Summary of the workshop on polarized positron source based on Compton back scattering

L. Rinolfi

CERN

POSITONS POLARISÉS

(in French)

Brief overview of the workshop

49 participants from :

Europe: BINP, CERN, CNRS, DESY, INFN, IN2P3, IPN Lyon, LAL, Liverpool Uni., NSC-KIPT, Oxford Uni., Humboldt Uni., RWTH Aachen, Zeuthen.

USA: ANL, BNL, LLNL, Northwestern University, SLAC.

Asia: Hiroshima University, KEK, Kyoto University, Waseda University

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+ 2 Laser companies: Amplitude Systemes, Time-Bandwidth Products

POSIPOL 2006

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ELAN

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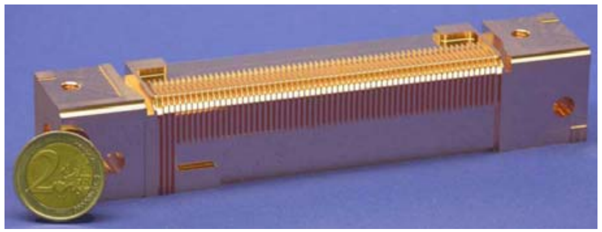
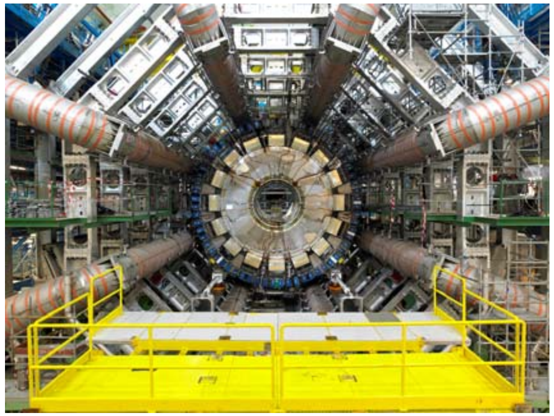
Visit of CLIC CTF3 ATLAS





Aims of the POSIPOL workshop

- discuss options and open issues of polarized positron source, based on laser Compton back scattering, for ILC and CLIC.
- assess and coordinate the outstanding R & D efforts towards a complete Compton source design.
- compare the issues with the undulator source.
- analyze the experimental programs carried out in the different laboratories.
- elaborate the baseline recommendation for CLIC.

Goals of physics at the LC

- Discovery of New Physics (NP)
  - complementary to the LHC
  - large potential for direct searches
  - impressive potential also for indirect searches
- Unraveling the structure of NP
  - precise determination of underlying dynamics and parameters
  - model distinction through model-independent searches
- High precision measurements
  - test of the Standard Model (SM) with unprecedented precision
  - even smallest hints of NP could be observed

→ **Beam polarization = decisive tool for direct and indirect searches!**

Polarization requested by physics

for ILC and CLIC

P (e^-) ~ 90%

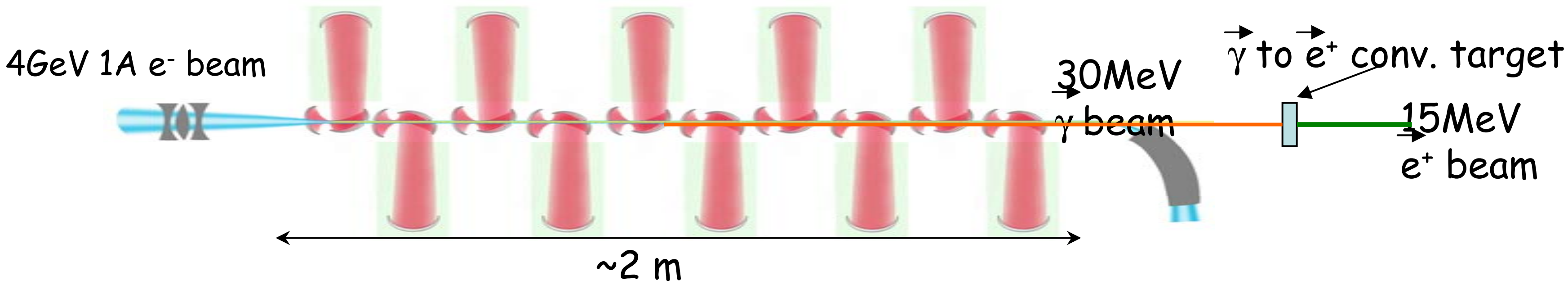
P (e^+) ≥ 60%

POSIPOL 2006

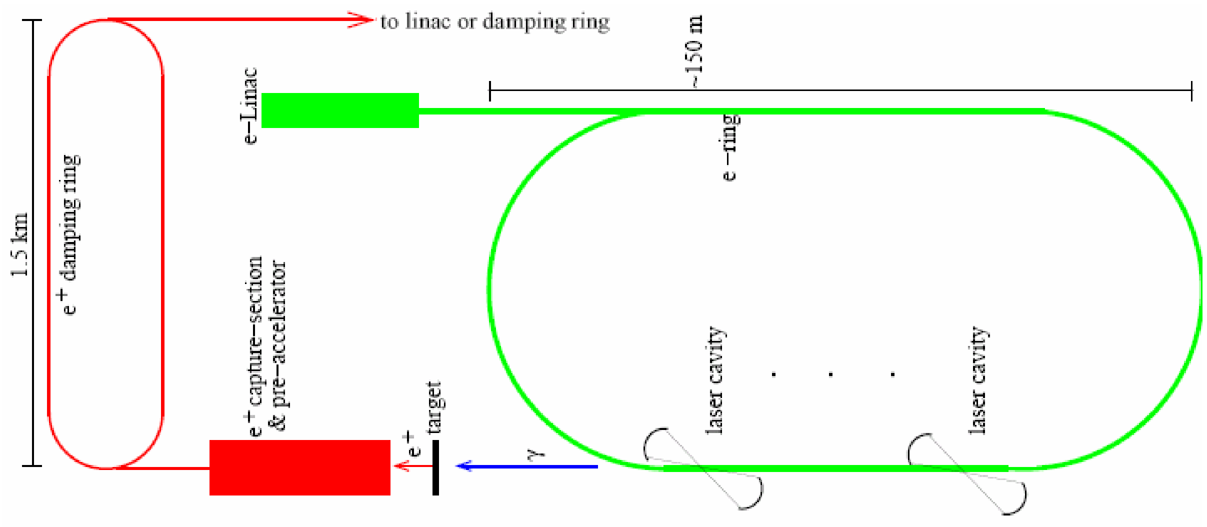
Two options for Compton

ELAN

Compton - Linac - *V. Yakimenko / BNL*



Compton - Ring



physics/0509016
CARE/ELANDocument-2005-013
CLIC Note 639
KEK Preprint 2005-60
LAL 05-94
September2,2005

Conceptual Design of a Polarized Positron Source Based on Laser Compton Scattering

A Proposal Submitted to Snowmass 2005

Positron charges for linear colliders

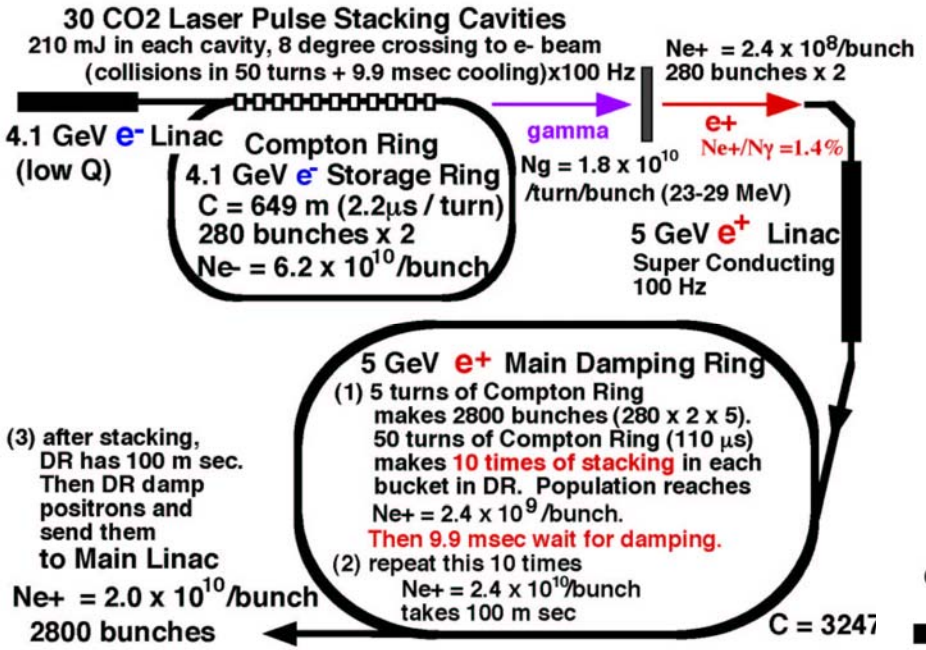
	Rep rate Hz	# of bunches per pulse	# of e^+ per bunch	# of e^+ per pulse
SLC	120	1	5.10^{10}	5.10^{10}
CLIC (3 TeV)	150	220	$2.56.10^{9}$	$56.3.10^{10}$
NLC	120	192	$0.75.10^{10}$	$1.4.10^{12}$
TESLA (TDR)	5	2820	2.10^{10}	$5.6.10^{13}$
ILC (Nominal)	5	2820	2.10^{10}	$5.6.10^{13}$
ILC (Upgrade)	5	5600	1.10^{10}	$5.6.10^{13}$

(X 10)

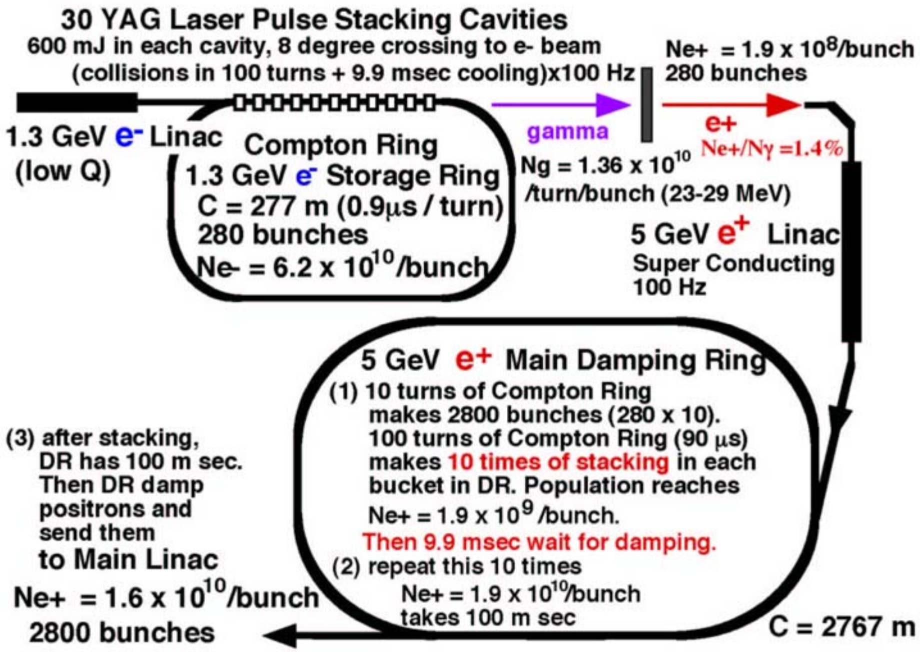
(X 1000)

ILC polarized e+ source w. CO2 or YAG laser

T. Omori, J. Urakawa / KEK



ILC Compton ring contains
30 coupled optical cavities



Compton ring design

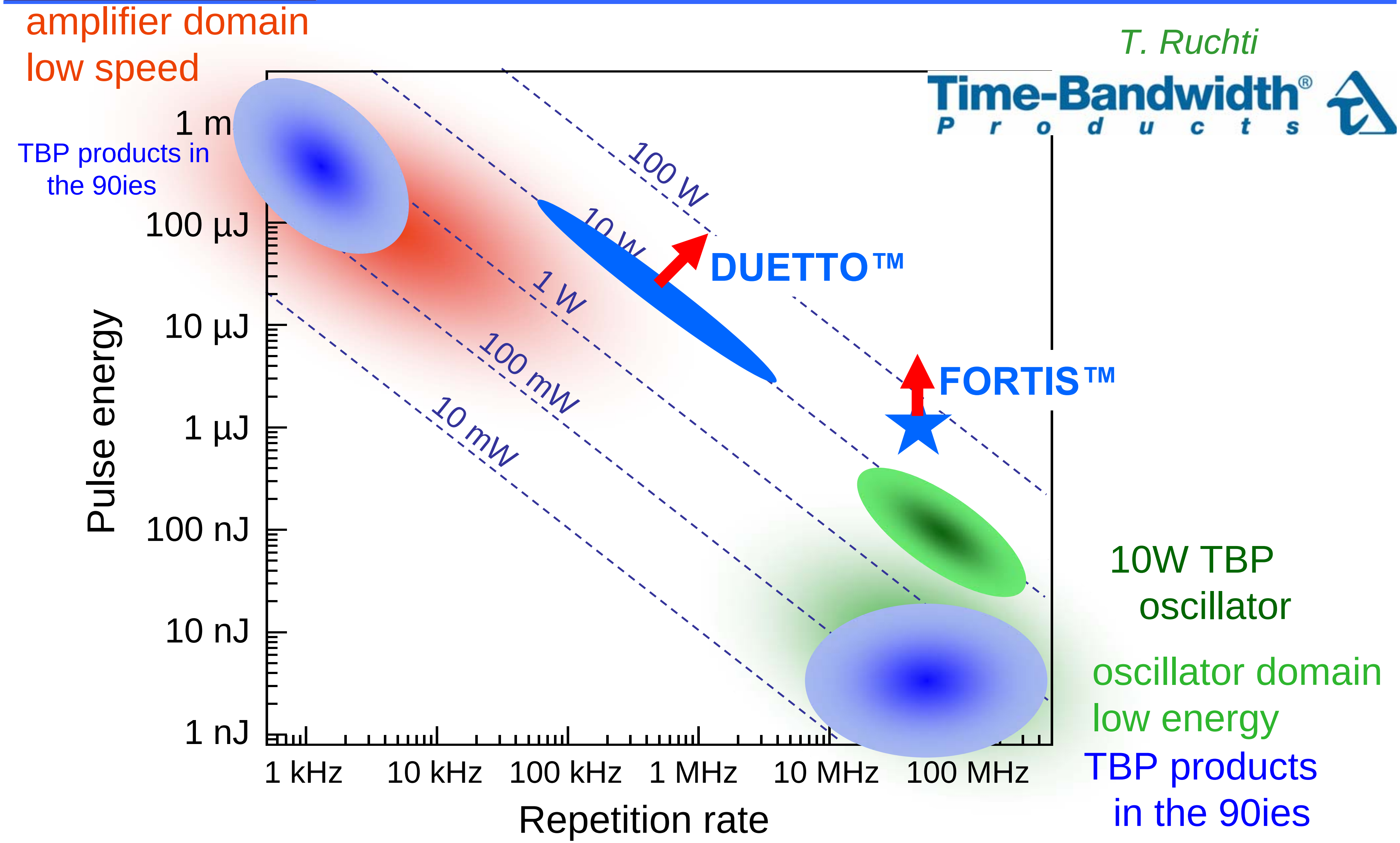
A preliminary lattice has been designed for ILC *(E. Bressi, S. Guidici / INFN)*
=> Insertion of wigglers and/or increase energy ring

Preliminary design for ILC and for CLIC *(E. Bulyak, P. Gladkikh / NSC-KIPT)*
=> RF phase manipulation in non linear lattice

Idea of bunch compressor with RF and magnetic chicane *(J. Urakawa / KEK)*
Bunch length reduced to 1mm in the region of IP:
⇒Photon yield increased by 4
⇒ Bunch charge from 10 nC to 2.5nC

Keeping 30 IP in the straight section of the Compton Ring, the injected laser energy can be reduced from 750µJ to 25µJ.
=> 30 mode-lock laser oscillators with 325MHz repetition rate and 25µJ output laser pulse.

New generation high power / pulse energy ps amplifier



High power ultra-fast fiber amplifiers

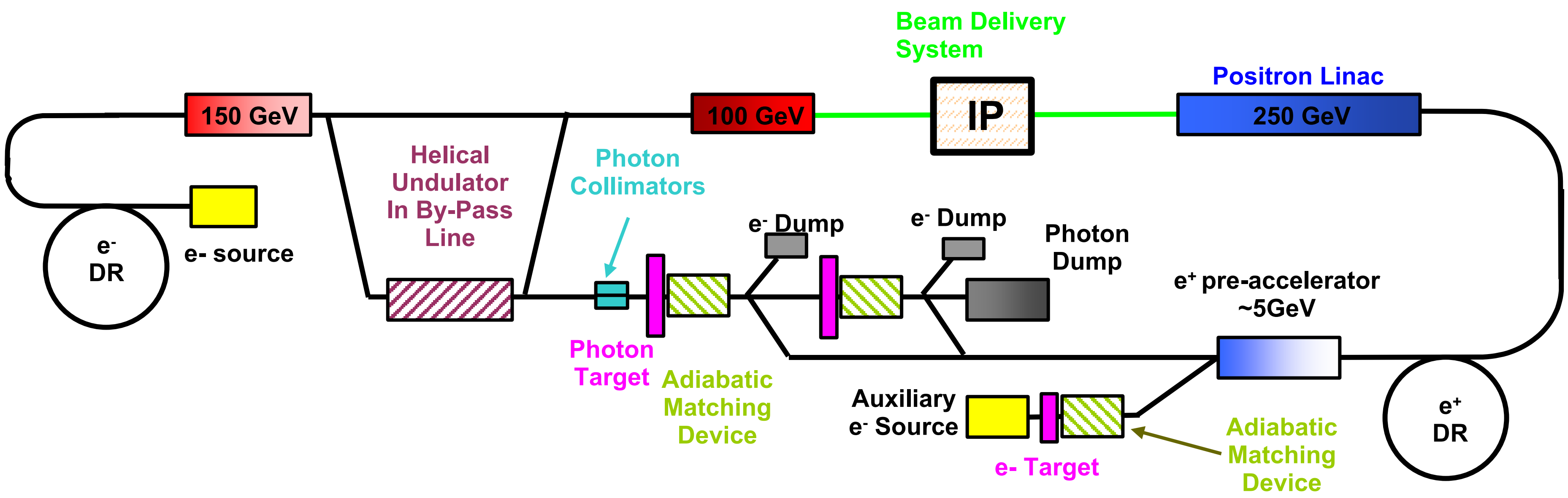
Y. Zaouter / Amplitude Systems

- Fiber design
  - Diffraction limited operation already demonstrated in a passive **100 µm** core diameter microstructured fiber
- Energy and power improvement
  - **10 mJ, 1ns** may (will ?) be achieved in the coming years
  - **"Kilowatt Femto"** is feasible

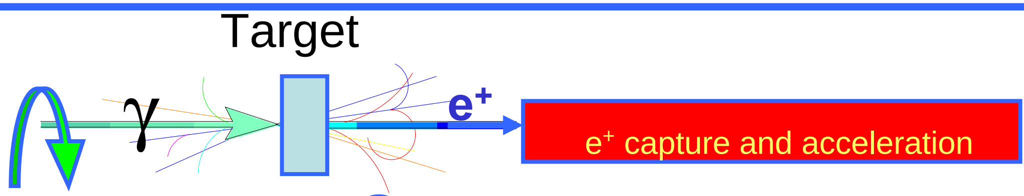
Layout of the ILC Positron Source

J. Sheppard / SLAC
M. Kuriki / KEK

- Photon production at 150 GeV electron energy
- K=1, λ=1 cm, 200 m long helical undulator
- Two e+ production stations including a back up.
- Keep alive auxiliary source is e+ side.



Common challenges for all schemes



Specific

Study presented by

I. Bailey/ Cockcroft Institute for works from EuroTeV, LLNL, SLAC, CCLRC Daresbury and University Liverpool.

Study presented by R. Chehab/IN2P3 for e+ generated from photons from the *Compton ring*. Simulations with **CAIN** for the photons, with **EGS** for the pair creation and with **PARMELA** for the e+ beam transport.

Study presented by W. Gei/ANL for e+ generated from photons from the *Undulator*. Simulations with **Monte Carlo** for the photons, with **EGSnrc** for the pair creation and with **PARMELA** for the e+ beam transport.

Common

- Target issues
- Remote handling
- Reliability

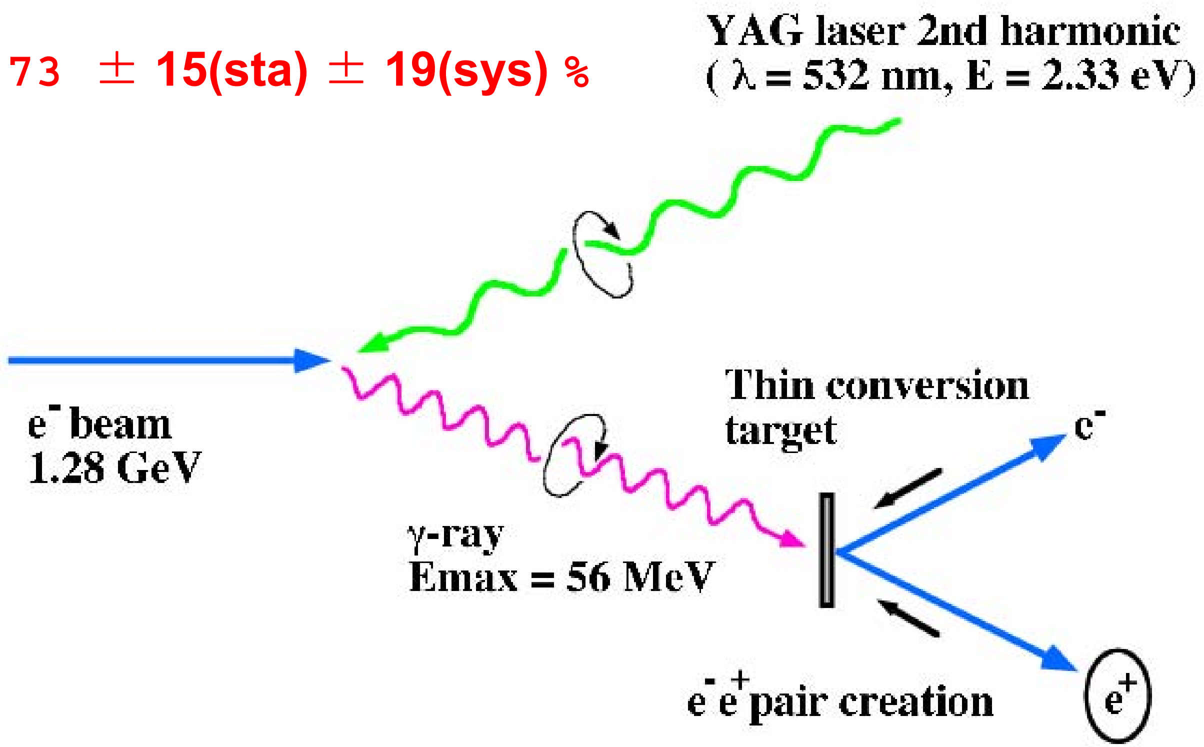
Capture systems (Magnets and RF)

ATF-Compton Experiment@KEK

T. Omori et al., PRL 96 (2006) 114801

1) The experiment was successful.
High intensity short pulse polarized
e^+ beam was firstly produced.

Pol. = 73 ± 15(sta) ± 19(sys) %

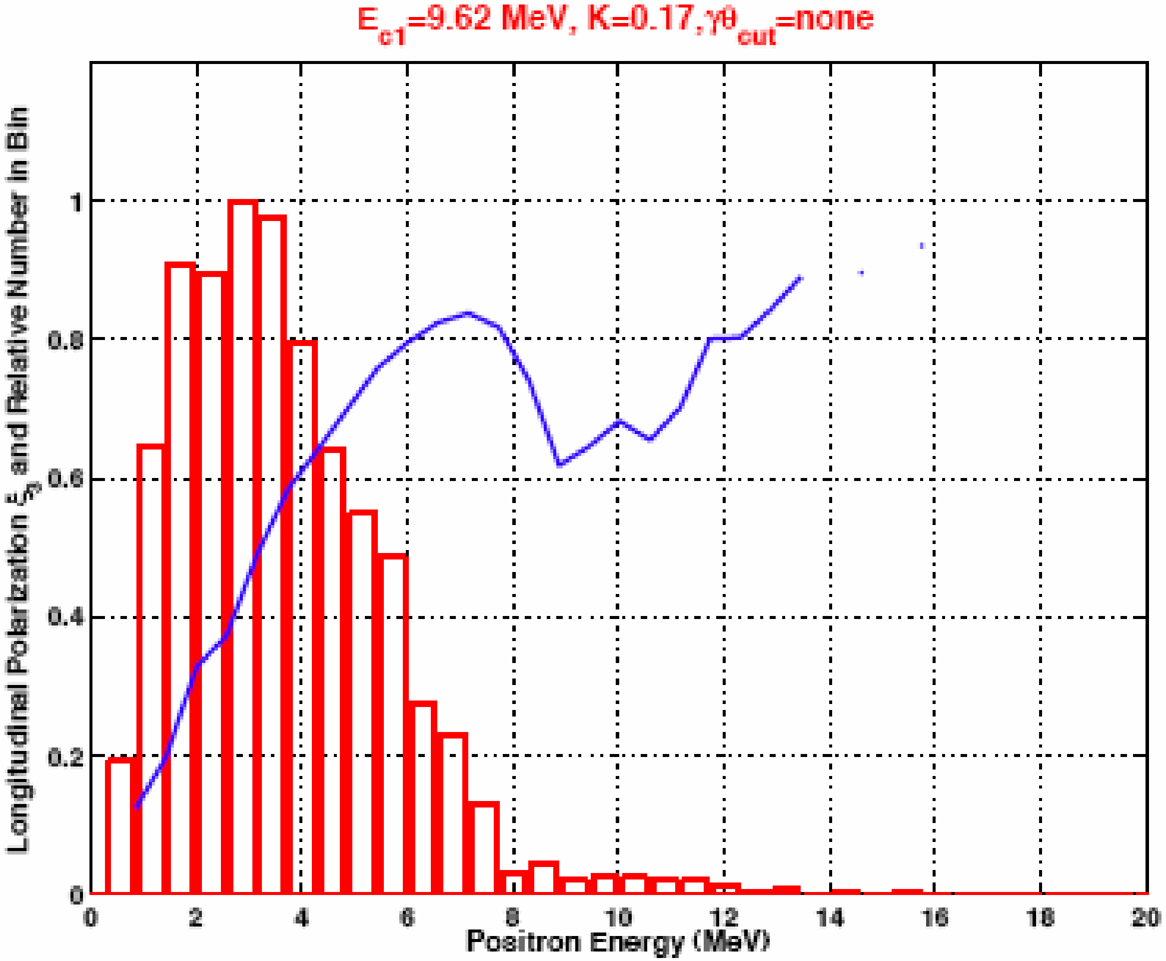


2) Confirmed propagation of the
polarization from laser -> γ-rays
-> created pairs e^+s & e^-s.

E-166 Experiment@SLAC

A. Schaelicke / DESY - Zeuthen
P. Schueler / DESY

e^+ energy & polarisation



Expected e⁺ polarization from simulations

$$P_\gamma = \frac{\delta}{A_\gamma P_e}$$

P_γ = photon polarization

δ = asymmetry

P_e= target polarization

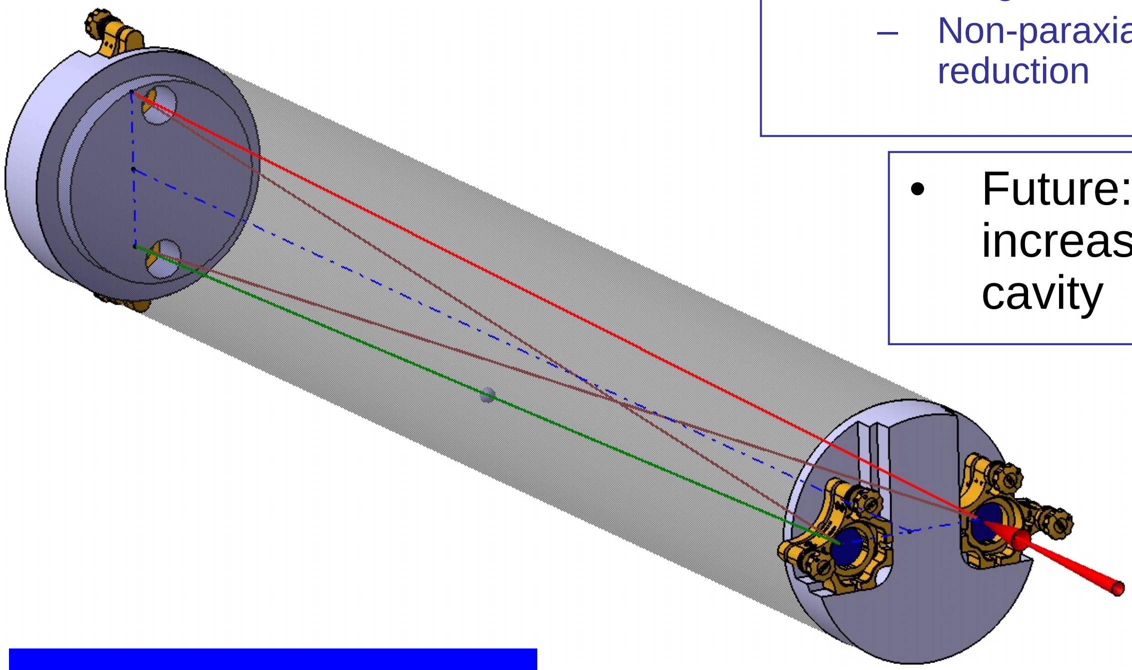
$A\gamma$ = analyzing power

Optical Resonator@LAL

F. Zomer / LAL

- 4 mirrors 2D or 3D high finesse cavity
  - Beam waist reduction & mechanical stability
  - Polarisation transport can be controlled & astigmatism effects reduced with 3D configuration
  - Non-paraxial corrections may limit the waist reduction

- Future: use a high power fibre laser to increase the laser power inside the cavity



Start mechanical setup in Autumn 2006

High circulating power ➔
coating damage AND non linear effects ?

Compton or Undulator for CLIC ?

In principle equivalent, but not quite (V. Strakhovenko / BINP)

photon spectrum
mean photon energy
angular photon distribution
power on conversion target
collimation efficiency
cost

Avoid Compton ring ?

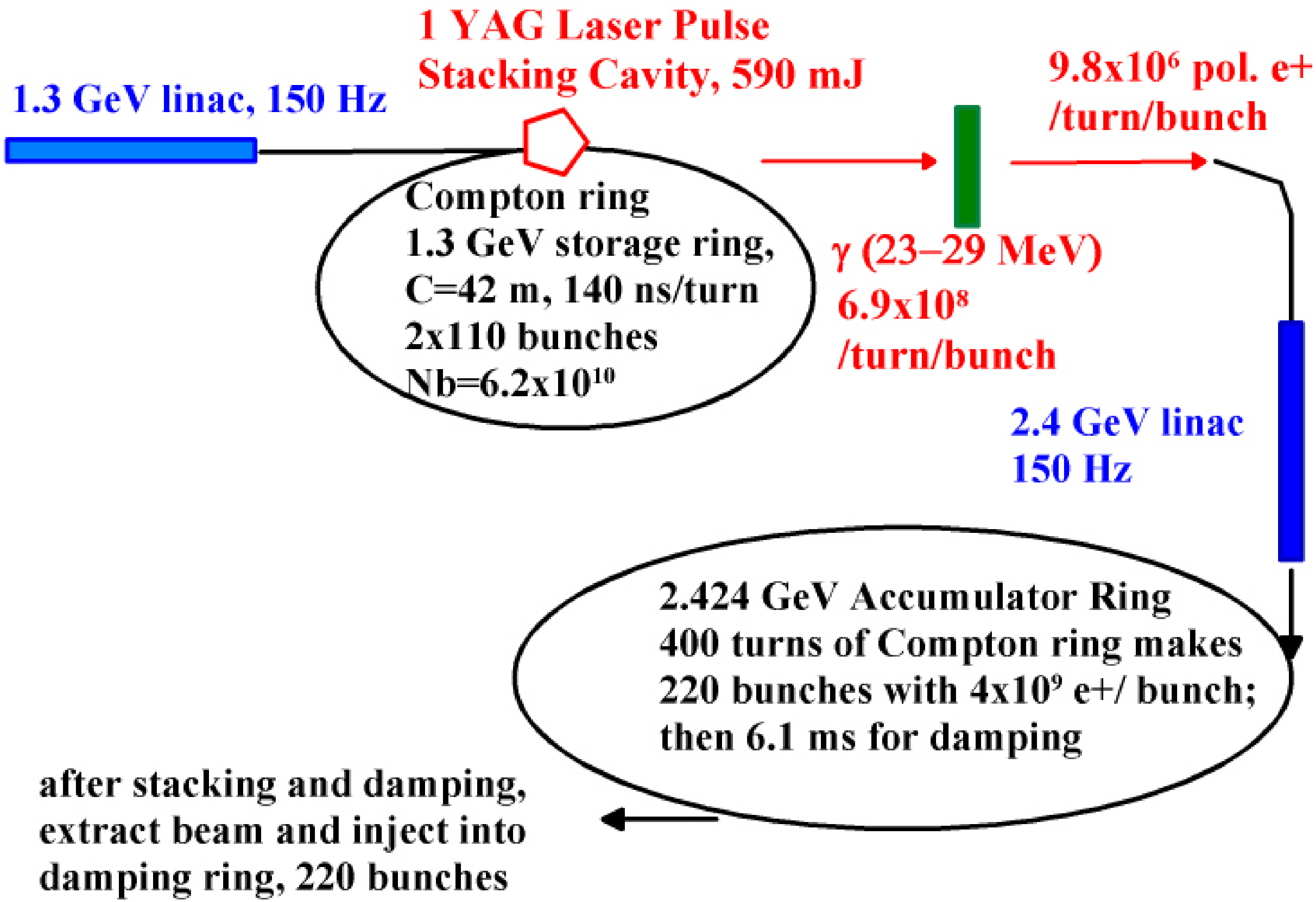
=> head-on collisions
=> use CLIC drive beam

CLIC - ILC differences

=> Bunch spacing in DR: 0.533 ns instead of 2.8 ns
=> 150 Hz instead of 5 Hz
=> e+ pre-damping ring required for CLIC (small emittances)

A possible Compton design for CLIC

F. Zimmermann / CERN



Recommendations

Compton

1) Publish a design of a Compton ring with BC
2) Develop reliable power laser and increasing cavity finesse taking into account polarization
3) Simulate stacking into DR
4) Experimental demonstration of fast stacking (KEK-ATF or DAΦNE).
5) Use CTF3 to test head-on scheme
6) Crab angle crossing scheme
7) Try to relax parameters in the Compton ring increasing the duty cycle
8) Optimization on the energy of Compton photon
9) Experimental optimization of Compton source inside laser cavity at BNL-ATF
10) Comparison of single pass scheme and ring scheme
11) Experimental demonstration using optical cavity and storage ring.
12) Compare CO2, YAG and Fibers Lasers
13) Possible use of laser cavity for gamma-gamma collisions

Undulator

1) Publish results from E-166
2) Evaluate and publish the emittance degradation in the undulator (CLIC emittance constraints, dynamic vacuum issues, wake fields, ion effects, spurious linac dispersion)
3) Evaluate the coupling of operation specially for CLIC
4) Do technical demonstration of undulator (several meters)
5) Finalize the complete layout
6) Do systematic studies of the collimators
7) Describe the transition between the keep-alive source and the Main linac

Common Recommendations

for Compton and Undulator

1) Analyze systematic errors of polarization measurements
2) Compare yield and polarization for both cases
3) Analyze the remote handling in radioactive area
4) Compare heat load dynamics for all schemes
5) Simulate the capture and transmission of e^+
6) Optimize pre and post selection of e^+
7) Evaluate cost estimate

Letter of Intent submitted to EU FP7 JRA on
'Positron polarized (POSIPOL) sources'

A. Variola / LAL

Design Study

- parameters optimization
- **<u>Compton ring</u>** design
- **collection system design**
- **<u>multiple injection</u>** schemes

Technological R&D

- high-power & high-repetition rate **<u>lasers</u>**
- Fabry-Perot **<u>optical cavities</u>** in pulsed regime
- polarimetry

Test Facility Experiments

- validation at **<u>ATF & DaΦne</u>** accumulation ring

Conclusion

- Aims of the workshop fulfilled rather well with assessments of outstanding R & D efforts for a complete Compton source design.
- Recommendations in order to solve the issues related to the Compton source and to the Undulator source elaborated in common.
- The experimental programs carried out in the different laboratories have shown very encouraging results.
- A proposal for a JRA "POSIPOL" in the FP7 program has been submitted.
- Web address for the POSIPOL workshop including all talks:

  www.cern.ch/posipol2006