ATS-GPU-NUFFT

Version 23.1.1
November 1, 2023

CONTENTS

Note: This is the documentation for AlazarTech's ATS-GPU version 23.1.1. Please visit our documentation homepage to find documentation for other versions or products.

CHAPTER

ONE

LICENSE AGREEMENT

1.1 Important

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CHAPTER

TWO

INTRODUCTION

ATS-GPU-NUFFT provides a framework to allow real-time, non-uniform Fourier transform processing from AlazarTech PCIe digitizers on a CUDA-compatible GPU.

ATS-GPU-NUFFT internally calls ATS-CUDA-NUFFT, which is a low-level library that performs all the necessary operations to perform the non-uniform Fourier Transform. ATS-CUDA-NUFFT is described later in this guide in the section *ATS-CUDA-NUFFT*.

This document assumes that the reader is familiar with ATS-SDK, the standard interface for programming AlazarTech digitizers. Having a copy of the ATS-SDK manual available can be helpful, since many references to ATSApi functions are done here. The latest version of the ATS-SDK manual can be downloaded free of charge from AlazarTech's website.

CHAPTER

THREE

PREREQUISITES

3.1 System requirements

This software requires a PC with a CUDA-enabled GPU, and sufficient CPU resources to supply data to the GPU at the desired data acquisition rate. It also requires a working installation of the same version of ATS-GPU-BASE and ATS-GPU-OCT. It was tested with a GeForce RTX 2080 Ti and a Quadro P5000. DDR4 memory and a modern chipset (X99, X299) will greatly improve transfer speed and overall performance.

Supported operating systems
: Windows and Linux operating systems are supported. Please verify that your Linux distribution is supported by NVIDIA which supplies the CUDA toolkit required to use ATS-GPU.

Compiler support
: CMake is required to build C/C++ code. CMake files are provided. On Linux, a C++11 compiler is required to build the library. On older Red Hat distributions, a devtoolset can be obtained to use a more recent version of gcc that supports C++11. NVCC is required to compile the example code, this compiler is included with CUDA toolkit.

CUDA driver requirements
: In order to use ATS-GPU, you must install the appropriate driver for your CUDA-enabled GPU. Drivers can be downloaded at https://www.nvidia.com/Download/index.aspx.

Note: Under Windows operating systems, dynamic link libraries releated to ATS-GPU-NUFFT are installed by default in %WINDIR%System32. For applications to link approripately to them, %WINDIR%System32 must be added to the Windows PATH Environment Variable.

CHAPTER

FOUR

ATS-GPU-NUFFT

ATS-GPU-NUFFT leverages ATS-GPU-BASE to transfer data from an ATS PCIe digitizer to a GPU in a highly efficient manner. It then takes care of doing NUFFT processing on the data before sending it back to the host computer's RAM. ATS-GPU-NUFFT also relies on ATS-GPU-OCT for standard FFT processing stages.

4.1 Usage

ATS-GPU-NUFFT acquisitions are very similar to standard ATSApi acquisitions. Only the differences are listed here for brevity.

The central function of the ATS-GPU-NUFFT interface is `ATS_GPU_NUFFT_Setup()`. This function calls its ATS-GPU-BASE counterpart `ATS_GPU_Setup()` internally, which in turns calls `AlazarBeforeAsyncRead()`. It takes a few extra parameters:

- `OCTFlags`: Used to define which data type, such as amplitude and phase, to obtain from the acquisition.
- `FFTLength`: This is used to select the length of the Fourier transform done on the GPU. This value should be a power of two for efficiency, and it also must be equal to or larger than the record length.
- `NUFFTFlags`: Used to define the source of the linearization function. Linearization can either be user defined by selecting `ATS_GPU_NUFFT_PRESET_LINEARIZATION` or be determined from a K-clock signal when `ATS_GPU_NUFFT_KCLOCK_LINEARIZATION` is used.

```
rc = ATS_GPU_NUFFT_Setup(
         boardHandle, channelMask, -(int) preTriggerSamples,
         samplesPerRecordPerChannel, recordsPerBuffer,
         buffersPerAcquisition * recordsPerBuffer, autoDMAFlags,
         OCTOptions, FFTLength, NUFFTFlags, NULL, &fftBytesPerBuffer);
// Error handling
```

If `NUFFTFlags` is setup with `ATS_GPU_NUFFT_KCLOCK_LINEARIZATION`, the channelMask must contain `CHANNEL_A` and at least one other active channel. With this flag, ATS-GPU-NUFFT will determine the linearization function for each record from the k-clock signal acquired on `CHANNEL_A` and use it to perform non-uniform FFT on every other active channel.

If NUFFTFlags was setup with ATS_GPU_NUFFT_PRESET_LINEARIZATION, the user is required to specify a precalibrated linearization function. This linearization function will be used to perform non-uniform FFT on every record of every active channel.

```
int precalibratedFunctionLength = 1000;
std::vector<float> precalibratedFunction(precalibratedFunctionLength);
for (int i = 0; i < precalibratedFunction.size(); i++) {
    precalibratedFunction[i] = i;
}
rc = ATS_GPU_NUFFT_SetLinearizationFunction(
            boardhandle, precalibratedFunction,
            &precalibratedFunction[0]);
// Error handling
```

Here, we generated a linear linearization function. Setting a linear precalibrated function represents a signal that is sampled linearly in k-space, thus equivalent to applying regular FFT.

The precalibrated linearization function can have any length as ATS-GPU-NUFFT will internally take care of re-sampling the function to a length equal to samplesPerRecordPerChannel. ATS-GPU-NUFFT will also normalize the function. The precalibrated linearization can therefore have any start and end values. The values of the precalibrated linearization function must always be increasing such as x[i]<x[i+1].

We then choose the window function applied to the acquired data before the FFT processing phase. The most common usage pattern is to first generate a window function using ATS_GPU_OCT_GenerateWindowFunction(), then to download it to the board using ATS_GPU_NUFFT_SetWindowFunction(). It is possible however to use entirely custom window functions instead of the ones generated by the API. It is also possible to use complex window functions by way of downloading two arrays of points: the first for the real part of the window and the other for the imaginary one.

```
rc = ATS_GPU_OCT_GenerateWindowFunction(
            FFT_WINDOW_HANNING, &window[0],
            samplesPerRecordPerChannel);
// Error handling

rc = ATS_GPU_NUFFT_SetWindowFunction(
            boardHandle, samplesPerRecordPerChannel,
            &window[0], NULL);
// Error handling
```

We then allocate memory on the GPU and CPU for data to be transferred to, and we post those buffers to the board. For this purpose, we use ATS_GPU_NUFFT_AllocBuffer(). This function allocates buffers on the GPU, and sets up all the intermediary states necessary for ATS-GPU-NUFFT to successfully transfer data. It also allocates data on the CPU to receive the processed data.

```
for (int i = 0; i < numberOfBuffers; i++)
{
    buffers[i] = (float*) ATS_GPU_NUFFT_AllocBuffer(
```

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```
        boardHandle, bytesPerResultBuffer, NULL);

    rc = ATS_GPU_NUFFT_PostBuffer(
        boardHandle, buffers[i], bytesPerResultBuffer);
    // Error handling
}
```

We can then start the acquisition with `ATS_GPU_NUFFT_StartCapture()`. Once the acquisition is started, `ATS_GPU_NUFFT_GetBuffer()` must be called as often as possible to retrieve a buffer containing processed data on the CPU. The data can then be used by the calling application. When no longer needed, the buffer needs to be posted back.

```
for (size_t i; i < buffers_per_acquisition; i++)
{
    rc = ATS_GPU_NUFFT_GetBuffer(
        boardHandle, buffers[bufferIndex],timeout_ms);
    // Error handling

    // TODO: Process sample data in this buffer.

    rc = ATS_GPU_NUFFT_PostBuffer(
        boardHandle, buffers[bufferIndex], bytesPerResultBuffer);
    // Error handling
}
```

When acquisition is complete, `ATS_GPU_NUFFT_AbortCapture()` must be called. Buffers allocated with `ATS_GPU_NUFFT_AllocBuffer()` should then be freed with `ATS_GPU_NUFFT_FreeBuffer()`.

```
ATS_GPU_NUFFT_AbortCapture(boardHandle);

if (gpuFile != NULL)
    fclose(gpuFile);

// Free buffers
for (int i = 0; i < numberOfBuffers; i++) {
    ATS_GPU_NUFFT_FreeBuffer(boardHandle, buffers[i]);
}
```

4.1.1 LabVIEW Programming

LabVIEW applications must use the managed interface which allows the API to allocate and manage a list of buffers available to be filled by the board. These applications should call `ATS_GPU_NUFFT_Setup()` with the AMDA_ALLOC_BUFFERS option selected in the "autoDMAFlags" parameter. This option will cause the API to allocate and manage a list of buffers available to be filled by the board. It is therefore not necessary for the application to call `ATS_GPU_NUFFT_AllocBuffer()` or `ATS_GPU_NUFFT_FreeBuffer()`. The application must call `ATS_GPU_NUFFT_ManageGetBuffer()` to wait for a buffer to be filled. When the board receives sufficient trigger events to fill a buffer, the API will copy the data from the internal buffer to the user-supplied buffer. `ATS_GPU_NUFFT_ManageGetBuffer()` internally calls `ATS_GPU_NUFFT_GetBuffer()` and `ATS_GPU_NUFFT_PostBuffer()` so applcation should not use these API calls when using the managed interface.

LabVIEW users might find it convenient to edit the VI search paths to locate the appropriate subVIs for the different ATS-GPU packages and ATS-SDK. The VI Search Path can be set in the "Tools" menu under "Options", in the "Path" category. Then select the "VI Search Path" from the drop down list. By unselecting "Use default" custom VI search paths can be added.

4.2 API Reference

Note: Errors from ATS-GPU-NUFFT will be logged in ATS_GPU.log. Relevant information about the error will be logged here and can be useful for debugging. For Windows users log file is located in %TEMP%. For Linux users log file is located in /tmp/.

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enum **ATS_GPU_NUFFT_OPTIONS**

Linearization source specifier. If ATS_GPU_NUFFT_KLCOCK_LINEARIZATION is used, k-clock signal must be connected to CHANNEL_A. If ATS_GPU_NUFFT_PRESET_LINEARIZATION is used, a linearization calibration function must be set using ATS_GPU_NUFFT_SetLinearizationWindowFunction(). This is used in ATS_GPU_NUFFT_Setup().

Values:

enumerator **ATS_GPU_NUFFT_PRESET_LINEARIZATION**

enumerator **ATS_GPU_NUFFT_KCLOCK_LINEARIZATION**

Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_AbortCapture" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_AbortCapture (HANDLE boardHandle) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_AbortCapture (HANDLE boardHandle) ————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_AbortCapture (HANDLE boardHandle) ————————————^

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Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_EnableVerificationMode" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_EnableVerificationMode (BOOL enable, U32 boardType) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_EnableVerificationMode (BOOL enable, U32 boardType) ————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_EnableVerificationMode (BOOL enable, U32 boardType) ————————————^

Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_FreeBuffer" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_FreeBuffer (HANDLE boardHandle, void *buffer) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_FreeBuffer (HANDLE boardHandle, void *buffer) ——————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_FreeBuffer (HANDLE boardHandle, void *buffer) ——————————^

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Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_GetVersion" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————————^

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Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_SetBuffer" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_SetBuffer (void *dataInputBuffer, void *CPUResultBuffer, U32 samplesPerBuffer) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_SetBuffer (void *dataInputBuffer, void *CPUResultBuffer, U32 samplesPerBuffer) ————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_SetBuffer (void *dataInputBuffer, void *CPUResultBuffer, U32 samplesPerBuffer) ————————————^

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Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_Setup" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_Setup (HANDLE boardHandle, U32 channelSelect, long transferOffset, U32 samplesPerFFT, U32 FFTsPerBuffer, U32 FFTsPerAcquisition, U32 autoDMAFlags, U32 OCTFlags, U32 FFTLength, U32 NUFFTFlags, void *reserved, U32 *bytesPerResultBuffer) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_Setup (HANDLE boardHandle, U32 channelSelect, long transferOffset, U32 samplesPerFFT, U32 FFTsPerBuffer, U32 FFTsPerAcquisition, U32 autoDMAFlags, U32 OCTFlags, U32 FFTLength, U32 NUFFTFlags, void *reserved, U32 *bytesPerResultBuffer) ————————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_Setup (HANDLE boardHandle, U32 channelSelect, long transferOffset, U32 samplesPerFFT, U32 FFTsPerBuffer, U32 FFTsPerAcquisition, U32 autoDMAFlags, U32 OCTFlags, U32 FFTLength, U32 NUFFTFlags, void *reserved, U32 *bytesPerResultBuffer) ————————————————^

Warning: doxygenfunction: Unable to resolve function "ATS_GPU_NUFFT_StartCapture" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 18] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_StartCapture (HANDLE boardHandle) ——————^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_StartCapture (HANDLE boardHandle) ————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 30] ATS_GPU_NUFFT_API RETURN_CODE ATS_GPU_NUFFT_StartCapture (HANDLE boardHandle) ————————————^

CHAPTER

FIVE

ATS-CUDA-NUFFT

ATS-CUDA-NUFFT provides a framework to allow non-uniform data processing on a CUDA-enabled GPU. ATS-CUDA-NUFFT internally calls ATS-CUDA and ATS-CUDA-OCT and should be used with ATS-CUDA for buffer and stream manipulation. ATS-CUDA-NUFFT requires an AlazarTech board on the system in order to be used.

5.1 API Reference

Note: Errors from ATS-CUDA-NUFFT will be logged in ATS_GPU.log. Relevant information about the error will be logged here and can be useful for debugging. For Windows users log file is located in %TEMP%. For Linux users log file is located in /tmp/.

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_CreateNuFFTPlan" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API atsNuFFTPlan * ATS_CUDA_NUFFT_CreateNuFFTPlan (U32 FFTLength, U32 samplesPerRecordPerChannel, U32 FFTsPerBuffer, cudaStream_t stream) ——————-^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 32] ATS_CUDA_NUFFT_API atsNuFFTPlan * ATS_CUDA_NUFFT_CreateNuFFTPlan (U32 FFTLength, U32 samplesPerRecordPerChannel, U32 FFTsPerBuffer, cudaStream_t stream) ————————————^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 32] ATS_CUDA_NUFFT_API atsNuFFTPlan * ATS_CUDA_NUFFT_CreateNuFFTPlan (U32 FFTLength, U32 samplesPerRecordPerChannel, U32 FFTsPerBuffer, cudaStream_t stream) ————————————^

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_NuFFT" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_NuFFT (atsNuFFT-Plan *NuFFTPlan, void *GPUBaseBuffer, void *GPUNuFFTOut, void *GPULinearizationBuffer, ATS_CUDA_Input_DataType inputDataType, void *GPUWindow) ——————-^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_NuFFT (atsNuFFT-Plan *NuFFTPlan, void *GPUBaseBuffer, void *GPUNuFFTOut, void *GPULinearizationBuffer, ATS_CUDA_Input_DataType inputDataType, void *GPUWindow) ——————————————-^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_NuFFT (atsNuFFT-Plan *NuFFTPlan, void *GPUBaseBuffer, void *GPUNuFFTOut, void *GPULinearizationBuffer, ATS_CUDA_Input_DataType inputDataType, void *GPUWindow) ——————————————-^

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_DestroyNuFFTPlan" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_DestroyNuFFTPlan (atsNuFFTPlan *NuFFTPlan) ——————————-^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_DestroyNuFFTPlan (atsNuFFTPlan *NuFFTPlan) ——————————————-^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_DestroyNuFFTPlan (atsNuFFTPlan *NuFFTPlan) ——————————————-^

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_CreateLinearizationPlan" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API atsLinearizationPlan * ATS_CUDA_NUFFT_CreateLinearizationPlan (U32 samplesPerRecordPerChannel, U32 recordsPerBuffer, ATS_CUDA_Input_DataType inputDataType, cudaStream_t stream) ——————————-^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 40] ATS_CUDA_NUFFT_API atsLinearizationPlan * ATS_CUDA_NUFFT_CreateLinearizationPlan (U32 samplesPerRecordPerChannel, U32 recordsPerBuffer, ATS_CUDA_Input_DataType inputDataType, cudaStream_t stream) ——————————————————-^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 40] ATS_CUDA_NUFFT_API atsLinearizationPlan * ATS_CUDA_NUFFT_CreateLinearizationPlan (U32 samplesPerRecordPerChannel, U32 recordsPerBuffer, ATS_CUDA_Input_DataType inputDataType, cudaStream_t stream) ——————————————————-^

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_GetLinearizationFromKclock" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromKclock (atsLinearizationPlan *linPlan, void *pKclock, void *GPULinearizationBuffer) ——————————- ^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromKclock (atsLinearizationPlan *linPlan, void *pKclock, void *GPULinearizationBuffer) ——————————————————- ^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromKclock (atsLinearizationPlan *linPlan, void *pKclock, void *GPULinearizationBuffer) ——————————————————- ^

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Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_GetLinearizationFromPrecalibratedFunction" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromPrecalibratedFunction (void *GPUPrecalibratedFunction, void *GPULinearizationBuffer, U32 samplesPerRecordIn, U32 samplesPerRecordOut, U32 recordsPerBuffer, cudaStream_t stream) ——————————- ^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromPrecalibratedFunction (void *GPUPrecalibratedFunction, void *GPULinearizationBuffer, U32 samplesPerRecordIn, U32 samplesPerRecordOut, U32 recordsPerBuffer, cudaStream_t stream) ——————————————————- ^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetLinearizationFromPrecalibratedFunction (void *GPUPrecalibratedFunction, void *GPULinearizationBuffer, U32 samplesPerRecordIn, U32 samplesPerRecordOut, U32 recordsPerBuffer, cudaStream_t stream) ——————————————————- ^

Warning: doxygenfunction: Unable to resolve function "ATS_CUDA_NUFFT_GetVersion" with arguments "None". Candidate function could not be parsed. Parsing error is Error when parsing function declaration. If the function has no return type: Error in declarator or parameters-and-qualifiers Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 19] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————-^ If the function has a return type: Error in declarator or parameters-and-qualifiers If pointer to member declarator: Invalid C++ declaration: Expected '::' in pointer to member (function). [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————————-^ If declarator-id: Invalid C++ declaration: Expecting "(" in parameters-and-qualifiers. [error at 31] ATS_CUDA_NUFFT_API RETURN_CODE ATS_CUDA_NUFFT_GetVersion (U8 *major, U8 *minor, U8 *revision) ——————————-^

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