THE SUPER HMS

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MAJOR DESIGN CONSTRAINTS

1. Requirements from high luminosity physics

   - Bending angle must be larger than 12^{o}
   - High momentum 12 GeV/c
   - Adequate solid angle at available magnetic gradient
   - Maximum momentum acceptance
   - Medium resolution matches HMS and SOS
   - Small scattering angle $< 6^{o}$

2. Geometric restriction:

   - Available space from target to the mouth of dump tunnel ~ 27 m
   - Useful free space : Left hand 25 m

3. Angle Limit by the quads and dipole magnets:

   - The envelope radius of HMS Q_1 (Slim) ~ 90 cm
   - Mechanical length / magnetic length ~ 1.255 (HMS Q_1)
   - The transverse dimension of dipole magnet

4. Spectrometer structure

   - Simplest structure of all elements
   - Building blocks structure - easy slide forwards / backwards
   - Easy installation / alignment
   - Flexible optical tunes
   - Partial rail loading (can be rotated between 5.7 - 25 ^{o})

5. Enough space to locate detector package:

	HMS (6 GeV/c)	SHMS (12 GeV/c)
Cherenkov	1.6 m	2.5 - 4 m
Wire chamber (spacing)	1.0 m	1.0 - 1.5 m
Shower counter	0.6 m	0.6 m
Hodoscope (spacing)	2.2 m	2.2 m
Total	3.8 m	6.3 - 8.3 m

CANDITATES OF SHMS ELEMENTS

1. Dipole magnet - SLAC ESA dipole magnet B202/203

   - Dimension: 112.5 cm x 171.7 cm x 300 cm
   - Max. central field : 2.05 Tesla
   - Bending angle φ: 1.526 Tesla 7°
     2.05 9.38°
   - Parasitic rotation: 1.526 Tesla 3.5°
     2.05 4.69°
   - Effective length 3.148 m
   - Power supplies 2 x 3 MW

2. Quadrupole magnets - CEBAF HMS Q_1

   - Dimension: 90 cm x 150 cm x 237.2 cm
   - Max. Gradient 8.4 T/m (from Oxford)
   - Effective length 189 cm
   - Max. current 1200 A
   - Correction coil Built-in 3rd order trim coils
   - Major high-order harmonics Dodecapole at the edges

THE FIRST - ORDER MATRIX

-0.90567	0.00000	0.00000	0.00000	0.00000	2.45668
-2.35746	-1.10415	0.00000	0.00000	0.00000	3.28187
0.00000	0.00000	-3.08412	0.89577	0.00000	0.00000
0.00000	0.00000	-2.51121	0.40513	0.00000	0.00000
-0.28192	-0.27125	0.00000	0.00000	1.00000	-0.13048
0.00000	0.00000	0.00000	0.00000	0.00000	1.00000

Focal Plane Tilt Angle $\Psi = -(x/\delta) / [(x/\theta\delta)(x/x)] \approx 4.2^{o}$

PERFORMANCE COMPARISON

Spectrometer ID	ESA*	HMS	SHMS
Configuration	QQQDD	QQQD	QQDD
Max. Rigidity (kGm)	533.7	200.1	400.0
Central Momentum (GeV/c)	16	6	12
In - Plane Angle (mr)	22	44	26
Off - Plane Angle (mr)	54	165	55 - 112
Max. Solid Angle (msr)	1.0	10	3.0
Momentum Acceptance (%)	20	20	20
Dispersion (cm/%)	2.787	3.92	2.45
D/M (cm/%)	0.8	1.2	2.7
Focal Plane Angle (degree)	1.75	4.5	4.2
Minimum Scattering Angle (^{o})	6.5	12.5	5.5
Optical Length (m)	30.01	23.65	20.7
Momentum Resolution (FWHM)	2×10^{-3}	10^{-3}	10^{-3}
Focal Plane Dimension (cm^2)	60 x 36	100 x 50	60 x 60
Max. Gradient of Quads (T/m)	9.5	7.5	8.0
Max. Dipole Central Field (T)	2.05	1.67	2.05
Sliding Distance (m)	-	0.4	1

STRATEGY OF OPTICS

1. Bending angle
   - Two ESA dipole : 14 - 18.7 ^{o}
   - One 3 Tesla superconducting dipole : 12 ^{o}
   - Either QQQD(SC) or QQD(ESA)D(ESA)

2. Small scattering angle
   - Increase the first drift distance
   - Use slim quad design
   - Use slim dipole design

3. Acceptance determined by:
   - Gradient of the first quad
   - First drift distance
   - Dipole magnetic geometry : pole width / gap
   - Sliding distance

- Quads polarities
- Imaging mode

4. Rigidity
   - Maximum gradient of first quad
   - Balance of object - image distance
   - Alternate transverse focusing mode

5. Priority of components choose in optics
   - Match the major physics requirements
   - Available magnetic elements from real world
   - Save the cost for new element design

SUMMARY

1. QQDD is the final configuration for SHMS.

2. The optics, magnetic elements, mechanical structure are all straightforward. No more magnet design tasks.

3. Hardware list:

   - two HMS Q1 quads & power supplies
   - two ESA dipole magnets & power supplies
   - Overlapped mechanical supporting structure design
   - Detector package
   - Shielding house
   - Partial rail

4. Further studies:

   - ESA dipole TOSCA modeling at 2 Tesla region
   - HMS Q1 TOSCA modeling at 8 T/m gradient
   - High-order optics and the 3-rd order correction
   - Adjust optics model by fitting TOSCA mapping data