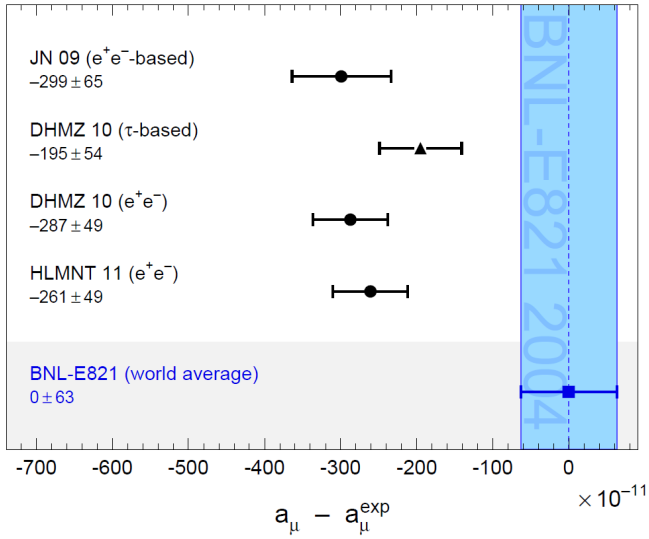
G.Simi

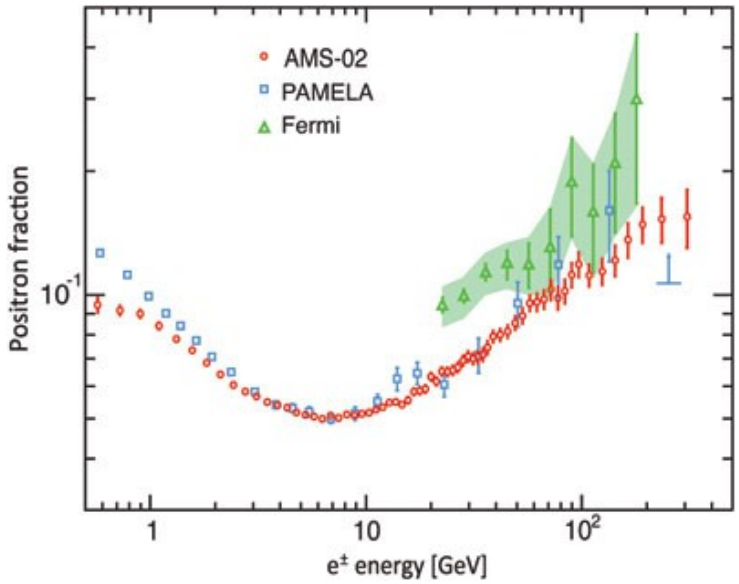
Consiglio di sezione INFN Padova

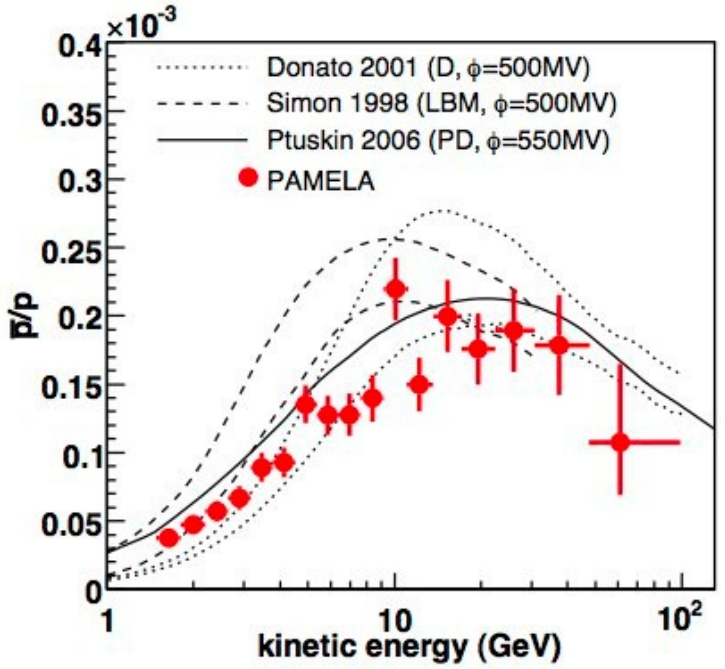
14/7/2014

Motivation

- Positron excess in PAMELA/AMS data
  - Difficult to explain by thermal DM annihilation
- g_μ-2 anomaly
- DAMA/LIBRA modulation
- 511 KeV line from galactic center

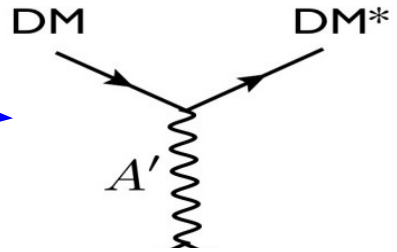




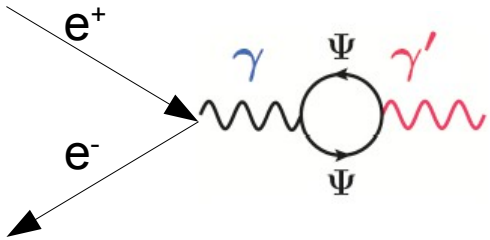


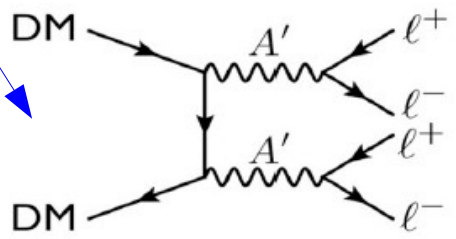
Hidden sector

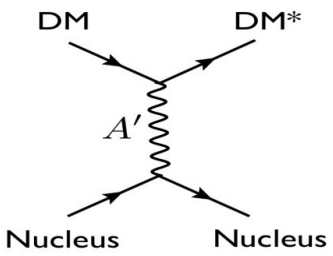
- New U(1)' gauge symmetry ⇒ A' gauge boson, force mediator for Dark Matter
  - Coupling to SM trough kinetic mixing $\varepsilon \sim 10^{-2}$–10^{-6}
  - [Holdom, Phys. Lett B166, 1986]
- Positron excess could be explained by DM annihilation into hidden sector photons
- g_μ-2 anomaly by a modification of the vertex diagram (PRD79,015014 PLB671,391)
- DM signal in DAMA/LIBRA from inelastic scattering via A' exchange
- Absence of anomaly in anti-protons
  - $M_{A'}<1$GeV
- Beam dump searches
  - $M_{A'}>20$MeV
- Decay into leptons

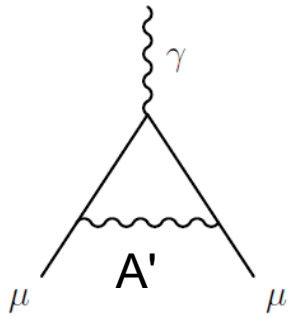


$$\Delta \mathscr{L} = \epsilon\, e\, A'_{\mu}\, J^{\mu}_{em}$$







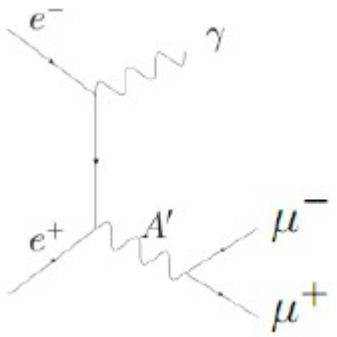


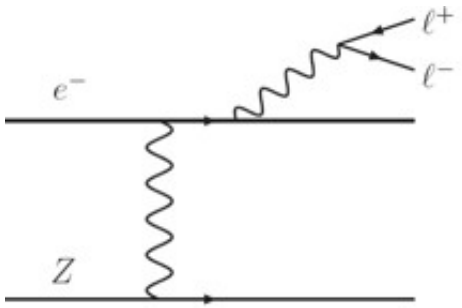
How to search for heavy photons

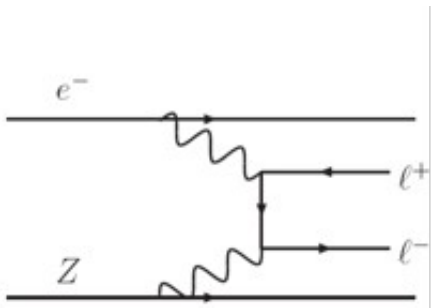
- in e^+e^- annihilations: Babar, Belle ($\mu^+\mu^-$)+ISR,

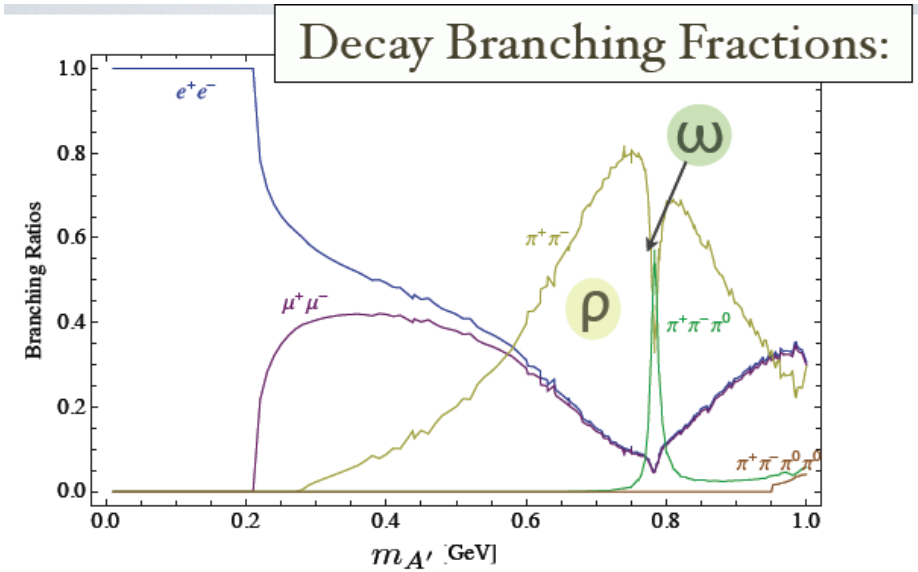
  KLOE, NA48 ($\pi^0 \rightarrow \gamma e^+e^-$)

- Electro-production in fixed target experiments
  - Without vertex detector
  - Using a vertex detector as proposed by D.Bjorken et. al. Phys. Rev. D80, 2009,075018
  - Signatures depend of A' mass



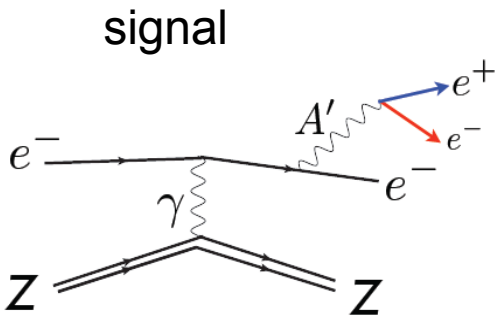


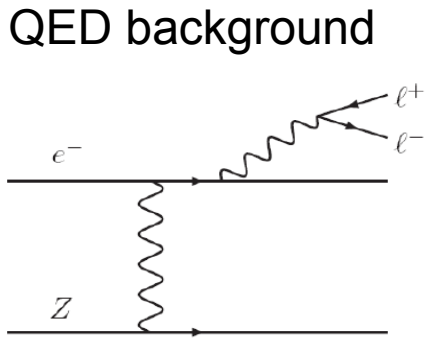


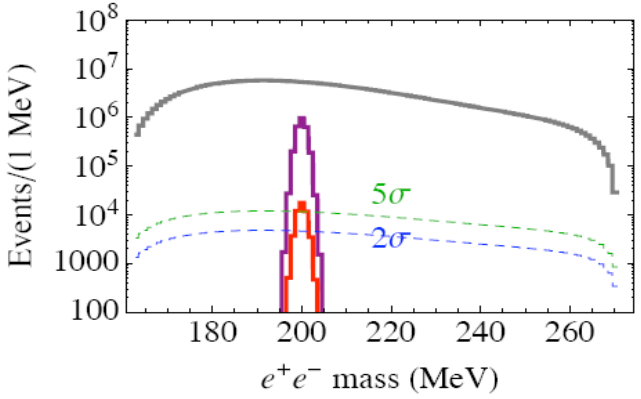


Signatures

- Invariant mass peak over a copious QED background

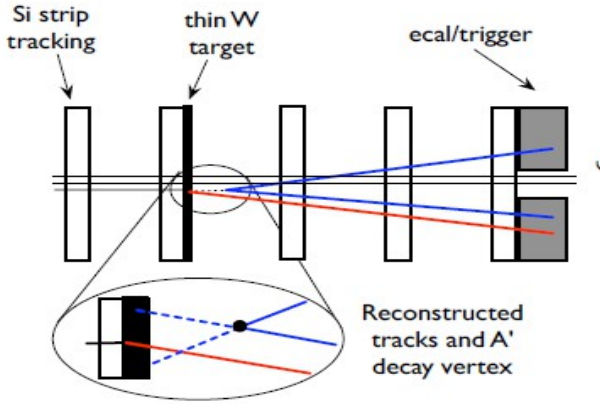


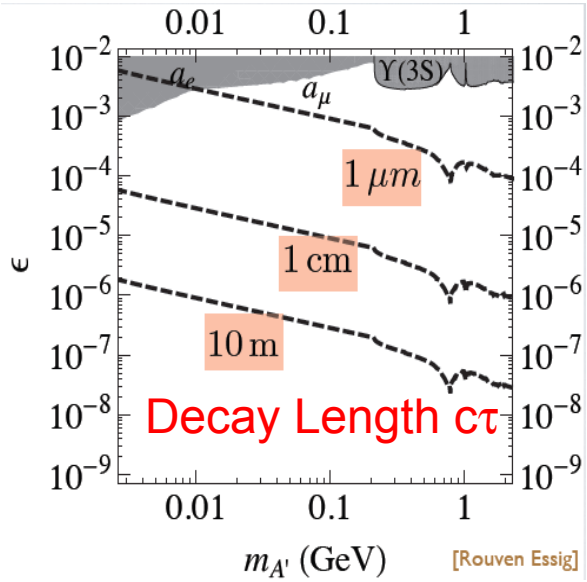




- Detached

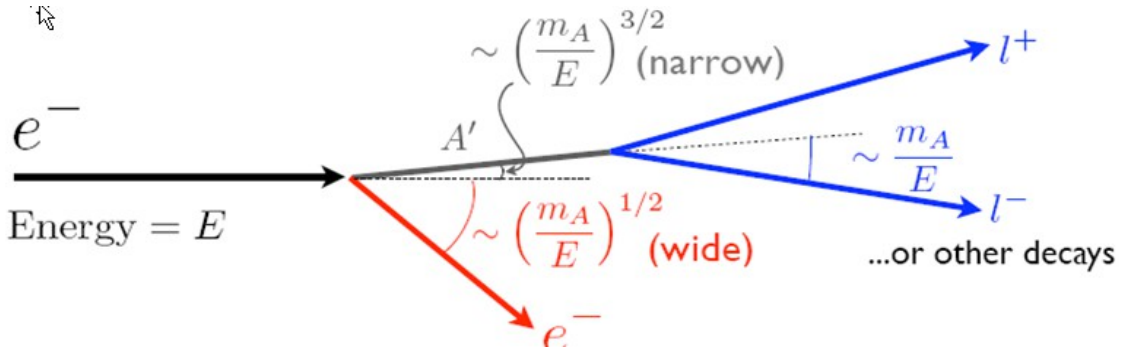
  decay vertex





HPS Design

- A' kinematics ⇒ need good forward coverage down to ~ $\theta_{decay}/2$. This puts detectors close to the beam.



$E_{A'} \approx E_{beam}$
$\theta_{A'} \approx 0$
$\theta_{decay} = m_{A'}/E_{A'}$

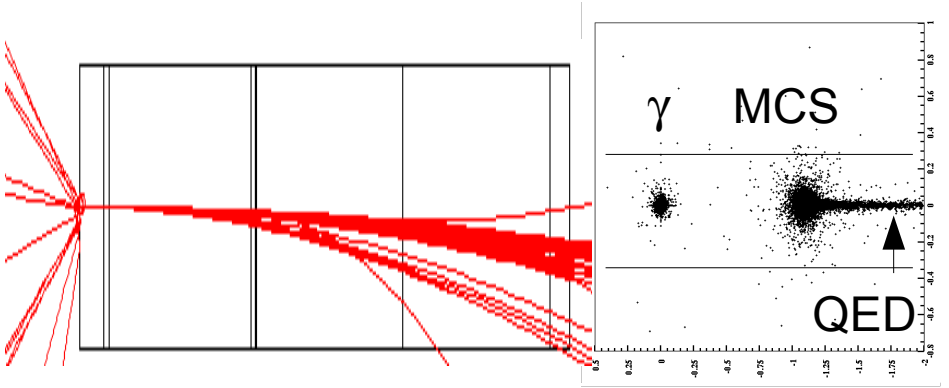
- Vertexing A' decays requires detectors close to the target. Bump hunting needs good momentum/mass resolution. Both need tracking and a magnet.

Want $\Delta m/m \sim 1\%$ for bump hunt
Want $\Delta z \sim 1$mm

Beam's Eye View
e^+ and e^-

entering ECal

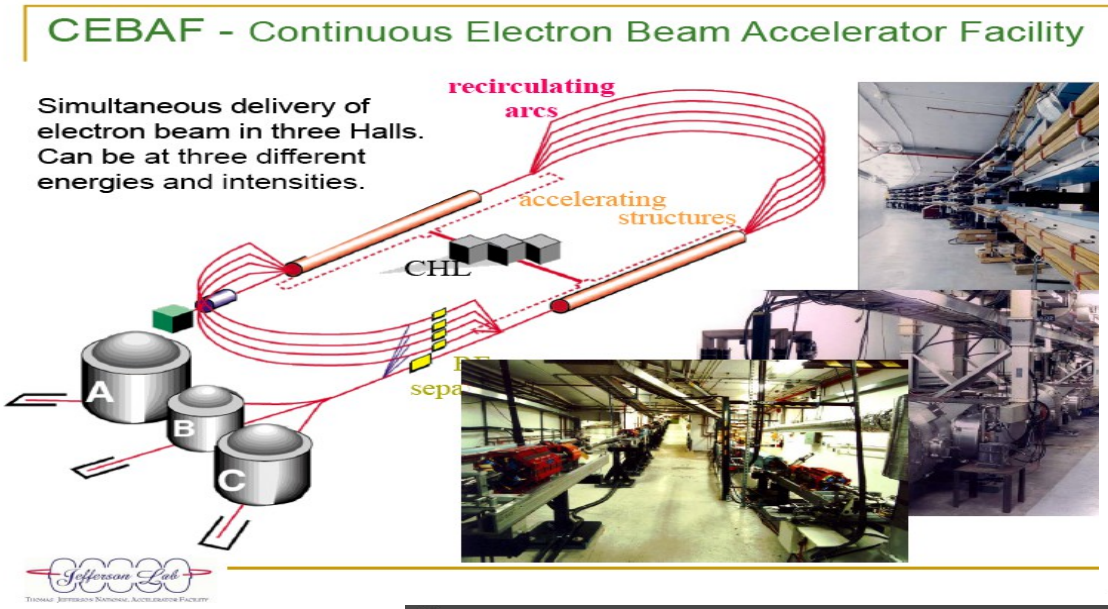
- Trigger with a high rate Electromagnetic Calorimeter downstream of the magnet to select e^+ and e^-.

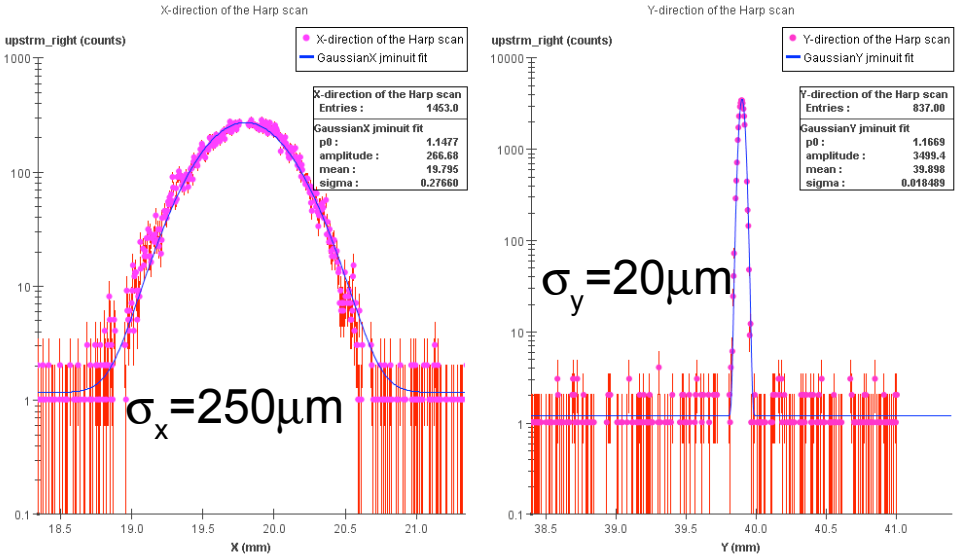


Dead zone

- Beam, QEDand Multiple Couplomb Scattering background in the bending plane => split detectectors

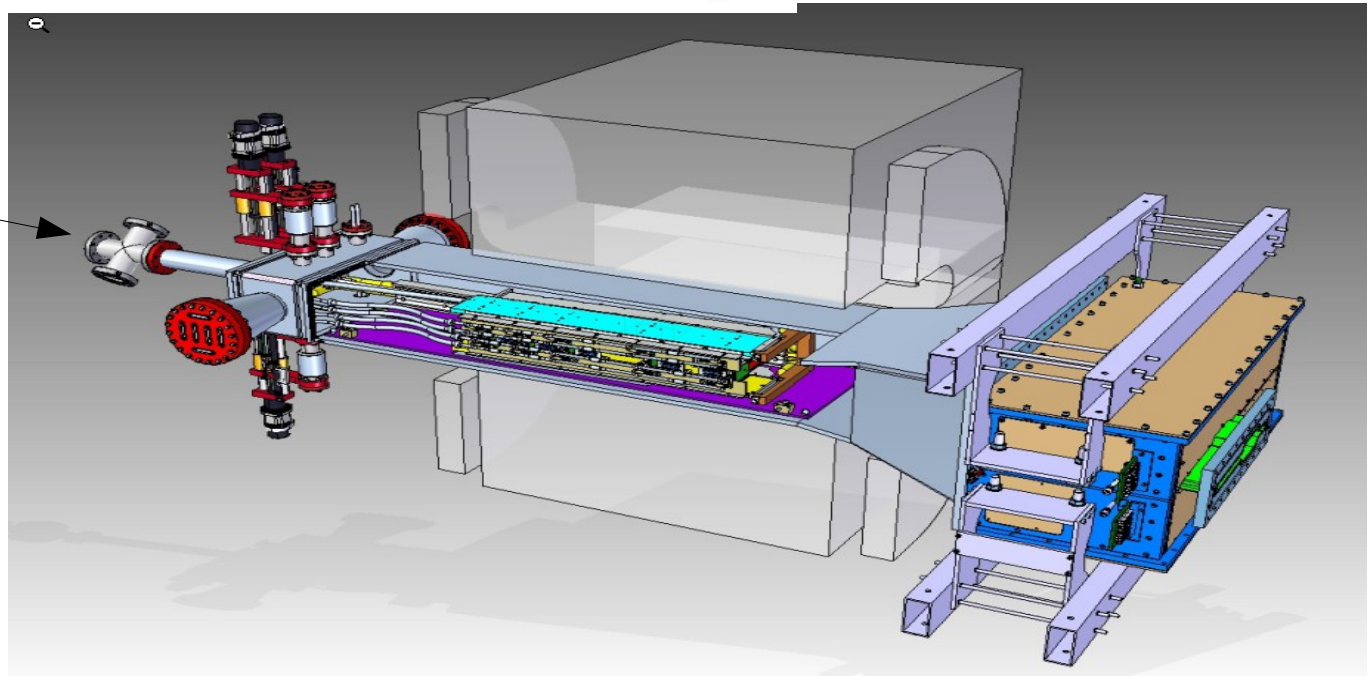
2012 Test Detector





Beam

γ beam on converter



Approval

HPS received JLAB approval for installation of HPS hardware after:

- Successful test measurement in 2012

- DOE HEP funding

- Progress in preparation of equipment

- Receive High Impact Status by JLAB advisor committee PAC41

Response to the Report from the DOE Review of the Heavy Photon Search Experiment on July 11, 2013
and
HPS Request for Formal JLab Approval

The Heavy Photon Search Test Detector

HPS Collaboration
March 14, 2014

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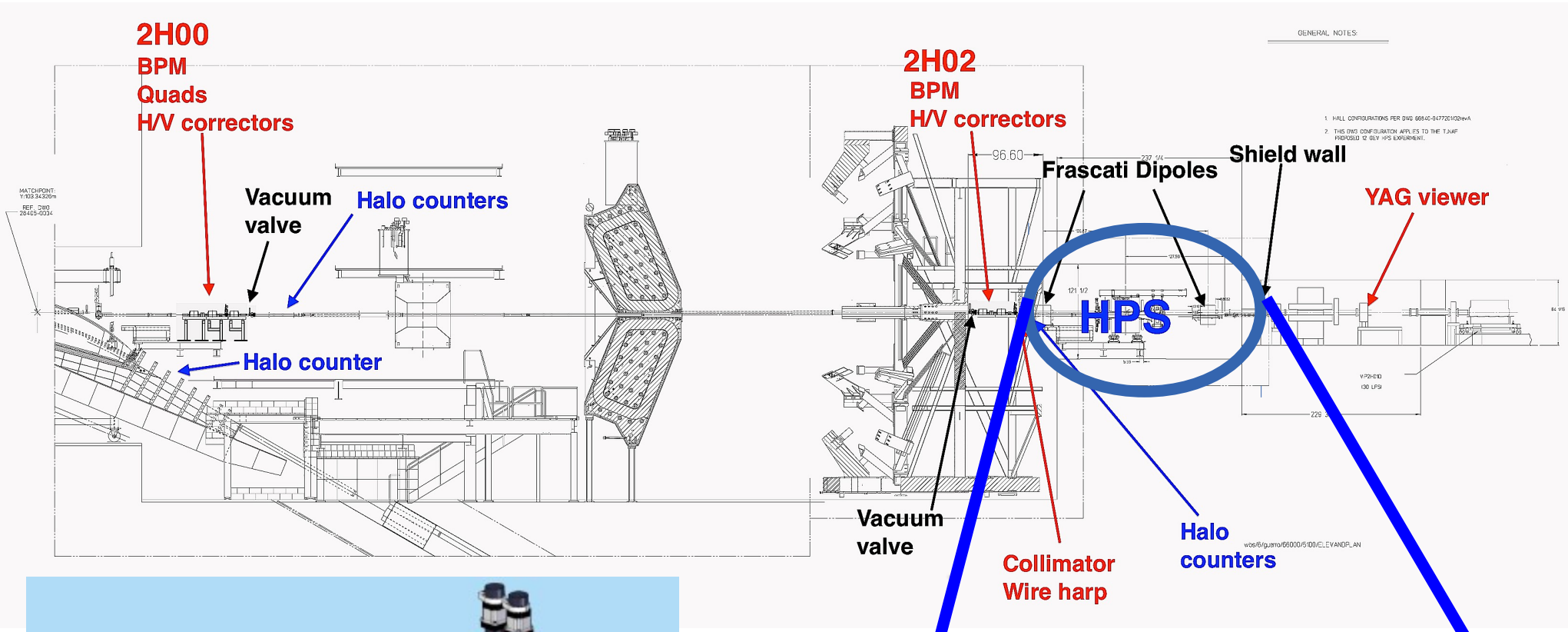
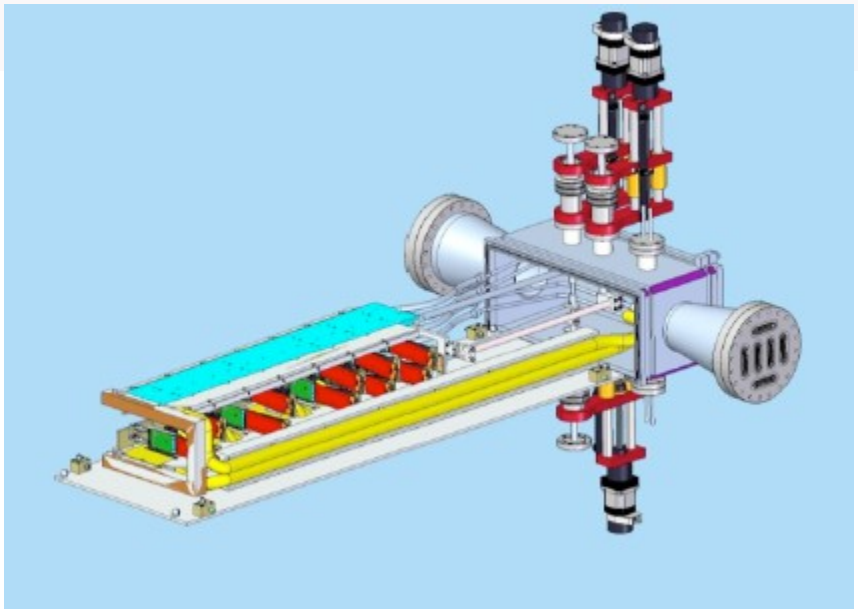
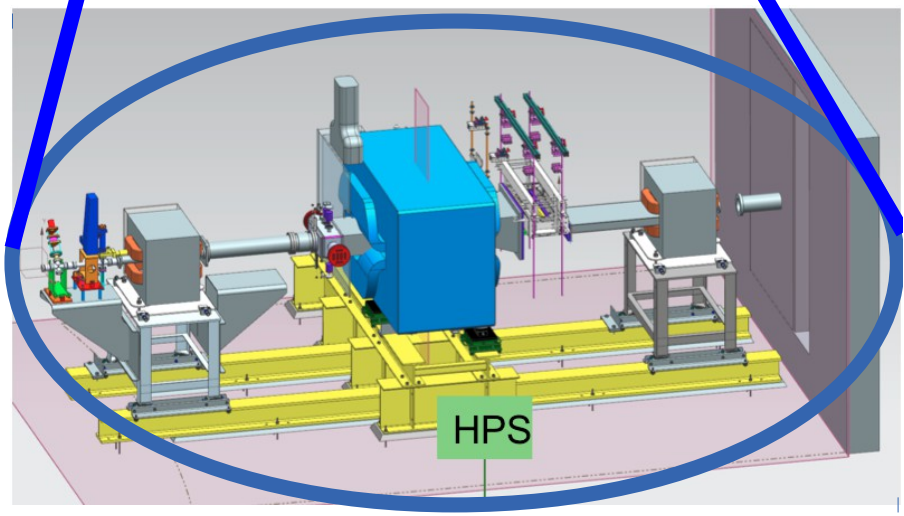
HPS Collaboration

Beam Line & Detector Design







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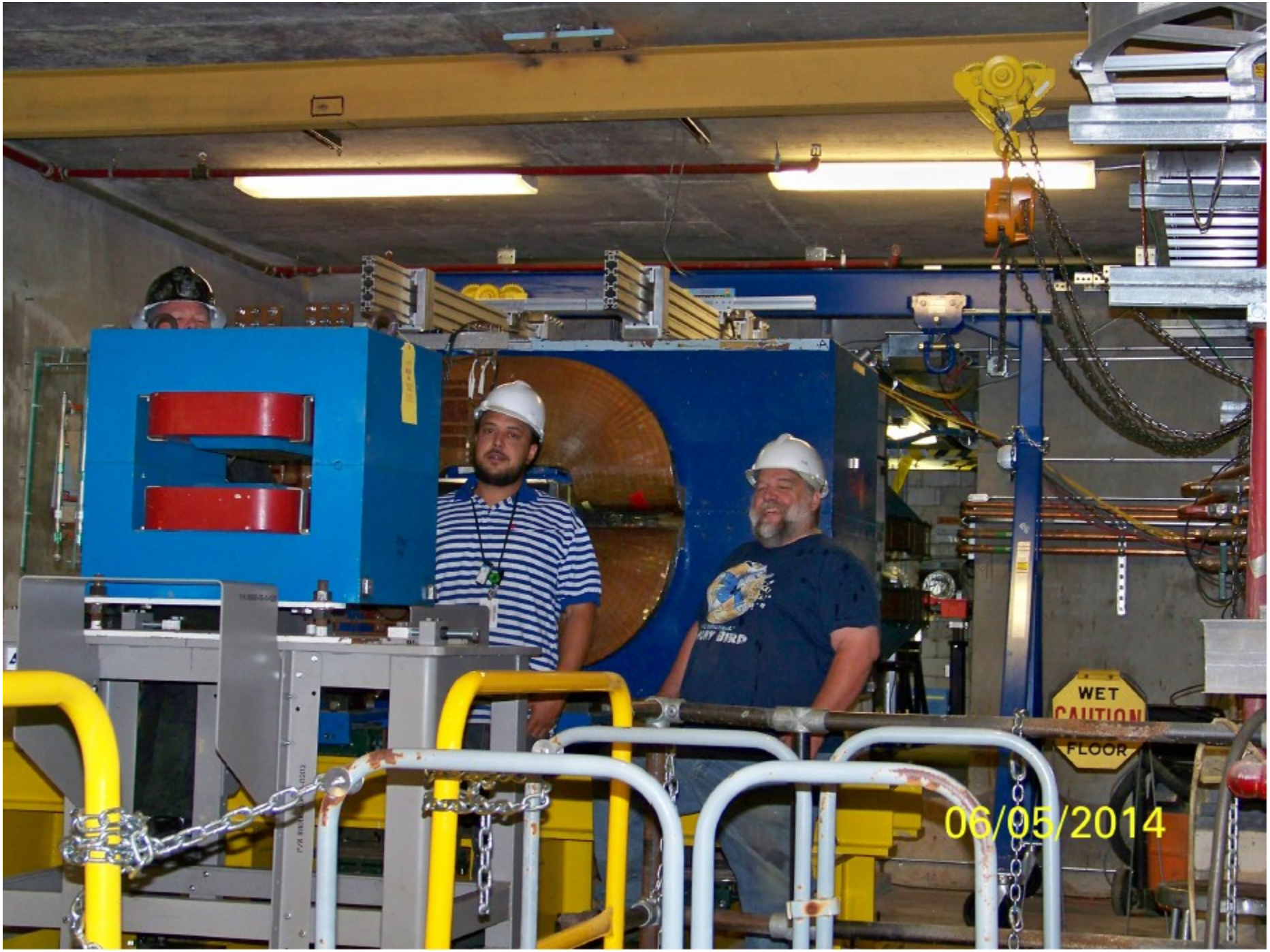
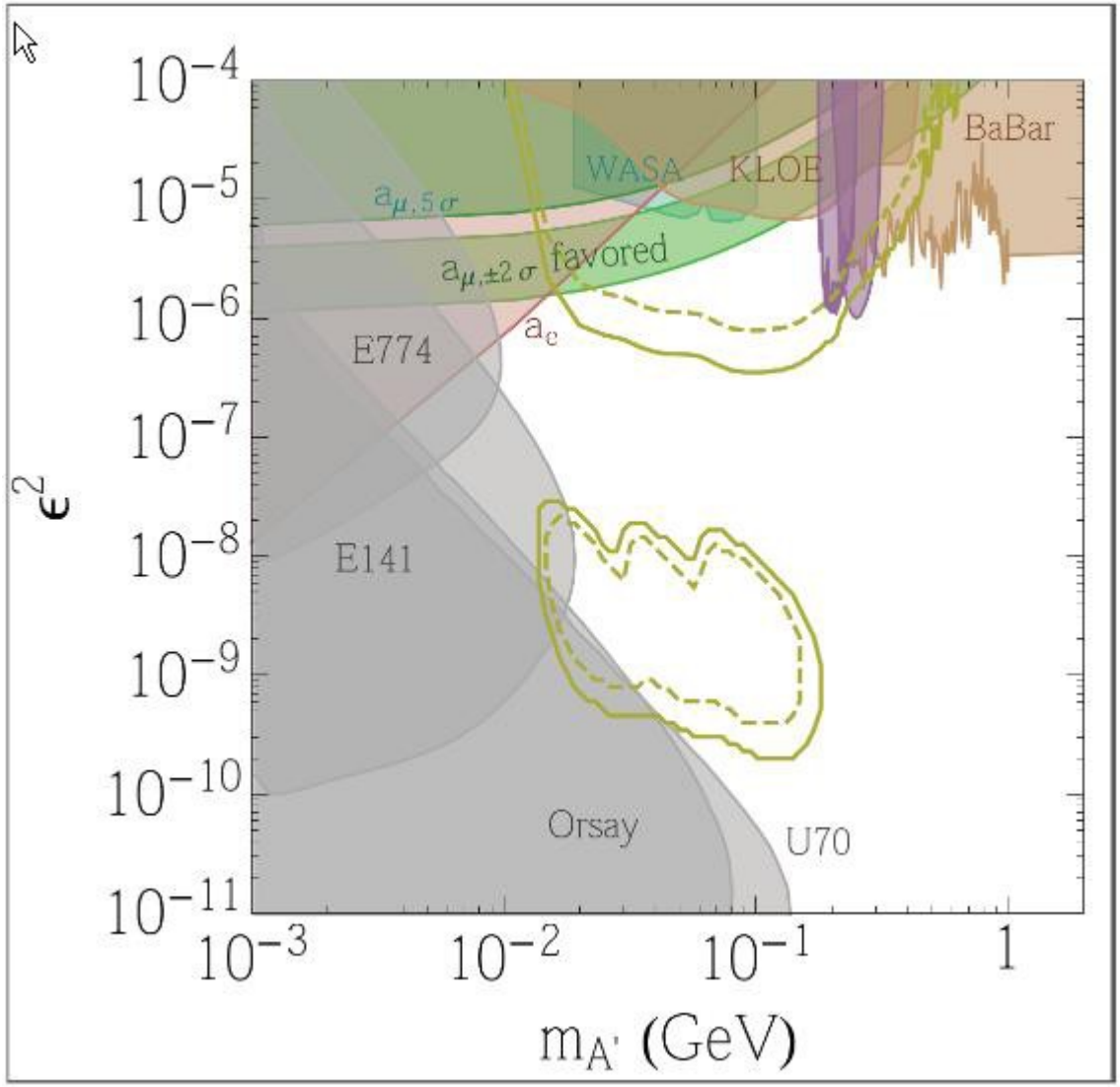


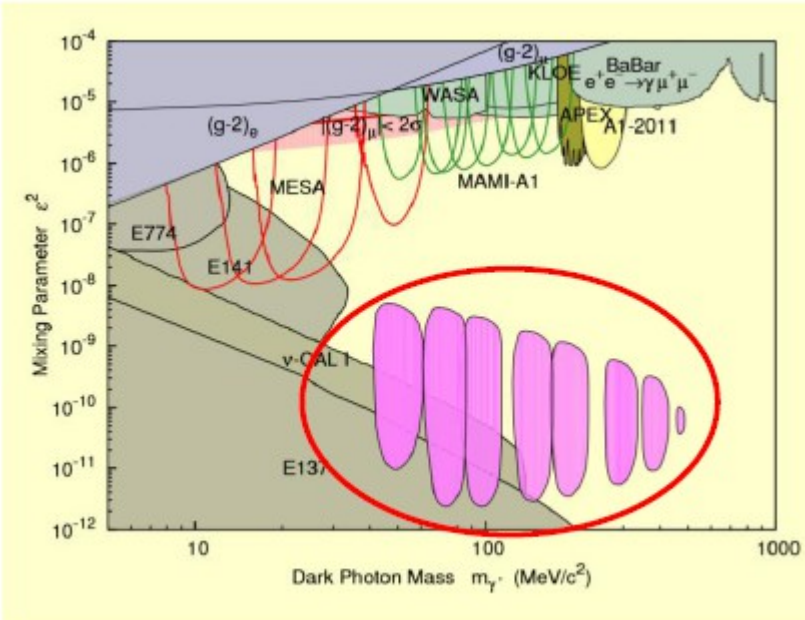
Run Plan

- 25 PAC days of engineering run approved
- 15 PAC days @ 4.4 GeV approved
  - A total of 13 weeks of shifts to be covered running nights and weekends
  - "Approval for future running beyond this engineering run will be contingent on successful demonstrated performance of the HPS apparatus during the engineering run."
- P5 will fund hidden sector particle searches in the "small projects portfolio" in the next 10 years"

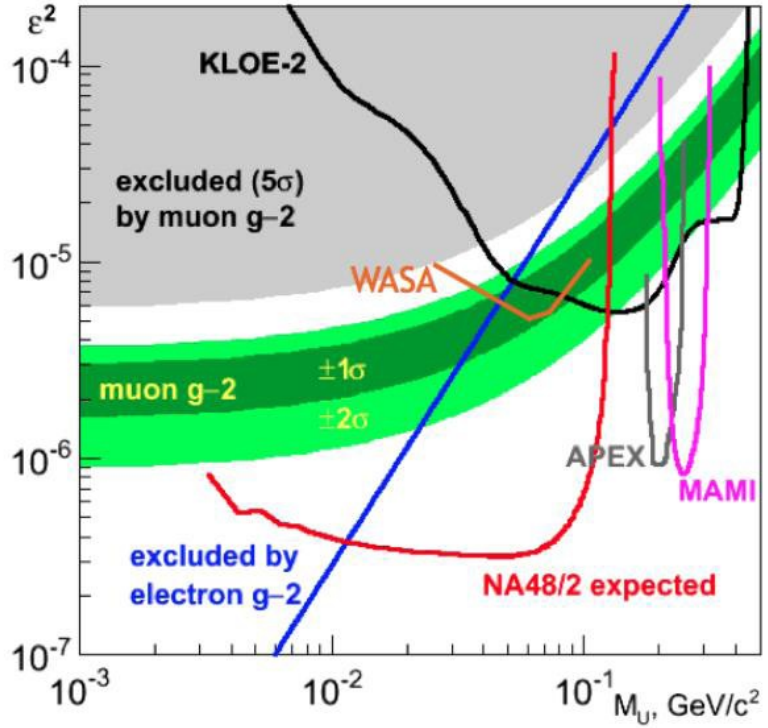


Run Plan

- Mainz is giving up on trying to cover the "vertex region." Backgrounds were unmanageable. (Michael Distler at DI2014)



- NA48/2 expected to cover remaining g-2 region. We may need to rethink the 1.1 GeV run. (Elizabeth Worcester at DI2014)

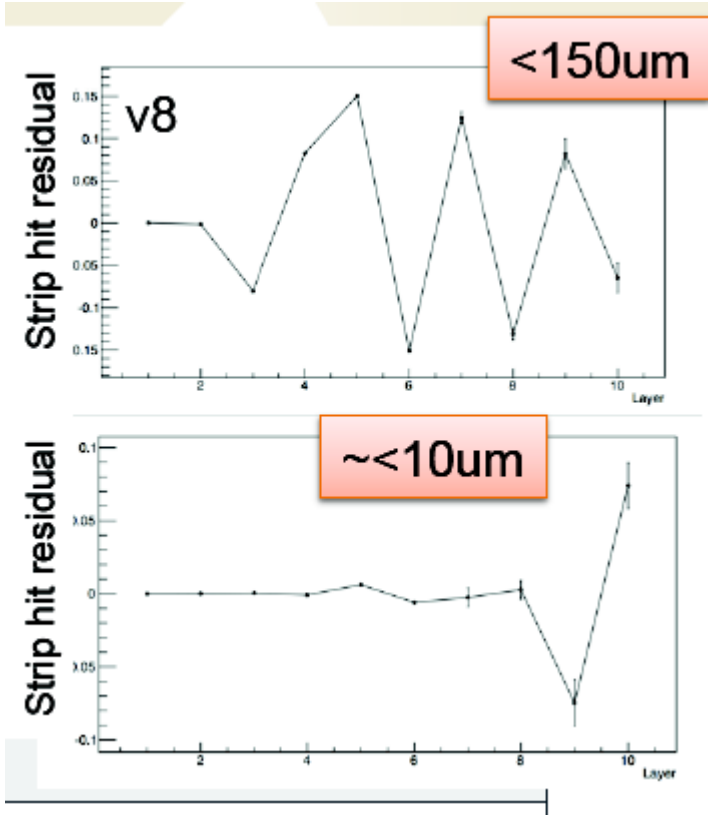


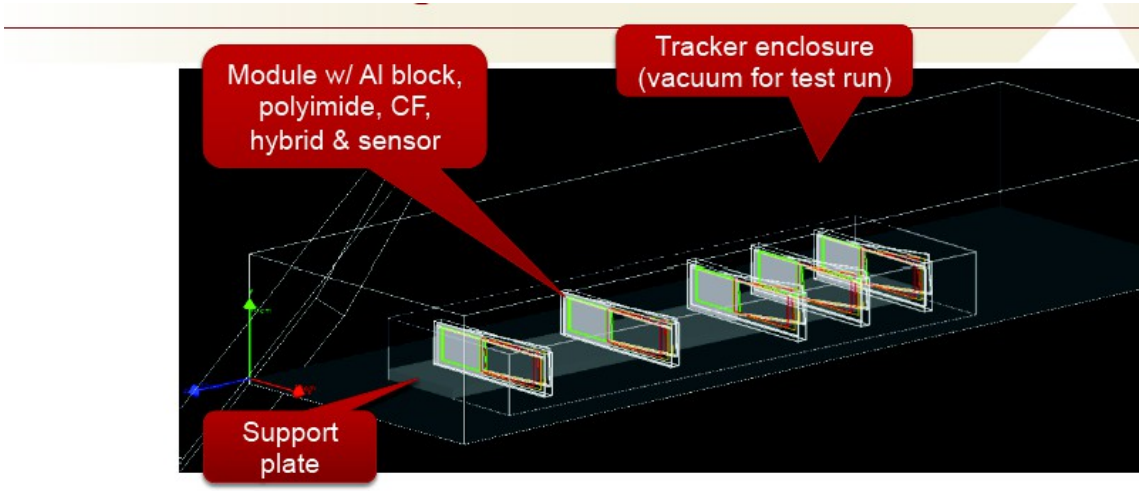
Possible involvmenets in SW projects (from discussions in november)

- Hit resolution
  - Simulation of the effect of the non uniform irradiation on resolution
- Alignment
  - Implement the Millipede track based algorithm
  - Implement partial alignment obtained from survey informations as input to the alignment procedure
- Tracking
  - Propagation of tracks trough the fringe fields
- Projects at the interface between hardware and software
  - Use of the timing information in the pattern recognition, effect of overlapping nearby pulses (spill-over) and include it in the track fit
- GBL [General broken line tracing] integration

Millepede Alignment with the test run data

- Test run residuals using survey data ~200um
- Residuals using millepede II track based alignment ~ 10um
- We showed it works for the test run data
  - Includes only translations
  - Need to add rotations
  - Need to do it for the final geometry
  - Include strait tracks to fix weak modes
  - Need to use new geometry description





Work Plans

- Complete the work on alignment
  - Rotations
  - Final detector geometry
  - Strait tracks
- Hit Time in track fit
  - Currently we simply make a cut on the hit time relative to the trigger and reject all the out of time hits
  - SVT Hits have a resolution of 2ns
    - => this information should be used in the track fitting
- Strait trough tracking with secondary target and B-field off
- Vertexing
  - Basic Billoir 2 tracks fitter exists, should be improved adding the recoil track

Anagrafica/Requests 2015

- G Simi , Ricercatore Universitario, 30%
- Missioni estere
  - per collaboration meeting e shifts:
    - 2 meeting di collaborazione 2kE
    - 4 blocchi di Shifts di presa dati 4kE