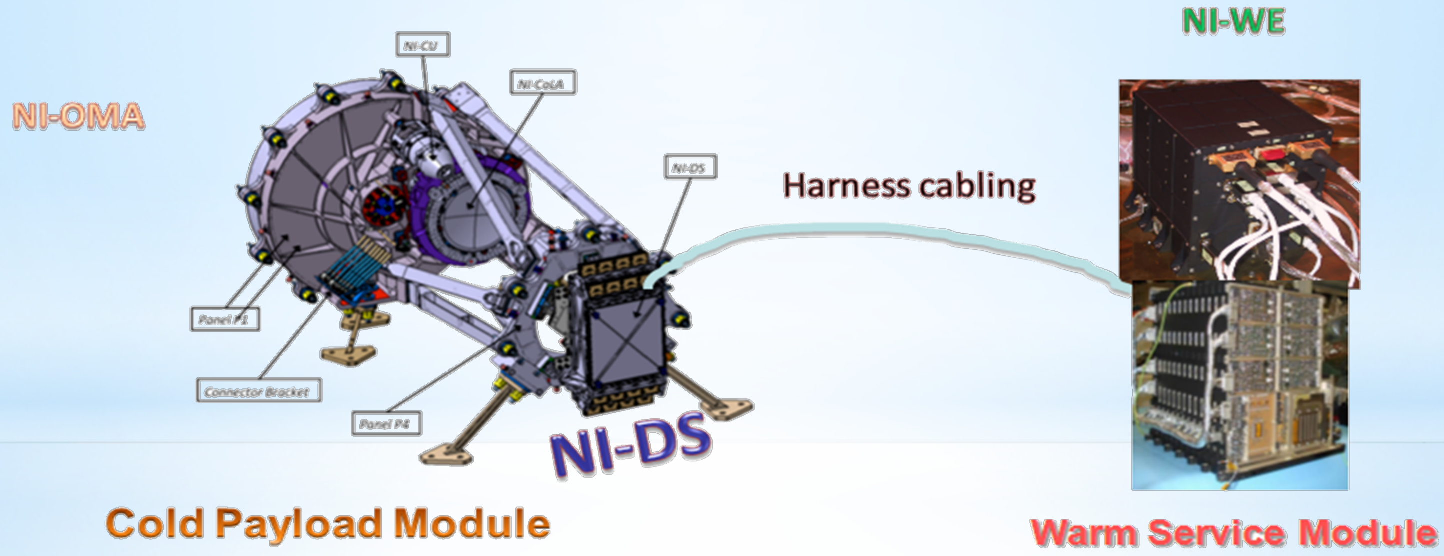
Assembly Integration and Verification (AIV) of the Near Infrared Spectro-Photometer’s (NISP) Warm Electronics (WE) in the EUCLID mission



Fulvio Laudisio

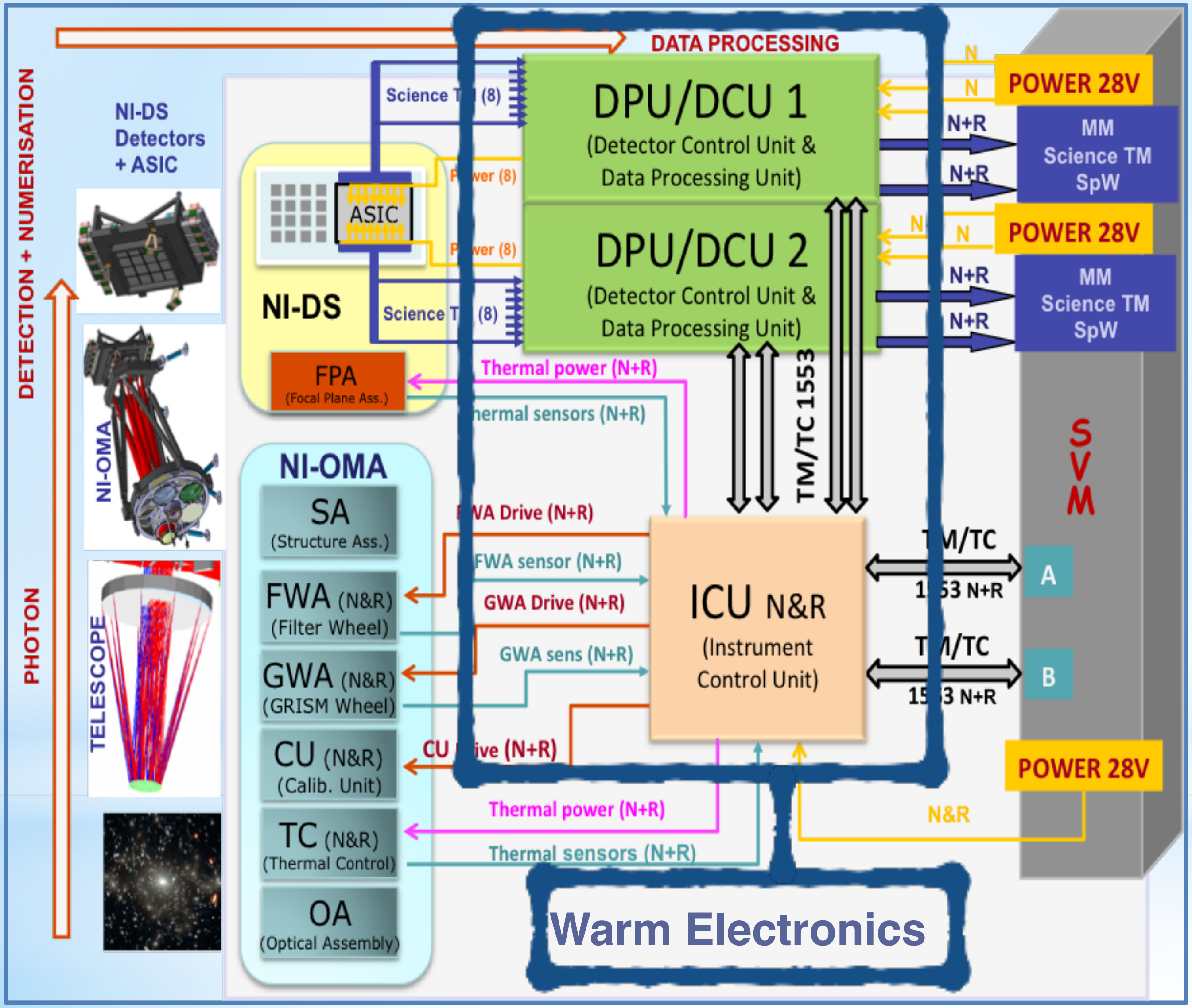
Università degli Studi di Padova

CISAS G. Colombo

The Euclid Mission

- **ESA mission**
- Selected in Oct. 2011 - Fully funded
- Partners: ESA, TAS, Airbus DS, Euclid Consortium (EC)
- Overall mass: ~2020 kg, Power : 1920 W (EOL)
- Data rate: 850 Gbit/day
- Telescope (T=125K, passive):
  - 1.2m aperture primary, 3 mirror Korsch anastigmat
- 2 Instruments (VIS, NISP) – T = 100-140 K (passive)
  - Wide field instrument, VIS: 36 e2v 4kx4k CCDs $0.55<\lambda<0.92$ µm, 576 M pixels, 0.11 arcsec/pix, 0.53 deg^2 FoV
  - Photom. (Y, J, H) +spectrom.: 16 H2GR HgCdTe detectors;
  - 64 Mpixels, 0.30 arcsec/pix, 0.53 deg^2 FoV (=VIS)
  - Grism slitless spectro (1B + 3R grisms) $0.92<\lambda<2.05$ µm, R>250
- Downlink Rate: X/X + K-band to Ground Station 55 Mbits/s. 850 Gbit/day to transfer 4hr/day.
- Ground Segment: ESA (50%,) EC (50%, EC leads science and external data): 1.5 billion galaxies for WL, 30 million redshifts, 12 billion sources (3sigma)
- L2 orbit
- Launch Vehicle – Soyuz-Fregat
- Launch date 2020, from Kourou space port
- 6.25 years mission + additional surveys (exopl, SN)
- Main surveys: 15,000 deg^2+40 deg^2 2 mag. deeper
- Science drivers: DE
- Science leads: Euclid Consortium

NISP Warm Electronics



DPU/DCU

- Data acquisition
- Data processing
- Data compression
- Data transfer to satellite memory

ICU

- Filter wheel & grism wheel control
- Telecommands dispatching
- Telemetry acquisition and transfer to SVM

Activities for the AIV

- ✓ Development of simulators for the missing hardware: ad hoc software running on pc implementing the communication interface.
- ✓ Preparation of test sequences for each requirement declared on the starting documents.
- ✓ Running the tests and compile the reports
- ✓ Write the documentation for all the operations that will be repeated on the upcoming hardware for the next phases (Electro Qualified Model and Flight Models)

Hardware Testing

- All the tests will be repeated in a space like environment.

- Thermal, and electrical, response of the hardware and of the detectors will be checked at LAM (Laboratoire d'Astrophysique de Marseille)

45 m^3 crio-vacuum chamber
77K and 10^{-6} mbar

Thank you for your attention

May I Introduce Myself

Daniela Piccioni Koch daniela.piccioni@kit.edu
KIT – SCC Germany

Karlsruhe Institute of Technology (KIT)
The Research University in the Helmholtz Association

The Karlsruhe Institute of Technology (KIT), was established by the merger of the ForschungsZentrum Karlsruhe (FZK) GmbH and the Universität Karlsruhe (TH) on 1st October, 2009.

Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

With more than 9,000 employees and an annual budget of about EUR 785 million, KIT is one of the biggest research and education institutions worldwide.
KIT combines the tasks of a university of the state of Baden-Württemberg with those of a research center of the Helmholtz Association in the areas of research, teaching, and innovation.

Universität Karlsruhe was founded in 1825 as a Polytechnic and ForschungsZentrum Karlsruhe was founded in 1956 as Nuclear Reactor Facility, whose first reactor (named FR2) started operation in 1962 .

Karlsruhe – The Fan(Fun) City

KIT
Karlsruher Institut für Technologie

SCC
Steinbuch Centre
for Computing

KIT
Karlsruhe Institute of Technology

First **Draisine** in1817
by **Karl** Freiherr von **Drais** (KA, 1785-1851)

“A castle at the center, from which the streets radiate in fan-like form: so 300 years ago, according to legend, the city founder Margrave Karl-Wilhelm von Baden-Durlach, saw his residence in a dream. On 17 June 1715, he had the foundation stone laid that would make his dream a reality.” (Dr. Frank Mentrup, Chief Burgomaster of Karlsruhe).

Karlsruhe Main Train Station Nowadays

„Yes, but with  !“

The Information Technology Centre of KIT

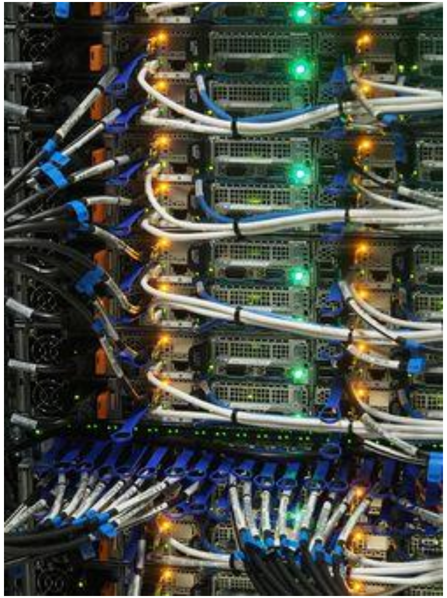
The Steinbuch Centre for Computing (SCC) is the information technology centre of KIT, which is named after the Karlsruhe computer scientist Karl Steinbuch (1917-2005). Its activities focus on research, development and innovation in the fields of **high performance computing (HPC), data intensive computing (DIC), and secure IT federations**. SCC's research focuses on scientific computing, modelling and simulation, data analysis, grids, cloud and cluster computing, innovative network technologies, IT security, and virtualisation. SCC operates very powerful HPC systems, which are used by regional and federal scientists from academia and industry for computationally intensive projects.

In this context the SCC **Simulation laboratories (SimLabs) 1.Energy, 2.Nanomicro, 3.Climate and Environment** represent the interfaces between users and High Performance Computing providers. Their main task is the software enhancement for an efficient use of supercomputers and distributed systems in interdisciplinary research and development. https://www.scc.kit.edu/en/research/5960.php

KIT HPC Systems – bwUniCluster

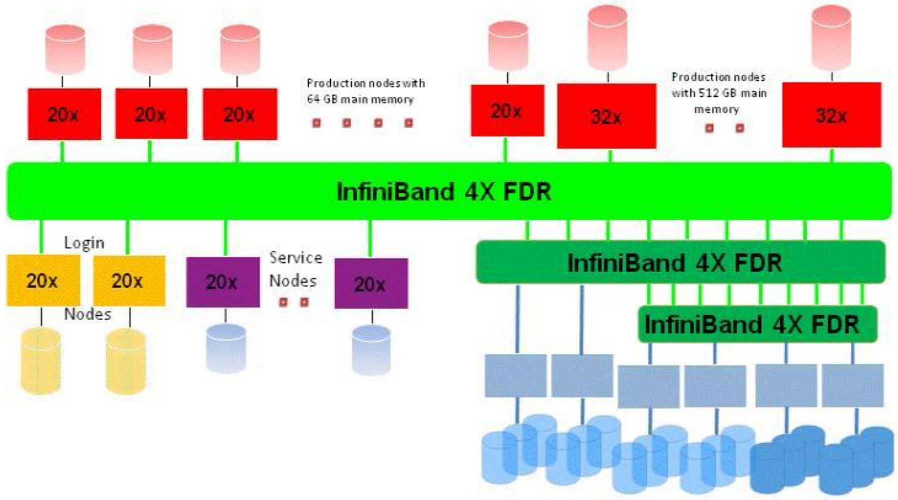
The bwUniCluster is a parallel computer with distributed memory. Each node has sixteen Intel Xeon processors, local memory, disks and network adapters. All nodes are connected by a fast InfiniBand 4X FDR interconnect. In addition the file system Lustre, that is connected by coupling the InfiniBand of the file server with the InfiniBand switch of the compute cluster, is added to bwUniCluster to provide a fast and scalable parallel file system.

	Compute nodes "Thin"	Compute nodes "Fat"	Compute nodes "Broadwell"	Login nodes "Thin / Fat"	Login nodes "Broadwell"	Service nodes
Number of nodes	512	8	352	2	2	10
Processors	Intel Xeon E5-2670 (Sandy Bridge)	Intel Xeon E5-4640 (Sandy Bridge)	Intel Xeon E5-2660 v4 (Broadwell)	Intel Xeon E5-2670 (Sandy Bridge)	Intel Xeon E5-2630 v4 (Broadwell)	Intel Xeon E5-2670 (Sandy Bridge)
Processor frequency (GHz)	2.6	2.4	2.0	2.6	2.2	2.6
Number of sockets	2	4	2	2	2	-
Total number of cores	16	32	28	16	20	16
Main memory	64 GB	1024 GB	128 GB	64 GB	128 GB	64 GB
Local disk	2 TB	7 TB	480 GB	4 TB	480 GB	1 TB
Cache per socket	Level 1: 8x64 KB Level 2: 8x256 KB Level 3: 20 MB	Level 1: 8x64 KB Level 2: 8x256 KB Level 3: 20 MB	Level 1: 8x64 KB Level 2: 14x256 KB Level 3: 35 MB	Level 1: 8x64 KB Level 2: 8x256 KB Level 3: 20 MB	Level 1: 8x64 KB Level 2: 10x256 KB Level 3: 25 MB	Level 1: 8x64 KB Level 2: 8x256 KB Level 3: 20 MB
Interconnect	4xFDR	4xFDR	4xFDR	4xFDR	4xFDR	4xFDR



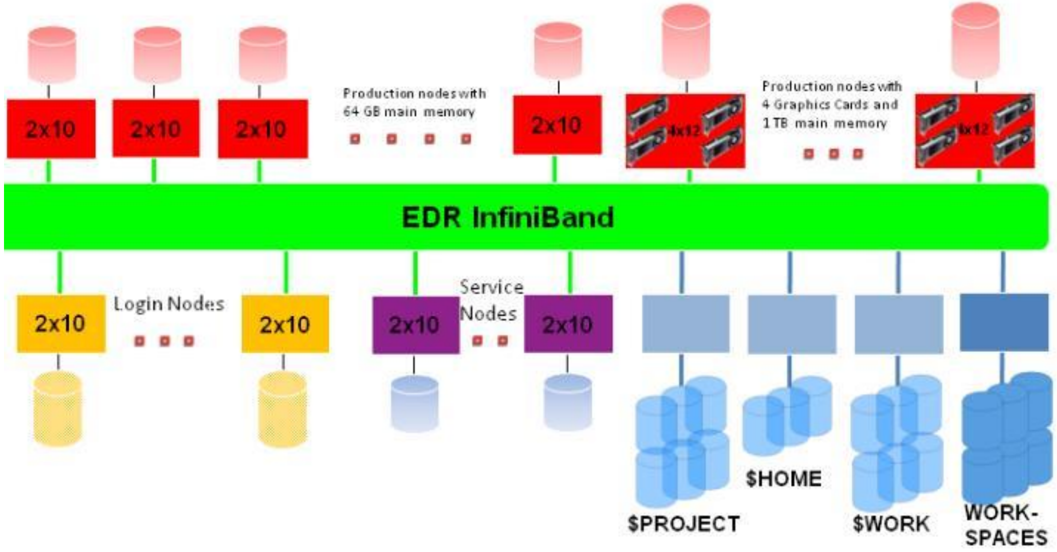
KIT HPC Systems – ForHLR I

- **512** 20-way Intel Xeon compute nodes. 400 GFLOPS peak performance and 64 GB main memory per node.
- **16** 32-way Intel Xeon compute nodes. Each of these nodes has 665,6 GFLOPS peak performance and 64 GB main memory
- **2** 20-way Intel Xeon login nodes. 400 GFLOPS peak performance and 64 GB main memory per node.
- **10** 20-way Intel Xeon service nodes. 400 GFLOPS peak performance and 64 GB main memory per node.



KIT HPC Systems – ForHLR II

- **1152** 20-way Intel Xeon compute nodes. Each of these nodes has a peak performance of 832 GFLOPS and 64 GB of main memory.
- **21** 48-way Intel Xeon rendering nodes. Each of these nodes has 4 NVIDIA GeForce GTX980 Ti graphic cards and 1 TB of main memory.
- **5** 20-way Intel Xeon login nodes. Each node has 256 GB main memory.
- **8** 20-way Intel Xeon service nodes, with 64 GB of main memory each.



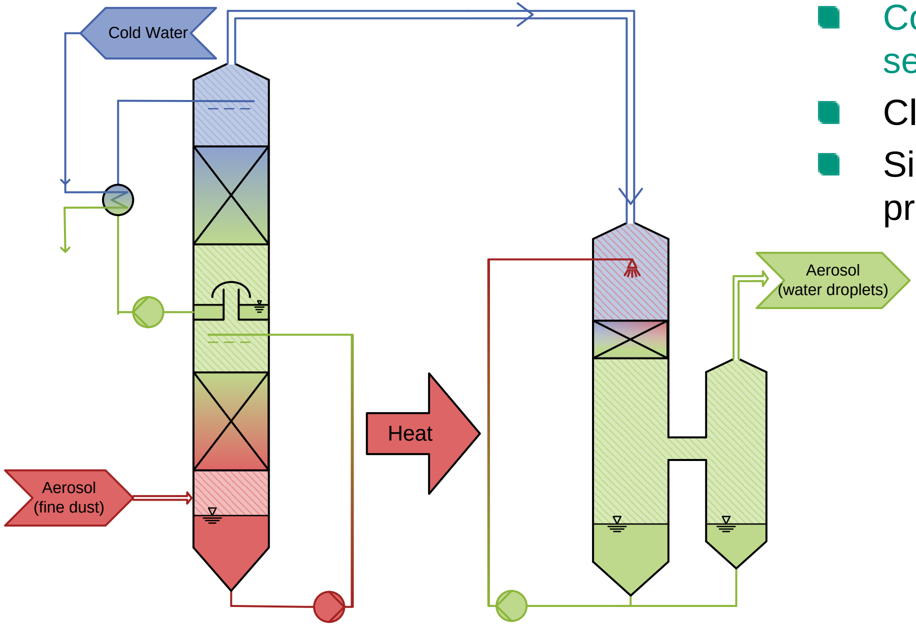
Simulation Lab Energy

Modelling and Simulation of Energy Systems

Modelling and simulation of electric power systems for the *Energiewende* in the frame of the Energy Lab. 2.0 Project and in cooperation with the Institute for Applied Computer Science (IAI) of the Karlsruhe Institute of Technology

www.elab2.kit.edu

Aersol Simlutions with AerCoDe



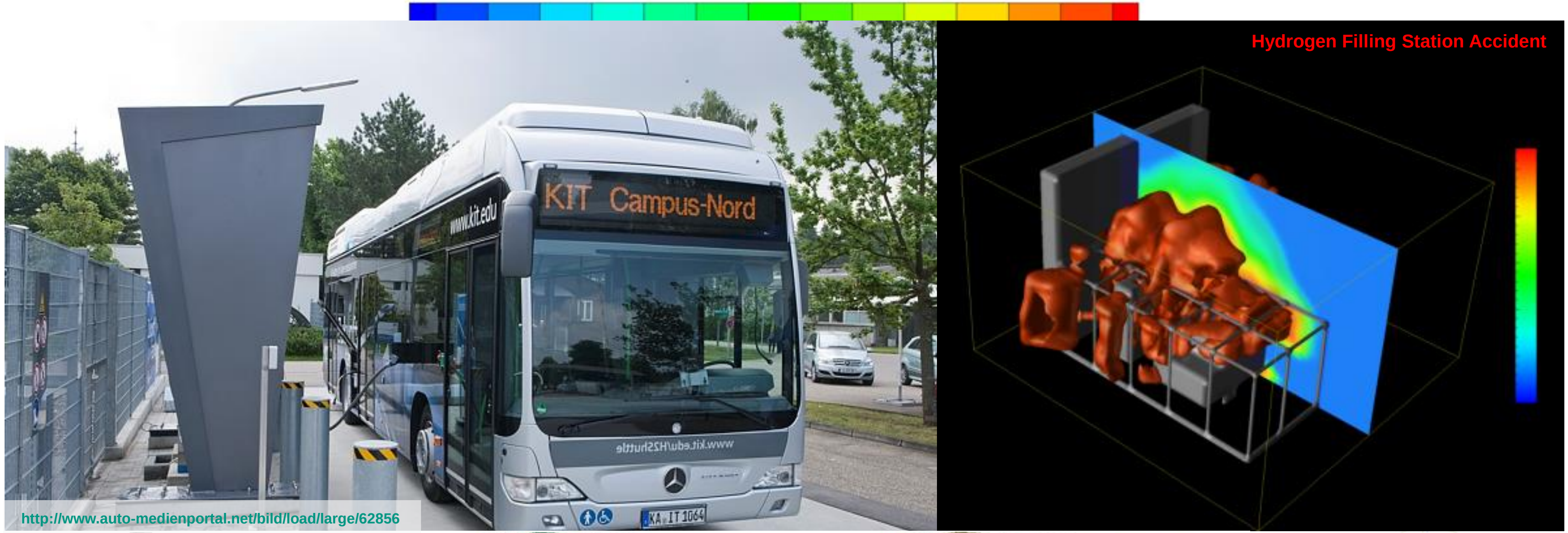
Concept for a condensation facility with two packed columns and reutilisation of thermal energy developed at ITTK.

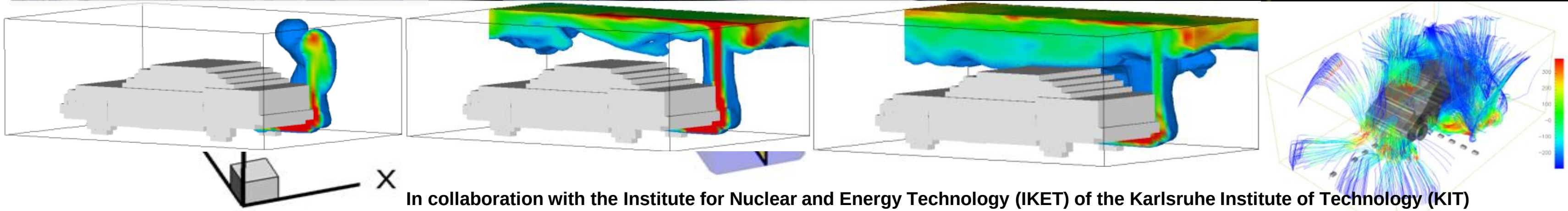
Possible applications

- Column design for condensation assisted fine dust separation
- Cleaning of industrial acidic gases
- Simulation of the behaviour of pyrolysis oil for the production of fuel from biomass (e.g. bioliq)

Simulation of a contact device to induce heterogeneous condensation

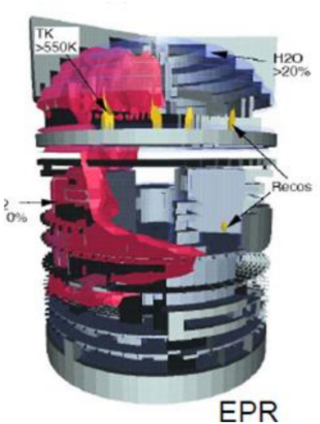
Automotive Hydrogen Safety Simulations with GASFLOW

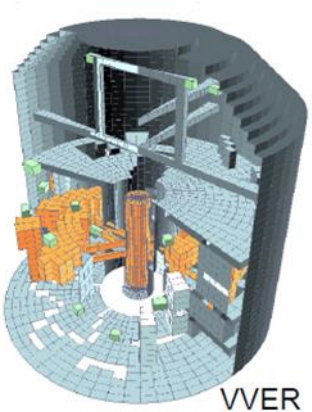


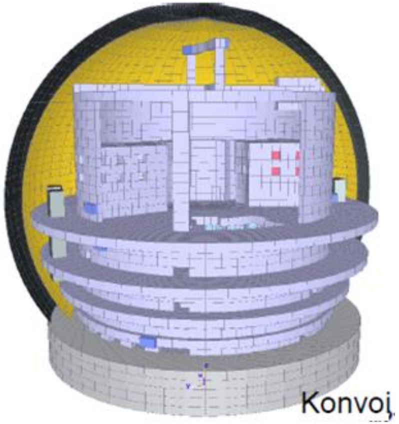


In collaboration with the Institute for Nuclear and Energy Technology (IKET) of the Karlsruhe Institute of Technology (KIT)

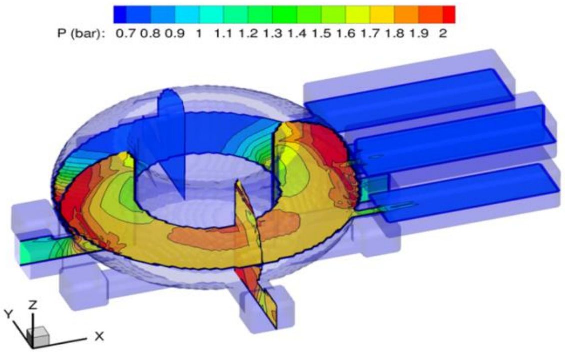
Hydrogen Safety Simulations for Nuclear and Fusion Research

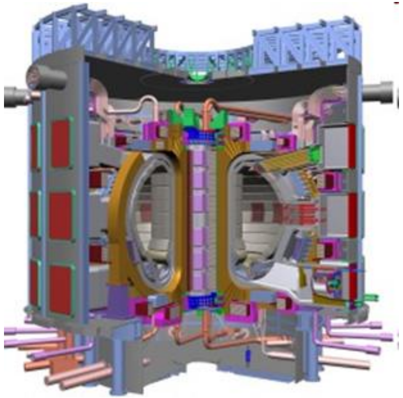






Simulations for Nuclear Reactor Safety





ITER

Simulations for ITER explosion scenarios

Thank you for your attention.

ESC17

Marco Roetta

Software Developer at INFN - LNL

Control systems for PIAVE accelerator

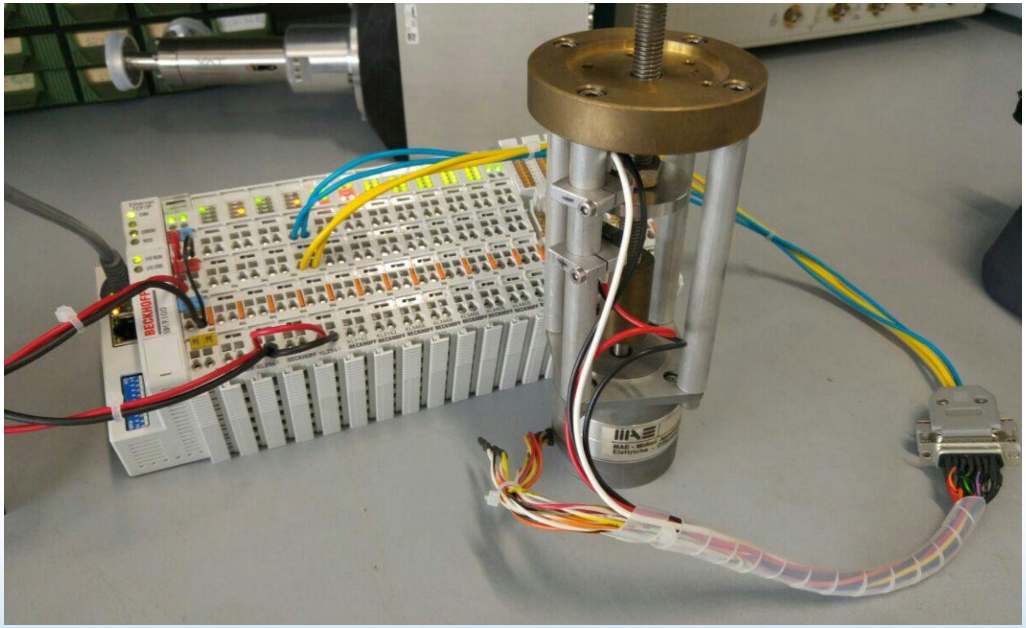
PLC based systems for auxiliary services

ECR Ion Source - 1

- Software Developer for the ECR Ion Source
- EPICS for logic and hardware communication systems
- CSS and Python for the operator GUI
- Control the hardware inside the HV platform form different remote consoles
- Monitor beam output (Faraday Cup) and machine components status
- Automated spectrum acquisition

ECR Ion Source - 2

- Divided in three components: GUI, PLC, VM (logic)
- Connected using an Ethernet network (copper, fiber)
- The system will be reused to control a Charge Breeder for the SPES project
- Same type of machine (plasma chamber) with a different scope



ESC17

Flavor Physics and Lattice QCD

ROMA TRE UNIVERSITÀ DEGLI STUDI

INFN Istituto Nazionale di Fisica Nucleare

European Twisted Mass Collaboration

Giorgio Salerno

Flavor Physics and Lattice QCD

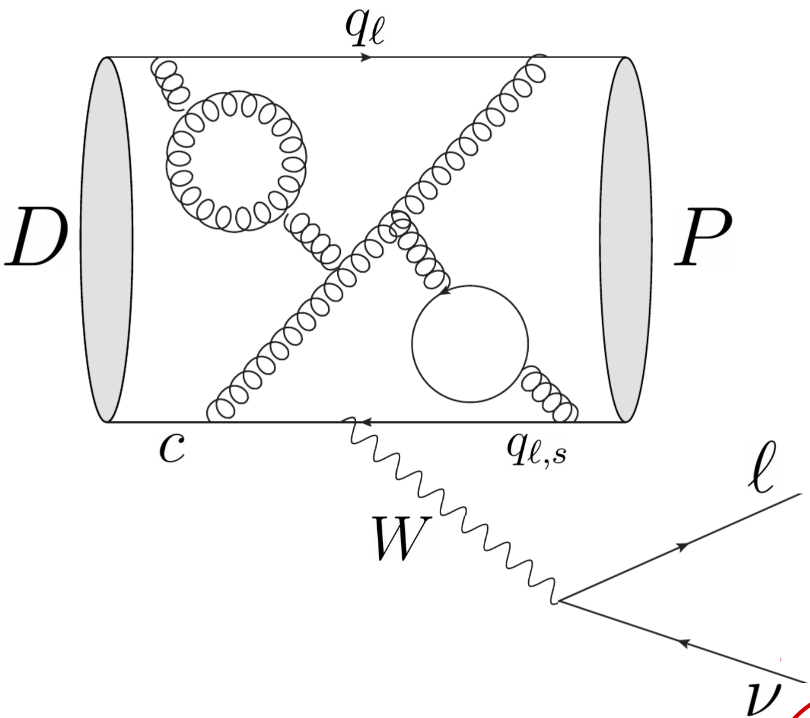
The Standard Model does not:

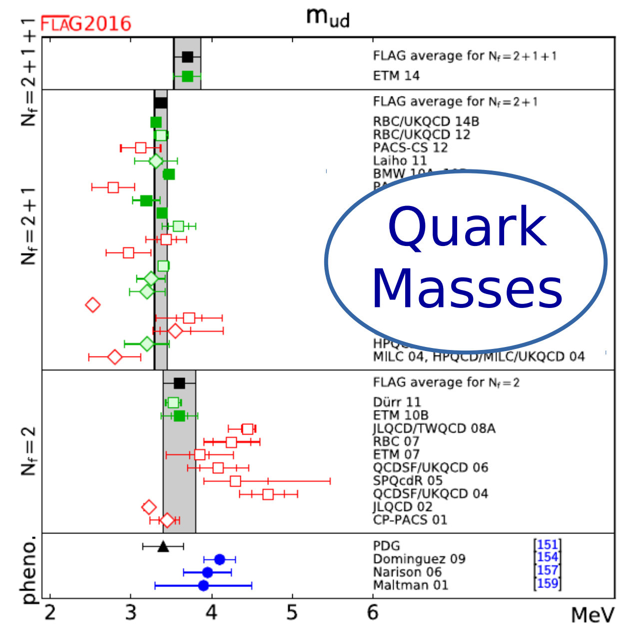
FLAVOR

- include gravity ($M_{Planck} = (\hbar c/G_N)^{1/2} \approx 10^{19}$ GeV)
- explain the origin of flavor, i.e. masses, mixing and CPV (M_{Flav}= ??)
- give a natural explanation of the hiearchy problem ($M_{Weak} << M_{Planck}$)
- provide (exact) gauge coupling unification ($M_{GUT} \approx 10^{15}$-10^{16} GeV)
- explain the smallness of neutrino masses ($m_\nu \approx (\lambda v)^2/M$, $M \approx 10^{15}$ GeV)
- produce the observed matter-antimatter asymmetry
- provide a viable dark matter candidate
- explain “dark” (vacuum) energy

Cosmology

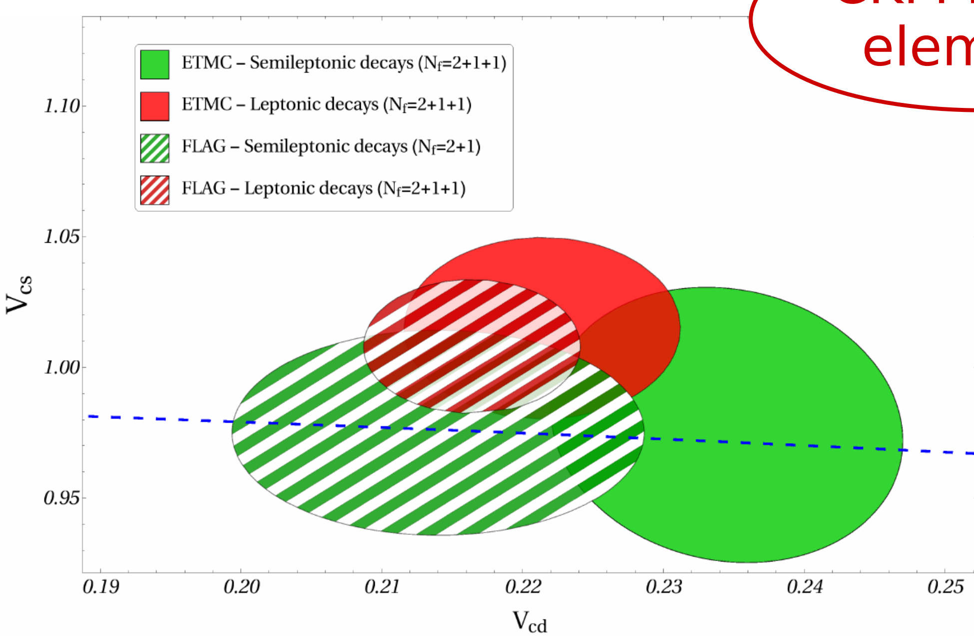
Flavor Physics and Lattice QCD

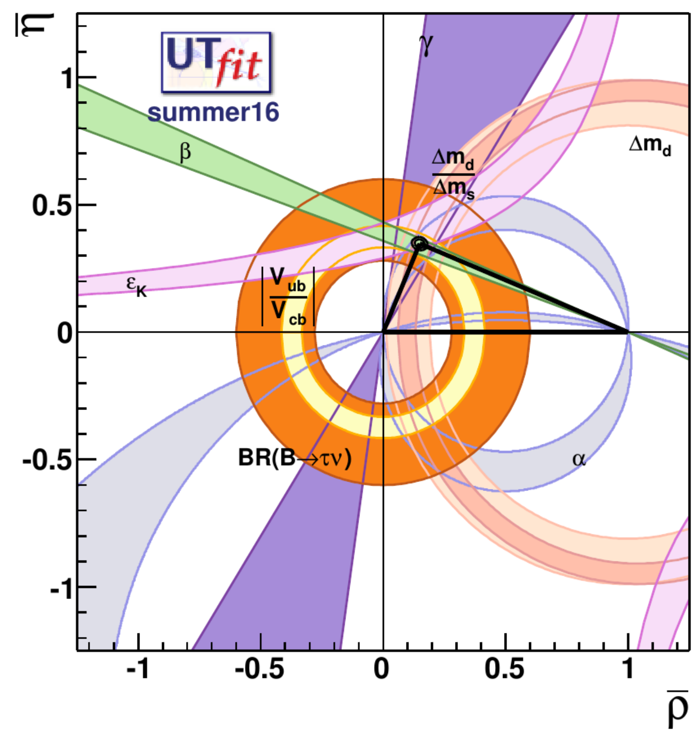




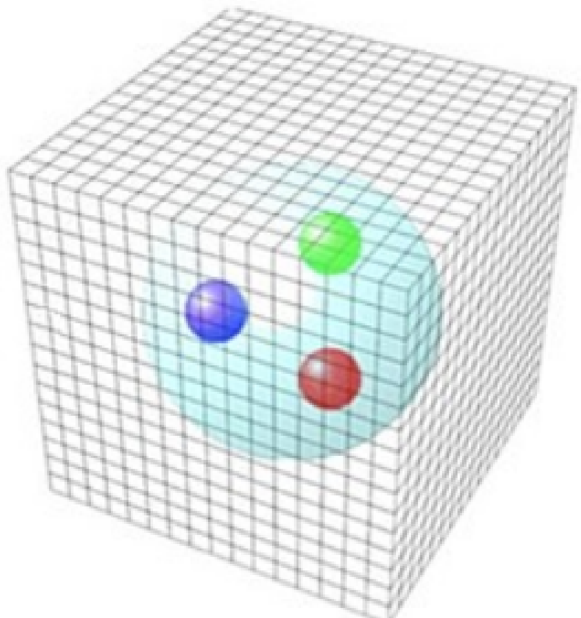
Quark Masses

CKM matrix elements





Lattice QCD



Non-perturbative long-distance QCD contributions from first principles

QCD simulated on a discrete space-time and finite volume

Flavor Physics and Lattice QCD

$$C(t) \equiv \langle O_\pi(t) O_\pi^\dagger(0) \rangle \approx \sum_n \frac{|\langle 0| O_\pi(0) |n\rangle|^2}{2E_n} \exp[-E_n t] \xrightarrow[t\to\infty]{} \frac{|\langle 0| O_\pi(0) |\pi\rangle|^2}{2M_\pi} \exp[-M_\pi t]$$

Calculated on the lattice (Importance sampling Monte Carlo)

$$\frac{1}{Z}\int \mathcal{D}[\phi]\, O_1(\phi)\, O_2(\phi)\, e^{-S_E[\phi]} \simeq \frac{1}{N_c}\sum_{c=1}^{N_c} O_1(\phi_c)\, O_2(\phi_c)$$

$$(\Delta O)^2 = \frac{1}{N_c}\sum_{c=1}^{N_c} (O(\phi_c) - \langle O \rangle)^2$$

Statistical error $\sim \frac{1}{\sqrt{N_c}}$

Thank you for the attention

Performance Optimizations & HEP

Servesh Muralidharan
Senior Fellow
IT-DI-LCG, UP Team
24 Oct 2017

CERN

Understanding Performance

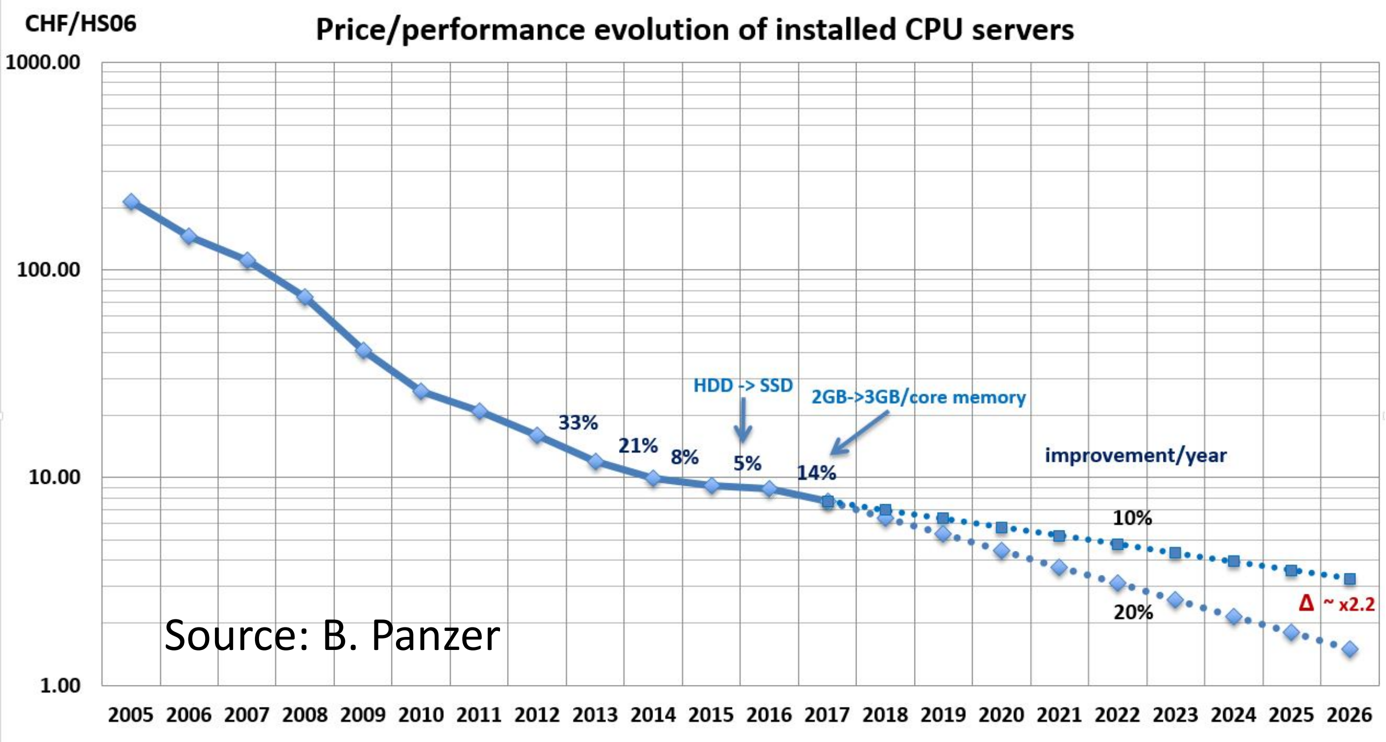
- Team in IT
  - Part of the WLCG team (IT-DI-LCG)
  - Closely working with the HSF and Software Technology Forum
  - Started January 2016
  - Regular meetings with some experiments : ATLAS, CMS, LHCb
- Long term activity
  - Focus on linking activities in the community
    - Software and infrastructure
  - Aggregation of knowledge about existing tools and data
  - Providing tools to understand, measure and improve performance
  - Analyze software and workflows
- Members
  - Markus Schulz
  - Andrea Sciaba
  - David Smith
  - Andrea Valassi
  - Servesh Muralidharan

Motivation - Gap between estimated compute resources for Run3 (~2021) and Run4 (~2024, HL-LHC)

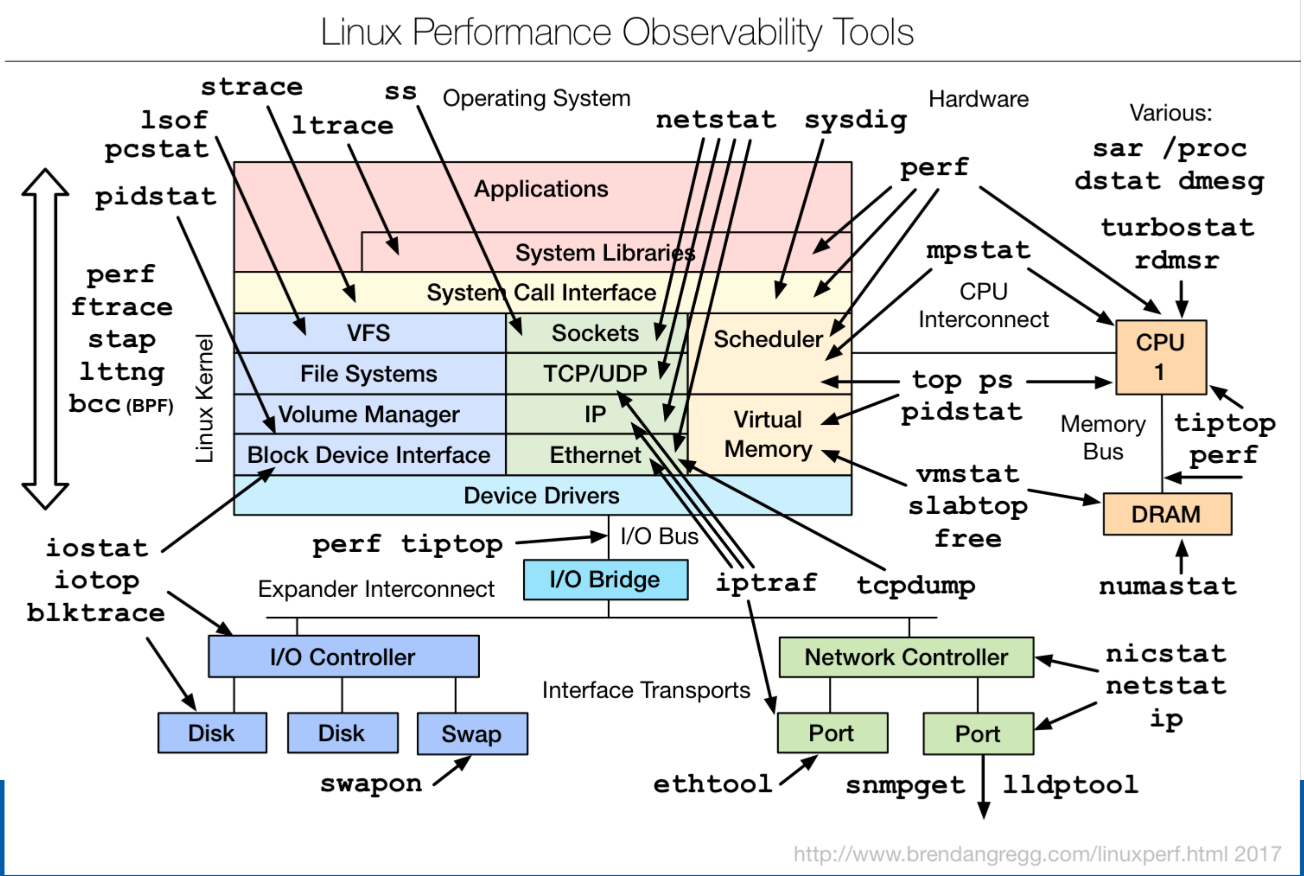
Gap:

8 – 25x
(optimistic)

30 – 85x
(conservative)



Understanding Performance – Sounds Easy???



Intel Advisor

Summary | Survey & Roofline | Refinement Reports

Vectorization Advisor

Vectorization Advisor is a vectorization analysis toolset that lets you identify loops that will benefit most from vector parallelism, discover performance issues preventing from effective vectorization and characterize your memory vs. vectorization bottlenecks with Advisor Roofline model automation.

Program metrics

Elapsed Time	170.37s		
Vector Instruction Set	AVX, AVX2	Number of CPU Threads	20
Total GFLOP Count	936.64	Total GFLOPS	5.50
Total Arithmetic Intensity	0.04		

Loop metrics

Total CPU time	2088.55s	100.0%
Time in **19** vectorized loops	7.02s	
Time in scalar code including time in **29** vectorized completely unrolled loops	2081.53s	99.7%

Vectorization Gain/Efficiency

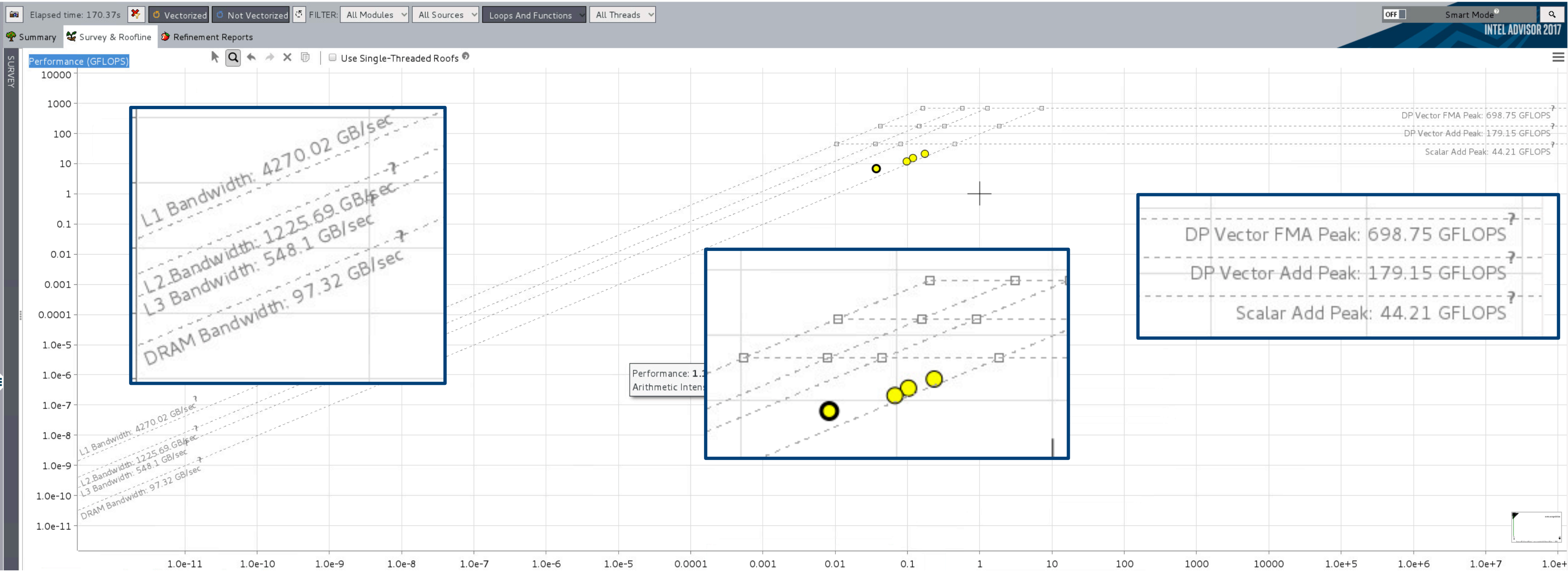
Vectorized Loops Gain/Efficiency	2.14x	~41%
Program Approximate Gain	1.00x	

Top time-consuming loops

Loop	Self Time	Total Time	Trip Counts
[loop in G4PolyPhiFace::InsideEdges at G4PolyPhiFace.cc:853]	30.015s	30.015s	15
[loop in G4ElasticHadrNucleusHE::HadrNucDifferCrSec at G4ElasticHadrNucleusHE.cc:892]	24.898s	44.284s	1
[loop in G4SteppingManager::DefinePhysicalStepLength at G4SteppingManager2.cc:165]	18.295s	270.912s	9
[loop in G4VoxelNavigation::VoxelLocate at G4VoxelNavigation.icc:52]	9.641s	24.850s	3
[loop in G4VCSGfaceted::Inside at G4VCSGfaceted.cc:227]	8.490s	143.584s	8

CERN

Intel Advisor – Roofline



Hotspot 1

File: MTwistEngine.cc:115 CLHEP::MTwistEngine::flat

Line	Source	Total Time	%	Loop/Function Time	%	
114						
115	`double MTwistEngine::flat() {`	7.688s		29.807s		
116	`unsigned int y;`	0.259s				
117		0.080s				
118	`if( count624 >= N ) {`	1.549s				
119	`int i;`					
120						
121	`for( i=0; i < NminusM; ++i ) {`	0.110s				
122	`y = (mt[i] & 0x80000000) | (mt[i+1] & 0x7fffffff);`	0.060s				
123	`mt[i] = mt[i+M] ^ (y >> 1) ^ ((y & 0x1) ? 0x9908b0df : 0x0 );`	0.100s				Shifts
124	`}`					
125						
126	`for( ; i < N-1 ; ++i ) {`	28.616s				
127	`y = (mt[i] & 0x80000000) | (mt[i+1] & 0x7fffffff);`					
128	`mt[i] = mt[i-NminusM] ^ (y >> 1) ^ ((y & 0x1) ? 0x9908b0df : 0x0 );`	0.030s				Shifts
129	`}`					
130		0.010s				
131	`y = (mt[i] & 0x80000000) | (mt[0] & 0x7fffffff);`					
132	`mt[i] = mt[M-1] ^ (y >> 1) ^ ((y & 0x1) ? 0x9908b0df : 0x0 );`	1.039s				
133						
134	`count624 = 0;`	0.040s				
	Selected (Total Time):	7.688s				

Hotspot 1

CLHEP::MTwistEngine::flat function at MTwistEngine.cc:115

f 36.324s	
Function	*Total time*
AVX; AVX2	28.556s
Instruction Set	*Self time*

Memory	**39% (117)**
Vector	**2% (7)**
AVX	**2% (7)**
Scalar	**37% (110)**
AVX	**11% (34)**
Other	**4% (10)**
x86	**22% (66)**
Compute	**3% (11)**
Scalar	**3% (11)**
x86	**3% (9)**
Other	**58% (170)**

Instruction Mix Summary

Code Optimizations

Compiler: Intel(R) C++ Intel(R) 64 Compiler for applications running on Intel(R) 64,

Version: 17.0.2.174 Build 20170213

Statistics for FLOPS And Data Transfers

GFLOPS	***6.85449***	Giga Floating-point Operations Per Second Per-loop GFLOPS = Total GFLOP / Elapsed Time. Elapsed time is the exclusive (self-time-based) wall time from the beginning to the end of loop/function execution. For single-threaded applications Elapsed time is equal to Self-Time.
AI	***0.037***	AI - Arithmetic Intesity - Ratio of Floating-point Operations to L1 Transferred Bytes
GFLOP	***14.531***	Giga Floating-point Operations

Data transfers between CPU and memory sub-system (total traffic, including L1, L2, LLC and DRAM traffic)

in Giga Bytes	***393.484***
in Giga Bytes Per Second	***185.609***

Traits

Shifts

Hotspot 2

File: G4ElasticHadrNucleusHE.cc:892 G4ElasticHadrNucleusHE::HadrNucDifferCrSec

Line	Source	Total Time	%	Loop/Function Time	%	
890	`Din2 = 0;`					
891	`DmedTot = 0;`					
892	`for(G4int l = 0; l<=i; l++)`			44.284s		
893	`{`					
894	`if(l == 0) BinCoeff = 1;`					
895	`else if(l !=0 ) BinCoeff = BinCoeff*(i-l+1)/l;`	4.688s				Divisions; Type Conversions
896						
897	`exp1 = l/R22B+(i-l)/R12B;`	0.200s				Divisions; Type Conversions
898	`exp1p = exp1+R12Apd;`	0.380s				
899	`exp2p = exp1+R12ApdR22Ap;`					
900	`exp3p = exp1+R22Apd;`	0.020s				
901						
902	`Din2 = Din2 + N2p*BinCoeff*`	1.350s				FMA
903	`(C1/exp1p*std::exp(-theQ2/4/exp1p)-`	4.672s				Divisions
904	`C2/exp2p*std::exp(-theQ2/4/exp2p)+`	6.400s				Divisions
905	`C3/exp3p*std::exp(-theQ2/4/exp3p));`	1.260s				Divisions
906						
907	`DmedTot = DmedTot + N2p*BinCoeff*`	5.929s				FMA
908	`(C1/exp1p-C2/exp2p+C3/exp3p);`					
909						
910	`N2p = -N2p*R23dR13;`					
911	`} // l`					

Hotspot 2

Loop in G4ElasticHadrNucleusHE::HadrNucDifferCrSec at G4ElasticHadrNucleusHE.cc:892

Scalar	44.284s (Total time)
AVX (Instruction Set)	24.898s (Self time)

Memory	40% (26)
Scalar	40% (26)
AVX	40% (26)
Compute	23% (15)
Scalar	23% (15)
AVX	16% (10)
FMA	7% (5)
Mixed	13% (9)
Scalar	13% (9)
AVX	13% (9)
Other	24% (15)

Instruction Mix Summary

Instruction Mix

Memory: 26 *Compute:* 15 *Mixed:* 9 *Other:* 15 *Number of Vector Registers:* 16

Memory: 40% / Scalar: 40% / AVX: 40%
Compute: 23% / Scalar: 23% / AVX: 16% / F...
Mixed:... / Scal... / AVX:...
Other: 24%

Trip Counts

Maximum:	40
Average:	**1**
Minimum:	1
Call Count:	63118400
Iteration Duration:	< 0.001s

Code Optimizations

Compiler: Intel(R) C++ Intel(R) 64 Compiler for applications running on Intel(R) 64,

Version: 17.0.2.174 Build 20170213

Statistics for FLOPS And Data Transfers

GFLOPS	***11.8651***	Giga Floating-point Operations Per Second Per-loop GFLOPS = Total GFLOP / Elapsed Time. Elapsed time is the exclusive (self-time-based) wall time from the beginning to the end of loop/function execution. For single-threaded applications Elapsed time is equal to Self-Time.
AI	***0.097***	AI - Arithmetic Intesity - Ratio of Floating-point Operations to L1 Transferred Bytes
GFLOP	***20.640***	Giga Floating-point Operations
FLOP Per Iteration	***29***	Floating-point Operations Per Loop Iteration

Data transfers between CPU and memory sub-system (total traffic, including L1, L2, LLC and DRAM traffic)

in Giga Bytes	***212.110***
in Giga Bytes Per Second	***121.934***
in Bytes Per Loop Iteration	***298.023***

Traits

Divisions

Type Conversions

FMA

Conclusions

- Good compilers and tools are available
- Architecture's peak performance
- Compute kernels
- Algorithm complexity
- Compiler readable code
- Good loops – Bounded, Linear and Minimal Intra Dependencies
- Iterative optimization – Design, Analyze, Optimize, Repeat

CERN

CERN

Nicholas Terranova
Self-Introduction

- 31 years old
- Nuclear Engineer
- From Bologna (Italy)
- Research fellow at CNAF-INFN of Bologna, since 16-Oct-2017

Nicholas Terranova (cont'd)

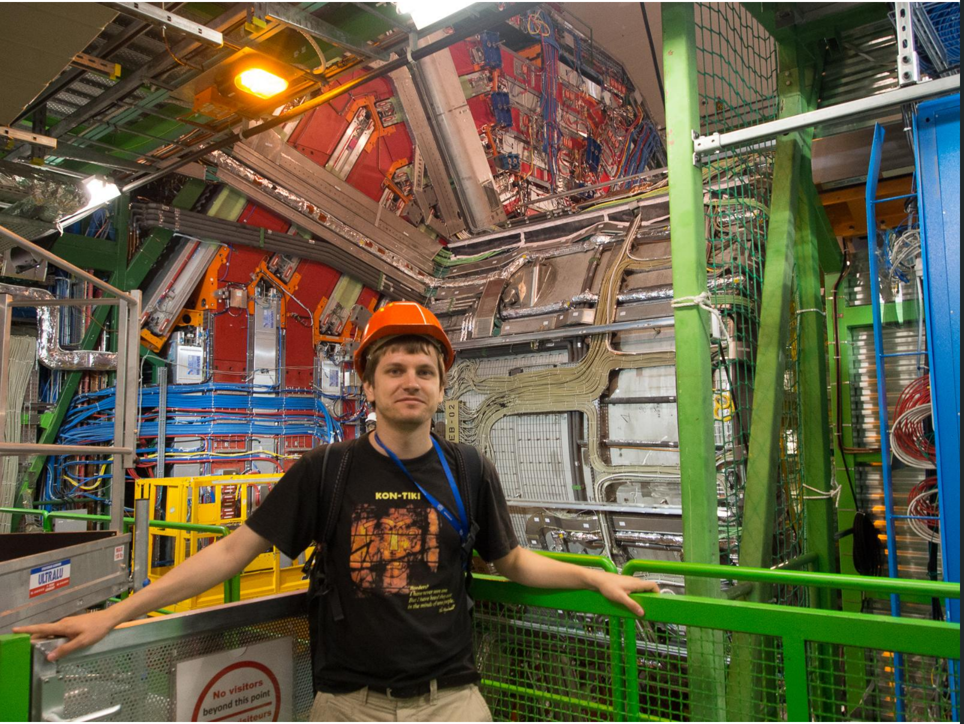
- Master degree in Nuclear Engineering in 2012;
- Master thesis at the University of Arizona, title: *Numerical benchmarks for the multi-group diffusion equation*;
- **PhD in Reactor Physics** in 2016;
- 2,5 year at the CEA (**French Atomic Energy Commission**) of **Cadarache** (south of France);
- Title: *Covariance matrix generation for nuclear data of interest to the reactivity loss uncertainty estimation of the Jules Horowitz Material Testing Reactor.*

Nicholas Terranova (cont'd)

- In the last year: **post-doc fellow at CEA-Saclay** (close to Paris);
- Development of reactivity perturbation and eigenvalue sensitivity features in **Tripoli-4**;
- **Tripoli-4 is a Monte Carlo transport code** for instrumentation, radiation protection and reactor criticality calculations developed by the Reactor Physics and Applied Mathematics Section of the CEA-Saclay.

Thank you for your attention

nicholas.terranova@cnaf.infn.it



Andres Tiko

INFN Padova

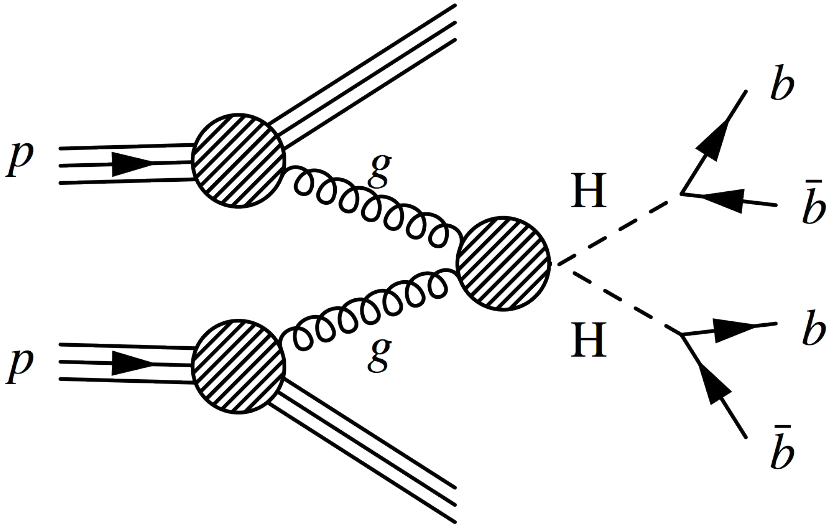
Experimental particle physics postdoc

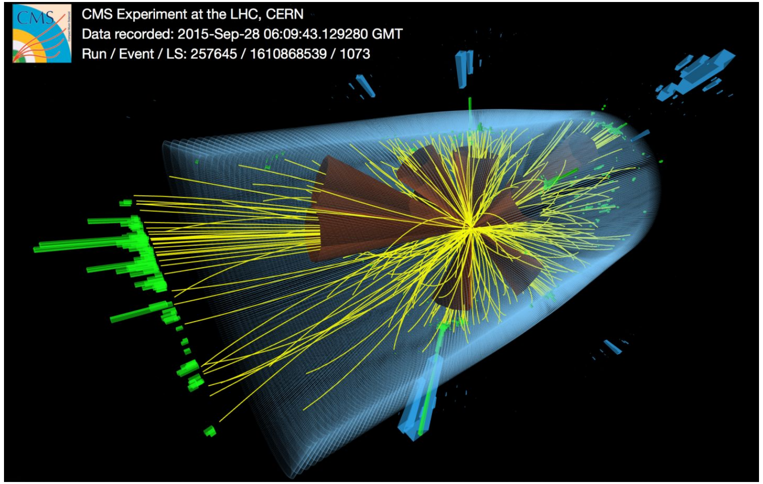
Member of CMS experiment

Current work

Trying to measure the production of Higgs boson pairs decaying to b-quarks

Rare process, but gives important insight into Higgs boson properties and further understanding of the Standard Model





Challenges

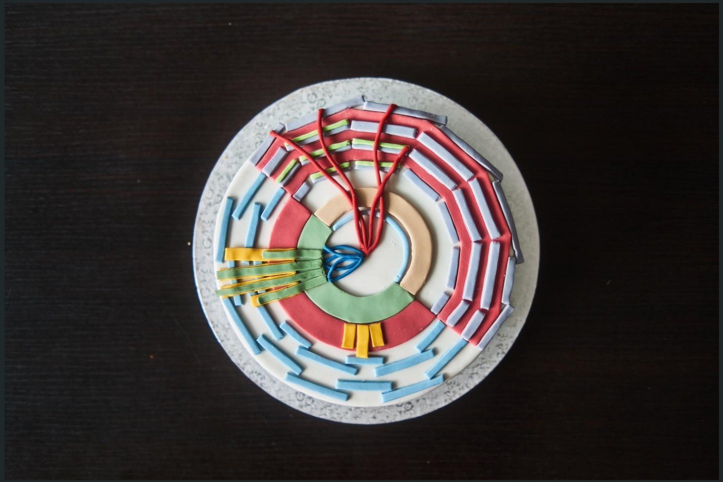
- Dealing with huge amounts of data - and increasing all the time
- Need to be able to process it efficiently within the framework of LHC computing grid - large, but not unlimited resources
- Overwhelming amounts of background processes mimicking the signal signature - need to distinguish between the two

Future interests

So far, high energy physics has mostly focused on the knowledge of physical processes to model and analyze data

New approaches are being introduced - using deep learning, we can treat the tracks of a collision in a detector as an image and use it directly for separating background and signal

Signal



Background

Average fractional polarization of extragalactic radio sources at Planck frequencies

ESC17 23-28/10/2017

Work in collaboration with of Carlo Burigana & Gianfranco de Zotti

The detection of CMB primordial B–mode polarization is the current challenge in cosmology & particle physic … They are crucial since carry a clean signature of primordial inflation

This signal is very faint ⇝ provides a measure of the energy scale of inflation ⇝
its amplitude is related to the tensor to scalar ratio $r = T/S$ &
is generated by weak tensor perturbations ($r < 0.07$)

But

Even in the cleanest 70% sky, Galactic & estimates of extragalactic POLARIZED FOREGROUND emissions DOMINATE over B-MODES & instrumental noise of MOST SENSITIVE forthcoming or proposed CMB EXPERIMENTS ›---» CORE, CMB Probe, PIXIE, LiteBIRD & CMB-S4

Foreground cleaning must reach at least 99.9% level @ $\ell \simeq 10$ …
99% level @ $\ell \simeq 100$ … 90% level @ $\ell \simeq 1000$

B-mode APS due to gravitational lensing exceeds primordial B- for $\ell \gtrsim 10$ if $r \lesssim 10^{-2}$ ⇝

primordial B- requires very accurate control of lensing effects

(contaminated by fluctuations of unresolved extragalactic sources...)

Crucial ⇝ precise understanding of extragalactic sources polarization properties

Different observations and analysis of radio sources polarimetric properties evidence broad variety of spectral shapes

The key is to characterize source contamination @ ν range [60–120] GHz ... where Planck data have min in T brightness spectra of diffuse polarized foregrounds

Although # extraG pol sources detected by Planck quite limited ...

< P fraction> of fainter sources can be estimate → stacking techniques

coadding the P signal from many objects detected in total intensity

(not in polarization) ... ⇧ signal-to-noise (S/N) ratio!

BIAS!!!!!

Low-res Planck data is complicated → each resolution element contains a source & other polarized signals: CMB itself & diffuse polarized emissions from the Galaxy (non Gaussian!)

MeTHOD

carry out a new investigation
adopting an independent simpler & analytical approach...

IDA ➨ intensity distribution analysis

Signals measurements in map @ given source catalogue...
The distribution of signals is compared with random positions away from sources ↠control fields

The mean polarized flux density of sources is then estimated as

$$\langle P \rangle = \left(\langle P^2_{sources} \rangle - \langle P^2_{CFields} \rangle \right)^{1/2}$$

to statistically remove the noise contributions to P, to the CMB & to polarized Galactic emissions ...

the method directly corrects for the 'noise bias' without the need of simulations!!!

Batch System as a Service on HPC resources

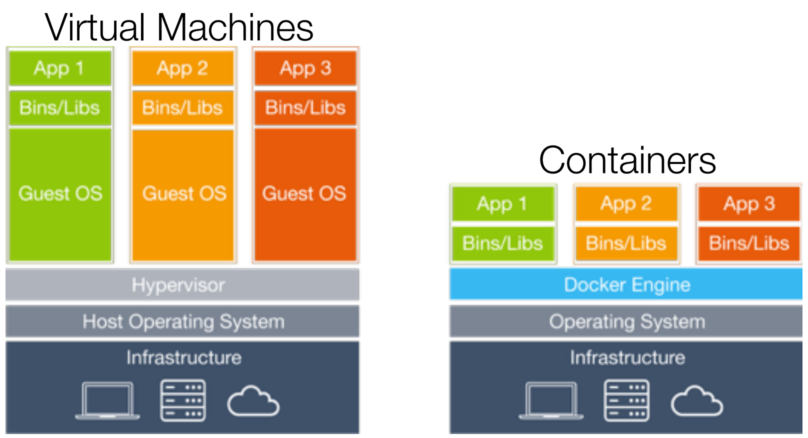
Speaker: Vallero Sara - INFN Torino

ESC17 School - Bertinoro (FC) October 23-28 2017

Cloud-like cluster management

OCCAM cluster @ C3S (Torino)
https://c3s.unito.it

light-weight virtualization (Linux containers)



According to GARTNER:

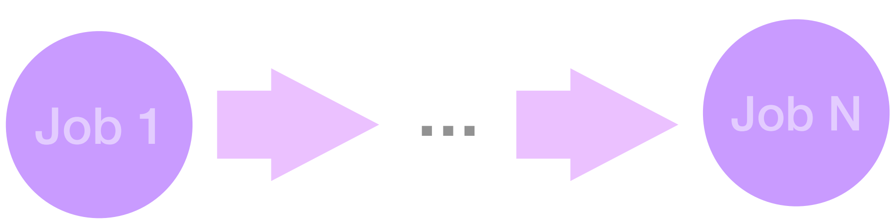
Cloud Computing is a style of computing in which scalable and elastic IT-enabled capabilities are delivered as a service using Internet technologies.

From VMs to Containers:

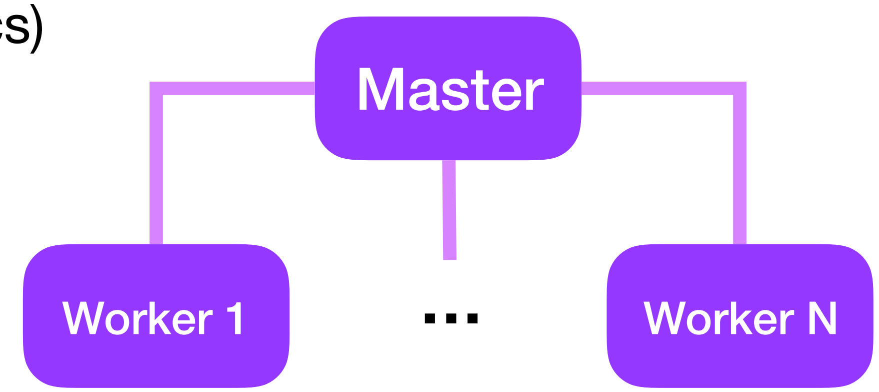
- package, ship and run distributed application components with guaranteed platform parity across different environments
- *democratizing* virtualization by providing it to developers in a usable, application-focused form
- full virtualization not suited for HPC applications

enable different applications (computing models) to run concurrently

PIPELINE
(i.e. BioTech)



BATCH SYSTEM
(i.e. Physics)



dynamic re-allocation of resources, autoscaling

Batch System as a Service

Automatically deploy a batch system cluster in highly-available and scalable configurations.

Schedule tasks on distributed resources

Apache MESOS™

A DISTRIBUTED KERNEL

1) Ad hoc Mesos framework

(https://github.com/svallero/HTMframe)

WORK IN PROGRESS

THE SCHEDULERS

- scheduler: implements custom policies on Mesos resource offers
  - instantiates *static roles* in ordered sequence: master, submitter and some executors
  - re-instantiate static roles on failure
- health-checks on static roles
- **auto-scaling according to HTCondor metrics**:
  - scale-out: in case of idle jobs (submitter publishes queue and nodes status)
  - scale-in: idle nodes publish unhealthy state
- HTTP API
- GUI (coming soon)

What we used so far…

2) Marathon framework

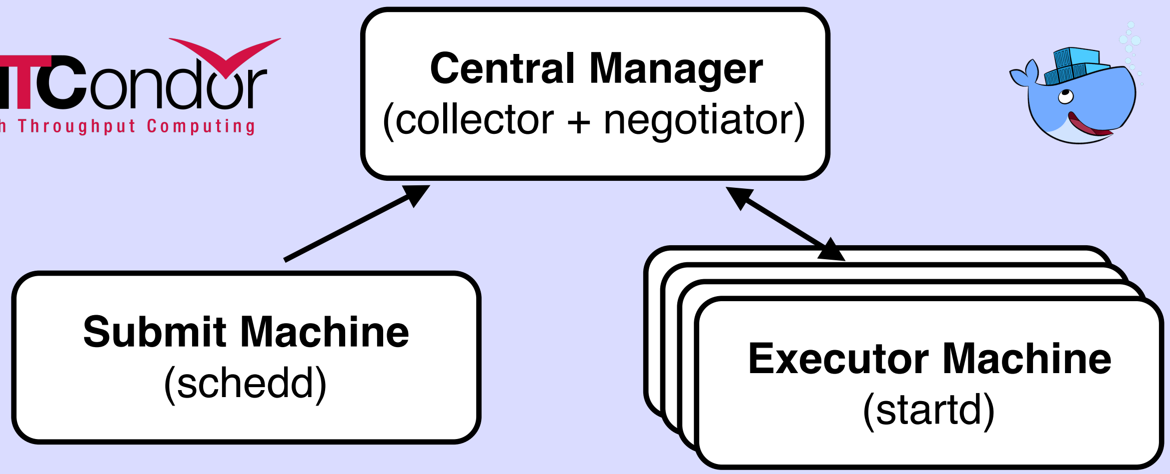
MARATHON

- containers are deployed as Long Running services
- health checks and failover
- no application specific auto-scaling

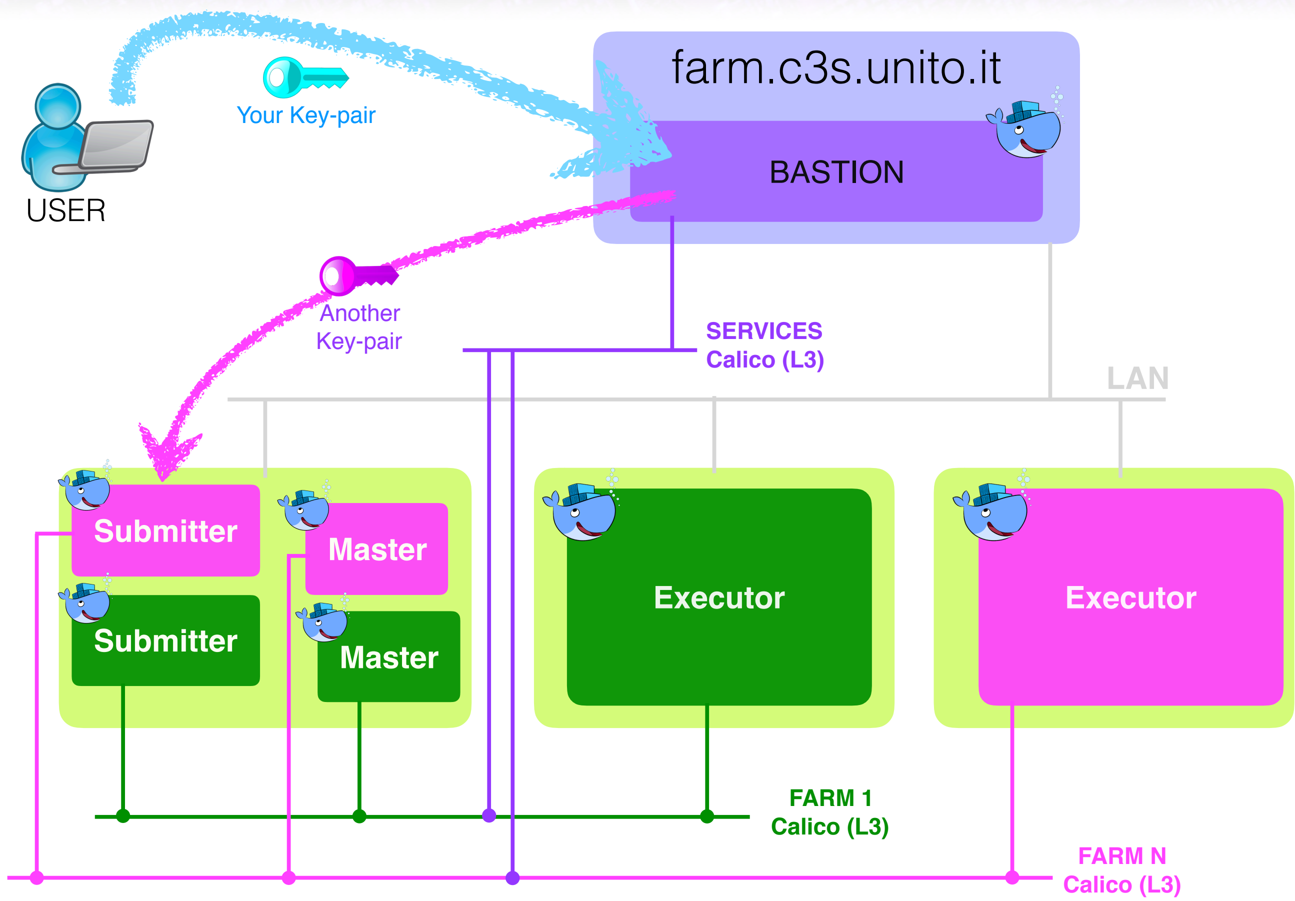
THE APPLICATION

All farm components are packaged in separate Docker containers

HTCondor High Throughput Computing

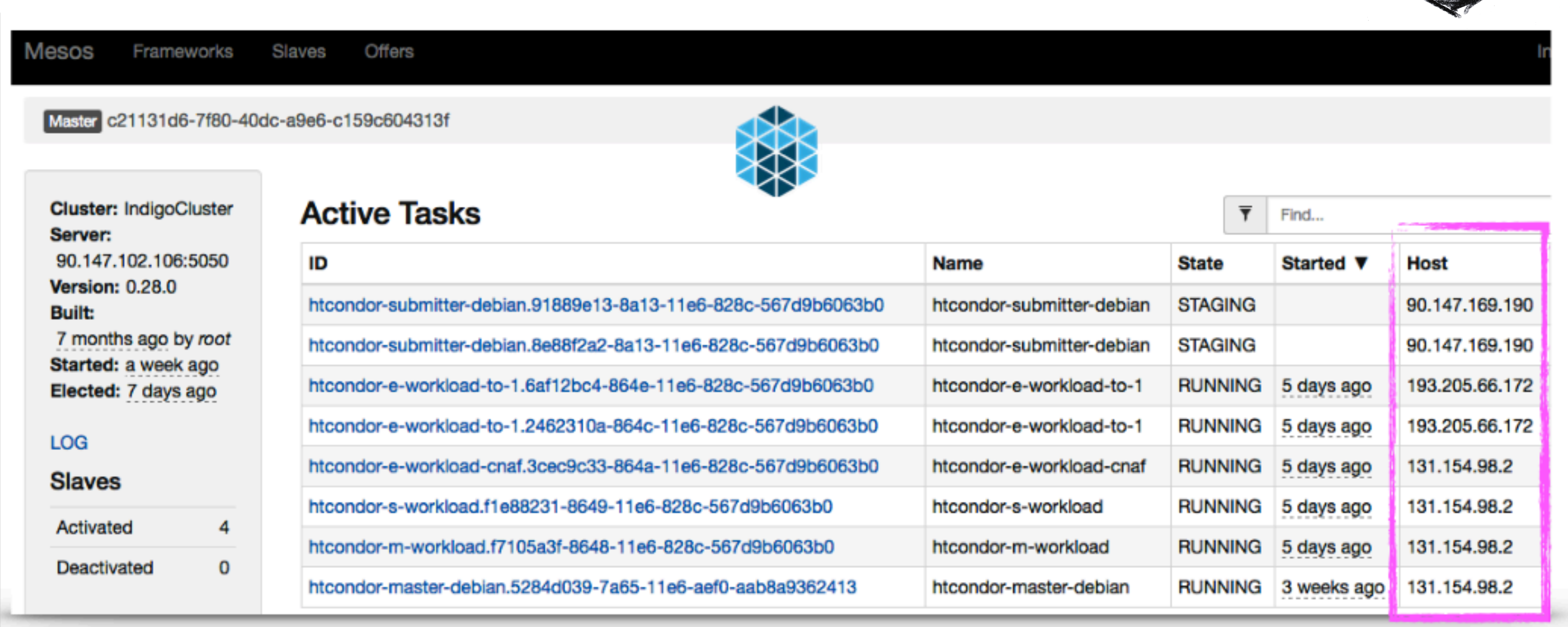


Application isolation



Calico functionalities:

- **Orchestrator Plugin:** to manage the Calico network as with the orchestrator (Docker) tools
- **Felix agent:** programs routing rules and ACLs into the Linux kernel (FIB and iptables)
- **etcd:** communication between components and datastore
- **BGP client:** distributes the routing tables around the datacenter



ID	Name	State	Started ▼	Host
htcondor-submitter-debian.91889e13-8a13-11e6-828c-567d9b6063b0	htcondor-submitter-debian	STAGING		90.147.169.190
htcondor-submitter-debian.8e88f2a2-8a13-11e6-828c-567d9b6063b0	htcondor-submitter-debian	STAGING		90.147.169.190
htcondor-e-workload-to-1.6af12bc4-864e-11e6-828c-567d9b6063b0	htcondor-e-workload-to-1	RUNNING	5 days ago	193.205.66.172
htcondor-e-workload-to-1.2462310a-864c-11e6-828c-567d9b6063b0	htcondor-e-workload-to-1	RUNNING	5 days ago	193.205.66.172
htcondor-e-workload-cnaf.3cec9c33-864a-11e6-828c-567d9b6063b0	htcondor-e-workload-cnaf	RUNNING	5 days ago	131.154.98.2
htcondor-s-workload.f1e88231-8649-11e6-828c-567d9b6063b0	htcondor-s-workload	RUNNING	5 days ago	131.154.98.2
htcondor-m-workload.f7105a3f-8648-11e6-828c-567d9b6063b0	htcondor-m-workload	RUNNING	5 days ago	131.154.98.2
htcondor-master-debian.5284d039-7a65-11e6-aef0-aab8a9362413	htcondor-master-debian	RUNNING	3 weeks ago	131.154.98.2

PoC of geographical deployment

- 3 autonomous systems: Torino, Bologna and Bari
- VPN connection among the 3 sites (IPoIP)
- each site runs an instance of: configuration store (etcd and Zookeeper), Calico, Mesos and Marathon
- one instance of each of the above services is elected as leader (fault tolerance)

MPI jobs and InfiniBand

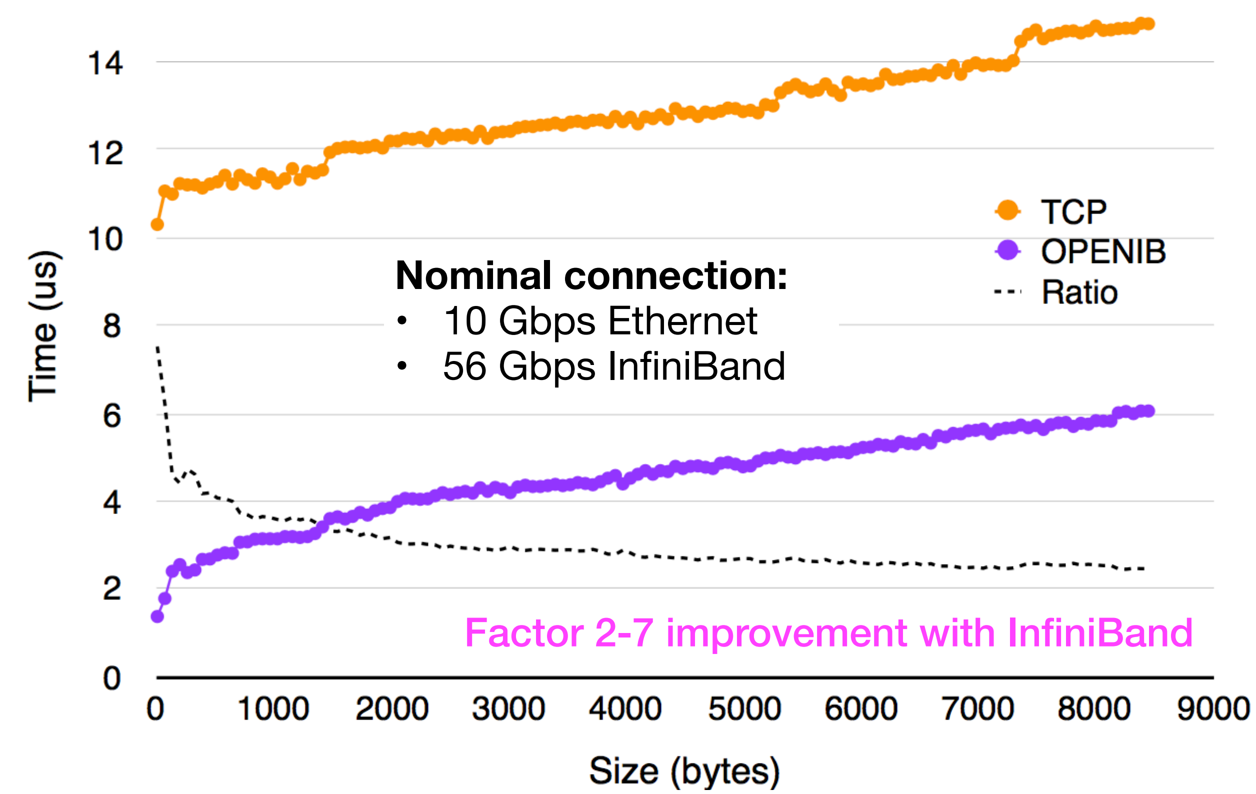
Executor role configuration (Marathon)

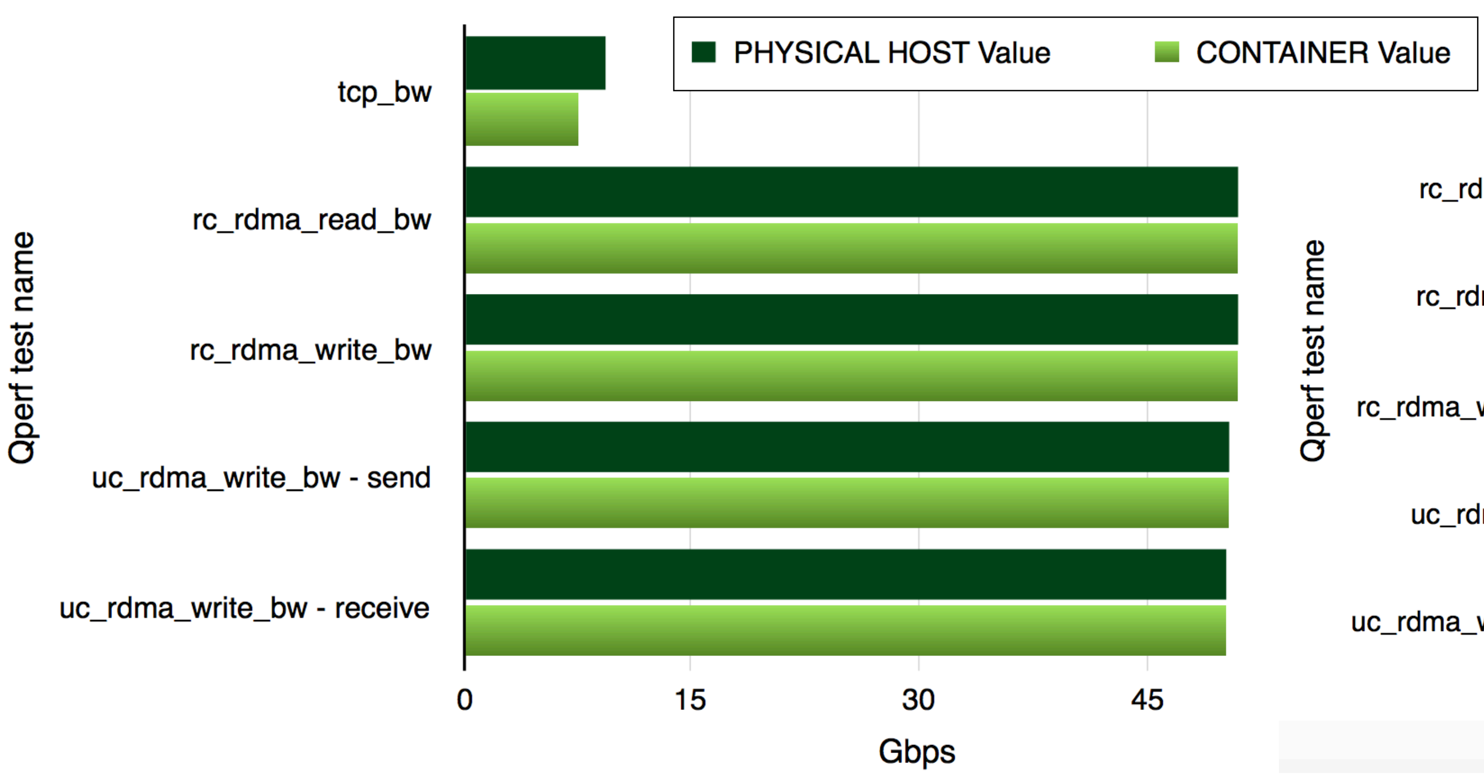
```
{
  "id": "/omkaar-executor-mpi",
  "cpus": 1,
  "mem": 2000,
  "disk": 0,
  "instances": 1,
  "container": {
    "type": "DOCKER",
    "volumes": [],
    "docker": {
      "image": "gitlab.c3s.unito.it:5000/htadmin/createdockers
      "parameters": [
        {
          "key": "net",
          "value": "omkaarnet"
        },
        {
          "key": "device",
          "value": "/dev/infiniband:/dev/infiniband"
        },
        {
          "key": "ulimit",
          "value": "memlock=-1:-1"
        }
```

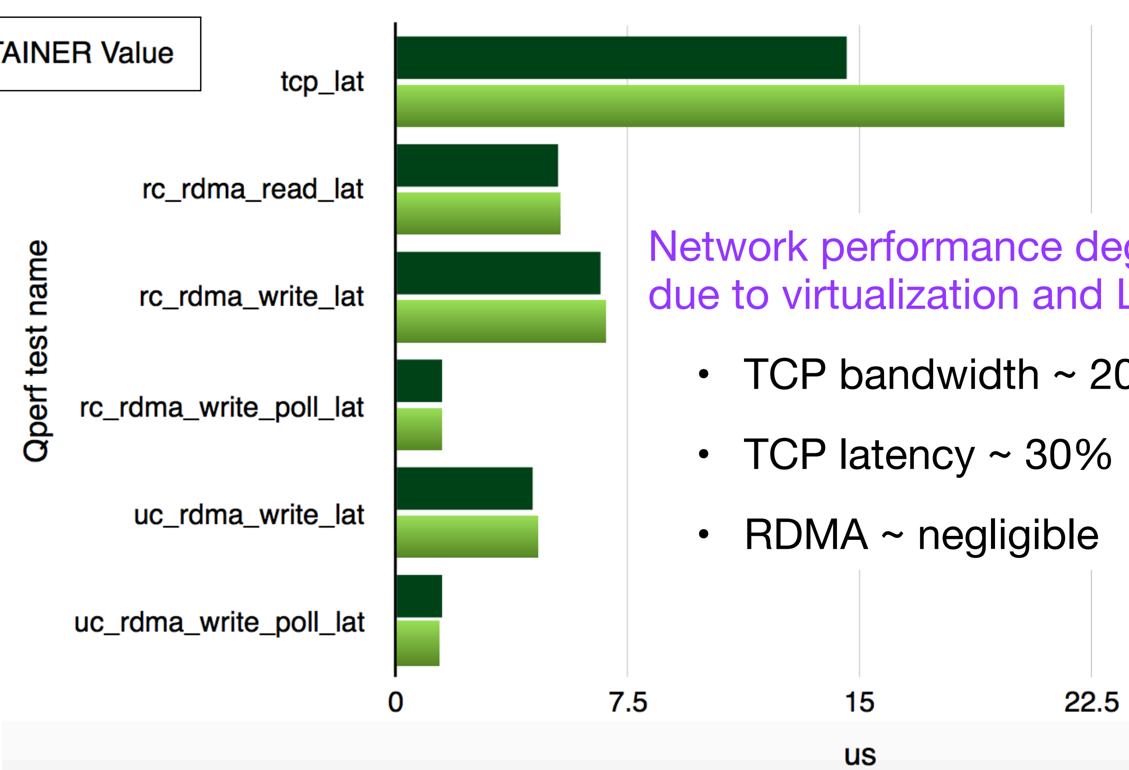
Calico net

InfiniBand

Roundtrip blocking communication between 2 farm nodes (mpptest suite on OpenMPI)







Network performance degradation due to virtualization and L3 overlay:

- TCP bandwidth ~ 20%
- TCP latency ~ 30%
- RDMA ~ negligible

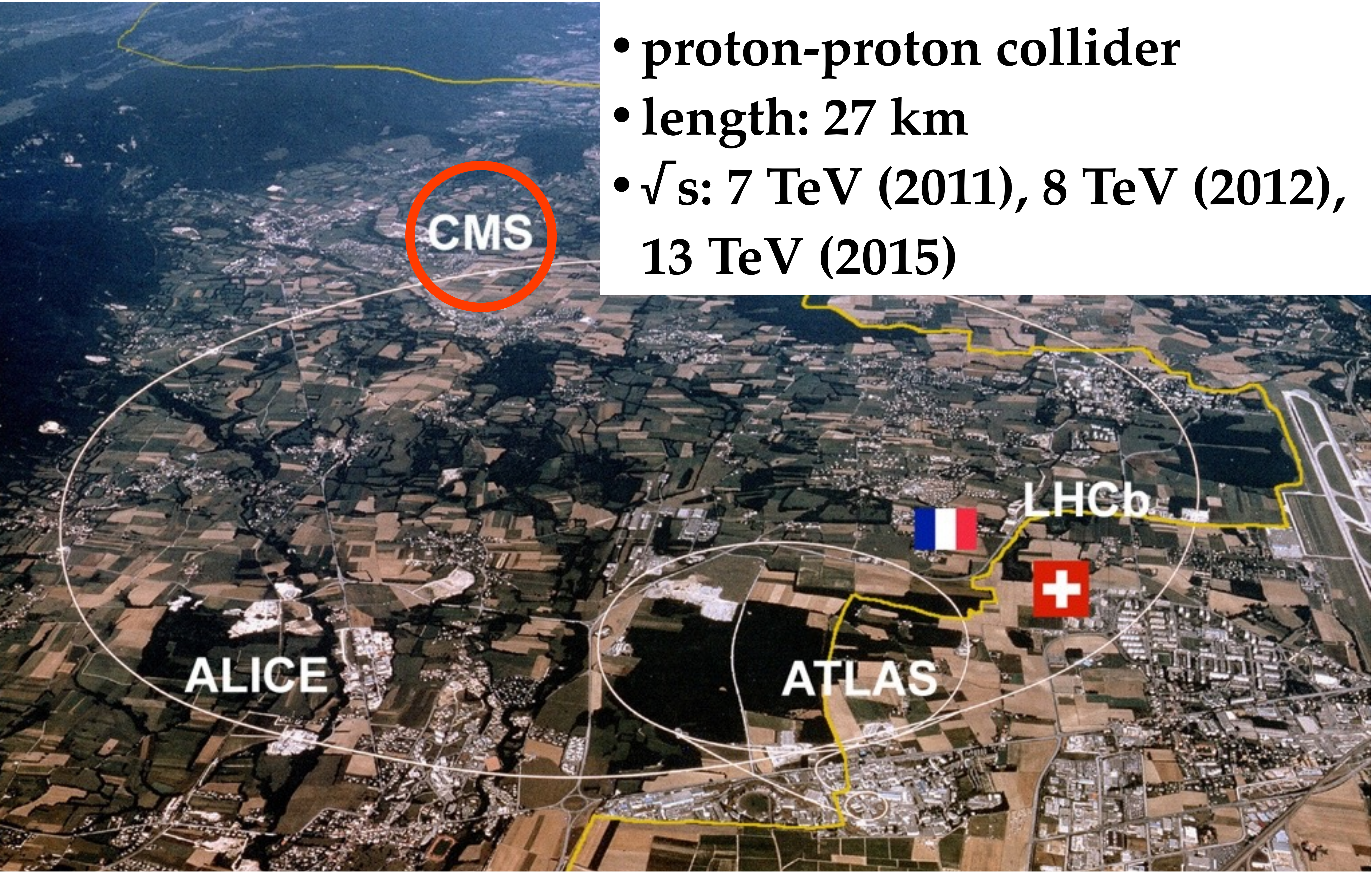
Hi!

Mauro Verzetti

fwo

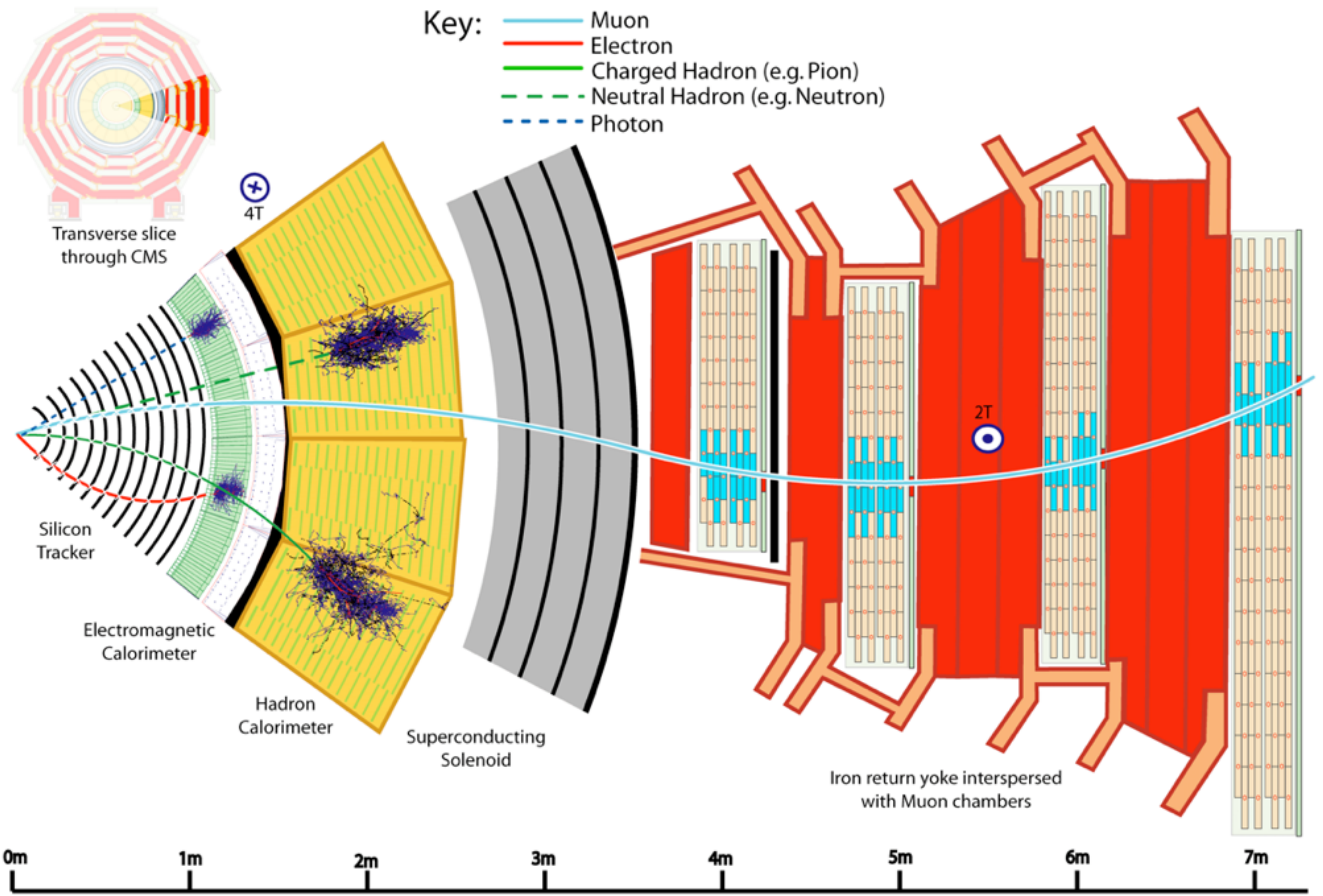
CERN

The LHC

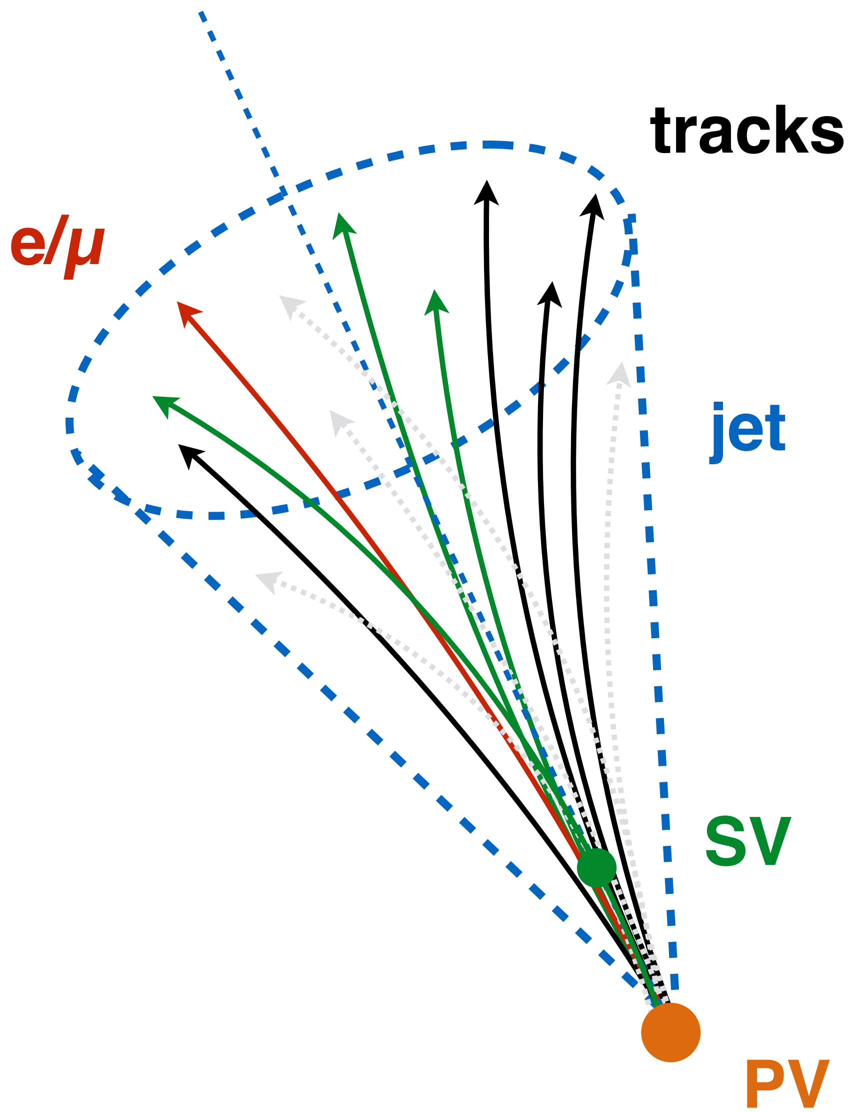


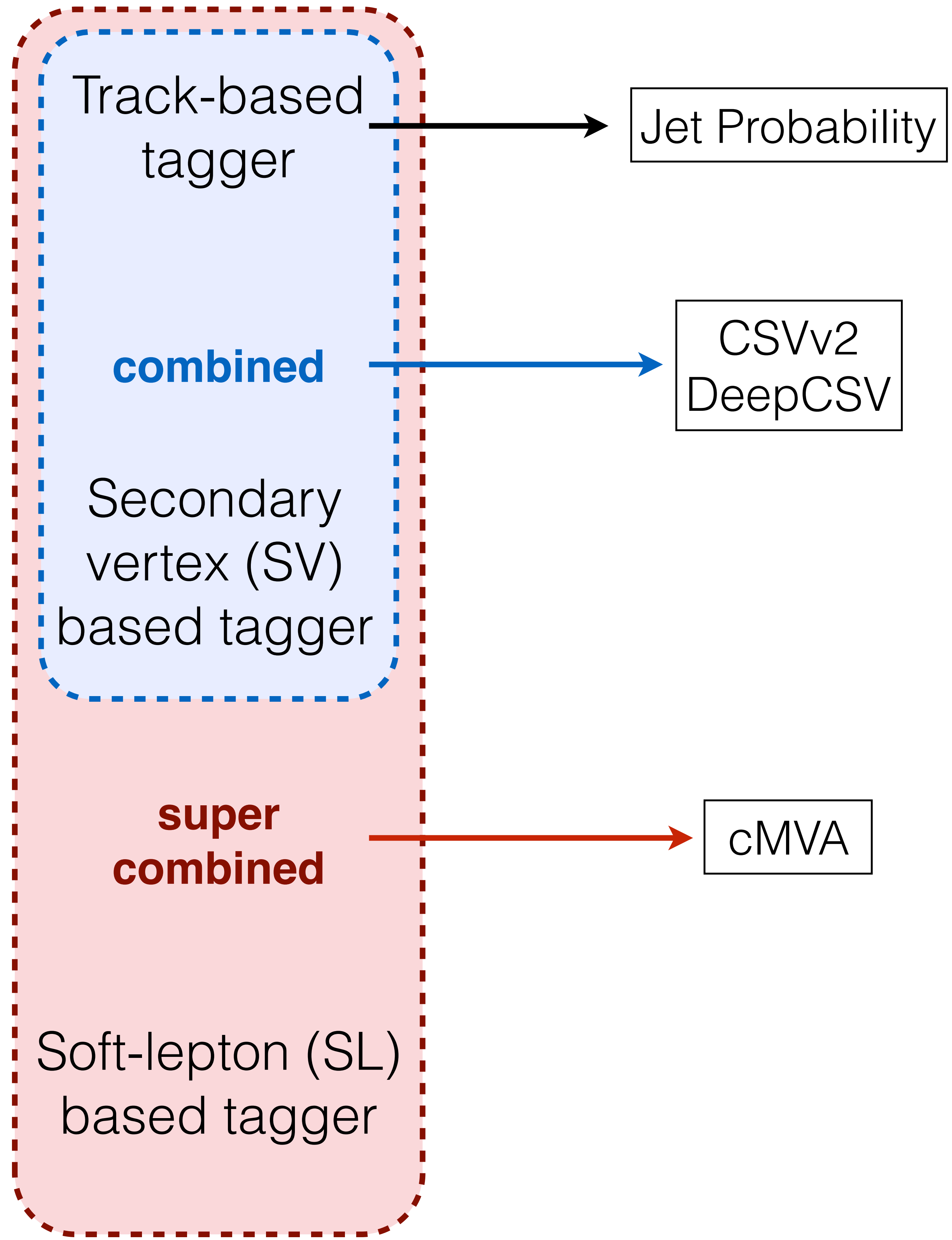
- proton-proton collider
- length: 27 km
- $\sqrt{s}$: 7 TeV (2011), 8 TeV (2012), 13 TeV (2015)

The CMS Experiment



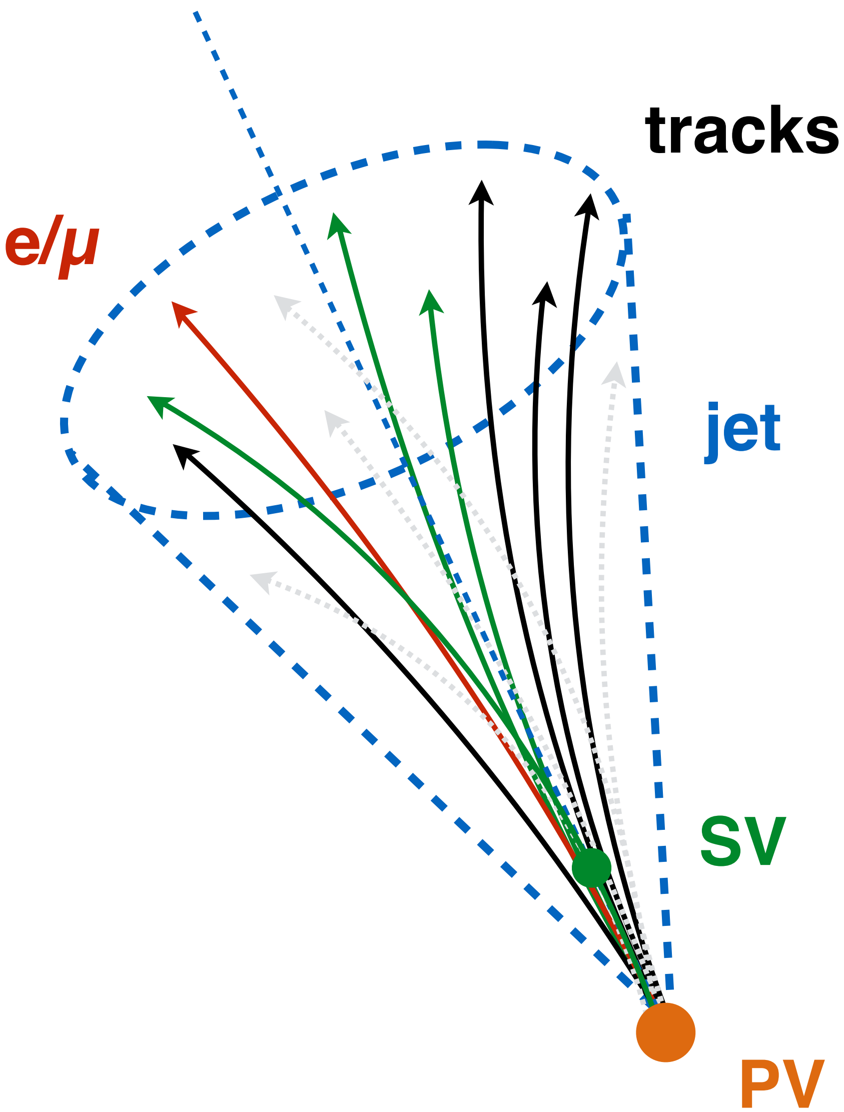
Heavy flavor jets

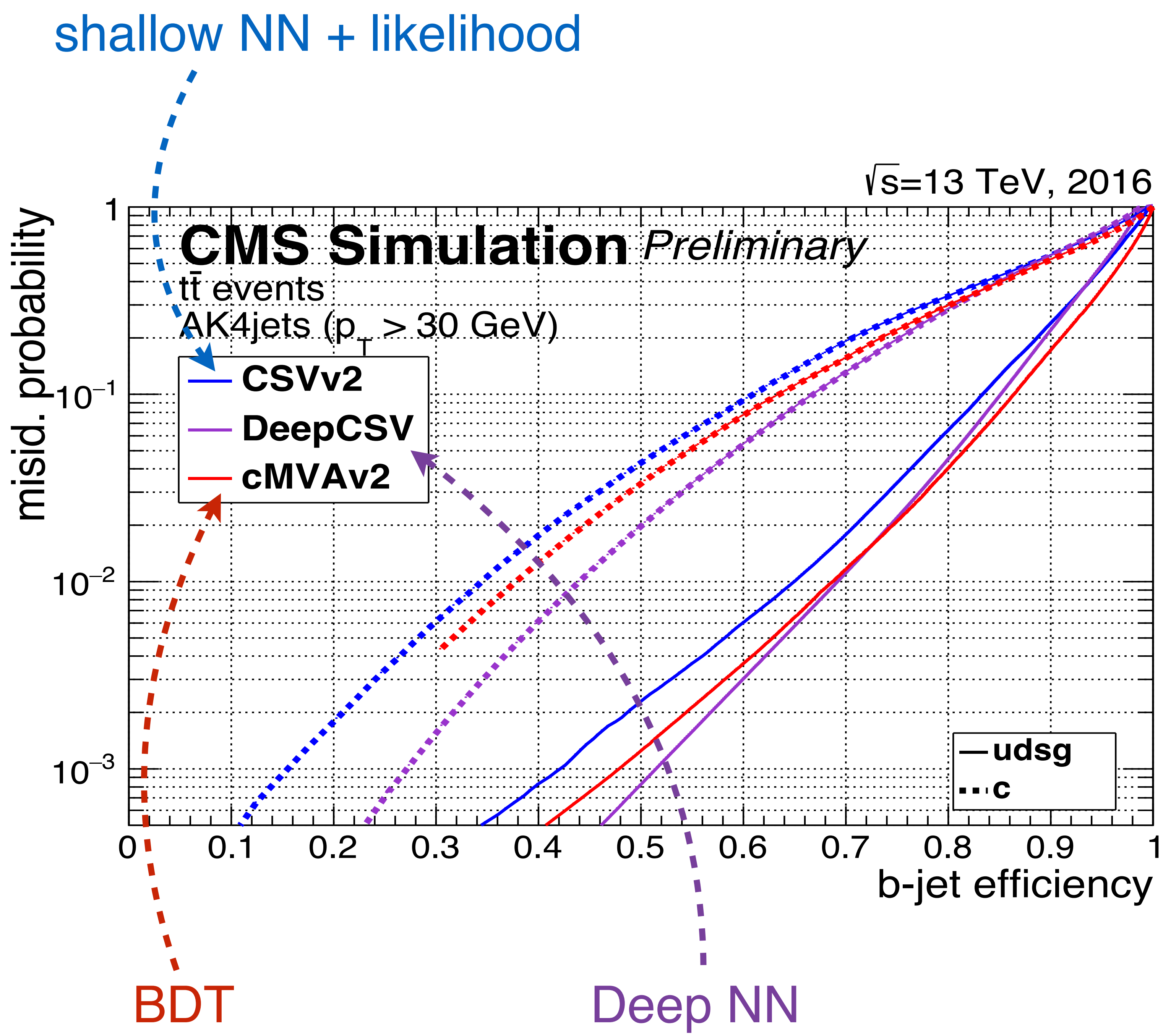




DP-2017-005

Heavy flavor jets





DeepNN shows best performance

DP-2017-005

ESC17: Architectures, tools and methodologies for developing efficient large scale scientific computing applications

Gravitational-wave luminosity of Binary Neutron Star Mergers

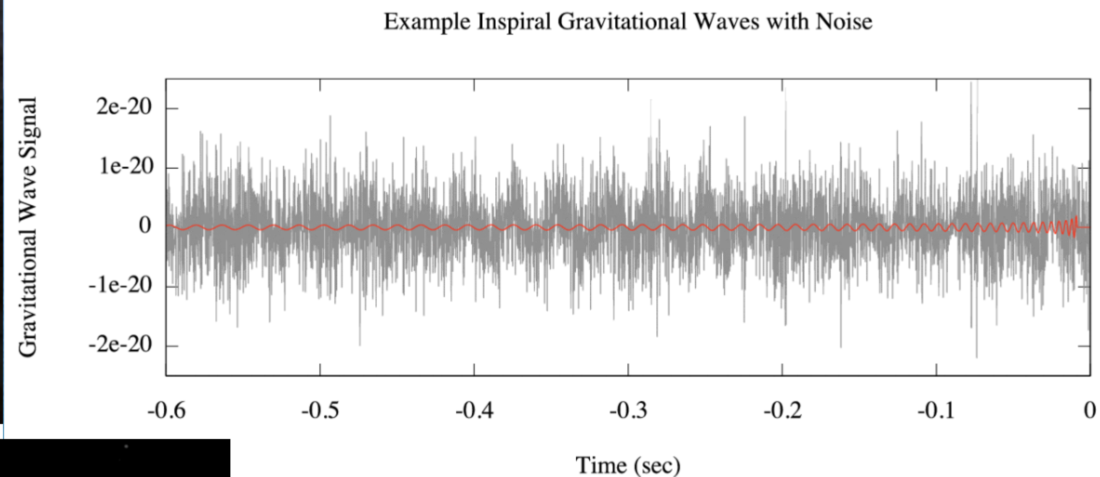
Numerical relativity for gravitational-wave modeling

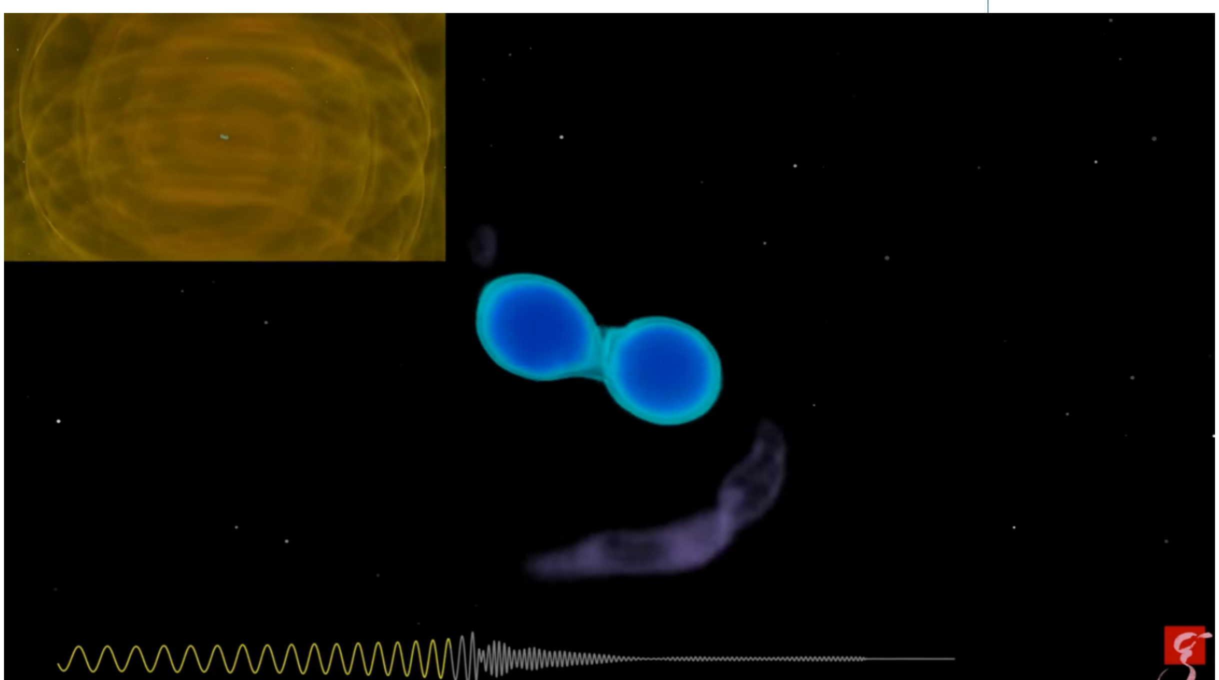
Francesco Zappa

UNIVERSITÀ DI PARMA

Ce.U.B. Bertinoro(FC), 23-28.10.2017

Gravitational-wave observations require waveform models





GW170817, simulation of the merger (T. Dietrich)

Simulations in general relativity (Numerical relativity)

Gravitational waves

Ricci curvature, proportional to second derivatives of $g_{\mu\nu}$

$$R_{\mu\nu} - \frac{1}{2} R\, g_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu}$$

Four-tensor metric, the unkown.

Stress-energy tensor (source term).

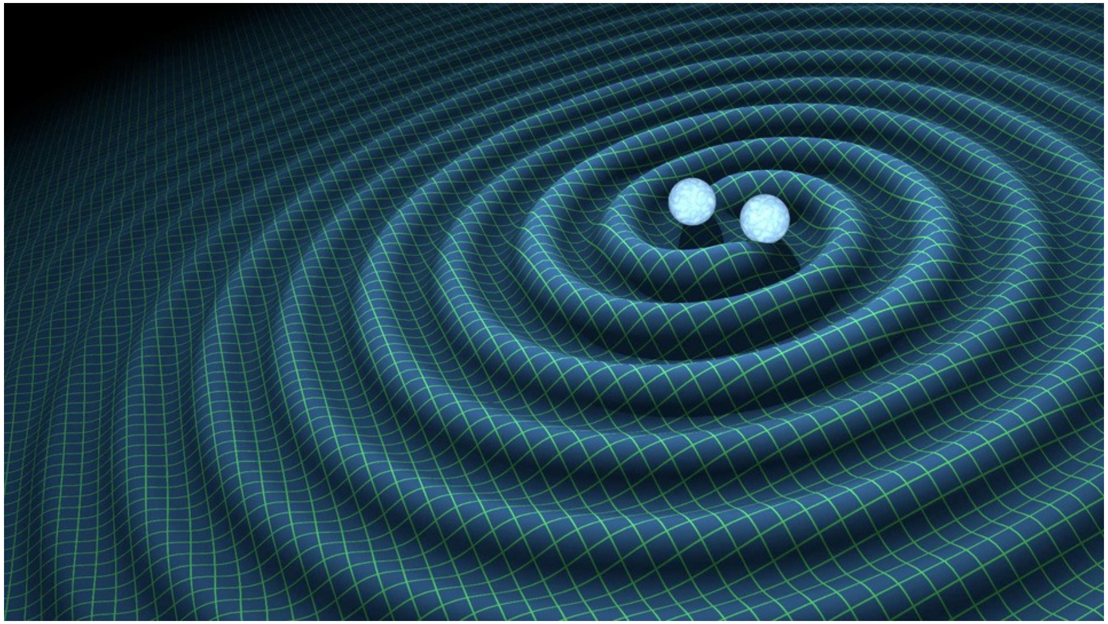
Ansatz GW:

$$g_{\mu\nu} = \eta_{\mu\nu} + h_{\mu\nu}$$

Small perturbation over the flat background

Linearized Einstein equations are tensor wave equations:

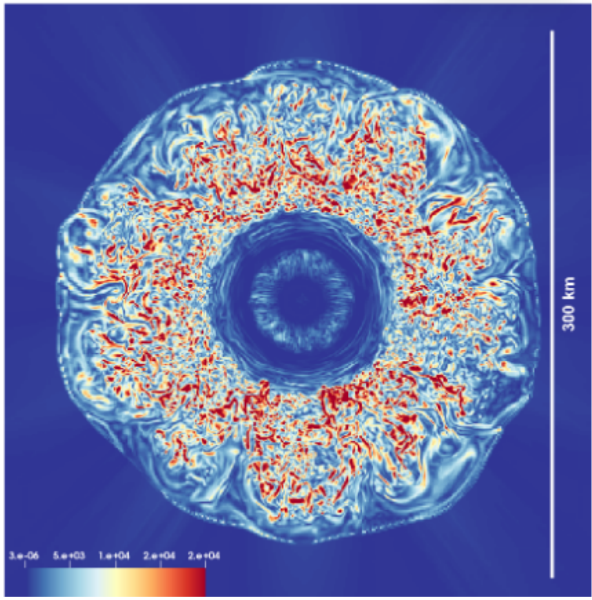
$$\partial_t^2 h_{ij} = \eta^{kl} \partial_k \partial_l h_{ij}$$



Numerical relativity

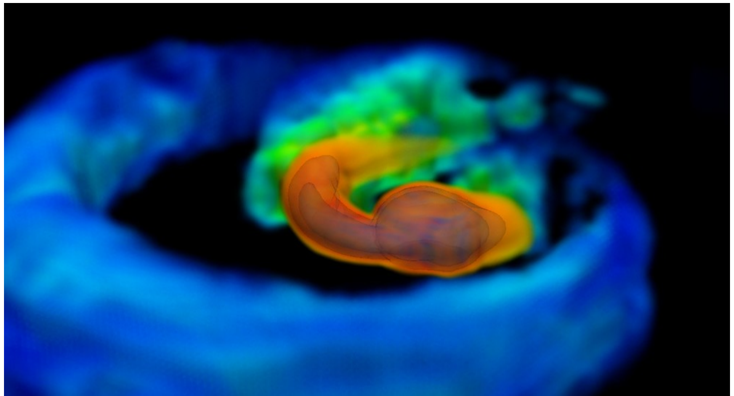
Challenges:

- GR formulation and Cauchy problem
- Coordinates
- GR hydrodynamics (Neutron star mergers, supernova bursts..)
- Strong and dynamical gravitational field
- Multi-physics and multiscales



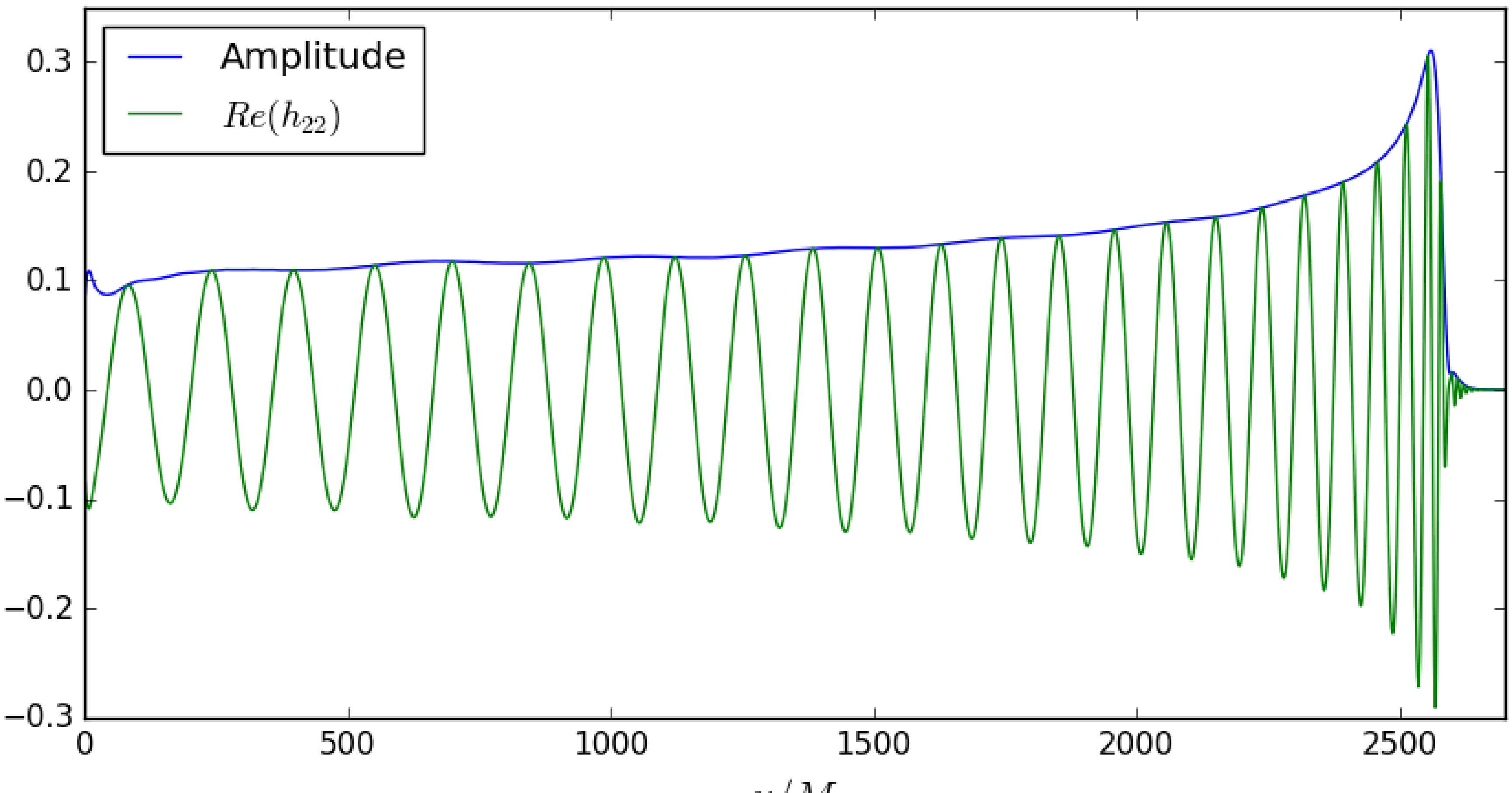
Application examples:

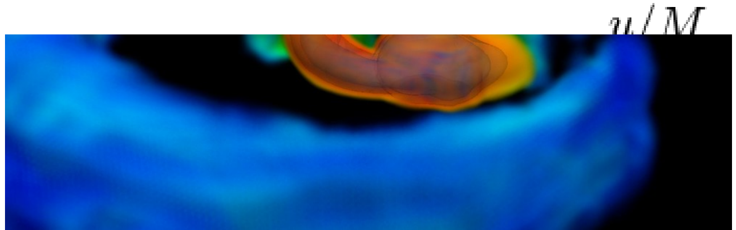
- Compact binary mergers [S. Bernuzzi 2012, D. Radice 2015]
- Supernova core collapse [Winteler 2012, D. Radice 2016]
- Gravitational wave modeling [S. Bernuzzi 2016, T. Dietrich 2017]



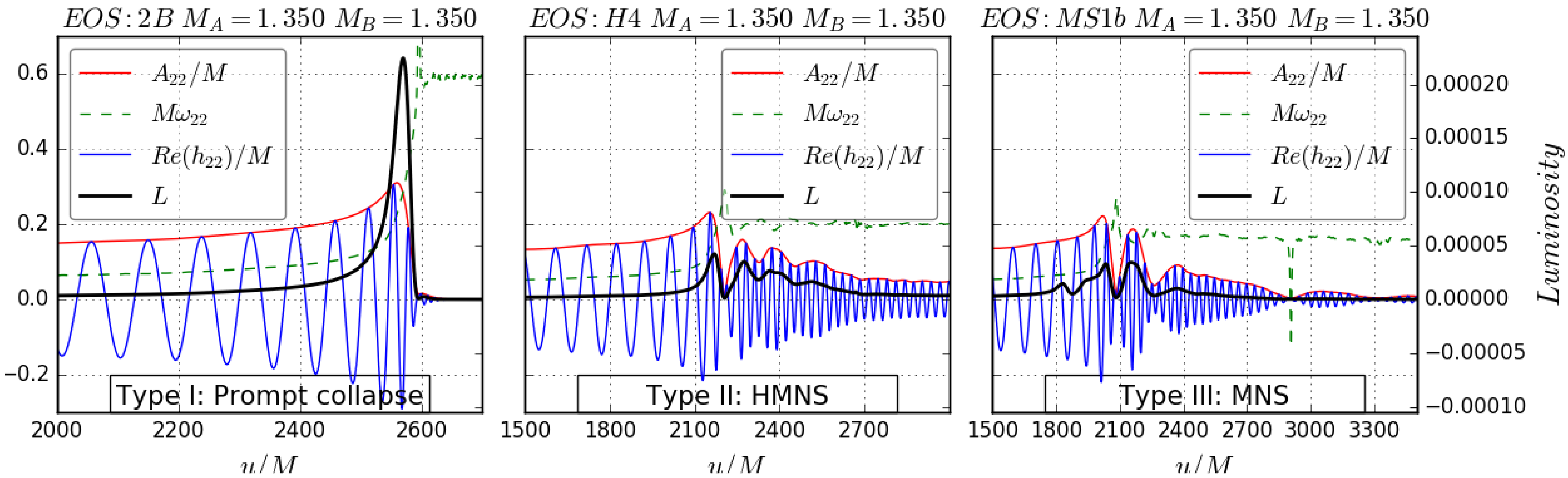
Numerical relativity

Challenges:





My work: luminosity of GWs



Tidal effects are quantified by one parameter κ^T_2 that strongly affects the merger's dynamic:

L_{peak}/κ^T_2 for many simulations → fit

My work: luminosity of GWs