Fermilab Accelerator Complex beyond PIP-II

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Competitiveness: Colliders

- Colliders for HEP
  - CERN
    - p-p colliders are the most effective way to get to highest energy
    - circular e+e- collider as a step to p-p colliders
  - Other possibilities
    - $\mu+\mu-$ colliders and linear colliders – significantly lower energy & luminosity
      ⇒ Barely competitive to pp colliders unless new ideas for physics experiments will come
  - Fermilab budgets are much lower than CERN's budget
    - **With such budgets we cannot compete**
      - We show/exchange our ideas
      - Ideas propagate much faster than characteristic construction time
        ⇨ Cannot compete
    - Collaboration with CERN in HEP and accelerators are the only choice
- Colliders for NP
  - ep collider
    - Extremely challenging project with relatively modest cost
    - **Fermilab is in a very good position to bid for such machine!!!**
      - We began working on high energy cooling (100 – 200 GeV)
      - Adjustments in the institutional scientific goals are required

Competitiveness: Other

- Neutrino & rare processes
  - We are very well positioned in these areas
  - Major competitors: PSI & J-PARC
- Project-X was suggested as an accelerator addressing these challenges
  - With lack of financial support it was reduced to PIP-II
- Present (party-line) incarnation
  - 800 MeV CW linac operating in a pulse regime
    - Supports 1.2 MW beam in MI
      & mu2e upgrade at 100 kW and 800 MeV

Next Decade

- PIP-I$^+$ is an effective way to address 1.2 MW power in MI
  - Relatively small cost: Booster < 5 M$, MI < 30 M$, 1.2 MW target has to be paid by LBNE
  - Requires considerable intellectual effort
    => Supports moral and scientific level of the team
  - Can be done within next few years with reasonable monetary support
    - Addresses major PIP-II goal of 1.2 MW in MI
      $\Rightarrow$ Political complications
- With present budgets I expect commissioning of PIP-II ~2030
  - Quite long time
  - Complications/delays are related with
    - Technical and scientific challenges due to high accelerating gradient
    - delays with SRF R&D due to low budgets
    - slow pace of our Indian colleagues
- Other
  - IOTA: OSC & integrable optics, space charge effects
  - FAST – we need to think about stronger experimental program

Possible Program after 2030

- PIP-III program is uncertain
  - More or less clear – mu2e upgrade
- My proposal is as following:
  - Built new RCS to achieve >2 MW in MI
  - Extend SC linac energy to at least 1.2 GeV
  - Support few experiments with muons: μ->e, μ->3e, …
  - PIP-II technology allows to support multiple experiments
  - Continue development of SRF technology
  - Targetry for neutrino experiments has to be capable to withstand 2 - 2.5 MW
  - If supported by physics program extend linac energy to ≥ 3 GeV

Conclusions

- Set PIP-I+ as an immediate and high priority goal
- We need to determine what are the goals of PIP-II project
  - PIP-I+ will address 1.2 MW in MI much faster than PIP-II
  - It needs to be done ASAP
- Built our scientific program complementary to CERN collider program
  - Rare processes and neutrino
- Bid for ep-collider
  - It would be the most interesting and challenging project following the PIP-II construction
  - R&D can start immediately