Another Crazy Idea of a LC Dump

by Albrecht Leuschner

Compared to the Water Dump Design

by the dump group:

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based on the experts reports by “FICHTNER” and “FRAMATOME”
Introduction

- The TESLA main dumps turn out to be large facilities like next generation spallation sources.
- The antis of the TESLA project can find here “good” arguments for their interests.
- That’s why a new idea of a dump is presented which sounds crazy but might be suitable nevertheless.
Risks not to get Permission for the Water Dump

- High **Hydrogen Gas** Production Rate (detonating gas). The whole water inventory (30 m³) is cracked 4 times per year!
- High **Tritium** content could be misused in **weapons**.
- High **Tritium** concentration in the coolant requires huge effort in radiation protection, e.g. chimney (>= 20m high), containment,…
- R&D of the Dump **Window** is more than a challenge (Diam.: 20 cm, static pressure: 10 bar, dynamic pressure: 0.5 bar, + radiation damage).
Graphite – Copper – Water Dump

- Cross section is 1 m x 1 m, length 5 m.
- Fast sweeping system distributes the beam energy within the graphite.
- Slow sweeping system distributes the beam into all graphite layers.
- Heat is conducted through the copper to the water.
- Concept dismissed early.

Front view
Water Dump

- Diameter 1.20 m, length 10 m.
- Fast sweeping system distributes the beam energy of a single train to avoid boiling (sweeping radius: 8 cm).
- Turbulent water flow ensures that every train is dumped in almost fresh water.
- A static pressure of 10 bar increases the boiling temperature of the water up to 180 degree C.
Noble Gas Dump

- Diameter including shielding: 1.20 m, length 1000 m. It’s built up with modules shaped like the cryo-modules.
- Noble gas (first attempt: Ar @ 1 bar) in the inner tube (Ø 8 cm) acts as scatterer, (energy deposition of 0.5 %) and distributes the beam energy longitudinally (no sweeping).
- Main part of the energy is dumped in the 50 cm thick iron shell (average 18 kW/m).
- Gas has damping properties with respect to energy deposition and pressure jumps.
- Can be used as a $\gamma$-$\gamma$ dump as well.
Tunnel Cross Section

at a length of 1000 m !!

Ar filled beam pipe

Iron cylinder

Water cooling
Energy deposition

400 GeV electron

Energy deposition in GeV/cm³

Radius in cm

Length in m

Air
Water
Iron
Argon
Material Recovery after Ionization

Beam energy is deposited by ionization: breaking of compounds (radiolysis of water), destruction of the structure of solid materials (metal lattices).

Absorber should be out of a one-atomic gas (Ar, Xe)

Graphite Dump
The impact of the beam on the Carbon lattice is not known. But an increase of the heat conductivity cannot be expected.

Water Dump
Dumping the beam into the water leads to a net Hydrogen gas production of 6 liter per second (NTP) @ 20 MW. The entire cooling water stream has to be depressed, degassed and pressed in every cycle.

Noble Gas Dump
The beam interacts first with a one-atomic gas (Ar, Xe). The low density of the gas lengthens the shower to 1000 m leading to low power densities in the gas and the surrounding metal (Fe).

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TRITIUM Production

Tritium production decreases with increasing atomic number and remains constant above 20:

Main part of the energy should be absorbed by elements heavier than Ca.

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**Graphite Dump**
- High
- Guess: 300 TBq (Saturation)
- 100 TBq in water,
- 200 TBq in C, Cu

**Water Dump**
- High
- Calc.: 300 TBq (Saturation)
- 300 TBq in water

**Noble Gas Dump**
- Medium
- Calc: 30 TBq (Saturation)
- 0.7 TBq in gas
- 0.02 TBq in water
- 30 TBq in iron
Beam - WINDOW

It has to withstand the static pressure of the dump medium as well the pressure jumps due to the beam. Radiation damage degrades its stability.

- Low static pressure.
- Low dynamic pressure jumps.
- Small diameter.

<table>
<thead>
<tr>
<th></th>
<th>Graphite Dump</th>
<th>Water Dump</th>
<th>Noble Gas Dump</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pressure:</strong></td>
<td>1 bar static</td>
<td>10 bar static</td>
<td>1 bar static</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.5 bar dyn.</td>
<td>0.01 bar dyn.</td>
</tr>
<tr>
<td><strong>Diameter:</strong></td>
<td>100 cm</td>
<td>20 cm</td>
<td>8 cm</td>
</tr>
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Component Activity

Residual activity leads to a permanent radiation level even after the beam is shut down. For maintenance dose rates lower than 0.1 mSv/h are desirable.

**Graphite Dump**
Not calculated, for a guess see Water dump.

**Water Dump**
1.2 mSv/h
Near the shielding at the shower maximum.

**Noble Gas Dump**
≈ 1 …10 mSv/h
Rough scaling, not calculated in detail.
Maintenance

The exchange of the beam window is taken as an example of maintenance. Comparison is done on the basis of Tritium release.

**Graphite Dump**
Not Considered.

**Water Dump**
The water of the primary circuit has to be deflate and the components to be dried by a gas flow. Let the gas dryer 5% of the activity get through. Here a 20 m high chimney is needed for a release of 10 GBq.

**Noble Gas Dump**
The activated Argon is rinsed out and pressed to a vessel. 5000 liter @ 1 bar. A leakage of 0.1% leads to a 0.03 GBq Tritium release.
Cases of Emergency

Impact of some cases of emergency on the public and/or the staff are evaluated from the point of radiation protection.

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<th>Graphite Dump</th>
<th>Water Dump</th>
<th>Noble Gas Dump</th>
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<tbody>
<tr>
<td>Leakage in the primary cooling water circuit.</td>
<td>High</td>
<td>Non</td>
</tr>
<tr>
<td>Beam window broken.</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Failure of the main pump.</td>
<td>Medium</td>
<td>Non (hour)</td>
</tr>
<tr>
<td>Gas leakage</td>
<td>Low</td>
<td>Low (sec.)</td>
</tr>
</tbody>
</table>
Permission much more likely for the Noble Gas Dump

- No **Hydrogen Gas** Production because the water is heated by conduction and not by ionization!
- Medium **Tritium** content (sat.act: 30 TBq) is housed in 8000 tons of iron. It can **not** be misused in **weapons**.
- No **Tritium** concentration in the coolant (0.02 TBq), and low **Tritium** concentration in the noble gas (0.7 TBq) do **not** require huge effort in radiation protection, e.g. chimney (>= 20m high), containment,…
- Dump **Windows** are already **available** (Diam.: 8 cm, static pressure: 1 bar, dynamic pressure: 0.01 bar, + radiation damage).
Problems to Solve for the Noble Gas Dump

- Whole dump philosophy of TESLA has to be changed. Crossing angle solutions are preferred. Dump halls are replaced by dump tunnels.
- 1000 m of the TESLA tunnel is activated to dose rate levels of a few mSv/h. The dump module has to be optimized and additionally shielded to reach some or less than 0.1 mSv/h. An adopted tunnel design is desirable.
Ventilation concepts for activated air were intensively studied at DESY (Lab.Notes DESY D3 –104, 104a). The comparison is done on this basis using Tritium production in air. The parameters are:

- Point loss: “shower length”: 6 m
- Beam power: 100 kW, linear loss power: 17 kW/m
- Shielding: 20 cm iron
- Tritium saturation activity: 0.45 GBq
- Air volume: 120 m³
- Specific saturation activity: 3.8 MBq/m³

### Air Activation

<table>
<thead>
<tr>
<th>Water Dump</th>
<th>Noble Gas Dump</th>
</tr>
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<tbody>
<tr>
<td>6 m</td>
<td>1000 m</td>
</tr>
<tr>
<td>3000 kW/m</td>
<td>18 kW/m</td>
</tr>
<tr>
<td>20 cm iron</td>
<td>50 cm iron</td>
</tr>
<tr>
<td>180 cm concrete</td>
<td>8.4 GBq</td>
</tr>
<tr>
<td>1.4 GBq</td>
<td>20000 m³</td>
</tr>
<tr>
<td>3000 m³</td>
<td>0.42 MBq/ m³</td>
</tr>
<tr>
<td>0.47 MBq/m³</td>
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</tbody>
</table>

Graphite Dump

Not calculated, for a guess see Water dump.
Direct Radiation: Muons

The muon range in soil is about 700 m behind a 400 GeV electron dump. Almost no radiative processes but ionization constitute the stopping power. Soil layer above the tunnel is not thick enough for muon shielding. Another 2 m are needed.

Graphite Dump

See Water dump

Water Dump

Electron beam is bent downward by 15 mrad.

Noble Gas Dump

Dump is longer than the muon range. 0.5 m iron = 2 m soil additional by the dump itself.
Direct Radiation: Neutrons

High energetic neutrons have a long attenuation length. They are emitted almost isotropically.

**Graphite Dump**
- See Water dump
- 3 m concrete + 7 m soil
- = 0.12 mSv/a

**Water Dump**
- 3 m concrete + 7 m soil
- = 0.12 mSv/a

**Noble Gas Dump**
- 0.4 m iron + 10 m soil
- = 0.05 mSv/a