INTRODUCTION TO MDSplus

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DIII-D NATIONAL FUSION FACILITY SAN DIEGO

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CLASS OUTLINE

Class 1: What is MDSplus and why should you care?

1. MDSplus — the philosophy
2. MDSplus at DIII–D
3. Basic concepts
4. MDSplus expressions
5. What you can do with MDSplus
6. Getting started

Class 2: How to use MDSplus

1. Overview
2. Examining tree structure
3. Reading data out of MDSplus
4. Writing data into MDSplus
5. Designing and building trees

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CLASS 2: HOW TO USE MDSplus

- This class presents the nuts and bolts of using MDSplus
- Overview
  - Examining tree (traverser)
  - Opening and closing trees
  - Reading data
  - Using MDSplus in existing tools (ReviewPlus)
  - Writing data to trees
  - Designing and building trees
  - Resources
- Use IDL for MDSplus function calls
  - If you would like C or Fortran information, please e-mail schacht@fusion.gat.com

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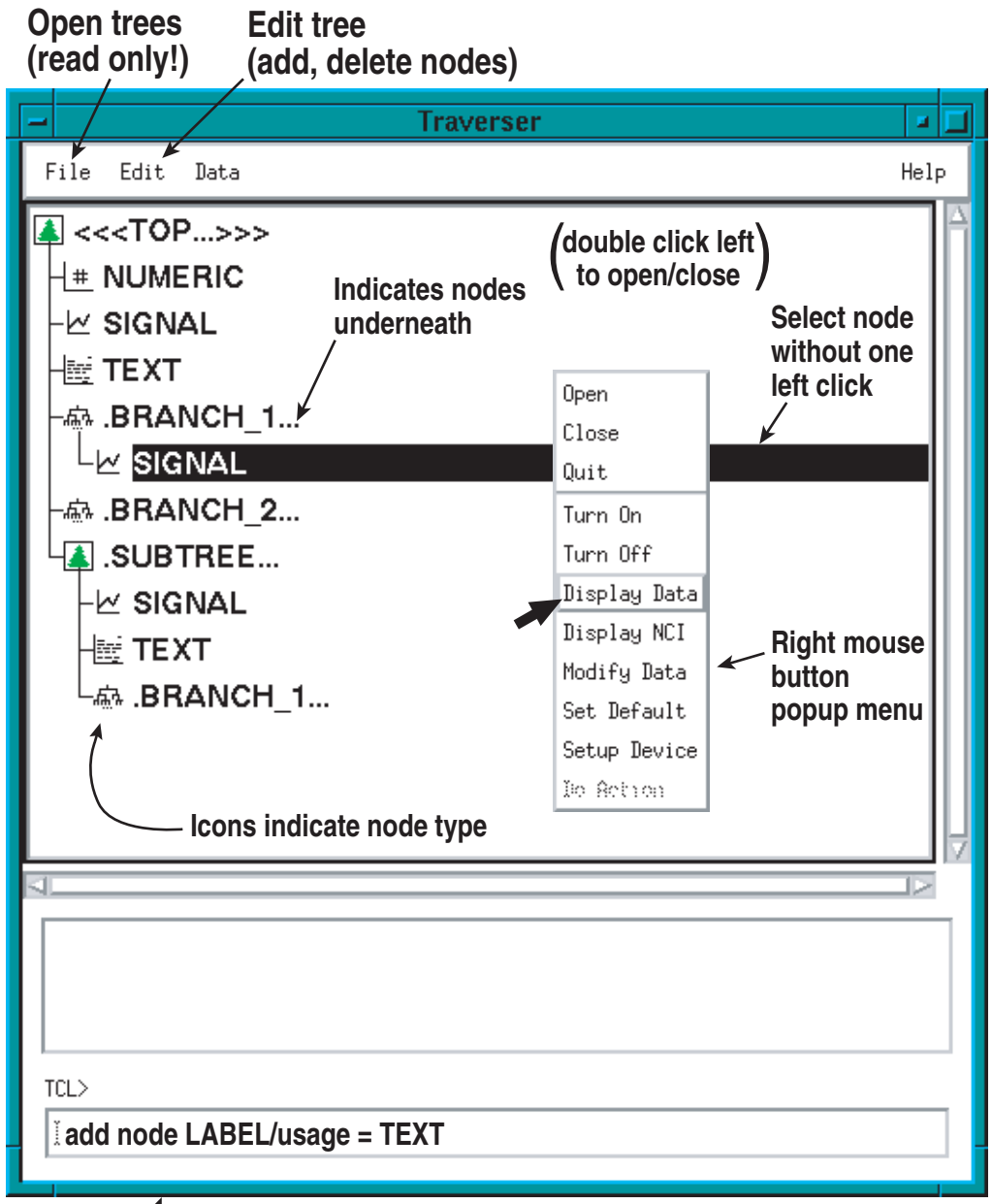
TRAVERSER MDSplus GUI FOR EXAMINING TREES



USING TCL TO EXAMINE TREES

- TCL is "Tree Command Language": used for browsing and editing trees
- Like a file system
  - Current location in tree ("default")
  - Relative versus absolute paths
  - Set default, dir commands
- Decompile: examine contents of node (if not too large!)
- Show db: current tree and shot
- Can do TCL in traverser
- Useful for writing macros and generating large trees
- Demonstration

Start TCL from IDL	mdstcl
Open EFIT01 Model	set tree EFIT01/shot=–1/readonly
Directory of tree	dir
Change default	set def .RESULTS.AEQDSK
Examine node contents	decompile WMHD

OPENING AND CLOSING TREES

- Tree must be opened before data within can be accessed
- Opening a tree opens all its subtrees unless you say otherwise
  - Can open subtree directly
- Demonstration

  mdsopen, 'EFIT01',97979
- Trees do not need to be closed
  - Most recently opened tree is current context
  - Reopening an already open tree saves overhead
  - Maximum of eight trees open at once, 9th open automatically closes tree on bottom of stack

ASIDE: MDSplus STATUS CODES

- All MDSplus routines in IDL have optional STATUS=status keyword
- If status is odd, success. If status is even, failure
- Use in IDL:

```
mdsopen, tree, shot, /quiet, status=status
if (status) then begin
      [ . . . retrieve data . . . ]
endif else begin
      print, 'Error opening'+tree+strtrim(shot,2)+mdsgetmsg(status)
endelse
```

- /quiet keyword suppresses messages
- mdsgetmsg() function returns string explaining error message corresponding to status code

(3) READING DATA

- **Three steps**
  - Locate node of interest (tree, path, and shot)
  - Open tree
  - mdsvalue(path)

- **Example: Core Thomson Scattering T_e profile**

Open electrons tree, shot 97979

```
mdsopen, 'ELECTRONS', 97979
```

Ask for tag \TSTE_CORE

```
data = mdsvalue('\TSTE_CORE',/quiet,status=status)
```

Check status

```
print,status+' = '+mdsgetmsg(status)
```

NODE REFERENCE

- Node references can be
  - Absolute

    data = mdsvalue('\ELECTRONS::TOP.TS.BLESSED.CORE:TEMP')
  - Relative

    mdssetdefault,'\ELECTRONS::TOP.TS.BLESSED.CORE'

    data = mdsvalue('TEMP')
  - Tag

    data = mdsvalue('\TSTE_CORE')

- Recommend that you avoid relative node references for now
  - Absolute or tag references are easier to understand when examining code
  - No ambiguity or potential for mistakes

    mdssetdefault,'\ELECTRONS::TOP.TS.BLESSED.CORE'

    te = mdsvalue('TEMP')

    mdssetdefault,'-.DIVERTOR'

    t = mdsvalue('DIM_OF(TEMP)')

    → Gets T_e from core system, but timebase from divertor system

PASSING PARAMETERS TO MDSVALUE

- mdsvalue() function (and mdsput procedure) accept parameter arguments
- Primary argument to mdsvalue() is a string expression
- Use “$” within the string to represent a parameter passed in from IDL
- data = mdsvalue(‘SOME_FUNCTION($,$)’,arg1,arg2)
- Simple example:

```
arg1 = 2. * !PI * FINDGEN(101)/100
data = mdsvalue(‘SIN($)’,arg1)
```

- Will come up later in use of GETNCI() and especially mdsput

CACHING AND TDI VARIABLES

- Every time you retrieve a node reference, the tree is read
  - Can be painful if large amount of data
  - O/S does some caching
- Can use TDI variable to "cache" the data in memory
- Example:

No caching	Caching: use TDI variable
te = mdsvalue('\TSTE_CORE')	te = mdsvalue(' _s = \TSTE_CORE ')
t = mdsvalue('DIM_OF(\TSTE_CORE,0)')	t = mdsvalue('DIM_OF(_s,0)')
z = mdsvalue('DIM_OF(\TSTE_CORE,1)')	z = mdsvalue('DIM_OF(_s,1)')
u = mdsvalue('UNITS(\TSTE_CORE)')	u = mdsvalue('UNITS(_s)')
Four separate reads of node	_s is a TDI variable, now equal to the signal \TSTE_CORE

- All TDI variables start with underscore character "_"
  - Distinguish them from node references

USING TDI

- **Math operations**

  data = mdsvalue(' \TSTE_CORE / 1000. ')

- **Can have expressions containing multiple signals**
  - Example: |I/aB| from EFIT

    mdsopen, 'EFIT01',97979

    data = mdsvalue(' _s = ABS(\IPMEAS / \AMINOR / \BT0 / 1.e6)')

- **Be careful that signals are all the same shape**
  - In example, the EFIT signals all have the same timebase
  - MDSplus will not prevent you from doing the wrong thing

- **Signal format is lost: no more dimensions**

  print,mdsvalue('DECOMPILE('_s)')

  Build_With_Units([. . .],"A/m/T")

- **But units information retained**

  print,mdsvalue('UNITS(_s)')

  A/m/T

USING GETNCI

- **Arguments to GETNCI: GETNCI (node_reference, item_requested, [usage])**
- **node_reference**
  - Some node or set of nodes in a tree
  - Use "\\" if absolute path or tag ("\\TSTE_CORE", "\\TOP:NAMELIST")
  - Wildcards:

    * = all nodes at this level

    *** = all nodes at this level and below

    Example: all nodes one level down \TOP.RESULTS.AEQDSK in EFIT tree

    "\\EFIT01::TOP.RESULTS.AEQDSK:*"

    Example: All RESULTS nodes in EFIT tree

    "\\EFIT01::TOP.RESULTS***"
  - If using wildcards, return value must be same shape for each node
- **item_requested**
  - Full name, tag name (minimum path), length, relatives, data
  - Many different possibilities: see TDI help, GETNCI function
- **usage**
  - If specified, limit wildcard search to nodes of specified type
  - Signal, text, numeric, etc.

USING GETNCI — AN EXAMPLE

- Get names and labels of EFIT signals

- Get node ID numbers (NID) for further reference:

  nids = mdsvalue('GETNCI("\\EFIT01::TOP.RESULTS.*:*:LABEL","NID_NUMBER")')

- Get labels from each node

  labels = mdsvalue('GETNCI($,"RECORD")',nids)

- Get signal names

  signals = mdsvalue('GETNCI(GETNCI($,"PARENT),"MINPATH")',nids)

  - ➔ Inner GETNCI() gets parent NID numbers
  - ➔ Outer GETNCI() gets minimum path (tag) for each parent NID

GETTING PTDATA FROM MDSplus

- TDI function PTDATA() is interface between MDSplus and PTDATA
- PTDATA() returns signal containing data, timebase, and units
- Example: IP for shot 96021
  - data = mdsvalue('_s = PTDATA($,$)', "IP", 96021)
  - time = mdsvalue('DIM_OF(_s)')
  - units = mdsvalue('UNITS(_s)')
    - ➔ Note parameter passing and caching
- Can also get PTDATA headers
  - PTHEAD_IFIX(pointname,shot)
  - PTHEAD_RFIX(pointname,shot)
  - PTHEAD_ASCII(pointname,shot)
  - PTHEAD_INT16(pointname,shot)
  - PTHEAD_INT32(pointname,shot)
  - PTHEAD_REAL32(pointname,shot)
- Interpreting the headers is up to you!
  - See the DFI web pages http://lithos.ga.com/dfi/

(4) USING MDSplus IN EXISTING TOOLS

- MDSplus is already integrated into GA codes
  - ReviewPlus
  - EFITtools
  - GAprofiles
  - READA/G
  - IDL “get” routines
  - etc.

- Plotting pointnames in ReviewPlus and REVIEW
  - “pointname” — string designating signal of interest
  - MDSplus searched to determine tree and signal
  - If not MDSplus, then pseudopointname or PTDATA
    - ➔ ReviewPlus uses IDL to evaluate data combinations

- Can also use TDI directly in ReviewPlus
  - Specify tree name in addition to TDI expression
  - TDI expression evaluator used

(5) WRITING DATA TO TREES

- Practice on “scratch” trees first!
- Basic command: mdsput, node_reference, expression [. . . arguments]
- Example:
  - Open scratch tree

    mdsopen,’TEST’,10
  - Put signal into \TOP:SIGNAL

    expression = ‘BUILD_SIGNAL(BUILD_WITH_UNITS($,$),*,BUILD_WITH_UNTS($,$))’

    mdsput,’\TOP:SIGNAL’,expression,findgen(100)^2, ‘gizmos’,findgen(100), ‘ms’

    ➔ Note use of parameters (“$”) in expression: pass in IDL variables

MORE ON WRITING DATA

- MDSplus automatically logs username of person writing and data entered
  - See manually with TCL: dir/full
  - Retrieve with GETNCI (“OWNER_ID” and “TIME_INSERTED”)

- MDSplus does not keep track of previous contents of node
  - ➔ Be careful not to erase data

- No built-in mechanism for tracking revisions to data
  - Thomson scattering stores different revisions
  - But not a generic situation — solved specifically for them
  - Can use elements of their solution for other codes if needed

(6) DESIGNING AND BUILDING TREES

- Get your own data into MDSplus!
- 5 steps:
  - Identify information and data
  - Draw tree structure — how to organize? signal names?
  - Identify dependencies in data
  - Construct tree (using TCL)
  - Write procedure to load it
- Can be iterative process
- Use scratch tree to start
- Once finalized, will become part of D3D tree

CONSIDERATIONS WHEN WRITING DATA

- **Units! Units! Units**
  - Not mandatory, but very helpful
- **Take advantage of indirect referencing for timebases, etc.**
  - Saves space
  - Clearer organization
- **Calibration factors and raw data**
  - Use TDI expressions to allow changing factors without rewriting data
- **Cascading changes**
  - Changing one node affects others
  - Example: “blessed” Thomson revision: \ELECTRONS::TOP.TS:BLESSED_ID
- **Tradeoffs: performance, storage, clarity**
  - In the end — its up to you!

SIGNAL NAMES

- "Pointname" retrieval from MDSplus
  - User does not need to know tree
  - Instead MDSplus function searches all trees for tag
  - Signal tags must therefore be unique across entire DIII–D tree
  - MDSplus only requires unique tags within subtree

- Length limits
  - REVIEW: 10 characters
  - MDSplus node name: 12 characters
  - MDSplus tag: 23 characters

- To be backwards compatible, can only use 10 characters in tag

TCL FOR BUILDING TREES

- **ADD NODE node_reference [/USAGE=usage]**
  - node_reference
    - ★ Can be absolute or relative
    - ★ Use ".NODE" for STRUCTURE nodes
  - usage
    - ★ If node is not STRUCTURE, must specify
    - ★ SIGNAL, NUMERIC, TEXT are most common

- **DELETE NODE node_reference**
  - All nodes under node_reference also deleted
  - Will ask for confirmation

- **ADD TAG node_reference tag_name**
  - tag_name: do not need "\" character

- **WRITE**
  - Save your changes!

TCL TIPS AND TRICKS

- Use macros if adding same group of nodes repeatedly with changes
  - Macro is set of TCL commands grouped together
  - Ask Jeff if interested
- Can write TCL script files
  - Invoke with "@" sign
  - Can pass parameters (VMS syntax)
- Can send TCL commands from IDL
  - Uses mdstcl procedure: mdstcl,tcl_command_string
  - Very handy for writing programs to build trees

OTHER TCL CONSIDERATIONS

- **SET NODE command: determine automatic compression and read/write settings**
  - General form: SET NODE node_reference /qualifiers
  - Qualifiers:

/COMPRESS_ON_PUT	: compress data when written
/WRITE_ONCE	: cannot rewrite data
/MODEL_WRITE	: can write only into MODEL (shot –1) (or /NOMODEL_WRITE)
/SHOT_WRITE	: can write only into pulse tree (or /NOSHOT_WRITE)

- **Trees can be manually compressed and cleaned**
  - Compression: reduce space occupied by data
  - Cleaning: remove old data from files

SECURITY AND ACCESS CONTROL

- Right now, all users have all access to all trees
  - BE CAREFUL!
- Will soon move to system where write access is restricted
  - Will be done by group membership
  - Example: all spectroscopists will have write access to SPECTROSCOPY tree
- Access is granted at the subtree level
  - Cannot control access to parts of the tree
- Offsite access will start as read only
  - Can grant write access to specific users from specific sites

(7) RESOURCES

- DIII–D Data Analysis Group website: http://fusion.gat.com/comp/analysis
  - MDSplus at DIII–D
  - Analysis code documentation
  - Signals documentation
  - Links to MIT site, online MDSplus help
- E-mail list? Newsgroup?
  - Wait to see demand
- Ask Jeff
  - X4168, 13/413
  - Always happy to answer questions

SUMMARY

- MDSplus is ready for use!
- Little added effort will return many more benefits
  - Direct access to data
  - Know exactly what you get
  - Retrieve more than just the numbers
- Get your data into MDSplus
  - Once in, everyone can see it
  - More efficient for everyone if you do the design work
  - Jeff will help and work on the “big” sets