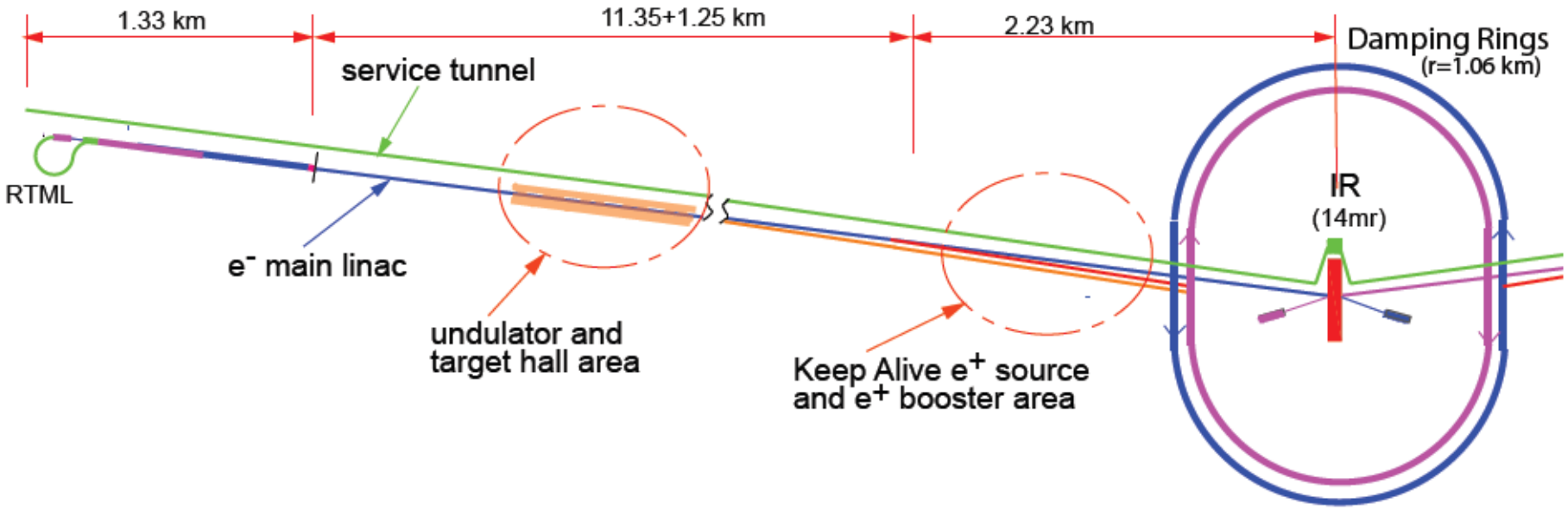
Integration of the Positron Source into the Central Region

Jim Clarke
ASTeC & Cockcroft Institute
Daresbury Laboratory

RDR Reminder

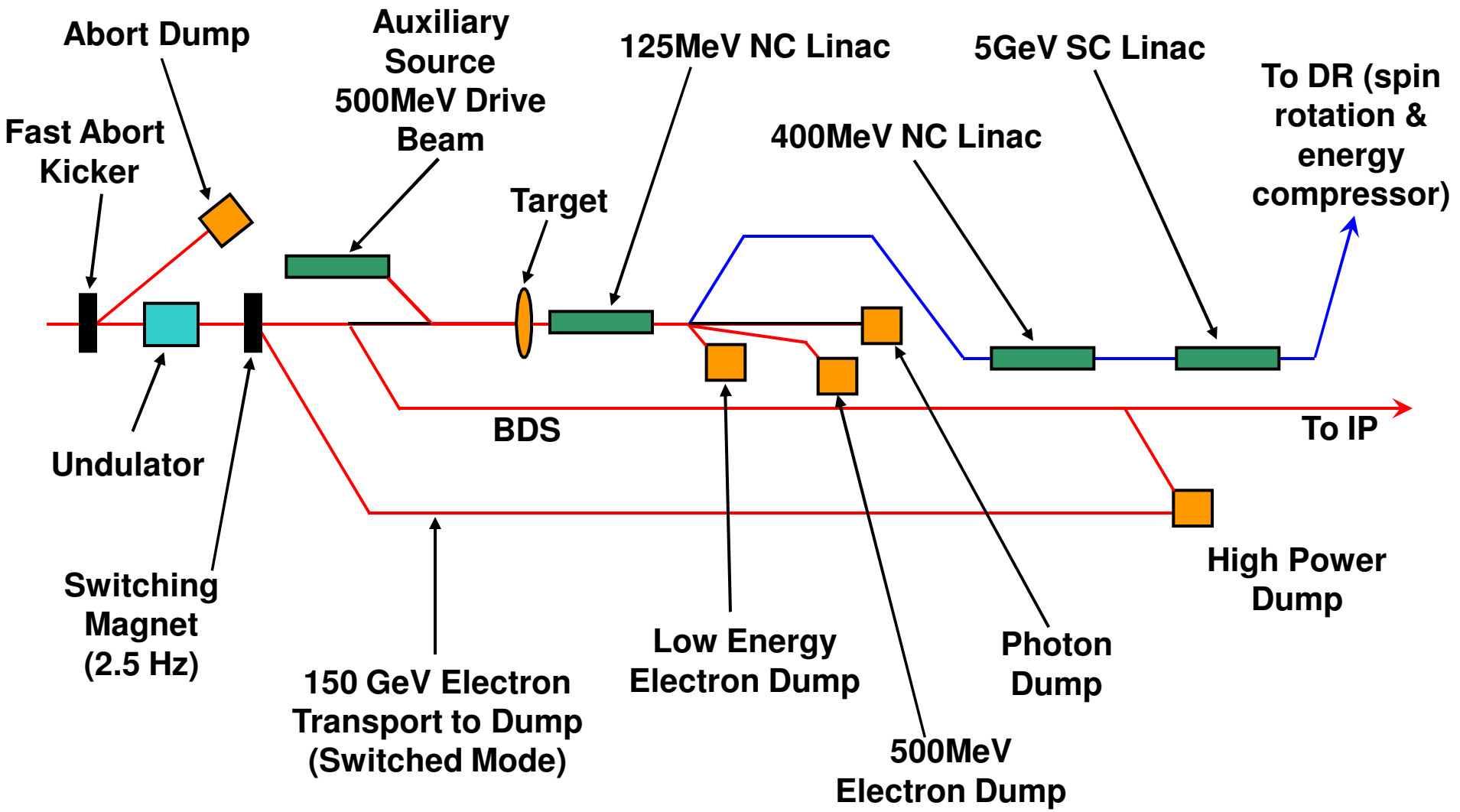
- Undulator at fixed energy of 150 GeV in main linac (in a chicane section)
- Separate Keep Alive Source generated ~10% intensity



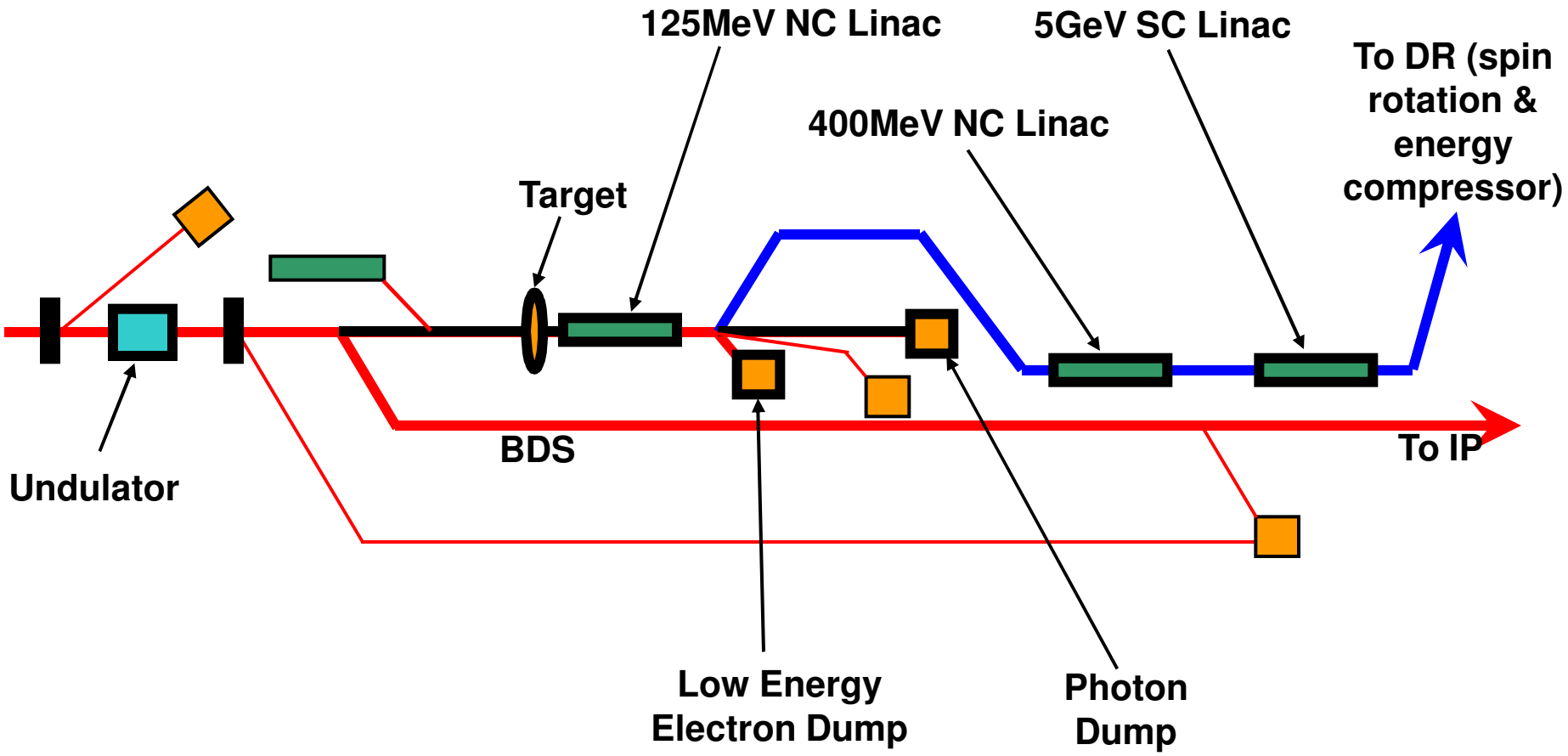
SB2009

- Undulator moved to end of main linac (on-axis)
- Flux concentrator replaced by simpler quarter wave transformer to reduce risk
  - **Independent of change in undulator location**
  - **Reduces positron capture so need more photons on target (longer undulator)**
- Keep Alive Source (~10% intensity) replaced by Auxiliary Source (few % intensity) which now uses same target, capture magnet, linacs, etc as main positron source

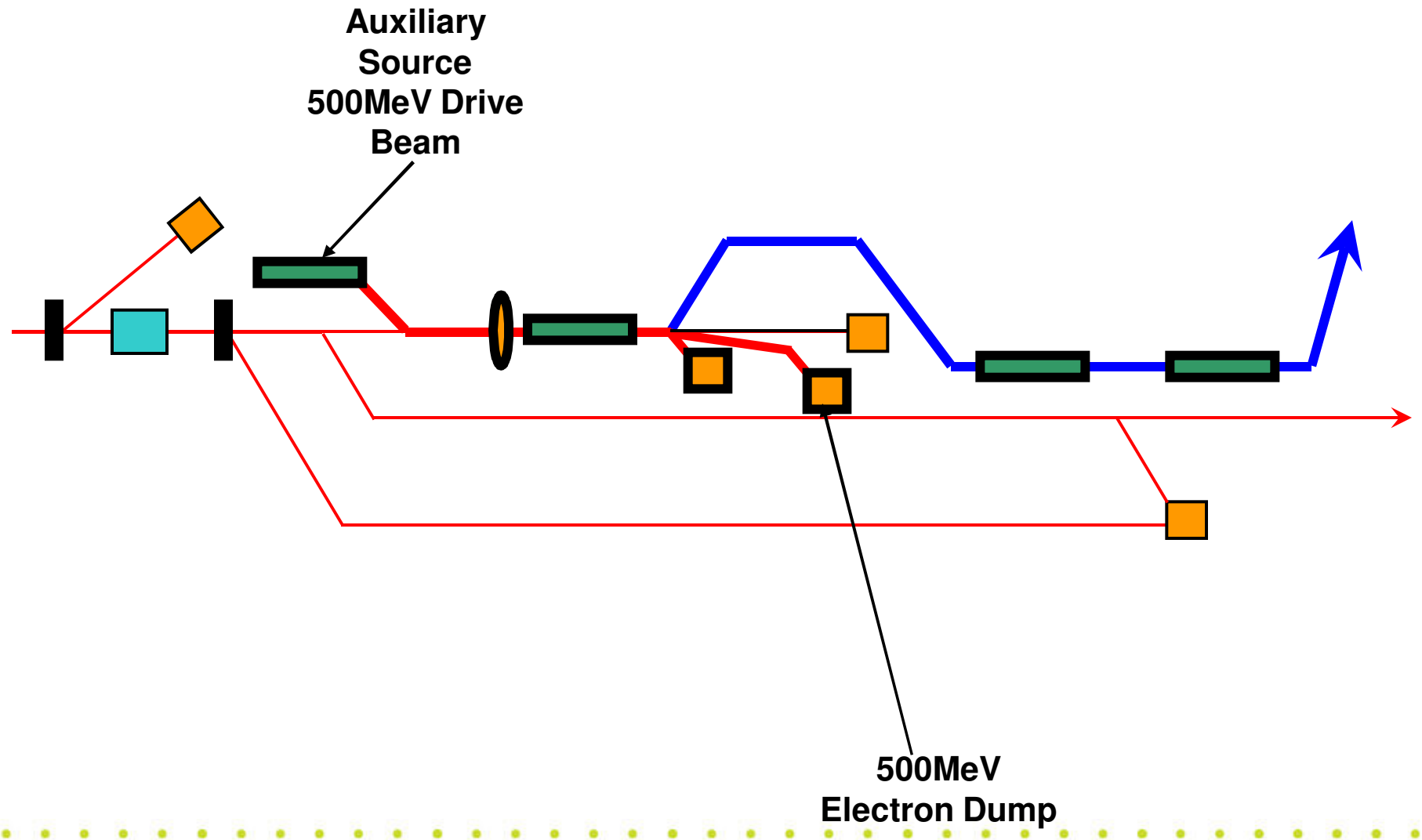
Schematic Layout



Normal Operation



Auxiliary Source Mode



Consequences of SB2009 (1)

- Machine protection systems for the smaller energy acceptance undulator and BDS beamlines can be combined into a single system, located immediately downstream of the main linac
- The undulator source can be better integrated into the upstream area of the BDS, where more tunnel space and more freedom of lattice design are available than in the main linac.
- All sources of restricted energy bandwidth are localised in the central region, leaving both the main SCRF linacs as systems with high energy bandwidth.

Consequences of SB2009 (2)

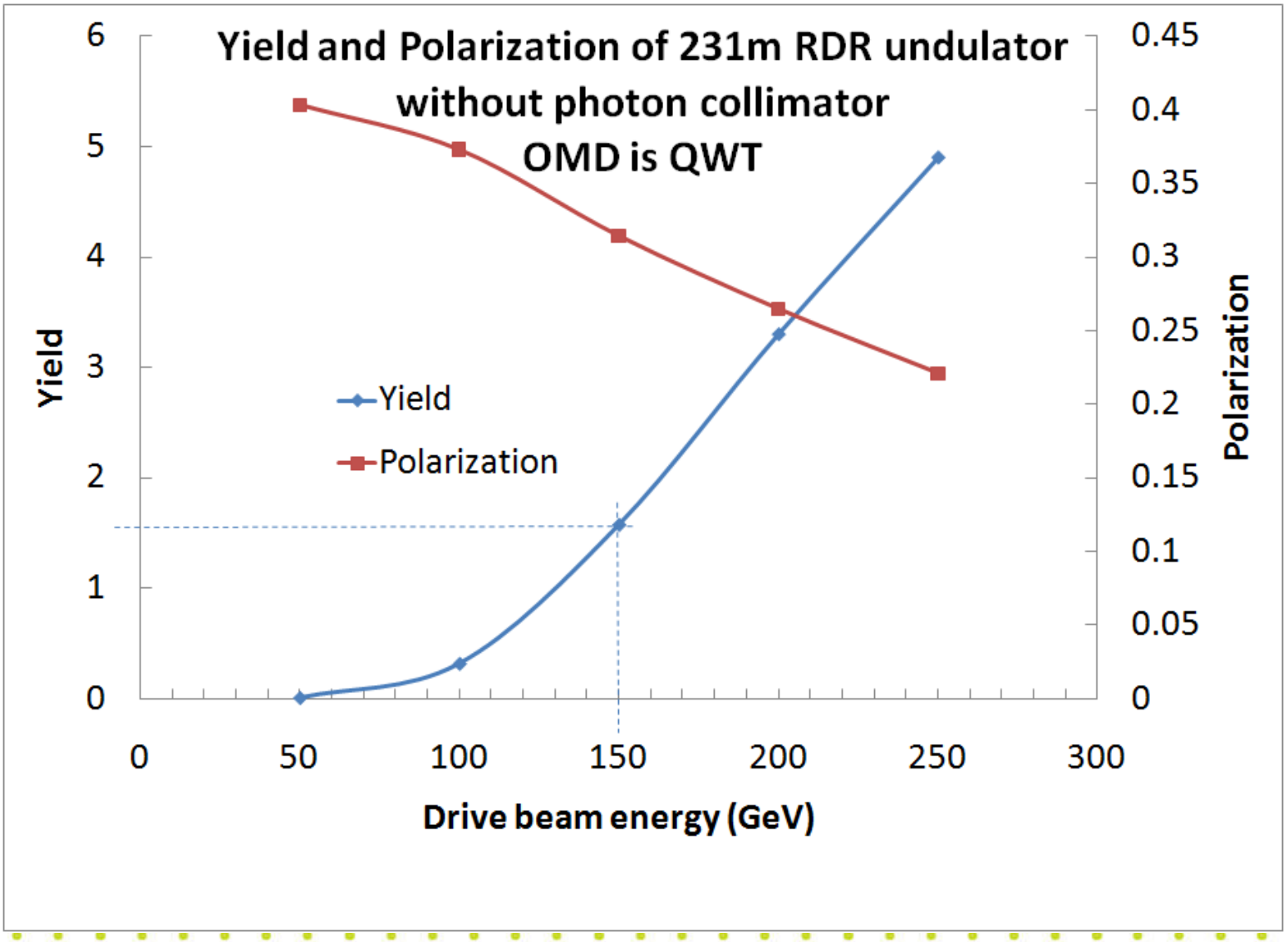
- All the high-radiation environment systems located within the central area
  - **expected to be beneficial for certain host sites (radiation safety and environmental impact).**
- A large energy overhead is available to drive the undulator source, which allows operational margin for the early commissioning in the event that the maximum-performance of the main linacs system is not achieved
- The energy of the electron beam passing though the undulator will vary with the required centre-of-mass operation
  - **See later talk on implications for "low energy" operations**

Consequences of SB2009 (3)

- Adoption of Quarter Wave Transformer reduces project risk at expense of longer undulator
- The Auxiliary Source removes the need for replication of many systems that were previously used by the Keep Alive Source (Target, Capture Magnet, Linacs, Remote Handling, etc)
- Long low energy transfer line to DR no longer needed

Parameter	RDR	SB2009	Units
Positrons per bunch at the IP	2×10^{10}	1 to 2×10^{10} (see Figure 4.3.3 for details)	
Bunches per pulse	2625	1312	
Pulse repetition rate	5	5 (125 to 250GeV) 2.5 (50 to 125GeV)	Hz
Positron energy (DR Injection)	5	5	GeV
DR transverse acceptance	0.09	0.09	m-rad
DR energy acceptance	±0.5	±0.5	%
Electron drive beam energy	150	125 to 250	GeV
Electron energy loss in undulator	3	0.5 to 4.9 (see Figure 4.3.4 for details)	GeV
Required additional electron linac overhead	3	4.1	GeV
Undulator period	11.5	11.5	mm
Undulator strength	0.92	0.92	
Active undulator length	147 (210 after polarisation upgrade)	231 (maximum, not all used when >150GeV)	m
Field on axis	0.86	0.86	T
Beam aperture	5.85	5.85	mm
Photon Energy (1^{st} harmonic)	10	1.1 (50 GeV) to 28 (250 GeV)	MeV
Photon beam power	131	102 at 150 GeV (less at all other energies)	kW
Target material	Ti – 6%Al – 4%V	Ti – 6%Al – 4%V	
Target thickness	14	14	mm
Target power adsorption	8	8	%

Positron Yield



High Energy Operation

- Beyond 150 GeV, the yield increases quite significantly, reaching a value of ~5 at a beam energy of 250 GeV
- In practice, some sections of the undulator will be switched off in order to bring the yield down towards 1.5
  - **inherently large safety margin at high energy**

Polarisation

- In RDR needed a simple upgrade (undulator length increased from 147 to 210m and addition of photon collimation) of positron source to achieve 60%
- SB2009 could upgrade in the same way but then undulator so long that photon powers become worrying and electron energy loss very high
- A better upgrade path is to replace the QWT by a flux concentrator (plus a photon collimator)
- Basically end up with similar system as RDR just in different location
  - **Disruption during upgrade would be minimal**

TDP2 (1)

- Main area of risk for the SB2009 is the target. The adoption of the QWT increases the length of the undulator (similar length as RDR polarisation upgrade length) and this enhances the peak photon beam power on the target
- The reduction in the number of bunches by a factor of two reduces the average power on the target, which effectively **increases the performance risk margin**
- The RDR target issues still remain to be resolved and the solutions validated
  - **pressure shock wave impact**
  - **the eddy current effect (an experiment is ongoing)**
  - **rotating vacuum seals to be confirmed suitable**

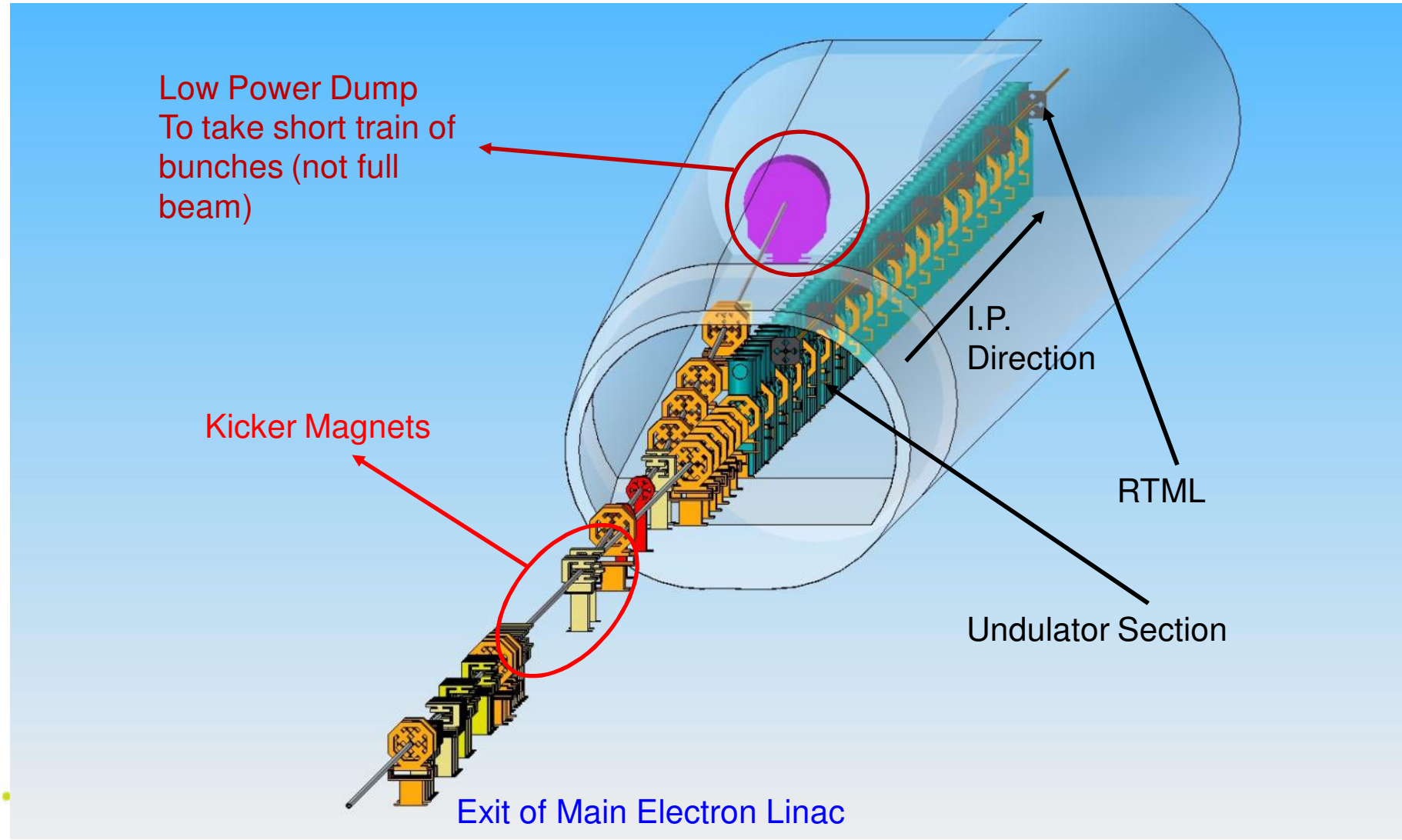
TDP2 (2)

- An SB2009-specific issue is the performance of the target when used as the Auxiliary Source in conjunction with a 500 MeV electron beam
- The performance of the source with realistic undulator magnets is planned for TDP 2
  - **Two full-length undulators have been constructed and tested**
  - **Use measurements to evaluate the actual spectral output from these devices.**
- A beam test with a full-scale undulator cryomodule would be desirable to check for unexpected issues, such as vessel heating, as well as confirm the photon spectrum.
- These are general issues with the undulator source, and not specific to SB2009

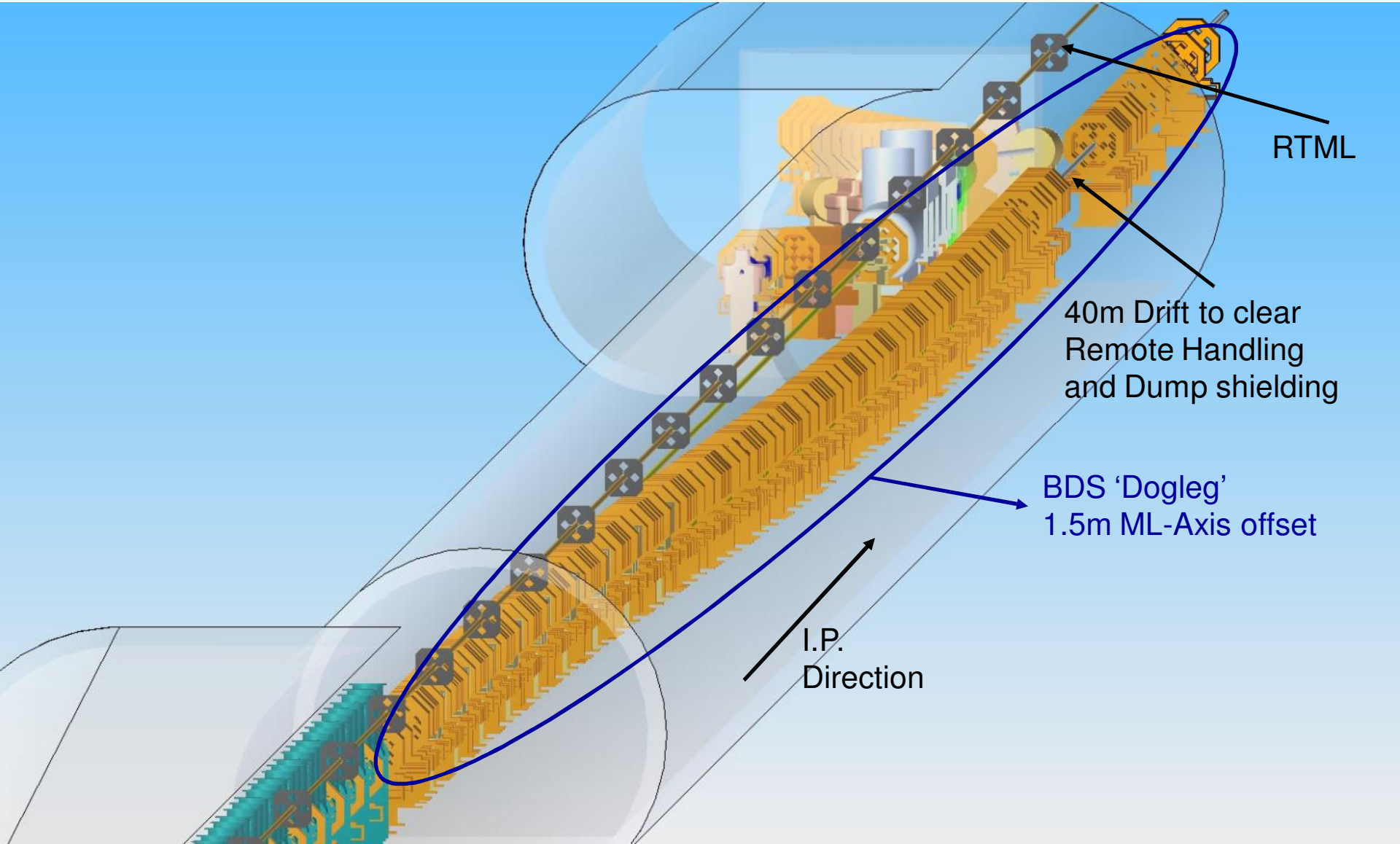
TDP2 (3)

- Since the best route to polarised positrons is through the flux concentrator, this device should continue to be studied. A feasible solution is still to be generated, although the latest findings are encouraging. This issue is not SB2009 specific.
- The remote handling unit still needs careful design and the operating scenarios need to be assessed in more detail. This issue is not SB2009 specific.

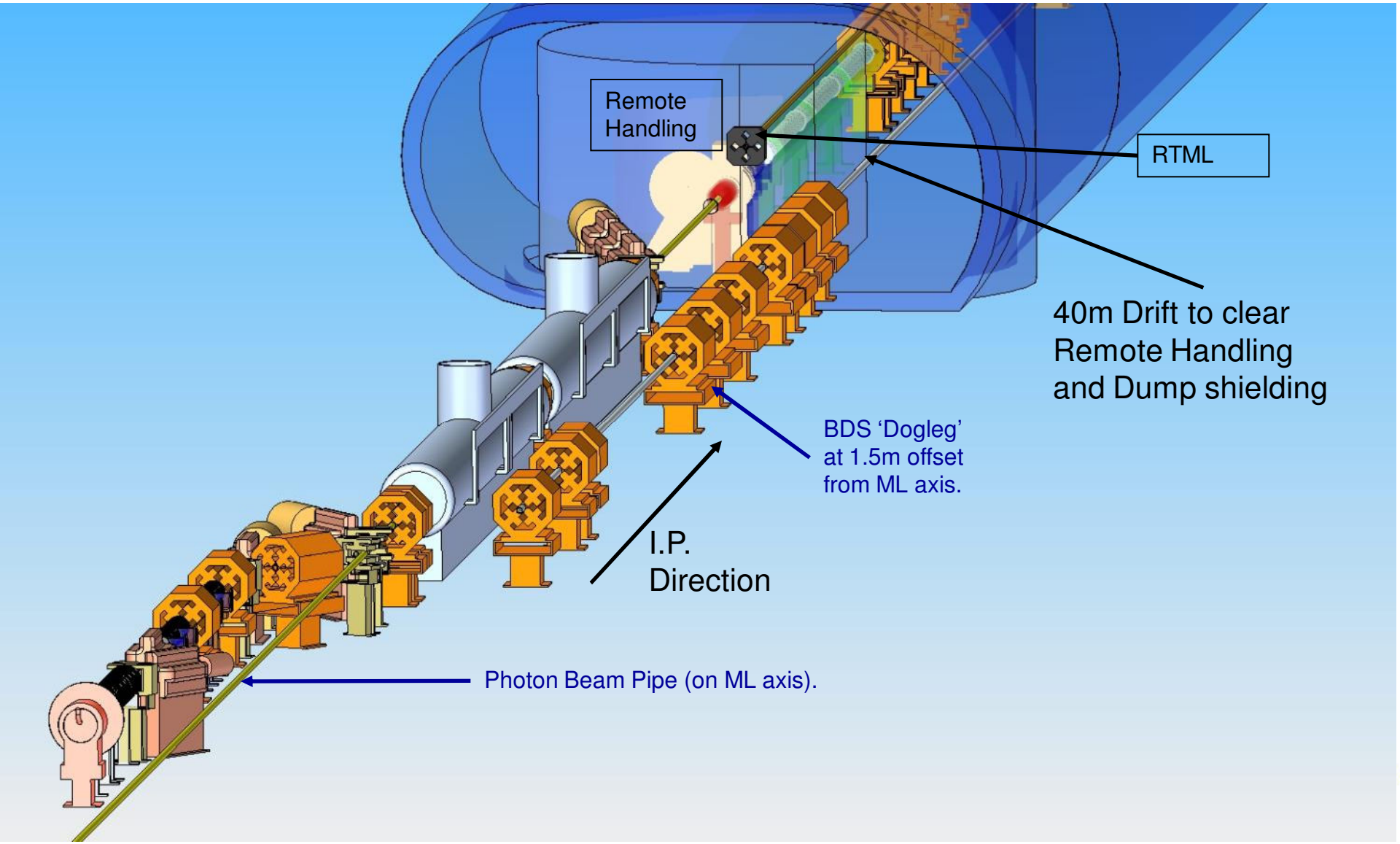
Fast Abort region



BDS Dogleg Region



Auxiliary Source Region



Target Area