SCINTILLATORS FOR MUONS

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SiD Workshop, University of Oregon

Outline

- Effort
  - Good news
- Latest test beam (preliminary) results
- Moving forward

EFFORT

- The effort on scintillator use for muon detectors is centered at Fermilab and revolves around test with cosmic rays and test beams.
- Groups involved are Fermilab, Northern Illinois, Notre Dame, Wayne State, INFN Udine (in no particular order)
- We have recently been joined by a strong group working on the Cosmic Ray Veto for μ2e
- Groups involved in CRV are Fermilab, University of Virginia, INFN Udine
  - some overlap, but many new people at Fermilab

EFFORT

- With added manpower, we have mounted another test beam at Fermilab
- We have convinced ourselves (and I think others) that it is possible to build a reliable, robust, efficient muon system using

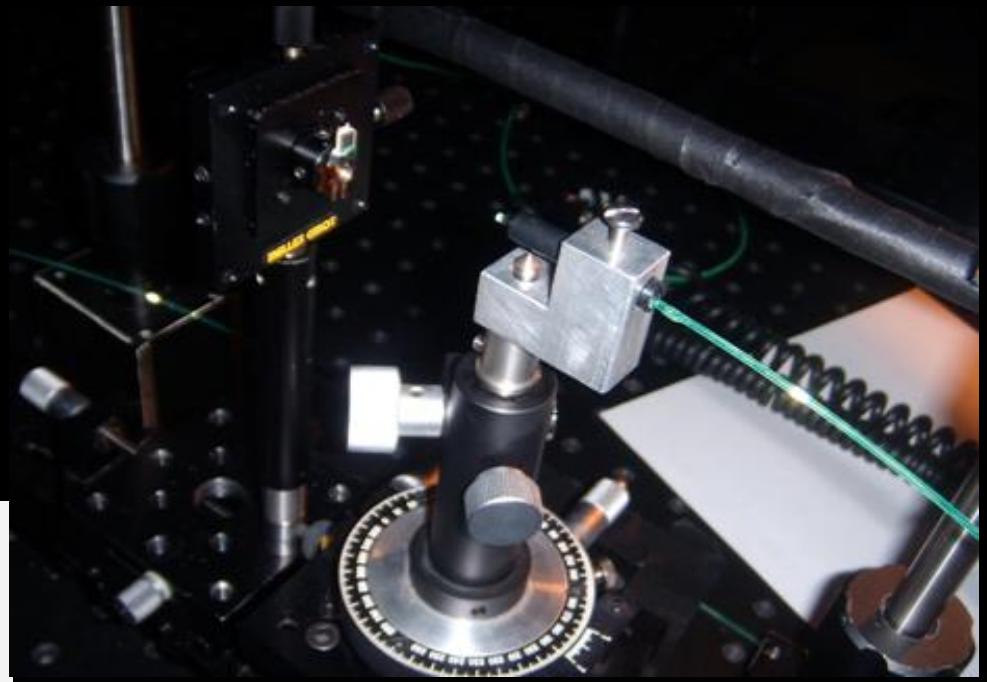
1. Scintillators
2. WLS fibers
3. SiPMs

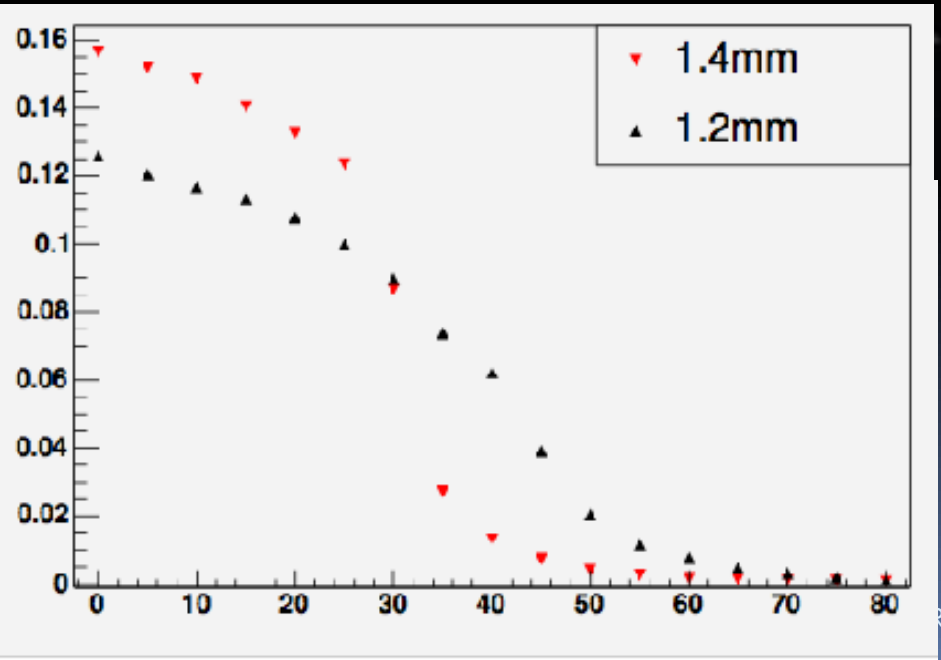
Need to work more on system aspects and cost

Need to continue collaborating with others to stay "in the game"

Measuring fiber properties

I provided the setup,
mu2e students provided
labor and analysis





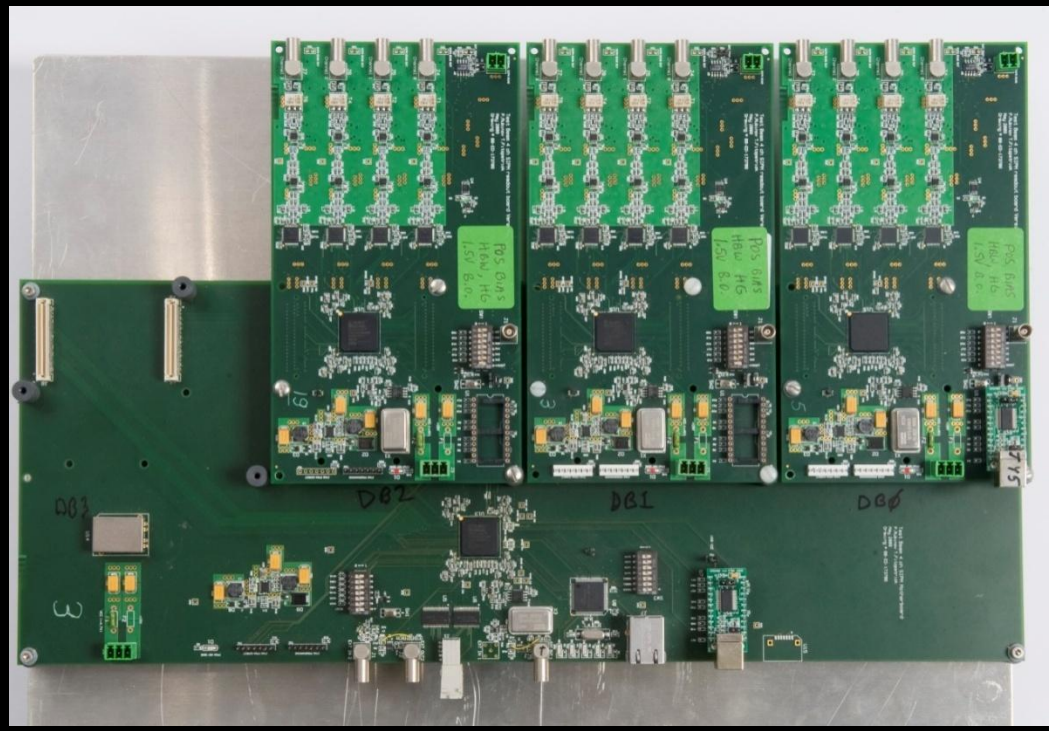
Latest test beam (with μ2e)

Points we measure:
horizontal: 0, 300, 600, 750 mm
vertical: 0, 180 mm

Flip the scintillator and repeat the procedure

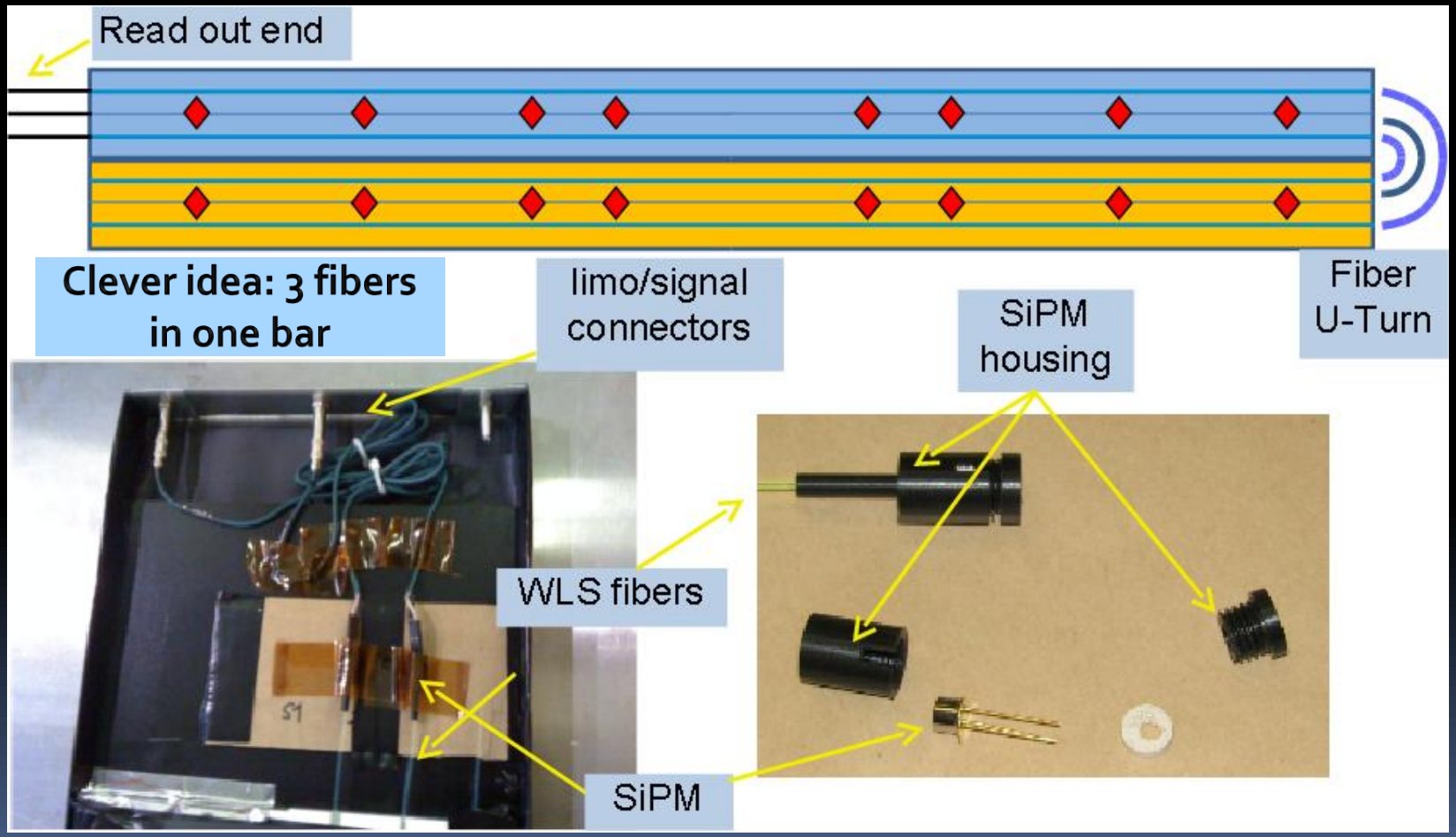
TB4 electronics

500hm inputs
12bit ADC,
212MSPS,
4k samples/ch
~100MHz bandwidth,
~30uV RMS noise
up to 16ch per MB
setup over USB,
readout over Ethernet

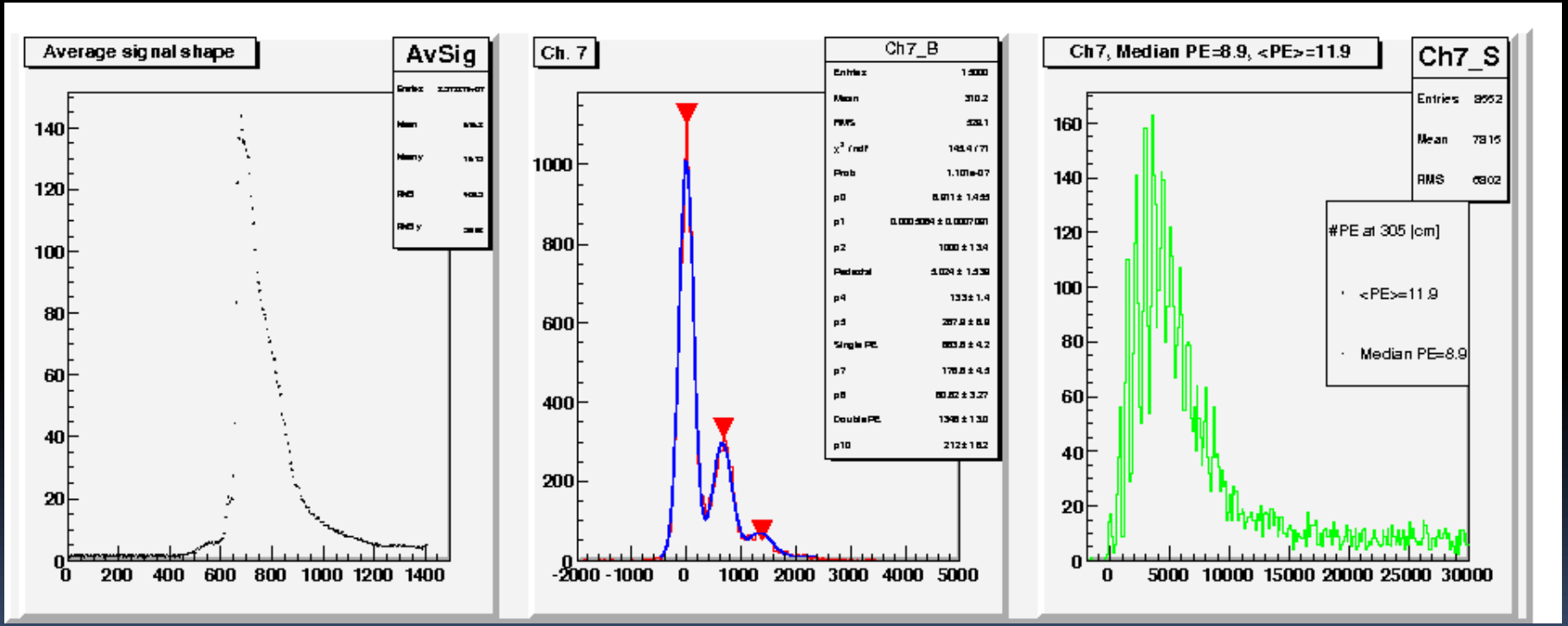


2 yrs old now, so could use a refresh. Newer FPGA: ½ price, x2 memory, faster, also new gigabit Ethernet for faster readout.

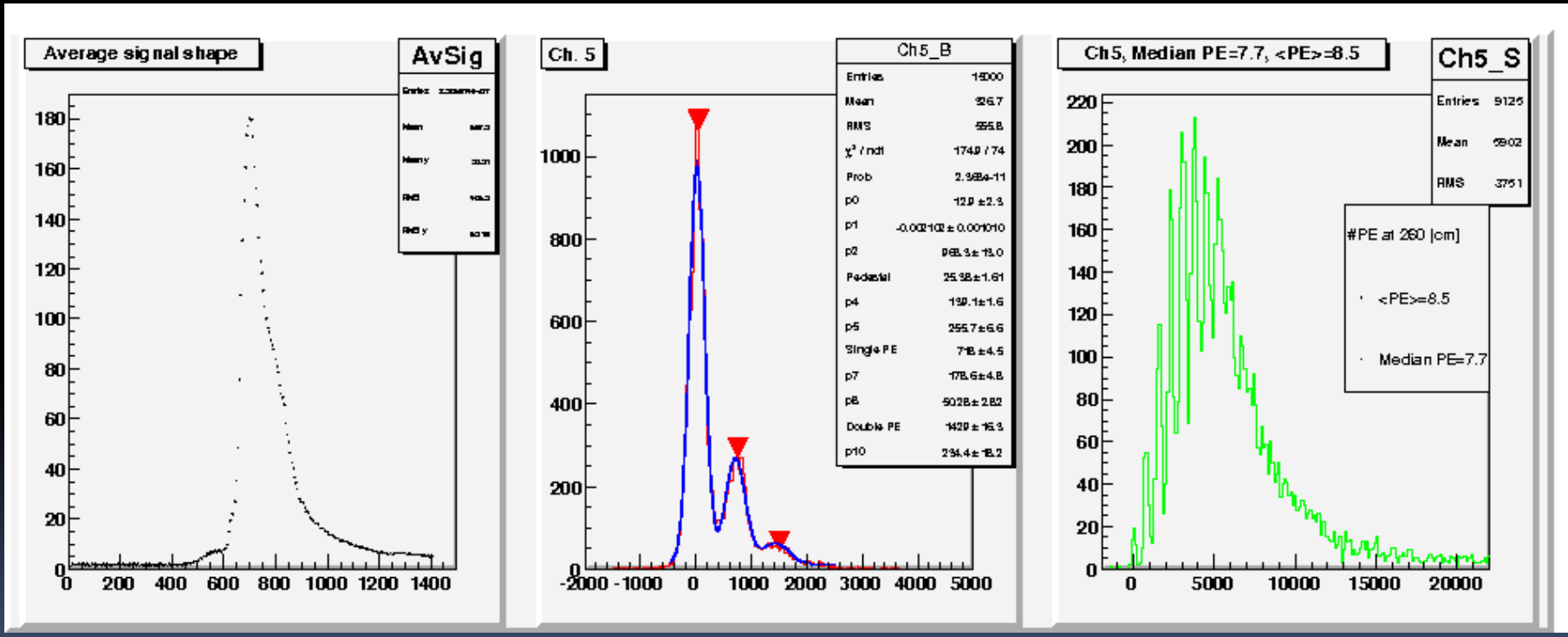
Latest test beam (with μ2e)



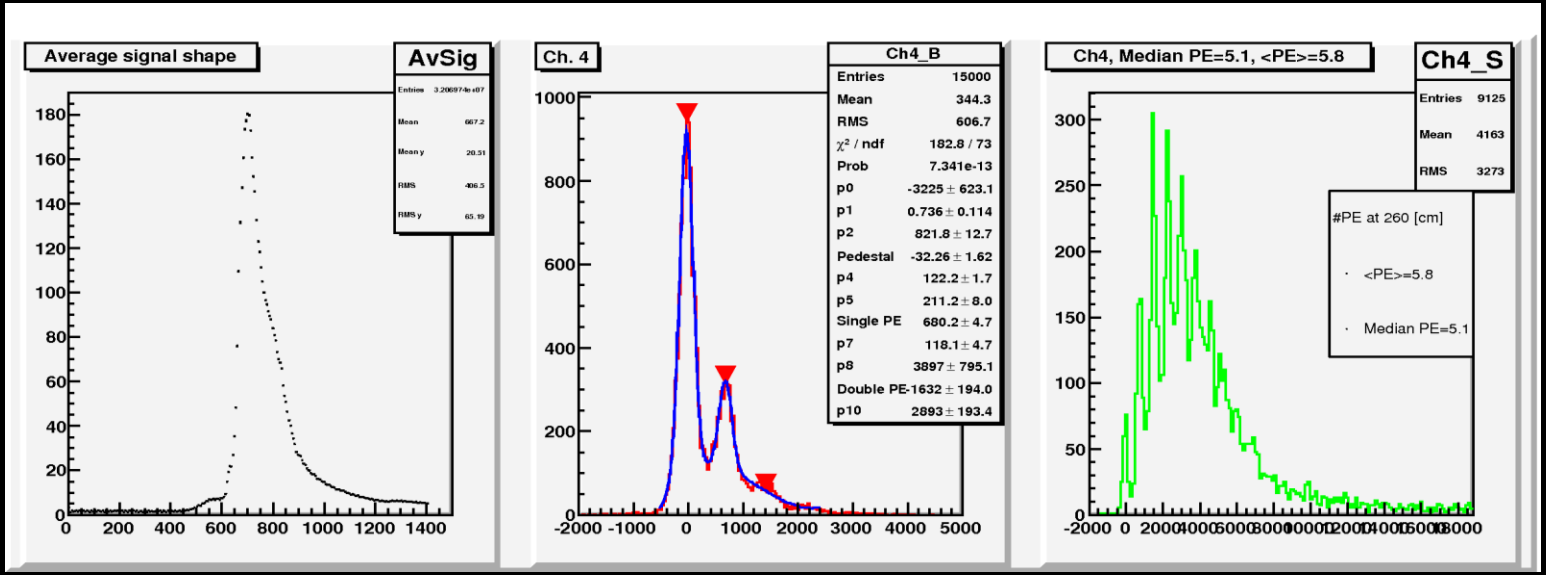
Gene's strip


Average signal shape
AvSig
Ch. 7
Ch7_B
Ch7, Median PE=8.9, <PE>=11.9
Ch7_S
Entries 9552
Mean 7815
RMS 6802
#PE at 305 [cm]
<PE>=11.9
Median PE=8.9

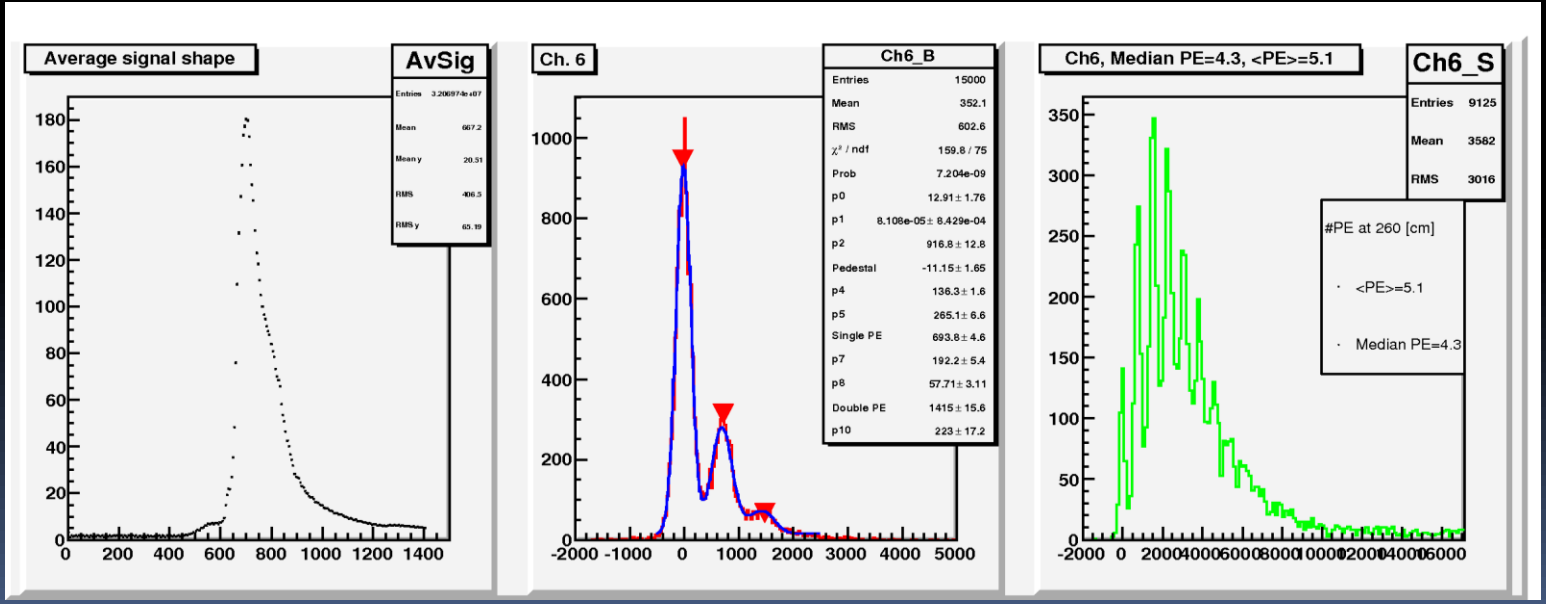
μ2e strip, middle fiber

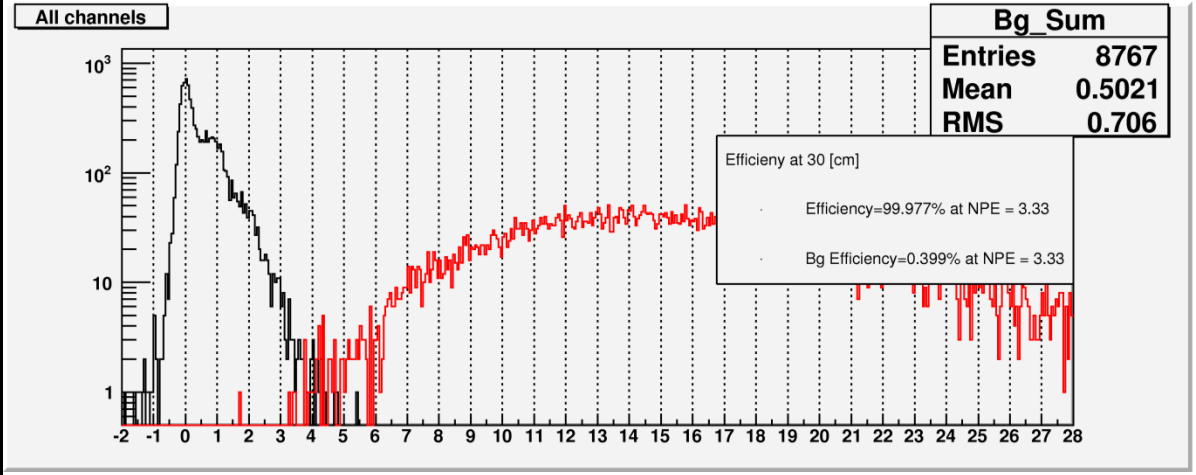


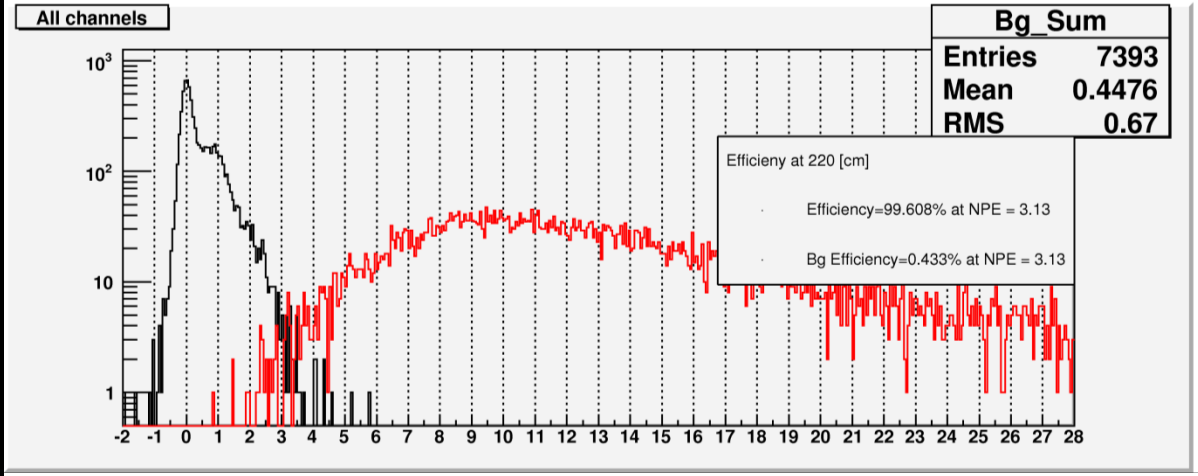
Top fiber

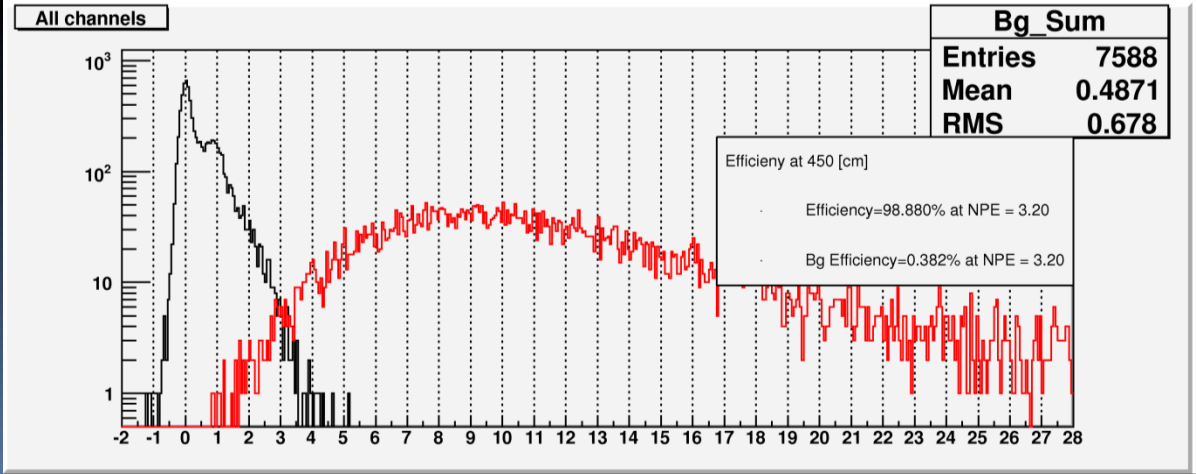


Bot fiber

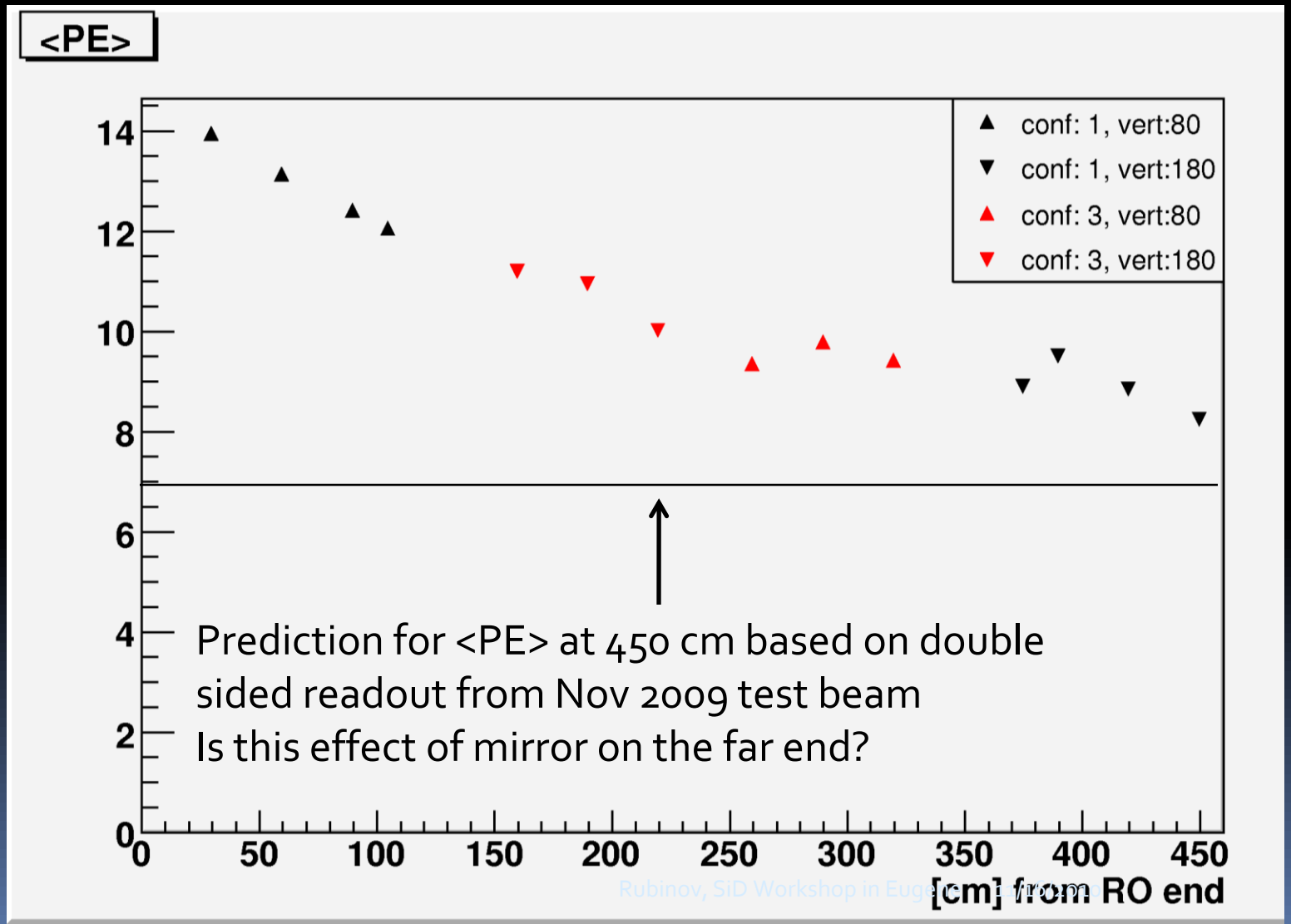


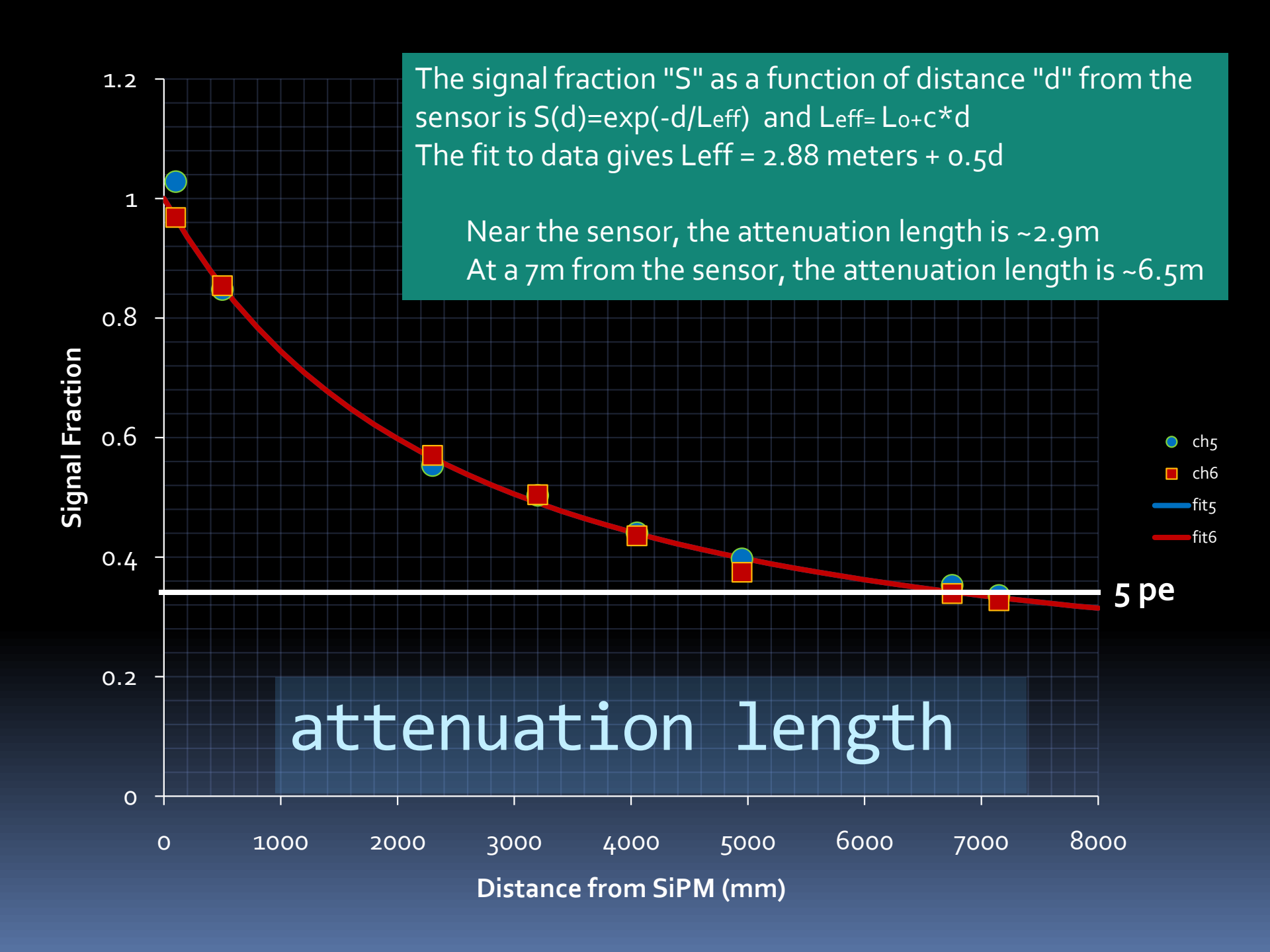

All channels
Bg_Sum
Entries 8767
Mean 0.5021
RMS 0.706
Efficieny at 30 [cm]
Efficiency=99.977% at NPE = 3.33
Bg Efficiency=0.399% at NPE = 3.33


All channels
Bg_Sum
Entries 7393
Mean 0.4476
RMS 0.67
Efficieny at 220 [cm]
Efficiency=99.608% at NPE = 3.13
Bg Efficiency=0.433% at NPE = 3.13

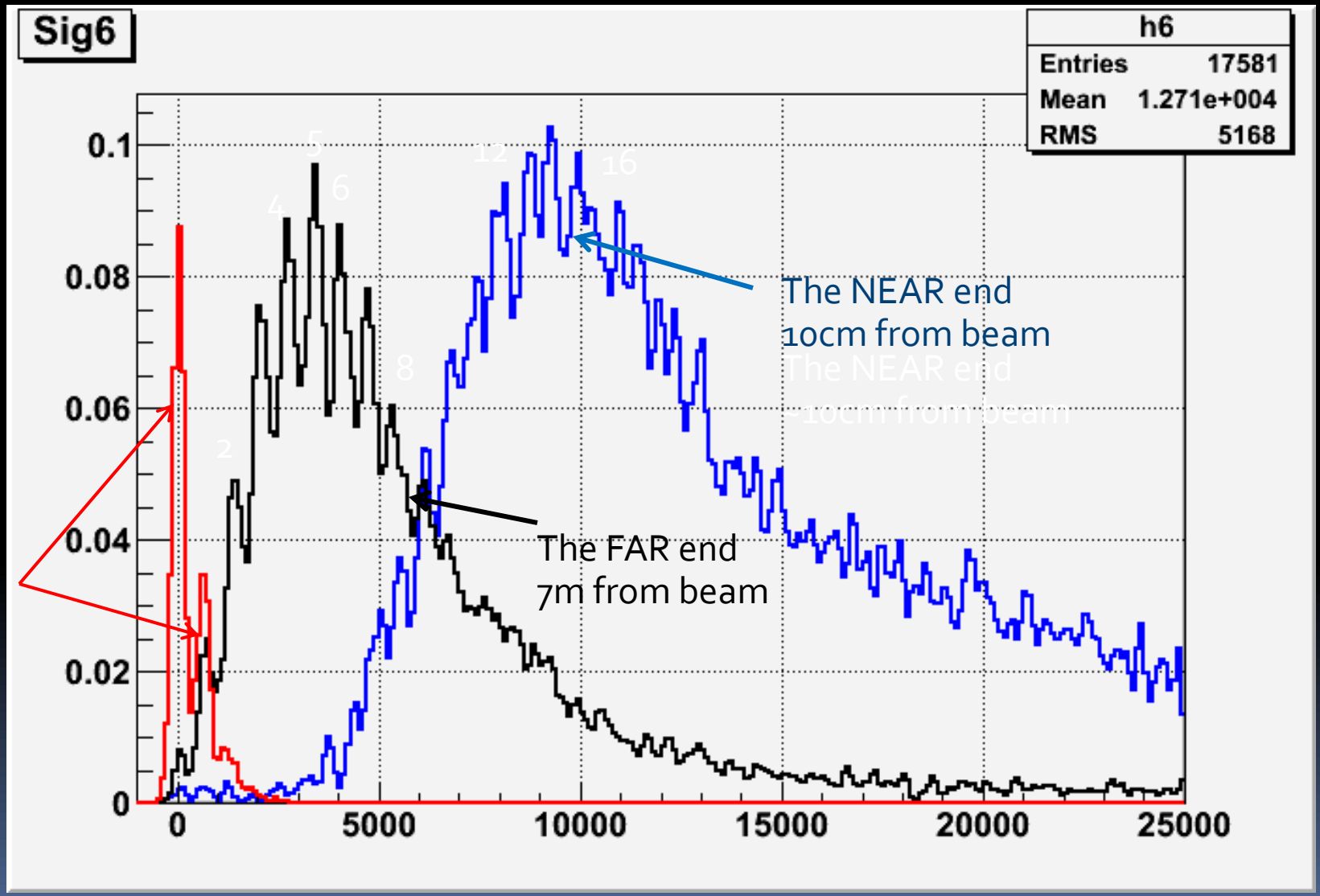

All channels
Bg_Sum
Entries 7588
Mean 0.4871
RMS 0.678
Efficieny at 450 [cm]
Efficiency=98.880% at NPE = 3.20
Bg Efficiency=0.382% at NPE = 3.20

Attenuation length for 5m μ2e strips




The signal fraction "S" as a function of distance "d" from the sensor is S(d)=exp(-d/Leff) and Leff= L0+c*d
The fit to data gives Leff = 2.88 meters + 0.5d
Near the sensor, the attenuation length is ~2.9m
At a 7m from the sensor, the attenuation length is ~6.5m
Signal Fraction
1.2
1
0.8
0.6
0.4
0.2
0
0
1000
2000
3000
4000
5000
6000
7000
8000
Distance from SiPM (mm)
ch5
ch6
fit5
fit6
5 pe
attenuation length

Previous result (Nov 2009)



Pedestal+ dark counts

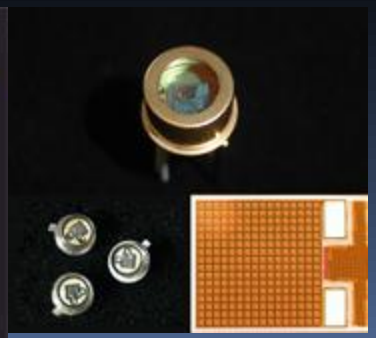
Runs 5045 and 5046 2/20/2010

Mini summary

- Similar results as previous test beams, but interesting new ideas
  - Triple fiber strip
- Invaluable help and additional manpower from collaboration with another project
  - This helps everybody
- If we had to build a muon system for SiD starting tomorrow, we could.

A few words about future

- SiPMs are still young- is rapid
  - 3 yrs ago, single "catalog" vendor, asking $100/device (but selling in qty for ~$25)
  - Now many more vendors
  - New generations of devices, price cut another x2
- Still much more to come
  - SiPM are made with modified CMOS, cost is $1/mm



The future

- Digital sensor + analog readout?
- SiPM is not a tiny PMT but it is a very simple ASIC

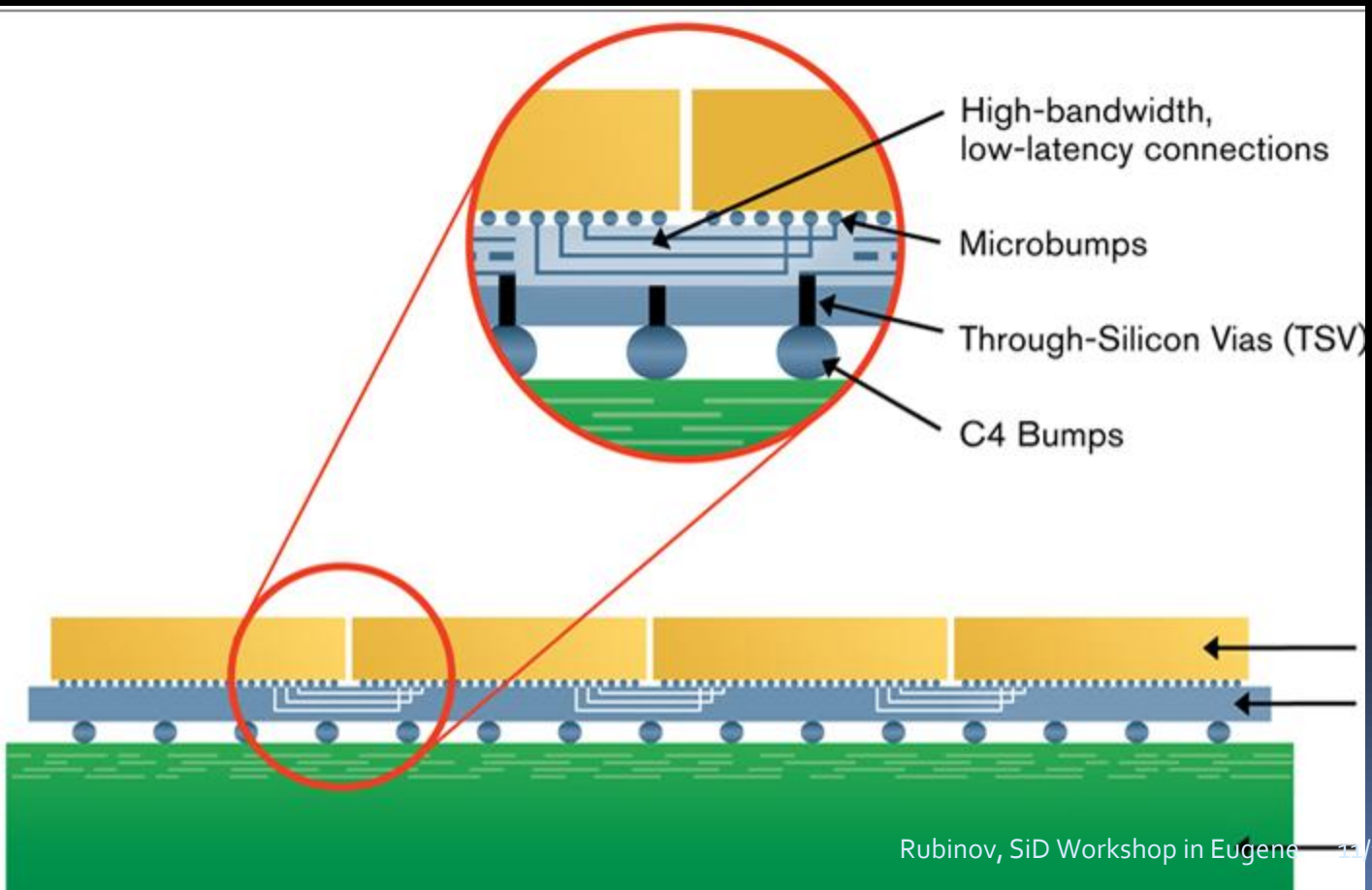
  Next step for SiPMs is ROC+Sensor unit

Oct 8, 2009 Philips announces breakthrough in fully digital light detection technology
Eindhoven, the Netherlands - Royal Philips Electronics today announced that its scientists have developed a highly innovative digital silicon photomultiplier technology that will allow faster and more accurate photon (the basic quantum unit of light) counting in a wide range of applications where ultra-low light levels need to be measured.

There is more future yet…

FERMILAB ASIC design group is playing a leading role in developing 3-d technology for High Energy Physics.

We are likely to see 4 or 5 generations of commercial electronics before ILC



This is much like the slides everyone shows for 3-d

But this one came from the Xilinx website.

Development potential

- SiPMs- huge potential
  - developing rapidly
  - driven by medical, scientific apps
  - ILC not a factor
- WLS fibers- some potential
  - currently optimized for PMT sensitivity
  - can have very, very long atten length at ~850nm
  - ILC resources could help?
- Scintillator- mature
  - but potential for improved extrusion technology
  - significant cost savings possible (in labor)
  - modest resources from ILC could really help

Conclusion

- In the current climate, collaboration is key
- Even limited resources can make impact in some areas
- A scintillator based muon system for SiD seems pretty doable, no big "challenges"