Physics requirements for HEP detectors at colliders

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Starting point : BRN

DOE Basic Research Needs Study on Instrumentation is in the process of releasing its conclusions on:

- Survey the present state of the HEP technology landscape.
- Identify key capabilities & performance requirements.
- Identify technologies to provide or enhance such capabilities.
- Articulate PRDs to push well beyond the current state of the art, potentially leading to transformative technological advances with broad-ranging applicability.
- Flesh out required R&D efforts with deliverables with notional timelines & key technical milestones.
- Elucidate the technical infrastructure required to support these efforts.
- Formulate a small set of instrumentation Grand Challenges that could result in game-changing experimental capabilities.

Note this is a 10-years view: Snowmass has a much long-term target (20 years-vision)
EF drivers in BRN

The transformative physics goals include 4 inspiring & distinct directions:

- Higgs properties @ sub-%
- Higgs self-coupling @ 5%
- Higgs connection to DM
- New multi-TeV particles

Technical requirements mostly from existing detector proposals.

- muon collider is not on the map
Beyond BRN

In the BRN physics drivers are very Higgs-centered, beyond Higgs:

- LLP searches could be an important benchmark for timing/trigger
  - Study of min radius for (few layers of) tracking detectors at future colliders
  - “Acceptance” for non-prompt charged particles at future detectors
- Boosted/Substructure object reconstruction is an important driver to guide detector design at future multi-TeV machines
  - pixel hit merging as one of the limiting factors
  - Also any improvement in tracking will directly impact jet reconstruction and calibration, pflow

More on this in today’s discussions

Just one example:

arXiv:1709.08705
EF drivers: b/c/strange-tagging

- A class of BSM models predicts that the origin of the 1st and 2nd generation fermion masses is an additional source of EWSB, predicts large deviations from the SM values
  - Higgs to ss as well as cs at future colliders is the next milestone to probe the nature of Yukawa couplings
- Strange quarks mostly hadronize to prompt kaons which carry a large fraction of the jet momentum
  - The most powerful high momenta K± tags with dedicated particle identification detectors may be an exclusive territory of e+ e- colliders
  - The leading V0 s (K0 s and Lambda) have a distinctive 2-prong vertices topology
- The use of precise timing information would become very relevant for flavor tagging and providing an additional handle for separation between light quarks.
  - Intermediate momentum K± ID from fast timing can become a significant contributor for b and c decays (s tag K± could be too high momentum for timing)
  - Detector design have a role too in capturing the high momenta V0 s that can decay deep into the tracker
    - Investigate optimal configurations for 4D tracking at future e+e- machines
HEP detector in the forward direction

Science driver (P5, BRN):

Search for the unknown:

- charged lepton flavor violation
- EDM

But also: general purpose detector in the forward direction [electroweak physics, dark sector, long lived particles (see panel today), Higgs to charm coupling...
### Forward detectors in the BRN

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**Parallel session 130**

**Importance of hadron identification**

**Community effort on the next generation of ASICs**
Key experimental features of EF forward detector

- **Software trigger**, maximum flexibility to pursue the “interesting physics”
- **High data rates/fast processing**
- Add 4th dimension (time) to allow for fast processing, vertex resolution
- New EM calorimeter with at least some components providing 5D information
- Optimization of granularity/time resolution requirements
- Rad-hardness for detector components close to the beam
Open questions

How we can design better detectors to improve on:

- *jet resolution and jet substructure observables by better combining tracking-calorimetry-timing?*
- **LLP searches**
  - Testing Higgs flavor: c/s-tagging, tau-tagging
  - Forward detector capabilities