Radified User's Guide for the Asus CUSL2

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Intro

The info contained in this **User's Guide** for the **Asus CUSL2 motherboard** comes from first-hand experience. I installed a CUSL2 myself (replaced my trusty BH6 + C300a). I got my board when the BIOS was still in beta for 1002. Further insights were gleaned from reading posts at the asusboards.com forums, and also from feedback received from other CUSL2 users.

This guide is intended for people who already know they want the board, especially those who've just ordered one & are preparing to install it. If your looking for a **review**, see here. I've seen the board selling for ~US$135 on Pricewatch.

This is a User's guide, not a hardware review. I'm not testing the board, rather I live with it. So I've included the kinds of things that I'd like to know before installing a new mobo (with a new chipset). Neither is this a FAQ. The only question of concern here is, "How can I get my CUSL2 up & running fast & painlessly as possible?"

You won't find any advertising on my site, so you don't have to worry about minced words. I try to tell it like I see it, not make you read between lines. Since I don't accept advertising (at least not yet), there's no rea$on for me to parallax my views.

I tried to keep this guide slim, but it has grown plump, thx primarily to other users, the world over, for sending the helpful tips they've learned. This guide began as a single page, then slowly grew into **8** pages. It's currently the third most popular destination at Radified. In other words, it went from being a side issue to a main feature. It's especially encouraging that several **first-time builders** have reported successfully assembling their first systems. I finish this guide with benchmarks. (More benchmarks here.)

My system

CPU = P3-700 (cB0, retail) @938MHz (1.80v). 2x128 and 1x256MB, for a total of 512MB, using all 3 RAM slots, Mushkin rev 1.5 PC133 (2-2-2, 7/9T, cannot get 5/7T). Have 3 ATA and 3 SCSI hard drives, network card (3Com 905C), home LAN, 2 soundcards (SB Live Value & CardDeluxe), 2 USB devices (webcam & scanner), burner (Plextor), printer (Epson) & other cool stuff. In other words, not a bare-bones system, which would have less chance of generating conflicts. This is the most stable mobo I've ever used.

Operating Systems

I'm dual-booting WinME/Win2K (actually triple-booting, with WinXP Pro RC1, also called Whistler).

I hear that both Redhat 7 & Mandrake 7.2 have native sppt for the 815e chipset, at least, partial native sppt. I've run both Caldera 2.4 & Mandrake 7, but not with the CUSL2, cuz my Radeon gfx card does not yet have native sppt in Linux (need v4.0x of xfree86). I'll re-install a couple Linux distros once the Radeon has Linux sppt. I also think there's a problem with ATA100 support in Linux (none).

Update 06apr2001: Tried to install MandrakeFreq. No luck. Not sure if it's due to the 815e chipset. Some people at Linuxnewbie think it might be the ATA100 controller & hard drives giving me the problem. I created a primary EXT2 partition (and a Linux swap) with Partition Magic. Drake sees the partition fine, but errors when I try to format it -> An error occurred. Mount failed: No such device.

I tried to install Linux to an IBM 75GXP (ATA100 drive). Supposedly Linux does not support anything above ATA33 without modifying things. Couldn't even exit out of the installer. Had to ctrl-alt-del. Hosed my whole system. Couldn't boot to *any* OS afterwards. Was ugly. Ended up having to restore several images to get my system back.

Support

The CUSL2 has its own website, run by **CrazyJohn**. It used to be cusl2.com, then after he sold the domain name to efront, it changed to cusl2c.com. Now it's asusboards.com. Hard to keep up with the changes. So if you run across some funky links to those sites, you'll know why. Hopefully it won't change again.

CrazyJohn has a bunch of forums there with decent traffic, where you can ask any question you might have. Having a site with forums dedicated to this particular mobo means you have a better chance of finding a solution to any problem you might have, compared to other mobos. That's good, cuz Asus sppt sux. I sent them a few emails, and have yet to receive a single reply. The questions weren't even that difficult. CrazyJohn also has links to plenty of reviews, if that's what you're looking for, or are yet undecided if the board is for you.

CUSL2 vs other 815e mobo's

Personally, I think the CUSL2 is the best 815e option - by a comfortable margin. Word is that the MSI board (815e Pro) is the next best, but they had nothing to market when I was looking, and I've seen reviews where the MSI board had probs with all 3 RAM slots full (see here). In Anand's 815/815e Round-up here, the CUSL2 was the **only** mobo that ran at 133 with all 3 RAM slots full. I read somewhere that Asus is the #1 manufacturer of mobos in the world.

If you like cool stuff, like black motherboards, check out the **Black Pearl** - a special edition version of the CUSL2. I dig black PCB. The Asus announcement, dated 03.15.01, is here. A picture of the board is here (beautiful), tho I still haven't seen a price on this board. Anybody know?

There are two versions of the CUSL2. One has onboard audio, the other does not. When you update your bios, you'll see that there are two different versions - one for each. There's also the CUSL2-C which comes with Intel's 815ep chipset, which lacks onboard video. Since most people use a dedicated AGP card, this is no great loss. I heard of one person who had a prob with the CUSL2-C that did not have the same prob with the regular CUSL2. He had both boards & was able to swap back & forth on the exact same system, & reproduce the prob with the -C version. But I only heard of one such prob, with many happy -C users.

The CUSL2-M comes in the **Micro-ATX** form factor. For those of you (like myself) who might be wondering why someone would want the **micro** version, Jeff Johnson writes to say: I'm building an integrated audio system for my car. My Kenwood deck has rear AUX-in inputs, so hooking up any audio source is easy. The CUSL2-**M** has everything I need already on it: Audio/Video/LAN/USB for $170 shipped. All the prices here are after shipping & tax.

A VIA C3 CPU which doesn't need a fan, just a heatsink, and runs at 667Mhz: $49 with heatsink. 64MB PC133 from Crucial: $20. Maxtor 100GB ATA100 HD: $296. 150W ATX-PS: $49. AC inverter: $30. MatrixOrbital LCD 4x40 display: $138. That means I get over **1,200 hours** (!) of

tunes in my car for $750.

I could do it for under $500 using cheaper parts, but I'd feel more comfortable with brand-name parts and the extra CPU power. That way I won't have a problem playing non-MP3 file formats like MPEG+, AAC, VQF, AC3, Ogg Vorbis, whatever. [Thx for the note, Jeff]

Also heard of a CUSL2-**LS** version, that comes with onboard **LAN & SCSI**, altho I don't have a link to drop. If anyone finds ones, lemme know. The only thing I've found is this. Let's move on to the good stuff.

Set-up Info

WinME has native (driver) support for the Intel 815e chipset. If you try to install the Intel chipset drivers to WinME, you'll get a message that says (something like): This version of Windows already has the latest chipset drivers. Update not needed. W2K does not have native sppt for the 815e chipset - nor does W98/SE, which means you'll have to install the Intel chipset drivers to W2K and W98/SE. You can also get the latest Intel chipset drivers here. It looks like the latest version is 2.80.012 (dated 17may2001).

I installed version .021b. These chipset drivers come with ATA33/66 sppt, but not ATA100. You'll need to install the Intel ATA drivers to get ATA100 sppt (for any OS), but some/many people are having probs with the ATA100 drivers - more on that later (I would wait on the ATA100 drivers).

* Better to install chipset drivers from the hard drive, not a floppy. Installed mine right after clean-installing the OS. Seemed to work good/fine that way. Have heard differing views on the subject, but, normally, chipset drivers would load with OS (like if you install Windows 98/SE to BX board). I think this way has less chance of conflicts. As a side note, after you get everything installed & tweaked just right, image your boot drive, so you can restore painlessly, should you screw something up, and be unable to boot (you know you will). Have a tutorial that will help flatten the Ghost/image learning curve.

* I did not overclock until after installing the OS & most apps. Ran 100/100/33 for most of the install/config.

* **Update** 15mar01: Current chipset drivers are v2.80.010. Heard reports of people having probs with a yellow-flagged **Unknown PCI device**, especially in Win2K. **Ozzie** suggests you install the chipset drivers in safe mode. I didn't do this and had no probs (version 021b).

My friend, **Joshua**, says he got rid of it by removing it & rebooting, and it went away. I skimmed thru the threads, and it seems that you want to install the chipset drivers right after you load the OS, but before you install any PCI to conflict with the chipset drivers.

* Many/most at cusl2.com forums seem to like/use WinME, but caution to do a **clean install** - not an upgrade. I did a clean install, and love WinME. Noticeably more stable (for me, w/ CUSL2) than W98/SE was with my old board (Abit BH6, original v1.0). The WinME user interface comes from Win2K. Since I dual-boot with Win2K, and like (love!) Win2K, I also like WinME.

* But I know people who have installed WinME (clean) to non-CUSL2 mobo, & had probs. So maybe it's only good for those with a CUSL2? I dunno. Not sure why some people (who know what they're doing with a PC) have had probs with ME. All I can say is how it works with my (clean installed, CUSL2-based) system, which is -> schweet. But there are more than a few CUSL2 users who have had probs with WinME & had to revert back to Win98/SE. So if you have probs with WME & the CUSL2, you're not alone.

The CUSL2, and all mobo's based on the Intel 815e chipset are limited to 512MB RAM. This is a limitation of the chipset, not the mobo. I read here (register) that WinME, & all W9x kernels, are

limited to 512MB RAM. I've read that MS has workaround by limiting the amount of vcache your system uses, by editing the system.ini file. I have not tried this myself, as I only have 256MB RAM.

If you definitely know you wanna run 512MB RAM, I'd get two 256MB sticks, as then you'd only have two slots filled. More on chipset limitations with all 3 RAM slots full later. I have 2x128MB sticks, but if I was buying today, I'd get a single 256MB stick.

I tried to migrate from BX chipset (Abit BH6) to CUSL2 without reformatting and re-installing the OS/apps & re-configuring everything. Was not able. Have heard of only a handful that claim to have made the migration successfully without reformatting & reinstalling. General consensus is that, anytime you upgrade to a new chipset, you should reformat & re-install your OS. Altho, if you have a lot of apps, this can be time-consuming.

Mario, aka **Judgementday**, posted a nice step-by-step CUSL2 install here.

Rick, aka **CuWalker**, let me post his system-specific config. If your system looks anything like his, then his settings may (also) work for you. See here.

Copied a post from **Mushkin** tech support & posted it here. It deals with setting up Mushkin RAM. Worth a look. This is why I buy Mushkin RAM. I've never seen any other company get involved in a bulletin board. Mushkin has the best service & sppt on the web.

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Intel ATA100 Drivers

* The biggest problems with this mobo seem to revolve around the new [Intel ATA drivers](#) (which include ATA100 sppt) currently at version **6.10** (posted 05apr2001). Some folks seem to have them working okay, but not everyone. Installing new ATA drivers takes two reboots.

I've had to restore my ([Ghost](#)) image each time with the earlier versions of the Win2K ATA100 drivers. [HD Tach](#) gives horrible CPU utililization scores running WinME with the Intel ATA drivers, but I think (not sure) this is due to a problem with HD Tach, more than the Intel drivers. The guy who writes the code for HD Tach admitted that he needs to update the program, but hasn't had time.

Both WinME & W2K will run fine (maybe better) without the the Intel ATA100 drivers. No single hard drive can yet saturate an ATA66 bus. The fastest drives can barely sustain 40MB/s at the fastest parts of the disk (outer sectors). The [IBM 75GXP](#) (one of the fastest ATA drives) claims to sustain a maximum data x-fer rates of 37MB/s. See [here](#) for an image of a benchmark (HD Tach) of an IBM 75GXP.

update 10mar2001: I installed that Intel **6.10** drivers last night, to both WinME & W2K (created images first). They seem to work fine for me, except HD Tach doesn't seem to like them. It locks on me in Win2K. Haven't tried WinME. Again, I tend to think this is more of a problem with HD Tach. Intel lists known issues & solutions [here](#).

update 05mar2001: Haven't noticed any probs myself, but received a note from **Ken Hilts**, who says: To add to your CUSL2 notes, I've had two problems with the latest Intel ATA drivers (v610 **beta2**):

1.) My CD burner (Plextor 12/10/32 ATAPI) is the master on my secondary IDE channel. If it has a disk in the tray at boot, I get the BIOS message Secondary Master Fails. This doesn't occur with Microsoft drivers, or any earlier Intel drivers. The problem is reproducible and "moves" with the Intel v610b2's.

2.) A couple of games (Unreal Tournament, Deus Ex [based on UT engine?]) won't start cuz they don't 'see' the game CD, even tho it's been inserted, and plenty of time is allowed for spin-up. Again, reproducible and not present with other drivers. [Thanks, Ken]

* Microsoft says W2K has no ATA100 sppt. See [here](#).

* **Warning**: When running the **HD Tach** bench, do **not** put a check in the box labeled Enable write test. At least one person has over-written portions of their data. If you read the instructions that comes with HD Tach (who reads instructions?), you'll see that the Write test is (only) for drives with a single partition, and it will **overwrite** your data.

I tried to perform the **Write** test, but HD Tach wouldn't let me, saying that I had multiple partitions on the drive (which I do). This is another reason why it's always good to have a back-up [image](#) of your boot partition on hand - so you can painlessly restore, within minutes, anytime you have a problem.

* One guy at asusboards.com forum posted benchmarks with various versions of Intel ATA drivers. Some benches looked better with the old, original drivers, but he had no ATA100 drives

(only ATA33 & ATA66). All Intel ATA drivers are (supposedly) backwards compatible.

 So it would be only slightly limited by running at ATA33 speeds. No probs running either ATA66 or ATA100 drives at ATA66 speeds (interface). At the end, I drop links to some benches I've run on both HD Tach & Sandra.

* Microsoft details how to enable ATA66 x-fer protocol for Win2K here (W2K comes with native ATA66 sppt). The Intel chipset drivers you install to Win2K (also) come with ATA66 drivers, but not ATA100 sppt. If you don't do the little registry tweak here, you'll be running at ATA33 protocol. Be extra alert anytime you bust into the registry. I had no prob - worked like magic.

* **update** 09mar2001: Microsoft has a W2K fix for ATA100. W2K does not natively sppt ATA100. This fix will supposedly be part of **SP2**, and MS suggests you wait for SP2, cuz the version of this fix that comes with SP2 will/may receive additional testing. I have downloaded the patch, but not installed it. You can read about & grab the patch here.

* **update** 16may2001: Microsoft posted Service Pack 2 for Win2K. It has ATA100 support. many people are using SP2 with no problems. You can download SP2 (for Win2K) here.

* My understanding is that both IDE/ATA controllers are ATA100-capable, but you need to use an 80-conductor ATA cable in order to get ATA100 performance from your (ATA100) drives. Seems that Asus ships only one 80-conductor (ATA100/66) cable with the board (the one with the blue connector). So if you want to use ATA100 drives on both ATA channels (at ATA100 protocol), then you'll need to buy another 80-conductor (ATA100) cable, which I've done. You can order/buy ATA100 cables (up to 36 inches) here.

* Asus color-codes the Primary IDE/ATA channel with a blue connector - same color as the connector on the ATA100 cable. This should not be interpreted to mean that only the Primary channel supports the ATA100 protocol. It means they only intended you to run ATA100 drives on the Primary channel. Most people run CDROMs or CD burners on the secondary channel, which don't require an 80-conductors ATA66/100 cable. But people like me, who have SCSI CDROMs and burners, use the secondary channel for ATA100 hard drives.

* The second IDE/ATA cable that Asus ships with the CUSL2 is not an 80-pin (ATA100) cable.

* If you have an ATA100 drive and you use an 80-pin (ATA100) cable, your drive's DMA Setting should (automatically) be set to [**5**]. If it doesn't, this might indicate a problem, such as, the drive is not really ATA100-capable, or the cable is not 80-conductor.

* Many (most?) prefer Microsoft ATA66 drivers drivers that comes with their OS'es (W98/SE, WME, W2K), citing lower CPU utilization & better performance. Seems that Microsoft rocks at writing drivers. They perform comprehensive testing before releasing drivers. Once Microsoft gets their hands on the Intel ATA100 driver, I'm sure they will make it work without problems.

* You usually have to go into the drive's settings in the Device Manager in Win98/SE/ME, and put a check in the DMA box, in order to enable DMA transfers, which yield a substantial performance improvement & lower CPU utilization. This is something you definitely want to do. The OS may give you a caution/warning, but if you know your hard drives are DMA capable (all hard drives manufactured in last couple years are DMA capable), then you definitely want to do that. You will need to reboot before the settings take effect.

* Some people are having problems getting ATA33 hard drives running in DMA mode in W2K. In the BIOS, they can't set the drive to anything except for Auto, or DMA [**2**]. They also get horrible HD Tach scores from the drive under PIO mode. They have no such trouble in WinME or W98/SE.

* After installing the Intel ATA100 drivers, the DMA check box disappeared from the device manager. Some say that ATA drives will show up as SCSI devices in the Device Manager after

installing the Intel ATA100 drivers, and that this was normal.

Latest Intel drivers [here](#).

* Traded a few emails with Greg Smith, who makes HD Tach. He says HD Tach supports both WinME + Win2K, but they're "seeing a lot of issues with the Intel driver and various software/hardware. The worst issues are with the W2K version of the driver."

Adrian has written to tutorial on how to enable/ensure DMA transfers in Win2K [here](#).

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* Earlier bioses have probs with temperature readings. I use 1006 final. My CPU temp responds appropriately (climbs fast) when Prime95 starts. Depending on ambient temp, my CPU (as measured by Motherboard Monitor 5) reads 90-100 F at idle. Climbs steadily to ~120 F within a few minutes after Prime95 starts. So it seems to be responding correctly. I have a P3-700 @ 938MHz (1.80v) with a Golden Orb, military-spec thermal paste.

* MBM can also monitor mobo/case temps. Mine reads between 80 & 90 F while the PC is running, depending on ambient temps. This is the first mobo I've owned that has any CPU temp readings at all. I set-up MBM to display both case ambient & CPU temps in my system tray (lower right), with bright-yellow backgrounds. MBM**4** is not recommended for the CUSL2, only MBM**5**.

* (updated 28jun2001) MBM_508 is out.

* Best way to update your bios is by loading the **Set-up defaults** both before and after flashing the bios, and that you should use the DOS flash, and that you should boot to DOS using a DOS boot floppy. You should execute the **aflash** from your hard drive, not your floppy, cuz floppies are less reliable.

But you also want the aflash utility and bios on the floppy, too - in case something goes wrong, and you can't get to your hard drive (be prepared for anything). Boot floppy should contains nothing but Command.com (92kb). IO.sys (217kb) & msdos.sys (& aflash.exe + the BIOS itself). See here for some files you might need.

* I would flash to latest release bios (currently 1006) before installing Windows. Can't think of any reason why you wouldn't want to. Most of the beta bios'es that Asus Germany has been releasing are good. Asus Germany has been cranking out bios'es versions faster than MacDonald's burgers. Nice to know we have good support.

* Asus supplies a temp monitoring system of their own, called Asus PC Probe, but I don't use it. I use Motherboard Monitor instead. Many use PC Probe. I am not familiar with it & will not comment, but have received a message from Dferg who says that the latest version of PC Probe works fine with all bios versions.

* updated 10/24 - Asus kicks up the +3.3 voltage to 3.4v (by default). Supposedly they do this for extra stability. Mine reads 3.48v (ave), and 3.54v (max). Page 21 of the manual details jumper settings that you can use to set your 3.3 voltage back to 3.3v, or up to 3.6v (default is 3.4v). Thx to UncleJoe for pointing out the I/O voltage jumpers.

* Lots of folks complaining about probs with SB Live & Live Value. Dang soundcards. Some say they conflict w/ Intel's new ATA drivers. I have both the SB Live Value & a CardDeluxe w/ no probs (two soundcards). Choose the PCI slot for your soundcard carefully, especially if you have a Live. My Live Value is in PCI slot #3, which shares its IRQ with the 2nd USB controller (see page 28 of the manual for IRQ settings).

Once I disabled the 2nd USB controller (not needed for me), all my weird probs went away. Others have had similar experiences. I have two USB devices - an HP scanner, and a ViCAM webcam (to talk to grandma with it).

Creative's FAQ says: **Q**: During the installation of Liveware 3.0 (web), I am prompted for joystick drivers, which cannot be found. What should I do?

A: This problem occurs only in Windows 98 (2nd Edition) with ACPI enabled. Click the Skip File button when prompted for the drivers' location and continue with the installation. You may have to do this twice.

Also this **Q**: Since I installed the Sound Blaster Live! 5.1, I can't get Hibernate to work in Windows Me.

A: The drivers that are included in the Live!Ware3 for Windows Me are .vxd drivers. The use of the Hibernate function in Windows Me requires the use of .wdm (Windows Driver Model) format drivers. Creative will be releasing a new version of CreativeWare in the future that will feature .wdm drivers for both Window Me and Windows 2000.

Paul from Connecticut reports: this one drove me nuts for a day. Installed everything but SCSI card -> no conflicts. Installed Adaptec 29160 -> conflicts. Removed 29160 and installed 2940 -> same conflict. Removed SB Live 5.1 Platinum, installed 29160 -> no conflicts. Installed SB Live 5.1 Platinum -> conflict returns. Could not move SB Live 5.1 from IRQ9. SCSI insisted being on IRQ9.

Solution: I disabled COM2 (COM2 not used anyways, keeping COM1). Forced IRQ on BIOS for slot with SCSI Card to IRQ 3 (SCSI home of Zip drive & scanner, non-priority). Reboot -> SB Live 5.1 moved to IRQ10, Adaptec 29160 shared with USB on IRQ3, and I have this "SCI used by ACPI Bus" all by itself on IRQ9. Magic, but it did worked. ACPI has been problematic for SB Live 5.1 on Win98SE, as noted on Creative website with incompatibility with Gameport (I can feel the finger-pointing already). Thanks Paul.

* Disable 2nd USB controller in the Device Manager -> Rt-click My Computer -> Properties (in W98/SE/ME) Manage (in W2K) -> Device Manager -> (near the bottom find) Universal Serial Bus Controllers -> Rt-click on the 2nd Universal Host Controller (in W2K now, might be diff in W98/SE/ME) I think it's number 2444 -> select Disable -> should get a red X. Shouldn't have to, but I'd reboot anyway. If you're dual-booting, you'll need to disable in both OS'es.

* I have 3Com 905C NIC in PCI slot #1, Tekram U2W SCSI adapter in PCI slot #2 (PCI slot #2 doesn't share an IRQ), Live Value is PCI #3 (this slot shares with the 2nd USB controller, which I had to disable). Slots 4 & 5 are open, CardDeluxe (pro sound card) is in last PCI slot (#6). Radeon DDR (32MB) in AGP slot (1280x1024x32). Working nice for me.

* If you don't have a USB mouse or keyboard, disable Legacy USB sppt in the bios. It is enabled by default. This was one of the first tips I read about when I found cusl2.com forums. Nobody said why, but it makes sense if you're not using it.

* Heard of one person not being able to access CD-ROM on secondary channel before loading OS, and chipset drivers. Solution was to slave out CD-ROM on primary channel, load OS + chipset drivers, then move CD-ROM to secondary channel. Sounds weird, but I've seen weirder.

The Intel 815e chipset is limited to an AGP aperture of 64MB (BX was 128). This limitation applies to the CUSL2 only cuz it uses the Intel chipset. You can read more about it here (pdf) .. see **page 49** of 172 .. refer to **bit 25**. Also, from a review at Anand's here:

"The last little trick Intel has managed to pull on us with the i815 chipset is to limit the AGP Aperture size to a maximum of 64MB. We've seen settings of 128 or 256MB on i440BX and VIA 133A motherboards, and it once again seems like Intel is doing this intentionally to cripple the i815. That means your graphics card cannot use more than 64MB of system memory for AGP texturing, but fortunately, we've yet to see a performance loss due to this limitation. And we most likely won't in the near future since AGP texturing is simply entirely too slow. So don't blame your motherboard when you can't set this higher than 64MB, blame Intel."

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* Disabled both Serial Ports 1 + 2 in the bios (under I/O Device Configuration) if you don't use the serial ports (I have Cable modem/NIC). If you have a dial-up connection, you'll need to leave at least one enabled.

* Check setting for Primary VGA (under PCI Configuration in mobo BIOS). It should be set to AGP Card if you have one.

* (updated 10/14) Heard rumors of probs running PC133 RAM in *all* (3) RAM slots. I use all three slots (128+128+256MB) at 133MHz. No problems. Some claim PC133 ram will run at PC100 speeds when you fill all 3 slots. Do you remember the embarrassing problems Intel had with a 3rd RAM slot/stick on their 820 chipset mobos? Some parts of the 815e chipset may be derived from the 820, which may introduce similar probs (?).

* I heard that Asus did some special stuff to the board to be able to get all 3 RAM slots to run at PC133.

* So 256MB sticks of RAM would probably be a better idea than 128MB sticks. Many say they run 3 sticks of PC133 just fine. But the chipset itself may be the source of these probs, cuz the review Anandtech did here, says ALL 815e boards had probs when all 3 RAM slots were filled (except the CUSL2!). Cicada says the prob stems from a limitation of the Intel chipset, involving signal-to-noise ratios (that's what I heard, too).

* Seems that Mushkin, Crucial, and perhaps other memory/RAM manufacturers, sometimes set the SPD on their 2-2-2 RAM to default at 3-3-3. They do this for reasons listed here. Bottom line is that you might need to go into the BIOS & manually set your CAS2 RAM (if you have CAS2 RAM) to 2-2-2. I know this is true for the Mushkin rev1.5 sticks, but I think the SPD for rev2 is set to 2-2-2 by default. Mushkin says they will set the SPD on their new rev3 sticks to 2-2-2.

*The board max'es out at 512MB RAM - so, again, a 256MB stick might not be a bad idea (3 x 128 = 384, which is <512).

updated 10/24 - Page 28 of the (original) manual details IRQ assignments. I originally thought that PCI slot 2 was the only slot *not* shared, but UncleJoe informs me that PCI slot 6 is also not shared. It *says* shared, but lists no other devices shared with it. I put my SCSI adapter (Tekram DC390-U2W) in PCI slot #2, cuz 2 doesn't share. UncleJoe says it would be better in PCI slot #1, cuz there it would receive PCI priority mode (whatever that is). PCI slot 1 shares with slot 5. UncleJoe advises simply not to use PCI slot 5, which I don't (no need yet).

PCI slot 3 shares with the 2nd USB controller. I disable the 2nd USB controller in the device manager. This made some problems go away for me. If you have probs with the device you have in your 3rd PCI slot, I would try disabling the 2nd USB controller, and see what happen. Other people seem to eliminated serious conflicts/probs by disabling the 2nd USB controller (in Windows Device Manager).

* Disable both AC97 onboard sound & video (in mobo bios, under I/O Device Configuration) if you're not using them. Default is Auto.

* I had problems getting my Golden Orb heatsink/fan to fit properly. There's a group of about 7

tall capacitor caps near the socket 370, which got in my way. Others say they mounted the Gorb with no problems, but I had to bust out a metal file, and file off about 3/8ths-inch off the Gorb. It's aluminum and files easily.

I also had to use a lot of torque (twisting force) to lock the Gorb in place. I was almost going to give up on it (not wanting to break/snap something), then, tried once last time, and it locked in place. Others have complained of problems mounting the Gorb. A few sent emails saying they had the same prob. Some said they installed their Gorb without any probs, but I'd find another heatsink solution for the CUSL2.

* The Gorb cooled only marginally better than the Intel supplied Retail heatsink & fan (2 or 3 degrees F). The big boys & serious overclockers are using Alpha heatsinks, but they're not cheap. If your 100Mhz FSB CPU is *almost* stable at 133, may wanna try an Alpha for max cooling/stability. Many are getting there with stock Intel heatsink/fan.

* 133 FSB runs at 134MHz. This is normal. A P3-700 set to 133 (really 134) will run the CPU at 938 as per both Motherboard Monitor & CPUID [not 933 like you may expect - bank error in your favor =)].

* Leave Plug & Play OS set to No, even tho Windows **is** a Plug-n-Play operating system - especially if you use W2K. Microsoft recommends this [here](). Had probs when I set PNP OS to Yes.

* Notice also that MS says IRQ9 will get lots of work in W2K. I have 5 or 6 things assigned to IRQ 9 in W2K. This is normal & I have no problems with this - altho UncleJoe says it's far from optimal for performance users, especially gamers. Personally, I don't game in Win2K (that's what I have WinME for).

* I disable SB16 support for my soundcard in the device manager of WinME. You will lose DOS sound, but this saves an IRQ & resolves problems for more than a few folks. I don't have any apps/games that need/use DOS sound - never had. Update -> seems that there are still many DOS gamers out there. Got a bunch of notes saying, "Rad, lots of us still play DOS games & there's a fix for the SB16 emulation prob" I think this is the fix, as posted by Johnnie:

Go into:
System Properties -> Device manager
open Creative Misc Devices
then on SB16 Emulation
Click on LPT Port Sharing.
WindowsME doesn't have this enabled by default, but enabling this will fix all problems

Creative has released new driver for WinME, but I read of conflicts with new drivers and probs with 'hibernate' function. Best to check before installing.

If you set the User or Supervisor passwords in the BIOS (I don't), and forget them, page 57 of the manual details how to shunt the jumpers to erase the CMOS real-time clock RAM (RTC-RAM), and reset the passwords. Thanks to Leo Burkey for pointing that out. He flashed his BIOS & couldn't boot afterwards. Didn't load set-up defaults. No clear reason why no bootage.

Update: Leo wrote back to say the reason he had probs flashing is that he didn't unzip the BIOS file. Yes, you need to unzip the (compressed) BIOS first Apparently the Aflash utility gives a message Bios successfully flashed, when using the zip file, but then users get problems. Leo said there's quite a few who have made this mistake.

If I had probs after flashing, that I couldn't resolve, I would try pulling the power cord from the PSU, and yanking the lithium battery - about the size of a dime. Legend says that, if you kiss it (the battery) for good luck, your PC will work on the next boot. Don't forget to disconnect and

(later) re-connect the power cord to the PSU. This has work for me once, on an Abit board. I have not had to yank the battery on the CUSL2 (knocks on wood). There's a site named badflash.com where you can get a new BIOS quickly sent to you. See here.

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* Current BIOS is **1006_Final** (released 02.24.01). I am using this BIOS with no problems. Each bios seems to be a little better. Can download latest release version of the BIOS here (have to scroll down the page). Somebody told me 1007 was the latest final, but at these sites, it says 1006.

* Asus has a new bios flash that lets you flash from Windows. I have not used this utility myself, but those who have, have reported no problems. I am from the old school on flashing your bios - which says to do it from (true) DOS. Doctor **Mike** from Greece is asking about the Live Update thing - says he gets the error: "File BS_LOAD.DLL missing" and the program exited. I have not used. If anyone has an answer/solution …

* You cannot use a Slot 1 CPU with this mobo (should be obvious).

* Many people have been having problems with their IDE burners, especially with the new Intel ATA drivers. I have a SCSI burner (Plextor) and have had no problems. This is one of the biggies. It's my understanding that people who don't install the Intel ATA drivers are not having probs with their burners.

But I don't have IDE burner, so if you do have - you should check more carefully - post a Q at forum and ask about best config of your particular burner (brand/model) & primary/secondary, master/slave config. My understanding is that, if you don't install the Intel ATA100 drivers, you won't have probs with your IDE burner - not absolutely positive, but pretty sure.

* Some people have complained of shutdown problems. I've had no probs w/ shutting down. An interesting note from **Paul** (Connecticut), who reports: I am running a Plextor 12/10/32 EIDE (W98SE). I have observed (reproducible) that if I leave a CD in the Plextor drive, it will hang on shutdown. Remove CD, and it shuts down fine.

* updated 24oct2000 - There is also the infamous cold boot problem (CBP) that resets your CPU voltage back to default (1.65) during cold boots - or at least that's how I understand it. I don't have this problem. I set my CPU core voltage to 1.80v, and that's where it stays. **Cicada** says we should refer to this as the default core voltage on cold boot problem, as there is much confusion + misinformation on the subject.

Not sure if this in some way stems from having all 3 RAM slots filled with PC133 ram. Since I don't have this prob myself, I (quite honestly) haven't researched it much. I did read one post, however, that said someone fixed the prob by cranking up his voltage. If you know more, lemme know. I will copy-n-paste what cicada has said about it:

On a cold boot, the CUSL2 does NOT apply the manual voltage setting for the processor until after a successful POST (after the BEEP). This is only a problem when over-clocking your CPU to it's upper limits, as the default voltage may not be enough to make a successful POST. There is currently NO FIX for this (apart from modifying the processor pins) and EVERY CUSL2 does this on cool boot. It's as simple as that.

Props & thanks. So it seems like you have to crank your CPU back (fate worse than death for overclockers), or get new one.

* **Guillermo** writes: I'd like to add a comment on the CBP .. and I must point out that I do not know the exact thread, but I've read this on the cusl2.com site, but it seems to be a **BIOS** problem. This usually happens when you change the FSB and voltage in the same session, then reboot.

The solution is to first change **voltage**, and reboot, let the system boot normally to windows. Then change the **FSB** (in a separate session). This workaround also seems to work for people having probs changing memory settings. Some say bios version 1003 beta 4 solves the cold boot problem, while some say it won't. I hope this helps overclockers.

Update 03mar2001: **Eric** writes: I have the infamous core voltage problem on cold boot, related to trying to overclock a Cel_566. As you may be aware, some sites encourage the use of a thin copper wire to fool the motherboard into cold booting at a higher voltage. But this risks blowing up the CPU.

I've found a way to bypass this problem, using the Suspend-to-RAM feature. It is not optimum because it involves spending a bit more in electricity costs, but I find it easier and less frustrating than having to shut down the power supply at the back of my computer every time.

The CUSL2 includes a feature called Suspend-to-Ram (enabled in BIOS). You need a compatible OS (W2K or WinME) & RAM. In fact, with the new BIOS version (1006), you can go straight to the BIOS, and enter the settings (both Vcore & bus speed) at the same time. Then, from the OS (W2K or WinME), when you are finished with your system, simply select **Stand-by**.

Then the computer will turn off almost everything, except power to the ram (hence the small extra electricity cost mentioned earlier). When you wake up the computer, it won't POST in the BIOS, and the (over-clocked) CPU settings will remain intact. Off course, I'll reboot once in a while .. but at least I don't have to crawl to the back of the power supply, or make change to the BIOS. Surely some people are doing the same, but I've never had a board with Suspend-to-Ram before, and I find it a much more secure way to overclock my system. [Thx for the note, Eric]

* The CUSL2 will let you run your CPU at FSB 133, with your (PC100) RAM at 100MHz. Pretty cool if you have PC100 RAM and don't want to buy new (PC133). Most heavy hitters are using [Mushkin](#)'s rev 2 stuff, for getting the highest RAM perf. Highest RAM perf comes from setting RAM timing to 2-2-2, 5/7. I run 2-2-2, 7/9. Heard the 1st number (**X**-X-X) makes biggest diff. In other words **2**-2-2 will run much faster than **3**-2-2 (all number don't have to be the same) than going to 3-**2**-**2** from 3-**3**-**3** (which doesn't do jack for performance). Biggest diff comes from going from 100MHz to 133MHz.

* Heard some say that same PC100 ram that will run at 133 on BX, won't run at 133 on CUSL2. This would not surprise me.

* Received a few notes asking about NT with legacy devices. Since I have neither, I can't comment. But if you know of any probs/solutions, I'd be glad to post.

* Word on the street is that Windows Media Player 7 is the worst part of WinME. You can get around using Media Player 7 cuz most don't know that WinME also comes with MP6.4, and can be used over the sucky MP7 by:

Open mplayer2.exe from C:\Program Files\Windows Media Player. Go to view > Options > Formats & select all file formats that you want to associate wmp6.4. From then on, all files that you select will open with wmp6.4. (Thx to SkyPilot for that one)

* Daniele wrote to say that AGP4X kicks back to 2X at FSBs >140. True for anyone else?

* AFAIK Redhat 7 is the only Linux distro with native sppt for the 815e chipset. **Arvidjaar** recommends waiting for Mandrake 7.2, citing Redhat 7 bugginess. Sounds smart to me.

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Post from Mushkin Tech Support

I have permission from **Bill Mushkin** to post these.

Copy-n-paste here:

The reason your motherboard is reporting the REV 1.5 module as 3-3-3 is because we program the SPD's for all of our CAS2 modules to run at CAS3 by default when the memory timings in the BIOS are set to automatic. We do this because there are a lot of other BIOS settings that can interfere with SDRAM running successfully at CAS2.

If we didn't set the SPD to default to CAS3 we could be inundated with calls because it is harder for our less technical customers to get there motherboards to run as stable at CAS2 than it is when memory is run at CAS3. This could result in increased prices because of the cost of adding staff to help with the increased amount phone calls, and possibly a temporary decrease in customer service standards. If the customer doesn't know how to manually set the BIOS timings, then we think it's best for them to temporarily run there computer at more conservative settings until they become familiar with there motherboards BIOS and there computers stability. This is because the amount of frustration caused by the possibility of having an unstable computer far outweighs any performance difference.

For customers who aren't familiar with there motherboards BIOS, I would suggest the following links:

(WinDrivers BIOS Center)
(Adrian Rojak Pot's BIOS Optimization Guide)
(BIOS Survival Guide)
(BIOS Tweak Guide)

I just want to make it clear that we are not selling modules advertised as CAS 2 that only work at CAS 3. Our CAS 2 modules can be run at CAS 2 but they have to be setup to do so manually through the BIOS. In some motherboards setting the CAS timing to 2 when the modules SPD is programmed for CAS 3 will result in a warning message at bootup that says "SPD settings recommend CAS 3". This will not affect stability or performance and can be safely ignored. And having to set the memory timings manually won't detrimentally affect performance either.

The REV 1.5 modules have been tested to be compatible with the ASUS CUSL2. Unofficially, I have gotten three REV 1.5 at a time to work at 2-2-2 on the ASUS CUSL2. But for anyone looking for more than 256MB, I would suggest our 256MB REV2 modules as Intel doesn't support running all three DIMM slots at 133MHz. There are a few reasons that the REV 1.5 might not be working but lets start by double checking your BIOS settings.

Under the 'ADVANCED MENU' choose 'CHIP CONFIGURATION' and set:
* SDRAM Timing: [User Define]
* SDRAM CAS Latency: [2T]
* SDRAM RAS to CAS Delay: [2T]
* SDRAM RAS Precharge Time: [2T]
* SDRAM Cycle time: [6T,8T] or [7T,9T] - Depending on which BIOS version you have. After you verify that your system is stable try [5,7], but that may or may not be stable.

* SDRAM Page Closing Policy: [All Banks] - After you verify your computer as stable, move to [One Bank]. This setting will only slightly affect real world video performance in 3D games, although you can ignore this setting if you are only using an external video card.
* Command Per Cycle: Disabled - After you verify your computer as stable, move to [Enabled]. This setting will only slightly affect real world video performance in 3D games, although you can ignore this setting if you are only using an external video card.
* SDRAM Data Driving Mode: [Normal] - Change to [Strong] if you have instability problems, especially if you have multiple memory modules installed. If it is set to [Strong], and you are having problems with one or multiple memory modules, change this setting to [Normal]

Also, make sure that the I/O voltage jumper on your motherboard is set at its default of 3.4V. If none of this helps, you may want to try a lower or slightly higher voltage.

* * *

Tech Support
Mushkin, Inc.
www.mushkin.com
1(800)569-1868

Here's another post from Mushkin sppt:

The i815(e) chipset based motherboards only officially support "a maximum of 2 double sided or 3 single sided DIMMs when the SDRAM interface is operating at 133MHz. Upon detection that additional rows are populated beyond these configurations, the BIOS must downshift the SDRAM clocks to 100MHz through a 2-wire interface of the system clock generator.". This is quoted from page 18 of the Intel i815 chipset datasheet available here (PDF).

So supposedly you can only use two 128MB REV 2 modules at a time without the motherboard automatically reverting to 100MHz. However in my experience, motherboard manufacturers aren't following that rule of reverting to 100MHz, and you can install 3 double sided DIMMs. But don't take my word for it, I would suggest following Intels suggestion even though some people may notice no ill affects.

So I would suggest avoiding three 128MB REV 2 modules and would instead suggest getting 128MB REV 3 modules since they are single sided and allow you to install 3 modules while still following what Intel officially supports. Or you could get two 256MB REV 2 modules which are double sided. The 256MB REV 2 modules will allow you to achieve the maximum amount of memory that the i815 chipset supports, 512MB. As opposed to the REV 3 128MB modules, where you'd be limited to 384MB.

* * *

Note that Mushkin now sells 256MB high-density sticks here, where it says, "This module uses high density IBM chips to create a single sided 256mb module. It is perfectly suited for users of the Intel i815E chip set which puts a limitation on the number of "banks" or "sides" of memory the system can use."

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System-specific configuration

Thanks to Rick, aka **CuWalker** (North Carolina)

If your system looks anything like this one, then perhaps these settings/configs will (also) work for you.

Following settings have worked best for me:
WinME Fresh install
V5 5500 (v1.04 drivers)
SB Live w/ new drivers for WinME + Liveware 3 (latest)
D-Link 10/100 NIC (WinME default drivers)
P3-700 @ 805
256MB PC100 RAM using all 3 slots (2 64's & 1 128)
KDS VS-195E 19" monitor (WinME default drivers)
HP 882C Printer on USB (drivers from HP CD that came with the printer)
Logitech Wireless KB & PS/2 mouse (Mouseware 9.0)
Microtek X6 EPP scanner (latest Microtek drivers)
NO i815 drivers installed except ones that come with WinMe
NO Intel ATA drivers installed except ones that come with WinMe
DirectX 8
IE 5.5 SP1 & MSN Explorer 6.0
Office 2000 SR-1
Crap load of games (Everquest, Q2, Q3, UT, NFS, Solitaire .. LOL)
System runs 24-7 with only minor bugs (knock on wood)

Settings I changed in BIOS

BIOS = 1003 Final
PNP OS = No
Sound (SB Live) = PCI Slot 6 and set manually to IRQ 3
COM 1 = 03F8, IRQ4
COM 2 = 03E8, IRQ4 (or disabled) they will NOT cause a conflict & it saves an IRQ
LPT = EPP, IRQ7
Reserve IRQ 7 and 4 in the exclusions list
Legacy USB = Disabled
Suspend to RAM = Enabled
Power up by USB = Enabled
All Shadowing = off
ECC CPU Checking = Enabled
Keyboard power on = CTRL+ESC (creates a higher wake signal than one key or mouse)
Video off method = V/H Blank (think that's what it's called .. I know its not DPMS)
AGP = 2X (why ask for more problems until 4x is even needed - 4X is not worth the headache yet)
If I left anything out let me know.

Leave Hibernate settings alone in Windows (all versions). CUSL2 does not support that type of hibernate (suspend to disk) in power management applet.

Been running with this config for a while, without any major probs. Everything works.

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Benchmarks

Sandra memory scores (2x128 Mushkin rev 1.5 PC133):
PC133 3-3-3 7/9T ALU/FPU: **323/363**
PC133 2-2-2 7/9T ALU/FPU: **380/445**

Notice the ~20% improvement in memory scores between 3-3-3 & 2-2-2. I am unable to set 5/7T with my Mushkin rev 1.5 memory. Largest perf increase comes from running RAM at 133MHz (compared to 100MHz). Next largest increase comes from running RAM at 2-2-2 (compared to 3-3-3). Smallest increase comes from running RAM at 5/7T (compared to 7/9T).

Need great RAM to run 2-2-2 at 5/7T @ 133MHz or better. I cannot, but I hear it's possible with Mushkin rev2. Same RAM chips (as rev 1.5), with better PCB. If anyone else can run 2-2-2 with 5/7T at 133MHz with RAM other than Mushkin rev2, I'd like to know.

Article here (TweakMax) says CAS-3 memory needs **112**MHz to get same bandwidth as CAS-2 at 100MHz .. and CAS-3 memory needs **154**MHz to get same bandwidth as CAS-2 at 133MHz. Benches are for **BX** chipset, but I'd expect similar numbers for 815e (not sure tho).

Brian Stone writes that, with Mushkin rev 2 (2x 128) set to 2-2-2 7/9T [P3 933/133, BIOS 102, WinME] he gets Sandra ALU/FPU of **386/454**. When overclocked to 140/140/35 (980MHz), he gets **402/472**. But anything above 140, his memory bench plummets to "well below" his 133/133/33 scores. Heard (from **Daniele**) that anything above 140 resets AGP to 2X. Anyone think this may be hurting memory perf >140 FSB?

Looks like **BIOS 1003** improves RAM perf. After flashing, Brian reports these Sandra ALU/FPU memory scores:
395/461 (133/133/33, 2-2-2, 5/7T)
405/476 (140/140/35, 2-2-2, 7/9T - cannot get 5/7T at 140)

Paul from Connecticut reports marginal improvements with 5/7T timings, but notices 0.5 fps less in UT at 5/7T (P3-866, no o/c):
PC133 2-2-2 5/7T: **398/428**
PC133 2-2-2 7/9T: **389/414**

Philster's memory benches:
With 2 modules of Mushkin Rev2 at CAS 3-3-2 7,9 154/154/38 (1001 MHz) Sandra: **418/484**
With 2 modeles of Mushkin Rev3 at CAS 2-2-2 5,7 154/154/38 (1001 MHz) Sandra: **448/526**

Sandra CPU scores (P3-700 @938): Dhry/Whet: **2572/1249**
Brian's: **2572/1249**

Sandra HDD 75GXP on WinME at ATA66 protocol (**23,883**): here
Brian's **Sandra HDD** (IBM 75GXP): **23,618**

BG reposts that a new version of Sandra - Sandra 2001 - has been released Nov 20, and that this will be the first version to completely sppt the CUSL2 & 815e chipset. There are some probs with the current version - like when to try to check out some mobo info, or the BIOS, the program will hang/lock.

HD Tach graph of IBM 75GXP on WinME at ATA66 protocol: here
HD Tach graph of IBM 18LZX on WinME at U2W/LVD protocol here
HD Tach graph of Seagate Cheetah X15 (15Krpm) on WinME at U160 protocol here
(compliments of **Rooster**)

Warning: If you run the HD Tach bench, do *__not__* put a check in the box that says Enable Write test. It has overwritten at least one person's hard drive (another reason why you want to use Ghost, or similar imaging program).

3DMark2000 v1.1 (Radeon DDR 32MB @183): 640x480x32: **6953**
800x600x32: **6163**
1024x768x32: **4818**

Brian's **3DMark2000** v1.1 (Herc Prophet II GTS 64MB w/ Det3 drivers) Default bench: **6855**

Quake III Arena (1024x768, 32-bit, highest everything, sound enabled, Radeon DDR 32MB @183 ala Power Strip) demo 001: **63**fps. (the kids are Counterstrike junkies, but my fave is Q3A Instagibs - one shot, baby!)
Brian's **Quake III Arena** demo 001 1280x1024x32 all setting MAX'ed out (WinME) **59**fps
Same **Quake III Arena** demo 001 as above (all settings MAX'ed out) except for 16-bit color (32-bit textures): **87**fps

WCPUID for P3-700, cB0 stepping, retail @938MHz. WCPUID AGP for Radeon DDR 32MB. Can get WCPUID here.

Closing comments:

Many are using the CUSL2 for their first system build. I recall my first, and yes, the mobo was most intimidating part - the BIOS, a no-mans land, where nothing made sense. Glad this guide has helped some first-time builders get up & running. The CUSL2's BIOS interface is one of its strengths. I'm used to Abit boards. The BH6 (w/ C300a) was my cherry build. Abits have great BIOS'es. If you like Abit boards, or appreciate a nice BIOS, you'll love the CUSL2.

My logic for buying the CUSL2 went something like this: My BH6 (original v1.0) didn't have (official) sppt for Coppermine CPUs - something about lacking necessary 8.4 voltage spec. I wrote to Abit, and they said the v1.1 boards would run Cumines, but v1.0 boards would not. Some claimed to be running Cumines on their v1.0 BH6's fine, but others reported probs. I didn't want to be in the position that, every time I had a prob, I wondered, "Is this cuz my BH6 doesn't have the necessary voltage support? .. or is it cuz of something else?"

Also, my AGP card at the time (V3-3K) wouldn't dance at 89MHz, and I wanted to run my RAM at 133Mhz. The BX chipset lacks a 1/2 AGP divider. Celeron2's with the BH6 was also an option I considered, but noticed that Celeron2's had poor perf compared to P3s (4-way vs, 8-way set associative). Built my 1st system Dec '98, w/ Cel300a @464MHz (pre-tested at 450 @ default voltage).

That CPU (US$125) lasted me until the CUSL2, w/ P3-700 (cB0, retail) @938 (1.8v). Almost 2 yrs. Good deal, and I woulda went with a Cel again, if they offered perf comparable to P3's. I'm too chicken to try a Via chipset, especially since I heard here that Via has probs with Win2K (incomplete AGP sppt), and I spend most of my time in W2K. Always heard that Intel made the best chipsets .. (altho their reputation is steadily declining, ever since the 820/840 fiascos).

At time, CUSL2 was only 815e board available. MSI was talking, but Pricewatch had not a single 815e Pro listed. Have no prob recommending one to a friend [the acid test, cuz you know he'll be calling you all hours of the night, if he has probs]. So the CUSL2 seemed like the best solution. I very happy with my choice.

It's usually the little things that kick your butt all weekend long. Hopefully this User's guide will help salvage your weekend & save you from undue headaches & frustration. Might even make the celebratory, initial boot-up beer taste better. It's a great mobo. Wouldn't have taken the time to write this if it wasn't. If there's something I missed, shoot me a note.

More benchmarks here.

The end

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