1   Executive Summary (2 pg, Hanany)

Responsibility: Hanany

2   Science (30.5 pages)

2.1   Introduction (1 pg, Hanany)

NASA suggested table of contents says Science Intro or Landscape section should include:

- State of the Art in the Field

- Compelling Outstanding Questions

- Needed Capabilities for Progress

To be included: State of the art in the field; Compelling outstanding questions; Needed capabilities for progress (Knox? + others)

2.2   Science Objectives (17.5 pgs)

The PICO Science Traceability Matrix (2pg, Hanany&Trangsrud) will be inserted around here. It is an 11x17 foldout, so it counts as 2 pages, which leaves 16 to all the rest in 2.2.

FOR EACH OF THE BELOW SUBSECTIONS:

- Introduce and elaborate on the applicable PICO "Science Objectives" from the STM table (what do they mean and why are they important)

- Observations/Measurements that enable PICO to accomplish each Science Objective (tell the data analysis story that connects the Observations column of the STM to the Science Objective column)

- Contextualize relative to sub-orbital and other space missions

- Science yield estimate (be quantitative. how well will PICO do at Baseline/Required performance? at Current Best Estimate performance?)

- Include a summary plot or table which demonstrates PICO's performance against the Science Objective as written (e.g. how it discriminates between different theories)

- Perceived science impact (be qualitative. this isn't about reducing the sigma on a parameter. this is about what we will learn about nature)

2.2.1   Fundamental Physics (6 pgs, Flauger, Green)

To include: Cosmic Inflation, Particle Physics (Neutrinos and Light Relics)
   Should address these Science Objectives from the STM:

- "Probe the physics of the big bang by detecting the energy scale at which inflation occurred if it is above 4×10^{15} GeV, or place an upper limit if it is below" [r]

- "Probe the physics of the big bang by excluding classes of potentials as the driving force of inflation" [n_s, n_{run}]

- "Determine the sum of neutrino masses, and distinguish between inverted and normal neutrino mass hierarchies" [Σm_ν]

- "Detect departures from or tightly constrain the thermal history of the universe" [N_{eff}]

- Origin of magnetic fields and cosmic birefringence

2.2.2 Cosmic Structure Formation and Evolution (4 pgs. Battaglia & Alvarez)

Should address these Science Objectives from the STM that relate to reionization + ??

2.2.3 Galactic Structure and Star Formation (5 pgs, Chuss & Fissel)

Should address these Science Objectives from the STM:

- "Determine whether the interstellar medium of our galaxy is unique by comparing the ratio of energy in magnetic field to turbulence to that in nearby galaxies."

- "Determine if magnetic fields are the dominant cause of low star formation efficiency in our Galaxy."

- "Determine whether radiative torque is responsible for the alignment of dust grains with magnetic fields"

- "Determine the influence of the magnetic field on Galactic dynamics within the Milky Way."

2.3 Measurement Requirements (2 pgs, Hanany & Trangsrud)

Some requirements derive from the science (τ = full sky) Some requirements derive from foregrounds (frequency coverage) and some from systematics (particular scan pattern)

2.4 Additional Science (2 pgs, de Zotti)

Describe science that we get for free.

2.5 Complementarity with other Measurements and Surveys (1 pg)

Should describe complementarity with sub-orbital CMB measurements and with other surveys, both in space and on the ground. This is summary text (more detail in subsections about specific objectives)

2.6 Foregrounds (4 pgs)

The state of knowledge and known challenges; how does PICO address the challenges; forecast of performance.

2.7 Systematic Errors (3 pgs, Crill)

State of knowledge; What have we assessed in this study; what's left to be done (Crill)

3 Instrument (6 pgs, Trangsrud & Hanany)

Telescope, focal plane, cooling, readout

4 Mission (3 pgs, Trangsrud)

To be included: mission architecture, spacecraft and subsystems, orbit, attitude control and determination (Trangsrud)

5 Technology Maturation (4 pgs, O'Brient & Trangsrud)

Requirements, planned activities, schedules and milestones, estimated cost (O'Brient?)
For each technology include:

- Requirements

- Planned activities

- Schedule and Milestones

- Estimated Cost

6 Management, Risk, Heritage, and Cost (4 pgs, Trangsrud)

cost, risk, heritage (Trangsrud)

References

ACS attitude control system

ADC analog-to-digital converters

ADS attitude determination software

AHWP achromatic half-wave plate

AMC Advanced Motion Controls

ARC anti-reflection coatings

ATA advanced technology attachment

BRC bolometer readout crates

BLAST Balloon-borne Large-Aperture Submillimeter Telescope

CANbus controller area network bus

CIB cosmic infrared background

CMB cosmic microwave background

CMM coordinate measurement machine

CSBF Columbia Scientific Balloon Facility

CCD charge coupled device

DAC digital-to-analog converters

DASI Degree Angular Scale Interferometer

dGPS differential global positioning system

DfMUX digital frequency domain multiplexer

DLFOV diffraction limited field of view

DSP digital signal processing

EBEX E and B Experiment

EBEX2013 EBEX2013

ELIS EBEX low inductance striplines

ETC EBEX test cryostat

FDM frequency domain multiplexing

FPGA field programmable gate array

FCP flight control program

FOV field of view

FWHM full width half maximum

GPS global positioning system

HDPE high density polyethylene

HIM high index materials

HWP half-wave plate

IA integrated attitude

IP instrumental polarization

JSON JavaScript Object Notation

LDB long duration balloon

LED light emitting diode

LCS liquid cooling system

LC inductor and capacitor

LZH Lazer Zentrum Hannover

MCP multi-color pixel

MSM millimeter and sub-millimeter

MLR multilayer reflective

MAXIMA Millimeter Anisotropy eXperiment IMaging Array

NASA National Aeronautics and Space Administration

NDF neutral density filter

PCB printed circuit board

PE polyethylene

PME polarization modulation efficiency

PSF point spread function

PV pressure vessel

PWM pulse width modulation

RMS root mean square

SLR single layer reflective

SMB superconducting magnetic bearing

SQUID superconducting quantum interference device

SQL structured query language

STARS star tracking attitude reconstruction software

SWS sub-wavelength structures

TES transition edge sensor

TDRSS tracking and data relay satellites

TM transformation matrix

UHMWPE ultra high molecular weight polyethylene

UMN University of Minnesota