Plan for the FRS settings in S271 main Run in August 10-15 2006
4 July 2006

Primary beam $^{24}Mg^{12+}$ with energy 600. A MeV, > 10^{10} $spill^{-1}$, a spill time of 4 s. Energy loss of ^{24}Mg in Seetram (13.5 mg/cm^2 Ti) is 0.2 MeV/u.
Optics settings: SISTSHFS$_S271-3.SET, the achromatic TA-S2 setting with the S1-wedge angle of 194.3 mrad fitting to **^{20}Mg isotope**, the S2-S4 optics to be in standard mode set for **^{17}Ne following the velocity of ^{19}Mg after the reaction target**.
To use the MOCADI files *MOC_Mg24_Mg20_Mg19_achr2_600.in and MOC_Mg19_Ne17_achr2_600.in* for Bρ calculations of TA-S2 and S2-S4, respectively. (For preliminary Bρ calculations, one may use the LISE++ file *Mg24-Mg20-wedge-ST-achro-591.lpp*)

1.) Primary beam ^{24}Mg through FRS, file *MOC_Mg24_notarget_nowedge_achr2_600.in*
E-SIS = 600.0 MeV/u, intensity ~ 1000 $spill^{-1}$,
No target, only Seetram, SIS-window is very thin, no S1 degrader.
Equipment at S2: all windows + detectors with MW22 +SC21(1mm)+SC31(2mm) in.
Bρ (TA-S2) = 8.1018 Tm, E = 599.6 MeV/u
Bρ (S2-S3) = 8.0123 Tm, E = 589.0 MeV/u
Bρ (S3-S4) = 7.9856 Tm, E = 585.8 MeV/u
No comparison with S2 without matter, but we can use an effective thickness of the matter at S2 from the test measurements.

2.) Test detectors (MWPC22, MWPC41/42, + CSI11/21/31/41 + DSSDs + MUSIC), sweep beam.

3.) Calibrate target thickness, file *MOC_Mg24_nowedge_achr2_600.in*
Insert 4007 mg/cm^2 ^{9}Be target, and scale TA-S2,
new Bρ (TA-S2) = 7.6704 Tm E=548.8 MeV/u.
Compare with ATIMA -> effective thickness.

4.) Calibrate wedge thickness, S0 target out, file *MOC_Mg24_notarget_achr2_600.in*.
No target, Insert S1 wedge (must be 4632 mg/cm^2 Al+ 2x50micron Ti), and scale S1-S2,
Bρ(TA-S1) = 8.1018 Tm like in 1.)
Bρ (S1-S2) = 7.6020 Tm, E = 540.8 MeV/u
Compare with ATIMA -> effective thickness.

5.) Calibrate S2 target thickness, ~2016 g/cm^2 of ^{9}Be (**two Be bricks must be on target holder!**), the S0-target + S1 wedge out, file *MOC_Mg24_reactiontarget_achr2_600.in*
new Bρ (S2-S3) = 7.8221 Tm, E=566.6 MeV/u, TA-S2 like in 1.), **Sc21 + MW22 out**
Bρ (S3-S4) = 7.7948 Tm, E=563.4 MeV/u,
new Bρ (S2-S3) = 7.7958 Tm, E=563.5 MeV/u, TA-S2 like in 1.), **Sc21 + MW22 in**
Bρ (S3-S4) = 7.7683 Tm, E=560.3 MeV/u,
Compare with ATIMA -> effective thickness.

6) Test chromaticity with primary beam ^{24}Mg, file *MOC_Mg24_achr2_test463.in*.
System becomes achromatic for ^{24}Mg at E = 463.0 MeV/u for TA-S2 with S1-wedge,
Bρ(TA-S1) = 6.9151 Tm, E=462.6 MeV/u, Bρ(S1-S2) = 6.3119 Tm, E=396.6 MeV/u
Change E-SIS by ± 5 MeV/u up and down and check positions, the beam spot should move at S1 by +-1.2 cm but at S2 the peak should not move!

7.) Calibrate TOF / MUSIC with different energies (optional, as we have 3 energies at S2: 1) notarget, nowedge; 2) nowedge; 3) target +wedge.
May need recalculation of Bρ with new effective thicknesses.
Change SIS energy by +-100 MeV/u, no target, no wedge, SCI21 +SCI31+MW22 in
E_{SIS} = 700 MeV/u, Bρ (TA-S2) = 8.9286 Tm, Bρ (S2-S3) = 8.8314 Tm, v = 24.538 cm/ns, Bρ (S3-S4) = 8.8051 Tm, v = 24.514 cm/ns
E_{SIS} = 600 MeV/u, Bρ (TA-S2) = 8.1049 Tm, Bρ (S2-S3) = 8.0123 Tm, v = 23.710 cm/ns, Bρ (S3-S4) = 7.9856 Tm, v = 23.680 cm/ns
E_{SIS} = 500 MeV/u, Bρ (TA-S2) = 7.2450 Tm, Bρ (S2-S3) = 7.1259 Tm, v = 22.615 cm/ns, Bρ (S3-S4) = 7.0933 Tm, v = 22.570 cm/ns

8.) Change energy back to 600 MeV/u, put in target and Scale to a secondary ^{20}Mg beam, a recalculation of Bρ with new effective thicknesses might be needed.
Primary target in (4007-Be), no S1 degrader, no SecTaget,
file *MOC_Mg24_Mg20_nowedge_noST_achr2_600.in*.
Bρ (TA-S2) = 6.3368 Tm, E=539.8 MeV/u
Bρ (S2-S3) = 6.2523 Tm, E= 528.0 MeV/u
Bρ (S3-S4) = 6.2137 Tm, E= 522.7 MeV/u
Expected intensity of ^{20}Mg is 570/spill at S2 and 150/spill at S4 for primary beam intensity 10^9/spill.
To measure a fragment spectrum (ΔE-ToF) at S2-S4 without S1 degrader and with minimum S2 matter (SC21+MW22+chamber+DSSD). Isotope ID by ^{8}Be, ^{9}B holes.
Close S2 slits (+-35 mm) to select mainly ^{20}Mg and to match the size of DSSDs.

9.) ^{20}Mg with S1 wedge, the same as 8) but with S1 wedge degrader in addition;
file *MOC_Mg24_Mg20_noST_achr2_600.in*.
Bρ (TA-S1) = 6.3368 Tm, E=539.8 MeV/u
Bρ (S1-S2) = 5.8000 Tm, E=466.4 MeV/u
Bρ (S2-S3) = 5.6928 Tm, E=452.1 MeV/u
Bρ (S3-S4) = 5.6610 Tm, E=447.9 MeV/u
Much less ^{20}Mg than before, 300/spill at S2 and 150/spill at S4 for primary beam intensity 10^9/spill . Clean of other isotopes, the distribution of ^{20}Mg is in +-4cm at DSSD.

10.) Transmission ^{20}Mg with secondary target ST, file *MOC_Mg24_Mg20_achr2_600.in*
To insert ST (2.016 g/cm^2) at S2 in the vacuum chamber and measure the S2-S4 transmission.
Bρ (TA-S1) = 6.3358 Tm, E=539.6 MeV/u

Bρ (S1-S2) = 5.8000 Tm, E=466.4 MeV/u
Bρ (S2-S3) = 5.4310 Tm, E=417.7 MeV/u
Bρ (S3-S4) = 5.3910 Tm, E=412.5 MeV/u
now 350/spill and 150/spill of ^{20}Mg with 10^9/spill of ^{24}Mg are expected at S2 and S4, respectively.

11.) Knockout ^{20}Mg -> ^{19}Mg, and 2p-decay ^{19}Mg->^{17}Ne+p+p
(a) file *MOC_Mg20_Mg19_achr2_600.in* , (b) file *MOC_Mg19_Ne17_achr2.in*
Bρ (TA-S1) = 6.3368 Tm, E=539.8 MeV/u
Bρ (S1-S2) = 5.8000 Tm, E=466.4 MeV/u
Set the sections S2-S4 for ^{17}Ne fragments from 19Mg.
Bρ (S2-S3) = 5.5372 Tm, E=417.3 MeV/u.
Bρ (S3-S4) = 5.5061 Tm, E=413.4 MeV/u.

One separate calculation, (a), with ^{20}Mg at 458.4 MeV/u -> ^{19}Mg on a secondary target gives E(^{19}Mg after ST) = 422.1 MeV/u, and then the calculation of energy loss of the same-velocity ^{17}Ne in the rest of S2 setup, (b): E(^{17}Ne before D3) = 417.3 MeV/u.
The expected ^{19}Mg production is 15 hour^{-1} (if ^{20}Mg intensity 500/spill and spill time 4s). The registration efficiency of micro-DSSD at S2 is of 35%, the transmissions S2-S3, S3-S4 are 78% and 44%, respectively.

Some reactions to measure in addition or in a case of pessimistic scenario.

i) ***Fragmentation Mg20->Ne18+2p, (might be interesting to astrophysics)***
file MOC_Mg24_Mg20_Ne18_achr2_600.in
Bρ (TA-S1) = 6.3368 Tm, E(^{20}Mg)=539.8 MeV/u
Bρ (S1-S2) = 5.8000 Tm, E(^{20}Mg)=466.4 MeV/u
Set the sections S2-S4 for ^{18}Ne fragments from ^{20}Mg direct fragmentation.
Bρ (S2-S3) = 5.8896 Tm, E(^{18}Ne)=421.1 MeV/u.
Bρ (S3-S4) = 5.8490 Tm, E=416.2 MeV/u.
The reaction rate is of 800 hour^{-1} (if ^{20}Mg intensity 500/spill and spill time 4s). The registration efficiency of microDSSD at S2 is of 35%, the transmissions S2-S3, S3-S4 are 67% and 37%, respectively.

ii) ***Fragmentation Ne17->O15+2p, (definitely interesting to astrophysics)***
files MOC_Mg24_Ne17_achr2_600.in, *MOC_Mg24_Ne17_O15_achr2_600.in*
First, we set the sections TA-S2 for ^{17}Ne ,
Bρ (TA-S1) = 6.4726 Tm, E(^{17}Ne)=540.9 MeV/u
Bρ (S1-S2) = 6.0259 Tm, E(^{17}Ne)=480.8 MeV/u
Rate of ^{17}Ne is up to 3000 spill^{-1} with ^{24}Mg of10^9 spill^{-1}
Then we set the sections S2-S4 for ^{17}Ne ,
Bρ (S2-S3) = 5.7317 Tm, E(^{17}Ne)=442.3 MeV/u.
Bρ (S3-S4) = 5.7071 Tm, E=439.1 MeV/u.
Second, we set the sections S2-S4 for ^{15}O from a ^{17}Ne direct fragmentation.

Bρ (S2-S3) = 6.3407 Tm, E(^{15}O)=445.2 MeV/u.
Bρ (S3-S4) = 6.3104 Tm, E=441.6 MeV/u.
The reaction rate is ~1400 hour^{-1} (if ^{17}Ne intensity of 500/spill and spill time 4s). The registration efficiency of microDSSD at S2 is 40%, the transmissions S2-S3, S3-S4 are 48% and 35%, respectively.

iii) *Knockout Ne17->Ne16 and decay Ne16->O14+2p, (the reference case)*

files MOC_Mg24_Ne17_achr2_600.in, MOC_Mg24_Ne17_Ne16_achr2_600.in, MOC_Ne16_O14_achr2.in

The same settings for the sections TA-S2 for ^{17}Ne as in ii)
Bρ (TA-S1) = 6.4726 Tm, E(^{17}Ne)=540.9 MeV/u
Bρ (S1-S2) = 6.0259 Tm, E(^{17}Ne)=480.8 MeV/u

The section S2-S4 settings for **^{17}Ne** :
Bρ (S2-S3) = 5.7317 Tm, E(^{17}Ne)=442.3 MeV/u.
Bρ (S3-S4) = 5.7071 Tm, E=439.1 MeV/u.

We set the sections S2-S4 for **^{15}O** from a ^{16}Ne two-proton decay.
Bρ (S2-S3) = 6.0041 Tm, E(^{14}O)=455.7 MeV/u.
Bρ (S3-S4) = 5.9827 Tm, E=453.0 MeV/u.
The reaction rate is 40 hour^{-1} (if ^{17}Ne intensity of 500/spill and spill time 4s). The registration efficiency of microDSSD at S2 is 38%, the transmissions S2-S3, S3-S4 are 75% and 47%, respectively.

Program

10-11.08	12.08	13.08	14.08	15.08, first shift	15.08, 2-3 shifts	16.08
Settings	^{19}Mg	^{19}Mg	^{19}Mg	^{20}Mg->^{18}Ne 3 hours; ^{17}Ne->^{15}O 5 hours	^{17}Ne->^{14}O	Calibrations