CFS consideration on the positron source; target and dumps

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CFS timeline on "Pre- and Preparation Phase"

FY	2018	2019	2020	2021	2022	2023	2024

Fix CFS Design of Accelerator and Detector

Establish CFS Engineering Documents (Bible!)

Detail Design

Startup period

Establish CFS Construction Ready Documents

Preparation for Construction

Ground Breaking

Our possible contribution

minor correction only

(A) Basic Design linked to CFS should be fixed.

- **Accelerator layout**
  - beamline
  - power supplies
- **Requirement of Utilities**
  - specification and route

(B) Selection of Positron Source Scheme

Note:
This timeline has been discussed and reached a consensus by the KEK LC-CFS members.

- M. Miyahara,
- H. Hayano,
- N. Terunuma,
- S. Michizono,
- K. Yokoya

Exception: Positron Source

- **Prepare designs for <u>all possible schemes</u> by (A)**
- **Scheme choice should be done by (B)?**

Radiation Control Requirement

- Equipment of the radiation protection will be a part of accelerator but have to be designed well with CFS especially for the higher radiation areas.

Control Policy and background

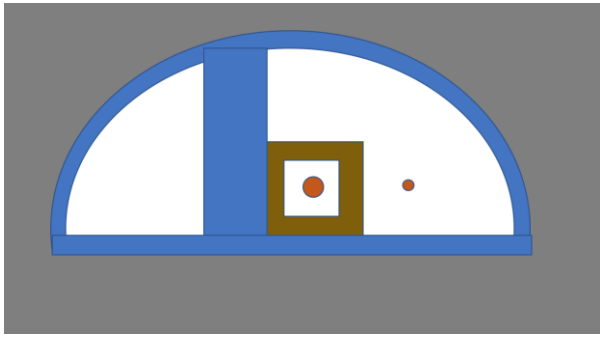
- As Low As Reasonably Achievable (ALARA) principle
- **Low activation of rock and groundwater**

  It should be less than the authorized level of radiation control.
- **Protect workers from the residual activations**

  (KEK) rad. workers < 20 uSv/h or 1 mSv/week
- **Design for decommissioning**

  A device expected to be highly activated should have a structure that can be disassembled.

Radiation control for the underground environment



Local Shielding
is required for the higher radiation sources.
It is not only for workers but also for the outside of 30 cm concrete of the tunnel wall as a public environment.

- **Activation of Rock and Groundwater should be lower than the authorized level.**
- **A guideline have been established for J-PARC.**

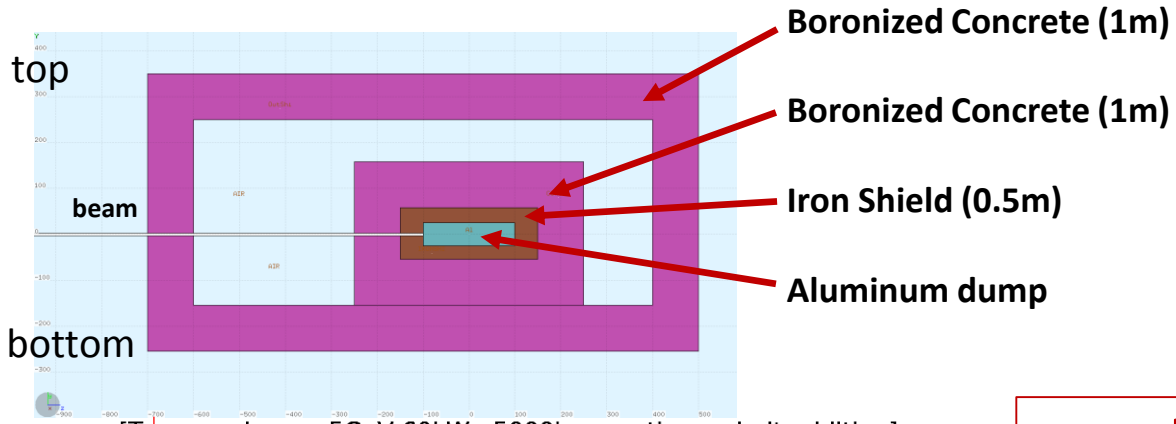
  5 mSv/h (neutron) when Beam ON
- **Neutron is dominant component especially for the transverse radiation** from a high power absorber even for electron machine.
- **The guideline for ILC have to be established as soon as possible, anyway.**

Heavy radiation area expected in Positron Source

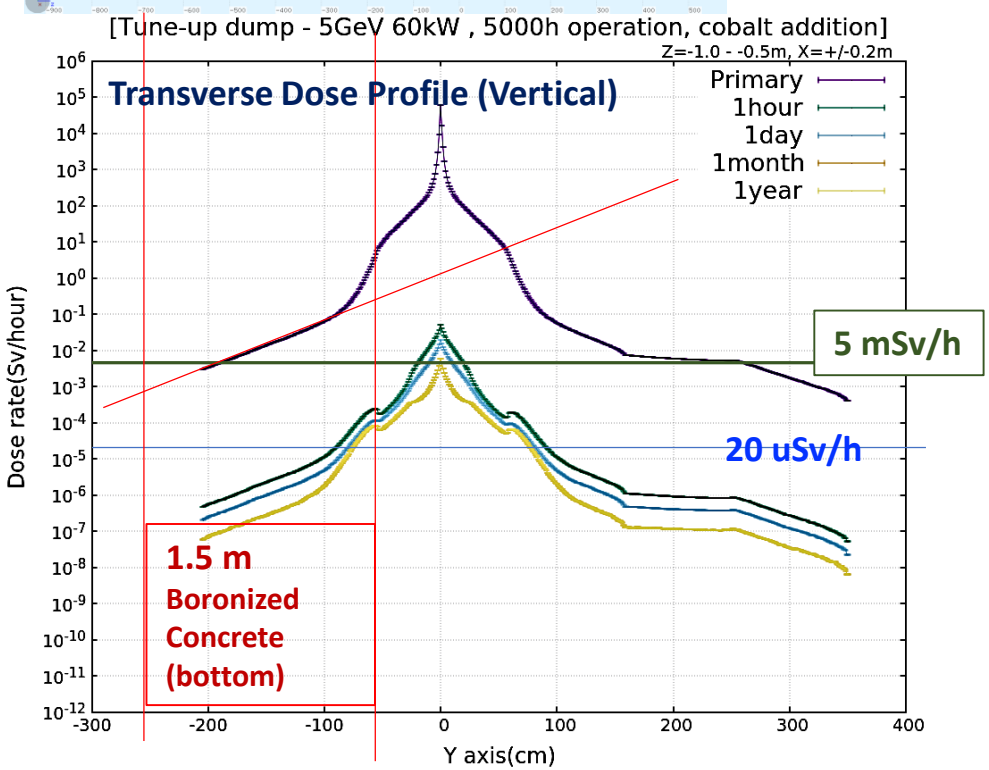
- **Radiation evaluation by FLUKA simulation**
  - assume a maximum intense beam; i.e., **luminosity upgrade option**
  - estimate radiation dose under beam operation
  - estimate residual activation: accumulation and decay in 20 years
- **60kW Tune-up Dump**
  - common for e-driven and undulator
- **Photon Dump**
  - undulator: assume the graphite dump
- **Positron Target and e^- dump**
  - e-driven
  - undulator

No evaluation for this e- dump is prepared today.
It should be done with an assumption of beam loss.

60 kW tune-up dump



- **5 GeV, 60 kW**
- **Located around the end of Positron Source LINAC.**



Iron Shield 0.5 m

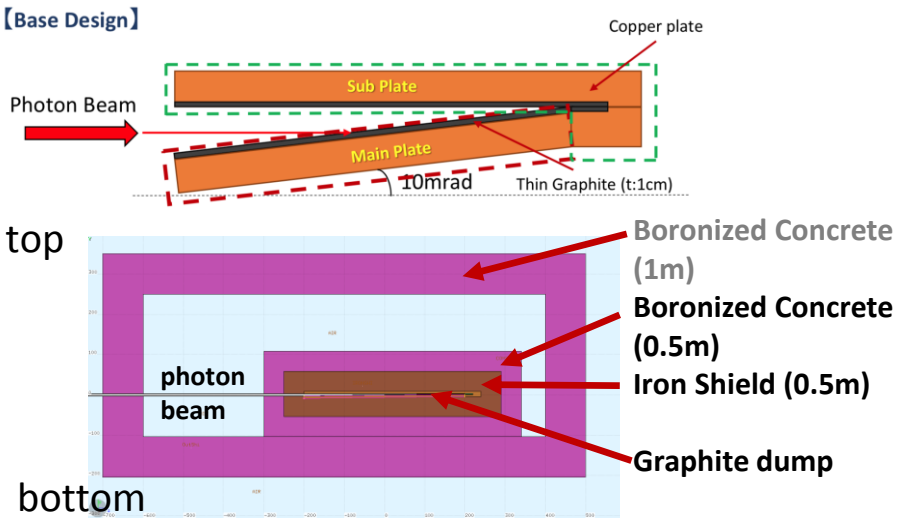
and

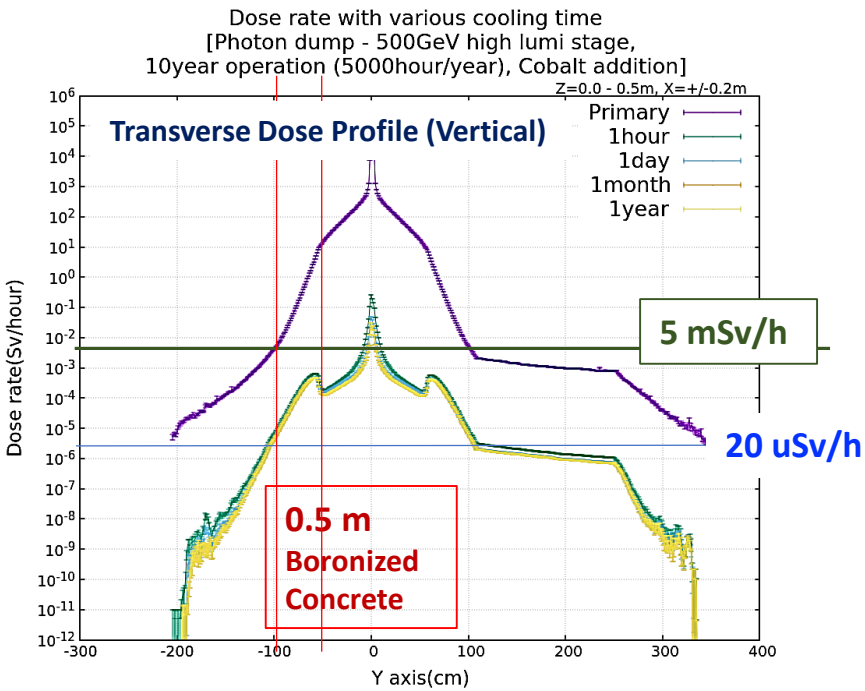
Boronized Concrete 1.5 m

This dump will not be able to set at the straight end of the source as described in TDR because of the shield thickness.

Short dump line will be required toward a tunnel wall.

Photon dump: graphite case





- **10 MeV, 120 kW** for 250 GeV, High luminosity stage
- **Located on the extended undulator photon line about 2 km.**

Iron Shield 0.5 m
and
Boronized Concrete 0.5 m

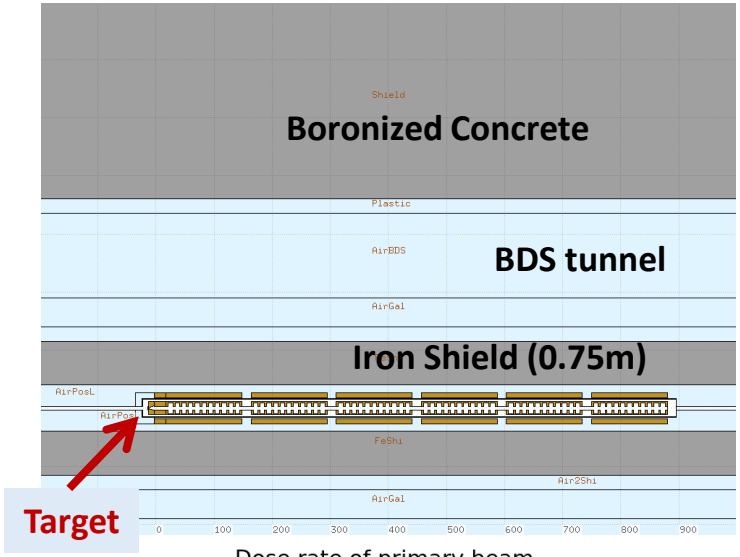
The Graphite Dump should be renewed every a few years.

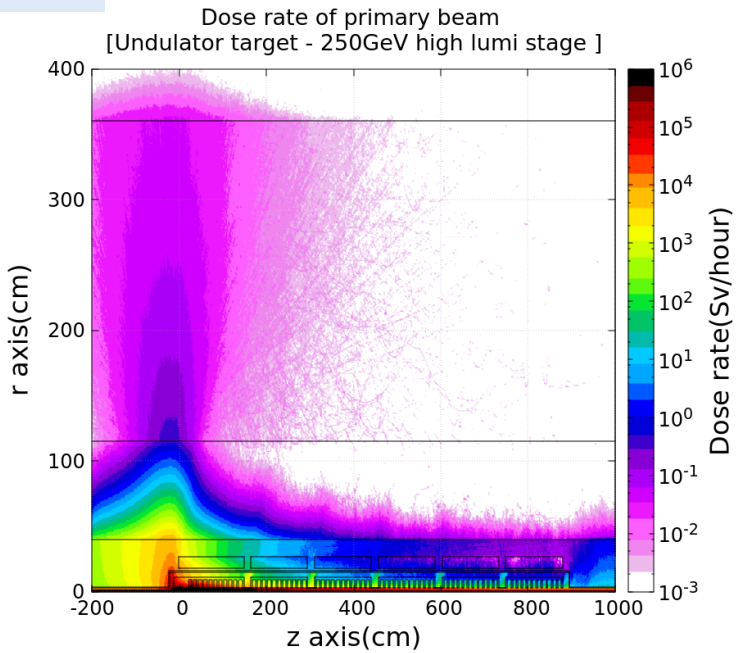
Working space for heavy activation graphite will require a significant size of room which pushes other beamlines away.

Where is this dump?

Detail layout of beam line configuration is required for CFS.

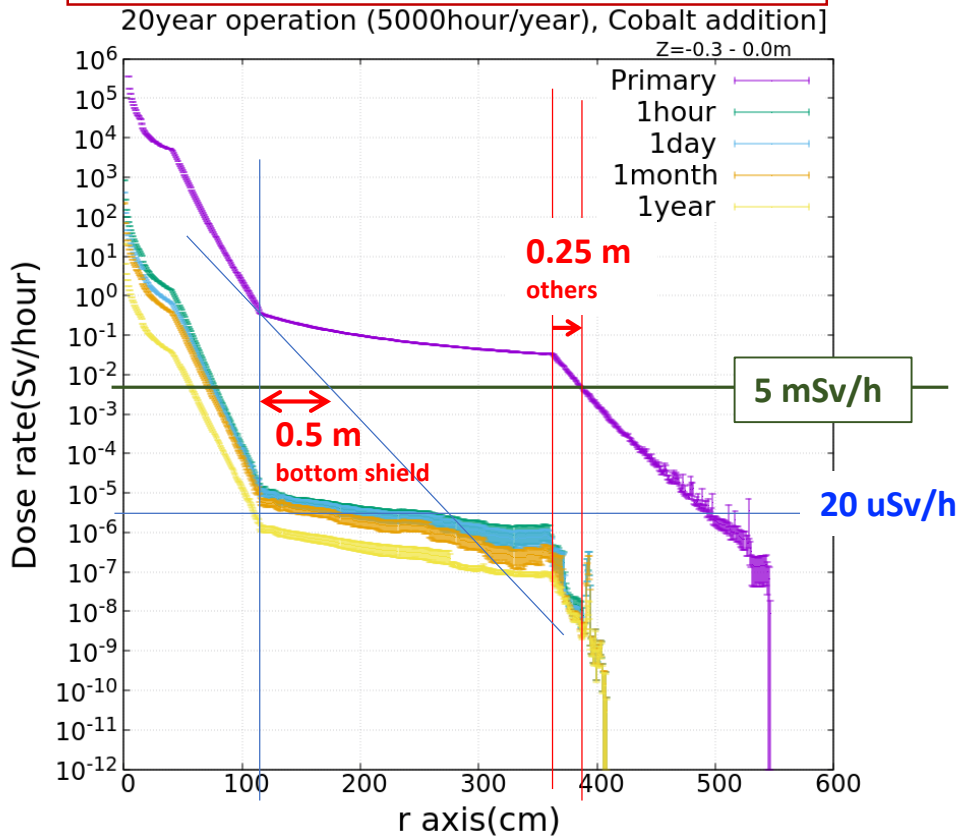
Positron target: undulator



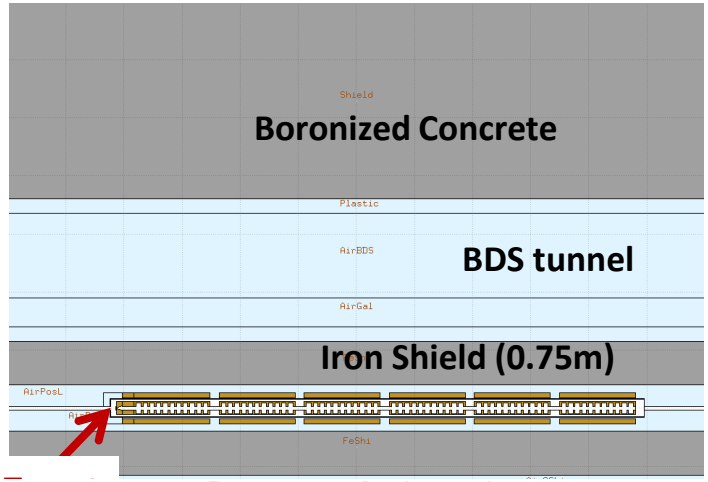


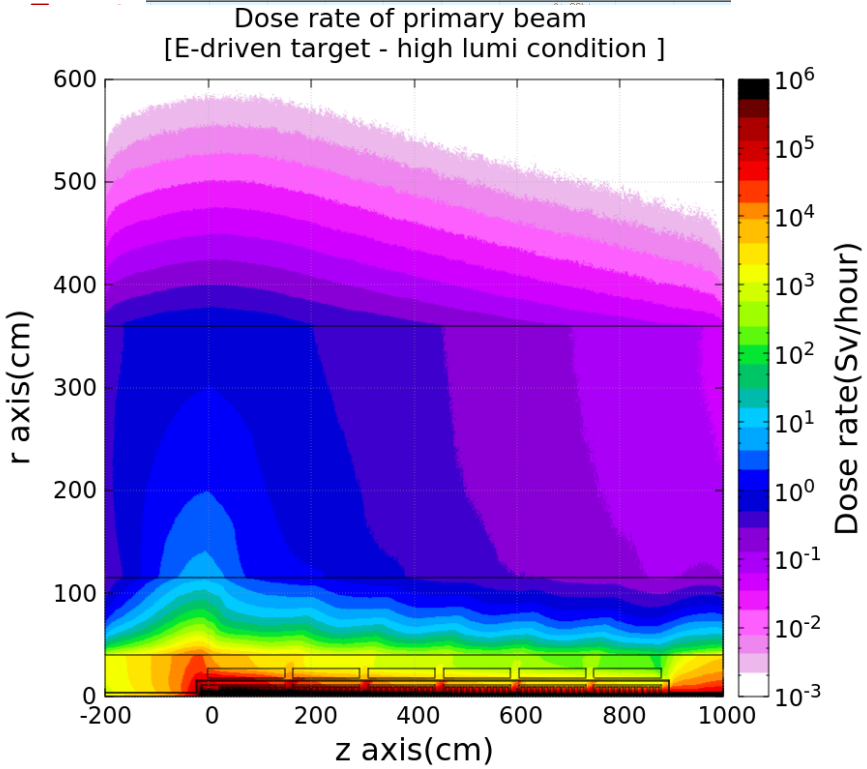
- **10 MeV, 15/120 kW** for 250 GeV, High luminosity stage

Iron Shield 0.75 m
and
Boronized Concrete 0.5 m



Positron target: e-driven

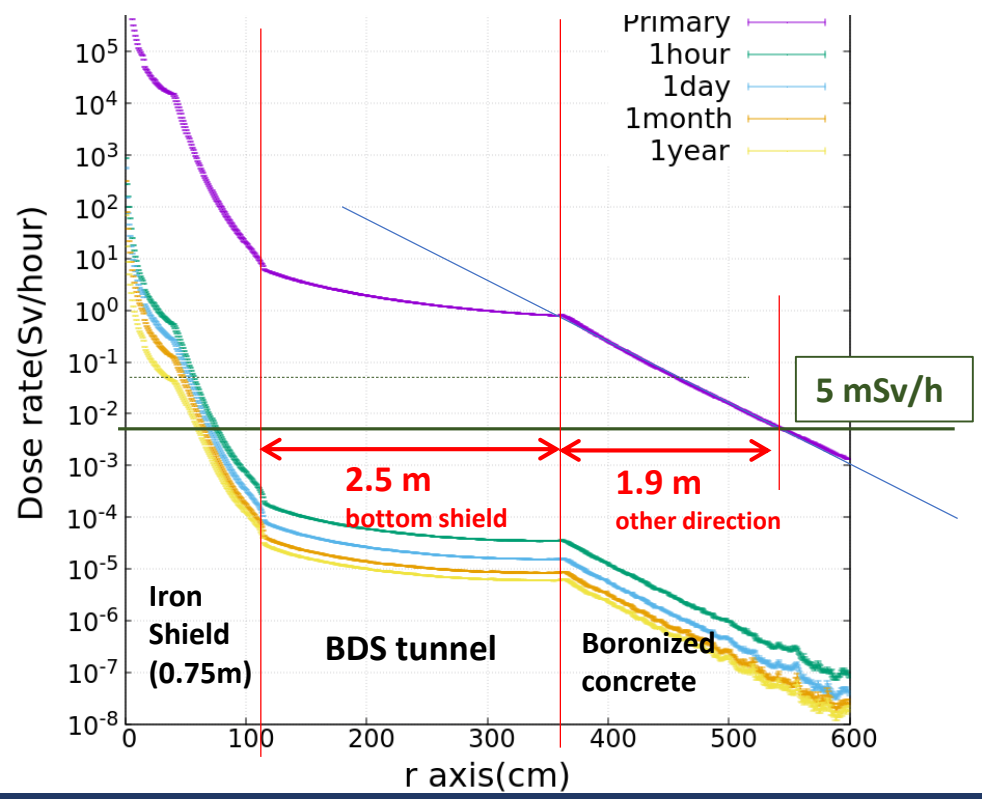




- **4.8 GeV, 30 uA; 144 kW**

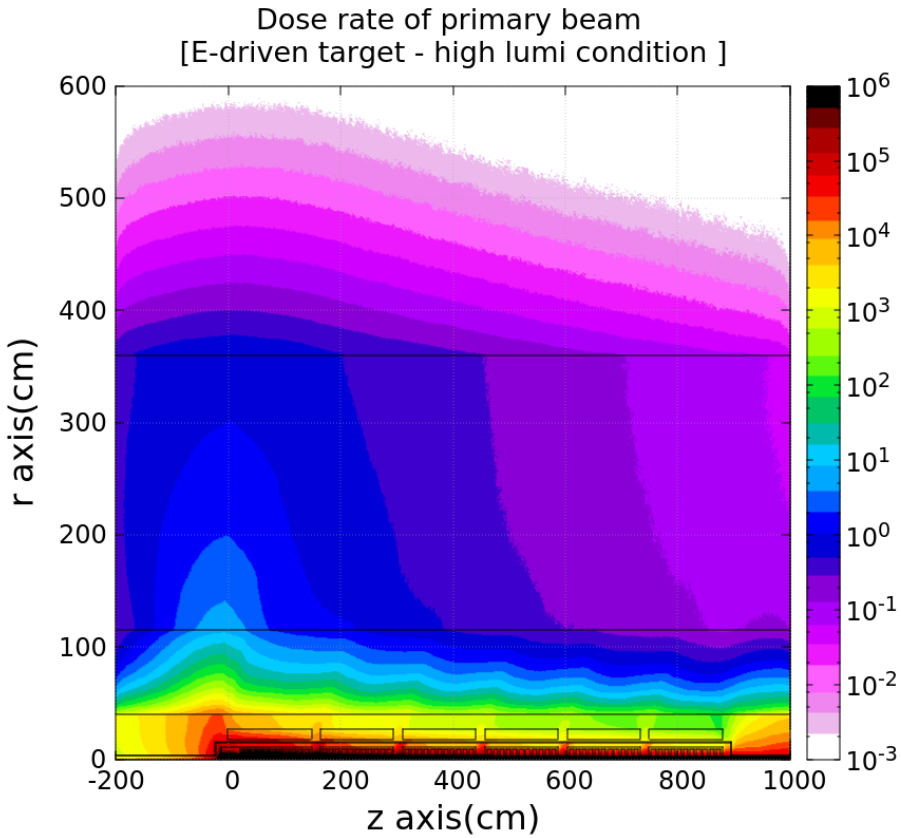
Iron Shield 0.75 m
and
Boronized Concrete 2.5 m

Note: If the guideline is relaxed by 10 times, the concrete is shorten to 1.6 m. It seems too optimistic.

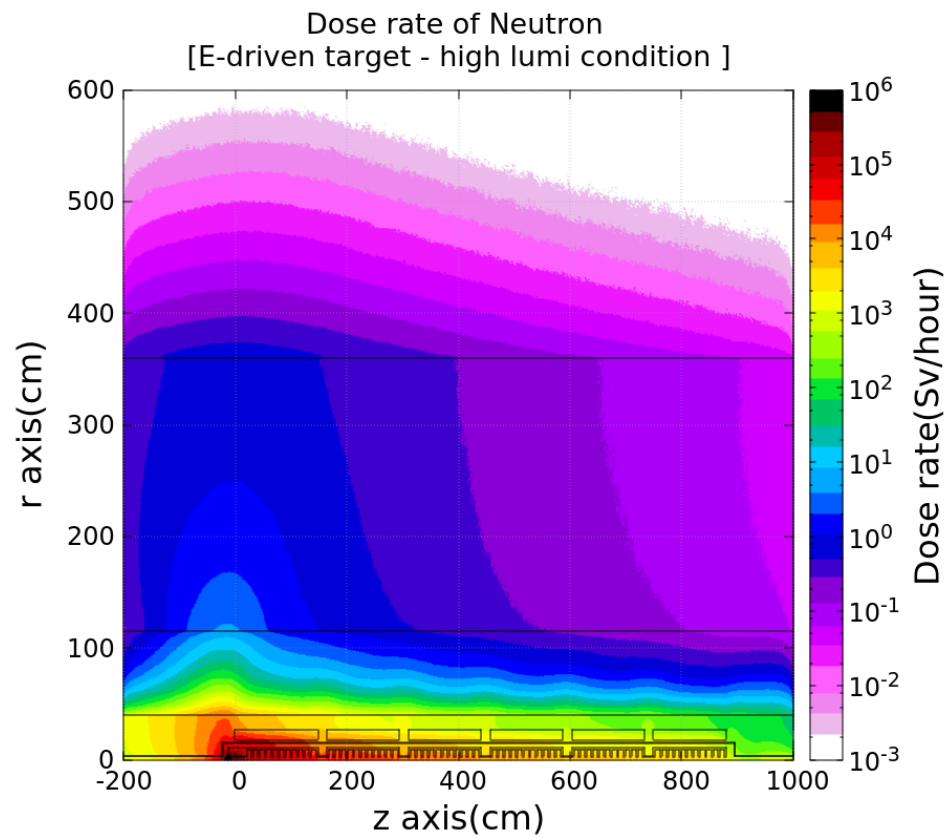


Neutron dominant radiation

Total Dose Rate Profile



Neutron Dose Rate Profile



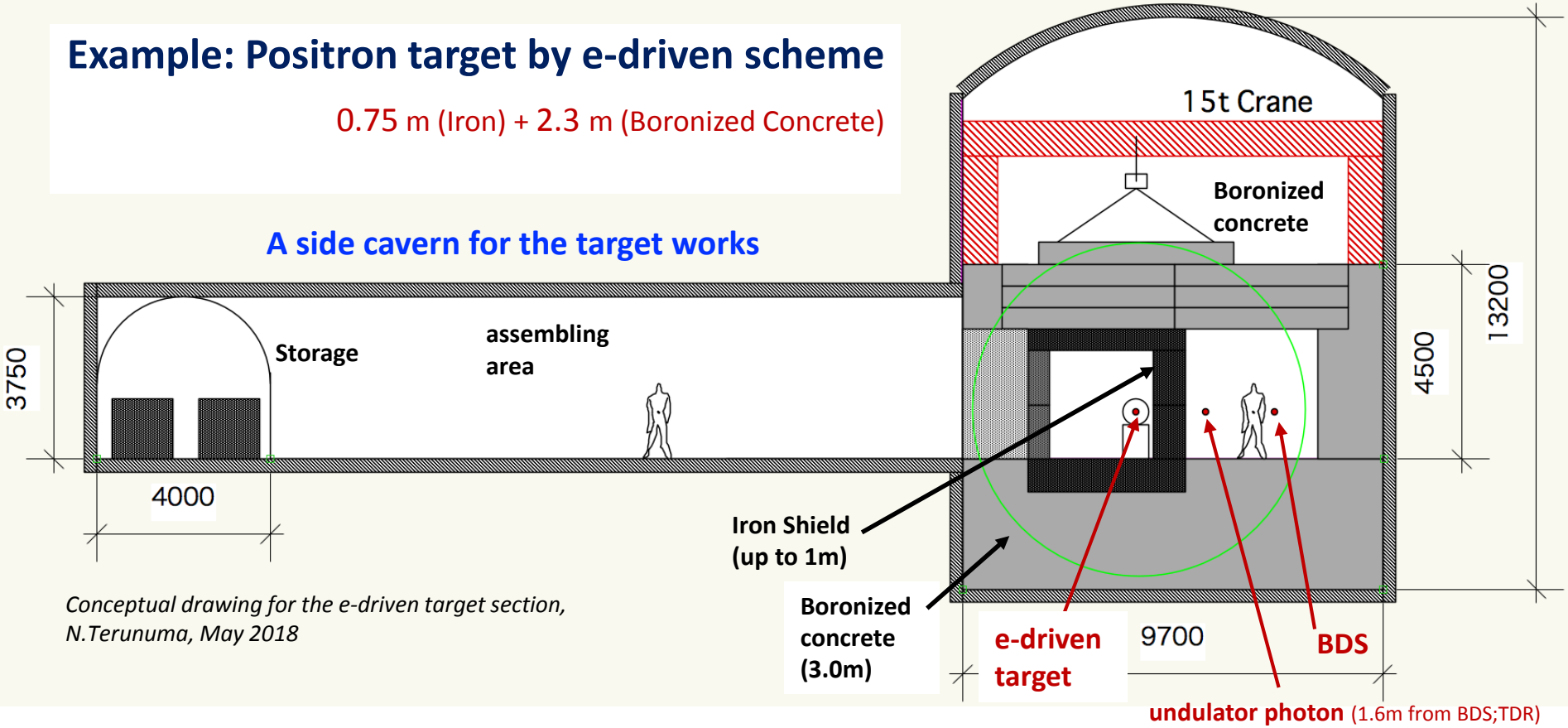
- **Difference of above figures is only for forward direction.**
  It will be by photons, electrons and muons.
- **These figures also show how long longitudinally-shielded-area is needed.**
  Dose rate drops about two orders for 10 m.

Cavern may be needed for heavy radiation point

Example: Positron target by e-driven scheme

0.75 m (Iron) + 2.3 m (Boronized Concrete)

A side cavern for the target works



Conceptual drawing for the e-driven target section, N.Terunuma, May 2018

- **For the decommissioning in future**

  Core part of heavy activation should have a possibility to remove from underground.

  ➔ assemble by blocks

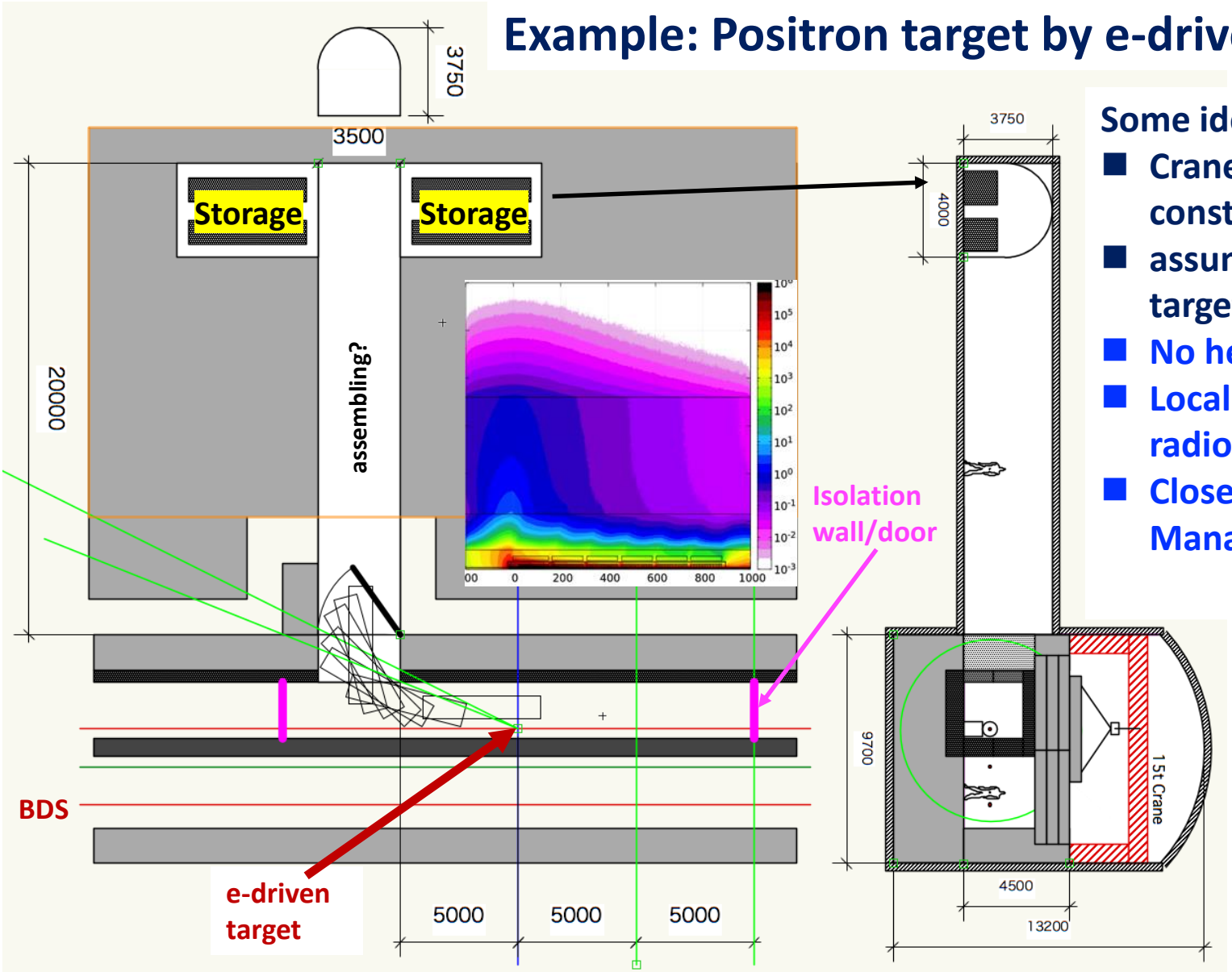
- **Iron and Concrete, about 3m shield is required for "underground environment".**

  Is it possible to make 2m-thick wall on the ceiling of large cavern? NO!

  ➔ put blocks on the primary shield box

For the exchange of Positron Target

Example: Positron target by e-driven scheme



Some ideas…

- Crane is used for construction only
- assumed 5m unit for a target exchange (max?)
- No heavy door
- Localizing the radioactive work
- Closed activated air Management

Power supply room in this region:

- Where?
- Anyway, we need shields.
- More wider/higher cavern?

Short summary of shield study for positron source

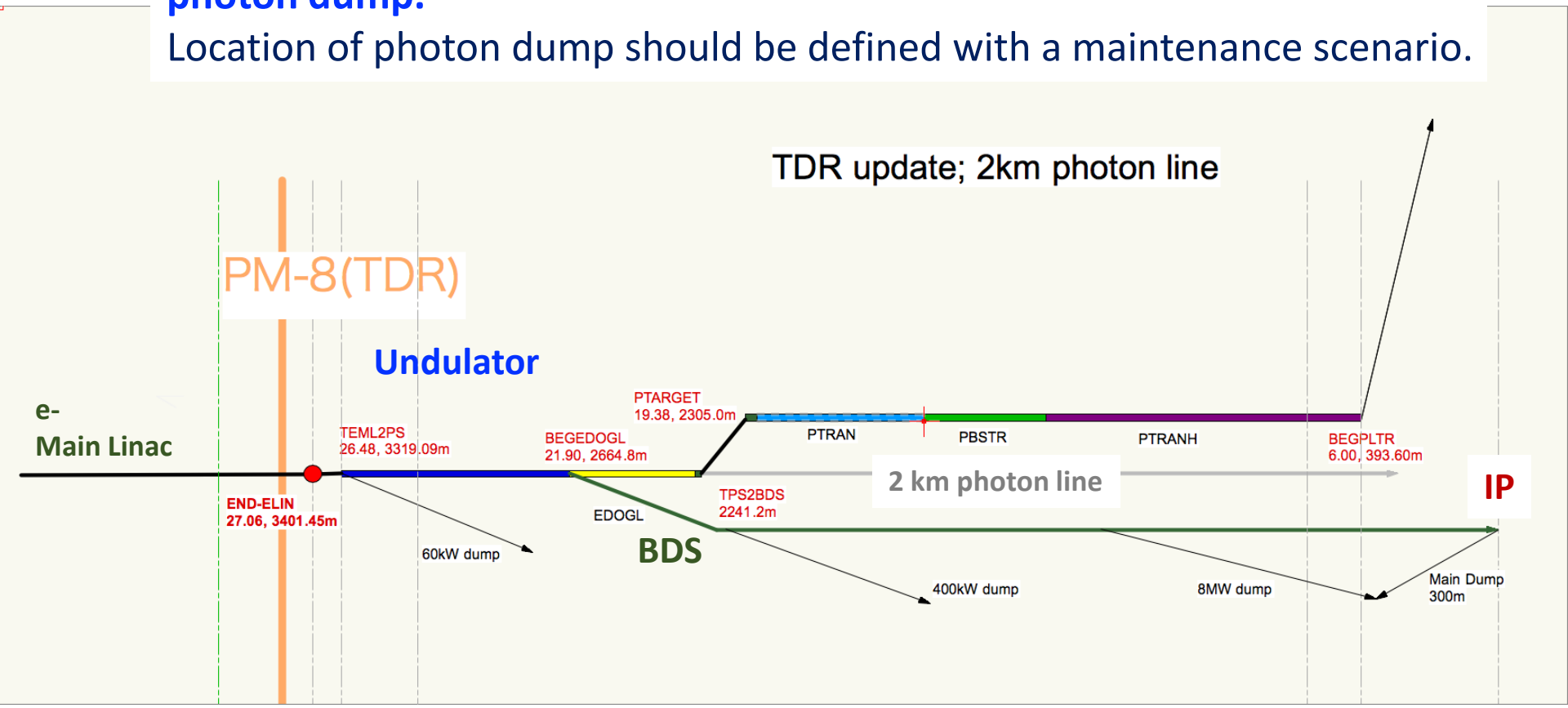
	beam spec. and deposit power	Thickness to 5 mSv/h for rock/groundwater (beam ON)		Thickness to 20 uSv/h for BDS workers (beam off)	personal comments
		Iron	Boronized concrete		
Target: e-driven	electron 98 kW	**0.75 m**	**2.3 m**	**0.75 m (Iron)**	**Cavern** may be required
Target: undulator	photon 15/120kW	**0.75 m**	**0.25 m**	←	
Photon dump (Graphite)	photon 120 kW	**0.5 m**	**0.5 m**	←	fix the location; i.e., **fix the multi-beamline configuration**
Tune-up dump	positron 60 kW	**0.5 m**	**1.5 m**	N/A. local pit in the wall	

Note: Above thickness means a transverse path length from a radiation source. Combination of shield materials and their thickness can be optimized.

Positron source beamline: baseline

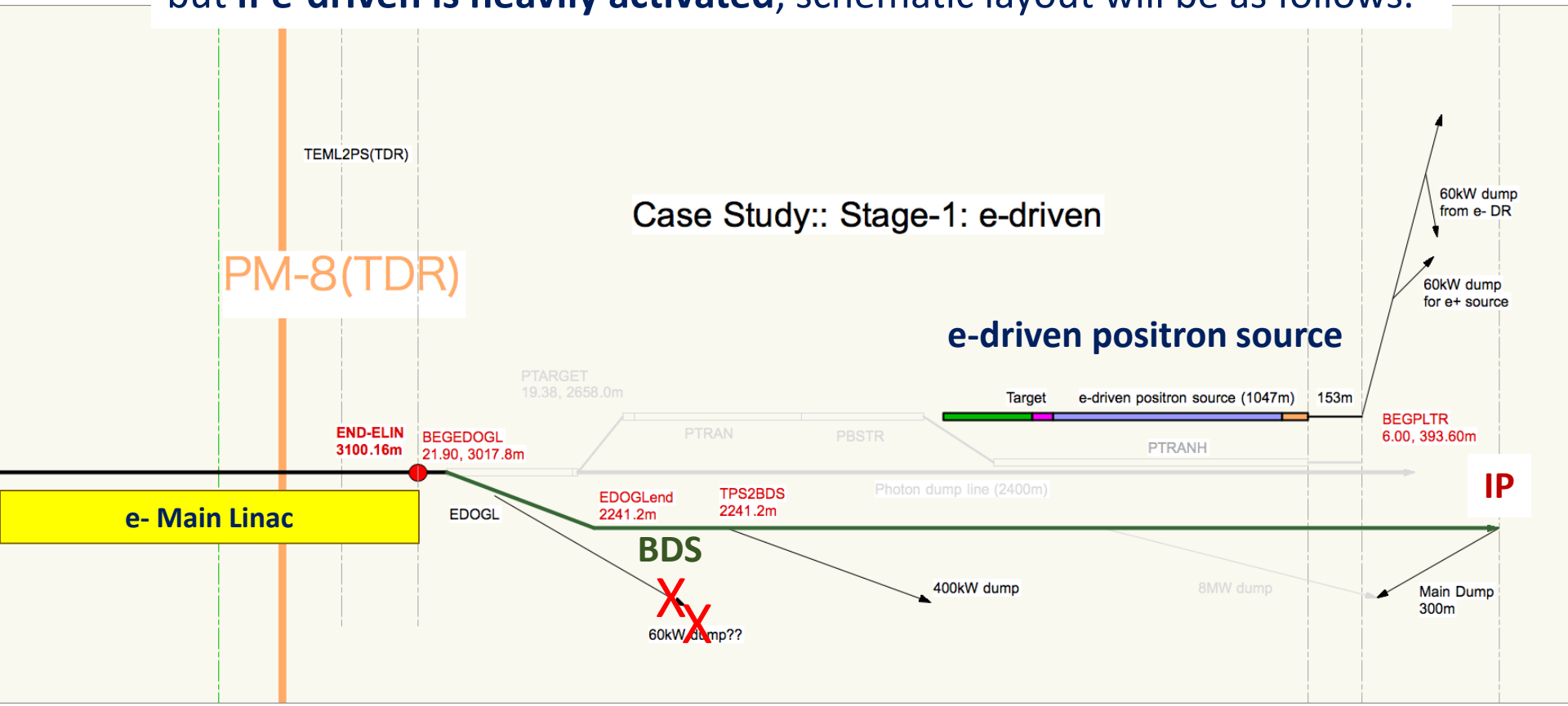
The beamline layout have to be updated with long photon line to the photon dump.

Location of photon dump should be defined with a maintenance scenario.



Positron source beamline: backup(1)

In the case of **starting with e-driven** and **change to undulator**,
but **if e-driven is heavily activated**, schematic layout will be as follows.



Positron source beamline: backup(2)

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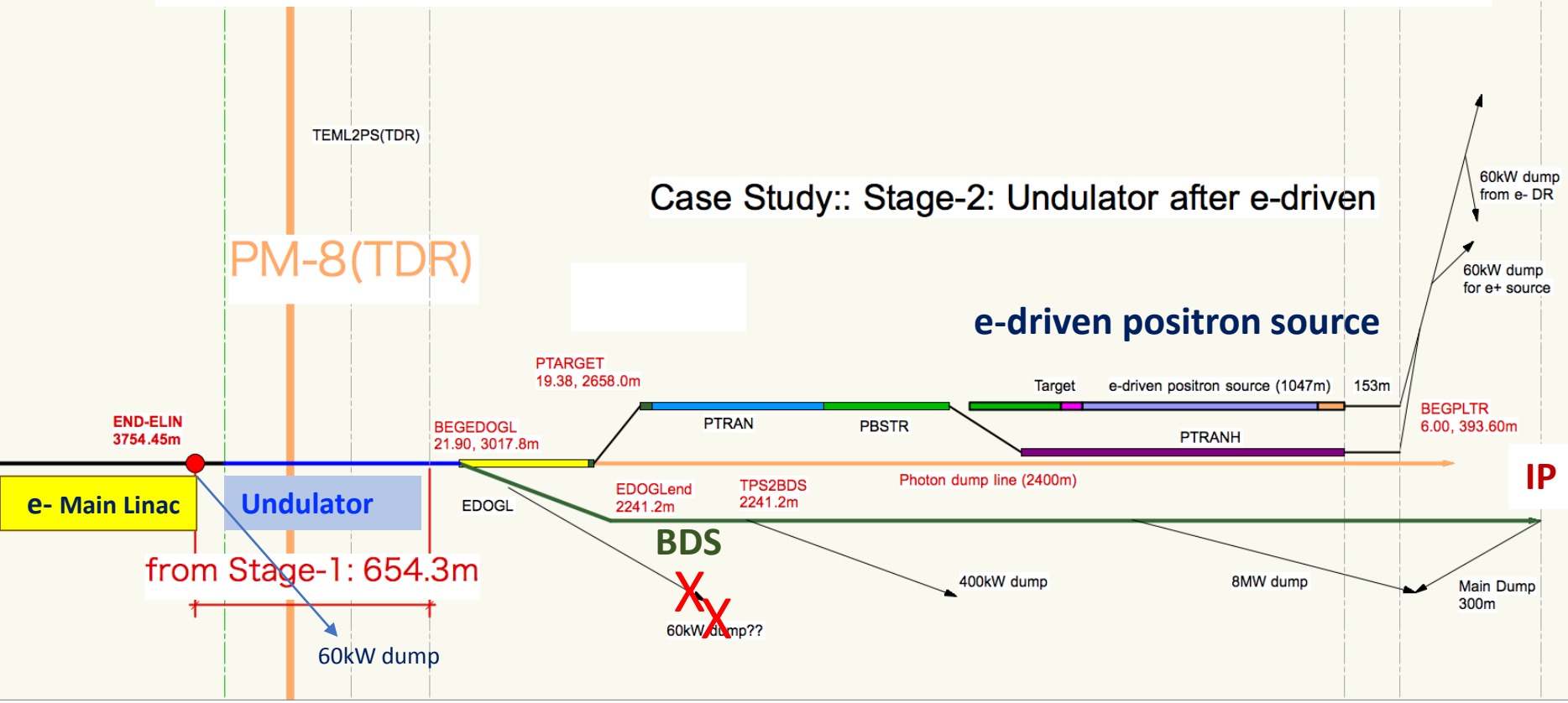
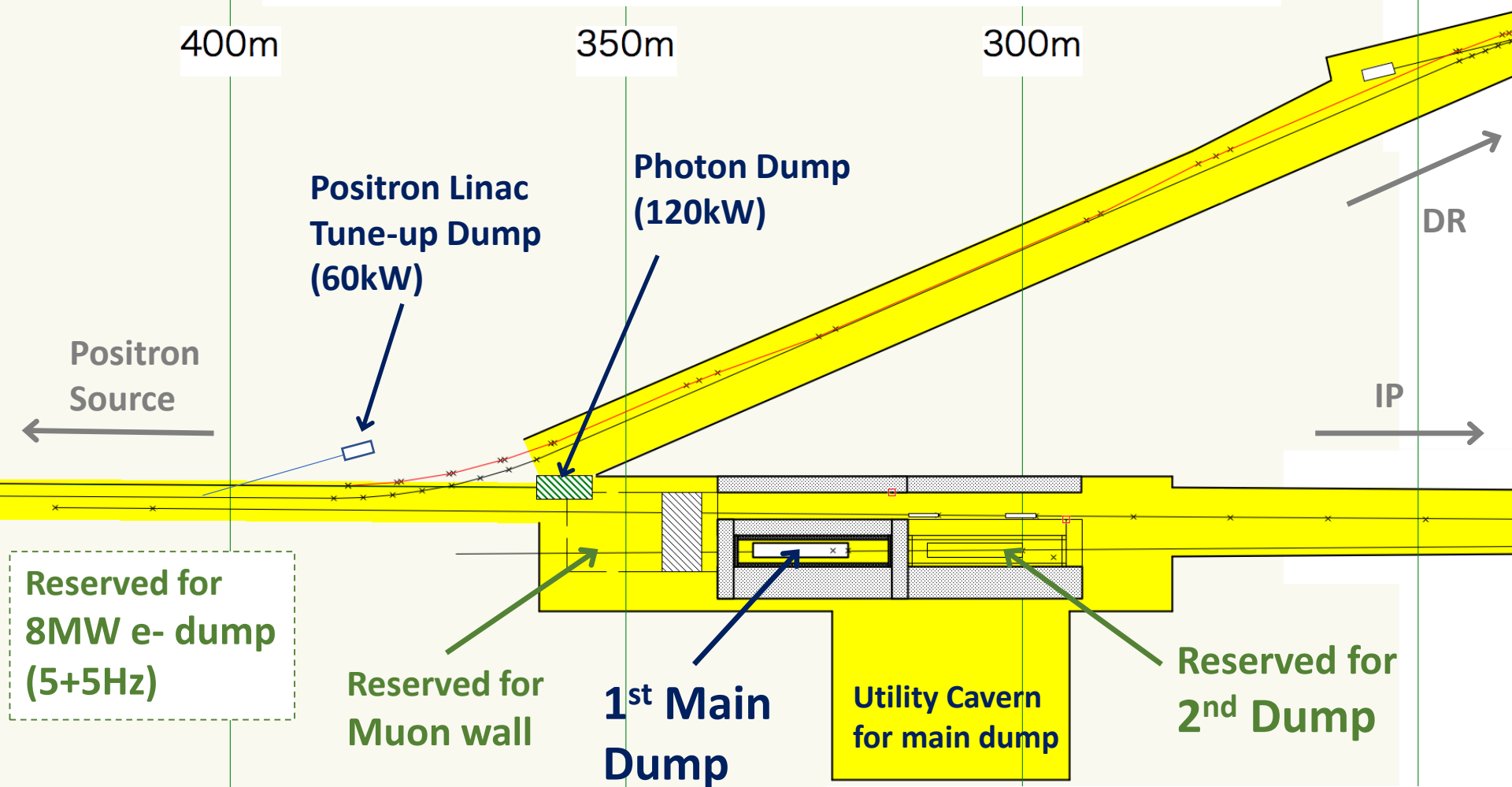


Summary: Main Beam Dump and Around

Time for the CFS engineering design is limited.
Fix beamlines, location and size of systems!



Where the 2nd-loop water come from?

Summary

- **A lot of design works are needed for CFS.**
  - **Fix accelerator layout both for e-driven and undulator, and also combination(?).**

Comments

- **A cavern for e-driven target** will be required but the construction itself **may not be a kind of show stopper.** We have many similar cavern already.
- **Heavy radiation of e-driven target section should be treated as one of the reliability issue.**
- **CFS cost related to each positron scheme will be pushed aside.** It is not a big portion anyway.

Backup slides


15t
HITACHI
LARK

Positron source beamline: baseline

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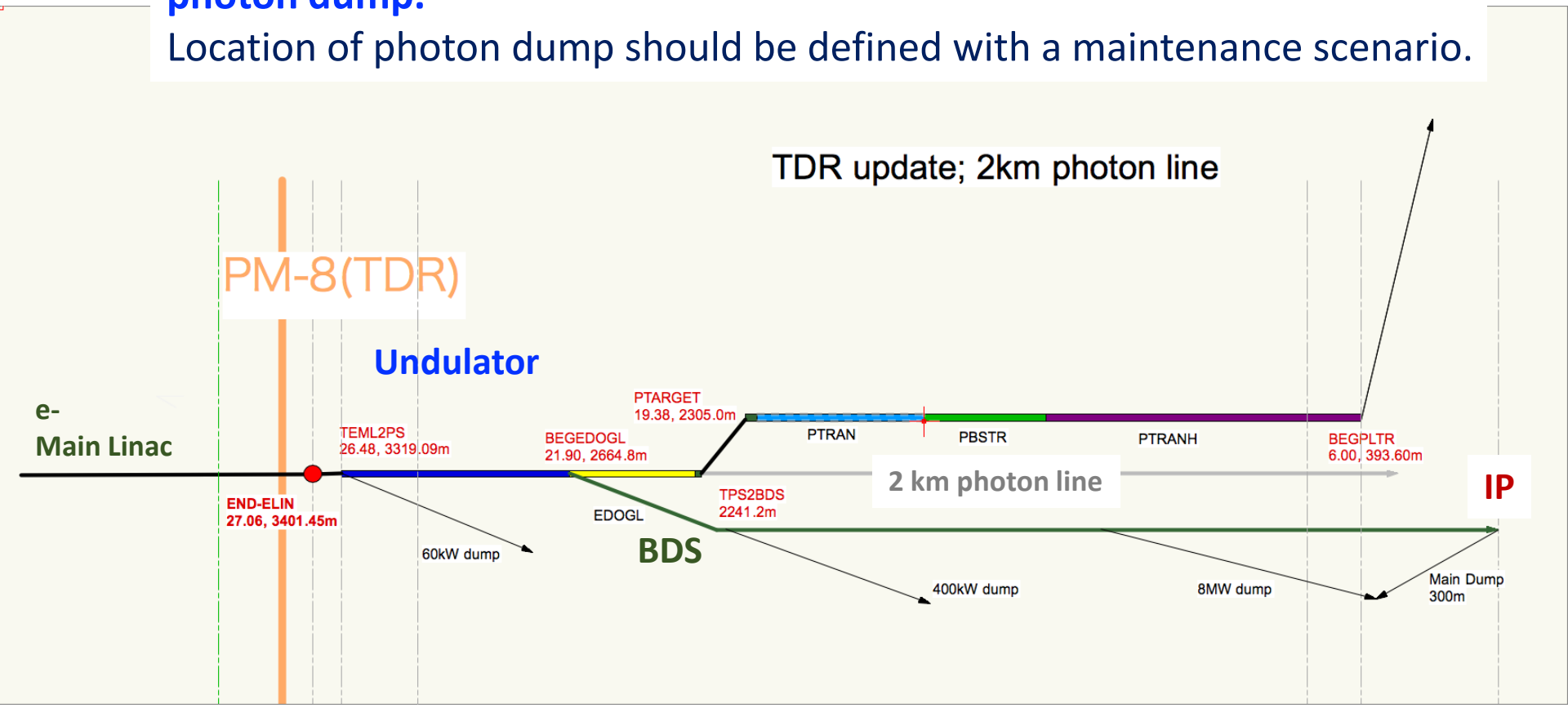

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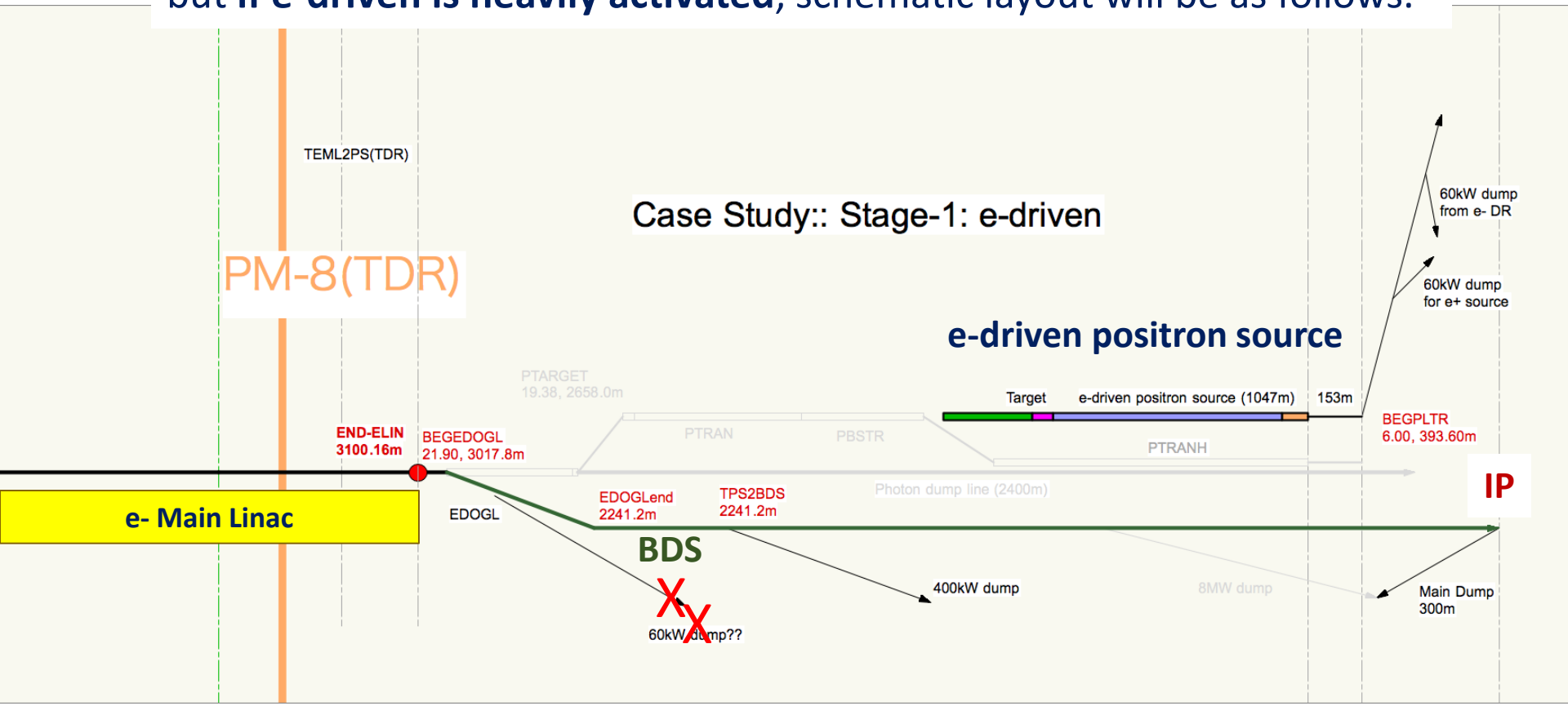

Positron source beamline: backup(2)

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