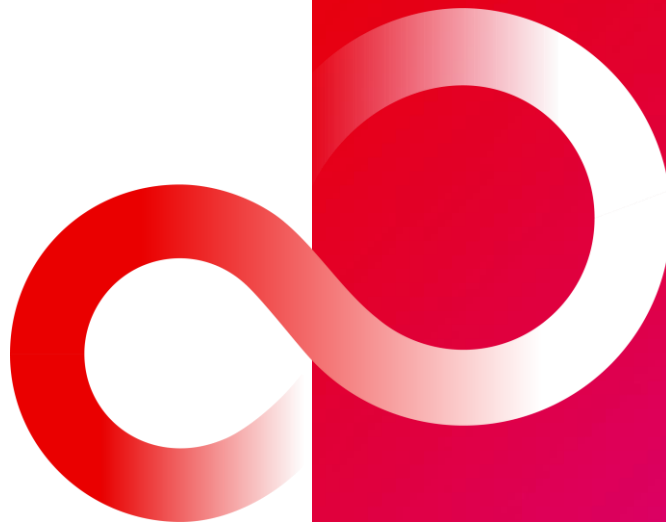


# Applications for PRIMEHPC FX1000/FX700

Fujitsu Limited

Created: November 2021

Revised: October 2023 (updated "Commercial Applications List")



- Overview

- Commercial Applications

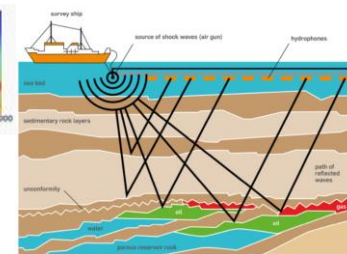
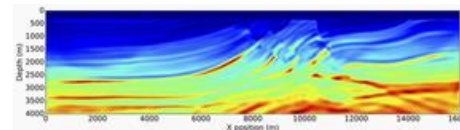
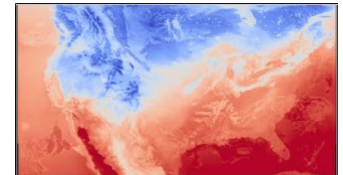
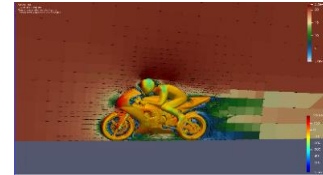
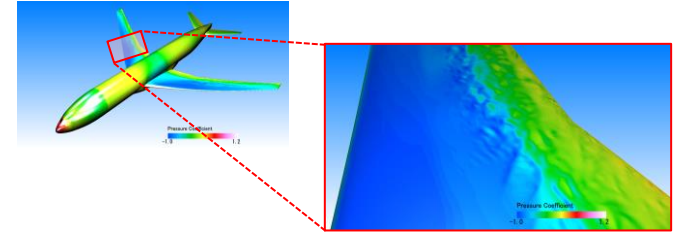
- Commercial Applications
- Commercial Applications List
- Ansys Fluent
- Ansys LS-DYNA
- CONVERGE
- Cradle CFD | scFLOW
- Poynting
- Applications for Automotive Industry

- Open-Source Software (OSS) Applications

- OSS Performance on FX1000 and FX700
- OSS Power Efficiency on FX1000 and FX700
- FrontISTR
- OpenFOAM
- WRF
- LAMMPS
- QUANTUM ESPRESSO
- Information and Tools for OSS

- Open-Source Oil & Gas Applications evaluated with Arm ecosystem collaborators

- A64FX advantage in Oil & Gas applications
- Devito
- GIRIH



# Overview

# Feature of PRIMEHPC FX1000 and FX700

- **PRIMEHPC FX1000** and **FX700** are featured by **ARM Processor A64FX** which is used in super-computer **Fugaku**.



© RIKEN

## A64FX processor



- ✓ Scalable Vector Extension (SVE) 512bit SIMD is implemented.
- ✓ An extension of Armv8.2-A instruction set architecture is applied.
- ✓ High memory throughput is realized by HBM2.
- ✓ It is designed to obtain high power efficiency.

## FUJITSU Supercomputer PRIMEHPC



### PRIMEHPC FX1000

Super-computer for very large-scale system

- ✓ 384nodes/rack
- ✓ Liquid cooling system
- ✓ Tofu Interconnect D



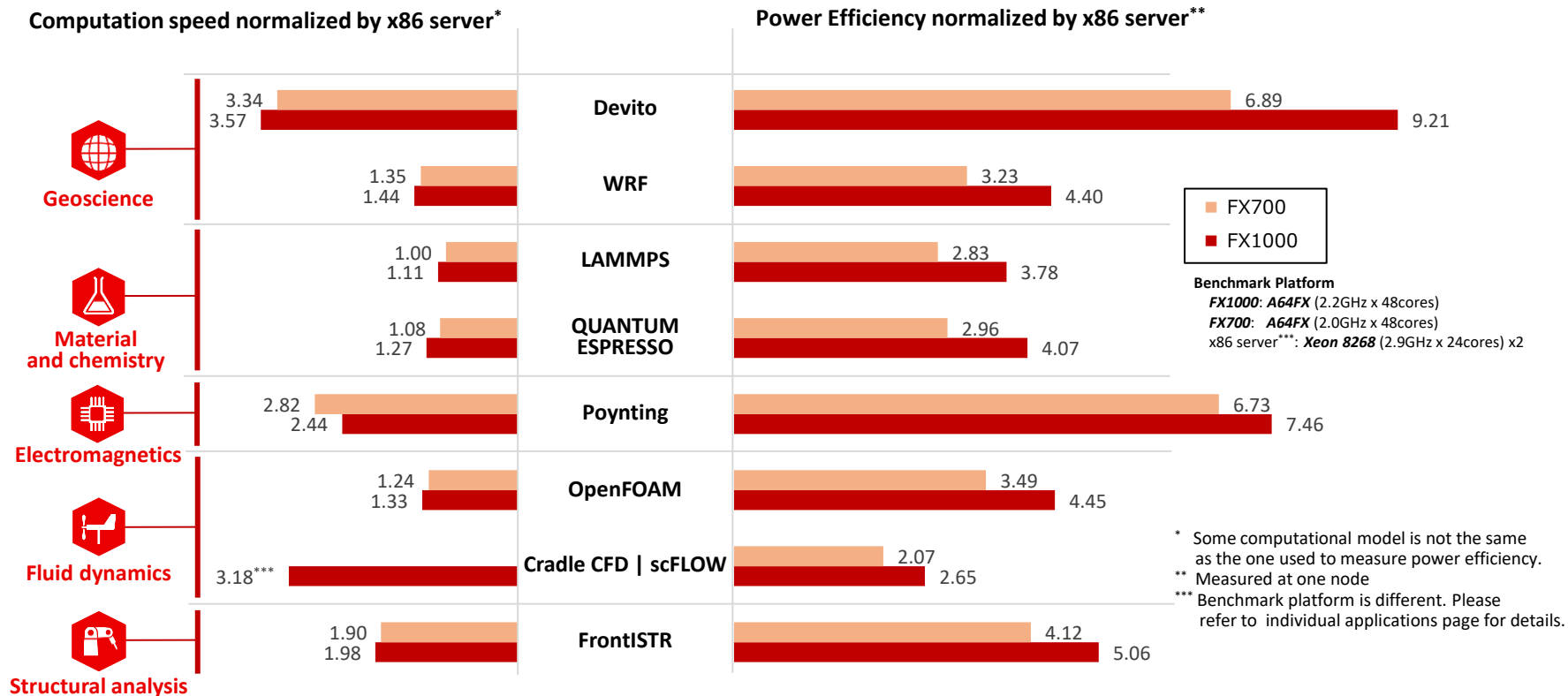
### PRIMEHPC FX700

Introduction model based on standard technology

- ✓ 8nodes/2U chassis
- ✓ Air cooling system
- ✓ InfiniBand

# Performance of FX1000 and FX700

○ In the five main categories, **FX1000** and **FX700** have better performance and power efficiency than x86 server.



# Commercial Applications

# Commercial Applications (as of October 2023)

Amber  
(by University of California, San Francisco.)

Gaussian 16  
(by Gaussian, Inc.)

VASP  
(by VASP Software GmbH)



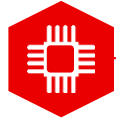
Chemistry



Fluid dynamics

COLMINA CAE Magnetic Simulator  
(by Fujitsu Limited)

Poynting  
(by Fujitsu Limited)



Electromagnetics



Fugaku

©RIKEN



Structural analysis



Others

Ansys Fluent

COLMINA CAE Particle-based Casting Simulator  
(by Fujitsu Limited)

**CONVERGE**  
CFD SOFTWARE

(by Convergent Science)

**Cradle | scFLOW**

(by HEXAGON | Cradle)

Simcenter STAR-CCM+

(by Siemens Digital Industries Software)

Ansys LS-DYNA

ESI Virtual Performance Solution (VPS)  
(by ESI Group)

NAG Fortran Compiler

(by nag)

= Already Available

= Verified on **Fugaku**

# Commercial Applications List (as of October 2023)

○ Availability of commercial applications for **FX1000** and **FX700**. Eleven applications were already verified on **Fugaku**(<sup>\*</sup>).

Categories	Applications	Vendors	Availability	Notes
Engineering (Fluid dynamics)	Ansys Fluent	ANSYS, Inc.	Available (beta version)	Solver components only
	COLMINA CAE Particle-based Casting Simulator	Fujitsu Limited	Available	Solver components only Verified on <b>Fugaku</b>
	CONVERGE	Convergent Science (East Asia distributor : IDAJ Co., LTD.)	Available	Solver components only Verified on <b>Fugaku</b>
	Cradle CFD   scFLOW	Software Cradle Co., Ltd.	Available	Verified on <b>Fugaku</b>
	Simcenter STAR-CCM+	Siemens Digital Industries Software	Available	Verified on <b>Fugaku</b>
Engineering (Structural analysis)	Ansys LS-DYNA	ANSYS, Inc.	Available	Verified on <b>Fugaku</b>
	ESI Virtual Performance Solution(VPS)	ESI Group	Available	Explicit features only Verified on <b>Fugaku</b>
Engineering (Electromagnetics)	COLMINA CAE Magnetic Simulator	Fujitsu Limited	Available	Verified on <b>Fugaku</b>
	Poynting	Fujitsu Limited	Available	Verified on <b>Fugaku</b>
Chemistry**	Amber	University of California, San Francisco	Available	Verified on <b>Fugaku</b>
	Gaussian 16	Gaussian, Inc.	Available	Verified on <b>Fugaku</b>
	VASP	VASP Software GmbH	Available	Verified on <b>Fugaku</b>
Others	NAG Fortran Compiler	Numerical Algorithms Group Ltd	Available	

\* Availability of commercial applications for **Fugaku** can be found from HPCI's web site (<https://www.hpci-office.jp/en>)

\*\* Collaboration with Australian National University

All application names used in this slide are trademarks or registered trademarks of their respective vendors.



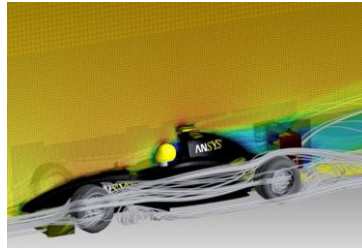
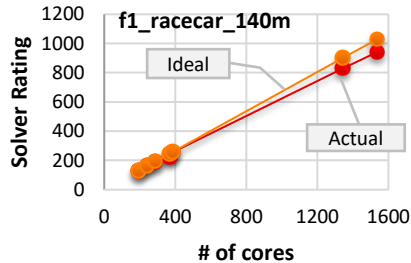
## About *Ansys Fluent*

- ✓ **Commercial CFD software** capable of creating advanced physics models and analyzing a variety of fluids phenomena
- ✓ Contains the best-in class physics models and can accurately and efficiently solve large, complex models
- ✓ More information : <https://www.ansys.com/products/fluids/ansys-fluent>
- ✓ Available on **FX1000** and **FX700**

## Verification and Performance evaluation

- ✓ **Ansys Fluent** alpha version (based on Ansys 2021 R2) for **FX1000/FX700**
  - The alpha version is built for generic Arm, and it includes scripts specific to Fujitsu PRIMEHPC
  - Available for **Ansys Fluent** users as requested
- ✓ Tested and evaluated on **FX1000/FX700**
  - The “Ansys Fluent Benchmarks” as the test cases
  - Up to 1,536 cores with f1\_racecar\_140m on **FX1000**

◆ Shows good scalability with the large model on **FX1000**



Computational model:  
External flow over a Formula-1 race car (140 million cells)

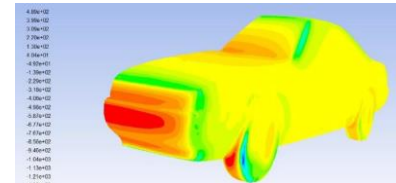
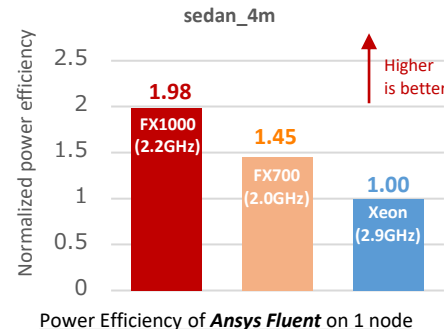
Scalability by *Ansys Fluent*'s "Solver Rating"

## Challenges on *Fugaku*\*

- ✓ Started performance evaluation on *Fugaku* from Nov 2021 for 6 months
- ✓ Planning to evaluate the performance and scalability using the largest model (280 million cells) of “Ansys Fluent Benchmarks” with more than 1,000 nodes

\* This work is using computational resources of the supercomputer *Fugaku* provided by RIKEN through the HPCI System Research Project (Project ID: hp210283).

◆ Power efficiency on **FX1000** and **FX700** is relatively better than **Xeon Platinum 8268** (2.9GHz)



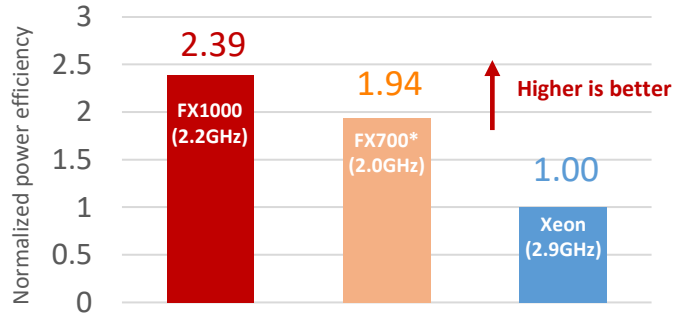
Computational model:  
External flow over passenger sedan (4 million cells)

## About **Ansys LS-DYNA**

- ✓ **Ansys LS-DYNA** is the industry-leading multi-physics simulation software used for complex real-world applications.
- ✓ **Ansys LS-DYNA** is the first-ever commercial CAE structural simulation software available on **FX1000**, **FX700** and **Fugaku**.
- ✓ Single precision **Ansys LS-DYNA** has been released in 2021, and double precision **Ansys LS-DYNA** will be release in 2022.  
<https://www.ansys.com/news-center/press-releases/10-15-2021-ansys-enables-more-sustainable-product-development-with-fujitsu>

## Verification and Performance evaluation

- ✓ Verified **Ansys LS-DYNA** key features.
- ✓ Verified parallel scalability up to 3,000 cores
- ✓ **Ansys LS-DYNA** on **FX1000** and **FX700** shows significant power efficiency.



**Ansys LS-DYNA** power efficiency on one node  
(Car to car model, 2.4 million elements)

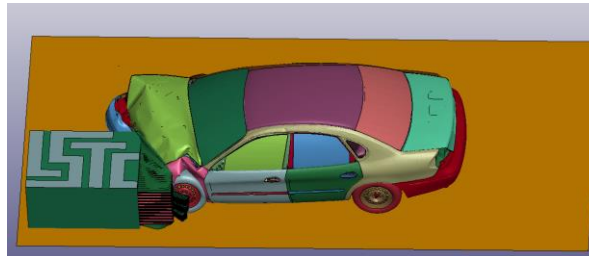
\*File system of FX700 is FEFS

## Challenge on **Fugaku** \*\*

Study of a high-performance and simulating complex real world problems:

- ✓ Car crash models of 30 millions elements was evaluated using 30000 cores on **Fugaku**
- ✓ JAMA has been conducting 12,000 cases of car crash simulation utilizing **Fugaku** with supporting of Fujitsu. JAMA has been collecting FEM analysis results with skeleton layout and strength balance as parameters and using these as teacher data of machine learning. By clarifying the correlation between the accuracy of machine learning predictions and the number of FEM analysis results accumulated, JAMA will revolutionize the conventional development process.

Fujitsu will work together with ANSYS, Inc. for higher parallel performance on **Fugaku**.



Car crash simulation image

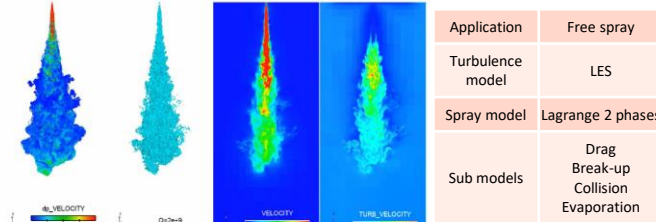
\*\*This work used computational resources of the supercomputer **Fugaku** provided by RIKEN through the HPCI System Research Project (Project ID: hp200228, hp210089).

## ○ About **CONVERGE**

- ✓ Commercial CFD software featuring **truly autonomous meshing, state-of-the-art physical models, a robust chemistry solver, and the ability to easily accommodate complex moving geometries**
- ✓ Used in various industries(engine cylinders, fuel injections, exhaust-gas aftertreatment devices, pumps, compressors, gas turbines, etc.)
- ✓ More information : <https://convergecf.com> / <https://www.idaj.co.jp/product/converge> (in Japanese)
- ✓ Available on **FX1000, FX700** and **Fugaku**

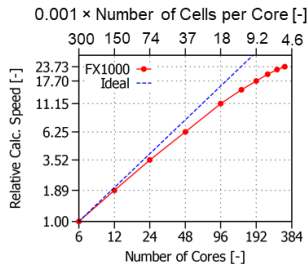
## ○ Verification and Performance evaluation

- ✓ Verified all features of **CONVERGE** on **FX1000** and **FX700**



Free spray analysis with using LES  
(Max. 10 million cells, 384 parallel on **FX1000**)

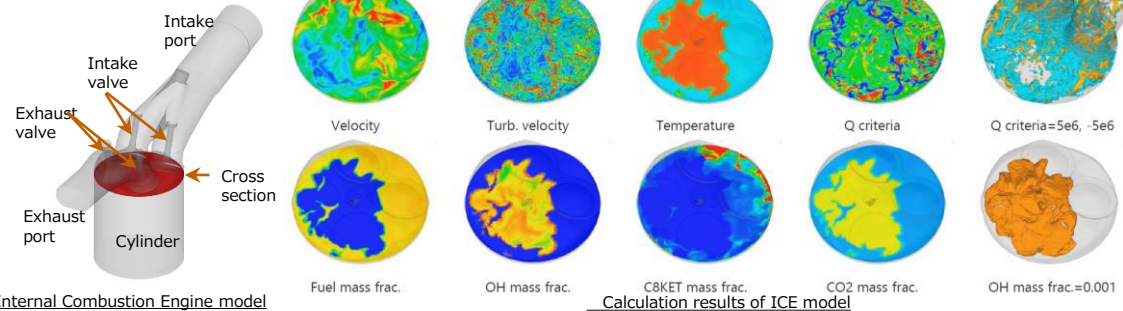
- ✓ Confirmed good scalability over 300 cores on **FX1000**



Scalability of steady port flow analysis

## ○ **CONVERGE** results on **Fugaku**\* : ICE combustion(LES, detailed chem)

- ✓ In-cylinder combustion simulation of Internal Combustion Engine(ICE) aims to evaluate heat release rate, emissions, knocking, etc., and eventually engine performance.
- ✓ Obtained wrinkled flame structure by **LES calculation with full-domain fine mesh** considering detail chemical reactions **in 2 hours**
- ✓ Expected to contribute not only to improve energy efficiency of conventional gasoline engines but also to **accelerate development speed of e-fuel engines** which is recently gathering attention, by **accurate knocking prediction in a practical calculation time**



Application	# of meshes	Mesh size	Turbulence model	Combustion model	# of parallel	Calculation time (combustion only)
ICE combustion	7 million (max.)	0.5mm (whole domain)	LES	Detailed chemistry	4,096	2 hours

## About *Cradle CFD | scFLOW*

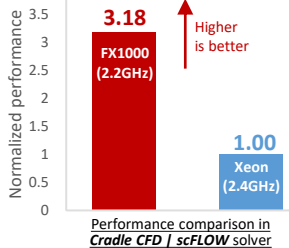
- ✓ Commercial CFD software with **multiphysics** and **general purpose** capabilities.
- ✓ Used in **various industries** (aerospace, automotive, construction, electronics, heavy manufacturing, medical and pharmaceutical, etc.)
- ✓ More information : <https://www.mscsoftware.com/product/scflow>
- ✓ Available on **FX1000**, **FX700** and **Fugaku**.

## Verification and performance evaluation

- ✓ Improved performance of the linear solver of system equation.

### Details

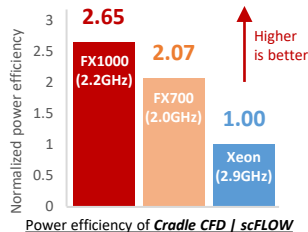
- Model : Aerodynamics of flow around car (108 million cells, RANS)
- 384procs x1thread
- (**Xeon 8260 Platinum**) 8nodes, (**FX1000**) 48nodes
- 100steps



- ✓ Power efficiency on **FX1000** and **FX700** is better than **Xeon Platinum 8268**.

### Details

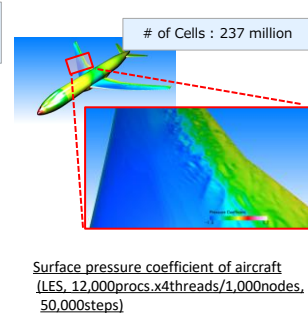
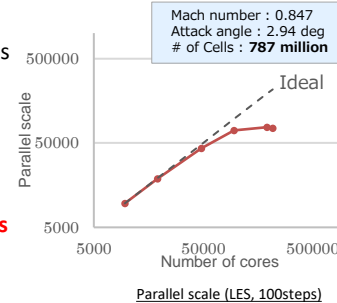
- Model : Aerodynamics of transonic-flow around aircraft (2 million cells, RANS)
- 48procs x1thread
- (**Xeon 8260 Platinum**) 1node, (**FX1000**) 1node, (**FX700**) 1node
- 2,000steps



## Challenges on *Fugaku*\*

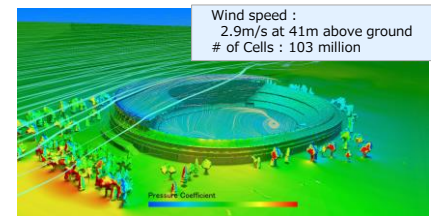
- ✓ **Achieved solving large-scale LES containing billions of element faces over the limitation of 32bit integer**

- ◆ Large-scale LES is important for the evaluation of stability and safety of aircrafts operations by a numerical simulation, especially for off-design conditions.
- ◆ Modified **Cradle CFD | scFLOW** code. It makes performance stably at over 48,000 hybrid parallel.
- ◆ **Max. 216,000 hybrid parallel / 4,500 nodes** was evaluated with 787 million cells model (containing 2.4 billion element faces).



- ✓ **Succeeded to create hundreds of millions of unstructured cells by parallelized mesher**

- ◆ Applied MPI parallelization into mesher of **Cradle CFD | scFLOW** in order to eliminates limitation of memory from meshing.
- ◆ Confirmed that the mesher succeeded to create max. 511 million of unstructured cells (model : National Stadium)



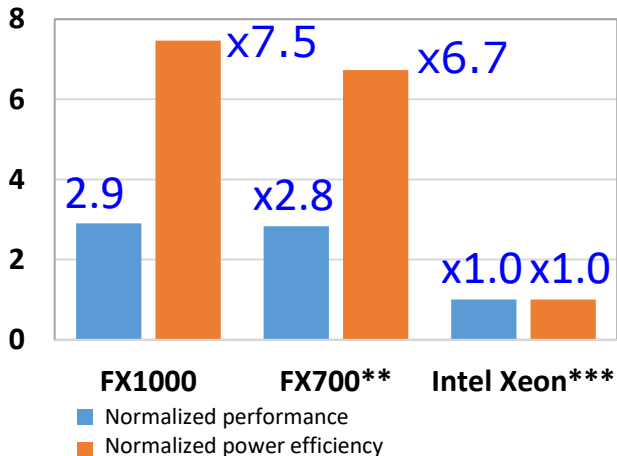
\*This work used computational resources of the supercomputer **Fugaku** provided by RIKEN through the HPCI System Research Project (Project ID: hp200209 and hp200302).

## ○ About *Poynting*

- ✓ *Poynting* is an electromagnetic wave analysis software based on FDTD method\* developed by Fujitsu.
- ✓ *Poynting* is an extremely advantageous electromagnetic wave analysis software on **FX1000** and **FX700**, because the FDTD\* method provides massive parallel efficiency while requires memory bandwidth.
- ✓ More information : <https://www.fujitsu.com/jp/solutions/business-technology/tc/sol/poynting/> (in Japanese)
- ✓ Available on **FX1000**, **FX700** and **Fugaku**

## ○ Verification and Performance evaluation

- ✓ Verified major features of Poynting solver
- ✓ Verified parallel scalability up to 115,200 cores
- ✓ Fujitsu Poynting on **FX1000** and **FX700** shows significant power efficiency.

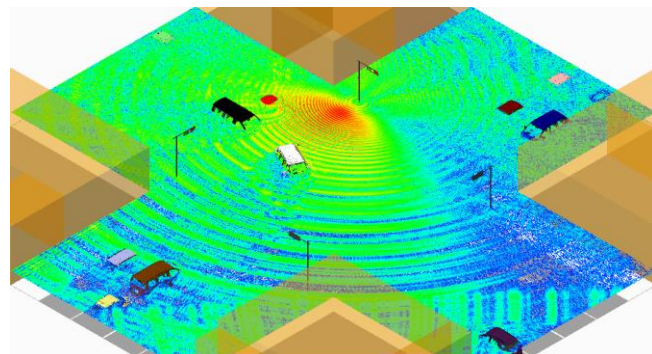


## ○ Challenge on *Fugaku* \*\*\*\*

- ✓ Verified extreme large-scale electromagnetic wave simulation with Poynting on **Fugaku**
- ✓ Verified 0.5 trillion cells model of 5G “Vehicle to Vehicle” and “Vehicle to Infrastructure” communications around a crossroad in 2 hours
- ✓ Verified that it is possible to consider the influence of fine(~5cm) structures in a space of the size of a crossroad(~100m), which was not possible with approximation methods such as ray tracing simulation



Number of Cells: **0.5 Trillion cells**  
 Calculation time:  
**2 hours on 115,200 cores of Fugaku**



Results of Simulation:  
**Electric field distributions around moving vehicles across a crossroad.**

\*FDTD method : finite-difference time-domain method \*\*File system of FX700 is FEFS \*\*\*Intel **Xeon Platinum 8268** x2sockets(2.9GHz x 24core)  
 \*\*\*\*This work used computational resources of the supercomputer **Fugaku** provided by RIKEN through the HPCI System Research Project (Project ID: ra010012).  
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○ **Japan Automobile Manufacturers Association (JAMA)** has started evaluating leading-edge computer aided engineering for automobile on supercomputer **Fugaku** with **Fujitsu's** supports since FY2020

- ✓ In FY2020, car crash models of 4 – 30 millions elements were evaluated, using **Ansys LS-DYNA** and **VPS** on **Fugaku** \*.
- ✓ In FY2021, to develop technologies improving the accuracy of crash performance prediction, JAMA has been conducting 12,000 cases of crash simulation utilizing **Fugaku** \*. Also, fluid dynamics using **Simcenter STAR-CCM+** will be evaluated on **Fugaku**.

\*This work used computational resources of the supercomputer **Fugaku** provided by RIKEN through the HPCI System Research Project (Project ID: hp200228, hp210089).

## Ansys LS-DYNA

- ✓ **Ansys LS-DYNA** is a multiphysics simulation software capable of solving complex real world problems.



## ESI Virtual Performance Solution (VPS)

- ✓ **VPS** is the world first car crash simulation software and later expanded to the other structural simulations by leveraging its Single Core Modeling concept.



## Simcenter STAR-CCM+

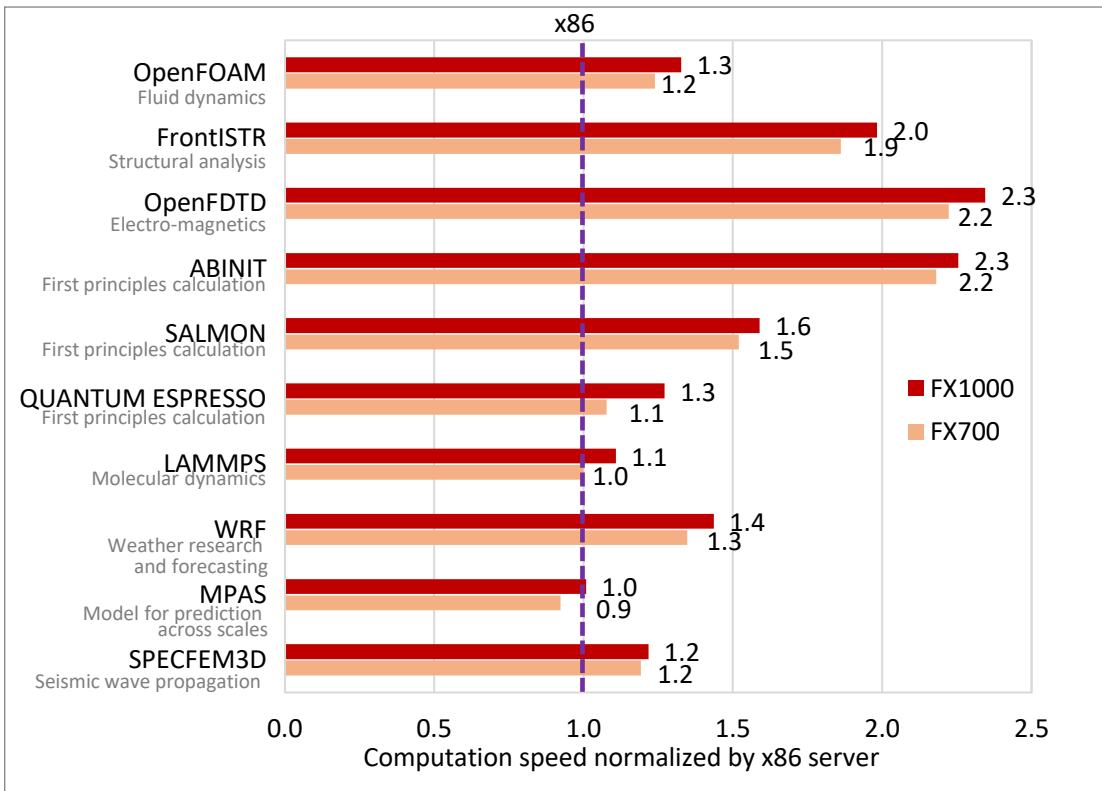
- ✓ **Simcenter STAR-CCM+** is a multiphysics computational fluid dynamics (CFD) software for the simulation of products operating under real-world conditions.



# Open-Source Software (OSS) Applications

# OSS Performance on FX1000 and FX700

## ○ Computation speed of **FX1000** and **FX700** compared with x86 server



- Computation speed of **FX1000** and **FX700** is faster than x86 server up to 2.3 times with these OSS.
- Performance is improved by
  - ✓ Enhanced microarchitecture (SVE)
  - ✓ High bandwidth memory(HBM)
- Several software are improved by code tuning and enhancement of compiler and libraries.



### Benchmark Platform

**FX1000: A64FX** (2.2GHz x 48cores)

**FX700: A64FX** (2.0GHz x 48cores)

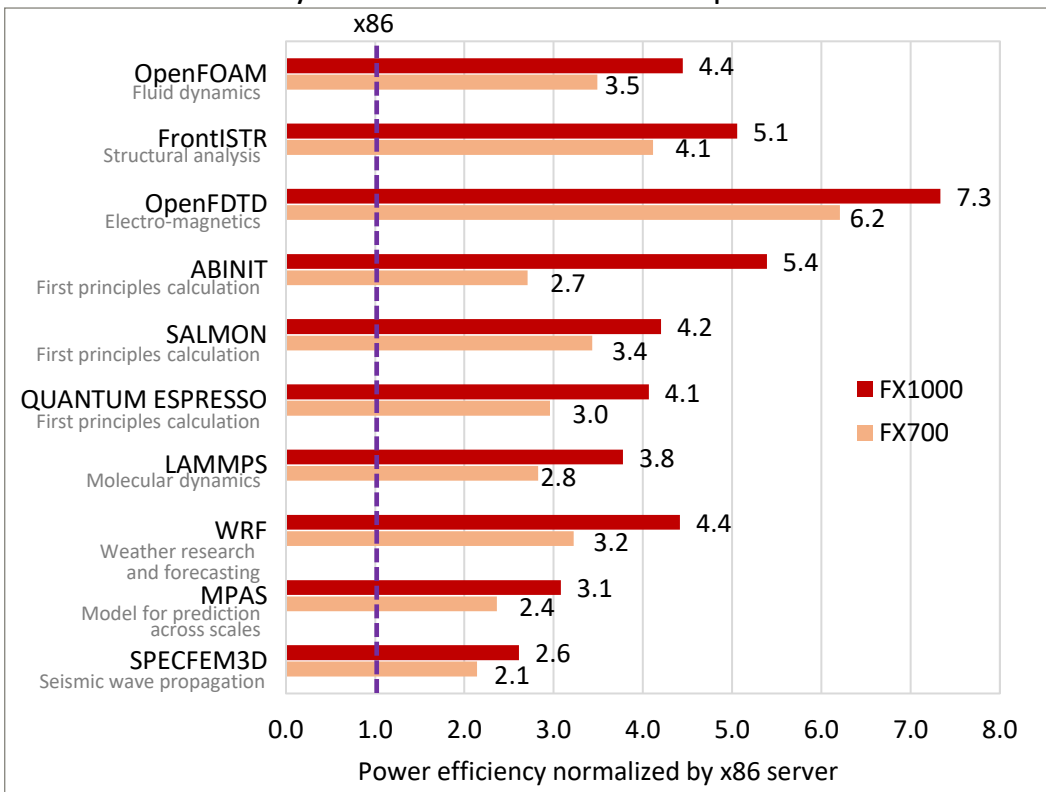
x86 server: **Xeon 8268** (2.9GHz x 24cores) x2





# OSS Power Efficiency on FX1000 and FX700

## Power efficiency of **FX1000** and **FX700** compared with x86 server



- Power efficiency of **FX1000** and **FX700** is at least twice greater than that of x86 server. **FX1000** and **FX700** have significant advantage of power efficiency in comparison with x86 server.
- The energy-saving technology developed for **Fugaku** which won the top of Green500 is applied to **FX1000**. This technology provides exceptional performance/power rates in large-scale systems. **FX700** contains the air-cooling system in each chassis and power efficiency is a bit less than **FX1000**.



**FX1000**



**FX700**

### Benchmark Platform

**FX1000:** A64FX (2.2GHz x 48cores)

**FX700:** A64FX (2.0GHz x 48cores)

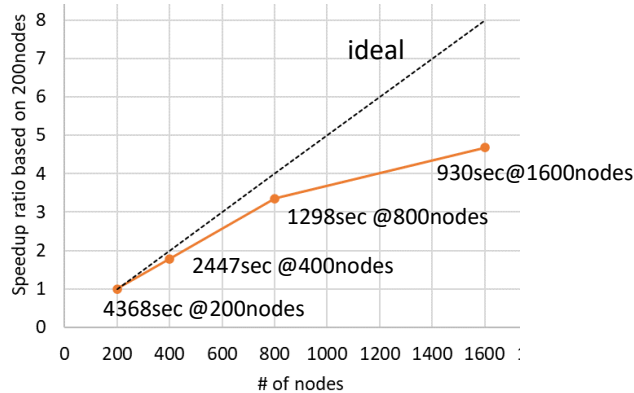
x86 server: **Xeon 8268** (2.9GHz x 24cores) x2

## About *FrontISTR*

- ✓ *FrontISTR* is an open-source large-scale parallel FEM program for structural analysis. It is implemented to run various nonlinear structural analyses including large deformation, contact, and various nonlinear materials on a parallel computer.
- ✓ *FrontISTR* is developed by *FrontISTR Commons* and distributed at <https://www.frontistr.com/> (in Japanese). A tuned code for *A64FX* is available at [github.com \(https://github.com/fujitsu/FrontISTR\)](https://github.com/fujitsu/FrontISTR)

## Performance evaluation

We verified scalability of *FrontISTR* on *Fugaku* up to 1600nodes using a 76 million elements short-fiber composite rubber analysis model.



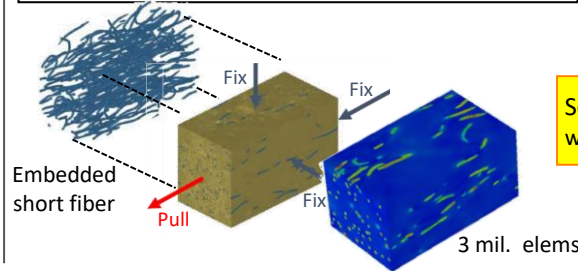
Strong scalability of *FrontISTR* (considering geometrical and material nonlinearity, 13 timesteps, CG with SSOR solver, 4p12t/node)

## Challenge on *Fugaku*\*

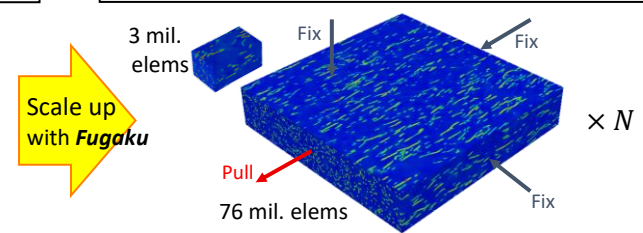
Mitsubishi Belting Ltd. studies on short fiber composite rubber with Fujitsu's support

- ✓ A large-scale analysis is required to evaluate mechanical properties of short fiber composite rubber used in friction transmission belts. Only confirming the stress concentration area is possible in current analysis scale.
- ✓ We confirmed that large-scale analysis can be done in a practical time through a benchmark using 76 million elements model with 200 to 1,600 nodes at *Fugaku*.
- ✓ It is planned to run multiple cases in the future to clarify the relationship between mechanical properties and fiber state such as fiber length, swell and orientation variation.

Current: 2mm x 1mm x 1mm area, single case



Target: 5mm x 5mm x 1mm area, multiple cases



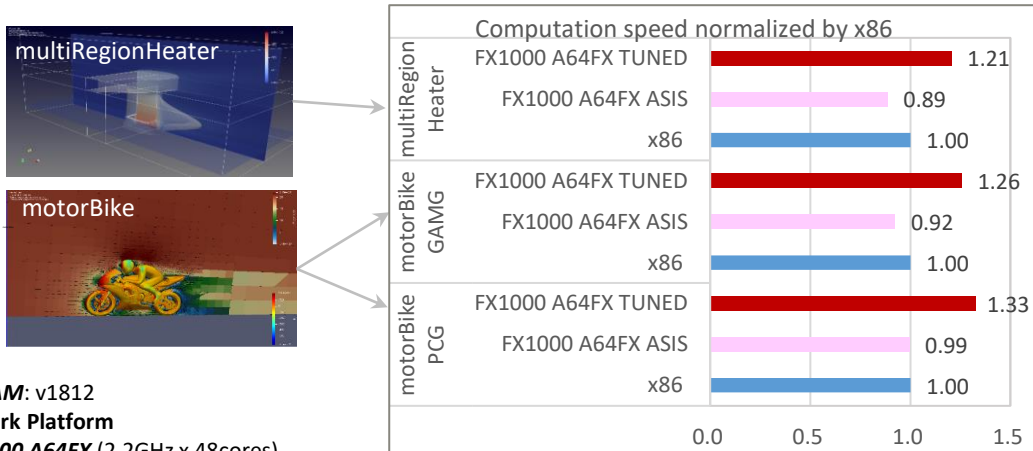
\*This works was conducted as part of the RIKEN-FOCUS-VINAS collaborative research aimed at the verification of industrial applications for the *Fugaku* Cloud Platform.

## About *OpenFOAM*

- ✓ **Open-source Field Operation And Manipulation (OpenFOAM)** is Open-source CFD software which has various functionality of fluid dynamics simulation, including thermal conduction and turbulence analysis (<https://www.openfoam.com/>).

## Performance evaluation

- ✓ Computation speed is better than x86 in most cases. It is much enhanced by code tuning. The optimization of loop structure to enhance vectorization (more efficient use of SIMD) in code tuning has significant effect with Computation speed for **A64FX**.
- ✓ Two benchmark models were calculated. One is aero-dynamics of motorBike (LES) and another is thermal fluid of multiRegionHeater (RANS). Two matrix solvers PCG and GAMG are applied to computation of motorBike model.



OpenFOAM: v1812

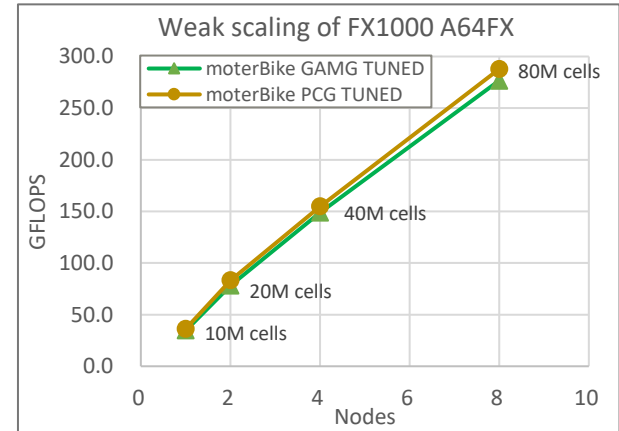
Benchmark Platform

FX1000 A64FX (2.2GHz x 48cores)

x86: Xeon 8268 (2.9GHz x 24cores) x2

Input data: multiRegionHeater and motorBike

Two benchmarks were calculated. Asis and tuned code are used in **FX1000**. High Computation speed is obtained compared with x86. (multiRegionHeater: 15M cells, motorBike:10M cells)



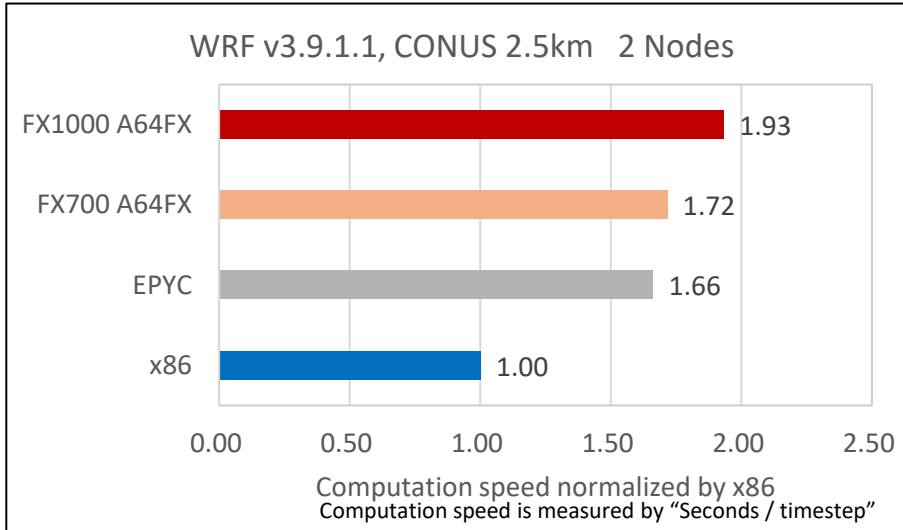
Weak scaling is shown. The size of input data is changed with the number of cores. **FX1000** has good weak scalability and computation scale increases with the number of nodes.

## About *WRF*

- ✓ **The Weather Research and Forecasting (WRF) Model** is a next-generation mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications. It features two dynamical cores, a data assimilation system, and a software architecture supporting parallel computation and system extensibility. (<https://www.mmm.ucar.edu/weather-research-and-forecasting-model>)

## Performance evaluation

- ✓ The performance of *WRF* on **A64FX** systems shows better performance than other platforms because of high memory bandwidth.
- ✓ The benchmark model “CONUS 2.5km” was applied to the estimation. Two node are used to calculate this benchmark model.



### **WRF: version 3.9.1.1 (Tuned code)**

#### **Benchmark platform**

**FX1000 A64FX** (2.2GHz x 48cores)

**FX700 A64FX** (2.0GHz x 48cores)

x86: **Xeon P8260M** (2.4GHz x 24cores) x2

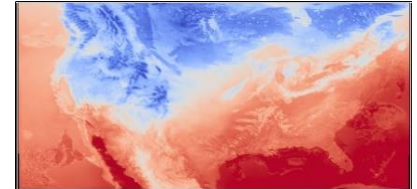
**EPYC : 7742** (2.25GHz x 64cores) x2

#### **Input data**

CONUS 2.5km

- 1501x1201x35

- 3 hours forecasting



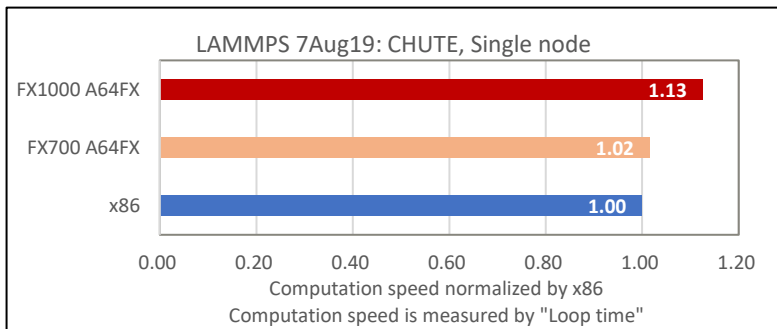
([https://www2.mmm.ucar.edu/wrf/bench/benchdata\\_v3911.html](https://www2.mmm.ucar.edu/wrf/bench/benchdata_v3911.html))

## About LAMMPS

- ✓ **Large-scale Atomic / Molecular Massively Parallel Simulator (LAMMPS)** is a classical molecular dynamics simulation code with a focus on materials modeling. It was designed to run efficiently on parallel computers. (<https://www.lammps.org/>)

## Performance evaluation

- ✓ The performance on **FX1000** was achieved 1.12x faster than x86. SIMD and efficient data access enhance performance of **FX1000** and **FX700**.
- ✓ The benchmark model CHUTE was applied to this estimation. Two sections “PAIR” and “MODIFY” which account for 90% of loop time with CHUTE were tuned to obtain fine performance of SIMD and high memory bandwidth.



LAMMPS: version 7Aug19 (Tuned code)

Benchmark platform

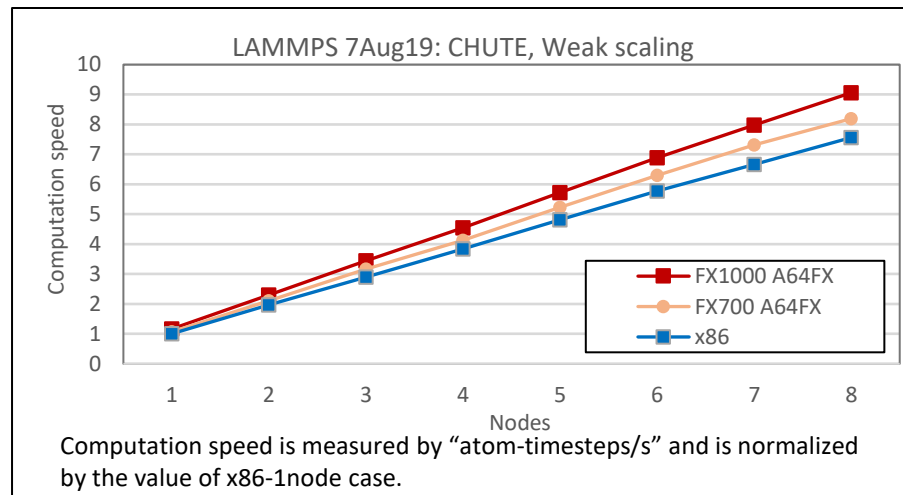
FX1000 A64FX (2.2GHz x 48cores)

FX700 A64FX (2.0GHz x 48cores)

x86: Xeon P8260M (2.4GHz x 24cores) x2

Input data: “CHUTE” Granular chute flow

12,800,000 atoms (/node) for 100 timesteps



Computation speed is measured by “atom-timesteps/s” and is normalized by the value of x86-1node case.

Ideal scalability is shown on **FX1000** and **FX700**

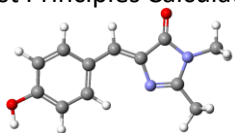
## About **QUANTUM ESPRESSO**

- ✓ **QUANTUM ESPRESSO** is an integrated suite of Open-Source computer codes for electronic-structure calculations and materials modeling at the nanoscale. It is based on density-functional theory, plane waves, and pseudopotentials (<https://www.quantum-espresso.org/>).

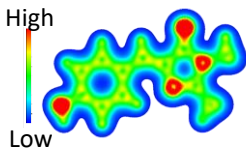
## Performance evaluation

- ✓ **A64FX** performance measurement for **QUANTUM ESPRESSO 6.4.1**

- ✓ First Principles Calculation

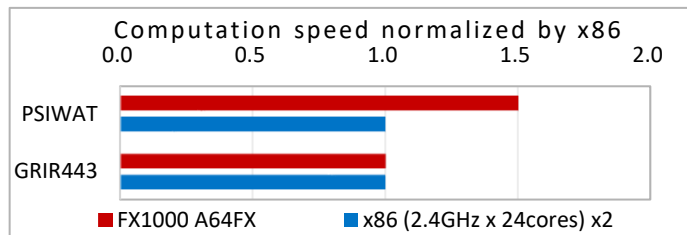


Molecular Geometry



Calculation of Electron Density

- ✓ **A64FX** is 1.5x faster over the x86 (2.4GHz x 24cores) x2 in QEF benchmark



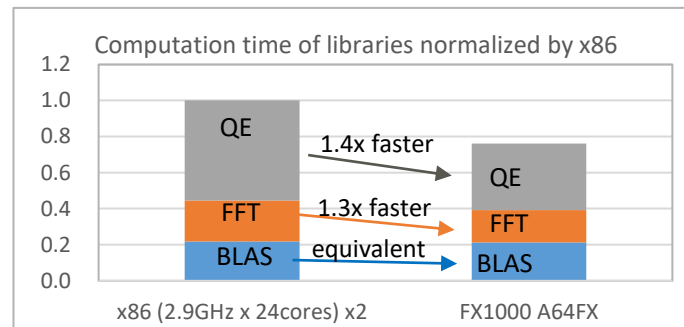
PSIWAT: QEF/benchmarks/PSIWAT/psiwat.in, 8 nodes  
GRIR443: QEF/benchmarks/GRIR443/grir443.in, 8 nodes

### Benchmark platform

**FX1000 A64FX** (2.2GHz x 48cores)  
x86: **Xeon P8260M** (2.4GHz x 24cores) x2

- ✓ **A64FX** is 1.3x faster over the x86 processor (2.9GHz x 24cores) x2 in structural optimization simulation

- QE<sup>\*1</sup>: 1.4x faster by high memory b/w and using SIMD instructions
- FFT<sup>\*2</sup>: 1.3x faster by long data-length and using SIMD instructions
- BLAS<sup>\*3</sup>: Equivalent performance by using cache and SIMD instructions



\*Input-data: Structural Optimization Simulation (SCF calculation),  
Based on QEF/benchmarks/small-benchmarks/test\_1.in, 224 atoms

\*1: ELPA used for deriving eigenvalue (<https://github.com/fujitsu/elpa>)

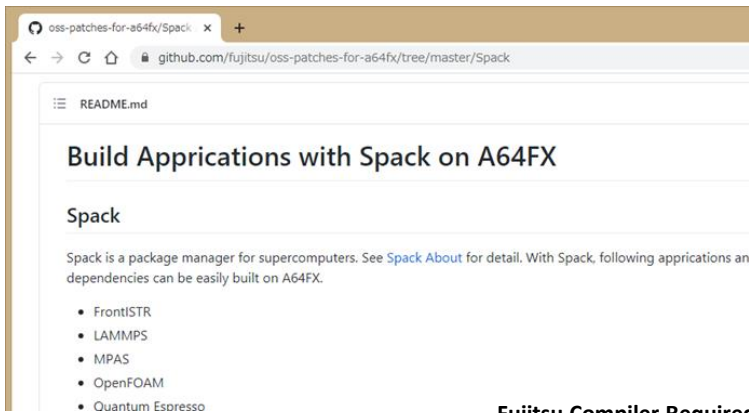
\*2: FFTW3 Library tuned by FUJITSU (<https://github.com/fujitsu/fftw3>)

\*3: FUJITSU SSL II Library

### Benchmark platform

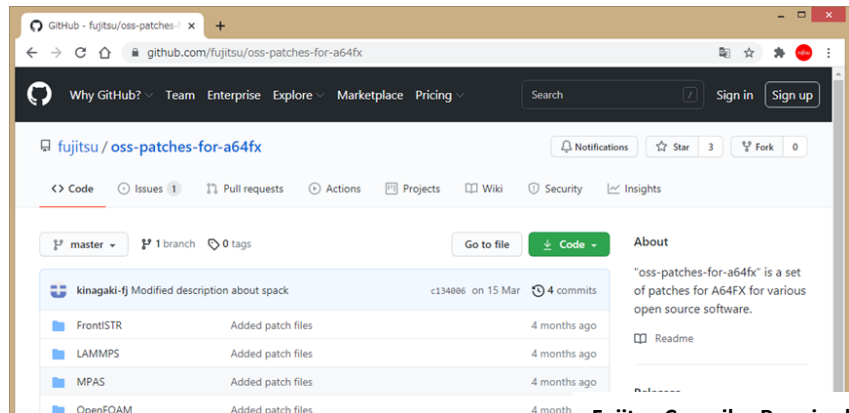
**FX1000 A64FX** (2.2GHz x 48cores)  
x86: **Xeon 8268** (2.9GHz x 24cores) x2

## Installation guides and build scripts using Spack



Fujitsu Compiler Required

## Performance tuning information and patches



Fujitsu Compiler Required

### ○ Target OSS



### ○ Target OSS



### ○ Information site (Provided by Spack\*)

<https://github.com/fujitsu/oss-patches-for-a64fx/tree/master/Spack>

### ○ Information site (Fujitsu official Github)

<https://github.com/fujitsu/oss-patches-for-a64fx>

\*Spack : An OSS package manager developed at Lawrence Livermore National Laboratory. For various computing environments and applications, a build script called a recipe is prepared, and the tool can build the application including the dependent library with one command. <https://spack.readthedocs.io/en/latest/>

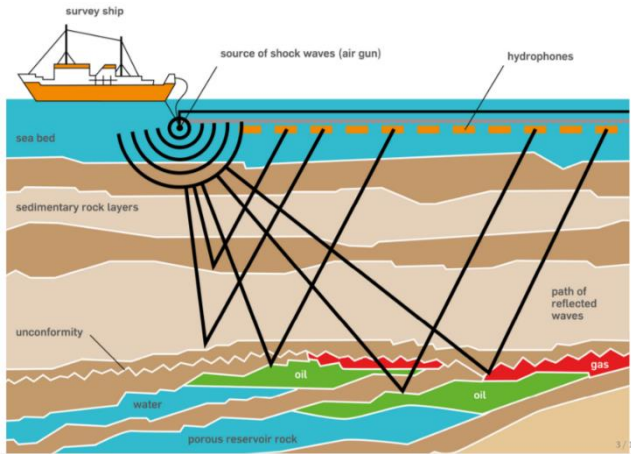
# Open-Source Oil & Gas Applications evaluated with Arm ecosystem collaborators



# A64FX advantage in Oil & Gas applications

- ✓ **Seismic simulation** = important technology for Oil & Gas vendors
- ✓ Requires a huge amount of 3D data calculation to identify the geological structure
- ✓ Can benefit from **High Bandwidth Memory** and **Scalable Vector Extension** of **A64FX**

## ➤ **Seismic Simulation** image

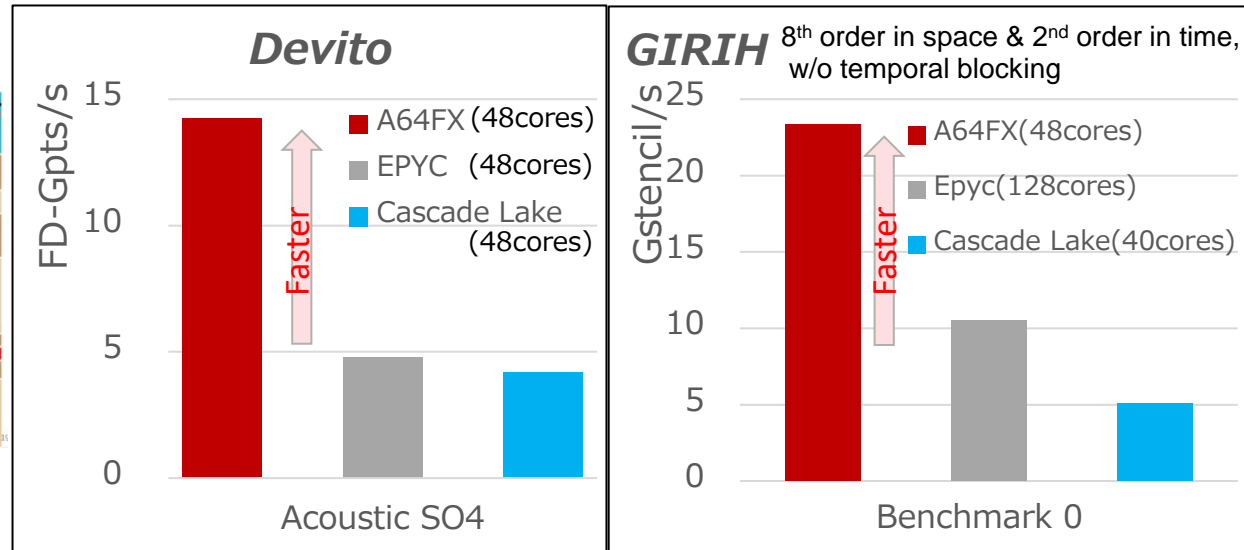


<https://www.devitoproject.org/>



<https://github.com/ecrc/girih>

## ➤ Example of **Seismic Simulation** Performance on **A64FX**



## ○ About *Devito*

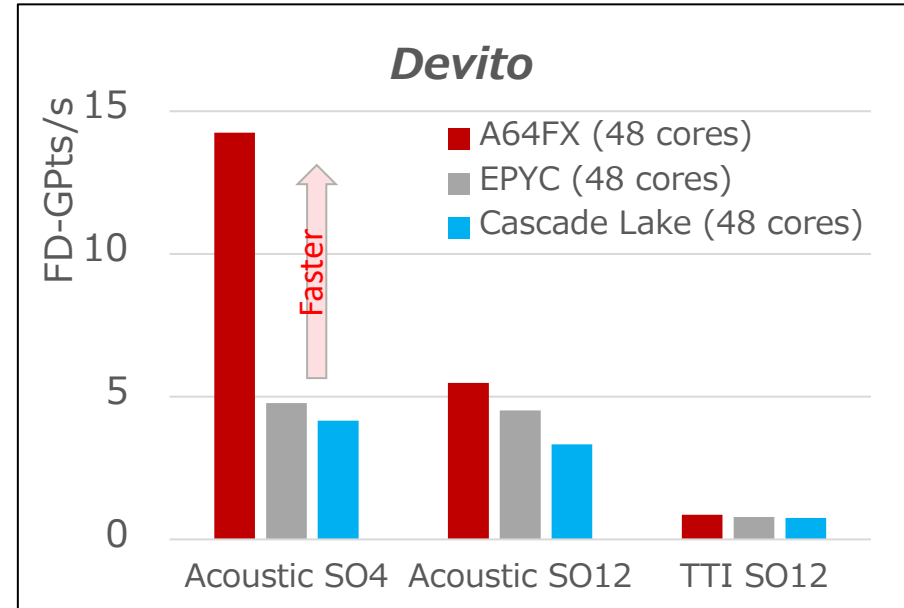
- ✓ Domain-specific Language (DSL) and code generation framework for the design of highly optimized finite difference kernels for use in inversion methods, developed by **Imperial college London** <https://www.devitoproject.org/>

## ○ Performance Data

- ✓ **A64FX** shows remarkable performance over other CPUs especially acoustic model of 4<sup>th</sup> space order (SO4)
- ✓ **HBM (High Bandwidth Memory)** and **SVE (Scalable Vector Extension)** contribute this advantage.

- ✓ Reference:  
[https://www.youtube.com/watch?v=-2LrXL6Y2g&list=PLcsG4X8Zn\\_UAdbYQODr5PQLCcdCo\\_sovO&index=36&t=61s](https://www.youtube.com/watch?v=-2LrXL6Y2g&list=PLcsG4X8Zn_UAdbYQODr5PQLCcdCo_sovO&index=36&t=61s)

- **A64FX**: 2.2GHz 48cores 32GB HBM2  
12 threads x 4 MPI process to fit A64FX Core Memory Group
- **Xeon 9275CL**: 2.4GHz 24cores x 2 sockets
- **EPYC 7R32**: 3.3GHz 48cores



## ○ About **GIRIH**

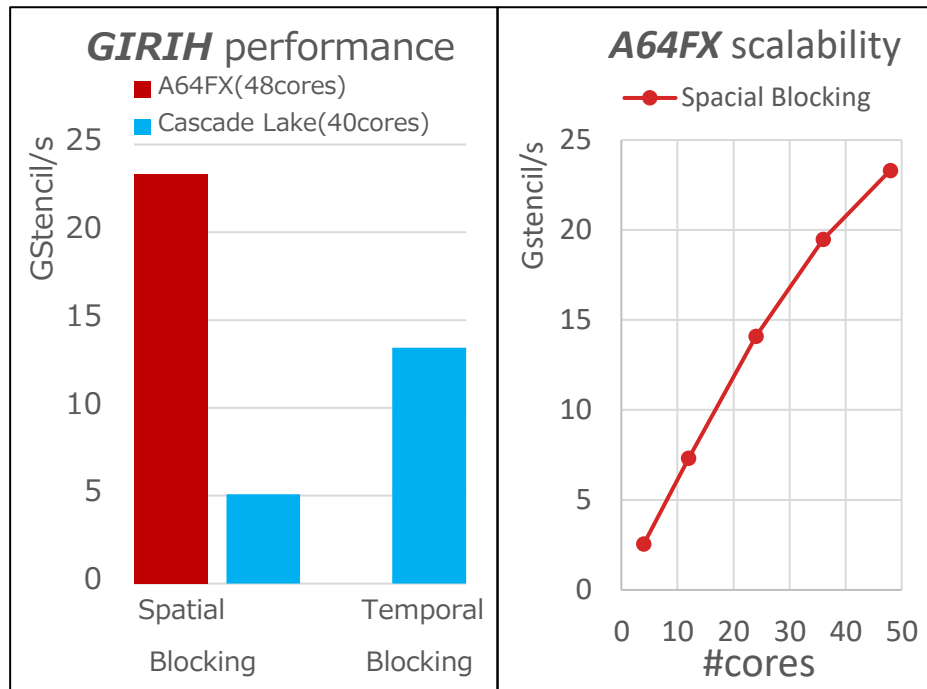
- ✓ A high-performance stencil framework using multicore wave front diamond tiling, developed by **Extreme Computing Research Center** at **KAUST** \*
- ✓ Spatial and temporal blocking techniques are implemented

## ○ Performance Data

- ✓ **A64FX** shows remarkable performance and scalability with spatial blocking, compared with spatial/temporal blocking performance on **Cascade Lake**.
- ✓ **HBM (High Bandwidth Memory)** and **SVE (Scalable Vector Extension)** contribute this advantage.

- 8<sup>th</sup> order, domain size 1024x1024x512, Single precision (benchmark 0)
- **A64FX**: 2.2GHz 48cores 32GB **HBM2** (Tuned code) 1/3/6/9/12 threads x 4 MPI process to fit **A64FX CMG (CMG=Core Memory Group)**
- **Cascade Lake** performance are quoted from **github** <https://github.com/ecrc/girih> and provided by **KAUST**.

\* **KAUST: King Abdullah University of Science and Technology**



**Thank you**

