



Status Update on STAR Upgrades

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For the STAR Collaboration

QM2012, Aug 13-18, 2012



RHIC – a Dedicated QCD Facility

QCD – Fundamental Corner Stone of the Standard Model !!

-Dynamics of QCD in bulk matter, vacuum structure and hadrons?

Condensed Matter Physics with Underlying QCD Interactions !

We are beyond the QGP discovery phase already !

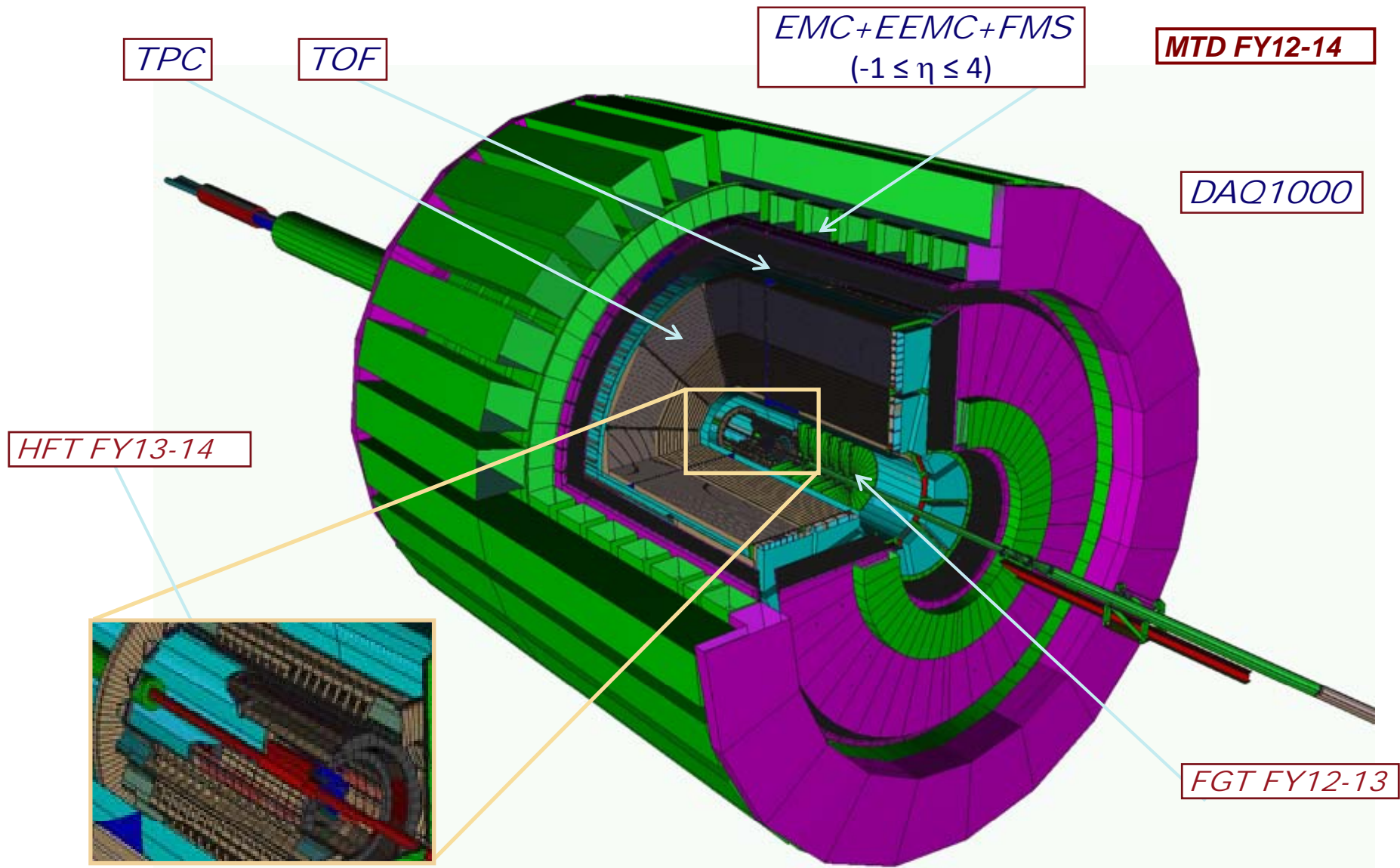
LHC -- Energy/Temperature Frontier

**RHIC – New Horizons in QCD Phase Structure, Vacuum
Excitation, Initial State Color Charge Dynamics,
Hadron Structure and Exotics**

**STAR continues to explore new QCD horizons with planned
detector upgrades and vigorous scientific programs
in the coming decade !**

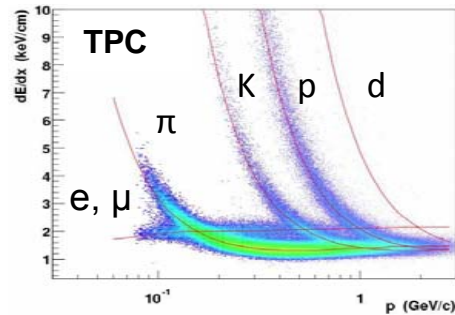


STAR Detectors *Fast and Full azimuthal particle identification*

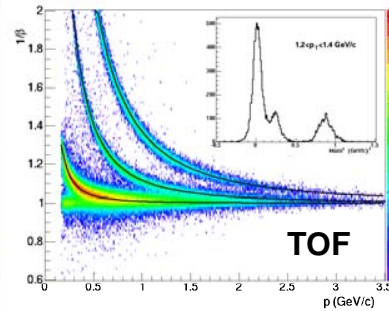




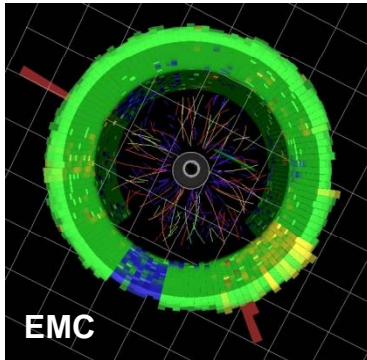
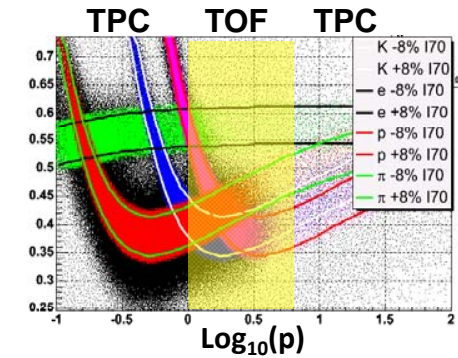
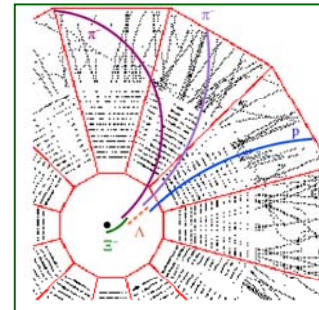
Particle Identification at STAR



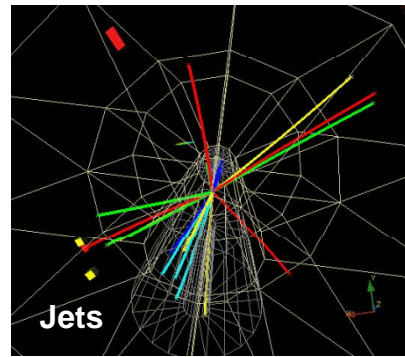
Charged hadrons



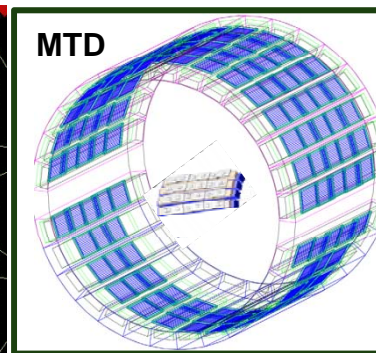
Hyperons & Hyper-nuclei



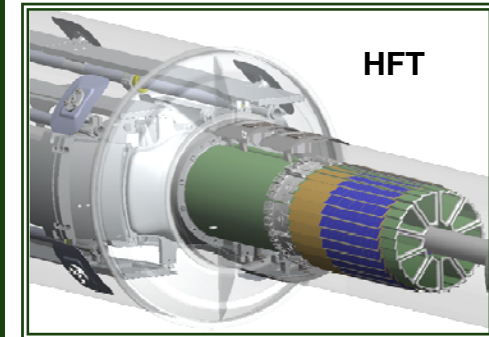
Neutral particles



Jets & Correlations



High p_T muons



Heavy-flavor hadrons

***Multiple-fold correlations among the identified particles!
Nearly perfect coverage at mid-rapidity***



STAR Upgrade Path

Ongoing and Near Term

FGT 14/24 quadrants in 2012 and complete for 2013 run
HFT engineering run 2013 and complete in FY14
MTD 13/118 in 2012, 50-75/118 run 13 and complete 14
Roman Pots Phase II – pp2pp

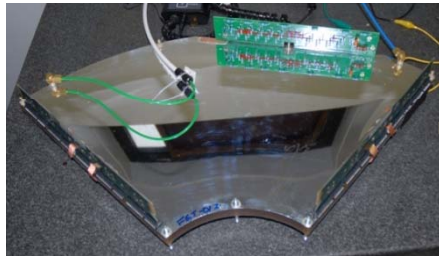
Physics Focuses:

FGT – W program from polarized p+p collisions
**HFT – Heavy quark collectivity and
separating Charm and Bottom energy loss**
MTD – Upsilon states and e- μ correlations

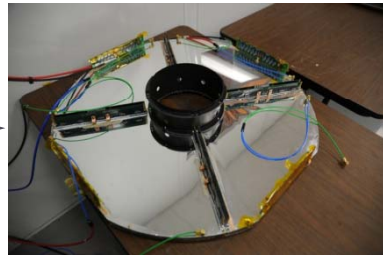


Forward GEM Tracker -- 2013

Layout



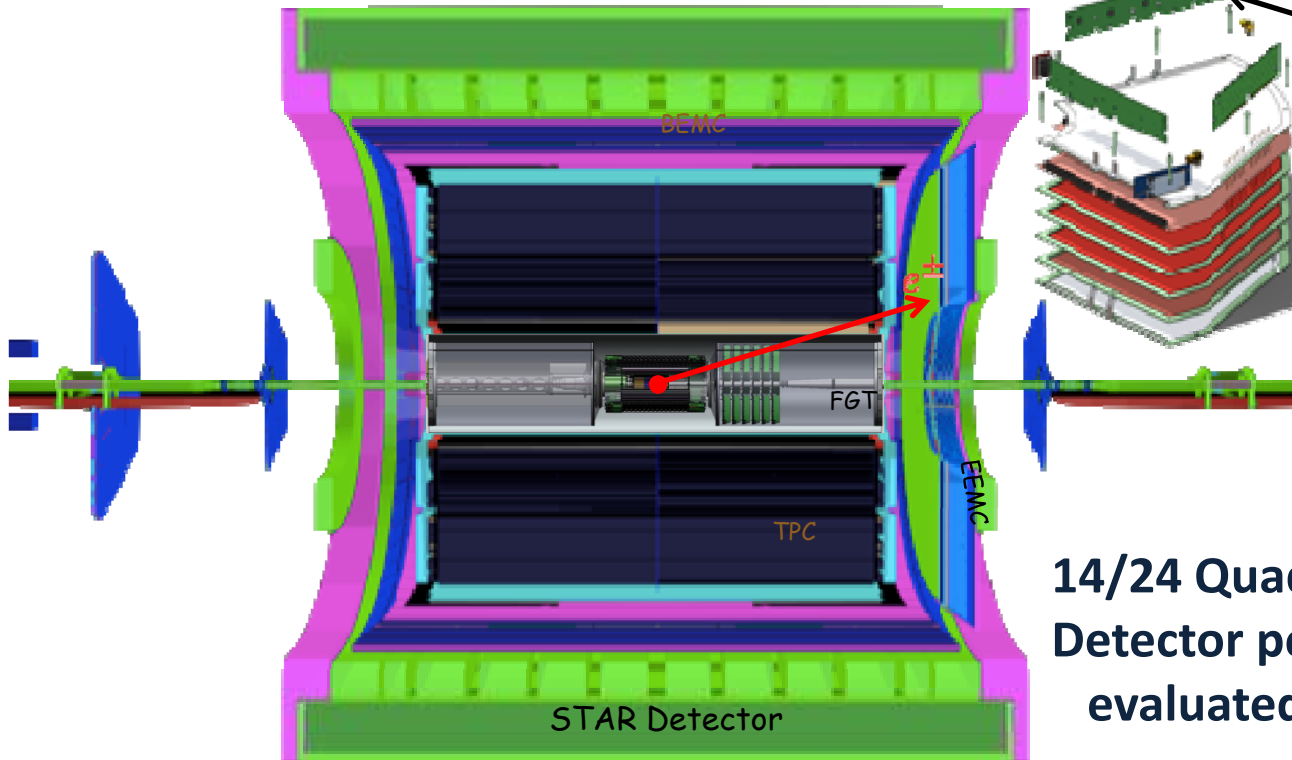
Quarter section



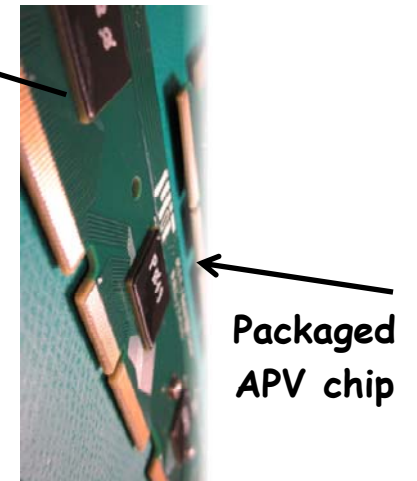
Disk



Quarter section



APV module

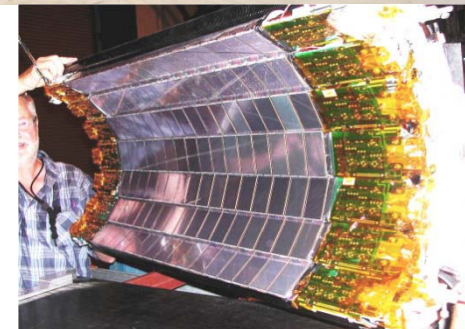
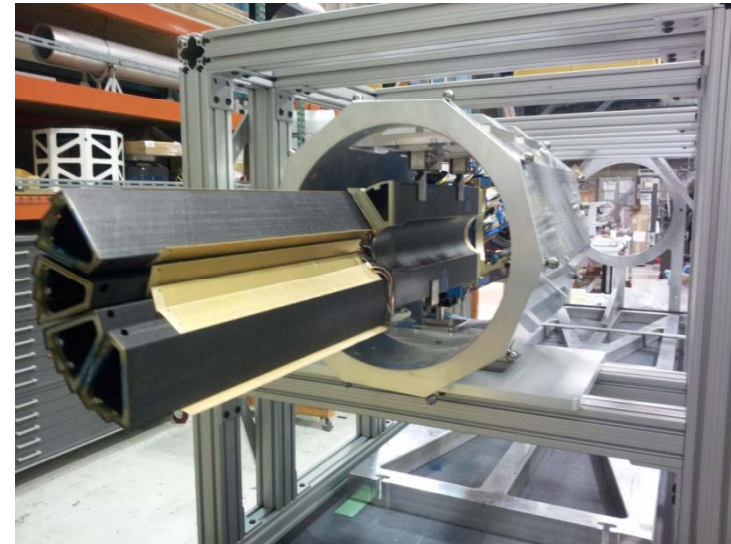
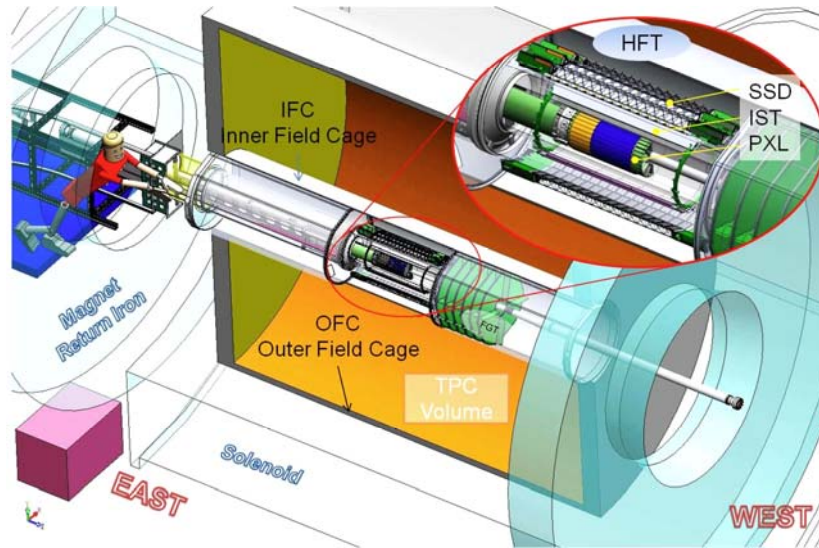


Packaged APV chip

**14/24 Quads installed for run 2012 !
 Detector performance is being evaluated.**



Heavy Flavor Tracker -- 2014

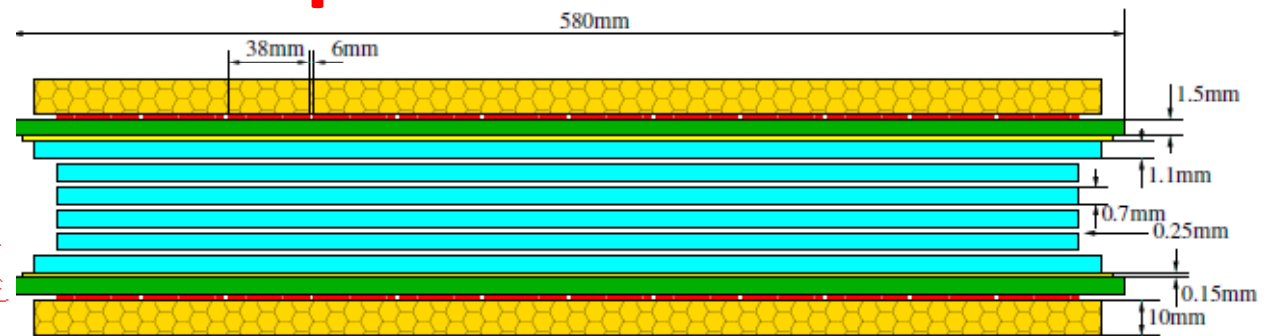
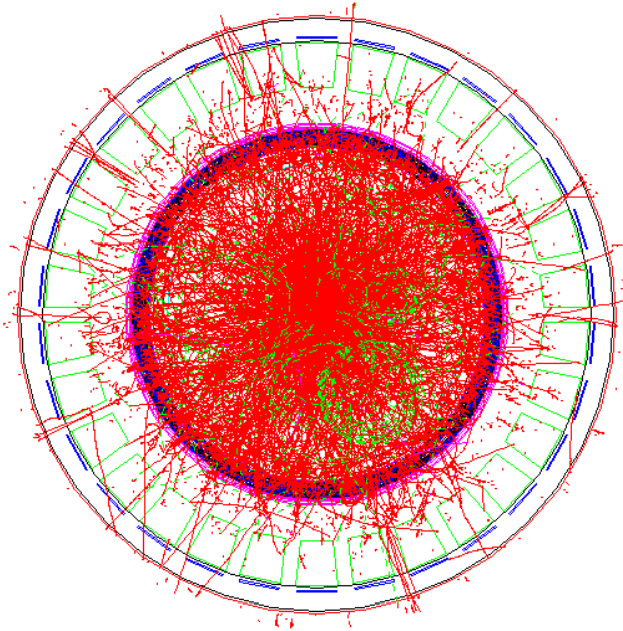


- 3 detector systems;
- PXL 2 layers of CMOS
 - IST 1 layer at 14 cm
 - SSD 1 layer
- Engineering run 2013
Full system installed in 2014

8/17/2012



Muon Telescope Detector -- 2014



Multi-gap Resistive Plate Chamber (MRPC):
gas detector, avalanche mode

A detector with long-MRPCs covers the whole iron bars and leave the gaps in-between uncovered. Acceptance: 45% at $|\eta| < 0.5$

118 modules, 1416 readout strips, 2832 readout channels

Long-MRPC detector technology, electronics same as used in STAR-TOF

Run 2012 -- 10%; 2013 – 43%+; 2014 – 100%
Successful commissioning run in 2012



8/17/2012



STAR Upgrade Path

Intermediate Future (Decadal Plan) 2016+

TPC Inner Sector Readout Upgrade

VFGT – using FGT technology in the very forward region

PID Detector – Meson/Baryon separation

Forward Calorimeter System

Physics Focuses:

Beam Energy Scan – Phase II program

Forward photon/electron/jet(leading hadron)

p+p -- transverse spin dynamics

(transversity function and Collins frag.

QCD twist-3 processes)

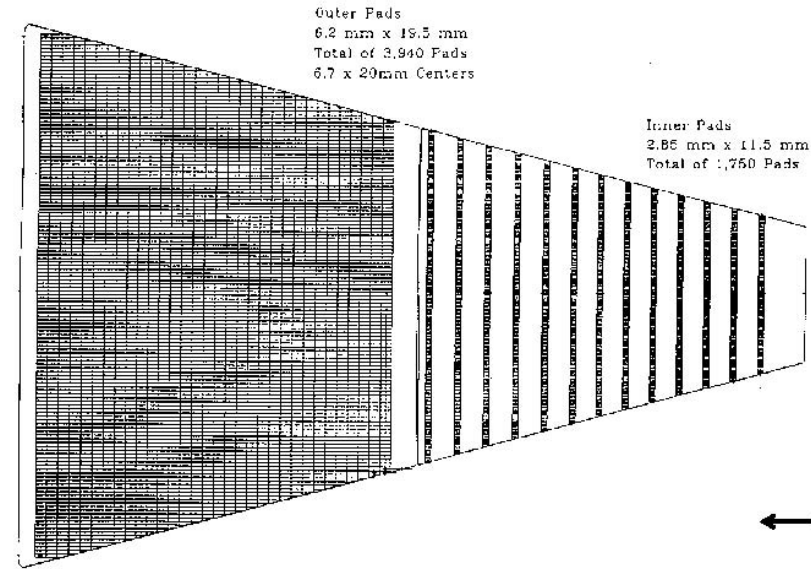
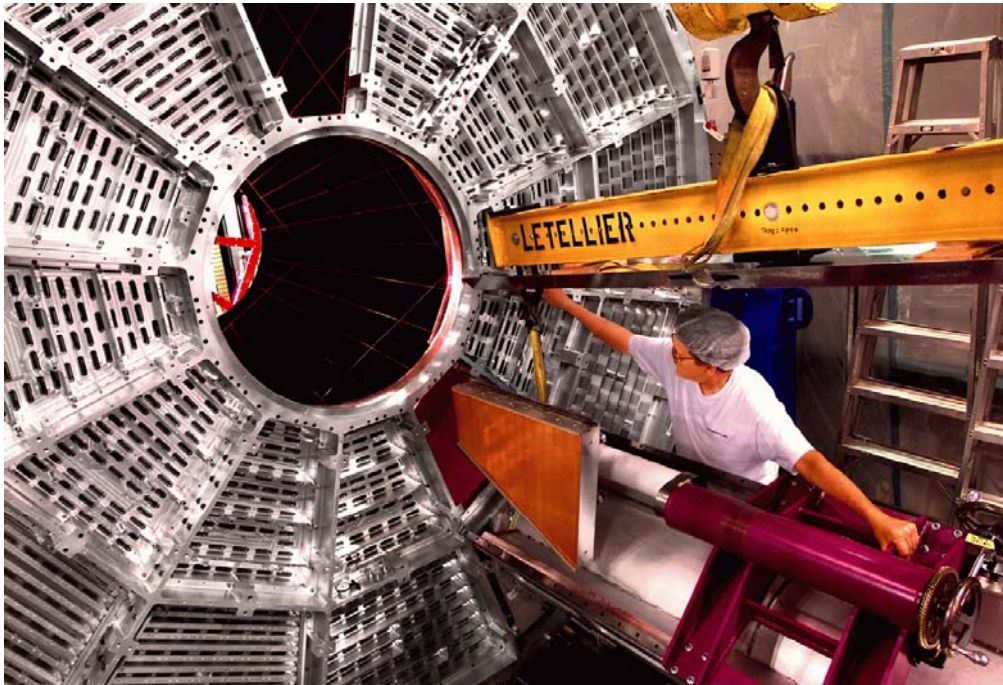
pp/pA -- Drell-Yan, h-h, gamma-h correlations

(initial conditions and CGC)

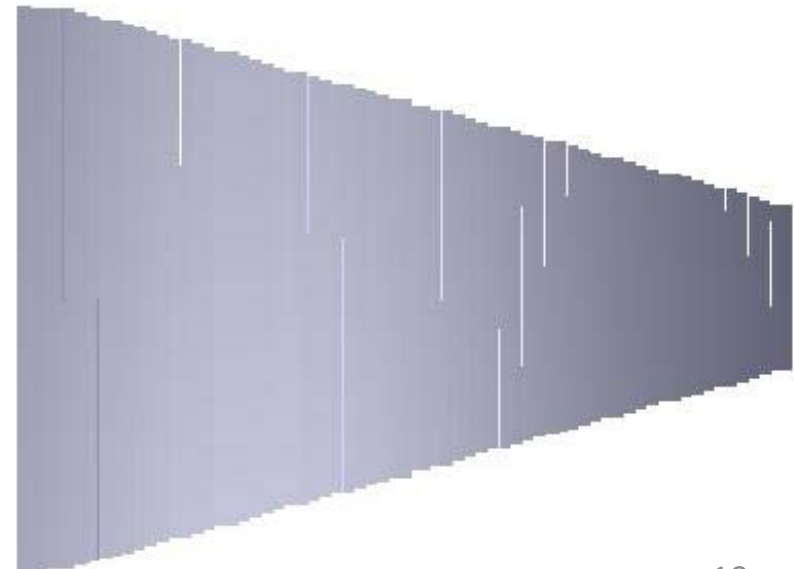
8/17/2012 AA -- Forward HQ NPE R_{AA} and eta dependence



STAR Inner TPC Pad Readout Upgrade – iTPad Project



Much better tracking and dE/dx PID capability
 η 1.0-1.7 region -- broad physics impact on
transverse spin physics program
hyperon and exotic particle searches
high p_T identified particles
BES Phase II+





STAR Vision for BES II Program

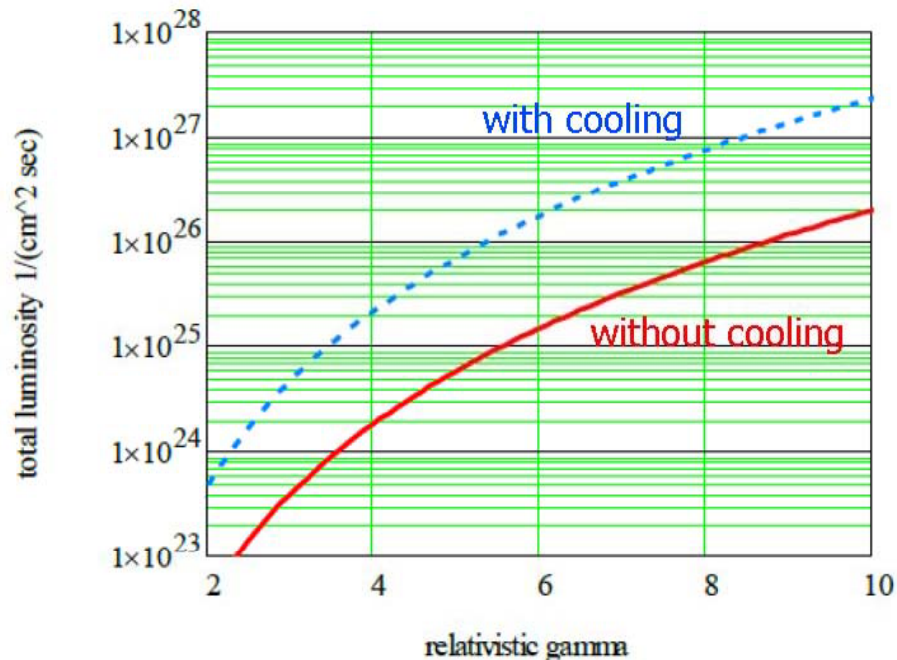
- Likely beam energies below 25 GeV with improved statistics particularly for the lower end of the beam energies !
- need electron cooling from CAD to be more efficient
- match iTPC upgrade schedule for better detector coverage

Electron cooling necessary !!
Use RF Gun Cooler OR
Use Fermi Lab Pelletron ?



8/17/2012

A. Fedotov – RHIC-AGS User Meeting 2012



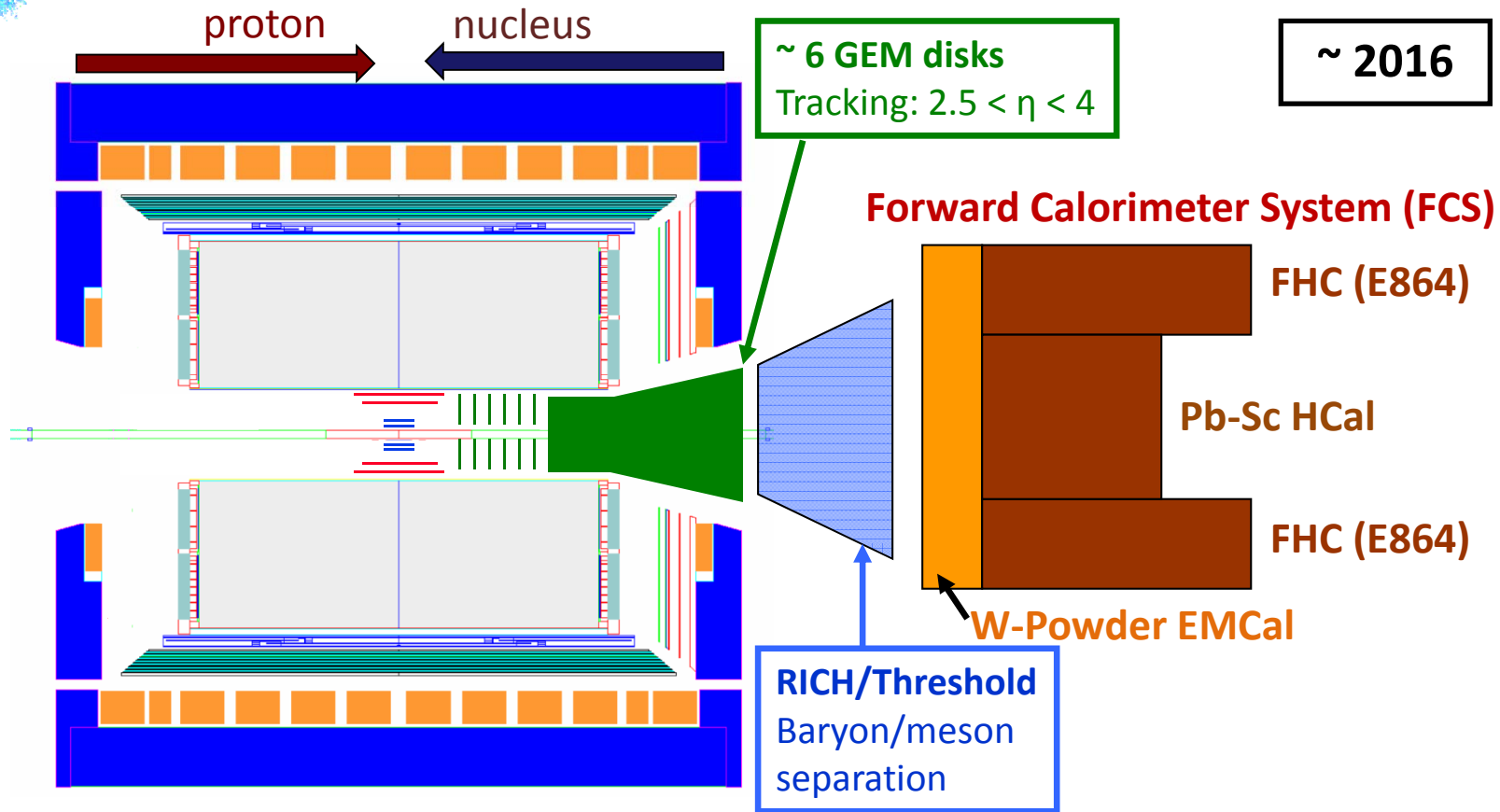
RHIC CAD installation of the e-cooling device

~ 4 years !

BES-II takes data in 2016 +



STAR forward instrumentation upgrade



- Forward instrumentation optimized for **p+A** and **transverse spin** physics
 - Charged-particle tracking
 - e/h and γ/π^0 discrimination
 - Possibly Baryon/meson separation



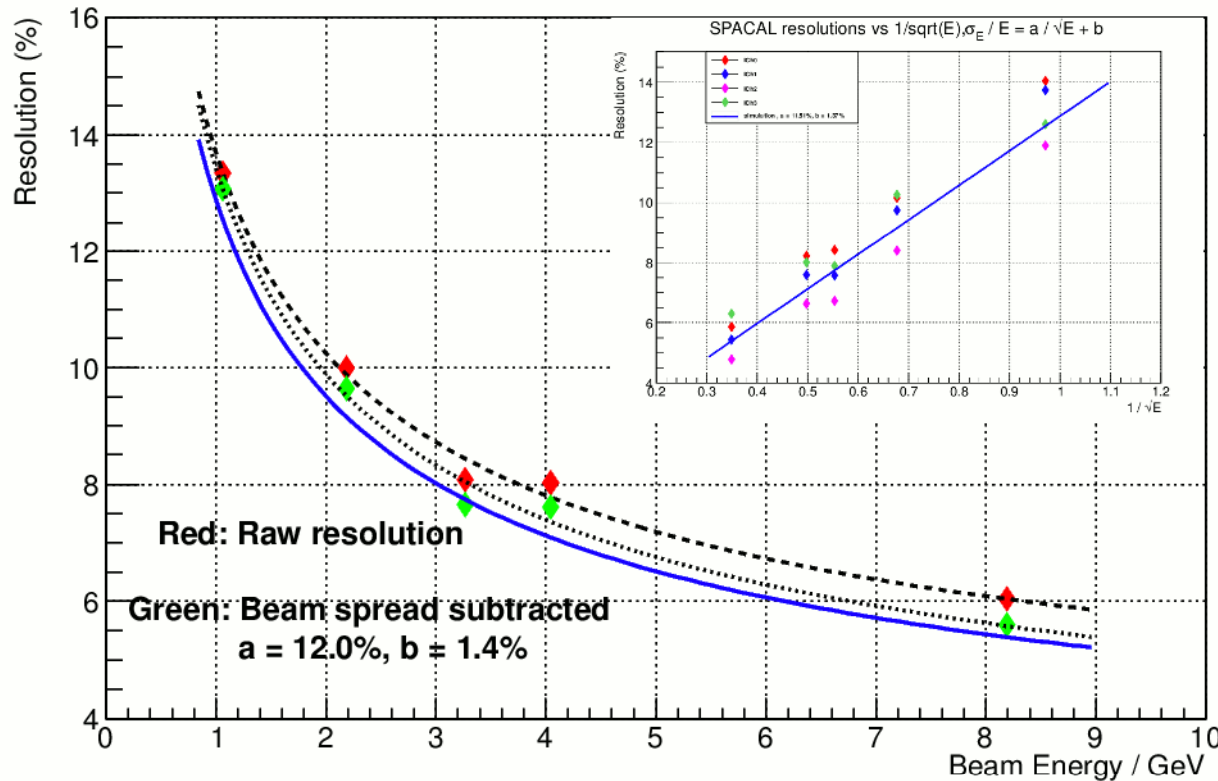
STAR Plan for the Forward Upgrades

- 1) The Forward Calorimeter System (FCS) benefited from an EIC detector R&D project for constructing W-powder EMC modules. Current R&D effort focuses on compact read-out scheme and mechanical properties. We plan to build a full-scale prototype FCS module.**
- 2) The Very Forward GEM Tracker (VFGT) detector is likely to be GEM based. Details of the design depends on our experiences with the FGT project.**
- 3) RICH detector in STAR forward direction has not been demonstrated. Threshold Cerenkov detector is also under consideration. This detector will not be included in the initial phase of the upgrade project.**
- 4) Schedule: Develop CD documents and Proposals aiming at VFGT/FCS construction starting 2015+**



EIC Detector R&D Project: SPACAL works!

SPACAL resolutions, averaged over 4 Channels, $\sigma_E / E = (a/\sqrt{E})+b$



Also measured:

1. *Uniformity of response across the towers.*
2. *Energy resolution with and without mirror.*
3. *Perform scans along the towers with electrons and muons.*
4. *Estimated effects of attenuation and towers non-uniformities on resolution.*

- 1) **Viable EMC detector technology developed through EIC R&D**
- 2) **A prototype hadron calorimeter module will be built in 2013**



STAR Upgrade Path Towards eSTAR

Future eSTAR Option -- Detector R&D:

EMC – Compact W-powder SPACAL

Crystals – PWO and BSO testing

ETTIE – electron PID and tracking in the forward

Simulations

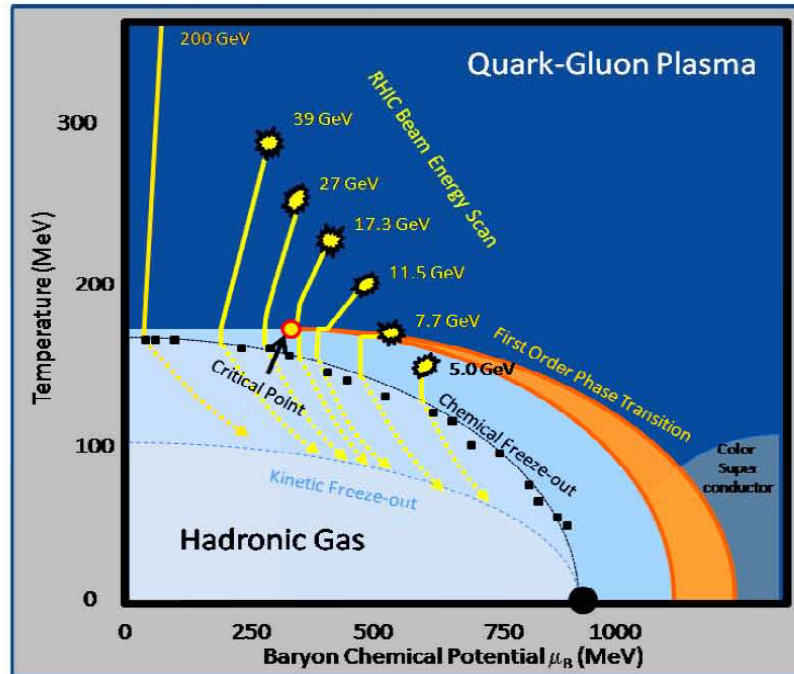
**STAR will be ready with a detector coverage
to explore eA physics during the initial phase
of the eRHIC development !**



Outstanding QCD Questions at RHIC

-- STAR Decadal Plan

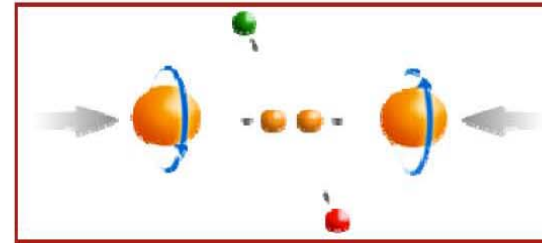
Hot QCD Matter



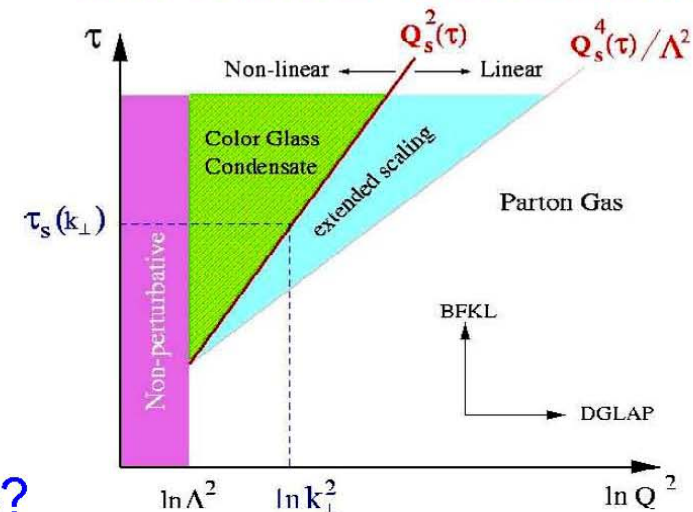
- 1: Properties of the sQGP
- 2: Mechanism of energy loss:
weak or strong coupling?
- 3: Is there a critical point, and if so, where?
- 4: Novel symmetry properties
- 5: Exotic particles

8/17/2012

Partonic structure



- 6: Spin structure of the nucleon
- 7: How to go beyond leading twist and collinear factorization?



- 8: What are the properties of cold nuclear matter?



Backup



STAR FCS R&D Status

- MC, stand alone GEANT4, done.
- Pi^0 reconstruction – 80% eff. At 100 GeV
- Energy resolution EM – $12/\sqrt{E}$, constant term $\sim 2\%$
- Energy resolution for hadrons $50\%-60\%/\sqrt{E}$, range 10-80 GeV
- e/h rejection $\text{few} \times 1000$ @ 80 GeV

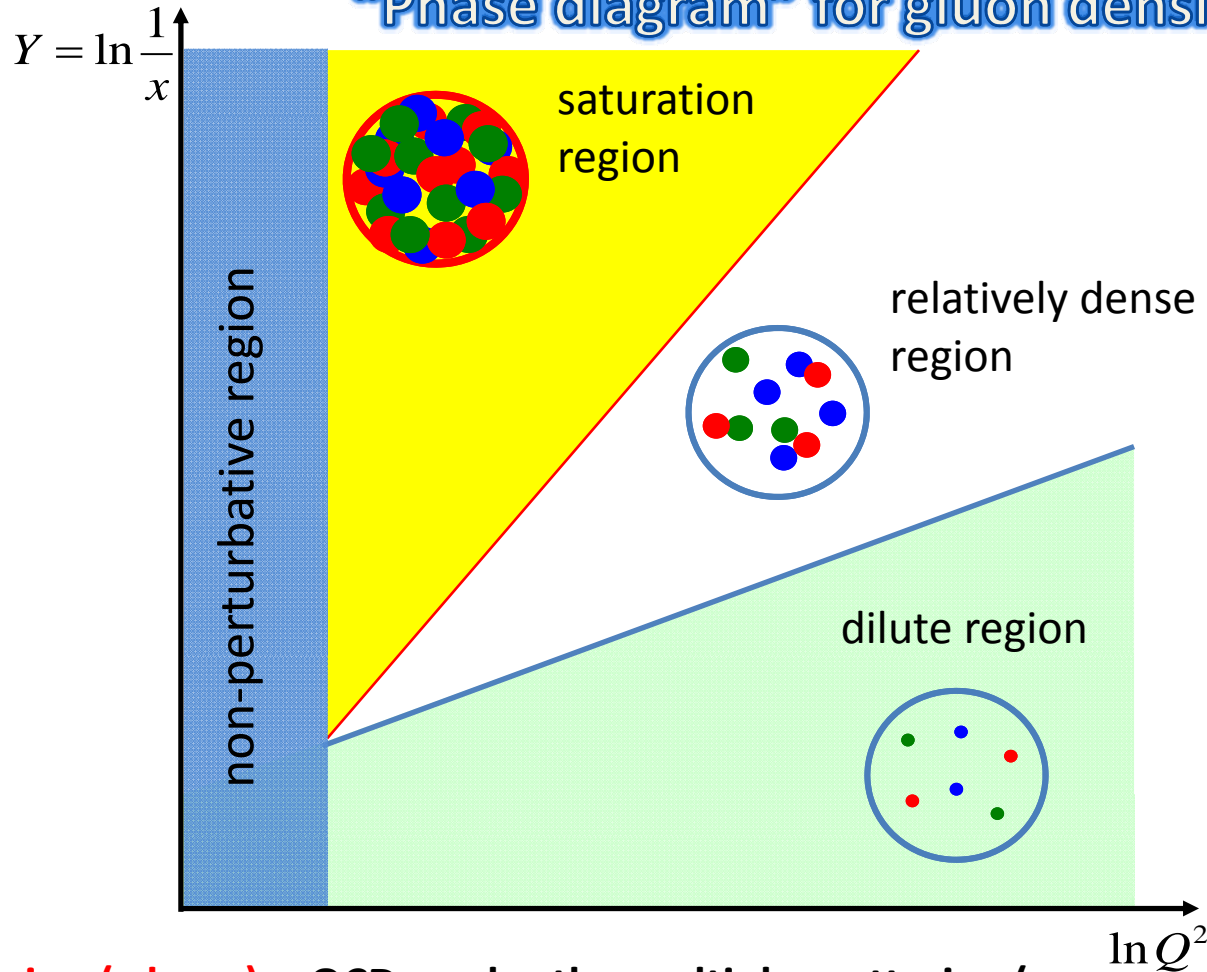
We plan to build a full scale prototype module !

What are the Physics Capability for this Detector?

Possible optimization of detector configuration with re-use of the E864 SPACAL?



"Phase diagram" for gluon density



Dilute region (x large): pQCD works, the multiple scattering (power corrections) are not important

Relatively dense region (x relatively small): multiple scattering starts to become important, any additional scattering is power suppressed by Q_s^2 / Q^2

Saturation region (x extremely small): all the additional scattering becomes equally important, all power terms $(Q_s^2 / Q^2)^n$ have to be resummed



Accessible x - Q^2 phase space from h-h correlations in the forward direction

