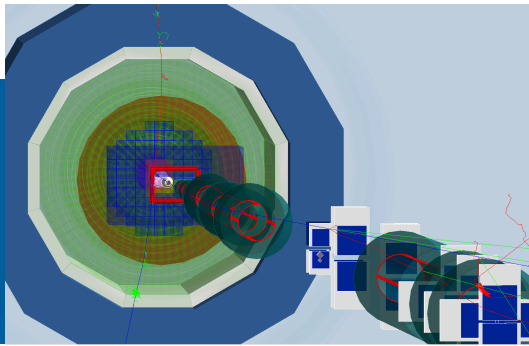
The TOPSiDE Detector Concept

Timing Optimized PID Silicon Detector



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Introduction

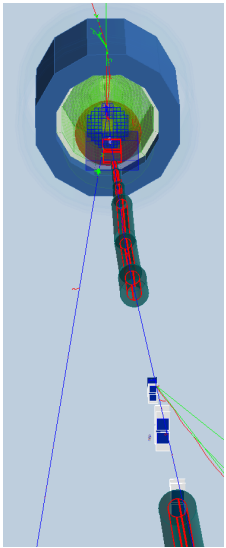
- TOPSiDE Concept
- Possible TOPSiDE implementation
- Detector Simulation Framework
- Physics driven detector optimization

What is TOPSiDE?

TOPSiDE is a central detector concept.

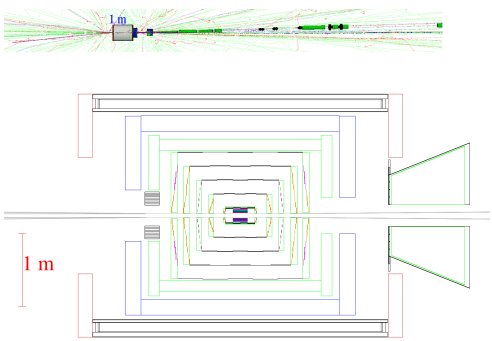
The basic ideas behind TOPSiDE:

- Simple design: **ultra-fast Si trackers** (UFSD) and calorimetry
- **PID with TOF** over central region ($-3.5 < \eta < 3.5$)
- A **well defined central region** where TOF provides PID
- Focused efforts for dedicated PID detectors in regions where they are most needed
- Minimal material in front of calorimeters



TOPSiDE

TOF Optimized PID Silicon Detector



Central detector region:

- Symmetric design with close to 4π coverage
  $\rightarrow$ **Ensure exclusivity**
- Ultra-fast Si detectors for TOF $\pi - K - p$ separation
  $\rightarrow$ Provides PID consistent with YR

η	θ	Nomenclature		Resolution	M	π/K/p PID	π/K/p Min E Photon	π/K/p p-Range (GeV/c)	π/K/p Separation	HCAL Resolution $\sigma E/E$	HCAL Energy	Muons
< -4.6		Far Backward Detectors	low-Q2 tagger									
-4.6 to -4.0												
-4.0 to -3.5												
-3.5 to -3.0												
-3.0 to -2.5												
-2.5 to -2.0												
-2.0 to -1.5												
-1.5 to -1.0												
-1.0 to -0.5												
-0.5 to 0.0												
0.0 to 0.5												
0.5 to 1.0												
1.0 to 1.5												
1.5 to 2.0												
2.0 to 2.5												
2.5 to 3.0												
3.0 to 3.5												
3.5 to 4.0			Instrumentation to separate charged particles from photons									
4.0 to 4.5												
> 4.6		Far Forward Detectors	Proton Spectrometer									
			Zero Degree Neutral Detection									

Detector Matrix

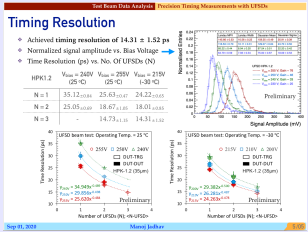
TOPSiDE Silicon Detectors

Use both UFSD and precision silicon detectors

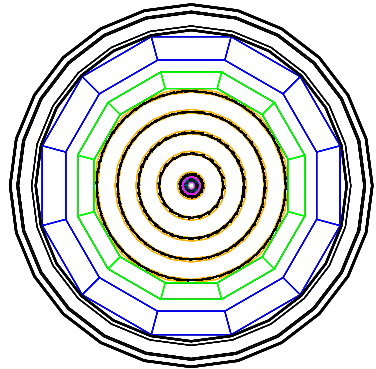
- Goal of 10 ps time resolution is at **track level**
- UFSD $\rightarrow$ precision timing
- UFSD not required for entire detector

Recent Detector Results

Picosecond Timing Resolution Measurements of Low Gain Avalanche Detectors with a 120 GeV Proton Beam for the TOPSiDE Detector Concept, M. Jadhav, et.al., arXiv:2010.02499.



See Jessica's talk.



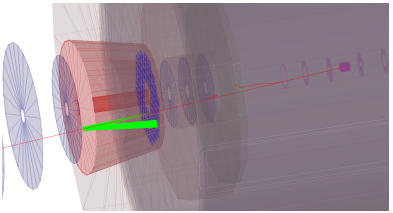
Calorimetry ideas to explore

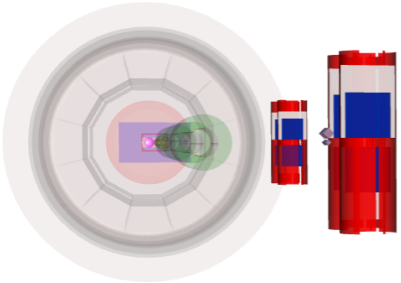
- Imaging calorimetry vs non-imaging
- Impact on reconstruction of low energy electrons
- Extra timing measurement at large radius?
- Muon PID

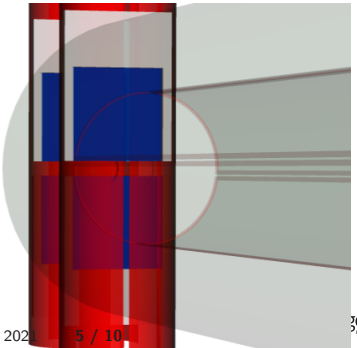
TOPSiDE Simulation Tools

Argonne Software Effort

- Detailed silicon detector descriptions
- Generic tracking reconstruction framework (ACTS)
- New detectors quickly and easily implemented
- Staves, frames, cables and other support easily added
- Modern reconstruction framework for algorithm development



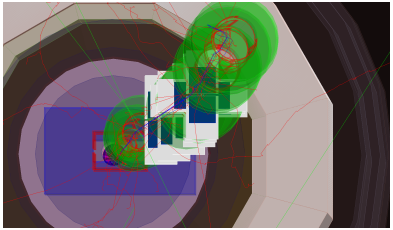


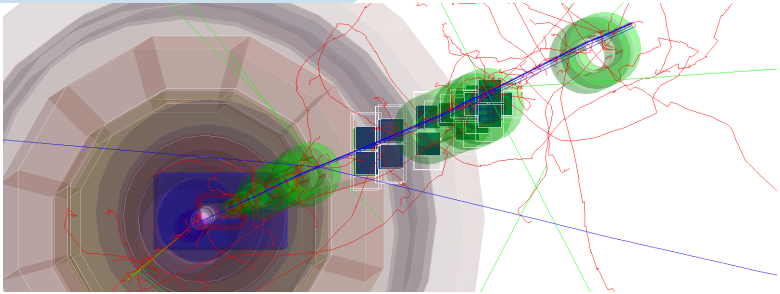


TOPSiDE Simulation Tools

Goals

- Develop/assemble end-to-end simulation and reconstruction framework
- Optimize multiple detector designs and concepts
- Optimization based on **physics performance**

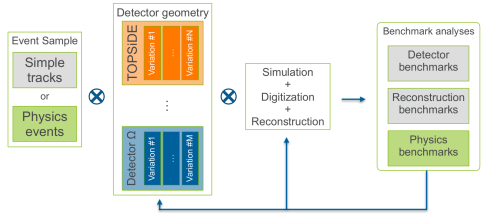


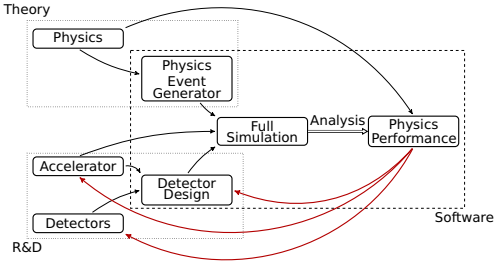


Full Detector Optimization

Challenges

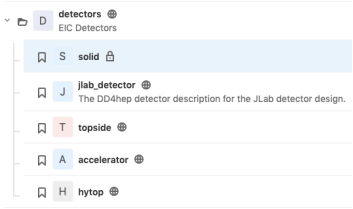
1. Need full set of Physics benchmarks to cover NAS program: Requires community buy-in to implement the physics benchmarks
2. Getting community input for detector designs: need multiple detectors for unbiased comparison of performance
3. Compiling all the metrics for the optimization
4. Develop algorithm to optimize detector on all physics measurements.

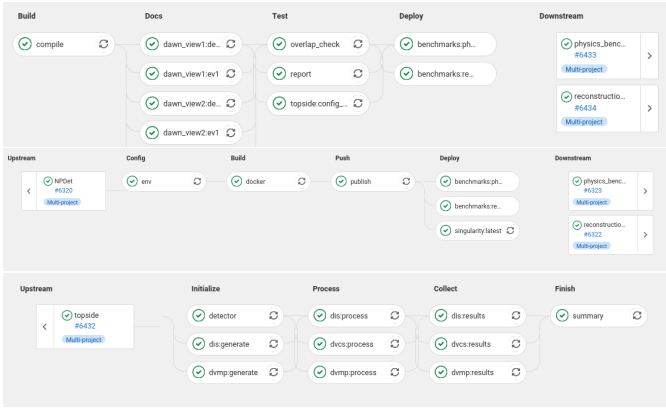




Simulation Workflow and Development

- Extensive use of gitlab-CI pipelines
- End-to-end simulation triggered via CI
- Fully containerized software
- Developing reconstruction and physics benchmarks.
- `eicweb.phy.anl.gov` is an excellent platform for collaborative development





Thank you to collaborators Ziyue Zhang and Zhenyu Ye (UIC) for contributing to the initial trial and debugging

Conclusion

- TOPSiDE is a detector concept centered on TOF PID to simplify the central region
- LGAD is the key technology to TOPSiDE implementation
- Full end-to-end simulation with extensive collection of benchmarks are under development to compare and optimize TOPSiDE (and other detectors).
- We are developing **physics performance** driven optimization framework for detector designs with **end-to-end detector simulations**

Thank You!