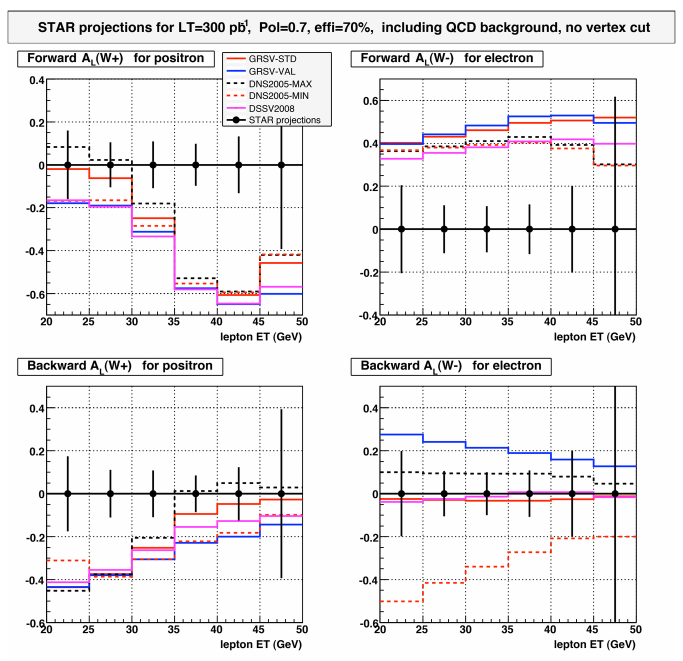
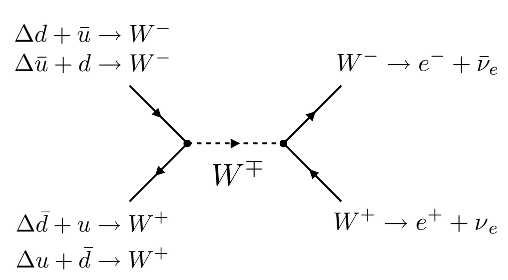
The STAR Forward GEM Tracker

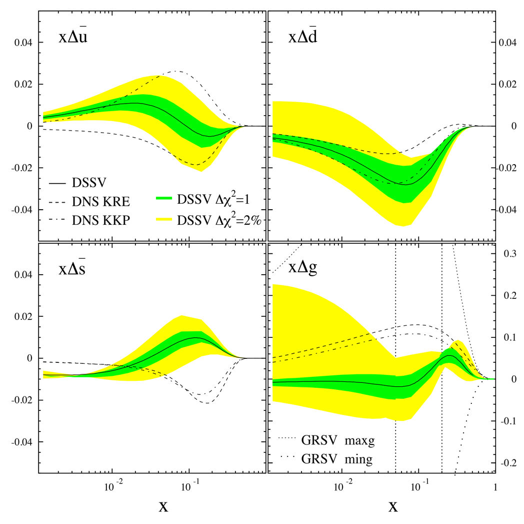
Bernd Surrow, On behalf of the STAR Collaboration
Laboratory for Nuclear Science, Massachusetts Institute of Technology, Cambridge, MA

FGT Physics Motivation

RHIC Spin program



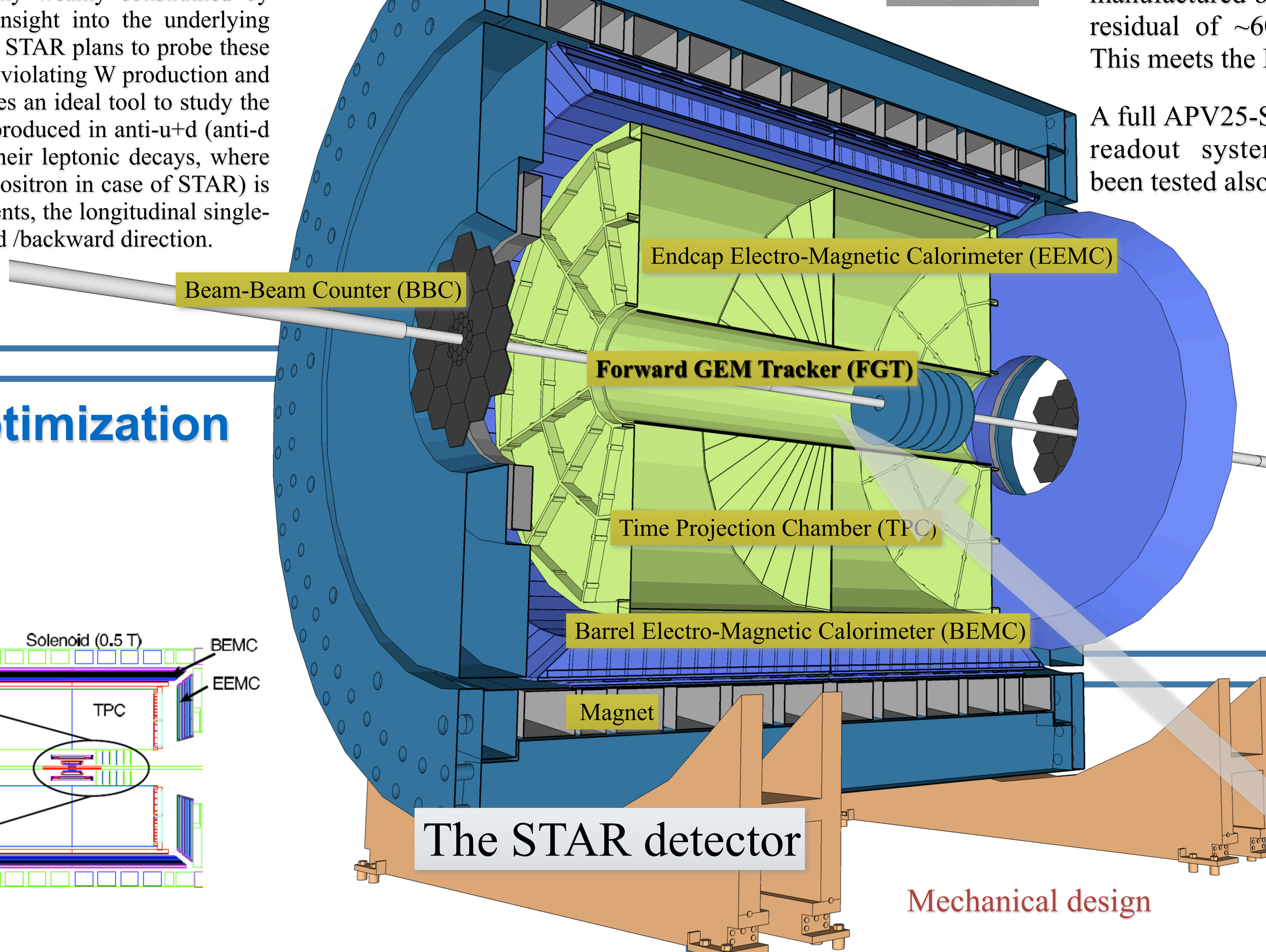



D. de Florian et al., hep-ph/0804.0422

The STAR collaboration is preparing a tracking detector upgrade to further investigate fundamental properties of the new state of strongly interacting matter produced in relativistic heavy-ion collisions at RHIC and to provide fundamental studies of the proton spin structure and dynamics in high-energy polarized proton-proton collisions at RHIC. The FGT project will focus on novel spin physics measurements in high-energy polarized proton-proton collisions in W boson production at a center-of-mass energy of 500GeV.

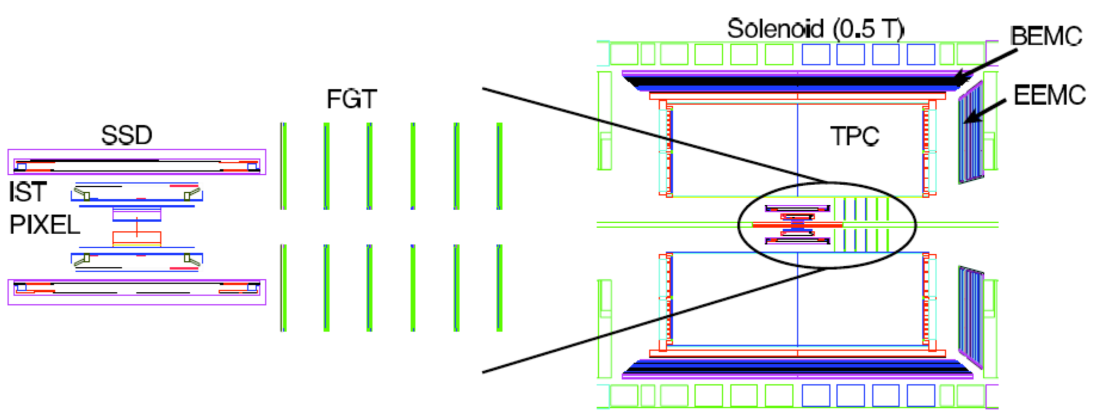
The polarization of anti-quarks

Measurements aimed at determining the flavor dependence of the proton sea are a primary future goal of the STAR spin program. These polarized parton distribution functions (PDFs) are only weakly constrained by polarized fixed target experiments, giving insight into the underlying mechanisms which produce the polarizes sea. STAR plans to probe these PDFs starting ~2010 and beyond using parity violating W production and decay. The production of $W^{-(+)}$ bosons provides an ideal tool to study the spin-flavor structure of the proton. $W^{-(+)}$ are produced in anti-u+d (anti-d +u) collisions and can be detected through their leptonic decays, where only the respective charged lepton (electron/positron in case of STAR) is measured. The sensitivity of those measurements, the longitudinal single-spin asymmetry A_L, is enhanced in the forward /backward direction.



FGT Layout and Optimization

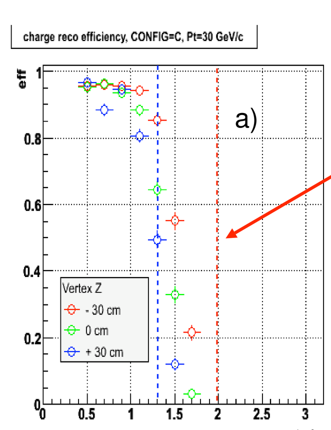
Layout



The discrimination of anti-u+d (anti-d+u) quark combinations requires distinguishing between high p_T $e^{-(+)}$ through their opposite charge sign, which in turn requires precise tracking information. An upgrade of the STAR forward tracking system is needed to provide the required tracking precision for charge sign discrimination. This upgrade will consist of six-triple-GEM detectors with two dimensional readout arranged in disks along the beam axis.

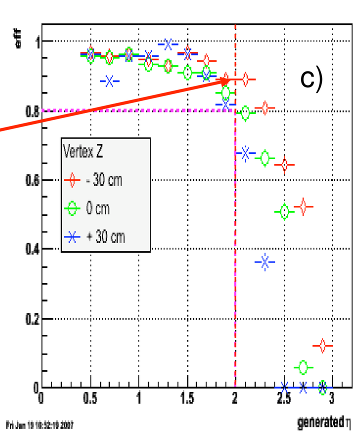
e^+/e^- separation

The charge-sign discrimination of high-p_T $e^{-(+)}$ to distinguish $W^{-(+)}$ bosons in the range $1<\eta<2$ will be based on using a beam line constraint, precise hit informations from six triple-GEM disks, hits from the TPC, and the electromagnetic cluster data from the shower-maximum detector of the STAR EEMC. Information from the existing detectors (without the FGT) is insufficient.



Conclusion:

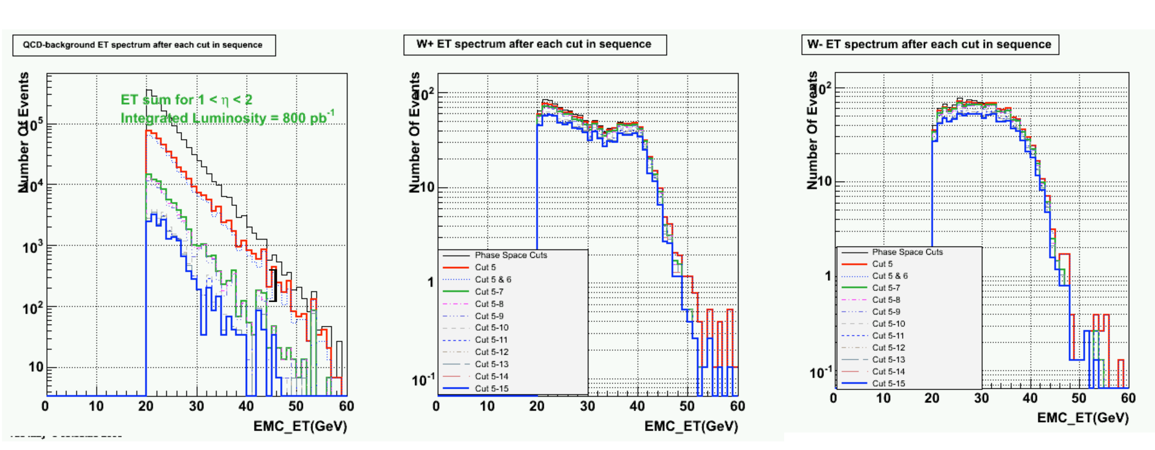
Charge sign reconstruction impossible beyond η = ~1.3



6 triple-GEM disks, assumed spatial resolution 60μm in x and y (Fairly insensitive for 60-100μm). Charge sign reconstruction probability above 90% for 30 GeV p_T over the full acceptance of the STAR EEMC for the full vertex spread

e/h separation

The separation of $e^{-(+)}$ from hadronic background will be important and therefore the full exploitation of the STAR EEMC with its intrinsic means for e/h separation besides global cuts such as isolation criteria will be crucial. These cuts will reduce significantly the hadronic background, but retain the W signal and allow a signal/background ratio at the level of 3-10 for p_T>25GeV/c.

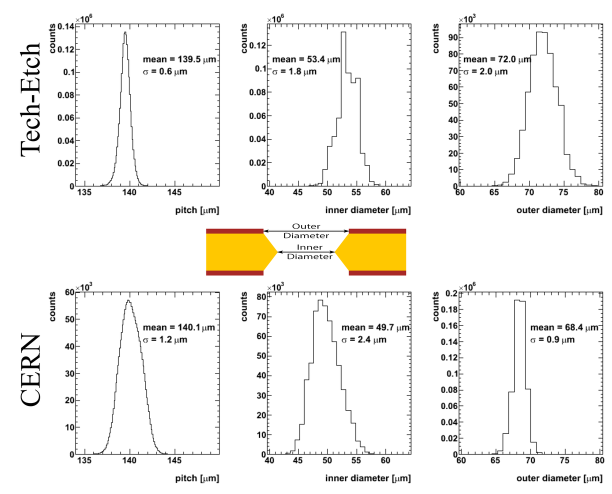


Hadronic background E_T distribution

W signal (left: e^+ / right e^-) E_T distribution

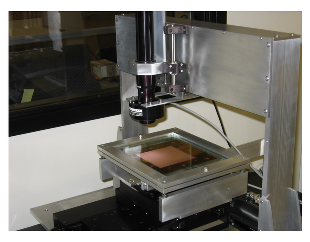
FGT Technology Development

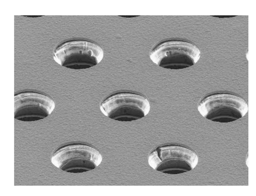
GEM technology development in industry



GEM technology is widely employed by current and future experiments in nuclear and particle physics. A SBIR* proposal has been approved and is the basis for the development of the industrial production of GEM foils at Tech-Etch Inc. to be used for the forward GEM tracking system. Extensive tests have been performed to evaluate the performance of GEM foils produced at CERN in comparison to Tech-Etch GEM foils. The optical quality (inner/outer hole diameter and pitch) has been measured using a CCD camera setup. Comparable performance has been found in optical uniformity and gain performance.

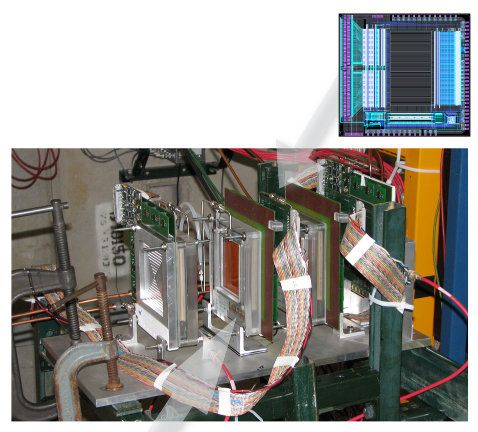
*US DOE program: Small Business Innovative Research



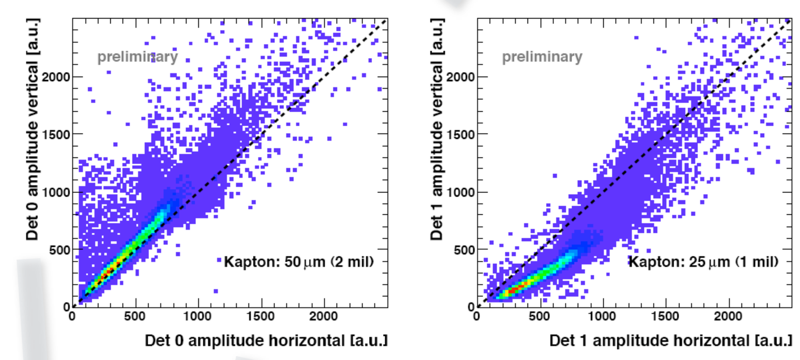


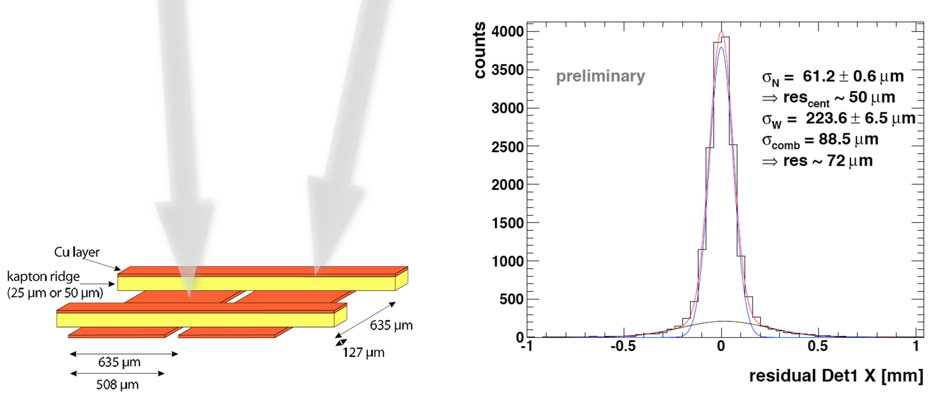
Test-beam results

The performance of three triple-GEM detectors has been evaluated in a testbeam experiment at FNAL. Good charge sharing performance based on a laser-etched 2D readout board manufactured by Compunetics Inc. and a residual of ~60μm has been achieved. This meets the FGT requirements.

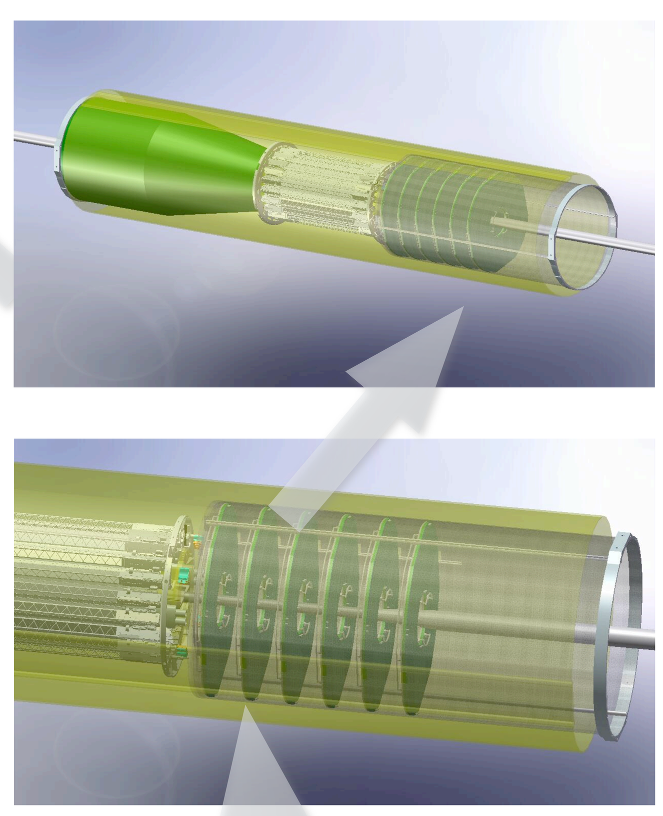


A full APV25-S1 chip readout system has been tested also.



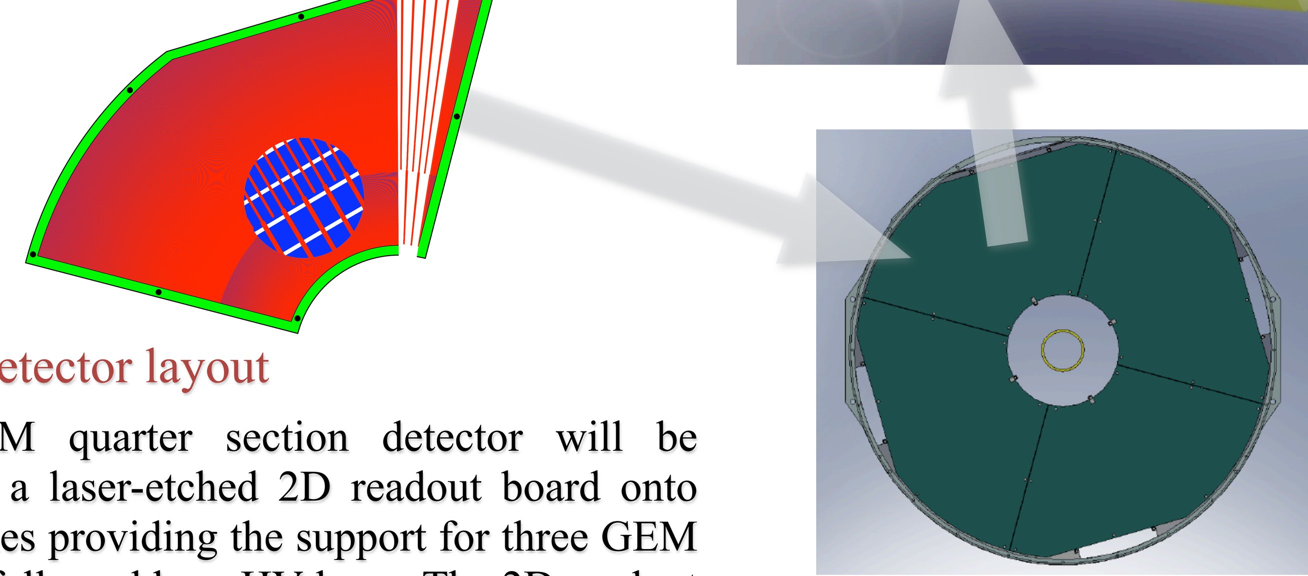


FGT Technical Realization



Mechanical design

The FGT mechanical support structure is based on a new support on one side of the STAR experiment using light-weight carbon materials. The other side will require a modification of the current support cone to allow the support of the new silicon vertex tracker, the STAR Heavy-Flavor Tracker. Each disk has a single honey-comb support disk onto which four individual quarter sections of triple-GEM chambers are mounted.



Triple-GEM detector layout

Each triple-GEM quarter section detector will be assembled onto a laser-etched 2D readout board onto which G10 frames providing the support for three GEM foils are glued, followed by a HV layer. The 2D readout board is organized into radial and azimuthal strips connected to a chip readout mother board using a flex-cable connection.