"Observing Dark Universe with Euclid"

2009/11/17-18 Report v1: I. Iwata

目次

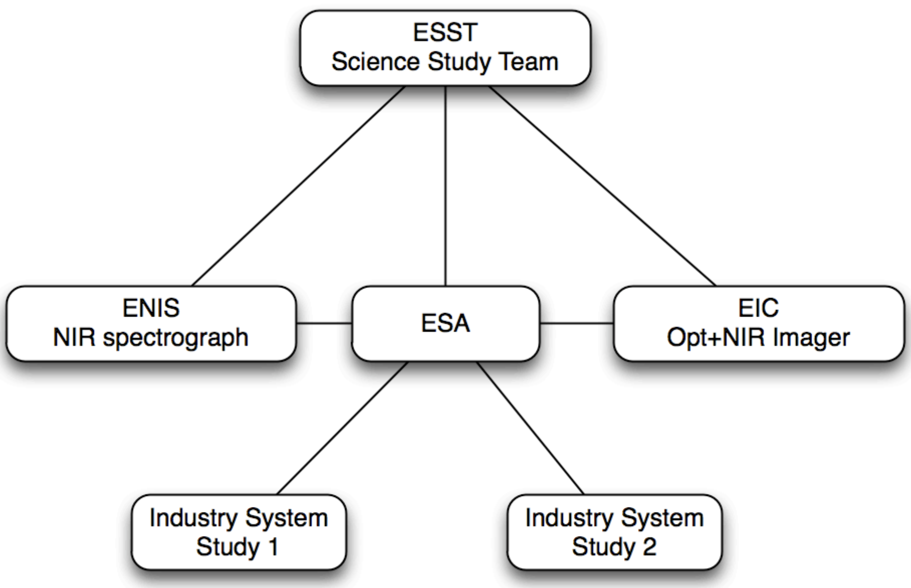
[Cosmic Vision selection process]

* L-class: LISA (de facto L-size mission candidate), IXO, Laplace (Jupitor mission)
* M-class: Plato (exo-planets), Solar Orbitor, Marco Polo,
  Euclid, Cross Scale (magnetosphere physics),
  SPICA (mission of opportunity
* 最初の予定では2017年にM-class 1機、2018年にL-class 1機であったが、L-classは延期となり、2017/2018年にM-class 2機の予定
* コスト上限は当初 L-class 650Mユーロ、M-class 350Mユーロであったが、M-classは450Mユーロに上昇した
* M-classはまず4機に絞る。public presentationは2009/12/1、assessment reportがwebに出る。recommendationが2010/1/13-15に出て、最終決定は2010年2月。
* 2機の決定は2011年末

* JDEMとのmergeについて: 2009年当初からJDEMとの合同が検討されたが、NASA側が検討を中止。CVのスケジュールに間に合わせるためEuclid (ESA単体)の検討を再開(2009年4月)。JDEMとの共同は将来にはあるかもしれない。
* JDEMはIDECSをやめて、”Omega”というarchitectureに、NIR detector only, weak lensing。Decadal survey次第。

[Assessment report]

* dark energy missionはCosmic Visionの2007年11月のrecommendationで”top priority”であった。DUNEとSPACEを合同してEuclidとなった
* 2008-2009年にindustrial assessmentを行った。2つのチーム(Thlaes Alenia Space and Astrium Gmbh)が独立に検討
* 検討チームの構造:



* M-class missionはどれも同じ検討ステータスでdown selectionを行うのが原則。

* IDECS (= Euclid + JDEM)の検討からEuclidに戻った段階での変更:

  ** 2.5um cutoff
  ** スリットレス分光をbaselineとし、DMD (digital micromirror devices)分光はoption

* Yellowbookは2009/11/16にESA HQに提出。2009/12/1にpublicに。

  Science Requirement Doc.
  Mission Requirement Doc.
  Payload Definition Doc.

[Euclid Mission Overview]

* 主目的は”extragalactic sky”全体(2x10^4 deg^2)のサーベイによる宇宙論。

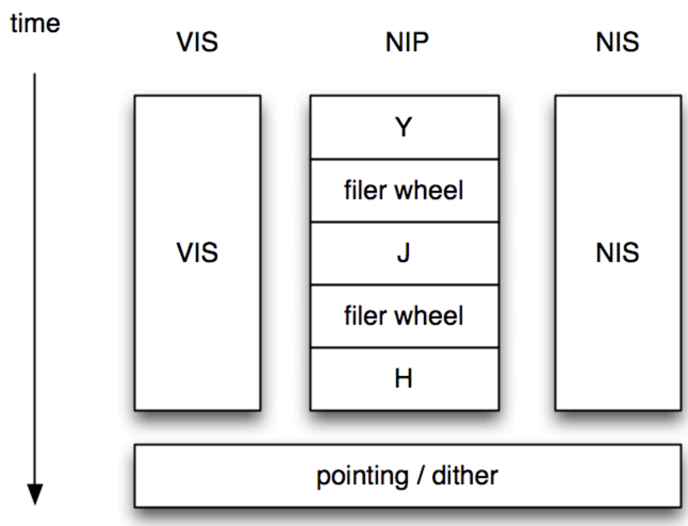
* secondary objectivesとして”legacy science” = astrophysics

* 望遠鏡: 1.2m Korsch, 副鏡のobscurationは0.37m

* 撮像: VIS, NIR (EIC): weak lensing

* 分光: NIR (ENIS): BAO

* launcher: Soyuz ST 2-1B
* survey mode: step and stare (continuous scanではない)。ditherはspacecraft levelで行う



500秒の観測ユニット

* mission lifetime: 5 years, 4.5 years for science
* 軌道: S-E L2, 4年でextragalactic sky全体をカバーできる予定

* passive cooling

[Euclid Imaging Consortium]

* PI: Refregier
* 科学的目標: weak lensing。BAOと組み合わせてwの制限を現在の10%から1% (時間変化も)にする

* requirements:
  ** 深さよりも広さ: wへの制限のため
  ** systematics: stable PSF, 50 bright stars to calibrate PSF => need access to space
  ** photo-z: visible maybe done from ground, but for NIR need access to space
* 視野: 0.5 sq. deg.

* wide survey: 2π sr.
  ** [RIz] < 24.5 0.18” FWHM <z>~0.9
  ** YJH < 24.0
* deep survey: 30 deg^2 at ecliptic poles
  ** PSF drift monitor
  ** + 2mag deeper than wide in both vis and NIR

* legacy science: “Genome project” of the observable universe?
  ** map mass and light in the universe
  ** physical drivers of star formation
  ** high-z objects: z=8-12 LBGs and QSOs
  ** galaxy clusters -- 4x10^4 clusters
  ** strong lensing systems
  ** search for exo-planets with microlensing

* wide survey: 36 fields / day, 4 dithers / field
* VIS: for shape measurement (WL)
  ** 36 (9 x 4) CCDs, e2v 4k x 4k, 0.1”/pix
  ** data rate: 500 Gbits / day, 2.8 compression
  ** 3CCD / read-out electronics
  ** thermal design completed: 150K, <3K gradient
  ** radiation effect investigated
* NIP:
  ** 18 (3 x 6) H2RG, 0.3”/pix
  ** data rate: 200 Gbits / day, 2.5 compression
  ** filter wheel: 4 holes
* simulation: CCD effect, PSF, jitter => cosmic shear error estimate => matches requirement
* compression rate are based on simulations
* mass budget: VIS+NIP 312 kg, power: 223 W

[Euclid Near Infrared Spectrograph]

* PI: Cimatti
* 科学的目標: cosmology with spectroscopic survey -- evolution of 3D map

* requirements
  ** number of zspec: 5x10^7
  ** coverage: >2x10^4 deg^2
  ** accuracy: $\sigma_z / (1+z) < 0.001$ at $0.5 < z < 2$
* deep survey: +2mag deeper, 30deg^2

* why space? => low background, no sky emission = simple selection function, higher redshift
* why near-IR? => Hα at 0.5 < z < 2, rest-frame optical spectra = good legacy than rest UV

* baseline: slitless spectroscopy
  ** detect Hα emission line (4e-16 erg/cm^2/s, H~19.5)
  ** redshift success rate: > 40%
  ** effective volume: 19 h^-3 Gpc^3
* option: DMD (=digital micromirror devices) slit spectroscopy
  ** detect all types of galaxies (continuum + emission), H~22.0
  ** lower sky background
  ** redshift success rate: > 80%
  ** 0.5 < z < 2.5
* studies for both slitless and DMD have been made. simulations of observed data (see talk by Garilli)
* slitlessの場合はconfusionが問題に。解決法としては2つ検討中:

  (1) multiple roll-angles
  (2) multiple filters -- 1.0-1.25um, 1.25-1.50um, 1.50-1.75um, 1.75-2.0um

* Science: BAO as standard ruler
  additionally: galaxies and AGN (star formation etc.), clusters of galaxies, high-z QSOs, most luminous z>7 galaxies, ultracool dwarf stars, IMF (complementary to GAIA)
  for additional science cases, DMD does much better than slitless.
* integration time: 500 secods

* slitless (baseline): R~500, 1-2 um
* DMD (option): R=200-400, 0.9-1.7um
* mass: 125 kg
* grism: high efficiency over λ coverage
* simulatorでの検討でも、DMDの方がずっとS/Nがよく、科学的には望ましいが、技術的問題(DMD自体の開発状況、pointingへの制限)からoptionとなっている。今後DMDに変更できるよう、slitlessになるべく合わせたデザインで検討している(光学系は当然より複雑だが)。

[mission payload]

* PSF requirement:
  ** ellipcity: <20%, ellipcity stability: <0.02% rms, FWHM stability: < 0.1% rms
* pointing requirement:
  ** RPE < 25 mas (500 seconds)
  ** APE < 10 as
  ** AME < 100 mas
* data rate: 850 Gbit / day => K-band
* guidance: 独立したガイド系(star tracker)を用意する方針。姿勢制御はcold gas or magnetic reaction wheel?

* 注意点:

  ** スケジュール: 2018年の打ち上げに間に合わせるには、2012年のdown selectionの後4年弱でPFM完成が必要

  ** DMDはできるか？

** NIR検出器の製作可能性: JWST / NIRCam, NIRSpecと比べると野心的

** 検出器のradiation test

[data handling, ground segment]

* VIS: 38 Gbit / frame
  NIP: 14.5 Gbit / frame
  NIS: 2.69 Gbit /frame
  total: 56 Gbit => compression: 21.5 Gbit
* 36 fields => 792 Gbit / day <=> K-band: 850 Gbit / ~4 hours slot: feasibile
* data size:
  ** Euclid: 5 PB
  ** Plank: 2TB / year
  ** GAIA: ~1PB

[システム検討(1): EADS astrium]

* VIS PSF requirement: 0.18 < FWHM < 0.23" - 83.6% within 3 x FWHM
* 36 CCDs, 26 NIR arrays
* orbit transfer:
  ** free-insertion large-amplitude orbit
  ** SSE angle < 30 deg
  ** daily visibility > 4 hours / day
  ** orbit maintenance ~ 30 days
* survey mode:
  ** nominal mode: sunshield perpendicular to the sun -- inefficient (SAA vary?)
  ** equinox mode: spacecraft tilted to the sun
  ** SAA 45 deg (worst case): 120 hours to setting time
  ** SAA <15 deg: set time negligible
* payload: homothetic design analog to GAIA, SiC, 783 kg (including 20% margin)
* service module: 650 kg
* thermal stability: ~30mK
* AOCS (guidance): 0.5 - 1 Hz

[システム検討(2): Thales]

* 望遠鏡にバッフルをつける。迷光(迷熱)とcontaminationの防御のため

* Herchel-like SVM
* instrument-own ICU (decentralized data handling)
* magnetic reaction wheel (予算的観点から)

* CeSiC structure
* temperature: telescope: 240K, instruments and components: 188K
* sky survey: SAA 30 deg -- cover extragalactic sky for 4 years

[サイエンス検討]

抜粋。

[Peacock: cosmology review]
[Amara: WL]
[Wang and Percival: BAO]
[Aghanim: Integrared Sach-Wolfe]
[Guzzo: Redshift distortion]
[Biviano and Weller: clusters of galaxies]

[Hook: Supernova]
* type Ia SN cosmology
* 40 visits / field desirable -- cadence TBD
* in J-band 1000-2000 SNIa at $z<0.7$ -- peak and +1 mag (to determine peak luminosity)
  x2 if detection only at $z<1.0$
* systematic errors -- many components. one issue in SN color dependence -- Euclid near-IR imaging benefits
* DES (CTIO 4m, vis) + VISTA があるが、Euclid SN surveyは精度で勝る
* additional science: SN rates -- metal enrichment, SF history

[Beaulieu: microlensing planet search]
* マイクロレンズ効果で惑星を探す。0.7等くらい明るくなる場合もあるらしい
* 今後3-8年で1.5AUまでの10 M_{earth}の惑星検出が可能に
* 10年後には0.1 M_{earth}まで検出可能に -- 太陽系の惑星は水星以外全て検出できる
* requirement: high spatial resolution, 24 hour duty cycle
* Keplerで検出できる惑星は<1 AU several M_{earth}、Euclid microlensingは>1AUで sub-M_{earth} planetsまで。棲み分けている
* 3 months <u>dedicated</u> program (銀河系中心方向を見る)-- 16 rocky planets, 580 $M_{jupitor}$ planets, free-floating planets
* 地球型のhabitable惑星を探すにはもっと時間が必要

[Lilly: photo-z performance]
* weak lensing requirements:
  ** $\sigma_z < 0.05 (1+z)$ <= photo-z
  ** $\sigma_{<z>} < 0.002 (1+z)$ <= photo-z + spectroscopic-z of subsample
* COSMOSの場合: Ilbert+ 2009
  ** 30 bands photo-z
  ** $\sigma_z = 0.007 (1+z)$を達成
  ** ただし、天体はEuclidの典型的な銀河より明るい、outliersを20%くらい除去している(photometryが悪いところとか)ことに注意。一方バンド毎のPSFが異なるのを処理しないといけないので、その点はEuclidの方が有利
* simulation: depths in optical ground-based observations are important to improve σ_z
* spec-z calibration: need many fields to avoid the effect of large-scale structure
* Galactic extinctionを誤って補正すると大きな問題になる -- need ‘internal’ extinction correction
* 異なるzの天体が重なった場合: 天体が同じくらいの明るさだとredshiftを大きく誤る可能性。lensing analysisでそういった天体を除去する必要。

* 可視のmultiband dataとしてはPanStarrsを想定しているらしい。(PS2 or PS3 21.5-22 AB)

[Garill: spectroscopy simulator]
* end-to-end simulation: mock galaxy catalog, instrument parameters, pointing definition => 2D image (for slitless case) and simulated spectra
* DMD case: 35% objects are selected
* spec-z reliability: 85% for slitless, 90% for spectroscopy
* slitless case: contamination of spectra is a serious problem:
  ** roll-angle approach or multiple filters

[Kitching: imaging simulator]
* end-to-end simulation: N-body simulation result, shear, PSF => simulate image => shear measurement
* N-body: Teyssier 2007 large number of particles, ray-tracing for WL map
* PSF simulator: optical component, AOCS (pointing)

[その他]

[Laureijs: Planck status]
* objective: ΔT~5uK, angular scale > 5', all-sky polarization (I, U, Q)
* additional science: S-Z for 10^3 of rich clusters, >10^4 extragalactic sources, galaxy map at 30-10^3 GHz
* 1.5m aperture, 5' resolution
* SEL2, 1deg./ 1 day, 1 revolution / min.
* passive cooling to 48K, then cryocoolers
* 2009/5/14 launch, 2009/7/3 100 mK reached
* sensitivity: good as expected
* life time current estimation: ~ Jan 2012

[WISHについてのコメント]

* Euclidとの差異は?

* Euclidとは独立にやるのか？JDEMとは?

* Euclidと共同できるか? Imaging componentとか?

* 1.5mは大きい

* passive coolingでmirror 100Kはいけるだろう