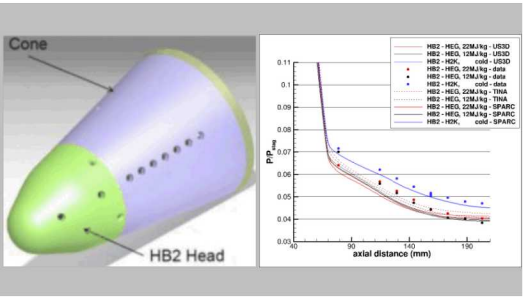
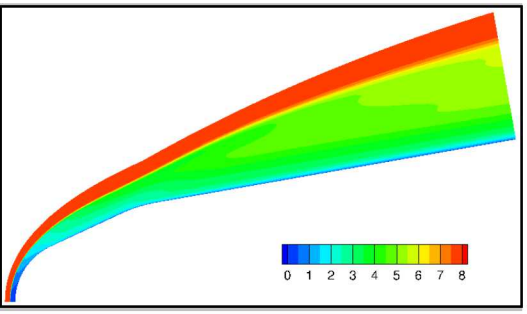
SAND2018-7556PE





Standard Probe CFD Results

7/9/2018

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Aerosciences Dept.
Sandia National Laboratories
Albuquerque, NM

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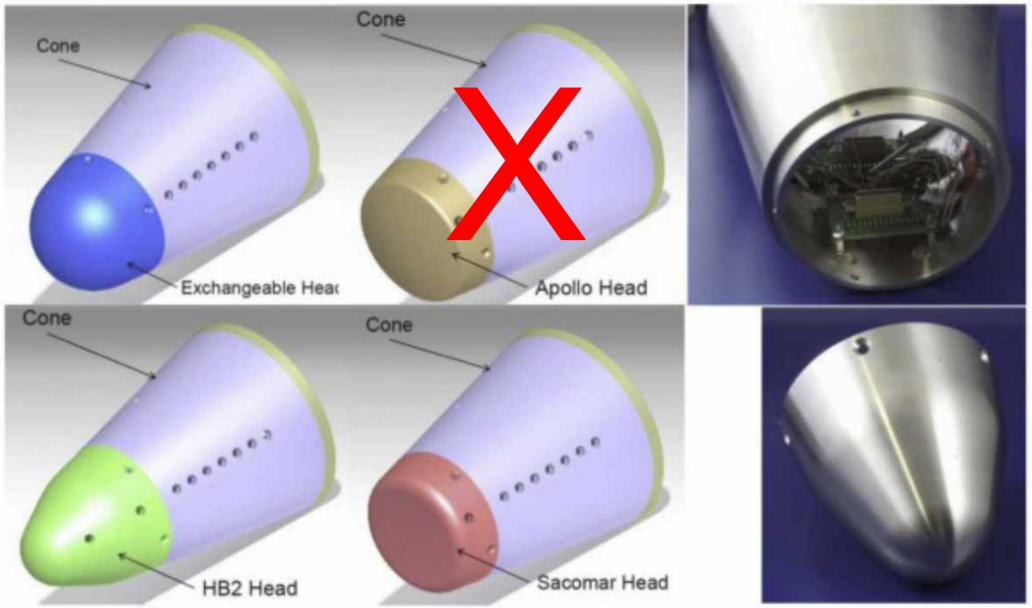
Geometries

- Analyzed 3 of 4 geometries: Spherecone, HB2, Sacomar
- Output:
  - Compare wall pressure against experimental data & TINA.
  - Plot wall shear stress and heat flux
  - Plot centerline pressure, temperature, Mach, density, species conc.



Conditions

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- HEG
  - 22 MJ/kg, T_∞ = 1187 K, p_∞ = 808 Pa, Mach number = 8.019

    0.7560 N_2, 0.0238 O_2, 0.0221 NO, 0.0000 N, 0.1973 O
  - 12 MJ/kg, T_∞ = 813 K, p_∞ = 971 Pa, Mach number = 8.061

    0.7408 N_2, 0.1484 O_2, 0.0559 NO, 0.0000 N, 0.0547 O
- H2K
  - Cold, T_∞ ~ 73.0 K, p_∞ ~ 360 Pa, Mach number = 7.030

    Perfect air

CFD Codes

Sandia National Laboratories

- US3D
  - Laminar, 2 Temperature, Gupta viscosity model, 5 sp. air - Park
  - 2^{nd} order inviscid flux - MSW, Implicit DPLR time integration
  - Mesh: $321 \times 201 \times 2$ nodes
- SPARC
  - Laminar, 2 Temperature, Blottner viscosity model, 5 sp. air - Park
  - 2^{nd} order inviscid flux – MSW, Implicit DPLR time integration
  - $321 \times 201 \times 2$ nodes

Runs

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run	geometry	tunnel	type	H0 (MJ/kg)	p (Pa)	T0 (K)	T (K)	M	rho (kg/m^3)	u (m/s)	gamma	N2	O2	NO	N	O	
US3D																	
1	Sacomar	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.756	0.0238	0.0221	0.0000	0.1973	
2	Sacomar	HEG	Shock	12	971		813	8.061	0.00394	4677	1.367	0.7408	0.1484	0.0559	0.0000	0.0547	
3	spherecone	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.756	0.0238	0.0221	0.0000	0.1973	
4	spherecone	HEG	Shock	12	971		813	8.061	0.00394	4677	1.367	0.7408	0.1484	0.0559	0.0000	0.0547	
5	HB2	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.756	0.0238	0.0221	0.0000	0.1973	
6	HB2	HEG	Shock	12	971		813	8.061	0.00394	4677	1.367	0.7408	0.1484	0.0559	0.0000	0.0547	
7	Sacomar	H2K	Blowdown	cold	370	792	*72.8*	7.030	*0.01772*	*1202.057*	1.4			perfect air			run 70
8	spherecone	H2K	Blowdown	cold	360	790	*72.6*	7.030	*0.01728*	*1200.538*	1.4			perfect air			run 43
9	HB2	H2K	Blowdown	cold	360	795	*73.0*	7.030	*0.01717*	*1204.331*	1.4			perfect air			run 64
3-11sp	spherecone	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.756	0.0238	0.0221	0.0000	0.1973	
SPARC																	
1	Sacomar	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.7566	0.0238	0.0221	0.0000	0.1975	
2	Sacomar	HEG	Shock	12	971		813	8.061	0.00394	4677	1.367	0.7410	0.1484	0.0559	0.0000	0.0547	
3	spherecone	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.7566	0.0238	0.0221	0.0000	0.1975	
4	spherecone	HEG	Shock	12	971		813	8.061	0.00394	4677	1.367	0.7410	0.1484	0.0559	0.0000	0.0547	
5	HB2	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.7566	0.0238	0.0221	0.0000	0.1975	
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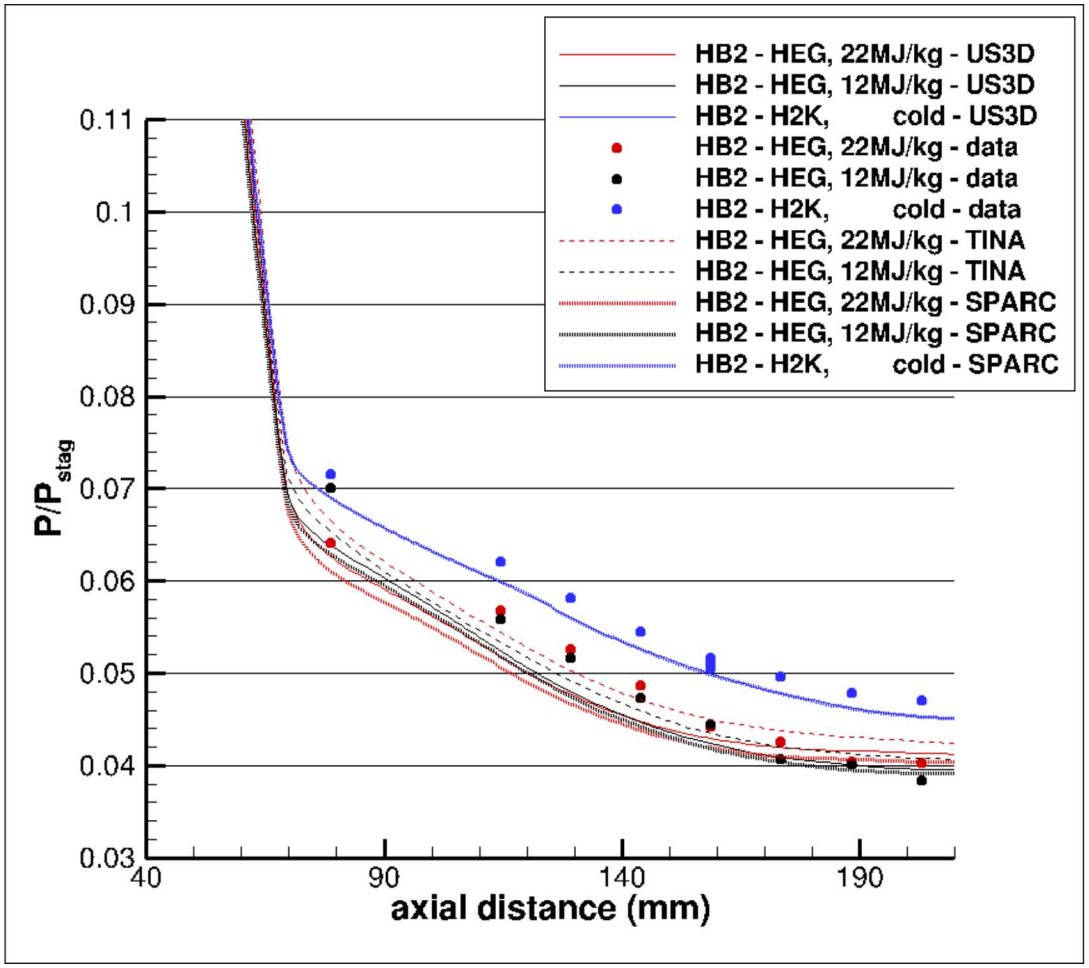
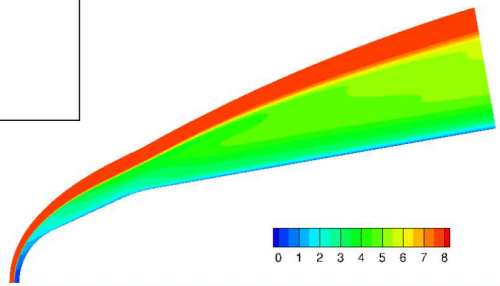
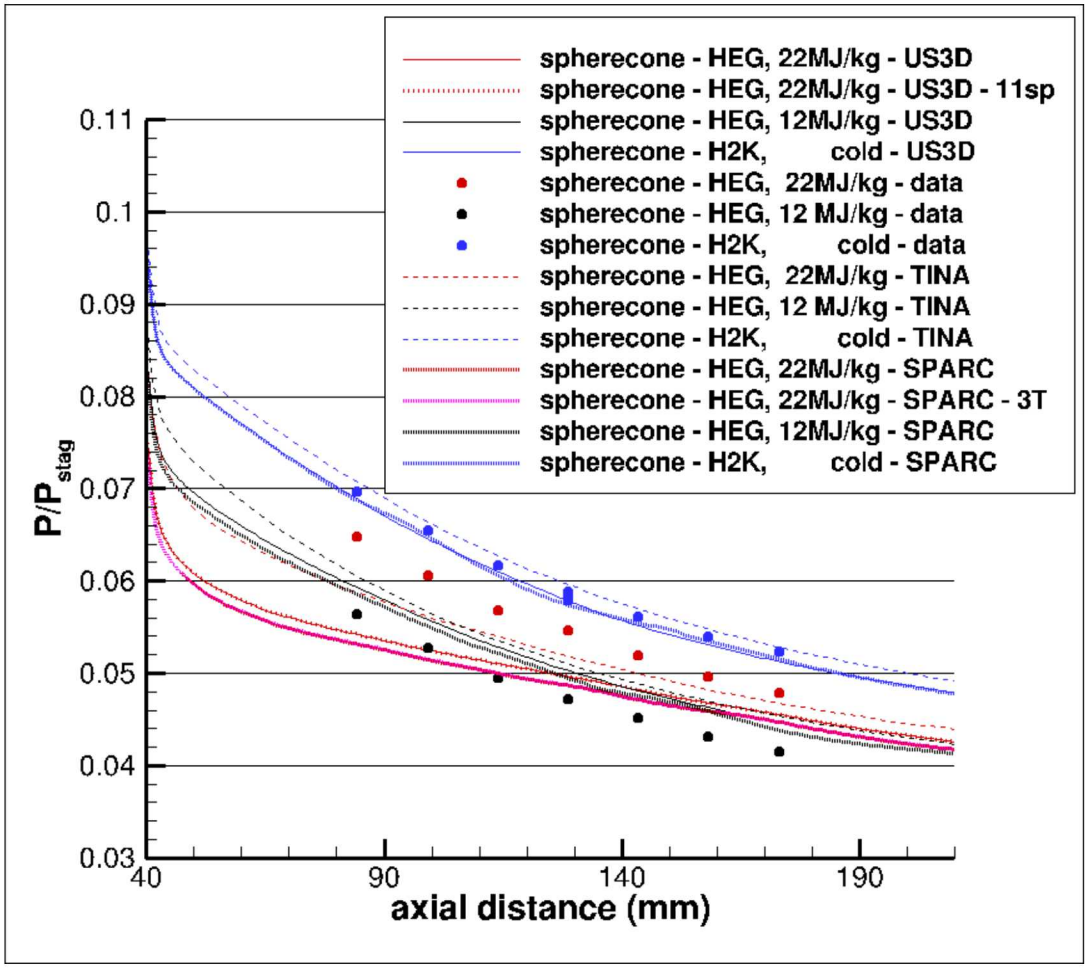
8	spherecone	H2K	Blowdown	cold	360	790	*72.6*	7.030	*0.01728*	*1200.538*	1.4			perfect air			run 43
9	HB2	H2K	Blowdown	cold	360	795	*73.0*	7.030	*0.01717*	*1204.331*	1.4			perfect air			run 64
3-3T	spherecone	HEG	Shock	22	808		1187	8.019	0.00200	5994	1.385	0.7566	0.0238	0.0221	0.0000	0.1975	

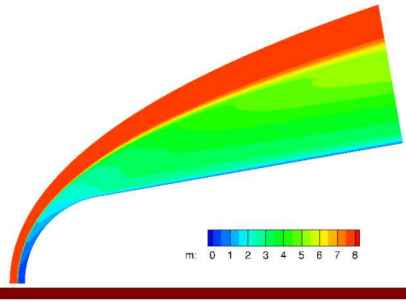
Pressures (HB2)



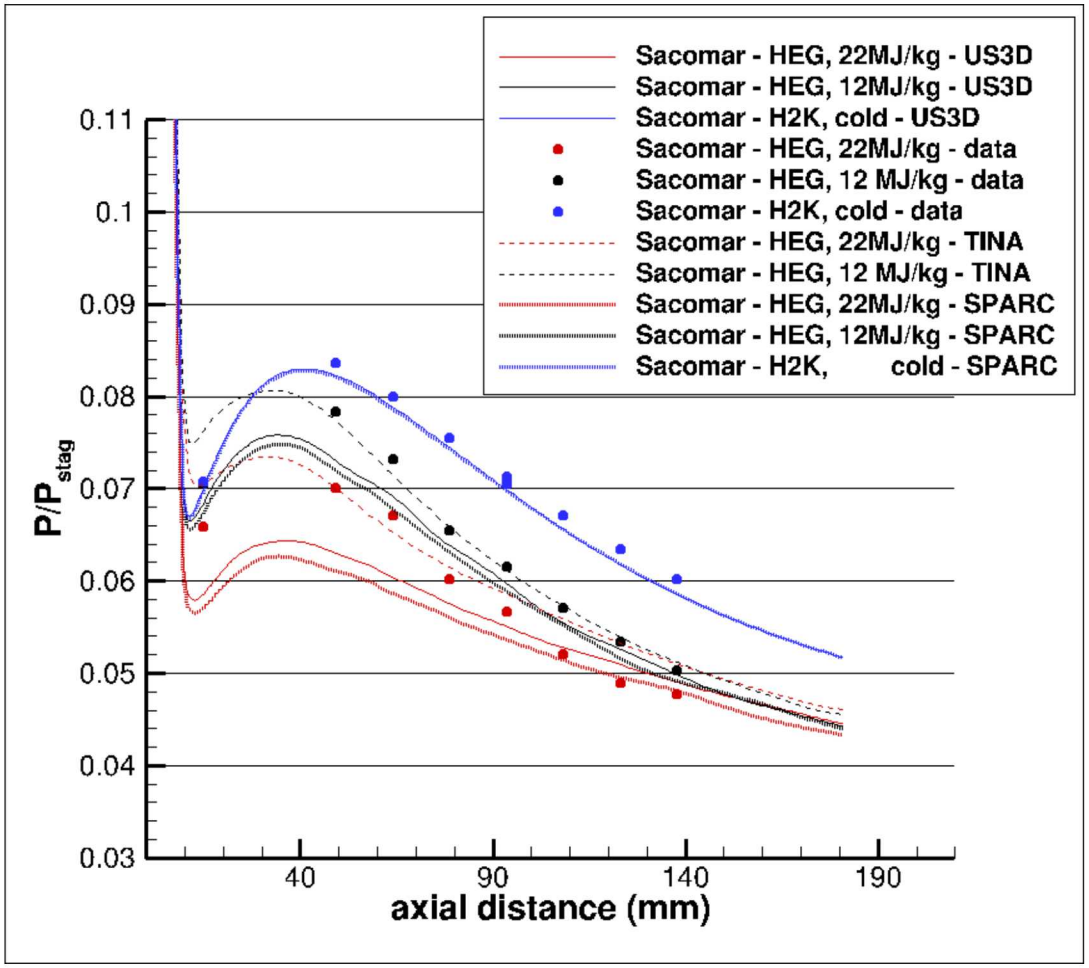


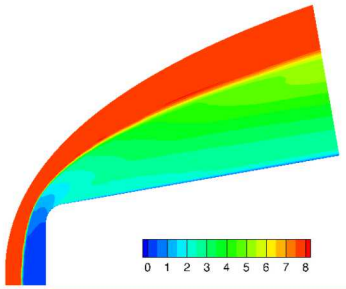
Pressures (Spherecone)





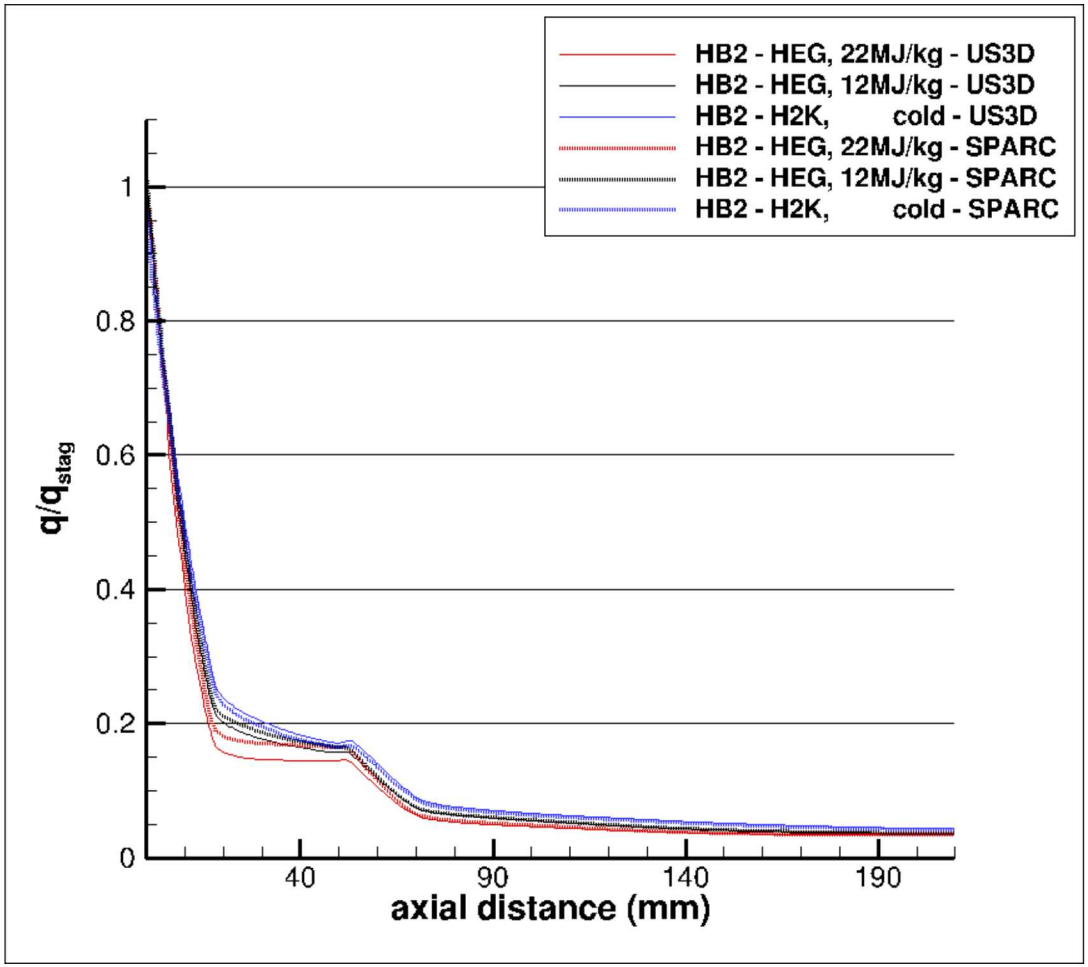
Pressures (Sacomar)

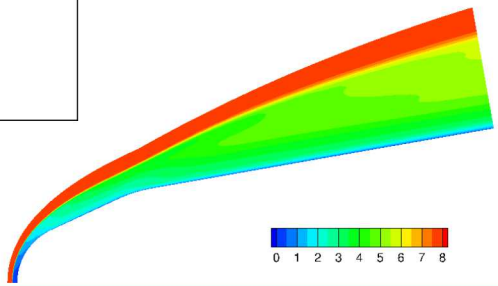




Heat Flux - normalized (HB2)

H_0(MJ/kg)	q_0(W/m^2)
22	1.279e7
12	8.268e6
cold	1.432e5





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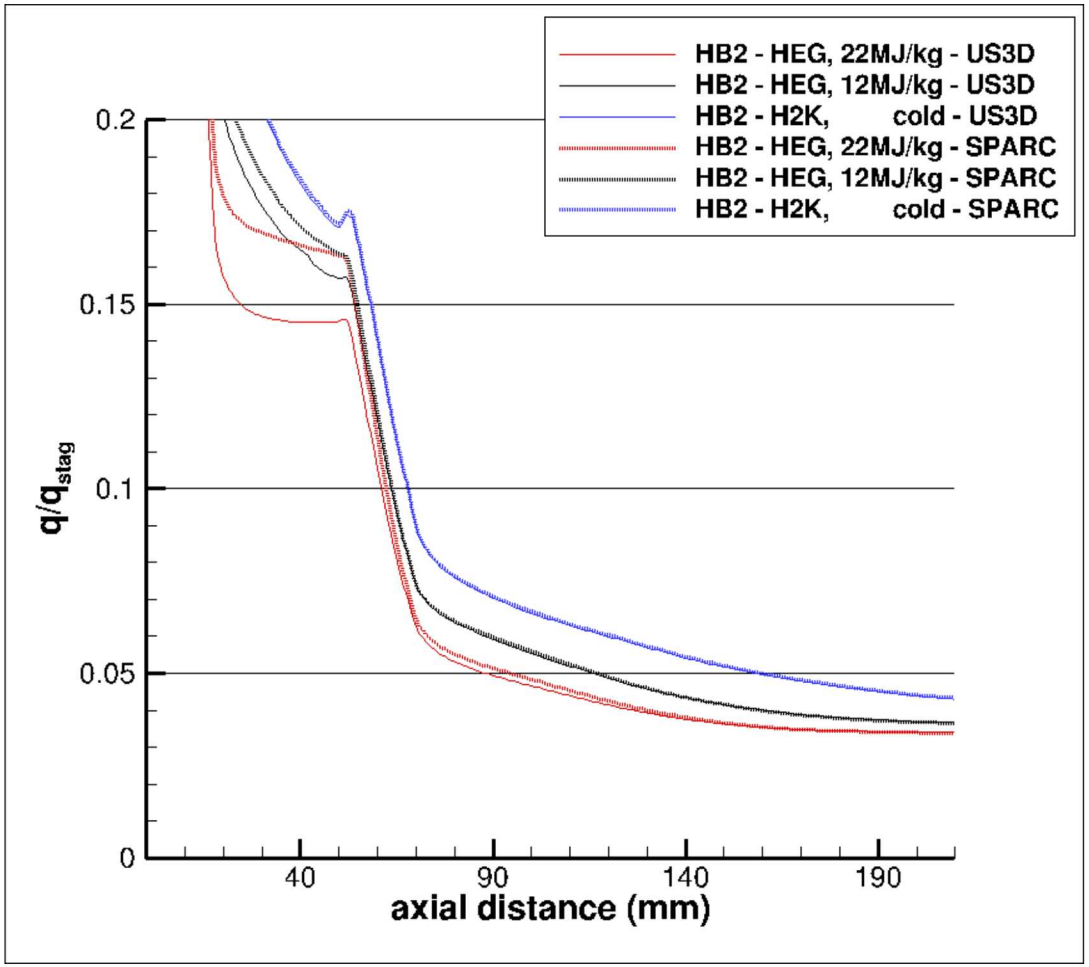
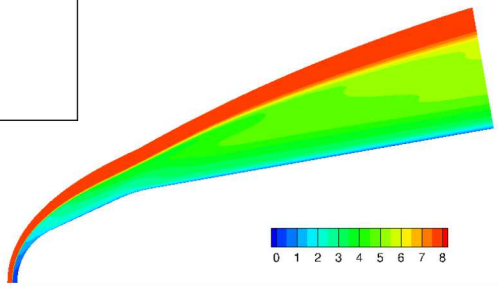
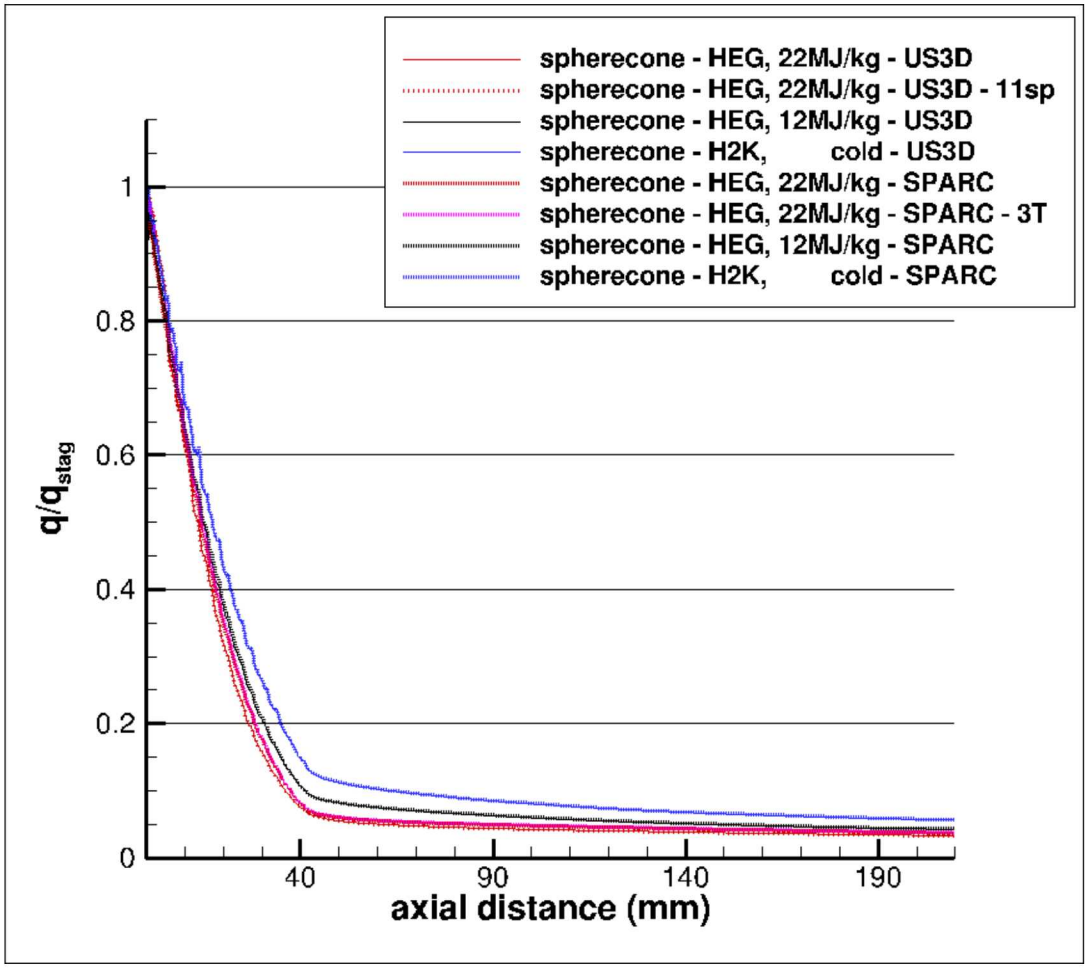
H_0(MJ/kg)	q_0(W/m^2)
22	1.279e7
12	8.268e6
cold	1.432e5

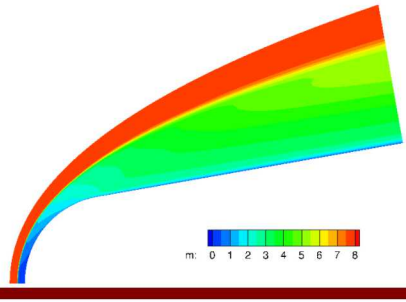




Heat Flux - normalized (Spherecone)

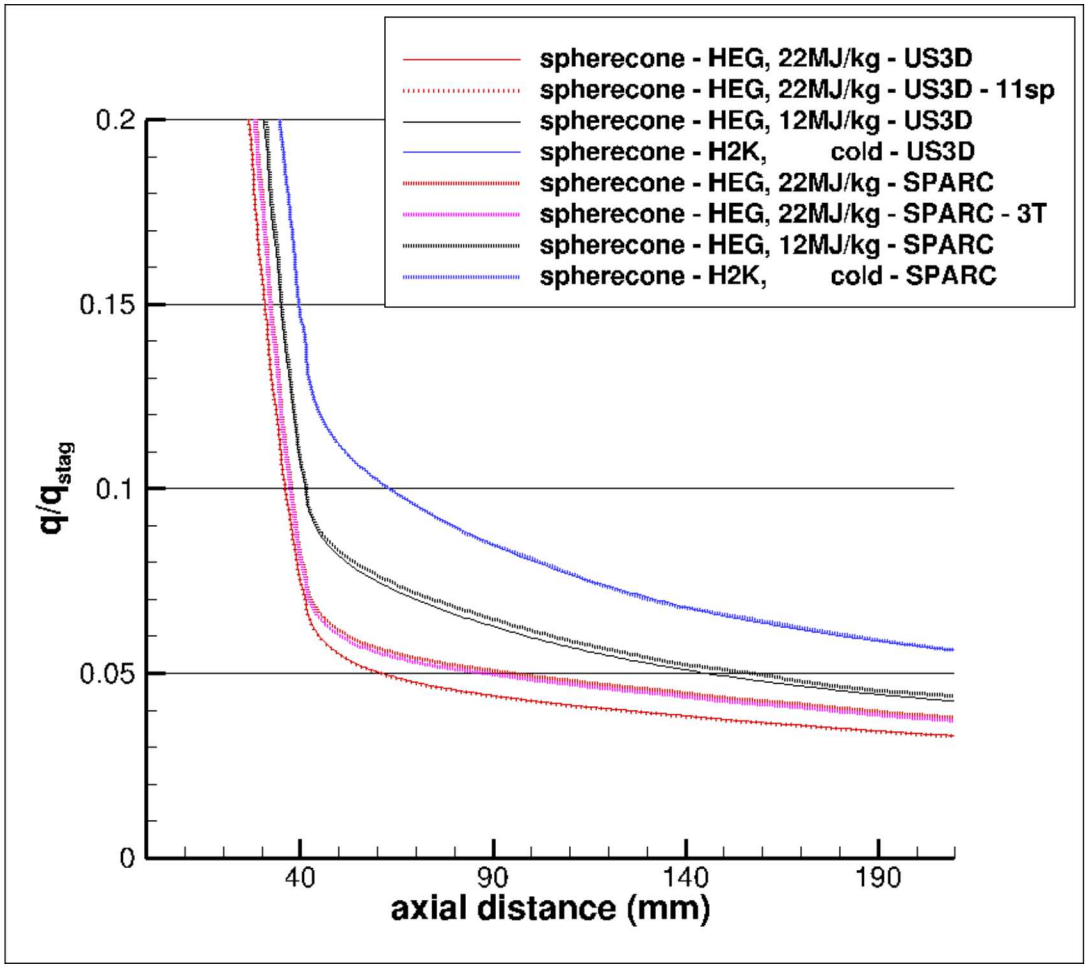
H_0(MJ/kg)	q_0(W/m^2)
22	1.070e7
12	6.585e6
cold	1.066e5

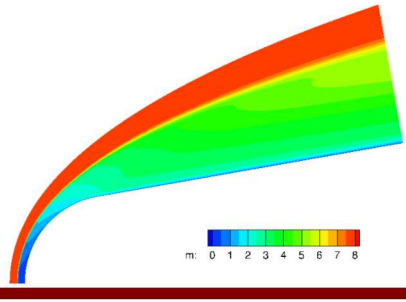




Heat Flux - normalized (Spherecone)

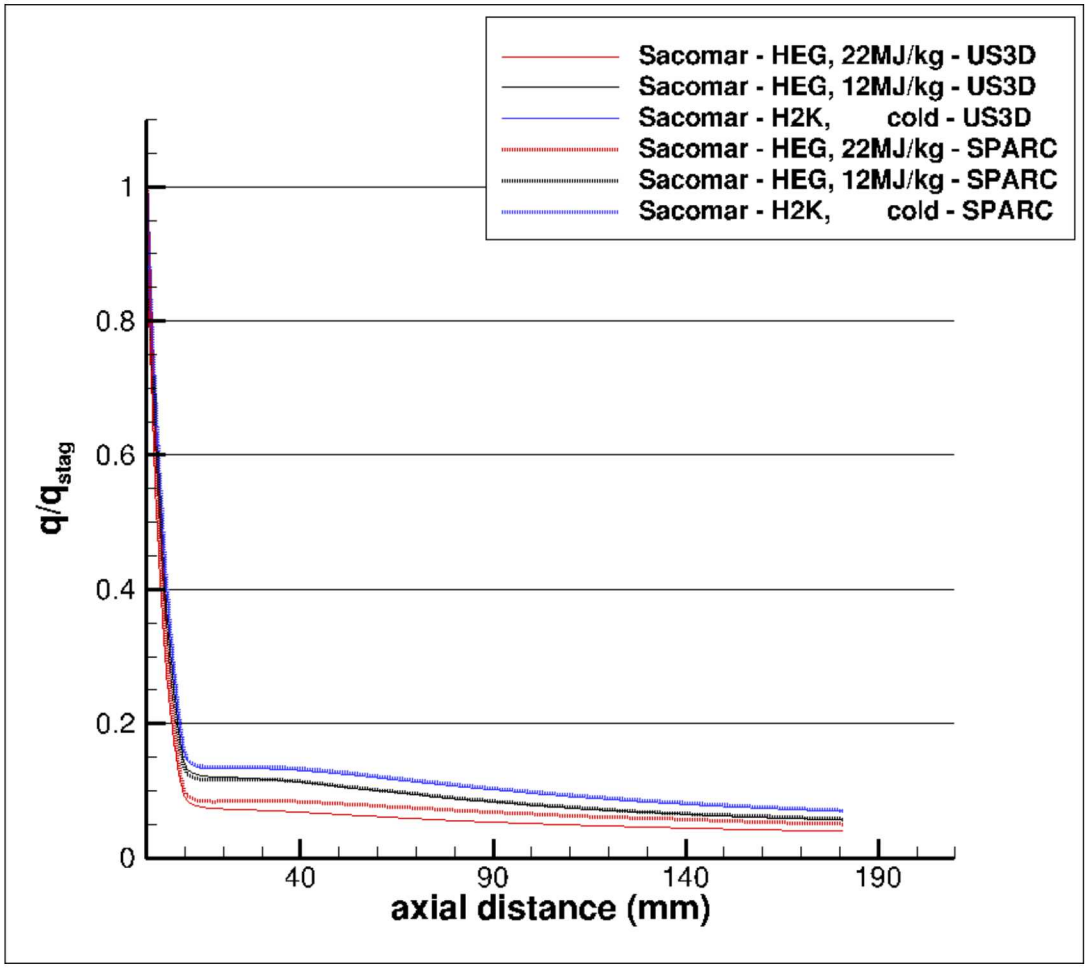
H_0(MJ/kg)	q_0(W/m^2)
22	1.070e7
12	6.585e6
cold	1.066e5

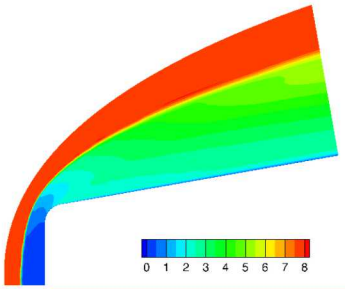




Heat Flux - normalized (Sacomar)

H_0(MJ/kg)	q_0(W/m^2)
22	8.464e6
12	5.056e6
cold	9.537e4





Heat Flux - normalized (Sacomar)

H_0(MJ/kg)	q_0(W/m^2)
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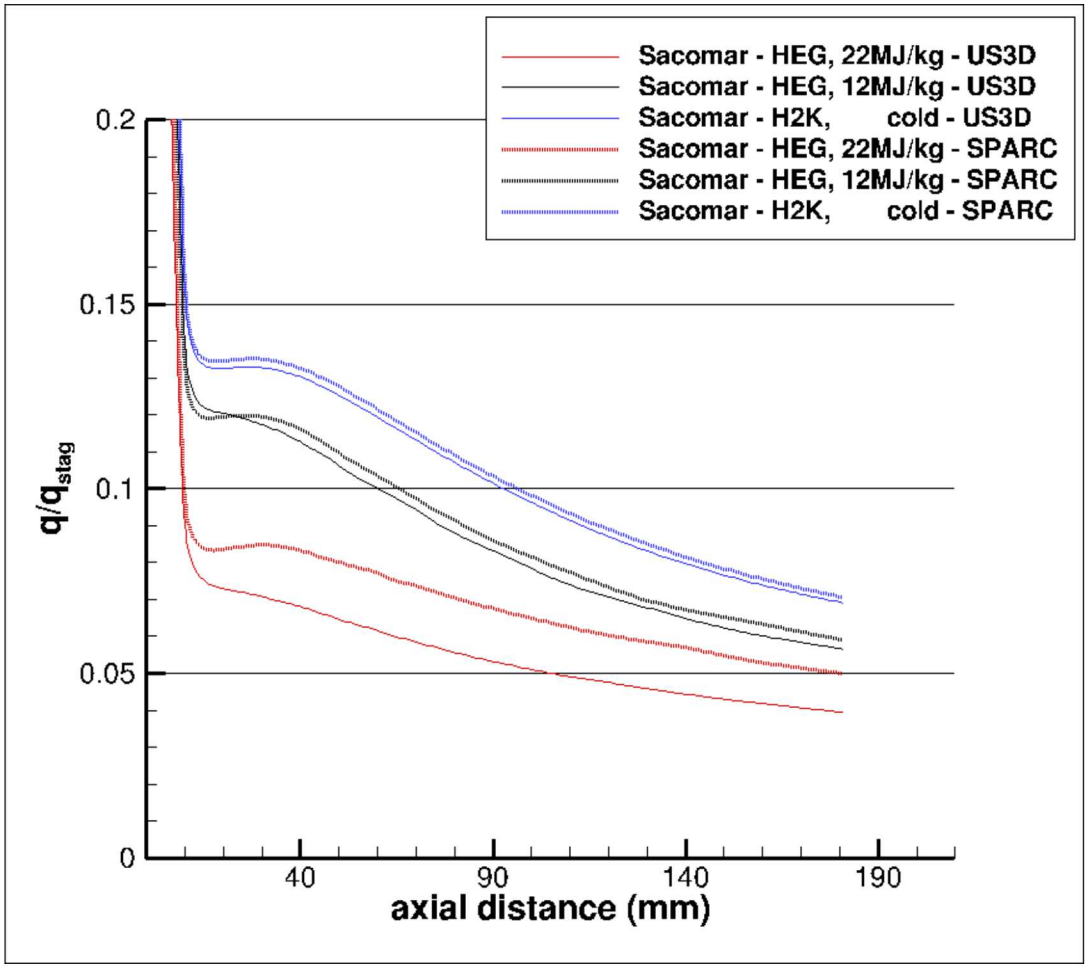
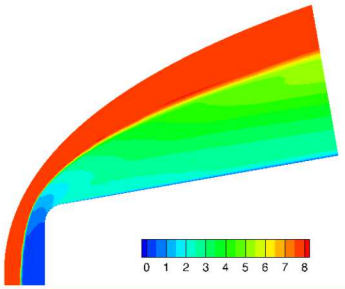
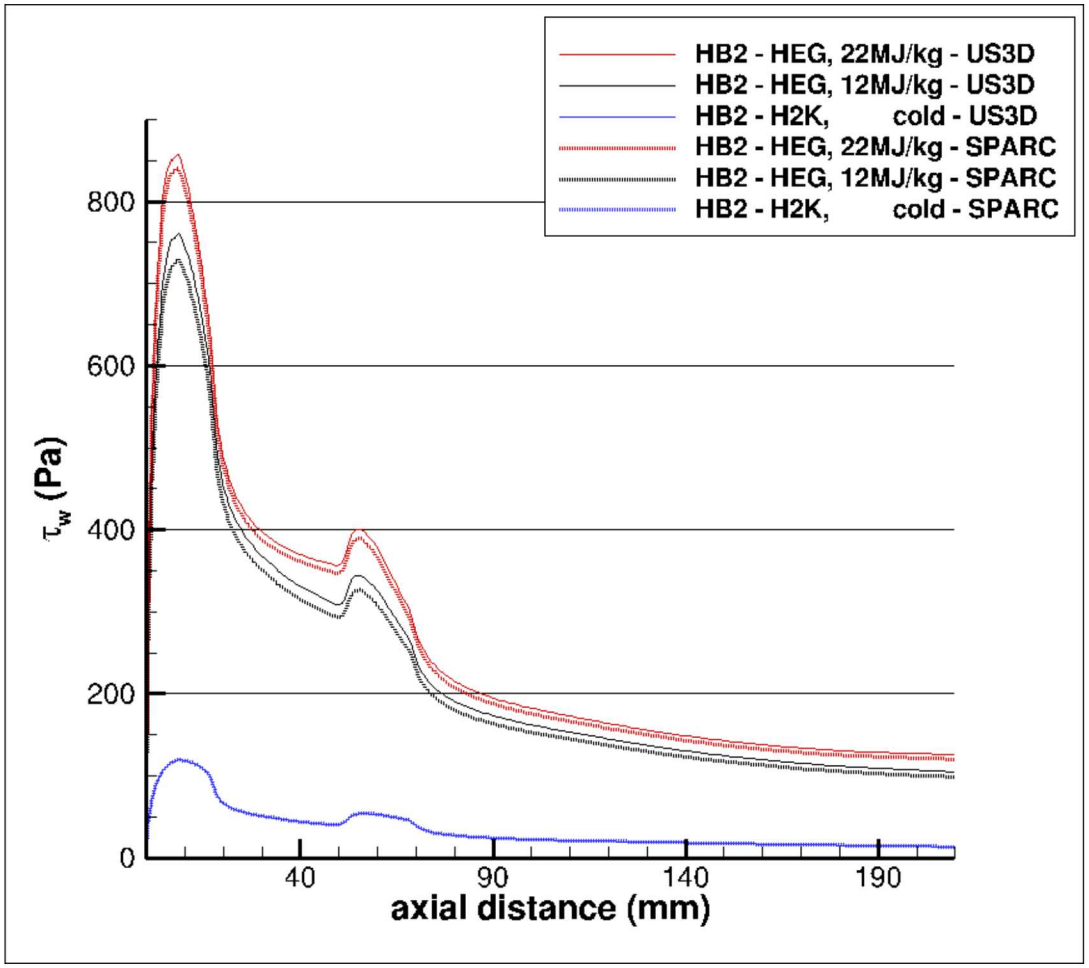
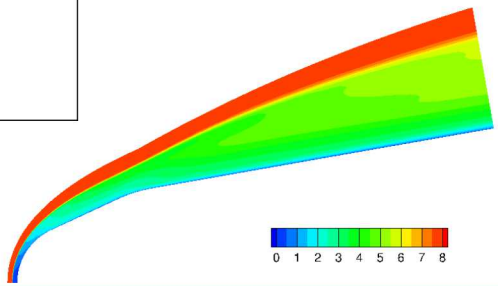
cold	9.537e4





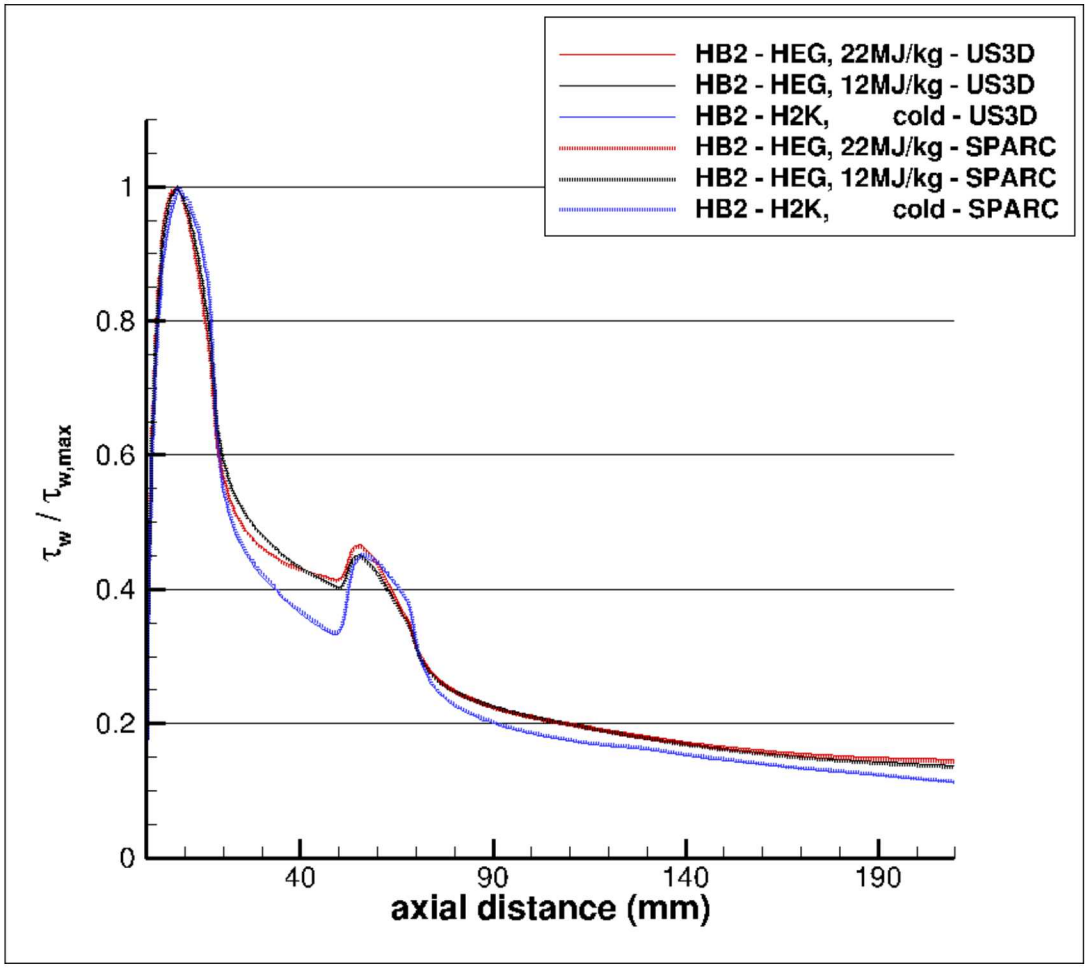
Shear Stress (HB2)

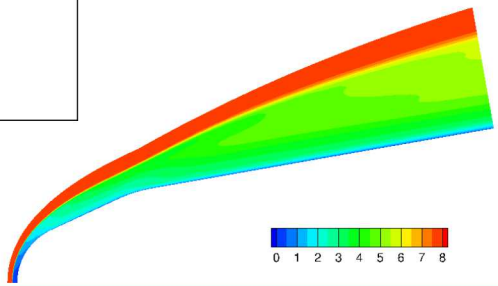




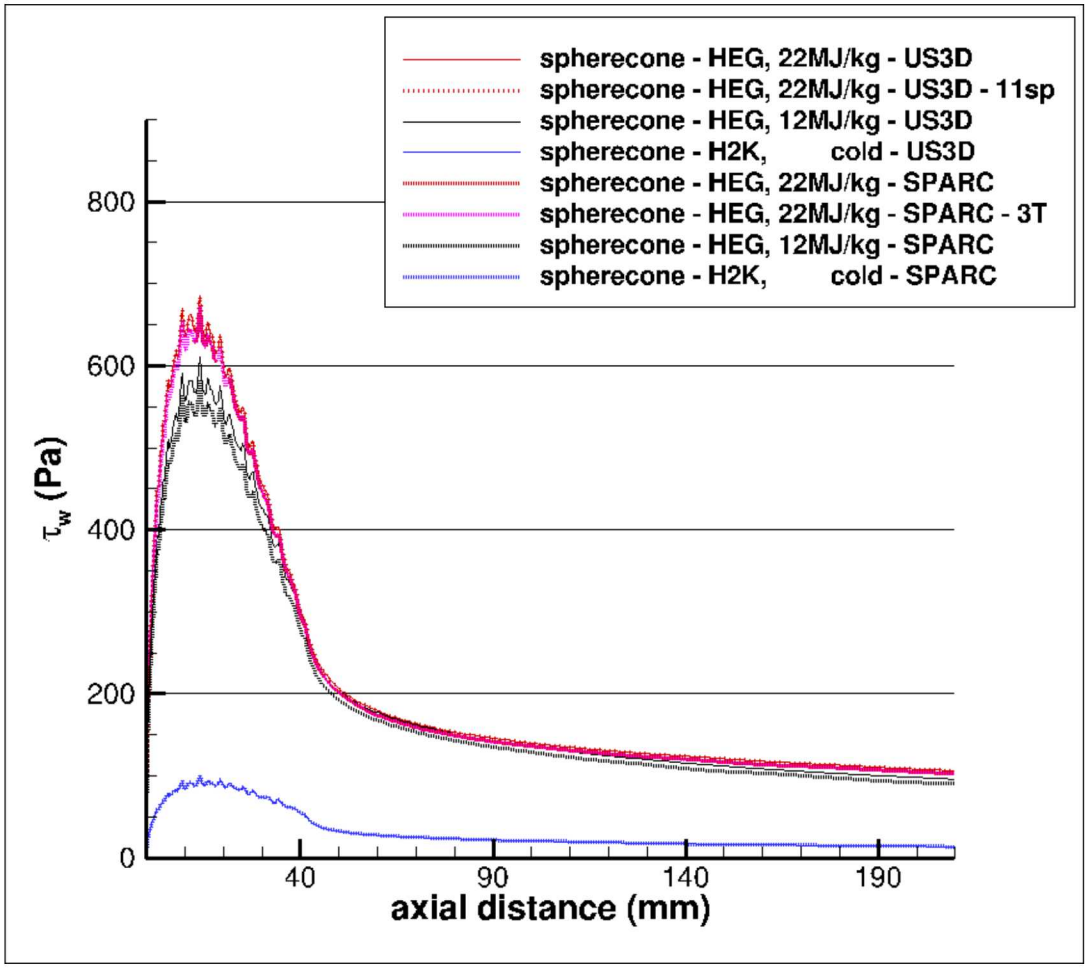
Shear Stress - normalized (HB2)

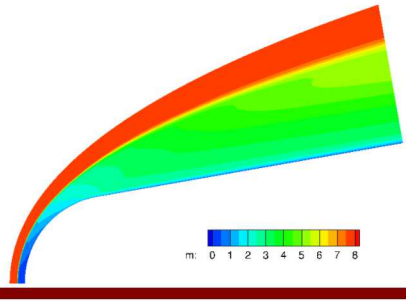
H_0(MJ/kg)	$\tau_{w,max}$(Pa)
22	840.6
12	729.4
cold	120.0





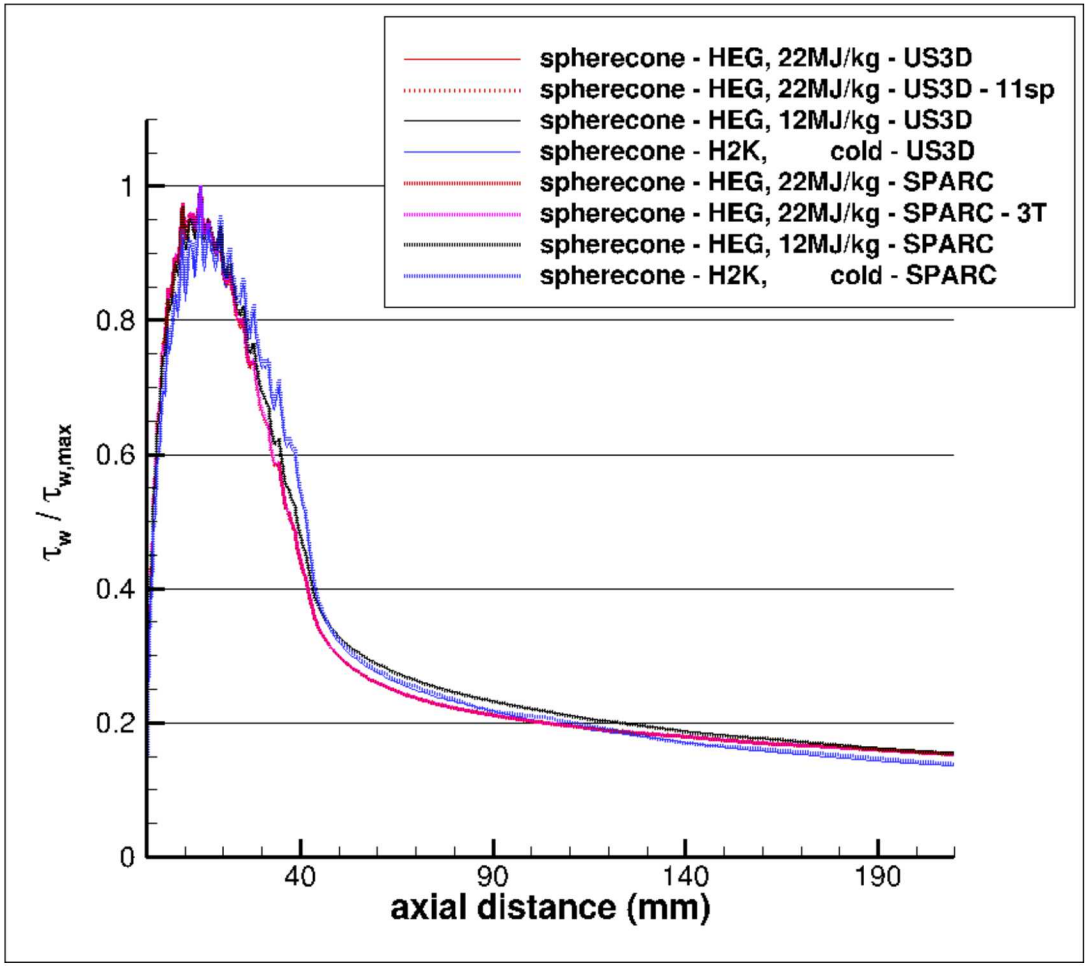
Shear Stress (Spherecone)

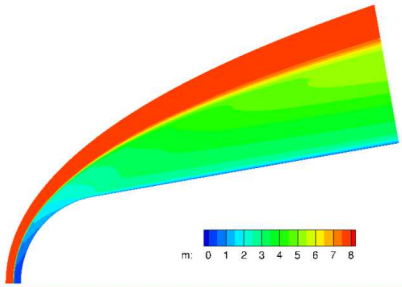




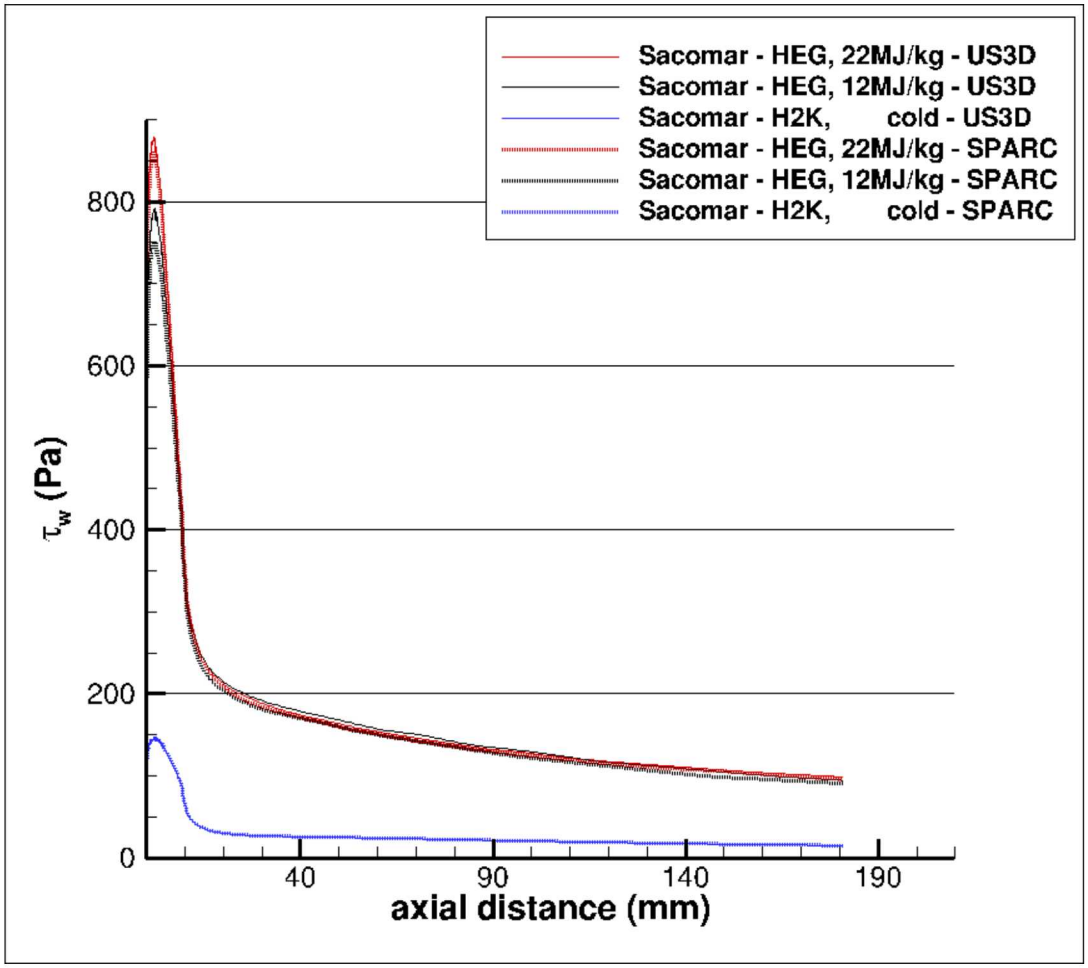
Shear Stress - normalized (Spherecone)

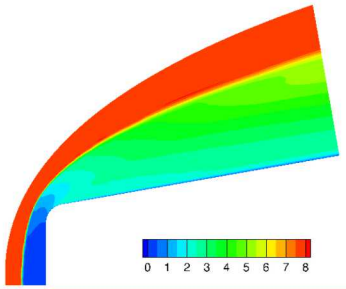
H_0(MJ/kg)	$\tau_{w,max}$(Pa)
22	672.2
12	583.6
cold	99.6





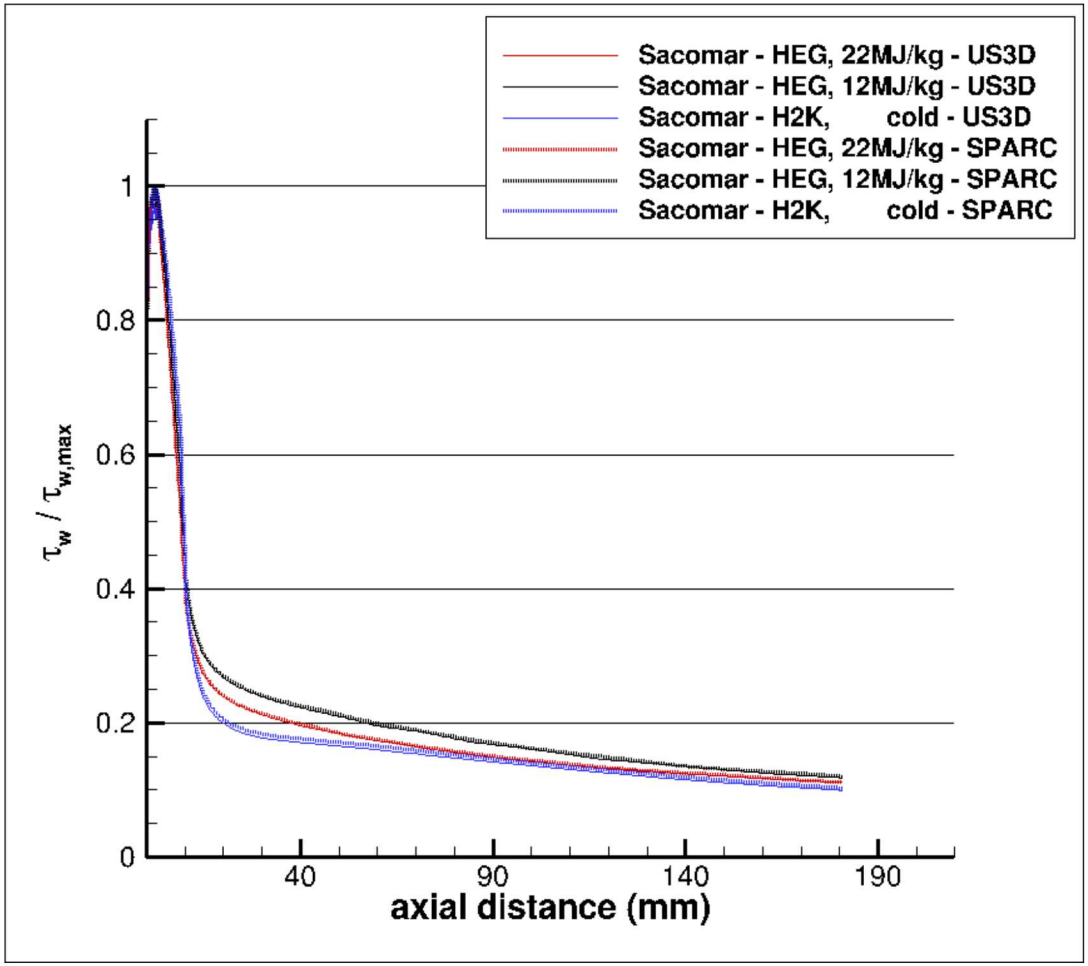
Shear Stress (Sacomar)

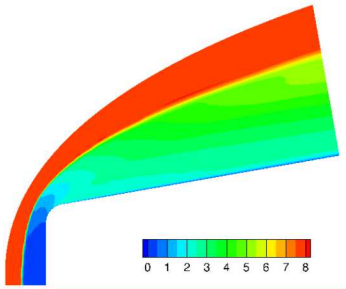




Shear Stress - normalized (Sacomar)

H_0(MJ/kg)	$\tau_{w,max}$(Pa)
22	862.2
12	751.4
cold	146.7





Centerline Plots

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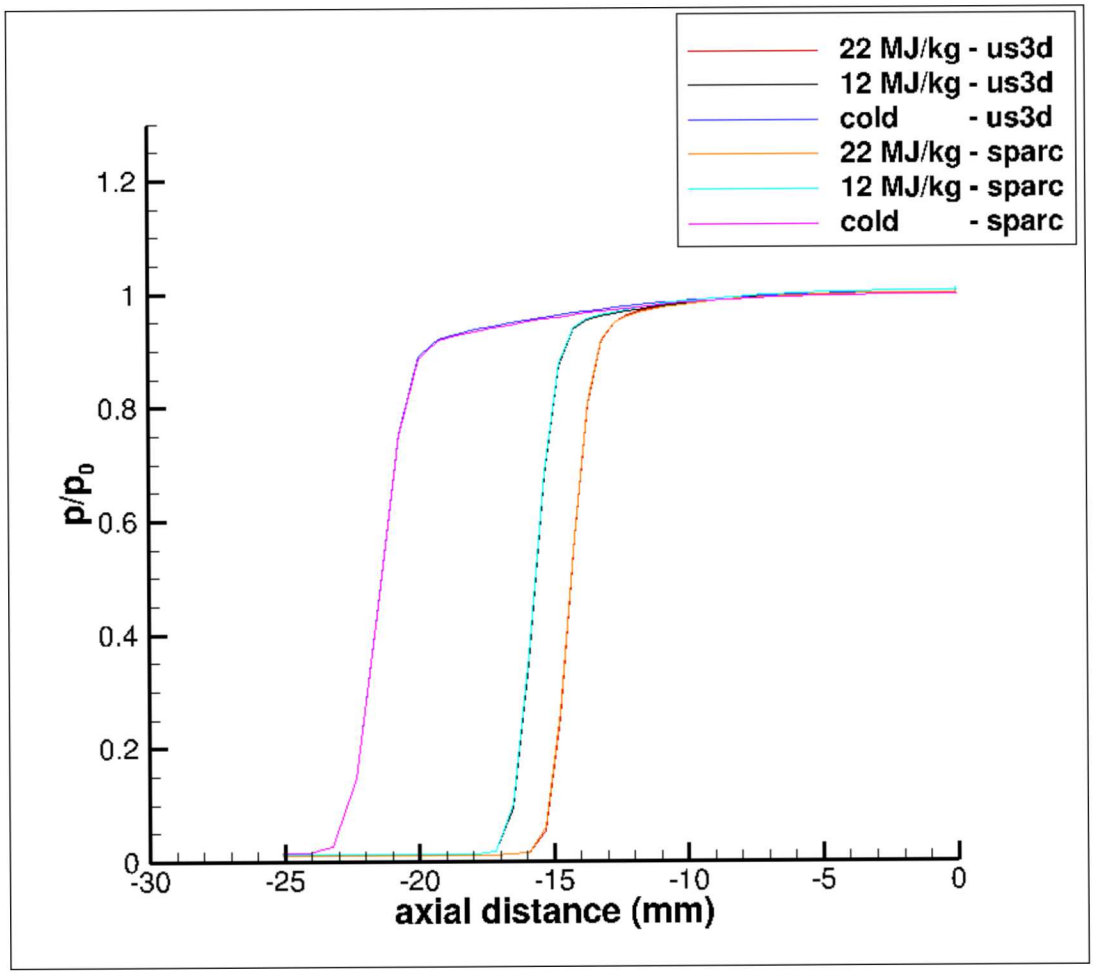
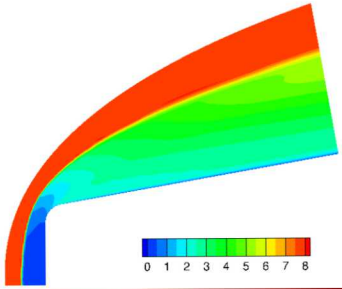
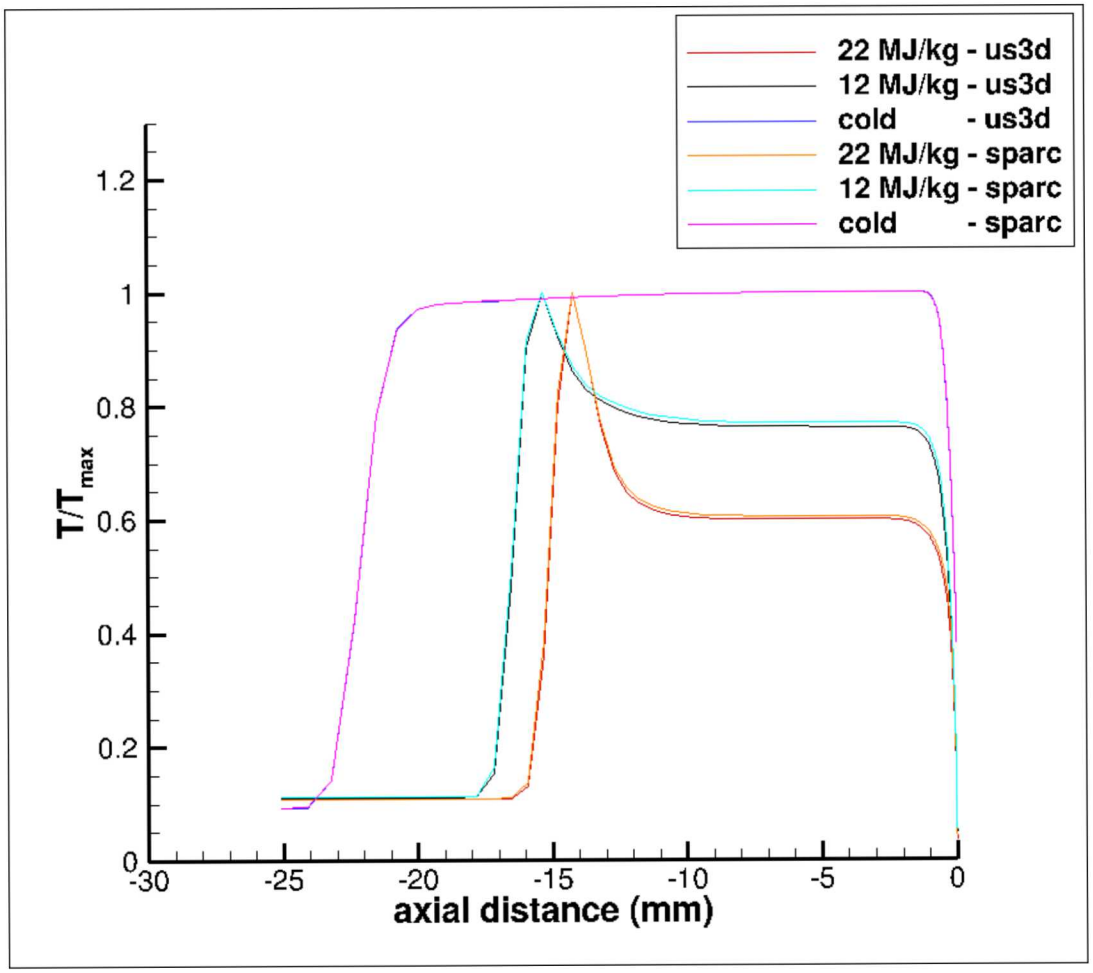
- Results shown for Sacomar only

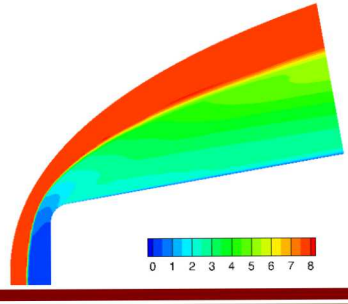
Pressure (Sacomar)



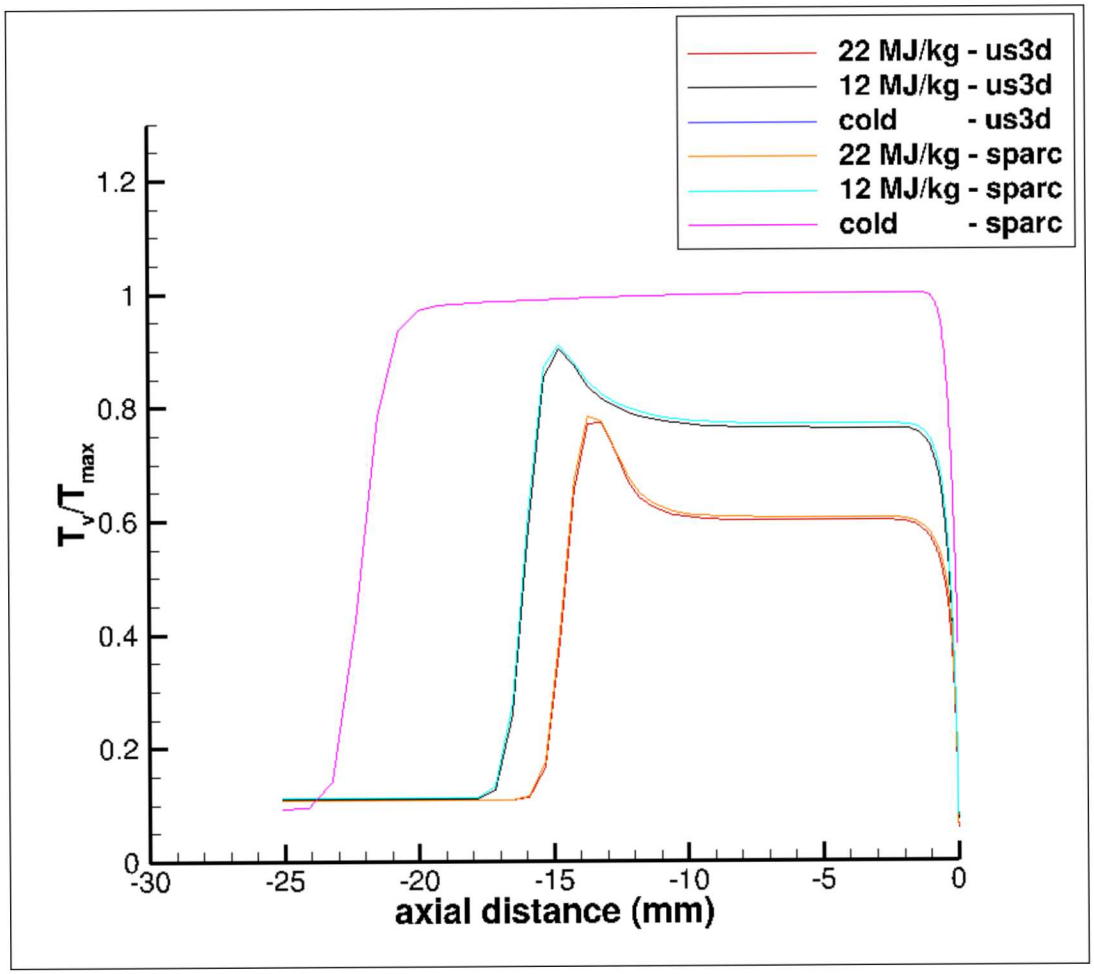


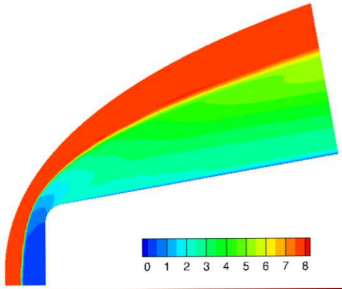
Temperature (Sacomar)



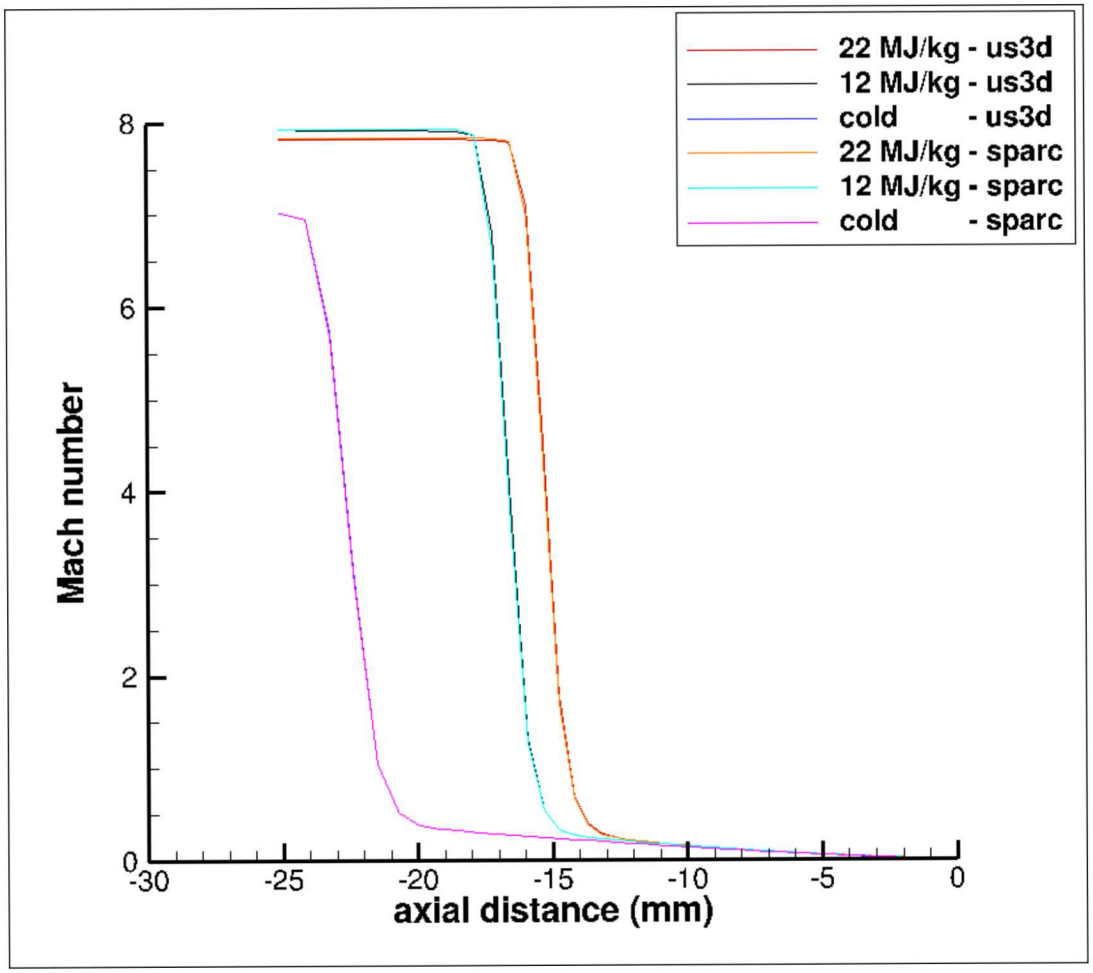


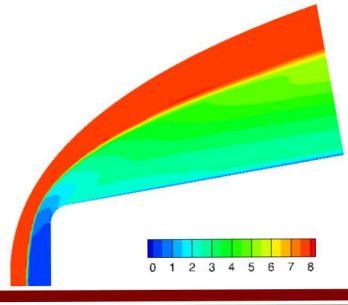
T_v (Sacomar)


22 MJ/kg - us3d
12 MJ/kg - us3d
cold - us3d
22 MJ/kg - sparc
12 MJ/kg - sparc
cold - sparc
T_v/T_{max}
1.2
1
0.8
0.6
0.4
0.2
0
-30
-25
-20
-15
-10
-5
0
axial distance (mm)

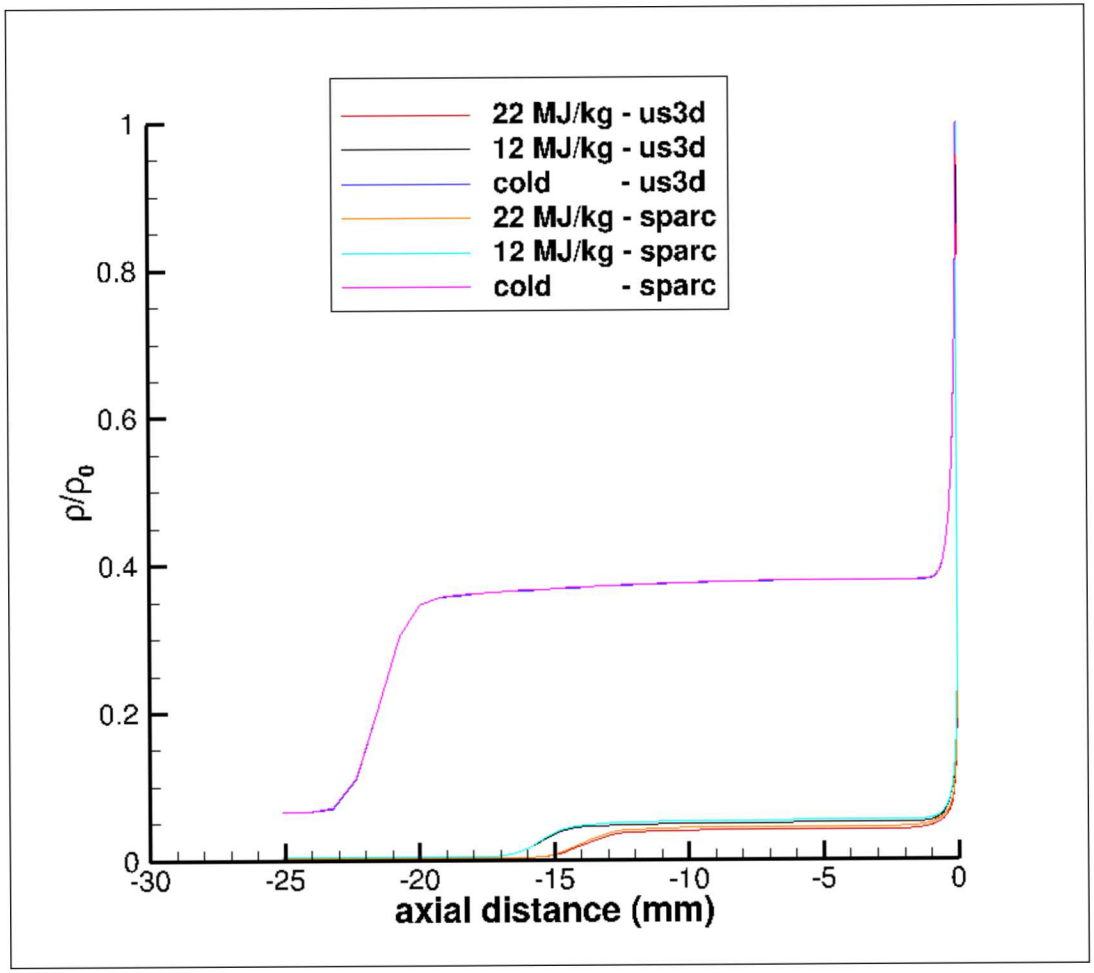

0 1 2 3 4 5 6 7 8

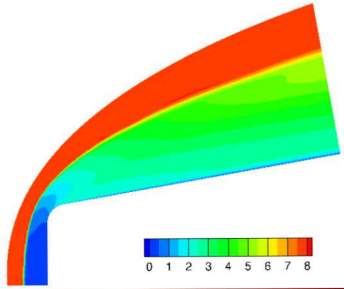
Mach number (Sacomar)



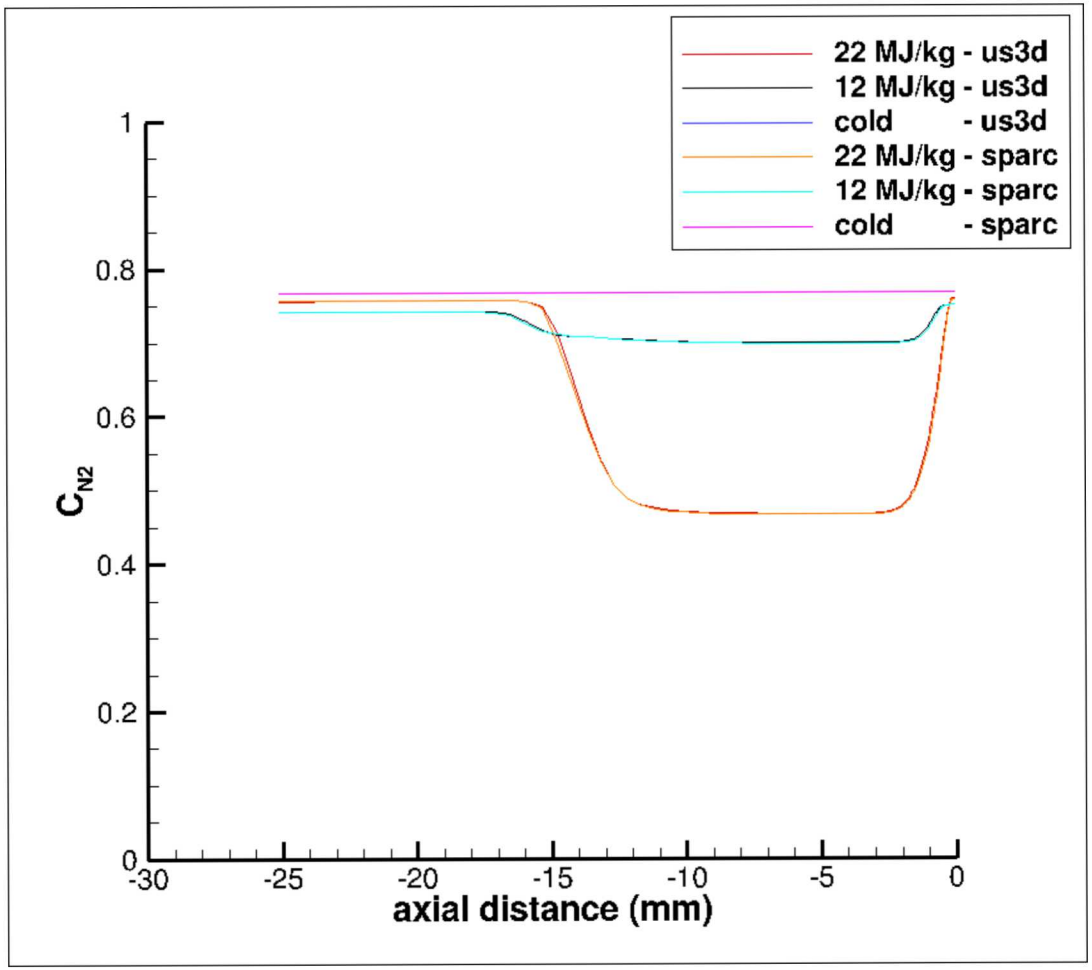


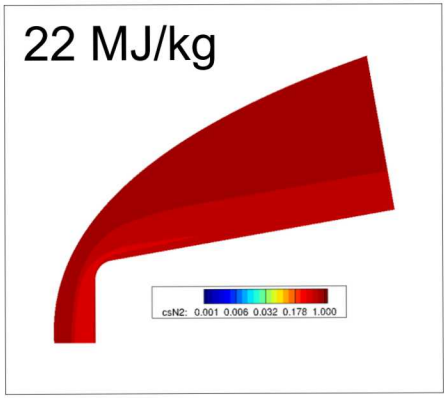
Density (Sacomar)

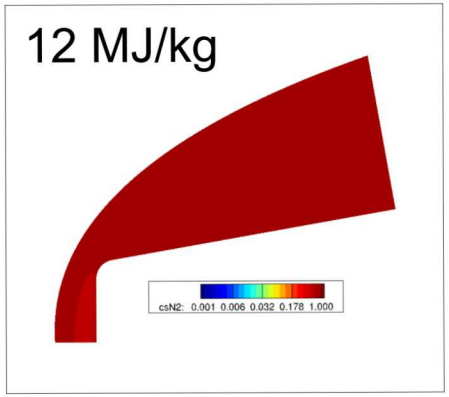




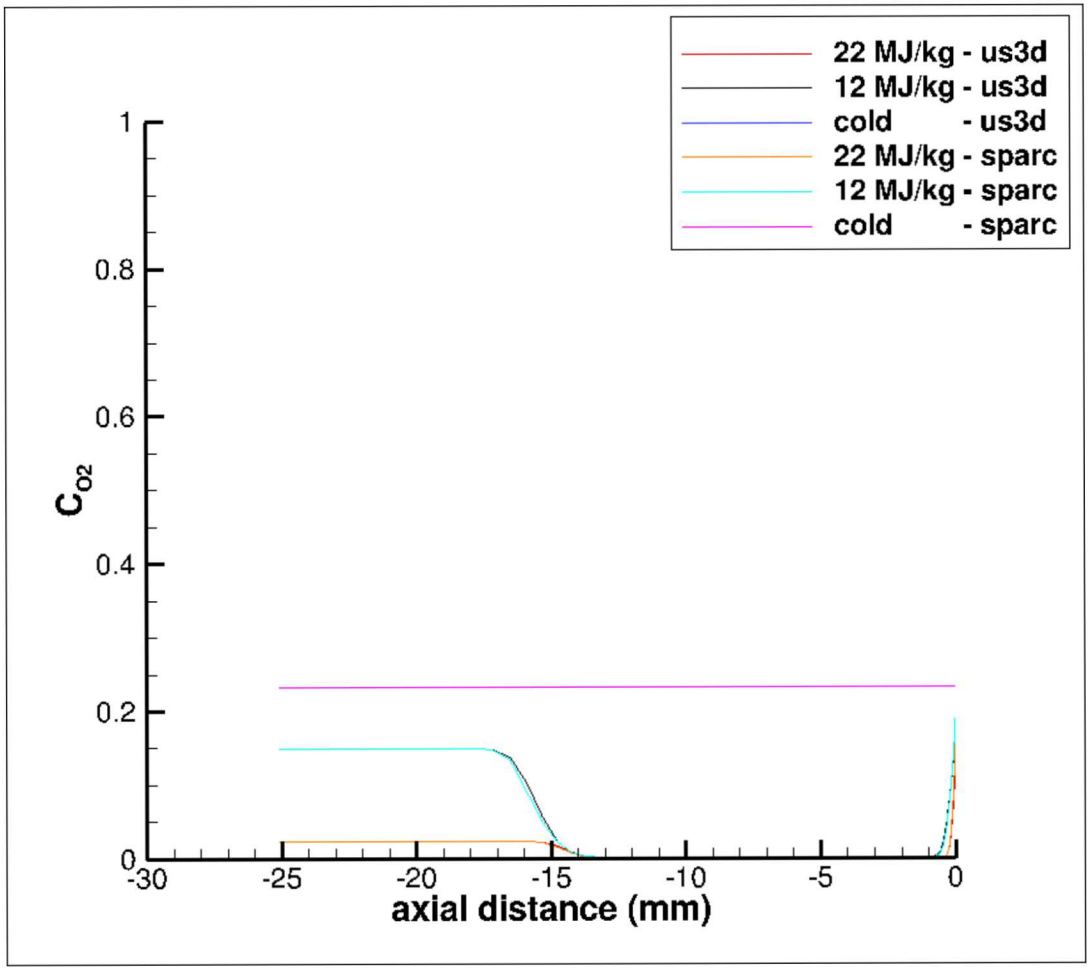
N_2 Concentration (Sacomar)

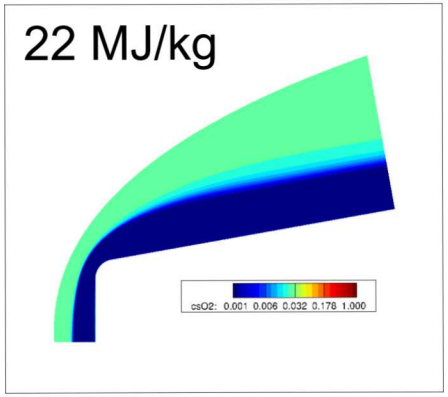


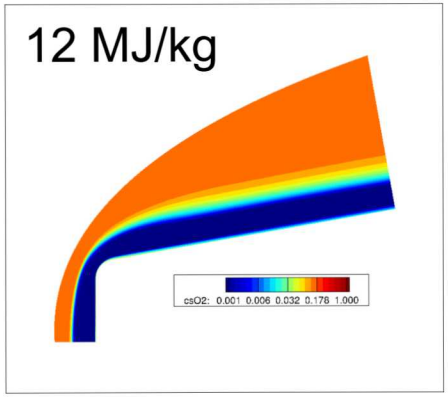




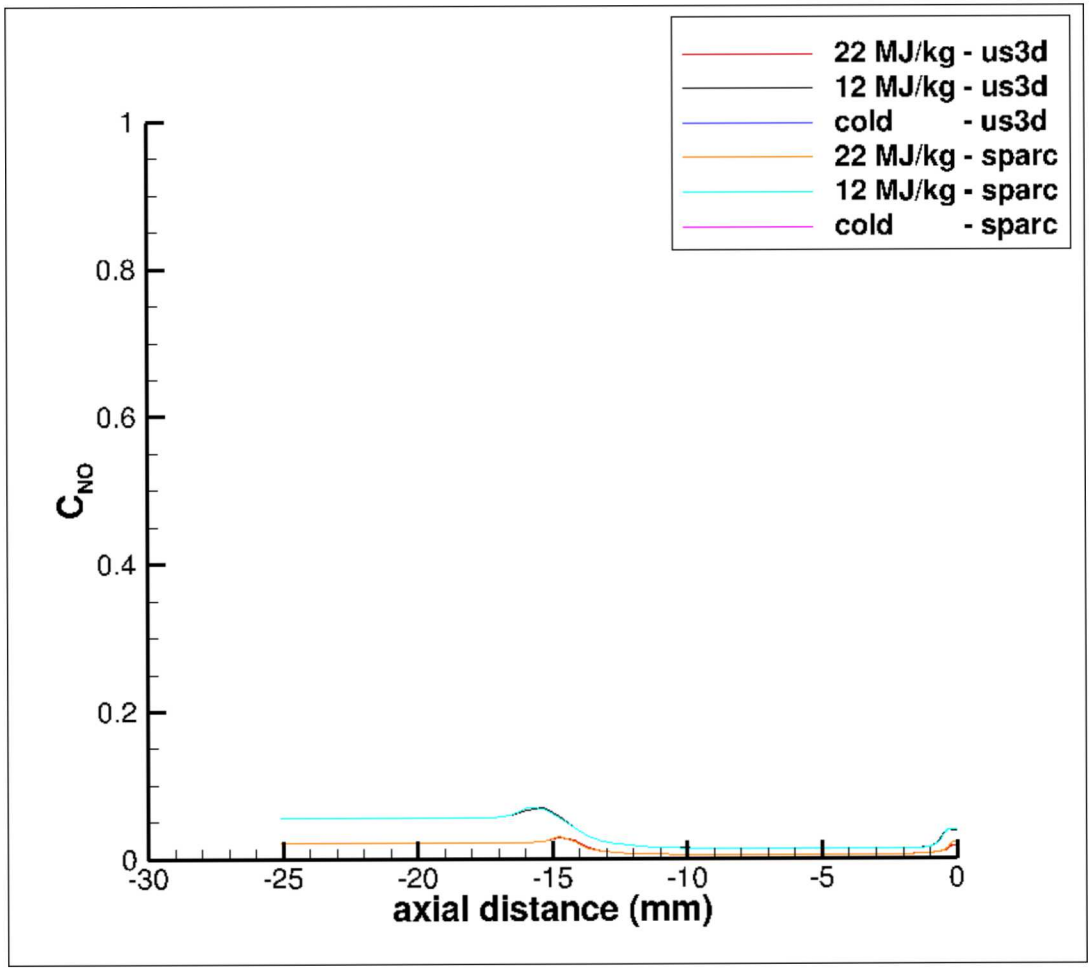
O_2 Concentration (Sacomar)

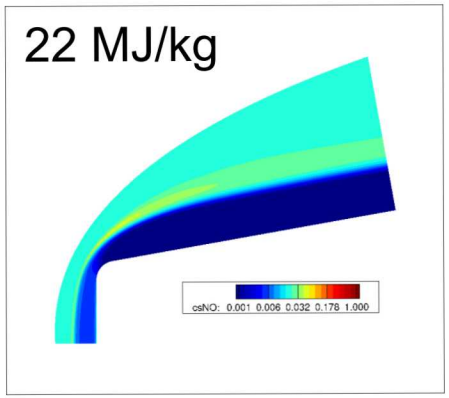




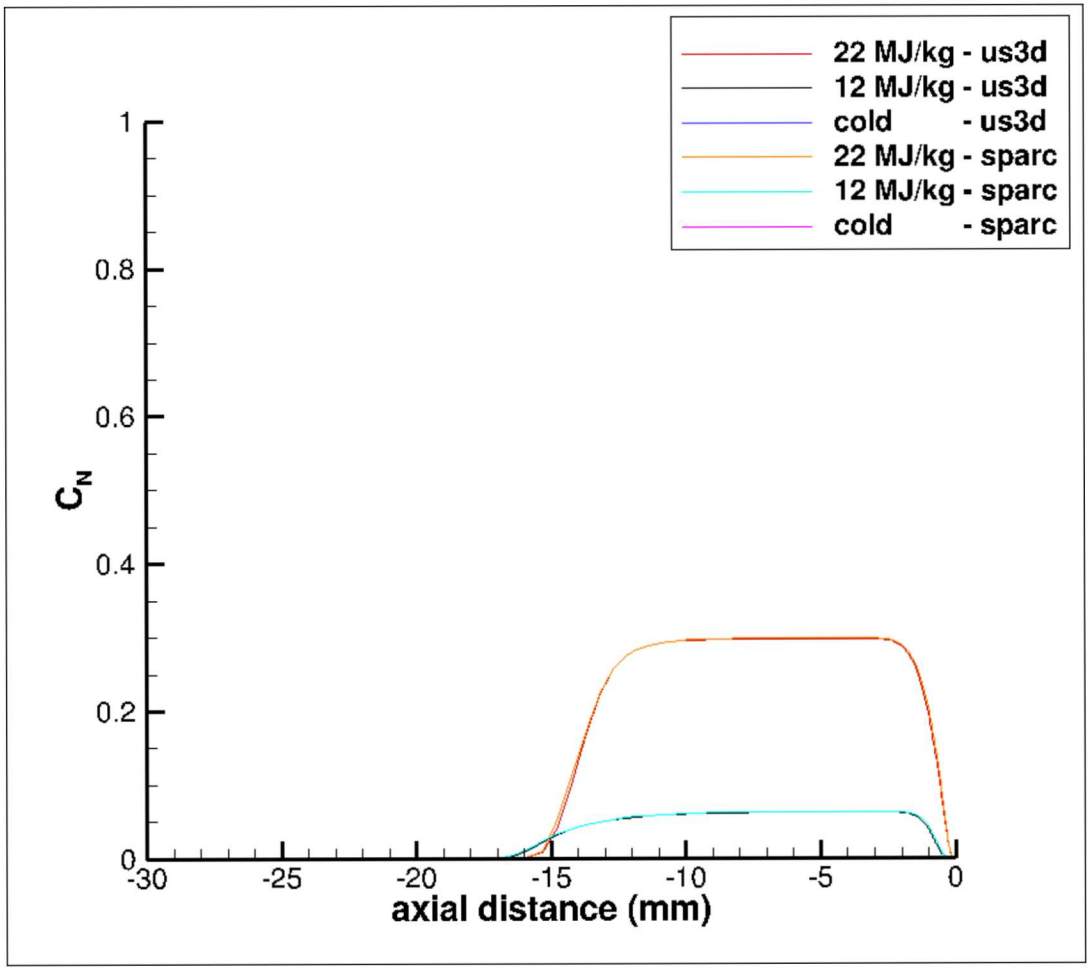


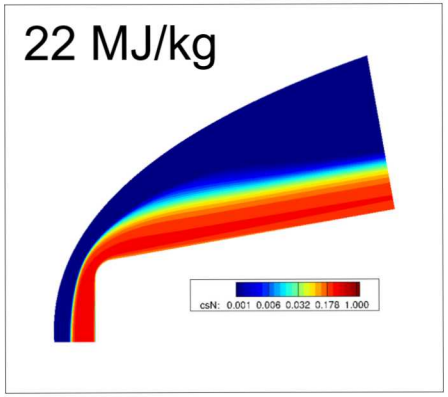
NO Concentration (Sacomar)

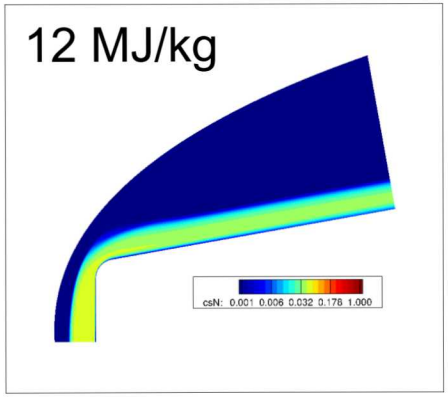




N Concentration (Sacomar)







O Concentration (Sacomar)