Introduction to Radioisotope Research & Production Program at BNL

Steve Vigdor

BLIP Operations Review

November 19, 2009

I. **Isotope production in the BNL organization**

II. **Interface with RHIC operations and plans**

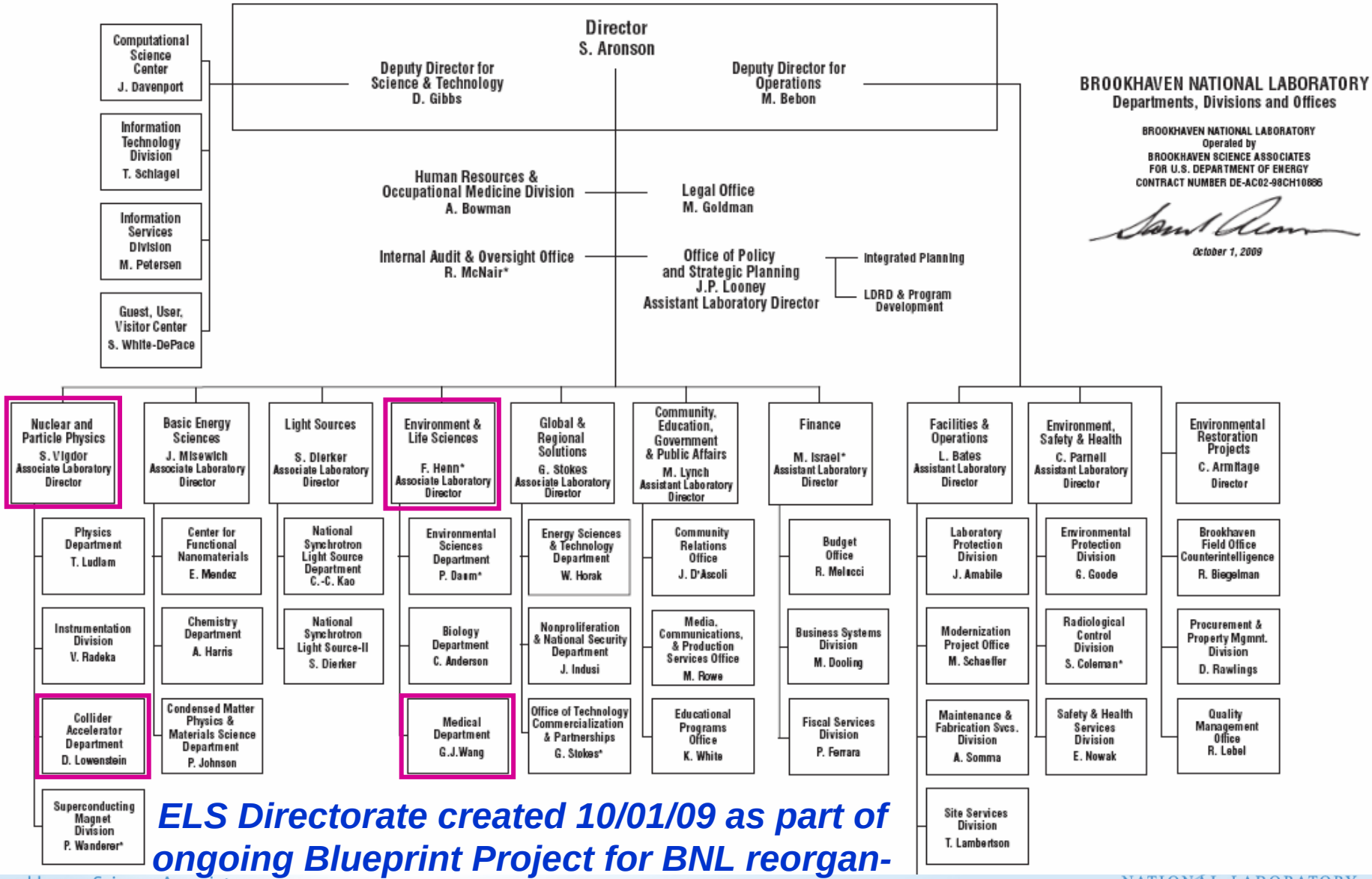
III. **Synergies and leveraging from other research at BNL**

BROOKHAVEN NATIONAL LABORATORY

a passion for discovery

Office of Science
U.S. DEPARTMENT OF ENERGY

Isotope Production Operations @ BNL Currently Straddle Two Directorates



ELS Directorate created 10/01/09 as part of ongoing Blueprint Project for BNL reorganization. Later move of Isotope Prod'n to NPP under consideration.

Radionuclide and Radiopharmaceutical Research (R&RR) Program
Medical Department, BNL
October, 2009

RR & P under ELS for now. Accelerator operations for isotope production under NPP/C-AD.

Associate Laboratory Director for Environment and Life Sciences
(F. Henn, Interim)

Chairman, Medical Dept.
G.-J. Wang

Head, R&RR Program
S.C. Srivastava, Ph.D.

Radionuclide Research and Production
L.F. Mausner, Ph.D. (Prgm Mgr)
C. Dodge, Ph.D.
E. Korach, M.S.
S. Kurczak, B.S.
D. Medvedev, Ph.D.
G. Meinken M.S.
J. O'Conor
H. Schnakenberg, B.S.

Radiopharmaceutical Research
S.C. Srivastava, Ph.D. (Prgm Head)
L.F. Mausner, Ph.D.
G.E. Meinken M.S.

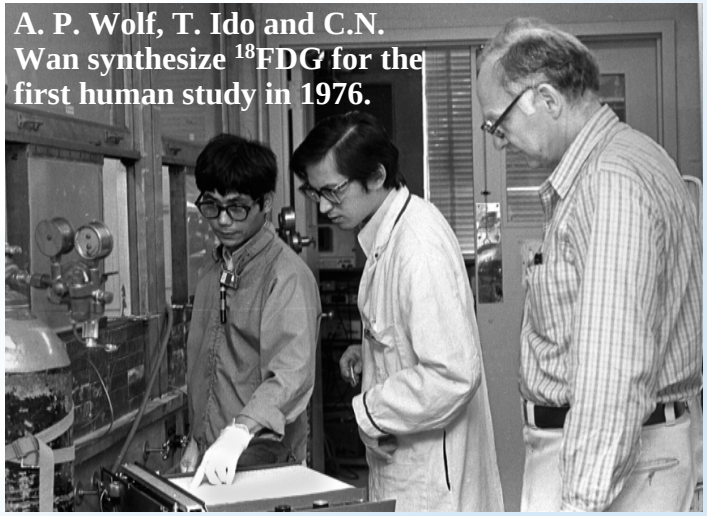
ESH Coordinator/ Quality Rep.
J. Bullis, M.S.

BNL is the Birthplace of Nuclear Medicine

Examples:

In the late 1950's, BNL scientists Walter Tucker and Powell Richards developed a generator system for producing Tc-99m and suggested its use for medical imaging. This revolutionized the practice of nuclear medicine . Tc-99m is now used in over 10 million patients/year in the U. S. alone.

In the 1970's, scientists at BNL, U. Penn and NIH, combined chemistry, neuroscience and instrumentation to develop ^{18}FDG (fluorodeoxyglucose), revolutionizing the study of the human brain. Also, in 1980, Brookhaven scientists first reported high FDG uptake in tumors, leading to FDG/PET for managing the cancer patient.

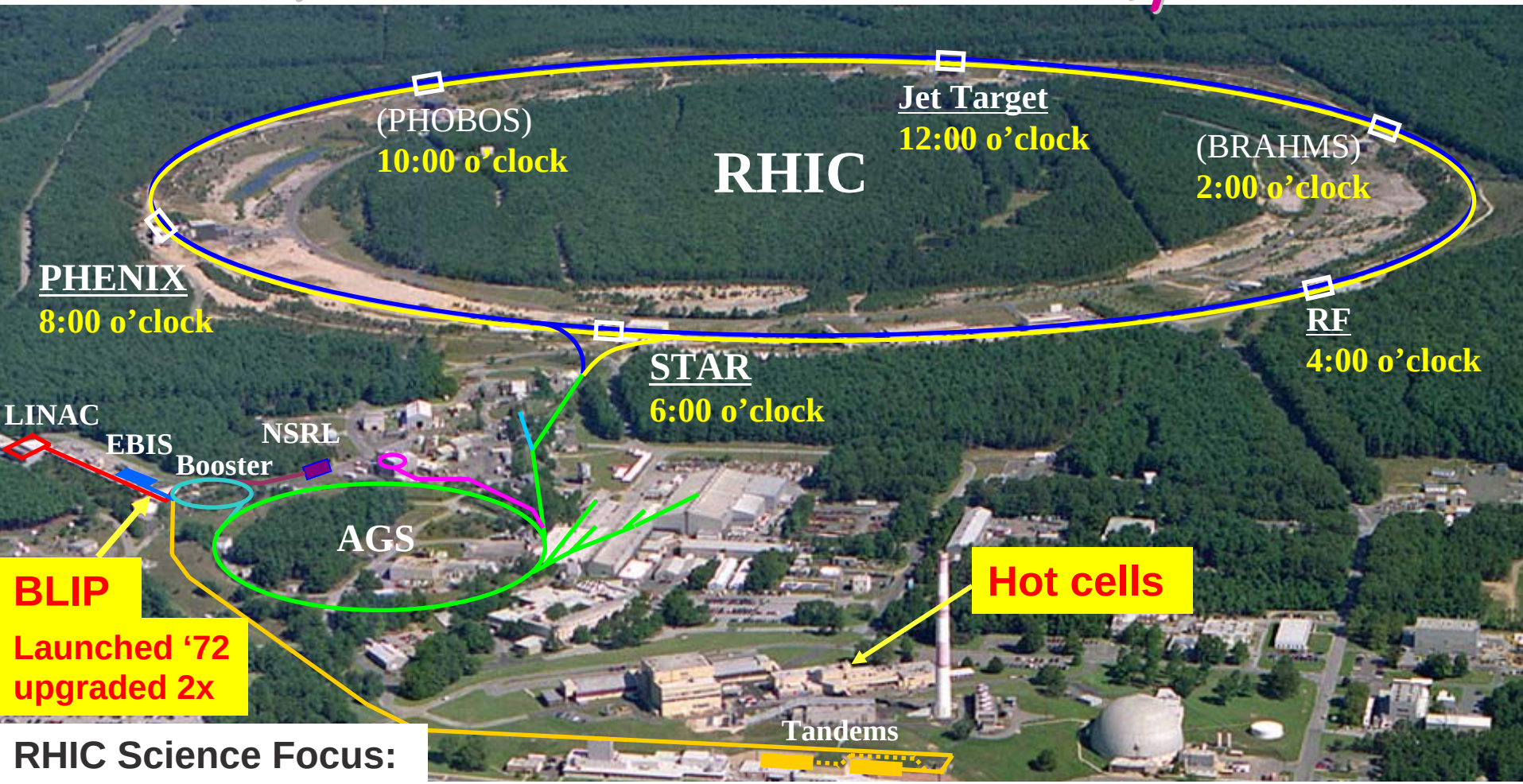


A. P. Wolf, T. Ido and C.N. Wan synthesize ^{18}FDG for the first human study in 1976.

Some other radionuclide generator systems developed at BNL:

^{132}Te/^{132}I; ^{90}Sr/^{90}Y; ^{68}Ge/^{68}Ga; ^{52}Fe/^{52m}Mn; ^{81}Rb/^{81m}Kr; ^{82}Sr/^{82}Rb; ^{122}Xe/^{122}I

Brookhaven Linac Isotope Producer (BLIP) is One of Two Major Applications Programs Utilizing Parts of AGS/RHIC Accelerator Complex

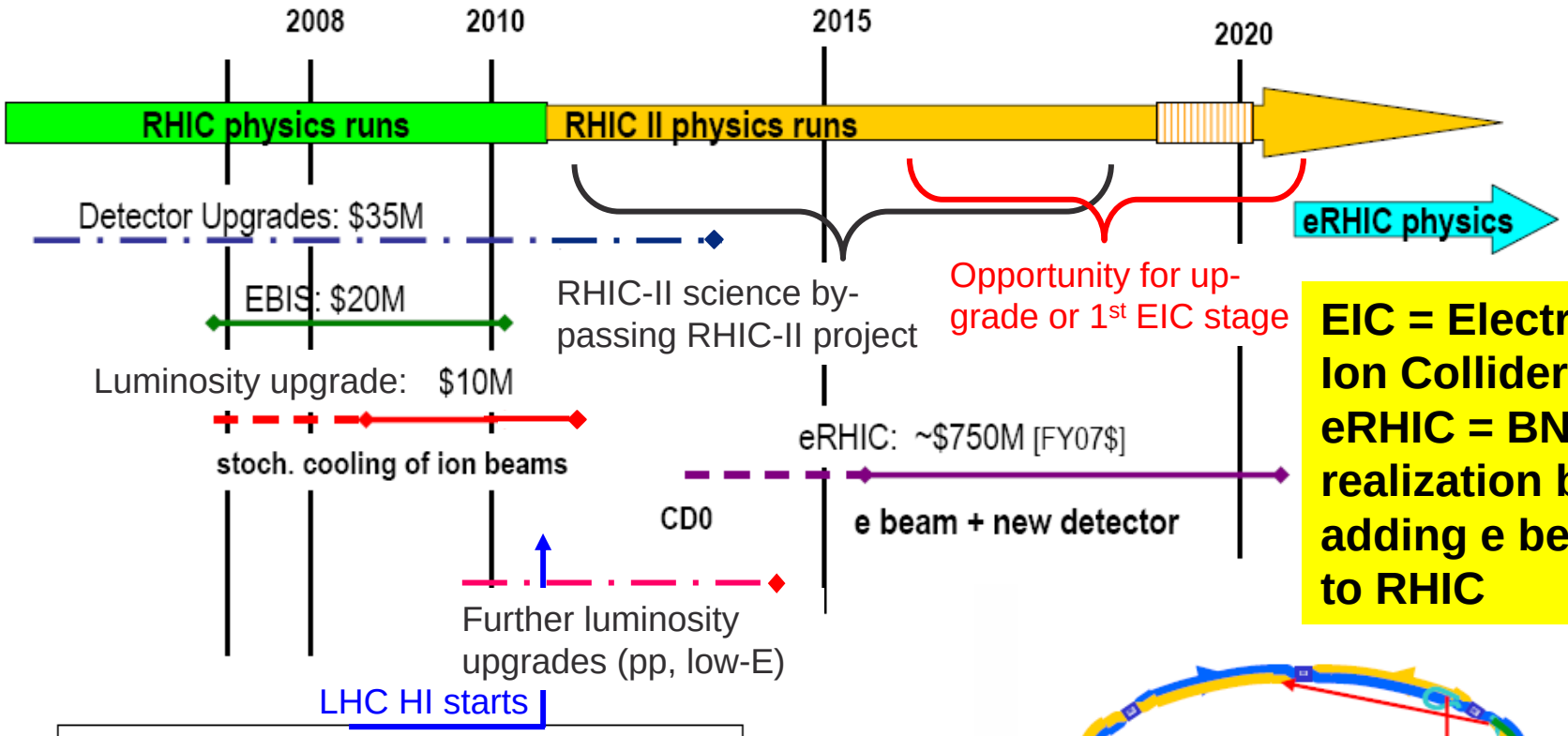


RHIC Science Focus:

1) Relativistic heavy-ion collisions to explore QCD matter phase diagram -- inject currently from tandems, switch to Electron Beam Ion Source (EBIS) in 2011

2) Polarized proton collisions to explore quark-gluon origin of proton spin -- inject from high-intensity Optically Pumped Polarized Ion Source via Linac pre-injector

A Long Term (Evolving) Strategic View for RHIC

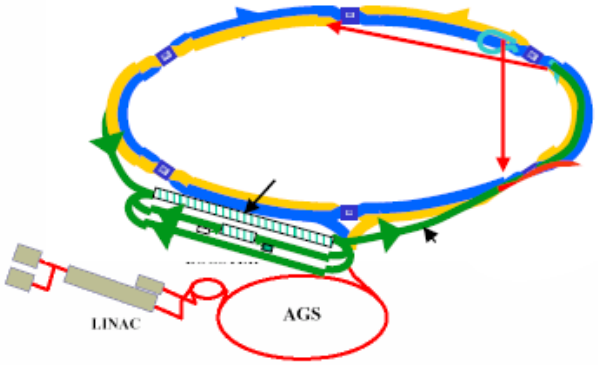


EIC = Electron-Ion Collider; eRHIC = BNL realization by adding e beam to RHIC

Legend:

- *R&D*
- *Construction*
- *Multiple small projects*

CD0: DOE Critical Decision, mission need



Detailed Strawman 5-Year Run/Upgrade Plan for RHIC ⇒ ~1/3 Time for Proton (Linac) Beams, When BLIP Can Run in Parasite Mode

Year	Likely Beam Species	Science Goals	New Detector Sub-systems	New Machine Upgrades	Gain from Machine Upgrades	Comments
FY10	Au+Au at 200, 62.4 GeV + assorted lower E	Low-mass dilepton spectrum; early collision temp.; improved jet quenching studies (especially e^- from heavy quarks); begin energy scan for critical pt.	STAR TOF completed; PHENIX HBD for heavy ions	Blue ring longitudinal + yellow and blue vertical stochastic cooling; yellow longitudinal cooling (μwave link) upgrade	Factor >2 increase in average store luminosity for full-energy Au+Au	Need 4-8 weeks early in run to (re)com-mission all 4 stoch. cooling systems, demonstrate gain in lumi. lifetime
FY11	Sub-injection Au+Au; 500 GeV p+p; short 200 GeV U+U	Continue critical pt. search; gluon polarization at low x + antiquark pol'n from W production; 1st characterization of deformation effects in U+U centrality distrib'ns	PHENIX VTX; upgraded PHENIX trigger (t0) barrel	EBIS (tandem as backup); 9 MHz cavity; AGS tune jump quads (comm'd in Run 10); RHIC spin flipper	U beam capability; improved pp vertex distrib'n; improved pol'n from AGS; reduced syst. errors	9MHz requires upgrade to main PS + "bouncer" cavity for both rings + longitudinal damper or Landau cavity for each ring.

Year	Likely Beam Species	Science Goals	New Detector Sub-systems	New Machine Upgrades	Gain from Machine Upgrades	Comments
FY12	Au+Au at 200 GeV; 500 GeV p+p	RHIC-II heavy-ion goals: heavy flavor, γ-jet, quarkonium, multi-particle correlations; anti-quark polariza-tions in proton	PHENIX FVTX and μ trigger; STAR FGT + HFT prototype;	Yellow + blue horiz. stoch. cooling (in-stalled FY11); 56 MHz SRF; e-lenses; OPPIS sole-noid + "proton cannon"; RHIC collimator upgrade	Full RHIC-II heavy-ion luminosity + improved vertex & store length; improved pp lumino-sity + polar-ization	Electron lens commission-ing $\Rightarrow$ Run 12 gains possible; detailed collimator upgrade plans still to be developed
FY13	200 GeV p+p; further heavy-ion running to comple-ment earlier runs	Continue RHIC-II heavy-ion goals; transverse spin asymmetry for γ + jet (2015 spin milestone); pp reference data for new subsystems	PHENIX FOCAL?	Catchup for ambitious FY12 upgrades plan		N.B. "Proton cannon" increases pol. source current, to allow scraping to improve polarization
FY14	200 GeV Au+Au; low-E Au+ Au dictated by Run 10+ 11 results	Continue pursuit of γ + jet, energy scan and identified heavy flavor (DM10-12) milestones.	Full STAR HFT	RHIC low-E electron cool-ing; R&D ERL to RHIC for coherent e-cooling test	Factor of several increase in lowest-E Au+Au luminosity	Low-E cooling relies on Pelletron from FNAL in late 2011

5 Distinct Operating/Cost Modes for BLIP Operations, Dependent on Parallel Uses of Complex

Mode	Description	Cost Algorithm
1	Dedicated Running	BLIP assumes all start-up and operating costs including a 6 operator shift rotation
2	RHIC Polarized Proton Running	BLIP runs during RHIC fills. Higher tube currents for BLIP increase tube replacement component of the rate. Linac start up cost paid by RHIC
3	NSRL Running with Tandem	NSRL runs 12 hour day shift/no weekends. BLIP assumes all start-up costs, overnight and weekend operating costs.
4	NSRL Running with Linac	NSRL runs 12 hour day shift/no weekends. BLIP assumes all overnight and weekend operating costs. Linac start up costs paid by RHIC.
5	RHIC Heavy Ion Running	BLIP pays dedicated costs associated with Linac operations and tube use. RHIC Program pays MCR labor cost.

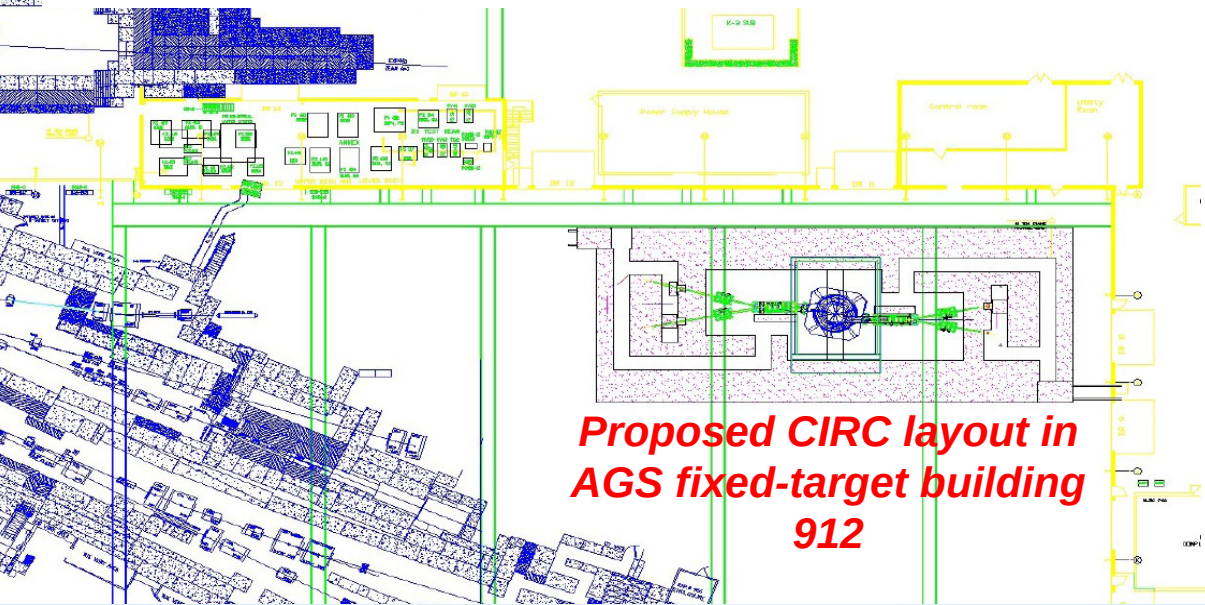
Cost details in D. Lowenstein presentation, vary with Linac energy used. BLIP operations performance, issues presented weekly during RHIC and/or NSRL runs at Tuesday C-AD Time Meetings. BLIP operations are coordinated with LANL Isotope Production Facility operations.

Multiple National Studies Have Urged Creation of a Dedicated DOE Facility for Radioisotope Prod'n

- NAS report, Future of US Chemistry Research, Benchmarks& Challenges, 2007
  - "Currently, there is no U.S. facility dedicated to year–round production of radioisotopes, severely compromising nuclear medicine practice and radioisotope R&D needed to advance targeted molecular therapy and other radioisotopes needs for the future."

Proposed BNL solution: ***Cyclotron Isotope Research Center (CIRC) -- details in L. Mausner presentation***

- ***1st proposed in 2000. Conceptual design adopted for new French Arronax facility, on which BNL scientists collaborate.***
- ***would greatly expand U.S. radioisotope research and production efficiency and flexibility per operating dollar cost, after construction outlay ~$40M***



Proposed CIRC layout in AGS fixed-target building 912

Research and training at CIRC would be a centerpiece of proposed joint BNL / Stony Brook graduate education program in nuclear & radiochemistry, to address serious current U.S. shortfall in producing scientists with needed skills.

Synergies and Leveraging of Isotope Production @ BNL

- ***NP operation of AGS/RHIC complex permits parasitic isotope production program at reduced cost***
- ***Collider-Accelerator Division provides eng&tech. support, not only for BLIP and target design, but also CIRC design & costing***
- ***Other BLIP applications to irradiation studies for high-power target and HTS material developments for other BNL divisions***
- ***Wide variety of accelerator operations and expertise at BNL provides extensive ES&H, including radiological control, support***
- ***Intellectual and collaborative connections to radiotracer chemistry program in Medical Dept., including radioisotope research use of small (17 & 19 MeV) medical cyclotrons***
- ***Availability of LDRD funding for radioisotope R&D – e.g., ongoing research on ^{52}Fe-labeled nanoparticles for dual PET/MRI (see D. Medvedev talk)***

Some Arising Cost Issues for Discussion:

- ***What is the appropriate operations cost model going forward, now that ONP funds both RHIC and BLIP operations? (see D. Lowenstein talk)***
- ***Substantial unforeseen equipment costs associated with near-term replacement of hot cell manipulators (see L. Mausner talk)***
- ***What are added manpower implications of growing strictness in application of CGMP compliance requirements? (see J. Bullis talk)***