ASHRAE Region VI CRC
Track III: Session 4
Dedicated Outdoor Air Systems

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Learning Objectives

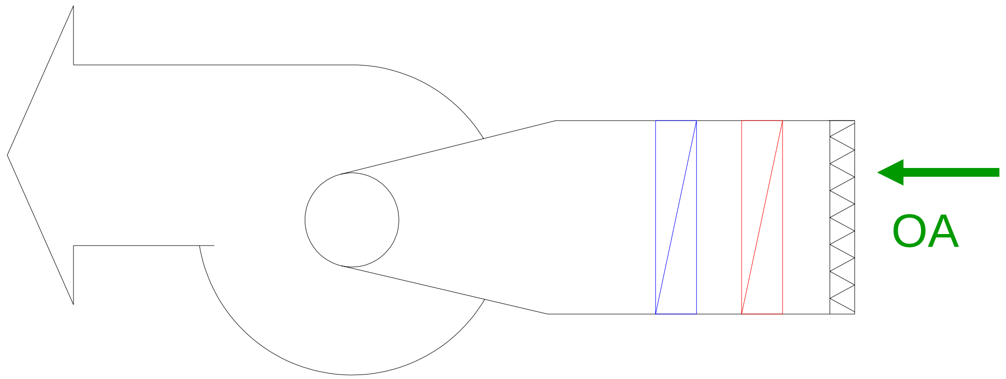
- Recognize situations where dedicated outdoor air systems are advantageous
- Understand the characteristic strengths and weaknesses of each type of dedicated outdoor air system
- Outline the various dedicated outdoor air system control schemes and optimal applications

Agenda

- Dedicated outdoor air systems
  - Definitions
  - True DOAS vs. Pre-conditioning systems
- Design options and examples
  - Pre-conditioning systems
  - DOAS
- Advantages and disadvantages

Dedicated Outdoor Air Options

- All options are based 100% outdoor air handling unit with preconditioning capability
  - Air cleaning/filtration
  - Preheating
  - Cooling
  - Dehumidification
  - Possible humidification
  - Possible heat recovery
  - Possible reheat



- Another system is provided for sensible cooling of space loads

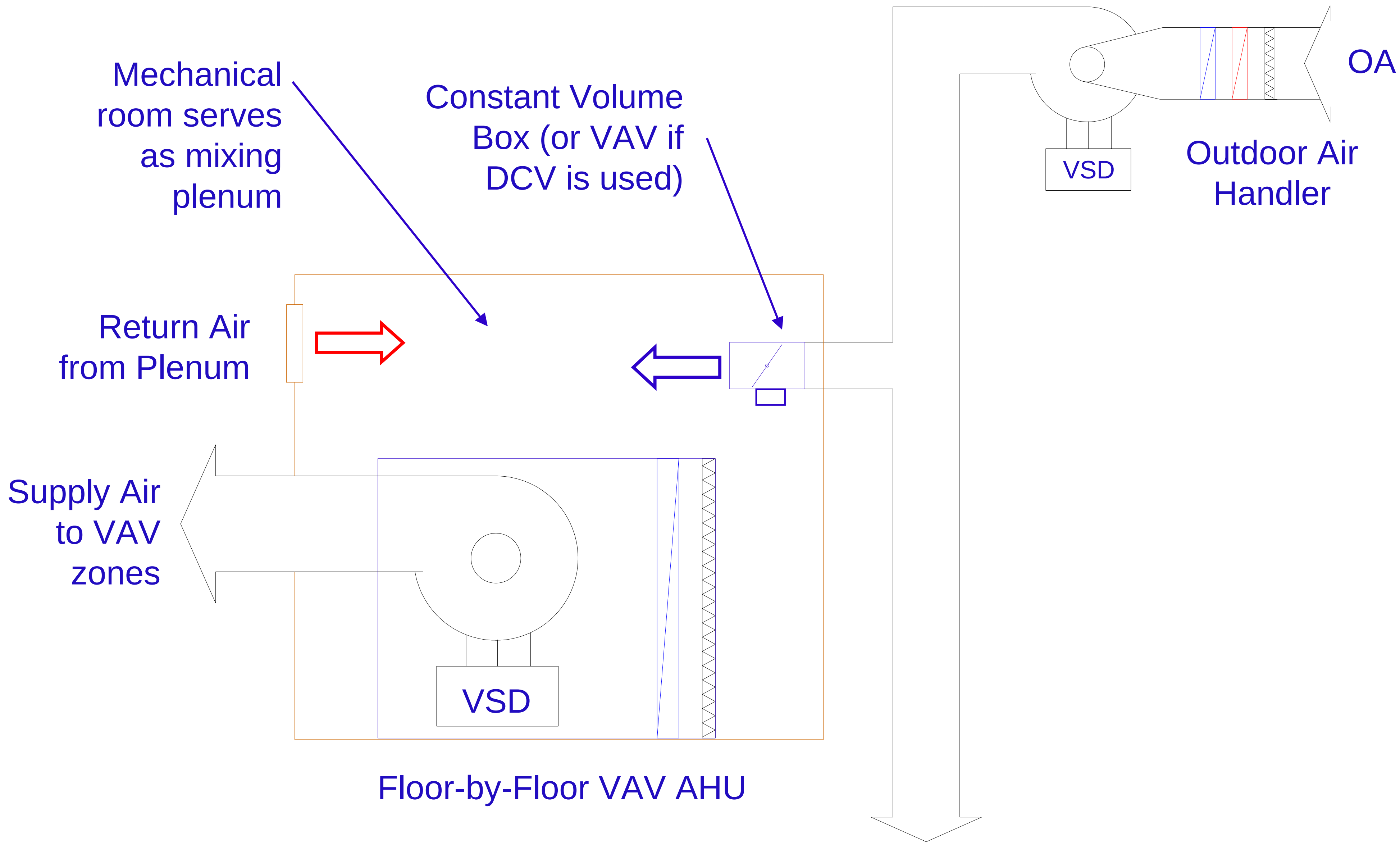
Dedicated Outdoor Air Options

- **OAHU ducted to a central VAV system**
  - Inlet side of AHU (series)
  - Outlet side of AHU (parallel)
- **OAHU ducted to each zone with zonal system for space sensible cooling/heating**
  - Inlet of zone terminal units
  - Discharge of zone terminal units
  - Dual duct VAV boxes served also by central VAV system
  - Separate diffusers + fan-coils
  - Separate diffusers + radiant system

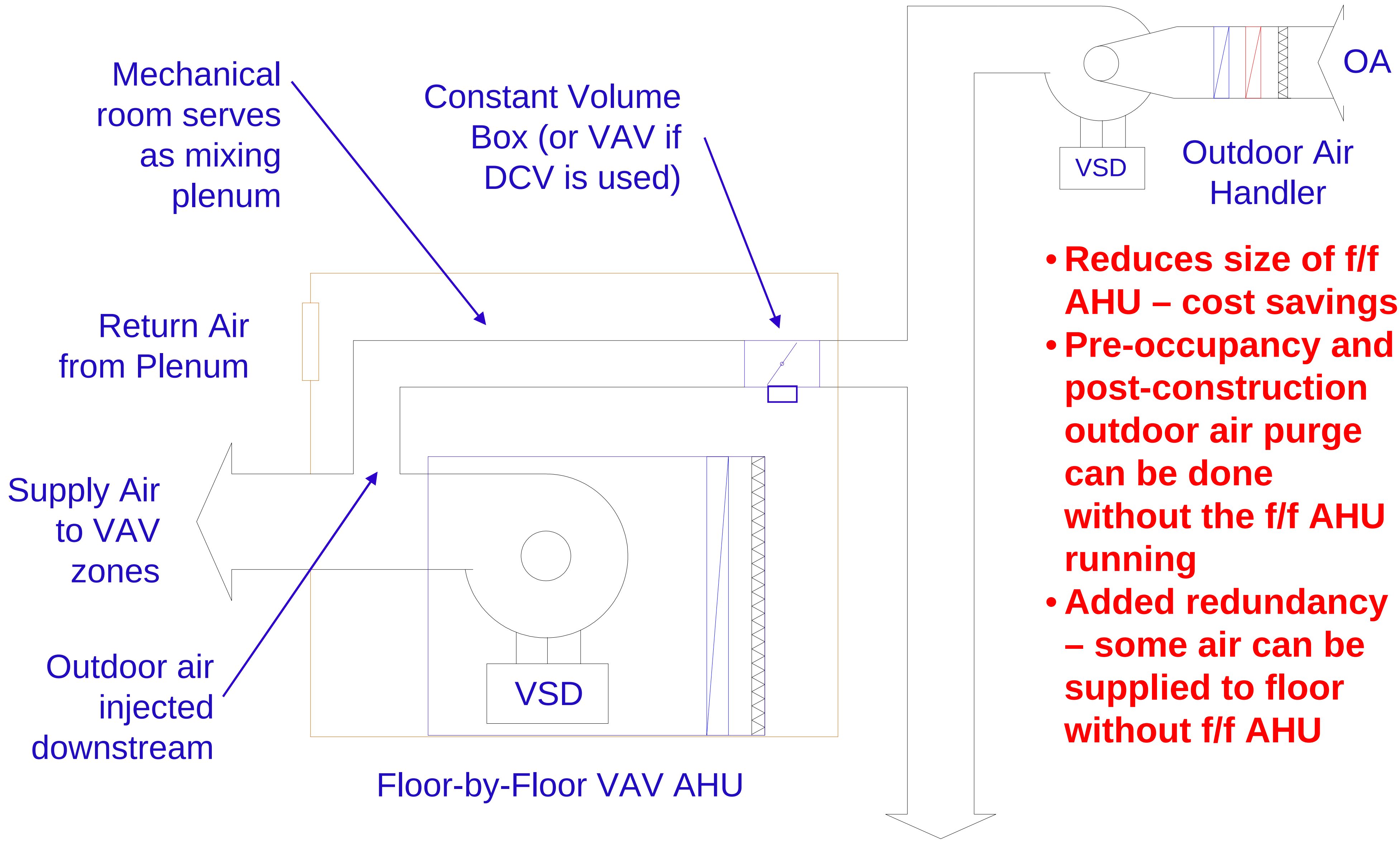
Pre-conditioning – other than pre-treatment, remainder of system is conventional

True DOAS – separates ventilation & dehumidification from space sensible loads

Example Pre-Conditioning Series Arrangement



Example Pre-Conditioning Parallel Arrangement

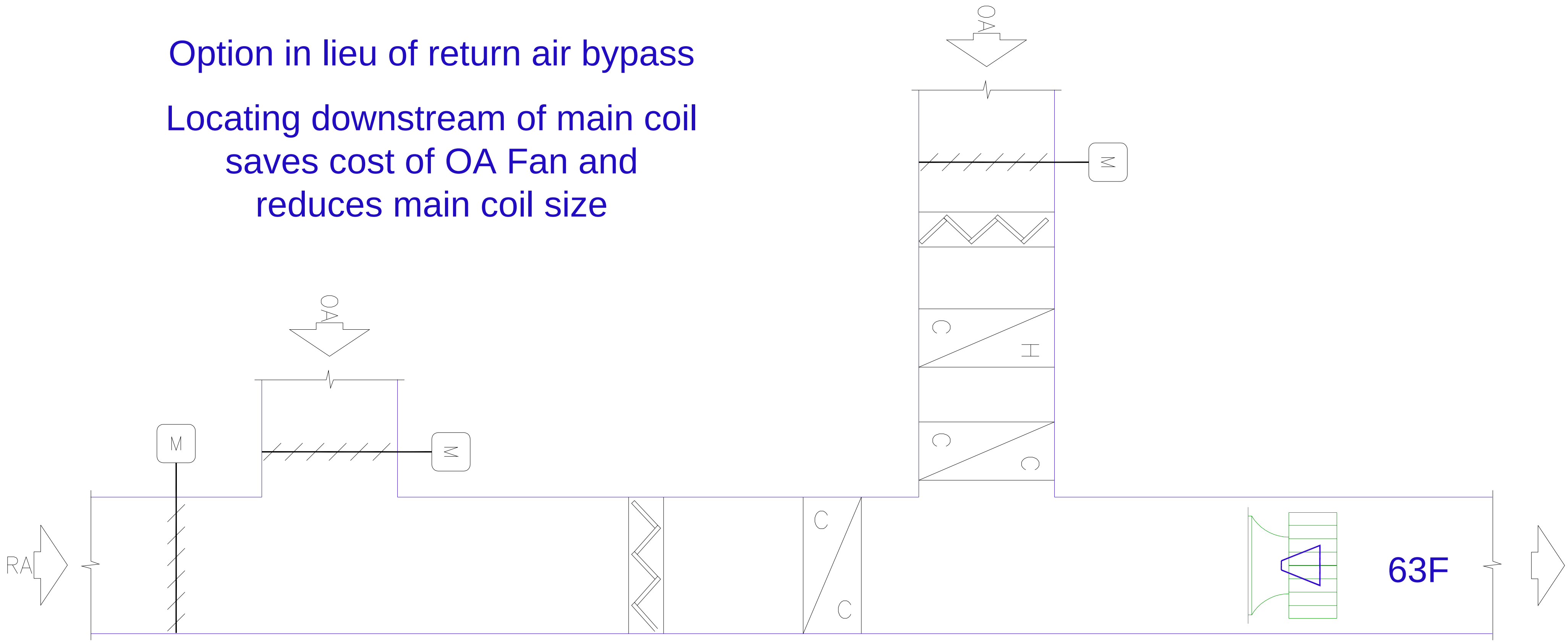


- **Reduces size of f/f AHU – cost savings**
- **Pre-occupancy and post-construction outdoor air purge can be done without the f/f AHU running**
- **Added redundancy – some air can be supplied to floor without f/f AHU**

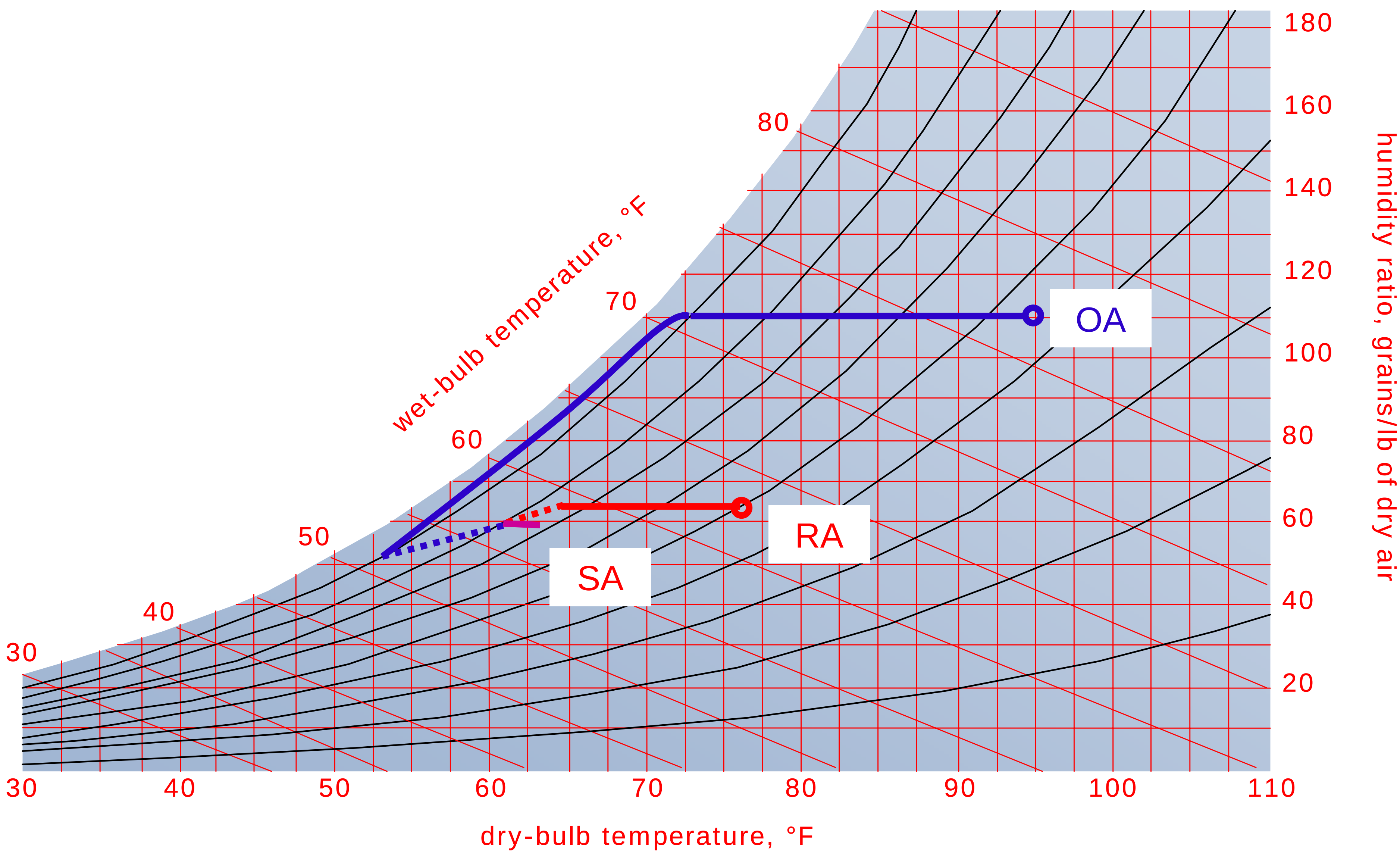
Underfloor System Precooling

Option in lieu of return air bypass

Locating downstream of main coil
saves cost of OA Fan and
reduces main coil size

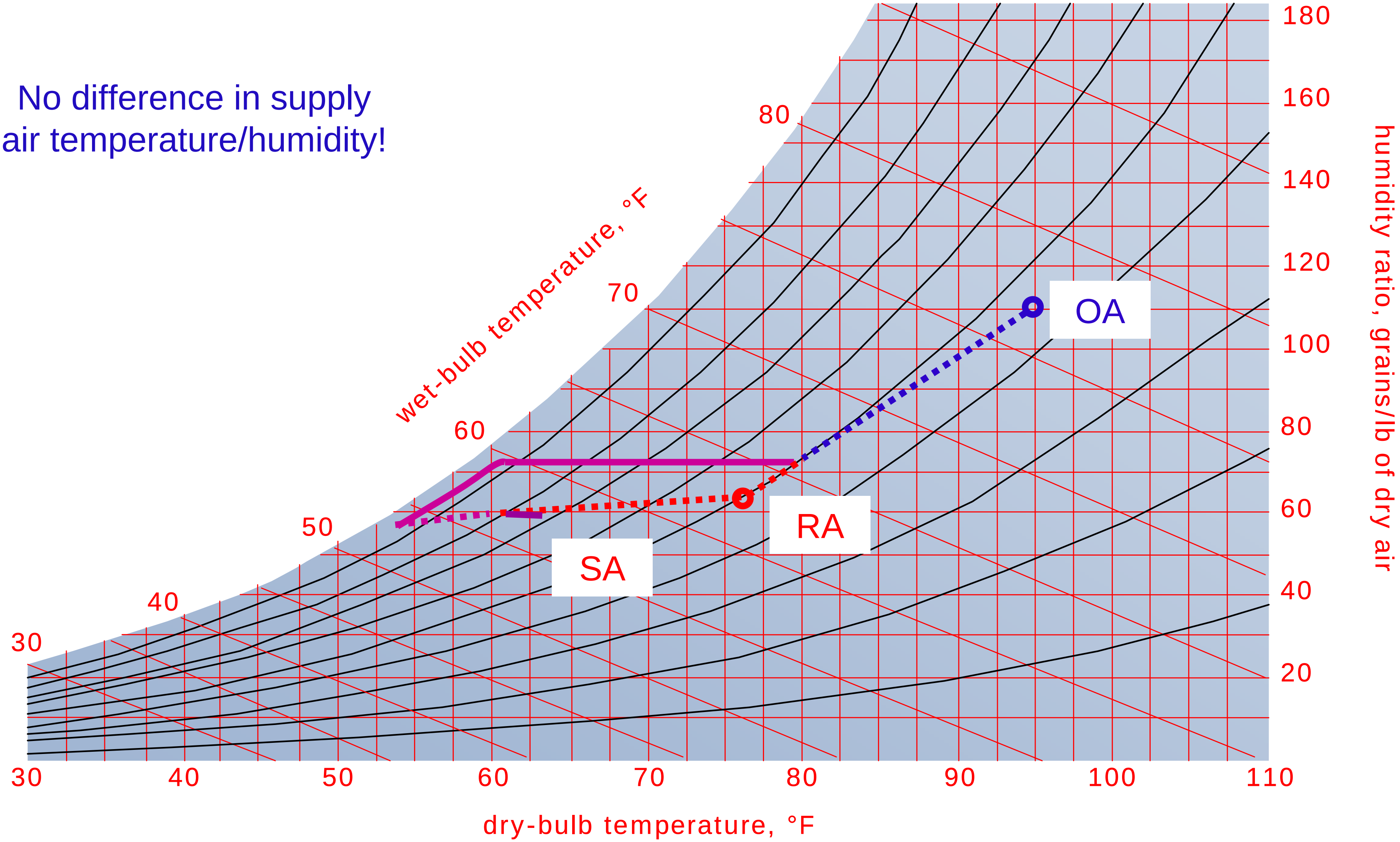


Underfloor System Precooling

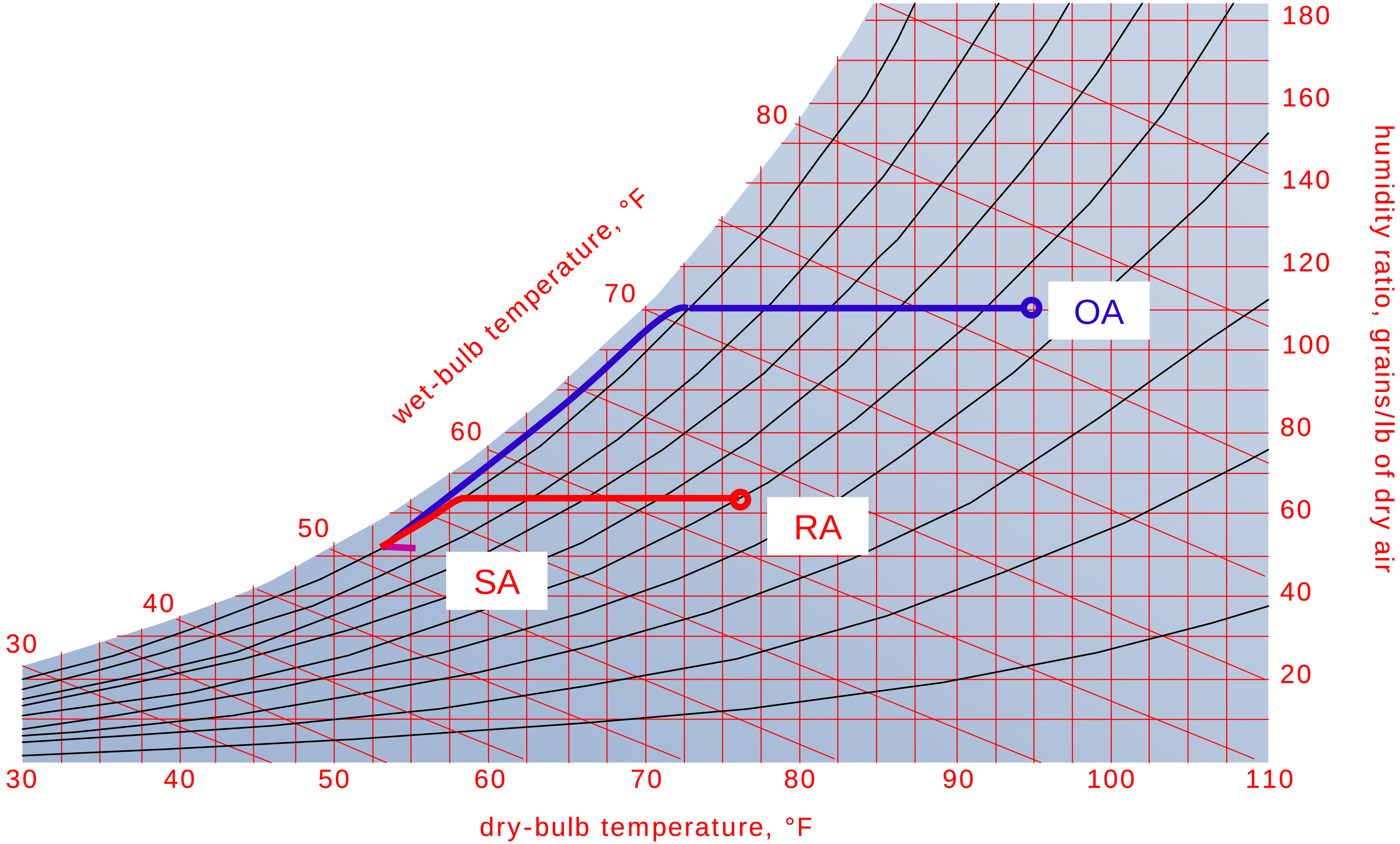


Underfloor System RA Bypass

No difference in supply
air temperature/humidity!



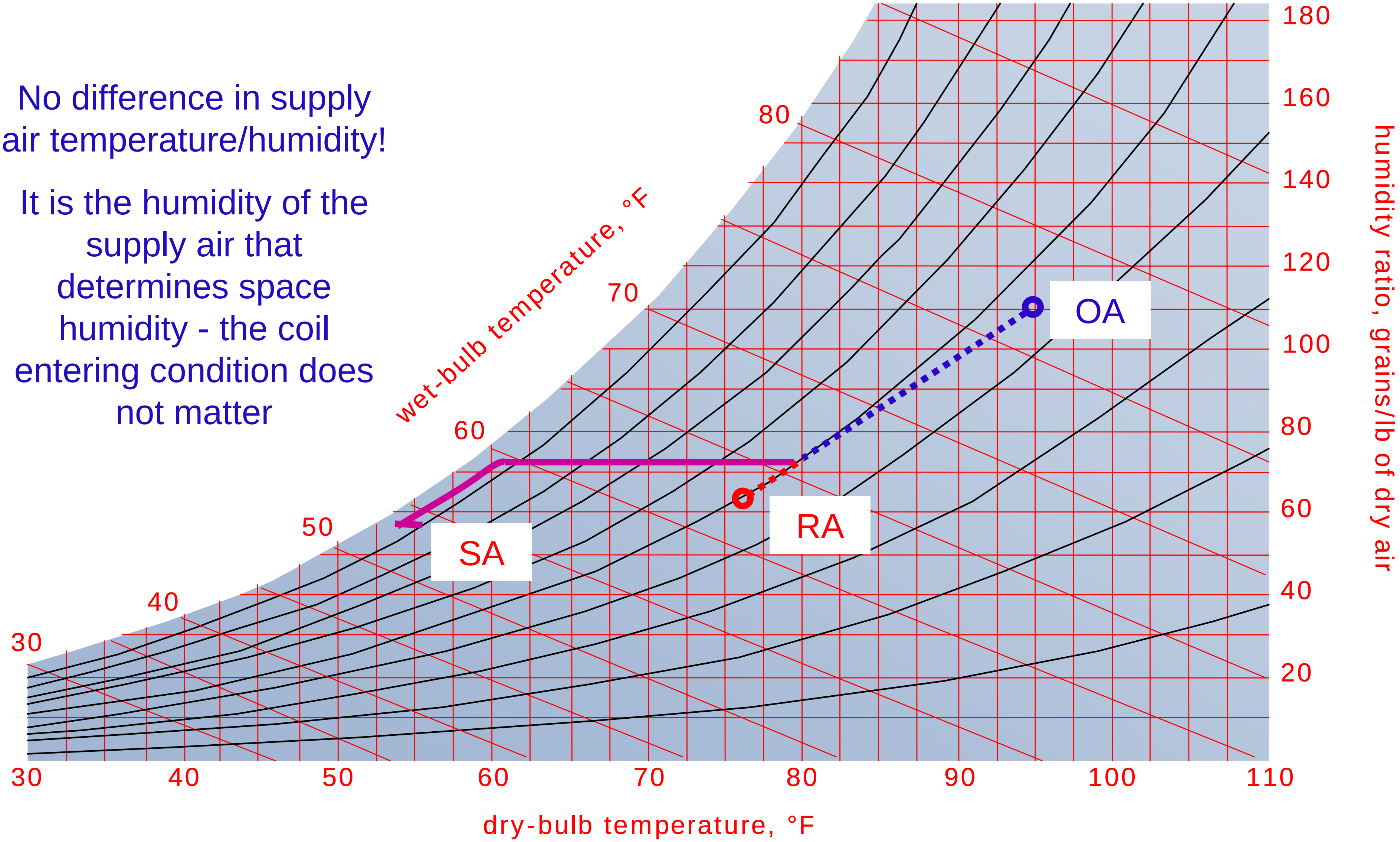
VAV System Precooling



VAV System without pre-cooling

No difference in supply air temperature/humidity!

It is the humidity of the supply air that determines space humidity - the coil entering condition does not matter



Pre-Conditioning w/VAV Systems

- **No advantages**
  - VAV inherently dehumidifies at standard supply air temperatures (e.g. 55F)
  - Still need outdoor airflow measurement and control – mixed air plenum pressures vary
  - Still need to deal with Standard 62.1 “multiple spaces” issues and inefficiencies
- **Only may make sense:**
  - If used in parallel arrangement in f/f system if you can reduce costs of f//f AHUs
  - In underfloor or displacement systems with warm supply air temperature in humid climates if less expensive than return air bypass

DOAS

Outdoor air ducted to zone, all latent cooling done by OAHU

- **Common DOAS Claim: "Outdoor air rates are lower than central systems due to multiple spaces inefficiencies"**

$$V_{ot} = \frac{\sum (R_P P_D D + R_B A_B)}{E_V}$$

- **Not always so:**
  - Occupant diversity largely offsets multiple spaces inefficiency
  - Need ~15 to 30 cfm/p to handle latent load (depending on activity level and supply air temperature) – new Standard 62 rates are much lower for densely occupied spaces
- **Rates tend to be higher for DOAS vs. VAV for densely occupied spaces and lower for spaces with relatively large "building component" rates such as offices**

Small School example

OA Intake Flow Summary

Ventilation System	OA Intake Vot
Single-Zone Clg	8,900
Single-Zone Htg	11,100
100% OA – CV	8,900
100% OA – VAV	7,040
VAV Default Ev	10,800
VAV Calculated Ev	8,400
Series FP VAV	7,600

No population diversity credit

Penalty for "too warm" htg air

No population diversity credit

Credit for population distribution

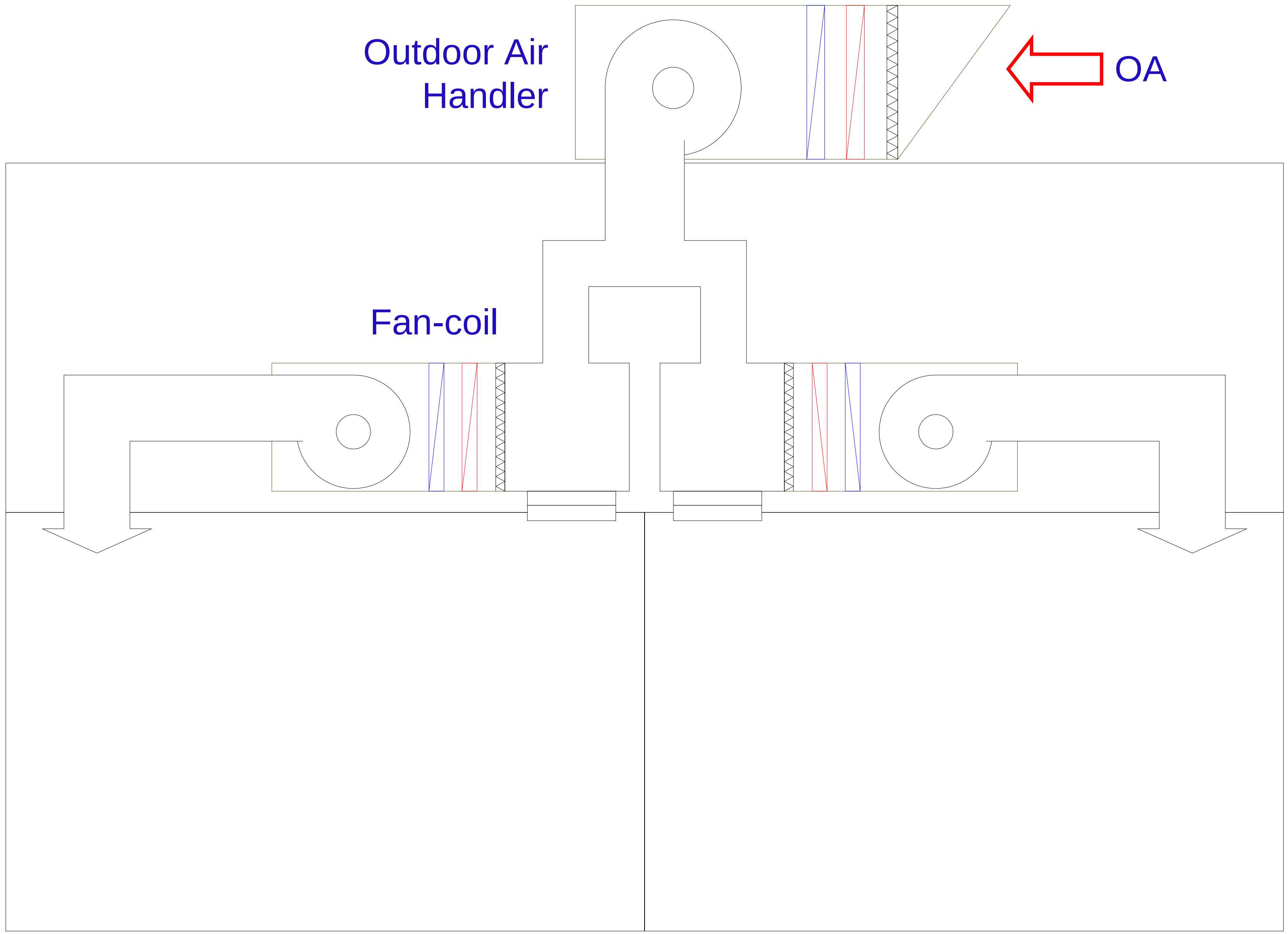
Conservatively low default Ev value

Equations for more accurate Ev

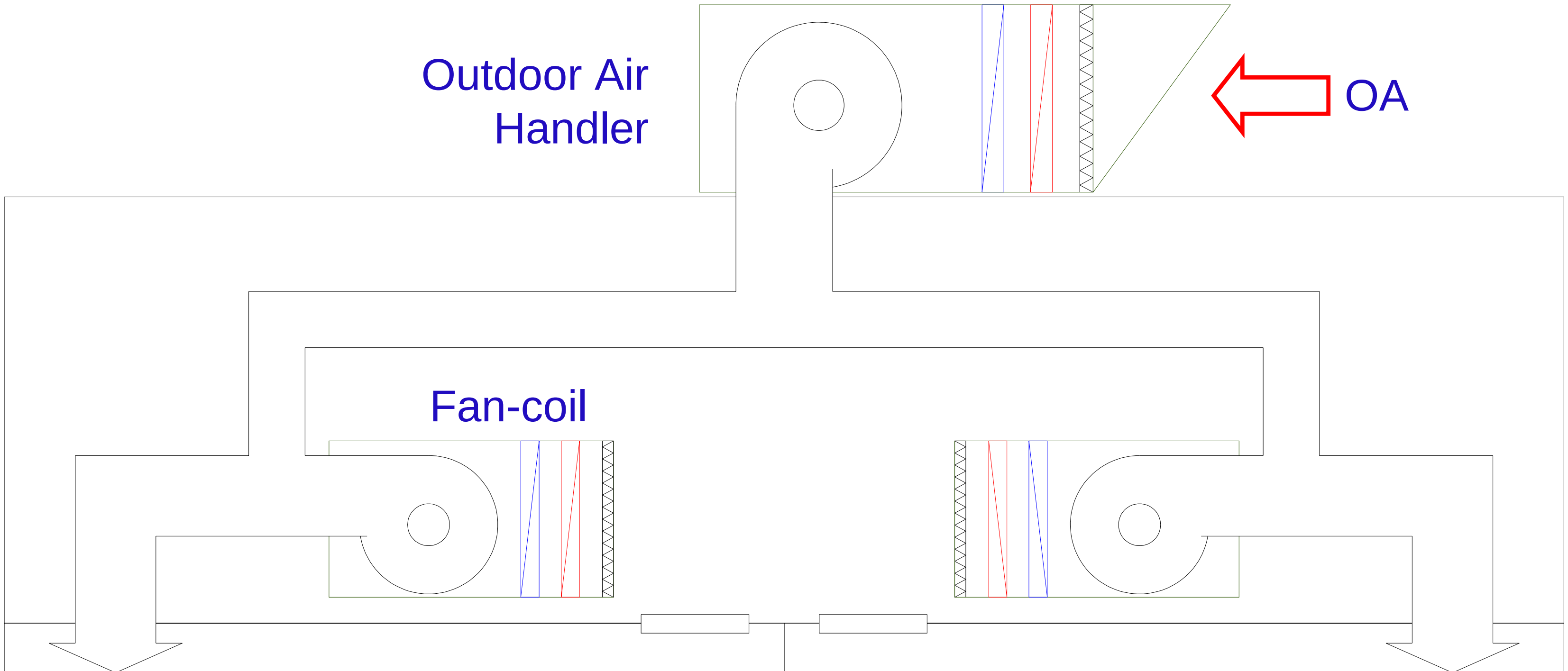
Two ventilation paths, highest Ev

Developed by Dennis Stanke, Trane

DOAS in series with Fan-coils or Heat Pumps



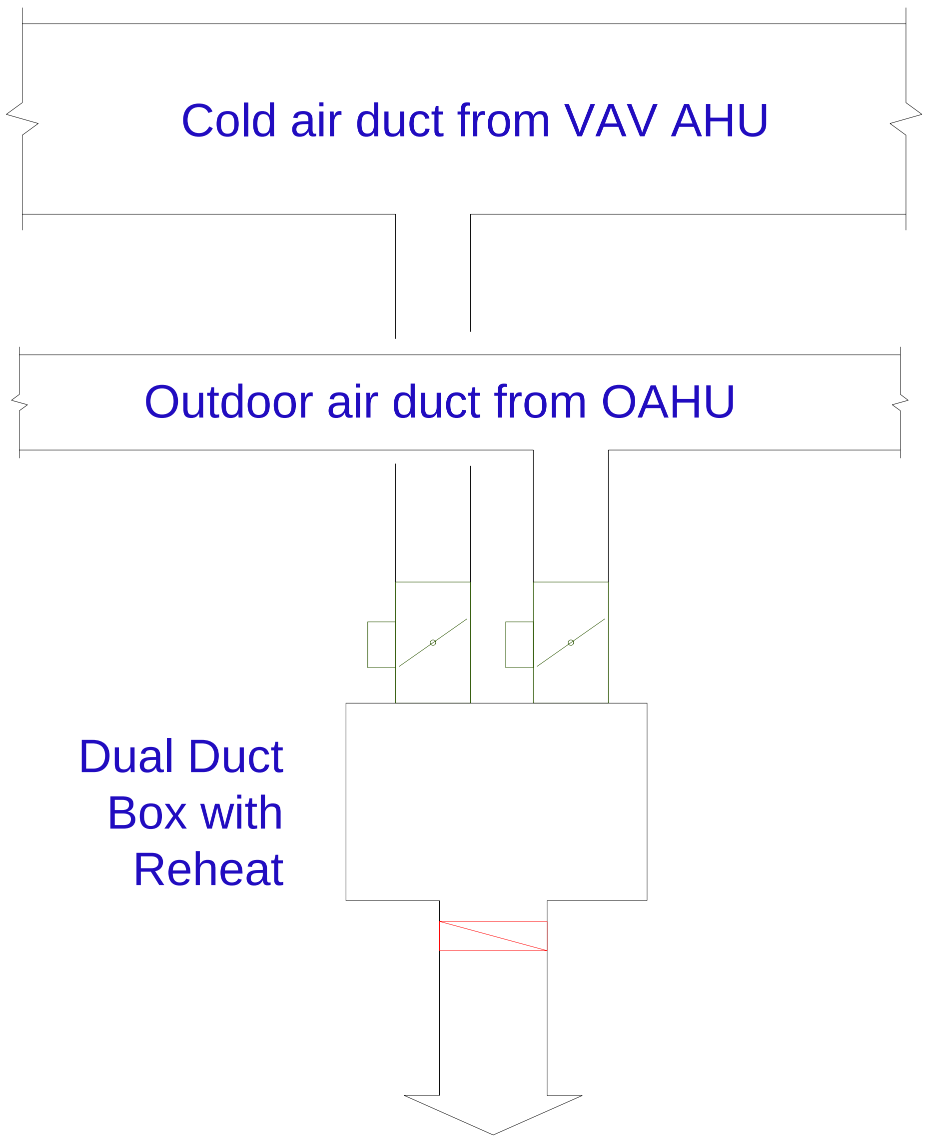
DOAS in parallel with Fan-coils or Heat Pumps

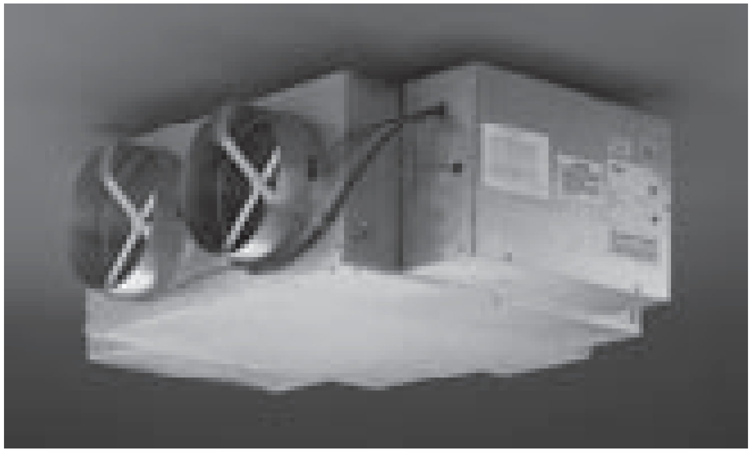


Preferred to series arrangement:

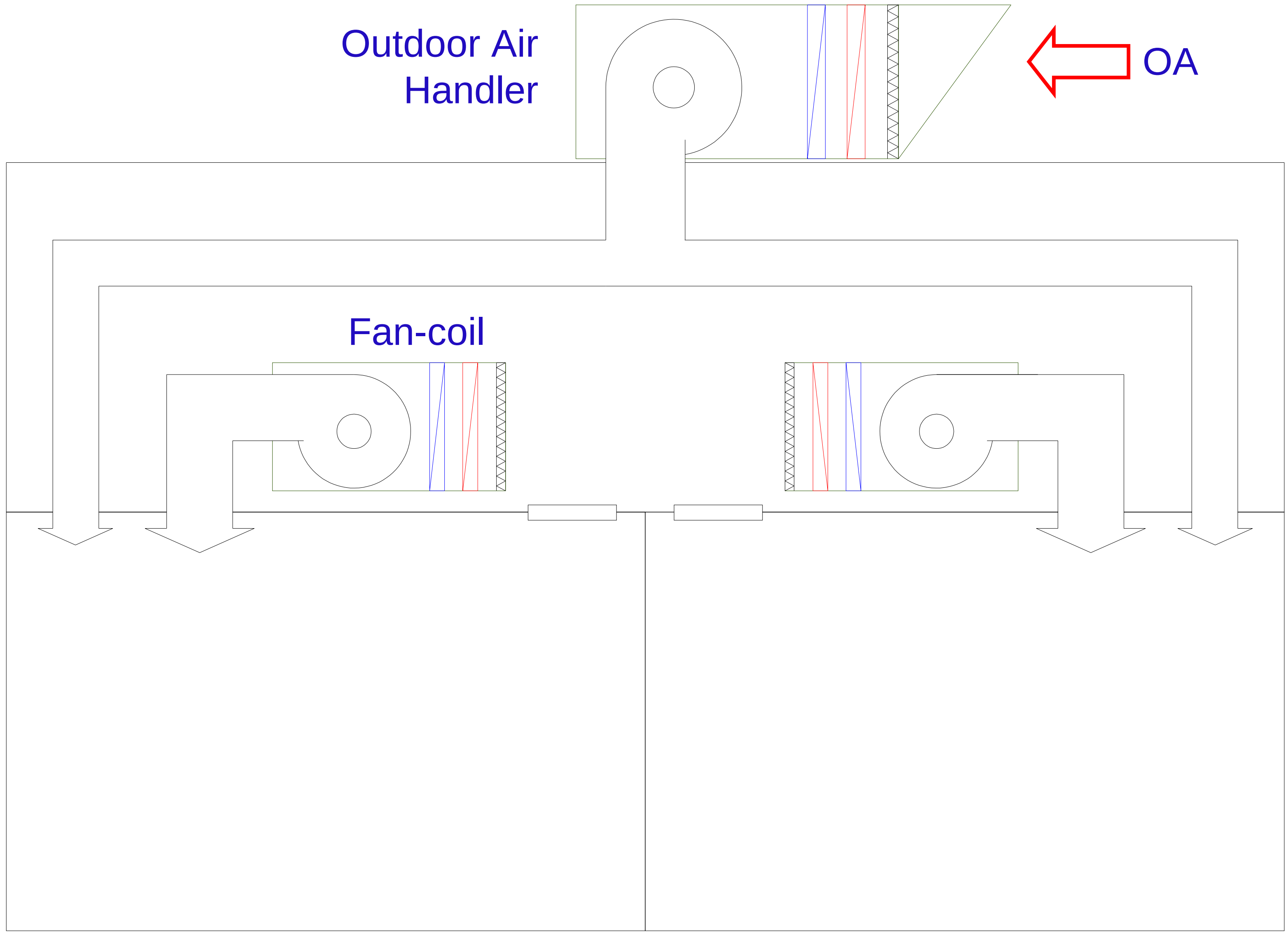
- Reduces size of fan-coil (airflow and tonnage)
- Allows proper cfm/ton ratio for packaged terminal units
- DOAS may run at night for pressurization in humid climates
- DOAS may run alone for pre-occupancy and post-construction purge
- Allows fan-coils to cycle on calls for heat/cool

DOAS with dual duct boxes

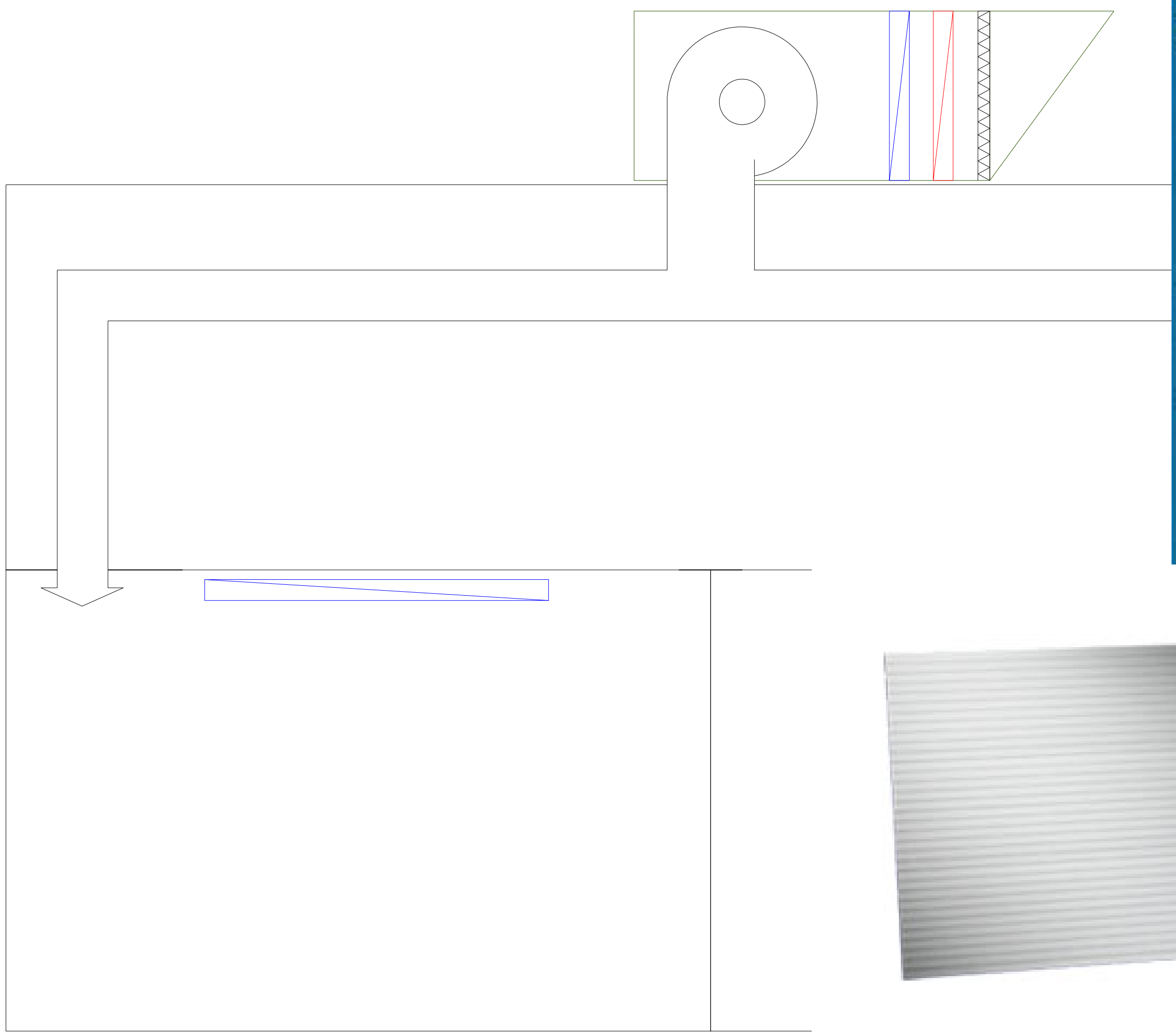


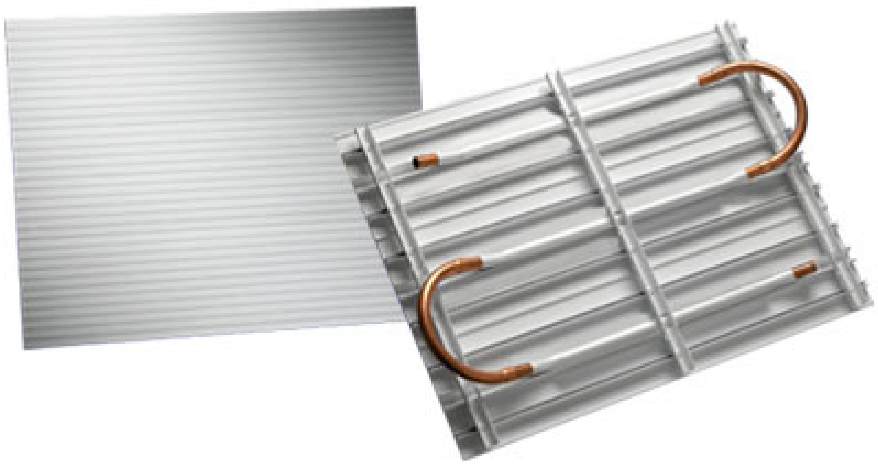


DOAS with Separate Diffusers & Fan-coils or Heat Pumps



DOAS with Flat Panel Radiant





DOAS with Chilled Beams

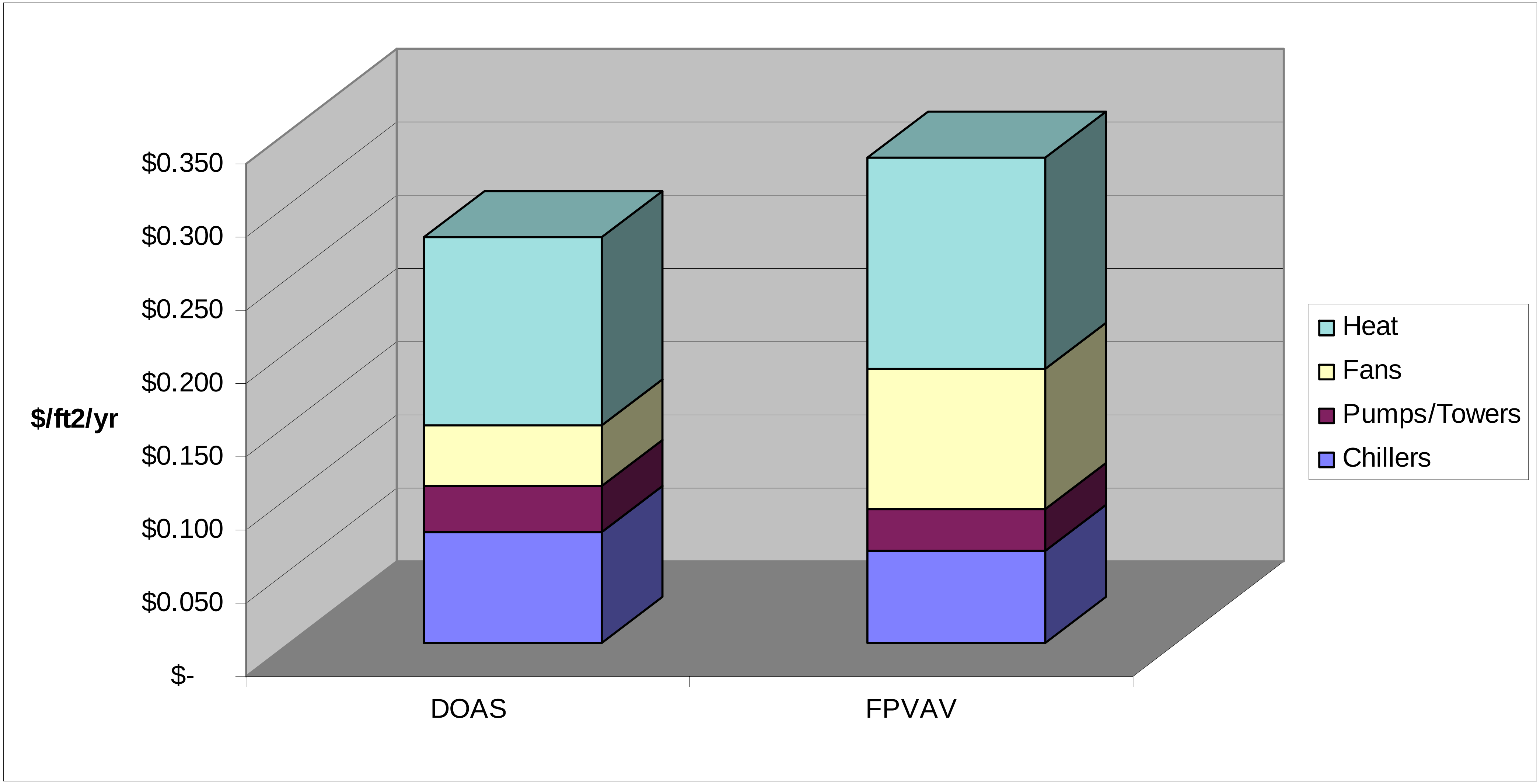
Active Chilled Beams
(OA is supplied through beam
to improve capacity through
induction)

Passive chilled beam
(Radiation and
convection only)

Radiant advantages & disadvantages

- **Advantages**
  - Quiet
  - Little ceiling space required
  - Possibly improved comfort
  - No zonal fan energy
  - No zonal filters/coils/fans
- **Disadvantages**
  - Cost
  - Low capacity – requires low space loads
  - Ceiling aesthetics
  - Chiller plant required
  - Limited ceiling access
  - Dewpoint control, condensation considerations
    - May require increased outdoor air; or sub-cooling with reheat or runaround coil at OAHU if latent loads are high

DOAS/Chilled Beam vs. Parallel Fan-powered VAV
Milwaukee Office



DOAS Enhancements

- **Supply OA cold without reheat**
  - Reduces capacity required of zonal systems
  - Reduces first costs
  - Reduces energy costs
  - Exception: high latent load, low sensible load applications like theaters
- **Use heat recovery on OAHU per 90.1**
  - And even in milder climates if OAHU runs 24/7
  - Make sure building is still pressurized – may eliminate this option in offices
- **Use water-side economizer if cooling tower available**
- **Consider TES in areas with high demand charges**
  - Also allows cold supply air temperature for radiant panel applications with high latent loads
- **Reset OAHU supply air temperature based on zone feedback to minimize overcooling in mild weather**
- **Use CO2 sensors and VAV control of outdoor air for densely occupied spaces**
  - Use of pressure independent VAV boxes at zones also allows for off-hour isolation of areas and outdoor air setpoints can be changed without rebalancing

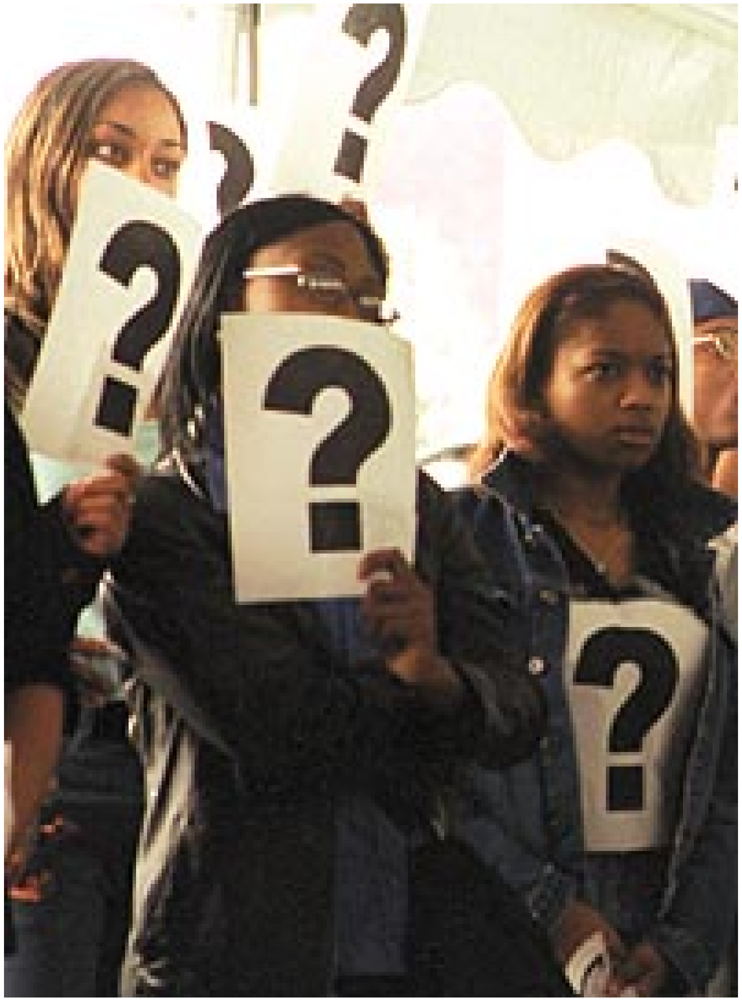
Advantages of DOAS

- **Assures design outdoor air rates delivered to space**
  - No “multiple spaces” issues
  - No concerns about minimum airflow setpoints and controls
  - Outdoor air rates are usually NOT lower than VAV systems
- **No complex outdoor airflow measurement/control devices**
  - See slides from Session 2
- **Assures space maximum humidity levels are maintained**
  - No coil bypass or reheat
  - No direct measurement of RH required
- **No economizer and mixing plenum**
  - No dampers to freeze up, maintain
  - No coil freeze problems from imperfect mixing
  - No RH/enthalpy sensors to maintain
- **Reduces fan energy if zonal system is passive (radiant, chilled beams)**
- **Reduces or eliminates reheat energy**
- **Less ceiling space required for duct mains**

Disadvantages

- **Reduced annual outdoor air supply compared to systems with economizers**
  - Fisk study shows significant indoor air quality and associated health benefits from economizers
- **Lack of economizer may cause energy usage to be higher than a well designed VAV system in mild climates**
- **High maintenance costs of zonal fan-coils or heat pumps**
  - Filters, coils, fans, pans, etc.
- **Usually higher first costs depending on design details**
  - Need OA duct, CHW, and HW to each zone
  - 4-pipe fan-coils and heat pumps are typically twice as expensive as VAV zones
  - Savings in OAHU/duct sizes vs. VAV system AHU/duct sizes can offset the zone costs in some cases

Questions?



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