Agenda

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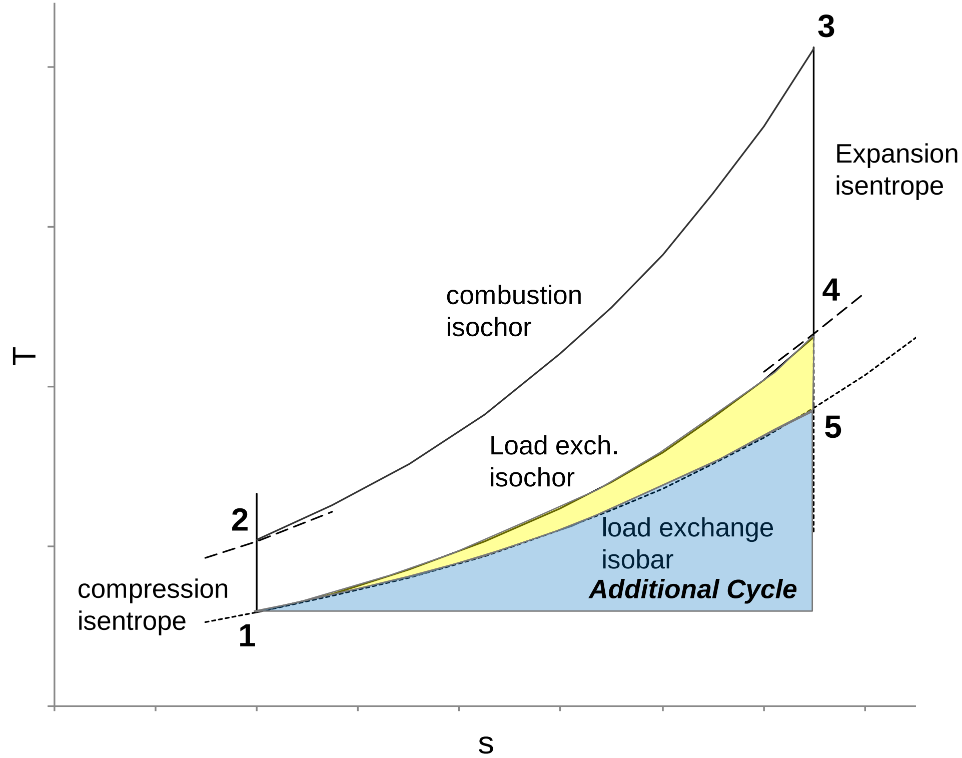
Main Topics of presentation

- Background/Reason for Technology development
- Gofficient technology spectrum
- Examples
  - Thermodynamic Efficiency Improvement: Twin AV
  - Waste Heat Recovery: Steam Direct Injection
  - Reduction of Scavenging losses: Variable Compressor/Expander Unit
- Combination of Technologies

Gasoline engine optimization

Technology Overview: TwinAV turbocharging Concept

- Background: Increasing expansion 3 → 4 (actual) → 5 (isobar) would significantly increase cycle efficiency
- Gain of Isochor/Isobar expansion triangle either by Miller or by TwinAV concept
- TwinAV gain this area with comparatively simple engine modifications
- The blue area must be gaines by additional bottoming cycles → Waste Heat Recovery



→ Gasoline engines have unused potential to achieve higher efficiency

Twin AV
Basic concept Twin AV principle

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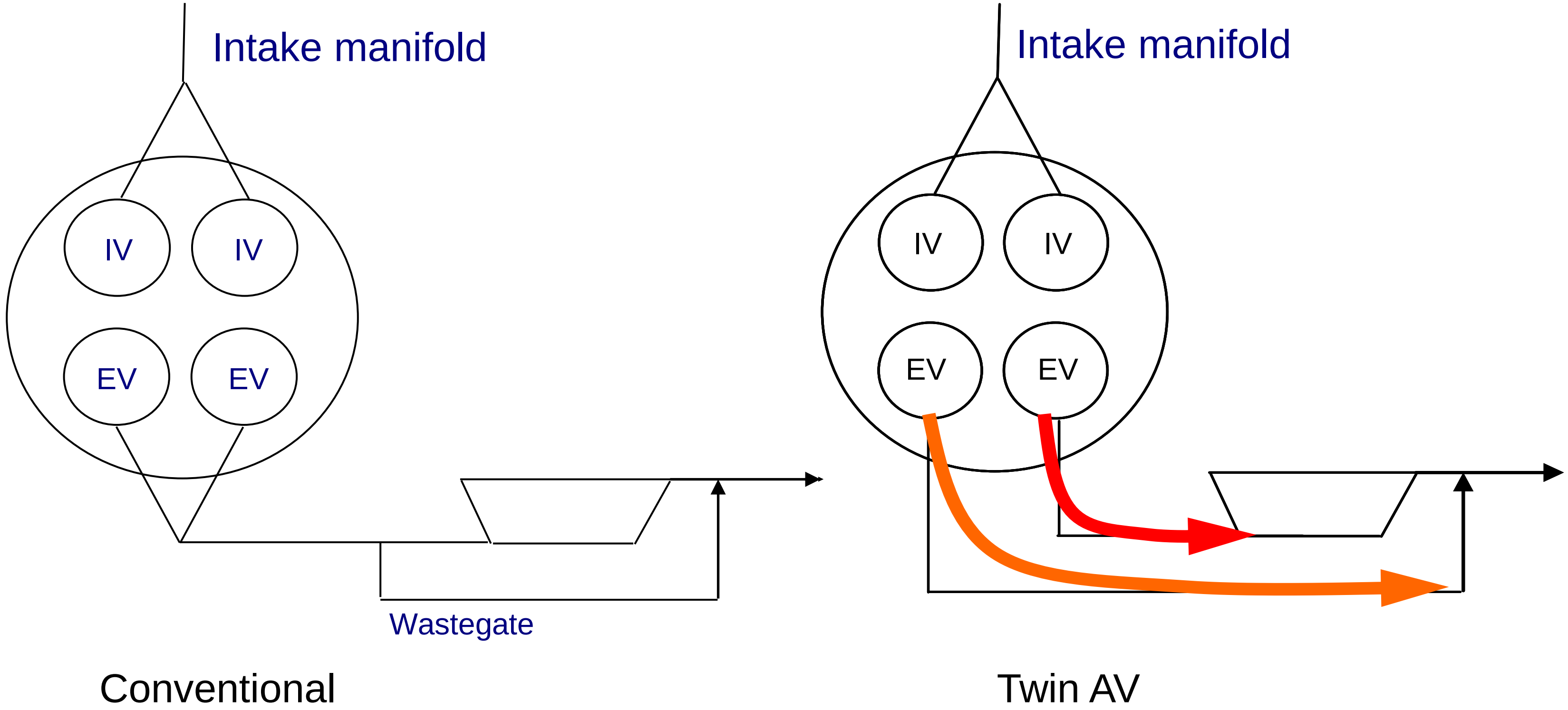
- No wastegate – Exhaust gas which is not used for turbocharging is bypassed through a separate exhaust valve
  → No exhaust backpressure at this LP exhaust valve
- Turbocharger has its own HP exhaust valve
- Small turbine with high typical pressure ratio can be applied



Twin AV

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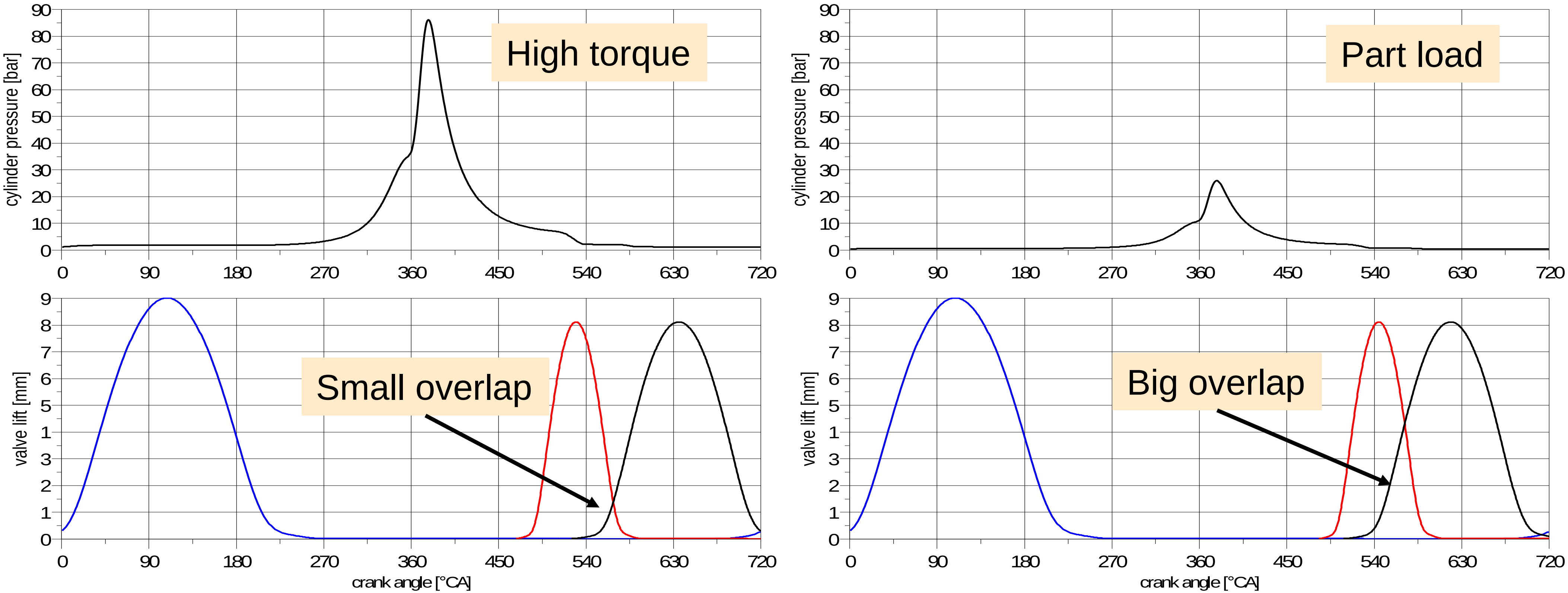
Control concept Twin AV principle

- Boost control is driven by relative movement between exhaust valves (instead of wastegate actuation)
- Just one additional camphaser necessary



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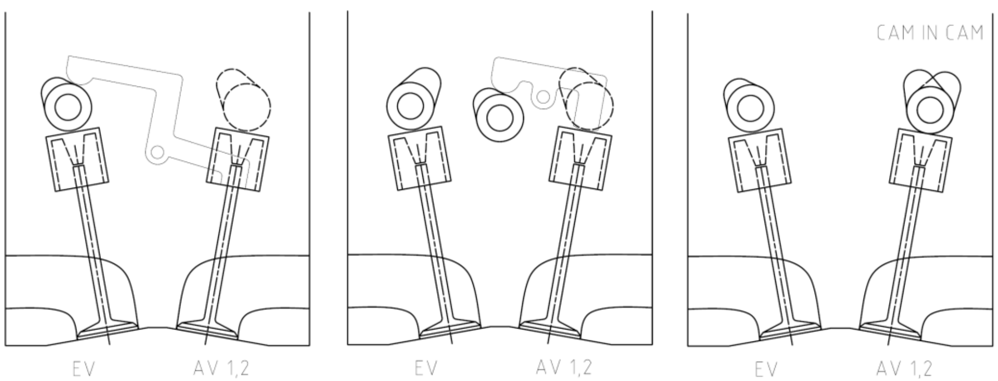
System Layout

- Turbine size smaller than conventional layout recommended
  → Less mass flow, higher backpressure
  → Same or more power than „base“ layout without TwinAV
- Combination with VTG could gain additional Turbo-Compound potential

Control concept Twin AV principle

- Different mechanical approaches for camphaser integration
- Combination with main intake and outlet phasing possible
  3-way cam-phasing



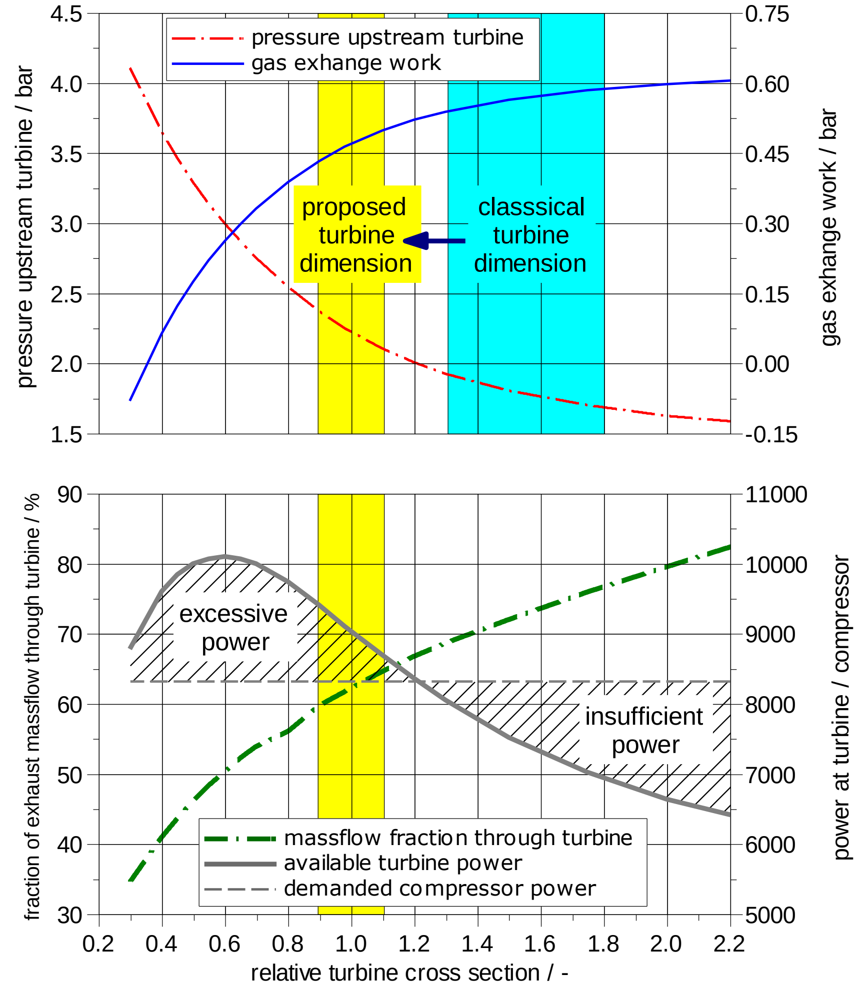


Diagram shows typical conditions upstream turbine at 2000 rpm / higher part load

Twin AV

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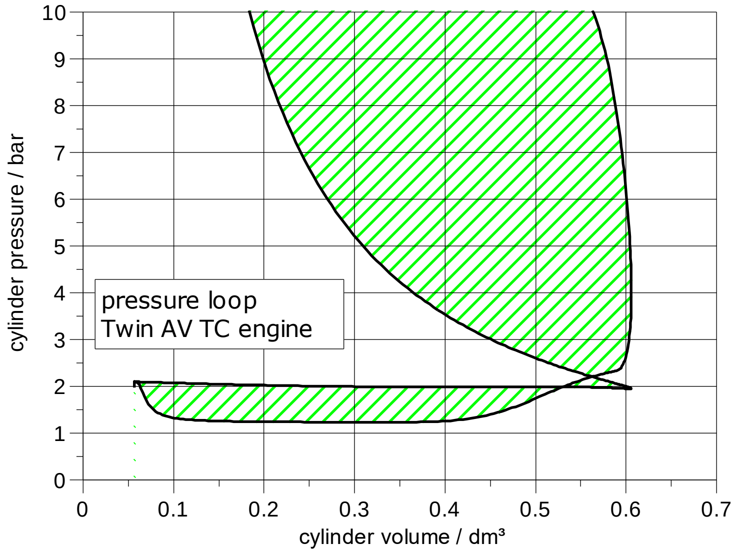

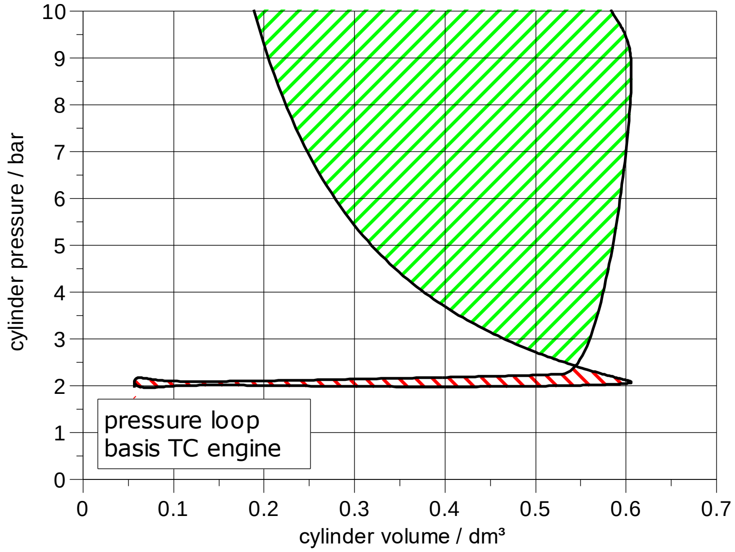

Comparison with conv. turbocharging

- Almost no statical backpressure upstream low pressure valve
- Smaller turbine than conventional TC to compensate less mass flow → slightly higher turbine pressure level
- Thermodynamically increasing effective expansion ratio
- Always positive scavenging pressure ratio → low knock retard
- Efficiency gain up to 6%
- Increased exhaust gas temperatures at turbine