



Magic Lantern

Canon EOS Camera Tool

www.magiclantern.fm

Libre Graphics Meeting 2014

02.04.2014

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What is Magic Lantern?

- Free Open Source (GPL) firmware addon for Canon EOS cameras.
- Developed by hobbyists but used by professionals.
- Magic Lantern adds advanced photo and film functionality.
- Runs from the SD/CF card and adds a host of new features to Canon EOS cameras that weren't included from the factory by Canon.



Supported Models, Statistics

13 active ports:

1100D (T3), 500D (T1i), 550D (T2i), 600D (T3i), 650D (T4i), 700D (T5i), EOS M, 50D, 60D, 6D, 7D, 5D2, 5D3

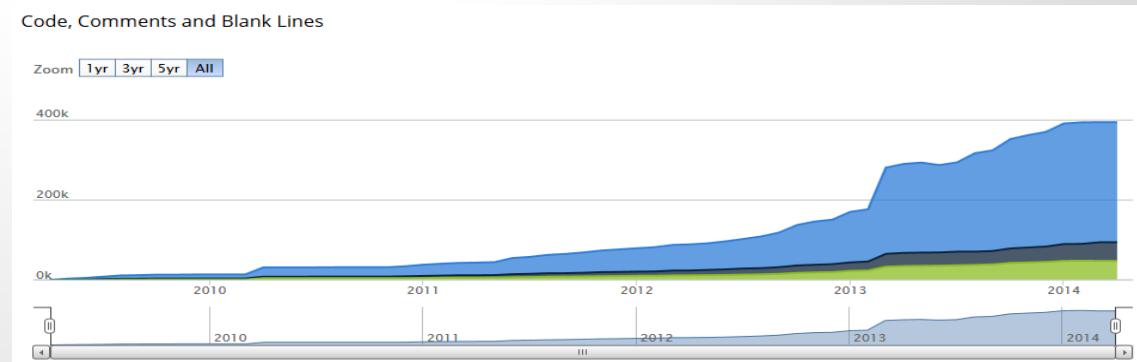
Community:

300k+ downloads and 28k+ *registered* users

Source Code:

- **10k+ commits** made by **106 contributors**, **76** in the last year
- **~300k lines of code** mostly **written in C**

Ohloh: "This is one of the largest open-source teams in the world, and is in the top 2% of all project teams on Ohloh."



How does Magic Lantern work?

- Runs in RAM only
 - No need to flash anything
 - We either...
 - Forge firmware update (with payload)
 - Use autoexec.bin functionality by setting a boot flag
- Hooks into original firmware startup
 - Shrinks memory pools
 - Hooks original firmware tasks
- Starts its own tasks under DryOS operating system
- Implements its own menu
 - Full control over visual appearance
 - More flexibility
- Accesses image buffers, hardware registers, and more

Legal issues

Similar to smartphone jailbreaking, but Cameras have no software ecosystems.

- Copyright
 - We do not copy verbatim Canon code in Magic Lantern.
- Reverse engineering
 - Both US and EU laws allow reverse engineering for interoperability, without requiring the permission from the copyright holder (Canon).
 - We examine Canon firmware by disassembling, decompiling and experimentation (trial and error).
- Encryption and Digital signatures
 - We do not publish crypto keys neither algorithms. Signing and encryption tool is kept internal to the team.
- "Ethical decisions"
 - We do not touch high-end cameras like the 1D series.

History and Community

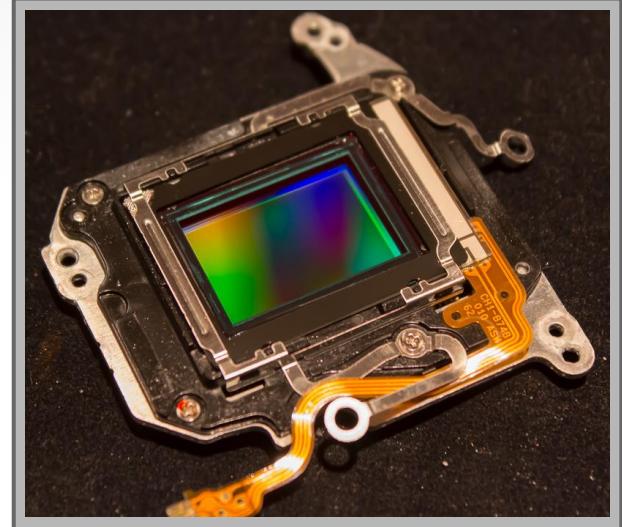
- **2009-2010:** mostly one-man show (Trammell Hudson)
 - Inspired by CHDK (boot method), but new code
 - First camera: EOS 5D Mark II
 - First code on Bitbucket: April 2009
 - Community mainly collaborated on mailing list, wiki and Vimeo group
- Since **2010:** Alex is the main dev and coordinator
- Xmas **2011:** HDR video
- **2012:** new website: www.magiclantern.fm
 - Post on mailing list, suggested setting up community website, people got together: Forums, twitter, etc..
 - EOS 7D finally working

History and Community

- **2013:**
 - Modules (move advanced functions from the core)
 - 14-bit RAW Video (this made lots of forum traffic!)
 - Auto ETTR, Dual ISO
 - Arkanoid :-)
- **2014 (works in progress):**
 - Lots of refactoring and backend improvements
 - RAW format v2.0 (MLV) getting ready (with sound!)
 - RSA Image Encryption
 - Unified Audio Framework
 - Scripting (TCC - <http://bellard.org/tcc/>)
 - “Sensor upgrade” (ISO research)

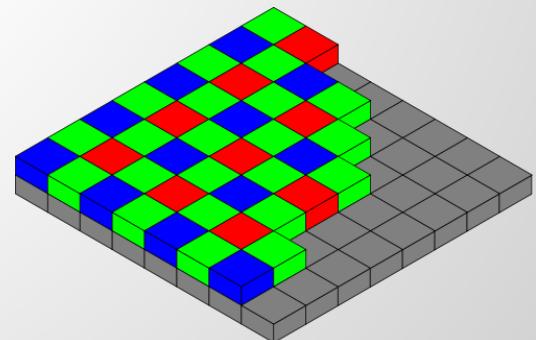
14-bit RAW Video

- Recording 1920x1080 @ 24 fps
- ~85 MiB/s video stream
- Saving raw bayer pattern bitstream
- 14 bits per pixel
- Needs post-processing
- Astounding results
- 60 fps possible



Quotes:

- EOSHD:** *"I have no other words to describe it – this is huge news (...) The world just exploded."*
- Cinema5D:** *"It's a revolutionary time for indie filmmakers"*
- Neumann Films:** *"We are impressed, to say the least!"*



source: Wikipedia

Standard H.264

Source: www.eoshd.com



RAW Video

Source: www.eoshd.com



What was just before RAW Video?

April 17, 2013

- Found the photo RAW buffers (what goes into CR2)
- RAW zebras and histogram ⇒ **correct overexposure warnings!**

April 26, 2013

- Found the LiveView RAW buffers (14-bit silent pictures)

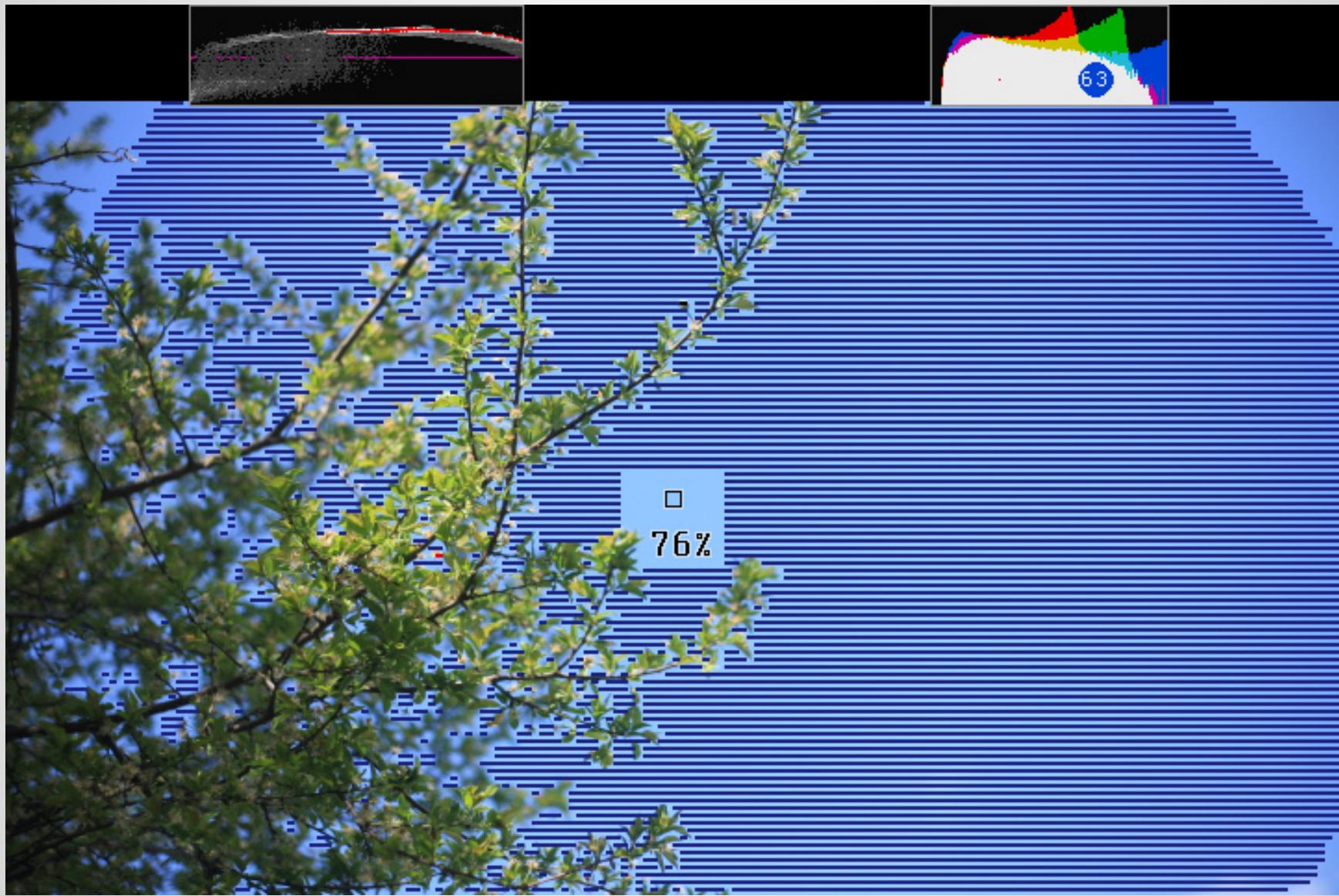
May 12, 2013

- 1000x cards fast enough for RAW video (1920x1080 24fps)
- **RAW video madness begins**

Not many people know that...

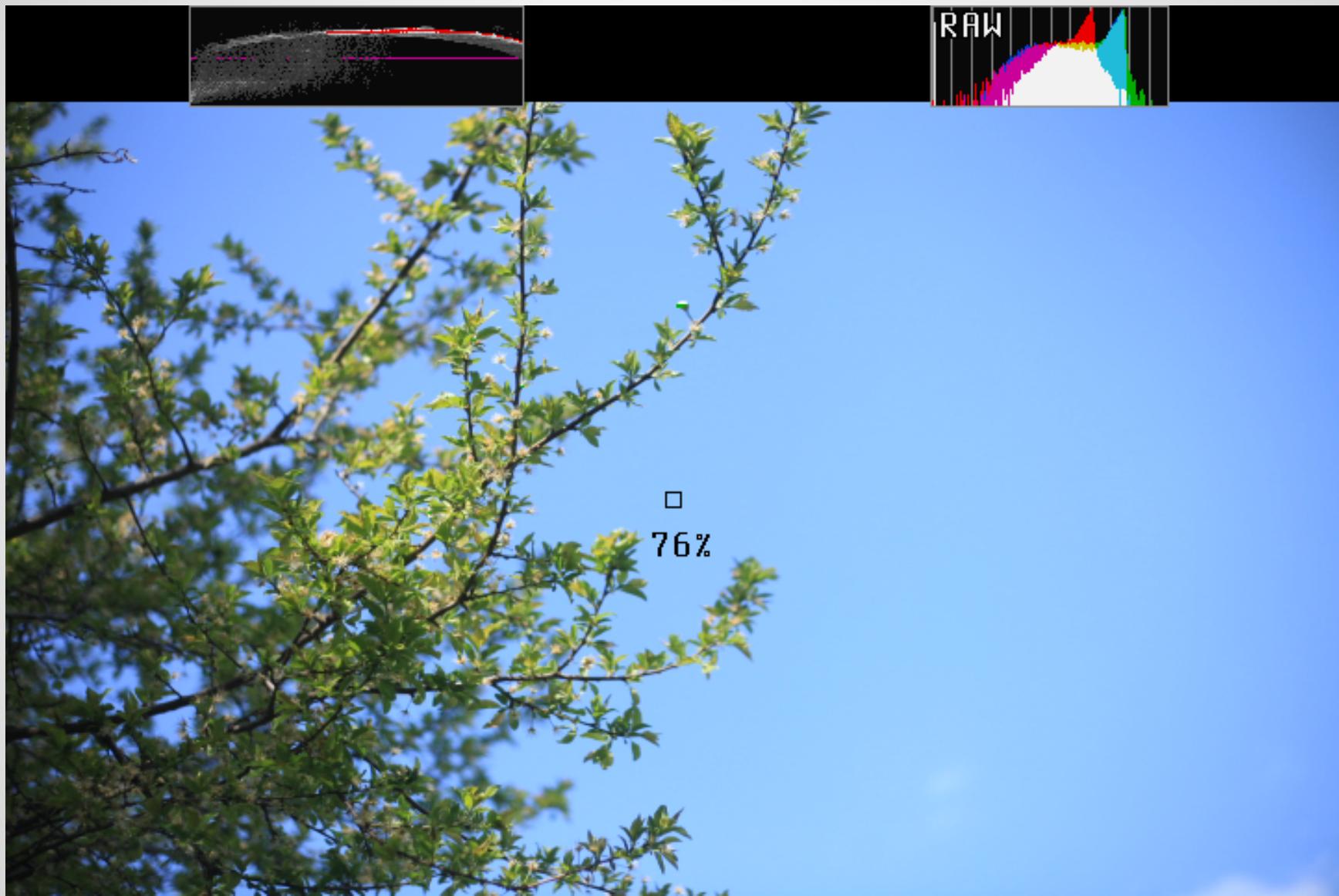
- RAW video started from a still-photo breakthrough!

What's wrong with JPEG zebras/histogram?



JPEG-based RGB zebras say this image is grossly overexposed. Really?

What's wrong with JPEG zebras/histogram?



RAW zebras: this image is actually **underexposed by at least 1 stop!**

ETTR - Expose To The Right

How to expose for minimal noise?

- Capture more photons
 - Slower shutter speed or wider aperture
 - 1 stop to the right ⇒ noise gets cut in half
- Increase ISO (once you've ran out of photons)
 - This reduces electronic noise (read noise)
 - It doesn't help with photon noise (in low light)
 - Little or no benefits above ISO 1600
- Make sure you don't clip important highlights
 - More highlights captured == more noise in shadows
 - You may want to clip spec(tac)ular highlights

Auto ETTR - Automate this Process

Settings:

- How many highlights you can clip?
 - (Highlight ignore, maybe also clip the green channel)
- How much noise you are OK with?
 - SNR limits for midtones and shadows
- Slowest shutter speed, maximum ISO...

⇒ Constrained optimization

(minimize noise without clipping important highlights)

Canon Exposure Metering



Canon metering (Av mode, LiveView metering): underexposed by about 1.5 EV

Canon Exposure Metering



Canon metering: overexposed by 0.5 EV just by changing the framing

Auto ETTR



ETTR metering - raw exposure is just right (with a small safety margin)

Auto ETTR



ETTR metering is consistent - exposure does not change with framing

Dual ISO - Extending Dynamic Range

As you know, on Canon cameras:

- ISO 100 is the noisiest* ISO available (weak signal, noisy electronics)
- Higher ISOs are cleaner, but they clip highlight details, forcing you to underexpose

* all other exposure variables being equal

Why not combine both?

5D3, ISO 100, +7.5 EV in post

Noisy shadows, great highlight detail



5D3, ISO 1600, +3.5 EV in post

Clean shadows, but highlights are clipped



5D3, Dual ISO 100/1600, +7.5EV in post

Clean shadows and good highlight detail!



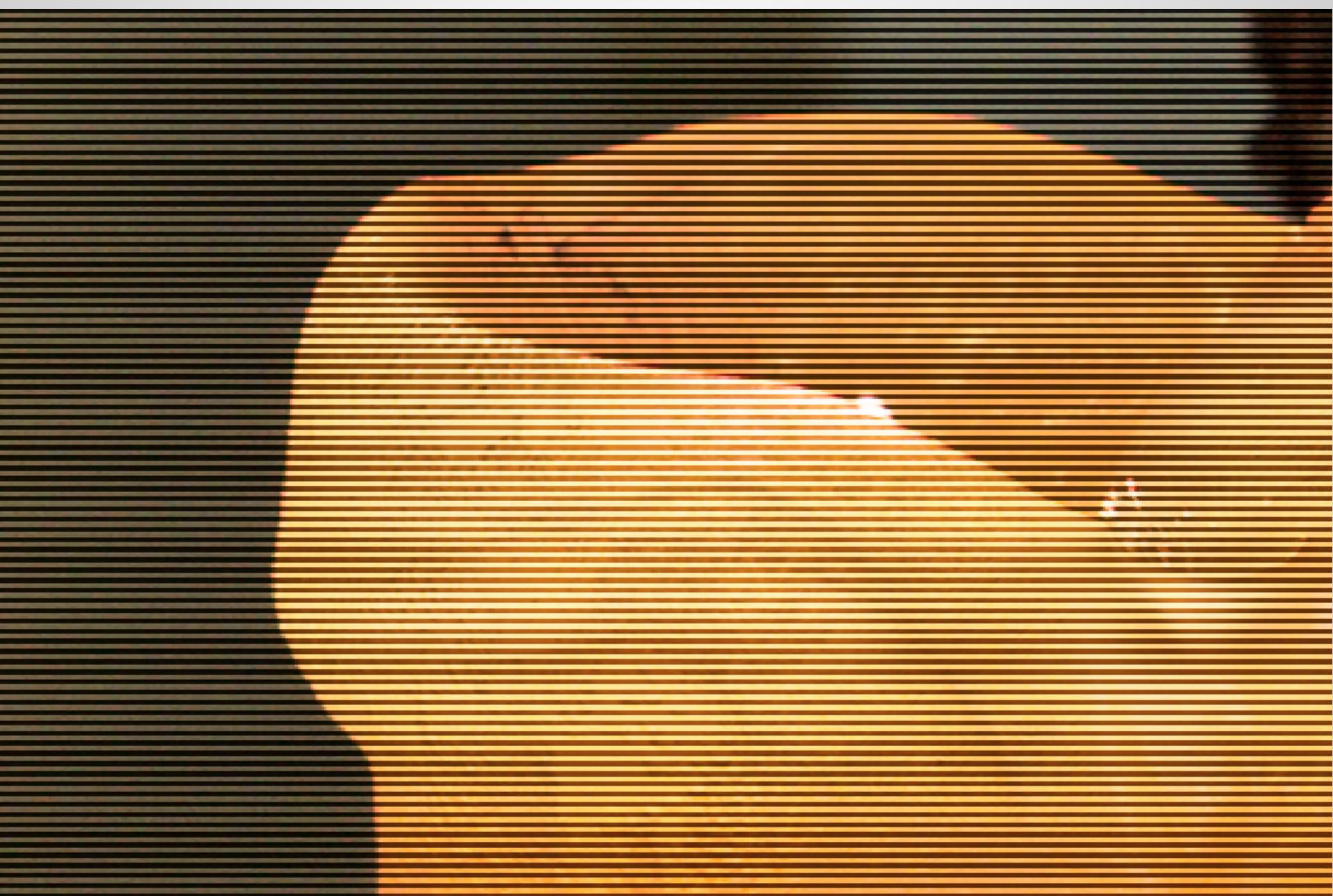
+1.5 EV in post (ufraw soft-film)

Back to ISO 100, +7.5 EV in post

Noisy shadows, great highlight detail



Dual ISO - alternate ISO every two lines



Dual ISO - dark image (as with ISO 100)



Dual ISO - you can raise the shadows!

... without the noise !



Try doing this with a stock Canon!

No problems with Nikon D800.

Sample from Jonathan Zdziarski, <http://www.zdziarski.com/blog/?p=2792>

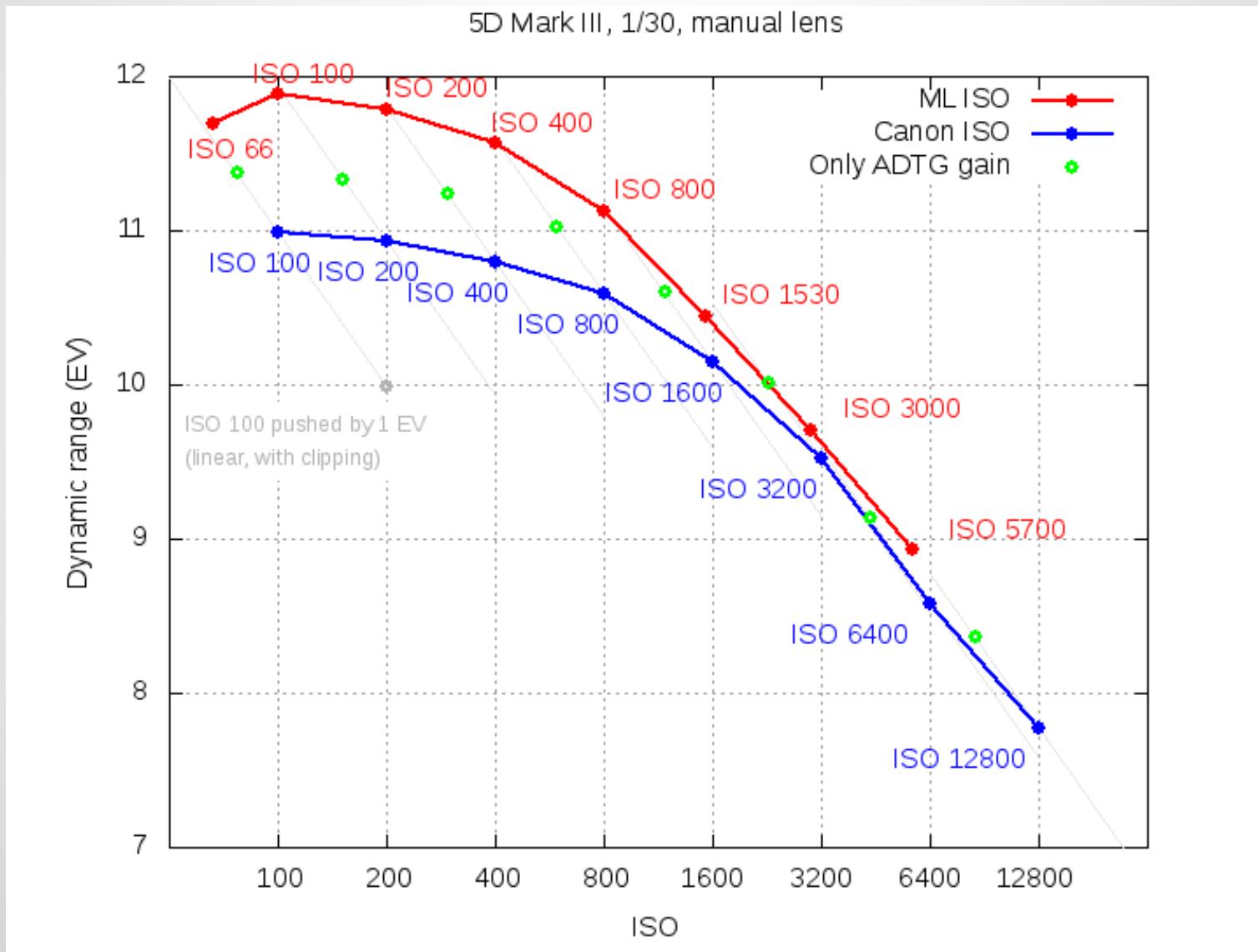
Open Source Brings High-End Canon 5D MK III Dynamic Range Closer to Nikon D800

Canon 5D MK III
ISO 100 f/5.6 1/10
+4 EV Added in POST

Nikon D800
ISO 100 f/5.6 1/10
+4 EV Added in POST

Work in progress: “sensor upgrade”

We will re-implement ISO settings for even lower noise
(almost 1 stop more dynamic range on 5D Mark II and III)



Work in progress: TCC scripting

Proof of concept working: run a C compiler on your camera!



TCC - Tiny C Compiler, <http://bellard.org/tcc/>

Future Outlook

It is very difficult to make any reasonable predictions
(who knew HDR or RAW video would be possible?)

Steady growth of community (both users and developers)
will present both new challenges and opportunities.

We'd love to see magic lantern features/file formats
supported in open source software... anyone? :)

... just keep the project rolling!

Thanks!

Please join us on friday
for the live workshop.
Bring your cameras!

Please visit:

www.magiclantern.fm

We are always looking
for more developers
and reverse engineers!

[Home Page](#) | [Downloads](#) | [User Guide](#)

Magic Lantern Forum

Welcome, Guest. Please login or register.
Did you miss your activation email?

Login with username, password and session length:
 forever

[Home](#) [Help](#) [Search](#) [Login](#) [Register](#)

Magic Lantern Forum

Headline news

An announcement regarding the forking of Magic Lantern, and the support that can be provided for these You can find our live webchat here: [amagiclantern@freenode.net](#)

Magic Lantern Releases

Nightly Builds
Stay up to date with the latest and greatest development (rolling release)
10 posts 5 topics

Camera-specific discussion
Post your thread for your camera and discuss porting issues there. For raw video, please use the dev forum thread below (not here).
Moderators: [Lucas_W](#)
Child Boards: [Archived porting threads](#)
11139 posts 48 topics

Showcasing Magic Lantern

Share Your Videos
Show off your Magic Lantern created films!
1429 posts 1193 topics

Share Your Photos
Show off your Magic Lantern created photos!
692 posts 191 topics

Using Magic Lantern

General Help & QA
Have a question about Magic Lantern? Confused by a feature? Here's the place to ask. Before you ask though, please read the FAQ, user guide, sticky topics, duplicate questions, and don't be afraid to search.
11205 posts 2947 topics

Child Boards: Camera Emergency Department, Duplicate Questions

Raw Video
For all your raw video needs
17919 posts 181 topics

Child Board: Raw Video Postprocessing

Bug Reports
For bug reports you will be redirected to the ML issue tracker on Bitbucket
6431 redcents

Hardware and Accessories
Lenses, Mics, Field Monitors, and More
3601 posts 299 topics

Tutorials and Creative Uses
Share your tips and techniques for getting the most out of Magic Lantern's many features.
895 posts 93 topics

Shoot Preparation
How to prepare your camera for a shoot. What specific settings are used at weddings, wildlife filming etc. Specific use of picture styles.
531 posts 75 topics

Post-processing Workflow
Sharing workflow and discover new ways to process your Magic Lantern created photos and videos.
1730 posts 152 topics

Child Boards: Raw Video Postprocessing, HDR and Dual ISO Postprocessing, Timelapse Postprocessing

Developing Magic Lantern

General Development Discussion
Need help compiling? Want to help with debugging and testing? Come here to stay up to date on current development efforts.
807 posts 415 topics

Feature Requests
Share new features that you would like to see in the next Magic Lantern release. Please search first to avoid duplicates.
7250 posts 1174 topics

ML Modules
This is the right place if you want to share your modules, scripts or if you simply have questions on how to use or develop them.
5850 posts 92 topics

Child Boards: Modules Registry, Scripts Repository, Modules Writing, Scripts Writing

Reverse Engineering and Firmware Design
Try your hand at reverse engineering the hardware! Come here for help implementing your ideas.
1349 posts 72 topics

New Posts
Moved to Camera-specific discussion
737 redcents

Change Log
View detailed updates to Magic Lantern and download source code on Bitbucket
33161 redcents

General Discussion

General Chat
Discuss new camera models (What's the 1024kii port coming??), DSLR filmmaking accessories, your favorite (or least favorite) picture styles, tricks of the trade, and any other random topics you'd like to bring up.
3310 posts 493 topics

User Introduction
Let us know who you are
554 posts 249 topics

Magic Lantern Forum and Site Discussion
Have a particular feature you'd like to see in a tutorial or an idea for a new board? Share with us your suggestions to make this site better.
508 posts 90 topics

Third Party Modifications (obsolete)

a.d. & pravdemi's SD2 builds
Want to use your SD2 with Magic Lantern? Check it (User interface & a few extras)
2185 posts 4 topics

No New Posts **Feed Board**

Magic Lantern Forum - Info Center

Recently Updated Topics

Magic Lantern (4K) Video format 10.0 rev. rev-001 by core_31 (Modules Repository) only pink frames - try to use (Capture Overview) Lightroom plugin v2.1 by [lumix](#) (Raw Video Postprocessing) How to Record a Clip with zoom H37 by [magics](#) (General Chat) Canon EOS 5D Mark IV by [lumix](#) (General Chat) Canon EOS 5D Mark IV by [lumix](#) (General Chat) not picking the first frame in AVE by [bridge](#) (Raw Video Postprocessing) 6d raw video by [SD2](#) (Raw Video Postprocessing) 1000D vs 700D - some conflicting info though by [lumix2](#) (General Help Q&A) Canon 60D installation - [ML-DATA-FONTS.DAT NOT FOUND](#) by [Guerrilla](#) (General Help Q&A) Thread for the new EOS 5D Mark IV by [lumix](#) (General Chat) User Guide Thread by [a3](#) (General Chat) Canon EOS 5D Mark IV by [lumix](#) (General Chat) 650D/740D Raw Video by [sd2](#) (Raw Video Postprocessing) Problems with the Canon 5D Mark IV by [lumix](#) (Hardware and Accessories) Highly Built - try the very latest stuff here by [Autumn](#) (Highly Built) Support for Canon EOS 5D Mark IV by [lumix](#) (Raw Video Postprocessing) Script for Automate: Multiple instances of exr2avi (Windows) by [Firman](#) (HDR and Dual ISO Postprocessing) How to write a proper [exr2avi](#)? (General Development Discussion)

Forum Stats

103268 Posts 8417 Topics by 28527 Members. Latest Member: [dphote](#) Last Post: [Magic Lantern \(RAW\) Video... - \[Today at 13:22:39 PM\]](#) View the most recent posts on the forum.

Users Online

82 Guests, 18 Users (2 Hidden)
Users active in past 5 minutes
Mike Blaauw, mario, Michael Ziller, Inakiros, Cammello, diphoto, Markus, fed, ranassira, chris_overseas, kichotof, disceglia, maguye, erim, Keppchen, RizZle, dpxmaij Host Online Today: 144, Most Online Ever: 564 (July 16, 2013, 07:08:43 PM)

Supported Cameras:
SD2, 5D, 5DII, 60D, 70D, 400D, 500D, 500D, 500D (T1), 550D (T2), 400D (T3), 650D (T5), 700D (T5i), 1100D (T1i), 1000D (T1i), 100D (T2i)

Main Features

Auto, Exposure, Live View Overlays, Movie, Sheet, Photo

Latest News

Tweets

Ready to get started?

[Yes, Take Me To The Downloads](#)

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Use at your own risk, we are not responsible for any damage to your camera.
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