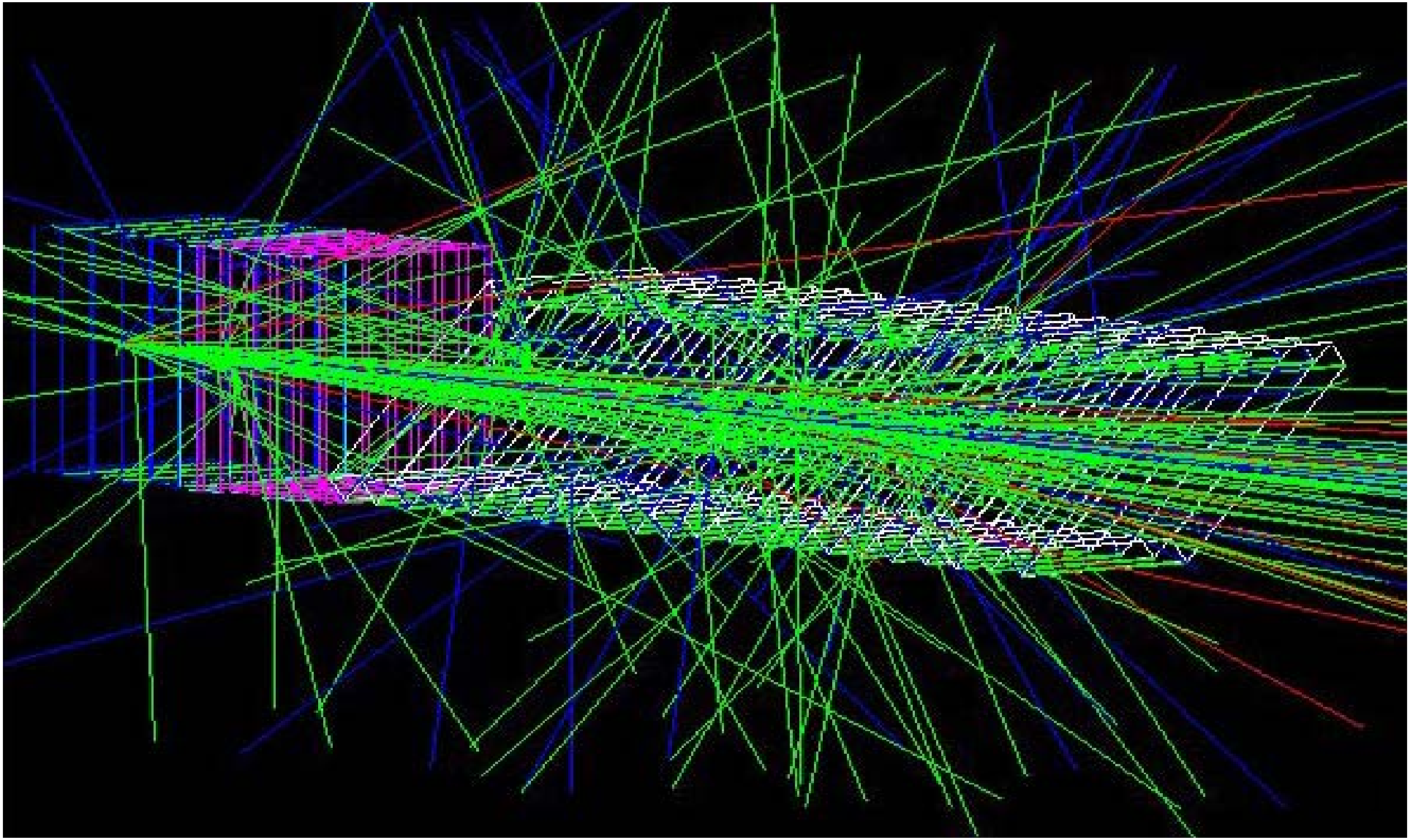
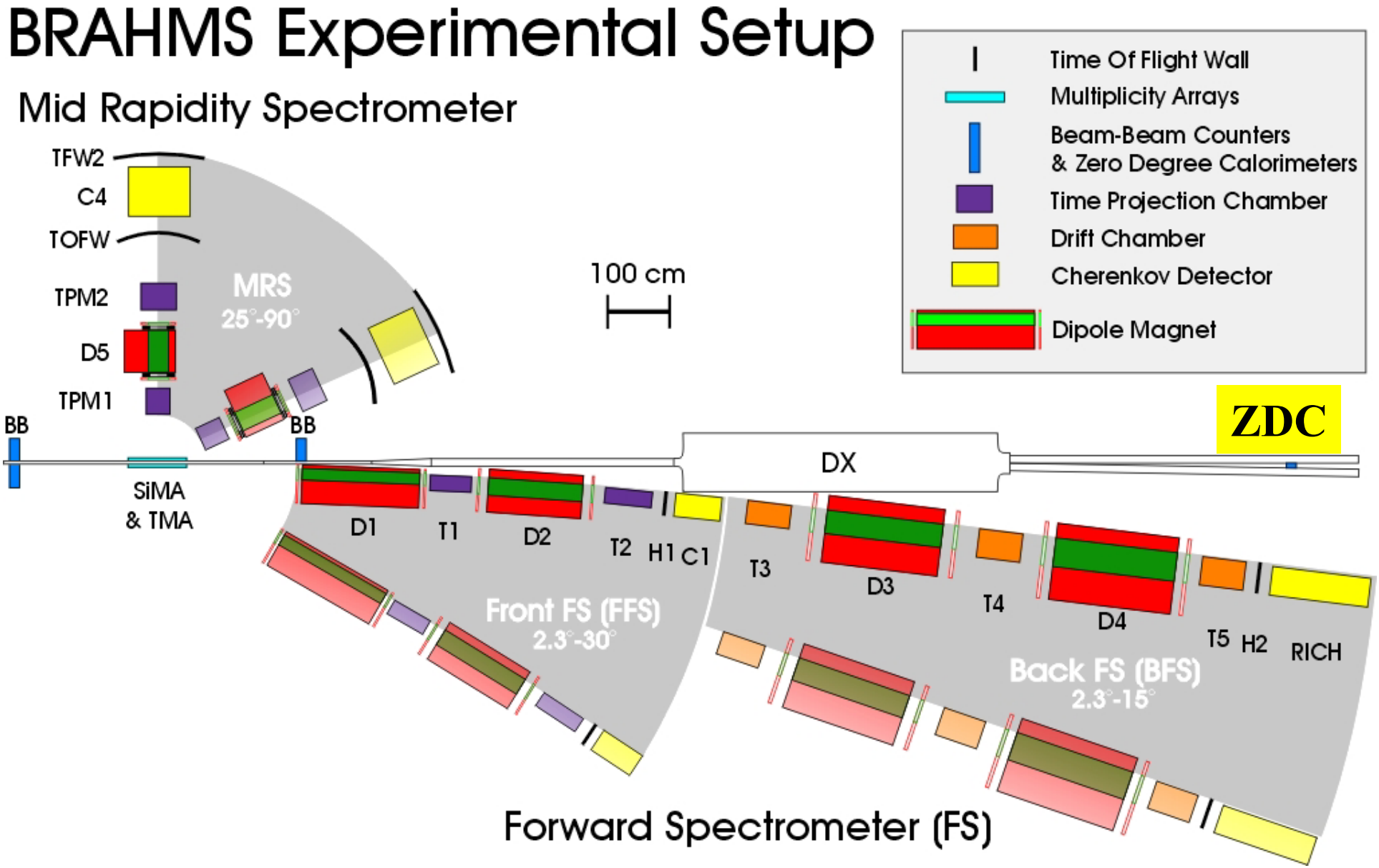
Zero Degree Calorimeters and Forward Physics in CMS



Outline

- The links between HERA, RHIC and LHC
  - BRAHMS data suggests gluon saturation at high rapidity
- RHIC experience with the ZDCs
  - Geometry of AuAu and dAu collisions
  - Tagging ultra-preipheral collisions
  - Luminosity monitoring for AuAu pp
- ZDCs in CMS
  - Capabilities
  - Status of project

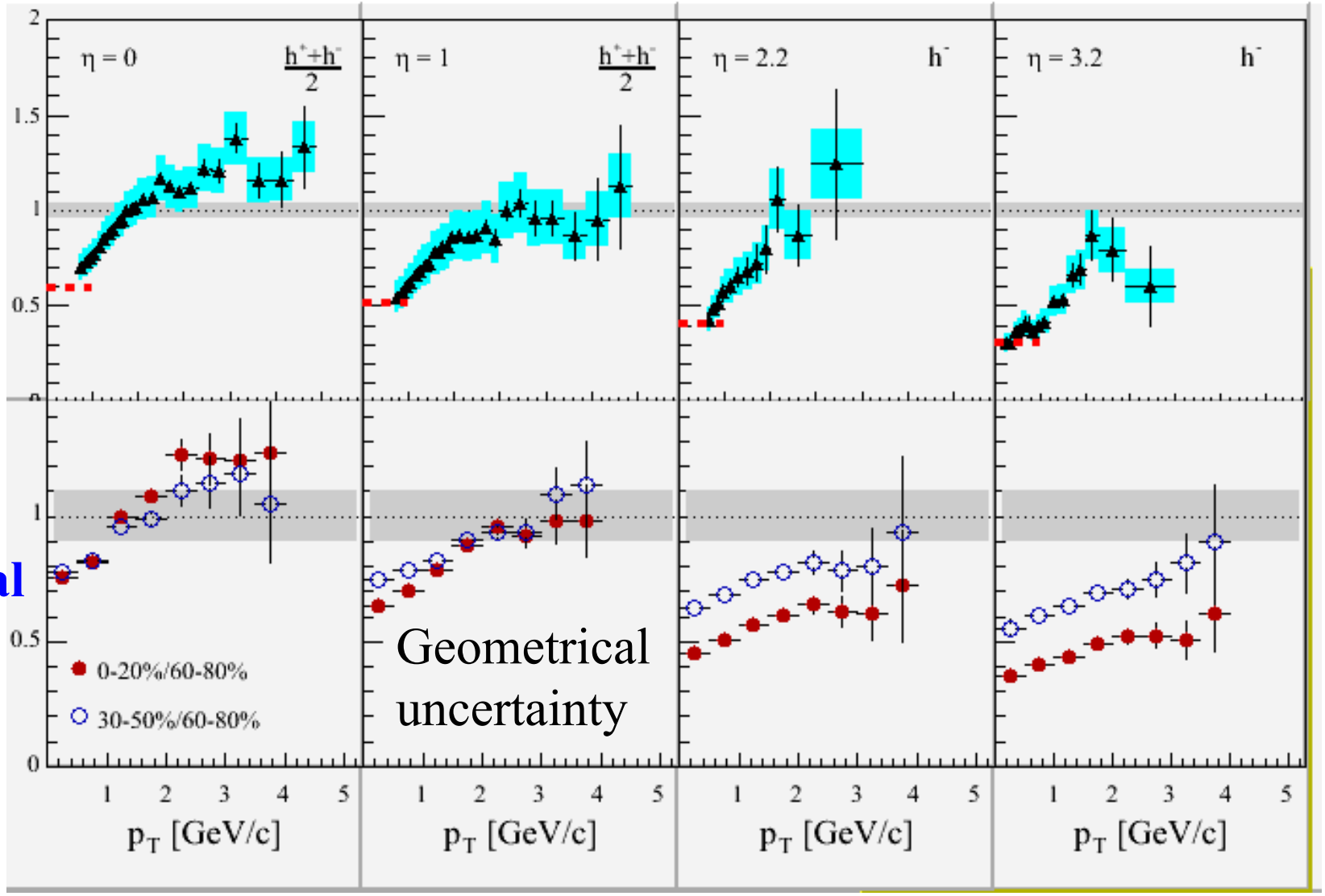
HERA ∄ RHIC: Brahms forward physics



dAu hadron yield is suppressed at high rapidity

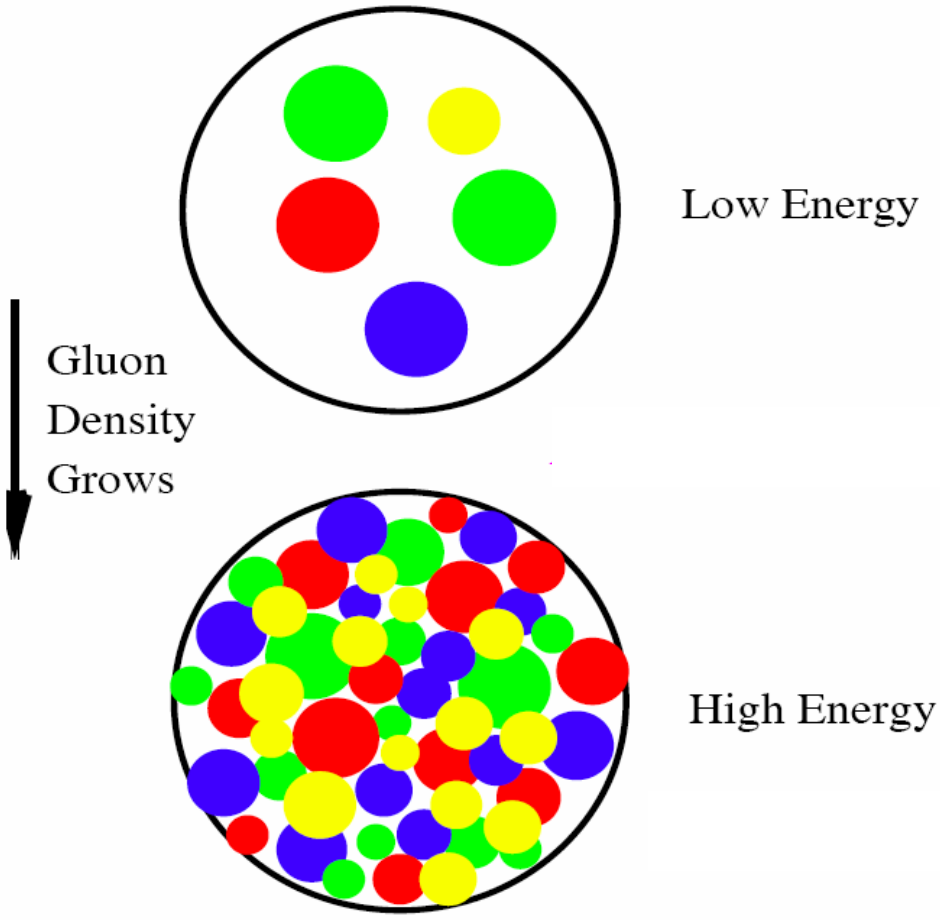
dAu
pp

Central
Peripheral



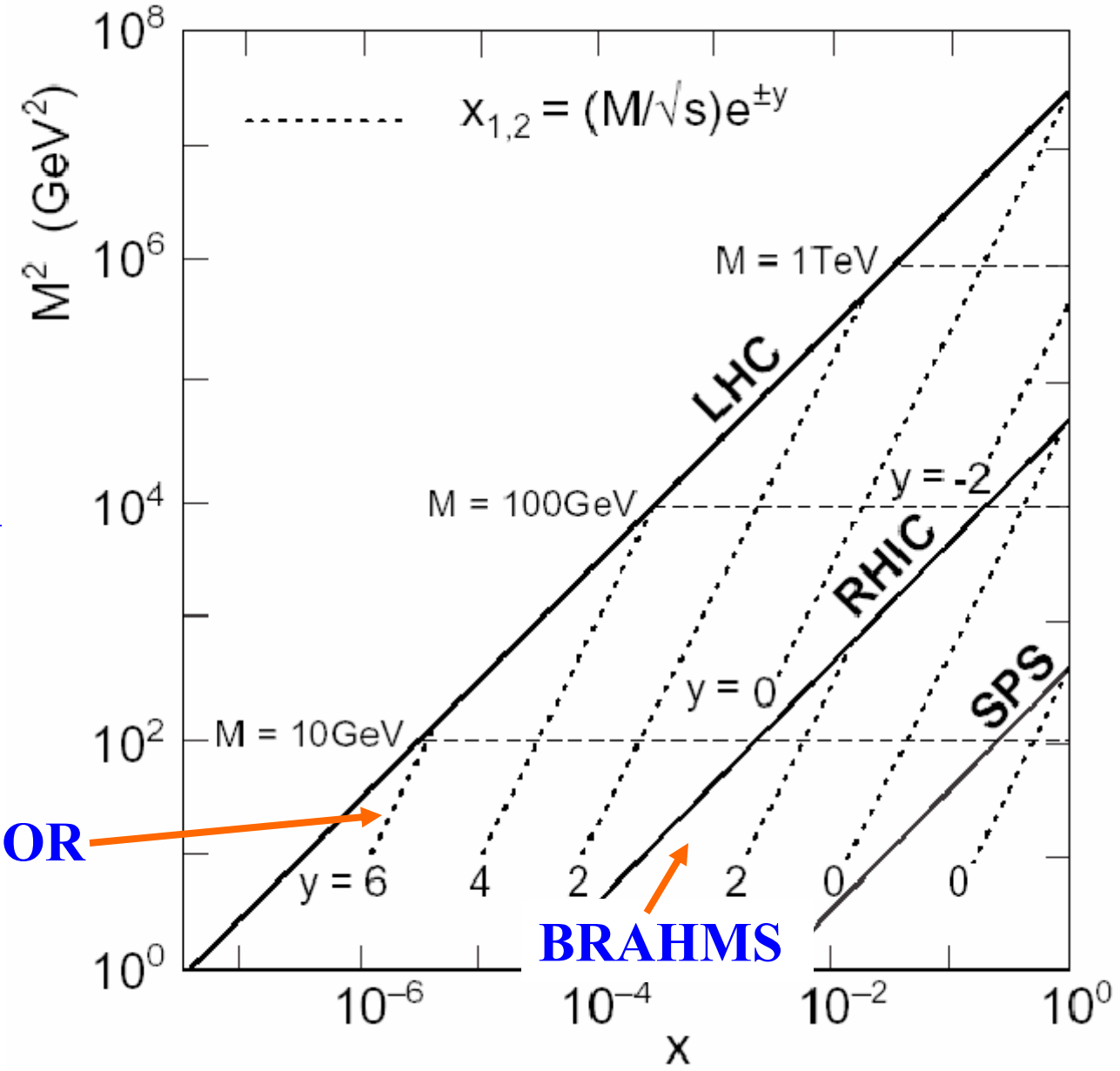
Possible explainations of dAu suppression

- Hard/soft recombination
  - Hwa nucl-th/
- Nuclear shadowing
  - Vogt
- Parton saturation a la HERA
  - Kharzeev, Mc Lerran
  - Amesto



RHIC⇔LHC: More energy and rapidity

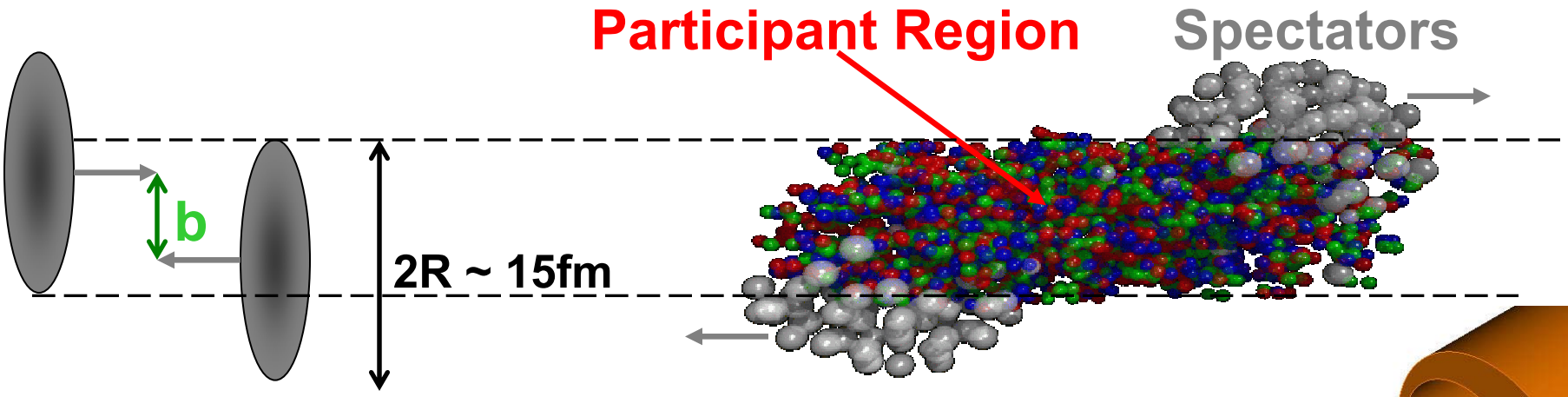
CMS can reach x values 100s of times smaller than BRAHMS

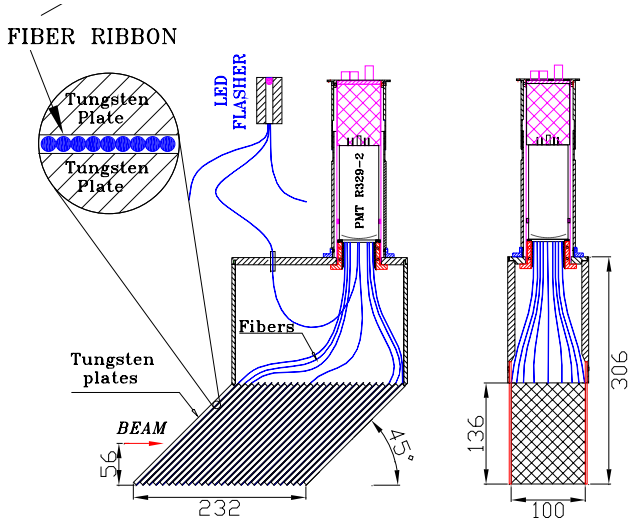


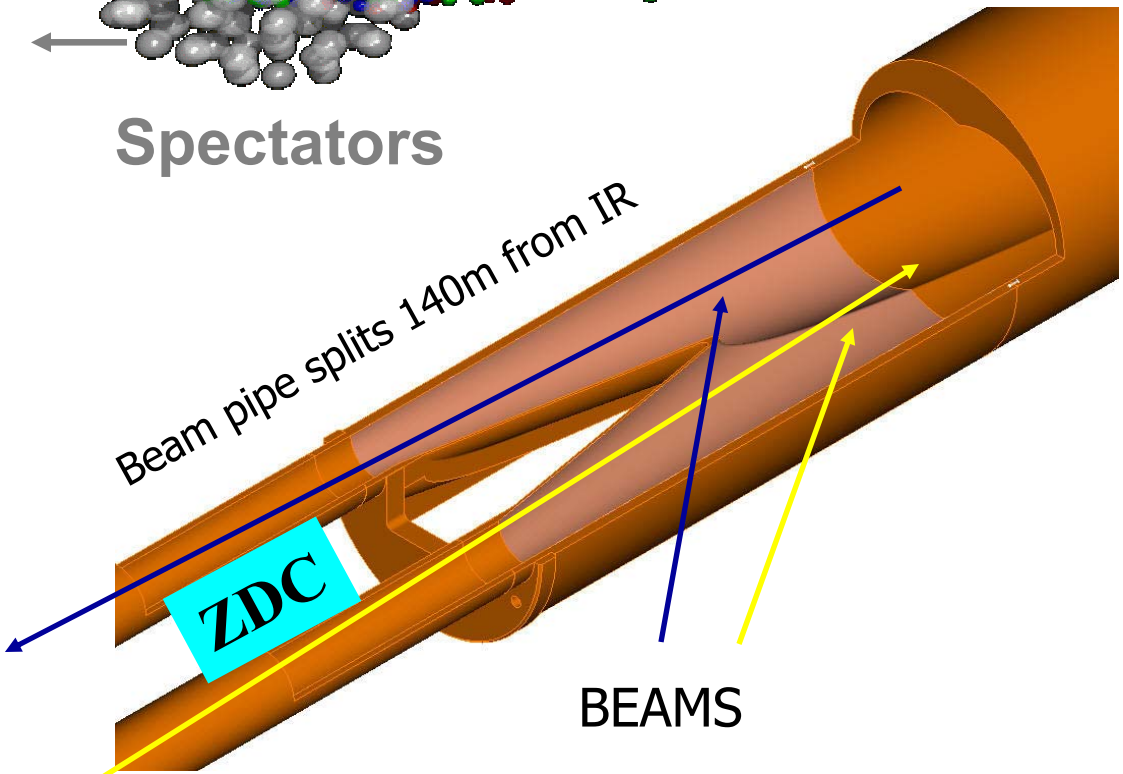
CASTOR

BRAHMS

The ZDCs catch spectator neutrons





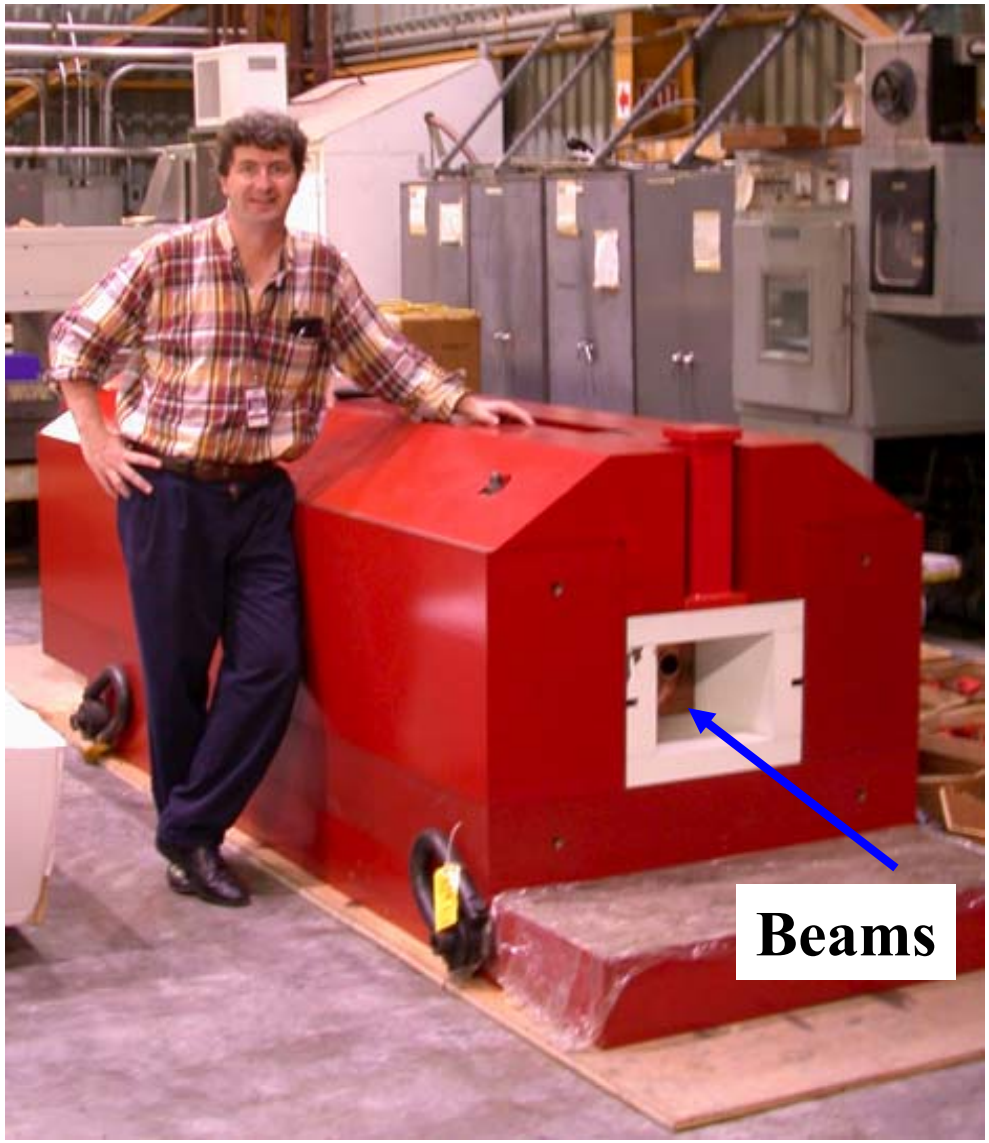


RHIC Experience

- ZDCs are standard tool for beam tuning in AuAu, dAu and pp runs
- $\sigma_E = 20\%$ at 100GeV, $\sigma_T \sim$ 90-100ps
- ZDCs are very useful for measuring nuclear geometry and background rejection
- ZDCs tag ultra-peripheral collisions via AuAu => Au* Au* + n + n + vector meson

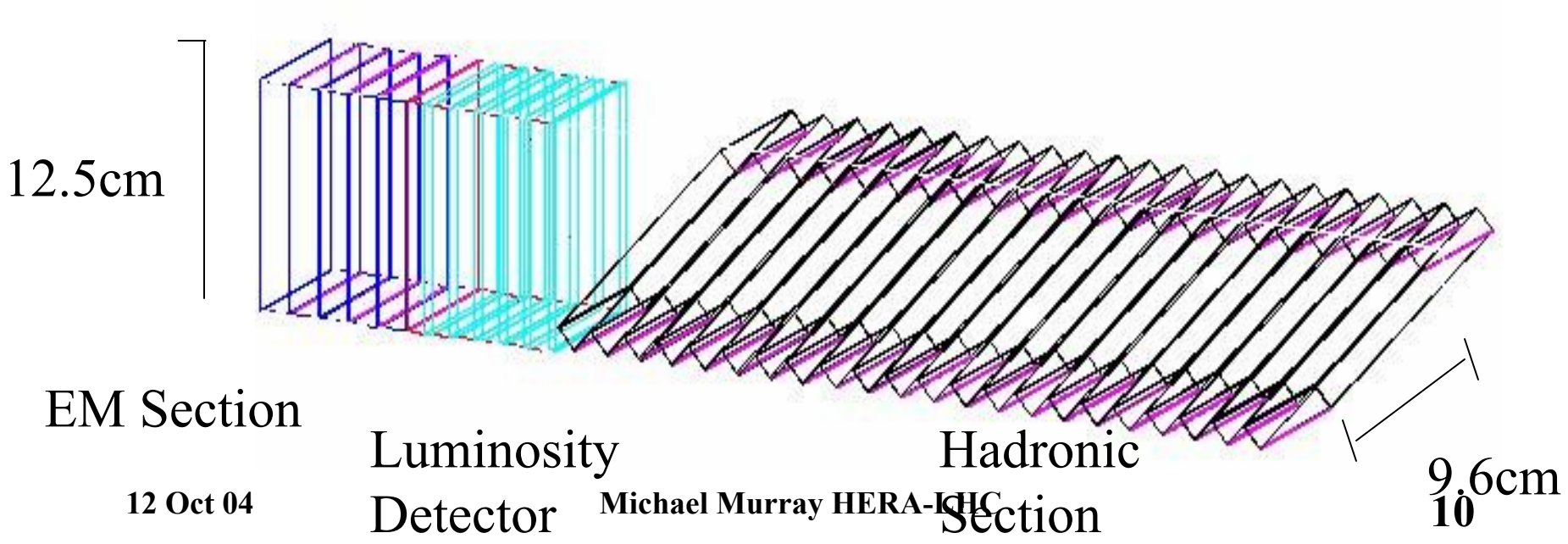
ZDC sits inside a narrow slit within the TAN

- **Slit is 10cm wide, 100cm deep ~ 30cm high**
- **Fill this with as much tungsten as possible and rad hard optical fiber**
- **During pp running sycnotron radiation will produce significant heat which will have to be dissipated.**

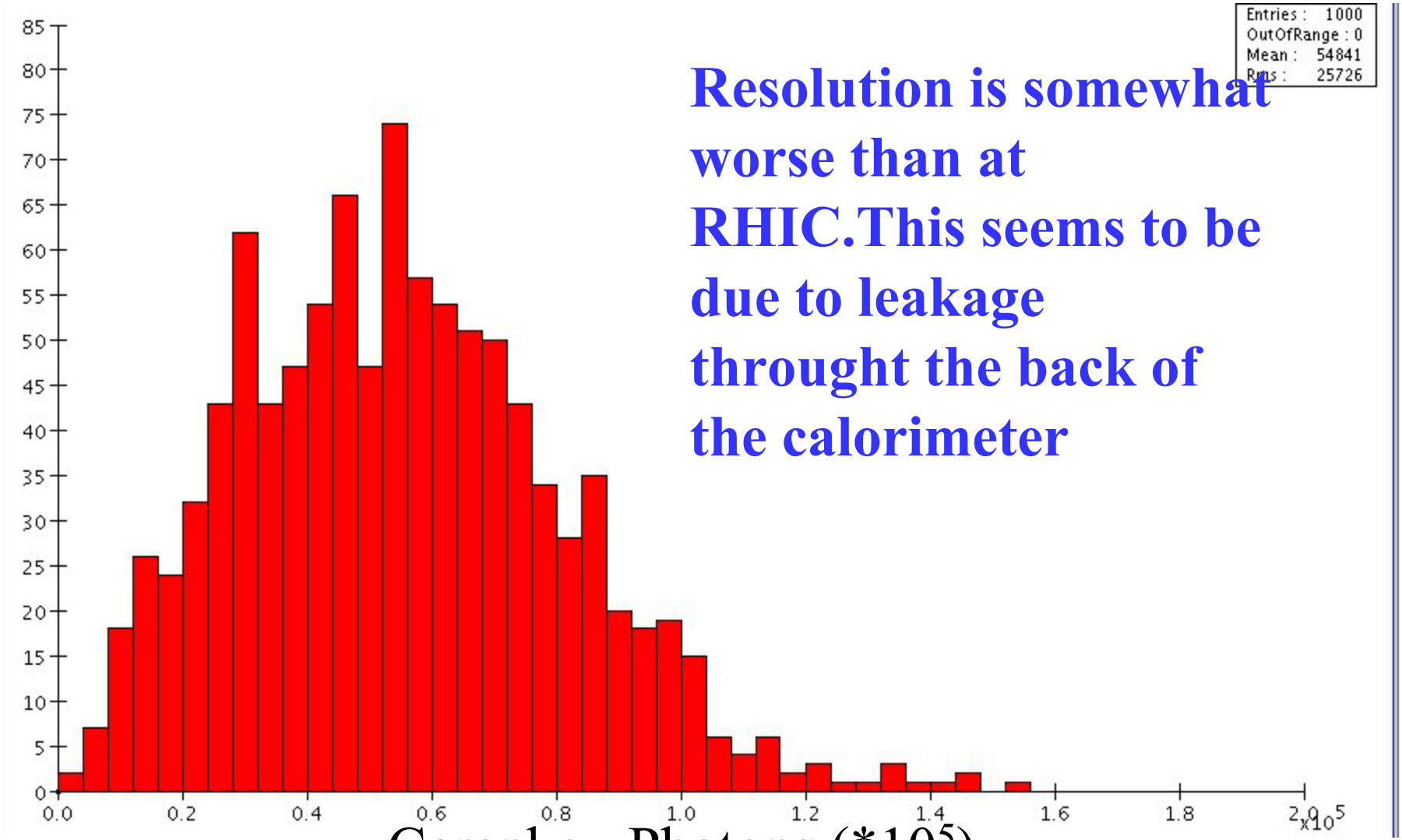


Design is dominated by tight geometry

- 100cm of space is available
- Luminosity monitor will occupy the second 10cm of the TAN and needs some material in front.
- EM section will be divided horizontally



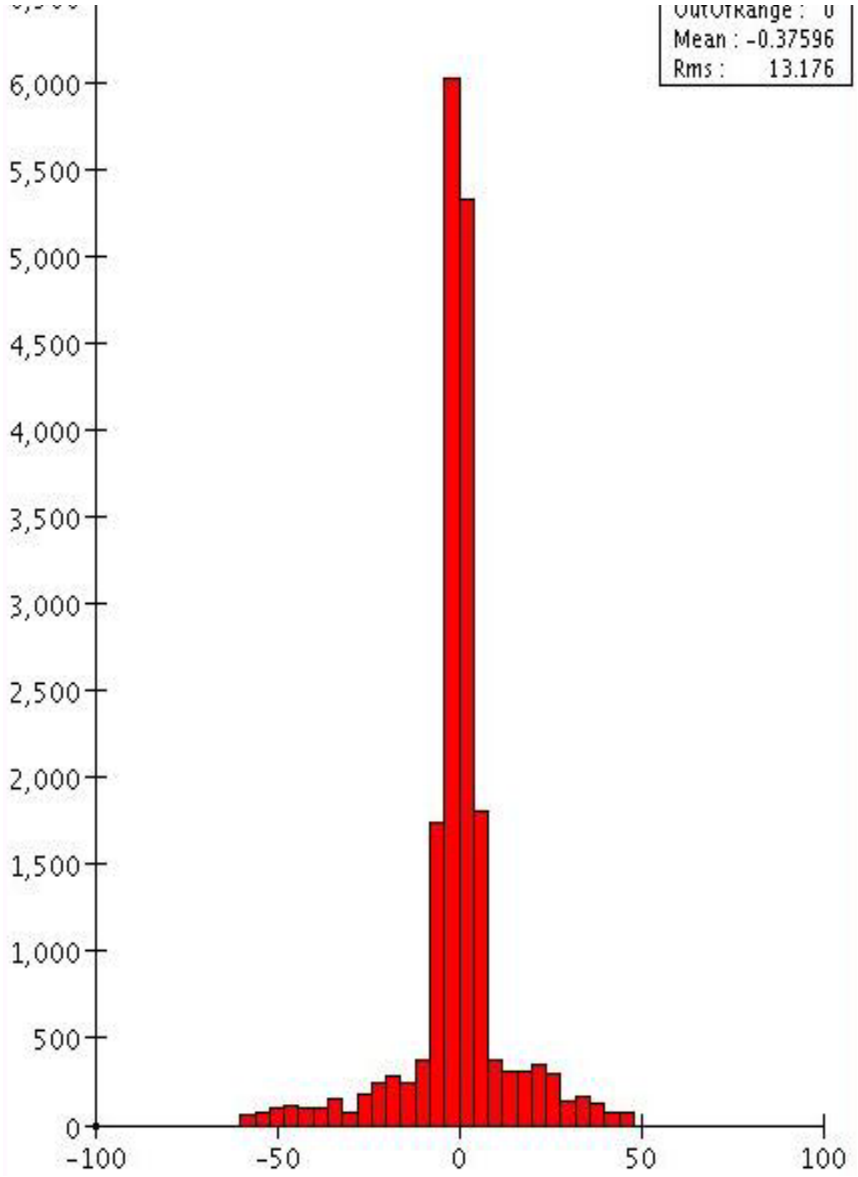
Monte Carlo for 1TeV neutrons



Resolution is somewhat worse than at RHIC.This seems to be due to leakage throught the back of the calorimeter

Cerenkov showers are very narrow

- **By dividing the EM section horizontally we can measure the beam positon and angle**
- **In pp events it may be possible to reconstruct π_0s from two photons**



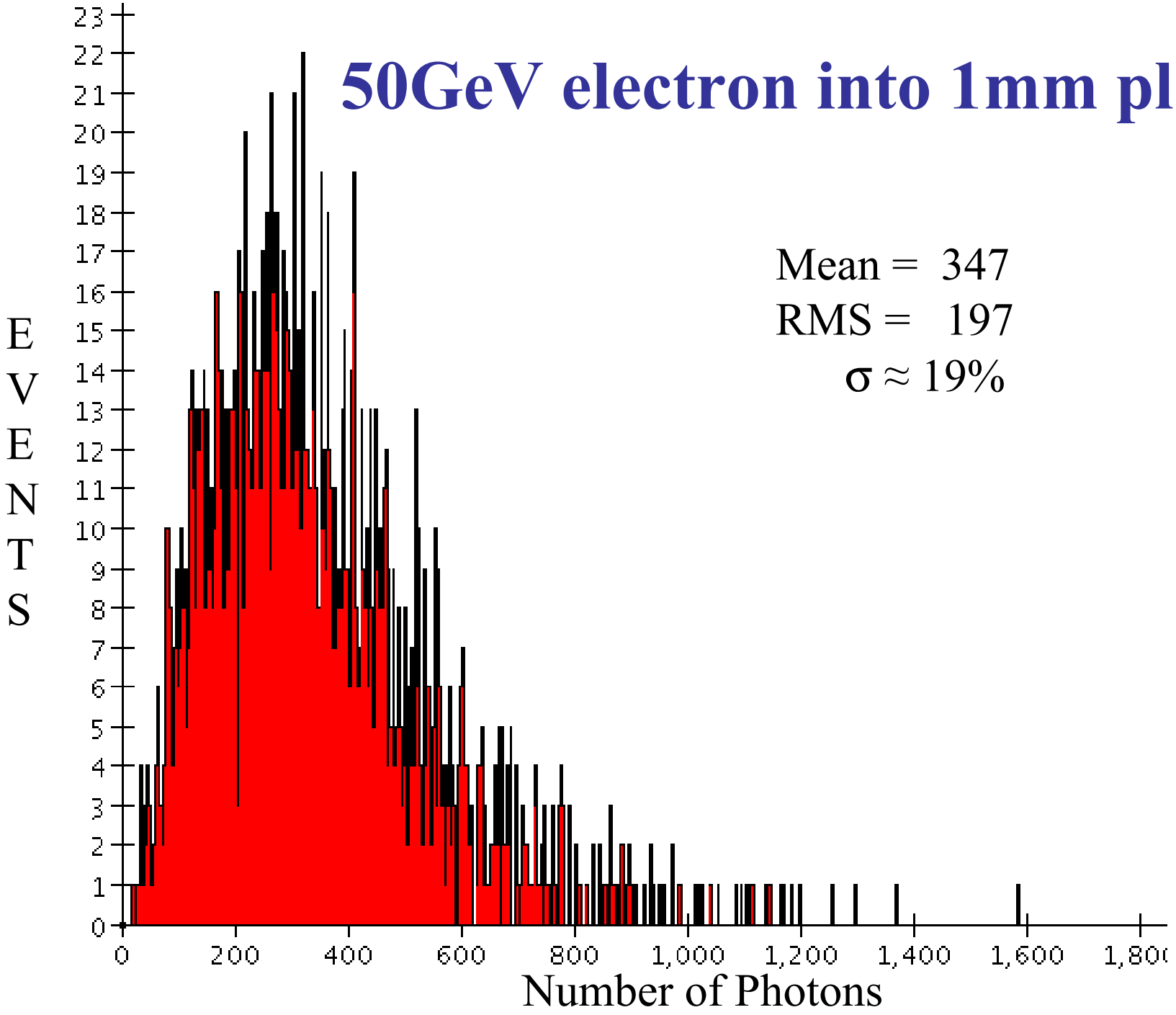
For DAQ ZDC is part of HCAL

- ZDC is cerenkov calorimeter, with signal shape very similar to HF.
  - We will use HCAL electronics ie QIE's etc
- This makes it easy to set up ZDC energy triggers.
- Should be able to have this trigger at level 0 (ZDC is "just in time" Wesley Smith)

Measuring pp → pp + photon

- The shower from a 50 GeV photon is almost completely contained in EM section.
- ZDC can "see" a 50GeV photon if we use 1mm plates in EM section.
- Resolution should be about 20%.
- Iowa group is testing very rad hard fibers
  - ZDC should survive first low luminosity pp runs

50GeV electron into 1mm plates

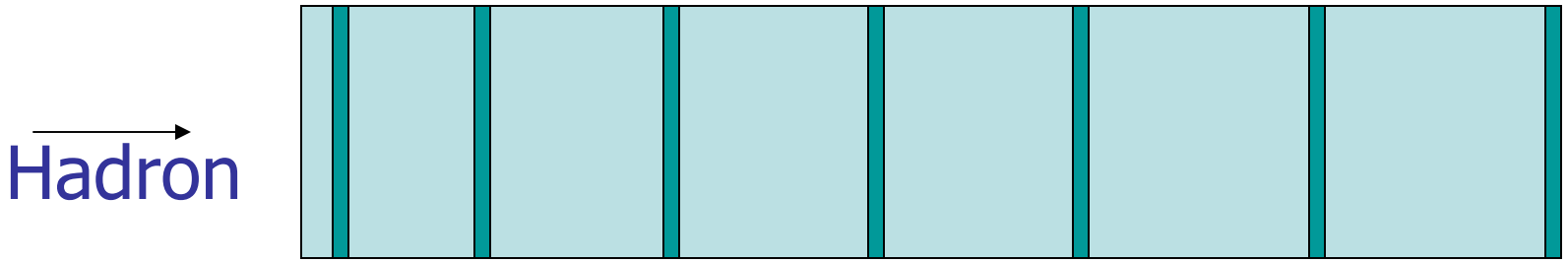


Mean = 347
RMS = 197
$\sigma \approx 19\%$

Radiation Hardness

For first 3 years of heavy ion and low luminosity pp running we expect 6GRad to hit the ZDC. So far we Iowa group has tested quartz/plastic fibers up to 1GRad without significant damage. We have asked for $20K in FY05 for more tests. However we are confident that quartz-quartz can do the job.

Iowa PPAC, a 2nd rad hard possibility



The green is solid metal.
Detectors that sample the shower
are shown in blue.
Detector near front end is for EM shower

Status of the project

- Nuclear Science Advisory Council said US should be part of LHC heavy ions
- We will ask for R&D funds in 2005 and construction in 2006
- Monte Carlo being ported into ORCA with help from FNAL and UIC
  - This should be ready by March
- TDR being prepared

Conclusions

- Saturation effects seen at HERA in ep may be more prominent in pA collisions
- ZDCs can help explore this physics by measuring the geometry of the collision
- Tungsten/cerenkov detectors are fast, rad hard and have good energy resolution
- In pp collisions they are sensitve to photons