Simulation of SBS experiments

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University of Connecticut

SBS collaboration meeting
Jefferson Lab, August 5-6, 2019

UCONN Jefferson Lab

Overview

*** Status of G4SBS and recent developments**

*** Recent MC applications**

*** Digitization / Interface with offline software**

*** Summary**

G4SBS status

* Source code is maintained in a githubrepository controlled by JLab:
https://github.com/JeffersonLab/g4sbs

* Master branch is most stable/full-featured

* Active development of the core framework and geometries of the “core” experiment geometries is done in uconn_dev (lastest uconn_dev merge into master: February 2019)

* Signficant development over the past few months in:
 - gen-rp_dev
 - tdis_dev
(PS: I suspect they are still actively used, albeit not commited often)

* no track of activity since last collaboration meeting in the other 16 (!) branches.

* 7 “forks” of g4sbs exist, mostly not in active development (according to repo)

Documentation available at:
https://hallaweb.jlab.org/wiki/index.php/Documentation_of_g4sbs

G4SBS status: working group

Name	Institution	Major Contributions/Responsibilities
Seamus Riordan (*former*)	ANL	Github repository creation, GEANT4 application framework, cmake build system, BB+SBS magnets, magnetic field implementation, event generators, GEMs, field clamps, targets, beamline, example scripts, UI commands, etc.
Andrew Puckett, Eric Fuchey, Freddy Obrecht (former) *+ Provakar Datta, Sebastian Seeds*	UConn	RICH, GEP beamline and scattering chamber, CDET, LAC, dynamic ROOT Tree output w/STL vectorization of array-valued branches, sensitive detector classification, organization and signal processing (hit aggregation), LUND/PYTHIA interface, more event generators, GEP ECAL, **documentation**, ROOT macros for analysis of simulation output, more example scripts, more UI commands, GMN/GEN beamline, GMN scattering chamber, GRINCH, BB shielding, GEP ECAL, TDIS geometry
Juan Carlos Cornejo	CMU	HCAL, GMN event generators, command-line interface improvements, example script organization and maintenance, more UI commands
John Annand, David Hamilton, Rachel Montgomery	Glasgow U	GEN-RP simulation, TDIS simulations, BB timing hodoscope
Ole Hansen	JLab	Hall A software, repository maintenance, write access control

G4SBS recent developments

Added the *optional* storage of the **full track information** for each hit of a defined sensitive detector:
* primary particle that caused the hit tracking back history (**Primary** info);
* ‘‘first’’ secondary particle (i.e. just after the parimary) if this particle is produced in a ‘‘target’’ or ‘‘analyzer’’ volume (**Original** info);
* info of particle that crosses the boundary of the detector (as defined in G4SBS).

Full details at:
https://github.com/JeffersonLab/g4sbs/commit/f564e7bdf066a4cab06fe2e37e3bba324c9458bb

Possible applications: evaluate the gain of statistics from recoil charge exchange in G_E^p

G4SBS recent developments

G4SBS cmake build modifications: new features to ease the handling of g4sbs to newcomers:
 * dynamic location of libraries dependencies;
 * removed restriction to run g4sbs from build directory;
 * automatic downloading of field maps;

New procedure:

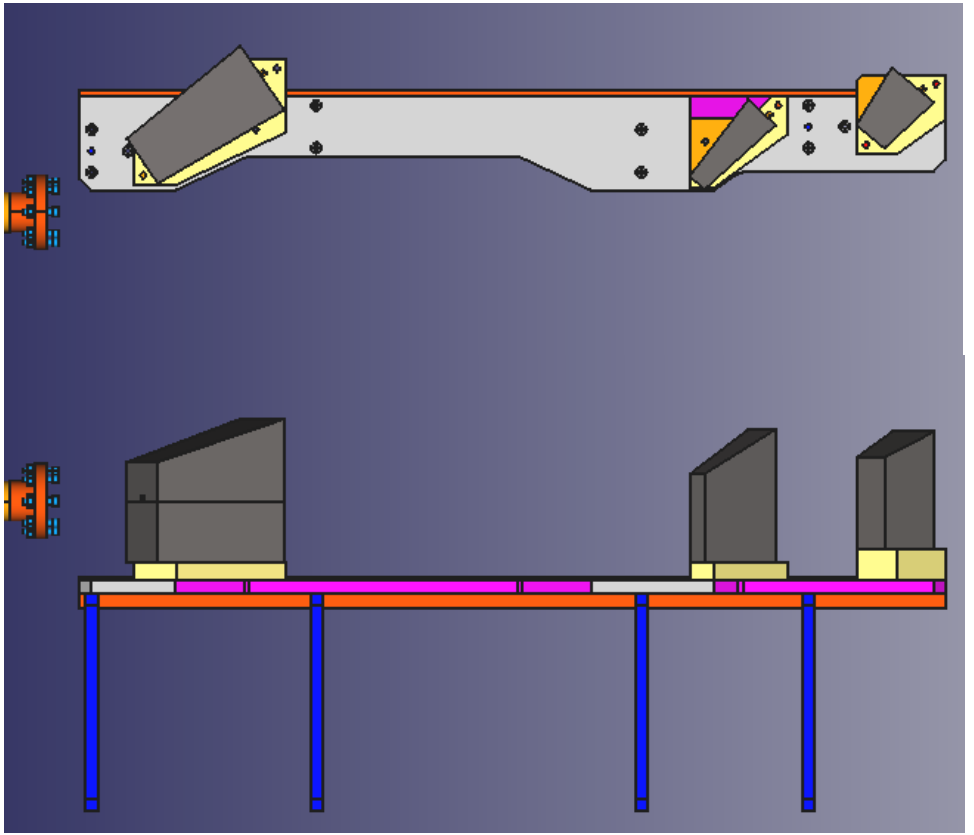
```
mkdir build
cd build
cmake ../g4sbs
make install
make
```

Status for individual experiment setups

* “Core” experiments G_M^n, G_E^n (^{3}He), SIDIS G_E^p setups have not evolved much since last collaboration meeting in February.

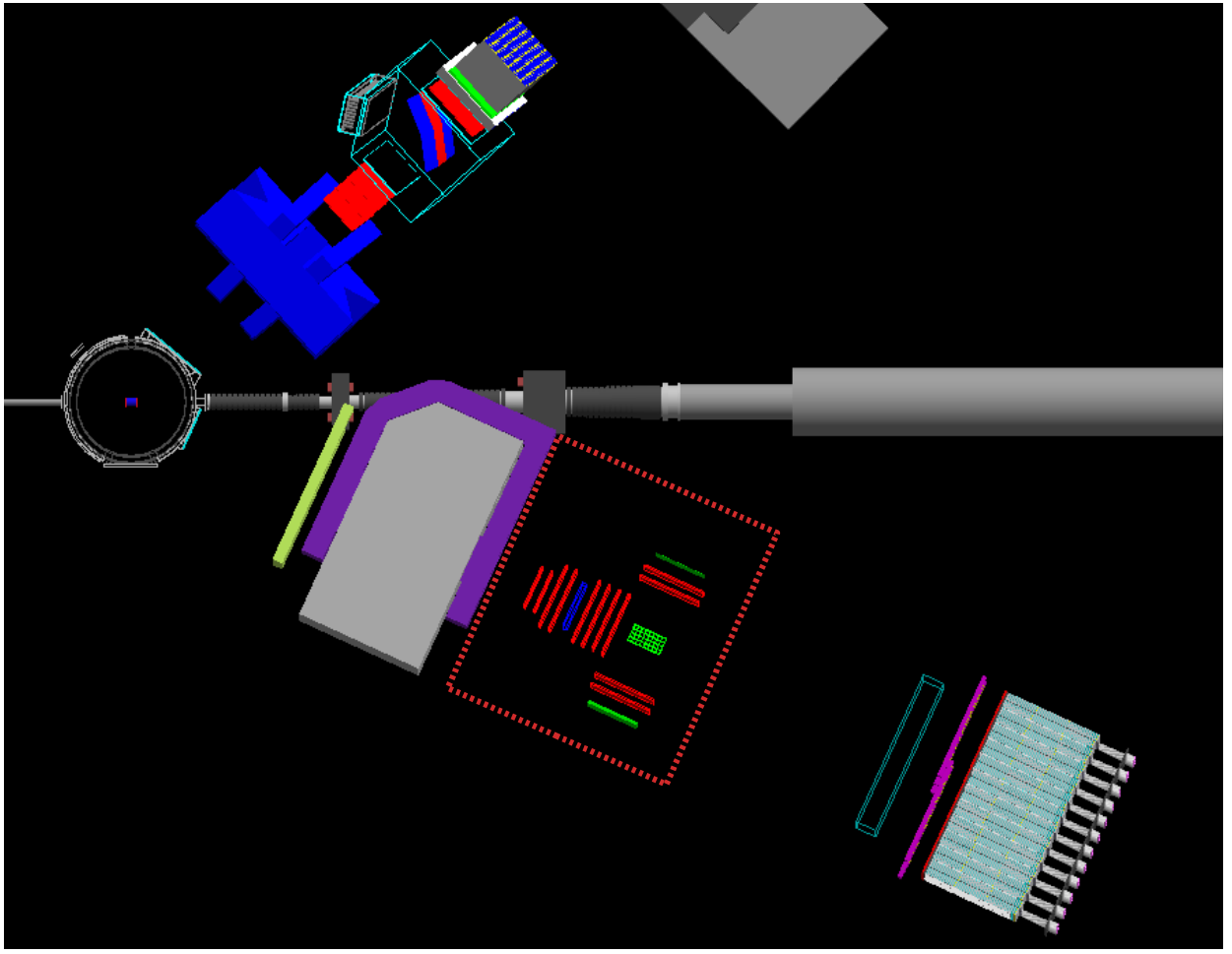
* Efforts have been carried on G_E^n RP and TDIS (next slide)

* Need to focus on G_E^n (^{3}He) beamline and target collimators, as a readinees review might come soon



Status for individual experiment setups

G_E^n RP: recoil polarimeter added by Glasgow group (rates calculations ?)



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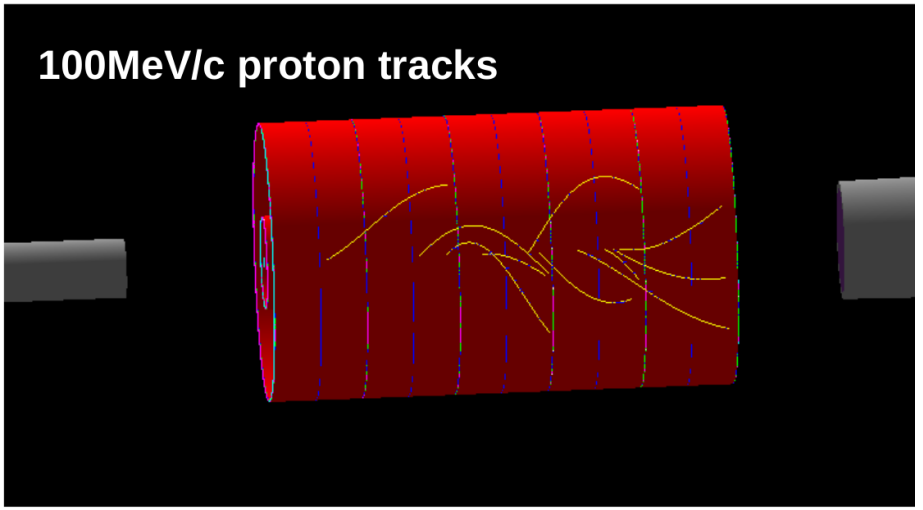
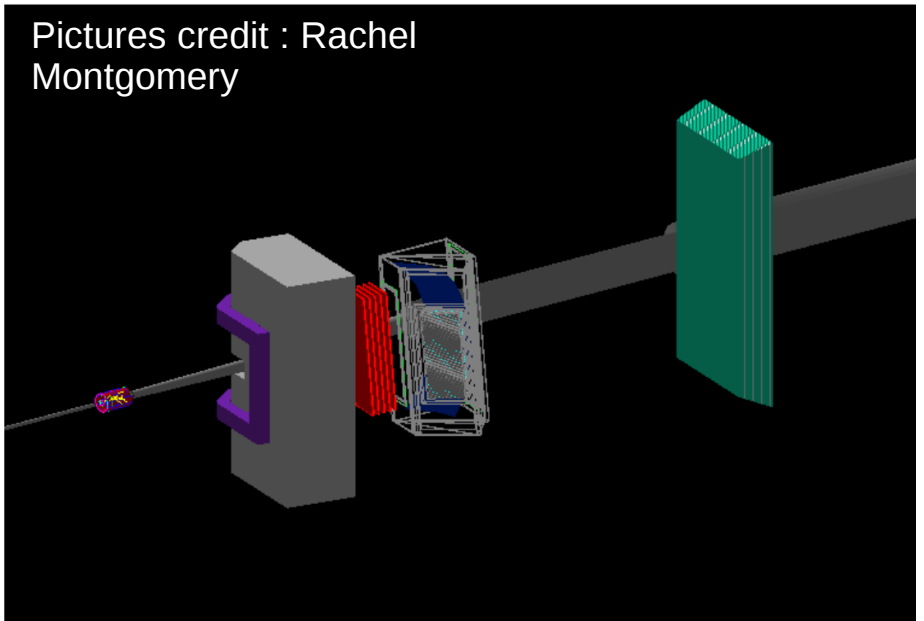
Status for individual experiment setups

TDIS mTPC added by Glasgow group from a GEMC model.
Actively used to understand acceptance of the device.





Recent MC applications
Update of GMn background (focus on GEMs)

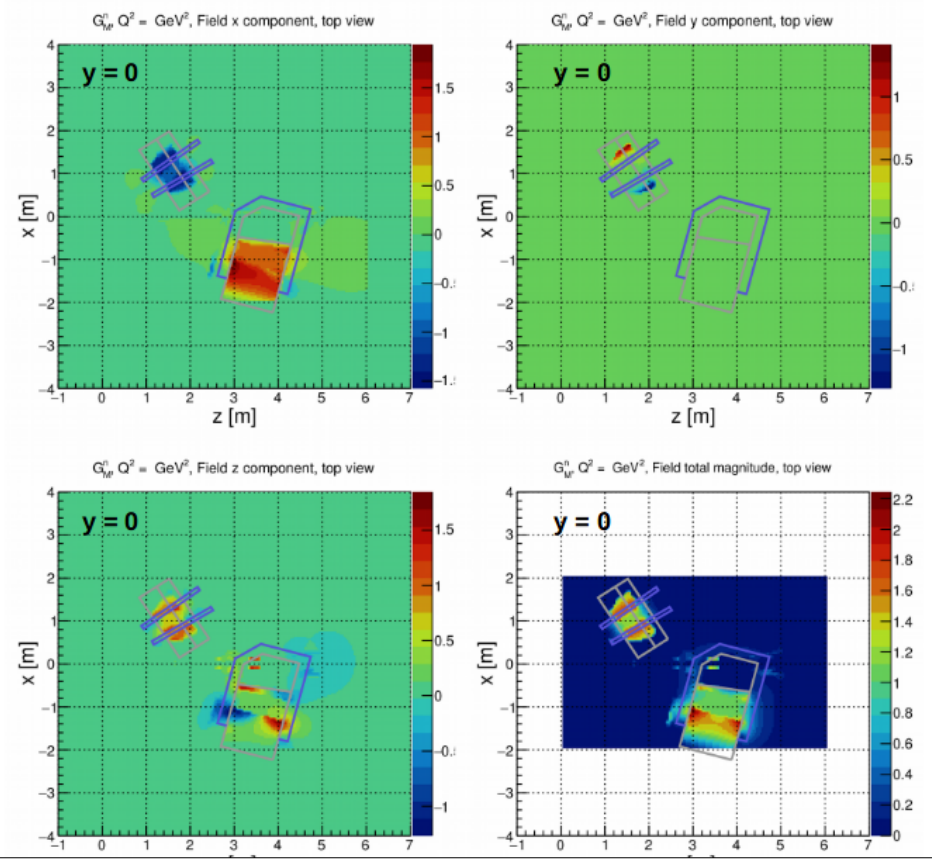
Summary and next steps

Slide from last summer's SBS meeting

*** Include new TOSCA field map with BB and reevaluate the background rates**

In progress

(previous Tosca map only includes SBS, BB field map added as a local field)



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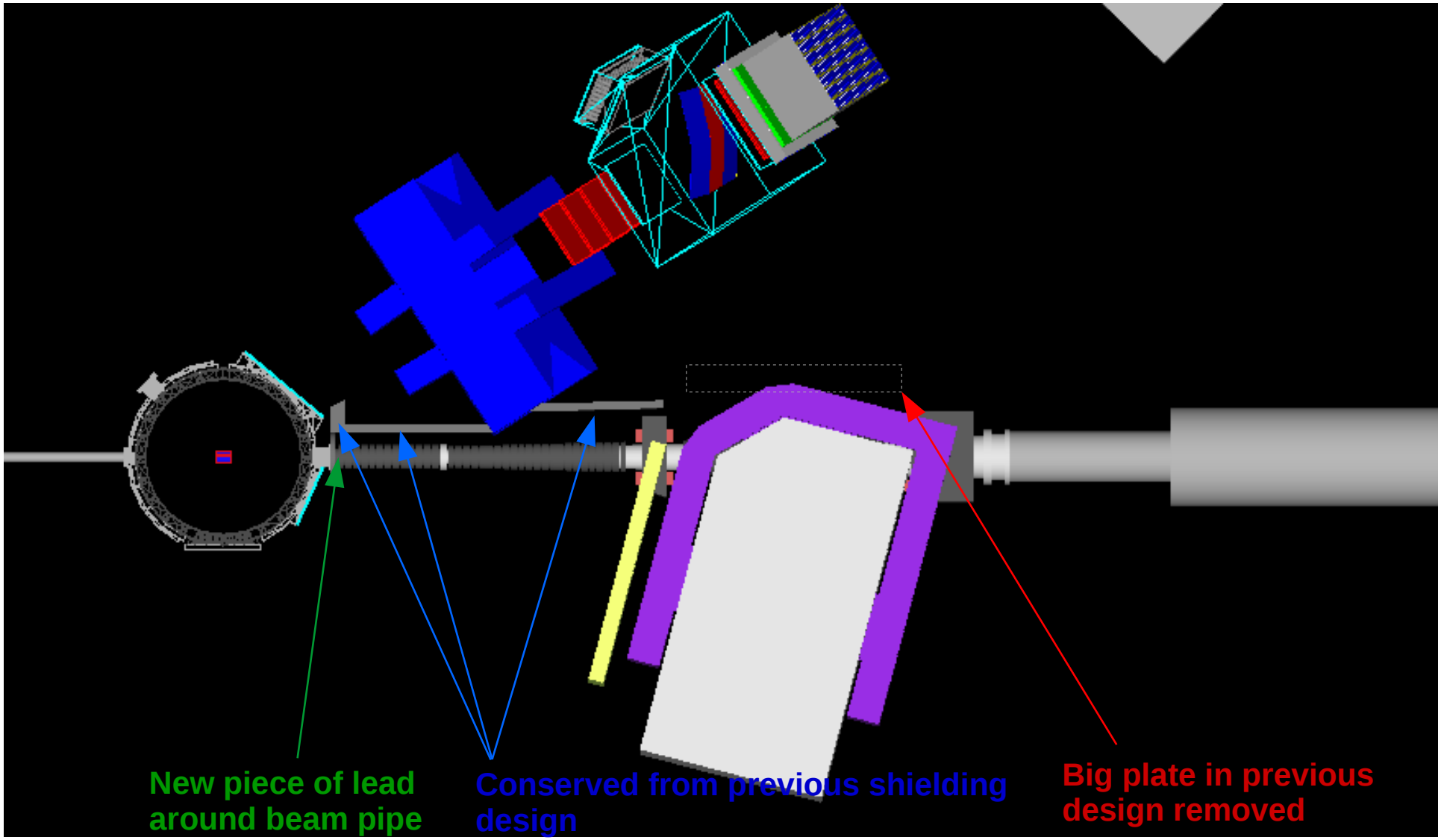
Turns out, the previous TOSCA field map was not using the right transformation
-> influence on background estimation

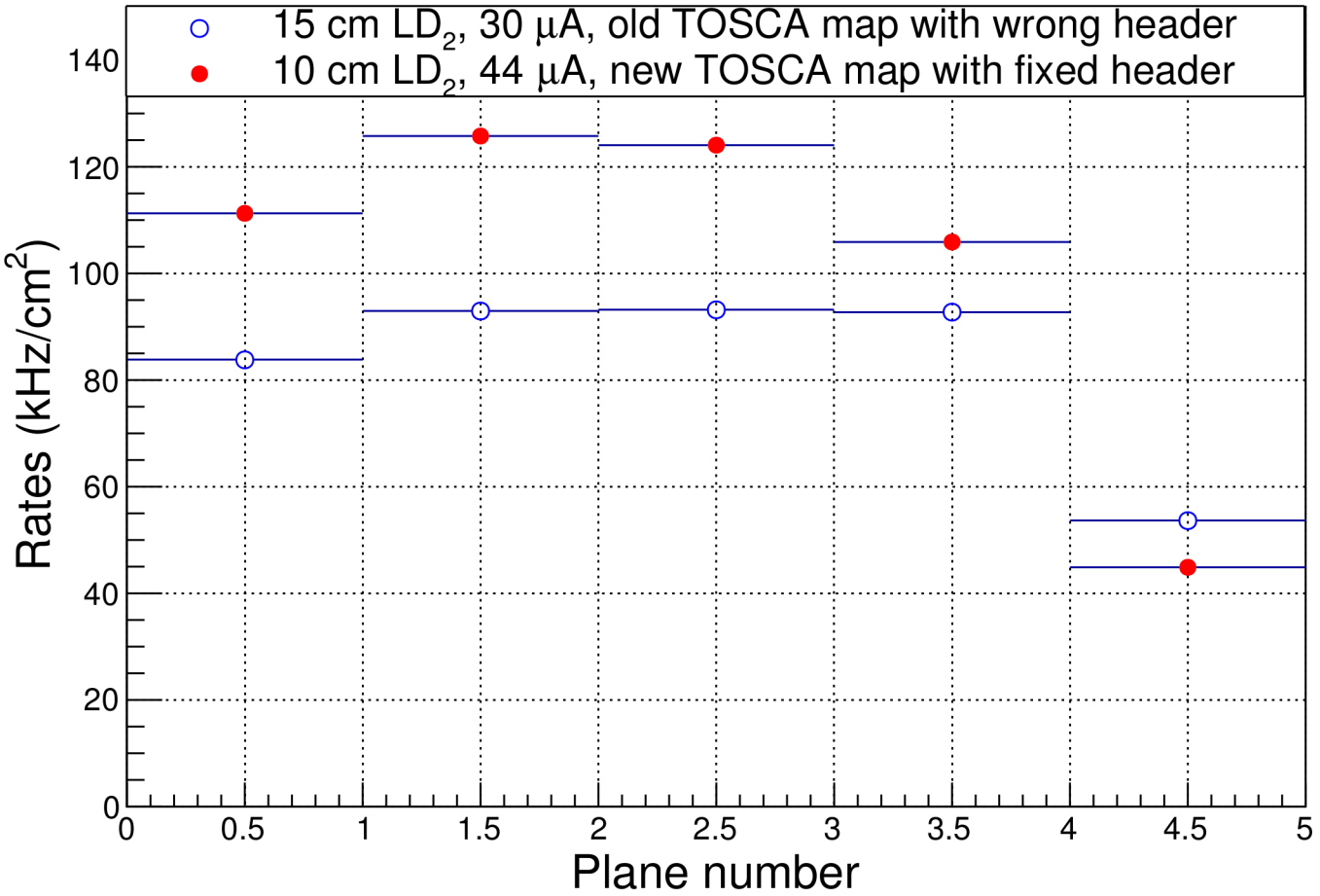
Recent MC applications
Update of GMn background (focus on GEMs)
Geometry/Beamline shielding tweaks



Previous design slide 17 in following link:
https://sbs.jlab.org/DocDB/0000/000012/001/EFuchey_SimuShieldpdate_20180722_edit.pdf

Recent MC applications
Update of GMn background (focus on GEMs)

Updates on rates: "Slightly" worse background (10-40 % worse) for INFN GEMs, 20 % better for UVA GEMs than for previous estimations used for tracking.

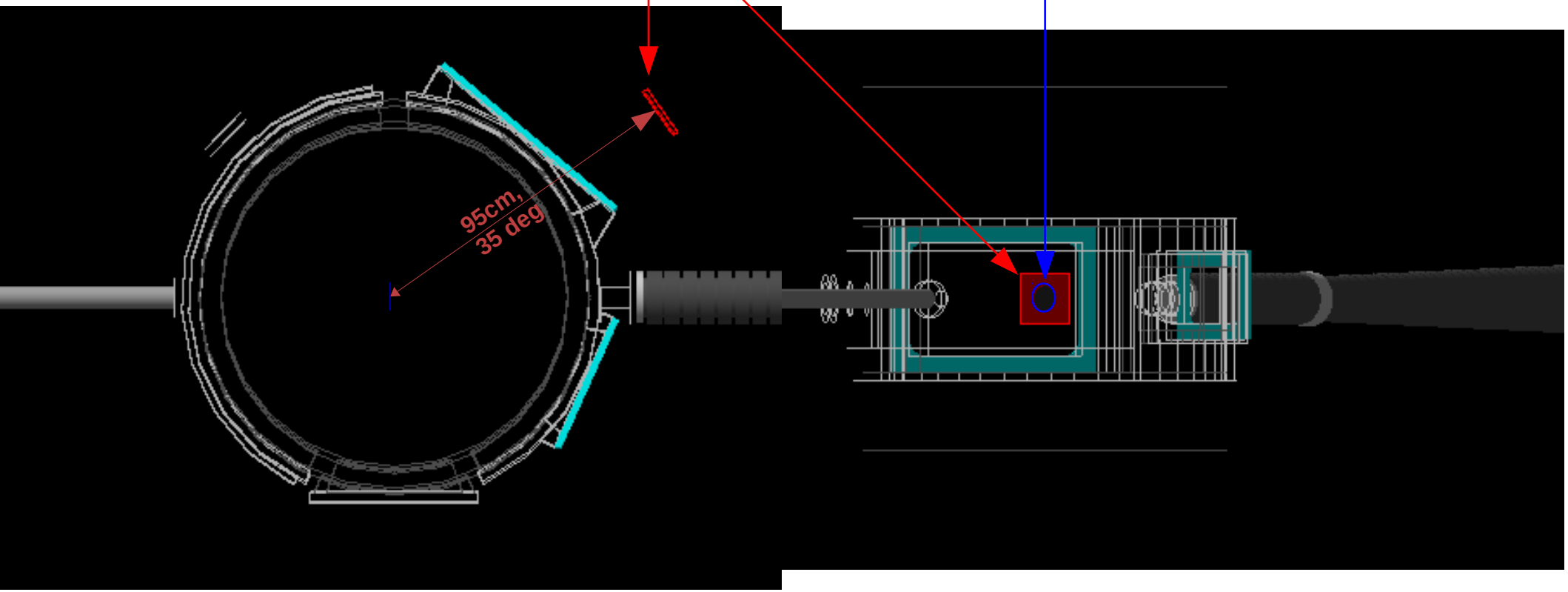


Previous estimation slide 14 (made with design on iteration 3) in following link:
https://sbs.jlab.org/DocDB/0000/000012/001/EFuchey_SimuShieldpdate_20180722_edit.pdf

This evolution of the GEM rates is affecting the tracking efficiency, fortunately marginally (< -5% relative - see my talk on tracking update tomorrow).

Recent MC applications
Hall C high rate GEM data reproduction with G4SBS

Setup: C16 scattering chamber
(even though it's probably not the right model)
15.36*15.36cm^2 GEM, 118µm carbon foil (1.5 % X_0)

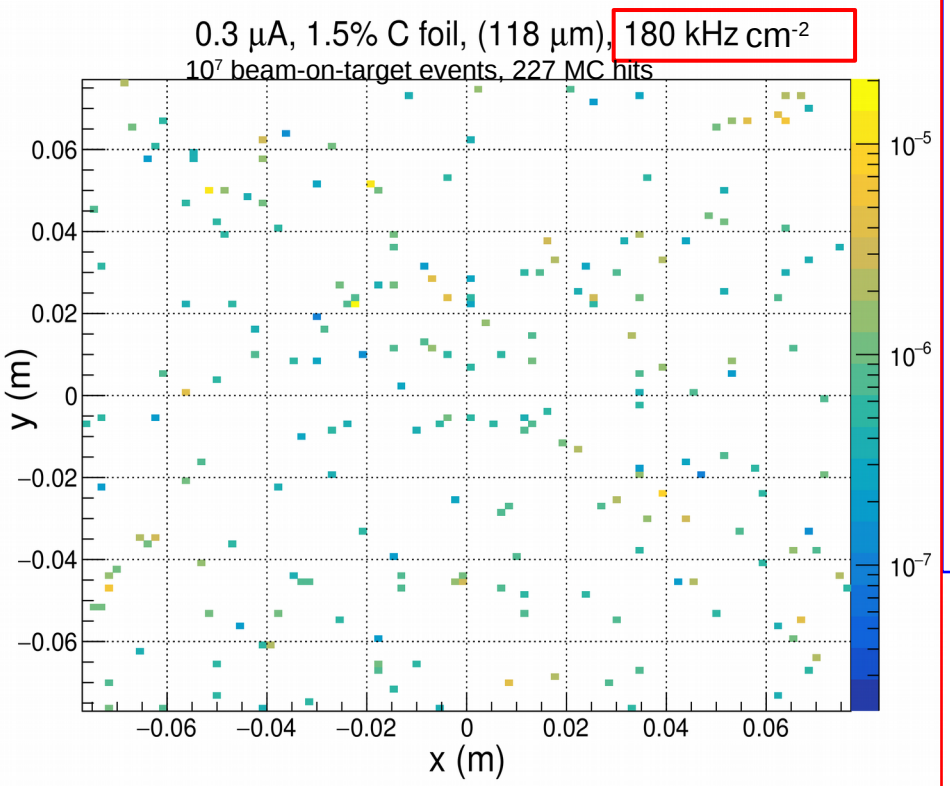


Beam : 10.6 GeV, 0.3 µA

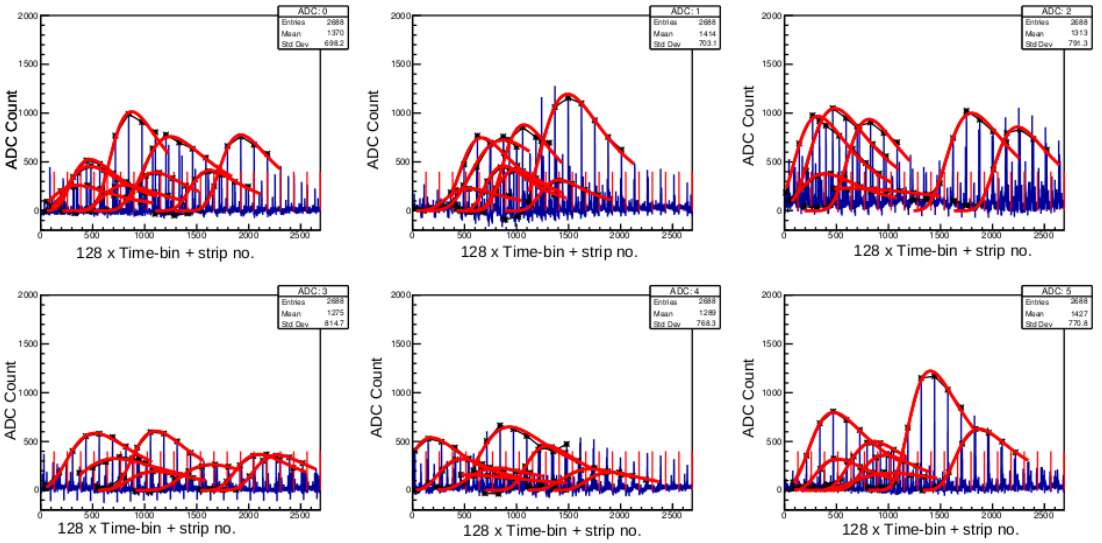
Recent MC applications
Hall C high rate GEM data reproduction with G4SBS

Number of hits recorded by G4SBS : comparison with actual data

G4SBS prediction: ~180 kHz/cm²
=> 23 recorded hits / event



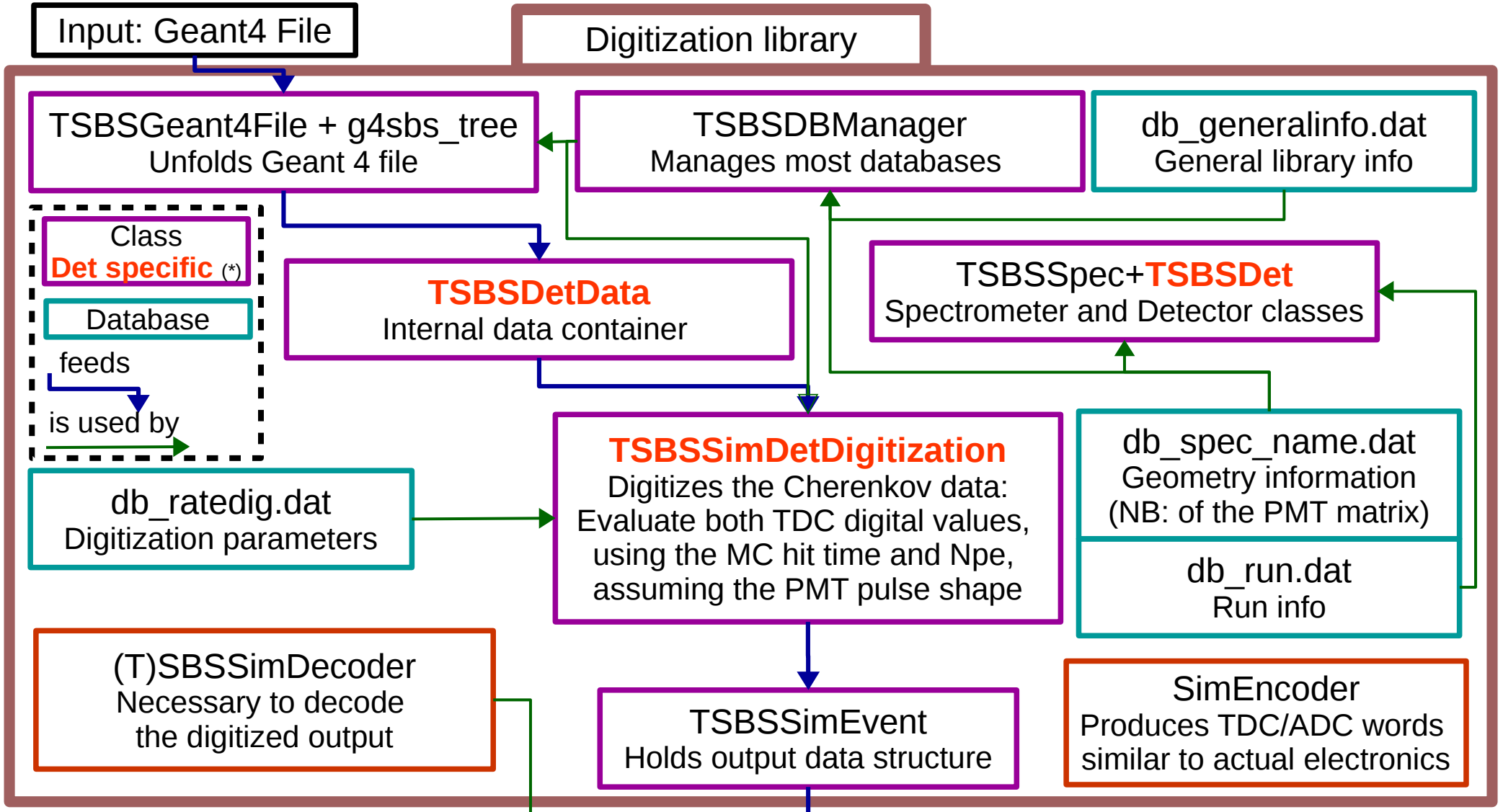
1 Hall C Event ~ 8 pulses / APV
=>24 reconstructed hits / event



Hall C events: 21 samples of 25 ns => 525ns
~10^6 electrons on target during one event @ 0.3 µA

Not perfect agreement between g4sbs recorded hits and data reconstructed hits, but it's in the same ball park.
Reconstruction of G4SBS pseudo data after digitization *might* show a better agreement...

Interface with SBS Software:
Digitization: library Class structure



Background addition *still missing*

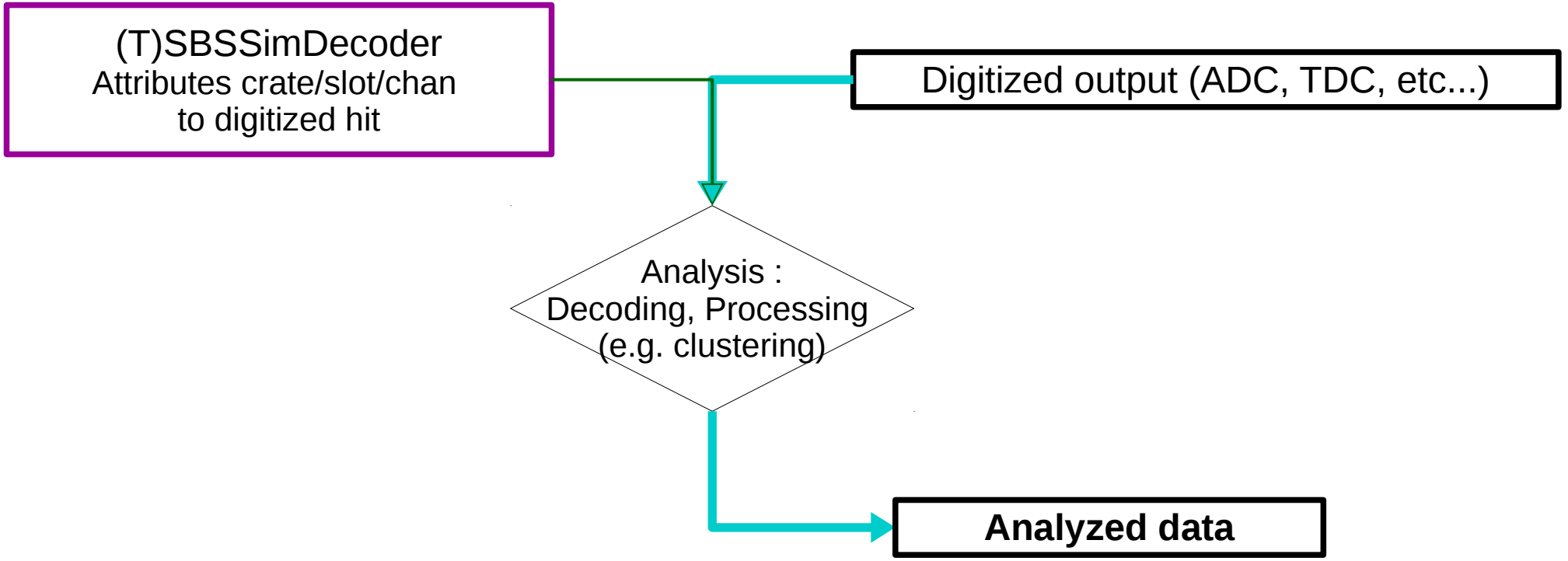
Most subsystems included

(*) : may inherit, but a template must be written

Interface with SBS Software:
Digitization Interface with analysis

Required for the interface:

* (T)SBSSimDecoder (inside or outside the Digitization library);
* Databases :
  - global parameter databases (theta, pcentral);
  - virtual cratemap (db_sbssim_cratemap.dat);
  - detector geometry database (in a format supported by analyzer 1.6, etc...)
* An analysis script which puts everything altogether ;



We have on hand most of the databases for G_M^n
but some are still incomplete
=> need to refocus on this.

Summary

*** Additional functionalities added to G4SBS:**

- full track information optionally available for the hits;
- build improvements to make G4SBS more user friendly;

*** Geometry development efforts have mainly been focussed on G_E^n-RP, TDIS**

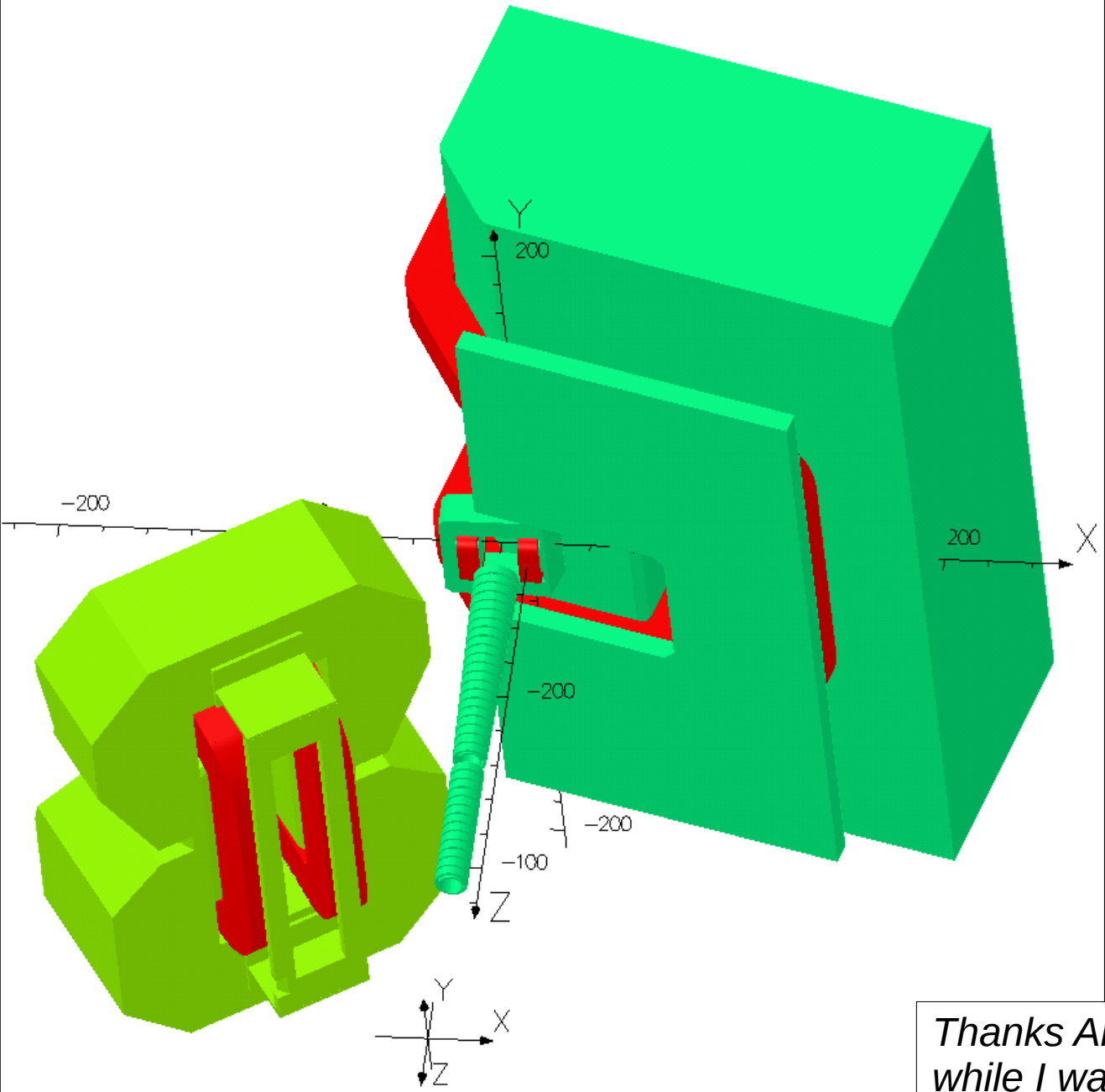
- need focus on $G_E n$ (^{3}He) beamline and target collimators for upcoming ERR

*** Interface with software chain close to functional, but needs refocus:**

- still need inclusion of background (at least beam background);
- a few databases are incomplete

Backup

Tosca field map transformation



Tosca map transformations

Tosca coordinates :

$x_{Tosca} = -x_{Hall}$

$y_{Tosca} = +y_{Hall}$

$z_{Tosca} = -z_{Hall}$

$(0, 0, 0)_{Tosca} = (0, 0, 0)_{Hall}$

=> 180 deg rotation by Oy_{Tosca};

+ read map by descending order of z

(NB : Andrew did the following:

180 deg rotation by Ox_{Tosca};

$x'_{Tosca} = +x_{Tosca} = -x_{Hall}$

$y'_{Tosca} = -y_{Tosca} = -y_{Hall}$

$z'_{Tosca} = -z_{Tosca} = +z_{Hall}$

180 deg rotation by Oz'_{Tosca};

$x''_{Tosca} = -x'_{Tosca} = +x_{Hall}$

$y''_{Tosca} = -y'_{Tosca} = +y_{Hall}$

$z''_{Tosca} = +z'_{Tosca} = +z_{Hall}$

+ read map by descending order of z

Shall be equivalent...)

For old Tosca map (slide 9) I was doing:

$z_{Hall} = z_{Tosca}$-796 cm;

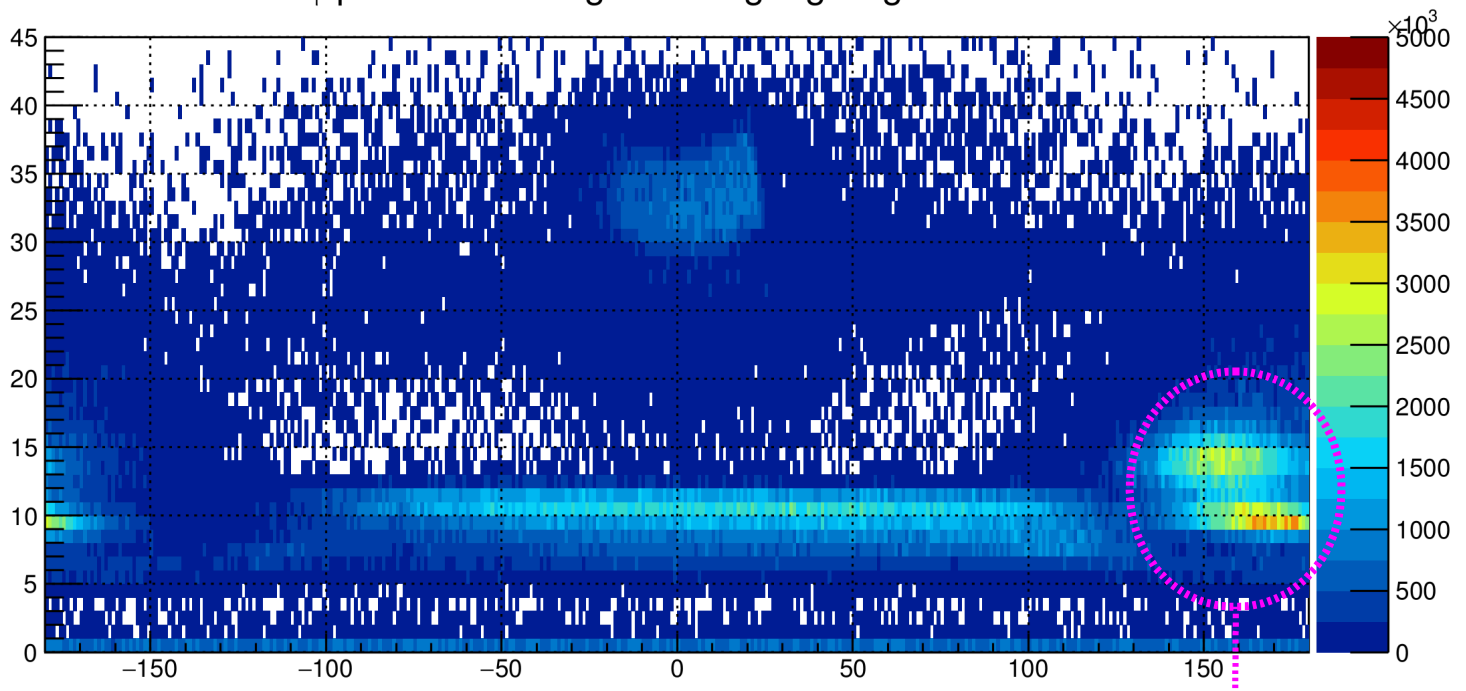
180 deg rotation by Oz'_{Tosca};

Not too big of a deal for SBS only.

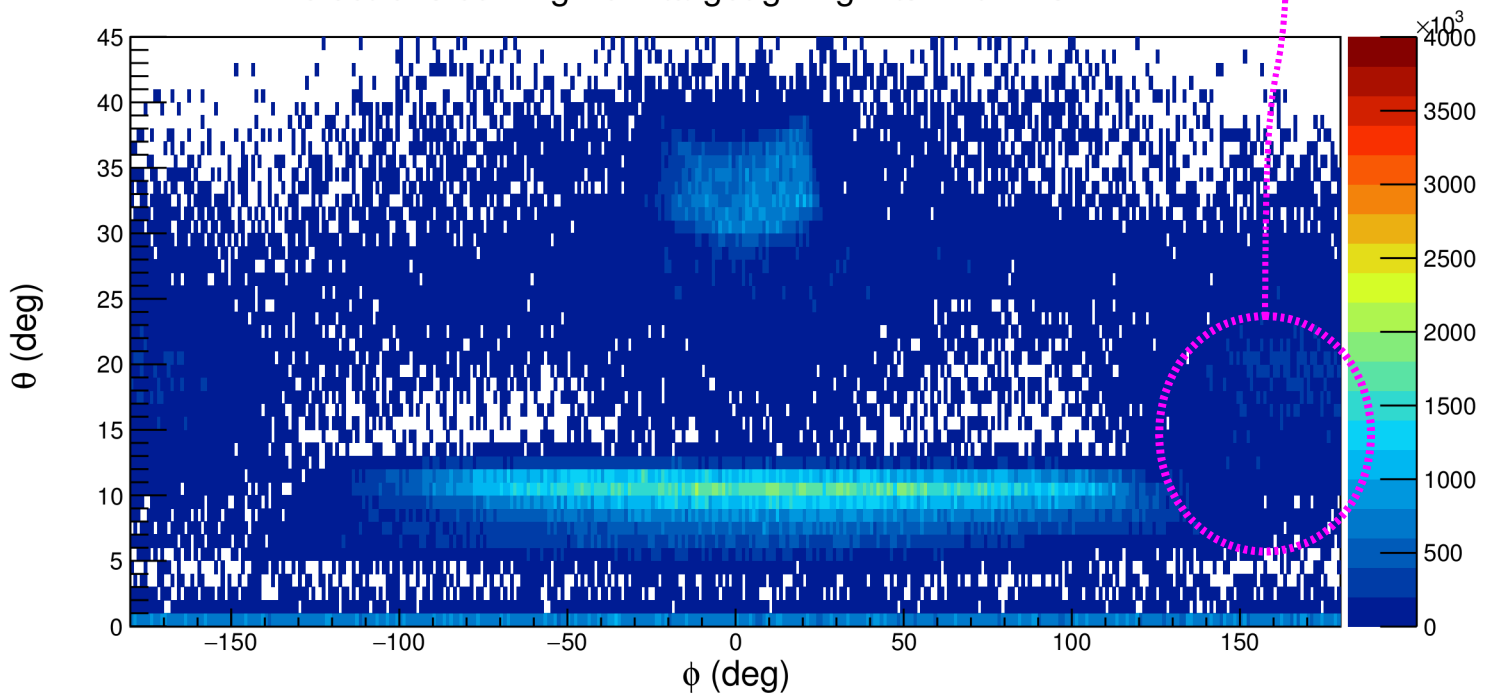
Thanks Andrew for taking care of that while I was dealing with PAC stuff...

Effect of SBS front clamp

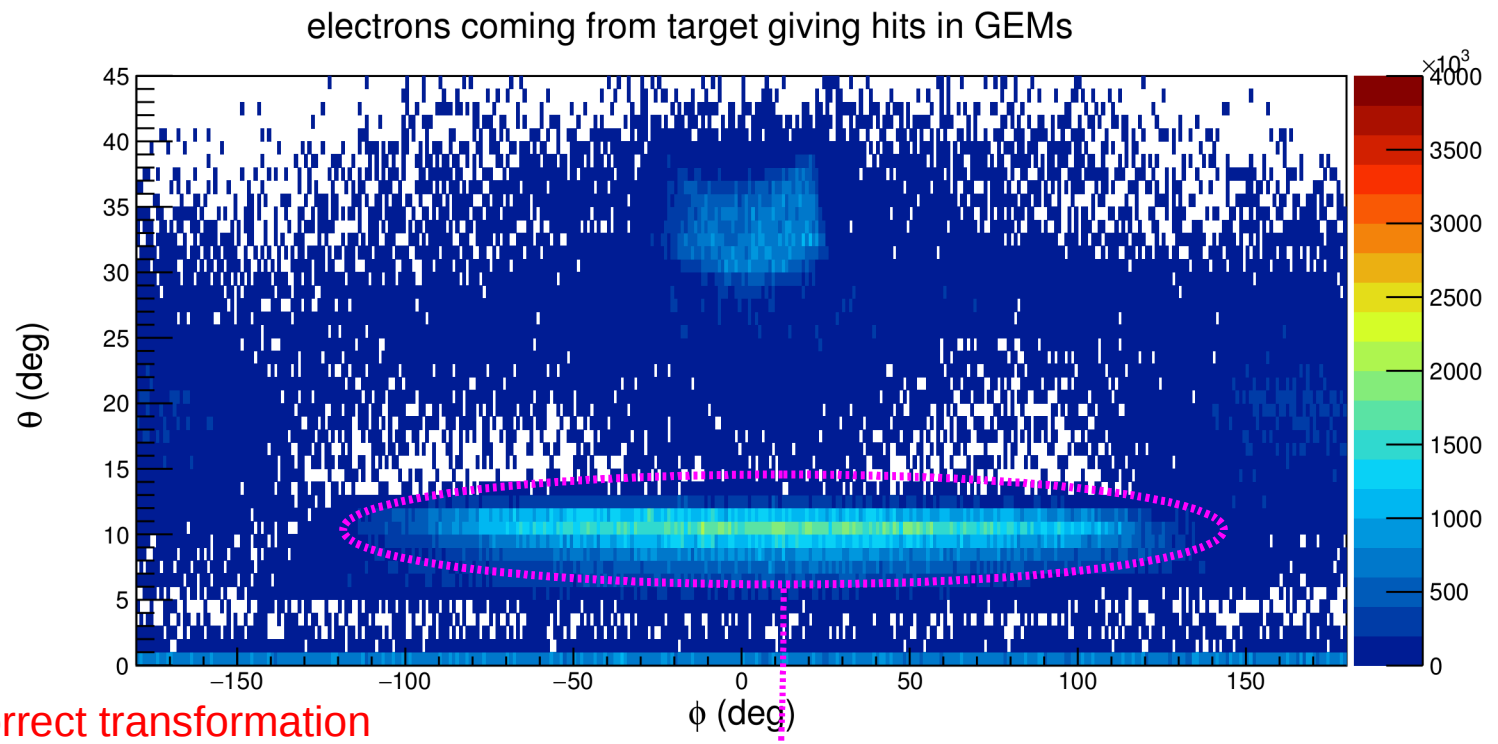
No SBS clamp



SBS clamp

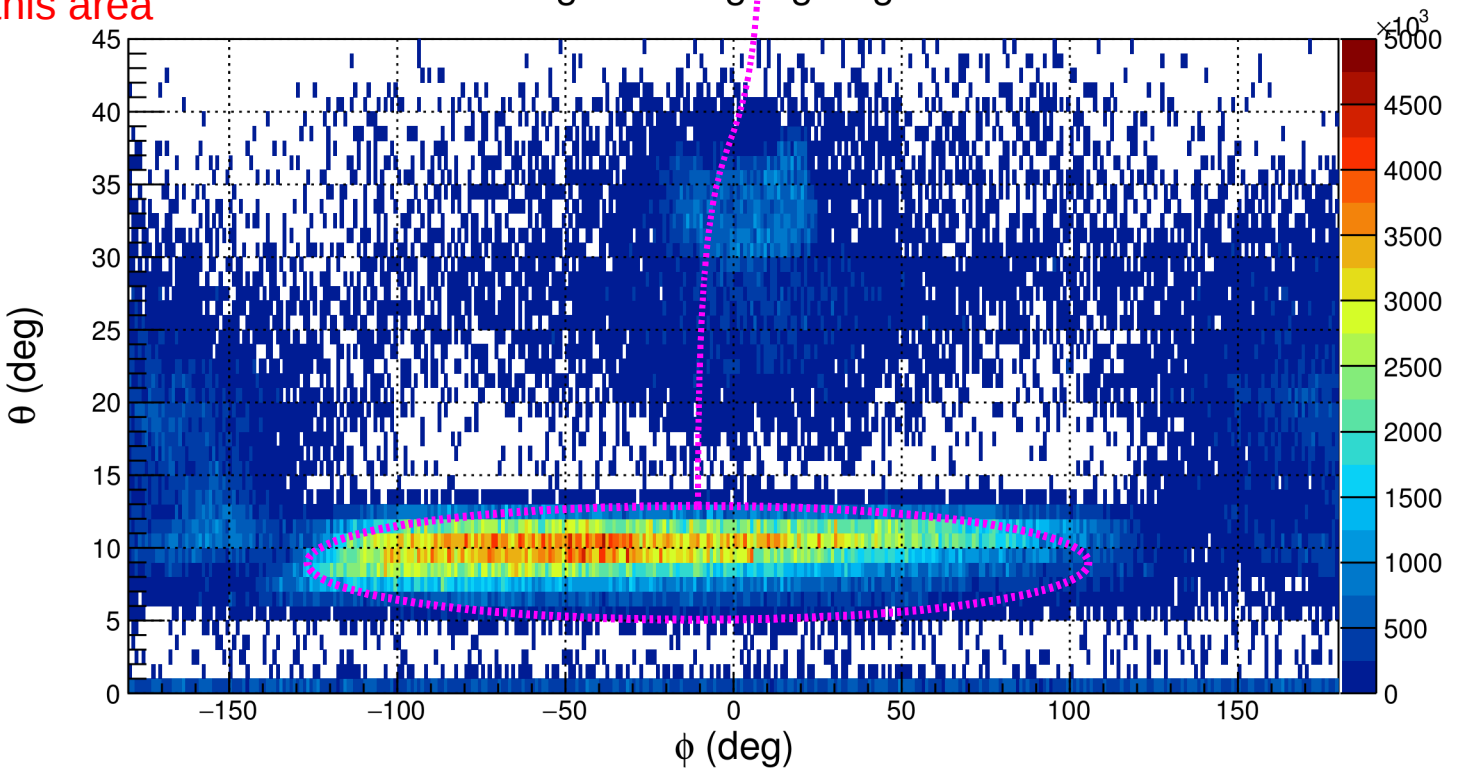


Old Tosca map,
Old transformatior



Unfortunately, the incorrect transformation was underestimating the number of electrons coming from this area

Old Tosca map,
New transformation



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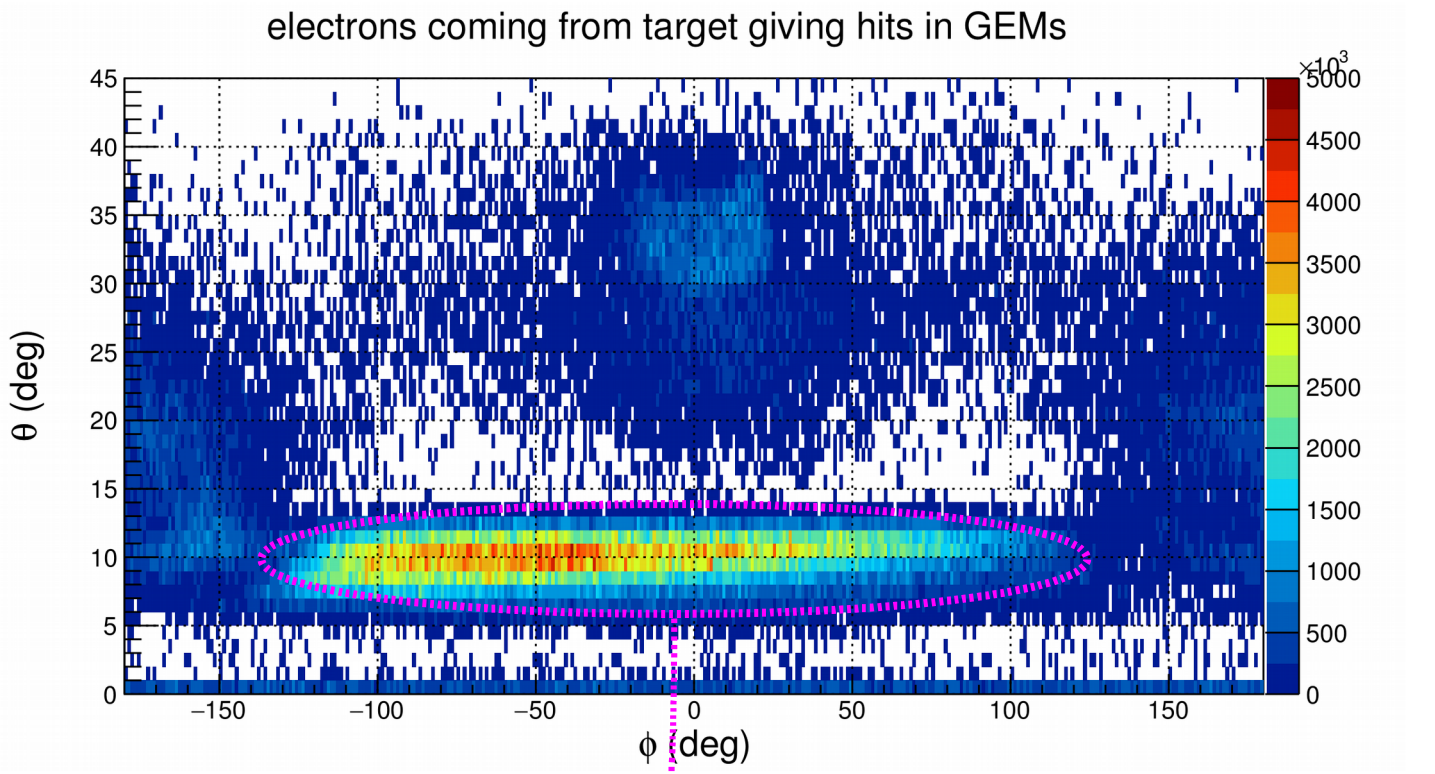
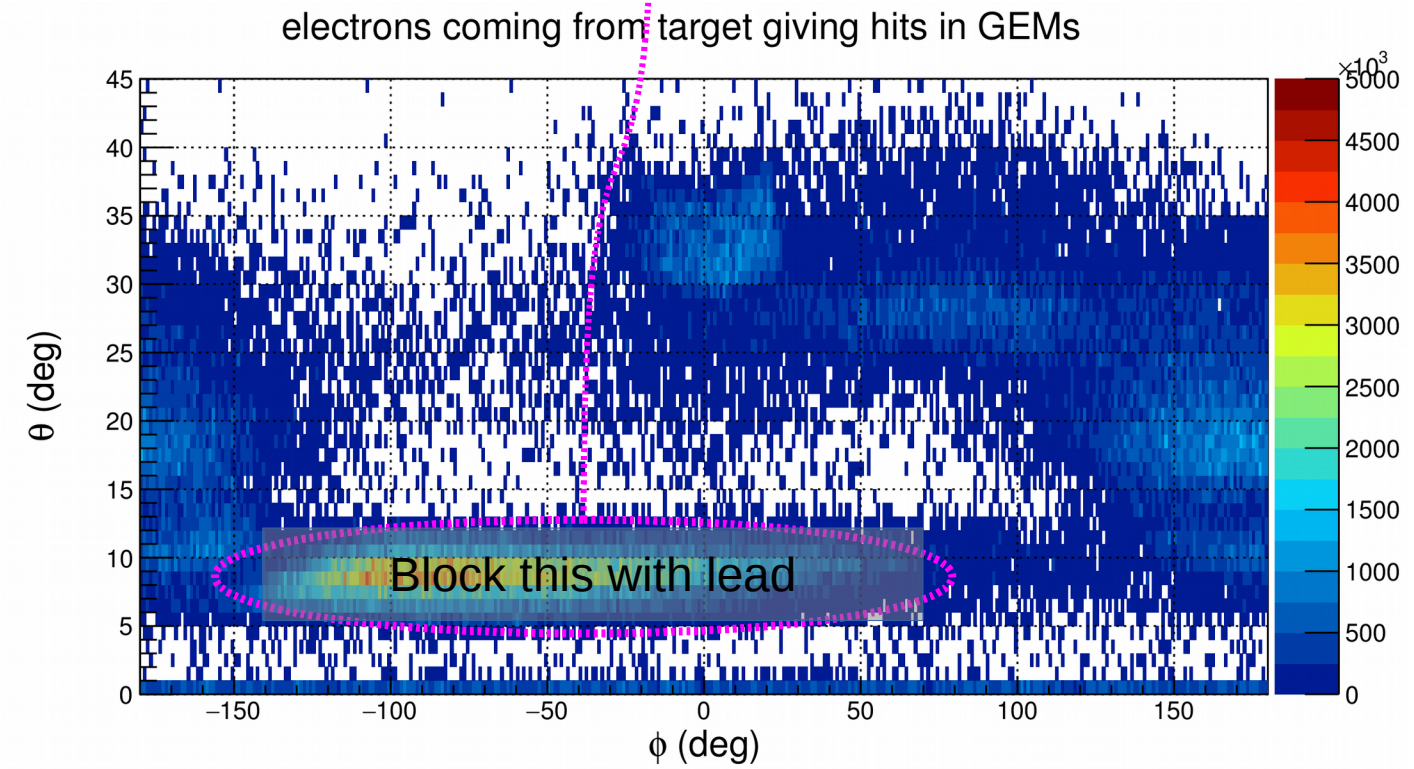


New Tosca map



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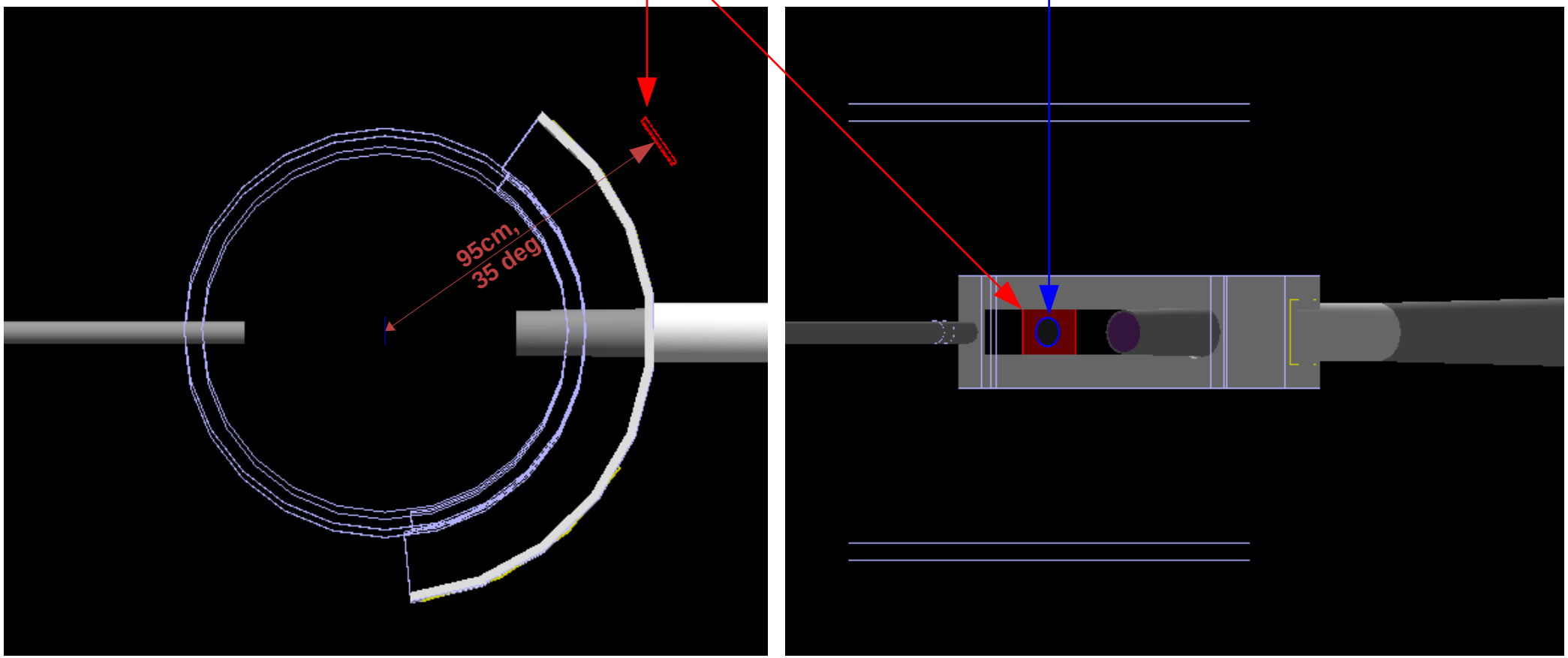


Beam : 10.6 GeV, 0.3 μA

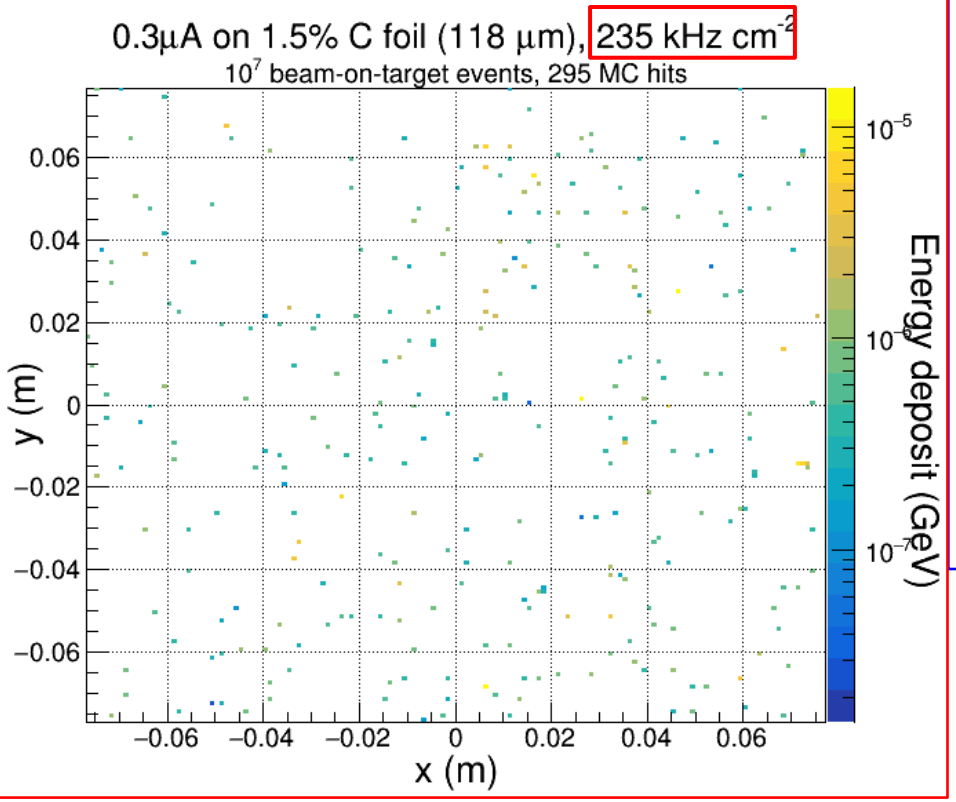
Recent MC applications
Hall C high rate GEM data reproduction with G4SBS

Alternate setup

Number of hits recorded by G4SBS: Comparison with actual data

G4SBS prediction: ~235 kHz/cm²

=> 30 recorded hits / event



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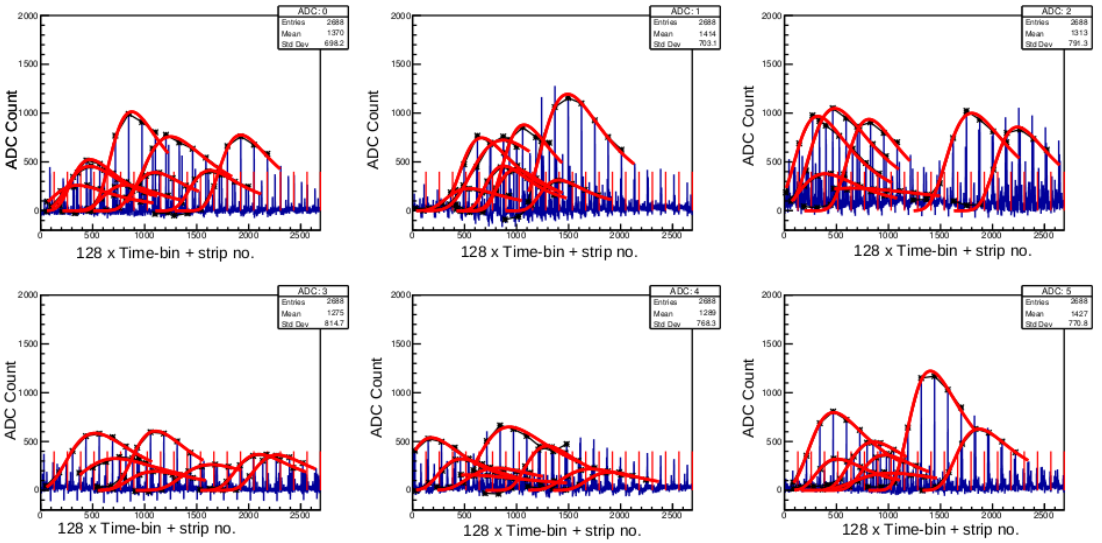

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