Secondary Particle Flux Detectors for the MERIT Experiment

Outline

- What we want to measure
- Experiment layout
- Error sources
- Detector possibilities

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What we want to measure

Questions to answer:
- Is there any particle yield reduction at high beam intensities?
  - Simulate high intensities with pump/probe method
- Is there any cavitation developed that reduces the effective target length?
  - We know that cavitation occurs but how it develops in a 15T magnetic field?
  - The times involved are “slow”, c~1.5km/sec not

Target parameters - reminder:
- 1-cm diameter Hg jet, \( v \approx 20\text{m/s} \)
- Pump-probe method to simulate target excitation and 50 Hz operation as in \( \nu \)-fact
- Proton beam:
  - 24 GeV/c from the PS (single turn)
  - 14 GeV/c (multiple turns, \( \Delta t > 1 \text{us} \))
- Bunch length:
  - 50ns (base), spaced every 131ns

PUMP: 6 bunches, \( 15\times10^{12} \) protons
PROBE: 2 bunches, \( 5\times10^{12} \) protons
The Experimental Layout

- Particle Detectors
- Cryo controls
- Hg loop controls
- HYDR. PUMP
- Optical Diagnostics
- DVB
- HEATER
- Beam profile measurement
- Beam Dump
- Solenoid / target
- Hg-loop system
Strategy

- No need to measure sub-bunch structure, i.e. integrate answer for each bunch
- **Relative** measurement between bunches
  - i.e. compare 6 measurements (pump) to two measurements (probe)
- Aim to an overall precision of few %
  - 5% should be possible, even 10% would be sufficient as answer

Detector requirements and constraints

- **Integrate** particle counting within **60 ns** (50ns pulse + margin)
- Readout within 60 ns or storage (memory)
- High particle fluxes: ~$10^7$ particles/cm$^2$/bunch
- Radiation
- Magnetic field
MERIT - Particle Detection System

**Measurement precision:**
Relative measurement between bunches → two sources of error

1. **The knowledge of the beam**
   - Beam intensity (bunch-to-bunch)
   - Beam direction ({x, y} at target, angle)
   - Beam longitudinal length (bunch shape, out of bunch particles)

2. **The precision of our detectors**
   - Number of particles to integrate, S/N
   - Stability over time
   - Acceptance vs target configuration
Input beam definition

Intensity measurement - Bunch-Current-Transformers (BCTs)

1. Inside the PS ring just before extraction
   - possible to measure bunch per bunch; 2-5% precision can be achieved

2. At TT2 transfer line, right after extraction
   - measure total intensity of the extracted beam

- Measurement error:
  - BCT precision, assuming same losses for pump and probe bunches in the TT2 line
    - Calibrate the two BCTs using a single turn extraction at 14 and 24 GeV/c
  - Kicker current setting would contribute for multiple turn extraction
    - Could be measured/corrected afterwards

- Test of kicker repeatability – during 2006 MDs ???

- Beam simulations:
  - particle losses in TT2 vs kicker setting
  - beam location at the MERIT target vs kicker setting
Input beam definition

Beam spot and angle measurement

1. Use beam profile monitors installed upstream of the experiment
   - Baseline: MTV screens
     - <1mm precision
     - 3 m distance → 160 micro-rad precision
   - Provide \{x, y\} location
   - Alignment: <0.3 mm relative between target and MTVs (6 m)

2. Alternative option:
   - BPMs of LHC

Longitudinal bunch shape

- Measured online inside the PS ring
- Gives also the number of particles out of bunch (<% effect)

All measurement data can be fetched from the PS control system logs
Particle fluxes

- MARS simulation results

- Detector locations:
  - at large angle around Z=0 cm
  - at large angle downstream
  - Cherenkov signal of fast protons
  - Small detectors
    - scintillators or silicon diodes
  - Behind the dump in straight line
  - Muon detector (scintillator)

- Particle fluxes:
  - $\sim 10^7$ particles/cm$^2$/10$^{12}$pot
  - 3x3 cm$^2$ detector
  - $\Rightarrow$ 10$^8$ particles /bunch

Fluxes of charged particle per pulse. $3 \cdot 10^{13}$ proton in pulse.

S. Striganov – 18.10.2005
The Experimental Layout

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**Beam profile measurement**

**Solenoid / target**

**Hg-loop system**

**Beam Dump**

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Threshold Cherenkov counter:
- 1m long pipe, 156mm OD
- Filled with N2 gas, set to pion threshold at >5 GeV/c
- Pb sheets in front to reduce electron rate