Internal report

On Future Prospects of BLAST

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1 Preface

After many years of planning, construction and commissioning, the BLAST (Bates Large Acceptance Spectrometer Toroid) experiment at MIT-Bates finally became reality and as such very successful. First proposed in 1989, funded and built from 1997-2001 and commissioned until 2003, BLAST took production data from December 2003 through May 2005 on spin-dependent scattering of longitudinally polarized electrons from polarized internal hydrogen and deuterium targets.

The great success of the production run in 2004 made it possible to achieve an extension and to postpone the scheduled end of the experiment and of Bates as a Nuclear User Facility by additional five months in 2005. It was recognized to be very unfortunate that the operation of the experiment had to terminated so soon after commissioning, literally at the pinnacle of its capability. Although an astonishing program could be accomplished with BLAST under the given circumstances and within the tight time frame, it is also clear that significant parts of the PAC-approved program had to remain undone. The addition of five months of running were not enough to cover the loss of a program that was meaningful to be run for at least another 2-3 years.

Given the impossibility of a continuation of BLAST at MIT-Bates, alternatives were started to be thought of as soon as the success of the run became obvious in 2004 after having overcome all technical challenges.

This document is a report about initiatives to seek for a continuation of BLAST at alternative places. In the following Section 2, the BLAST experiment is briefly summarized with its key features. Section 3 contains an overview of the physics program that could be done with Blast and internal targets at a multi-GeV electron storage ring. In Section 4 the chronology of the BLAST@ELSA initiative is documented. Section 5 describes a possible scenario of BLAST@DESY. Other places are briefly considered in Section 6, before a conclusion is given in Section 7.

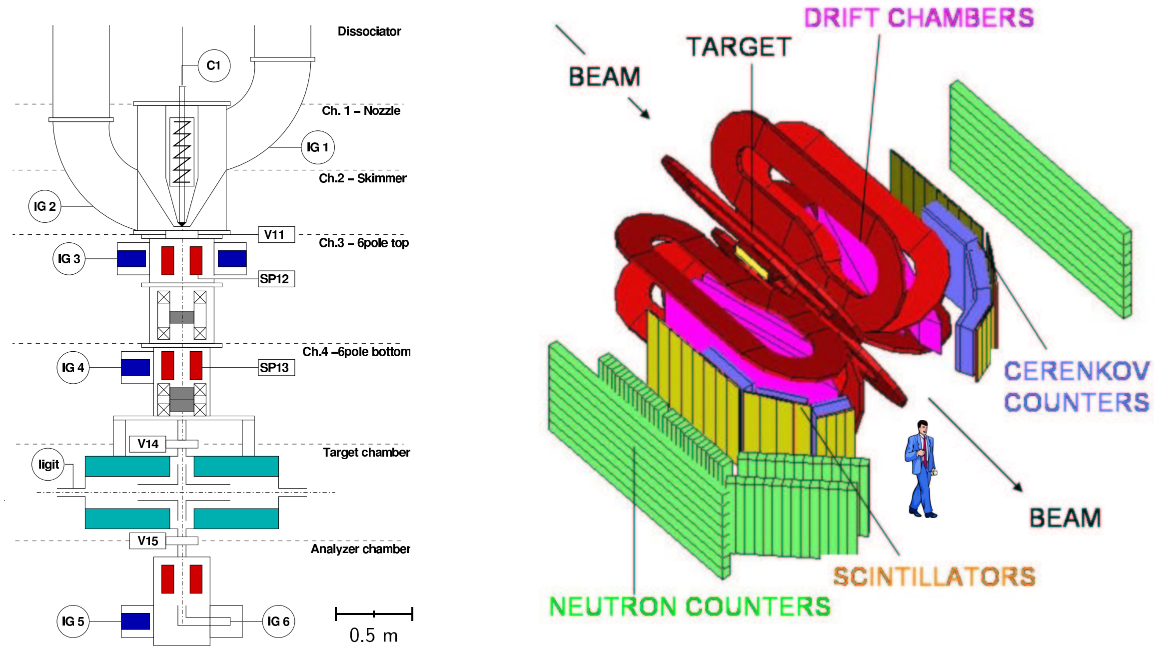

Figure 1: Schematics of the Atomic Beam Source (left) and the BLAST detector (right).

2 Overview of the BLAST experiment

The BLAST Experiment (Bates Large Acceptance Spectrometer Toroid) at the MIT-Bates Linear Accelerator Center enables spin-dependent inclusive and exclusive scattering of longitudinally polarized electrons stored in a ring from internal targets of polarized hydrogen or vector and tensor-polarized deuterium, respectively, provided by an Atomic Beam Source (ABS) [1]. Polarized inclusive scattering (e,e') along with the exclusive channels (e,e'p), (e,e'n), (e,e'd) und (e,e'π) are measured simultaneously with the BLAST detector, in order to extract e.g. the proton form factor ratio G_E^p/G_M^p [2], the form factors of the neutron G_E^n [3] and G_M^n [4], electromagnetic structure observables of the deuteron such as e.g. the tensor analyzing powers T_{20} and T_{21} [5], vector spin correlation parameters T_{10} and T_{11} [6], or the structure functions of the quasielastic deuteron breakup [7] as well as multipoles of the pion production in the Delta resonance region from precision measurements of single and double polarization observables [8].

The BLAST detector shown in Fig. 1 is a toroidal spectrometer with eight normal-conducting magnetic coils. The two opposite in-plane sectors are equipped symmetrically with drift chambers for reconstruction of charged tracks, Cherenkov detectors for e/π discrimination and with plastic scintillators for time of flight, particle identification and trigger. In addition, the detector is surrounded with large-area, thick walls of plastic scintillators for neutron detection (time-of-flight method). The angle acceptance covers scattering angles between 20 and 80 degrees as well as up to ±15 degrees out of plane. In the MIT-Bates South Hall Ring, beam currents of typically 150-200 mA are stored at 65% longitudinal polarization and with a beam lifetime of 20-30 minutes. The beam energy was 850 MeV during the entire program.

The target apparatus shown in Fig. 1 provides an atomic beam of highly polarized, isotopically pure hydrogen or deuterium (typically 70-85% polarization), which is injected into a cylindrical, 60 cm long open-ended target cell oriented along the beam axis. Since the internal target has no windows, there is no quasielastic or other backgrounds from the walls when the beam passes through the target. The direction of the target spin can be freely chosen within the scattering plane by Helmholtz coils.

The observables of BLAST are single and double spin asymmetries with respect to target or beam spin reversal and are thus independent of detector efficiencies. Super ratios of asymmetries are furthermore independent of the polarization. Since the target spin has been chosen to point by 32 (47) degrees into the left sector, both the asymmetries with the target spin approximately parallel and perpendicular to the momentum transfer direction are measured simultaneously in both sectors. By measuring many reaction channels at the same time over a large range of momentum transfer and due to frequent and rapid beam and target spin reversal the systematic errors are minimal. One of the key experiments with BLAST is the precise determination of the electric form factor of the neutron, i.e. its internal charge distribution by measuring the beam-target spin asymmetry in quasielastic scattering $^2\vec{\mathrm{H}}(\vec{\mathrm{e}},\mathrm{e'n})$ from vector-polarized deuterium at low momentum transfer Q^2 in a range of 0.1 to 0.7 (GeV/c)^2.

So far, first preliminary results have been presented at various conferences. A first paper presenting the obtained results on the proton electric to magnetic form factor ratio G_E^p/G_M^p has been submitted for publication in Physical Review Letters [2].

Data taking with BLAST has been terminated in June 2005, and final results and a considerable number of papers are expected to be published in the coming months. A further publication presenting details of the BLAST detector is in preparation. Below is a tentative list of expected results on the most prominent reaction channels soon to be published:

- Measurement of the proton electric to magnetic form factor ratio from $^1\vec{\mathrm{H}}(\vec{\mathrm{e}},\mathrm{e'p})$, submitted to Phys. Rev. Lett.
- Proton electric to magnetic form factor ratio from quasifree $^2\vec{\mathrm{H}}(\vec{\mathrm{e}},\mathrm{e'p})$ knockout
- Precision measurement of the tensor analyzing power T_{20} in tensor polarized elastic electron-deuteron scattering

- A new measurement of the deuteron magnetic dipole form factor at low Q^2 in doubly polarized elastic electron-deuteron scattering
- Measurement of the neutron electric form factor at low Q^2 using the $^2\vec{\mathrm{H}}(\vec{\mathrm{e}},\mathrm{e'n})$ reaction
- Extraction of the neutron magnetic form factor from doubly polarized inclusive electron-deuteron scattering $^2\vec{\mathrm{H}}(\vec{\mathrm{e}},\mathrm{e'})$
- Study of deuteron structure and reaction mechanism in quasielastic vector and tensor polarized deuteron ^{2}H(e,e'p) electrodisintegration
- Double-polarization observables in inclusive electron scattering in the Delta excitation region
- Single and double polarization observables in exclusive pion π^+ and π^0 electroproduction in the Delta excitation region

3 Physics Program with BLAST

While a very successful program could be accomplished with BLAST at MIT-Bates within a very tight time frame, significant parts of the PAC-approved program had to remain undone. Moreover, there are additional experiments of great scientific interest that can be carried out with BLAST and/or an Internal Target Facility at a multi-GeV lepton storage ring. This section gives a brief overview of such an experimental program.

The experiments are grouped into three main physics topics, although some experiments could be listed in more than group:

1. "Understanding the Electromagnetic Probe" – Two-photon effects in electron-nucleon interaction
2. "Testing QCD in the Chiral Limit" – Low-energy structure of the nucleon and physics of the meson cloud
3. "Standard Model of Nuclear Physics" – Structure of few-body systems and nuclear astrophysics

The combination of the BLAST detector with an internal target in an electron storage ring provides a unique tool to address important aspects of the above three categories. A future setup of BLAST would have unique features that are not available to conventional experiments with extracted beams:

- **Thin targets.** The combination of thin targets with the intensity of stored beams at similar luminosity compared to experiments with thick targets and extracted beams minimizes energy loss and multiple scattering of outgoing detected particles and thus enables a new class of unprecedented experiments in few-body structure, near-threshold production and nuclear astrophysics.

- **Polarized and pure targets.** The use of internal polarized hydrogen, deuterium and helium-3 targets enables essentially background-free scattering from isotopically pure and highly polarized protons, deuterons, and helium-3 nuclei with frequent spin flip capability allowing to measure single and double polarization observables with minimized systematic errors.

- **Forward tagger.** The combination of stored beam on thin targets with a forward-tagging device for quasi-real photons through small-angle electron scattering will represent a unique tool that provides a flux of quasi-real photons with high linear and circular polarization beyond the intensity of conventional bremsstrahlung-based photon taggers. With a forward tagging system, the full available beam energy can be converted into polarized tagged photons.

- **Positrons.** The possibility to use intense stored positron beams in addition to electrons on internal targets opens a new door to address important questions such as two-photon exchange in lepton-hadron scattering and is orthogonal to conventional electron scattering facilities with external beam and target.

To most experiments listed in the following sections, the use of a large-acceptance detector with good tracking capability for charged particles such as the BLAST detector is essential.

3.1 Understanding the Electromagnetic Probe

The recently observed discrepancies for the proton form factors from unpolarized and polarized measurements might be explained to a large part by the exchange of two or more photons during the scattering process. Such an explanation implies in turn that certain lepton-proton scattering observables actually differ from their one-photon exchange expectation value. The effect of two-photon exchange on the real part of the lepton-nucleon scattering amplitude can be investigated by studying the dependence of the proton electric to magnetic form factor ratio on the value of virtual photon polarization ϵ. More directly, a non-zero two-photon amplitude would result in different cross sections for unpolarized electron-proton and positron-proton scattering, as shown in Fig. 1. The imaginary part of the two-photon amplitude would give rise to non-zero

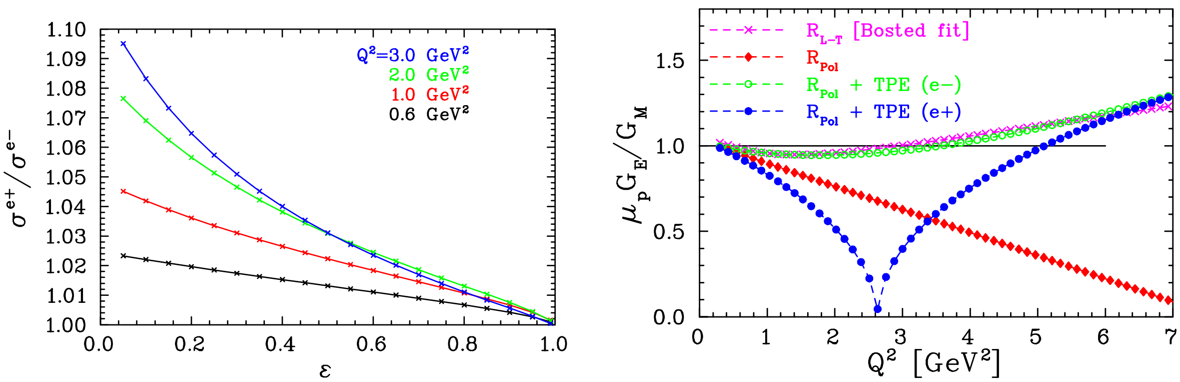

Figure 1: L.h.s.: Ratio of elastic positron-proton to electron-proton cross section versus virtual photon polarization for given Q^2. R.h.s.: Proton electric to magnetic form factor ratio $\mu_p G_E^p/G_M^p$ from polarized measurements and from e$^+$-p and e$^-$-p Rosenbluth separations. The electric form factor G_E^p from unpolarized e$^+$-p scattering has a node expected at $Q^2 \approx 2.6$ (GeV/c)^2.

transverse single-spin asymmetries, of either the beam (A_n), the target (A_y) or the induced polarization (P_y).

Below is a list of measurements that can be done with BLAST in combination with an internal hydrogen target at a storage ring:

- Measurement of the elastic electron-proton to positron-proton cross section ratio at low ϵ with BLAST using an internal unpolarized hydrogen target and intense stored beams of unpolarized positrons and electrons at energies between 2.0 and 4.5 GeV. The effect of two-photon exchange leads to an enhancement of the elastic positron-proton cross section over the electron-proton cross section as displayed in Fig. 1. Only a storage ring experiment with internal target provides enough luminosity for both electrons and positrons to do such a study while having good control over systematic errors. Additional measurement at high ϵ will allow to perform Rosenbluth separations for both electron and positron cross sections.

- Measurement of the proton form factor ratio G_E^p/G_M^p from 0.4 to 1.5 (GeV/c)^2 using a 1.5 GeV energy stored beam provides an extension of the previous BLAST Q^2 coverage and precise measurement of the ratio in the transition region, from which a decline of the G_E^p/G_M^p ratio based on the measurements at Jefferson Lab with the method of recoil polarimetry has been observed. Figure 2 shows the projected errors for the form factor ratio for an experiment of 1000h at $5{\cdot}10^{31}$ cm^{-2}s^{-1}. With higher beam energy, this measurement can be extended to higher Q^2. The drop of the form factor ratio had been observed solely with the method of polarization transfer. Although formally equivalent, this measure-

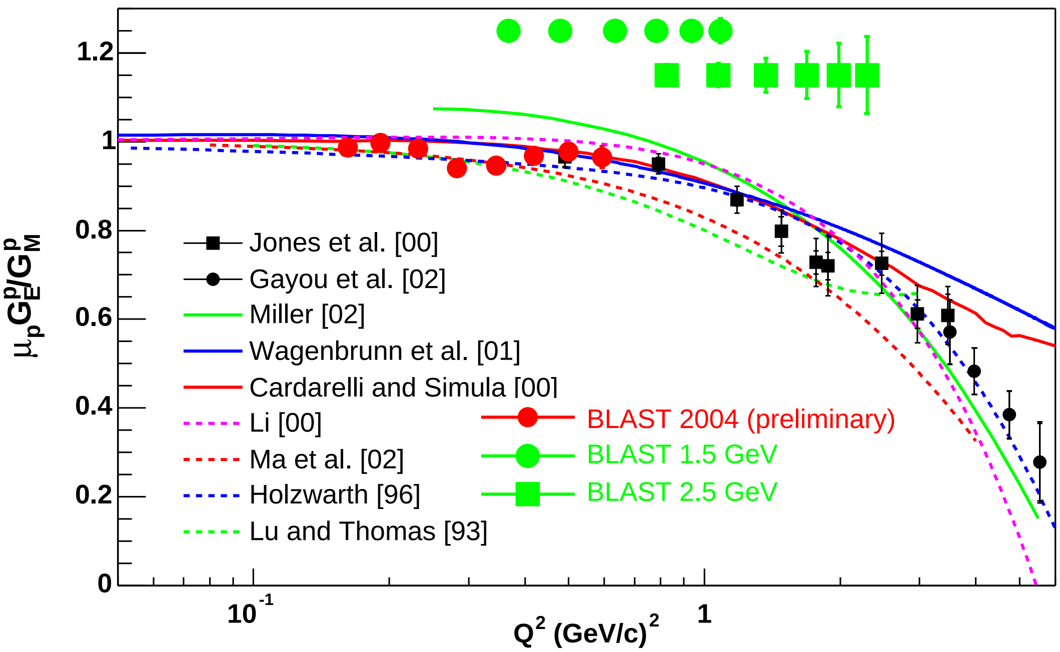

Figure 2: Projected proton electric to magnetic form factor ratio from double-polarized elastic electron-proton scattering with BLAST at beam energies of 1.5 and 2.5 GeV, respectively, with 1000h at $5 \cdot 10^{31}$ $\mathrm{cm}^{-2}\mathrm{s}^{-1}$, along with the preliminary BLAST result at 850 MeV.

ment will provide an independent verification of the form factor ratio with the polarized-target method.

- Measurement of the dependence of the form factor ratio as extracted under the assumption of one-photon exchange on the virtual photon polarization ϵ. The existence of two-photon exchange would mostly affect the extracted ratio at low ϵ.

- Measurement of the T-odd vertical target spin asymmetry A_y in elastic scattering p↑(e,e'p) as a quantitative search for two-photon exchange effects in e-p scattering. The observable A_y relates to the imaginary part of the two-photon amplitude. It would be identical zero in absence of two-photon exchange. Theoretical estimates predict A_y to be on the order of 1%. This observable requires a vertical spin alignment; however, it does not require a polarized beam. Moreover, A_y is expected to have different signs for the e^--p and e^+-p processes.

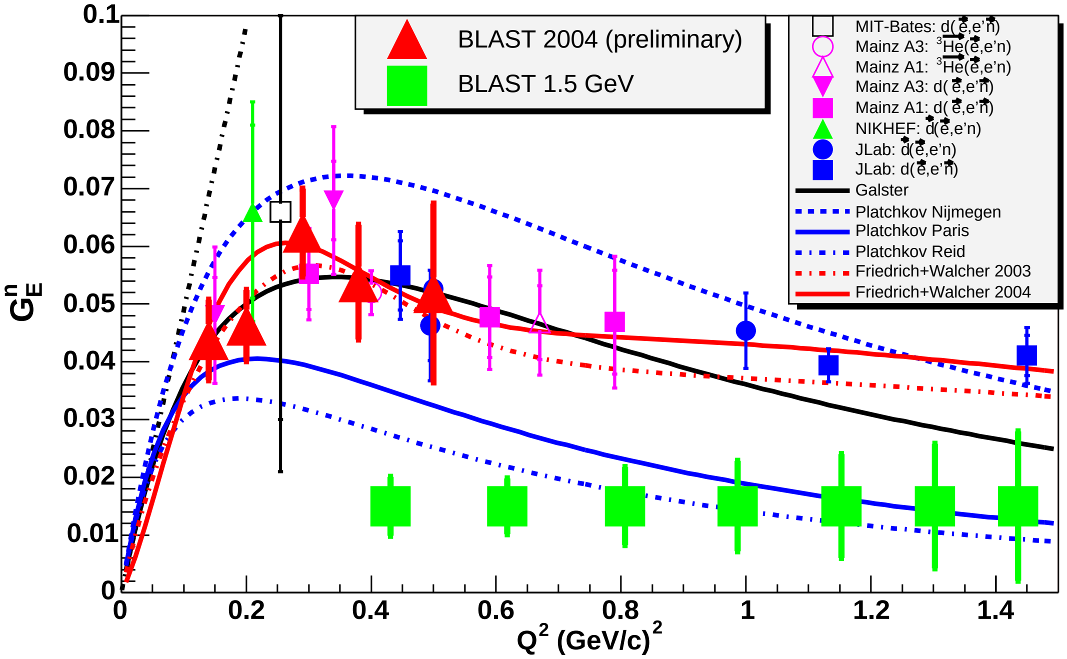

Figure 3: Projected neutron electric form factor G_E^n from double-polarized quasielastic electron-deuteron scattering with BLAST at a beam energy of 1.5 GeV with 1000h at $5 \cdot 10^{31}$ cm^{-2}s^{-1}, along with the preliminary BLAST result at 850 MeV.

3.2 Testing QCD in the Chiral Limit

This category of experiments mainly focuses on the structure of the nucleon through elastic scattering from the proton and quasilelastic scattering from deuterium and helium-3, as well as through photo- and electroexcitation of the nucleon and subsequent production of mesons at intermediate energies.

- Measurement of the proton charge radius: This PAC-approved experiment at MIT-Bates, which was deferred for lack of time aims to combine a precise determination of the G_E^p/G_M^p ratio from the beam-target double spin asymmetry with the relative shape of the unpolarized differential cross section at very low momentum transfer, in order to extract a precision value for the proton radius. At the same time, the magnetic radius of the proton will be measured. From the combination of the G_E^p/G_M^p ratio with the world cross section, a precision determination of G_M^p at low Q^2 will be obtained, where Rosenbluth separation results are uncertain.

- Measurement of rms radii from small-angle electron scattering with the forward

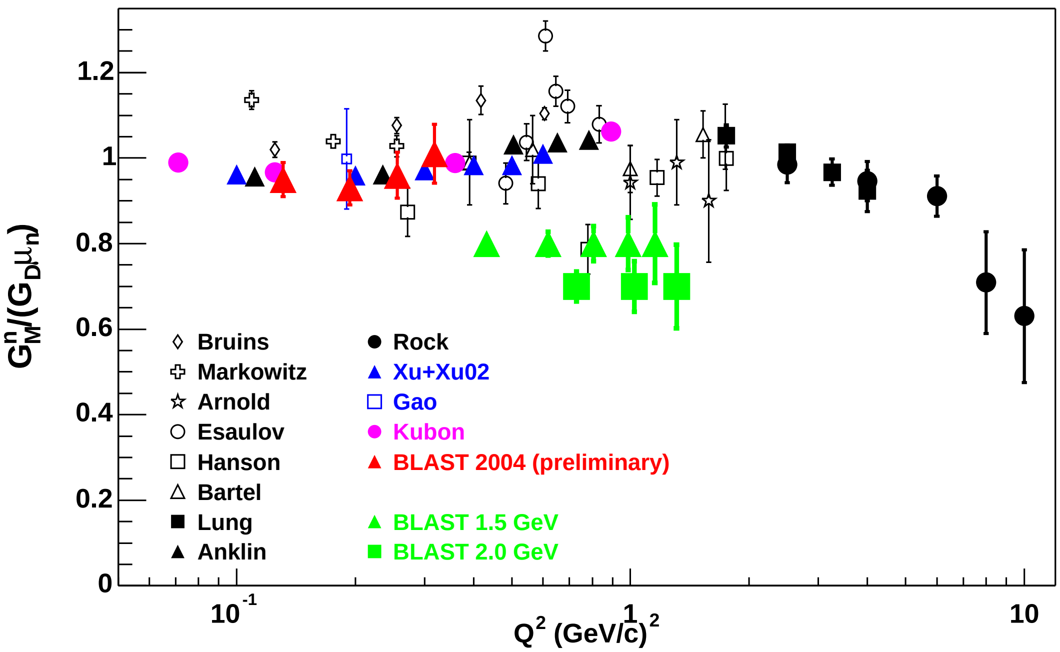

Figure 4: Projected neutron magnetic form factor G^n_M from double-polarized quasielastic inclusive electron-deuteron scattering with BLAST at a beam energies of 1.5 and 2.0 GeV with 1000h at $5 \cdot 10^{31}$ cm^{-2}s^{-1}, along with the preliminary BLAST result at 850 MeV.

tagger. Rms radii are quantities that are sensitive to effects of the meson cloud of the nucleon.

- Measurement of the neutron electric form factor G^n_E from $Q^2 = 0.4$ to 1.5 (GeV/c)^2 with the method of beam-target vector asymmetry in the quasifree $\vec{\mathrm{d}}(\vec{\mathrm{e}}$,e'n) reaction, using a stored beam of 1.5 GeV. The asymmetry with the target spin aligned perpendicular to the momentum transfer direction is proportional to the interference term $G^n_E G^n_M$. This method of a G^n_E measurement has been proven to be most effective and provides systematic errors <5%, including both the experimental and the model dependency. A projection of statistical errors for an experiment with BLAST at 1.5 GeV of 1000 h at $5 \cdot 10^{31}/(\mathrm{cm}^2\mathrm{s})$ is shown in Fig. 3.

- Measurement of the neutron magnetic form factor G^n_M from $Q^2 = 0.4$ to 1.5 (GeV/c)^2 with the method of beam-target vector asymmetry in the quasifree inclusive $\vec{\mathrm{d}}(\vec{\mathrm{e}}$,e') reaction, using a stored beam of 1.5 GeV. The extraction of G^n_M from the super ratio of inclusive asymmetries with spin parallel and perpendicular to the momentum transfer direction assumes the better known proton form

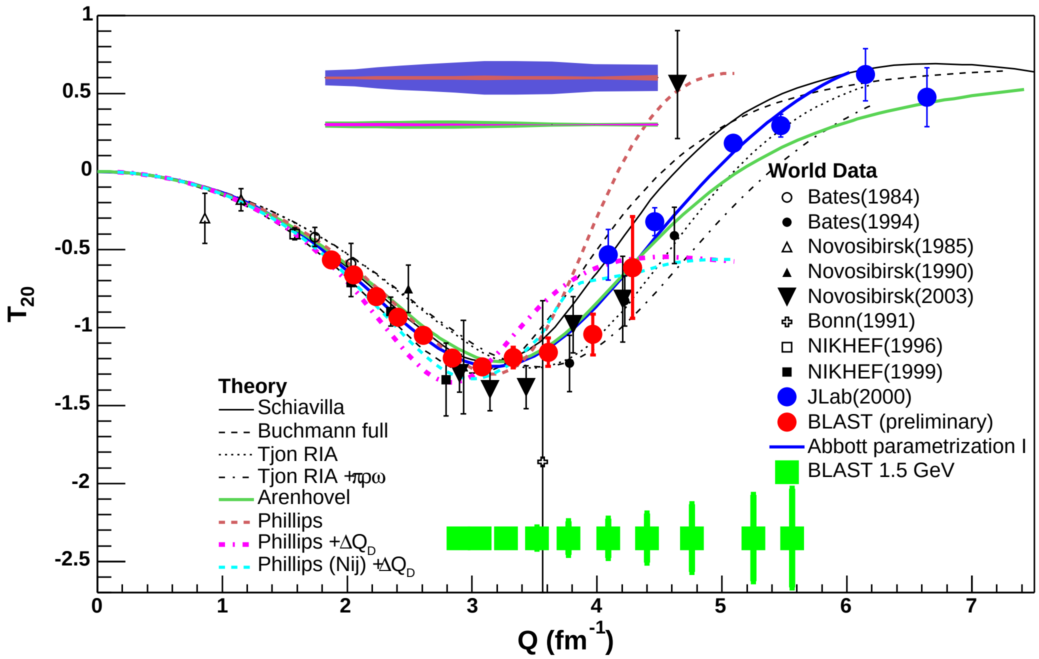

Figure 5: Projected deuteron tensor analyzing power T_{20} at a beam energy of 1.5 GeV with 1000h at $5 \cdot 10^{31}$ cm^{-2}s^{-1}, along with the preliminary BLAST result at 850 MeV.

factors G_E^p and G_M^p. In a similar way G_M^n was extracted first by Gao and Xu from inclusive quasifree scattering off polarized ^{3}He. The world data is separated into two groups of older and newer data from which a new trend is indicated. In the Q^2 region accessible with BLAST @ 1.5 GeV most of the existing data are based on the ratio method of the absolute (e,e'n)/(e,e'p) cross sections which assumes the precise knowledge of the detector efficiencies. A projection of statistical errors for an experiment with BLAST at 1.5 and 2.0 GeV of 1000 h at $5 \cdot 10^{31}$/(cm^{2}s) is shown in Fig. 4.

- Measurement of the electric form factor of the neutron G_E^n from $Q^2 = 0.4$ to 1.5 (GeV/c)^2 with the method of beam-target vector asymmetry in the reaction $^3\vec{\mathrm{He}}(\vec{\mathrm{e}},\mathrm{e'n})$. The measurement is carried out under the same conditions in the identical kinematical region with the identical detector as in the case of vector-polarized deuterium and thus allows for a direct comparison of the two methods. While the corrections by nuclear structure and final state interaction are considered reliable in case of deuterium, they are tested in case of ^{3}He. Through the stronger binding of the nucleons in ^{3}He also the question is raised if the nucleon form factors are modified in the nuclear medium.

- Measurement of the electric form factor of the neutron G_E^n from $Q^2 = 0.12$ to

0.6 $(\text{GeV/c})^2$ with the method of beam-target vector asymmetry in the reaction $^3\vec{\text{He}}(\vec{\text{e}}$,e'n), using a stored beam of 850 MeV. The measurement will be compared to the results for G_E^n obtained from polarized deuterium with BLAST at MIT-Bates.

- Measurement of the magnetic form factor of the neutron G_M^n from $Q^2 = 0.1$ to 0.6 and 0.4 to 1.5 $(\text{GeV/c})^2$ with the method of beam-target asymmetry in the inclusive reaction $^3\vec{\text{He}}(\vec{\text{e}}$,e'), using stored beams of 0.85 and 1.5 GeV. Polarized ^{3}He is considered to be a polarized neutron target to a good approximation while the two proton spins are antialigned. As discussed above, the latest data on G_M^n are based on this method. Although with BLAST the same statistical errors are not reachable, but as in the case of G_E^n a direct comparison with the G_M^n measurement extracted from vector-polarized deuterium is possible, which allows for an evaluation of the systematic error in case of ^{3}He due to the model dependency.

- Near-threshold pion and kaon photoproduction with polarized beams and targets using a forward tagging system and an extension of the detector to track charged particles at forward angles. These data will stringently test the predictions of Chiral Perturbation theory in the SU(2) and SU(3) sectors.

- Measurement of the spin structure of the $N-\Delta$ transition in the inclusive and exclusive channels p(e,e'), p(e,e'π^+)n, p(e,e'p)π^0 , p(e,e'n)π^+ , with polarization degrees of freedom of the electron, the target proton, or both. Electroproduction of $N-\Delta$ double polarization observables from high-purity, highly polarized hydrogen targets is neither possible at MAMI nor at Jefferson Lab.

- Pion electroproduction with polarization degrees of freedom in the region of the Roper resonance.

- Measurement of polarized kaon electroproduction response functions (with forward-angle detection capabilities).

- Primakoff effect and π^0 lifetime.

3.3 Standard Model of Nuclear Physics

In this category, studies of few-body systems are proposed to characterize the nucleon-nucleon interaction and its role in the understanding of the properties of complex nuclei.

- Measurement of the tensor analyzing power T_{20} from $q = 2.9$ to 5.5 fm^{-1}: Besides A and B, the tensor analyzing power T_{20} is a third fundamental structure observable of the deuteron. Only a precise knowledge of a polarization observable like T_{20} allows one to separate all three elastic deuteron form factor G_C, G_Q and G_M. In the above kinematical region, two incompatible datasets exist along with enormous variations in theoretical descriptions. The measurement of T_{20} does not require a polarized electron beam. Figure 5 shows the sensitivity of a T_{20} measurement with BLAST at 1.5 GeV in 1000 h at $5 \cdot 10^{31}/(\mathrm{cm}^2\mathrm{s})$.

- Measurement of the structure observables of the deuteron breakup in the region of $Q^2 = 0.4$ to 1.5 (GeV/c)^2. These measurements represent a comprehensive test of the deuteron model and allow for a significant refinement of the present knowledge about the bound n-p system.

- Pion photo and electroproduction (π^+, π^0, π^-) from the deuteron with polarization degrees of freedom near threshold, in the Delta and in the Roper resonance region.

- Investigation of the spin structure of the two-body and three-body breakup of ^{3}He with polarization degrees of freedom in the reactions $^3\vec{\mathrm{He}}(\vec{\mathrm{e}}$,e'p)d,pn; $^3\vec{\mathrm{He}}(\vec{\mathrm{e}}$,e'd)p and $^3\vec{\mathrm{He}}(\vec{\mathrm{e}}$,e'n)pp. This measurement makes full use of the extension of BLAST with low-threshold recoil detectors.

- Electroproduction of pions from ^{3}He with polarization degrees of freedom – medium effects, pion excess and preformed Δs: Does the Δ isobar play a role in the ground state of nuclei? As a consequence of short-range correlations Δ baryons could contribute significantly to the ground state wave function of nuclei. The experimental starting point is electroproduction of pions from ^{3}He. Desirable are detailed studies of the reaction channels ^{3}He(e,e'π^+)nd,nnp, ^{3}He(e,e'π^-)ppp, ^{3}He(e,e'pπ^+)nn, and ^{3}He(e,e'pπ^-)pp. The use of polarized beams and targets will shed new light on this long standing problem. Closely related is the search for pion excess in nuclei: Measurements of exclusive quasifree (longitudinal) non-resonant pion electroproduction from light nuclei represent a direct probe of the pion field in nuclei.

- Measurement of the E2 contribution to the important astrophysical reaction $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ by measurement of ^{16}O(e,e'α)^{12}C. A BLAST experiment to measure inelastic electron scattering at forward angles at 400 MeV from an unpolarized internal oxygen target was highly rated by the Bates PAC. By extrapolating to low Q^2, the $^{16}\mathrm{O}(\gamma,\alpha)^{12}\mathrm{C}$ cross section can be extracted and from this, by detailed balance, the $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ rate. The recoil α and ^{12}C particles would be detected by using silicon detectors. The measured yields would be normalized to e-p elastic scattering yields.

4 BLAST at ELSA

BLAST has been designed and developed to deliver precision results of the second generation for many questions of intermediate-energy physics. The fact that BLAST cannot be continued at Bates, is regarded as a big loss for medium energy physics, however it was a political decision and defies further control. In comparison with the experimental program at Jefferson Lab or MAMI, BLAST is without competition since as an internal-target experiment in a storage ring it provides technical solutions that are not possible with external beams. The main advantage is the usability of highly polarized, isotopically pure and windowless targets. Besides a usage of the above described ABS target also the operation of laser-driven hydrogen or helium targets should be considered.

In spring of 2005 a move of BLAST to the Electron Stretcher Accelerator (ELSA) at University of Bonn, Germany, was first considered. In ELSA, electrons of up to 3.5 GeV at intensities of 50-100 mA are stored. The ring is mainly used as a pulse stretcher ring with a slow extraction to an external experiment (Crystal Barrel) with a photon tagging facility. In the past, ELSA had also been used for electron scattering experiments (e.g. ELAN), however due to the limited luminosity this activity was terminated when the operation of Jefferson Lab was started.

Several considerations particularly motivated the initiative to propose BLAST at ELSA. The possible physics with BLAST in combination with polarized internal targets and a multi-GeV storage ring has been summarized in the previous section. With an installation of BLAST in Bonn, ELSA would elude the competition with MAMI and Jefferson Lab and the issue of limited luminosity in experiments with extracted beams in a very elegant way. Another argument was considered in regard of the expected cost. Although estimates were quite uncertain, it appeared obvious that the cost for transfer and installation and for eventual modifications of BLAST, as well as for the necessary spin rotator and modifications at ELSA would be only a fraction of the invested money to build BLAST. The total equipment of the BLAST detector and the target has an estimated investment value of more than US$ 6M.

Besides the technical and financial aspects it was emphasized that with the present BLAST collaboration a group of scientists with exceptional expertise, valuable experience and strong interest in a continuation of the project and the collaboration supported the initiative. On a brisk transatlantic exchange of scientists and know-how could be counted. It was envisioned that among the "Transregio 16" research group at Bonn local scientists could be interested for the project and that they would contribute with their experience and expertise in polarized electron scattering.

During spring and summer 2005, the members of the BLAST collaboration were convinced from the idea and widely supported the initiative. The management in Bonn was contacted and it was suggested to hold a first meeting on the subject. At that time one of the biggest concerns was the possible civil construction necessary to accomodate an internal target station with BLAST at ELSA. It was suggested that a seminar be given at Bonn to present the physics case, however no suitable time could yet be found in the spring semester.

In summer 2005, a memorandum was written that would summarize the science goals to be achieved with BLAST at ELSA [9]. Originally, this memorandum was meant to be submitted as a letter of intent to the PAC meeting on ELSA and MAMI on September 29-30, 2005. The time frame was however too short for this move, and instead the memorandum was sent to a considerable number of scientists mainly situated in Germany, with the aim to raise interest and awareness for the initiative.

In November 2005, a delegation from MIT (D. Hasell, J. van der Laan, and M.K.) were visiting Bonn. M.K. gave two presentations on BLAST at MIT-Bates at the Transregio-16 meeting on November 23, 2005 in Giessen, Germany, and on the future program with BLAST at ELSA on November 29, 2005 at Bonn. During the Bonn visit, the local infrastructure was inspected in detail. It was soon realized that the existing buildings, especially the geometry of the ELSA ring tunnel would be insufficient to accomodate the BLAST detector. Significant civil construction would be involved with the construction of a new experimental hall to cover the BLAST detector. This fact was seen as a major obstacle and risk for the lab funding that could eventually only be justified with a compelling physics reason. The Bonn management was noticeably impressed by the results from BLAST and the offer of a prolonged collaboration, however they appeared not to be entirely convinced that the presented physics case would justify the high risks. More preparational work would have to be done. It was agreed to continue the discussion with more workshops in the future to address the physics case.

Until spring 2006 the physics program for BLAST at ELSA was internally revised. It was seen as problematic that the program was too manifold, and that no clear key question would be raised and its clear answer be proposed with BLAST at ELSA. The program was then restructured into the three categories described in the previous section, "Understanding the Electromagnetic Probe" – Two-photon effects in electron-nucleon interaction, "Testing QCD in the Chiral Limit" – Low-energy structure of the nucleon and physics of the meson cloud, and "Standard Model of Nuclear Physics" – Structure of few-body systems and nuclear astrophysics.

Finally, a workshop meeting was held on July 28, 2006 at MIT-Bates, as a satellite meeting prior to the Gordon conference from 7/30 - 8/4, 2006 at Tilton, New Hampshire. This allowed four faculty people from Bonn to attend the workshop. The program of BLAST in the past and in the future was presented and discussed in detail, along with the current activities and future plans of the Bonn group at ELSA. Again, the problem of civil construction was seen as the major obstacle and as such causing high risks for the lab. Opening the ELSA ring for civil construction would interrupt operations for at least 1-2 years which could not be afforded presently. The situation of ELSA is such that the proposed and approved program with Crystal Barrel is already delayed, and that a successful continued running would be crucial to justify operations of the lab for the present and near-term future beyond 2008, when the current funding expires. The next review of ELSA and time to determine the program for 2008-2011 would be in mid-2007, therefore in the given timeframe until mid-2007 a proposal of BLAST at ELSA involving extended civil construction would likely exceed the tolerable risks.

The consideration was raised wether the BLAST detector could be used at ELSA in an external setup with extracted beams. This way, civil construction could be avoided as the existing experimental halls are sufficiently large to provide enough space. However, it can be argued that such a setup would lack key features for which BLAST was designed in the first place, namely the use of highly polarized internal targets with intense stored beams. As a result of this workshop, it was concluded to not further pursue the option of BLAST at ELSA.

5 BLAST at DESY

The storage ring DORIS at DESY in Hamburg, Germany, provides intense stored positrons and electrons at energies up to 4.5 GeV and intensities of 100 mA. This makes DORIS a very suitable location for BLAST to pursue a study of two-photon exchange effects in a comparison of the elastic electron-proton and positron-proton cross sections with high precision and good control of systematics.

This option has recently been considered [10] and may become a promising opportunity until further notice.

6 BLAST elsewhere

Other storage rings that could accomodate BLAST were mentioned – Argonne, Novosibirsk, Sendai, Lund, Aarhus, TUNL – none of them were found to be suited to run an internal-target program with BLAST. Either they are used as light sources, or the energies are too low, or they have already strong commitments for other research programs.

7 Conclusion

The initiative to propose BLAST at ELSA did not thrive after all, however the main outcome of this attempt was the continued maintenance of the detector and electronics equipment which were conserved and prevented from being disassembled, scrapped or used elsewhere. As of October 2006, the BLAST magnet and support structure are still fully assembled and in place at MIT-Bates, only the detector components and the ABS target have been taken out and are stored separately, however without being further decomposed. Without the attempt of proposing BLAST at ELSA, the detector would likely have been dismantled as were all other previous setups at MIT-Bates (OOPS in the South Hall and the entire setups of the North Hall) in the process of the Bates D&D effort.

The possiblity of utilizing the BLAST setup in a search for two-photon exchange effects in elastic lepton-proton scattering at the storage ring DORIS at DESY, Hamburg, Germany, is presently considered and may be pursued in the future.

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