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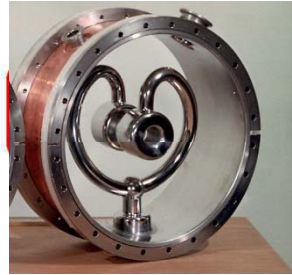
News from ATLAS: the Argonne Tandem Linear Accelerator System

Robert V. F. Janssens

***Scientific Director of the ATLAS Facility
Director Physics Division***

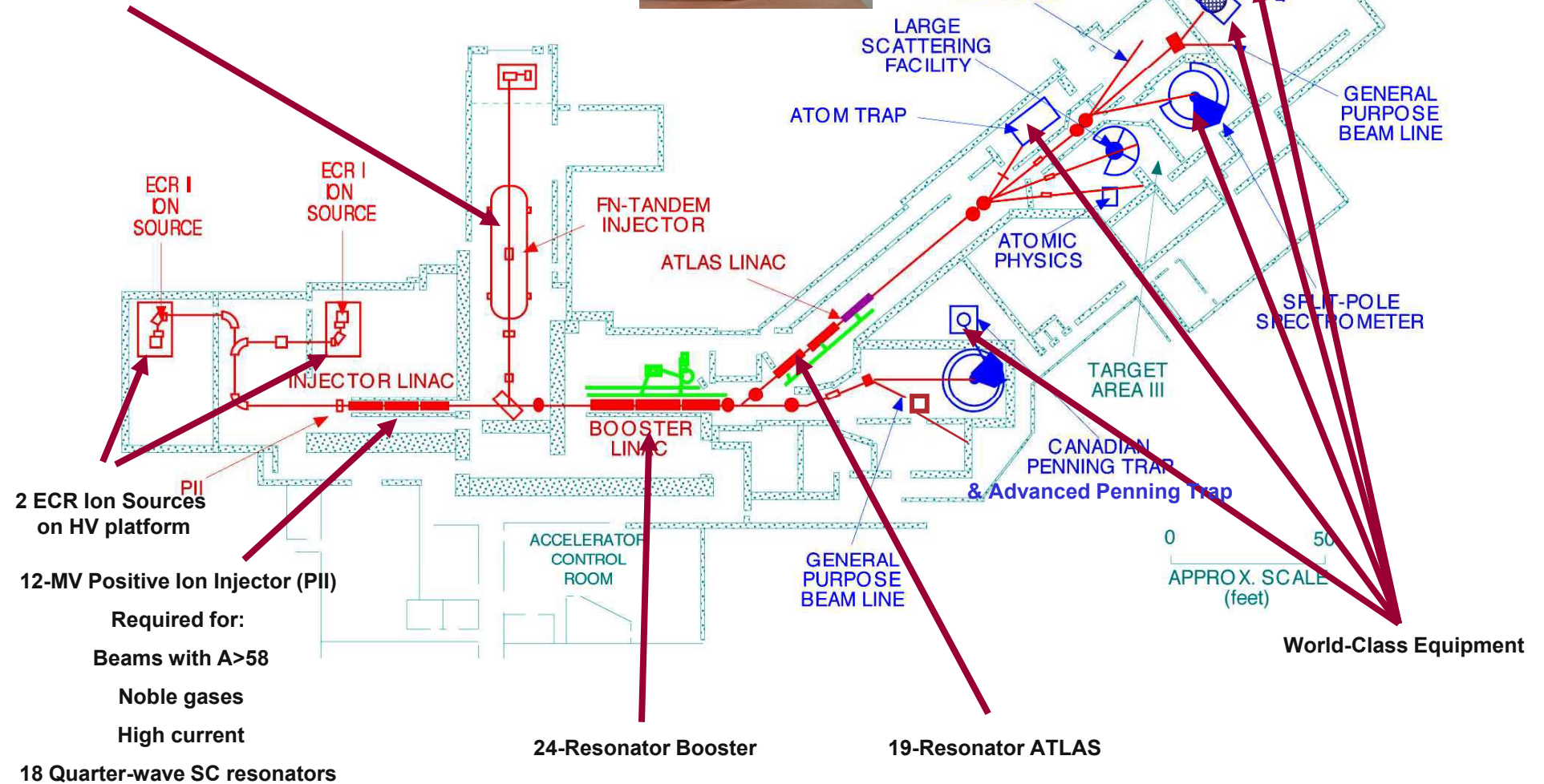
NSAC Meeting February 26, 2010

The ATLAS Facility



8.5-MV Tandem Injector

Important for:
Beams of $A < 58$
Long-lived RIB's



ATLAS Operations:

Operations statistics

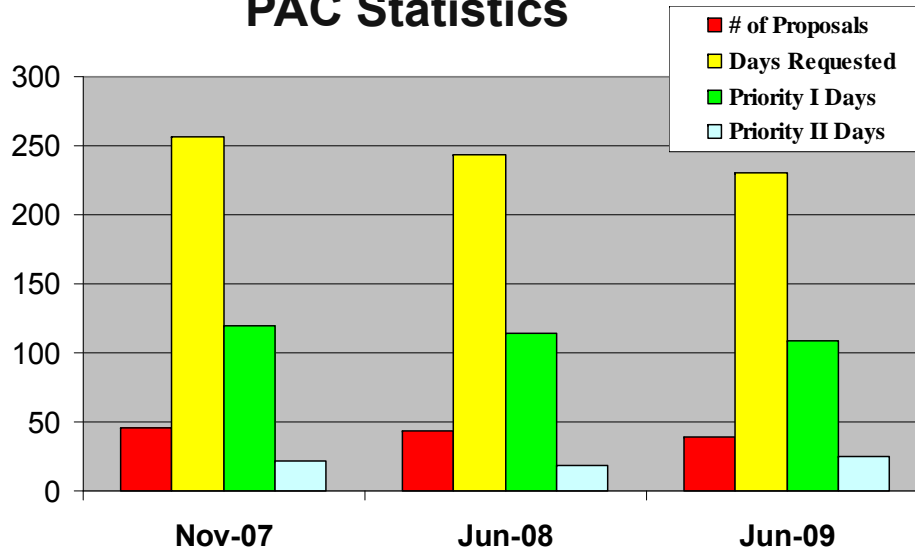
Activity	FY2009 Total Hours
Research Hours	4642
Beam Studies Hours	214
Setup/Tuning hours	632
Total Delivered Operating Hours	5488
Failure & Unscheduled Shutdown Hours	234
Total Scheduled Operating Hours	5722
Scheduled Maintenance Hours	667
Reliability	.959

Performance measures:

- (a) effective beam usage: 92.4% as determined by Users
- (b) 5488 delivered operating hours, above 5200 hours baseline

- Delivered more hours than anticipated in 7days/week mode → addresses high Users demand
- Reliability still at > 95%

PAC Statistics



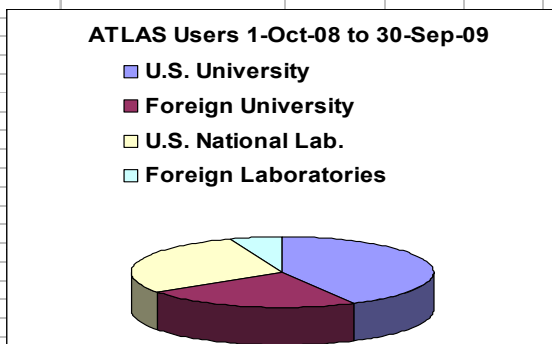
Trends persist, i.e.,

- high number of proposals
- oversubscription by ~ 2
- Continue to operate with priority I & II modes to optimize efficiency of program
- Small backlog as requested by Users
- Next PAC April 2-3

ATLAS Operations

User Program

Institutions	Number	
U.S. University	165	42%
Foreign University	91	23%
U.S. National Lab.	112	29%
Foreign Laboratories	22	6%
<i>Total</i>	390	

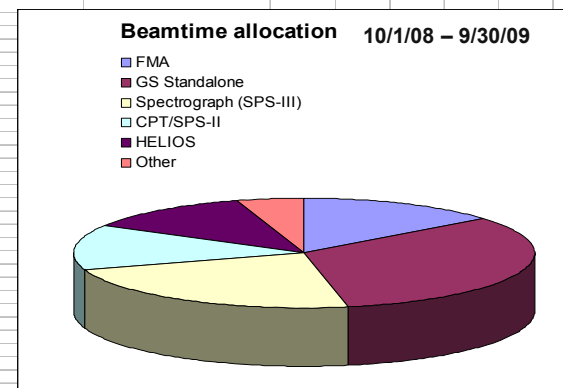


- **FY09 – 390 Users (69 Students/ 10 Theses) 77 pubs in refereed journals (18 letters)**
- **FY08 – 387 Users (71 Students / 9 Theses) 63 pubs in refereed journals (13 letters)**
- **FY07 – 330 Users (62 Students / 9 Theses) 57 pubs in refereed journals (15 letters)**

Research Program

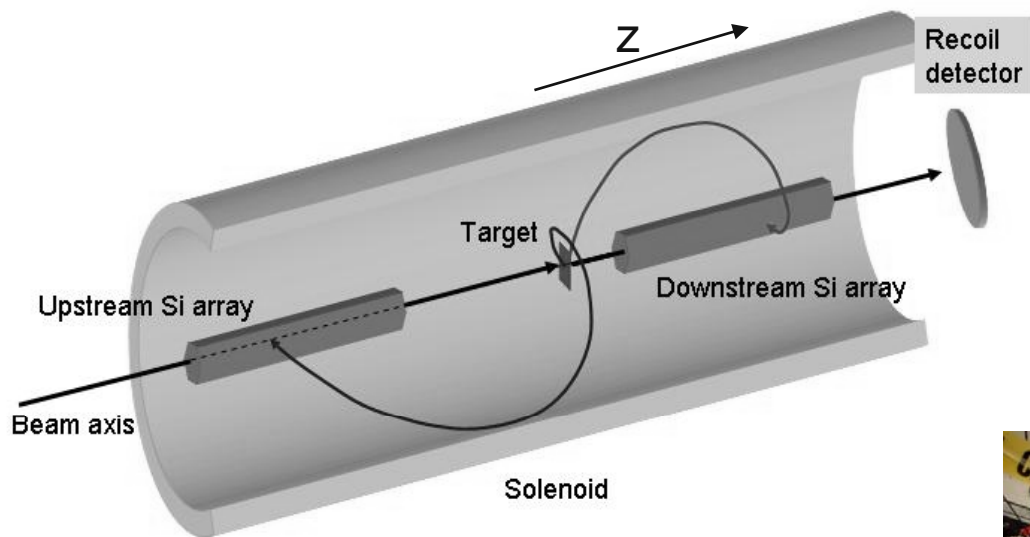
- **Continues to address major scientific questions of the field**
- **Takes advantage of all the instrumentation available at ATLAS**
- **Continues to develop new techniques and instruments**

Type	Hours	
FMA	696	14%
GS Standalone	1607	33%
Spectrograph (SPS-III)	1124	23%
CPT/SPS-II	648	13%
HELIOS	592	12%
Other	228	5%
<i>Total</i>	4895	



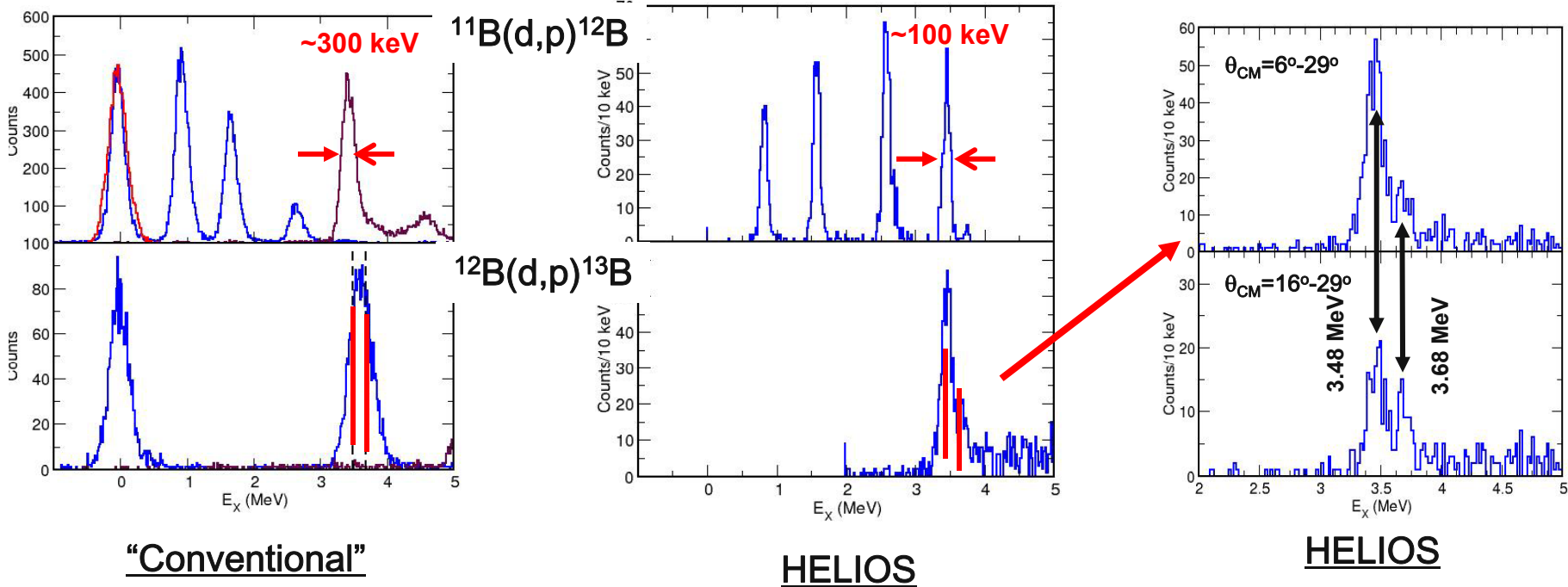
First results from HELIOS

U. Western Michigan, Manchester, ANL collaboration



Low-Energy Research: Highlights

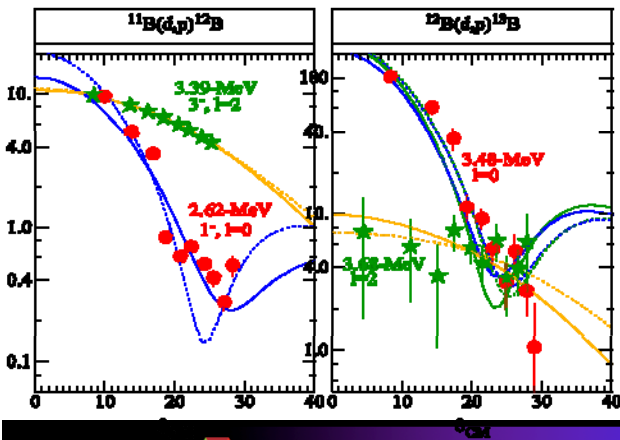
Highlight: First data from HELIOS with an exotic beam: $^{12}\text{B}(d,p)^{13}\text{B}$



“Conventional”

HELIOS

HELIOS

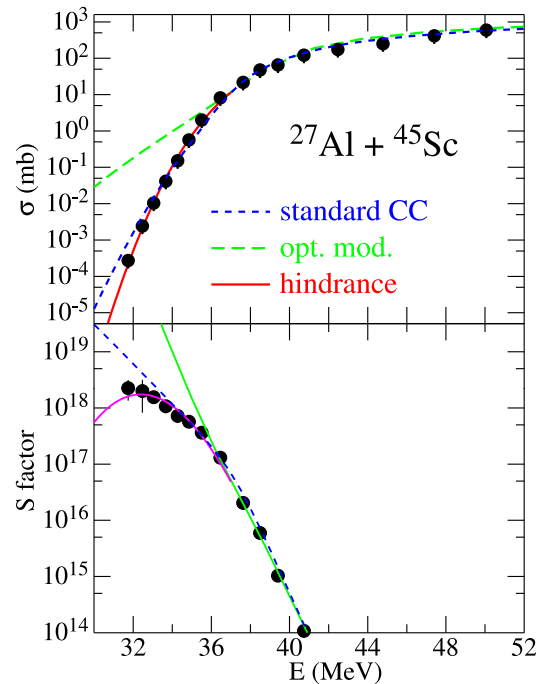


- Performance of HELIOS with in-flight RIB demonstrated
- Superior performance above conventional Si detection confirmed
- New I^π information on ^{13}B states obtained
- Data show inadequacy of shell model calculations \rightarrow associated with melting of N=8 shell closure??

B.B. Back et al., PRL submitted

Low-Energy Research: Highlights

Highlight : First evidence for fusion hindrance in system with positive Q value



$^{27}\text{Al} + ^{43}\text{Sc}$: $Q=9.63$ MeV

- First system with $Q>0$ measured down to where hindrance can be observed → confirms general nature of phenomenon
- Important impact on astrophysics: rate of C and O burning in massive late-type stars → C ignition shifted to higher temperatures, general reduction in rates, impact on abundance of key elements (^{26}Al , ^{56}Ni ,...)
- C.L. Jiang et al., PRC Rapid Comm. In press

ATLAS Projects: ATLAS Energy Upgrade

ATLAS Energy Upgrade: A complete success

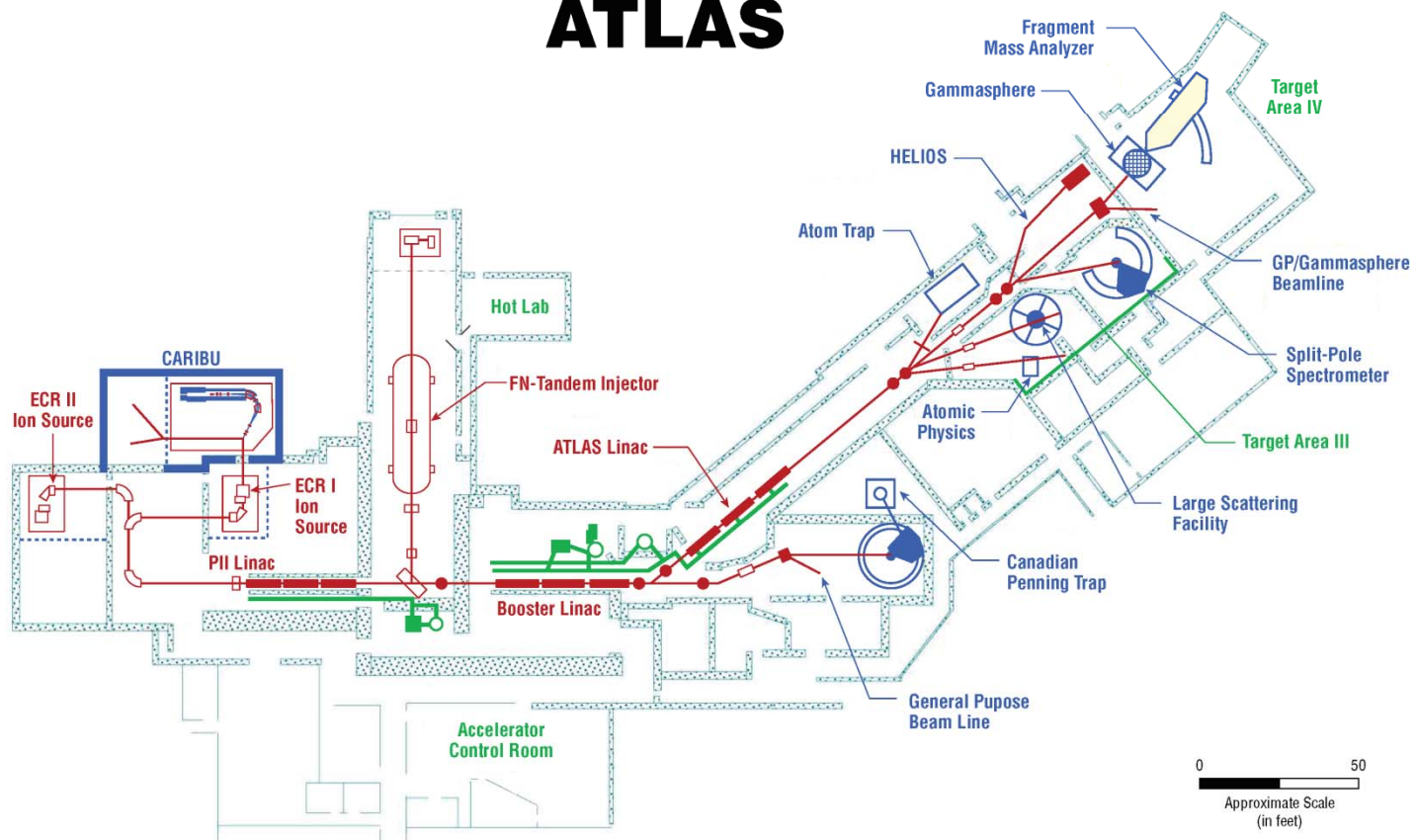


- A new cryomodule containing 7 $\beta=0.15$ quarter-wave cavities has been added to the ATLAS heavy ion linac, increasing beam energy by 30-40%.
 - This represents the first successful demonstration of separate cavity and insulating vacuum for a low- β cryomodule.
 - Operational since June 2009
 - Used in $\frac{1}{2}$ runs since installation – no deterioration in performance
-
- Cryomodule:
 - represents a factor 3 gain in cavity performance
 - represents the first implementation of new surface preparation (particle- free) techniques for low- β cavities
 - **a new world record for low- β cavities**
 - The design is suitable as a basis for the next generation of ion linacs
 - Further developments to maximize the potential of state-of-the-art QWRs:
 - Optimized EM/mechanical design
 - Fast piezoelectric or magnetostrictive tuners for low intensity beams
 - High power RF couplers for high current beams
 - Very high voltages (4 MV per cavity) are realistic even for lower beta ~ 0.075

ATLAS Projects: CARIBU

Californium Rare Ion Breeder Upgrade

ATLAS



ATLAS Projects: CARIBU

Status:

- Gas catcher installed & operational; beam properties measured with stable beams
- Shield cask ready for 2 mCi source
- Transport to isobar separator ready
- First magnet of isobar separator installed and characterization of magnet completed, characterization of second magnet on-going
- Authorization to start commissioning with 2mCi source received

Project has experienced delays due mainly to issues with manufacturer of isobar separator (late delivery & quality control issues). There were burn-in problems with the gas catcher as well.



ATLAS Projects: CARIBU

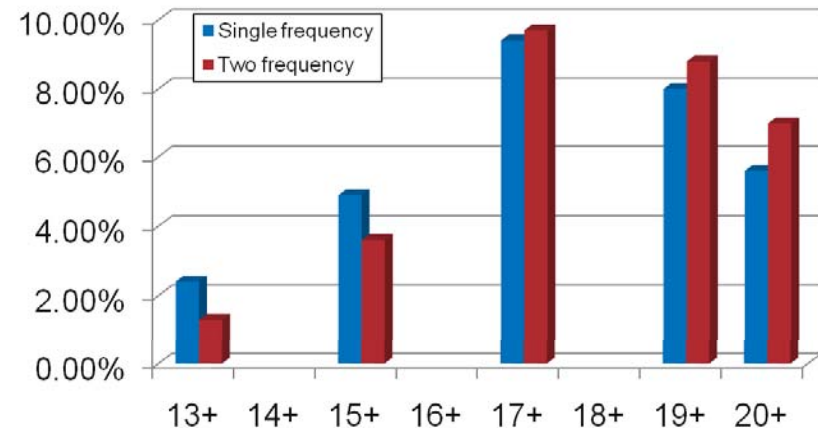
Status:

Present situation:

- great progress on charge breeding:
9.7% achieved for ^{85}Rb \rightarrow world record
(CARIBU goal was 5%)
- extensive beam studies at ATLAS in
preparation for ^{143}Ba acceleration
- CPT moved to CARIBU

Plan:

- March install 2 mCi source (as soon as stable beam
studies of isobar separator are complete)
- March - April: establish charge breeding efficiency for ^{143}Ba
and accelerate through ATLAS
- May – September: Install 80 mCi source, establish baseline
intensities for representative fragments, accelerate first
beams for demonstration experiments at HELIOS,
Gammasphere etc., start stopped beam program
- Fall - Winter: Install 1 Ci source & start experimental program



ATLAS Operations 2010

- 5900 h of operation (7 days/week mode)
- PAC meeting: April 2-3 (proposals due 3/1) – requests for proposals with stable beams only

- CARIBU Plan:

Isotope	Half-life (s)	Low-Energy Beam Yield (s ⁻¹)	Accelerated Beam Yield (s ⁻¹)
¹⁰⁴ Zr	1.2	1.5x10 ³ / 4.8x10 ⁴ / 6.0x10 ⁵	5.3x10 ¹ / 1.7x10 ³ / 2.1x10 ⁴
¹⁴³ Ba	14.3	3.0x10 ⁴ / 9.6x10 ⁵ / 1.2x10 ⁷	1.1x10 ³ / 3.4x10 ⁴ / 4.3x10 ⁵
¹⁴⁵ Ba	4.0	1.4x10 ⁴ / 4.4x10 ⁵ / 5.5x10 ⁶	5.0x10 ² / 1.6x10 ⁴ / 2.0x10 ⁵
¹³⁰ Sn	222.	2.5x10 ³ / 7.8x10 ⁴ / 9.8x10 ⁵	9.0x10 ¹ / 2.9x10 ³ / 3.6x10 ⁴
¹³² Sn	40.	9.3x10 ² / 3.0x10 ⁴ / 3.7x10 ⁵	3.5x10 ¹ / 1.1x10 ³ / 1.4x10 ⁴
¹³⁸ Xe	846.	2.5x10 ⁴ / 7.8x10 ⁵ / 9.8x10 ⁶	1.8x10 ³ / 5.8x10 ⁴ / 7.2x10 ⁵
¹¹⁰ Mo	2.8	1.6x10 ² / 5.0x10 ³ / 6.2x10 ⁴	5.8x10 ⁰ / 1.8x10 ² / 2.3x10 ³
¹¹¹ Mo	0.5	8.3x10 ⁰ / 2.6x10 ² / 3.3x10 ³	0.3x10 ⁰ / 9.6x10 ⁰ / 1.2x10 ²

Spring 2010: 2 mCi source → tests & yields studies

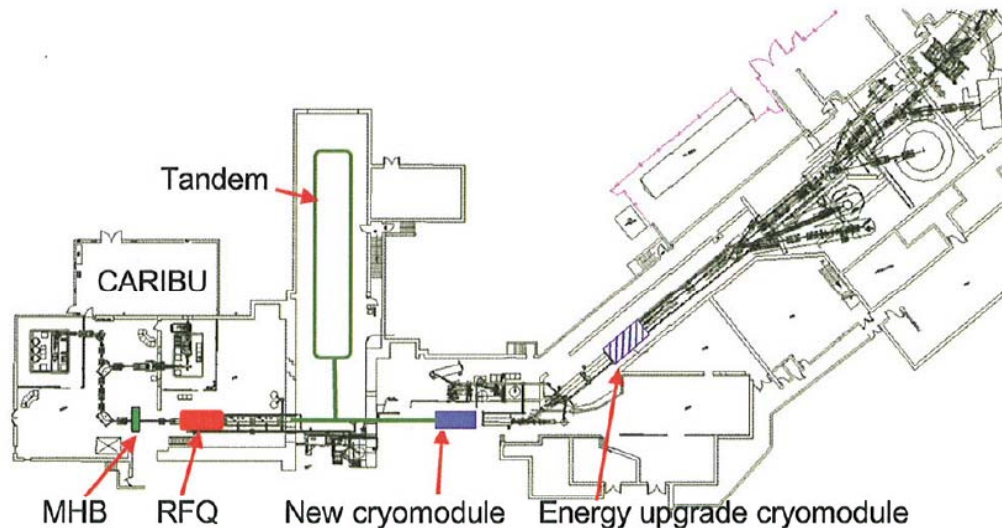
Summer-Fall 2010: 100 mCi source → 1st test expts.

End 2010: 1 Ci source → Full research program

- Equipment Initiatives: Complete HELIOS Spectrometer, develop laser program, digitize Gammasphere and upgrade FMA

ATLAS Efficiency & Intensity Upgrade:

Phase 1:



ARRA Funding + AIP

- Build an RFQ to deliver 250 keV/u ion beams with $q/A \geq 1/7$.
- Modify low-energy beamlines to provide beam matching upstream and downstream of the RFQ.
- Develop a new $\beta_G=0.077$ quarter-wave SC resonator optimized for high-intensity beams.
- Build a cryomodule with 7 of the new SC cavities ($\beta_G=0.077$) to replace 3 Booster cryomodules.
- Upgrade the ATLAS liquid helium distribution system.
- Modify the first cryomodule of the PII to increase both the transverse and longitudinal acceptance.
- Re-locate the best $\beta=0.1$ split-ring cavities into 3 cryostats instead of the 4 cryostats they occupy now.

One order of magnitude gain in intensity for stable beams and in-flight RIB beams
Double intensity for CARIBU re-accelerated beam intensities

ATLAS Efficiency & Intensity Upgrade: The Science

(1) Nuclear Structure:

■ Neutron-rich nuclei:

- This is where the field is moving & where we expect changes
 - *Single particle structure ...more detailed/further out (HELIOS with more n-rich RIBs, deep inelastic reactions with stable beams & Gammasphere)*
 - *Collective properties (Coulex at Gammasphere/FMA, Gretina)*
 - *Ground-state properties (decay station, CPT, laser)*

■ Neutron-deficient nuclei:

- Many challenges remain
 - *Spectroscopy around ^{100}Sn (FMA+Digital DSSD, Digital Gammasphere)*
 - *Beta decay studies around N=Z line (FMA+Digital DSSD)*
 - *Exotic collective phenomena (Digital Gammasphere, FMA+)*
 - *Gamma spectroscopy after secondary reactions (Intense In-flight RIBs)*

■ Superheavy nuclei:

- *Shell evolution and fission barrier moving up from Z~100 to Z~103-108 (Gas-Filled Spectrometer)*
- *More n-rich isotopes (requires ISOL facility)*

Higher intensity beams, somewhat higher beam energy, improved instrumentation

ATLAS Efficiency & Intensity Upgrade: The Science

(2) Nuclear Astrophysics:

■ r-process

- *Masses, spins, lifetimes, beta-delayed neutrons on r-process path, or as close to it as possible (decay station, CPT)*
- *Particle transfer reaction, similar goals to nuclear structure and n-capture, on very n-rich (HELIOS with more n-rich RIBs)*

■ rp-, α p-, ν p-, CNO, ...

- *reactions with HELIOS on more exotic and higher intensity RIBs (mostly close to $N=Z$)*
- *Mass measurements past $N=Z$ line (CPT+)*
- *very high intensity, low energy, light stable beams for $^{12}\text{C} + ^{12}\text{C}$ etc.*

Higher intensity beams, somewhat higher beam energy, improved instrumentation

ATLAS Efficiency & Intensity Upgrade: The Science

(3) Fundamental symmetries:

■ EDM

- EDM in octupole deformed nuclei
 - *Need a stronger source of ^{225}Ra and similar nuclei ($>10^8/\text{s}$)*

Intensity upgrade or FRIB w/o ISOL are of no help here, need a high power ISOL facility to significantly improve over sources

■ Search for currents beyond V-A

- *Angular correlation in beta decay in optical traps (^6He , ^{18}Ne , ...)*
- *Angular correlation in beta decay in ion traps (light nuclei)*

Higher intensity beams, somewhat higher energy range, improved instrumentation

[ATLAS Efficiency & Intensity Upgrade: Phase 2](#)

Context :

- → **Annual ATLAS Users Workshop:** held on August 8 – 9 2009
more than 100 participants
topics covered: science drivers for ATLAS upgrade
upgrade of facility (accelerator & instrumentation)
- → **ATLAS Strategic Plan:** drafted by ATLAS users executive committee and ANL management
available on the web since 11/2009

A Strategic Plan for the Argonne
Tandem Linac Accelerator System

*Physics Division
Argonne National Laboratory
Argonne, IL*

November 2009

http://www.phy.anl.gov/atlas/workshop09/Reports_on_Workshop.pdf

ATLAS Efficiency and Intensity Upgrade:
Phase II

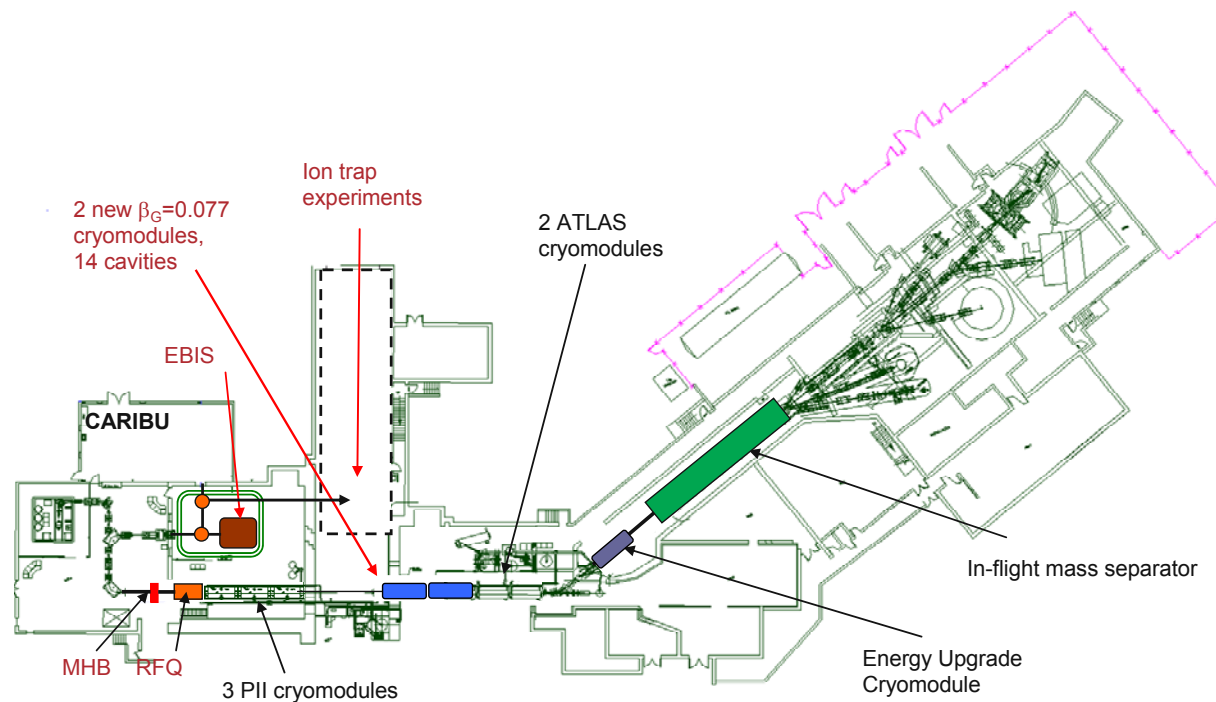
Response to the May 2009 Science & Technology Review
of the
Argonne Tandem Linac Accelerator System (ATLAS)

Physics Division, Argonne National Laboratory, December 2009

- → **Upgrade plan sent to DOE on 12/9/09 as part of the Response to S&T Review, dialog with DOE on-going**

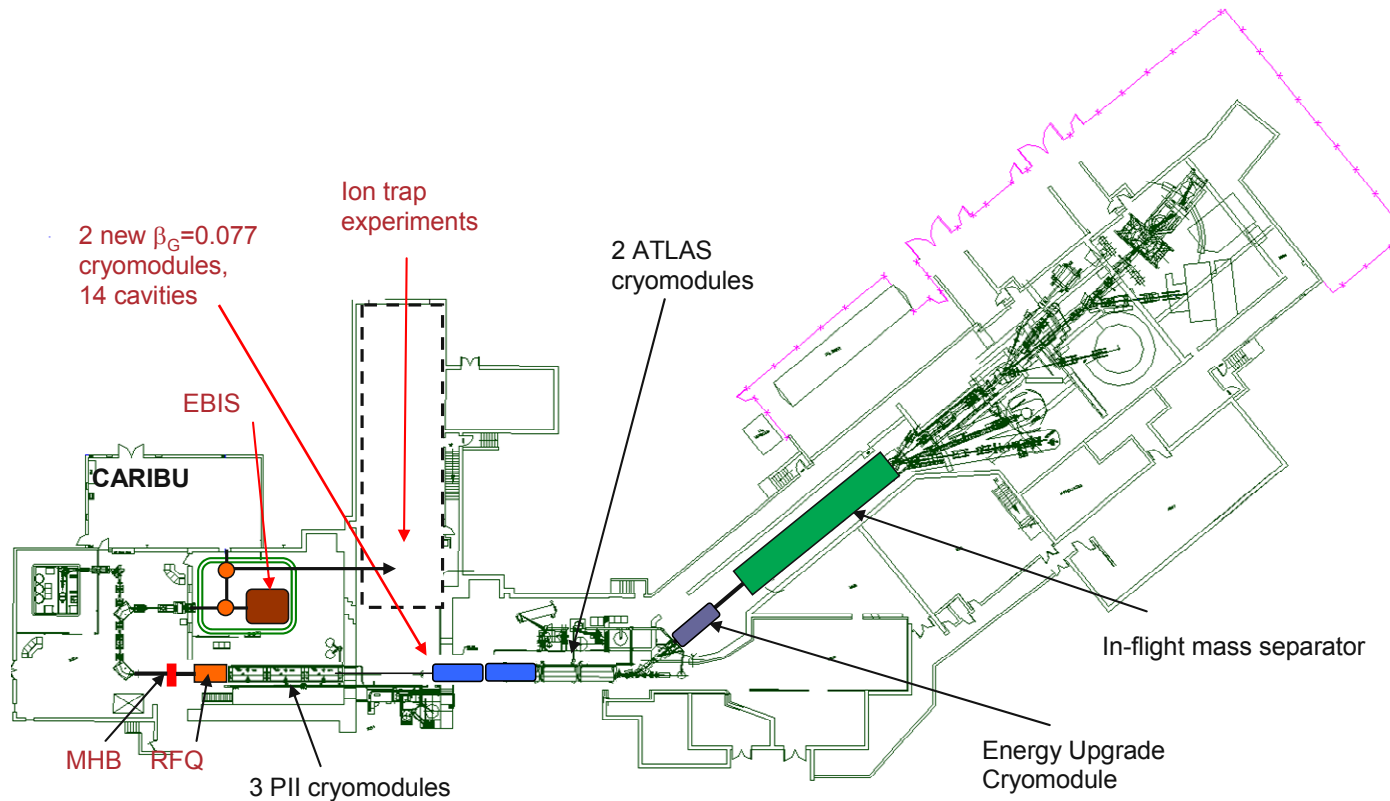
ATLAS Efficiency & Intensity Upgrade: Phase 2

Phase 2:



Replace CARIBU ECR by EBIS → **increase charge breeding by a factor of ~ 5**
→ further reach for n-rich nuclei, faster experiments, new types of experiments
Remove Tandem → **full low-energy program** → β decay, moments, masses,..
1 new cryostat + reconfiguration of ATLAS → **higher intensities & higher energies (20 MeV/A for A~20, 12 MeV/A for A~238)** → small σ , new in-flight RIBs, n-rich nuclei with deep inelastic (access to n-rich nuclei near Z=82, N=126)
New ECR source → **higher intensities & improved reliability** → small σ , new in-flight RIBs, n-rich nuclei with deep inelastic (access to n-rich nuclei near Z=82, N=126), isotope production
Recoil separator for in-flight RIBs → **higher purity & transport efficiency, access to more experimental stations** → in-flight rib program for structure & nuclear astrophysics

ATLAS Efficiency & Intensity Upgrade



On the Horizon of 2015-2020, with the completed Upgrade ATLAS will be

- **a state-of-the-art stable beam facility**
- **with RIB capabilities for specific areas (complementary to ISOL facilities & relieving pressure on FRIB for special cases)**

ATLAS and the FY2011 President's Budget

- Accelerator Operations: + 3.6%
- Experimental Support: + 4.8%
- Low Energy Research: + 3.5%

→ Operations can continue at FY2010 level

- Accelerator Capital Equipment: - 30.8%
- Experimental Support Capital Equipment: -15.4%
- Accelerator Improvement Projects: -13.1 %

This still represents CE budgets larger than those available before FY2009.

→ Priority will be given to Phase 1 of the Upgrade
Replacement/Upgrade of Accelerator components delayed
New Detector Initiatives will be reduced in scope or delayed

We shall continue to work with DOE/ONP & ATLAS user community to optimize choices