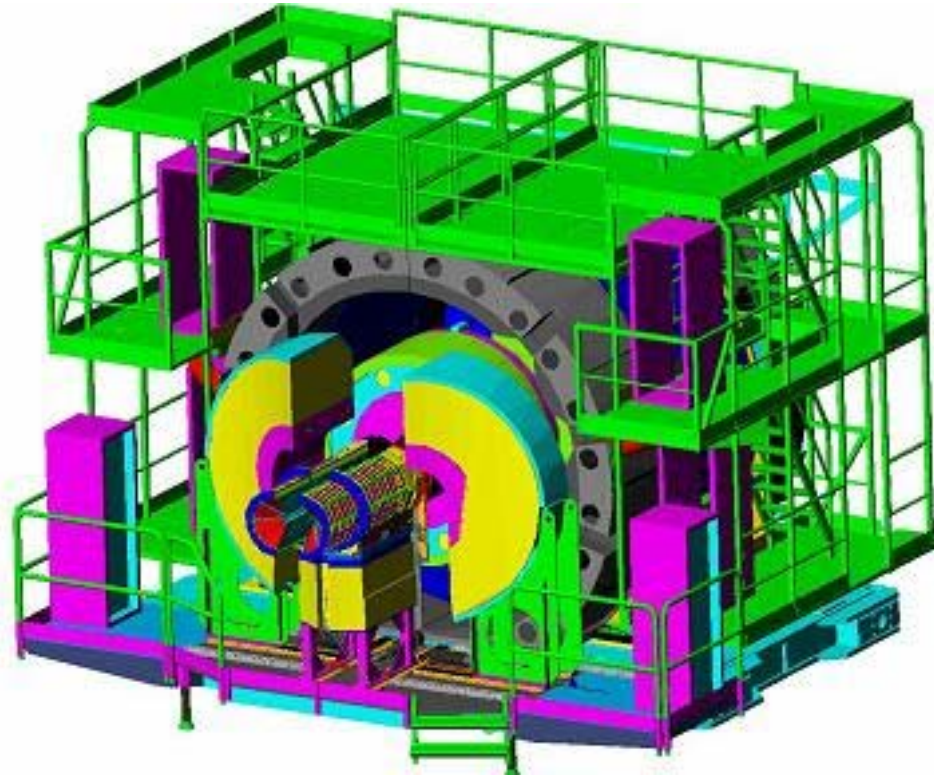


## Task K/HF: CMS PHYSICS AT BU...

### FOCUSING ON QUARTZ CHERENKOV FORWARD CALORIMETRY

with Fermilab, Iowa (Y. Onel), and Texas Tech (N. Akchurin)



M. Oriunno, Engineering Design Review, 31 Jan 2006

Faculty

Students:

Electronic Engineers, EDF:

Engineering Faculty:

Mechanical Engineer, SIF:

L. Sulak, with J. Rohlf

M. Carleton, C. Hugon\*, and N. Sen\*

E. Hazen and S. Wu

J. Sullivan (Aerospace and Mechanical) + senior student design team

D. Osborne

...those who are here today

\*Candidate PhD students, trained by LRS at Marseille during 2 year DOE sabbatical; pending DOE support

## Forward Calorimeter: In this presentation

Why Cherenkov, sensitive only to  $\pi^0$  component of jet?

to record jets to  $\eta \sim 5$ , need optical sensitivity out to  $\eta \sim 5.5$  due to e-shower radius  
 but 100% occupancy beyond  $\eta \sim 4$  at design luminosity  
 only technology possessing full baseline restoration within 25 ns bunch spacing

Why Quartz?

only material transparent up to Grad and high neutron fluence, *i.e.*  $\sim 5$  years @  $10^{34}$   
 quartz-clad quartz (silica) fibers lose 30% of light beyond  $\eta \sim 4$   
 but plastic-clad quartz installed...choice driven by cost... $\sim 90\%$  loss after  $\sim 5$  years

In this update for HF?

Current state of HF and BU contributions

How we helped get us here

What performance is expected?

after extensive beam evaluations:

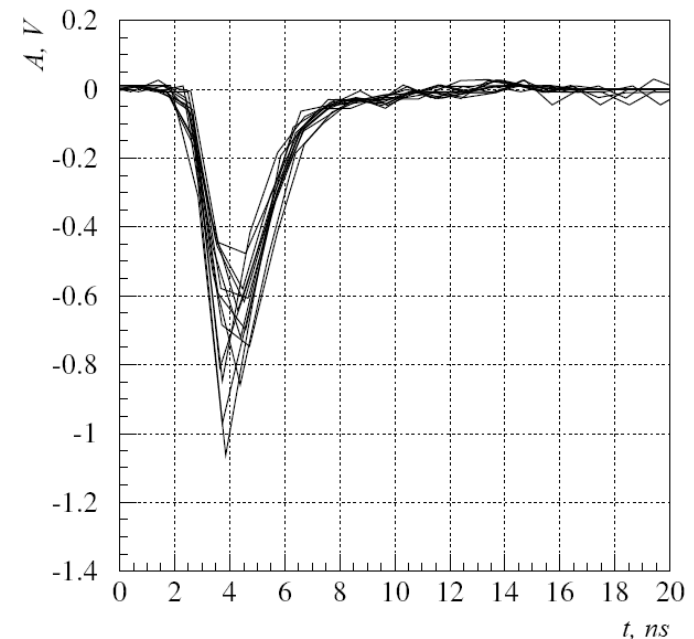
BNL, FNAL, CERN

HF CERN test beam calibration summer '05

simulation tuned by beam tests

as luminosity monitor

Proposed BU work over next 3 years



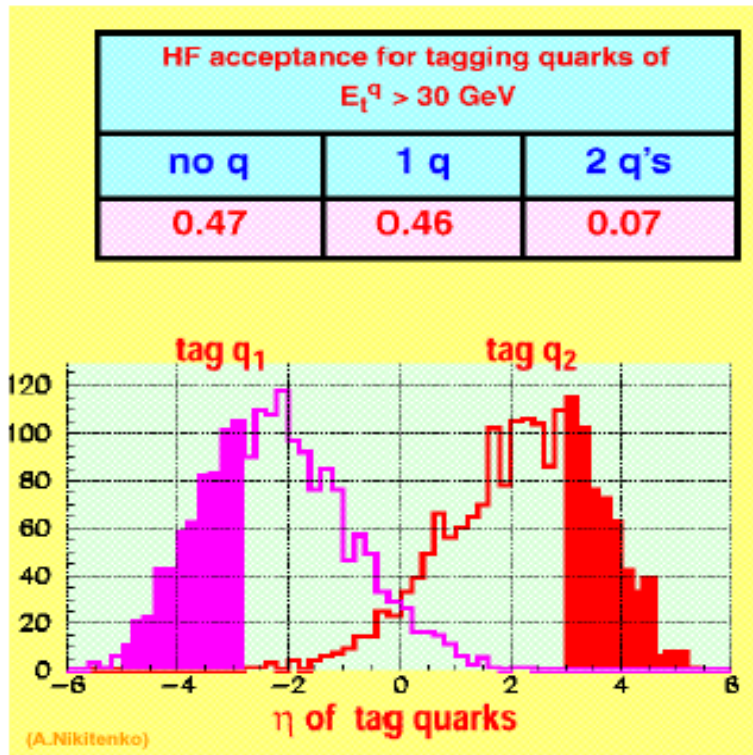
100 GeV pion showers into central tower  
 of 7 BU/HF modules in CERN test beam 1999

from GEM at SSC to HEPAP 2001

fast, rad hard quartz fiber technology won over European gas PPCs in CMS  
 $3 < \eta < 5$  HF provides full coverage for forward jets,  $\sim 1/2$  of phase space

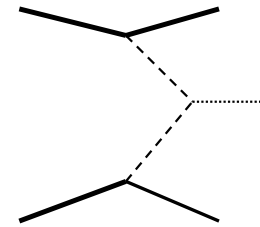


## VV Fusion - “Tag Jets”



WW Fusion

$W W \rightarrow H$



CMS calorimetry extends to  $|\eta| = 5$  to cover the region of “tag jets”.

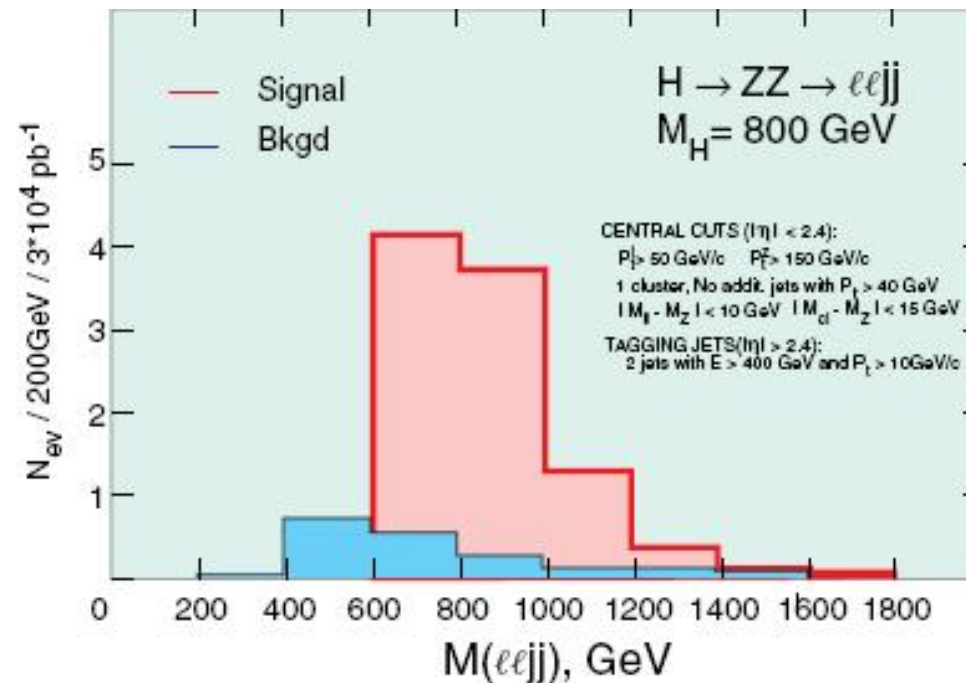
HEPAP - April 20, 2001

11

$H \rightarrow ZZ \rightarrow \ell\ell jj$  in HF ?

two forward jets critical to identifying high mass Higgs production by vector boson fusion

$$p_t > 10 \text{ GeV}/c$$

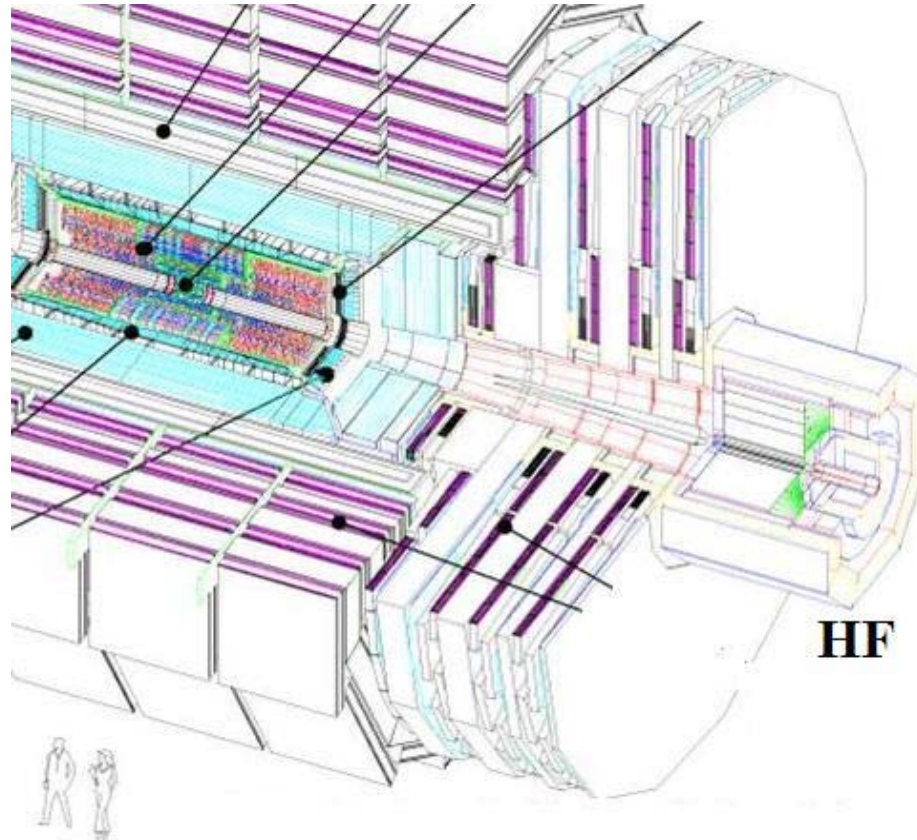


low level of background  $\Rightarrow$  benefit greatly from high luminosity of Super-LHC

even if Higgs has low mass, important to measure WW, WZ, and ZZ coupling at high energy

the HCal End cap to Forward Calorimeter transition...

overlap at  $\eta = 3$  a big challenge for jet reconstruction

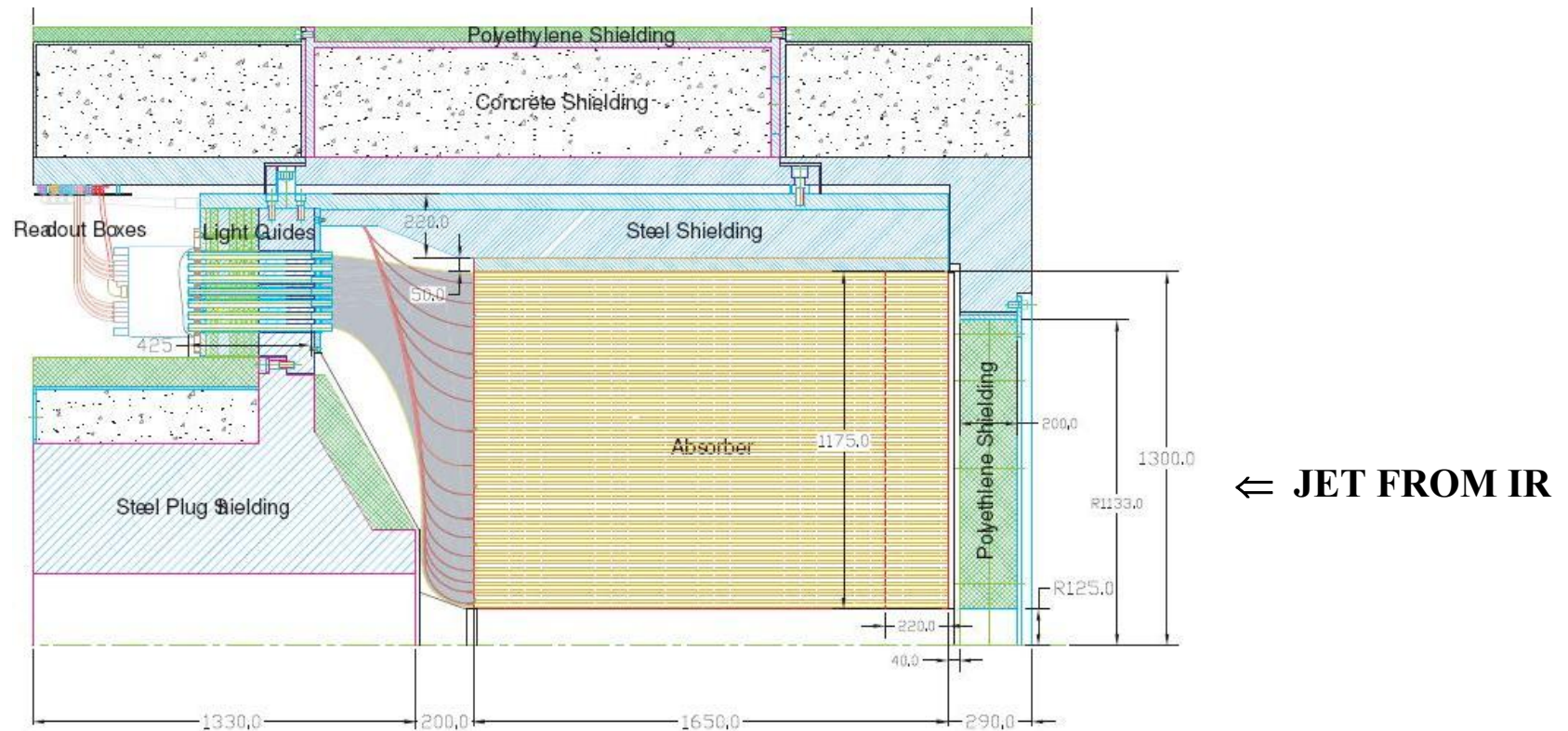


(physically HF is "small," 1.9 *m* along beam line, 1.4 *m* in radius)

M. Oriunno, Engineering Design Review, 31 Jan 2006



Cross section of HF along beam line  
 through center of wedge (1 of 18 from each of two HF's)  
 jets from the interaction region (IR) enter from the right, going left



full length fibers starting at front sample electromagnetic component  
 short fibers starting at **vertical red line** sample **hadronic content**

light from left end of fibers guided to pms in readout boxes at upper left

M. Oriunno, Engineering Design Review, 31 Jan 2006

several HF wedges after hand-stuffing of quartz fibers, September 2005...



not shown: a light mixer, air light guide\*, then phototube  
mount on each circular fiber bundle, allowing easy maintenance

\* developed by D. Osborne, BU

CERN oreach photo 2005-012

assembled HF minus, July 2006

under test with radioactive source calibration, Task K/HF doing its share  
at CERN Meyrin before move from assembly area to intersection region



collision end lead shielding doors open, concrete plug neutron absorbers visible

BU photo Matt Carleton, July 7, 2006



300 ton HF + "on the move" last week

rolling on 182 wheels



just before a "soft landing"



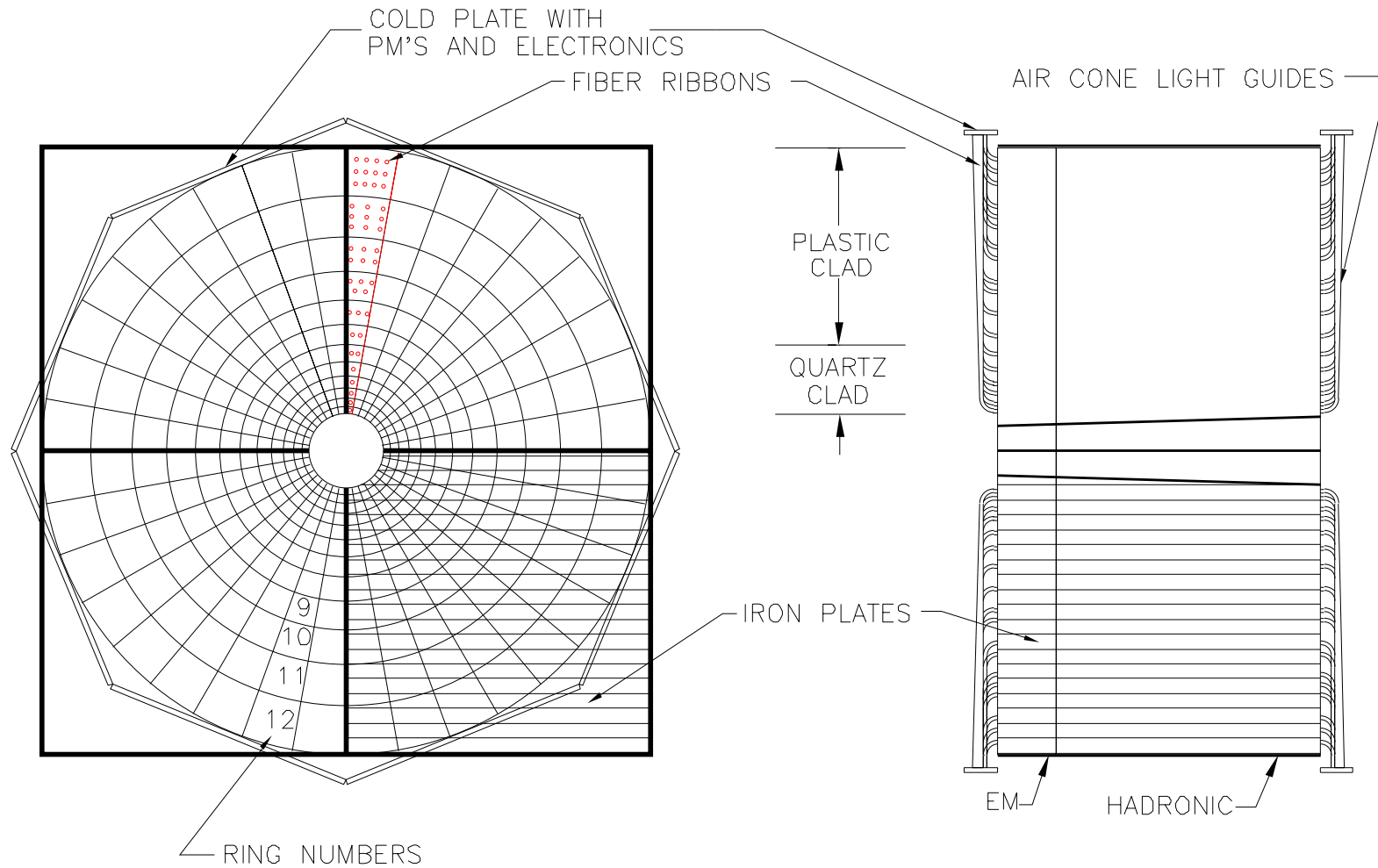
PM boxes must be recabled to BU front ends, and cable track installed  
confirm operation with LEDs at PMs and with lasers pulses to ends of towers  
check with wire sources calibration of this summer

(Feb '07)

we from Task K/HF will be there, as we were this summer

BU Mission: insure integrity of data, at each step until high luminosity (3 years)

the conceptual design, BU DOE Site Visit 1999, points way to Super-LHC



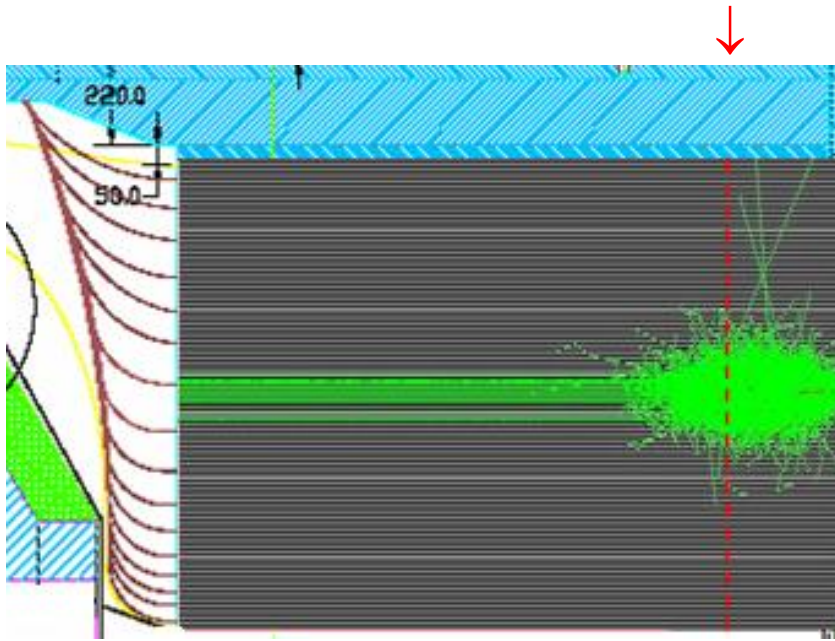
must replace damaged plastic clad fiber in central region after  $\sim 5$  years

from Task K renewal for 2000

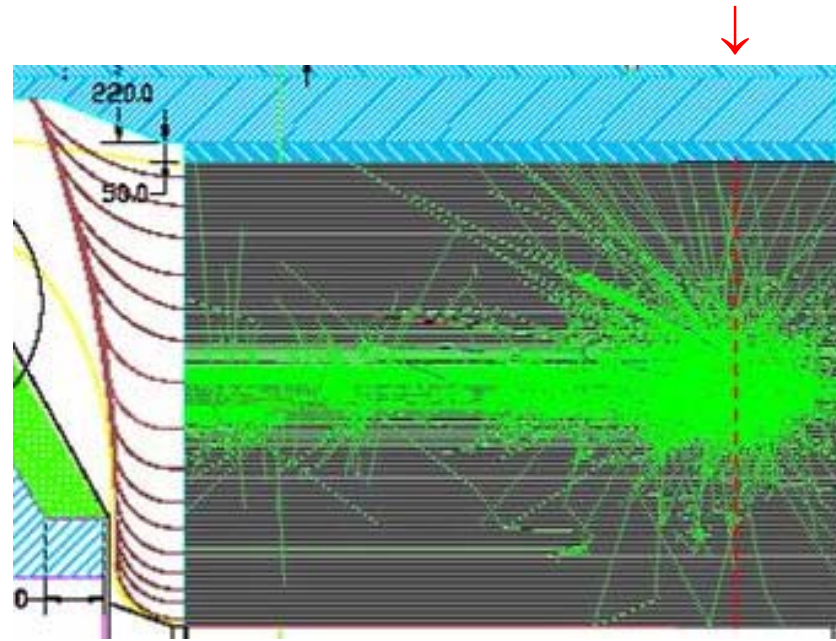


How well should it work? particle identification capability?

2 typical simulated showers



**100 GeV electron shower**



**100 GeV proton shower**

← JET

code for optimizing design and modeling results from test beam studies

next job for Task K/HF: add HF to Physics TDR, *e.g.*

$H \rightarrow Z^0 Z^0 \rightarrow e^+ e^- e^+ e^-$  from vector boson fusion: HF not yet studied

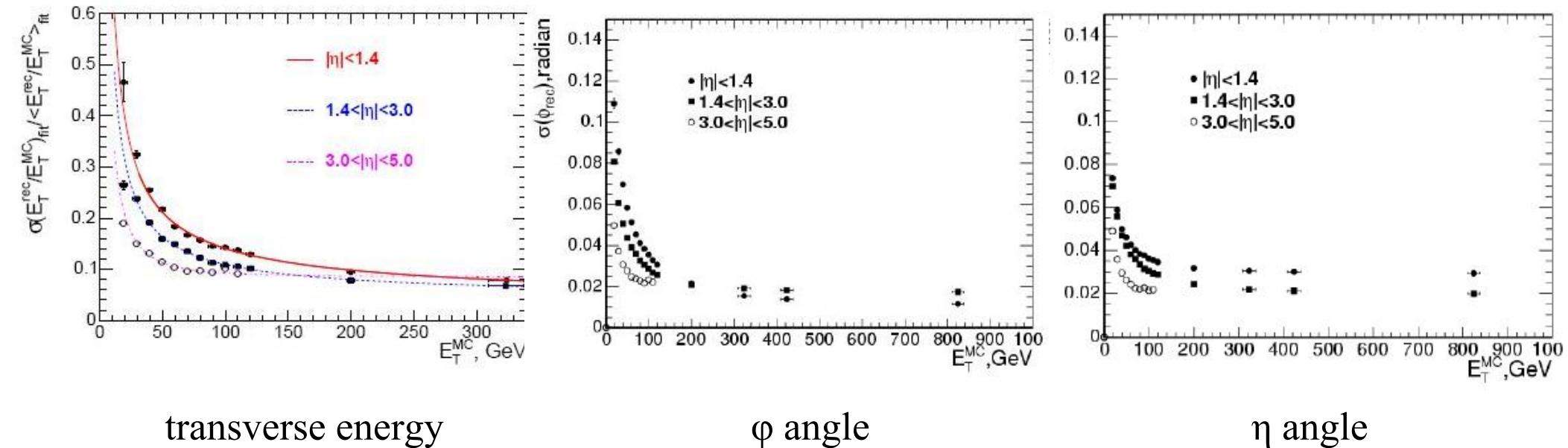
time to incorporate HF into FNAL LHC Physics Center (LPC)

working with Daniel Elvira, using summer '05 test beam data

Akchurin, <http://hepd.pnpi.spb.ru/~rdms2005>

## Resolutions critical to jet energy and missing $E_t$

HF lowest curves (open circles, labeled  $3.0 < \eta < 5.0$ )  
 HCal End Cap middle curves  
 HCal Barrel top curves



HF has the best resolution of the 3 elements of HCal

All details in

"Design, Performance and Calibration of CMS Forward Calorimeter," G. Baiatian *et al.*  
 N. Akchurin, primary author, LRS, editor, submitted to NIM this fall





more of this summer's work: HF web documentation coded by Matt Carleton

HFWikiHome < CMS < TWiki - Mozilla Firefox

File Edit View Go Bookmarks Tools Help

https://twiki.cern.ch/twiki/bin/view/CMS/HFWikiHome

ani\_shower.gif (GIF I... ani\_hisandtrack.gif (... Essential Cosmic Lect...

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iCMS

US CMS

You are here: TWiki > CMS Web > HFWikiHome

r15 - 13 Nov 2006 - 03:14:46 - Main.carleton



CMS HF

<a href="#">Construction Status</a>	<a href="#">Photographs of HF</a>	<a href="#">HF-Related Papers</a>	<a href="#">HF Contributors</a>
<a href="#">Monitoring database</a>	<a href="#">Channel mapping</a>	<a href="#">Run List</a>	<a href="#">Software</a>
<a href="#">Geometry</a>	<a href="#">Meetings</a>	<a href="#">Mailing List</a>	

News

3.8.06

HF Wiki page is completed

18.7.06

HF+ and HF- have both been delivered to SX5

5.7.06

Launch of HF homepage.

[Edit](#) | [WYSIWYG](#) | [Attach](#) | [Printable](#) | [Raw View](#) | Backlinks: [Web](#), [All Webs](#) | [History](#): r15 < r14 < r13 < r12 < r11 | [More topic actions](#)

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writing, maintaining the test beam documentation, and taking test beam shifts...



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You are here: [TWiki](#) > [CMS Web](#) > TestBeam06PhotoIndex

r3 - 08 Sep 2006 - 12:57:34 - Main.jfreeman

## 2006 ECAL/HCAL Combined Test Beam

Various photos from the 2006 ECAL/HCAL test beam

Test Beam, 24 July



software by M. Carleton, BU



## **proposed Task/HF work at BU over next 3 years?**

### **HF must be fully operational at LHC startup next Sept 1**

HF is CMS luminosity monitor, with web readout directly to control room  
the "Boston, Maryland, Princeton Project"

### **HF shakedown...before close on Sept 1...only 9 more months...can't wait**

on-detector front end electronics reinstallation and commissioned  
LED at each PM  
lasers light to end of each tower  
recalibration of each tower with radioactive source wire driver  
(firing on cosmic ray showers?)

### **tuning HF timing for 100% occupancy, after stable beam, 2008**

phase each tower for in-time signal at beginning of 25 ns digitization period  
any signal over two periods = out-of-time, beam-related background

### **data quality monitoring**

insure integrity of critical physics observables:  
jet energy, jet direction, electron/hadron shower ID  
need grad student on CMSSW analysis package...now  
plastic/quartz degradation and annealing with exposure and time since beam  
complex calibration issue...LRS working with Merlo & Mayda Velasco

## **HF for the Super-LHC shutdown 2012:**

### **HF electronics upgrade to avoid event ambiguity?**

upgrade for SLHC: 12.5ns or 75ns projected repetition times\*

12.5ns: HF would need new front-end

Hazen, and LRS, considering HF options

(ok for HB & HE: long scintillator decay time spreads pulse over cycles)

\* Jordan Nash, [http://cmsdoc.cern.ch/cms/electronics/html/elec\\_web/docs/slhcusg/JN\\_CMS\\_Perspective.ppt](http://cmsdoc.cern.ch/cms/electronics/html/elec_web/docs/slhcusg/JN_CMS_Perspective.ppt)

## **Evaluation of replacement of inner quartz fibers: plastic-clad to quartz-clad**

in event of catastrophic beam loss (remember UA 1 scintillator)

for 10 times more luminosity at Super LHC, before HF is too hot due to LHC

2007: Assessment of space and mounting

2008: R&D for automatic fiber stuffer

2009: Upgrade plan for fiber recycling for Super-LHC, shutdown of 2012



## details of proposed study for replacing plastic-clad with quartz-clad fibers for high $\eta$ ?

### Mechanical & chemical radiation damage of plastic-clad quartz fiber

characterize for neutrons at MIT research reactor

do fibers still slide, does plastic coating become sticky

in radiogenic  $O_3$  or  $NO_2$  corrosive atmosphere

function of fluence, flux exposure

using same steel grooves, humidity, etc.

measure change of surface and bulk properties

complement work in proton and electron beams by Merlo at LIL/CERN

changes in transverse dimensions of steel laminates, grooves size change?

*e.g.* destroying hole registration?

(with Matt Carleton)

### Auto-replacement of quartz fibers

prepare and design

prototype an automated fiber stuffer for the super-LHC

(Sullivan + senior design team from Engineering)

(Osborne)

### Before HF too "hot" to approach, at CERN

verify fixations & space at back of HF; are we ready to support an auto stuffer?

### Confirming hole positions after darkened fibers withdrawn:

diffusion welded steel plates, using a gas first, then a wire?

### Vetting double, 2D pinch roller design for stuffing fibers

feed fibers one-by-one, achievable with only 90 degree access?

pneumatic tube feeding of fibers?

servomotor or stepping motor control?

classic "control theory" problems

specialties of our Aerospace and our Manufacturing Eng. Dep'ts

(robotic and NASA satellite work)

time budget for replacement, *e.g.* radio activation of the steel.

how long a shut down necessary for radiation levels to drop?

## CMS/HF Summary

- 2007      Shakedown and commissioning of HF, *in situ*,  
LED, laser, and radiation source monitoring, cosmic showers  
Recalibrate with wire sources  
            with collaborators...  
            "we never have enough help on HF," Aldo Penzo, CERN HF manager
- 2008      Run as luminosity monitor for beam optimization, and for data at low luminosity  
  
Tune phase of each tower on low intensity beam so that true pulses fully in bucket  
  
During beam shutdown, evaluate potential inner fiber replacement
- 2009      Final conceptual engineering of fiber replacement  
Tune with high intensity beam

we're eager to continue to do realize the potential of HF  
excited about the physics it will make possible

# RESERVE



## Probable timeline for HF operations over the 3 years of this renewal proposal

(BU/HF personnel at CERN)  
(Carleton, Sulak)

June - July '06 finished initial check out of both HF's at assembly hall

July '06 both HF's moved from CERN Assembly Building 186 at Meyrin to surface building at SX5

Aug '06 lower each HF's down to center of pit, then to garage positions at either end

Aug - Sept '06 HCAL Test Beam '06: (Carleton, Sulak)  
Confirm that production grade electronics operates as anticipated in an accelerator environment prone to ground loops, RF pickup, correlated noise, *etc.*

October '06 Install and connect moveable cable chains to HF  
lay cables; connect to counting house, continuity test of cables

> Nov '06 limited tests of HF's in the pit potentially possible

Jan-Feb '07 confirm that both HF's survived the move to the pit and are fully operational (Hugon, Sulak)  
Cross check all channels of both HF's with onboard LEDs  
test entire chain with laser in counting house  
Calibrate HF+ to 5% with radioactive source and high statistics in garage

May '07 move HF's out of their garages, raise 15 m up to beam height, open them

June '07 before HF's get activated, plan mounting of fixtures for emergency fiber replacement and  
for Super LHC (Osborne, Sulak, Sullivan)

June-Aug '07 calibrate HF- to 5%  
Recheck calibrations of HF+ in final position at beam height  
cross check all channels  
commission and shake down electronics in counting house  
Trigger on cosmic rays  
final tests before beam closure (Carleton, Hugon, Sen, Sulak)

September '07 accelerator ring closes for initial engineering run





HF commissioning as luminosity monitor

Monitor HF fibers for rad damage; measure and characterize attenuation changes

“beam commissioning to injection energy,  $E_{\text{cm}} = 0.9$  TeV and engineering run” at low luminosity with few bunches

Increase luminosity, bunch number, and energy in planned phases [3,7]

Dec'07 - Mar '08 annual 3 month beam shutdown

Maintenance work on HF:

Replace pms, electronics, etc. that have succumbed to infant mortality  
recalibrate both HF's with sources to track rad damage

March - Dec '08 first physics run at 10% design luminosity

June '08 data taking

(Sulak)

Summer '08

(Carleton, Hugon, Sen)

Winter '09 annual 3 month beam shutdown

HF maintenance after first significant running  
replace pms, electronics, etc.

(Sulak)

Final work to plan automatic fiber replacement

(Osborne, Sulak, Sullivan)

March – Dec '09 second year of physics running, full design luminosity

Summer '09 data taking

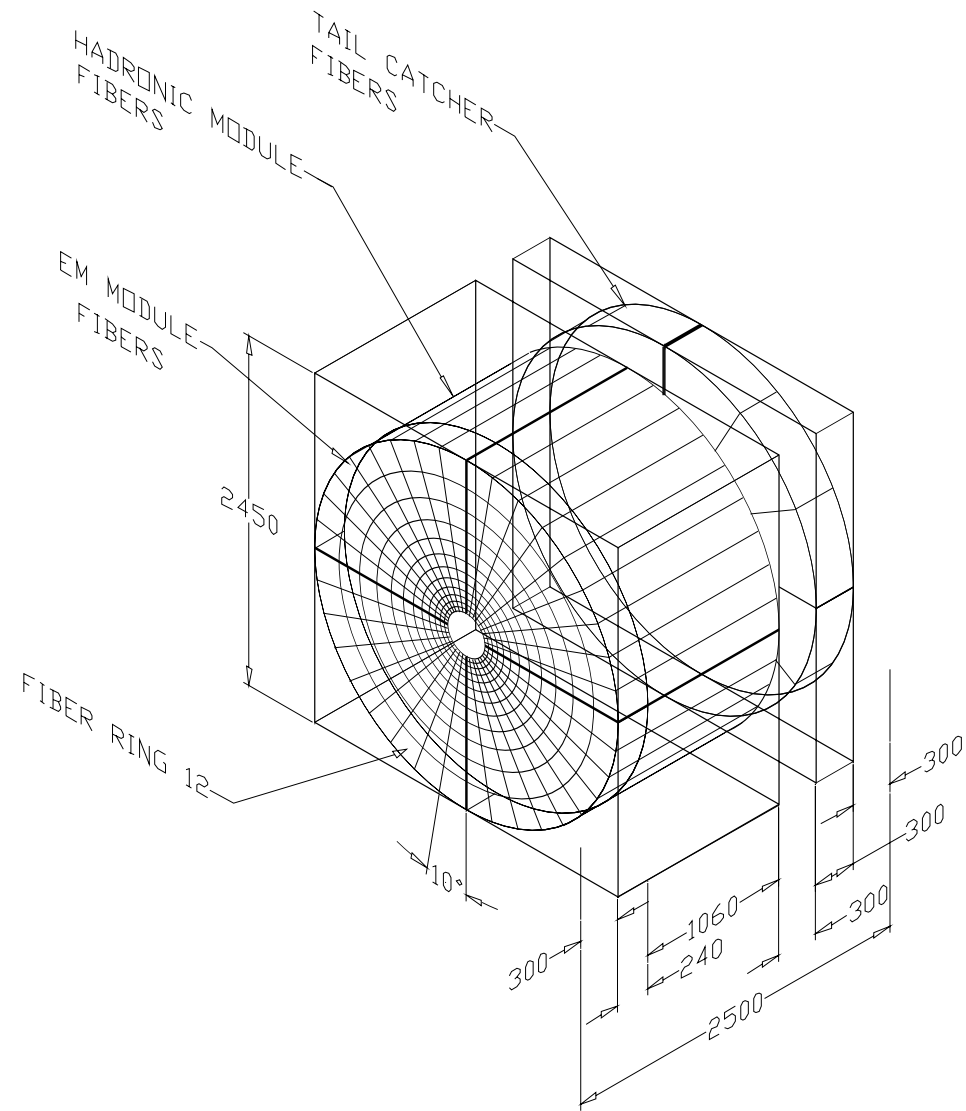
(Carleton, Hugon Sen)

August '09

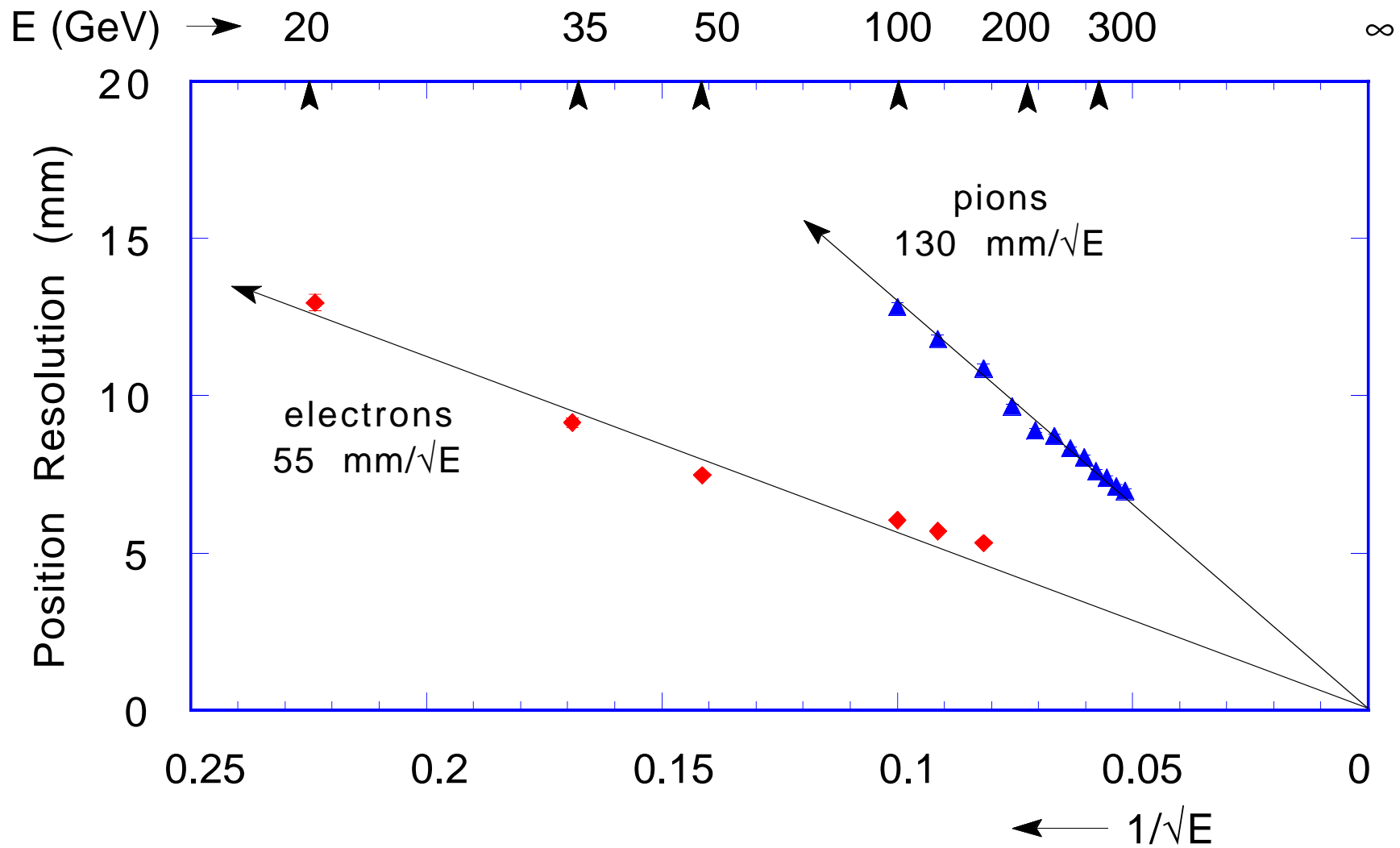
(Sulak)

Winter '10 annual 3 month beam shutdown, HF Maintenance

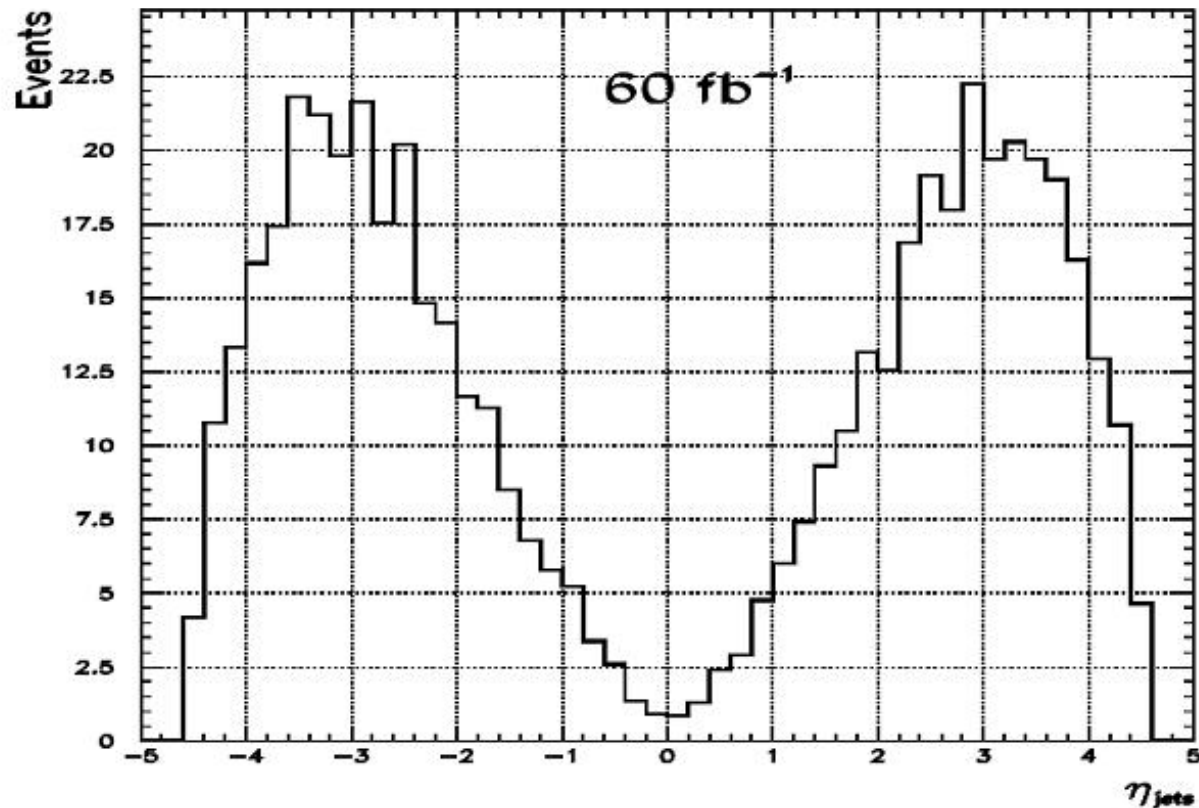
(Hugon, Sulak)



# What physics resolution from the forward calorimeter?



## rapidity distribution of tagging jets produced in heavy Higgs production



$3 < \eta < 5$  range of HF provides full coverage for forward jets,  $\sim 1/2$  of phase space

Kunori; Gavrilov, <http://hepd.pnpi.spb.ru/~rdms2005/>

absorber wedge during hand-stuffing of quartz fibers



bundles at high rapidity, high radiation region (top of wedge) last to be stuffed,  
easiest to remove

CERN oreach photo 2005-012



**300 ton HF + "on the move" last week  
just below ground level**



