This substorm onset matrix shows relevance of various observations/modelings to various substorm-onset physical models. Comments and suggestions are very welcome.	excuse, other explanations, critisism, comments	merit	near-earth reconnection	flow braking	current disturptio n	ballooning/ interchange	convection reduction	Nishimura/ Lyons model	Alfven wave model	M-I coupling model	Catapult slingshot model
Below are from GEM Substorm FG presentations on June 19, 2012.											
session 1 (10:30-12:15)											
Faifai Jiang: What is the causing of the preexsiting arc? FAST in 1998 statistics (210 events) using E-field measurements. Most equatorward electron acceleration structures observed within one hour before the substorm onset are considered as pre-existing arc. Most of the preexisiting arc is located within 1 degree of R1/R2 FAC boundary. Equatorward E-field increases significantly from lower to higher latitudes of the preexisting arc in the postmidnight. In premidnight, such enhancement is not seen. Relation between flow shear associated with the arc and large-scale convection flow should be clearified.						Consistent with the kinetic ballooning model, since ballooning instability becomes most unstable near the boundary of R1/R2 currents (Cheng and Zaharia, 2004).					
Eric Donovan: periodic beads structure seen in the onset arc. Motoba et al. (GRL, 2012) show clear conjugacy of onset auroral beads at conjugate stations in northern and southern hemispheres.	The beads move 5km/s at the ionosphere in longitudes, difficult to consider as a ballooning instability (too fast). There are some evidences that these beads occur after the flow bursts. Drift-mirror instability can also make similar structure.					The beads move 5km/s at the ionosphere in longitudes, difficult to consider as a ballooning instability (too fast)					
Larry Lyons: three unexpected suggestions. 1. current wedge response on ground magnetic field data delayed to the auroral brightening, and responds much stronger to auroral streamers (plasma sheet flow channels). 2. Flow channels leading to pre-substorm onet PBIs and streamers can extend from well within the polar cap towards PC boundary. 3. Polar-cap boundary streamers after onset make additional poleward expansion and brightening of aurora when they touch the brightening aurora. The low-entropy plasma of flow burst touches the equstorward arc and instability in the inner magnetosphere develops further.	How the low-entropy plasma makes precipitation? Does the instability necessary? Just a braking process may be enough to cause aurora brightening.			Item 3 can be explained that the flow braking causes auroral brightening.				Item 3 is consistent with the idea of FB causes near-earth instability			
Toshi Nishimura: correspondence between aurroal signatures and midlatitude Pi2 to separate Pi2 models (directly driven by BBF, ballooning instability, or cavity mode resonance) Quasi-periodic auroral streamers (brightenings) appear repeatingly after the onset. The on/off of these streamers corresponds to the Pi2 pulsations at middle and low latitudes, consistent with the model that multiple BBF creates Pi2.	Correspondence between repeating streamers and flow burst in the tail is not clear.										
Vassilis Angelopoulos: Earthward FB causes a pair of upward/downward currents. Tailward FB causes an opposite pair of upward/downward currents. The currents are inferred from ground magnetic field data.											
Misha Sitnov: Accumulation of magnetic flux at the tailward end of the thin tail current sheet. It was theoretically expected, and Geotail observation by Machida et al. (2009) show such a signature of Bz increase before the onset. Particle simulation show that the accumulation (tearing instability, slippage) accelerates particles earthward before the reconnection (Sitnov and Swisdak, 2011), consistently with the idea of catapult scenario for substorms by Machida et al. (2009).	time difference between non-reconnection flow and reconnection start is too short in the model (less than 1 min) to explain the Machida's observation (more than a few min).										Explains the generation of catapult slingshot before the X-reconnection.
session 2 (13:30-15:00)											
Joe Baker: Suppression of westward ionospheric convection for a few minutes at subauroral latitudes during auroral substorm onset in the onset meridian. Currently there is no good explanation on this phenomenon.											
Jiang Liu: Measruements of currents sheet at the dipolarization front (DF), THEMIS statistics at X=-6 to -13 Re. Current at DF is more field aligned at higher latitudes, and more perpendicular to the field at lower latitudes. Jx>0 in morning and Jx<0 in evening, which is consistent with R1 sense.											

Joo Hwang: Tailward-moving dipolarization front (DF) followed by an earthward-moving DF observed by Cluster at X=-14Re. Tailward flow causes stretching of plasma sheet and initiate X-type lobe reconnection that causes subsequent earthward flow.	Flow velocity is earthward during tailward-moving DF. What does it mean? DF may be just an enhancement of Bz.										
Joachim Birn: 1) There is a few-min timing delay from reconnection to SCW formation. 2) Energetic electron/proton motion in the simulated BBF. The particle has two source regions, one from tail frank side (early, higher energy), and the other from the reconnection region (later, lower energy). They have anisotropy, pancake at low latitudes, and cigar (field-aligned) at higher latitudes.											
Xuzhi Zhou: ion beams in the PSBL. THEMIS observation at two satellites (P4 and P5) for 18 events. PSBL ion flow bursts are followed by adjacent CPS flow bursts and dipolarization fronts for 16/18 events.											
Stefan Kiehas: ARTEMIS observation during substorm-like phenomena. Several examples. P1 and P2 are separated about 7 Re in X or in Y. The scale size of the substorm signature (TCR/flux ropes/plasmoid) in the near-Earth tail at X~-60 Re do not extend over the entire tail.											
session 3 (15:30-17:00) joint with mapping FG											
Shin Ohtani: DMSP FAC/particle data (large data set) show b3a (equatorward boundary of monoenergetic electron precipitation) occurs at R1/R2 current boundary. b3b (poleward boundary of monoenergetic electron precipitation) occurs at poleward boundary of R1 current. (Ohtani et al., 2010)	growth-phase arc will be only a very small fraction of the used dataset.										
Toshi Nishimura: Using CHAMP FAC and THEMIS ASI, the pre-onset arc was located (event 1) at the peak of R1 currrents, (event 2) at the middle of the R2 currents, (event 3) at the middle of the R2 current, and (event 4) at the poleward edge of R2 current. The onset arc is in the R2 current in the onset meridian, while it is at the boundary of R1/R2 current at dusk/dawn side of the onset meridian.						Inconsistent with the kinetic ballooning model, since ballooning instability becomes most unstable near the boundary of R1/R2 currents (Cheng and Zaharia, 2004). But they assume symmetric magnetosphere.					
Jun Liang: The tailward boundary of upgoing quasi-parallel electron beam (QPEBs) in the CPS is used to map the equatorward boundary of auroral arc region to the magnetosphere, using THEMIS E and A difference. The pre-breakup arc region is found as situated in the near-tail region, i.e., a transition region from quasi-dipolar to stretched current sheet tomology, inferred by estimating magnetic field curvature.											
Larry Lyons: Mapping implications of the very thin auroral oval in the late growth phase. The sequence of "PBI->eqauatorward-moving streamer -> auroral brightening onset" was investigated for thick oval cases (typical, 97%) and thin oval cases (rare, 3%). THEMIS data show difference in Ptot increase. Thin case: less PBIs, streamers, flow channels. Thick case: stronger, monotonic increase of Ptot at growth phase, and more thinning of tail.											
Jian Yiang: Substorm-time Magnetic field model based on the equilibrium version of RCM (SUMMER) was developed. Even you have a very good empirical model, the equatorial crossing X-distance is very different.											

At the end, we agreed to have a similar joint session with mapping FG next year. We should distinguish morphological mapping and field-line mapping.