Needs and Considerations for a consortium of accelerator modeling

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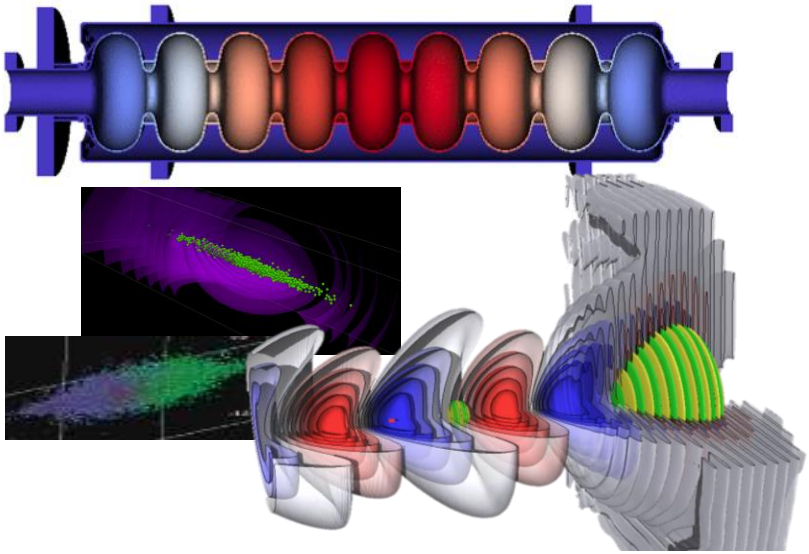
Designs of accelerators are limited by what we can build, afford and compute!



Computer modeling is essential for:

- **optimizing** existing accelerators
- **cost effective** design
- devel. **game changing** technologies

- Trend requires **team work**

  increasingly complex accelerators call for

  increasingly sophisticated simulation software

- Current situation is **inefficient**
  - numerous codes within projects with little coordination or reuse
  - **no dedicated funding** for development, support & training

  ➔ especially problematic for codes with growing popularity

New initiative

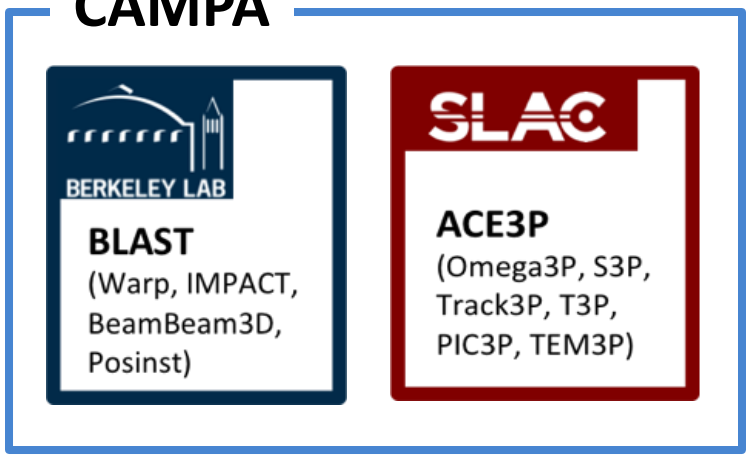
Consortium for Advanced Modeling of Particle Accelerators

Mission:

- **develop**, **maintain**, **distribute** & **support** an **integrated** suite of state-of-the-art accelerator computer codes
- promote **collaboration** & **re-use** of codes & data through **common** interfaces, data standards, visualization and analysis capabilities;
- use codes to **advance accelerator science** through **advanced computation**
- **train** new generation in accelerator modeling on the latest hardware

CAMPA started as LBNL-SLAC collaboration

Consortium for
Advanced
Modeling of
Particle
Accelerators



Points of contact:

LBNL: J.-L. Vay, J. Qiang

SLAC: C.-K. Ng, Z. Li

Initial investment by U.S. DOE-HEP:

- $250k in FY14 for LBNL-SLAC

Expanded to LBNL-SLAC-FNAL collaboration

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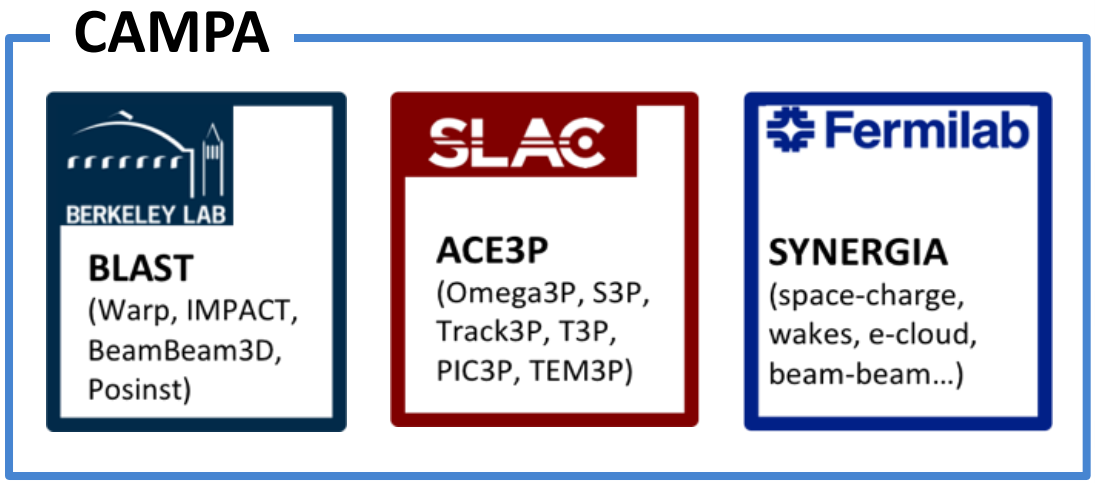


Points of contact:

LBNL: J.-L. Vay, J. Qiang

SLAC: C.-K. Ng, Z. Li

FNAL: J. Amundson, E.G. Stern

Initial investment by U.S. DOE-HEP:

- $250k in FY14 for LBNL-SLAC
- $500k in FY15 for LBNL-SLAC-FNAL

Need of solution for non-disruptive integration

Significant investments of HEP into existing pool of codes:

- essential to **minimize disruptions** to developers and users,
- while **enabling interoperability** and **expandability**.

Challenges:

Technical

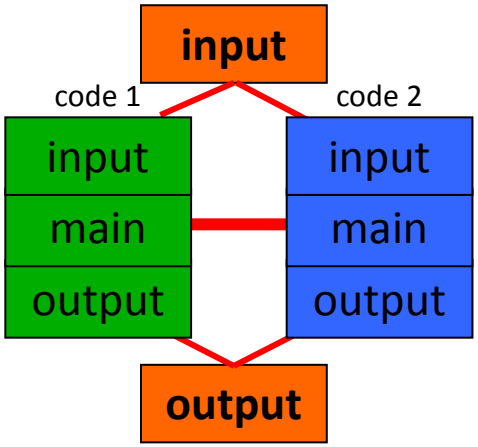
- programming languages
- data formats, parallelism
- code architectures
- open vs proprietary sources
- keep creativity

Human

- changing habits is hard
- different visions
- (re)build trust
- corporatism/rivalry
- recognition
- distance

Mitigation of difficulties through adiabatic transition

Existing set of separate codes ➔ **ecosystem** of **interconnected codes**



…

Bridge codes to enable:

- **unified** input/output interface
- **sharing** of functionalities
- **collaborative** development of common units
- "natural" **down selection** of modules
- devel. & users playing **Lego** with "code genes"

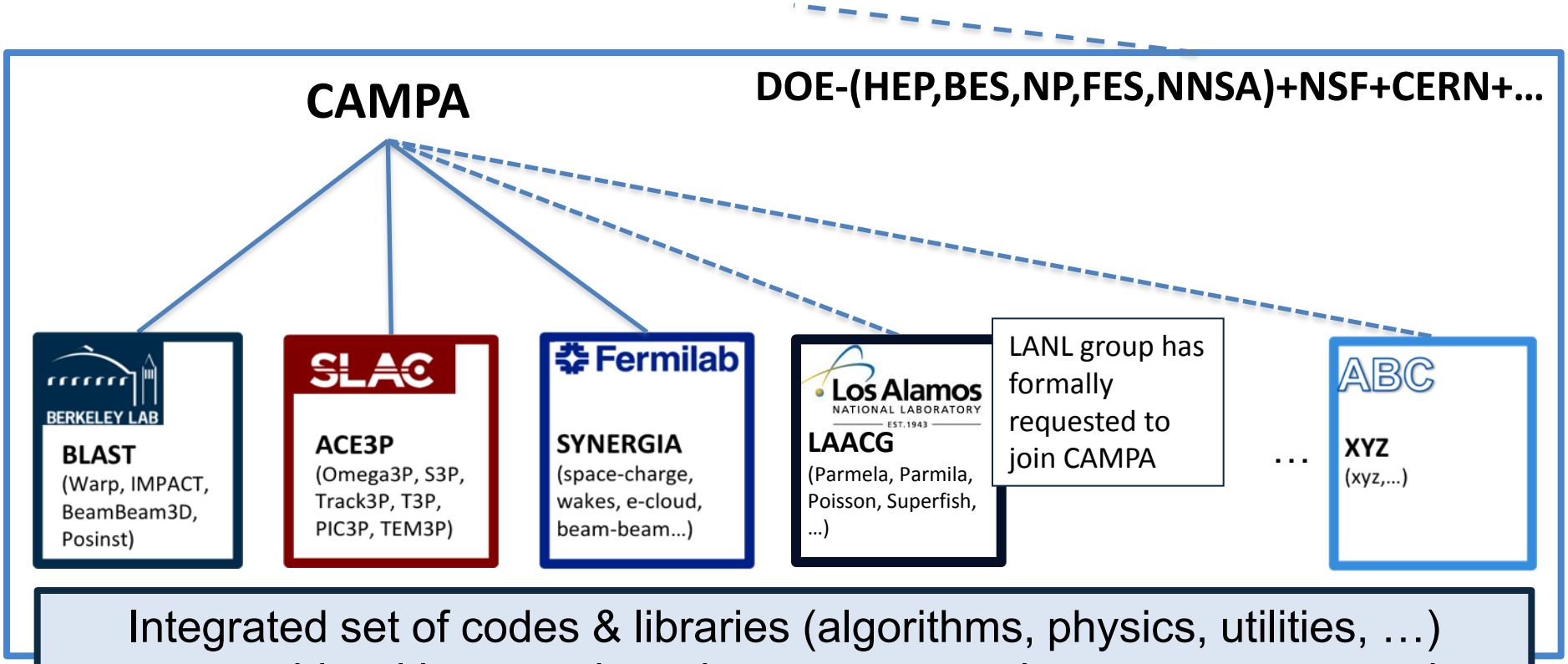
Common modules in libraries of compiled C, C++ or FORTRAN

Unified I/O and framework in Python:

- Python scripting language has unique attributes:
  - rapid development and prototyping of scientific applications is expandable and couples to FORTRAN, C and C++

Possible evolution of CAMPA

US DOE-HEP Forum for Computational Excellence/ International HEP Software Foundation



Integrated set of codes & libraries (algorithms, physics, utilities, …)
Partnership with CS and AM (DOE-ASCR, SciDAC ComPASS, etc)

HSF/FCE/CAMPA are synergistic – looking forward to cross-benefits!

Extras

Example of duplication in beam dynamics codes

Codes section from Accelerator Handbook (A. Chao, 2013)

Beam Dynamics Codes:

(Below, PIC refers to codes with particle-in-cell space-charge capability.)

Code	URL or Contact	Description/Comments
ASTRA	tesla.desy.de/~meykopff	3D parallel, general charged particle beams incl. space charge
AT	sourceforge.net/projects/atcollab/	Accelerator Toolbox
BETACOOL	betacool.jinr.ru	Long term beam dynamics: ECOOL, IBS, internal target
Bmad, Tao	www.lns.cornell.edu/~dcs/bmad/	General purpose toolbox library + driver program
COSY INFINITY	www.cosyinfinity.org	Arbitrary-order beam optics code
CSRTrack	www.desy.de/xfel-beam/csrtrack	3D parallel PIC; includes CSR; mainly for e- dynamics
Elegant/SDDS suite	aps.anl.gov/elegant.html	parallel; track, optimize; errors; wakes; CSR
ESME	www-ap.fnal.gov/ESME	Longitudinal tracking in rings
HOMDYN	Massimo.Ferrario@LNF.INFN.IT	Envelope equations, analytic space charge and wake fields
IMPACT code suite	amac.lbl.gov	3D parallel multi-charge PIC for linacs and rings
LAACG code suite	laacg.lanl.gov	Includes PARMILA, PARMELA, PARMTEQ, TRACE2D/3D
LiTrack	www.slac.stanford.edu/~emma/	Longitudinal linac dynamics; wakes; GUI-based; error studies
LOCO	safranek@slac.stanford.edu	Analysis of optics of storage rings; runs under matlab
LUCRETIA	www.slac.stanford.edu/accel/ilc/codes	Matlab-based toolbox for simulation of single-pass e- systems
MaryLie	www.physics.umd.edu/dsat	Lie algebraic code for maps, orbits, moments, fitting, analysis
MaryLie/IMPACT	amac.lbl.gov	3D parallel PIC MaryLie optics + IMPACT space charge
MAD-X	mad.web.cern.ch/mad	General purpose beam optics
MERLIN	www.desy.de/~merlin	C++ class library for charged particle accelerator simulation
OPAL	amas.web.psi.ch	3D parallel PIC cyclotrons, FFAGs, linacs; particle-matter int.
ORBIT	jzh@ornl.gov	Collective beam dynamics in rings and transport lines
PATH	Alessandra.Lombardi@cern.ch	3D PIC; linacs and transfer lines; matching and error studies
SAD	acc-physics.kek.jp/SAD/sad.html	Design, simulation, online modeling & control
SIMBAD	agsrhichome.bnl.gov/People/luccio	3D parallel PIC; mainly for hadron synchrotrons, storage rings
SIXTRACK	frs.home.cern.ch/frs/	Single particle optics; long term tracking in LHC
STRUCT	www-ap.fnal.gov/users/drozhdin	Long term tracking w/ emphasis on collimators
Synergia	https://compacc.fnal.gov/projects	3d parallel PIC: space charge, nonlinear tracking and wakes
TESLA	lyyang@bnl.gov	Parallel; tracking; analysis; optimization
TRACK	www.phy.anl.gov/atlas/TRACK	3D parallel PIC mainly for ion or electron linacs
LIBTRACY	libtracy.sourceforge.net/	Library for beam dynamics simulation
TREDI	www.tredi.enea.it	3D parallel PIC; point-to-point Lienard-Wiechert
UAL	code.google.com/p/ual/	Unified Accelerator Libraries
WARP	DPGrote@lbl.gov	3D parallel ES and EM PIC with accelerator models
ZGOUBI	sourceforge.net/projects/zgoubi/	Magnetic optics; spin; sync radiation; in-flight decay

Value added to science, agencies, users & developers

Accelerator S. & T.

- offers path toward **game changer modeling tools**
  - virtual prototyping/experiments
  - online modeling for realtime feedback

➔ **speed up design** and **innovation**

DOE

- **accelerate discovery**
  ➔ higher return on investment
- **single point of contact** for modeling tool funding

Code users

- **integrated**, **comprehensive** & **more capable** (multiphysics/multiscale) software
- **single point of contact** for simulation tool solutions

Code developers

- **dedicated funding** for user support, algorithmic, code implementation & maintenance
- **recognition** for acc. software development,
- a **carrier path**