Ver-1: 2022/March/2

## **Time-critical WPs for the ILC construction**

(For Sources Only)

IDT-WG2

## **Time-critical WPs for the ILC construction**

IDT-WG2

(Ver.1,2022-March-2)

The MEXT ILC advisory panel recommends that the development work in the key technological issues for the next-generation accelerator should be carried out by further strengthening the international collaboration among institutes and laboratories, shelving the question of hosting the ILC. This document is a re-organized summary of the time-consuming work packages for ILC construction.

The previous "Technical Preparation and Work Packages (WPs) during ILC Pre-lab" summarized the accelerator work necessary for producing the final engineering design and documentation during the ILC Pre-lab<sup>2</sup> phase. A total of 18 WPs (3 SRF, 8 Sources, 7 DR/BDS/Dumps) were proposed as illustrated in Figure 1.

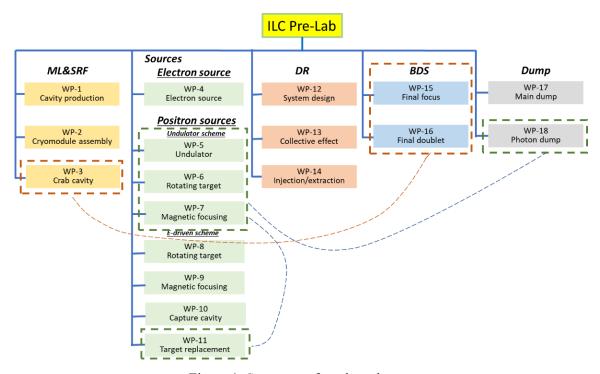


Figure 1: Summary of work packages.

Some essential (and time-consuming) WPs (so called "time-critical WPs") start earlier by international collaboration. We assume here that Pre-lab will start ~2 years later. (Total Pre-lab period can be squeezed since the time-consuming WPs started in advance.) Figure 2 shows the schedule assumptions for the time-critical WPs.

The Pre-lab work-packages are categorized by "A", "B" and "Pre-lab" where

A: Essential and higher-priority WP item,

<sup>2</sup> Proposal for the ILC Preparatory Laboratory (Pre-lab), https://doi.org/10.5281/zenodo.4884744

<sup>&</sup>lt;sup>1</sup> http://doi.org/10.5281/ zenodo.4742018

B: WP item that should be started early if possible,

Pre-lab: WP item that can be done during Pre-lab.

In this document, only Priority A and B are summarized. The required budget, FTEs, etc. are summarized in the Appendix.

The time-critical WPs will be implemented on the basis of the MoUs between the international Institutes. It is envisaged that this document will be used for negotiations between the candidate Institutes.

	P1	P2	P3	P4											
Pre-lab proposal	e-lab proposal Pre-lab ~4 years				Construction ~10 year										
	Y1	Y2	Y3/P1?	Y4/P2?											
Time-critical WPs	~4 years														
	Pre-lab 3~4 years					Constr	uction	~10 ye	ar						

Figure 2: Assumed schedule of the time-critical WPs

## 2:Sources

(Ver.1,2022-March-2)

## WP-prime 4: Higher voltage ILC Photo-gun R&D

#### Program and schedule:

WP4 consists of the drive laser system, high-voltage photo gun and GaAs/GaAsP Photocathodes. Among these the photon gun is the most urgent item. It is selected as WP-prime 4 (category B).

A high voltage photo-gun meeting the beam specifications of the 90-120 kV SLC gun was required during the GDE, with increased voltage, reduced vacuum and no field emission. Jefferson Lab built two ILC prototype guns, adopting an inverted geometry high voltage insulator design. The first gun was operated to 225 kV after gas-conditioning, and the second gun was commissioned to 200 kV and then operated at 130 kV since 2010. Both guns would meet the requirements of the TDR, providing 4.8 nC bunches within a pulse duration of 1 nsec from a laser with diameter of 1 cm at the photocathode.

However, experience during the past 10 years motivates further improvements to the ILC gun technical design. Still, based upon the inverted insulator geometry, improvements have been made a) improving the high voltage triple point junctions, to achieve higher operating voltage while maintaining maximum gradients < 10 MV/m to prevent field emission, b) for improving the cathode-anode geometry to suppress asymmetric fields within the accelerating gap to suppress beam deflection and aberration, and c) for improving the vacuum design to achieve extreme high vacuum and limiting ion back-bombardment, required for long photocathode quantum efficiency (QE) lifetime.

Additionally, gun voltages >200 kV offer the potential for meaningful performance improvements, by a) exploring laser pulse lengths shorter than 1 nsec to relax sub-harmonic bunching requirements, and b) exploring the benefit of reduced ion back-bombardment QE degradation, because the ionization cross section decreases rapidly with electron beam energy.

The proposed work over a 2 year period includes,

- beam dynamics simulations of shorter <1 nsec, higher peak current bunches that define the allowable initial longitudinal and transverse laser pulse shapes,
- an electrostatic design which maximizes gradient at the photocathode while limiting gradient on the electrode surfaces to < 10 MV/m when operating at voltage  $\sim 300 \text{ kV}$ ,
- a triple point junction shield design to linearize potential along the inverted insulator,
- a tilted biased anode design to correct for the asymmetric electrostatic field created by the insulator,
- vacuum modeling to achieve static vacuum <2 x 10-12 Torr, and
- a biased anode design to limit ion back-bombardment from entering the cathode anode gap, to extend
  photocathode operating lifetime.

The scope, tasks and projected timeline are detailed in the table below.

Main task	Main 41	Sub ta-1-	D. 7.14. 1			ar 1		Year 2				Year 3			
Simulations  Residual and the service of the section of the sectio	Main task	Sub-task			Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Electrode Electrode Electrode Electrode Electrostatic Anode-cathode pap  Anode-cathode pap  Electrostatic design  HV Feedlurough HV Feedlurough HV Feedlurough HV Feedlurough Electrode in commercial cable  Design and commercial cable Design triple point princion shield to limit ion- boundaries. (CST-GPT) Design and the commercial cable Design HV Feedlurough compatible with 36 bV commercial cable Design triple point princion shield to limit photocathode pap Design triple point princion shield to limit photocathode ion dumage (MOEFLOW-GPT-CST) Design and produce engineering drawings HV Feedlurough Electrode is vaccum chamber PNEG modibles HV Peedlurough Electrode support drawings Electrode support frame  Engineering Point junction Ander asupport frame  Engineering Fabrication  Electrode in the commercial cable of the cable o	•	1 -									Ī				
Electrostatic geometry (CST-GPT) Anode-cathode grap Design and to compensate beam deflection. (CST-GPT) Design and the compensate beam deflection. (CST-GPT) Design and produce makes and the compensation of the compensation of the compensation of the compensation. The compensation of the c	simulations	& shape													_
Maximize gradient at the photocathode < 10 MV/m: Define   Anocle-cathode   Photocathode   Phot		Electrode													
Electrostatic app  NEG modules  Negroup of the state of t															
Electrostatic design  Anode-catalode application of the policy in the companion of the comp															_
Electrostatic design  We with V Feedthrough Design anode to compensate beam deflection. (CST-GPT) Design anode to compensate beam deflection. (CST-GPT) Design anode to compensate beam deflection. (CST-GPT) Design the V Feedthrough Design Electrode are and on mode-cathode properties of the V Feedthrough Design problem by the Peedthrough and decletode size, and on mode-cathode properties of the V Feedthrough Design problem been by Electrode are triple point junction shield to linearize potential days and the V Feedthrough Point junction shield the V Feedthrough Design and produce engineering drawings  Work with vendor to develop engineering drawings  Electrode a triple point junction shield and drawings  Electrode a triple point junction shield and drawings  Electrode a triple point junction shield and the V Feedthrough Design and drawings  Electrode and the V Feedthrough Design and drawings Design and drawings  Electrode and the V Feedthrough Design and Design electrode support to HV feedthrough with internal damp to accept photocathe pucks  Engineering drawings ready  Vaccums chamber + NEG modules  Fabrication  Electrode + triple point junction shield  Anode + support finuse  Electrode + triple procure, vendor finite another procure to the definition of the procure vendor finite another vendor vendor procure vendor finite another		Anode-cathode	5												
Design HV Feedthrough HV Feedthrough HV Feedthrough Design HV Feedthrough compatible with 350 kV commercial cable Define HV Feedthrough compatible with 350 kV Design HV Feedthrough compatible with 350 kV Design HV Feedthrough compatible with 550 kV Design HV Feedthrough compatible with 550 kV Design HV Feedthrough compatible with 550 kV Design HV Feedthrough keeping E-10 MV/m at 350 kV Design HV Feedthrough Design triple point junction shield to finestive potential along IV Feedthrough keeping E-10 MV/m at 350 kV Design and produce engineering E-10 MV/m at 350 kV Design and produce engineering design and design mode drift tube to limit photocathode ion damage (MOLFLOW-FOFT-CST)  Electroda triple point junction when the feed of t		gap													
IIV Feeddrough   Define HV chamber size based on HV feeddrough and electrods size, and on anode-candod gap   Design triple point junction shield to linearize potential anode with the total market point junction shield to linearize potential anode with tube to limit photocarthode ion damage (MOLIELOW-GPT-CST)   Define pumping scheme to achieve <1E-12 Torr   Optimize anode drift tube to limit photocarthode ion damage (MOLIELOW-GPT-CST)   Design and produce engineering drawings   Design and drawings   Design electrode support structure   Design electrode support structure   Anode + support firms   Design electrode support structure   Design and electrode support firms   Design anode drift tube + support firms   Design anode + support   Design anode + drift tube + support firms   Design anode + drift tube + support firms   Design anode + support   Design anode + drift tube + support firms   Design anode + support   Design anode + drift tube + support + design anode + drift tube + design anode +	design														
Procure   Proc		HV Feedthrough													
Design risple point junction shield to linearize potential all all and put Vicediruogh keeping E>10 MVm at 350 kV   Note of the pumping scheme to achieve <1E-12 Torr   Optimize amode drift tube to limit photocenthode ion damage (MOLF-LOW-GPT-CST)   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to achieve <1E-12 Torr   Note of the pumping scheme to scheme the pumping scheme to achieve the shield end from and back ends shield   Note of the point junction also per to accept photocathe pucks   Design electrode + shield = front and back ends shape to accept photocathe pucks   Design acktrode suppoort frame   Design acktrode suppoort frame   Procure, vendor makes NEG modules   Procure, vendor makes NEG modules   Procure, vendor fabricates vacuum chamber   Note of the point junction shield   Procure, vendor fabricates vacuum chamber   Procure, vendor															
Neg modules   Define pumping scheme to achieve <1E-12 Tor												H			-
Anode support    Components ready   Anode support															
Design and produce engineering drawings   Design and produce engineering drawings	Vacuum	NEG modules	Define pumping scheme to achieve <1E-12 Torr												
Electrostatic * vacuum design ready  Vacuum chamber + NEG modules  Engineering design  Electrode * triple point junction shield  Anode * support frame  Procure, vendor makes NEG modules  HV Feedthrough  Electrode * support frame  Engineering drawings ready  Vacuum chamber + NEG modules  HV Feedthrough  Electrode * support frame  Engineering drawings ready  Vacuum chamber + NEG modules  HV Feedthrough  Electrode * support frame  Engineering drawings ready  Vacuum chamber + NEG modules  Fabrication  Electrode * support frame  Electrode * support frame  Electrode * support frame  Fabrication  Anode * support frame  Fabricate anode and drift tube + support frame  Fabricate in Saided  Anode * support frame frame  Fabricate anode and drift tube  Fabricate electrode  Fabricate electrode  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode triple point junction shield  Anode * support frame and biasing/mounting hardware  Electrode support frame and biasing/mounting hardware  Electrode triple point junction shield  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment support and dummy puck with State of the puck of t		Anode support													
Vacuum chamber   Procure   Vacuum chamber			(MOLFLOW+GPT+CST)												_
# NEG modules HV Feedthrough Electrode + triple point junction shield Anode + support frame  Fabrication  Fabrication  Fabrication  Fabricate Betrode + triple point junction shield Anode + support frame  Fabricate Betrode + triple point junction shield Anode + support frame  Fabricate triple point junction shield Anode + support frame  Fabricate triple point junction shield Anode + support frame  Vacuum chamber Fabricate anode and drift tube Fabricate triple point junction shield shield Anode + triple point junction shield Anode + support frame  Vacuum chamber Fabricate with vendor fabricates vacuum chamber Fabricate triple point junction shield shield Anode + support frame  Vacuum chamber Fabricate with vendor fabricates wi	Electrostatic + va														_
Engineering design  Electrode + triple point junction shield  Anode + support frame  Engineering drawings ready  Vacuum chamber Fabrication  Electrode + support frame  Electrode + triple point junction shield  Anode + support frame  Electrode + triple point junction shield  Anode + support frame  Electrode + triple point junction shield  Anode + support frame  Electrode + triple point junction shield  Anode + support frame  Electrode + triple point junction shield  Anode + support frame  Electrode + triple point junction shield  Fabricate anode support frame and biasing/mounting hardware  Electrode support frame and biasing/mounting hardware  Fabricate anode support frame and biasing/mounting hardware  Electrode support frame and biasing/mounting hardware  Fabricate anode support frame and biasing/mounting hardware  Electrode support frame and biasing/mounting hardware  Fabricate anode support frame and biasing/mounting h			Design and produce engineering drawings												
Electrode + triple point junction shield  Electrode support frame  Engineering draw in the state of the state			Work with vendor to develop engineering design and												
Engineering design  Electrode support shield  Electrode support structure  Anode + support frame  Engineering drawings ready  Vacuum chamber + NEG modules  Fabrication  Electrode + triple point junction shield  Anode + support frame  Procure, vendor makes NEG modules  Procure, vendor fabricates vacuum chamber Point junction shield  Electrode + triple point junction shield  Anode + support frame  Electrode support bring Fabricate anode and drift tube  Fabricate photocathe pucks  Fabricate photocathe pucks  Fabricate anode and photocathe pucks  F			drawings												
Shield Electrode support structure  Design electrode support to HV feedthrough with internal shape to accept photocathe pucks Design puck for dummy SS substrate puck Design anode + drift tube + support frame  Engineering drawwings ready  Vacuum chamber + NEG modules Procure, vendor makes NEG modules Procure, vendor fabricates vacuum chamber Procure HV feedthrough Electrode + triple point junction shield Anode + support frame  Electrode + support frame  Fabricate electrode Fabricate anode and drift tube Fabricate anode and drift tube Fabricate anode support frame  Electrode support structure  Fabricate dectrode datachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Electrode + triple point junction shield Clean  Weld to flange + leak check Clean clectrode attachment support and dummy puck with SS substrate Mount electrode + triple point junction shield + dumy puck and fiducial  Nace and fiducial  Nace also point junction shield + dumy puck and fiducial  Nace and fiducial  Gun ready for vacuum bake  Gun ready for vacuum bake		· ·	Design electrode + shield + front and hook ends												
Electrode support structure  Anode + support frame  Engineering drawings ready  Vacuum chamber + NEG modules  Procure, vendor makes NEG modules Procure, vendor fabricates vacuum chamber Procure HV feedthrough Electrode + triple point junction shield Anode + support frame  Electrode support frame  Electrode support frame  Fabrication  Anode + support frame  Electrode support frame and biasing/mounting hardware  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Electrode support frame and biasing/mounting hardware  Vacuum chamber + NEG modules Electrode + triple point junction shield shield  Vacuum chamber + NEG modules Electrode + triple point junction Shield  Vacuum degass to 900 C Polish Clean  Weld to flamge + leak check Clean electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal Vacuum degass to 900 C Polish Clean  Anode assembly  Anode assembly  Gun ready for vacuum bake  Gun ready for vacuum bake  Electrode support frame and fiducial  Gun ready for vacuum bake			Design electrode i sineid i from and back ends												
Structure    Design puck for dummy SS substrate puck	design	structure	Design electrode suppoort to HV feedthrough with internal												
Anode + support frame    Procure, vendor makes NEG modules												Н			_
Engineering drawnigs ready  Vacuum chamber + NEG modules   Procure, vendor makes NEG modules   Procure, vendor fabricates vacuum chamber   Procure HV feedthrough   Vendor fabricates HV feedthrough   Procure HV feedthrough   Vendor fabricates HV feedthrough   Vendor fabricate electrode   Pabricate electrode   Pabricate anode and drift tube   Fabricate anode support frame and biasing/mounting   Fabricate anode support frame and biasing/mounting   Fabricate anode support frame and biasing/mounting   Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks   Fabricate Mo puck for dummy SS substrate puck   Vacuum chamber + NEG modules   NEG modules   Vacuum degass to 900 C   Vacuum degass to 9			Design puck for dummy SS substrate puck												
Engineering drawings ready  Vacuum chamber + NEG modules  HV Feedthrough  Fabricate lectrode + triple point junction shield  Anode + support frame  Electrode support structure  Fabricate anode and drift tube  Fabricate anode support frame and biasing/mounting hardware  Fabricate anode and drift tube  Fabricate anode and drift		_	Design anode + drift tube + support frame												
Vacuum chamber + NEG modules  HV Feedthrough  Fabrication  Fabrication  Fabrication  Fabrication  Fabrication  Fabrication  Fabrication  Fabricate + triple point junction shield  Anode + support frame Fabricate anode support frame and biasing/mounting hardware  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Assembly  Weld to flange + leak check  Clean  Weld to flange + leak check  Clean down and fiducial  Install on chamber and align per fiducal  Anode assembly  Gun ready for vacuum bake  Gun ready for vacuum bake  Procure, vendor fabricates wocum chamber   Procure, vendor fabricates vacuum chamber   Procure HV feedthrough   Procur	Engineering dray	•													
Fabrication  Fabrication  Fabrication  Fabrication  Fabricate  HV Feedthrough  Electrode + triple point junction shield Fabricate anode and drift tube Fabricate anode and drift tube Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware  Electrode support structure  Electrode support structure  Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware  Fabricate anode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Electrode + triple point junction shield  Electrode + triple point junction shield  Weld to flange + leak check  Clean  Weld to flange + leak check  Clean electrode attachammet support and dummy puck with SS substrate Mount electrode attachammet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Gun ready for vacuum bake  Gun ready for vacuum bake  Gun ready for vacuum bake  Fabricate electrode  Fabricate electrode  Fabricate anode and drift tube  Fabricate anode and drift tube  Fabricate anode and biasing/mounting hardware  Fabricate anode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate anode attachment to HV feedthrough with internal shape to accept photocathe pucks  Vacuum degass to 900 C  Polish  Clean  Assembly	Engineering trav		Progress vander maker NEG modules					$\vdash$							_
HV Feedthrough Electrode + triple point junction shield Anode + support frame Electrode support structure  Electrode support structure  Vacuum chamber + NEG modules Electrode + triple point junction shield  Assembly  HV Feedthrough  Vacuum bake at 400 C for deagassing Electrode + triple point junction shield  HV Feedthrough  Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum bake at 400 C for deagassing Install NEG modules Electrode + triple point junction shield  Electrode + triple point junction shield  HV Feedthrough  HV Feedthrough  HV Feedthrough  HV Feedthrough  Guar ready for vacuum bake  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate anode support frame and biasing/mounting hardware  Fabricate anode assembly  Vacuum bake at 400 C for deagassing Install NEG modules, screen, extractor gauge  Vacuum degass to 900 C  Polish Clean  Anode assembly  Anode assembly  Anode assembly  Guar ready for vacuum bake  HV Feedthrough  Assemble and install on chamber and fiducial  Guar ready for vacuum bake			,					H				$\vdash$			_
HV Feedthrough Electrode + triple point junction shield Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware Electrode support structure  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Electrode + triple point junction shield  Assembly  HV Feedthrough  HV Feedthrough  HV Feedthrough  HV Feedthrough  Assembly  Assembly  HV Feedthrough  HV Feedthrough  Anode assembly  HV Feedthrough  Anode assembly  Gun ready for vacuum bake  Vacuum degass to 900 C  Polish Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake		1 NEO modules	*												_
Electrode + triple point junction shield  Anode + support frame  Electrode support structure  Electrode support structure  Electrode support structure  Electrode support structure  Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Electrode + triple point junction shield  Electrode + triple point junction shield  HV Feedthrough  HV Feedthrough  HV Feedthrough  Anode assembly  Anode assembly  Anode assembly  Fabricate anode and drift tube Fabricate anode and drift tube Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mount gasassing  Vacuum degass to 900 C  Polish Clean  Weld to flange + leak check Clean electrode attachammet support and dummy puck with SS substrate Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish Clean Assemble and install on chamber and fiducial  Gun ready for vacuum bake		Electrode + triple point junction													
Fabrication shield Fabricate triple point junction shield Fabricate and and drift tube Fabricate and support frame Fabricate and support frame and biasing/mounting hardware Fabricate lectrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate puck Fabricate Mo puck for dummy SS substrate puck   Components reat  Vacuum chamber + NEG modules Install NEG modules, screen, extractor gauge Vacuum degass to 900 C Polish Clean  HV Feedthrough Weld to flange + leak check Clean electrode attachment support and dummy puck with SS substrate Mount electrode + triple point junction shield Install on chamber and align per fiducal Vacuum degass to 900 C Polish Clean Assembly Anode assembly			Vendor fabricates HV feedthrough												
Fabricate triple point junction shield  Anode + support frame  Electrode support structure  Electrode support structure  Electrode support structure  Electrode support structure  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Assembly  HV Feedthrough  HV Feedthrough  Anode assembly  Anode assembly  Fabricate anode and drift tube Fabricate anode support frame and biasing/mounting hardware Fabricate Mo puck for dummy SS substrate puck  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Vacuum bake at 400 C for deagassing Install NEG modules, screen, extractor gauge  Vacuum degass to 900 C  Polish  Clean  Weld to flange + leak check  Clean electrode attachammet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial			Fabricate electrode												
Anode + support frame  Electrode support structure  Electrode support structure  Fabricate anode support frame and biasing/mounting hardware  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Electrode + triple point junction shield  Clean  Weld to flange + leak check  Clean electrode attachammet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Anode assembly  Anode assembly  Gun ready for vacuum bake	Fabrication		Fabicate triple point junction shield												
Fabricate anode support frame and biasing/mounting hardware  Electrode support structure  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Electrode + triple point junction shield  Electrode + triple point junction shield  HV Feedthrough  HV Feedthrough  HV Feedthrough  Anode assembly  Anode assembly  Fabricate anode support frame and biasing/mounting hardware  Fabricate anode support frame and biasing/mounting hardware  Fabricate anode support frame and biasing/mounting hardware  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks  Fabricate electrode attachment support  Vacuum degass to 900 C  Polish  Clean electrode attachment support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial		11	Fabricate anode and drift tube												
Electrode support structure  Fabricate electrode attachment to HV feedthrough with internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Electrode + triple point junction shield  HV Feedthrough  HV Feedthrough  HV Feedthrough  Anode assembly  Fabricate Mo puck for dummy SS substrate puck  Vacuum bake at 400 C for deagassing Install NEG modules, screen, extractor gauge  Vacuum degass to 900 C  Polish  Clean  Weld to flange + leak check Clean electrode attachamnet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake			Fabricate anode support frame and biasing/mounting												
Electrode support structure internal shape to accept photocathe pucks Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules Install NEG modules, screen, extractor gauge  Electrode + triple point junction shield  Clean  Weld to flange + leak check  Clean electrode + triple point junction shield + dumy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal  Anode assembly  Anode assembly  Gun ready for vacuum bake															
Structure Fabricate Mo puck for dummy SS substrate puck  Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Clean  Weld to flange + leak check  Clean electrode attachamnet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Anode assembly  Anode assembly  Fabricate Mo puck for dummy SS substrate puck  Vacuum bake at 400 C for deagassing  Vacuum degass in 900 C  Polish  Clean  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake		Electrode support	_												
Components ready  Vacuum chamber + NEG modules  Electrode + triple point junction shield  Assembly  Assembly  HV Feedthrough  Anode assembly  Anode assembly  Vacuum bake at 400 C for deagassing Install NEG modules, screen, extractor gauge  Vacuum degass to 900 C Polish Clean  Weld to flange + leak check Clean electrode attachamnet support and dummy puck with SS substrate Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal  Vacuum degass to 900 C Polish Clean  Assemble and install on chamber and fiducial  Gum ready for vacuum bake		structure													
Vacuum chamber + NEG modules	Components ready														
HV Feedthrough HV Feedthrough  Assembly  House	7	<del>'</del>	Vacuum bake at 400 C for deacassing					┢				$\vdash$			_
Electrode + triple point junction shield  Assembly  HV Feedthrough  HV Feedthrough  Anode assembly  Anode assembly  House a sample and install on chamber and fiducial  Assemble and install on chamber and fiducial  Gun ready for vacuum bake  Vacuum degass to 900 C  Polish  Clean  Weld to flange + leak check  Clean electrode attachamnet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial	Assembly														_
Assembly  HV Feedthrough HV Feedthrough Assembly  Holish Clean  Weld to flange + leak check Clean electrode attachamnet support and dummy puck with SS substrate Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish Clean Assemble and install on chamber and fiducial  Gun ready for vacuum bake															_
Assembly  HV Feedthrough HV Feedthrough  Assembly  House assembly  Anode assem		point junction										Н			_
Assembly  HV Feedthrough  HV Feedthrough  HV Feedthrough  Anode assembly  Anode assembly  Clean  Clean  Weld to flange + leak check  Clean electrode attachamnet support and dummy puck with SS substrate  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gum ready for vacuum bake			Polish												
Assembly HV Feedthrough HV Feedthrough HV Feedthrough HV Feedthrough HV Feedthrough HV Feedthrough FSS substrate Mount electrode + triple point junction shield + dumy puck and fiducial Install on chamber and align per fiducal Vacuum degass to 900 C Polish Clean Assemble and install on chamber and fiducial  Gun ready for vacuum bake			Clean												
Assembly HV Feedthrough    SS substrate   Mount electrode + triple point junction shield + dumy puck and fiducial   Install on chamber and align per fiducal   Vacuum degass to 900 C   Polish   Clean   Assemble and install on chamber and fiducial   Our ready for vacuum bake   Our re		HV Feedthrough	Weld to flange + leak check												
HV Feedthrough  Mount electrode + triple point junction shield + dumy puck and fiducial  Install on chamber and align per fiducal  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake															
Anode assembly															
Anode assembly  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake								L					_		
Anode assembly  Vacuum degass to 900 C  Polish  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake			Install on chamber and align per fiducal												
Anode assembly Polish Clean Assemble and install on chamber and fiducial Gun ready for vacuum bake				Ī						П					
Anode assembly  Clean  Assemble and install on chamber and fiducial  Gun ready for vacuum bake		Anode assembly								Н		H			=
Assemble and install on chamber and fiducial  Gun ready for vacuum bake				$\vdash$	$\vdash$			$\vdash$		$\vdash$		$\vdash$			$\dashv$
Gun ready for vacuum bake				H		$\vdash$		$\vdash$		$\vdash$		Н			
			Assemble and install on chamber and fiducial	H				$\vdash$		H		$\vdash$			
	Gun ready for va	icuum bake	b												

## **Work Packages for the Undulator Positron Source**

#### Overview

The baseline design of the positron source no longer has impediments to its further progress. A full-scale working superconducting ILC undulator module has been successfully demonstrated and tested [1]. A prototype experiment for an undulator-based polarised positron source has already been successfully performed at SLAC [2]. Furthermore, several years of successfully operating FELs with very long undulator sections exist [3] and their alignment requirements exceed by far the requirements of the undulator-based e+ source. The ILC baseline design has been described in detail in the ILC TDR (Vol 3-II, Chapter 5, 2013) including a remote-handling scheme for the target assembly as well as a low-intensity auxiliary source for commissioning purposes. A few final design choices and engineering works have yet to be completed. Since the ILC positron working group report [4] was made in 2018, substantial progress had been achieved in the following areas: successful experimental tests of thermal target stress, the detailed design of radiative target cooling, and the design of an optical matching device (OMD), a pulsed solenoid, for securing the required yield overhead factor of 1.5 [13]. The undulator positron source IDT work packages are listed below.

#### WP5 (Undulator)

minor design choices of the undulator parameters and its masks design, alignment requirements and optimized undulator parameters for the 250-GeV phase, will be finalized soon [6]. This will not be included in the category A and B.

#### WP6 (Rotating target)

Parts of WP6 items (Full wheel validation) concern engineering issues and some technical specifications, for instance those of the magnetic bearings or target tests [8], have been done already, see also [9,10,12]. But since the engineering design for the full wheel validation depend on the final technical specifications of the OMD, this WP6 will be accomplished subsequently (category B).

#### WP7 (Magnetic Focusing System)

Within the next 2 years, laboratory tests of a prototype and lab measurements of the magnetic field for different pulses, the eddy currents etc. are envisaged so that the final design of the OMD is finished. This is the most urgent work (Category A).

A prototype for an alternative OMD design, based on new accelerator technologies, using plasma lens as focusing system, have already secured funding from the German BMBF and are envisaged within this time period as well (Category A) [11].

Concrete Plans for year 1+2

WP7 (Magnetic Focusing System)

Detailed simulations (magnetic forces, stresses and temperatures in the coil conductor, including retaining bolts, yield calculations with varied target-solenoid gaps below 4mm, increased magnetic field at the target) for the pulsed solenoid are already ongoing so that the principal design for a prototype pulsed solenoid can be specified in the first half of year one.

Based on those results the production engineering for the 1:1 scaled pulsed prototype can started, so that the actual measurements can already be started in the second phase of year one. Envisaged are field measurements with 1kA (pulsed and DC) and with 50kA both in a single pulse mode and finally in a 5ms pulsed mode. These measurements are envisaged to take about one year so that the final OMD design can be finished within the second year.

Also the prototype for an alternative OMD design, the plasma lens, will be envisaged until the end of year two with already approved funding.

#### WP6 (Target)

The 'priority B' items, the engineering design and vendor negotiations for the magnetic bearings as well as the mock-up for the radiation cooling of the rotating wheel is therefore be scheduled towards the end of year 2.

#### **References:**

- [1] D J Scott et al, Demonstration of A High Field Short Period Superconducting Helical Undulator Suitable for Future TeV-Scale Linear Collider Positron Sources, PRL 107, 174803 (2011).
- [2] G. Alexander, J. Barley, Y. Batygin, S. Berridge, V. Bharadwaj, G. Bower, W. Bugg, F. J. Decker, R.

Dollan and Y. Efremenko, 29et al., Observation of Polarized Positrons from an Undulator-Based Source,

Phys. Rev. Lett. 100 (2008), 210801; G. Alexander, J. Barley, Y. Batygin, S. Berridge, V. Bharadwaj, G.

Bower, W. Bugg, F. J. Decker, R. Dollan and Y. Efremenko, et al., Undulator-Based Production of Polarized Positrons, Nucl. Instrum. Meth. A, **610** (2009), 451-487.

[3] Heung-Sik Kang et al, Journal of Synchrotron Radiation, Vol 26, p1127-1138, July 2019; H-D Nuhn, Proceedings of FEL 2009, p714,

## https://accelconf.web.cern.ch/FEL2009/papers/thoa02.pdf

- [4] Positron Working Group Report, May 23, 2018,
- http://edmsdirect.desy.de/item/D0000001165115.
- [5] S. Riemann et. al., 2002.10919 [physics:acc-ph].
- [6] K. Alharbi, et al., 2001.08024 [physics.acc-ph]
- [7] K. Fujii et al., 1801.02840 [hep-ph], PhD Thesis, R. Karl, Hamburg University, 2019,
- J. Beyer et al., 2002.02777 [hep-ex])
- [8] F. Dietrich et al., 1902.07744 [physics.acc-ph], A. Ushakov et al.,
- IPAC2017 (TUPAB002), and T. Lengler, Ba Thesis, Hamburg University, 2020.
- [9] I. Bailey et. al, EUROTeV-Report-2008-028-1, EPAC08 (MOPP069). I. Bailey et al., IPAC2010 (THPEC033).

- [10] S. Antipov et al., PAC07 (THPMN087).
- [11] M. Formela et al., 2003.03138 [physics.acc-ph].
- [12] M. Breidenbach et al., PoS ICHEP2016 (2016) 871.
- [13] C. Tenholt, talk at ICLX workshop, Nov. 2021; M. Fukuda, G. Loisch, M. Mentink, G. Moortgat-Pick, T.
- Okugi, S. Riemann, P. Sievers, C. Tenholt, K. Yokoya, in preparation.

Work package	Items					
WP- 5: Undulator	Simulation (field,errors, masks, alignment, optimisation for 250GeV)					
	Design finalization, partial laboratory test, mock-up design					
WP- 6: Rotating target	Magnetic bearings: performance, specification, test					
	Full wheel validation, mock-up					
WP- 7: Magnetic focusing	Design finalisation for the pulsed solenoid, including yield calculation					
system	OMD with fully assembled wheel					

## **Work Packages for the Electron-Driven Positron Source**

## **WP-prime 8: Rotating Target**

The aim of the work package is to develop the technical design of the rotating target for E-Driven e+source for ILC. It consists from three sub-packages: Target stress calculation, vacuum seal study, and target module prototyping. The first two sub-packages should be proceeded with a high priority, and the prototyping is made at a low priority.

## WP-prime 9: Magnetic Focusing System

The aim of the work package is to develop the technical design of the magnetic focusing system for E-Driven e+ source for ILC. The prototyping of the device should be executed with a low priority. Other sub-work packages for the conductor study mainly by FEM simulation, and a conceptual design study for the transmission line should be proceeded at a high priority.

## WP-prime 10: Capture Cavity and Linac

The aim of the work package is to develop the technical design of the capture linac including the APS cavity and the operation. The all prototype work should be executed at a low priority. Other subpackages for the beam loading compensation and the operation should be proceeded at a high priority.

# Work Package common to the Undulator and e-Driven system WP-prime 11: Target Maintenance

The aim of the work package is to complete the technical design of the target exchange system as a common effort for E-Driven and Undulator positron sources. This WP is defined as one in the prelab. Proposal, but it should be divided as 11-1) conceptual design, 11-2) Technical design, and 11-3) Component prototyping. 11-1) and 11-3) should be executed at a high priority, and 11-2) at a low priority.