Linear Collider Positron Source System Integration

Jim Clarke, James Jones, Ian Bailey, Leo Jenner, James Rochford, Alexander Mikhailichenko, John A. Osbourne, John Noonan, Peter H. Garbincius, John Sheppard, ….

Linear Collider – Positron Source

System Integration:

What is it?

What have we got?

Where are we at?

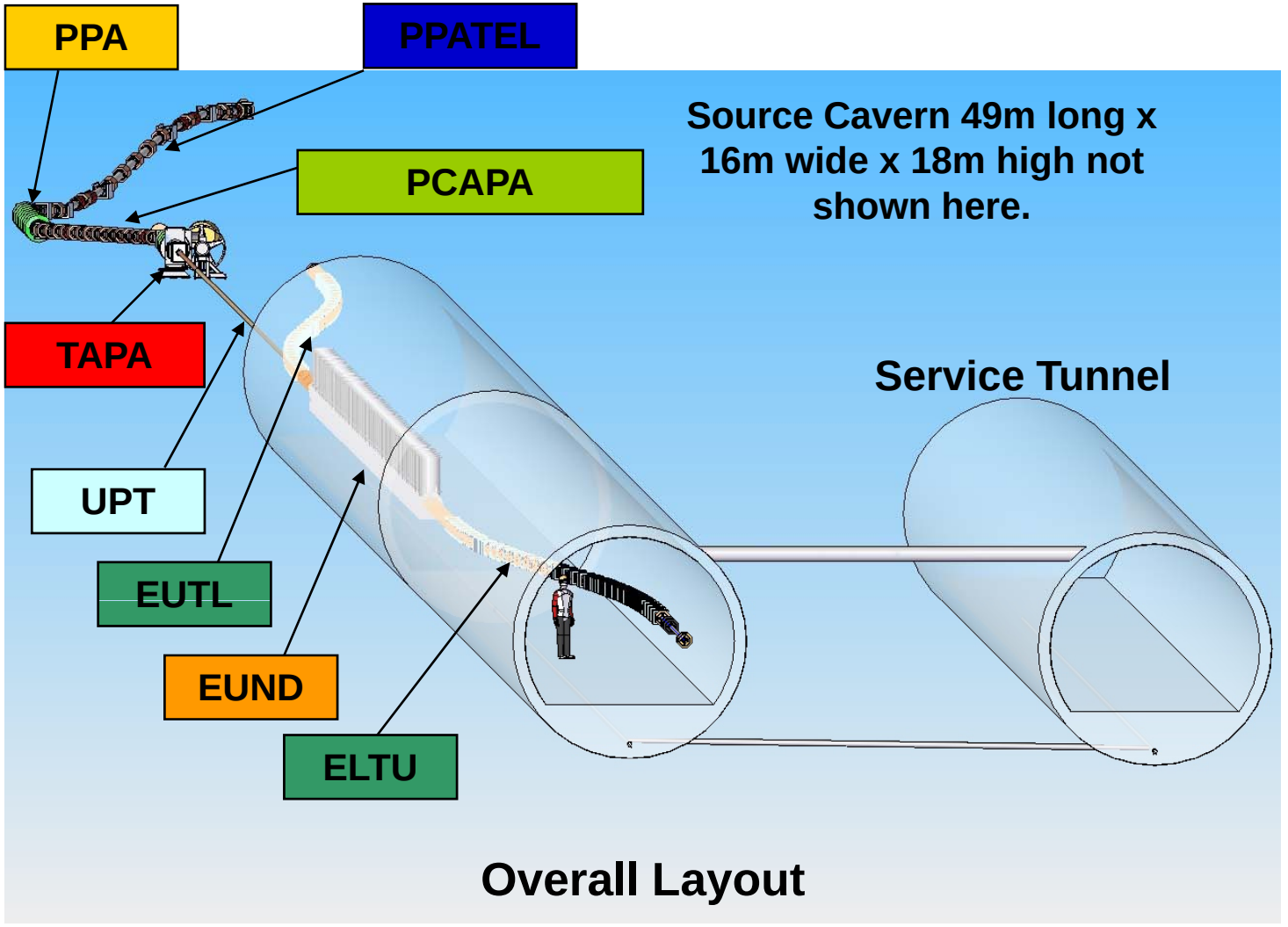
Overall layout

Issues, Risks, Opportunities.

Cost Drivers

Minimal Machine and options

Actions



Science & Technology Facilities Council

Linear Collider – Positron Source Integration – What is it?

System Integration -> Mission

The Technical Coordination shall care for the entire Positron Source facility.

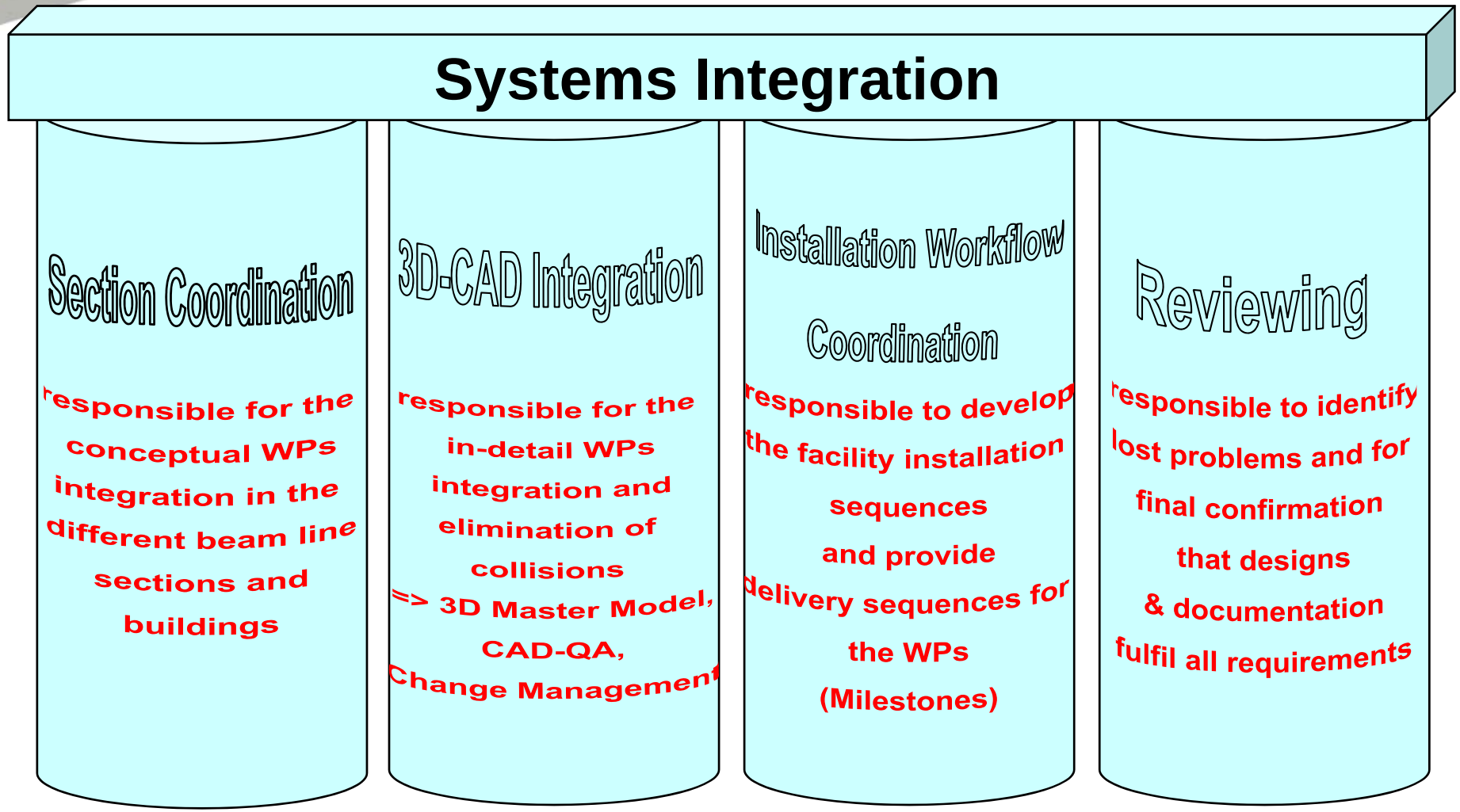
The Systems Integration shall identify and solve problems and satisfy all needs, which arise out of the WPs integration towards the final facility.

Systems Integration -> Primary Scope

1. **Ensure all inter-WP interfaces get clarified / defined, i.e all components will match.**
2. **Ensure all components will fit into the buildings, i.e there are no spatial collisions.**
3. **Establish an overall-optimised installation sequence, i.e all components can get installed in the shortest possible time with a minimum of mutual disturbances. This is possibly a long way off, but well worth keeping in mind for the design.**
4. **Provide information to all relevant parties in order to achieve the most cost effective and value engineered solution.**

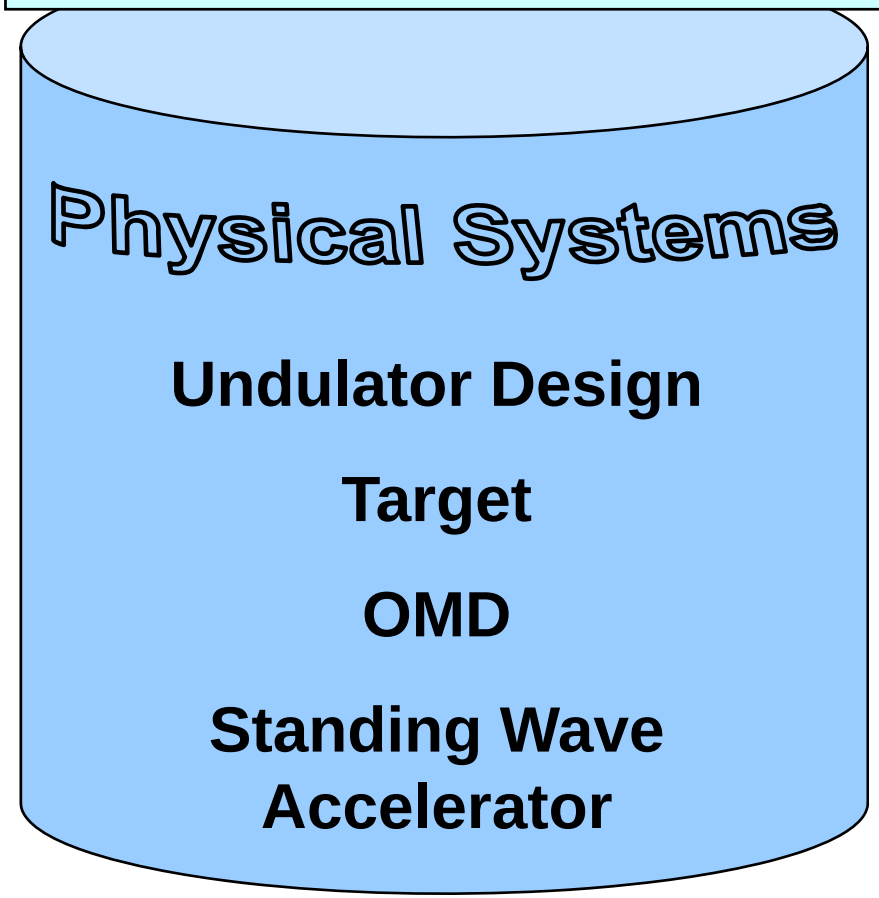
Science & Technology Facilities Council

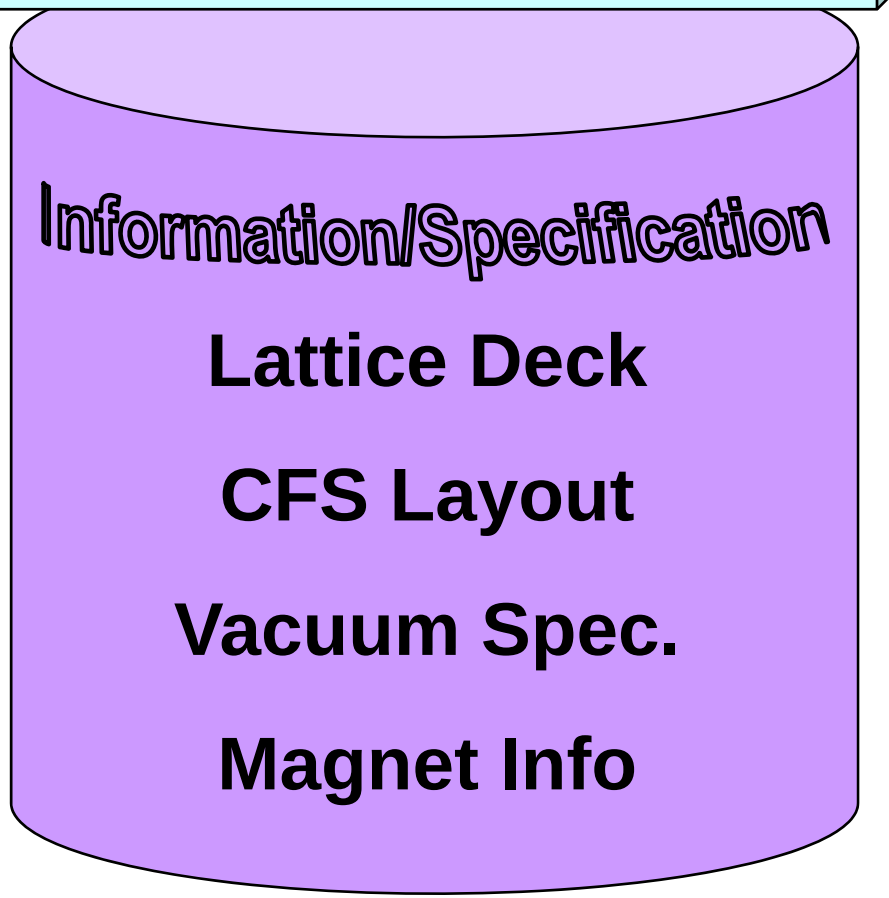
Systems Integration => Based on 4 pillars



Linear Collider – Positron Source

What have we got from an Engineering point of view?





Linear Collider – Positron Source

Where are we at, again, from an Engineering point of view

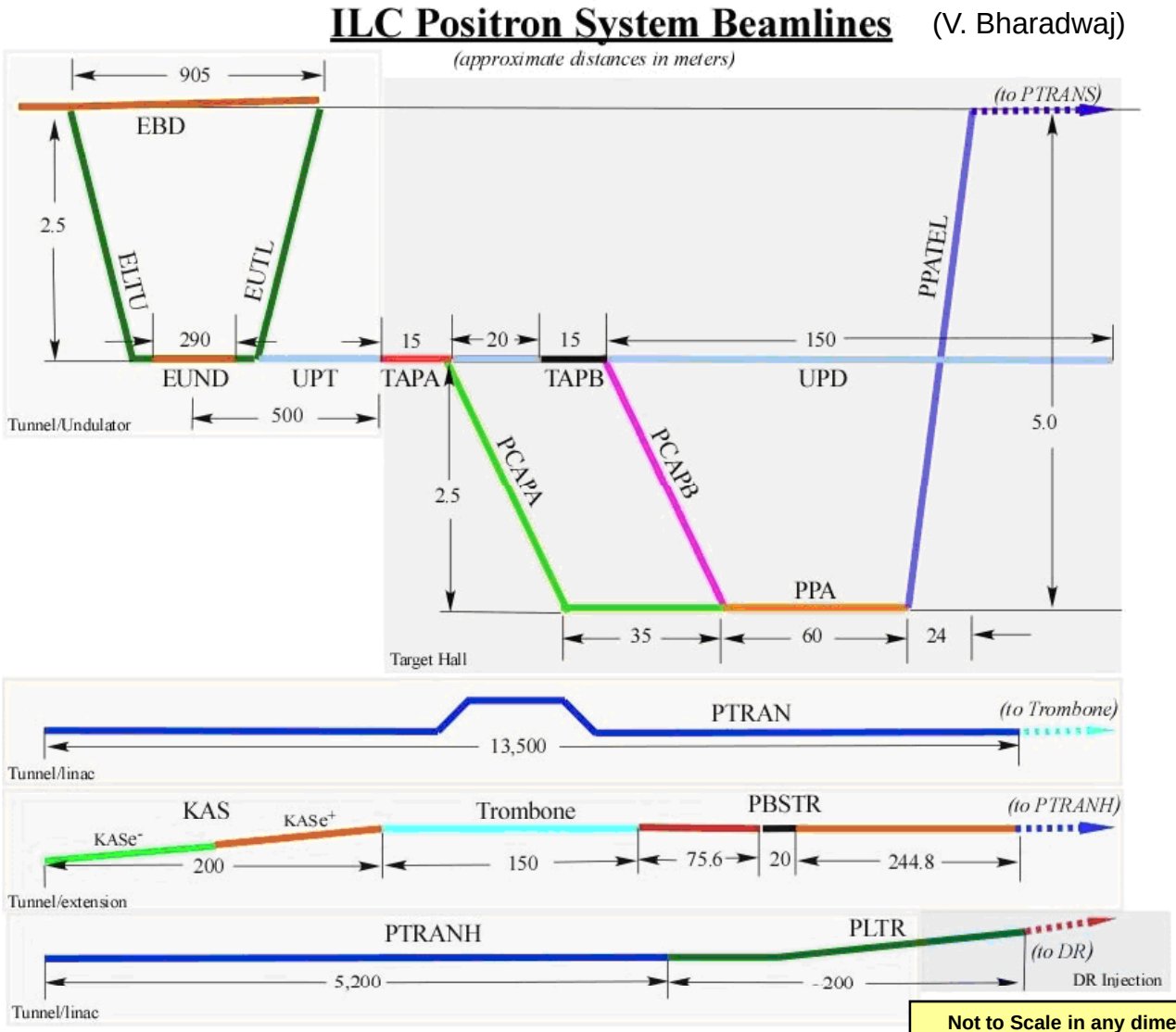
- Checked Lattice Deck to illustrate data is sound (validation).
  - Conversion into Excel data,
  - Import into CAD after data manipulation,
  - Verify layout agrees with other WG, in particular CFS,
  - Create 3D model and verify.
- Identified some Issues, Risks and Opportunities.
  - Apparent clash of components with tunnel,
  - Shallow departure angles require serious thinking during detail design, e.g. beam going through magnet structure,
  - Reduction in Source cavern size,
  - Side (location) of Service tunnel discussion.

Linear Collider – Positron Source
How it all started

Information from end of PPATEL onwards is not included in 3D CAD.

Decision was made to exclude this until the minimum machine discussions have concluded.

KAS info not yet included in 3D model.

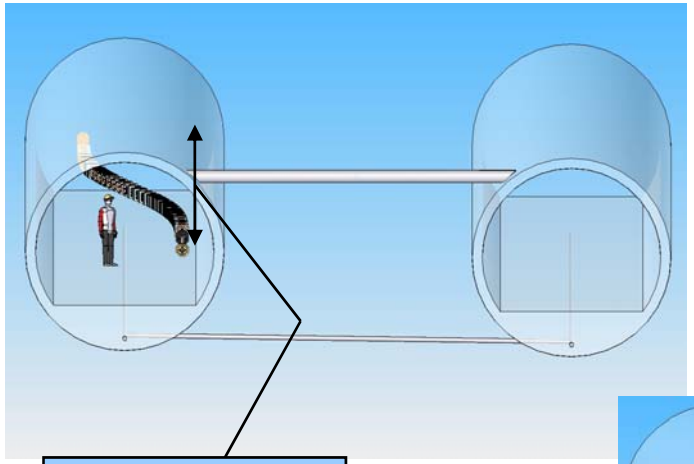


Not to Scale in any dimension

Linear Collider – Positron Source

Abbreviations explained (V. Bharadwaj)

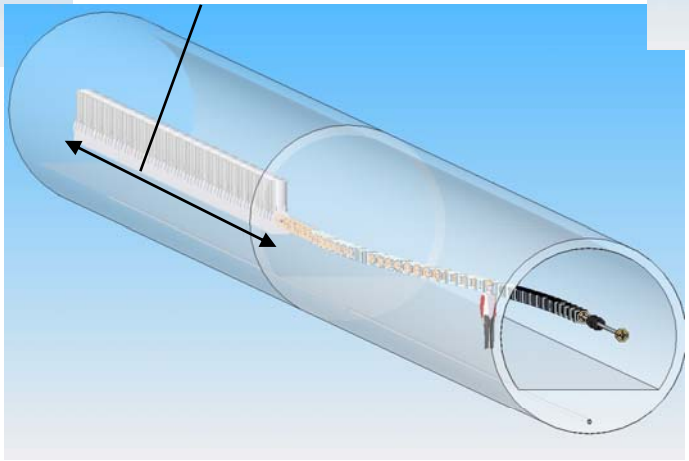
ELTU (Electron Linac To Undulator), **EUND** (Electron through Undulator), and **EUTL** (Electron Undulator To Linac) are the bypass chicane that allow the 150 GeV main linac electrons to go through the helical undulator for photon production.

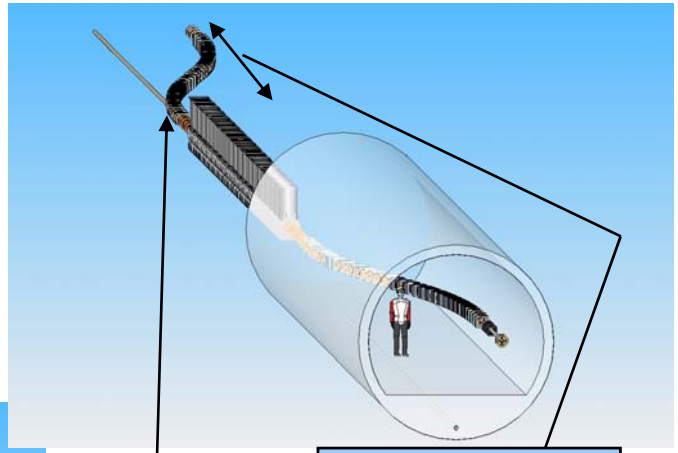


IP is defined as datum (all WGs)

EUND

From Z = 7476m
to Z = 7184m





ELTU

From Z = 7866m
to Z = 7476m

EUTL

From Z = 7184m
to Z = 6862m

Photon Branch Point (UPT start)

Z = 7134.5m

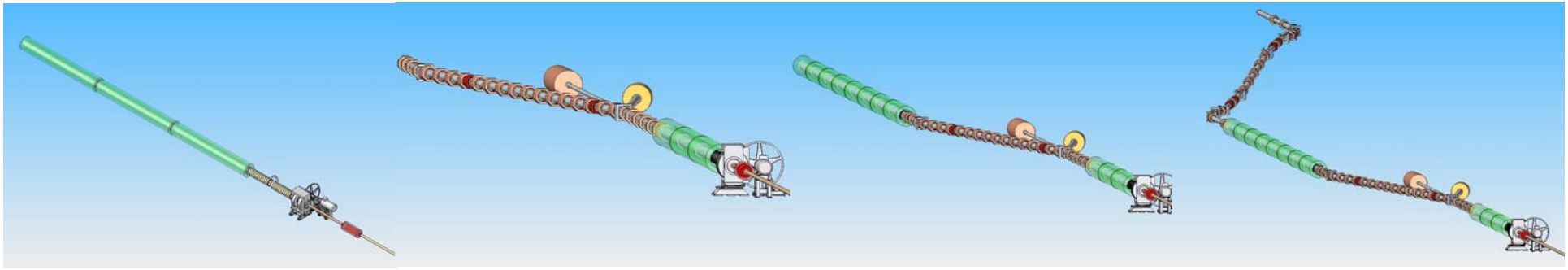
Abbreviations continued (V. Bharadwaj)

TAPA (Target AMD Pre-Acceleration system A) and **TAPB** (Target AMD Pre-Acceleration system B) are the two positron production targets and associated capture and initial acceleration of the electromagnetic shower products. Only one of these targets is used at any one time, the other is a "hot" spare system. This system will accelerate the positrons to 125 MeV.

PCAPA (Positron CAPture system A) and **PCAPB** (Positron CAPture system B) are the beamlines that separate the positrons from the electrons and photons (again only one of these is used the other is a "hot" spare). These beam lines incorporate an electron beam dump.

PPA (Positron Pre-Accelerator) accelerates the positrons from 125 to 400 MeV.

PPATEL (Positron Pre-Accelerator To Electron Linac tunnel) is the beamline that move the 400 MeV positrons from the target hall back into the main linac tunnel for transport to the positron side of the ILC.

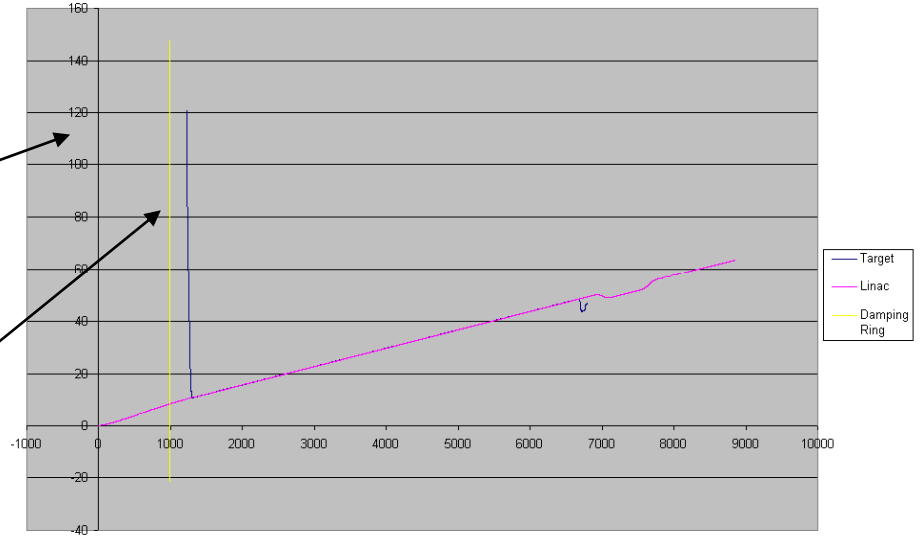


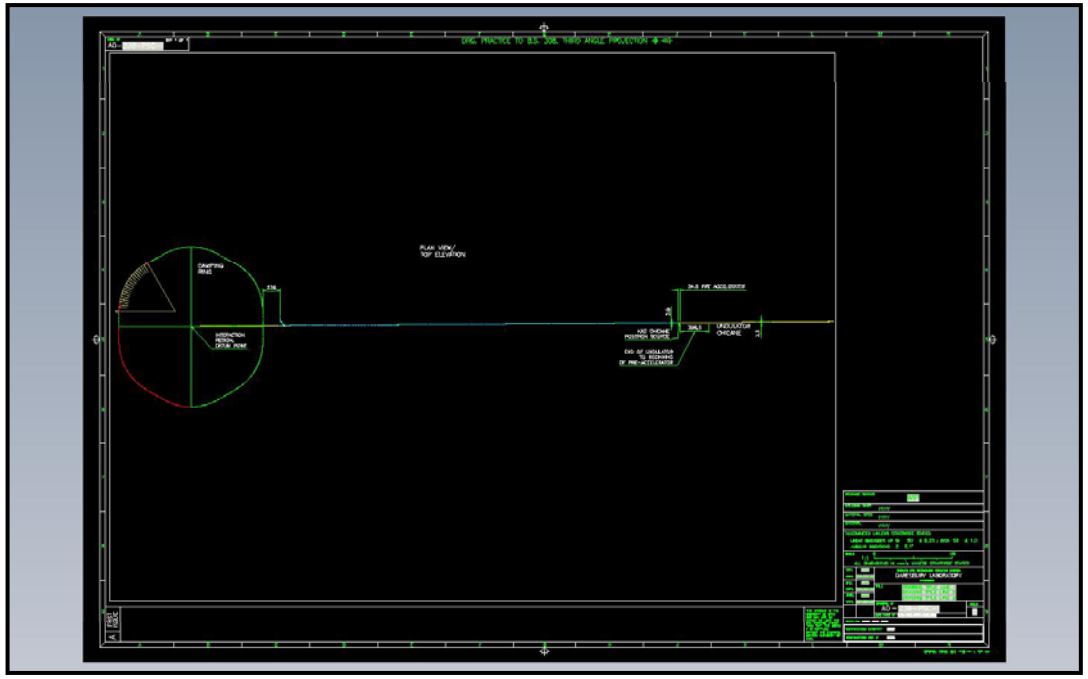
TAPA	+ PCAPA	+ PPA	+ PPATEL
No Lattice info. Working back from PCAPA.	From Z = 6788m To Z = 6753m	From Z = 6753m To Z = 6718m	From Z = 6718m To Z = 6672m

Linear Collider – Positron Source

After some data translation efforts and a few iterations, the final spreadsheet could be converted to illustrate the Target, LINAC and Damping Ring data as initial layout (graph plot).

It was observed that the Target does NOT join the Damping Ring using the baseline MAD files.





More data manipulation was required to 'convert' the Excel data into '2D-CAD' format.

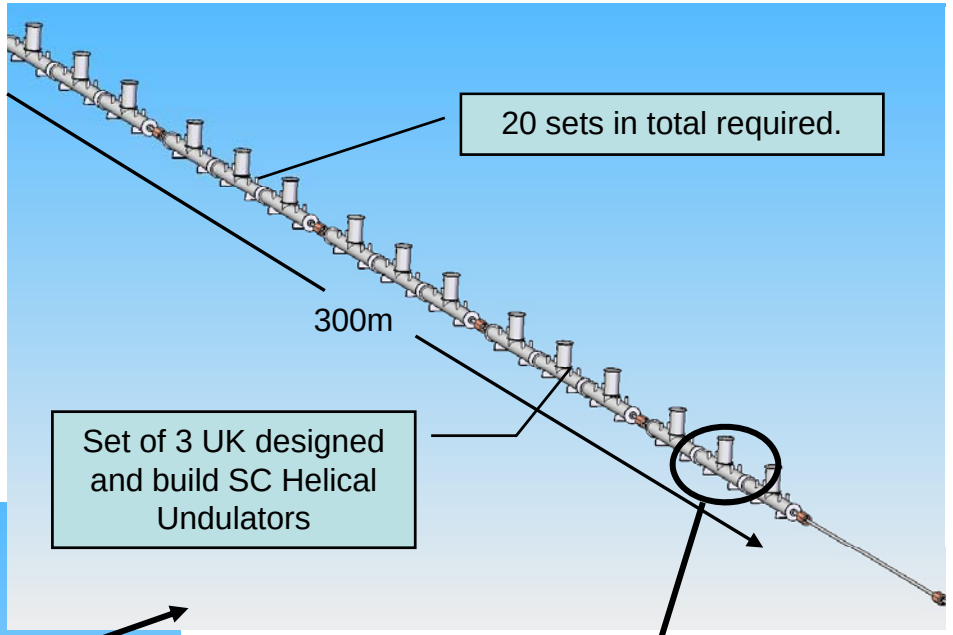
A larger than expected time was spend on this process before results proved satisfactory.

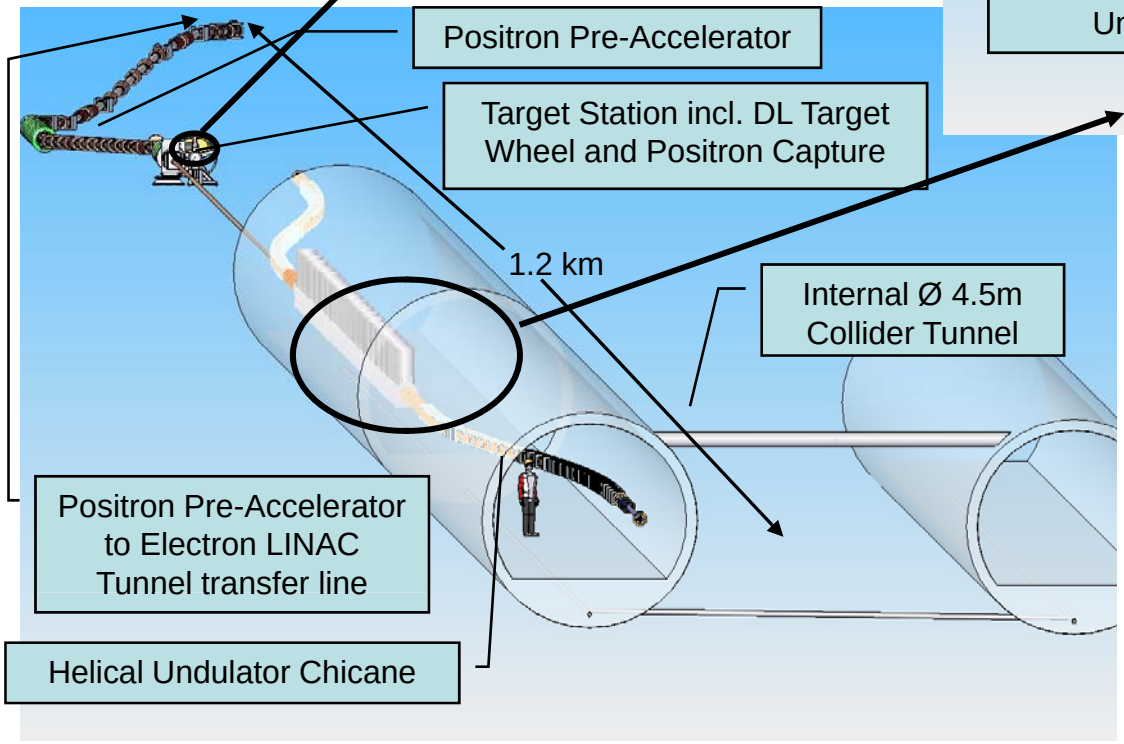
Inconsistencies between the Excel data compared with the CAD results proved that we required an automation process to reduce the iteration time.

Science & Technology Facilities Council

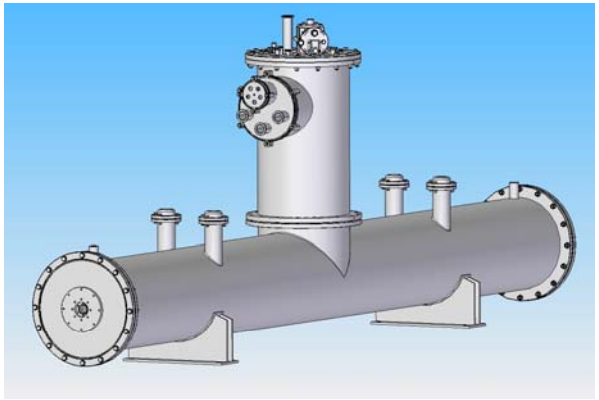
Linear Collider – Positron Source

Target Wheel installation and testing at Daresbury Laboratory





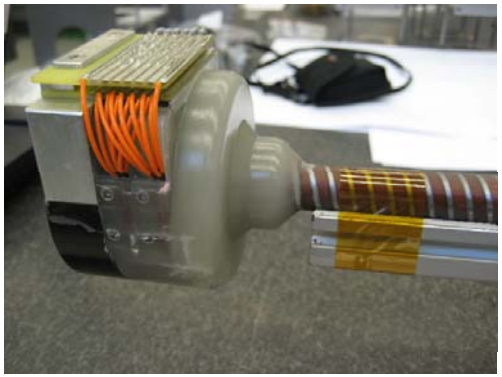
4m long Superconducting Helical Undulator

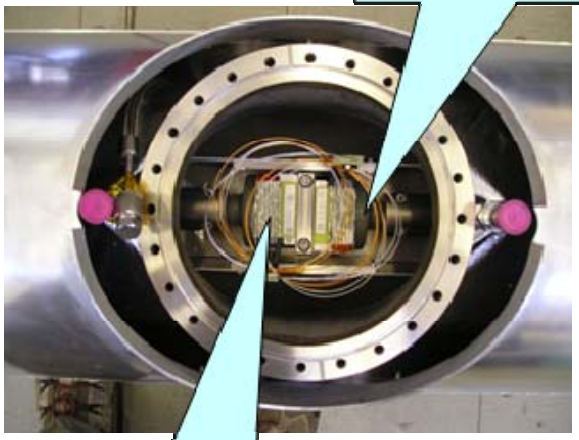


Science & Technology Facilities Council

Linear Collider – Positron Source

Following winding each coil is potted and end connections to ribbon made





Mag 2 connection

Mag 1 connection

Logging system connected

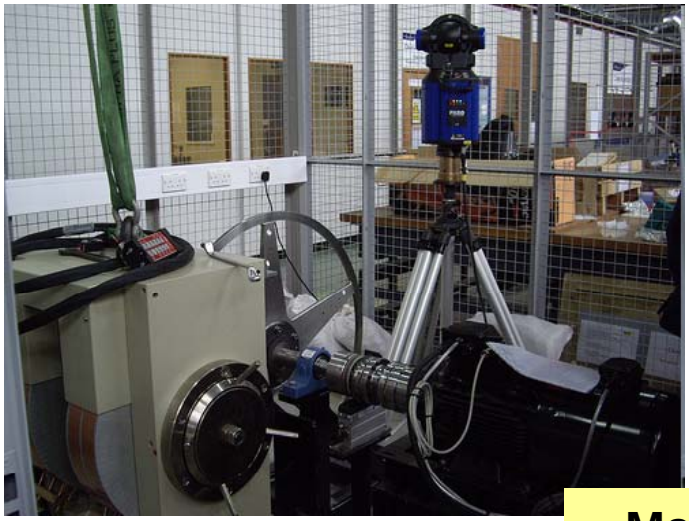
Testing successful.

One down – 59 to go

Science & Technology Facilities Council

Linear Collider – Positron Source

Target Wheel Installation and Testing at low RPM

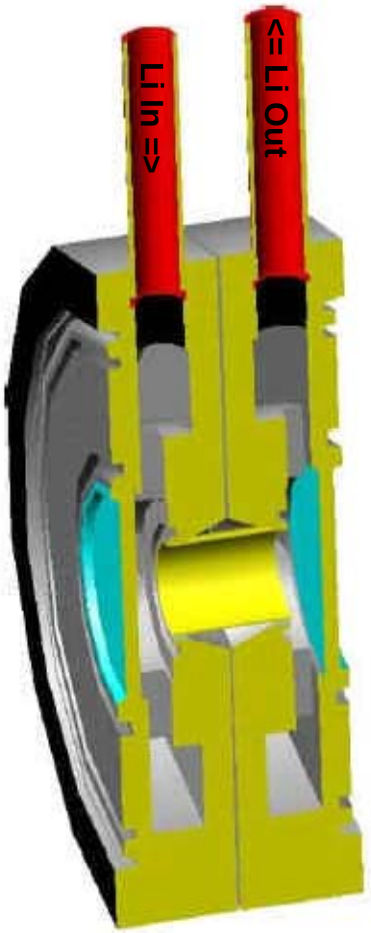


Magnets placed using Laser Tracker for alignment

Enclosure required for Health and Safety

Linear Collider – Positron Source

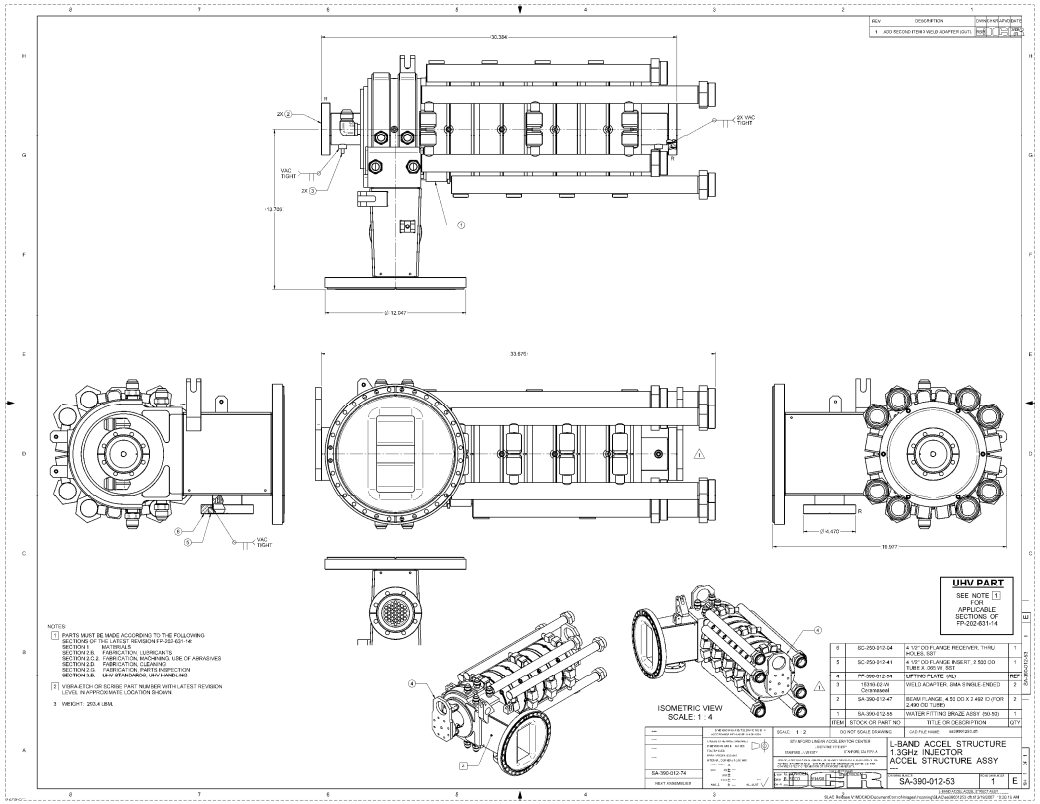
Lithium Lens with feeding cables.
(Courtesy of Yu. Shatunov, BINP)



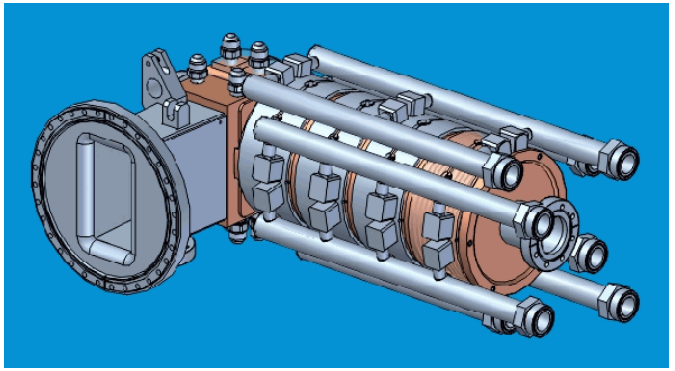
Lithium Lens CAD model section view.
(Courtesy of **Alexander Mikhailichenko**, Cornell)

Linear Collider – Positron Source

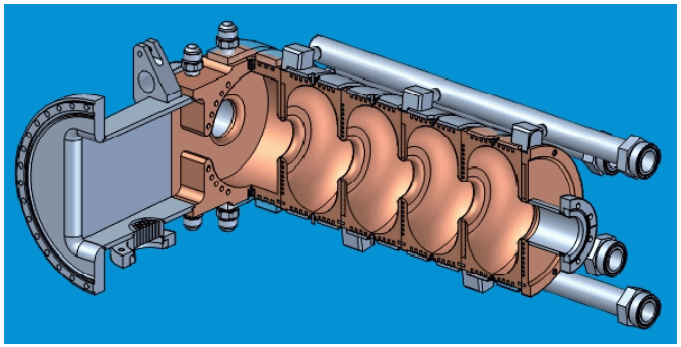
SLAC Standing Wave Accelerator



SLAC Standing Wave Accelerator CAD model



Section View



Science & Technology Facilities Council

Photon Collimator --- Models (Lei Zang)

Model 1

• Copper is used as an absorber because of high thermal conductivity (~401W/m/K) and high melting point (T_{melt}~1357.77K)

• Titanium (melting point ~1941K) is used as spoilers whose length is 1cm (0.28 radiation length).

Model 1

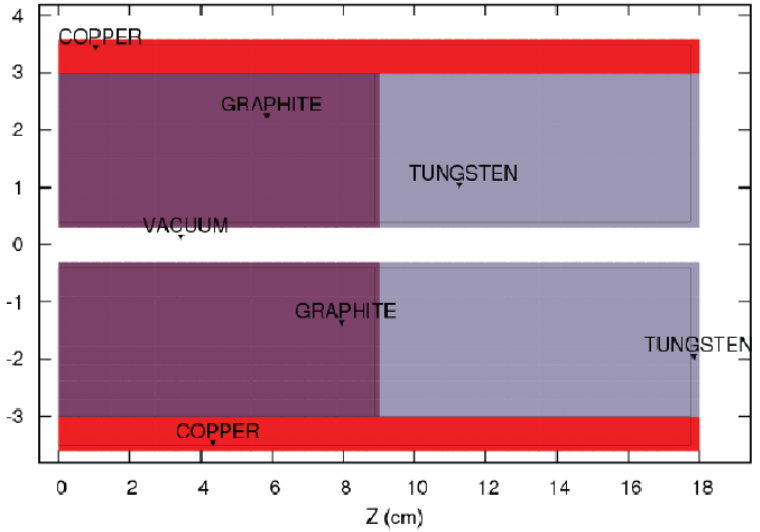
• Absorber Length is 90 cm (64.3 radiation length). And between spoilers there are 6 cm gaps.

Model 2

• Cylinder shape collimator consisting of Graphite and Tungsten as a spoiler and absorber respectively.

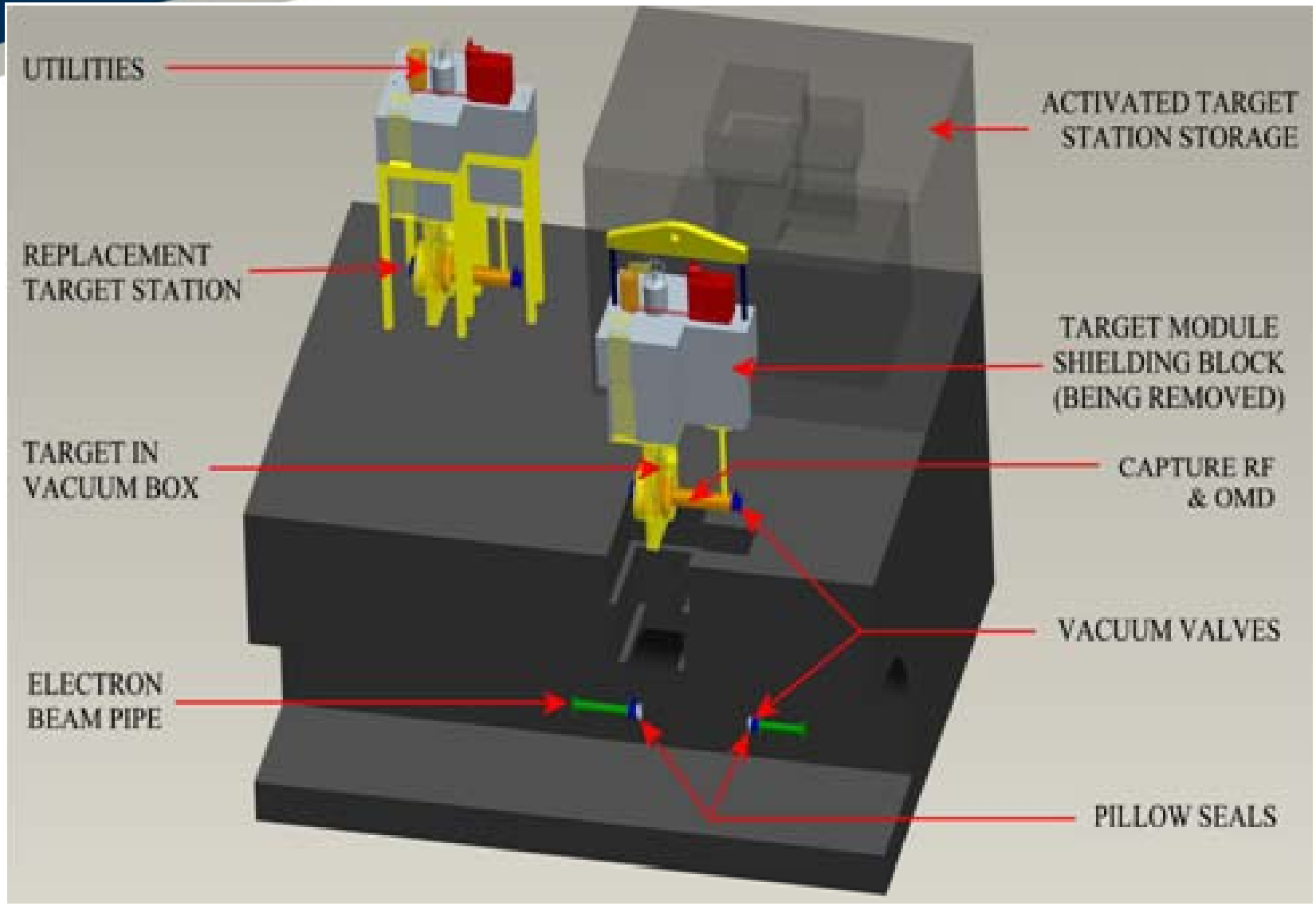
• Both Graphite (T_{melt}~4000) and Tungsten (T_{melt}~3695) have very high melting points.

Model 2 (A. Mikhailichenko, EPAC'06)



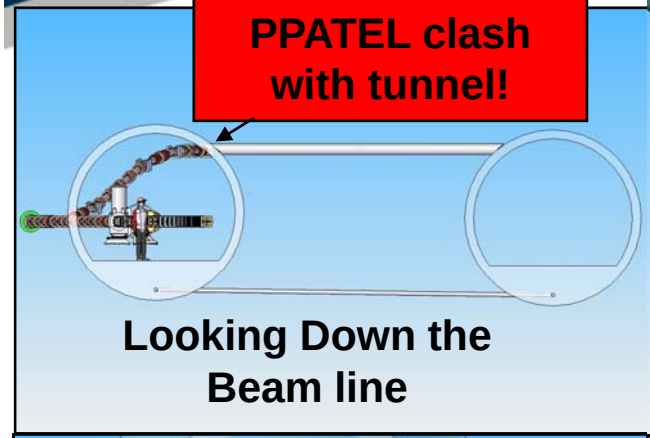
Science & Technology Facilities Council

Linear Collider – Positron Source



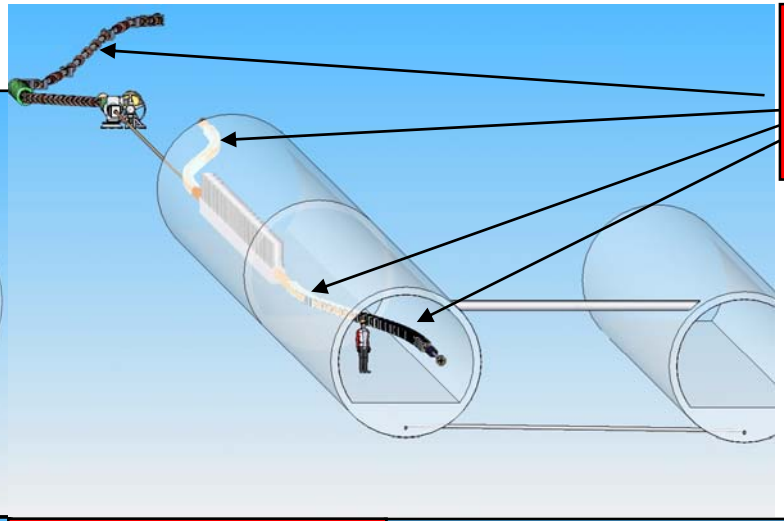
Science & Technology Facilities Council

Linear Collider – Positron Source

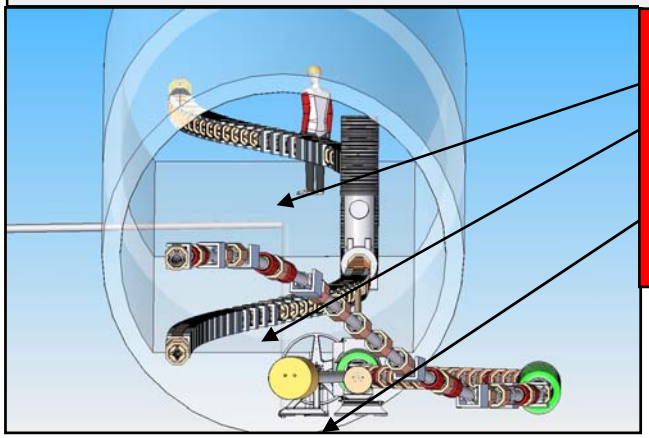


PPATEL clash with tunnel!

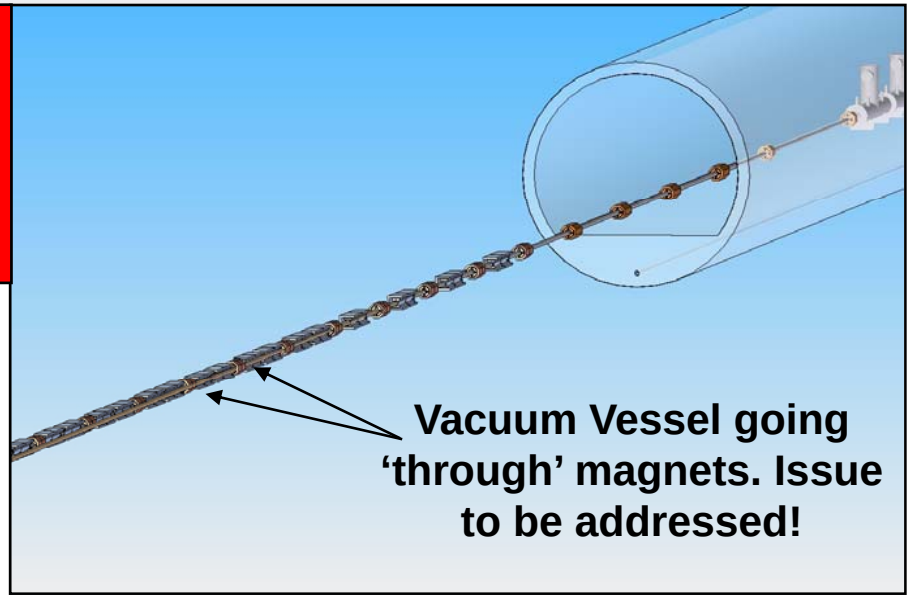
Looking Down the Beam line



Power deposition in bends?



Access to areas for installation, commissioning and maintenance?

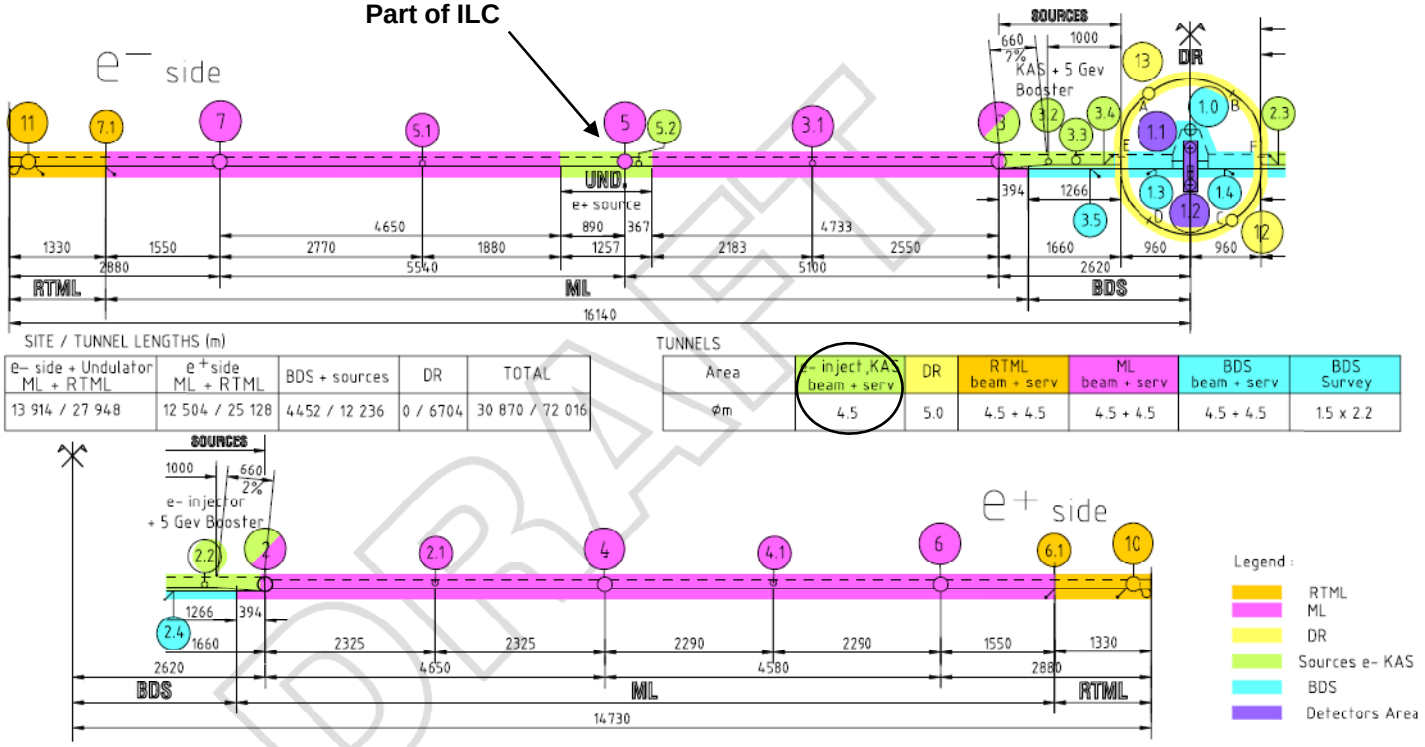


Vacuum Vessel going 'through' magnets. Issue to be addressed!

Science & Technology Facilities Council

John Andrew Osborne Dubna Presentation

Positron Source Part of ILC



SITE / TUNNEL LENGTHS (m)

e− side + Undulator ML + RTML	e+ side ML + RTML	BDS + sources	DR	TOTAL
13 914 / 27 948	12 504 / 25 128	4452 / 12 236	0 / 6704	30 870 / 72 016

TUNNELS

Area	e- inject,KAS beam + serv	DR	RTML beam + serv	ML beam + serv	BDS beam + serv	BDS Survey
⌀m	4.5	5.0	4.5 + 4.5	4.5 + 4.5	4.5 + 4.5	1.5 x 2.2

SHAFTS

Point	1.0	1.1	1.2	2	3	3.3	5.2	4	5	6	7	10	11	12/C	13/A
⌀m	9	16	16	14	14	4	4	14	14	9	9	14	14	9	9

BORINGS

Point	2.1, 3.1, 4.1, 5.1	2.2, 3.2	1.3, 1.4, 2.4, 3.5
⌀m	1.50		

SHAFT BASE CAVERNS

Point	2, 3, 4, 5, 6, 7, 10, 11
(LxWxH) m	49 x 16 x 18 3 storeys

MUON WALL WIDENINGS

Point	1.3, 1.4
(LxWxH) m	25 x7x6 +15x7x6

SOURCES CAVERNS

Point	Undulator 5.2	KAS 3.3	2.2, 3.2
(LxWxH) m	21 161m3	6 574m3	7 X 15 X 7.5

DR ALCOVES

Point	12/C, 13/A	B, D, E, F
(LxWxH) m	75 x 10 x 10 + 1 storey	16 x 8 x 8

DETECTORS HALL

Point	1.1, 1.2	1.0
(LxWxH) m	120 x 25 x 39	40 x 15 x 15

BEAM DUMPS CAVERNS (↖)

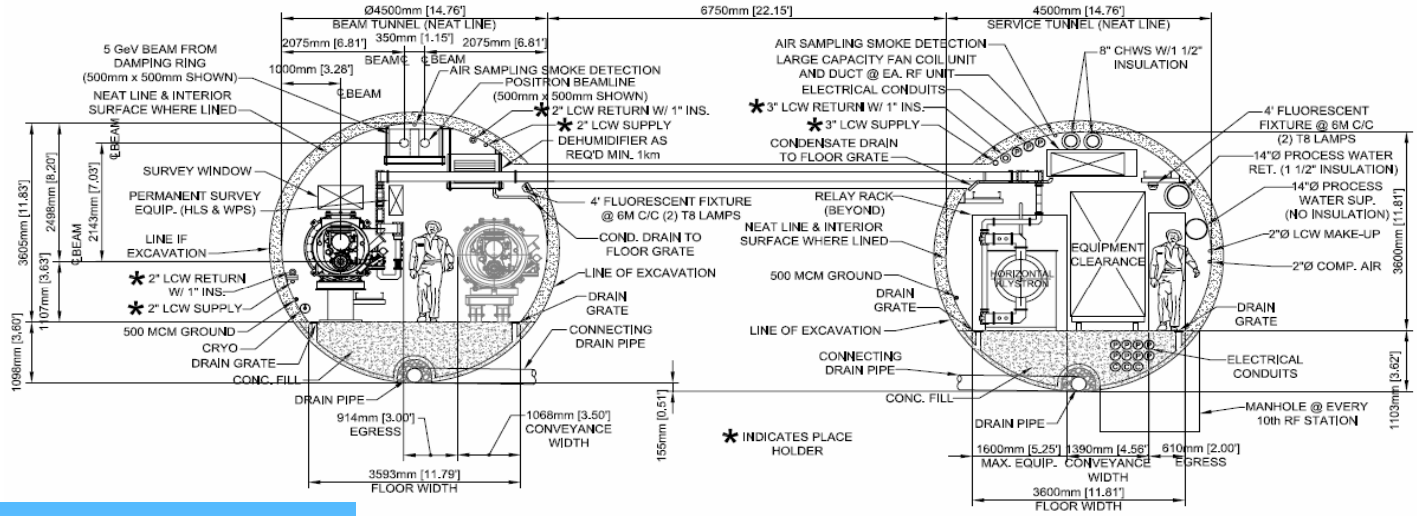
Point	SOURCES 2.3, 3.4	RTML 6.1, 7.1, 10, 11	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	5 x 4 x 4		20 x 9 x 15 + 1 storey

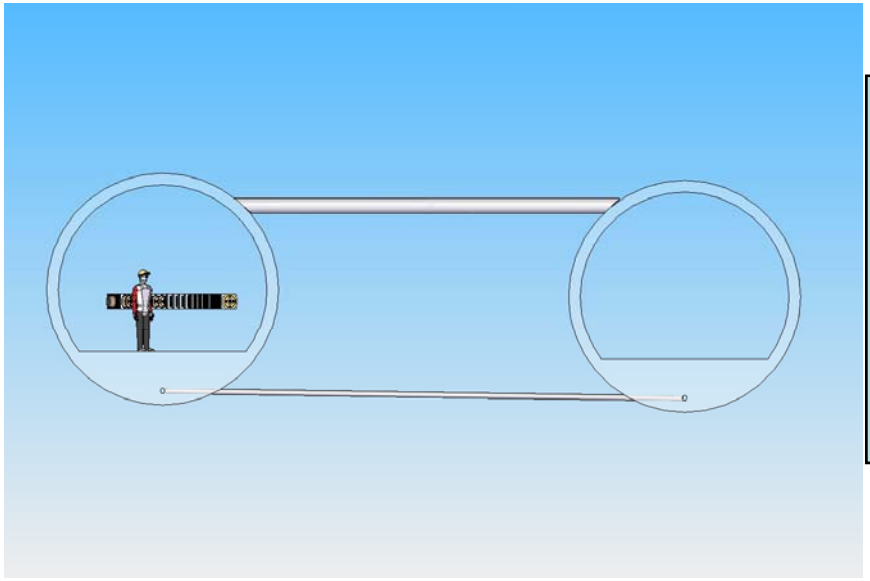
BEAM DUMP SERVICE HALLS (↖)

Point	BDS 1.3, 1.4, 2.4, 3.5
(LxWxH) m	30x20x 10

RDR Tunnel Layout (p.III-213)

RDR Tunnel Layout shows that space is already at a premium in both.





Current CAD Tunnel looks pretty empty.

Integration of all Work Groups' Work Packages is an enormous task and requires more resources.

The current plan is to share resources more effectively between WGs.

Linear Collider – Positron Source

Issues:

1. Tunnel Clash of PPATEL and PTRAN.
2. Positron Transport Line descending an rising in tunnel. Height variation of 1 m. Suspect Earth curvature correction required.
3. Power deposition in Chicane Bends require investigation.

Risks:

1. Precise Installation Plan required.
2. Commissioning and Maintenance access needs to be evaluated.
3. Systems ‘share’ same space e.g. the shallow departure angles mean the tangential components may clash or require careful designs.

Opportunities:

1. Re-think Remote Handling area design
2. Reduction in Tunnel, Cavern and Shaft size (re-evaluate spatial distribution of systems).
3. Provides a visual aid to identify and evaluate quickly other machine configurations.

Cost Drivers:

1. Identified Tunnel, Shaft and Cavern as highest cost per meter driver.
2. Is there another hidden cost driver? If so what can be done to reduce the cost?

Science & Technology Facilities Council

Linear Collider – Positron Source Summary and Actions

The lattice information is now ‘spot on’ (to RDR basline).

We have a basic virtual Positron source machine.

We are making good progress on a number of systems.

Decision on which CAD package to use needs to made in order to progress to the next level.

During the last Positron Source workshop the priority has been set to include other WG place-holders in the CAD model.

The inclusion of more detail design into the model is ongoing.

Address issues raised and propagate the information to relevant persons for discussion.

Look at more detailed and feasible Remote Handling design.

Liaise with other WGs to identify space requirements.

Start support and vacuum design phase (basic place holders).

Incorporate ‘new lattice’ if available.