



Technology Overview of PAT in Biochemical Manufacturing

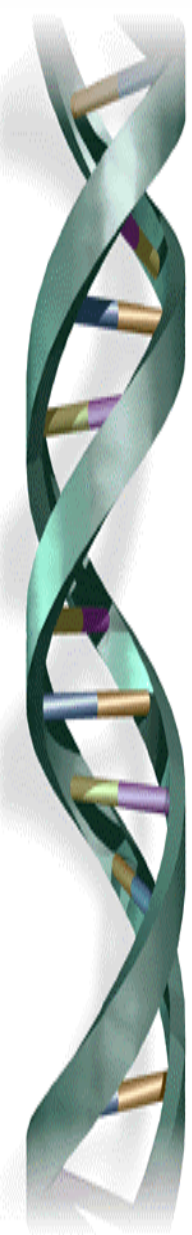
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Summary of Current Measurements

- ♦ Optical Density
- ♦ Temperature
- ♦ Pressure
- ♦ Volume
- ♦ pH
- ♦ Dissolved O₂
- ♦ O₂ and CO₂ flow
- ♦ Conductivity
- ♦ Flowrate (air & liquid)
- ♦ Turbidity



Future Areas for Growth

Sensors that could be implemented now

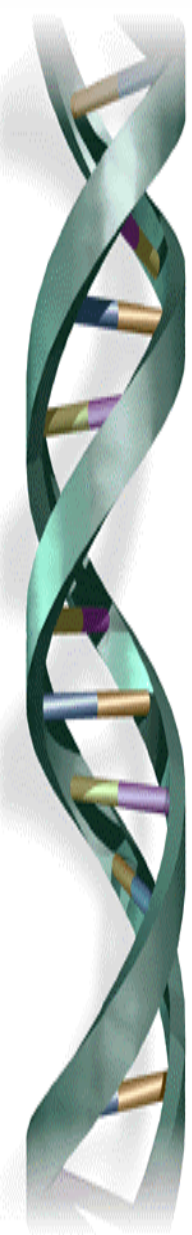
- ♦ Capacitance (viable cell density)
- ♦ NIR (moisture & vacuum detection in lyophilized vials)

Sensors for the near future

- ♦ Biosensors

Sensors for the more distant future

- ♦ NIR in aqueous streams
- ♦ Fluorescence
- ♦ Raman

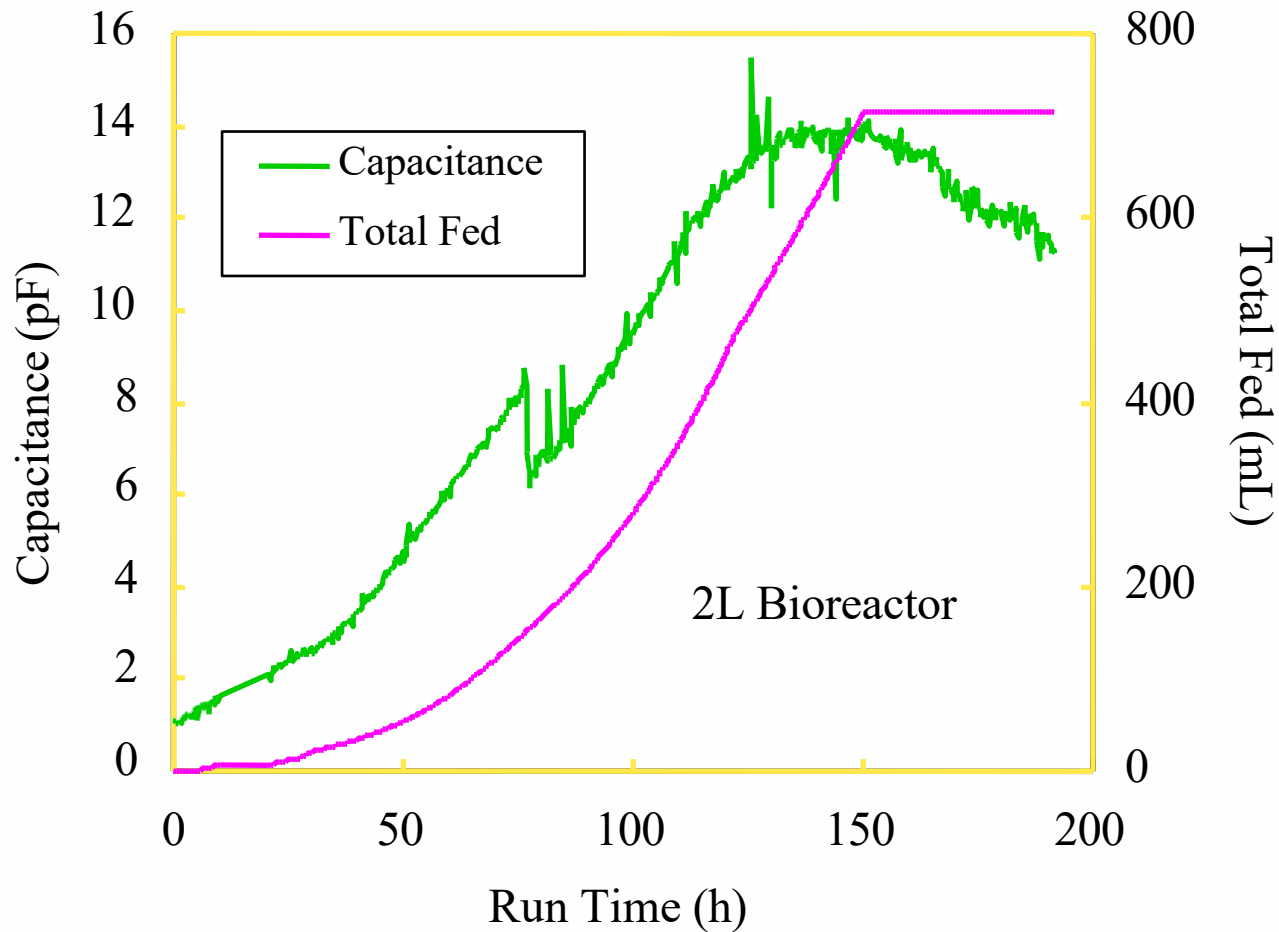


Future Areas for Growth

Technologies other than sensors

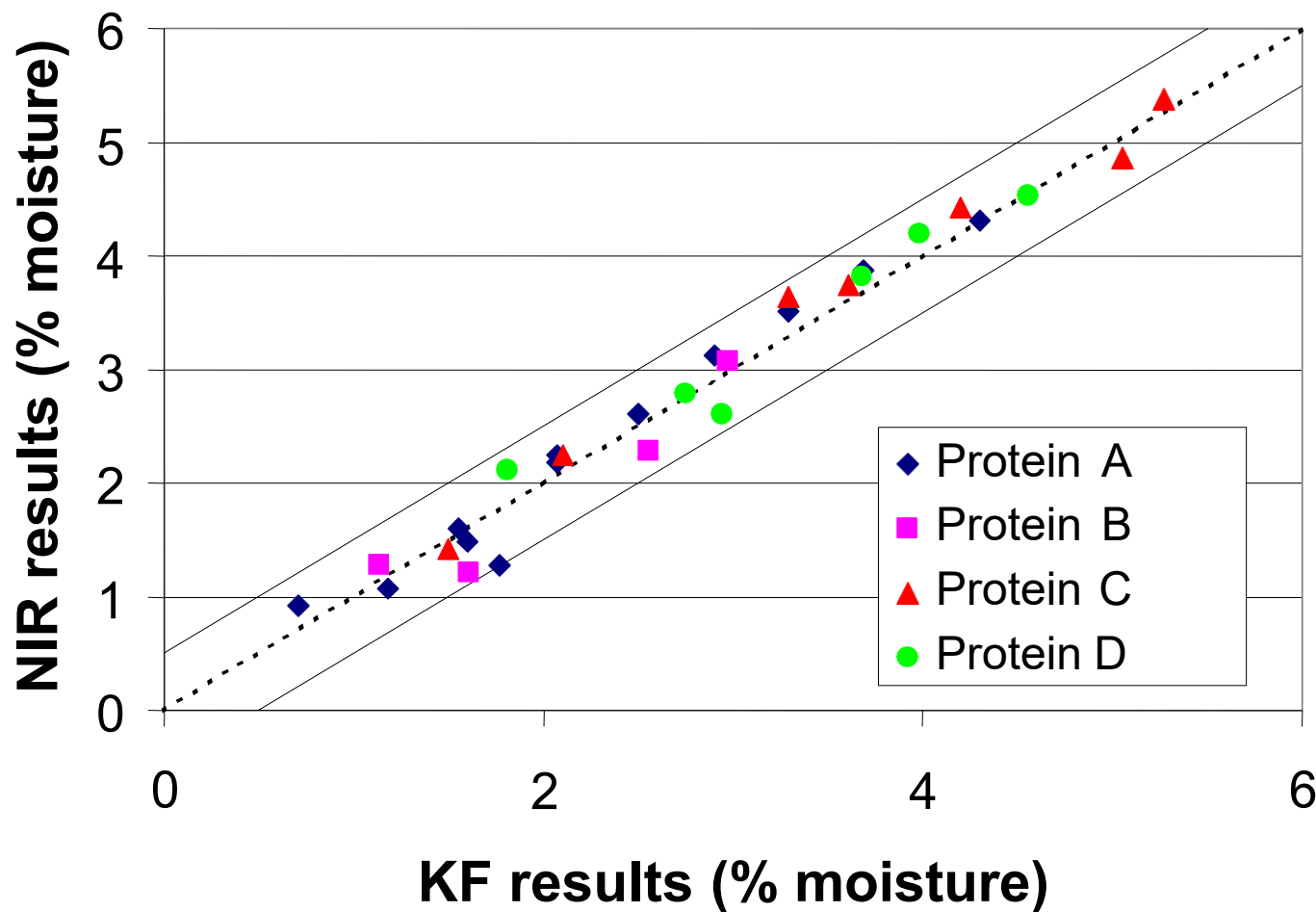
- ◆ Data technology
- ◆ Raw Material Characterization
 - ◆ NIR, Raman, ICP, etc.
- ◆ Rapid Microbial Detection

Capacitance probes can measure viable cell count

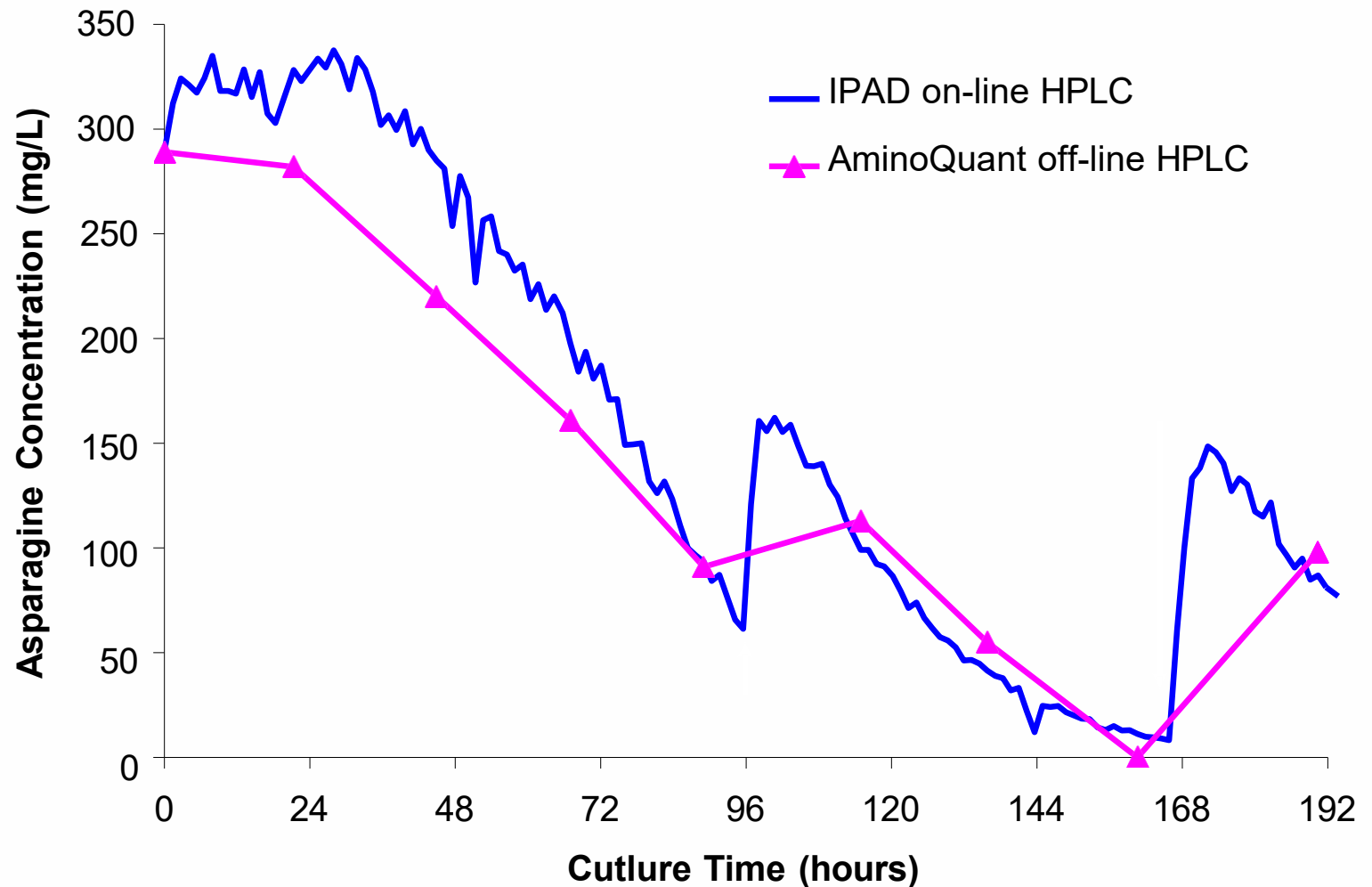


Data courtesy of Bob Kiss and Paul Magreta

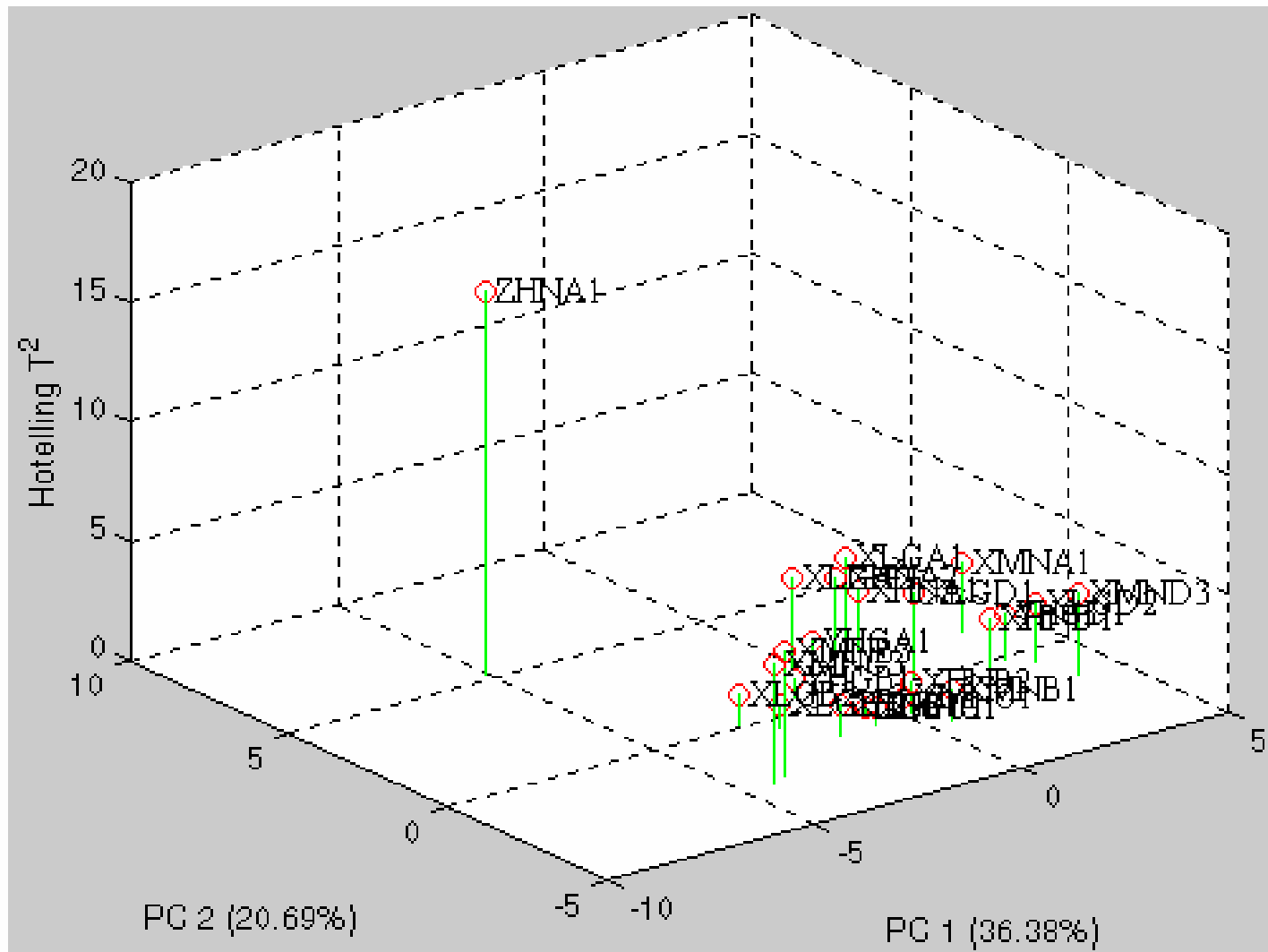
NIR to replace destructive moisture detection in lyophilized vials



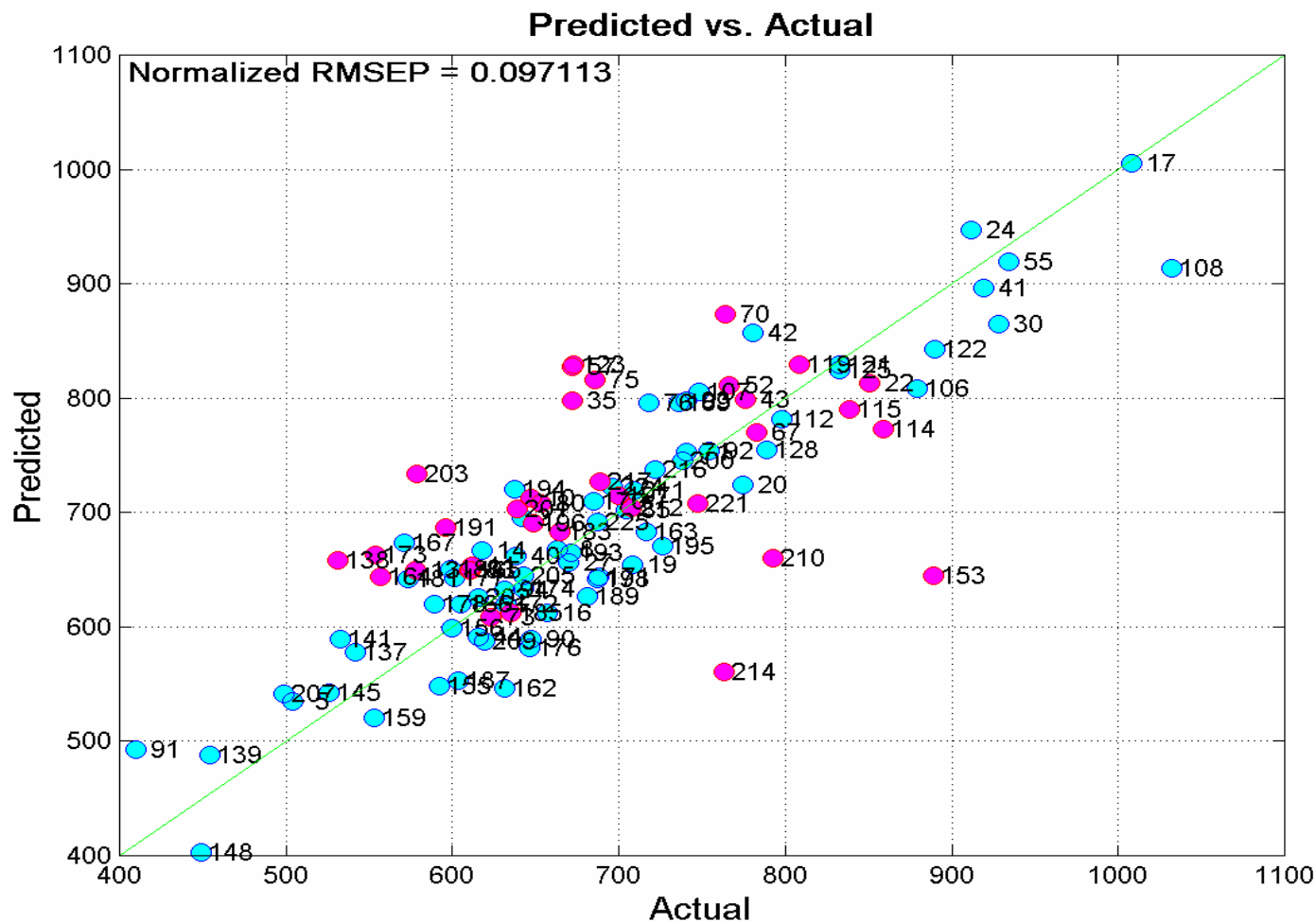
Amino acid & sugar analysis (HPLC shown, biosensor better)



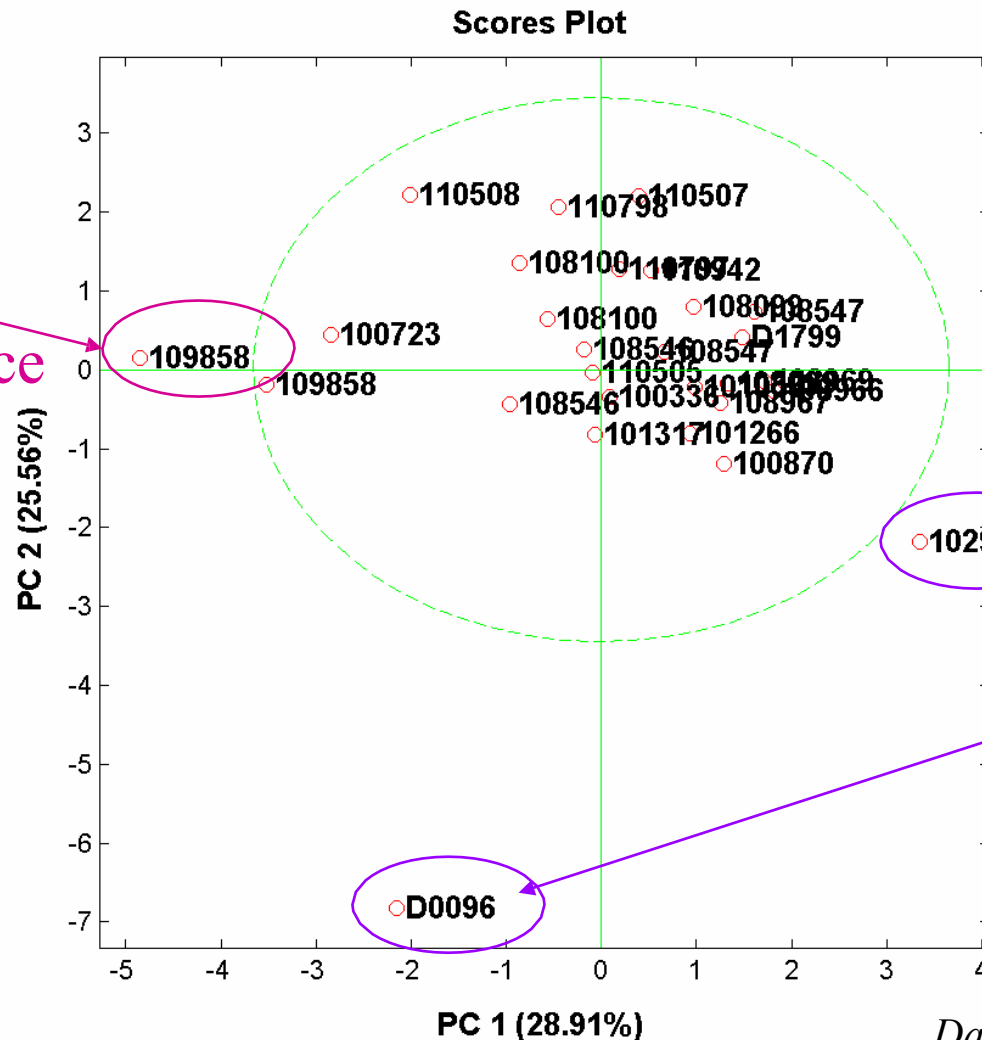
Product Z exhibits variation inside of the model



PLS model to predict titer based on 1695 variables



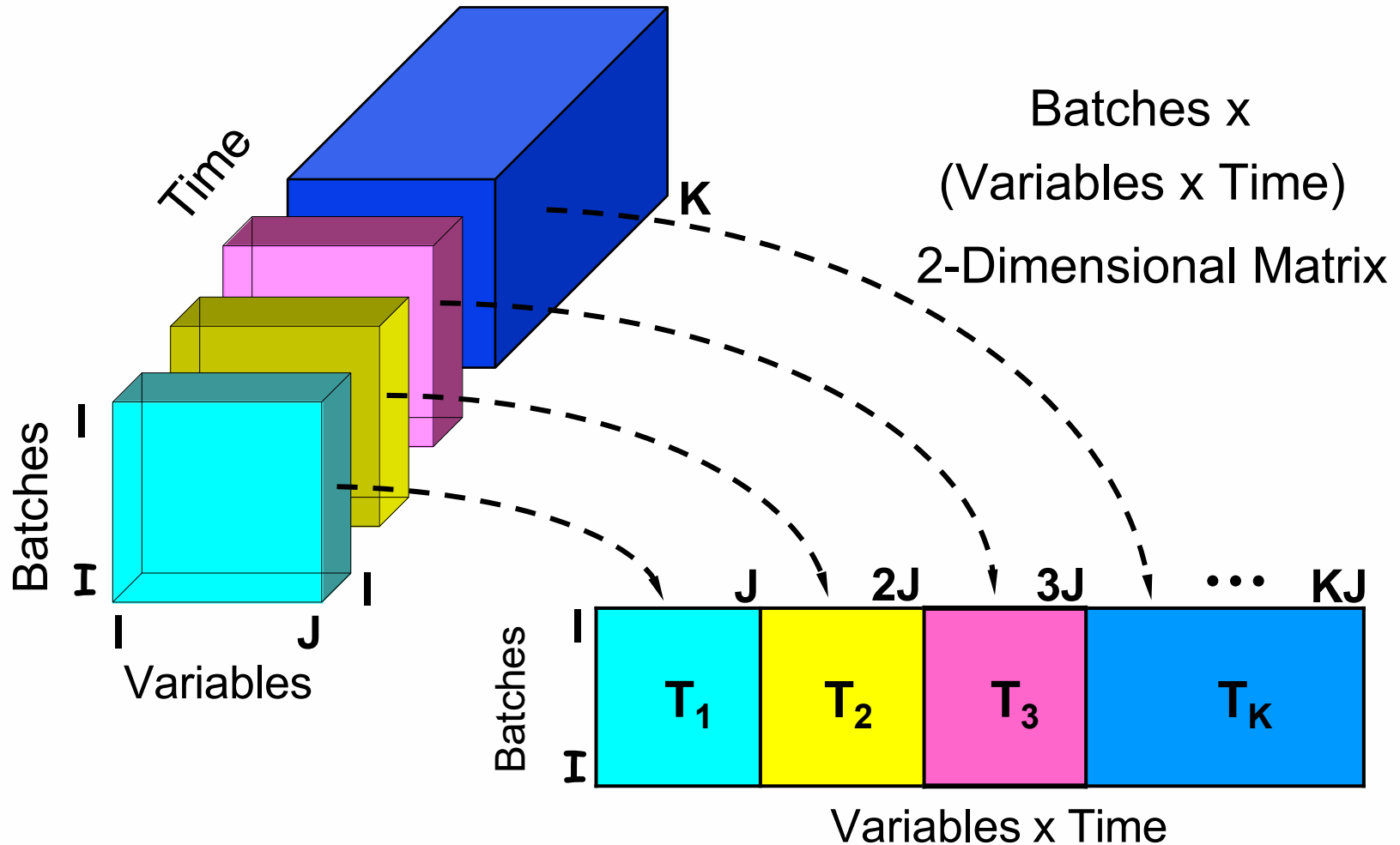
Correlating raw material ICP results to process performance



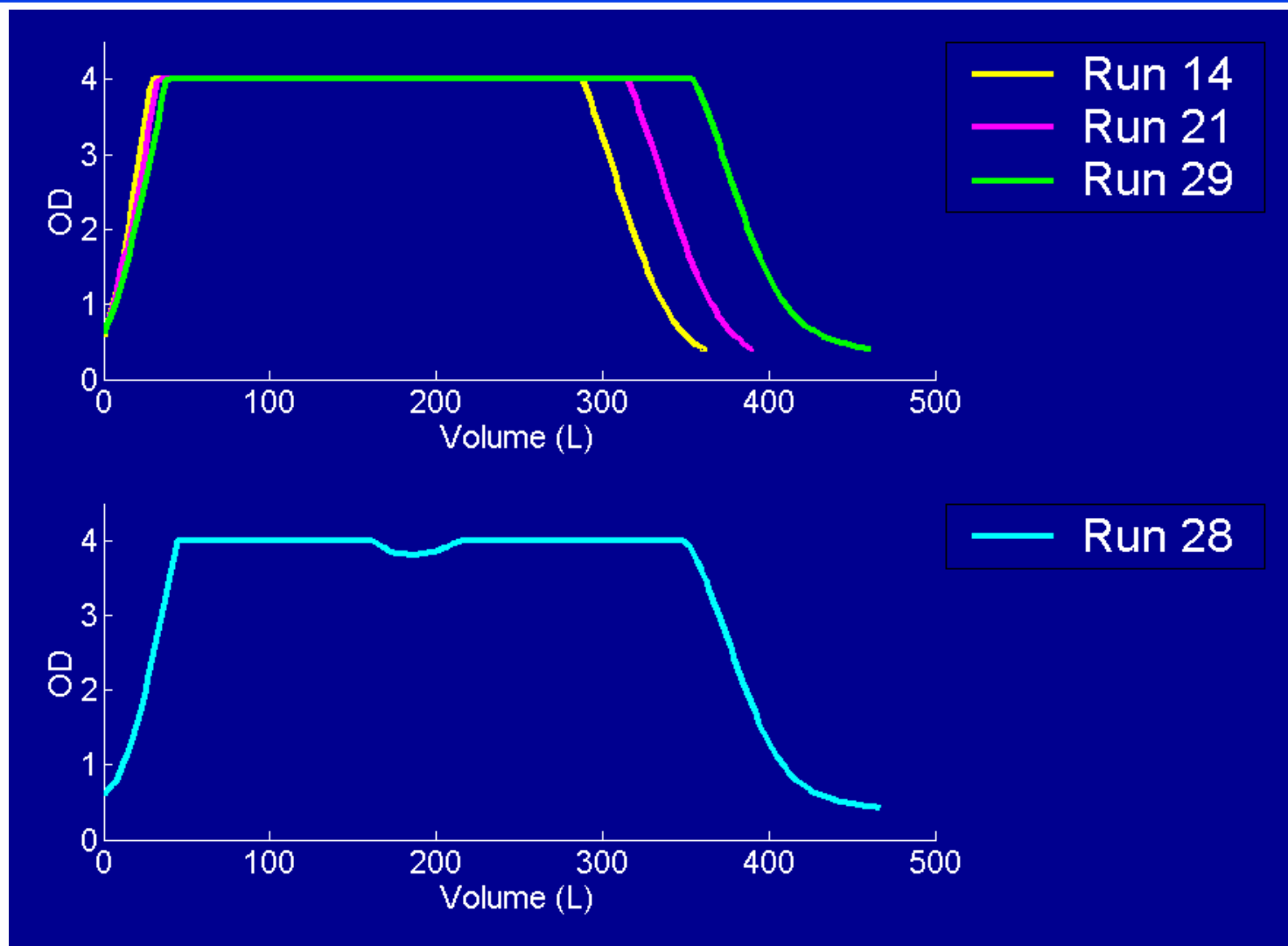
Good
Performance

Poor
Performance

Multi-way PCA

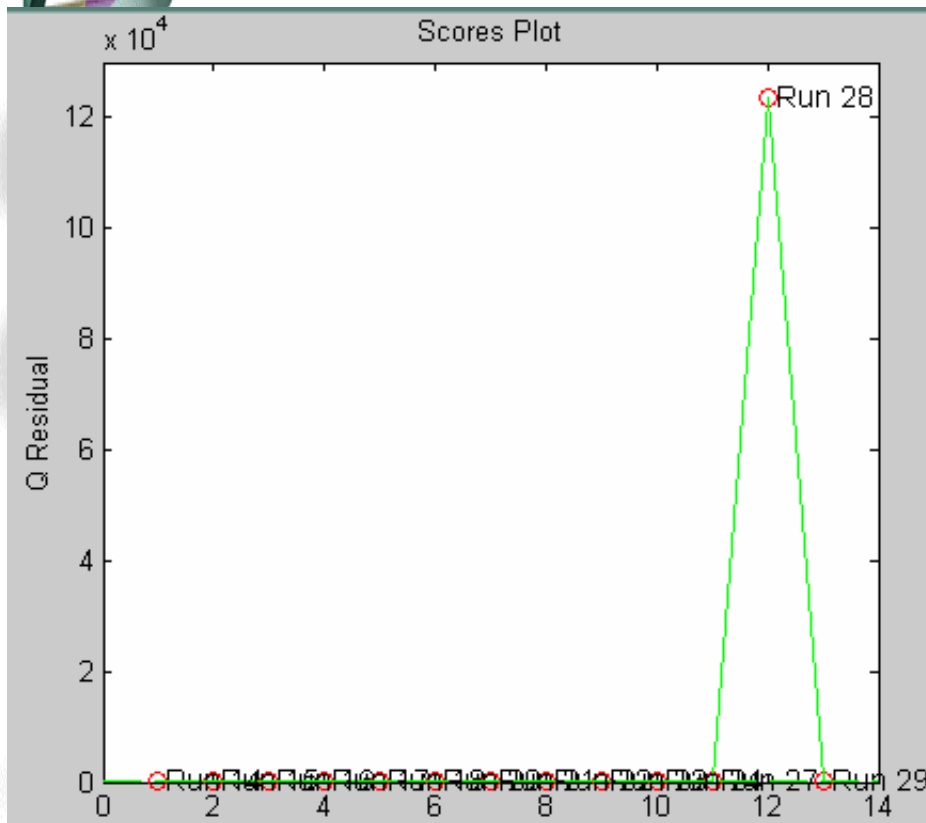


MPCA for chromatogram review



PCA analysis easily picks up change in peak shape

Q_{residual}



Hotelling's T²

