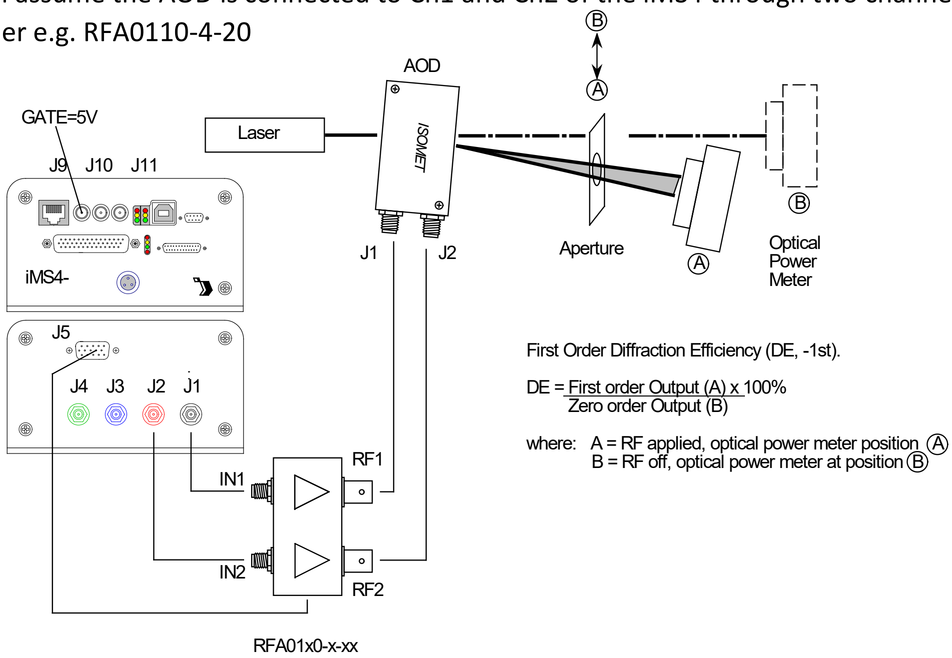
Functional test of the D1384 AO deflector using the iMS4 Isomet Studio.

The method uses the iMS4 in Tone Buffer mode with LUT files supplied by Isomet.
It is a convenient means to set the AOD Bragg angle and check for scan uniformity.

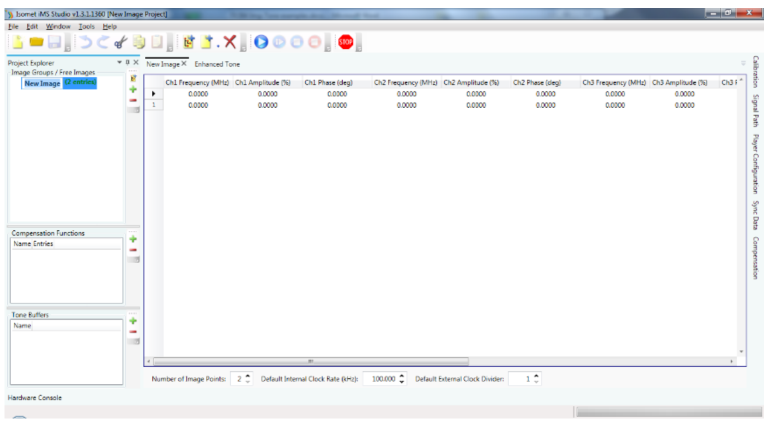
- For X-Y AO deflectors, each AO deflector is tested in turn starting with the X-axis.
- The D1384 is a quartz deflector. The input polarization must be vertical with respect to the scan (diffraction) axis.
- Always ensure cooling water is flowing through AOD. (This does NOT depend on the input laser power).
- To install the software, please refer to *Quick Start Guide.pdf*
- For further reading on Compensation LUT files, please refer to *iMS4 Compensation LUT Guide.pdf*

This app note describes set-up using the D1384-aQ110-7 at 515nm.
Please see note on page 10 for 355nm models.

We will assume the AOD is connected to Ch1 and Ch2 of the iMS4 through two channels of the amplifier e.g. RFA0110-4-20



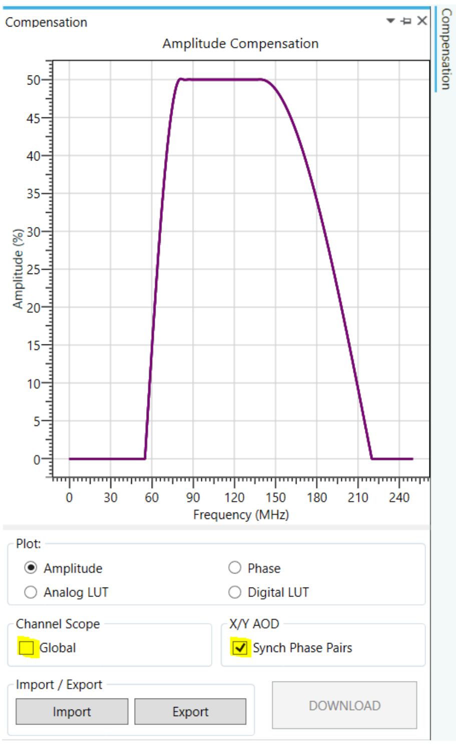
Start the Isomet Studio



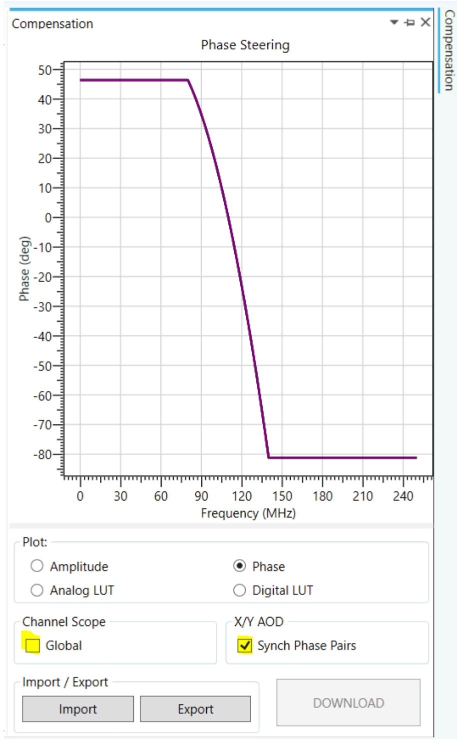
1: Navigate to the location of your iMS4 files.
File > Open > ..\..*D1384-40Mswp-515nm-D90-Ch80.iip*

Select ***Compensation*** menu
2: Deselect ***Global***
3: Select ***Sync Phase Pairs***
Navigate to file location
4: ***Import*** ..\..\ *Default-A50%-PCalc-515nm.LUT*
This LUT file uses theoretical calculated phase values and constant 50% amplitude.
(For reference, this LUT can also be generated from within the GUI. See: Tools > AO chooser)
Compensation curves will be displayed:

Amplitude vs. frequency



Phase vs. frequency



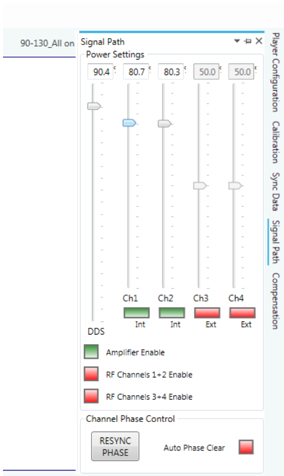
5: ***Download***

6: Select ***Signal Path*** menu

7: Set ***DDS*** wiper to 90% (applies to all outputs)

8: Set ***Ch1*** wiper to 80% AND set ***Ch2*** wiper to 80%.
MUST BE SAME

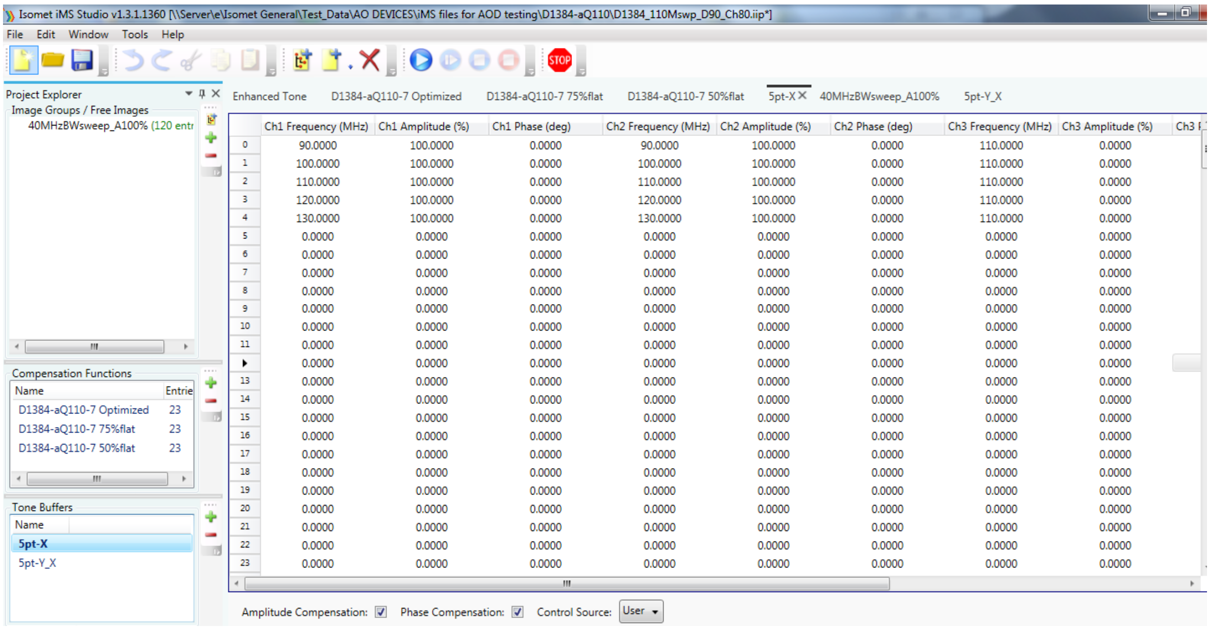
9: To be safe, disable Ch3 and Ch4 .
Hit buttons below "Ch3" , "Ch4" wipers
Will change from Green (INT) > Red (Ext))



10: ***Amplifier Enable*** (Red > Green)

11: **Ensure** a TTL high input is applied to the GATE input, SMA J9 on the iMS4-

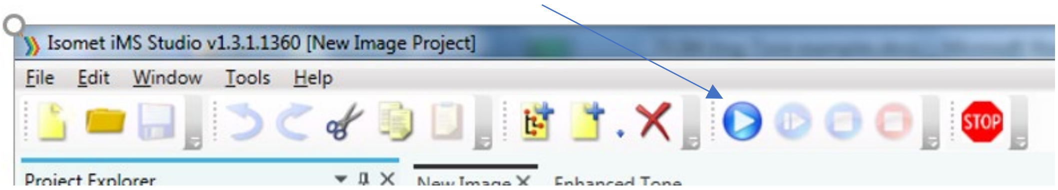
12: In the ***Tone Buffers*** window, select table ***5pt-X***



	Ch1 Frequency (MHz)	Ch1 Amplitude (%)	Ch1 Phase (deg)	Ch2 Frequency (MHz)	Ch2 Amplitude (%)	Ch2 Phase (deg)	Ch3 Frequency (MHz)	Ch3 Amplitude (%)
0	90.0000	100.0000	0.0000	90.0000	100.0000	0.0000	110.0000	0.0000
1	100.0000	100.0000	0.0000	100.0000	100.0000	0.0000	110.0000	0.0000
2	110.0000	100.0000	0.0000	110.0000	100.0000	0.0000	110.0000	0.0000
3	120.0000	100.0000	0.0000	120.0000	100.0000	0.0000	110.0000	0.0000
4	130.0000	100.0000	0.0000	130.0000	100.0000	0.0000	110.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
7	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
8	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
11	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
▸	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
13	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
15	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
16	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
17	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
18	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
19	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
20	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
21	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
22	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
23	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

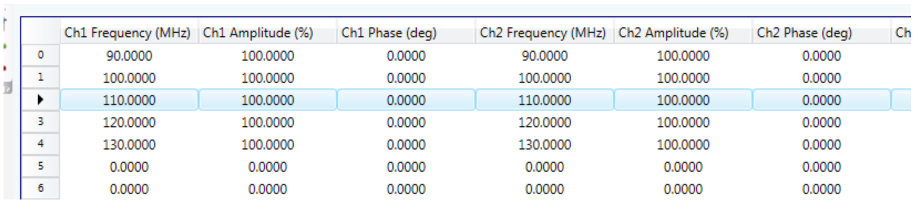
This table comprises 5 frequency points equally spaced across the maximum diffraction bandwith of the AOD.

13: Hit ***Play*** button to enable Tone Output



14: Select row-2 containing the AOD centre frequency. In this case 110MHz.
The active row will be highlighted when selected.

To ensure the single tone output has been initated, navigate to a blank (all zeros) row e.g. row-6 and then back to row-2 (110MHz)



	Ch1 Frequency (MHz)	Ch1 Amplitude (%)	Ch1 Phase (deg)	Ch2 Frequency (MHz)	Ch2 Amplitude (%)	Ch2 Phase (deg)
0	90.0000	100.0000	0.0000	90.0000	100.0000	0.0000
1	100.0000	100.0000	0.0000	100.0000	100.0000	0.0000
▸	110.0000	100.0000	0.0000	110.0000	100.0000	0.0000
3	120.0000	100.0000	0.0000	120.0000	100.0000	0.0000
4	130.0000	100.0000	0.0000	130.0000	100.0000	0.0000
5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
6	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

17: **Adjust Bragg angle** for maximum diffraction efficiency. At this stage it should be between 70% and 80%. (See page Appendicies)

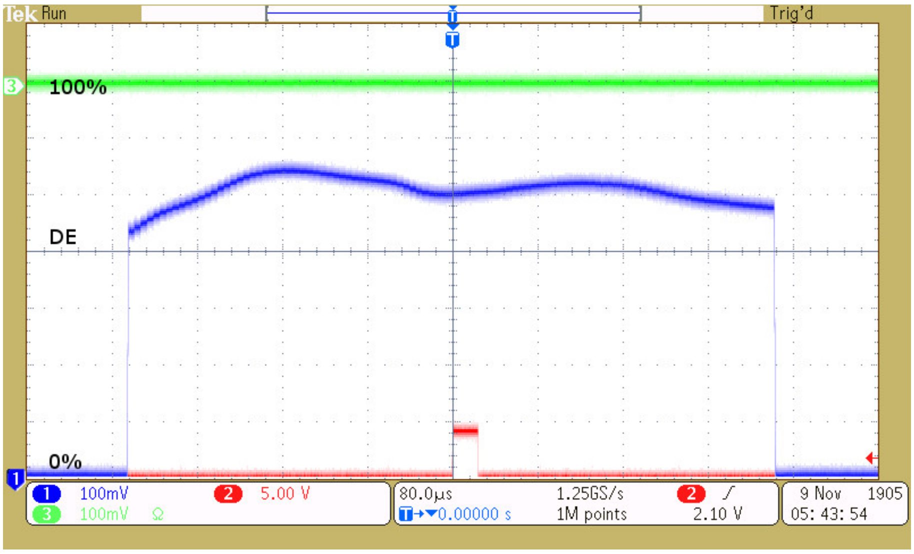
18: Step though all 5 frequencies. Measure the efficiency at each frequency. Centre the power meter on the diffracted beam at each scan angle. Do not readjust Bragg until all 5 measurement are taken.

19: If all is correct for the selected first order, the results will be similar to the table values below.

Table Row	Freq MHz	Diffraction Efficiency	RF drive power per input
0	90	73%	9W
1	100	83%	9W
2	110	78%	9W
3	120	74%	9W
4	130	69%	9W

The diffraction efficiency variation is less than <+/- 10%

The equivalent sweep response, from 90-130MHz,100steps



Comment

This is a typical response for the default LUT table and confirms that the RF connections and optical alignment are broadly correct.   At this stage, it is not optimized but it is approximately flat across the scan. See 21: Improving Scan Efficiency

20: **Error Conditions**

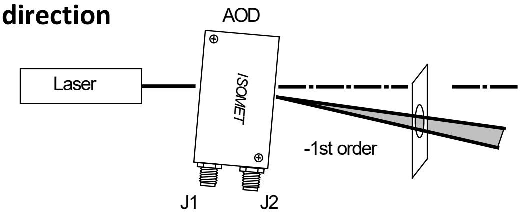
These will occur if :

- RF connection order is incorrect
- Opposite diffraction order has been selected

Note: the efficiency at the centre frequency will still be good but the uniformity will be poor .

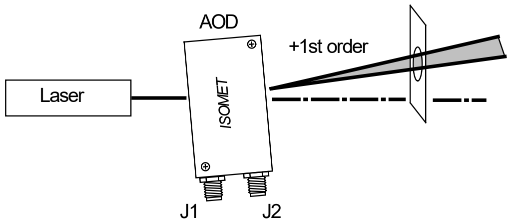
RF Connection v. Scan direction

Minus Bragg requires iMS4 output **J1** to connect (via the amplifer) to AOD input **J1**, and iMS4 **J2** to AOD input **J2**



Conversley :

Plus Bragg requires iMS4 output **J1** to connect (via the amplifer) to AOD input **J2**, and iMS4 **J2** to AOD input **J1**



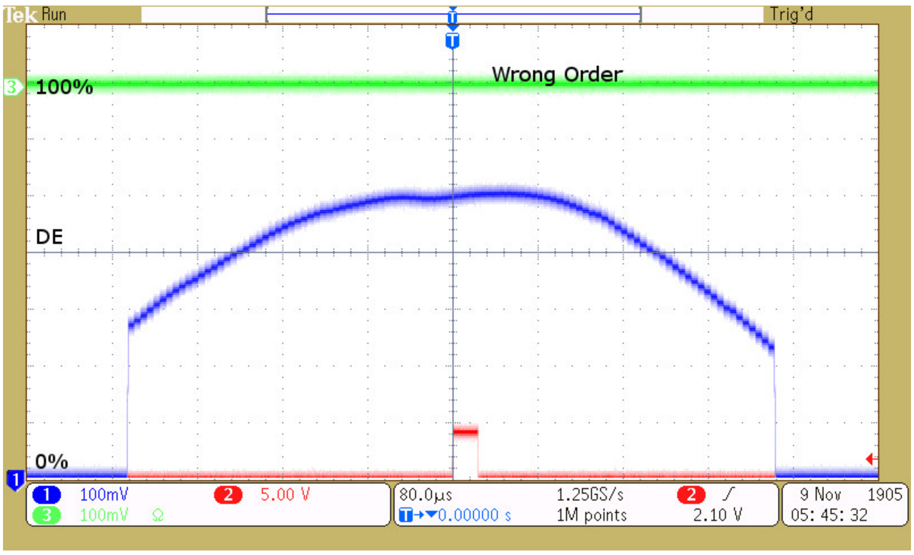
Example:

Using the same set-up but aligning the power meter on the opposite first order beam,

Table Row	Freq MHz	Diffraction Efficiency	RF drive power per input
0	90	40%	9W
1	100	70%	9W
2	110	77%	9W
3	120	64%	9W
4	130	34%	9W

Note the large variatation in diffraction effiency . Almost +/- 20%

The equivalent sweep response, from 90-130MHz in 100 steps



IMPORTANT. It is not possible to improve the efficiency with drive power or Bragg adjustment.

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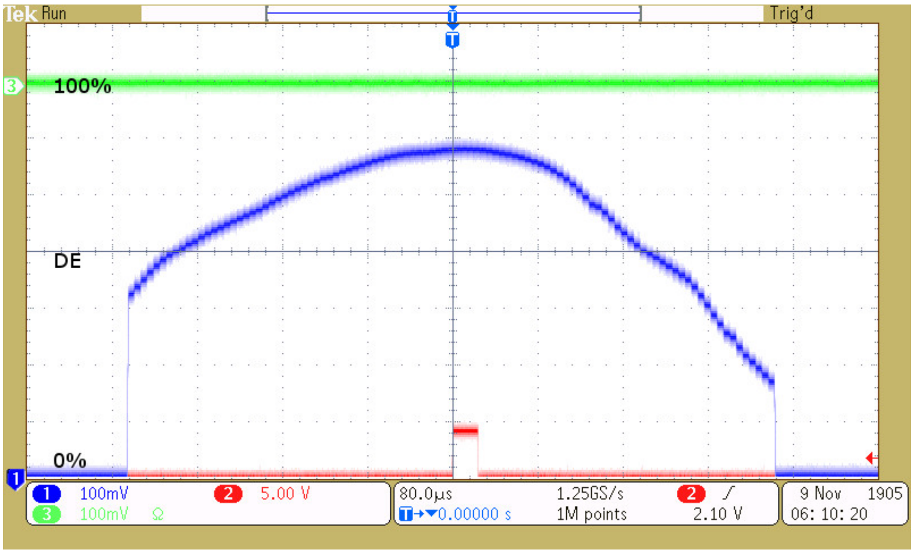
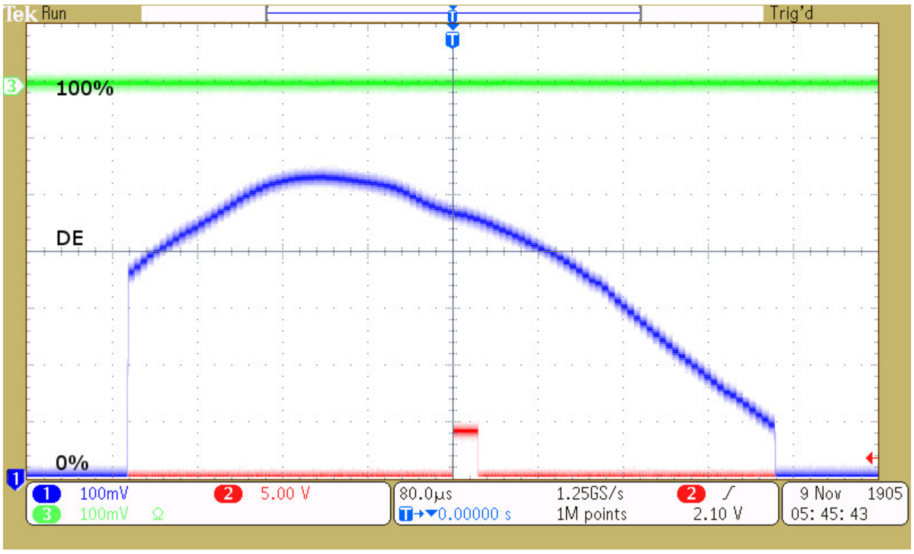
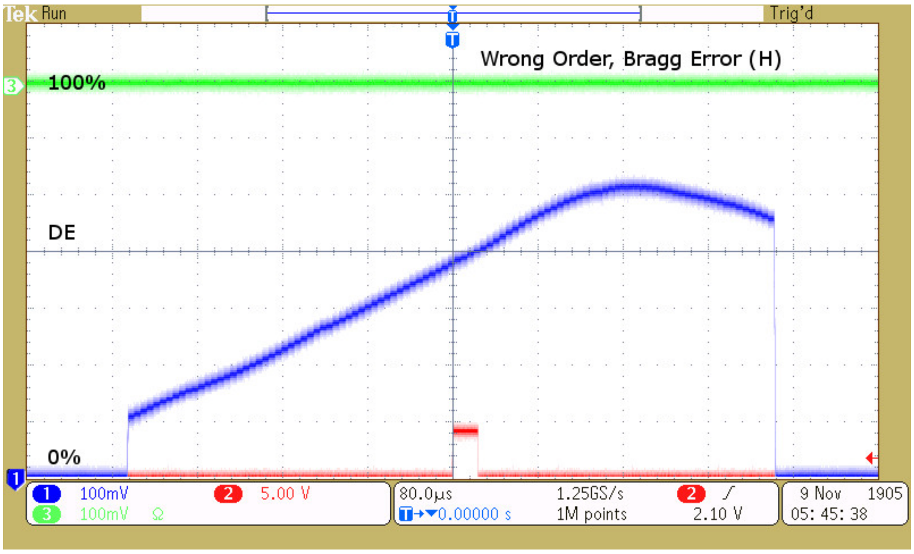
e.g. Error Condition. Increasing RF power = no benefit



Bragg adjusted for low of centre frequency = no benefit



Bragg adjusted for high of centre frequency = no benefit



21: **Improving scan efficiency**.

If your initial results are similar to section 19, continue to 22:

If your initial results are similar to section 20, swap the RF connections at the AOD input and repeat steps 17,18,19.

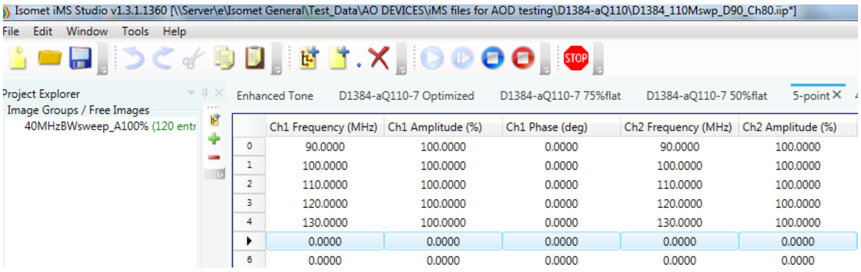
22: A simple increase in LUT amplitude will provide reasonable flatness and efficiency

This can illustrated by loading a new LUT file as follows.

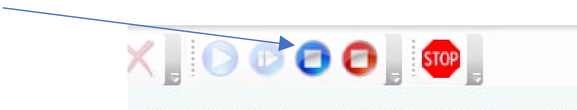
First, stop the running Tone Buffer in order to upload a new compensation LUT file.

To fully end the Tone Buffer mode, follow steps below A: and B: in order.

A: Select a row containing zero values to stop the RF output e.g. row-5



B: Hit ***STOP*** to disable the current Tone Mode



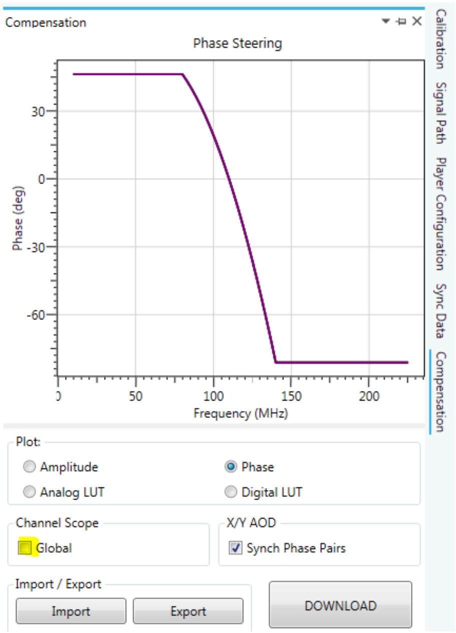
22: Select ***Compensation*** tab

Navigate to your IMS4 files location.

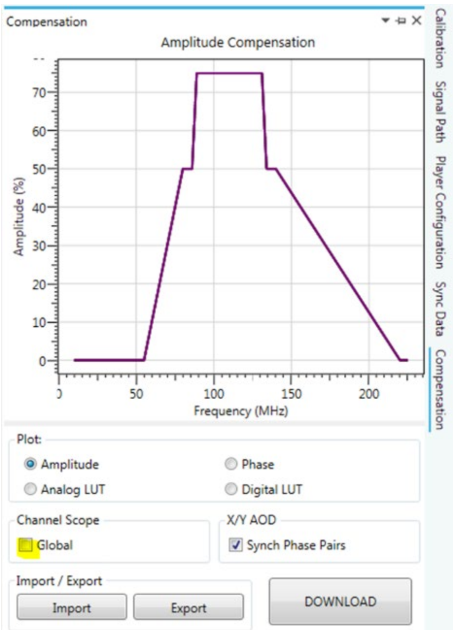
Import ..\..\ *Simple-A75%-PCalc-515nm.LUT*

This LUT files also uses the theoretical phase values but with increased amplitudes.

Amplitude vs. frequency



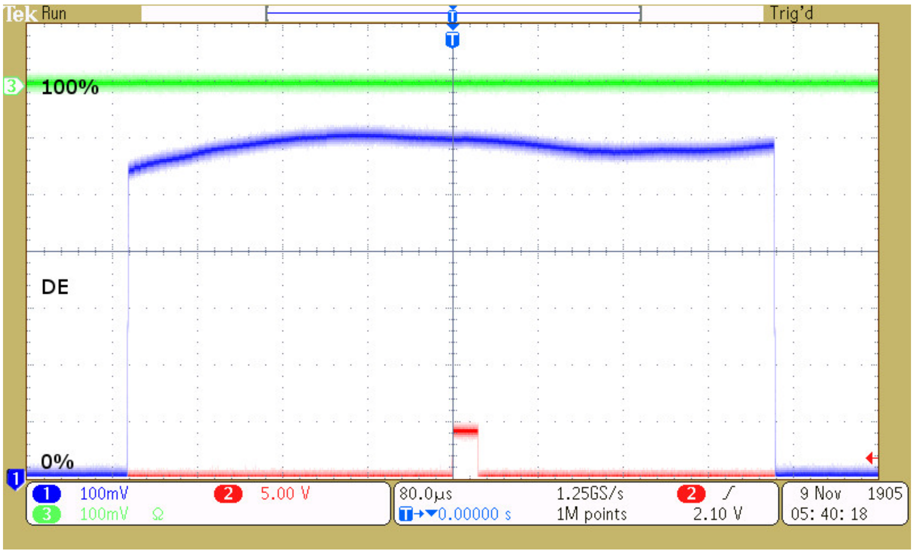
Phase vs. frequency



Result:

Table Row	Freq MHz	Diffraction Efficiency	RF drive power per input
0	90	85%	16W
1	100	90%	15W
2	110	89%	15W
3	120	84%	15W
4	130	83%	14W

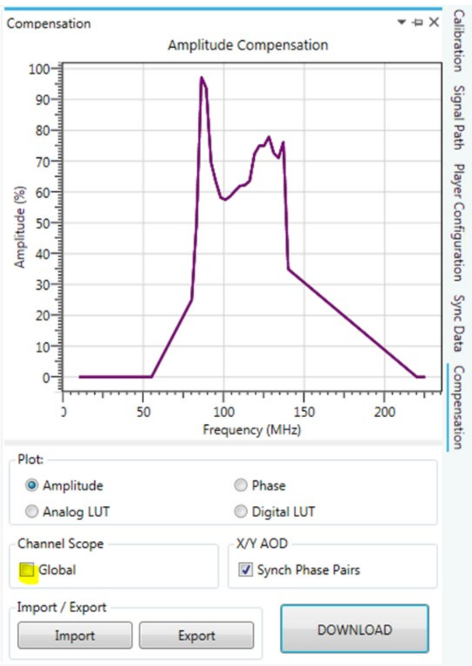
The equivalent sweep response, from 90-130MHz ,100steps



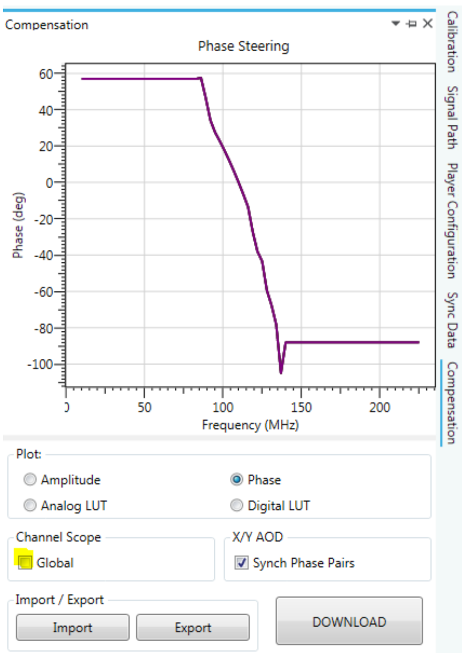
Comment : Depending on the application, this may be acceptable.

23: **Optimization.** For further improvement use the Calibration routine.
This allows precise adjustment of both amplitude and phase at each test frequency.
(For more detail see *iMS4 Compensation LUT Guide.pdf*)
For example: the LUT file: *Opzd-Acomp-Pcomp-532nm-D90-Ch80.LUT*

Amplitude vs. frequency



Phase vs. frequency

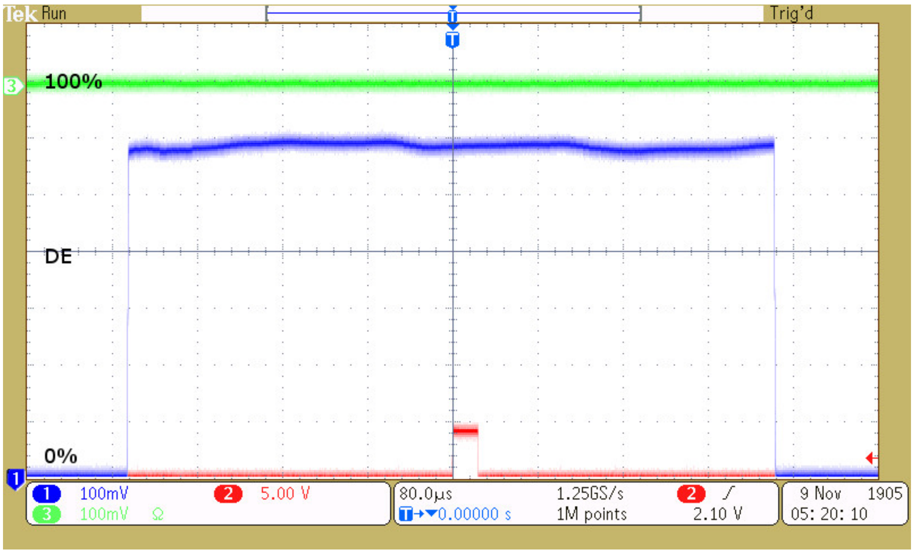


Result:

Table Row	Freq MHz	Diffraction Efficiency	RF drive power per input
0	90	88%	19W
1	100	89%	11W
2	110	87%	12W
3	120	86%	15W
4	130	86%	15W

This optimization achieves a variation of +/- 2% across the scan

A 90-130MHz sweep with the optimized LUT file



23: **Dual Axis**

Assuming X-axis connected to iMS4 Ch1 and Ch2, Y-axis to Ch3, Ch4
Similar priniciple, but operate the X-axis at a fixed scan angle = centre frequency.
Repeat steps 1 – 22 above for the Y-axis with the followimg changes :

At step 8: Set ***Ch1*** wiper to 80% AND set ***Ch2*** wiper to 80%.
Set ***Ch3*** wiper to 80% AND set ***Ch4*** wiper to 80%.

At step 9: Eanble all Channels

At step 12: In the ***Tone Buffers*** window, select table ***5pt-Y-X.***
This file fixes the X-axis at the centre frequency and Y-axis to 1 of 5 selected.

At Step 17: After finding the best Bragg angle, rotate the half waveplate to peak the Y-axis diffraction effiency (see Appendix 3)

Remember the overall efficiency will be lower.
e.g. For X-axis efficiency = 90% , Y-axis efficiency = 90% then overall efficiency = 81%

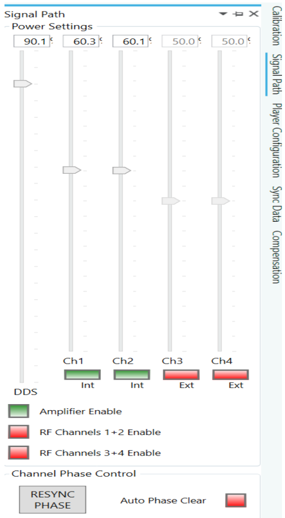
24: **D1384 at other wavelengths**

D1384-aQ120-9 at 355nm

The powers level described in this app note are for the D1384-aQ110-7 (7mm) at 515nm/532nm using the RFA0110-4-20 amp.

For the D1384-aQ120-9 (9mm) at 355nm
- Wavelength is lower (355nm) = less RF power. Ratio = (355/515)^2
- Aperture is higher (9mm) = more RF power. Ratio = 9/7
- Amplifier = RFA0120-4-15 requires ~25% lower input signal from iMS4

Taking all this into consideration, the DDS wiper % values described in this app note will be similar but the Channel Wipers will need to be set 10-20% lower.



The absolute RF power levels (Watts) recorded in the 'Result' tables will be ~40% lower for 355nm

Corresponding example files:

Section1: *D1384-40Mswp-355nm-D90-Ch60.iip*

Section4: *Default-A50%-PCalc-355nm.LUT*

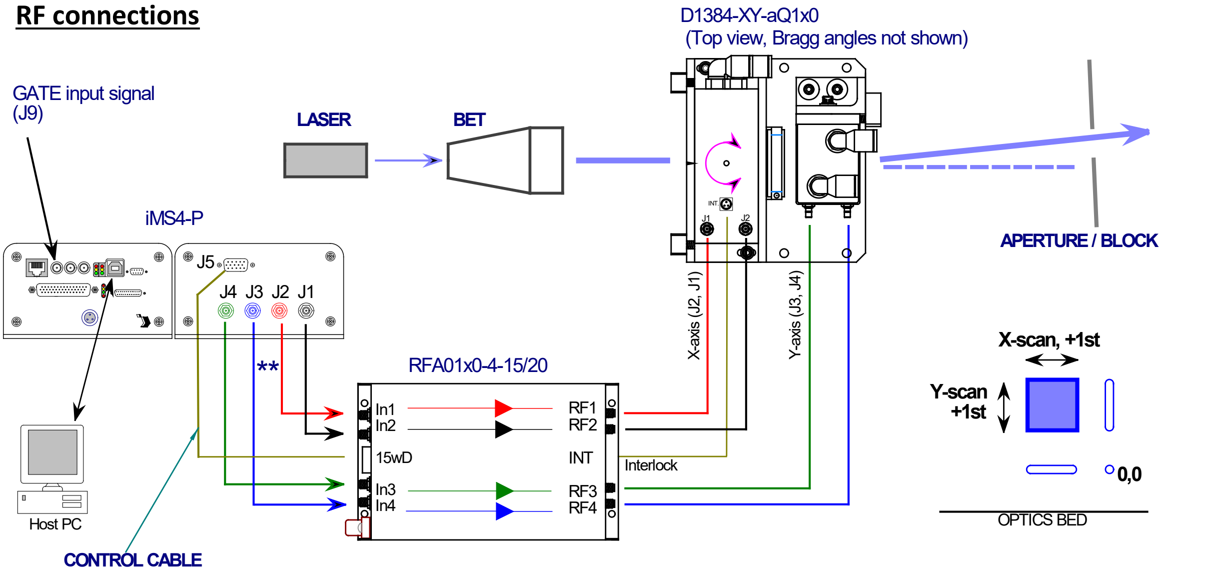
Section22: *Simple-A75%-PCalc-355nm.LUT*

Section 23: *Opzd-A&Pcomp-355nm-D82-Ch60.LUT*

Appendix 1:

1: Configuration for +1, +1 XY scan

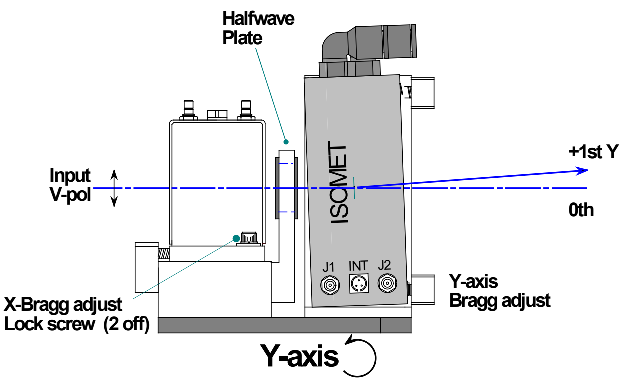
RF connections



**** Note the specific connection order between the four iMS4 outputs to the RFA01x0-4 amplifier inputs.**

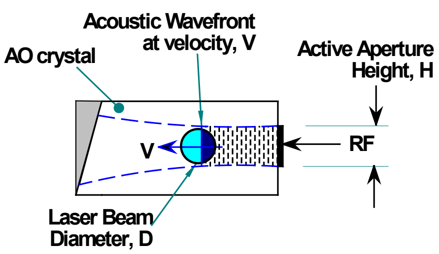
1.1 Beam Alignment

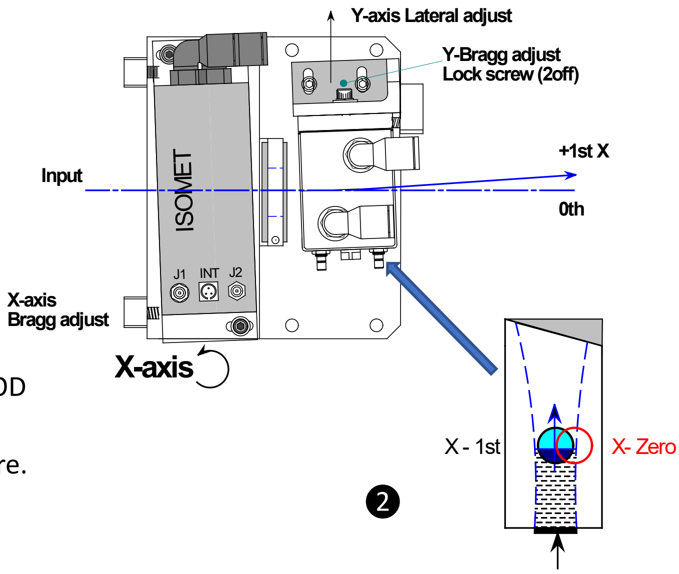
Angles and lateral adjustments exaggerated for clarity



As drawn here, the correct Bragg angle requires a counter-clockwise rotation of the AO deflectors from normal incidence of the input beam.

❶ Align beam central in aperture, above Bragg Pivot point.

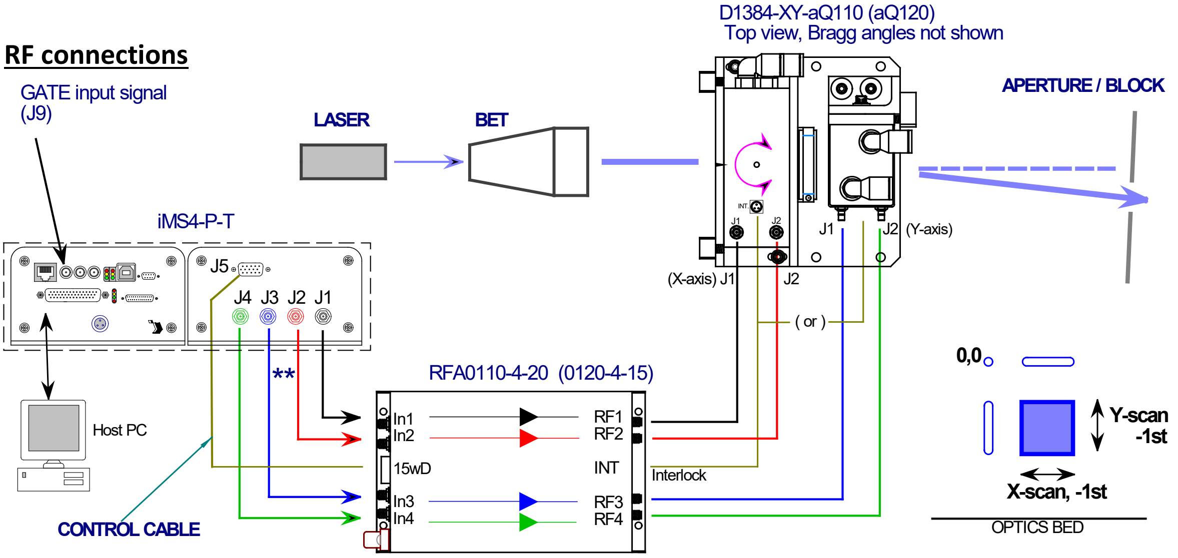




❷ For the Y-axis, use slotted holes on the AOD mounts for lateral movement. Align X-axis 1st order output in centre of Y-axis active aperture.

2: Configuration for -1, -1 XY scan

RF connections

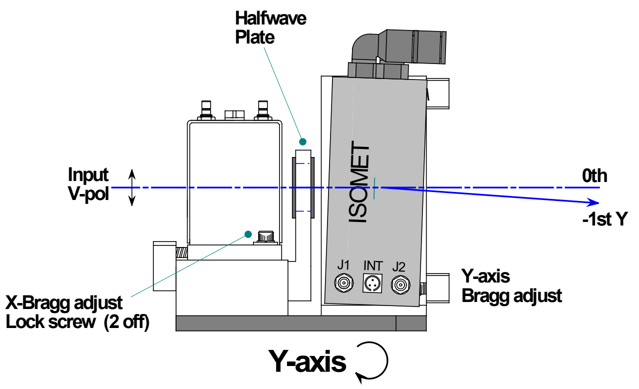


**** Note the specific connection order between the four iMS4 outputs to the RFA01x0-4 amplifier inputs.**

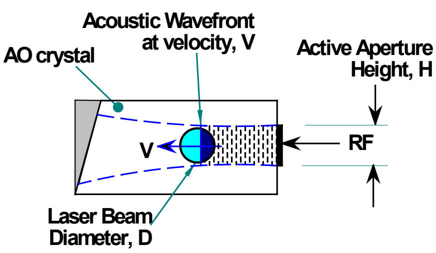
1.2 Beam Alignment

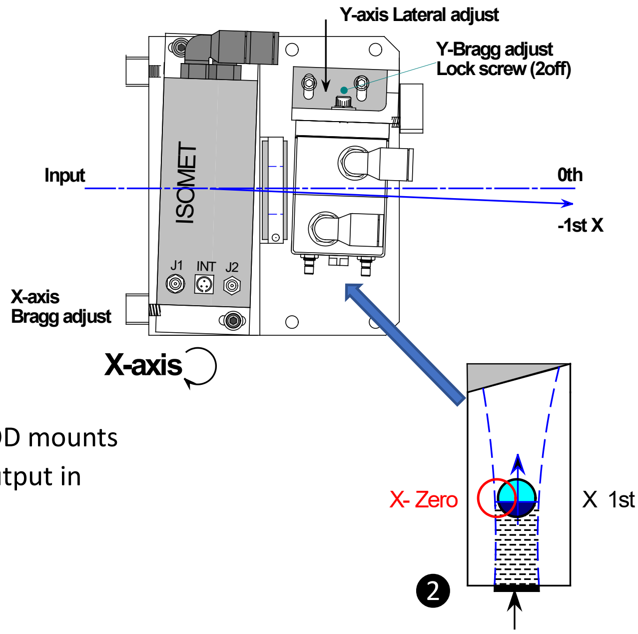
Angles and lateral adjustments exaggerated for clarity

As drawn here, the correct Bragg angle requires a clockwise rotation of the AO deflector from normal incidence of the input beam.



❶ Align beam central in aperture, above Bragg Pivot point.



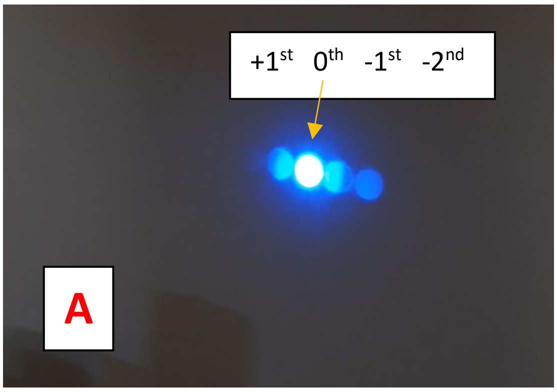


❷ For the Y-axis, use slotted holes on the AOD mounts for lateral movement. Align X-axis 1st order output in centre of Y-axis active aperture.

Appendix 2:
Typical Output Beams, Bragg Angle Adjustment, Single Axis

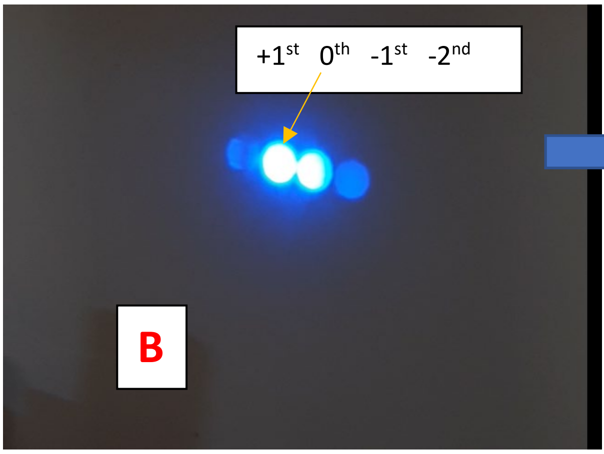
Adjusting Bragg angle for -1^{st} Order Beam

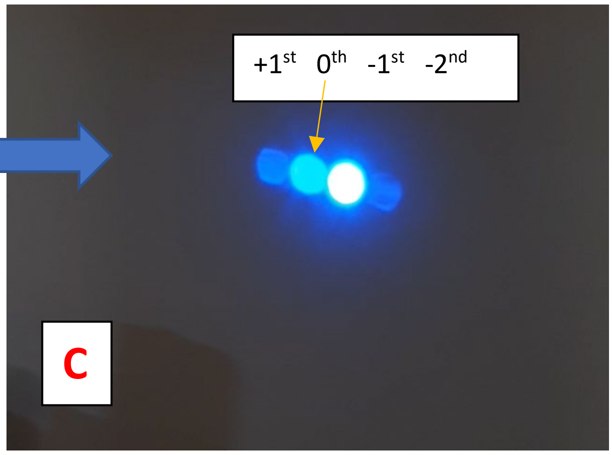
A: AOD normal to input laser Beam



B: Incorrect adjustment

C: Optimized adjustment





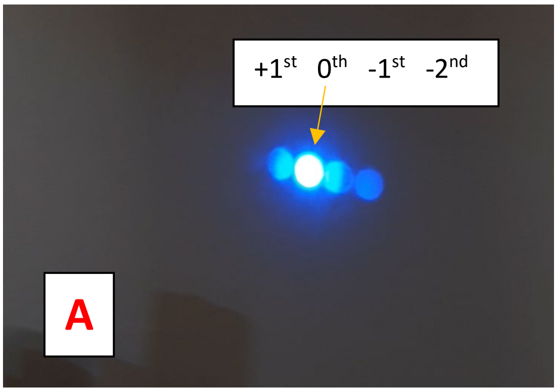
Angle Adjustment is extremely SENSITIVE.

e.g. for the D1384-aQ120 at 355nm, from A -> C = 3.7mrad = 0.2 degrees!
for the D1384-aQ110 at 515nm, from A -> C = 5.0mrad = 0.3 degrees!

Similarly

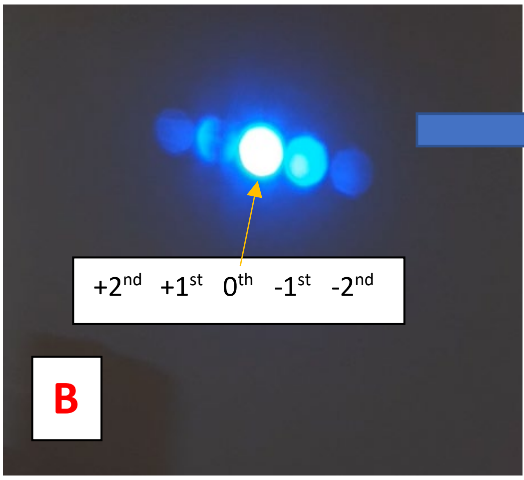
Adjusting Bragg angle for $+1^{st}$ Order Beam

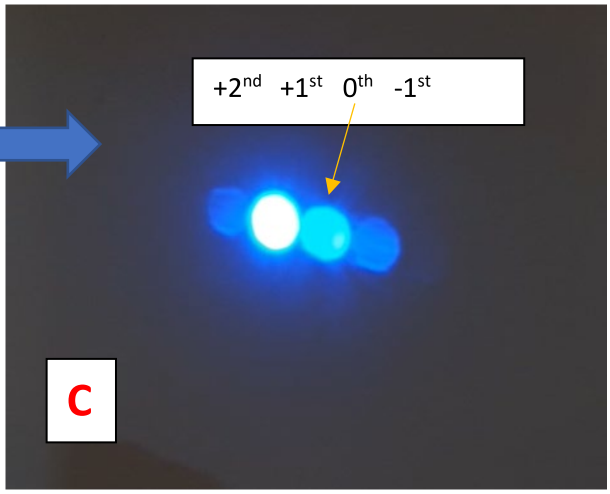
A: AOD normal to input laser Beam



B: Incorrect adjustment

C: Optimized adjustment





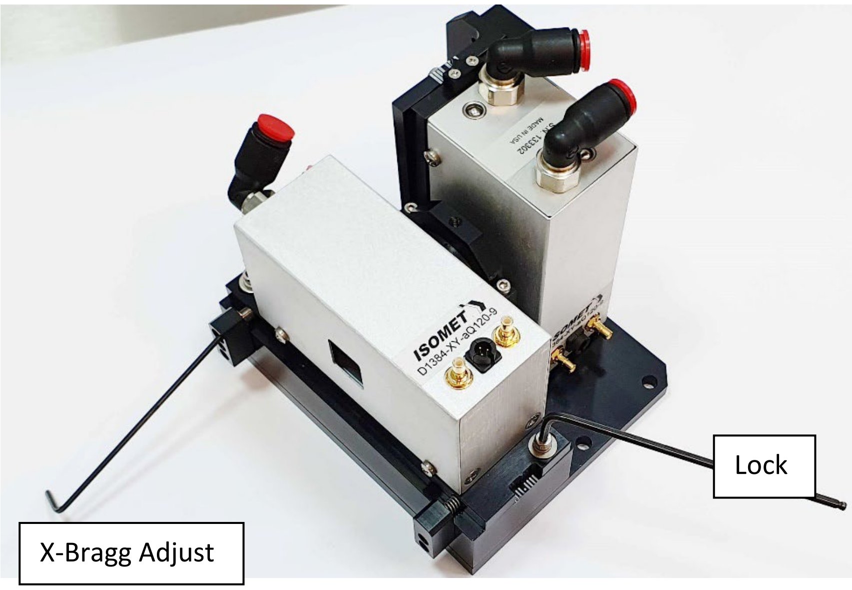
Angle adjustment is extremely SENSITIVE.

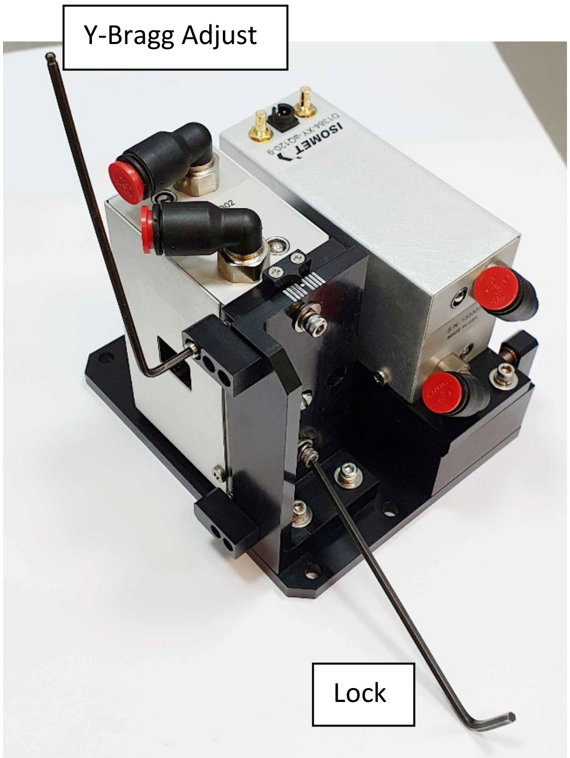
e.g. for the D1384-aQ120 at 355nm, from A -> C = 3.7mrad = 0.2 degrees!
for the D1384-aQ110 at 515nm, from A -> C = 5.0mrad = 0.3 degrees!

Appendix 3: D1384-XY Adjuster Locations

Bragg Adjust = 5/64th Hex Allen key

Lock screws (x2 per axis) = 7/64th Hex Allen key

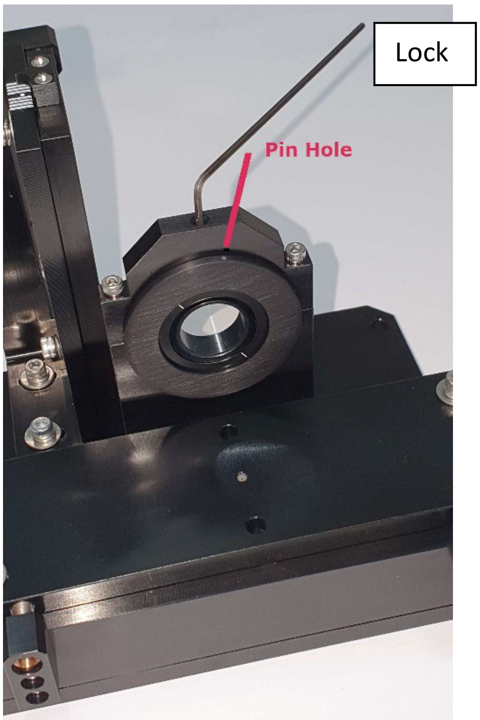




The coolant and RF connections can resist Bragg angle adjustment. It may be necessary to assist the AOD rotation with a little hand pressure on the AOD case. This is most likely needed for counter-clockwise rotation of the Bragg adjuster.

__Waveplate adjustment__

(AOD's removed for clarity)



Ring lock screw = 1/16th Hex Allen key

A small pin can be placed in one of 4 holes located around the holder ring. This can help to rotate the half waveplate.