Accelerator Physics Topics

REPORT

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LAL-Orsay

LCWS 2005

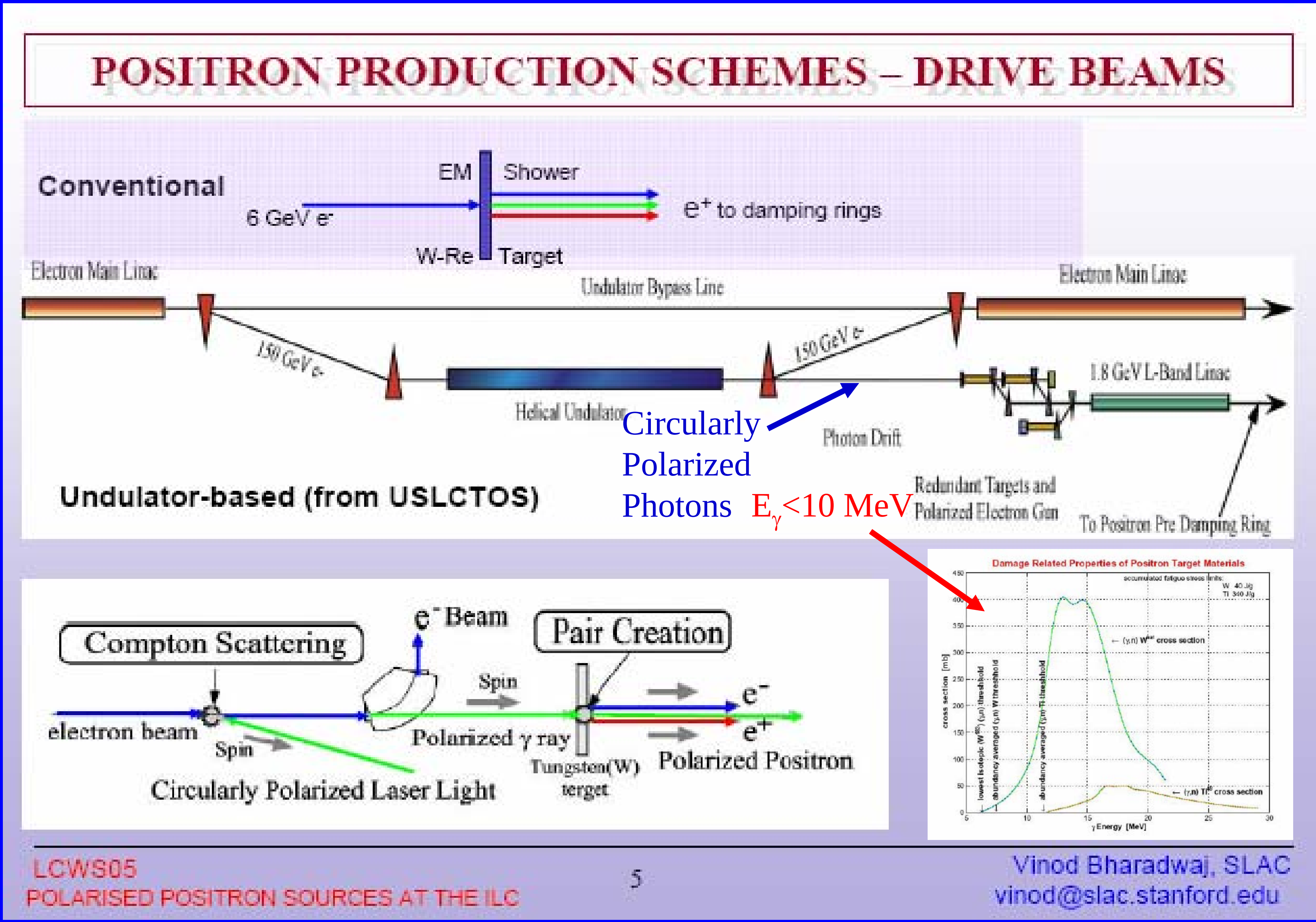
Stanford, 22 March 2005

TOPICS

- Positron source (polarized)
- Enhanced polarimetry (+ positrons ?)
- Damping ring
- Beam-based feedback (IP)
- Beam instrumentation
- ATF2 proposal (beam @ ILC-like IP ?)
- Supports and vibration control

TALKS

- Polarized positron sources at the ILC — V. Bharadwaj, SLAC
- Enhanced Fabry-Perot resonators for applications in polarimetry and positron sources — A. Variola, Orsay
- Beam dynamics simulation of the γ-ray based positron source — W. Gai, Argonne
- Status of experiment E166 at SLAC — R. Poeschl, DESY
- Polarized positron generation experiment at KEK-ATF — T. Omori, KEK
- Damping ring design overview — K.-J. Kim, BNL
- ATF2 — A. Seryi, SLAC
- CESR-c wigglers — S. Temnykh, Cornell
- IP FB system R&D — P. Burrows, QMUL
- Petra and ATF laser0wire results and plans — G. Blair, RHUL
- Summary of support tube R&D — H. Yamaoka, KEK


POSITRON PRODUCTION SCHEMES – DRIVE BEAMS
Conventional
EM
Shower
6 GeV e-
e+ to damping rings
W-Re
Target
Electron Main Linac
Undulator Bypass Line
Electron Main Linac
150 GeV e-
150 GeV e-
1.8 GeV L-Band Linac
Helical Undulator
Circularly Polarized Photons
Photon Drift
Undulator-based (from USLCTOS)
E$_\gamma$<10 MeV
Redundant Targets and Polarized Electron Gun
To Positron Pre Damping Ring
Damage Related Properties of Positron Target Materials
cross section [mb]
γ Energy [MeV]
Compton Scattering
e- Beam
Pair Creation
Spin
e-
e+
electron beam
Spin
Polarized γ ray
Tungsten(W) terget
Polarized Positron
Circularly Polarized Laser Light
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POLARISED POSITRON SOURCES AT THE ILC
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POSITRON DRIVE BEAM PARAMETERS (USLCTOS)

Parameter	γ-beam (und)	e-beam
Electron Drive Beam Energy (GeV)	153	6.2
Electron Drive Beam Intensity (10**10/bunch)	2	2
Beam Energy Loss (GeV)	4.9	–
Beam Energy Spread In %()	0.5	–
Beam Energy Spread Out (%)	0.46	–
Additional linac length (m)	170	230
Undulator length (m)	150	–
Undulator insertion length (m)	790	–
Positron source length (m)	450	450
Photon energy (MeV)	10.7	–
Undulator type	K=1; helical	–
Undulator field (T)	1.07	–
Undulator period (cm)	1	–
Undulator full gap (mm)	6	–
Positron yield†	1.5	1.5
Expected Positron Polarization (@ full luminosity)	40-70%	–

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POLARISED POSITRON SOURCES AT THE ILC

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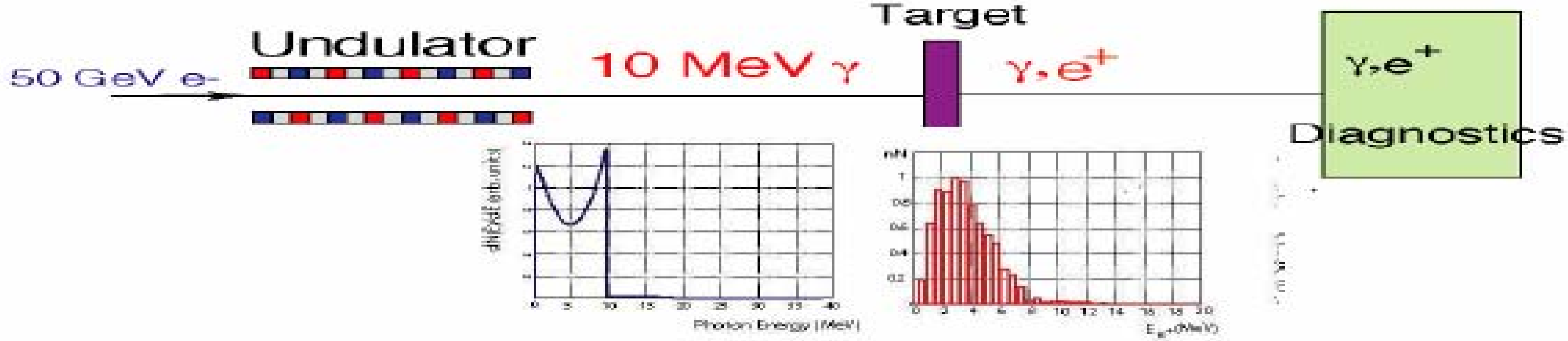
Demonstration experiment

Roman Pöschl

Principle of the E166-Experiment



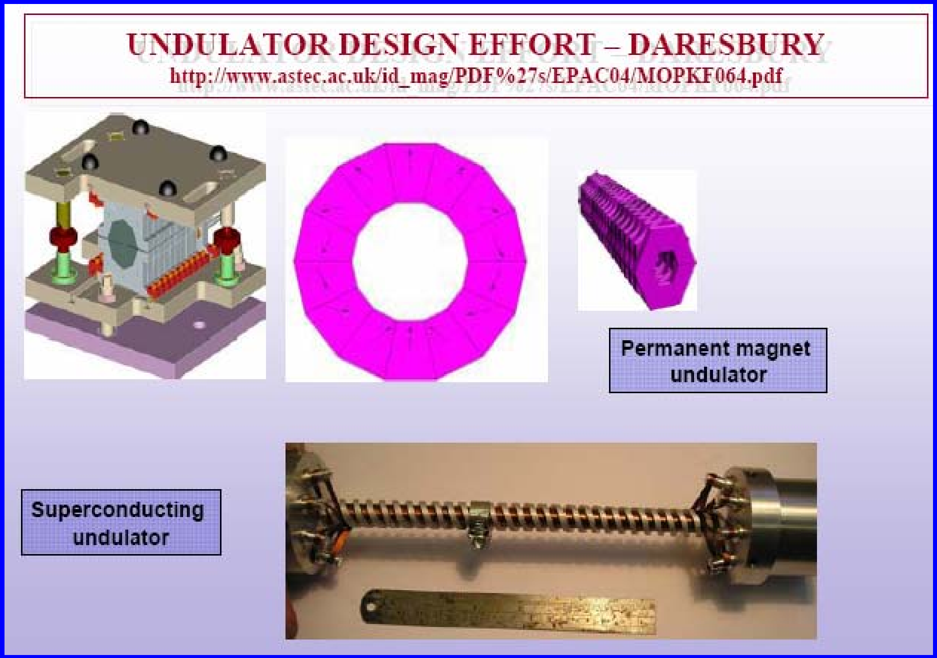
- E-166 uses the 50 GeV SLAC-Beam in conjunction with a 1m long helical Undulator for the production of Polarized Photons.

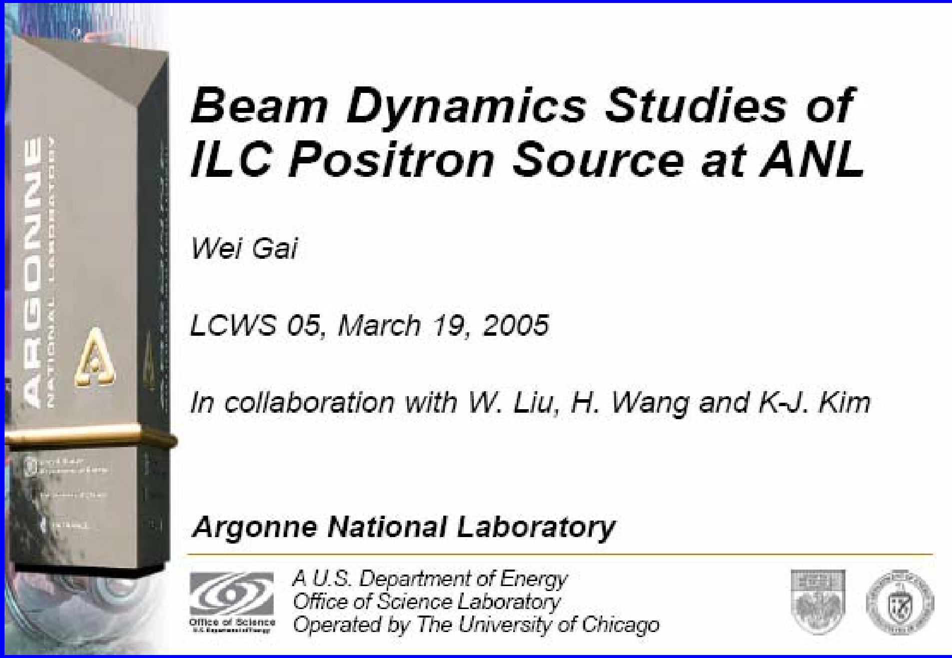
- These photons are converted by a ~0.5 X_0 thick Absorber into Polarized Positrons (und Electrons).

- The Polarization of the Positrons (und Photons) is measured

First October 2004 run interrupted by accident

Planned run in May 2005 : confirm low background, see polarized e^+ ?





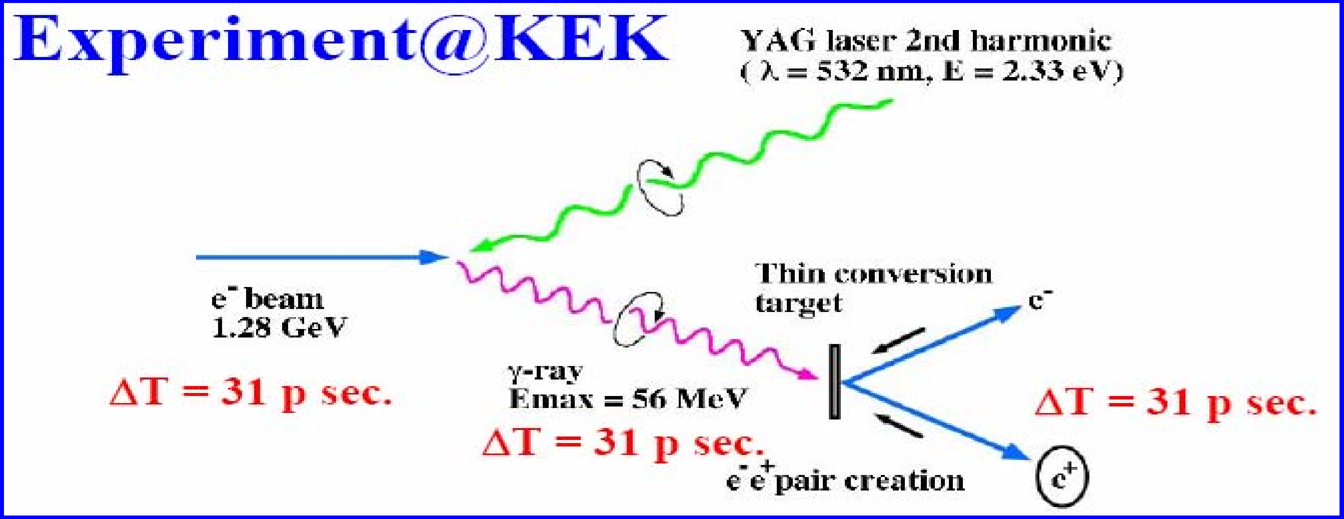
SUMMARY & PLANS

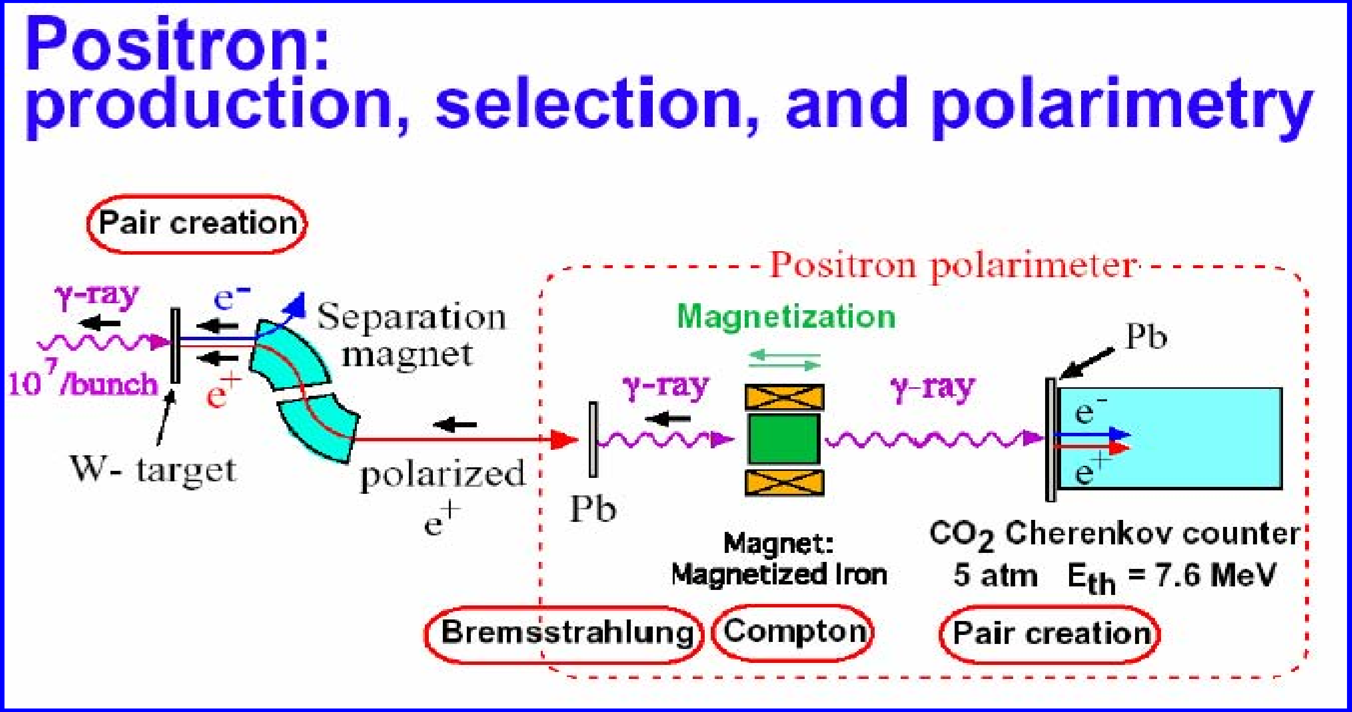
- *Polarized positron source using helical undulator and the ILC main linac electron beam is feasible*
  - *As easy as an undulator-based **unpolarized** source* ⇒ Base-line ?
  - *Reliability issues need to be fully understood*
- *Positron workshop in Daresbury (April 10-13)*
  - *Discuss issues for all positron source schemes*
  - *Organize who is doing what*
  - *Prepare plan for Snowmass*
- *Snowmass August 14-27*
  - *CDR plan*
  - *R&D plan for TDR*

Compton based

measured e^+ polarization ~ 80%

ILC : ~ 100 laser !

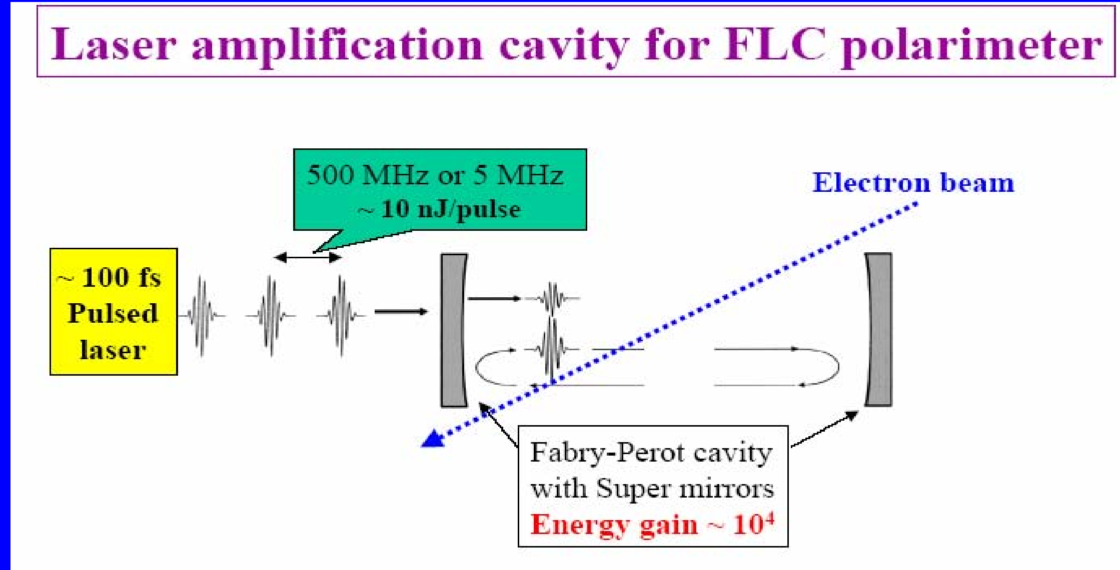




High gain (10^4) 100 fs laser amplification in Fabry-Perot cavity :

Option for polarimetry ?

Generic technical R&D
+ other potential uses
- γγ-collider
- e+ Compton source



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EuroTeV

BRISSON Violette
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MOENIG Klaus
PASCAUD Christian
SOSKOV Viktor
VARIOLA Alessandro
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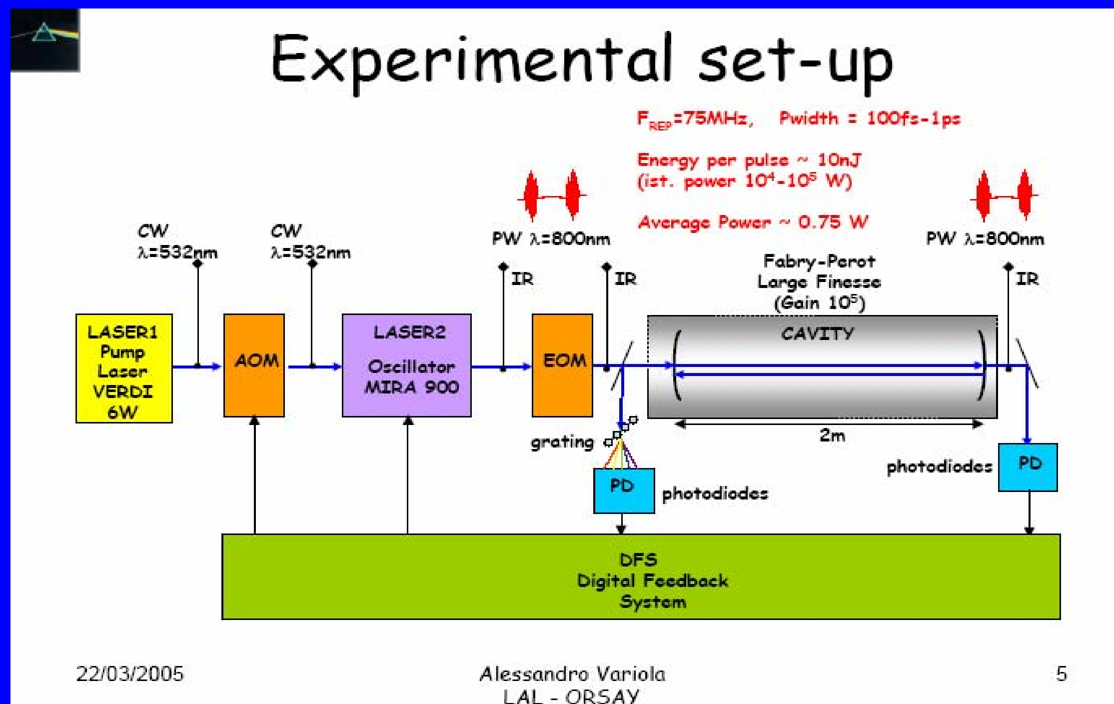
ZOMER Fabian



Requirements for ILC Damping Ring

- **Compress 1 ms linac bunch train in to a "reasonable size" ring**
  - Fast kicker
- **2820 bunches, 2×10^{10} electrons or positrons per bunch, bunch length= 6 mm**
  - instabilities
- **Damping of $\gamma\varepsilon_{x,y}$= 10^{-2} m-rad positron beams to $(\gamma\varepsilon_H, \gamma\varepsilon_v)=(8 \times 10^{-6}, 2 \times 10^{-6})$ m-rad**
  - Low emittance
- **Cycle time 0.2 sec→ τ=27 ms**
  - Damping wiggler
- **Dynamic aperture ≥ 10 σ**
  - Injection loss < 1 %

Damping Ring Topics

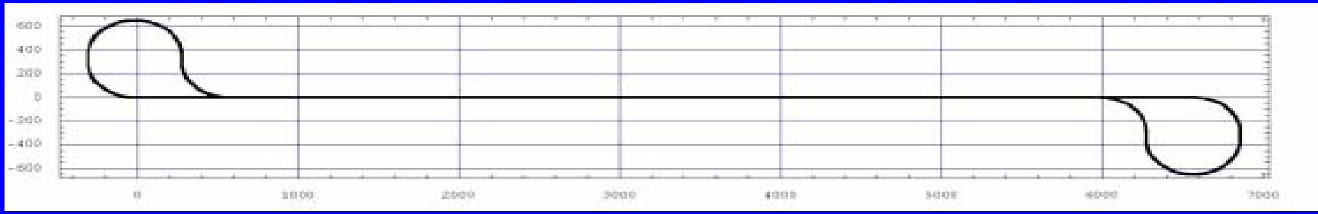
- **Lattice design and optimization**
  - TME or FODO
- **Dynamic aperture**
- **Automatic lattice design**
- **Space charge tune shift**
  - Coupling bump
- **Collective effects**
  - Electron cloud, fast ion→ vacuum vessel and level
- **Novel schemes**
- **Tracking to determine injection efficiency**
- **Error tolerance in lattice and wiggler**
- **Wiggler technology**
- **Kicker R&D**
- ***And many more!***

CESR-c experience with wigglers

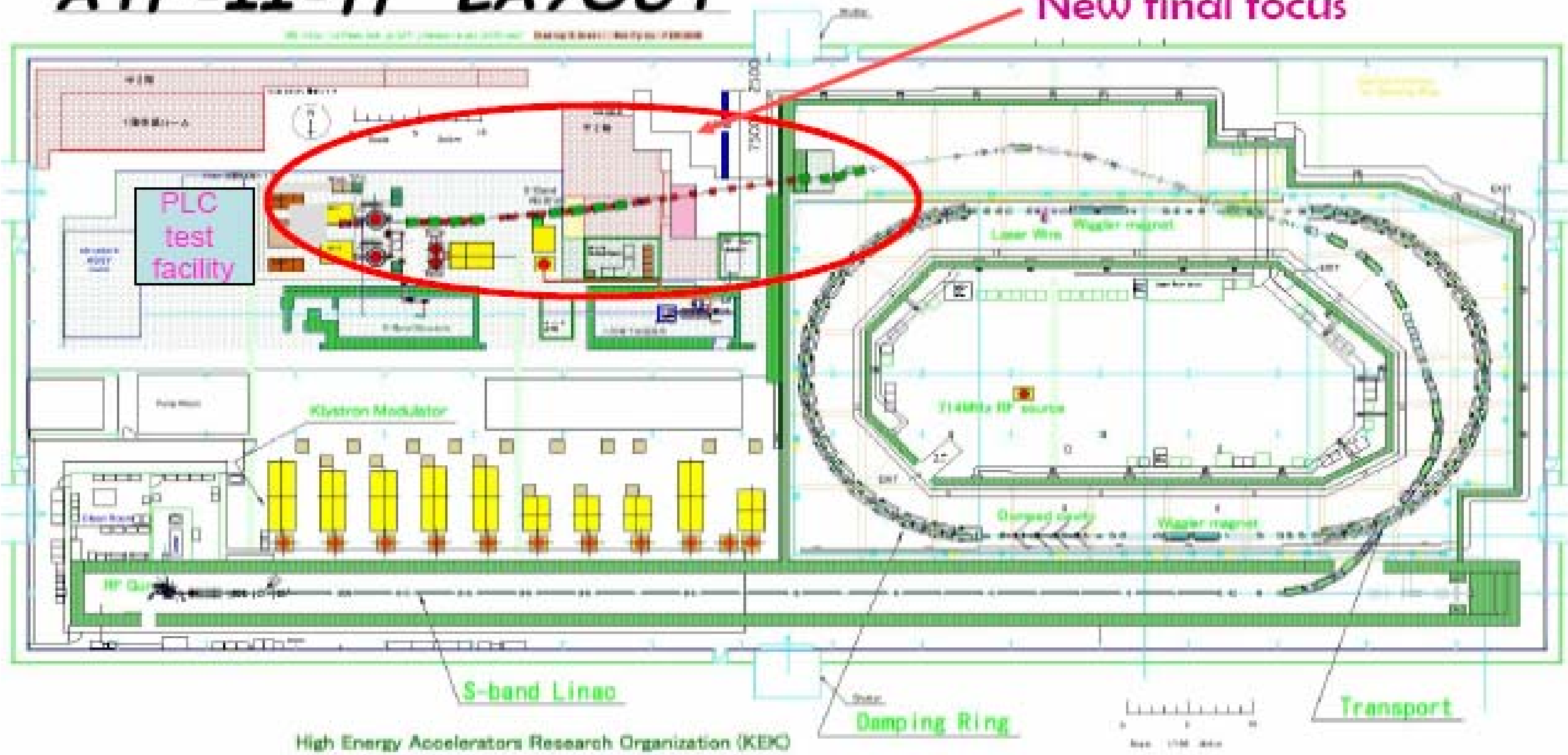
Some ILC Damping Ring Designs

Parameters	TESLA DB (W. Decking)	SLAC DB (Y. Cai)	LBL (DB) (A. Wolski)	ANL-FNAL Circular (A. Xiao, L. Emery)
Energy E(Gev)	5	5	5	5.0
Circumference (m)	17,000	17,014	15,815	6114
Horizontal emittance (nm)	0.50	0.62	0.715	0.8
Damping time (ms)	28	27	27	27
Tunes, ν_x,ν_y,ν_s	76.31, 41.18, 0.071	83.73, 83.65, 0.072	75.78, 76.41, 0.41	56.58,41.62,0.0348
Momentum compaction α_c	1.22×10^{-4}	1.11×10^{-4}	5.6×10^{-4}	1.42×10^{-4}
Bunch length σ_z (mm)	6.04	5.90	6.0	6
Energy spread σ_e/E	1.29×10^{-3}	1.30×10^{-3}	1.63×10^{-3}	1.3×10^{-3}
Chromaticity ξ_x, ξ_y	-125,-62.5	-105.27, -106.70	-90.98, -94.86	-74.4,-55.4
Energy loss per turn (MeV)	20.4	21.0	19.75	7.73
Cavity Voltage (MV)	50	50	312	27

"Dog-bone" remains favored ?



ATF-II-ff LAYOUT



ATF2 Goals & stages:

(A) Small beam size (with Shintake BSM at IP)

(A1) Obtain σ_y ~ 35nm

(A2) Maintain for long time

(B) Stabilization of beam center (with nano-BPM at IP)

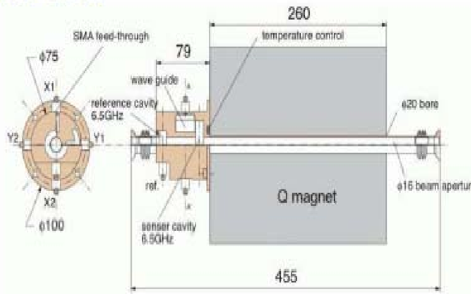
(B1) Down to < 2nm by nano-BPM

(B2) Bunch-to-bunch feedback of ILC-like train

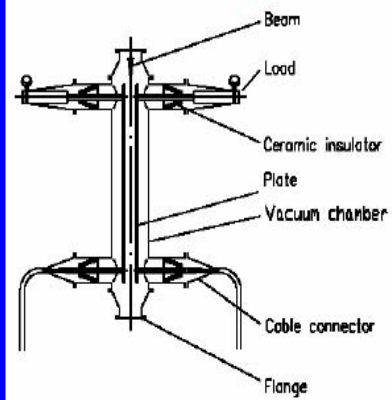
As ILC, ATF2 critically depends on instrumentation

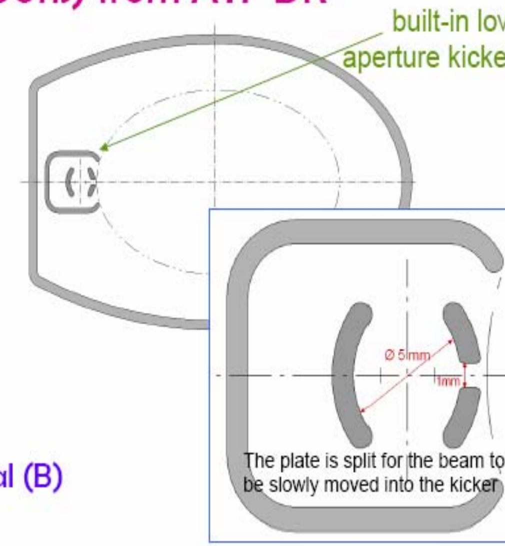
- Beam Size Monitor to confirm 35nm beam size
  - shorter laser wavelength than what used at FFTB, to resolve 30nm
  - easier for single bunch, more difficult for each bunch in the train
- nano-BPM at IP to see the nm stability
  - complicated by large beam divergence, angle jitter and x-y coupling
- Laser-wire to tune the beam
- Cavity BPMs to provide stable orbit
- Movers, active stabilization, alignment system, etc.

ATF laser-wire program → 1μm



ILC-like train (~20b * 300ns) from ATF DR





Essential for the goal (B)

- Two approaches of counter-fed stripline kicker:
  - TDR/BINP kicker (two sets in ATF DR: at ZH39R and QM6R.1)
  - low aperture (5mm) kicker with local orbit correction before ejection (require modification of existing septum to reduce thickness of its 22mm knife)

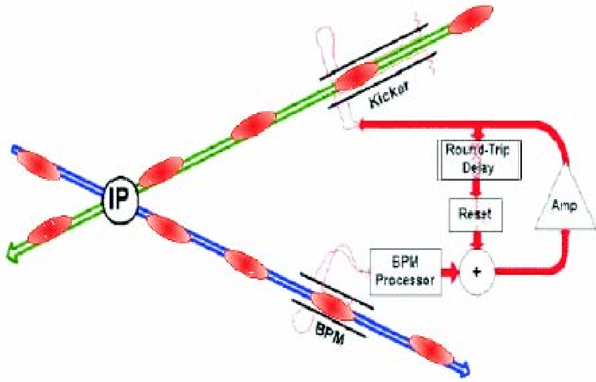
1. Much ILC – relevant technical testing
2. Training component
3. Some aspects harder than needed for ILC

Time-line → international participation

- January – March: preparation of the proposal document
  - presently ~2/3 of material collected, editing is ongoing
- Finalize the design and proposal in June 05 (BDIR workshop in UK)
  - negotiate contributions from participating institutions
- Start hardware production in mid 2005, aim for the first beam in FF at the beginning of 2007

Intra-train Beam-based Feedback

Intra-train beam feedback is last line of defence against relative beam misalignment



Key components:

Beam position monitor (BPM)

Signal processor

Fast driver amplifier

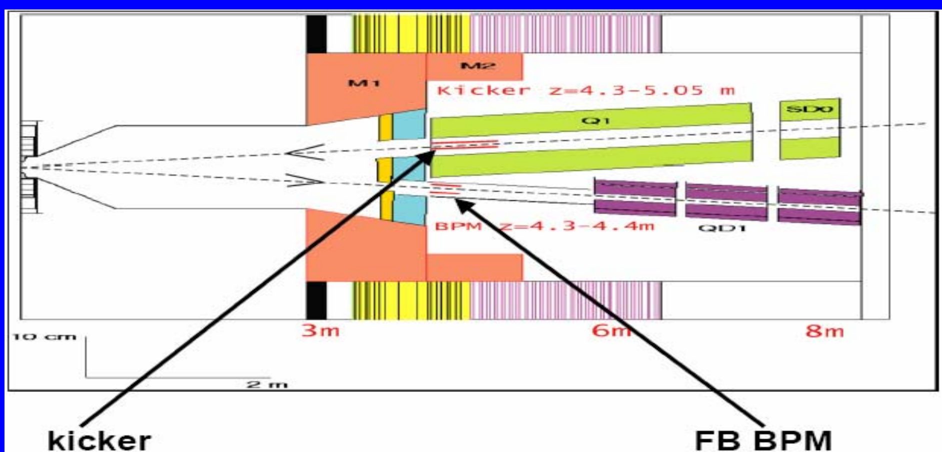
E.M. kicker

Fast FB circuit

TESLA TDR: principal IR

beam-misalignment correction

Philip Burrows *LCWS05, Stanford 20/3/05*



March 2005: Commission final version of superfast processor + jitter monitor

May 2005: FONT3 closed-loop feedback tests

During 2005: Develop prototype for FONT4 digital feedback system for ILC bunch spacing

December 2005: First commissioning studies with prototype digital system: 3 bunches extracted from ATF ring w. spacing 150ns

Spring 2006: First feedback tests with digital system + 3 ILC bunches

2007 (?): Feedback tests w. 20 bunches @ 337ns

Study of performance of FB hardware in realistic IR environment: e+e- and gamma backgrounds

Simulating e+e- and gamma fluxes in SLAC A-line:
2005/6: install BPM and study noise/long-term radiation effects

Concerns about EM pickup in FB BPM – test in IR mockup?

Intra-train beam feedback technology widely applicable:
emergency fast beam abort (DONT)?
beam position stabilisation for diagnostics:
laserwire, bunch-length monitor, Shintake monitor …

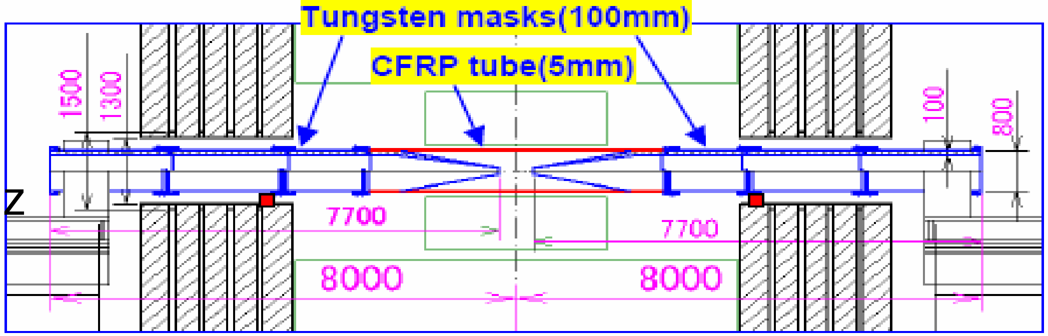
Need to optimise IP feedback component locations

Need to produce engineered system designs for TDR

Summary of Support tube R&D

KEK H. Yamaoka

Natural frequency ~ 70 Hz



- Tungsten tube: 100mm thick, CFRP: 5mm thick
  → Correlation is given to both-sides tubes in oscillating behavior.

- In case of L*= 2m;
  Support position: Both ends + 3.85m from I.P.
- In case of L*= 4m;
  Support position: Both ends

- Active vibration isolation system is necessary.
  → ・ Amplitude is magnified if support tube is mount on a support stand.
  - To eliminate culture noise.
  - CFRP tube is not efficient to reduce amplitude less than 2nm.

- It is necessary to design the stiff support base as possible
  → Natural frequency becomes high.
    → Amplitude decreases in proportion to frequency.

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Conclusions

- Much activity…
- Wide range of topics…
- Increasing participation from particle physicists
- Appropriate balance to be found between generic and streamlined R&D work
- Important GDE task to structure / orient the work while continuing to build a wide community base to exploit the vast amount of competence