Muon Collider Physics Workshop: Concluding Remarks

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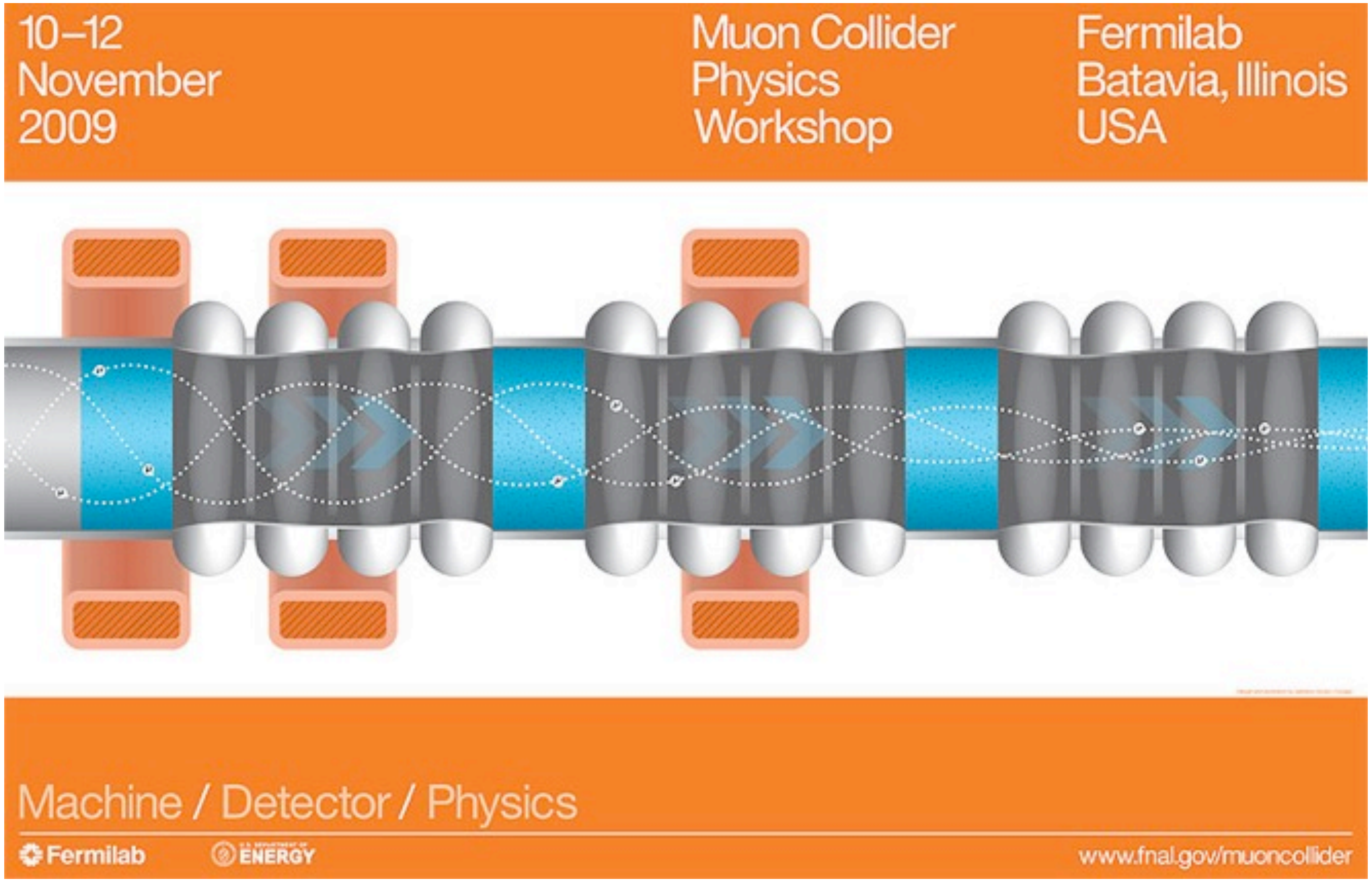


Thank You

- The Chairs E.E., Ken Peach, Jacobo Konigsberg thank:
  - The Conveners and Session Chairs:

    Physics: Tao Han, Ayres Freitas; Detectors: John Hauptman, Sergey Klimenko; MDI: Nikolai Mokhov, Bob Palmer
  - The speakers:
    - Joe Lykken, Michael Zisman, Nikolai Mokhov, Daniel Schulte, Andrei Seryi, Marcel Demarteau, Hitoshi Yamamoto, Norman Graf, Pere Mato, and all the WG speakers
  - The Organizing Committee:
    - Vernon Barger, Grahame Blair, Jim Brau, Alan Bross, Marcela Carena, Sekhar Chivukula, Dave Cline, Marcel Demarteau, Steve Geer, Norman Graf, Franco Grancagnolo, Jack Gunion, Gail Hanson, John Hauptman, Chris Hill, Ken Long, Nikolai Mokhov, Mark Oreglia, Adam Para, Francois Richard, Liz Simmons, Carlos Wagner, Richard Wigmans, Hitoshi Yamamoto
  - The Support Staff: Barb Book, Marilyn Smith, Monica Sasse, and the AV staff
  - Fermilab: Young-Kee Kim and Pier Oddone
  - The participants - All of you

For making this an informative and productive workshop

Workshop Charge

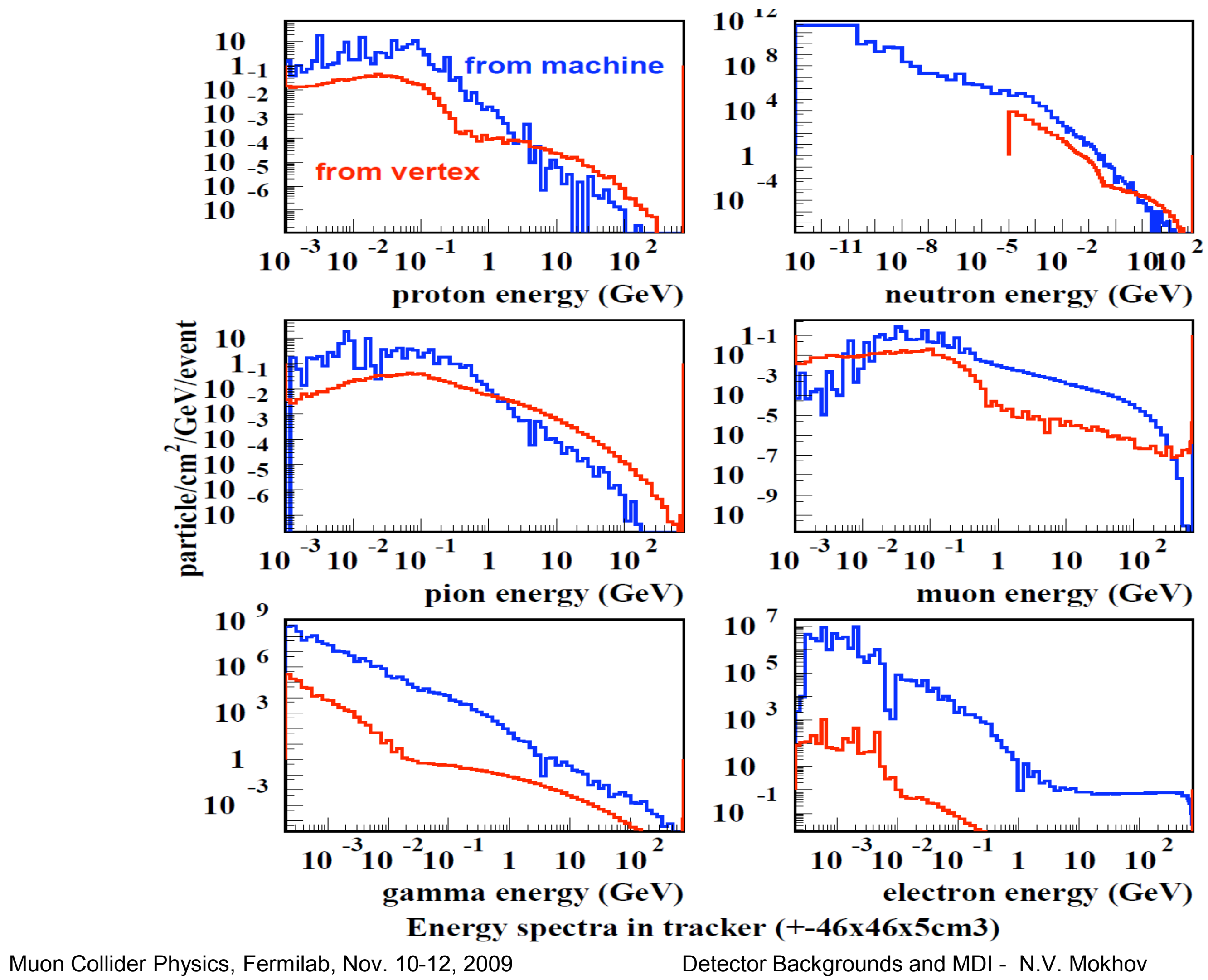
This is the organizing workshop for the study of physics, detectors and backgrounds at a Muon Collider in the 1.5 to 5 TeV energy range (a benchmark 1.5 TeV and 3.0 TeV machine parameters). This study will draw on the previous work on Muon Colliders but update and reevaluate the possibilities in light of the substantial recent advances. The goal of the workshop is to deliver within ~18 months a report on the physics potential of such a Muon Collider. This study should set requirements on luminosity, energy, determine acceptable background event rates and suggest feasible methods of attaining these levels. The impact of the polarized beams, energy spread, and detector fuducial volume should be evaluated. The physics opportunities should be compared to the CLIC option and take account of the substantial running of LHC after a luminosity upgrade. Synergies with the ILC/CLIC and LHC detector R&D should be exploited.

A Good Start

- Heard status reports:
  - Physics after the LHC -> Joe Lykken - Many physics questions will remain, new ones will arise.
  - Previous work on the Muon Collider - Complex, Detectors, MDI - Mike Zisman, Marcel Demarteau, Nikolai Mokhov
  - Other detector efforts (ILC, CLIC) - Daniel Schulte, Hitoshi Yamamoto
  - Other machine-detector interfaces (ILC, CLIC) - Andrei Seryi
- Explored opportunities for common efforts:
  - Physics benchmarks (ILC, CLIC)
  - Detector components (CLIC, LHC, CLIC) - Hitoshi Yamamoto, Norman Graf, Marcel Demarteau
  - Simulation Framework (detector, physics) - Pere Mato
- New work reported in Working Groups (and previous summaries)

A Good Start

- Machine-Detector Interface
  - Many challenges: ~2 KW/m heat load from decays.
  - First simulation using MARS15 of MDI backgrounds for 1.5 TeV Muon collider with a new lattice and a 6° Tungsten shielding cone shown.
  - fluences electrons and photons an order of magnitude larger than for the old 20° cone design.



A Good Start

MDI

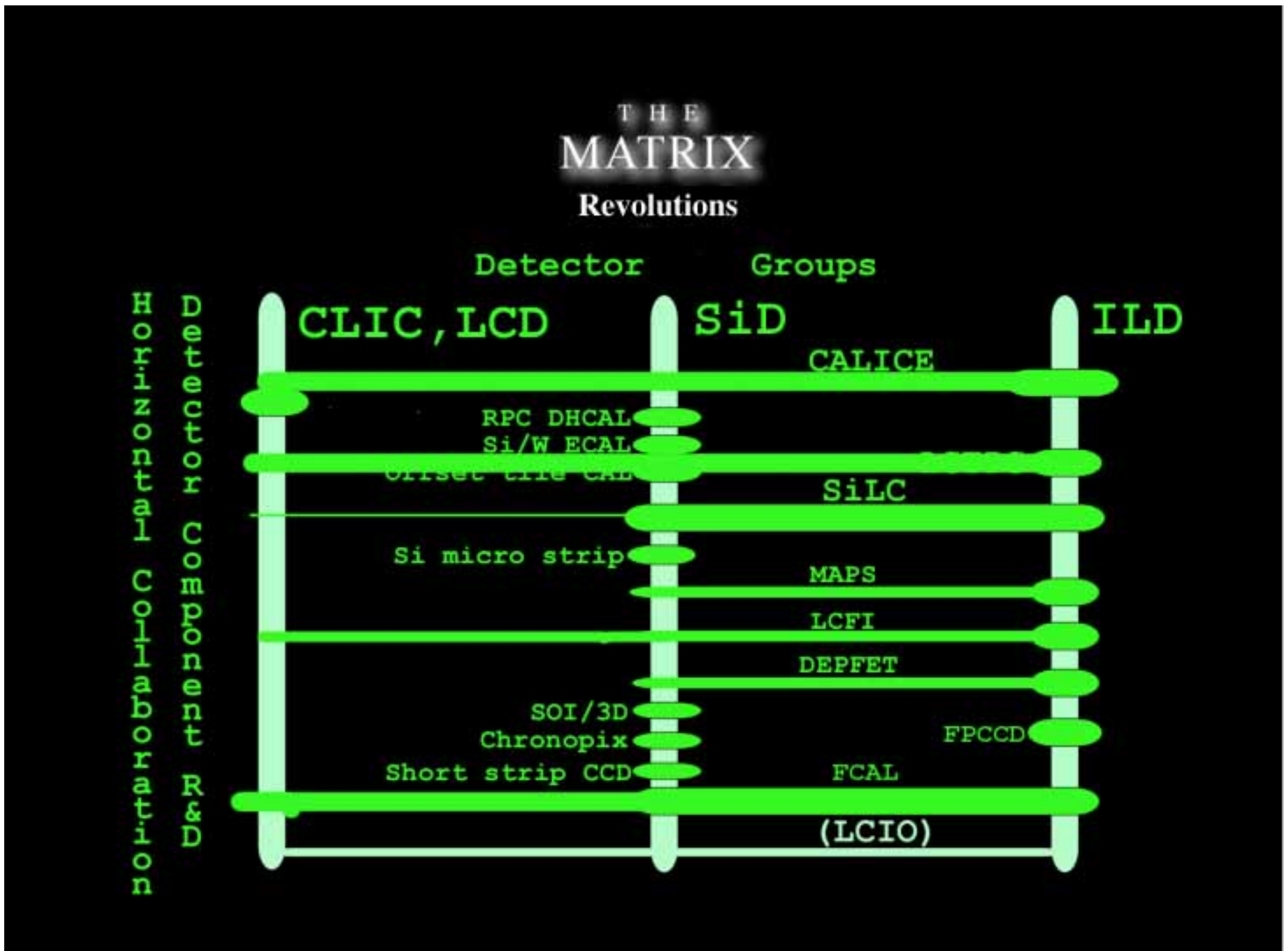
Deleterious effects of background on muon collider machine, magnet and detector design and performance remain to be the critical issue. There have been impressive presentations and constructive dialogue of MDI at this Workshop. We now have: a consistent 1.5-TeV lattice with large dynamic aperture and momentum acceptance; full MARS model of IR and detector (based on 4th concept) with an interface to detector simulator; several possible technologies for the IR and ring magnets.

First direct comparison was performed of backgrounds from mumu collisions and machine. Backgrounds from incoherent pair production are manageable with the appropriate nozzle design. Backgrounds from beam halo are taken care with an appropriate collimation system. The main source – muon beam decay – give rise to the background and radiation loads in detector comparable to those at the LHC at the design luminosity. Optimization of the tungsten nozzle, choice of the appropriate IR magnet technology, and implementation of other protective measures (catchers in magnet interconnect regions, magnetized wall for Bethe-Heitler muons, a high-field solenoid close to IP, promise to substantially reduce these levels. Issues to work on have been identified. Need to form an MDI group now!

Muon Collider Physics, Fermilab, Nov. 10-12, 2009 MDI Summary - N. Mokhov and R. Palmer 1

A Good Start

- Detectors
  - First full simulations for 4th concept detector including machine backgrounds.
  - Horizontal Collaborations - Hitoshi Yamamoto



Detector Summary

- Significant detector R&D in the scope of ILC and CLIC – a great reference point for MC
- An arsenal of tools for combined simulation of machine, detector and physics.
- Integration with machine detector interface
  - need smart ideas and a lot of work to mitigate background
  - expect a significant impact on detector design
- Integration with physics
  - need a clear physics case
  - quantify impact of the background on the MC physics potential
  - need a set of benchmark physics processes to estimate detector performance and establish technical design specifications
- Detector R&D
  - Innovative detector concepts are available/developing, expect more in the next 10 years →keep detector diversity/options open
  - "horizontal" vs dedicated R&D → integration of MC detector into coherent R&D program

S.Klimenko, November 11, 2009, FNAL, MC workshop

A Good Start

- **Physics Case:**
  - S channel resonance production (spin zero (H_0), one (Z'), two (KK))
    - Narrow s-channel states played an important role in past lepton colliders. If such states exist in the multi-TeV region, they will play a similar role in precision studies for new physics. Sets the minimum luminosity scale.
  - S channel pair production - high mass pairs clearly accessible
    - A multiTeV lepton collider is required for full coverage of Tevascale physics.
    - The physics potential for a muon collider at $\sqrt{s} \sim 3$ TeV and integrated luminosity of 1 ab^{-1} is outstanding. Particularly strong case for SUSY and new strong dynamics.
  - T channel fusion processes -> provides a wide band beam
    - Similar to a hadron collider without the strong interaction backgrounds
    - An Electroweak Boson (W/Z) collider.
- **Next Step is a detailed study of the physics case for a 1.5 - 5.0 TeV muon collider**
  - Identify benchmark processes: pair production (slepton; new fermion), Z' pole studies, h^0 plus missing energy, resolving nearby states (H^0-A^0; ρ_T-ω^0_T), ...
  - Dependence on initial beam [electron/muon, polarization and beam energy spread] as well as luminosity should be considered.
  - Estimates of collision point environment and detector parameters needed.
  - Must be able to withstand the real physics environment after ten years of running at the LHC.

How to Proceed

- Strongly coupled problem - Machine Detector Interface Design
  Detector Design
  Physics Requirements
- Apply Interative method

  1. Develop physics benchmarks -> initially without machine backgrounds
  2. Chose a MDI -> Determine machine backgrounds
  3. Pick a Strawman Detector -> Simulate physics benchmark processes with full backgrounds
  4. Do a Failure Analysis -> adjust point (MDI, Detector, Physics)
  5. Repeat until stable

- Global vs Local Maximum

  1. Chose widely separated starting points - other detector designs, various new physics scenarios, different machine lattices and shielding strategies
  2. Broaden and deepen effort.

- Part of a Global Strategy - Detectors and Simulations -> Horizontal Collaborations

--> Steve Geer and Young-Kee Kim