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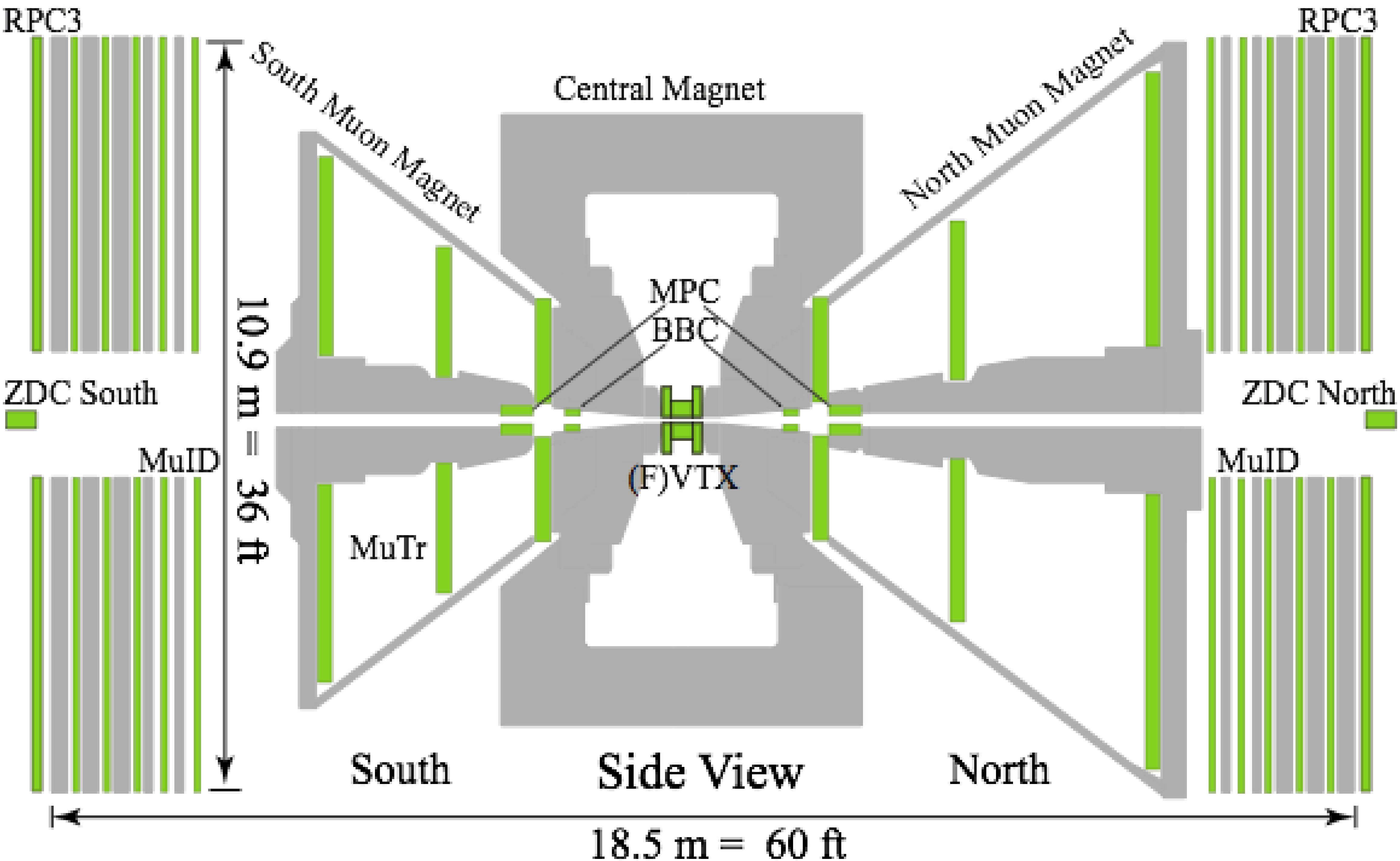
for the PHENIX Collaboration

Calorimetry based upgrade to PHENIX at RHIC

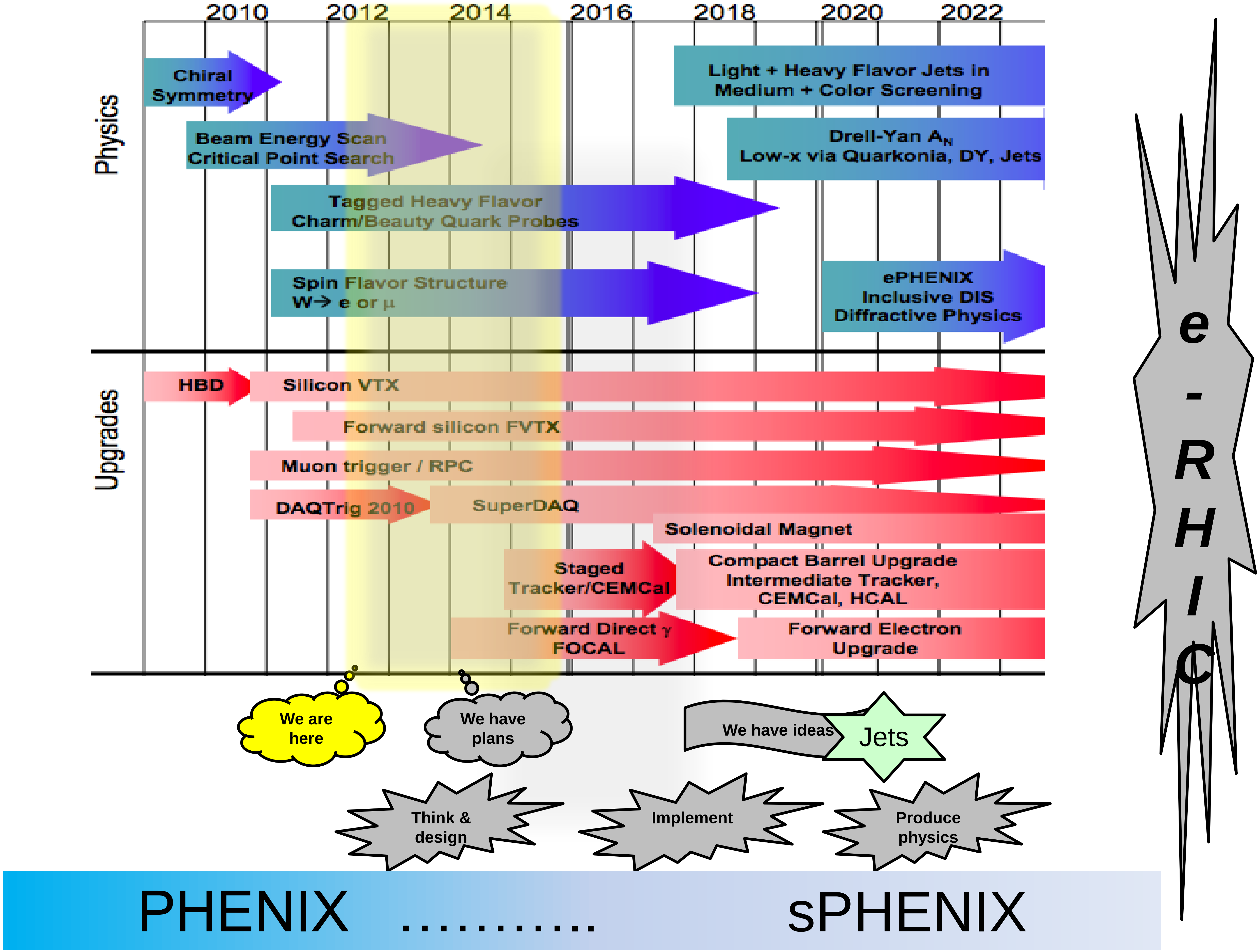
CALOR 2012

Santa Fe, NM, June 4-8, 2012

PHENIX today



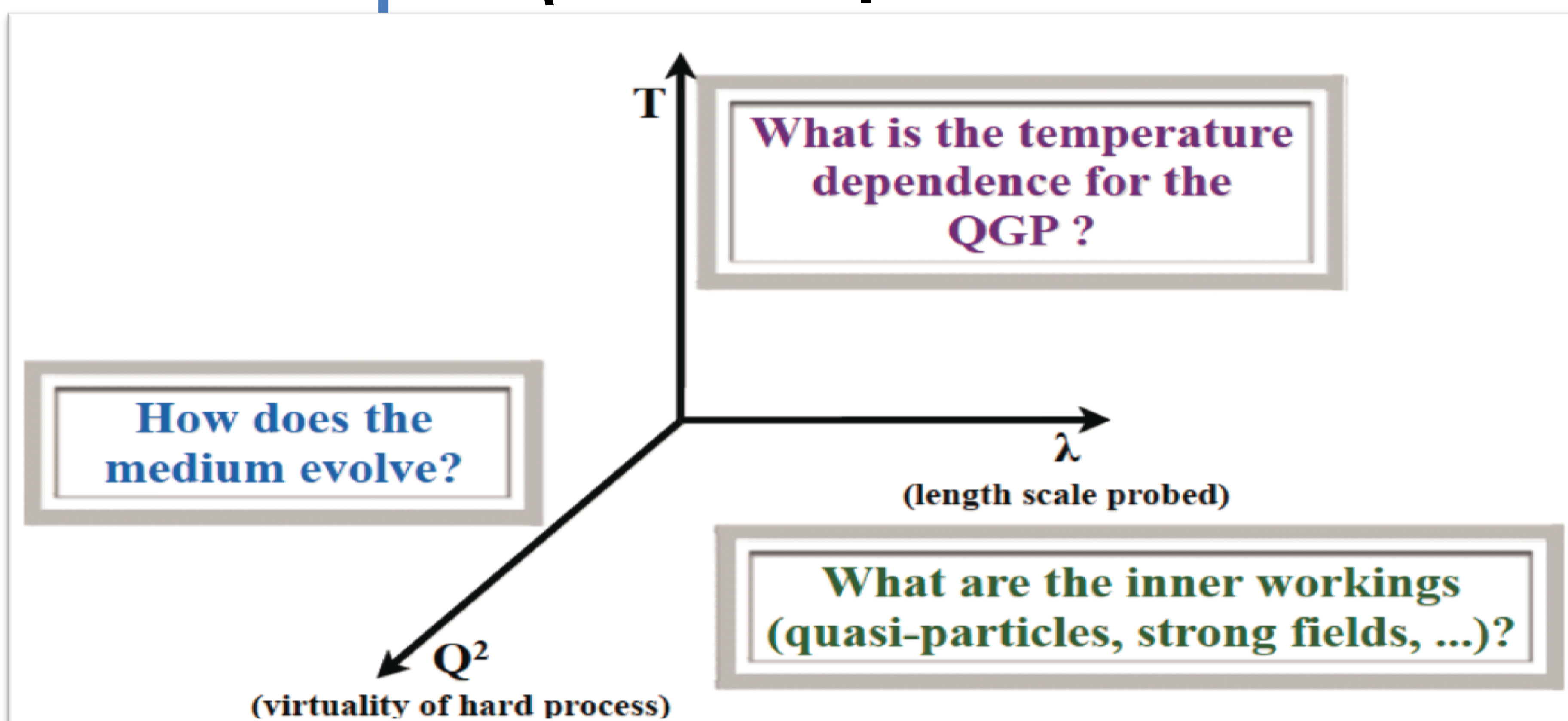
PHENIX – plans for the future



Jet observables at RHIC

are critical to the field by probing the threshold behavior of QGP near 1-2 T_c and at distances comparable to the thermal scale;

relate transverse momentum kick to fast moving parton ($\hat{q}$) and its energy loss dE/dx to the transverse transport of momentum in the medium η/s and equation of state.



Leveling the playing field with LHC

Use advantages of RHIC (machine is dedicated to HI physics);

Vary the species (shape, isotopic content);

Study threshold behavior varying collision energy;

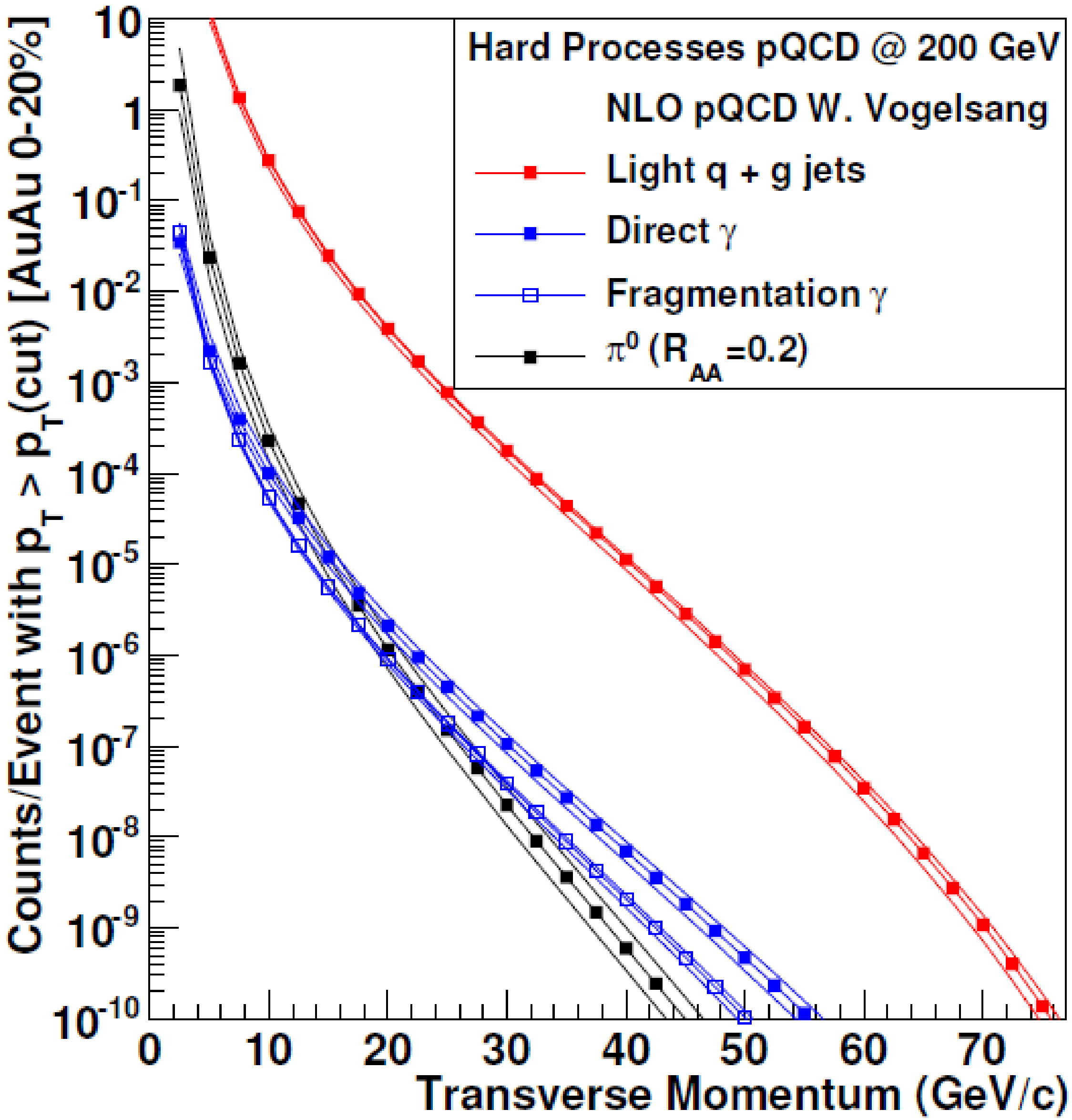
Go to extremes (very low and very high pT’s);

Do better measurements

- comparable or increased coverage;
- comparable or better resolution;
- better hermeticity, uniformity;

More physics per $ of cost

RHIC performance is still improving

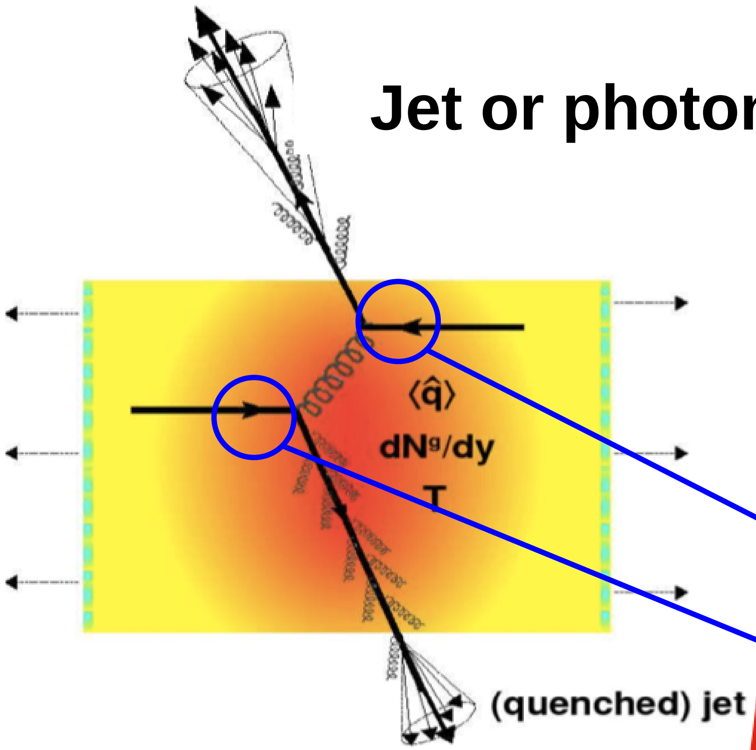


	Au+Au (central 20%)	p+p	d+Au
>20GeV	10^7 jets 10^4 photons	10^6 jets 10^3 photons	10^7 jets 10^4 photons
>30GeV	10^6 jets 10^3 photons	10^5 jets 10^2 photons	10^6 jets 10^3 photons
>40GeV	10^5 jets	10^4 jets	10^5 jets
>50GeV	10^4 jets	10^3 jets	10^4 jets

rates based on full stochastic cooling, but no additional accelerator upgrades

Huge rates allow differential measurements with geometry (v_2, v_3, A+B, U+U, …)
precise control measurements (d+Au and p+p)
Over 60% as dijets!

New ways of Event tagging

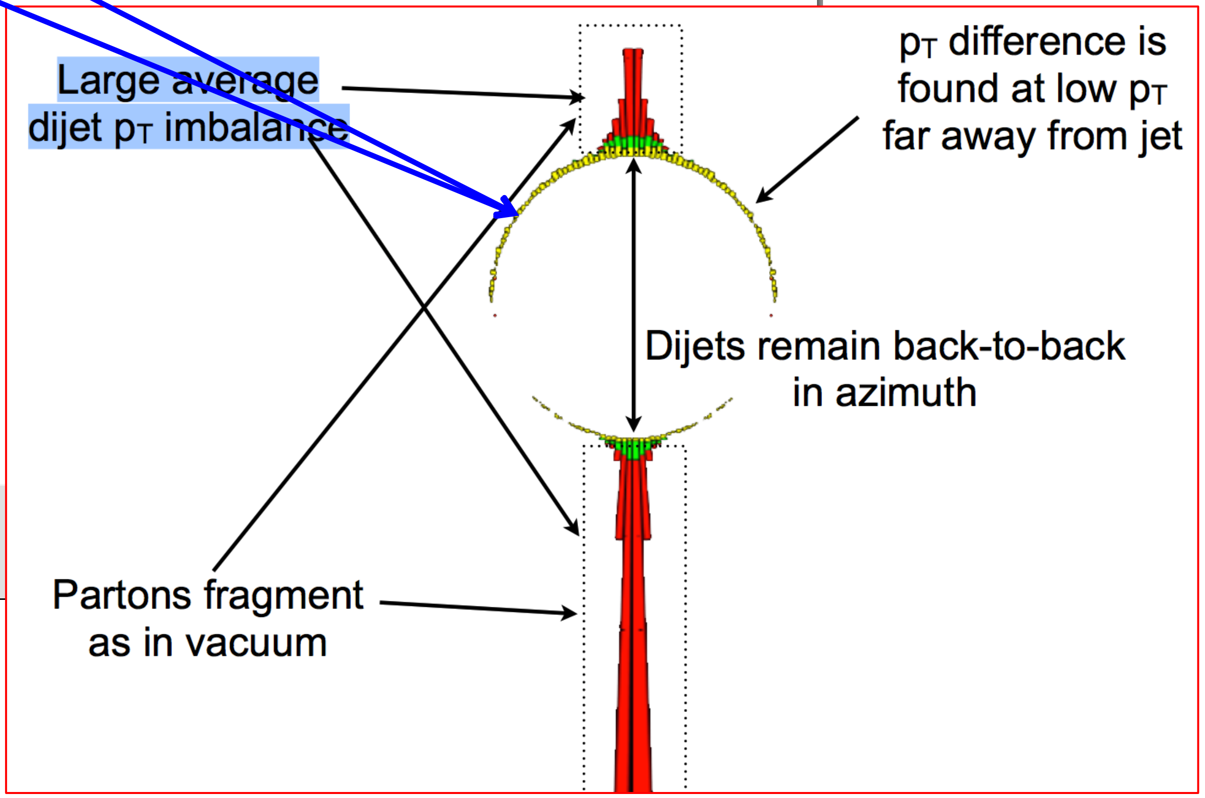


$$R_{AA} = \frac{1/N_{\rm evt}\, d^2N/dy\,dp_T}{\langle T_{AB}\rangle d^2\sigma_{pp}/dy\,dp_T}$$

For color-less probes, $R_{AA} \sim 1$:
- Photons
- Z^0s

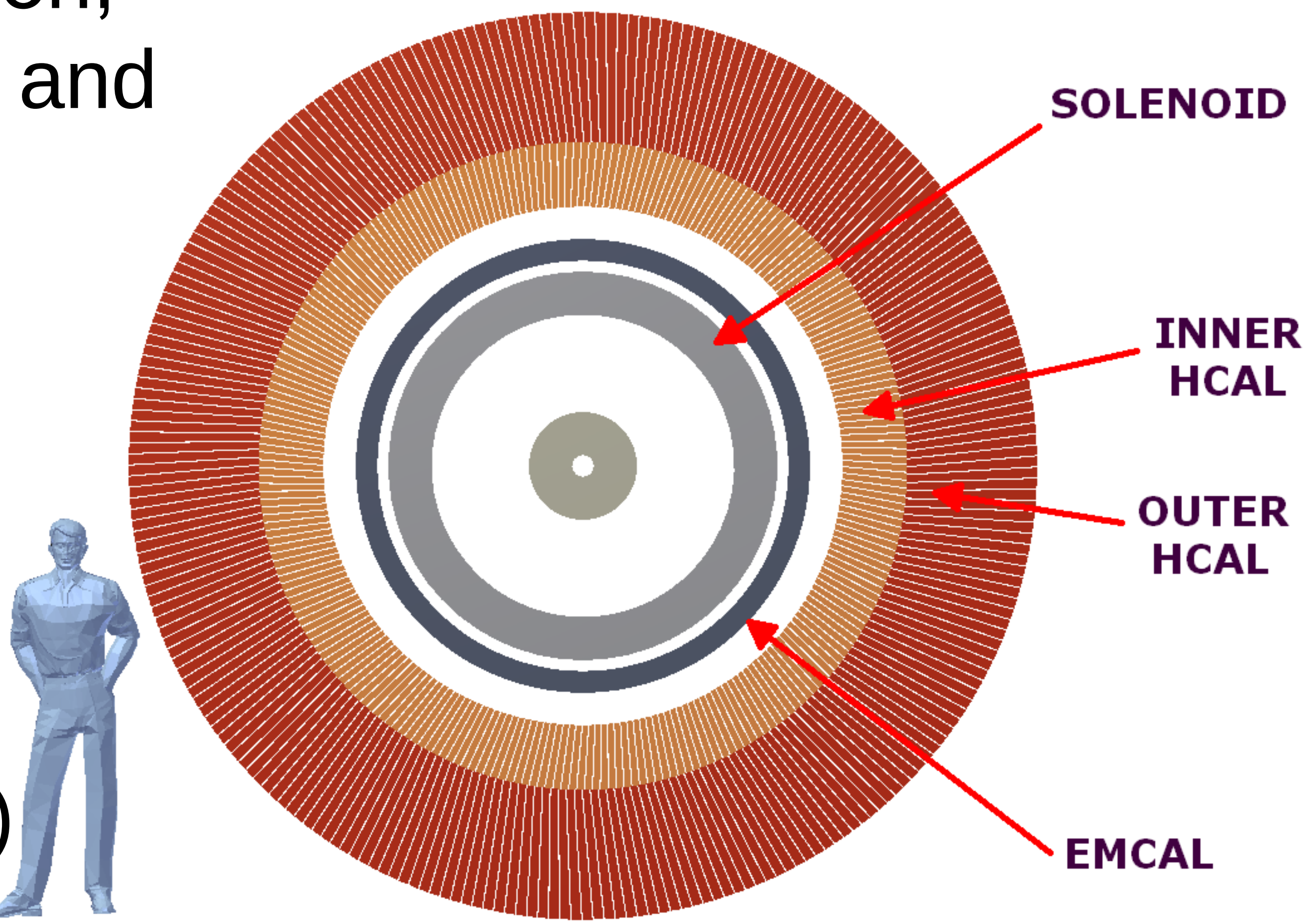
For jets fragmentation products, $R_{AA} < 1$ ("jet quenching")
- Charged hadrons
- $B \to J/\psi$

Full jet reconstruction
- Dijet asymmetry and angular correlation
- Missing p_T
- Fragmentation functions
- Jet-track correlations



Boundary conditions

- Cost
- Coverage
- Geometrical pointing
- “Reasonable” resolution (photon, electron and jet measurements and identification);

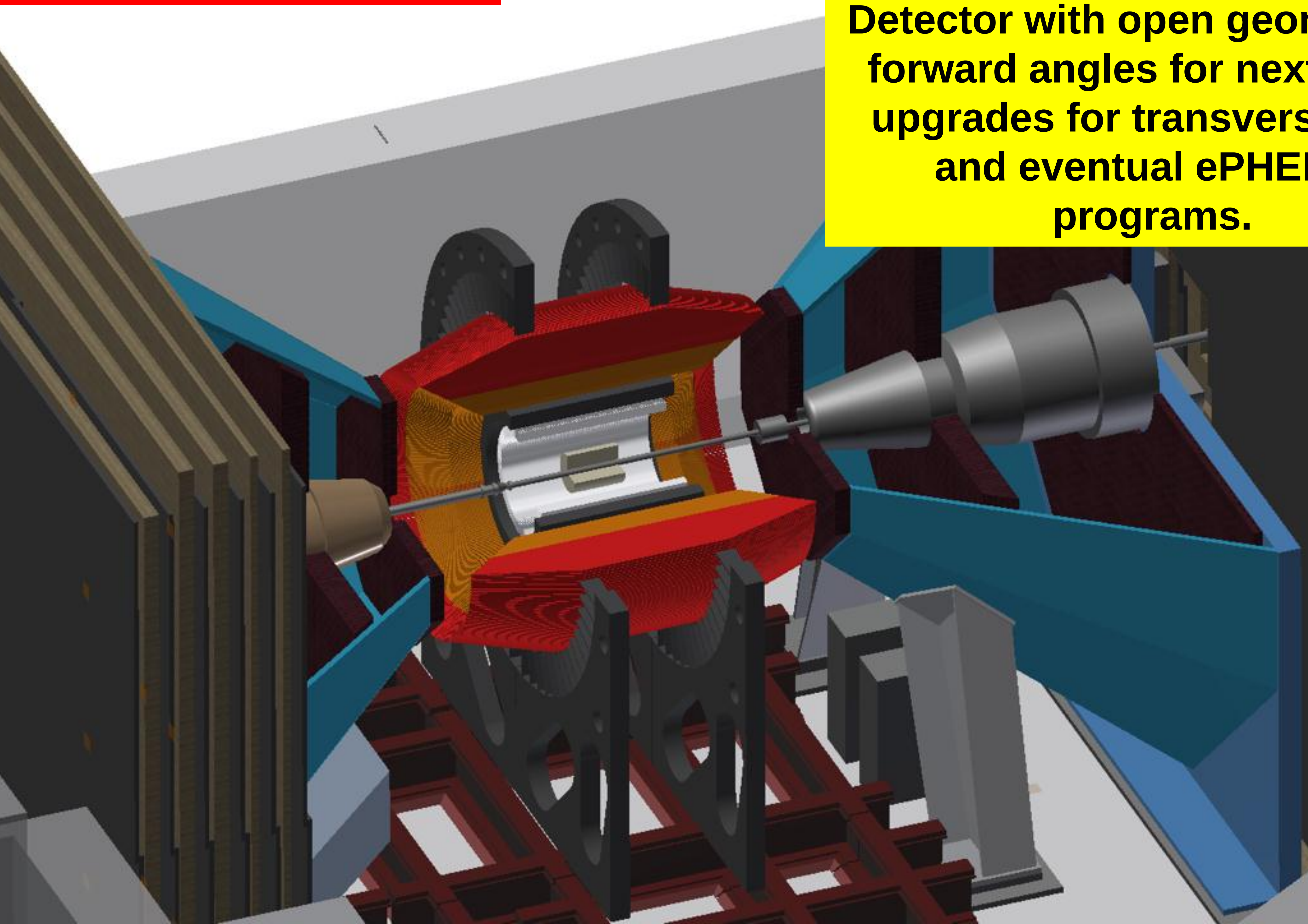


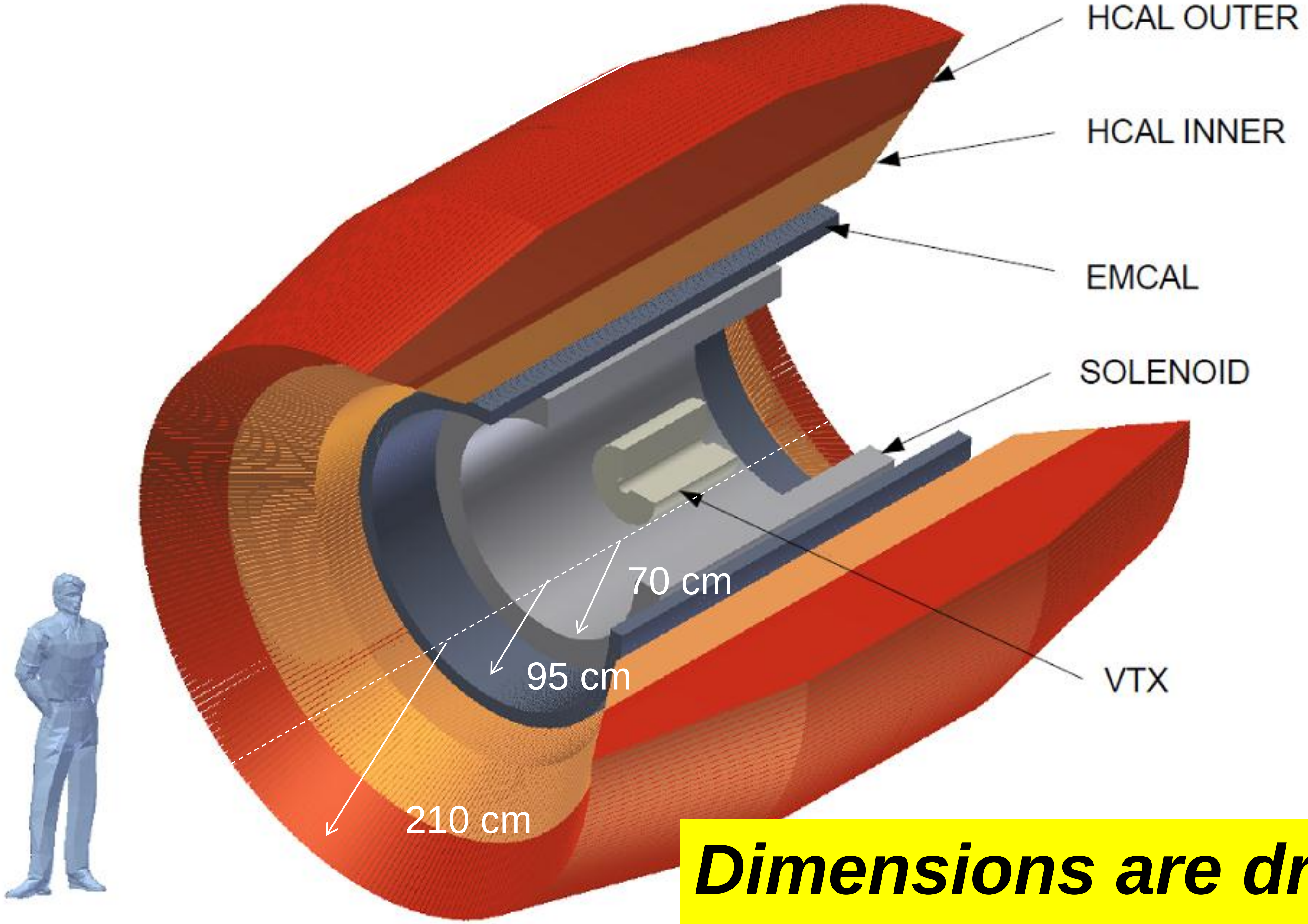
Implementation

1. Existing inner tracking (VTX)
2. Superconducting solenoid
3. Compact Electromagnetic Calorimeter
4. Compact Hadron Calorimeter
5. Software

PHENIX tomorrow ..

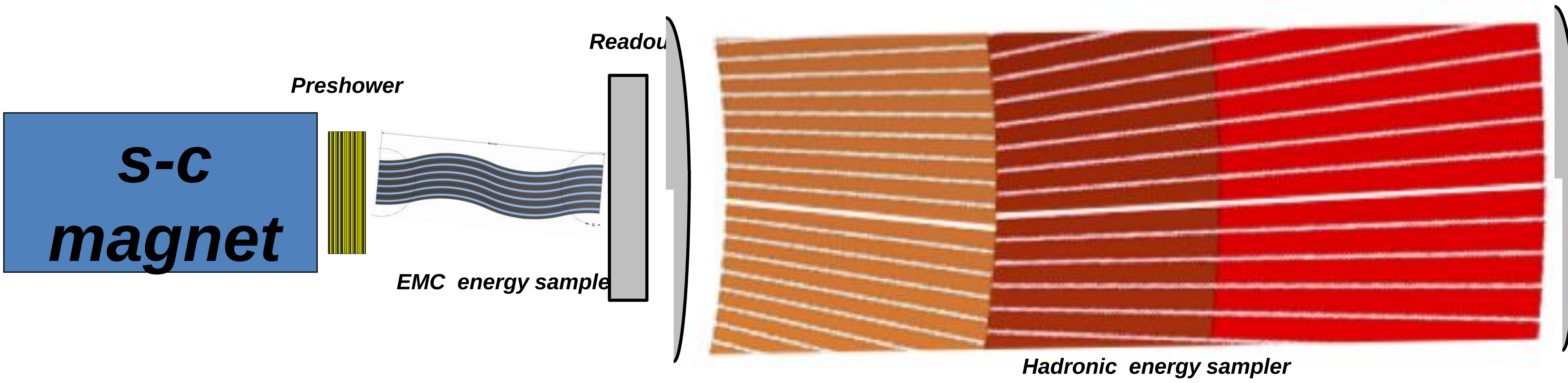
Compact Calorimetry
Detector with open geon
forward angles for next
upgrades for transvers
and eventual ePHEN
programs.





Dimensions are driven by central tracking

sPHENIX Central Calorimetry



-em energy resolution: 14% at 1 GeV

-em depth: 20 X0 or more;

-had. Resolution – better 50% at 1 GeV

-had depth: ~5 Labs

-Active preshower ~4 X^0 (includes coil)

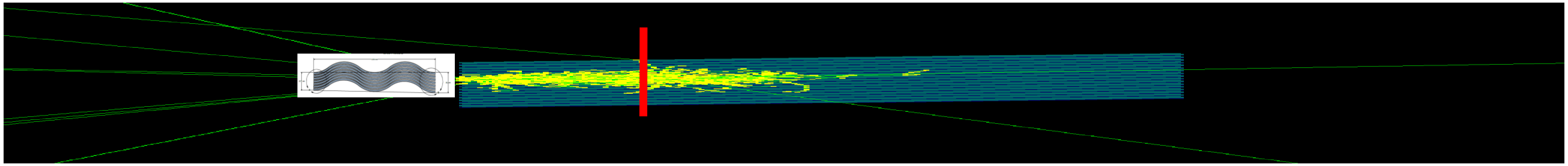
-Accordion EM sampler: 2 mm W +1(0.5) mm SciFi (ongoing R&D)

-Fe & Sc in hadronic-sampling segments

-Optical (SiPMT based) readout in E-sampling segments

sPHENIX EMC and HC have many commonalities

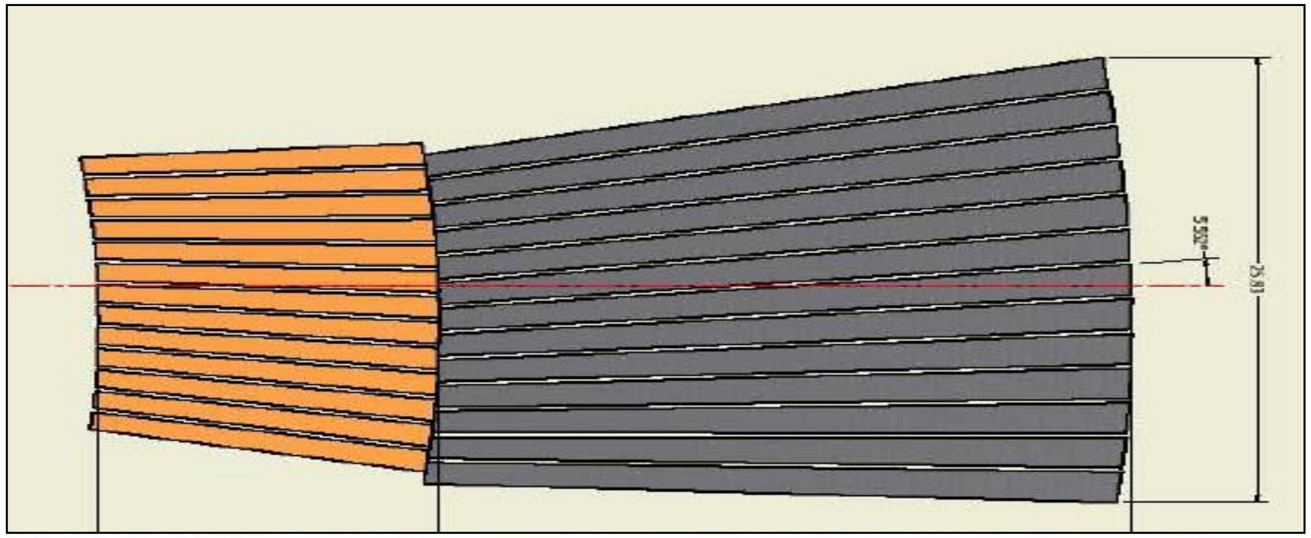
-Both are sampling devices with similar sampling fraction of 3-5%;
-Both are "no inner boundaries" devices – excellent uniformity and coverage;
-Both have similar light collection efficiency and similar luminous properties. Use identical photodetectors (SiPMT's) immune to magnetic field;
-Both are easy to industrialize and build (C.Woody's talk).

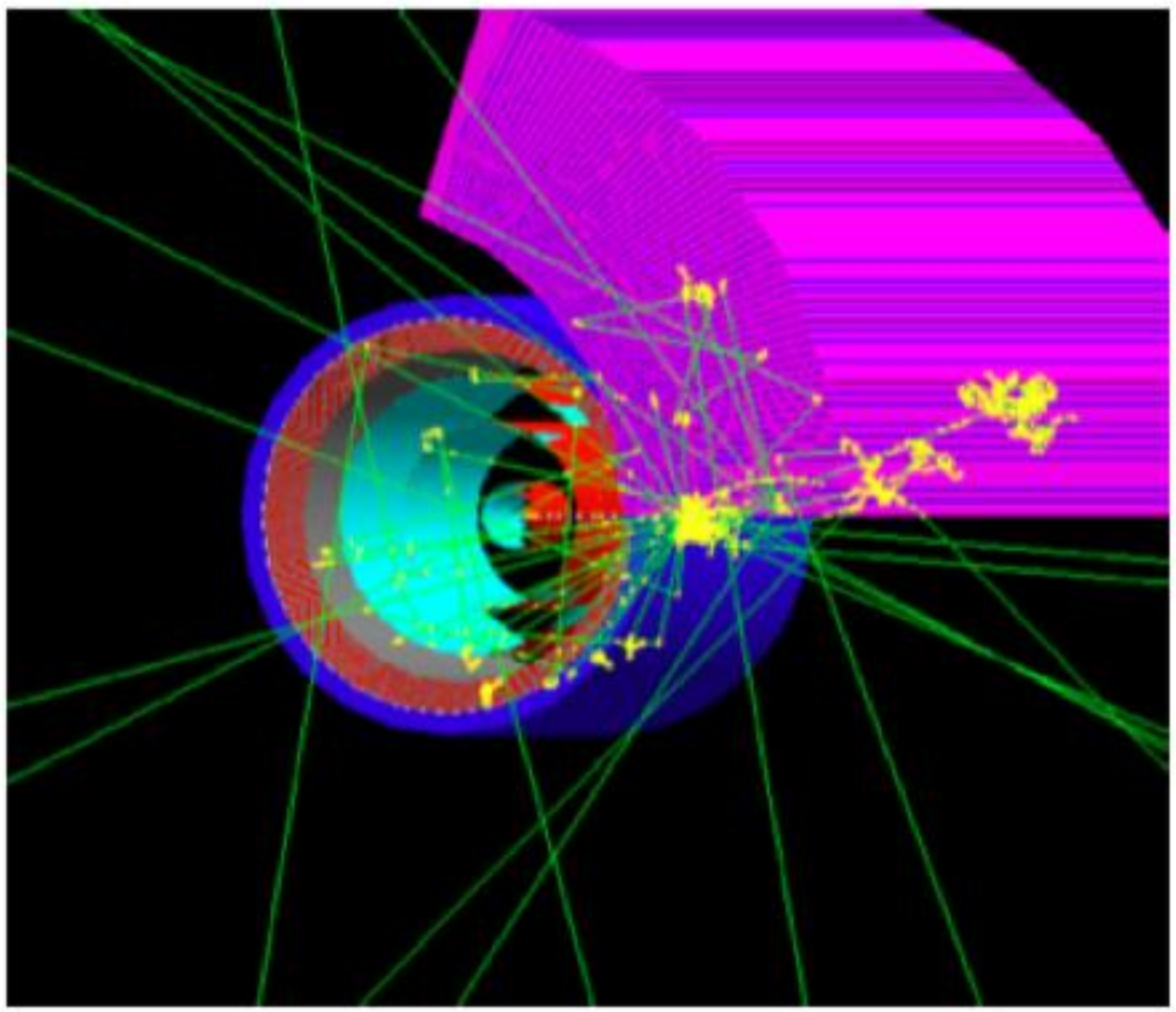


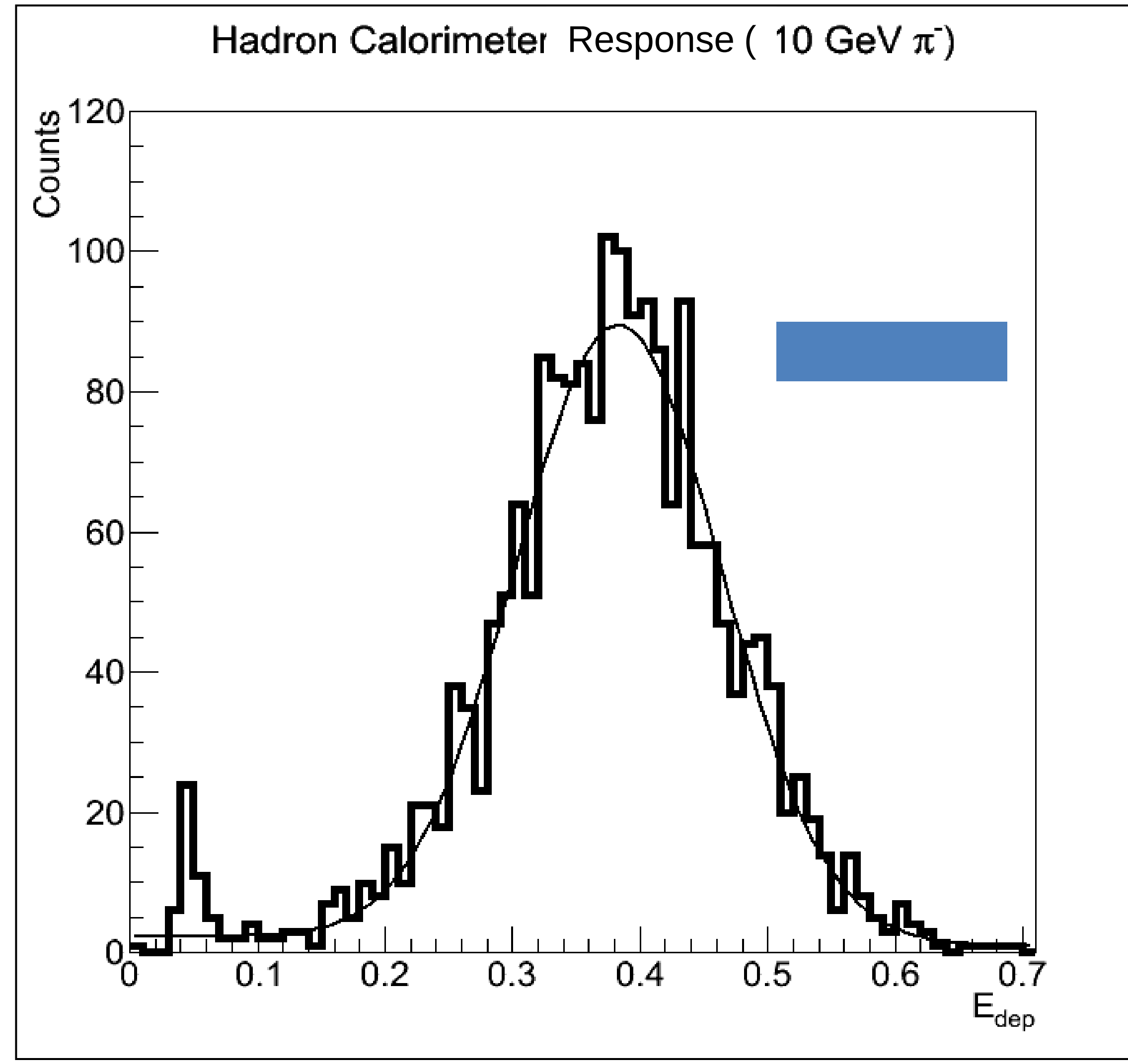
Critical decisions

-arranging sensitive media in layers nearly parallel to developing shower core;
-allowing for the sampling fraction to vary with the depth in calorimeter;
- longitudinally segmenting HC and using LCG measurements to compensate for longitudinal fluctuations and e/h response differences in system components.

HC response line

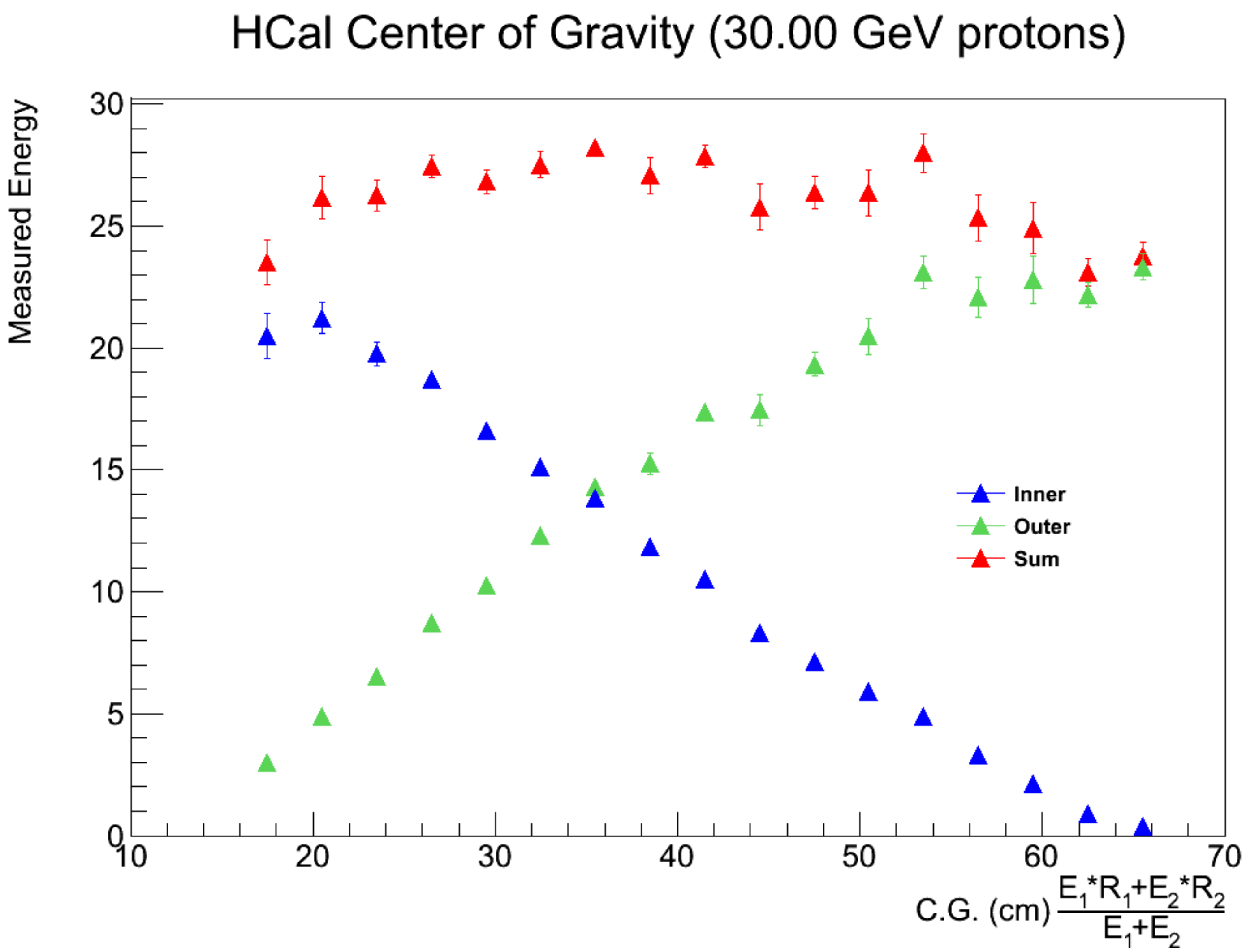


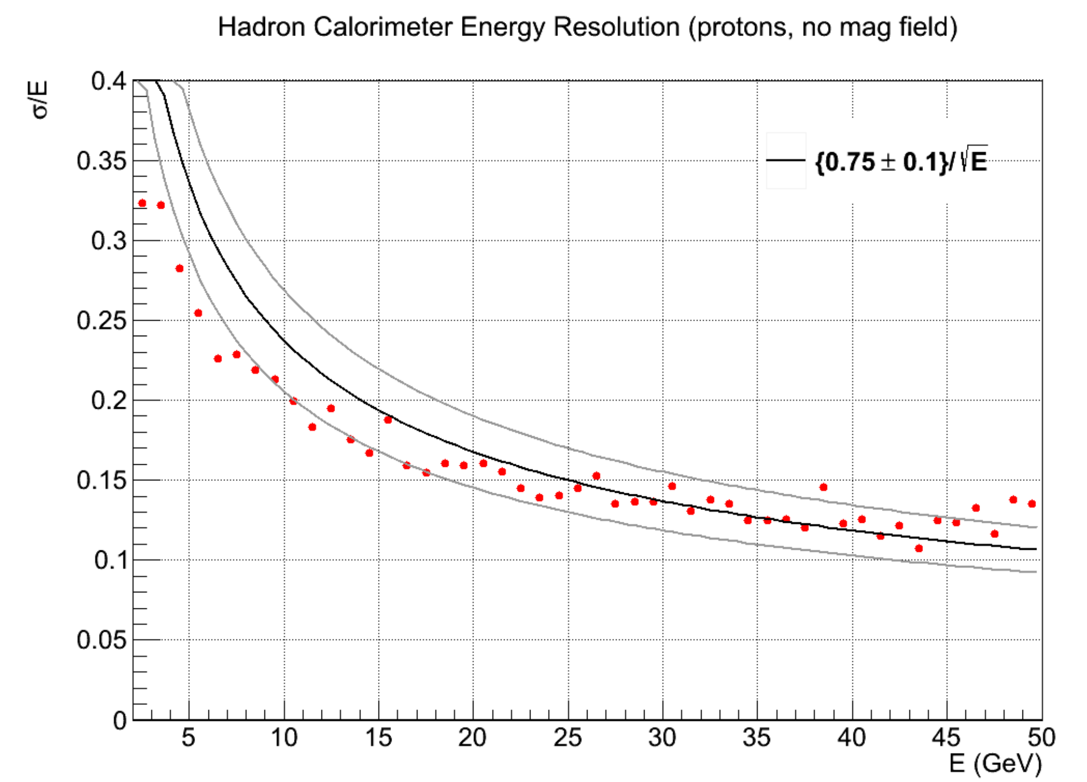


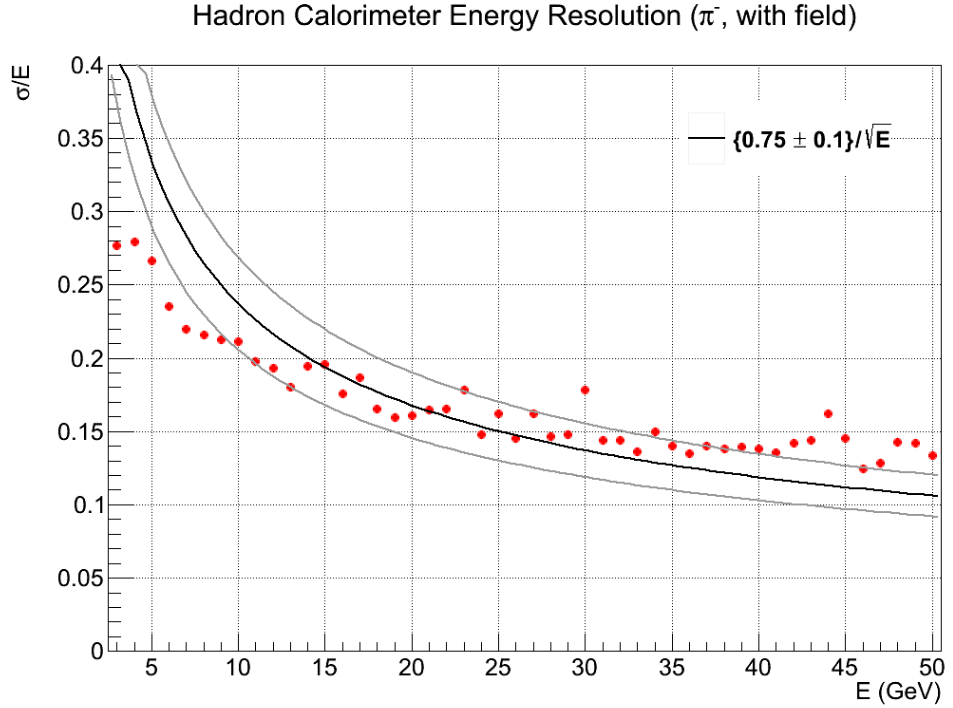


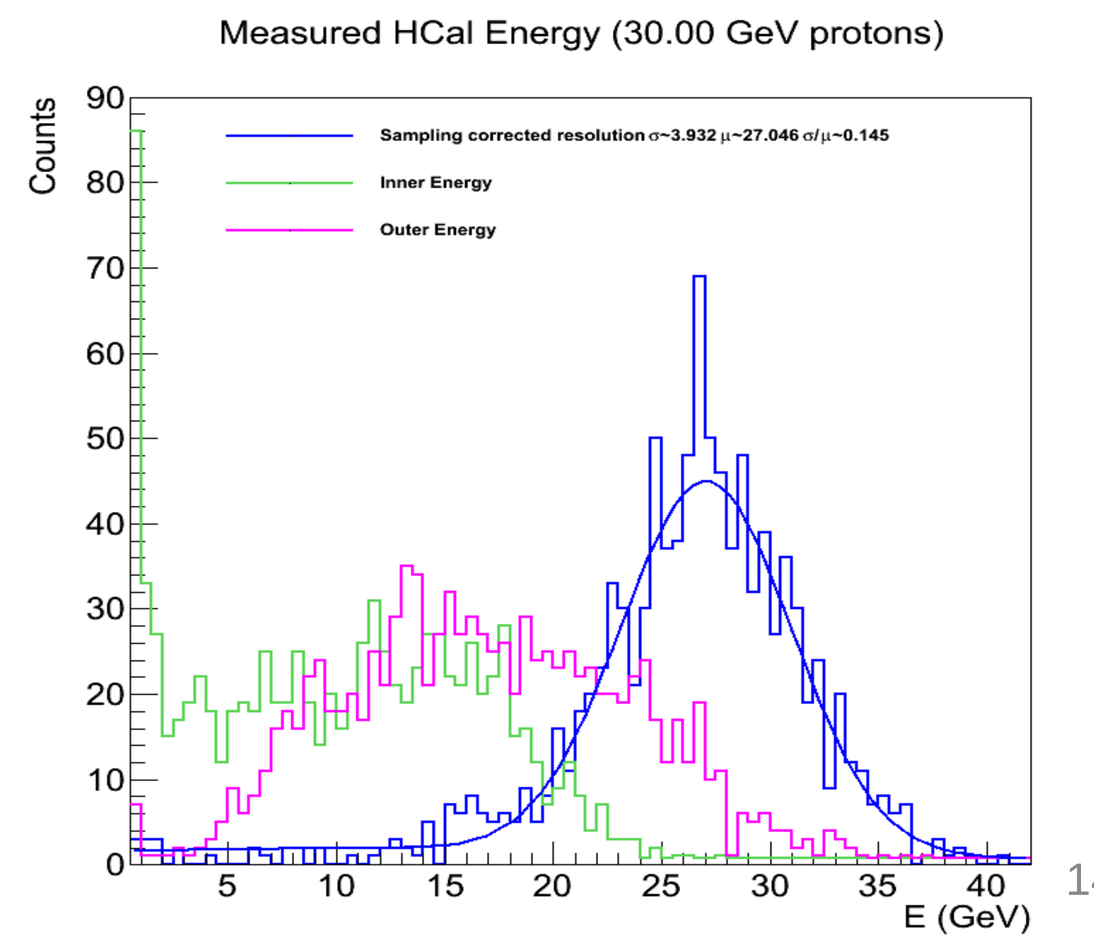
Corresponds to 75%/√E

First look on HC resolution (average SF per section)

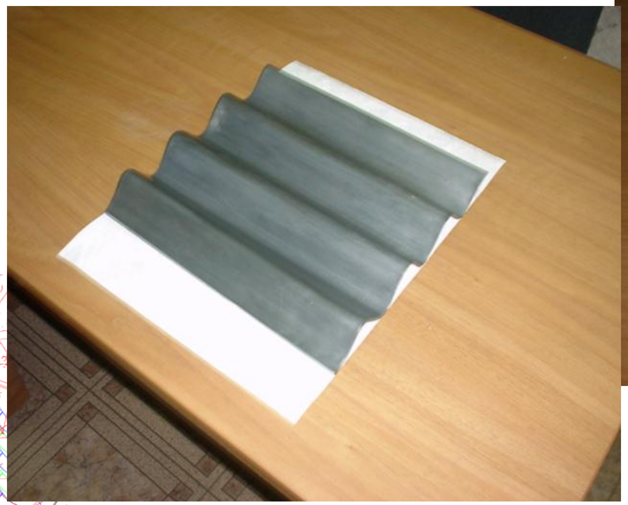




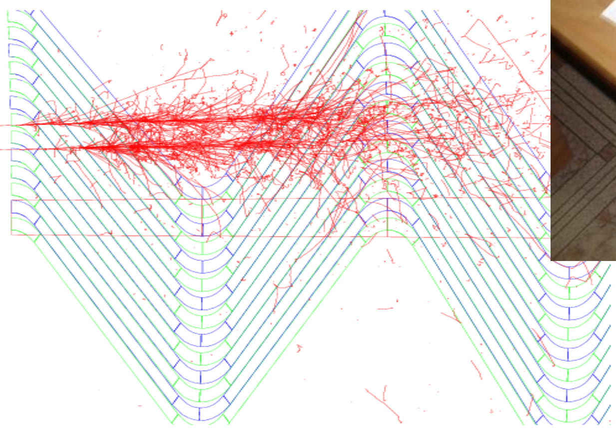




EMCal R&D: Accordion 2001 - 2012



2001



2012

2011

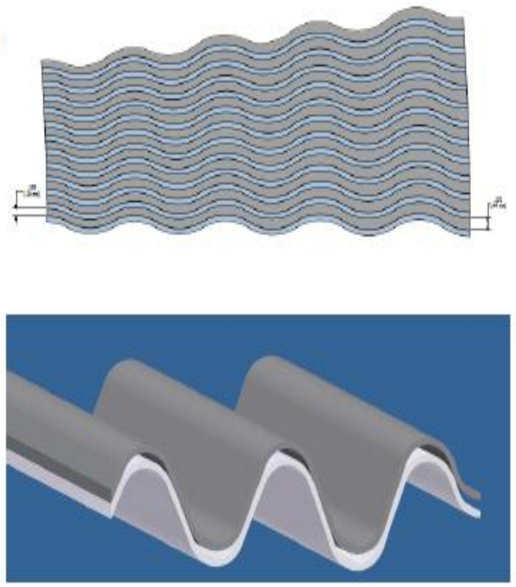


Fig. 1. a) Optical accordion design showing tapered thickness tungsten plates (shown in gray) with uniform thickness scintillator plates or fibers (shown in blue) forming a projective geometry in the plane perpendicular to the beam direction b) detail of the tungsten and scintillator plates in the accordion design showing the variation in the thickness and radius of curvature at the apex of the oscillations (large oscillation shown to demonstrate effect).

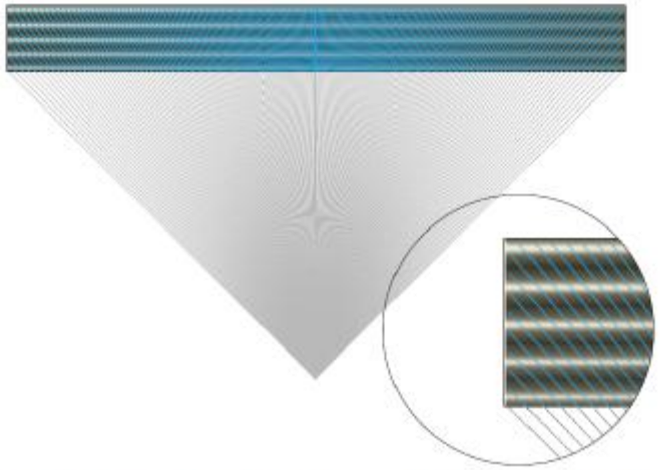
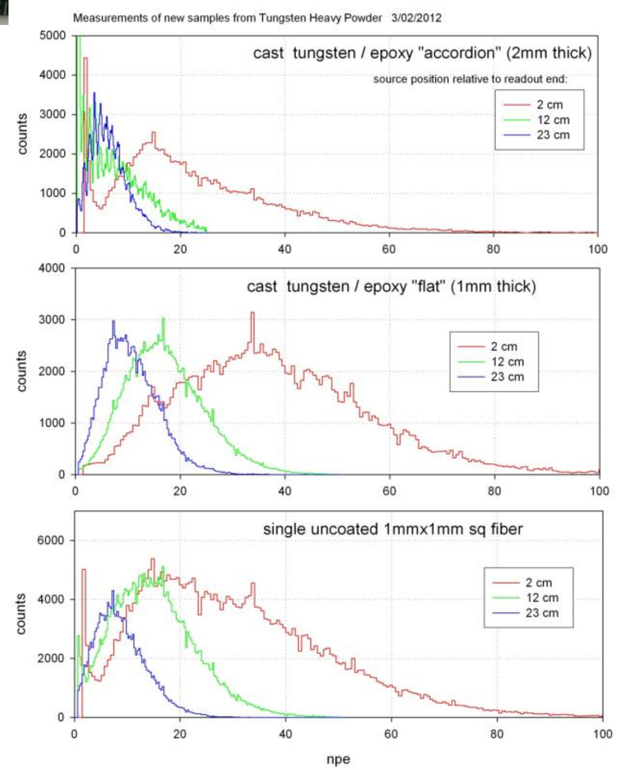


Fig. 3. Projective geometry of the accordion design along the beam direction using either scintillating fibers or wavelength shifting fibers embedded in scintillator plates.



HC – R&D

- simulation;
- geometry of grooves;
- efficiency and uniformity of ligh collection to photodetector;

T2K

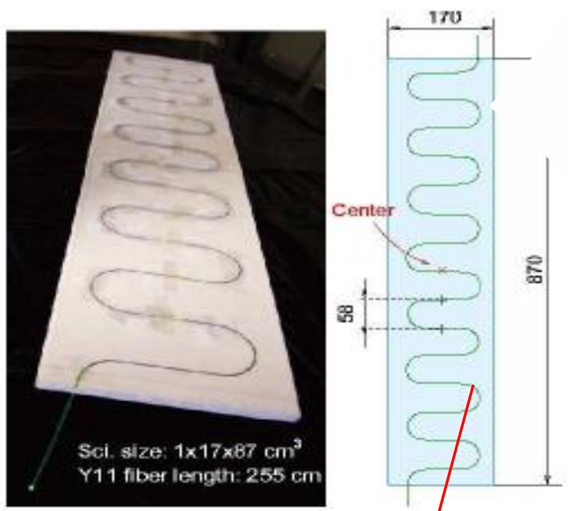
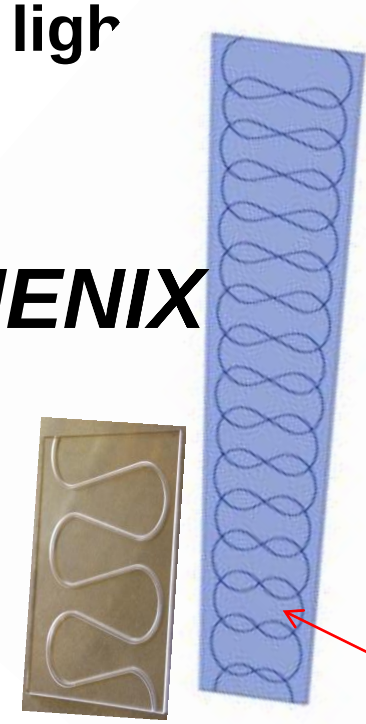
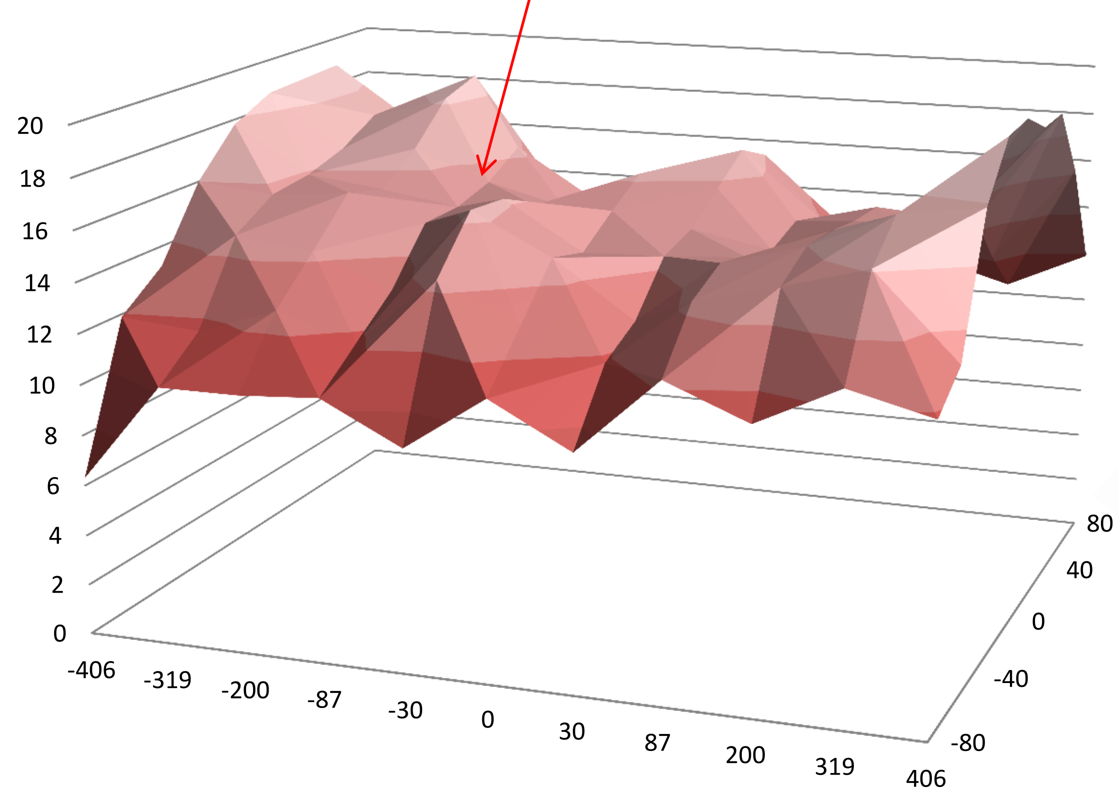
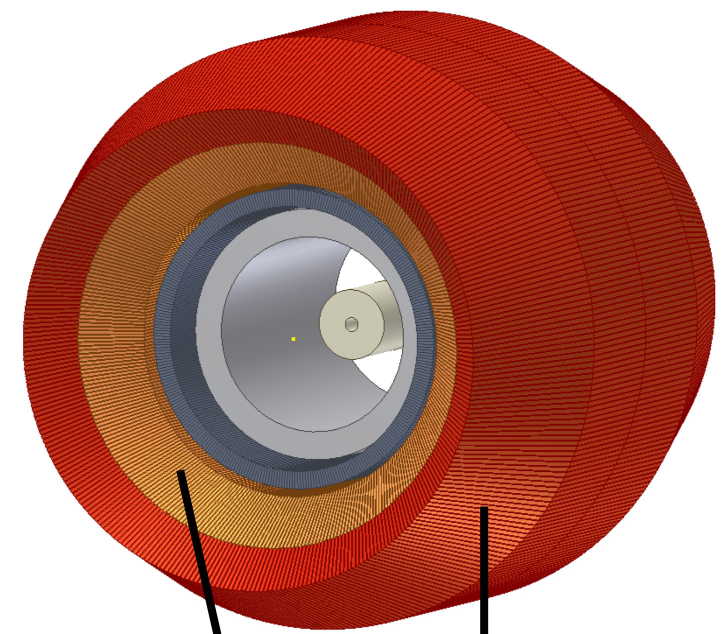


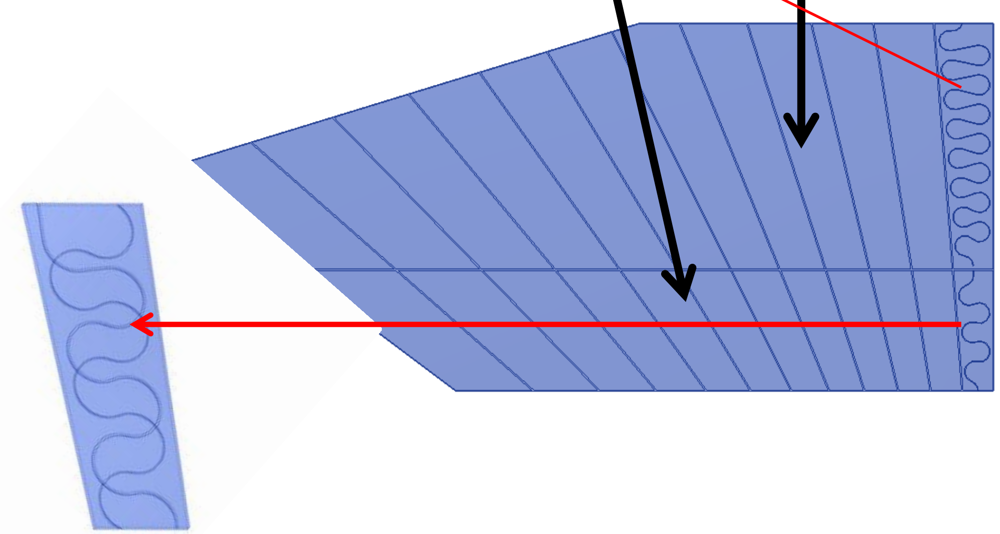
Figure 13: Scintillator slab with S-shaped fiber readout: photograph (left) and schematic view (right).

sPHENIX





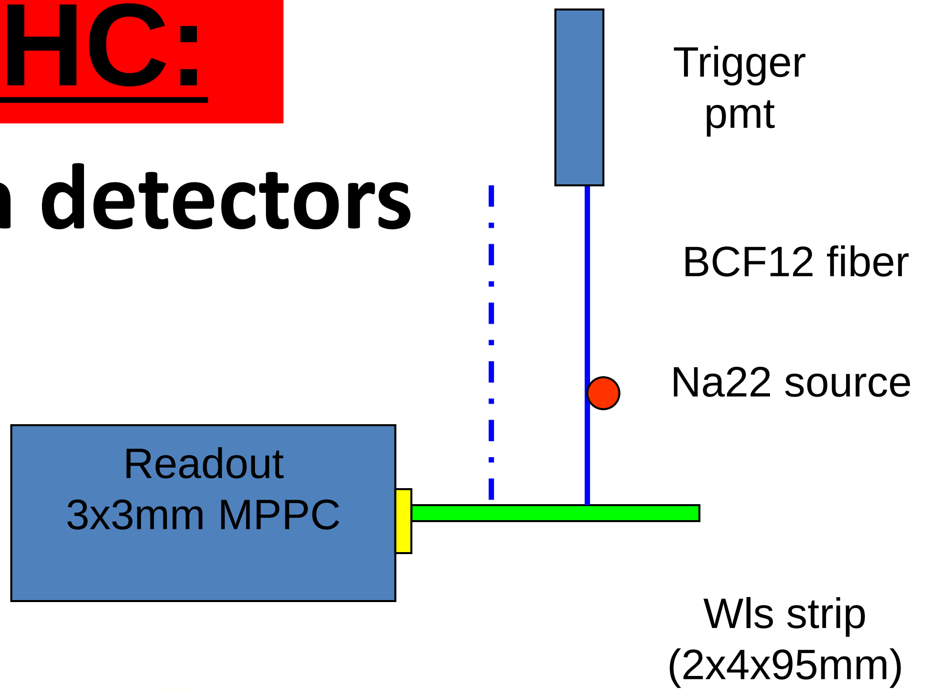




Prototype & test beam are next

R&D common to both EMC and HC:

Light collection and coupling to photon detectors (SiPMT)



EMC:

- integrating sphere or WLS bar *(ongoing R&D)*
- Optimization of SiPM coupling through a dimple in the WLS plate allows to recover good uniformity (see : F.Simon, MPI Munich)

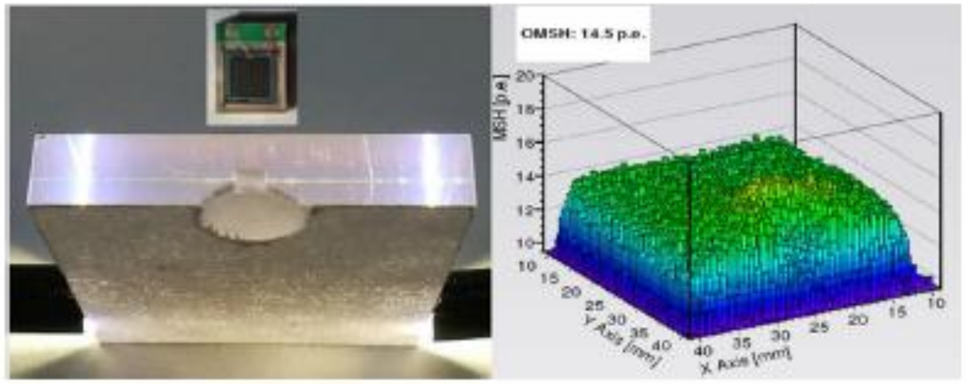


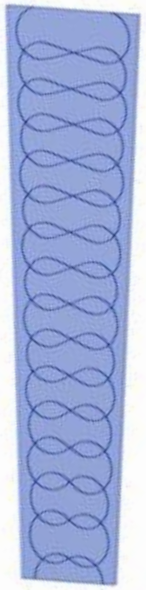
Figure 8: *Left) Special shaped tile of 5 mm thickness with a depression and a slit for the integration of a surface mount MPPC25-P. Right) Signal amplitude measured over the surface area, showing a high degree of uniformity. The mean amplitude is 14.5 p.e, [24].*

HC:

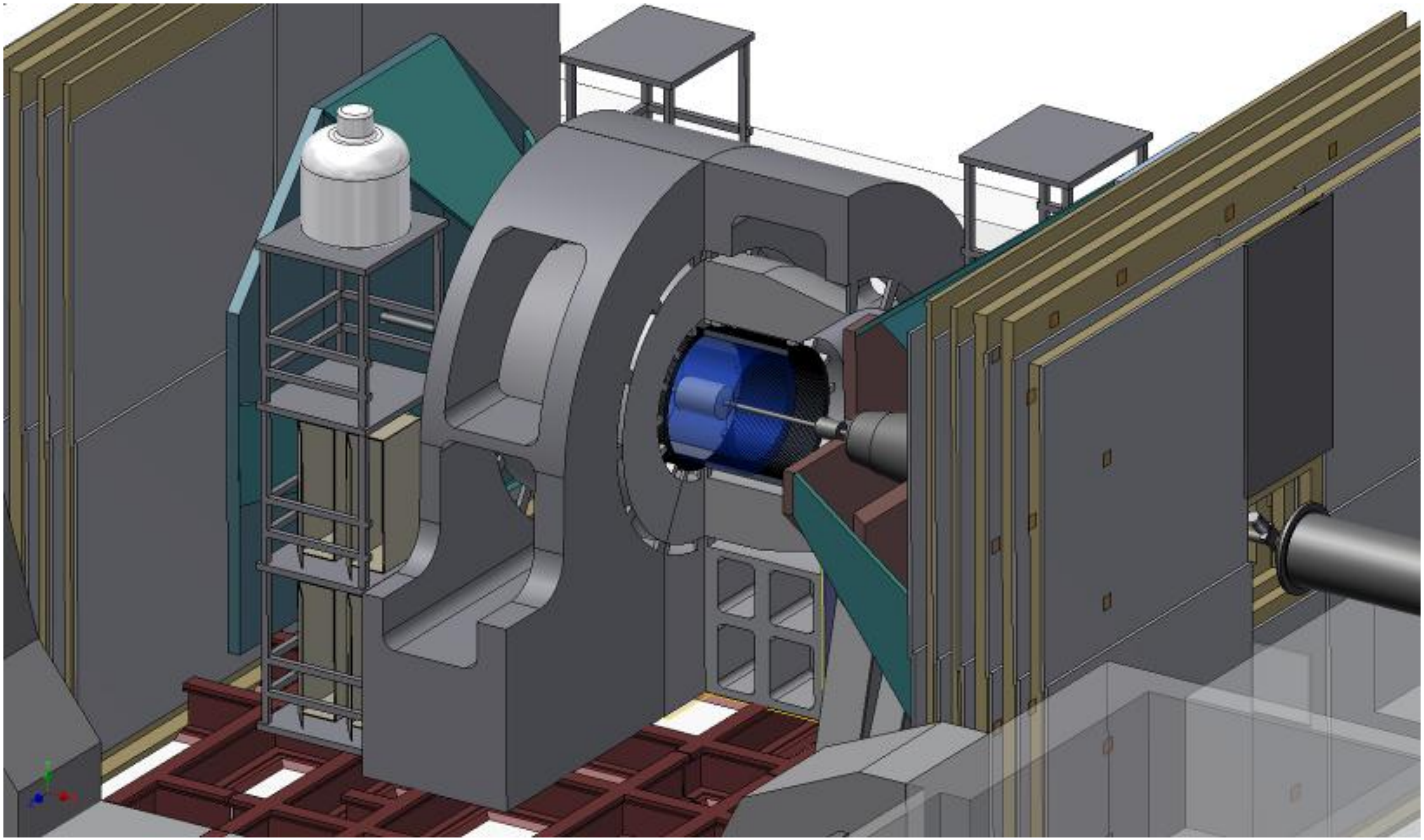
WLS fibers (8 per tower) bandled opposite SiPM inside reflective cavity *(ongoing R&D)*

Multiple SiPMT's - one per fiber *(dreadful)*

Are there interest in workshop on new ideas for large area optical matching to small modern photodetectors?



Integration and mechanics



Summary

Heavy Ion Collisions produced major discoveries in “Physics in Collisions” in the last 10 years, jet quenching and saturated elliptic flow are two examples;

In the era of LHC RHIC still offers unique opportunities for detailed studies of matter phase transition on a phase boundary close to critical temperature;

Calorimetry based upgrade to PHENIX will create a tool to explore this opportunity with jets and direct photons being event observables and event tags of choice;

The sPHENIX calorimeters will use readout elements oriented close to shower core and software to compensate for fluctuations and particle dependent response variations. The system performance is chosen to match physics.