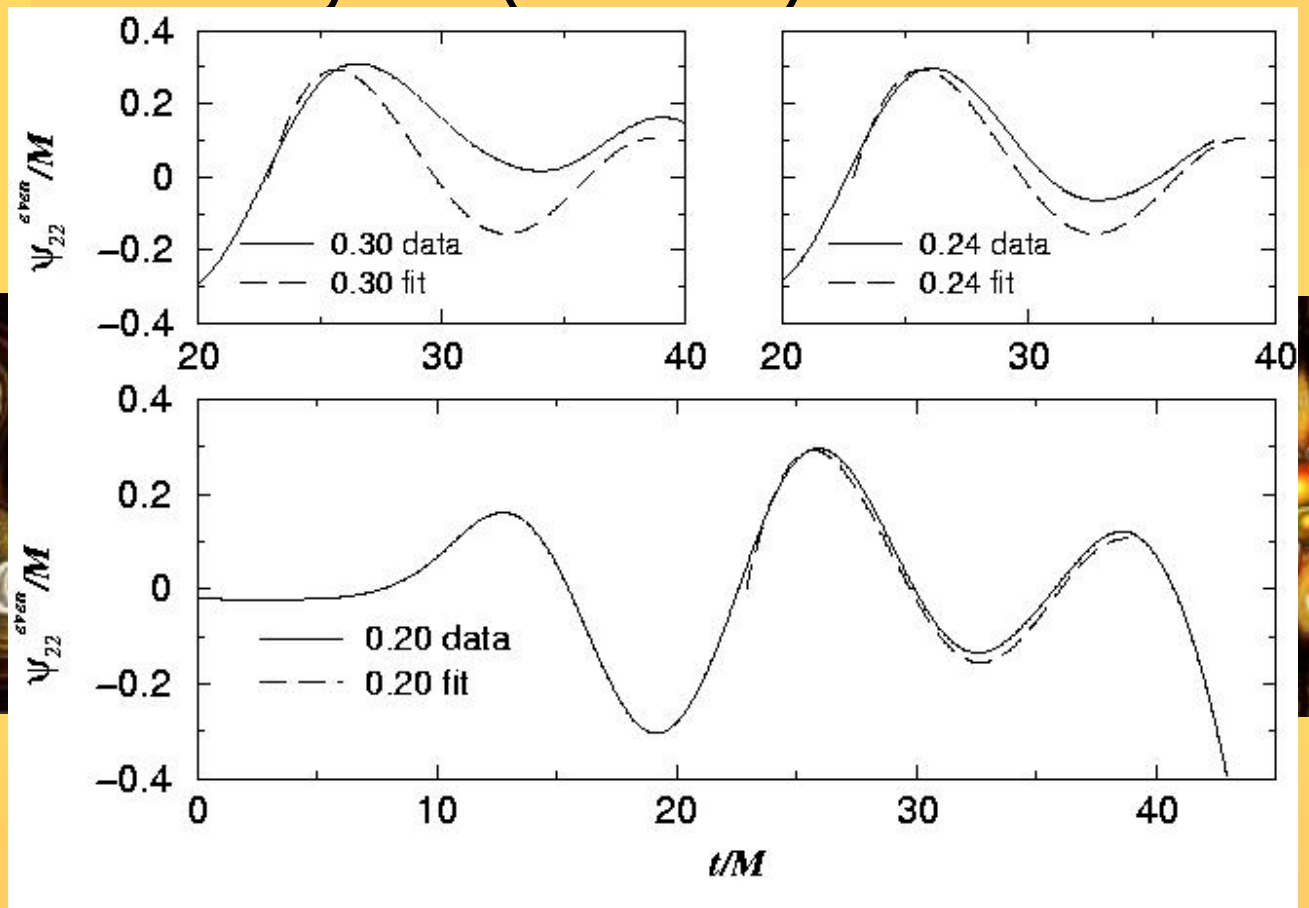
EU Astrophysics Network Overview

- Progress on 3D BH Collsions (me)
- 3D Hydro (Luciano)



Objectives of Network

A Training program to build a community

Enablers

Computational Tools

Cactus

Viz

Grid

ASC

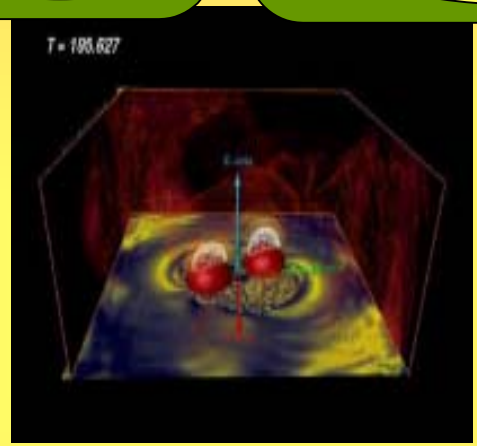
Theoretical Tools

Einstein Eqs

Post-Newtonian Theory

Pert. theory

Focus Physics Areas



3D BH Collisions

3D NS processes and mergers

Other (strange stars, Core collapse, etc)

Outreach /Leverage

ZIB/Garching

LBL/NCSA/ANL

Cactus Community

People 65:10!

World

NSF ASC

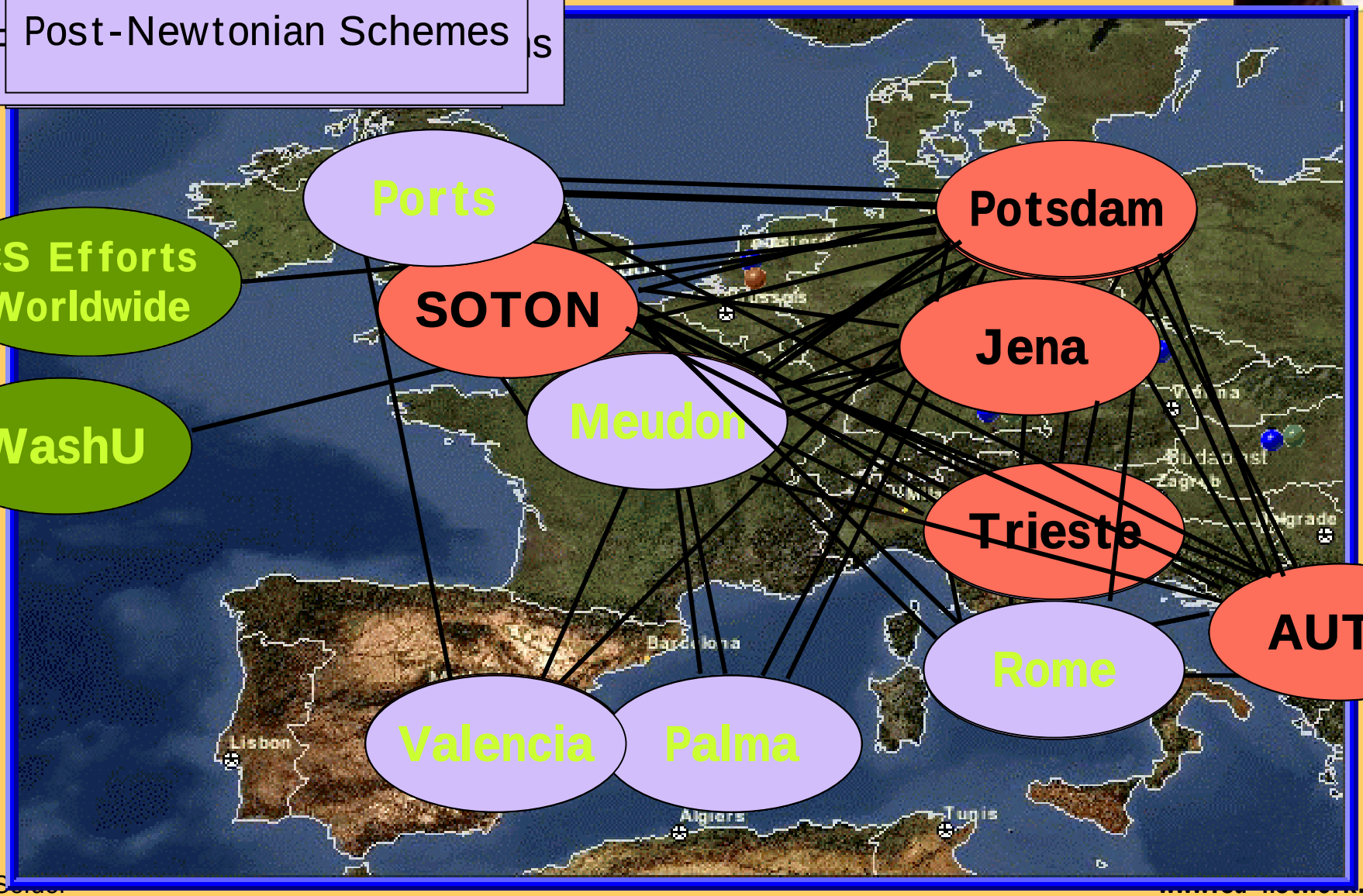
GridLab

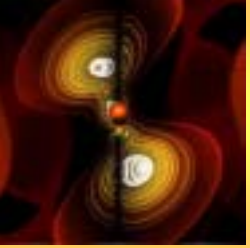
Ed Seidel
Albert Einstein Institute

Our Team

7 Focus areas, links created, strengthened by Network

Post-Newtonian Schemes



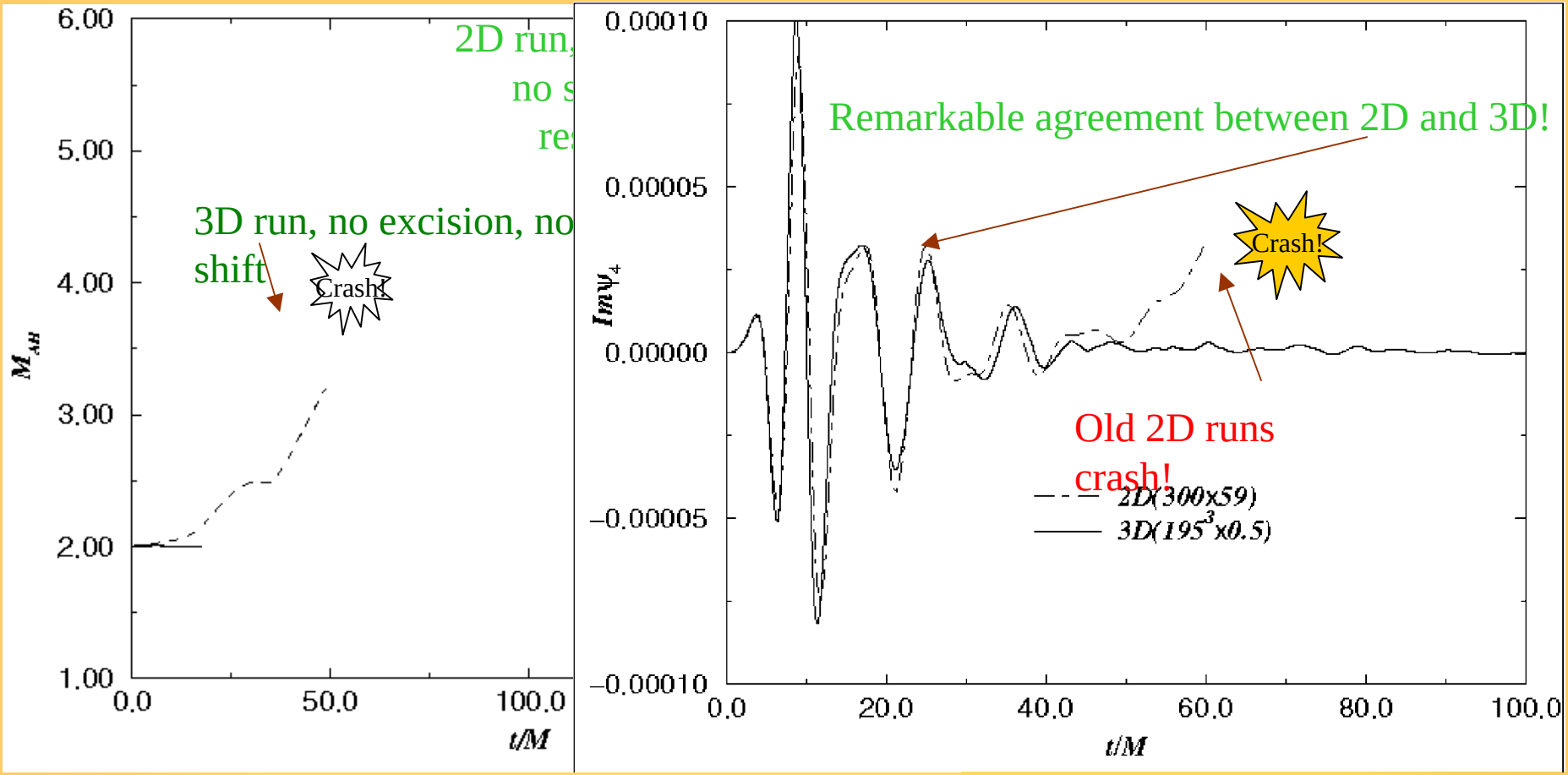


Steps to BBH Orbits

(AEI/UT-Brownsville/Meudon)

- Step 0: Better Formulations (BSSN), gauges, excision
- Step 1: Do 3D single, rotating distorted BHs individually
  - *t ~ 100s - 1000s M* with convergence, solid masses, waveforms
  - Some instability may appear after *t ~ 200 - 500M* in full 3D
- Step 2: Do head-on BH collisions
  - *100s - 1000s M* with convergence, solid masses, waveforms
- Step 3: Go to co-rotating frame for orbits!
  - Can just about do this today…

Step 1:
Single 3D BHs Become "Routine"



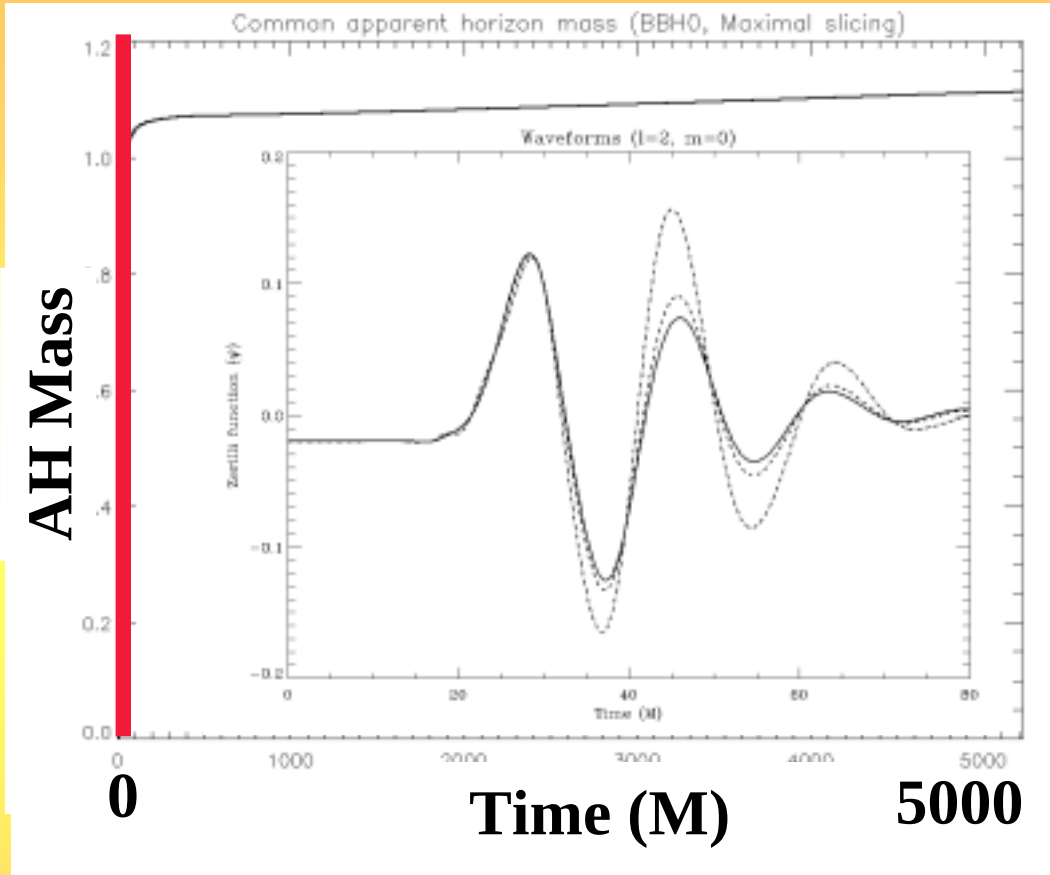
Comparison of Schwarzschild BHs

Highly Distorted Rotating BH Waveform

Ed Seidel
Albert Einstein Institute

Step 2:
3D Head-On Collisions "Routine"

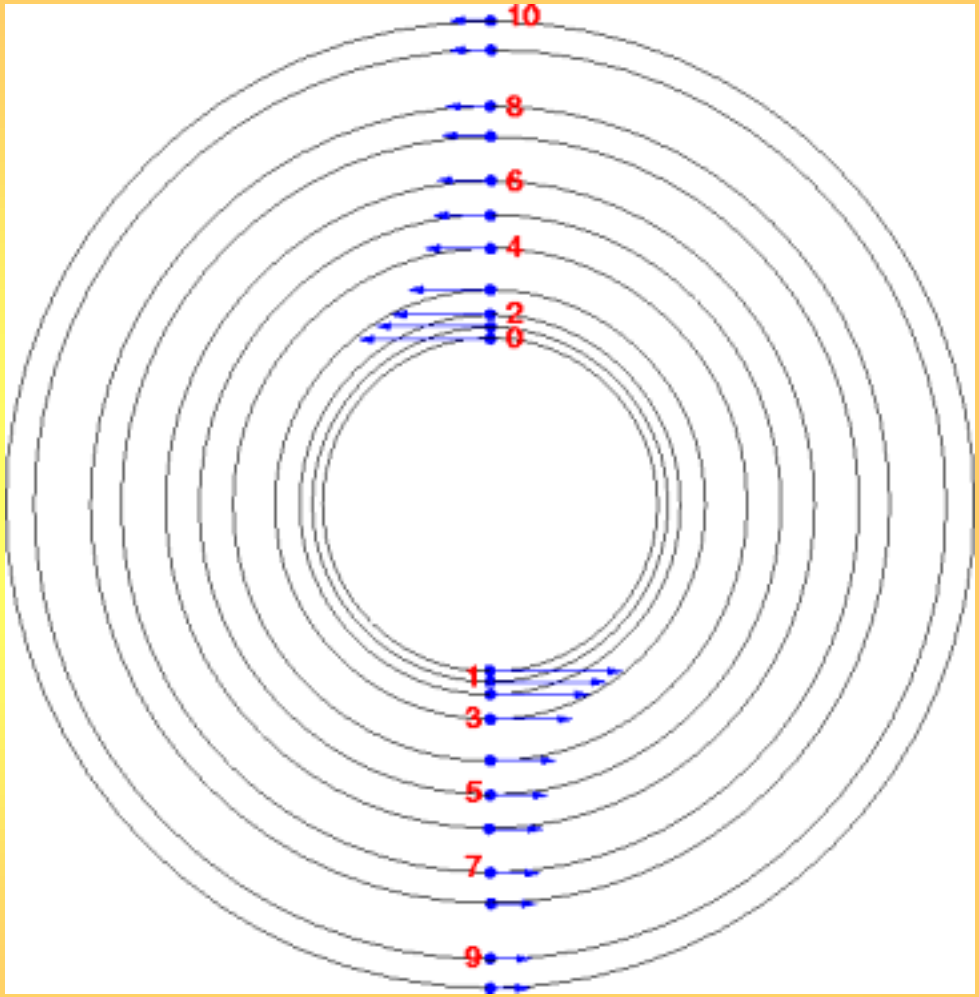
- Brill-Lindquist
  - Approx ISCO separation
  - No momentum
  - Similar to Misner μ=2.2
  - New dynamic shift/lapse combo
  - No Excision!!!



From Peter Diener…

Step 3: Co-rotating frame for Orbits

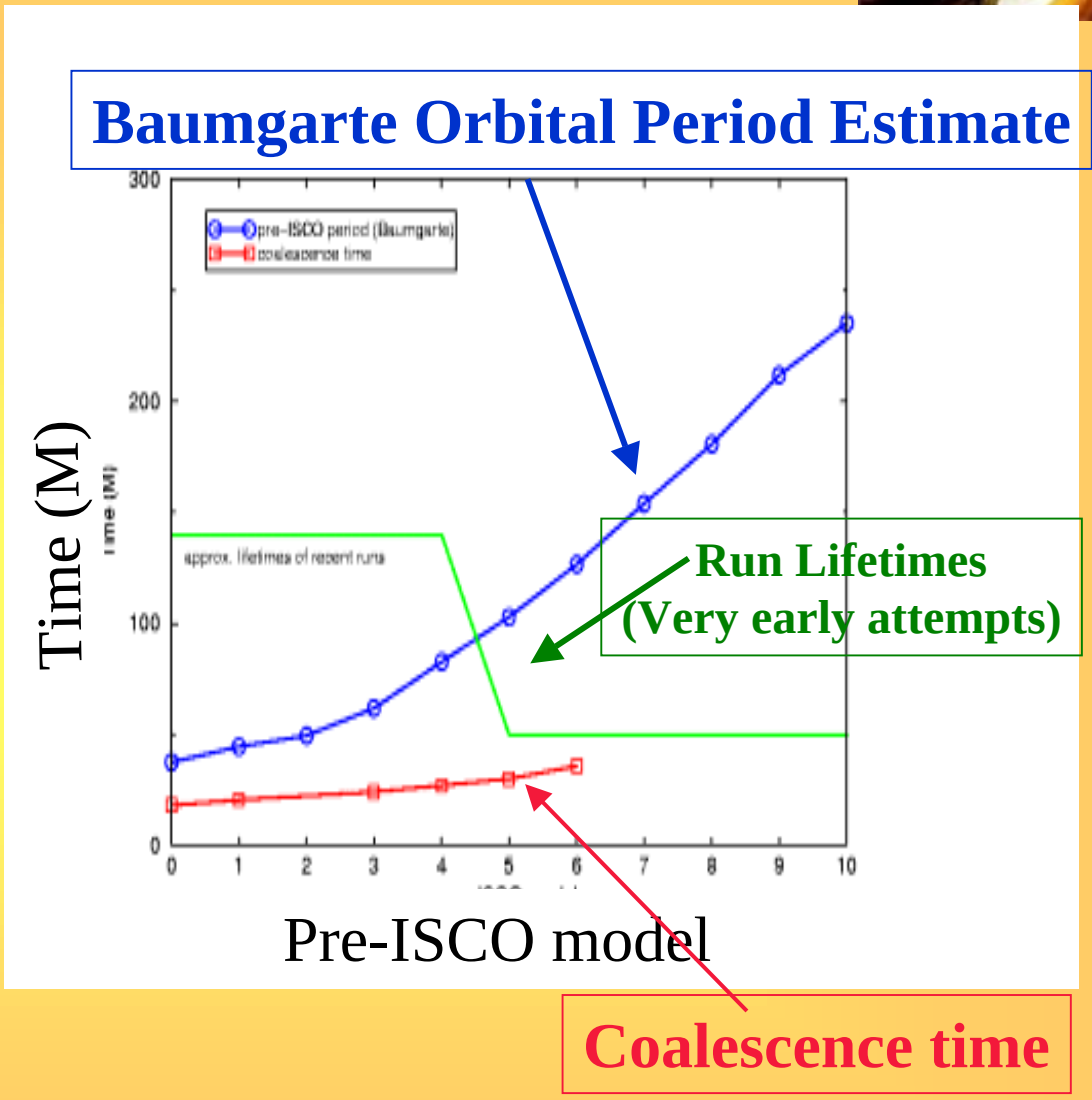
- New Techniques
  - Excision
  - Gauges, formulations
  - Co-rotating frame
- Baumgarte initial data
  - Estimated Innermost Stable Circular Orbit (ISCO)
  - Other circular orbits, too ("Pre-ISCO" sequence: PI-1-10)



From Denis Pollney…

Overview of Evolutions So Far

- Major problem is finding data sets that want to orbit!
- Baumgarte data
  - Seem to have momentum too low for circular orbits
  - Ω seems to be overestimated by factor of 2
- Evolutions solid (e.g., horizon mass accurate to 10% at t~100M)



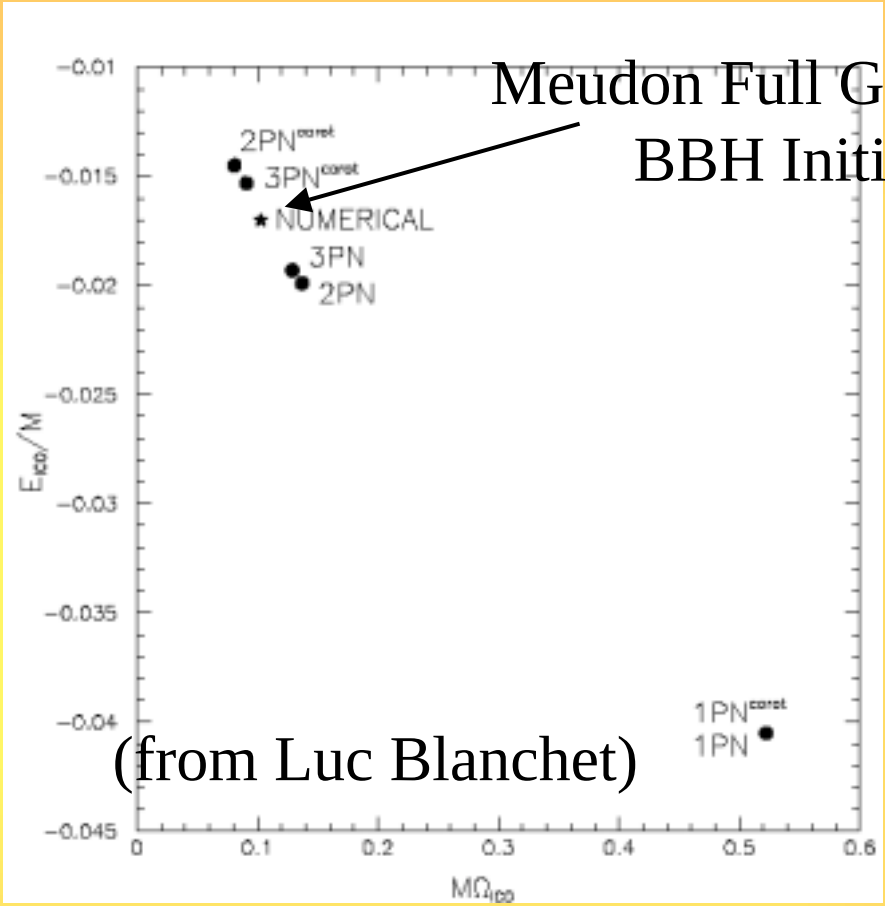
Example: Pre-ISCO 3

K_{zz} in x-y plane, showing excision (corotating)

AHs and Ψ_4 (Corotation taken out)

Increasing sophistication in IVP
Grandclement (Meudon) BBH data

- Builds in approx helical Killing vector
- Has orbital period of ~ 2x that of potential method (also what we see in evolutions!)
- Post-Newtonian expansions seem to converge towards the numerical BBH data



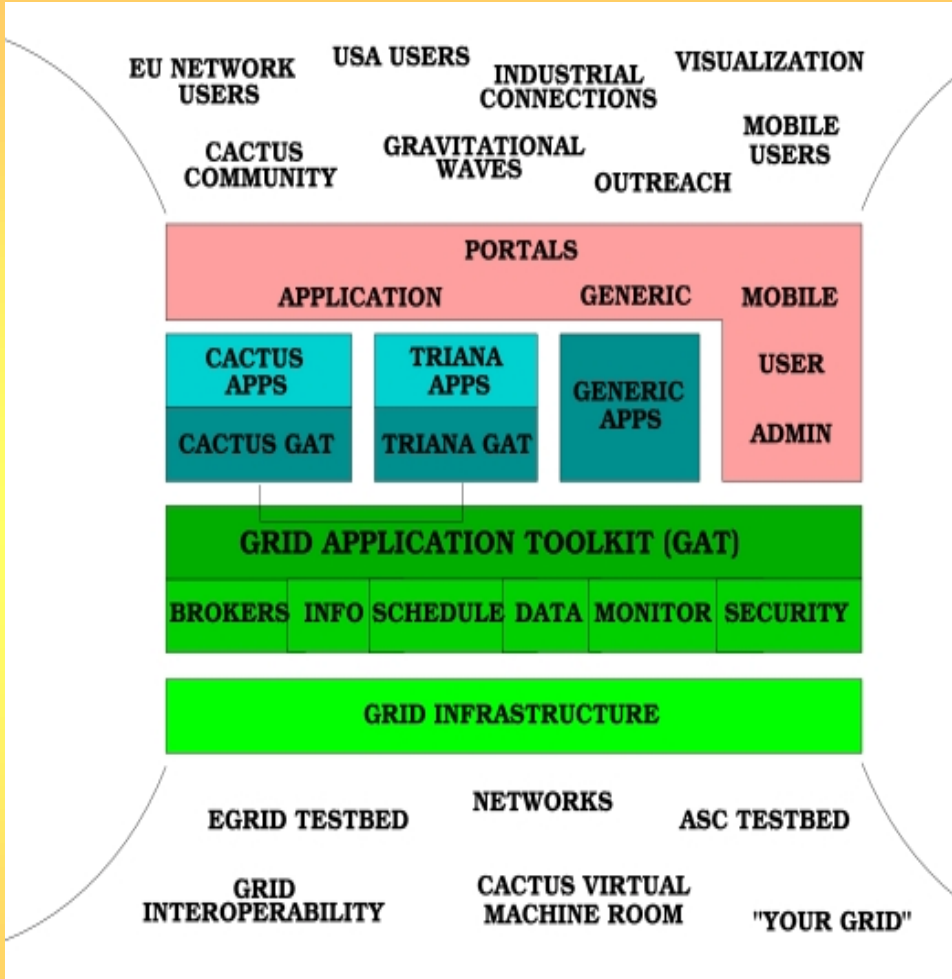
- Meudon Group: most astrophysically relevant binary BH data to date. Now in Cactus as EU Network Project

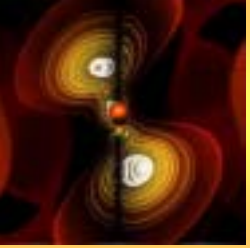
GridLab:

www.gridlab.org

Enabling Dynamic Grid Applications

- EU Project (€5M)
  - AEI, ZIB, PSNC, Lecce, Athens, Cardiff, Amsterdam, SZTAKI, Brno, ISI, Argonne, Wisconsin, Sun, Compaq
- Grid Application Toolkit for application developers (APIs/Tools)
- Develop new grid scenarios for 2 main apps:
  - Numerical relativity
  - Grav wave data analysis

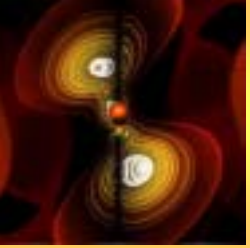




Discovery Channel wants Pre-ISCO 3! This June...

Building a Community (through) Code: Advantages

- Sharing of Expertise: No single group or community can do these problems
- Sharing of Code among projects
  - Infrastructure
  - BH routines apply directly to NS work, etc…
  - But free to keep routines in group as long as desired
- Better Code
  - Open source encourages people to be more careful in coding!
  - Encourages documentation
  - Encourages deeper thinking about how it interfaces to another code
- More trusted code, results
  - When code becomes open, and people can run it for themselves, they will begin to believe the results
- Improvements propagate quickly though community
- Not well accepted yet, but we are starting a good trend…



Cactus User Community

Using and Developing Physics Thorns

Numerical Relativity/Astrophysics

AEI

Soton

UNAM

Wash U

RIKEN

Goddard

Monash

Thessaloniki

Pitt

PSU

Tuebingen

TAC

SISSA

Portsmouth

UT

EU Astrophysics Network

NASA

Arizona

Etc...

Other Applications

Chemical Engineering (U.Kansas)

Climate Modeling (NASA,AMS)

Bio-Informatics (Canada)

Geophysics (Stanford)

Early Universe (LBL)

Plasma (Princeton)

Astrophysics (Zeus)

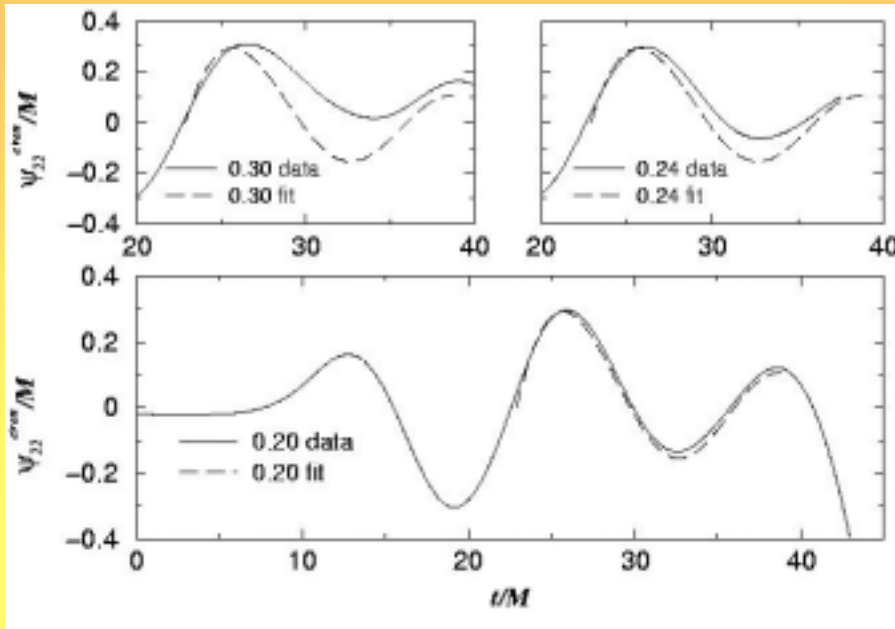
Meeting in May:

Theoretical Foundations of Einstein's Equations for Numerical Relativity

(Using Cactus to investigate and compare different implementations)

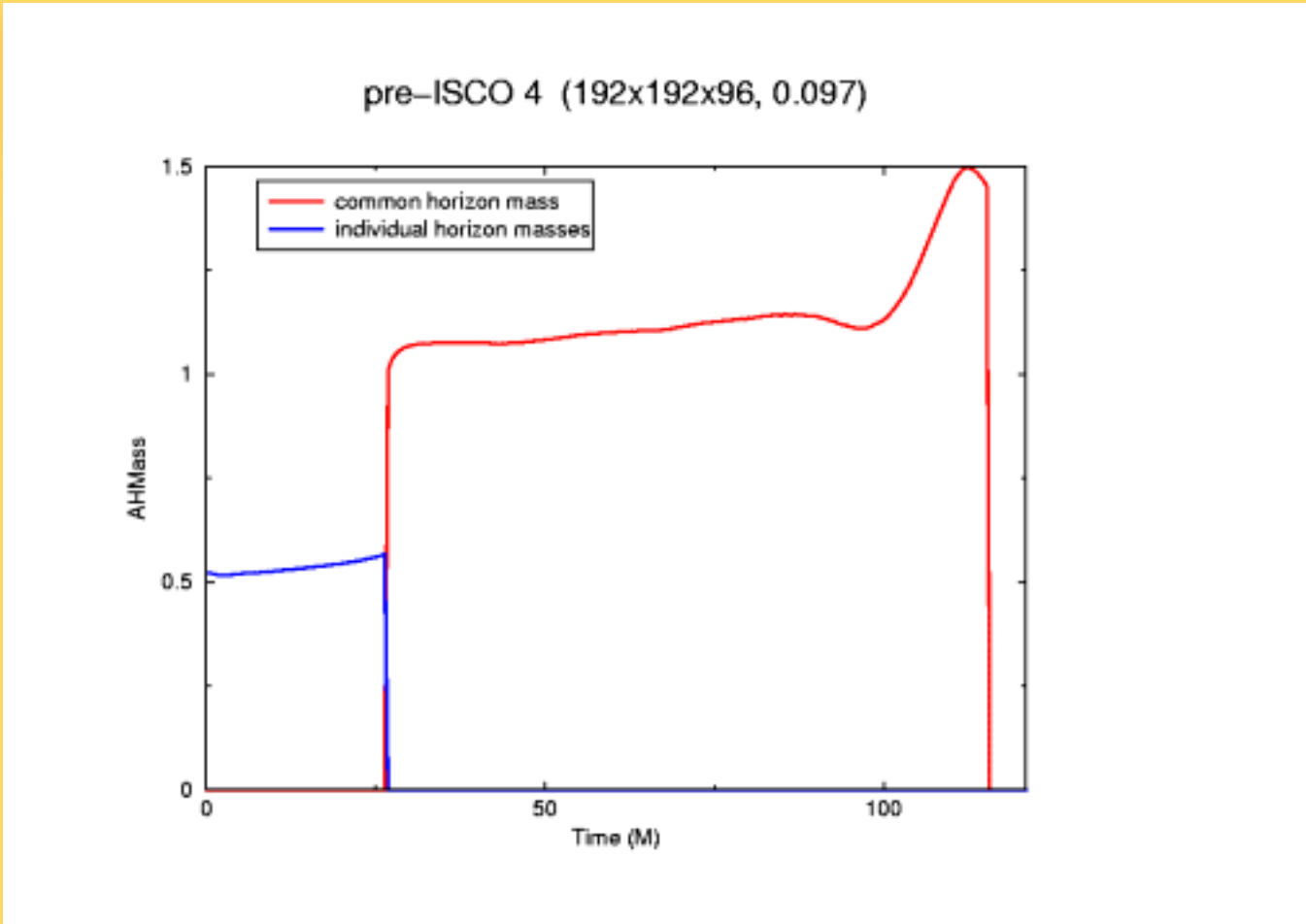
Previous 3D BH Results

new formulations*, *no shift*, *no excision



- Grazing Collision 1999
  - Big Advance: 3D, unequal mass, spin, J
  - Physics!
  - But Code crash by 40M

Horizon Mass for Pre-ISCO 4



- Low resolution (192x192x96), but mass conserved to ~ 10% until ~100M
- Now exploring parameters to find orbital configurations