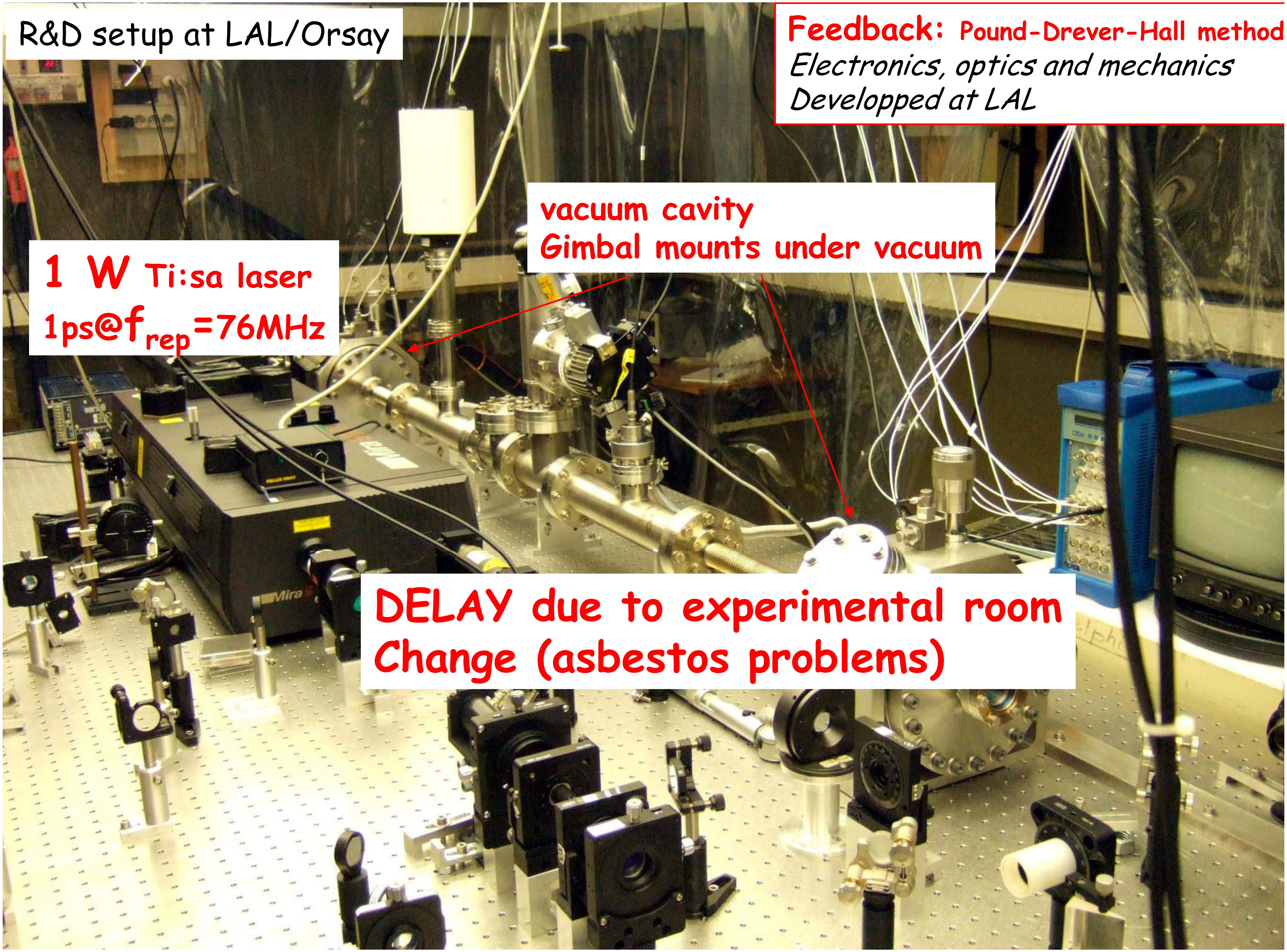
Compton Source: ERL & Ring STATUS

Alessandro Variola
LAL-IN2P3-CNRS

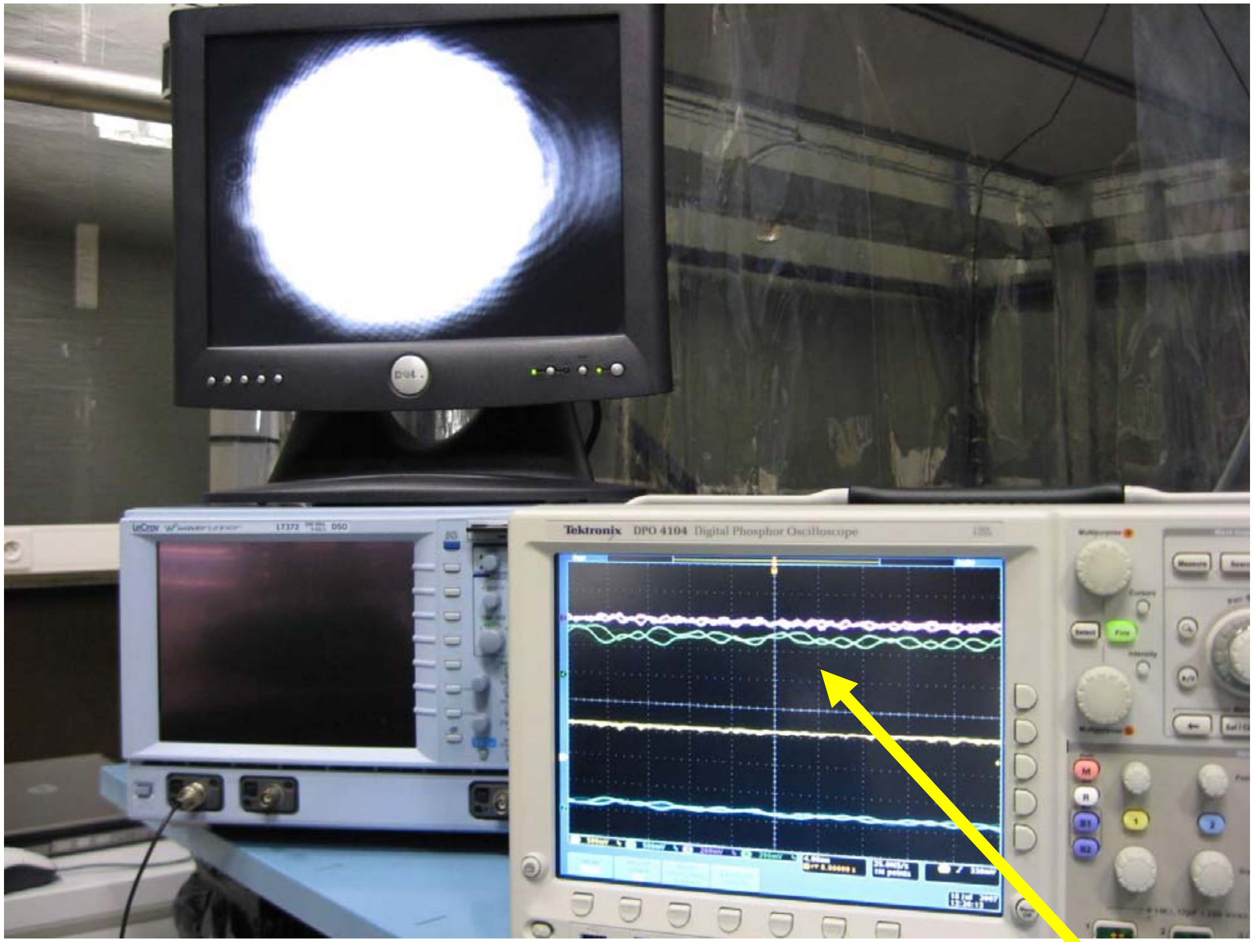
Optical Cavities & Lasers

- 1)R&D on Cavities 2- 4 mirrors and high average power laser in Orsay
- 2)ATF experiment


R&D setup at LAL/Orsay
Feedback: Pound-Drever-Hall method
Electronics, optics and mechanics
Developped at LAL
vacuum cavity
Gimbal mounts under vacuum
1 W Ti:sa laser
1ps@f_rep=76MHz
DELAY due to experimental room
Change (asbestos problems)

Status : Cavity locked ('*low gain*' ~ 1200)

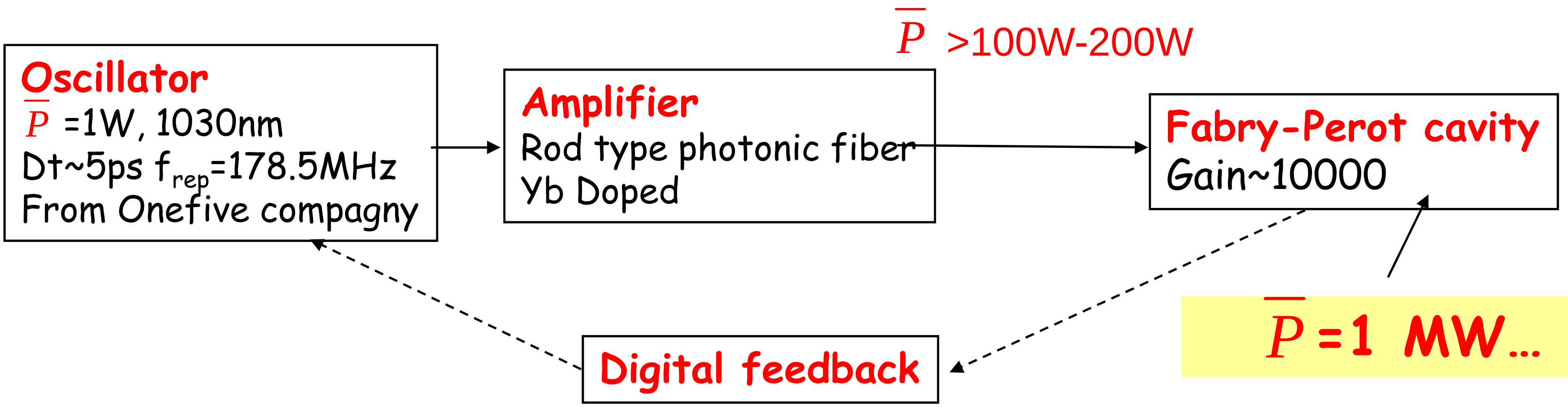
- Digital feedback (VHDL programming)
- Already $\Delta f_{rep}/f_{rep}$~10^{-10} ➔ Δf_{rep}~76mHz for f_{rep}~76MHz
- New mirrors asap ! ➔ gains 10^4-10^5



Locked cavity :
Transmitted signal stable

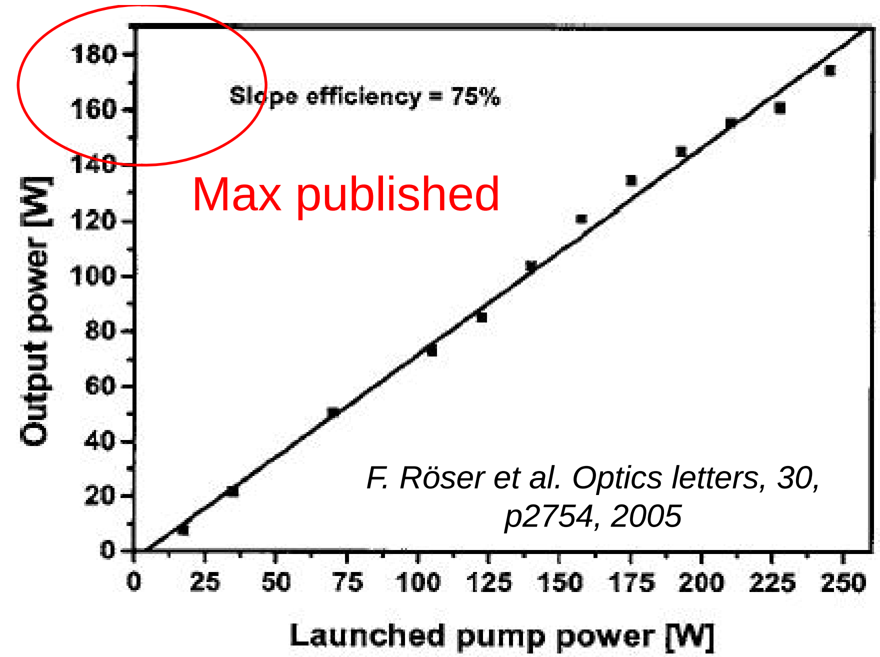
New R&D : started february 2008
Funds: GIS P2I+IN2P3 (+ANR ?)
Reduced power in respect to the Eu program……

1. Setup the following system at CELIA (Bordeaux)/LAL

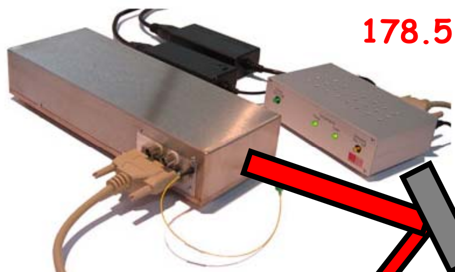


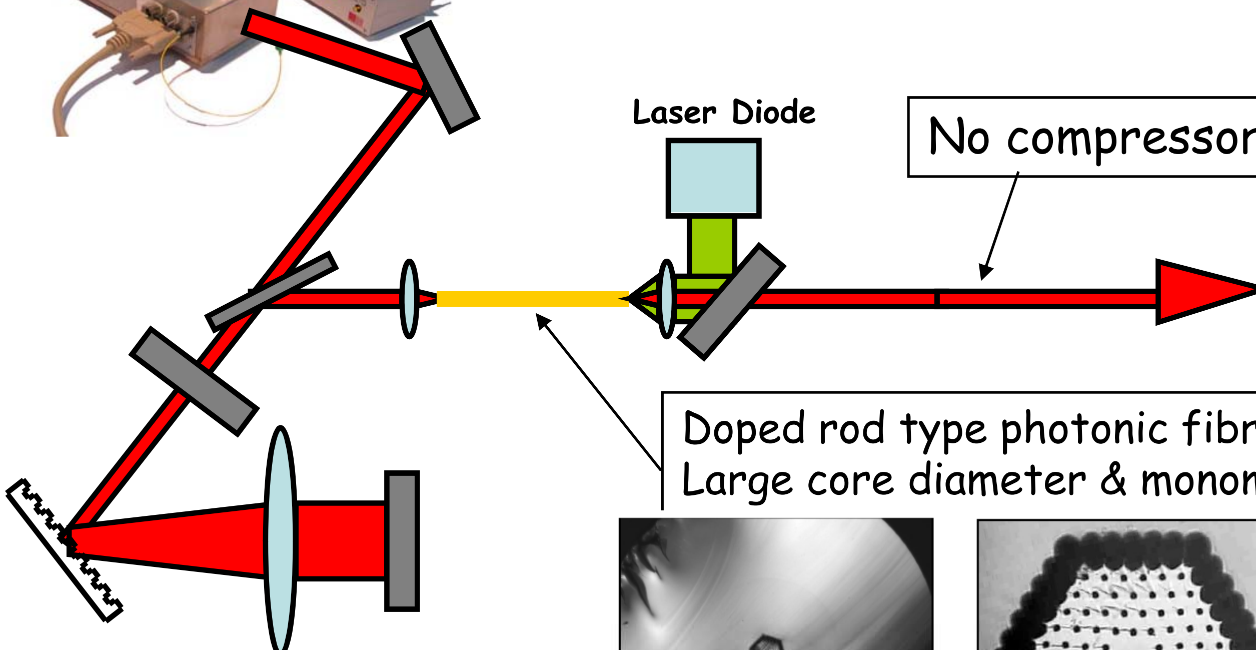
2. Optics studies: phase noise (CPA or not CPA), power stability, cavity mirror heating (CELIA/LMA) …
3. Installation of the system at ATF/KEK (with KEK)

The laser amplification R&D
➔E. Cormier (CELIA)



OneFive laser
Δt=2-5ps,
178.5 MHz, 1W

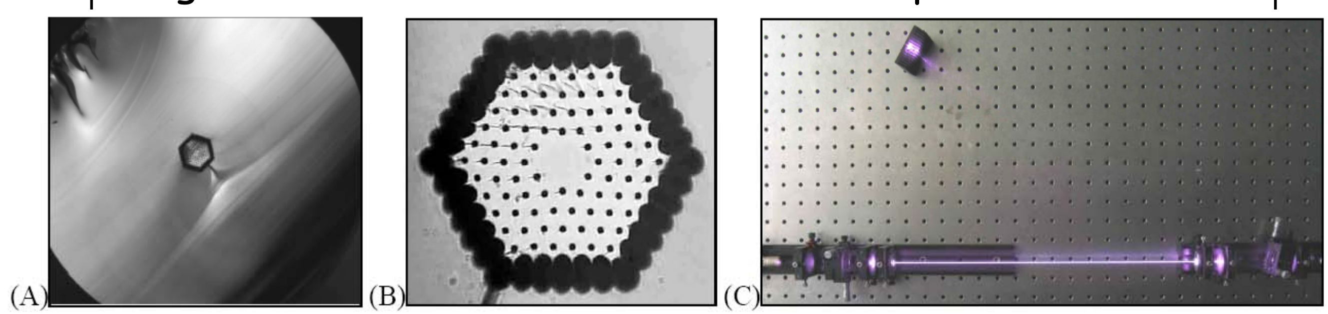




No compressor needed a priori…

Possible average power 100W-300W (simulation)

Doped rod type photonic fibre:
Large core diameter & monomode developed for CELIA



Gold grating-based strectcher gives negative chirp for spectral compression

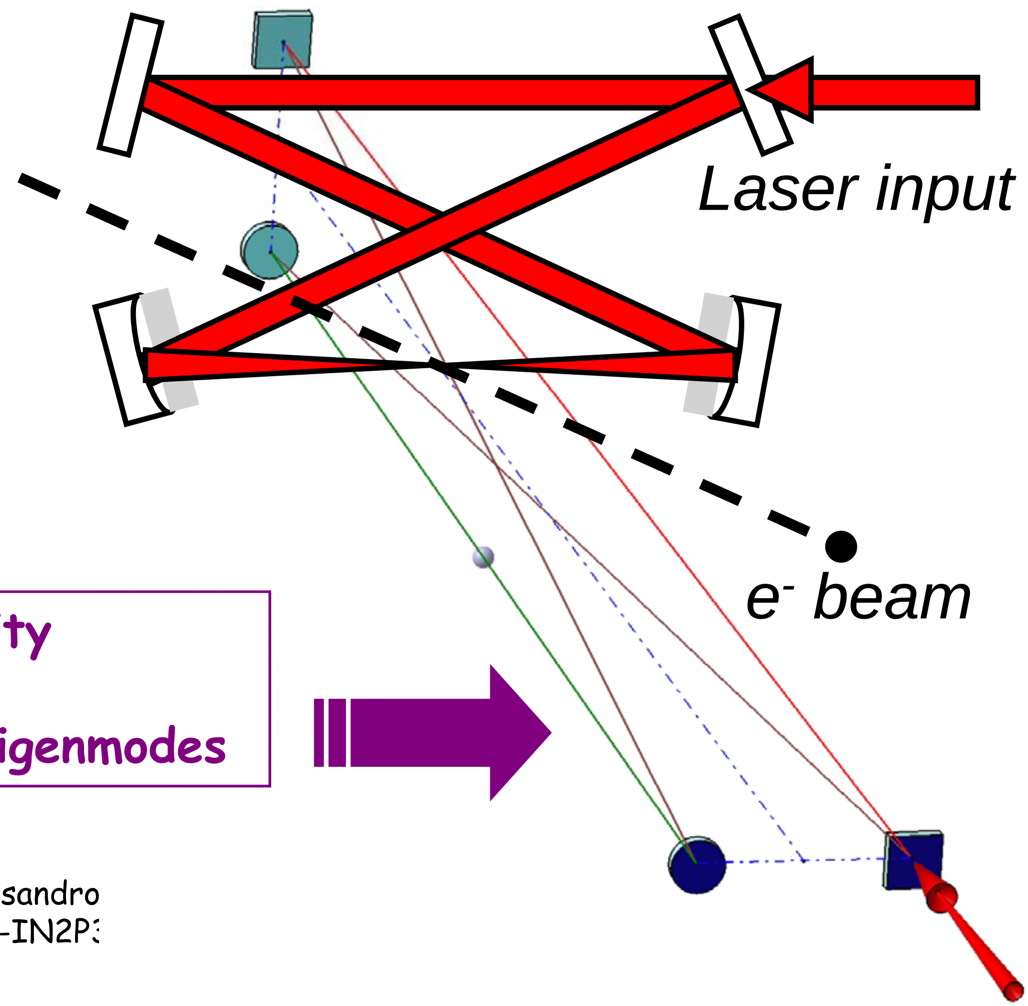
Toward small laser spot size

Small laser spot size &2 mirrors cavity ➔ unstable resonator (concentric resonator)

Stable solution: 4 mirror cavity as in Femto lasers

BUT➔ astigmatic & linearly polarised eigen-modes

Non-planar 4 mirrors cavity
➔Astigmatism reduced &
~circularly polarised eigenmodes

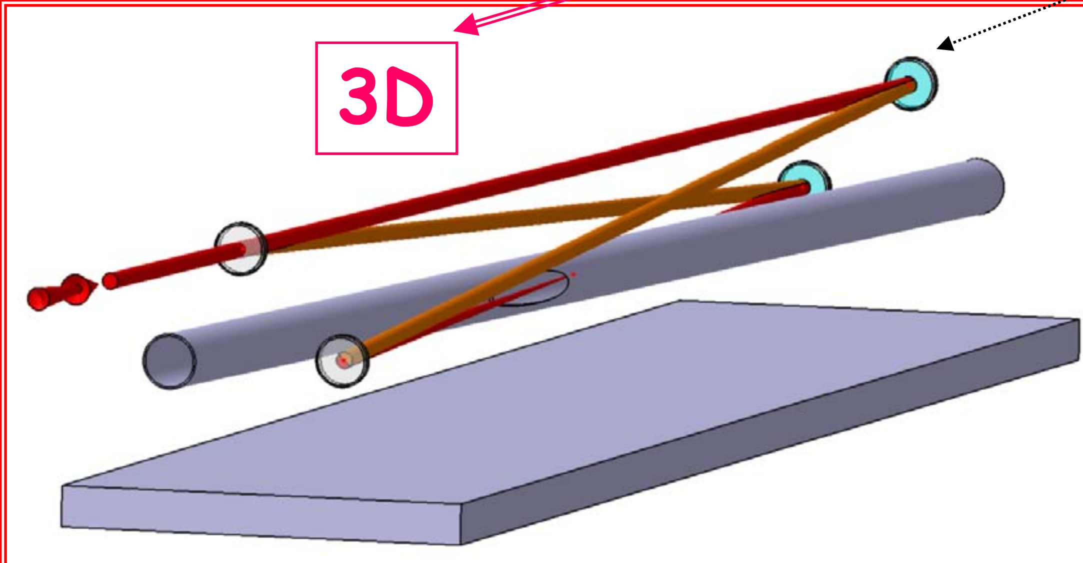


Choice of the cavity geometry
Interaction plane must be horizontal

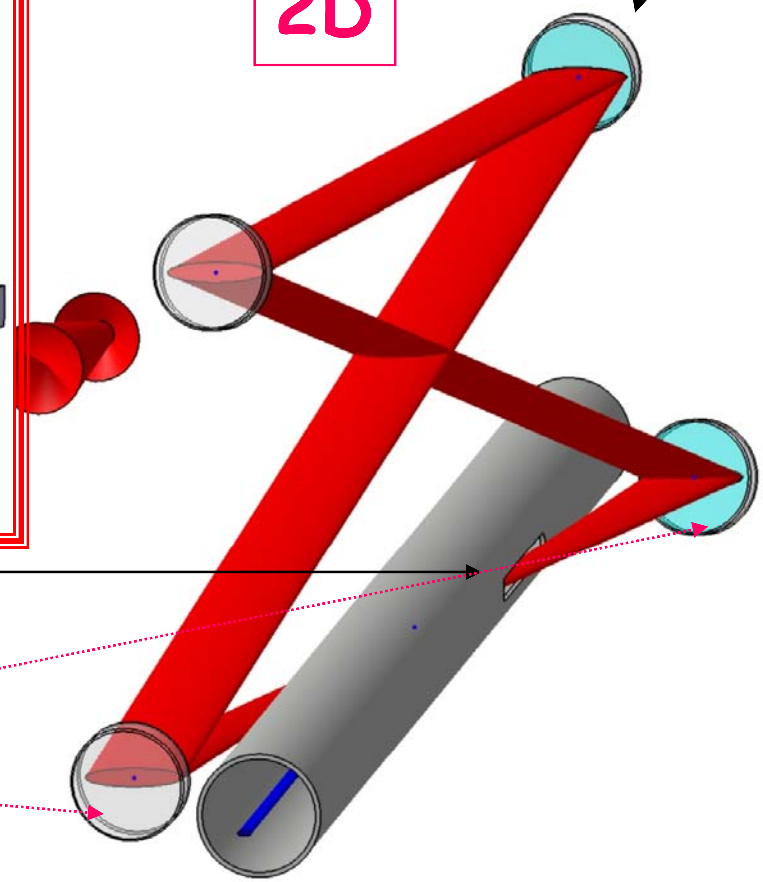
Valorisation en cours :
monture motorisées
Gimbal sous ultra-vide

2 choices

3D



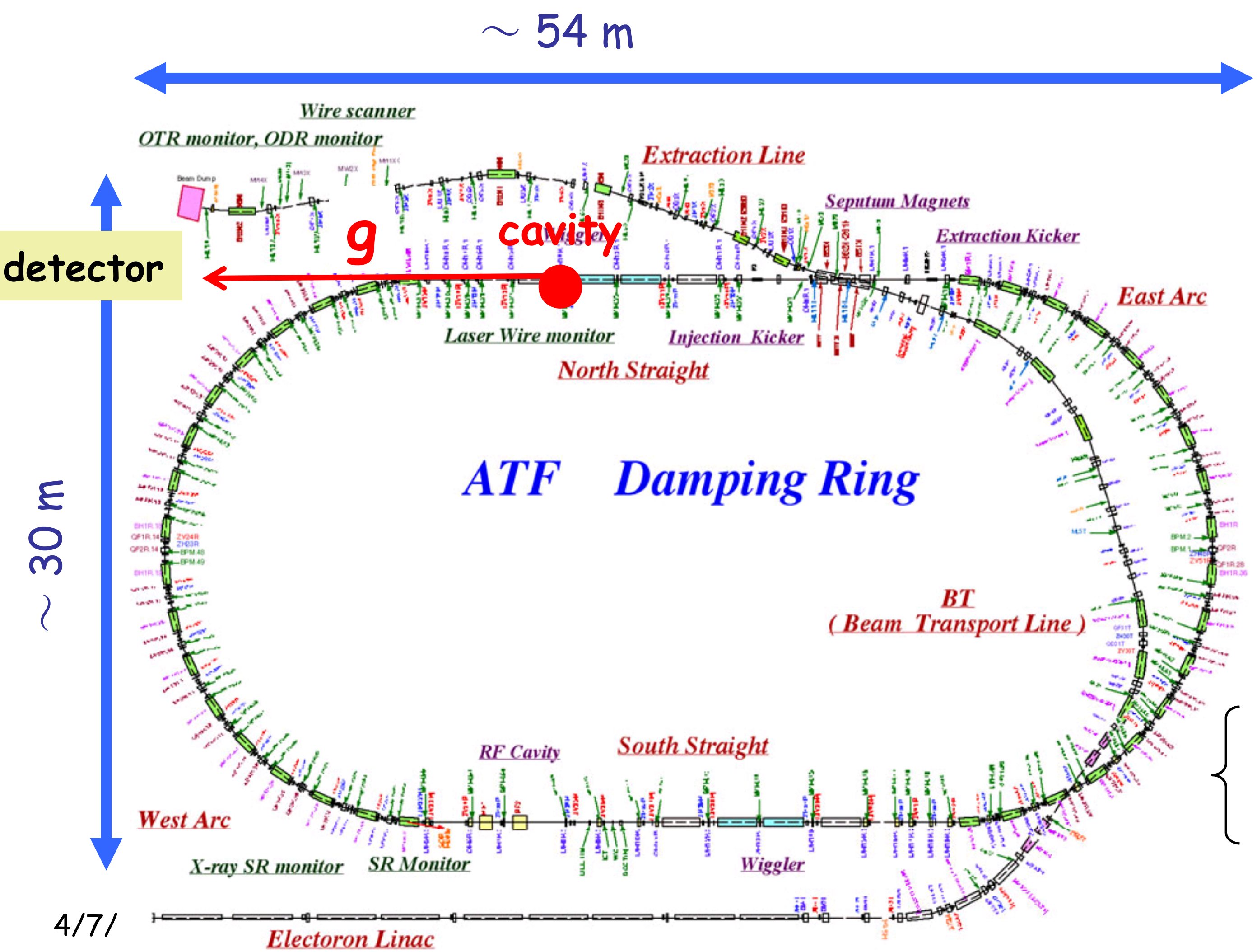
2D



Main constraint: 5mm vertical slit width

- Optical path length = c/178.5MHz~1.6m
- 2 sperical mirrors with R=500mm

Cavity installation on the Accelerator Test Facility (ATF) at KEK



Beam Energy → 1.28GeV

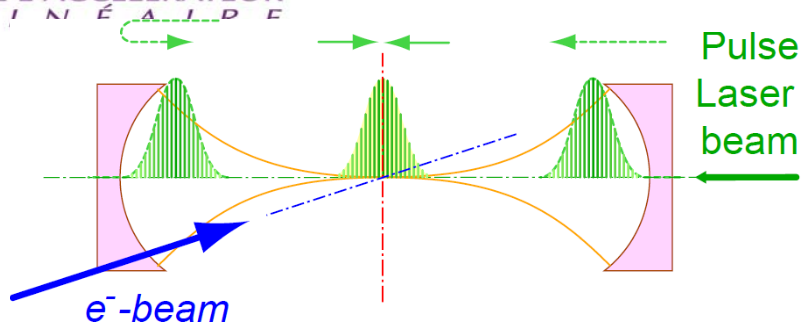
Beam Size → 100μm × 10μm

Emittance → 1.0×10^{-9} rad.m, 1.0×10^{-11} rad.m (Ultra Low !!)

(H. Shimizu)

γ-ray Generation with Laser Stacking Cavity in ATF

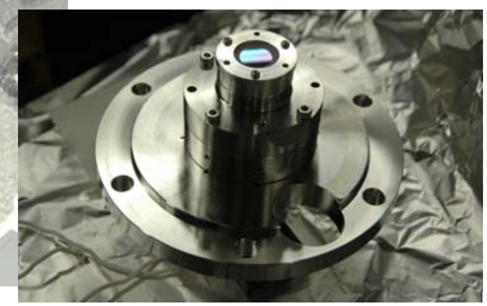
Hiroshima-Waseda-IHEP-KEK

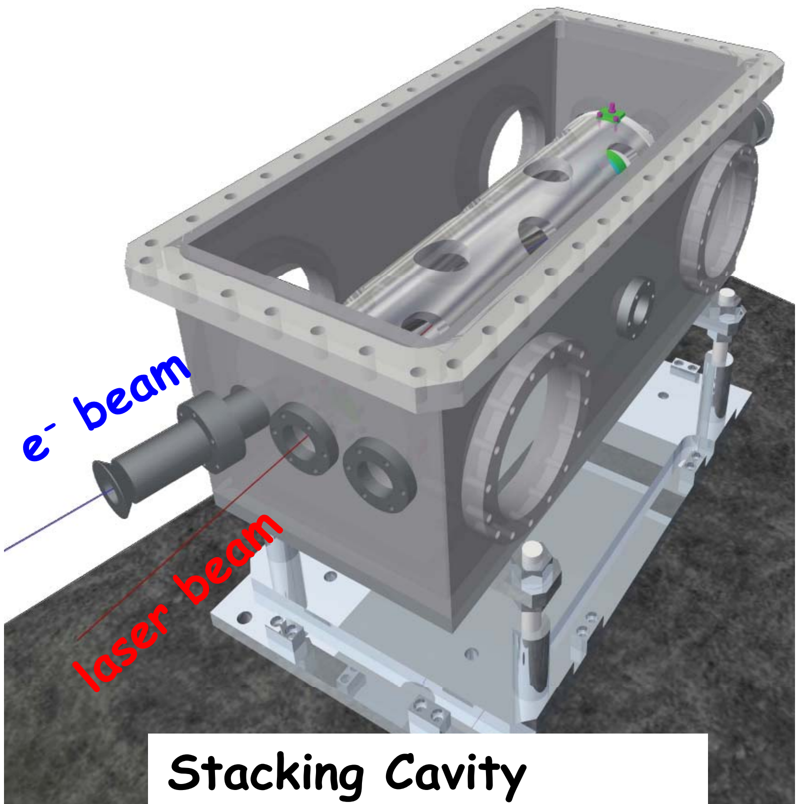


Pulse Stacking
2-Mirror
Cavity

L_{cav} = 420 mm

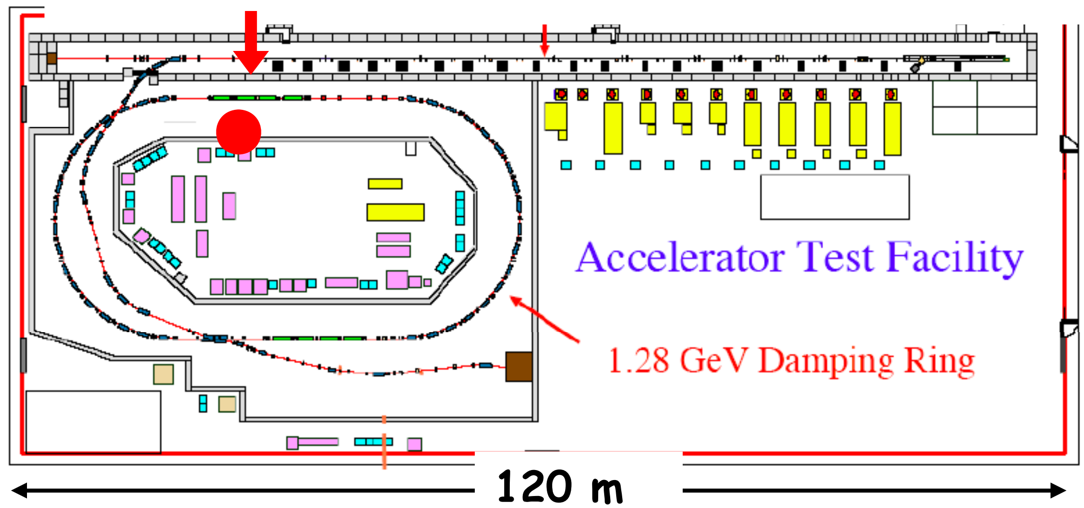
Mirror with
Piezo Actuator





Stacking Cavity
in Vacuum Chamber

Installed in ATF at KEK October 2007



γ-ray Generation with Laser Stacking Cavity in ATF

Aim of the Experiment

1. Start experiment quickly with simple 2-mirror cavity
2. Achieve both high enhancement & small spot size
3. Establish feedback technology of Stacking Cavity (Mirror position)
4. Achieve small crossing angle
5. Get experience with e^- beam

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1. Enhancement = 1000 (with Mirror R = 99.9%)
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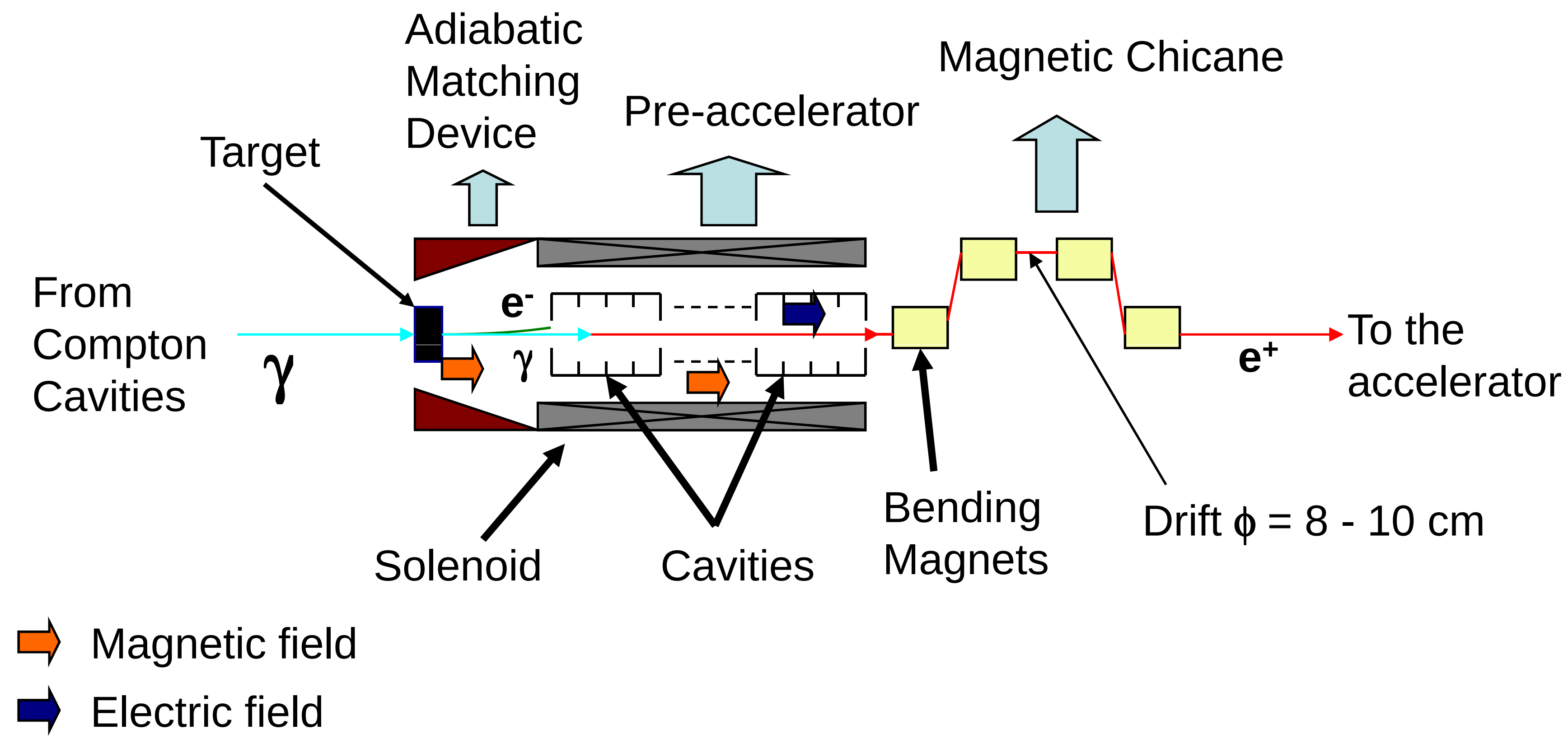
Status

1. Cavity was installed in ATF at KEK, October 2007
2. Still straggling to establish feedback, to make good laser input matching, and to isolate system from vibrations

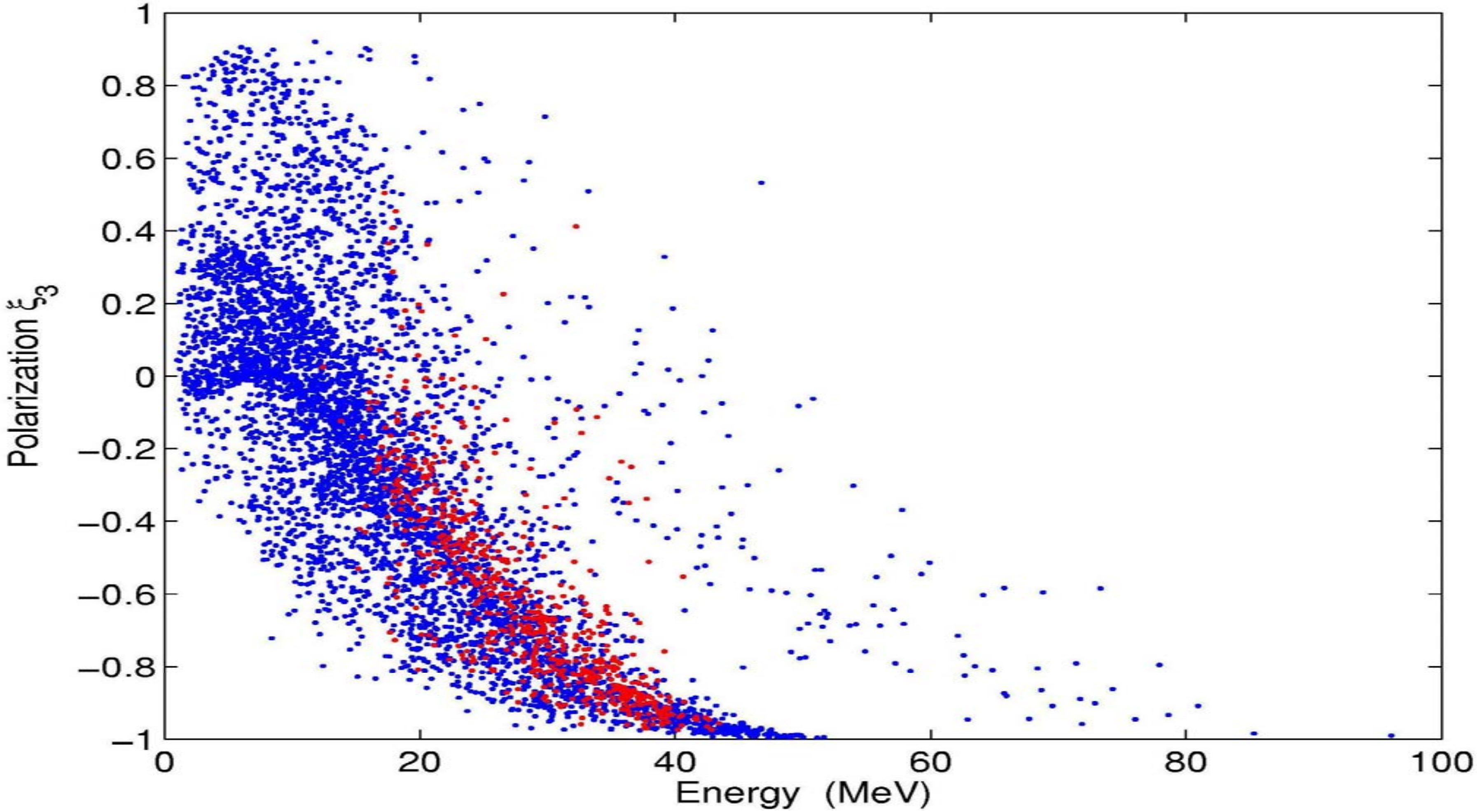
Capture+Stacking Simulations (F.Zimmermann& A.Vivoli)
Different solutions are analysed………

Capture Section (+ CHICANE)



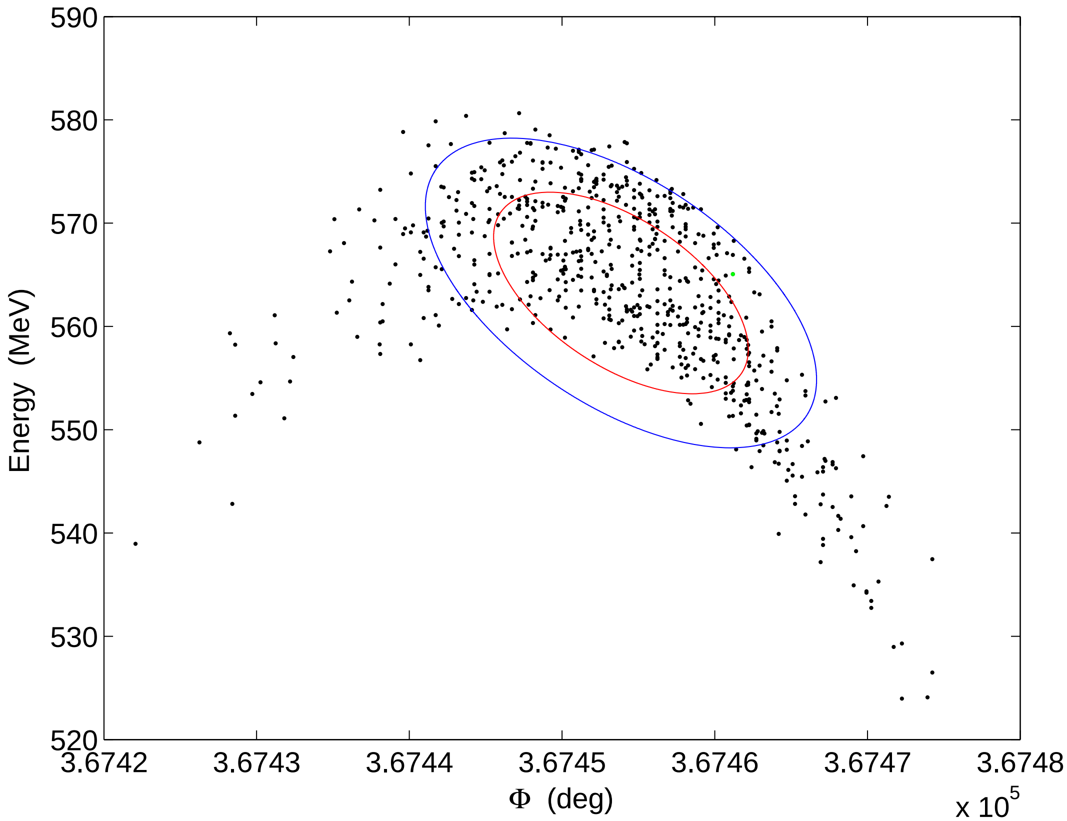
Polarization

Estimated polarization of accepted positrons at the target : 60%



Type	N. γ	Yield e^+/γ %	N. e^+	ε_x π mm mrad	ε_y π mm mrad	ε_z π cm MeV	σ_z cm	σ_E MeV
1.3 / 5 (150 MeV)	$0.67\ 10^{10}$	0.36	$2.39\ 10^{7}$	15	17	1.53	1.67	3.55
1.3 / 5 B. C. (0.3 X0)	$0.67\ 10^{10}$	0.40	$2.66\ 10^{7}$	16	15	2.64	0.28	9.99
1.3 / 5 B. C. (0.4 X0)	$0.67\ 10^{10}$	0.36	$2.42\ 10^{7}$	13	14	2.74	0.28	10.64
1.3 / 5 B. C. (0.5 X0)	$0.67\ 10^{10}$	0.40	$2.69\ 10^{7}$	16	17	2.91	0.28	10.92
1.8 / 5 (180 MeV)	$0.75\ 10^{10}$	0.88	$6.65\ 10^{7}$	19	19	2.15	1.85	5.6
1.8 / 5 B. C. 1	$0.75\ 10^{10}$	0.90	$6.78\ 10^{7}$	17	15	3.89	0.32	12.71
1.8 / 5 B. C. 2	$0.75\ 10^{10}$	0.81	$6.08\ 10^{7}$	14	15	2.51	0.97	5.06

Type	N. e^+	ε_x π mm mrad	ε_y π mm mrad	ε_z π cm MeV	σ_z cm	σ_E MeV	σ_x cm	σ_y cm
1.8 / 5 563 MeV	$6.83\ 10^7$	7.5	6.5	4.32	0.53	9.77	0.84	0.73

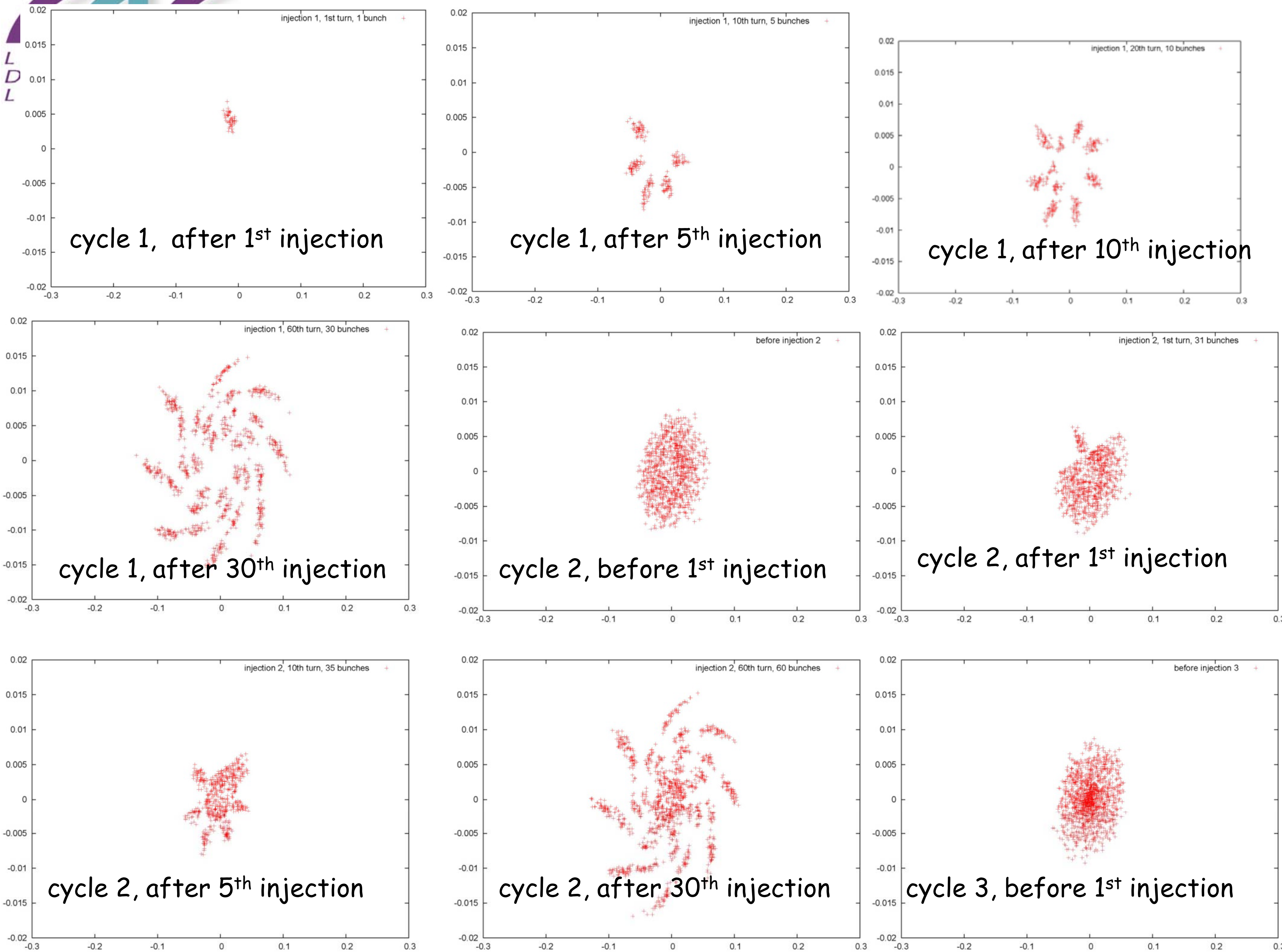


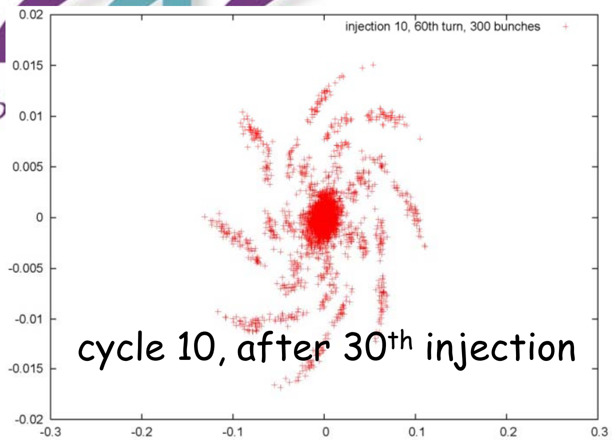
similar assumptions as for Snowmass'05

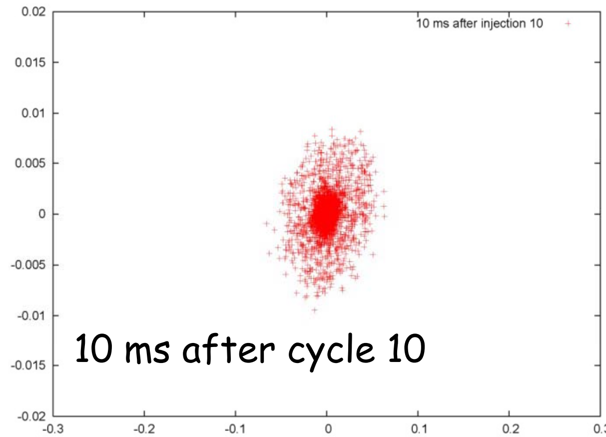
- stacking in longitudinal phase space
- sinusoidal rf, momentum compaction, radiation damping and quantum excitation
- injection septum placed at location with large dispersion; septum blade << transverse beam size
- between successive injections orbit at the septum is varied with fast bumper magnets
- energy of injected beam is ramped such that the transverse position of the septum always corresponds to a separation of 2 s_{d0} from beam centroid of injected beam

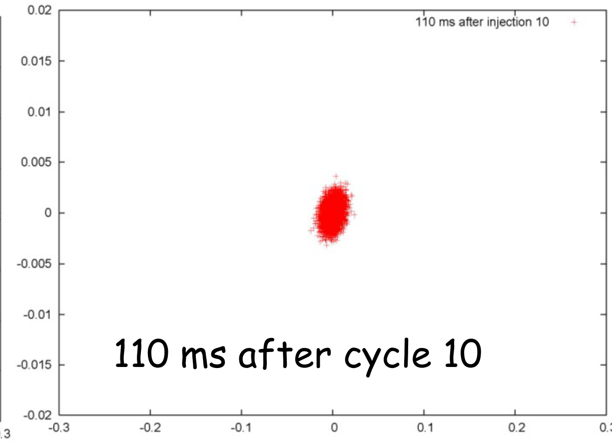
- Inj Scheme: ILC 2008: inject every second turn (80 MHz ERL) into the same bucket - 30 times; then wait 10 ms (~450 turns, ~1 damping time) and repeat 9 times; total injections/bucket: 300; synchrotron phase advance between two injections: 0.134

simulation for ILC2008









1st result: 76% of injected e+ are lost!
for a single cycle: 35% loss

why is it worse than in 2005?

- less e+ per injected bunch → more injections
- less momentum acceptance of damping ring
- larger damping time

possible remedies:

- ❑ smaller momentum compaction factor
- ❑ larger rf voltage
- ❑ reduced synchrotron tune
- ❑larger interval between cycles (but already too short for complete vertical damping – Vitaly Yakimenko)
- ❑more particles x injection
- ❑different circumference
- ❑ two rings, or pre-damping ring
- ❑More positrons/pulse (cross cavities)

additional DR wigglers for faster damping [x2]
✓ larger rf voltage [x 1.5]
March 14 (A. Vivoli):
best energy pre-compression "x2"

...

I am now trying

- ✓ energy pre-compression [x2] (R. Chehab)
- ✓ additional DR wigglers for faster damping [x2]
- ✓ larger rf voltage [x 1.5]

	ILC 2008 - **February**	ILC 2008 - **March**	ILC 2008 - **April**
beam energy	5 GeV	5 GeV	5 GeV
circumference	6695 m	6695 m	6695 m
particles per extracted bunch	2.0×10^{10}	2.0×10^{10}	2.0×10^{10}
rf frequency	650 MHz	650 MHz	650 MHz
harmonic number	14516	14516	14516
no. trains stored in the ring	52.5 (52.5/pulse)	52.5 (52.5/pulse)	52.5 (52.5/pulse)
#bunches/train	50	50	50
bunch spacing	6.15 ns	6.15 ns	6.15 ns
gap between trains	~50 ns	~50 ns	~50 ns
#e+ / injection	6.65×10^7	6.65×10^7	**6.82×10^7**
#turns between injections in 1 bucket	2	2	2
injections/bucket per cycle	30	30	30
injection frequency	80 MHz	80 MHz	80 MHz
full cycle length	200 ms	200 ms	200 ms
time between injection periods	10 ms	10 ms	10 ms
#turns between cycles	450	450	450
length of one injection period	0.963 ms	0.963 ms	0.963 ms
TI=total # injections/bucket	300	300	300
ST=store time after last injection	110 ms	110 ms	110 ms
IP=time interval with injection periods	90 ms	90 ms	90 ms
energy loss/turn	**2 MeV**	**8.7x2 MeV**	**8.7x2 MeV**
longitudinal damping time $t_{\|\|}$	**12.8 ms**	**6.4 ms**	**6.4 ms**

e+/pulse is too high for ERL option, or?

	ILC 2008 – **February**	ILC 2008 – **March**	ILC 2008 – **April**
transv. normalized edge emittance at injection (10x rms)	0.063 rad-m	0.063 rad-m	**0.070, 0.060 rad-m**
transv. normalized dynamic aperture (Ax+Ay)gamma	0.4 rad-m	0.4 rad-m	0.4 rad-m
rms bunch length at injection	3.8 mm	**11.4 mm**	**9 mm**
rms energy spread at injection	0.12%	**0.04%**	**0.059%**
final rms bunch length	9 mm	**5.2 mm**	**5.2 mm**
final rms energy spread	0.128%	**0.091 %**	**0.091 %**
longit. "edge" emittance at inj.	0.72 meV-s	0.72 meV-s	**0.87 meV-s**
rf voltage	24 MV	**36 MV**	**36 MV**
momentum compaction	4.2×10^{-4}	4.2×10^{-4}	4.2×10^{-4}
2nd order momentum compaction	-	-	-
synchrotron tune	0.067	**0.084**	**0.084**
bucket area	150 meV-s	**129 meV-s**	**129 meV-s**
ICM=bucket area / long. edge emit. /p	66	**57**	**47**
RMIN=TI/ICM	5	5	**6**
$IP/RMIN/t_{\|\|}$	1.4	**2.8**	**2.3**
$IP/RACT/t_{\|\|}$	0.78	**1.56**	**1.56**
synchronous phase	21.30°	**28.97°**	**28.97°**
separatrix phases 1&2	158.70 °, -124.19 °	**151.03 °, -82.64 °**	**151.03 °, -82.64 °**
max. momentum acceptance	+/- 1.57%	+/- 1.6%	+/- 1.6%
total loss	76%	**11%**	**15%**
loss for single injection cycle	35%	**11%**	**15%**

energy pre-compression at 5 GeV should further improve the yield

questions & comments

- 2x3 km ring is option from Andy Wolski; it could reduce the damping times by factor 2, if we do not reduce the length of the wigglers
- ring parameters can be considered somewhat flexible; at present parameters are optimized for the undulator based source
- can we reduce initial energy spread to 2 MeV rms?
- option of pre-damping ring for ILC?