Title: Tuning the beam for AMS
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Intended readers: maintenance, operator, ymp
Maintainer: D. Elmore (to whom changes and suggestions should be sent)
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Operator(s) Initials: _____ Date and time:_____

This check sheet is not for beginners. Knowledge of basic machine and computer operation is assumed. Check off each item as you do it. If you are doing a retune, optionally skip steps that start with "*".
In most cases you should not bother to tune lenses on a retune -- just tune steerers and analyzers. Make a note if you don't follow this list for any reason. Don't check steps that you skip.

Use the readings from a previous tune of the same radionuclide. In the following, "set" means set to previous value, but leave alone if this is a retune.

Use the following values of slits for tuning:

NAME	TYPE / DIR	Be.	C	Al	Ca	Cl	I	
Pre Accel	Aperture	in	in	in	in	in	in	
Inj image	Aperture	in	in	in	in	in	in	
Inj image	Slit L/R	2.38	13.0	2.38	2.38	2.38	2.38	mm
	Slit U/D	2.38	13.0	2.38	2.38	2.38	2.38	mm
LEBL	Aperture	out	out	out	out	out	out	
Analyzer obj	Slit L/R	100	100	100	200	100	100	mil
	Slit U/D	100	500	500	200	500	200	mil
Anal image	Fixed slits	in	in	in	in	in	in	
Anal HVEC img	Slit L/R	200	500	200	200	200	100	mil
	Slit U/D	200	500	200	200	500	100	mil
Switching mag	Aperture-man	0.25	0.25	0.25	0.25	0.25	0.25	in
Detector (man)	Aperture-man1	1	1	1	1	1	1	in
Detector	Aperture	in	in	in	in	in	in	

Use the following values of slits for running:

NAME	DIRECTION	Be	C	Al	Ca	Cl	I	
Pre Accel	Aperture	out	out	out	out	out	out	
Inj image	Aperture	out	out	out	out	out	out	
Inj image	Slit L/R	2.38	13.0	2.38	2.38	2.38	2.38	mm
	Slit U/D	2.38	13.0	2.38	2.38	2.38	2.38	mm
LEBL	Aperture	out	out	out	out	out	out	
Analyzer obj	Slit L/R	500	500	500	200	500	200	mil
	Slit U/D	500	500	500	200	500	200	mil
Anal image	Fixed slits	out	out	out	out	out	out	
Anal HVEC img	Slit L/R	200	500	200	100	200	100	mil
	Slit U/D	200	500	500	200	500	200	mil
Switching mag	Aperture-man1	1	1	1	1X1/4	1	1X1/4	in
Detector (man)	Aperture-man	1	1	1	1	1	1	in
Detector	Aperture	out	out	out	in	out	in	

Apertures available at SM:

1/4" round
1 " round
1" wide X 1/4" high

Apertures available at detector:
  1/2" round
1/2" wide X 1/4" high
1/2" wide X 1" high
1 " round

Offset cup positions:

Be 9: BR cup #1 - 1.950"
C 12: BR cup #1 - 0.425"
C 13: BR cup #2 - 0.875"
  Al 27: BL cup   - 0.000"
Cl 35: BR cup #2 - 2.750"
Cl 37: BL cup   - 0.425"
Ca 40: BR cup #2 - 2.800"
I 127: BR cup #2 - 3.100"

For high intensity beams (9Be, 12C, 35Cl, 1291) make sure the chopper is on before you remove the injector cup. For 27Al, the beams are low enough that you can leave the chopper off. The instructions do not always bother to say which cups and viewers need to be in or out -- this should be obvious.

When instructions say to tune two steerers together or two lenses together, proceed as follows:
- Tune the first control to maximize beam
- Record (or remember) the value of the beam current
- Mis-tune the second control (decrease first) until beam drops by 10-50%
- Tune the first one again, record if higher
- If beam max is higher, mis-tune the second control more in same direction
- If beam max is lower, mis-tune the second control in the other direction
- If beam max is the same, mis-tune the second control by a larger amount
- Repeat above until you find the highest beam maximum. You don't know if it is the maximum unless you have seen it go down on either side. Set to maximum value.
- Note that if things are tuned properly, the LE steerers should be close to zero, HE X steerers are at zero, and HE Y steerers have a large dogleg.

When the instructions say to find the Full Width at Half Maximum (FWHM) in the beam intensity for a parameter, proceed as follows: First note the beam current or radionuclide counting rate (15 sec rate cpm). Then lower the parameter until it drops by a factor of two. The beam will probably be very unsteady, so just be sure it oscillates roughly at the 50% value. A quick way to find this point is to lower by half of the previous FWHM. Record this value of the parameter (low end of range). Then raise it until it again drops a factor of two, and record the high end of the range.
The parameter should then be set to the average value.

When instructions say to execute an urs command, do the following:
- At the urs prompt type:
  URS> execute #
  where # is the mode to execute:
    1 switches inj magnet to isotope 1
    2 switches inj magnet to isotope 2

3 switches inj magent to isotope 3
10 measures transmission (inj to image)

o Start data acquisition
o Wait for desired function to occur
o Stop data acquisition

For radiocarbon, calculate injector to image transmission (S on R) as follows:
o Read image 13C current in HVEC cup
o Put injector cup in
o At urs prompt type:
URS> execute 2 <- this will switch to 12C inj mag field
o Read 12C current in injector cup
o Calculate transmission:

$$\text{Transmission} = \frac{\text{< 13C Image cup current >}}{\text{< 12C injector cup current >}} * \frac{100}{0.011 * 3} \ \%$$

o At urs prompt type:
URS> execute 1 <- this will switch to 13C inj mag field
o Remove injector cup and continue tuning

--*-*-*-*-*-*-*- Tuning procedure starts here -*-*-*-*-*-*-*-*-*-*-*-*-*

Warm up source
* Record ion source vacuum = _____ cooling = _____
* Insert sample wheel of blanks and standards
* Change sample to a blank
* Open all beamline gate valves
* Set source HV supplies, except ionizer and oven
* Warm up ionizer slowly, keeping current below 20 Amps

Do the following while waiting for ionizer to warm up
* If gas stripping is to be used set gas pressure before terminal voltage is turned up
o Set all slits, apertures, and viewers to closed values for tuning
* Set image offset cup(s) to correct distance(s)
0 Make sure current integrators are on standby
* Adjust wiring of offset cups to use correct cup(s)
* Short any unused connections with terminators
o Wire cups appropreately for tuning (meter to center cup)
o Turn current integrator back to operate
* Set machine parameters to those from log sheet from last run
Use S on R settings for elements that are changed for S on R
For Cl use 37Cl
* Set electronics to values from log sheet from last run
* Remember to set up diverter appropriately for current nuclide
* Set terminal regulation system to GVM control
* Bring machine up to voltage for radionuclide on stable nuclide (example: for tuning with 37 Cl, set to 36/37 of running value)
* When ionizer is hot, set oven (no need to raise slowly)

Set Ursula for new nuclide
* Find the name of an old parameter file from near the end of the last run for the same nuclide (example: $ dir gm:gm*0.par). Record it here_____

* Read in the old parameter file (example: URS> read par gm:gm1040)
* URS> create RL (where RL are the new run letters)
* Write the run letters at the top of these instructions
* URS> write par (this writes a new default file)
* URS> BC
* Turn off injector magnet trim power supply
* Find average of lightest and heaviest isotope injector magnet fields
* Adjust injector magnet to approximately this average field
* Turn injector magnet trim power supply back on
* URS> F (Watch field stabilize -- should not take over 5 minutes)
* URS> change wheel 1
* check that PF1-1 is on sample 101 and that RLETT and SNAME are correct
* URS> bc
* Adjust sample order (F11) as needed for tuning

Tune to injector image
o Remove attenuator
o Insert injector cup
o Tune injector object X steerer (may be near or at zero)
o Tune injector object Y steerer
o Tune two source einzel lenses together (tune only first one on a retune)
o Tune extraction voltage
o Repeat above 4 steps until you get no improvement
o Switch metering to remote

Tune to LE cup
o Tune injector image X steerer
o Tune injector image Y steerer
o Tune injector image einzel lens
o Tune LEBL einzel lens
o Repeat above 4 steps until you get no improvement

Set up for S on R
* Terminal voltage should have previously been set to S on R value
o Insert DET cup-NEVER REMOVE UNTIL RUNNING AMS
o Turn chopper on
* Set chopper for -150 na

Tune to HE cup from control room
* Set LE X2 and Y2 steerers to zero
* Tune LE X1 steerer
* Tune LE Y1 steerer
* Tune LEBL einzel lens
* Repeat above 3 steps until you get no improvement

Tune to IMAGE cup (S on R)
o Find beam in image cup (scan terminal voltage)

o Set terminal regulation to SLIT control
o Tune HE quad A
o Tune HE quad B
o Tune X1 HE steerer
o Tune Y1 HE steerer
o Repeat the above 4 steps if you got an increase
o Record HE ES quadrupole values (S on R): A=_____ kV B=_____kV
o Tune LE X1 steerer
o Tune LE Y1 steerer
o Tune LE einzel lens
o Repeat the above 3 steps if you got an increase

o Set image cup to be read by computer
o Set chopper to computer control
o Record INJ to IMAGE cup transmission (img/inj/q)
URS> execute 10 trans = _____%

Typical Transmission values:
Be: 17% C: 27% Al: Ca: Cl: I:
o If trans is low, change foils and/or adjust stripper gas
o Retune above if you changed the stripper gas or foil

o Set terminal regulation to GVM
o Measure terminal voltage FWHM:
in image cup: Vt = LO:_____ HI:_____ Width:_____ AVE:_____ MV
o Set terminal regulation back to slit control

Tune to SM viewer
* Set EXB to previous S on R tuning values
* Tune (increase) transmission quad to focus on viewer (don't bother on a retune unless you get steering)

o Adjust HE steerers and EXB to eliminate quad steering as follows:
---------- QUAD B and EXB / Y steerers --------
o First try EXB
o Increase trans quad B and note if beam moves up/down _____
o Put trans quad back to focus position
o Adjust EXB magnet coarse dial up/down corresponding to above
o Repeat above 3 steps until no movement

Quad B focus: Dial _____ V _____ %

EXB setting		When quad B increased beam goes:	
dial	current	Up	Down
_____	_____A	__	__
_____	_____A	__	__
_____	_____A	__	__
_____	_____A	__	__
_____	_____A	__	__

o If the EXB doesn't solve problem, next try HE steerers
o Increase trans quad B and note if beam moves up/down _____
o Put trans quad back to focus position
o Do the following if beam moves
o Move up/down (corresponding to above) HE Y2 to reduce beam by 50%
o Insert image cup by holding down button for following step

- Peak beam with with HE Y1
- Repeat above until no beam movement with trans quad B

Steerer settings Y1	Y2	When quad B increased beam goes: Up	Down
_____ %	__0__ %	_____	_____
_____ %	_____ %		_____
_____ %	_____ %	_____	_____
_____ %	_____ %		_____
_____ %	_____ %	_____	_____

---------- QUAD A, Term voltage and X steerers --------

- Increase trans quad A and note if beam moves right/left in table
- Put trans quad back to focus position
- Do the following if beam moves
  - Note beam current in table below
  - Move HE X1 steerer right/left (corresponding to above) 5 units
  - Insert image cup by holding down button for following step
  - Peak beam with terminal voltage
  - Repeat above until no beam movement with trans quad A
  - Make sure there is not a significant loss in beam current

TRANS Quad A focus: Dial _____ V _____ ø

Beam in image cup	X1 steerer	Terminal Voltage	When quad A increased beam goes: Right	Left	Centered
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____
_____nA	_____ %	_____MV	_____	_____	_____

- If Vt doesn't solve problem, then try
  - Move right/left (corresponding to above) HE X2 to reduce beam by 50%
  - Insert image cup by holding down button for following step
  - Peak beam with HE X1
  - Repeat above until no beam movement with trans quad A

Quad A focus: Dial _____ V _____ ø

Steerer settings X1	X2	When quad A increased beam goes: Right	Left
_____ %	__0__ %	_____	_____
_____ %	_____ %	_____	_____
_____ %	_____ %	_____	_____
_____ %	_____ %	_____	__
_____ %	_____ %	_____	_____

Tune to SM cup

o Remove SM viewer
o Record EXB voltage settings: dial: _____ Voltage: _____
o Tune SM
o Tune transmission quad A (will need to decrease)
o Tune transmission quad B (will need to decrease)
o Tune EXB voltage
o Repeat above 4 steps until you get no improvement
o Record EXB voltage settings: dial: _____ Voltage: _____%
  If there is a big change, recheck transmission quad steering with viewer
o Check IMG to SM transmission
  Img cup: _____na SM cup: _____na Transmission: _____ 9

Tune to DET BPM
o Put attenuator in
o Turn chopper off
** Note: Beam profile monitors will not work with chopped beam!!!
o Turn on DET beam profile monitor
o Open up SM aperture to open
o Crashproof computer
o Focus beam with beamline quad using BPM
o Adjust ESA to center beam on BPM fiducial in left/right direction
o Adjust Y magnetic steerer to maximize beam current through Det
  aperture in up/down direction
  NOTE: this will not be centered on BPM ficucial mark
o Adjust SM to eliminate horizontal quad steering as follows:
  o Increase beamline quad A and note if beam moves left/right _____
  o Put quad back to focus position
  o Do the following if beam moves
  o Decrease/increase (corresponding to above) SM until beam moves
    -- Usually the SM fine dial has to be increased by several hundred on
       the dial to eliminate the quad left/right steering
  o Put beam back on circle with the ESA
  o Repeat above 5 steps until no beam movement with quad A or B in
    left/right direction

BL quad A focus: Dial _____ V _____9

Switching Magnet		ESA Setting		When BL quad A increased beam goes	
F Dial	Field	Dial	Voltage	Right	Left
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____	_____	_____
_____	_____	_____	_____ %	_____	_____

BL quad B focus: Dial _____ V _____9

Switching Magnet		ESA Setting		When BL quad A increased beam goes	
F Dial	Field	Dial	Voltage	Right	Left
_____	_____	_____	_____ %	_____	_____

  o If the beam moves in the up/down direction, slightly move EXB
    voltage to center beam in beamline quad

EXB Voltage		When BL quad A increased beam goes		
Dial	Field	Up	Down	
_____	_____	_____	_____	STARTING VALUE

_____ _____ _____ _____
_____ _____ _____ _____

o Turn off BPM
o Turn chopper back on (manual)
o Take attenuator out

Tune to detector cup
o Be sure DET cup is in
o Tune ESA
o Tune Y magnetic steerer
o Tune beamline quad A
o Tune beamline quad B
o Repeat the above 4 steps until you get no improvement
o Record image to detector transmission:
  Image cup: _____ na Det cup: _____na Trans: _____%

Check terminal voltage range

o Record terminal voltage, ESA, and EXB:
  Vt = _____ MV ESA = _____ kV
  EXB Voltage: dial _____ V _____% Magnet: dial _____ i _____ A

o Switch terminal regulation system to GVM control
o Open all slits to running position (check them off on table page 1)
o Put attenuator in
o Turn chopper off
o Turn on DET beam profile monitor
o Look at beam on BPM scope for the following step
o Sweep terminal voltage up and down using the GVM fine control and note
  how beam moves. It should travel to either side of marked center position.
  As the Vt is raised the beam spot should move left until it starts to go
  away. As the Vt is lowered the spot should move right until it starts to
  go away. The beam spot shouldn't change shape as it is swept across the
  fiducial mark.
  If not, adjust the beamline quad until it does.
  You should find TM or DE if you are unsure about this.
o Turn off BPM
o Turn chopper on (manual)
o Take attenuator out
o Insert image cup
o Record terminal FWHM range
  in image cup: Vt = LO:_____ HI:_____ Width:_____ AVE:_____ MV
  Dial _____ _____ _____ _____
o Record terminal FWHM range
  in detector cup: Vt = LO:_____ HI:_____ Width:_____ AVE:_____ MV
  Dial _____ _____ _____ _____
o Set terminal voltage to average
o Switch image cup to be read by computer
o Set chopper to computer control
o Use urs to put image cup in
o Record transmissions TRANSMISSION
  URS> execute 10 INJ to IMG: _____ %

o Set chpper to manual
o Set image cup to local

Image Cup: _____na Det Cup: _____na IMG to DET: _____ %
o Note value of SM field (use . status display) and enter URS> set swmf #####

Tune S on S

o Insert LEFC
o Set terminal voltage to running value from previous run log sheet
o Set ES quad to previous S on S value
o Set EXB to previous S on S value
o Set ESA to previous S on S value
o Set analyzer field to previous S on S value
o urs> set sanalf <analyzer field frorn above>
o Insert analyzer image fixed slits
o Record terminal FWHM range
in image cup: Vt = LO: _____ HI: _____ Width: _____ AVE: _____ MV
Dial _____ _____ _____ _____
o Set terminal to average
o Tune LE einzel lens
o Tune LE X1 steerer
o Tune LE Y1 steerer
o Tune HE ES quad
o Repeat above 4 steps until you get no improvement
o Switch image cup to be read by computer
o Set chopper to computer control
o Record INJ to IMAGE transmission:
URS> execute 10 TRANSMISSION: _____ %
o Set chopper to manual control
o Set image cup to local
o Insert LE faraday cup
o set current integrators to standby
o Set analyzing magnet back to R field
o Move metering wire frorn HVEC cup to appropriate offset cup
o set current integrators to operate
o urs> set sanalf <analyzer field frorn above>
o Remove analyzer image fixed slits

Set offset faraday cup

o Remove LE faraday cup
o Read beam on offset cup, still on GVM
o Measure FWHM of insertion distance and set to average
Low: _____ in High: _____ in Width: _____ in Avg: _____ in
o Measure terminal voltage FWHM:
in offset cup: t = LO: _____ HI: _____ Width: _____ AVE: _____ MV
Dial _____ _____ _____ _____
This should be very close to that measured for SonS above

Measure first R/S ratios

o URS> BC
o Change to a standard on the sample order display (goto command)
o fix run order so that this sample is first on the list
o URS> change nc 10
o Remove all cups except injector and image
o Set current metering switch to computer
o set chopper to computer control
o Push start
* URS> set shift false (36Cl only)
o URS> set FM20TMIN 100
o URS> set reg_termv false
o Check on PF1-2 that QSTATE is correct
o Check that stable nuclide was measured properly, wait for radionuclide
o Adjust detector amplifiers until signals are about 5 volts each
o Uncrashproof computer
* Check delays for radioisotope beam and pulsers using scope
* Check gates for radioisotope beam and pulsers as follows:
* URS> show ld
  this starts up GKS spectra plots
* put detector cup in
* urs> br
* Adjust and set pulsar gates in SET 2 delta E2 and delta E3
    pulsar voltages should normally be about 8 volts
    set gates - 50 counts on each side of peak
* remove detector cup
* urs> br
* Adjust gates in SET 1 to select radioisotope
* Adjust gates in SET 3 to select interference nuclide (36S only)
* URS> set shift true (36Cl only)
o Check gates, set 1
* Stop data acquisition
* Insert injector cup
* urs> goto <blank sample>
* Remove injector cup
* Verify that radionuclide peak has disappeared from all gates
* Stop data acquisition
* Insert injector cup
* urs> goto <standard sample>
* Remove injector cup
* urs> br
o Using a standard, watch the counting rate in the log file for the following: Vary Vt with fine control, type BR, and run 1 minute to get 50-500 counts for each step. Check that the beam position sweeps from one side of the detector to the other (necessary for computer control to work). Do not attempt computer control for 1291 (will lock on 1271). If beam does not sweep all the way across the detector, you may need to retune the beamline quad.

Vt	dial	CPM	INTF	******** Beam position **********
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |
_____MV	_____	_____	_____	| o |

_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	
_____MV	_____	_____	_____	o	

- o Record terminal FWHM
  in detector Vt = LO:_____ HI:_____ Width:_____ AVE:_____ MV
- o URS> set sterm 16000
- o Check on PF1-2 that FTERMCO, FTERMC1, FTERM_P, and FTERMV are correct for the terminal voltage you are using. If not- calculate new values.
  - o FTERMCl and FTERM_P are constants that should not need changing.
  - o urs> set FTERMV <average term voltage from above>
  - o calculate FTERMCO = (-16000 * FTERMC1) + FTERMV
  - o urs> set FTERMCO <number calculated above>
- o Set Vt to average of FWHM using fine GVM reference control
- o Adjust ESA fine control to center beam in position spectrum (F12)(not 1291)
- o Using a standard, watch the counting rate in the log file:
  Vary the EXB wein filter high voltage dial, type BR, and run 1 minute to get 50 to 500 counts for each step. Record and plot high voltage dial vs cpm and high voltage dial vs INTF.

EXB High Voltage %	dial	CPM	INTF
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____
_____	_____	_____	_____

- o Record high voltage FWHM in detector for the CPM:
  HV EXB = LO:__________ HI:__________ Width:__________ AVE:__________ dial
- o Set EXB high voltage to average
  If INTF is still high or a problem, you may have to set the high voltage dial offset from the average setting
- o For 1291, plot cpm vs ESA and set ESA 0.05 kV to lower side of peak
  look at the ESA scan for spurious peaks and compare with previous run

ESA VOLTS	CPM	INTF
kV		
kV		
kV		
kV		
kV		
kV		
kV		
kV		
kV		
kV		
kV		
kV		
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kV		
kV		

- o Set reg_termv true (except for 1291)

o URS> set FM20TMIN 0 (0.4 for 14C)
* Cycle on a few standards and blanks
o Record tune ending date: _____ time: _____
* Set the default background (fbkgd,fbkgd_er on PF1-2)
* Set the default interference factor (fifcf and fifcf er on PF1-2)
* Load quality control wheel, run that for about 2 hours or until
  you obtain good data
