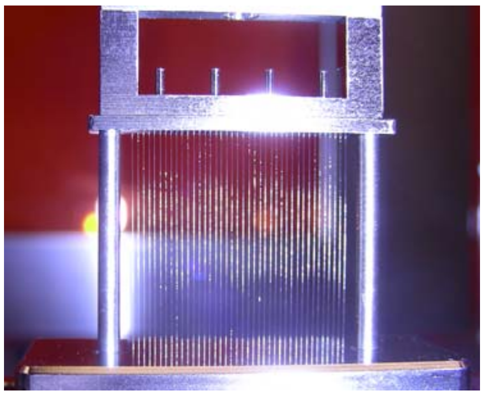
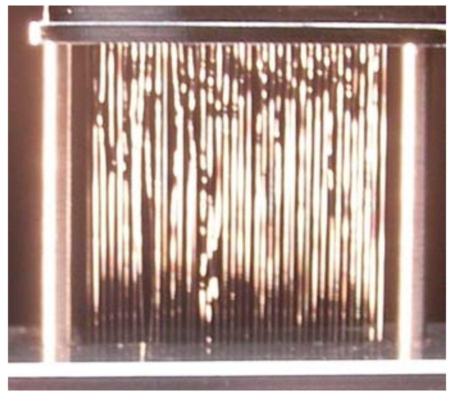
SAND2008-5767P

May-June 2007
Saturn planar wire array shots
Data analysis


Wire fixturing


40-wire, 20-mm-wide tungsten planar array


Al 5056 wires not as straight as tungsten

Return current cage with B-dots shown on anode insert

Document prepared by:

B. Jones

Sandia National Laboratories

July 26, 2007

National Nuclear Security Administration

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Notes

- See file SaturnPlanarShots20070726.xls for summary data and load descriptions.
- This file summarizes current, total radiated power and yield analysis, and shows the MLM imager time-resolved pinhole imaging data. I will provide the MITL and load current, LOS A and B total radiated power waveforms in separate pff and text files.
- This analysis corrects for XRD, PCD, and MLM timing errors.
- The PCD data has not yet been analyzed. This will be most interesting for shot 3688, where PCDs with 8 um Be + 1 um CH filters will give Al K-shell power and yield.
- Shot 3688 also had TIXTL data showing time-integrated, axially-resolved Al and Mg K-shell lines. This has been processed and will be discussed at the end of this file.
- The MLM quick-scan images are shown in this file along with timing information. The high-resolution scans have not yet been processed and conversion from OD to exposure using the step wedge images has not yet been performed. Because of a timing error in the MLM imager that we only worked out after the shot series, many of the images were taken after peak x-rays.
- Shot 3685 fielded the Cuneo/Waisman/Fowler voltage monitor and may have usable data. Eduardo is looking at this. Hopefully we can obtain L(t) and address questions of energy coupling.
- Preliminary observations:
  - These planar arrays radiate ~10 TW at ~3 MA on Saturn. This may point toward I^2 scaling, but we would benefit from matched Zebra shots at 1 MA and higher current (e.g. 5 MA in 100 ns if possible) on Saturn.
  - There is a reduction in radiated power with decreased array width, though one could also expect better coupling to a hohlraum with a smaller array. Maybe the 12 mm width is not so bad. Roger Vesey may offer insight here.
  - Although yield increased with increasing implosion time, the ~10 TW level was not exceeded. We did one long-implosion-time 6 MA shot (3675) which produced a broad 8 TW pulse. Perhaps the long implosion time (and large wire size) may have degraded the performance, and it would be interesting to do shots at high current while keeping the ~100 ns implosion time, and to try higher wire number.
  - Comparing the numbers in SaturnPlanarShots20070726.xls, it seems that a 0D model cannot predict adequate coupled kinetic energy to explain the x-ray yield in the first pulse—it is a factor of 2-3 short in all cases (unless we assume extremely high convergences).
  - The MLM imager offers some insight on dynamics. Shot 3685 shows the implosion progressing, with bright spots on the leading edge that become broad emitting regions in the stagnated column. There is a lot of axial structure. Shot 3683 shows what looks like m=1 instability growing and breaking up the ~1-mm-diameter column at the time of peak x-rays. A broad ~4-mm-wide striated column is formed that retains its structure for a long time after peak x-rays (seen in many shots, perhaps formed by the same mechanism for all). We may be able to address what convergence ratio is obtained using the images and the voltage monitor data, and start to address energy coupling. It could be interesting to study the formation of the striated structure and its impact on pinch resistance with MHD modeling. If such a simulation could be shown to produce the appropriate density contrast parameter and resistance that Chuvatin is using, this would be interesting and would help produce a convincing story that resistance is important.

SaturnPlanarShots20070726.xls

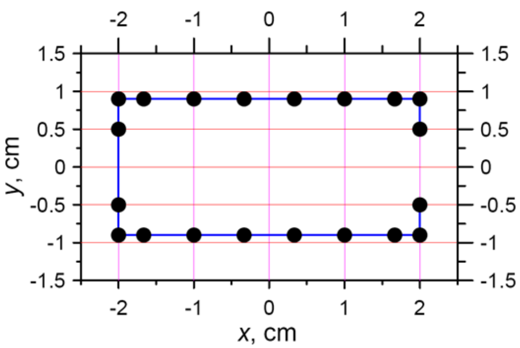
[illegible]

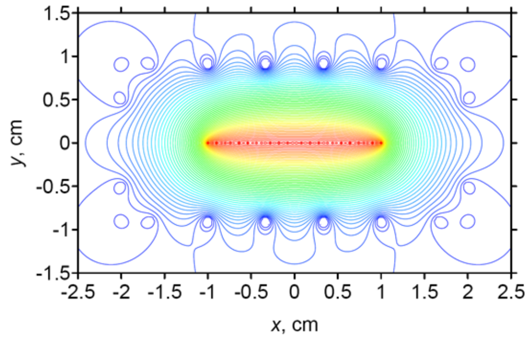
Load design parameters									
Shot	Material	Density (g/cm^3)	Planar array width, W (mm)	Interwire gap, IWG (mm)	Wire number, N	Wire diameter (um)	Total mass/length (mg/cm)	Total mass (mg)	Implosion time design goal
3670	W	19.25	20	0.512821	40	9.09	0.500	0.999	Nominal
3671	W	19.25	20	0.512821	40	6.41	0.248	0.497	Early
3672	W	19.25	20	0.512821	40	12.86	1.000	2.000	Late
3673***	W	19.25	20	0.512821	40	12.86	1.000	2.000	Late
3674*,**	W	19.25	20	0.512821	40	9.09	0.500	0.999	Nominal
3675	W	19.25	20	0.512821	40	25.58	3.957	7.914	Very Late
3682	W	19.25	20	0.512821	40	9.09	0.500	0.999	Nominal
3683	W	19.25	8	0.533333	16	28.21	1.925	3.850	Nominal
3684	W	19.25	12	0.521739	24	19.25	1.345	2.689	Nominal
3685*	W	19.25	12	0.521739	24	19.25	1.345	2.689	Nominal
3686	W	19.25	8	0.533333	16	28.21	1.925	3.850	Nominal
3688	Al	2.7	20	0.512821	40	23.60	0.472	0.945	Nominal

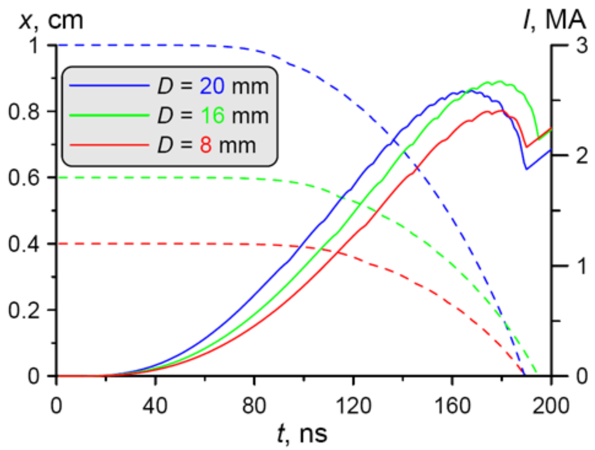
- I realize that the above is too small to read (though print this on 11x17 paper and it might be ok). I will also include it in an Excel file.
- On the left is an excerpt showing the basic shot plan.
- *=voltage monitor fielded, but reduced load current perhaps due to post-hole convolute short
- **=broken wires, data not usable
- ***=MITLs not pulled and cleaned prior to shot, data may or may not be ok

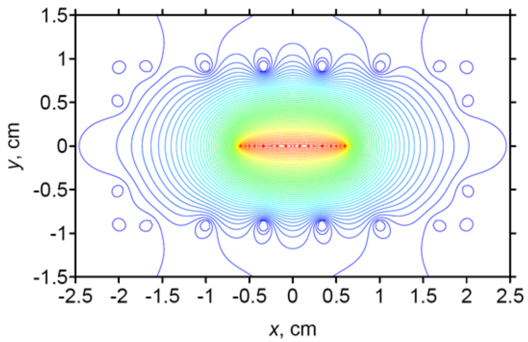
- These shots can definitely be used in the 'mass and implosion time scan at fixed width 20 mm' data set: 3670, 3671, 3672, 3675, 3682
- These shots can definitely be used in the 'width scan at fixed ~100 ns implosion time' data set: 3670, 3682, 3683, 3684, 3686
- 3688 was the one Al 5056 shot that we did

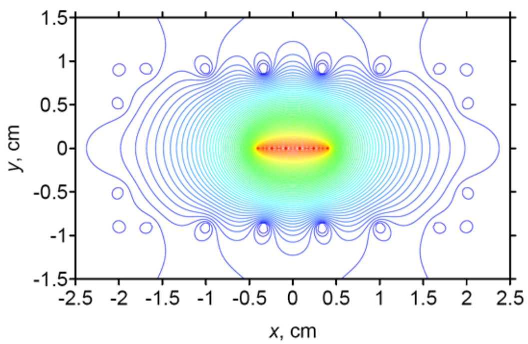
Loads designed with 0D implosion simulations





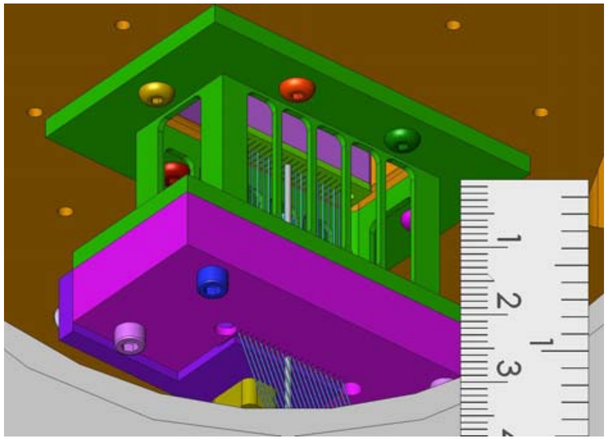


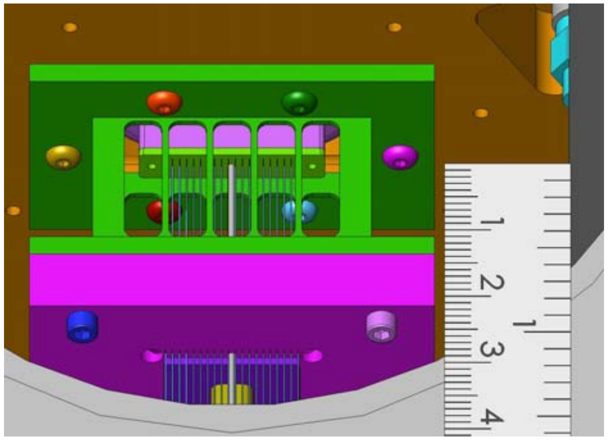


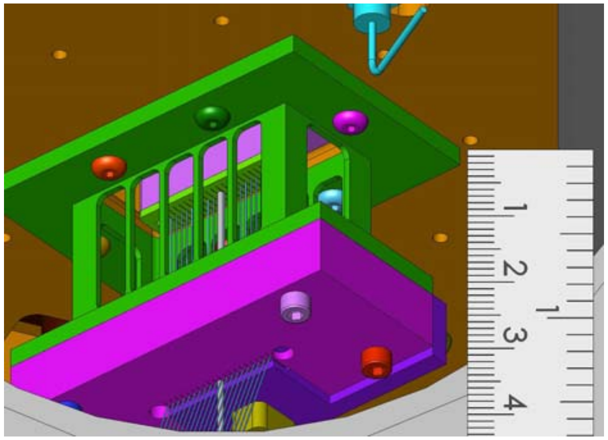


- Andrey Esaulov calculations shown here
  - Inductive current division between discrete wires
  - Return current cage boundary condition
  - 0D implosion of wires, no ablation
  - Expected to give accurate estimate of initial inductance
  - Expected to give reasonable estimate of coupled energy (all kinetic energy plus collisional losses when adjacent wires collide, conserving momentum)
  - Q: Are kinetic energy values in spreadsheet already including the coupled energy lost in wire collisions?
- Sasha Chuvatin also implemented 0D model
  - Uniform current division between wires
  - Similar results for implosion times and coupled energy
  - Some residual questions on disagreement between Esaulov, Chuvatin results—circuit model differences?
- Eduardo Waisman also implemented Rudakov's 0D model with simplified field structure assumed to calculate inductance
  - Inductance not expected to be accurate, particularly at high convergence
- In the end, Esaulov's model predominantly used for load design guidance. Post-shot comparison with experimental results will be used to refine models.

Diagnostic view from Line of Sight A (LOS A)	Diagnostic view from Line of Sight B (LOS B)	Diagnostic view from Line of Sight C (LOS C)







20 mm wide, 40-wire planar array shown. Gray rod on axis represents the stagnated pinch location (view factor correction obtained from these images). Ruler is in the plane perpendicular to the isometric viewing direction, and not parallel to the pinch. All three views are 35° from the horizontal.

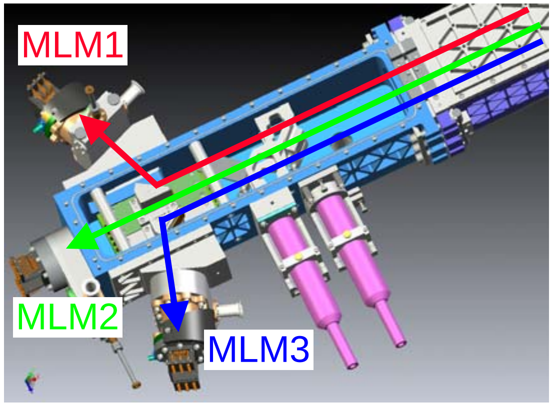
Diagnostics on LOS A:

XRD (5 um kimfol filter)
Bare Ni bolometer
PCDs (8 um Be + 1 um CH filter)

The MLM imager combines three 8-frame pinhole cameras gated with 1 ns pulses. MLM1 and MLM3 view hν=277 eV images reflected from multilayer mirror monochromators. MLM2 employs an 8 um Be filter to view hν>1 keV images.

Diagnostics on LOS B:

XRD (5 um kimfol filter)
Bare Ni bolometer
PCDs (8 um Be + 1 um CH filter)
MLM imager



Diagnostics on LOS C:

TIXTL (KAP, 2" radius, 20° rotation; 0.5 mils Be filter; fielded only on shot 3688 to look at time-integrated, axially resolved Al/Mg K-shell spectrum)

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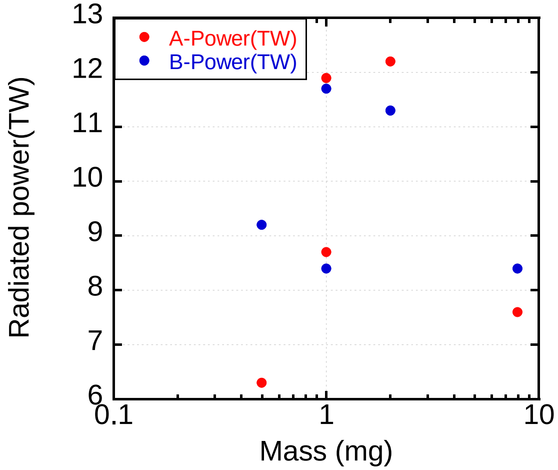
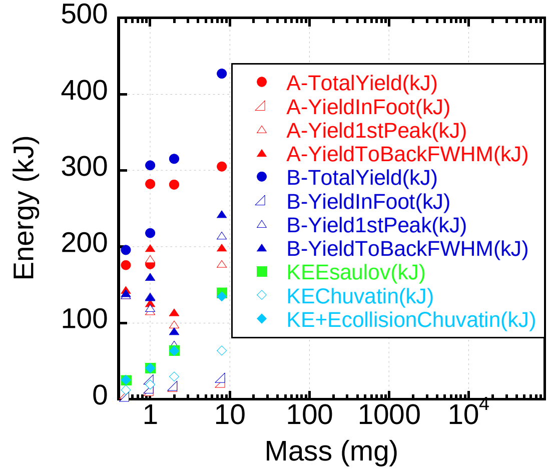
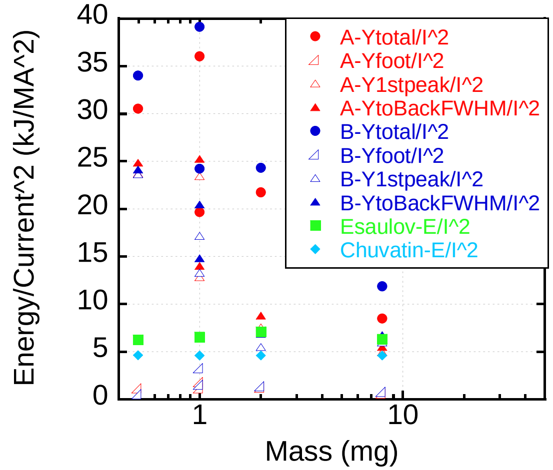
Summary analysis plots and comments



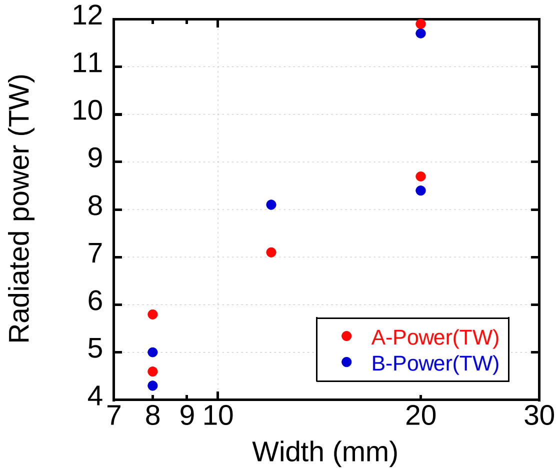
Optimum power at 1-2 mg, ~100 ns implosion time?



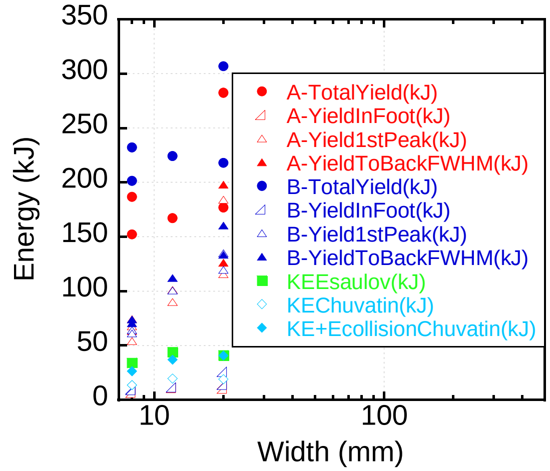
Yield even in first peak exceeds 0D estimated kinetic energy. More yield in first peak for shorter implosion times near, comparing 0.5-2mg? Opposite 0D trend?



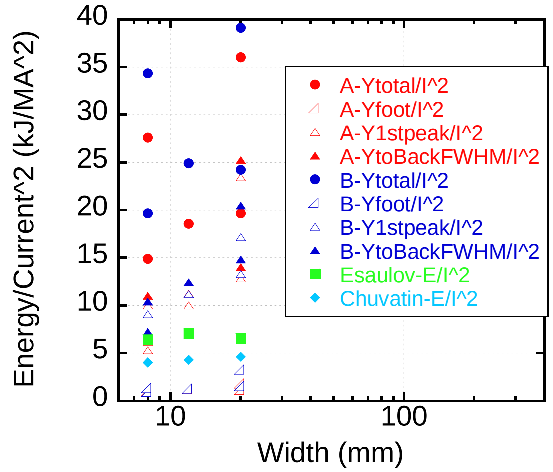
0D is flat as expected, while first peak yield trends toward 0D value for large mass or small width. Small mass, large width more subject to resistance?



Larger width does better, but smaller array can drive more compact hohlraum. What is optimum?



0D trend is flat, but larger width has more first peak yield (though fairly flat total yield).



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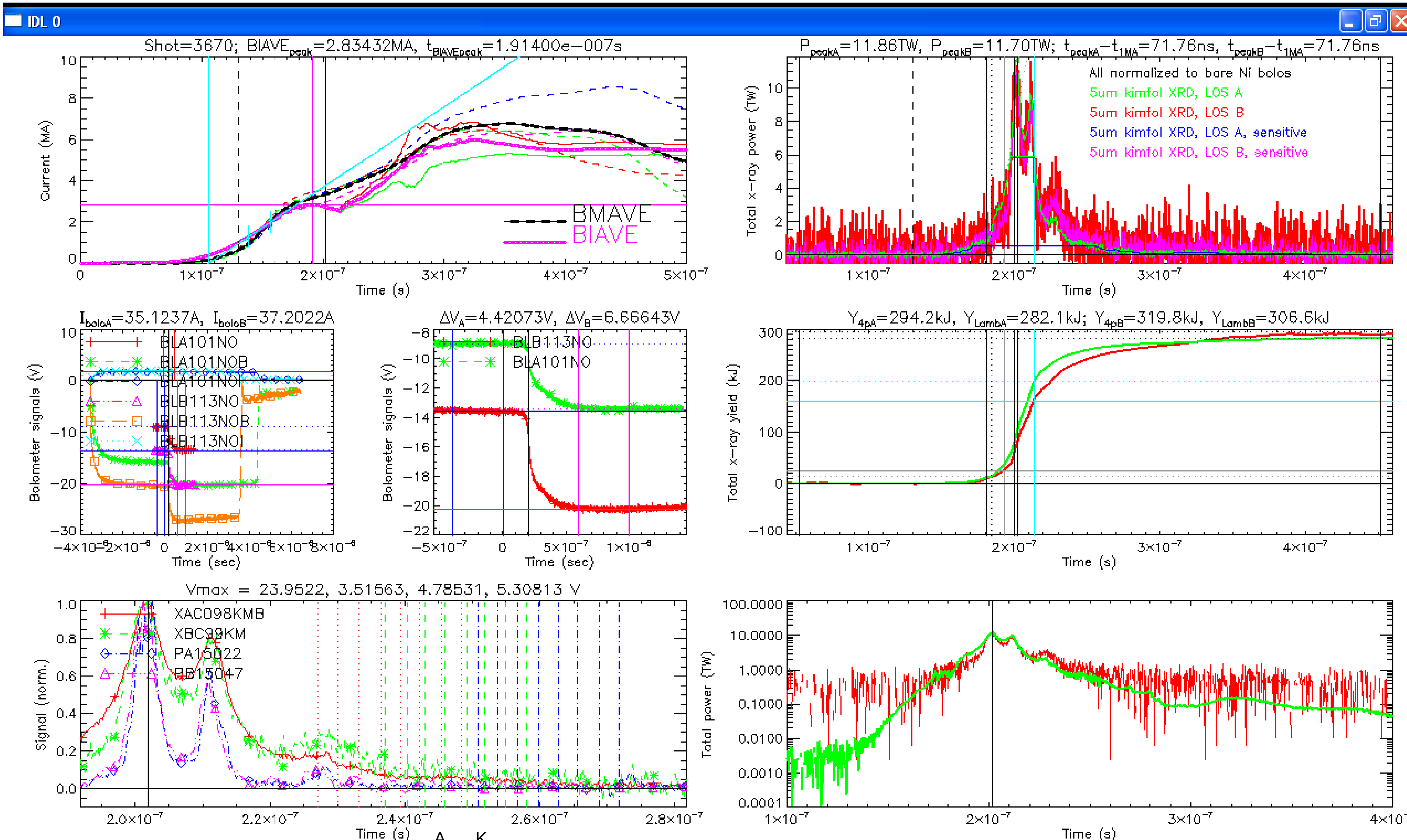


MLM 1, 277 eV

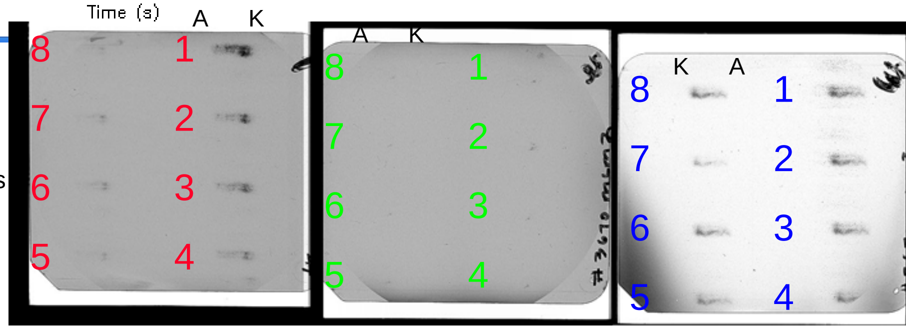
MLM 2, >1 keV

MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-300
MLM2	-250
MLM3	-400

Distance scale corrected for MAG=1/2:
10 mm



Camera mounting orientation on MLM3 flipped the anode (A)-cathode (K) orientation relative to the other two cameras for this shot series. This will be corrected in the future. Recall also that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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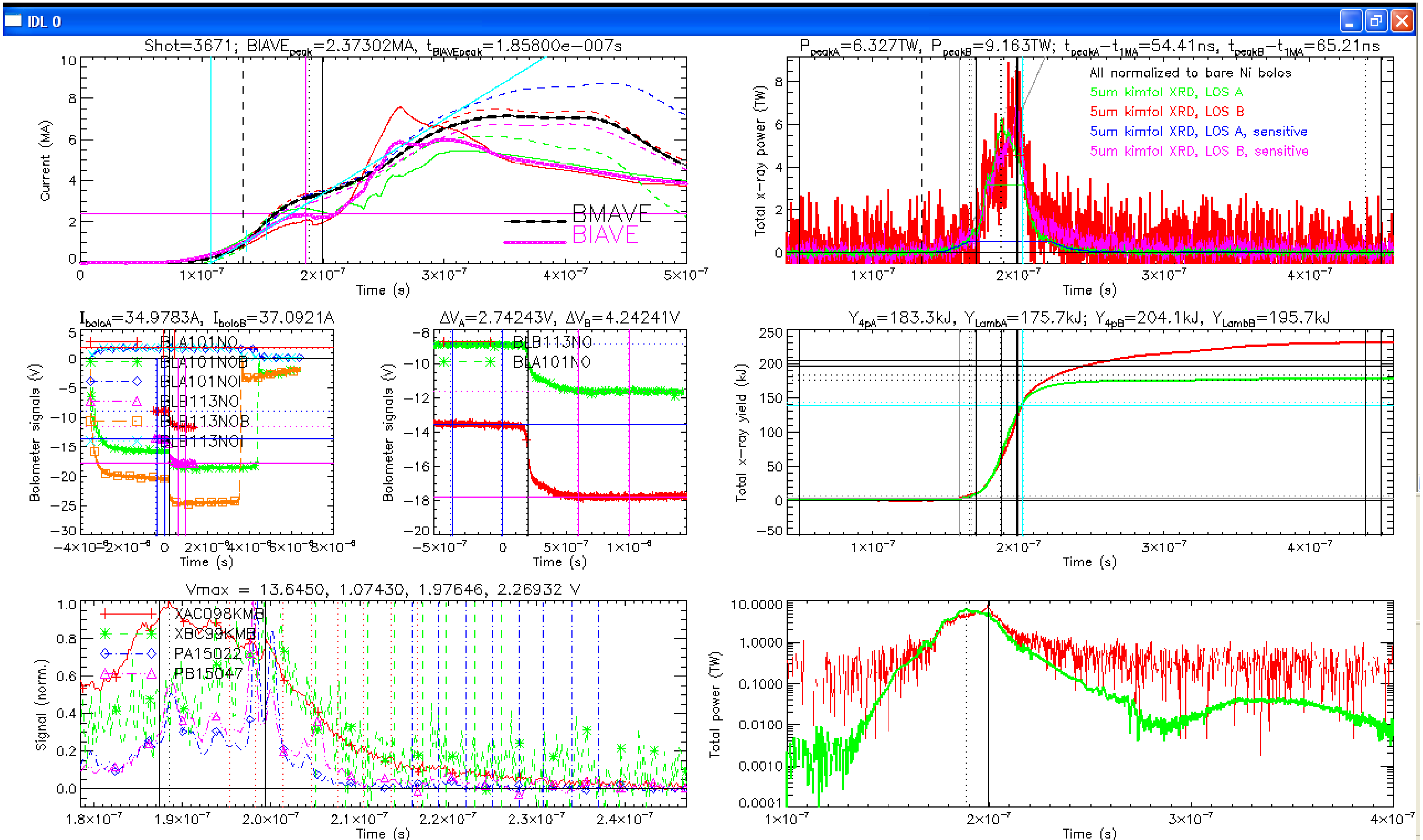

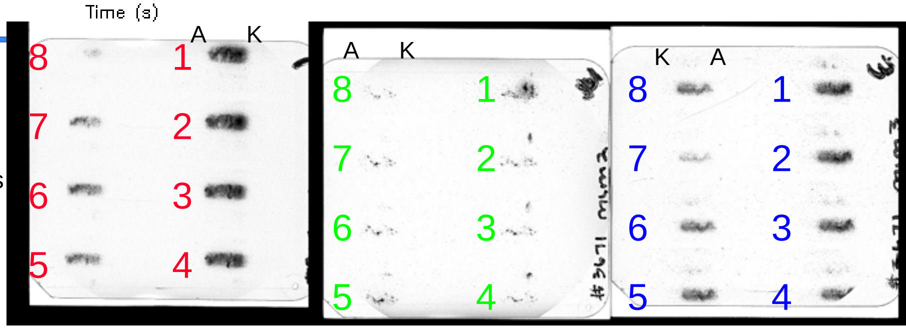

MLM 1, 277 eV
MLM 2, >1 keV
MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-400
MLM3	-440

Distance scale corrected for MAG=1/2:
10 mm

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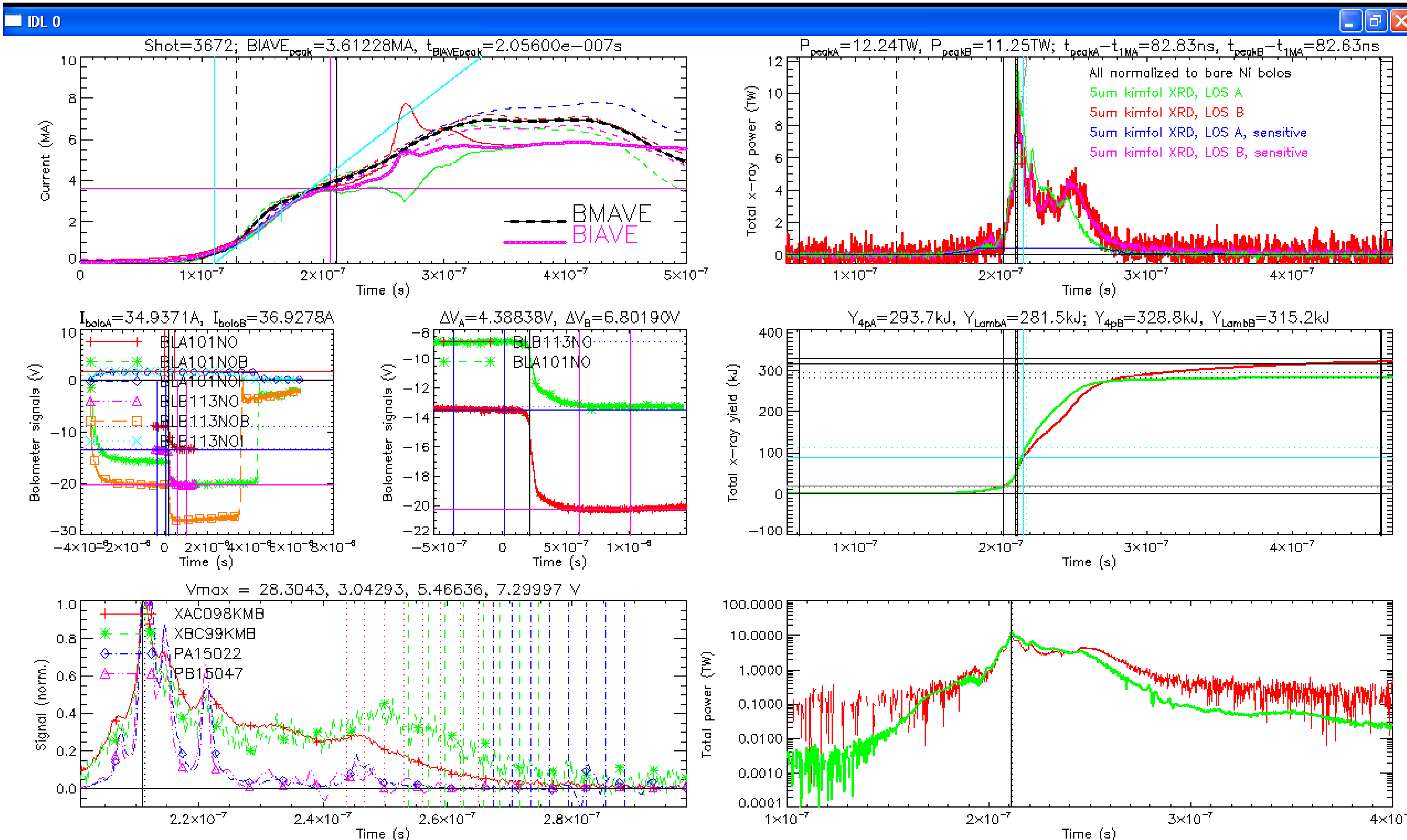


MLM 1, 277 eV

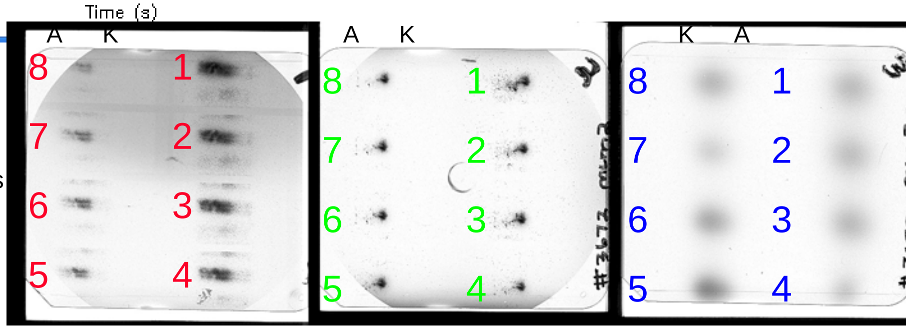
MLM 2, >1 keV

MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-430
MLM3	-470

Distance scale corrected for MAG=1/2:
10 mm



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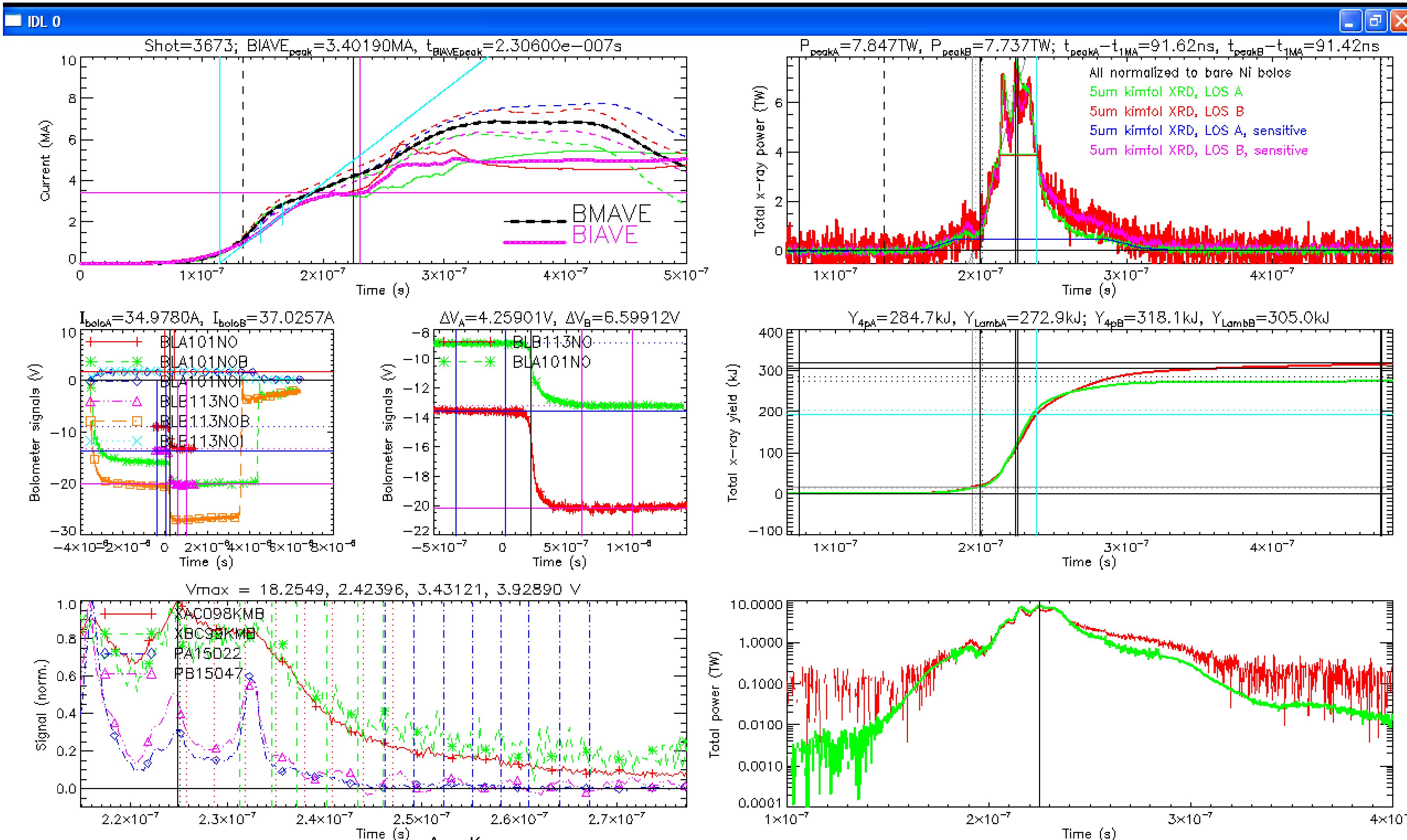

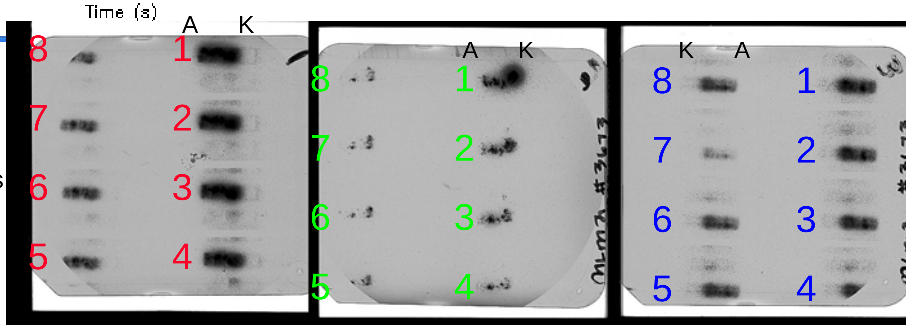

MLM 1, 277 eV
MLM 2, >1 keV
MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-370
MLM2	-400
MLM3	-450

Distance scale corrected for MAG=1/2:
10 mm

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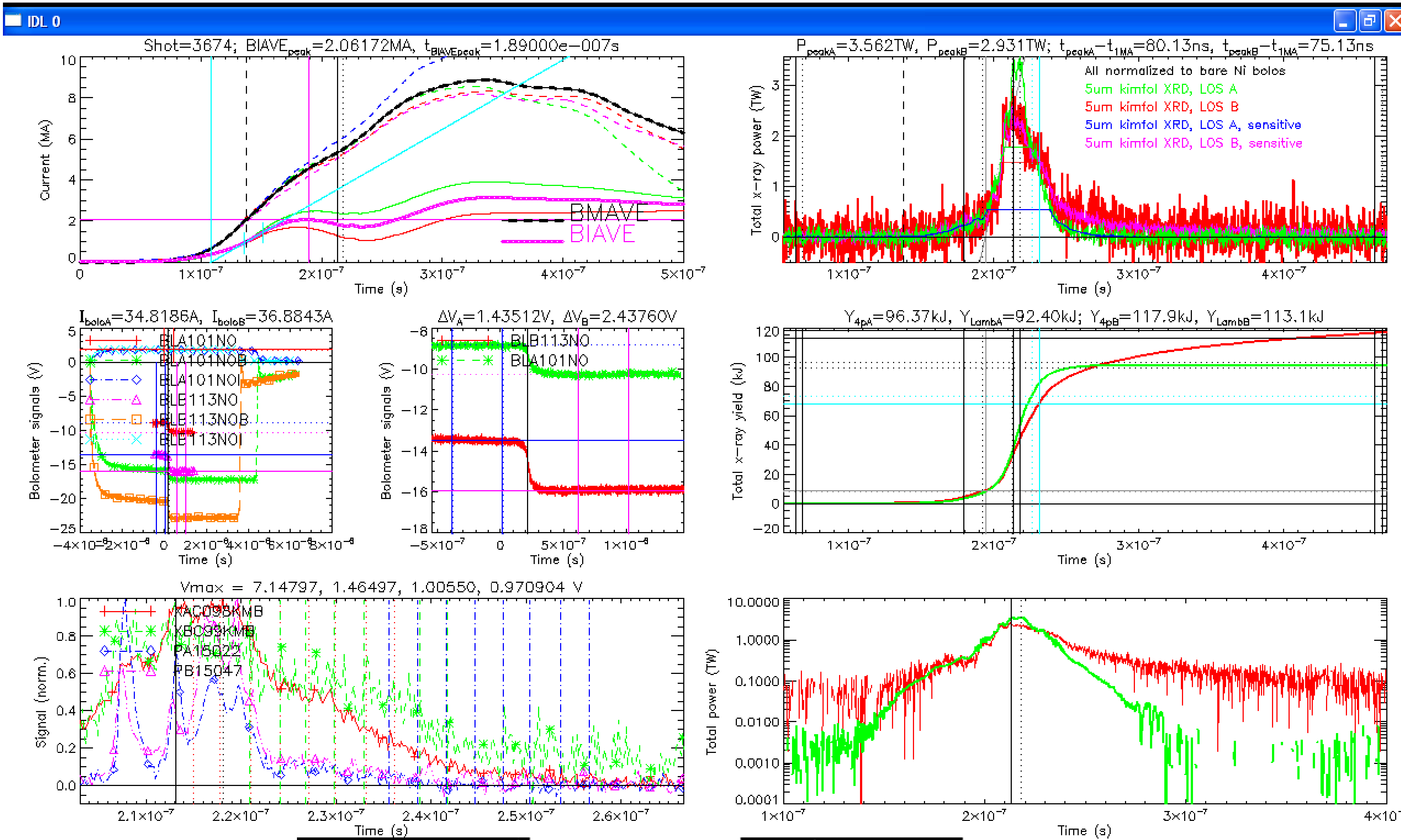
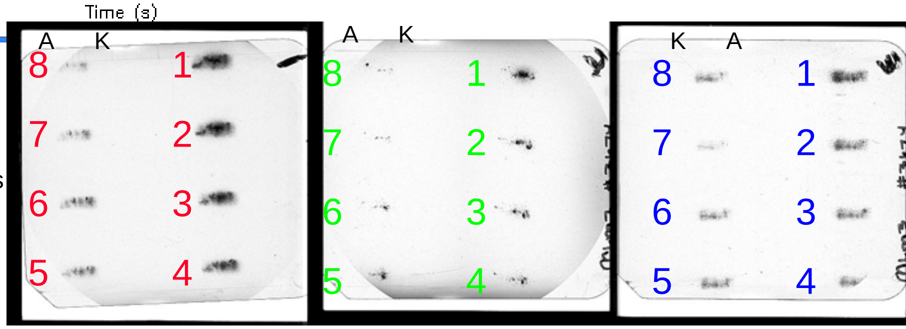


- .... MLM 1, 277 eV
- - - - MLM 2, >1 keV
- -·-·- MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-330
MLM2	-400
MLM3	-430

Distance scale corrected for MAG=1/2:
10 mm ▬



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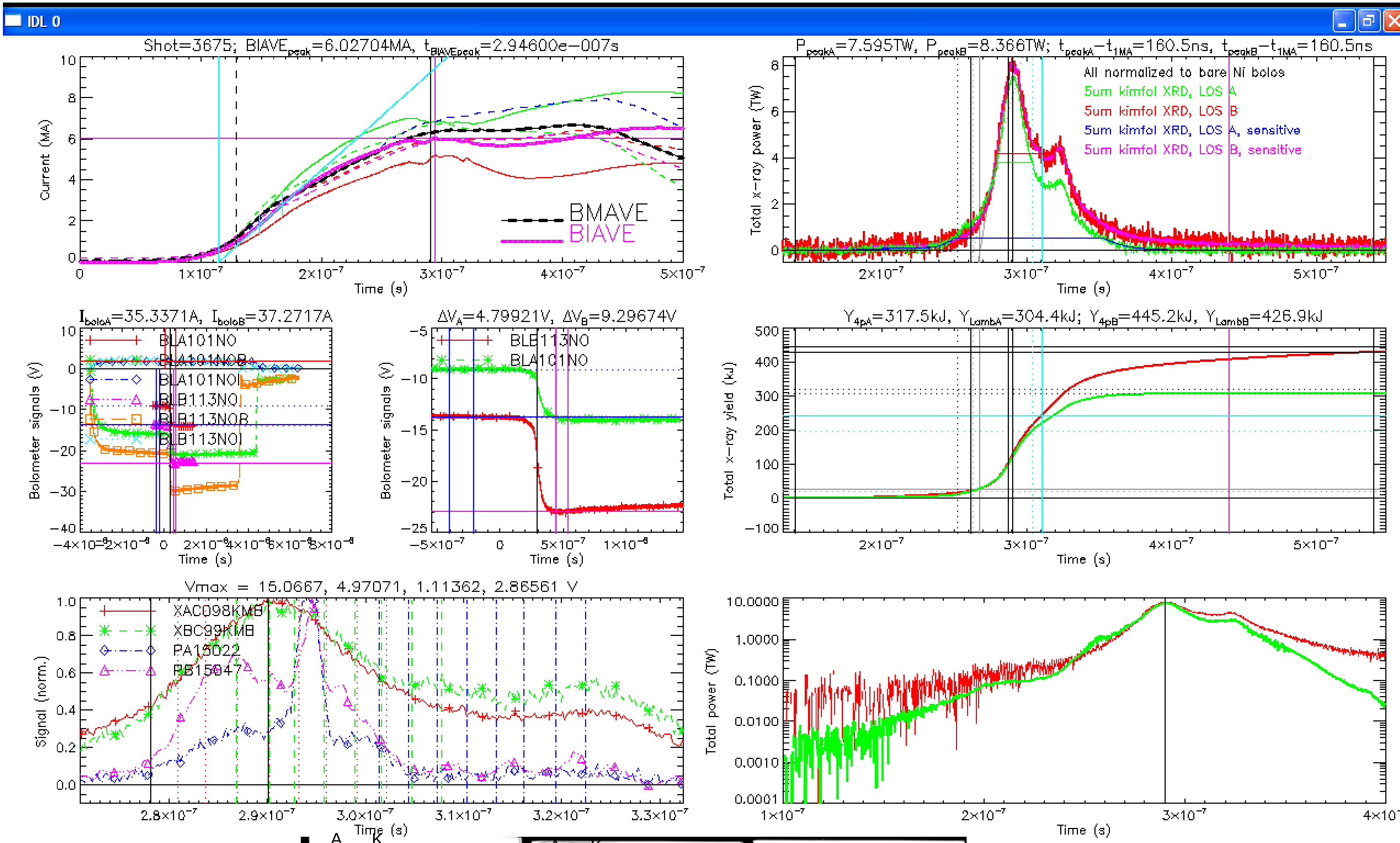

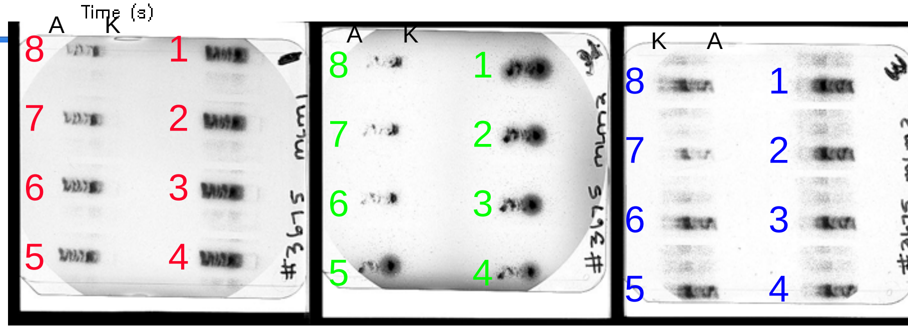

MLM 1, 277 eV
MLM 2, >1 keV
MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-300
MLM2	-400
MLM3	-400

Distance scale corrected for MAG=1/2:
10 mm

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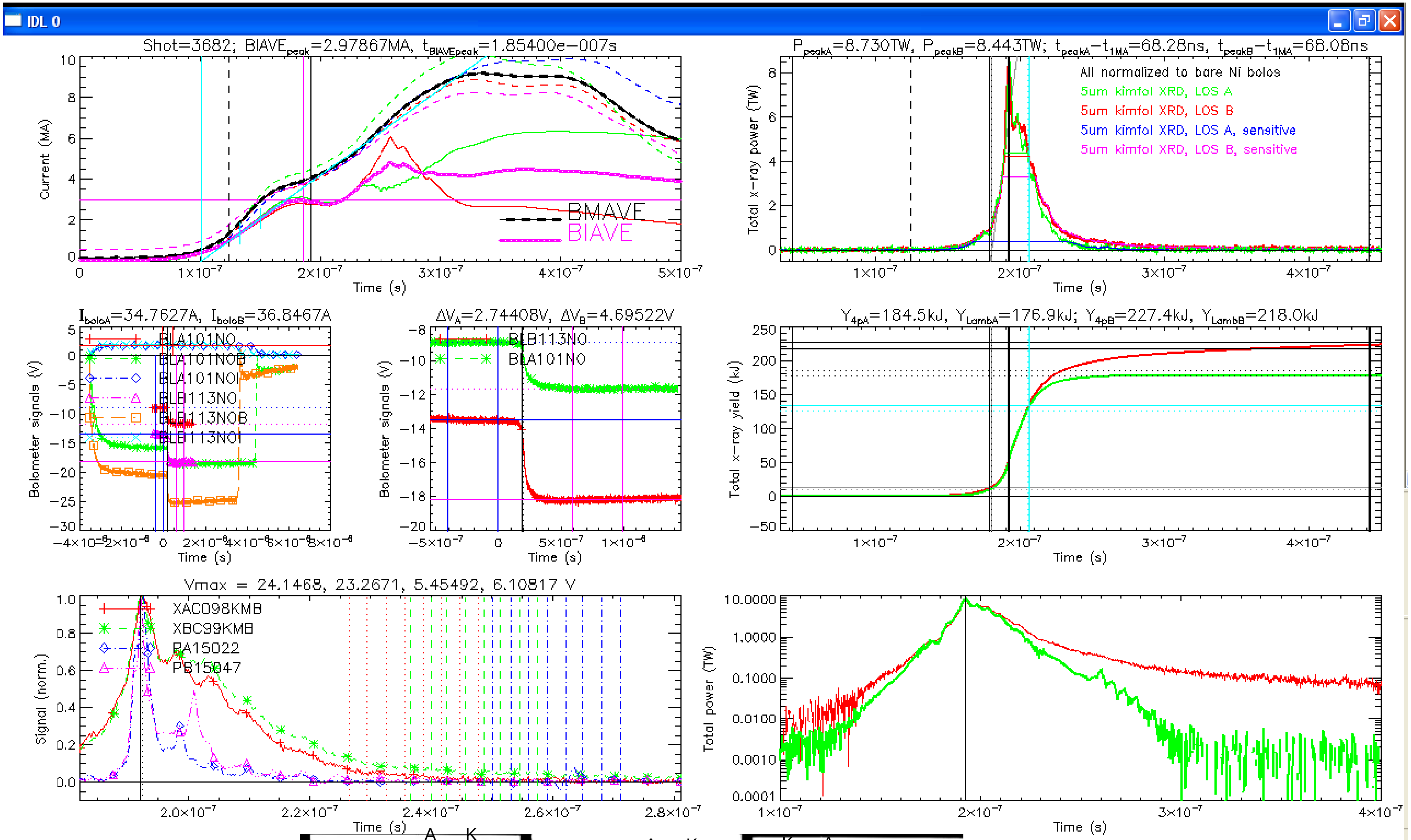

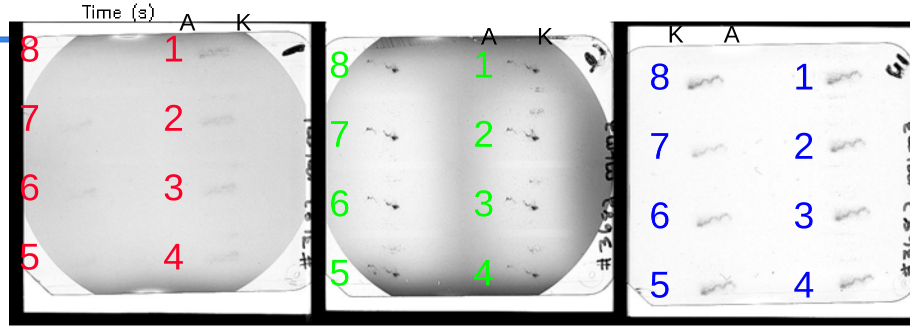

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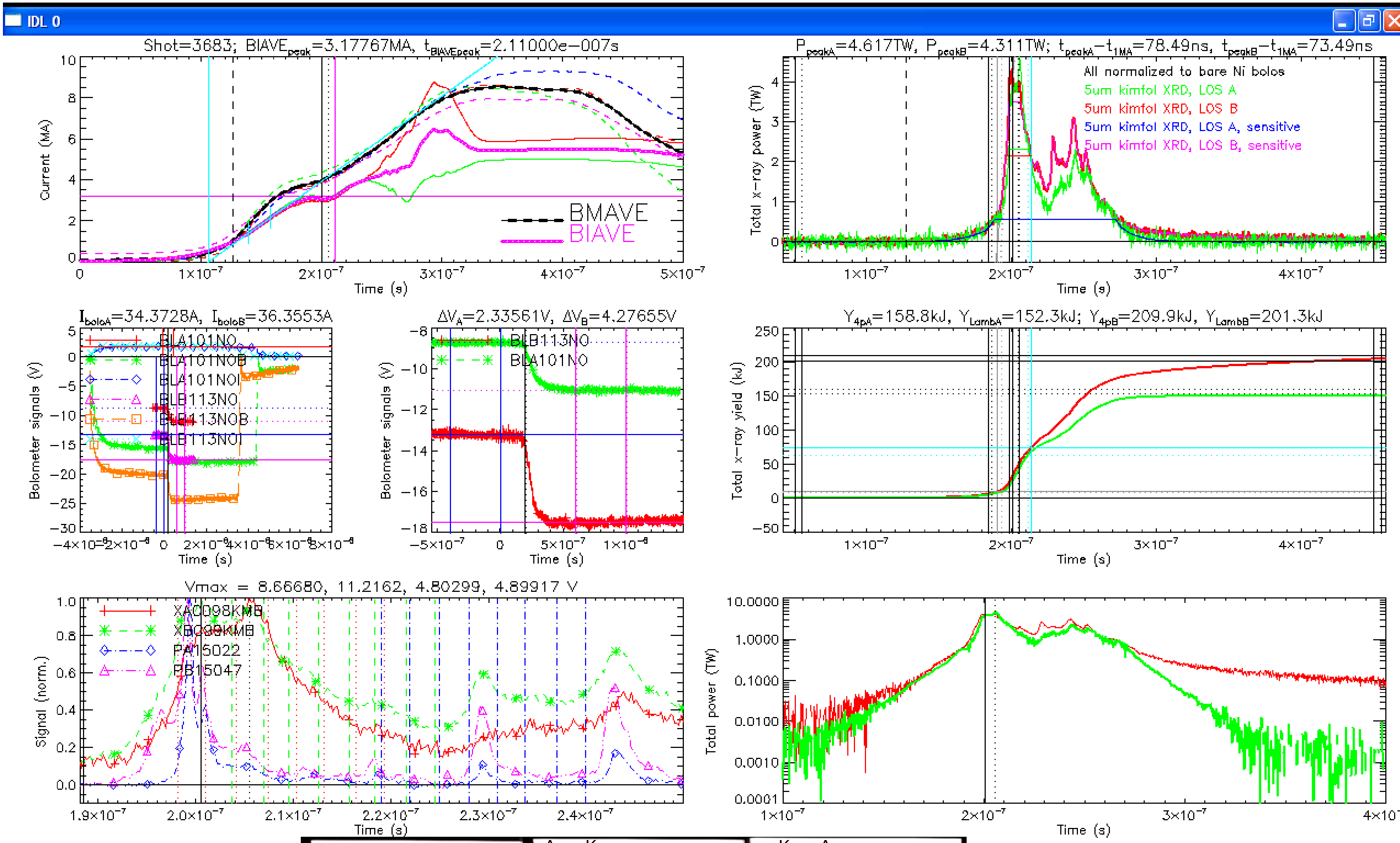


MLM 1, 277 eV

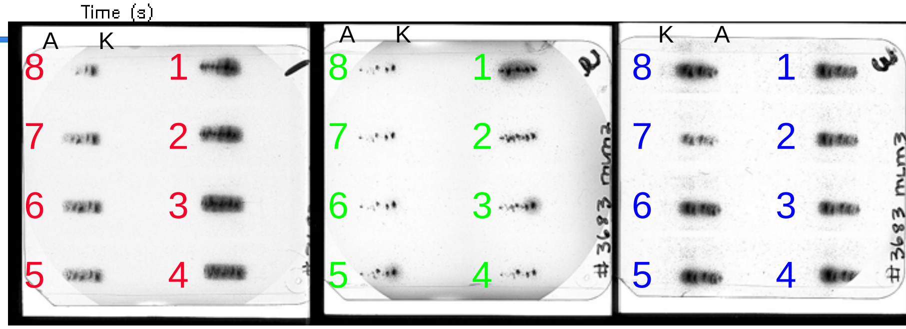
MLM 2, >1 keV

MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-400
MLM3	-450

Distance scale corrected for MAG=1/2: 10 mm



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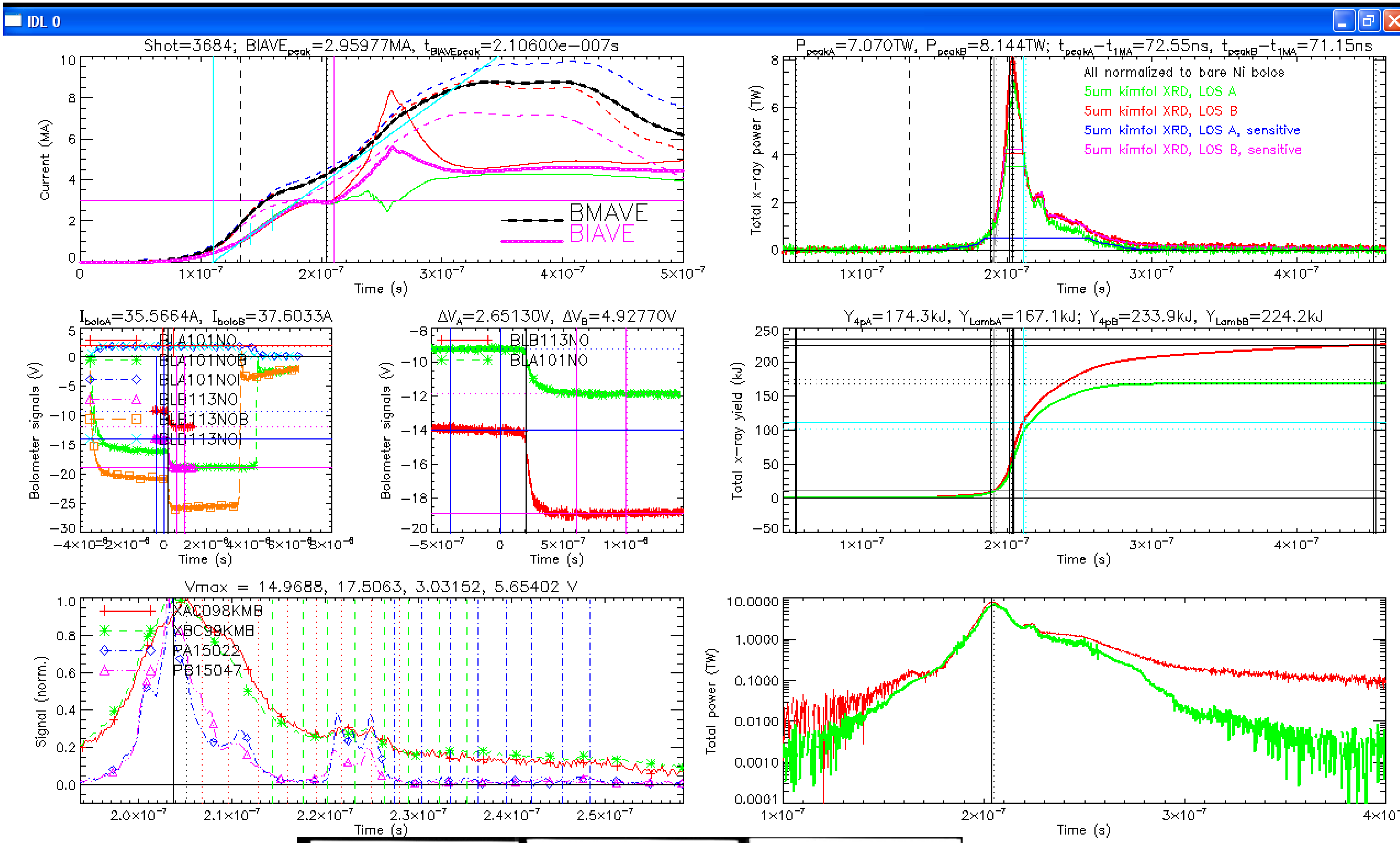
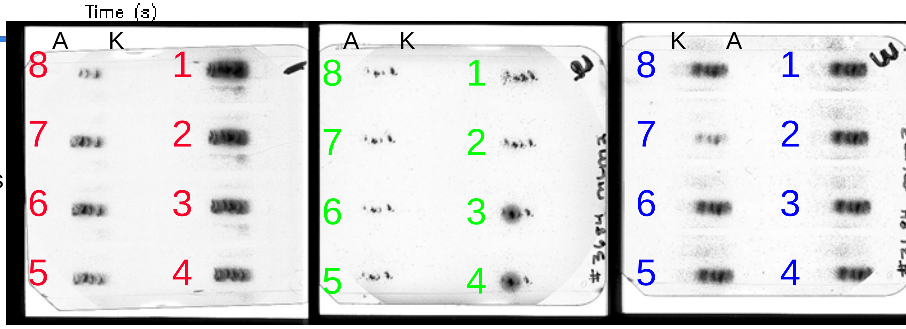


- .... MLM 1, 277 eV
- - - - - MLM 2, >1 keV
- . - . - MLM 3, 277 eV



1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1 -350
MLM2 -400
MLM3 -450

Distance scale corrected for MAG=1/2:
10 mm

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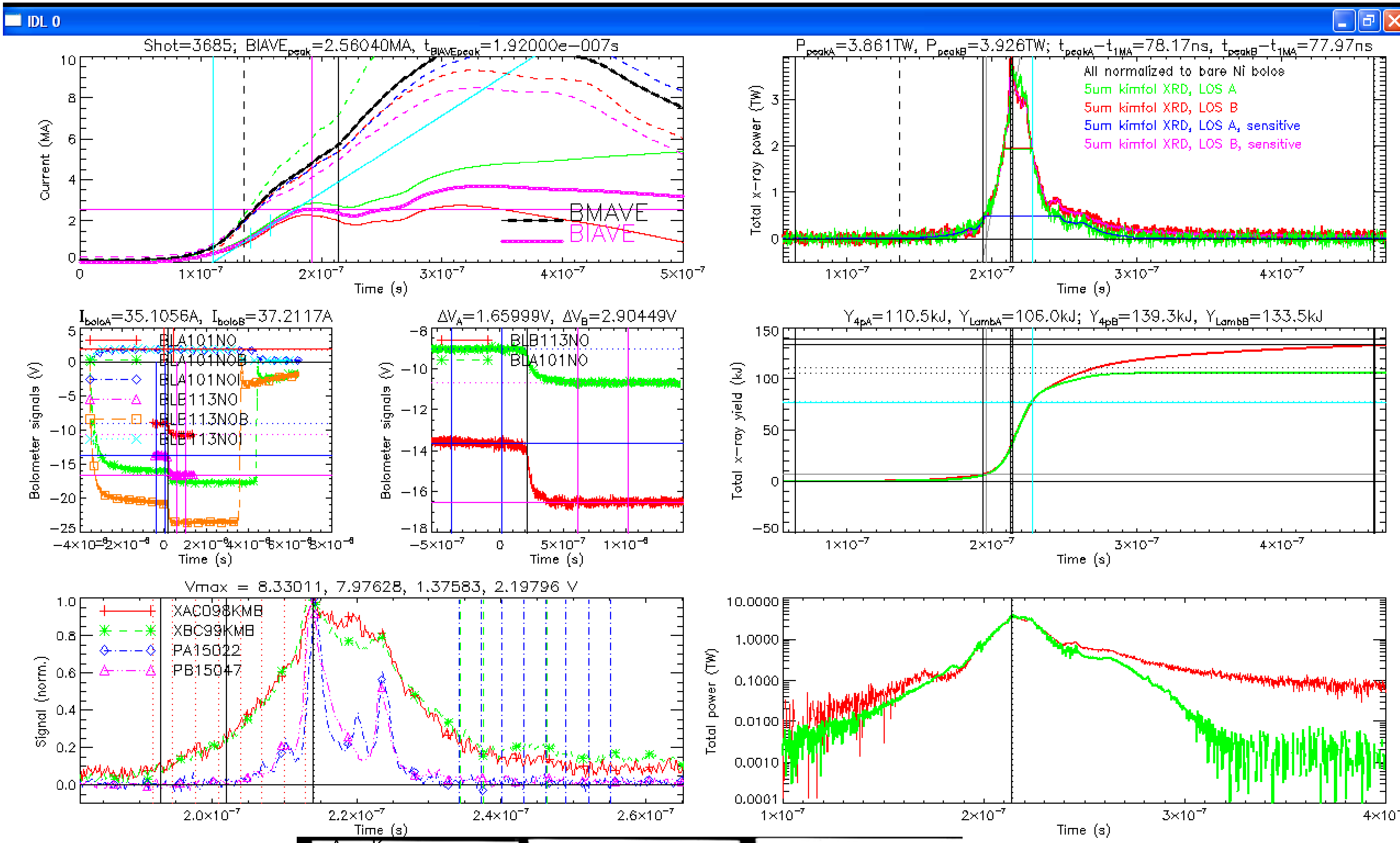

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MLM3	-450

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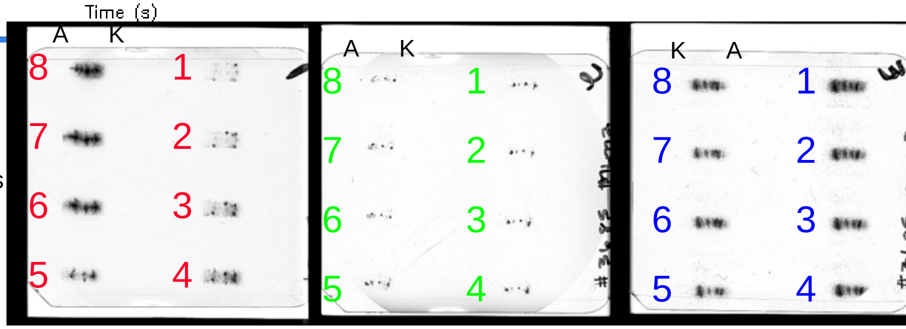

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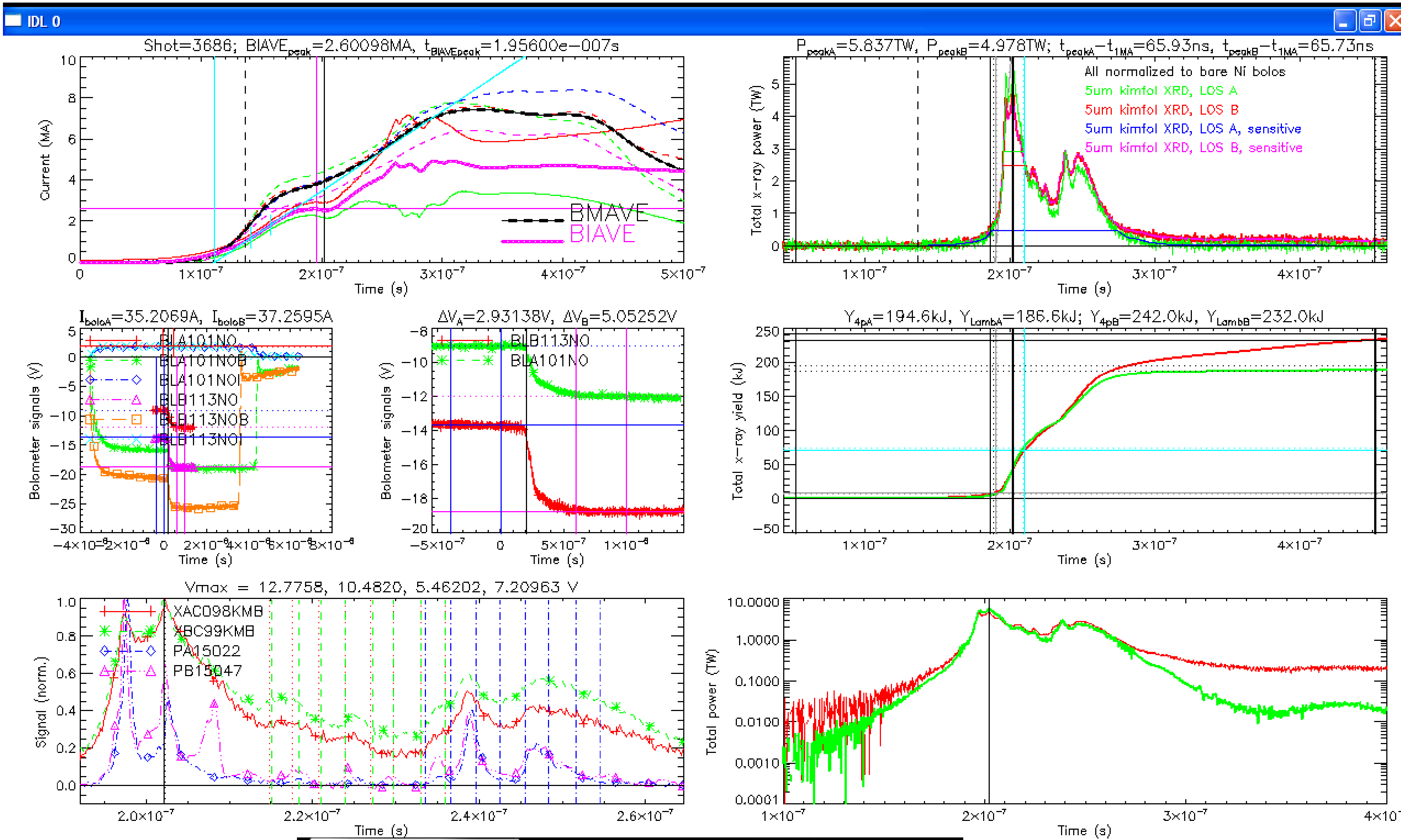

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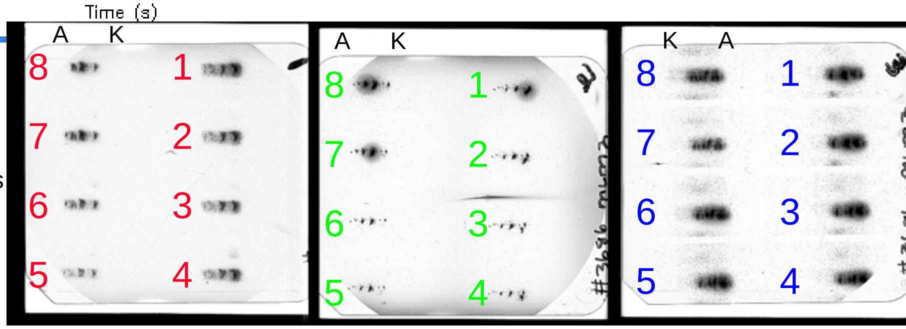
MLM1	-350
MLM2	-400
MLM3	-450

Distance scale corrected for MAG=1/2: 10 mm



Camera mounting orientation on MLM3 flipped the anode (A)-cathode (K) orientation relative to the other two cameras for this shot series. This will be corrected in the future. Recall also that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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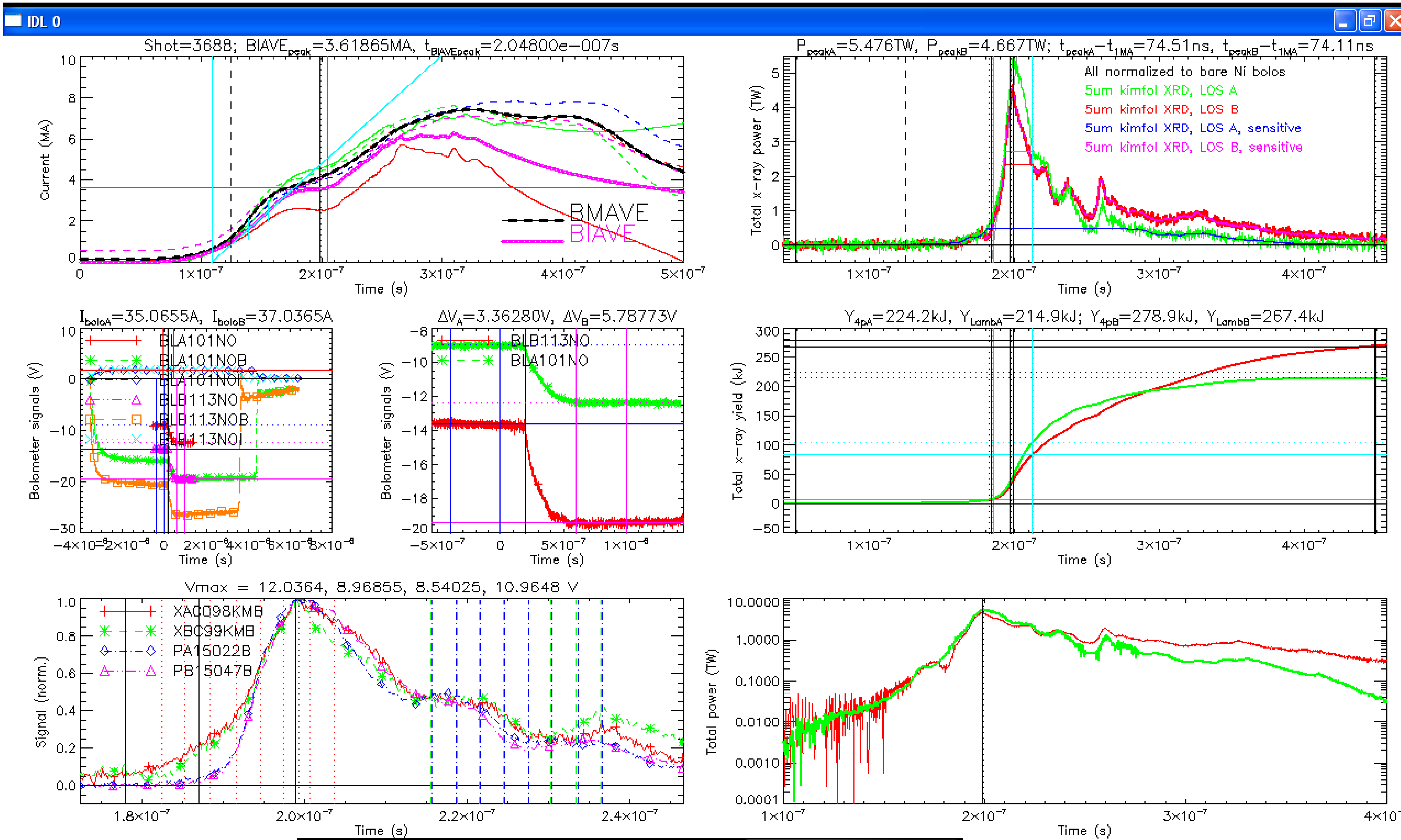
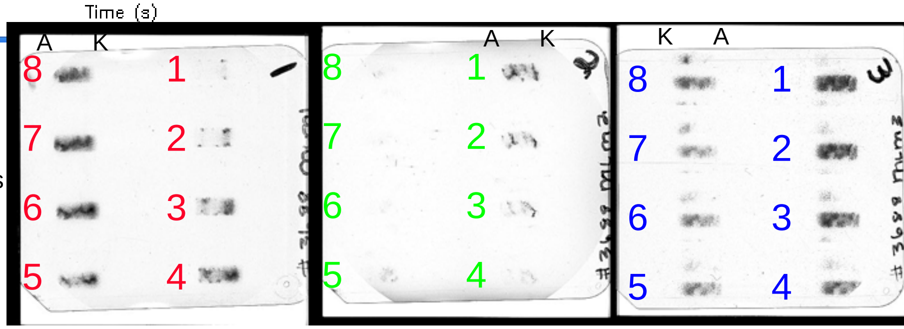


- MLM 1, 277 eV
- MLM 2, >1 keV
- MLM 3, 277 eV

1 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-320
MLM2	-180
MLM3	-420

Distance scale corrected for MAG=1/2:
10 mm



Camera mounting orientation on MLM3 flipped the anode (A)-cathode (K) orientation relative to the other two cameras for this shot series. This will be corrected in the future. Recall also that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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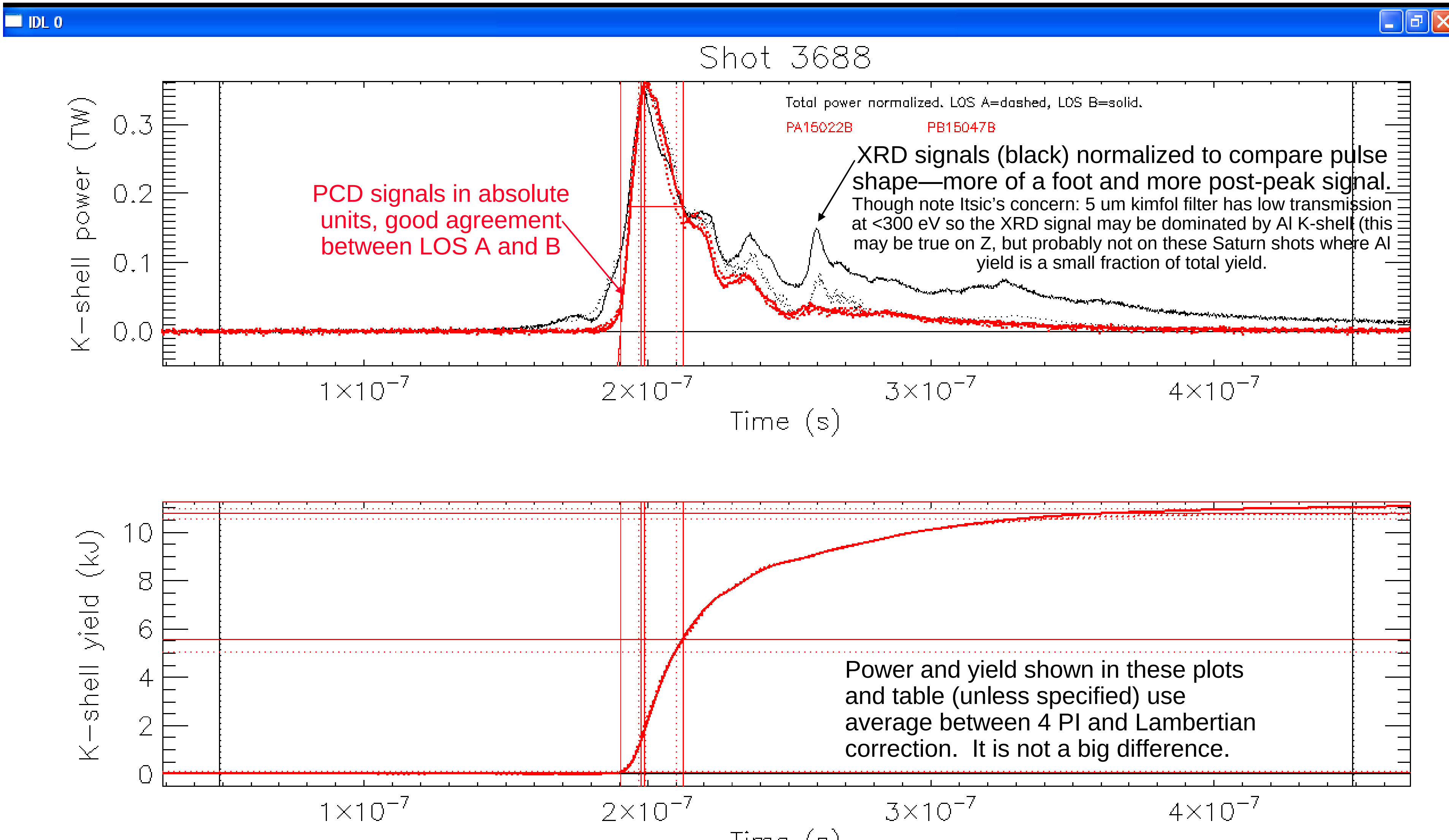

LOS	Signal	Power(TW)	YieldLamb(kJ)	Yield4p(kJ)	YieldFoot(kJ)	YieldToPeak(kJ)	YieldFirstPulse(kJ)	Rise(ns)	FWHM(ns)
A	PA15022	Clipped							
A	PA15022B	0.362265	10.5364	10.9892	0.122603	2.11297	4.94223	6.70447	16.2790
A	PA15052	Bad cal							
A	PA15052B	Bad cal							
B	PB15047	Clipped							
B	PB15047B	0.360903	10.7912	11.2550	0.0624984	1.72512	5.51869	7.20820	18.4650
B	PB15051	Huge noise							
B	PB15051B	Huge noise							

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3688 TIXTL analysis

- TIXTL analysis is performed with Greg Rochau's EXRAY program. The following slides discusses this analysis in detail.
- I can also provide lineouts at various steps along the way (e.g. before OD to exposure conversion, before efficiency correction) to Alla and students for their independent processing.
- The main question I have now is regarding what crystal reflectivity I should use. Right now I am using the average of the 'prins' and 'mosaic' models built into EXRAY. This could be modified.
- The following table includes wavelengths of certain K-shell lines (from Yitzhak Maron) that will be used as reference lines. In assigning the dispersion axis, I have tried to match Al Ly-α, Al He-α, Mg Ly-α, and Mg He-α.

	Ly_α		He_α		He_β		He_γ	
	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)
Na X,XI	10.025	1237	11.003	1127	9.433	1314	8.983	1380
MgXI,XII	8.4210	1472	9.1688	1352	7.8505	1579	7.4731	1659
Al XII,XIII	7.1727	1729	7.7573	1598	6.6348	1869	6.3139	1964

3688 TIXTL set up

quickscan of film

- TIXTL convex crystal spectrometer on LOS C
- KAP chosen to see Al and Mg K-shell lines, 2” radius, 20° rotation
- 0.5 mil Be filter
- 2497 film
- Time integrated spectrum
- Axially resolved, ~900 μm spatial resolution
  - M=p/q=0.5 (magnification)
  - p=$TOF_{LOSB,Aubolo}$*c+6” = 13.7ns*3e8m/s+6”=4.26 m (distance source to slit, approx.)
  - d=200, 300 μm (slit sizes)
  - hν=1.3 keV (worst case, e.g. Mg He-α)
    - $\sigma_{geometric}$=(M+1)*d/M=600, 900 μm
    - $\sigma_{diffraction}$= 2.44*h*c/(hν*e)*p/d =50,33 μm (formula for pinhole)
    - σ=SQRT($\sigma_{geometric}$^2+ $\sigma_{diffraction}$^2)=602,901 μm
  - hν=1.7 keV (e.g. Al lines)
    - $\sigma_{geometric}$=(M+1)*d/M=600, 900 μm
    - $\sigma_{diffraction}$= 2.44*h*c/(hν*e)*p/d =38, 25 μm (formula for pinhole)
    - σ=SQRT($\sigma_{geometric}$^2+ $\sigma_{diffraction}$^2)=601, 900 μm
- One slit image is cropped (off the side of the film). It looks like this is the lighter one, so probably the smaller slits. I will just process the full 300 um slit image, which will have 900 um spatial resolution. To start, I’ll average over the spatial structure in the non-clipped image.
- Field of view=10.4 mm
  - Max FOV=10.4 mm limited by can slot height based on CAD drawing from Marcelino. With the 35 degree viewing angle, the images should look 8.5 mm tall after MAG correction is done. But also due to the steep angle, it may look longer due to emission out of the plane of the array
- Film image data available in pff or hdr/img format;
  I don’t know how to make a tiff.

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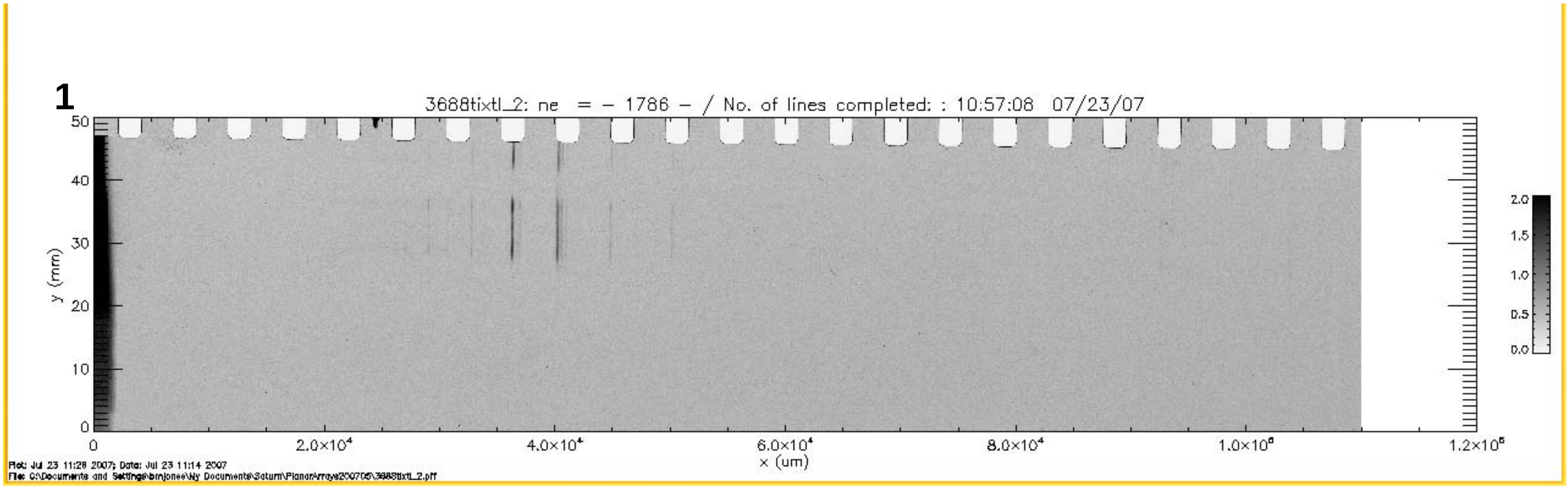
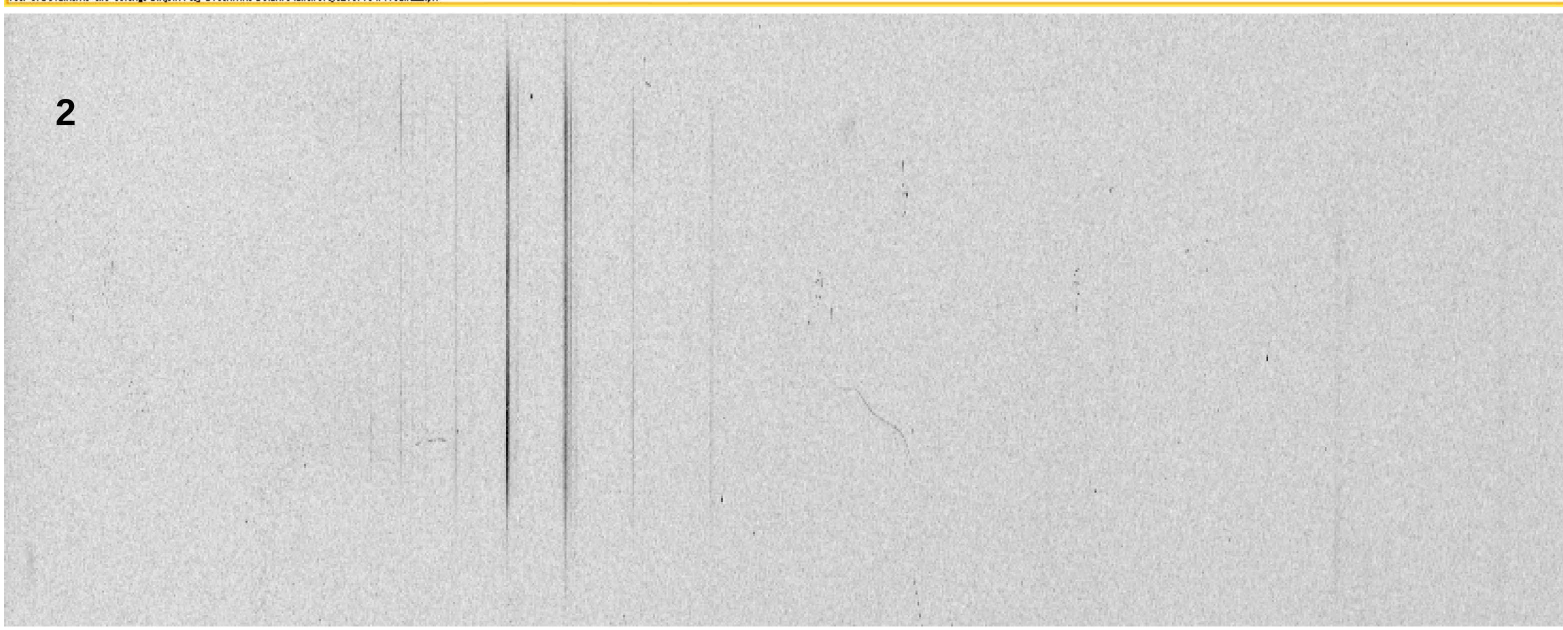
3688 TIXTL processing – axial – pff prep

- Plot 1: raw film, optical density, y-axis corrected for magnification
- Plot 2: bottom non-clipped image from plot 1, I will process this one

1

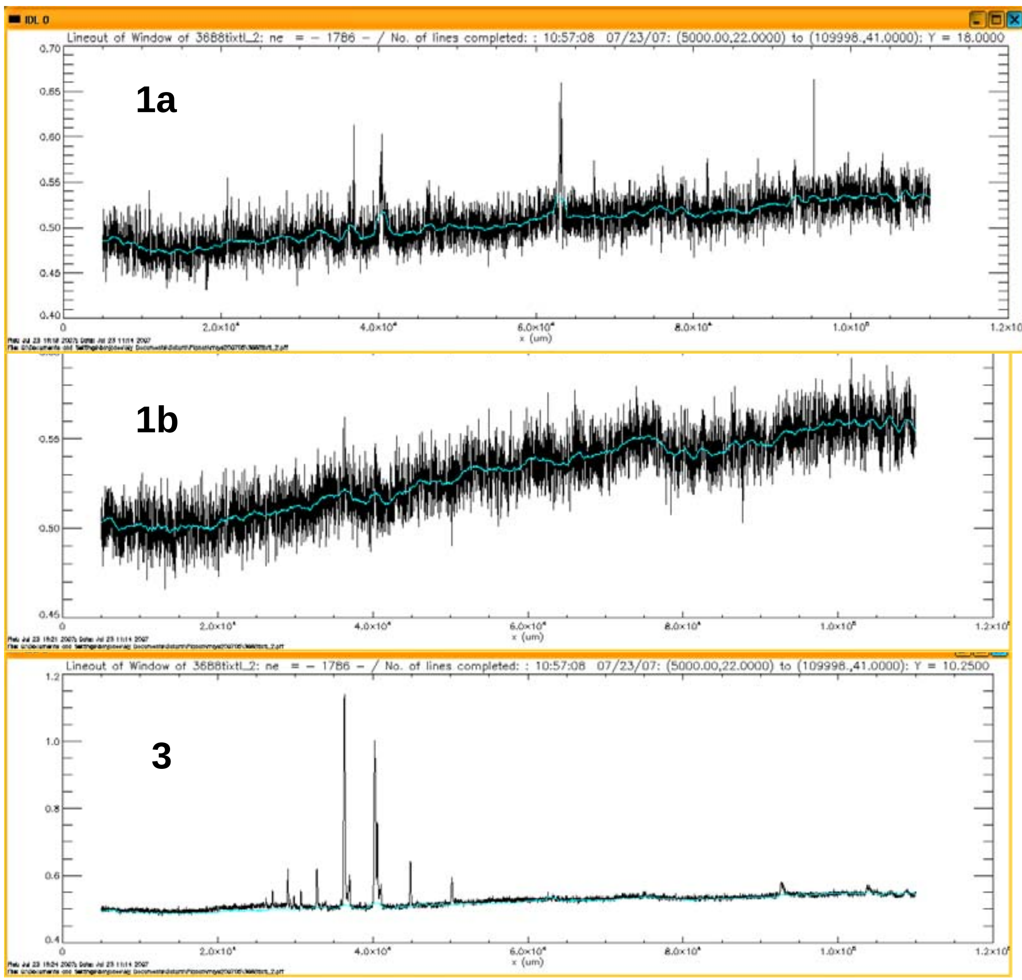


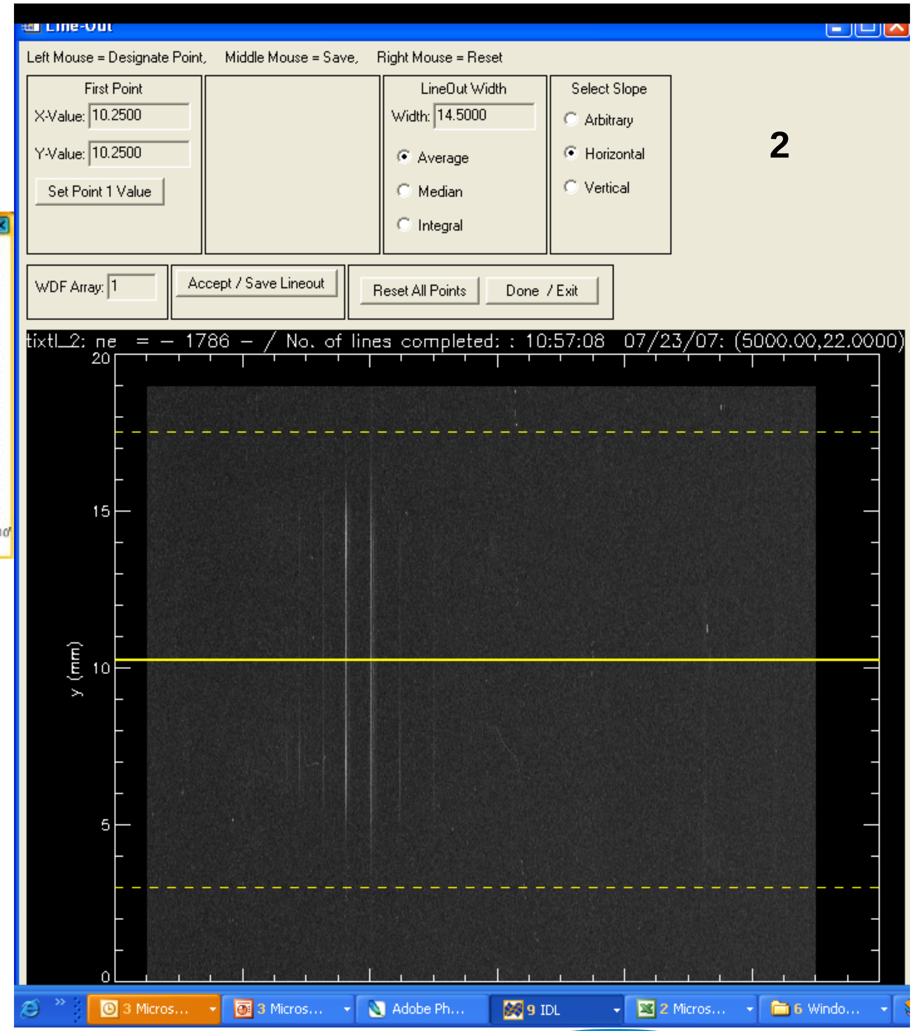
2



3688 TIXTL processing – axial – pff prep cont.

- Plot 1a,b: lineout of film background at y=18.0 mm, dy=1 mm; and y=1mm,dy=2mm; average of smoothed lines will be subtracted as film background; saved as file 3688tixtl_2_bgd.ufo
- Plot 2,3: lineout averages over entire radial dimension; saved as file 3688tixtl_2_bottomslitavg.ufo
- pff file saved as 3688tixtl_2_prep.pff





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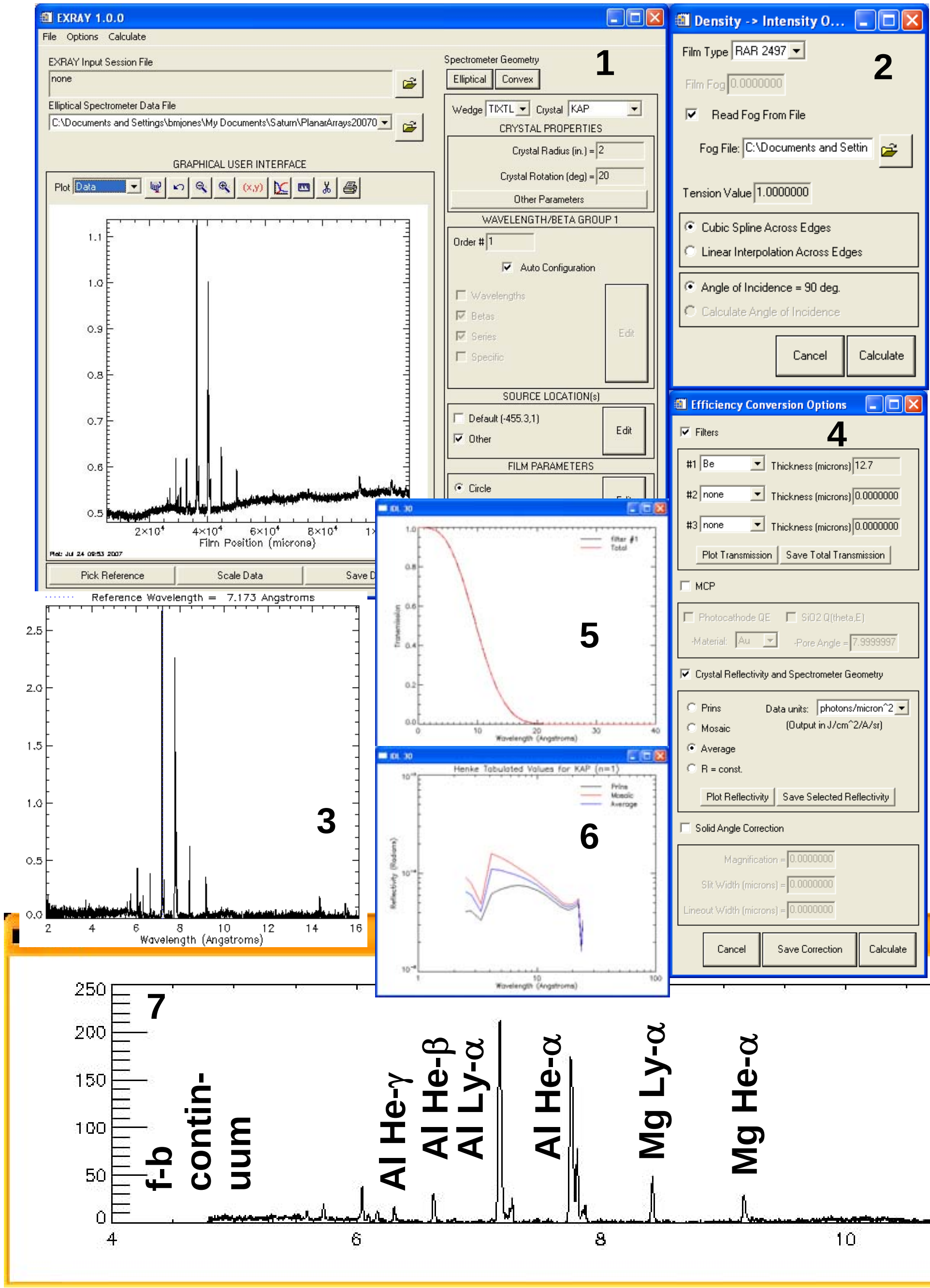
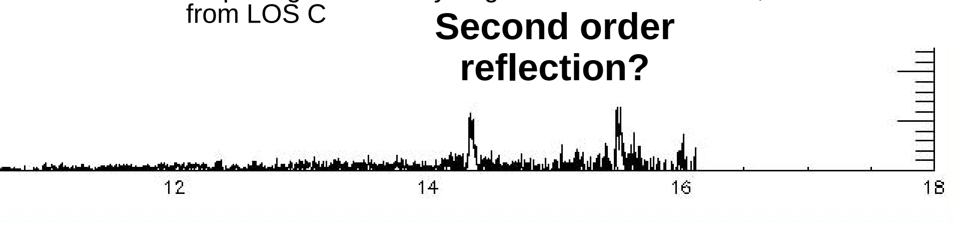
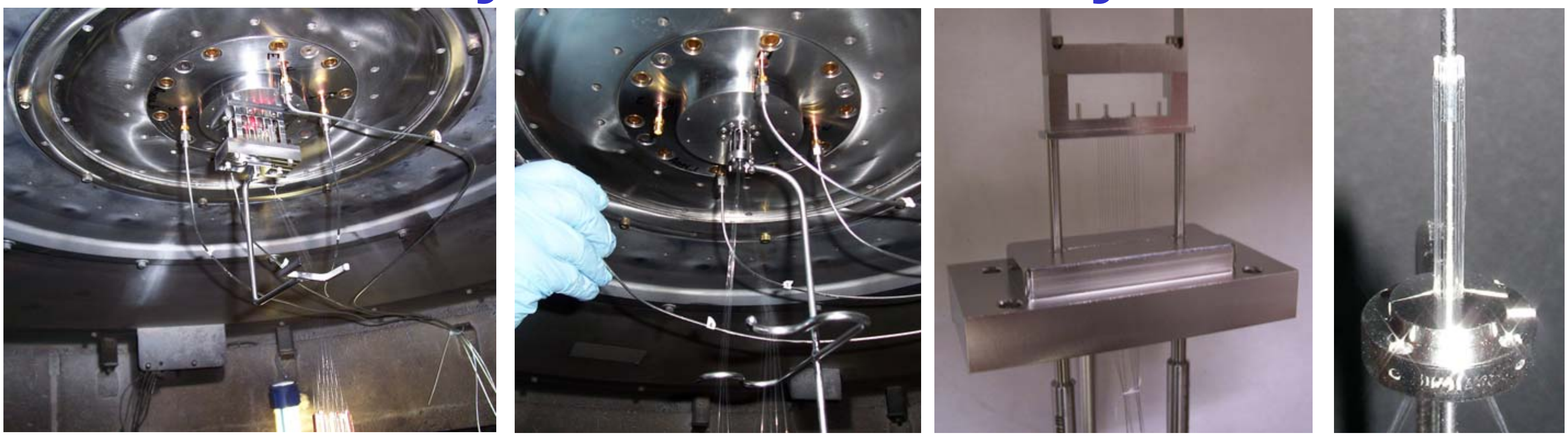
3688 TIXTL processing - EXRAY





- Wavelength scale (plot 1):
  - Used source distance x=(TOF_Aubolo,LOSB*c+6")*1.5=-638.9,y=1 which should be about right
  - Pick reference: Al Ly-α res, 7.173 Å—Using this line per earlier discussion with Itsic and Jim re: TREX
  - Film distance changed from 8.5 to 8.18 cm to align Al He-α, Mg Ly-α, Mg He-α
  - Saved as 3688tixtl_2_bottomslitavg_lambda.ufo
- Optical density to exposure conversion (plots 2,3)
  - Used z1518t135r_bgd.ufo for film fog subtraction
  - Exposure in photons/um^2
  - Saved as 3688tixtl_2_bottomslitavg_lambda_ODtoExp.ufo
- Efficiency correction (plot 4); Rochau says do the following through EXRAY:
  - Filter correction (plot 5): 0.5 mils Be—this is a significant correction at the wavelengths of interest (plot 3) but Rochau says correction will be reliable. Filter transmission saved as file 3688tixtl_2_filtertrans.ufo
  - Crystal reflectivity: Prins model saved as 3688tixtl_2_xtlreflectprins.ufo; Mosaic model saved as 3688tixtl_2_xtlreflectmosaic.ufo. I don't know which is better so for now I am using the average, saved as 3688tixtl_2_xtlreflectavg.ufo; I need to ask Greg and Jim for advice on what the models mean and what to use, or maybe Alla knows.
  - Intensity units in photons/um^2, but no solid angle correction is implemented—so units are arb. But relative amplitudes should be good.
  - Saved corrected spectrum as 3688tixtl_2_bottomslitavg_lambda_ODtoExp_EXReffcorr.ufo; plotted in plot 7. This is the final spectrum for comparison with modeling.
  - I don't know why the spectrum was cut off near 5A in plot 7, but from plot 3 the signal to noise is not good in the free-bound continuum region so I don't think I can use those data anyway
  - Strong Mg relative to Al—opacity may be important—not surprising for the fairly large mass of these loads, and the view from LOS C

August 2008
Saturn planar and compact cylindrical wire array shots; data analysis



Document prepared by:

B. Jones

Sandia National Laboratories

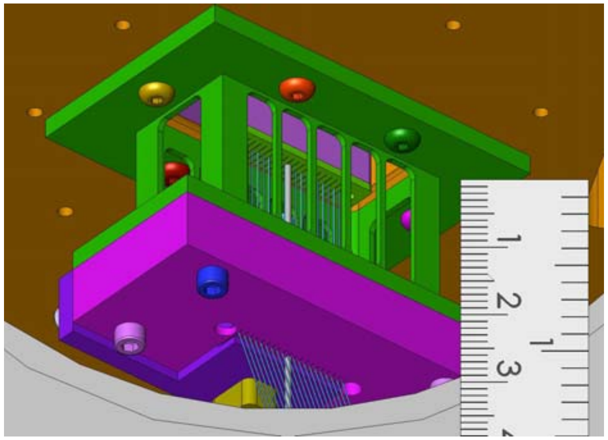
August 25, 2008

2008 planar and compact cyclindrical Saturn experiments

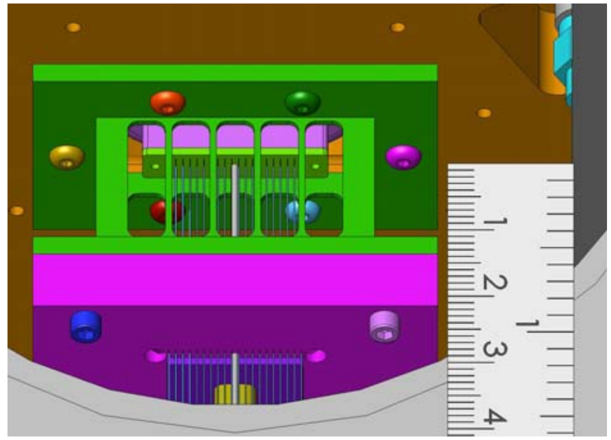
Shot	Material	Density (g/cm^3)	Planar array width, W (mm)	Interwire gap, IWG (mm)	Wire number, N	Wire diameter (um)	Total mass/length (mg/cm)	Total mass (mg)	Implosion time design goal	Peak current (prior to peak x-rays) (MA)	Implosion time = t_peak-t_0MA (ns)
3744	W	19.25	8	0.533333	16	40.60	3.987	7.975	Nominal	5.52	61.9
3745	W	19.25	12	0.521739	24	23.50	2.004	4.008	Nominal	5.38	62.6
3746	W	19.25	12	0.521739	24	23.50	2.004	4.008	Nominal	5.27	54.0
3747	W	19.25	8	0.533333	16	40.60	3.987	7.975	Nominal	4.67	61.7
3748	Al 5056	2.7	20	0.512821	40	30.50	0.789	1.578	Nominal	5.49	59.6
3752	W	19.25	20	0.512821	40	11.43	0.790	1.580	Nominal	5.66	59.6
Shot	Material	Density (g/cm^3)	Cylin-drical array dia. (mm)	Interwire gap, IWG (mm)	Wire number, N	Wire diameter (um)	Total mass/length (mg/cm)	Total mass (mg)	Implosion time design goal		
3753	W	19.25	3	0.3927	24	40.60	5.981	11.962	Short	4.99433	44.9448
3754	W	19.25	3	0.3927	24	30.50	3.375	6.751	Shorter	4.36189	45.8535
3755	W	19.25	3	0.3927	24	40.60	5.981	11.962	Short	5.13968	55.2374
3756	W	19.25	3	0.3927	24	30.50	3.375	6.751	Shorter	4.64103	47.2508

- See file SaturnPlanarCompactArrayShots20080825.xls for summary data and load descriptions of all shots, including experimental measurements and Esaulov/Chuvatin modeling. Table above is an excerpt.
- Data for all planar and compact 3 mm shots from 2008 are in SaturnPlanarCompactBJ20080825.pff
- This file summarizes current, total radiated power and yield analysis, and shows the MLM imager time-resolved pinhole imaging data. I will provide the MITL and load current, total radiated power waveforms (LOS B data using two separate bolometers) in pff and text files.
- Shots 3744-3747 will be added to current scaling data. All 2007-2008 tungsten planar shots (except ones with issues such as broken wires, dirty MITLs) will be used in multivariate scaling fit.
- TIXTL and PCD data are available for both 3688 and 3748 to look at Al K-shell.
- Four Saturn-style B-dots for this series: N (0°), S (180°), W, E; <0.5 MA difference between N/S and W/E, so these are all averaged here.

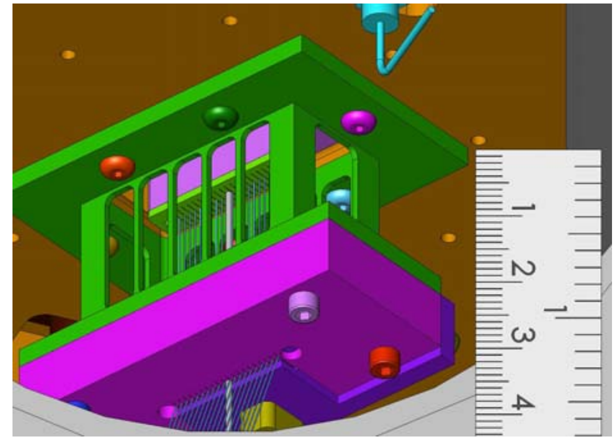
Diagnostic view from Line of Sight A (LOS A)



Diagnostic view from Line of Sight B (LOS B)



Diagnostic view from Line of Sight C (LOS C)



20 mm wide, 40-wire planar array shown. Gray rod on axis represents the stagnated pinch location (view factor correction obtained from these images). Ruler is in the plane perpendicular to the isometric viewing direction, and not parallel to the pinch. All three views are 35° from the horizontal. Hardware is same as in 2007.

Diagnostics on LOS A:

PCDs (8 um Be + 1 um CH filter; PA15022 and PA15047 were on shots 3752-3756 only; these were same diamonds as in 3688)

PCDs (also PA15049, PA16052)

No XRDs or bolos in 2008

Diagnostics on LOS B:

XRD (5 um kimfol filter; XRDB99 and also a second detector XRDB103 for shots 3752-3756)
Bare Ni bolometers (113 was on LOS B in 2007, 101 was on LOS A in 2007 and is now on LOS B)
PCDs (8 um Be + 1 um CH filter; PB15047 was also on in 2007; PB15022 was on LOS A, now on LOS B for most shots in 2008)
MLM imager

Diagnostics on LOS C:

TIXTL (KAP, 2" radius, 20° rotation; 1/3 mils Be filter (was 0.5 mils in 2007 shot 3688); fielded only on shot 3748 to look at time-integrated, axially resolved Al/Mg K-shell spectrum)

The MLM imager combines three 8-frame pinhole cameras gated with 1 ns pulses. MLM1 and MLM3 view hν=277 eV images reflected from multilayer mirror monochromators. MLM2 employs a 50 um Kapton + 2500 A Al filter to view hν>2 keV images (the 8 um Be filter was in use on Z—I thought I asked for another one to be made but it was not available at the time of Saturn shots).

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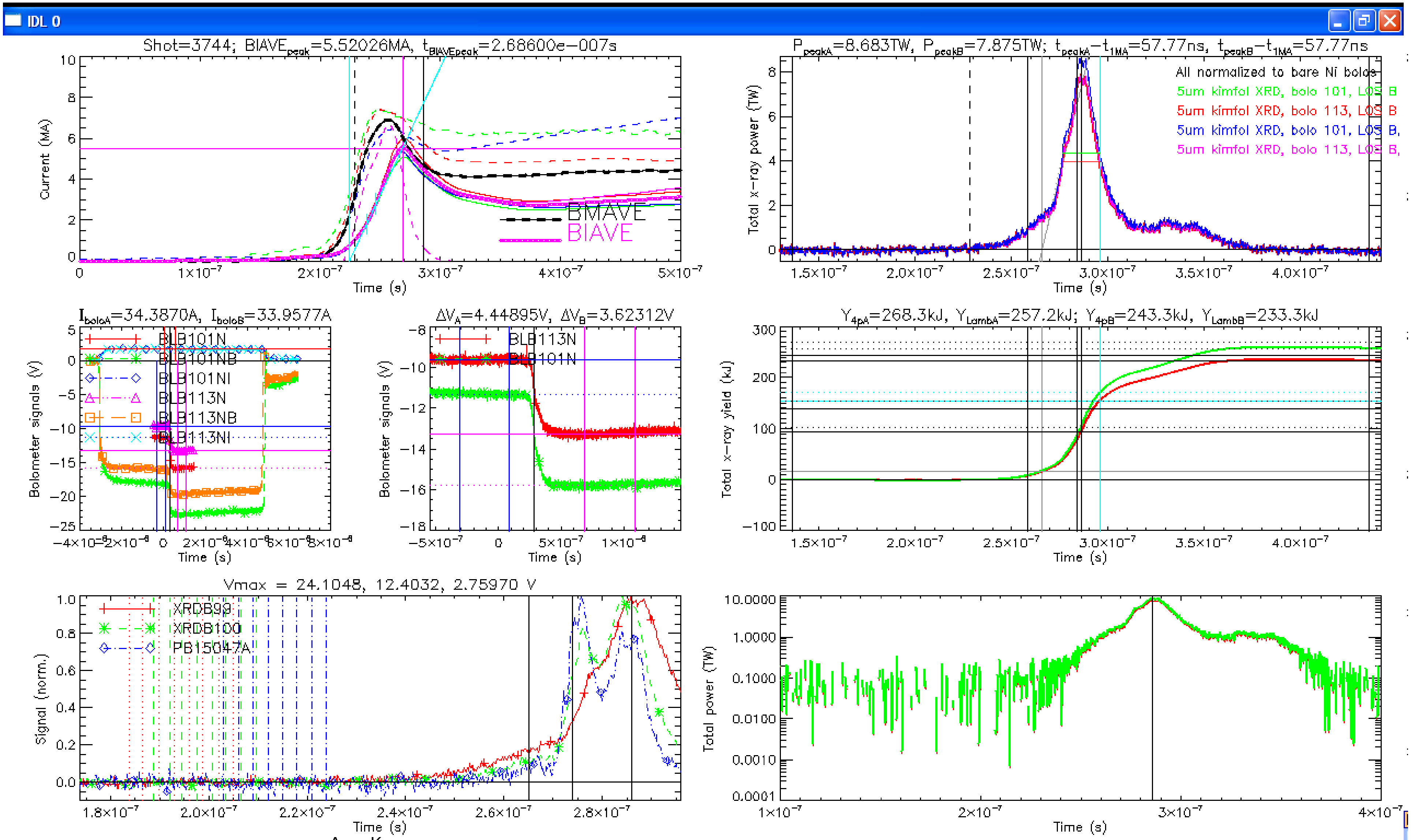


MLM 1, 277 eV

MLM 2, >2 keV

MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

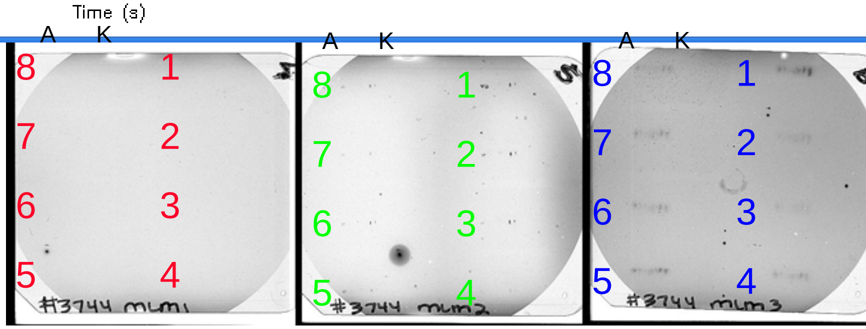
MLM1 -350

MLM2 -400

MLM3 -450

Distance scale corrected for MAG=1/2:

10 mm



Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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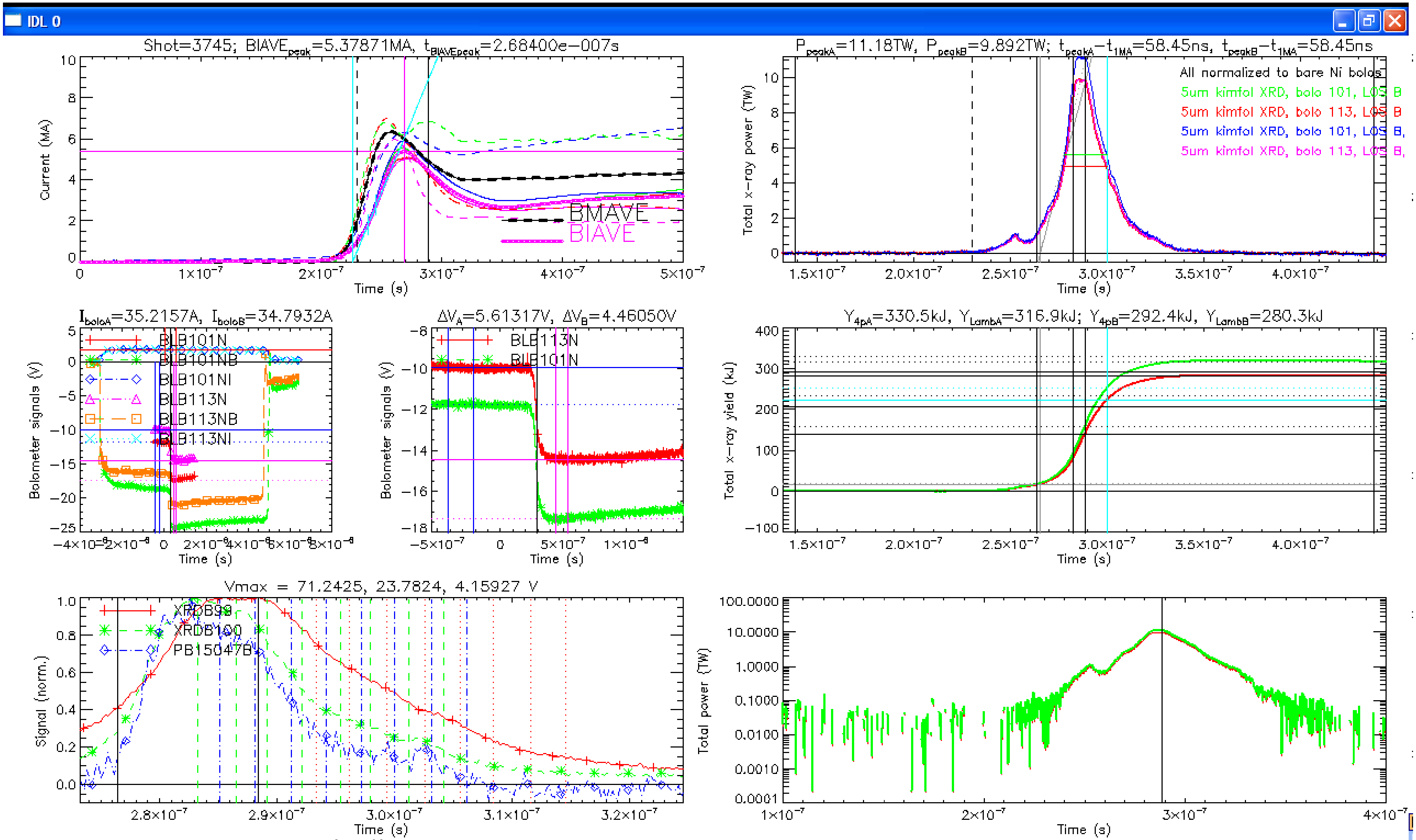
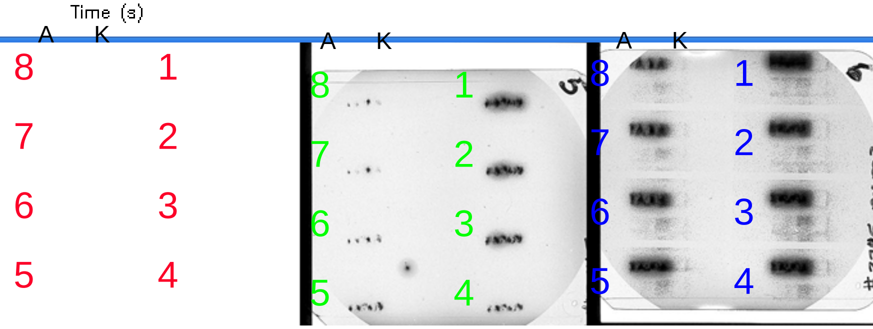
Brent Jones, 7/26/2007





MLM 1, 277 eV

MLM 2, >2 keV

MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	NA
MLM2	-400
MLM3	-400

Distance scale corrected for MAG=1/2: 10 mm

Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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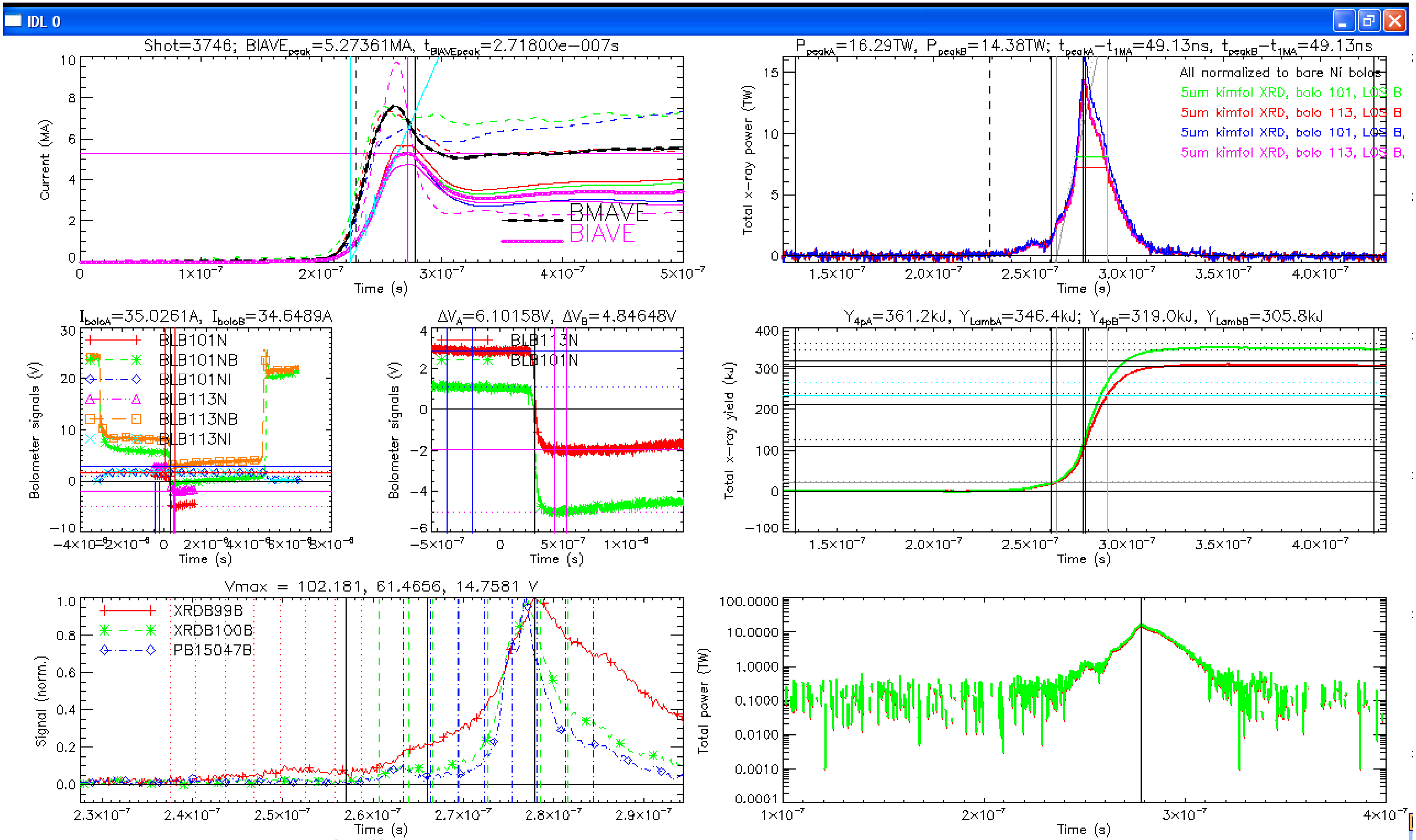

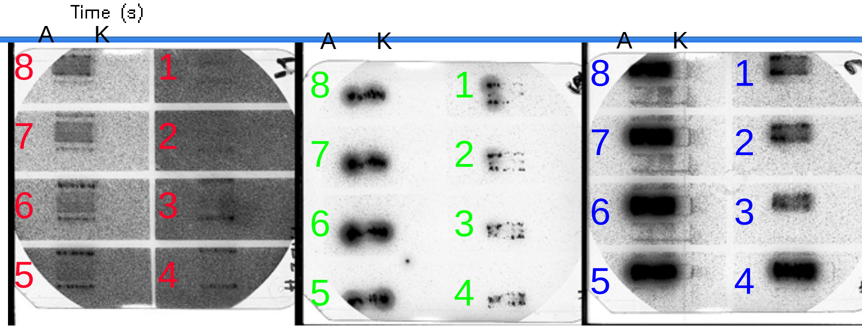

MLM 1, 277 eV
MLM 2, >2 keV
MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-400
MLM3	-400

Distance scale corrected for MAG=1/2:
10 mm

Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2. This shot was the highest power planar array, and had the best MLM data in 2008 (though need to check for saturation).

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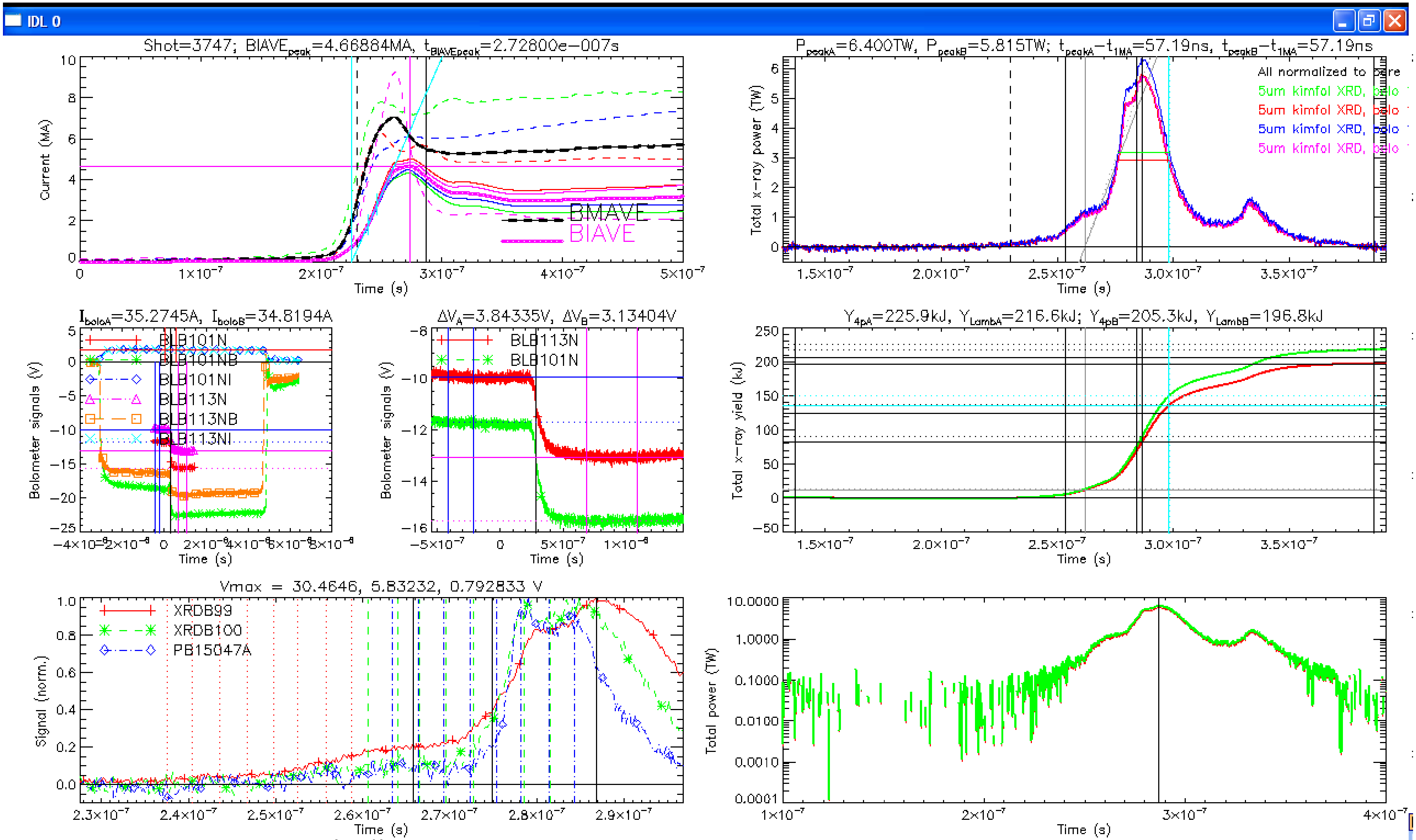
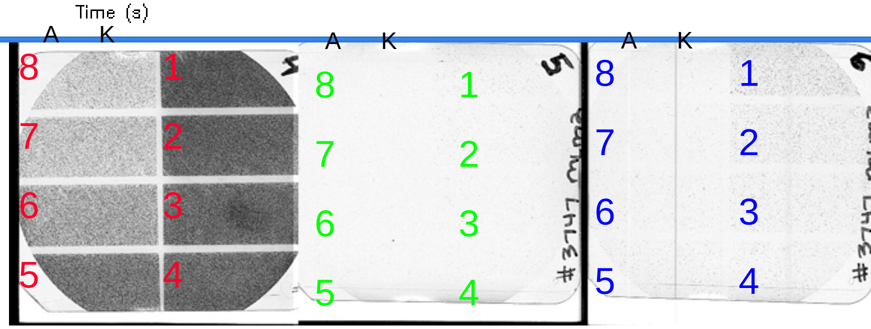


....	MLM 1, 277 eV
- - - -	MLM 2, >2 keV
-·-·-·	MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-380
MLM3	-400

Distance scale corrected for MAG=1/2:
10 mm



Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2. Gate valve accidentally left closed on this shot so no data on MLM.

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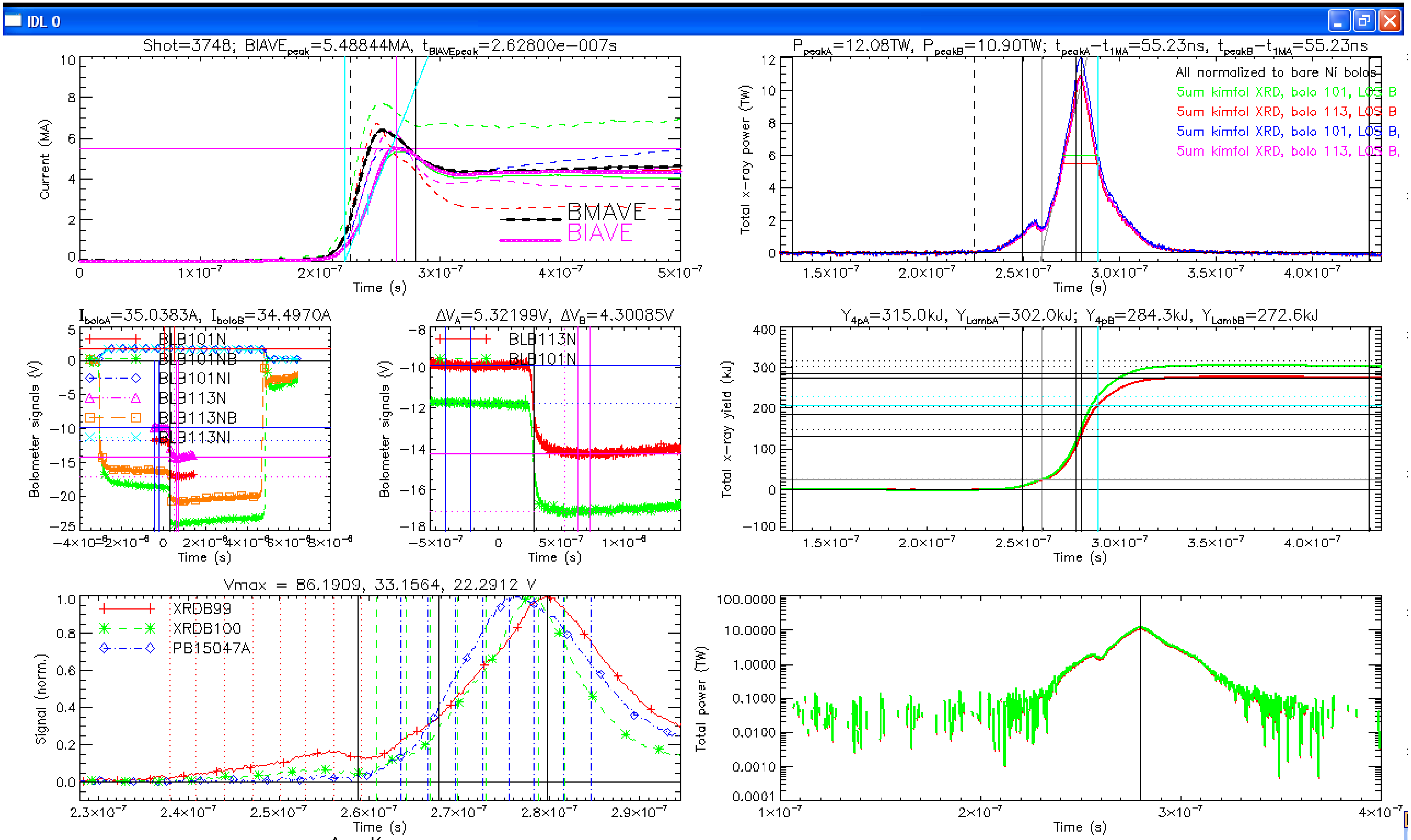
Brent Jones, 7/26/2007

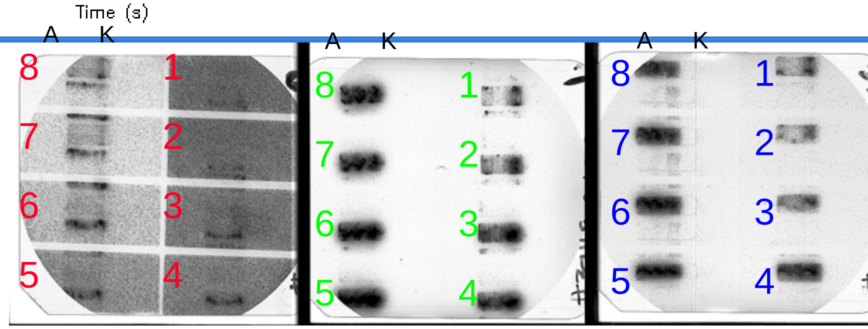


········	MLM 1, 277 eV
– – – –	MLM 2, >2 keV
– · – · –	MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-300
MLM3	-350

Distance scale corrected for MAG=1/2:
10 mm ▬



Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2. This is the Al 5056 shot.

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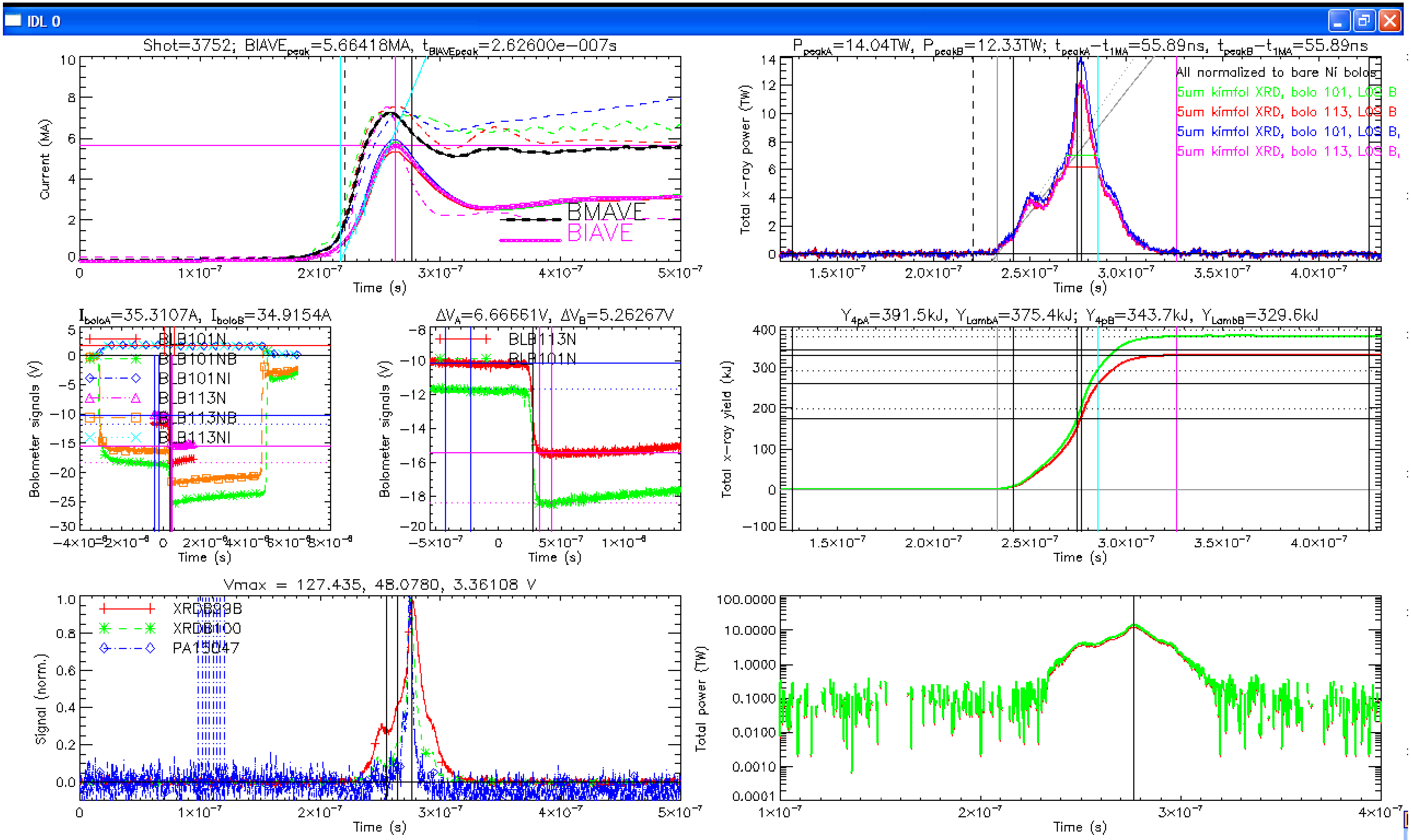


MLM 1, 277 eV

MLM 2, >2 keV

MLM 3, 277 eV

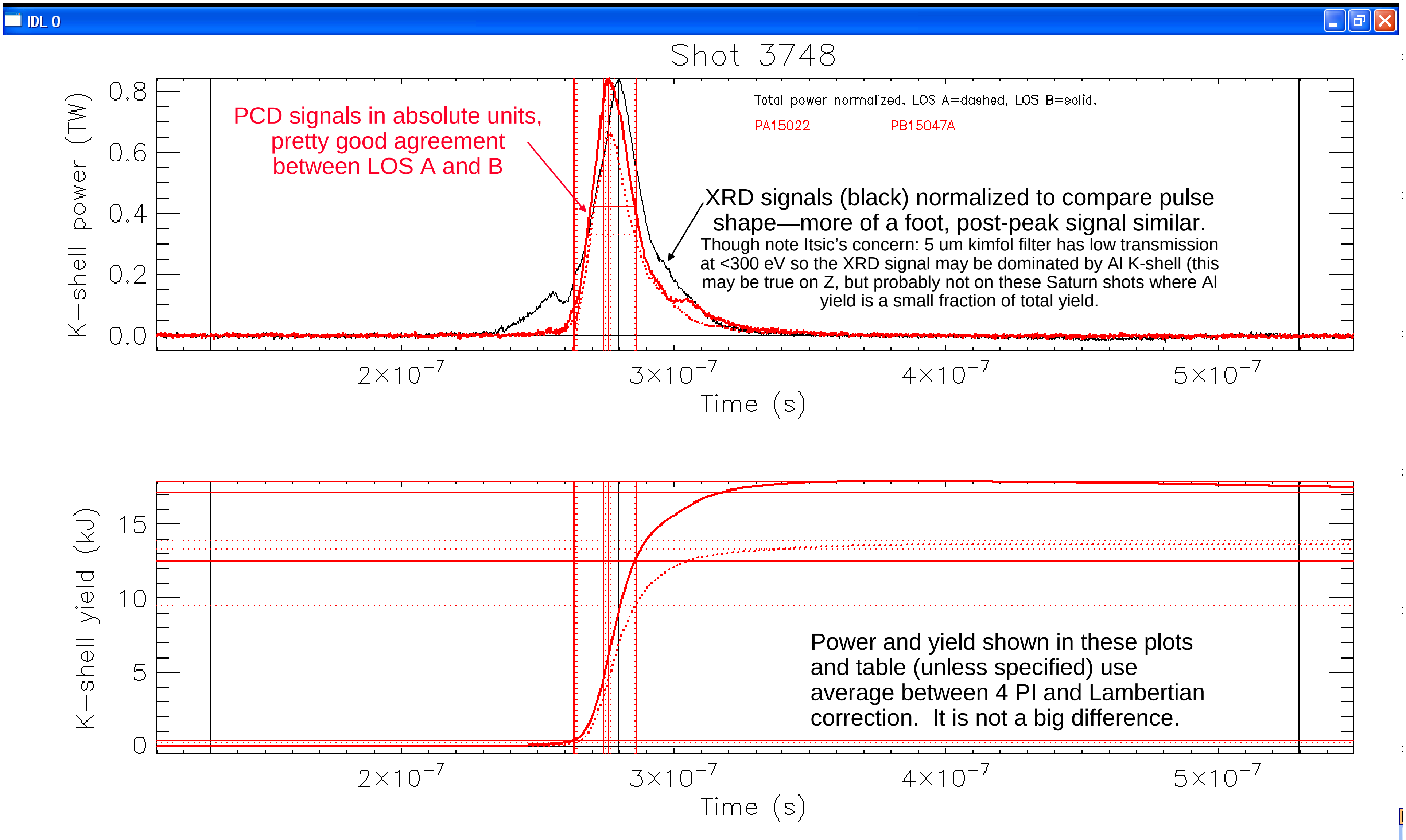
3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	NA
MLM2	NA
MLM3	NA

Distance scale corrected for MAG=1/2:
10 mm

Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2. MLM vacuum leak, so gate valve shut for shot and no MLM data.

Brent Jones, 7/26/2007



LOS	Signal	Power(TW)	YieldLamb(kJ)	Yield4p(kJ)	YieldFoot(kJ)	YieldToPeak(kJ)	YieldFirstPulse(kJ)	Rise(ns)	FWHM(ns)
A	PA15022	0.663558	13.3402	13.9135	0.255572	5.07370	9.22165	10.2305	16.3988
B	PB15047A	0.841557	17.1541	17.8913	0.417861	5.96736	12.1216	10.9073	16.4887

- Use LOS B values, since there is a concern with the different viewing angle of LOS A which could impact opacity (planar arrays may not produce cylindrically symmetric pinches; more trailing mass between core and PCD from LOS A? This would affect TIXTL too) and LOS A sees slightly less axial length

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3748 TIXTL analysis

- TIXTL analysis is performed with Greg Rochau's EXRAY program. The following slides discusses this analysis in detail.
- I can also provide lineouts at various steps along the way (e.g. before OD to exposure conversion, before efficiency correction) to Alla and students for their independent processing.
- The main question I have now is regarding what crystal reflectivity I should use. Right now I am using the average of the 'prins' and 'mosaic' models built into EXRAY. This could be modified.
- The following table includes wavelengths of certain K-shell lines (from Yitzhak Maron) that will be used as reference lines. In assigning the dispersion axis, I have tried to match Al Ly-α, Al He-α, Mg Ly-α, and Mg He-α.

	Ly_α		He_α		He_β		He_γ	
	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)	λ(Å)	ΔE (eV)
Na X,XI	10.025	1237	11.003	1127	9.433	1314	8.983	1380
MgXI,XII	8.4210	1472	9.1688	1352	7.8505	1579	7.4731	1659
Al XII,XIII	7.1727	1729	7.7573	1598	6.6348	1869	6.3139	1964

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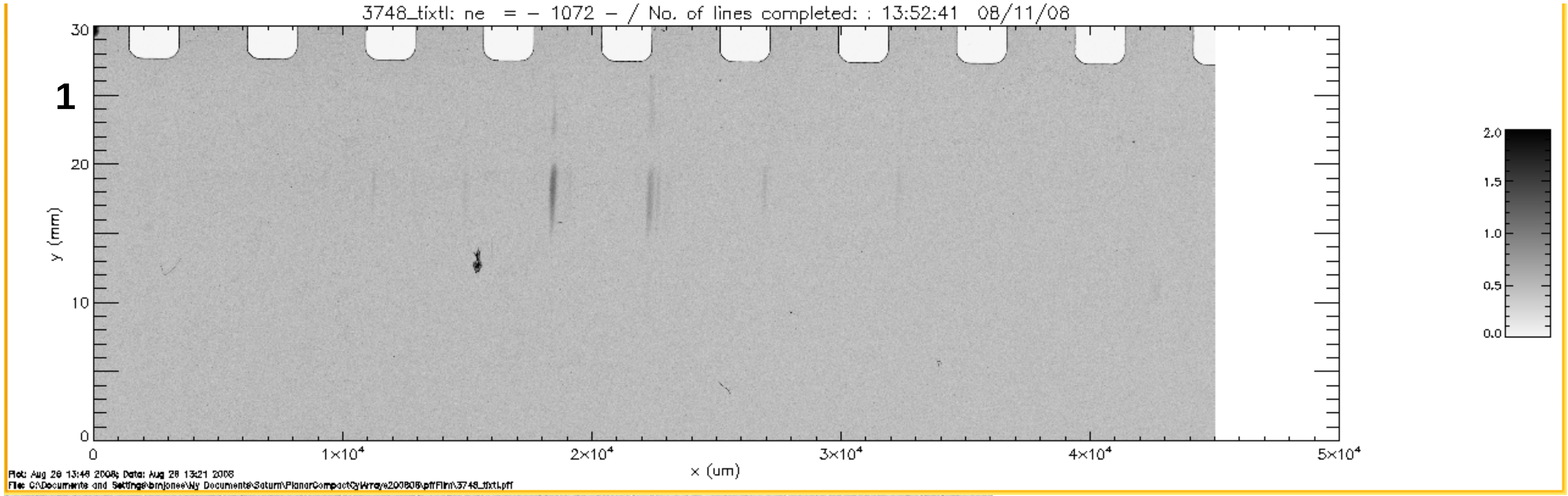
3748 TIXTL set up

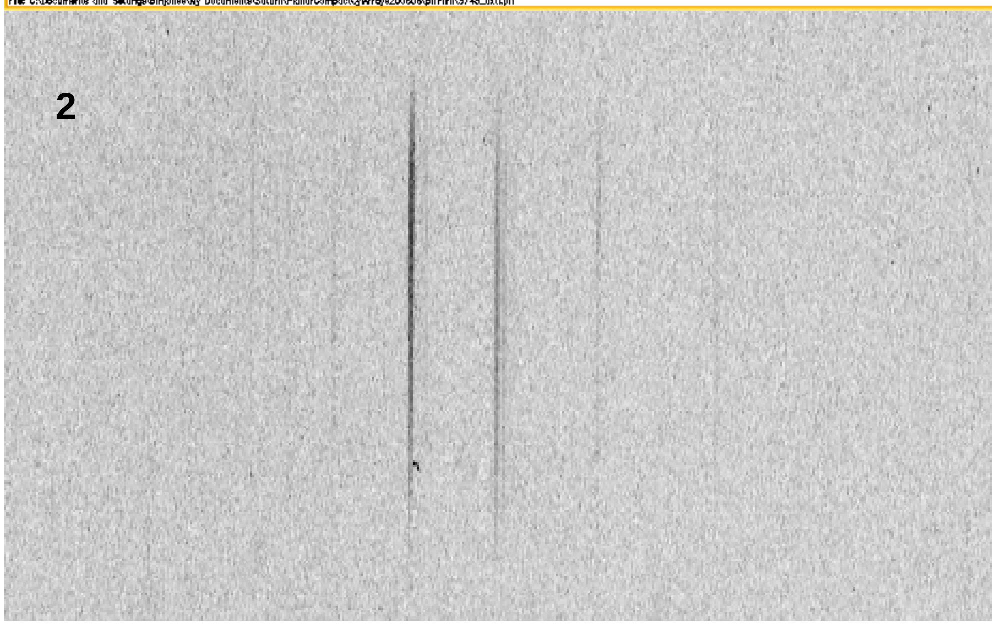
quickscan of film

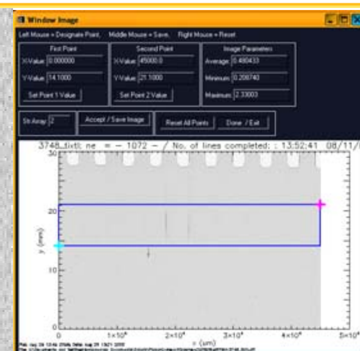
- TIXTL convex crystal spectrometer on LOS C
- KAP chosen to see Al and Mg K-shell lines, 2” radius, 20° rotation
- 1/3 mil Be filter (note: this is different than 3688)
- 2497 film
- Time integrated spectrum
- Axially resolved, ~900 μm spatial resolution
  - M=p/q=0.5 (magnification)
  - p=$TOF_{LOSB,Aubolo}$*c+6” = 13.7ns*3e8m/s+6”=4.26 m (distance source to slit, approx.)
  - d=200, 300 μm (slit sizes)
  - hν=1.3 keV (worst case, e.g. Mg He-α)
    - $\sigma_{geometric}$=(M+1)*d/M=600, 900 μm
    - $\sigma_{diffraction}$= 2.44*h*c/(hν*e)*p/d =50,33 μm (formula for pinhole)
    - σ=SQRT($\sigma_{geometric}$^2+ $\sigma_{diffraction}$^2)=602,901 μm
  - hν=1.7 keV (e.g. Al lines)
    - $\sigma_{geometric}$=(M+1)*d/M=600, 900 μm
    - $\sigma_{diffraction}$= 2.44*h*c/(hν*e)*p/d =38, 25 μm (formula for pinhole)
    - σ=SQRT($\sigma_{geometric}$^2+ $\sigma_{diffraction}$^2)=601, 900 μm
- One slit image is cropped (off the side of the film). It looks like this is the lighter one, so probably the smaller slits. I will just process the full 300 um slit image, which will have 900 um spatial resolution. To start, I’ll average over the spatial structure in the non-clipped image.
- Field of view=10.4 mm
  - Max FOV=10.4 mm limited by can slot height based on CAD drawing from Marcelino. With the 35 degree viewing angle, the images should look 8.5 mm tall after MAG correction is done. But also due to the steep angle, it may look longer due to emission out of the plane of the array
- Film image data available in pff or hdr/img format;
  I don’t know how to make a tiff.

3748 TIXTL processing – axial – pff prep

- Plot 1: raw film, optical density, y-axis corrected for magnification
- Plot 2: bottom non-clipped image from plot 1, I will process this one







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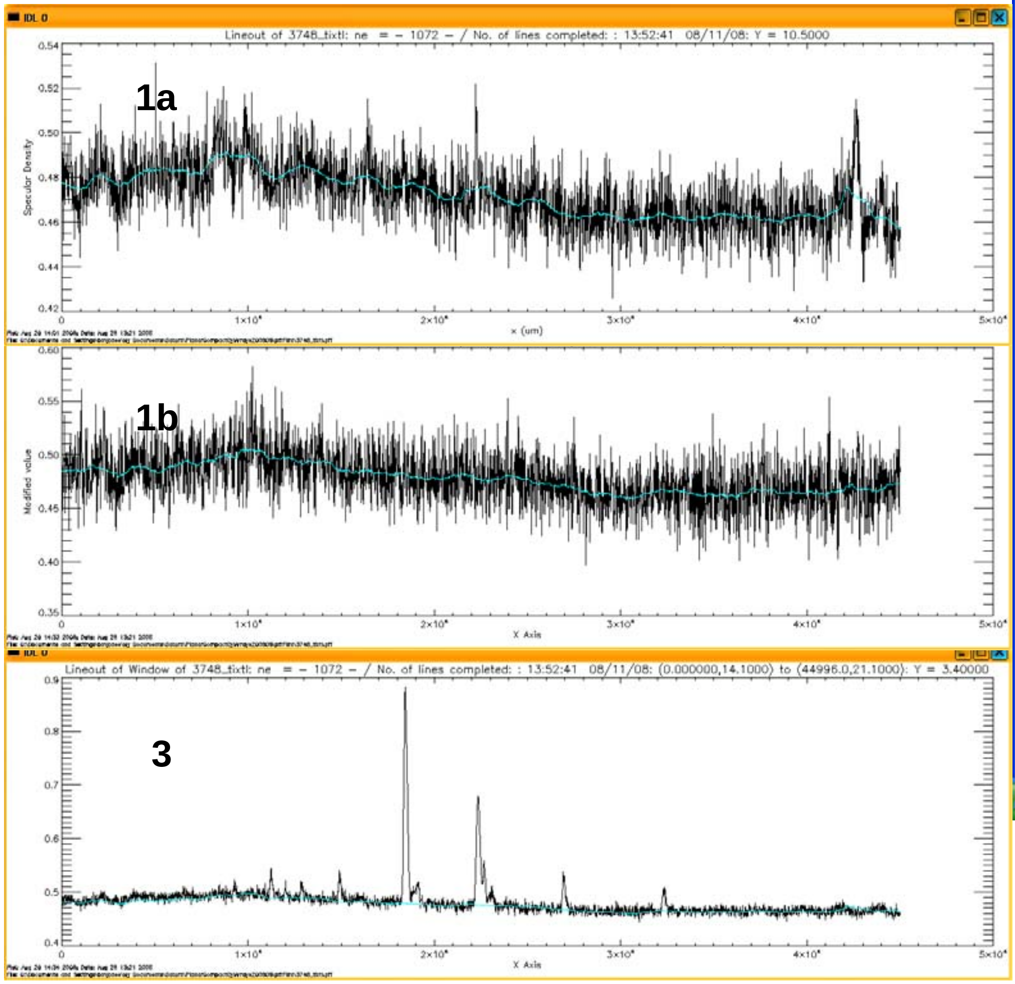
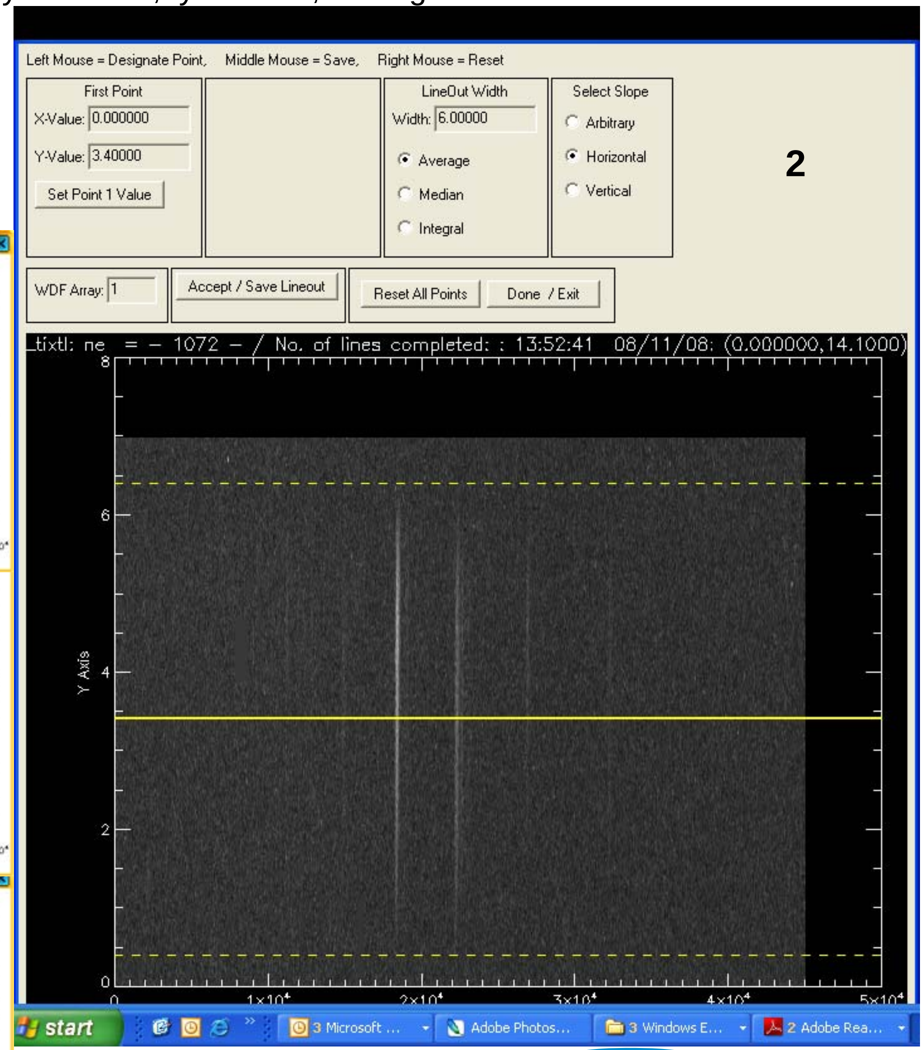
3748 TIXTL processing – axial – pff prep cont.

- Plot 1a,b: lineout of film background at y=10.5 mm, dy=2 mm; and y=21.1mm,dy=0.5mm; average of smoothed lines will be subtracted as film background; saved as file 3748tixtl_bgd.ufo
- Plot 2,3: lineout averages over entire radial dimension; saved as file 3748tixtl_bottomslitavg.ufo
- pff file saved as 3748tixtl_prep.pff





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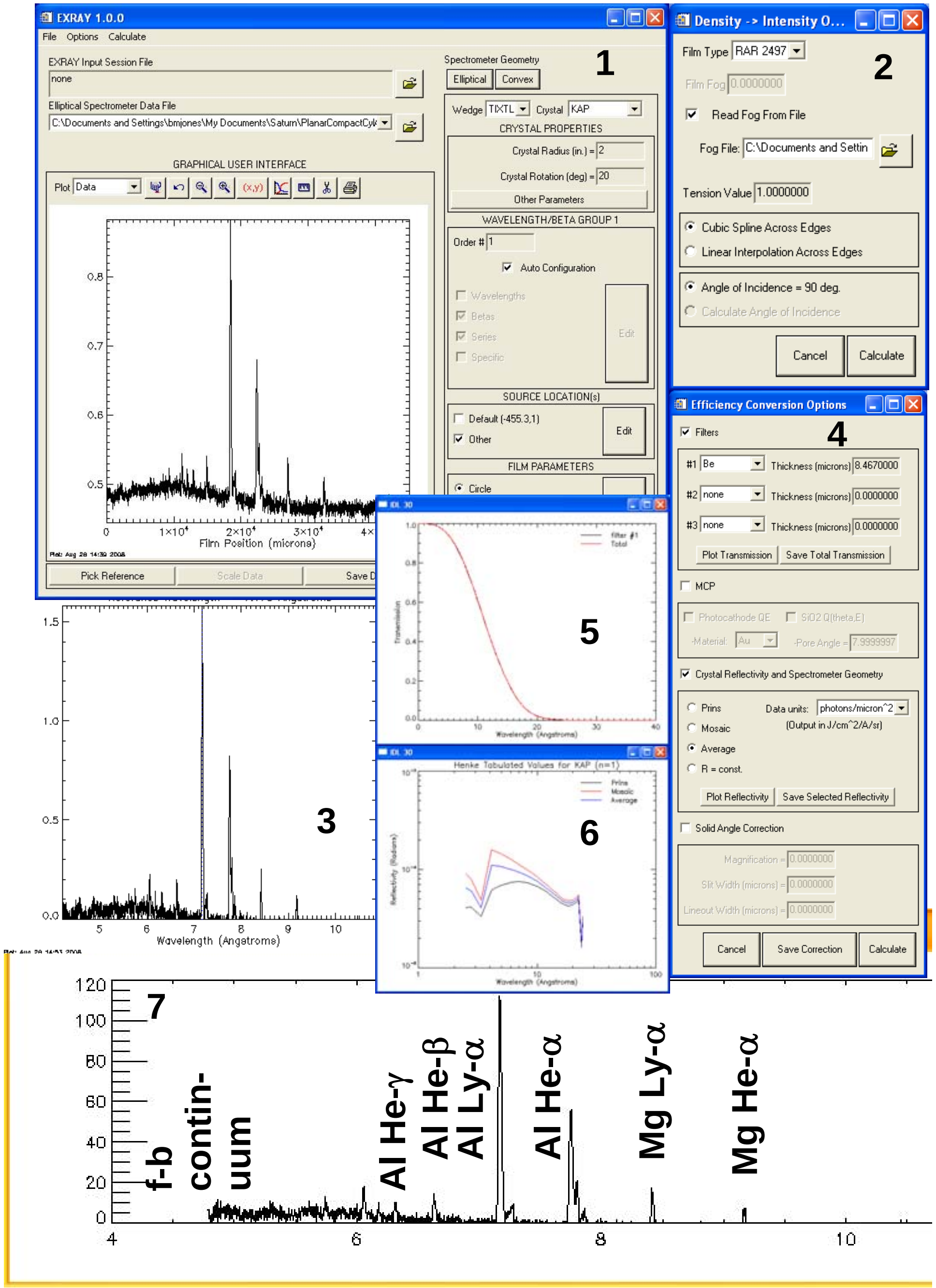
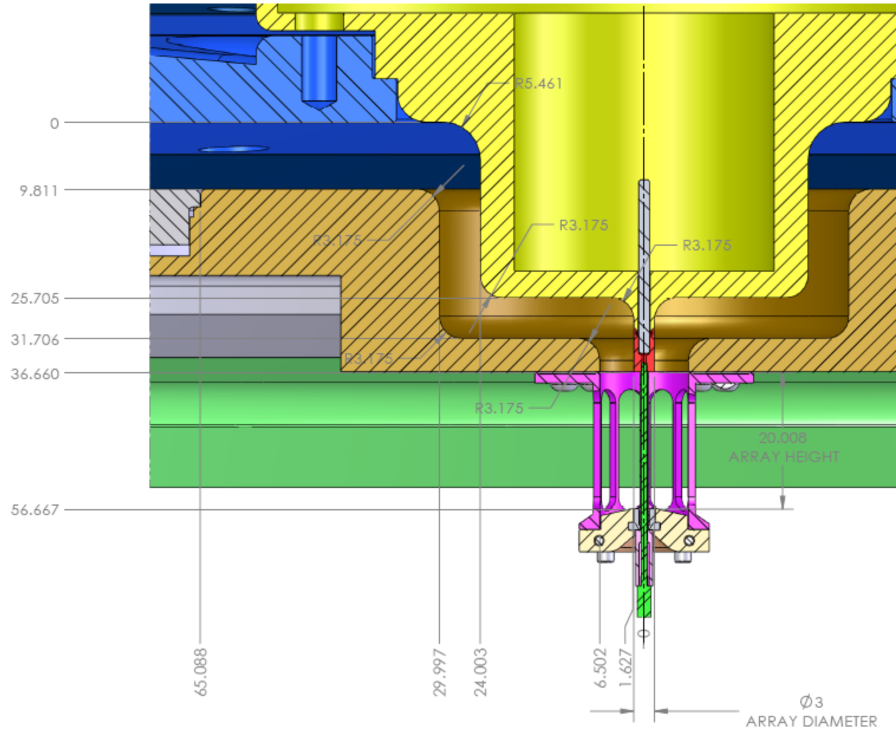
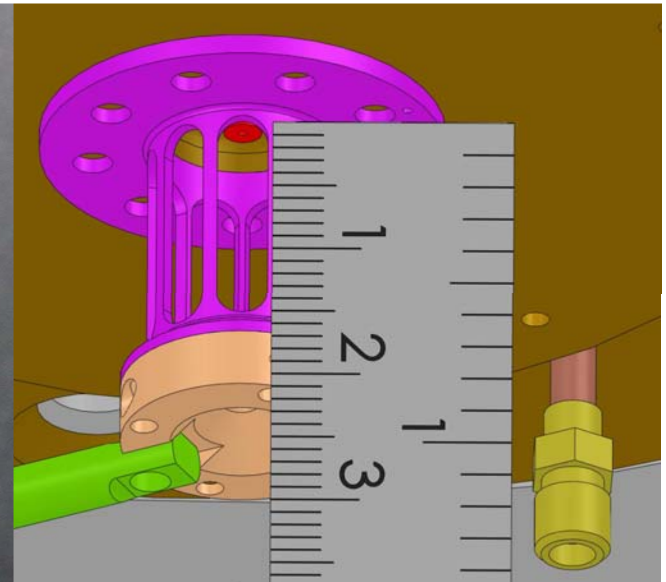
3748 TIXTL processing - EXRAY



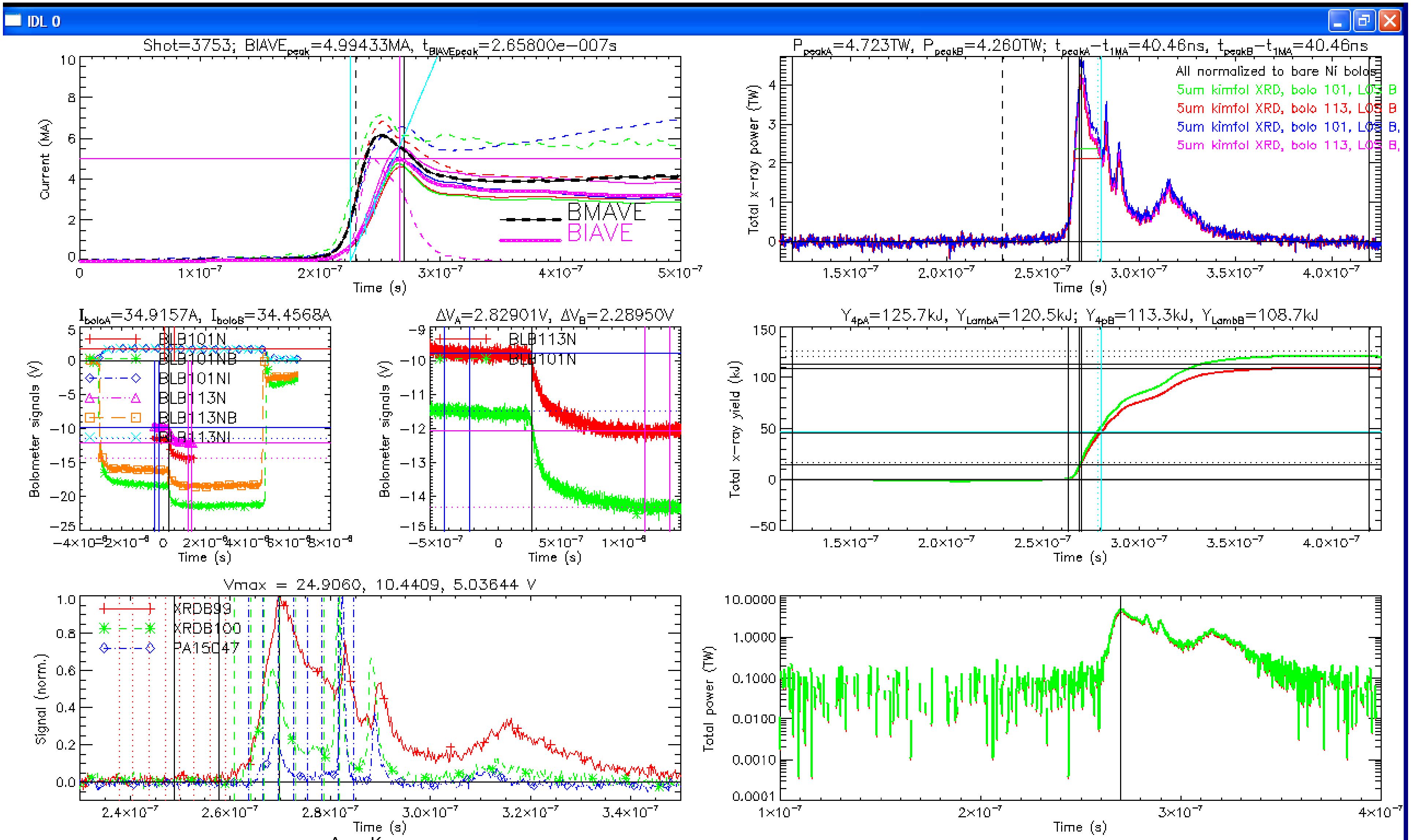
- Wavelength scale (plot 1):
  - Used source distance x=(TOF_Aubolo,LOSB*c+6")*1.5=-638.9,y=1 which should be about right
  - Pick reference: Al Ly-α res, 7.173 Å—Using this line per earlier discussion with Itsic and Jim re: TREX
  - Film distance changed from 8.5 to 8.18 cm to align Al He-α, Mg Ly-α, Mg He-α
  - Saved as 3748tixtl_bottomslitavg_lambda.ufo
- Optical density to exposure conversion (plots 2,3)
  - Used 3748_tixtl_bgd.ufo for film fog subtraction; concern about <0 values at long lambda, but this is much better than doing no background subtraction
  - Exposure in photons/um^2
  - Saved as 3748tixtl_bottomslitavg_lambda_ODtoExp.ufo
- Efficiency correction (plot 4); Rochau says do the following through EXRAY:
  - Filter correction (plot 5): 1/3 mils Be—this is a significant correction at the wavelengths of interest (plot 3) but Rochau says correction will be reliable. Filter transmission saved as file 3748tixtl_filtertrans.ufo
  - Crystal reflectivity: Prins model saved as 3748tixtl_xtlreflectprins.ufo; Mosaic model saved as 3748tixtl_xtlreflectmosaic.ufo. I don't know which is better so for now I am using the average, saved as 3748tixtl_xtlreflectavg.ufo; I need to ask Greg and Jim for advice on what the models mean and what to use, or maybe Alla knows.
  - Intensity units in photons/um^2, but no solid angle correction is implemented—so units are arb. But relative amplitudes should be good.
  - Saved corrected spectrum as 3748tixtl_bottomslitavg_lambda_ODtoExp_EXReffcorr.ufo; plotted in plot 7. This is the final spectrum for comparison with modeling.
  - I don't know why the spectrum was cut off near 5A in plot 7, but from plot 3 the signal to noise is not good in the free-bound continuum region so I don't think I can use those data anyway
  - Strong Mg relative to Al—opacity may be important—not surprising for the fairly large mass of these loads, and the view from LOS C
  - Al Ly-a/He-a ratio is larger than 3688 => hotter? This ratio is probably reliable. I don't like how background subtraction has made lambda>8A have negative offset so I don't know about trusting Mg lines relative to Al.

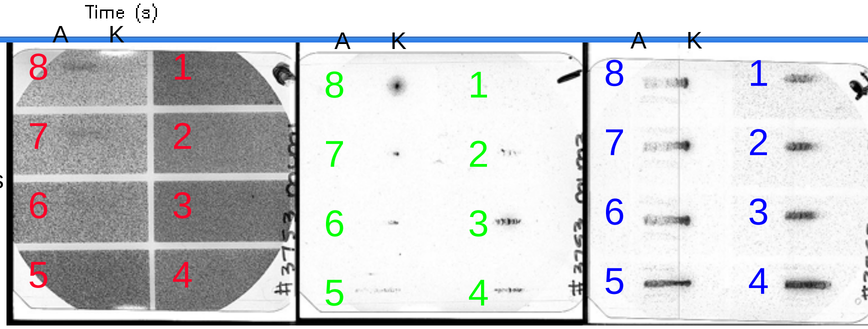
Compact 3 mm dia. cylindrical wire arrays





- On 3 mm shots, bolo has a long tail which may indicate there are a lot of soft photon coming out late in time that are not seen by the XRDs (5 um or 2 um kimfol). We had discussed putting a bare, apertured Si diode on these shots, but ran out of time.
- MLM shows column almost equal in size to the initial 3 mm diameter. Striations likely due to m=0 as seen in Zebra 3 mm laser shadowgraphy. >2 keV photons are also striated—have to analyze to see if we can tell how the images are aligned. Opacity is apparent in all images—looks like we are seeing one side of the pinch only; arcs instead of ovals.
- ~6 TW max power obtained at 4.6 MA. Not as amazing as hoped. Would be interesting to compare scaling with Zebra data. Maybe 3 mm is too small—would be interesting to try 4-6 mm diameter.





MLM 1, 277 eV
MLM 2, >2 keV
MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
MLM2	-300
MLM3	-350

Distance scale corrected for MAG=1/2:
10 mm

Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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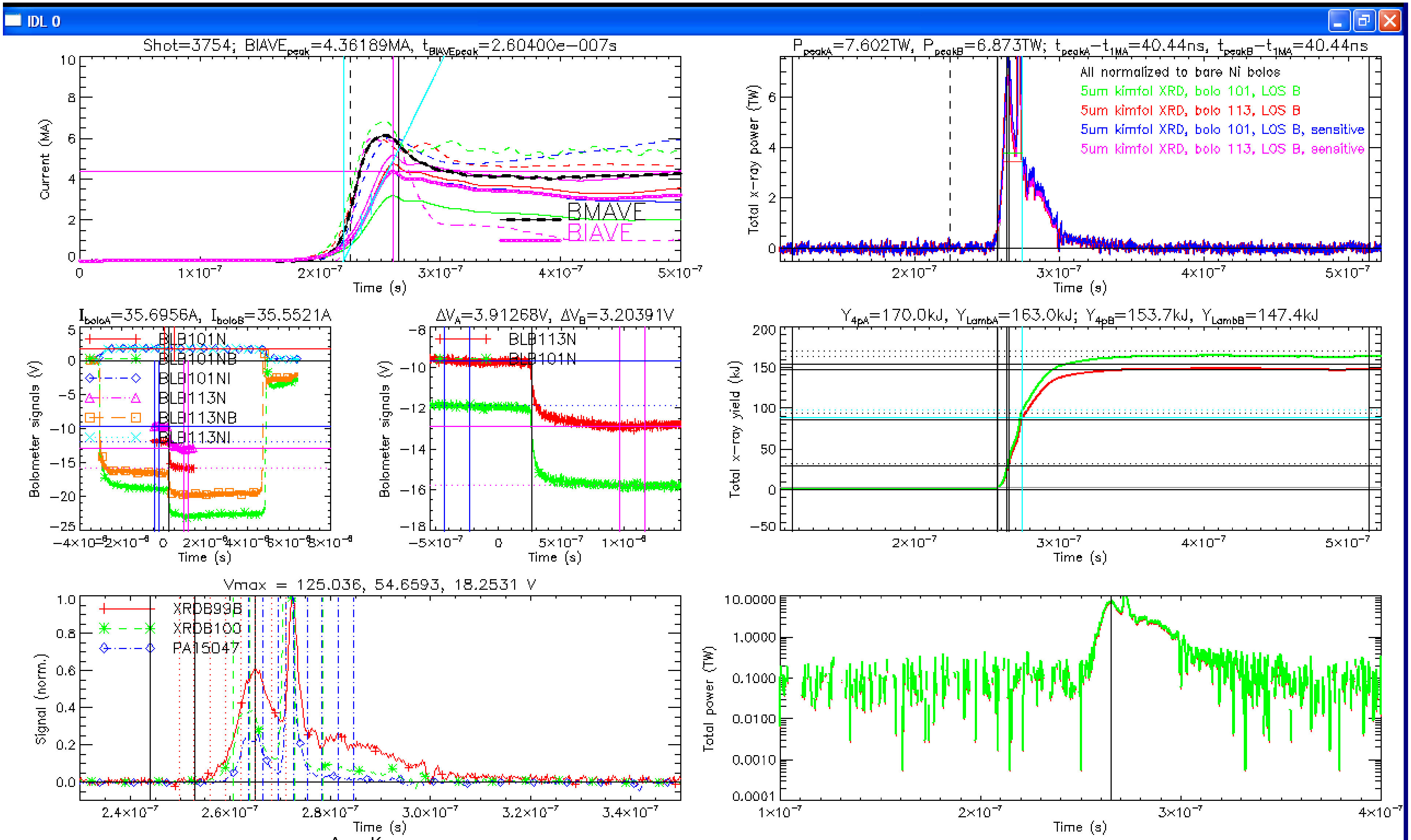

MLM 1, 277 eV
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3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-350
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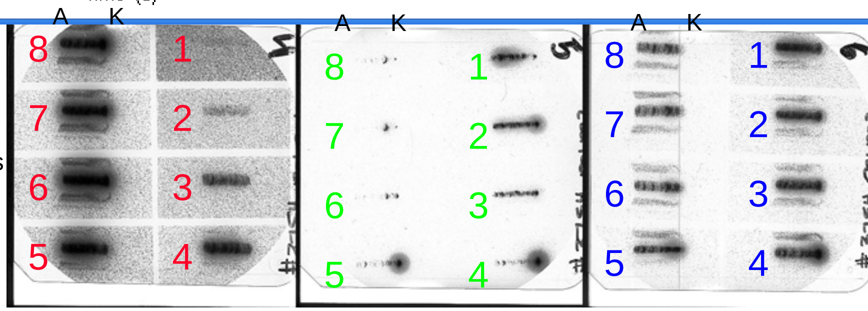
Distance scale corrected for MAG=1/2: 10 mm



Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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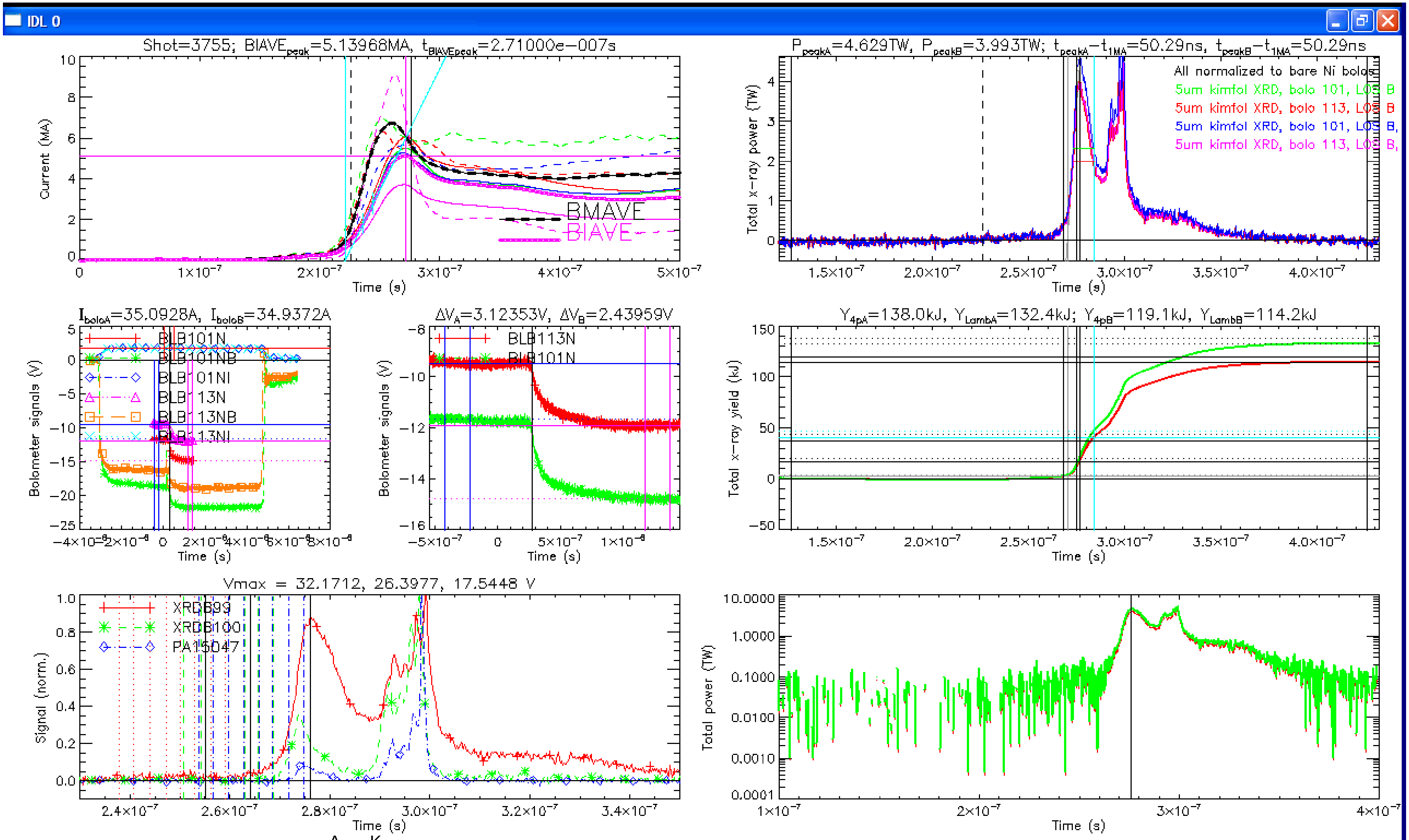
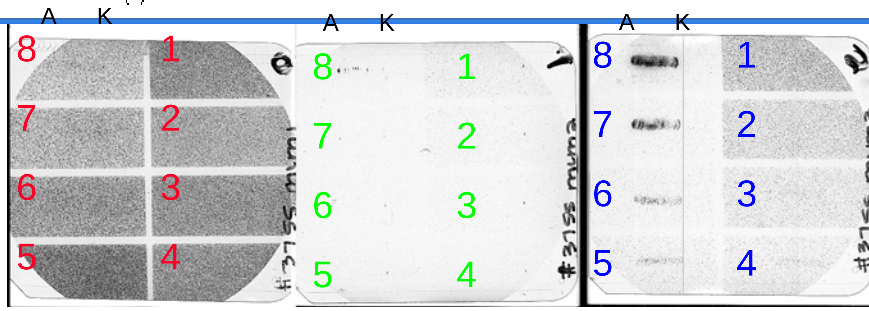


········	MLM 1, 277 eV
- - - -	MLM 2, >2 keV
-·-·-·	MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-300
MLM2	-300
MLM3	-350

Distance scale corrected for MAG=1/2: 10 mm ▬



Recall that MLM1 and MLM3 will have images mirrored in horizontal direction relative to MLM2.

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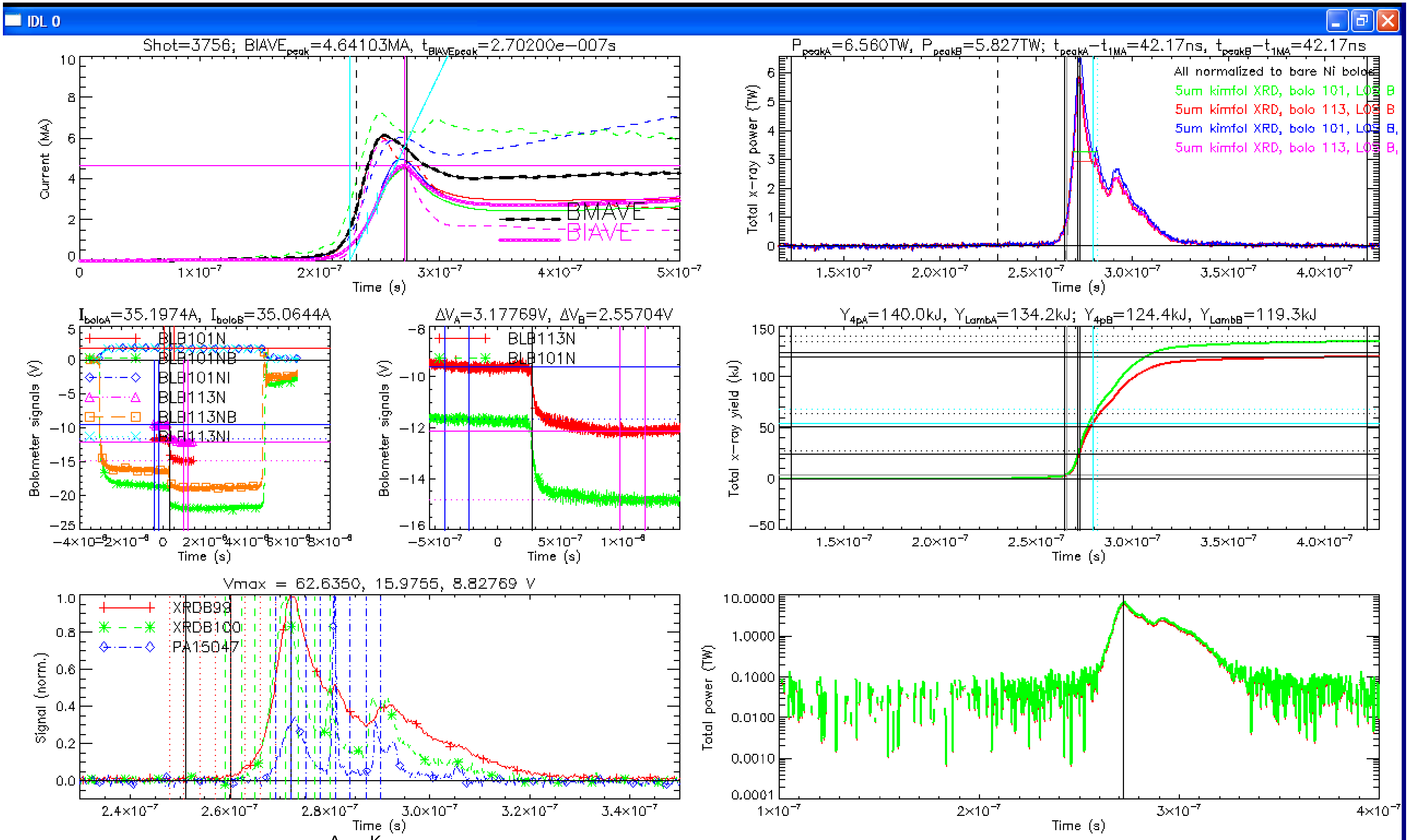


MLM 1, 277 eV

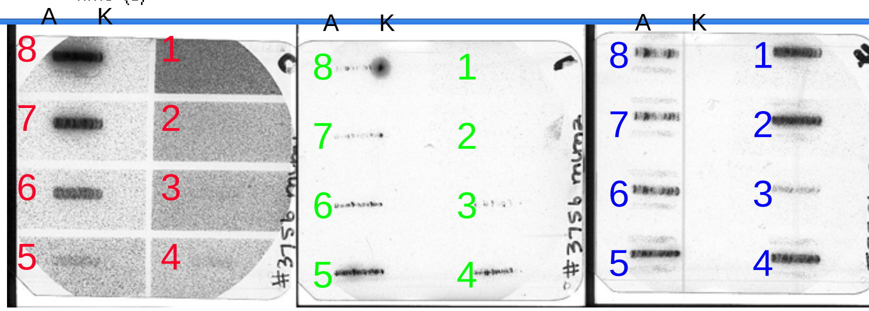
MLM 2, >2 keV

MLM 3, 277 eV

3 ns gate pulse, 2 kV phosphor bias for all cameras. DC bias (V) =

MLM1	-300
MLM2	-300
MLM3	-300

Distance scale corrected for MAG=1/2:
10 mm



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