Testing and Characterization of the JENSA Gas Jet Target

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on behalf of the JENSA Collaboration

DNP 2013

Motivation

We need improvements in beams, targets, and detector systems in order to continue to push the frontiers of nuclear science

- facilities like FAIR, FRIB, KoRIA, RIBF, ISAC-2 and SPIRAL-2, among others, are (or will be) providing major progress in RIB production
- detector systems like superORRUBA, ANASEN, TACTIC, VANDLE, Greta/Gretina, Tigress, Paris, etc, are pushing the boundaries of radiation/particle detection

Motivation

We need improvements in beams, targets, and detector systems in order to continue to push the frontiers of nuclear science

- so what about targets? ...we can accomplish more here!
  - commonly using thin metal foils, implanted targets, small gas cells
  - windowless gas targets and liquid/solid (cryogenic) targets are becoming more widely utilized
  - these types of targets won't work for everything...

Constraints

- Inverse kinematics
- Exotic beams may be low intensity
- Low cross sections (astrophysical reactions)
- Light targets for hydrogen- or helium-induced reactions
- Reaction products have low energies
- High efficiency, high-solid-angle coverage for particle detection
- Recoil/gamma detection

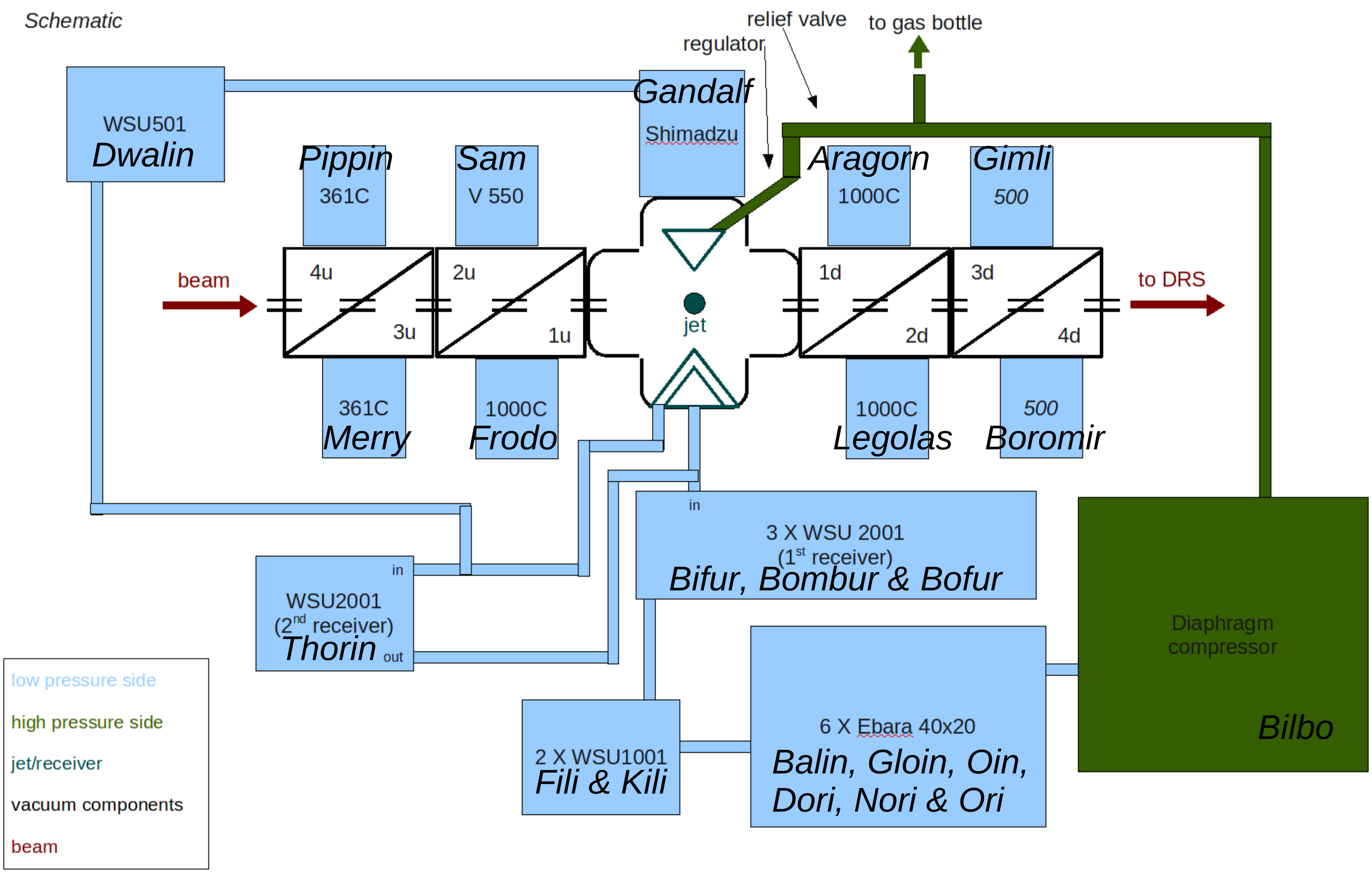
A Solution? Gas Jet Targets

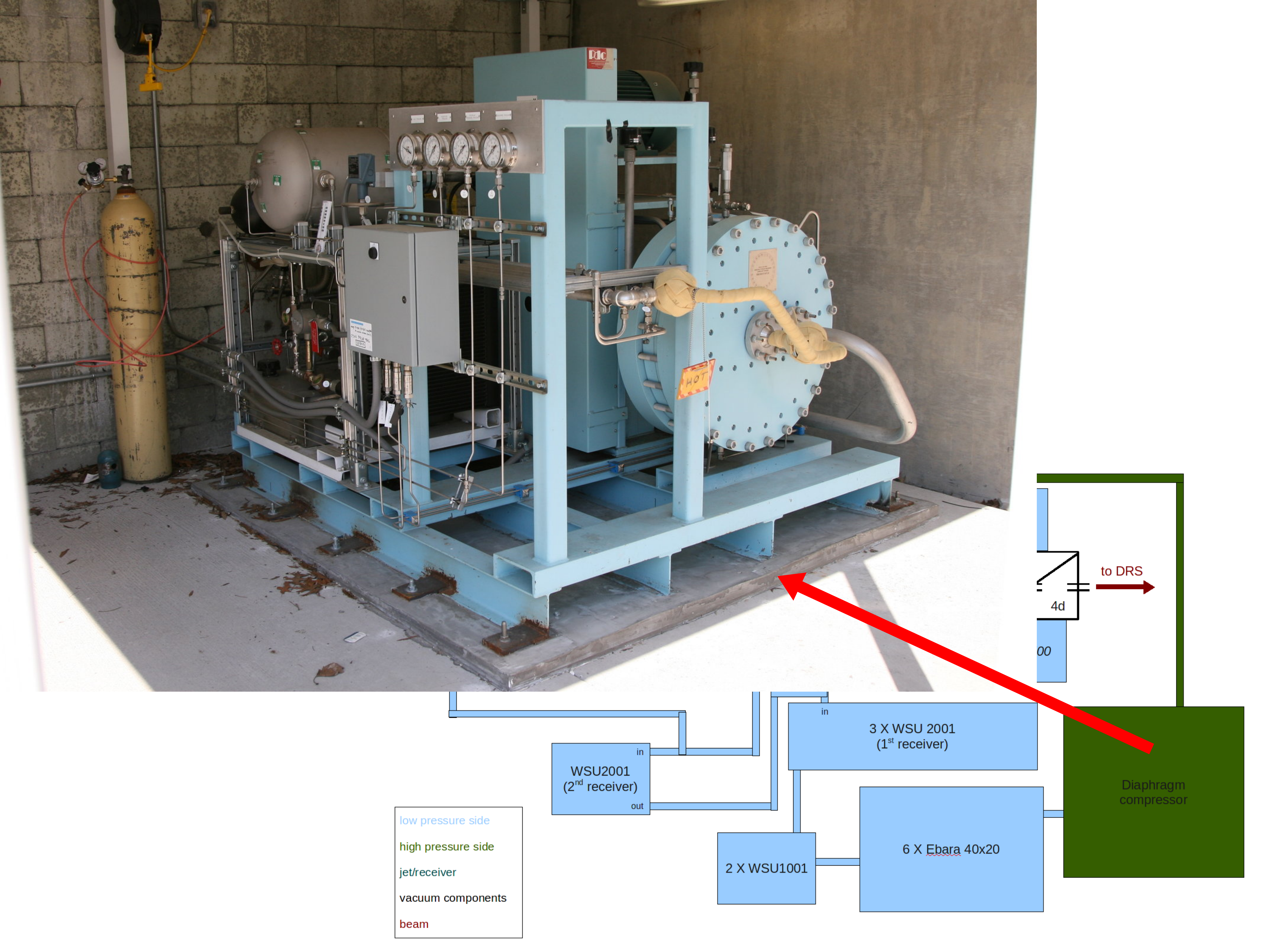
Create a jet of light gas (helium or hydrogen) – with the correct engineering, a target that is

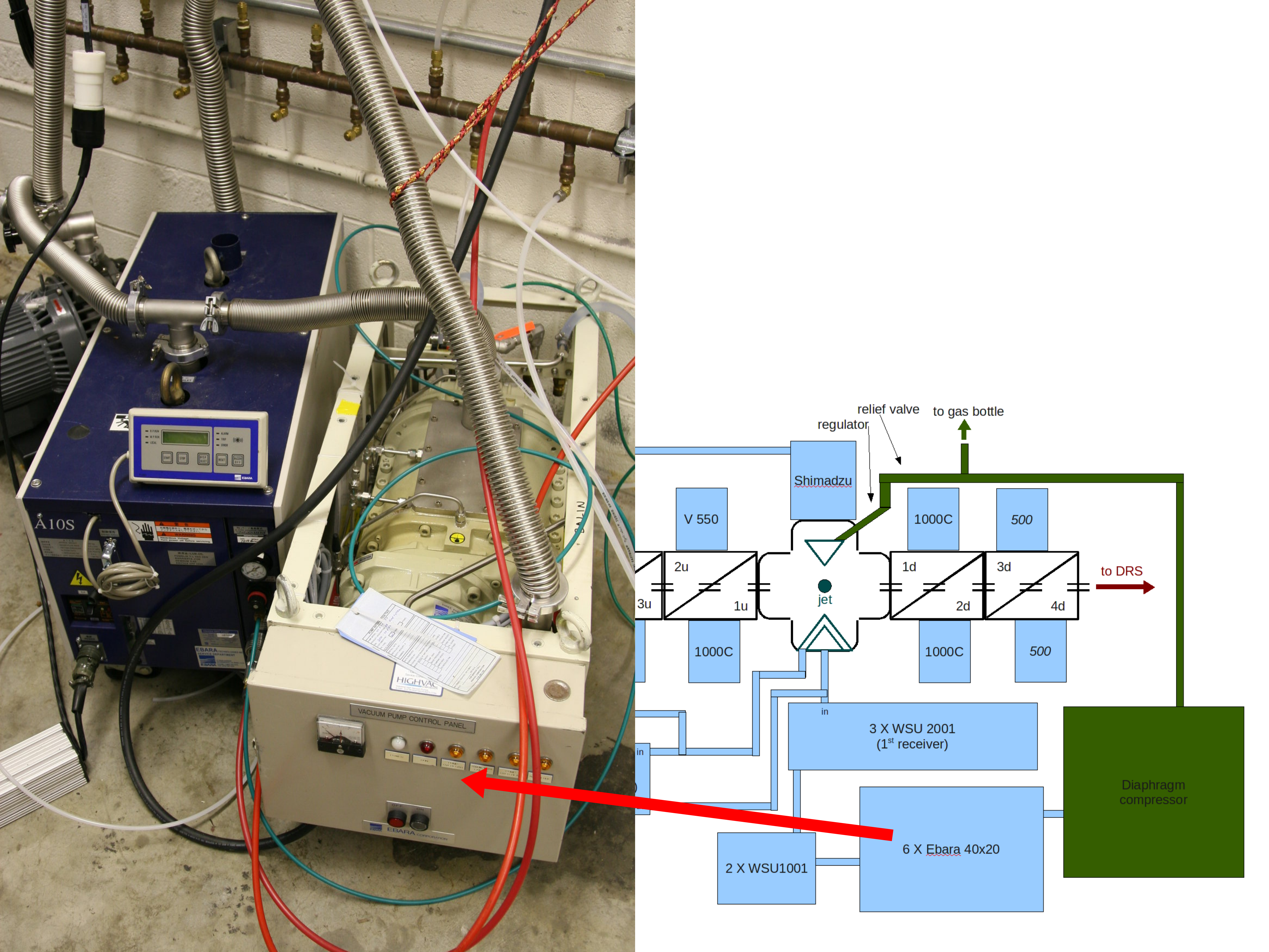
dense, pure, homogeneous, and localized

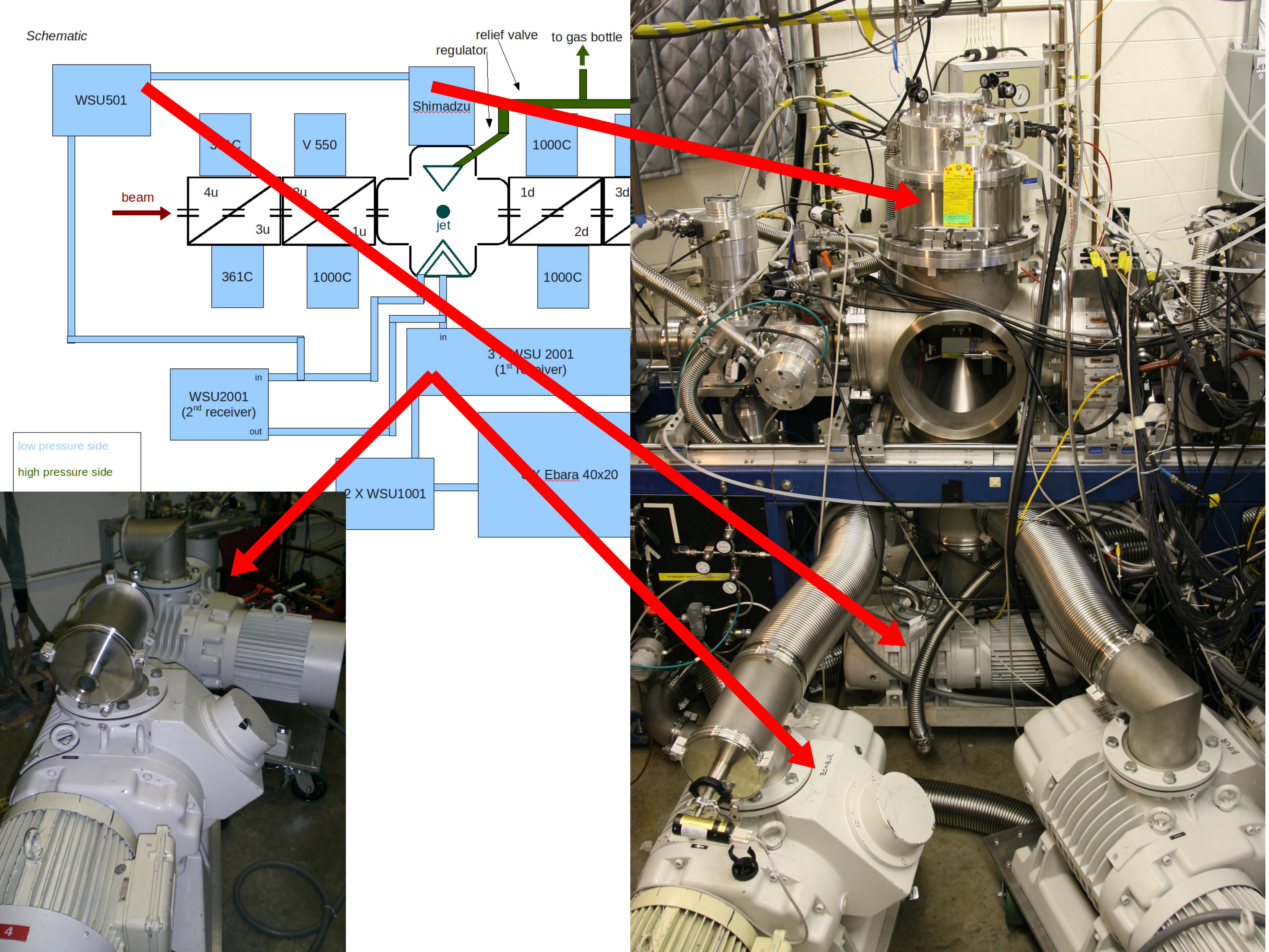
can be produced
(targets of this type, though smaller in scale, have existed for decades)

Introducing JENSA!



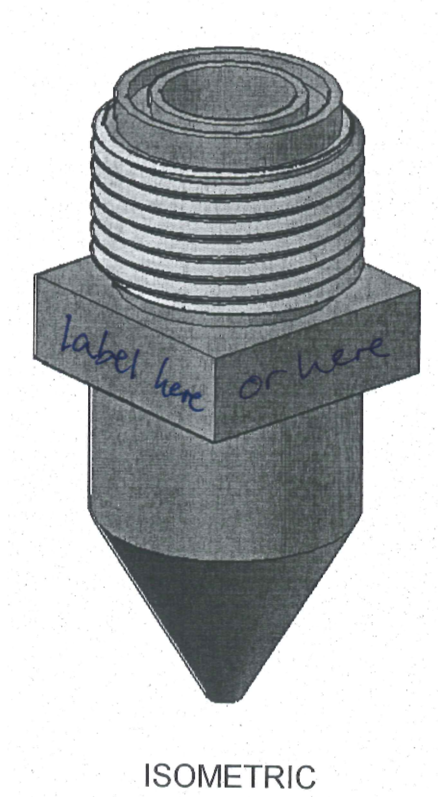

to DRS
4d
00
in
3 X WSU 2001
(1st receiver)
in
WSU2001
(2nd receiver)
out
Diaphragm
compressor
6 X Ebara 40x20
2 X WSU1001
low pressure side
high pressure side
jet/receiver
vacuum components
beam
HOT

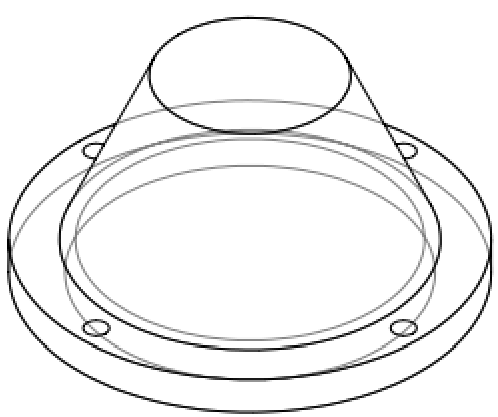

A10S
VACUUM PUMP CONTROL PANEL
EBARA
HIGHVAC
relief valve
to gas bottle
regulator
Shimadzu
V 550
1000C
500
2u
1u
3u
1d
2d
3d
4d
jet
to DRS
1000C
1000C
500
in
3 X WSU 2001
(1st receiver)
in
Diaphragm
compressor
6 X Ebara 40x20
2 X WSU1001



Schematic
relief valve
regulator
to gas bottle
WSU501
Shimadzu
V 550
1000C
beam
4u
3u
1u
jet
1d
2d
3d
361C
1000C
1000C
in
WSU 2001
WSU2001
(2nd receiver)
in
out
low pressure side
high pressure side
2 X WSU1001
Ebara 40x20

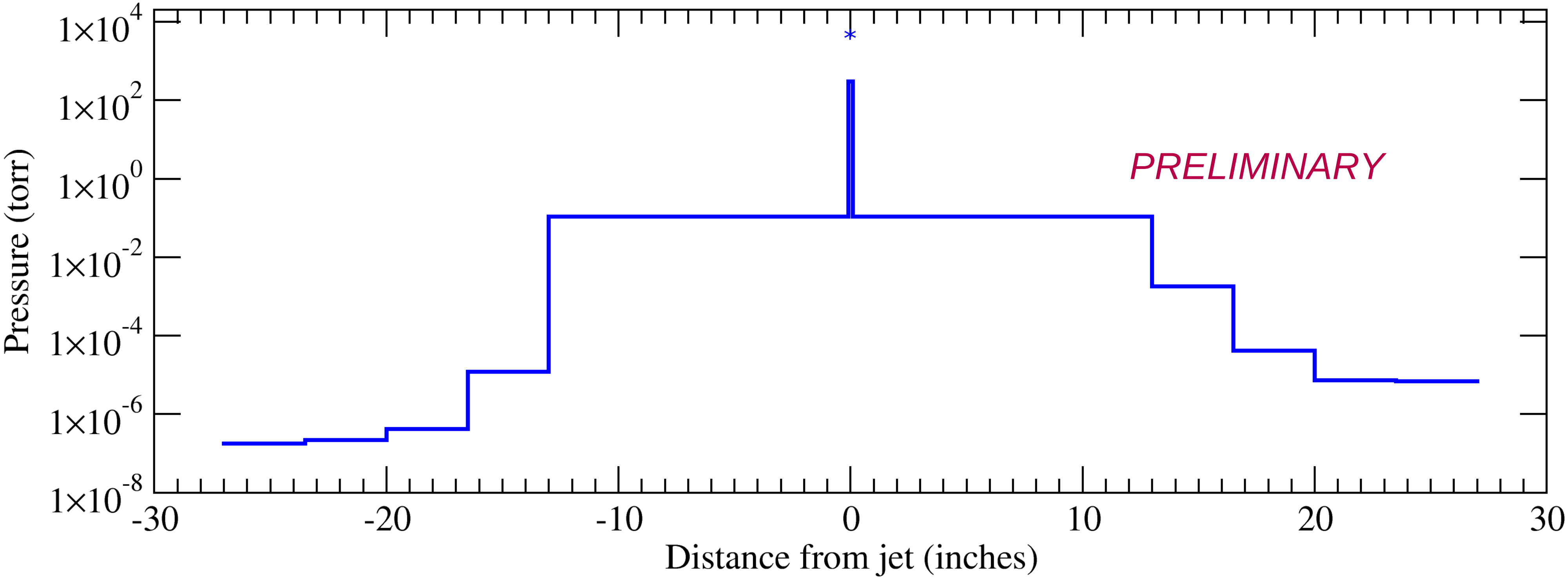
Nozzle Specs

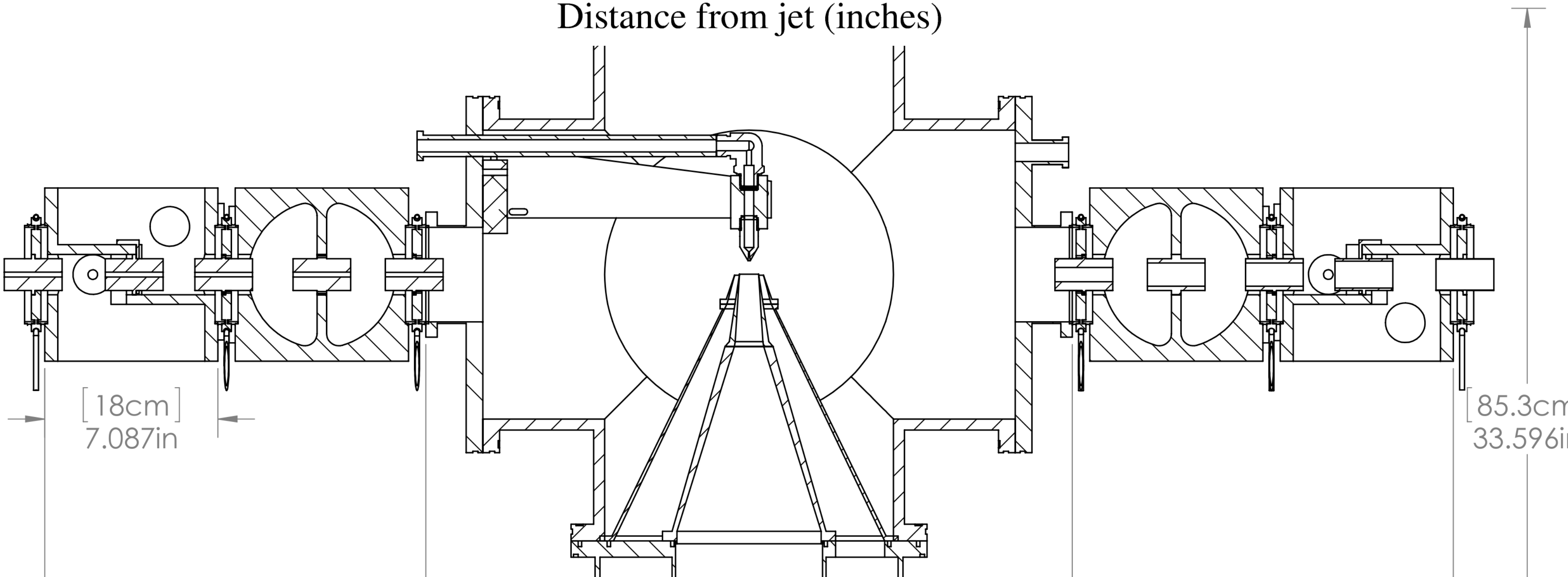




currently installed nozzle: Laval (convergent-divergent) with 0.8mm neck
additional nozzle: 1.1mm neck
receiver nozzles: 15mm inner and 25mm outer
additional receivers: 10 and 20mm inner; 20 and 30mm outer
1.4cm nozzle-receiver distance (free jet region)

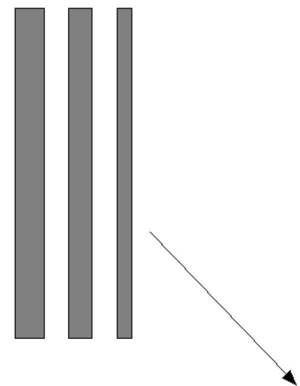
Pressure Profiles

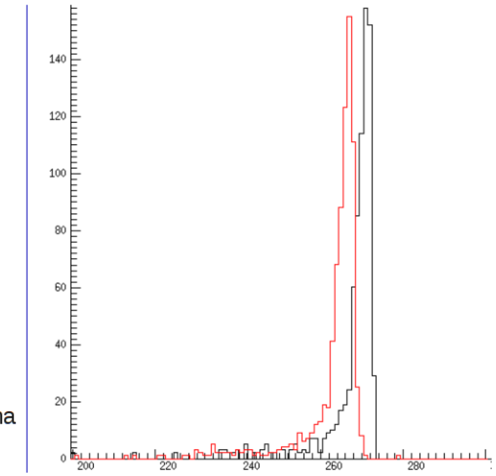




Test Setup

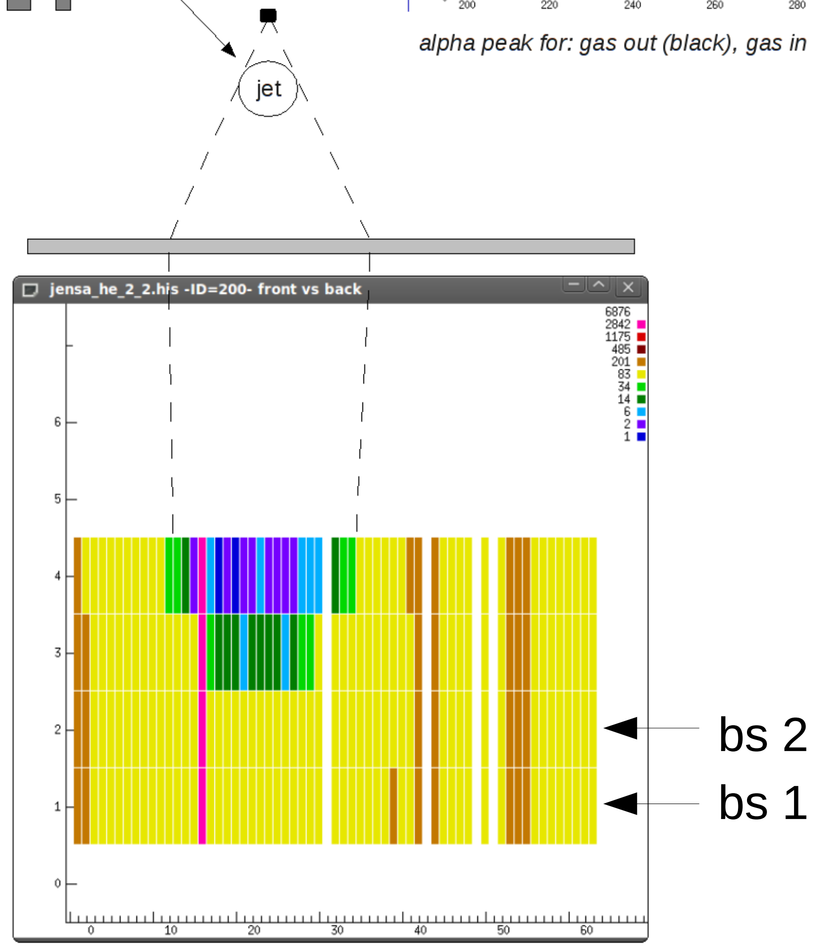
aluminum strips of known widths (5,4,3mm) were put in the jet location prior to gas to precisely determine the projection "factor"





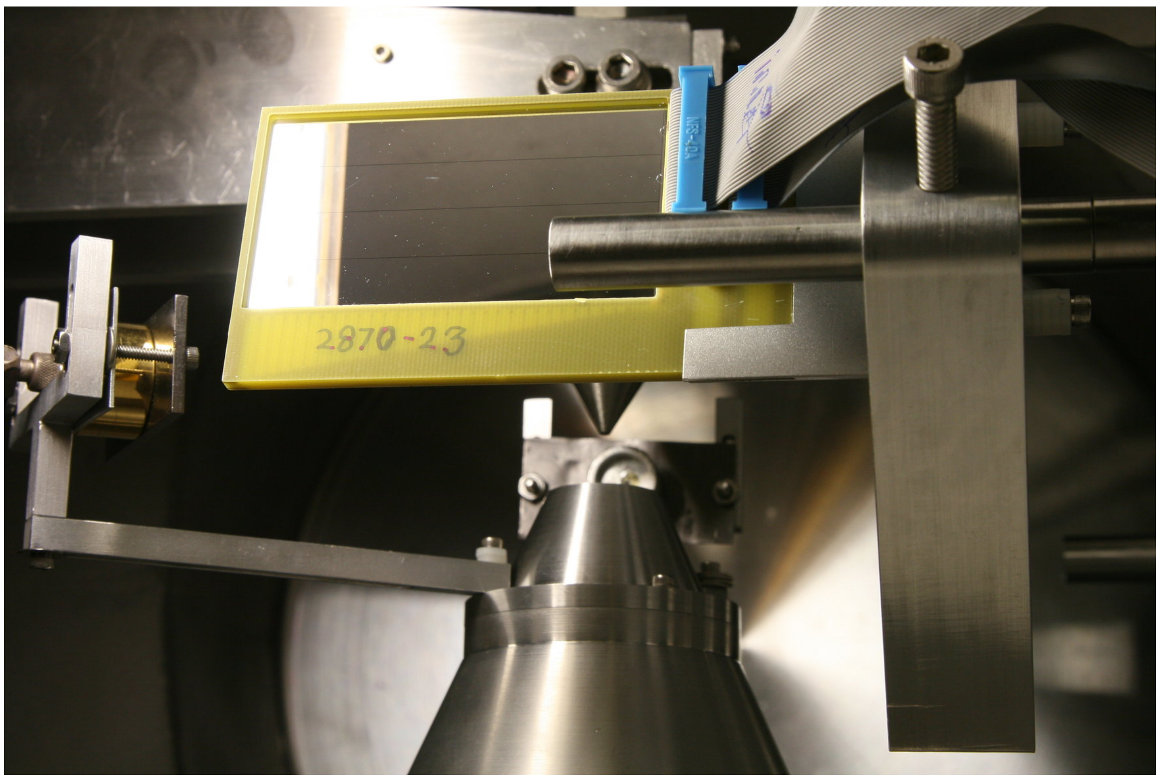
alpha peak for: gas out (black), gas in (red)

244Cm alpha source

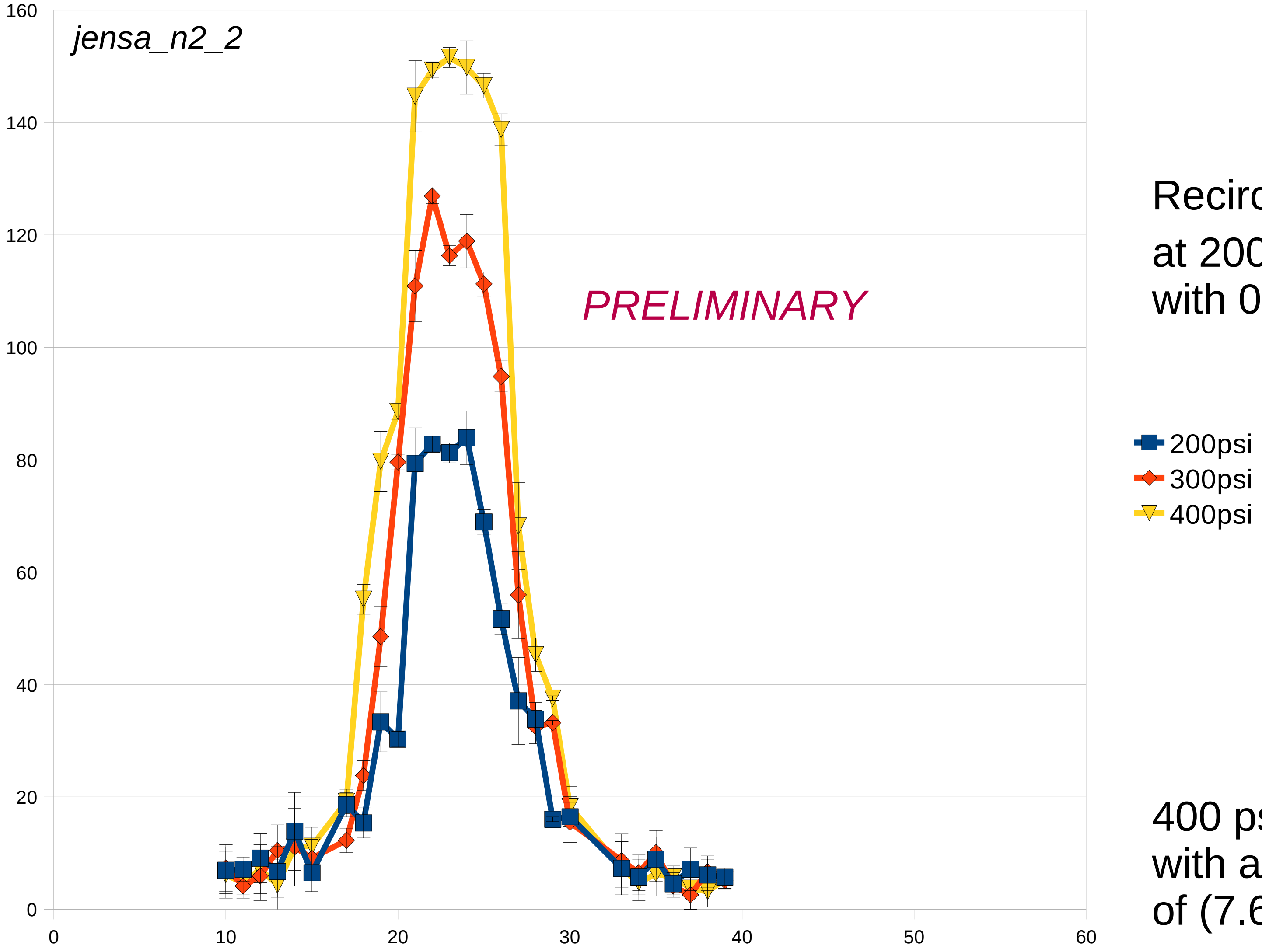


hit pattern on superORRUBA pixels

superORRUBA detector
(64 1.2mm vertical strips facing source;
4 1cm horizontal strips on back)



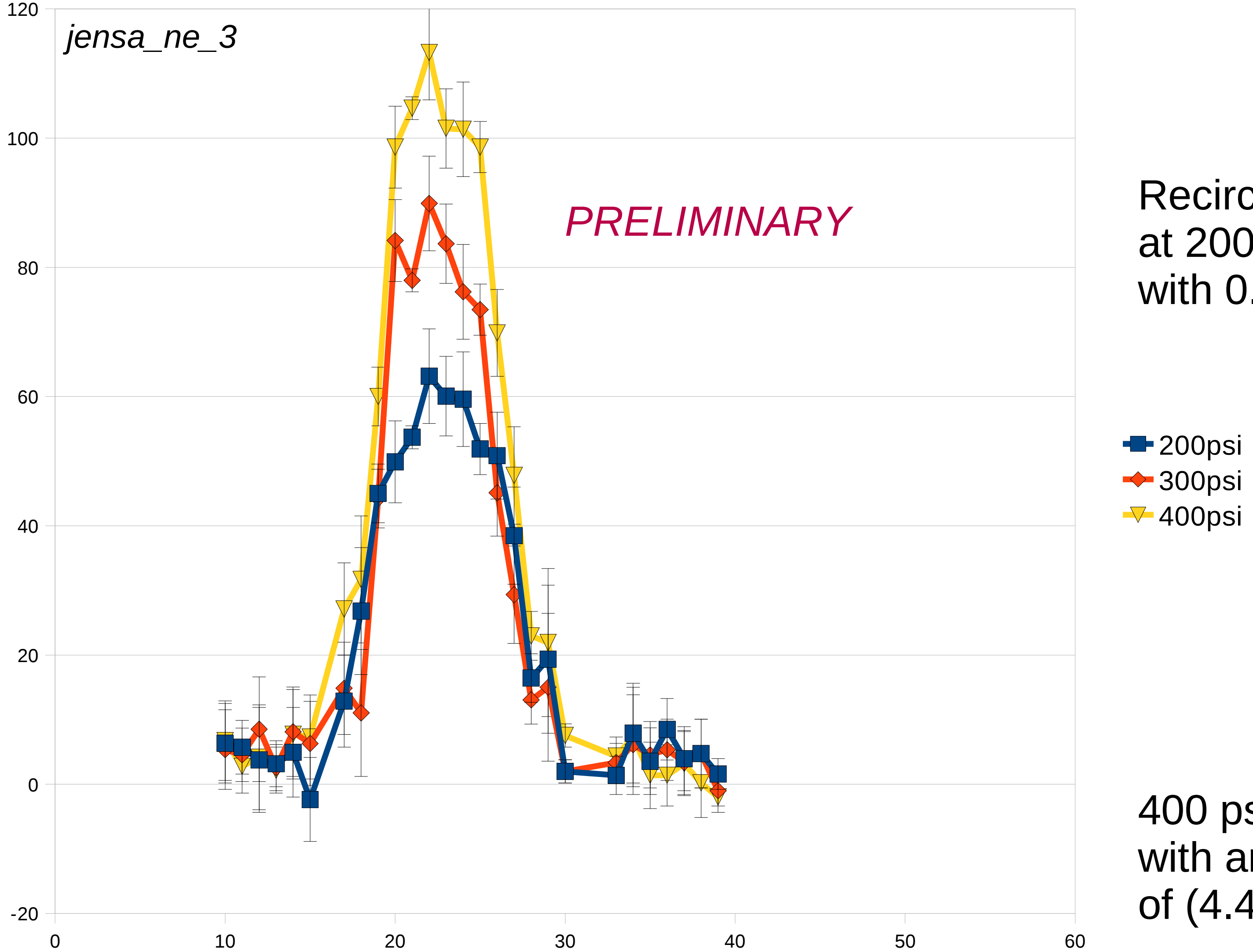
Energy Loss → Jet Density



Recirculating N_2 jet
at 200, 300, and 400 psi
with 0.8 mm nozzle

400 psi jet is 4 mm diameter
with an average areal density
of $(7.6 \pm 2.4)\times10^{18}$ atoms/cm^2

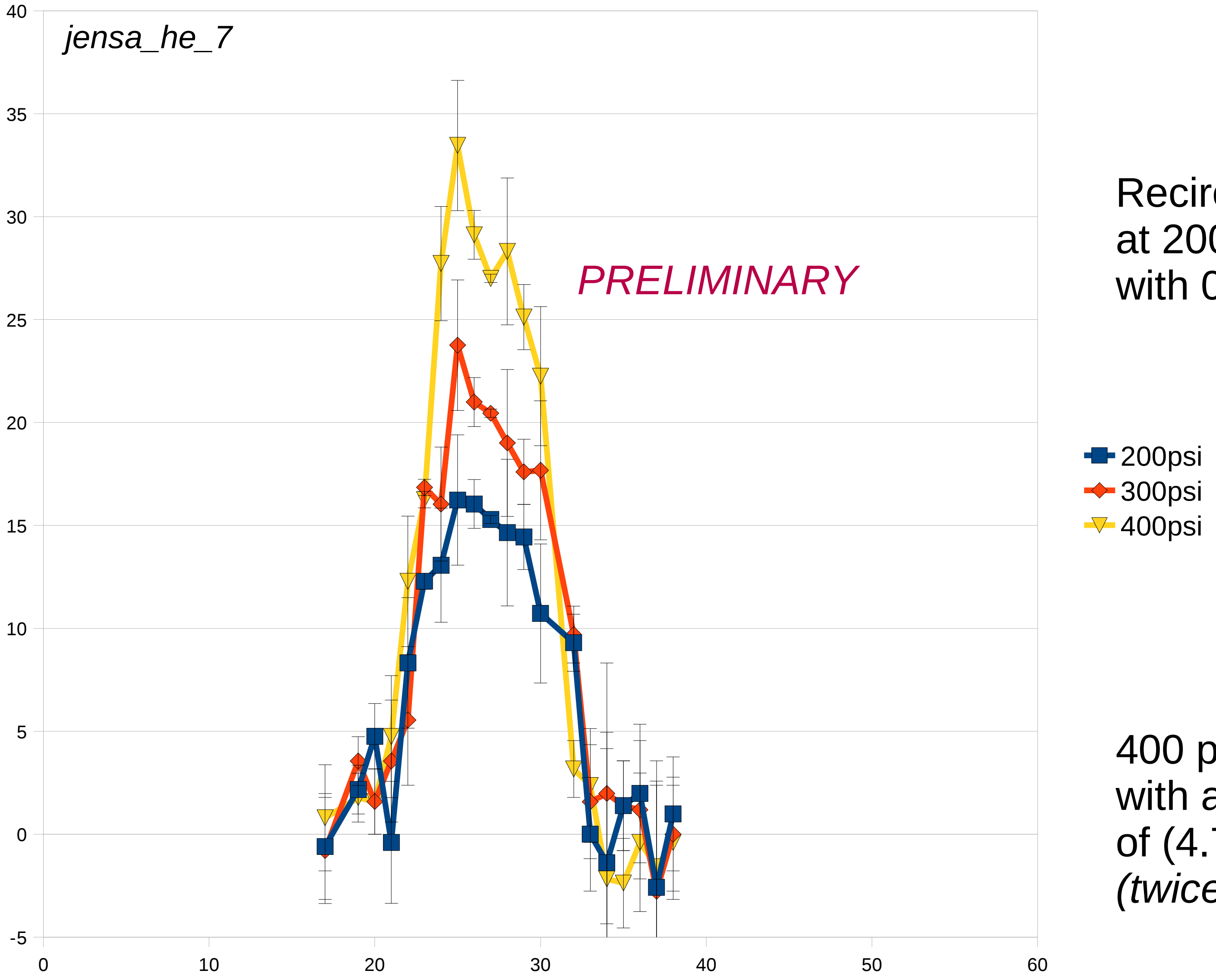
Energy Loss → Jet Density



Recirculating Ne jet
at 200, 300, and 400 psi
with 0.8 mm nozzle

400 psi jet is 4 mm diameter
with an average areal density
of $(4.4 \pm 2.8)\times10^{18}$ atoms/cm^2

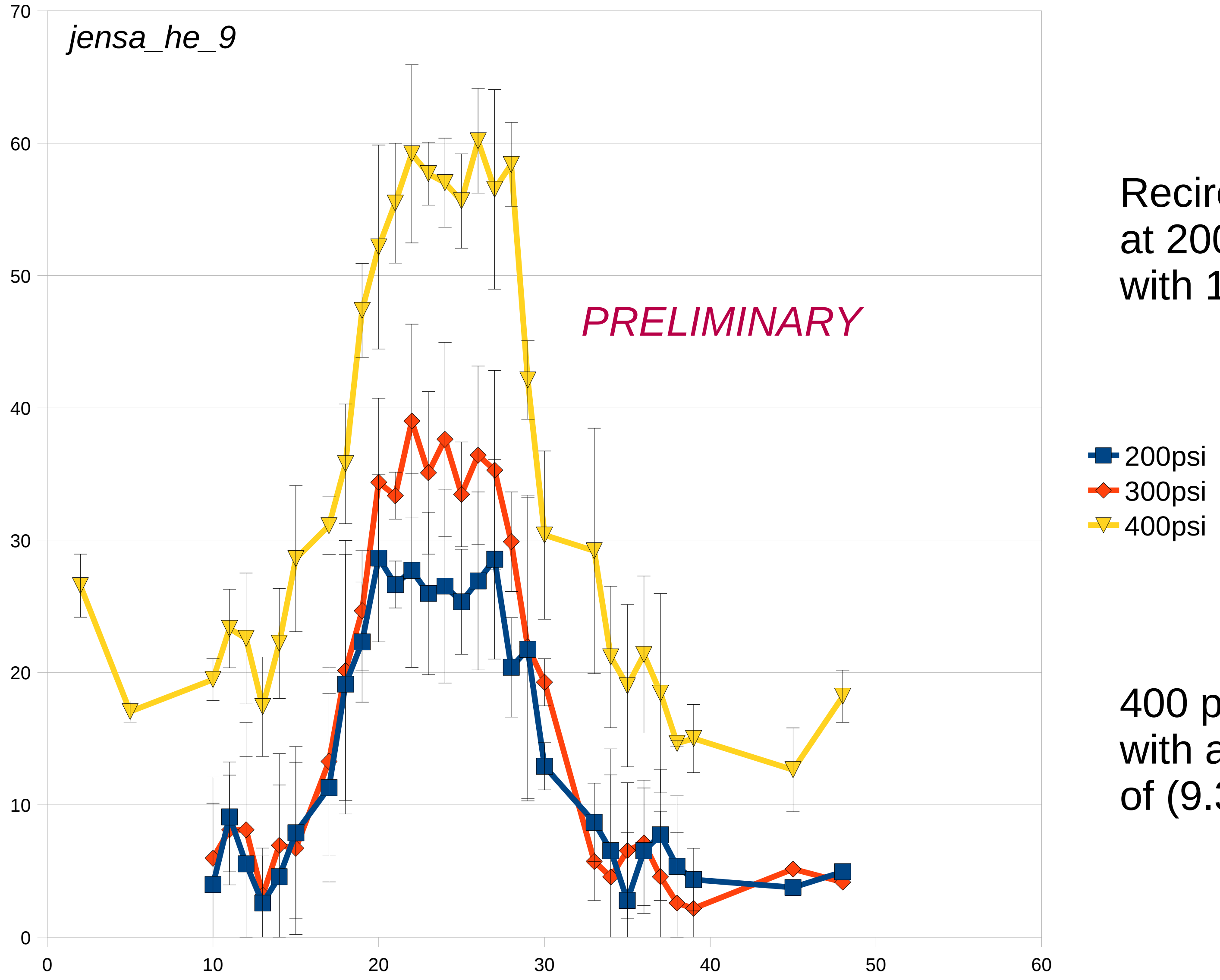
Energy Loss → Jet Density



Recirculating He jet
at 200, 300, and 400 psi
with 0.8 mm nozzle

400 psi jet is 4 mm diameter
with an average areal density
of $(4.7 \pm 0.5)\times10^{18}$ atoms/cm^2
(twice our DOE benchmark)

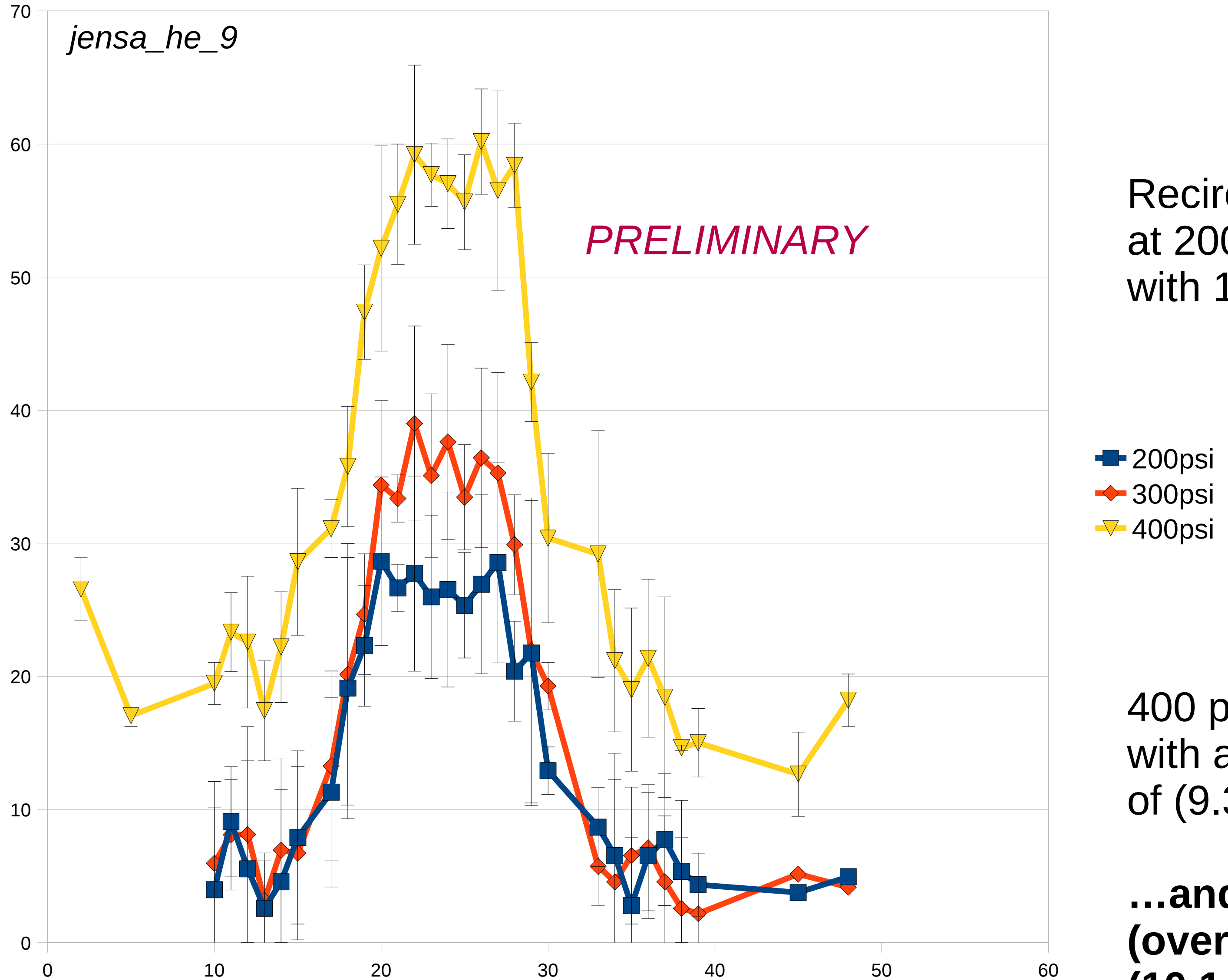
Energy Loss → Jet Density



Recirculating He jet
at 200, 300, and 400 psi
with 1.1 mm nozzle

400 psi jet is 5 mm diameter
with an average areal density
of $(9.3 \pm 0.8)\times10^{18}$ atoms/cm^2

Energy Loss → Jet Density



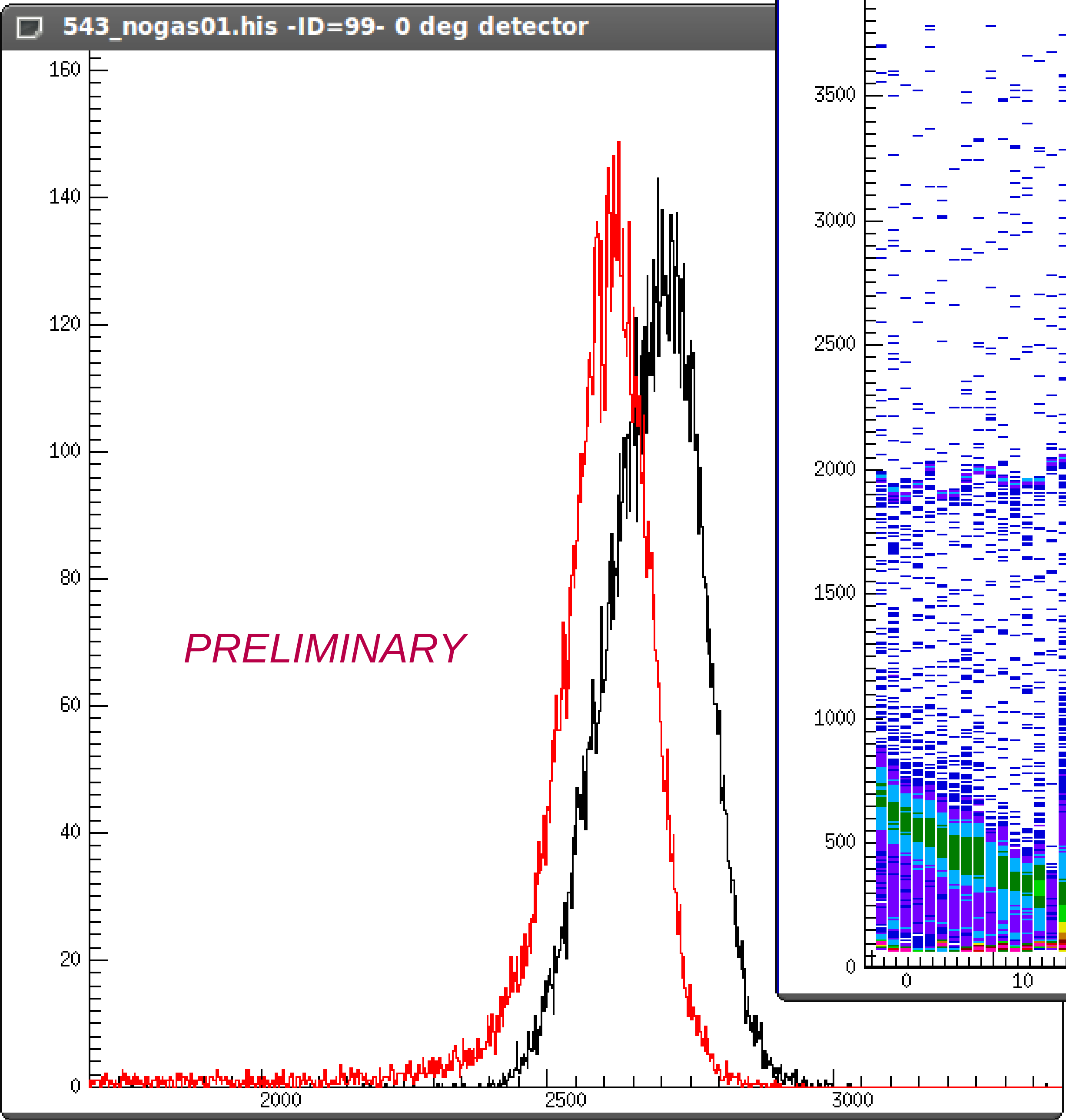
Recirculating He jet
at 200, 300, and 400 psi
with 1.1 mm nozzle

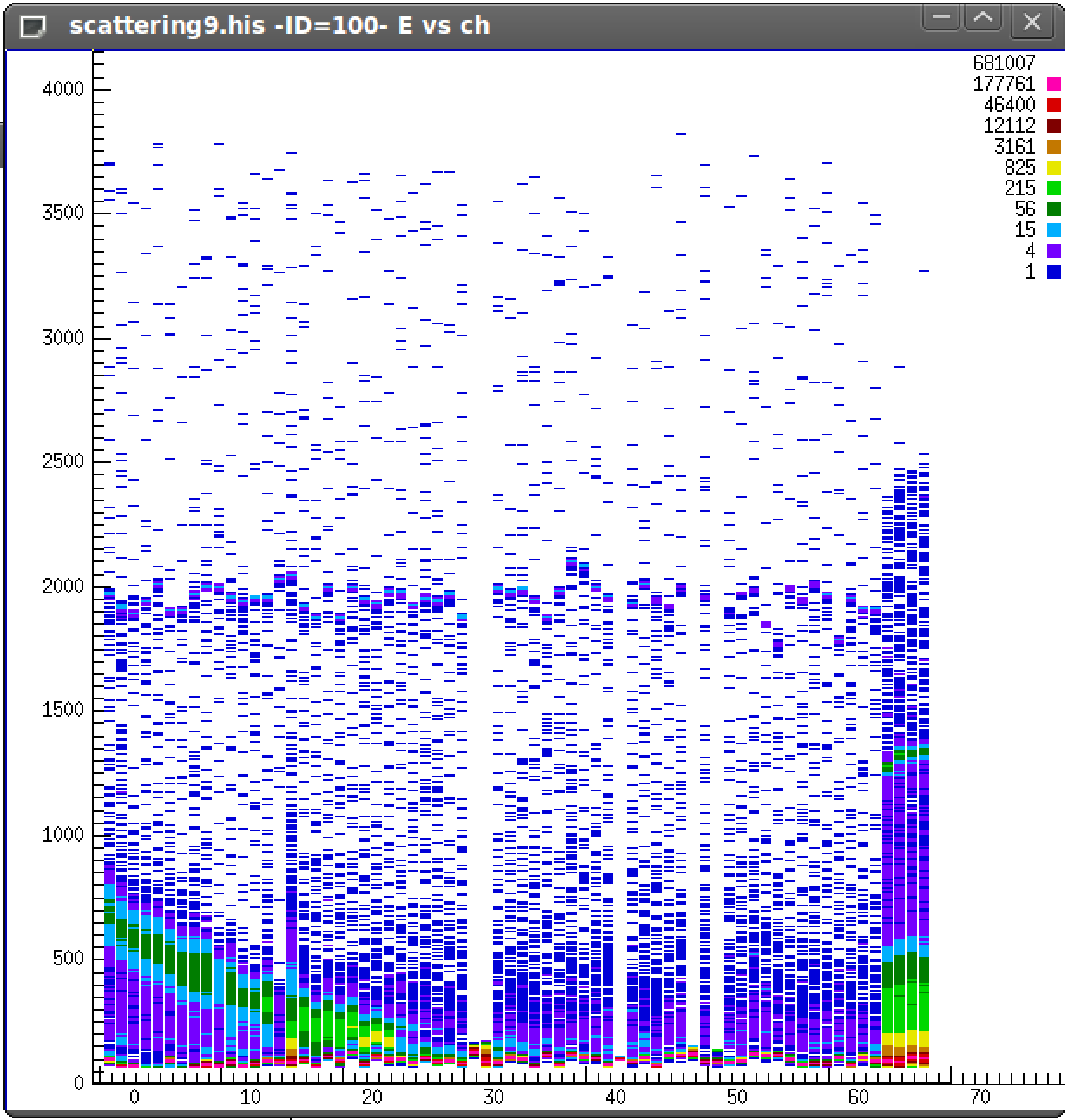
400 psi jet is 5 mm diameter
with an average areal density
of $(9.3 \pm 0.8) \times 10^{18}$ atoms/cm^2

…and a peak areal density (over a 3mm beam spot) of $(10.1 \pm 0.8) \times 10^{18}$ atoms/cm^2 !

In-Beam Test

40 MeV $^{120}Sn + N_2$ gas

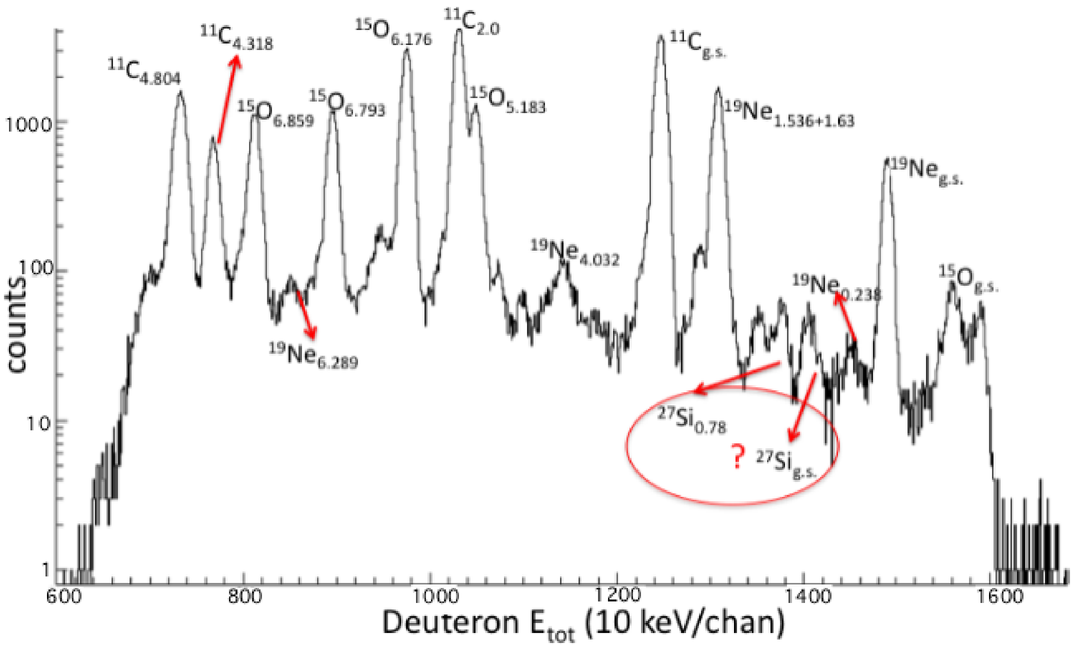


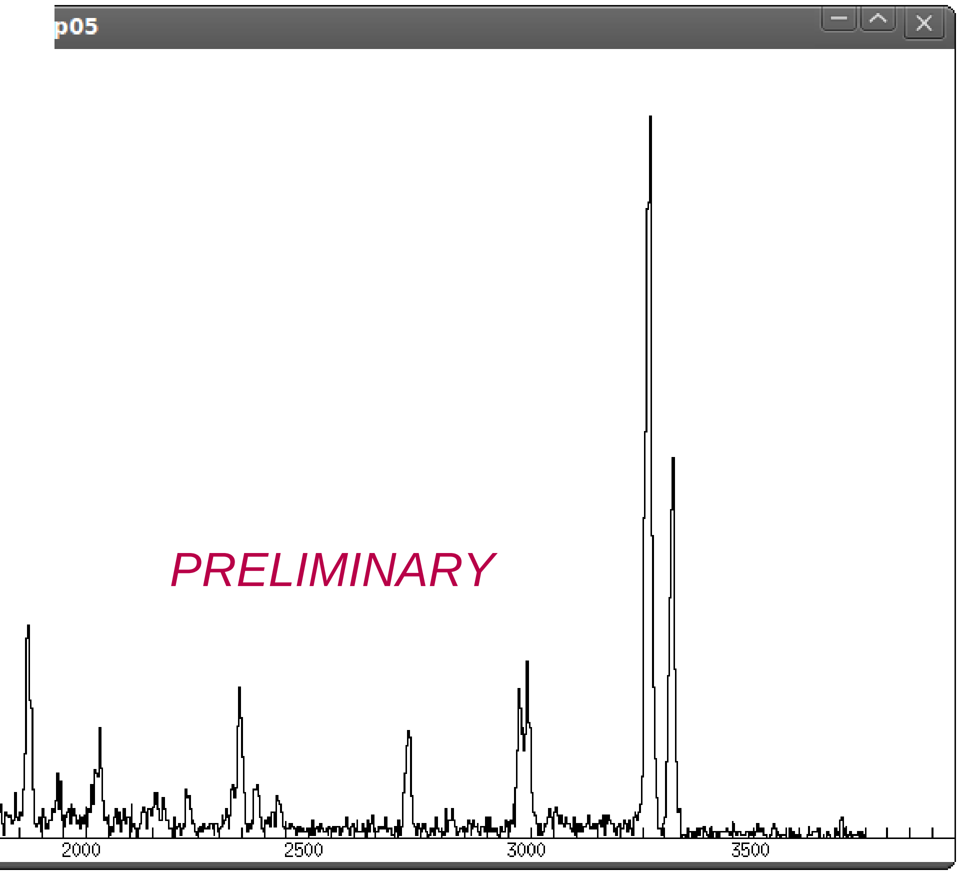


see Allison Sachs' poster!

Time at ORNL

- Maybe a little... science?





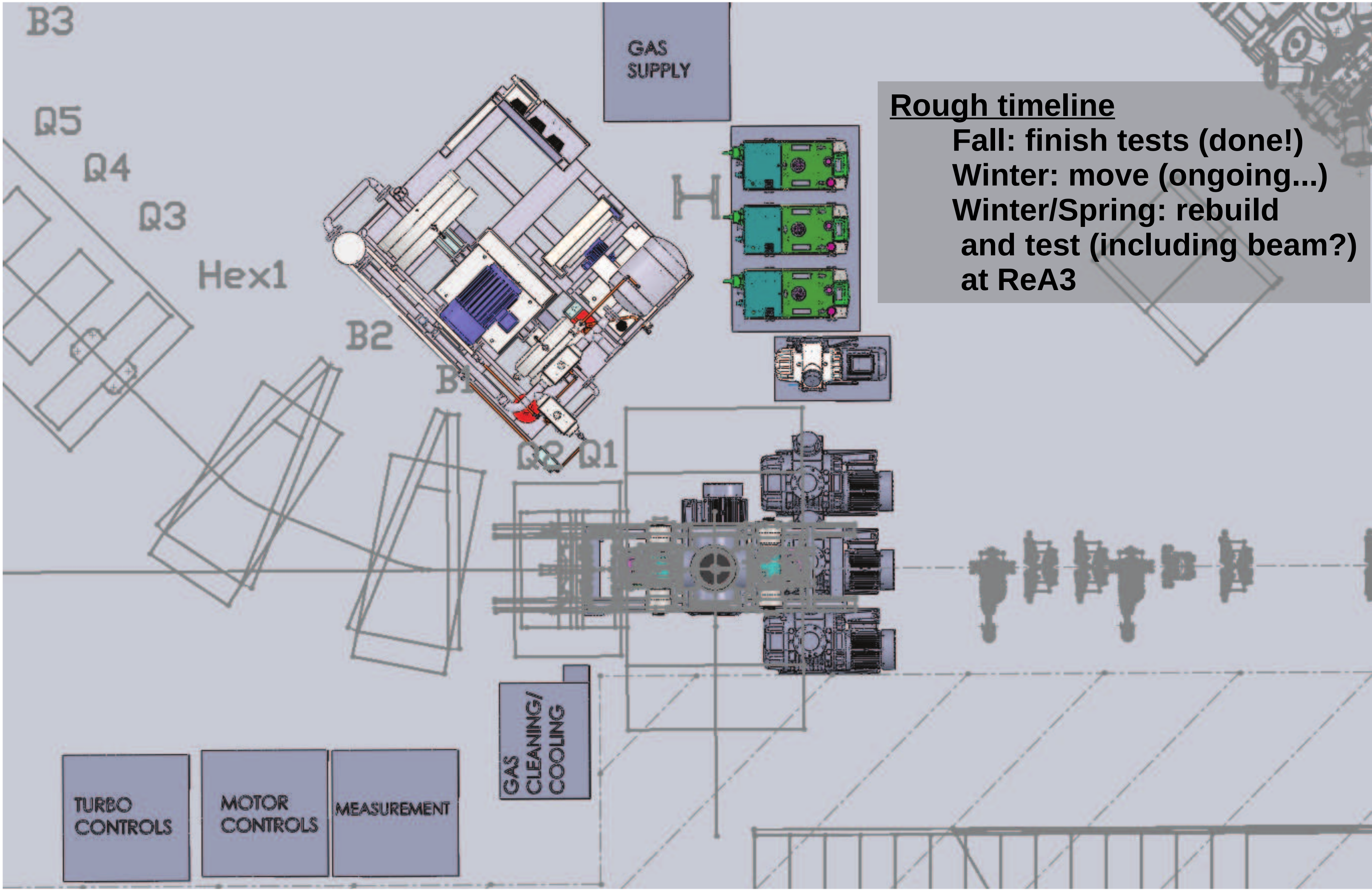
Experimental Campaign

- (^{3}He,d) proton transfer
  - constraint of proton capture reactions too weak to measure directly (proton scattering to locate resonances)
  - important to novae and x-ray bursts: ^{25}Al, ^{29}P, ^{30}P, ^{33}Cl, ^{34}Cl, ^{35}Ar, ^{37}Ar, ^{37}K, ^{38}K, ^{45}V
- direct (α,p)
  - ^{14}O, ^{18}Ne, ^{22}Mg, ^{26}Si, ^{30}S in x-ray bursts
  - alpha scattering to locate resonances

Experimental Campaign

- (d,p) transfer reactions
  - constrain (n,γ)
  - progress in reaction formalism
  - can also constrain (p,γ) with mirror arguments
- plenty more
  - two-proton emission (^{17}Ne, ^{20}Mg)
  - alpha capture, proton capture
  - coupling with SECAR to expand possibilities

Move to ReA3



Rough timeline

Fall: finish tests (done!)
Winter: move (ongoing...)
Winter/Spring: rebuild and test (including beam?) at ReA3

Thanks/Collaborators

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