A Revolutionary Positron-Based SSRV Vehicle for Application to Human Exploration and Development of Space

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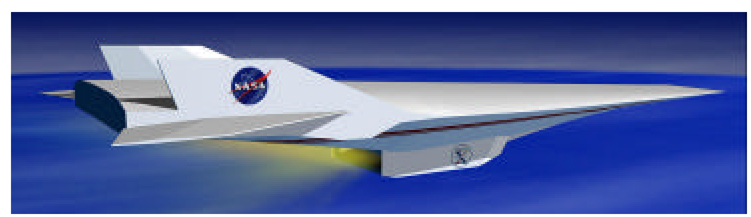
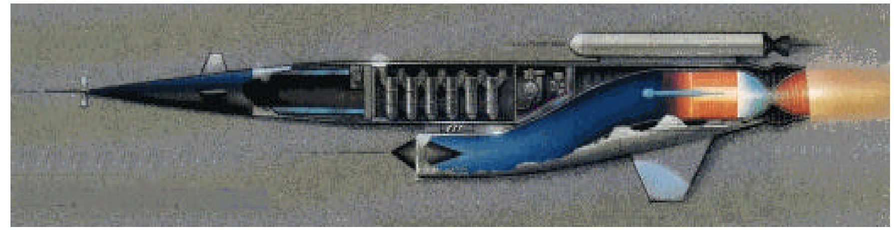
Current SSRV Technology

- The Space Shuttle uses multi-staging to minimize propellant mass (2 x10^6 kg, overall).
- A single-stage reusable vehicle (SSRV) requires air-breathing technology to offset increased mass and allow horizontal launch.
  - RBCCs include ERJ/RJ/R, ESJ/SJ/R, AAR/SJ/R.
  - Combination engines include TRJ,SJ,R and ESJ/SJ, R.
  - GLOWs typically range from 250 to 700 Mg, with Mo/Mb ratios exceeding 5.0 (exceeds runway limits).
  - Beyond state-of-the-art technology are required for chemical propulsion-based systems.



Project Pluto

- Nuclear technology can be used for heat transfer in ramjets and SCRAMjets.
- In 1954, Project Pluto focused on developing a nuclear ramjet to power supersonic cruise missiles.



Photos from Lawrence Livermore National Laboratory archives

- At Mach 2.8, P = 513 MW and T = 35,000 lb.
- Project cancelled in 1964 due to environmental concerns (open-air nuclear system).

Positrons--Advantages

- 0.511 MeV gamma rays are produced from the positron-electron annihilation equation:

$$e^{+} + e^{-} \rightarrow g + g$$

- The gamma ray products have a range of 10 mm in tungsten, 20 cm in light-weight carbon, and 90 m in air.
- The energy is sub-threshold for all nuclear reactions (antiprotons are not).
- In other words, the by-products of a positron-based aircraft WILL NOT CONTAMINATE the atmosphere, ground, or the aircraft itself!

SOLUTION: Develop an SSRV using positron-heating to replace fuel combustion in turbomachinery.

Mass Comparison

VEHICLE COMPONENT	*MASS*
Structure	25,700 kg
Thermal Protection	12,300 kg
Propulsion (4 engines)	14,900 kg
Electronics	7,600 kg
Total Dry Mass	60,500 kg
15% Margin + Unus. Propellants	11,400 kg
Payload	11,340 kg (25,000 lb)
Burnout Mass	83,200 kg
Total Propellant	368,300 kg
GLOW	451,600 kg (995,500 lb)

*From NGC report to Kaiser-Marquardt for HTHL blended-body SSTO engine, “Vision Vehicle Final Report,” April 30, 1998.

STI Positron-assisted TRJ, R configured SSRV

VEHICLE COMPONENT	*MASS*
Total Dry Mass	60,500 kg
15% Margin + Unus. Propellants	11,400 kg
Payload	11,340 kg (25,000 lb)
Burnout Mass	83,200 kg
Total Propellant	176,000 kg
GLOW	259,000 kg

*Assumes no bipropellants used during turbojet and ramjet phases of mission, and the dry mass is approximately the same after reducing LOX/LH tank mass and surrounding structure and increasing ramjet engine size.

How many positrons?

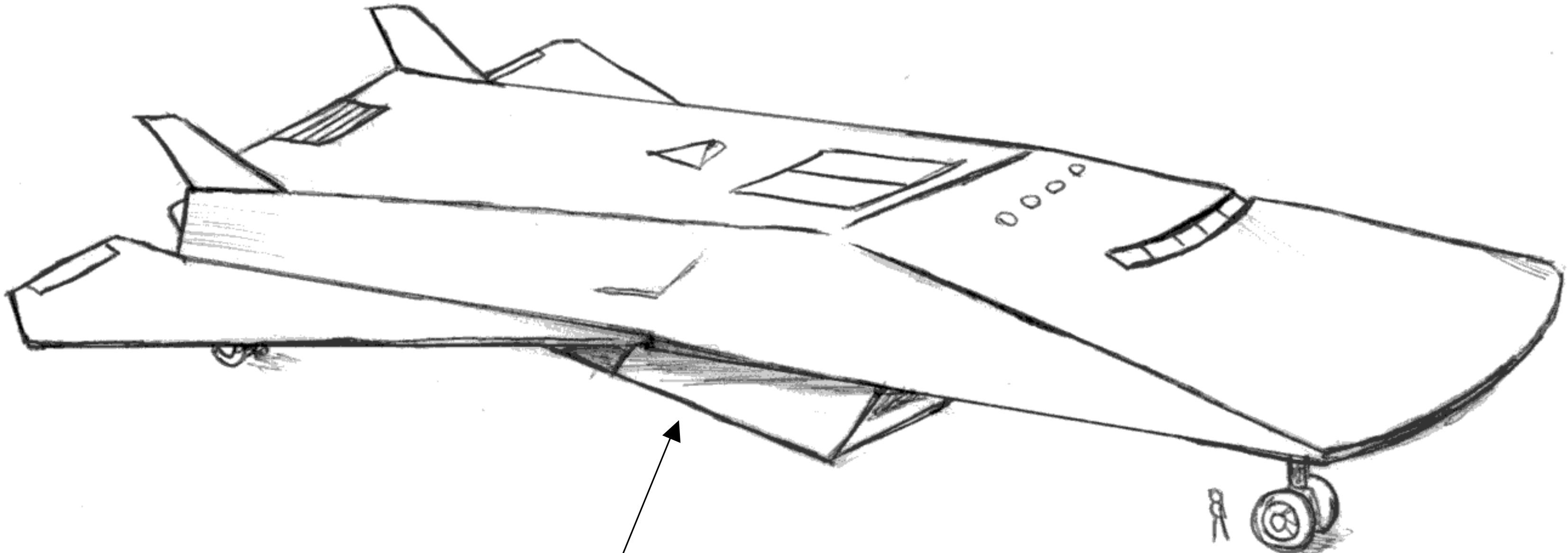
MISSION MODE	*MASS OF e^+*
Turbojet – launch	2.5 mg
Ramjet	76.5 mg
10% margin (for turbojet mode upon landing, inclination changes, etc)	8 mg
TOTAL	87 mg

- Current positron production is 1 pg/sec (30 µg/yr).
- USAF target is for 1-10 mg/year.

- 1 mg positrons can launch an SSRV with 1 MT dry mass to 300 km.
- In 10 years, cost of production of 1mg positrons can be $6M .*
- These costs are comparable to ~$6M/metric ton for existing unmanned launch systems.

*G.R. Schmidt, et al, J.Prop and Power, 16, 5, 2000

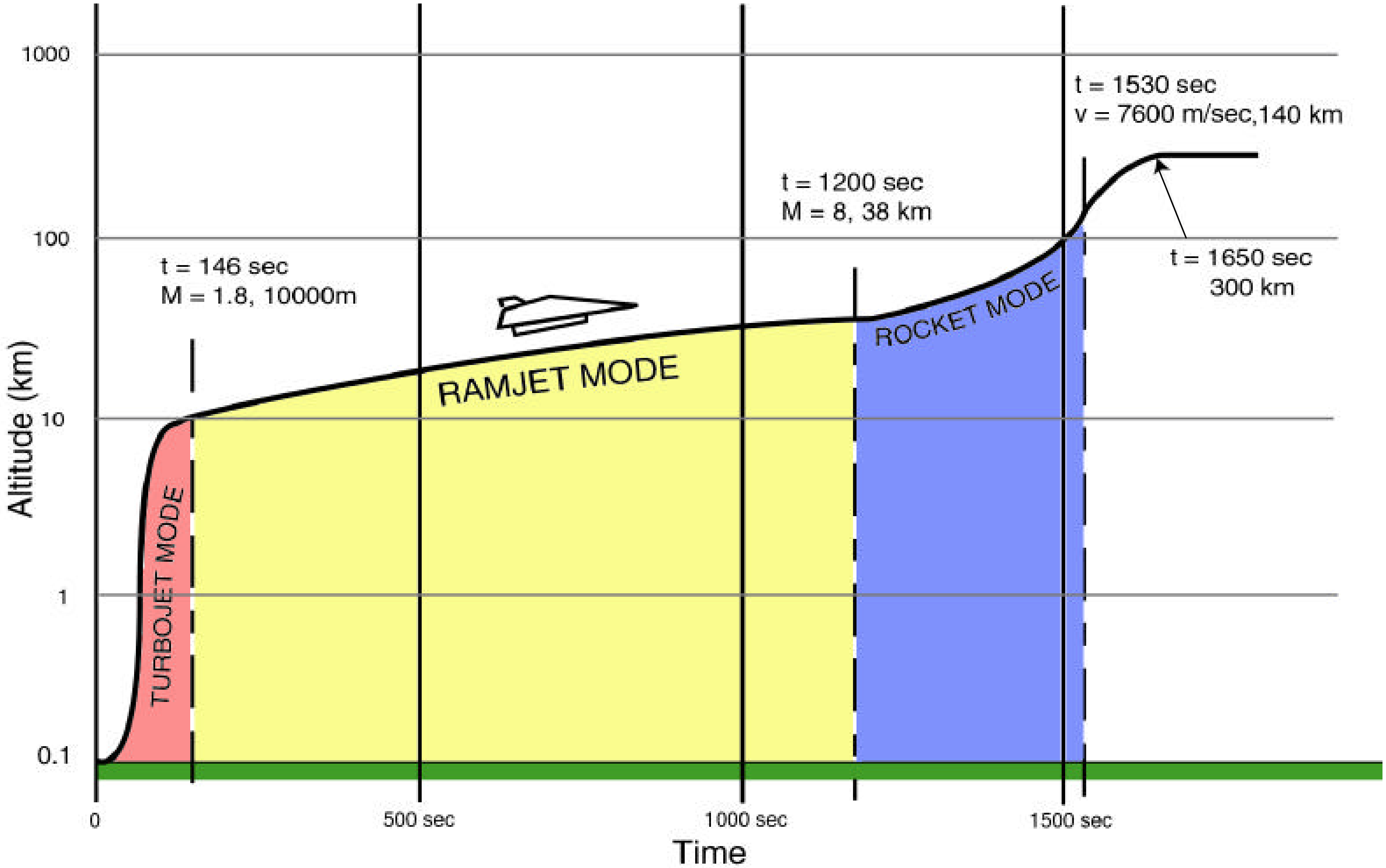
Conceptual Drawing



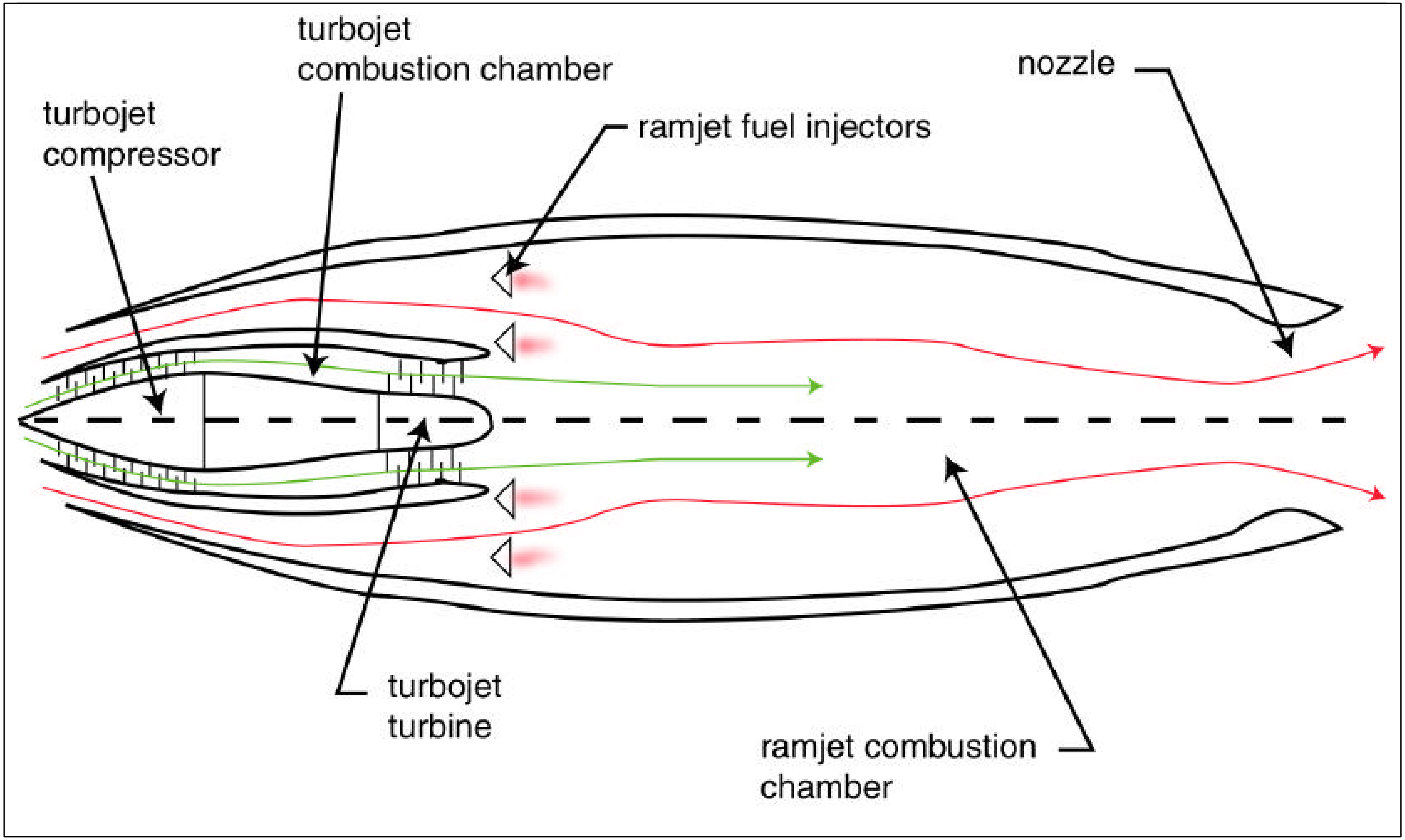
Twin-engine design

KJM 02/01

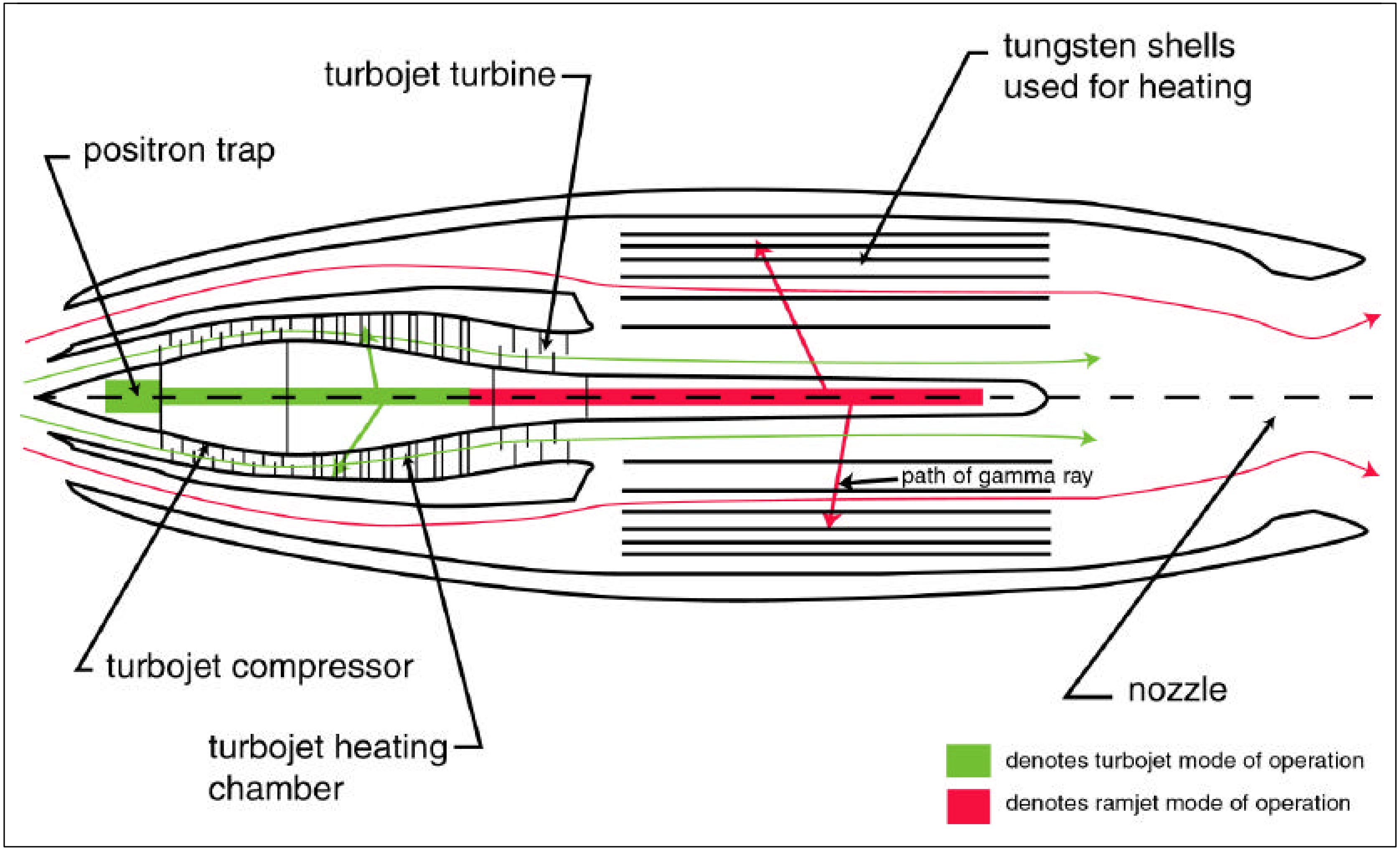
Launch-to-LEO Scenario



Combustion Turboramjet



Positron-based Turboramjet



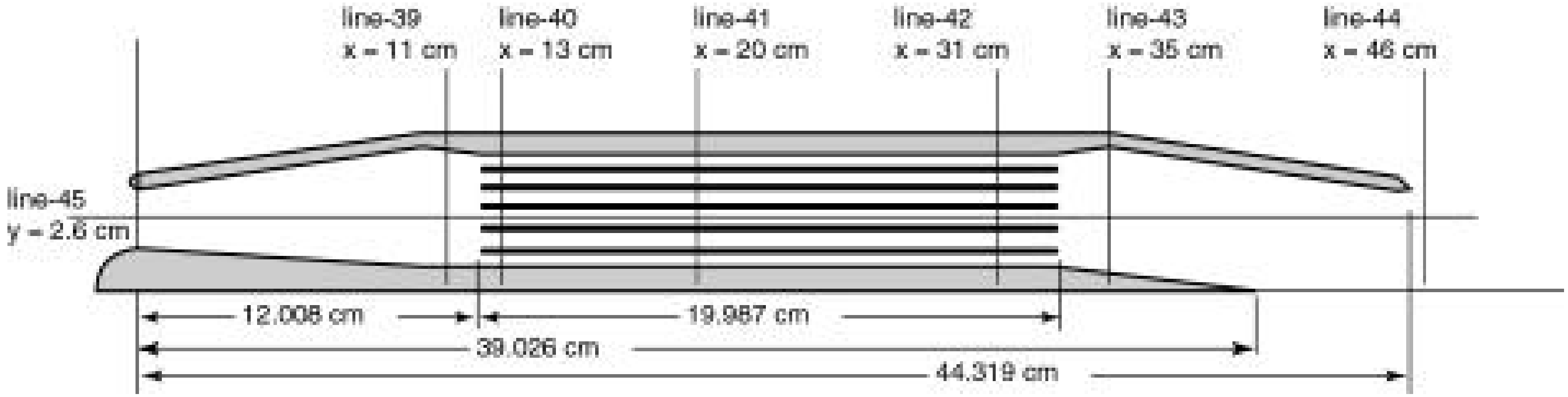
STI Trapping Research (USAF)

- Stage 1 $\rightarrow$ 1 picogram (10^{15} positrons)
  - Modified Penning Traps
  - Modified multi-mirrors
- Stage 2 $\rightarrow$ 1 mg
  - Stabilized positronium
  - Lattice traps

Stage 1 trapping is realizable using today's technologies; Stage 2 realization requires experiments in stabilization and storage.

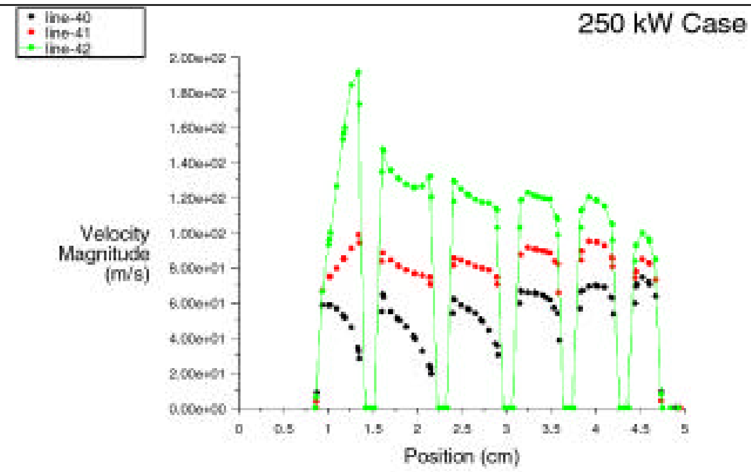
STI CFD Research (USAF)

- USAF contract to investigate positron heating in ramjets.
- Configuration below used for preliminary case of M = 0.5 - 1.3.
- Geometry used in FLUENT CFD code.

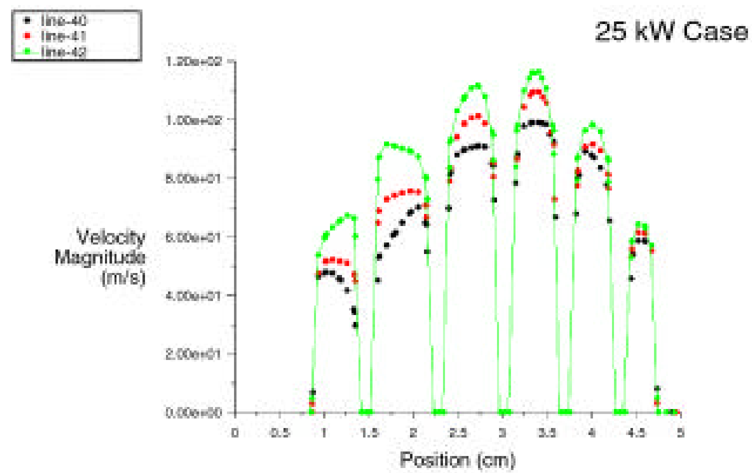


STI CFD Research (USAF)

- Contours across shells show x2 velocity increase for 250 kW input power.



- Input power and geometries can be altered to reflect true SSRV engines.



Summary

- Number of positrons required for an ambitious SSRV (dry mass of 83,000 kg) is between 50-100 mg.
- Near-term technology can make it possible to launch a small-scale SSRV with 1000 kg dry mass in 10 years, with costs competitive with existing launch systems.