

ITU BS.1770 Revisited

ATSC A/85 & The CALM Act

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WBA Conference • Madison, WI • October 13, 2011



Agenda

Loudness Wars

Commercials, pop/rock
Sample peak level, data reduction

BS.1770-2

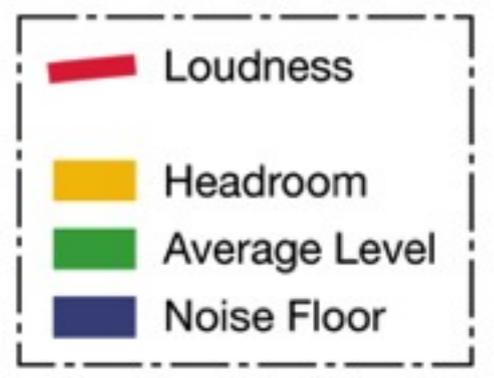
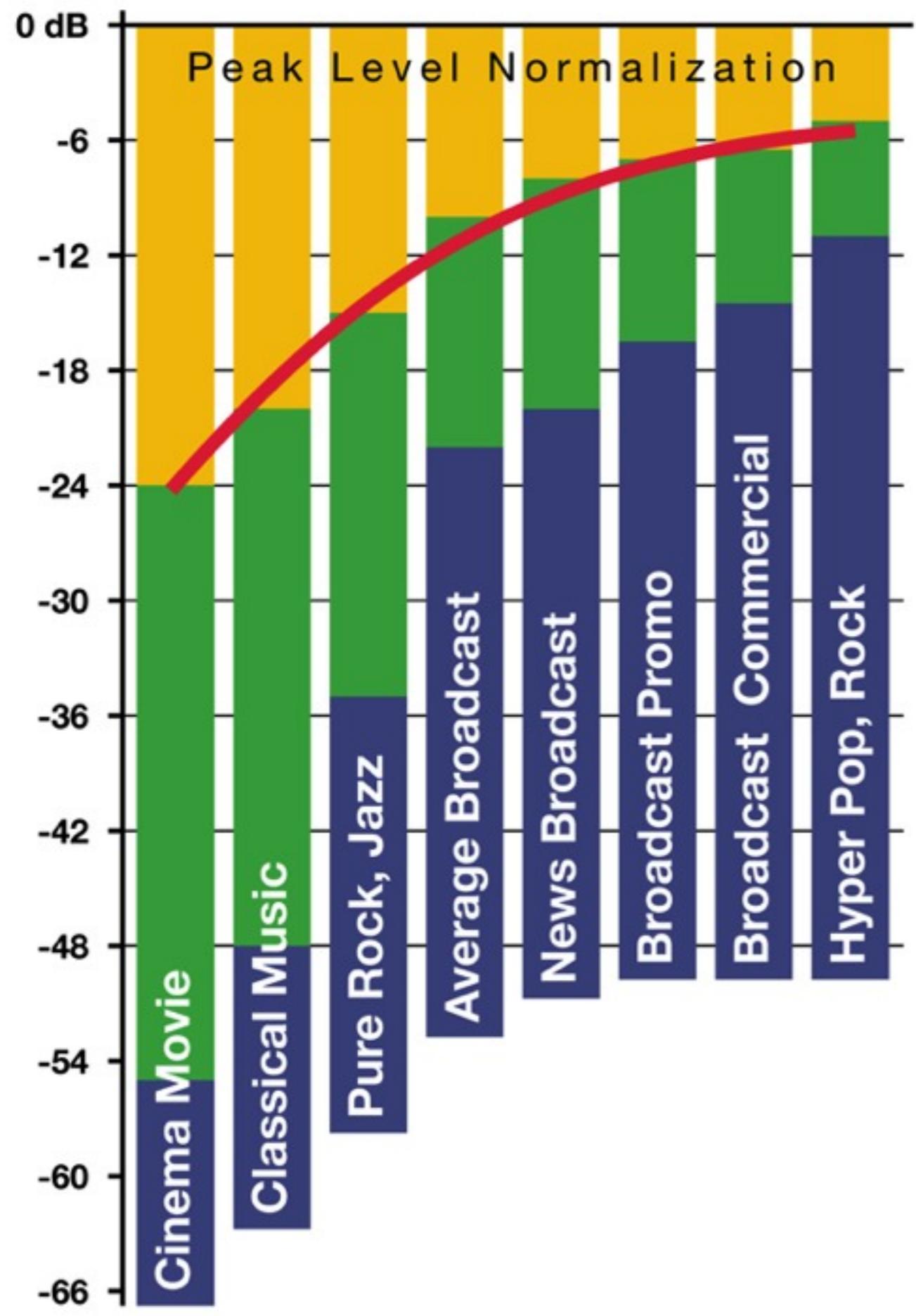
LKFS, LUFS, LU, normalization
True-peak level, speech level

New Tools

Harmonized metering, EBU R128
Satisfying CALM act requirements

Conclusion

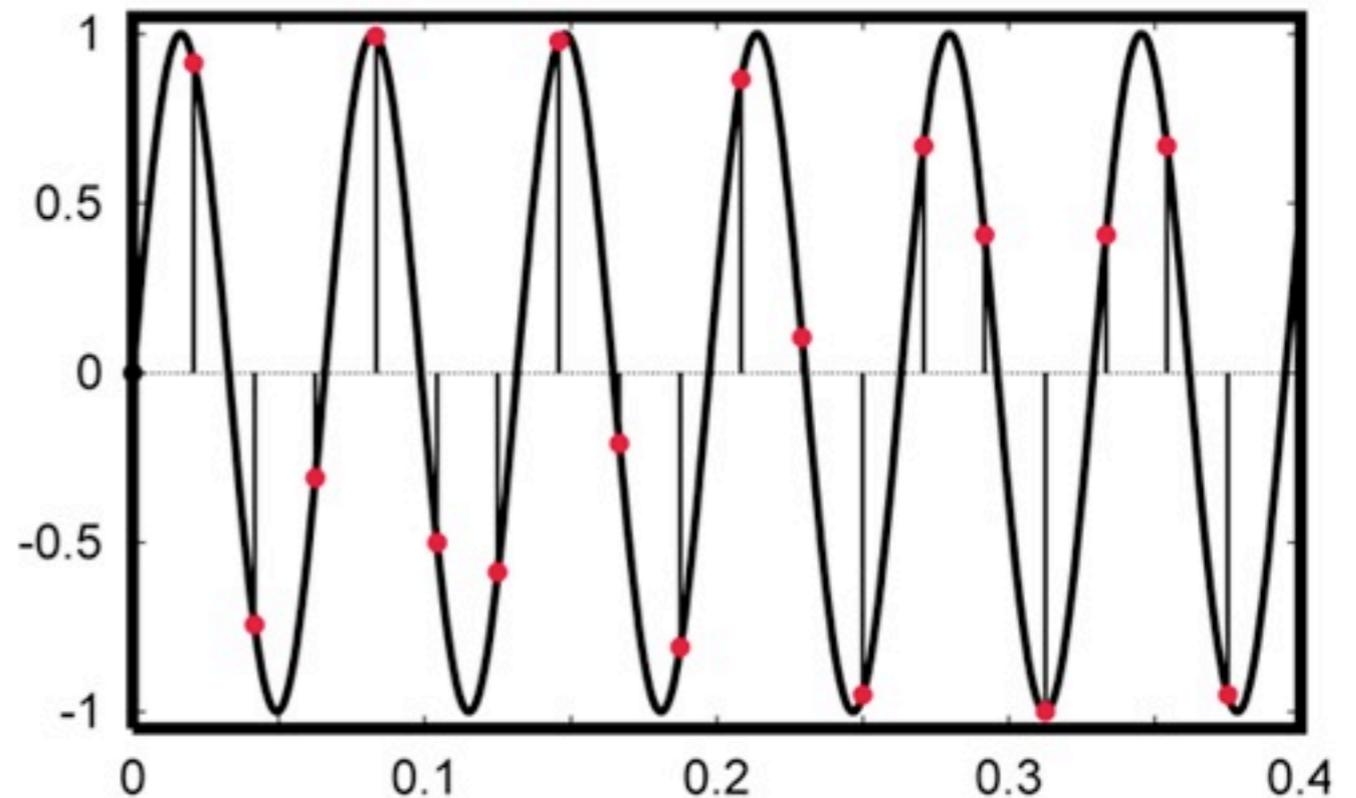
ATSC A/85, station workflow,
metadata, cross-platform, mobile TV



True-peak Level

Even in a linear audio system, analog and digital level is not the same.

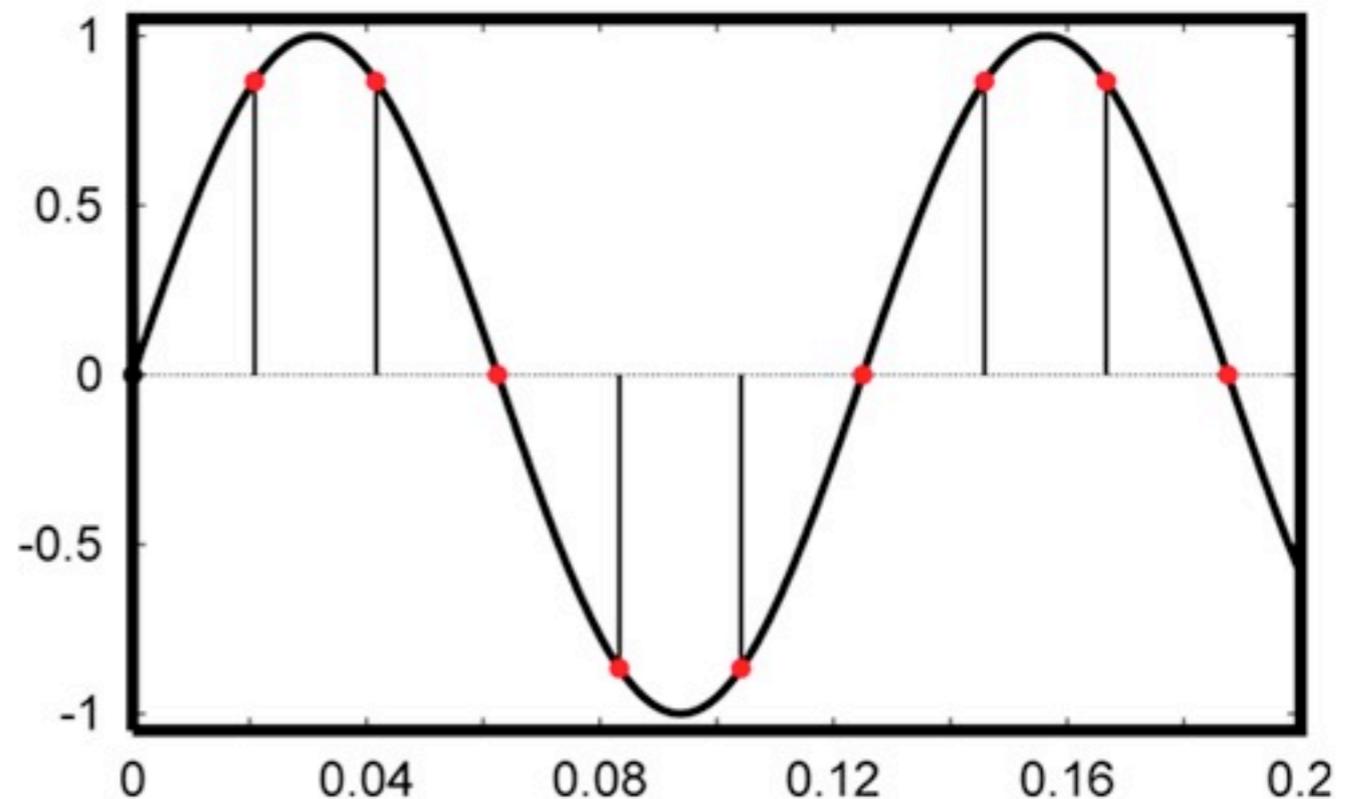
1



Analog Level:
Black Line

Digital Level:
Red Dots

2



0 dBFS+

Listening example:

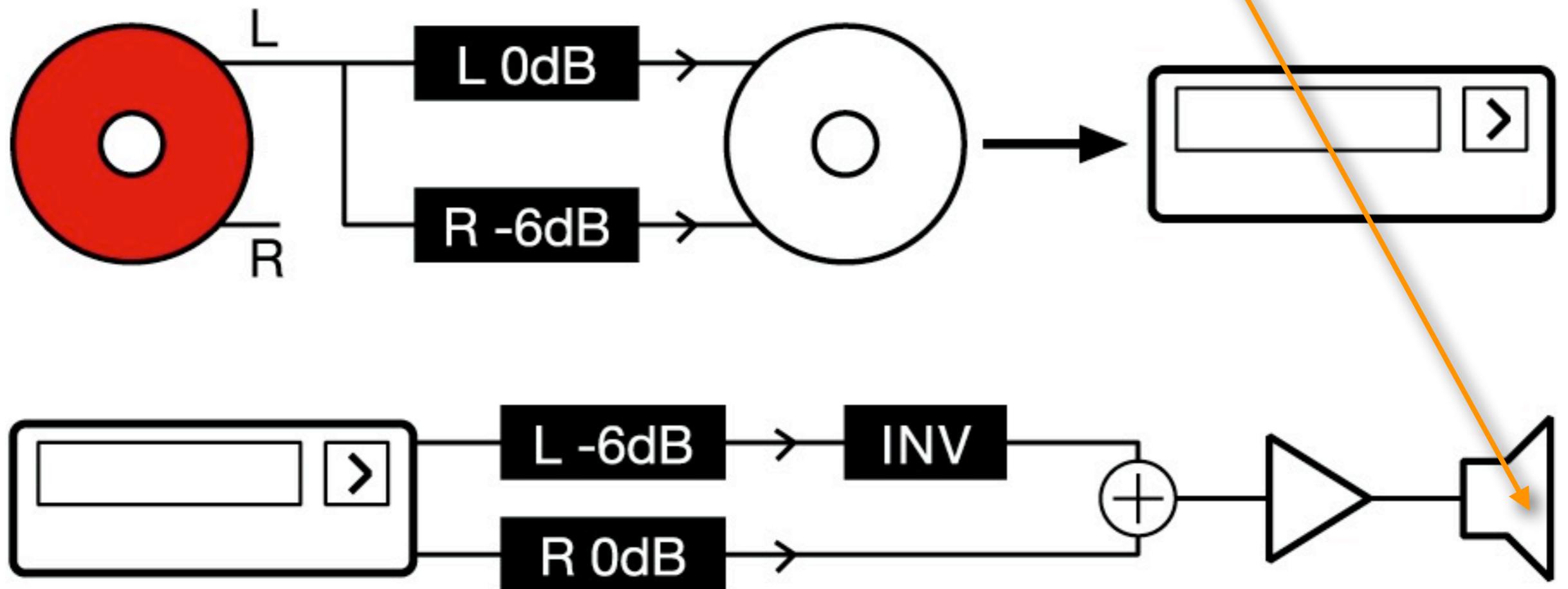
Don't Stop, Anastacia

Original CD

Remember how loud this track is in order to compare against distortion level in the next examples.

0 dBFS+

Same song, NAD512 CD player, listening here



Headroom

Critical Areas

Headroom is needed several places in the signal-path:

- DA Converters
- Filters, analog and digital
- Sample rate converters
- Data reduction codecs (e.g. MP3)

0 dBFS+ level is hit more and more frequently on new pop/rock releases.

Data Reduction

AES23 Distortion.pdf (13 Pages)

NIELSEN AND LUND

OVERLOAD IN SIGNAL CONVERSION

<i>Algorithm</i>	<i>Mode</i>	<i>Datarate [kbit/s]</i>	<i>Avg. per ch. [kbit/s]</i>	<i>Max. peak re. 0.5</i>
MPEG-1 L II	stereo	384	192	+1.3 dB
MPEG-1 L II	stereo	224	112	+1.3 dB
MPEG-1 L III	stereo HQ	320	160	+1.7 dB
MPEG-1 L III	stereo HQ	160	180	+2.3 dB
MPEG-1 L III	int-st HQ	128	64	+5.3 dB
MPEG-1 L III	int-st fast	128	64	+3.0 dB
MPEG-1 L III	int-st HQ	96	48	+4.7 dB
MPEG-2 L III	22.05 kHz, i-st HQ	80	40	+1.7 dB
DTS	6 ch.	1234	206	+0.6 dB
Ogg Vorbis	stereo	var., Q=10	157-193	+0.3 dB
Ogg Vorbis	stereo	var., Q=5	49-64	+1.8 dB

Table 4: *Maximum peak values observed in 12 hot CD excerpts (length 14-33 s) perceptually coded with various algorithms, data rates and modes.*

Data Reduction

Not before
transmission

Bandwidth doubles in 20 months.

Don't risk compatibility or audio quality.

Data reducing music without
attenuation leads to distortion in radio
station archives (and in iTunes).

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BS.1770-2

LKFS, LUFS, LU, normalization
True-peak level, speech level

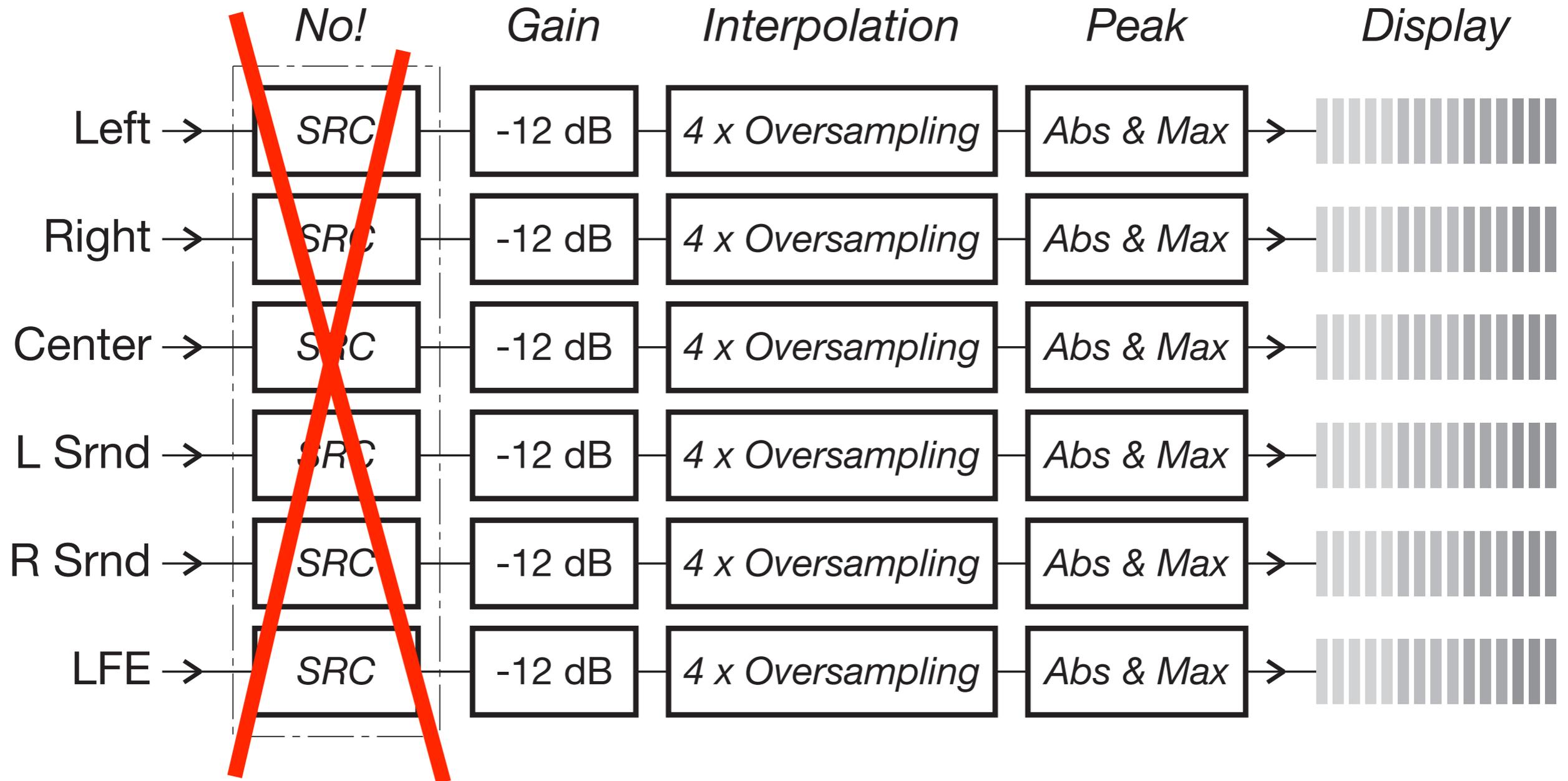
New Tools

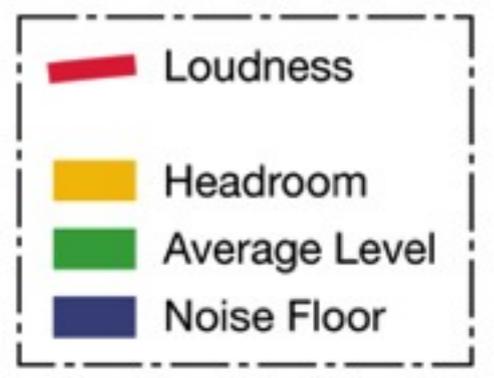
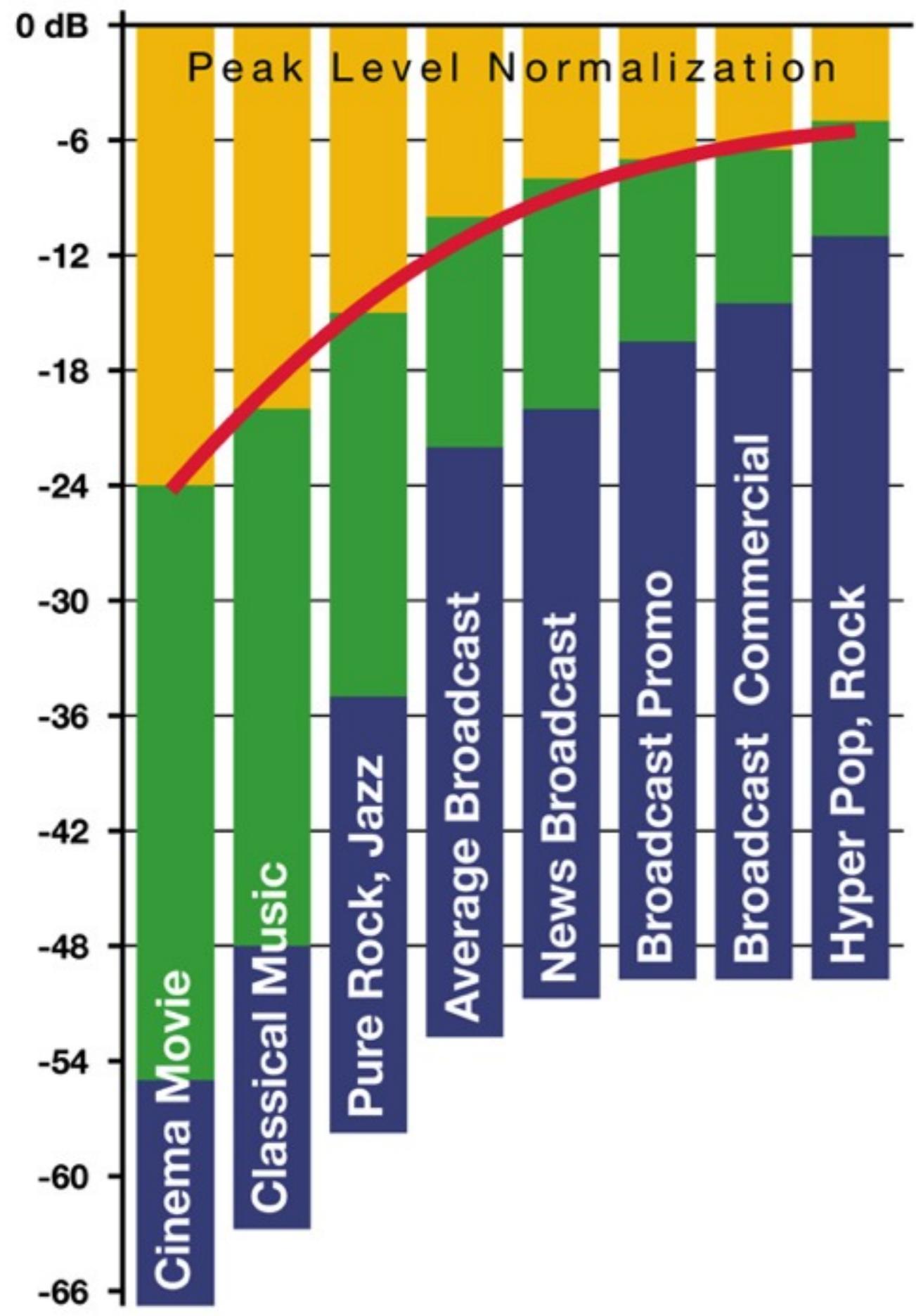
Harmonized metering, EBU R128
Satisfying CALM act requirements

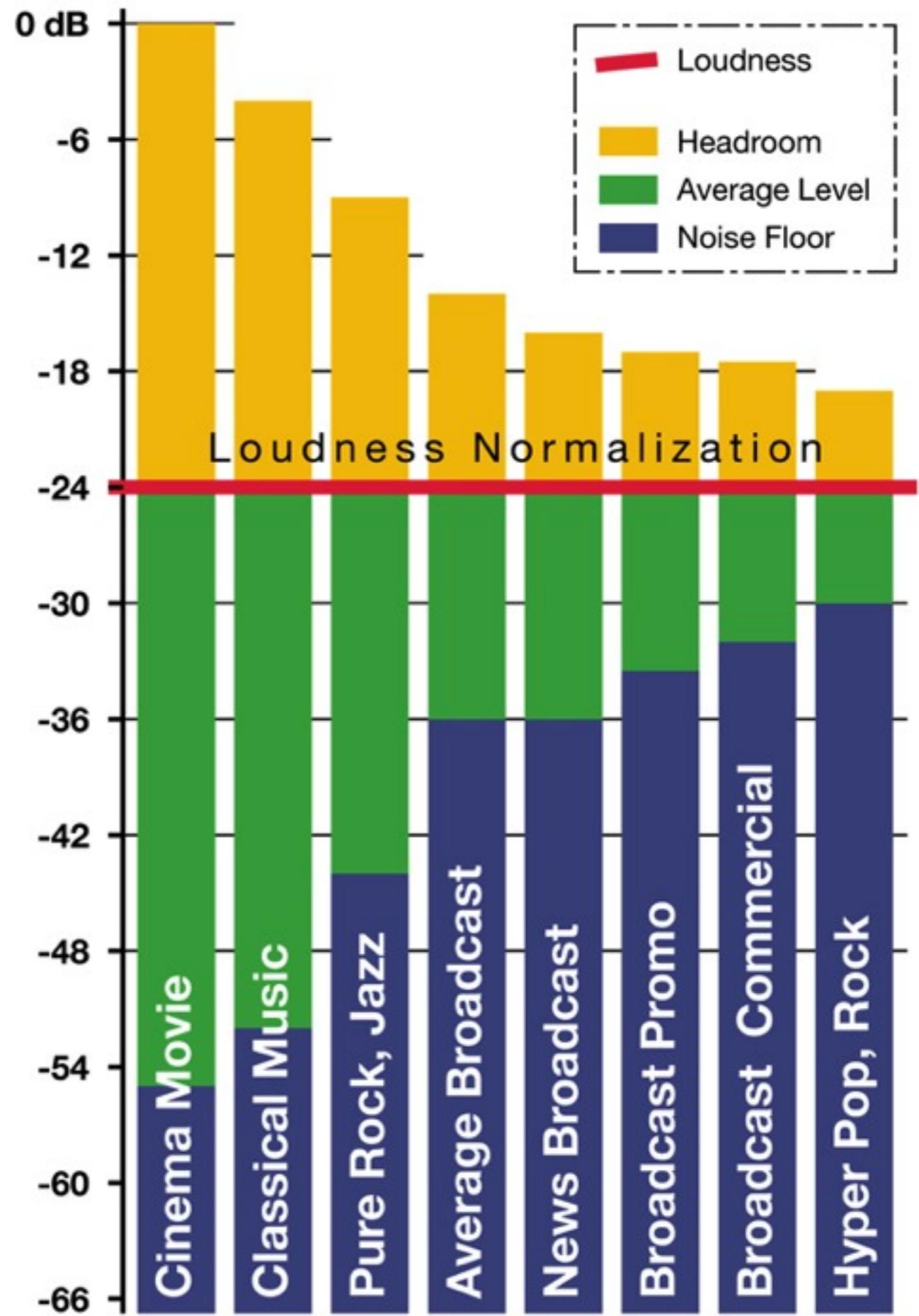
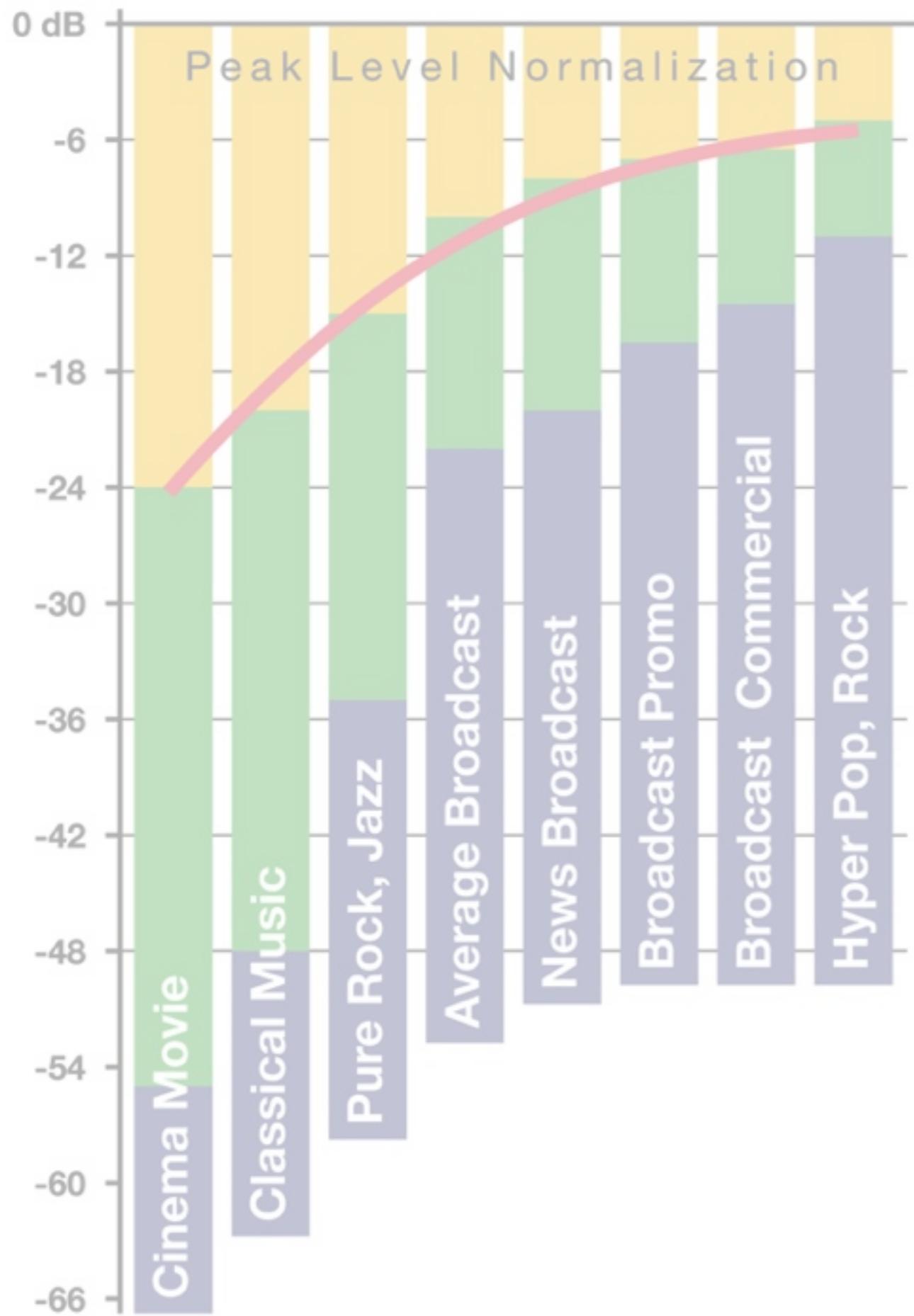
Conclusion

ATSC A/85, station workflow,
metadata, cross-platform, mobile TV

BS.1770-2 True-peak







Loudness

Unlike Level, Loudness is **subjective**. Listeners weigh a number of factors differently:

- Sound Pressure Level
- Frequency Contents
- Duration

Variability between listeners: BLV (Age, Culture, Gender etc.)

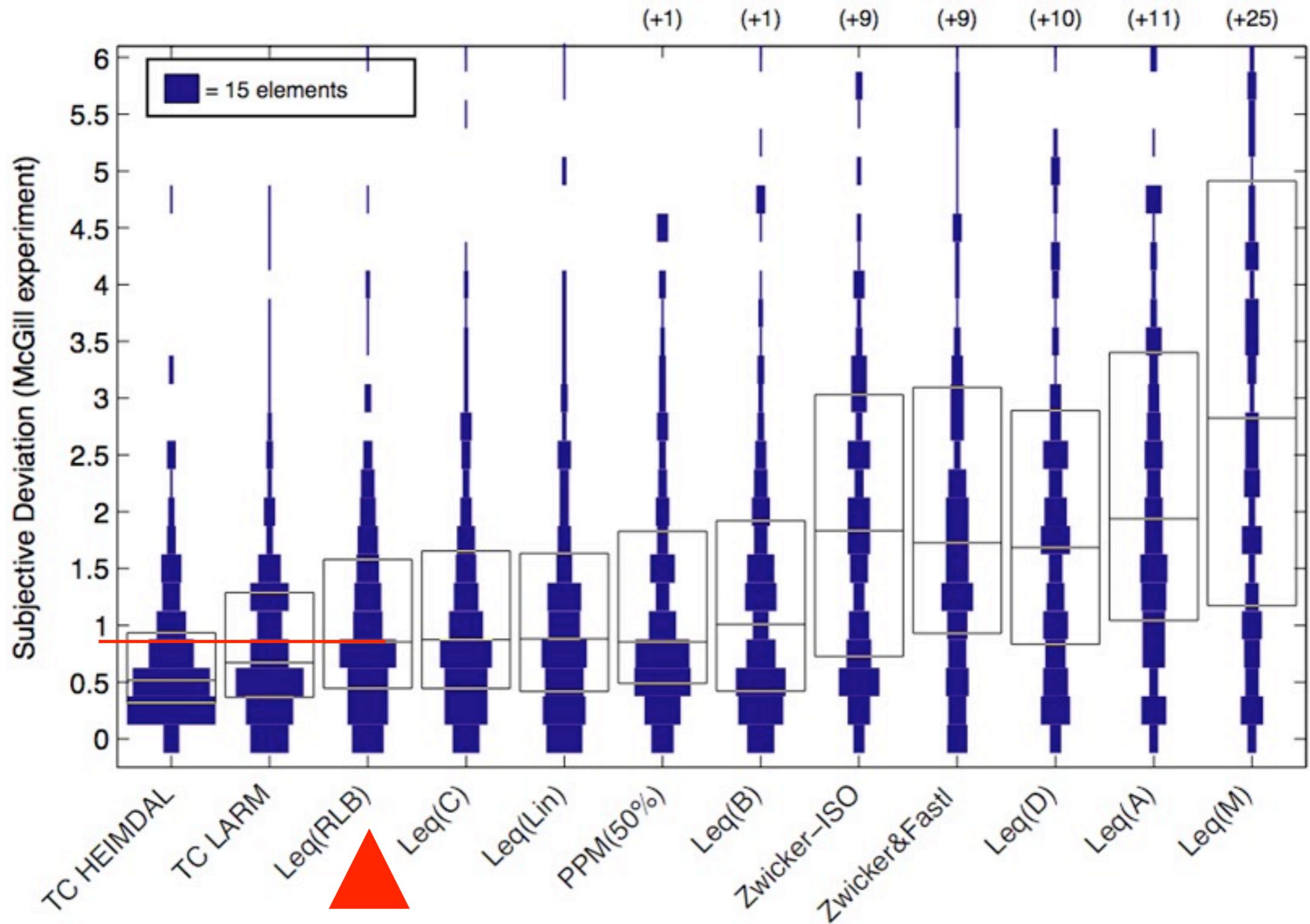
Variability within the same listener: WLV (Mood, Focus etc.)

Variation in reproduction equipment.

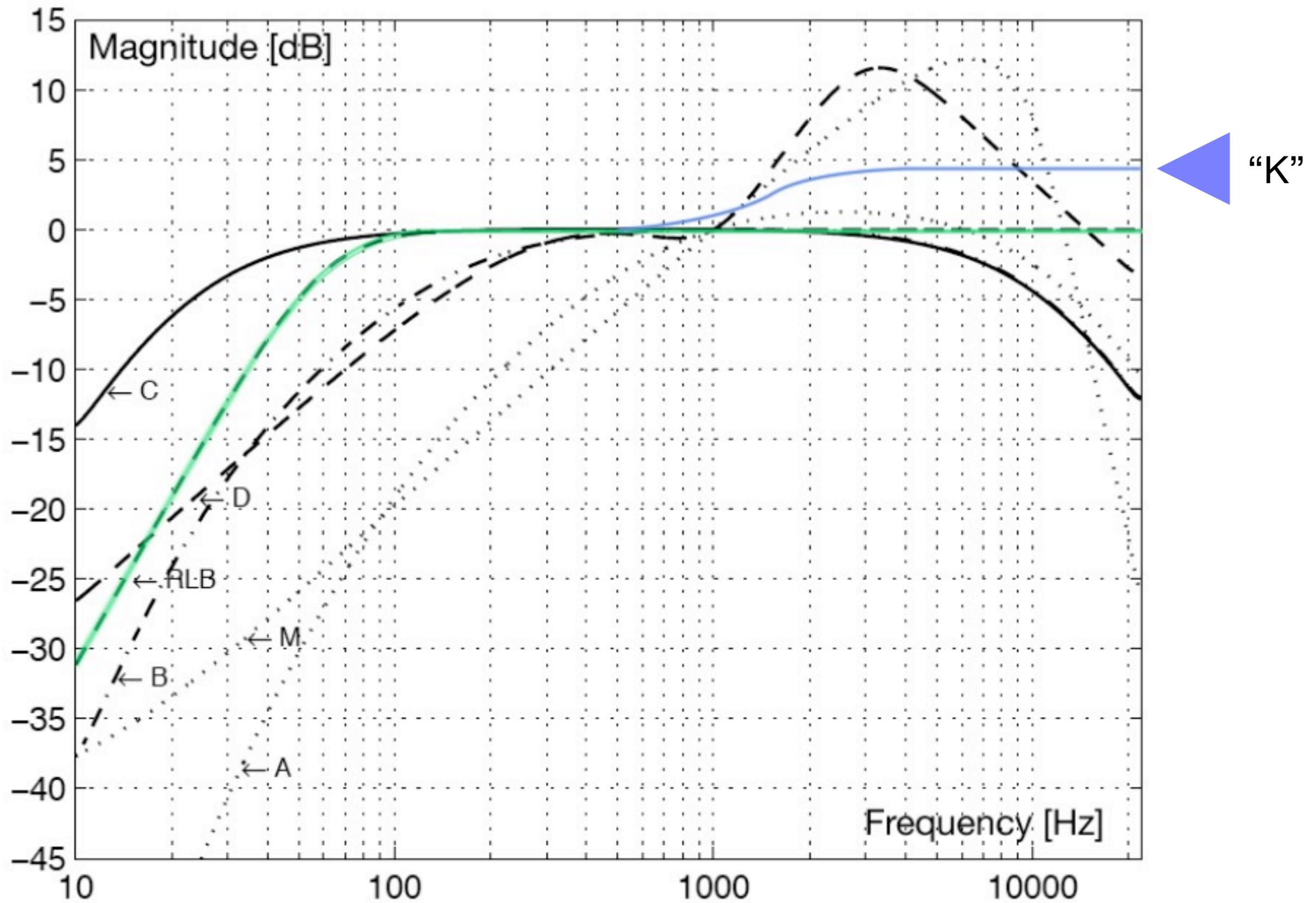
A Loudness measure must be based on **solid statistics**.

Listening tests together with McGill University.

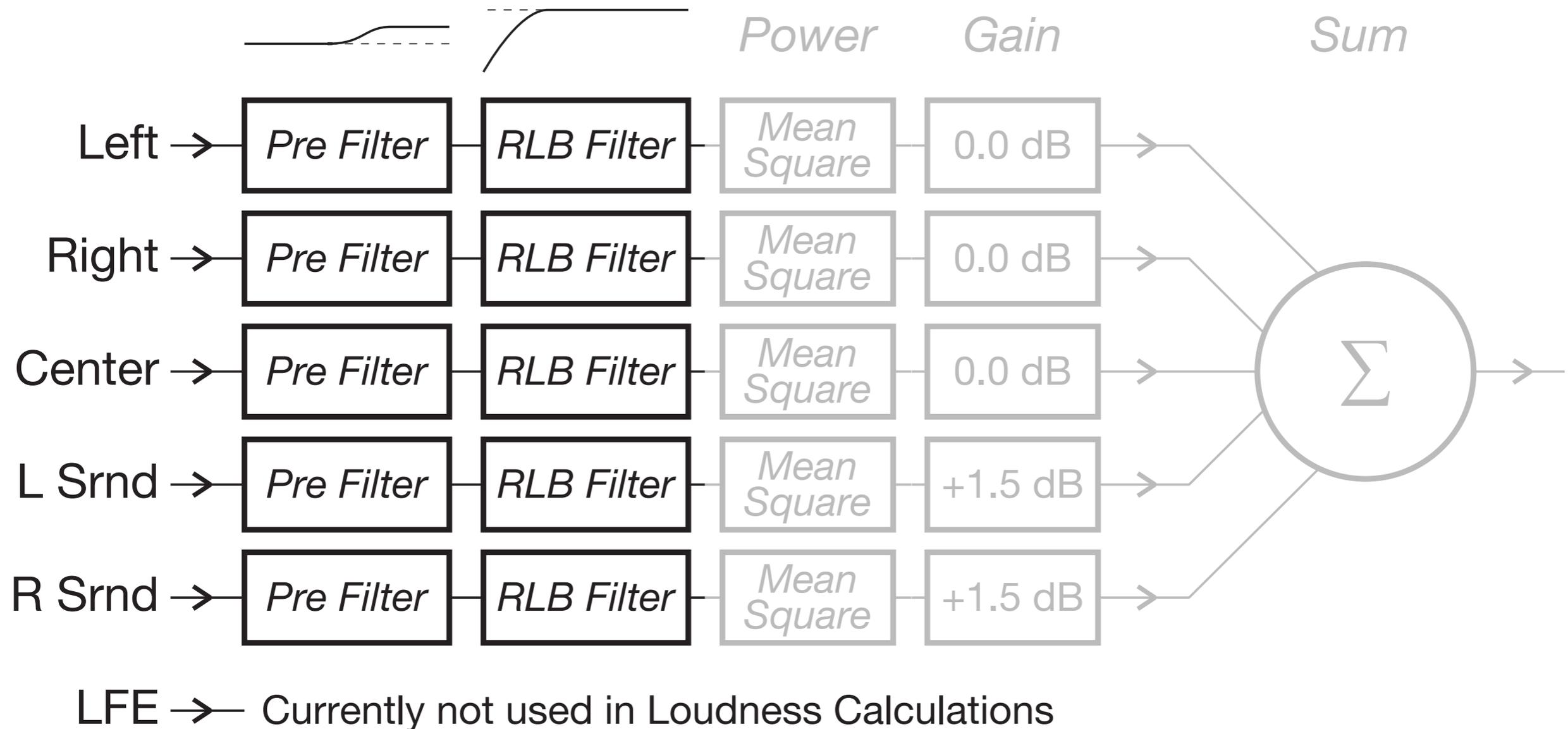
Loudness



Leq Weighting



BS.1770-2 Loudness



Works for mono, stereo and 5.1

Words: LUFS, LKFS and LU

LUFS = LKFS

Unit for **absolute loudness level**

Compare with [dBFS] for level

-24.0 LUFS is the same as -24.0 LKFS

Only the spelling is different

LU

Unit for **relative loudness level**

Compare with [dB] for level

Loudness at **Target Level** = 0 LU

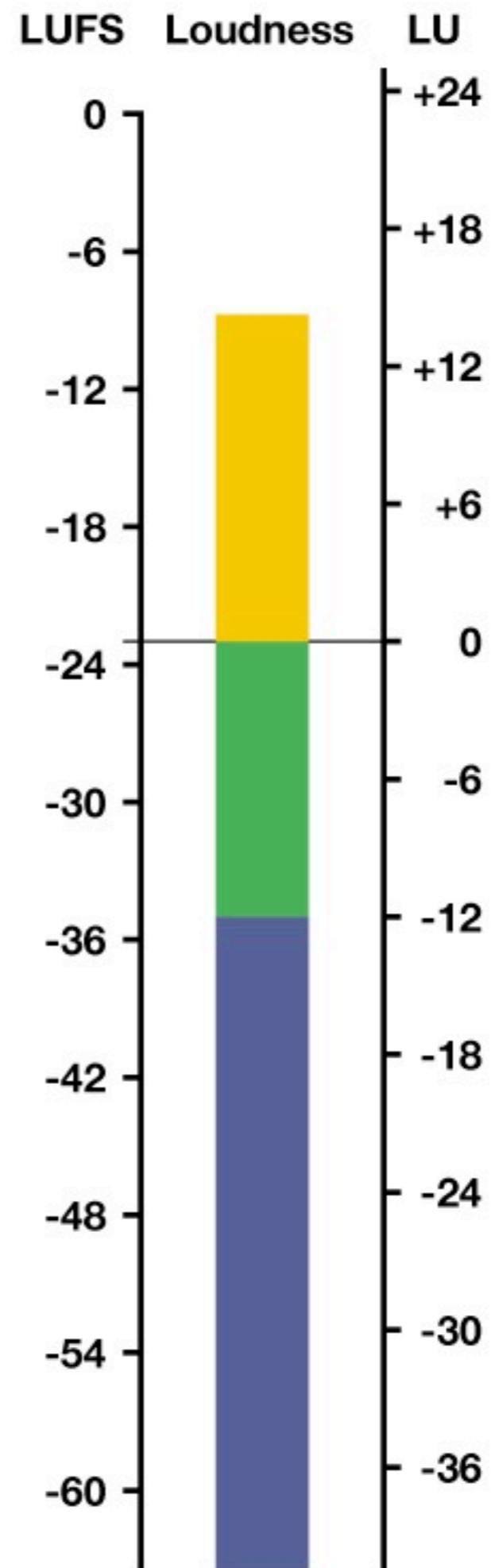
LUFS and LU

0 LU = Target Level.

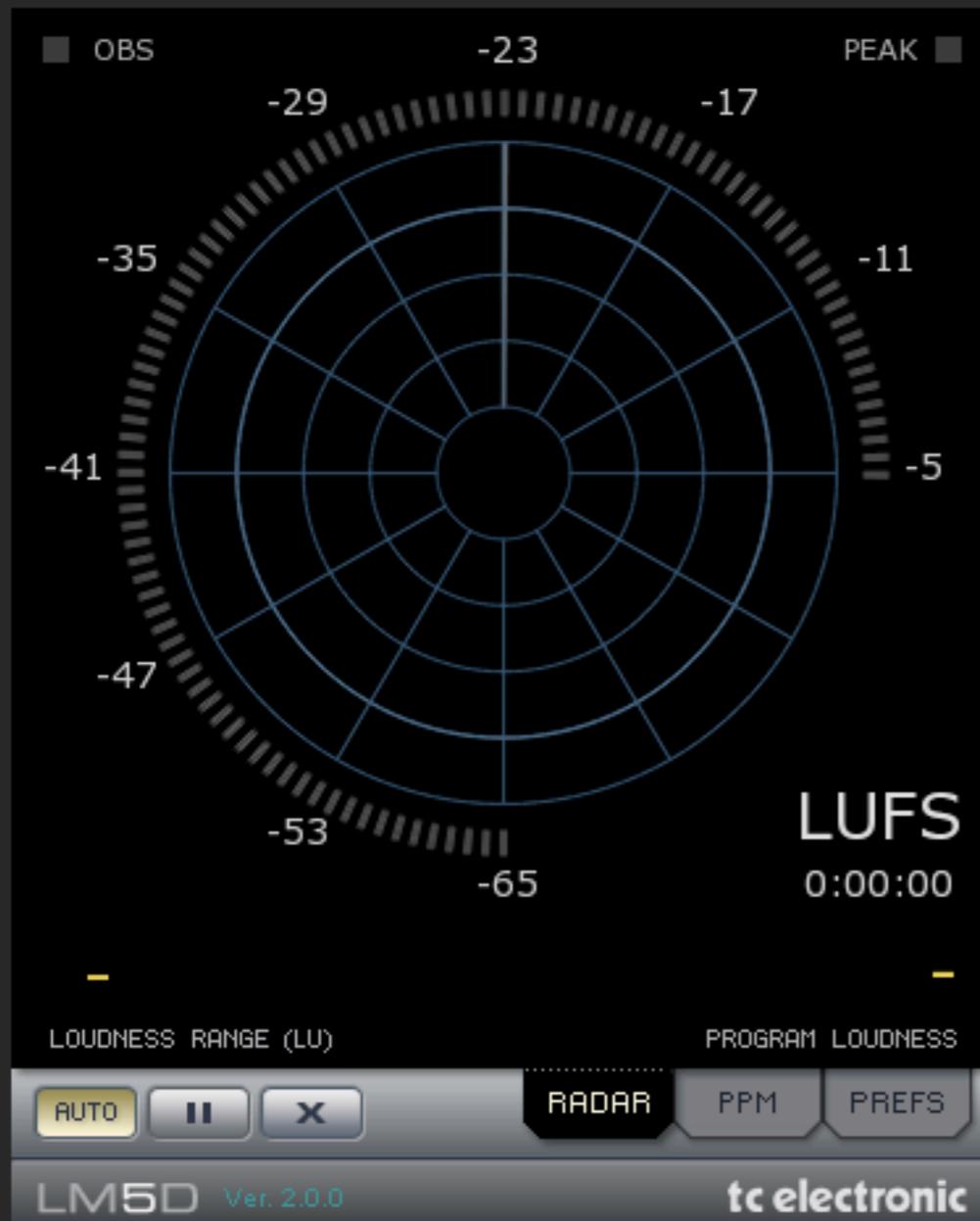
In this example, Target Level is -23 LUFS.

A/85 specifies -24 LUFS.

Remember: LUFS is the same as LKFS.



Meter Examples: LUFS and LU

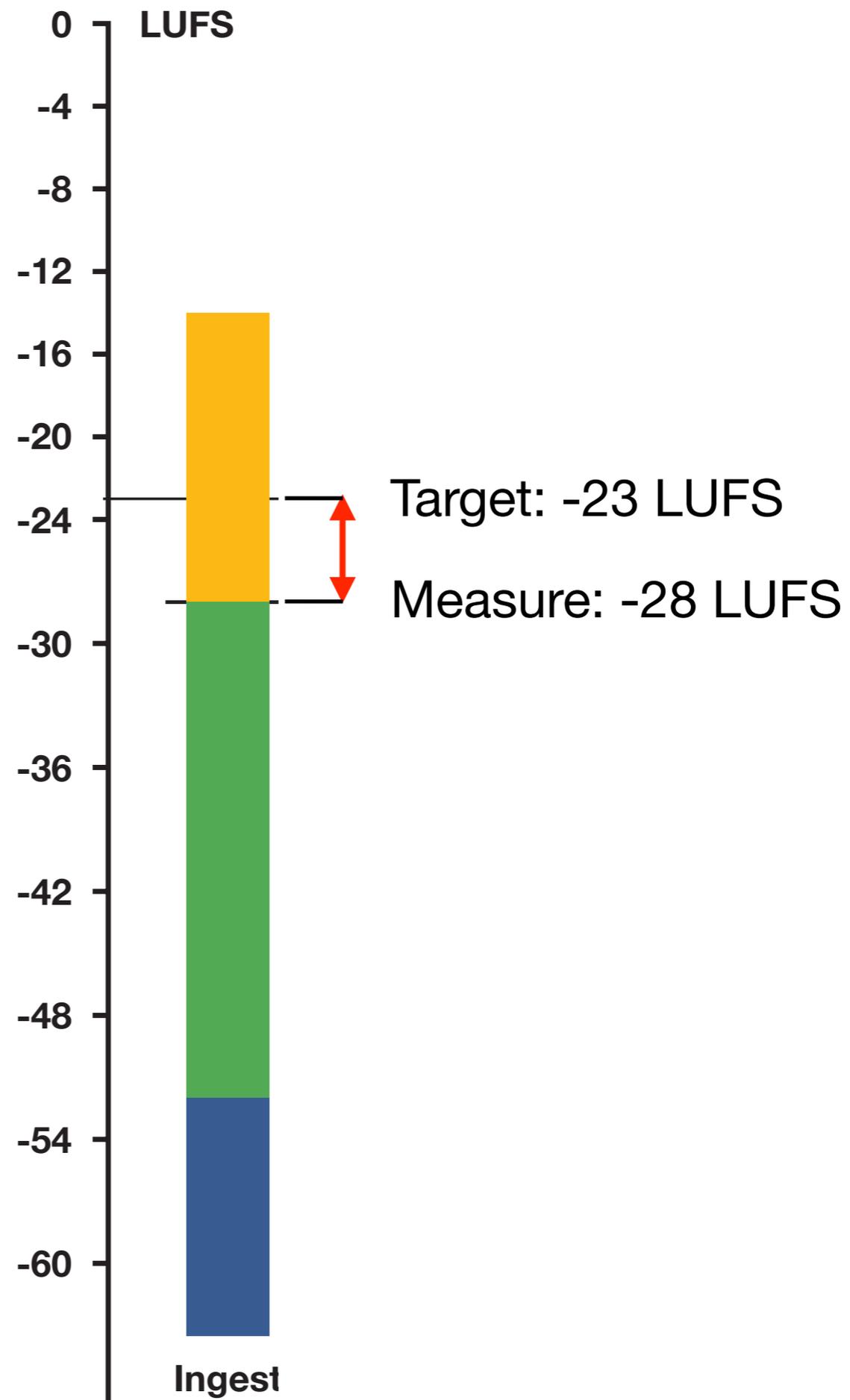


Program Loudness

Use to **normalize** programs.

In this example, Target Level is -23 LUFS.

A/85 specifies -24 LUFS.

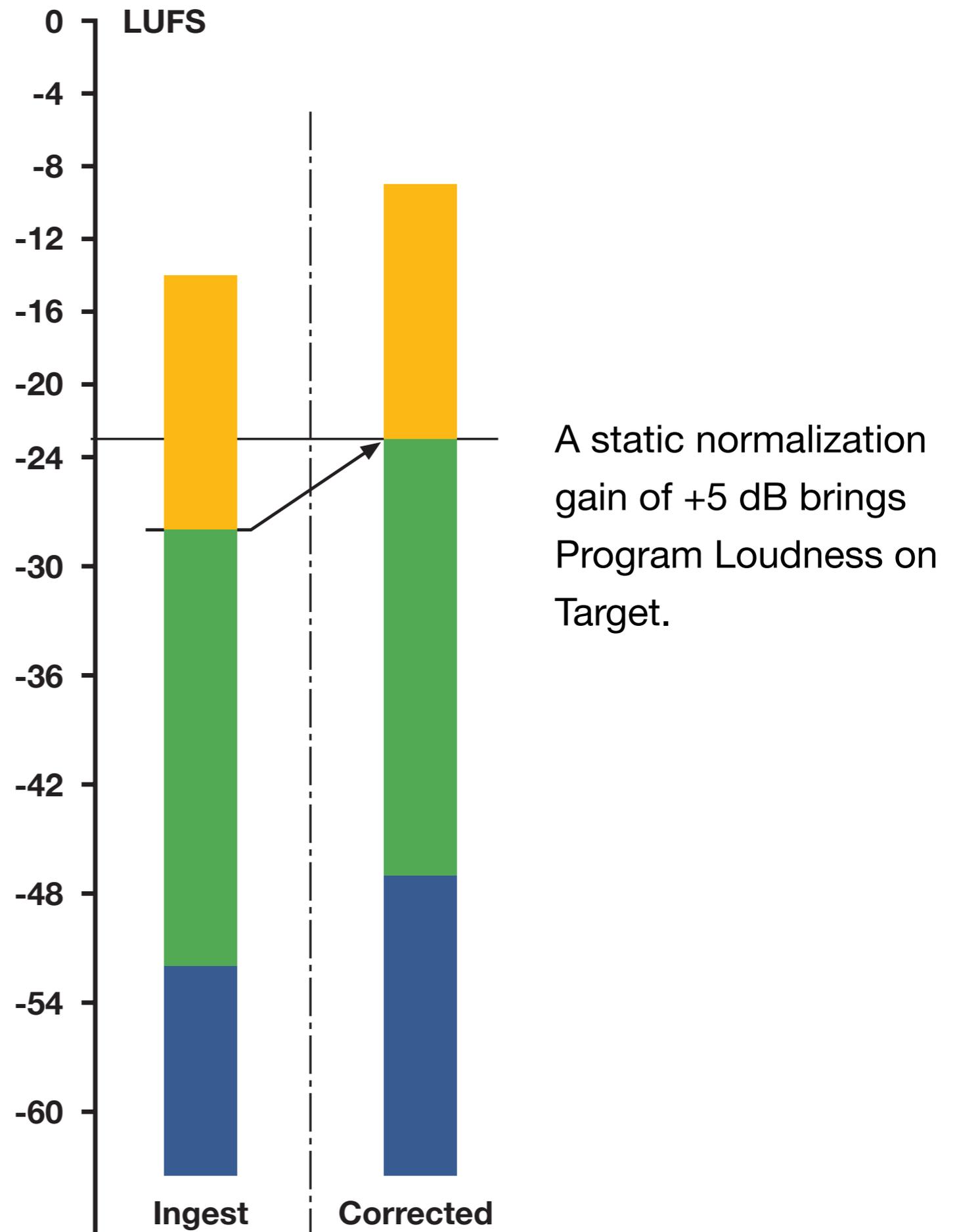


Program Loudness

Use to **normalize** programs.

In this example, Target Level is -23 LUFS.

A/85 specifies -24 LUFS, whereby normalize gain would have been +4 dB.



Why the gate in BS.1770-2?

EBU

A relative gate between -10 and -6 LU gave significantly better normalization results than no gate, or other gating schemes.

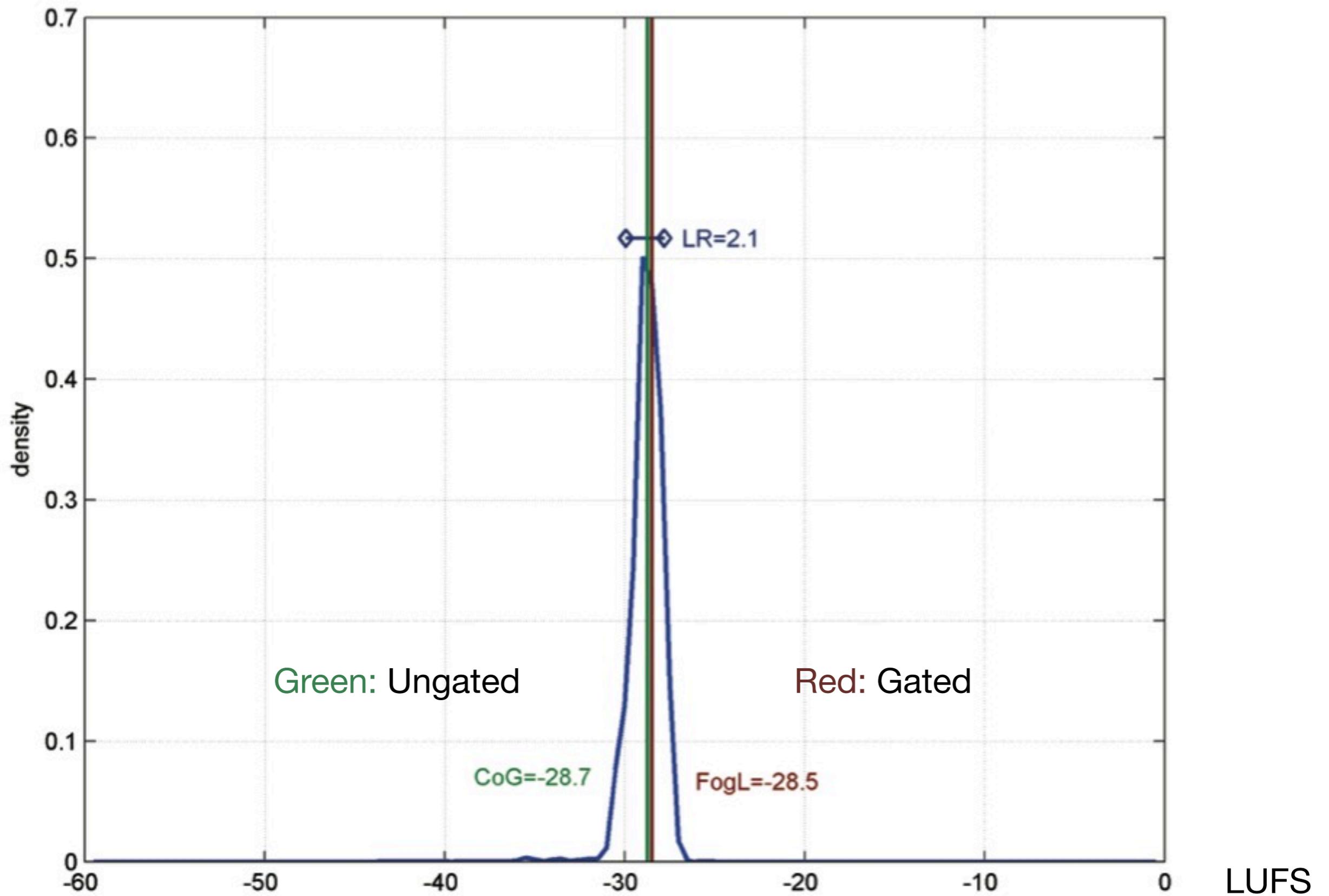
NHK & ARIB

Independent verification by NAB/ARIB **and** by NHK support relative gating method and a threshold of -8 LU.

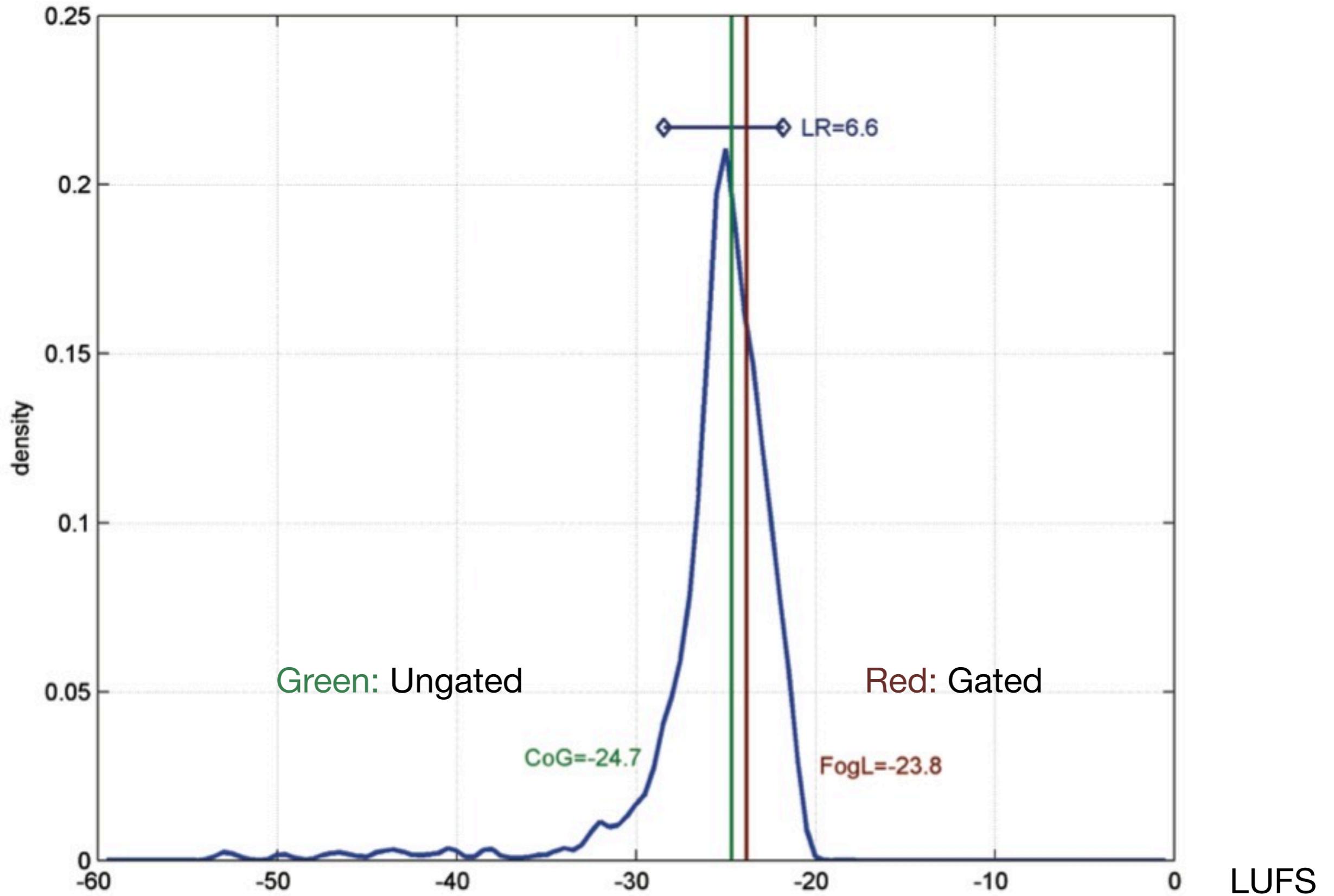
CRC

Independent verification: -8 LU relative gate shows best MSD performance.

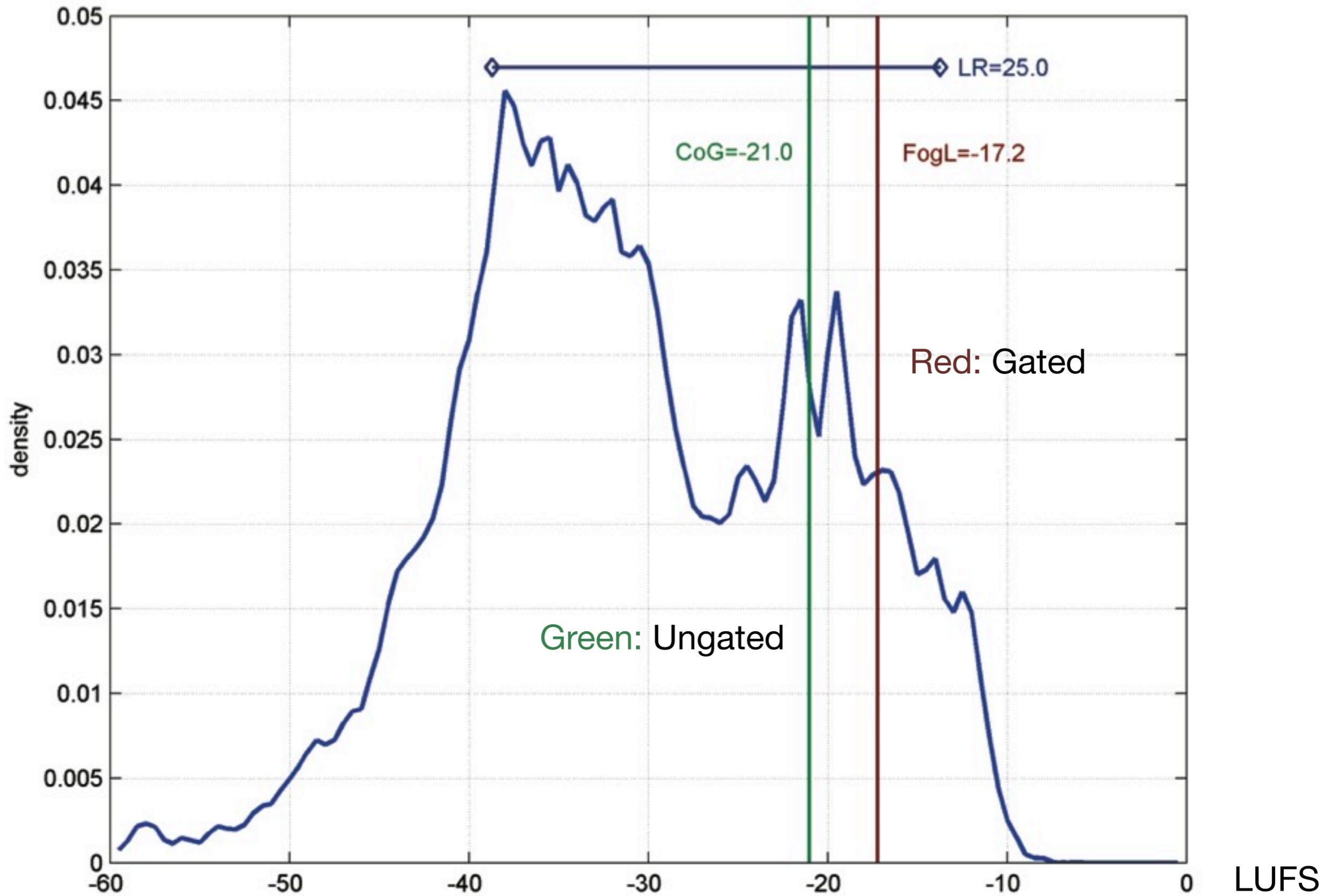
News Speaker (NLR)



Episode of Friends (MLR)



The Matrix Movie (WLR)



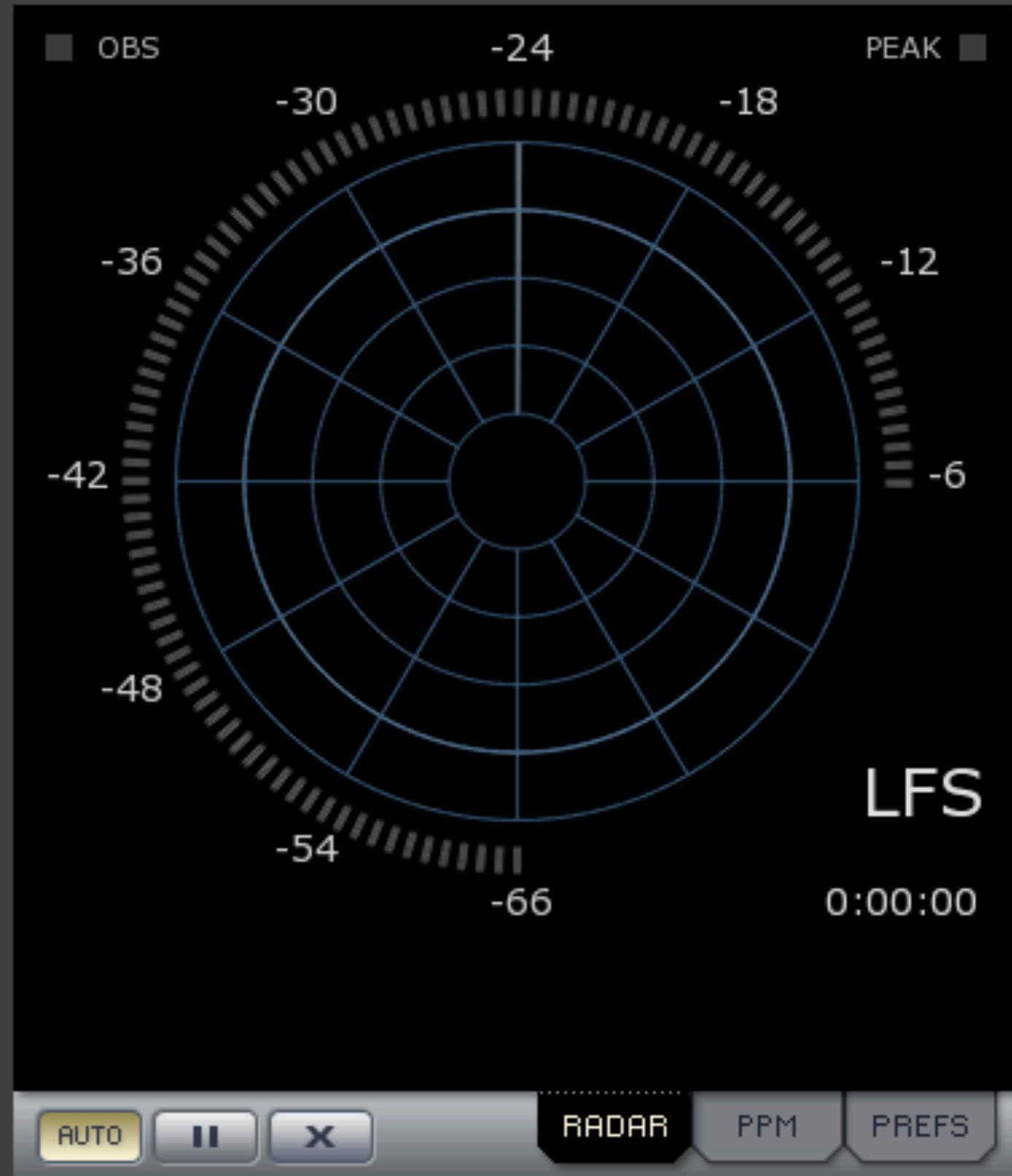
Speech normalized

ATSC A/85

= Too simplistic

Four Programs:

1. Movie
2. Commercial
3. Drama
4. Pop



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Satisfying CALM act requirements

Conclusion

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metadata, cross-platform, mobile TV

EBU: Harmonized Metering

Program
Loudness



The **loudness of a full program**.
Gated measure. Same as BS.1770-2.

EBU: Harmonized Metering

Program
Loudness

L

The **loudness of a full program**.
Gated measure. Same as BS.1770-2.

▶ Momentary
Loudness

M

400 ms measure of loudness.
Un-gated rectangular window.

EBU: Harmonized Metering

Program
Loudness

L

The **loudness of a full program**.
Gated measure. Same as BS.1770-2.

Momentary
Loudness

M

400 ms measure of loudness.
Un-gated rectangular window.

Short-term
Loudness

S

3 sec measure of loudness.
Un-gated sliding window.

EBU: Harmonized Metering

Program
Loudness

L

The **loudness of a full program**.
Gated measure. Same as BS.1770-2.

Momentary
Loudness

M

400 ms measure of loudness.
Un-gated rectangular window.

Short-term
Loudness

S

3 sec measure of loudness.
Un-gated sliding window.

Loudness
Range

LRA

The **loudness variations of a program**.
Independent of absolute level.

EBU Meter Example

Momentary Loudness

400 ms window

Short-term Loudness

Radar, 3 sec window history

Target Level

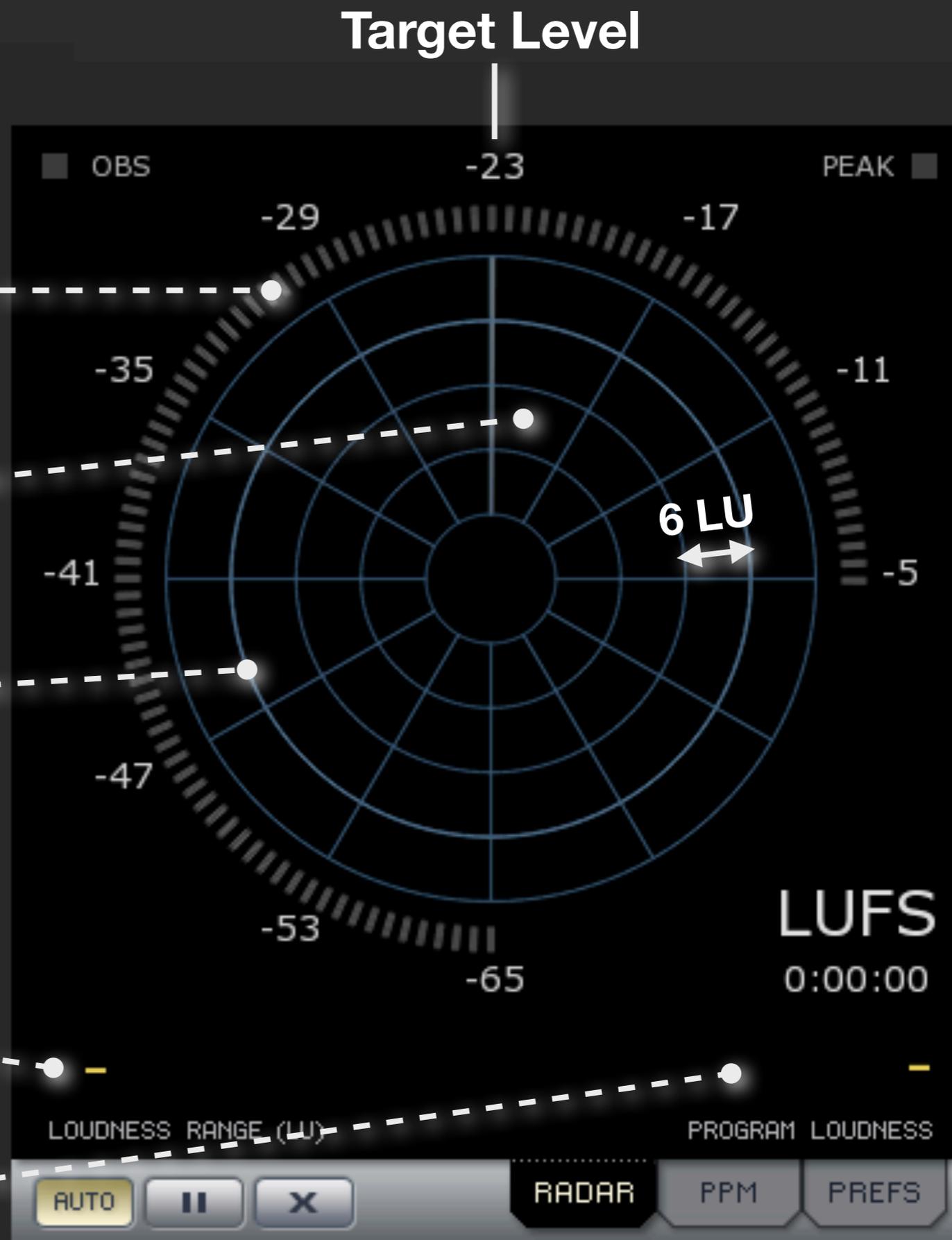
At 12 o'clock and at bold circle

Loudness Range

Loudness variation of program

Program Loudness

Same as BS.1770-2

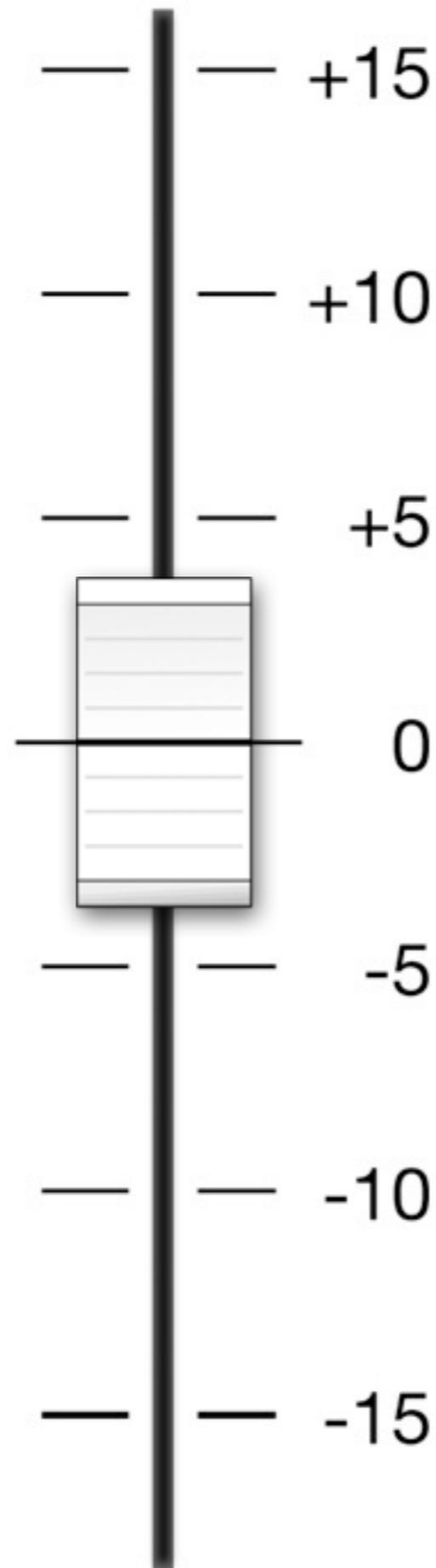


Loudness Range

Example:

LRA = 10 LU

To keep a **constant** loudness during the program, a ± 5 dB fader gain ride would be required.

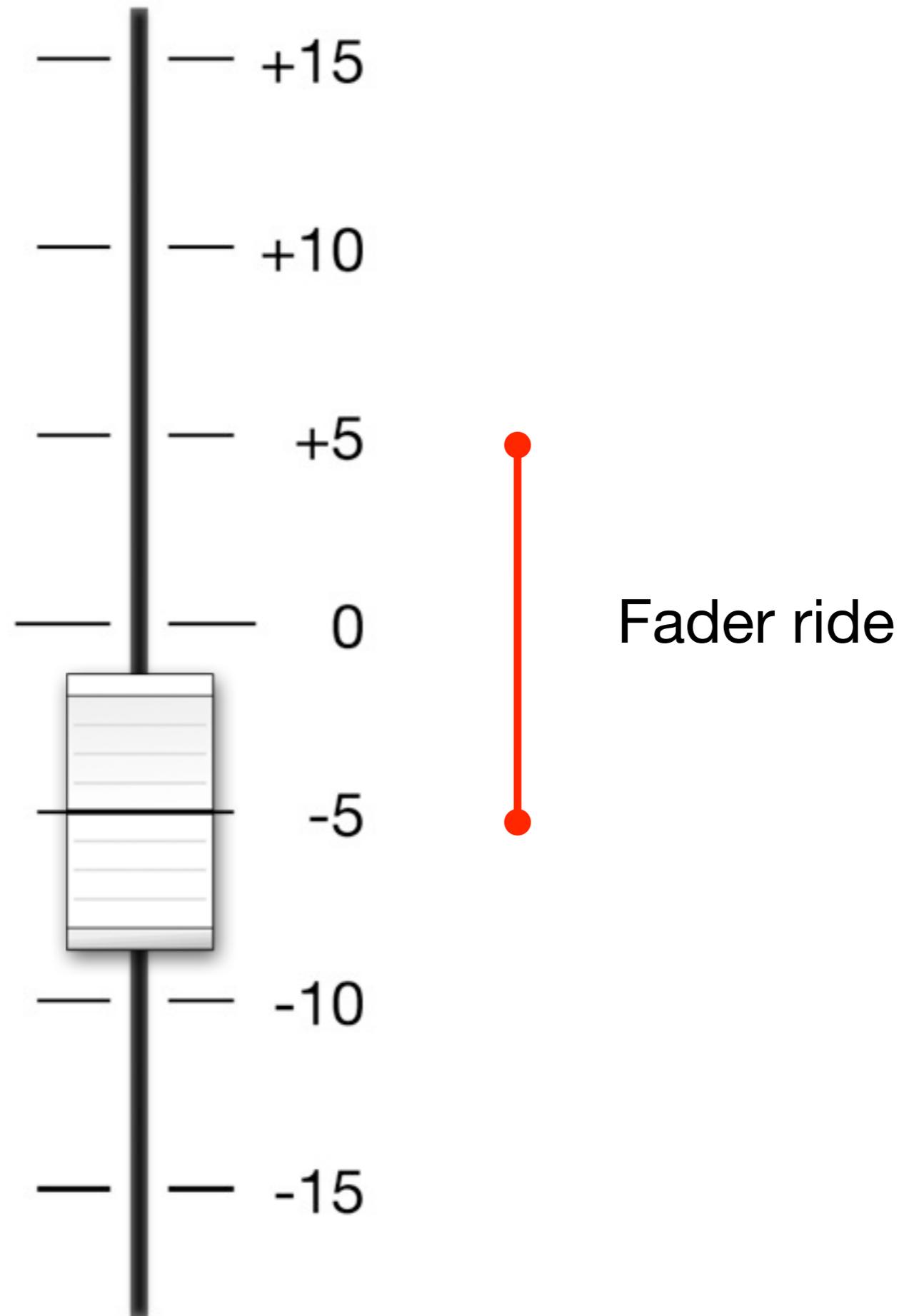


Loudness Range

Example:

LRA = 10 LU

To keep a **constant** loudness during the program, a ± 5 dB fader gain ride would be required.

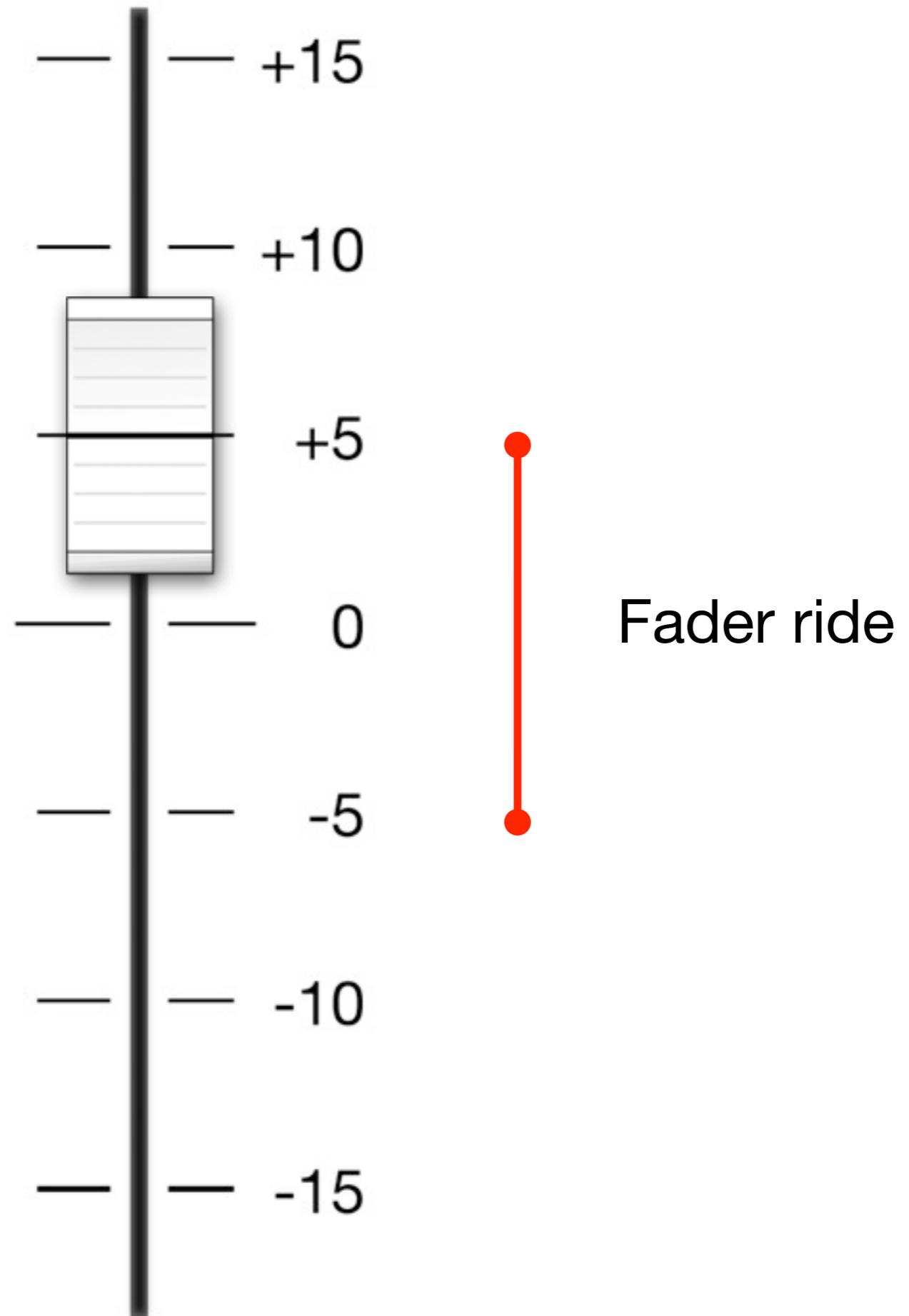


Loudness Range

Example:

LRA = 10 LU

To keep a **constant** loudness during the program, a ± 5 dB fader gain ride would be required.



Loudness Range

Delivery Specs

Guideline: Settle expectations.
Not FM radio, not cinema.

Compatibility

Loudness Range predicts if a program fits consumer requirements, or if platform processing is needed.

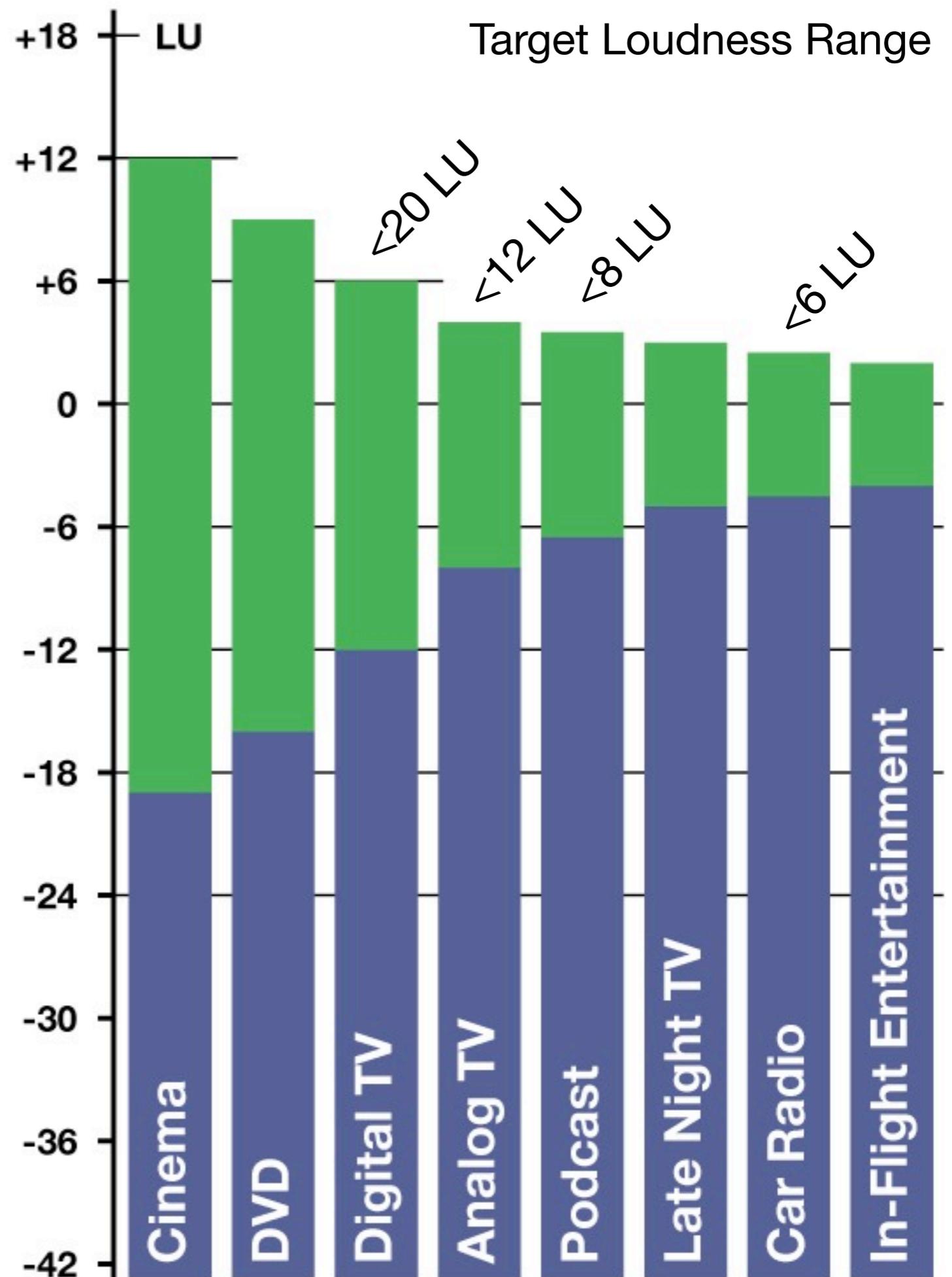
“Fingerprinting”

To check downstream signal-path incl. satellite, cable and STB.

Loudness Range

The ideal loudness range depends on the listener.

A high background noise calls for a low loudness range.



IRT NoTube project

Loudness Web Evaluation now online – be part of it!

Posted on [October 6, 2011](#) by [Peter](#)

End of 2010, we conducted a user evaluation to compare different ways to normalise the loudness of video clips. It [showed a significant improvement](#) of loudness normalised videos following [EBU-R 128](#) compared to the original video clips without any normalisation, the “Max PPM=0 dBFS” normalisation used in CD production and the former European Broadcast Recommendation “Max QPPM=-9 dBFS” (see the [Research Topics pages](#) for more information).

Following the results of this test, we decided to perform another user evaluation to investigate the variation of both the Programme Loudness and Loudness Range (LRA) considering different listening situations as they can occur in the context of NoTube, i.e. using a computer, a mobile device or a Hybrid TV. We prepared different versions of a number of video clips to evaluate the application of loudness and LRA adaptation for typical listening situations of users.

The test can be carried out via the Web and to acquire the largest possible number of test cases for this evaluation we invite everyone to participate! Go to <http://survey.irt.de/notube> or scan the QR code with your smart phone to take part and to learn more about Loudness Normalisation on the Web! The evaluation will be open until Wednesday, October 12th 2011.

Posted in [Evaluations](#), [Loudness](#) | [Leave a comment](#)



Loudness Jumps

How much can be tolerated *between* programs?

2003 “Comfort Zone” paper

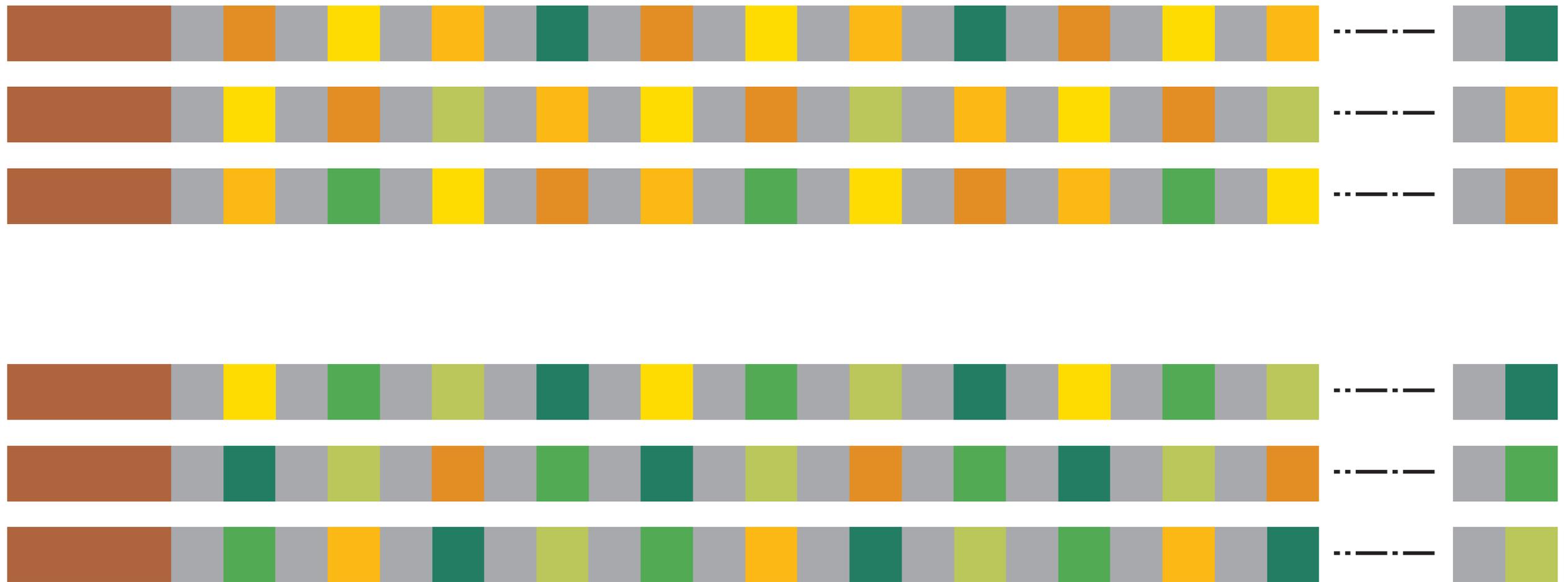
- Blind to anything but speech
- Study not based on BS.1770 when measuring segments

AES 2009 paper: New study based on BS.1770

- Commercials, drama, news, pop music, movie
- Measures all sources

Loudness Jump Tolerance

Tests with mostly speech



Tests with mostly music and effects

Loudness Jump Tolerance

Results

50% would adjust volume
for a loudness *increase* of 3 LU
for a loudness *decrease* of 6 LU

95% would adjust volume
for a loudness *increase* of 5 LU
for a loudness *decrease* of 8 LU

Conclusion

Any type of sound could trigger a level-adjustment

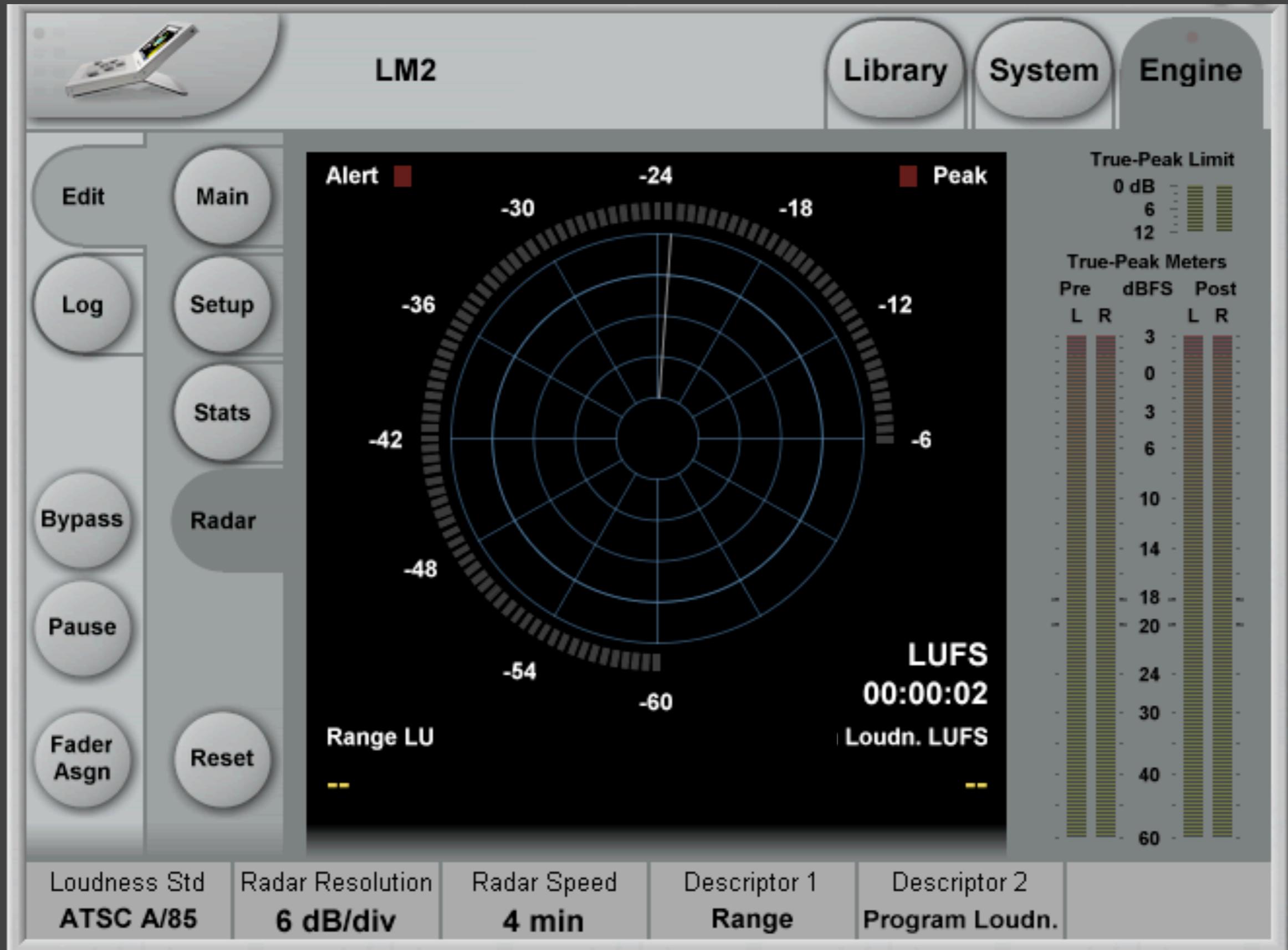
CALM Act

Transparency when normalizing commercials is a must

- for the advertiser
- for the broadcaster

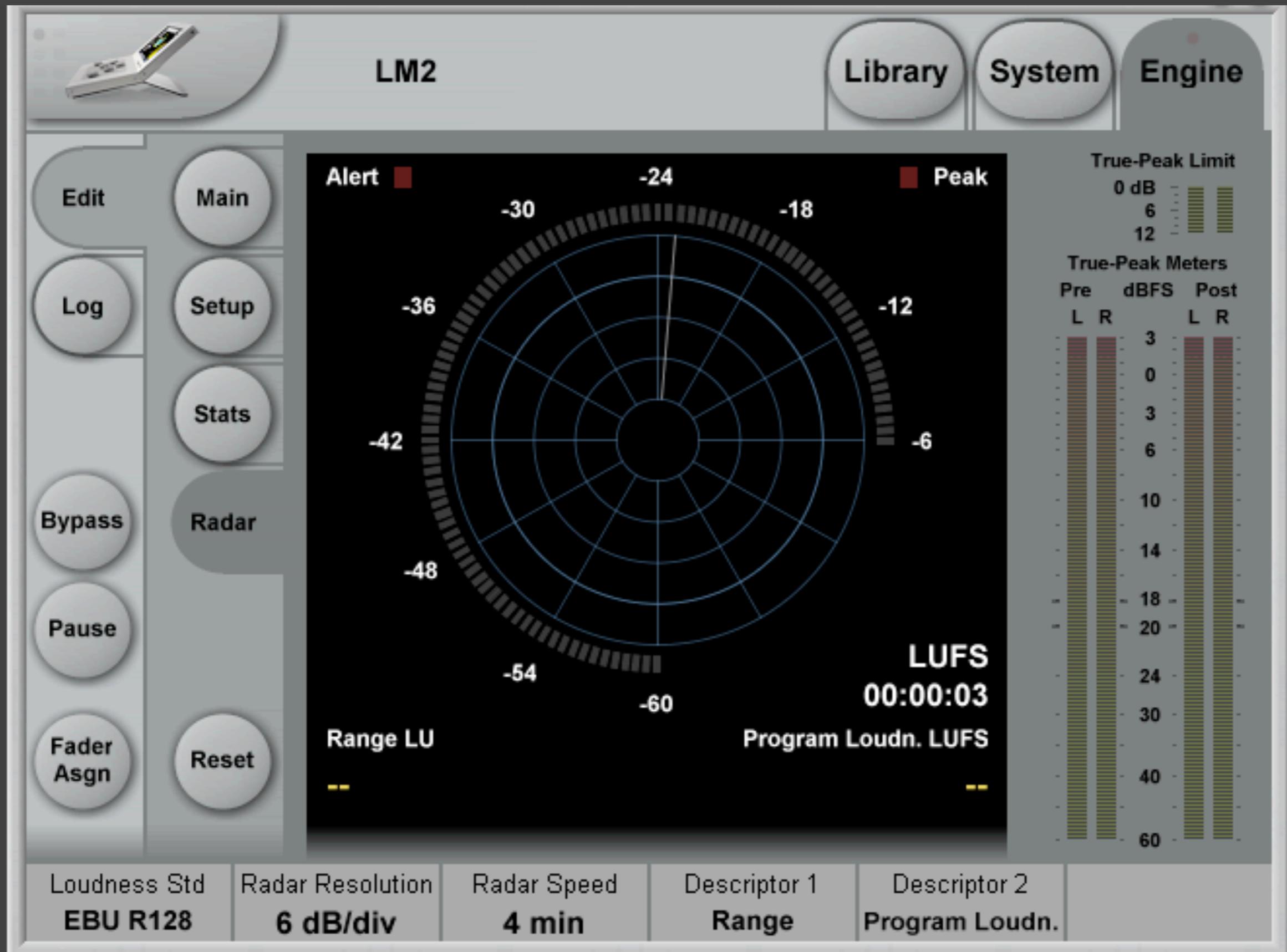
Commercial, un-gated

BS.1770 and BS.1770-1



Commercial, Program Loudness

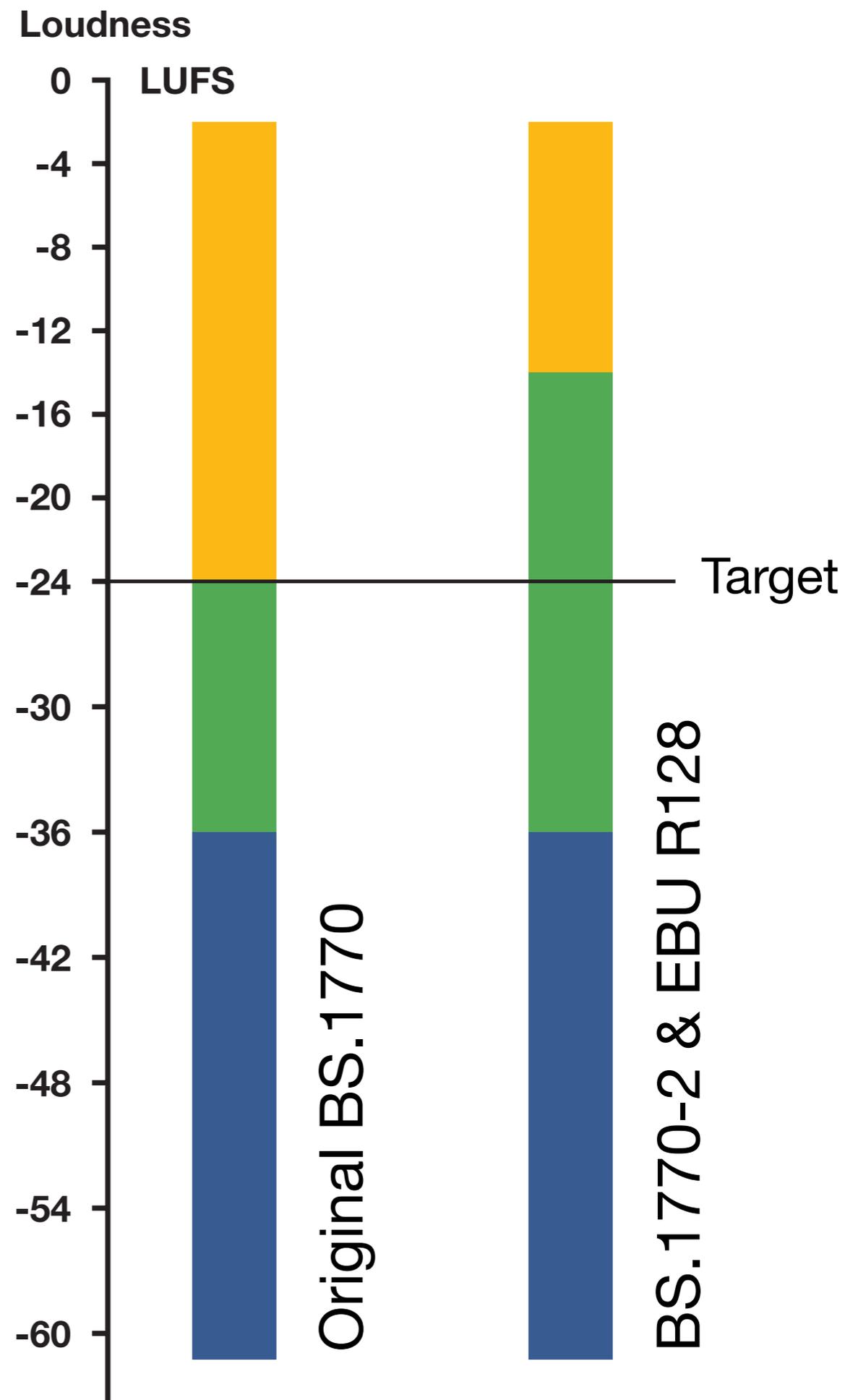
BS.1770-2



One commercial

Two results

Gating gives focus to foreground sound: Louder and potentially annoying parts of a program.



Leq(K) “Loudness”

Un-gated
ATSC A/85 (maybe)

Includes silence

Application critical

Cross-genre critical

Similar numbers with NLR material

Different numbers with WLR material

Gated @ -10 LU
BS.1770-2, R128, TR-B32

Focus on foreground

Application friendly

Cross-genre friendly

Where is ATSC on Loudness?

July 25, 2011

2 REFERENCES

At the time of publication, the editions indicated below were valid. All referenced documents are subject to revision, and users of this Recommended Practice are encouraged to investigate the possibility of applying the most recent edition of the referenced document.

2.1 Informative References

The following documents contain information that may be helpful in applying this Recommended Practice.

- [1] ATSC: "ATSC Digital Television Standard, Part 5 – AC-3 Audio System Characteristics," Doc. A/53 Part 5:2010, Advanced Television Systems Committee, Washington, D.C., 6 July 2010.
- [2] IEEE: "Use of the International Systems of Units (SI): The Modern Metric System," Doc. IEEE/ASTM SI 10-2002, Institute of Electrical and Electronics Engineers, New York, N.Y.
- [3] ITU-R: "Recommendation BS.1770-1, Algorithms to measure audio programme loudness and true-peak audio level," International Telecommunications Union, Geneva, 2007.
- [4] ATSC: "Digital Audio Compression (AC-3, E-AC-3) Standard," Doc. A/52B, Advanced Television Systems Committee, Washington, D.C. 14 June 2005.
- [5] IEC: "IEC 60268-17 (1990), Sound system equipment, Part 17: Standard volume indicators."
- [6] SMPTE: "SMPTE RP 200 – Relative and Absolute Sound Pressure Levels for Motion-Picture Multichannel Sound Systems," Society of Motion Picture and Television Engineers, White Plains, N.Y.
- [7] SMPTE: "SMPTE 302M-2007 Television – Mapping of AES3 Data into MPEG-2 Transport Stream," Society of Motion Picture and Television Engineers, White Plains, NY, 2007.



**Techniques for
Audio L**

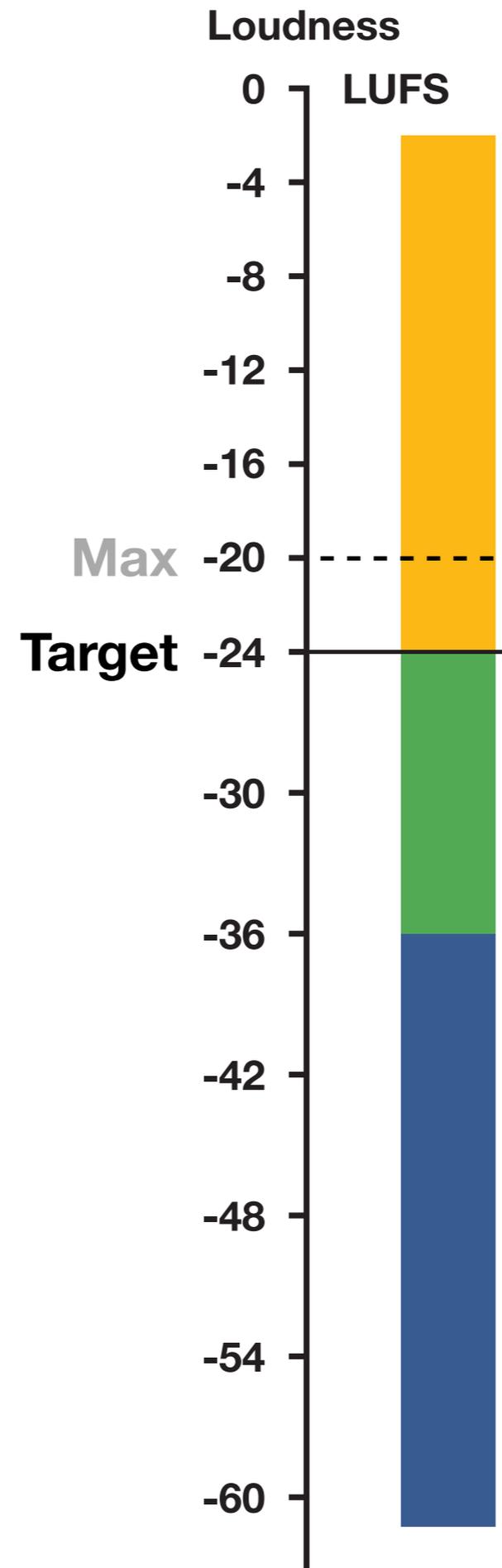
CALM Act

Alternative solution:
Use Max Loudness

BCAP procedure.

Max Loudness prevents
short programs from ever
getting annoyingly loud.

3 sec sliding window



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Production Guidelines

Speech

Regular speech: -27 to -23 LUFS

Music

Foreground: -24 to -21 LUFS

Loudness Range

Get expectations cleared early

True-peak Level

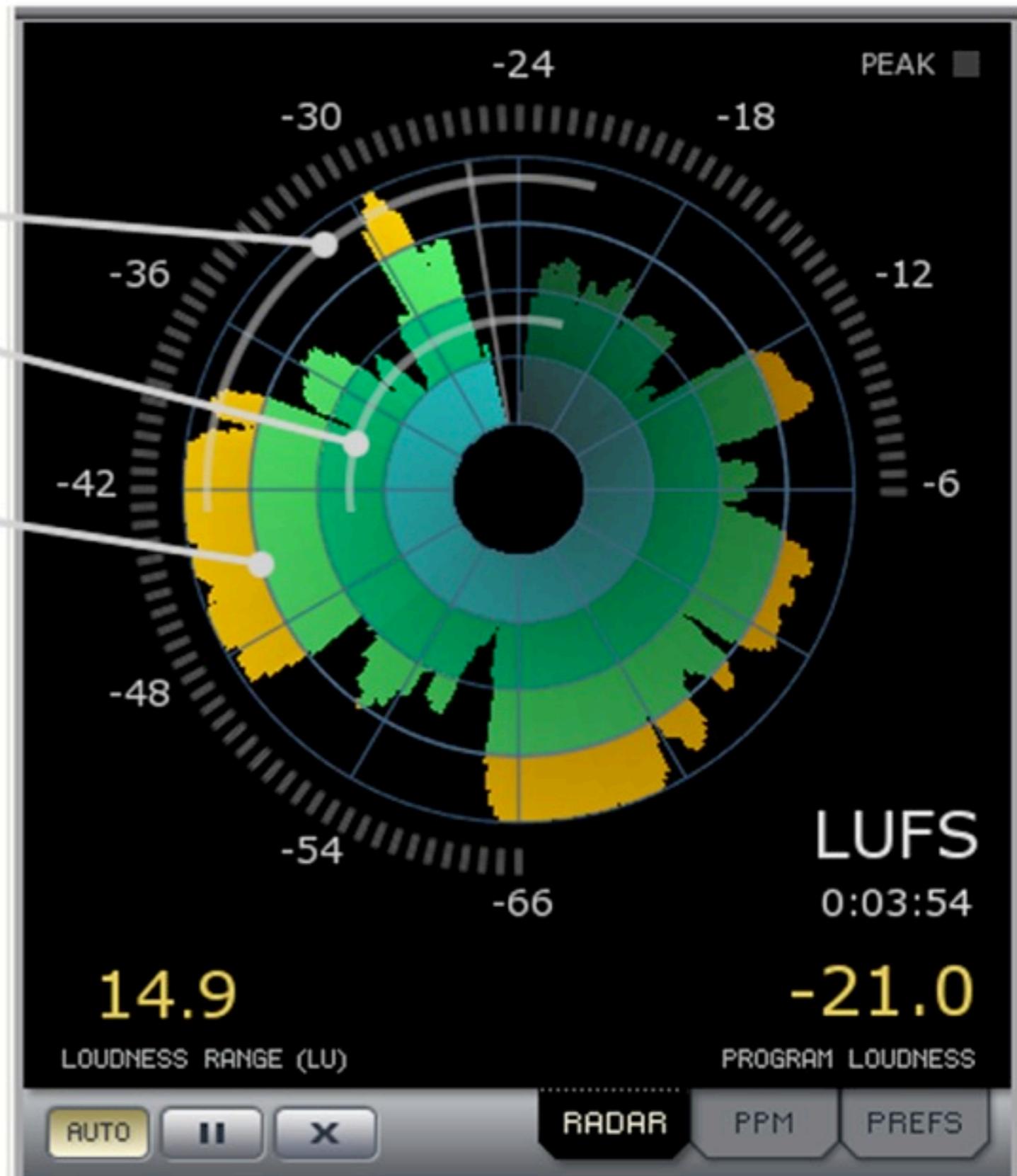
No higher than -1 dBTP

May need further lowering downstream,
depending on platform and codec

Broadcast Production:

Most of the time,
stay between +4 LU
and -8 LU

Target: -24 LUFS
(LUFS = LKFS)



*Example from Pirates movie
which clearly falls outside
broadcast specs*

Live Metering

Loudness meter easier to use than peak or VU

Look at a Sliding measure and Program Loudness

Start 1 LU below the Target

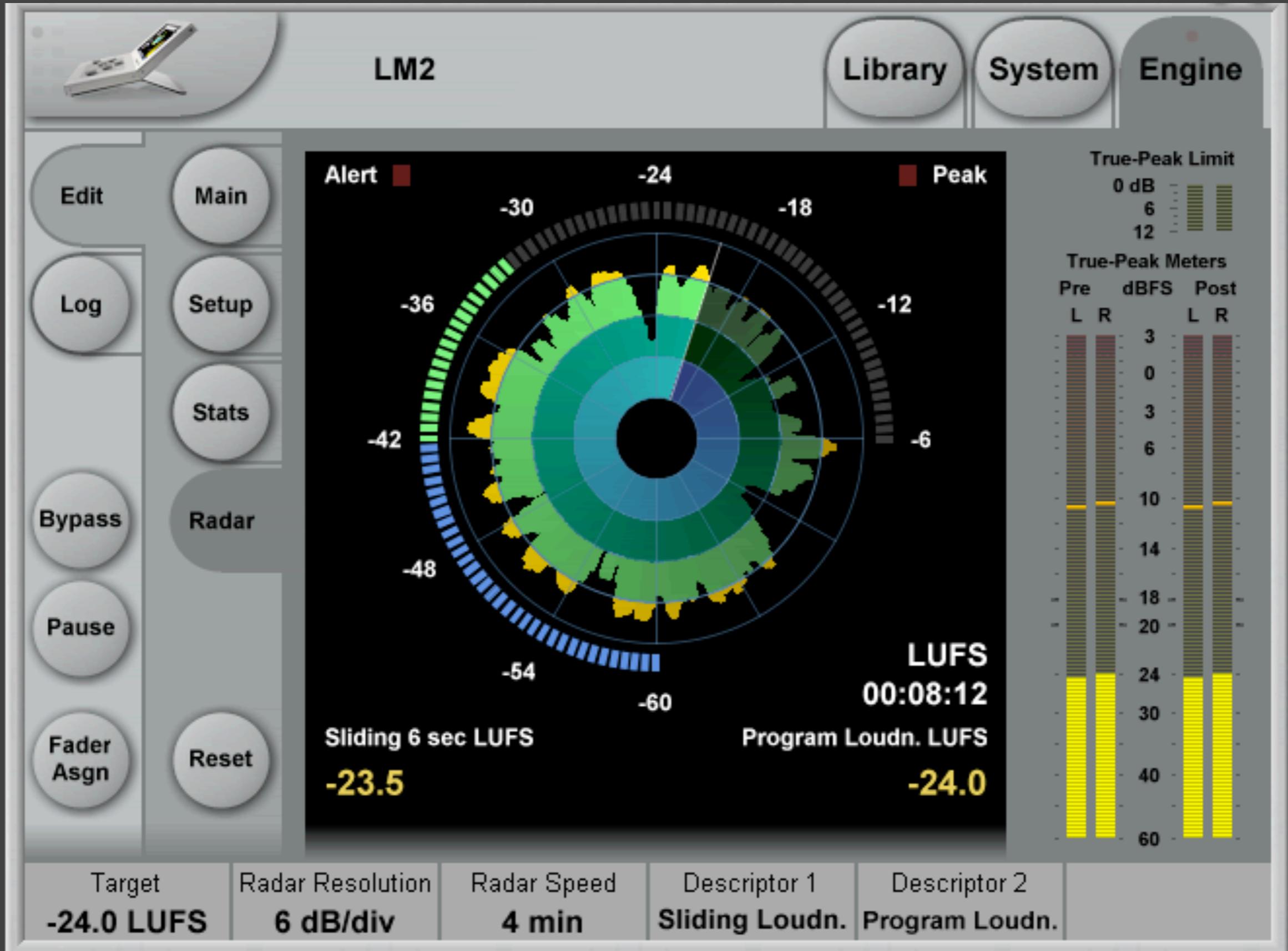
Use your ears

Peak meters are only there to avoid overload

Move up to the Target at the end

Live Sports

Sliding Window and Program Loudness



Where to Normalize

At the station or using metadata?

EBU recommends normalization **at the station:**

- one thing less to go wrong
- a benefit to all platforms
- more predictable
- lower workload
- cheaper (fewer Dolby boxes)

Platform Trickle-down

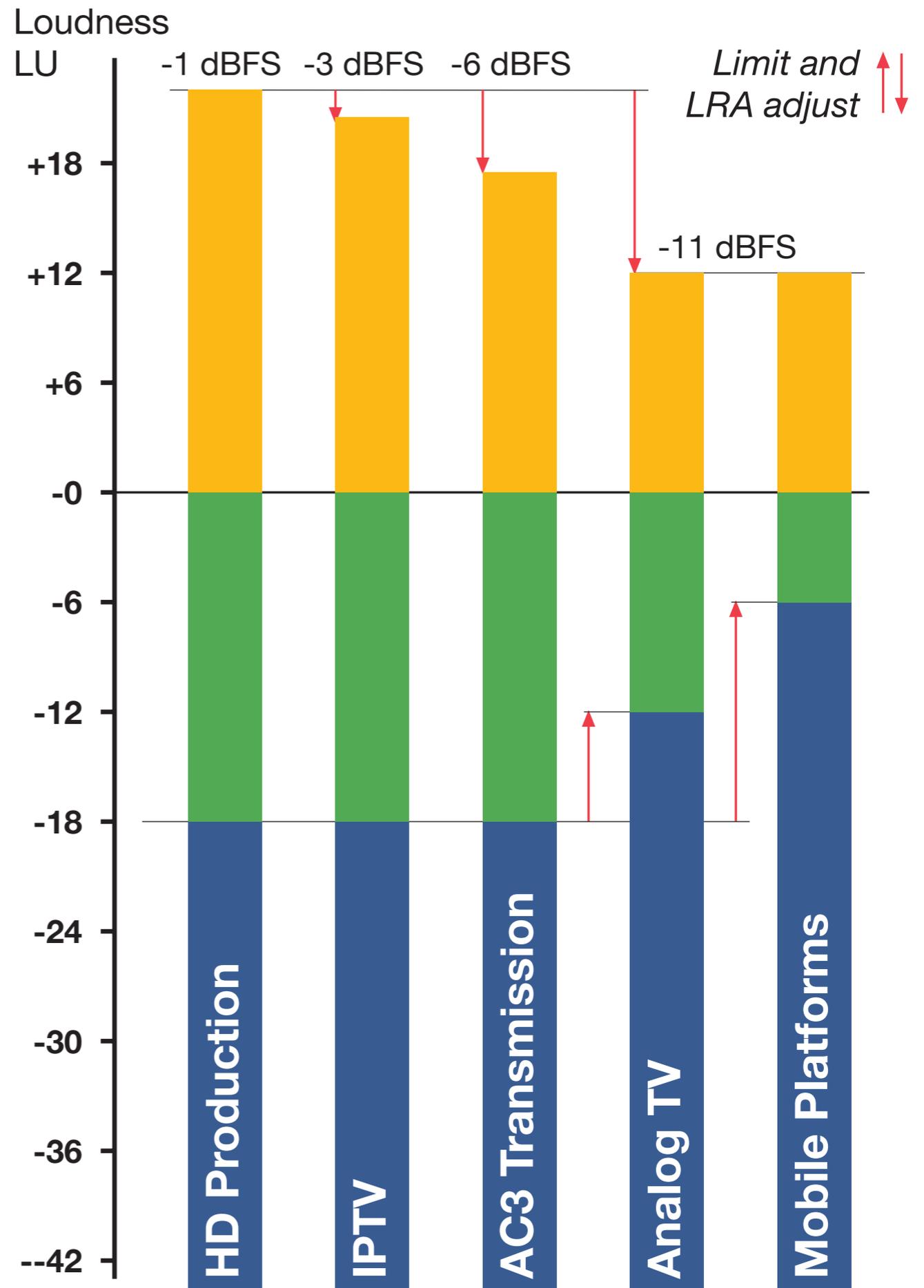
Normalize first.

Automatic LRA restriction around the Target level for lo-res platforms is the audio friendly and low workload solution.

Note:

0 LU = -24 LUFS

LUFS is the same as LKFS



Program Loudness at -24 LUFS is too low for pod/mobile platforms

Apple Sound Check aims at **-16.5** LUFS using BS.1770-2

	<i>no G</i>	↓	<i>G8</i>	<i>Max</i>	<i>LRA</i>	<i>TP</i>
Pop, Rock, Clas. Music Gilgamesh, Battle of Titans, Osaka Symphony	-16,6	-15,1	-14,5	-10,7	19,7	-0,9
Land of Hope and Glory, BBC Orchestra, Proms	-17,6	-16,8	-16,6	-9,4	18,7	-0,9
The Other Side, Pendulum	-14,1	-13,4	-13,3	-12,2	16,7	-4,9
Running To Stand Still, U2	-21,4	-20,6	-20,5	-14,0	16,0	-1,0
Stairway to Heaven, Led Zeppelin	-16,8	-16,1	-15,7	-10,7	15,5	-3,4
Someone Saved My Life Tonight, Elton John	-18,2	-17,5	-17,0	-12,5	15,4	-1,1
Mozart, Quartet in G minor, K. 478, Andante, Brendel	-20,8	-20,1	-19,7	-12,8	14,5	-1,1
C'Era Una Volta Il West, Ennio Morricone	-15,8	-15,4	-15,0	-10,5	13,2	-1,6
Beethoven, Violin Son No 3, Mullova & Bezuidenhout	-19,9	-19,3	-18,9	-9,8	12,9	+0,4
Hotel California, Eagles	-19,3	-18,9	-18,7	-15,0	12,8	-1,0
Beethoven, Sonata in F Op. 17 Kliegel & Tichman	-19,7	-19,2	-19,0	-13,4	12,0	-0,9
Broadcast Videnskabens verden, poly, 13/4-2011, 59:10	-19,6	-19,1	-18,9	-11,3	6,3	0,0
Videnskabens verden, poly, 16/10-2010, 57:18	-20,6	-19,8	-19,6	-12,4	9,4	-0,6
Videnskabens verden, poly, 5/12-2009, 59:10	-19,8	-19,3	-19,2	-14,9	4,6	-3,2
Rosenkjær, Hvor tomt er...? 30/4-2007, 28:36	-16,0	-15,7	-15,6	-11,0	5,0	+0,4
Rosenkjær, Vil liv på andre...? 7/5-2007, 29:16	-20,4	-20,1	-20,0	-14,5	5,6	-0,7
Rytteriet pakke 68, poly, 15:55	-15,5	-15,1	-14,9	-10,1	8,2	-2,7
Rytteriet pakke 70 (nytår), poly, 17:52	-19,4	-18,9	-18,8	-13,0	7,7	-3,7
Average	-16,8	-16,5	-16,3	-12,9	7,7	

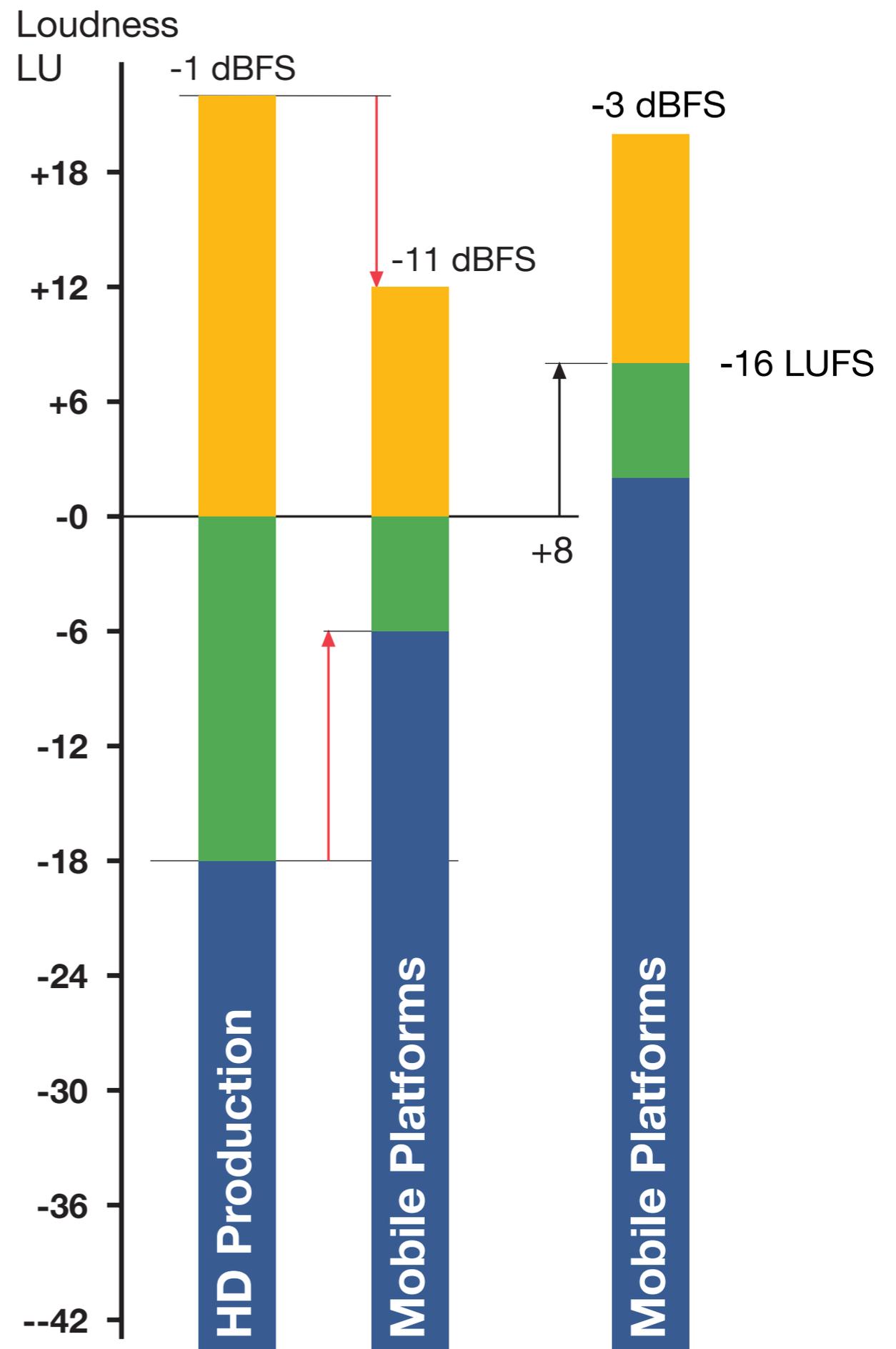
Platform Trickle-down: Mobile Platforms

1. Normalize
2. LRA and Limit
3. Make-up gain

Note:

0 LU = -24 LUFS

LUFS is the same as LKFS



Getting the best out of AC3

Normalize

Normalize programs at the station using BS.1770-2

Limit

Protect AC3 from peak overload, especially when transmitting 5.1 format

Metadata

Change metadata *only* when switching between stereo and 5.1

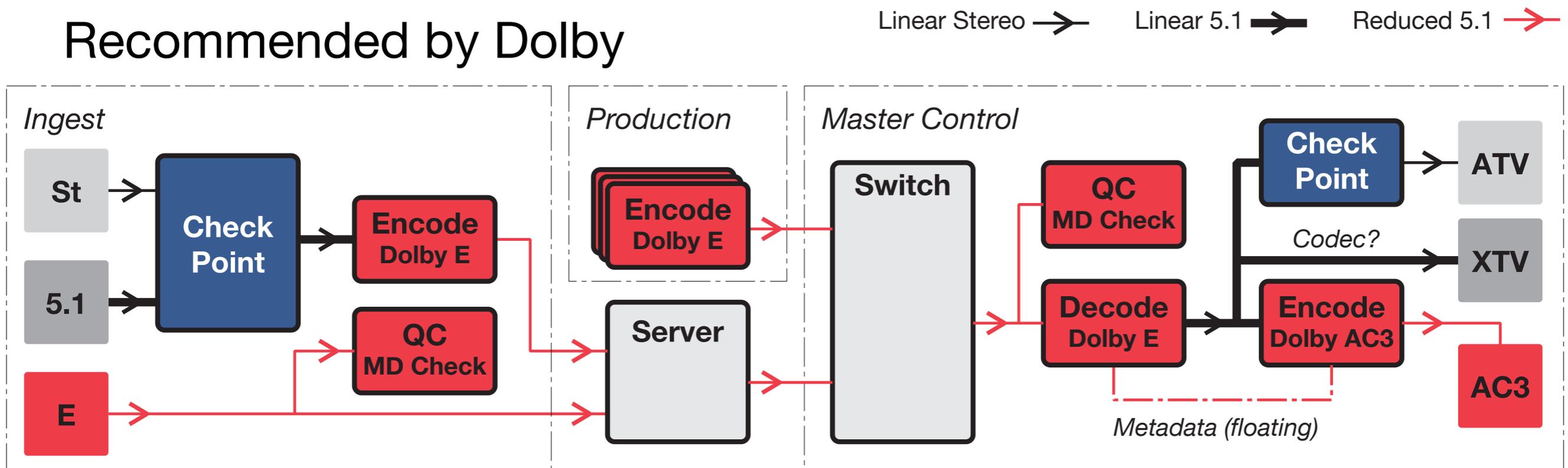
Enter -24 as dialnorm number

Note: The AC3 decoder is not speech based. Dialnorm just tells the average level of a program

Platform Strategies including AC3

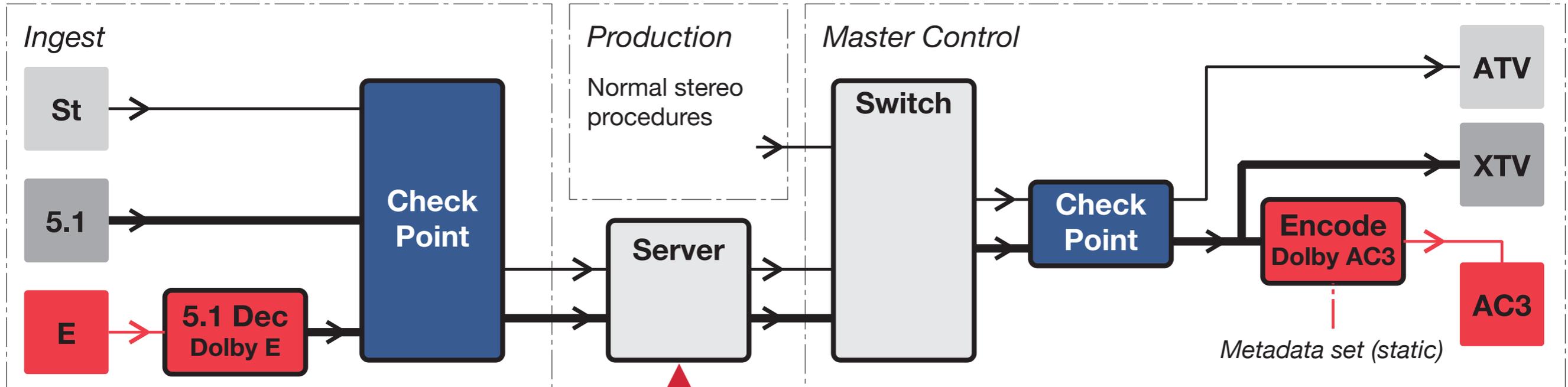
Half a solution for only one platform

Recommended by Dolby

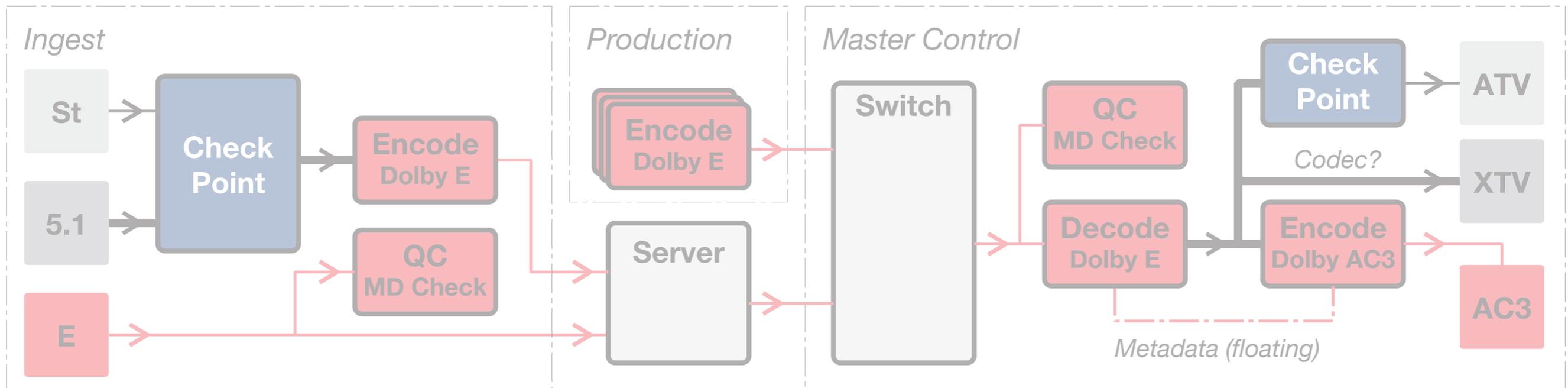


Platform Strategies including AC3

Recommended by EBU. Fixed Target -23 or -24 LUFS



Recommended by Dolby



Normalize audio?

Broadcast is not cinema

Picture is modified heavily

Expensive, unpredictable not to normalize

Plenty of headroom with Target at -24 LUFS

You may transmit The Matrix or Bolero without processing!

Logging

Check & Improve

Make it a goal not to process more than needed

production

logging ingest

transmission

Use the same Loudness Tools to gather Logs, and for calculating Statistical Program Summaries:

2010-09-16	08:29:46	-24.5
2010-09-16	08:29:47	-24.7
2010-09-16	08:29:48	-24.1
2010-09-16	08:29:49	-23.5
2010-09-16	08:29:50	-22.3
2010-09-16	08:29:51	-24.8
2010-09-16	08:29:52	-24.5
2010-09-16	08:29:53	-24.3
2010-09-16	08:29:54	-24.5
2010-09-16	08:29:55	-25.4
2010-09-16	08:29:56	-25.6
2010-09-16	08:29:57	-25.2
2010-09-16	08:29:58	-24.2
2010-09-16	08:29:59	-23.0
2010-09-16	08:30:00	-23.2
2010-09-16	08:30:01	-24.6



Global understanding: Loudness instead of Peak level

A/85

HDTV Only Focus

Anchor for WLR

Monitoring guidelines

AC3 manual

R128

All Platforms

One Number

Distribution guidelines

Open standards

Harmonized metering

Tools to control commercials

BS.1770-2 and R128

Better at controlling **commercials**

Better at normalizing **WLR** content

Better at setting **metadata**

than a speech or a
peak based measure

Enables transparent normalization across **all platforms**

Open standard, no proprietary technology

Automated handling, runs on a server

Harmonized metering across brands

=> cheaper



AES New York 2011 Workshop

Saturday, October 22, 11:00 am – 1:00 pm

Loudness Wars: The Tides Have Changed

Chair:
 Thomas Lund

Panelists:
 John Atkinson
 Bob Katz
 Bob Ludwig
 Susan Rogers

Abstract:
 2011 will go down in history as the year when ITU-R BS.1770-2 was introduced, and the sample peak measurement got retired. The old measurement is responsible for the ruining of 15 years of music heritage at the source, while the new one takes away the loudness advantage squashed productions had over dynamic content. Picking up where the panel left last year, you can expect an updated tour de force in listening examples, theory, and discussions. Find out how the changing tide will influence you when heard from a perceptual, a mixing, a mastering, and a consumer perspective. From Bach to Beyoncé, Monty to Matrix, headphone to HD playback.

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EXHIBITION HOURS

Oct. 21 10am - 6pm

Ugly CD Examples



PROGRAM LOUDNESS

1. Danish Pop
2. Kelly Clarkson
3. Metallica
4. Pink Noise (FS)

-7.2

-4.2

-3.0

-8.7

LUFs

PROGRAM LOUDNESS



Don't let the same happen to broadcast

References



Read More

Zwicker & Fastl, 1990

Psychoacoustics - Facts and Models

Moore et al., 2003 (JAES no 12)

Why are Commercials so Loud?

Nielsen & Lund, 1999 - 2006 (AES 23, 107, 109, 111, 121)

0 dBFS+ Level in Mastering and Audio Production

Skovenborg & Lund, 2007 - 2009 (AES 123, 125, 127)

Loudness Descriptors to Characterize Programs and Music Tracks

ITU-R BS.1770-2, ATSC A/85

EBU R128, Tech docs 3341, 3342, 3343, 3344

Glossary: www.tcelectronic.com/loudness

IRT NoTube project: www.notube.tv

AES New York Oct 20, 16:30-18:30 - Papers on loudness

Oct 21, 14:00-15:30 - TV Loudness panel

Oct 22, 11:00-13:00 - Loudness War Tribunal



End

Thomas Lund

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