Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Event Display for NPP

STAR, SPHENIX, ePIC, EIC-UG

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2024-01-30

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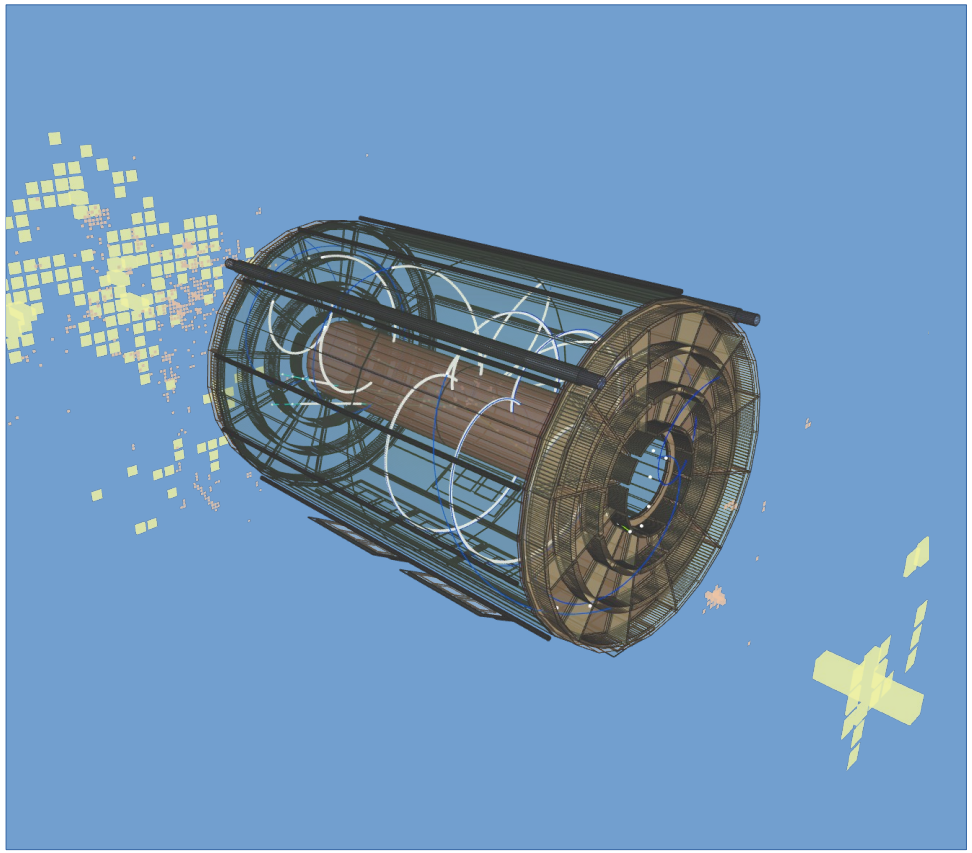
EVD for NPP

- **Intro**
  - a web-based standalone Event Display is available for NPP Experiments
  - initially developed by me at BNL to cover the needs of STAR / SPHENIX collaborations, also EIC UG
  - 100% organic development: all currently supported features were requested by collaborators
  - field-tested: used by STAR since Run 13, by SPHENIX since Run 1

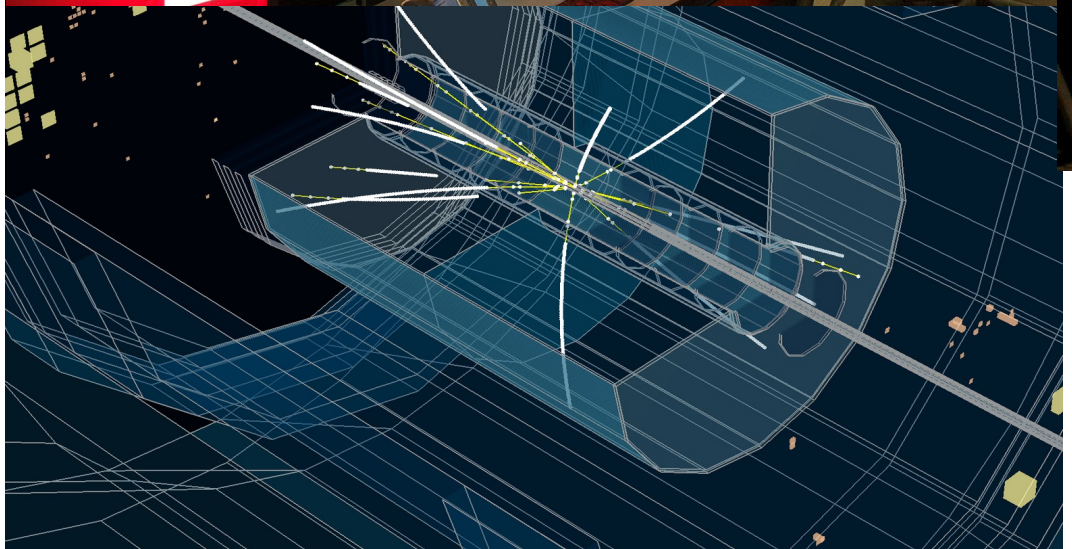
- **History**
  - **2013**: first version of the display
    https://online.star.bnl.gov/display/
  - **2017**: second version of the display
    https://www.sphenix.bnl.gov/edisplay/
  - **2024**: ePIC review?

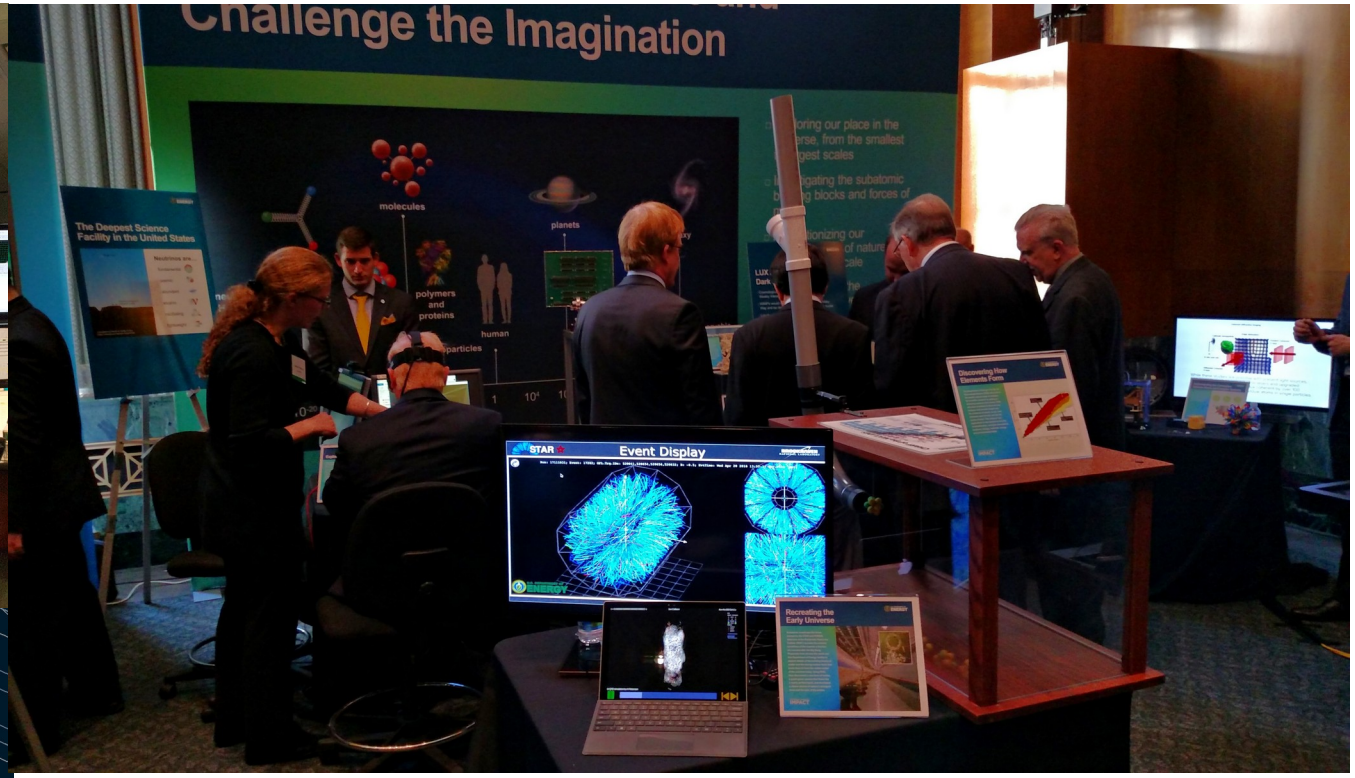
- **Source code**: https://github.com/dmarkh/evd-epic
- **Development Stack**: Javascript ES6, Webpack, NPM
- **License**: MIT

Compiles into JS+CSS, no external dependencies, no server-side codes



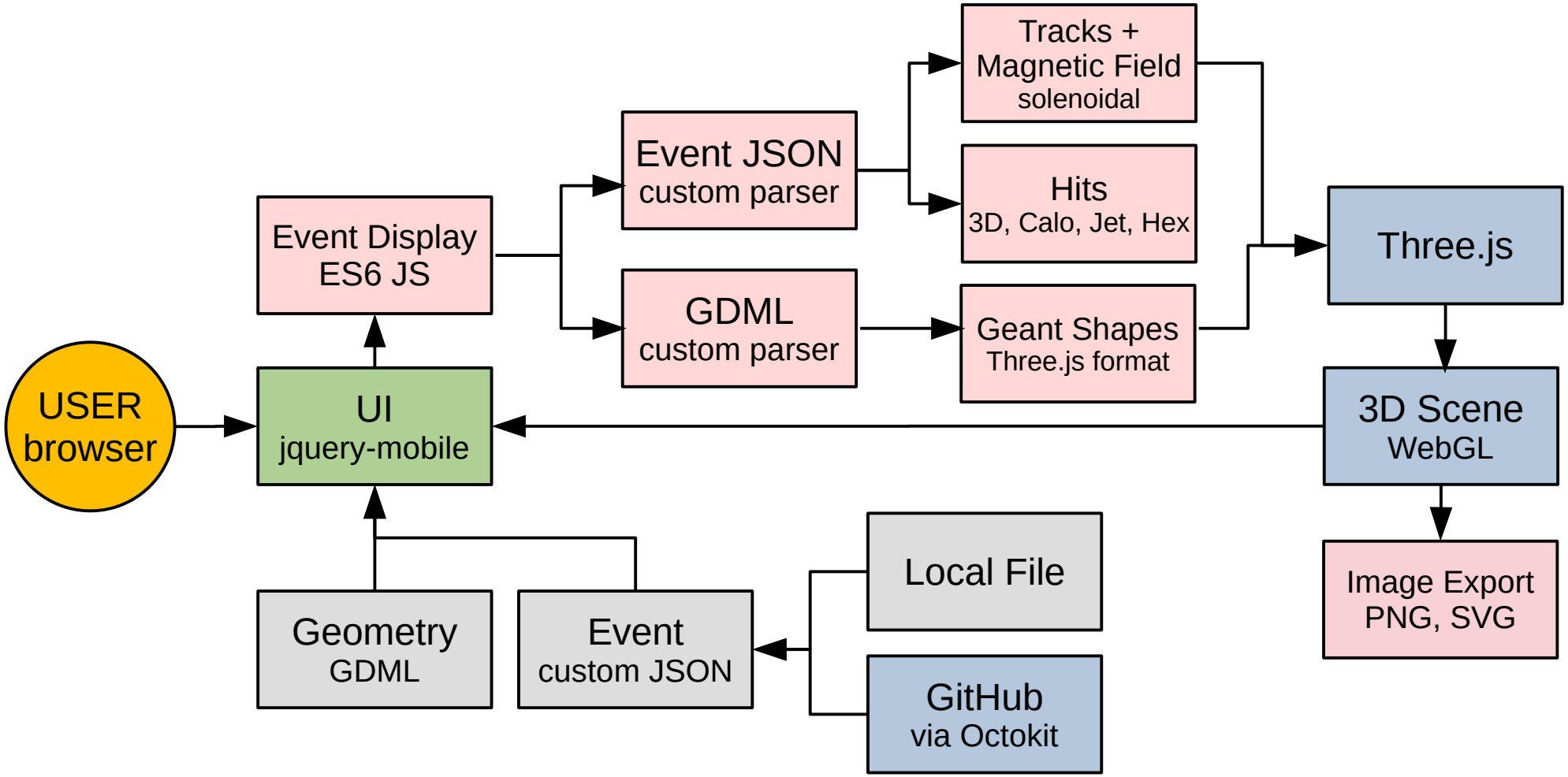
EVD: Usage





STAR Control Room, RHIC Control Room, EICUG Event Display (publication cover), sPHENIX Event Display, DOE Events (public outreach)

EVD: Overview (internals)



This is a standalone JS application fully contained in the browser. No server-side support needed.

EVD: Input Formats – Geometry = GDML

```
<?xml version="1.0" encoding="UTF-8" standalone="no" ?>
<gdml xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:noNamespaceSchemaLocation="http://service-spi.web.cern.ch/service-spi/app/releases/GDML/schema/gdml.xsd">
  <define/>
  <materials>
    <isotope N="1" Z="1" name="H10x5664170">
      <atom unit="g/mole" value="1.00782503081372"/>
    </isotope>
    <isotope N="2" Z="1" name="H20x5664200">
      <atom unit="g/mole" value="2.01410199966617"/>
    </isotope>
    <element name="H0x5664270">
      <fraction n="0.999885" ref="H10x5664170"/>
      <fraction n="0.000115" ref="H20x5664200"/>
    </element>
    <material name="G4_Galactic0x22b4cc00" state="gas">
      <T unit="K" value="2.73"/>
      <P unit="pascal" value="3e-18"/>
      <MEE unit="eV" value="21.8"/>
      <D unit="g/cm3" value="1e-25"/>
      <fraction n="1" ref="H0x5664270"/>
    </material>
    ……..
```

Full GDML standard supported in JS

```
    ……..
    <physvol name="MICROMEGAS_0_tile_7_z_phys0x197d7ac0" copynumber="0">
      <volumeref ref="invisible_MICROMEGAS_0_tile_7_z_logic"/>
      <positionref ref="MICROMEGAS_0_tile_7_z_phys0x197d7ac0inWorldpos"/>
      <rotationref ref="MICROMEGAS_0_tile_7_z_phys0x197d7ac0inWorldrot"/>
    </physvol>
    <physvol name="World_1" copynumber="1">
      <volumeref ref="World0x1"/>
      <positionref ref="World_1inWorldpos"/>
    </physvol>
    <physvol name="BOX_2" copynumber="2">
      <volumeref ref="BOX"/>
      <positionref ref="BOX_2inWorldpos"/>
    </physvol>
    <physvol name="log_MVTX_Wrapper_3" copynumber="3">
      <volumeref ref="log_MVTX_Wrapper"/>
      <positionref ref="log_MVTX_Wrapper_3inWorldpos"/>
    </physvol>
  </volume>
</structure>
<setup name="default" version="1.0">
  <world ref="TPC"/>
  <world ref="TPOT"/>
  <world ref="INTT"/>
  <world ref="MVTX"/>
  <world ref="BEAMPIPE"/>
</setup>
</gdml>
```

Multiple GDML Worlds
(aka entry points) supported

EVD: Input Formats – Events = JSON


```
"META": {
   "HITS": {
      "TRACKHITS": {
         "type": "3D",
         "options": {
              "size": 10,
              "transparent": 0.8,
              "color": 16777215
          }
       },
       "CEMC": {
            "type": "PROJECTIVE",
              "options": {
                  "rmin": 90,
                  "rmax": 116.1,
                  "deta": 0.025,
                  "dphi": 0.025,
                  "color": 16711680,
                  "transparent": 0.9,
                  "scaleminmax": true
              }
        },
        "JETS": {
            "type": "JET",
            "options": {
                "rmin": 0,
                "rmax": 78,
                "emin": 0,
                "emax": 30,
                "color": 16777215,
                "transparent": 0.5
            }
```


HIT DESCRIPTORS


```
"HITS": {
   "CEMC": [
          { "eta": -0.836801, "phi": -2.56482, "e": 0.282775},
          { "eta": -0.736801, "phi": -2.36482, "e": 0.182775}
   ],
   "HCALIN": [
          { "eta": -0.870833, "phi": -2.50346, "e": 0.125797},
          { "eta": -0.800833, "phi": -2.20346, "e": 0.055797}
   ],
   "HCALOUT": [
          { "eta": -0.9625, "phi": -2.60163, "e": 1.4437},
          { "eta": -0.9625, "phi": -2.50346, "e": 0.349091},
          { "eta": -0.870833, "phi": -2.69981, "e": 0.278089},
          { "eta": -0.870833, "phi": -2.60163, "e": 1.91704},
          { "eta": -0.870833, "phi": -2.50346, "e": 5.52037},
          { "eta": -0.779167, "phi": -2.69981, "e": 0.14792},
          { "eta": -0.779167, "phi": -2.60163, "e": 0.153837},
          { "eta": -0.779167, "phi": -2.50346, "e": 0.100585},
          { "eta": -0.4125, "phi": 2.89616, "e": 0.14792}
    ],
    "TRACKHITS": [
          { "x": 40, "y": 0, "z": 0, "e": 1 },
          { "x": 50, "y": 0, "z": 0, "e": 1 },
          { "x": 60, "y": 0, "z": 0, "e": 1 }
    ],
    "JETS": [
          { "eta": -0.870833, "phi": -2.50346, "R": 0.6, "e": 30.0 }
    ]
}
```


HIT DATA

compact, human-readable, gzip-friendly


```
"TRACKS": {
  "TRACKER": [
    {
       "color": 400,
       "pt":    2.881,
       "p":   -0.645,
       "q": -1,
       "nh": 8,
        "l":  120.522,
        "xyz": [   0.000,   0.000,   0.000],
        "pxyz": [   2.303,  -1.731, -13.004],

        "pts": [
            [  1.835,  -1.369, -10.333],
            [   4.457,  -3.293, -25.014],
            [   7.157,  -5.230, -40.014],
            [  10.783,  -7.766, -59.985],
            [  14.448, -10.255, -79.985],
            [  18.818, -13.128,-103.588]
         ]
    },
……..

    "EVENT": {
      "runid": 1,
      "evtid": 1,
      "time": 0,
      "type": "Collision",
      "s_nn": 0,
      "B": 3.0,
      "pv": [0,0,0]
    },
```

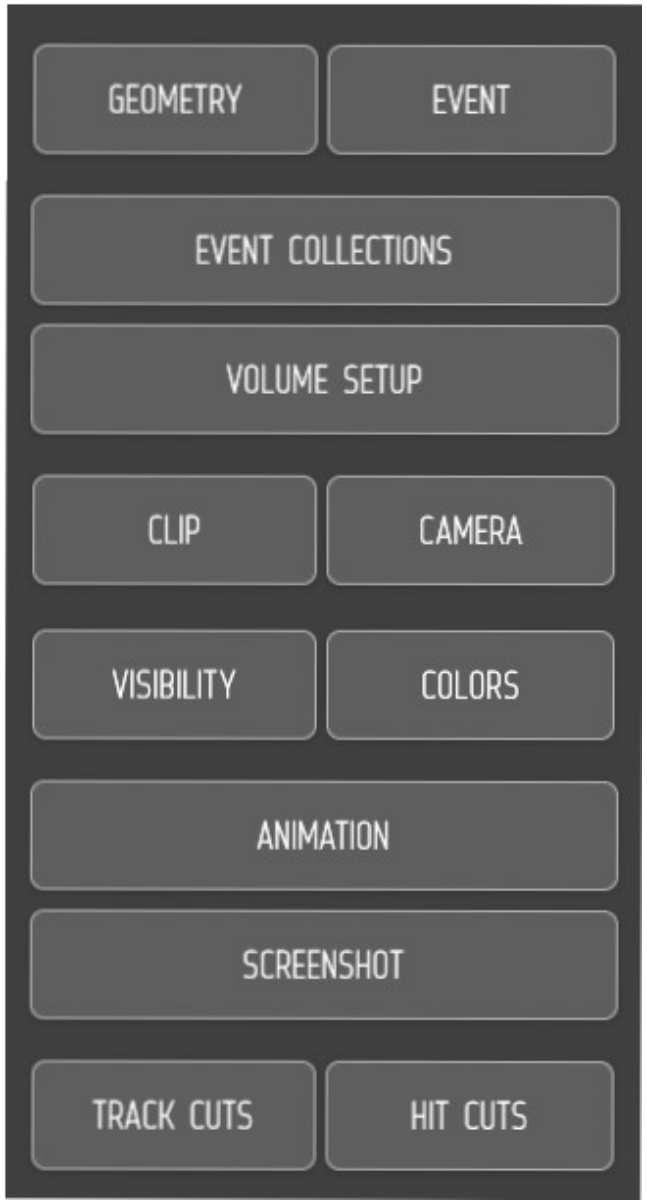

TRACK DATA

EVENT METADATA

EVD: Features

- **Camera** Controls
  - position, direction, FOV, ortho;
- Basic Geometry **Clipping**
  - 1/8,1/4,1/2,etc;
- **Image Export**:
  - PNG (scalar)
  - SVG (vector, unlimited resolution for publications)
- GDML **Volume identification**
  - ...via raycasting (see visibility / logs menu)

- Geometry/Track **Color setup**
- **Animation** (scene rotation)
- Track **Cuts** / Hit Cuts
  - energy, p, pT, eta/phi…
- **Event Collections** support
  - timer-based automatic rotation of events in the collection
- **GitHub** integration:
  - store your events to git repo, automatically download via UI



Summary and Outlook

- **Web-based Event Display** is available for ePIC consideration
  - satisifies most published requirements of ePIC (draft version)
  - proven to cover the needs of RHIC / NP experiments
  - experiment-agnostic: does not depend on any experiment-specific tools or packages

- **TODO**:
  - Codebase TLS:
    - UI: use Svelte/React + MaterialUI
    - 3D: use latest Three.js version for WebGL2 support
    - Build: use newest webpack version
  - Features:
    - add offscreen rendering support for batch image generation?
    - implement ePIC-specific hit types support?
    - Implement track selection?