DIANA

Dakota Ion Accelerator for Nuclear Astrophysics

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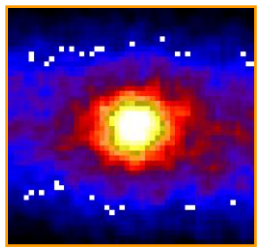
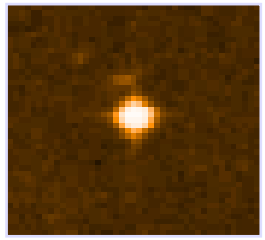
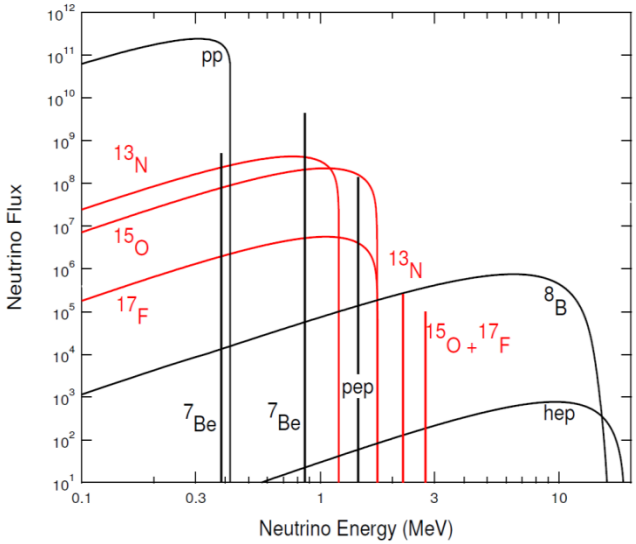
University of Notre Dame

- Science Justification
- Collaboration Team
- Design Overview & Project Progress

Scientific Motivation



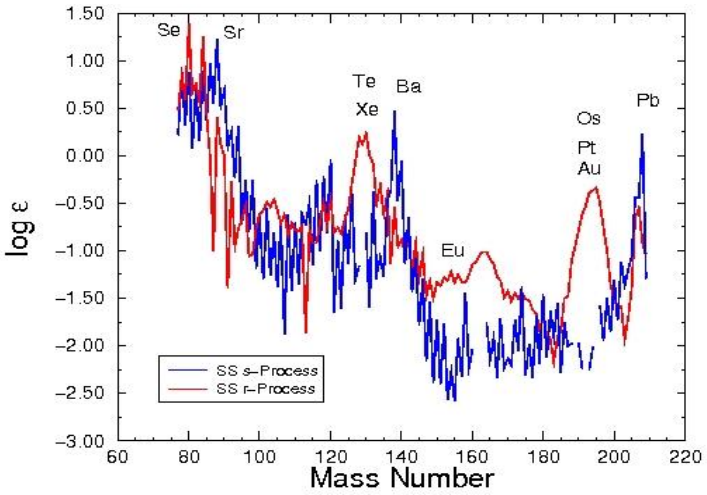




Stellar Neutrino Sources

in the sun & massive stars

Reduction of uncertainty down to 5%

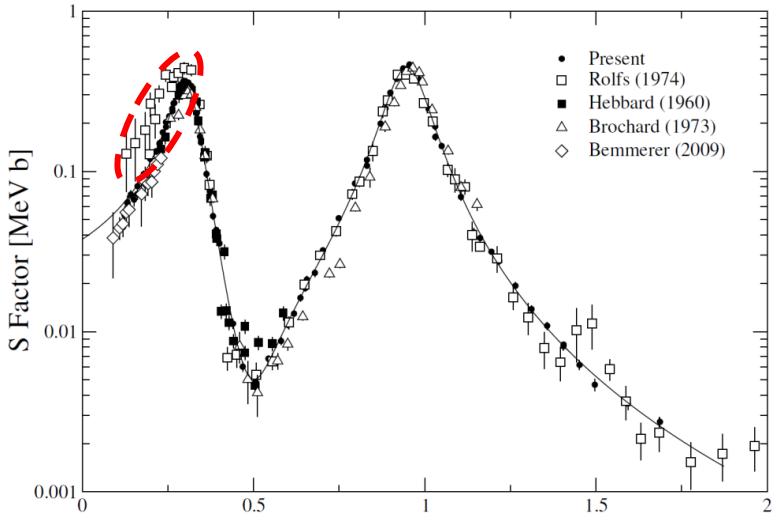


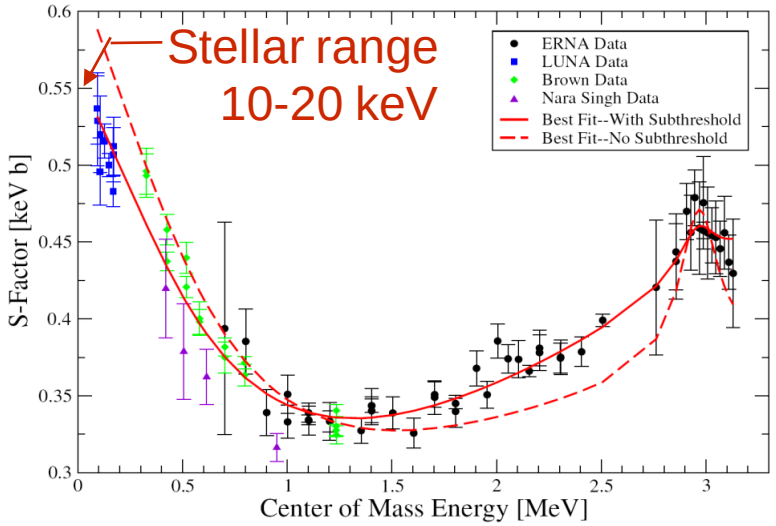
Origin of the Elements

in early & present Universe

Reduction of uncertainty down to 10%

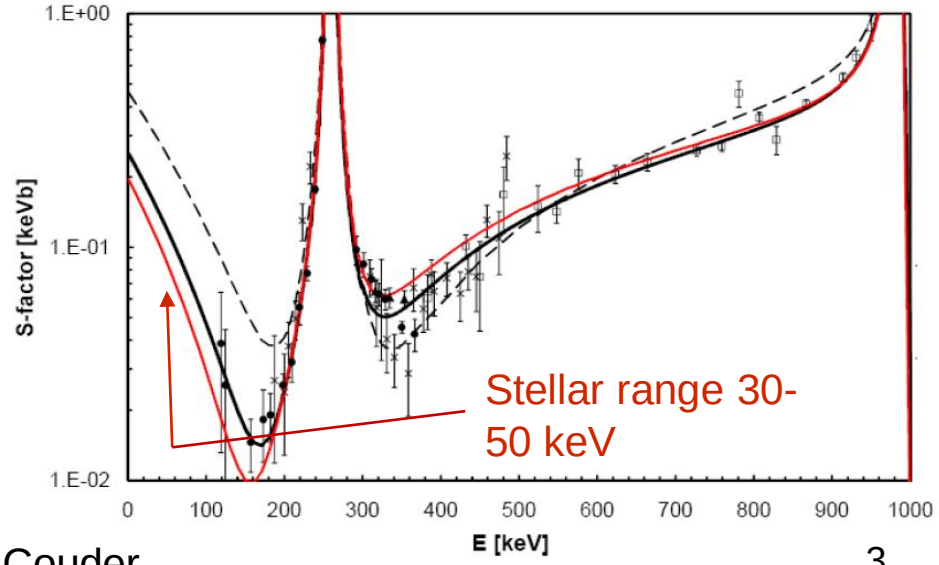
Solar Neutrino Sources
$^3He(\alpha,\gamma)^7Be$ (pp) and $^{14}N(p,\gamma)^{15}O$ (CNO)



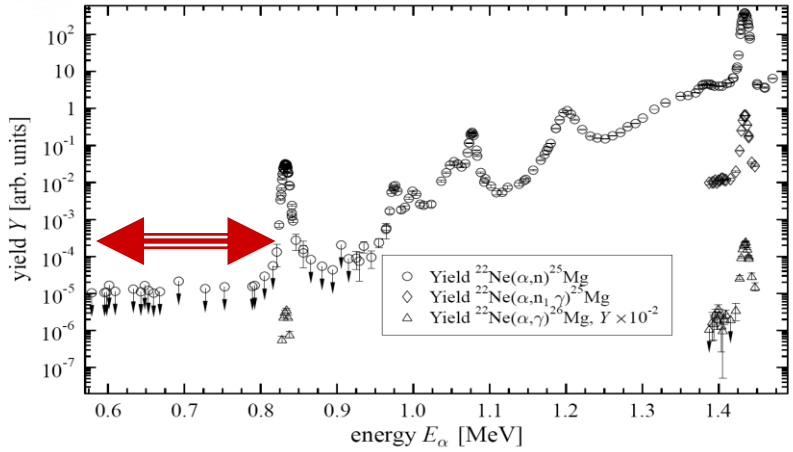


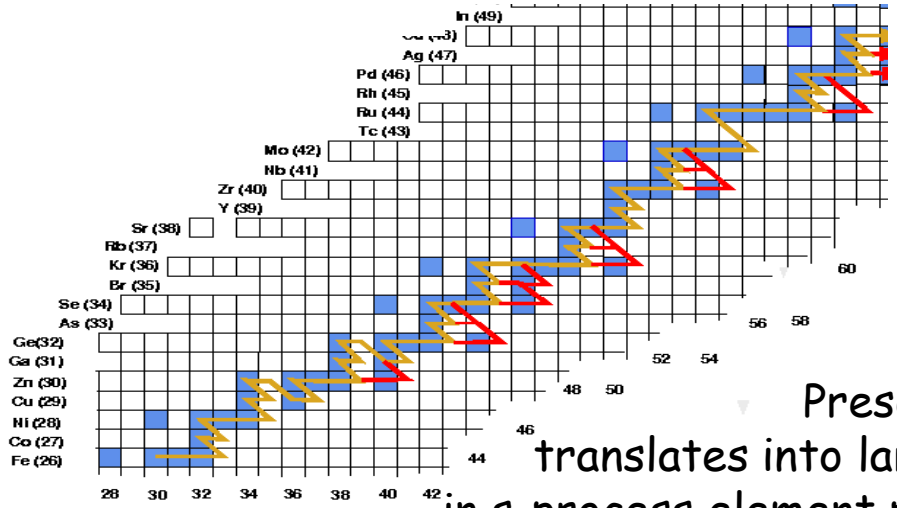
LUNA experiments are close to stellar energy range, theory based extrapolations suffer from model uncertainties.

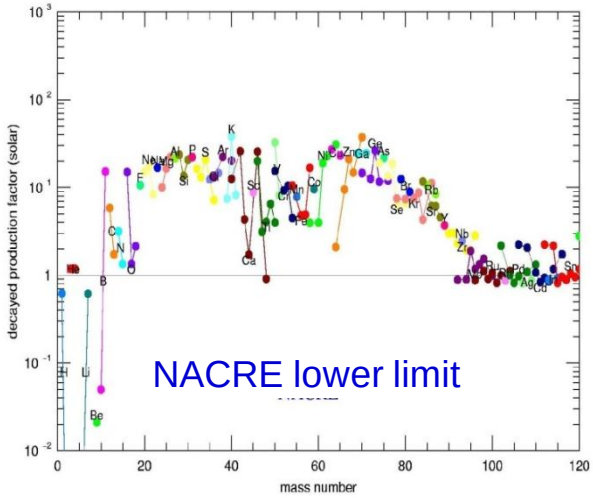
LUNA Measurements indicated already substantial deviations from earlier results and predictions!

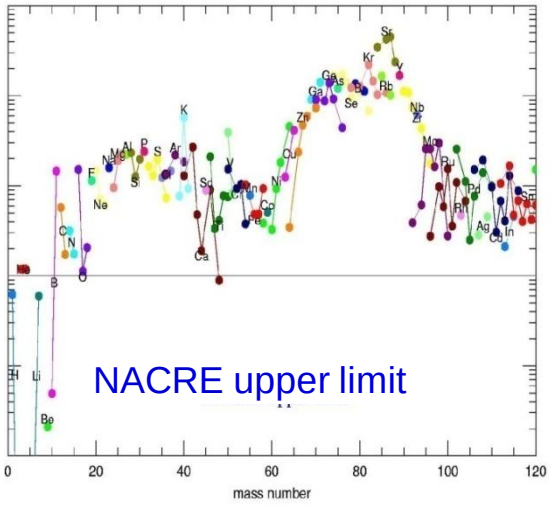


The $^{22}Ne(\alpha,n)$ neutron source





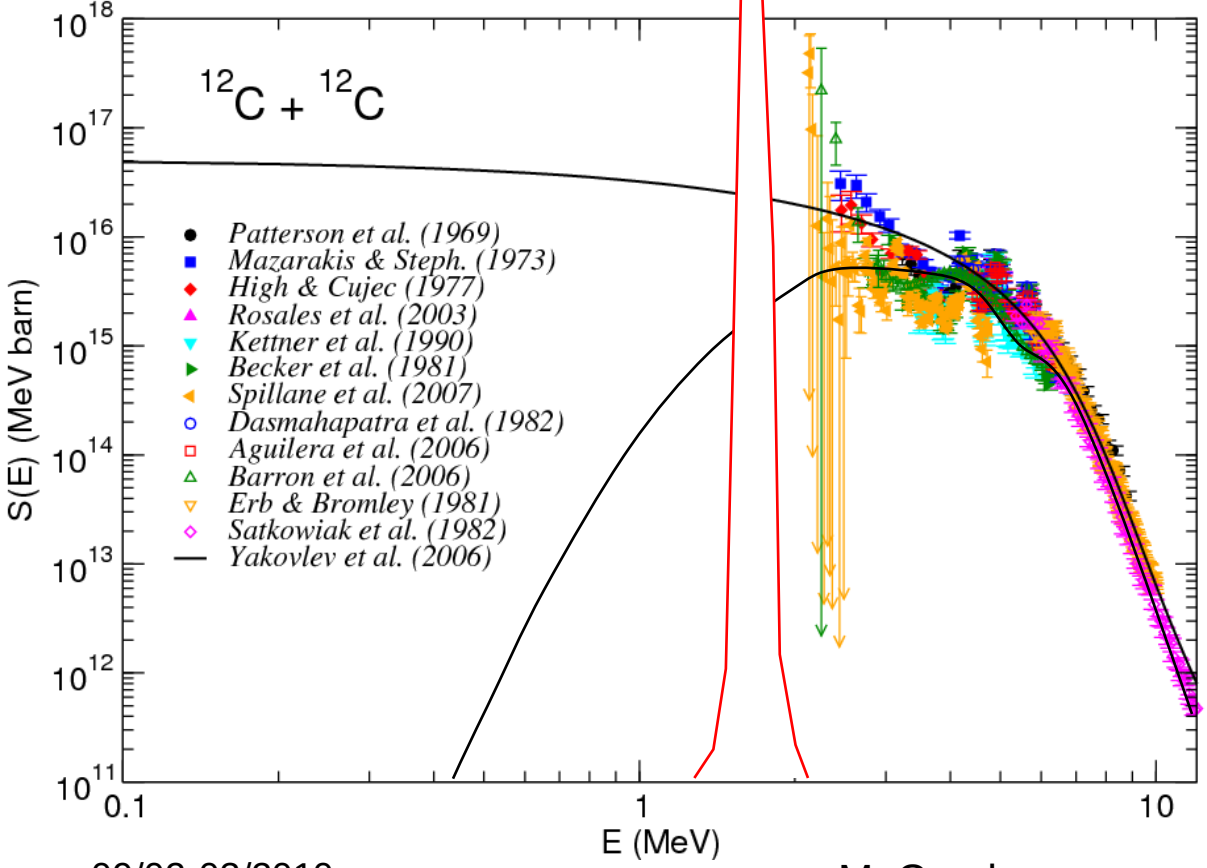


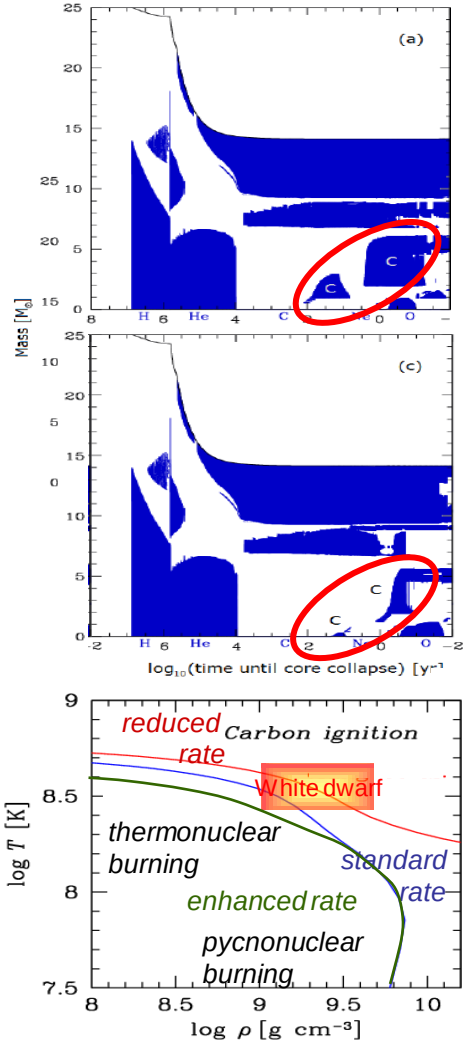


Present uncertainty translates into large uncertainty in s-process element production with broad consequences for explosive scenarios of nucleosynthesis such as p-process and r-process

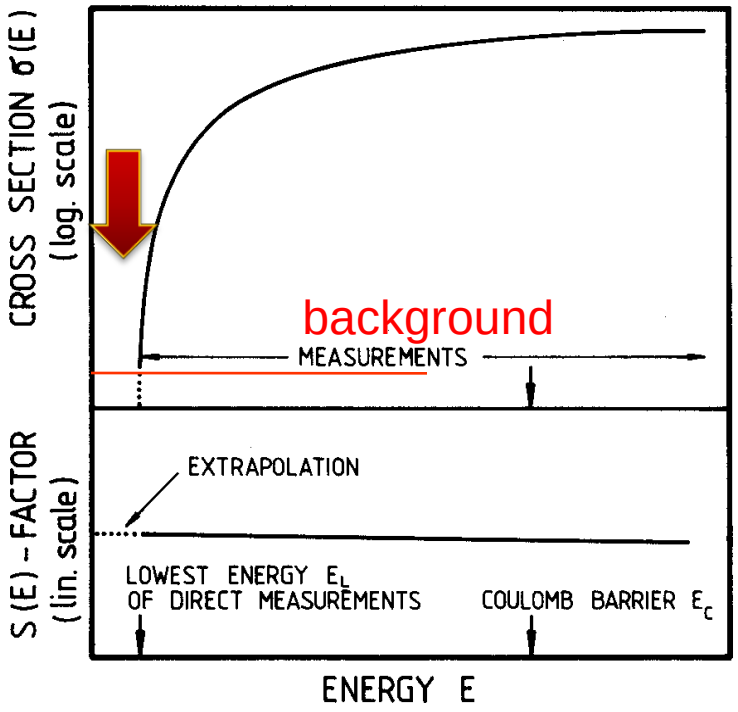
Low Energy Fusion Reactions

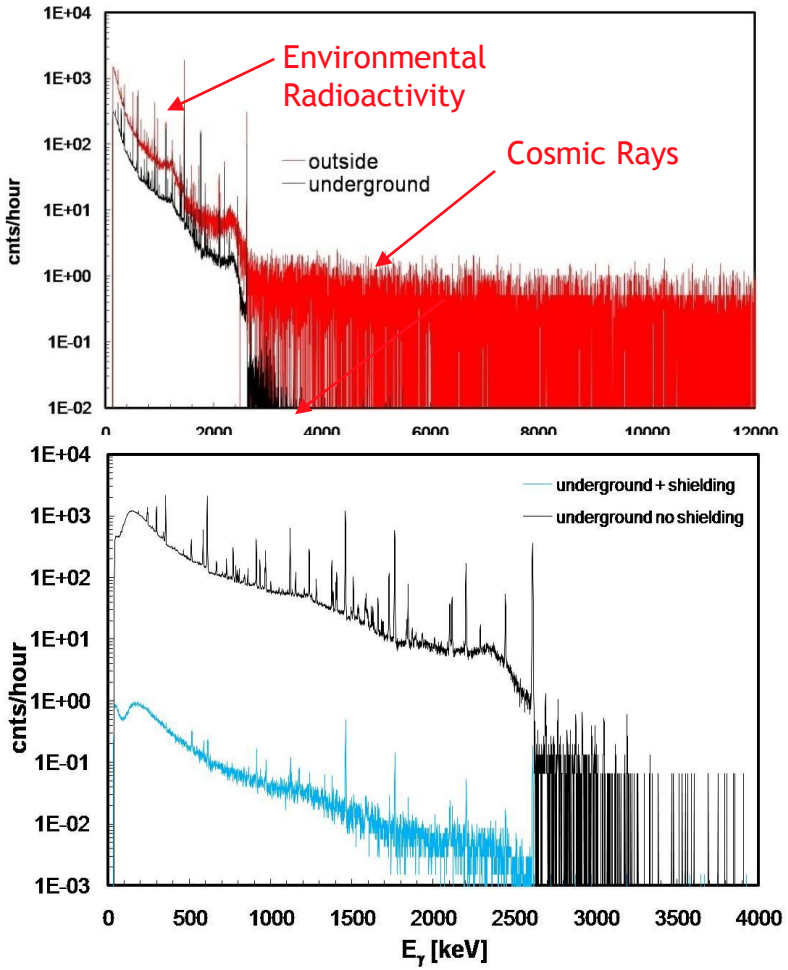
Late stellar evolution → disappearance of onion structure
Type Ia supernovae → ignition conditions
Superbursts → explosive carbon burning





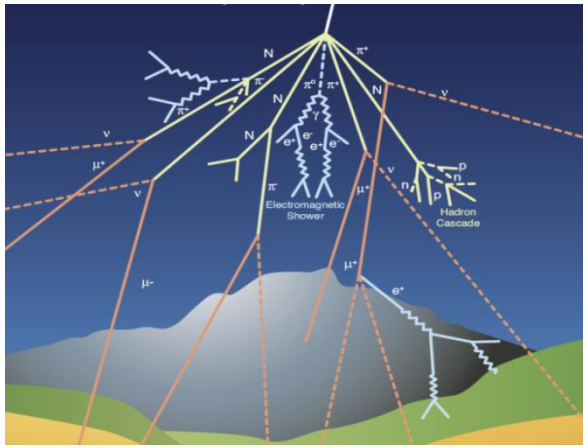
Why going underground?



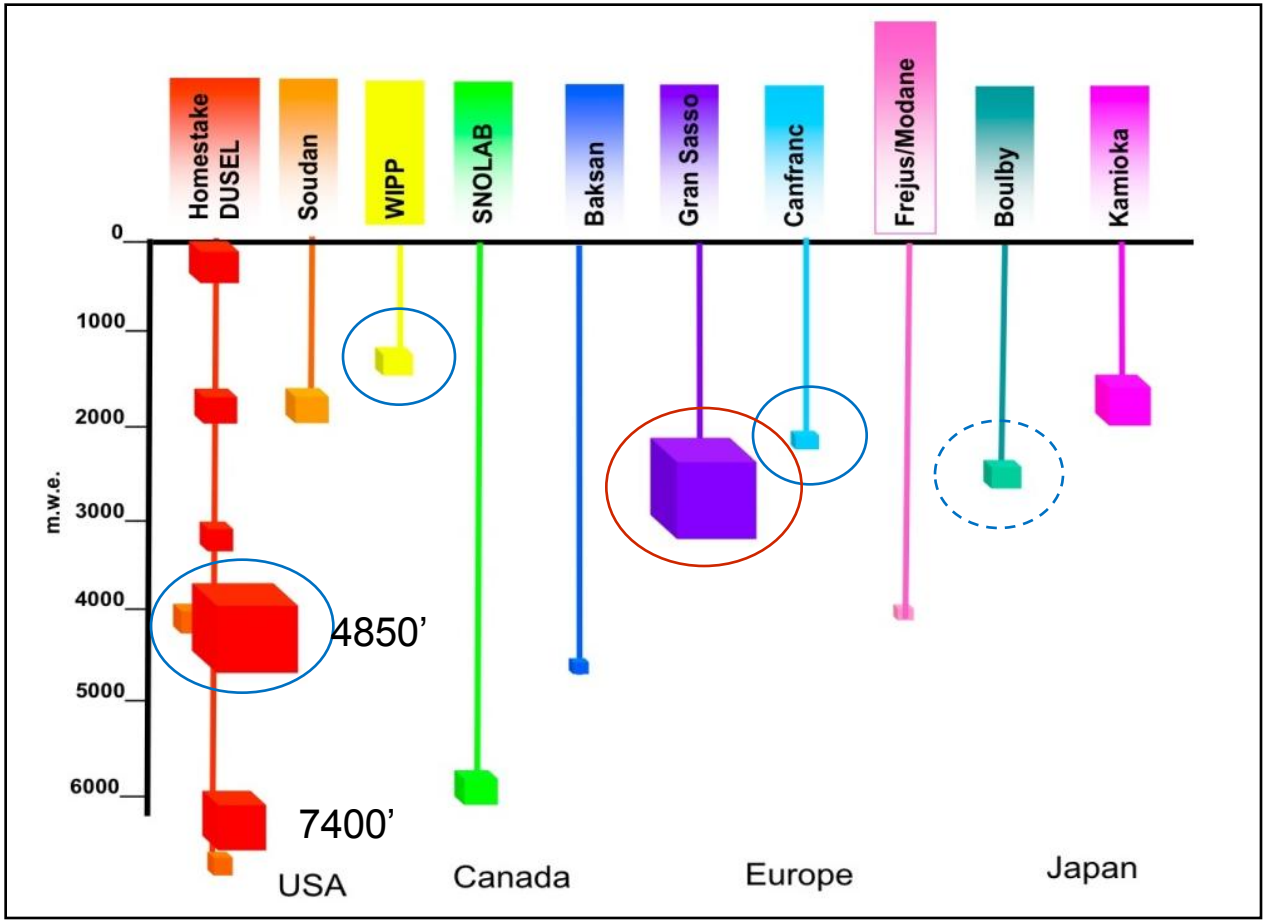


For low Q-value reaction: Local shielding (Pb) is more effective when the muon flux is reduced!

The International Situation



in the underground accelerator business



The DIANA Team

DIANA Collaboration:

Michael Wiescher (U. Notre Dame) PI
Matthaeus Leitner (LBNL) Project Manager
Adrian Hodgkinson (LBNL) Project Manager
Arthur Champagne (U. North Carolina)
Philippe Collon (U. Notre Dame)
Manoel Couder (U. Notre Dame)
Michael Famiano (West Michigan U.)
Frederick Gray (Regis U.)
Uwe Greife (Colorado School of Mines)
Christian Iliadis (U. North Carolina)
Daniela Leitner (LBNL)
Alberto Lemut (LBNL)
Edward Stech (U. Notre Dame)
Paul Vetter (LBNL)

Communication with LUNA & Canfranc
as well as Felsenkeller team in Dresden

New team members (since 2010):

Maria Luisa Aliotta (U. Edinburgh, UK)
Frank Strieder (RU Bochum, Germany)
Lucio Gialanella (Federico II Naples, Italy)
Gianluca Imbriani (Federico II Naples, Italy)

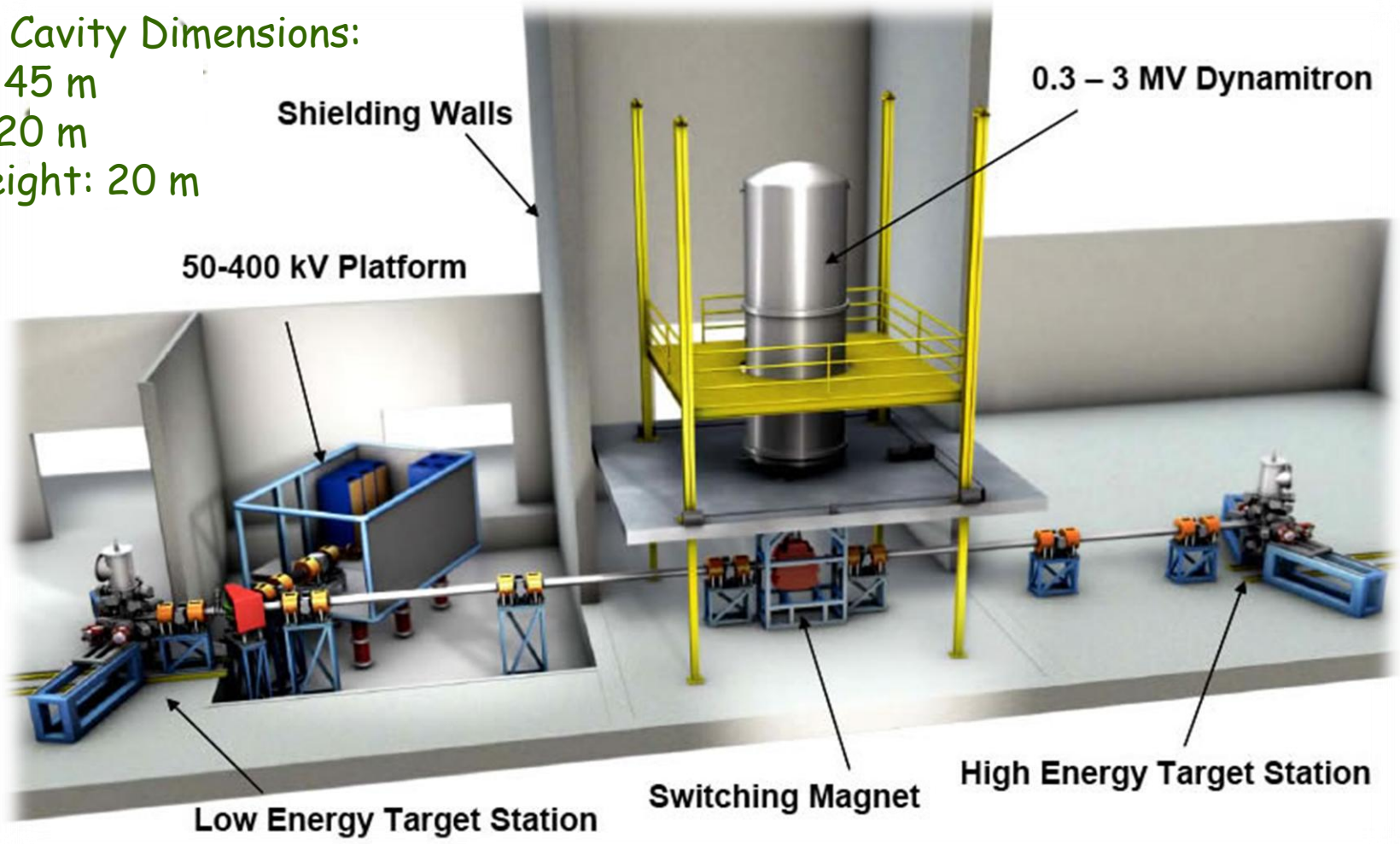
several graduate & undergraduate students
associated with the project

Technical Requirements to Reach Scientific Goals

- Coupled accelerator system for mapping reaction cross section over a wide energy range (different beam option)
- High beam currents are necessary to extend measurements towards Gamow window
- high power target capabilities (gas jet & solid targets)
- advanced detector design for active background rejection & event identification
- passive shielding for room background rejection & beam induced background shielding

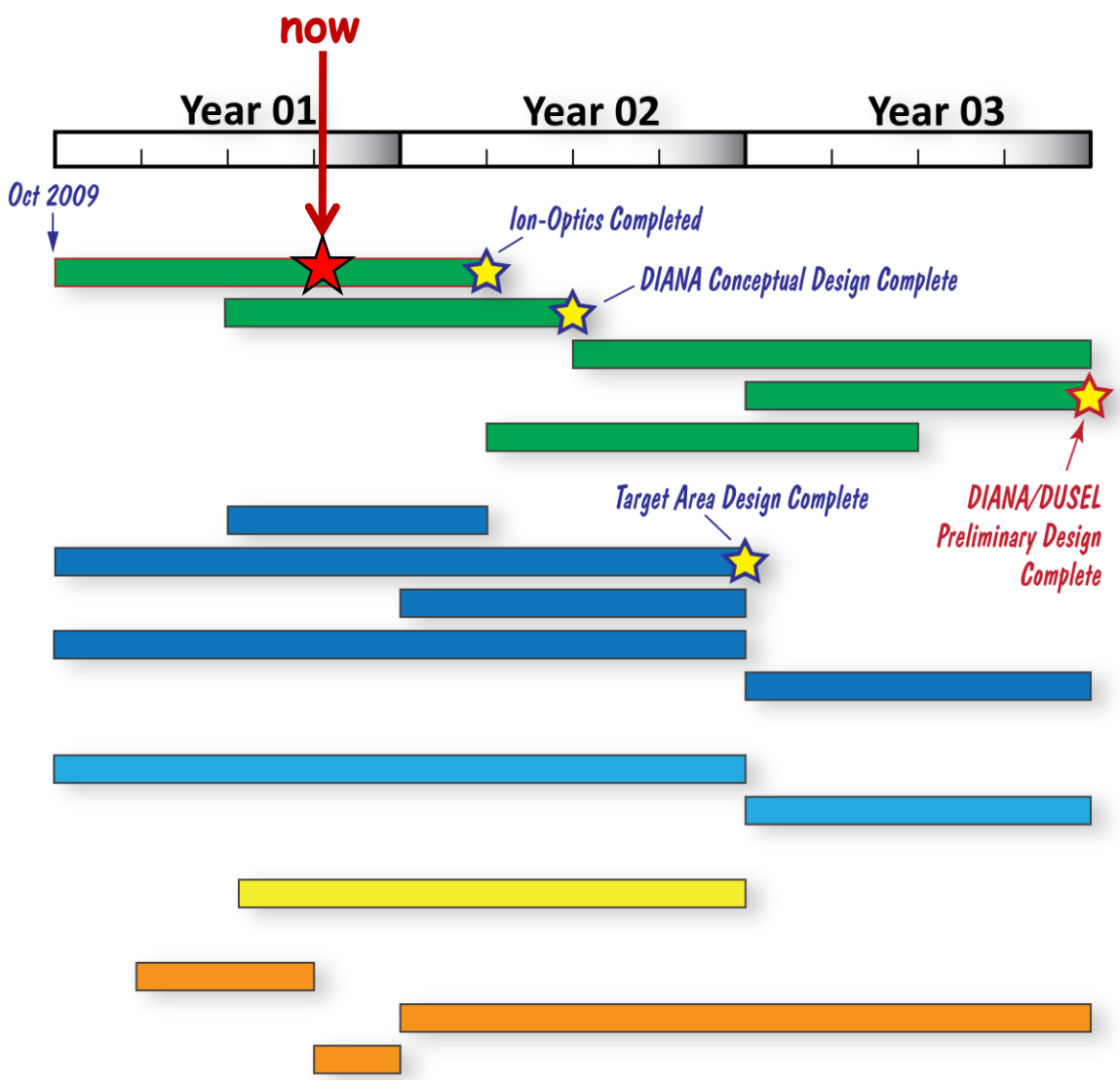
Laboratory Lay-Out

Approx. Cavity Dimensions:
Length: 45 m
Width: 20 m
Max. Height: 20 m



Schedule / Milestones 2010 & 2011

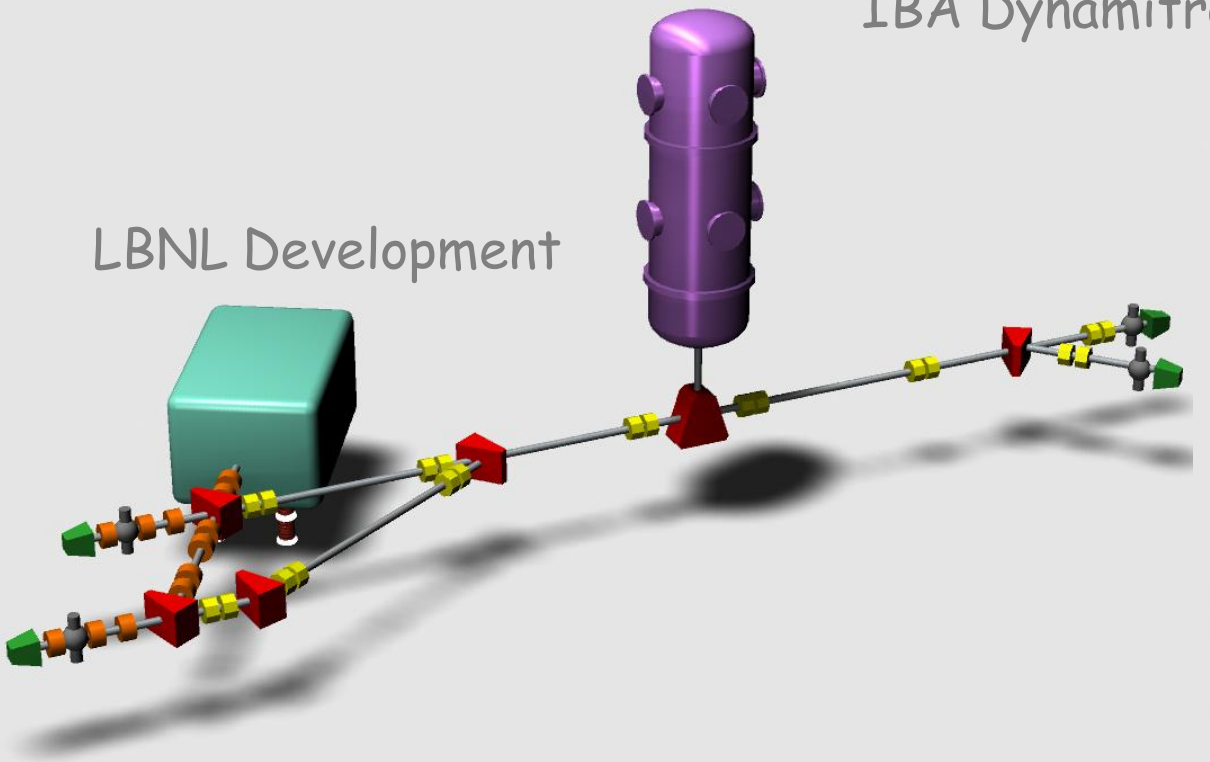
LBNL	Ion Optics Design
	Conceptual Design and Procurement Planning
	Preliminary Engineering Design
	Facility Integration
	Operations Planning and Safety Assessment
UND	Ion Optics Design
	Target Area and Gas Jet Design
	Gas Jet Experiments
	Neutron Detector Design and Experiments
	Final Design Documents
UNC	HPGe Detector Simulation and Design
	LXe Detector Evaluation
CSM	Gas Jet Design
WMU	Background Simulations
	Shielding Design Calculation Support
	Biological Effects Determination

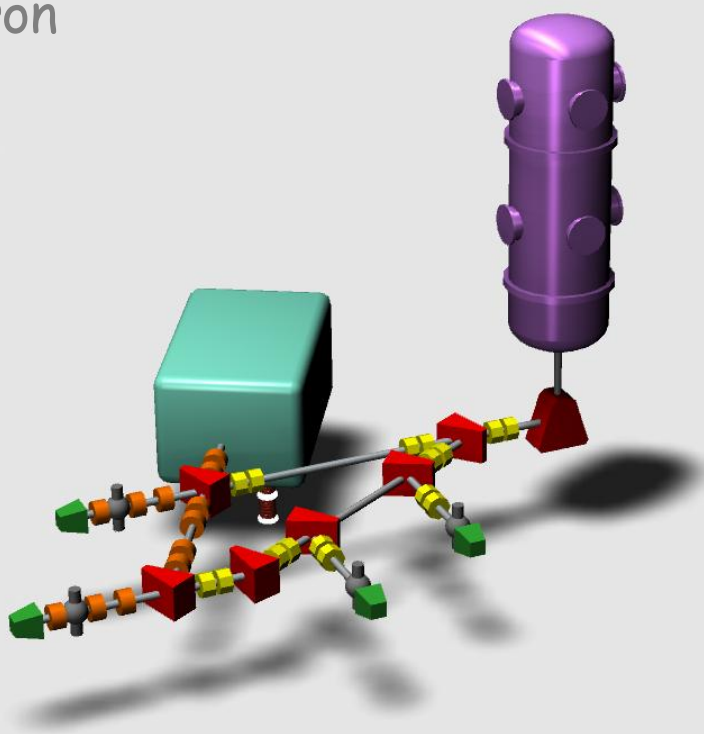


Present Focus on beam line optimization and beam optics

Presently in discussion with NEC Pelletron & IBA Dynamitron

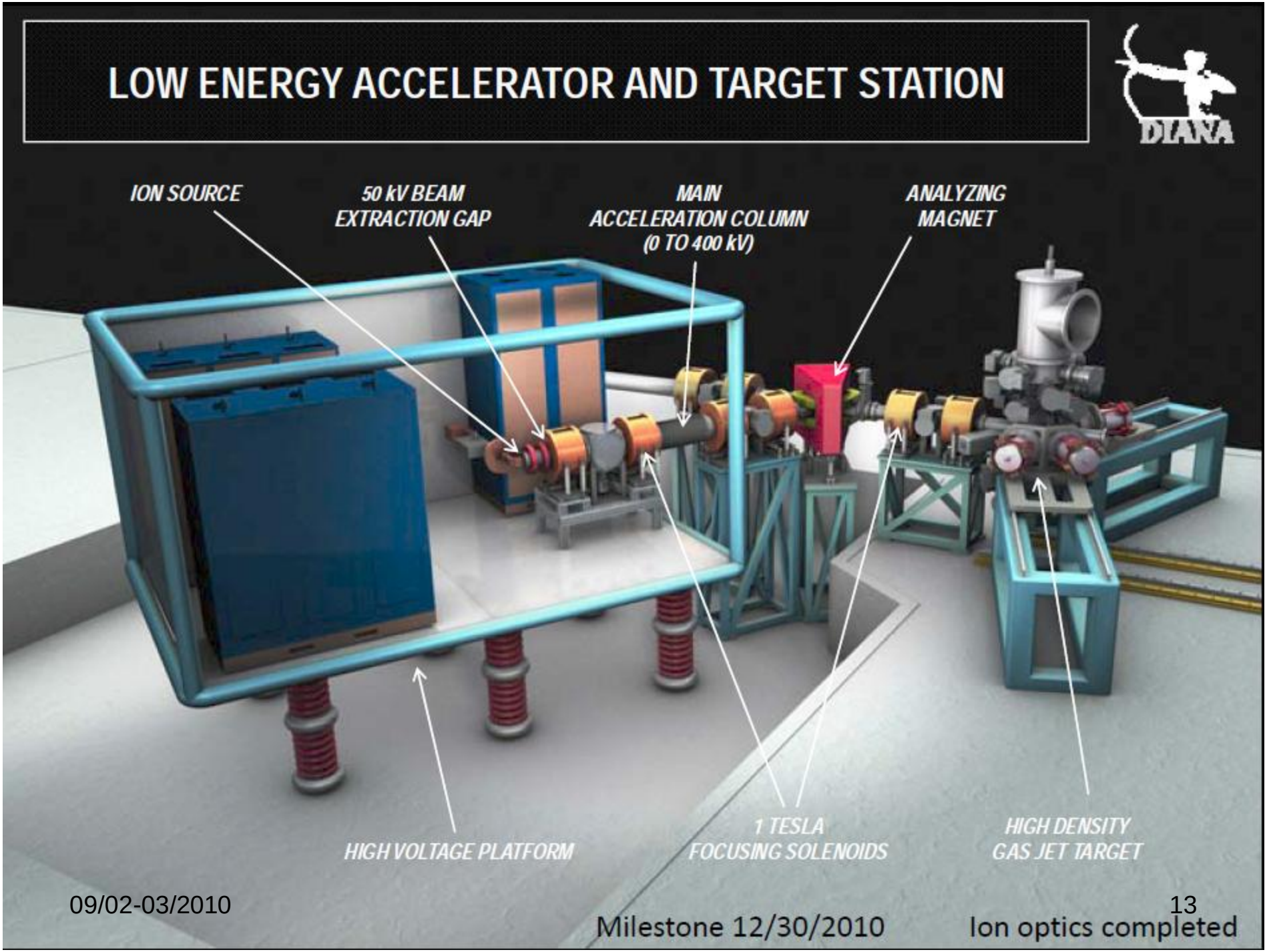
LBNL Development





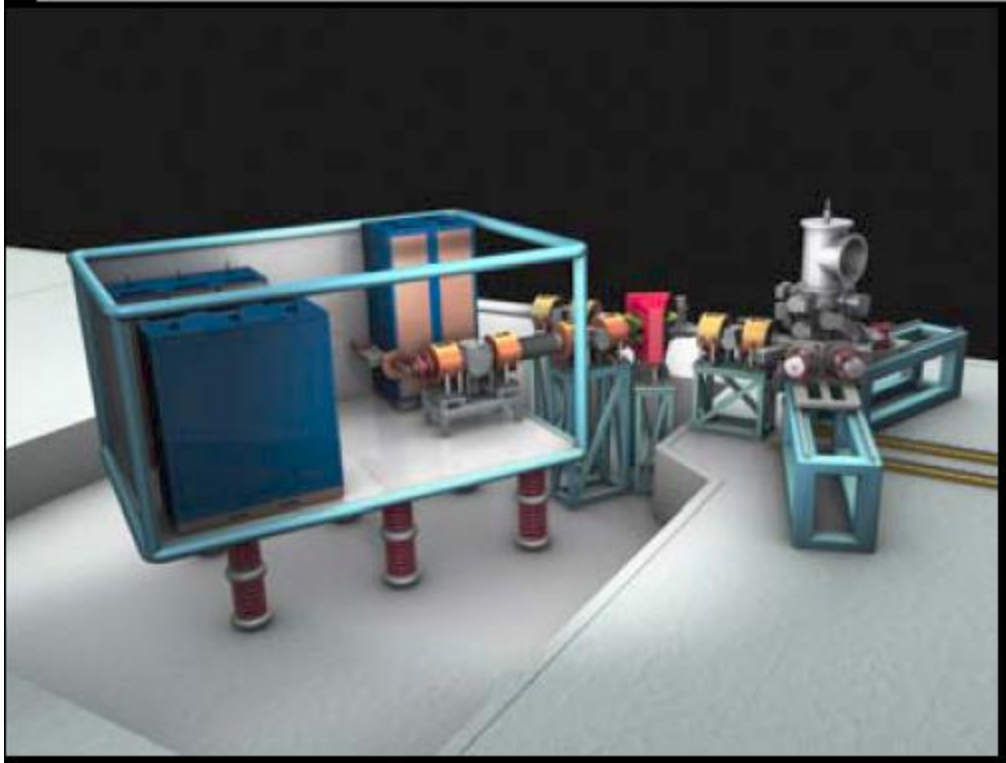
Compact design not feasible because of beam-optics conditions and space limitations for detectors & shielding

LOW ENERGY ACCELERATOR AND TARGET STATION



Milestone 12/30/2010 Ion optics completed

Low Energy Accelerator Challenges and R&D items



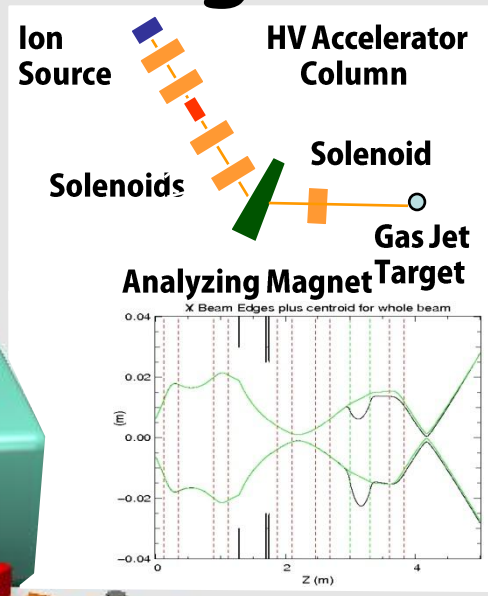
Unique Features

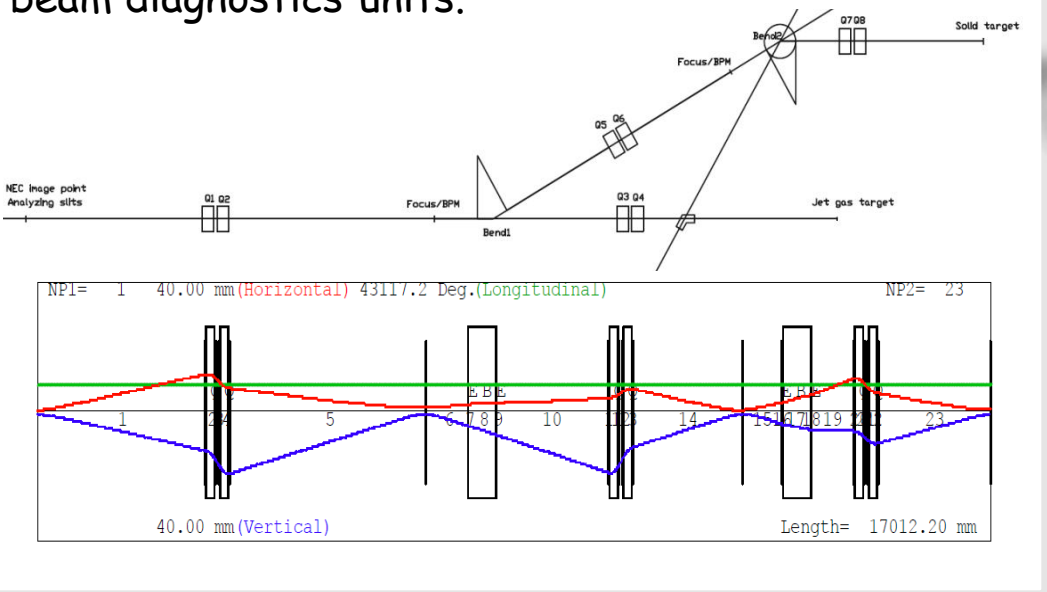
- open-air high voltage platform for easy access
- high intensity from 50kV-400kV (up to 100 mA proton and 20 mA helium beam)
- beam focus < 1 cm
- energy Distribution: +/- 0.05 % of beam energy
- unique high density jet gas target
- coupled target with the high energy accelerator

Up to 2 orders of magnitude higher beam current than presently available at state of the art facilities (to address the low count rates close to the Gamow window energies.)

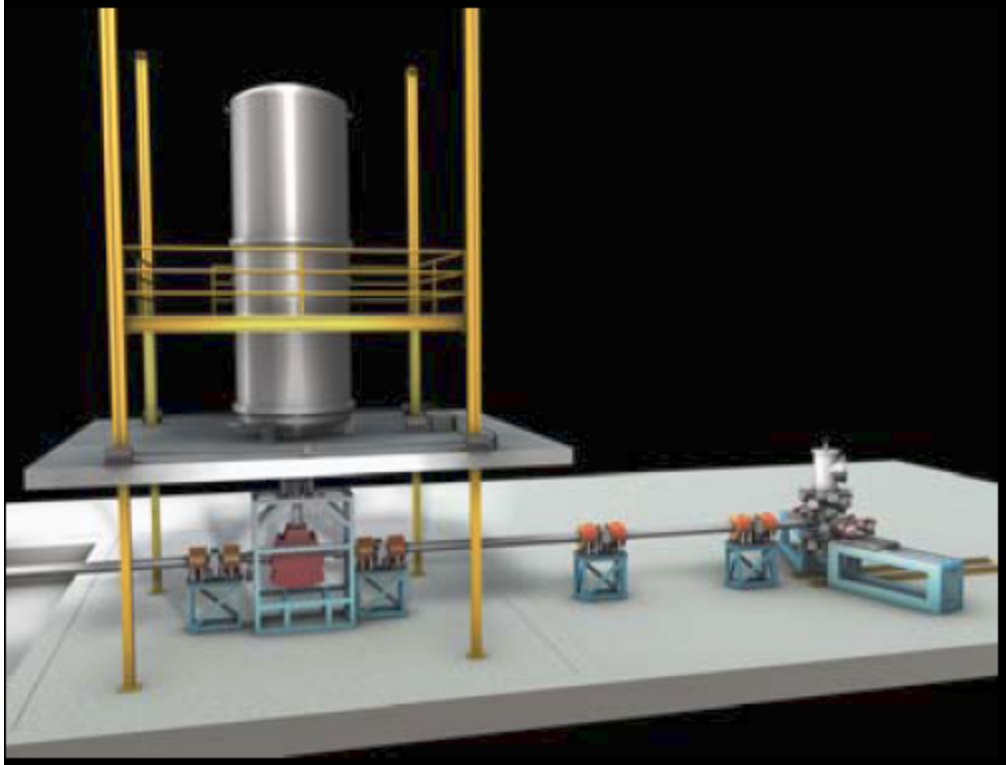
Beam optics design

Beam optics design has been successfully completed for both accelerators; present task is the identification of beam steering and focusing units as well as of beam diagnostics units.





High Energy Accelerator And Target Stations



Commercial accelerator with some unique features:

- High intensity from 350kV to 3MV (≥ 1mA)
- Coupled targets with the low energy accelerator
- 2 independent target station for simultaneous experiments and future expansion

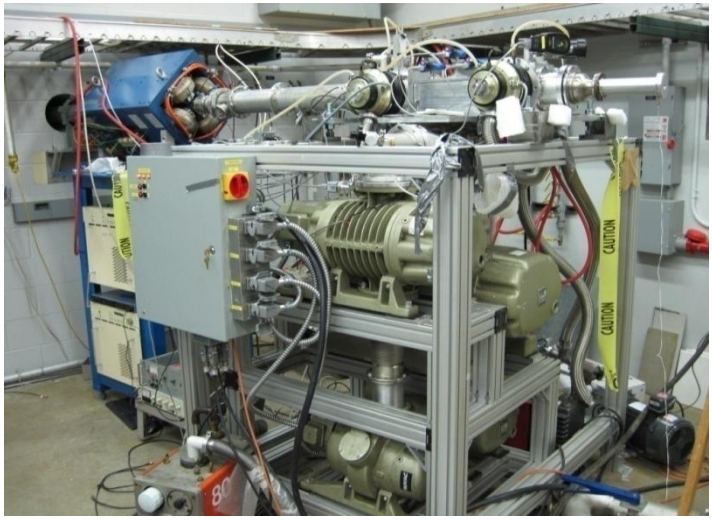
The high energy accelerator allows consistent measurements of resonant structures and expands the physics program to helium burning reactions and late stellar evolution reaction

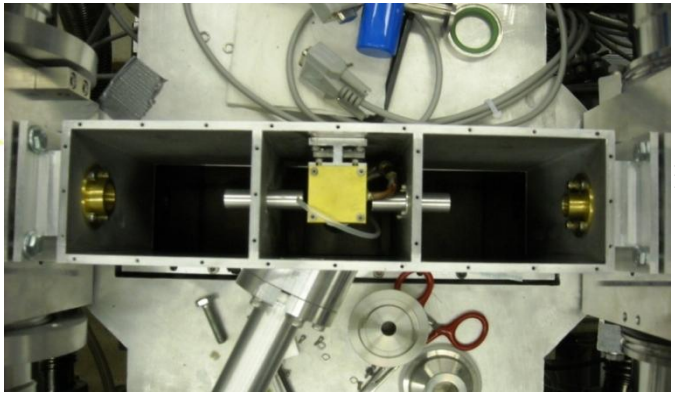
Equipment Development

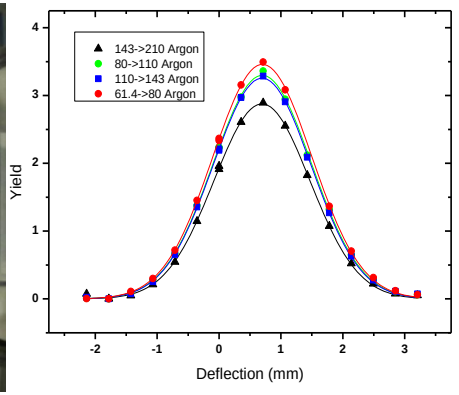
by university consortium

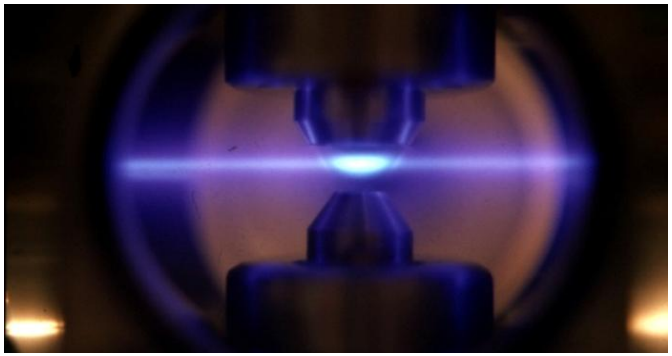
- Target systems
- Detector arrays
- Shielding

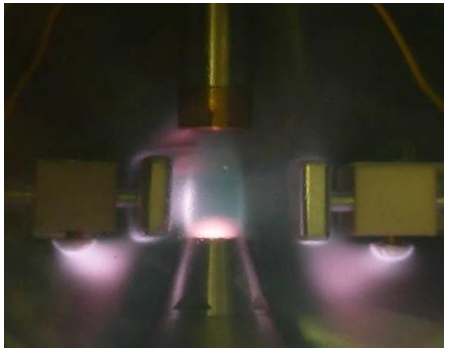
Jet Gas Target System



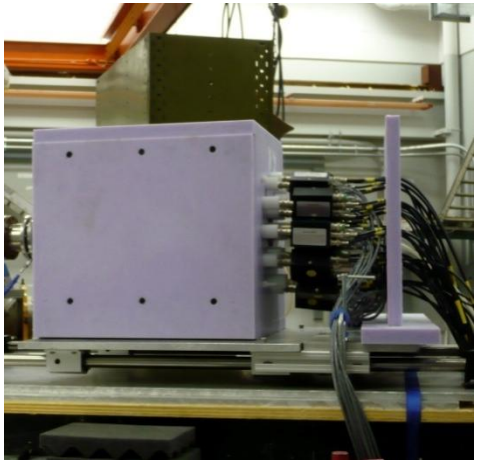


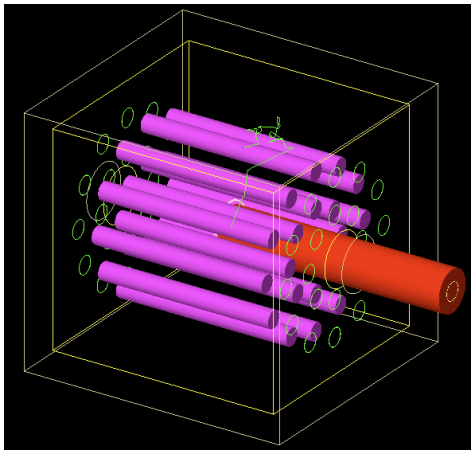




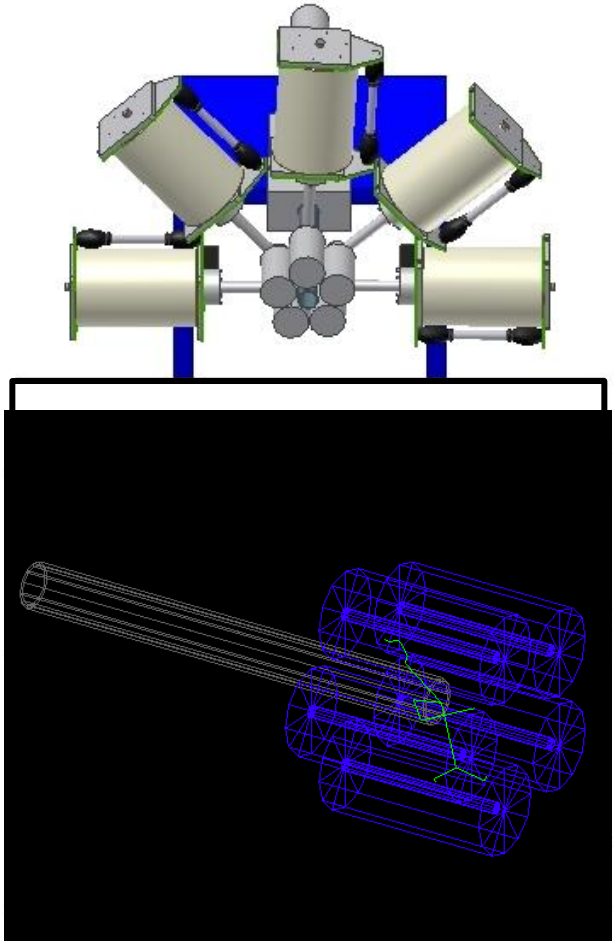


Neutron and Gamma Detectors

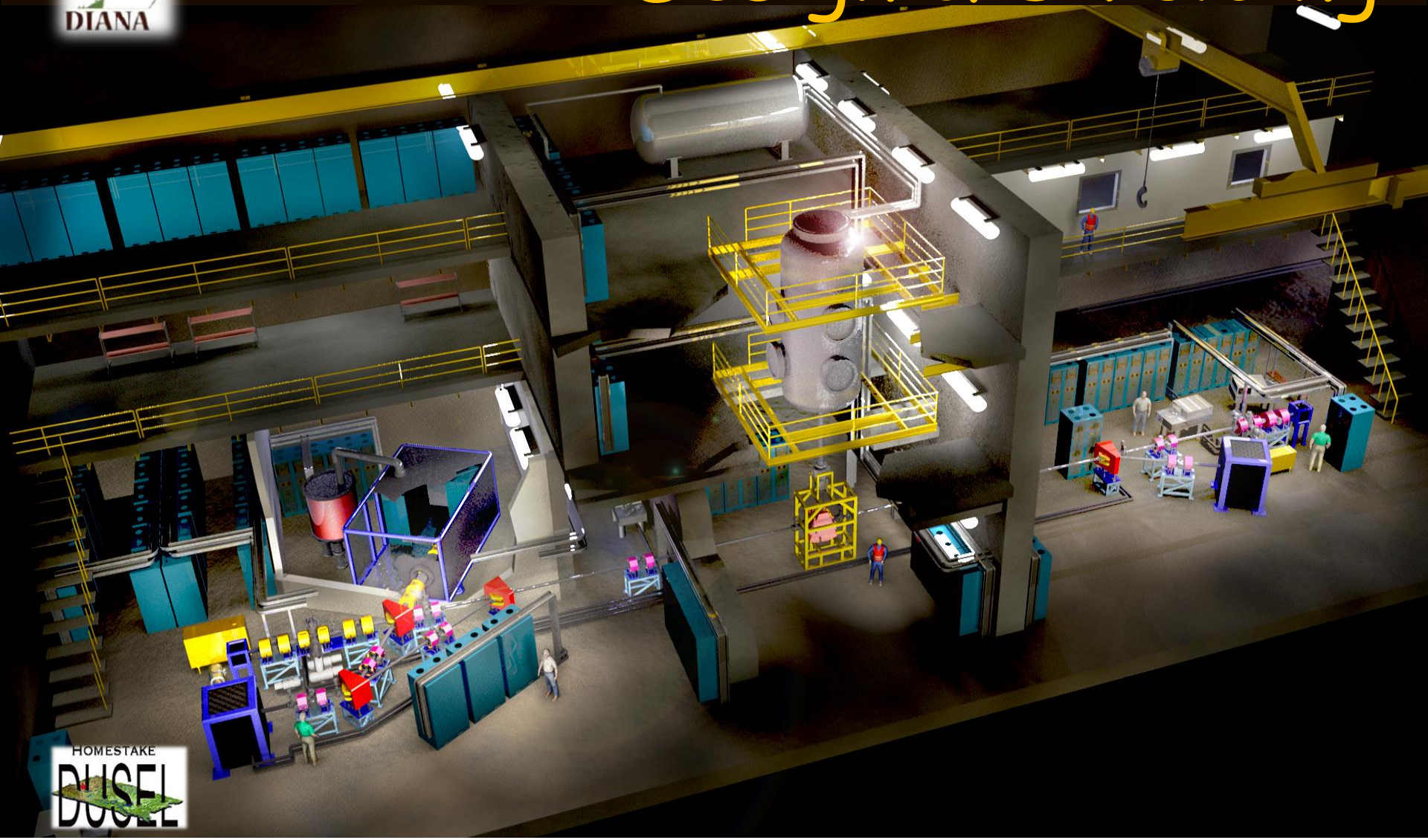




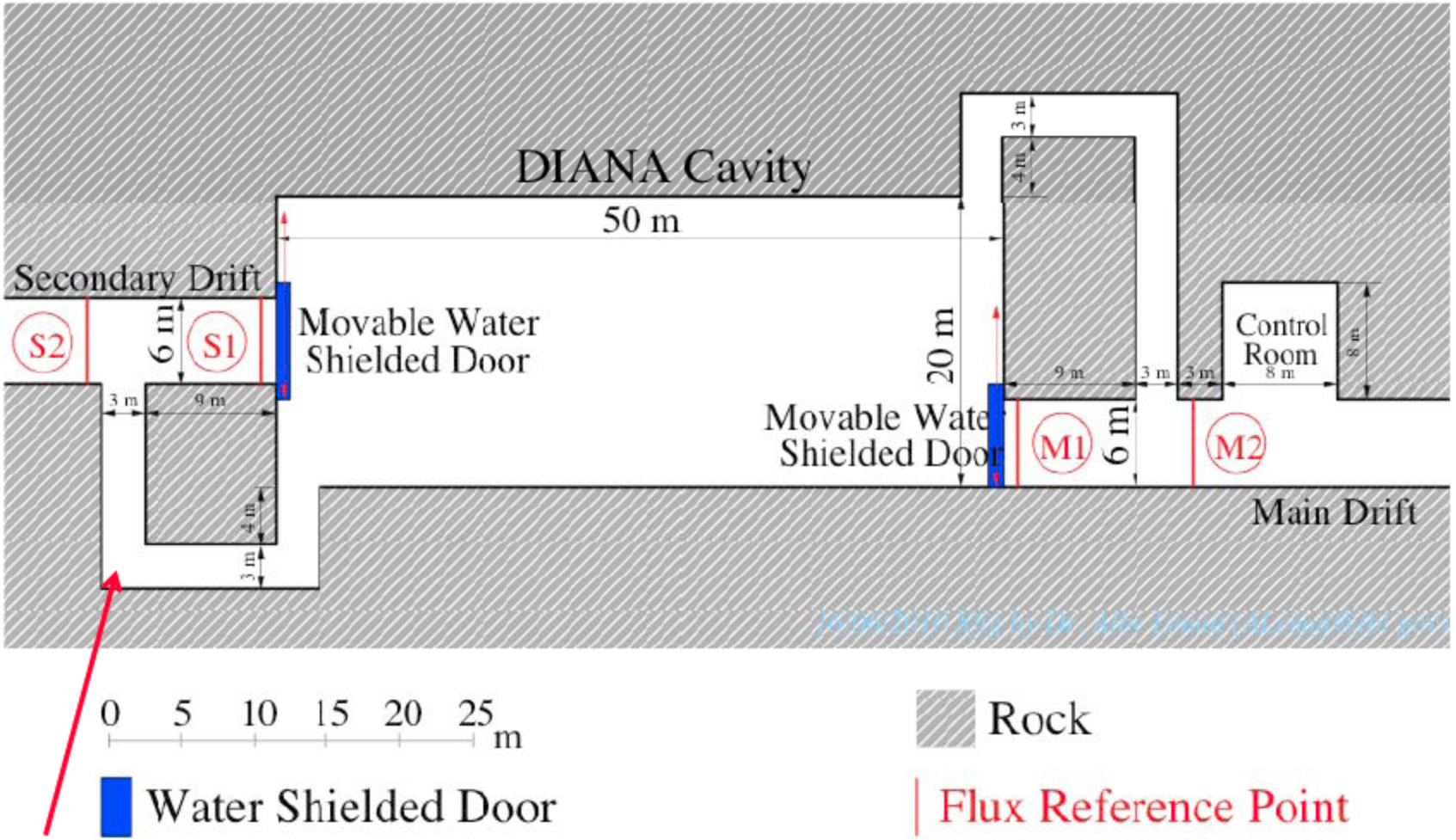
- Test design completed with ^{3}He tubes on loan.
- Several $^{18}O,^{26}Mg(\alpha,n)$ reactions measured for general performance and internal background test!
- Underground detector tests planned in fall 2010 for DUSEL, Gran Sasso, WIPP environment!
- Monte Carlo Simulation for Germanium detector arrangement and tracking design!



Design & Shielding



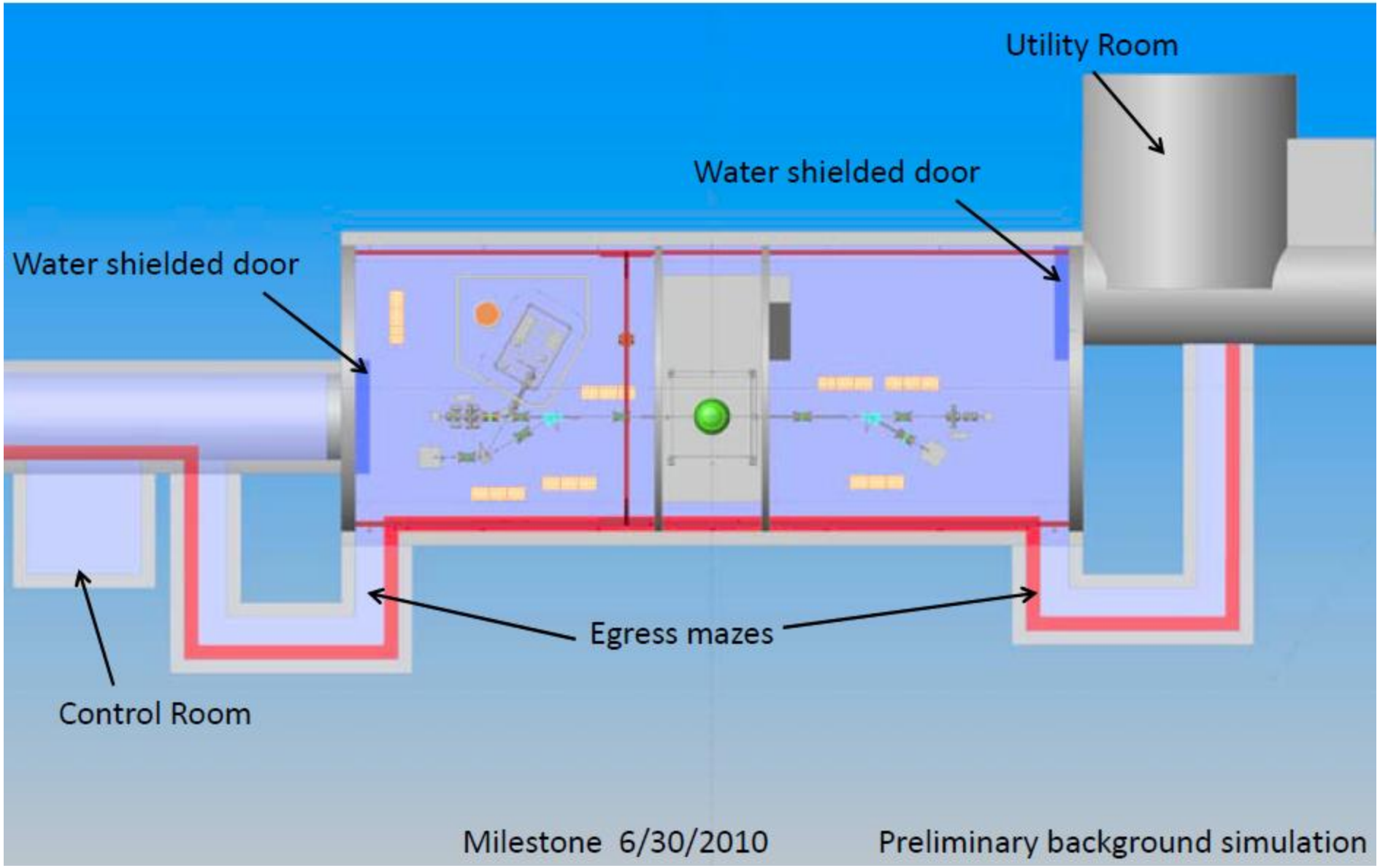
Shielding layout and flux reference points based on the preliminary design layout of Lab module 1



Entrance maze 3 × 3 m² (W × H, DIANA & DUSEL Defined)

No induced neutron field outside cavity (M2,S2)

Shielding layout and flux reference points based on the 60% PDR layout of Lab module 1



Milestone 6/30/2010

Preliminary background simulation

Summary

- Unique experimental facility, will ensure US leadership in this area (for the next 20 to 30 years)
- Next generation facility for low and high energy precision data needs
- Growing international interest & collaboration (invited talks at NIC2010 & INPC2010, 3 review papers in 2010)
- Technical progress is on track
- DIANA will be ready for installation in 2017 (as soon as Lab module becomes available)