Meeting minutes for the GF SPS-PoP meeting in Krakow on 29/02/2019

Present : S. Alden, R. Alemany Fernandez, J. Bieron, D. Budker (remote), K. Cassou, C. Curatolo, Y. Dutheil, T. Lefevre (remote, V. Fedosseev, S. Gibson, B. Goddard, W. Krasny, A. Petrenko (remote), W. Placzek, S. Pustelny (remote), M. Sapinski, A. Surzhykov

Brennan: intro

- Funding model important with the project breakdown and collaboration details, might not be realistic for the 20121 deadline.
- SPS PoP motivation needs to clearly show the utility for the LHC experiment, and also the choice of the demonstrator for LHC
- List of key questions for the WS to address

Yann: parameters

- Time available for measurement? Typically could expect 4-5 8h dedicated shifts per year. Ideally (for more time) would be in a parallel operation which depends on the stripper being ppm and the cycle length in the SPS SC
- Finding the overlap? Expect to be efficient once photons are seen, spatial, frequency and phase to be adjusted. Detector sensitivity crucial.
- Laser spot size? Too small, needs updating in the table.
- Operational aspects important to fold into the design of the experiment procedure

Jacek: transition

- Hartree-Fock equations starting point for more refined starting calculations
- Calculated energies are 230/232 eV pm 1%, what is maximum range to assume, 0.1% for the initial scan would be plenty. Reviewed best numbers on the 30th and added to the parameter table.
- What is an interesting absolute precision to measure the frequency? Around the 0.1 – 1 eV range. For sure, an absolute energy calibration of around 1e-3 would be interesting.
    - SPS to look at absolute level which can be reached (Bren/Francesco/Reyes/Yann) with all ingredients.
    - Absolute gamma precision in SPS is 3e-4, but need to add in all the other contributions.
- Lifetime 67-76 ps, pm 1%. Not clear the interest to measure this with any specific precision

Kevin: laser

- Wavelength fixed with 2e-4 tuning range, 1030-1040 central wavelength

- 1 uJ/pulse entering the cavity
- Polarization: purity needs to be very high, unlikely.
- Laser design, not progressed much, parameters updated somewhat
- Cavity design, looking also at 2 mirror cavity, many advantages, can reach 2.4 deg and 5 mJ in the cavity
- Temperature stability in tunnel important, to get info (Reyes)
- Looking at integration in tunnel
- Motorized movers or moving the beam? Prefer the latter, to be defined
    - Look at the beam position/angle range from correctors (Francesco/Yann)
- Radiation sensitivity, can plug in the electronics modules prior to the experiment. Can't be deported and not enough time to develop radiation hard versions.
- Need to discuss with CERN R2E experts to present the use cases, the doses, the electronics and define the follow-up.
- RF synchro signal needed locally
- Input needed from CERN on several aspects
- Impedance of cavity design crucial, needs evaluation

Valentine: laser integration

- List of requirements for laser system
- For tuning the laser up needs some sort of mobile barriers in the tunnel to allow work while access – needs a safety plan. Otherwise the system enclosure is fully closed and interlocked.
- LSS6 has space around the beam and also maybe for shielding, keep as baseline (LSS4/ECA4 if single-shot laser without cavity)
- Residual radiation levels OK
- R2E experts to look at the possible SEU effects of HEH and thermal neutrons
- Timing and synch is a separate task to be worked out. Should use the experience from AWAKE and extraction to LHC

Alexey: simulations

- Emitted fluorescence radiation is isotropic in ion rest frame
- Density of photons (using 2 deg. and 5 mJ Fourier limited laser) at 10 m and 80 mm from axis is 300 photons per mm^2 per bunch per turn. Check thermal load!
- Coming closer to the IP only intercept ions that decay early and reduce the occupancy for a pixel-type detector
- Maximum of 7-8 MeV mm2 per bunch per turn (at maximum), unless get closer to the axis

Thibaut & Mariusz: detection

- Start by assuming a ring-shaped detector with 1 cm transverse size around the ring, diameter = 80 mm
- Detector in vacuum
- Large photon flux in few keV range after 10 m

- Different technologies possible, already some established types in use (scintillators, diamonds, timepix …)
- Priority requirements for detectors are:
    - Sensitivity for finding the resonance
    - Dynamic range to optimize the parameters
- Characterization of the photon flux looks more difficult?
- Photon counting regime – SPS has non-negligible radiation and background, might affect the sensitivity
- Possible to have several identical detectors at longitudinal intervals? To evaluate
- Visible photons at the IP? Around 70 per crossing on resonance – experience in LHC on visible photon counting.
    - Need to check if we really see anything change while cooling or not – calculate the how the image changes?
- Commissioning time for detector? Should be very fast, and essentially the same for all technologies. Need to make sure the detector is alive, scintillator is certain to work, and can add a way to inject a calibration signal to check the rest of the system is alive.
    - Need to have a system that works from day 1. Everything installed in the vacuum needs to be fully robust.
- Pixel size for solid state? Many options.
- System for photon counting would have higher energy resolution for 2nd phase for spectral characterization.
- Precision on the knowledge of the absorption much higher than that of the emission, but precision needed on measured rate of emission. No energy discrimination needed.
- Micocalorimeters? Could involve in future discussions.
- Impedance…major concern.

Andrey: atomic physics

- Overlap with storage ring and accelerator facility at FAIR, for atomic physics
- Electronic structure:
    - Li-like, transition 2s1/2 -> 2p3/2 is inaccessible with conventional lasers, measured at GSI with resonant coherent excitation, interesting for GF?
    - Boron-like ions with 5 electrons, with 2p1/2 -> 2p3/2 which is perfect testing ground for relativistic and QED effects…experiments with EBIT only up to Cu24+, range of around 4 keV energy
- Parity violation:
    - Some advantages over neutral atoms, as simpler systems, large e-n overlap, effects scale with Z^5, levels with opposite parity almost degenerate
    - Rely on difference of the left- and right-circular polarization
- EDM and CP violation
    - Can polarize by repeated interaction with circular polarized laser, question on whether polarization can be maintained in SPS.
- Scattering
    - Elastic photon scattering important
    - Pair production in laser field, gives input into the knowledge of angle differential cross section for ion-atom collisions

- Should review and pick the most promising experimental idea for the SPS which would help immensely for the LOI to the SPSC
- Discussion on which of these are worthwhile or accessible for following up more for SPS PoP experiment, in view of useful conceptual or experimental development for LHC demonstrator? Spectroscopy of Li-like Pb is already very useful and valid stepping stone toward LHC.
- Dark matter with GF, should be seen as complimentary to beam dump experiment
- Twisted photons in 100 MeV range would be unique, as would circularly polarized gammas.

Discussion

- Optimization could include differential methods e.g. different isotopes
- Having a different scenario for the laser could be interesting, with a single pulse excitation without cavity. Will investigate intermediate approaches, also could serve as backup or staging. Can also be an option in case the radiation aspects prevent the location in the tunnel. Specify scenarios for this, Kevin/Stephen to generate a table
- What would be situation with monochromatic excitation? Would lose in efficiency and photons emitted, but would not change the spectral purity of the emitted photons in the lab frame.
- Physics of preservation of nuclear polarization? To investigate.
- Dynamic range of BI for bunch…depends on the accuracy with which we want to measure, to check per instrument as a function of time
- Commissioning and MDs, plan sequence, will be crucial to pre-commission everything possible. Prepare for the worst-case scenario.
- Should endeavor to publish some of the parts separately, as bringing the GF to the attention of the wider community.