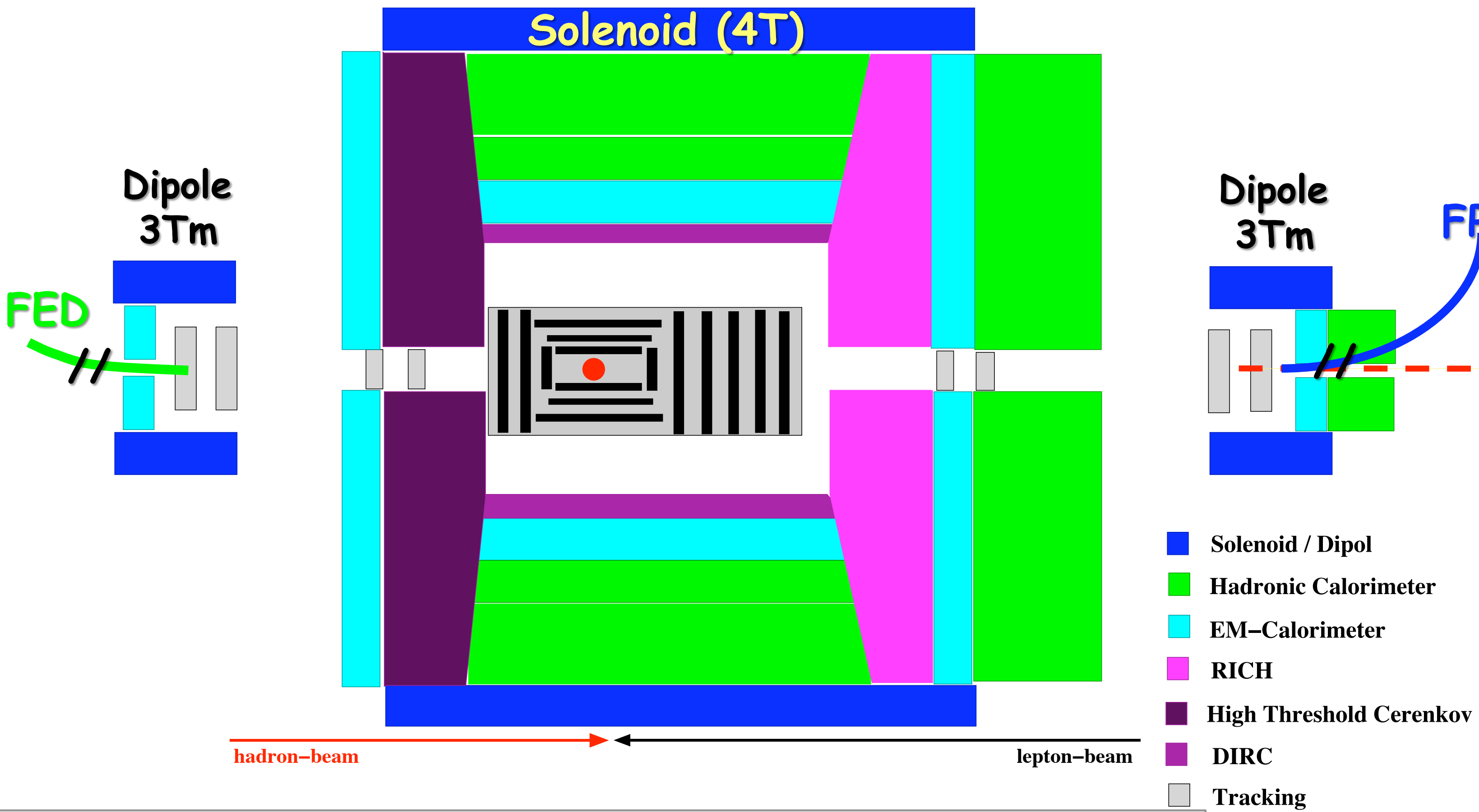
# Common Detector R&D Plan for MeRHIC & MEIC

# First ideas for a detector concept




- Dipoles needed to have good forward momentum resolution
  - Solenoid no magnetic field @ r ~ 0
- DIRC, RICH hadron identification → $\pi$, K, p
- high-threshold Cerenkov → fast trigger for scattered lepton
- radiation length very critical → low lepton energies

# Common Detector R&D

- low mass vertex-tracker / tracker
  - important to keep resolution for low energy scattered electrons as good as possible
    - Possible solutions
      - Gossip (investigated by LHeC)
      - GEM-Tracker (STAR)
      - high resolution gas-chambers
    - TRD
      - combine tracking and lepton/hadron separation
      - develop a radiator which allows e/h at low momentum p~1GeV (compare Alice-TRD)
- PID @ mid-rapidity
  - develop a detector concept to separate $\pi$, K and p for momenta =< 4 GeV
    - Possible solutions
      - DIRC Panda vs. BABAR concept
      - high resolution ToF ~20ns → 4 GeV@1m from IP
        - Multi-Gap Resistive Plate Chamber (MRPC)

# Common Detector R&D

- Photon detection
  - develop cost-effective photon detection replacing PMTs
    - Possible Solutions
      - big area SiPMs
        - work in magnetic field without any shielding
        - large dynamic range (number of pixels)
        - extremely compact → space → hermitcity
        - cost effective → no light guides
      - HPDs
- ION Polarimetry
  - need small systematics ~3% with high statistics → bunch by bunch measurements
    - protons: high intensity polarised jet vs. unpolarised jet
    - He-3: how ? Will the technology for proton work

# Fast DAQ/Electronics R&D

Prove that a DAQ/trigger system can handle the high event rates and data volumes (a combination of luminosity, detector channels, multiplicity and background) associated with the highest-projected luminosity and, for MEIC, with RF at frequencies of 0.5 (1.5) GHz.

1) MEIC/ELIC specific: Push event readout @ relatively small event size

- Explore development of higher channel density per Flash ADCs
- Continue development of on-board high-speed FPGA, including algorithm development, timing simulation, and board layout techniques
- Include latest high-speed Gigabit serial I/O for transporting readout and trigger data. Includes firmware, timing simulation, layout analysis
- R&D for a VXS "switch" path for the event readout data from each crate exceeding present VME readout rate.
- Continue R&D with latest FPGA devices and develop global trigger algorithms for use with pipeline front end modules and large scale, complex detector geometries. E.g., R&D inclusion of vertex tracking in trigger algorithm.

2) General (Common R&D): Push data volume rate

- Develop fast zero subtraction electronics to minimize data volume
- Faster ASIC chip development for inner detector readout

# (MEIC) Detector/IR Critical R&D

The most critical "pre-R&D" is to prove that a DAQ/trigger system can handle the high data rates (a combination of luminosity, detector channels, multiplicity and background) associated with the highest-projected luminosity and RF at frequencies of 0.5 (1.5) GHz. We anticipate this to be a 2-3 year project done in close collaboration between the Fast Electronic Group and the MEIC Nuclear Physicists.

This requires (see slides in Appendix for details):

1) 5.5 FTE-years:
   - one electrical engineer for a three-year period
   - one electrical designer for a three-year period

2) $150K in procurements
   - applying 40% of contingency/overhead

*Note: in 2007 this task was estimated as 10 FTE-years and $700K M&S, and was as 5-year task included in plans presented to NSAC/LRP and DOE/NP.*

Next-in-line most critical MEIC "pre-R&D" item:
Effort from SC Magnet engineering manpower starting FY10, totaling about 4 FTEs, + small ($300K?) contracts to verify feasibility of detector and final-focusing SC magnets (following 12 GeV model)

# BACKUP

# Appendix: MEIC Physics Most Critical R&D

| Activity | Detailed Description | Manpower |
|---|---|---|
| Flash ADC | Explore the development of higher channel density per module. ADC available at higher sampling rates but power consumption is a significant challenge. New multichannel, low power devices with serial outputs are attractive. | .5 FTE (EE) |
| FADC FPGA | Continue development of on board high speed FPGA using the latest FPGA devices. Development includes algorithm development work, timing simulation, and board layout techniques | .5 FTE (EE) |
| Gigabit FPGA | Continue development with FPGA that contain the latest high speed Gigabit Serial I/O for transporting readout and trigger data. Development includes firmware, timing simulation, and board layout analysis tools | .5 FTE (EE) |
| Event Readout (DATA Path) | Build on the existing success of our VXS trigger data transmission. Begin R&D for a VXS 'Switch' path for the event readout data from each crate that easily exceeds the present VME readout data rate. | 1 FTE (EE) |
| Global Trigger FPGA Processing | Continue R&D with the latest FPGA devices and develop global trigger algorithms for use with pipeline front end modules and large scale, complex detector geometries | 1 FTE (EE) |
| Computer Aided Design Computer Aided Engineering CAD/CAE | This is not R&D, but the manpower associated with the R&D efforts will require Designers with expertise in high speed, multi-layer circuit boards, schematic capture, and circuit board modeling tools. | 2 FTE (ED) |
| TOTAL (FTE) | | 5.5 FTE |

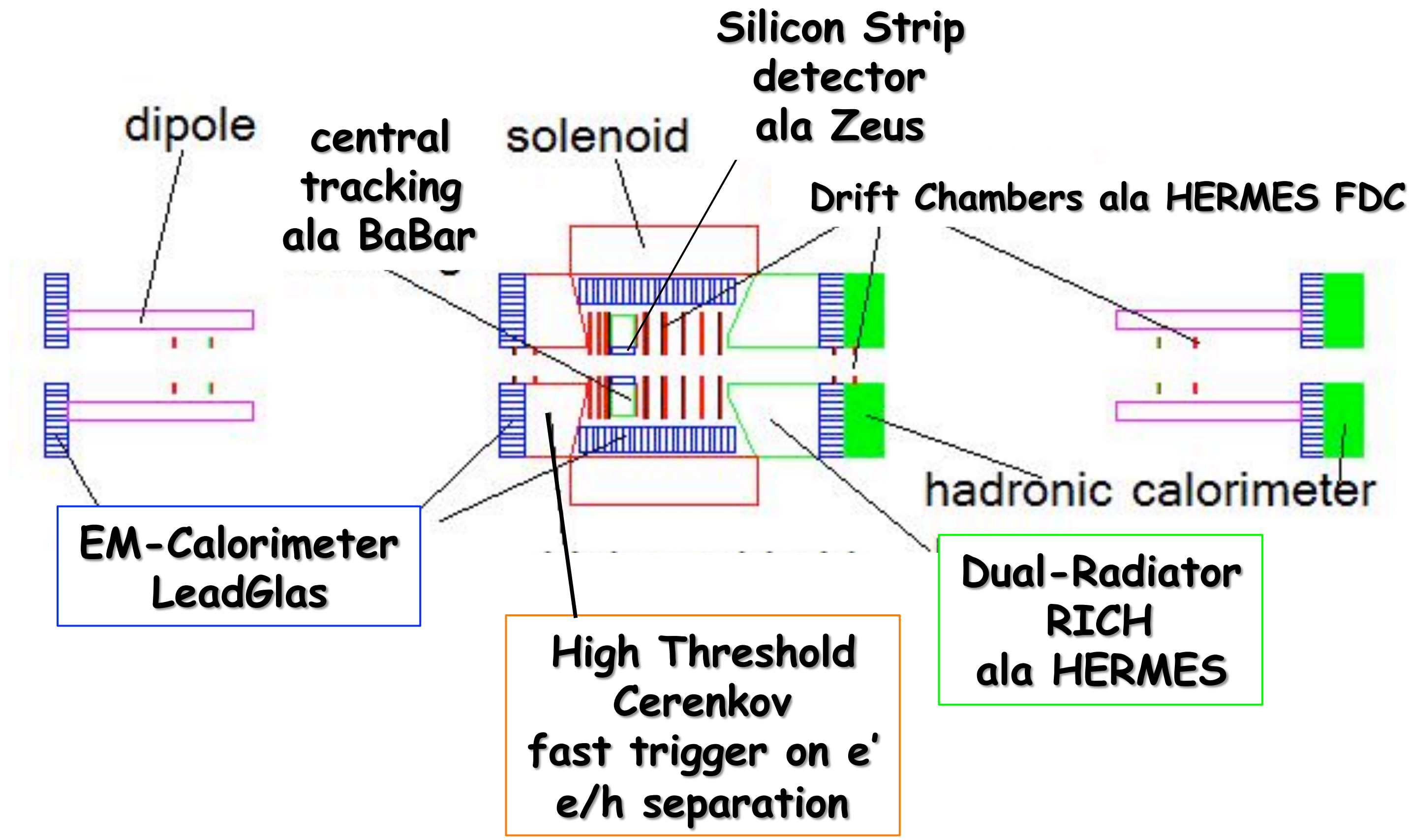
# Appendix: MEIC Physics Most Critical R&D

| Procurements | | Cost (USD) |
|---|---|---|
| FPGA Tools | Xilinx or Altera full development tools (2 Licenses) | $6K |
| Schematic capture; Board Layout | "Altium" design suite or equal (2 Licenses) | $8K |
| VHDL Synthesis and Simulation Tools | Aldec, MicroSim, or other tools from FPGA vendors (2 Licenses) | $6K |
| FPGA Evaluation Modules | Latest versions of FPGA devices available from vendors for testing and algorithm simulation (2 eval kits) | $6K |
| Oscilloscope | Digital Serial Analyzer (DSA) for high speed multi-Gigabit serial devices and circuit designs | $50K |
| Test crates | VXS full crate with power supply | $10K |
| Peripherals | Board extenders, fiber optic devices, test equipment, cabling | $15K |
| | | |
| TOTAL | | $101K |

# Detector Requirements from Physics

- ep-physics
  - the same detector needs to cover inclusive (ep -> e'X), semi-inclusive (ep -> e'hadron(s)X) and exclusive (ep -> e'pπ) reactions
    - large acceptance absolutely crucial (both mid and forward-rapidity)
    - particle identification is crucial
      - e, π, K, p, n over wide momentum range and scattering angle
      - excellent secondary vertex resolution (charm)
    - particle detection to very low scattering angle
      - around 1° in e and p/A direction
      - → in contradiction to strong focusing quads close to IP
  - small systematic uncertainty (~1%/~3%) for e/p polarization measurements
  - very small systematic uncertainty (~1%) for luminosity measurement
- eA-physics
  - requirements very similar to ep
    - challenge to tag the struck nucleus in exclusive and diffractive reactions.
    - difference in occupancy must be taken into account

# MeRHIC Detector in Geant-3




- DIRC: not shown because of cut; modeled following Babar
- no hadronic calorimeter in barrel, because of vertical space @ IP-2