Detector concepts for the RF frontier exploiting fast timing (few ps) & low mass tracking

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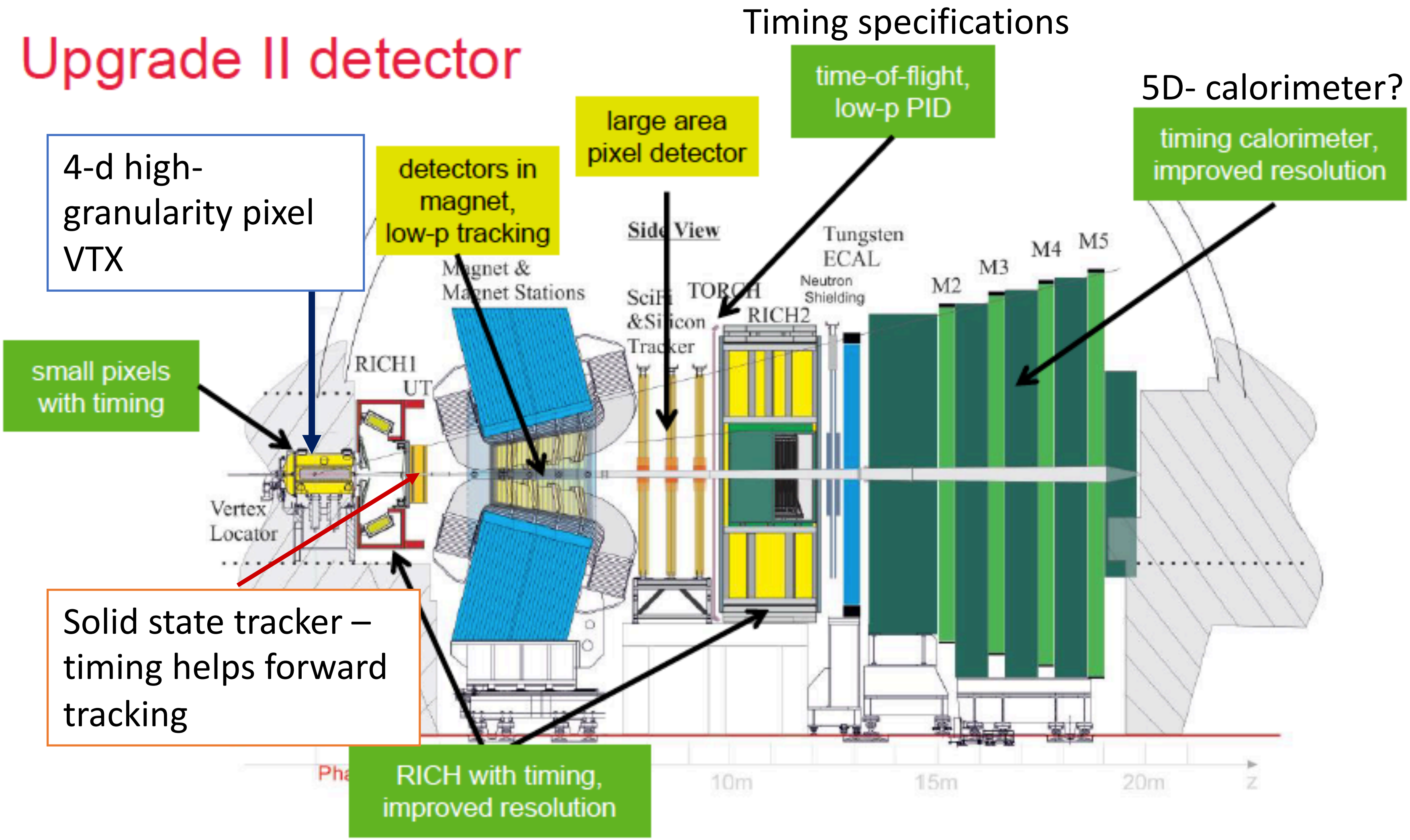
Case study I: the LHCb phase II upgrade

- The key components of the physics:
  - Flexible fully software based trigger ⇔ general purpose detector in the forward direction:
    - New phenomena in rare b and c decays (anomalies…)
    - Precision tests of SM parameters (Yukawa couplings..)
    - Forward high p_T physics (EW, Higgs-charm coupling, dark sector..}
  - High quality tracking and vertexing
  - Improved electron/photon detection (5d calorimetry)

The LHCb phase II upgrade



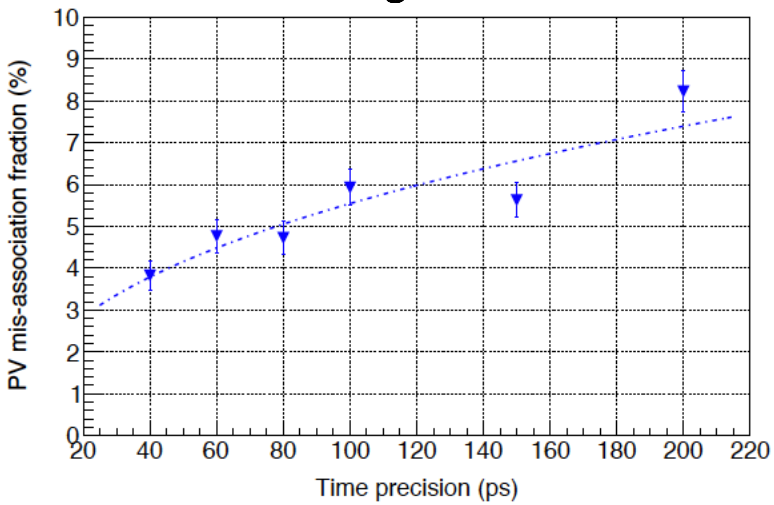
The role of timing – tracking

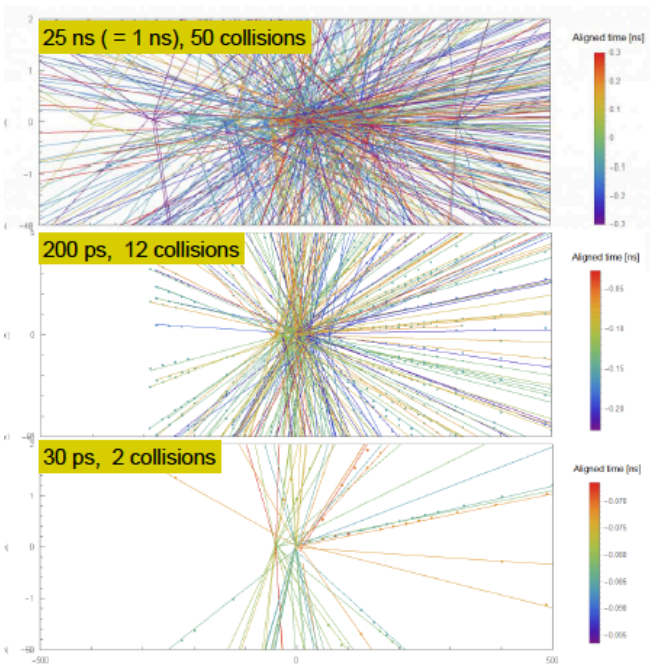
What time buys us:

Real time analysis

- ❑ Disentangle multiple primary vertices
- ❑ Disentangle secondary vertices obscured by other primary vertices
- ❑ Reduce “ghost tracks” [very important to reduce track rate]
- ❑ Pattern recognition speed and efficiency

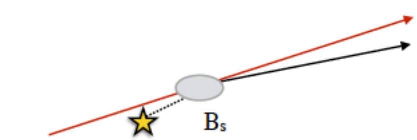
No timing – fraction 20%

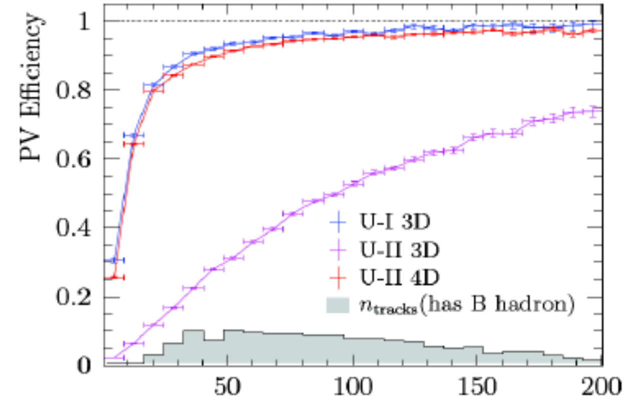


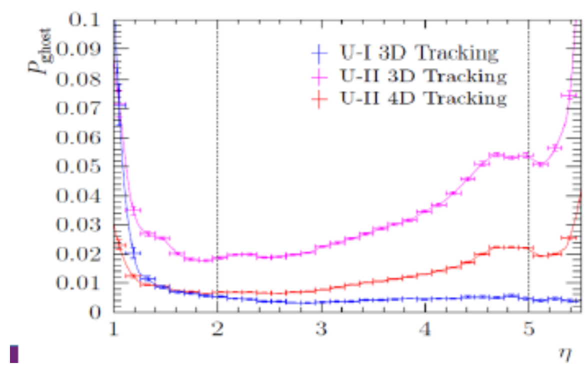


The role of timing - trigger

- First level of software trigger relies on impact parameter of B candidate with respect to associated primary vertex
- With high multiplicity, secondary vertex can be obfuscated/generate long decision time (combinatorics) - resolved by precision timing





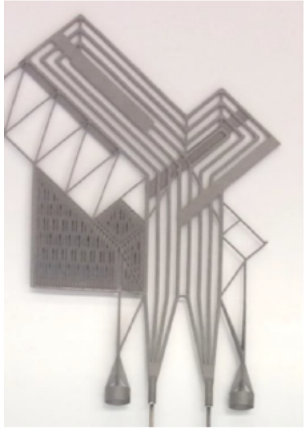


Summary of fast-timing needs

- Precision timing for tracking detectors (10-30ps/hit)
- Timing information added to the electromagnetic calorimeter (10-30 ps per track in the medium range, ongoing optimization studies)
- Timing in hadron ID devices (torch 10-30 ps/track) possible upgrade (1-3ps/track)
- Infrastructure issues e.g. system level timing
- Related goals, fast moving of high data rate&tackle high radiation environment

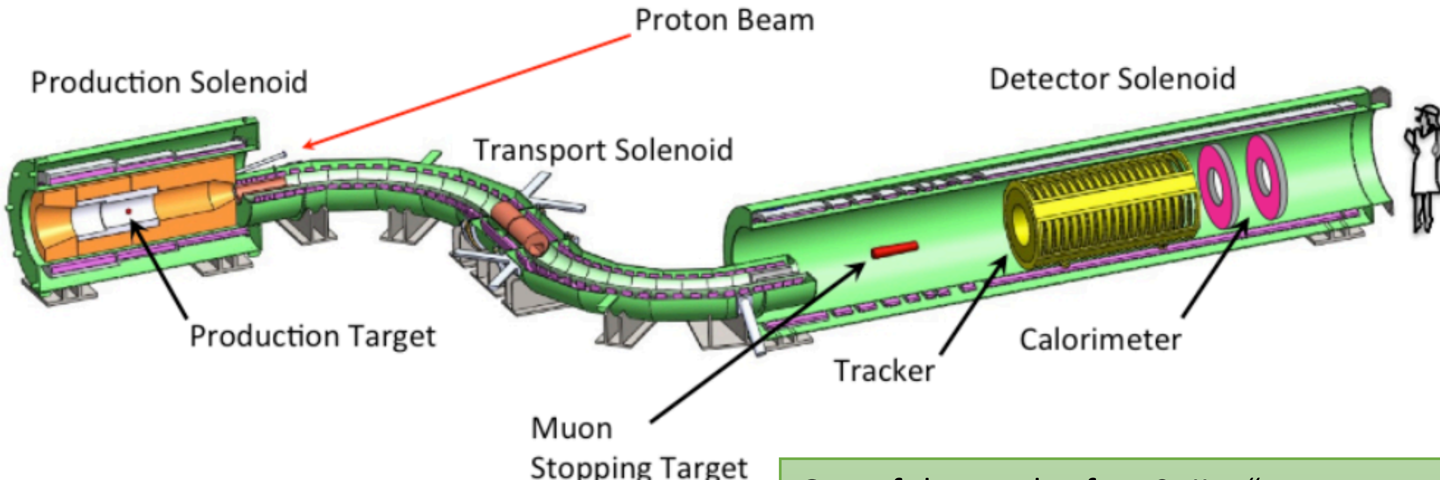
Low mass tracking

- Minimization of inert material, especially in front of the first hit
- Data transmission challenge (what is going to be the next flex cable? A new way to transmit data?)
- Cooling challenge (how to minimize the material associated with the cooling system, additional power for high granularity, fast timing)



The LVF perspective – mu2eII

mu2eII's goal: improve the sensitivity by x10 with respect to mu2e



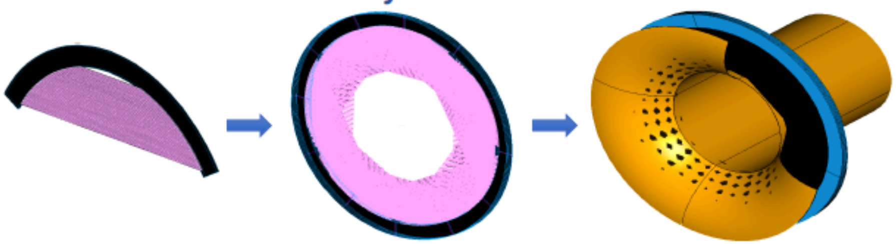
One of the goals of mu2eII – "transparent tracker": Low mass[preliminary calculation indicates a requirement for the tracker total material budget ~<5 10^{-3} X0], high granularity detector: baseline alternatives of low-mass straw tubes or a drift chamber with separated structural support [technologies studied thin silicon, μ-R-well radial TPC.. [see LOI]

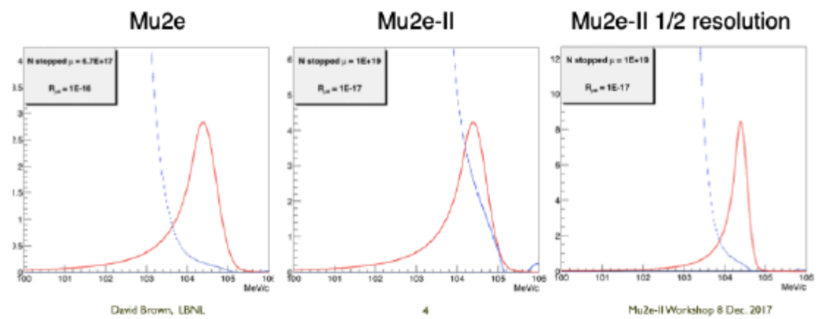
Possible synergies in low-mass tracking with other communities

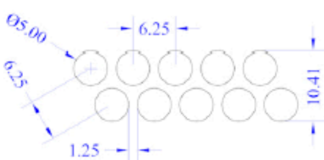
Issues for the tracker

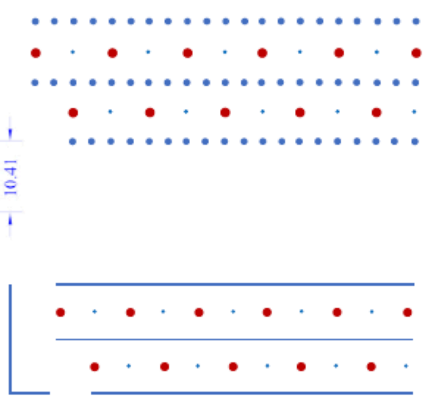
Becky Chislett
https://indico.fnal.gov/event/45713/sessions/16420/

The increased muon intensity in the Mu2e-II experiment means the resolution of the tracker needs to be improved by about a factor 2









Reduction in the tracker mass

- Use thinner (8um) straws – currently testing a prototype and
- Remove the 200 angstrom layer of gold inside each straw

Different detector geometry

- Use an ultra light gas vessel to ease straw leakage requirements
- Consider an all wires construction and remove the straws
- Or wires separated by mylar walls
- Developing FastSim to assess this along with radiation levels

Different detector technology (e.g. Si sensors)

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Summary on the low-mass needs of the applications discussed

- Optimize detector thickness and granularity for specific application
- Integrate electronics (perhaps 3d integration/with some local processing)
- New ways to push the data out (beyond the dataflex)
- Low mass cooling
- Minimize material before 1st hit measurement (beam pipe or velo RF foil)