Working group summaries

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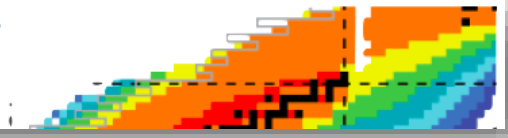
FRIB Users Organization

Facility for Rare Isotope Beams



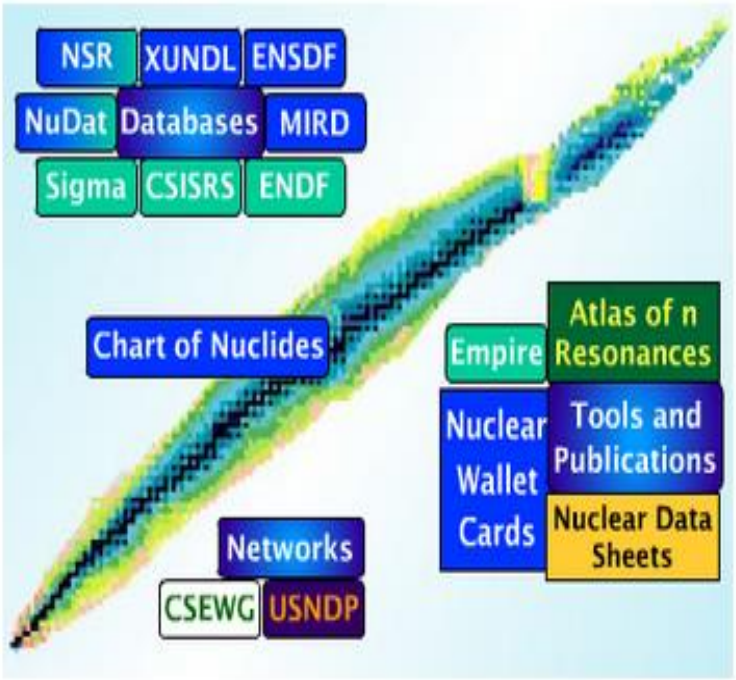
FRIB

Initial comments

- I attended 3 (of 11) working groups
- I will discuss pre-workshop meeting summaries…
- I will briefly discuss the output from each group
- Oversights are my own; process is more important than a summary talk
- Conclude with some observations

Summary statement of workshop on "Nuclear Data" (Wednesday/Thursday, August 10-11)

The US Nuclear Data Program is central to experiment and theory in basic nuclear science and nuclear astrophysics. Evaluated nuclear structure and reactions data represent the fundamental building blocks in these research areas and reliable, up-to-date and comprehensive databases of nuclear properties and bibliographical information are essential. It is important to maintain a high level of expertise and activity in the critical area of nuclear structure data evaluation.



Workshop on Nuclear Data Needs & Capabilities for Basic Science summary recommendations (B. Sherrill w/DJD edits)

- The USNDP must be maintained and improved
- Maintain a high level of expertise and activity in the critical area of nuclear structure data evaluation
- Continue the active role of the USNDP in research
- Expand USNDP scope to include more theory and nuclear astrophysics activities
- Community 'data management' plan for Nuclear Data
- Continue development of new tools and products
- Hold workshops for emerging issues (continuous data)
- Investigate the possibility to offer data-related pre-review of manuscripts
- Version controlled publication of ENSDF to allow reproducible citations
- Continue the effort to digitize and catalogue old graphical data and obscure publications

Tracking Detectors for Fast Beams Workshop

2016 Low-Energy Community Meeting
University of Notre Dame

Thursday, August 11, 2016

The workshop gave an comprehensive overview of the present detector technology for tracking/timing detector for fast beam, including performances, limitations, and challenges posed by future experiments in the FRIB era. It also discussed progress made with new concepts and most advanced detector developments, including micro-pattern gaseous detector structures, parallel-plate avalanche counter with optical readout, diamond-based particle detectors, fast fiber-scintillator based devices, micro-channel plates and pixelated (solid scintillator) radiation-hard detectors.

Summary statement of workshop on "Data Acquisition" (Thursday, August 11, 1:00-6:00pm)

The Data acquisition satellite workshop met to give the community a report on the activities of the working group and to collect community input on these topics. The program included:

- A report of a topical study on the experiment interfaces to the accelerator and beam line controls
- The launch of a topical study on time synchronization and global time distribution
- Presentations on software and hardware developments for data acquisition in the FRIB community:
  - Handling of increasing data volumes
  - Internal and external high speed network connections
  - Event file storage and computing resources
  - Common data analysis needs
  - Coordination with commercial vendors

There will be a workshop on data analysis in the FRIB era coordinated with the next LECM meeting.

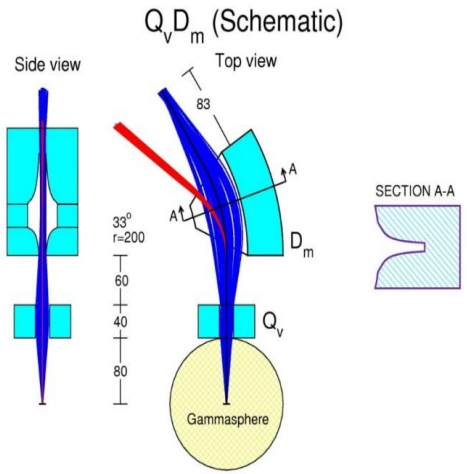
Summary statement of workshop on "ARUNA" (Thursday, August 11, 9:00am-12:00pm)

The ARUNA Laboratories (FSU, UK, UML, NDU, OU, TAMU, TUNL, and CENPA) are characterized by their independent research profile and a competitive program at their local accelerator facilities. These programs are complemented by an experimental and development program at national research initiatives, for example: ANASEN@NSCL/FRIB, CASPAR@SURF, HRS@NSCL/FRIB, LANSCE@LANL, MaJORANA@SURF, MR-ToF@ANL, NIF@LLNL, and SECAR@NSCL/FRIB.

Summary statement of workshop on "Spectrographs at ARUNA facilities" (Thursday, August 11, 1:00-3:00pm)

High-resolution magnetic spectrographs have enabled some of the precision methods of experimental nuclear science. With the scientific focus shift to exotic nuclei, unbound states and nuclear astrophysics requires new spectrograph experiments with updated ancillary detectors. The required experimental capabilities in the US were lost with the closure of the Yale-accelerator, but three ARUNA laboratories are in the process of refurbishing or reinstalling high-resolution magnetic spectrographs, TUNL, Notre Dame and FSU. The envisioned scientific programs aim at resonances in astrophysical nucleosynthesis, as well as the collective and exotic single-particle structure of nuclei.

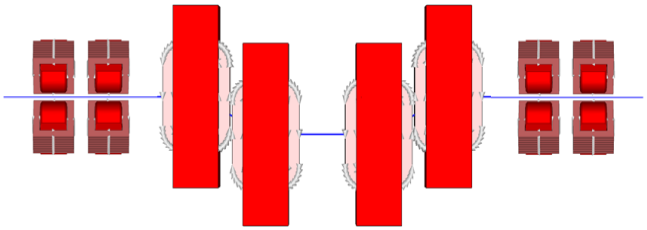
Workshops on experimental devices and collaborations:



AGFA: Argonne Gas-Filled Analyzer:

STATUS: Magnets and support stand being built, power supplies in procurement
COMPLETION: Spring 2017

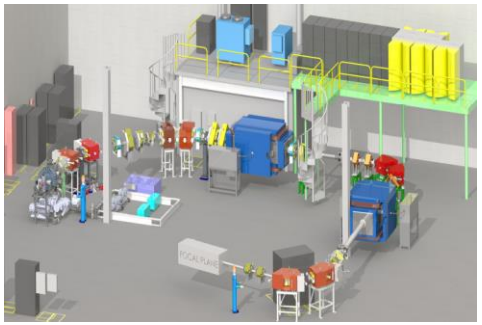
AIRIS: Argonne In-flight Radioactive Ion Separator



STATUS: Endorsed by NP community at May 2014 ATLAS Users meeting
PROJECT START: June 2016
COMPLETION: Spring 2018

SECAR: Separator for Capture Reactions

STATUS: On budget and on schedule to deliver SECAR by 2021 (FY2022 Q1) manage to early completion in 2020



Primary Beam Priorities

Beam	Bench-marks
Year One	
^{238}U	7, 10, 12, 15
^{48}Ca	2, 14
^{78}Kr	3, 8, 9, 16, 17
^{124}Xe	1, 11, 17
^{18}O	2, 8
^{86}Kr	1, 3, 4, 6, 14, 15
^{16}O	2, 8
^{36}Ar	8
Year Two	
^{82}Se	1, 3, 4, 5, 6, 13, 14, 15
^{92}Mo	1, 3, 9, 11, 16, 17
^{58}Ni	1, 3
^{22}Ne	2
^{64}Ni	1, 13, 14

- Primary beams estimated to be best to produce key rare isotopes in 17 benchmarks
- ^{86}Kr and ^{36}Ar used to demonstrate FRIB Project's Key Performance Parameters
- Beam power:
  - Year One – 10 kW
  - Year Two – 50 kW
- Secondary beams driven by scientific benchmarks
- Time scale:
  - Early completion in FY21
  - CD4 in FY22

Precision Measurements

Physics covered:

- Fundamental symmetries tests
- Nuclear Astro physics
- Nuclear structure

Experimental technique:

- decay station (SuN), tape station
- laser spectroscopy
- multi-pass time-of-flight mass spectrometry
- penning trap mass spectrometry
- beta-energy calorimeter
- beta-decay angular correlation
- laser trap
- Paul trap
- optical singe atom detection

Beams we want

- Xe and above, especially Fr
- light mass elements (Z = 3 ~ 18) from cyclotron stopper
- intense alkali/alkali earth beams (e.g. Ra) from solid target, etc.
- very exotic neutron- and proton- rich nuclei

Available Equipment at FRIB

- EUV spectrometer with NIST or Clemson Univ. (absolute charge radius)
- LEBIT/SIPTrap (mass measurement)
- BECOLA/CRIS (laser sepctroscopy)
- Decay spectroscopy station
- ORISS (mass measurements)

DAQ requirements?

Use individual DAQ system

Assignment from FRIB EC

Precision group

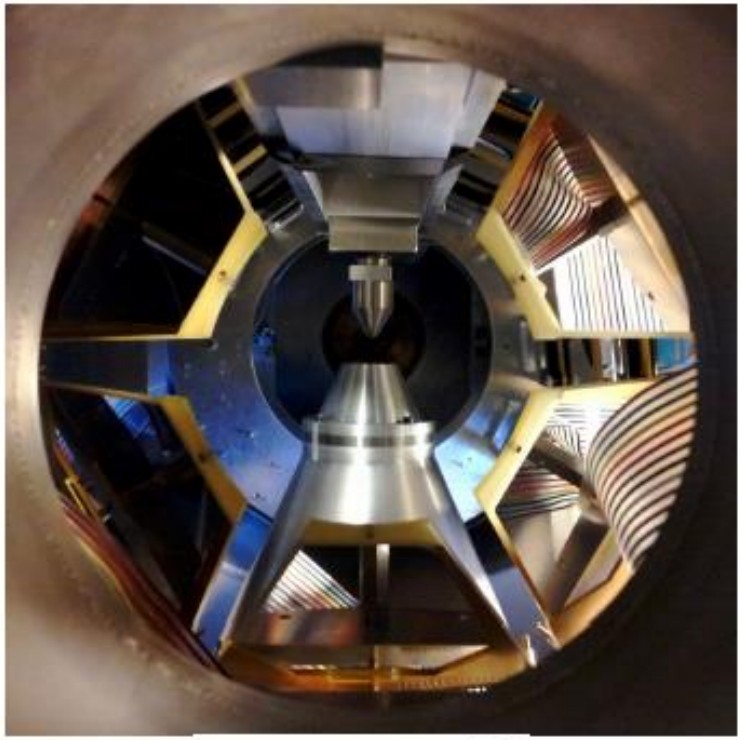
- high-priority rare isotopes that should be produced?
  - stopped beams?
    - Xe and above, especially Fr
    - light mass elements (Z = 3 ~ 18) from cyclotron stopper
    - intense alkali/alkali earth beams (e.g. Ra) from solid target, etc.
    - very exotic neutron- and proton- rich nuclei

- experimental equipment available for first experiments?
  - at FRIB (~2020)?
    - EUV spectrometer (with NIST or Clemson Univ.) (X-ray spectroscopy)
    - LEBIT/SIPTrap (mass)
    - BECOLA/CRIS (laser spectroscopy)
    - Decay spectroscopy station/system/traps
    - ORISS

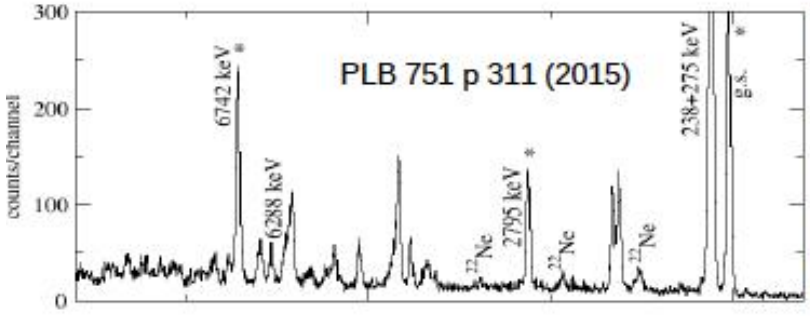
- other questions/concerns for the FRIB facility or other working groups?
  - General ion source for stable beams as reference beams for stopped experiments
  - Parallel running capability (fast/stopped/ReA3) using a He-gas jet, solid target or, some ion source
  - Purification of stopped beams; stable, molecular, radioactive isobar/isomer contaminant
  - More space for stopped beam experiments

Reacceleration

Gas Jets Working Group:



JENSA



GJWG Goals

→ Emphasize the continuing operation of JENSA in standalone mode (separate from SECAR) for astrophysics measurements

→ Possible operation of transfer with JENSA using SECAR as a recoil tag

→ Design and build a neutron array for (d,n) studies with a gas jet – world-unique

→ Design and build a gas jet for the ReA12 hall, to utilize higher energy reaccelerated beams (cf. ReA12 whitepaper), and perhaps operate with GRETINA/GRETA – also world-unique

→ Design and build gas jets for ARUNA laboratories (clean scattering/transfer/etc measurements for filling in knowledge gaps & fundamentals)

Gas Jets Working Group:

Priority Physics (at 10, 50, 100 kW)

(a,p)
(a,n)
(d,n)
(d,p)
(^{3}He,d)
(p,a)

Priority Beams (at 10, 50, 100 kW)

^{30}P
^{25}Al
^{18}F
^{26}Si
^{56,57}Ni (^{59}Cu?)
Se, Ge, Kr
Sn, Te, Xe
stable C, N, O, Ne, Mg, Cl, S, Si...
^{15}O (with SECAR)

Priority (Planned) Equipment (at 10, 50,100 kW)

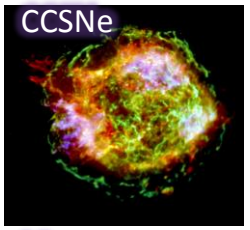
- JENSA upgrades: cryogenic chiller, new target chambers
- Neutron array for (d,n) with JENSA
- Gas jet for ReA12
- Gas jet with capability to run with GRETINA/GRETA

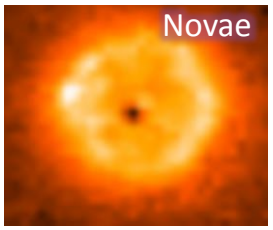
Beam property/DAQ requirements?

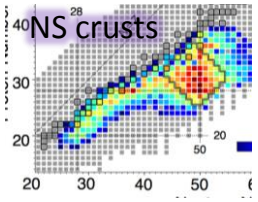
- "pencil" beams
- 1-2mm beamspot
- pulsed (~few ns) for neutron measurements, or near-DC beam for capture/transfer
- beam intensities >10^4 pps
- purities >60% (needs to be better at higher intensities)
- DAQ/controls as-is

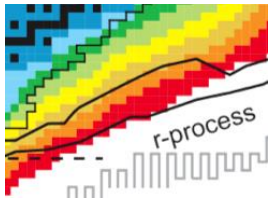
Astrophysics Working Group Summary

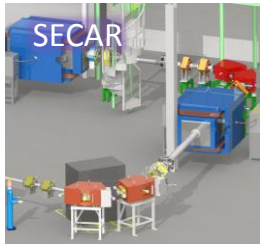
- Exciting, Broad, Robust Day One Science Program in Astrophysics
  - diverse topics include CCSNe, SNIa, Novae, XRBs, NS Mergers, Pop III stars
  - covering rp– , r– , αp–, νp–, hot CNO, hot pp processes
- Broad Range of measurement types
  - capture, transfer, (α,p), decay, masses, charge exchange, total cross sections, TAS, LI fusion, HI collisions, HI fusion for EOS, fission …
- Diverse set of beams
  - ReA3 beams – ^{30}P, ^{18}F, ^{22}Mg, ^{26}Si, ^{30}S, ^{56}Ni, ^{59}Cu, ^{34}Ar, ^{38}K; ^{8}B, ^{9}C, ^{13}O, ^{14}O
  - ReA6 – ReA12 beams – ^{30}P, ^{38}K, ^{59}Cu, ^{61}Ga, ^{65}As; ^{81}Ni, ^{76}Cu, ^{78}Zn, ^{80}Ga, ^{86,88}As, ^{131}Cd, $^{133-137}$Sn, ^{137}Te
  - Fast beams – ^{31}F, ^{125}Tc, ^{132}Sn, ^{19}C, ^{28}Ne
  - Stopped beams – near N=82 and N=126, Uranium
  - Stable beams (for commissioning) – ^{20}Ne, ^{15}N, ^{21}Ne, Ti, Ni, Al, Mg
- Wide range of intensities
  - capture 10^7 pps, transfer & chargex 10^5 pps, fusion 10^3 pps, decay << 10^2 pps

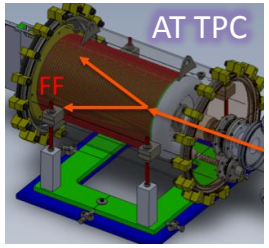


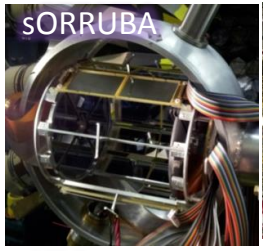


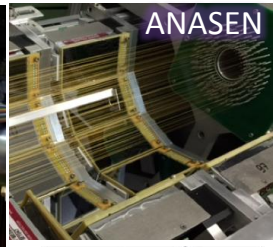


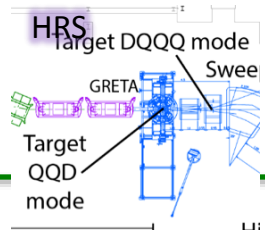


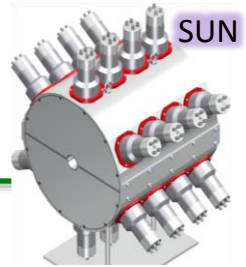






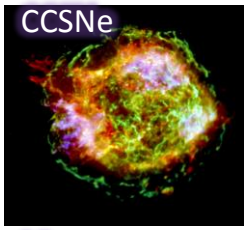


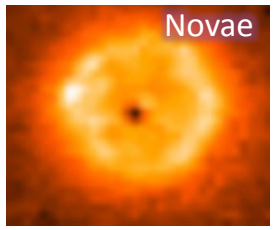


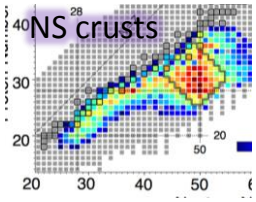


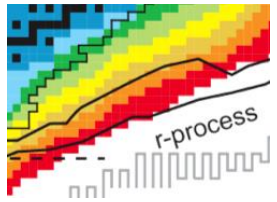
Astrophysics Working Group Summary

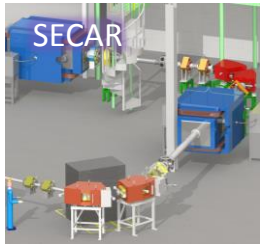
- Wide range of experimental stations in all FRIB halls
  - SECAR, JENSA, HRS , ISLA, HELIOS, GRETINA/GRETA, AT TPC, HR AT TPC ANASEN, S800, DECAY STATION, SUN, MUSIC
- Numerous facility requirements
  - suite of intense >10^5-10^6 pps ReA3 beams with gas and solid stopper
  - beam purification methods; long-pulse beam time structure
  - small beam widths < 3 mm; use ^{64}Zn primary beam for ^{59}Cu ReA3 beam
  - DAQ: unified, digital, > 1000 channels
- Other requirements
  - H_2, ^{3}He operations in JENSA
  - dispersion matched HRS with long flight path, precise 0.4 mm positions, <30 ps time resolution
  - GRETA with auxilary detectors; fast detectors for high contamination
  - …

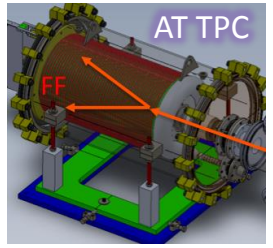


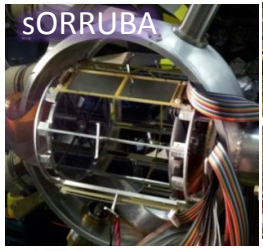


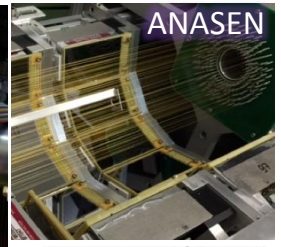


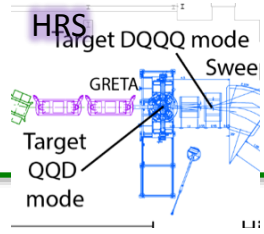


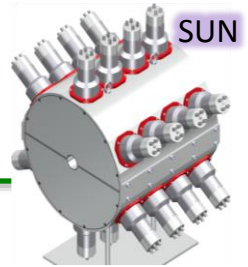












ReA energy upgrade + ISLA ReA12 recoil separator joint WG session

ReA3 update

- Performance (efficiency) has been tested and improved for the gas cell, the beam cooler buncher, EBIT, and accelerator & transport, ensuring efficient and reliable operation.
- Cyclotron stopper and advanced cryogenic gas stopper are being developed and tests are planned.
- EBIT timing structure has been improved with slow extraction for broad pulse widths (up to 100~200 ms).

From recent experiment with ANASEN at ReA3

- Recent experiment with the 4.5AMeV ^{47}K beam (~20kpps) was successfully performed. No issue for timing structure due to the EBIT improvement.

ISLA update

- Magnet mechanical design, possible layout with a swinger, and coupling to GRETA are under consideration.
- Aberration analysis was made for homogeneous dipoles and will be performed with realistic field based on preliminary magnet designs.

ReA energy upgrade + ISLA ReA12 recoil separator joint WG session

Solenoidal spectrometer

- Highly versatile device for direct reaction studies with an option to combine with other systems (Apollo, gas target, ion chamber, etc)
- 4T solenoid available at ANL for possible use at ReAx
- Requirements for beam spot size, energy, and time resolution/period are discussed.
- Scope of the project including the coupling with AT-TPC as well as fast-beam measurements with a solenoidal spectrometer will be discussed and defined before LECM2017.

Updates on target activities

- Center for Accelerator Target Science (CATS) is being proposed to request additional personnel (postdoc with nuclear chemistry background) and more time for new research directions and community outreach (target requests).

Considerations of pre conceptual layout of ReA6-12

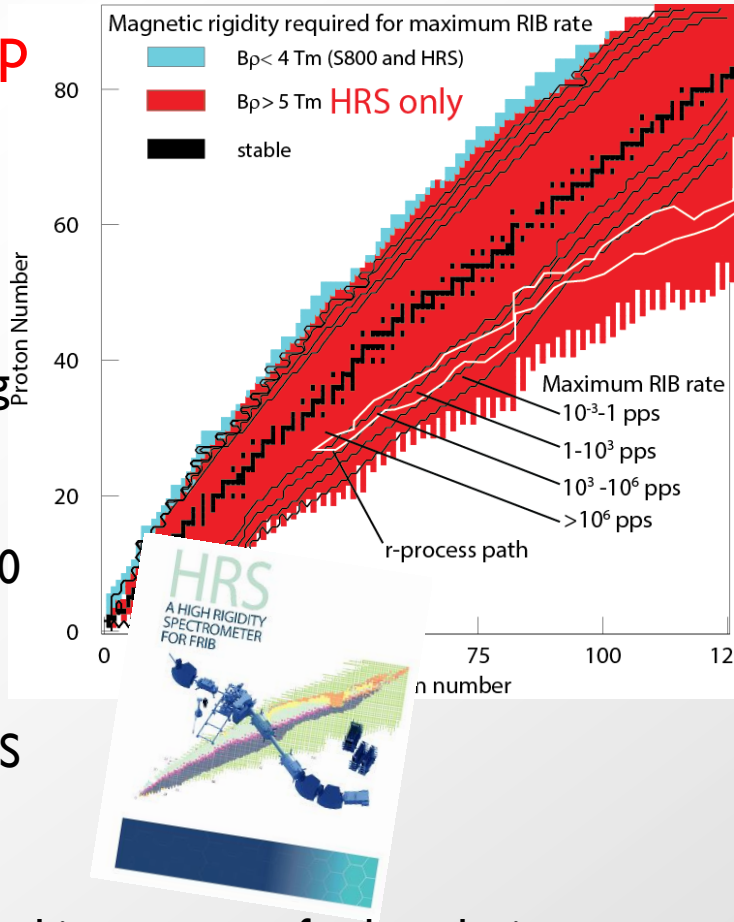
- Pre-conceptual layout will be brushed up. Input from users is welcome for possible plans and ideas for new equipment and measurements.

A High Rigidity Spectrometer for FRIB

hrs.lbl.gov

HRS working group

- The HRS will increase the luminosity for experiments with fast rare-isotope beams for the vast majority of nuclei available at FRIB – gain factors of 10 or more for the most neutron-rich nuclei
- The HRS will impact science associated with all overarching scientific themes of FRIB
- HRS will not be immediately available at FRIB – great opportunities for early-FRIB science will exist with the S800 spectrograph or sweeper magnet
- Pre-conceptual layout in progress: meet the stringent requirements for the science program presented in the HRS whitepaper (Support from by DOE Office of Science, Nuclear Physics)

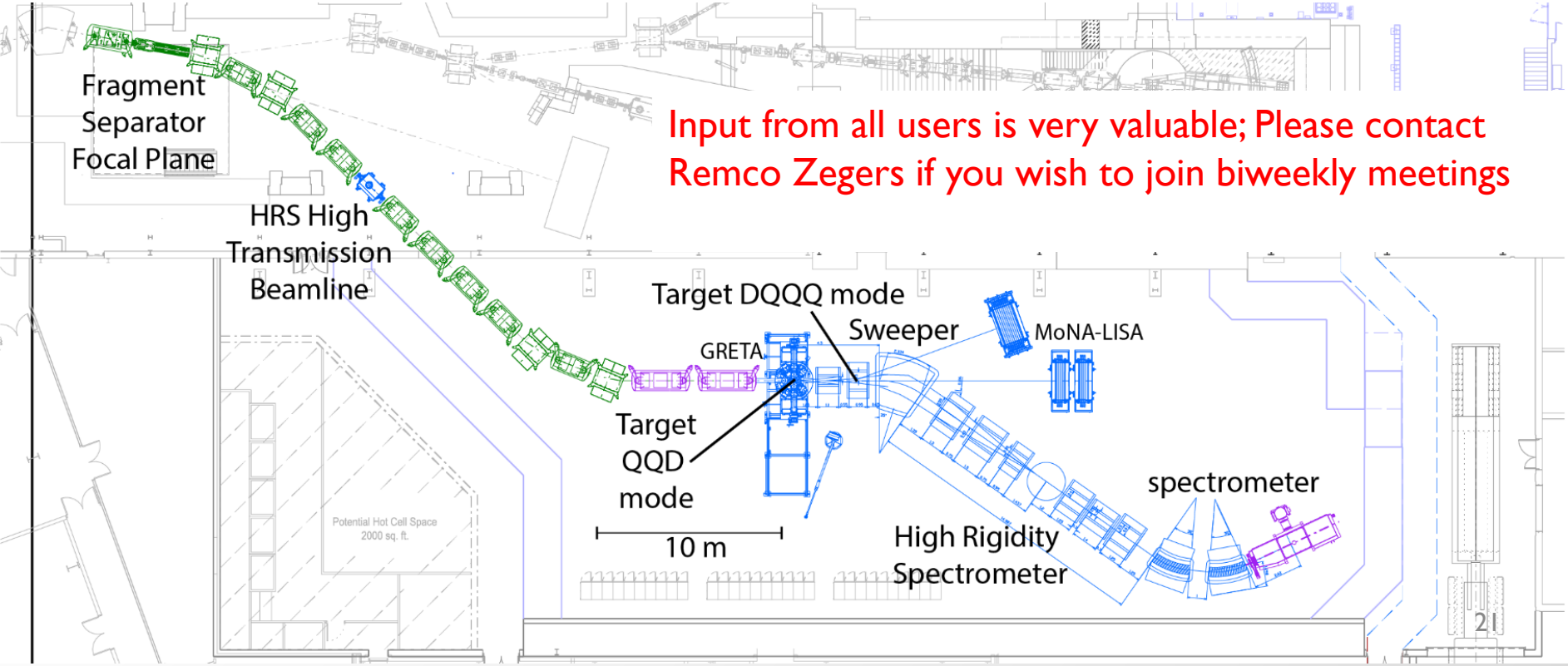


- Biweekly online meetings: close coordination with users, working groups of other devices (GRETA, MoNA-LISA etc), FRIB fragment separator and magnet groups…
- Development of novel techniques for tracking (see e.g. Workshop on Tracking Detectors for Fast Beams during LEC meeting) and coordinated DAQ for multiple detector systems (end-station and beam-line (aligned with activities of DAQ working group)

HRS pre-conceptual layout: current status

Facilitates the requirements set by the diverse science program of the HRS whitepaper

- Invariant mass spectroscopy ("QQD" – 12m long) and high resolution ("DQQQ" – 26m long) configurations
- Achromatic & angular/momentum dispersion matching ion-optical modes
- Other significant devices that will be used with HRS are incorporated in layout (GRETA, MoNA-LISA etc)
- Large acceptance beam line from FRIB fragment separator to HRS
- MSU commissioned a conceptual design of a new high bay that will house the HRS



Input from all users is very valuable; Please contact Remco Zegers if you wish to join biweekly meetings

Hi Resolution In-Flight Gamma Spec WG

Priority Physics (at 10, 50, 100 kW):

The science case for in-beam g-ray spectroscopy has been laid out in the GRETA whitepaper and covers all overarching FRIB science topics and uses fast and reaccelerated beams at various intensities.

Priority Beams (at 10, 50, 100 kW):

The science cases presented in the GRETA whitepaper, which will likely evolve, would require, for example, ^{48}Ca, ^{82}Se, ^{238}U and ^{78}Kr.

We stress that in-beam g-ray spectroscopy offers science opportunities across the nuclear chart and thus primary beams reaching neutron-rich as well as neutron-deficient regions are needed. Undoubtedly, the science opportunities will evolve until FRIB comes online and some limited flexibility in the year-1 beam list would be appreciated.

Priority (Planned) Equipment (at 10, 50,100 kW)

GRETINA will be available at FRIB day-1 (10 kW). Full GRETA will be available starting at about 50kW and is needed to realize the full scientific potential of FRIB. Ancillary devices (separators, particle detectors) are essential along with appropriate targetry.

Beam property and DAQ requirements?

At ReA: beam “as DC as possible”, need good beam/target diagnostics.

Fast beams: tracking of incoming beam profile and angles, RF separator in beam line for optimized purity for p-rich and N=Z nuclei.

TPC and AT: Time Projection Chambers and Active Targets

The following subjects were presented:

- Introductory remarks: Wolfgang Mittig(MSU)
- Recent results with MUSIC: Calem Hoffman (ANL)
- protoAT_TPC: Yassid Ayyad (MSU)
- AT-TPC: Daniel Bazin (MSU)
- ANASEN: Ingo Wiedenhoever (FSU)
- SPIRIT: first results William Lynch (MSU)
- SPIRIT: track analysis Giordano Cerizza
- TexAT: Gregory Rogachev(TAMU)
- proton decay detector: Chris Wrede (MSU)
- Developments-recommendations

- There was no time to discuss in the necessary detail the “first day experiments”, and should be part of the next LECM meeting. It was recommended to include ^{208}Pb in the list of the first beams.

TPC and AT: Time Projection Chambers and Active Targets

The discussion was mainly oriented to establish an efficient collaboration in this growing community, and in particular:

- *Establish a shared address-book* starting with the persons present to exchange information
- *Share hardware* when possible (example: the 4T solenoid from ANL)
- *Share specific technical information* (example: gas detector properties of target gases)
- *Analysis of Data*, a hardware and work-intensive subject: share methods and software; computer power needed is high, and hardware may be shared (example: Texat computer); a coordinated framework (with a responsible person) should be established; a high speed network should be provided to allow for analysis at several institutions
- *TPC's are a forerunner* in the need of high data rate experiments; they imply high computer power and high storage need; they will drive the general trend for the high rate experiments at FRIB
- *Higher level trigger* development is recommended corresponding to needs of these detectors, and quite certainly at FRIB

Neutron Detectors WG

Priority Physics (at 10, 50, 100 kW)

Reactions and decay studies
Invariant/Missing Mass near or past the neutron dripline (high power)
Prefragmentation dynamics (low power)
Isospin dependence Reactions/Equation of State (low intensity)
Gamow-Teller resonances
Beta-delayed neutron spectroscopy
r-process

Priority Beams (at 10, 50, 100 kW)

Beginning - ^{48}Ca and ^{82}Se
Eventually ^{76}Ge and ^{86}Kr

^{238}U, ^{82}Se, ^{48}Ca beams for decay and direct reaction studies.

Priority (Planned) Equipment (at 10, 50,100 kW)

MoNA/LISA + Sweeper + S800 (day 1)
Segmented target
Need for position/current monitoring devices
Support for HRS
LENDA (day 1),VANDLE (day 1)
New high-resolution neutron spectrometer for decay and direct reaction measurements. Capitalize on emerging neutron detector technologies.

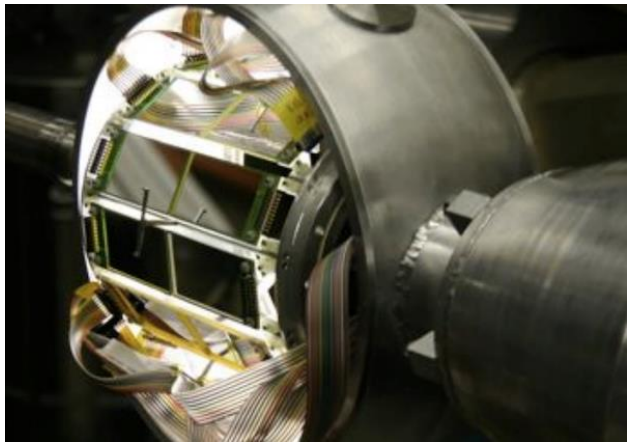
Beam property and DAQ requirements?

Common DDAS protocol/format including timestamps and perhaps dynamic merging
Online ROOT converter

Silicon Array Working Group:

Heard community updates on:

- Physics scope
- Existing, new and planned devices
- Community needs for instrumentation
- Community needs for beams and *beam quality* (esp. purity)



Session Agenda

• *Decay measurements at FRIB*	Chris Wrede (MSU)
• *Helios Silicon Upgrade*	Daniel McNeel (University of Connecticut)
• *APOLLO with HELIOS*	Jack Winkelbauer (LANL)
• *ANASEN Overview*	Jeff Blackmon (Louisiana State University)
• *sORRUBA + JENSA for astrophysics*	Kelly Chipps (ORNL)
• *Si Tracking Array*	Dennis Mücher (University of Guelph)
• *Silicon + gamma setups at FRIB*	Steve Pain (ORNL)
• *Update on HINP4 ASICs*	Lee Sobotka (WashU)

- Community discussion

Silicon Array Working Group:

Priority Physics

- Direct (a,p) (p,a) measurements
- Scattering and transfer on rp process nuclei
- Transfer on r process nuclei
- Surrogate measurements for n capture
- Decay measurements on proton-rich nuclei

Priority Beams

- Si detectors are used for too broad a physics scope to list individual nuclides here
- Proton-rich beams of rp-process nuclei
- Neutron-rich nuclei (esp in vicinity of shell closures)

Priority (Planned) Equipment

- Community support for a large (up to 1000ch) suite of standardized FRIB digitizer/DAQ explicitly for Si, well integrated and readily coupled to other large devices (HRS,GRETINA,ISLA,etc)
- ASICs system required for large (1000+) channel systems
- Some standardization of FRIB detectors possible, but many individual systems stewarded across the community
- Si for HELIOS-like spectrometer

Beam property and DAQ requirements?

- Beam purity is a paramount concern to the community
- Community concern about beam detectors coping with contaminated beams at FRIB rates (and time structure)
- May be necessary to couple to recoil separators to fill this need (at cost of experimental complication)
- Well integrated DAQ with other devices, ability to view/analyze merged data in real time

Decay Station Working Group :

Priority Physics (at 10, 50, 100 kW)

Support of FRIB white paper physics goals. Limits of nuclear existence Shell-evolution far from stability Evolution of shapes, Correlations revealed in particle and gamma decays, Exotic decay modes – two proton emission, beta-delayed fission, beta-delayed multi-neutron emission, direct neutron emission, r-process, rp-process, fundamental symmetries

Priority Beams (at 10, 50, 100 kW)

During Year 1/Year 2, it is anticipated that ample new decay properties will be obtained using primary beams of 238U,124Xe, 78Kr, 86Kr,48Ca, 92Mo, 82Se. Additional or alternative beams may be recommended as new information comes forward; we would like to explore the options of developing other primary beams e.g. 144Sm,112Sn for the studies around proton drip line

Priority (Planned) Equipment (at 10, 50,100 kW)

Decay spectroscopy equipment will be ready for Year-One experiments including various implantation arrays (Si, Ge, Scintillator), neutron counters (^{3}He and Scintillator),clover array, TAS

New: high granularity Si DSSD array, high-resolution neutron detector, and modern high-resolution gamma-ray detectors, all providing new capabilities.

Beam property and DAQ requirements?

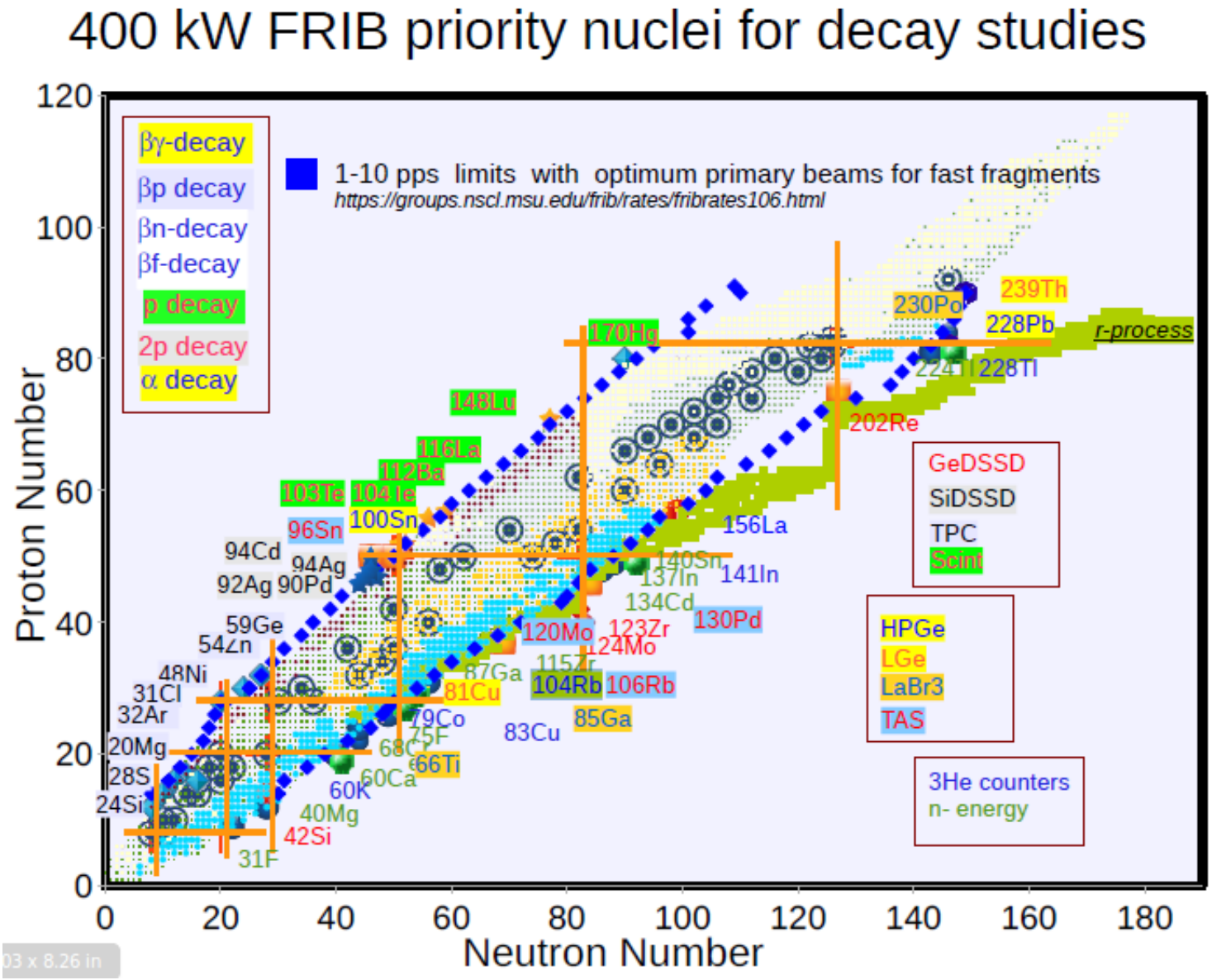
Fast beams: 1-5 cm diameter, adjustable, RF kicker

Low energy beam: 20-60keV, 1 mm

Unified Digital Data Acquisition preferably a decay station pool of electronics.

Identification method for high-Z nuclei

Decay station FRIB isotopes



Data Acquisition Working Group August 11, 2016

- **Issues in data acquisition**
  - Accelerator/controls interfaces
  - Timing synchronization
- **DAQ Computer resources at FRIB - a recommendation is being developed**
  - Network
    - GRETA, DDAS trace collection
    - High speed networks - 10 to 40 Gbit/s
      - Currently deployed network technology, 100Gbit/s is part of 802.3 standard
    - Moving data off-site - 100Gbit/s (ESnet)
      - Deployed now on ESnet backbone
  - Storage
    - Experiments might take 100 to 200 terabytes (see B.Tsang talk)
    - 10 weeks of running may exceed 2 petabytes
    - Longer term data retention requires more storage
  - Computation
    - Enough computing to understand the experiment in realtime, analyze the experiment in 10% of the measurement time
    - Enough computing to analyze the experiment in a **week**
    - High priority access, high network bandwidth from event store to computation.
    - Use high performance computing wherever it is - MSU HPCC, NERSC, RCF

DAQ WG 11Aug2016

- **Data Analysis**
  - *Why is this here?*
    - Online analysis a big concern
      - Need flexibility and speed to analyze entire event stream
      - Lightweight tools and resources needed for this
    - New techniques available, new resources available
      - High performance computing centers
      - Cluster computation, cluster data distribution
      - Big Data analysis techniques
  - *Organize a workshop on data analysis at FRIB around the next LECM meeting*
    - Explore approaches, techniques and technologies
- **Communication with the vendor community**
- **Talks and other documents at**
  - **https://www.phy.ornl.gov/fribdaq**

Final comments

- I see excitement! (This is good)
- Planning and projects are underway
  - Projects (SECAR, GRETA)
  - Detailed planning (HRS, ReA6-12,…)
  - Detector combination plans
  - Experimental infrastructure (DAC, interoperability,…)
- There will still be a PAC process
  - 1-2 years worth of ‘day 1’ experiments
- The first experiments need a ‘wow’ factor even at 10 kW
- Healthy tension between
  - Capability building
  - Specific experimental questions

Keep up the good work

SNS

11 July 2011

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The Dayside : Is there something wrong with the Spallation Neutron Source?

The US paid $1.4 billion for the SNS, a facility whose publicity brochure says, "The capabilities of the SNS will enable scientific breakthroughs that will enrich our lives in ways we haven't even imagined."

I admit that the title of this post is deliberately provocative, but it's also intended as an open question: Is there something wrong with the SNS?

SNS is fine today, but at that stage, there were questions…

DAY (or month) ONE success -- important