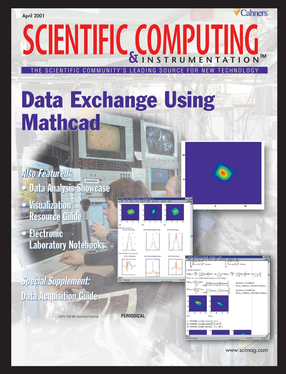
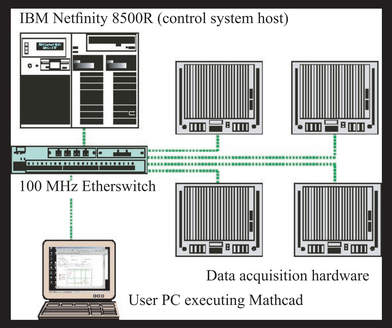
Empowering ATF Users :
Control System Interface via Mathcad

Introduction and Background

- ATF users now have the option of writing their own control/data acquisition algorithms using Mathcad
- Under this scheme, a user's Mathcad worksheet becomes a client which can both import and export data from the ATF computer control system
- Originally developed for in-house operations, usage has broadened to include any interested ATF user
- Communication is via a Berkely-style network socket connection
- Support is presently for Microsoft Windows-based PCs only
- Novel usage profiled in cover story of April 2001 issue of *Scientific Computing and Instrumentation* magazine





Why Mathcad?

- Relatively low cost, especially for students and academicians
- Many users already proficient in its use as a computational tool
- Free form, worksheet-like interface
- Native data type is double precision complex (scalars, vectors, matrices)
- Two dimensional, natural mathematic notation with standard operators/notations
- Physics becomes more transparent and natural, with details of computation hidden
- Modifications can be tested quickly (interpreted; no compiling/linking)
- Many built-in mathematics capabilities:
  - Numerical linear algebra, integration and differentiation
  - Numerical optimization
  - Solutions to systems of equations
  - Probability distributions
  - 2- and 3-dimensional plots
  - Numerical solution to differential equations, boundary value problems
  - Probability distributions, statistical tests, spectral analysis
  - Curve fitting, smoothing, regression
- Ability to import data from other sources (Microsoft Excel, Mathworks MATLAB, image files, ASCII data)
- Symbolic calculations

Mathcad vs. traditional code

$$T := \sum_{i=1}^{n} a_i$$

vs.

```
double a[n]
double t = 0.0;
long i;

for (i = 1; i < n; i++)
{
  t += a[i];
}
```

$$x := (A^T A)^{-1} A^T b$$

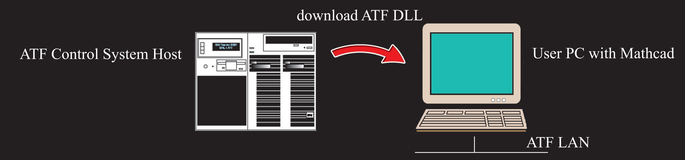
vs.

```
double A[m][n];
double x ;
double Atr[n][m];
double Atrinv[n][m];

matrix_transpose(A,m,n,Atr);
matrix_mult(Atr,n,m,A, );
matrix_inv (Atr A,n,Atr Ainv);
matrix_mult (Atr Ainv,n,n,Atr,n,m,Atr Ainv Atr)
matrix_mult (Atr Ainv Atr,nxm,b,m,1,x);
```

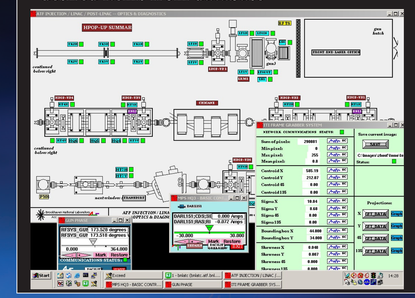
How to get started?

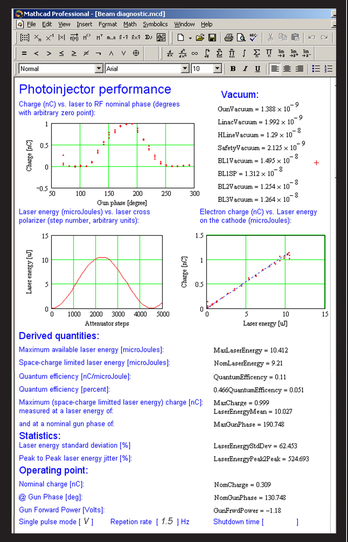
1. Request a copy of the ATF Mathcad Dynamic Link Library (DLL) and a starter worksheet (has the most commonly used ATF operations pre-defined).
2. Copy the ATF DLL to your Mathcad "Userefi" folder.
   This installs ATF functions and makes them available to Mathcad on next startup. There are no modifications made to user's registry, file structure, etc. There is no license fee for using this library.
3. Connect user PC to ATF local area network
4. Turn off automatic calculation.
5. Add ATF functions calls to worksheet. Enter "Calculate Worksheet" when ready to execute.
6. To remove the DLL, just delete it from the Mathcad "Userefi" folder.
   No uninstall procedure is necessary.



How Does It Support ATF Users?

- All capabilities available under the GUI are available programmatically in Mathcad. This includes:
  - Magnet power supplies
  - Video frame grabbers, switching
  - Beam profile monitors
  - Laser diagnostics
  - Optics stages
  - Laser joulemeters
  - Stepping motors
  - Contact inputs/ outputs
  - RF system
- All units, clip limits, scale factors carry over directly from GUI to Mathcad worksheet
- Improved collaboration: individual user solutions can be shared among groups
- Users can verify ATF operational parameters themselves (e.g., beam emittance)
- Faster implementation; no need to wait for ATF staff to develop needed capability.
- Repetitive or complicated logic easily programmed.
- Data acquisition, timing and synchronization have been developed and tested by ATF: user need only select desired items from database



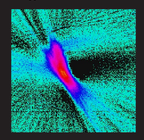


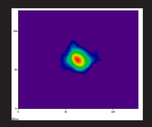
<= All operations available through the GUI are also accessible through the worksheet ⇑

Success Stories

A number of ATF experiments have used the Mathcad interface as part of their data collection and analysis. This includes:

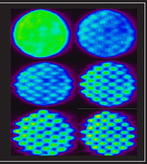
- Longitudinal Phase Space Tomography





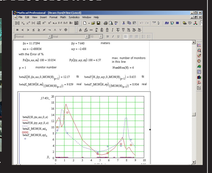
- VISA-II

- Emittance analysis for non-uniform transverse laser distribution



- UCLA Chicane debug/diagnostics

- Dielectric Wakefield Accelerator



sample user worksheet =>

- All Users: Daily operational parameters

Future Plans

If user interest is sufficient, a downloadable simulator which will permit testing Mathcad worksheets at the users location, before coming to ATF.

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