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SPM-TWIN TELESCOPES: PROJECT OVERVIEW

J. Jesús González[1] and The SPM-Twin Project Team

RESUMEN

Se presenta el Proyecto de los Telescopios Gemelos en SPM. Esta es una iniciativa internacional que consiste en un par de telescopios de 6.5-m en el Observatorio Astronómico Nacional en San Pedro Mártir (SPM) cuyo fin es el de proporcionar una plataforma flexible y altamente competitiva para nuevos descubrimientos. El proyecto se enfoca a nichos científicos técnicamente difíciles de resolver con los telescopios de mayor apertura existentes o en construcción, y al mismo tiempo explota la superioridad del sitio de SPM. La pareja de telescopios que constituyen el proyecto se basan en el concepto comprobado y altamente eficiente del telescopio Magallanes, pero cada uno bajo una diferente optimización, con el propósito de cubrir dos aspectos complementarios, y a la vez mutuamente excluyentes: (a) el "Telescopio de Campo Estándar" (SFT) abarcaría un campo visual de $15' - 30'$, capaz de observar desde el óptico hasta el infrarrojo térmico ($0.4 - 24\,\mu$m) y estaría preparado para óptica adaptiva, y (b) el "Telescopio de Gran Campo" (WFT) con campo visual de $1.5°$ o mayor, capaz de realizar espectroscopía de objetos múltiples, espectroscopía de unidad de campo integral (IFU), y potencialmente también obtener imágenes en banda angosta; la espectroscopía en el WFT se extendería desde 0.36 a 1.8 μm y contendría varios miles de fibras.

ABSTRACT

The SPM-Twin Project is an international initiative for a pair of 6.5-m telescopes, at the San Pedro Mártir Observatory (SPM), to provide a limber, and highly competitive, platform for discovery by focusing on scientific niches technically difficult for existing or planned larger aperture telescopes, and by exploiting the superiority of the SPM site. The telescopes are based on the proven and highly efficient Magellan concept, but each with a distinct optimization to cover two complementary but mutually exclusive aspects: (a) the "Standard Field Telescope" would have a field of view of $15' - 30'$, capable of observing in the optical through the thermal infrared ($0.4 - 24\,\mu$m) and prepared for adaptive optics, and (b) the "Wide Field Telescope" (WFT) with a field of view of $1.5°$ or more, capable of multi-object fiber spectroscopy, integral field unit (IFU) spectroscopy, and potentially narrow-band imaging as well. The WFT spectroscopy would extend from 0.36 to 1.8 μm, and would contain several thousand fibers. We present a general overview of the project.

Key Words: **TELESCOPES**

1. INTRODUCTION

The SPM-Twin Telescope project is an international initiative for a pair of 6.5-m telescopes for the San Pedro Mártir Observatory (SPM) that will provide a limber platform for discovery to the astrophysical community in the current and coming eras, characterized by 8-m – 10-m aperture telescopes and Extremely Large Telescopes (ELT). The SPM-Twin performance advantage is achieved by focusing on scientific niches technically difficult for existing or planned larger aperture telescopes and by exploiting the superiority of the SPM site.

The site atop the Sierra of San Pedro Mártir, is among the best four areas worldwide suitable for astronomical observations, together with the Hawaiian and Canarian islands in the northern hemisphere and the north of Chile in the southern hemisphere. In particular, SPM excels in the transparency and darkness of the night sky, in the percentage of clear nights and in the natural image quality and stability. But, unlike the other sites, it is yet to host large next-generation telescopes, and to reach its destiny as a world-class observatory. The SPM-Twin initiative represents the first and more secure step towards the optimal scientific exploitation and development of the SPM site, through a cost-effective short-time scale and extremely competitive project.

The first SPM-Twin 6.5-m telescope (WFT) is to be optimized for wide and integral field spectroscopy (optical and near infrared) and wide-field narrow-band imaging, with a potential field of view significantly greater than one degree in diameter. The second 6.5-m telescope (SFT) is a more conventional

[1]Instituto de Astronomía, Universidad Nacional Autónoma de México, Apdo. Postal 70–264, D. F. 04510, México (jesus@astroscu.unam.mx).

Standard Field facility for generic science projects to naturally complement the WFT with a finer image quality, a far better infrared performance, and more suitable for high spatial resolution (adaptive optics) capabilities for diffraction-limited images in the future, over a moderate field of view. In this fashion, the SPM-Twin project aims for the uncompromising wavelength coverage from 0.32 to about 28 μm, with well-balanced, integrally designed instrumentation.

The project plans to adopt proven successful concepts from the Magellan and MMT telescopes, to minimize the level of non-recurring engineering (NRE) and to concentrate the efforts on the key novel or unsolved aspects of a fully integral concept. The integrated design approach of SPM-Twin optimizes the telescopes simultaneously for optical performance, scientific potential, data handling and operations.

The investment needed for the procurement of the SPM-Twin facility is estimated at 160 million US Dollars, given the previous development and experience of Magellan and MMT, and can be completed in six to seven years. The potential partnership consists of Mexico, Korea, the universities of Arizona, Princeton, Florida and Central Florida in the US, and Durham University in the UK. Several other interested parties including the University of Alabama, the University of California, and the University of Illinois are present at this meeting and involved in the discussions.

2. THE SCIENCE OF THE SPM-TWIN PROJECT

New telescope facilities, and their associated instrumentation, attempt to improve along three directions: larger collecting area, better resolution in wider fields, and broader wavelength coverage. Unfortunately, for a given resolution and sampling performance, telescope aperture and covered field compete against each other. On the other hand, from the point of view of the relevant scientific drivers, both wide-field and high-spatial resolution optical-IR telescopes are the most needed tools to address key astronomical questions.

SPM-Twin is not just another large telescope, but a concept that concentrates on scientific niches that are technically unreachable for Extremely Large Telescopes (ELTs) or that cannot be easily tackled by other general purpose Very Large Telescopes (VLTs) of similar aperture. More specifically, among the relevant and unique scientific contributions and goals of this highly-optimized complementary-telescope pair are:

- To complete a series of nested surveys that can uniquely contribute to solve major astronomical issues such as the nature of Dark Energy and Dark Matter, and the details of the formation and evolution of galaxies, stars and chemical elements (e. g., Yamamoto et al. 2006). In particular:
  - Redshift survey of a million galaxies to constrain the Dark Matter equation of state.
  - Survey of extragalactic spectra within 6.5 billion years (z$\sim$1) to determine their evolutionary state and the large-scale structure of the Universe at these scales.
  - Spectroscopic survey with finite spatial resolution to measure the dynamics (masses) of intermediate-distance galaxies.
  - A simultaneous survey of the detailed structure of thousands of extended galaxies within 150 Mpc, providing also the key connection between observables of local objects with those in the distant universe.
  - A mapping of tens of thousands stars in the solar neighborhood, that are members of the first stellar generation of the galactic disk, tracing the genesis and evolution of our own galaxy.
- To complement and follow up these surveys and their additional serendipitous results with studies requiring detailed observations, deeper exposure times or other instrumentation or techniques.
- To contribute significantly not only to the detection but also to the deeper characterization of extra-solar planets.
- To be capable of observing all kinds of astronomical objects, from the visible to the mid-infrared, within the limitations of the Earth's atmosphere up to the diffraction limit of a large aperture telescope.
- To give the SPM-Twin community prompt access to a large-aperture, first-class facility to carry out hundreds of their potential astronomical projects and, particularly relevant to Mexico and Korea, access to competitive telescopes needed for the solidification and significant growth of astronomical research nationwide.

This list shows why the scientific keyword of the SPM-Twin project is the study of EVOLUTION and STRUCTURE by looking at the Universe at many of its scales, starting from detailed studies in the solar neighborhood and within our own galaxy, through stellar systems in the local universe, and up to the study of the distant universe, its structures and the nature of forces, mass and energy that govern its formation and evolution. Far beyond these short

Fig. 1. A map of the location of SPM and Ensenada.

statements, the dedicated articles to the specific science for the WFT and SFT telescopes by Terlevich (2007) and Richer (2007), respectively, as well as many other contributions in this volume detail the relevant scientific impact of the SPM-Twin facility.

3. THE SPM SITE

The Observatorio Astronómico Nacional (OAN) in the Sierra de San Pedro Mártir in Baja California, México, has been developed and operated by IA-UNAM for over three decades. Support facilities are located in the city of Ensenada, which is some 100 km from the US border, where the UNAM also has first-class research departments in Physics and Astronomy. These civil and human infrastructures provide a very solid support for the SPM-Twin development and operations.

The observatory is reached from Ensenada by a 250 km road, paved except for the final kilometers (inside the national park). This is the only ground access to the OAN, and the closest settlement along the road is a ranch 40 km away.

3.1. *Artificial light pollution*

The OAN is located within the National Park "Sierra de San Pedro Mártir", where 3055 hectares including the present grounds of the observatory are reserved for exclusive astronomical use. This is an important buffer zone and a major advantage over other sites, particularly those in the US, for the development of astronomy projects. The isolation of SPM is evident from night-time satellite images. The closest urban center to SPM, the port of San Felipe to the East, has a population close to 10,000 and is 56 km from the OAN as the crow flies. It does not add significantly to sky brightness. Urban centers with populations close to or exceeding 500,000 inhabitants (Ensenada, Tijuana, San Diego and Mexicali) are at least 90 km to the north. Only Mexicali is in the line of sight of the highest point at the OAN. Dispersed light from it can only be seen in the horizon.

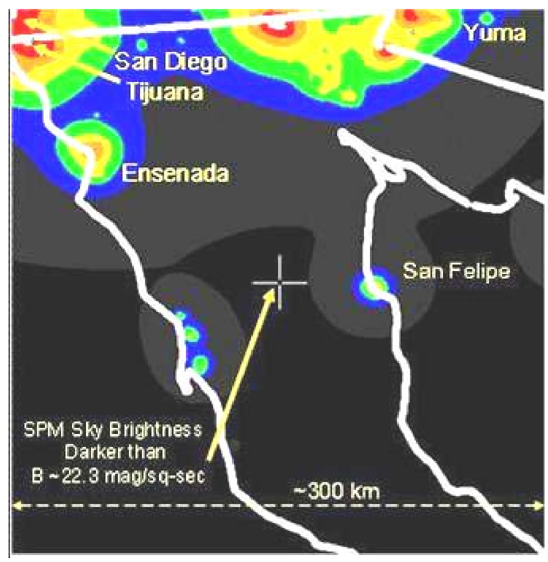

Fig. 2. Present-day isophotes of artificial light pollution.

Current illumination practices are not invasive and use efficient lamps and shades. But since growth is expected, UNAM promoted a project to control the use of urban, tourist, and industrial illumina-

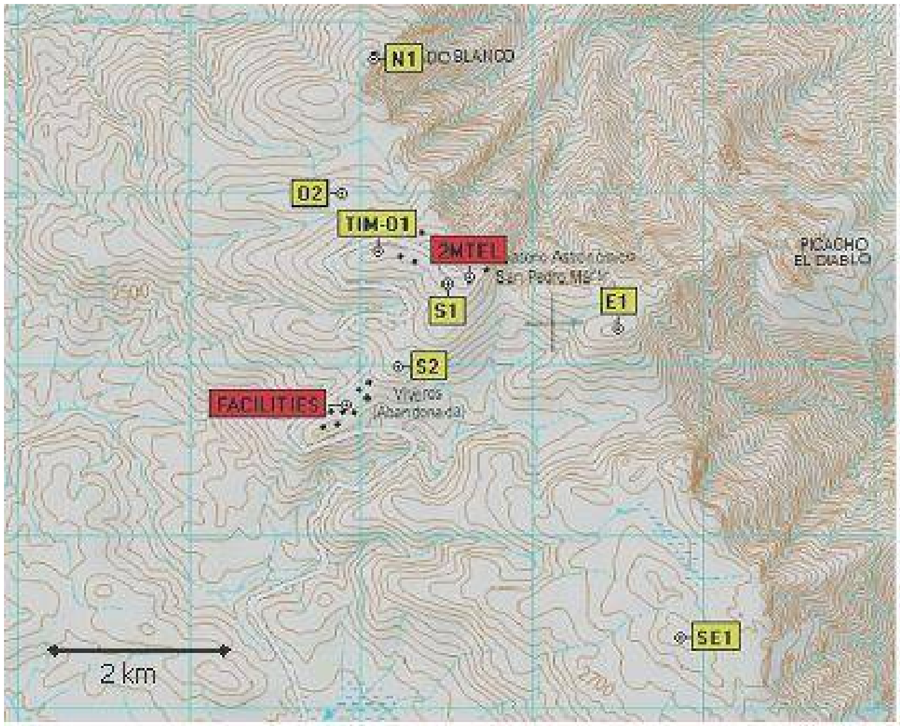

Fig. 3. SPM offers numerous potential sites for large-telescope facilities. Among the several that have been tested, SPM-Twin will be located at site labeled TIM-01, not far from the OAN 1.5-m telescope.

tion, whose details have been worked out with the local authorities. Ensenada recently approved the local ordinance for the "Ley del Cielo" (Sky Darkness Law). The governor of the state of Baja California fully supports this initiative, and is promoting the establishment of similar state and municipal ordinances in the rest of the state, where night sky is explicitly mentioned as a protected resource. In the near future we expect to reach an agreement with the national government in order to eliminate commercial flights above SPM.

Demographic statistics for the five largest cities in Baja California and small communities closer to the Observatory, predict that compared to 2005, urban population would be roughly 1.3 times larger when SPM-Twin starts operations around 2013. Night sky illumination would increase by a similar factor if current trends and practices continue. These are upper limits, since growth rates will decline as it becomes increasingly difficult to provide services. Night sky illumination will certainly deteriorate much less, as the municipal and state laws are enforced throughout Baja California in the near future. In any case, it should be remarked that the present night sky brightness at SPM is well below the levels at most other astronomical sites.

3.2. *Astronomical site evaluation of SPM*

The astronomical site evaluation of SPM has been extensively described in a dedicated volume by Cruz-González, Avila, & Tapia (2003) and in Tapia (2007). In terms of percentage of clear and usable nights, the Erasmus & van Staedel (2003) report, based upon a long-term survey of the atmospheric conditions at a large number of potential astronomical sites, found SPM to be the best in the Northern Hemisphere. They also report a mean precipitable water vapor (PWV) at SPM of 2.63 mm. In the Northern Hemisphere and excluding mid-summer, they find lower PWV only for Mauna Kea (2.02 mm) and Olancha in Northern California (1.53 mm), both at considerably higher altitudes (∼4000m).

Sky brightness shows SPM as the second darkest site in the Northern Hemisphere after Mauna Kea. A comparison of the atmospheric extinction k_y at 549 nm with La Silla and Cerro Tololo in Chile, and Kitt Peak, McDonald and Mauna Kea in the US, shows that only Mauna Kea has less extinction than SPM during photometric nights. When SPM is compared with 17 major astronomical sites worldwide where seeing has been measured with DIMM instruments (Michel et al. 2003), SPM clearly ranks among the best. Monthly variations of high-altitude wind veloc-

Fig. 4. The selected site for the SPM-Twin Telescopes at +31° 2.72′ N, 115° 28.086′ W, at an altitude of 2800 m, has been extensively characterized and is well documented.

ity (Carrasco & Sarazin 2003) show that San Pedro Mártir and Mauna Kea are comparable and among the most suitable sites to apply slow wavefront corrugation correction techniques.

These qualities have already been appreciated by two of the largest ground-based astronomy projects under development. The Thirty Meter Telescope Project is currently measuring local sky and weather conditions on a small number of short-listed sites, in Chile and at Mauna Kea and SPM in the Northern Hemisphere. The Large Synoptic Survey Telescope (LSST) also considered SPM and Cerro Pachón in Chile as its two final locations.

3.3. *SPM infrastructure*

The OAN has been operating in SPM since 1970. A vast experience has been accumulated during this time, and the staff efficiently deals not only with the everyday chores of supplying the observatory but also with exceptional circumstances, such as large snow or rainstorms, health emergencies, etc.

The Observatory is connected to Ensenada and the outside world through a microwave link followed by an optical fiber; the bandwidth of the entire connection is 2 Mbps.

To match the excellent astronomical site with first class infrastructure, significant investments have been made over the last few years to improve the facilities available at the summit and the access road. There is a new residence with 42 bedrooms, along with kitchen, dining, laundry, computing and leisure facilities.

All these provide a very good and reliable material base for the development of new ambitious astronomy projects such as SPM-Twin. Nevertheless, it is advisable to make important upgrades in communications. UNAM plans to increase bandwidth by a factor of 5 (up to 16 Mbps) by 2007. A high-speed 2 Gbps fiber-optic connection to San Diego via Ensenada will be a costly, but eventually necessary, investment. Were the power requirements to significantly exceed the current generating capacity (beyond 250 KVA or so) it would also be sensible to consider connecting to the national electricity grid.

3.4. *The SPM-Twin Telescopes site within San Pedro Mártir*

The OAN occupies about 500 hectares at the eastern edge of SPM. The National Park is a 72,900 hectare area of which slightly more than 3,055 hectares, centered at OAN, are reserved exclusively for Astronomical research. There are at least seven potential sites for large-telescope facilities. Among them, the proposed site for SPM-Twin (named TIM-O1) has been extensively characterized and documented.

A detailed geological study of the SPM-Twin site was recently conducted (Sánchez et al. 2003). The stratographic profile shows a 10–12 meter thick layer, at a depth between 1.3 and 3.0 meters, that is adequate to support the entire structure of a large telescope, due to its high load-bearing capacity. Furthermore, this layer was found to be suitable for electric grounding due to its low resistivity.

4. SPM-TWIN GENERAL TECHNICAL CONCEPT

Among relevant top-level requirements of the SPM-Twin Project for its technical definition are:

1. **Large Grasp Concept:** SPM-Twin large grasp (product of aperture, efficiency, multiplex advantage, field-of-view and pass-band) makes it possible to explore a unique discovery space in the ELT era.

2. **Integrated Design:** Telescopes will be designed simultaneously with their major instrumentation, guaranteeing robust performance and minimizing overheads and compromises in each telescope.

3. **Risk mitigation:** By exploiting highly successful existing designs, the SPM-Twin facility performance is guaranteed.

4. **Fast Schedule:** Focusing efforts mostly on the new developments required for the science programs, the schedule to build SPM-Twin should be relatively short, i.e., of the order of five to seven years.

5. **Economy:** By maximally exploiting existing designs, non-recurring engineering costs are minimized. The integrated engineering approach will simplify operations once scientific observations commence, saving operations costs.

The main scientific requirements for the Instrumentation are summarized in Table 1.

4.1. *Technical Concept based on MMT & Magellan*

The SPM-Twin 6.5-m telescopes capitalize on the present status of the Magellan & MMT telescopes, as a starting base reference to reach the goals of the SPM-Twin Telescopes Project. The top-level requirements previously described translate cleanly into instrumental requirements met in principle with a choice of MMT/Magellan design options that minimize the required NRE. More specifically:

• **Requirements for good thermal design for the SFT and large FoV for the WFT require different optical designs for these two telescopes:** It is impossible to simultaneously satisfy constraints on emissivity for mid-infrared capabilities and requirements for wide field performance in the same telescope design. The MMT has achieved this goal at the expense of considerable operational complexity. Following the integrated design principle, SPM-Twin separates the optimal IR and wide field features between the SFT and the WFT. Both telescopes will, however, use the same kind of MMT/Magellan primary mirror and cell.

• **MMT/Magellan F/15 Cassegrain Design:** The SFT must be a thermally clean design that will permit observation well into the mid-IR ($\sim 28\,\mu m$). The MMT/Magellan F/15 design, if optimized for low emissivity, will be a very clean IR telescope.

• **MMT F/15 Adaptive Optic (AO) Secondary:** The signal-to-noise for a telescope improves as the aperture diameter to the fourth power (D^4) with AO, but only as the second power (D^2) in seeing limited operation; i. e., without AO. Any future infrared telescope will require AO to compete effectively with other astronomical facilities in the ELT era. The MMT AO F/15 secondary is now in operation providing a clean, efficient, diffraction-limited PSF to the MMT focal plane. The AO secondary of the SPM-Twin SFT telescope can be designed for bi-conjugated AO tuned to SPM, and could consider a mode for ground-layer correction for sub-seeing wide-field routine operations, once these promising techniques become of age on the timescale of the Twin project.

• **The SFT will be configurable to general observing modes:** While the intended use for AO on the SFT is near- to mid-infrared observing, the design will incorporate the Nasmyth and pseudo-Nasmyth accommodations in the mirror cell. Accommodation for the support of a tertiary mirror and an F/11 Gregorian secondary are included in the baseline design.

• **The WFT Cassegrain port can be fed with a copy of the MMT/Magellan WFC:** At first light, the Cassegrain location of the WFT could be instrumented with a copy of the MMT/Magellan WFC which provides a spectroscopic, curved 1° FoV focal plane with atmospheric dispersion compensation suitable for multi-object spectrographs like Hectospec or deployable Integral Field Units (IFUs). The WFC can be reconfigured to provide a flat $\frac{1}{2}^\circ$ imager. The Cassegrain hole in the primary mirror and the mirror cell should be designed to make it possible to expand the FoV to 2°, to accommodate the 1.5° WFC corrector, and for the later generations of extremely wide-field focal plane instrumentation, like the WFMOS effort of the Gemini and Subaru Observatories (also known as KAOS).

• **The WFT focal ratio must feed optical fibers efficiently:** The prime focal plane instrument of the WFT will be a fiber-fed, multi-object spectrograph with deployable integral field units (IFUs). To feed optical fibers efficiently, the WFT must have the ca-

TABLE 1

GENERAL SPM-TWIN INSTRUMENT CONCEPT

	Wide-Field Telescope (WFT) (Modified Magellan/MMT)	Standard Field Telescope (SFT) (Updated Magellan/MMT)
Optimized for:	Wide-Integral-Field Spectroscopy	Multi-purpose Seeing-limited Visible-IR Astronomy and AO prepared
Field of view:	$\Phi \geq \sim 1.5^\circ$	$\Phi \sim 1.5'$ (seeing limited) $\Phi \sim 1'$ (with AO)
Operation Range:	Visible to NIR (0.32–1.8μm)	Visible to Mid-IR ($\sim 0.4 - 28\mu$m)
Spatial Resolutions	Seeing-limited (Narrow-Band imaging) $\sim 1'' - 3''$ Spaxel-limited sampling (Integral-Field Spectroscopy)	Seeing-limited (normal mode) Diffraction limited (AO mode)
Spectral Resolutions	~ 4000 (IF Spectroscopy) $\leq \sim 1000$ (Tunable N-B imaging)	Wide range (science instrument suite)
1^{st} Generation Instrumentation	a) Wide-Field & Atmospheric Dispersion Corrector system b) Deployable single-spaxel and Integral-Field units, coupled to a suit of spectrographs, for simultaneous full-range spectra spectra of thousands of objects c) Wide-Field Imager (Tunable Narrow-Band)	a) Secondary set (Nass/Cass/AO) b) High-Resolution Visible & Near-Infrared Spectrographs c) NIR/AO Science Instrument d) Mid-IR New-Generation Instrument Ready to accommodate: (i) Artificial-Star System & Adaptive secondary mirror (ii) Guest & Replicated Instruments

pability to operate at a focal ratio between F/4 - F/6. The MMT/Magellan WFC has been designed to provide an optimal F/5 focal ratio, and use of this design will minimize cost, risk, and schedule.

• **SPM-Twin will support Nasmyth and pseudo-Nasmyth ports:** The telescopes must be flexible enough to respond to new instrumentation. It is also essential that opportunities exist for small, experimental or highly targeted instruments to be mounted without interfering with the core observations and increasing the operation overhead on the support staff. This requirement is met by having an F/11 Gregorian mode with a rotatable tertiary, similar to that at the Clay telescope.

• **Changeover from F/5 Cassegrain to F/11 Gregorian must be fast and straightforward:** Changing between modes in the same station should proceed extremely rapidly. Going from F/5 to F/11 requires secondary exchange and deployment of a tertiary mirror/ADC. The mechanical interface should be very simple and an integral alignment system will make it possible to change modes in less than a day. This requirement is not met by either of the two Magellan designs, and some NRE will be required to achieve this goal.

• **Major focal plane instrumentation will be changed very infrequently:** The combination of Cassegrain, Nasmyth and pseudo-Nasmyth port makes it possible to leave instrumentation in place until it is removed for service or replacement. While there may be frequent changes between instruments that are mounted on the pseudo-Nasmyth ports, these instruments are expected to be small packages supported by the instrument teams that conceive and build them. The major instruments at the Cassegrain and Nasmyth port are "permanent" and activities in support of smaller instruments never need interfere with their operation.

• **Utilizing the MMT/Magellan configurations makes it possible to have existing matching instrumentation visit SPM-Twin:** Taking wide-field instrumentation as an example, the Smithsonian Astrophysical Observatory (SAO) has a program underway to develop several instruments for the MMT/Magellan F/5. MegaCam, a $0.5° \times 0.5°$ CCD imager has been in use at the MMT since 2003, and will be shared with Magellan when the Magellan WFC is completed in 2006. SAO is currently building MMIRS, an infrared multi-slit spectrograph similar to Flamingos II, which will be used at the MMT and Magellan. Given their matching configurations, it will be possible to explore sharing present and future instrumentation efforts and visiting-instrument programs among SPM-Twin, Magellan and MMT. This may also be of relevance to SPM-Twin to guarantee good science at first light.

4.2. *Building and Telescope Structures*

SPM-Twin adopts the Magellan Building and Telescope designs. The SPM-Twin acquires through its partnership with the University of Arizona (a member of the Magellan Consortium) the drawings and documentation of the detailed design of the Magellan telescopes and will update, and potentially upgrade, these designs before starting construction.

Figures 5 and 6 show the domes and buildings (as constructed) as well as the telescope structure (at the L&F factory) and an example of the detailed drawings of Magellan.

4.3. *Optical Design for the SPM-Twin Wide-Field Telescope*

Unlike the SFT which is basically an updated clone of the Magellan Design, the spectroscopic WFT will be the first of its class, so its technical feasibility under a Magellan-like concept had to be further investigated. In particular, it was important to verify that a telescope very similar to Magellan could deliver fields as large or larger than 1.5° under spectroscopic requirements.

A detailed discussion of the merits of different optical solutions is presented in González & Orlov (2007).

4.3.1. *WFT Field Integration*

There are around 24 million square arc-seconds in the 1.5° field-of-view of the SPM-Twin WFT, so it is technically impossible to attempt to cover this field with spatial probes or "spaxels" only a few arc-seconds in diameter. Therefore, the WFT will be sampling its wide field and broad spectral range (0.36–1.8 μm) with two complementary techniques:

1. Full wavelength coverage, at moderate and high spectral resolutions, for thousands spatial pixels ("spaxels"). The three spectral octaves will be covered with multiple spectrographs fed by optical fibers. The base spectral resolution is close to the natural line-width of star-forming emission-line regions ($R \equiv \lambda/\Delta\lambda \sim 4000$), and the spaxel dimension will be such as to maximize the throughput of unresolved extragalactic sources (between 1 and 3 arcseconds).

2. Full spatial sub-arcsecond sampling of the field at limited wavelength resolution and coverage. LSST, Pan Stars and other ambitious wide-field imaging projects will provide full and deep sky surveys with broad filters ($\Delta\lambda > 100$ angstroms) while low-order, variable-gap Fabry-Perot interferometers known as tunable filters will give the WFT the capability for wide-field, narrow-band imaging ($\Delta\lambda \sim 10$ angstroms), adjustable to any wavelength within the WFT spectral range.

While tunable-filters are already installed on large telescope instruments such as the IMACS and OSIRIS instruments (on Magellan and GTC respectively), the spectroscopic field integration is the most challenging and demanding aspect of the SPM-Twin WFT, since no other working project plans, except for WFMOS (Smee et al. 2006) for as many fibers and wide wavelength coverage. Although there are many technical issues to resolve during the design phase of the WFT field integrator, the project attempts to sparsely cover the 1.5° field of view with three different samplings or spaxel distributions:

a) High-z and Stellar objects require several thousands of individual spaxels (sparse sampling) each with a limited patrol field):

- Super Sloan-like surveys (Dark Energy, Large Scale Structure)
- Stellar surveys (thick disk, Local Group stellar systems)
- Extragalactic Globular Cluster & Planetary Nebulae systems
- HII Regions in local-z galaxies

b) The Intermediate-z Universe and semi-crowded fields call for a few tens of relatively small IFUs (sparse with limited-continuous sampling) and relatively large patrol fields:

- Indicative galaxy dynamics, stellar-population/chemical gradients, and mass
- Indicative structure (notches, pair interaction, etc.)

c) The "local" 150 Mpc Universe. By installing a single, large IFU at the center of the WFT (see Figure 7) with continuous sampling of ~ 1 arc-minute, providing complete and deep 3-D (wavelength and spatial coverage) the above surveys can provide stud-

Fig. 5. The Magellan telescopes in operation at Las Campanas (left panel), showing the housing and common facility buildings. The right panel shows the telescope structure at the L&F factory.

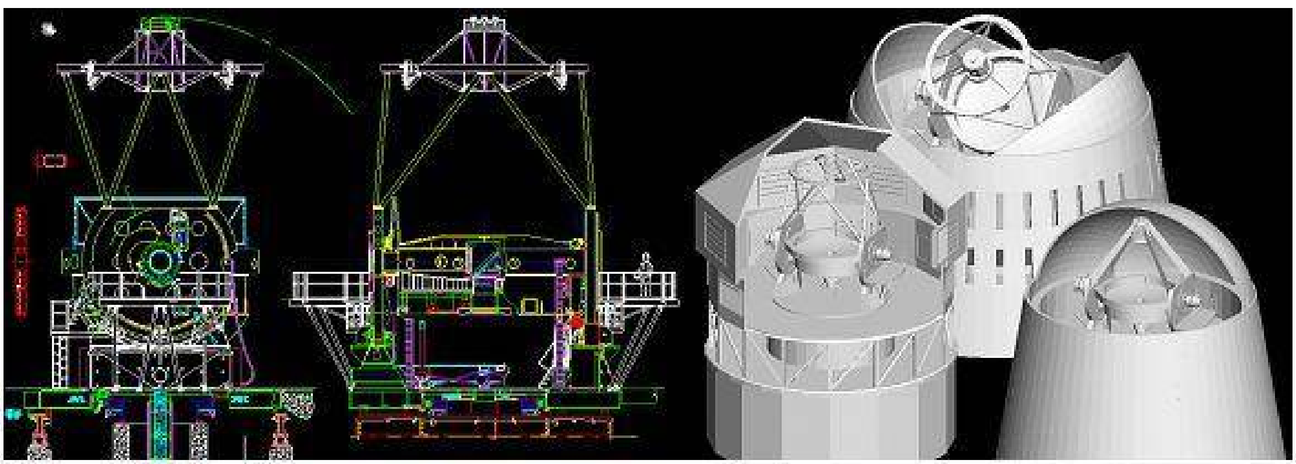

Fig. 6. Examples of detailed Magellan proprietary drawings and design updates. Some potential upgrades and optimizations are also shown: a higher building (for better seeing at SPM), wind-flow optimized dome, top-end of telescope optimizations for a wide-field secondary of WFT and low-emissivity SFT.

ies of tens of thousands of galactic objects and galaxies in the nearby Universe:

- Large galaxies (Milky Way satellites, field galaxies, groups and clusters of galaxies in the local universe)
- Extended galactic sources (HII regions, supernovae remnants, planetary nebulae, star clusters and star-forming regions, among others)

4.4. *Design for the SPM-Twin Standard Field Telescope*

The SFT is basically a straight copy of the Magellan concept, since this is a well-proven, highly efficient, general purpose and follow-up telescope. Magellan and MMT instruments and configurations can be adopted and interchanged, and SPM-Twin SFT may mostly build on the experience of these two highly successful projects.

The SFT will be constructed for first light just as a standard Magellan telescope, but being complementary to the WFT capabilities, and since adaptive-optics astronomy will be more and more relevant in the near future, the SPM-Twin SFT has to be prepared for AO once this technique becomes of age. As mentioned above, SPM is a very competitive site for AO Astronomy.

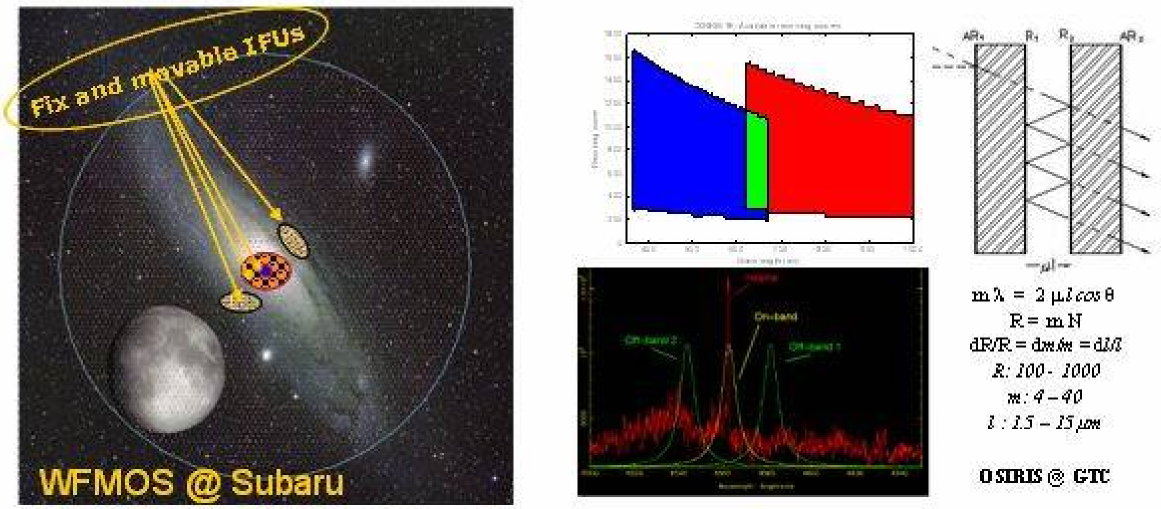

Fig. 7. WFT aims for complementary field and spectral coverage. Full wavelength range coverage, with carefully chosen spatial sampling, can be achieved by combining the sparse, point-like apertures of WFMOS (a project for the Subaru telescope) with a deployable and central IFU (left). On the other hand, full spatial coverage scanning a finite wavelength range is possible with narrow-band tunable imagers like OSIRIS on GTC (right panel).

5. FINAL REMARKS

To summarize, SPM-Twin is an extremely competitive, cost effective and fast deployable facility that takes full scientific advantage of the SPM virtues. The SPM-Twin partnership is a strong group of countries and institutions with the required expertise to successfully develop and operate this facility, and is now seeking the necessary funds for the detailed designs and construction.

A project like this would exploit fully SPM as one of the best and last pristine northern spots for ground-based astronomical observations, from the atmospheric cut-off in the UV to the thermal infrared.

The SPM-Twin initiative is the collective work of many individuals and the partnership institutions, a group too large to list. In particular, J. Bohigas, V. Orlov, E. Ruiz, A. Szentgyorgyi and R. Terlevich provided relevant input to this contribution.

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