Damping Rings Update (after the RDR)

Andy Wolski

Design "Corrections"

- Timing
  - **Circumference and fill patterns in the RDR lattice (OCS6) are not consistent with constraints on the bunch spacing in the linac imposed by the (electron source) sub-harmonic buncher.**
  - **After some investigation, a new circumference (6476 m, harmonic number 14042) has been chosen as a baseline for the EDR.**
- Lattice
  - **Work has been done to develop the lattice design, including:**
    - new circumference (harmonic number 14042)
    - injection and extraction in opposite straights
    - improved optics for injection/extraction systems
    - more space for RF cryostats
    - inclusion of circumference adjustment chicane, phase trombone…
- Power distribution
  - **The RDR costs include the cable-based power distribution system, which is not technically very difficult.**
  - **Further work has been done on the bus-based power distribution system. This is a more attractive solution in technical and economic terms.**

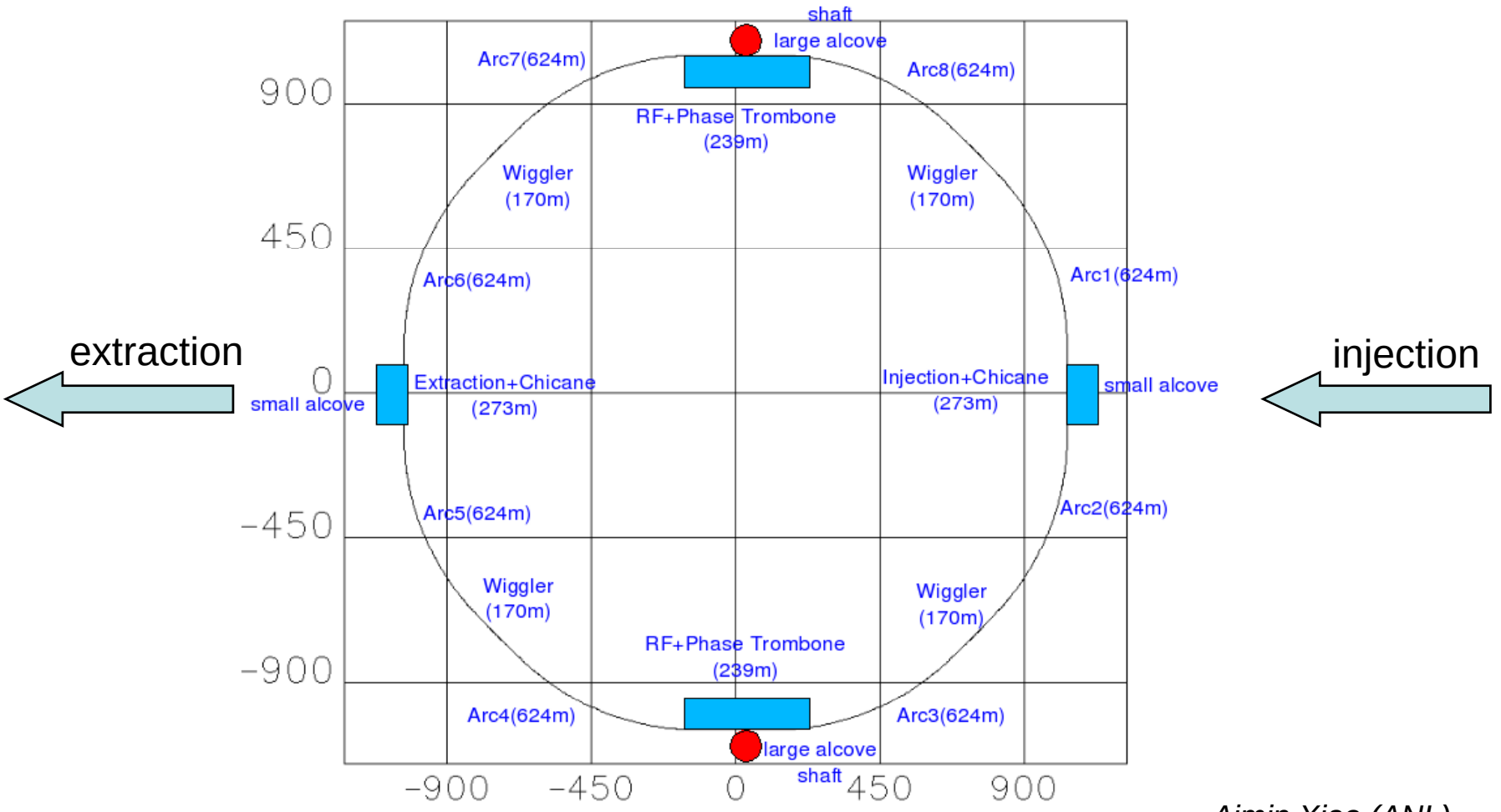
Timing

Damping Rings Fill Pattern		Nominal EDR Circumference						RDR Circumference					Alternative 1			
DR bunch spacing	DR RF buckets	2	2	2	2	4	4	2	2	2	3	4	2	2	4	4
Pattern repetition factor	p	117	90	78	65	58	32	123	118	82	71	61	119	85	59	42
Bunches per even-numbered minitrain	f2	0	0	0	0	23	23	0	0	0	22	22	0	0	23	23
Gaps per even-numbered minitrain	g2	0	0	0	0	30	126	0	0	0	37	32	0	0	30	78
Bunches per odd-numbered minitrain	f1	45	45	45	45	22	23	44	44	44	22	22	44	44	22	22
Gaps per odd-numbered minitrain	g1	30	66	90	126	30	122	30	35	89	34	28	32	80	30	78
Linac average current	**milli-amps**	**9**	**9**	**9**	**9**	**9**	**5**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**6**
Derived Parameters																
Ring harmonic number		**14042**	**14042**	**14042**	**14042**	**14042**	**14042**	**14516**	**14516**	**14516**	**14516**	**14516**	**14282**	**14282**	**14282**	**14282**
DR circumference	meters	6476	6476	6476	6476	6476	6476	6695	6695	6695	6695	6695	6587	6587	6587	6587
DR average current	milli-amps	405	405	405	405	401	226	396	396	396	393	393	396	396	402	267
Total number of bunches		5265	4050	3510	2925	2610	1472	5412	5192	3608	3124	2684	5236	3740	2655	1890
Bunch population	1.00E+10	1.04	1.35	1.56	1.87	2.07	2.07	1.02	1.06	1.53	1.75	2.04	1.04	1.45	2.07	1.94
Extraction kicker interval	DR RF buckets	120	156	180	216	240	432	118	123	177	203	236	120	168	240	336
Linac bunch spacing	Linac RF buckets	240	312	360	432	480	864	236	246	354	406	472	240	336	480	672
Linac bunch spacing	nanoseconds	184.62	240.00	276.92	332.31	369.23	664.62	181.54	189.23	272.31	312.31	363.08	184.62	258.46	369.23	516.92
Linac pulse length	**microseconds**	**971.82**	**971.76**	**971.72**	**971.67**	**963.32**	**977.65**	**982.30**	**982.30**	**982.21**	**975.34**	**974.14**	**966.46**	**966.39**	**979.94**	**976.47**
Average injected power	kW	219	219	219	219	217	122	221	221	221	220	219	217	217	221	147
Total population of damping ring	1.00E+13	5.46	5.46	5.46	5.46	5.41	3.05	5.52	5.52	5.52	5.48	5.47	5.43	5.43	5.51	3.66
Linac bunch spacing (buckets) mod 6		0	0	0	0	0	0	2	0	0	4	4	0	0	0	0
Linac bunch spacing (buckets) mod 12		0	0	0	0	0	0	8	6	6	10	4	0	0	0	0
Linac bunch spacing (buckets) mod 24		0	0	0	0	0	0	20	6	18	22	16	0	0	0	0

G. Penn, "Timing Issues for ILC Damping Rings" (May 2007)

https://wiki.lepp.cornell.edu/ilc/pub/Public/DampingRings/WebHome/ilc_timing.pdf

Latest “baseline” lattice: OCS8

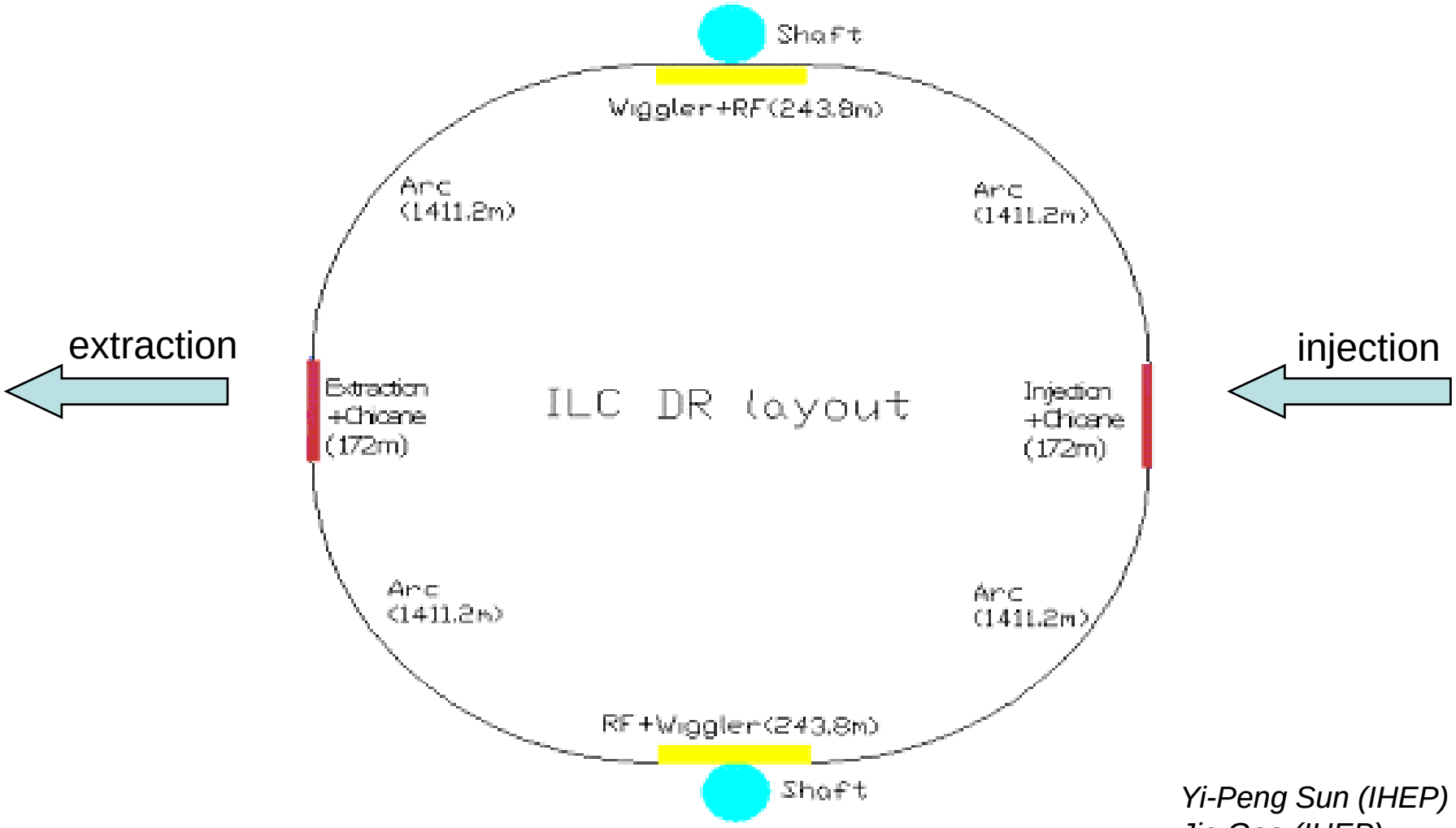


Aimin Xiao (ANL)
Louis Emery (ANL)

Latest “baseline” lattice: OCS8

- Modifications since RDR lattice (OCS6):
  - **Circumference adjusted to 6476.4395 m (h = 14042)**
  - **Injection and extraction on opposite sides of the ring**
  - **Modified injection/extraction optics to “lump” fast kickers (stacking may also be possible…)**
  - **Separated RF from wiggler sections**
  - **Includes circumference adjustment chicane (±7.5 mm)**
  - **Includes phase trombone for tune adjustments**
- Still to be completed:
  - **Optimisation of injection/extraction systems, to ease specifications on septum, and confirm capability for stacking**
  - **Design of injection/extraction lines to match new optics**
  - **Optimisation of dynamic aperture**

Possible “alternative” FODO lattice



Yi-Peng Sun (IHEP)
Jie Gao (IHEP)

Possible “alternative” FODO lattice

- Potential advantages of the FODO alternative include:
  - **improved flexibility, from the ability to vary the momentum compaction factor (can play off bunch length against instability thresholds);**
  - **improved performance, from increased dynamic aperture;**
  - **reduced cost, from reduced number of magnets.**
- The OCS8 lattice is more mature, and the engineering design studies are more likely to proceed smoothly if based on this lattice.
- A systematic comparison is needed to decide whether the potential benefits of the FODO lattice could be realised in practice.
- Comparative studies of the OCS8 and FODO lattice are planned, and a decision on the lattice will be made by the end of 2007.

R&D Planning

ILC Global R&D Board, S3 (Damping Rings) Task Force

Report on the Damping Rings R&D Plan

Revision 11: 31 August 2007

Contents

https://wiki.lepp.cornell.edu/ilc/pub/Public/DampingRings/WebHome/S3Plan-V11.pdf

R&D Workshops

- ILCDR06/Cornell
  - **September 26-28, 2006**
  - **47 participants**
  - **Electron cloud; fast kickers; impedance**
  - **https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/ILCDR06/**

- ILCDR07/LNF
  - **March 5-7, 2007**
  - **29 participants**
  - **Lattice design; low-emittance tuning; ion effects**
  - **http://www.lnf.infn.it/conference/ilcdr07/**

- ILCDR07/KEK
  - **December 18-20, 2007**
  - **Electron cloud; fast kickers; impedance**
  - **https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/ILCDR07_KEK/WebHome**

Development of Plans for the EDR

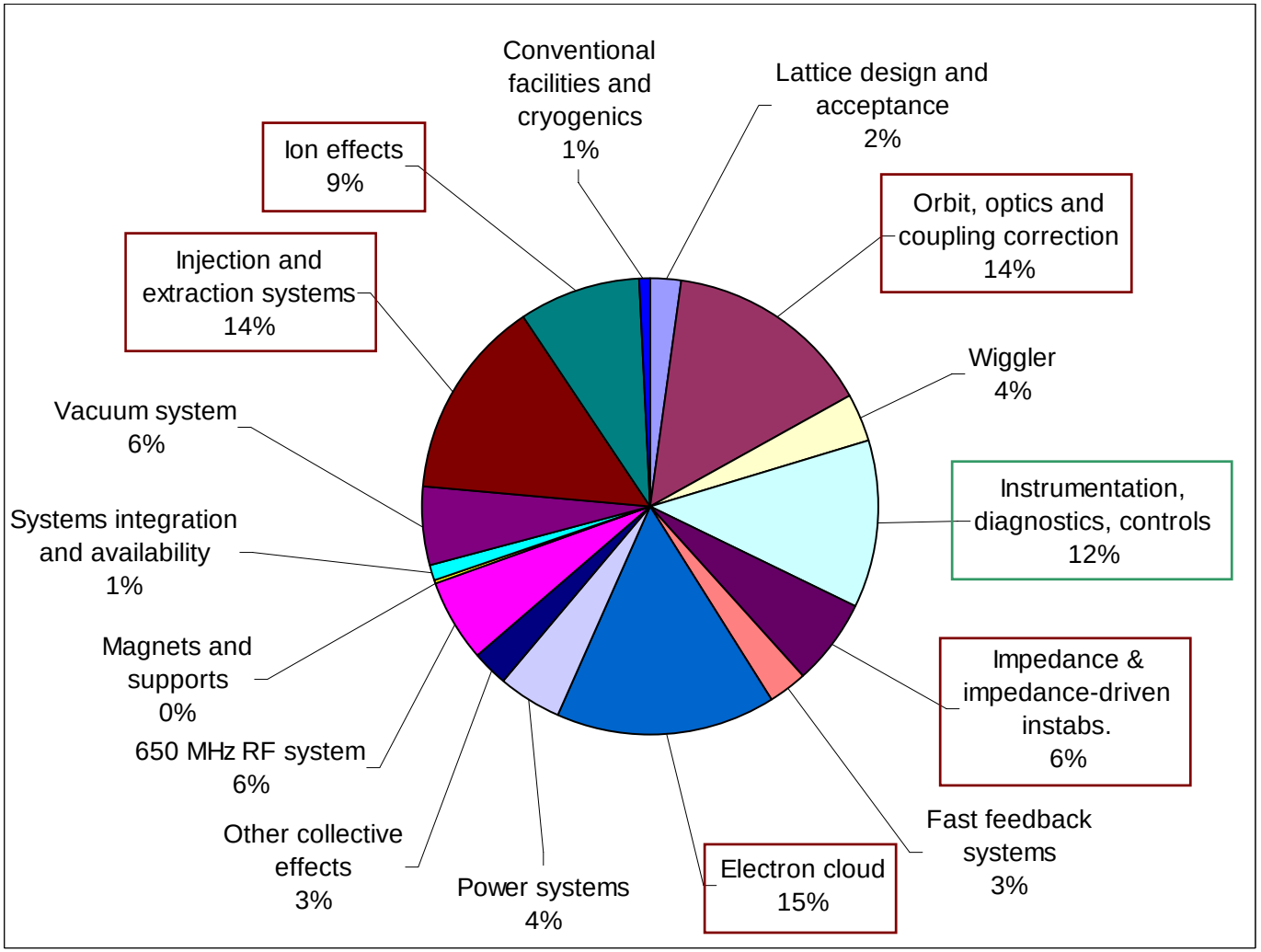
3 June 2007 (LCWS07)	Zeroth-order plan, including tentative work packages, tasks and deliverables.
16 August 2007	Call for Expressions of Interest in damping rings WPs.
9 October 2007	WebEx meeting held to discuss Expressions of Interest; Work Package Managers proposed.
18 October 2007	WP descriptions prepared and submitted to PMO.
23 October 2007 (GDE FNAL)	Selected Work Packages reviewed. The way forward discussed.
24 October 2007	Work Package Managers asked to provide descriptions of deliverables (see later slides).
Nov - Dec 2007	Review of planned deliverables, resources and schedule. Development of complete, consistent plan for EDR. *Comparison of OCS8 and FODO lattices.*
18-20 Dec 2007	**Damping Rings R&D Workshop, KEK.** (Ecloud; Kickers; Impedance) ***Baseline EDR lattice officially "released".*** **Launch of implementation phase.**

Damping Rings Work Packages

The following work packages are proposed for the damping rings engineering design phase:

WP#	WP Title	Proposed WP Leader
1	Lattice design and acceptance	Louis Emery
2	Orbit, optics and coupling correction	David Rubin
3	Wiggler	Mark Palmer
4	Instrumentation, diagnostics, controls	Manfred Wendt/Margaret Votava
5	Impedance & impedance-driven instabs.	Gennady Stupakov/Cho Ng
6	Fast feedback systems	John Fox
7	Electron cloud	Mauro Pivi
8	Power systems	Paul Bellomo
9	Other collective effects	Marco Venturini
10	650 MHz RF system	Derun Li
11	Magnets and supports	Steve Marks
12	Systems integration and availability	Andy Wolski
13	Vacuum system	Oleg Malyshev
14	Injection and extraction systems	Susanna Guiducci
15	Ion effects	Junji Urakawa
16	Conventional facilities and cryogenics	Tom Lackowski/Alan Jackson

Distribution of Effort (from EOI's)



Very high priority R&D topics

Experimental program support

15 Institutions Returned DR EOI's

WP Title	ANL	Cornell	FNAL	SLAC	LBNL	LANL	LLNL	UIUC	UM	CI	DESY	LNF	KEK	IHEP	KNU	Approx Total FTE
Lattice design and acceptance	X	X			X				X			X		X	X	2.6
Orbit, optics and coupling correction	X	X		X	X				X	X		X	X			7.9
Wiggler		X			X											1.9
Instrumentation, diagnostics, controls		X	X		X								X	X		6.9
Impedance & impedance-driven instabs.	X			X	X					X			X	X		3.0
Fast feedback systems				X	X							X				1.5
Electron cloud	X	X	X	X	X	X						X		X	X	8.5
Power systems		X		X												0.3
Other collective effects		X	X	X	X							X		X		1.8
650 MHz RF system		X		X	X											1.2
Magnets and supports					X									X		0.2
Systems integration and availability										X						0.2
Vacuum system				X	X					X		X		X		3.1
Injection and extraction systems		X	X	X	X		X	X				X	X			7.6
Ion effects		X		X	X						X		X	X	X	4.7
Conventional facilities and cryogenics	X		X		X									X		0.2
Global Systems Work Packages																
Survey and alignment	X															0.3
Installation and commissioning plans	X															0.3
Polarisation										X	X					0.3
Approximate Total FTE																52.1

Work Package Manager

Specifying the Deliverables

- Each Work Package Manager must specify a set of deliverables for their work package.
  - **The WP Manager must have ownership of the deliverables in his/her WP.**
  - **The WP Manager will be responsible for the completion of these deliverables by a specified date.**
- Deliverables will be of two types (though may not be formally distinguished):
  - **Providing some input for another work package, for example:**
    - specification of electron cloud mitigation techniques (WP7) to allow vacuum system design to be “finalised” (WP13);
    - technical design of a vacuum chamber component (from WP13) to allow impedance model to be developed (by WP5);
    - specification of alignment tolerances and stability (WP2) to support technical design of magnet girders/stands (WP11).
  - **Providing a contribution to the Engineering Design Report**
    - technical specifications/designs/costs (e.g. of magnets -- WP11; or vacuum system -- WP13);
    - evidence of ability to meet damping rings performance specifications (e.g. acceptance -- WP1; or orbit stability and low-emittance tuning -- WP2).
- Deliverables will be guided by the overall goals for the EDR, but will depend on the resources available: we must be realistic!

Managing the Interfaces will be Critical

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Lattice design and acceptance	1		op	ip		op	op	op		op	ip	io	io	op	io	op	op
Orbit, optics and coupling correction	2	ip			io							io	io				
Damping wiggler design	3	op						io	op				io	io			op
Instrumentation, diagnostics and controls	4		io										io	io			
Impedance and impedance-driven instabilities	5	ip					op				ip			ip	ip		
Fast Instability Control Feedback	6	ip				ip					ip			ip	ip		
Electron cloud	7	ip		io										io			
Power systems	8			ip								io	io				op
Other collective effects	9	ip															
650 MHz SRF cavity design	10	op				op	op						io				op
Magnets and supports	11	io	io						io				io	io	io		op
Systems integration and availability	12	io	io	io	io				io		io	io		io	io		io
Vacuum system	13	ip		io	io	op	op	io				io	io		io	io	op
Injection and extraction systems	14	io				op	op					io	io	io			
Ion effects	15	ip												io			
Conventional facilities and cryogenics	16	ip		ip					ip		ip	ip	io	ip			

ip: requires input from
op: provides output for
io: requires input from and provides output for

In an ideal world, the inputs and outputs are so clearly defined that the necessary exchange of information happens with complete reliability by direct communication between Work Package Managers, without any need for (intervention by) the Area System Manager.

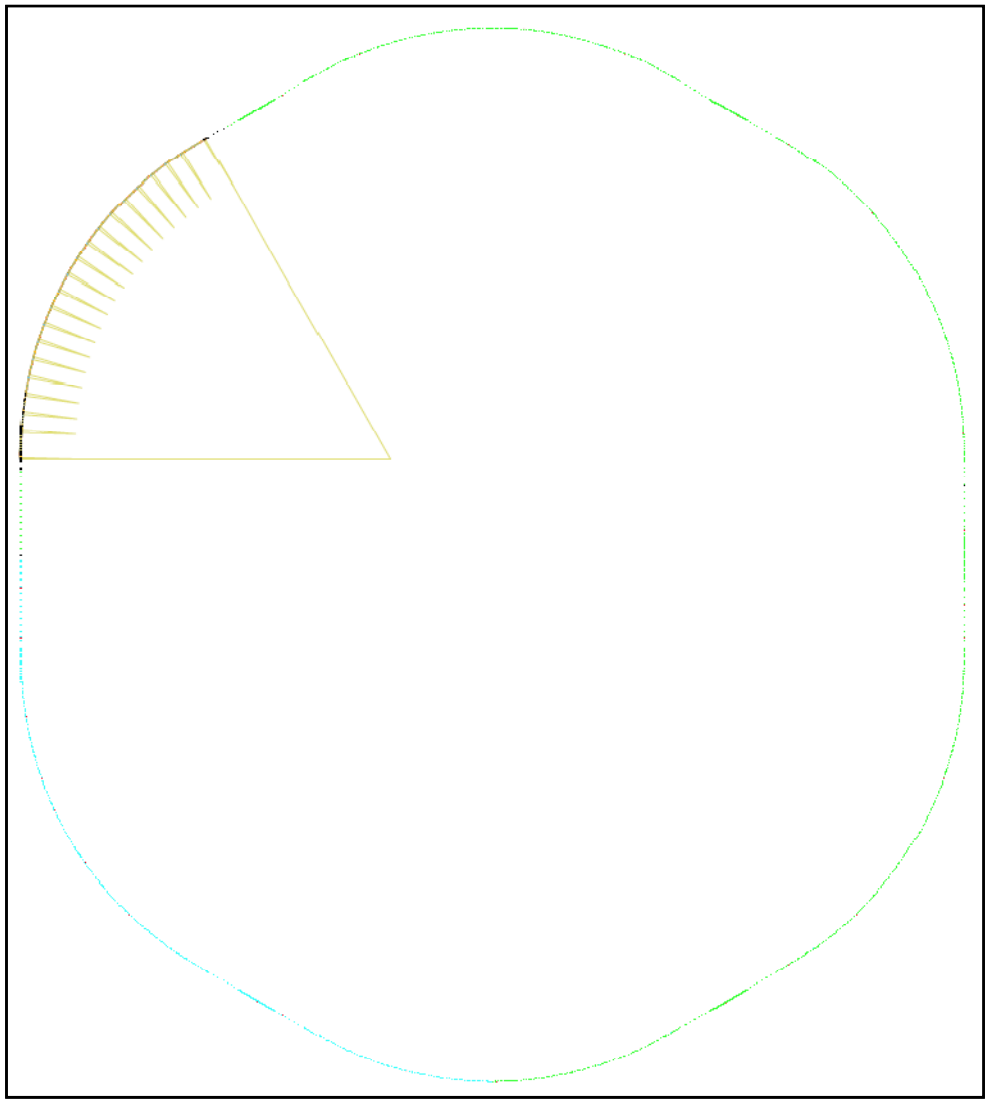
Defining the Deliverables

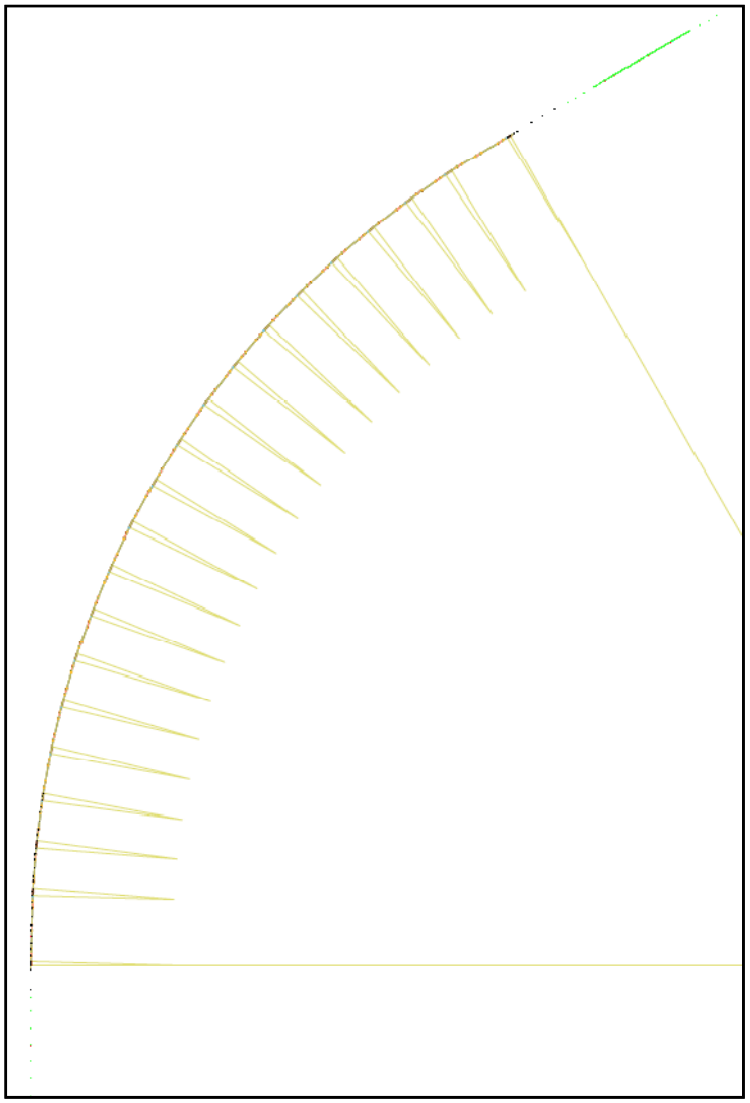
- The proposed WP Managers have been asked to provide a list of deliverables for their work package.
- For each deliverable, there should be:
  - **a brief description (i.e. one or two sentences saying what the deliverable consists of);**
  - **whether the deliverable is an input for another work package, or is an "ultimate" deliverable for the Engineering Design Report;**
  - **a date by which the deliverable should be achieved;**
  - **the names of people responsible for doing the work for the deliverable (or a statement that the people are not yet identified), and their expected level of effort;**
  - **the information input required to achieve the deliverable, together with the work package that should be responsible for providing the information, and the date the information will be needed.**
- The specifications of the deliverables will be collated, and a complete, consistent plan developed through a series of WebEx meetings between WP Managers
  - **"consistency" means that all the inputs and outputs match between the various Work Packages.**

Integration

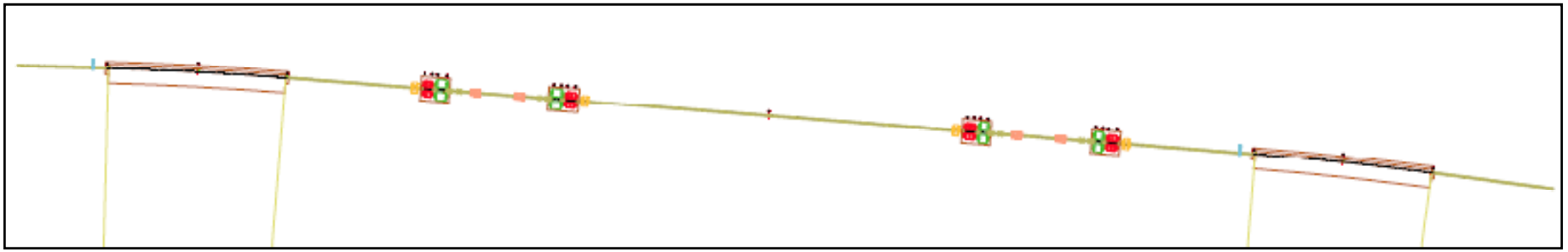
- Work Package 12 will cover Integration (and availability).
- This Work Package will be led by Cockcroft Institute.
  - **Requires an Engineer (0.5 FTE?) to work on developing and maintaining a model of the damping rings.**
  - **Strong connections with many other work packages, including magnets, vacuum, CF&S…**
- Perhaps Management should be included in this Work Package?
- Presently, we have a design engineer at Daresbury funded by LC-ABD2.
  - **The stated aims are to develop technical designs for the vacuum components (i.e. work within WP13, providing input for WP5), to allow a reliable impedance model to be put together.**
  - **Initially, the engineering effort is being directed towards the development of component layouts. This is necessary for the vacuum work, but we should be careful about allowing this to evolve into an integration activity over the longer term.**

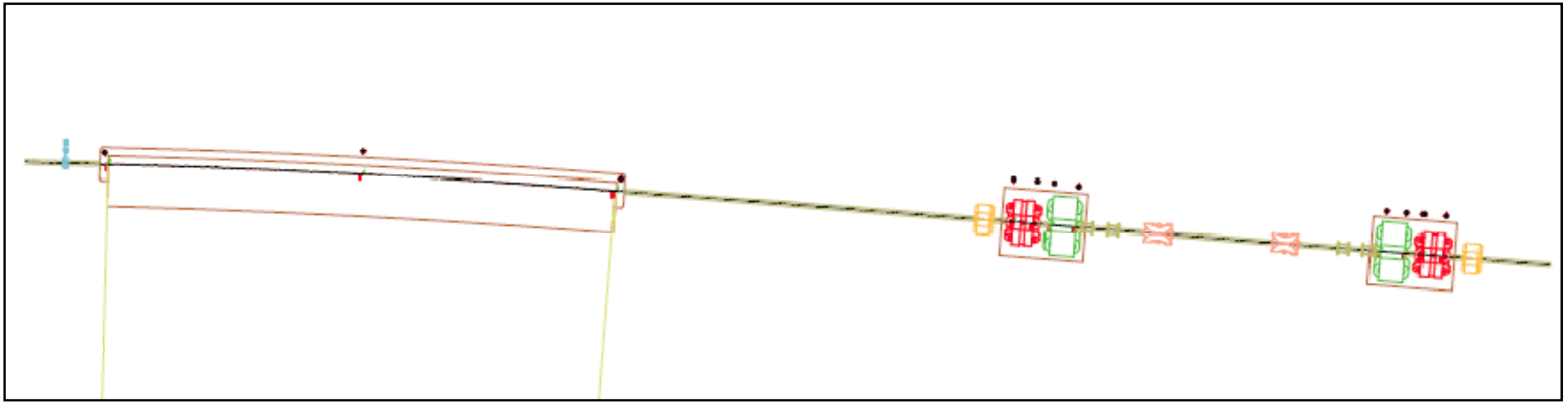
CAD Layouts: 1



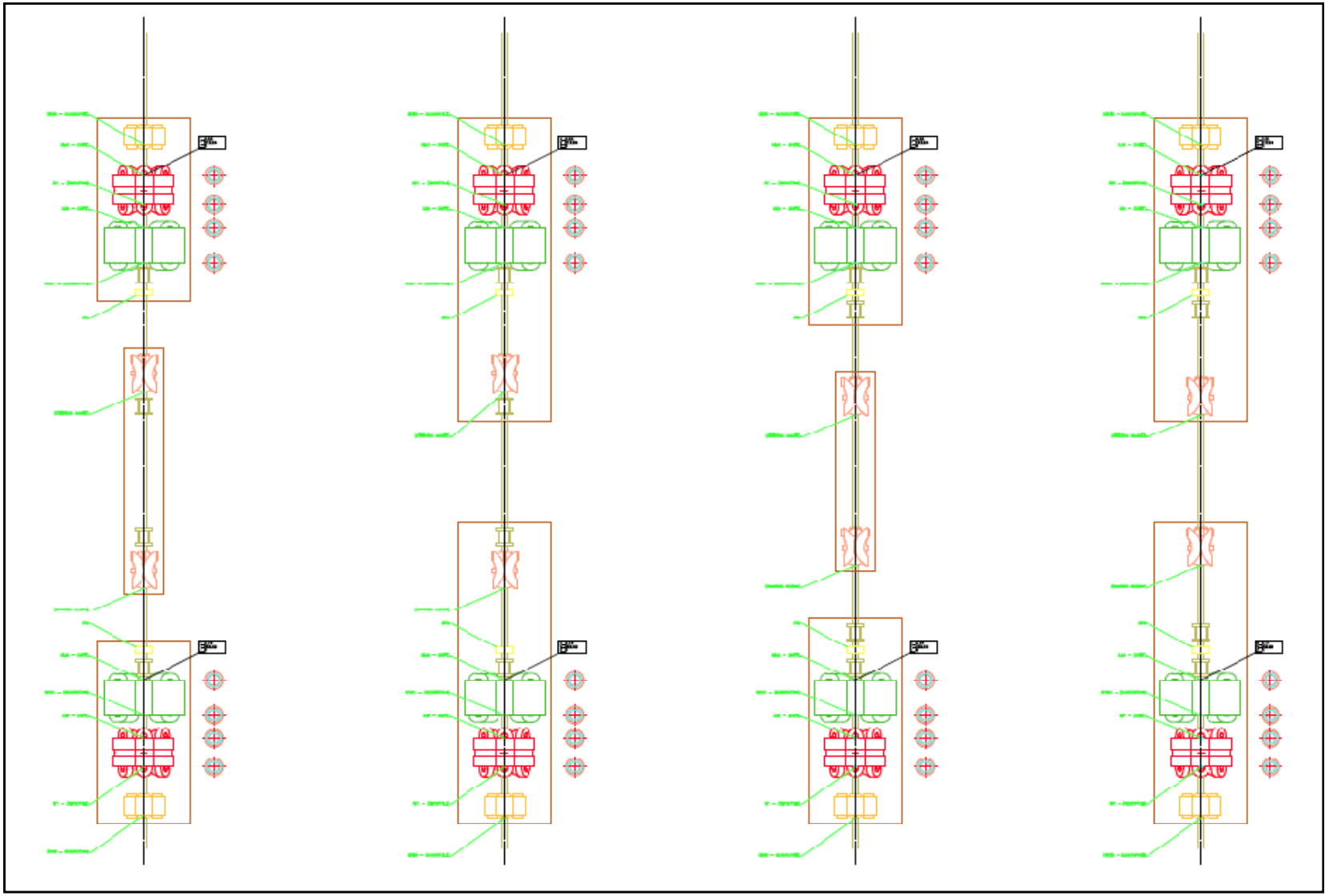


CAD Layouts: 2





CAD Layouts: 3



Comments and Discussion: RDR

- The reference design was developed from a beam dynamics perspective.
  - **We produced a "physics" design, with technical and engineering aspects tagged on in a very uneven fashion.**
    - Costed items ranged from a vacuum flange ($100) to the tunnel ($110,000,000)
  - **The Technical Systems Groups did a very good job given the shortcomings (lack of technical expertise, experience and guidance) in the Area System leadership.**
  - **Getting at a cost estimate was as much as we could do; we did not address properly the *uncertainty* in the estimate.**
- The documentation is incomplete and out-of-date; but still useful.
  - **Maintaining the documentation is a major task.**
  - **The intention was to make the task manageable by giving the responsibility for documentation to all the "designers": in practice, it was easier for one or two people to compile and maintain the specification sheets.**
- Many important issues were not properly addressed, including:
  - **Tunnel temperature (absolute value and stability)**
  - **Installation**
  - **Alignment and survey**

Comments and Discussion: R&D

- Work on the lattice design and other R&D issues has been continuing.
  - **The goal is to "freeze" the damping rings lattice by the end of 2007.**
  - **Injection and extraction line lattices will need to be updated.**
- The work of the S3 Task Force has:
  - **identified the priorities**
  - **outlined plans for addressing the very high priority items, including goals, schedule and required resources.**
- Much of the R&D is intrinsic to the work of the EDR.
  - **Techniques to mitigate electron cloud must be specified to allow technical design of the vacuum system to be completed.**
  - **Low emittance tuning studies will inform the requirements for survey; alignment; stabilisation; quantities, locations and functionality of diagnostics and correctors…**

Comments and Discussion: EDR

- We are proposing a structure of 16 Work Packages with widely-distributed effort.
  - **Is this workable?**
  - **Are there any more realistic alternatives?**
- Activities will range from R&D to technical design and engineering.
  - **How do we coordinate these activities and ensure effective communication between R&D and engineering?**
- We need the right kind of effort.
  - **We need help from a skilled project manager.**
  - **We need engineering effort to develop and maintain a model in which all the subsystems/components are properly integrated.**
- Who is responsible for the "global" issues?
  - **For example: timing; polarisation; alignment; installation…**
- What can we really achieve by early 2010?
  - **A "point" design will already be a significant challenge. Is it realistic to ask for cost derivatives?**