ACCELERATOR R&D

P5 @ BNL

3/6/08

S U M M A R Y

Medium & Longer Term

[AARD = Advanced Accelerator R&D]

- Accelerators remain an essential component in Elementary Particle Physics Research
- Accelerator capabilities are *prominent in defining* the frontiers of Elementary Particle Science
- EPP2010: referring to the importance of a broad program – "***Another example is the historical stewardship of accelerator science and technology by the elementary particle physics program. Particle accelerators continue to affect a broad spectrum of scientific and technological activities. Advanced research into new accelerator technologies is vital to the future of accelerator based elementary particle physics as well as to emerging technologies in other areas. The United States has long been a lead player in this area and should strive to remain so".*** [Strategic Principle 4]

- 2005 – 2006 a HEPAP Sub-Panel chaired by JAY MARX examined this subject in depth:
  - http://accelerator-rd.org/
- We adopt their definitions of the 3 categories of AARD
  - *short term*: for planned or approved new facilities or upgrades of operating facilities **NOT TREATED HERE**
  - *medium term*: to bring new concepts to practice so that they can be considered for the design of a new facility
  - *longer term*: exploratory research aimed at developing new concepts for acceleration, new magnet and rf technologies, new materials and scientific understanding of core materials and advanced simulation techniques.

Training of new researchers is important part of all

What should AARD be?

What defines it?

What are its elements?

Various ways of display

- you have just seen and heard two examples of different character, each suitable to its own nature; one very focused and one more diffuse but both system oriented
- another way, which displays the great diversity involved explicitly, is to use a matrix – subjects (rows) complete systems (columns)

SEE THE HANDOUT

Accelerator R&D Matrix

mt 3/04/07

R&D Subjects	Possible Applications									
	ν factory	Muon collider	e+e- linear collider	Project X	VLHC+ SLHC	Linac light source nc	Linac light source sc	Medical, Fusion, Industrial	Neutron sources	Storage ring light source
e-cloud	x	x	x	x	x			x	x	x
Ion effects	x	x	x				x	x		x
Coherent Synch Rad			x			x	x			x
Space charge effects	x	x	x	x	x	x	x	x	x	x
Short bunch wakes			x			x	x			
Simulation/computation	x	x	x	x	x	x	x	x	x	x
Theory	x	x	x	x	x	x	x	x	x	x
Instrumentation	x	x	x	x	x	x	x	x	x	x
High gradient nc[1]	x	x	x			x				
High gradient sc[2]	x	x	x	x	x		x		x	
Electron cooling										
Stochastic cooling[3]					x					
Ionization cooling	x	x								
HOM damping			x	x			x		x	x
Ultra low emittance		x	x			x	x			x
Ultra bright sources[4]			x			x	x			
Positron source			x							
High power targets	x	x	x	x					x	
Magnets sc[5]	x	x		x	x					
Fixed Field Alt Grad	x	x						x		
Laser based[6]			x			x				
Beam wakefield			x							
Test Facilities	x	x	x				x			

1. Cavities and amplifiers – improved capabilities and efficiency
2. cavities, processes and materials
3. microwave and optical
4. photosources - ncrf, scrf and dc
5. magnet structures, processes and materials
6. laser plasma, optical linac

The theme here is diversity of subject matter

- All of the rows are now important subjects and will be important in the future and so need caring for;

  we give – very briefly – 4 examples

  - *Theory and Simulation:* more and more important as the complexity confronting us has deepened – very non linear regimes for acceleration, transport, collision bring in new phenomena blocking achievement of needed parameters + evaluate of new schemes; standards ↑
  - *Instrumentation:* same as above – new kinds of instruments for understanding the new phenomena on shorter time scales with new backgrounds, e.g. ecloud, ultra low emittance…..
  - *sc Magnets:* ultra high fields demand new materials and mechanical schemes in face of high cost – long timescale

- *Test Facilities*: VERY CHALLENGING; accelerator systems producing beams of advanced character are needed for R&D on many of the row subjects, e.g. ecloud, ultra low emittance, various beam cooling approaches……. These are very expensive to operate. In past used existing particle physics accelerators for much of this – our culture encouraged it. Now, test facilities have to stand on their own feet making the threshold for creating them much higher → a chilling effect on R&D→we'll have to focus much more carefully, reducing the breadth which has been a hallmark of our enterprise. International coordination can relieve the situation e.g. CTF for "high gradient nc" STF? and TTF? for "high gradient sc", ATF(KEK), MICE, MERIT, ….. already in play – not a complete answer

Before taking too much comfort -

- to make really profitable use of a foreign test facility we must be recognized as a significant partner – high threshold
- very difficult to involve students the way we can here
- requires a level of planning inconsistent with some r&d

↓

- more pressure on the remaining US accelerator and test facilities to accommodate broader use – need a plan which encompasses need for training students with real accelerators → introduce culture of thinking of the future

- To match the diversity of subject matter, a diversity of practitioners is also important in order to bring the needed intellectual & physical resources to bear
  - national labs (big infrastructures and test facilities with engineering, IT and technical services to go with) each with its own specialties to bring to the table
  - universities (many diverse scientific specialties to be called upon for theoretical and analytical capabilities, materials and instrumentation expertise - in physics, chemistry and engineering – AND of course STUDENTS with strong focus on particulars and potential for carrying the culture forward if properly nurtured
  - industry (brings special intellectual, physical and financial, e.g. sbir, resources)

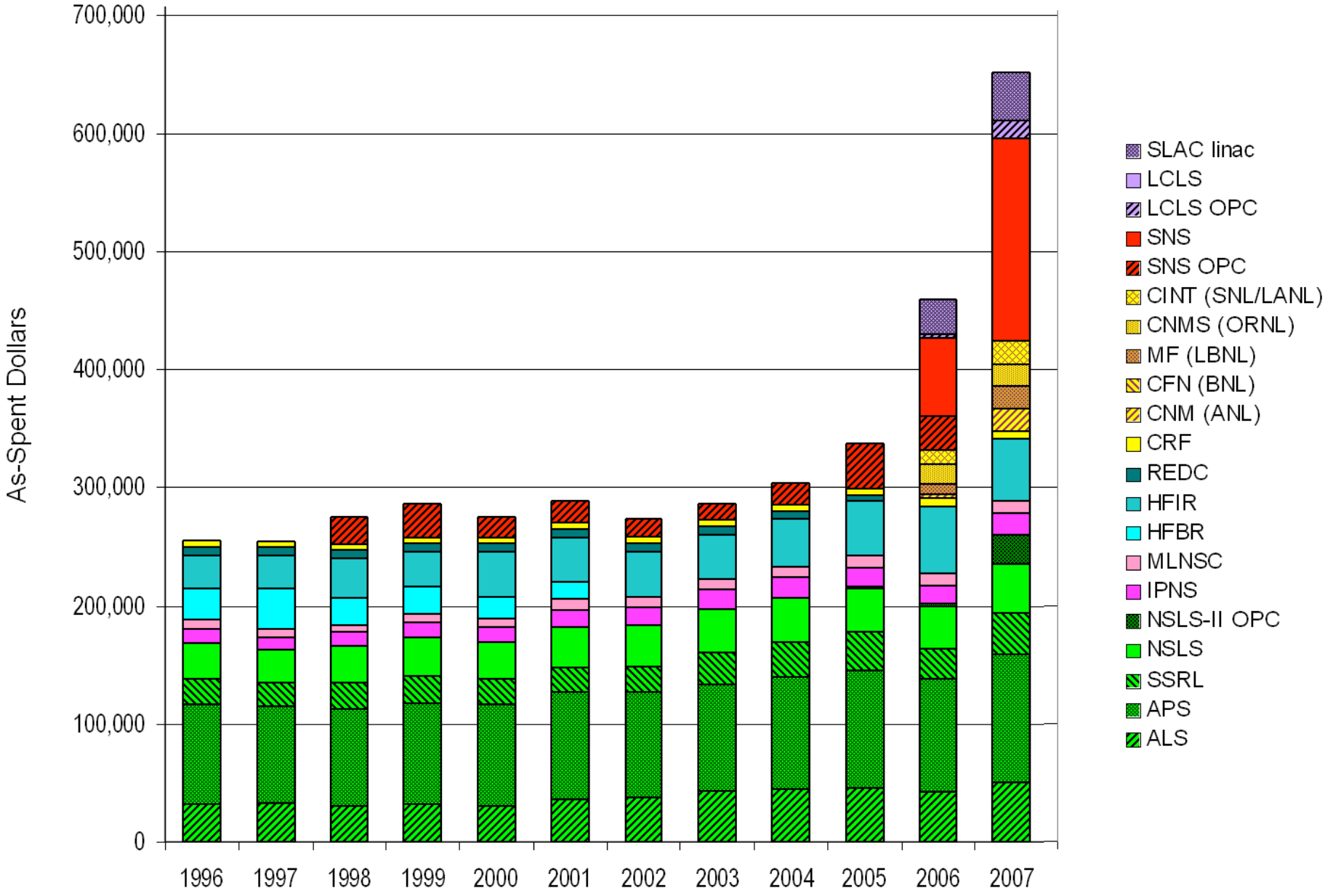
need a vision of how these are to be incorporated now

In the Matter of Stewardship

- DOE-HEP/NSF-PHY must be stewards, for the time being
  - it's a matter of culture in DOE-HEP and NSF-PHY long established
  - but it's important to recognize that accelerator based science in other sectors has now exceeded HEP in operations budget by a lot – brings new responsibilities

have a look at this

OPERATING BUDGETS FOR BES FACILITIES



Domestic Particle Physics Facilities Have Gone in the Opposite Direction

- While there is nothing to be done immediately - keep it in mind for both the Office of Science (DOE) + Directorate of Mathematical and Physical Sciences (NSF) overall
- BES already does respond to proposals for projects that have obvious bearing on their planned programs. Perhaps in future this can be expanded to include some more general R&D activities and attitudes – even using existing accelerators in their stable?
- We need to work with NSF-DMR similarly

Now that we have had a tour – where does that leave us?

Question for P5

With the dramatic change of operating environment and budgets, what is needed to maintain sufficient breadth & depth in *accelerator science and technology* to pursue a leadership role in accelerator based particle physics?

- *Why we are here today – an insufficiency*
- Designing and costing the right program requires:
  - detailed survey of what we're doing and why
  - arranging alignment with accelerator potential and vision for accelerator based particle physics now being developed with YOUR help + setting priorities

- Irresponsible to state detailed budgets without these preliminaries in place
- The needed program basics can be stated today:
  - materials for making higher fields (magnet, rf & optical)
  - devices for higher fields (magnets, nc and sc accelerating structures, rf sources and lasers)
  - theory and simulation tool developments

    under-supported as measured by what's needed now
- some accelerator based paths to the future – even just to establish feasibility of concept – are under-supported
- other areas need clearer objectives in order to assess the appropriateness of the current support

- the current level of support for "medium term" and "longer term" AARD is ~ 70M ('07) → crafting an accelerator program with sufficient depth and breadth to support a leading particle physics program in the medium and longer term futures will be extremely challenging
- This AARD program needs to be aligned with the overall HEP program and its vision for the "medium term" and "longer term" adopted by DOE/NSF following on the P5/HEPAP recommendations to come shortly
  - this will require refocusing, taking great care not to cut off possibilities for the future inadvertently
  - implementation recommendations might best come from a special group able to interpret physics program needs and vision in terms of accelerator R&D elements, priorities and costs

Final Word

- We are not now supporting work on nearly all of the R&D subjects mentioned in our matrix
- Nevertheless we need to focus yet more sharply to support those things deemed most vital to our future in accelerator based particle physics
- Without a strong and steady program in AARD, carefully designed, we'll surely not get there
- P5 needs to affirm the importance of strong support for that AARD program
- The particle physics vision that will follow from the P5 deliberations, together with future accelerator potential will be the foundation for crafting the needed AARD program