PQ → SDR (NBCU LUT5) Conversion Example Summary Example of Processing Flow

1. Decode & Convert PQ Y′CbCr → RGB Float (No Clipping)

Converts incoming BT.2020/PQ limited-range Y′CbCr to BT.2020/PQ full-range RGB float using zscale to avoid ingest clipping.

```
zscale=primariesin=bt2020:transferin=smpte2084:matrixin=bt2020nc:rangein=limited
: primaries=bt2020:transfer=smpte2084:range=full,format=gbrpf32le
```

2. Pre-Pack into LUT 0-1 Range while preserving under/overshoot (with Safety Margin (ε = 0.001))

Maps the working range [-0.073059 … 1.094749] into [0.001 … 0.999] so the LUT never hits cube edges.

```
geq=red_expr='((r(X,Y)*0.854224375+0.0633849':
green_expr='((g(X,Y)*0.854224375+0.0633849':
blue_expr='((b(X,Y)*0.854224375+0.0633849'
```

3. Apply NBCU PQ→SDR LUT5 (Tetrahedral)

Transforms PQ HDR to SDR in RGB float via NBCU_PQ2SDR_DL_v1.2.cube with tetrahedral interpolation.

```
lut3d=file='.../5-NBCU_PQ2SDR_DL_v1.2.cube':interp=tetrahedral
```

4. Post-Unpack LUT 0-1 working range back to float values that preserve under/overshoot below 0 and above 1 (Exact Inverse of Pre-Pack)

Restores the original numeric scale after the LUT while still in RGB float.

```
geq=red_expr='((r(X,Y)*1.1701493-0.0742291':
green_expr='((g(X,Y)*1.1701493-0.0742291':
blue_expr='((b(X,Y)*1.1701493-0.0742291'
```

5. Identify SDR BT.709 + convert to Legal Y′CbCr (Dithered)

Declares SDR BT.709 primaries/transfer and produces limited-range Y′CbCr 10■bit 4:2:2, using error■diffusion dithering.

```
zscale=primariesin=bt709:transferin=bt709:matrixin=bt709:rangein=limited: primar
ies=bt709:transfer=bt709:matrix=bt709:range=limited:dither=error_diffusion,forma
t=yuv422p10le
```

6. Encode as v210 & Embed SDR Metadata

Encodes as v210 (Y′CbCr 4:2:2 10■bit limited) and writes correct Rec.709 SDR metadata.

```
-codec:v v210 -color_primaries bt709 -color_trc bt709 -colorspace bt709
-color_range tv -movflags +write_colr
```

Result: Clean PQ→SDR down■map via LUT5 that avoids LUT-domain clipping, preserves highlight detail in RGB float, and legalizes only at final YUV output.