APPLE CONCEPT

The Li_2O Flowing Particulates Blanket Design

Configuration and Related Issues

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Accomodation of Penetrations in the APPLE Chamber

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- There are two shapes of penetrations that may be needed in the chamber:

  Rectangular as in RF

  Circular as in NB or pellet injection

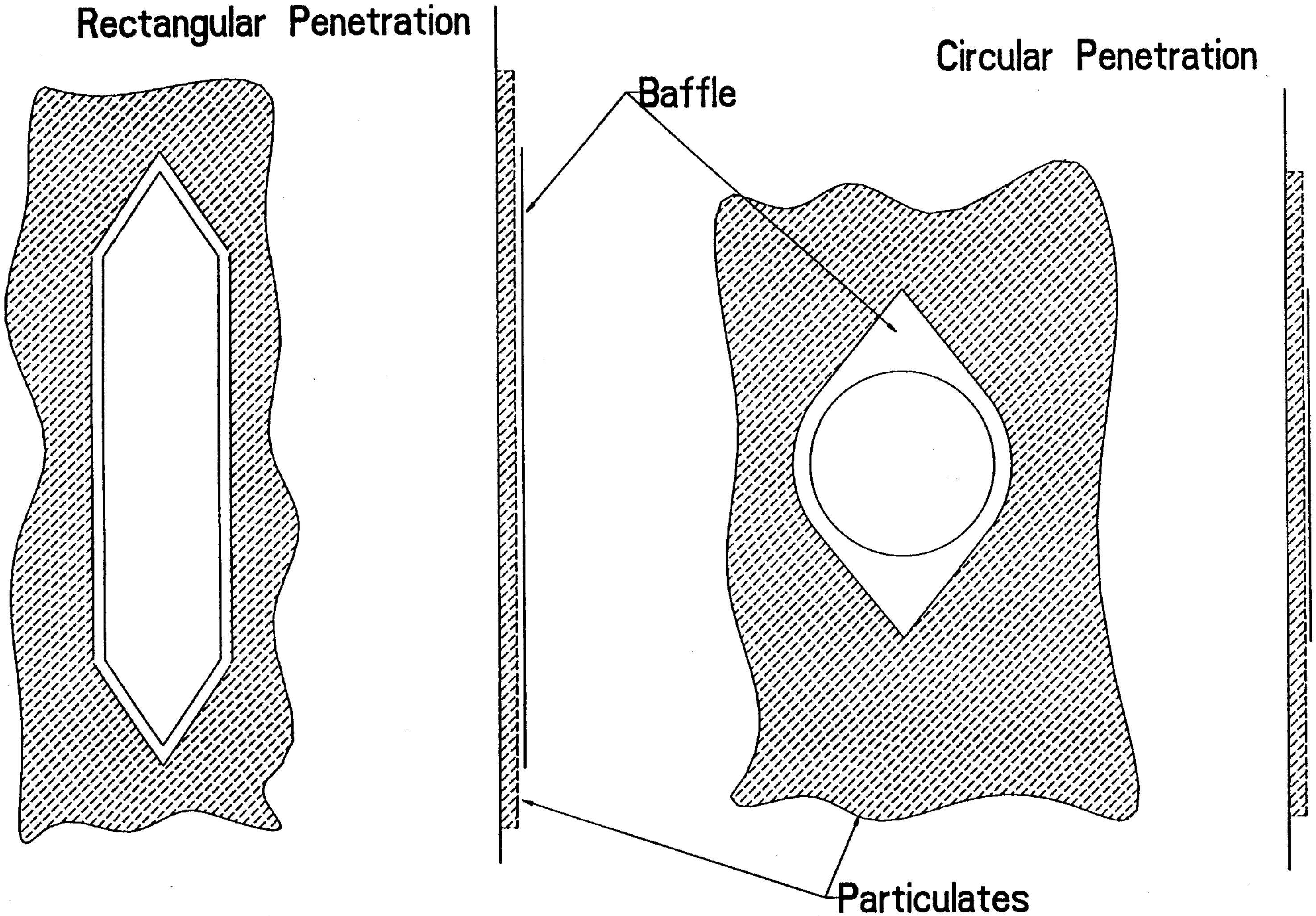
- Particulate flow around the penetrations must be smooth with no possibility of bouncing off in the wrong direction.

- Streamlining the flow above the penetration will be needed with baffles to prevent bouncing or scattering.

- Underneath the penetrations, there must be flow deflectors to move the particulates back under the penetration in order to continue their downward path.

- An issue with this scheme is the cooling of the baffles. One possibility is to use deflectors in the vertical legs to slow down the particulates and fill the space between the baffles and the back wall with higher density particles and thus provide cooling in that way.

Penetrations in APPLE Chamber First Wall



Effect of Disruptions on the APPLE Chamber

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- In the event of a disruption the plasma current will transfer into the nearest conducting surface, which in this case is the metalic reflector/shield
- This reflector/shield is a massive steel lifetime component which can withstand very high forces from J X B interactions
- The thermal component of the disruption will either impact the flowing breeder particulates or possibly the SiC baffles.
- If the particulates are impacted, some evaporation will take place or they may get accelerated and scattered around the chamber. Scattered particulates drain to the bottom and out of the chamber.
- If the SiC baffles are impacted, some material will be ablated. The BUCKY code will be used to determine the amount ablated and the recoil impulses. The design can then use this information to insure survivability.
- The bottom diverter baffle will have a drain to remove scattered particulates
- Recovery and start-up after a disruption should be relatively quick

Maintenance of Exposed APPLE Components

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- All the plasma facing components are made from SiC
- These components are non-structural and can withstand high radiation damage
- The plasma facing components will be designed for access and replacement through a single special purpose port
- Vacuum integrity is maintained by the metalic surface of the vacuum chamber
- The upper breeder isolation valves are closed and the breeder material is drained through the bottom of the chamber
- With the breeder removed, the empty blanket components are very light
- In the case of a LAR-ST, the whole blanket can be replaced wholesale through the top or through the bottom, as in ARIES-ST
- In the case of a conventional tokamak with a normal aspect ratio, segments of the blanket separated poloidally will be removed through upper access ports between coils (early ITER) or if that is not possible, they can be extracted in the radial direction through vacuum ports between coils (ARIES-RS).

Neutronics Summary

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- Overall TBR>1.2 is achievable
- A minimum blanket thickness of 40 cm required for structure to be lifetime component
- A total blanket/reflector/shield thickness of 105 cm required to allow for VV rewelding
- An additional 40 cm thick VV/shield required for adequate magnet shielding
- More than an order of magnitude reduction in decay heat and short term activity results from placing the structure behind the Li_2O particulate blanket
- Using LAFS permanent structure behind the Li_2O particulate blanket allows for near surface burial of the radwaste

What Are the Key Issues with the APPLE Concept?

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- Design and effectiveness of upper flow diversion baffles
- Cooling baffles exposed to the plasma
- Electromagnetically levitated Li_2O dust
- Plasma charge-up of particulates and consequent effects
- O_2 contamination of the plasma

Many of the R&D Experiments to Support APPLE are Simple and Inexpensive

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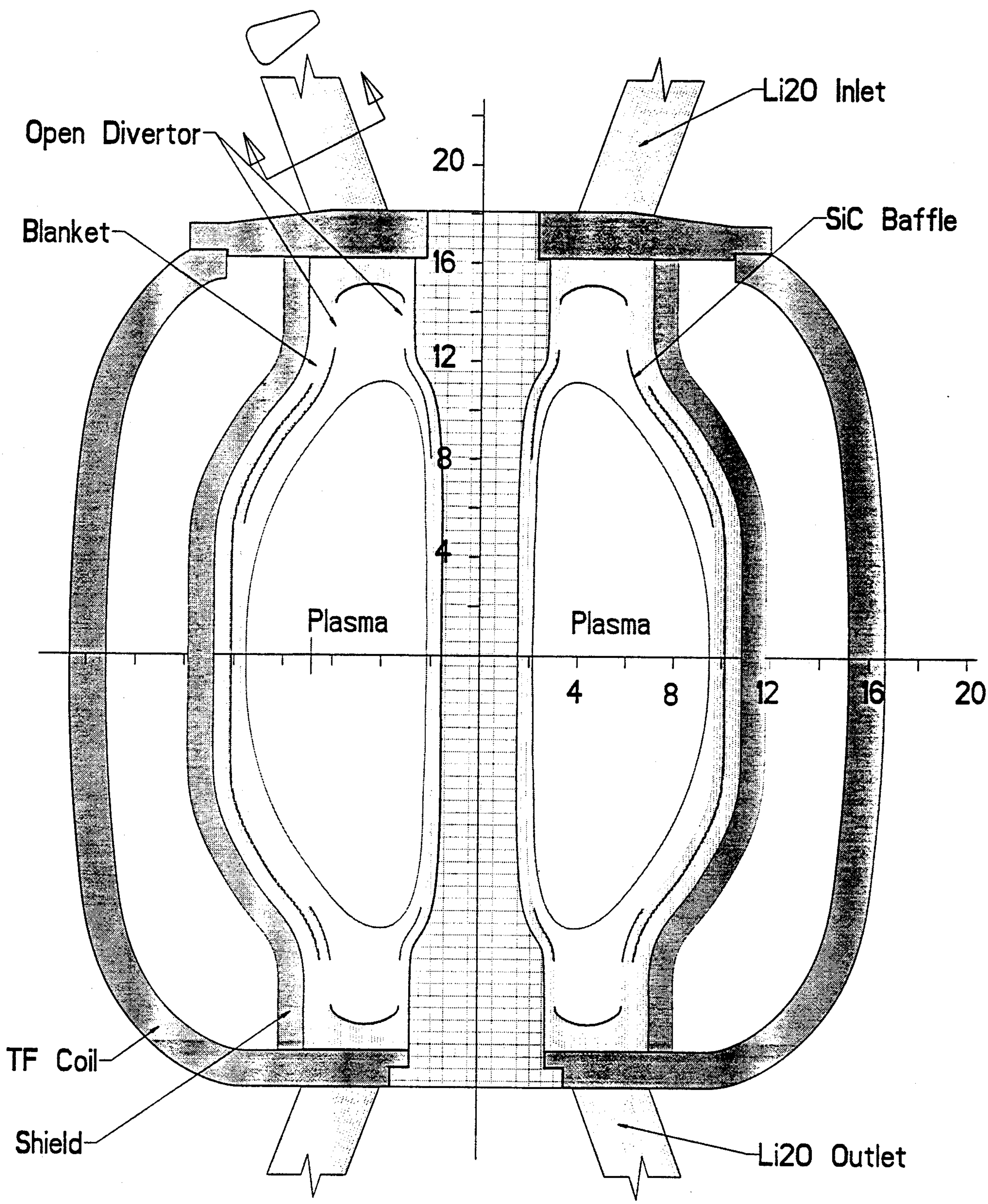
- Testing thermal hydraulic effects of SiC baffles exposed to the plasma (non-nuclear)
- Particulate charge-up of particulates and consequent effects
- Design of the flow diversion baffles and their effectiveness
- Electromagnetically levitated Li_2O dust
- Pumping of ions by moving particulates

The APPLE Concept Solves Several Difficult Tokamak Problems

- **Plasma disruptions**
- **Diverter high heat flux**
- **Ash Pumping**
- **Startup and shutdown**

Example of Granular Flow Li2O Blanket for ARIES-ST



Configuration of the APPLE First Wall and Blanket

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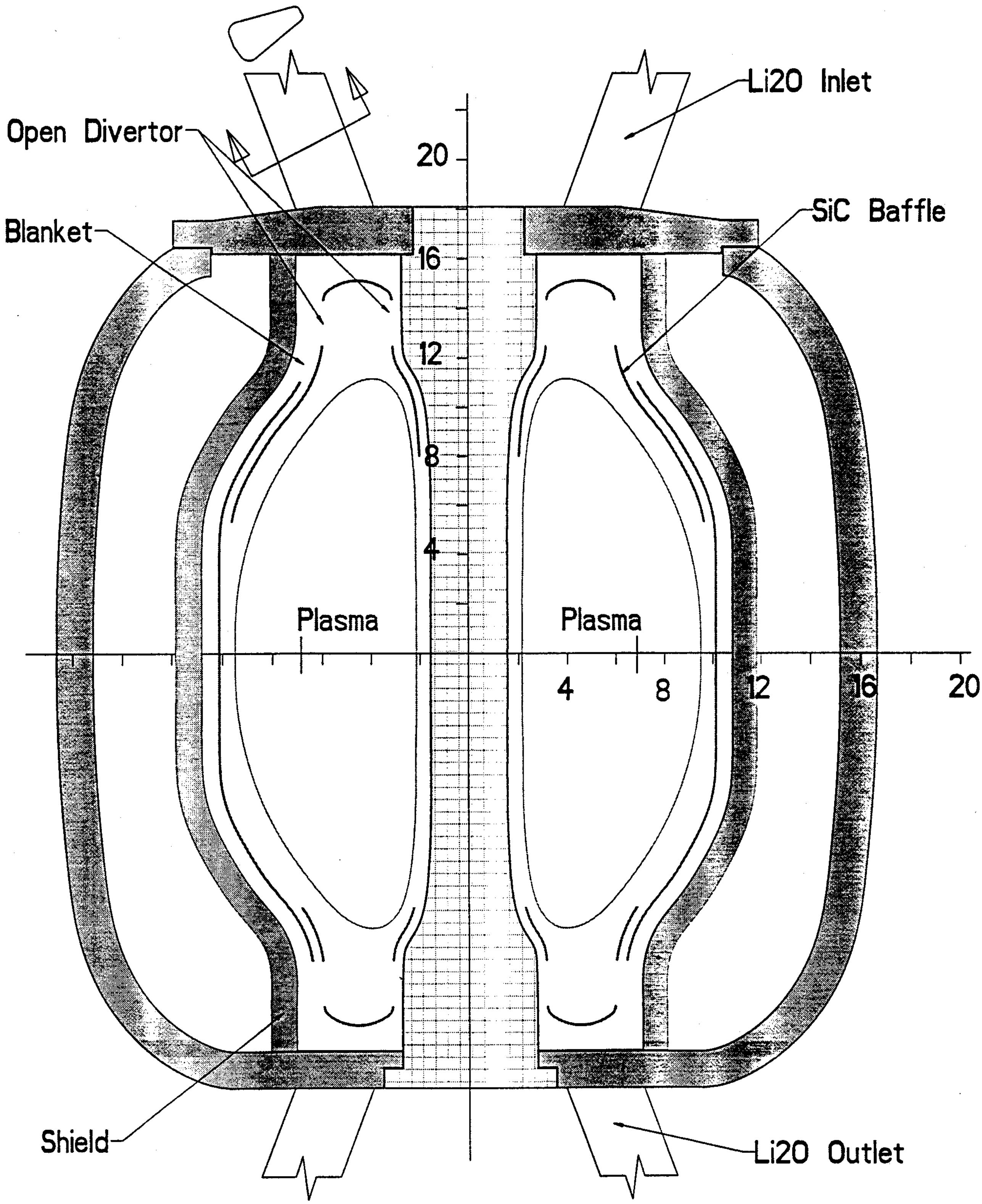
- The APPLE scheme is best applicable to high Beta high elongation plasmas
- All baffles and blanket structures are made of SiC
- The SiC baffles at the top and bottom of the plasma chamber direct Li_2O solid breeder particulates around the plasma then let them fall by gravity to the bottom
- These baffles are non-structural and are made for easy replacement
- The blanket has controlled flow channels behind the first wall for additional Li_2O solid breeder material
- Diverters are open to the plasma with exposed flowing Li_2O particulates
- Penetrations will have streamlined flanges for guiding the particulates around them
- After going through the chamber the particulates drain through tubes in the bottom and then are directed to the power cycle.

Configuration of An Exposed Solid Breeder Blanket Concept as Applied to A LAR Tokamak



Other Salient Features of the Li_2O Flowing Particulates Blanket Design

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- Very low vapor pressure of Li_2O has the potential for high thermal conversion efficiency (50%) and low plasma contamination.

- There are no pressure boundaries at the FW eliminating leaks.

- No MHD problems.

- High coverage blanket means high TBR without Be

- A free surface regenerative diverter is provided with high heat flux capability

Other Salient Features of the Li_2O Flowing Particulates Blanket Design

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- Potential for reducing heat load on the diverter by intercepting some flux lines at the midplane by free surface particulates

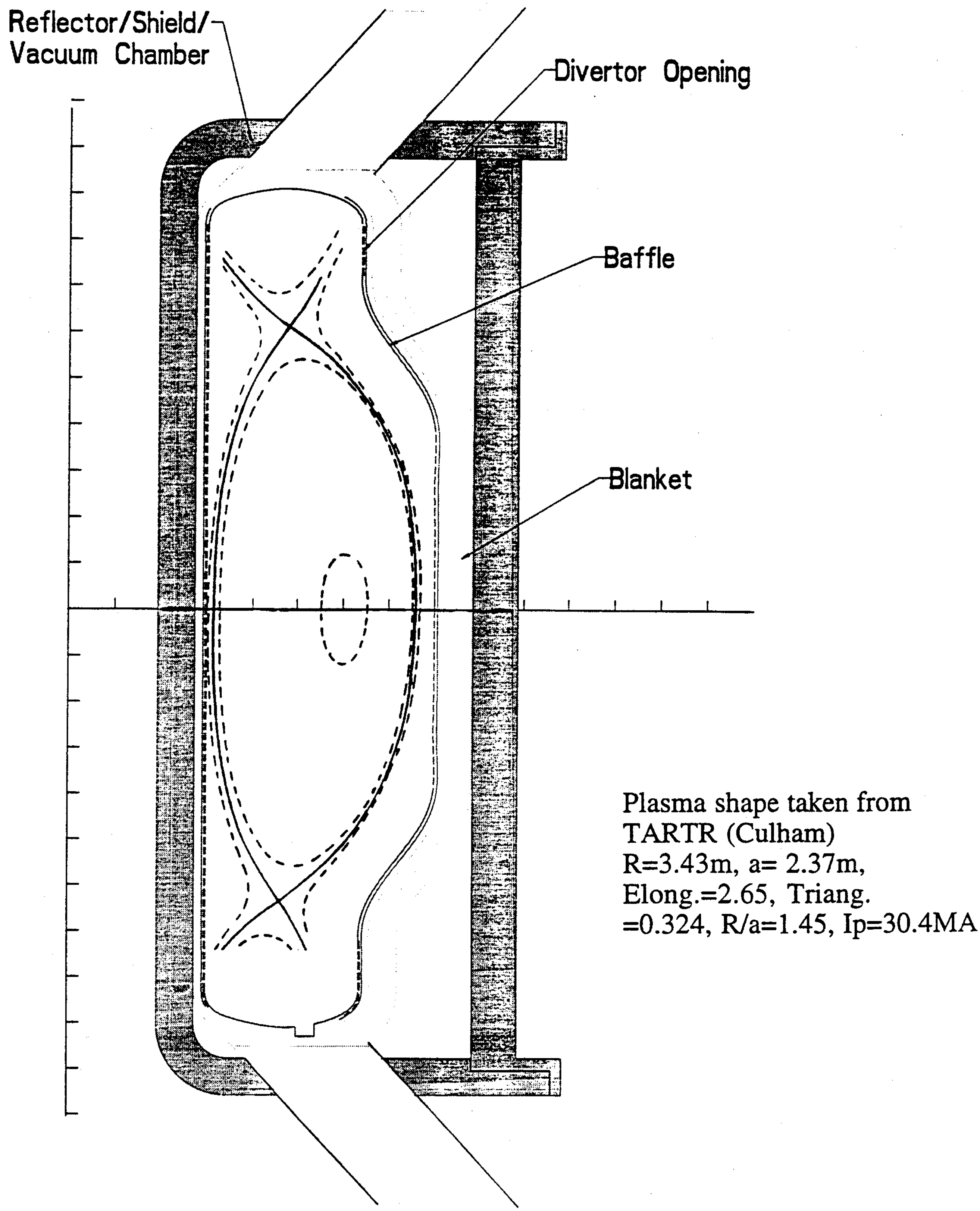
- Potential for pumping DT and He by ions embedding in the particulates and getting swept out akin to a diffusion pump

- Simple SiC structures can be made easy to replace

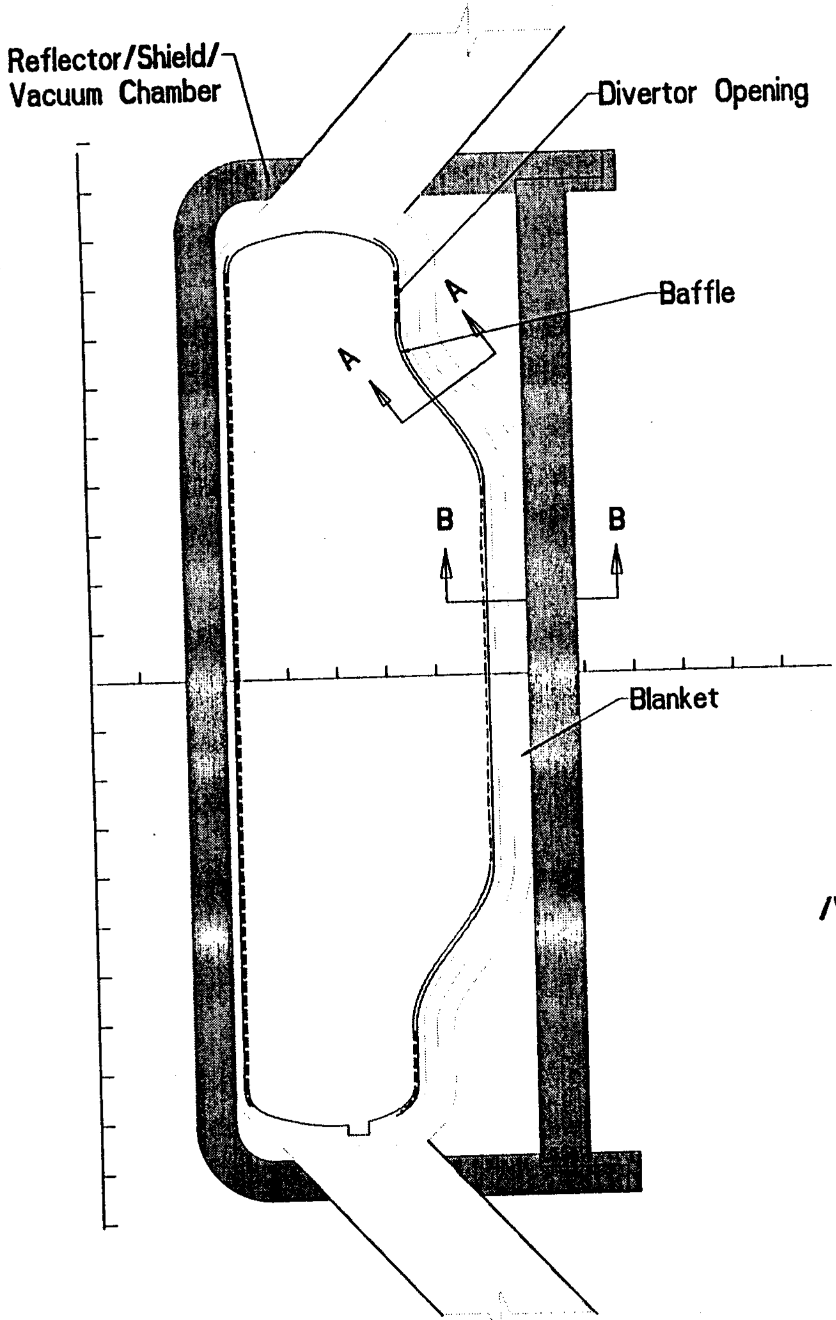
- Low decay heat structure eliminates problems of LOCA and LOFA

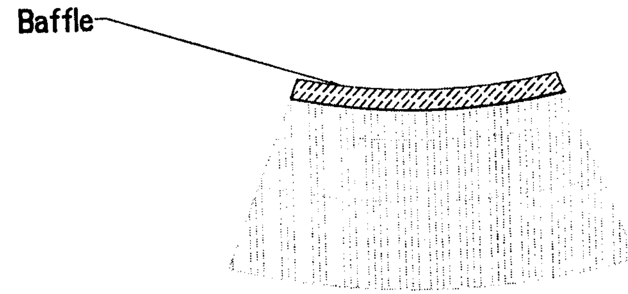
- Potential for the structure to be near surface burial when disposed

A Possible Configuration of the APPLE Chamber

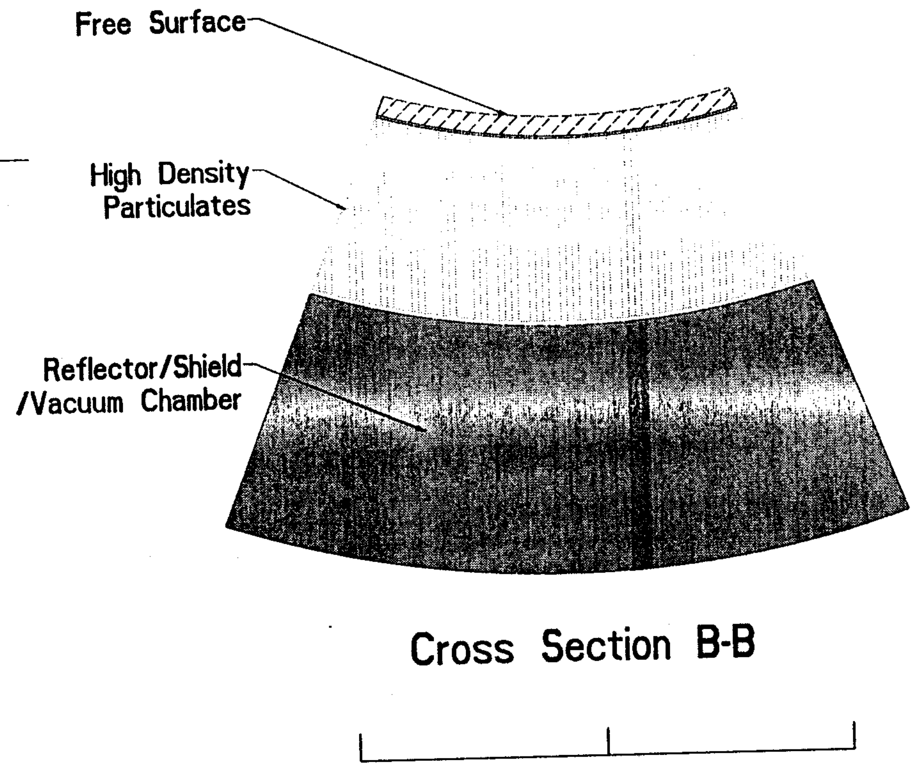


APPLE Configuration with Blanket/Shield Cross Section





Cross Section A-A



Cross Section B-B