

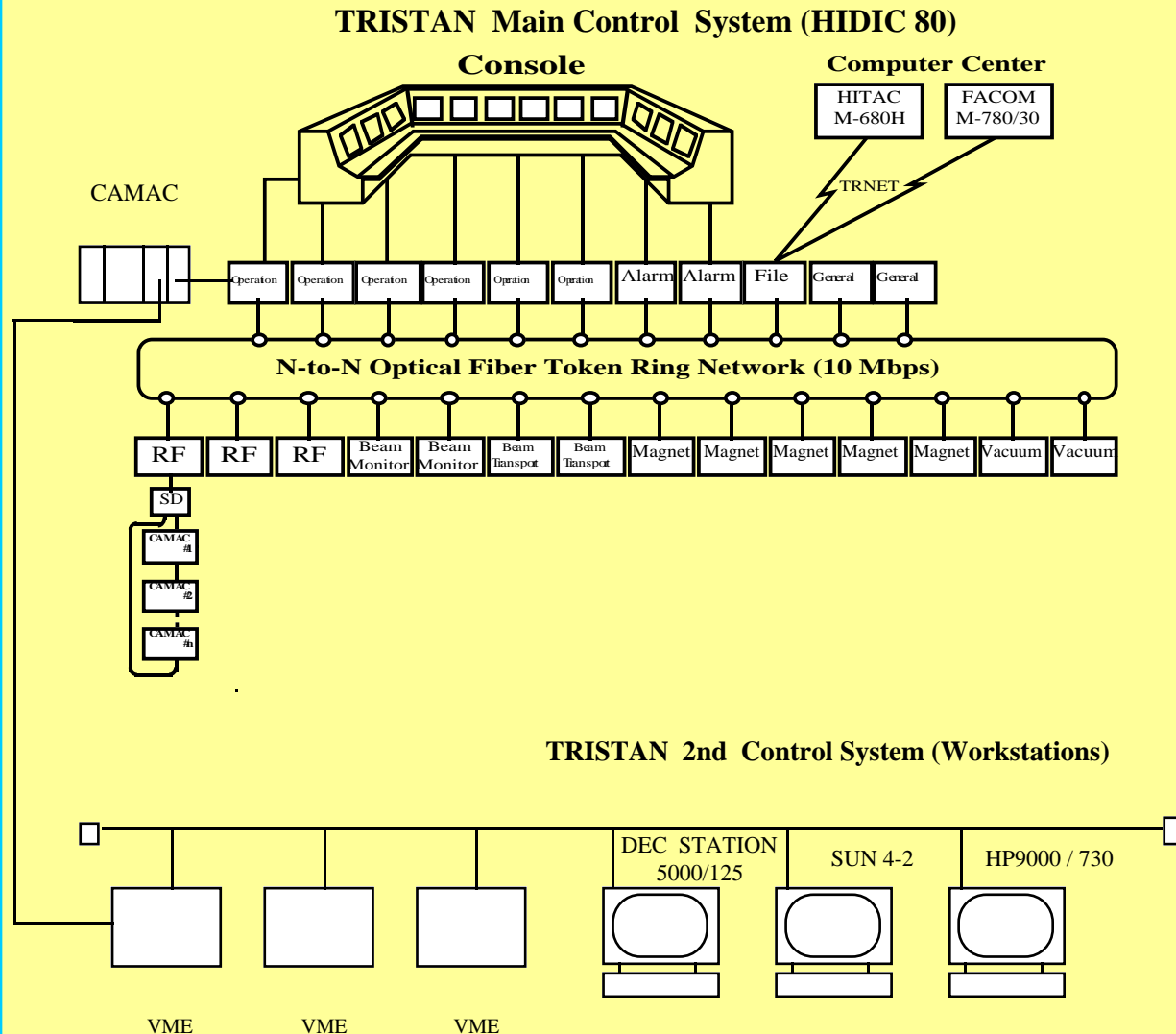
# Accelerator Model in an Accelerator Control System

--- the Case of TRISTAN and KEKB ---

Noboru Yamamoto  
KEK, Accelerator Facility



# TRISTAN Control System



- ◆ Modeling Program runs on
  - ◆ HIDIC Mini computers : in-house optics calculation program written in NODAL.
  - ◆ Mainframe computers : PETROK, MAGIC
- ◆ Model Programs are used for:
  - ◆ Orbit Correction/Control
  - ◆ Optics control
    - ◆ Twiss parameters
    - ◆ Tune
  - ◆ Chromaticity correction
- ◆ Data Transfer Method: Files

# Problems in TRISTAN Control System

- Several Accelerator models in various applications.
  - Discrepancy between models
  - Different input format
  - Difficult to maintain consistency between models.

# SAD

- Developed in KEK for Accelerator Simulation since 1986.
- 1-fits-All for Accelerator Study
- SAD Script Programming Interface in *Mathematica* Style
  
- Channel Access Interface
- Python/Tk Interface

# SAD:1-fits-All for Accelerator Studies

- Structural Definitions of Beam Line & Component
  - Elements
    - DRIFT
    - BEND, QUAD, SEXT, OCT, DECA, DODECA, MULT, ST, SOL
    - CAVI
    - MON, MARK, APERT
  - Beam Line(LINE) : List of Elements and/or Lines
- Optics Matching
  - Optical/Geometrical matching
  - Off-momentum matching
  - Finite-amplitude matching
  - Spin Matching

# SAD: 1-fits-All for Accelerator Studies (cont'd)

- Particle Tracking
  - 6D full-symplectic tracking
  - Dynamic aperture survey
  - Synchrotron radiation
- Nonlinear Analysis
  - Taylor map by automatic differentiation
  - Lie algebraic map
- Emittance Calculation
  - 6D Beam-matrix method
  - Anomalous emittance
- Spin de-polarization

# SAD: Script Programming Interface in *Mathematica* Style

- Built-in, System- and user-defined functions for accelerators
  - Data types
    - (Real) Number, String, List
  - Functions for Beam Optics
    - Twiss, BeamMatrix, OptimizeOptics, .....
  - Flow control
    - IF, Do, For, .....
  - Input/Output
  - Graphics
  - Numerical Functions
    - Sin, Cos, BesselJ, .....
  - List Manipulations
    - First, Last, Join, Append, .....
  - Functional Operations
    - Apply, Map, Thread, .....



SAD/FFS functions:

**Constants:**

Degree GoldenRatio I INF\* Infinity NaN\* E  
SpeedOfLight

**Elementary-functions:**

ArcCos ArcCosh ArcSin ArcSinh ArcTan  
ArcTanh Cos Cosh Exp Log Sin Sinh Sqrt Tan  
Tanh

**Special-functions:**

BesselI BesselJ BesselK Bessely Erf Erfc  
Factorial Gamma LogGamma LogGamma1  
GammaRegularized GammaRegularizedQ\*  
GammaRegularizedP\*

**Numerical-functions:**

Abs Ceiling Floor Max Min Mod Round Sign

**Matrix-operations:**

Det Eigensystem IdentityMatrix Inner  
LinearSolve Outer SingularValues Transpose

**Random-number:**

GaussRandom\* Random\* SeedRandom

**Complex:**

Complex ComplexQ Conjugate Im Re

**Fourier-Transformation:**

Fourier InverseFourier

**Data-Manipulation:**

FindRoot Fit\*

**Minimization:**

DownhillSimplex\*

**List-manipulations:**

Append Complement Delete Depth Dimensions  
Drop Extract Flatten FlattenAt HeldPart Insert  
Intersection Join Length Part Partition Prepend  
Product Range ReplacePart Rest Reverse Select  
Sort Sum Take Table Union

**Character-strings:**

FromCharacterCode CharacterPosition  
StringDrop StringInsert StringLength  
StringPosition Symbol SymbolName ToCharacterCode  
ToLowercase ToUppercase ToExpression

**Functional-Operations:**

Apply Cases Count DeleteCases Identity Fold  
Function Level Map MapAll MapAt MapIndexed  
MapThread Nest Position Scan SelectCases\*  
SwitchCases\* Thread

**Flow-Control:**

Break Catch Check Continue Do For Goto If  
Label Return Switch Throw Which While

**Tests:**

AtomQ ComplexQ MatchQ MatrixQ MemberQ  
NumberQ Order VectorQ

**Input/Output:**

Close Flush\* Get OpenRead OpenWrite  
OpenAppend Print Read Write WriteString

**Scoping:**

Block Module With\*

**Attributes:**

Clear Evaluate Head Hold Protect ReleaseHold  
SetAttributes\* Unevaluated Unprotect

**Graphics:**

ColumnPlot ListPlot Plot Show OpticsPlot  
FitPlot

**System Interface:**

Directory Environment Fork GetEnv\* GetGID\*  
GetPID\* GetUID\* SetDirectory System\*  
TemporaryName\* Wait

**Utility:**

Date DateString Definition FromDate ToDate  
Pause MemoryCheck\* Message Off On Sleep  
TimeUsed Timing TracePrint

Functions listed above work basically in the  
same way as Mathematica's except those marked  
by \*.

**FFS-dedicated-functions:**

BeamMatrix CalculateOptics  
DynamicApertureSurvey Element Emittance FL  
FitValue FitWeight LINE OptimizeOptics  
RadiationField RadiationSpectrum  
SymplecticJ SetElement TrackParticles Twiss  
VariableRange

**Beam-line-functions:**

BeamLine BeamLineName ExtractBeamLine  
PrintBeamLine WriteBeamLine

# SAD for Control system

- Control Algorithm is developed in SAD and test in simulation on SAD.
- It provides natural concept, like Twiss parameter, for an accelerator physicist.
- Accelerator physicist controls an accelerator model using SAD script -> Why not controllers an accelerator using SAD script.

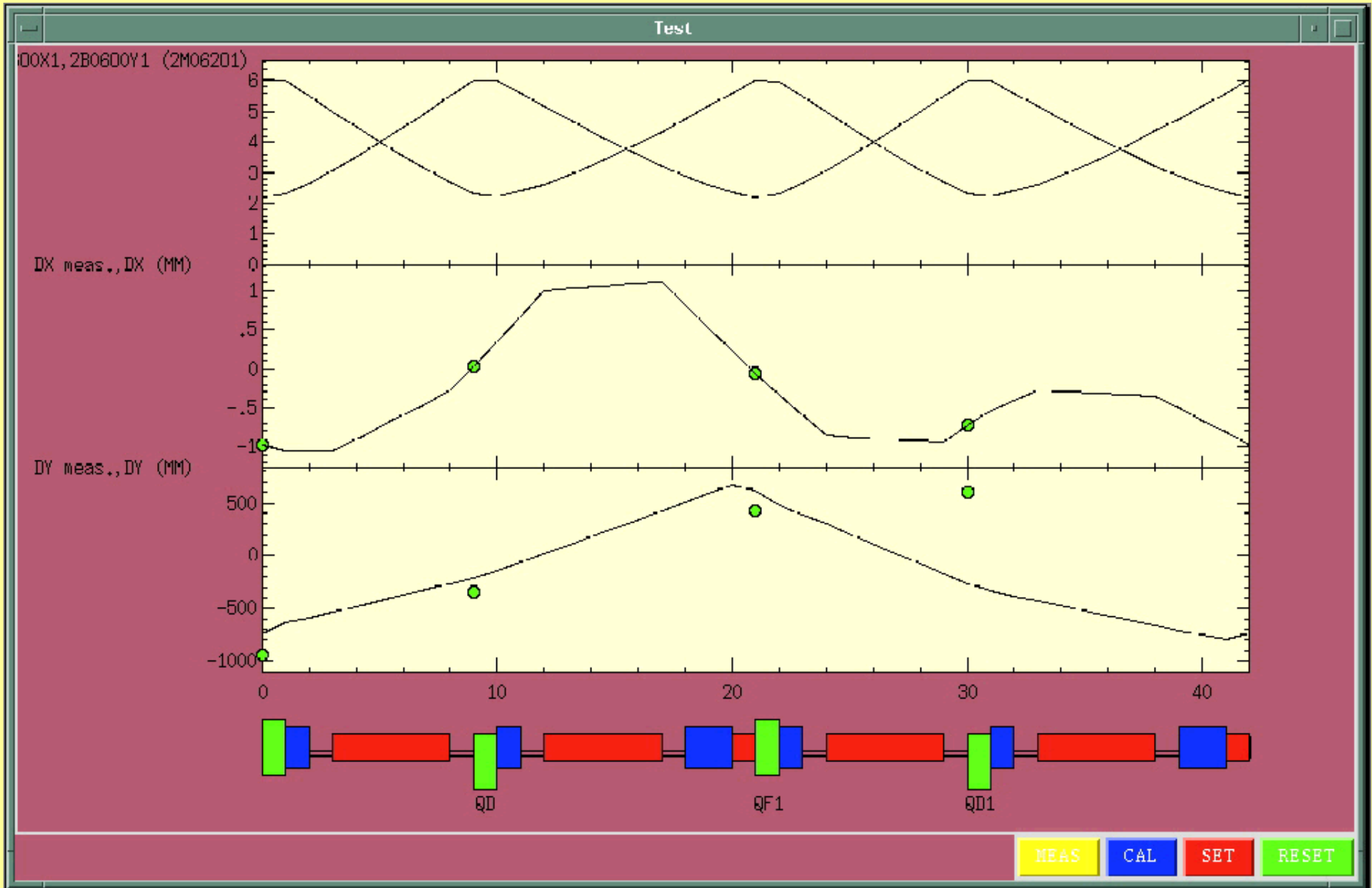
# SAD:Channel Access Interface

- Four Functions for CA.
  - CaOpen[]
  - CaRead[]
  - CaWrite[]
  - CaClose[]
- Argument for these functions are:
  - String (channel name)
  - Number(channel ID returned by CaOpen)
  - A List of these
    - bpms=CaOpen[{"BPM1", "BPM2", ....}]
    - orbit=CaRead[bpms]

## SAD:Python/Tk interface

- Graphical user interface is required for the modern control system
- Tk library provides a simple framework to develop GUI.
- SAD can access Tk widget through Python/Tk library.
  - Text
  - Graph(Canvas, BLT)
  - Slider
  - Button.....
- Python - Oracle interface is being tested.  
-> ORACLE database access from SAD

# A Sample display : SAD/Tkinter.



# SAD

- provides a rich set of functions to control or to analyze an accelerator.
- can interact with the control system through CA.
- can interact with an operator through GUI.