2nd milliQan Collaboration Meeting

Chris Hill (Ohio State)

We have come a long way since last year

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- Last year:
  - *We were still debating the site for the experiment*
  - *We were still debating the baseline technology*
  - *We were just beginning to think about the triggering, readout, powering*
  - *We had no mechanical designs*
  - *We hadn't yet measured in situ backgrounds*
  - *We did not have an integrated simulation*
  - *We were still looking for collaborators*
  - *We hadn't yet written an EOI/LOI*
  - *We hadn't applied for funding*
  - *We hadn't yet discussed co-existence with CMS*
- Most of these things have evolved significantly in the last year, and we will hear the details during the workshop
- I'll just remind of some of the highlights in the next slides

We now have a site

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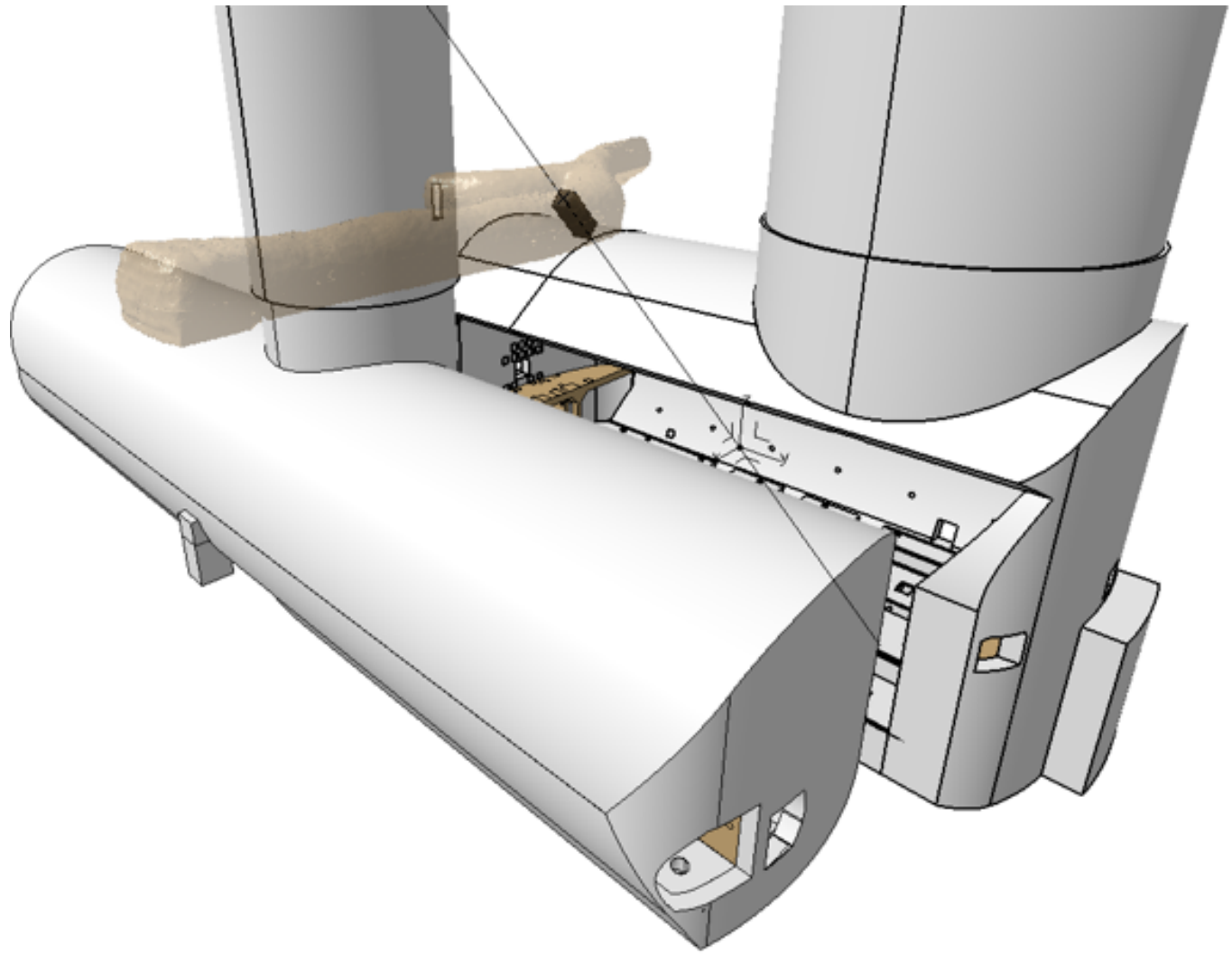
- "Drainage Gallery" at LHC Point 5
  - *33 m from IP*
  - *17 m through rock*
  - *Angle from horizontal plane is 43.1 deg*
  - *Clearance to gallery boundaries is ~30 mm*



We have a Baseline Detector Design

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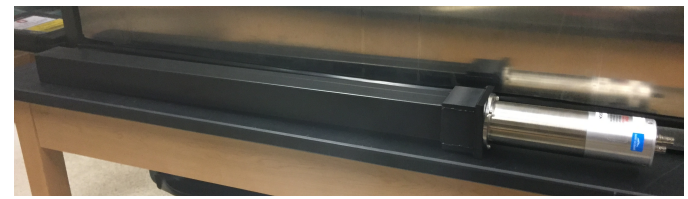
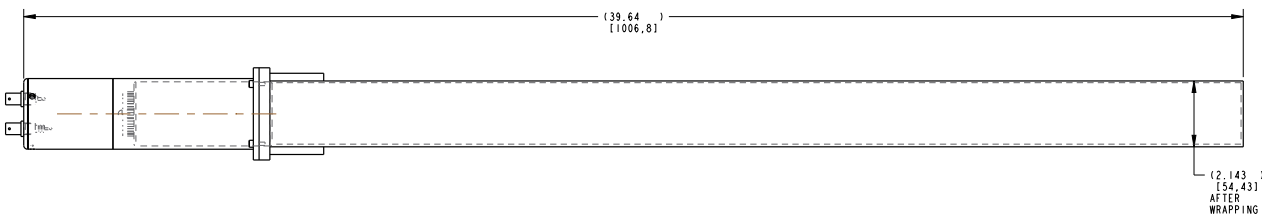
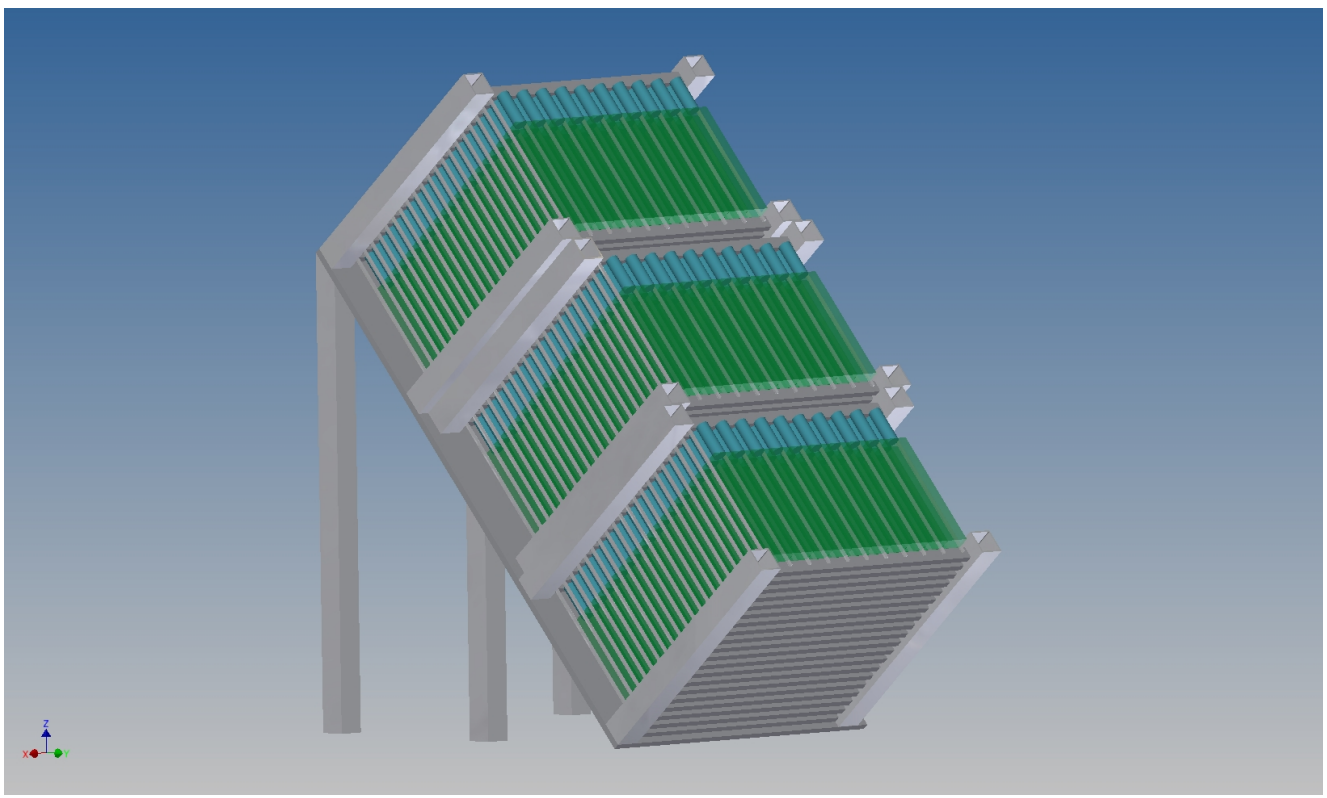
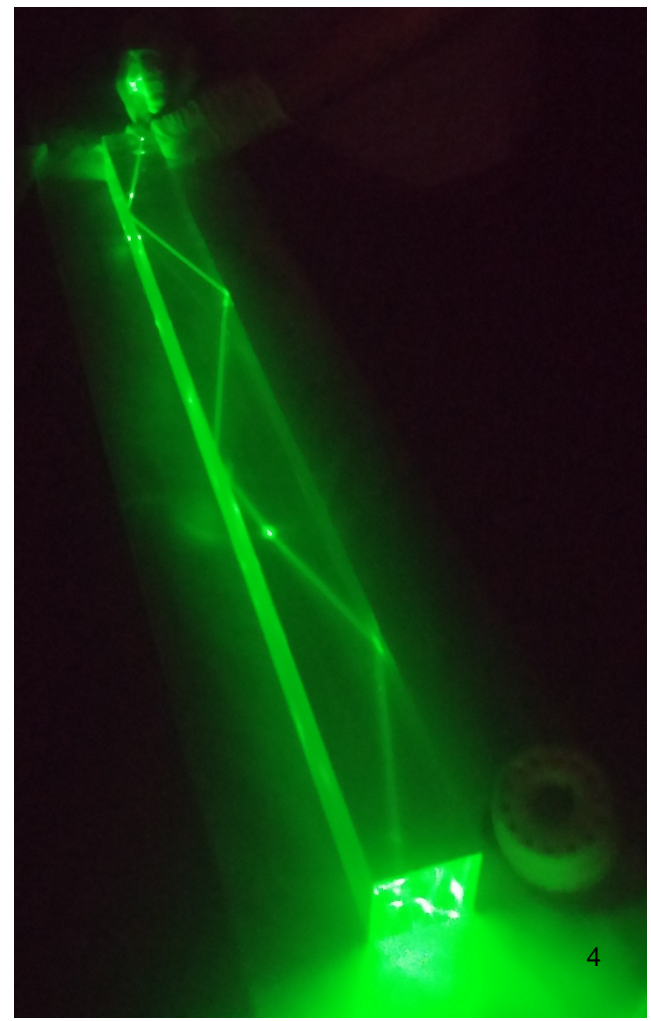
- Basic element is a 5 cm^2 x 80 cm bar pf plastic scintillator (BC 408) + PMT (HPK R7725)
- Arranged in a 20 x 20 x 3 array
  - *Supported by movable mechanical structure*
    - **Alignment to IP + retraction to allow passage through gallery**

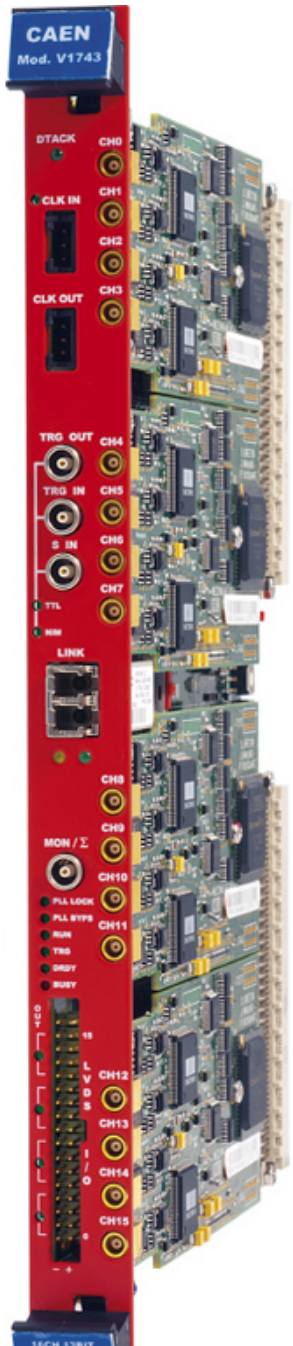








We have the basics of Readout & Trigger



- Readout via CAEN V1743 12 bit digitizer
- 16 channels
  - *Sampled at 3.2 GS/s (a sample each 312.5 ps)*
  - *1024 analog buffer ring (320 ns long).*
  - *Analog noise is about 0.75 mV per channel, allowing good identification of and triggering on single PE signals*
- Trigger
  - *If 2 of 3 bars coincident in 15 ns window, self-triggers to read out whole detector*
  - *Data will be read out via CAEN CONET 2 over 80 Mbps optical fiber to a PCI card in dedicated DAQ*

We produced two documents in 2016

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Available on CMS information server

CMS IN -2016/002

CMS Internal Note

The content of this note is intended for CMS internal use and distribution only

28 April 2016

An Expression of Interest to Install a Milli-charged Particle Detector at LHC P5

Austin Ball,[1] Jim Brooke,[2] Claudio Campagnari,[3] Albert De Roeck,[1] Brian Francis,[4] Martin Gastal,[1] Frank Golf,[3] Joel Goldstein,[2] Andy Haas,[5] Christopher S. Hill,[4] Eder Izaguirre,[6] Benjamin Kaplan,[5] Gabriel Magill,[7,6] Bennett Marsh,[3] David Miller,[8] Theo Prins,[1] Harry Shakeshaft,[1] David Stuart,[3] Max Swiatlowski,[8] and Itay Yavin[7,6]

[1]*CERN*
[2]*University of Bristol*
[3]*University of California, Santa Barbara*
[4]*The Ohio State University*
[5]*New York University*
[6]*Perimeter Institute for Theoretical Physics*
[7]*McMaster University*
[8]*University of Chicago*

Abstract

In this EOI we propose a dedicated experiment that would detect "milli-charged" particles produced by pp collisions at LHC Point 5. The experiment would be installed during LS2 in the vestigial drainage gallery above UXC and would not interfere with CMS operations. With 300 fb^{-1} of integrated luminosity, sensitivity to a particle with charge $\mathcal{O}(10^{-3})$ e can be achieved for masses of $\mathcal{O}(1)$ GeV, and charge $\mathcal{O}(10^{-2})$ e for masses of $\mathcal{O}(10)$ GeV, greatly extending the parameter space explored for particles with small charge and masses above 100 MeV.

A Letter of Intent to Install a Milli-charged Particle Detector at LHC P5

Austin Ball,[1] Jim Brooke,[2] Claudio Campagnari,[3] Albert De Roeck,[1] Brian Francis,[4] Martin Gastal,[1] Frank Golf,[3] Joel Goldstein,[2] Andy Haas,[5] Christopher S. Hill,[4] Eder Izaguirre,[6] Benjamin Kaplan,[5] Gabriel Magill,[7,6] Bennett Marsh,[3] David Miller,[8] Theo Prins,[1] Harry Shakeshaft,[1] David Stuart,[3] Max Swiatlowski,[8] and Itay Yavin[7,6]

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(Dated: July 19, 2016)

Abstract

In this LOI we propose a dedicated experiment that would detect "milli-charged" particles produced by pp collisions at LHC Point 5. The experiment would be installed during LS2 in the vestigial drainage gallery above UXC and would not interfere with CMS operations. With 300 fb^{-1} of integrated luminosity, sensitivity to a particle with charge $\mathcal{O}(10^{-3})$ e can be achieved for masses of $\mathcal{O}(1)$ GeV, and charge $\mathcal{O}(10^{-2})$ e for masses of $\mathcal{O}(10)$ GeV, greatly extending the parameter space explored for particles with small charge and masses above 100 MeV.

Current composition of milliQan

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- 6 CMS groups
  - *Ohio State (**C. Hill**, B. Francis)*
  - *UCSB (**D. Stuart, C. Campagnari**, F. Golf)*
  - *CERN (**A. Ball, A. De Roeck, M. Gastal**, H. Shakeshaft, Michael Hauschild?)*
  - *Bristol (**J. Goldstein**, J. Brooke)*
  - *FNAL (**J. Hirschauer**)*
  - *UVA (**C. Neu**)*
- 1 potential CMS group
  - *Indian Institute of Science (**J. Komaragiri**)*
  - *KIT (**R. Ulrich**)*
- 2 ATLAS groups
  - *NYU (**A. Haas**, B. Kaplan)*
  - *Chicago (**D. Miller**)*
- 2 Theory groups
  - *Perimeter Institute (**I. Yavin**, G. Magill)*
  - *BNL (**E. Izaguirre**)*

22 people!

Reminder of Proposed Timeline

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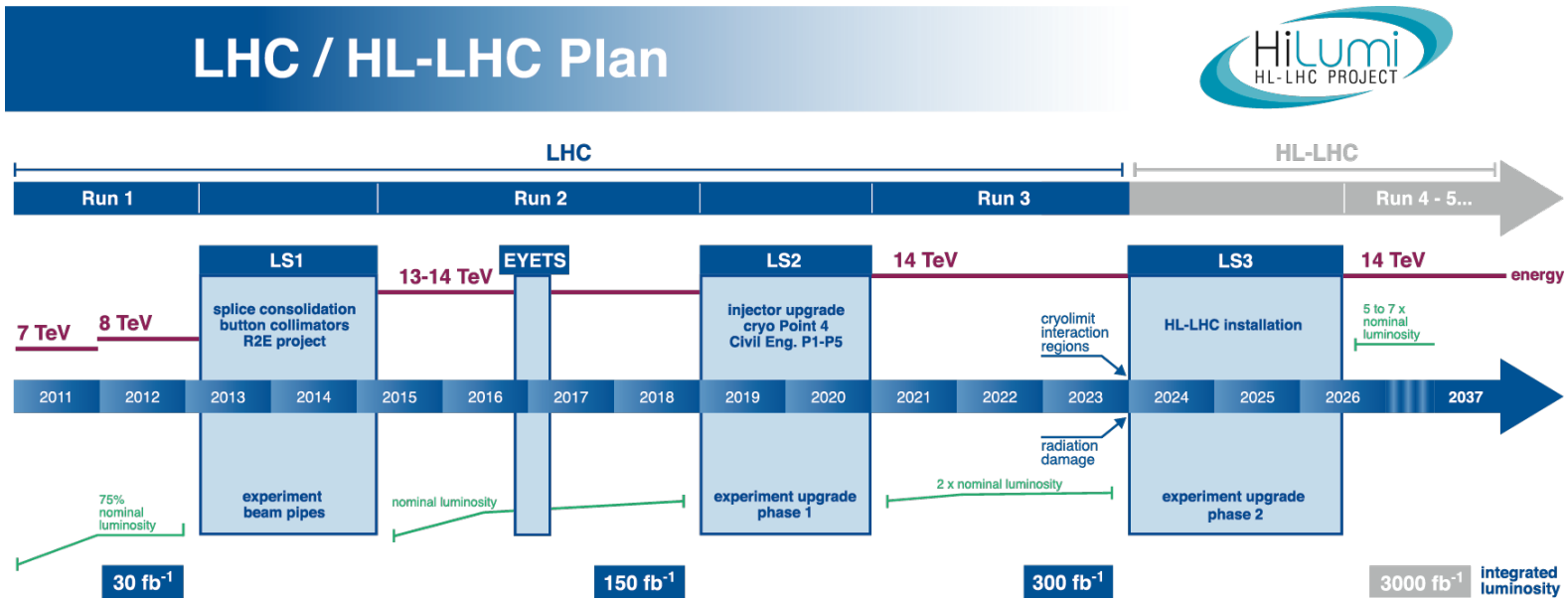

- Install (small part of) detector by end of Run 2 (2018)
  - *Installation during YETS 2017 + TS's during 2018, need R&D money this year!*
- Have full experiment ready for physics before Run 3 (2021)
  - *Construction during LS2 (starts 2019, need serious money by then, i.e. full proposal in 2018 at latest)*
  - *Commission by end of 2020, take data for Run 3,4,5… to get to 3000 fb^{-1}*
  - *2019-2037 is 18 years of construction/commissioning/operation, must factor this into our planned costs*

But we still have a long way to go

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- We need to get funding, at least for R&D, asap
  - *We talked to DOE and were discouraged from including milliQan in base grants in 2016*
  - *We did not seriously pursue any other avenues in US for 2016, but should look to NSF in 2017 (depending on budget we could also try again with DOE)*
  - *We should look to Europe, Asia, and private foundations for other options*
- Though we have received tacit approval of CMS MB in April, and support of current spokesperson, we still need to either get formal adoption by CMS or we need to get formal approval by LHCC
  - *It is difficult to see how we can get serious money until one of these happens*
  - *We also need a more serious costing estimate*
  - *We will need to have a more "organized" collaboration (also needed to handle new groups that want to join)*

On the technical side (not an exhaustive list)

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- Need to have a better understanding of in situ backgrounds
  - *Validate assumption that dark pulses are dominant source*
  - *Show we can remove ALL sources of coincident backgrounds*
- Need to more firmly validate BC-408 choice
  - *Initial results look like it meets needs and is good value for $, but more work needed to firmly establish this*
  - *Rule out ALL alternatives by cost, performance, etc*
- Need to more firmly validate R7725 choice
  - *Initial results look like it meets needs (though might require some cooling to achieve 500 Hz target) and is good value for $, but more work needed to firmly establish this*
  - *Rule out ALL alternatives by cost, performance, etc*
- I think we will need a convincing “demonstrator” that shows we have reasonable single PE efficiency, should think about what this would entail
- On readout, CAEN board looks like it works but rest of readout chain still needs work
  - *Scaled up DAQ code needed (also powering and slow controls)*
  - *Realistic trigger implementation needed*
- Have ~unified generation -> simulation -> reconstruction -> analysis workflow, but more work needed in all areas

Goals for the workshop

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- Summarize technical status in all areas
  - *Site, Mechanics*
  - *Scintillator, PMT*
  - *Powering, Cooling*
  - *Readout and Trigger*
  - *Simulation, Offline*
- Make a serious funding plan
  - *Identify targets, deadlines, and assign responsibles for writing/submitting (related is to discuss who will be PIs on such proposals)*
  - *Discuss costs (material costs of baseline design ~well-known, but what about computing, personnel, travel, etc)*
- Discuss Organizational issues
  - *Revisit who will do what, and go over how can/should the individual efforts be coordinated going forward*
  - *Discuss membership policy*
  - *Discuss leadership structure*
  - *Discuss meeting schedule for 2017*