Surface Composition of small NEOs in light of Chelyabinsk: Implications for Impact Hazard Assessment

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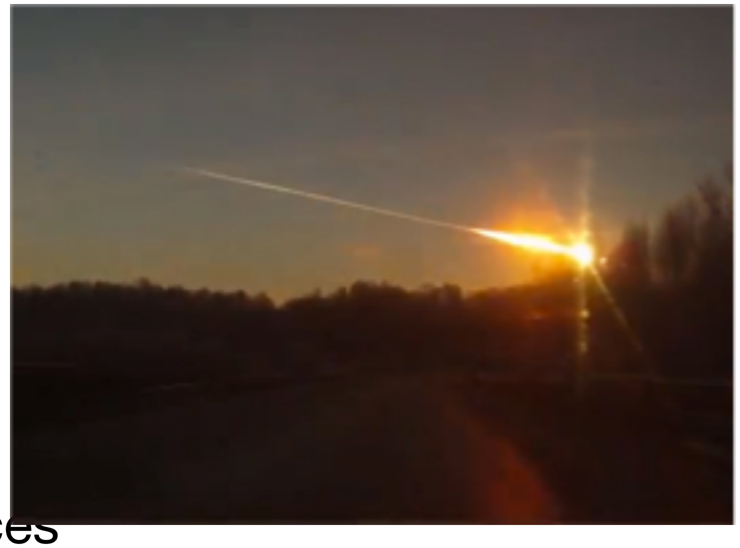
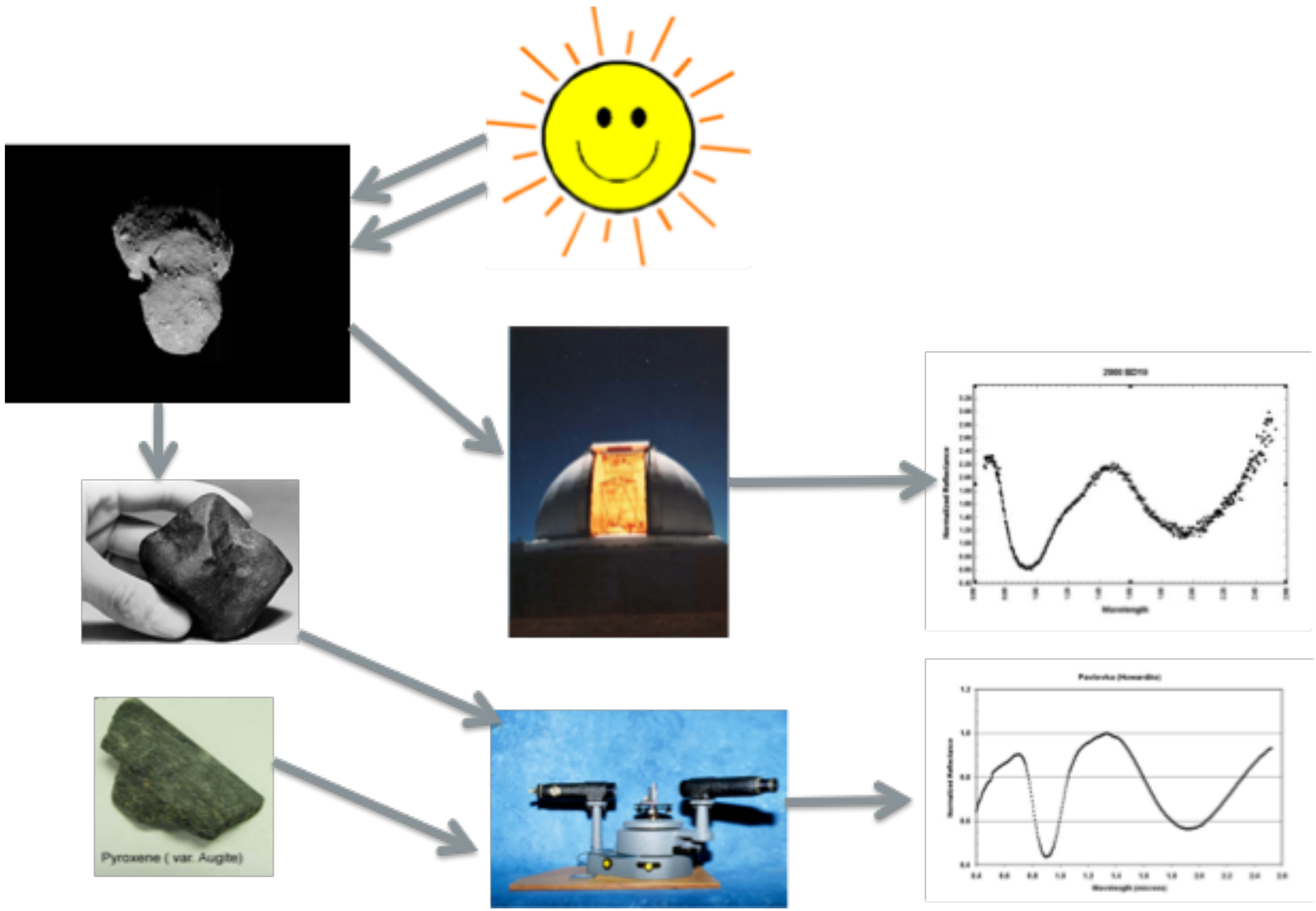


Spectroscopy 101



Chelyabinsk: What do we know so far?

- Composition similar to LL5 chondrite meteorites
- Type of ordinary chondrite (15% of OCs are LL Chondrite or 11% of all meteorites)
- Ordinary Chondrites are most common meteorites (72%)
- NEAs with LL chondrite composition more abundant (60%) Vernazza et al. (2008)
- Primarily derived from $\nu6$ resonance, Flora family.

Two distinct lithologies
65% LL5 and 35% Impact Melt
Compositionally indistinguishable

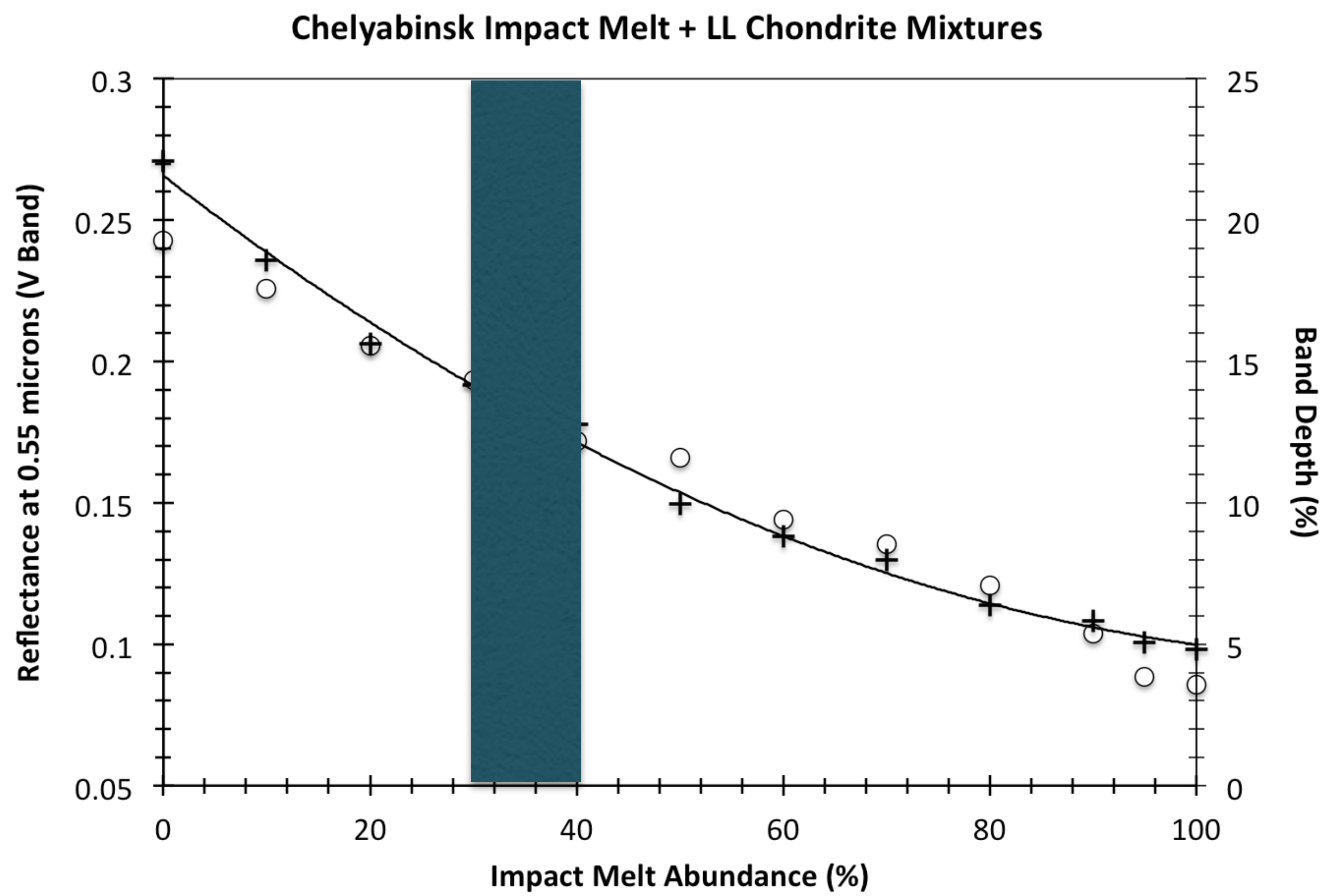
How would we have characterized the Chelyabinsk NEA had we discovered it prior to impact?

- Could we accurately classify the NEA in terms of taxonomy and mineralogy
- Unique opportunity to validate and calibrate characterization tools and protocols
- Main concern here is the effect of impact melt on spectra of NEAs and its implications for hazard assessment
- Impacts are very common in the asteroid population. Any 4-6 km/sec impact (35-40 GPa) would produce impact melt.
- Chelyabinsk is moderately shocked (S4) 30-35 GPa.

Only issue is that we don't have any spectra of Chelyabinsk NEA!

The Solution

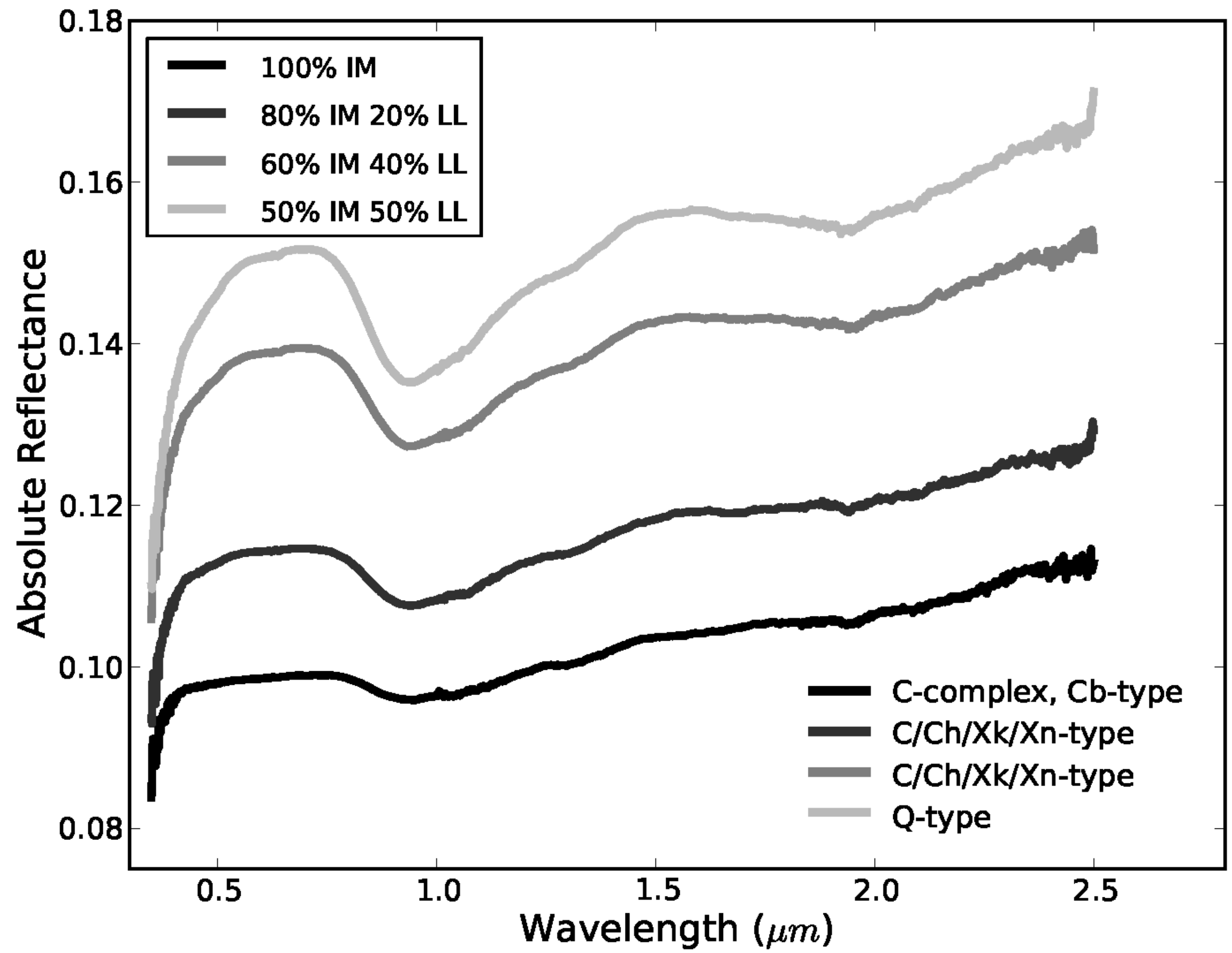
- We simply use the meteorite samples as proxy
- End members give us a hint as to how the asteroid might have looked like.
- Intimate mixtures are more representative of the real surface.
- Mixture of Impact melt and LL5 chondrites at 10% intervals
- Recall Chelyabinsk has ~60-70% LL and 30-40% IM



Impact melt can easily make a high albedo NEA into low albedo one without changing the composition

Taxonomy

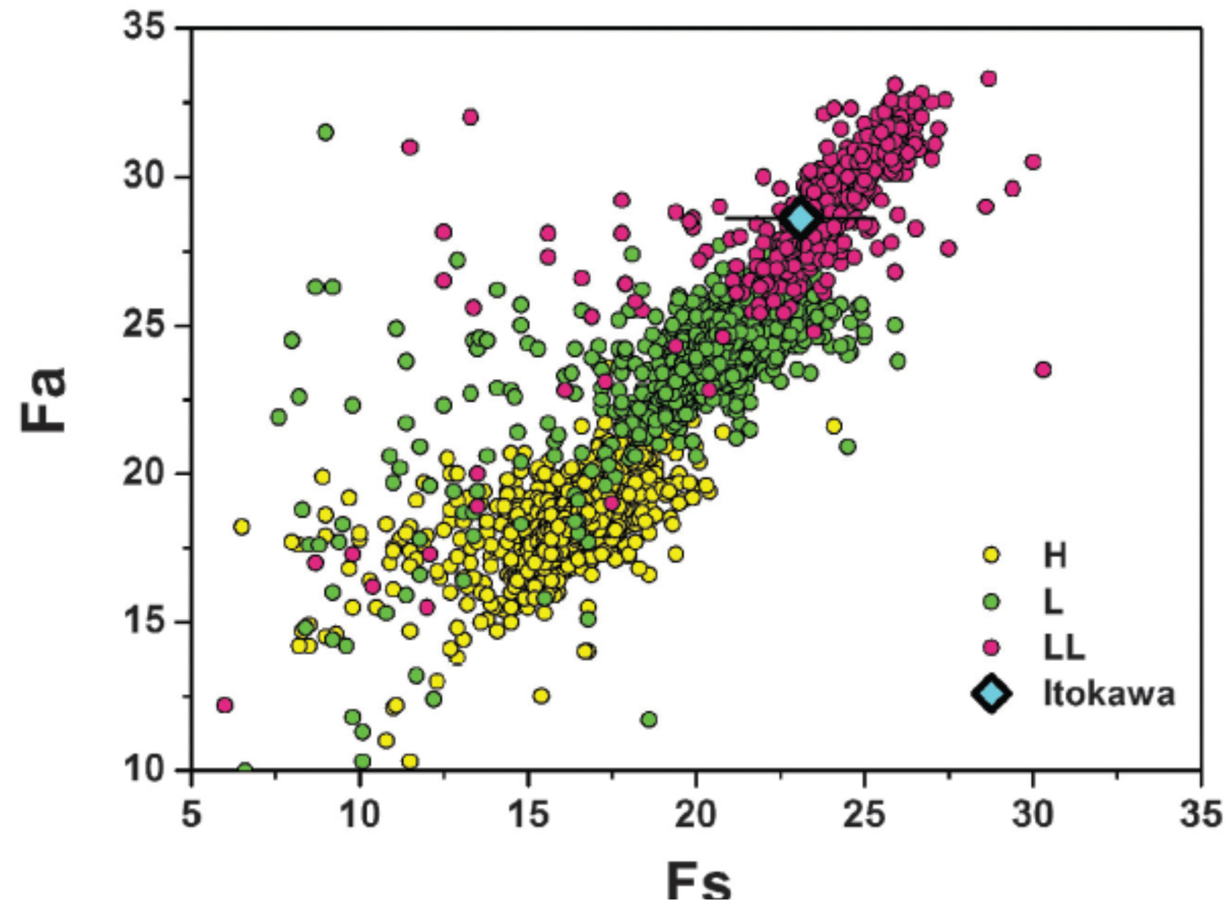
- Very useful tool for first cut physical characterization
- In the right hands it can be invaluable tool
- Bus-DeMeo Taxonomy: Latest
- Primarily made for asteroid spectra; not meteorite spectra
- Albedo and/or intensity of the absorption bands (if present) are parameters normally used for taxonomic classification

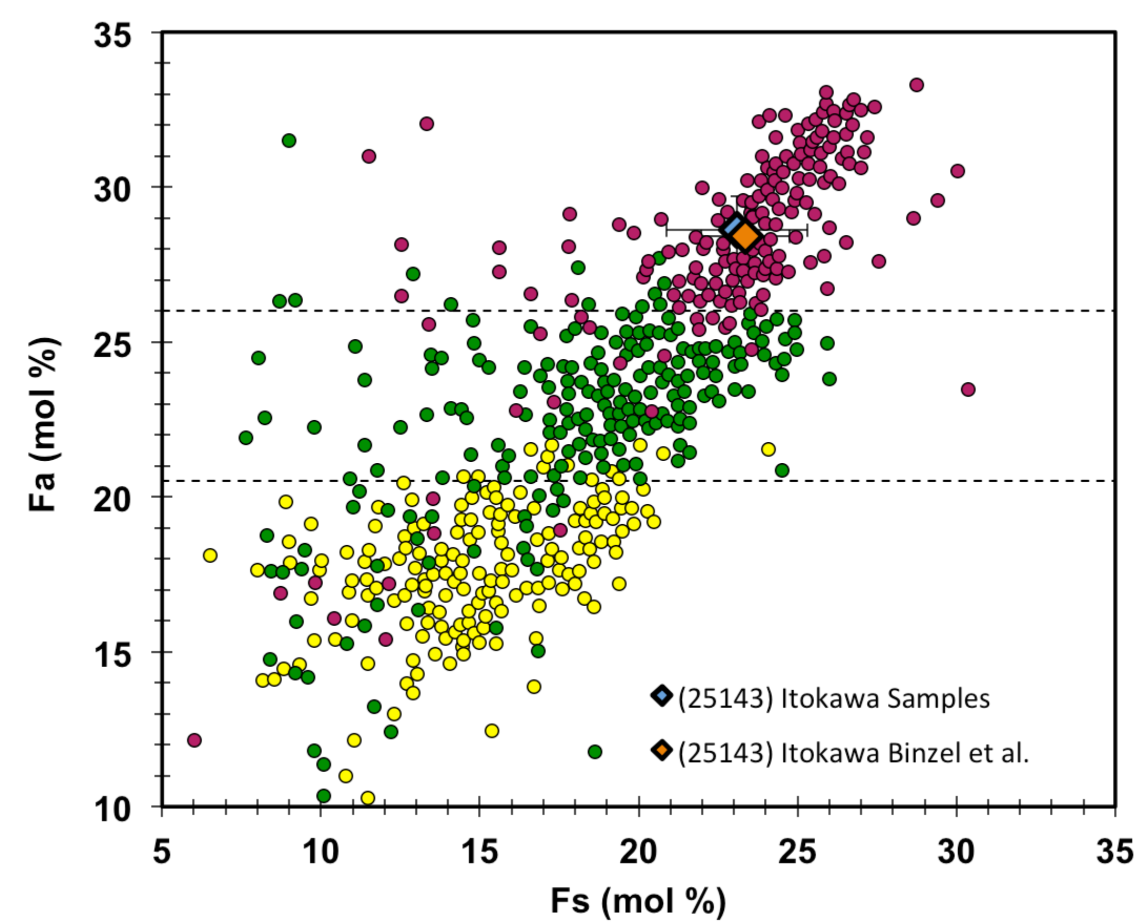


Taxonomy would have accurately identified Chelyabinsk

Mineralogy

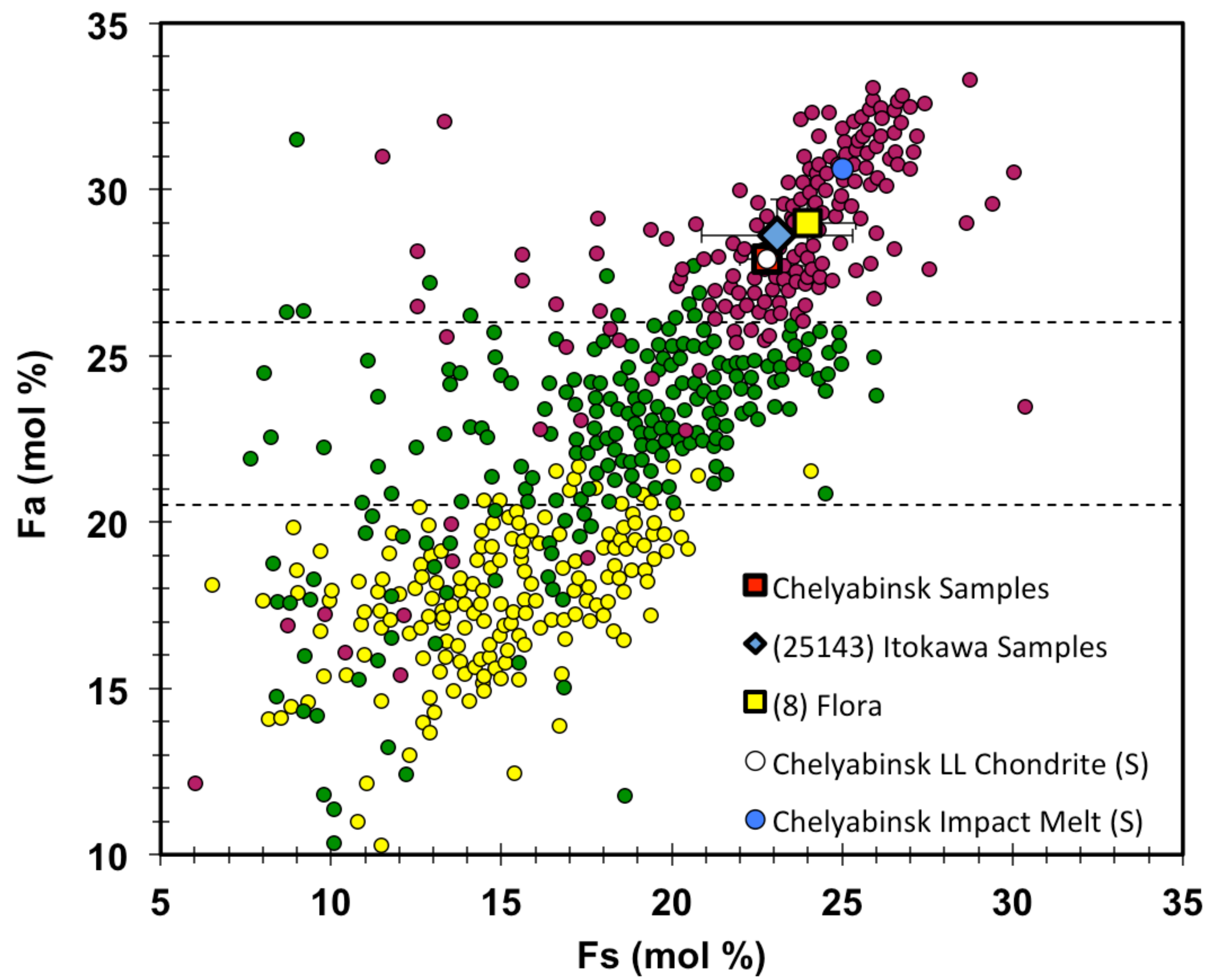
- Surface mineralogy is diagnostic for establishing compositional link
- Hazards: Meteorite analog, density
- H, L and LL ordinary chondrites have varying iron abundance in olivine and pyroxene (redox state)
- Olivine (Fayalite) and Pyroxene (Ferrosillite)
- Dunn et al. (2010) equations for extracting Fa Fs from spectral parameters
- How valid are these equations? Itokawa Study





Chelyabinsk

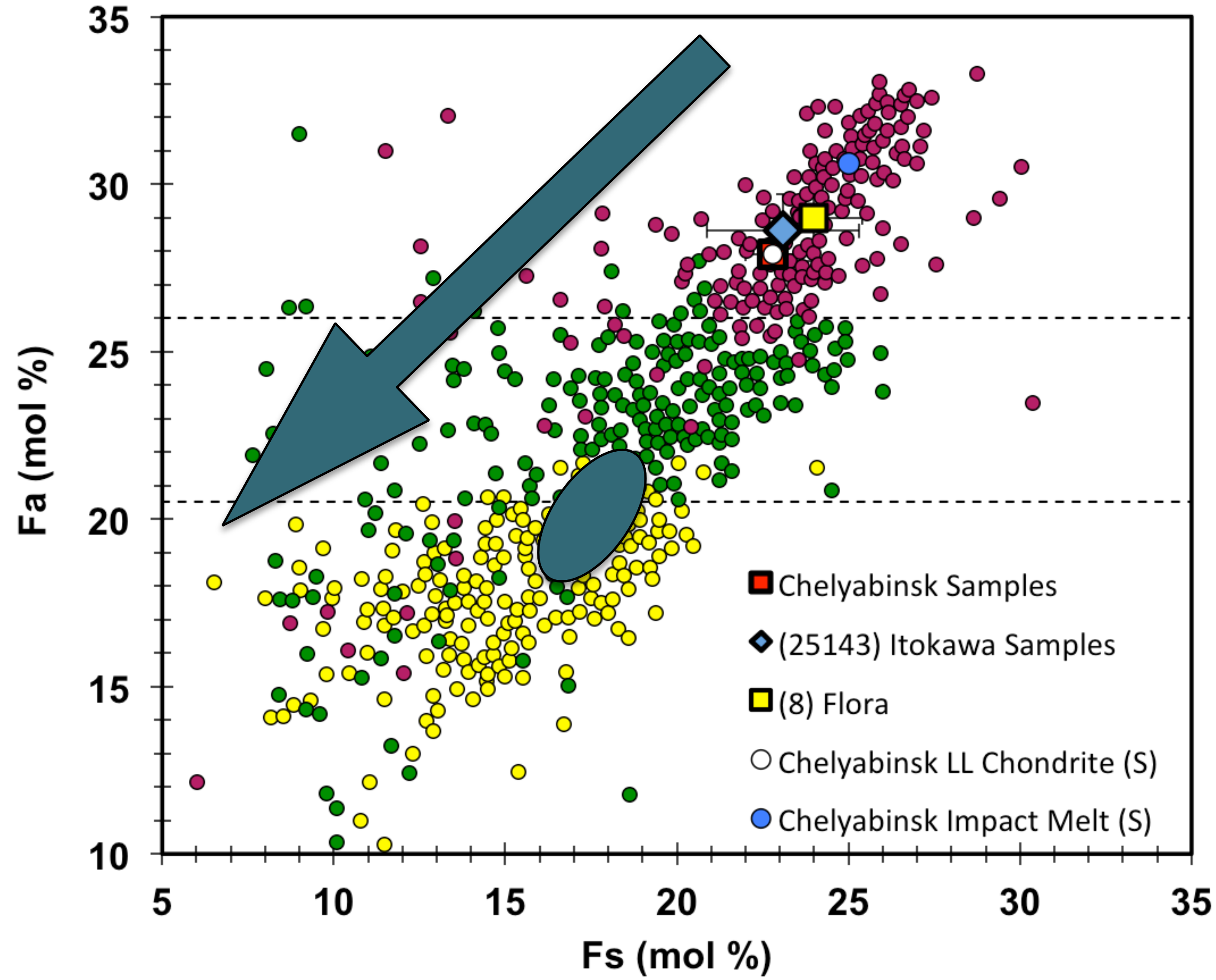
- Laboratory samples match with LL chondrites, Itokawa and Flora
- Differences in spectrally derived (S) olivine and pyroxene chemistries of impact melt and LL5 chondrite components
- However, both fall within the LL chondrite zone.



We would have accurately characterized Chelyabinsk as an LL5 Chondrite

However….

- We got lucky with Chelyabinsk.
- Had the impact melt % been higher than 50%, we would have different taxonomic type
- Impact melt also has strong effect on mineralogical characterization depending on particle size
- Smaller particle sizes could leac to incorrect meteorite analog (LL > L/H)



Are some low albedo NEAs rich in impact melt rather than carbonaceous?

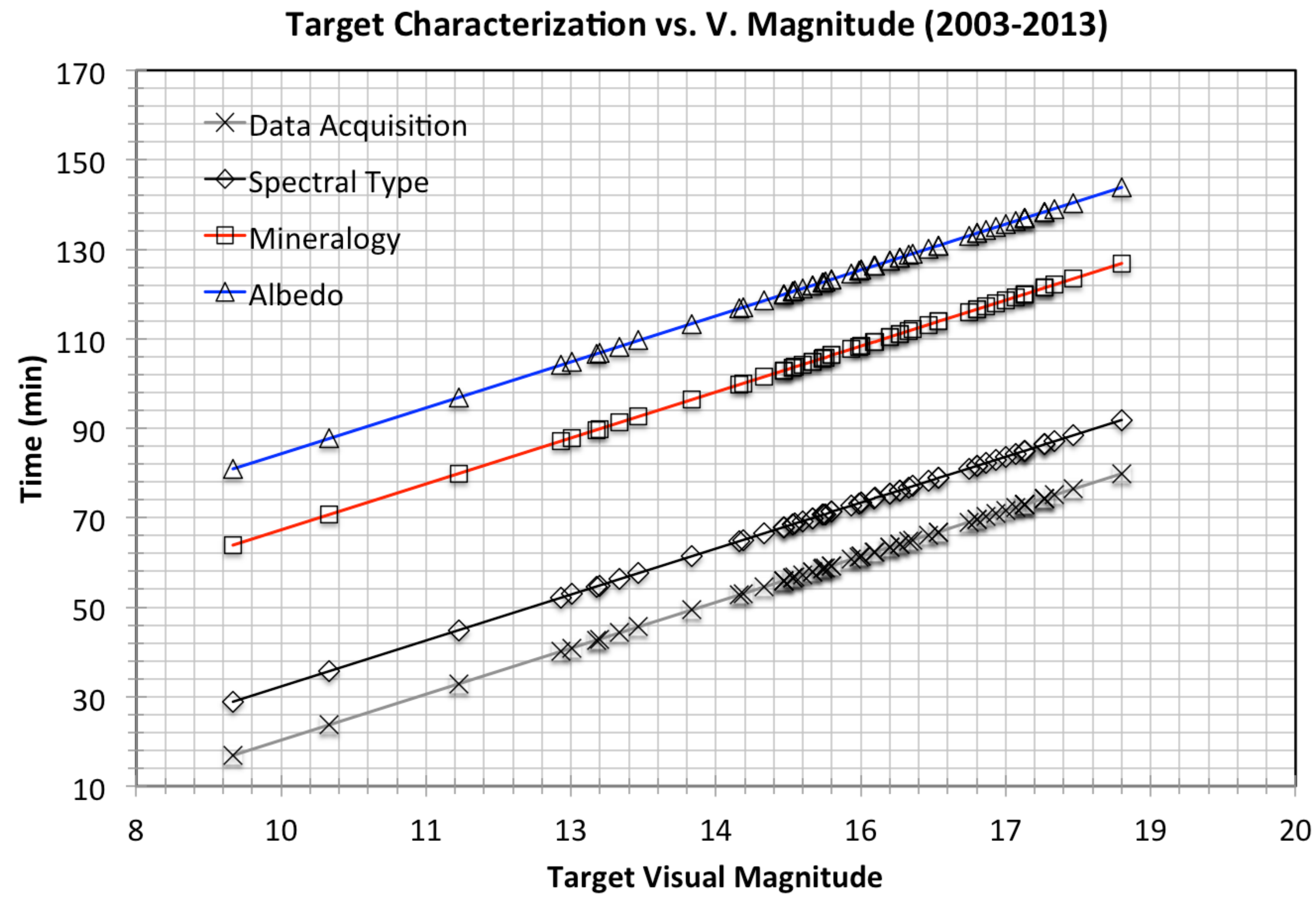
….Probably

- Effect of impact melt on Baptistina Asteroid Family
- 20-30 meter chunk of impact melt composition possible
- How to differentiate between impact melt and carbonaceous material using remote sensing?
- Future work: Studying impact melts in other ordinary chondrites (L and H)


Chergach H5 Chondrite

Operational Readiness

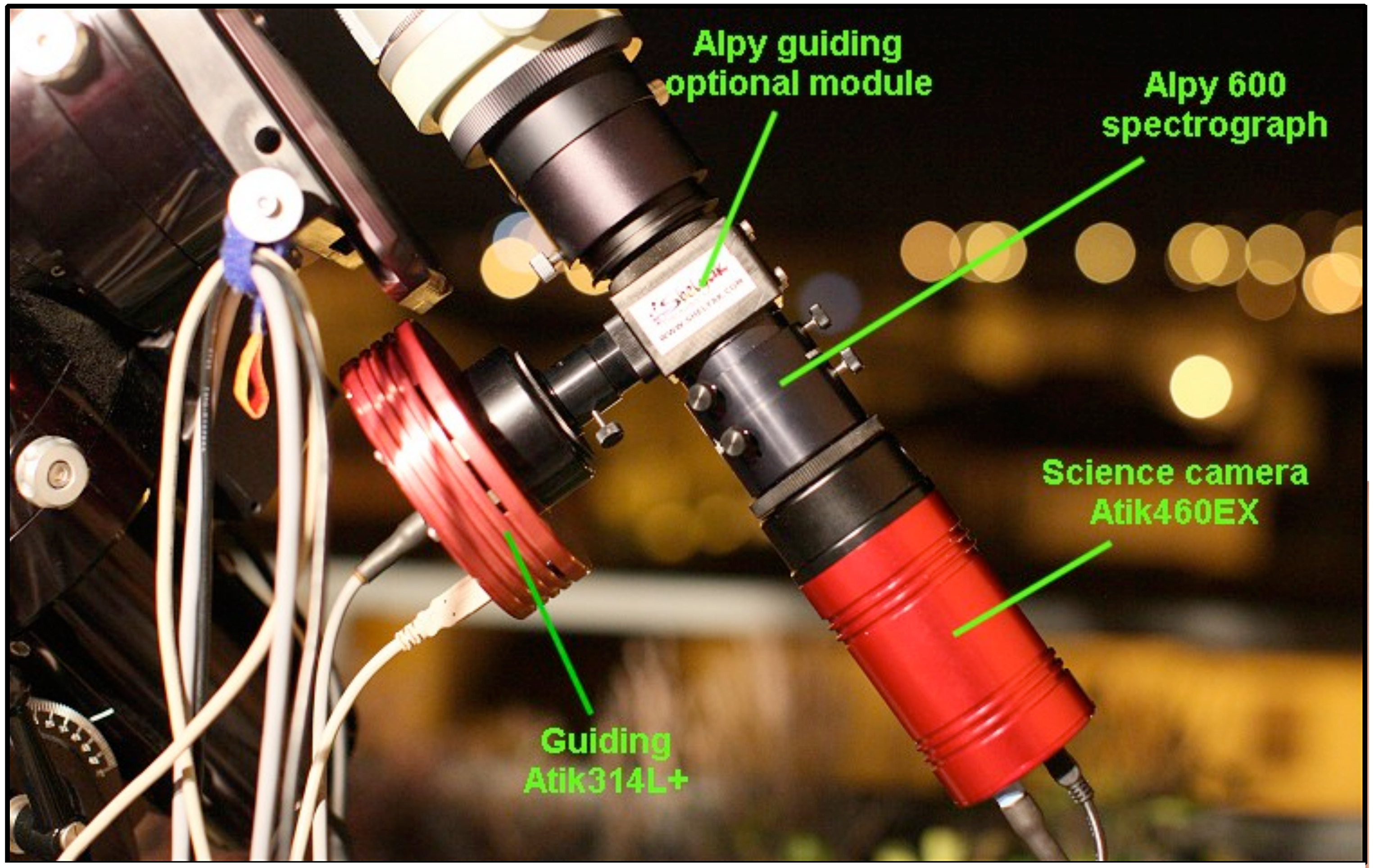
- Operational Readiness for imminent impactor physical characterization
- How long does it take to characterize an impactor after discovery?
- Historical data over a decade o[f] NEO characterization
- Live characterization exercises based on real NEO discoveries
- Most accurate characterization in the least amount of time



NEO observed with the NASA IRTF
56 observing runs
After Data Acquisition:
12 mins - Spectral Type
47 mins - Mineralogy (A/S/V-types)
64 mins - “Albedo”

Other Activities

- Weather radar to track and recover meteorites (Collaboration: Marc Fries, JSC)
- Southwest Meteor Camera Network (UoA/PSI/MSFC); Phil Bland (Australia)
- Evaluation of low-cost and low resolution (R~100) visible wavelength spectrometers (0.3-1.0 μm) for amateurs to characterize small bodies (self funded)
- Topic for discussion later today.



Spec. Res. R~600; Cost~$3000
Better wavelength Calibration

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