Pixelized Photodetectors for Dual Readout Calorimetry?

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Background: Why?

- W's and Z' and hadronic jets may become the fundamental tool to unravel the physics of the newly discovered families of particles at ~ TeV scale
- High resolution hadron calorimetry can be accomplished with total absorption calorimeter. Scintillation is the primary (the only?) detection technique.
- Dual readout (scintillation+Cherenkov) enables a shower-by-shower correction for nuclear energy losses, thus offering a prospect of hadron energy resolution in the range $(0.1\text{-}0.15)/\sqrt{E}$

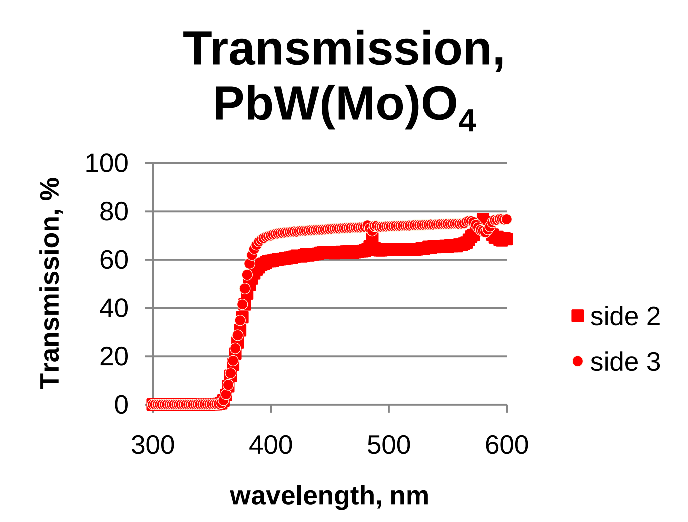
New Avenues

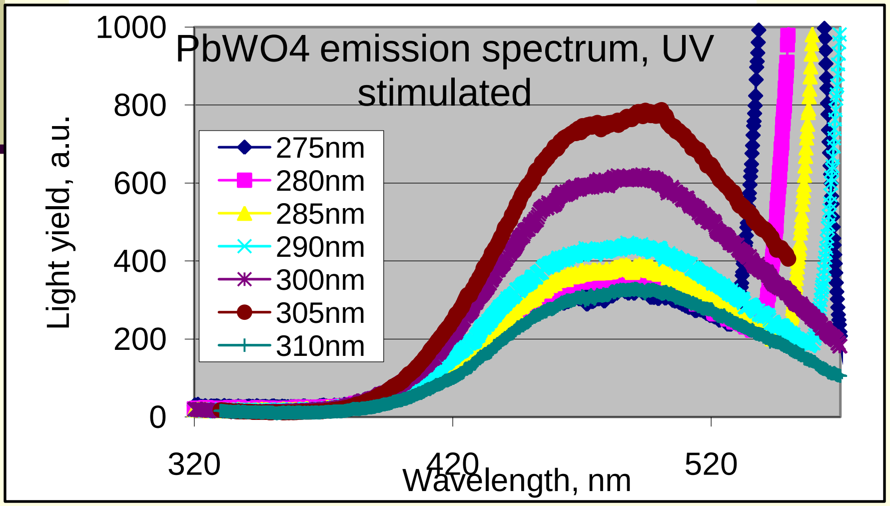
- Detection of Cherenkov light as a part of a calorimetric measurement offers new interesting capabilities of charged particle identification via:
- Time-of-flight (especially in conjunction with pico-second timing capabilities)
- Threshold Cherenkov
- Ring imaging Cherenkov
- Particle identification capabilities of the dual readout calorimeter are primarily related to the photodectors used for the Cherenkov component. Synergy with ‘Fast timing’ (Chicago) and ‘Large area fast photodetectors’ (Argonne) initiatives

High Resolution Calorimetry Development

- New dense, inexpensive crystals optimized for dual readout
- Photodetectors for scintillation and Cherenkov component. Principal challenges – Cherenkov light detection:
  - Spectral sensitivity
  - Area
  - Time resolution
  - Pixelized readout
- Evaluation of crystals and photodetectors
- Development of front-end readout electronics
- Detailed simulations, understanding of the underlying physics, detector design optimization

Crystals Characterization





- Existing infrastructure at Lab 6 very helpful
- but somewhat limited
  - size of allowed samples
  - functionality (spatial variation of the crystal properties)
- Need also characterization of mechanical properties of crystals:
  - Young's modulus
  - Poisson ratio

Crystals+Photodetectors Characterization

- (Under design and construction): Cosmics/test beam telescope for the evaluation of light yield (scintillation and Cherenkov) of various combinations of crystals and photodetectors
- Development of the crystal calibration and monitoring procedure is of critical importance to achieve high energy resolution of a calorimeter

Photodetectors for Dual Readout

- SiPM/MPPC are likely adequate candidates for the readout of scintillation light. The principal challenge is the precise response calibration. Elimination/reduction of afterpulsing would be of huge importance.
- Cherenkov readout is a primary challenge:
  - Large(r) area blue sensitive SiPM's ? Large dark count rate may not be a big problem given the fast timing of the signal
  - Large area APD's? (problematic..)
  - New inexpensive and compact, pixelized photodetectors based on a photocathode (Argonne)?
  - Performance of these detectors (time resolution and pixelized readout) is the key to the particle ID capabilities of the calorimeter. (Note: this pixelization has nothing to do with the pixelization of the SiPM)

Front-end Readout Electronics

- Readout electronics must be optimized for the photodetectors (electrically, and mechanically: formfactors, granularity)
- SiPM’s are likely candidates for the readout of the scintillation component (at least) of the calorimeter.
- SiPM’s are rapidly becoming very popular and adopted for many applications (CMS upgrade a good example). Their applications are somewhat limited by the lack of readout schemes. Vendors provided some solutions, but they are limited to small scale applications (gigantic size, huge price)
- Attractive solution/opportunity: SiPM-oriented ASIC with a broad range of functionality:
  - Bias voltage adjustment
  - Rate measurement/self-calibration
  - Pulse shaping and integration
  - Time measurement
  - Temperature readout
  - Temperature regulation