TRANSP run using EFIT equilibrium

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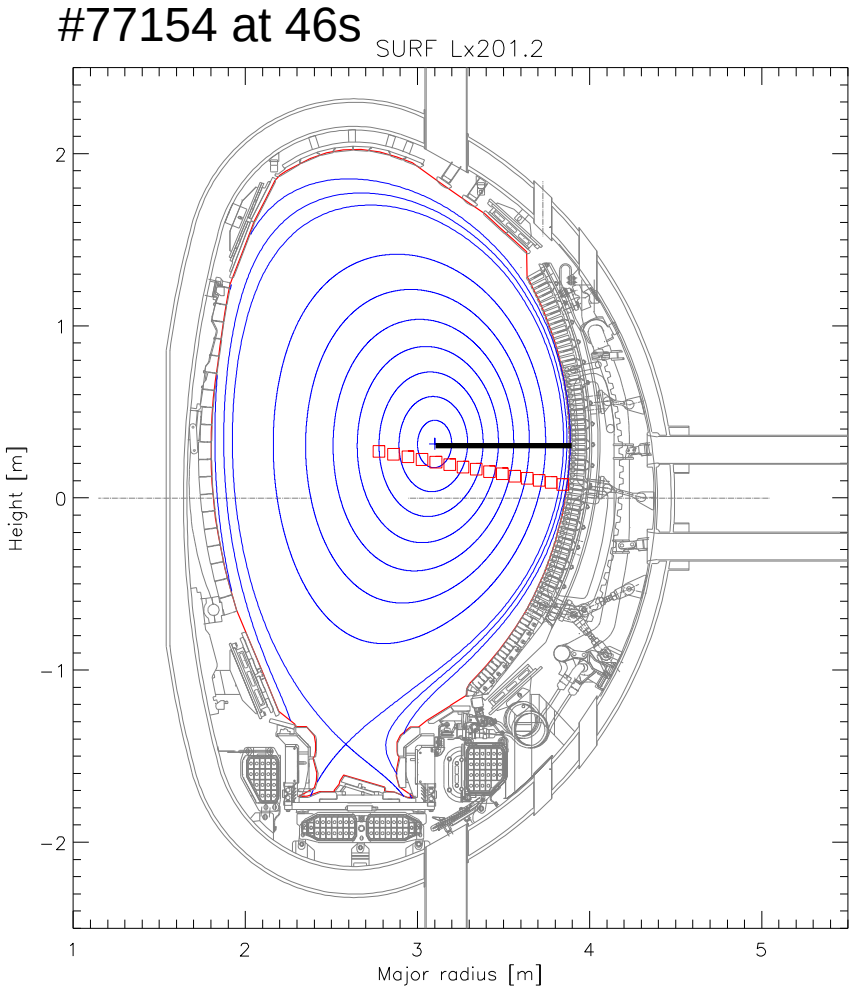
The views and opinions expressed herein do not necessarily reflect those of the European Commission.

content

1. Motivation
2. MHD equilibrium and Poloidal Field Diffusion Equation (PDE) in TRANSP
3. Comparison of TRANSP results using EFIT equilibrium
4. How to run TRANSP using EFIT

Line of sight of CXRS measurement

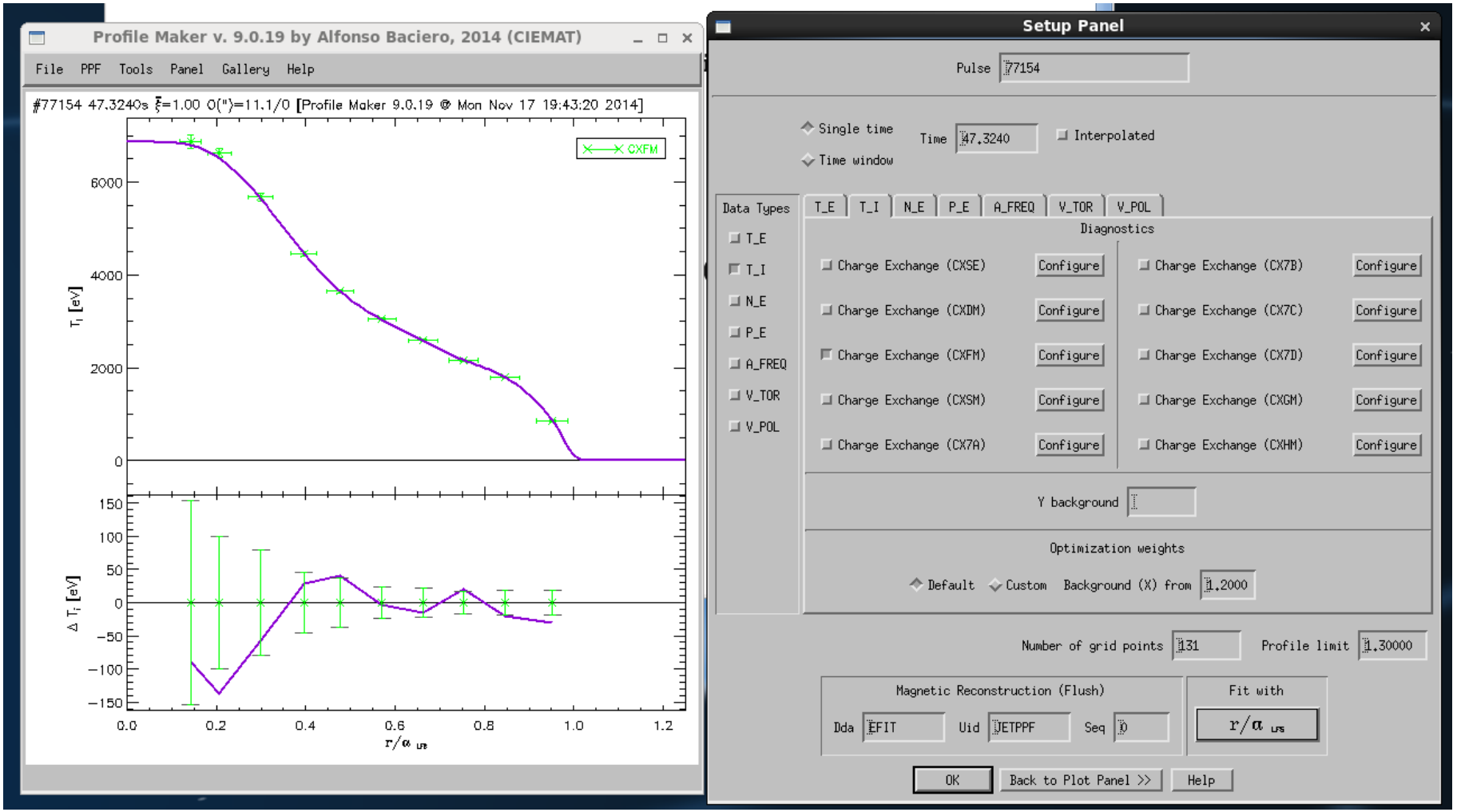


The Input data for TRANSP run must be the profile on the mid-plane i.e. from magnetic axis to boundary surface at low field side.

However, CX data is measured along the line of sight, which is deviated from the mid-plane.

This requires mapping process of the measured data.

Input data is mapped with EFIT



However, TRANSP internal equilibrium can be different with EFIT.

MHD Equilibrium

Numerical solution to Grad-Shafranov equation :-

$$-\mu_0 R^2 \frac{dp}{d\psi} - \mu_0 F \frac{dF}{d\psi} = \Delta^* \psi(R,z) \equiv R^2 \nabla \cdot \left(\frac{\nabla \psi(R,z)}{R^2} \right) \longrightarrow$$

to find Ψ in real space R and z coordinate.

where

Ψ= Poloidal Flux Function

$F = RB_T \times$ Poloidal current outside constant ψ surface

$p =$ plasma pressure

R = Major Radius

$B_T =$ toroidal angle

RB_T is measured, and p come from measurements and modelling

Boundary of plasma is obtained from EFIT.

Poloidal field Diffusion Equation (PDE)

$$-\frac{\partial \vec{B}(\sqrt{\Phi_N},t)}{\partial t} = \frac{1}{\mu_0}\nabla\times(\eta\nabla\times\vec{B}(\sqrt{\Phi_N},t))$$

where

η = plasma resistivity

$\sqrt{\Phi_N}$ is sqrt of normalized toroidal flux

Method 1. q is calculated by solving PDE.

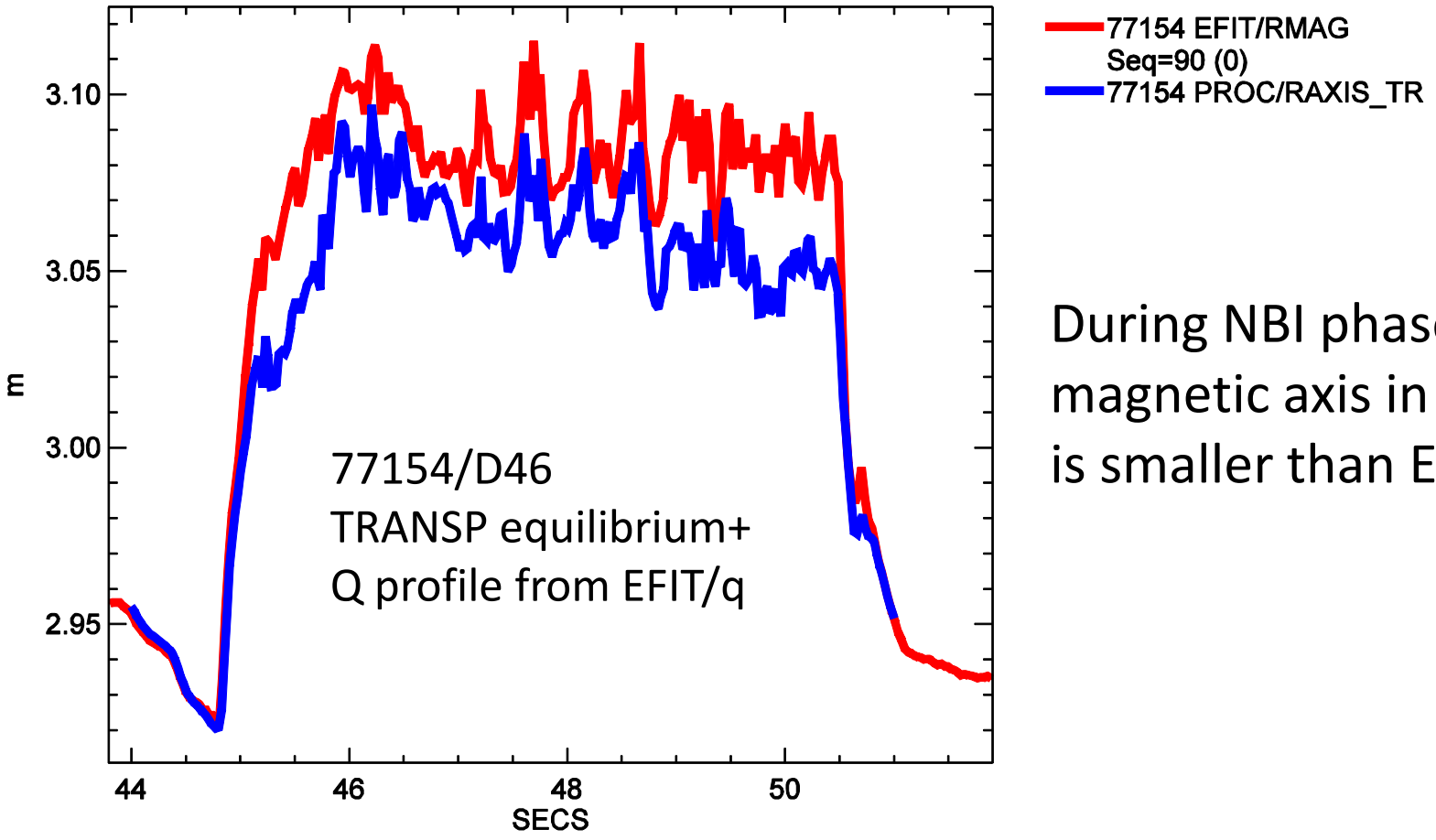
$$\eta = \eta_{spitzer}(T_e, Z_{eff}) \rightarrow \vec{B}(\sqrt{\Phi_N},t) \rightarrow \Psi(\sqrt{\Phi_N},t) \rightarrow \frac{d\Phi}{d\Psi} = q(\sqrt{\Phi_N},t)$$

Method 2. q is prescribed from EFIT/q .

$$q(\Psi,t) = \frac{d\Phi}{d\Psi} \rightarrow \Psi(\sqrt{\Phi_N},t) \rightarrow \vec{B}(\sqrt{\Phi_N},t) \rightarrow \eta$$

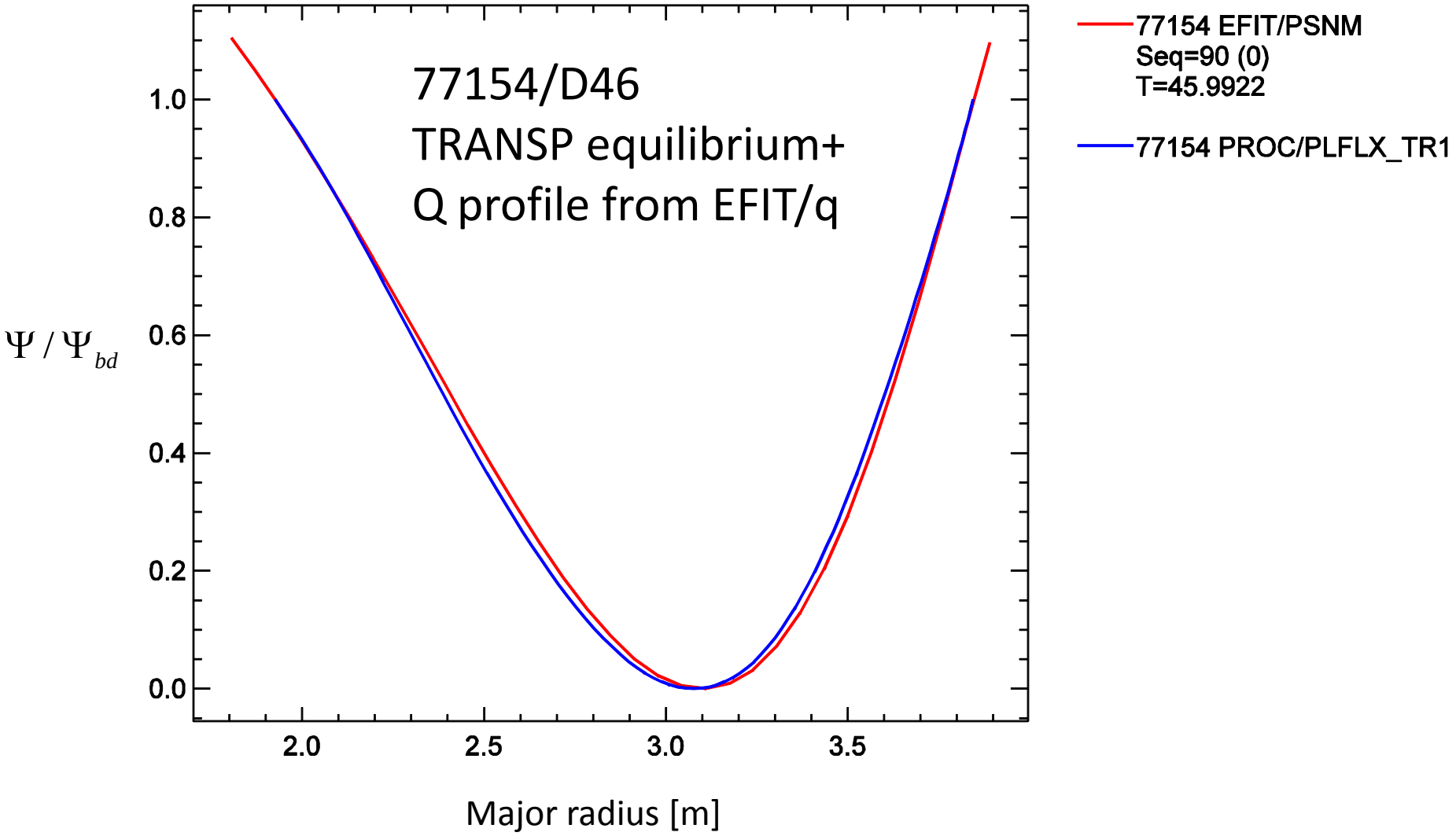
J. Ongena, et al/ Fusion Science and Technology / Volume 45 / Number 2T / March 2004 / Pages 371-379

Magnetic axis: EFIT and TRANSP

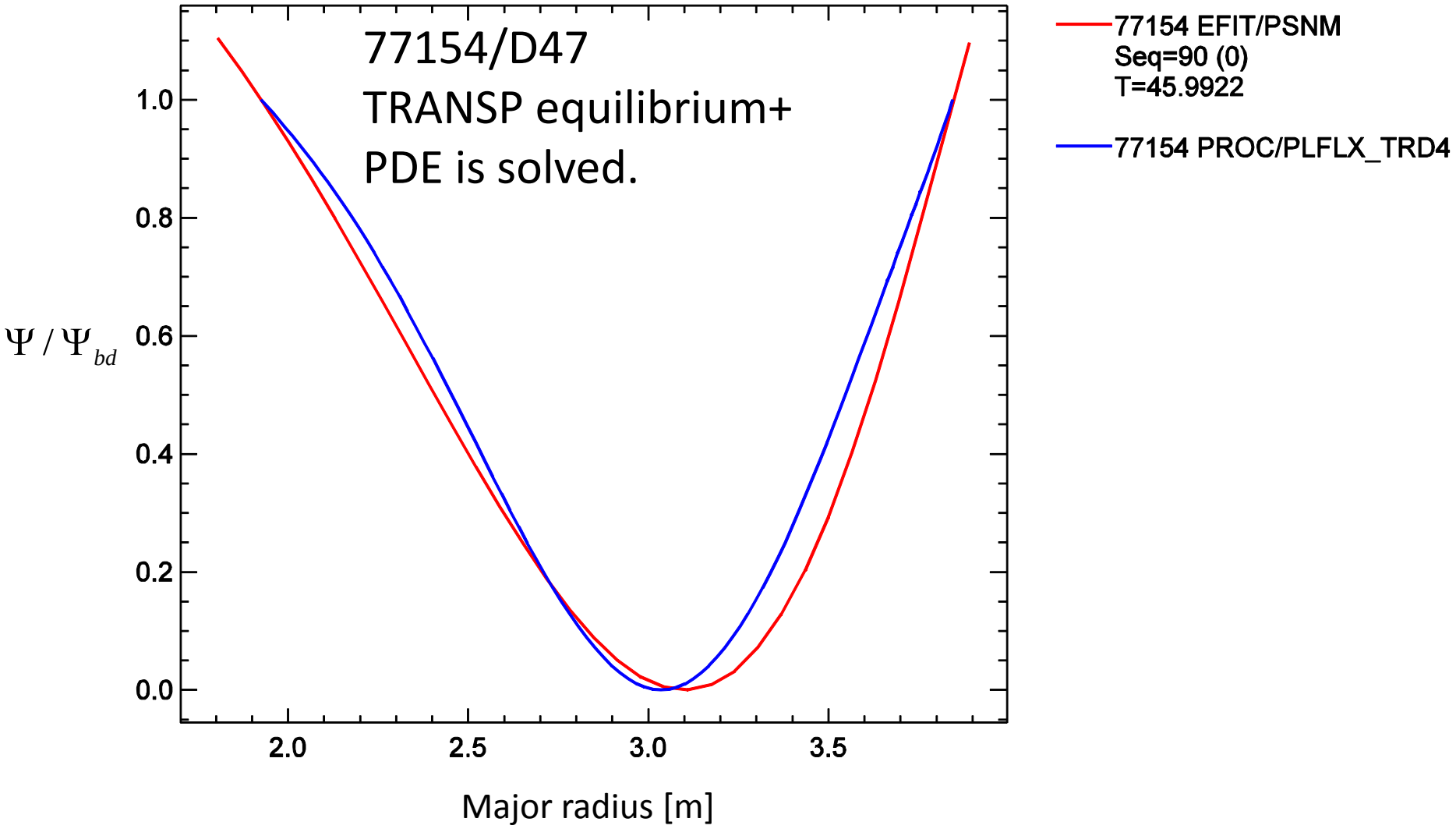


During NBI phase, magnetic axis in TRANSP is smaller than EFIT.

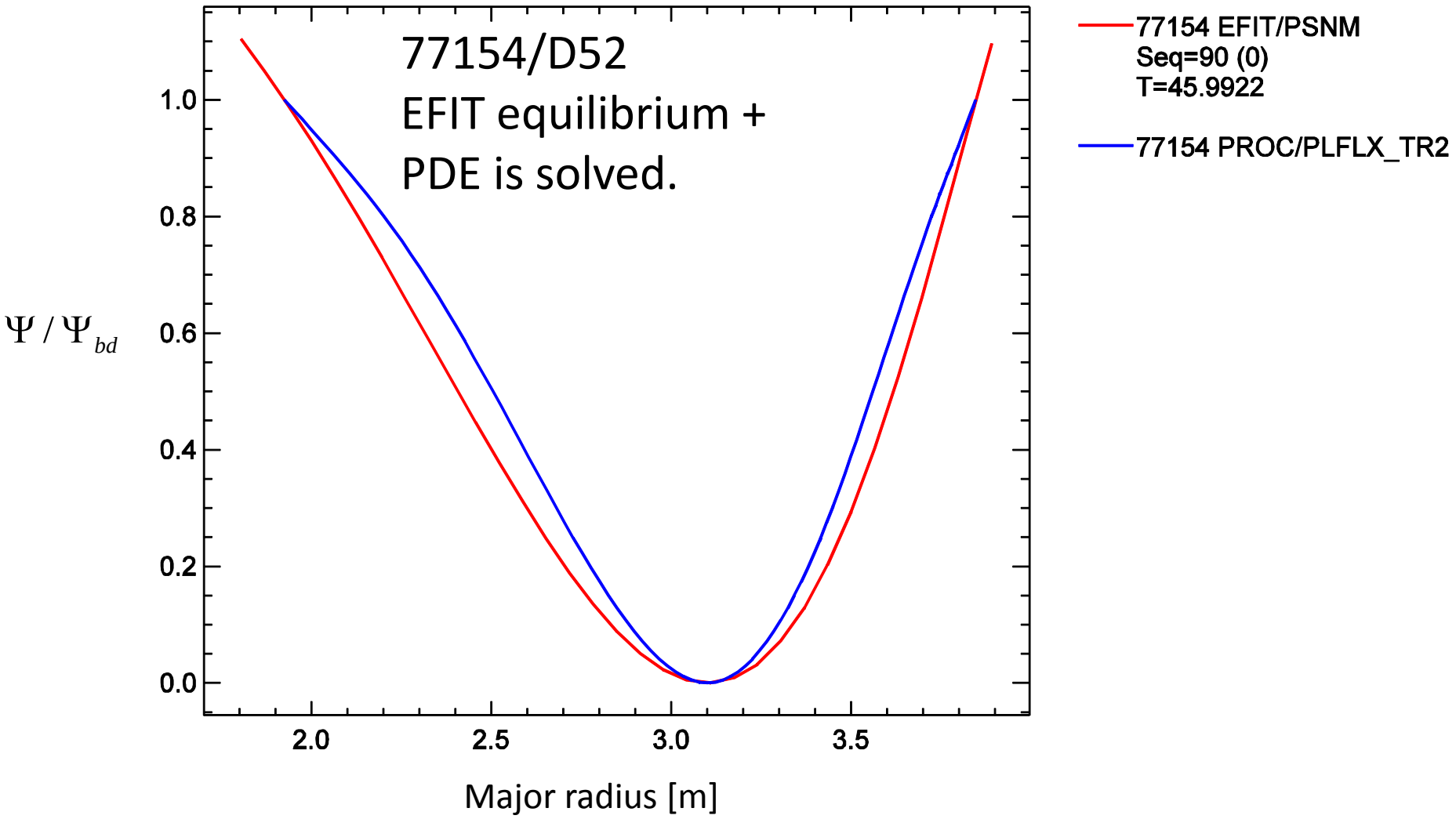
Normalized psi: EFIT and TRANSP



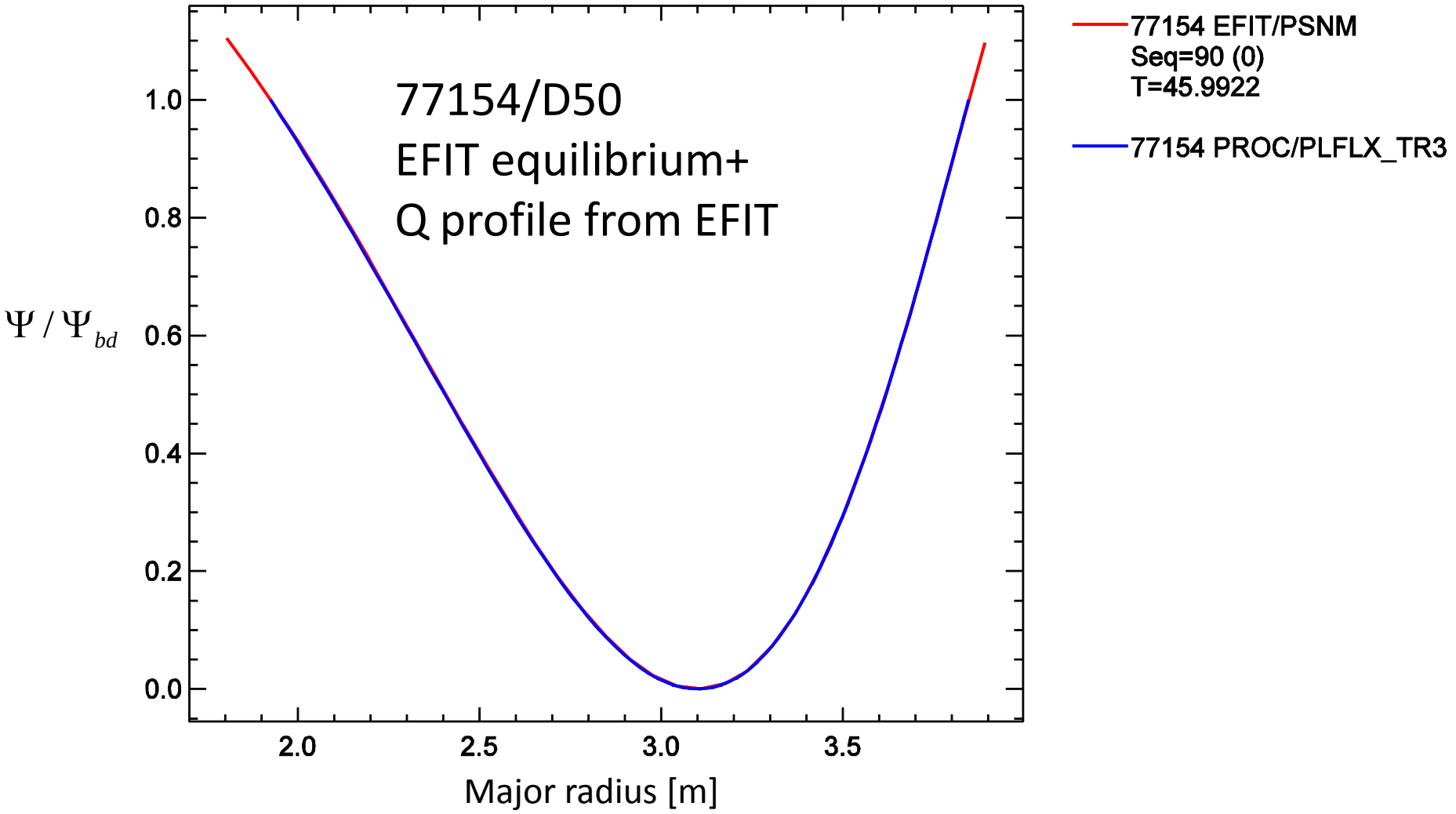
Normalized psi: EFIT and TRANSP



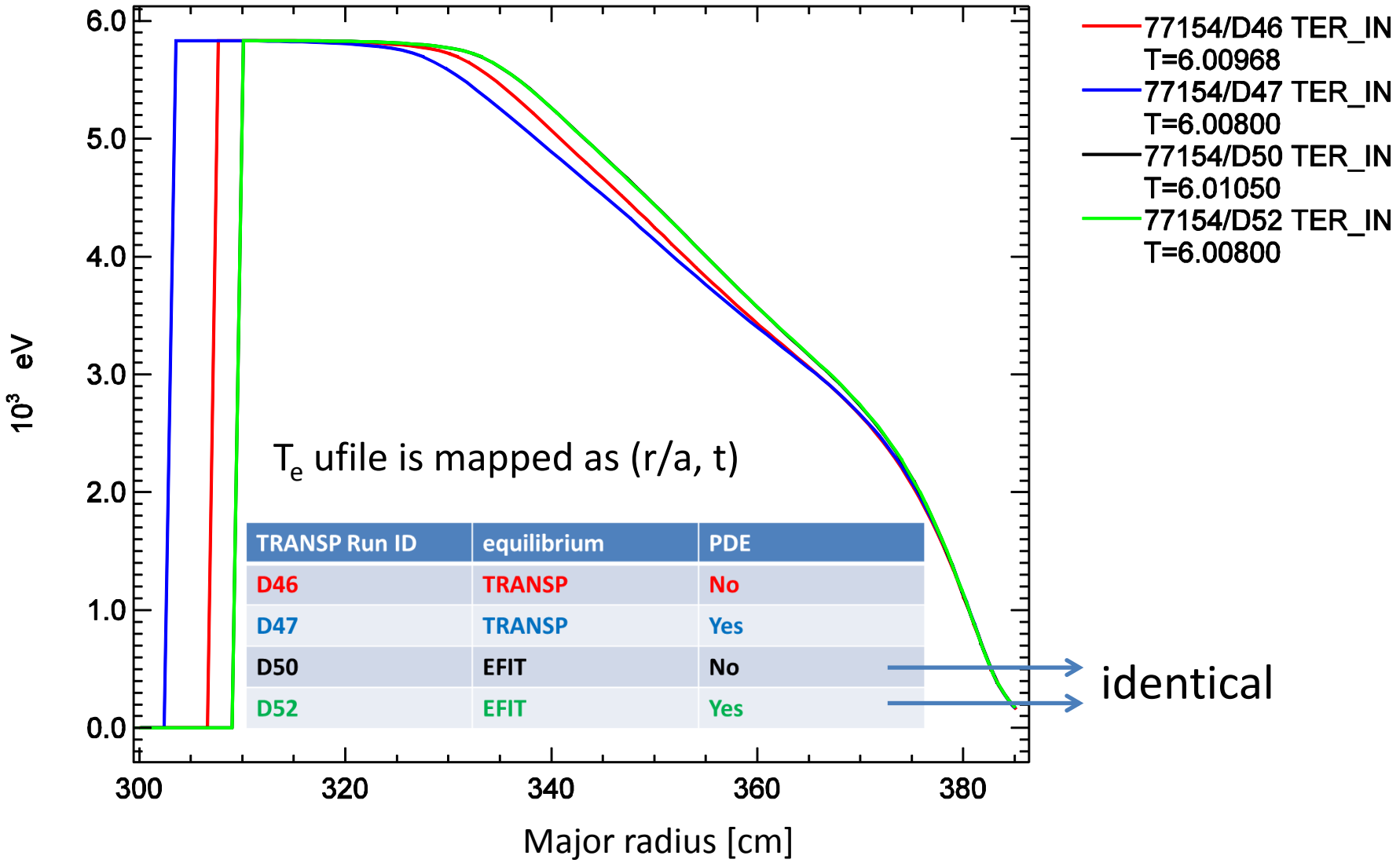
Normalized psi: EFIT and TRANSP



Normalized psi: EFIT and TRANSP

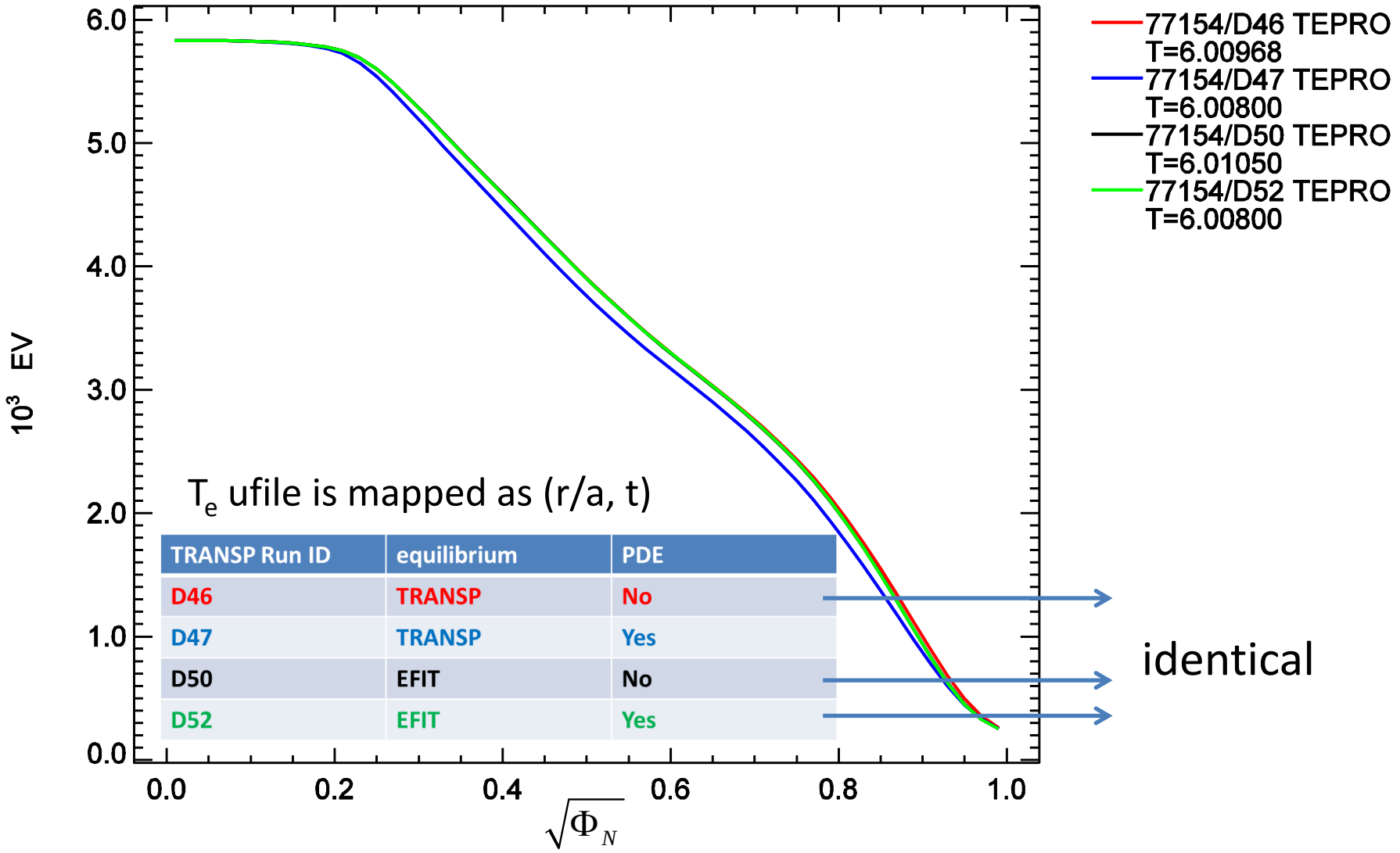


TER_IN: TER data as input



TRANSP Run ID	equilibrium	PDE
D46	TRANSP	No
D47	TRANSP	Yes
D50	EFIT	No
D52	EFIT	Yes

TEPRO: INPUT Te PROFILE



T_e ufile is mapped as (r/a, t)

TRANSP Run ID	equilibrium	PDE
D46	TRANSP	No
D47	TRANSP	Yes
D50	EFIT	No
D52	EFIT	Yes

How to run TRANSP using EFIT equilibrium

1. Open TRANSP window and set $SDD for a new run

2. Create gfiles folder in $SDD

(e.g. $SDD/gfiles= /common/transp_shared/Data/data/JETdirs/77154/gfiles)

3. Copy and paste g eqdisk files and index.dat into the gfiles folder

(e.g. /home/jec2020/runs/transp_test/77154/efit.0/gfiles/index.dat → $SDD/index.dat)

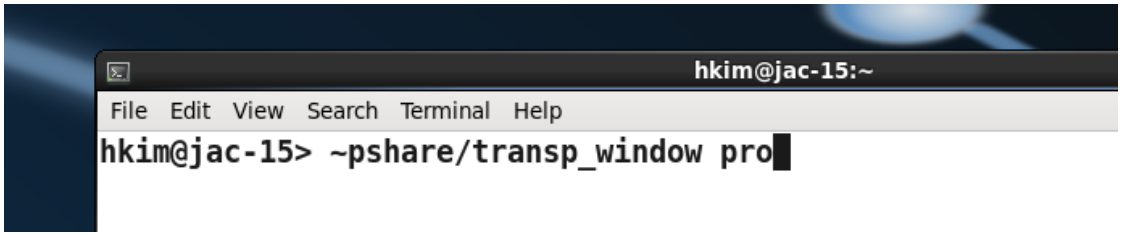
4. Reduce the timeslices in index.dat, and save it as index.dat_2

5. Run Scrunch2 using the index.dat_2 in $SDD/gfiles, produce MMX ufile (e.g. $SDD/gfiles/EQD77154.MMX), and copy it into $SDD (e.g. $SDD/EQD77154.MMX_0000)

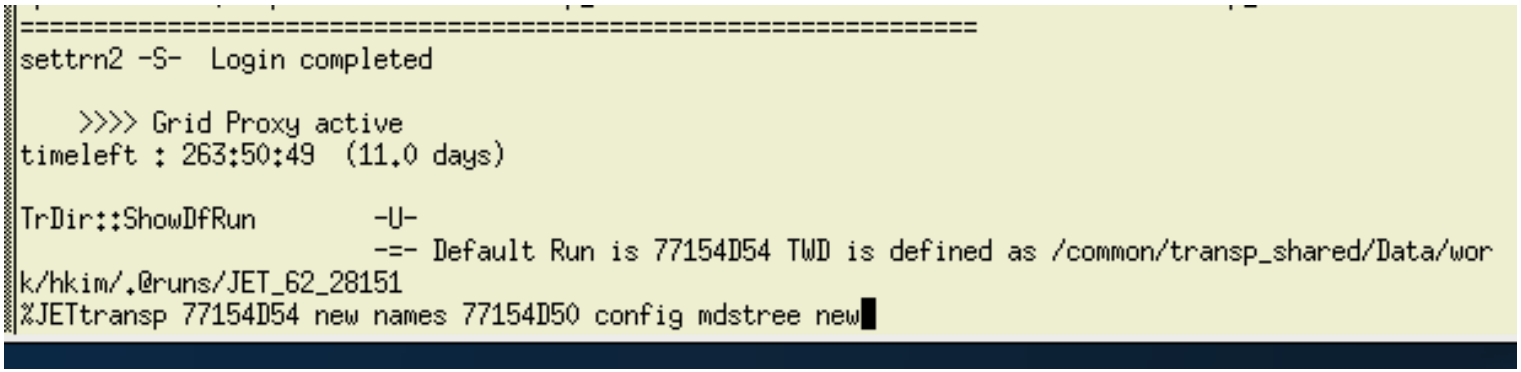
6. Run TRANSP and modify the namelist file (e.g. 77154D46TR.DAT) during the step config

1. Open TRANSP window and set $SDD for a new run

- Open TRANSP window



- Set $SDD (Standard data directory) for a new run e.g. 77154



2. Create gfiles folder in $SDD

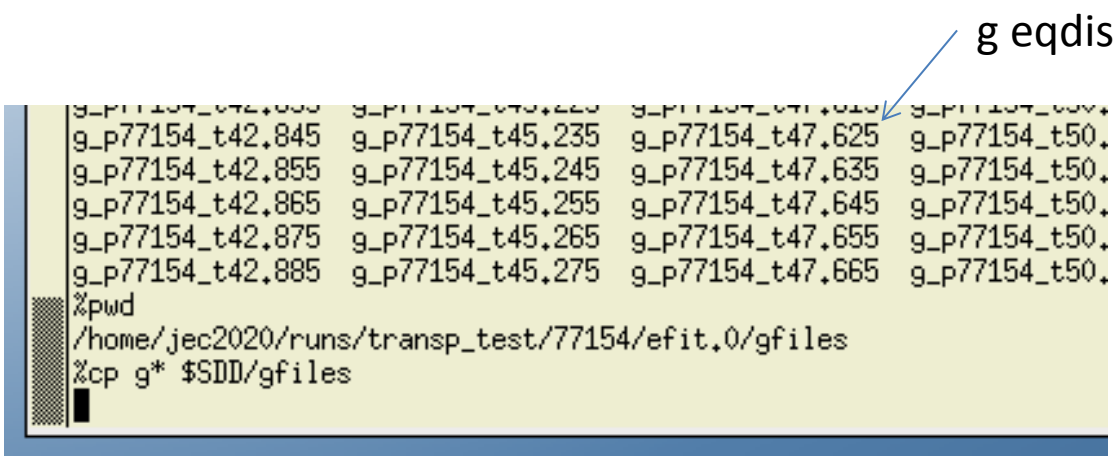
- %cd $SDD
- %mkdir gfiles

```
%pwd
/common/transp_shared/Data/data/JETdirs/77154
%ls
77154                EDG77154.FLW_0081   #err#~              HRTS77154.NE_0177   HRTS77154.TE_0183   MAGN77154.FLX_0003~  MG277154.XLM_0062~  PNBI77154.NBL_0175  TIN77154.RNT_0189~
77154~               EDG77154.FLW_0081~  ~filfix.pro         HRTS77154.NE_0183   HRTS77154.TE_0186   MAGN77154.ITOR_0003  MG377154.VPA_0062   _scruncher_         TrFile.PtoU
BOLO77154.TOBU_0051  EFIT77154.Q_0090    GASM77154.MAJR_0129 HRTS77154.NE_0186   HRTS77154.TE_0203   MAGN77154.ITOR_0003~ MG377154.VPA_0062~  _scruncher_~        TrFile.PtoU~
BOLO77154.TOBU_0051~ EFIT77154.Q_0177    GASM77154.MAJR_0129~ HRTS77154.NE_0203   KS377154.ZEFV_0165  MG277154.BET_0062    MSCR77154.MRY_0170  scruncher_170.log
CXFM77154.AFCR_0205  EFIT77154.Q_0186    GASM77154.MAJR_0186 HRTS77154.TE_0157   KS377154.ZEFV_0179  MG277154.BET_0062~   MSCR77154.MRY_0170~ scruncher.log
CXFM77154.TICR_0205~ EFTM77154.Q_0206    gfiles              HRTS77154.TE_0157~  KS377154.ZEFV_0195  MG277154.XIP_0062    out                 TIN77154.RNT_0163
CXFM77154.TICR_0242  EFTM77154.Q_0238    HRTS77154.NE_0157   HRTS77154.TE_0157~~ KS377154.ZEFV_0195~ MG277154.XIP_0062~   PNBI77154.NBI_0169  TIN77154.RNT_0176
CXFM77154.ZFCX_0205  #err#               HRTS77154.NE_0157~  HRTS77154.TE_0177   MAGN77154.FLX_0003  MG277154.XLM_0062    PNBI77154.NBI_0169~ TIN77154.RNT_0189
%
```

Create gfiles folder in $SDD

3. Copy and paste g eqdisk files and index.dat into the gfiles folder

- %cd /home/jec2020/runs/transp_test/77154/efit.0/gfiles
- %cp g* $SDD/gfiles
- %cp index.dat $SDD/gfiles.



4. Reduce the timeslices in index.dat

- %nedit index.dat

# of timeslices. 2627 is too many!

index.dat - /common/transp_shared/Data/data/JETdirs/77154/gfiles/

File Edit Search Preferences Shell Macro Windows

```
ntimes=2627
path="/home/jec2020/runs/transp_test/77154/efit.0/gfiles"
time=40.505    filename=g_p77154_t40.505
time=40.515    filename=g_p77154_t40.515
time=40.525    filename=g_p77154_t40.525
time=40.535    filename=g_p77154_t40.535
time=40.545    filename=g_p77154_t40.545
time=40.555    filename=g_p77154_t40.555
time=40.565    filename=g_p77154_t40.565
time=40.575    filename=g_p77154_t40.575
time=40.585    filename=g_p77154_t40.585
time=40.595    filename=g_p77154_t40.595
time=40.605    filename=g_p77154_t40.605
time=40.615    filename=g_p77154_t40.615
time=40.625    filename=g_p77154_t40.625
time=40.635    filename=g_p77154_t40.635
time=40.645    filename=g_p77154_t40.645
time=40.655    filename=g_p77154_t40.655
time=40.665    filename=g_p77154_t40.665
time=40.675    filename=g_p77154_t40.675
time=40.685    filename=g_p77154_t40.685
time=40.695    filename=g_p77154_t40.695
time=40.705    filename=g_p77154_t40.705
time=40.715    filename=g_p77154_t40.715
```

4. Reduce the timeslices in index.dat

- Reduce the number of timeslices. (errors can occur with too many time slices.)
- 10~ 20 time slices per second is recommeded as other input data.

index.dat_2 - /common/transp_shared/Data/data/JETdirs/77154/gfiles/

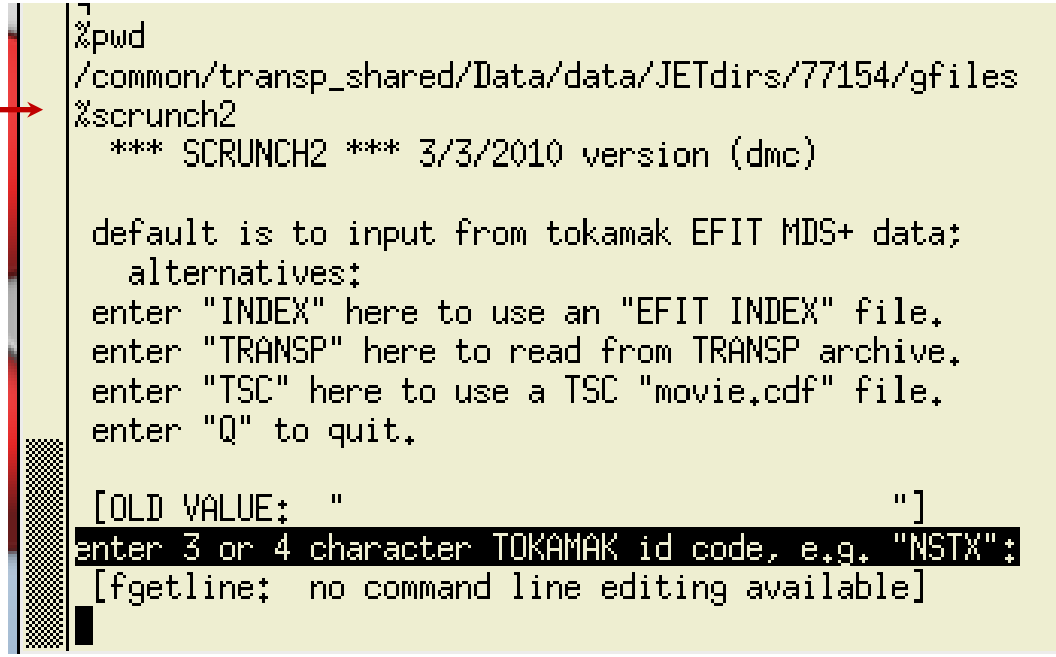
File Edit Search Preferences Shell Macro Windows

```
ntimes=73
path="/home/jec2020/runs/transp_test/77154/efit.0/gfiles"
time=43.995   filename=g_p77154_t43.995
time=44.005   filename=g_p77154_t44.005
time=44.105   filename=g_p77154_t44.105
time=44.205   filename=g_p77154_t44.205
time=44.305   filename=g_p77154_t44.305
time=44.405   filename=g_p77154_t44.405
time=44.505   filename=g_p77154_t44.505
time=44.605   filename=g_p77154_t44.605
time=44.705   filename=g_p77154_t44.705
time=44.805   filename=g_p77154_t44.805
time=44.905   filename=g_p77154_t44.905
time=45.005   filename=g_p77154_t45.005
time=45.105   filename=g_p77154_t45.105
time=45.205   filename=g_p77154_t45.205
time=45.305   filename=g_p77154_t45.305
time=45.405   filename=g_p77154_t45.405
time=45.505   filename=g_p77154_t45.505
time=45.605   filename=g_p77154_t45.605
time=45.705   filename=g_p77154_t45.705
time=45.805   filename=g_p77154_t45.805
time=45.905   filename=g_p77154_t45.905
time=46.005   filename=g_p77154_t46.005
```

- Save the modified index.dat as index.dat_2

5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile

execute scrunch2
in $SDD/gfiles



5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile

Switch to use a index file

The name of index file to be used

JET

Shot number

Y if okay

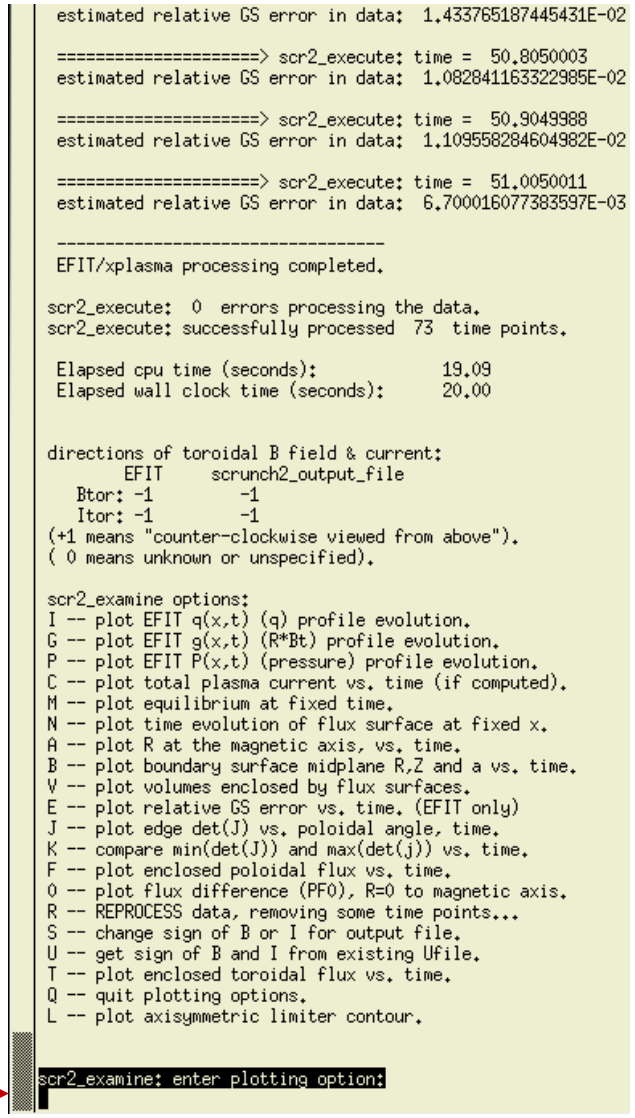
```
%scrunch2
  *** SCRUNCH2 *** 3/3/2010 version (dmc)

 default is to input from tokamak EFIT MDS+ data;
   alternatives:
 enter "INDEX" here to use an "EFIT INDEX" file.
 enter "TRANSP" here to read from TRANSP archive.
 enter "TSC" here to use a TSC "movie.cdf" file.
 enter "Q" to quit.

 [OLD VALUE:  "                                "]
enter 3 or 4 character TOKAMAK id code, e.g. "NSTX":
 [fgetline:  no command line editing available]
INDEX
  %enter "q " or "Q " to skip index file...
 %unixfile:  enter a complete, literal unix file specification,
 or "r " or "R " to set up a directory path (with environment
 variable name translation) and then specify a relative file
 specification.

 [OLD VALUE:  "..."]
unixfile (scrunch2 (G-Eqdsk index file)):  enter file spec or "r":
index.dat_2
  %scrunch2: EFIT INDEX file OK.
  ...please provide labeling information...
 [OLD VALUE:  "    "]
tokamak id (3 or 4 characters e.g. "MAST"):
JET
 [OLD VALUE:           0]
shot number (non-negative integer.le.999999):
77154
 %get_tokyr: subroutine jetyr.for: tokamak JET  shot  77154 => shot year: 2009
  tokamak: JET   shot:  77154
  shot year:       2009
enter "Y" to verify:
```

5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile

Several options for producing MMX ufile are available.

'A' → produce MMX ufile with g eqdisk files as they are.

5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile



Plotting option is available.

Q → go to the next step.

5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile

Y → write MMX ufile

P → create prefix name of the MMX ufile
i.e. EQD → EQD77154.MMX
(default prefix name is AA)

```
scr2_examine: enter plotting option:
Q
scr2_examine: write the data to Ufiles? (Y/N):
Y
 Ufile path:  current directory.
 -->Ufile prefix:  "AA"
 Psi(poloidal) vs. t Ufile suffix:  "PLF"
 Psi(toroidal) vs. t Ufile suffix:  "TRF"
 delta(Psi(poloidal)) (machine axis to mag. axis) vs. t Ufile suffix:  "PFO"
 P profile Ufile suffix:  "PRS"
 G profile Ufile suffix:  "GRB"
 Q profile Ufile suffix:  "QPR"
 moments data Ufile suffix:  "MMX"
 limiter data Ufile suffix:  "LIM"
 ...data to be written in MKS mode.

 P -- modify Ufile prefix
 S -- modify Ufile suffixes
 D -- modify directory path
 T -- set output mode (TRANSP or MKS)


 0 -- (zero): restore default settings
 W -- WRITE the data and exit
 Q -- quit without writting.

scr2_write: enter option code letter:
P
 [OLD VALUE:  "AA              "]
prefix for all Ufiles:
EQD
 Ufile path:  current directory.
 -->Ufile prefix:  "EQD"
 Psi(poloidal) vs. t Ufile suffix:  "PLF"
 Psi(toroidal) vs. t Ufile suffix:  "TRF"
 delta(Psi(poloidal)) (machine axis to mag. axis) vs. t Ufile suffix:  "PFO"
 P profile Ufile suffix:  "PRS"
 G profile Ufile suffix:  "GRB"
 Q profile Ufile suffix:  "QPR"
 moments data Ufile suffix:  "MMX"
 limiter data Ufile suffix:  "LIM"
 ...data to be written in MKS mode.

 P -- modify Ufile prefix
 S -- modify Ufile suffixes
 D -- modify directory path
 T -- set output mode (TRANSP or MKS)


 0 -- (zero): restore default settings
 W -- WRITE the data and exit
 Q -- quit without writting.

scr2_write: enter option code letter:
```

5. Run Scrunch2 using index.dat_2 in $SDD/gfiles, and produce MMX ufile

W → EQD77154.MMX
Is produced in $SDD/gfiles.

Q → Finish scrunch2

```
scr2_write: enter option code letter:
W
 NAMED FILE:  EQD77154.PLF
 NAMED FILE:  EQD77154.PF0
 NAMED FILE:  EQD77154.TRF
 NAMED FILE:  EQD77154.PRS
 NAMED FILE:  EQD77154.QPR
 NAMED FILE:  EQD77154.LIM
 NAMED FILE:  EQD77154.GRB
 NAMED FILE:  EQD77154.MMX
 default is to input from tokamak EFIT MDS+ data;
   alternatives:
 enter "INDEX" here to use an "EFIT INDEX" file.
 enter "TRANSP" here to read from TRANSP archive.
 enter "TSC" here to use a TSC "movie.cdf" file.
 enter "Q" to quit.

 [OLD VALUE:  "                              "]
enter 3 or 4 character TOKAMAK id code, e.g. "NSTX":
Q
%
```

- copy the produced MMX ufile into $SDD

%cp EQD77154.MMX $SDD/EQD77154.MMX_0000

6. Run TRANSP and modify the namelist file (e.g. 77154D46TR.DAT) during step config

- %JETtransp step config
- Modify the namelist file as shown below
  - LEVGEO= 8 !To use an equilibrium ufile, LEVGEO=11 is to use TRANSP equilibrium solver (TEQ)
  - LFIXUP=2 !For automatic unit conversion and time axes swapping. Note, the units labels must be correct. LFIXUP=0 is default.
  - PREMMX='EQD'
  - EXTMMX='MMX_0000 UFL:3:tranppf:0:$SDD' !Equilibrium ufile is specified to be read.
  - !PREMRY='MSCR'
  - !EXTMRY='MRY_0170 UFL:2:tranppf:0170:$SDD:EFIT/170/JETPPF'

  !Equilibrium boundary condition is no more required.
- After all these steps TRANSP should run with EFIT equilibrium.