Synamedia

Quality Control for Real-Time VBR Encoding

QC-VBR

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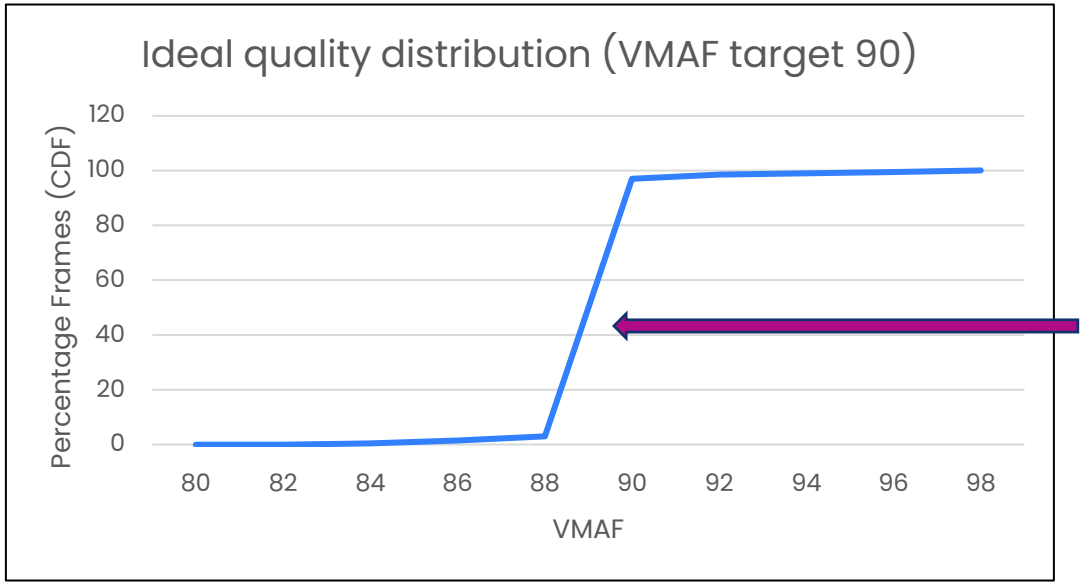
Motivation

For a user that wants output video of a constant quality

- Bitrate too high → quality achieved, but wasting bandwidth (overshoot)
- Bitrate too low → quality below the user's desired quality level (undershoot)
- User will often also have some upper bitrate limit



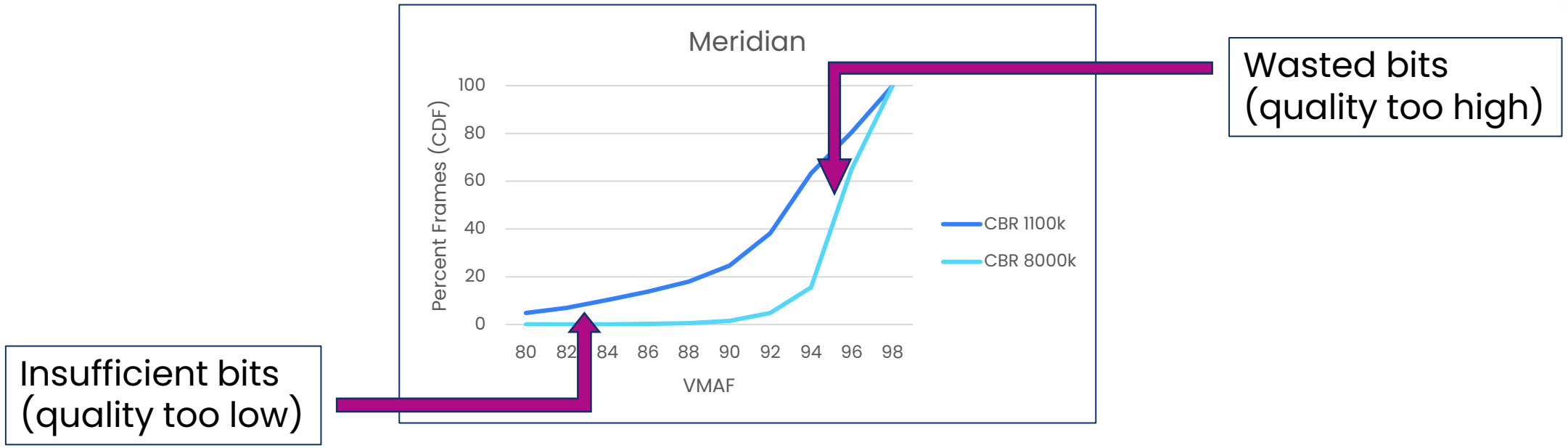
~all frames at VMAF 90

Constant bitrate (CBR) limitations

CBR allows only limited bitrate variations (VBV buffer)

Difficult to get good quality distribution with CBR

CBR rate to achieve the right quality differs by content



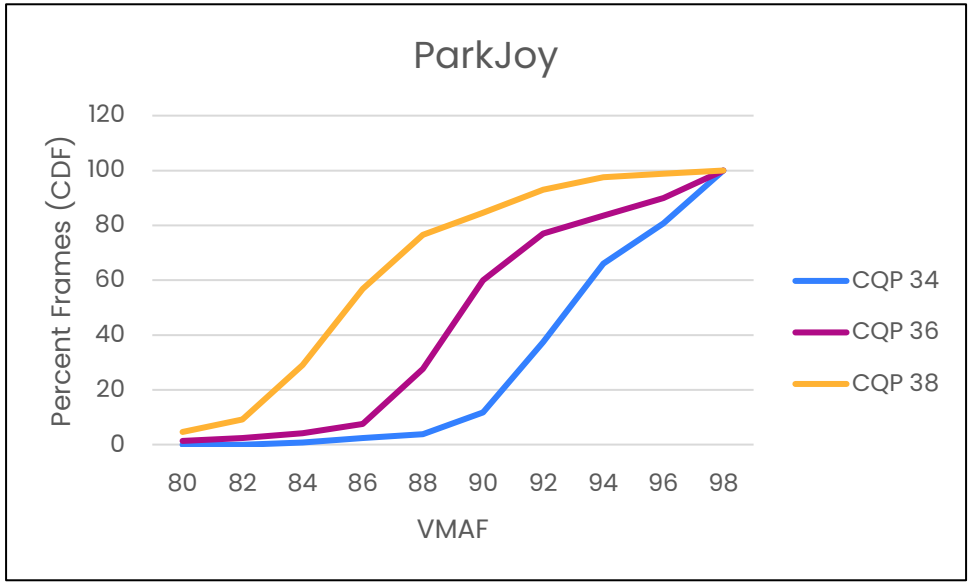
Variable bitrate (VBR)

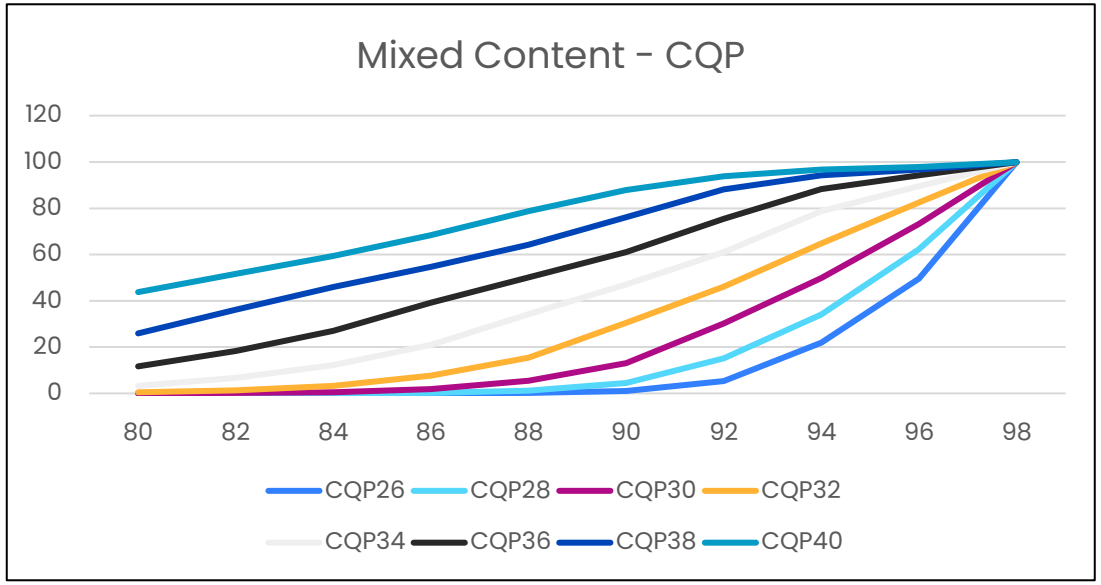
Better but still not ideal

- Traditional VBR methods: constant QP (CQP), constant rate factor (CRF)
  - CQP: constant QP for whole encode
  - CRF: CQP + some additional subjectively-tuned variation

Better than CBR for consistent quality – allows for bitrate peaks at hard content

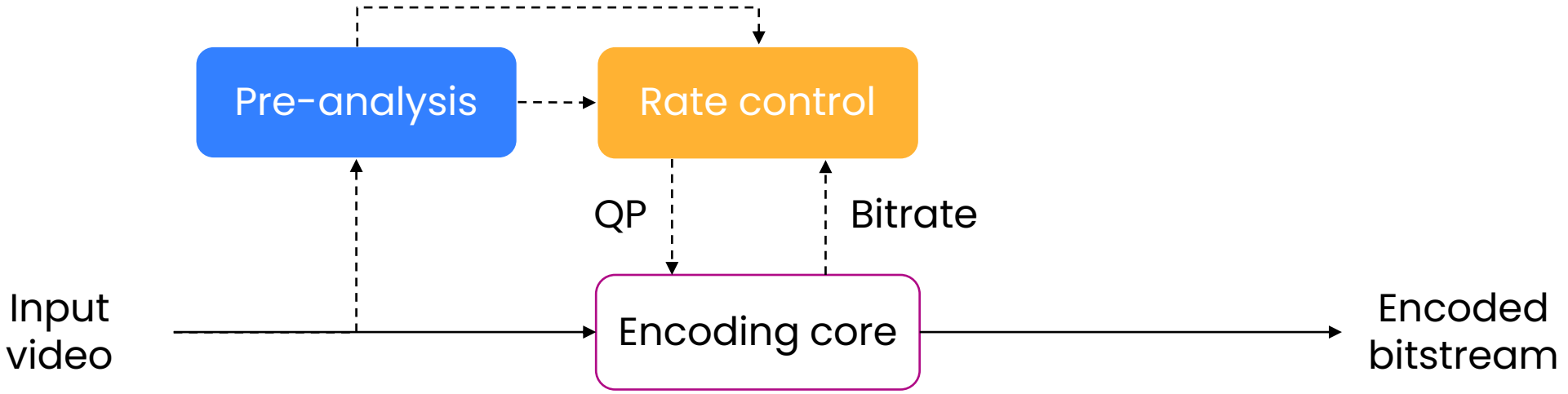
Configuration difficulty: single CRF or CQP may give inconsistent results between clips





From Rate Control to Quality Control

- CRF-like VBR bitrate control is normally based on subjective quality heuristics
  - ex. increase compression on high motion, region of interest boosting
- Difficult to accurately assess the quality result in a computationally-cheap way
- Final result may not yield desired quality



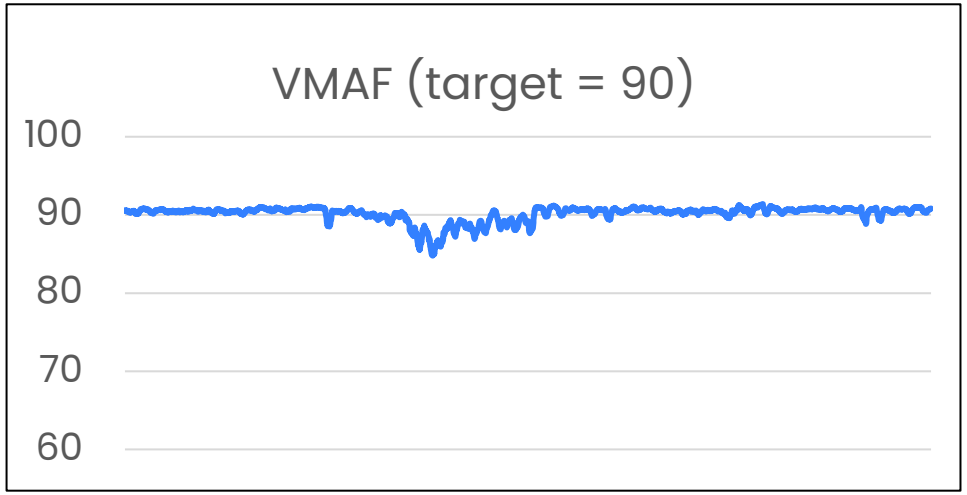
From Rate Control to Quality Control

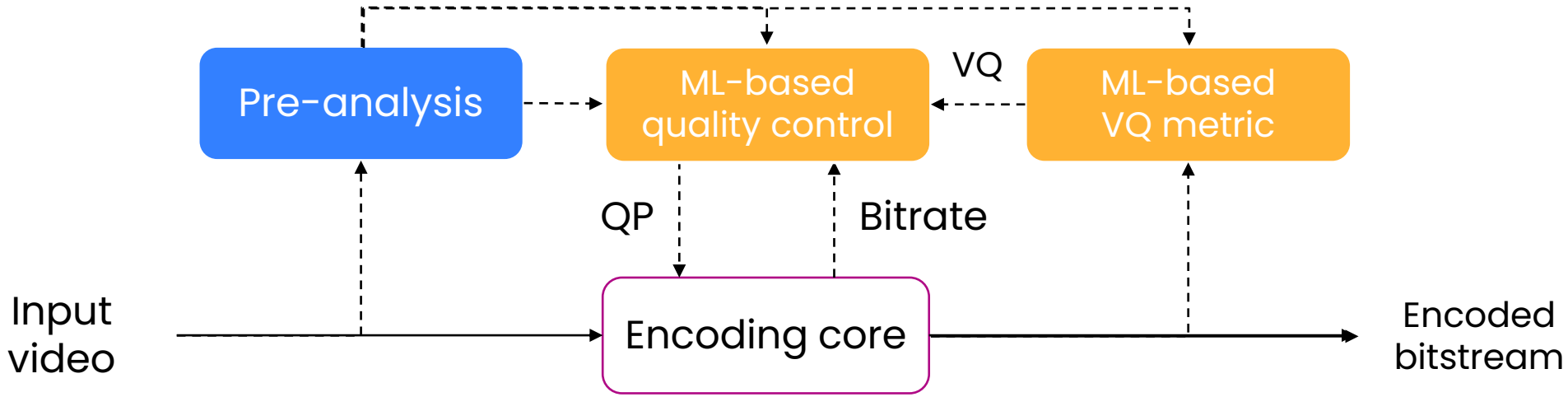
Introduced PVMAF – fast, accurate estimation of VMAF

- Fast QP to quality measurement is only the first step ($PVMAF_{est}$)
- Fast estimation of final encode quality provides an error-correcting feedback path (PVMAF)

QC-VBR: integrates low-complexity VQM metrics inside encoder, both pre and post-encode

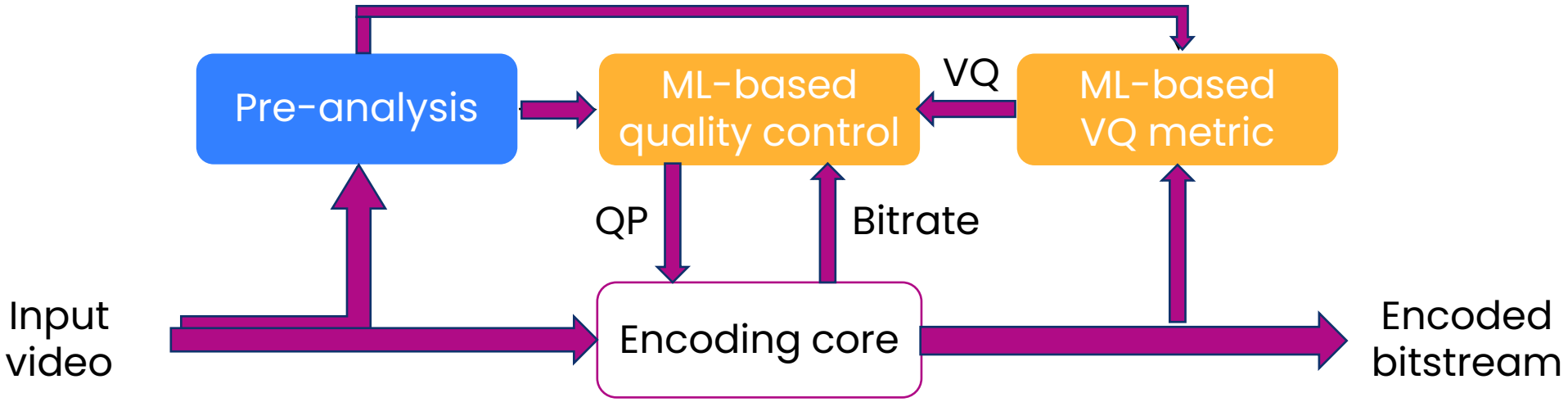
Rate control becomes quality control





Quality-Based Rate Control

Goal: select QP to give desired quality



Pre-analysis generates stats
$PVMAF_{est}$ calculated

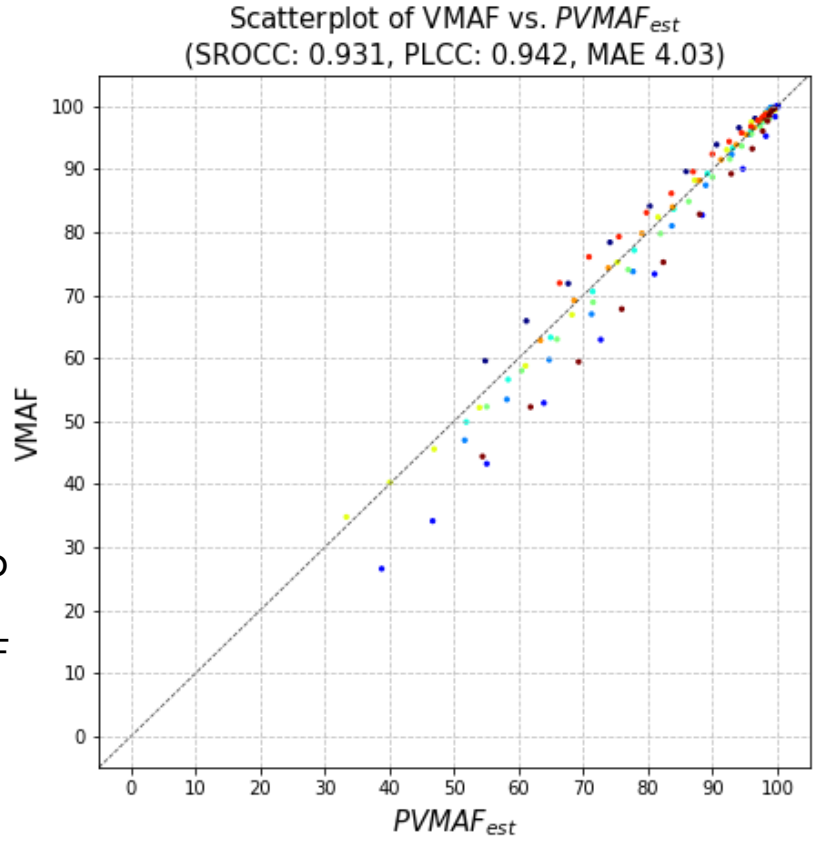
Rate control selects QP to achieve desired quality
Frame encodes at the selected QP

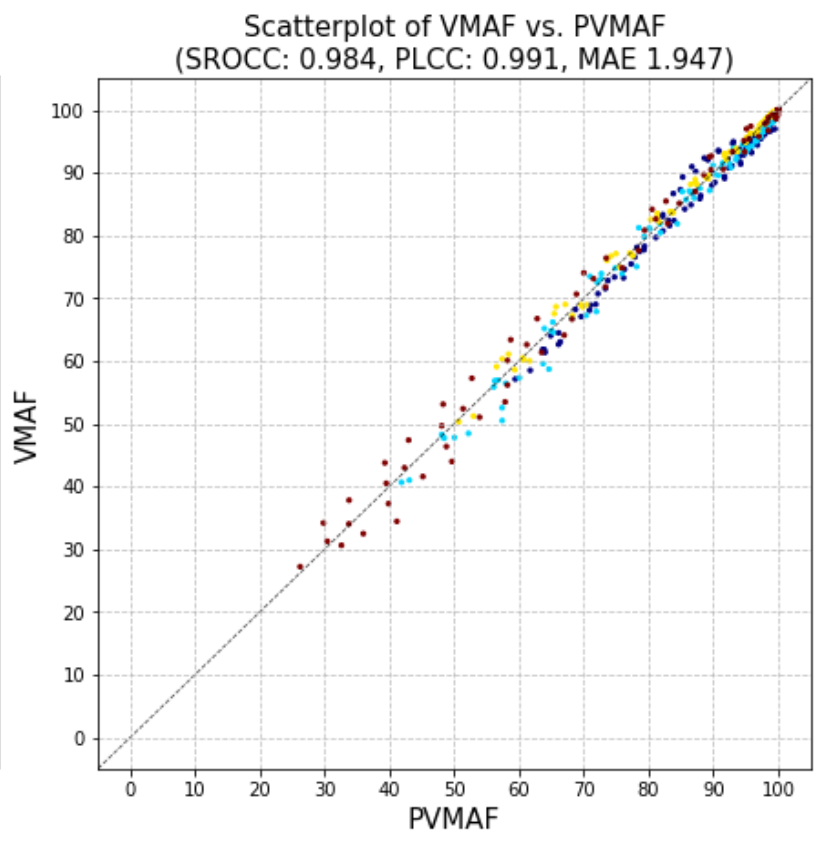
PVMAF is used to generate PVMAF
PVMAF error refines future estimation

Quality-centric control loop

PVMAF results

- Good approximations of VMAF with much lower complexity (1000x)
- Low cost by reusing stats/features from the encoder pre-analysis and main loop
- Higher accuracy for post-encode PVMAF (recon pixel stats available) used as corrective feedback
- Need different models per codec
  - AVC, HEVC, VVC models all different

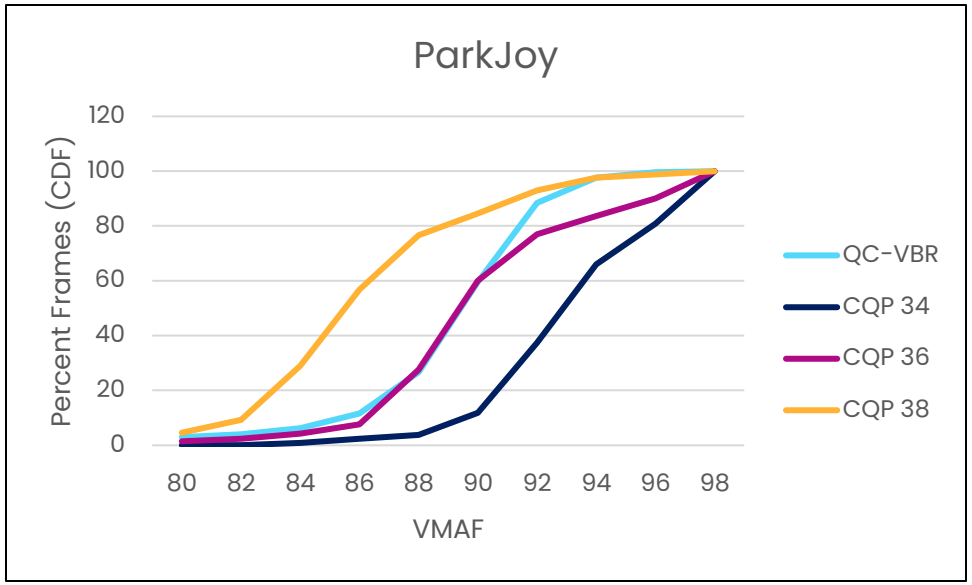


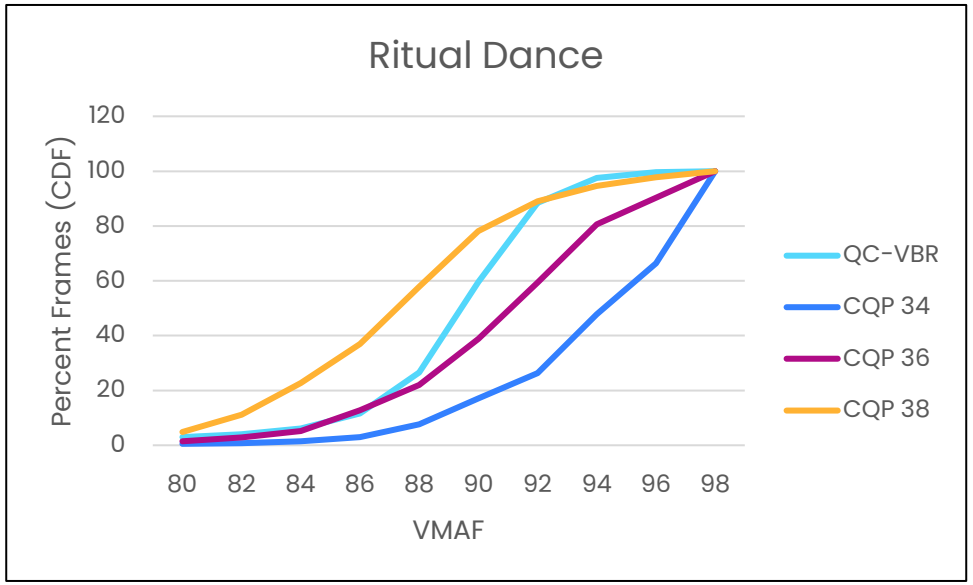


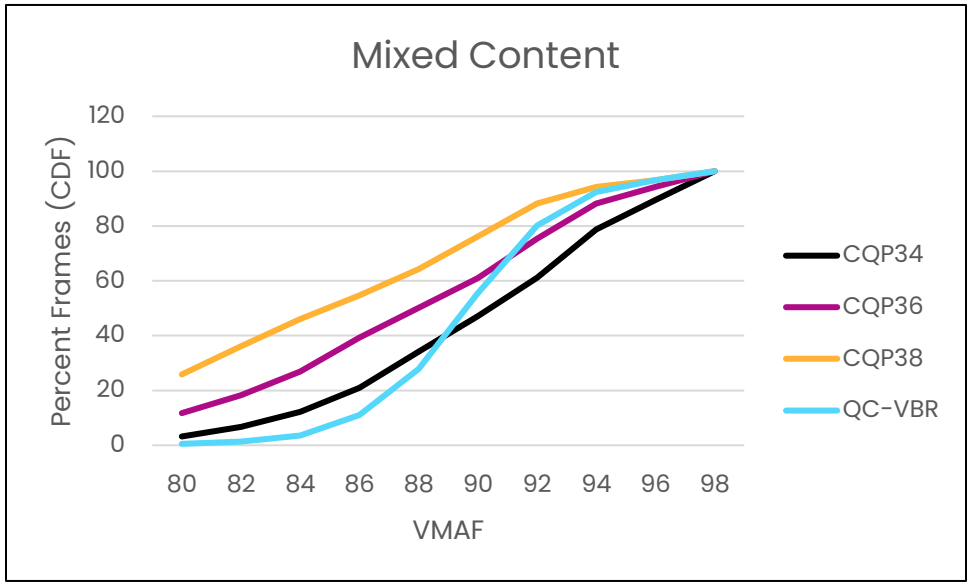
Metric	$PVMAF^{est}$	PVMAF
Spearman Correlation	0.931	0.984
Pearson Correlation	0.942	0.991
MAE	4.03	1.947

QC-VBR Results

- Comparing Synamedia AVC QC-VBR vs CQP
- Better target quality concentration in QC-VBR
- Single target quality setting works across varying content







Future improvements

Continuous model improvements

- Improvements to VMAF estimation directly leads to better quality matching

Tracking other subjective models

- Similar methodology could be used for other subjective models (SSIM, etc)

Codec integration

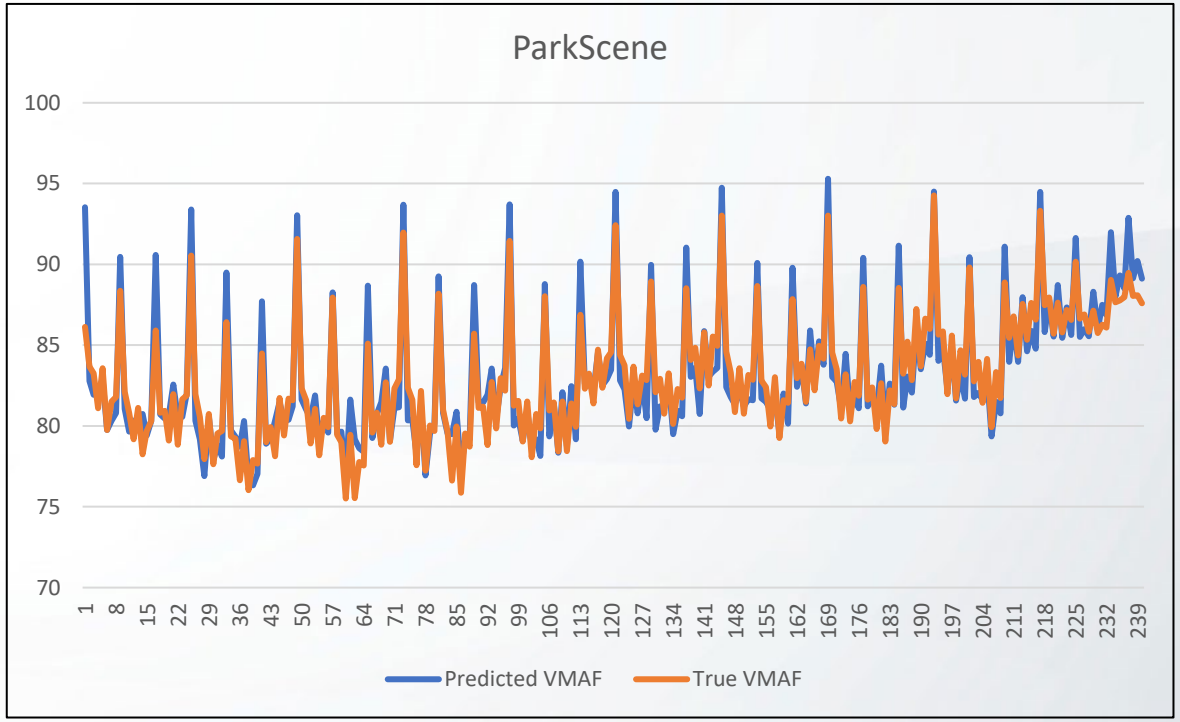
- Different models do need training per codec type
- Already integrated in Synamedia AVC, HEVC -- VVC soon

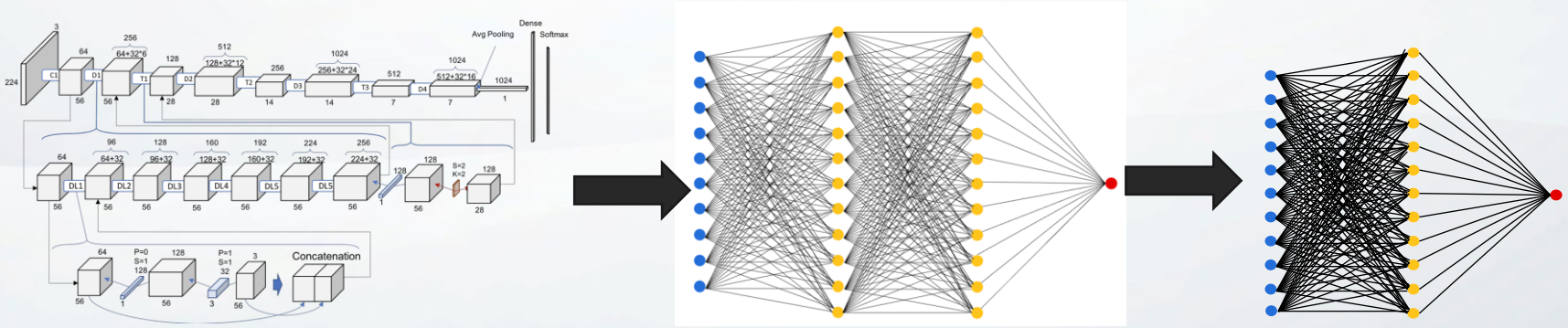
Questions?

Backup slides

Lightweight VQ measurement with PVMAF

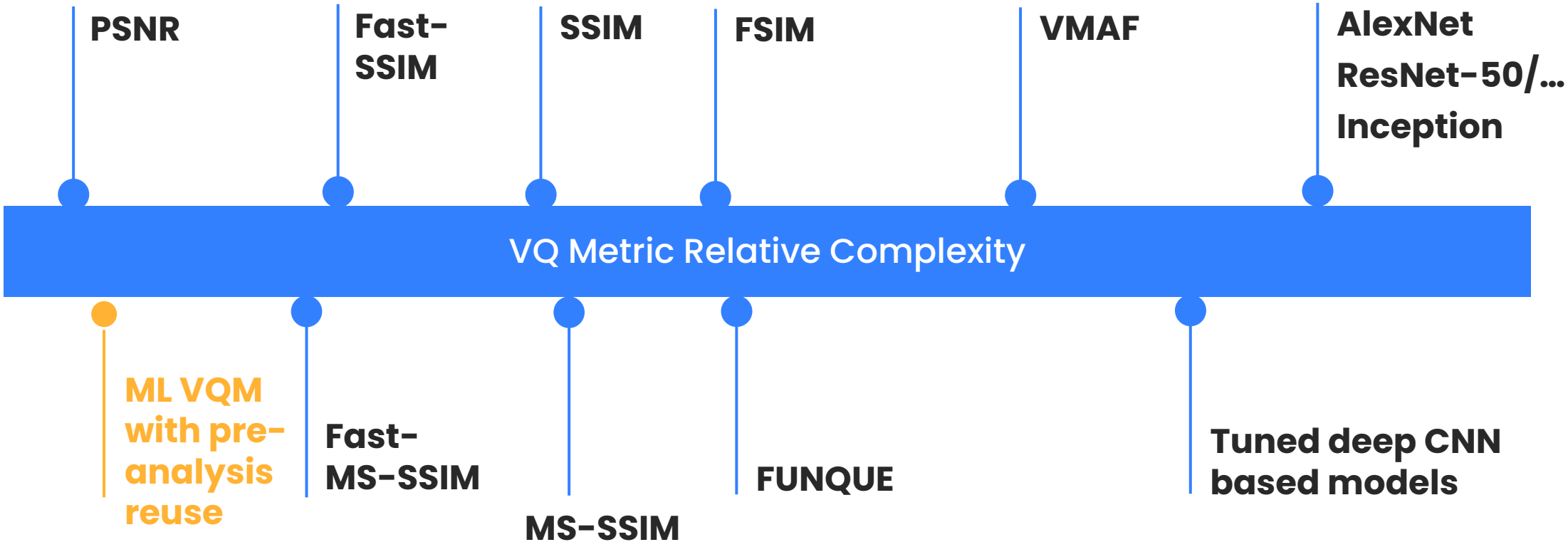
- Predicted VMAF (PVMAF)
  - VMAF approximation
  - 100x faster
  - Integrated in-loop
  - Real-time measurement
  - Real-time decision making
  - Both pre and post-encode estimation





Introduction

- Many VQ metrics have been developed
- Live / Real-time video compression needs metrics with very low complexity
- ML approaches can be leveraged for fast approximations
- Shallow networks can be sufficient for fast and accurate metrics



QC-VBR vs x264 CRF

- Synamedia AVC vs x264 CRF
- Synamedia CQP is closer to x264 CRF than x264 CQP
- More codec differences, but similar shape to versus Synamedia CQP