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Experimental Design
Experimental Design

- Laser
- Wall
- Magnetic Field
- Plunger
- Phototube
Experimental Design

\[
P_{\text{regen}} = \frac{16B_1^2 B_2^2 \omega^4}{M^4 m_\phi^8} \sin^2 \left( \frac{m_\phi^2 L_1}{4\omega} \right) \cdot \sin^2 \left( \frac{m_\phi^2 L_2}{4\omega} \right)
\]

B1 = B2 = 5.0 T

L1 + L2 = 6.0 m

Oscillation Length: 3 m

\[P_{\text{regen}} = 4 \times 10^{-21}\]
Experimental Design

3.2 W laser

5ns pulse
20 Hz

100 Hz noise

signal rate = $4 \times 10^{-3}$ photons/sec

coincident noise rate = $1 \times 10^{-5}$ photons/sec

signal-to-noise ratio = 400
Design Goals

- Black = BFRT 3 sigma upper bound
- Pink = PVLAS 5 sigma signal region
- Grey = GammeV 3 sigma exclusion with 5 hours running at each plunger position
  - Blue = center of magnet
  - Red = 0.8m from end
- By changing the baseline, we cover the entire PVLAS signal region

GammeV

\[ m_\phi \, [\text{eV}] \]

BFRT limit
PVLAS IR rot.
L1=3.0, L2=3.0
L1=0.8, L2=5.2
Systems

- Optical System
  - Laser
  - Alignment system
  - Detector
- Mechanical System
  - Magnet
  - Vacuum
  - Plunger
- Electronic System
  - Control
  - Data acquisition
Optical System
Optical System

5ns pulse
160 mJ/pulse
20Hz
532nm

Pre-alignment path (3m)

Low-power Alignment Laser

Movable Mounts

Photodiodes for monitoring scattered light

Power Meter
Optical System
Optical System

- Incoming and return beams
- Focusing Mirror (10m focal length)
- Plunger
- Party/Photon trajectory
- Dark Box
- Focusing Lens
- PMT Detector
Optical System

Hamamatsu H7422P-40 PMT
100 Hz dark current
40% QE

Dark Box
Optical System
Mechanical System
Mechanical System

- Spare Tevatron dipole magnet
  - 5T magnetic field

- Dark box adapter

- Guide rail and chain-driven carriage

- Spare LHC warm bore evacuated to <10^{-4} torr

- Plunger evacuated to <10^{-4} torr
Mechanical System

Guide rail, carriage, and adapter

Tevatron dipole magnet
Mechanical System

Magnetic Field vs. Current

Magnetic Field vs. Position
“QuarkNet” boards control the laser and data acquisition systems.

- Sample time to 1.25 ns
- Configurable with FPGA
- Graphical user interface
- Well understood
  “QuarkNet” is a public outreach cosmic ray detector array for high school students
GammeV Apparatus
Schedule

- November – first discussion
- April – review and approval
- May/June acquire or machine parts
- Currently
  - Assemble apparatus
  - Test electronics
  - Calibrate PMT
- July – start taking data
Conclusions

- Variable path length allows us to probe different particle masses
- Pulsed laser system gives high signal-to-noise ratio (400)
- Relatively simple design reduces phase space of “things that go wrong”
- Small budget, small team, small scope, table top experiment

http://gammev.fnal.gov