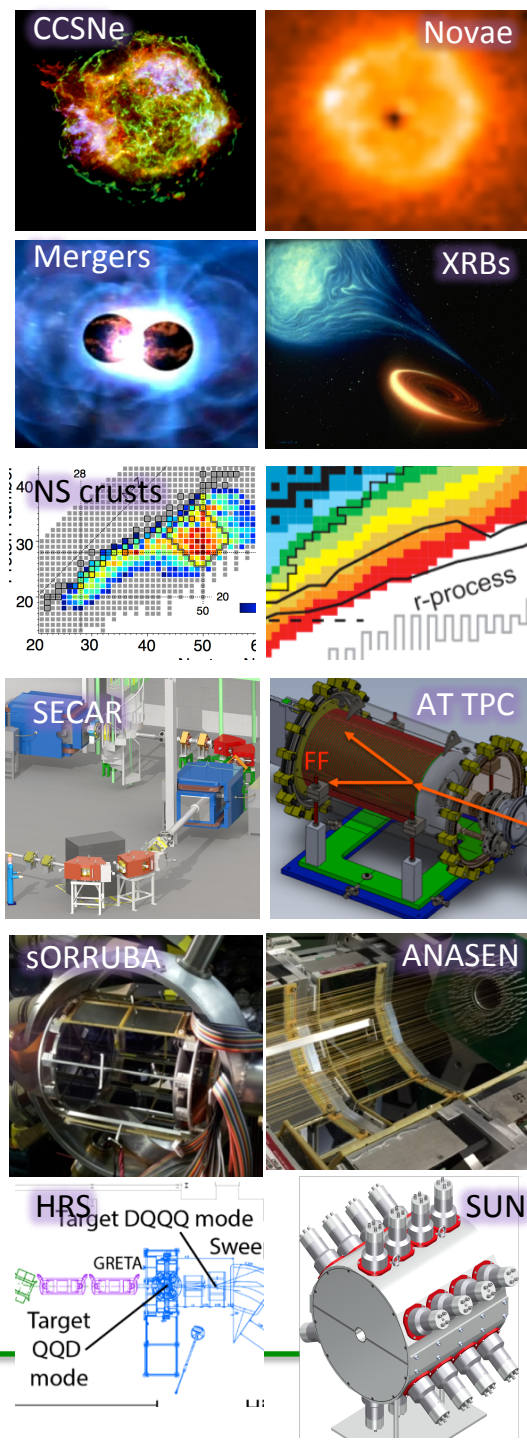


Astrophysics Working Group Summary

- Exciting, Broad, Robust Day One Science Program in Astrophysics
 - diverse topics include CCSNe, SNIa, Novae, XRBs, NS Mergers, Pop III stars
 - covering rp –, r –, αp –, vp –, hot CNO, hot pp processes
- Broad Range of measurement types
 - capture, transfer, (α, p), decay, masses, charge exchange, total cross sections, TAS, LI fusion, HI collisions, HI fusion for EOS, fission ...
- Diverse set of beams
 - ReA3 beams – ^{30}P , ^{18}F , ^{22}Mg , ^{26}Si , ^{30}S , ^{56}Ni , ^{59}Cu , ^{34}Ar , ^{38}K ; ^8B , ^9C , ^{13}O , ^{14}O
 - ReA6 – ReA12 beams – ^{30}P , ^{38}K , ^{59}Cu , ^{61}Ga , ^{65}As ; ^{81}Ni , ^{76}Cu , ^{78}Zn , ^{80}Ga , $^{86,88}\text{As}$, ^{131}Cd , $^{133-137}\text{Sn}$, ^{137}Te
 - Fast beams – ^{31}F , ^{125}Tc , ^{132}Sn , ^{19}C , ^{28}Ne
 - Stopped beams – near $N=82$ and $N=126$, Uranium
 - Stable beams (for commissioning) – ^{20}Ne , ^{15}N , ^{21}Ne , Ti, Ni, Al, Mg
- Wide range of intensities
 - capture 10^7 pps, transfer & charge 10^5 pps, σ 10^3 pps, decay $\ll 10^2$ pps
- Wide range of experimental stations in all FRIB halls
 - SECAR, JENSA, HRS, ISLA, HELIOS, GRETA/GRETA, AT TPC, HR AT TPC, ANASEN, S800, DECAY STATION, SUN, MUSIC
- Numerous facility requirements
 - suite of intense $>10^5$ – 10^6 pps ReA3 beams with gas and solid stopper
 - beam purification methods; long-pulse beam time structure
 - small beam widths < 3 mm; use ^{64}Zn primary beam for ^{59}Cu ReA3 beam
 - DAQ: unified, digital, > 1000 channels
- Other requirements
 - H_2 , ^3He operations in JENSA; dispersion matched HRS with long flight path, precise 0.4 mm positions, <30 ps time resolution; GRETA with auxiliary detectors; fast detectors for high contamination ...



Astrophysics Working Group Summary

- **General:**
 - aggressively develop intense ReA3 beams with a full suite of stopping and isotope collection
 - many astrophysics experiments need $>1\text{e}5 - 1\text{e}6$ pps
- **(p, γ) reactions direct measurements for rp-process with SECAR:**
 - $>1\text{e}6$ pps beams with gas and solid stopper technology. Examples: ^{30}P , ^{38}K , ^{59}Cu
 - Suite of intense stable beams to commission SECAR
 - Add ^{64}Zn primary beam to list
- **(α ,p),(p, α) reactions for rp/ α p/vp process: ANASEN, JENSA**
 - $>1\text{e}6$ pps of ^{18}F , ^{22}Mg , ^{26}Si , ^{56}Ni , ^{59}Cu reaccelerated beams
 - development of techniques to deal with contamination - purification, fast detection systems
 - lower intensity ($< 1\text{e}4$ pps) (α ,p) studies with MUSIC, ^8B , ^8C , ^{14}O , ^{18}Ne
- **(d,p), (d,n), (^3He ,d) transfer for rp-process**
 - $>1\text{e}5$ pps beams, many beams
 - ^3He operation of JENSA
- **decay studies: r-process around N=82 first, mostly Uranium beams**
- **Masses with TOF**
 - HRS, dispersion matched optics mode, long flight path, precise tracking 0.4 mm, time detection with <30 ps resolution
- **(p, γ) resonance studies for rp-process with GRETA**
 - auxiliary detectors for neutron and charged particle detection needed for GRETA
 - may need dedicated systems, DAQ integration
- **Fission for r-process: Actinide fast beams**
- **EOS probes through heavy ion collision, fast ^{132}Sn beam**
 - modify AT-TPC for intense fast beams, but could be done with system today
 - AT-TPC in fast beam HRS area (move magnet, or use different magnet)
- **TAS for r-process (n, γ rates and beta decay)**
- **$^{12}\text{C} + ^{19}\text{C}$ and $^{20}\text{Ne} + ^{28}\text{Ne}$ fusion for neutron star crusts**
 - <500 pps but exotic short-lived neutron rich beams - issues of isobars from decay?
- **weak interaction strength with charge exchange for supernovae and neutron stars**
 - Need HRS + TPC