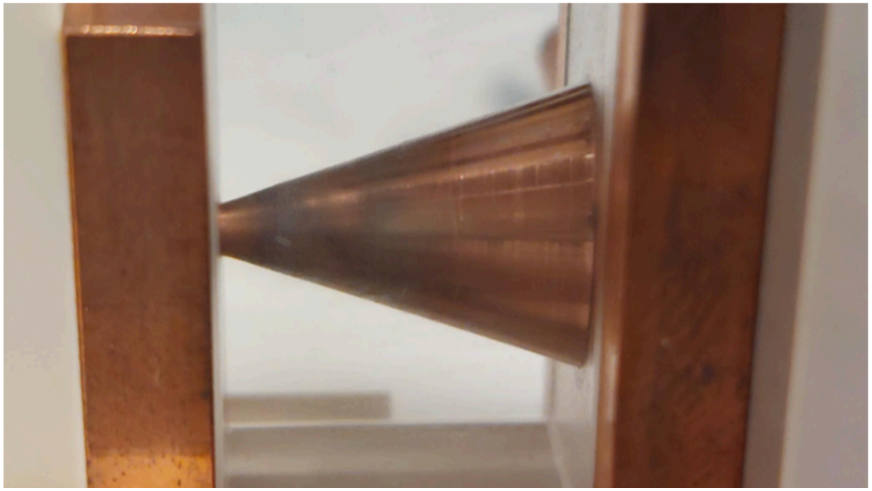
OMD Design: Plasma Lens

IPAC 24, Formela, Hamann, Loisch, et al

Prototype Plasma Lenses

- plasma achieved, first measurements done
- surprising copper coating from electrodes …
- on simulation side: Ar implementatio

➡ please stay tuned, lots of exciting work on prototypes ongoing !



G. Moortgat-Pick et al, ITN Meeting, Tokyo 7/24