Computational Design of the Low-Loss Accelerating Cavity for the International Linear Collider

DOE/HEP SciDAC AST Project:

"Advanced Computing for 21st Century Accelerator Science and Technology"

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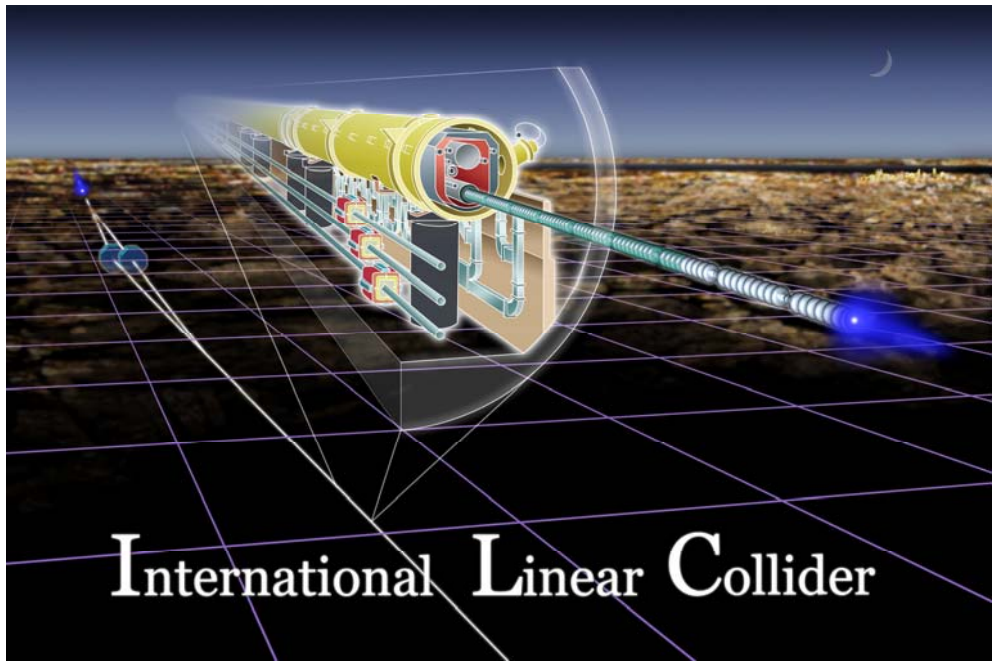
High Energy Physics-International Linear Collider

http://www.linearcollider.org/cms/

*The **ILC** is the highest priority future DOE/HEP accelerator facility that will be designed, funded, managed and operated as a fully international scientific project at an estimated cost of $10 billion+*



The ILC Global Design Effort (GDE) has been established to focus the efforts of hundreds of accelerator scientists and particle physicists in North America, Europe and Asia.

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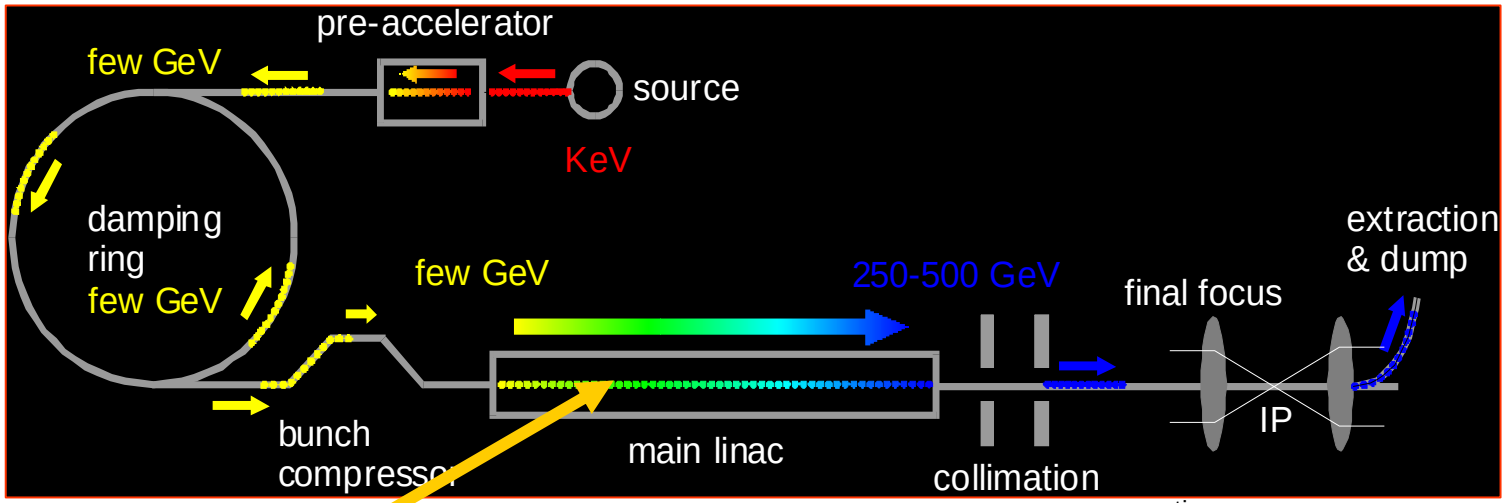
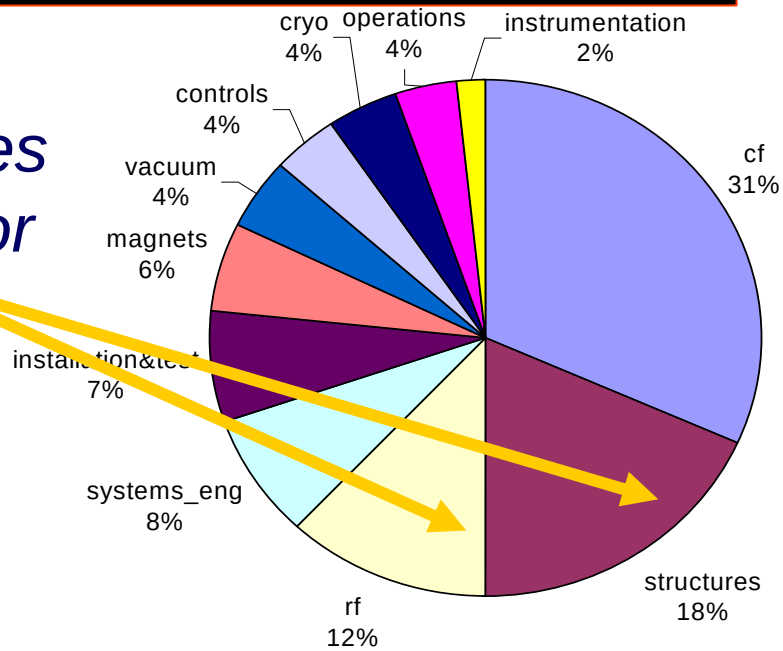
ILC Superconducting RF Main Linac

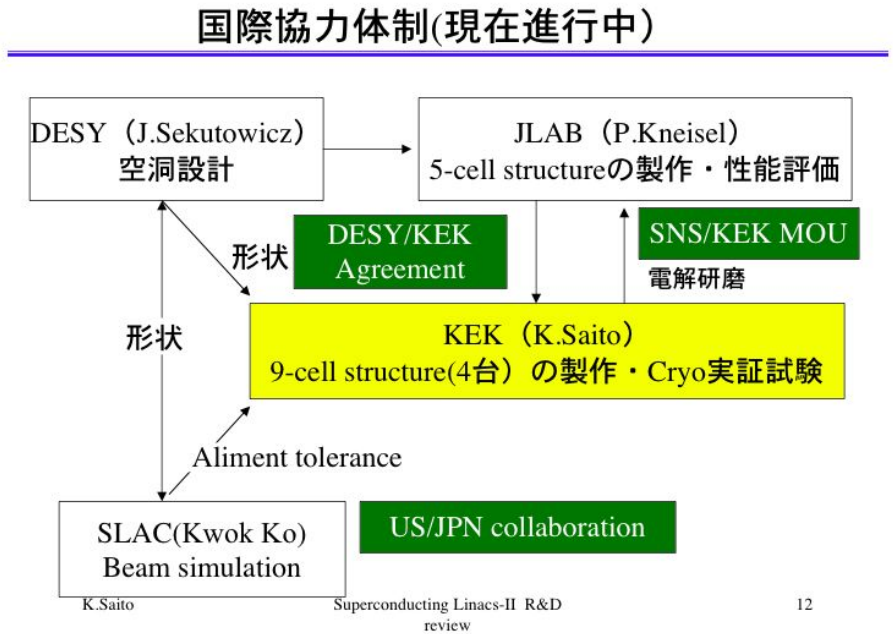


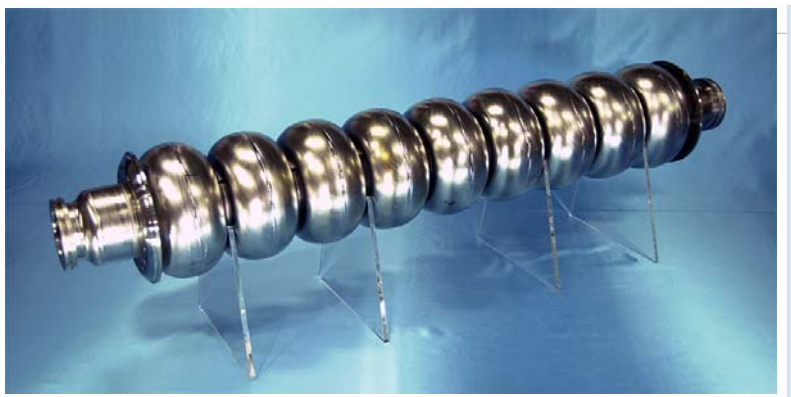
SRF Main Linac constitutes the heart of the accelerator at 30% of its total cost & consists of 20,000 SRF cavities to accelerate the beams to 0.5 TeV energy



ILC Low-Loss Accelerating Cavity Design

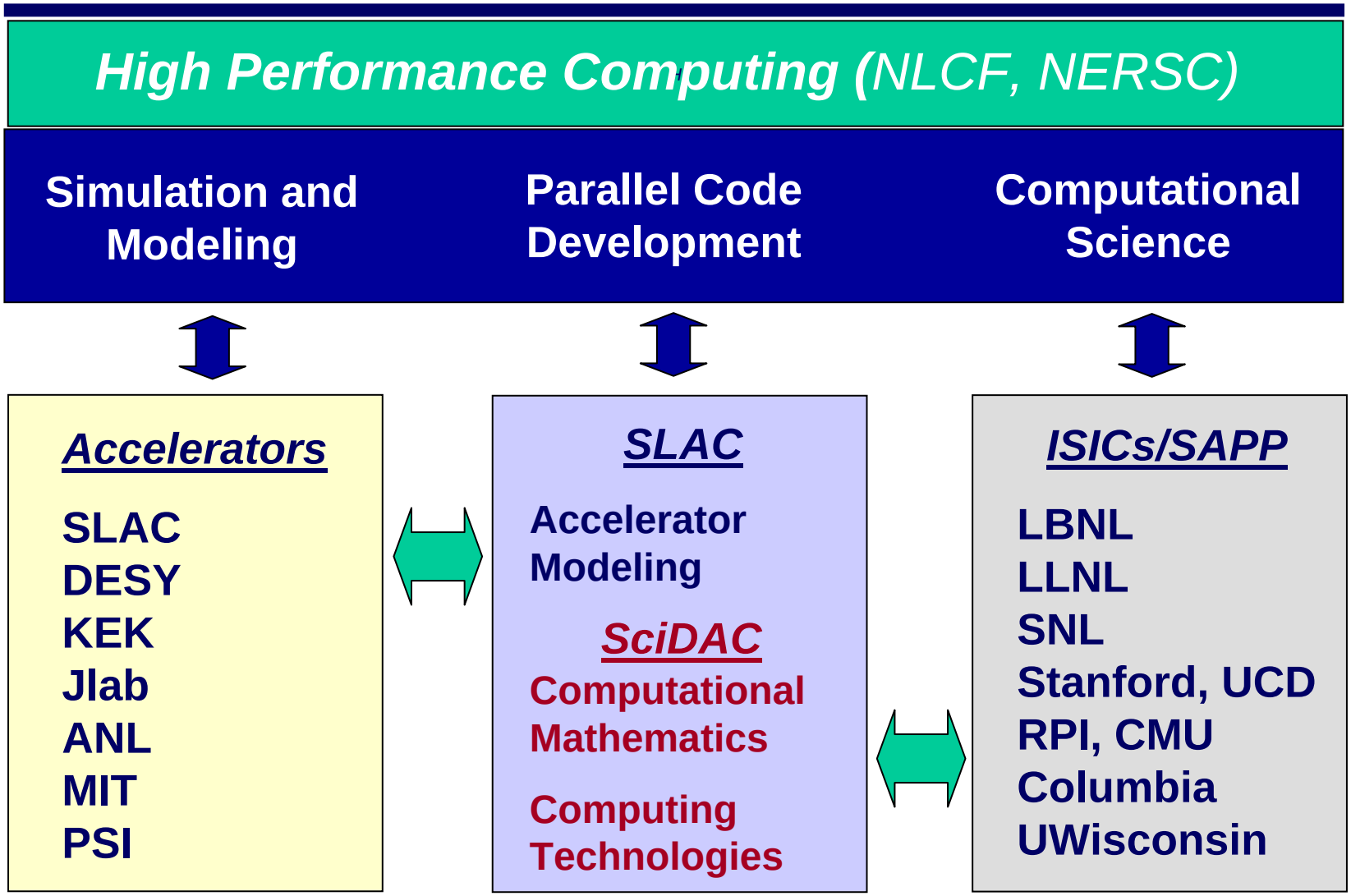
An international team comprising KEK, DESY, FNAL, Jlab and SLAC is developing the Low-Loss design for the ILC accelerating cavity as a viable alternative to the standard TESLA cavity.





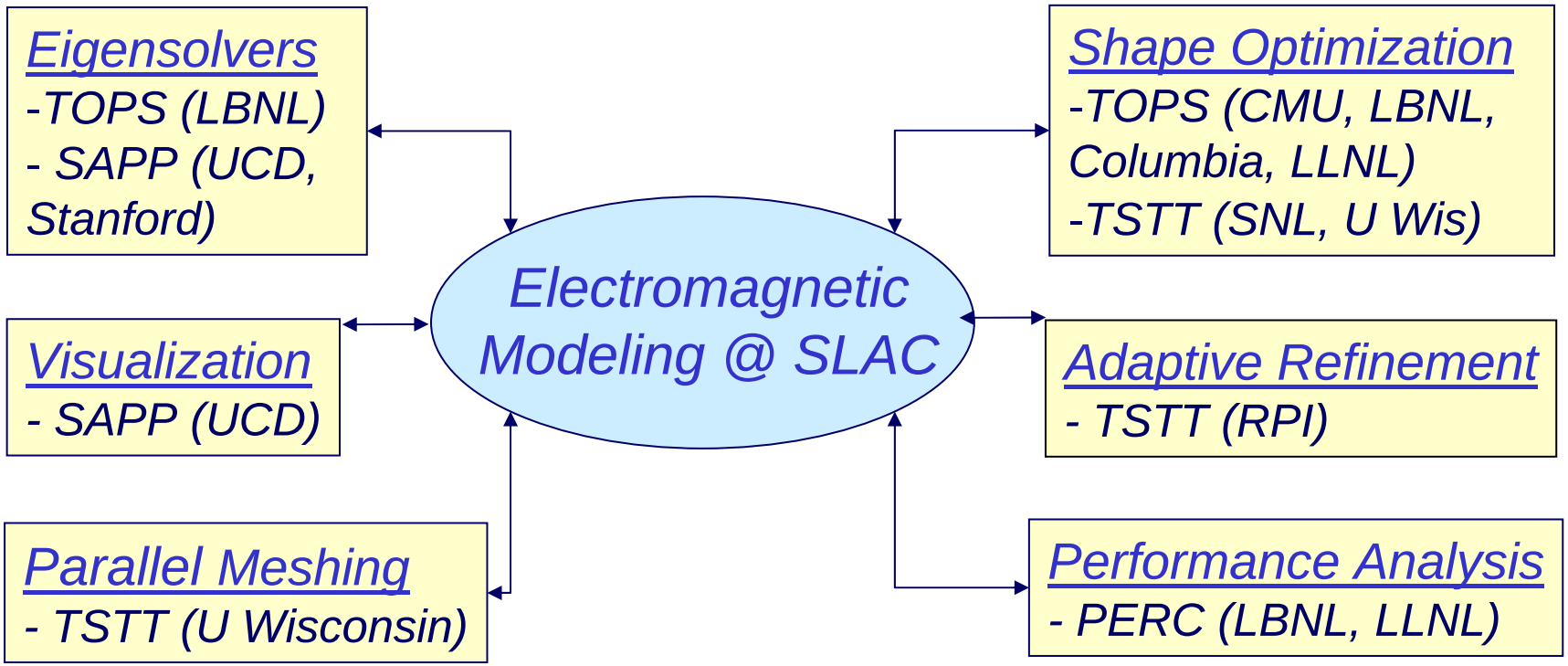
Single LL cell shape reaches 46.5 MV/m field gradient versus TESLA's 35 MV/m while the LL cavity has 20% less cryogenic loss.

SciDAC AST Project at SLAC



ISIC/SAPP Collaborations in Progress

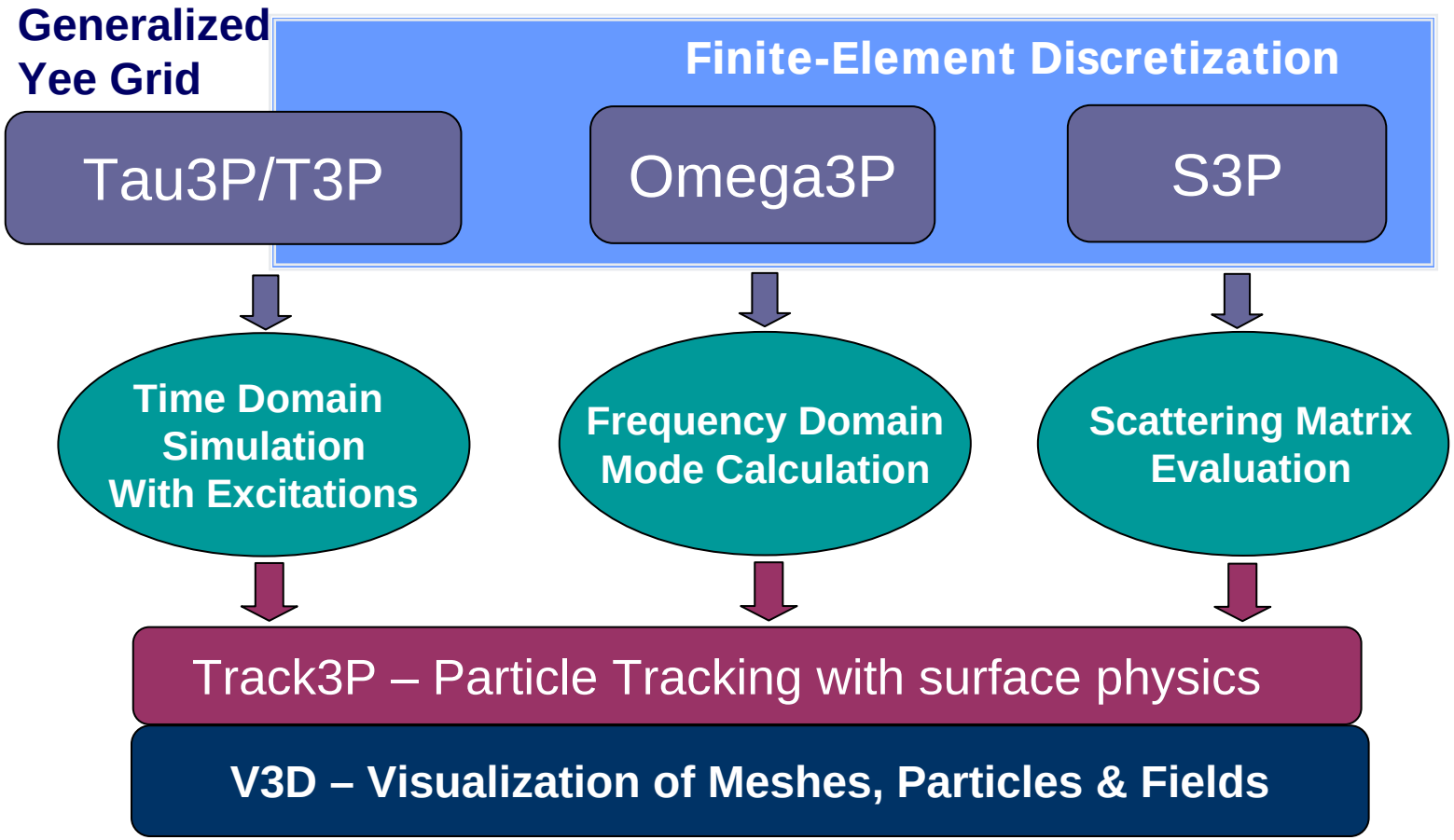
SLAC is collaborating with 3 national labs and 6 universities in computational science research to enable large-scale EM modeling for accelerator projects across Office of Science



See Poster by L. Lee "Achievements in ISIC/SAPP Collaborations for Electromagnetic Modeling of Accelerators"

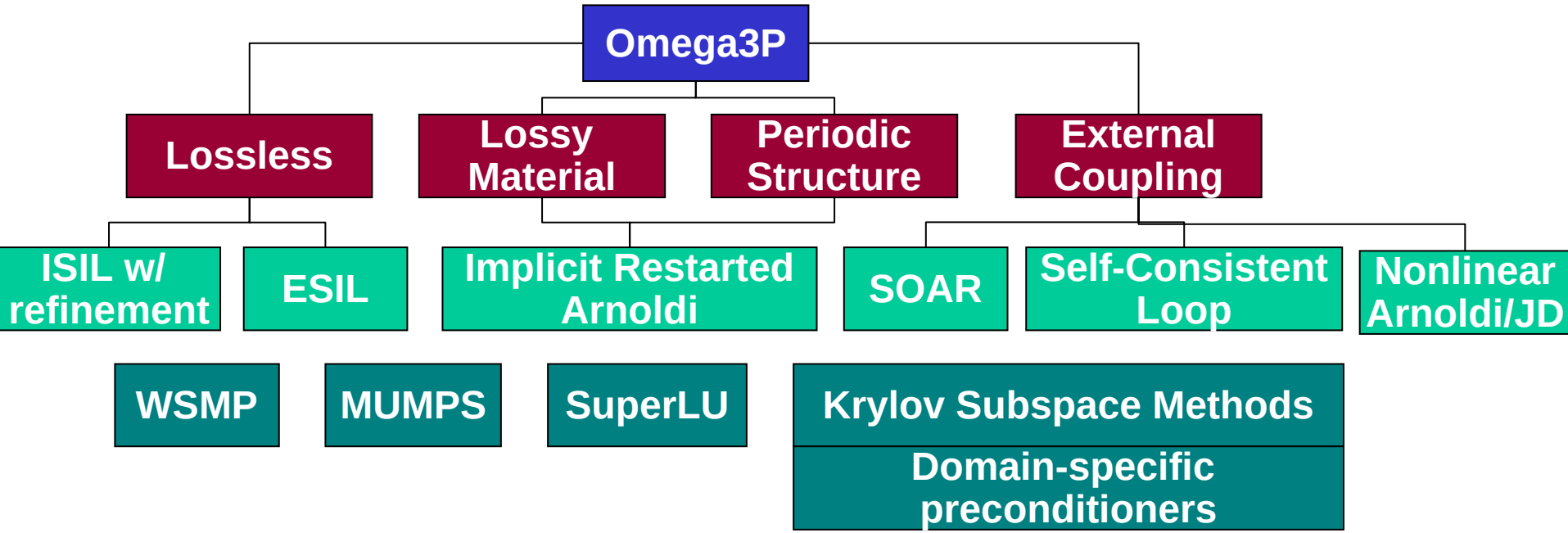
SLAC's Parallel EM Code Suite

*Solve Maxwell's equations in time & frequency domains using **unstructured grid** and **parallel computing***



Omega3P for ILC Cavity Calculations

(SLAC, TOPS/SAPP - LBL, UC Davis, Stanford)



Calculating HOM damping in the ILC cavities requires a nonlinear eigensolver when modeling the coupling to external waveguides (FM & HOM couplers) to obtain the complex mode frequencies as a result of power outflow

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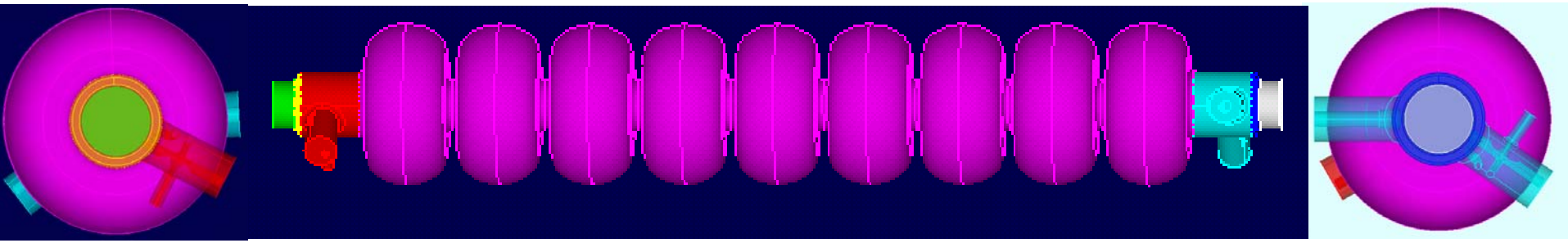
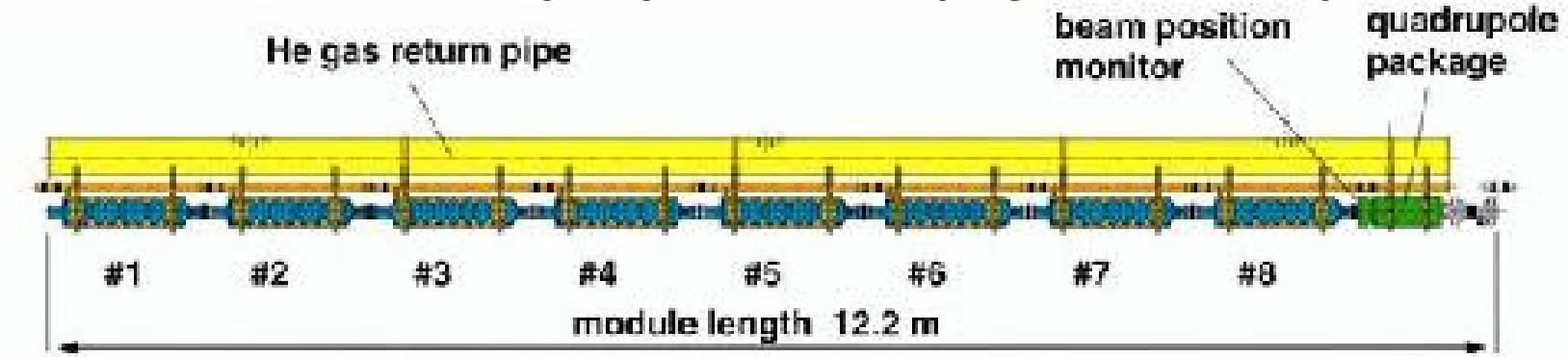
Electromagnetic Modeling of Low-Loss Design



Simulation tasks on X1E under SciDAC AST project:

- *Optimize the LL design for most effective High-Order-Mode (HOM) damping to meet beam stability requirements*
- *Model a multi-cavity cryomodule (e.g. 8 cavities)*



Porting Omega3P to the X1E

- *MICS awarded large allocation on Phoenix in May 2005*
- *First experience of running Omega3P on vector machine*

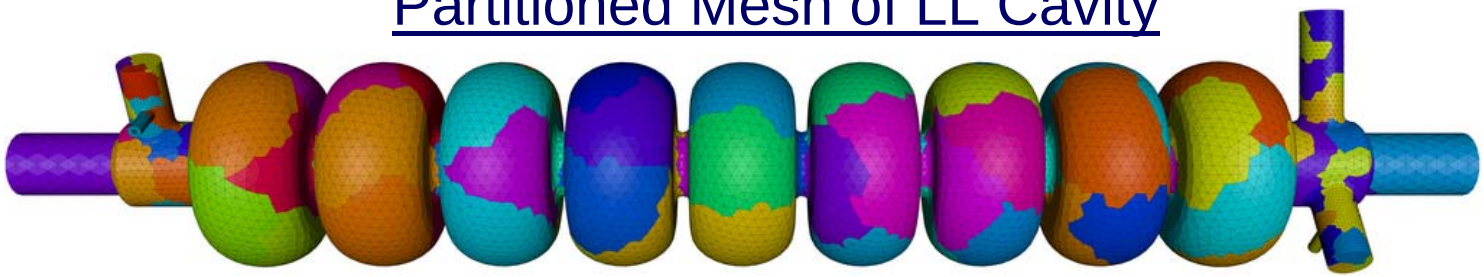
  (Much help from NCCS staff: James White, William Renaud, Richard Barrett, Richard Mills, Rebecca Facey, etc)
- *Algorithmic changes to improve performance include*
  - *Replacing METIS by ParMETIS for matrix reordering*
  - *Removing synchronization in Second Order Arnoldi*

Comparison of 18 eigenmodes on 500K mesh/3M DOFs:

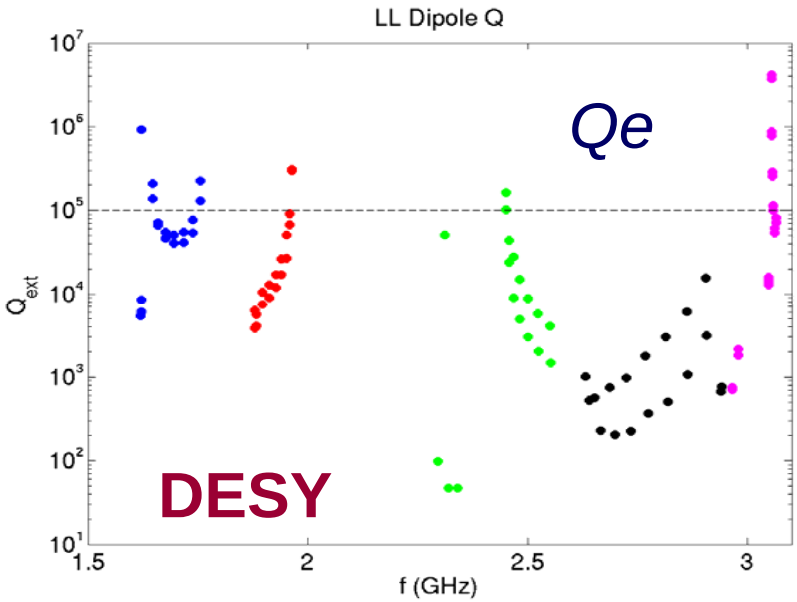
	Phoenix (32 MSPs, allocated with 128 MSPs for memory)	***Seaborg*** (32 nodes with 2 tasks per node and 8 threads per tasks, 512 CPUs)
Eigensolver (SOAR) Time	1869 seconds	2114 seconds

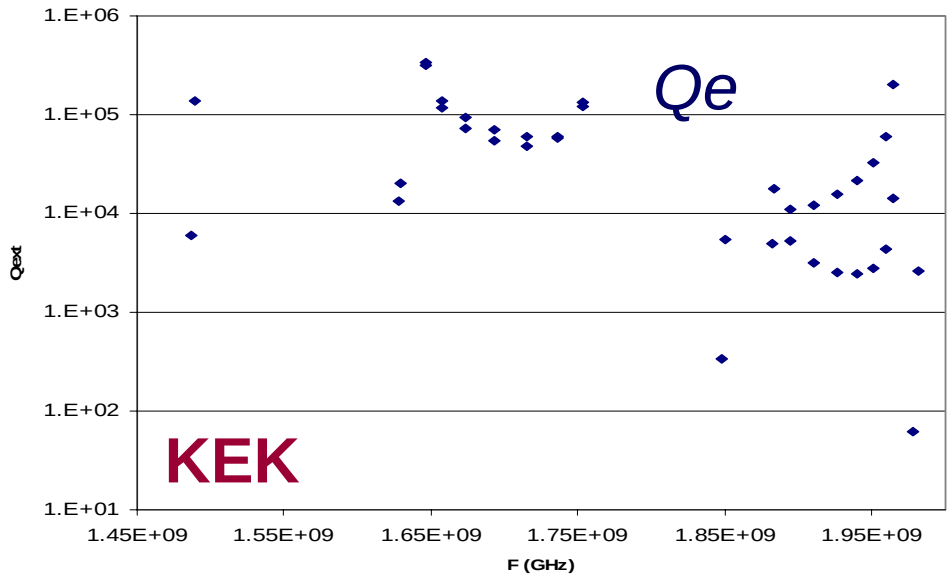
HOM Damping in LL Cavity Design

Partitioned Mesh of LL Cavity



Qext in ICHIRO-2 cavity



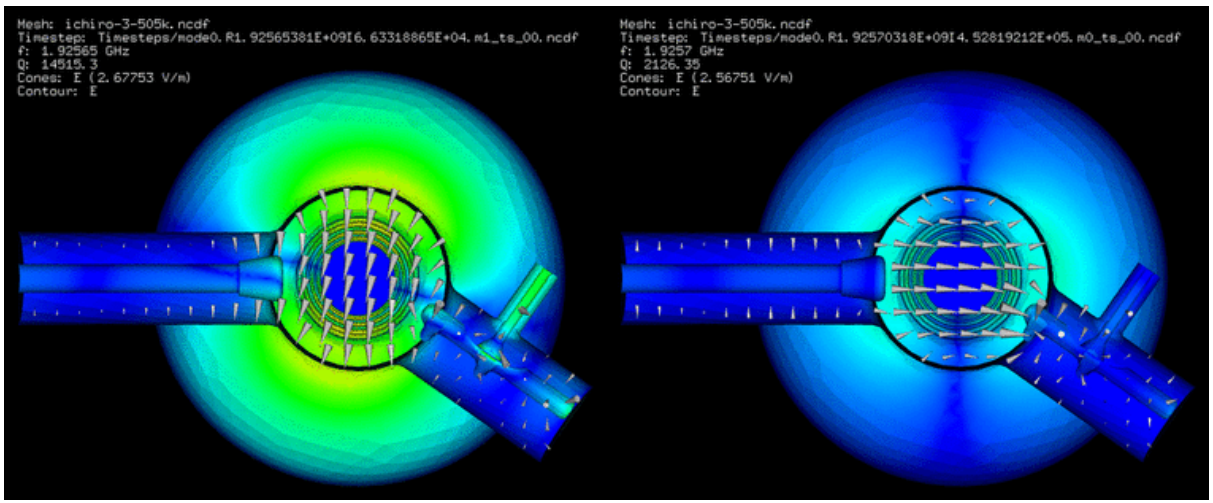


Omega3P *computes the complex frequency to provide* $Qe = \omega_R/2\omega_I$ *of dipole modes due to damping by the HOM couplers*

Omega3P Achievement/Discovery

- ***FY05 MICS Joule report by Kenneth Roche*** - *Enhancement in science driven performance is 81.3 % and increase in science capability is ~3.89*

- ***Mode Rotation*** **–** *A new mode rotation effect was unveiled in visualizing the HOM mode patterns from Omega3P simulations of the ILC LL cavity. Impact on the beam dynamics is under investigation.*



QuickTime™ and a
MS-MPEG4v2 Codec decompressor
are needed to see this picture.

Papers in Proc. of SciDAC05

Journal of Physics: Conference Series, 16, 2005

- K. Ko et al, Impact of SciDAC on accelerator projects across the office of science through electromagnetic modeling, pp 195-204
- L. Lee et al, Achievements in ISICs/SAPP collaborations for electromagnetic modeling of accelerators, pp 205-210
- C. Yang et al, Solving large-scale eigenvalue problems in SciDAC applications, pp 425-434
- V. Akcelik et al, Adjoint methods for electromagnetic shape optimization of the low-loss cavity for the International Linear Collider, pp 435-445
- X. S. Li et al, The roles of sparse direct methods in large-scale simulations, pp 476-480
- T. Tautges et al, Interoperable geometry and mesh components for SciDAC applications, pp 486-490
- K. Ma et al, Scientific discovery through advanced visualization, pp 491-500