HPSTR updates

PF, Cam

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U.S. DEPARTMENT OF ENERGY | Stanford University

SLAC NATIONAL ACCELERATOR LABORATORY

Introduction

- Hpstr (Heavy Photon Search Toolkit for Reconstruction) is a C++/python based package for data analysis.
- The package does:
  - Conversion from **LCIO -> ROOT ntuples** (a la DST), defining a ROOT based EDM with **objects**, i.e. tracks/particles/vertices, and **links** between them
  - ROOT tuples processing to produce **histograms** and/or **flat-Ntuples**
  - Post processing of **histograms** or **flat-Ntuples** as well.

- The package repository:
  - https://github.com/JeffersonLab/hpstr
  - A README is provided with full instructions from checkout to processing LCIO files
- **A full description of the actual content and structure of the package is beyond the scope of this update today**

Checkout

```
mkdir hpstr
cd hpstr
mkdir src build install
cd src
git clone git@github.com:JeffersonLab/hpstr.git
cd ..
```

Compilation

```
cd build
cmake3 -DCMAKE_INSTALL_PREFIX=../install/ -DLCIO_DIR=$LCIO_DIR  ../src/hpstr/
make -j4 install
```

To compile with debug information, just add -DCMAKE_BUILD_TYPE=Debug to the cmake3 command. After compilation it is necessary to source the setup script in the `intall/bin` directory by

```
source install/bin/setup.sh
```

The setup script should be automatically generated by CMake.

Usage

The basic command string to run hpstr is

```
Usage: hpstr <config.py> [options]

Options:
  -h, --help            show this help message and exit
  -i inFilename, --inFile=inFilename
                        Input filename.
  -d outDir, --outDir=outDir
                        Specify the output directory.
  -o outFilename, --outFile=outFilename
                        Output filename.
```

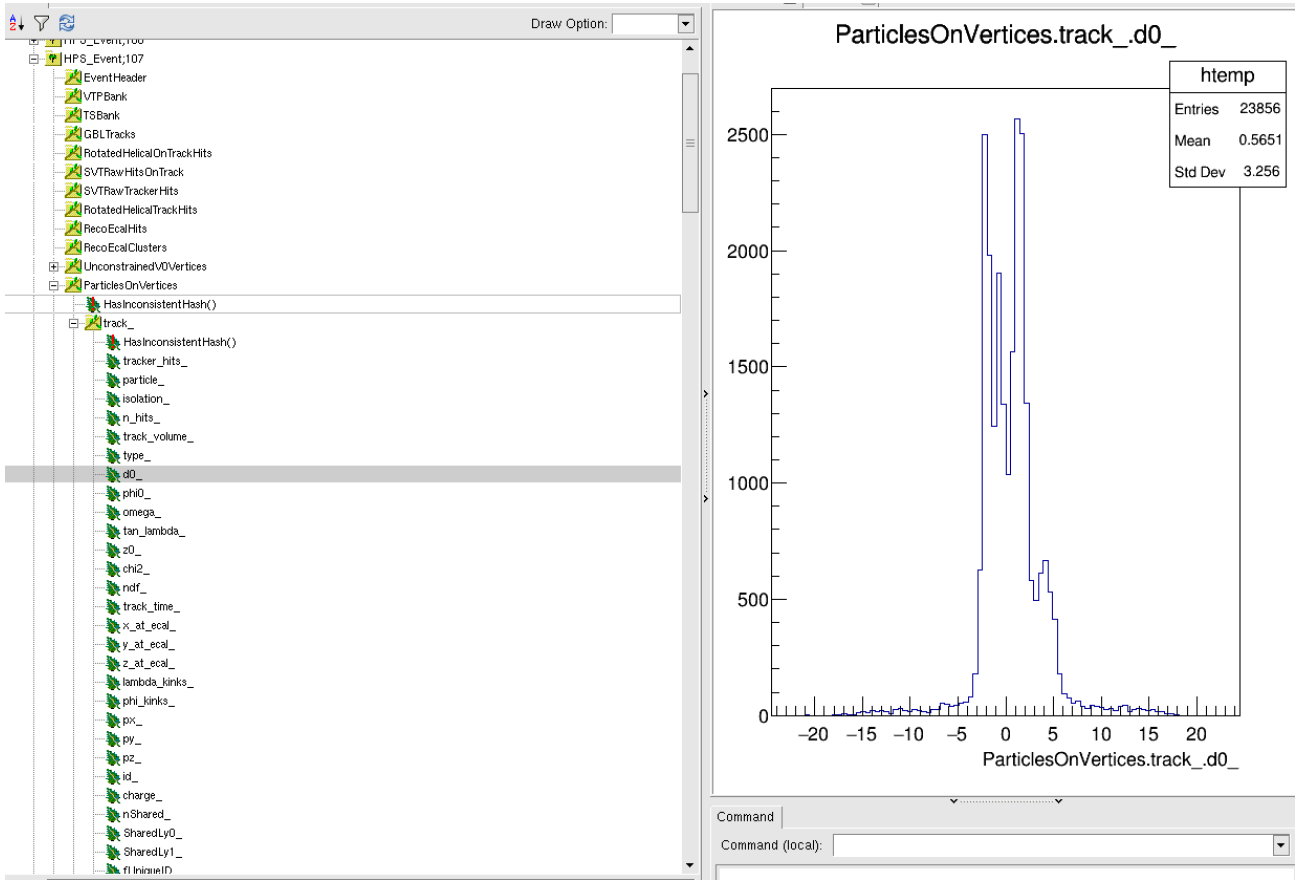
where `<config.py>` is a config file (which are stored in `hpstr/processors/config/`), followed by various command line options. Different configuration files, might have specific command line options. Please check each configuration file to check which options are available on top of the common ones.

Hpstr can both run on LCIO files to produce ROOT ntuples, producing the hpstr event with all the objects needed for analysis, and on ROOT ntuples to produce histograms. This can be setup by using the appropriate configuration file.

Ntuples production

Current Status

- HPSTR has now a fully implemented processing of LCIO to a ROOT n-tuple that has the structure for performing both **vertex** and **BH** analysis
- Content:
  - **Unconstrained and TargetConstrained V0s**
  - **Particles** containing associated tracks and clusters
  - **All tracks** of the events containing the **hits on tracks**
  - **All clusters** in the Calo containing **Calo hits**
  - **Event Information including trigger flags**

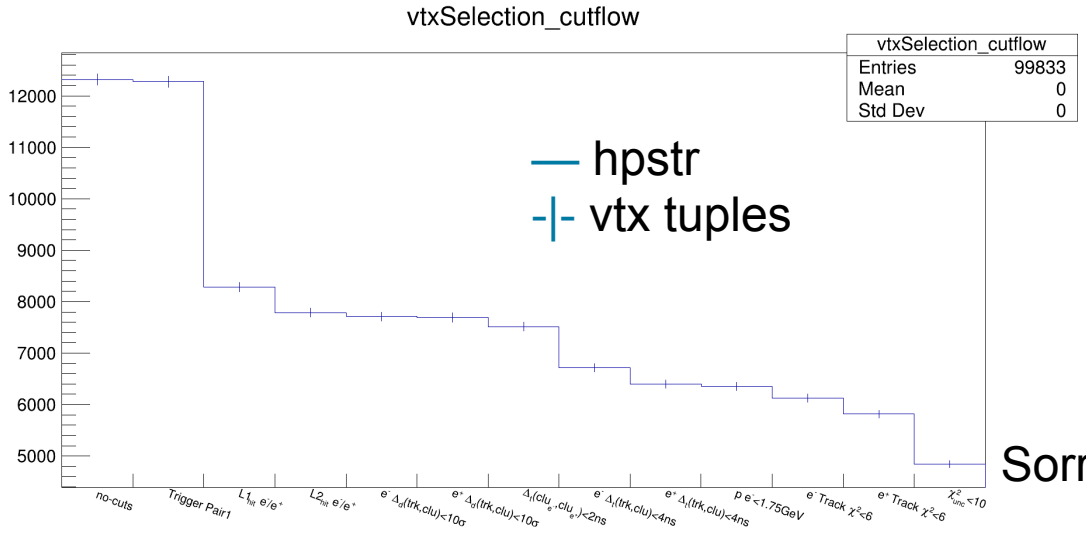


Example - Ntuple Processing and Vtx Cutflow

- Hpstr is currently implementing event selections in json files to keep an ordered and clear structure for bookeeping cuts
- Cut values, order and presence can be changed without recompilation
  - Easy to add **orthogonal control/validation/ signal** regions
  - Cutflows are generated automatically
- Vertex preselection cutflow matches between flat-tuple based analysis and hpstr based analysis => **analysis flow validated**

analysis/selections/vtxSelection.json

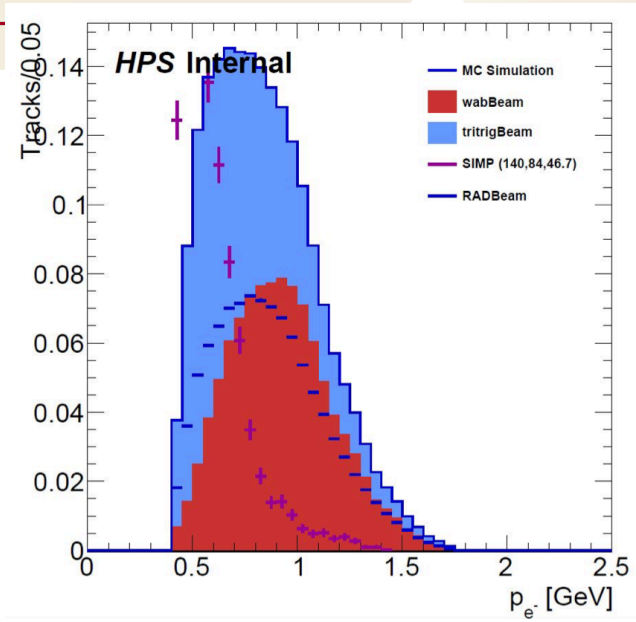
```
{
    "Pair1_eq" : {
        "cut"  : 1,
        "id"   : 0,
        "info" : "Trigger Pair1"
    },
    "eleTrkCluMatch_lt" : {
        "cut"  : 10,
        "id"   : 1,
        "info" : "e^{-} #Delta_{d}(trk,clu)<10#sigma"
    },
    "posTrkCluMatch_lt" : {
        "cut"  : 10,
        "id"   : 2,
        "info" : "e^{+} #Delta_{d}(trk,clu)<10#sigma"
    },
    "eleposCluTimeDiff_lt" : {
        "cut"  : 1.45,
        "id"   : 3,
        "info" : "#Delta_{t}(clu_{e^{-}},clu_{e^{+}})<1.45ns"
    },
    "eleTrkCluTimeDiff_lt" : {
        "cut"  : 4,
        "id"   : 4,
        "info" : "e^{-} #Delta_{t}(trk,clu)<4ns"
    },
    "posTrkCluTimeDiff_lt" : {
        "cut"  : 4,
        "id"   : 5,
        "info" : "e^{+} #Delta_{t}(trk,clu)<4ns"
    },
    "eleMom_lt" : {
        "cut" : 1.75,
        "id"  : 6,
        "info" : "p e^{-}<1.75GeV"
    },
    "eleTrkChi2_lt" : {
        "cut"  : 6,
        "id"   : 7,
        "info" : "e^{-} Track #chi^{2}<6"
    },
```



Sorry, plot on old selection, but still valid

Example - Plotting: bkg and shape comparison

- Hpstr provides easy support for including different processes:
  - Data / MC
  - A' or SIMPs signal
- Includes scripts for:
  - Plotting shape comparisons and bkg composition
  - Cutflow tables
- Examples here for SIMPs search (I had these plots easily available)
- Plots are defined in json files so changes can be made at run time

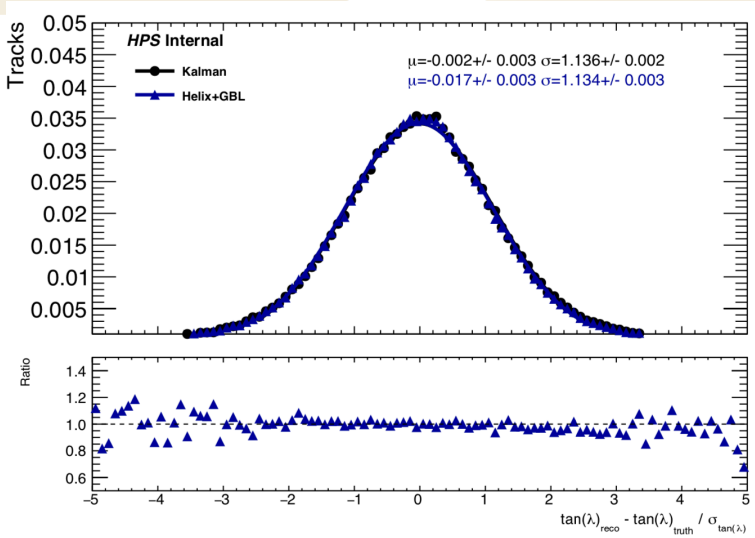


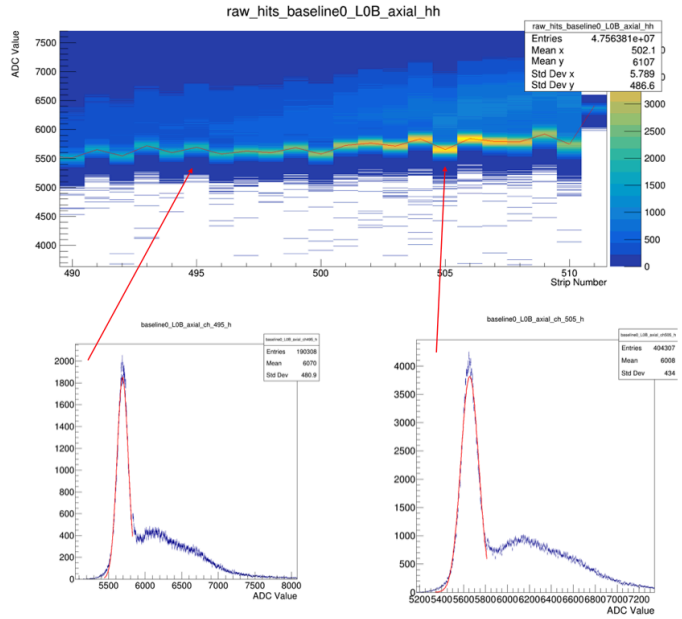
(Stanislava L. S.)

		ϵ_{tot}
Trigger Pair1	5760	–
$e^-\Delta_d$(trk,clu)$< 10\sigma$	5742	0.997
$e^+\Delta_d$(trk,clu)$< 10\sigma$	5742	0.997
$\Delta_t(\mathrm{clu}_{e^-}, \mathrm{clu}_{e^+}) < 1.45$ns	5640	0.979
$e^-\Delta_t$(trk,clu)< 4ns	5635	0.978
$e^+\Delta_t$(trk,clu)< 4ns	5627	0.977
$\mathrm{p}_{e^-} < 1.75$GeV	5627	0.977
e^- Track $\chi^2 < 6$	5512	0.957
e^+ Track $\chi^2 < 6$	5424	0.942
$\chi^2_{unc} < 10$	4378	0.76
$p_e^- > 0.4$ [GeV]	4099	0.712
$p_e^+ > 0.4$[GeV]	4099	0.712
$p_{vtx} < 2.4$ [GeV]	4099	0.712

Example - Tracking / hit studies

- Hpstr can provide support for also for performance studies:
  - **Tracking analysis**, i.e. Kalman-GBL comparison, track efficiency, truth matching…
  - Baseline extraction for **SVT hits** including gaussian+landau fit for charge deposition and baseline extraction
  - **Calo/Hodo hits/cluster studies** (in principle as I haven't done much there personally
- Of course analysis flow, radiative fraction and statistical interpretation for BH analysis are included in the framework too





Summary

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- Hpstr framework is **getting in good shape** to support 2019 analysis
  - **Vertexing analysis flow validated up to preselection**
    - BH analysis flow in course of validation but:
      - **Radiative Fraction** can be extracted (and agrees with Rafo's)
      - **Statistical interpretation** has been ported from old repo to hpstr (Cam showed that in previous meetings)
- **New users** (Stany) which joined HPS were able to produce first results fast on SIMPs searches
  - **README with working examples** and default processing documented in the repo
- Hpstr also useful to do **performance studies** relative
  - Tracking, hit/cluster studies in SVT/Calo/Hodo …
- **Plotting** support with an "hps" style already added.
- Still lot of work to be done to finish implementing and porting all corrections (track/hit efficiency, smearing ….)