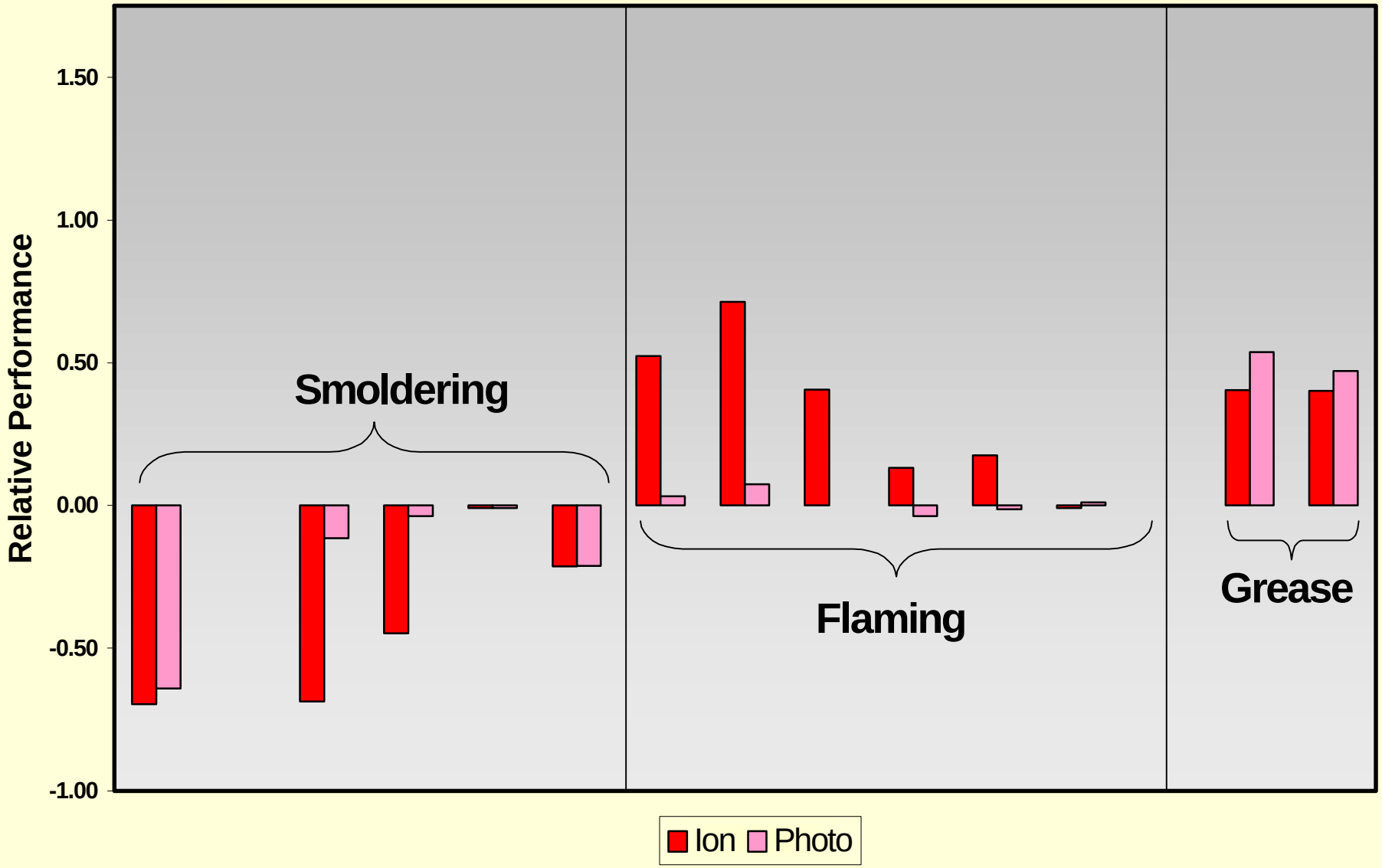
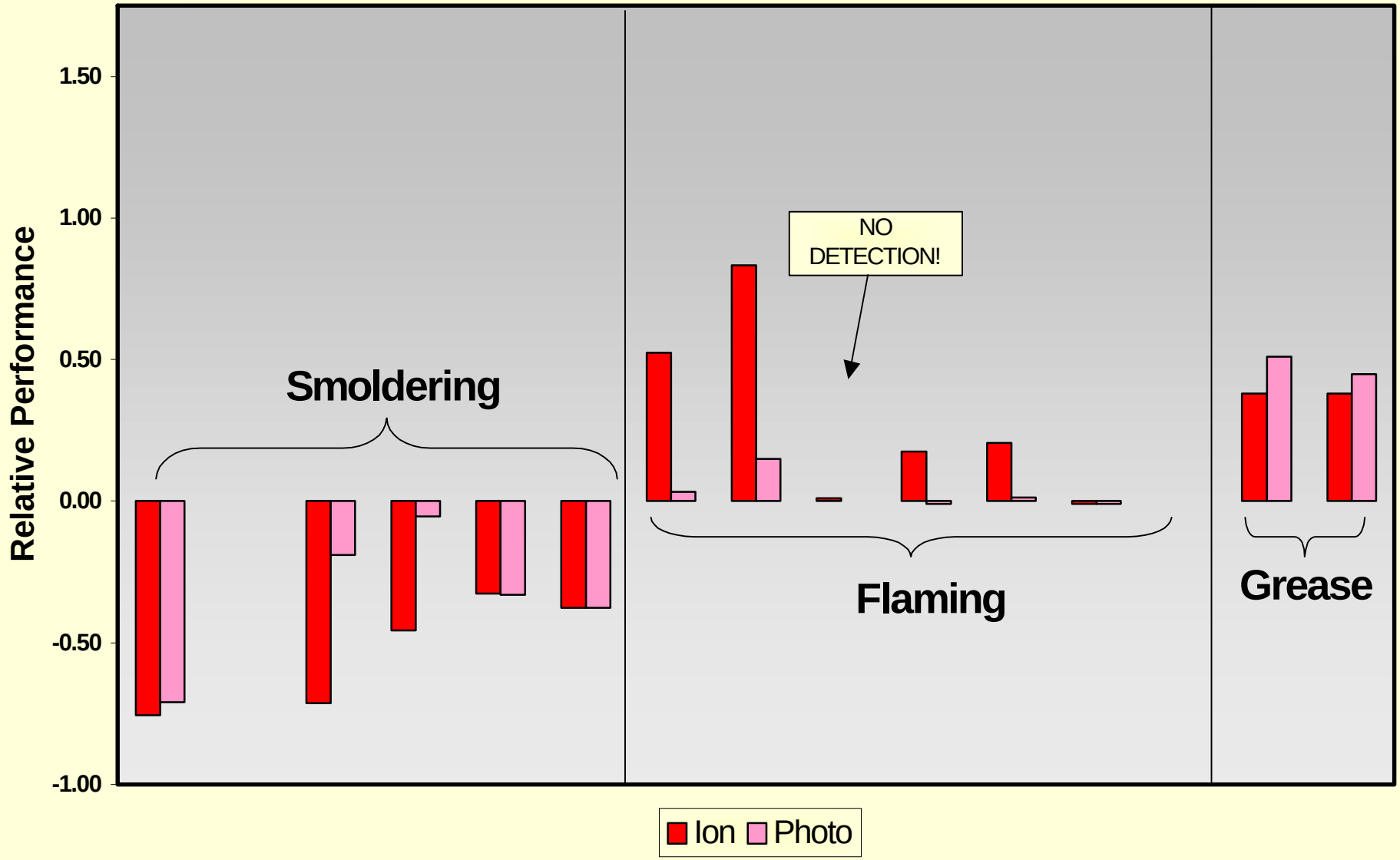
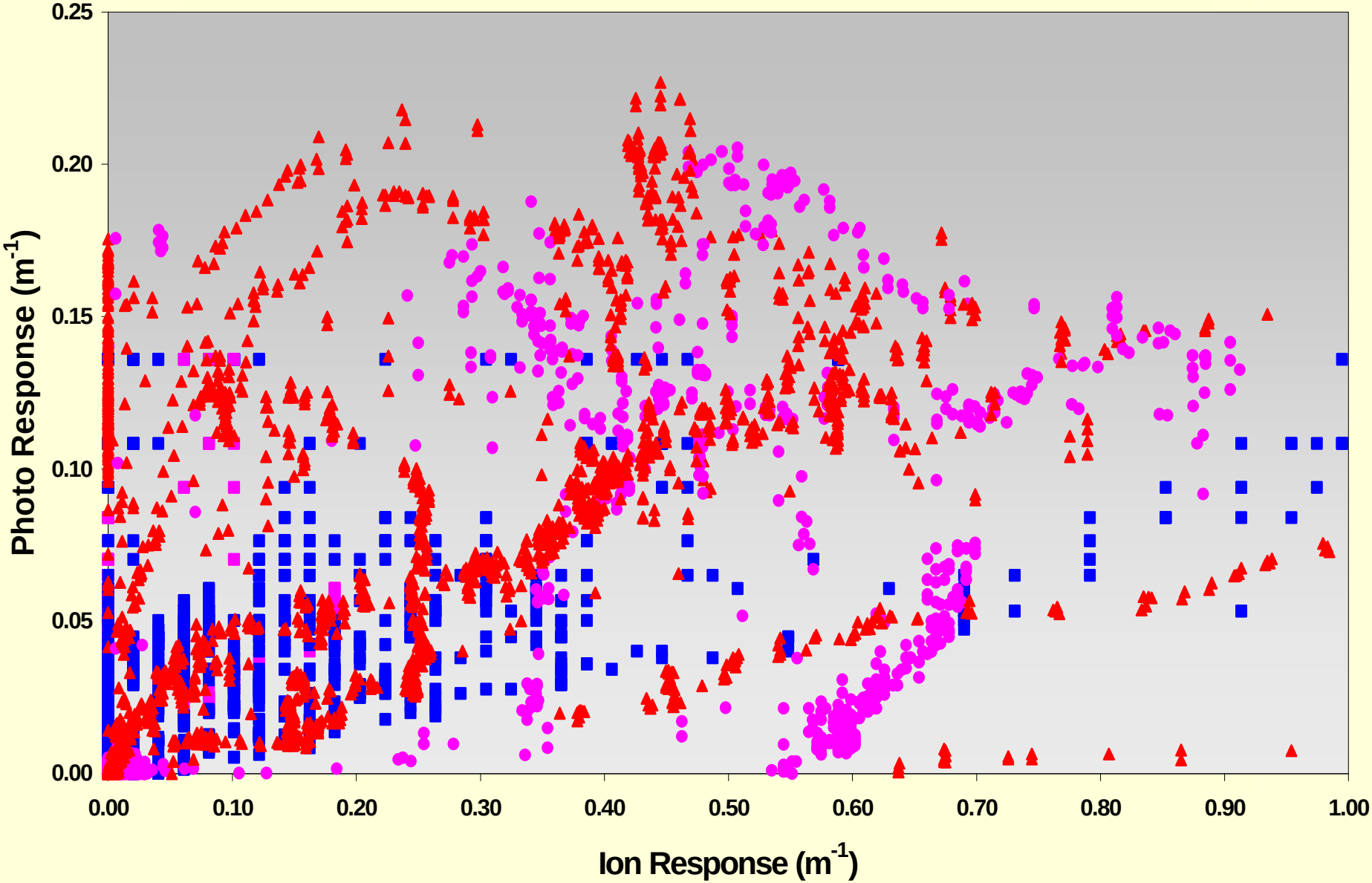
[Ion x (CO-5) > 0.15] OR (CO > 17) OR (Ion > 0.15)
Algorithm Performance



[Photo x (CO - 5) > 0.08] Or (CO>17) Or (Photo > 0.5) Algorithm Performance



Ionization vs. Photoelectric Detector Response



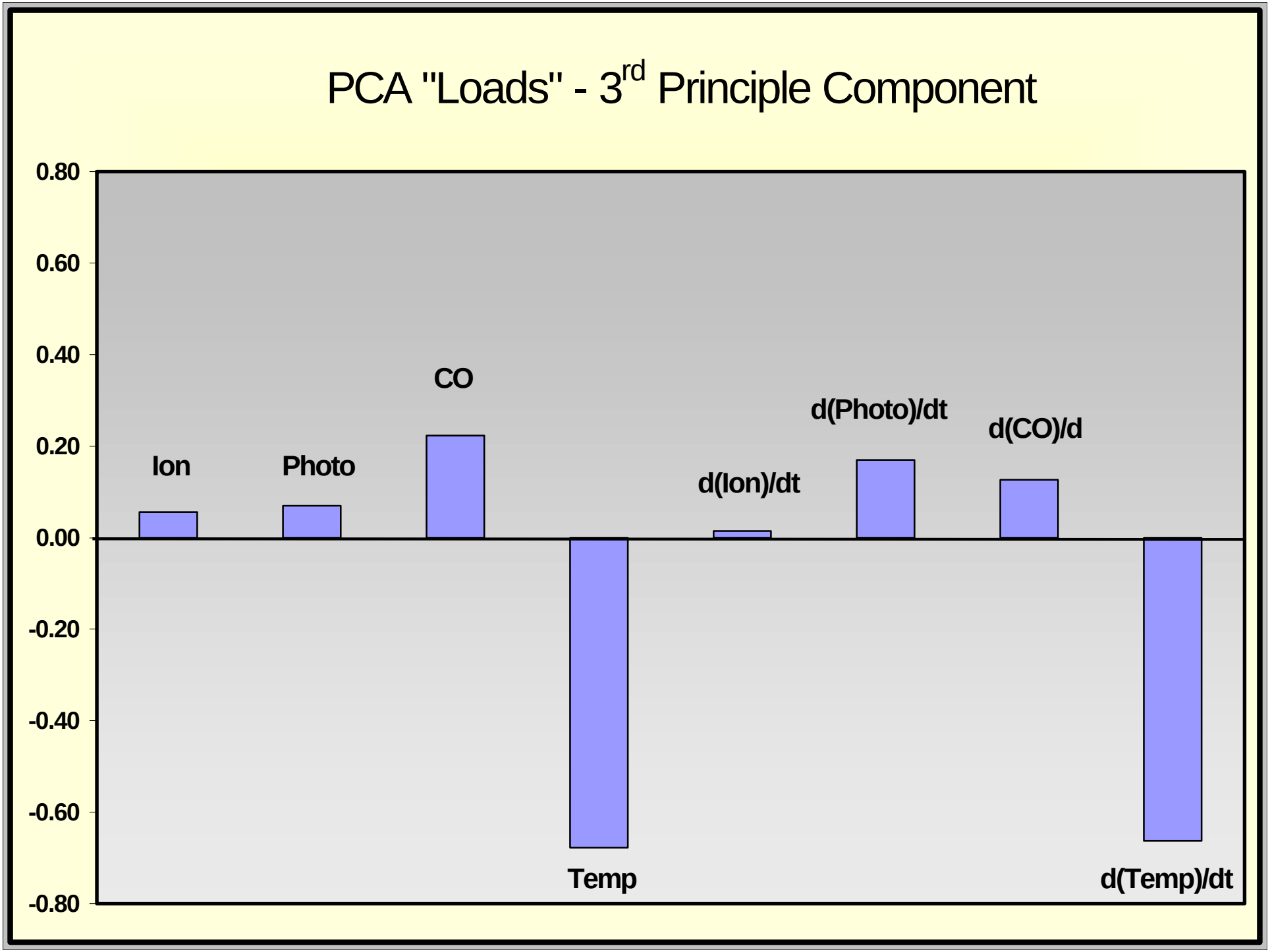
Principle Component Analysis (PCA)

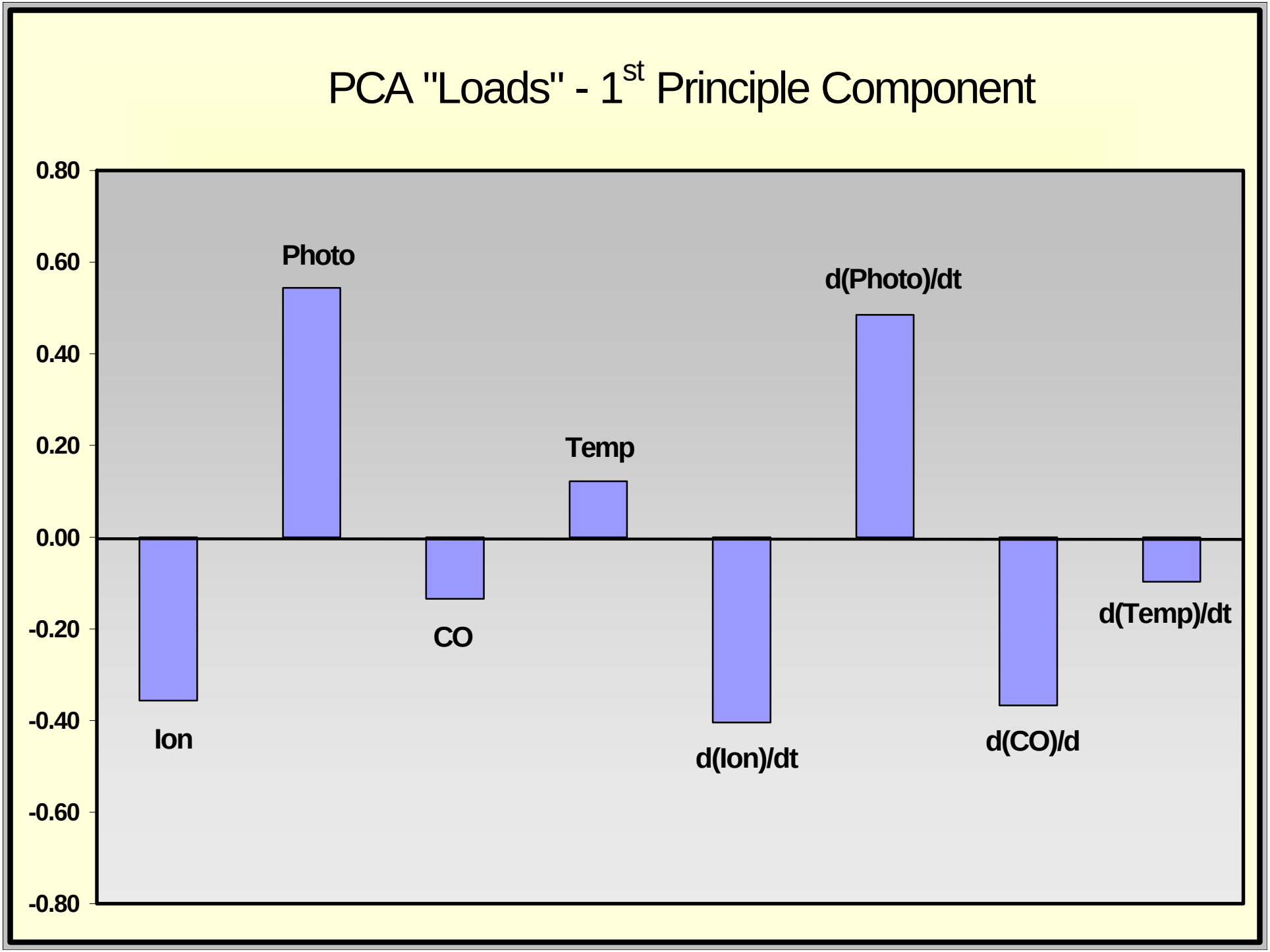
PCA = Data Compression

Principle Component Analysis (PCA)

$$X = t_1 p_1^T + t_2 p_2^T + \ldots + t_k p_k^T + E$$

where, $\quad \mathrm{cov}(X) p_i = \lambda_i p_i$


PCA "Loads" - 3rd Principle Component
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Ion
Photo
CO
Temp
d(Ion)/dt
d(Photo)/dt
d(CO)/d
d(Temp)/dt


PCA "Loads" - 1st Principle Component
0.80
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
Ion
Photo
CO
Temp
d(Ion)/dt
d(Photo)/dt
d(CO)/d
d(Temp)/dt

Applying the Loads

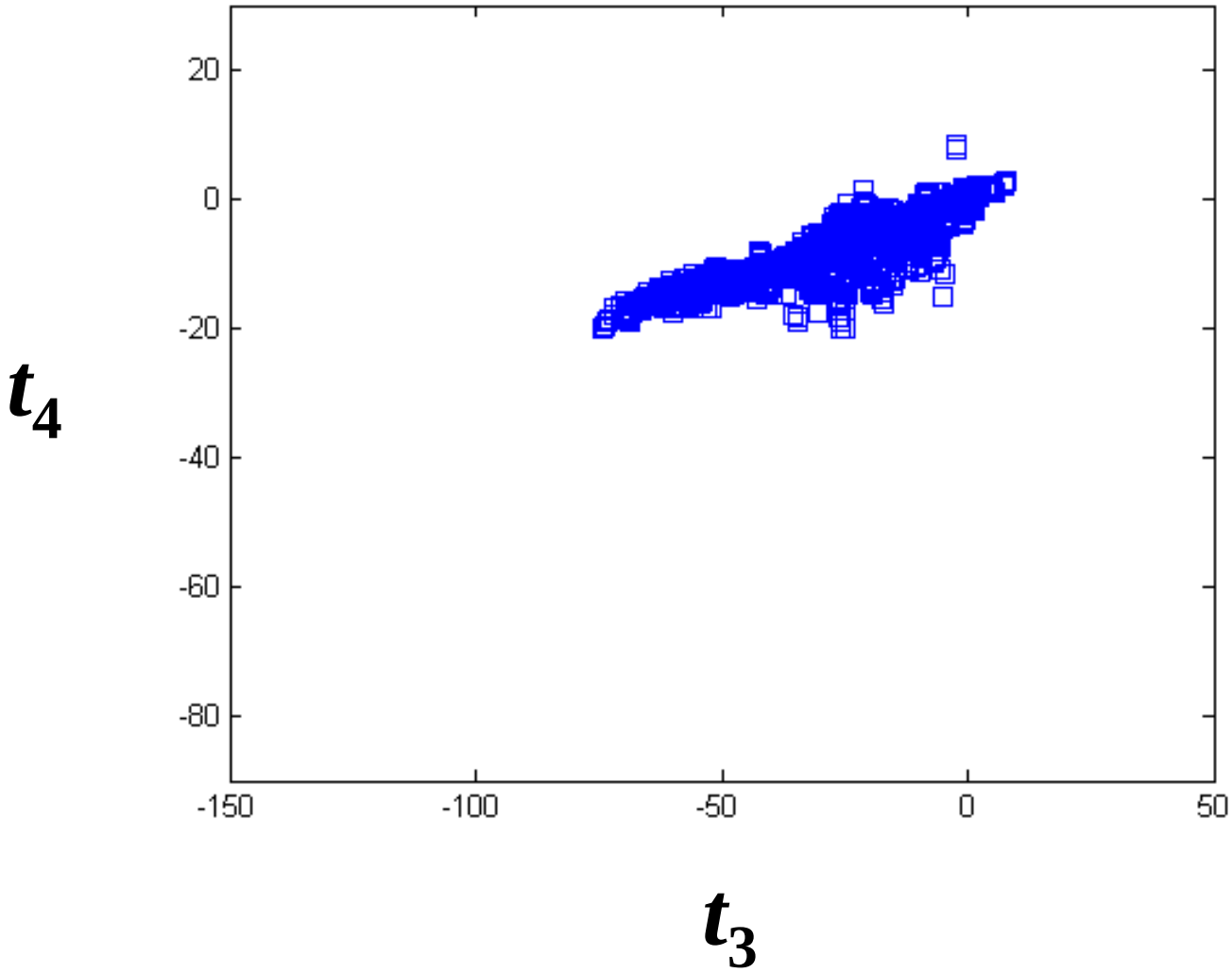
$$[t_i] = [X][p_i]$$

$$t_1 = \begin{array}{c} \begin{array}{cccccccc} \textit{Ion} & \textit{Photo} & \textit{CO} & \cdots & & & & \end{array} \\ \begin{bmatrix} X_1 & X_2 & X_3 & X_4 & X_5 & X_6 & X_7 & X_8 \end{bmatrix} \end{array} \bullet \begin{bmatrix} p_{1,1} \\ p_{2,1} \\ p_{3,1} \\ p_{4,1} \\ p_{5,1} \\ p_{6,1} \\ p_{7,1} \\ p_{8,1} \end{bmatrix} \begin{array}{c} \text{Ion} \\ \text{Photo} \\ \text{CO} \\ \vdots \end{array}$$

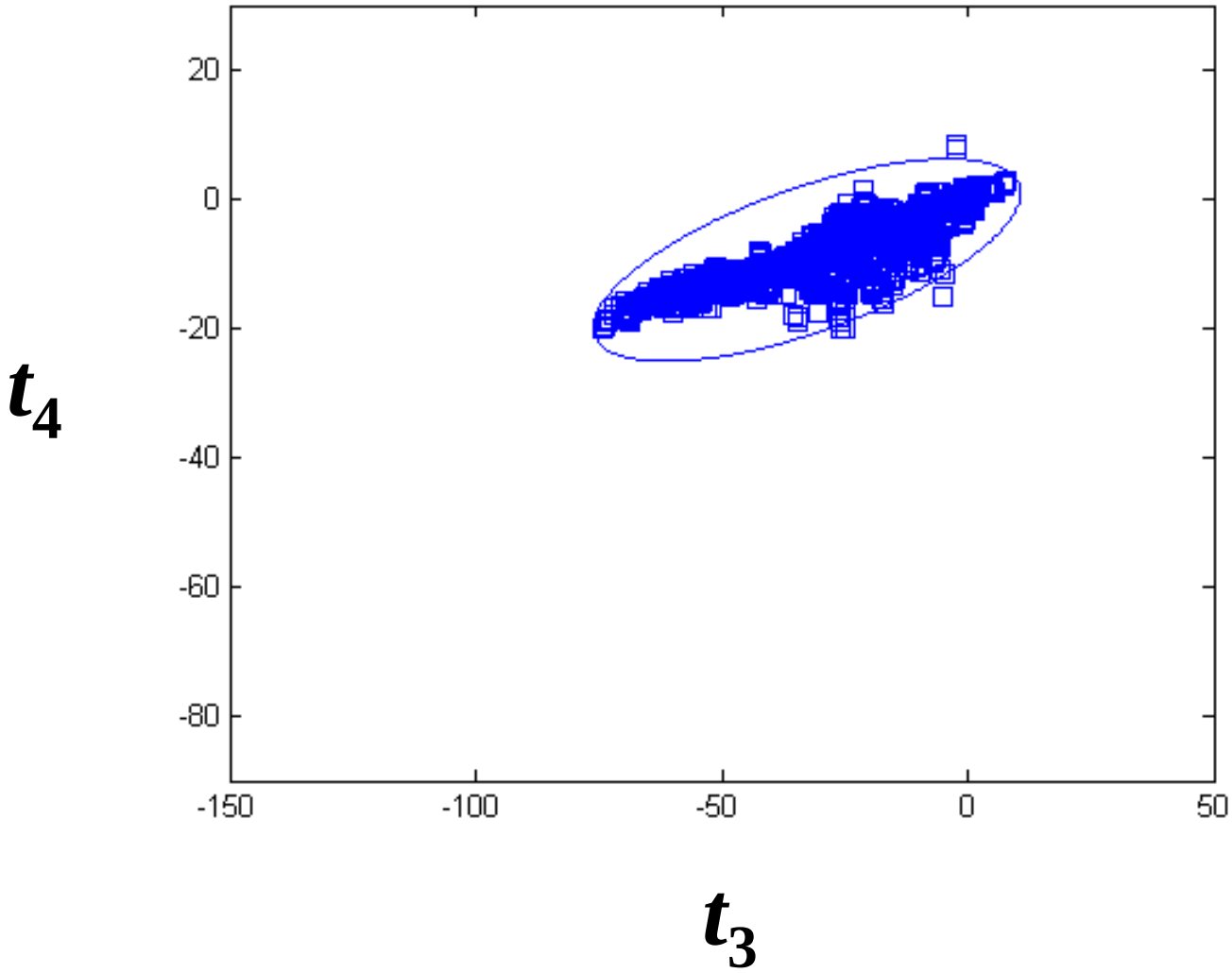
Raw Measurement Vector

Load Vector

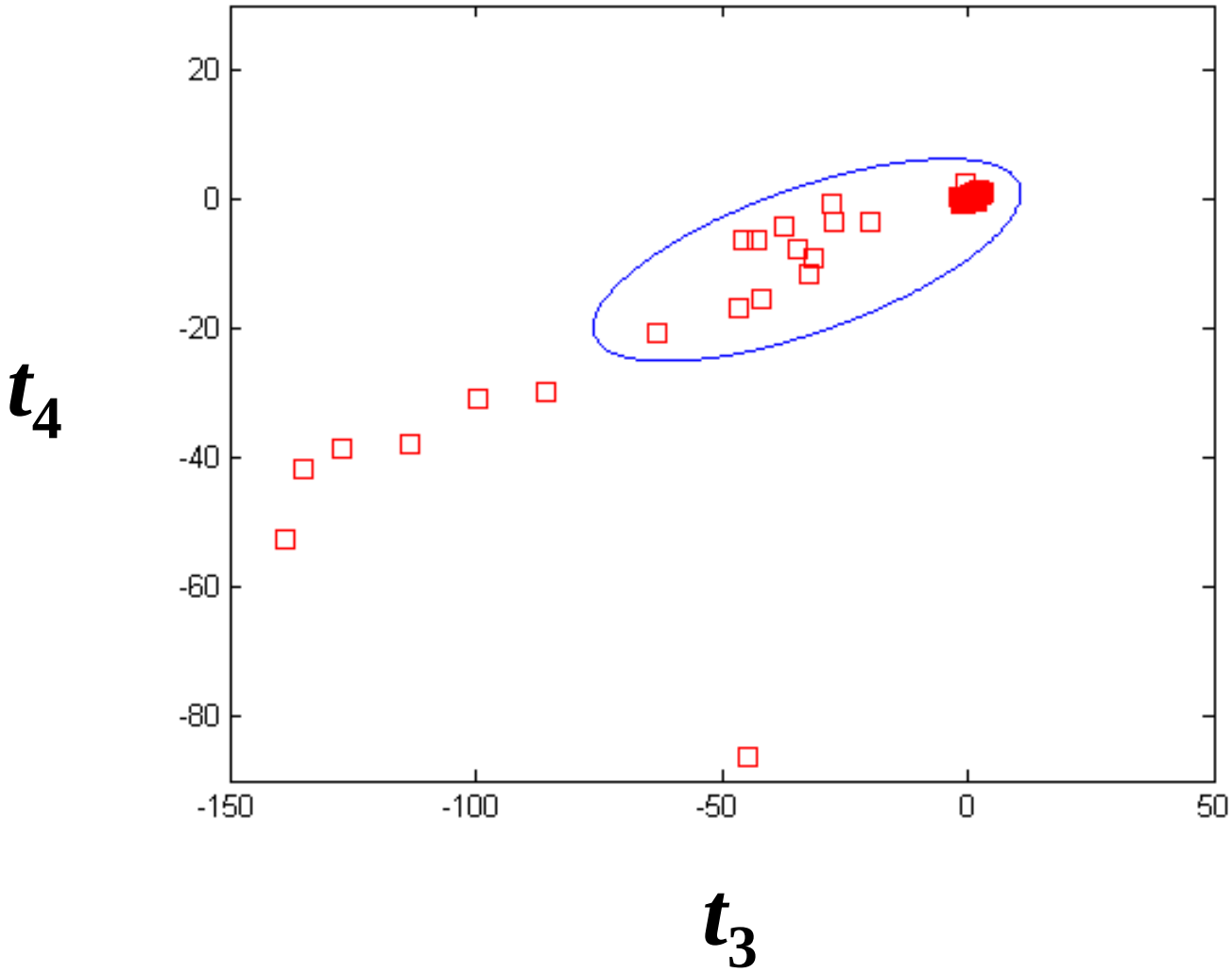
t_3 vs. t_4



t_3 vs. t_4



t_3 vs. t_4



2D PCA Algorithms

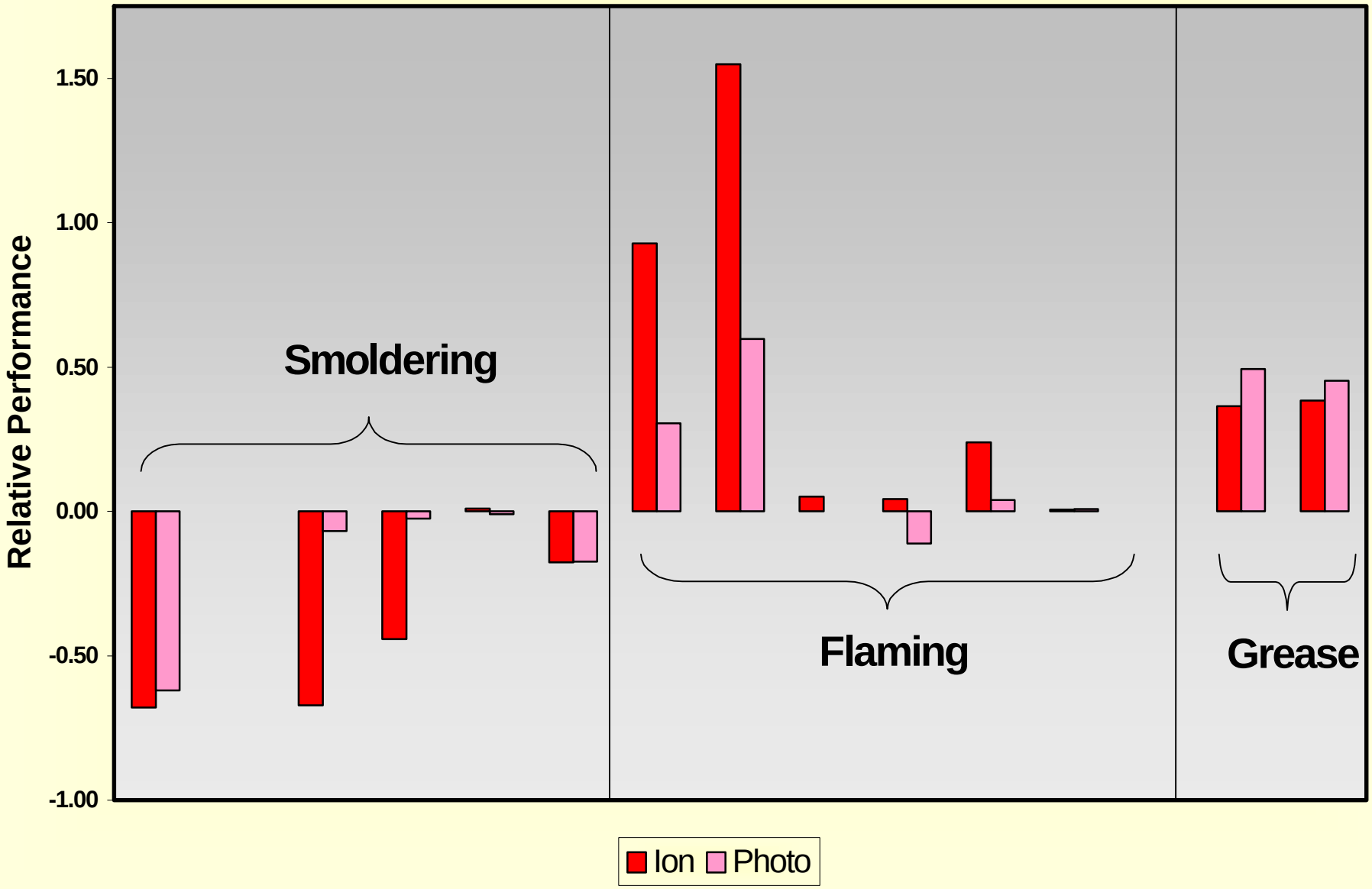
- t_1-t_2
- t_1-t_3
- t_1-t_4
- t_2-t_3
- t_2-t_4
- t_3-t_4

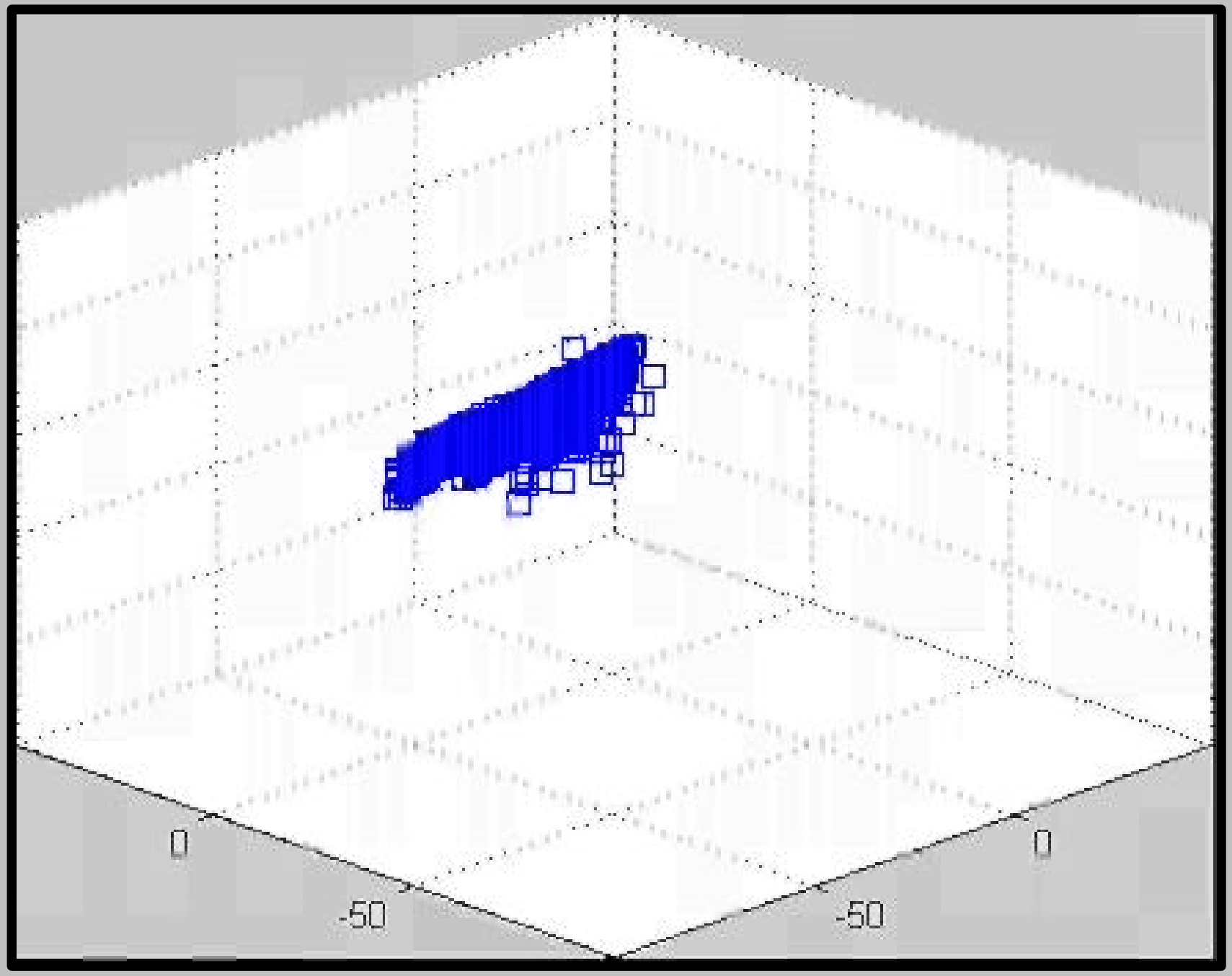
$$\frac{t_x^2}{a} + \frac{t_y^2}{b} = 1,$$

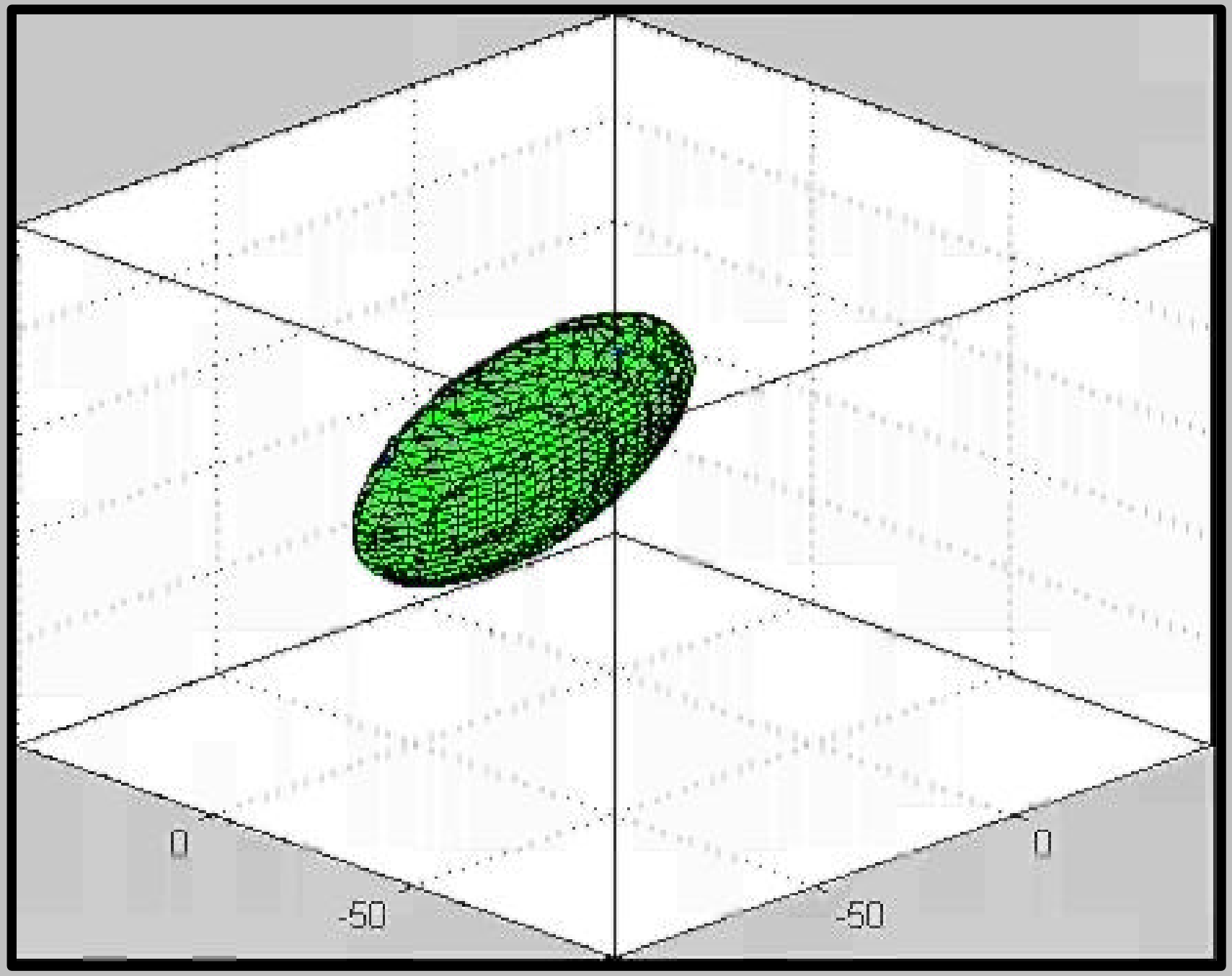
Coordinate Transformation
to Rotate

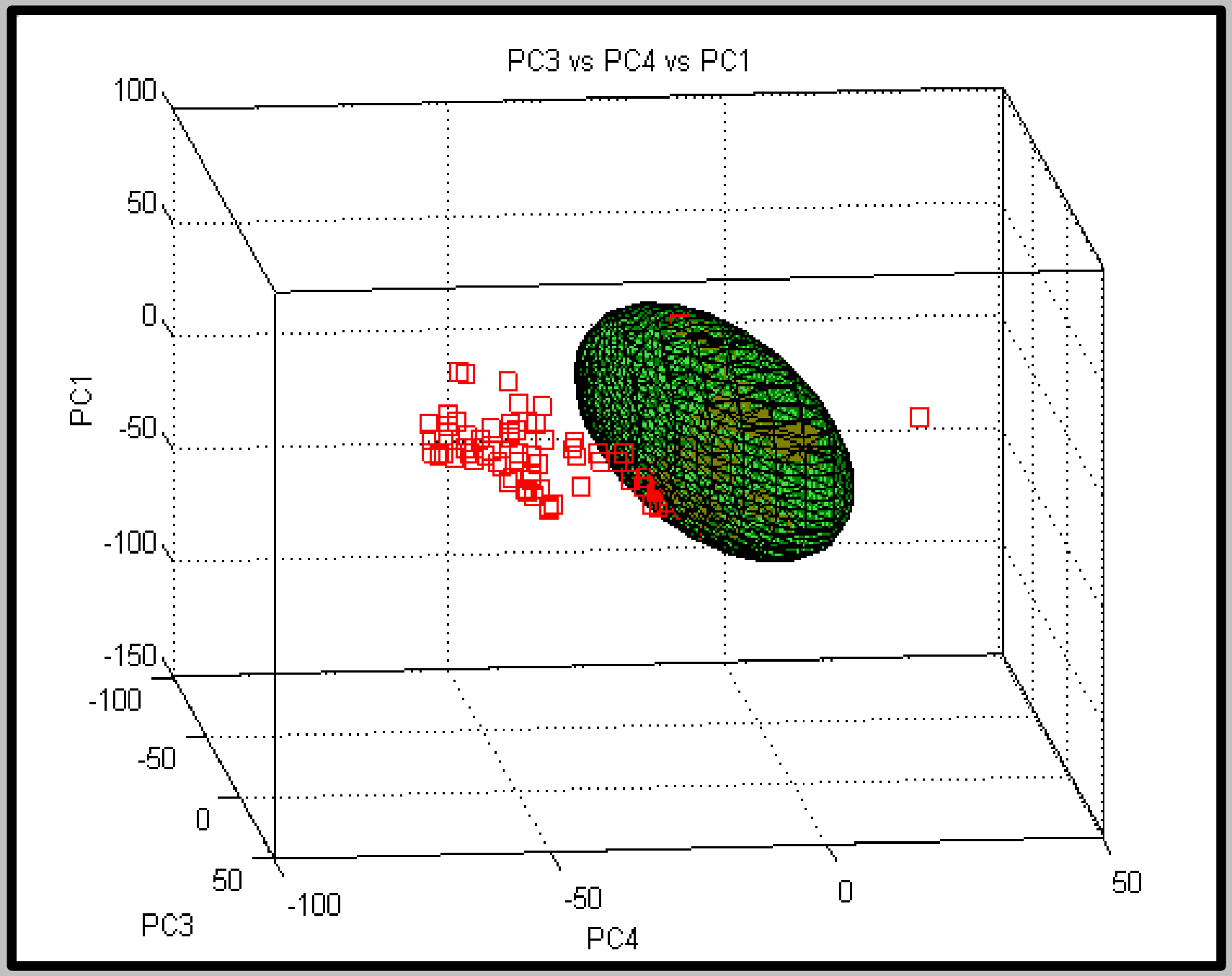
PCA Algorithm Performance

t_3- t_4




0
-50
0
-50


0
-50
0
-50


PC3 vs PC4 vs PC1
100
50
0
-50
-100
-150
PC1
-100
-50
0
50
PC3
-100
-50
0
50
PC4

3D PCA Algorithms

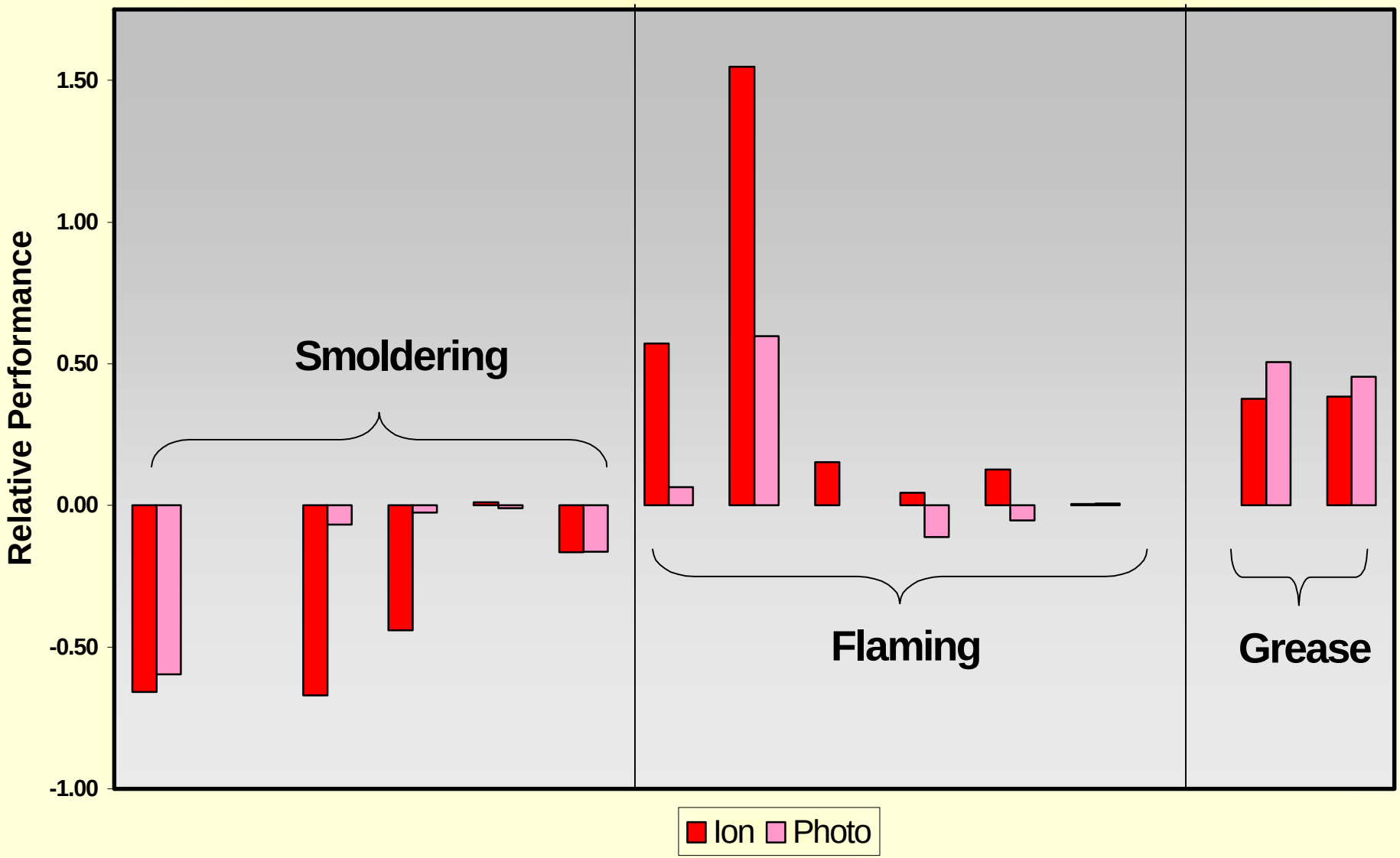
- t_1-t_2-t_3
- t_1-t_2-t_4
- t_1-t_3-t_4
- t_2-t_3-t_4

$$\frac{t_x^2}{a} + \frac{t_y^2}{b} + \frac{t_z^2}{c} = 1,$$

Coordinate Transformation
to Rotate

PCA Algorithm Performance

t_3-t_4-t_2



Preliminary Conclusions

- Ion and Photo are poor discriminators.
- Rate of Temperature Rise provides good discrimination and fast detection of flaming fires.
- CO provides good discrimination and fast detection of smoldering fires.
- Combined dT/dt – CO – Ion most promising.
- PCA does not provide significant benefit with current data set.

Questions?