PIP2IT Extinction Measurment

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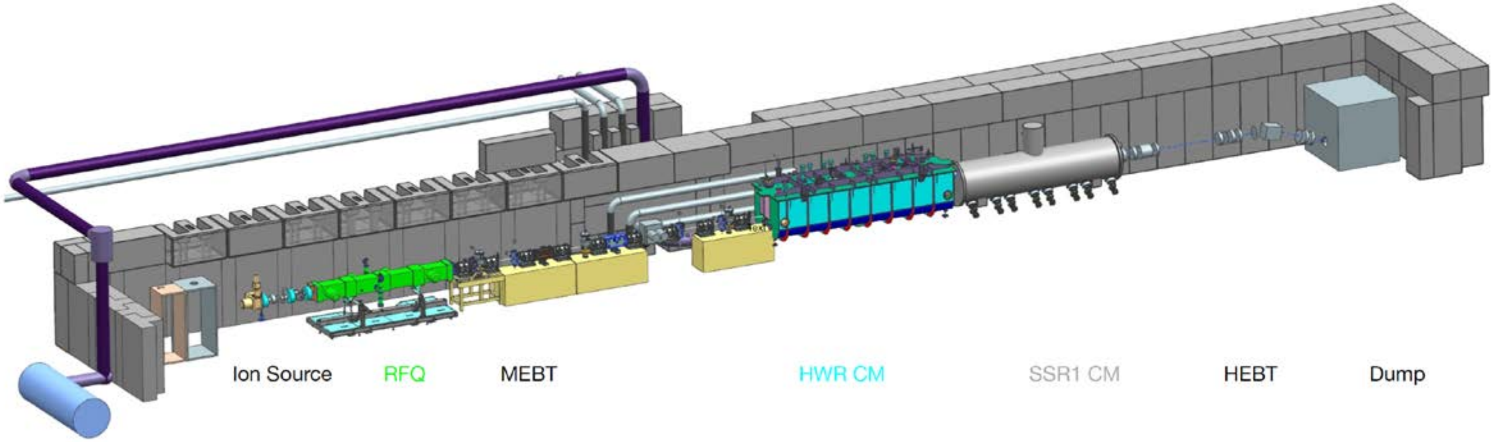
Outline

- PIP II Injector Test (PIP2IT)
- Basics of H-
- Outline of insertion region
  - Entrance sweeping magnet
  - Laser system
  - Exit sweeping magnet
  - Electron detection

PIP II Injector Test

- The PIP-II Injector Test (PIP2IT) accelerator is located at CMTF
- Will be operating with a 25 MeV H^- beam by 2020
- There is a location designated for diagnostic instruments where the extinction measurement system could be installed



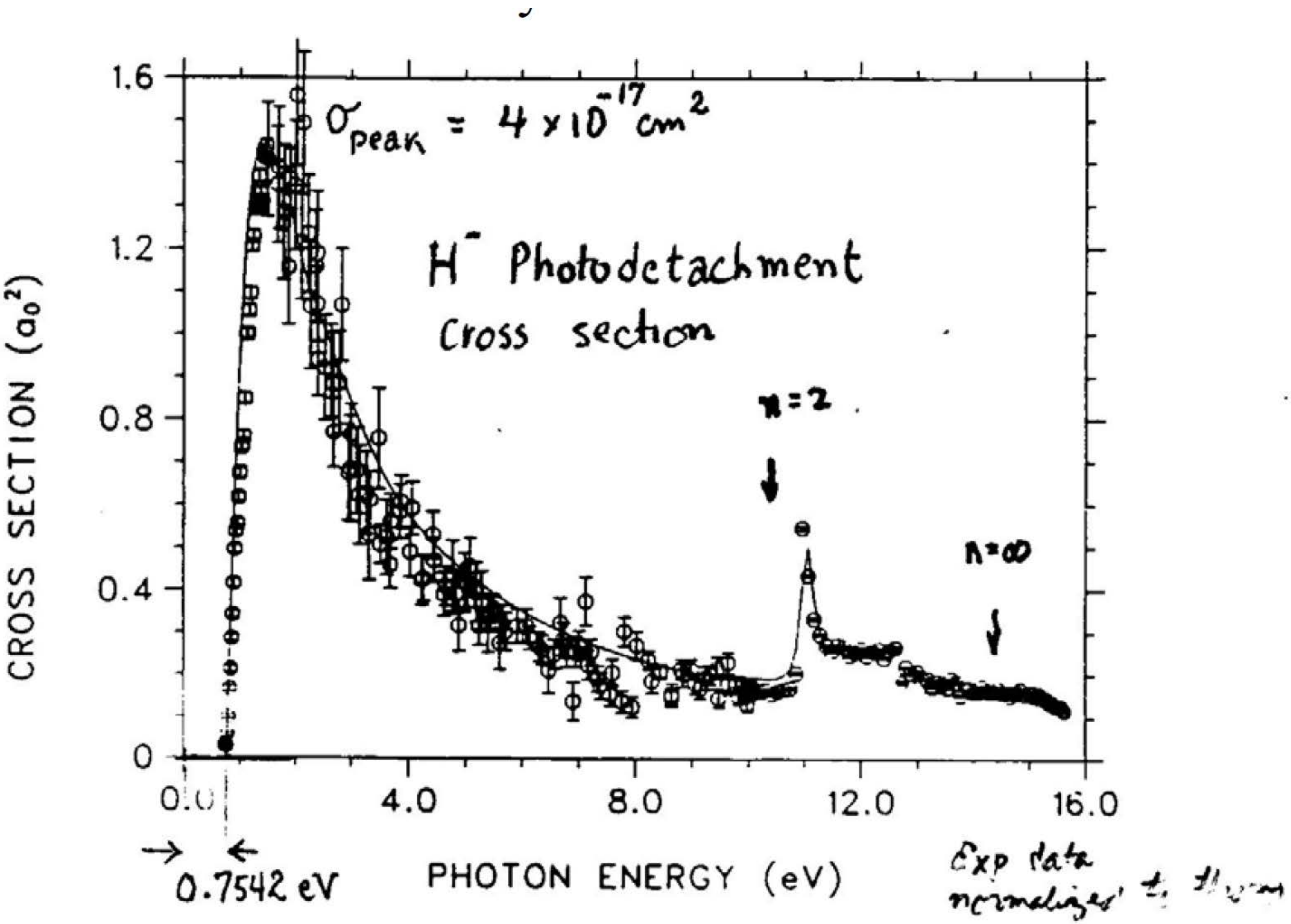
PIP II Beam Chopper

- The PIP-II project has developed a beam chopper that can create a programmable bunch pattern at 162.5 MHz.
- The ratio of beam in the programmed bunches to beam in the ‘empty’ bunches is important for calculation of backgrounds.
- The requirements for the PIP-II project are much weaker (ratio of 10^{-3}) than the requirements for Mu2e-II (ratio of 10^{-11}).

Basics of H^-

- We will talk about three species:
  - Proton - p
  - Neutral Hydrogen – H
  - Hydrogen with an additional electron - H^-
- H^- has one stable state – no excited states
- The "second" electron is bound at 0.7542 eV
- H^- can be photoionized:
  - Neutralize: $H^- + \gamma \rightarrow H + e^-$
  - Ionize: $H^- + \gamma \rightarrow p + 2e^-$

Basics of H^-



σ_peak = 4 × 10^-17 cm^2
H^- Photodetachment
Cross section
n=2
n=∞
CROSS SECTION (a_0^2)
1.6
1.2
0.8
0.4
0
0.0
4.0
8.0
12.0
16.0
0.7542 eV
PHOTON ENERGY (eV)
Exp data

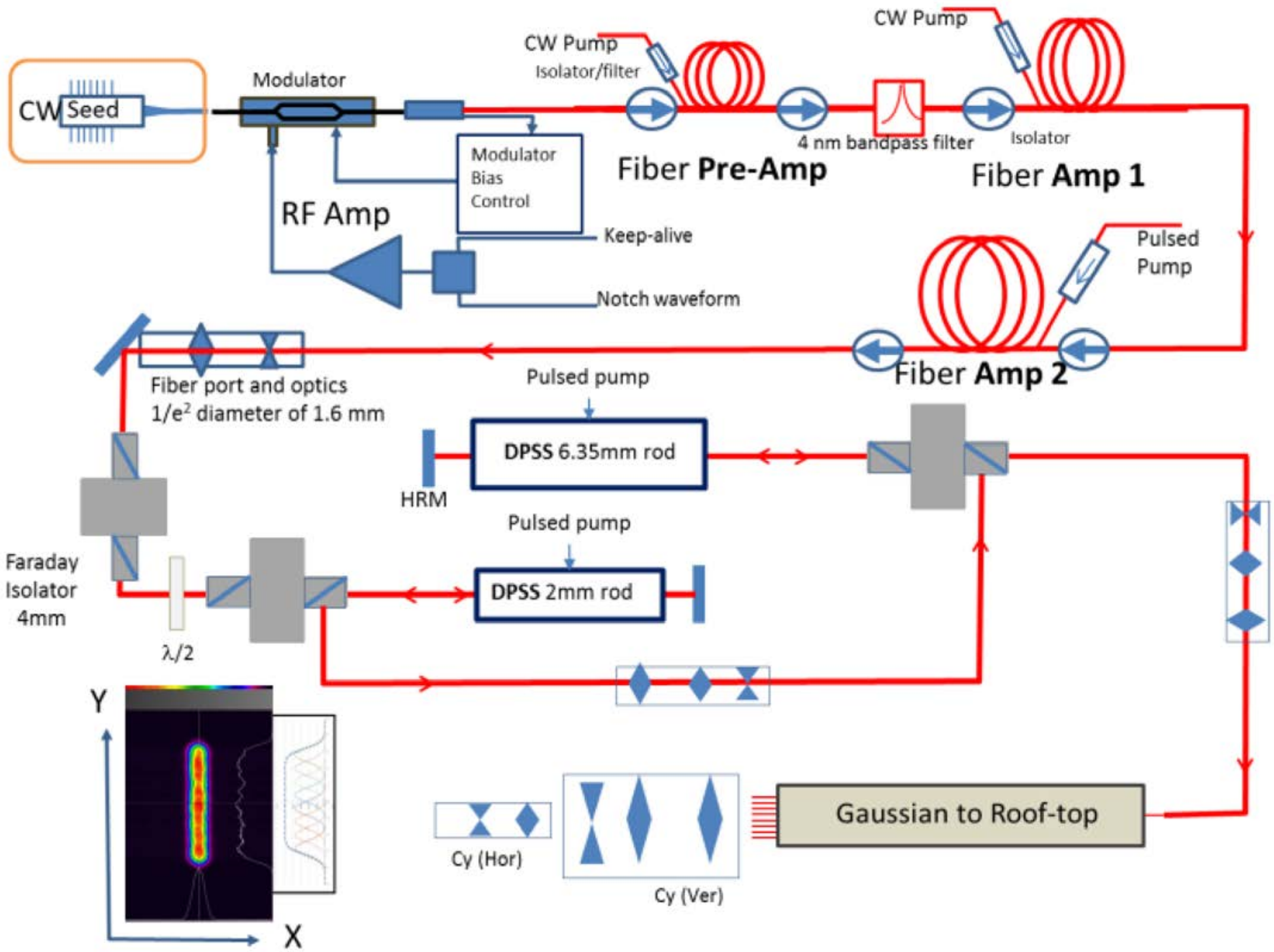
Neutralization

- As the H^- propagates through the accelerator there are several neutralization processes:
  - Interaction with black body radiation
  - Interaction with changing electric or magnetic fields
  - Interaction with residual gas
- Our initial calculations show black body radiation and residual gas are the largest effect.
- Consequently, the beam will consist of H^-, H and e^-

Insertion region

- Because there will be electrons in the beam from the neutralization processes, we insert a few hundred gauss dipole to sweep the electrons out of the beam
- We then introduce a laser beam, synchronized to the RF system so it only pulses during the time when the beam should be extinguished.
- The laser system is reflected several times down the insertion region.
- The liberated electrons will have the same velocity as the H^-, so the momentum will be 12.5 keV.
- This is similar to the Notcher in use in the linac.

Simplified Notcher Laser System



Insertion region

- A second dipole magnet sweeps the 12.5 keV electrons into a detector, and restores the direction of the H^- beam, although with a shift.
- To measure extinction to 10^{-11} need to look for a single H^- in 1000 pulses.
- Need high efficiency of neutralization and high efficiency of electron detection.
- Have looked at several devices
  - MPPC with thin coating
  - Electron multiplier tube
  - Micro channel plate

Status

- We have submitted a LDRD proposal.
- We have been working on making detailed calculations.
- We are setting up a test for 10 keV electrons, starting with a UV MPPC from Hamamatsu.