Some interesting studies at RIA

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This report is meant to complement that of H. Esbensen's. We expressed common interests at the heavy-ion-discussion group, and followed with later discussion.

1) Nuclear structure study far from stability
Especially single particle energy level
J^{π}, spectroscopic factor and others
A lot of studied can be done for (d,p),(d,t),(d,n), (p,p') etc.
For 400 MeV/u machine (at 100 kW) we can have strong beam intensity, followings are intensities for some double magic nuclei,

^{56}Ni 1.8E+9 (Fragmentataion) (100-400 6)
^{68}Ni 3.5E+8 (Fragmentataion) (100-400 6)
^{78}Ni 6.0E+1 (Inflight-fission) (2.3 Fragmentation) (100-400 6)
^{80}Zr 2.4E+5 (Fragmentataion) (100-400 8)
^{132}Sn 8.8E+9 (Two-step fission) (1.3E+5 Fragmentation) (100-400 4)

The intensity of the beams at some regions is enough to do detailed transfer reaction studies (we may have to have a good energy resolution spectrograph).

2) Reaction mechanism study (also far from stability)

A. Fusion, fusion-fission

a. Induced by halo and skin nuclei (fine beam, much better than on-line fragmentation beam measurement)
one has to measure breakup cross section itself carefully in order to explain the influence of breakup to fusion and to fusion-fission.
Right now no way to do good experiment for ^{11}Li, RIA can do.
Following are candidates of beam to study the problem:

		S_n	S_{2n}
^{6}He	4.9E8 (Frag.)		0.97
^{11}Li	3.4E7 (Frag.)	1.051	0.290
^{11}BE	7.2E9 (Frag.)		
^{14}BE	8.2E6 (Frag.)		1.28
^{17}B	3.7E5 (Frag.)	(2.45)	
^{19}B	3.0E2 (Frag.)	(0.87)	
^{17}C	1.2E8 (Frag.)	0.793	
^{19}C	1.9E5 (Frag.)	(0.22)	

		S_p
^{8}B	1.7E10 (Frag.)	0.14
^{9}C	1.0E9 (Frag.)	1.299
^{12}N	1.1E10 (Frag.)	0.601
^{17}F	3.1E10 (Frag.)	0.600
^{17}Ne	3.9E8 (Frag.)	0.96

As more masses of nuclei measured accurately, more halo and skin nuclei will be identified.

b. Induced by heavier neutron-rich nucleus

Other degrees of freedom may become more important at subbarrier or above barrier region.

We can use different neutron-rich beams, to measure the excitation fuctions, also the odd-even effect is interesting.

Following are examples the beam we can use (the odd-A beam too).

^{78}Kr-^{86}Kr stable

^{88}Kr 2.0E11 (Two-step fission)

^{90}Kr 5.2E11 (Two-step fission)

^{92}Kr 4.2E11 (Two-step fission)

^{94}Kr 3.4E10 (Two-step fission)

^{96}Kr 1.5E9 (Two-step fission)

^{98}Kr 6.5E6 (Two-step fission)

^{100}Kr 6.8E3 (Two-step fission)

^{112}Sn-^{124}Sn stable

^{128}Sn 1.2E10 (Two-step fission)

^{130}Sn 1.3E10 (Two-step fission)

^{132}Sn 8.7E9 (Two-step fission)
^{134}Sn 5.9E8 (Two-step fission)
^{136}Sn 4.4E6 (Two-step fission)
^{138}Sn 7.9E3 (Two-step fission)

^{144}Sm-^{154}Sm stable
^{156}Sm 4.2E8 (Two-step fission)
^{158}Sm 4.4E8 (Two-step fission)
^{160}Sm 1.3E8 (Two-step fission)
^{162}Sm 6.0E6 (Two-step fission)
^{164}Sm 2.3E5 (Two-step fission)
^{166}Sm 2.0E2 (Two-step fission)

B. Multi-nucleons transfer reaction mechanism
Neutron-flow, pairing effect etc.
Same beam can be used as listed above.

3) Nuclear Astrophysics
Experiments relevant to rp-process, along the Z=N line,
rather good beam intensities we will have, for example:

^{44}Ti 6.2E9 (Frag.)
^{48}Cr 4.1E9 (Frag.)
^{52}Fe 2.8E9 (Frag.)
^{56}Ni 1.8E9 (Frag.)
^{60}Zn 7.2E8 (Frag.)
^{64}Ge 2.9E7 (Frag.)
^{68}Se 1.1E7 (Frag.)
^{72}Kr 2.5E7 (ISOL)
^{76}Sr 7.3E5 (Frag.)
^{80}Zr 2.4E5 (Frag.)
^{84}Mo 4.8E4 (Frag.)
^{88}Ru 6.1E3 (Frag.)
^{92}Pd 7.5E2 (Frag.)
^{96}Cd 4.4E1 (Frag.)

PS I can put several lines on my two dimensional yield-z-n plot, they represent the minimum beam intensities for various experiments. On MSU document p76, they give a table.

How many minimum beam intensities lines put on a plot have to be decided by you. then I will make them.