PDPWA Spectrometer

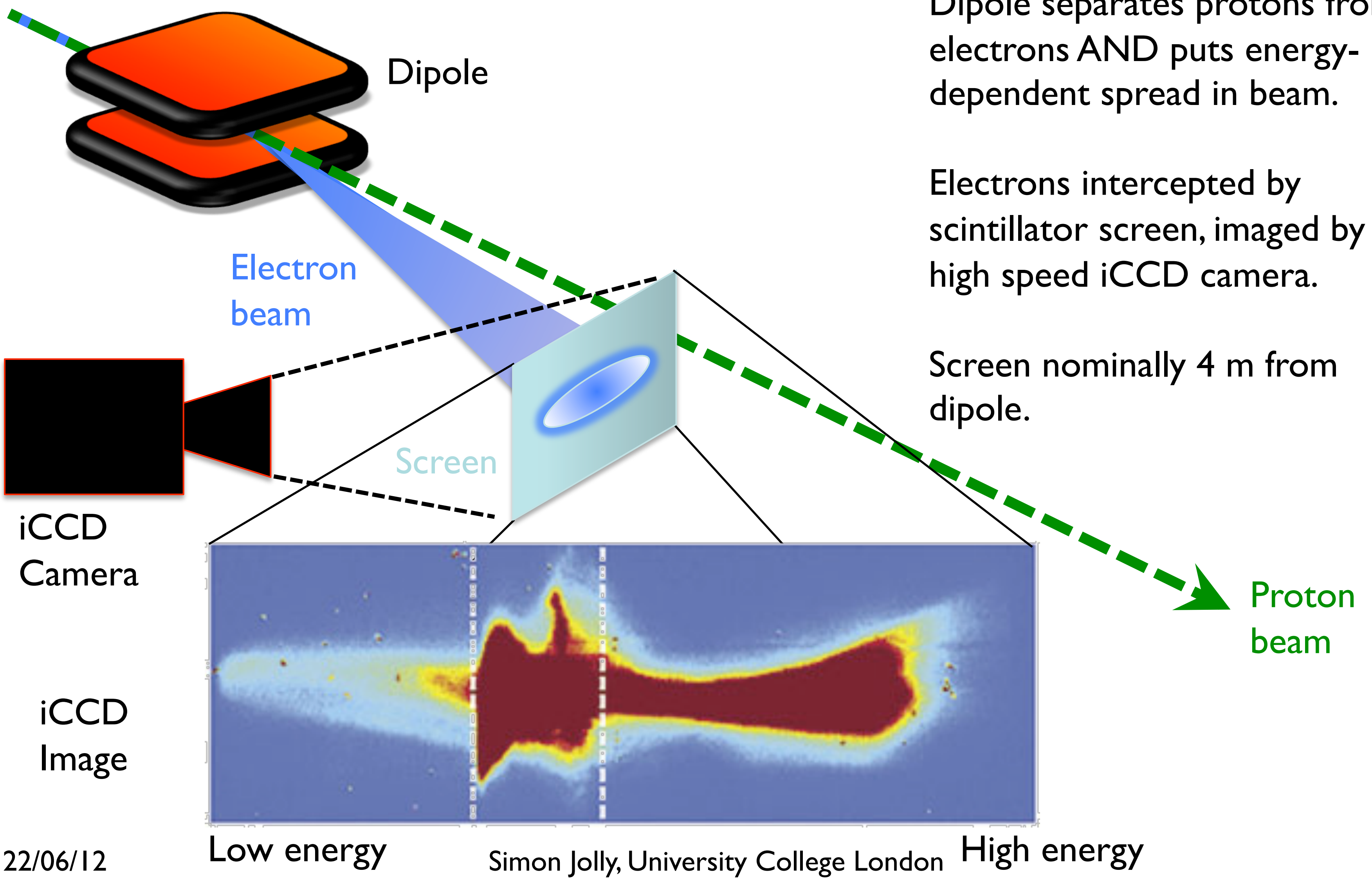
Simon Jolly (UCL)

22nd June 2012

Spectrometer Specifications

- Wakefield accelerated electrons ejected colinear with proton beam: need to separate the 2 and measure energy of electron beam only.
- Must be able to resolve energy *spread* as well as energy: spectrometer must accept a range of energies, probably 0-2 GeV.
- Simple conceptual layout:
  - Dipole mounted at plasma exit separates proton and electron beams.
  - Scintillator screen 4 m downstream of dipole intercepts electron beam ONLY.
  - Scintillator imaged by intensified CCD camera viewing upstream face of scintillator screen.

Spectrometer Layout



Dipole separates protons from electrons AND puts energy-dependent spread in beam.

Electrons intercepted by scintillator screen, imaged by high speed iCCD camera.

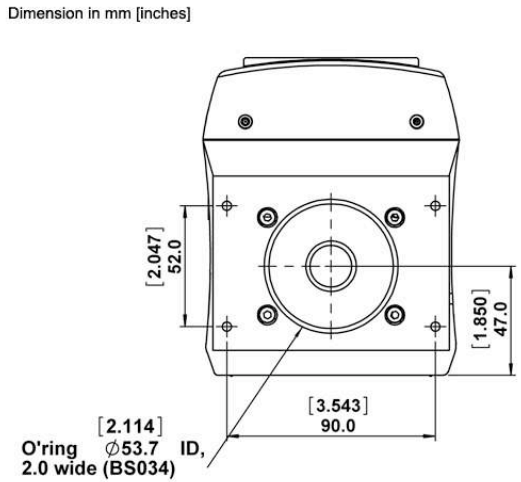
Screen nominally 4 m from dipole.

Spectrometer Simulations

- Beamline simulations to be carried out in General Particle Tracer to fix preliminary component layout.
- Stage 1:
  - 2-D Gaussian beam, 0-2 GeV uniform energy spread, ideal dipole field.
  - Track beam from plasma exit 4 m downstream to screen.
  - Include proton beam: make sure we have good separation and adequate energy resolution.
  - Check effects of increasing drift or dipole field.
- Stage 2:
  - Include "real" beam from plasma simulations.
  - Rerun particle tracking, optimising layout for best energy resolution.
- Stage 3:
  - Measure field uniformity and fringe fields of real dipole magnet.
  - Include in particle tracking as field map: check effect of real fields on energy resolution.
- Important: shorter dipole-to-screen distance means $\Delta\theta$ dominates over x' from beam. Disadvantage is more powerful dipole required: are there any others? Fringe fields?

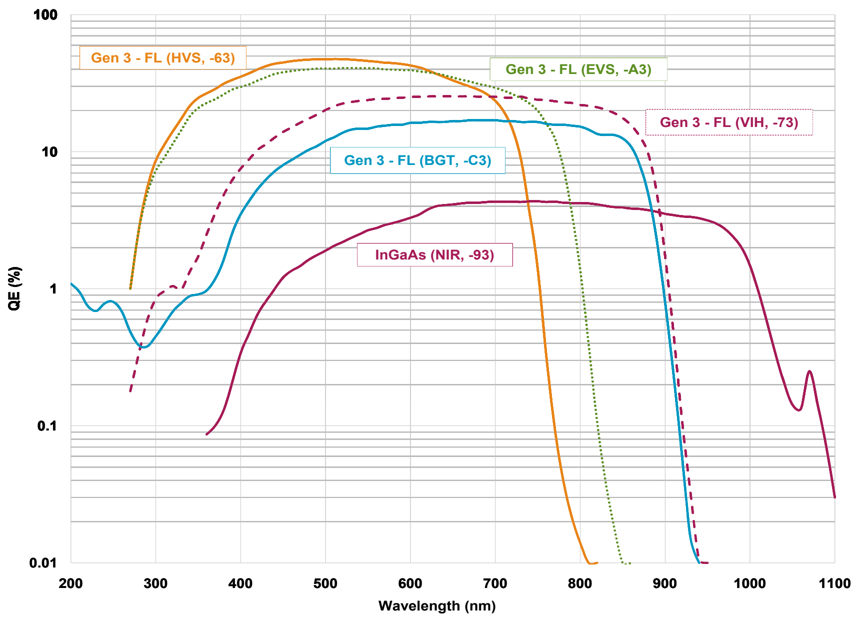
Spectrometer Camera

- Camera already selected (funds approved within UCL).
- Andor iStar 340T iCCD camera:
  - 2048 x 512 total pixels (1850 x 512 or 1330 x 512 active, depending on 18 mm or 25 mm intensifier).
  - 13.5 um pixels.
  - Gated intensifier <2 ns.
  - 16-bit readout, 150 ke^- pixel full well.
  - http://www.andor.com/scientific_cameras/istar_iccd_camera/340-intensified-sensor/
- Camera setup:
  - DAQ and control software.
  - Data analysis software to give online measurement of witness beam energy spectrum.
  - Mechanical design of camera support system for tests and installation in SPS tunnel (comes later).

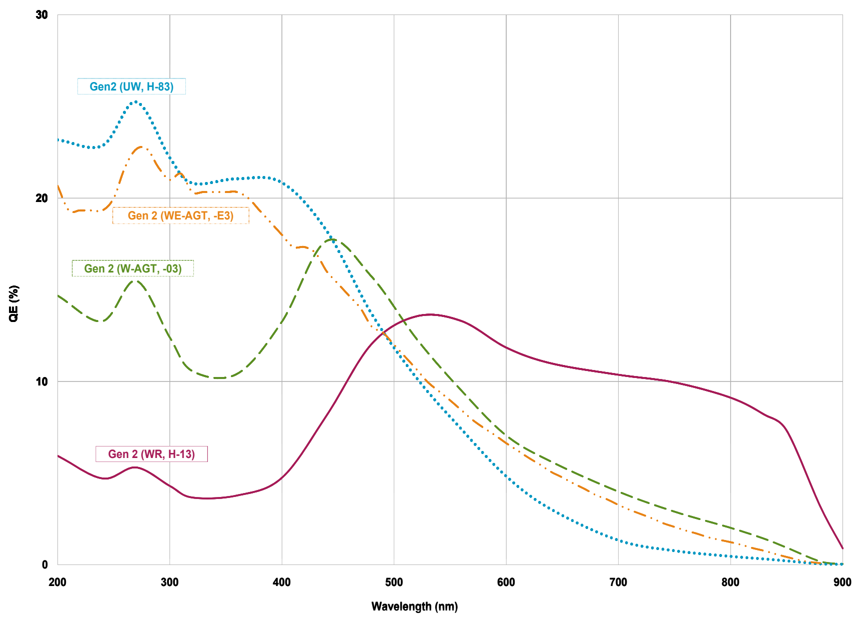


340T Intensifier Options

Gen 3 Intensifiers



Gen 2 Intensifiers



Workplan

- Simulations to determine overall and detailed design
- Purchase of camera, software interfaces, setting up DAQ
- Assessing and testing different scintillators
- Tests of scintillator, camera DAQ set up at RAL : wakefield experiment with natural electron energy spread
- Design of magnet system. Then need cooperation (ASTeC, CERN, …) for build.

Questions for the Collaboration

- What is the likely energy range of the witness beam?
- Is there an electron cloud surrounding the proton beam?
- Are there any preferred scintillators? Al_2O_3 (used in LHC)? YAG:Ce? Need:
  - High light output.
  - Radiation hard.
  - Vacuum safe.
- What spectral range should the iCCD intensifier cover? Higher QE across only visible or broader range with lower QE?
- What limitations are there on the geometry of the whole setup? Could we go to 10 m drift (for example) from dipole to screen rather than 4 m?
- How close can we place camera to beamline? Closer means more light captured but greater chance of radiation damage…