Capture Radiation Management

Muon Collider 2011

Telluride, Colorado

June 27–July 1, 2011

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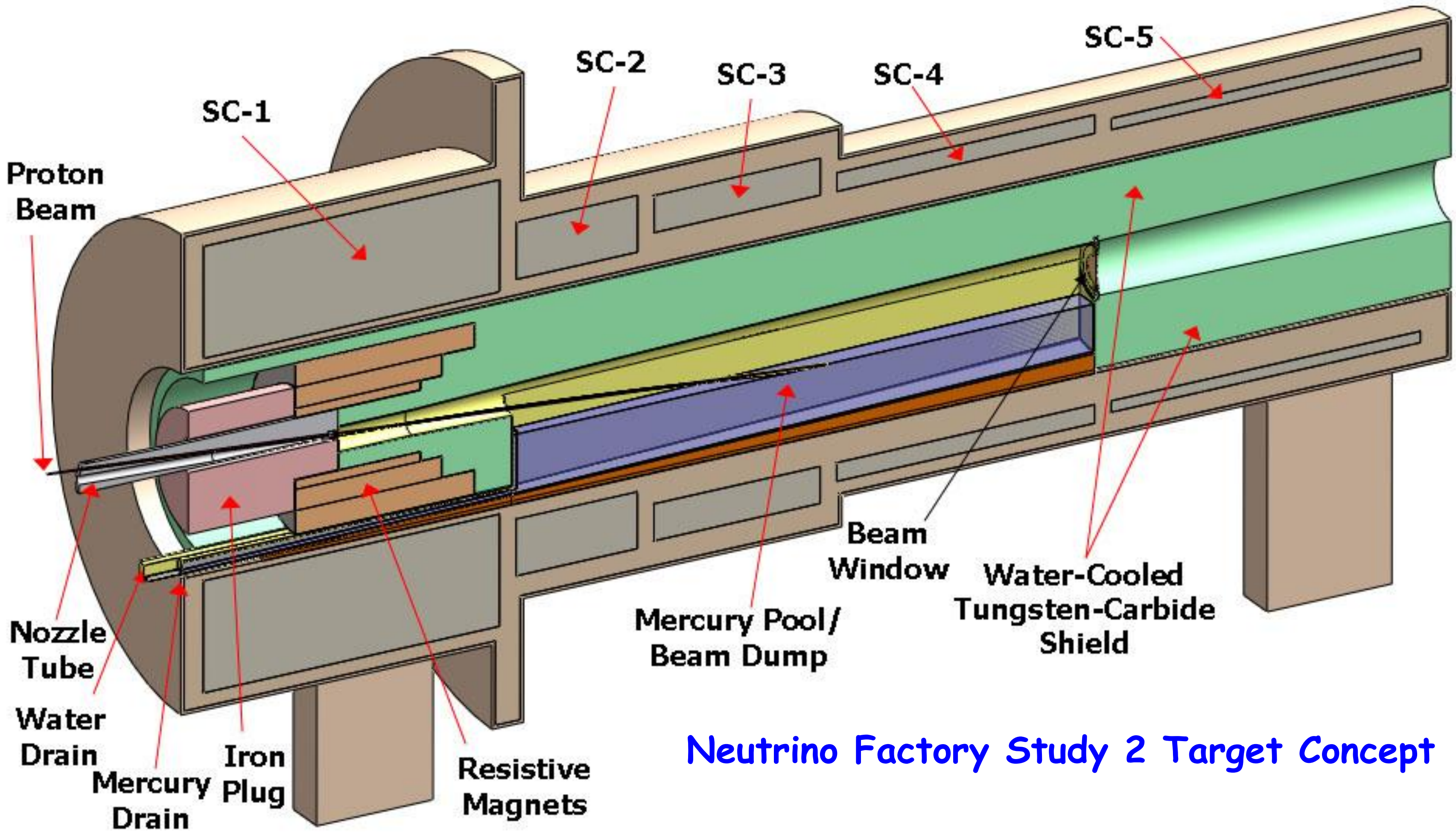
The Study 2 Target System



Neutrino Factory Study 2 Target Concept

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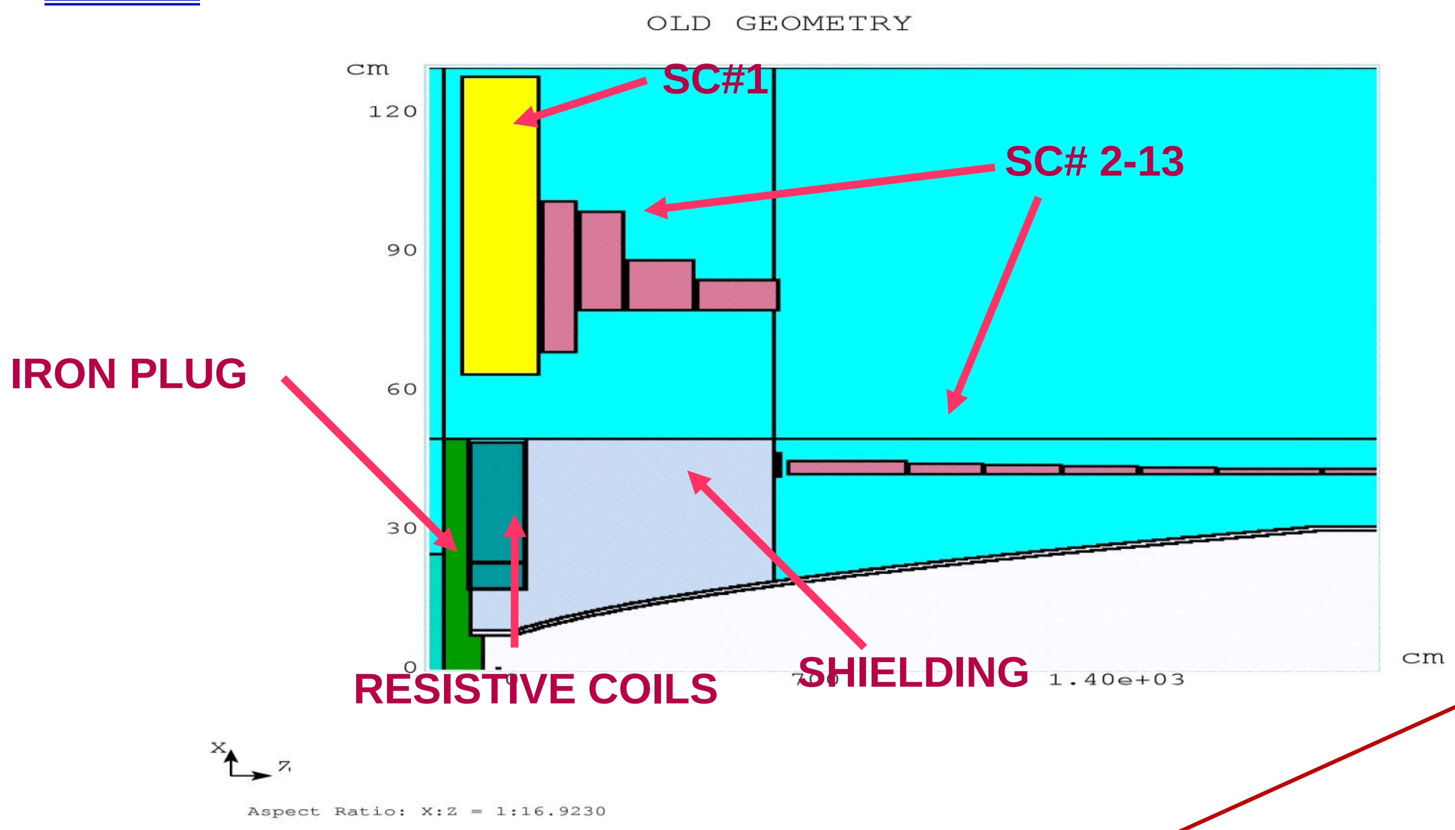
STUDY II SOLENOID GEOMETRY

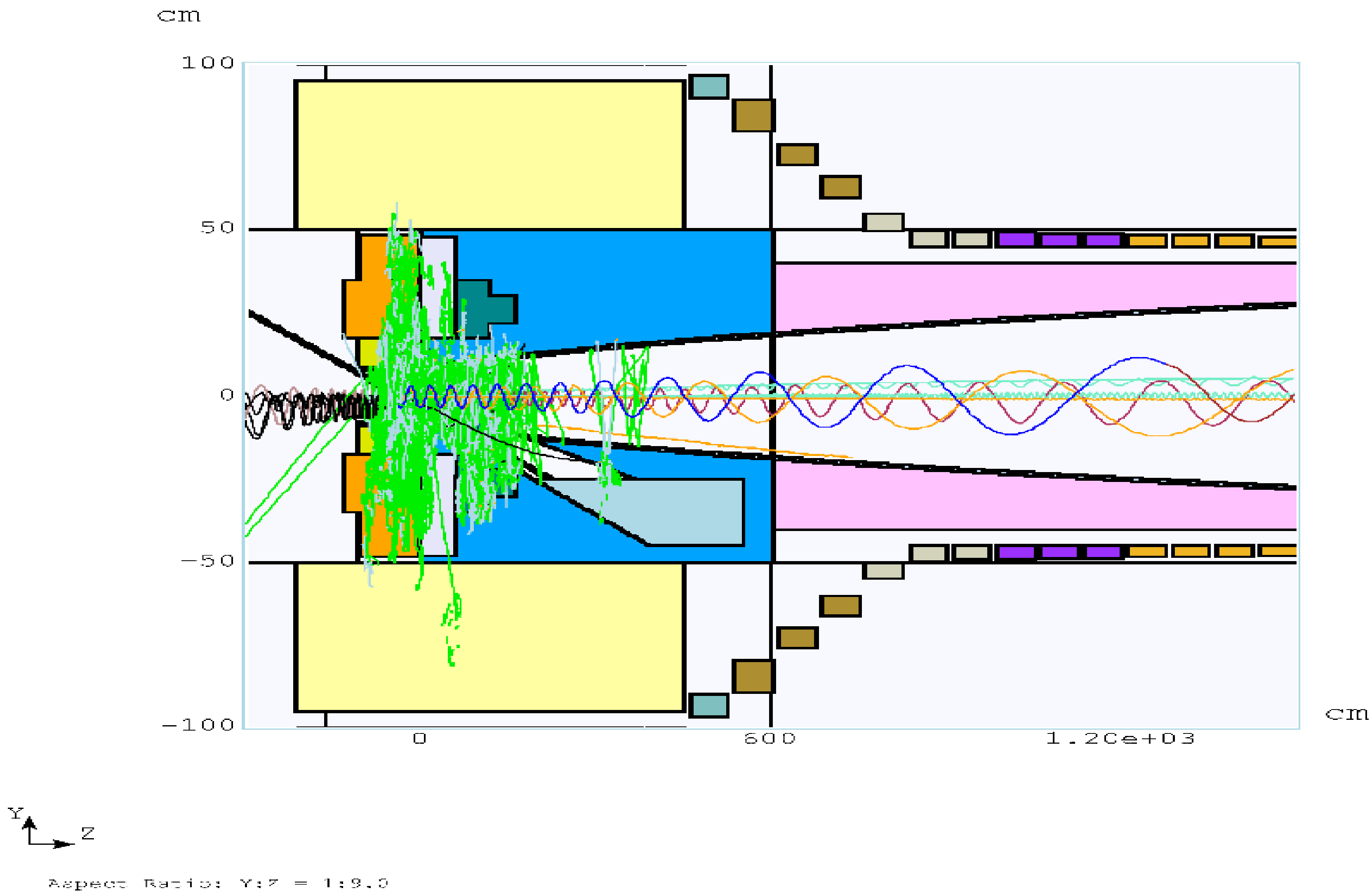


SC #1 IR

SC#1	-120<z<57.8 cm	R_{in}=63.3 cm	R_{out}=127.8 cm	
SC#2	67.8<z<140.7 cm	R_{in}=68.6 cm	R_{out}=101.1 cm	
SC#6-13	632.5<z<218.7 cm	R_{in}=42.2 cm	R_{out}=45.1-->43.4 cm	(TOTAL # SC=13)

Secondary Particle Production

Black=p, Green=n, Red/Blue=π±, Orange/Turquoise=e±, Gray=γ.



DEPOSITED ENERGY WITH 24 GeV AND 8 GeV BEAM

N. Souchlas

MARS WITH 0.1 MeV DEFAULT NEUTRON ENERGY CUTOFF VS.

MARS+MCNP WITH 10^{-11} MeV NEUTRON ENERGY CUTOFF.

ENERGY DEPOSITED IN SOLENOIDS IN kW.

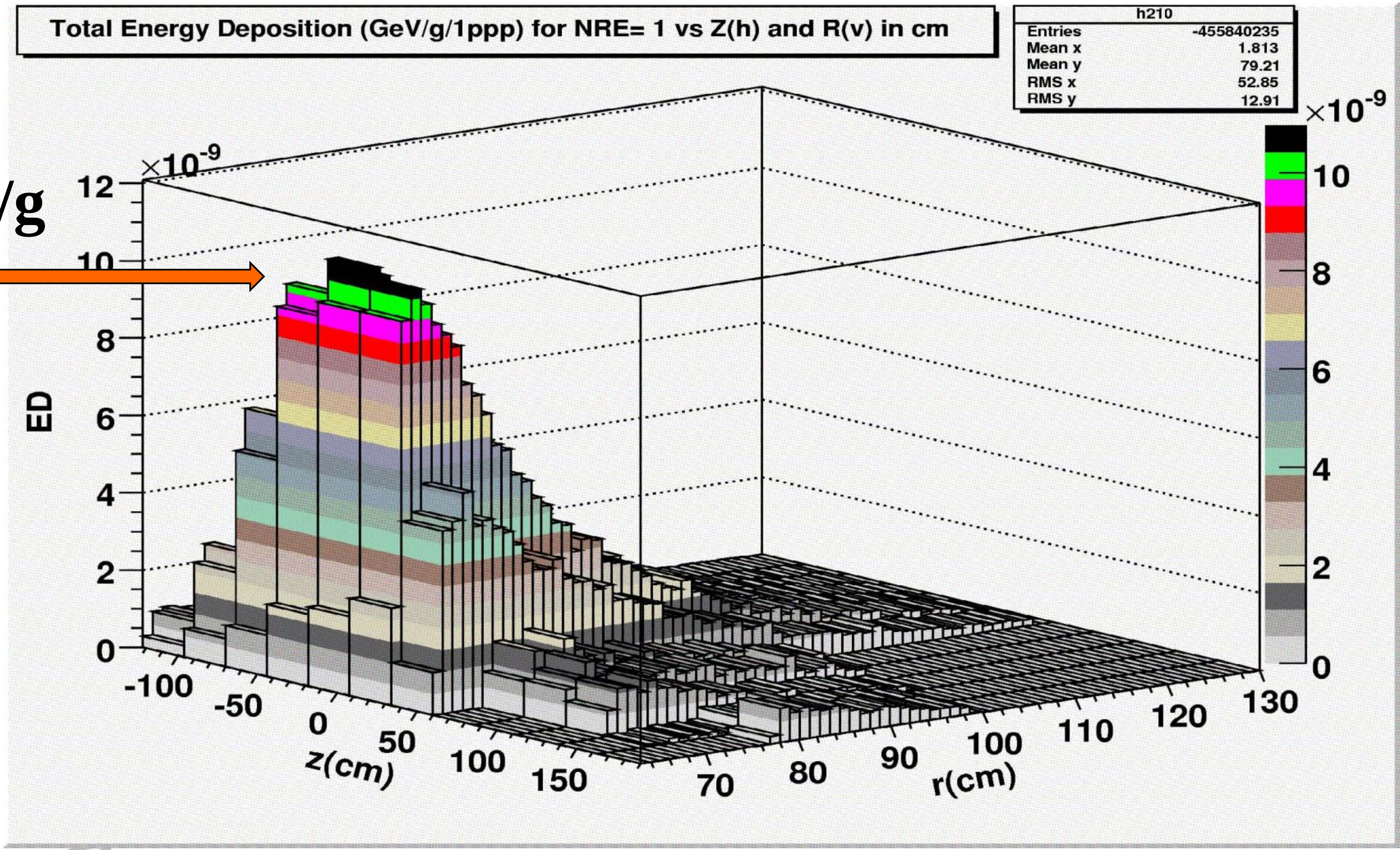
		SC#1	%	SC#2-13	%	Total	%	
24 GeV	a	14.28	–	14.90	–	29.18	–	MARS
	b	22.06	+54.48	16.30	+9.40	38.36	+31.50	MARS+MCNP
8 GeV	c	24.97	+74.86	11.84	-20.54	36.81	+26.15	MARS
	d	37.62	+50.66	12.46	+5.24	50.08	+36.05	MARS+MCNP

From 24 GeV to 8 GeV, and from a more detail treatment of low energy neutrons: from ~14 kW to ~38 kW power in SC1 and from ~29 kW to 50 kW in total power.

50kW at 4^0 K → ~20MW wall power

Peak Energy Deposition

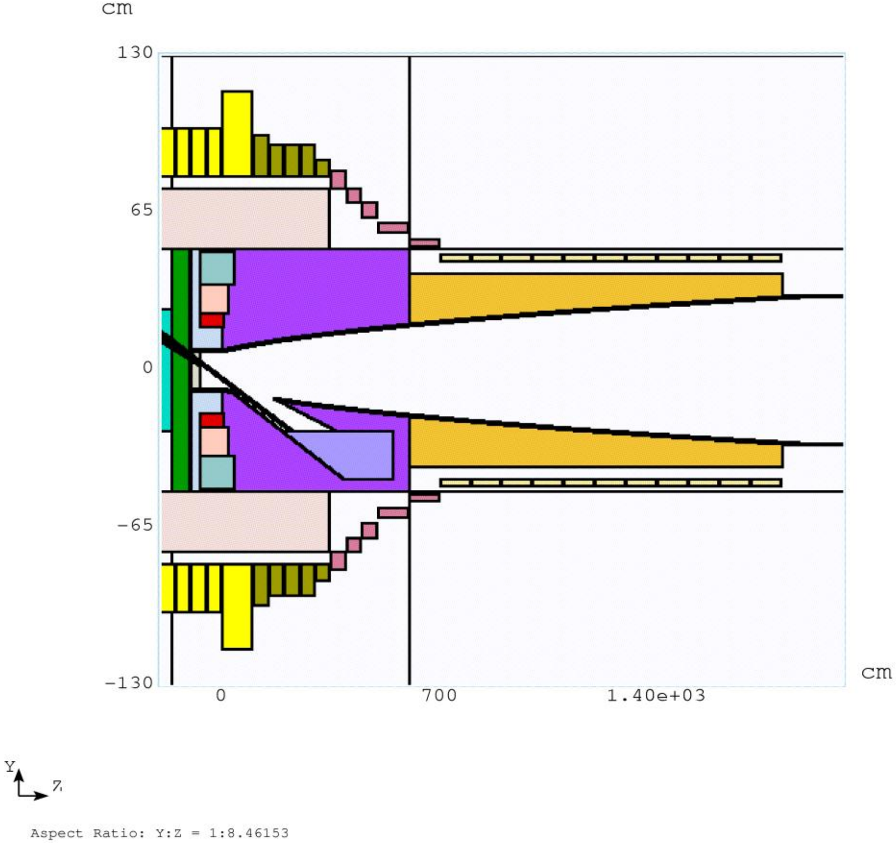
5.5mW/g

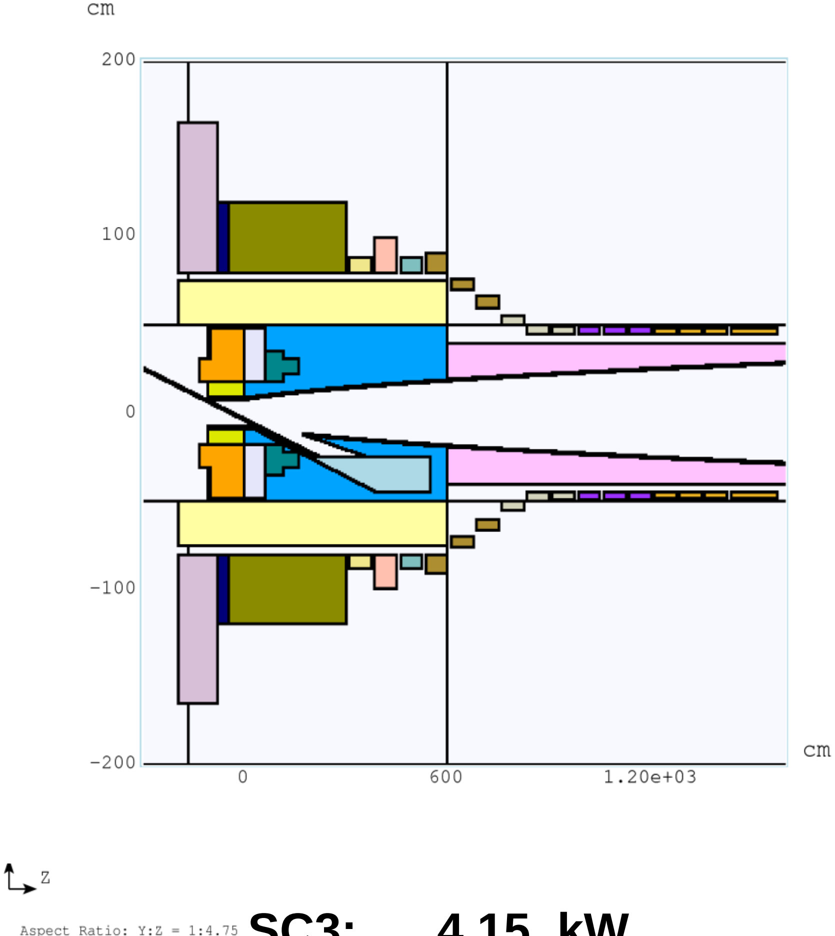


ITER Limit: 1mW/cc → 0.15mW/g

IDS80 GEOMETRY

IDS80f GEOMETRY (Bob Weggel)





SC#1-5: 2.6 kW
TOTAL: 3.47 kW
Peak SC5: 0.36 mW/gr

SC3: 4.15 kW
TOTAL: 5.69 kW
Peak SC3: 0.42 mW/gr

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Energy Deposition Results

MARS+MCNP(NEUTRON ENERGY CUTOFF 10^{-11} MeV)

60%WC+40% H_2O SHIELDING

STUDY II **IDS80**

SC#1: 42.5 kW -------->SC#1-5: 2.4 kW

SC#1-13: 58.1 kW-------->SC#1-26: 3.4 kW

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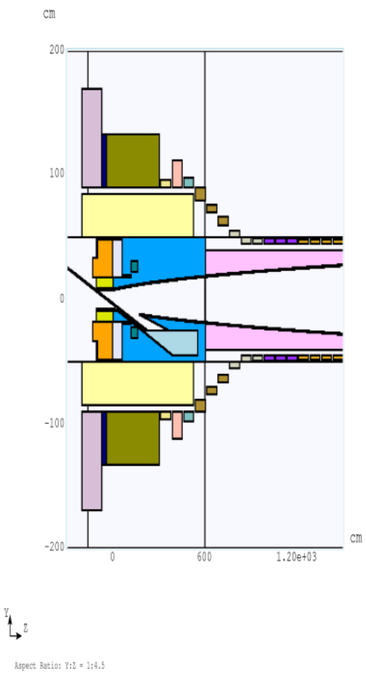
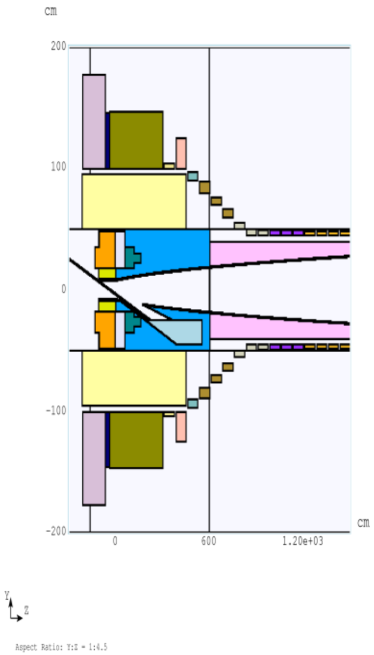
IDS GEOMETRIES

(Bob Weggel)

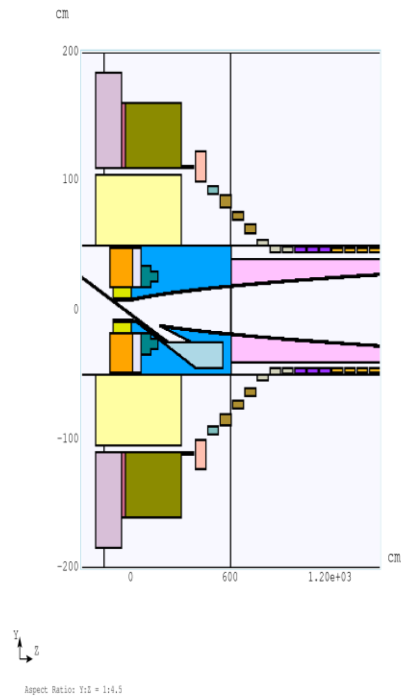
IDS90f



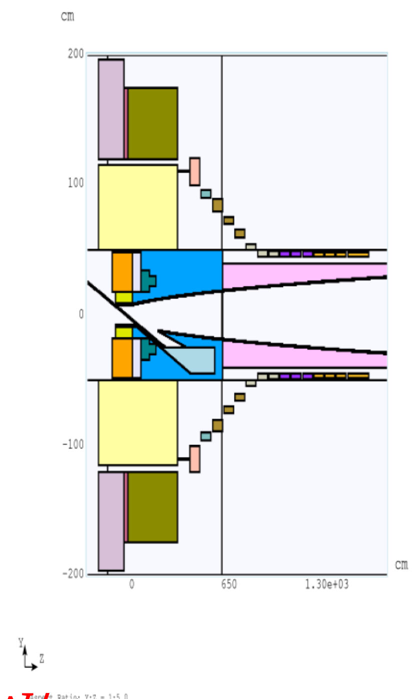
IDS100f



IDS110f



IDS120f



Energy Deposition: Total (kW) Peak (mW/g)

SC3: 2.07
TOTAL: 2.45
Peak SC3: 0.15
SC10: 0.07

SC3: 1.01
TOTAL: 1.41
Peak SC3: 0.08
SC9: 0.05
SC10: 0.10
SC11: 0.04

SC3: 0.49
SC5: 0.20
TOTAL: 1.14
Peak SC3: 0.03
SC5: 0.05
SC12/19 : 0.09

SC3: 0.26
SC5: 0.19
TOTAL: 0.97
Peak SC3: 0.03
SC7: 0.07
SC14: 0.08

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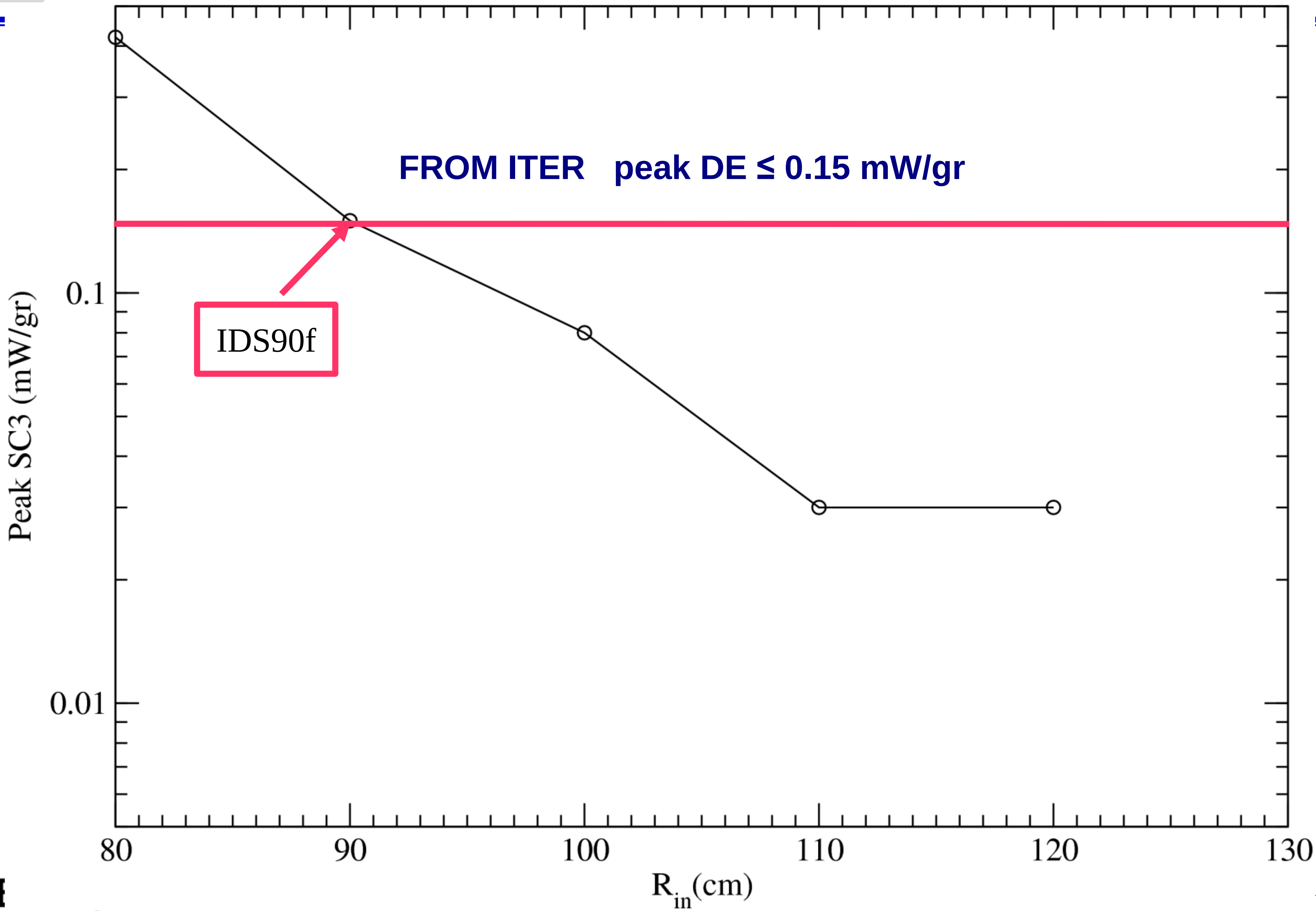
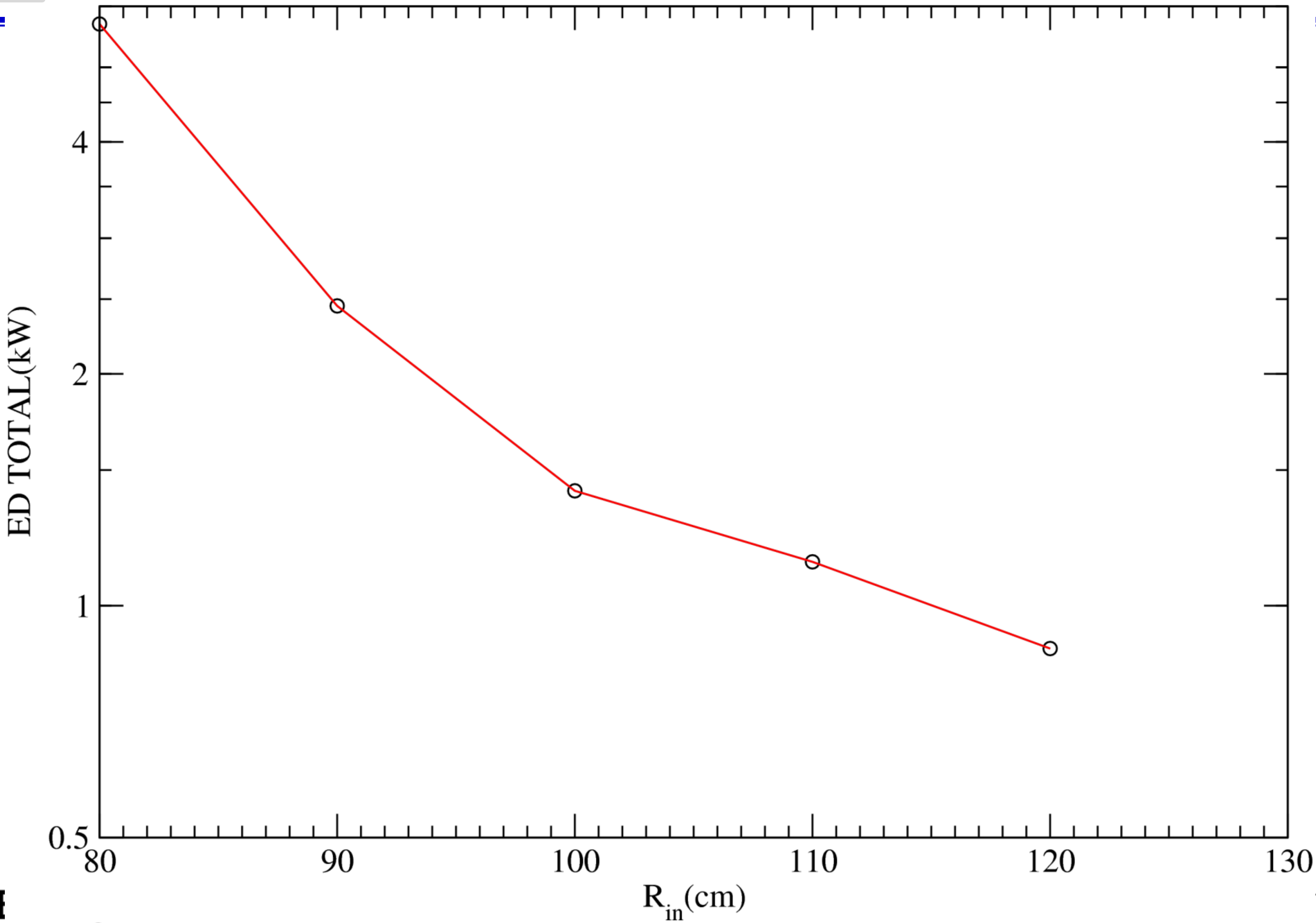
Peak Energy Depositions

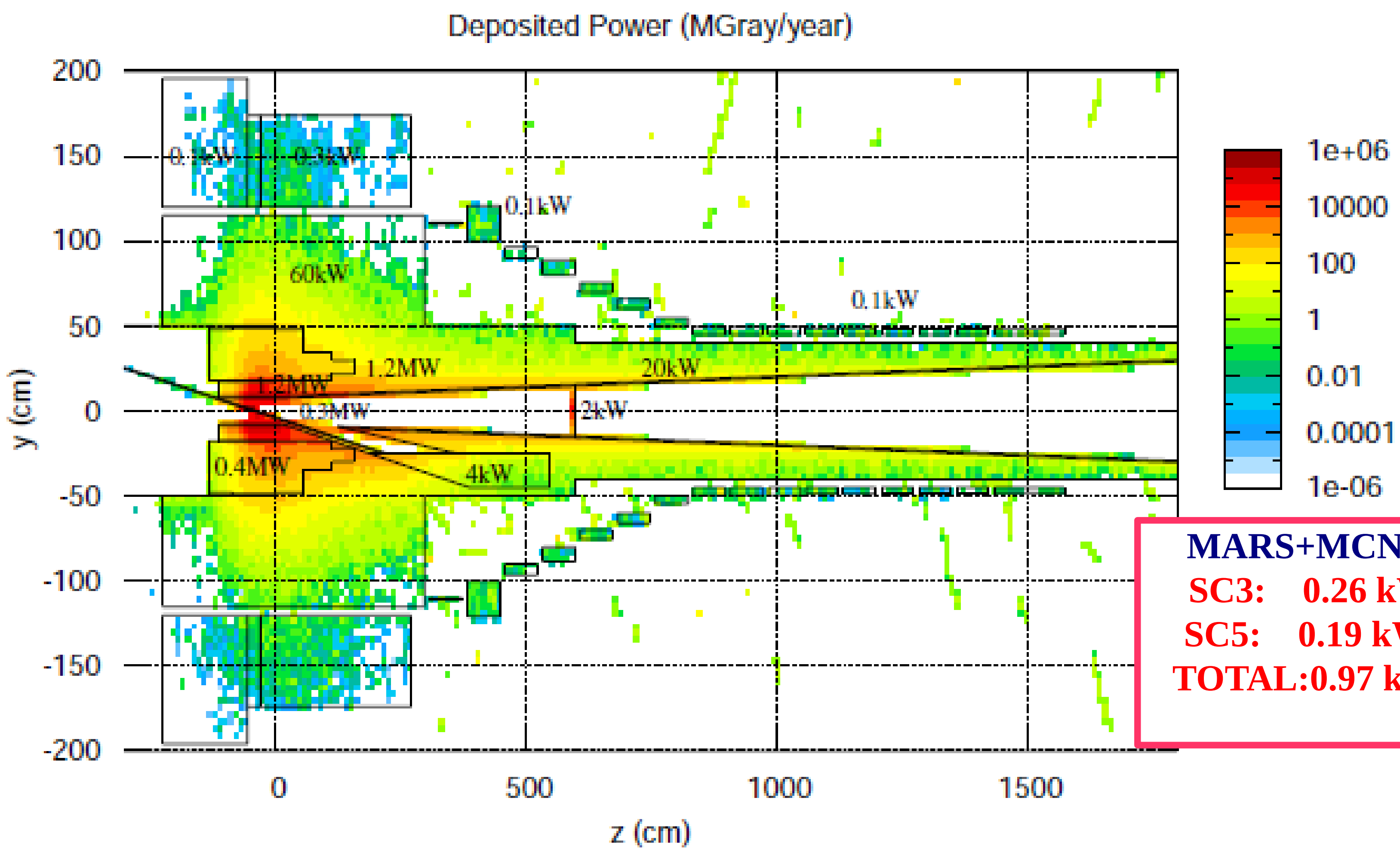


Total Energy Depositions



FLUKA Simulations - John Back 2/8/2011

Typical distribution of beam power



MARS+MCNP
SC3: 0.26 kW
SC5: 0.19 kW
TOTAL:0.97 kW

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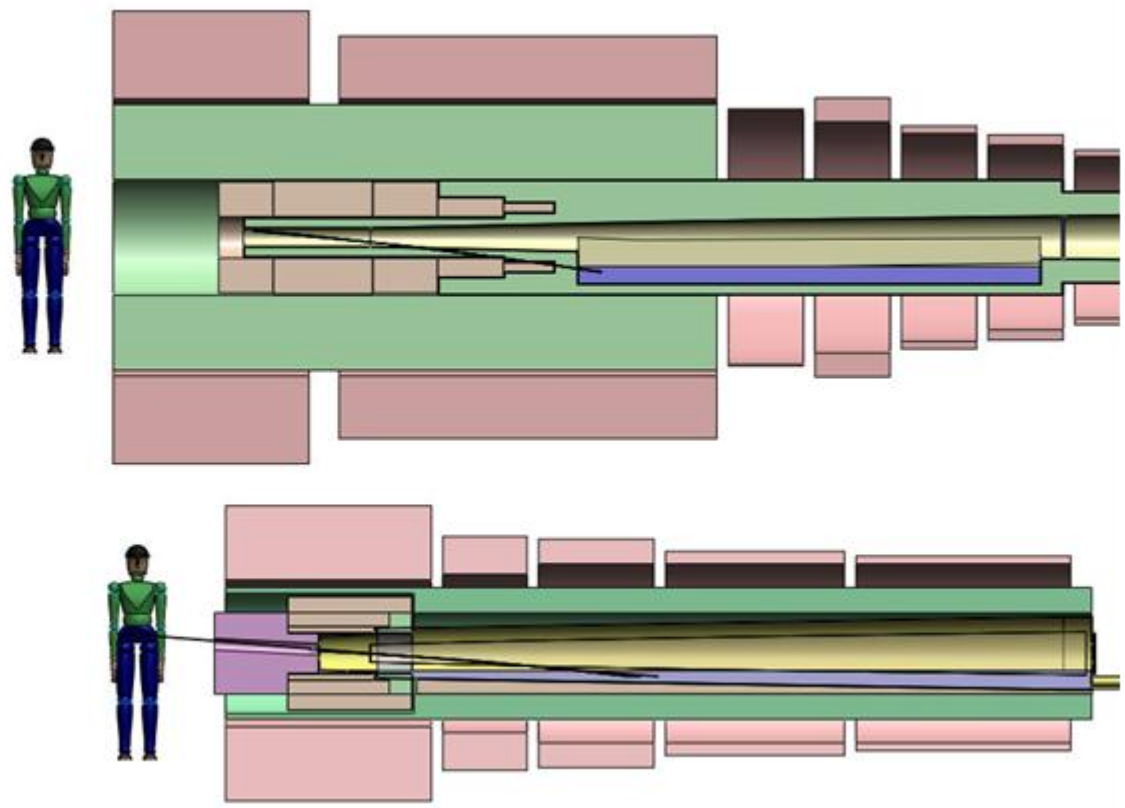
MARS/FLUKA Energy Depositions

TOTALS	MARS	FLUKA
SC#1-19	0.97	0.56
SH#1-4	2020.06	2148.9
RS#1-5	329.55	405.1
BP#1-3	458.39	482.8
Hg TARG.	376.5	319
Hg POOL	10.16	4.4
Be WIND.	0.53	2.1
TOTAL	3196.16	3362.86

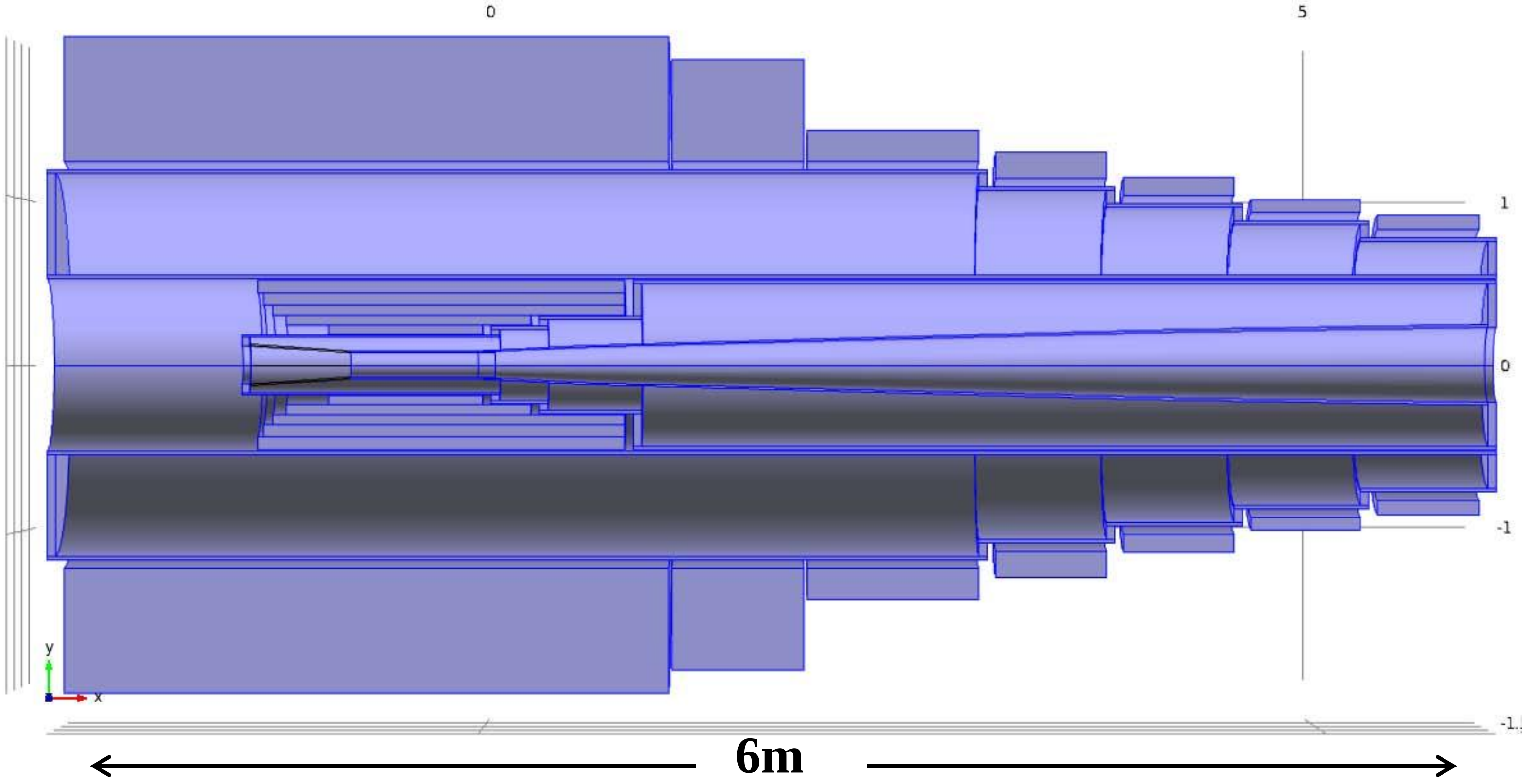
Capture Systems Comparisons

IDS-120

Study 2



Latest Configuration-Bob Weggel



SC B Field: 15T **Resistive Field: 5T** **Power Consumption: 11.5MW**

SUMMARY

- Bulk of energy deposition in capture solenoids is due to neutrons
- Study II capture configuration had large energy deposition and hence a large dynamic heat load
- Study II configuration had peak energy depositions which exceeded ITER criteria by a factor of ~35
- New (IDS 120) configuration has reduced the dynamic heat load in the capture solenoids to ~1kW and the peak energy deposition to < 0.15mW/g
- But the capture solenoids stored energy now > 3GJ

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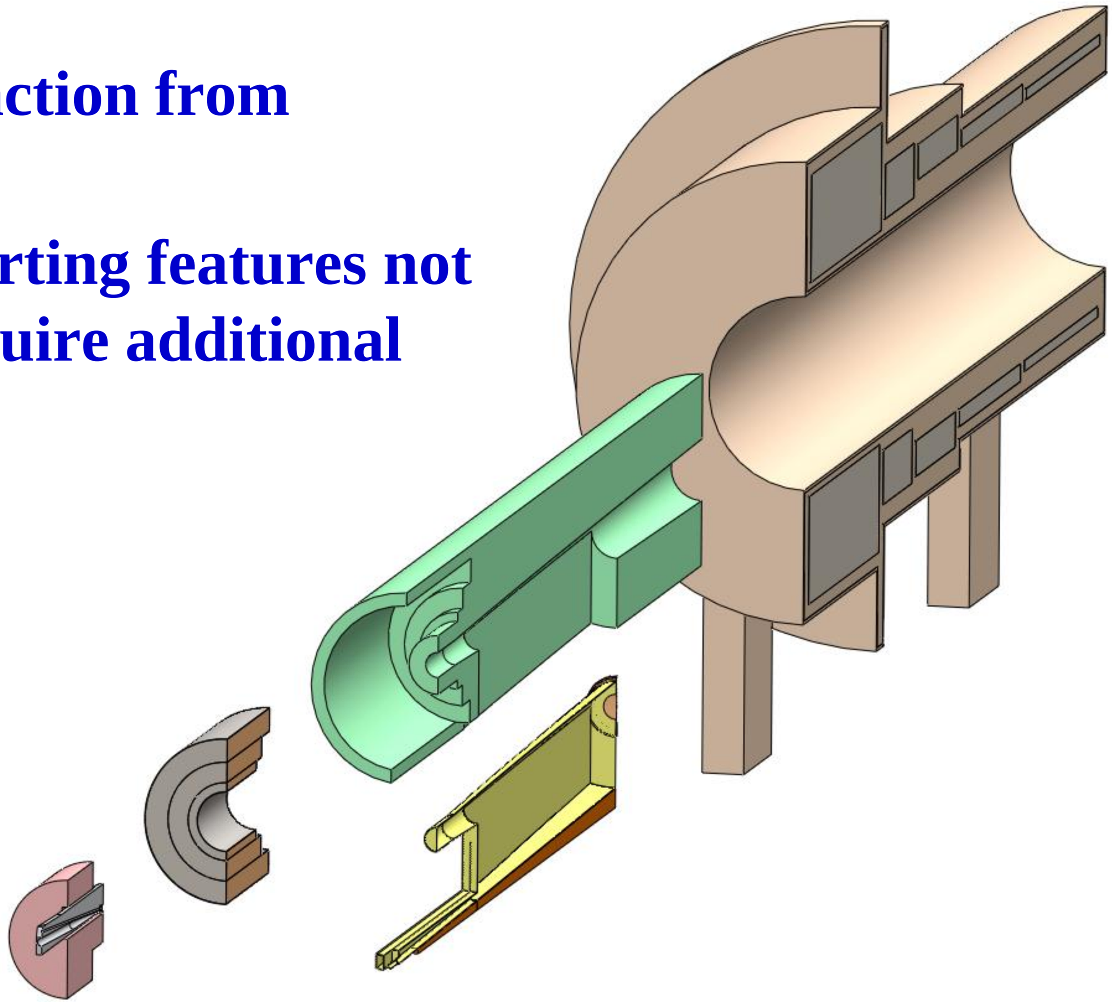
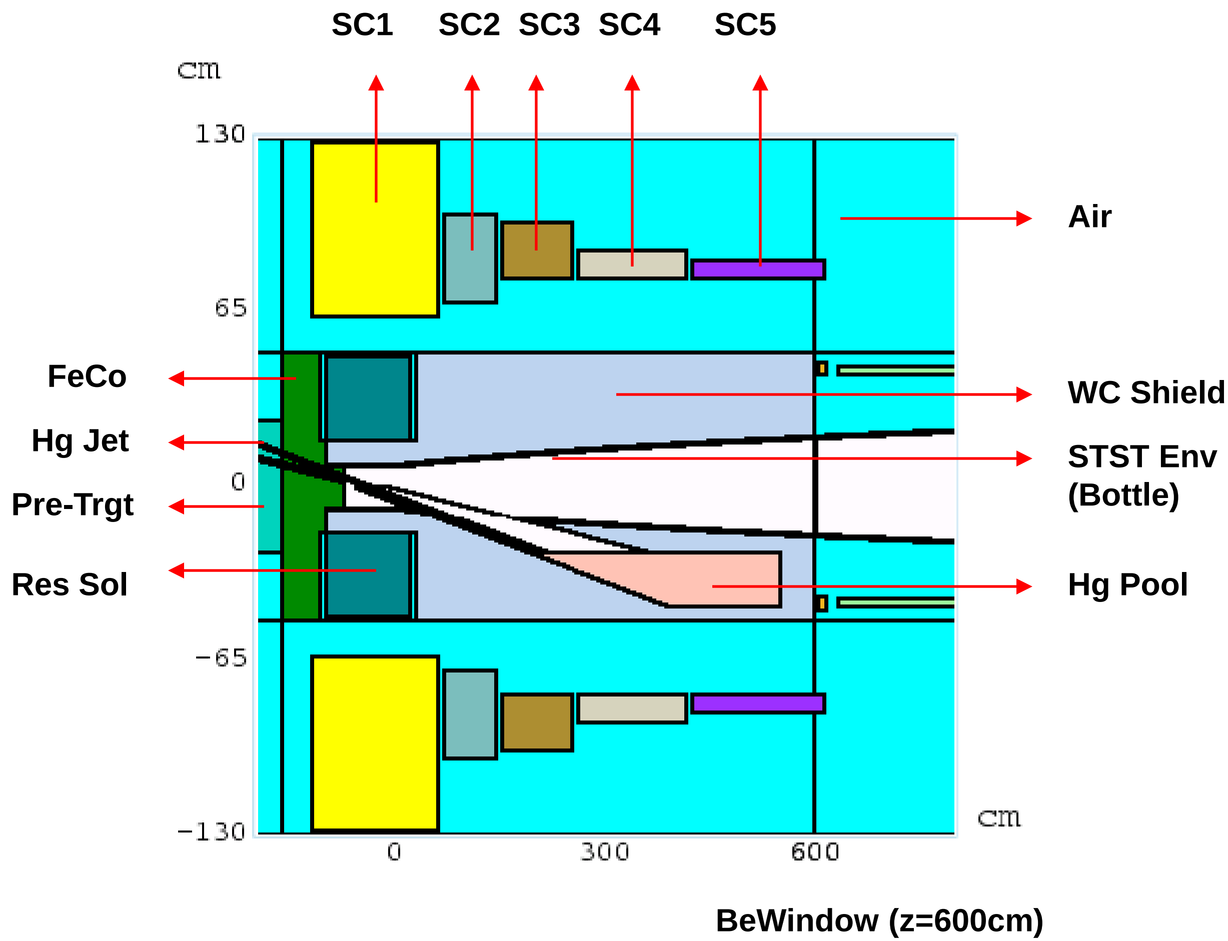
Backup Slides

Target System Exploded View

- All insertion/extraction from upstream end
- Locating & supporting features not shown – will require additional space

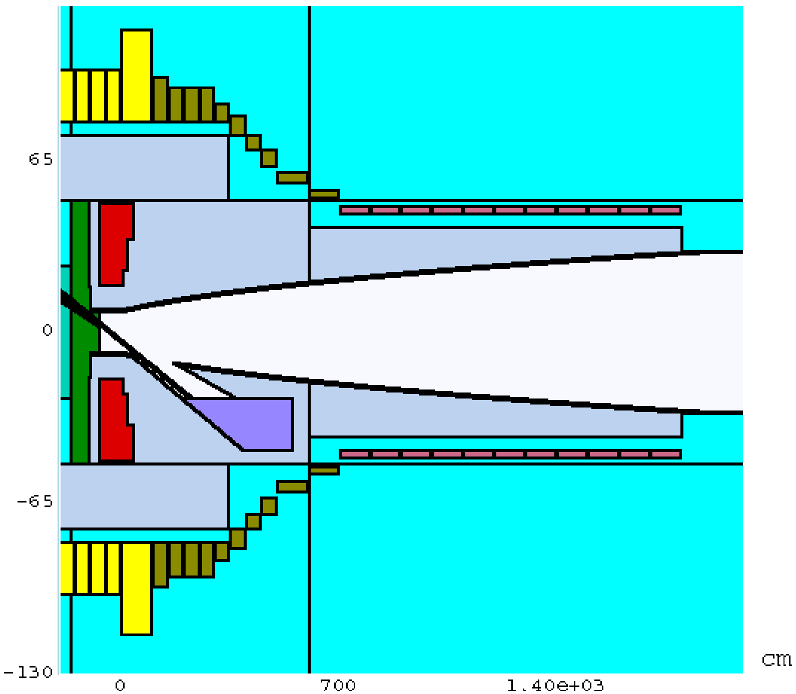


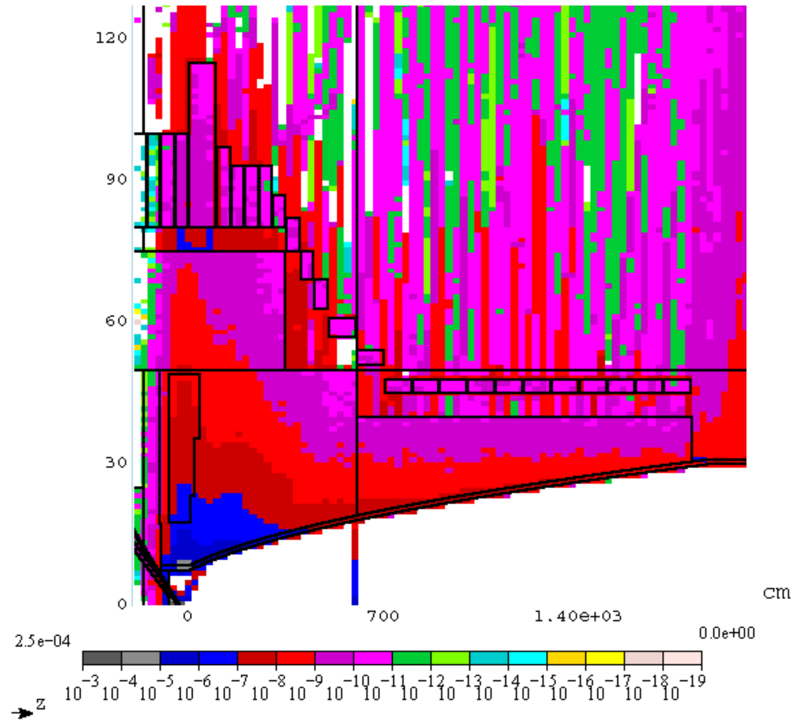
MARS Energy Deposition Studies



MARS15 study of Study 2 configuration yields 25KW energy deposition in SC1 alone

Reconfigure SC magnets





Increase the SC ID's. Fill released volume with shielding.

Rult: Total energy deposition in all SC's reduced to 2.4kW.

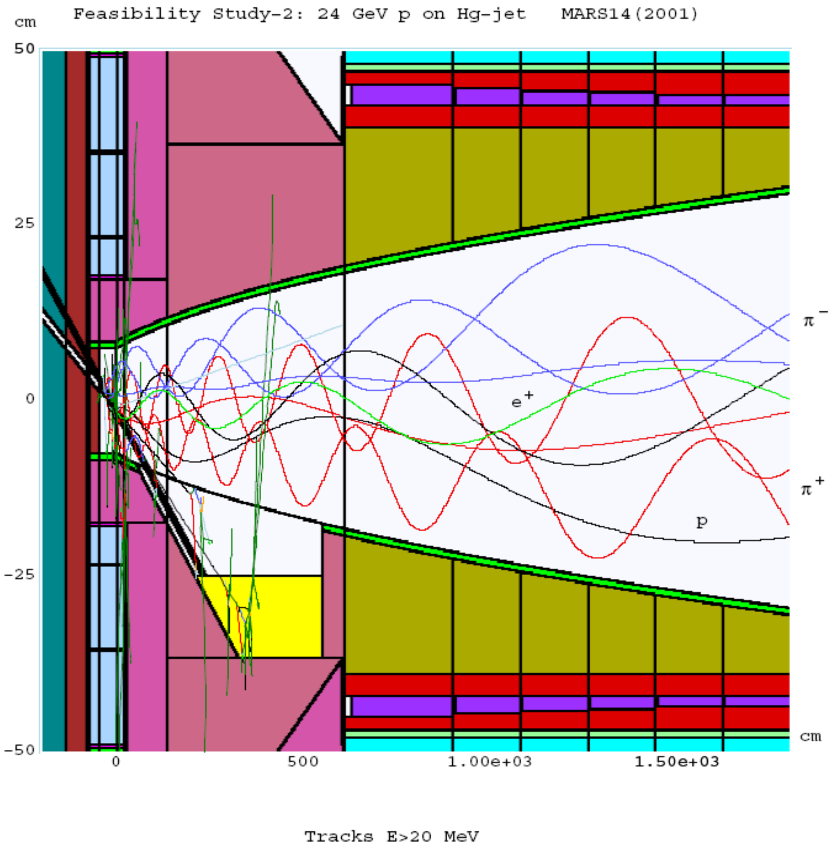
But SC magnets around target are now extremely difficult.

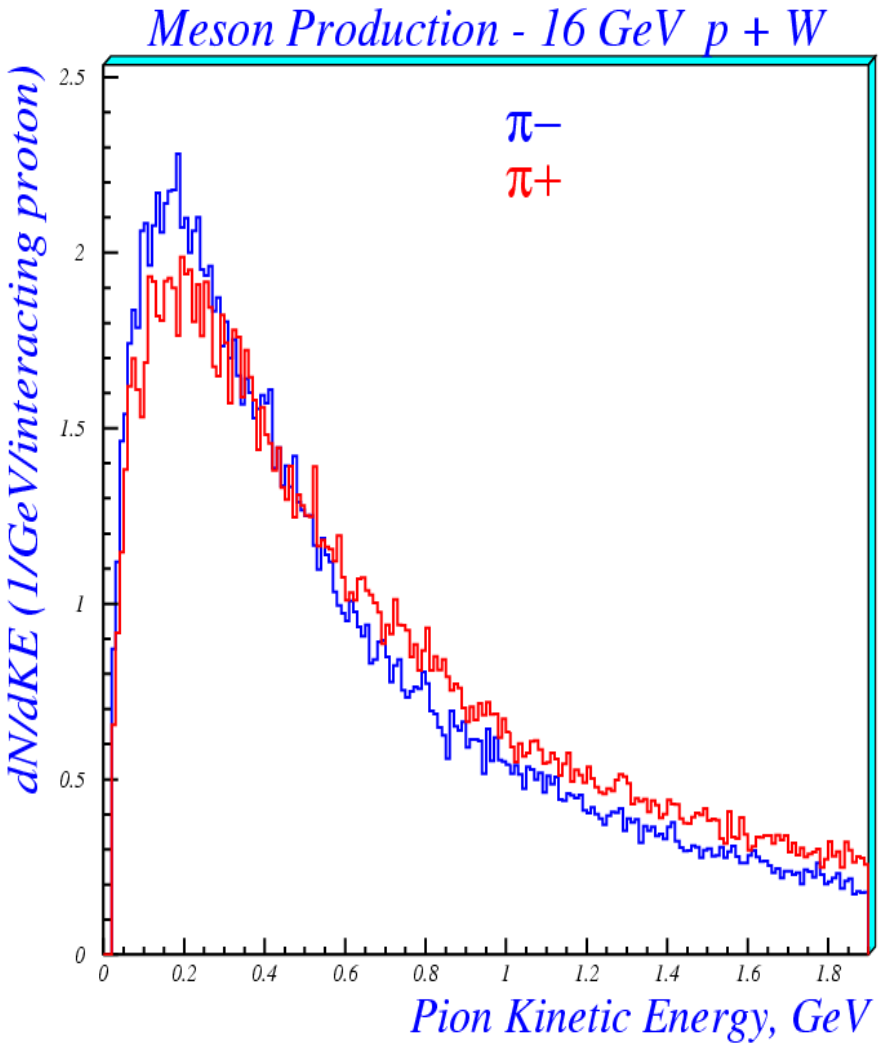
Require an iterative approach

The Neutrino Factory Target Concept

Maximize Pion/Muon Production

- **Soft-pion Production**
- **High-Z materials**
- **High-Magnetic Field**





Palmer, PAC97

Harold G. Kirk

Target Baseline Proton Beam Assumptions

Proton Beam Energy	8 GeV
Rep Rate	50 Hz
Bunch Structure	3 bunches, 320 μsec total
Bunch Width	2 ± 1 ns
Beam Radius	1.2 mm (rms)
Beam β^*	≥ 30cm
Beam Power	4 MW (3.125 × 1015 protons/sec)

Target System Baseline

Target type	Free mercury jet
Jet diameter	8 mm
Jet velocity	20 m/s
Jet/Solenoid Axis Angle	96 mrad
Proton Beam/Solenoid Axis Angle	96 mrad
Proton Beam/Jet Angle	27 mrad
Capture Solenoid Field Strength	20 T

Key Target Challenges

General Target Issues

- Thermal management (~3MW power deposited)
- Shielding (SC Solenoids required)
- Target integrity (Thermal Shock)
- Target regeneration (50Hz rep-rate)
- 20T environment

Liquid Hg specific issues

- Stable fluid flow (Nozzle performance)
- Hg handling system

The Key Parameters

Proton Driver

- 4 MW Beam Power
- 5-15 GeV KE (8GeV is currently favored)
- 50 Hz operation
- 3 Bunch structure (280μs total favored)

Target System

- 20T Solenoid Magnet
- Liquid Jet
- 20 m/s flow rate (50Hz operations)
- High-Z (Hg favored)