ILC/CLIC common issues for the positron sources

Louis Rinolfi

On behalf of the ILC/CLIC e^+ working group

Acknowledgments

Ankara University (TU):	E. Eroglu, E. Pilicer
ANL (USA):	W. Gai, L. Wanming
BINP (Russia):	V. Strakhovenko
BNL (USA):	I. Pogorelski, V. Yakimenko
CERN:	S. Doebert, A. Vivoli, F. Zimmermann
Cockcroft Institute (UK):	I. Bailey, J. Clarke, L. Zang
IPNL-Lyon (France)	R. Chehab
Hiroshima University (JP):	M. Kuriki
KEK (Japan):	T. Kamitani, T. Omori, J. Urakawa
Kharkov Institute (Ukraine):	E. Bulyak, P. Gladikh
LAL (France):	O. Dadoun, P. Lepercq, A. Variola
SLAC (USA):	J. Sheppard

Subjects with strong synergy

ILC/CLIC Working Groups & Conveners

	CLIC	ILC
Physics & Detectors	L. Linssen, D. Schlatter	F. Richard, S. Yamada
Beam Delivery System (BDS) & Machine Detector Interface (MDI)	D. Schulte, R. Tomas Garcia E. Tsesmelis	B. Parker, A. Seriy
Civil Engineering & Conventional Facilities	C. Hauviller, J. Osborne.	V. Kuchler
Positron Generation (new)	L. Rinolfi	J. Clarke
Damping Rings (new)	Y. Papaphilipou	M. Palmer
Beam Dynamics	D. Schulte	A. Latina, K. Kubo, N. Walker
Cost & Schedule	P. Lebrun, K. Foraz, G. Riddone	J. Carwardine, P. Garbincius, T. Shidara

Mandate of the working group

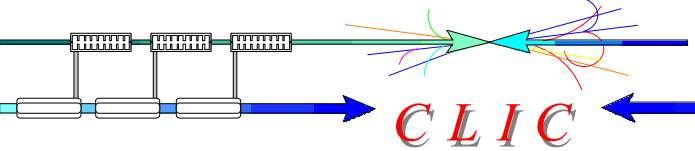
The ILC study considers the Undulator option as the base line while the Compton schemes are alternative options. The CLIC study considers the Compton schemes as the base line for polarized e^+ while the Undulator is an alternative option. Additionally, both projects are interested in the development of conventional sources (ILC as an auxiliary source and CLIC as the baseline for the CDR).

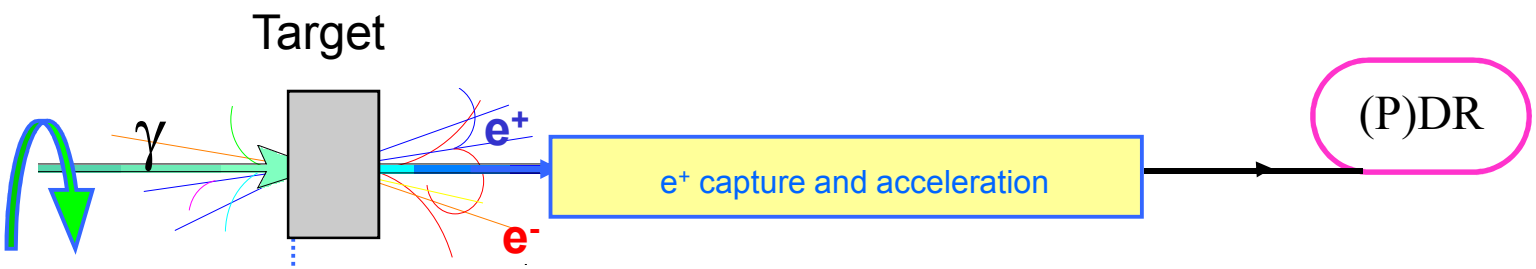
The working group should:

- Develop the synergy between the ILC and CLIC e^+ studies.
- Evaluate the common technical issues related to production of positrons.
- Prioritize R&D.
- Review the existing tests facilities where further tests could be performed.
- Invite experts from different institutes to contribute to the studies.
- Evaluate where cost savings could be obtained.
- Promote common meetings and workshops.

http://clic-study.web.cern.ch/CLIC-Study/CLIC_ILC_Collab_Mtg/ILC_CLIC_e+_working_group.pdf

ILC/CLIC main common issues





Specific to the scheme

Common

Target issues (Material, thermal load, …)

Capture systems (Matching Devices, RF, …)

(Pre-) Damping Ring acceptance

Spin preservation (for polarized e^+)

Beam instrumentation (large emittances, polarization, …)

Remote handling (Radioactive area)

Stability and reliability

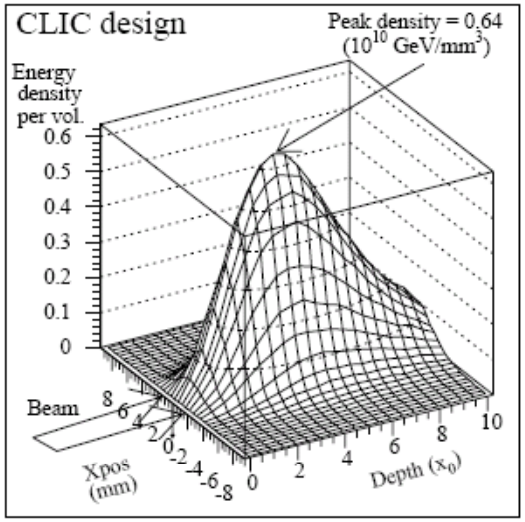
Cost estimate

Not exhaustive ILC/CLIC issues for e^+ source

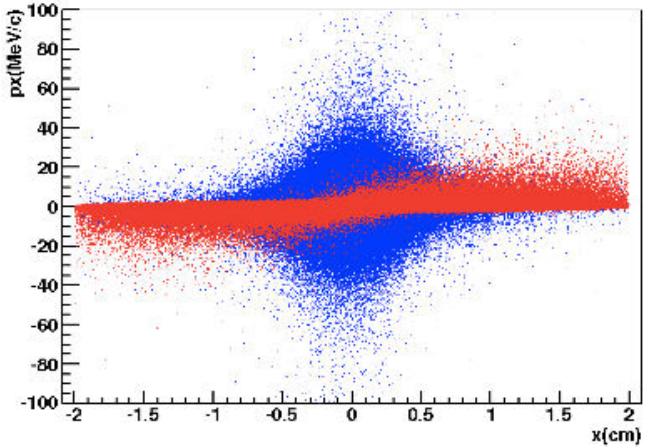
1) Reliable and efficient conventional e^+ sources (Auxiliary for ILC and hybrid targets for CLIC)
2) Production of polarized photons (from Compton schemes and from Undulator)
3) Undulator magnet
4) Photon collimators
5) Devices based on Compton schemes (Ring, ERL, Linac)
6) Laser systems related to the Compton schemes
7) Targets issues (Heat load dynamics, beam energy deposition, shock waves, breakdown limits, activation, ….)
8) Adiabatic Matching Device (AMD) or Optical Matching Device (OMD)
9) Capture and acceleration sections (Transport and collimation of large emittances)
10) Find out a maximum e^+ yield (Trade off between yield and polarization)
11) Stacking process in a ring
12) Polarization issues (Analyze systematic errors of polarization measurements)
13) Development of codes + efficient use of existing codes (EGS4, FLUKA, Geant4, PPS-Sim, …)
14) Integration issues for the target station (remote handling in radioactive area)
15) Radioactivity issues
16) ……..

Simulations for e+ targets

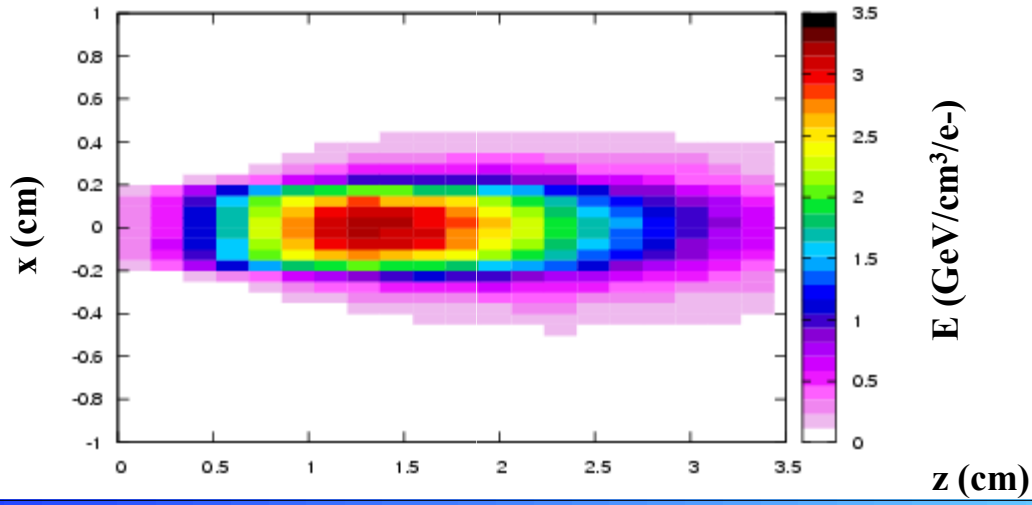
EGS4: T. Kamitani / KEK



GEANT4: O. Dadoun / LAL



FLUKA: E. Eroglu/Ankara

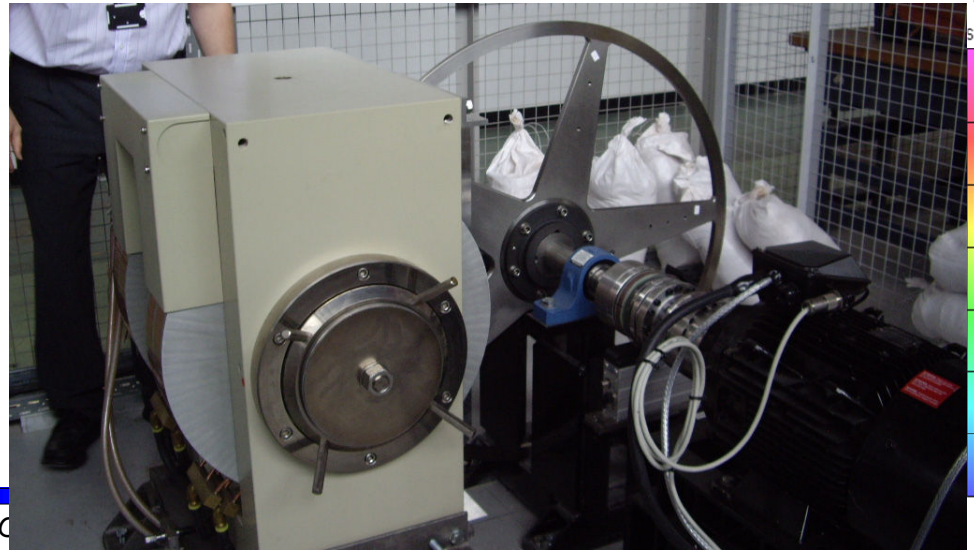


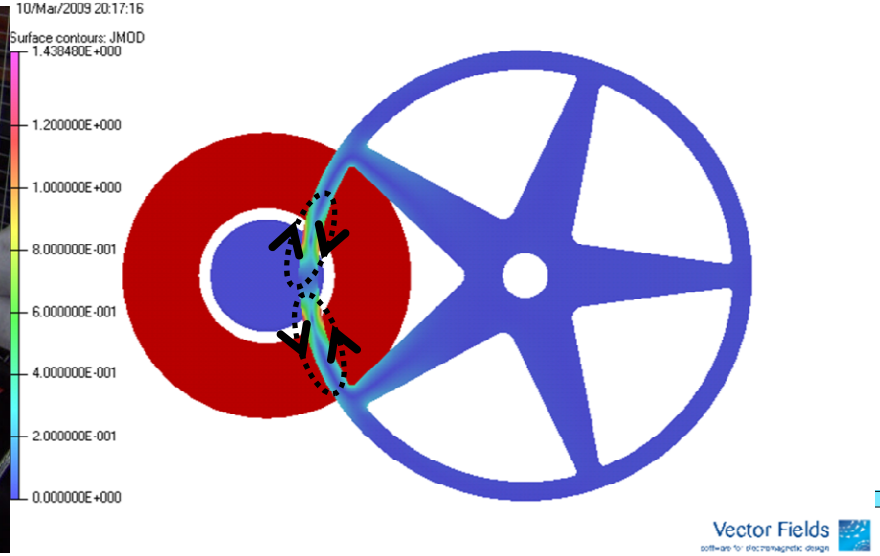
Critical target issues

I. Bailey, J. Clarke

- ILC Target
  - Rotating titanium wheel
    - Eddy current heating (~ 5kW for 1T)
    - Photon beam heating
    - Pressure shock waves
    - Cooling/vacuum/radiation resistance
    - Prototype exists and Eddy current effects will be carefully measured and quantified/benchmarked
    - Analysis of pressure shock waves ongoing

Rotation reduces the energy density to 24 J/g

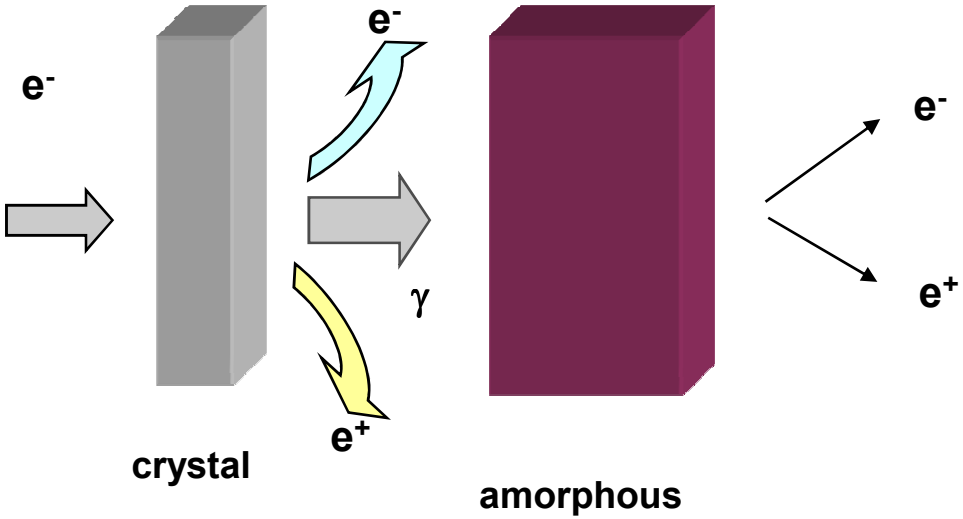




Target issues

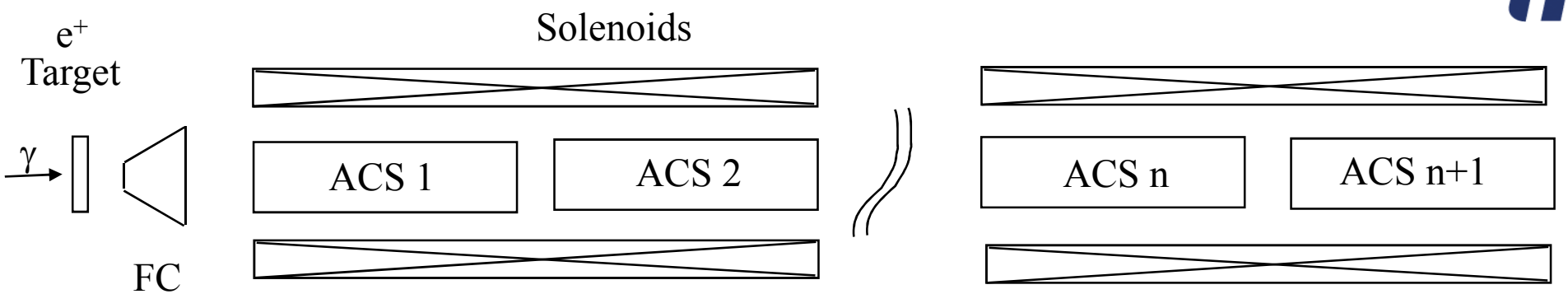
R. Chehab, A. Variola

- CLIC Target
  - Fixed tungsten targets
    - Electron and photon beam heating
    - Pressure shock waves
    - Cooling/vacuum/radiation resistance
    - For 500 GeV, PEDD is very close to the limit
    - Prototype does not exist and carefully tests should be performed
    - KEK proposal for experiments is ongoing



Hybrid targets reduce the energy density to 16 J/g

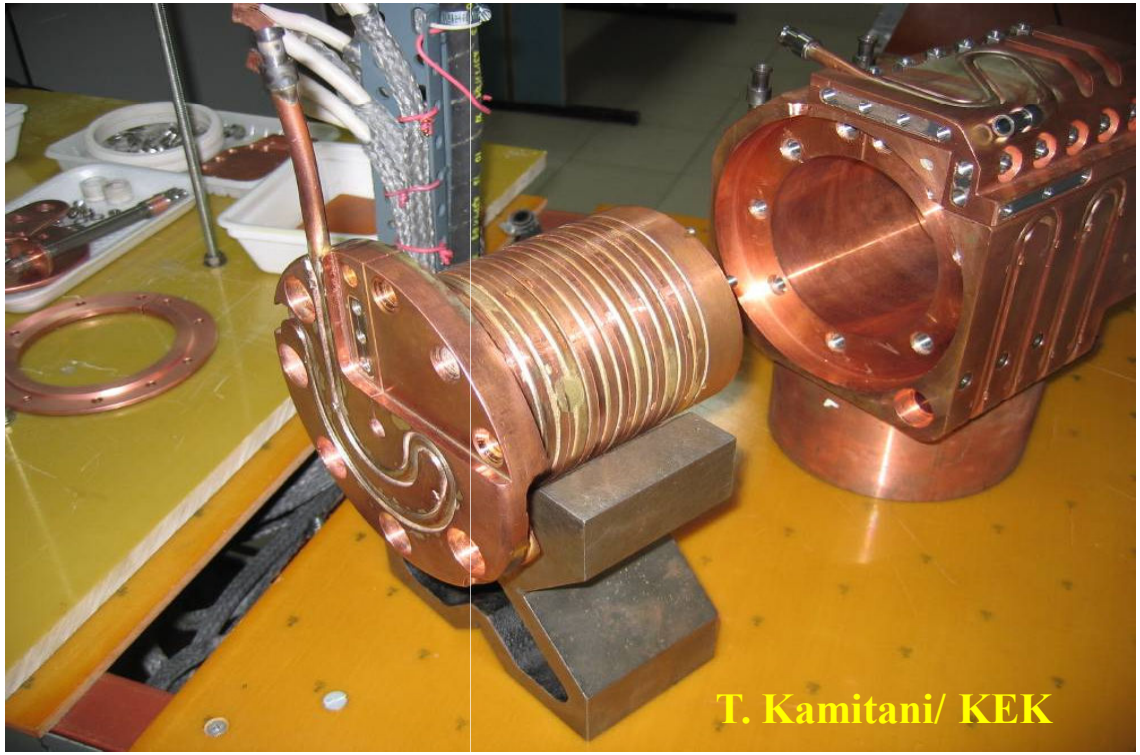
Capture systems



Flux Concentrator: FC		ILC	CLIC
Max magnetic field	T	7	6
Length	m	0.14	0.5
Solenoid magnetic field	T	0.5	0.5
Length of linac with solenoids	m		42
Pulse length	ms	1	156×10^{-6}
Frequency	Hz	5	50

Flux concentrator issues

- Magnetic field on the target
- Long pulse (ILC), high repetition rate (CLIC)
- Power supply
- Engineering to handle cooling and forces



Other devices

Quarter wave transformer

- Very low magnetic field on the target
- Simple solenoids arrangement
- Lower capture efficiency

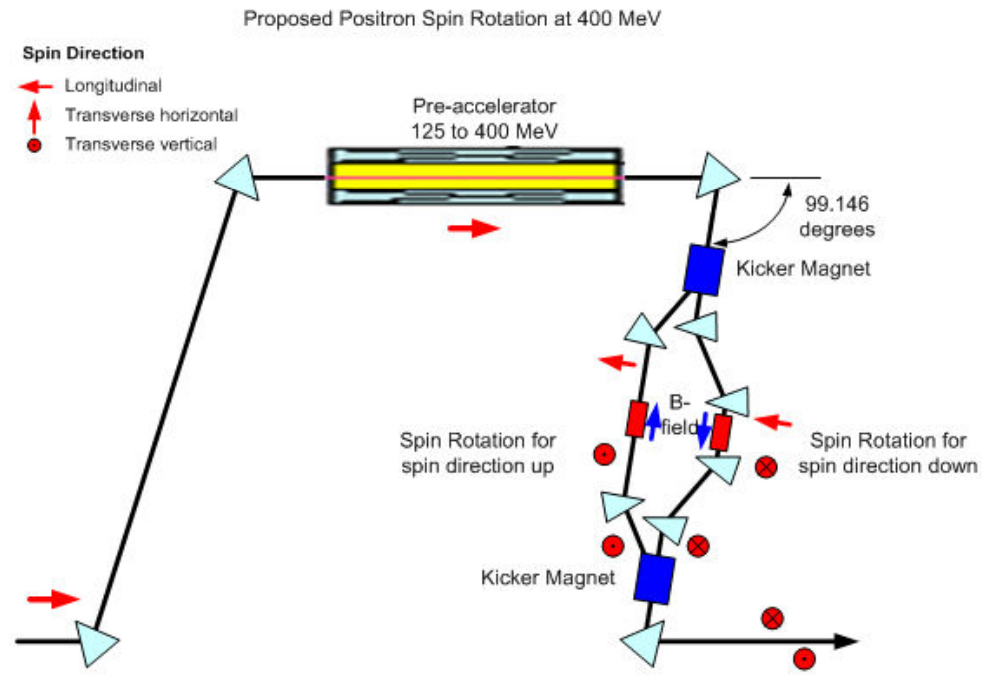
Lithium lens

- Liquid metal
- BN window
- Cavitation in liquid metal

Spin rotators before DR

K. Moffeit / SLAC

- Proposal to move from 5 GeV to 0.4 GeV
- Considerably easier magnets and less civil engineering needed
- 5Hz flipping much simpler and looks tolerant



For CLIC, the spin rotators installed at 200 MeV

50 Hz flipping needs to be investigated

Beam instrumentation

Diagnostic
Total charge
Beam position monitors
Streak camera
Profile monitors
Bunch length
Beam loss monitors
Energy
Energy spread
Emittances
Polarization

Institutes and tests facilities

Positron sources:

ANL	BINP	BNL	CERN	CI	Cornell	DESY	Durham	NSC-KIPT
IPNL	KEK	LAL	LLNL	STFC				

- Positron target tests (CI) at Daresbury (UK)
- ATF and KEKB e^+ source at KEK
- Li lens, window tests, liquid Li and Pb targets at BINP (Russia)
- Li lens for e^+ beam at CesrTA (USA)
- Optical cavity at LAL (F)
- NA63 experiment at CERN (CH) [a possibility under discussion]

Conventional sources (Conventional targets and hybrid targets)

Simulations (Geant4) to optimize the unpolarized e+ yield with hybrid targets (with LAL)
Simulations (FLUKA) to optimize the beam energy deposition in targets (with Ankara Uni.)
Proposal for tests of e+ targets at ATF and KEKB (with KEK, LAL, CERN)

Undulator-based source

Develop Geant4 model of collimator, target, capture optics, and capture RF assembly (at CI)
Positron target tests (at CI)
Optimise parameters wrt yield, polarisation (with ANL)

Compton source

Design of the Compton ring (with NSC KIPT)
Optical stacking cavity (with LAL and KEK)
Stacking simulations (at CERN)

Lithium lens capture

Evaluate suitability for Undulator and Compton schemes (with KEK, BINP and Cornell)

ILC/CLIC meetings for e+ studies

2008

- ILC e+ workshop 29th -31st October 2008 at Daresbury
- LCWS08 & ILC 08 workshop 15th -20th November 2008 at Chicago

2009

- GDE meeting 17th -21st April 2009 at KEK
- POSIPOL workshop 23rd - 25th June 2009 in Lyon
- ALCPG workshop 29th September - 3rd October 2009 in Albuquerque
- CLIC workshop 12th -16th October 2009 at CERN

2010

- Common ILC/CLIC workshop

- **Regular Webex meetings called "ILC/CLIC e+ studies" take place each first Thursday of month** [managed by T. Omori / KEK]

Summary

1) Many common issues for ILC and CLIC e^+ sources.

2) Unpolarized e^+ source for ILC and CLIC seems reachable BUT polarized e^+ sources still require a lot of studies and R&D for a future linear collider.

3) Fortunately several international collaborations have been set-up and important progress are expected.

The ILC/CLIC "e^+ studies" working group is a major asset to find out solutions to the e^+ source issues.