GADGET*

Motivation

Work packages

- ***Wigglers***
- ***Instrumentation Test Beam***
- ***Intra Beam Scattering***
- ***Vacuum Systems***

Overview of requests

*Generation And Diagnostics Gear for tiny EmiTtance

Key Ingredients for Linear collider

Produce very high brightness e^- & e^+ beams

Accelerate fast & efficient

Preserve brightness up to IP

Key Ingredients for Linear collider	Relative amounts of CLIC efforts *(manpower in AB)*
Produce very high brightness e^- & e^+ beams	1%
Accelerate fast & efficient	94 %
Preserve brightness up to IP	5%

GADGET

Minimizing the equilibrium beam emittance in electron storage rings to values an order of magnitude below present state of the art is a key requirement for linear collider damping rings as well as for next generation storage ring based synchrotron radiation facilities.
The goal of GADGET is the development of key technologies and theoretical tools essential for achieving this objective. This includes:

- Development and test of superconducting wigglers with high on axis field, short period length and heat isolation against SR power.
- Development of instrumentation to measure, control and tune low emittance beams. This includes an instrumentation test beamline (ITB) at the CTF3 probe beam linac
- Improve Intra beam scattering (IBS) theory for IBS dominated beams and perform measurements on existing synchrotron radiation facilities to verify theoretical predictions
- ~~Development of low jitter, low ripple kickers with solid state pulsers for damping ring extraction~~
- ***NEW*** Development, characterization and beam test of coating techniques for critical vacuum chamber components.

Key component to get high brightness are dampings ring

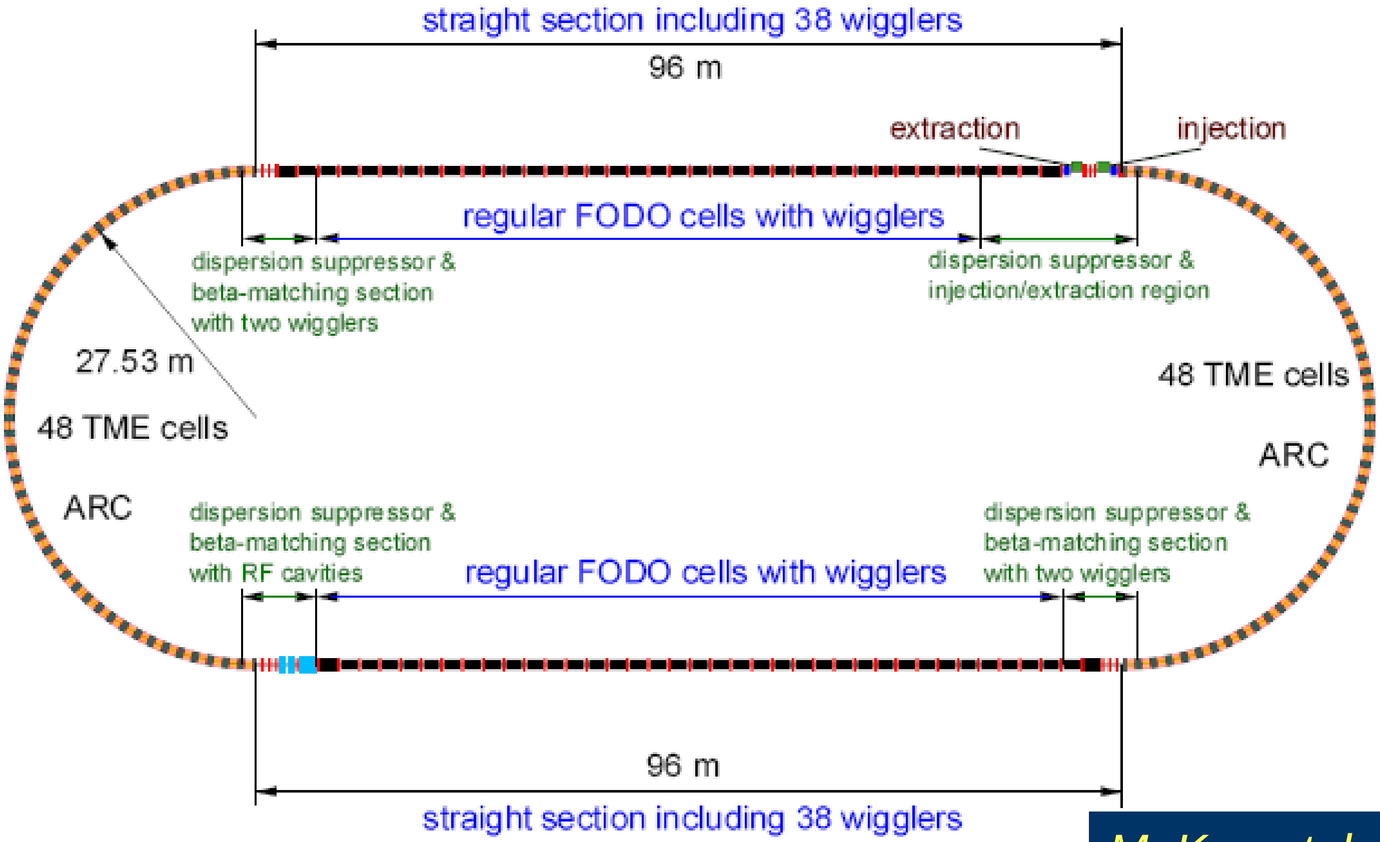
Damping rings and 3rd generation SR facility parameters

table from Yannis Papaphilippou

PARAMETER	NLC	ILC	CLIC	ATF	ALS	SLS
energy [GeV]	1.98	5.00	**2.424**	1.3	1.9	2.4
Bunch charge [10^9]	7.5	<20	**4.4**	10	4	6
circumference [m]	299.79	6695.1	**365.2**	139	197	288
hor. normalized emittance [nm]	2370	5600	**395**	2798	25656	23483
ver. normalized emittance [nm]	20	20	**4.2**	25	19	20
$N_B/\varepsilon_X\varepsilon_Y$ [10^5 nm^2]	1.58	1.78	**26.5**	1.42	0.082	0.128

These are challenges for lattice design and beam dynamics theory

- Emittance IBS dominated
- Very strong damping with 2.5 T s.c. wiggler $\tau_x / \tau_y / \tau_z$ = 1.5 / 1.5 / 0.75 ms
- Issues: Wiggler technology, IBS, e-cloud, orbit & optics control, dynamic aperture…



M. Korostelev

Only superconducting wiggler magnets with unprecedented parameters can provide sufficient damping strength.

Two institutes, BINP and ANKA have made paper studies for such wigglers, Documented in conference papers at EPAC'06 and PAC'07

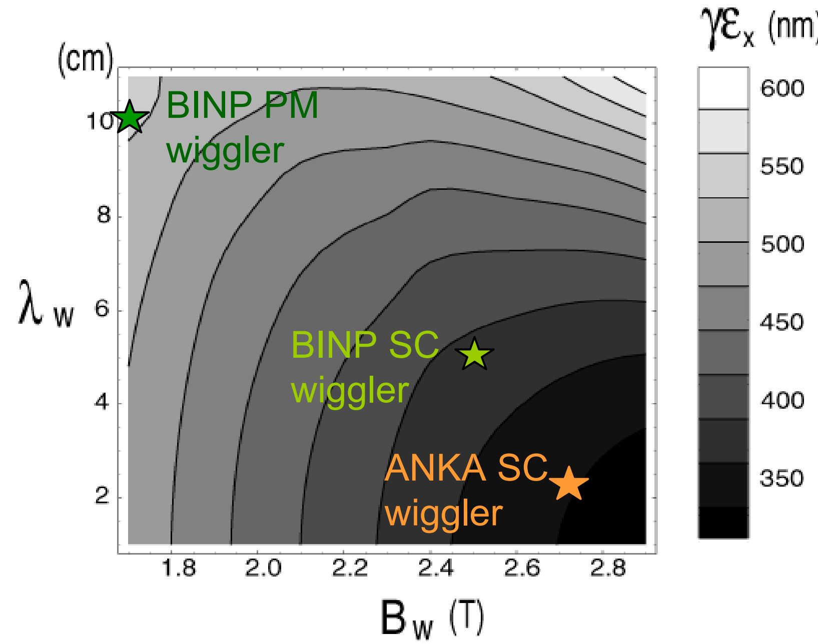
Both, BINP and ANKA have an impressive record of achievements with this type of magnet technology

In GADGET we want to design & produce two full size (2m) prototypes of each wiggler type including magnet measurements and tests with beam in ANKA 2.5 GeV SR source.

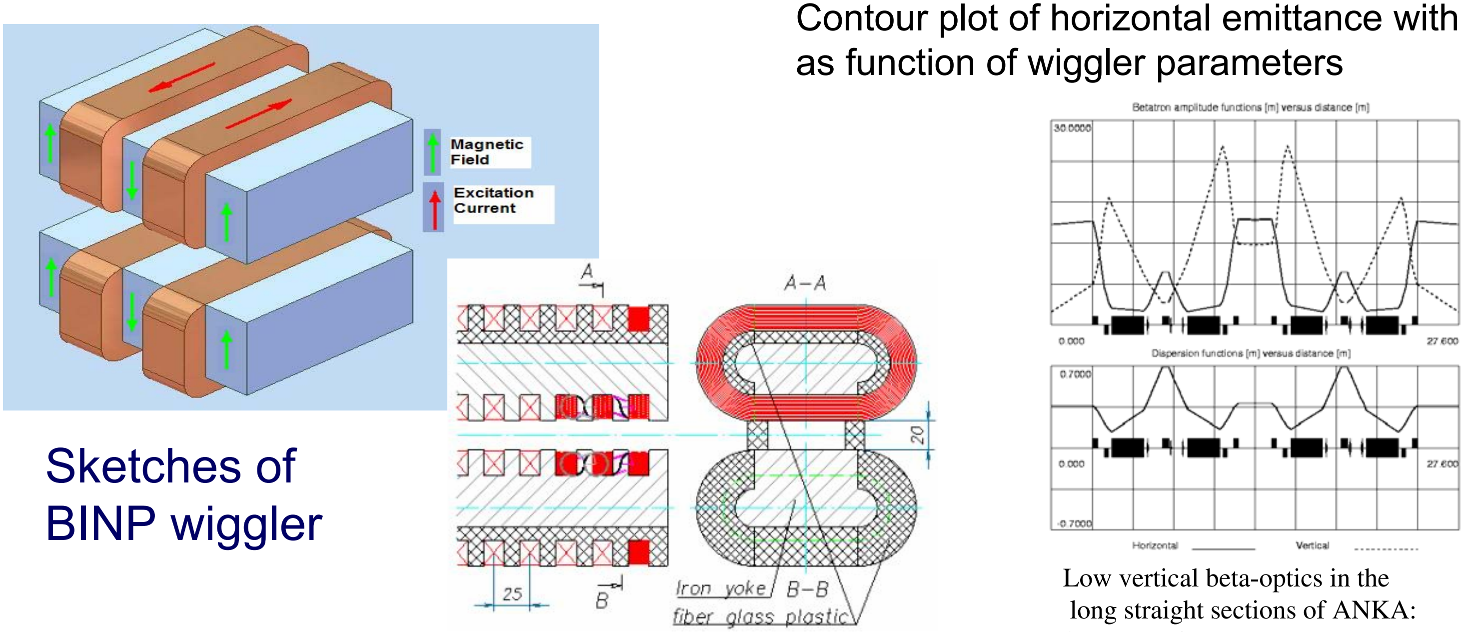
Goals are

- *Demonstrate feasibility of wiggler concepts*
- *Understand limitations and permissible parameter space for wigglers (therefore two types !)*
- *Get realistic wiggler description for beam dynamics*

	BINP	ANKA
B_{peak}	2.5 T	2.7 T
λ_W	50 mm	21 mm
Beam aperture full height	12 mm	5 mm
Conductor type	NbTi	$NbSn_3$
Operating temperature	4.2 K	4.2 K



Contour plot of horizontal emittance with IBS as function of wiggler parameters



Sketches of BINP wiggler

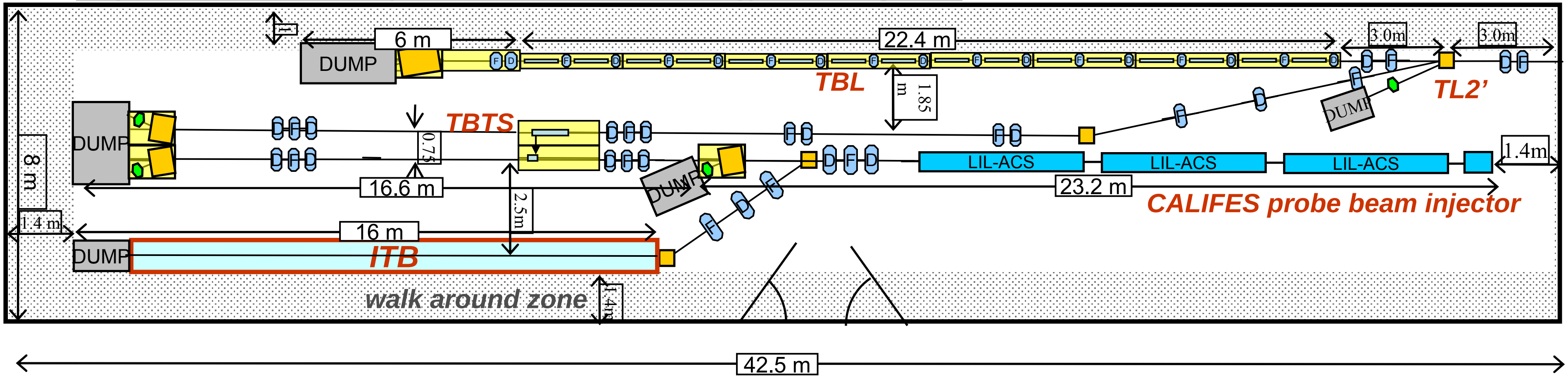
Low vertical beta-optics in the long straight sections of ANKA: β_x =14 m, β_y = 1.9 m, ε_x = 40 nm

Instrumentation Test Beam Line , ITB

Dedicated beam line for beam diagnostics R&D using CALIFES beam

Features: low ε beam, possibility to achieve very short bunch length, variable time structure, space, accessibility

Layout of CLEX-A** (A=Accelerator housing) **floor space



Beamline design and construction JAI and CERN

Diagnostics R&D in ITB requested in GADGET

Coherent diffraction radiation methods	JAI
BPM's for integration in DR-wiggler cryostat	TU Berlin
Quantitative halo monitors	Univ. Heidelberg and Karlsruhe
Gas jet for "calibration halo"	Univ. Heidelberg and Karlsruhe
Single shot emittance measurements	CERN

IBS workpackage

CLIC DR's emittance will be dominated by Intrabeam scattering

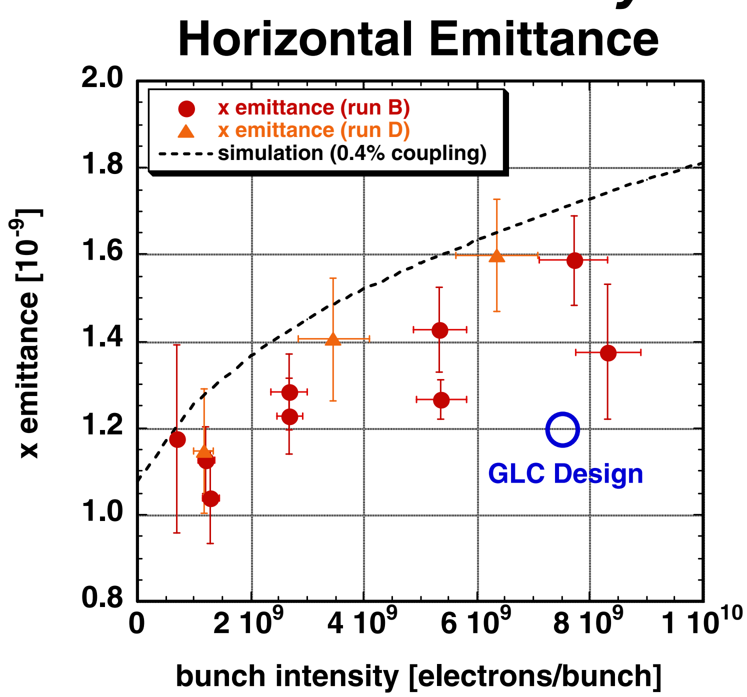
Predictive power of existing theory for this regime is questionable

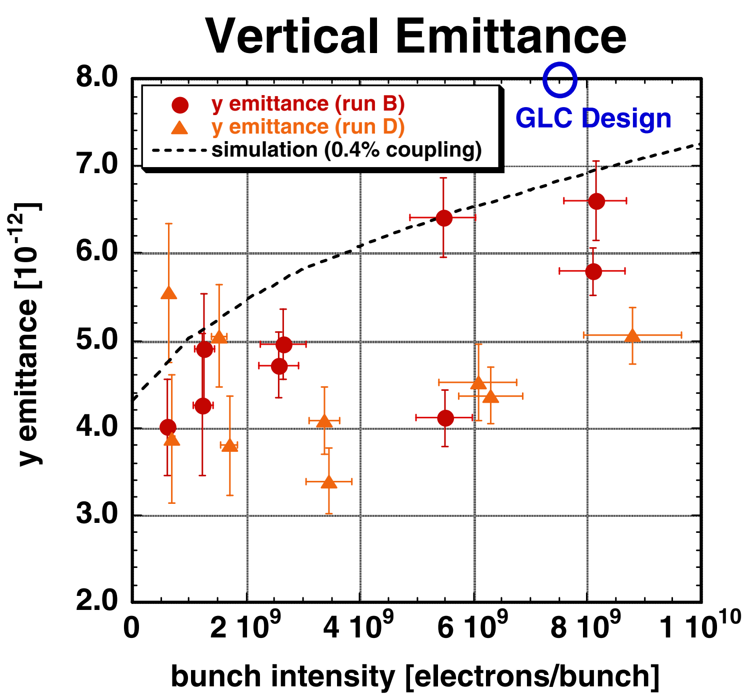
- New approaches to compute phase space distribution
- Methods to predict halo generation due to IBS
- IBS and beam polarisation
- Ad initio design of magnet lattice for minimum IBS+SR emittance
- Experimental verification of theory with experiments in existing storage rings

ATF Results

Single bunch Transverse Emittance

by Laser wire





X emittance determined by Ring Design. Measured data points are fit to simulation.

Y emittance =6.5pm at GLC intensity, is below GLC design.

Vacuum systems

Major worries for DR's are instabilities due to Ions and e-cloud.
Reduction of residual gas pressure and reduction of secondary emission with appropriate coatings (NEG, TiN,…) may cure these efffects.
This requires a good understanding of a wide range of coating properties and fabrication techniques. There are potential spin-offs with other CLIC and ILC vacuum systems, but also with LHC injector chain.

- **LNF**

  Test of vacuum chamber coatings with beam in DAΦNE ring

- **Cockcroft Institute**

  Behavior of NEG coatings under conditions close to those expected in damping rings. Measurement of photo-electron yield, photon-stimulated desorption rates, conditioning rates, ….
  Some data are already available, but need for a set of systematic and rigorous measurements to be able to design a vacuum system with confidence.

- **CERN**

  Correlate SEY with surface composition and conditioning
  Develop new production technique for NEG coated vacuum pipes of small diameter (few mm)
  Improve capability to simulate vacuum properties in long chambers pumped by NEG films

Guidelines from ESGARD (as communicated by Erk Jensen)

All ESGARD steered accelerator R&D grouped in three integrated actvities. GADGET in “Novel Acceleration Systems”, (coordinator Erk Jensen, CERN)

Target for GADGET total cost	3.0 M€ + 1.5 M€ (optional) = **4.5 M€**
Target for GADGET request to EU	1.0 M€ + 0.5 M€ (optional) = **1.5 M€**
Target for ratio EU request/Total cost	**0.5**

GADGET budget overview

Workpackage	Interest	Institute		Material			Manpower with overhead				Total / workpackage	EU / workpackage
				Lab	EU	Sum	Lab	EU	Sum	Total		
Wiggler	CLIC	ANKA	SC-Wiggler ANKA	0	450	450	500	100	600	1050	2150	850
		CERN	SC-Wiggler ANKA, CERN contribution	100	0	100	0	0	0	100		
		BINP	SC-Wiggler BINP	100	300	400	500	0	500	900		
		CERN	SC-Wiggler BINP, CERN contribution	100	0	100	0	0	0	100		
Instrumentation Test Beams	CLIC & ILC	CERN	ITB CERN	230	0	230	120	0	120	350	2921	681
		JAI	ITB John Adams	33	75	108	860	200	1060	1168		
		LAPP	BPM Electronics	50	50	100	120	0	120	220		
		JAI	CDR experiment	29	105	134	314	0	314	448		
		Uni. Heidelberg	Halo diagnostic developments	60	60	120	180	0	180	300		
		Uni. Karlsruhe	ITB Halo Studies Univ. Karlsruhe	0	0	0	0	0	0	0		
		CERN	single shot emittance measurement	0	30	30	90	0	90	120		
		TU Berlin	Wiggler BPM	46	21	67	30	140	170	237		
		CERN	Wiggler BPM	18	0	18	60	0	60	78		
IBS	CLIC & ILC	PSI	IBS experiments at SLS/PSI	0	0	0	0	0	0	0	394	44
		ANKA	IBS/wiggler experiment in ANKA	100	0	100	100	0	100	200		
		Cockcroft	IBS theory	0	0	0	150	44	194	194		
Vacuum chamber coating	ILC & CLIC & LHC injectors	LNF	Ecloud with NEG chamber coating studies in DAΦNE	0	0	0	180	180	360	360	1150	540
		Cockcroft	Surface characteristion of NEG coating	100	50	150	280	140	420	570		
		CERN	Small NEG coated chambers, SEY, vac. simulation	50	50	100	0	120	120	220		

	Material Lab	Material EU	Material Sum	Manpower Lab	Manpower EU	Manpower Sum	Total	Total / workpackage	EU / workpackage
Grand Totals	1016	1191	**2207**	3484	924	**4408**	**6615**	**6615**	**2115**
ESGARD Goals								**4500**	**1500**

	Material	Manpower with overhead		Total / workpackage and EU / workpackage
Ratio EU / Lab. commitment	1.17	0.27		0.47
ESGARD Goals				0.50