What work has been carried out by STFC at Daresbury/Rutherford Appleton Laboratory?

Please refer to the EDMS Transfer data folder for files mentioned in this document.

STFC (CCLRC) has been involved in the International Linear Collider for a number of years. I have gathered information from STFC, SLAC and other Institutions pertinent to the ILC reaching back as far as 2006.

Existing data that has not altered in light of the machine value engineering process since the August 2007 RDR are the Primary Dump facilities[1], the Positron Beam Delivery System[2] and the Remote Handling[3].

Major changes between the RDR 2007 and the current SB2009 layout occurred in the following Work Groups:

Damping Ring:

Damping Ring changed from an Octagonal layout positioned with the centre above the Interaction Region (6.7km circumference) to a 'Racetrack' layout. During a meeting at DESY (AD&I meeting 18th June 2008) Marc Ross presented the new priority and review list. Initially, the Damping Rings had a 6.4km circumference (Lattice Deck No. DC04, 18/08/2009) racetrack layout with the Rings one above the other. Parameter changes permitted this to be reduced to a 3.2km circumference (Lattice Deck No. DSB3_2, 09/09/2009). Work on the 6.4km Damping Ring refers to close out report ILC-NOTE-2010-057. A further decision was made during a CFS workshop at Daresbury to position the Damping Ring opposite to the Primary Main Dump[4].The initial off-set of 50m proved insufficient due to CFS constraints and is currently 90m[5]. Work on the Damping Ring by STFC had ceased in March 2010 and no further updates are known. CAD data is available for the 6.4km circumference version upon request for work completed by Daresbury Laboratory. This covers detail design of the Arc Cell (Positron and Electron) including magnets, structural support systems, BPM system and vacuum systems. The Wiggler section has the same level of detail design as the Arc Cells. Note these are for the 6.4km Damping Ring; however the design is such that it can be adapted to the 3.2km version.

Ring To Main LINAC (RTML):

The above had a significant impact on the RTML in the Central Integration Region. The defining positions are a result of the collaboration between the RTML, Damping Ring, Positron Source and Beam Delivery work groups with valuable input from CF&S. This permitted to specify the injection and extraction points relative to the I.P. and the optics determining the form of the Transfer lines between the main tunnel and the Damping Ring[6]. This permitted Nikolay to model the RTML beam lines accordingly.

Beam Delivery System (Positron side):

The Beam Delivery System (Positron side) remains unchanged since the RDR. This section is modelled in 3D CAD[7] according to the lattice deck[8]. The components are a graphical representation only depicting the position of systems (to lattice), their approximate size (estimate) and their effective length (accurate). The vacuum vessels have not been included. The lattice deck used to create this model is the SB2009 AD&I version. In a later (SB2009 Nov2010) lattice deck, an additional Polarimeter Chicane has been introduced. The upstream polarisation chicane was separated in both electron and positron side of the BDS. Matching quadrupoles at the end of DMBB0 obtain beam waists in the polarimeter chicane and a matching section is added after the polarimeter chicane to match twiss parameters to the Final focus. This line adds ~150m extra length in both the BDS length. A CAD model to reflect this would need to be created (or existing model updated).

Beam Delivery System (Electron side):

The Beam Delivery System (Electron side) has undergone major changes from the RDR layout compared with the SB2009 layout.

The major modification to electron side BDS was required for SB2009 due to the change of location of the undulator based positron source. These decks were used for AD& I CFS drawings.

Modifications to RDR Electron BDS:

In order to protect the small gap Undulator, the sacrificial collimators in the beginning of RDR BDS & detection of off-energy error beam for fast abort were moved before the Undulator. For detection of off-energy error beam, energy spectrometer chicane (beam line EFFs from ilc612_eff1.xsif) was copied before the Undulator and the fast abort line was mirrored from the ILC2006e deck. The fast abort line needs to be modified as the beam dump at the end will not be full power beam dump (11/18 MW) but only a few kW (estimated at 240kW[9]). If this line will be used for commissioning of the LINAC then the power rating of the dump and the design of the fast abort line needs to be revised accordingly.

After the fast abort take-off section, matching quads match TWISS to the undulator section, which is then followed by the Undulator. The Positron Target is located ~400m from the undulator and needs a transverse offset of 1.5m at the target location. To provide a 400m path for photons, a dogleg has been designed to take the beam to the BDS. The constraints are to provide the required offset of 1.5m in 400m and with a drift of 40m parallel to the target location without components.

A matching section at the end of the dogleg matches TWISS to the beginning of the skew correction/emittance measurement section of the RDR. The combined chicane (MPS, polarimetry and laser wire photon detection) in the RDR has been shortened as the MPS functionality is removed. An additional polarimeter chicane is envisaged but not included in this version. It was planned to shorten the Final Focus System (FFS) to allow this additional chicane to be included without affecting the overall AD&I BDS length.

A fast abort line becomes DC tuning line and thus the kickers can be replaced by DC magnets. This is not done and needs to be designed. Since the fast abort line is kept the same in this version and the distance after kickers "DMBB0" is reduced from 52.8 m to 14.2 m. This leads to clashing of the elements in the AD&I deck. This should not be the case when the DC line will be re-designed with few strong DC dipoles instead of pulsed magnets.

The matching quadrupoles at the end of ebsy2 match the TWISS to start of FFS (beginning of betatron collimation section). Rest of the line (betatron collimation, energy collimation, matching section, energy spectrometer, matching section, final focus, IP) remains the same as in the RDR.

See Excel spreadsheet “SB2009_2009_11_11_e+ and e-_BDS”, translated from xsif files[10]. Engineering simplified versions of this are: “Electron BDS - SB2009 simplified” and “Positron Source - SB2009 simplified”.

It is understood that the end of the Main LINAC forms the beginning of the Positron source small gap Undulator protection system. As such, working “backward” from the I.P. the dimensions for the beginning of the protection system “determine” the end of the Main LINAC.

See: http://projects.astec.ac.uk/ilcdecks/ for more details.

Positron Source:

The source of the largest cost saving through value engineering. In the RDR the Undualtor was located in approximately the middle of the Main LINAC (150GeV). It required a Tune-up line, Pre undulator protection and matching section before a chicane with a 2.5m horizontal beam offset. This produced the photon beam running parallel to the remaining Main LINAC before impinging on the Positron Target to produce Positrons. The 2nd LINAC section start coincided with the Remote Handling area and start of the Positron Production area requiring a “large” hall[11]. The Tune-up line, Pre undulator protection and matching section were omitted from most RDR documentation and only very few references were found to its existence.

A decision to move the Undulator to the end of the Main LINAC eliminated the first “dogleg” of the chicane, the complexity of a Remote Handling area directly adjacent to the Main LINAC and shortened the Positron Transfer beam line from 5km to just over 1km. A further benefit is the inclusion of an Auxiliary Power source for Positron production, which will fit into the standard tunnel. This in turn led to the “elimination” of the RDR envisaged ‘Keep-Alive-Source’ requiring also an additional underground hall.

To reduce tunnel length, underground halls and beam-line complexity, close liaison between the Positron source and Beam Delivery work groups resulted in the current layout. Suffice it to say that the process required a number of iterations so far; however, the design as it is now is very near its optimum. 'Minor' optimisation is very unlikely to impact the CF&S work group tasks (except maybe the fast abort line).

What data exists and how reliable is this?

The lattice design for the Positron Source is 'complete' for the pre-undulator protection including the fast abort (needs optimising as it is a copy from the RDR Tune-up design), the matching section, the undulator itself (now an effective length of ~235m = ~306m physical length due to energy changes), the 1.5m off set beam line (dogleg) and a 40m drift section. The BDS is considered to start from this point on (~500m from end of last undulator). The 3D CAD has been created from the lattice design SB2009 Nov10.

The Auxiliary Source, Positron Production area (i.e. Target, capture, pre-acceleration), Positron Transfer line1, the 5GeV Booster section, Positron Transfer line 2 and Positron Line To Ring (PLTR) have no lattice design at this moment in time. The 3D CAD model was created to ensure all the minimum components are included; i.e. Photon beam, AUX source systems, Target, QWT, dumps, etc. The layout determining where those systems are has been estimated by extrapolating data from the RDR parameters and team members of the Positron Source work group. It represents a true dimensional layout, however, some components may need to be moved up or down the beam line or additional magnets included. A fundamental omission is the Auxiliary source electron dump. No information is available as to size (kW??) or position (approximate would suffice for the time being).

The PLTR is a very rough estimate of the components required and MUST be designed properly before long. This has been driven by the following parameters:

Damping Ring Injection point location, permissible angle steps (Spin dependent and specified at multiples of 7.9316 degree), the need for energy compression and a Spin Rotator[12] before the Positron elevator. This in turn provides the branch point from the Positron Transfer line 2. Altering the multiple of the 7.9316° affects the transfer tunnel length and the RTML design.

The Auxiliary source is a "straight" copy of the electron source with the gun being thermionic instead of laser driven. The CAD data is a "best guess" approach based on information available[13] and work group workshops.

The 5 GeV Booster section is currently located just upstream of the BDS Tune-up dump. This "string of Cryo-modules" can be moved up (preferably) or downstream to accommodate detail design changes.

Note: The entire Positron Transfer line is in the same horizontal plane as the Main LINAC and BDS; NOT as previously along the ceiling adjacent to the RTML.

To achieve beam parameters for higher energy, a 10 Hz option is under discussion. This is a key area that is outstanding for the Positron Source.

Establish a Code of practice for the CAD community.

A flow chart has been created to illustrate a Global 3D CAD Central Integration process[14]. The process lists the segmentation into 100m sections. This has not occurred yet as we are still investigating the overall layout. However, a proposal on how to section the beam lines has been made (N. Walker, document in EDMS). It is essential to carry out this process during the TDR phase. In practice, the overall layout has been created using a more global approach as presented in the TILC 2009 NC Integration Powerpoint presentation.

Gather information from relevant work groups to create CAD model.

The basis for the 3D CAD models is the lattice design. This determines where components and systems are located and what they are. At this stage the different work group information is most likely specific to their area (even broken down into sub systems but not necessarily correlated) and requires relating to adjacent or other pertinent areas of the machine/systems. Daresbury was in a good position to have an expert on site to help with this.

Have MAD/XSIF files translated into Excel for CAD purposes.

This follows on from the above. Most work groups have their lattice design with a local “start point” for their system or sub-systems. The General Layout spreadsheet has the required geometry (7 mrad) angle obtained from an intermediate step (Mathematica) from the MAD deck. There may not be a need to have the rotation included in the 100 m sections (linear local system).

Arrange Excel data and manipulate it for CAD import.

The data may have to be manipulated according to the CAD system used. The data it must contain is the Name (for identification) of the Node, the length (to verify coordinates, with units), the type of the element (quad, drift, etc). This must be followed by the X, Y and Z coordinates (units) relative to the I.P. for the general layout or translated to a local coordinate system for the 100 m sections. In addition, the X-Rotation (pitch), Y-Rotation (yaw) and Z-Rotation (roll) are essential for the general layout (units) [12]. The 100 m sections may require this information if there is a sufficient “bend” in the beam, however, the rotation must then be relative to the linear model. It is recommended to check the data by creating a simple scatter graph (with smooth lines).

Create beam line model.

It is recommended to approach the general layout by creating coordinate systems which define the start point of components. The following component’s start point must form the end point (to be checked when manipulating the Excel data) to ensure there are no undesired gaps. Once the coordinate system has been created, components or sub-assemblies can simply be 'dropped' onto them. It is impertinent that the CAD model is checked for correct rotation, gaps/discontinuities and collisions.

Liaise with WG leaders if any issues arise and feed information back to beam designers (iterative process).

In the Central Region a number of beam-lines occupy one tunnel. There are a number of criteria from different work groups such as emergency egress routes, installation and maintenance access to systems, HVAC and other services affecting the integration. Some collisions will occur and they need to be addressed.

To start with however, the general layout must be examined for potential collisions and the information fed back to the WG leader to start the lattice design iteration. Not only does the CAD Q.A. ensure that for instance 2 magnets don't occupy the same space, it will further provide information about beam separation for i.e. shielding purposes or emergency egress.

Provide costing for Positron source.

The costing for the Positron Source was carried out through scaling an existing cost estimate[15]. The vacuum cost contribution depicts the differences between the RDR layout and the SB2009 layout. Vacuum lengths and quantities have been adjusted accordingly and EDI cost is based on the new figures[16]. Magnet costs are based on the new quantities required and PHG's modified Magnets_uberSummary cost estimate[17]. This resulted in the current SB2009 cost estimate[18].

Provide power distribution and tunnel heat load.

This information is based on a number of 2007 estimates. The one outstanding document is the "07-02-28 ILC Magnet Power Supply List" Excel spreadsheet for Magnets. A further essential document is the "Dumps and Collimators-RDR Config-v2" Excel spreadsheet for all dump and collimator related estimates. The Global Positron Source data[19] is a summary of a number of Positron Source subsystems. Each of these subsystems (separate spreadsheets) is broken down into further sections, but contained within their relevant parent spreadsheets. The breakdown is as follows:

1. e+ Undulator Power Distribution Estimate
2. Post Undulator Dogleg Power Distribution Estimate
3. e+ Production Area Power Distribution Estimate
4. e+ Transport (PTRAN) Power Distribution Estimate

For the PLTR a place holder was used in the Global Estimate based on experience from a number of people. The Main LINAC information was used for the sections where Cryomodules are required (AUX source, 5 GeV Bosster)[20].

Reference Documents (to be stored on EDMS):

1 “CCLRC Drawings”, Number 0067-404-Main Dump Layout and 0067-410-Main Dump Layout

2 “STFC RDR BDS e+ Summary Data”, Excel spreadsheet from Positron BDS Lattice and 238-RDR-Positron-BDS System layout CAD model.

3 “Positron Remote Handling”, CAD model td-1117-122 and 080-D-010 Remote Handling of Target Station Report_version4 Word document.

4 “ILC-Daresbury_2009_Sept_NC”, Powerpoint presentation and John A. Osborne presentation “20090901SB2009_ILC3D”.

5 “20100223-ILC-CE-3D-Update” A. Kosmicki presentation illustrating difference in machine layout

6 “CFS Positron Source 2010_07_13” presentation, slide 22

7 “238-RDR-Positron-BDS” 3D CAD model to SB2009 AD&I lattice deck

8 “RDR BDS e+ Summary Data” Excel spreadsheet from SB2009 AD&I lattice deck

9 “Dumps and Collimators-RDR Config-v2”, Excel spreadsheet, J. Sheppard and “Dumps Central Region NC comment”, E. Huedem & N. Collomb

10 “SB2009 Nov10 link”, from http://projects.astec.ac.uk/ilcdecks/ extracts from webpage reproduced in this document

11 “238-20000-ZS”, 3D CAD model

12 “Positron Source - SB2009 simplified”, Excel spreadsheet, simplified for engineering purposes and key dimension points added in areas where no lattice design exists.

13 “KAS Layout”, PDF marked up.

14 “Visio-TILC 2009 Intergration NC”, PDF file

15 “Und_1May07_costs”, Excel spreadsheet by J. Sheppard

16 “vacuum_Positron_source_vacuum_cost_estimates_04_Nov_2009”, Excel spreadsheet

17 “Magnets_uberSummary_allStyles_070427_v5x”, Excel spreadsheet

18 “SB2009 Costs V2a” Excel spreadsheet

19 “Positron Global Heat Load Summary” Excel spreadsheet

20 “Positron Source” PDF file

Actions:

Note: The below is applicable for the SB2009 overall layout. It is a pre-requisite for the TDR phase.

Damping Rings:

There is currently a short section modelled in 3D CAD to illustrate the Injection and Extraction points. It would be beneficial to create the 2 (3) Rings with graphical representations for magnets, RF modules and other components in order to visualize/demonstrate the space constraints for CF&S. This is essential prior to determining the Tunnel size. Kicking off this process will furthermore force a revisit of the Damping Ring lattice design where cost savings can be achieved according to ILC-NOTE-2010-057, Evolution of the Lattice Design and Mechanical Design sections.

Create 3D model.

RTML:

The RTML is in need of a detail lattice design for the Damping Ring to the first repetitive component transfer line. Starting at the DR Extraction point a geometrical sketch has been provided.

Lattice design according to spatial requirements

Create 3D model

Beam Delivery System (Positron side):

Update or re-create the 3D model to reflect lattice design changes (SB2009 Nov2010)

Beam Delivery System (Electron side):

Excellent work has been carried out by the BDS workgroup and as a first approach this design is feasible. There are optimising steps that can be taken. These are listed on the webpage in 10 (see: http://projects.astec.ac.uk/ilcdecks/).

Main actions are to design the DC tuning line and modify the fast abort line (pre Undulator).

Update 3D CAD accordingly

Positron Source:

Optimise the Fast Abort line

Create lattice design for Positron source from end of undulator (photon beam) through target, QWT and capture section through to Damping Ring Injection point.

Create lattice design for the Auxiliary source and target (material) and corresponding electron dump.

Create or update 3D CAD accordingly for the entire Positron Source

Investigate 10Hz option in more detail and model