BNL LHC Accelerator Program + HEP Accelerator R&D

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Superconducting Magnet Division

The Accelerator R&D is an overview of the breakout session

Outline

US LHC Accelerator Program
- Magnet production
- Cable Testing
- Costs

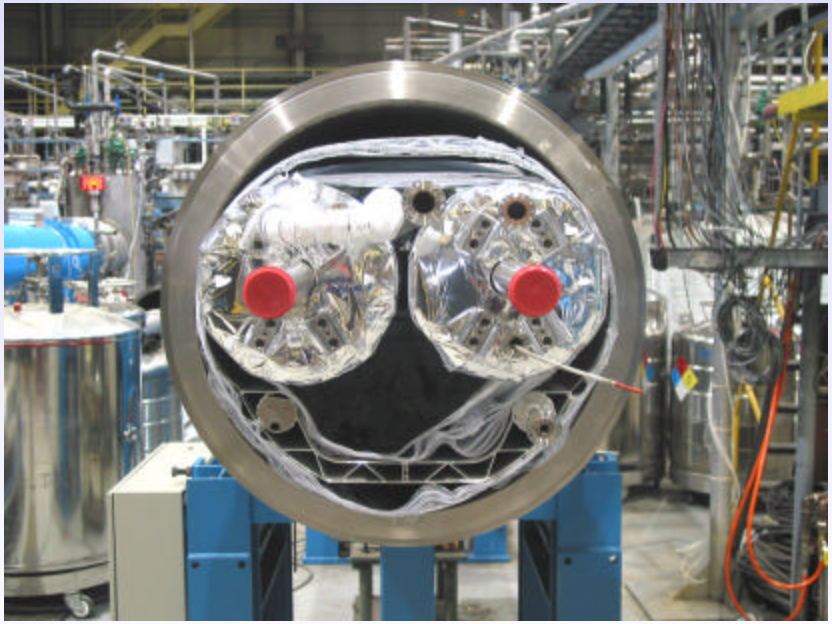
HEP Accelerator R&D
- Accelerator Test Facility (Ben-Zvi)
- Muon Collider/Neutrino Factory (Palmer)
- Superconducting Magnet R&D (Harrison)
- Neutrino Superbeam (Roser)

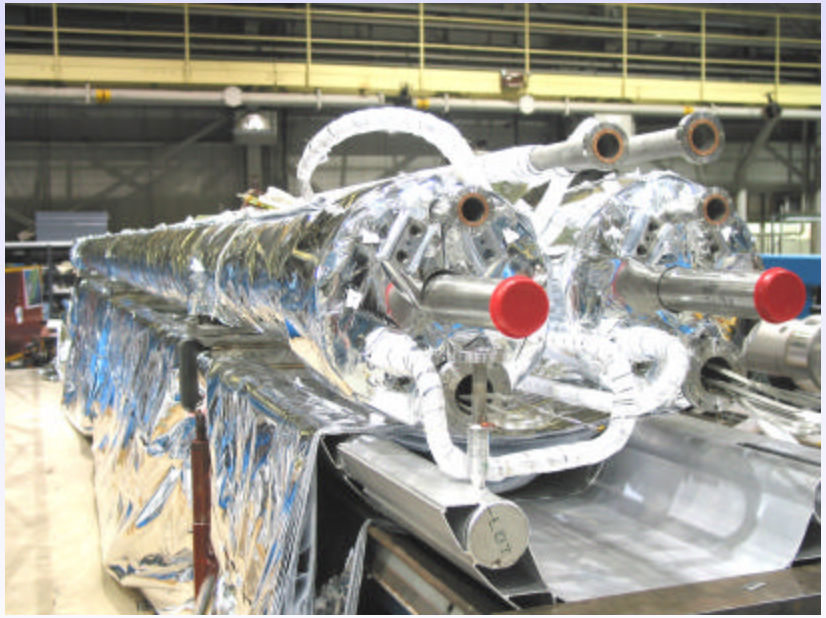
Conclusions

The bottom line: BNL is active and innovative in both fundamental accelerator R&D and HEP project oriented developments. We are a major national resource for HEP.

US LHC Accelerator Program - BNL Production Status

Part of the US/Japan collaboration to provide the LHC Interaction Regions.
BNL provides the specialty dipoles (based on RHIC style coils)





- The last series of dipoles (D3's) are in production
- 2-in-1 RHIC style cold masses in a LHC style cryostat

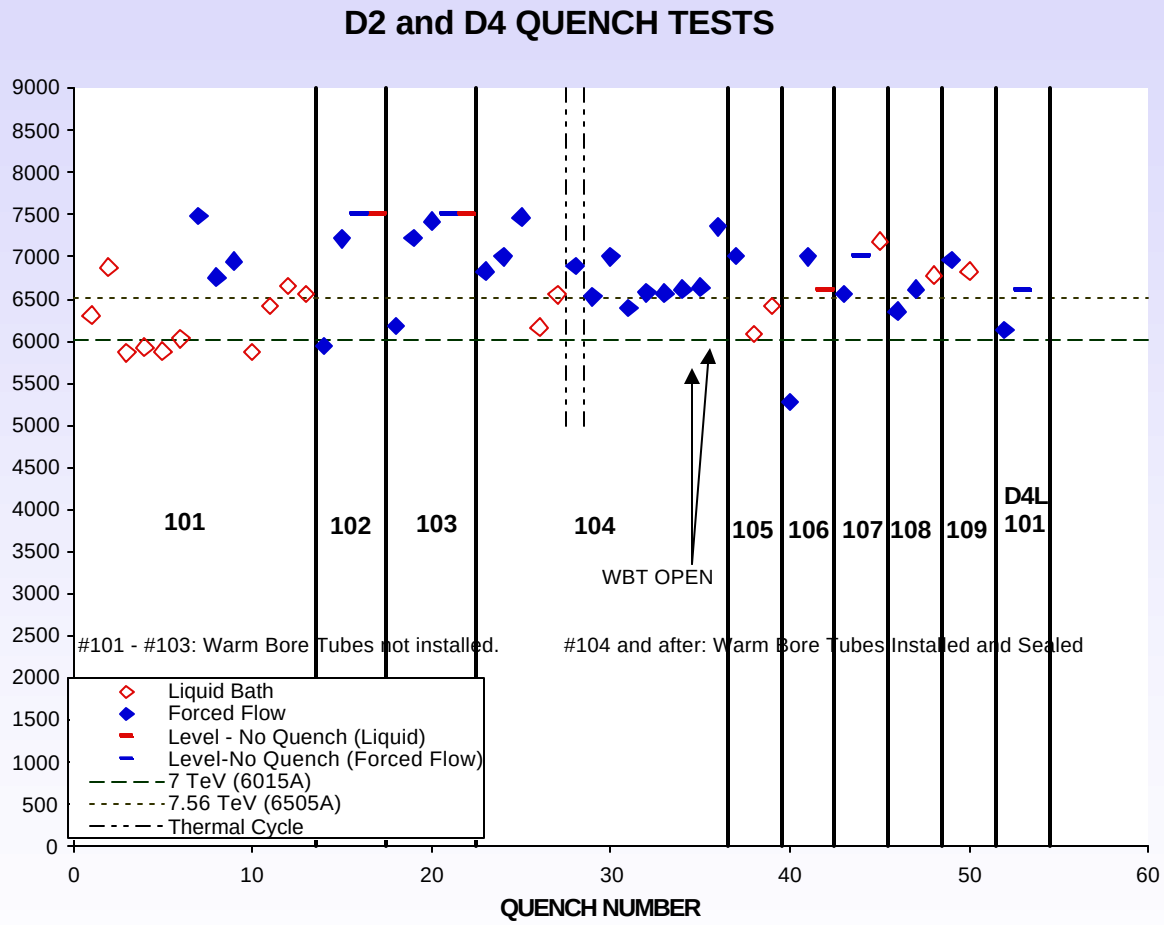
US LHC Accelerator Program - BNL Production Status

- D1: magnet fabrication complete (5 units), 4 shipped, 1 retested successfully.
- D2: magnet fabrication and testing complete (9 units), 3 shipped.
- D4: magnet fabrication complete (3 units), 1st magnet tested.
- D3: magnet fabrication complete (3 units).
- Design effort complete. D1 interconnects to DFBX in production. This is the final construction activity

US LHC Accelerator Program - BNL Production Issues

- Issues
  - Last minute redesign of D3 helium line anchors (anchors from center to NLE, flex lines added for thermal contraction, etc.)
    - Design, parts covered by BCR
    - Added costs from schedule delays (labor inefficiencies) not covered
  - 2mm horizontal bow in D1 magnets
    - Reported by CERN after acceptance
    - Root cause found to be asymmetric welds on shell
    - Corrected on D3 cold masses (corrective weld stripes)
      - Added assembly steps
      - Added survey labor
      - Added material (welding) costs
  - Scientific, EDIA, tech labor due to magnet acceptance/testing:
    - Retest of D1 magnet required due to heater short
    - CERN pushed back on D2 pipe survey, reinstated into program
      - Extra survey labor
      - Minor corrections being requested, performed
  - (Most recent problem) – shorted temp sensors in D3 #2 magnet
    - Need to remove end volume, add replacement sensors
    - Potential schedule delay

US LHC Accelerator Program - Magnet Performance

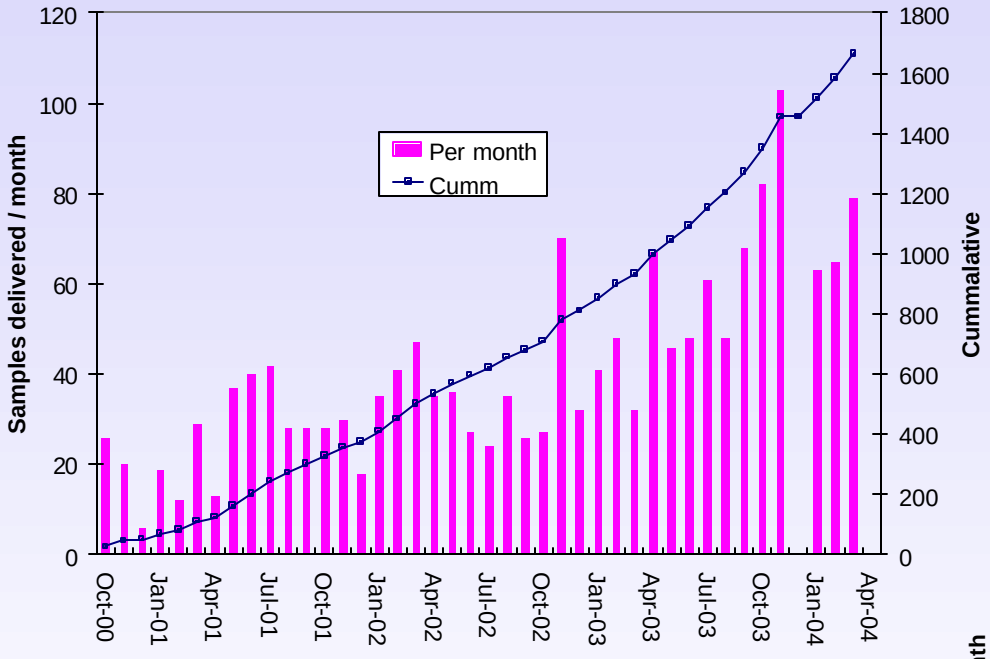


With the exception of the test stand Commissioning (#101) and the "magnet from Hell" (#104) all magnets have tested O.K.

LHC Cable Testing

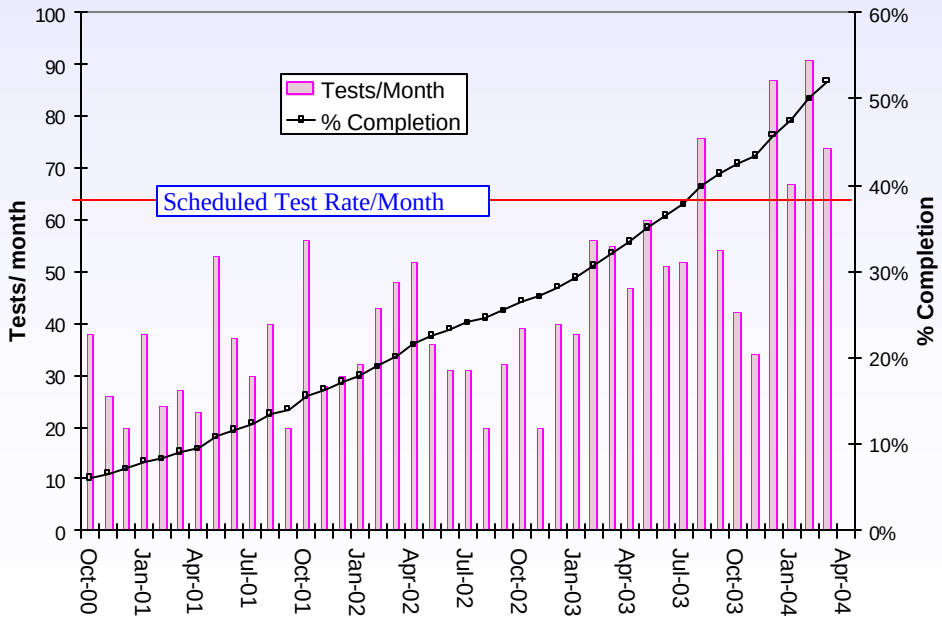
- Three test stations are in continuous operation.
- Cable Production schedule status:
  - Completion expected by Sep-30-05
  - 01 Cable (Dipole Inner)⇨ delivered 53.2%
  - 02 Cable (Dipole Outer)⇨ delivered 53.6%
  - 03 Cable (Quadrupole)⇨ delivered 58%
  - MQM/MQY cable delivered⇨ ~ 38%
- Cable production is almost at peak rate
  - Brugg Cabling machine not at plateau rate
  - Furukawa completed its octant in Apr'03 and are now producing a second octant of 02-cable (Alstom producing only 2 octants of 02)
  - Outokumpu-Advanced Superconductor complete their octant April'04. Cabling is at Furukawa Electric.
  - New England Wire, who are cabling for Outokumpu-Pori, is ramping up to plateau rate
- 1896 samples tested (represents 52% of 3643 samples)

LHC Cable Testing



Sample Delivery Rate from CERN

Samples Tested/Month



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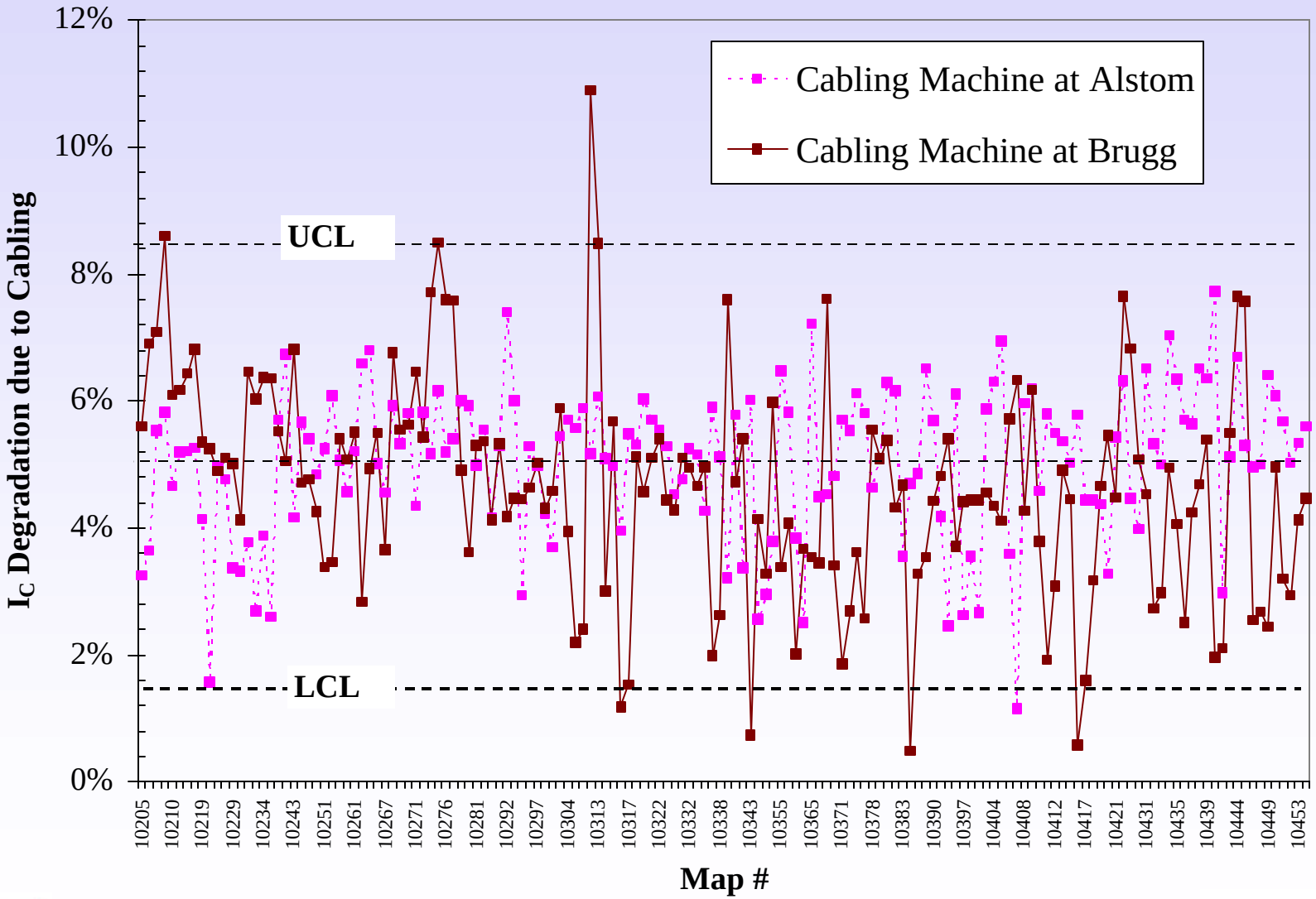
Cable Critical Current Performance

- Except for a few cases, samples tested so far have met minimum electrical requirements.
- Worldwide, 5 cabling machines are in operation. Cabling quality varies between different manufacturers as evidenced by electrical measurements.
- Example of cables from two suppliers are shown that highlight the differences in the control of cabling parameters, the tracking of cabling degradation.

01-Cable Cabling Degradation



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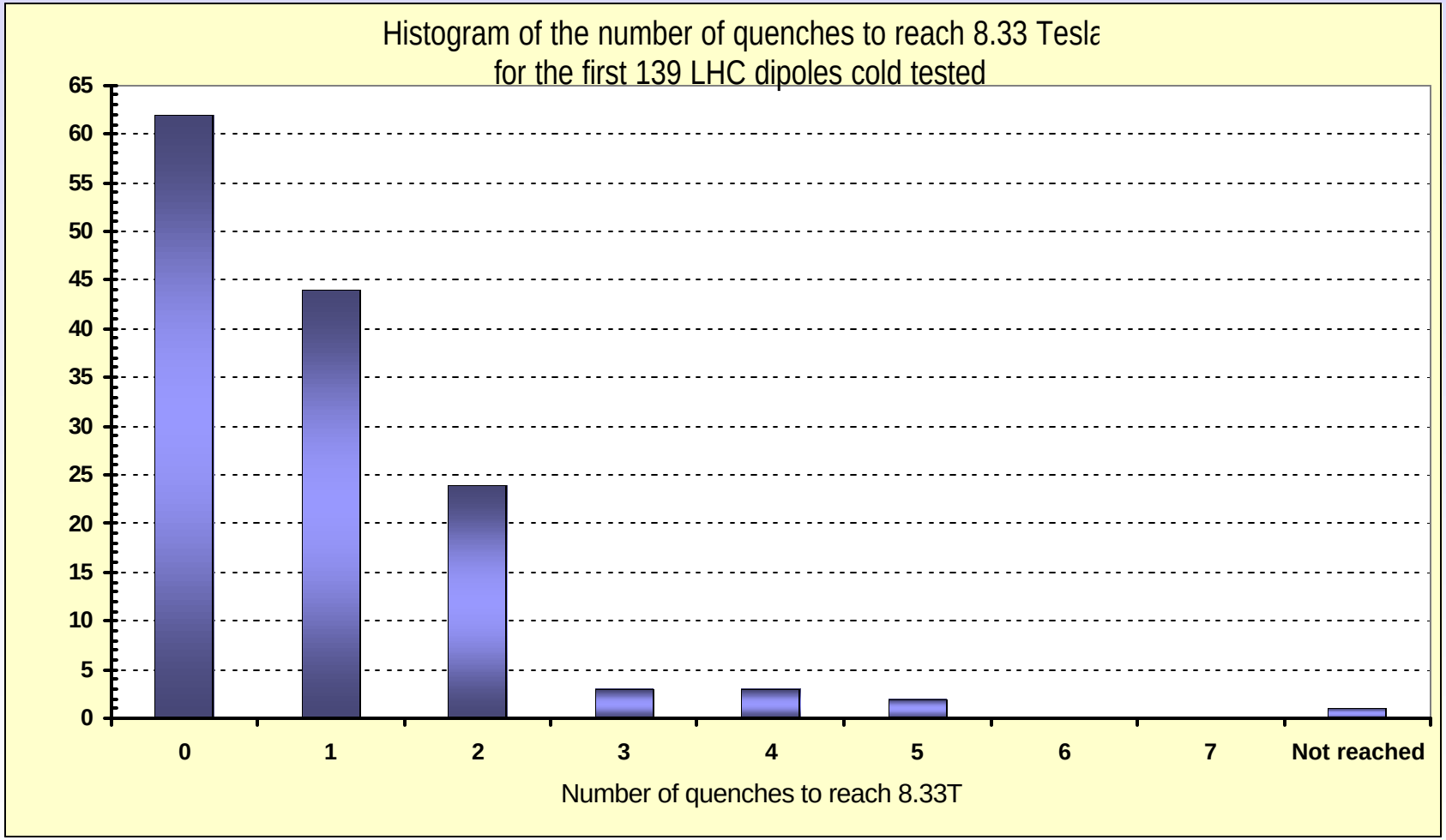
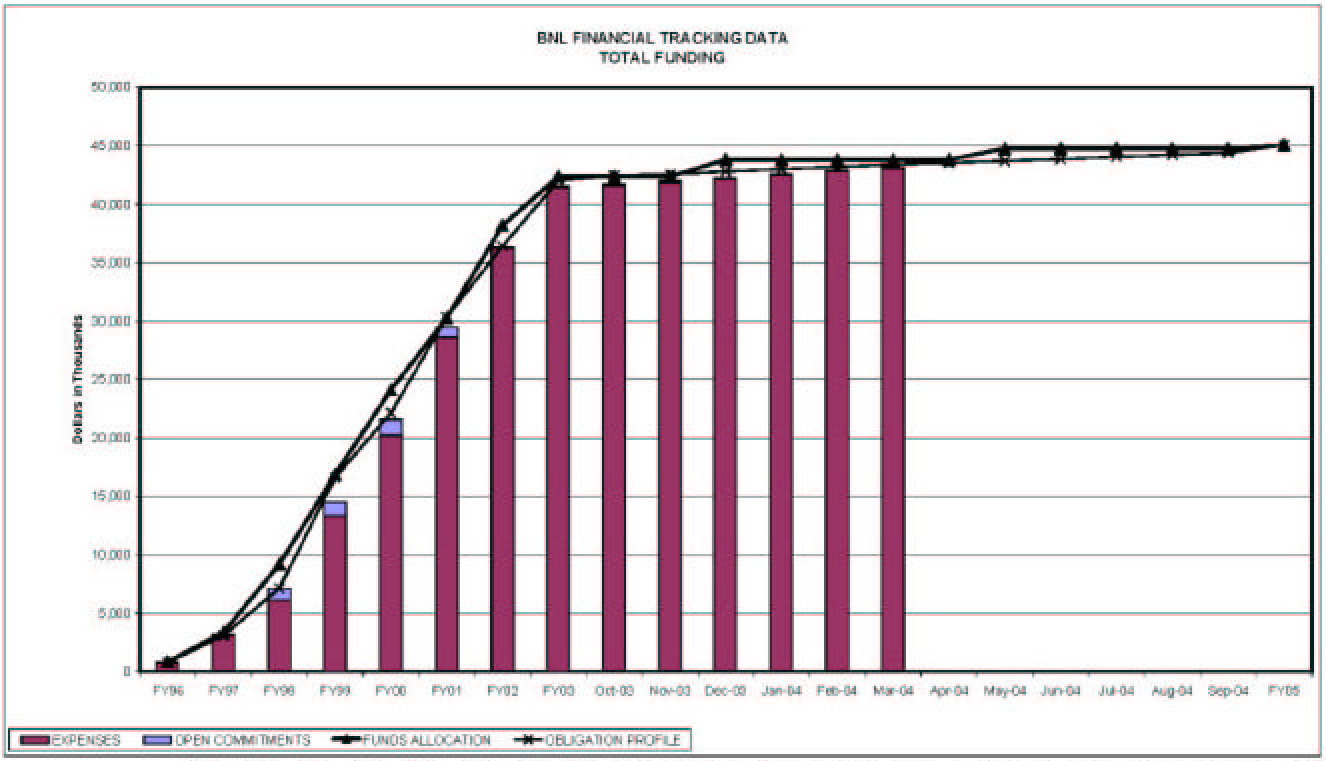
LHC Cable testing - Efficacy of the program



Only 1 magnet fails to work - cold solder joint

US LHC Accelerator Program - Funding



	FY96	FY97	FY98	FY99	FY00	FY01	FY02	FY03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04	Sep-04	FY05
INCREMENTAL																					
FUNDS ALLOCATION	840	2,545	5,800	7,690	7,237	6,167	7,912	4,177	0	0	1,450	0	0	0	0	950	0	0	0	0	302
OBLIGATION PROFILE	802	2,302	4,034	9,472	5,522	8,200	6,069	5,624	418	116	242	210	191	210	146	160	153	176	167	176	302
EXPENSES	786	2,300	3,009	7,258	6,851	8,407	7,653	5,186	146	251	280	359	318	275							
OPEN COMMITMENTS	30	26	938	161	200	-482	-764	-37	51	16	-23	-36	-23	-40							
CUMULATIVE																					
FUNDS ALLOCATION	840	3,385	9,185	16,875	24,112	30,279	38,191	42,368	42,368	42,368	43,818	43,818	43,818	43,818	43,818	44,768	44,768	44,768	44,768	44,768	45,071
OBLIGATION PROFILE	802	3,105	7,139	16,610	22,133	30,332	36,402	42,026	42,444	42,560	42,802	43,012	43,204	43,414	43,560	43,720	43,873	44,049	44,216	44,391	45,071
EXPENSES	786	3,086	6,095	13,353	20,204	28,611	36,264	41,450	41,596	41,847	42,126	42,486	42,804	43,079							
OPEN COMMITMENTS	30	57	995	1,156	1,356	874	109	72	160	176	153	118	95	55							

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US LHC Accelerator Program - Costs

Since April of 2003 we have spent ~$4M and have generated a cost variance of -$200K

Materials	+$80K
Labor	-$280K

Most of the labor variance is acceptance/EDIA rather than touch labor.

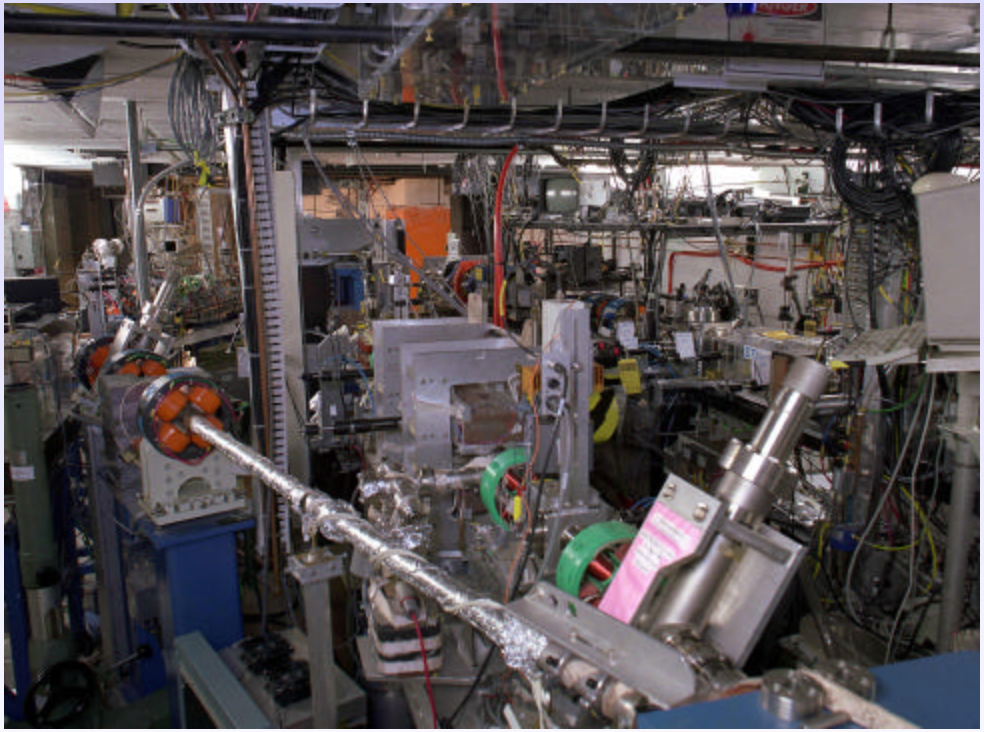
We have $2M left to go to finish the Project. Assuming no magnet failures encountered during testing then we do not see any projected cost overruns.

At this point the biggest challenge on costs is not the LHC construction effort but rather is internal to BNL due to lack of continuity between this Project and the LARP (LHC Accelerator Research Program) M&O funding causing a large FY05 problem. FY02 -> FY05 will see Magnet Division LHC related funding $10M -> $1M.

Schedule will not be an issue

Accelerator R&D - BNL Accelerator Test Facility (ATF)

- The ATF is a proposal-driven, advisory committee reviewed, USER FACILITY for long-term R&D into the Physics of Beams.
- The ATF features:
  - High brightness electron gun
  - 70 Mev Linac
  - High power lasers beam-synchronized at the picosec level
  - 4 beam lines + controls
- The ATF serves the whole community: National Labs, universities, industry and international collaborations.
  - ATF contributes to Education in Beam Physics.
- In-house R&D on photoinjectors, lasers, diagnostics, computer control and more.
- Support from HEP and BES.



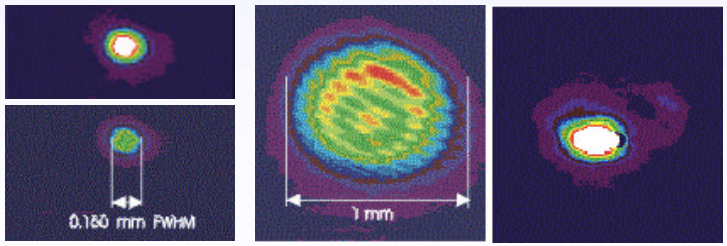
ATF: The comprehensive nature of the facilities creates a unique world-wide resource

Accelerator R&D - Recent developments at the ATF:

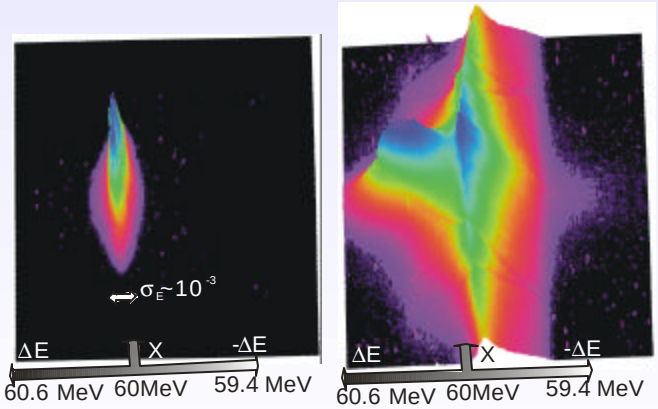
- The ATF moved to the Physics Department from the NSLS in FY03.
- ATF Users now supported by the RHIC-AGS Users' Center
- Vitaly Yakimenko was assigned as Deputy ATF Director.
- New faces at the ATF: Kelly Bergesen (software and graphics), Todd Corwin (Mechanical and electrical systems), Don Davis (laser and mechanical systems), Igor Pavlishin (laser physics) Takahiro Watanabe (accelerator physics) Karl Kusche (ESH&Q).
- The facility performance continues to be enhanced:
  - Continuous improvement of e-beam brightness, stability, experimental chambers, diagnostics, control systems and much more.
  - Higher power lasers, new channeling capabilities, better uniformity, stability….
  - Improved communications with users: Long-range schedule, web information, e-mail newsletter, training...

Accelerator R&D - Recent Results from the ATF

- High-Gain Harmonic Generation FEL, Visible SASE FEL, photoinjectors…
- and since last year:
  - Mono-energetic laser acceleration
  - Measurement of focusing/acceleration as function of phase in plasma wake-field
  - CO2 laser channeling in plasma



Plasma off Plasma on



Wake Field off Wake Field on

Accelerator R&D - Neutrino Factories

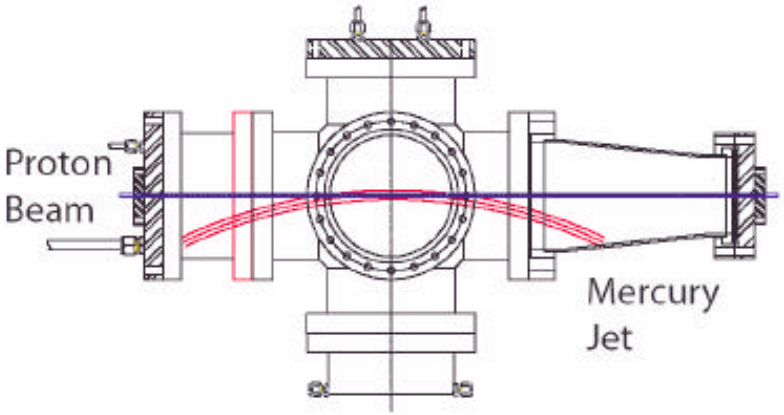
Main National Activities

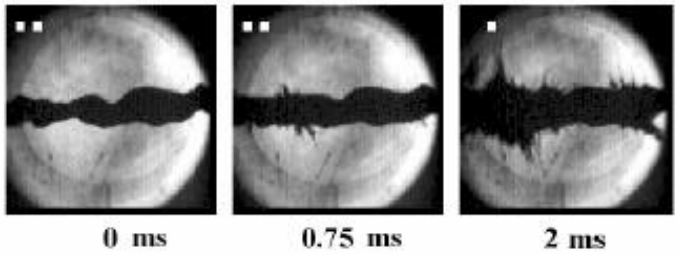
Targets for 1-4 MW	BNL
Superconducting RF Acceleration	Cornell
Cooling components	Fermilab
Design studies	BNL

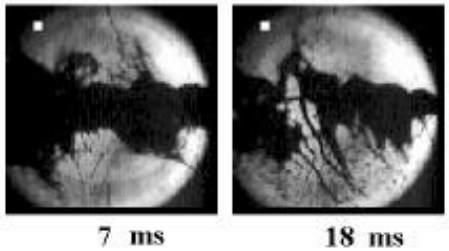
There is also the International MICE (Muon Ionisation Cooling Experiment) proposal with BNL collaboration. Main US lead is Fermilab/IIT

Accelerator R&D - High power targets

AGS Experiment E951







- 4 Tp/bunch $(4\ 10^{12})$
  But density equiv to 1 MW
- Non-Explosive Dispersion
- Good Result

But

1 MW Nu-Factory requires:
16 Tp/bunch $(1.6\ 10^{13})$

4 MW Nu-Factory requires:
32 Tp/bunch $(3.2\ 10^{13})$

SO

- Need further Experiment
  With more intensity
  and Magnet

Accelerator R&D - Neutrino factory design studies

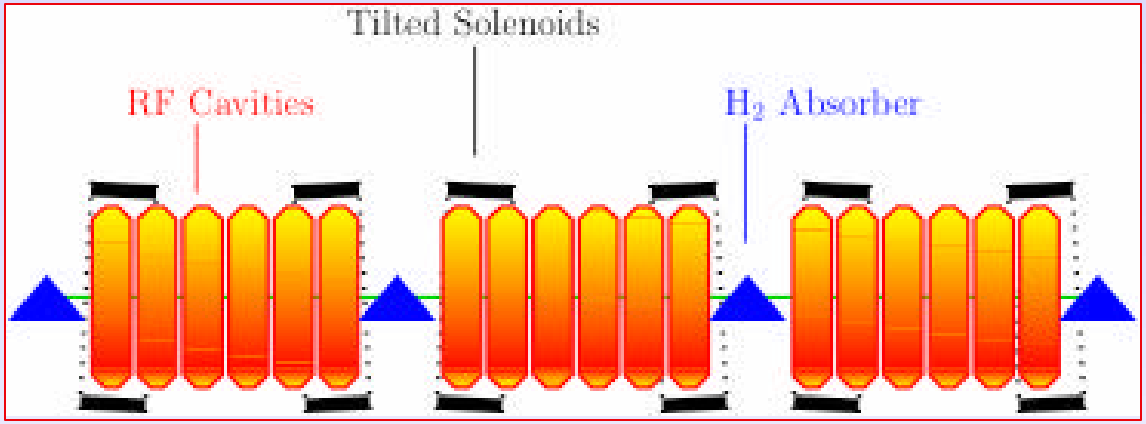
Design Studies in the US

- Neutrino Factory Study I
  - Emphasized Feasibility
  - Sponsored by Fermi (finished March 00)
  - "Entry Level" ($\approx$ **0.2** 10^{20} $\mu/10^{7}$sec at 1 MW)
- Neutrino Factory Study II
  - Emphasized Performance with Feasibility
  - Sponsored by BNL (finished April 01)
  - Similar Cost
  - "Higher Flux" ($\approx$ **1.2** 10^{20} $\mu/10^{7}$sec at 1 MW)

- Current Neutrino Factory Work
  - Emphasize Lower Cost
  - Further Improve Performance
  - Study III (In about 2 Years)

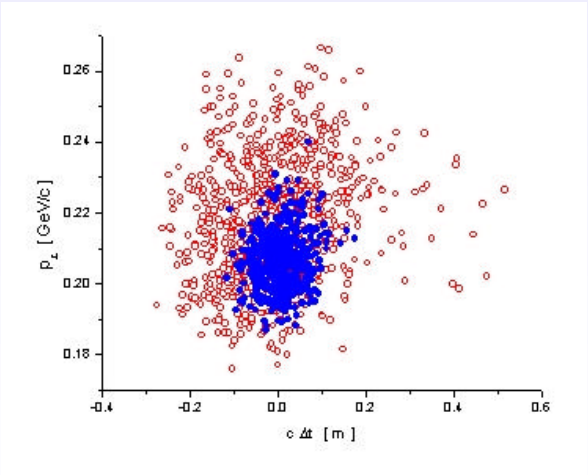
Current studies suggest performance 2 $\times$
Cost of the order of 1/2

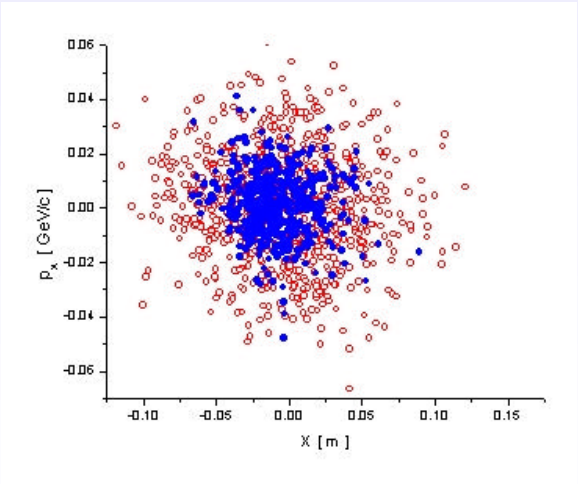
Accelerator R&D - Neutrino factory design studies



Ionization cooling design work

- 33m circumference
- RFOFO lattice
- Solenoidal focusing
- 'realistic' design e.g. injection, windows etc….

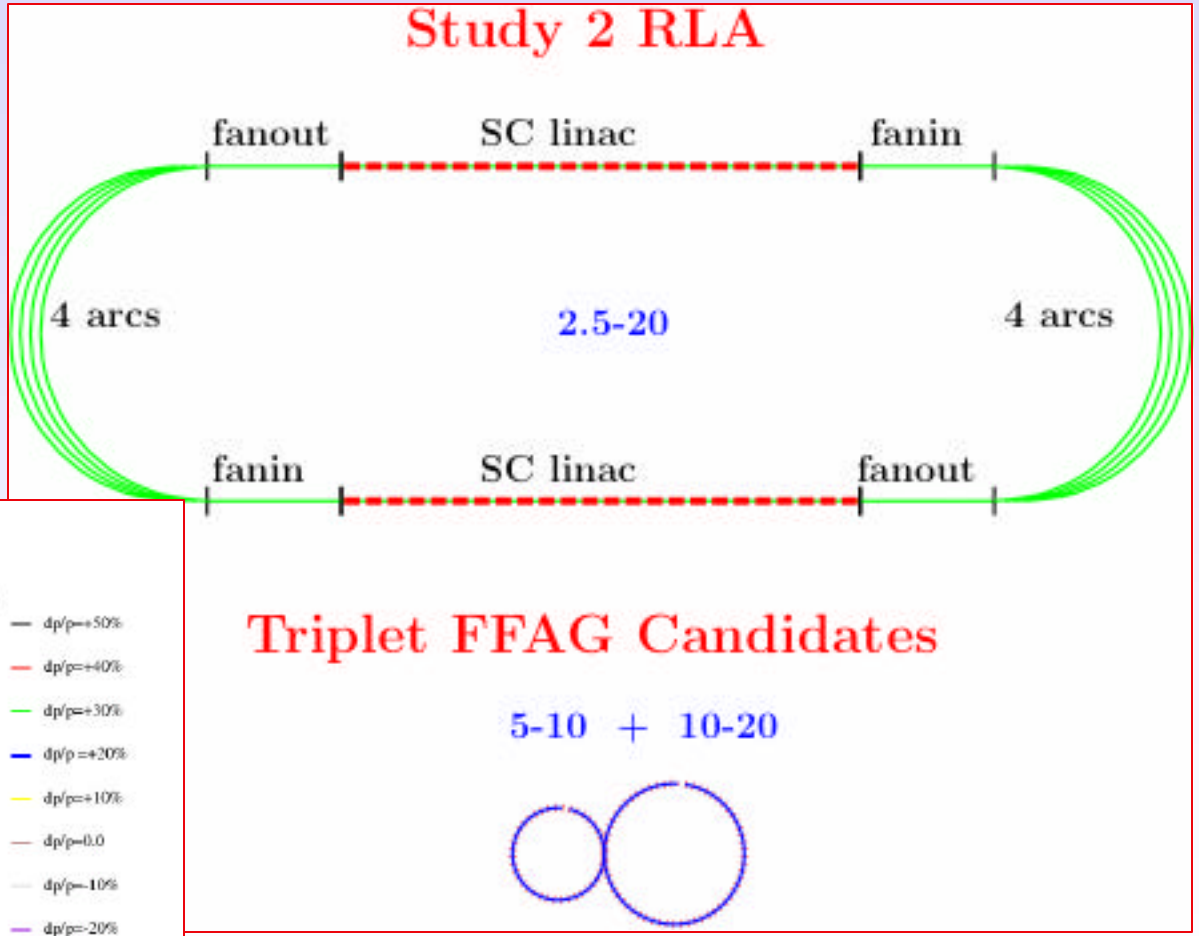


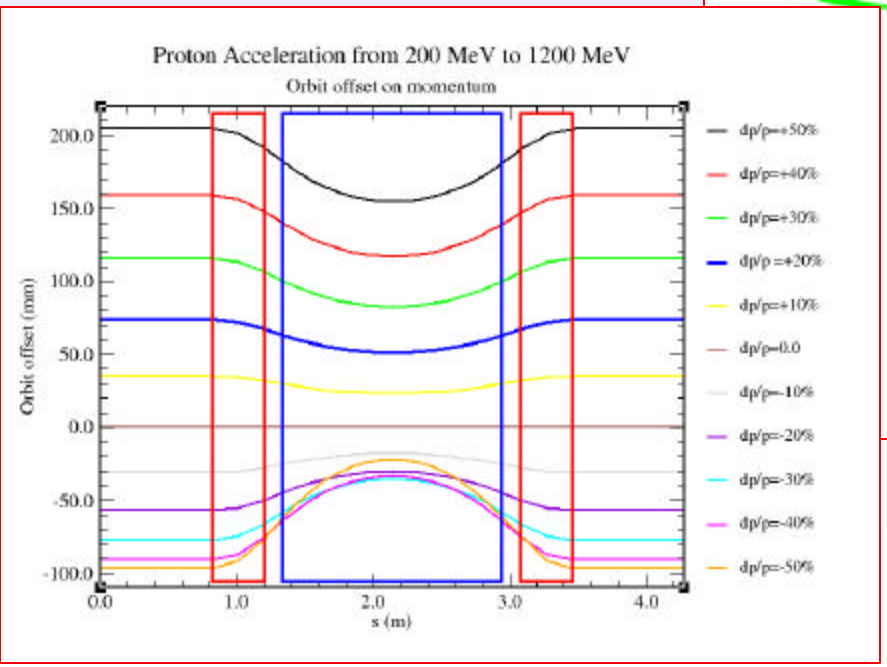


Phase space reduction by a factor of 4 in 15 turns

Accelerator R&D - Neutrino factory design studies

- A significant amount of effort in last several years on the potential use of FFAG rings for the acceleration stage.
- FFAG's also have potential as high intensity proton sources





Superconducting Magnet R&D

Directed R&D towards future US HEP Projects

Linear Collider: final focus /beam delivery system

- Compact superconducting final focus quads + accelerator physics of the beam delivery system

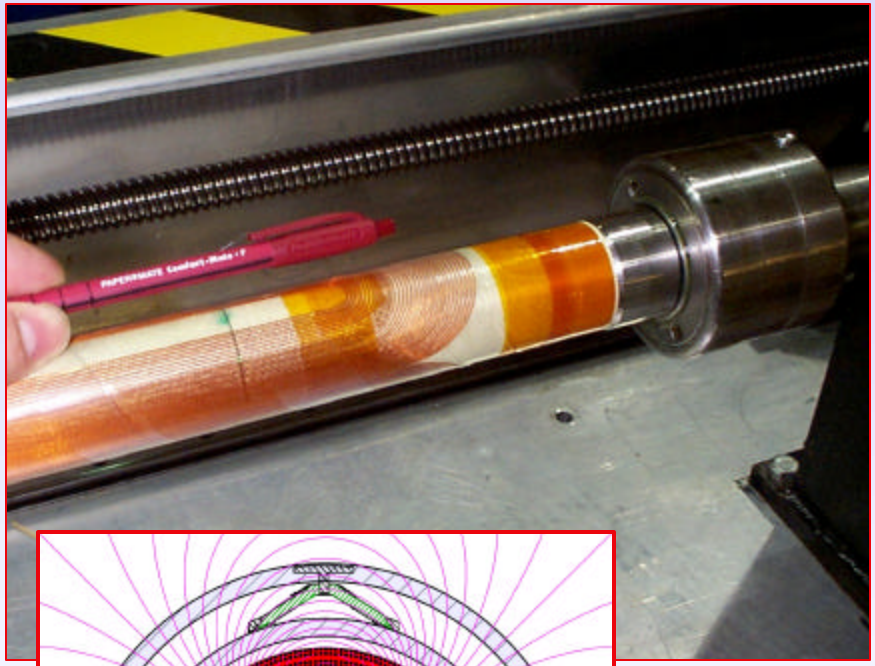
LHC Upgrade (LARP): high performance IR's

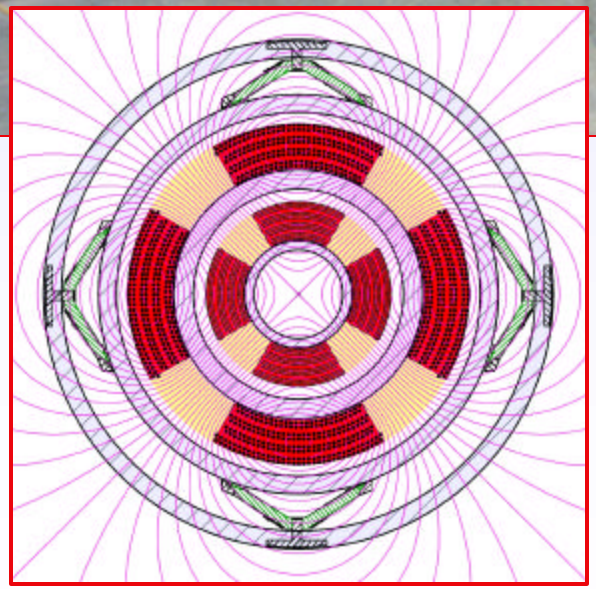
- Radiation resistant high field dipoles

HEP Technology Development

- Superconducting Materials Development
- High Field magnet development
- Work-for-Others

Superconducting Magnet R&D - Linear Collider



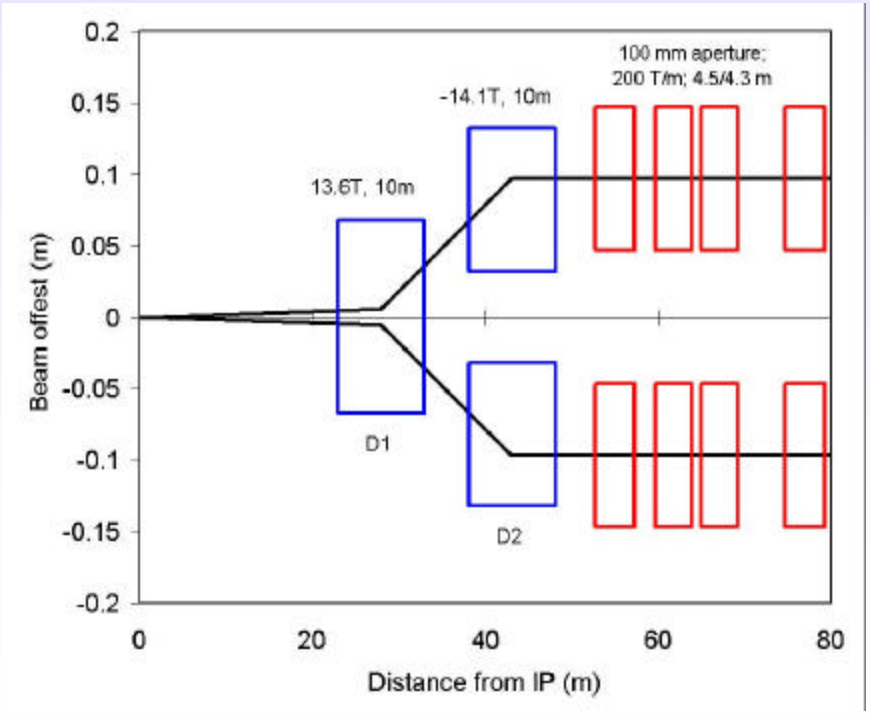


Linear Collider final focus R&D:

- ultra compact “direct wind”superconducting magnets.
- Independent of warm or cold technology (if the IR has a X-ing angle)
- First ‘full length’ coil in FY04 (presently at SLAC for ITRP visit)

- BNL LDRD for coil development
- NLC R&D funds (via SLAC) for vibration work
- SBIR proposal with Exstrom Laboratories on magnetic probe for vibration work.
- SBIR with Energen Inc on active vibration damping
- No real engineering yet: we need DOE for this

120 parasitic long range collisions may give a beam-beam interaction problem at higher than design beam intensities. A dipole first IR design is one way to try to minimize this problem.



Design Requirements:

- High field ~14T (space)
- Large Aperture (beam separation)
- Field Quality (high beta lattice location)
- Beam heating (first active element from the IP sees 1.5KW)

Superconducting Magnet R&D - HEP Technology development

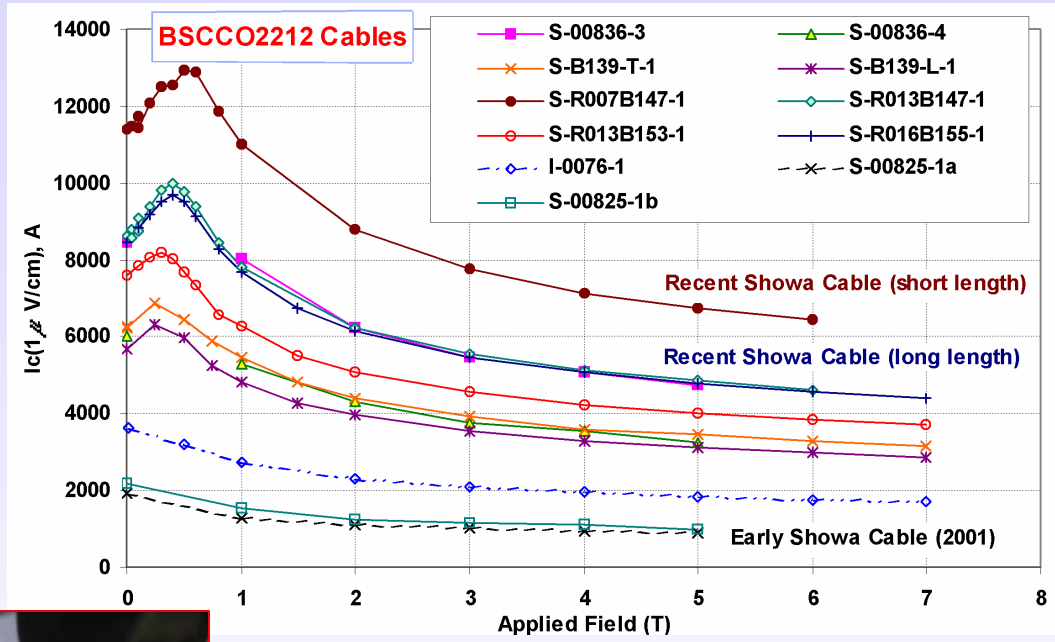
HEP Technology Development:

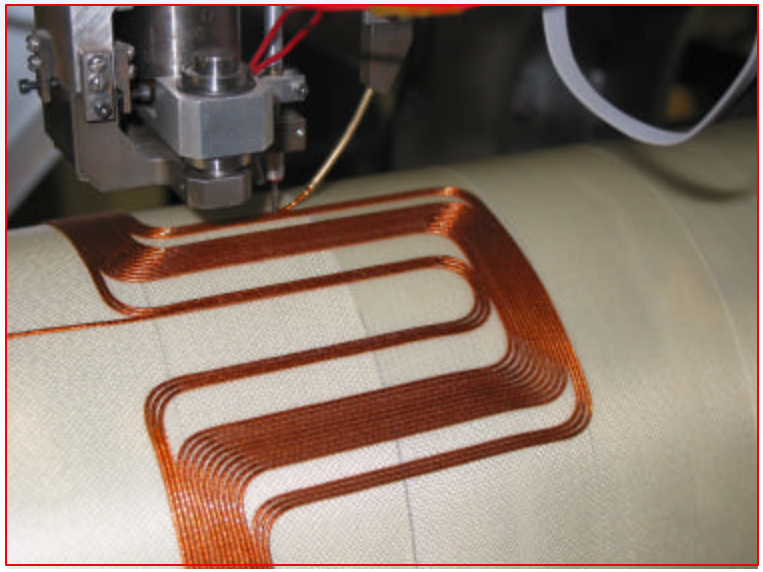
- Superconducting Materials R&D
- High Field Magnet R&D

Work For Others (HEP related):

- BEPC II micro-beta quads
- J-PARC Neutrino line
- GSI rapid cycling SC magnets

- BTev (?)





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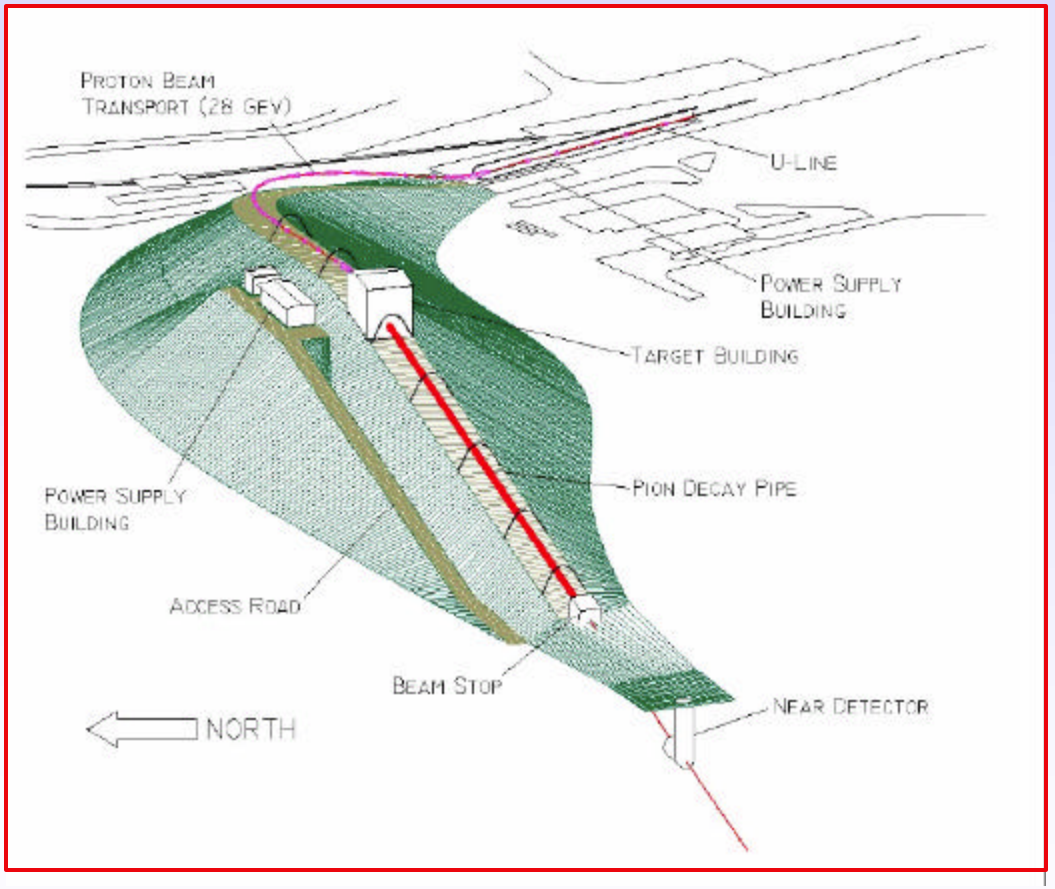
Accelerator R&D - AGS based Neutrino Superbeam

A 1 MW proton beam based on the AGS complex

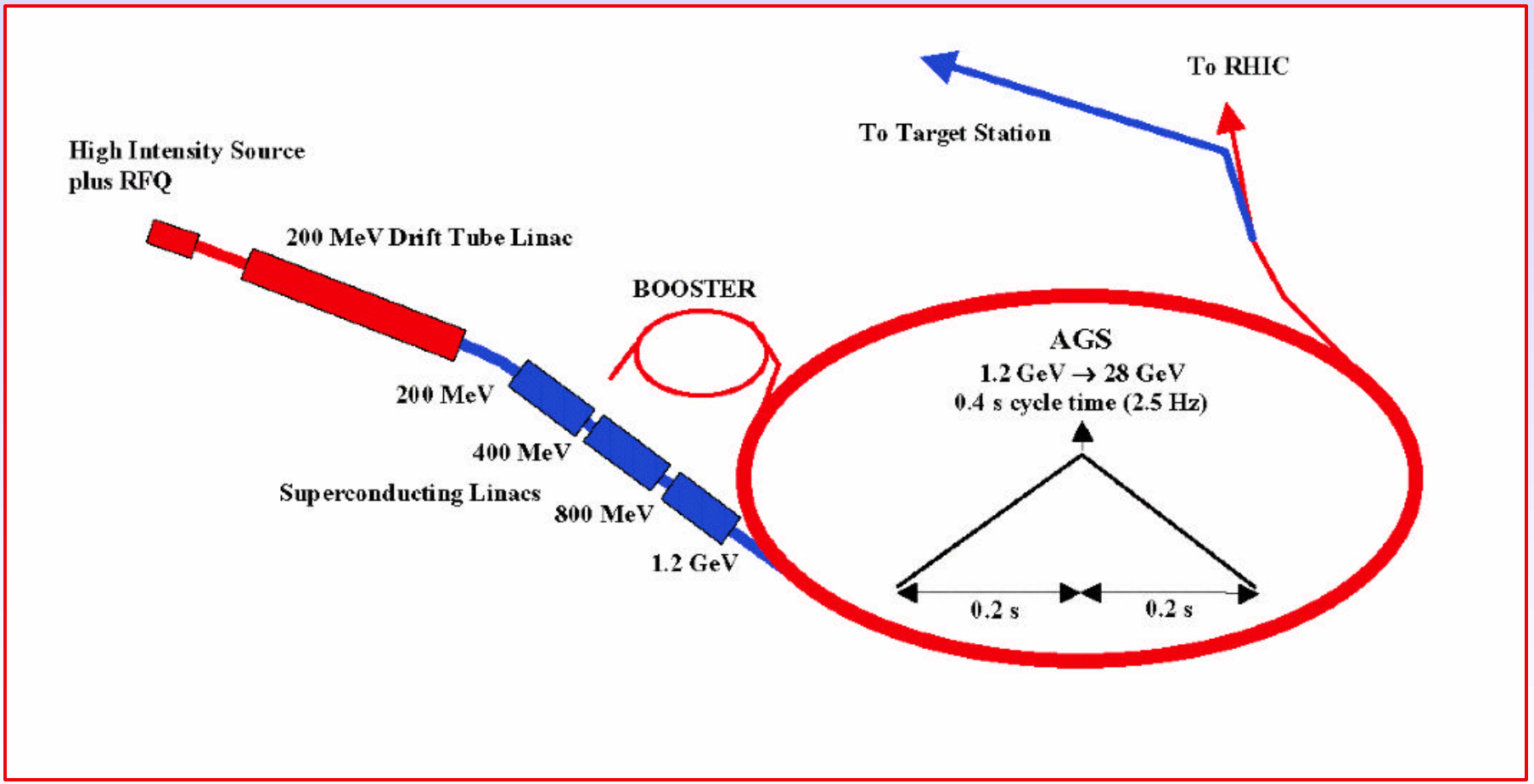
Increased AGS rep-rate
Modestly increased bunch intensity
AGS energy unchanged at 28 Gev
Beam power from more protons rather than higher energy

New beam line & target station
New portion of SC linac to avoid the Booster
New AGS power supply system



A conceptual design study will be completed in June 2004

Accelerator R&D - AGS based Neutrino Superbeam



The use of much of the existing complex gives a (highly) cost effective Project.

Synergy with RHIC operations results in (highly) cost effective operations.

Conclusions

The BNL magnet production program and materials support for the LHC is drawing to a successful conclusion. Cost issues have proved as much of a challenge as the technical ones. Inter-lab and International collaboration is always 'interesting', we continue to learn.

There is a major FY05 problem in the Superconducting Magnet Division due to the underfunding and/or delayed funding in the LHC program. The lack of linear collider R&D support does not help in this regard either.

The BNL Accelerator R&D Program is well balanced and cutting edge with generic, focused, and programmatic components. There is a broad facility base, and much experience, with huge benefits from synergy with the NP (and other BNL based) program