

# NICER Analysis Workshop

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# NICER

Neutron star Interior Composition Explorer

NICER New Software Release  
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MOOG



# Overview

- Big changes
- Smaller changes
- Longer term goals
- Filter file changes



## *Big Changes / Feature Upgrades*

- Response calculators `nicerarf` & `nicerrmf`
  - Calculates ARF / RMF for your specific observation conditions
- `nicerl2` command line options to select/deselect desired detectors: `nifpmsel`
- Tools to combine multiple observations
- Status:
  - Submitted to HEASoft developers, final bugs being worked out



## *Response Calculators*

- Why?
  - As discussed in next presentation, actual response depends on particular conditions of your observation
    - ARF – off-axis pointing angle
    - ARF – which detectors are enabled
    - RMF – optical light change resolution and low energy trigger efficiency
- Solution
  - Response calculator tasks `nicerarf` and `nicerarmf`, which compute custom response for given observation



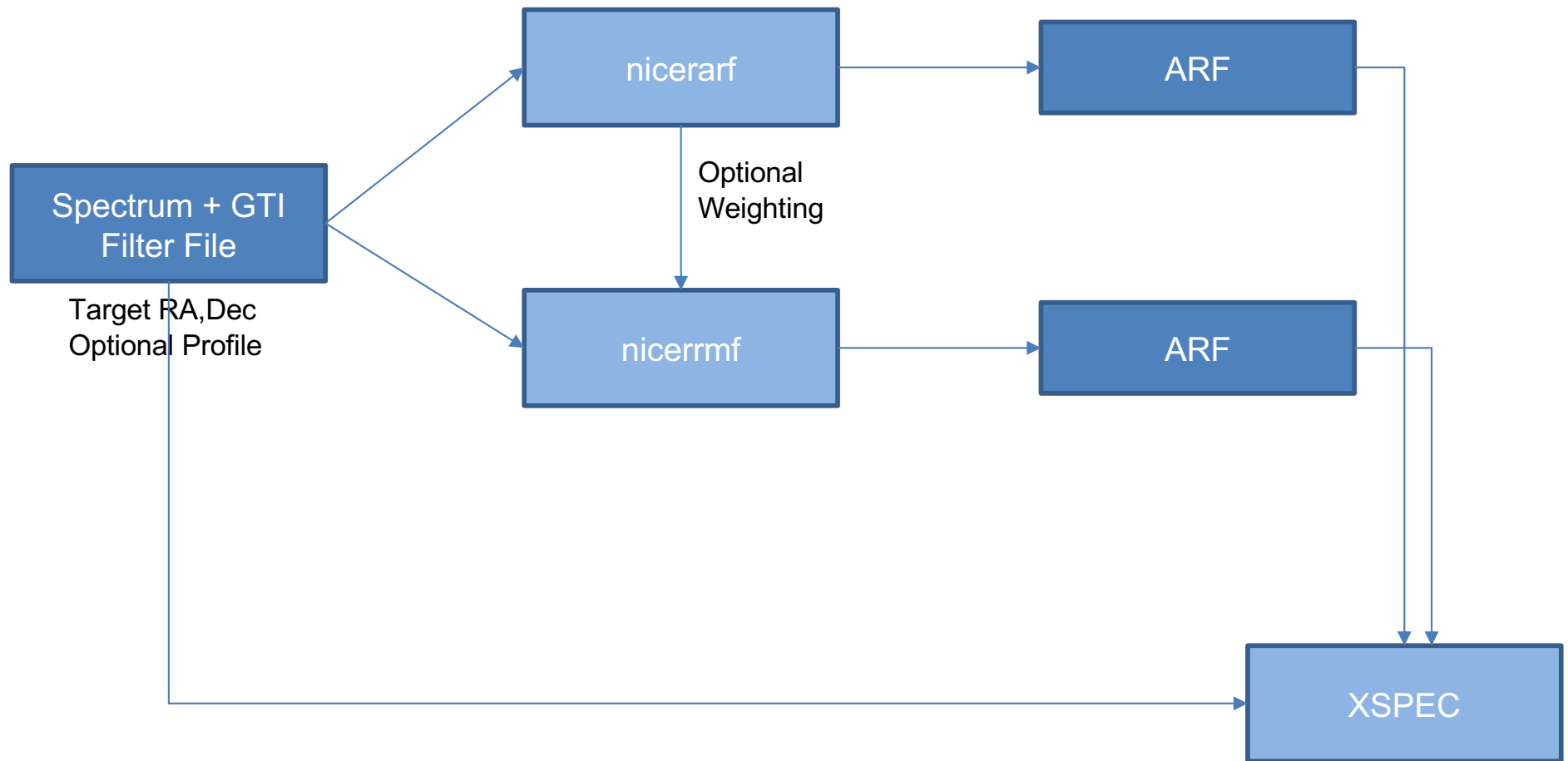


## *Inputs to Response Calculators*

- Extracted spectrum with GTI extension
- Target position (R.A. and Dec)
- Filter file
- Optional: list of detectors
  
- Sky surface brightness distributions supported
  - Point
  - Gaussian
  - Flat (uniform sky background)
  - User-specified radial brightness distribution



# Response Calculator Flow Diagram



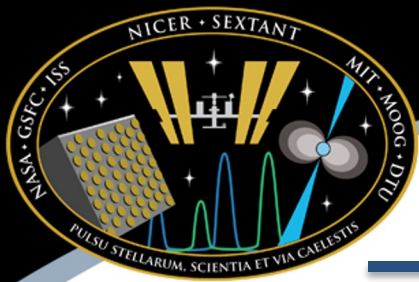


## *The ARF Calculator: nicerarf*

- How to run:

```
nicerarf myspectrum.pha 350.85 +58.815 \  
filter.mkf filter.mkf myspectrum.arf
```

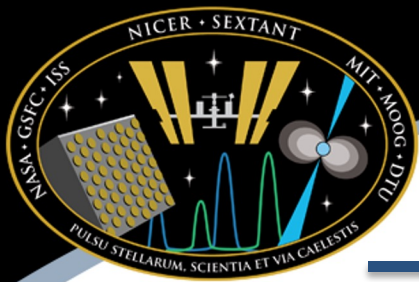
- myspectrum.pha – spectrum of interest (with GTI)
- 350.85 +58.815 = right ascension and declination of target (assumed point source in this case)
- filter.mkf – filter file used for response calculation
- filter.mkf – FPM Selection file used for detector on/off calculation (can be filter file)
- myspectrum.arf – output ARF file



## *ARF Variation: Deselecting Detectors*

- You may wish to de-select certain detectors if you screened them out of your event file.
  - Example, excluding detectors 14 and 34
  - Command  
`nicerarf .. detlist=-14,-34`
  - The “-14,-34” means to exclude 14 and 34 from ARF generation
  - Note that nicerarf will use the filter file to determine which detectors are on/off, so you do not have to exclude those





## *ARF Variation: Passing Information to RMF Stage*

- Much of the same information used to select/deselect detectors are ARF stage can be re-used in RMF stage
- Use  
`nicerarf ... outwtfile=arfweights.lis`  
and generated file can be used as input to the RMF generator
- Generating per-detector ARFs  
`nicerarf ... savedetarf=YES`  
Output files are saved to `myspectrum_detid.arf`



## *ARF Variation: Diffuse Sources*

- The ARF calculator has several options for diffuse sources
  - Point, gaussian, flat, and custom radial
- Example, gaussian surface brightness with  $\sigma=60''$   
`nicerarf ... profile=gaussian profpar=sigma:60`
- Note. Does not make sense to use the diffuse source options for features
  - Finer than  $\sim 10''$  (grid spacing of calibration data)
  - More diffuse than  $\sim 200''$  (NICER FOV)

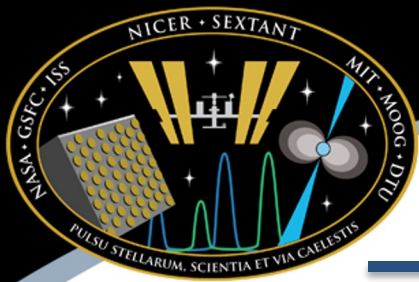


## *The RMF Calculator: nicerrmf*

- How to run:

```
nicerrmf myspectrum.pha filter.mkf \  
myresponse.rmf
```

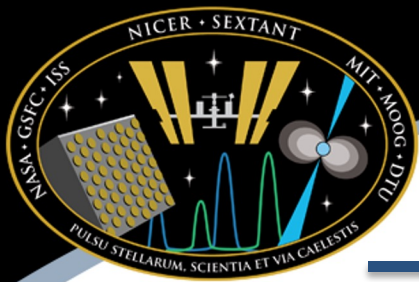
- myspectrum.pha – spectrum of interest (with GTI)
- filter.mkf – filter file used for response calculation
- myspectrum.rmf – output RMF file



## *RMF Variation: Deselecting Detectors*

- You may wish to de-select certain detectors if you screened them out of your event file.
  - detlist parameter works as before  
`nicerrmf .. detlist=-14,-34`
  - Also can use the ARF weighting file produced by `nicerarf` (see previous slides) to reduce chances of user error  
`nicerrmf .. detlist=arfweights.lis`





## *Other RMF Variations*

- Possible to perform ARF-weighting of RMF
  - Must generate per-detector ARFS and use `outdetlisfile=arfdetlist.lis` option
  - Run `nicerrmf` with `detlist=arfdetlist.lis`
- Possible to generate a combined ARF+RMF file (usually called RSP)
  - Same conditions as ARF-weighting, plus `outmode=RSP`



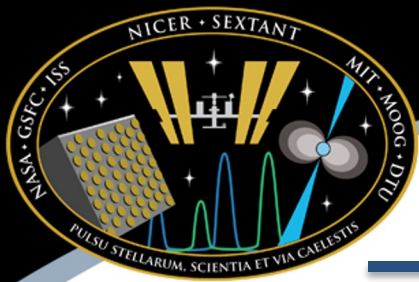
## *FPM Selections*

- NICERDAS introduces a new way to consistently select or de-select detectors of interest
- Currently scientists manually remove detectors using ‘ftselect’ task
  - Incumbent upon analyst to keep track of which detectors they have included/excluded
  - Difficult to manage, when considering large observations with multiple snapshots
- **New method is an “FPM Selection” file.** This file is a tabulated list of which detectors have been enabled/disabled at hardware level, as well as de-selected by analyst.
- Scientist can still use the “old way” if they wish



## *What is the FPM Selection File?*

- FPM Selection information is typically attached to the event file
  - FPM\_SEL extension: 56 element exposure vector, sampled each second
  - GTIs for each detector
  - Automatically generated by NICER pipeline and attached to event files
- The ARF calculator can use FPM selection information to generate an accurate ARF
  - You can also use the filter file, which has detector enable/disable data, but not selected/de-selected information



## *How to Take Advantage of FPM Selection*

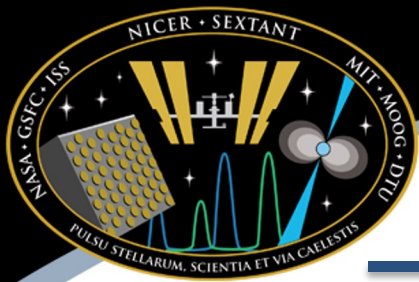
- FPM selection data passed to ARF calculator
- When running nicerl2
  - Use detlist parameter to de-select certain detectors  
nicerl2 ... detlist=-14,-34
  - Events from detectors 14 and 34 will be removed from event file, and FPM selection data is updated
- Use nifpmsel task with existing event file
  - User can apply more strict filtering to events, and FPM selection data is updated





## *How to Keep FPM Selection Updated*

- Use the tasks
  - nicerl2
  - nifpmsel
  - niextract-events
- All of these tasks will keep FPM selection information up to date and usable by ARF calculator
- **If you do not use these tasks (e.g. use ftselect) you are “on your own” to keep track of detector selections**



# Smaller / Convenience Improvements

- nicerl2
  - Make selecting various filter file options easier (single filtcolumns parameter, instead of setting various parameters)
  - Select which portions of nicerl2 runs using tasks parameter
    - ALL – run everything
    - CALMERGE – calibration
    - MKF – generate filter files
    - SCREEN – run screening
  - For many users which simply want to change screening options and not re-calibrate every single run of nicerl2 this should save computer time and disk space
- nicerl2 / nimaketime: easier to adjust both overshoot components with one option
  - `overonly_range` parameter controls both the overall range and the `overonly` expression



## *Filter File Improvements*

- COR\_NYM – adjusted cut-off rigidity that accounts for geomagnetic disturbances
- SOLAR\_PHI - solar modulation potential (solar mod. of cosmic ray intensity)
- Median undershoot value (in addition to mean, better outlier resistance)
- FPM\_DEADTIME - Per-FPM deadtime, and improved deadtime recipe
- Per-FPM noise rates
- HV\_ON – Per-FPM high voltage enabled
- ON\_TIME – Per-FPM exposure time in each one second bin?
- SAATIME – calculated more correctly
- TIME\_SINCE\_SUNSET – number of seconds since sun set below earth limb
- BETA\_ANGLE – angle between orbit plane and sun direction (long-term temperature/heating of NICER)
- SUN\_ELV – angle of sun above earth limb?
- Attitude pointing jitter – indicates if NICER pointing is jittering, reduces throughput and may introduce jitter-related instrumental "QPO"

**NOTE: old columns will not change, these are additions to filter file, after running niprefilter2 and/or nicerl2**



## *How To Merge Filter Files*

- Problem
  - Filter files from different software releases are impossible to merge because they have different numbers of columns or column orders
- Solution: `nimkfmerge`
  - Similar to `ftmerge` but is able to merge any NICER filter files, even if columns are mismatched
  - Example

```
nimkfmerge filter1.mkf,filter2.mkf merged.mkf
```
  - Even if some columns are missing from `filter2.mkf`, they will still be merged (missing columns will be filled with NULL values)





## *Summary*

- NICDAS version 8 contains major changes and improvements
- Response calculators
- Dealing with detector selections
- New filter file columns
- Improved way to merge filter files