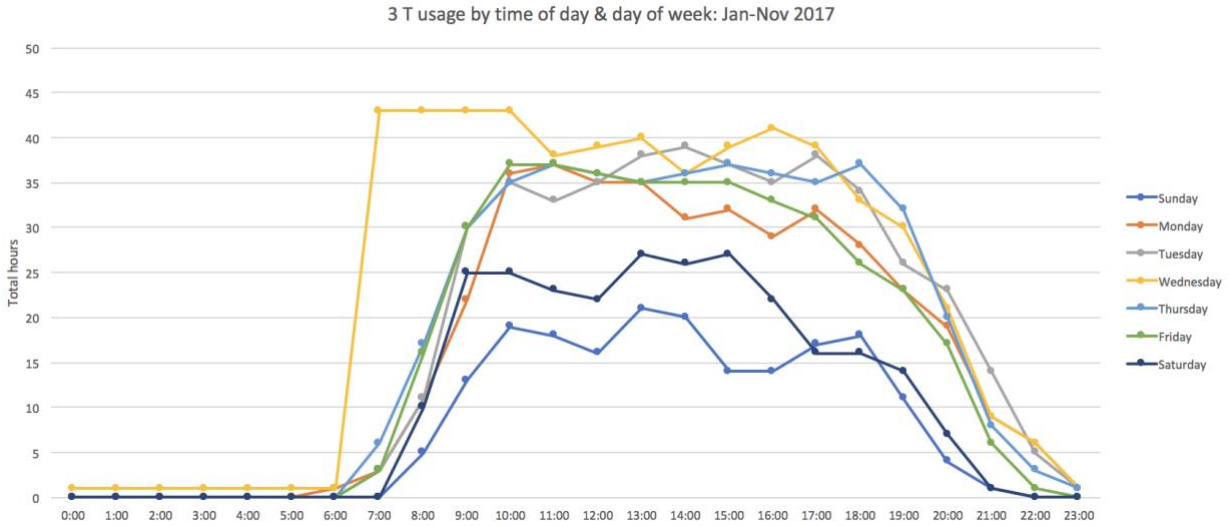
2017 – BIC Highlights

For the first time in several years, this year did not kick off with the BIC Research Day, our annual review meeting at which we highlight some of the work of the prior year. The first BIC Research Day happened in December 2001, but we switched from December to January in 2013 so that more people could attend. Over the years, the BIC Research Day got to be quite large and selecting highlights became increasingly difficult. As it grew bigger and more formal, it also lost its early focus on in-depth technical discussions and began to resemble a traditional scientific research meeting, which was never the goal. We outgrew the original idea. So, for the time being, the BIC Research Day is on hiatus. In its stead, of course, we have the NorCal SNUG for technical discussions at a local level.

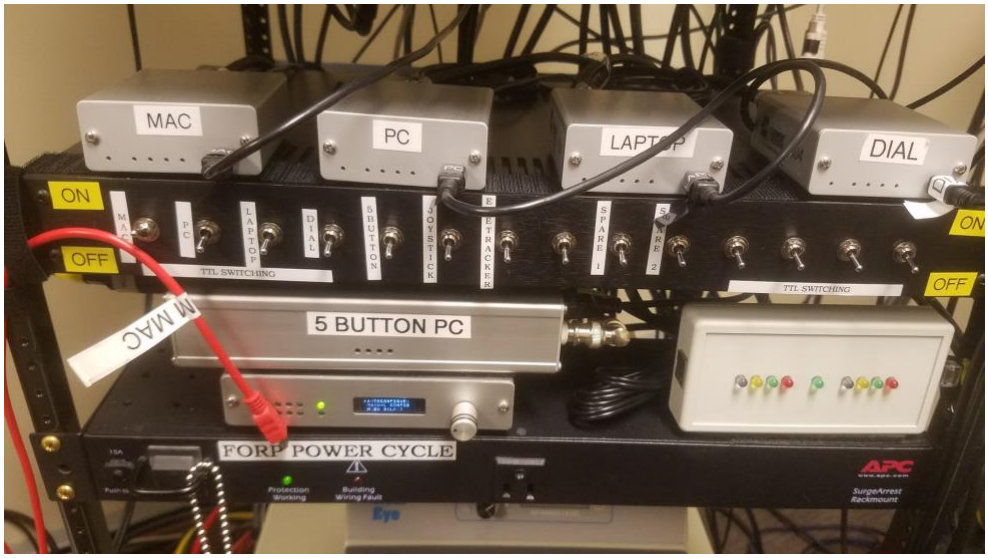
Instead of research highlights, the year got off to an auspicious start as the 3 T gradient set sprung a leak in late January, and had to be replaced by Siemens. With most of February lost to maintenance, BIC users wasted no time catching back up later in the spring. March through June was the busiest period in BIC history, with reserved scanner usage averaging 11.3 hours every single day, seven days a week. While schedule congestion eased in the summer months, the year remained busy but not significantly different from 2014 usage (compare the graph below to the one in the 2014 report), with two notable exceptions. Early Wednesday mornings are now when most BIC staff work is scheduled. (We work in cancelled slots otherwise.) And there is an interesting boost in Saturday scanning this year, compared to 2014. Weekday early mornings before 9 am, except Wednesday, still look like your best bet if you want to get more scanning done.



Ever wondered why the scanner gets so busy at times? A few more numbers that might be of interest. In the five-and-a-half years since we moved the BIC into Li Ka Shing, in May 2012, around 350 people have passed the BIC safety quiz. In the first decade of the BIC's existence – to the end of 2010 – approximately 400 people had passed the safety quiz. Thus, new people are now coming through the doors at a rate nearly double that of our early years. The same trend shows in qualified scanner operators. Over 200 people have become qualified users of the Siemens Trio since it was installed in January 2008; very nearly a decade ago. In the period 2001-

2010 inclusive, 110 people were qualified to scan on either the Varian 4 T (which was shut off in early 2009) or the Siemens 3 T. So, again, we're producing qualified operators at twice the rate we were ten years ago. What are the explanatory factors? We had two scanners running for only a few months, and most studies (and people) moved from the Varian to the Siemens right away, making that a very small factor. The more likely explanation is that principal investigators have been more successful at getting grants in recent years, thereby supporting more people, and at the same time we have streamlined operations so that our scanner is more productive. We're still not at capacity, as the graph above shows. (Early mornings! Get 'em while they're hot!) But we do occasionally get frantic periods which test everything, from scheduling to equipment durability to lab tidiness!

While Siemens replaced our gradients in February, Rick upgraded the main rack holding peripheral equipment, then redid all the cabling and connectors for the audio and video matrix switches, TTL signals from the scanner, and USB hubs. These changes add robustness and upgrade some older parts that were in danger of wearing out or becoming obsolete. Miguel then revised the peripherals documentation, adding for good measure some laminated "cheat sheets" and flow charts to various pieces of equipment around the operator suite. These are your best bet for a quick refresher on a device you've not used in a while. They should also help with trouble-shooting.



The new peripherals rack, with fORPs along the top of the toggle switch box controlling TTL reception.

The Northern California Siemens Neuro User Group (NorCal SNUG) convened in April at the Martinez VA, a meeting organized by VA physicist XJ Kang. Emphasis for the meeting was susceptibility-weighted imaging (SWI) and quantitative susceptibility mapping (QSM), two methods that have gained attention for their ability to detect and perhaps quantify microscopic hemorrhage in traumatic brain injury. Also of interest to the attendees was the possibility that QSM might be able to quantify (de)myelination in white matter. There has been extensive collaboration between the VA in Martinez and BIC over the years – several years ago the scan protocols for TBI and stroke patients were matched between the BIC and VA scanners – and through SNUG we should improve the technical overlap as well as the scientific overlap. For

those of you interested in technical discussions, the next NorCal SNUG meeting is tentatively scheduled for April 2018 and may return to Berkeley.

In the spring, Rick added a new CO_2 monitor to the BIOPAC setup. Naturally, out of the box the device didn't work as we wanted it to, so after several custom modifications and having replaced the defective amplifier we received initially, Rick, Daniel and Ben managed to get it to work over in the summer. While we are still acquiring some tests of different breath holding patterns and trying to ensure we have the lags calibrated, expired CO_2 measurement is now available for those wanting to do it. There are some technical limitations but it can be made to work if you really need it.

In the summer, Daniel received a request from the Ivry Lab to diagnose an artifact in an electromyography (EMG) signal being used with a TMS rig in Tolman Hall. He quickly determined that multiple artifacts were present, including ground loop fluctuations and direct coupling of TMS magnetic field pulses to the EMG unit sensors and to the EMG amplifier. Consequently, Daniel designed and built a regulated battery power supply for the EMG unit to eliminate the ground loop artifacts. He then made recommendations to change operating procedures to reduce the direct coupling artifacts. Finally, he built a timing control system for the synchronization and triggering of TMS, EEG, EMG, oscilloscope and subject button response units. The system is Matlab-based and uses standard PC components for the control and interface boxes. The improved timing of TMS experiments outside the scanner now matches the control precision that Daniel implemented last year for our MRI-compatible MagPro TMS system.

In July, Miguel began a new blog, TechniCal fMRI, dedicated to peripheral equipment issues: *"A blog dedicated to exploring, explaining, and testing the equipment utilized during fMRI experiments. Because you need more than just an MRI machine to do the science!"* In his first series of posts he covers our customized visual display system. He is now walking through the design and construction of the BIC's custom 3D printer. TechniCal fMRI joins PractiCal fMRI and MathematiCal Neuroimaging in the family of BIC staff blogs. We won't make Rick write a blog, he's too busy making all our custom widgets!

In October, we got to play with a new prototype receive-only coil, which we refer to as the "nested birdcage" coil. The main design ideas came from Daniel, with minor input from Ben, and we contracted an expert RF engineer in Utah, Ken Bradshaw, to figure out how to convert the general ideas into electronics reality. Rick spent a lot of time sourcing parts, and over the course of a year the new coil slowly took shape. Ken hit several obstacles – if it was easy someone else would have done it years ago! – but once he'd got all those issues solved and put the coil on a scanner, it worked first time! Not only that, but the half-scale prototype worked so close to expectations that all the planned tests were completed in under two hours! There are always new things to do, of course, and nothing is perfect even if we exhausted our tests in record time. The team recognized a new possibility that might be refined in the full-sized coil. If this new feature comes to pass then the nested birdcage coil will be able to satisfy all the original specifications and several more to boot. The prototype had to go back to Utah to undergo slight modifications before a decision can be made on the final specifications for a full-sized head coil. But those of you doing simultaneous TMS-fMRI experiments have a lot of reasons to be excited. More details to follow soon.

This year saw the departure of Matthew Brett back to the UK, to a position at Birmingham University, and JB Poline accepted a position at McGill University in Canada. Good luck, gents! Those institutions are lucky to have you. You'll be sorely missed by the BIC community. Thanks for everything you did under the BIC umbrella.

We welcomed Professor John Clarke into the BIC family this year. John is a condensed matter physicist and a pioneering world authority on the design and use of superconducting quantum interference devices (SQUIDs). Over the past two decades, one of his projects has been to develop an ultralow field (ULF) MRI scanner based on SQUID sensors, as found in commercial MEG machines. His custom scanner, which resides in the Birge Hall basement, operates at magnetic fields between about 50 and 250 microtesla. (The earth's magnetic field is approximately 50 microtesla.) Although John and Ben have been collaborating on ULFMRI since 2004, recent results have started to suggest a natural overlap with the broader interests of the BIC community in areas such as traumatic brain injury and stroke, as well as functional MRI. Assisted by visiting collaborators from Korea, China and Germany, some early human brain work appeared back in 2013. This year the team demonstrated an intriguing sensitivity of ULFMRI to changes in tissue structure, suggesting that ULFMRI contrast may have exquisite sensitivity to the very earliest consequences of traumatic brain injury: that is, to changes in protein conformation. Several more papers are in the works, including a follow-up to the preliminary human brain imaging paper.