

**ECFA LC2013**

**European Linear Collider Workshop**

**27-31 May 2013**



# Summary: Injector systems

**W. Gai (ANL), M. Kuriki (KEK),  
Y. Papaphilippou (CERN), S. Riemann (DESY)**



**May 31<sup>st</sup>, 2013**



# Sessions' Organisation

- Two and a half days of presentations and discussion
- One day dedicated to **damping rings** including a **joint** session with **BDS/MDI/lumi**
- One and half day, dedicated to **sources** including half day **joint** session with **polarisation**
- Total of 30 talks (7 given remotely)
- ~20 participants on average
- Thanks to all speakers and participants

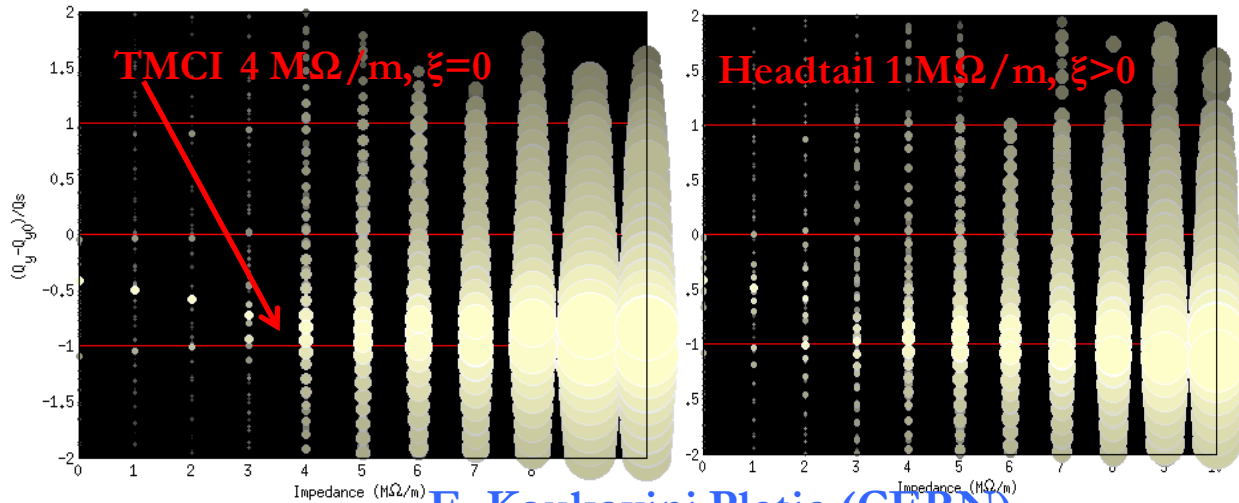
# Damping rings



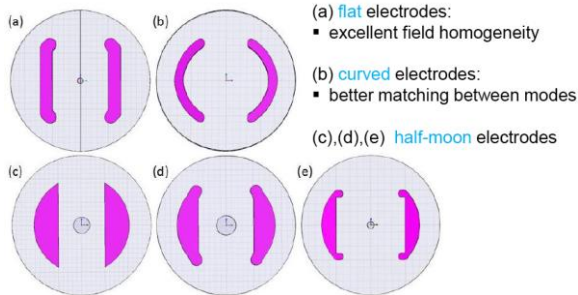
<b>The SPS as a damping rings test facility</b>	<i>PAPAPHILIPPOU, Yannis</i>	
<i>SemRm 66, DESY Hamburg</i>		09:00 - 09:30
<b>Impedance budget and effect of chamber coating on CLIC DR beam stability</b>	<i>KOUKOVINI PLATIA, Eirini</i>	
<i>SemRm 66, DESY Hamburg</i>		09:30 - 10:00
<b>Turn-by-turn measurements at the SLS</b>	<i>ZISOPOULOS, Panagiotis</i>	
<i>SemRm 66, DESY Hamburg</i>		10:00 - 10:30
<b>Status and update plan of the ATF DR</b>	<i>TERUNUMA, Nobuhiro</i>	
<i>FLASH, DESY Hamburg</i>		11:50 - 12:10
<b>Turn-by-turn Optics measurements int the ATF DR</b>	<i>RENIER, Yves</i>	
<i>FLASH, DESY Hamburg</i>		12:10 - 12:30
<b>Extraction kicker for the CLIC damping ring</b>	<i>BELVER AGUILAR, Carolina</i>	
<i>FLASH, DESY Hamburg</i>		12:30 - 12:50
<b>Electron Cloud Instabilities at CESRTA</b>	<i>BILLING, Michael</i>	
<i>SemRm 66, DESY Hamburg</i>		14:30 - 15:00
<b>Diffraction Radiation Test at CESRTA: April 2013 Summary</b>	<i>BOBB, Lorraine Marie</i>	
<i>SemRm 66, DESY Hamburg</i>		15:00 - 15:30
<b>Recent Intrabeam Scattering Measurements from CesrTA</b>	<i>EHRlichman, Michael</i>	
<i>SemRm 66, DESY Hamburg</i>		15:30 - 16:00
<b>A turn-by-turn beam profile monitor using visible synchrotron radiation at CESR-TA</b>	<i>RUBIN, David</i>	
<i>SemRm 66, DESY Hamburg</i>		16:30 - 17:00
<b>Comparison of EC Density Measurements at 5.3GeV</b>	<i>SIKORA, John</i>	
<i>SemRm 66, DESY Hamburg</i>		17:00 - 17:30
<b>Changing RF Frequency and Path-length</b>	<i>RUBIN, David</i>	
<i>SemRm 66, DESY Hamburg</i>		17:30 - 18:00

- Three talks on damping ring design (two on beam dynamics, one on technology)
- Nine talks on measurements in test facilities and light sources (five in CESRTA, two in ATF DR, one in SLS)
- One talk on proposal for a new test facility (SPS)
- Two talks on ILC and CLIC BDS design covered by P. Bambade

# Damping rings design



E. Koukovini Platia (CERN)



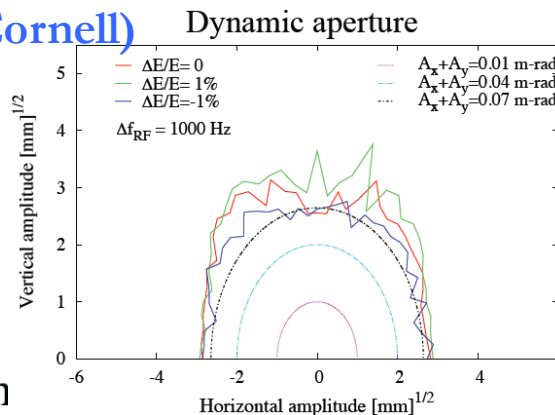
- (a) flat electrodes:
  - excellent field homogeneity
- (b) curved electrodes:
  - better matching between modes
- (c),(d),(e) half-moon electrodes

	Maximum error	Field inhomogeneity
Horizontal	$\pm 0.2$ mm	$\pm 0.015\%$
Vertical	$\pm 0.1$ mm	$\pm 0.02\%$
Inclination	$0.06^\circ$	$\pm 0.01\%$

C. Belver Aguilar (IFIC)

D. Rubin (Cornell)

$f_{RF} = 650$  MHz  
 $\Delta f_{RF} = 1$  kHz  
 $\Delta C = -4.9$  mm  
 $\alpha_p = 3.335 \times 10^{-3}$   
 $\Delta E/E = 0.046\%$   
 $\epsilon_x = (1 - 0.0106)\epsilon_{x0}$   
 $\Delta P = 5000 \times 4.9$  mm = -24.5m



- Impedance thresholds for the CLIC DRs, including kickers and coating
  - Material property characterisation in high-frequencies with measurements of waveguides
- Design for CLIC extraction kicker, including electrode supports, feedthroughs, field homogeneity, power transmission and coupling impedance
  - Prototype to be built and tested at ALBA/ATF2 (including inductive adder)
- Manipulating ILC DR RF frequency 9 to compensate  $\pm 1$ m path length differences looks feasible
  - E... DA... RF...

# e-Cloud at CESR TA

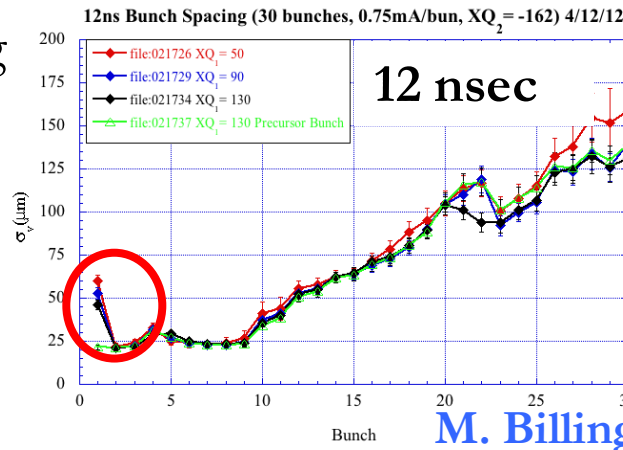


Experiments for clarifying why lead bunch become unstable in a 30 bunch e+ trains (un-anticipated effect)

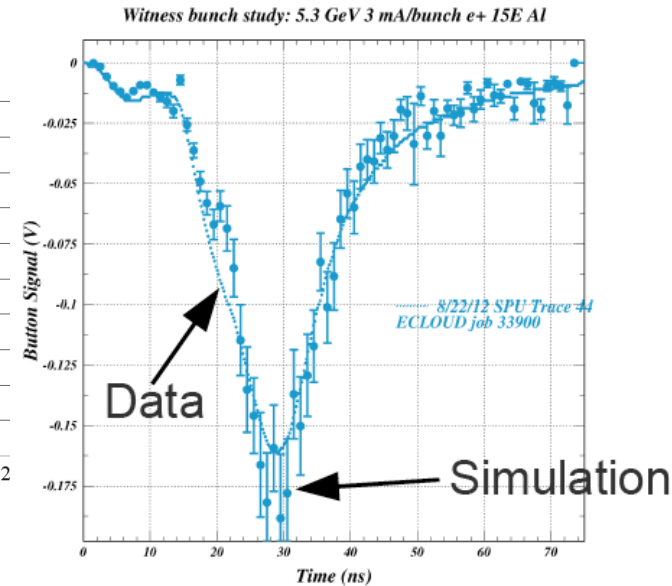
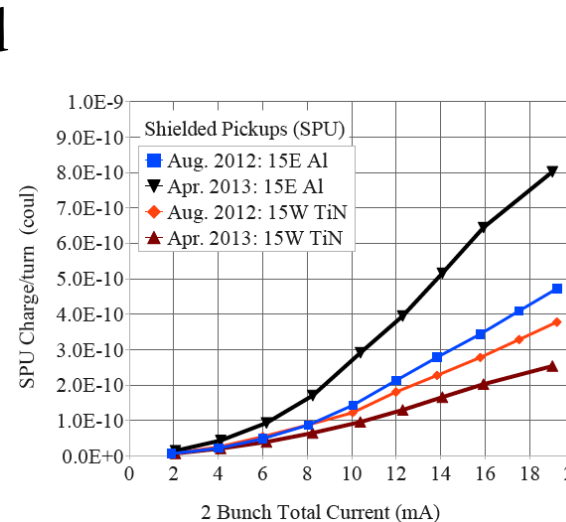
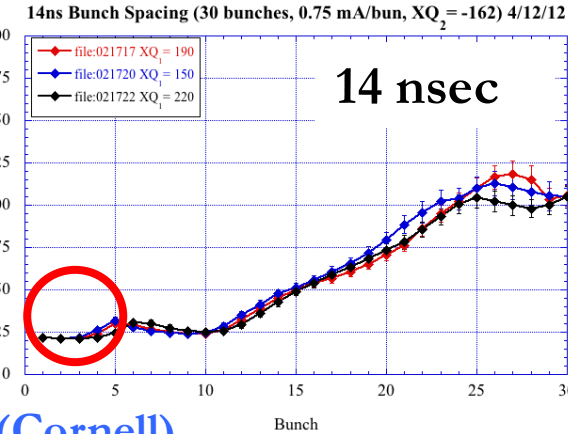
- Positrons but not electrons (long-lived e-cloud?)

Comparison of e-cloud density measurements

- Shielded PU (excellent agreement with simulations), TR-RFA, TE-wave
- EC density in a TiN coated chamber decreases with processing whereas in a bare aluminum chamber increases with processing



M. Billing (Cornell)



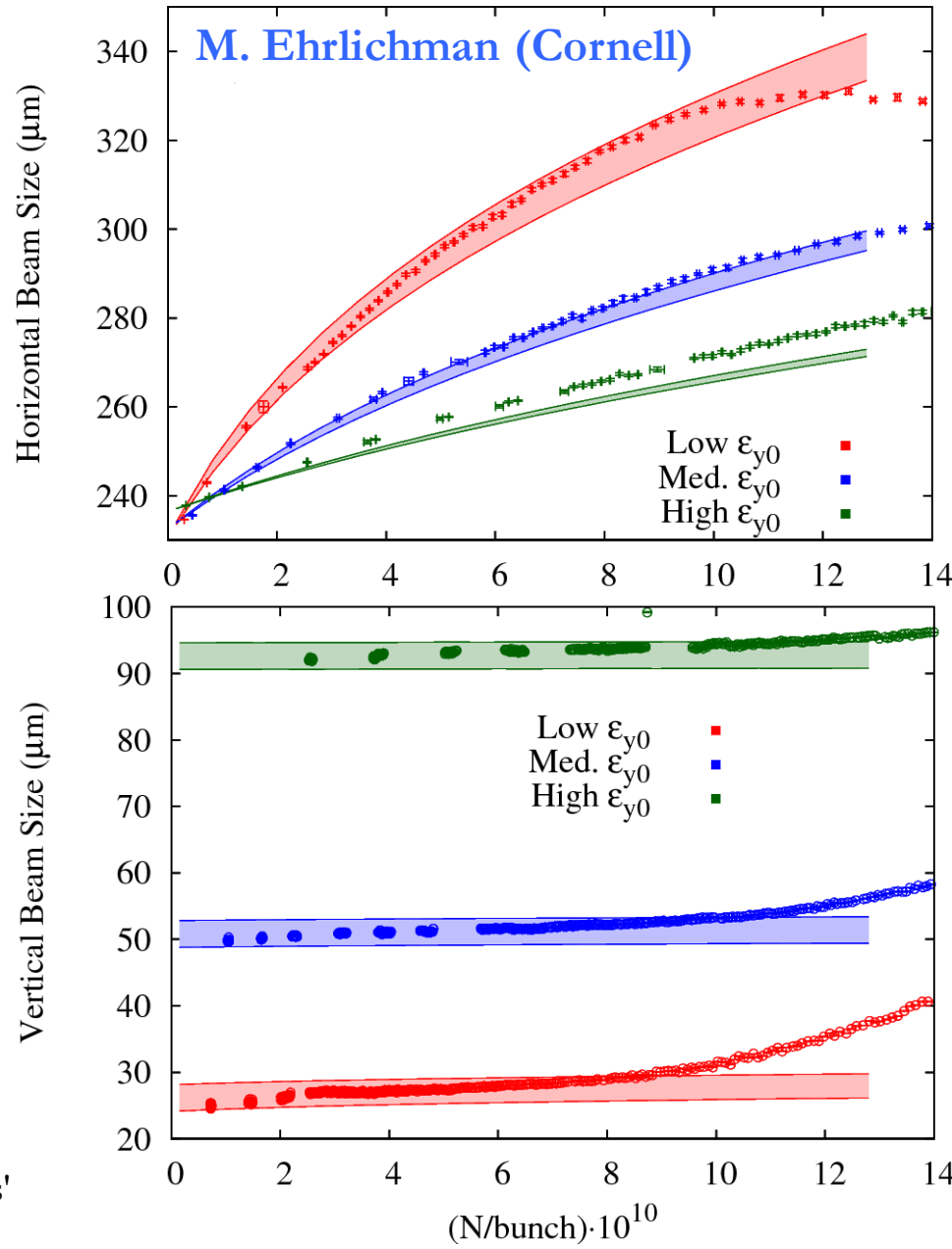
J. Sikora (Cornell)

# IBS measurements at CESRTA

- IBS measurements over range of energies, particle densities, and RF voltages.

- Good agreement with horizontal and longitudinal but not vertical data at high current

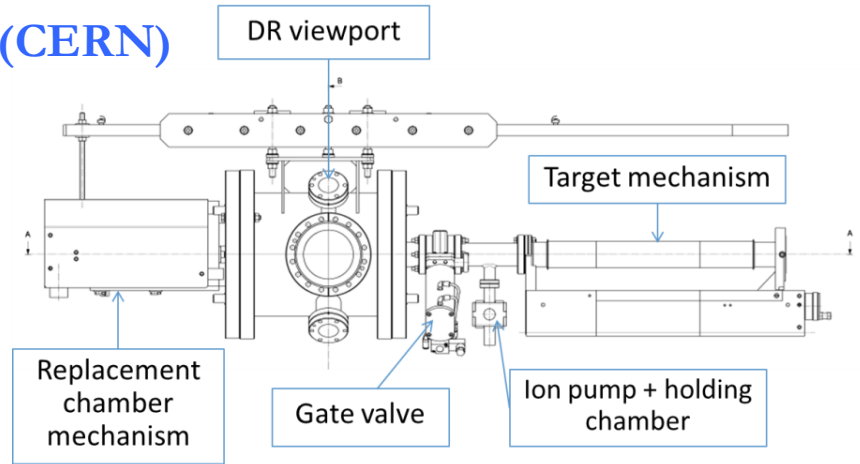
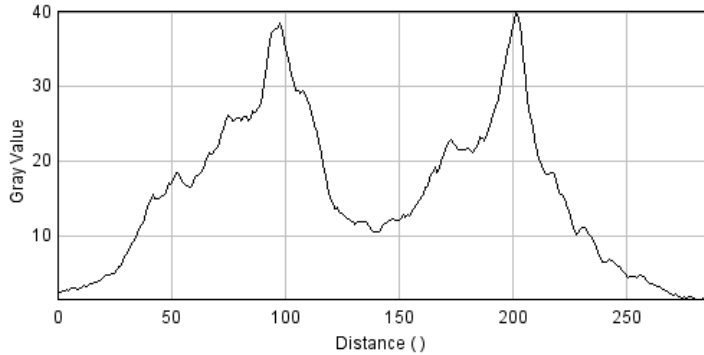
- Future studies include global coupling, various damping rates, 1.8 GeV, and lower vertical emittance





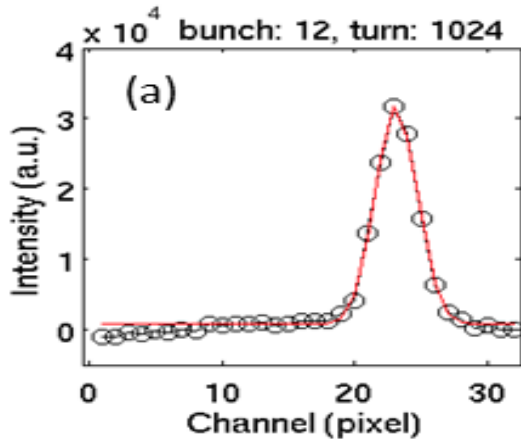
# Beam instrumentation at CESRTA

L. Bobb (CERN)

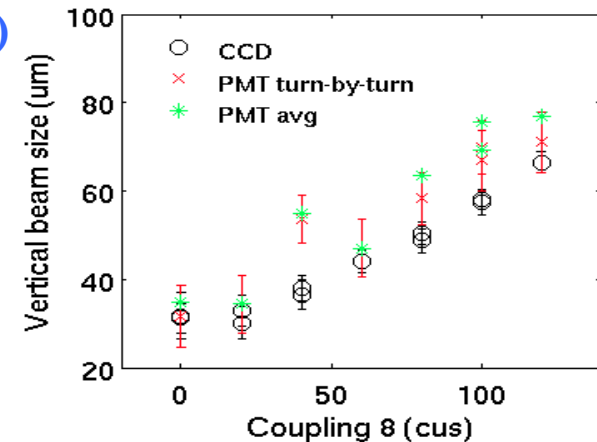
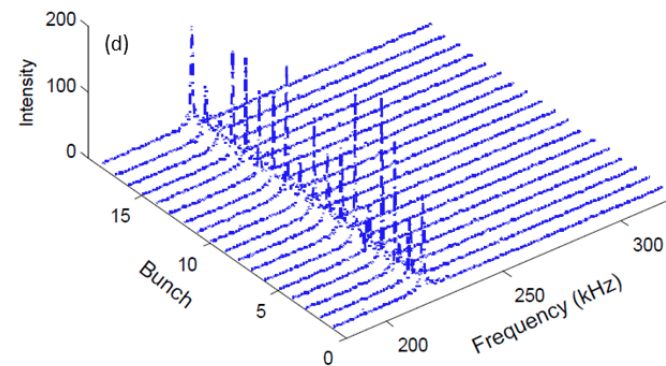


- Diffraction radiation measurements at CESRTA (micron scale resolution for CLIC)
  - Two targets used, better results with molecular adhesion target
  - Lots of data to be analysed, but also plans for single turn measurements and improvement of optical system

- Developing TBT and BBB measurement of horizontal and vertical beam size with visible synchrotron light with fast readout electronics based on Hamamatsu photomultiplier
- Vertical beam size with  $\pi$ -polarisation



D. Rubin for S.T. Wang, (Cornell)

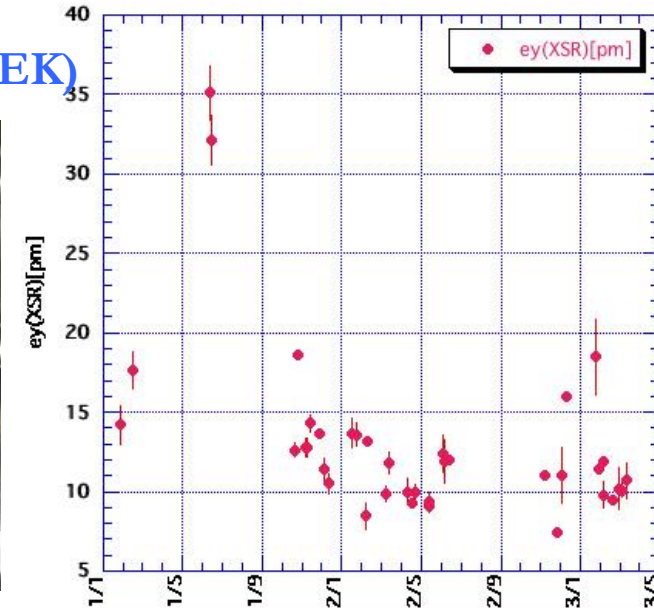


# ATF DR status and new TF proposal

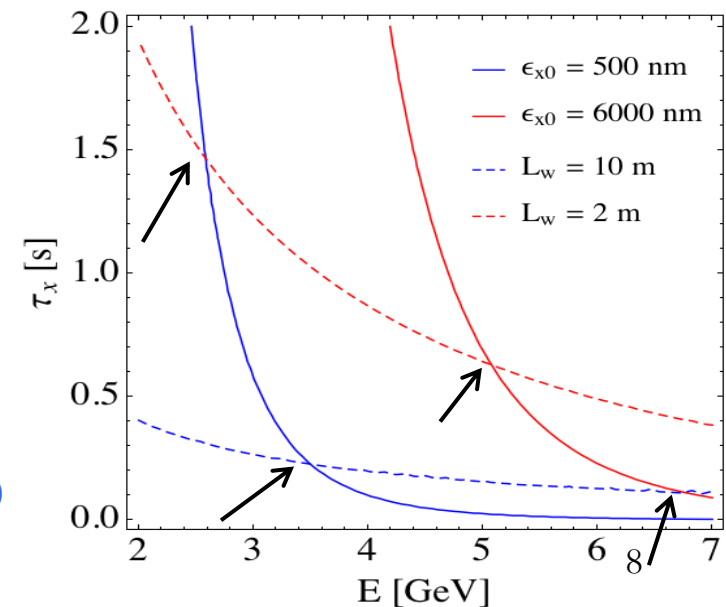


- Emittance of the ATF DR is typically 10 pm recently.
  - Small emittance study toward 2 pm should be redone
- Cavity Compton studies
- DR laser wire
- Proposal for using the SPS as DR test facility
- Very interesting parameters obtained for both ILC and CLIC in the 2 to 5 GeV energy range (including IBS)
- Considerations for reviving e/p pre-injectors are on-going

N. Terunuma (KEK)



Y. Papaphilippou (CERN)



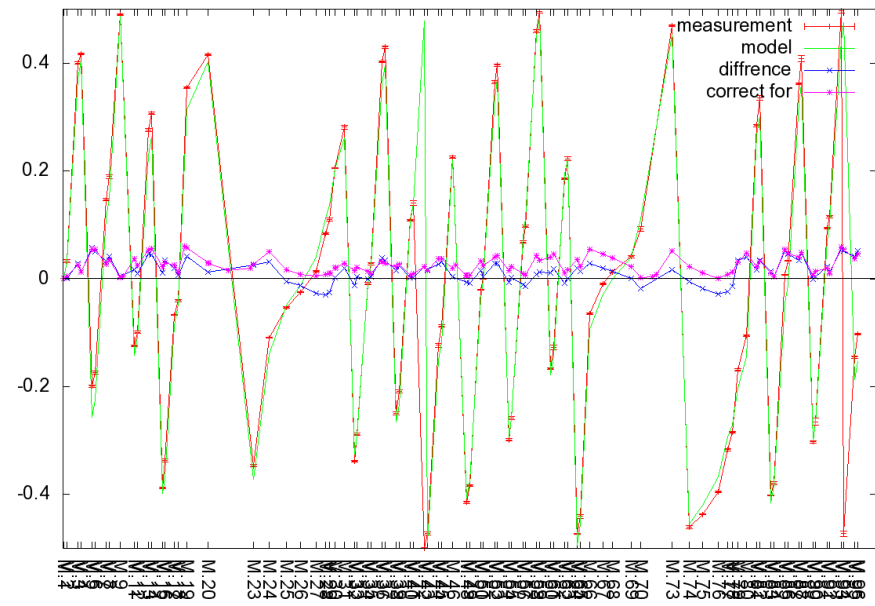
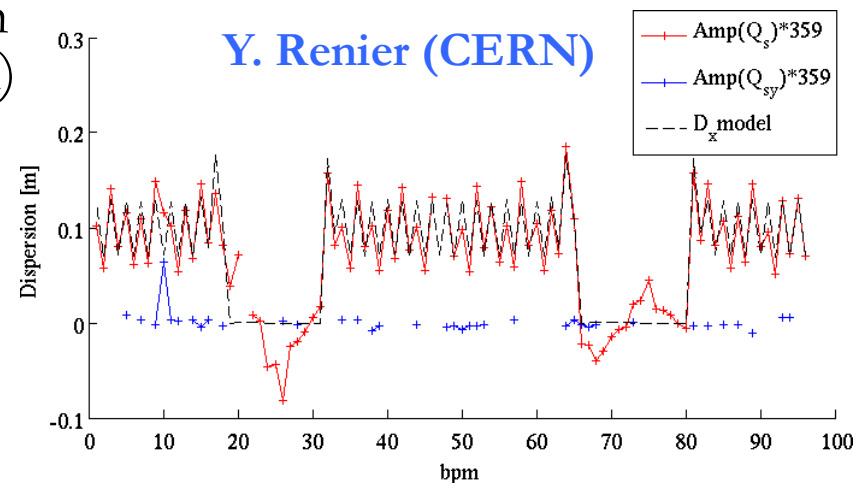
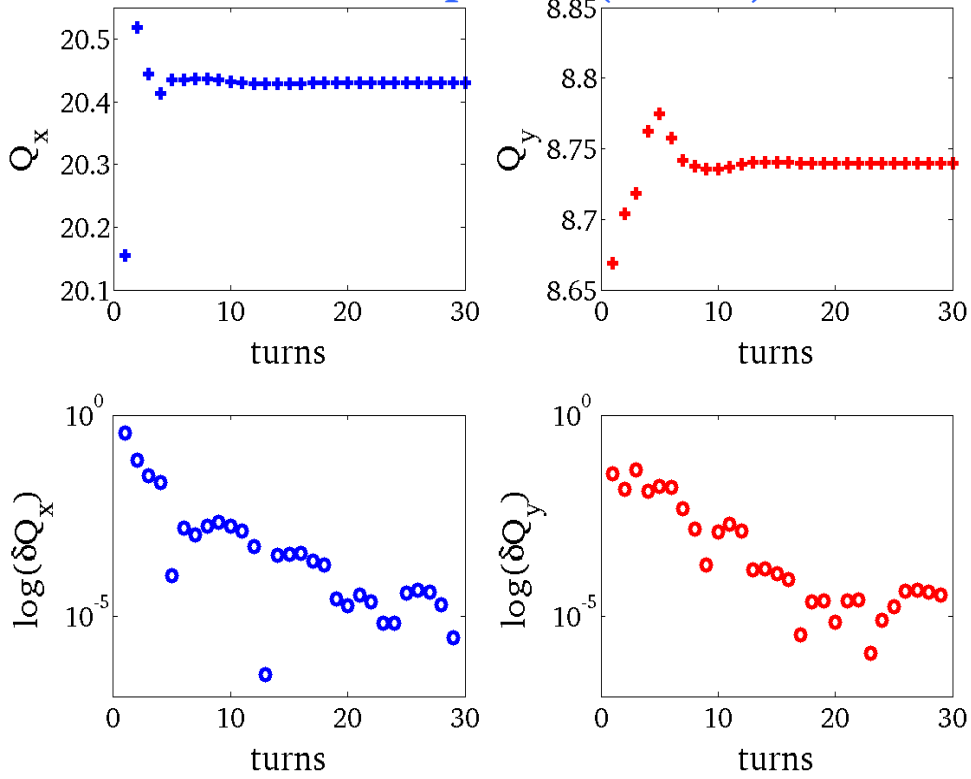




# TBT measurements in ATF DR and SLS

- TBT data from ATF DR and SLS through refined Fourier methods (NAFF, SUSSIX)
  - Twiss functions measurements and correction
  - Tune measurement in a few tens of turns mixing all BPMs in every turn
  - Dispersion and chromaticity measured from energy oscillation at ATF

P. Zisopoulos (CERN)



# Sources



<b>Positron polarization in the staged approach</b>	MOORTGAT-PICK, Gudrid
SemRm 66, DESY Hamburg	09:00 - 09:30
<b>CLIC Source update</b>	DOEBERT, Steffen
SemRm 66, DESY Hamburg	09:30 - 10:00
<b>Spin Tracking at the ILC</b>	KOVALENKO, Valentyn
SemRm 66, DESY Hamburg	10:00 - 10:20
<b>Conventional e+ source: Overview</b>	OMORI, tsunehiko
SemRm 66, DESY Hamburg	10:50 - 11:20
<b>Conventional e+ source: Target R/D</b>	OMORI, tsunehiko
SemRm 66, DESY Hamburg	11:20 - 11:50
<b>Conventional e+ source: 300 Hz linac R/D</b>	URAKAWA, Junji
SemRm 66, DESY Hamburg	11:50 - 12:20
<b>Compton R/D in France</b>	ZOMER, fabian
SemRm 66, DESY Hamburg	16:00 - 16:30
<b>Compton R/D in Japan</b>	TAKAHASHI, Tohru
SemRm 66, DESY Hamburg	16:30 - 17:00
<b>High QE and High polarization photocathode</b>	YAMAMOTO, Naoto
SemRm 66, DESY Hamburg	09:00 - 09:30
<b>High brightness beam generation with a photo-cathode 500kV DC gun</b>	KURIKI, Masao
SemRm 66, DESY Hamburg	09:30 - 10:00
<b>Baseline e+ source: Target and FC</b>	GRONBERG, Jeff
SemRm 66, DESY Hamburg	10:30 - 11:00
<b>Induced Pressure in Target Material for Positron Production</b>	ADEYEMI, Olufemi
SemRm 66, DESY Hamburg	11:00 - 11:20

<b>Simulations of Positron Source at 120 GeV</b>	USHAKOV, Andriy
SemRm 66, DESY Hamburg	13:40 - 14:10
<b>Which polarization can be achieved at which cm energy?</b>	LIU, Wanming
SemRm 66, DESY Hamburg	14:10 - 14:40
<b>Photon collimator &amp; polarization</b>	STAUFENBIEL, Friedrich
SemRm 66, DESY Hamburg	14:40 - 15:10
<b>Ideas for e+ source and e+ polarization</b>	OMORI, tsunehiko
SemRm 66, DESY Hamburg	15:10 - 15:40

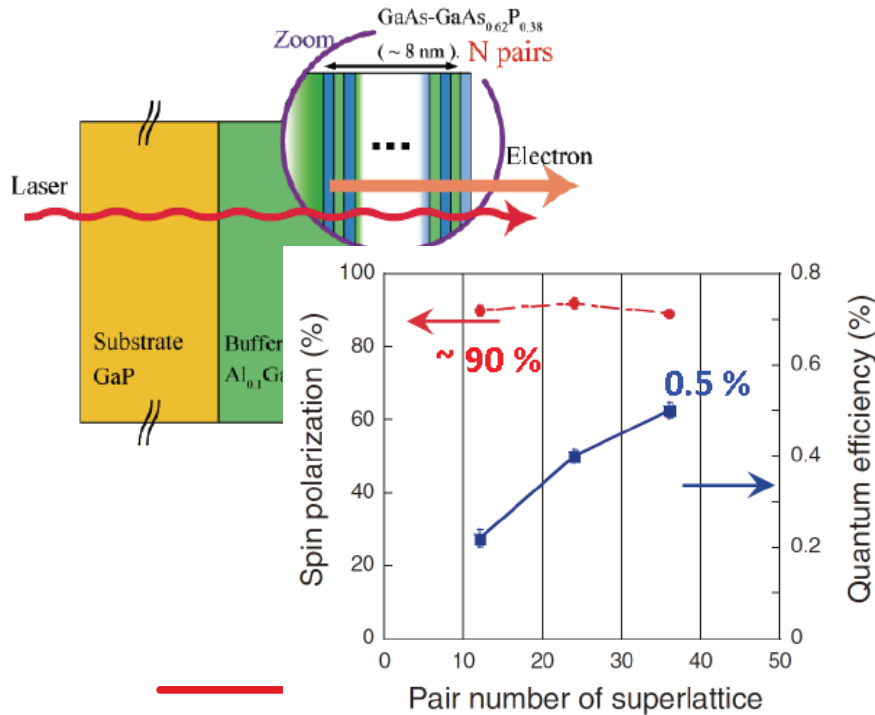
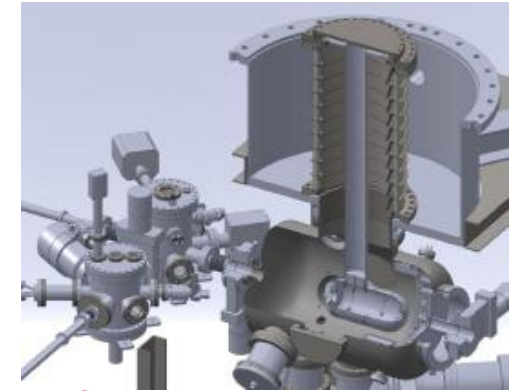
- Five talks on polarisation (one on physics + four during joint session)
- Two talks on electron source
- Seven talks on positron production
- One talk on CLIC sources + one talk on spin tracking for ILC DR



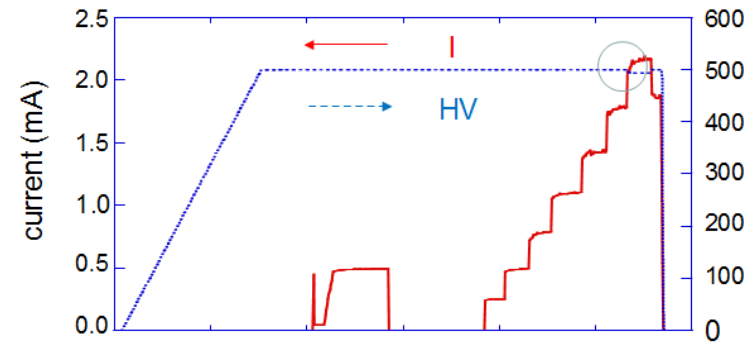
# Highly Polarized Beam Generation with High QE based on Transmission type cathode: *N. Yamamoto*

## High brightness beam generation with a photo-cathode 500kV DC gun: *M. Kuriki*

- Transmission cathode (GaAs/GaAsP strain compensated Super-Lattice ) for higher QE.
- 500kV DC gun make the bunch length much shorter and simplifies the injector design with less beam loss.

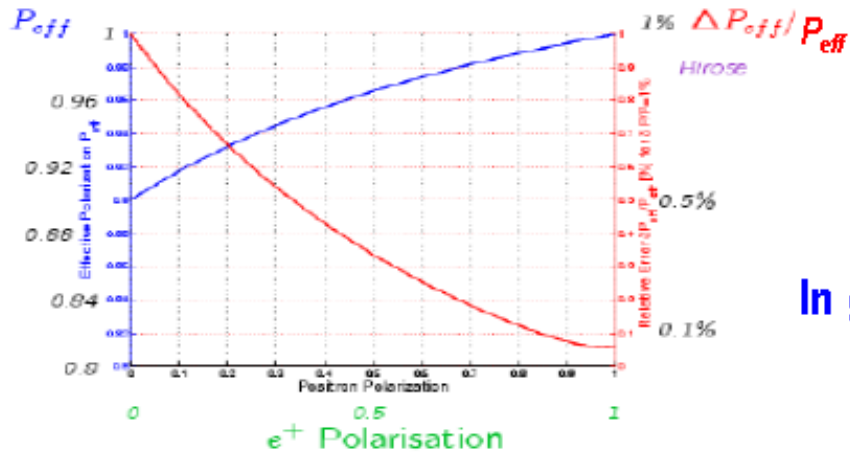


**Stable 500kV bias voltage  
10mA (40C life-charge)**





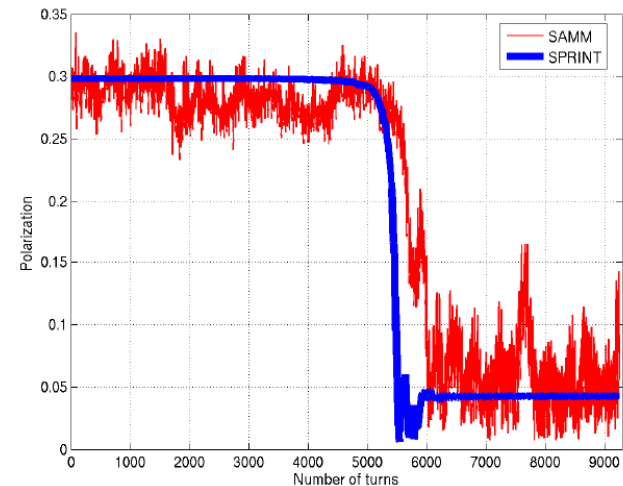
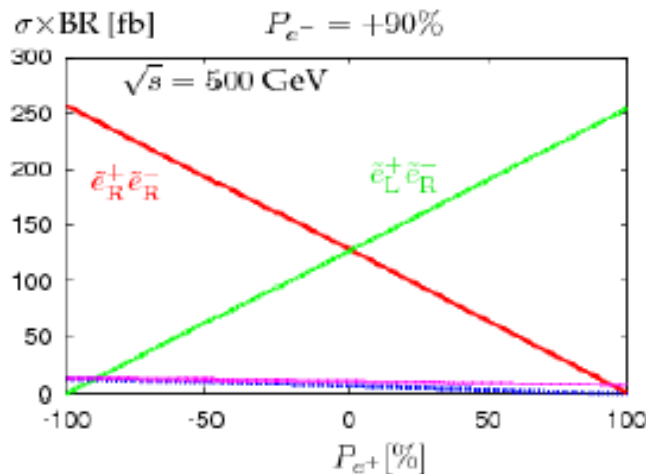
# Positron polarization in the staged approach : *Gudi Moortgat-Pick* Resonant Depolarization at the ILC DR with RF Dipole : *V. Kovalenko*



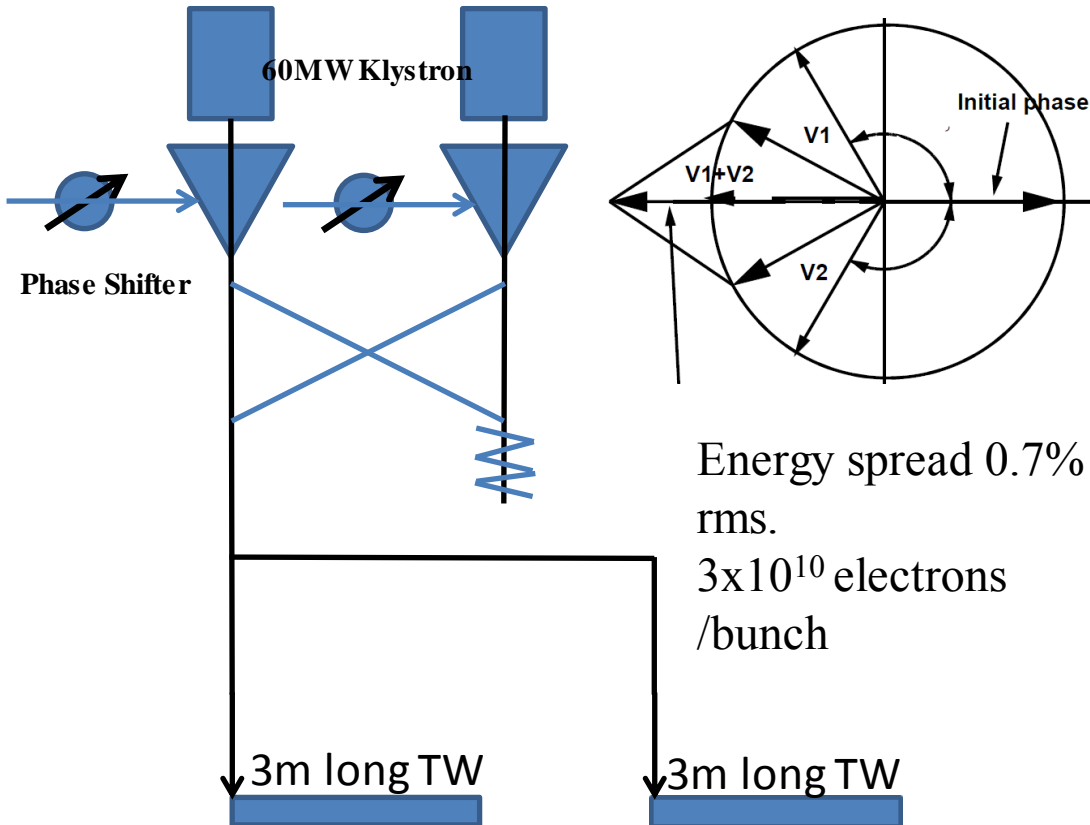
Positron polarization gives us

- Higher luminosity,
- Higher accuracy,
- Access to something new.

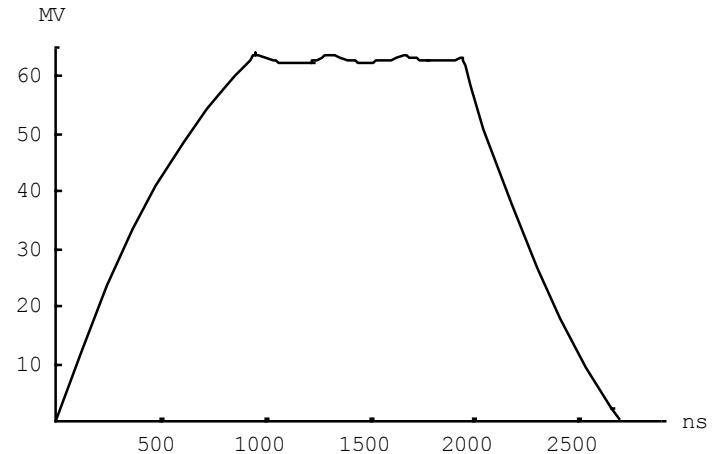
In (For calibration, unpolarized beam is made by a resonant depolarization.



## Conventional e<sup>+</sup> source: 300 Hz linac R/D: J. Urakawa



- Combining two RF sources, fast amplitude modulation by phase shifters is possible.
- Flat acceleration in the 300Hz linac is possible with the feed-forward control in a heavy beam loading condition.

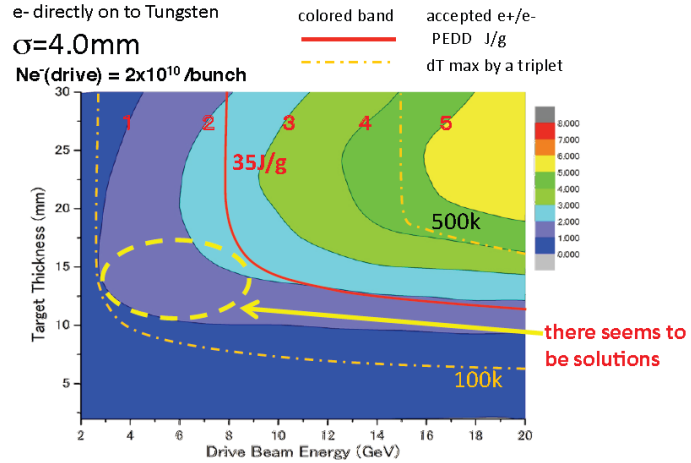
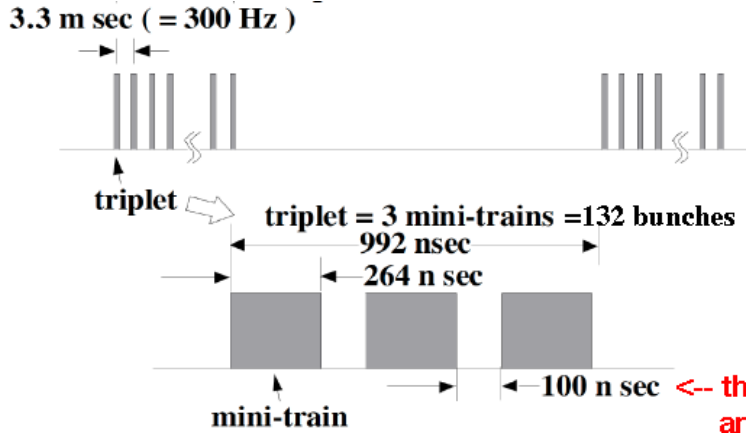






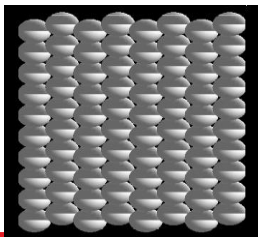
# Overview of 300 Hz Conventional e<sup>+</sup> Source for ILC: T. Omori

## Target studies for the ILC 300 Hz conventional e<sup>+</sup> source : T. Omori

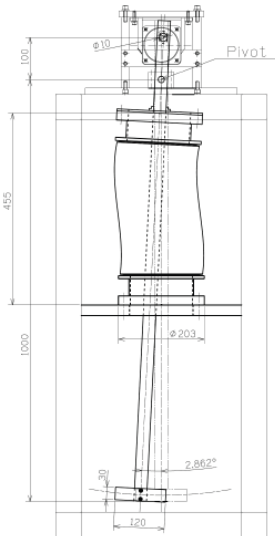


### Prototyping of Pendulum Target

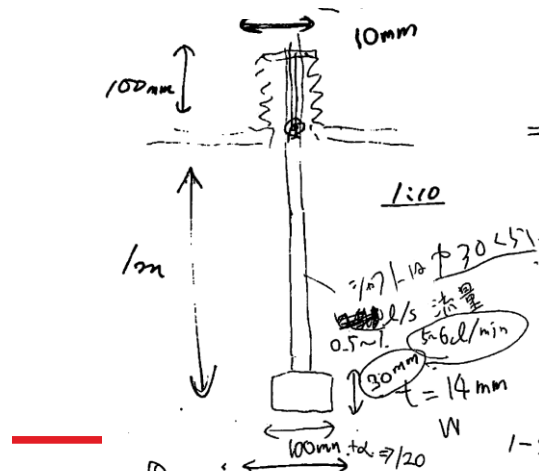
- W-solid,
- Granular target



### M. Yamanka

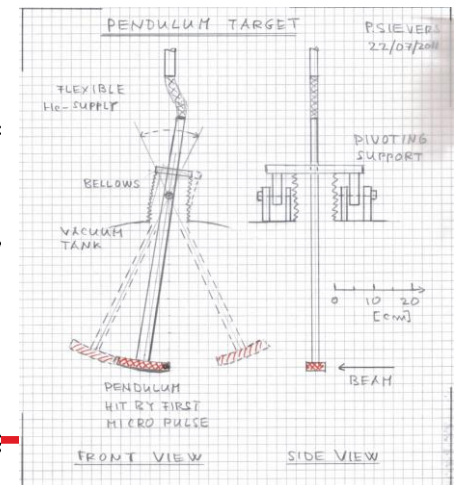


### T. Omori



April 23, 2013

### P. Sievers



Paris, France



# Polarized Positrons

Positron production @ ILC: helical undulator

- **Circularly polarized photons  $\rightarrow$  ILC  $e^+$  beam is polarized**
- **Degree of  $e^+$  polarization: depends on undulator parameters and beam energy**

147 m active length for  $E_{cm} = 500$  GeV

$P_{e^+} \approx 30\%$

147 m active length for  $E_{cm} = 375$  GeV

$P_{e^+} \approx 30\%$

} TDR

**Study of A. Ushakov:**

**231m active length for  $E_{cm} = 250$  GeV,**

**$P_{e^+} = 30\%$**

with normal 5Hz scheme and RDR undulator

- **Degree of  $e^+$  polarization can be enhanced up to 40% to 60% by photon beam collimation and changing the K value**

70 m  $E_{cm} = 500$  GeV,  $K=0.92$ ,  $r_{coll} = 1.0\text{mm}$   $\rightarrow P_{e^+} \approx 50\%$

196 m  $E_{cm} = 375$  GeV,  $K=0.92$ ,  $r_{coll} = 1.4\text{mm}$   $\rightarrow P_{e^+} \approx 55\%$

**231m  $E_{cm} = 250$  GeV,  $K=0.92$ ,  $r_{coll} = 3.5\text{mm}$   $\rightarrow P_{e^+} = 40\%$**

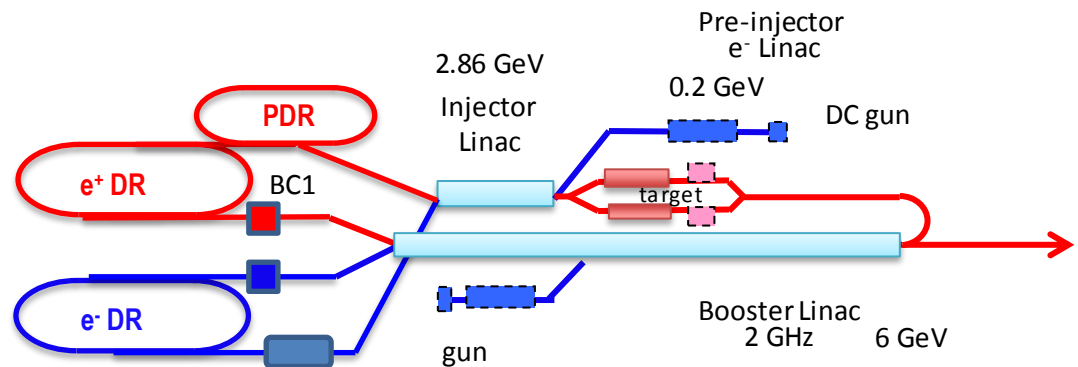
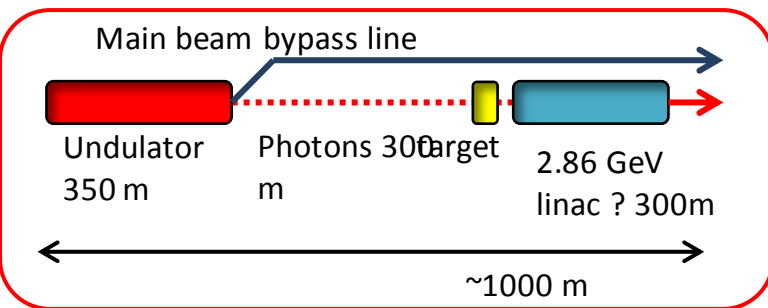
for more details see talks of W. Liu, F. Staufenbiel and A. Ushakov

Polarization upgrade of 300Hz conventional source should be possible for undulator and Compton based  $e^+$  source (T. Omori)



# CLIC Source Update: S. Döbert

- Polarized electron source with GaAs Super-lattice cathode.
- Hybrid positron generation with crystalline target.
- Exercise for system optimization for cost reduction,
  - No PDR for electrons,
  - Use 2 GHz bunch spacing for shorter rf
  - Optimise timing of the beams to gain efficiency
  - Booster linac as positron driver
  - Provide cost model for optimization
- Upgrade scenario for polarized positron with undulator.

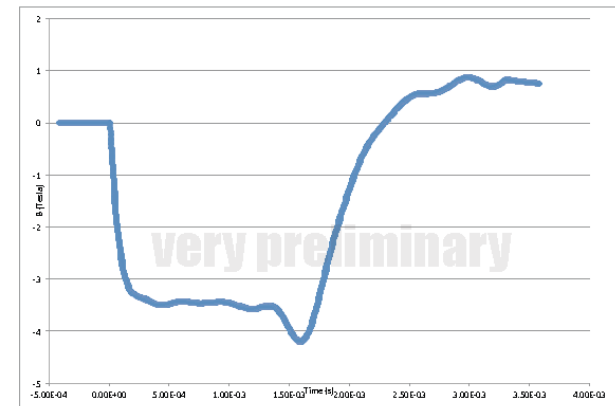
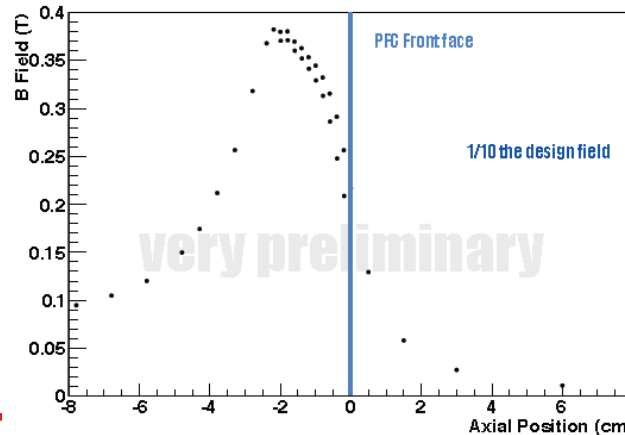
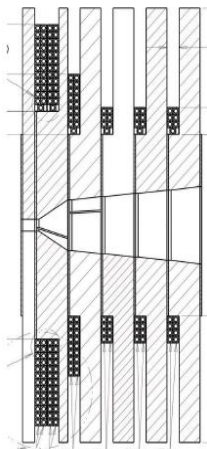
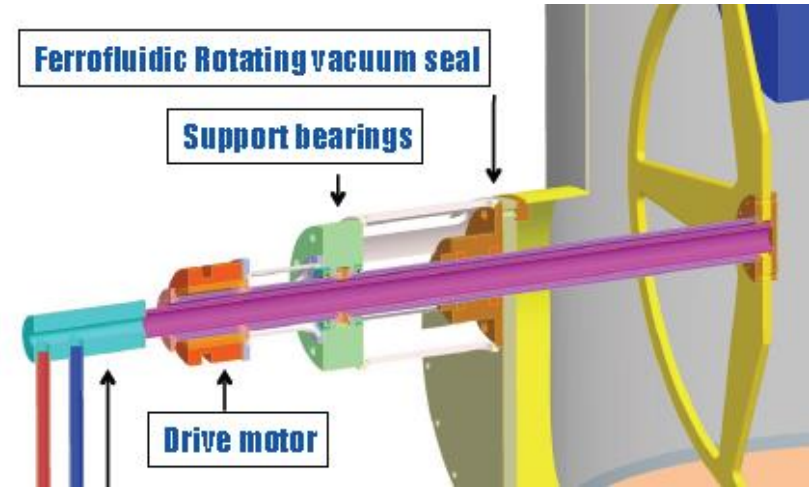




# Design and prototyping of the ILC positron production target: J. Gronberg

Ferro-fluid seals for rotating rod of the target were examined.

- 2000rpm was obtained.
- Vacuum spikes were observed.
- To make a technical design, need to understand the seal property well.
- Flux concentrator prototyping shows good results.



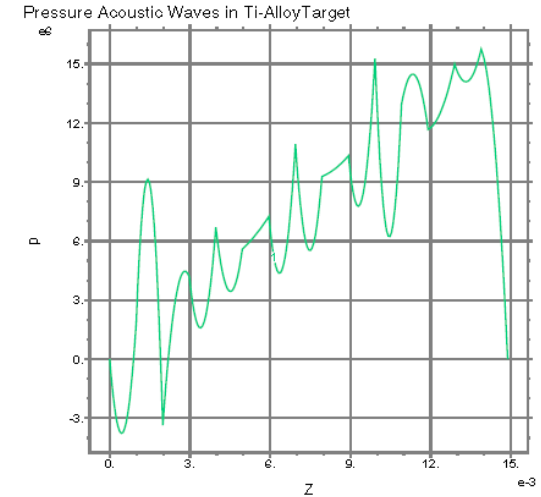


## Induced Pressure in Positron Production Target: *O. Adeyemi*

Acoustic pressure in target is numerically and analytically simulated.

By one bunch injection, several 10 MPa is expected.

$$\frac{\partial Q}{\partial t} = \frac{8Q_{bunch}c}{\pi\sqrt{\pi}\sigma_r^2\sigma_z L\chi} \frac{z}{L} \exp\left(-\left(\frac{r}{\sigma_r}\right)^2\right) \exp\left(-\left(\frac{z-ct}{\sigma_z}\right)^2\right)$$

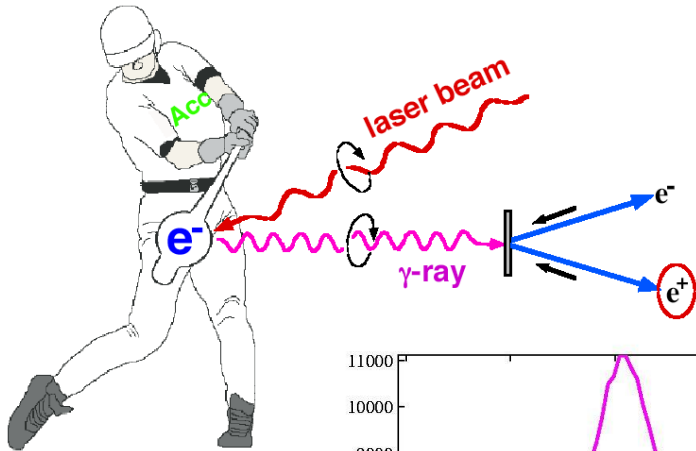




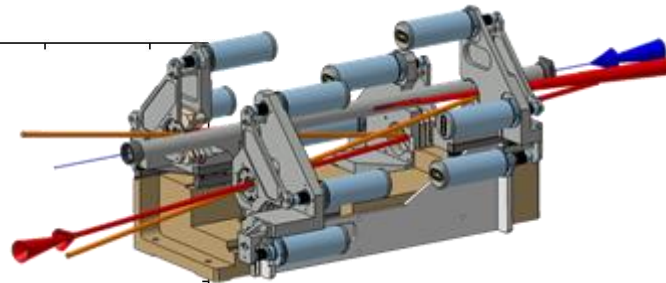
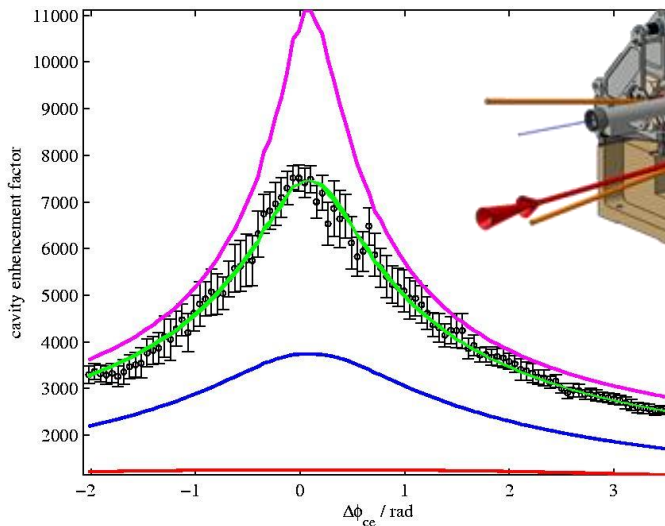
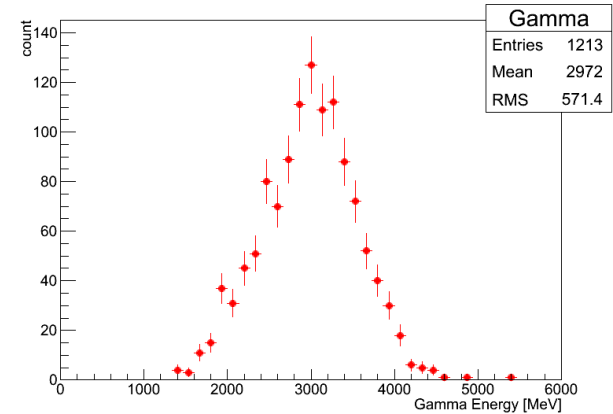


# Overview of enhancement cavity work at LAL/Orsay: *F. Zomer* Status of R&D of Optical Cavities at KEK-ATF : *T. Takahashi*

Polarized positron from gamma ray from Laser Compton scattering.



120 gamma / train  
 $2.6 \times 10^8$  gamma/sec



To 1MW stored energy :  
Optical cavity Gain  $1e+4$  (LAL)  
150W fiber laser (CELIA)

# Summary of the summary



- Damping rings
  - Main activity concentrated on experimental tests and less in design
  - Collaborations across different projects exist (CESRTA, ATF) and will continue to grow (see also Low Emittance Rings collaboration)
- Sources
  - Polarised Electron source development advancing well
  - Polarised positron production is a hot (and challenging) subject
    - Conventional positron scheme worked-out as a back up solution
    - For the undulator  $e^+$  source, an international technical effort for rotating target is needed. R&D of flux concentrator shows a significant progress.
    - Novel schemes using  $\gamma$ -rays from laser Compton scattering are being developed