Photon Dump for the Undulator Driven Positron Source

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1.Introduction

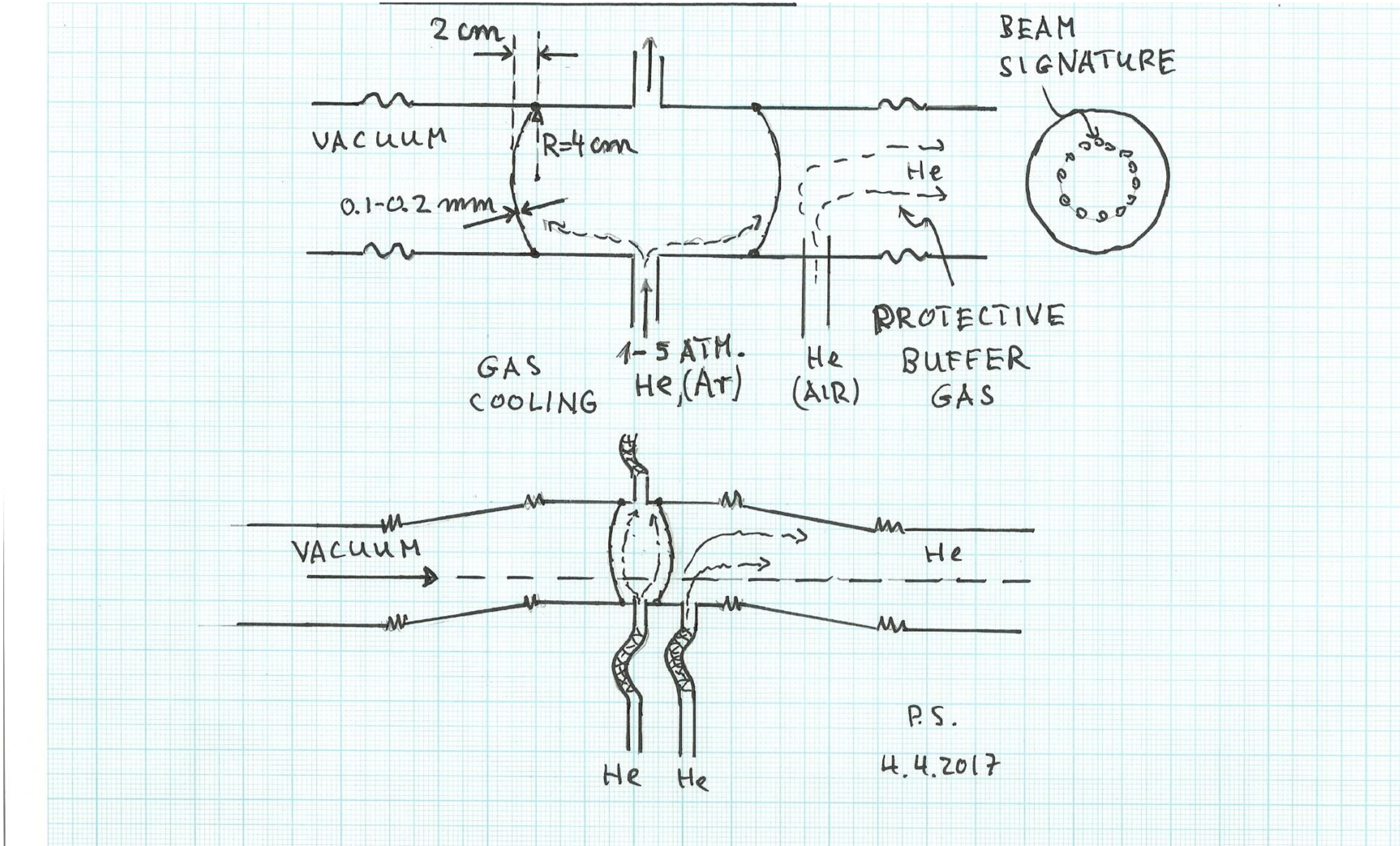
- An undulator with 250 GeV and 2625 bunches is assumed.High Lumi.
- Computations for 125 GeV and 1312 has still to be done. Simple down scaling is not good enough.
- FLUKA computations for the passage of the photon beam through thin Ti-windows and in water were made for High Lumi.
- They show, that the energy deposition EDD in thin windows rises linearly with the thickness and the radial distribution is close to the profile of the incident photon beam.

- To investigate the influence of the photon beam size, which depends due to its divergence, on the Target-Window distance, two cases have been considered.
- Close Window, at 48 m from the target.
- Far Window, at 1 km from the target.

2. The Tumbling Window

- As presented previously in the recent Morioka Workshop, a stationary Ti-window will suffer from elevated temperatures, thermal stresses and fatigue and radiation damage.
- Only very thin windows of 0.1-0.2 mm thickness can be used.
- Since the photon beam cannot be swept, the window has to be "swept".
- Therefore a "Tumbling Window" is considered.

Lay Out of the Tumbling Window



- The tumbling movement, the frequency, is 0.16 Hz, enough to displace the window by one beam width between pulses. The time between hits of the same spot is thus 6.4 s, much longer than for a stationary window with 0.2 s. Number of hits per spot is reduced by a factor 32.
- Therefore gas cooling is much simpler for the tumbling window. Optimize gas pressure and gas velocity.

- To accommodate the beam signature on the window, a circle with a diameter of 5 cm, the diameter of the window has to be 8 cm.
- For the flow of the buffer gas, injected downstream of the window, air or better He of several kg/h is to be used.

Design Figures for the «Close» Tumbling Window at High Lumi

Window Thickness (mm)	0.1	0.2
ΔT/Pulse (K)	47.	94.
Thermal Stress/ Pulse (MPa)	71.	141.
Peak Temp. in Steady State with He-Gas Cooling 1Atm. (C).	67.	114.
Static Stress by Gas Pressure at 1 Atm (5 Atm) (MPa).	20. (100.)	10. (50.)
Life Time (h) for max 0.5 dpa.	1150.	1150.

Design Figures for the “Far” Tumbling Window at High Lumi. PEDD scaled down by a Factor 7.5, tbc.

Window Thickness (mm)	0.1	0.2
ΔT/Pulse (K)	6.2	12.5
Thermal Stress/pulse(MPa)	9.5	19.
Peak Temperature in Steady State with He-Cooling (C).	26.2	32.5
Static Stress with He at 1 Atm (5 Atm).	20. (100.)	10. (50.)
Life Time (h) for 0.5 dpa	8000.	8000.

3. The Water Curtain Dump.

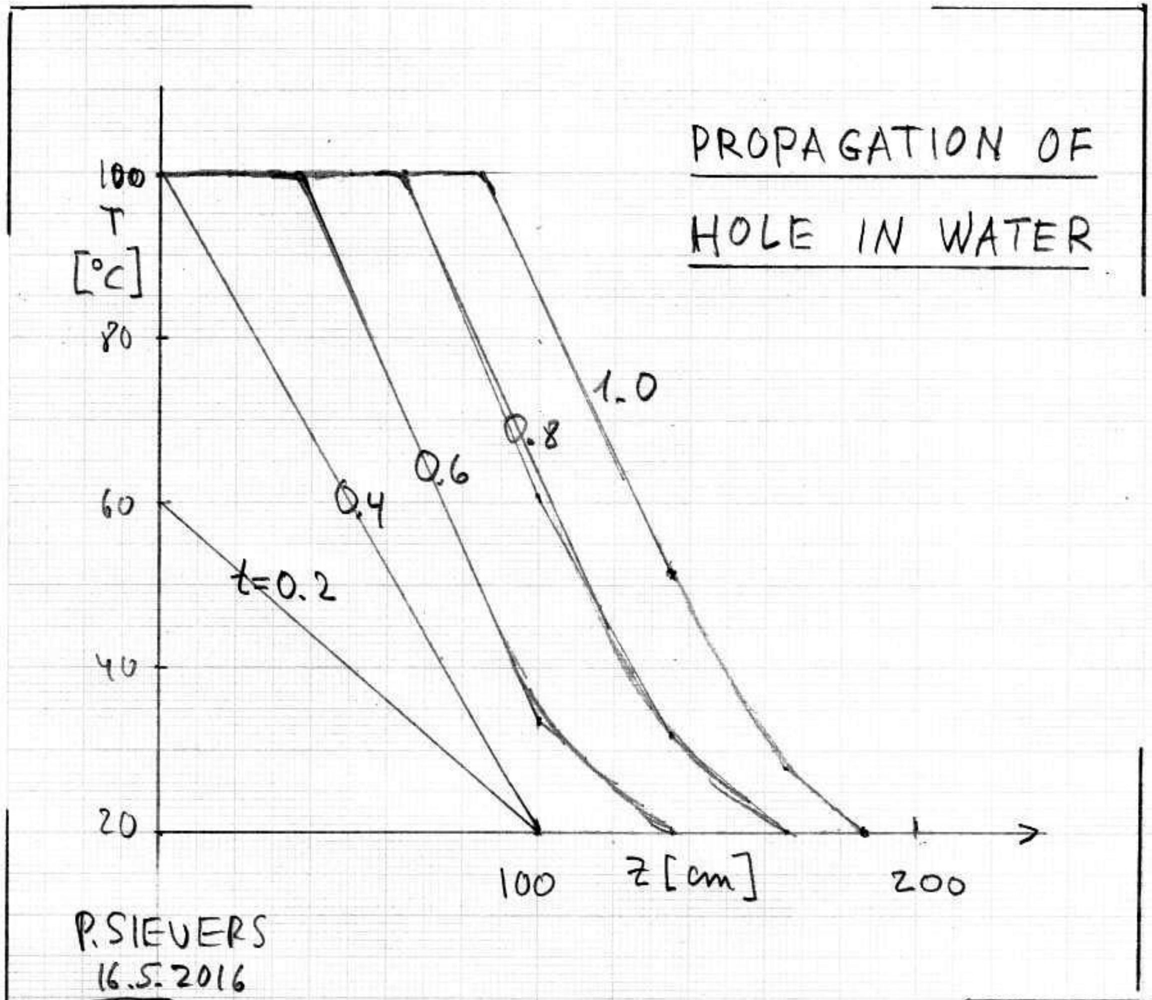
- A Ti-window in direct contact with the water of the dump should be avoided. High pressure, corrosion, thermal stresses, radiation damage.
- The tumbling window solves part of this problem.
- The “hot” cascade in the water, where most of the energy is deposited, extends over about 1 m and a radius of 5 cm. It contains 66% of the beam power of 86 kW.
- Along the axis, the energy deposition is still very narrow, close to the beam size.

- Energy deposition by the High Lumi beam in the water dump (A. Ushakov), placed at 48 m and 1 km downstream of the target.

Axial Position z (cm)	**0.01**	**4.-5.**
PEDD (J/g) for close (far) dump	~ 80. (11.)	760. (101.)
ΔT/pulse (K)	~ 10. (~1.-2.)	181.! (~ 24.)

- To avoid pile up of the temperature in the water between pulses, a vertical flow of the water of some cm over 200 ms, 0.1 m/s is required.
- Whenever a EDD of about 340 J/g is reached, (see A.Ushakov), the water will start to boil.
- The vapor created along the axis may push aside the surrounding water.
- A hole may be created already DURING the beam pulse.
- The remaining beam pulse will continue to drill.
- Where does this process end?

A simple Model: Assume an EDD decreasing linearly with z from 760 J/g to zero at z=100 cm and at t= 1ms.

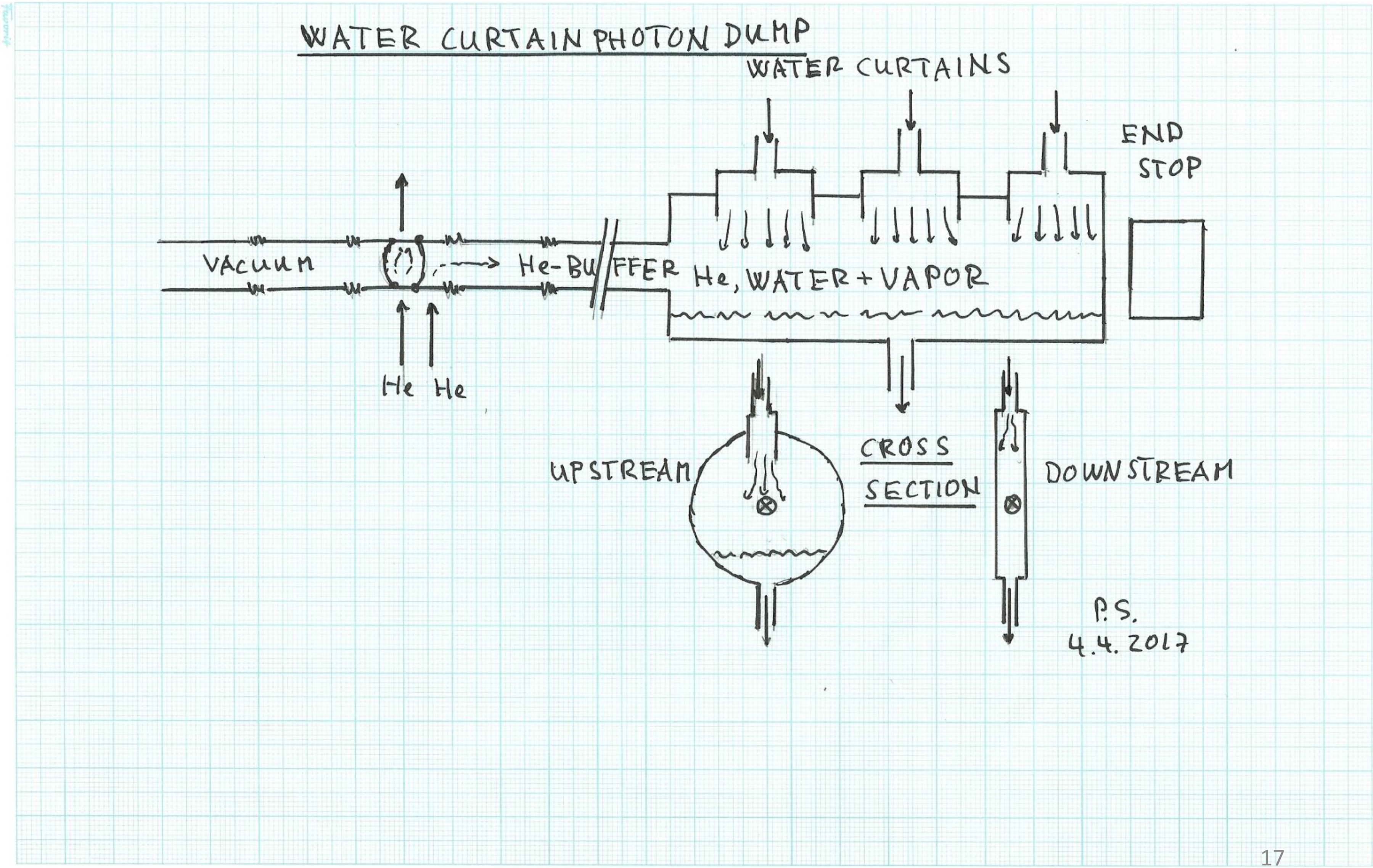


- This should be calculated more precisely.
- However, one may expect that the depth of the hole due to boiling at the end of the pulse will be about 1. m.
- One needs an additional water length of some meters, to contain during 1 ms fully the evaporated zone and to provide downstream additional “healthy” water, to contain fully the beam energy, till a safe metallic end stop can be used.

Pressure Waves in the Water

- In addition to the boiling problem, the beam causes linearly rising thermal expansion of the liquid volume over 1 ms.
- This is partially prevented by the surrounding, cold water and by the mass inertia of the heated volume itself.
- This can cause pressure waves with positive and negative pressure (depletion) waves already during the pulse.
- At “negative” pressures, the water may “brake up”, start to boil and create a hole.
- Such negative pressures of -1.5 atm have been reported for the TESLA-water dump (M. Schmitz).
- At what time during the pulse does this occur? To be studied.

Water Curtain Photon Dump



4. Discussion and Conclusion.

- A tumbling window, in combination with a water curtain dump at 1 atm could be an option.
- By placing the tumbling window about 10 m upstream of the water dump, its replacement or preventive exchange can be envisaged.
- Direct contact of the window with water is avoided. It is only in contact with air (?)or He.
- The water and vapor is completely confined in a closed circuit.

- The production of water vapor in the tank of the dump must be tolerated.
- The response of the water to the beam pulse must be studied in more detail, using professional FEM-codes, comprising dynamic effects, depletion waves and phase change in water.
- At what time during the pulse does this occur?

- The water of the dump is continuously "reconditioned" in the associated water treatment plant. So, no radiation damage.
- The required water flow is about 10-30 kg/s.
- The total length of the water dump could be about 8 m (tbc) to allow for a safe end window and end stop.
- Space for shielding and other safety aspects, water leaks, production of Tritium, Be7,…to be studied.

- The Ti-window is probably the most critical part.
- Tests of Ti-windows are under way at MAMI.
- Further expertise with Ti-windows exists with proton beams at T2K, PSI,….
- With preventive maintenance of the window, its limited life time can be handled.
- Due to the enlarged beam size for the far dump, the window will have a much longer life time.

- Also the dynamic effects in the water, if they exist, will be much smaller in the far dump.
- The water treatment plant for the ILC main dumps can be used in parallel for the water treatment of the photon dump.
- For the far dump, the pointing direction of the photon beam should be controlled within +/- 10 μ rad.
- Prototyping and long term tests of the entire system is virtually impossible.
- So, lets jump into the cold water!
- Thank you.