

## WET NGU P1 6-7D : Conjugate Gradient&Cosine-Squared 3.36 DeltatV+XTV starting model :

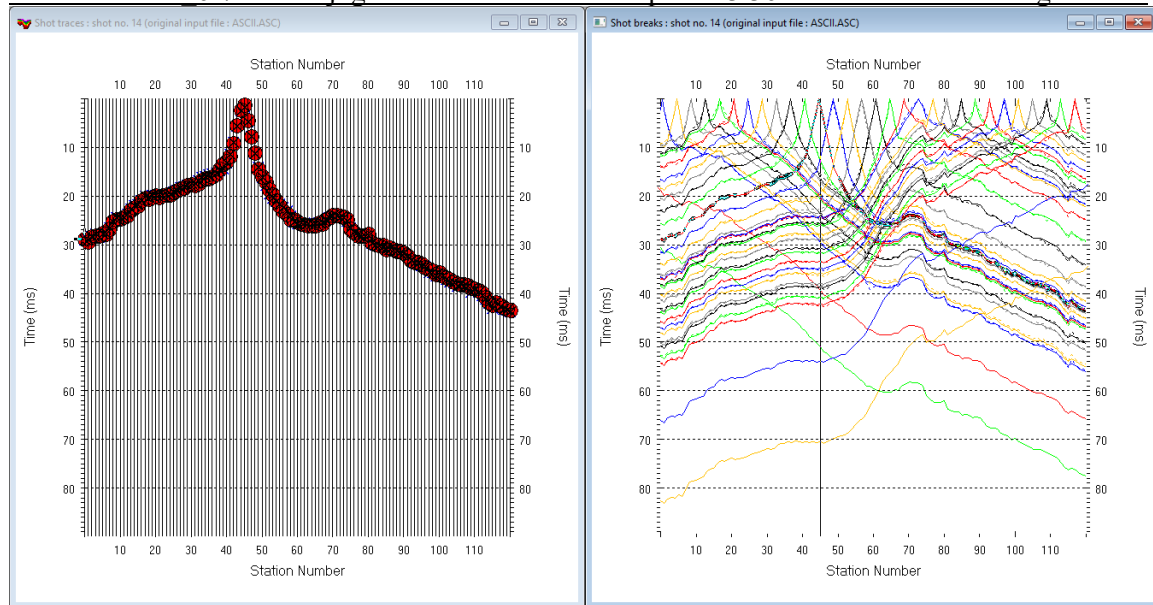


Fig. 1 : left : *Trace|Shot gather*, right : *Refractor|Shot breaks*. Shows fit between picked times (solid colored curves, red circles) and modeled times (dashed colored curves, blue crosses) obtained for 2D WET inversion output (Fig. 9)

To create the profile database, import the data and browse the imported shots do these steps :

- **File|New Profile...**, set *File name* to **P1\_6-7D** and click *Save button*
- in **Header|Profile...** set *Line type* to **Refraction spread/line**. Set *Station spacing* to 2.0 m.
- check box *Force grid cell size* and set *Cell size[m]* to 0.4m. See Fig. 2.
- unzip **P1\_6-7D.zip** with files **1\_6-7DASCII.ASC**, **1\_6-7DCOORDS.COR**, **1\_6-7DSHOTS.SHO** & **1\_1D.CLR** in directory **C:\RAY32\P1\_6-7D\INPUT**
- select **File|Import Data...** and set *Import data type* to **ASCII column format**. See Fig. 3.
- leave *Default spread type* at 10: **360 channels**
- click *Select button*, navigate into **C:\RAY32\P1\_6-7D\INPUT** and select file **P1\_6-7DASCII.ASC**
- set *Default sample count* to 900 to setup the y scale for *Trace|Shot gather* & *Refractor|Shot breaks*
- click **Import shots button** for batch import of all shots contained in **P1\_6-7DASCII.ASC**
- select **File|Update header data|Update Station Coordinates**
- navigate into directory **C:\RAY32\P1\_6-7D\INPUT**
- select file **1\_6-7DCOORDS.COR**. Click *Open button*.
- **File|Update header data|Update Shotpoint coordinates** with **1\_6-7DSHOTS.SHO**
- select **Trace|Shot gather** and **Window|Tile** to obtain Fig. 1

To configure and run DeltatV+XTV inversion and display the pseudo-2D inversion output :

- uncheck **DeltatV|DeltatV Settings|Reduced offset 0.0 is valid trace with time 0.0**. See Fig. 11.
- check **DeltatV|DeltatV Settings|Suppress velocity artefacts**
- check **DeltatV|DeltatV Settings|Process every CMP offset**
- check **DeltatV|DeltatV Settings|Smooth CMP traveltimes curves**
- select **DeltatV|XTV parameters**. Click button **Layer model**. Edit fields as in Fig. 14 & click **Accept**.
- select **DeltatV|Interactive DeltatV**. Confirm prompt and edit parameters as in Fig. 12.
- click **Export Options** and set **Gridding method** to **Nearest Neighbor** as in Fig. 13 & click **Accept**
- click button **DeltatV inversion**
- in dialog **Save DeltatV output** click yellow **Create new folder** icon at upper right
- name new folder as **Stack45Curr5%\_Smooth2nd**. Double-click this new folder to enter it.

- set *File name* to `Stack45Curr5%_Smooth2nd`. Click *Save* button.
- wait for the *DeltatV+XTV inversion* to complete
- select *Grid|Grid and image DeltatV.TXT file*
- select `C:\RAY32\P1_6-7D\Stack45Curr5%_Smooth2nd\MAXVELO.TXT`
- select *Grid|Surfer plot Limits*. Click *Reset to grid*. Navigate into profile subdirectory `C:\RAY32\P1_6-7D\Stack45Curr5%_Smooth2nd`. Click on file `MAXVELO.GRD` & click *Open*.
- check box ***Plot limits active***. Set *Min. elevation* to 20m. Set *Max. elevation* to 72m. See Fig. 4.
- set *Min. velocity* to 500 m/s and *Max. velocity* to 6,000 m/s. Edit fields as in Fig. 4. Click *OK*.
- select *Grid|Image and contour velocity and coverage grids* & above `MAXVELO.GRD` to obtain Fig. 7

To configure and run WET inversion and display 2D inversion output :

- check *WET Tomo|WET tomography Settings|Blank no coverage after last iteration*.
- uncheck *WET Tomo|WET tomography Settings|Blank below envelope after last iteration*
- check *WET Tomo|WET tomography Settings|Write|Store modeled picks after last iteration only*
- check *WET Tomo|WET tomography Settings|Scale wavepath width*. See Fig. 15.
- check *WET Tomo|WET tomography Settings|Scale WET filter height*
- check *WET Tomo|WET tomography Settings|Edit maximum valid WET velocity*
- in *WET Tomo|WET velocity update* set *a* to 0.5 and *b* to 10.0. Click *OK*. See Fig. 5.
- set *WET Tomo|Interactive WET tomography|Ricker differentiation* to -2 [Cosine-Squared]
- set *Min. velocity* to 200 m/s & *Max. velocity* to 5,700 m/s. See Fig. 6 (left).
- click radio button ***Conjugate Gradient***
- set *CG iterations* (outer loop) to 15 and *Line Search iters.* (inner loop) to 3. See [Shewchuk 1994](#) .
- click button *Edit grid file generation* & set *Store each nth iteration only : n =* to 20. Click *OK*.
- click ***Edit velocity smoothing***. Check ***Manual specification of smoothing filter*** . See Fig. 6 (right).
- set ***Half smoothing filter width*** to 3 columns & set ***Half smoothing filter height*** to 1 rows
- uncheck ***Adapt shape of filter***. Set ***Maximum velocity update*** to 25% .
- set ***Smooth nth iteration : n =*** to 2 to obtain Fig. 8. Set to 3 to obtain Fig. 9.
- click ***Uniform*** button. Leave ***Damping*** at default 0.9. Click ***Accept*** button.
- click button ***Start tomography processing*** to obtain Fig. 8 & 10
- in Surfer 16 click on *menu View*. Check ***Properties check box***.
- in Surfer 16 window for Fig. 8 click on ***Custom colormap*** button to right of ***Colors label***. Click on ***Load*** button. Navigate into `C:\RAY32\P1_6-7D\INPUT` & select `1_1D.CLR` . Click ***Open&Apply&OK***.

Here some references to help file chapters and other relevant tutorials :

- for our [multiscale WET](#) inversion see updated [help file](#) chapter ***WET tomography processing***
- see also our [SAGEEP11 tutorial](#) showing ***Conjugate Gradient WET*** inversion using 1D-gradient initial model for SAGEEP11 synthetic data forward-modeled over fault zone model
- see also our [2017 tutorial](#) showing ***Steepest Descent WET inversion*** using Plus-Minus layered refraction starting model for [NGU 2017](#) P1\_1 synthetic data

**Edit Profile**

Line ID: P1\_6-7D  
 Line type: Refraction spread/line  
 Job ID: NGU synthetic data 2018

Instrument:   
 Client:   
 Company:   
 Observer:   
 Note:   
 Time of Acquisition: Date:   
 Time:   
 Time of Processing: Date:   
 Time:   
 Units: meters  
 Sort: As acquired  
 Const:   
 Station spacing [m]: 2.0000  
 Min. horizontal separation [%]: 25  
 Profile start offset [m]: 0.0000  
 Left handed coordinates  
 Force grid cell size  
 Cell size [m]: 0.4000

Add borehole lines for WET tomography

Borehole 1 line: Select   
 Borehole 2 line: Select   
 Borehole 3 line: Select   
 Borehole 4 line: Select

OK Cancel Reset

Fig. 2 : Header|Profile

**Import shots**

Import data type: ASCII column format

Input directory: select one data file. All data files will be imported  
 Select: D:\ray32\P1\_6-7D\INPUT\

Take shot record number from: Record number

Optionally select .HDR batch file and check Batch import  
 .HDR batch:   
 Write .HDR batch file listing shots in input directory  
 Output .HDR:   
 Write .HDR only  Import shots and write .HDR

Overwrite existing shot data:   
 Overwrite all  Prompt overwriting  Limit offset  Batch import

Maximum offset imported [station nos.]: 1000.00

Default shot hole depth [m]: 0.00  
 Default spread type: 10: 360 channels

Target Sample Format: 32-bit floating point

Turn around spread by 180 degrees during import  
 Correct picks for delay time (use e.g. for .PIK files)

Default sample interval [msec]: 0.100000000  
 Default sample count: 900

Import shots Cancel import Reset import

Fig. 3 : File|Import Data

**Edit Surfer plot limits**

Plot Limits  
 Plot limits active

Min. offset: 0.000 [m]  
 Max. offset: 240.000 [m]  
 Min. elevation: 20.000 [m]  
 Max. elevation: 72.000 [m]  
 Min. velocity: 500 [m/sec.]  
 Max. velocity: 6000 [m/sec.]

Plot Scale  
 Proportional XY Scaling  
 Page unit centimeter. Uncheck for inch.  
 X Scale length: 6.000 [inch]  
 Y Scale length: 4.000 [inch]

Color Scale  
 Adapt color scale

Scale height: 1.340 [inch]  
 Velocity interval: 500 [m/sec.]  
 Coverage: 100 [paths/pixel]

OK Cancel Reset Reset to grid

Fig. 4 : Grid|Surfer plot Limits

**WET update weighting**

Parameters for Cosine-Squared weighting function

a : Cosine argument: 0.500 [power]  
 b : Cosine-Squared power: 10.000 [power]

Decrease velocity update in high-coverage areas  
 Decrease update active  
 Velocity update: 0.000 [power]

OK Cancel Reset

Fig. 5 : WET Tomo|WET Update weighting

**Edit WET Wavpath Eikonal Traveltime Tomography Parameters**

Specify initial velocity model

Stop WET inversion after

Number of WET tomography iterations :  iterations

or RMS error gets below  percent

or RMS error does not improve for n =  iterations

or WET inversion runs longer than  minutes

WET regularization settings

Wavepath frequency :  Hz

Ricker differentiation [-1:Gaussian; 2:Cosine]  times

Wavepath width [percent of one period] :  percent

Wavepath envelope width [% of period] :  percent

Min. velocity  Max. velocity  m/sec.

Width of Gaussian for one period [sigma] :  sigma

Gradient search method

Steepest Descent  Conjugate Gradient

Conjugate Gradient Parameters

CG iterations  Line Search iters.

Tolerance  Line Search tol.

Initial step   Steepest Descent step

**Edit WET Tomography Velocity Smoothing Parameters**

Determination of smoothing filter dimensions

Full smoothing after each tomography iteration

Minimal smoothing after each tomography iteration

Manual specification of smoothing filter, see below

Smoothing filter dimensions

Half smoothing filter width :  columns

Half smoothing filter height :  grid rows

Suppress artefacts below steep topography

Adapt shape of filter. Uncheck for better resolution.

Maximum relative velocity update after each iteration

Maximum velocity update :  percent

Smooth after each nth iteration only

Smooth nth iteration : n =  iterations

Smoothing filter weighting

Gaussian  Uniform  No smoothing

Used width of Gaussian  sigma

Uniform central row weight  [1..100]

Smooth velocity update before updating tomogram

Smooth velocity update  Smooth last iteration

Damping of tomogram with previous iteration tomogram

Damping   Damp before smoothing

Fig. 6 : left : WET Tomo|Interactive WET tomography right : Edit velocity smoothing

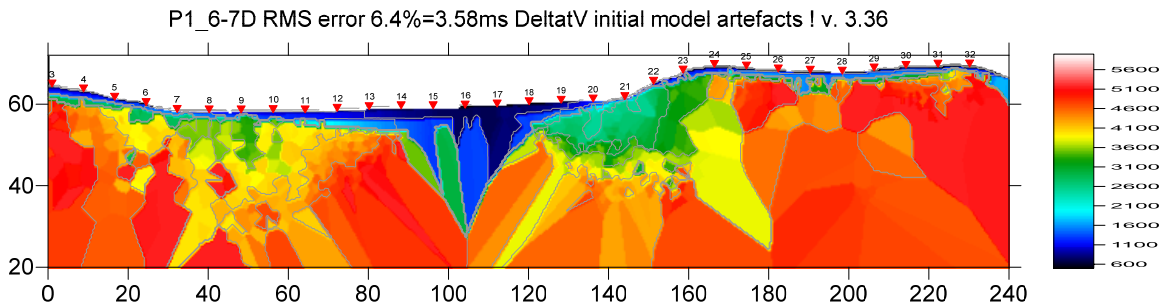


Fig. 7 : DeltatV|Interactive DeltatV output. See Fig. 11/12/13/14 for DeltatV Settings & parameters and XTV parameters

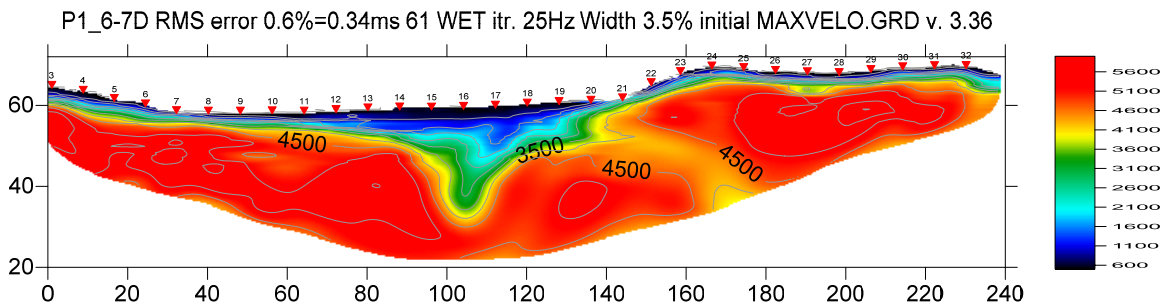


Fig. 8 : WET output. Starting model is Fig. 7. See Fig. 1 for misfit. Smooth nth iteration = 2.

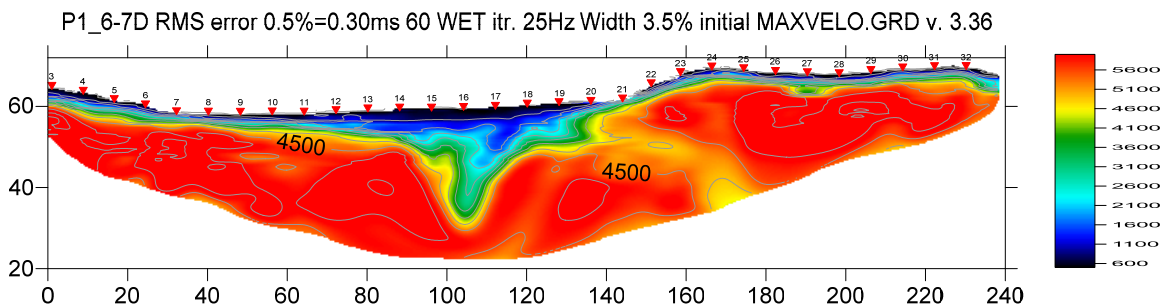


Fig. 9 : Same WET parameters as for Fig. 8 except Smooth nth iteration = 3 instead of 2. Starting model is Fig. 7.

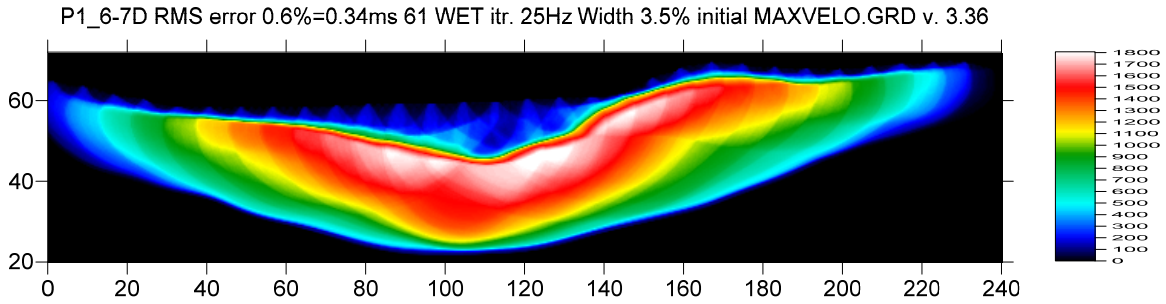


Fig. 10 : Wavepath coverage plot obtained with Fig. 8. Unit is wavepaths per pixel.

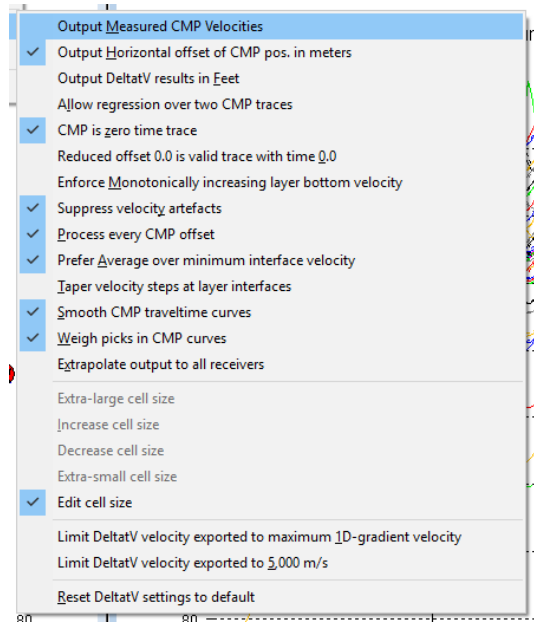


Fig. 11 : *DeltatV*|*DeltatV Settings*. Check *Suppress velocity artefacts* to enforce continuous CMP sorted traveltimes curves and filter out bad picks from traveltimes curves.

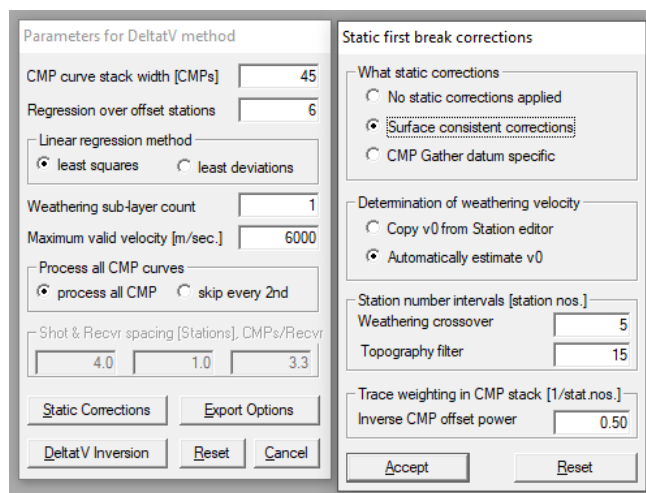


Fig. 12 : edit parameters in dialog *DeltatV*|*Interactive DeltatV* (left). Click button *Static Corrections* to edit more parameters (right). Check radio button *No static corrections applied* to completely disable static corrections. Increase *Inverse CMP offset power* from default 0.5 to 0.9 to give more weight to central CMP curve when stacking CMP curves. This increases the lateral resolution. Decreasing *Inverse CMP offset power* to 0.2 increases lateral smoothing.

DeltatV method export options

Max. velocity exported [m/sec.]

limit velocity exported  negative depths

Handling of too high velocities  
 set to max. exported  do not export

Depth information exported  
 absolute elevations  depth below topo

Gridding method

Fig. 13 : *DeltatV|InteractiveDeltatV|Export Options*

XTV Parameters dialog

Enable Modified Dix layer inversion

Intercept time layer inversion  
 Enable Intercept time layer inversion  
 Minimum velocity ratio :  ratio  
 Minimum velocity increase :  m/s

Multiple adjacent Intercept time layer inversion  
 Allow adjacent Intercept layer inversion  
 Overlying layer velocity step :  percent  
 Current layer velocity step :  percent  
 Prefer measured layer top velocity over inverted

Fig. 14 : edit XTV parameters

- Blank >
- Write >
- Update imaged grid depth
- Scale wavepath width
- Scale WET filter height
- Disable wavepath scaling for short profile
- Limit WET velocity to maximum velocity in initial model
- Limit WET velocity to 5,000 m/s
- Edit maximum valid WET velocity
- Safe line search with bracketing and Brent
- Hybrid Conjugate Gradient update formula
- Alternate coverage update during Conjugate Gradient inversion
- Use full Steepest Descent step for Conjugate Gradient
- Disable traveltime grid caching
- Force RAM allocation
- Enable AWE physical memory page caching
- Enable multi-core heap
- Reset WET tomography settings to default

Fig. 15 : edit menu *WET Tomo|WET tomography Settings*

To restore database files and result files :

Subdirectories `c:\RAY32\P1_6-71D\Stack45Curr5%_Smooth3rd`, `...\INPUT` and `...\seis32_Mar3_2019` are available in this [RAR archive](#). Open the `...\Stack45Curr5%_Smooth3rd\VELOIT61.PAR` file e.g. with Windows Notepad editor to review *WET inversion* parameters used.

Use Rayfract® 3.36 command **Grid|Reset DeltatV and WET settings to .PAR file...** with file `...\Stack45Curr5%_Smooth3rd\VELOIT61.GRD` to reset your profile's *DeltatV and WET inversion settings* to `...\Stack45Curr5%_Smooth3rd\VELOIT61.PAR`.

Or quit our software via **File|Exit**. In Windows Explorer copy all 34 `seis32.*` database files from directory `...\seis32_Mar3_2019` into `c:\RAY32\P1_6-7D` directory. Now reopen your profile with **File|Open Profile...** and `c:\RAY32\P1_6-7D\SEIS32.DBD`.

Summary, parameter optimization :

NGU 2018 report with Fig. 4.5.2 showing *WET inversion* of above synthetic model data is available at [http://www.ngu.no/upload/Publikasjoner/Rapporter/2018/2018\\_015.pdf](http://www.ngu.no/upload/Publikasjoner/Rapporter/2018/2018_015.pdf). For above Fig. 8 & Fig. 9 we further improve our DeltatV+XTV settings for pseudo-2D starting model and 2D WET inversion settings compared to settings used for Fig. 4.5.2.

We optimized DeltatV+XTV and WET settings to more clearly image the overburden layers and the double fault zone and minimize artefacts in basement. We changed the following settings compared to Fig. 4.5.2 :

- *DeltatV stack width* 45 instead of 30 to minimize artefacts in basement
- *Static setting Inverse CMP offset power* 0.50 (default) instead of 0.20 to increase lateral resolution
- unchecked XTV option *Enable Modified Dix layer inversion* to remove artefact in basement
- increased XTV *Overlying layer velocity step* from 0 percent to 10 percent to better resolve overburden
- decreased XTV *Current layer velocity step* from 25 percent to 5 percent to better resolve overburden
- increased WET smoothing parameter *Smooth nth iteration* : n = from 2 (Fig. 8) to 3 (Fig. 9) for sharper layer & fault zone boundaries

WET inversion shown in Fig. 8 with 15 Conjugate-Gradient iterations and parameters shown in Fig. 6 took about 90 seconds on 2017 Apple iMac (2.3 GHz Intel Core i5 processor) running Windows 10 Pro 64-bit in Parallels Desktop 14 for Mac Pro Edition.

We thank Georgios Tassis at NGU for making available above report and synthetic data.

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